Universal Serial Bus Power Delivery Specification

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Revision History

Revision	Version	Comments	Issue Date
1.0	1.0	Initial release Revision 1.0	5 July, 2012
1.0	1.1	Including errata through 31-October-2012	31 October 2012
1.0	1.2	Including errata through 26-June-2013	26 June, 2013
1.0	1.3	Including errata through 11-March-2014	11 March 2014
2.0	1.0	Initial release Revision 2.0	11 August 2014
2.0	1.1	Including errata through 7-May 2015	7 May 2015
2.0	1.2	Including errata through 25-March-2016	25 March 2016
2.0	1.3	Including errata through 11-January-2017	11 January 2017
3.0	1.0	Initial release Revision 3.0	11 December 2015
3.0	1.0a	Including errata through 25-March-2016	25 March 2016
3.0	1.1	Including errata through 12-January-2016	12 January 2017

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1. Introduction

USB has evolved from a data interface capable of supplying limited power to a primary provider of power with a data interface. Today many devices charge or get their power from USB ports contained in laptops, cars, aircraft or even wall sockets. USB has become a ubiquitous power socket for many small devices such as cell phones, MP3 players and other hand-held devices. Users need USB to fulfill their requirements not only in terms of data but also to provide power to, or charge, their devices simply, often without the need to load a driver, in order to carry out "traditional" USB functions.

There are however, still many devices which either require an additional power connection to the wall, or exceed the USB rated current in order to operate. Increasingly, international regulations require better energy management due to ecological and practical concerns relating to the availability of power. Regulations limit the amount of power available from the wall which has led to a pressing need to optimize power usage. The USB Power Delivery Specification has the potential to minimize waste as it becomes a standard for charging devices that are not satisfied by ***[USBBC 1.2]***.

Wider usage of wireless solutions is an attempt to remove data cabling but the need for "tethered" charging remains. In addition, industrial design requirements drive wired connectivity to do much more over the same connector.

USB Power Delivery is designed to enable the maximum functionality of USB by providing more flexible power delivery along with data over a single cable. Its aim is to operate with and build on the existing USB ecosystem; increasing power levels from existing USB standards, for example Battery Charging, enabling new higher power use cases such as USB powered Hard Disk Drives (HDDs) and printers.

With USB Power Delivery the power direction is no longer fixed. This enables the product with the power (Host or Peripheral) to provide the power. For example, a display with a supply from the wall can power, or charge, a laptop. Alternatively, USB power bricks or chargers are able to supply power to laptops and other battery powered devices through their, traditionally power providing, USB ports.

USB Power Delivery enables hubs to become the means to optimize power management across multiple peripherals by allowing each device to take only the power it requires, and to get more power when required for a given application. For example battery powered devices can get increased charging current and then give it back temporarily when the user's HDD requires spinning up. ***Optionally*** the hubs can communicate with the PC to enable even more intelligent and flexible management of power either automatically or with some level of user intervention.

USB Power Delivery allows Low Power cases such as headsets to negotiate for only the power they require. This provides a simple solution that enables USB devices to operate at their optimal power levels.

The Power Delivery Specification, in addition to providing mechanisms to negotiate power also can be used as a side-band channel for standard and vendor defined messaging. Power Delivery enables alternative modes of operation by providing the mechanisms to discover, enter and exit Alternate Modes. The specification also enables discovery of cable capabilities such as supported speeds and current levels.

1.1 Overview

This specification defines how USB Devices can negotiate for more current and/or higher or lower voltages over the USB cable (using the USB Type-C CC wire as the communications channel) than are defined in the ***[USB 2.0]***, ***[USB 3.1]***, ***[USB Type-C 1.2]*** or ***[USBBC 1.2]*** specifications. It allows Devices with greater power requirements than can be met with today's specification to get the power they require to operate from V_{BUS} and negotiate with external power sources (e.g. Wall Warts). In addition, it allows a Source and Sink to swap power roles such that a Device could supply power to the Host. For example, a display could supply power to a notebook to charge its battery.

The USB Power Delivery Specification is guided by the following principles:

Works seamlessly with legacy USB Devices
Compatible with existing spec-compliant USB cables
Minimizes potential damage from non-compliant cables (e.g. 'Y' cables etc.)
Optimized for low-cost implementations

This specification defines mechanisms to discover, enter and exit Modes defined either by a standard or by a particular vendor. These Modes can be supported either by the Port Partner or by a cable connecting the two Port Partners.

The specification defines mechanisms to discover the capabilities of cables which can communicate using Power Delivery.

This specification adds a mechanism to swap the data roles such that the upstream facing Port becomes the downstream facing Port and vice versa. It also enables a swap of the end supplying V_{CONN} to a powered cable.

1.2 Purpose

The USB Power Delivery specification defines a power delivery system covering all elements of a USB system including: Hosts, Devices, Hubs, Chargers and cable assemblies. This specification describes the architecture, protocols, power supply behavior, connectors and cabling necessary for managing power delivery over USB at up to 100W. This specification is intended to be fully compatible and extend the existing USB infrastructure. It is intended that this specification will allow system OEMs, power supply and peripheral developers adequate flexibility for product versatility and market differentiation without losing backwards compatibility.

USB Power Delivery is designed to operate independently of the existing USB bus defined mechanisms used to negotiate power which are:

- ***[USB 2.0]***, ***[USB 3.1]*** in band requests for high power interfaces.
- ***[USBBC 1.2]*** mechanisms for supplying higher power (not mandated by this specification).
- ***[USB Type-C 1.2]*** mechanisms for supplying higher power

Initial operating conditions remain the USB Default Operation as defined in ***[USB 2.0]***, ***[USB 3.1]***, ***[USB Type-C 1.2]*** or ***[USBBC 1.2]***.

- The DFP sources ***vSafe5V*** over V_{BUS}.
- The UFP consumes power from V_{BUS}.

1.3 Scope

This specification is intended as an extension to the existing ***[USB 2.0]***, ***[USB 3.1]***, ***[USB Type-C 1.2]*** and ***[USBBC 1.2]*** specifications. It addresses only the elements required to implement USB Power Delivery. It is targeted at power supply vendors, manufacturers of ***[USB 2.0]***, ***[USB 3.1]***, ***[USB Type-C 1.2]*** and ***[USBBC 1.2]*** Platforms, Devices and cable assemblies.

Normative information is provided to allow interoperability of components designed to this specification. Informative information, when provided, illustrates possible design implementation.

1.4 Conventions

1.4.1 Precedence

If there is a conflict between text, figures, and tables, the precedence ***Shall*** be tables, figures, and then text.

1.4.2 Keywords

The following keywords differentiate between the levels of requirements and options.

1.4.2.1 Conditional Normative

Conditional Normative is a keyword used to indicate a feature that is mandatory when another related feature has been implemented. Designers are mandated to implement all such requirements, when the dependent features have been implemented, to ensure interoperability with other compliant Devices.

1.4.2.2 Deprecated

Deprecated is a keyword used to indicate a feature, supported in previous releases of the specification, which is no longer supported.

1.4.2.3 Discarded

Discard, ***Discards*** and ***Discarded*** are equivalent keywords indicating that a Packet when received ***Shall*** be thrown away by the PHY Layer and not passed to the Protocol Layer for processing. No ***GoodCRC*** Message ***Shall*** be sent in response to the Packet.

1.4.2.4 Ignored

Ignore, ***Ignores*** and ***Ignored*** are equivalent keywords indicating Messages or Message fields which, when received, ***Shall*** result in no special action by the receiver. An ***Ignored*** Message ***Shall*** only result in returning a ***GoodCRC*** Message to acknowledge Message receipt. A Message with an ***Ignored*** field ***Shall*** be processed normally except for any actions relating to the ***Ignored*** field.

1.4.2.5 Invalid

Invalid is a keyword when used in relation to a Packet indicates that the Packet's usage or fields fall outside of the defined specification usage. When ***Invalid*** is used in relation to an Explicit Contract it indicates that a previously established Explicit Contract which can no longer be maintained by the Source. When ***Invalid*** is used in relation to individual K-codes or K-code sequences indicates that the received Signaling falls outside of the defined specification.

1.4.2.6 May

May is a keyword that indicates a choice with no implied preference.

1.4.2.7 May Not

May Not is a keyword that is the inverse of ***May***. Indicates a choice to not implement a given feature with no implied preference.

1.4.2.8 N/A

N/A is a keyword that indicates that a field or value is not applicable and has no defined value and ***Shall Not*** be checked or used by the recipient.

1.4.2.9 Optional/Optionally/Optional Normative

Optional, Optionally and ***Optional Normative*** are equivalent keywords that describe features not mandated by this specification. However, if an ***Optional*** feature is implemented, the feature ***Shall*** be implemented as defined by this specification.

1.4.2.10 Reserved

Reserved is a keyword indicating reserved bits, bytes, words, fields, and code values that are set-aside for future standardization. Their use and interpretation ***May*** be specified by future extensions to this specification and ***Shall Not*** be utilized or adapted by vendor implementation. A ***Reserved*** bit, byte, word, or field ***Shall*** be set to zero by the sender and ***Shall*** be ***Ignored*** by the receiver. ***Reserved*** field values ***Shall Not*** be sent by the sender and ***Shall*** be ***Ignored*** by the receiver.

1.4.2.11 Shall/Normative

Shall and ***Normative*** are equivalent keywords indicating a mandatory requirement. Designers are mandated to implement all such requirements to ensure interoperability with other compliant Devices.

1.4.2.12 Shall Not

Shall Not is a keyword that is the inverse of ***Shall*** indicating non-compliant operation.

1.4.2.13 Should

Should is a keyword indicating flexibility of choice with a preferred alternative; equivalent to the phrase "it is recommended that…".

1.4.2.14 Should Not

Should Not is a keyword is the inverse of ***Should***; equivalent to the phrase "it is recommended that implementations do not…".

1.4.2.1 Valid

Valid is a keyword that is the inverse of ***Invalid*** indicating either a Packet, Signaling that fall within the defined specification or an Explicit Contract that can be maintained by the Source.

1.4.3 Numbering

Numbers that are immediately followed by a lowercase "b" (e.g., 01b) are binary values. Numbers that are immediately followed by an uppercase "B" are byte values. Numbers that are immediately followed by a lowercase "h" (e.g., 3Ah) or are preceded by "0x" (e.g. 0xFF00) are hexadecimal values. Numbers not immediately followed by either a "b", "B", or "h" are decimal values.

1.5 Related Documents

- ***[USB 2.0]*** – Universal Serial Bus Specification, Revision 2.0, plus ECN and Errata http://www.usb.org/developers/docs/usb20_docs/.
- ***[USB 3.1]*** – Universal Serial Bus 3.1 Specification, Revision 1 plus ECN and Errata (this includes the entire document release package including the OTG&EH v3.0 specification). www.usb.org/developers/docs.
- ***[USBTypeCAuthentication 1.0]***, Universal Serial Bus Type-C Authentication Specification, Revision 1.0, March 25, 2016. www.usb.org/developers/docs.
- ***[USBPDFirmwareUpdate 1.0]***, Universal Serial Bus Power Delivery Firmware Update Specification, Revision 1.0. www.usb.org/developers/docs. Expected publication date H2 2016.
- ***[USBBC 1.2]*** – Universal Serial Bus Battery Charging Specification, Revision 1.2 plus Errata (referred to in this document as the Battery Charging specification). www.usb.org/developers/devclass_docs#approved.
- ***[USBBridge 1.0]*** – Universal Serial Bus Type-C Bridge Specification, Revision 1.0, March 25, 2016. www.usb.org/developers/docs.
- ***[USBTypeCBridge 1.0]*** – Universal Serial Bus Type-C Bridge Specification, Revision 1.0, March 25, 2016. www.usb.org/developers/docs.
- ***[USBPD 2.0]*** – Universal Serial Bus Power Delivery Specification, Revision 2, Version 1.2, March 25, 2016. www.usb.org/developers/docs.
- ***[USBPDCompliance]*** – USB Power Delivery Compliance Plan version 1.0 http://www.usb.org/developers/docs/devclass_docs/.
- ***[USB Type-C 1.2]*** – Universal Serial Bus Type-C Cable and Connector Specification, Revision 1.2, March 25, 2016. www.usb.org/developers/docs.
- ***[IEC 60958-1]*** IEC 60958-1 Digital Audio Interface Part:1 General Edition 3.0 2008-09 www.iec.ch
- ***[IEC 60950-1]*** IEC 60950-1:2005 Information technology equipment – Safety – Part 1: General requirements: Amendment 1:2009, Amendment 2:2013
- ***[IEC 62368-1]*** IEC 62368-1 Audio/Video, information and communication technology equipment – Part 1: Safety requirements

- ***[IEC 63002]*** Draft CD for IEC 63002 Identification and Communication Interoperability Method for External DC Power Supplies Used With Portable Computing Devices.
- ***[ISO 3166]*** ISO 3166 international Standard for country codes and codes for their subdivisions. http://www.iso.org/iso/home/standards/country_codes.htm.

1.6 Terms and Abbreviations

This section defines terms used throughout this document. For additional terms that pertain to the Universal Serial Bus, see Chapter 2, "Terms and Abbreviations," in ***[USB 2.0]***, ***[USB 3.1]***, ***[USB Type-C 1.2]*** and ***[USBBC 1.2]***.

Table 1-1 Terms and Abbreviations

Term	Description
Active Cable	A cable with a USB Plug on each end at least one of which is a Cable Plug supporting SOP', that also incorporates data bus signal conditioning circuits. The cable supports the Structured VDM ***Discover Identity*** Command to determine its characteristics in addition to other Structured VDM Commands (Electronically Marked Cable see ***[USB Type-C 1.2]***).
Active Mode	A Mode which has been entered and not exited.
Alternate Mode	As defined in ***[USB Type-C 1.2]***. Equivalent to Mode in the PD Specification.
Alternate Mode Adapter (AMA)	A PDUSB Device which supports Alternate Modes as defined in ***[USB Type-C 1.2]***. Note that since an AMA is a PDUSB Device it has a single UFP that is only addressable by SOP Packets.
Alternate Mode Controller (AMC)	A DFP that supports connection to AMAs as defined in ***[USB Type-C 1.2]***. A DFP that is an AMC can also be a PDUSB Host.
Augmented Power Data Object (APDO)	Data Object used to expose a Source Port's power capabilities or a Sink's power requirements as part of a ***Source_Capabilities*** or ***Sink_Capabilities*** Message respectively. Programmable Power Supply Data Object is defined.
Atomic Message Sequence (AMS)	A fixed sequence of Messages as defined in Section 8.3.2 typically starting and ending in one of the following states: ***PE_SRC_Ready***, ***PE_SNK_Ready*** or ***PE_CBL_Ready***. An AMS can be Interruptible or Non-interruptible.
Attach	Mechanical joining of the Port Pair by a cable.
Attached	USB Power Delivery ports which are mechanically joined with USB cable.
Battery	A power storage device residing behind a Port that can either be a source or sink of power.
Battery Supply	A power supply that directly applies the output of a Battery to V_{BUS}. This is exposed by the Battery Supply PDO (see Section 6.4.1.2.4)
Binary Frequency Shift Keying (BFSK)	A Signaling Scheme now ***Deprecated*** in this specification. BFSK used a pair of discrete frequencies to transmit binary (0s and 1s) information over V_{BUS}. See ***[USBPD 2.0]*** for further details.
Biphase Mark Coding (BMC)	Modification of Manchester coding where each zero has one transition and a one has two transitions (see ***[IEC 60958-1]***).
BIST	Built In Self-Test – Power Delivery testing mechanism for the PHY Layer.
BIST Data Object (BDO)	Data Object used by ***BIST*** Messages.
BIST Mode	A BIST receiver or transmitter test mode enabled by a ***BIST*** Message.
Cable Plug	Term used to describe a PD Capable element in a Multi-Drop system addressed by SOP'/SOP'' Packets. Logically the Cable Plug is associated with a USB plug at one end of the cable. In a practical implementation the electronics might reside anywhere in the cable.
Cable Reset	This is initiated by ***Cable Reset*** Signaling from the DFP. It restores the Cable Plugs to their default, power up condition and resets the PD communications engine to its default state. It does not reset the Port Partners but does restore V_{CONN} to its Attachment state.
Chunk	A ***MaxExtendedMsgChunkLen*** (26 byte) or less portion of a Data Block. Data Blocks can be sent either as a single Message or as a series of Chunks.
Chunking	The process of breaking up a Data Block larger than ***MaxExtendedMsgLegacyLen*** (26-bytes) into two of more Chunks.
Cold Socket	A Port that does not apply ***vSafe5V*** on V_{BUS} until a Sink is Attached.

Term	Description
Command	Request and response pair defined as part of a Structured Vendor Defined Message (see Section 6.4.4.2)
Configuration Channel (CC)	Single wire used by the BMC PHY Layer Signaling Scheme (see ***[USB Type-C 1.2]***).
Connected	USB Power Delivery ports that have exchanged a Message and a ***GoodCRC*** Message response using the USB Power Delivery protocol so that both Port Partners know that each is PD Capable.
Consumer	The capability of a PD Port (typically a Device's UFP) to sink power from the power conductor (e.g. V_{BUS}). This corresponds to a USB Type-C Port with Rd asserted on its CC Wire.
Consumer/Provider	A Consumer with the additional capability to act as a Provider. This corresponds to a Dual-Role Port with Rd asserted on its CC Wire.
Continuous BIST Mode	A BIST Mode where the Port or Cable Plug being tested sends a continuous stream of test data.
Constant Voltage (CV)	A mode in which the Source output Voltage remains constant as the load changes.
Contract	An agreement on both power level and direction reached between a Port Pair. A Contract could be explicitly negotiated between the Port Pair or could be an Implicit power level defined by the current state. While operating in Power Delivery mode there will always be either an Explicit or Implicit Contract in place. The Contract can only be altered in the case of a (re-)negotiation, Power Role Swap, Data Role Swap, Hard Reset or failure of the Source.
Control Message	A Message is defined as a Control Message when the ***Number of Data Objects*** field in the Message Header is set to 0. The Control Message consists only of a Message Header and a CRC.
Current Foldback (CF)	A current limiting feature for a Source. When the Sink attempts to draw more current from the Source than the requested current foldback value, the Source reduces its output voltage so the current it supplies remains at or below the requested value.
Data Block	An Extended Message payload data unit. The size of each type of Data Block is specified as a series of bytes up to ***MaxExtendedMsgLen*** bytes in length. This is distinct from a Data Object used by a Data Message which is always a 32-bit object.
Data Message	A Data Message consists of a Message Header followed by one or more Data Objects. Data Messages are easily identifiable because the ***Number of Data Objects*** field in the Message Header is a non-zero value.
Data Object	A Data Message payload data unit. This 32 bit object contains information specific to different types of Data Message. Power, Request, BIST and Vendor Data Objects are defined.
Data Role Swap	Process of exchanging the DFP (Host) and UFP (Device) roles between Port Partners using the ***[USB Type-C 1.2]*** connector.
Dead Battery	A device has a Dead Battery when the Battery in a device is unable to power its functions.
Detach	Mechanical unjoining of the Port Pair by removal of the cable.
Detached	USB Power Delivery ports which are no longer mechanically joined with USB cable.
Device	When lower cased (device), it refers to any USB product, either USB Device or USB Host. When in upper case refers to a USB Device (Peripheral or Hub).
Device Policy Manager (DPM)	Module running in a Source or Sink that applies Local Policy to each Port in the Device via the Policy Engine.
Discovery Process	Command sequence using Structured Vendor Defined Messages resulting in identification of the Port Partner, its supported SVIDs and Modes.
Downstream Facing Port (DFP)	Indicates the Port's position in the USB topology which typically corresponds to a USB Host root Port or Hub downstream Port as defined in ***[USB Type-C 1.2]***. At connection the Port defaults to operation as a USB Host (when USB Communication is supported) and Source.
Dual-Role Data (DRD)	Capability of operating as either a DFP or UFP.
Dual-Role Data Port	A Port Capable of operating as DRD..
Dual-Role Power (DRP)	Capability of operating as either a Source or Sink.
Dual-Role Power Device	A product containing one or more Dual-Role Power Ports that are capable of operating as either a Source or a Sink.
Dual-Role Power Port	A Port capable of operating as a DRP.

Term	Description
End of Packet (EOP)	K-code marker used to delineate the end of a packet.
Enter Mode Process	Command sequence using Structured Vendor Defined Messages resulting in the Port Partners entering a Mode.
Error Recovery	Error recovery process as defined in ***[USB Type-C 1.2]***.
Exit Mode Process	Command sequence using Structured Vendor Defined Messages resulting in the Port Partners exiting a Mode.
Explicit Contract	An agreement reached between a Port Pair as a result of the Power Delivery negotiation process. An Explicit Contract is established (or continued) when a Source sends an ***Accept*** Message in response to a ***Request*** Message sent by a Sink followed by a ***PS_RDY*** Message indicating that the power supply is ready; this corresponds to the ***PE_SRC_Ready*** state for a Source Policy Engine and the ***PE_SNK_Ready*** state for a Sink Policy Engine. The Explicit Contract can be altered through the re-negotiation process. All Port pairs are required to make an Explicit Contract.
Extended Message (EM)	A Message containing Data Blocks. The Extended Message is defined by the ***Extended*** field in the Message Header being set to one and contains an Extended Message Header immediately following the Message Header.
Extended Message Header	Every Extended Message contains a 16-bit Extended Message Header immediately following the Message Header containing information about the Data Block and any Chunking being applied.
Fast Role Swap	Process of exchanging the Source and Sink roles between Port Partners rapidly due to the disconnection of an external power supply.
Fixed Battery	A Battery that is not easily removed or replaced by an end user e.g. requires a special tool to access or is soldered in.
Fixed Supply	A well-regulated fixed voltage power supply. This is exposed by the Fixed Supply PDO (see Section 6.4.1.2.2)
Frame	Generic term referring to an atomic communication transmitted by PD such as a Packet, Test Frame or Signaling.
Hard Reset	This is initiated by ***Hard Reset*** Signaling from either Port Partner. It restores V_{BUS} to USB Default Operation and resets the PD communications engine to its default state in both Port Partners as well as in any Attached Cable Plugs. It restores both Port Partners to their default Data Roles and returns the VCONN Source to the Source Port.
HDD	A Hard Disk Drive.
Hot Swappable Battery	A Battery that is easily accessible for a user to remove or change for another Battery.
ID Header VDO	The VDO in a ***Discover Identity*** Command immediately following the VDM Header. The ID Header VDO contains information corresponding to the Power Delivery Product.
Implicit Contract	An agreement on power levels between a Port Pair which occurs, not as a result of the Power Delivery negotiation process, but as a result of a Power Role Swap or Fast Role Swap. Implicit Contracts are transitory since the Port pair is required to immediately negotiate an Explicit Contract after the Power Role Swap. An Implicit Contract ***Shall*** be limited to USB Type-C Current (see ***[USB Type-C 1.2]***).
Initiator	The initial sender of a Command request in the form of a query.
Interruptible	An AMS that, on receiving a Protocol Error, returns to the appropriate ready state in order to process the incoming Message is said to be Interruptible. Every AMS is Interruptible until the first Message in the AMS has been sent (a ***GoodCRC*** Message has been received). An AMS of Vendor Messages is Interruptible during the entire sequence.
IoC	The negotiated current value as defined in ***[IEC 63002]***.
IR Drop	The voltage drop across the cable and connectors between the Source and the Sink. It is a function of the resistance of the ground and power wire in the cable plus the contact resistance in the connectors times the current flowing over the path.
K-code	Special symbols provided by the 4b5b coding scheme. K-codes are used to signal Hard Reset and Cable reset, and delineate Packet boundaries.

Term	Description
Local Policy	Every PD Capable device has its own Policy, called the Local Policy that is executed by its Policy Engine to control its power delivery behavior. The Local Policy at any given time might be the default policy, hard coded or modified by changes in operating parameters or one provided by the system Host or some combination of these. The Local Policy ***Optionally*** can be changed by a System Policy Manager.
LPS	Limited Power Supply as defined in ***[IEC 62368-1]***.
Message	The packet payload consisting of a Message Header for Control Messages and a Message Header and data for Data Messages and Extended Messages as defined in Section 6.
Message Header	Every Message starts with a 16-bit Message Header containing basic information about the Message and the PD Port's Capabilities.
Messaging	Communication in the form of Messages as defined in Chapter 6.
Modal Operation	State where there are one or more Active Modes. Modal Operation ends when there are no longer any Active Modes.
Mode	Operation defined by a Vendor or Standard's organization, which is associated with a SVID, whose definition is outside the scope of USB-IF specifications. Entry to and exit from the Mode uses the Enter Mode and Exit Mode Processes. Modes are equivalent to "Alternate Modes" as described in ***[USB Type-C 1.2]***.
Multi-Drop	Refers to a Power Delivery system with one or more Cable Plugs where communication is to the Cable Plugs rather than the Port Partner. Multi-Drop systems share the Power Delivery communication channel with the Port Partners.
Negotiation	This is the PD process whereby: 1. The Source advertises its capabilities. 2. The Sink requests one of the advertised capabilities. 3. The Source acknowledges the request and alters its output to satisfy the request. The result of the negotiation is a Contract for power delivery/consumption between the Port Pair.
Non-interruptible	An AMS that, on receiving a Protocol Error, generates either a Soft Reset or Hard Reset. Any power related AMS is Non-interruptible once the first Message in the AMS has been sent (a ***GoodCRC*** Message has been received).
OCP	Over-Current Protection
OTP	Over-Temperature Protection
OVP	Over-Voltage Protection
Packet	One entire unit of PD communication including a Preamble, ***SOP****, payload, CRC and ***EOP*** as defined in Section 5.6.
Passive Cable	Cable with a USB Plug on each end at least one of which is a Cable Plug supporting SOP' that does not incorporate data bus signal conditioning circuits. Supports the Structured VDM ***Discover Identity*** to determine its characteristics (Electronically Marked Cable see ***[USB Type-C 1.2]***). Note this specification does not discuss Passive Cables which are not Electronically Marked Cables.
PD	USB Power Delivery
PD Capable	A Port that supports USB Power Delivery.
PD Connection	See Connected.
PD Power (PDP)	The output power of a Source, as specified by the manufacturer and expressed in Fixed Supply PDOs as defined in Section 10.
PDUSB	USB Device Port or USB Host Port that is both PD capable and capable of USB Communication. See also PDUSB Host, PDUSB Device and PDUSB Hub.
PDUSB Device	A USB Device with a PD Capable UFP. A PDUSB Device is only addressed by SOP Packets.
PDUSB Host	A USB Host which is PD Capable on at least one of its DFPs. A PDUSB Host is only addressed by SOP Packets.
PDUSB Hub	A port expander USB Device with a UFP and one or more DFPs which is PD Capable on at least one of its Ports. A PDUSB Hub is only addressed by SOP Packets.
PDUSB Peripheral	A USB Device with a PD Capable UFP which is not a PDUSB Hub. A PDUSB Peripheral is only addressed by SOP Packets.

Term	Description
PHY Layer	The Physical Layer responsible for sending and receiving Messages across the USB Type-C CC wire between a Port Pair.
Policy	Policy defines the behavior of PD capable parts of the system and defines the capabilities it advertises, requests made to (re)negotiate power and the responses made to requests received.
Policy Engine (PE)	The Policy Engine interprets the Device Policy Manager's input in order to implement Policy for a given Port and directs the Protocol Layer to send appropriate Messages.
Port	An interface typically exposed through a receptacle, or via a plug on the end of a hard-wired captive cable. USB Power Delivery defines the interaction between a Port Pair.
Port Pair	Two Attached PD Capable Ports.
Port Partner	A Contract is negotiated between a Port Pair connected by a USB cable. These ports are known as Port Partners.
Power Conductor	The wire delivering power from the Source to Sink. For example USB's V_{BUS}.
Power Consumer	See Consumer
Power Data Object (PDO)	Data Object used to expose a Source Port's power capabilities or a Sink's power requirements as part of a ***Source_Capabilities*** or ***Sink_Capabilities*** Message respectively. Fixed, Variable and Battery Power Data Objects are defined.
Power Delivery Mode	Operation after a Contract has initially been established between a Port pair. This mode persists during normal Power Delivery operation, including after a Power Role Swap. Power Delivery mode can only be exited by Detaching the ports, applying a Hard Reset or by the Source removing power (except when power is removed during the Power Role Swap procedure).
Power Provider	See Provider
Power Reserve	Power which is kept back by a Source in order to ensure that it can meet total power requirements of Attached Sinks on at least one Port.
Power Role Swap	Process of exchanging the Source and Sink roles between Port Partners.
Preamble	Start of a transmission which is used to enable the receiver to lock onto the carrier. The Preamble consists of a 64-bit sequence of alternating 0s and 1s starting with a "0" and ending with a "1" which is not 4b5b encoded.
Product Type	Product categorization returned as part of the ***Discover Identity*** Command.
Product Type VDO	VDO identifying a certain Product Type in the ID Header VDO of a ***Discover Identity*** Command.
Programmable Power Supply (PPS)	A power supply whose output voltage can be programmatically adjusted in small increments over its advertised range. The PPS also has a programmable output current fold back. The capabilities of the PPS are exposed by the Programmable Power Supply APDO (see Section 6.4.1.2.5).
Protocol Error	An unexpected Message during an Atomic Message Sequence. A Protocol Error during a Non-interruptible AMS will result in either a Soft Reset or a Hard Reset. A Protocol Error during an Interruptible AMS will result in a return to the appropriate ready state where the Message will be handled.
Protocol Layer	The entity that forms the Messages used to communicate information between Port Partners.
Provider	A capability of a PD Port (typically a Host, Hub, or Wall Wart DFP) to source power over the power conductor (e.g. V_{BUS}). This corresponds to a USB Type-C Port with Rp asserted on its CC Wire.
Provider/Consumer	A Provider with the additional capability to act as a Consumer. This corresponds to a Dual-Role Power Port with Rp asserted on its CC Wire.
PS1, PS2	Classification of electrical power as defined in ***[IEC 62368-1].***
Rd	Pull-down resistor on the USB Type-C CC wire used to indicate that the Port is a Sink (see ***[USB Type-C 1.2]***).
Reattach	Attach of the Port Pair by a cable after a previous Detach.
Re-negotiation	A process wherein one of the Port Partners wants to alter the negotiated Contract.
Request Data Object (RDO)	Data Object used by a Sink Port to negotiate a Contact as a part of a ***Request*** Message.

Term	Description
Re-run	Start an Interruptible AMS again from the beginning after a Protocol Error.
Responder	The receiver of a Command request sent by an Initiator that replies with a Command response.
Rp	Pull-up resistor on the USB Type-C CC wire used to indicate that the Port is a Source (see ***[USB Type-C 1.2]***).
Safe Operation	Sources must have the ability to tolerate ***vSafe5V*** applied by both Port Partners.
Signaling	A Preamble followed by an ordered set of four K-codes used to indicate a particular line symbol e.g. ***Hard Reset*** as defined in Section 5.4.
Signaling Scheme	Physical mechanism used to transmit bits. Only the BMC Signaling Scheme is defined in this specification. Note: the BFSK Signaling Scheme supported in previous Revisions of this specification has been ***Deprecated***.
Single-Role Port	A Port that is a Port only capable of operating as a Source or Sink, but not both.
Sink	The Port consuming power from V_{BUS}; most commonly a Device.
Sink Directed Charge	A charging scheme whereby the Sink connects the Source to its battery through safety and other circuitry. Sink Directed Charge has two different modes of operation: • When the Current Foldback feature is not activated, the Sink controls the Source's output current by adjusting the Source's output voltage • When the Current Foldback feature is activated, the Source automatically controls its output current by adjusting its output voltage. The Sink is responsible for managing the current so as not to exceed the advertised capability of the Source and to protect itself from over-current events.
Soft Reset	A process that resets the PD communications engine to its default state.
SOP Communication	Communication using SOP Packets also implies that a Message sequence is being followed.
SOP Packet	Any Power Delivery Packet which starts with an ***SOP***.
SOP* Communication	Communication with a Cable Plug using SOP* Packets, also implies a Message sequence is being followed.
SOP* Packet	A term referring to any Power Delivery Packet starting with either ***SOP***, ***SOP'*** or ***SOP''***.
SOP' Communication	Communication with a Cable Plug using SOP' Packets, also implies that a Message sequence is being followed.
SOP' Packet	Any Power Delivery Packet which starts with an ***SOP'*** used to communicate with a Cable Plug.
SOP'' Communication	Communication with a Cable Plug using SOP'' Packets, also implies that a Message sequence is being followed.
SOP'' Packet	Any Power Delivery Packet which starts with an ***SOP''*** used to communicate with a Cable Plug when SOP' Packets are being used to communicate with the other Cable Plug.
Source	A role a Port is currently taking to supply power over V_{BUS}; most commonly a Host or Hub downstream port.
Standard ID (SID)	16-bit unsigned value assigned by the USB-IF to a given industry standard.
Standard or Vendor ID (SVID)	Generic term referring to either a VID or a SID. SVID is used in place of the phrase "Standard or Vendor ID".
Start of Packet (SOP)	K-code marker used to delineate the start of a packet. Three start of packet sequences are defined: ***SOP, SOP'*** and ***SOP''***, with ***SOP**** used to refer to all three in place of ***SOP***/***SOP'***/***SOP''.***
System Policy	Overall system policy generated by the system, broken up into the policies required by each Port Pair to affect the system policy. It is programmatically fed to the individual devices for consumption by their Policy Engines.
System Policy Manager (SPM)	Module running on the USB Host. It applies the System Policy through communication with PD capable Consumers and Providers that are also connected to the Host via USB.
Test Frame	Frame consisting of a Preamble, ***SOP****, followed by test data (See Section 5.9).
Test Pattern	Continuous stream of test data in a given sequence (See Section 5.9)
Tester	The Tester is assumed to be a piece of test equipment that manages the BIST testing process of a PD UUT.
Unexpected Message	Message that a Port supports but has been received in an incorrect state.

Term	Description
Unit Interval (UI)	The time to transmit a single data bit on the wire.
Unit Under Test (UUT)	The PD device that is being tested by the Tester and responds to the initiation of a particular BIST test sequence.
Unrecognized Message	Message that a Port does not understand e.g. a Message using a ReservedMessage type, a Message defined by a higher specification Revision than the Revision this Port supports, or an Unstructured Message for which the VID is not recognized.
Unsupported Message	Message that a Port recognizes but does not support. This is a Message defined by the specification but which is not supported by this Port.
Upstream Facing Port (UFP)	Indicates the Port's position in the USB topology typically a Port on a Device as defined in ***[USB Type-C 1.2]***. At connection the Port defaults to operation as a USB Device (when USB Communication is supported) and Sink.
USB Attached State	Synonymous with the ***[USB 2.0]***] and ***[USB 3.1]*** definition of the Attached state
USB Default Operation	Operation of a Port at Attach or after a Hard Reset where the DFP Source applies ***vSafe0V*** or ***vSafe5V*** on V_{BUS} and the UFP Sink is operating at ***vSafe5V*** as defined in ***[USB 2.0]***, ***[USB 3.1]***, ***[USB Type-C 1.2]*** or ***[USBBC 1.2]***.
USB Device	Either a hub or a peripheral device as defined in ***[USB 2.0]*** and ***[USB 3.1]***.
USB Host	The host computer system where the USB host controller is installed as defined in ***[USB 2.0]*** and ***[USB 3.1]***.
USB Powered State	Synonymous with the ***[USB 2.0]*** and ***[USB 3.1]*** definition of the powered state.
USB Safe State	State of the USB Type-C connector when there are pins to be re-purposed (see ***[USB Type-C 1.2]***) so they are not damaged by and do not cause damage to their Port Partner.
USB Type-A	Term used to refer to any A plug or receptacle including Micro-A plugs and Standard-A plugs and receptacles. Micro-AB receptacles are assumed to be a combination of USB Type-A and USB Type-B.
USB Type-B	Terms used to refer to any B-plug or receptacle including Micro-B plugs and Standard-B plugs and receptacles, including the PD and non-PD versions. Micro-AB receptacles are assumed to be a combination of USB Type-A and USB Type-B.
USB Type-C	Term used to refer to the USB Type-C connector plug or receptacle as defined in ***[USB Type-C 1.2]***.
USB-IF PD SID (PD SID)	Standard ID allocated to this specification by the USB Implementer's Forum.
Variable Supply	A very poorly regulated power supply that is not a Battery. This is exposed by the Variable Supply PDO (see Section 6.4.1.2.3).
VCONN Powered Accessory	An accessory that is powered from VCONN to operate in a Mode (see ***[USB Type-C 1.2]***).
VCONN Source	The USB Type-C Port responsible for sourcing VCONN.
VCONN Swap	Process of exchanging the VCONN Source between Port Partners.
VDM Header	The first Data Object following the Message Header in a Vendor Defined Message. The VDM Header contains the SVID relating to the VDM being sent and provides information relating to the Command in the case of a Structured VDM (see Section 6.4.4).
Vendor Data Object (VDO)	Data Object used to send Vendor specific information as part of a ***Vendor_Defined*** Message.
Vendor Defined Message (VDM)	PD Data Message defined for vendor/standards usage. These are further partitioned into Structured VDM Messages, where Commands are defined in this specification, and Unstructured VDM Messages which are entirely Vendor Defined (see Section 6.4.4).
Vendor ID (VID)	16-bit unsigned value assigned by the USB-IF to a given Vendor.
VI	Same as power (i.e. voltage * current = power)
Wall Wart	A power supply or "power brick" that is plugged into an AC outlet. It supplies DC power to power a device or charge a Battery.

1.7 Parameter Values

The parameters in this specification are expressed in terms of absolute values. For details of how each parameter is measured in compliance please see ***[USBPDCompliance]***.

1.8 Changes From Revision 2.0

This specification includes the following updates:

- PD Power rules (also applied to ***[USBPD 2.0]***).
- Mechanisms to avoid collisions and simplify communication.
- Support for ***[IEC 63002]*** included extended power supply capabilities and status.
- Battery capabilities and status.
- Ability to perform a fast power role swap.
- Support for ***[USBTypeCAuthentication 1.0]*** and ***[USBPDFirmwareUpdate 1.0]***.

The following have been ***Deprecated*** from this specification:

- The BFSK signaling scheme.
- Definitions of Standard/Micro A/B cables and connectors.
- Dead battery operation for A/B Ports.
- Profiles (replaced by PD Power Rules).

The following have been moved to other specifications:

- System Policy which is now defined in ***[USBTypeCBridge 1.0]***.

For more details see Section 2.3.1.

1.9 Compatibility with Revision 2.0

Revision 3.0 of the USB Power Delivery specification is designed to be fully interoperable with ***[USBPD 2.0]*** systems using BMC signaling over the ***[USB Type-C 1.2]*** connector and to be compatible with Revision 2.0 hardware.

Please see Section 2.3.2 for more details of the mechanisms defined to enable compatibility.

2. Overview

This section contains no ***Normative*** requirements.

2.1 Introduction

In USB Power Delivery, pairs of directly Attached ports negotiate voltage, current and/or direction of power flow over the USB cable, using the USB Type-C connector's CC wire as the communications channel. The mechanisms used, operate independently of other USB methods used to negotiate power.

USB Power Delivery also acts as a side-band channel enabling support for Standard or Vendor defined Modal Operation. Modes are associated with a Standard or Vendor ID (SVID). Power Delivery Structured VDM Messages can be used to discover supported SVIDs and Modes and then to enter and exit Modes as required. Multiple Active Modes can also be in operation at the same time.

Any Contract negotiated using this specification, supersedes any and all previous power contracts established whether from standard ***[USB 2.0]***, ***[USB 3.1]***, ***[USB Type-C 1.2]*** or ***[USBBC 1.2]*** mechanisms. While in Power Delivery Mode there will be a Contract in place (either Explicit or Implicit) determining the power level available and the direction of that power. The Port Pair remains in Power Delivery Mode until the Port Pair is Detached, there is a Hard Reset or the Source removes power (except during a Power Role Swap or Fast Role Swap when the initial Source removes power in order to for the new Source to apply power).

An Explicit Contract is negotiated by the process of the Source sending a set of Capabilities, from which the Sink is required to request a particular capability and then the Source accepting this request.

An Implicit Contract is the specified level of power allowed in particular states (i.e. during and after a Power Role Swap or Fast Role Swap). Implicit Contracts are temporary; Port Pairs are required to immediately negotiate an Explicit Contract.

Each Provider has a Local Policy, governing power allocation to its Ports. Sinks also have their own Local Policy governing how they draw power. A System Policy can be enacted over USB that allows modification to these local policies and hence management of overall power allocation in the system.

When PD Capable devices are Attached to each other, the DFPs and UFPs initially default to standard USB Default Operation. The DFP supplies ***vSafe5V*** and the UFP draws current in accordance with the rules defined by ***[USB 2.0]***, ***[USB 3.1]***, ***[USB Type-C 1.2]*** or ***[USBBC 1.2]*** specifications. After Power Delivery negotiation has taken place power can be supplied at higher, or lower, voltages and higher currents than defined in these specifications. It is also possible to perform a Power Role Swap or Fast Role Swap to exchange the power supply roles such that the DFP receives power and the UFP supplies power, to perform a Data Role Swap such that the DFP becomes the UFP and vice-versa and to perform a V_{CONN} Swap to change the end supplying V_{CONN} to the cable.

Prior to an Explicit Contract the Source can discover the capabilities of the Attached cable assembly. This is important for ***[USB Type-C 1.2]*** where 5A cabling is marked as well as other details of the cable assembly such as the supported speed. Cable discovery occurs on initial Attachment of a Port Pair, before an Explicit Contract has been established where the DFP is the Source. It is also possible to carry out cable discovery after a Power Role Swap or Fast Role Swap prior to establishing an Explicit Contract, where the UFP is the Source and an Implicit Contract is in place.

Once an Explicit Contract is in place only the DFP is permitted to communicate with the Attached cable assembly. This communication can consist of discovering capabilities but can also include discover of SVIDs, Modes and the entering/exiting of Modes supported by the cable assembly.

2.2 Section Overview

This specification contains the following sections:

Section 1	Introduction, conventions used in the document, list of terms and abbreviations, references and details of parameter usage.
Section 2	Overview of the document including a description of the operation of PD and the architecture.
Section 3	Mechanical and electrical characteristics of the cables and connectors used by PD. Section ***Deprecated***. See ***[USBPD 2.0]*** for legacy PD connector specification.
Section 4	Electrical requirements for Dead Battery operation and cable detection.
Section 5	Details of the PD PHY Layer requirements
Section 6	Protocol Layer requirements including the Messages, timers, counters and state operation.
Section 7	Power supply requirements for both Providers and Consumers.
Section 8	Device Policy Manager requirements. Policy Engine Message sequence diagrams and state diagrams
Section 9	USBPD Device requirements including mapping of V_{BUS} to USB states. System Policy Manager requirements including descriptors, events and requests.
Section 10	Rated Output Power definitions for PD.
Appendix A	Example CRC calculations.
Appendix B	Scenarios illustrating Device Policy Manager operation.
Appendix C	Examples of Structured VDM usage.

2.3 Revision 2.0 Changes and Compatibility

2.3.1 Changes From Revision 2.0

The following is a summary of the major changes between this specification (USB PD Revision 3.0) and *[USBPD 2.0]*:

- Support for both Revision 2.0 and Revision 3.0 operation mandated for products to ensure backwards compatibility with existing products (see Section 6.2.1.1.5).
- Profiles ***Deprecated*** and replaced with PD Power Rules (see Section 2.7.9).
  - Change also applied to *[USBPD 2.0]*.
- BFSK support ***Deprecated*** including legacy cables, legacy connectors, legacy dead battery operation and related test modes.
- Extended Messages with a data payload of up to 260 bytes defined (see Section 6.2.1.2):
  - Support for Chunking of Extended Messages to *[USBPD 2.0]* size mandated to enable compatibility with legacy PD hardware.
- Only the VCONN Source is allowed to communicate with the Cable Plugs (see Section 2.5.4).
- Source coordinated collision avoidance scheme to enable either the Source or Sink to initiate an Atomic Message Sequence (AMS):
  - *[USB Type-C 1.2]* Rp resistor values used by the Source to indicate when the Sink can/cannot initiate an AMS to either the Source or a Cable Plug (see Section 2.7.3).
  - Either the Source or Sink can initiate a Structured Vendor Defined AMS.
  - Either the Source or the Sink can communicate with the Cable Plugs provided they are sourcing VCONN.
- Limitations on timing for *Attention* Commands removed:
  - Fast Role Swap defined to enable externally powered docks and hubs to rapidly switch to bus power when their external power supply is removed (see Section 6.3.17).
- Additional status and discovery of:
  - Power Supply extended capabilities and status.
  - Battery capabilities and status.
  - Manufacturer defined information.
- Changes to fields in the Passive Cable, Active Cable and AMA VDOs indicated by a change in the Structured VDM Version to 2.0 (see Section 6.4.4.2).
- Support for USB Security related requests and responses (see *[USBTypeCAuthentication 1.0]*).
- Support for USB PD firmware update requests and responses (see *[USBPDFirmwareUpdate 1.0]*).
- System Policy now references *[USBTypeCBridge 1.0]*.

2.3.2 Compatibility with Revision 2.0

Revision 3.0 of the USB Power Delivery specification is designed to be fully interoperable with *[USBPD 2.0]* systems using BMC signaling over the *[USB Type-C 1.2]* connector and to be compatible with Revision 2.0 hardware.

This specification mandates that all Revision 3.0 systems fully support Revision 2.0 operation. They must discover the supported Revision used by their Port Partner and any connected Cable Plugs and revert to operation using the lowest common Revision number (see Section 6.2.1.1.5).

This specification defines Extended Messages containing data of up to 260 bytes (see Section 6.2.1.2). These Messages will be larger than expected by existing PHY HW. To accommodate Revision 2.0 based systems a Chunking mechanism is mandated such that Messages are limited to Revision 2.0 sizes unless it is discovered that both systems support the longer Message lengths.

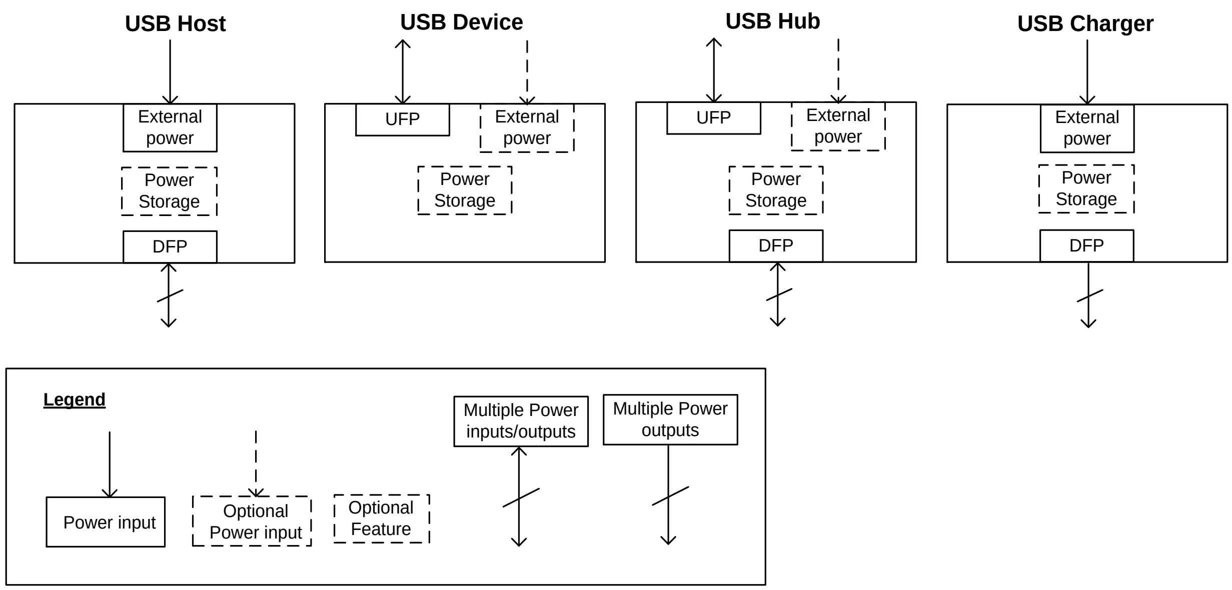
This specification includes changes to the Vendor Defined Objects (VDO) used in the discovery of passive/active marked cables and Alternate Mode Adapters (AMA) (see Section 6.4.4.2). To enable systems to determine which VDO format is being used the Structured Vendor Defined Message (SVDM) version number has been incremented to 2.0.

Version numbers have also been incorporated into the VDOs themselves to facilitate future changes if these become necessary.

2.4 USB Power Delivery Capable Devices

Some examples of USB Power Delivery capable devices can be seen in Figure 2-1 (a Host, a Device, a Hub, and a Charger). These are given for reference only and do not limit the possible configurations of products that can be built using this specification.

Figure 2-1 Logical Structure of USB Power Delivery Capable Devices



Each USB Power Delivery capable device is assumed to be made up of at least one Port. Providers are assumed to have a Source and Consumers a Sink. Each device contains one, or more, of the following components:

- UFPs that:
  - Sink power.
  - ***Optionally*** source power (a Dual-Role Power Device).
  - ***Optionally*** communicate via USB.
  - Communicate using SOP Packets.
  - ***Optionally*** Communicate using SOP* Packets.
- DFPs that:
  - Source power.
  - ***Optionally*** Sink power (a Dual-Role Power Device).
  - ***Optionally*** communicate via USB.
  - Communicate using SOP Packets.
  - ***Optionally*** Communicate using SOP* Packets.
- A Source that can be:
  - An external power source e.g. AC.
  - Power Storage (e.g. Battery).
  - Derived from another Port (e.g. bus-powered Hub).

- A Sink that can be:
  - Power Storage (e.g. a Battery).
  - Used to power internal functions.
  - Used to power devices Attached to other devices (e.g. a bus-powered Hub).
- A Vconn Source that:
  - Can be either Port Partner, either the DFP/UFP or Source/Sink.
  - Powers the Cable Plug(s).
  - Is the only Port allowed to talk to the Cable Plug(s) at any given time.

2.5 SOP* Communication

2.5.1 Introduction

The Start of Packet (or SOP) is used as an addressing scheme to identify whether the Communications were intended for one of the Port Partners (SOP Communication) or one of the Cable Plugs (SOP'/SOP'' Communication). SOP/SOP' and SOP'' are collectively referred to as SOP*. The term Cable Plug in the SOP'/SOP'' Communication case is used to represent a logical entity in the cable which is capable of PD Communication and which might or might not be physically located in the plug.

The following sections describe how this addressing scheme operates for Port to Port and Port to Cable Plug Communication.

2.5.2 SOP* Collision Avoidance

For all SOP* the Source co-ordinates communication in order to avoid bus collisions by allowing the Sink to initiate messaging when it does not need to communicate itself. Once an Explicit Contract is in place the Source indicates to the Sink that it can initiate a message sequence. This sequence can be communication with the Source or with one of the Cable Plugs. As soon as the Source itself needs to initiate a message sequence this will be indicated to the Sink. The Source then waits for any outstanding Sink SOP* Communication to complete before initiating a message sequence itself.

2.5.3 SOP Communication

SOP Communication is used for Port to Port communication between the Source and the Sink. SOP Communication is recognized by both Port Partners but not by any intervening Cable Plugs. SOP Communication takes priority over other SOP* Communications since it is critical to complete power related operations as soon as possible. Message sequences relating to power are also allowed to interrupt other sequences to ensure that negotiation and control of power is given priority on the bus.

2.5.4 SOP'/SOP'' Communication with Cable Plugs

SOP' Communication is recognized by electronics in one Cable Plug which is the Cable Plug that detected VCONN at Attach (see ***[USB Type-C 1.2]***). SOP'' Communication can also be supported when SOP' Communication is also supported. SOP'' Communication is recognized by the electronics in the Cable Plug that did not detect VCONN at Attach.

The Vconn Source is the DFP/Source at Attach although all of these roles can later be swapped using PD messaging.

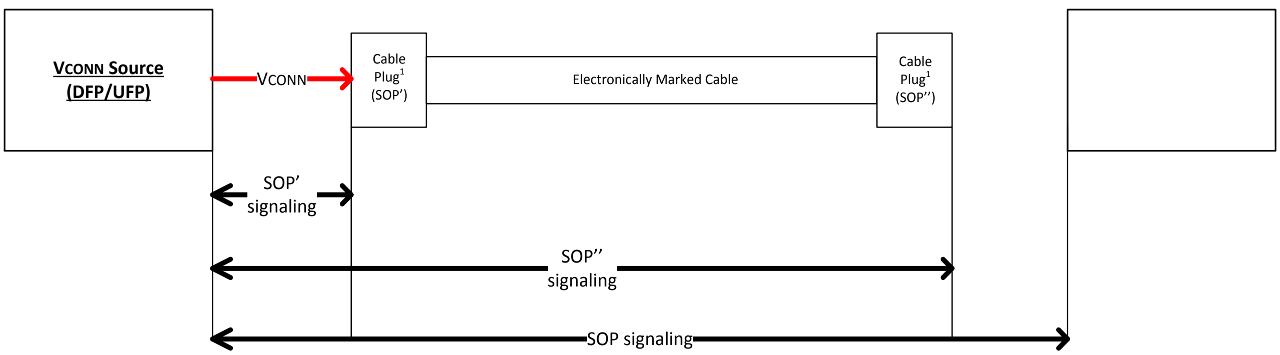
SOP Communication between the Port Partners is not recognized by the Cable Plug. Figure 2-2 outlines the usage of SOP* Communications between a VCONN Source (DFP/UFP) and the Cable Plugs.

All SOP* Communications take place over a single wire (CC). This means that the SOP* Communication periods must be coordinated to prevent important communication from being blocked. For a product which does not recognize SOP/SOP' or SOP'' Packets, this will look like a non-idle channel, leading to missed packets and retries. Communications between the Port Partners take precedence meaning that communications with the Cable Plug can be interrupted, but will not lead to a Soft or Hard Reset.

When no Contract or an Implicit Contract is in place (e.g. after a Power Role Swap or Fast Role Swap) the Source (which can be either the DFP or UFP but must also be the VCONN Source) can communicate with a Cable Plug using SOP' Packets in order to discover its characteristics (see Figure 2-2). During this phase all communication with the Cable Plug is initiated and controlled by the Source which acts to prevent conflicts between SOP* Packets. The Sink does not communicate with the Cable Plug, even if it is the DFP, and ***Discards*** any SOP' Packets received.

When an Explicit Contract is in place the VCONN Source (either the DFP or the UFP) can communicate with the Cable Plug(s) using SOP'/SOP'' Packets (see Figure 2-2). During this phase all communication with the Cable Plug is initiated and controlled by the VCONN Source which acts to prevent conflicts between SOP* Packets. The Port that is not the VCONN Source does not communicate with the Cable Plug and does not recognize any SOP'/SOP'' Packets received. Only the DFP, when acting as a VCONN Source, is allowed to send SOP* in order to control the entry and exiting of Modes and to manage Modal Operation.

Figure 2-2 Example SOP' Communication between VCONN Source and Cable Plug(s)



1 Cable Plug can be physically Attached to either the DFP or UFP.

2.6 Operational Overview

A USB Power Delivery Port supplying power is known as a Source and a Port consuming power is known as a Sink. There is only one Source Port and one Sink Port in each PD connection between Port Partners. At Attach the Source Port (the Port with Rp asserted see ***[USB Type-C 1.2]***) is also the DFP and VCONN Source. At Attach the Sink Port (the Port with Rd asserted) is also the UFP and is not the VCONN Source.

The Source/Sink roles, DFP/UFP roles and VCONN Source role can all subsequently be swapped orthogonally to each other. A Port that supports both Source and Sink roles is called a Dual-Role Power Port (DRP). A Port that supports both DFP and UFP roles is called a Dual-Role Data Port (DRD).

When USB Communications Capability is supported in the DFP role then the Port will also be able to act as a USB Host. Similarly when USB Communications Capability is supported in the UFP role then the Port will also be able to act as a USB Device.

The following sections describe the high level operation of ports taking on the roles of DFP, UFP, Source and Sink. These sections do not describe operation that is not allowed; however if a certain behavior is not described then it is probably not supported by this specification.

For details of how PD maps to USB states in a PDUSB Device see Section 9.1.2.

2.6.1 Source Operation

The Source operates differently depending on Attachment status:

- At Attach (no PD Connection or Contract):
  - For a Source-only Port the Source detects Sink Attachment.
  - For a DRP that toggles the Port becomes a Source Port on Attachment of a Sink
  - The Source then typically sets V_{BUS} to ***vSafe5V***.
- Before PD Connection (no PD Connection or PD Contract):
  - Prior to sending ***Source_Capabilities*** Messages the Source can detect the type of cabling Attached and can alter its advertised capabilities depending on the type of cable detected:
    - The Source attempts to communicate with one of the Cable Plugs using SOP' Packets. If the Cable Plug responds then communication takes place.
    - The default capability of a USB Type-C cable is 3A, but SOP' Communication is used to discover other capabilities of the cable.
  - The Source periodically advertises its capabilities by sending ***Source_Capabilities*** Messages every ***tTypeCSendSourceCap.***
- Establishing PD Connection (no PD Connection or Contract):
  - Presence of a PD Capable Port Partner is detected either:
    - By receiving a ***GoodCRC*** Message in response to a ***Source_Capabilities*** Message.
    - By receiving ***Hard Reset*** Signaling.
- Establishing Explicit Contract (PD Connection but no Explicit Contract or Implicit Contract after a Power Role Swap or Fast Role Swap):
  - The Source receives a ***Request*** Message from the Sink and responds with an ***Accept*** Message, if this is a ***Valid*** request, followed by a ***PS_RDY*** Message when its power supply is ready to source power at the agreed level. At this point an Explicit Contract has been agreed.
  - A DFP does not generate SOP' or SOP'' Packets, is not required to detect SOP' or SOP'' Packets and ***Discards*** them.
- During PD Connection (Explicit Contract - ***PE_SRC_Ready*** State):
  - The Source processes and responds (if a response is required) to all Messages received and sends appropriate Messages whenever its Local Policy requires:
    - The Source informs the Sink whenever its capabilities change, by sending a ***Source_Capabilities*** Message.
    - The Source will always have Rp asserted on its CC wire.

        - When this Port is a DRP the Source can initiate or receive a request for the exchange of power roles. After the Power Role Swap this Port will be a Sink and an Implicit Contract will be in place until an Explicit Contract is negotiated immediately afterwards.
        - When this Port is a DRD the Source can initiate or receive a request for an exchange of data roles. After a Data Role Swap the DFP (Host) becomes a UFP (Device). The Port remains a Source and the VCONN Source role (or not) remains unchanged.
        - The Source can initiate or receive a request for an exchange of VCONN Source. During a VCONN Swap VCONN is applied by both ends (make before break). The Port remains a Source and DFP/UFP roles remain unchanged.
    - The Source when it is the VCONN Source can communicate with a Cable Plug using SOP' or SOP'' Communication at any time it is not engaged in any other SOP Communications:
        - If SOP Packets are received by the Source, during SOP' or SOP'' Communication, the SOP' or SOP'' Communication is immediately terminated (the Cable Plug times out and does not retry)
        - If the Source needs to initiate an SOP Communication during an ongoing SOP' or SOP'' Communication (e.g. for a Capabilities change) then the SOP' or SOP'' Communications will be interrupted.
    - When the Source Port is also a DFP:
        - The Source can control the entry and exiting of modes in the Cable Plug(s) and control Modal Operation.
        - The Source can initiate Unstructured or Structured VDMs.
        - The Source can control the entry and exiting of modes in the Sink and control Modal Operation using Structured VDMs.
    - When the Source Port is part of a multi-port system:
        - Will issue GotoMin requests when the Power Reserve is needed.
- Detach or Communications Failure:
    - A Source detects plug Detach and takes V_{BUS} down to ***vSafe5V*** within ***tSafe5V*** and ***vSafe0V*** within ***tSafe0V*** (i.e. using USB Type-C Detach detection via CC).
    - When the Source detects the failure to receive a ***GoodCRC*** Message in response to a Message within ***tReceive:***
        - Leads to a Soft Reset, within ***tSoftReset*** of the ***CRCReceiveTimer*** expiring.
        - If the soft reset process cannot be completed a Hard Reset will be issued within ***tHardReset*** of the ***CRCReceiveTimer*** to restore V_{BUS} to USB Default Operation within ~1-1.5s:
            - When the Source is also the VCONN Source, VCONN will also be power cycled during the Hard Reset.
    - Receiving no response to further attempts at communication is interpreted by the Source as an error (see Error handling).
    - Errors during power transitions will automatically lead to a Hard Reset in order to restore power to default levels.
- Error handling:
    - Protocol Errors are handled by a ***Soft_Reset*** Message issued by either Port Partner, that resets counters, timers and states, but does not change the negotiated voltage and current or the Port's role (e.g. Source, DFP/UFP, VCONN Source) and does not cause an exit from Modal Operation.
    - Serious errors are handled by ***Hard Reset*** Signaling issued by either Port Partner. A Hard Reset:
        - Resets protocol as for a Soft Reset but also returns the power supply to USB Default Operation (***vSafe0V*** or ***vSafe5V*** output) in order to protect the Sink.
        - Restores the Port's data role to DFP.
        - When the Sink is the VCONN Source it removes VCONN then the Source Port is restored as the VCONN Source.
        - Causes all Active Modes to be exited such that the Source is no longer in Modal Operation.
    - After a Hard Reset it is expected that the Port Partner will respond within ***tNoResponse***. If this does not occur then ***nHardResetCount*** further Hard Resets are carried out before the Source performs additional Error Recovery steps, as defined in ***[USB Type-C 1.2]*** , by entering the ***ErrorRecovery*** state.

2.6.2 Sink Operation

- At Attach (no PD Connection or Contract):
  - Sink detects Source Attachment through the presence of ***vSafe5V***.
  - For a DRP that toggles the Port becomes a Sink Port on Attachment of a Source.
  - Once the Sink detects the presence of ***vSafe5V*** on V_{BUS} it waits for a ***Source_Capabilities*** Message indicating the presence of a PD capable Source.
  - If the Sink does not receive a ***Source_Capabilities*** Message within ***tTypeCSinkWaitCap*** then it issues ***Hard Reset*** Signaling in order to cause the Source Port to send a ***Source_Capabilities*** Message if the Source Port is PD capable.
  - The Sink does not generate SOP' or SOP'' Packets, is not required to detect SOP' or SOP'' Packets and does not recognize them.
- Establishing PD Connection (no PD Connection or Contract):
  - The Sink receives a ***Source_Capabilities*** Message and responds with a ***GoodCRC*** Message.
  - The Sink does not generate SOP' or SOP'' Packets, is not required to detect SOP' or SOP'' Packets and ***Discards*** them.
- Establishing Explicit Contract (PD Connection but no Explicit Contract or Implicit Contract after a Power Role Swap or Fast Role Swap):
  - The Sink receives a ***Source_Capabilities*** Message from the Source and responds with a ***Request*** Message. If this is a ***Valid*** request the Sink receives an ***Accept*** Message followed by a ***PS_RDY*** Message when the Source's power supply is ready to source power at the agreed level. At this point the Source and Sink have entered into an Explicit Contract:
    - The Sink Port may request one of the capabilities offered by the Source, even if this is the ***vSafe5V*** output offered by ***[USB 2.0]***, ***[USB 3.1]***, ***[USB Type-C 1.2]*** or ***[USBBC 1.2]***, in order to enable future power negotiation:
      - A Sink not requesting any capability with a ***Request*** Message results in an error.
    - A Sink unable to fully operate at the offered capabilities requests the default capability but indicates that it would prefer another power level and provide a physical indication of the failure to the end user (e.g. using an LED).
    - A Sink does not generate SOP' or SOP'' Packets, is not required to detect SOP' or SOP'' Packets and ***Discards*** them.
- During PD Connection (Explicit Contract – ***PE_SNK_Ready*** state):
  - The Sink processes and responds (if a response is required) to all Messages received and sends appropriate Messages whenever its Local Policy requires.
  - A Sink whose power needs have changed indicates this to the Source with a new ***Request*** Message. The Sink Port can request one of the capabilities previously offered by the Source, even if this is the ***vSafe5V*** output offered by ***[USB 2.0]***, ***[USB 3.1]***, ***[USB Type-C 1.2]*** or ***[USBBC 1.2]***, in order to enable future power negotiation:
    - Not requesting any capability with a ***Request*** Message results in an error.
    - A Sink unable to fully operate at the offered capabilities requests an offered capability but indicates a capability mismatch i.e. that it would prefer another power level also providing a physical indication of the failure to the End User (e.g. using an LED).
  - The Sink will always have Rd asserted on its CC wire.
  - When this Port is a DRP the Sink can initiate or receive a request for the exchange of power roles. After the Power Role Swap this Port will be a Source and an Implicit Contract will be in place until an Explicit Contract is negotiated immediately afterwards.
  - When this Port is a DRD the Sink can initiate or receive a request for an exchange of data roles. After a Data Role Swap the DFP (Host) becomes a UFP (Device). The Port remains a Sink and VCONN Source role (or not) remains unchanged.
  - The Sink can initiate or receive a request for an exchange of VCONN Source. During a VCONN Swap VCONN is applied by both ends (make before break). The Port remains a Sink and DFP/UFP roles remain unchanged.

- The Sink when it is the VCONN Source can communicate with a Cable Plug using SOP' or SOP'' Communication at any time it is not engaged in any other SOP Communications:
  - If SOP Packets are received by the Sink, during SOP' or SOP'' Communication, the SOP' or SOP'' Communication is immediately terminated (the Cable Plug times out and does not retry)
  - If the Sink needs to initiate an SOP Communication during an ongoing SOP' or SOP'' Communication (e.g. for a Capabilities change) then the SOP' or SOP'' Communications will be interrupted.
  - When the Sink Port is also a DFP the Sink can control the entry and exiting of modes in the Cable Plug(s) and control Modal Operation.
- When the Sink Port is also a DFP:
  - The Sink can initiate Unstructured or Structured VDMs.
  - The Sink can control the entry and exiting of modes in the Source and control Modal Operation using Structured VDMs.

- Detach or Communications Failure:
  - A Sink detects the removal of V_{BUS} and interprets this as the end of the PD Connection:
    - This is unless the ***vSafe0V*** is due to either a Hard Rest, Power Role Swap or Fast Role Swap.
  - A Sink detects plug removal and discharges V_{BUS}.
  - When the Sink detects the failure to receive a ***GoodCRC*** Message in response to a Message within ***tReceive:***
    - Leads to a Soft Reset, within ***tSoftReset*** of the ***CRCReceiveTimer*** expiring.
    - If the soft reset process cannot be completed a Hard Reset will be issued within ***tHardReset*** of the ***CRCReceiveTimer*** to restore V_{BUS} to USB Default Operation within ~1-1.5s.
    - Receiving no response to further attempts at communication is interpreted by the Sink as an error (see Error handling).
  - Errors during power transitions will automatically lead to a Hard Reset in order to restore power to default levels.
- Error handling:
  - Protocol Errors are handled by a ***Soft_Reset*** Message issued by either Port Partner, that resets counters, timers and states, but does not change the negotiated voltage and current or the Port's role (e.g. Sink, DFP/UFP, VCONN Source) and does not cause an exit from Modal Operation.
  - Serious errors are handled by ***Hard Reset*** Signaling issued by either Port Partner. A Hard Reset:
    - resets protocol as for a Soft Reset but also returns the power supply to USB Default Operation (***vSafe0V*** or ***vSafe5V*** output) in order to protect the Sink.
    - restores the Port's data role to UFP.
    - when the Sink is the VCONN Source it removes VCONN then the Source Port is restored as the VCONN Source.
    - causes all Active Modes to be exited such that the Source is no longer in Modal Operation.
- After a Hard Reset it is expected that the Port Partner will respond within ***tTypeCSinkWaitCap***. If this does not occur then 2 further Hard Resets are carried out before the UFP stays in the ***PE_SNK_Wait_for_Capabilities*** state.

2.6.3 Cable Plugs

- Cable Plugs are powered when Vconn is present but are not aware of the status of the Contract.
- Cable Plugs do not initiate message sequences and only respond to messages sent to them.
- Detach or Communications Failure:
  - Communications can be interrupted at any time.
  - There is no communication timeout scheme between the DFP/UFP and Cable Plug.
  - The Cable Plug is ready to respond to potentially repeated requests.
- Error handling:
  - The Cable Plug detects Hard Reset Signaling to determine that the Source and Sink have been reset and will need to reset itself (equivalent to a power cycle).
    - The Cable Plug cannot generate Hard Reset Signaling itself.

        - The Hard Reset process power cycles both VBUS and Vconn so this is expected to reset the Cable Plugs by itself.
    - A Cable Plug detects Cable Reset Signaling to determine that it will need to reset itself (equivalent to a power cycle).

2.7 Architectural Overview

This logical architecture is not intended to be taken as an implementation architecture. An implementation architecture is, by definition, a part of product definition and is therefore outside of the scope of this specification.

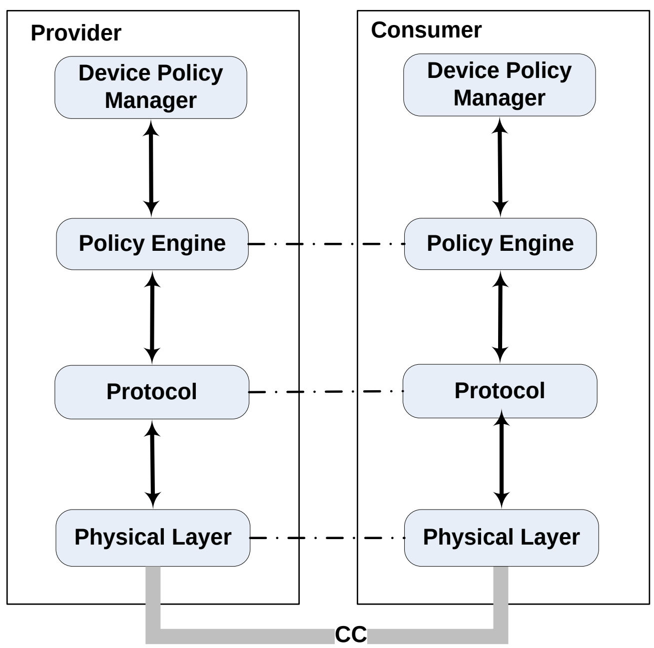
This section outlines the high level logical architecture of USB Power Delivery referenced throughout this specification. In practice various implementation options are possible based on many different possible types of PD device. PD devices can have many different configurations e.g. USB or non-USB communication, single versus multiple ports, dedicated power supplies versus supplies shared on multiple ports, hardware versus software based implementations etc. The architecture outlined in this section is therefore provided only for reference in order to indicate the high level logical model used by the PD specification. This architecture is used to identify the key concepts and also to indicate logical blocks and possible links between them.

The USB Power Delivery architecture in each USB Power Delivery capable Device is made up of a number of major components.

The communications stack seen in Figure 2-3 consists of:

- A **Device Policy Manager** (see Section 8.2) that exists in all devices and manages USB Power Delivery resources within the device across one or more ports based on the Device's Local Policy.
- A **Policy Engine** (see Section 8.3) that exists in each USB Power Delivery Port implements the Local Policy for that Port.
- A **Protocol Layer** (see Chapter 6) that enables Messages to be exchanged between a Source Port and a Sink Port.
- A **Physical Layer** (see Chapter 5) that handles transmission and reception of bits on the wire and handles data transmission.

Figure 2-3 USB Power Delivery Communications Stack



Additionally USB Power Delivery devices which can operate as USB devices can communicate over USB (see Figure 2-4). An ***Optional*** **System Policy Manager** (see Chapter 9) that resides in the USB Host communicates with the PD Device over USB, via the root Port and potentially over a tree of USB Hubs. The **Device Policy Manager** interacts with the USB interface in each device in order to provide and update PD related information in the USB domain. Note that a PD device is not required to have a USB device interface.

Figure 2-4 USB Power Delivery Communication Over USB

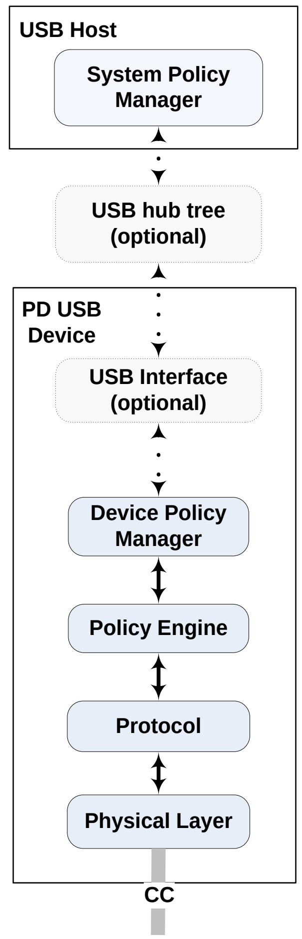


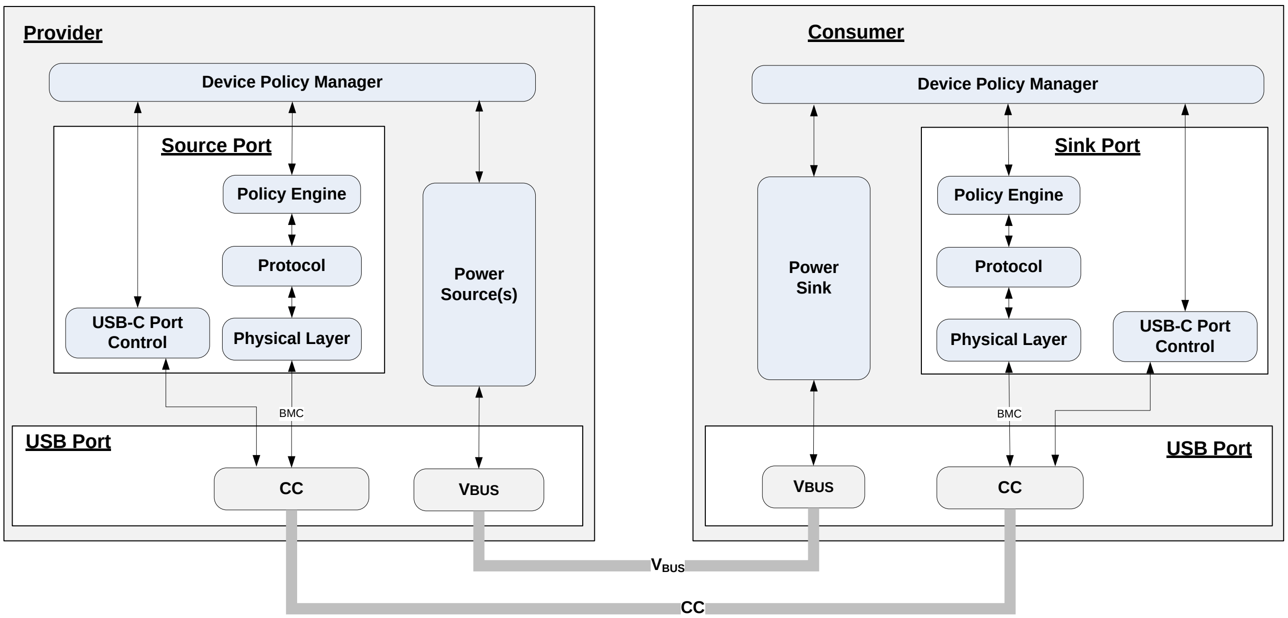
Figure 2-5 shows the logical blocks between two Attached PD ports. In addition to the communication stack described above there are also:

- For a Provider or Dual-Role Power Device: one or more **Sources** providing power to one or more ports.
- For a Consumer or Dual-Role Power Device: a **Sink** consuming power.
- A **USB-C Port Control** module (see Section4.4) that detects cable Attach/Detach as defined in ***[USB Type-C 1.2]***.
- USB Power Delivery uses standard cabling as defined in ***[USB Type-C 1.2]***.

The **Device Policy Manager** talks to the communication stack, Source/Sink and the USB-C Port Control block in order to manage the resources in the Provider or Consumer.

Figure 2-5 illustrates a Provider and a Consumer. Dual-Role Power Devices can be constructed by combining the elements of both Provider and Consumer into a single device. Providers can also contain multiple Source Ports each with their own communications stack and USB-C Port Control.

Figure 2-5 High Level Architecture View



2.7.1 Policy

There are two possible levels of Policy:

1) System Policy applied system wide by the System Policy Manager across multiple Providers or Consumers.
2) Local Policy enforced on a Provider or Consumer by the Device Policy Manager.

Policy comprises several logical blocks:

- System Policy Manager (system wide).
- Device Policy Manager (one per Provider or Consumer).
- Policy Engine (one per Source or Sink Port).

2.7.1.1 System Policy Manager

Since the USB Power Delivery protocol is essentially point to point, implementation of a System Policy requires communication by an additional data communication mechanism i.e. USB. The System Policy Manager monitors and controls System Policy between various Providers and Consumers connected via USB. The System Policy Manager resides in the USB Host and communicates via USB with the Device Policy Manager in each connected Device. Devices without USB data communication capability or are not data connected, will not be able to participate in System Policy.

The System Policy Manager is ***Optional*** in any given system so USB Power Delivery Providers and Consumers can operate without it being present. This includes systems where the USB Host does not provide a System Policy Manager and can also include “headless” systems without any USB Host. In those cases where a Host is not present, USB Power Delivery is useful for charging purposes, or the powering of devices since useful USB functionality is not possible. Where there is a USB Host but no System Policy Manager, Providers and Consumers can negotiate power between themselves, independently of USB power rules, but are more limited in terms of the options available for managing power.

2.7.1.2 Device Policy Manager

The Device Policy Manager provides mechanisms to monitor and control the USB Power Delivery system within a particular Consumer or Provider. The Device Policy Manager enables Local Policies to be enforced across the system by communication with the System Policy Manager. Local Policies are enacted on a per Port basis by the Device Policy Manager's control of the Source/Sink Ports and by communication with the Policy Engine and USB-C Port Control for that Port.

2.7.1.3 Policy Engine

Providers and Consumers are free to implement their own Local Policies on their directly connected Source or Sink Ports. These will be supported by negotiation and status mechanisms implemented by the Policy Engine for that Port. The Policy Engine interacts directly with the Device Policy Manager in order to determine the present Local Policy to be enforced. The Policy Engine will also be informed by the Device Policy Manager whenever there is a change in Local Policy (e.g. a capabilities change).

2.7.2 Message Formation and Transmission

2.7.2.1 Protocol Layer

The Protocol Layer forms the Messages used to communicate information between a pair of ports. It is responsible for forming Capabilities Messages, requests and acknowledgements. Additionally it forms Messages used to swap roles and maintain presence. It receives inputs from the Policy Engine indicating which Messages to send and indicates the responses back to the Policy Engine.

The basic protocol uses a push model where the Provider pushes it capabilities to the Consumer that in turn responds with a request based on the offering. However, the Consumer can asynchronously request the Provider's present capabilities and can select another voltage/current.

Extended Messages of up to a Data Size of ***MaxExtendedMsgLen*** can be sent and received provided the Protocol Layer determines that both Port Partners support this capability. When one of both Port Partners do not support Extended Messages of Data Size greater than ***MaxExtendedMsgLegacyLen*** then the Protocol Layer supports a Chunking mechanism to break larger Messages into smaller Chunks of size ***MaxExtendedMsgChunkLen***.

2.7.2.2 PHY Layer

The PHY Layer is responsible for sending and receiving Messages across the USB Type-C CC wire and for managing data. It tries to avoid collisions on the wire, recovering from them when they occur. It also detects errors in the Messages using a CRC.

2.7.3 Collision Avoidance

2.7.3.1 Policy Engine

The Policy Engine in a Source will indicate to the Protocol Layer the start and end of each Atomic Message Sequence (AMS) that the Source initiates. The Policy Engine in a Sink will indicate to the Protocol Layer the start of each AMS the Sink initiates. This enables co-ordination of AMS initiation between the Port Partners.

2.7.3.2 Protocol Layer

The Protocol Layer in the Source will request the PHY to set the Rp value to ***SinkTxOk*** to indicate that the Sink can initiate an AMS by sending the first Message in the sequence. The Protocol Layer in the Source will request the PHY to set the Rp value to ***SinkTxNG*** to indicate that the Sink cannot initiate an AMS since the Source is about to initiate an AMS.

The Protocol Layer in the Sink, when the Policy Engine indicates that an AMS is being initiated, will wait for the Rp value to be set to ***SinkTxOk*** before initiating the AMS by sending the first Message in the sequence.

2.7.3.3 PHY Layer

The PHY Layer in the Source will set the Rp value to either ***SinkTxOk*** or ***SinkTxNG*** as directed by the Protocol Layer. The PHY Layer in the Sink will detect the present Rp value and inform the Protocol Layer.

2.7.4 Power supply

2.7.4.1 Source

Each Provider will contain one or more Sources that are shared between one or more ports. These Sources are controlled by the Local Policy. Sources start up in USB Default Operation where the Port applies ***vSafe0V*** or ***vSafe5V*** on V_{BUS} and return to this state on Detach or after a Hard Reset. If the Source applies ***vSafe0V*** as their default, it detects Attach events and transitions its output to ***vSafe5V*** upon detecting an Attach.

2.7.4.2 Sink

Consumers are assumed to have one Sink connected to a Port. This Sink is controlled by Local Policy. Sinks start up in USB Default Operation where the Port can operate at ***vSafe5V*** with USB default specified current levels and return to this state on Detach or after a Hard Reset.

2.7.4.3 Dual-Role Power Ports

Dual-Role Power Ports have the ability to operate as either a Source or a Sink and to swap between the two roles using Power Role Swap or Fast Role Swap.

2.7.4.4 Dead Battery or Lost Power Detection

[USB Type-C 1.2] defines mechanisms intended to communicate with and charge a Sink or DRP with a Dead Battery.

2.7.5 DFP/UFP

2.7.5.1 Downstream Facing Port (DFP)

The Downstream Facing Port or DFP is equivalent in the USB topology to the USB A-Port. The DFP will also correspond to the USB Host but only if USB Communication is supported while acting as a DFP. Products such as Wall Warts can be a DFP while not having USB Communication capability. The DFP also acts as the bus master when controlling alternate mode operation.

2.7.5.2 Upstream Facing Port (UFP)

The Upstream Facing Port or UFP is equivalent in the USB topology to the USB B-Port. The UFP will also correspond to the USB Device but only if USB Communication is supported while acting as a UFP. Products which charge can be a UFP while not having USB Communication capability.

2.7.5.3 Dual-Role Data Ports

Dual-Role Data Ports have the ability to operate as either a DFP or a UFP and to swap between the two roles using Data Role Swap. Note that products can be Dual-Role Data Ports without being Dual-Role Power ports i.e. they can switch logically between DFP and UFP roles even if they are Source-only or Sink-only Ports.

2.7.6 VCONN Source

One Port, initially the Source Port, is the VCONN Source. The Cable Plugs use this supply to determine which Cable Plug is SOP'. The responsibility for sourcing VCONN can be swapped between the Source and Sink Ports in a make before break fashion to ensure that the Cable Plugs continue to be powered. To ensure reliable communication with the Cable Plugs only the VCONN Source is permitted to communicate with the Cable Plugs. Prior to a Power Role Swap, Data Role Swap or Fast Role Swap each Port needs to ensure that it is the VCONN Source if it needs to communicate with the Cable Plugs after the swap.

2.7.7 Cable and Connectors

2.7.7.1 USB-C Port Control

The USB-C Port Control block provides mechanisms to inform the Device Policy Manager of cable Attach/Detach events.

The USB Power Delivery specification assumes certified USB cables and associated detection mechanisms as defined in the ***[USB Type-C 1.2]*** specification.

2.7.8 Interactions between Non-PD, BC and PD devices

USB Power Delivery only operates when two USB Power Delivery devices are directly connected. When a Device finds itself a mixed environment, where the other device does not support the USB Power Delivery Specification, the existing rules on supplying ***vSafe5V*** as defined in the ***[USB 2.0]***, ***[USB 3.1]***, ***[USBBC 1.2]*** or ***[USB Type-C 1.2]*** specifications are applied.

There are two primary cases to consider:

- The Host (DFP/Source) is non-PD and as such will not send any advertisements. An Attached PD capable Device will not see any advertisements and operates using the rules defined in the ***[USB 2.0]***, ***[USB 3.1]***, ***[USBBC 1.2]*** or ***[USB Type-C 1.2]*** specifications.
- The Device (UFP/Sink) is non-PD and as such will not see any advertisements and therefore will not respond. The Host (DFP/Source) will continue to supply ***vSafe5V*** to V_{BUS} as specified in the ***[USB 2.0]***, ***[USB 3.1]***, ***[USBBC 1.2]*** or ***[USB Type-C 1.2]*** specifications.

2.7.9 Power Rules

Power Rules define voltages and current ranges that are offered by USB Power Delivery Sources and used by a USB Power Delivery Sink for a given value of PD Power. See Section 10 for further details.

3. USB Type-A and USB Type-B Cable Assemblies and Connectors

This section has been ***Deprecated***. Please refer to ***[USBPD 2.0]*** for details of cables and connectors used in scenarios utilizing the BFSK Signaling scheme in conjunction with USB Type-A or USB Type-B connectors.

4. Electrical Requirements

This chapter covers the platform's electrical requirements for implementing USB Power Delivery.

4.1 Interoperability with other USB Specifications

USB Power Delivery ***May*** be implemented alongside the ***[USB 2.0]***, ***[USB 3.1]***, ***[USBBC 1.2]*** and ***[USB Type-C 1.2]*** specifications. In the case where a Device requests power via the Battery Charging Specification and then the USB Power Delivery Specification, it ***Shall*** follow the USB Power Delivery Specification until the Port Pair is Detached or there is a Hard Reset. If the USB Power Delivery connection is lost, the Port ***Shall*** return to its default state, see Section 6.8.2.

4.2 Dead Battery Detection / Unpowered Port Detection

Dead Battery/Unpowered operation is when a USB Device needs to provide power to a USB Host under the circumstances where the USB Host:

- Has a Dead Battery that requires charging or
- Has lost its power source or
- Does not have a power source or
- Does not want to provide power.

Dead Battery charging operation for connections between USB Type-C connectors is defined in ***[USB Type-C 1.2]***.

4.3 Cable IR Ground Drop (IR Drop)

Every PD Sink Port capable of USB communications can be susceptible to unreliable USB communication if the voltage drop across ground falls outside of the acceptable common mode range for the USB Hi-Speed transceivers data lines due to excessive current draw. Certified USB cabling is specified such that such errors don't typically occur (See ***[USB Type-C 1.2]***).

4.4 Cable Type Detection

Standard USB Type-C cable assemblies are rated for PD voltages higher than ***vSafe5V*** and current levels of at least 3A (See ***[USB Type-C 1.2]***). The Source ***Shall*** limit maximum capabilities it offers so as not to exceed the capabilities of the type of cabling detected.

Sources ***Shall*** detect the type of Attached cable and limit the Capabilities they offer based on the current carrying capability of the cable determined by the Cable capabilities determined using the ***Discover Identity*** Command (see Section 6.4.4.2) sent using SOP' Communication (see Section 2.5) to the Cable Plug. The Cable VDO returned as part of the ***Discover Identity*** Command details the maximum current and voltage values that ***Shall*** be negotiated for a given cable as part of an Explicit Contract.

The cable detection process is usually run when the Source is powered up, after a Power Role Swap or Fast Role Swap or when power is applied to a Sink. The exact method used to detect these events is up to the manufacturer and ***Shall*** meet the following requirements:

- Sources ***Shall*** run the cable detection process prior to the Source sending ***Source_Capabilities*** Messages offering currents in excess of 3A and/or voltages in excess of 20V.
- Sinks with USB Type-C connectors ***Shall*** select Capabilities from the offered Source Capabilities assuming that the Source has already determined the Capabilities of the cable.

5. Physical Layer

5.1 Physical Layer Overview

The Physical Layer (PHY Layer) defines the signaling technology for USB Power Delivery. This chapter defines the electrical requirements and parameters of the PD Physical Layer required for interoperability between USB PD devices.

5.2 Physical Layer Functions

The USB PD Physical Layer consists of a pair of transmitters and receivers that communicate across a single signal wire (CC). All communication is half duplex. The PHY Layer practices collision avoidance to minimize communication errors on the channel.

The transmitter performs the following functions:

- Receive packet data from the protocol layer.
- Calculate and append a CRC.
- Encode the packet data including the CRC (i.e. the payload).
- Transmit the Packet (Preamble, ***SOP****, payload, CRC and ***EOP***) across the channel using Biphase Mark Coding (BMC) over CC.

The receiver performs the following functions:

- Recover the clock and lock onto the Packet from the Preamble.
- Detect the SOP*.
- Decode the received data including the CRC.
- Detect the EOP and validate the CRC:
    - If the CRC is ***Valid***, deliver the packet data to the protocol layer.
    - If the CRC is ***Invalid***, flush the received data.

5.3 Symbol Encoding

Except for the Preamble, all communications on the line ***Shall*** be encoded with a line code to ensure a reasonable level of DC-balance and a suitable number of transitions. This encoding makes receiver design less complicated and allows for more variations in the receiver design.

4b5b line code ***Shall*** be used. This encodes 4-bit data to 5-bit symbols for transmission and decodes 5-bit symbols to 4-bit data for consumption by the receiver.

The 4b5b code provides data encoding along with special symbols. Special symbols are used to signal ***Hard Reset***, and delineate packet boundaries.

Table 5-1 4b5b Symbol Encoding Table

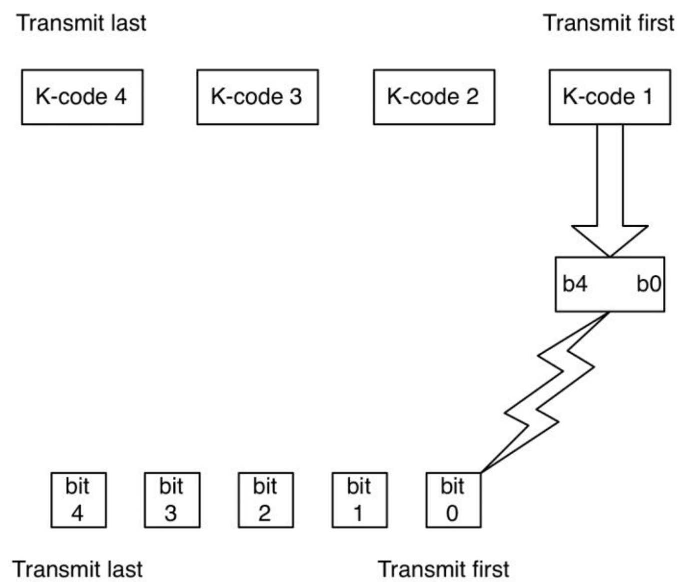
Name	4b	5b Symbol	Description
0	0000	11110	hex data 0
1	0001	01001	hex data 1
2	0010	10100	hex data 2
3	0011	10101	hex data 3
4	0100	01010	hex data 4
5	0101	01011	hex data 5
6	0110	01110	hex data 6
7	0111	01111	hex data 7
8	1000	10010	hex data 8
9	1001	10011	hex data 9
A	1010	10110	hex data A
B	1011	10111	hex data B
C	1100	11010	hex data C
D	1101	11011	hex data D
E	1110	11100	hex data E
F	1111	11101	hex data F
Sync-1	K-code	11000	Startsynch #1
Sync-2	K-code	10001	Startsynch #2
RST-1	K-code	00111	Hard Reset #1
RST-2	K-code	11001	Hard Reset #2
EOP	K-code	01101	EOP End Of Packet
Reserved	Error	00000	***Shall Not*** be used
Reserved	Error	00001	***Shall Not*** be used
Reserved	Error	00010	***Shall Not*** be used
Reserved	Error	00011	***Shall Not*** be used
Reserved	Error	00100	***Shall Not*** be used
Reserved	Error	00101	***Shall Not*** be used
Sync-3	K-code	00110	Startsynch #3
Reserved	Error	01000	***Shall Not*** be used
Reserved	Error	01100	***Shall Not*** be used
Reserved	Error	10000	***Shall Not*** be used
Reserved	Error	11111	***Shall Not*** be used

5.4 Ordered Sets

Ordered sets ***Shall*** be interpreted according to Figure 5-1.

An ordered set consists of 4 K-codes sent as shown in Figure 5-1.

Figure 5-1 Interpretation of ordered sets



A list of the ordered sets used by USB Power Delivery can be seen in Table 5-2. ***SOP**** is a generic term used in place of ***SOP***/***SOP'***/***SOP"***.

Table 5-2 Ordered Sets

Ordered Set	Reference
Cable Reset	Section 5.6.5
Hard Reset	Section 5.6.4
SOP	Section 5.6.1.2.1
SOP'	Section 5.6.1.2.2
SOP'_Debug	Section 5.6.1.2.4
SOP"	Section 5.6.1.2.3
SOP"_Debug	Section 5.6.1.2.5

The receiver ***Shall*** search for all four K-codes and when it finds either three out of four or all four in the correct place, it ***May*** interpret it as a ***Valid*** ordered set (see Table 5-3).

Table 5-3 Validation of Ordered Sets

	1st code	2nd code	3rd code	4th code
Valid	Corrupt	K-code	K-code	K-code
Valid	K-code	Corrupt	K-code	K-code
Valid	K-code	K-code	Corrupt	K-code
Valid	K-code	K-code	K-code	Corrupt
Valid (perfect)	K-code	K-code	K-code	K-code
Invalid (example)	K-code	Corrupt	K-code	Corrupt

5.5 Transmitted Bit Ordering

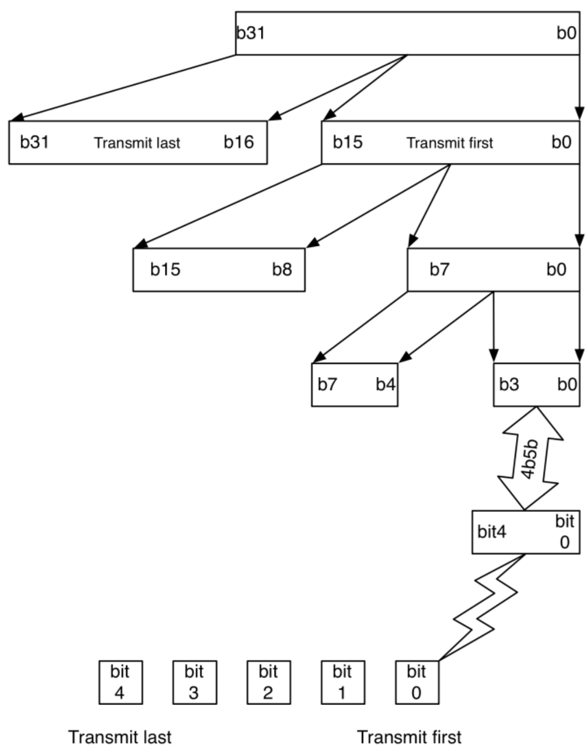
This section describes the order of bits on the wire that ***Shall*** be used when transmitting data of varying sizes. Table 5-4 shows the different data sizes that are possible.

Figure 5-2 shows the transmission order that ***Shall*** be followed.

Table 5-4 Data Size

	Unencoded	Encoded
Byte	8-bits	10-bits
Word	16-bits	20- bits
DWord	32-bits	40-bits

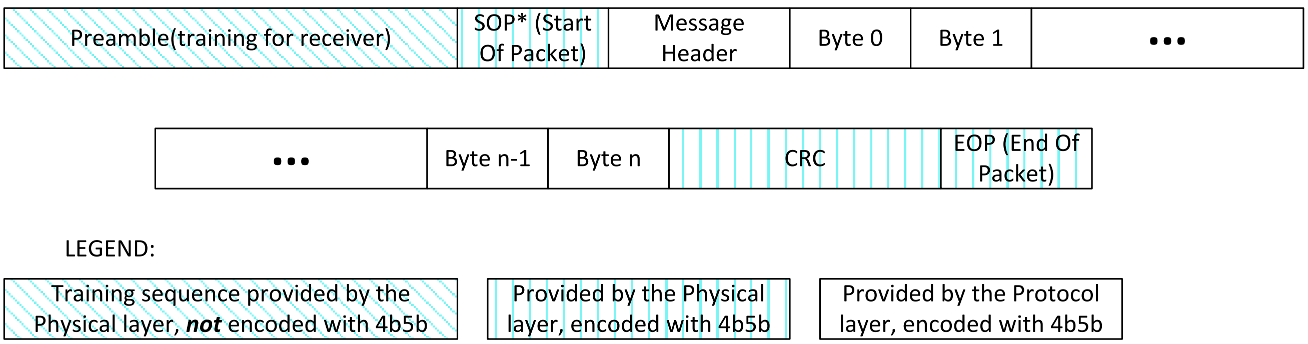
Figure 5-2 Transmit Order for Various Sizes of Data



5.6 Packet Format

The packet format ***Shall*** consist of a Preamble, an ***SOP****, (see Section 5.6.1.2), packet data including the Message Header, a CRC and an ***EOP*** (see Section 5.6.1.5). The packet format is shown in Figure 5-3 and indicates which parts of the packet ***Shall*** be 4b/5b encoded. Once 4b/5b encoded, the entire Packet ***Shall*** be transmitted using BMC over CC. Note that all the bits in the Packet, including the Preamble, are BMC encoded. See Section 6.2.1 for more details of the Packet construction for Control, Data and Extended Messages.

Figure 5-3 USB Power Delivery Packet Format



5.6.1 Packet Framing

The transmission starts with a Preamble that is used to allow the receiver to lock onto the carrier. It is followed by a ***SOP**** (Start of Packet). The packet is terminated with an ***EOP*** (End of Packet) K-code.

5.6.1.1 Preamble

The Preamble is used to achieve lock in the receiver by presenting an alternating series of "0s" and "1s", so the average frequency is the carrier frequency. Unlike the rest of the packet, the Preamble ***Shall Not*** be 4b/5b encoded.

The Preamble ***Shall*** consist of a 64-bit sequence of alternating 0s and 1s. The Preamble ***Shall*** start with a "0" and ***Shall*** end with a "1".

5.6.1.2 Start of Packet Sequences

5.6.1.2.1 Start of Packet Sequence (SOP)

SOP is an ordered set. The ***SOP*** ordered set is defined as: three ***Sync-1*** K-codes followed by one ***Sync-2*** K-code (see Table 5-5).

Table 5-5 SOP ordered set

K-code number	K-code in code table
1	***Sync-1***
2	***Sync-1***
3	***Sync-1***
4	***Sync-2***

A Power Delivery Capable Source or Sink ***Shall*** be able to detect and communicate with packets using ***SOP***. If a ***Valid SOP*** is not detected (see Table 5-3) then the whole transmission ***Shall*** be ***Discarded***.

Sending and receiving of SOP Packets ***Shall*** be limited to PD Capable Ports on PDUSB Hosts and PDUSB Devices. Cable Plugs ***Shall*** neither send nor receive SOP Packets. Note that PDUSB Devices, even if they have the physical form of a cable (e.g. AMAs), are still required to respond to SOP Packets.

5.6.1.2.2 Start of Packet Sequence Prime (SOP')

The ***SOP'*** ordered set is defined as: two ***Sync-1*** K-codes followed by two ***Sync-3*** K-codes (see Table 5-6).

Table 5-6 SOP' ordered set

K-code number	K-code in code table
1	***Sync-1***
2	***Sync-1***
3	***Sync-3***
4	***Sync-3***

A Cable Plug capable of SOP' Communications ***Shall*** only detect and communicate with packets starting with ***SOP'***.

A Port needing to communicate with a Cable Plug capable of SOP' Communications, Attached between a Port Pair will be able to communicate using both packets starting with ***SOP'*** to communicate with the Cable Plug and starting with ***SOP*** to communicate with its Port Partner.

For a Cable Plug supporting SOP' Communications, if a ***Valid SOP'*** is not detected (see Table 5-3) then the whole transmission ***Shall*** be ***Discarded***. For a Port supporting SOP' Communications if a ***Valid SOP*** or ***SOP'*** is not detected (see Table 5-3) then the whole transmission ***Shall*** be ***Discarded***. When there is no Explicit Contract or an Implicit Contract in place a Sink ***Shall Not*** send SOP' Packets and ***Shall Discard*** all packets starting with ***SOP'***.

5.6.1.2.3 Start of Packet Sequence Double Prime (SOP'')

The ***SOP''*** ordered set is defined as the following sequence of K-codes: ***Sync-1***, ***Sync-3***, ***Sync-1***, ***Sync-3*** (see Table 5-7).

Table 5-7 SOP'' ordered set

K-code number	K-code in code table
1	***Sync-1***
2	***Sync-3***
3	***Sync-1***
4	***Sync-3***

A Cable Plug capable of SOP'' Communication, ***Shall*** have a SOP' Communication capability in the other Cable Plug. No cable ***Shall*** only support SOP'' Communication. A Cable Plug to which SOP'' Communication is assigned ***Shall*** only detect and communicate with packets starting with ***SOP''*** and ***Shall Discard*** any other packets.

A Port needing to communicate with such a Cable Plug, Attached between a Port Pair will be able to communicate using packets starting with ***SOP'*** and ***SOP''*** to communicate with the Cable Plugs and packets starting with ***SOP*** to communicate with its Port Partner. A Port which supports SOP'' Communication ***Shall*** also support SOP' Communication and ***Shall*** co-ordinate SOP* Communication so as to avoid collisions.

For the Cable Plug supporting SOP'' Communication, if a ***Valid SOP''*** is not detected (see Table 5-3) then the whole transmission ***Shall*** be ***Discarded***. For the Port if a ***Valid SOP**** is not detected (see Table 5-3) then the whole transmission ***Shall*** be ***Discarded***.

5.6.1.2.4 Start of Packet Sequence Prime Debug (SOP'_Debug)

The ***SOP'_Debug*** ordered set is defined as the following sequence of K-codes: ***Sync-1***, ***RST-2***, ***RST-2***, ***Sync-3*** (see Table 5-8). The usage of this Ordered Set is presently undefined.

Table 5-8 SOP'_Debug ordered set

K-code number	K-code in code table
1	***Sync-1***
2	***RST-2***
3	***RST-2***
4	***Sync-3***

5.6.1.2.5 Start of Packet Sequence Double Prime Debug (SOP''_Debug)

The ***SOP''_Debug*** ordered set is defined as the following sequence of K-codes: ***Sync-1***, ***RST-2***, ***Sync-3, Sync-2*** (see Table 5-9). The usage of this Ordered Set is presently undefined.

Table 5-9 SOP''_Debug ordered set

K-code number	K-code in code table
1	***Sync-1***
2	***RST-2***
3	***Sync-3***
4	***Sync-2***

5.6.1.3 Packet Payload

The packet payload is delivered from the protocol layer (Section 6.2) and ***Shall*** be encoded with the hex data codes from Table 5-1.

5.6.1.4 CRC

The CRC ***Shall*** be inserted just after the payload. It is described in Section 5.6.2.

5.6.1.5 End of Packet (EOP)

The end of packet marker ***Shall*** be a single ***EOP*** K-code as defined in Table 5-1. This ***Shall*** mark the end of the CRC. After the ***EOP***, the CRC-residual ***Shall*** be checked. If the CRC is not good, the whole transmission ***Shall*** be ***Discarded***, if it is good, the packet ***Shall*** be delivered to the Protocol Layer. Note an ***EOP May*** be used to prematurely terminate a Packet e.g. before sending ***Hard Reset*** Signaling.

5.6.2 CRC

The Message Header and data ***Shall*** be protected by a 32-bit CRC.

CRC-32 protects the data integrity of the data payload. CRC-32 is defined as follows:

- The CRC-32 polynomial ***Shall*** be = 04C1 1DB7h.
- The CRC-32 Initial value ***Shall*** be = FFFF FFFFh.
- CRC-32 ***Shall*** be calculated for all bytes of the payload not inclusive of any packet framing symbols (i.e. excludes the Preamble, ***SOP****, ***EOP***).
- CRC-32 calculation ***Shall*** begin at byte 0 bit 0 and continue to bit 7 of each of the bytes of the packet.
- The remainder of CRC-32 ***Shall*** be complemented.
- The residual of CRC-32 ***Shall*** be C704 DD7Bh.

Note: This inversion of the CRC-32 remainder adds an offset of FFFF FFFFh that will create a constant CRC-32 residual of C704 DD7Bh at the receiver side.

Note: The CRC implementation is identical to the one used in ***[USB 3.1]***.

Figure 5-4 is an illustration of CRC-32 generation. The output bit ordering ***Shall*** be as detailed in Table 5-10.

Figure 5-4 CRC 32 generation

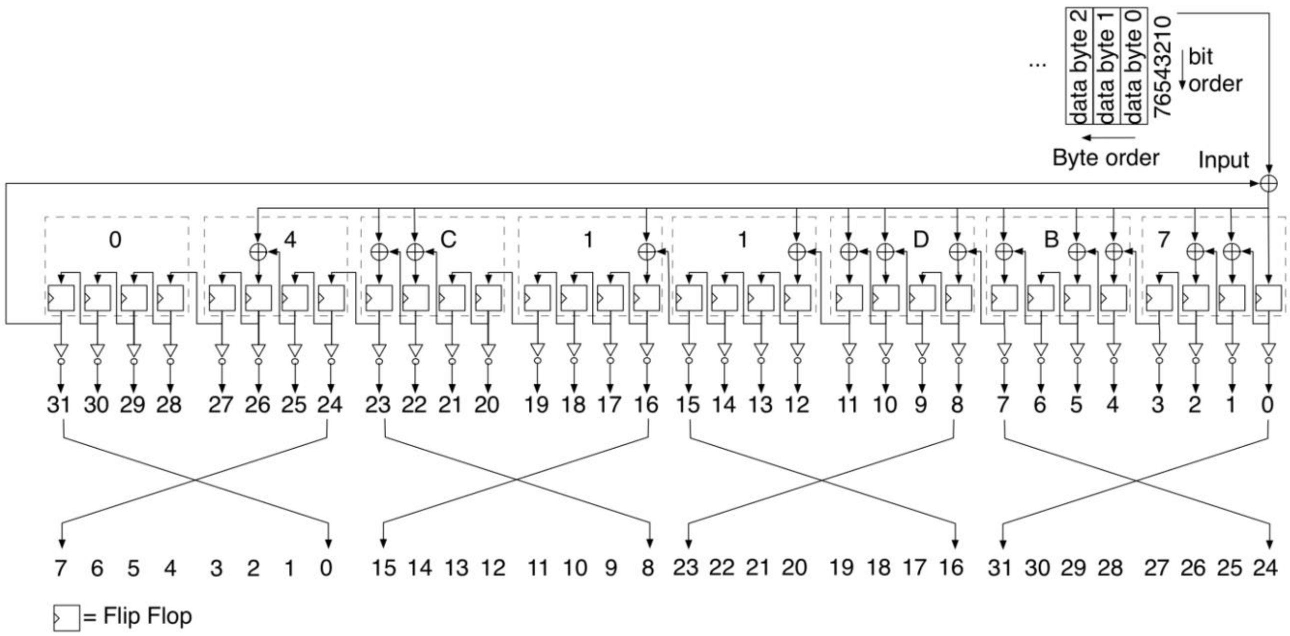


Table 5-10 CRC-32 Mapping

CRC-32	Result bit Position in CRC-32 Field
0	31
1	30
2	29
3	28
4	27
5	26
6	25
7	24
8	23
9	22
10	21
11	20
12	19
13	18
14	17
15	16
16	15
17	14
18	13
19	12
20	11
21	10
22	9

CRC-32	Result bit Position in CRC-32 Field
23	8
24	7
25	6
26	5
27	4
28	3
29	2
30	1
31	0

The CRC-32 ***Shall*** be encoded before transmission.

5.6.3 Packet Detection Errors

CRC errors, or errors detected while decoding encoded symbols using the code table, ***Shall*** be treated the same way; the Message ***Shall*** be ***Discarded*** and a ***GoodCRC*** Message ***Shall Not*** be returned.

While the receiver is processing a packet, if at any time V_{BUS} becomes idle the receiver ***Shall*** stop processing the packet and ***Discard*** it (no ***GoodCRC*** Message is returned). See Section 5.8.6.1 for the definition of BMC idle.

5.6.4 Hard Reset

Hard Reset Signaling is an ordered set of bytes sent with the purpose to be recognized by the PHY Layer. The ***Hard Reset*** Signaling ordered set is defined as: three ***RST-1*** K-codes followed by one ***RST-2*** K-code (see Table 5-11).

Table 5-11 Hard Reset ordered set

K-code number	K-code in code table
1	***RST-1***
2	***RST-1***
3	***RST-1***
4	***RST-2***

A device ***Shall*** perform a Hard Reset when it receives ***Hard Reset*** Signaling. After receiving the ***Hard Reset*** Signaling, the device ***Shall*** reset as described in Section 6.8.2. If a ***Valid Hard Reset*** is not detected (see Table 5-3) then the whole transmission ***Shall*** be ***Discarded***.

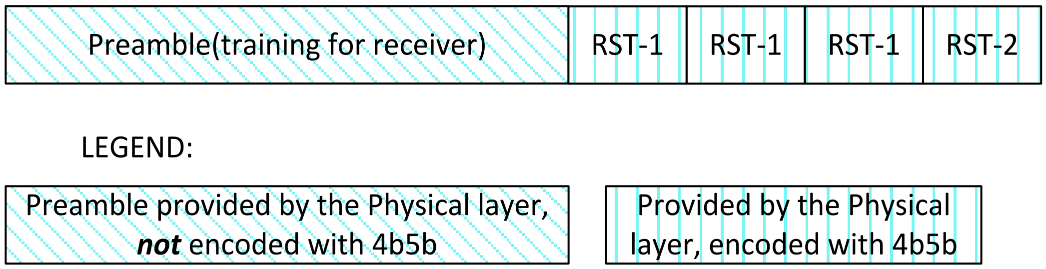
A Cable Plug ***Shall*** perform a Hard Reset when it detects ***Hard Reset*** Signaling being sent between the Port Partners. After receiving the ***Hard Reset*** Signaling, the device ***Shall*** reset as described in Section 6.8.2.

The procedure for sending ***Hard Reset*** Signaling ***Shall*** be as follows:

1. If the PHY Layer is currently sending a Message, the Message ***Shall*** be interrupted by sending an ***EOP*** K-code and the rest of the Message ***Discarded***.
2. If CC is not idle, wait for it to become idle (see Section 5.8.6.1).
3. Wait ***tInterFrameGap.***
4. If CC is still idle send the Preamble followed by the 4 K-codes for ***Hard Reset*** Signaling.
5. Disable the channel (i.e. stop sending and receiving), reset the PHY Layer and inform the Protocol Layer that the PHY Layer has been reset.
6. Re-enable the channel when requested by the Protocol Layer.

Figure 5-5 shows the line format of ***Hard Reset*** Signaling which is a Preamble followed by the ***Hard Reset*** Ordered Set.

Figure 5-5 Line format of Hard Reset



5.6.5 Cable Reset

Cable Reset Signaling is an ordered set of bytes sent with the purpose to be recognized by the PHY Layer. The ***Cable Reset*** Signaling ordered set is defined as the following sequence of K-codes: ***RST-1***, ***Sync-1***, ***RST-1***, ***Sync-3*** (see Table 5-12).

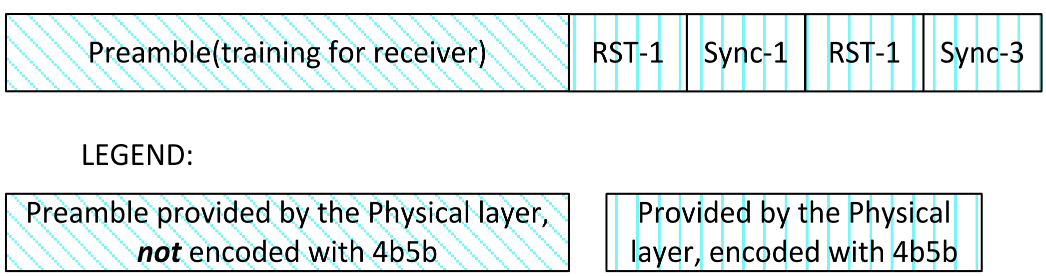
Table 5-12 Cable Reset ordered set

K-code number	K-code in code table
1	***RST-1***
2	***Sync-1***
3	***RST-1***
4	***Sync-3***

Cable Reset Signaling ***Shall*** only be sent by the DFP. The ***Cable Reset*** Ordered Set is used to reset the Cable Plugs without the need to Hard Reset the Port Partners. The state of the Cable Plug after the ***Cable Reset*** Signaling ***Shall*** be equivalent to power cycling the Cable Plug.

Figure 5-6 shows the line format of ***Cable Reset*** Signaling which is a Preamble followed by the ***Cable Reset*** Ordered Set.

Figure 5-6 Line format of Cable Reset



5.7 Collision Avoidance

The PHY Layer ***Shall*** monitor the channel for data transmission and only initiate transmissions when CC is idle. If the bus idle condition is present, it ***Shall*** be considered safe to start a transmission provided the conditions detailed in Section 5.8.5.4 are met. The bus idle condition ***Shall*** be checked immediately prior to transmission. If transmission cannot be initiated then the packet ***Shall*** be ***Discarded***. If the packet is ***Discarded*** because CC is not idle, the PHY Layer ***Shall*** signal to the protocol layer that it has ***Discarded*** the Message as soon as CC becomes idle. See Section 5.8.6.1 for the definition of idle CC.

In addition the PHY Layer ***Shall*** control the Rp resistor value to avoid collisions between Source and Sink transmissions. The Source ***Shall*** set an Rp value corresponding to a current of 3A to indicate to the Sink that it ***May*** initiate an AMS. The Source ***Shall*** set an Rp value corresponding to a current of 1.5A this ***Shall*** indicate to the Sink that it ***Shall Not*** initiate an AMS and ***Shall*** only respond to Messages as part of an AMS. See ***[USB Type-C 1.2]*** for details of the corresponding Rp values.

Table 5-13 details the Rp values that ***Shall*** be used by the Source to control Sink initiation of an AMS.

Table 5-13 Rp values used for Collision Avoidance

Source Rp	Parameter	Description	Sink operation	Source operation
1.5A@5V	***SinkTxNG***	Sink Transmit "No Go",	Sink cannot initiate an AMS. Sink can only respond to Messages as part of an AMS	Source can initiate an AMS ***tSinkTx*** after setting Rp to this value.
3A@5V	***SinkTxOk***	Sink Transmit "Ok"	Sink can initiate an AMS.	Source cannot initiate an AMS while it has this value set.

See also Section 6.6.15 and Section 6.11.2.1.

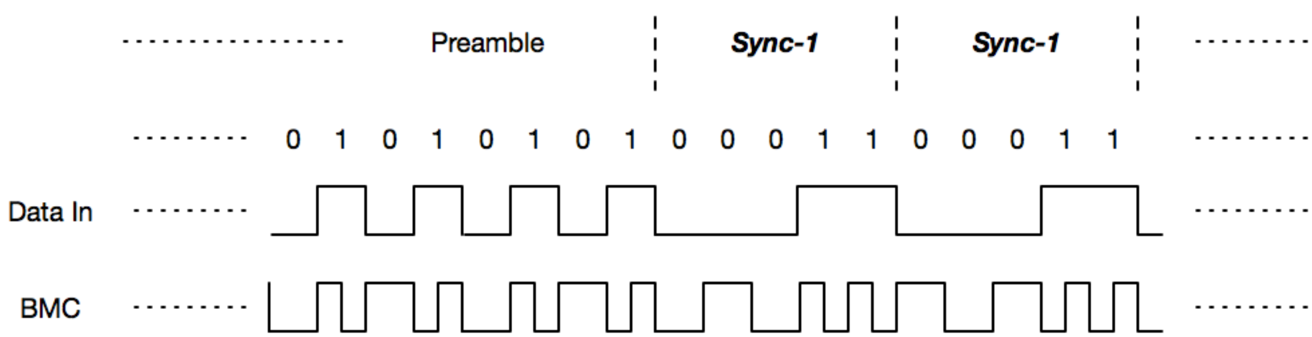
5.8 Biphase Mark Coding (BMC) Signaling Scheme

Biphase Mark Coding (BMC) is the physical layer Signaling Scheme for carrying USB Power Delivery Messages. This encoding assumes a dedicated DC connection, identified as the CC wire, which is used for sending PD Messages.

Biphase Mark Coding is a version of Manchester coding (see ***[IEC 60958-1]***). In BMC, there is a transition at the start of every bit time (UI) and there is a second transition in the middle of the UI when a 1 is transmitted. BMC is effectively DC balanced, (each 1 is DC balanced and two successive zeroes are DC balanced, regardless of the number of intervening 1's). It has bounded disparity (limited to 1 bit over an arbitrary packet, so a very low DC level).

Figure 5-7 illustrates Biphase Mark Coding. This example shows the transition from a Preamble to the ***Sync-1*** K-codes of the ***SOP*** Ordered Set at the start of a Message. Note that other K-codes can occur after the Preamble for Signaling such as ***Hard Reset*** and ***Cable Reset***.

Figure 5-7 BMC Example



5.8.1 Encoding and signaling

BMC uses DC coupled baseband signaling on CC. Figure 5-8 shows a block diagram for a Transmitter and Figure 5-9 shows a block diagram for the corresponding Receiver.

Figure 5-8 BMC Transmitter Block Diagram

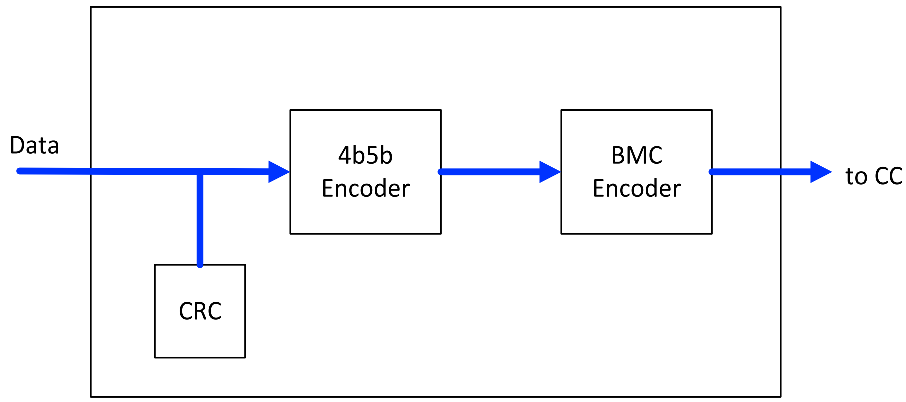
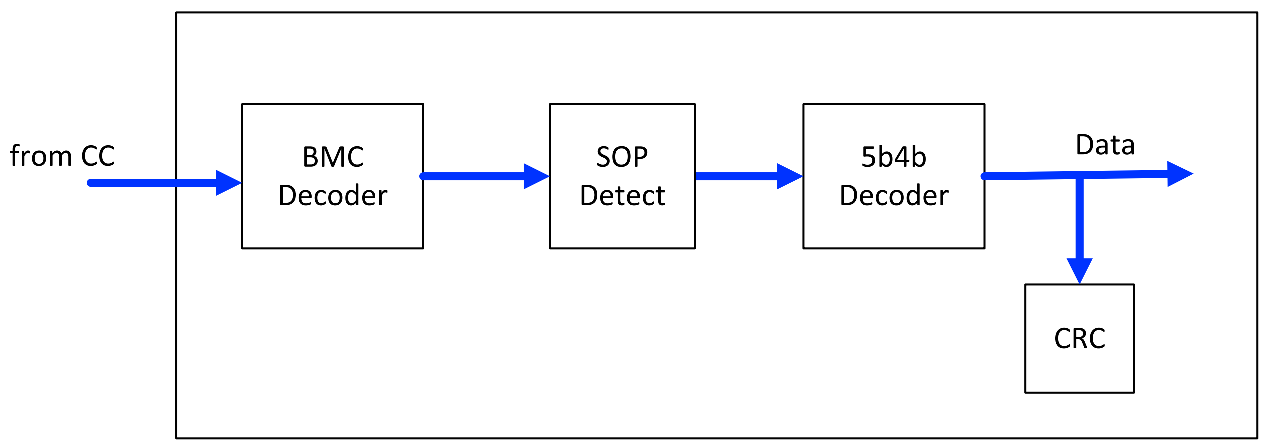


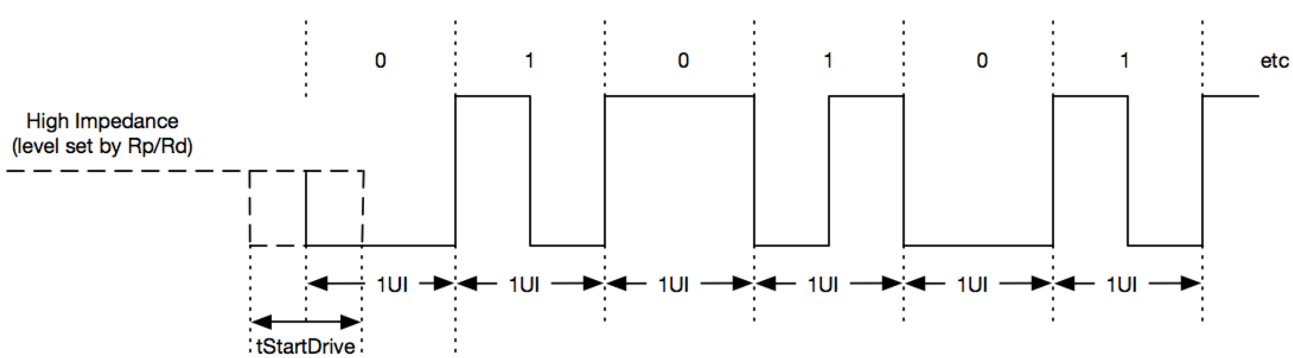
Figure 5-9 BMC Receiver Block Diagram



The USB PD baseband signal ***Shall*** be driven on the CC wire with a tristate driver that ***Shall*** cause a ***vSwing*** swing on CC. The tristate driver is slew rate limited (see min rise/fall time in Section 5.8.5) to limit coupling to D+/D- and to other signal lines in the USB Type-C fully featured cables (see ***[USB Type-C 1.2]***). This slew rate limiting can be performed either with driver design or an RC filter on the driver output.

When sending the Preamble, the transmitter ***Shall*** start by transmitting a low level. The receiver ***Shall*** tolerate the loss of the first edge. The transmitter ***May*** vary the start of the Preamble by ***tStartDrive*** min (see Figure 5-10).

Figure 5-10 BMC Encoded Start of Preamble



The transmitter ***Shall*** terminate the final bit of the Frame by an edge (the "trailing edge") to help ensure that the receiver clocks the final bit. If the trailing edge results in the transmitter driving CC low (i.e. the final half-UI of the frame is high), then the transmitter:

1. ***Shall*** continue to drive CC low for ***tHoldLowBMC***.
2. Then ***Shall*** continue to drive CC low for ***tEndDriveBMC*** measured from the trailing edge of the final bit of the Frame.
3. Then ***Shall*** release CC to high impedance.

Figure 5-11 illustrates the end of a BMC encoded Frame with an encoded zero for which the final bit of the Frame is terminated by a high to low transition. Figure 5-12 illustrates the end of a BMC Encoded frame with an encoded one for which the final bit of the Frame is terminated by a high to low transition. Both figures also illustrate the ***tInterFrameGap*** timing requirement before the start of the next Frame when the Port has either been transmitting or receiving the previous Frame (see Section 5.8.5.4).

Figure 5-11 Transmitting or Receiving BMC Encoded Frame Terminated by Zero with High-to-Low Last Transition

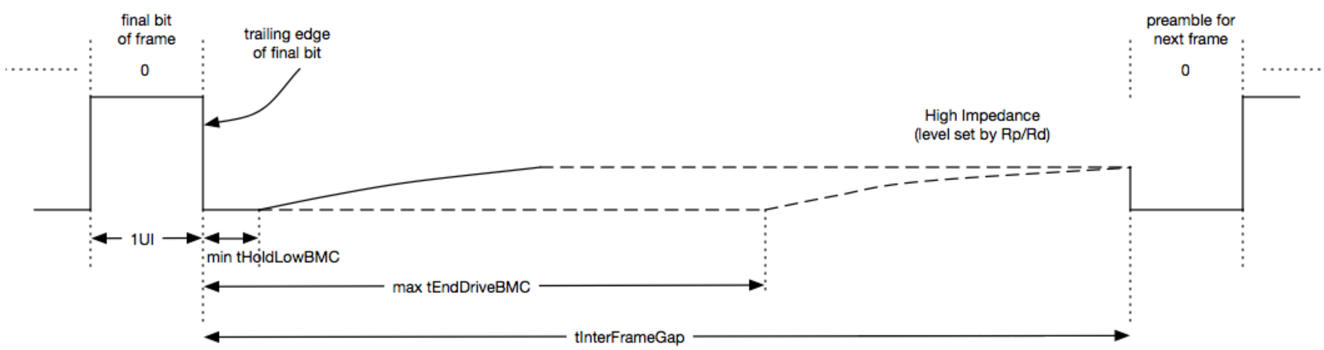
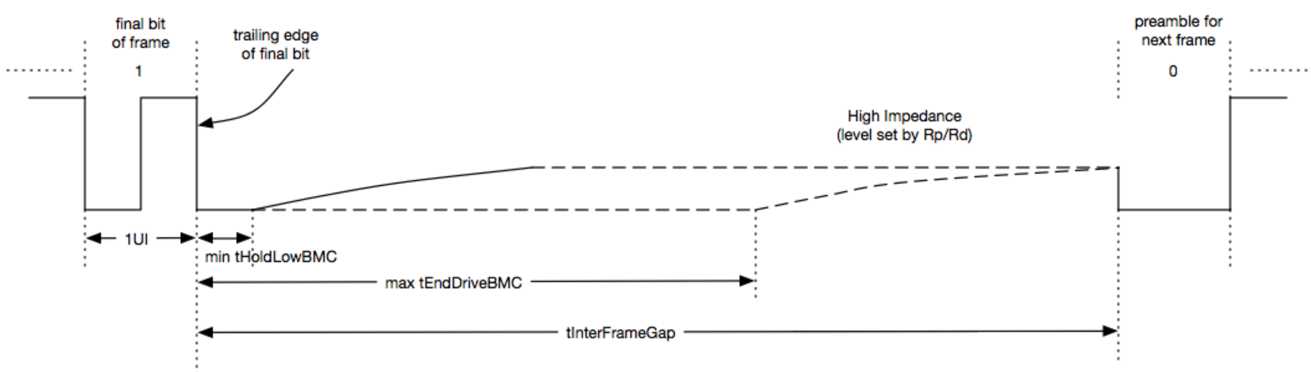


Figure 5-12 Transmitting or Receiving BMC Encoded Frame Terminated by One with High-to-Low Last Transition



If the trailing edge results in the transmitter driving CC high (i.e. the final half-UI of the frame is low), then the transmitter:

1. ***Shall*** continue to drive CC high for 1 UI.
2. Then ***Shall*** drive CC low for ***tHoldLowBMC***.
3. Then ***Shall*** continue to drive CC low for ***tEndDriveBMC*** measured from the final edge of the final bit of the Frame.
4. Then ***Shall*** release CC to high impedance.

Figure 5-13 illustrates the ending of a BMC encoded Frame that ends with an encoded zero for which the final bit of the Frame is terminated by a low to high transition. Figure 5-14 illustrates the ending of a BMC encoded Frame that ends with an encoded one for which the final bit of the Frame is terminated by a low to high transition. Both figures also illustrate the ***tInterFrameGap*** timing requirement before the start of the next Frame when the Port has either been transmitting or receiving the previous Frame (see Section 5.8.5.4).

Figure 5-13 Transmitting or Receiving BMC Encoded Frame Terminated by Zero with Low to High Last Transition

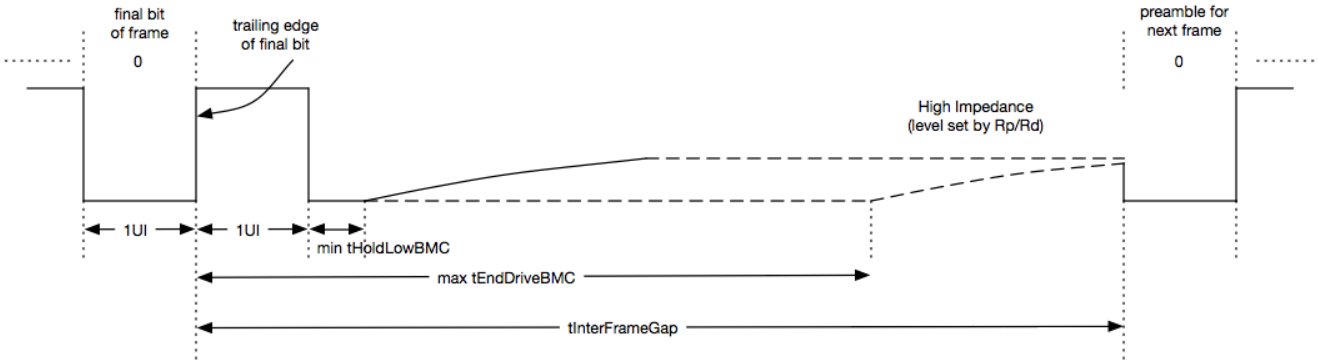
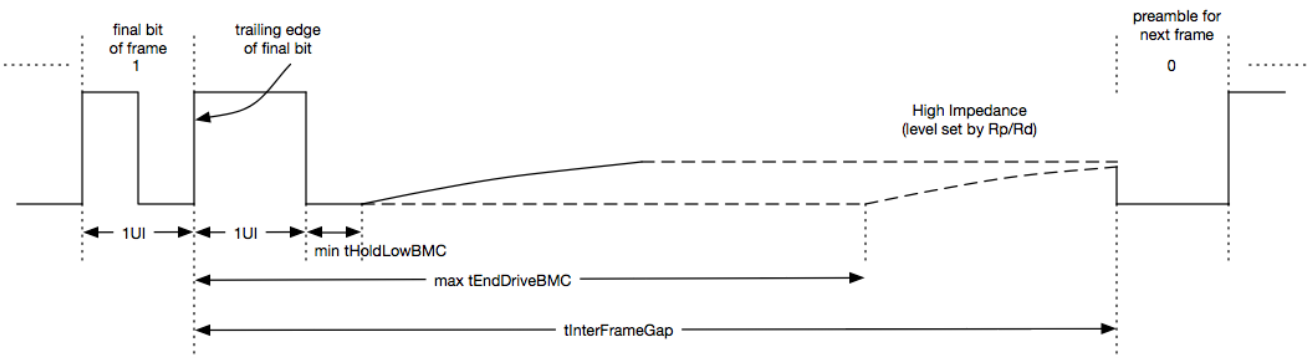


Figure 5-14 Transmitting or Receiving BMC Encoded Frame Terminated by One with Low to High Last Transition



Note: There is no requirement to maintain a timing phase relationship between back-to-back packets.

5.8.2 Transmit and Receive Masks

5.8.2.1 Transmit Masks

The transmitted signal ***Shall Not*** violate the masks defined in Figure 5-15, Figure 5-16, Table 5-14 and Table 5-15 at the output of a load equivalent to the cable model and receiver load model described in Section 5.8.3. The masks apply to the full range of Rp/Rd values as defined in ***[USB Type-C 1.2]***. Note: the measurement of the transmitter does not need to accommodate a change in signal offset due to the ground offset when current is flowing in the cable.

The transmitted signal ***Shall*** have a rise time no faster than ***tRise***. The transmitted signal ***Shall*** have a fall time no faster than ***tFall***. The maximum limits on the rise and fall times are enforced by the Tx inner masks.

Figure 5-15 BMC Tx 'ONE' Mask

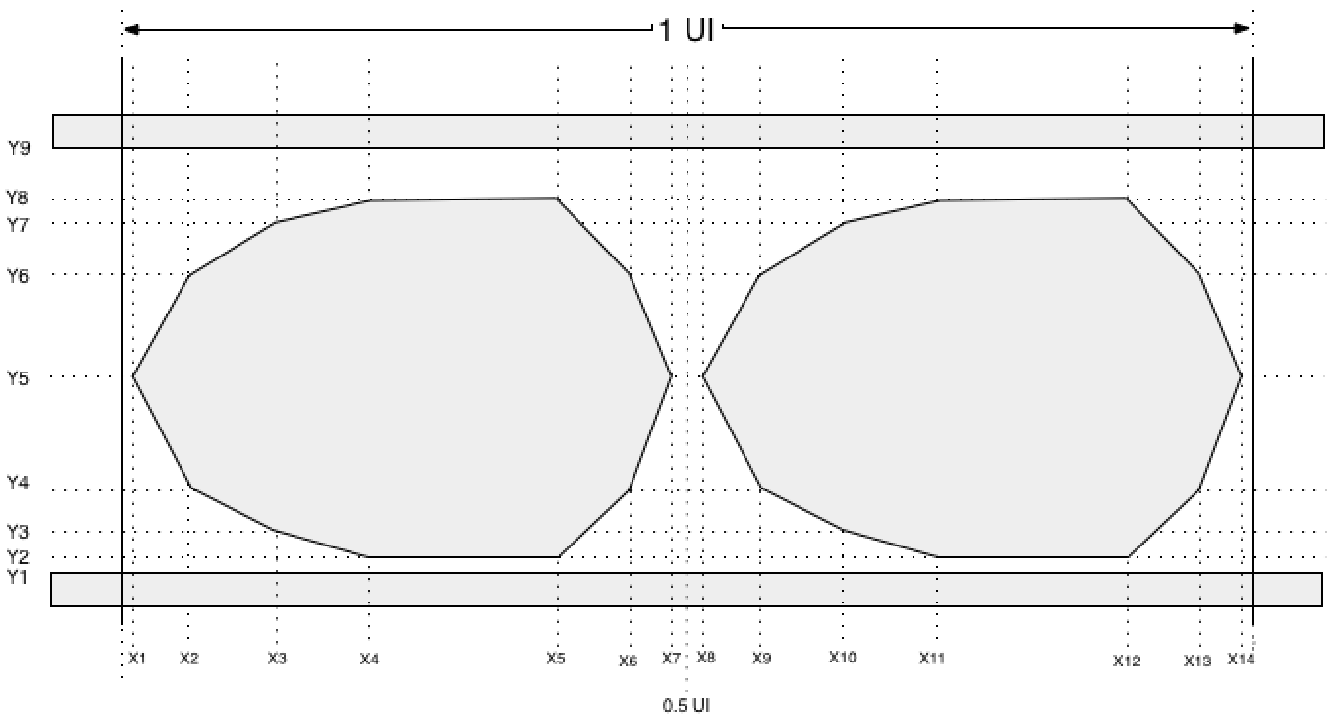


Figure 5-16 BMC Tx 'ZERO' Mask

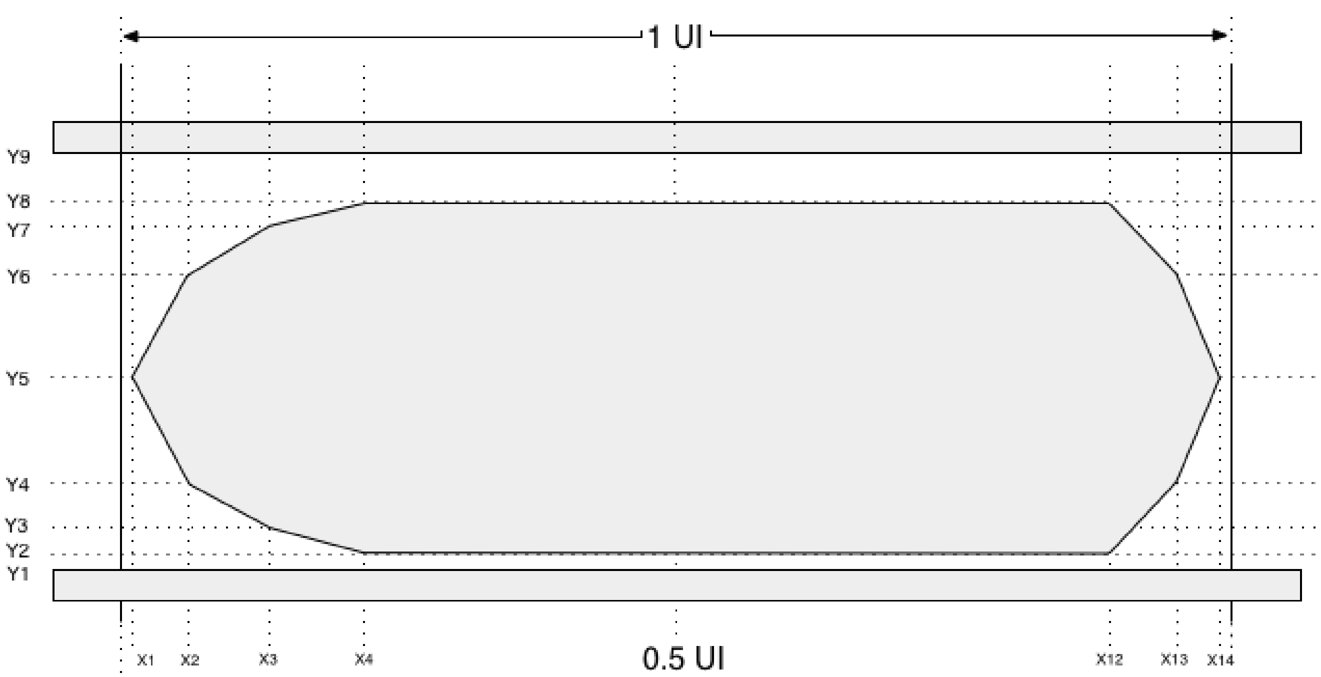


Table 5-14 BMC Tx Mask Definition, X Values

Name	Description	Value	Units
X1Tx	Left Edge of Mask	0.015	UI
X2Tx	see figure	0.07	UI
X3Tx	see figure	0.15	UI
X4Tx	see figure	0.25	UI
X5Tx	see figure	0.35	UI
X6Tx	see figure	0.43	UI
X7Tx	see figure	0.485	UI
X8Tx	see figure	0.515	UI
X9Tx	see figure	0.57	UI
X10Tx	see figure	0.65	UI
X11Tx	see figure	0.75	UI
X12Tx	see figure	0.85	UI
X13Tx	see figure	0.93	UI
X14Tx	Right Edge of Mask	0.985	UI

Table 5-15 BMC Tx Mask Definition, Y Values

Name	Description	Value	Units
Y1Tx	Lower bound of Outer mask	-0.075	V
Y2Tx	Lower bound of inner mask	0.075	V
Y3Tx	see figure	0.15	V
Y4Tx	see figure	0.325	V
Y5Tx	Inner mask vertical midpoint	0.5625	V
Y6Tx	see figure	0.8	V
Y7Tx	see figure	0.975	V
Y8Tx	see figure	1.04	V
Y9Tx	Upper Bound of Outer mask	1.2	V

5.8.2.2 Receive Masks

A Source using the BMC Signaling Scheme ***Shall*** be capable of receiving a signal that complies with the mask when sourcing power as defined in Figure 5-17, Figure 5-18 and Table 5-16. The Source Rx mask is bounded by sweeping a Tx mask compliant signal, with added ***vNoiseActive*** between power neutral and Source offsets.

A Consumer using the BMC Signaling Scheme ***Shall*** be capable of receiving a signal that complies with the mask when sinking power as defined in Figure 5-21, Figure 5-22 and Table 5-16. The Consumer Rx mask is bounded by sweeping a Tx mask compliant signal, with added ***vNoiseActive*** between power neutral and Consumer offsets.

Every product using the BMC Signaling Scheme ***Shall*** be capable of receiving a signal that complies with the mask when power neutral as defined in Figure 5-19, Figure 5-20 and Table 5-16.

Dual-Role Power Devices ***Shall*** meet the receiver requirements for a Source when providing power during any transmission using the BMC Signaling Scheme or a Sink when consuming power during any transmission using the BMC Signaling Scheme.

Cable Plugs ***Shall*** meet the receiver requirements for both a Source and a Sink during any transmission using the BMC Signaling Scheme.

The parameters used in the masks are specified to be appropriate to either edge triggered or oversampling receiver implementations.

The masks are defined for 'ONE' and 'ZERO' separately as BMC enforces a transition at the midpoint of the unit interval while a 'ONE' is transmitted.

The Rx masks are defined to bound the Rx noise after the Rx bandwidth limiting filter with the time constant ***tRxFilter*** has been applied.

The boundaries of Rx outer mask, ***Y1Rx*** and ***Y5Rx***, are specified according to ***vSwing*** max and accommodate half of ***vNoiseActive*** from cable noise coupling and the signal offset ***vIRDropGNDC*** due to the ground offset when current is flowing in the cable.

The vertical dimension of the Rx inner mask, ***Y4Rx*** **-** ***Y2Rx***, for power neutral is derived by reducing the vertical dimension of the Tx inner mask, ***Y7Tx*** **-** ***Y3Tx***, at time location ***X3Tx*** by ***vNoiseActive*** to account for cable noise coupling. The received signal is composed of a waveform compliant to the Tx mask plus ***vNoiseActive***.

The vertical dimension of the Rx inner mask for sourcing power is derived by reducing the vertical dimension of the Tx inner mask by ***vNoiseActive*** and ***vIRDropGNDC*** to account for both cable noise coupling and signal DC offset. The received signal is composed of a waveform compliant to the Tx mask plus the maximum value of ***vNoiseActive*** plus ***vIRDropGNDC*** where the ***vIRDropGNDC*** value transitions between the minimum and the maximum values as allowed in this spec.

The vertical dimension of the Rx inner mask for sinking power is derived by reducing the vertical dimension of the Tx inner mask by ***vNoiseActive*** max and ***vIRDropGNDC*** max for account for both cable noise coupling and signal DC offset. The received signal is composed of a waveform compliant to the Tx mask plus the maximum value of ***vNoiseActive*** plus ***vIRDropGNDC*** where the ***vIRDropGNDC*** value transitions between the minimum and the maximum values as allowed in this spec.

The center line of the Rx inner mask, ***Y3Rx***, is at half of the nominal ***vSwing*** for power neutral, and is shifted up by half of ***vIRDropGNDC*** max for sourcing power and is shifted down by half of ***vIRDropGNDC*** max for sinking power.

The receiver sensitivity ***Shall*** be set such that the receiver does not treat noise on an undriven signal path as an incoming signal. Signal amplitudes below ***vNoiseIdle*** max ***Shall*** be treated as noise when BMC is idle.

Figure 5-17 BMC Rx 'ONE' Mask when Sourcing Power

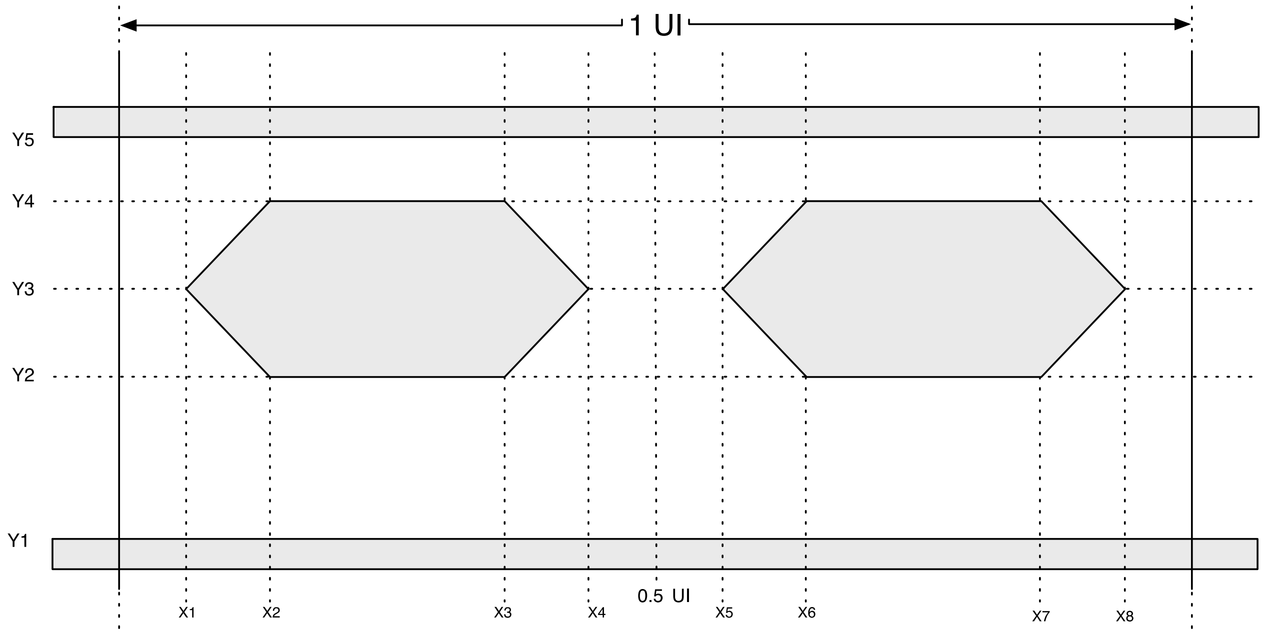


Figure 5-18 BMC Rx 'ZERO' Mask when Sourcing Power

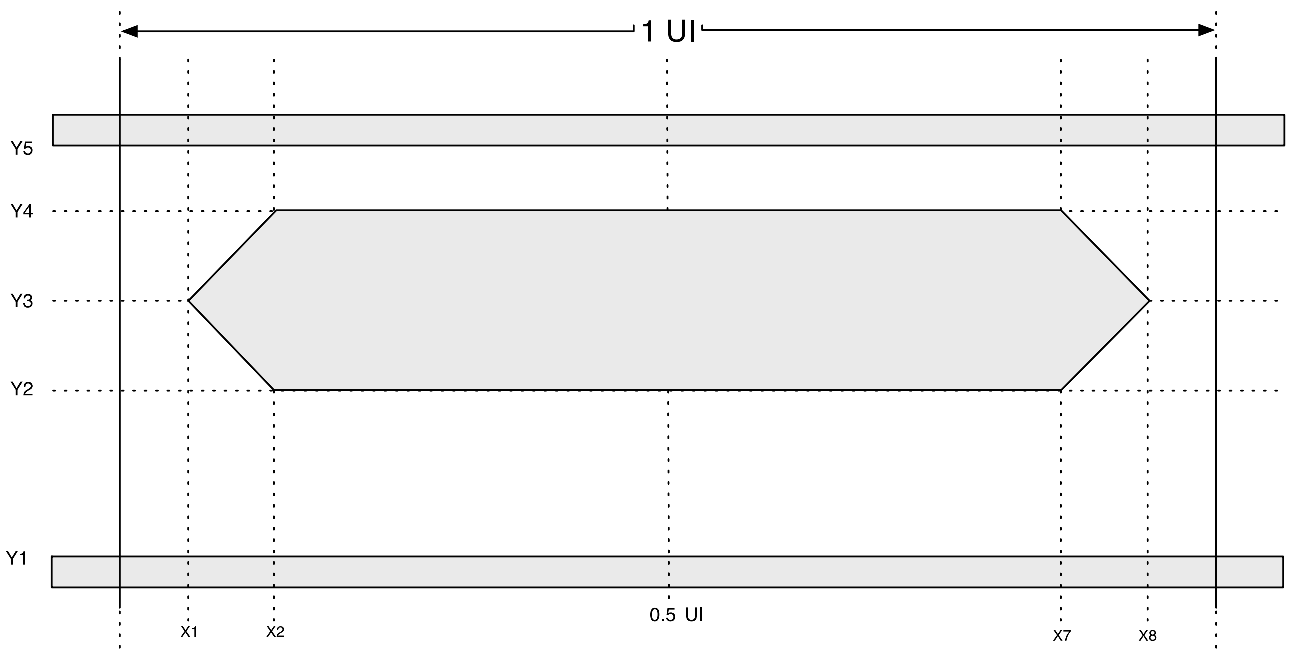


Figure 5-19 BMC Rx 'ONE' Mask when Power neutral

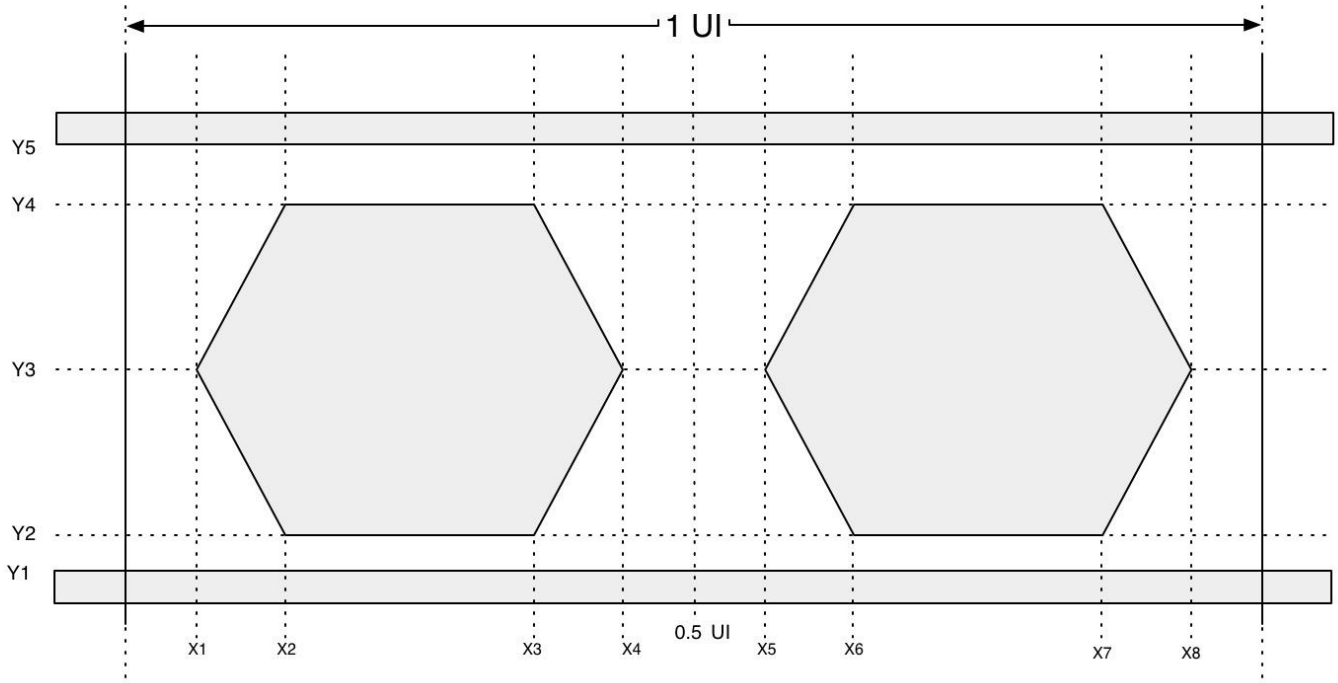


Figure 5-20 BMC Rx 'ZERO' Mask when Power neutral

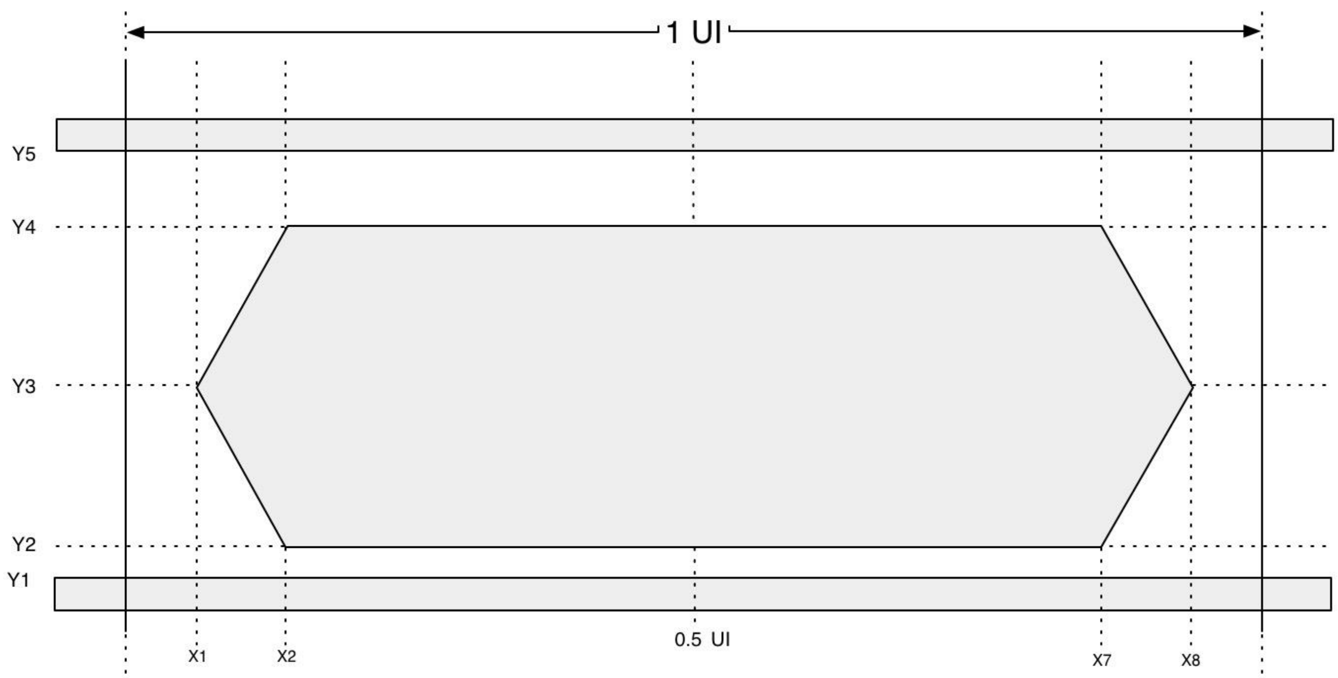


Figure 5-21 BMC Rx 'ONE' Mask when Sinking Power

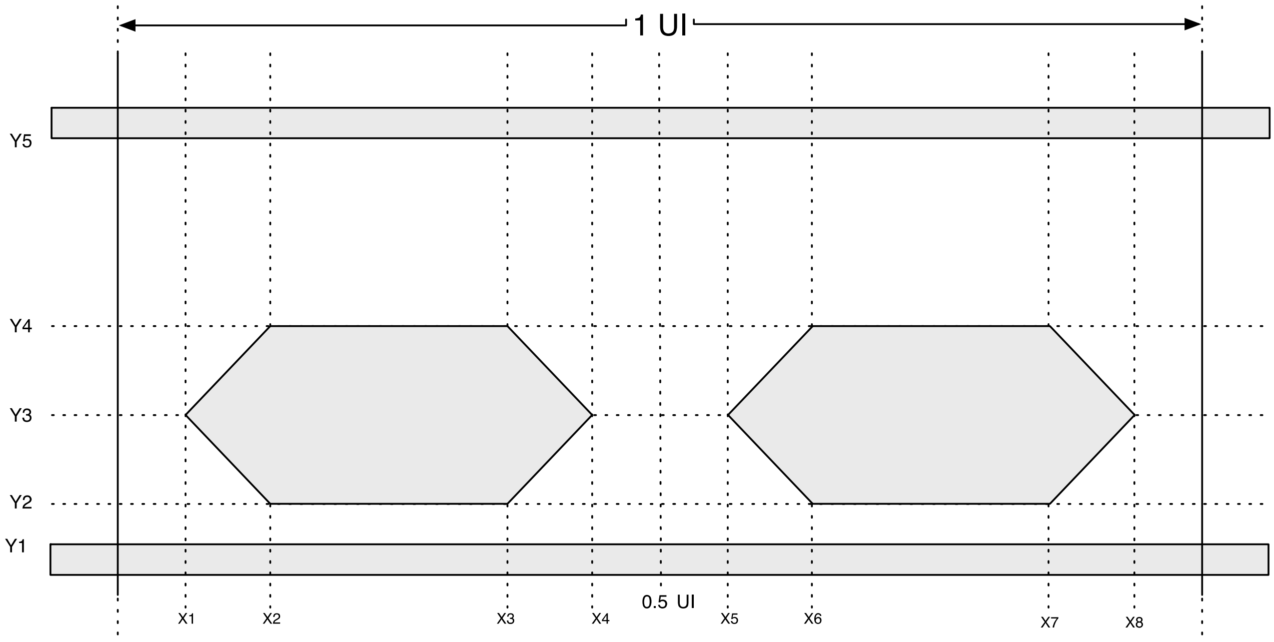


Figure 5-22 BMC Rx 'ZERO' Mask when Sinking Power

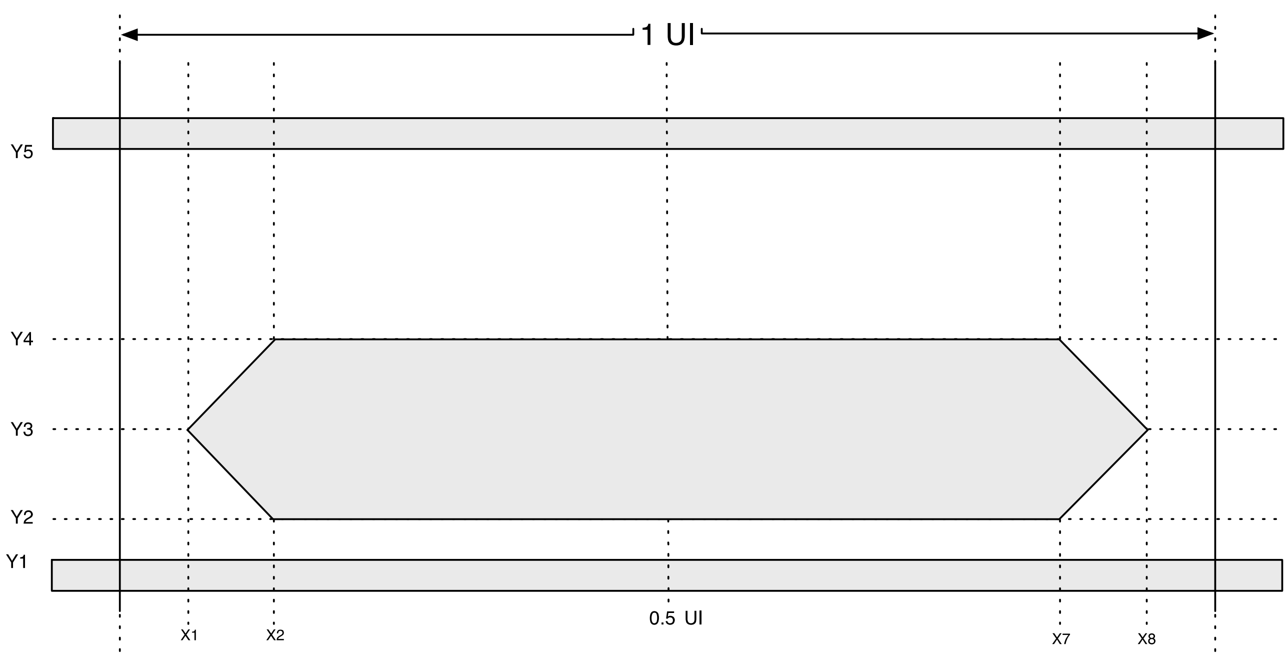


Table 5-16 BMC Rx Mask Definition

Name	Description	Value	Units
X1Rx	Left Edge of Mask	0.07	UI
X2Rx	Top Edge of Mask	0.15	UI
X3Rx	See figure	0.35	UI
X4Rx	See figure	0.43	UI
X5Rx	See figure	0.57	UI
X6Rx	See figure	0.65	UI
X7Rx	See figure	0.85	UI
X8Rx	See figure	0.93	UI
Y1Rx	Lower bound of Outer Mask	-0.3325	V
Y2Rx	Lower Bound of Inner Mask	*Y3Rx* – 0.205 when sourcing power[1] or sinking power[1] *Y3Rx* – 0.33 when power neutral[1]	V
Y3Rx	Center line of Inner Mask	0.6875 Sourcing Power[1] 0.5625 Power Neutral[1] 0.4375 Sinking Power[1]	V
Y4Rx	Upper bound of Inner mask	*Y3Rx* + 0.205 when sourcing power[1] or sinking power[1] *Y3Rx* + 0.33 when power neutral[1]	V
Y5Rx	Upper bound of the Outer mask	1.5325	V
Note 1: The position of the center line of the Inner Mask is dependent on whether the receiver is Sourcing or Sinking power or is Power Neutral (see earlier in this section).			

5.8.3 Transmitter Load Model

The transmitter load model ***Shall*** be equivalent to the circuit outlined in Figure 5-23 for a Source and Figure 5-24 for a Sink. It is formed by the concatenation of a cable load model and a receiver load model. See ***[USB Type-C 1.2]*** for details of the Rp and Rd resistors. Note the parameters *zCable_CC*, *tCableDelay_CC* and *cCablePlug_CC* are defined in ***[USB Type-C 1.2]***.

Figure 5-23 Transmitter Load Model for BMC Tx from a Source

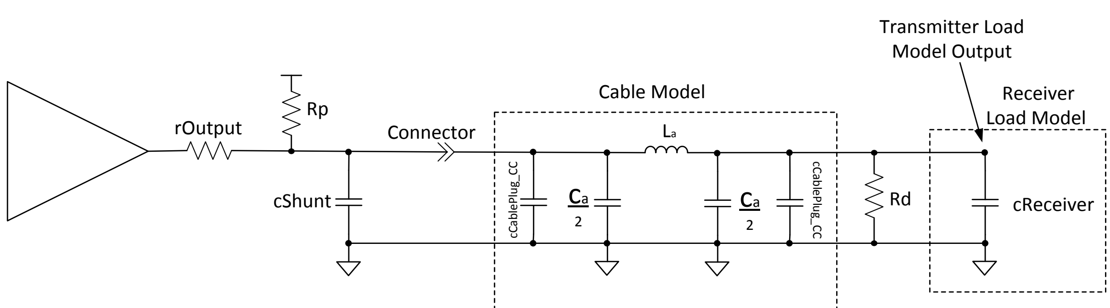
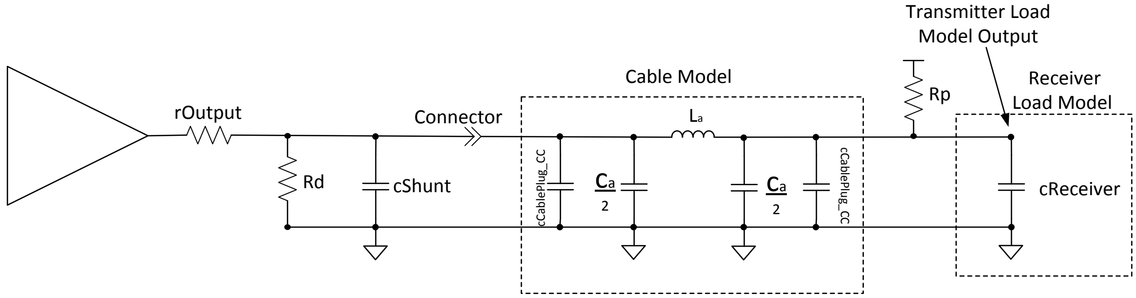


Figure 5-24 Transmitter Load Model for BMC Tx from a Sink



The transmitter system components *rOutput* and *cShunt* are illustrated for informative purposes, and do not form part of the transmitter load model. See Section 5.8.5 for a description of the transmitter system design.

The value of the modeled cable inductance, La, (in nH) ***Shall*** be calculated from the following formula:

$$La = tCableDelay\_CC_{max} * zCable\_CC_{min}$$

tCableDelay_CC is the modeled signal propagation delay through the cable, and *zCable_CC* is the modeled cable impedance.

The modeled cable inductance is 640 nH for a cable with $zCable\_CC_{min}$ = 32 Ω and $tCableDelay\_CC_{max}$ = 20 nS.

The value of the modeled cable capacitance, Ca, (in pF) ***Shall*** be calculated from the following formula:

$$Ca = \frac{tCableDelay\_CC_{max}}{zCable\_CC_{min}}$$

The modeled cable capacitance is Ca = 625 pF for a cable with $zCable\_CC_{min}$ = 32 Ω and $tCableDelay\_CC_{max}$ = 20 nS. Therefore, Ca/2 = 312.5 pF.

cCablePlug_CC models the capacitance of the plug at each end of the cable. ***cReceiver*** models the capacitance of the receiver. The maximum values ***Shall*** be used in each case.

Note: the transmitter load model assumes that there are no other return currents on the ground path.

5.8.4 BMC Common specifications

This section defines the common receiver and transmitter requirements.

5.8.4.1 BMC Common Parameters

The electrical requirements specified in Table 5-17 ***Shall*** apply to both the transmitter and receiver.

Table 5-17 BMC Common Normative Requirements

Name	Description	Min	Nom	Max	Units	Comment
fBitRate	Bit rate	270	300	330	Kbps	
tUnitInterval[1]	Unit Interval	3.03		3.70	μs	1/***fBitRate***
Note 1: ***tUnitInterval*** denotes the time to transmit an unencoded data bit, not the shortest high or low times on the wire after encoding with BMC. A single data bit cell has duration of 1UI, but a data bit cell with value 1 will contain a centrally placed 01 or 10 transition in addition to the transition at the start of the cell.						

5.8.5 BMC Transmitter Specifications

The transmitter ***Shall*** meet the specifications defined in Table 5-18.

Table 5-18 BMC Transmitter Normative Requirements

Name	Description	Min	Nom	Max	Units	Comment
pBitRate	Maximum difference between the bit-rate during the part of the packet following the Preamble and the reference bit-rate.			0.25	%	The reference bit rate is the average bit rate of the last 32 bits of the Preamble.
rFRSwapTx	Fast Role Swap request transmit driver resistance (excluding cable resistance)			5	Ω	Maximum driver resistance of a Fast Role Swap request transmitter. Assumes a worst case cable resistance of 15Ω as defined in ***[USB Type-C 1.2]***. Note: based on this value the maximum combined driver and cable resistance of a Fast Role Swap request transmitter is 20Ω.
tEndDriveBMC	Time to cease driving the line after the end of the last bit of the Frame.			23	µs	Min value is limited by ***tHoldLowBMC***.
tFall	Fall Time	300			ns	10 % and 90 % amplitude points, minimum is under an unloaded condition.
tHoldLowBMC	Time to cease driving the line after the final high-to-low transition.	1			µs	Max value is limited by ***tEndDriveBMC***.
tInterFrameGap	Time from the end of last bit of a Frame until the start of the first bit of the next Preamble.	25			µs	
tFRSwapTx	Fast Role Swap request transmit duration	60		120	µs	Fast Role Swap request is indicated from the initial Source to the initial Sink by driving CC low for this time.
tRise	Rise time	300			ns	10 % and 90 % amplitude points, minimum is under an unloaded condition.
tStartDrive	Time before the start of the first bit of the Preamble when the transmitter ***Shall*** start driving the line.	-1		1	µs	
vSwing	Voltage Swing	1.05	1.125	1.2	V	Applies to both no load condition and under the load condition specified in Section 5.8.3.
zDriver	Transmitter output impedance	33		75	Ω	Source output impedance at the Nyquist frequency of ***[USB 2.0]*** low speed (750 kHz) while the source is driving the CC line.

5.8.5.1 Capacitance when not transmitting

cReceiver is the capacitance that a DFP or UFP ***Shall*** present on the CC line when the DFP or UFP's receiver is not transmitting on the line. The transmitter ***May*** have more capacitance than ***cReceiver*** while driving the CC line, but

Shall meet the waveform mask requirements. Once transmission is complete, the transmitter ***Shall*** disengage capacitance in excess of ***cReceiver*** from the CC wire within ***tInterFrameGap***.

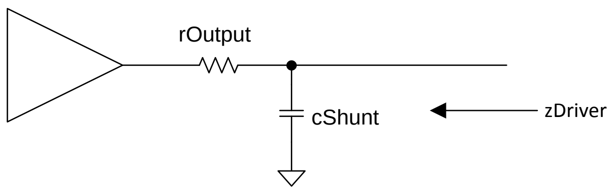
5.8.5.2 Source Output Impedance

Source output impedance ***zDriver*** is determined by the driver resistance and the shunt capacitance of the source and is hence a frequency dependent term. ***zDriver*** impacts the noise ingression in the cable. It is specified such that the noise at the Receiver is bounded.

zDriver is defined by the following equation:

$$zDriver = \frac{rOutput}{1 + s * rOutput * cShunt}$$

Figure 5-25 Transmitter diagram illustrating zDriver



cShunt ***Shall Not*** cause a violation of ***cReceiver*** when not transmitting.

5.8.5.3 Bit Rate Drift

Limits on the drift in ***fBitRate*** are set in order to help low-complexity receiver implementations.

fBitRate is the reciprocal of the average bit duration from the previous 32 bits at a given portion of the packet. The change in ***fBitRate*** during a packet ***Shall*** be less than ***pBitRate***. The reference bit rate (refBitRate) is the average ***fBitRate*** over the last 32 bits of the Preamble. ***fBitRate*** throughout the packet, including the ***EOP***, ***Shall*** be within ***pBitRate*** of refBitRate. ***pBitRate*** is expressed as a percentage:

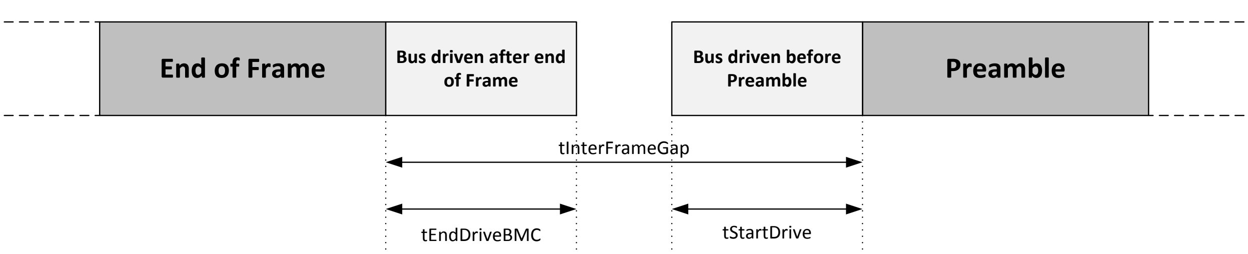
pBitRate = **|** ***fBitRate*** – refBitRate **|** / refBitRate x 100%

The transmitter ***Shall*** have the same ***pBitRate*** for all packet types. The ***BIST Carrier Mode*** and Bit Stream signals are continuous signals without a payload. When checking ***pBitRate*** any set of 1044 bits (20 bit ***SOP*** followed by 1024 PRBS bits) within a continuous signal ***May*** be considered as the part of the packet following the Preamble and the 32 preceding bits considered to be the last 32 bits of the Preamble used to compute refBitRate .

5.8.5.4 Inter-Frame Gap

Figure 5-26 illustrates the inter-Frame gap timings.

Figure 5-26 Inter-Frame Gap Timings



The transmitter ***Shall*** drive the bus for no longer than ***tEndDriveBMC*** after transmitting the final bit of the Frame.

Before starting to transmit the next Frame's Preamble the transmitter of the next Frame ***Shall*** ensure that it waits for ***tInterFrameGap*** after either:

1. Transmitting the previous frame, for example sending the next Message in an AMS immediately after having sent a ***GoodCRC*** Message, or
2. Receiving the previous frame, for example when responding to a received Message with a ***GoodCRC*** Message, or
3. Observing an idle condition on CC (see Section 5.7). In this case the Port is waiting to initiate an AMS observes idle (see Section 5.8.6.1) and then waits ***tInterFrameGap*** before transmitting the Frame. See also Section 5.7 for details on when an AMS can be initiated.

Note: the transmitter is also required to verify a bus idle condition immediately prior to starting transmission of the next Frame (see Section 5.8.6.1).

The transmitter of the next Frame ***May*** vary the start of the Preamble by ***tStartDrive*** (see Section 5.8.1).

See also Section 5.8.1 for figures detailing the timings relating to transmitting, receiving and observing idle in relating to Frames.

5.8.5.5 Shorting of Transmitter Output

A Transmitter in a Port or Cable Plug ***Shall*** tolerate having its output be shorted to ground for ***tFRSwapTx*** max. This is due to the potential for Fast Role Swap to be signaled while the Transmitter is in the process of transmitting (see Section 5.8.5.6).

5.8.5.6 Fast Role Swap Transmission

The Fast Role Swap process is intended for use by a PDUSB HUB that presently has an external wall supply, and is providing power both through its downstream Ports to USB Devices and upstream to a USB Host such as a notebook. On removal of the external wall supply Fast Role Swap enables a V_{BUS} supply to be maintained by allowing the USB Host to apply ***vSafe5V*** when it sees V_{BUS} droop below ***vSafe5V*** after having detected Fast Role Swap signaling. The Fast Role Swap AMS is then used to correctly assign Source/Sink roles and configure the Rp/Rd resistors (see Section 8.3.2.7).

The initial Source ***Shall*** signal a Fast Role Swap request by driving CC to ground with a resistance of less than ***rFRSwapTx*** for ***tFRSwapTx***. The initial Source ***Shall*** only signal a Fast Role Swap when it has an Explicit Contract. On transmission of the Fast Role Swap signal any pending Messages ***Shall*** be ***Discarded*** (see Section 6.11.2.2.1).

The Fast Role Swap signal ***May*** override any active transmissions.

Since the initial Sink's response to the Fast Role Swap signal is to send an ***FR_Swap*** Message, the initial Source ***Shall*** ensure Rp is set to ***SinkTxOk*** once the Fast Role Swap signal is complete.

5.8.6 BMC Receiver Specifications

The receiver ***Shall*** meet the specifications defined in Table 5-19.

Table 5-19 BMC Receiver Normative Requirements

Name	Description	Min	Nom	Max	Units	Comment
cReceiver	CC receiver capacitance	200		600	pF	The DFP or UFP system ***Shall*** have capacitance within this range when not transmitting on the line.
nBER	Bit error rate, S/N = 25 dB			10^{-6}		
nTransitionCount	Transitions for signal detect	3				Number of transitions to be detected to declare bus non-idle.

Name	Description	Min	Nom	Max	Units	Comment
tFRSwapRx	Fast Role Swap request detection time	30		50	µs	A Fast Role Swap request results in the receiver detecting a signal low for at least this amount of time.
tRxFilter	Rx bandwidth limiting filter (digital or analog)	100			ns	Time constant of a single pole filter to limit broad-band noise ingression[1].
tTransitionWindow	Time window for detecting non-idle	12		20	µs	
vFRSwapCableTx	Fast Role Swap request voltage detection threshold	490	520	550	mV	The Fast Role Swap request has to be below this voltage threshold to be detected.
vIRDropGNDC	Cable Ground IR Drop			250	mV	As specified in ***[USB Type-C 1.2]***
vNoiseActive	Noise amplitude when BMC is active.			165	mV	Peak-to-peak noise from V_{BUS}, USB 2.0 and SBU lines after the Rx bandwidth limiting filter with the time constant ***tRxFilter*** has been applied.
vNoiseIdle	Noise amplitude when BMC is idle.			300	mV	Peak-to-peak noise from V_{BUS}, USB 2.0 and SBU lines after the Rx bandwidth limiting filter with the time constant ***tRxFilter*** has been applied.
zBmcRx	Receiver Input Impedance	1			MΩ	
Note 1: Broad-band noise ingression is due to coupling in the cable interconnect.						

5.8.6.1 Definition of Idle

BMC packet collision is avoided by the detection of signal transitions at the receiver. This is the equivalent of squelch for FSK modulation. Detection is active when ***nTransitionCount*** transitions occur at the receiver within a time window of ***tTransitionWindow***. After waiting ***tTransitionWindow*** without detecting ***nTransitionCount*** transitions the bus ***Shall*** be declared idle.

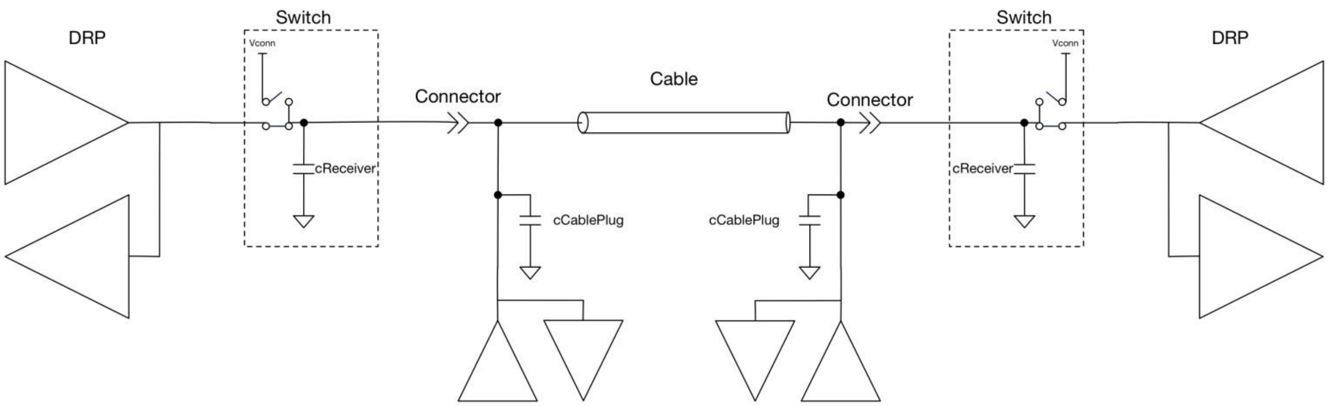
Refer to Section 5.8.5.4 for details of when transmissions ***May*** start.

5.8.6.2 Multi-Drop

The BMC Signaling Scheme is suitable for use in Multi-Drop configurations containing one or two BMC Multi-Drop transceivers connected to the CC wire, for example where one or both ends of a cable contains a Multi-Drop transceiver. In this specification the location of the Multi-Drop transceiver is referred to as the Cable Plug.

Figure 5-27 below illustrates a typical Multi Drop configuration with two DRPs.

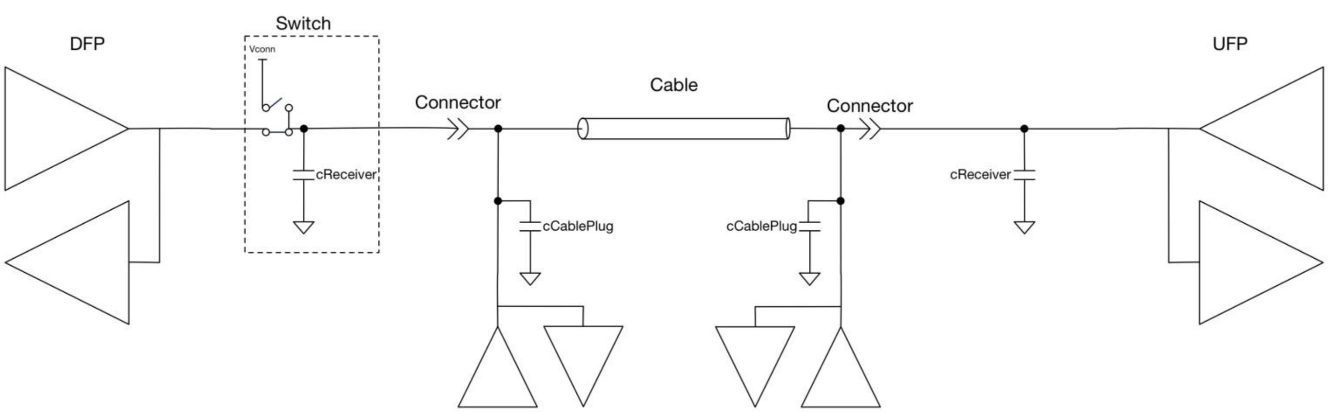
Figure 5-27 Example Multi-Drop Configuration showing two DRPs



The Multi-Drop transceiver ***Shall*** obey all the electrical characteristics specified in this section except for those relating to capacitance. The maximum capacitance allowed for the Multi-Drop node when not driving the line is *cCablePlug_CC* defined in ***[USB Type-C 1.2]*** . There are no constraints as to the distance of the Multi-Drop transceiver from the end of the plug. The Multi-Drop transceiver(s) ***May*** be located anywhere along the cable including the plugs. The Multi-Drop transceiver suffers less from ground offset compared to the transceivers in the host or device and contributes no significant reflections.

It is possible to have a configuration at Attach where one Port is able to be a Vconn Source and the other Port is not able to be a Vconn Source, such that there is no switch in the second Port. An example of a DFP with a switch Attached to a UFP without a switch is outlined in Figure 5-28. The capacitance on the CC line for a Port not able to be a VCONN Source ***Shall*** still be within ***cReceiver*** except when transmitting.

Figure 5-28 Example Multi-Drop Configuration showing a DFP and UFP



5.8.6.3 Fast Role Swap Detection

An initial Sink prepares for a Fast Role Swap by ensuring that once it has detected the Fast Role Swap signal its power supply is ready to respond by applying ***vSafe5V*** according to the timing detailed in Section 7.1.13. The initial Sink ***Shall*** only respond to the Fast Role Swap signal when it has an Explicit Contract. On detection of the Fast Role Swap signal any pending Messages ***Shall*** be ***Discarded*** (see Section 6.11.2.2.1).

When the initial Sink is prepared for a Fast Role Swap and the bus is idle the CC voltage averaged over ***tFRSwapRx*** min remains above 0.7V (see ***[USB Type-C 1.2]***) since the Source Rp is either 1.5A or 3.0A. However ***vNoiseIdle*** noise ***May*** cause the CC line voltage to reach 0.7V-***vNoiseIdle***/2 for short durations. When the initial Sink is prepared for a Fast Role swap while it is transmitting and the initial Source is signaling a Fast Role swap request, the transmission will be attenuated such that the peak CC voltage will not exceed ***vFRSwapCableTx*** min. Therefore, when the initial

Sink is prepared for a Fast Role Swap, it ***Shall Not*** detect a Fast Swap signal when the CC voltage, averaged over ***tFRSwapRx*** min, is above 0.7V. When the initial Sink is prepared for a Fast Role Swap, it ***Shall*** detect a CC voltage lower than ***vFRSwapCableTx*** min for ***tFRSwapRx*** as a Fast Role Swap request. Note: the initial Sink is not required to average the CC voltage to meet these requirements.

The initial Sink ***Shall*** initiate the Fast Role Swap AMS within ***tFRSwapInit*** of detecting the Fast Role Swap request in order to assign the Rp/Rd resistors to the correct Ports and to re-synchronize the state machines (see Section 6.3.17).

The initial Sink ***Shall*** become the new Source and ***Shall*** start supplying ***vSafe5V*** at USB Type-C Current (see ***[USB Type-C 1.2]***) no later than ***tSrcFRSwap*** after V_{BUS} has dropped below ***vSafe5V***. An initial Sink ***Shall*** disable its V_{BUS} Disconnect Threshold detection circuitry while Fast Role Swap detection is active.

Note: while power is transitioning the VCONN Source to the Cable Plug(s) cannot be guaranteed.

5.9 Built in Self-Test (BIST)

The following sections define BIST functionality which ***Shall*** be supported.

5.9.1 BIST Carrier Mode

In ***BIST Carrier Mode***, the Physical Layer ***Shall*** send out a BMC encoded continuous string of alternating "1"s and "0"s. This enables the measurement of power supply noise and frequency drift.

Note that this transmission is a purely a sequence of alternating bits and ***Shall Not*** be formatted as a Packet.

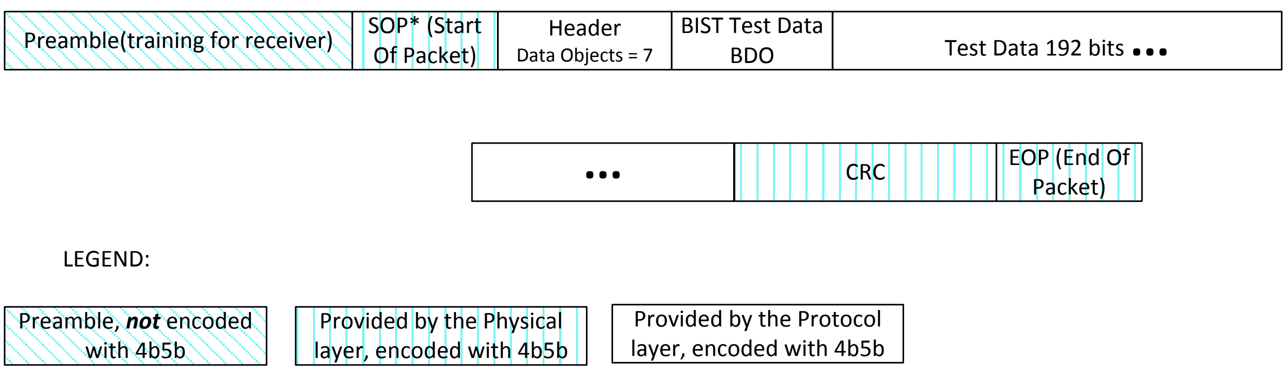
See also Section 6.4.3.

5.9.2 BIST Test Data

A ***BIST Test Data*** Message is used by the Tester to send various Tester generated test patterns to the UUT in order to test the UUT's receiver. See also Section 6.4.3.

Figure 5-29 shows the Test Data Frame which ***Shall*** be sent by the Tester to the UUT. The ***BIST*** Message, with a ***BIST Test Data*** BIST Data Object consists of a Preamble, followed by ***SOP****, followed by the Message Header with a data length of 7 Data Objects, followed a ***BIST Test Data*** BIST Data Object, followed by 6 Data Objects containing Test data, followed by the CRC and then an ***EOP***.

Figure 5-29 Test Data Frame



6. Protocol Layer

6.1 Overview

This chapter describes the requirements of the USB Power Delivery Specification's protocol layer including:

- Details of how Messages are constructed and used.
- Use of timers and timeout values.
- Use of Message and retry counters.
- Reset operation.
- Error handling.
- State behavior.

Refer to Section 2.6 for an overview of the theory of operation of USB Power Delivery.

6.2 Messages

This specification defines three types of Messages:

- Control Messages that are short and used to manage the Message flow between Port Partners or to exchange Messages that require no additional data. Control Messages are 16 bits in length.
- Data Messages that are used to exchange information between a pair of Port Partners. Data Messages range from 48 to 240 bits in length.
  - There are three types of Data Messages:
    - Those used to expose capabilities and negotiate power
    - Those used for the BIST
    - Those that are Vendor Defined
- Extended Messages that are used to exchange information between a pair of Port Partners. Extended Messages are up to ***MaxExtendedMsgLen*** bytes.
  - There are several types of Extended Messages:
    - Those used for Source and Battery information
    - Those used for Security
    - Those used for Firmware Update
    - Those that are vendor defined

6.2.1 Message Construction

All Messages ***Shall*** be composed of a Message Header and a variable length (including zero) data portion. A Message either originates in the Protocol Layer and is passed to the Physical Layer, or it is received by the Physical Layer and is passed to the Protocol Layer.

Figure 6-1 illustrates a Control Message as part of a Packet showing the parts are provided by the Protocol and PHY Layers.

Figure 6-1 USB Power Delivery Packet Format including Control Message Payload

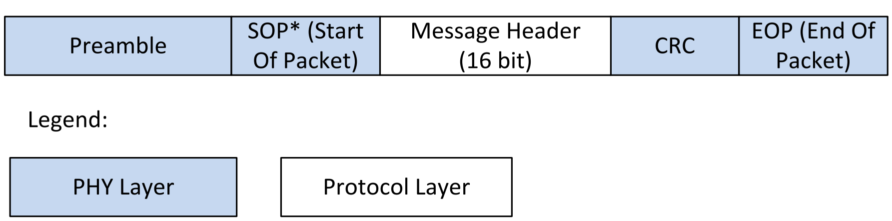


Figure 6-2 illustrates a Data Message as part of a Packet showing the parts are provided by the Protocol and PHY Layers.

Figure 6-2 USB Power Delivery Packet Format including Data Message Payload

Preamble	SOP* (Start Of Packet)	Message Header (16 bit)	0..7 Data Object(s)	CRC	EOP (End Of Packet)

Legend:

PHY Layer

Protocol Layer

Figure 6-3 illustrates an Extended Message as part of a Packet showing the parts are provided by the Protocol and PHY Layers.

Figure 6-3 USB Power Delivery Packet Format including an Extended Message Header and Payload

Preamble	SOP* (Start Of Packet)	Message Header (16 bit)	Extended Message Header (16 bit)	Data (0..260 bytes)	CRC	EOP (End Of Packet)

Legend:

PHY Layer

Protocol Layer

6.2.1.1 Message Header

Every Message ***Shall*** start with a Message Header as shown in Figure 6-1, Figure 6-2 and Figure 6-3 and as defined in Table 6 1. The Message Header contains basic information about the Message and the PD Port Capabilities.

The Message Header ***May*** be used standalone as a Control Message when the Number of Data Objects field is zero or as the first part of a Data Message when the ***Number of Data Objects*** field is non-zero.

Table 6-1 Message Header

Bit(s)	Start of Packet	Field Name	Reference
15	SOP*	***Extended***	Section 6.2.1.1.1
14…12	SOP*	***Number of Data Objects***	Section 6.2.1.1.2
11…9	SOP*	***MessageID***	Section 6.2.1.1.3
8	SOP only	***Port Power Role***	Section 6.2.1.1.4
	SOP'/SOP''	***Cable Plug***	Section 6.2.1.1.7
7…6	SOP*	***Specification Revision***	Section 6.2.1.1.5
5	SOP only	***Port Data Role***	Section 6.2.1.1.6
	SOP'/SOP''	***Reserved***	Section 1.4.2.10
4…0	SOP*	***Message Type***	Section 6.2.1.1.8

6.2.1.1.1 Extended

The 1-bit ***Extended*** field ***Shall*** be set to zero to indicate a Control Message or Data Message and set to one to indicate an Extended Message.

The ***Extended*** field ***Shall*** apply to all SOP* Packet types.

6.2.1.1.2 Number of Data Objects

When the ***Extended*** field is set to zero the 3-bit ***Number of Data Objects*** field ***Shall*** indicate the number of 32-bit Data Objects that follow the Message Header. When this field is zero the Message is a Control Message and when it is non-zero, the Message is a Data Message.

The ***Number of Data Objects*** field ***Shall*** apply to all SOP* Packet types.

When both the ***Extended*** bit and ***Chunked*** bit are set to one, the ***Number of Data Objects*** field ***Shall*** indicate the number of Data Objects in the Message padded to the 4-byte boundary including the Extended Header as part of the first Data Object.

When the ***Extended*** bit is set to one and ***Chunked*** bit is set to zero, the ***Number of Data Objects*** field ***Shall*** be ***Reserved***. Note that in this case, the message length is determined solely by the ***Data Size*** field in the Extended Message Header.

6.2.1.1.3 MessageID

The 3-bit ***MessageID*** field is the value generated by a rolling counter maintained by the originator of the Message. The ***MessageIDCounter Shall*** be initialized to zero at power-on as a result of a Soft Reset, or a Hard Reset. The ***MessageIDCounter Shall*** be incremented when a Message is successfully received as indicated by receipt of a ***GoodCRC*** Message. Note: the usage of ***MessageID*** during testing with BIST Messages is defined in ***[USBPDCompliance]***.

The ***MessageID*** field ***Shall*** apply to all SOP* Packet types.

6.2.1.1.4 Port Power Role

The 1-bit ***Port Power Role*** field ***Shall*** indicate the Port's present power role:

- 0b Sink
- 1b Source

Messages, such as ***Ping***, and ***GotoMin***, that are only ever sent by a Source, ***Shall*** always have the ***Port Power Role*** field set to Source. Similarly Messages such as the ***Request*** Message that are only ever sent by a Sink ***Shall*** always have the ***Port Power Role*** field set to Sink.

During the Power Role Swap Sequence, for the initial Source Port, the ***Port Power Role*** field ***Shall*** be set to Sink in the ***PS_RDY*** Message indicating that the initial Source's power supply is turned off (see Figure 8-6 and Figure 8-7).

During the Power Role Swap Sequence, for the initial Sink Port, the ***Port Power Role*** field ***Shall*** be set to Source for Messages initiated by the Policy Engine after receiving the ***PS_RDY*** Message from the initial Source (see Figure 8-6 and Figure 8-7).

During the Fast Role Swap Sequence, for the initial Source Port, the ***Port Power Role*** field ***Shall*** be set to Sink in the ***PS_RDY*** Message indicating that V_{BUS} is not being driven by the initial Source and is within ***vSafe5V*** (see Figure 8-13).

During the Fast Role Swap Sequence, for the initial Sink Port, the ***Port Power Role*** field ***Shall*** be set to Source for Messages initiated by the Policy Engine after receiving the ***PS_RDY*** Message from the initial Source (see Figure 8-13).

Note that the ***GoodCRC*** Message sent by the initial Sink in response to the ***PS_RDY*** Message from the initial Source will have its ***Port Power Role*** field set to Sink since this is initiated by the Protocol Layer. Subsequent Messages initiated by the Policy Engine, such as the ***PS_RDY*** Message sent to indicate that V_{BUS} is ready, will have the ***Port Power Role*** field set to Source.

The ***Port Power Role*** field of a received Message ***Shall Not*** be verified by the receiver and ***Shall Not*** lead to Soft Reset, Hard Reset or Error Recovery if it is incorrect.

The ***Port Power Role*** field ***Shall*** only be defined for SOP Packets.

6.2.1.1.5 Specification Revision

The ***Specification Revision*** field ***Shall*** be one of the following values (except 11b):

- 00b –Revision 1.0
- 01b –Revision 2.0
- 10b – Revision 3.0
- 11b – ***Reserved***, ***Shall Not*** be used

To ensure interoperability with existing USBPD Products, USBPD Products ***Shall*** support every PD Specification Revision starting from ***[USBPD 2.0]***.

The 2-bit ***Specification Revision*** field of a ***GoodCRC*** Message does not carry any meaning and ***Shall*** be considered as don't care by the recipient of the Message. The sender of a ***GoodCRC*** Message ***Should*** set the ***Specification Revision*** field to 00b.

The ***Specification Revision*** field ***Shall*** apply to all SOP* Packet types.

When the Source Port first communicates with the Sink Port the ***Specification Revision*** field ***Shall*** be used as described by the following steps:

1. The Source Port sends a ***Source_Capabilities*** Message to the Sink Port setting the ***Specification Revision*** field to the highest Revision of the Power Delivery Specification the Source Port supports.
2. The Sink Port responds with a ***Request*** Message setting the ***Specification Revision*** field to the highest Revision of the Power Delivery Specification the Sink Port supports that is equal to or lower than the ***Specification Revision*** received from the Source Port.
3. The Source and Sink Ports ***Shall*** use the ***Specification Revision*** in the ***Request*** Message from the Sink in step 2 in all subsequent communications until they are Detached.

When a VCONN Source first communicates with a Cable Plug the ***Specification Revision*** field ***Shall*** be used as described by the following steps:

1. The VCONN Source sends a ***Discover Identity*** REQ to the Cable Plug (SOP') setting the ***Specification Revision*** field in the Message to the highest Revision of the Power Delivery Specification the VCONN Source supports. After a VCONN Swap the required ***Soft_Reset*** / ***Accept*** message exchange is used for the same purpose (see Section 6.3.13).
2. The Cable Plug responds with a ***Discover Identity*** ACK setting the ***Specification Revision*** field in the Message to the highest Revision of the Power Delivery Specification the VCONN Source supports that is equal to or lower than the ***Specification Revision*** it received from the Source Port.
3. The Cable Plug and VCONN Source ***Shall*** communicate using the lower of the two revisions until an Explicit Contract has been established.
4. Table 6-2 shows the ***Specification Revision*** that ***Shall*** be used between the Port Partners and the Cable Plugs when the ***Specification Revision*** has been discovered and an Explicit Contract is in place.

Note: when a Cable Plug does not respond to a Revision 3.0 ***Discover Identity*** REQ with a ***Discover Identity*** ACK or BUSY the VCONN Source ***May*** repeat steps 1-4 using a Revision 2.0 ***Discover Identity*** REQ in step 1 before establishing that there is no Cable Plug to communicate with.

A VCONN Source that supports Revision 3.0 of the Power Delivery Specification ***May*** communicate with a Cable Plug also supporting Revision 3.0 using Revision 3.0 Compliant Communications regardless of the ***Specification Revision*** of its Port Partner until it enters an Explicit Contract. After the Explicit Contract has been established the Port Partners and Cable Plug(s) ***Shall*** use Table 6-2 to determine the Revision to be used.

All data in all Messages ***Shall*** be consistent with the ***Specification Revision*** field in the Message Header for that particular Message.

A Cable Plug ***Shall Not*** save the state of the agreed ***Specification Revision***. A Cable Plug ***Shall*** respond with the highest ***Specification Revision*** it supports that is equal to or lower than the ***Specification Revision*** contained in the Message received from the VCONN Source.

Cable Plugs ***Shall*** operate using the same Specification Revision for both SOP' and SOP''. Cable assemblies with two Cable Plugs ***Shall*** operate using the same Specification Revision for both Cable Plugs.

See Table 6-2 for details of how various Revisions ***Shall*** interoperate.

Table 6-2 Revision Interoperability during an Explicit Contract

Port 1 Revision	Cable Plug Revision	Port 2 Revision	Port to Port operating Revision	Port to Cable Plug operating Revision
2	2	2	2	2
2	2	3	2	2
3	2	3	3	2
2	3	2	2	2
2	3	3	2	2
3	3	2	2	2
3	3	3	3	3

6.2.1.1.6 Port Data Role

The 1-bit ***Port Data Role*** field ***Shall*** indicate the Port's present data role:

- 0b UFP
- 1b DFP

The ***Port Data Role*** field ***Shall*** only be defined for SOP Packets. For all other SOP* Packets the ***Port Data Role*** field is ***Reserved*** and ***Shall*** be set to zero.

Should a USB Type-C Port receive a Message with the ***Port Data Role*** field set to the same Data Role as its current Data Role, except for the ***GoodCRC*** Message, USB Type-C Error Recovery actions as defined in ***[USB Type-C 1.2]*** ***Shall*** be performed.

For a USB Type-C Port the ***Port Data Role*** field ***Shall*** be set to the default value at Attachment after a Hard Reset: 0b for a Port with Rd asserted and 1b for a Port with Rp asserted.

In the case that a Port is not USB Communications Capable, at Attachment a Source Port ***Shall*** default to DFP and a Sink Port ***Shall*** default to UFP.

6.2.1.1.7 Cable Plug

The 1-bit ***Cable Plug*** field ***Shall*** indicate whether this Message originated from a Cable Plug:

- 0b Message originated from a DFP or UFP
- 1b Message originated from a Cable Plug

The ***Cable Plug*** field ***Shall*** only apply to SOP' and SOP'' Packet types.

6.2.1.1.8 Message Type

The 5-bit ***Message Type*** field ***Shall*** indicate the type of Message being sent. To fully decode the ***Message Type***, the ***Number of Data Objects*** field is first examined to determine whether the Message is a Control Message or a Data Message. Then the specific ***Message Type*** can be found in Table 6-5 (Control Message) or Table 6-6 (Data Message).

The ***Message Type*** field ***Shall*** apply to all SOP* Packet types.

6.2.1.2 Extended Message Header

Every Extended Message (indicated by the ***Extended*** field being set in the Message Header) ***Shall*** contain an Extended Message Header following the Message Header as shown in Figure 6-3 and defined in Table 6-3.

The Extended Message Header is used to support Extended Messages containing Data Blocks of ***Data Size*** either sent in a single Message or as a series of Chunks. When the Data Block is sent as a series of Chunks, each Chunk in the series, except for the last Chunk, ***Shall*** contain ***MaxExtendedMsgChunkLen*** bytes. The last Chunk in the series ***Shall*** contain the remainder of the Data Block and so could be less than ***MaxExtendedMsgChunkLen*** bytes and ***Shall*** be padded to the next 4-byte Data Object boundary.

Table 6-3 Extended Message Header

Bit(s)	Start of Packet	Field Name	Reference
15	SOP*	***Chunked***	Section 6.2.1.2.1
14…11	SOP*	***Chunk Number***	Section 6.2.1.2.2
10	SOP*	***Request Chunk***	Section 6.2.1.2.3
9	SOP*	***Reserved***	Section 1.4.2.10
8…0	SOP*	***Data Size***	Section 6.2.1.2.4

6.2.1.2.1 Chunked

The Port Partners ***Shall*** use the Unchunked Extended Messages Supported fields in the ***Source_Capabilities*** Message and the ***Request*** Message to determine whether to send Messages of Data Size > ***MaxExtendedMsgLegacyLen*** bytes in a single Unchunked Extended Message (see Section 6.4.1.2.2.6 and Section 6.4.2.6).

When either Port Partner only supports Chunked Extended Messages:

1. The ***Chunked*** bit in every Extended Message ***Shall*** be set to one
2. Every Extended Message of Data Size > ***MaxExtendedMsgLegacyLen*** ***Shall*** be transmitted between the Port Partners in Chunks
3. The ***Number of Data Objects*** in the Message Header ***Shall*** indicate the number of Data Objects in the Message padded to the 4-byte boundary including the Extended Header as part of the first Data Object.
4. Point 1, Point 2 and Point 3 above ***Shall*** apply until the Port Pair is Detached, there is a Hard Reset or the Source removes power (except during a Power Role Swap or Fast Role Swap when the initial Source removes power in order to for the new Source to apply power).

When both Port Partners support Unchunked Extended Messages:

1. The ***Chunked*** bit in every Extended Message ***Shall*** be set to zero.
2. Every Extended Message ***Shall*** be transmitted between the Port Partners Unchunked
3. The ***Number of Data Objects*** in the Message Header is ***Reserved***.
4. Point 1, Point 2 and Point 3 above ***Shall*** apply until the Port Pair is Detached, there is a Hard Reset or the Source removes power (except during a Power Role Swap or Fast Role Swap when the initial Source removes power in order to for the new Source to apply power).

When sending Extended Messages to the Cable Plug the VCONN Source ***Shall*** only send Chunked Messages. Cable Plugs ***Shall*** always send Extended Messages of Data Size > ***MaxExtendedMsgLegacyLen*** Chunked and ***Shall*** set the ***Chunked*** bit in every Extended Message to one.

When Extended Messages are supported Chunking ***Shall*** be supported.

6.2.1.2.2 Chunk Number

The ***Chunk Number*** field ***Shall*** only be ***Valid*** in a Message if the ***Chunked*** flag is set to one. if the ***Chunked*** flag is set to zero the ***Chunk Number*** field ***Shall*** also be set to zero.

The ***Chunk Number*** field is used differently depending on whether the Message is a request for Data or a requested Data Block being returned:

In a request for data the ***Chunk Number*** field indicates the number of the Chunk being requested. The requestor ***Shall*** only set this field to one of the following values:

- Zero to request the first Chunk in the series
- The number of the last received Chunk in the series
- The number of the next Chunk in the series (the next Chunk after the last received Chunk)

In the requested Data Block the ***Chunk Number*** field indicates the number of the Chunk being returned. The Chunk number for each Chunk in the series ***Shall*** start at zero and ***Shall*** increment for each Chunk by one up to a maximum of 9 corresponding to 10 Chunks in total.

6.2.1.2.3 Request Chunk

The ***Request Chunk*** bit ***Shall*** only be used for the Chunked transfer of an Extended Message when the ***Chunked*** bit is set to 1 (see Figure 6-7). For Unchunked Extended Message transfers Messages ***Shall*** be sent and received without the request/response mechanism (see Figure 6-4).

The ***Request Chunk*** bit ***Shall*** be set to one to indicate that this is a request for a Chunk of a Data Block and ***Shall*** be set to zero to indicate that this is a Chunk response containing a Chunk. Except for Chunk zero, a requested Chunk of a Data Block ***Shall*** only be returned as a Chunk response to a corresponding request for that Chunk. Both the Chunk request and the Chunk response ***Shall*** contain the same value in the ***Message Type*** field. When the ***Request Chunk*** bit is set to one the ***Data Size*** field ***Shall*** be zero.

6.2.1.2.4 Data Size

The ***Data Size*** field ***Shall*** indicate how many bytes of data in total are in Data Block being returned. The total number of data bytes in the Message ***Shall Not*** exceed ***MaxExtendedMsgLen***.

If the ***Data Size*** field is less than ***MaxExtendedMsgLegacyLen*** and the ***Chunked*** bit is set then the Packet payload ***Shall*** be padded to the next 4-byte Data Object boundary with zeros (0x00).

If the ***Data Size*** field is greater than expected for a given Extended Message but less than or equal to ***MaxExtendedMsgLen*** then the expected fields in the Message ***Shall*** be processed appropriately and the additional fields ***Shall*** be ***Ignored***.

6.2.1.2.5 Extended Message Examples

The following examples illustrate the transmission of Extended Messages both Chunked (***Chunked*** bit is one) and Unchunked (***Chunked*** bit is zero). The examples use a ***Security_Request*** Message of ***Data Size*** 7 bytes which is responded to by a ***Security_Response*** Message of ***Data Size*** 30 bytes. The sizes of these Messages are arbitrary and are used to illustrate Message transmission; they are not intended to correspond to genuine security related Messages.

During negotiation of the Explicit Contract after connection, the Port Partners use the Unchunked Extended Messages Supported fields in the ***Source_Capabilities*** Message and the ***Request*** Message to determine the value of the ***Chunked*** bit (see Table 6-4). When both Port Partners support Unchunked Messages then the ***Chunked*** bit is zero otherwise the ***Chunked*** bit is one.

The ***Chunked*** bit is used to determine whether or not:

- The Chunk request/response mechanism is used
- Extended Messages are Chunked
- Padding is applied
- The ***Number of Data Objects*** field is used

The following examples illustrate the expected usage in each case.

Table 6-4 Use of Unchunked Message Supported bit

		Source: ***Source_Capabilities*** Message	
		Unchunked Message Supported bit = 0	Unchunked Message Supported bit = 1
Sink: ***Request*** Message	Unchunked Message Supported bit = 0	***Chunked*** bit = 1	***Chunked*** bit = 1
	Unchunked Message Supported bit = 1	***Chunked*** bit = 1	***Chunked*** bit = 0

6.2.1.2.5.1 Security_Request/Security_Response Unchunked Example

Figure 6-4 illustrates a typical sequence for a ***Security_Request*** Message responded to by a ***Security_Response*** Message using Unchunked Extended Messages (***Chunked*** bit is zero) between a USB Host and a power brick. The entire Data Block is returned in one Message. The Chunk request/response mechanism is not used.

Figure 6-4 Example Security_Request sequence Unchunked (Chunked bit = 0)

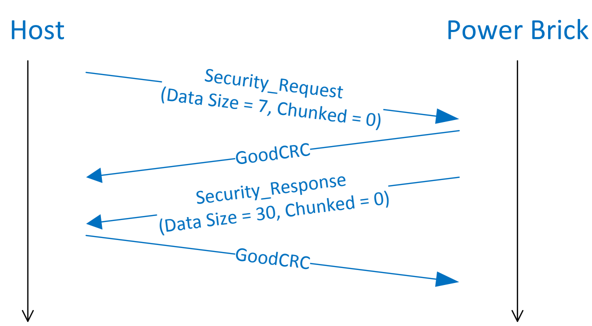


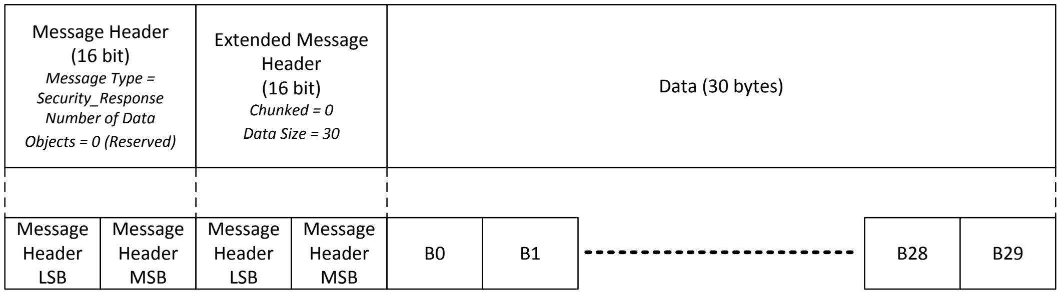
Figure 6-5 details the ***Security_Request*** Message shown in Figure 6-4. The figure shows the byte ordering on the bus as well as the fact that there is no padding in this case. The ***Number of Data Objects*** field has a value of 0 since it is ***Reserved*** when the ***Chunked*** bit is zero. The ***Data Size field*** indicates the length of the Extended Message when the ***Chunked*** bit is set to 0, which in this case is 7 bytes.

Figure 6-5 Example byte transmission for Security_Request Message of Data Size 7 (Chunked bit is set to 0)

Message Header (16 bit) *Message Type = Security_Request Number of Data Objects = 0 (Reserved)*		Extended Message Header (16 bit) *Chunked = 0 Data Size = 7*		Data (7 bytes)						
Message Header LSB	Message Header MSB	Message Header LSB	Message Header MSB	B0	B1	B2	B3	B4	B5	B6

Figure 6-6 details the ***Security_Response*** Message shown in Figure 6-4. The figure shows the byte ordering on the bus as well as the fact that there is no padding in this case. The ***Number of Data Objects*** field has a value of 0 since it is ***Reserved*** when the ***Chunked*** bit is zero. The ***Data Size field*** indicates the length of the Extended Message when the ***Chunked*** bit is set to 0, which in this case is 30 bytes.

Figure 6-6 Example byte transmission for Security_Response Message of Data Size 7 (Chunked bit is set to 0)



6.2.1.2.5.2 Security_Request/Security_Response Chunked Example

Figure 6-7 illustrates a typical sequence for a ***Security_Request*** Message responded to by a ***Security_Response*** Message using Chunked Extended Messages (***Chunked*** bit is one) between a USB Host and a power brick. Note that ***Chunk Number*** zero in every Extended Message is sent without the need for a Chunk Request, but ***Chunk Number*** one and following need to be requested with a Chunk request.

Figure 6-7 Example Security_Request sequence Chunked (Chunked bit = 1)

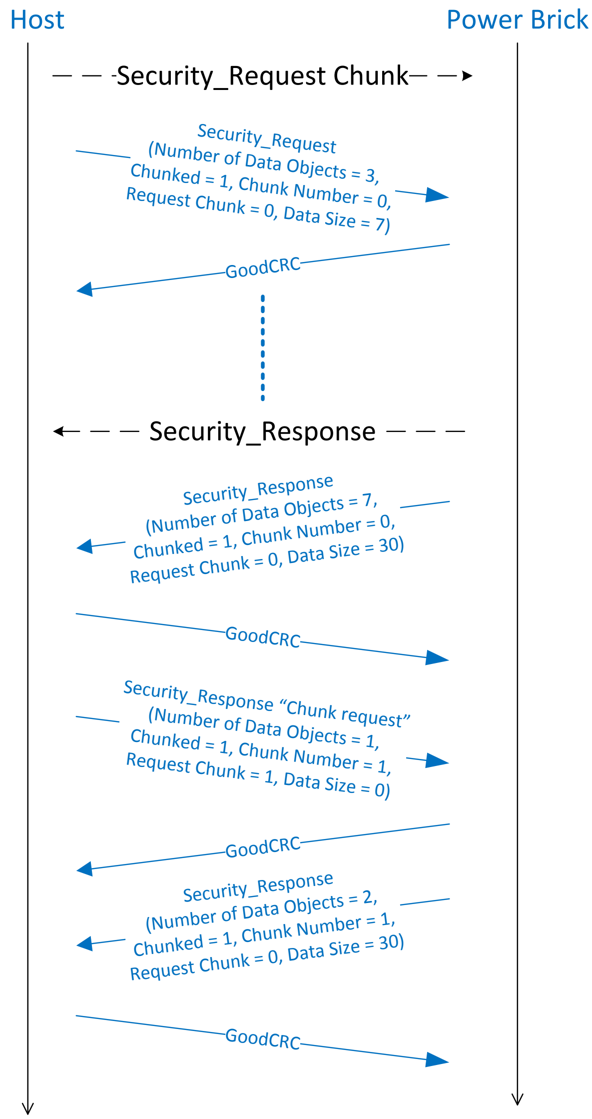


Figure 6-8 shows the ***Security_Request*** Message shown in Figure 6-7 in more detail including the byte ordering on the bus and padding. Three bytes of padding have been added to the Message so that the total number of bytes is a multiple of 32-bits, corresponding to 3 Data Objects. The ***Number of Data Objects*** field is set to 3 to indicate the length of this Chunk. The ***Chunk Number*** is set to zero and the ***Data Size*** field is set to 7 to indicate the length of the whole Extended Message.

Figure 6-8 Example Security_Request Message of Data Size 7 (Chunked bit set to 1)

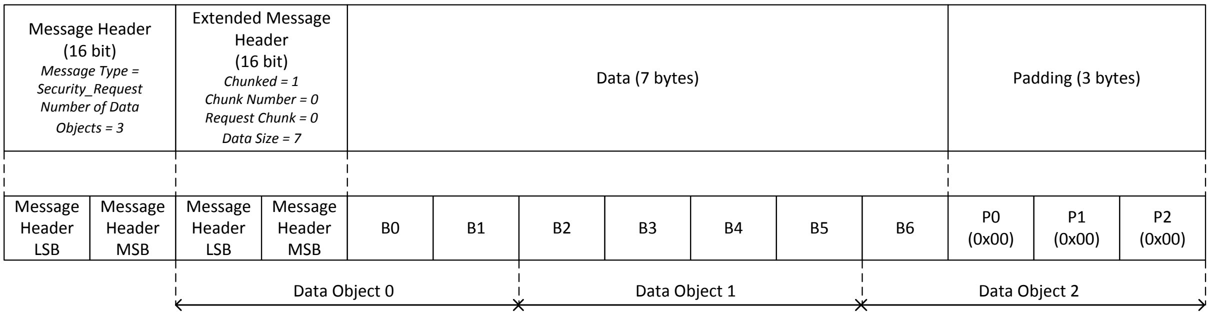


Figure 6-9 shows ***Chunk Number*** zero of the ***Security_Response*** Message shown in Figure 6-7 in more detail including the byte ordering on the bus and padding. No padding is need for this Chunk since the full 26-byte payload plus 2-byte Extended Message Header is a multiple of 32-bits, corresponding to 7 Data Objects. The ***Number of Data Objects*** field is set to 7 to indicate the length of this Chunk and the ***Data Size*** field is set to 30 to indicate the length of the whole Extended Message.

Figure 6-9 Example Chunk 0 of Security_Response Message of Data Size 30 (Chunked bit set to 1)

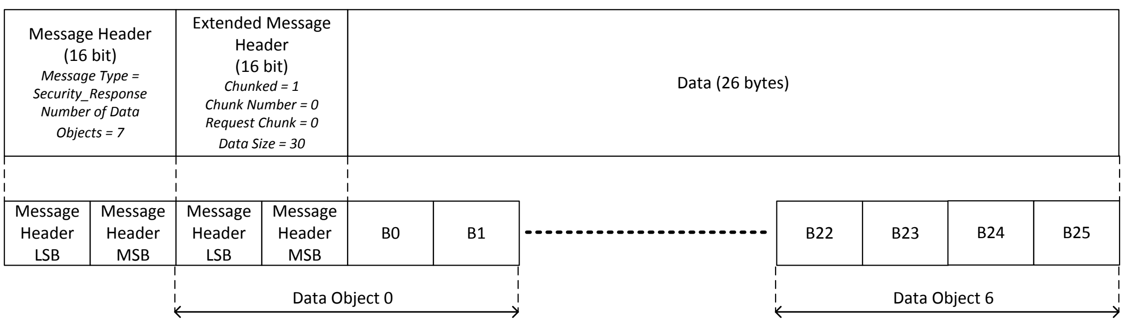


Figure 6-10 shows an example of the Message format, byte ordering and padding for the ***Security_Response*** Message Chunk request for ***Chunk Number*** one shown in Figure 6-7. In the Chunk request the ***Number of Data Objects*** field in the Message is set to 1 to indicate that the payload is 32 bits equivalent to 1 data object. Since the ***Chunked*** bit is set to 1 the Chunk request/Chunk response mechanism is used. The Message is a Chunk request so the ***Request Chunk*** bit is set to one, and in this case Chunk one is being requested so ***Chunk Number*** is set to one. ***Data Size*** is set to 0 indicating the length of the Data Block being transferred. Two bytes of padding are added to ensure that the payload is a multiple of 32 bits.

Figure 6-10 Example byte transmission for a Security_Request Message Chunk request (Chunked bit is set to 1)

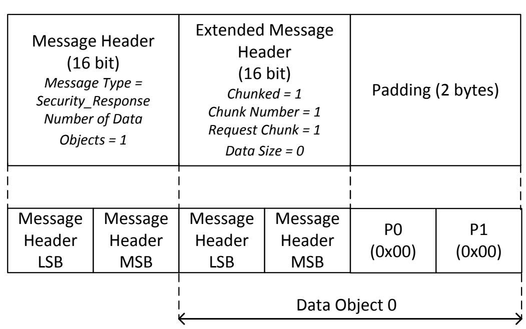
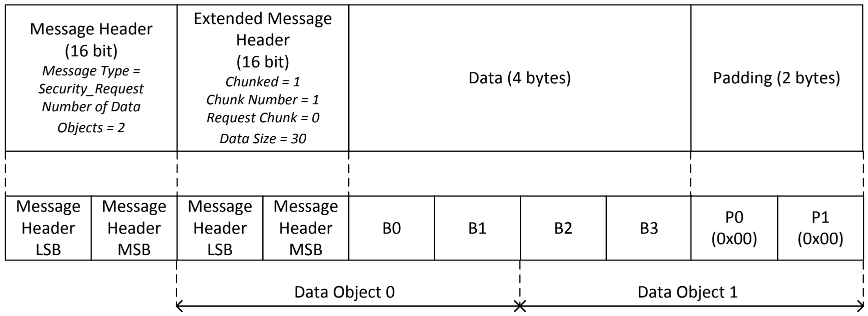


Figure 6-11 shows ***Chunk Number*** one of the ***Security_Response*** Message shown in Figure 6-7 in more detail including the byte ordering on the bus and padding. Two bytes of padding are added to ensure that the payload is a multiple of 32 bits, corresponding to 2 Data Objects. The ***Number of Data Objects*** field is set to 2 to indicate the length of this Chunk and the ***Data Size*** field is set to 30 to indicate the length of the whole Extended Message.

Figure 6-11 Example Chunk 1 of Security_Response Message of Data Size 30 (Chunked bit set to 1)



6.3 Control Message

A Message is defined as a Control Message when the ***Number of Data Objects*** field in the Message Header is set to 0. The Control Message consists only of a Message Header and a CRC. The Protocol Layer originates the Control Messages (i.e. ***Accept*** Message, ***Reject*** Message etc.).

The Control Message types are specified in the Message Header's ***Message Type*** field (bits 4…0) and are summarized in Table 6-5. The Sent by column indicates entities which ***May*** send the given Message (Source, Sink or Cable Plug); entities not listed ***Shall Not*** issue the corresponding Message. The "Valid Start of Packet" column indicates the Messages which ***Shall*** only be issued in SOP Packets and the Messages which ***May*** be issued in SOP* Packets.

Table 6-5 Control Message Types

Bits 4…0	Message Type	Sent by	Description	Valid Start of Packet
0 0000	***Reserved***	N/A	All values not explicitly defined are ***Reserved*** and ***Shall Not*** be used.	
0 0001	***GoodCRC***	Source, Sink or Cable Plug	See Section 6.3.1.	SOP*
0 0010	***GotoMin***	Source only	See Section 6.3.2.	SOP only
0 0011	***Accept***	Source, Sink or Cable Plug	See Section 6.3.3.	SOP*
0 0100	***Reject***	Source or Sink	See Section 6.3.4.	SOP only
0 0101	***Ping***	Source only	See Section 6.3.5.	SOP only
0 0110	***PS_RDY***	Source or Sink	See Section 6.3.6.	SOP only
0 0111	***Get_Source_Cap***	Sink or DRP	See Section 6.3.7.	SOP only
0 1000	***Get_Sink_Cap***	Source or DRP	See Section 6.3.8.	SOP only
0 1001	***DR_Swap***	Source or Sink	See Section 6.3.9	SOP only
0 1010	***PR_Swap***	Source or Sink	See Section 6.3.10	SOP only
0 1011	***VCONN_Swap***	Source or Sink	See Section 6.3.11	SOP only
0 1100	***Wait***	Source or Sink	See Section 6.3.12	SOP only
0 1101	***Soft_Reset***	Source or Sink	See Section 6.3.13	SOP*
0 1110-0 1111	***Reserved***	N/A	All values not explicitly defined are ***Reserved*** and ***Shall Not*** be used.	
1 0000	***Not_Supported***	Source, Sink or Cable Plug	See Section 6.3.14	SOP*
1 0001	***Get_Source_Cap_Extended***	Sink or DRP	See Section 6.3.15	SOP only
1 0010	***Get_Status***	Source or Sink	See Section 6.3.16	SOP only

Bits 4…0	Message Type	Sent by	Description	Valid Start of Packet
1 0011	***FR_Swap***	Sink[1]	See Section 6.3.17	SOP only
1 0100	***Get_PPS_Status***	Sink	See Section 6.3.18	SOP only
1 0101	***Get_Country_Codes***	Source or Sink	See Section 6.3.19	SOP*
1 0110-1 1111	***Reserved***	N/A	All values not explicitly defined are ***Reserved*** and ***Shall Not*** be used.	
Note 1: In this case the Port is providing ***vSafe5V*** however it will have Rd asserted rather than Rp and sets the ***Port Power Role*** field to Sink, until the Fast Role Swap AMS has completed.				

6.3.1 GoodCRC Message

The ***GoodCRC*** Message ***Shall*** be sent by the receiver to acknowledge that the previous Message was correctly received (i.e. had a good CRC). The ***GoodCRC*** Message ***Shall*** return the Message's ***MessageID*** so the transmitter can determine that the correct Message is being acknowledged. The first bit of the ***GoodCRC*** Message ***Shall*** be returned within ***tTransmit*** after receipt of the last bit of the previous Message.

BIST does not send the ***GoodCRC*** Message while in a Continuous BIST Mode (see Section 6.4.3).

6.3.2 GotoMin Message

The ***GotoMin*** Message applies only to those Sinks that have requested power with the GiveBack capable flag set in the Sink Request Data Object.

It is a directive to the Sink Port to reduce its operating power level to the amount specified in the Minimum Operating Current field of its latest Sink Request Data Object.

The GotoMin process is designed to allow the Source to temporarily reallocate power to meet a short term requirement. For example, a Source can reduce a Sink's power consumption for 10-20 seconds to allow another Sink (e.g. an HDD to spin up).

The Source sends this Message as a means to harvest power in order to meet a request for power that it cannot otherwise meet. The Device Policy Manager determines which Port or ports will receive the Message.

The Sink ***Shall*** respond to a ***GotoMin*** Message by reducing its power consumption to less than or equal to the pre-negotiated value (Minimum Operating Current) within ***tSnkNewPower*** time.

The Source sends a ***GotoMin*** Message as a shortcut in the power negotiation process since the Source and Sink have already made a Contract with respect to the power to be returned. In essence, the Source does not have to advertise its Capabilities and the Sink does not have to make a Request based on them. The Source simply sends the ***GotoMin*** Message in place of the ***Accept*** Message normally sent during the power negotiation process (see step 19 in Figure 8-5). The power negotiation process then completes from this point in the normal manner with the Source sending a ***PS_RDY*** Message once the power supply transition is complete. The steps of the GotoMin process are fully described in Figure 8-6.

The Source ***Shall*** return power to the Sink(s) it has 'borrowed' from using the GotoMin mechanism before it can allocate any 'new' power to other devices.

6.3.3 Accept Message

The ***Accept*** Message is a ***Valid*** response in the following cases:

- It ***Shall*** be sent by the Source to signal the Sink that the Source is willing to meet the ***Request*** Message.
- It ***Shall*** be sent by the recipient of the ***PR_Swap*** Message to signal that it is willing to do a Power Role Swap and has begun the Power Role Swap sequence.

- It ***Shall*** be sent by the recipient of the ***DR_Swap*** Message to signal that it is willing to do a Data Role Swap and has begun the Data Role Swap sequence.
- It ***Shall*** be sent by the recipient of the ***VCONN_Swap*** Message to signal that it is willing to do a VCONN Swap and has begun the VCONN Swap sequence.
- It ***Shall*** be sent by the recipient of the ***FR_Swap*** Message to indicate that it has begun the Fast Role Swap sequence.
- It ***Shall*** be sent by the recipient of the ***Soft_Reset*** Message to indicate that it has completed its Soft Reset.

The ***Accept*** Message ***Shall*** be sent within ***tReceiverResponse*** of the receipt of the last bit of the Message (see Section 6.6.2).

6.3.4 Reject Message

The ***Reject*** Message is a ***Valid*** response in the following cases:

- It ***Shall*** be sent to signal the Sink that the Source is unable to meet the ***Request*** Message. This ***May*** be due an ***Invalid*** request or because the Source can no longer provide what it previously advertised.
- It ***Shall*** be sent by the recipient of a ***PR_Swap*** Message to indicate it is unable to do a Power Role Swap.
- It ***Shall*** be sent by the recipient of a ***DR_Swap*** Message to indicate it is unable to do a Data Role Swap.
- It ***Shall*** be sent by the recipient of a ***VCONN_Swap*** Message that is not presently the VCONN Source, to indicate it is unable to do a VCONN Swap.

The ***Reject*** Message ***Shall*** be sent within ***tReceiverResponse*** of the receipt of the last bit of Message (see Section 6.6.2).

Note: the ***Reject*** Message is not a ***Valid*** response when a Message is not supported. In this case the ***Not_Supported*** Message is returned (see Section 6.3.14).

6.3.5 Ping Message

The ***Ping*** Message was previously used on USB Type-A and USB Type-B connectors to determine the continued presence of the Sink when no other messaging was taking place. USB Type-C connectors have a mechanism to determine Sink presence so when the Port Partners are both connected using USB Type-C connectors the ***Ping*** Message is not necessary but ***May*** be sent by a Source if desired. A Sink using a USB Type-C connector ***Shall Not*** expect to receive ***Ping*** Messages but ***Shall Not*** treat ***Ping*** Messages as an error if they are received.

6.3.6 PS_RDY Message

The ***PS_RDY*** Message ***Shall*** be sent by the Source (or by both the new Sink and new Source during the Power Role Swap sequence or Fast Role Swap sequence) to indicate its power supply has reached the desired operating condition (see Section 8.3.2.2).

6.3.7 Get_Source_Cap Message

The ***Get_Source_Cap*** (Get Source Capabilities) Message ***May*** be sent by a Port to request the Source Capabilities and Dual-Role Power capability of its Port Partner (e.g. Dual-Role Power capable). The Port ***Shall*** respond by returning a ***Source_Capabilities*** Message (see Section 6.4.1.1.1).

6.3.8 Get_Sink_Cap Message

The ***Get_Sink_Cap*** (Get Sink Capabilities) Message ***May*** be sent by a Port to request the Sink Capabilities and Dual-Role Power capability of its Port Partner (e.g. Dual-Role Power capable). The Port ***Shall*** respond by returning a ***Sink_Capabilities*** Message (see Section 6.4.1.1.2).

6.3.9 DR_Swap Message

The ***DR_Swap*** Message is used to exchange DFP and UFP operation between Port Partners while maintaining the direction of power flow over V_{BUS}. The DR_Swap process can be used by Port Partners whether or not they support USB Communications capability. A DFP that supports USB Communication Capability starts as the USB Host on Attachment. A UFP that supports USB Communication Capability starts as the USB Device on Attachment.

[USB Type-C 1.2] DRPs ***Shall*** have the capability to perform a Data Role Swap from the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** states. DFPs and UFPs ***May*** have the capability to perform a Data Role Swap from the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** states. A Data Role Swap ***Shall*** be regarded in the same way as a cable Detach/re-Attach in relation to any USB communication which is ongoing between the Port Partners. If there are any Active Modes between the Port Partners when a ***DR_Swap*** Message is a received then a Hard Reset ***Shall*** be performed (see Section 6.4.4.3.4). If the Cable Plug has any Active Modes then the DFP ***Shall Not*** issue a ***DR_Swap*** Message and ***Shall*** cause all Active Modes in the Cable Plug to be exited before accepting a DR Swap request.

The Source of V_{BUS} and VCONN Source ***Shall*** remain unchanged as well as the Rp/Rd resistors on the CC wire during the Data Role Swap process.

The ***DR_Swap*** Message ***May*** be sent by either Port Partner. The recipient of the ***DR_Swap*** Message ***Shall*** respond by sending an ***Accept*** Message, ***Reject*** Message or ***Wait*** Message.

- If an ***Accept*** Message is sent, the Source and Sink ***Shall*** exchange operational roles.
- If a ***Reject*** Message is sent, the requester is informed that the recipient is unable, or unwilling, to do a Data Role Swap and no action ***Shall*** be taken.
- If a ***Wait*** Message is sent, the requester is informed that a Data Role Swap might be possible in the future but that no immediate action ***Shall*** be taken.

Before a Data Role Swap the initial DFP ***Shall*** have its ***Port Data Role*** bit set to DFP, and the initial UFP ***Shall*** have its ***Port Data Role*** bit set to UFP.

After a successful Data Role Swap the DFP/Host ***Shall*** become the UFP/Device and vice-versa; the new DFP ***Shall*** have its ***Port Data Role*** bit set to DFP, and the new UFP ***Shall*** have its ***Port Data Role*** bit set to UFP. Where USB Communication is supported by both Port Partners a USB data connection ***Should*** be established according to the new data roles.

If the Data Role Swap, after having been accepted by the Port Partner, is subsequently not successful, in order to attempt a re-establishment of the connection on the CC Wire, USB Type-C Error Recovery actions, such as disconnect, as defined in ***[USB Type-C 1.2]*** will be necessary.

See Section 8.3.2.6, Section 8.3.3.16.1 and Section 8.3.3.16.2 for further details.

6.3.10 PR_Swap Message

The ***PR_Swap*** Message ***May*** be sent by either Port Partner to request an exchange of power roles. The recipient of the Message ***Shall*** respond by sending an ***Accept*** Message, ***Reject*** Message or ***Wait*** Message.

- If an ***Accept*** Message is sent, the Source and Sink ***Shall*** do a Power Role Swap.
- If a ***Reject*** Message is sent, the requester is informed that the recipient is unable, or unwilling, to do a Power Role Swap and no action ***Shall*** be taken.
- If a ***Wait*** Message is sent, the requester is informed that a Power Role Swap might be possible in the future but that no immediate action ***Shall*** be taken.

After a successful Power Role Swap the Port Partners ***Shall*** reset their respective Protocol Layers (equivalent to a Soft Reset): resetting their ***MessageIDCounter***, ***RetryCounter*** and Protocol Layer state machines before attempting to establish an Explicit Contract. At this point the Source ***Shall*** also reset its ***CapsCounter***.

Since a UFP Source can attempt to send a ***Discover Identity*** Command using SOP' to a Cable Plug prior to the establishment of an Explicit Contract, a DFP Sink ***Shall*** disable the receiving of SOP' Messages until an Explicit

Contract has been established. This ensures that only the Cable Plug responds with a ***GoodCRC*** Message to the ***Discover Identity*** Command.

The Source ***Shall*** have Rp asserted on the CC wire and the Sink ***Shall*** have Rd asserted on the CC wire as defined in ***[USB Type-C 1.2]***. When performing a Power Role Swap from Source to Sink, the Port ***Shall*** change its CC Wire resistor from Rp to Rd. When performing a Power Role Swap from Sink to Source, the Port ***Shall*** change its CC Wire resistor from Rd to Rp. The DFP (Host), UFP (Device) roles and VCONN Source ***Shall*** remain unchanged during the Power Role Swap process.

Note: during the Power Role Swap process the initial Sink does not disconnect even though V_{BUS} drops below ***vSafe5V***.

For more information regarding the Power Role Swap, refer to Section 7.3.9 and Section 7.3.10 in the Power Supply chapter, Section 8.3.2.6, Section 8.3.3.16.3 and Section 8.3.3.16.4 in the Device Policy chapter and Section 9.1.2 for V_{BUS} mapping to USB states.

6.3.11 VCONN_Swap Message

The ***VCONN_Swap*** Message ***Shall*** be supported by any Port that can operate as a VCONN Source.

The ***VCONN_Swap*** Message ***May*** be sent by either Port Partner to request an exchange of VCONN Source. The recipient of the Message ***Shall*** respond by sending an ***Accept*** Message, ***Reject*** Message or ***Wait*** Message.

- If an ***Accept*** Message is sent, the Port Partners ***Shall*** perform a VCONN Swap. The new VCONN Source ***Shall*** send a ***PS_RDY*** Message within ***tVCONNSourceOn*** to indicate that it is now sourcing VCONN. The initial VCONN Source ***Shall*** cease sourcing VCONN within ***tVCONNSourceOff*** of receipt of the last bit of the ***EOP*** of the ***PS_RDY*** Message.
- If a ***Reject*** Message is sent, the requester is informed that the recipient is unable, or unwilling, to do a VCONN Swap and no action ***Shall*** be taken. A ***Reject*** Message ***Shall*** only be sent by the Port that is not presently the Vconn Source in response to a ***VCONN_Swap*** Message. The Port that is presently the Vconn Source ***Shall Not*** send a ***Reject*** Message in response to ***VCONN_Swap*** Message.
- If a ***Wait*** Message is sent, the requester is informed that a VCONN Swap might be possible in the future but that no immediate action ***Shall*** be taken. A ***Wait*** Message ***Shall*** only be sent by the Port that is not presently the Vconn Source in response to a ***VCONN_Swap*** Message. The Port that is presently the Vconn Source ***Shall Not*** send a ***Wait*** Message in response to ***VCONN_Swap*** Message.

The DFP (Host), UFP (Device) roles and Source of V_{BUS} ***Shall*** remain unchanged as well as the Rp/Rd resistors on the CC wire during the VCONN Swap process.

Note: VCONN ***Shall*** be continually sourced during the VCONN Swap process in order to maintain power to the Cable Plug(s) i.e. make before break.

Before communicating with a Cable Plug a Port ***Shall*** ensure that it is the VCONN Source and that the Cable Plugs are powered, by performing a VCONN swap if necessary. Since it cannot be guaranteed that the present VCONN Source is supplying VCONN, the only means to ensure that the Cable Plugs are powered is for a Port wishing to communicate with a Cable Plug to become the VCONN Source. If a ***Not_Supported*** Message is returned in response to the ***VCONN_Swap*** Message then the Port is allowed to become the VCONN Source until a Hard Reset or Detach.

Note: even when it is presently the VCONN Source, the Sink is not permitted to initiate an AMS with a Cable Plug unless Rp is set to ***SinkTxOk*** (see Section 6.9).

6.3.12 Wait Message

The ***Wait*** Message is a ***Valid*** response to a ***Request***, a ***PR_Swap***, ***DR_Swap*** or ***VCONN_Swap*** Message.

- It ***Shall*** be sent to signal the Sink that the Source is unable to meet the request at this time.
- It ***Shall*** be sent by the recipient of a ***PR_Swap*** Message to indicate it is unable to do a Power Role Swap at this time.
- It ***Shall*** be sent by the recipient of a ***DR_Swap*** Message to indicate it is unable to do a Data Role Swap at this time.

- It ***Shall*** be sent by the recipient of a ***VCONN_Swap*** Message that is not presently the VCONN Source to indicate it is unable to do a VCONN Swap at this time.

The ***Wait*** Message ***Shall*** be sent within ***tReceiverResponse*** of the receipt of the last bit of the Message (see Section 6.6.2).

6.3.12.1 Wait in response to a Request Message

The ***Wait*** Message is used by the Source when a Sink that has reserved power, requests it. The ***Wait*** Message allows the Source time to recover the power it requires to meet the request through the GotoMin process. A Source ***Shall*** only send a ***Wait*** Message in response to a ***Request*** Message when an Explicit Contract exists between the Port Partners.

The Sink is allowed to repeat the ***Request*** Message using the ***SinkRequestTimer*** and ***Shall*** ensure that there is ***tSinkRequest*** after receiving the ***Wait*** Message before sending another ***Request*** Message.

6.3.12.2 Wait in response to a PR_Swap Message

The ***Wait*** Message is used when responding to a ***PR_Swap*** Message to indicate that a Power Role Swap might be possible in the future. This can occur in any case where the device receiving the ***PR_Swap*** Message needs to evaluate the request further e.g. by requesting Capabilities from the originator of the ***PR_Swap*** Message. Once it has completed this evaluation one of the Port Partners ***Should*** initiate the Power Role Swap process again by sending a ***PR_Swap*** Message.

The ***Wait*** Message is also used where a Hub is operating in hybrid mode when a request cannot be satisfied (see ***[USBTypeCBridge 1.0]***).

A Port that receives a ***Wait*** Message in response to a ***PR_Swap*** Message ***Shall*** wait ***tPRSwapWait*** after receiving the ***Wait*** Message before sending another ***PR_Swap*** Message.

6.3.12.3 Wait in response to a DR_Swap Message

The ***Wait*** Message is used when responding to a ***DR_Swap*** Message to indicate that a Date Role Swap might be possible in the future. This can occur in any case where the device receiving the ***DR_Swap*** Message needs to evaluate the request further. Once it has completed this evaluation one of the Port Partners ***Should*** initiate the Data Role Swap process again by sending a ***DR_Swap*** Message.

A Port that receives a ***Wait*** Message in response to a ***DR_Swap*** Message ***Shall*** wait ***tDRSwapWait*** after receiving the ***Wait*** Message before sending another ***DR_Swap*** Message.

6.3.12.4 Wait in response to a VCONN_Swap Message

The ***Wait*** Message is used when responding to a ***VCONN_Swap*** Message to indicate that a ***VCONN_Swap*** might be possible in the future. This can occur in any case where the device receiving the ***VCONN_Swap*** Message needs to evaluate the request further. A ***Wait*** Message ***Shall*** only be sent by the Port that is not presently the Vconn Source in response to a ***VCONN_Swap*** Message. The Port that is presently the Vconn Source ***Shall Not*** send a ***Wait*** Message in response to ***VCONN_Swap*** Message. Once it has completed this evaluation one of the Port Partners ***Should*** initiate the VCONN Swap process again by sending a ***VCONN_Swap*** Message.

A Port that receives a ***Wait*** Message in response to a ***VCONN_Swap*** Message ***Shall*** wait ***tVCONNSwapWait*** after receiving the ***Wait*** Message before sending another ***VCONN_Swap*** Message.

6.3.13 Soft Reset Message

A ***Soft_Reset*** Message ***May*** be initiated by either the Source or Sink to its Port Partner requesting a Soft Reset. The ***Soft_Reset*** Message ***Shall*** cause a Soft Reset of the connected Port Pair (see Section 6.8.1). If the ***Soft_Reset*** Message fails a Hard Reset ***Shall*** be initiated within ***tHardReset*** of the last ***CRCReceiveTimer*** expiring after ***nRetryCount*** retries have been completed.

A ***Soft_Reset*** Message is used to recover from Protocol Layer errors; putting the Message counters to a known state in order to regain Message synchronization. The ***Soft_Reset*** Message has no effect on the Source or Sink; that is the previously negotiated direction. Voltage and current remain unchanged. Modal Operation is unaffected by Soft Reset. However after a Soft Reset has completed, an Explicit Contract negotiation occurs, in order to re-establish PD Communication and to bring state operation for both Port Partners back to either the ***PE_SNK_Ready*** or ***PE_SRC_Ready*** states as appropriate (see Section 8.3.3.4).

A ***Soft_Reset*** Message ***May*** be sent by either the Source or Sink when there is a Message synchronization error. If the error is not corrected by the Soft Reset, ***Hard Reset*** Signaling ***Shall*** be issued (see Section 6.8).

A ***Soft_Reset*** Message ***Shall*** be targeted at a specific entity depending on the type of SOP* Packet used. ***Soft_Reset*** Messages sent using SOP Packets ***Shall*** Soft Reset the Port Partner only. ***Soft_Reset*** Messages sent using SOP'/SOP'' Packets ***Shall*** Soft Reset the corresponding Cable Plug only.

After a VCONN Swap the VCONN Source needs to reset the Cable Plug's Protocol Layer in order to ensure ***MessageID*** synchronization. If after a VCONN Swap the VCONN Source wants to communicate with a Cable Plug using SOP' Packets it ***Shall*** issue a ***Soft_Reset*** Message using a SOP' Packet in order to reset the Cable Plug's Protocol Layer. If the VCONN Source wants to communicate with a Cable Plug using SOP'' Packets it ***Shall*** issue a ***Soft_Reset*** Message using a SOP'' Packet in order to reset the Cable Plug's Protocol Layer.

6.3.14 Not_Supported Message

The ***Not_Supported*** Message ***Shall*** be sent by a Port in response to any Message it does not support. Returning a ***Not_Supported*** Message is assumed in this specification and has not been called out explicitly except in Section 6.12 which defines cases where the ***Not_Supported*** Message is returned.

6.3.15 Get_Source_Cap_Extended Message

The ***Get_Source_Cap_Extended*** (Get Source Capabilities Extended) Message is sent by a Port to request additional information about a Port's Source Capabilities. The Port ***Should*** respond by returning a ***Source_Capabilities_Extended*** Message (see Section 6.5.1).

6.3.16 Get_Status Message

The ***Get_Status*** Message is sent by a Port to request the Port Partner's present status. The Source or Sink ***Shall*** respond by returning a ***Status*** Message (see Section 6.5.2). A Port that receives an ***Alert*** Message (see Section 6.4.6) indicates that the Source or Sink's Status has changed and ***Should*** be re-read using a ***Get_Status*** Message.

6.3.17 FR_Swap Message

The ***FR_Swap*** Message ***Shall*** be sent by the new Source within ***tFRSwapInit*** after it has detected a Fast Role Swap signal (see Section 5.8.6.3 and Section 6.6.16). The Fast Role Swap AMS is necessary to apply Rp to the new Source and Rd to the new Sink and to re-synchronize the state machines.

The recipient of the ***FR_Swap*** Message ***Shall*** respond by sending an ***Accept*** Message.

After a successful Fast Role Swap the Port Partners ***Shall*** reset their respective Protocol Layers (equivalent to a Soft Reset): resetting their ***MessageIDCounter***, ***RetryCounter*** and Protocol Layer state machines before attempting to establish an Explicit Contract. At this point the Source ***Shall*** also reset its ***CapsCounter***.

Since a UFP Source can attempt to send a ***Discover Identity*** Command using SOP' to a Cable Plug prior to the establishment of an Explicit Contract, a DFP Sink ***Shall*** disable the receiving of SOP' Messages until an Explicit Contract has been established. This ensures that only the Cable Plug responds with a ***GoodCRC*** Message to the ***Discover Identity*** Command.

Prior to the Fast Role Swap AMS the new Source ***Shall*** have Rd asserted on the CC wire and the new Sink ***Shall*** have Rp asserted on the CC wire. Note that this is an incorrect assignment of Rp/Rd (since Rp follows the Source and Rd follows the Sink as defined in ***[USB Type-C 1.2]***) that is corrected by the Fast Role Swap AMS.

During the Fast Role Swap AMS the new Source ***Shall*** change its CC Wire resistor from Rd to Rp and the new Sink ***Shall*** change its CC Wire resistor from Rp to Rd. The DFP (Host), UFP (Device) roles and VCONN Source ***Shall*** remain unchanged during the Fast Role Swap process.

The initial Source ***Should*** avoid being the VCONN source (by using the VCONN Swap process) whenever not actively communicating with the cable, since it is difficult for the initial Source to maintain VCONN power during the Fast Role Swap process.

Note: a Fast Role Swap is a "best effort" solution to a situation where a PDUSB Device has lost its external power. This process can occur at any time, even during a Non-interruptible AMS in which case error handling such as Hard Reset or ***[USB Type-C 1.2]*** Error Recovery will be triggered.

Note: during the Fast Role Swap process the initial Sink does not disconnect even though V_{BUS} drops below ***vSafe5V***.

For more information regarding the Fast Role Swap process, refer to Section 7.1.13 and Section 7.2.9.2 in the Power Supply chapter, Section 8.3.3.16.5 and Section 8.3.3.16.6 in the Device Policy chapter and Section 9.1.2 for V_{BUS} mapping to USB states.

6.3.18 Get_PPS_Status

The ***Get_PPS_Status*** Message is sent by the Sink to request additional information about a Source's status. The Port ***Shall*** respond by returning a ***PPS_Status*** Message (see Section 6.5.10).

6.3.19 Get_Country_Codes

The ***Get_Country_Codes*** Message is sent by a Port to request the alpha-2 country codes its Port Partner supports as defined in ***[ISO 3166]***. The Port Partner ***Shall*** respond by returning a ***Country_Codes*** Message (see Section 6.5.11).

6.4 Data Message

A Data Message ***Shall*** consist of a Message Header and be followed by one or more Data Objects. Data Messages are easily identifiable because the ***Number of Data Objects*** field in the Message Header is a non-zero value.

There are several types of Data Objects:

- BIST Data Object (BDO) used for PHY Layer compliance testing.
- Power Data Object (PDO) used to expose a Source Port's power capabilities or a Sink's power requirements.
- Request Data Object (RDO) used by a Sink Port to negotiate a Contract.
- Vendor Defined Data Object (VDO) used to convey vendor specific information.
- Battery Status Data Object (BSDO) used to convey Battery status information.
- Alert Data Object (ADO) used to indicates events occurring on the Source or Sink.

The type of Data Object being used in a Data Message is defined by the Message Header's ***Message Type*** field and is summarized in Table 6-6. The Sent by column indicates entities which ***May*** send the given Message (Source, Sink or Cable Plug); entities not listed ***Shall Not*** issue the corresponding Message. The Valid Start of Packet column indicates the Messages which ***Shall*** only be issued in SOP Packets and the Messages which ***May*** be issued in SOP* Packets.

Table 6-6 Data Message Types

Bits 4…0	Type	Sent by	Description	Valid Start of Packet
0 0000	***Reserved***		All values not explicitly defined are ***Reserved*** and ***Shall Not*** be used.	
0 0001	***Source_Capabilities***	Source or Dual-Role Power	See Section 6.4.1.2	SOP only
0 0010	***Request***	Sink only	See Section 6.4.2	SOP only
0 0011	***BIST***	Tester, Source or Sink	See Section 6.4.3	SOP*

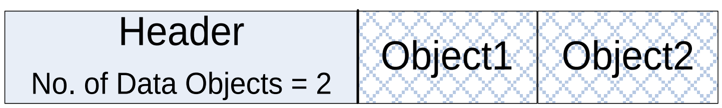
Bits 4…0	Type	Sent by	Description	Valid Start of Packet
0 0100	***Sink_Capabilities***	Sink or Dual-Role Power	See Section 6.4.1.3	SOP only
0 0101	***Battery_Status***	Source or Sink	See Section 6.4.5	SOP only
0 0110	***Alert***	Source or Sink	See Section 6.4.6	SOP only
0 0111	***Get_Country_Info***	Source or Sink	See Section 6.4.7	SOP only
0 1000 -0 1110	***Reserved***		All values not explicitly defined are ***Reserved*** and ***Shall Not*** be used.	
0 1111	***Vendor_Defined***	Source, Sink or Cable Plug	See Section 6.4.4	SOP*
1 0000-1 1111	***Reserved***		All values not explicitly defined are ***Reserved*** and ***Shall Not*** be used.	

6.4.1 Capabilities Message

A Capabilities Message (***Source_Capabilities*** Message or ***Sink_Capabilities*** Message) ***Shall*** have at least one Power Data Object for ***vSafe5V***. The Capabilities Message ***Shall*** also contain the sending Port's information followed by up to 6 additional Power Data Objects. Power Data Objects in a Capabilities Message ***Shall*** be sent in the following order:

1. The ***vSafe5V*** Fixed Supply Object ***Shall*** always be the first object.
2. The remaining Fixed Supply Objects, if present, ***Shall*** be sent in voltage order; lowest to highest.
3. The Battery Supply Objects, if present ***Shall*** be sent in Minimum Voltage order; lowest to highest.
4. The Variable Supply (non-Battery) Objects, if present, ***Shall*** be sent in Minimum Voltage order; lowest to highest.
5. The Programmable Power Supply Objects, if present, ***Shall*** be sent in Maximum Voltage order, lowest to highest.

Figure 6-12 Example Capabilities Message with 2 Power Data Objects



In Figure 6-12, the ***Number of Data Objects*** field is 2: ***vSafe5V*** plus one other voltage.

Power Data Objects (PDO) and Augmented Power Data Objects (APDO) are identified by the Message Header's Type field. They are used to form ***Source_Capabilities*** Messages and ***Sink_Capabilities*** Messages.

There are three types of Power Data Objects. They contain additional information beyond that encoded in the Message Header to identify each of the three types of Power Data Objects:

- Fixed Supply is the most commonly used to expose well-regulated fixed voltage power supplies.
- Variable power supply is used to expose very poorly regulated power supplies.
- Battery is used to expose batteries than can be directly connected to V_{BUS}.

There is one type of Augmented Power Data Object:

- Programmable Power Supply is used to expose a power supply whose output voltage can be programmatically adjusted over the advertised voltage range.

Power Data Objects are also used to expose additional capabilities that ***May*** be utilized; such as in the case of a Power Role Swap.

A list of one or more Power Data Objects ***Shall*** be sent by the Source in order to convey its capabilities. The Sink ***May*** then request one of these capabilities by returning a Request Data Object that contains an index to a Power Data Object, in order to negotiate a mutually agreeable Contract.

Where Maximum and Minimum Voltage and Current values are given in PDOs these ***Shall*** be taken to be absolute values.

The Source and Sink ***Shall Not*** negotiate a power level that would allow the current to exceed the maximum current supported by their receptacles or the Attached plug (see ***[USB Type-C 1.2]***). The Source ***Shall*** limit its offered capabilities to the maximum current supported by its receptacle and Attached plug. A Sink ***Shall*** only make a request from any of the capabilities offered by the Source. For further details see Section 4.4.

Sources expose their power capabilities by sending a ***Source_Capabilities*** Message. Sinks expose their power requirements by sending a ***Sink_Capabilities*** Message. Both are composed of a number of 32-bit Power Data Objects (see Table 6-7).

Table 6-7 Power Data Object

Bit(s)	Description	
B31…30	**Value**	**Parameter**
	00b	Fixed supply (Vmin = Vmax)
	01b	Battery
	10b	Variable Supply (non-Battery)
	11b	Augmented Power Data Object (APDO)
B29…0	Specific Power Capabilities are described by the PDOs in the following sections.	

The Augmented Power Data Object (APDO) is defined to allow support for more than the four PDO types by extending the Power Data Object field from 2 to 4 bits when the B31…B30 are 11b. The generic APDO structure is shown in Table 6-8.

Table 6-8 Augmented Power Data Object

Bit(s)	Description
B31…30	11b – Augmented Power Datat Object (APDO)
B29…28	00b – Programmable Power Supply 01b-11b - ***Reserved***
B27…0	Specific Power Capabilities are described by the APDOs in the following sections.

6.4.1.1 Use of the Capabilities Message

6.4.1.1.1 Use by Sources

Sources send a ***Source_Capabilities*** Message (see Section 6.4.1) either as part of advertising Port capabilities, or in response to a ***Get_Source_Cap*** Message.

Following a Hard Reset, a power-on event or plug insertion event, a Source Port ***Shall*** send a ***Source_Capabilities*** Message after every ***SourceCapabilityTimer*** timeout as an advertisement that ***Shall*** be interpreted by the Sink Port on Attachment. The Source ***Shall*** continue sending a minimum of ***nCapsCount Source_Capabilities*** Messages until a ***GoodCRC*** Message is received.

Additionally, a ***Source_Capabilities*** Message ***Shall*** only be sent in the following cases:

- By the Source Port from the ***PE_SRC_Ready*** state upon a change in its ability to supply power.
- By a Source Port or Dual-Role Power Port in response to a ***Get_Source_Cap*** Message.

6.4.1.1.2 Use by Sinks

Sinks send a ***Sink_Capabilities*** Message (see Section 6.4.1.3) in response to a ***Get_Sink_Cap*** Message.

A USB Power Delivery capable Sink, upon detecting ***vSafe5V*** on V_{BUS} and after a ***SinkWaitCapTimer*** timeout without seeing a ***Source_Capabilities*** Message, ***Shall*** send a Hard Reset. If the Attached Source is USB Power Delivery capable, it responds by sending ***Source_Capabilities*** Messages thus allowing power negotiations to begin.

6.4.1.1.3 Use by Dual-Role Power devices

Dual-Role Power devices send a ***Source_Capabilities*** Message (see Section 6.4.1) as part of advertising Port capabilities when operating in Source role. Dual-Role Power devices send a ***Source_Capabilities*** Message (see Section 6.4.1) in response to a ***Get_Source_Cap*** Message regardless of their present operating role. Similarly Dual-Role Power devices send a ***Sink_Capabilities*** Message (see Section 6.4.1.3) in response to a ***Get_Sink_Cap*** Message regardless of their present operating role.

6.4.1.2 Source_Capabilities Message

A Source Port ***Shall*** report its capabilities in a series of 32-bit Power Data Objects (see Table 6-7) as part of a ***Source_Capabilities*** Message (see Figure 6-12). Power Data Objects are used to convey a Source Port's capabilities to provide power including Dual-Role Power ports presently operating as a Sink.

Each Power Data Object ***Shall*** describe a specific Source capability such as a Battery (e.g. 2.8-4.1V) or a fixed power supply (e.g. 12V) at a maximum allowable current. The ***Number of Data Objects*** field in the Message Header ***Shall*** define the number of Power Data Objects that follow the Message Header in a Data Message. All Sources ***Shall*** minimally offer one Power Data Object that reports ***vSafe5V***. A Source ***Shall Not*** offer multiple Power Data Objects of the same type (fixed, variable, Battery) and the same voltage but ***Shall*** instead offer one Power Data Object with the highest available current for that Source capability and voltage. Sinks with Accessory Support do not source V_{BUS} (see ***[USB Type-C 1.2]***) however when sourcing VCONN they ***Shall*** advertise ***vSafe5V*** with the Maximum Current set to 0mA in the first Power Data Object.

A Sink ***Shall*** evaluate every ***Source_Capabilities*** Message it receives and ***Shall*** respond with a ***Request*** Message. If its power consumption exceeds the Source's capabilities it ***Shall*** re-negotiate so as not to exceed the Source's most recently advertised capabilities.

A Sink that evaluates the ***Source_Capabilities*** Message it receives and identifies a PPS APDO ***Shall*** periodically re-request the PPS APDO at least every ***tPPSRequest*** until either:

- The Sink requests something other than PPS APDO.
- There is a Power Role Swap.
- There is a Hard Reset.

A Source that has accepted a ***Request*** Message with a Programmable RDO ***Shall*** issue ***Hard Reset*** Signaling if it has not received a ***Request*** Message with a Programmable RDO within ***tPPSTimeout***. The Source ***Shall*** discontinue this behavior after:

- Receiving a ***Request*** Message with a Fixed, Variable or Battery RDO.
- There is a Power Role Swap.
- There is a Hard Reset.

6.4.1.2.1 Management of the Power Reserve

A Power Reserve ***May*** be allocated to a Sink when it makes a request from Source Capabilities which includes a Maximum Operating Current/Power. The size of the Power Reserve for a particular Sink is calculated as the difference between its Maximum Operating Current/Power field and its Operating Current/Power field. For a Hub with multiple ports this same Power Reserve ***May*** be shared between several Sinks. The Power Reserve ***May*** also be temporarily used by a Sink which has indicated it can give back power by setting the GiveBack flag.

Where a Power Reserve has been allocated to a Sink the Source ***Shall*** indicate the Power Reserve as part of every ***Source_Capabilities*** Message it sends. When the same Power Reserve is shared between several Sinks the Source ***Shall*** indicate the Power Reserve as part of every ***Source_Capabilities*** Message it sends to every Sink. Every time a Source sends capabilities including the Power Reserve capability and then accepts a request from a Sink including the Power Reserve indicated by its Maximum operating Current/Power it is confirming that the Power Reserve is part of the Explicit Contract with the Sink.

When the Reserve is being temporarily used by a giveback capable Sink the Source ***Shall*** indicate the Power Reserve as available in every ***Source_Capabilities*** Message it sends. However in this situation, when the Power Reserve is requested by a Sink, the Source ***Shall*** return a ***Wait*** Message while it retrieves this power using a ***GotoMin*** Message. Once the additional power has been retrieved the Source ***Shall*** send a new ***Source_Capabilities*** Message in order to trigger a new request from the Sink requesting the Power Reserve.

The Power Reserve ***May*** be de-allocated by the Source at any time, but the de-allocation ***Shall*** be indicated to the Sink or Sinks using the Power Reserve by sending a new ***Source_Capabilities*** Message.

6.4.1.2.2 Fixed Supply Power Data Object

Table 6-9 describes the Fixed Supply (00b) PDO. See Section 7.1.3 for the electrical requirements of the power supply.

Since all USB Providers support ***vSafe5V***, the required ***vSafe5V*** Fixed Supply Power Data Object is also used to convey additional information that is returned in bits 29 through 25. All other Fixed Supply Power Data Objects ***Shall*** set bits 29…22 to zero.

For a Source offering no capabilities, the Voltage (B19…10) ***Shall*** be set to 5V and the Maximum Current ***Shall*** be set to 0mA. This is used in cases such as a Dual-Role Power device which offers no capabilities in its default role or when external power is required in order to offer power.

When a Source wants a Sink, consuming power from V_{BUS}, to go to its lowest power state, the Voltage (B19…10) ***Shall*** be set to 5V and the Maximum Current ***Shall*** be set to 0mA. This is used in cases where the Source wants the Sink to draw ***pSnkSusp***.

Table 6-9 Fixed Supply PDO - Source

Bit(s)	Description
B31…30	Fixed supply
B29	Dual-Role Power
B28	USB Suspend Supported
B27	Unconstrained Power
B26	USB Communications Capable
B25	Dual-Role Data
B24	Unchunked Extended Messages Supported
B23…22	***Reserved*** – ***Shall*** be set to zero.
B21…20	Peak Current
B19…10	Voltage in 50mV units
B9…0	Maximum Current in 10mA units

6.4.1.2.2.1 Dual-Role Power

The Dual-Role Power bit ***Shall*** be set when the Port is Dual-Role Power capable i.e. supports the ***PR_Swap*** Message.

This is a static capability which ***Shall*** remain fixed for a given device regardless of the device's present power role. If the Dual-Role Power bit is set to one in the ***Source_Capabilities*** Message the Dual-Role Power bit in the ***Sink_Capabilities*** Message ***Shall*** also be set to one. If the Dual-Role Power bit is set to zero in the ***Source_Capabilities*** Message the Dual-Role Power bit in the ***Sink_Capabilities*** Message ***Shall*** also be set to zero.

6.4.1.2.2.2 USB Suspend Supported

Prior to a Contract or when the USB Communications Capable bit is set to zero, this flag is undefined and Sinks ***Shall*** follow the rules for suspend as defined in ***[USB 2.0]***, ***[USB 3.1]***, ***[USB Type-C 1.2]*** or ***[USBBC 1.2]***. After a Contract has been negotiated:

- If the USB Suspend Supported flag is set, then the Sink ***Shall*** follow the ***[USB 2.0]*** or ***[USB 3.1]*** rules for suspend and resume. A PDUSB Peripheral ***May*** draw up to ***pSnkSusp*** during suspend; a PDUSB Hub ***May*** draw up to ***pHubSusp*** during suspend (see Section 7.2.3).

- If the USB Suspend Supported flag is cleared, then the Sink ***Shall Not*** apply the ***[USB 2.0]*** or ***[USB 3.1]*** rules for suspend and ***May*** continue to draw the negotiated power. Note that when USB is suspended, the USB device state is also suspended.

Sinks ***May*** indicate to the Source that they would prefer to have the USB Suspend Supported flag cleared by setting the No USB Suspend flag in a ***Request*** Message (see Section 6.4.2.5).

6.4.1.2.2.3 Unconstrained Power

The Unconstrained Power bit ***Shall*** be set when an external source of power is available that is sufficient to adequately power the system while charging external devices, or when the device's primary function is to charge external devices.

To set the Unconstrained Power bit as a result of an external source, the external source of power ***Should*** be either:

- An AC supply, e.g. a wall wart, directly connected to the Sink.
- Or, in the case of a PDUSB Hub:
  - A PD Source with its Unconstrained Power bit set.
  - Multiple PD Sources all with their Unconstrained Power bits set.

6.4.1.2.2.4 USB Communications Capable

The USB Communications Capable bit ***Shall*** only be set for Sources capable of communication over the USB data lines (e.g. D+/- or SS Tx/Rx).

6.4.1.2.2.5 Dual-Role Data

The Dual-Role Data bit ***Shall*** be set when the Port is Dual-Role data capable i.e. it supports the ***DR_Swap*** Message. This is a static capability which ***Shall*** remain fixed for a given device regardless of the device's present power role or data role. If the Dual-Role Data bit is set to one in the ***Source_Capabilities*** Message the Dual-Role Data bit in the ***Sink_Capabilities*** Message ***Shall*** also be set to one. If the Dual-Role Data bit is set to zero in the ***Source_Capabilities*** Message the Dual-Role Data bit in the ***Sink_Capabilities*** Message ***Shall*** also be set to zero.

6.4.1.2.2.6 Unchunked Extended Messages Supported

The Unchunked Extended Messages Supported bit ***Shall*** be set when the Port can send and receive Extended Messages with ***Data Size*** > ***MaxExtendedMsgLegacyLen*** bytes in a single, Unchunked Message.

6.4.1.2.2.7 Peak Current

The USB Power Delivery Fixed Supply is only required to deliver the amount of current requested in the Operating Current (IOC) field of an RDO. In some usages however, for example computer systems, where there are short bursts of activity, it might be desirable to overload the power source for short periods.

For example when a computer system tries to maintain average power consumption, the higher the peak current, the longer the low current (see Section 7.2.8) period needed to maintain such average power. The Peak Current field allows a power source to advertise this additional capability. This capability is intended for direct Port to Port connections only and ***Shall Not*** be offered to downstream Sinks via a Hub.

Every Fixed Supply PDO ***Shall*** contain a Peak Current field. Supplies that want to offer a set of overload capabilities ***Shall*** advertise this through the Peak Current field in the corresponding Fixed Supply PDO (see Table 6-10). Supplies that do not support an overload capability ***Shall*** set these bits to 00b in the corresponding Fixed Supply PDO. Supplies that support an extended overload capability specified in the PeakCurrent1…3 fields of the ***Source_Capabilities_Extended*** Message (see Section 6.5.1) ***Shall*** also set these bits to 00b. Sinks wishing to utilize these extended capabilities ***Shall*** first send the ***Get_Source_Cap_Extended*** Message to determine what capabilities, if any are supported by the Source.

Table 6-10 Fixed Power Source Peak Current Capability

Bits 21…20	Description
00	Peak current equals IOC (default) or look at extended Source capabilities (send ***Get_Source_Cap_Extended*** Message)
01	Overload Capabilities: 1. Peak current equals 150% I_{OC} for 1ms @ 5% duty cycle (low current equals 97% I_{OC} for 19ms) 2. Peak current equals 125% I_{OC} for 2ms @ 10% duty cycle (low current equals 97% I_{OC} for 18ms) 3. Peak current equals 110% I_{OC} for 10ms @ 50% duty cycle (low current equals 90% I_{OC} for 10ms)
10	Overload Capabilities: 1. Peak current equals 200% I_{OC} for 1ms @ 5% duty cycle (low current equals 95% I_{OC} for 19ms) 2. Peak current equals 150% I_{OC} for 2ms @ 10% duty cycle (low current equals 94% I_{OC} for 18ms) 3. Peak current equals 125% I_{OC} for 10ms @ 50% duty cycle (low current equals 75% I_{OC} for 10ms)
11	Overload Capabilities: 1. Peak current equals 200% I_{OC} for 1ms @ 5% duty cycle (low current equals 95% I_{OC} for 19ms) 2. Peak current equals 175% I_{OC} for 2ms @ 10% duty cycle (low current equals 92% I_{OC} for 18ms) 3. Peak current equals 150% I_{OC} for 10ms @ 50% duty cycle (low current equals 50% I_{OC} for 10ms)

6.4.1.2.3 Variable Supply (non-Battery) Power Data Object

Table 6-11 describes a Variable Supply (non-Battery) (10b) PDO for a Source. See Section 7.1.3 for the electrical requirements of the power supply.

The voltage fields ***Shall*** define the range that output voltage ***Shall*** fall within. This does not indicate the voltage that will actually be supplied, except it ***Shall*** fall within that range. The absolute voltage, including any voltage variation, ***Shall Not*** fall below the Minimum Voltage and ***Shall Not*** exceed the Maximum Voltage.

Table 6-11 Variable Supply (non-Battery) PDO - Source

Bit(s)	Description
B31…30	Variable Supply (non-Battery)
B29…20	Maximum Voltage in 50mV units
B19…10	Minimum Voltage in 50mV units
B9…0	Maximum Current in 10mA units

6.4.1.2.4 Battery Supply Power Data Object

Table 6-12 describes a Battery (01b) PDO for a Source. See Section 7.1.3 for the electrical requirements of the power supply.

The voltage fields ***Shall*** represent the Battery's voltage range. The Battery ***Shall*** be capable of supplying the Power value over the entire voltage range. The absolute voltage, including any voltage variation, ***Shall Not*** fall below the Minimum Voltage and ***Shall Not*** exceed the Maximum Voltage. Note, only the Battery PDO uses power instead of current.

The Sink ***May*** monitor the Battery voltage.

Table 6-12 Battery Supply PDO - Source

Bit(s)	Description
B31…30	Battery
B29…20	Maximum Voltage in 50mV units
B19…10	Minimum Voltage in 50mV units
B9…0	Maximum Allowable Power in 250mW units

6.4.1.2.5 Programmable Power Supply Augmented Power Data Object

Table 6-13 below describes a Programmable Power Supply (1100b) APDO for a Source. See Section 7.1.3 for the electrical requirements of the power supply. This APDO is used primarily for Sink Directed Charge of a Battery in the Sink. When applying a current to the Battery greater than the cable supports, a high efficiency fixed scaler ***May*** be used in the Sink to reduce the cable current.

The voltage fields define the output voltage range over which the power supply ***Shall*** be adjustable in 20mV steps. The Maximum Current field contains the current the Programmable Power Supply ***Shall*** be capable of delivering over the advertised voltage range.

Table 6-13 Programmable Power Supply APDO - Source

Bit(s)	Description
B31…30	11b – Augmented Power Data Object (APDO)
B29…28	00b – Programmable Power Supply 01b…11b - ***Reserved***, ***Shall Not*** be used
B27…25	***Reserved*** – ***Shall*** be set to zero
B24…17	Maximum Voltage in 100mV increments
B16	***Reserved*** – ***Shall*** be set to zero
B15…8	Minimum Voltage in 100mV increments
B7	***Reserved*** – ***Shall*** be set to zero
B6…0	Maximum Current in 50mA increments

6.4.1.3 Sink Capabilities Message

A Sink Port ***Shall*** report power levels it is able to operate at in a series of 32-bit Power Data Objects (see Table 6-7). These are returned as part of a ***Sink_Capabilities*** Message in response to a ***Get_Sink_Cap*** Message (see Figure 6-12). This is similar to that used for Source Port capabilities with equivalent Power Data Objects for Fixed, Variable and Battery Supplies as defined in this section. Power Data Objects are used to convey the Sink Port's operational power requirements including Dual-Role Power Ports presently operating as a Source.

Each Power Data Object ***Shall*** describe a specific Sink operational power level, such as a Battery (e.g. 2.8-4.1V) or a fixed power supply (e.g. 12V). The ***Number of Data Objects*** field in the Message Header ***Shall*** define the number of Power Data Objects that follow the Message Header in a Data Message.

All Sinks ***Shall*** minimally offer one Power Data Object with a power level at which the Sink can operate. A Sink ***Shall Not*** offer multiple Power Data Objects of the same type (fixed, variable, Battery) and the same voltage but ***Shall*** instead offer one Power Data Object with the highest available current for that Sink capability and voltage.

All Sinks ***Shall*** include one Power Data Object that reports ***vSafe5V*** even if they require additional power to operate fully. In the case where additional power is required for full operation the Higher Capability bit ***Shall*** be set.

6.4.1.3.1 Sink Fixed Supply Power Data Object

Table 6-14 describes the Sink Fixed Supply (00b) PDO. See Section 7.1.3 for the electrical requirements of the power supply. The Sink ***Shall*** set Voltage to its required voltage and Operational Current to its required operating current. Required operating current is defined as the amount of current a given device needs to be functional. This value could be the maximum current the Sink will ever require or could be sufficient to operate the Sink in one of its modes of operation.

Since all USB Consumers support ***vSafe5V***, the required ***vSafe5V*** Fixed Supply Power Data Object is also used to convey additional information that is returned in bits 29 through 20. All other Fixed Supply Power Data Objects ***Shall*** set bits 29…20 to zero.

For a Sink requiring no power from the Source, the Voltage (B19…10) ***Shall*** be set to 5V and the Operational Current ***Shall*** be set to 0mA.

Table 6-14 Fixed Supply PDO - Sink

<table>
<tr><th>Bit(s)</th><th>Description</th></tr>
<tr><td>B31…30</td><td>Fixed supply</td></tr>
<tr><td>B29</td><td>Dual-Role Power</td></tr>
<tr><td>B28</td><td>Higher Capability</td></tr>
<tr><td>B27</td><td>Unconstrained Power</td></tr>
<tr><td>B26</td><td>USB Communications Capable</td></tr>
<tr><td>B25</td><td>Dual-Role Data</td></tr>
<tr><td>B24…23</td><td>Fast Role Swap required USB Type-C Current (see also [USB Type-C 1.2]):
<table><tr><th>Value</th><th>Description</th></tr><tr><td>00b</td><td>Fast Swap not supported (default)</td></tr><tr><td>01b</td><td>Default USB Power</td></tr><tr><td>10b</td><td>1.5A @ 5V</td></tr><tr><td>11b</td><td>3.0A @ 5V</td></tr></table></td></tr>
<tr><td>B22…20</td><td>Reserved – Shall be set to zero.</td></tr>
<tr><td>B19…10</td><td>Voltage in 50mV units</td></tr>
<tr><td>B9…0</td><td>Operational Current in 10mA units</td></tr>
</table>

6.4.1.3.1.1 Dual-Role Power

The Dual-Role Power bit ***Shall*** be set when the Port is Dual-Role Power capable i.e. supports the ***PR_Swap*** Message. This is a static capability which ***Shall*** remain fixed for a given device regardless of the device's present power role. If the Dual-Role Power bit is set to one in the ***Source_Capabilities*** Message the Dual-Role Power bit in the ***Sink_Capabilities*** Message ***Shall*** also be set to one. If the Dual-Role Power bit is set to zero in the ***Sink_Capabilities*** Message the Dual-Role Power bit in the ***Sink_Capabilities*** Message ***Shall*** also be set to zero.

6.4.1.3.1.2 Higher Capability

In the case that the Sink needs more than ***vSafe5V*** (e.g. 12V) to provide full functionality, then the Higher Capability bit ***Shall*** be set.

6.4.1.3.1.3 Unconstrained Power

The Unconstrained Power bit ***Shall*** be set when an external source of power is available that is sufficient to adequately power the system while charging external devices, or when the device's primary function is to charge external devices.

To set the Unconstrained Power bit as a result of an external source, the external source of power ***Should*** be either:

- An AC supply, e.g. a wall wart, directly connected to the Sink.
- Or, in the case of a PDUSB Hub:
  - A PD Source with its Unconstrained Power bit set.
  - Multiple PD Sources all with their Unconstrained Power bits set.

6.4.1.3.1.4 USB Communications Capable

The USB Communications Capable bit ***Shall*** only be set for Sinks capable of communication over the USB data lines (e.g. D+/- or SS Tx/Rx).

6.4.1.3.1.5 Dual-Role Data

The Dual-Role Data bit ***Shall*** be set when the Port is Dual-Role data capable i.e. it supports the ***DR_Swap*** Message. This is a static capability which ***Shall*** remain fixed for a given device regardless of the device's present power role or data role. If the Dual-Role Data bit is set to one in the ***Source_Capabilities*** Message the Dual-Role Data bit in the

Sink_Capabilities Message ***Shall*** also be set to one. If the Dual-Role Data bit is set to zero in the ***Source_Capabilities*** Message the Dual-Role Data bit in the ***Sink_Capabilities*** Message ***Shall*** also be set to zero.

6.4.1.3.1.6 Fast Role Swap USB Type-C Current

The Fast Role Swap USB Type-C Current field ***Shall*** indicate the current level the Sink will require after a Fast Role Swap has been performed.

Initially when the new Source applies ***vSafe5V*** it will have Rd asserted but ***Shall*** provide the USB Type-C Current indicated by the new Sink in this field. If the new Source is not able to supply this level of current it ***Shall Not*** perform a Fast Role Swap. When Rp is asserted by the new Source during the Fast Role Swap AMS (see Section 6.3.17), the value of USB Type-C Current indicated by Rp ***Shall*** be the same or greater than that indicated in the Fast Role Swap USB Type-C Current field.

6.4.1.3.2 Variable Supply (non-Battery) Power Data Object

Table 6-15 describes a Variable Supply (non-Battery) (10b) PDO used by a Sink. See Section 7.1.3 for the electrical requirements of the power supply.

The voltage fields ***Shall*** be set to the output voltage range that the Sink requires to operate. The Operational Current field ***Shall*** be set to the operational current that the Sink requires at the given voltage range. The absolute voltage, including any voltage variation, ***Shall Not*** fall below the Minimum Voltage and ***Shall Not*** exceed the Maximum Voltage. Required operating current is defined as the amount of current a given device needs to be functional. This value could be the maximum current the Sink will ever require or could be sufficient to operate the Sink in one of its modes of operation.

Table 6-15 Variable Supply (non-Battery) PDO - Sink

Bit(s)	Description
B31…30	Variable Supply (non-Battery)
B29…20	Maximum Voltage in 50mV units
B19…10	Minimum Voltage in 50mV units
B9…0	Operational Current in 10mA units

6.4.1.3.3 Battery Supply Power Data Object

Table 6-16 describes a Battery (01b) PDO used by a Sink. See Section 7.1.3 for the electrical requirements of the power supply.

The voltage fields ***Shall*** be set to the output voltage range that the Sink requires to operate. The Operational Power field ***Shall*** be set to the operational power that the Sink requires at the given voltage range. The absolute voltage, including any voltage variation, ***Shall Not*** fall below the Minimum Voltage and ***Shall Not*** exceed the Maximum Voltage. Note, only the Battery PDO uses power instead of current. Required operating power is defined as the amount of power a given device needs to be functional. This value could be the maximum power the Sink will ever require or could be sufficient to operate the Sink in one of its modes of operation.

Table 6-16 Battery Supply PDO - Sink

Bit(s)	Description
B31…30	Battery
B29…20	Maximum Voltage in 50mV units
B19…10	Minimum Voltage in 50mV units
B9…0	Operational Power in 250mW units

6.4.1.3.4 Programmable Power Supply Augmented Power Data Object

Table 6-17 below describes a Programmable Power Supply (1100b) APDO used by a Sink. See Section 7.1.3 for the electrical requirements of the power supply.

The Maximum and Minimum Voltage fields ***Shall*** be set to the output voltage range that the Sink requires to operate. The Operational Current field ***Shall*** be set to the maximum current the Sink requires over the voltage range. The Operating Current is defined as the maximum amount of current the device needs to fully support its function (e.g., Sink Directed Charge).

Table 6-17 Programmable Power Supply APDO - Sink

Bit(s)	Description
B31…30	11b – Augmented Power Data Object (APDO)
B29…28	00b – Programmable Power Supply
B27…25	***Reserved*** – ***Shall*** be set to zero
B24…17	Maximum Voltage in 100mV increments
B16	***Reserved*** – ***Shall*** be set to zero
B15…8	Minimum Voltage in 100mV increments
B7	***Reserved*** – ***Shall*** be set to zero
B6…0	Maximum Current in 50mA increments

6.4.2 Request Message

A ***Request*** Message ***Shall*** be sent by a Sink to request power, typically during the request phase of a power negotiation. The Request Data Object ***Shall*** be returned by the Sink making a request for power. It ***Shall*** be sent in response to the most recent ***Source_Capabilities*** Message (see Section 8.3.2.2). A ***Request*** Message ***Shall*** return one and only one Sink Request Data Object that ***Shall*** identify the Power Data Object being requested.

The ***Request*** Message includes the requested power level. For example, if the ***Source_Capabilities*** Message includes a Fixed Supply PDO that offers 12V @ 1.5A and if the Sink only wants 12V @ 0.5A, it will set the Operating Current field to 50 (i.e. 10mA * 50 = 0.5A). The ***Request*** Message requests the highest current the Sink will ever require in the Maximum Operating Current Field (in this example it would be 100 (100 * 10mA = 1.0A)).

The request takes a different form depending on the kind of power requested. The Fixed Power Data Object and Variable Power Data Object share a common format shown in Table 6-18 and Table 6-19. The Battery Power Data Object uses the format shown in Table 6-20 and Table 6-21. The Programmable Request Object the format shown in Table 6-22.

Table 6-18 Fixed and Variable Request Data Object

Bits	Description
B31	***Reserved*** – ***Shall*** be set to zero
B30…28	Object position (000b is ***Reserved*** and ***Shall Not*** be used)
B27	GiveBack flag = 0
B26	Capability Mismatch
B25	USB Communications Capable
B24	No USB Suspend
B23	Unchunked Extended Messages Supported
B22…20	***Reserved*** - ***Shall*** be set to zero.
B19…10	Operating current in 10mA units
B9…0	Maximum Operating Current 10mA units

Table 6-19 Fixed and Variable Request Data Object with GiveBack Support

Bits	Description
B31	***Reserved*** – ***Shall*** be set to zero
B30…28	Object position (000b is ***Reserved*** and ***Shall Not*** be used)
B27	GiveBack flag =1
B26	Capability Mismatch

Bits	Description
B25	USB Communications Capable
B24	No USB Suspend
B23	Unchunked Extended Messages Supported
B22…20	***Reserved*** - ***Shall*** be set to zero.
B19…10	Operating Current in 10mA units
B9…0	Minimum Operating Current 10mA units

Table 6-20 Battery Request Data Object

Bits	Description
B31	***Reserved*** – ***Shall*** be set to zero
B30…28	Object position (000b is ***Reserved*** and ***Shall Not*** be used)
B27	GiveBackFlag = 0
B26	Capability Mismatch
B25	USB Communications Capable
B24	No USB Suspend
B23	Unchunked Extended Messages Supported
B22…20	***Reserved*** - ***Shall*** be set to zero.
B19…10	Operating Power in 250mW units
B9…0	Maximum Operating Power in 250mW units

Table 6-21 Battery Request Data Object with GiveBack Support

Bits	Description
B31	***Reserved*** – ***Shall*** be set to zero
B30…28	Object position (000b is ***Reserved*** and ***Shall Not*** be used)
B27	GiveBackFlag = 1
B26	Capability Mismatch
B25	USB Communications Capable
B24	No USB Suspend
B23	Unchunked Extended Messages Supported
B22…20	***Reserved*** - ***Shall*** be set to zero.
B19…10	Operating Power in 250mW units
B9…0	Minimum Operating Power in 250mW units

Table 6-22 Programmable Request Data Object

Bits	Description
B31	***Reserved*** – ***Shall*** be set to zero
B30…28	Object position (000b is ***Reserved*** and ***Shall Not*** be used)
B27	***Reserved*** – ***Shall*** be set to zero
B26	Capability Mismatch
B25	USB Communications Capable
B24	No USB Suspend
B23	Unchunked Extended Messages Supported
B22…20	***Reserved*** - ***Shall*** be set to zero.
B19…9	Output Voltage in 20mV units
B8…7	***Reserved*** - ***Shall*** be set to zero.
B6…0	Operating Current 50mA units

6.4.2.1 Object Position

The value in the Object Position field ***Shall*** indicate which object in the ***Source_Capabilities*** Message the RDO refers. The value 1 always indicates the 5V Fixed Supply PDO as it is the first object following the ***Source_Capabilities*** Message Header. The number 2 refers to the next PDO and so forth.

6.4.2.2 GiveBack Flag

The GiveBack flag ***Shall*** be set to indicate that the Sink will respond to a ***GotoMin*** Message by reducing its load to the Minimum Operating Current. It will typically be used by a USB Device while charging its Battery because a short interruption of the charge will have minimal impact on the user and will allow the Source to manage its load better.

6.4.2.3 Capability Mismatch

A Capability Mismatch occurs when the Sink cannot satisfy its power requirements from the capabilities offered by the Source. In this case the Sink ***Shall*** make a ***Valid*** request from the offered capabilities and ***Shall*** set the Capability Mismatch bit (see Section 8.2.5.2).

When a Sink returns a Request Data Object in response to advertised capabilities with this bit set, it indicates that the Sink wants power that the Source cannot provide. This can be due to either a voltage that is not available or the amount of available current. At this point the Source can use the information in the ***Request*** Message combined with the contents of the ***Sink_Capabilities*** Message to ascertain the Voltage and Current required by the Sink for full operation.

In this context a ***Valid Request*** Message means the following:

- The Object position field ***Shall*** contain a reference to an object in the last received ***Source_Capabilities*** Message.

- The Operating Current/Power field ***Shall*** contain a value which is less than or equal to the maximum current/power offered in the ***Source_Capabilities*** Message.
- If the GiveBack flag is set to zero i.e. there is a Maximum Operating Current/Power field:
  - If the Capability Mismatch bit is set to one:
    - The Maximum Operating Current/Power field ***May*** contain a value larger than the maximum current/power offered in the ***Source_Capabilities*** Message's PDO as referenced by the Object position field. This enables the Sink to indicate that it requires more current/power than is being offered. If the Sink requires a different voltage this will be indicated by its ***Sink_Capabilities*** Message.
  - Else if the Capability Mismatch bit is set to zero:
    - The Maximum Operating Current/Power field ***Shall*** contain a value less than or equal to the maximum current/power offered in the ***Source_Capabilities*** Message's PDO as referenced by the Object position field.
- Else if the GiveBack flag is set to one i.e. there is a Minimum Operating Current/Power field:
  - The Minimum Operating Current/Power field ***Shall*** contain a value less than the Operating Current/Power field.

6.4.2.4 USB Communications Capable

The USB Communications Capable flag ***Shall*** be set to one when the Sink has USB data lines and is capable of communicating using either ***[USB 2.0]*** or ***[USB 3.1]*** protocols. The USB Communications Capable flag ***Shall*** be set to zero when the Sink does not have USB data lines or is otherwise incapable of communicating using either ***[USB 2.0]*** or ***[USB 3.1]*** protocols. This is used by the Source to determine operation in certain cases such as USB suspend. If the USB Communications Capable flag has been set to zero by a Sink then the Source needs to be aware that USB Suspend rules cannot be observed by the Sink.

6.4.2.5 No USB Suspend

The No USB Suspend flag ***May*** be set by the Sink to indicate to the Source that this device is requesting to continue its Contract during USB Suspend. Sinks setting this flag typically have functionality that can use power for purposes other than USB communication e.g. for charging a Battery.

The Source uses this flag to evaluate whether it ***Should*** re-issue the ***Source_Capabilities*** Message with the USB Suspend flag cleared.

6.4.2.6 Unchunked Extended Messages Supported

The Unchunked Extended Messages Supported bit ***Shall*** be set when the Port can send and receive Extended Messages with ***Data Size*** > ***MaxExtendedMsgLegacyLen*** bytes in a single, Unchunked Message.

6.4.2.7 Operating Current

The Operating Current field in the Request Data Object ***Shall*** be set to the actual amount of current the Sink needs to operate at a given time. A new ***Request*** Message, with an updated Operating Current value, ***Shall*** be issued whenever the Sink's power needs change e.g. from Maximum Operating Current down to a lower current level. In conjunction with the Maximum Operating Current field or Minimum Operating Current field, it provides the Source with additional information that allows it to better manage the distribution of its power.

The Operating Current field in the Programmable Request Data Object is used in addition by the Sink to request the Source for the Current Foldback level it needs. When the request is accepted the Source's output current supplied into any load ***Shall*** be less than or equal to the Operating Current. When the Sink attempts to consume more current, the Source ***Shall*** reduce the output voltage so as not to exceed the Operating Current value.

The value in the Operating Current field ***Shall Not*** exceed the value in the Maximum Current field.

This field ***Shall*** apply to the Fixed, Variable and Programmable RDO.

6.4.2.8 Maximum Operating Current

The Maximum Operating Current field in the ***Request*** Message ***Shall*** be set to the highest current the Sink will ever require. The difference between the Operating Current and Maximum Operating Current fields (when the GiveBack Flag is cleared) is used by the Device Policy Manager in the Source to calculate the size of the Power Reserve to be maintained (see Section 8.2.5.1). The Operating Current value ***Shall*** be less than or equal to the Maximum Operating Current value.

When the Capabilities Mismatch bit is set to zero the requested Maximum Operating Current ***Shall*** be less than or equal to the current in the offered Source Capabilities since the Source will need to reserve this power for future use. The Maximum Operating Current field ***Shall*** continue to be set to the highest current needed in order to maintain the allocation of the Power Reserve. If Maximum Operating Current is requested when the Power Reserve is being used by a GotoMin capable device then the resulting Message will be a ***Wait*** Message to enable the Source to reclaim the additional current (see Section 6.3.12.1 and Section 8.2.5.1).

When the Capabilities Mismatch bit is set to one the requested Maximum Operating Current ***May*** be greater than the current in the offered Source Capabilities since the Source will need this information to ascertain the Sink's actual needs.

See Section 6.4.2.3 for more details of the usage of the Capabilities Mismatch bit.

This field ***Shall*** apply to the Fixed and Variable RDO.

6.4.2.9 Minimum Operating Current

The Minimum Operating Current field in the ***Request*** Message ***Shall*** be set to the lowest current the Sink requires to maintain operation. The difference between the Operating Current and Minimum Operating Current fields (when the GiveBack Flag is set) is used by the Device Policy Manager to calculate the amount of power which can be reclaimed using a ***GotoMin*** Message. The Operating Current value ***Shall*** be greater than the Minimum Operating Current value.

This field ***Shall*** apply to the Fixed and Variable RDO.

6.4.2.10 Operating Power

The Operating Power field in the Request Data Object ***Shall*** be set to the actual amount of power the Sink wants at this time. In conjunction with the Maximum Operating Power field, it provides the Source with additional information that allows it to better manage the distribution of its power.

This field ***Shall*** apply to the Battery RDO.

6.4.2.11 Maximum Operating Power

The Maximum Operating Power field in the ***Request*** Message ***Shall*** be set to the highest power the Sink will ever require. This allows a Source with a power supply shared amongst multiple ports to intelligently distribute power.

When the Capabilities Mismatch bit is set to zero the requested Maximum Operating Power ***Shall*** be less than or equal to the power in the offered Source Capabilities since the Source will need to reserve this power for future use. The Maximum Operating Power field ***Shall*** continue to be set to the highest power needed in order to maintain the allocation of the Power Reserve. If Maximum Operating Power is requested when the Power Reserve is being used by a GotoMin capable device then the resulting Message will be a ***Wait*** Message to enable the Source to reclaim the additional power (see Section 6.3.12.1 and Section 8.2.5.1).

When the Capabilities Mismatch bit is set to one the requested Maximum Operating Power ***May*** be greater than the current in the offered Source Capabilities since the Source will need this information to ascertain the Sink's actual needs

See Section 6.4.2.3 for more details of the usage of the Capabilities Mismatch bit.

This field ***Shall*** apply to the Battery RDO.

6.4.2.12 Minimum Operating Power

The Minimum Operating Power field in the ***Request*** Message ***Shall*** be set to the lowest current the Sink requires to maintain operation. When combined with the Operating Power, it gives a Source with a power supply shared amongst multiple ports information about how much power it can temporarily get back so it can to intelligently distribute power.

This field ***Shall*** apply to the Battery RDO.

6.4.2.13 Output Voltage

The Output Voltage field in the Programmable Request Data Object ***Shall*** be set by the Sink to the voltage the Sink requires as measured at the Source's output connector. The Output Voltage field ***Shall*** be greater than or equal to the Minimum Voltage field and less than or equal to the Maximum Voltage field in the Programmable Power Supply APDO.

This field ***Shall*** apply to the Programmable RDO.

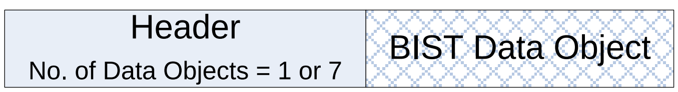
6.4.3 BIST Message

The ***BIST*** Message is sent to request the Port to enter a Physical Layer test mode (see Section 5.9) that performs one of the following functions:

- Enter a Continuous BIST Mode to send a continuous stream of test data to the Tester.
- Send BIST test data to the UUT.

The Message format is as follows:

Figure 6-13 BIST Message



All ports ***Shall*** be able to be a Unit Under Test (UUT) only when operating at ***vSafe5V***. All of the following BIST Modes ***Shall*** be supported:

- Process reception of a ***BIST Carrier Mode*** BIST Data Object that ***Shall*** result in the generation of the appropriate carrier signal.
- Process reception of a ***BIST Test Data*** BIST Data Object that ***Shall*** result in the Message being ***Ignored***.

It is ***Optional*** for a Port to take on the role of a Tester.

When a Port receives a ***BIST*** Message BIST Data Object for a BIST Mode when Power Role swapped or not operating at ***vSafe5V***, the ***BIST*** Message ***Shall*** be ***Ignored***.

When a Port receives a ***BIST*** Message BIST Data Object for a BIST Mode it does not support the ***BIST*** Message ***Shall*** be ***Ignored***.

When a Port or Cable Plug receives a ***BIST*** Message BIST Data Object for a Continuous BIST Mode that it supports, the Port or Cable Plug enters the requested BIST Mode and ***Shall*** remain in that BIST Mode for ***tBISTContMode*** and then ***Shall*** return to normal operation (see Section 6.6.7.2).

The usage model of the PHY Layer BIST modes generally assumes that some controlling agent will request a test of its Port Partner. A UUT Port minimally has to process a request to enter test mode and return error counters. A Tester Port ***Shall*** have a means to place the UUT Port into receiver test mode and retrieve the error counters from the UUT. A Port, that is not part of a Tester, is not expected to be the initiator of a receiver test operation, but is not precluded from doing so.

In Section 8.3.2.14 there is a sequence description of the test sequences used for compliance testing.

The fields in the BIST Data Object are defined in the Table 6-23.

Table 6-23 BIST Data Object

Bit(s)	Value	Parameter	Description	Reference
B31…28	0000b…0100b	Reserved	***Shall Not*** be used	Section 1.4.2.10
	0101b	***BIST Carrier Mode***	Request Transmitter to enter BIST Carrier Mode	Section 6.4.3.1
	0110b…0111b	Reserved	***Shall Not*** be used	Section 1.4.2.10
	1000b	***BIST Test Data***	Sends a Test Data Frame.	Section 6.4.3.2
	1001b…1111b	Reserved	***Shall Not*** be used	Section 1.4.2.10
B27…0		Reserved	***Shall*** be set to zero.	Section 1.4.2.10

6.4.3.1 BIST Carrier Mode

Upon receipt of a ***BIST*** Message, with a ***BIST Carrier Mode*** BIST Data Object, the UUT ***Shall*** send out a continuous string of alternating "1"s and "0"s. Note: that in the case that the BMC Signaling Scheme is used the "1"s and "0"s will in addition be BMC encoded.

The UUT ***Shall*** exit the Continuous BIST Mode within ***tBISTContMode*** of this Continuous BIST Mode being enabled (see Section 6.6.7.2).

6.4.3.2 BIST Test Data

Upon receipt of a ***BIST*** Message, with a ***BIST Test Data*** BIST Data Object, the UUT ***Shall*** return a ***GoodCRC*** Message and ***Shall*** enter a test mode in which it sends no further Messages except for ***GoodCRC*** Messages in response to received Messages. See Section 5.9.2 for the definition of the Test Data Frame.

The test ***Shall*** be ended by sending ***Hard Reset*** Signaling to reset the UUT.

6.4.4 Vendor Defined Message

The ***Vendor_Defined*** Message (VDM) is provided to allow vendors to exchange information outside of that defined by this specification.

A ***Vendor_Defined*** Message ***Shall*** consist of at least one Vendor Data Object, the VDM Header, and ***May*** contain up to a maximum of six additional VDM Objects (VDO).

To ensure vendor uniqueness of ***Vendor_Defined*** Messages, all ***Vendor_Defined*** Messages ***Shall*** contain a ***Valid*** USB Standard or Vendor ID (SVID) allocated by USB-IF in the VDM Header.

Two types of ***Vendor_Defined*** Messages are defined: Structured VDMs and Unstructured VDMs. A Structured VDM defines an extensible structure designed to support Modal Operation. An Unstructured VDM does not define any structure and Messages ***May*** be created in any manner that the vendor chooses.

Vendor_Defined Messages ***Shall Not*** be used for direct power negotiation. They ***May*** however be used to alter Local Policy, affecting what is offered or consumed via the normal PD Messages. For example a ***Vendor_Defined*** Message could be used to enable the Source to offer additional power via a ***Source_Capabilities*** Message.

The Message format ***Shall*** be as shown in Figure 6-14.

Figure 6-14 Vendor Defined Message

The VDM Header ***Shall*** be the first 4-byte object in a Vendor Defined Message. The VDM Header provides command space to allow vendors to customize Messages for their own purposes. Additionally vendors ***May*** make use of the Commands in a Structured VDM.

The fields in the VDM Header for an Unstructured VDM, when the VDM Type Bit is set to zero, ***Shall*** be as defined in Table 6-24. The fields in the VDM Header for a Structured VDM, when the VDM Type Bit is set to one ***Shall*** be as defined in Table 6-25.

Both Unstructured and Structured VDMs ***Shall*** only be sent and received after an Explicit Contract has been established. The only exception to this is the ***Discover Identity*** Command which ***May*** be sent by Source when no Contract or an Implicit Contract (in place after a Power Role Swap or Fast Role Swap) is in place in order to discover Cable capabilities (see Section 8.3.3.22.3). A VDM Message sequence ***Shall Not*** interrupt any other PD Message Sequence. A VDM Message sequence ***Shall*** be interruptible by any other PD Message Sequence.

6.4.4.1 Unstructured VDM

The Unstructured VDM does not define the contents of bits B14…0 in the VDM Header. Their definition and use are the sole responsibility of the vendor indicated by the VID. The Port Partners and Cable Plugs ***Shall*** exit any states entered using an Unstructured VDM when a Hard Reset appears on PD.

The following rules apply to the use of Unstructured VDM Messages:

- Unstructured VDMs ***Shall*** only be used when an Explicit Contract is in place.
- Prior to establishing an Explicit Contract Unstructured VDMs ***Shall Not*** be sent and ***Shall*** be ***Ignored*** if received.
- Only the DFP ***Shall*** be an Initiator of Unstructured VDMs.
- Only the UFP or a Cable Plug ***Shall*** be a Responder to Unstructured VDM.
- Unstructured VDMs ***Shall Not*** be initiated or responded to under any other circumstances.
- A “command” sequence ***Shall*** be interruptible e.g. due to the need for a power related AMS.
- Unstructured VDMs ***Shall*** only be used during Modal Operation in the context of an Active Mode.
- Unstructured VDMs ***May*** be used with SOP* Packets.
- When a DFP or UFP does not support Unstructured VDMs or does not recognize the VID it ***Shall*** return a ***Not_Supported*** Message.

Table 6-24 illustrates the VDM Header bits.

Table 6-24 Unstructured VDM Header

Bit(s)	Parameter	Description
B31…16	Vendor ID (VID)	Unique 16-bit unsigned integer. Assigned by the USB-IF to the Vendor.
B15	VDM Type	0 = Unstructured VDM
B14…0	Available for Vendor Use	Content of this field is defined by the vendor.

6.4.4.1.1 USB Vendor ID

The Vendor ID field ***Shall*** contain the 16-bit Vendor ID value assigned to the vendor by the USB-IF (VID). No other value ***Shall*** be present in this field.

6.4.4.1.2 VDM Type

The VDM Type field ***Shall*** be set to zero indicating that this is an Unstructured VDM.

6.4.4.2 Structured VDM

Setting the VDM Type field to 1 (Structured VDM) defines the use of bits B14…0 in the Structured VDM Header. The fields in the Structured VDM Header are defined in Table 6-25.

The following rules apply to the use of Structured VDM Messages:

- Structured VDMs ***Shall*** only be used when an Explicit Contract is in place with the following exception:
  - Prior to establishing an Explicit Contract a Source ***May*** issue ***Discover Identity*** Messages, to a Cable Plug using SOP' Packets, as an Initiator (see Section 8.3.3.22.3).
- Either Port ***May*** be an Initiator of Structured VDMs except for the ***Enter Mode*** and ***Exit Mode*** Commands which ***Shall*** only be initiated by the DFP.
- A Cable Plug ***Shall*** only be a Responder to Structured VDMs.
- ***Enter Mode*** and ***Exit Mode*** Commands ***Shall*** only be responded to by a UFP or Cable Plug.
- Structured VDMs ***Shall Not*** be initiated or responded to under any other circumstances.
- When a DFP or UFP does not support Structured VDMs any Structured VDMs received ***Shall*** return a ***Not_Supported*** Message.
- When a Cable Plug does not support Structured VDMs any Structured VDMs received ***Shall*** be ***Ignored***.
- A DFP, UFP or Cable Plug which supports Structured VDMs and receiving a Structured VDM for a SVID that it does not recognize ***Shall*** reply with a NAK Command.
- A Structured VDM Command sequence ***Shall*** be interruptible e.g. due to the need for a power related AMS.

Table 6-25 Structured VDM Header

Bit(s)	Field	Description
B31…16	Standard or Vendor ID (SVID)	Unique 16 bit unsigned integer, assigned by the USB-IF
B15	VDM Type	1 = Structured VDM
B14…13	Structured VDM Version	Version Number of the Structured VDM (not this specification Version): • Version 1.0 = 00b (***Shall Not*** be used) • Version 2.0 = 01b • Values 2-3 are ***Reserved*** and ***Shall Not*** be used
B12…11	***Reserved***	For Commands 0…15 ***Shall*** be set to 0 and ***Shall*** be ***Ignored*** SVID Specific Commands (16…31) defined by the SVID.
B10…8	Object Position	For the ***Enter Mode, Exit Mode*** and ***Attention*** Commands (Requests/Responses): • 000b = ***Reserved*** and ***Shall Not*** be used. • 001b…110b = Index into the list of VDOs to identify the desired Mode VDO • 111b = Exit all Active Modes (equivalent of a power on reset). ***Shall*** only be used with the ***Exit Mode*** Command. Commands 0…3, 7…15: • 000b • 001b…111b = ***Reserved*** and ***Shall Not*** be used. SVID Specific Commands (16…31) defined by the SVID.
B7…6	Command Type	00b = REQ (Request from Initiator Port) 01b = ACK (Acknowledge Response from Responder Port) 10b = NAK (Negative Acknowledge Response from Responder Port) 11b = BUSY (Busy Response from Responder Port)
B5	***Reserved***	***Shall*** be set to 0 and ***Shall*** be ***Ignored***
B4…0	Command[1]	0 = ***Reserved***, ***Shall Not*** be used 1 = ***Discover Identity*** 2 = ***Discover SVIDs*** 3 = ***Discover Modes*** 4 = ***Enter Mode*** 5 = ***Exit Mode*** 6 = ***Attention*** 7-15 = ***Reserved***, ***Shall Not*** be used 16…31 = SVID Specific Commands

Bit(s)	Field	Description
Note 1: In the case where a SID is used the modes are defined by a standard. When a VID is used the modes are defined by the Vendor.		

Table 6-26 shows the Commands, which SVID to use with each Command and the ***SOP**** values which ***Shall*** be used.

Table 6-26 Structured VDM Commands

Command	VDM Header SVID Field	SOP* used
Discover Identity	***Shall*** only use the PD SID.	***Shall*** only use ***SOP***/***SOP'***.
Discover SVIDs	***Shall*** only use the PD SID.	***Shall*** only use ***SOP***/***SOP'***.
Discover Modes	***Valid*** with any SVID.	***Shall*** only use ***SOP***/***SOP'***.
Enter Mode	***Valid*** with any SVID.	***Valid*** with ***SOP****.
Exit Mode	***Valid*** with any SVID.	***Valid*** with ***SOP****.
Attention	***Valid*** with any SVID.	***Valid*** with ***SOP***.
SVID Specific Commands	***Valid*** with any SVID.	***Valid*** with ***SOP**** (defined by SVID).

6.4.4.2.1 SVID

The SVID field ***Shall*** contain either a 16-bit USB Standard ID value (SID) or the 16-bit assigned to the vendor by the USB-IF (VID). No other value ***Shall*** be present in this field.

Table 6-27 lists specific SVID values referenced by this specification.

Table 6-27 SVID Values

Parameter	Value	Description
PD SID	0xFF00	Standard ID allocated to this specification.

6.4.4.2.2 VDM Type

The VDM Type field ***Shall*** be set to one indicating that this is a Structured VDM.

6.4.4.2.3 Structured VDM Version

The Structured VDM Version field indicates the level of functionality supported in the Structured VDM part of the specification. This is not the same version as the version of this specification. This field ***Shall*** be set to 01b to indicate Version 2.0.

To ensure interoperability with existing USBPD Products, USBPD Products ***Shall*** support every Structured VDM Version number starting from Version 1.0.

On receipt of a VDM Header with a higher Version number than that supported, a Port ***Shall*** respond using the highest Version number it supports.

The Structured VDM Version field of the ***Discover Identity*** Command sent and received during VDM discovery ***Shall*** be used to determine the lowest common Structured VDM Version supported by the Port Partners or Cable Plug and ***Shall*** continue to operate using this Specification Revision until they are Detached. After discovering the Structure VDM Version, the Structured VDM Version field ***Shall*** match the agreed common Structured VDM Version.

6.4.4.2.4 Object Position

The Object Position field ***Shall*** be used by the ***Enter Mode*** and ***Exit Mode*** Commands. The ***Discover Modes*** Command returns a list of zero to six VDOs, each of which describes a Mode. The value in Object Position field is an index into that list that indicates which VDO (e.g. Mode) in the list the ***Enter Mode*** and ***Exit Mode*** Command refers to. The Object Position ***Shall*** start with one for the first Mode in the list. If the SVID is a VID, the content of the VDO for the Mode

Shall be defined by the vendor. If the SVID is a SID, the content ***Shall*** be defined by the Standard. The VDO's content ***May*** be as simple as a numeric value or as complex as bit mapped description of capabilities of the Mode. In all cases, the Responder is responsible for deciphering the contents to know whether or not it supports the Mode at the Object Position.

This field ***Shall*** be set to zero in the Request or Response (REQ, ACK, NAK or BUSY) when not required by the specification of the individual Command.

6.4.4.2.5 Command Type

6.4.4.2.5.1 Commands other than Attention

This Command Type field ***Shall*** be used to indicate the type of Command request/response being sent.

An Initiator ***Shall*** set the field to REQ to indicate that this is a Command request from an Initiator.

If Structured VDMs are supported, then the responses are as follows:

- "Responder ACK" is the normal return and ***Shall*** be sent to indicate that the Command request was received and handled normally.
- "Responder NAK" ***Shall*** be returned when the Command request:
- Has an ***Invalid*** parameter (e.g. ***Invalid*** SVID or Mode).
- Cannot not be acted upon because the configuration is not correct (e.g. a Mode which has a dependency on another Mode or a request to exit a Mode which is not Active).
- Is Unrecognized.
- The handling of "Responder NAK" is left up to the Initiator.
- "Responder BUSY" ***Shall*** be sent in the response to a VDM when the Responder is unable to respond to the Command request immediately, but the Command request ***May*** be retried. The Initiator ***Shall*** wait ***tVDMBusy*** after a "Responder BUSY" response is received before retrying the Command request.

6.4.4.2.5.2 Attention Command

This Command Type field ***Shall*** be used to indicate the type of Command request being sent. An Initiator ***Shall*** set the field to REQ to indicate that this is a Command request from an Initiator. If Structured VDMs are supported, then no response ***Shall*** be made to an ***Attention*** Command.

6.4.4.2.6 Command

6.4.4.2.6.1 Commands other than Attention

This field contains the value for the VDM Command being sent. The Commands explicitly listed in this field are used to identify devices and manage their operational Modes. There is a further range of Command values left for the vendor to use to manage additional extensions.

A Structured VDM Command consists of a Command request and a Command response (ACK, NAK or BUSY). A Structured VDM Command is deemed to be completed (and if applicable, the transition to the requested functionality is made) when the ***GoodCRC*** Message has been successfully received by the Responder in reply to its Command response.

If Structured VDMs are supported, but the Structured VDM Command request is not recognized it ***Shall*** be NAKed (see Table 6-28).

6.4.4.2.6.2 Attention Command

This field contains the value for the VDM Command being sent (***Attention***). The ***Attention*** Command ***May*** be used by the Initiator to notify the Responder that it requires service.

A Structured VDM ***Attention*** Command consists of a Command request but no Command response. A Structured VDM ***Attention*** Command is deemed to be completed when the ***GoodCRC*** Message has been successfully received by the Initiator in reply to its ***Attention*** Command request.

If Structured VDMs are supported, but the Structured VDM ***Attention*** Command request is not recognized it ***Shall*** be ***Ignored*** (see Table 6-28).

6.4.4.3 Use of Commands

The VDM Header for a Structured VDM Message defines Commands used to retrieve a list of SVIDs the device supports, to discover the Modes associated with each SVID, and to enter/exit the Modes. The Commands include:

- ***Discover Identity***.
- ***Discover SVIDs***.
- ***Discover Modes***.
- ***Enter Mode***.
- ***Exit Mode***.
- ***Attention***.

Additional Command space is also reserved for Standard and Vendor use and for future extensions.

The Command sequences use the terms Initiator and Responder to identify messaging roles the ports are taking on relative to each other. This role is independent of the Port's power capability (Provider, Consumer etc.) or its present power role (Source or Sink). The Initiator is the Port sending the initial Command request and the Responder is the Port replying with the Command response. See Section 6.4.4.3.6.

All Ports that support Modes ***Shall*** support the ***Discover Identity***, ***Discover SVIDs***, the ***Discover Modes***, the ***Enter Mode*** and ***Exit Mode*** Commands.

Table 6-28 details the responses a Responder ***May*** issue to each Command request. Responses not listed for a given Command ***Shall Not*** be sent by a Responder. A NAK response ***Should*** be taken as an indication not to retry that particular Command.

Table 6-28 Commands and Responses

Command	Allowed Response	Reference
Discover Identity	ACK, NAK, BUSY	Section 6.4.4.3.1
Discover SVIDs	ACK, NAK, BUSY	Section 6.4.4.3.2
Discover Modes	ACK, NAK, BUSY	Section 6.4.4.3.3
Enter Mode	ACK, NAK	Section 6.4.4.3.4
Exit Mode	ACK, NAK	Section 6.4.4.3.5
Attention	None	Section 6.4.4.3.6

Examples of Command usage can be found in Appendix G.

6.4.4.3.1 Discover Identity

The ***Discover Identity*** Command is provided to enable an Initiator to identify its Port Partner and for an Initiator (VCONN Source) to identify the Responder (Cable Plug). The ***Discover Identity*** Command is also used to determine whether a Cable Plug is PD-Capable by looking for a ***GoodCRC*** Message Response.

The ***Discover Identity*** Command ***Shall*** be used to determine whether a given Cable Plug is PD Capable (see Section 8.3.3.18.1 and Section 8.3.3.22.3). In this case a ***Discover Identity*** Command request sent to SOP' ***Shall Not*** cause a Soft Reset if a ***GoodCRC*** Message response is not returned since this can indicate a non-PD Capable cable. Note that a Cable Plug will not be ready for PD Communication until tVCONNStable after VCONN has been applied (see ***[USB Type-C 1.2]***). During Cable Plug discovery, when there is an Explicit Contract, ***Discover Identity*** Commands are sent at a rate defined by the ***DiscoverIdentityTimer*** (see Section 6.6.14) up to a maximum of ***nDiscoverIdentityCount*** times (see Section 6.7.5).

A PD-Capable Cable Plug ***Shall*** return a ***Discover Identity*** Command ACK in response to a ***Discover Identity*** Command request sent to SOP'.

A PD-Capable UFP that supports Modal Operation ***Shall*** return a ***Discover Identity*** Command ACK in response to a ***Discover Identity*** Command request sent to SOP.

The SVID in the ***Discover Identity*** Command request ***Shall*** be set to the ***PD SID*** (see Table 6-27).

The ***Number of Data Objects*** field in the Message Header in the ***Discover Identity*** Command request ***Shall*** be set to 1 since the ***Discover Identity*** Command request ***Shall Not*** contain any VDOs.

The ***Discover Identity*** Command ACK sent back by the Responder ***Shall*** contain an ID Header VDO, a Cert Stat VDO, a Product VDO and the Product Type VDOs defined by the Product Type as shown in Figure 6-15. This specification defines the following Product Type VDOs:

- Cable VDO (see Section 6.4.4.3.1.4).
- Alternate Mode Adapter VDO (see Section 6.4.4.3.1.5).

No VDOs other than those defined in this specification ***Shall*** be sent as part of the ***Discover Identity*** Command response. Where there is no Product Type VDO defined for a specific Product Type, no VDOs ***Shall*** be sent as part of the ***Discover Identity*** Command response. Any additional VDOs received by the initiator ***Shall*** be ***Ignored***.

Figure 6-15 Discover Identity Command response

Header No. of Data Objects = 4-7[1]	VDM Header	ID Header VDO	Cert Stat VDO	Product VDO	0..3[2] Product Type VDO(s)

[1] Only Data objects defined in this specification can be sent as part of the ***Discover Identity*** Command.

[2] The following sections define the number and content of the VDOs for each Product Type.

The ***Number of Data Objects*** field in the Message Header in the ***Discover Identity*** Command NAK and BUSY responses ***Shall*** be set to 1 since they ***Shall Not*** contain any VDOs.

6.4.4.3.1.1 ID Header VDO

The ID Header VDO contains information corresponding to the Power Delivery Product. The fields in the ID Header VDO ***Shall*** be as defined in Table 6-29.

Table 6-29 ID Header VDO

Bit(s)	Description	Reference
B31	USB Communications Capable as USB Host: • ***Shall*** be set to one if the product is capable of enumerating USB Devices. • ***Shall*** be set to zero otherwise	Section 6.4.4.3.1.1.1
B30	USB Communications Capable as a USB Device: • ***Shall*** be set to one if the product is capable of being enumerated as a USB Device. • ***Shall*** be set to zero otherwise	Section 6.4.4.3.1.1.2
B29…27	Product Type (UFP): • 000b – Undefined • 001b – PDUSB Hub • 010b – PDUSB Peripheral • 011b…100b – ***Reserved***, ***Shall Not*** be used. • 101b – Alternate Mode Adapter (AMA) • 110b…111b – ***Reserved***, ***Shall Not*** be used. Product Type (Cable Plug): • 000b – Undefined • 001b…010b – ***Reserved***, ***Shall Not*** be used.	Section 6.4.4.3.1.1.3

Bit(s)	Description	Reference
	• 011b – Passive Cable • 100b – Active Cable • 101b…111b – ***Reserved***, ***Shall Not*** be used.	
B26	Modal Operation Supported: • ***Shall*** be set to one if the product supports Modal Operation. • ***Shall*** be set to zero otherwise	Section 6.4.4.3.1.1.4
B25…23	Product Type (DFP): • 000b – Undefined • 001b – PDUSB Hub • 010b – PDUSB Host • 011b – Power Brick • 100b - Alternate Mode Controller (AMC) • 101b…111b – ***Reserved***, ***Shall Not*** be used.	
B22…16	***Reserved***. ***Shall*** be set to zero.	
B15…0	16-bit unsigned integer. USB Vendor ID	***[USB 2.0]***/***[USB 3.1]***

6.4.4.3.1.1.1 Data Capable as a USB Host

The Data Capable as a USB Host field is used to indicate whether or not the Port has a USB Host Capability.

6.4.4.3.1.1.2 Data Capable as a USB Device

The Data Capable as a USB Device field is used to indicate whether or not the Port has a USB Device Capability.

6.4.4.3.1.1.3 Product Type (UFP)

The Product Type (UFP) field indicates the type of Product when in UFP Data Role, whether a VDO will be returned and if so the type of VDO to be returned. For DRD Products this field ***Shall*** indicate the capability regardless of the present Data Role. Table 6-30 defines the Product Type VDOs which ***Shall*** be returned.

Table 6-30 Product Types (UFP)

Product Type	Description	Product Type VDO	Reference
Undefined	***Shall*** be used where no other Product Type value is appropriate.	None	
PDUSB Hub	***Shall*** be used when the Product is a PDUSB Hub.	None	
PDUSB Peripheral	***Shall*** be used when the Product is a PDUSB Device other than a PDUSB Hub.	None	
Alternate Mode Adapter	***Shall*** be used when the Product is a PDUSB Device that supports one or more Alternate Modes.	AMA VDO	Section 6.4.4.3.1.5

6.4.4.3.1.1.4 Product Type (Cable Plug)

The Product Type (Cable Plug) field indicates the type of Product when the Product is a Cable Plug, whether a VDO will be returned and if so the type of VDO to be returned. Table 6-31 defines the Product Type VDOs which ***Shall*** be returned.

Table 6-31 Product Types (Cable Plug)

Product Type	Description	Product Type VDO	Reference
Undefined	***Shall*** be used where no other Product Type value is appropriate.	None	
Active Cable	***Shall*** be used when the Product is a cable that incorporates signal conditioning circuits.	Active Cable VDO	Section 6.4.4.3.1.4.2
Passive Cable	***Shall*** be used when the Product is a cable that does not incorporate signal conditioning circuits.	Passive Cable VDO	Section 6.4.4.3.1.4.1

6.4.4.3.1.1.5 Modal Operation Supported

The Modal Operation Supported bit is used to indicate whether or the not the Product supports Modes.

6.4.4.3.1.1.6 Product Type (DFP)

The Product Type (DFP) field indicates the type of Product when in DFP Data Role, whether a VDO will be returned and if so the type of VDO to be returned. For DRD Products this field ***Shall*** indicate the capability regardless of the present Data Role. Table 6-32 defines the Product Type VDOs which ***Shall*** be returned.

Table 6-32 Product Types (DFP)

Product Type	Description	Product Type VDO	Reference
Undefined	***Shall*** be used where no other Product Type value is appropriate.	None	
PDUSB Hub	***Shall*** be used when the Product is a PDUSB Hub.	None	
PDUSB Host	***Shall*** be used when the Product is a PDUSB Host.	None	
Power Brick	***Shall*** be used when the Product is a Power Brick/Wall Wart.	None	
Alternate Mode Controller	***Shall*** be used when the Product is a PDUSB Host or DFP that supports one or more Alternate Modes.	AMA VDO	Section 6.4.4.3.1.5

6.4.4.3.1.1.7 Vendor ID

Manufacturers ***Shall*** set the Vendor ID field to the value of the Vendor ID assigned to them by USB-IF. For USB Devices or Hubs which support USB communications the Vendor ID field ***Shall*** be identical to the Vendor ID field defined in the product's USB Device Descriptor (see ***[USB 2.0]*** and ***[USB 3.1]***).

6.4.4.3.1.2 Cert Stat VDO

The Cert Stat VDO ***Shall*** contain the XID assigned by USB-IF to the product before certification in binary format. The fields in the Cert Stat VDO ***Shall*** be as defined in Table 6-33.

Table 6-33 Cert Stat VDO

Bit(s)	Description	Reference
B31…0	32-bit unsigned integer, XID	Assigned by USB-IF

6.4.4.3.1.3 Product VDO

The Product VDO contains identity information relating to the product. The fields in the Product VDO ***Shall*** be as defined in Table 6-34.

Table 6-34 Product VDO

Bit(s)	Description	Reference
B31…16	16-bit unsigned integer. USB Product ID	*[USB 2.0]*/*[USB 3.1]*
B15…0	16-bit unsigned integer. bcdDevice	*[USB 2.0]*/*[USB 3.1]*

Manufacturers ***Should*** set the USB Product ID field to a unique value identifying the product and ***Should*** set the bcdDevice field to a version number relevant to the release version of the product.

6.4.4.3.1.4 Cable VDO

The Cable VDO defined in this section ***Shall*** be sent when the Product Type is given as Passive or Active Cable. Table 6-35 and Table 6-36 define the Cable VDOs which ***Shall*** be sent in each case.

6.4.4.3.1.4.1 Passive Cable VDO

A Passive Cable has a USB Plug on each end at least one of which is a Cable Plug supporting SOP' Communication. A Passive Cable ***Shall Not*** incorporate data bus signal conditioning circuits and hence has no concept of Super Speed Directionality. A Passive Cable ***Shall*** include a V_{BUS} wire and ***Shall*** only respond to SOP' Communication. Passive Cables ***Shall*** support the Structured VDM ***Discover Identity*** Command and ***Shall*** return the Passive Cable VDO in a ***Discover Identity*** Command ACK as shown in Table 6-35.

Table 6-35 Passive Cable VDO

Bit(s)	Field	Description
B31…28	HW Version	0000b…1111b assigned by the VID owner
B27…24	Firmware Version	0000b…1111b assigned by the VID owner
B23…21	VDO Version	Version Number of the VDO (not this specification Version): • Version 1.0 = 000b Values 001b…111b are ***Reserved*** and ***Shall Not*** be used
B20	***Reserved***	***Shall*** be set to zero.
B19…18	USB Type-C plug to USB Type-C/Captive	00b = ***Reserved***, ***Shall Not*** be used 01b = ***Reserved***, ***Shall Not*** be used 10b = USB Type-C 11b = Captive
B17	***Reserved***	***Shall*** be set to zero.
B16…13	Cable Latency	0000b – ***Reserved***, ***Shall Not*** be used 0001b – <10ns (~1m) 0010b – 10ns to 20ns (~2m) 0011b – 20ns to 30ns (~3m) 0100b – 30ns to 40ns (~4m) 0101b – 40ns to 50ns (~5m) 0110b – 50ns to 60ns (~6m) 0111b – 60ns to 70ns (~7m) 1000b – > 70ns (>~7m) 1001b ….1111b ***Reserved***, ***Shall Not*** be used Includes latency of electronics in Active Cable
B12…11	Cable Termination Type	00b = VCONN not required. Cable Plugs that only support ***Discover Identity*** Commands ***Shall*** set these bits to 00b. 01b = VCONN required 10b…11b = ***Reserved***, ***Shall Not*** be used

Bit(s)	Field	Description
B10…9	Maximum V_{BUS} Voltage	Maximum Cable VBUS Voltage: 00b – 20V 01b – 30V 10b – 40V 11b – 50V
B8…7	***Reserved***	***Shall*** be set to zero.
B6…5	V_{BUS} Current Handling Capability	00b = ***Reserved***, ***Shall Not*** be used. 01b = 3A 10b = 5A 11b = ***Reserved***, ***Shall Not*** be used.
B4…3	***Reserved***	***Shall*** be set to zero.
B2…0	USB SuperSpeed Signaling Support	000b = USB 2.0 only, no SuperSpeed support 001b = ***[USB 3.1]*** Gen1 010b = ***[USB 3.1]*** Gen1 and Gen2 011b…111b = ***Reserved***, ***Shall Not*** be used See ***[USB Type-C 1.2]*** for definitions.

The HW Version field (B31…28) contains a HW Version assigned by the VID owner.

The FW Version field (B27…24) contains a FW Version assigned by the VID owner.

The VDO Version field (B23…20) contains a VDO version for this VDM version number. This field indicates the expected content for this VDO.

The Connector Type field (B19…18) ***Shall*** contain a value corresponding to the connector type on the opposite end from the USB Type-C connector.

The Cable Latency field (B16…13) ***Shall*** contain a value corresponding to the signal latency through the cable which can be used as an approximation for its length.

The Cable Termination Type field (B12…11) ***Shall*** contain a value indicating whether the Passive Cable needs VCONN only initially in order to support the ***Discover Identity*** Command, after which it can be removed, or the Passive Cable needs VCONN to be continuously applied in order to power some feature of the Cable Plug.

The Maximum V_{BUS} Voltage field (B10…9) ***Shall*** contain the maximum voltage that ***Shall*** be negotiated using a Fixed Supply over the cable as part of an Explicit Contract where the maximum voltage that ***Shall*** be applied to the cable is ***vSrcNew*** max + ***vSrcValid*** max. For example when the Maximum V_{BUS} Voltage field is 20V, a Fixed Supply of 20V can be negotiated as part of an Explicit Contract where the absolute maximum voltage that can be applied to the cable is 21.5V.

The V_{BUS} Current Handling Capability field (B6…5) ***Shall*** indicate whether the cable is capable of carrying 3A or 5A.

The USB SuperSpeed Signaling Support field (B2…0) ***Shall*** indicate whether the cable supports only ***[USB 2.0]*** , or in addition Supports ***[USB 3.1]*** Gen1, or Gen1 and Gen2.

6.4.4.3.1.4.2 Active Cable VDO

An Active Cable has a USB Plug on each end at least one of which is a Cable Plug supporting SOP' Communication. An Active Cable ***Shall*** incorporate data bus signal conditioning circuits and ***May*** have a concept of Super Speed Directionality on its Super Speed wires. An Active Cable ***May*** include a V_{BUS} wire. An Active Cable ***Shall*** respond to SOP' Communication and ***May*** respond to SOP'' Communication. Active Cables ***Shall*** support the Structured VDM ***Discover Identity*** Command and ***Shall*** return the Active Cable VDO in a ***Discover Identity*** Command ACK as shown in Table 6-36.

Table 6-36 Active Cable VDO

Bit(s)	Field	Description
B31…28	HW Version	0000b…1111b assigned by the VID owner
B27…24	Firmware Version	0000b…1111b assigned by the VID owner
B23…21	VDO Version	Version Number of the VDO (not this specification Version): • Version 1.0 = 000b Values 001b…111b are ***Reserved*** and ***Shall Not*** be used
B20	***Reserved***	***Shall*** be set to zero.
B19…18	USB Type-C plug to USB Type-C/Captive	00b = ***Reserved***, ***Shall Not*** be used 01b = ***Reserved***, ***Shall Not*** be used 10b = USB Type-C 11b = Captive
B17	***Reserved***	***Shall*** be set to zero.
B16…13	Cable Latency	0000b – ***Reserved***, ***Shall Not*** be used 0001b – <10ns (~1m) 0010b – 10ns to 20ns (~2m) 0011b – 20ns to 30ns (~3m) 0100b – 30ns to 40ns (~4m) 0101b – 40ns to 50ns (~5m) 0110b – 50ns to 60ns (~6m) 0111b – 60ns to 70ns (~7m) 1000b –1000ns (~100m) 1001b –2000ns (~200m) 1010b – 3000ns (~300m) 1011b ….1111b ***Reserved***, ***Shall Not*** be used Includes latency of electronics in Active Cable
B12…11	Cable Termination Type	00b…01b = ***Reserved***, ***Shall Not*** be used 10b = One end Active, one end passive, V_{CONN} required 11b = Both ends Active, V_{CONN} required
B10…9	Maximum V_{BUS} Voltage	Maximum Cable V_{BUS} Voltage: 00b – 20V 01b – 30V 10b – 40V 11b – 50V
B8…7	***Reserved***	***Shall*** be set to zero.
B6…5	V_{BUS} Current Handling Capability	When V_{BUS} Through Cable is "No", ***Reserved***, ***Shall Not*** be used. When V_{BUS} Though Cable is "Yes": 00b = ***Reserved***, ***Shall Not*** be used. 01b = 3A 10b = 5A 11b = ***Reserved***, ***Shall Not*** be used.
B4	V_{BUS} Through Cable	0 = No 1 = Yes
B3	SOP" Controller Present	0 = No SOP" controller present 1 = SOP" controller present

Bit(s)	Field	Description
B2…0	USB SuperSpeed Signaling Support	000b = ***[USB 2.0]*** only 001b = ***[USB 3.1]*** Gen1 010b = ***[USB 3.1]*** Gen1 and Gen2 011b…111b = ***Reserved***, ***Shall Not*** be used

The HW Version field (B31…28) contains a HW Version assigned by the VID owner.

The FW Version field (B27…24) contains a FW Version assigned by the VID owner.

The VDO Version field (B23…20) contains a VDO version for this VDM version number. This field indicates the expected content for this VDO.

The Connector Type field (B19…18) ***Shall*** contain a value corresponding to the connector type on the opposite end from the USB Type-C connector.

The Cable Latency field (B16…13) ***Shall*** contain a value corresponding to the signal latency through the cable which can be used as an approximation for its length.

The Cable Termination Type field (B12…11) ***Shall*** contain a value corresponding to whether the Active Cable has one or two Cable Plugs requiring power from VCONN.

The Maximum V_{BUS} Voltage field (B10…9) ***Shall*** contain the maximum voltage that ***Shall*** be negotiated using a Fixed Supply over the cable as part of an Explicit Contract where the maximum voltage that ***Shall*** be applied to the cable is ***vSrcNew*** max + ***vSrcValid*** max. For example when the Maximum V_{BUS} Voltage field is 20V, a Fixed Supply of 20V can be negotiated as part of an Explicit Contract where the absolute maximum voltage that can be applied to the cable is 21.5V.

The V_{BUS} Current Handling Capability field (B6…5) ***Shall*** indicate whether the cable is capable of carrying 3A or 5A. The V_{BUS} Current Handling Capability ***Shall*** only be ***Valid*** when the V_{BUS} Through Cable field indicates an end to end V_{BUS} wire.

The V_{BUS} Through Cable field (B4) ***Shall*** indicate whether the cable contains an end to end V_{BUS} wire.

The SOP'' Controller Present field (B3) ***Shall*** indicate whether one of the Cable Plugs is capable of SOP'' Communication in addition to the ***Normative*** SOP' Communication.

The USB SuperSpeed Signaling Support field (B2…0) ***Shall*** indicate whether the cable supports only ***[USB 2.0]*** , or in addition Supports ***[USB 3.1]*** Gen1, or Gen1 and Gen2.

6.4.4.3.1.5 Alternate Mode Adapter VDO

The Alternate Mode Adapter (AMA) VDO defined in this section ***Shall*** be sent when the Product Type is given as Alternate Mode Adapter. Table 6-37 defines the AMA VDO which ***Shall*** be sent.

Table 6-37 AMA VDO

Bit(s)	Field	Description
B31…28	HW Version	0000b…1111b assigned by the VID owner
B27…24	Firmware Version	0000b…1111b assigned by the VID owner
B23…21	VDO Version	Version Number of the VDO (not this specification Version): • Version 1.0 = 000b Values 001b…111b are ***Reserved*** and ***Shall Not*** be used
B20…8	***Reserved***.	***Shall*** be set to zero.
B7…5	V_{CONN} power	When the V_{CONN} required field is set to "Yes" V_{CONN} power needed by adapter for full functionality 000b = 1W 001b = 1.5W 010b = 2W 011b = 3W 100b = 4W 101b = 5W 110b = 6W 111b = ***Reserved***, ***Shall Not*** be used When the V_{CONN} required field is set to "No" ***Reserved***, ***Shall*** be set to zero.
B4	V_{CONN} required	0 = No 1 = Yes
B3	V_{BUS} required	0 = No 1 = Yes
B2…0	USB SuperSpeed Signaling Support	000b = ***[USB 2.0]*** only 001b = ***[USB 3.1]*** Gen1 and USB 2.0 010b = ***[USB 3.1]*** Gen1, Gen2 and USB 2.0 011b = ***[USB 2.0]*** billboard only 100b…111b = ***Reserved***, ***Shall Not*** be used

The HW Version field (B31…28) contains a HW Version assigned by the VID owner.

The FW Version field (B27…24) contains a FW Version assigned by the VID owner.

The VDO Version field (B23…20) contains a VDO version for this VDM version number. This field indicates the expected content for this VDO.

When the VCONN required field indicates that VCONN is required the VCONN power field ***Shall*** indicate how much power the AMA needs in order to fully operate.

The VCONN required field ***Shall*** indicate whether VCONN is needed for the AMA to operate.

The V_{BUS} required field ***Shall*** indicate whether V_{BUS} is needed for the AMA to operate.

The USB SuperSpeed Signaling Support field (B2…0) ***Shall*** indicate whether the cable supports only ***[USB 2.0]*** , or in addition Supports ***[USB 3.1]*** Gen1, or Gen1 and Gen2 or ***[USB 2.0]*** billboard only.

6.4.4.3.2 Discover SVIDs

The ***Discover SVIDs*** Command is used by an Initiator to determine the SVIDs for which a Responder has Modes. The ***Discover SVIDs*** Command is used in conjunction with the ***Discover Modes*** Command in the Discovery Process to determine which Modes a device supports. The list of SVIDs is always terminated with one or two 0x0000 SVIDs.

The SVID in the ***Discover SVIDs*** Command ***Shall*** be set to the ***PD SID*** (see Table 6-27) by both the Initiator and the Responder for this Command.

The ***Number of Data Objects*** field in the Message Header in the ***Discover SVIDs*** Command request ***Shall*** be set to 1 since the ***Discover SVIDs*** Command request ***Shall Not*** contain any VDOs.

The ***Discover SVIDs*** Command ACK sent back by the Responder ***Shall*** contain one or more SVIDs. The SVIDs are returned 2 per VDO (see Table 6-38). If there are an odd number of supported SVIDs, the ***Discover SVIDs*** Command is returned ending with a SVID value of 0x0000 in the last part of the last VDO. If there are an even number of supported SVIDs, the ***Discover SVIDs*** Command is returned ending with an additional VDO containing two SVIDs with values of 0x0000. A Responder ***Shall*** only return SVIDs for which a ***Discover Modes*** Command request for that SVID will return at least one Mode.

A Responder that does not support any SVIDs ***Shall*** return a NAK.

The ***Number of Data Objects*** field in the Message Header in the ***Discover SVIDs*** Command NAK and BUSY responses ***Shall*** be set to 1 since they ***Shall Not*** contain any VDOs.

If the Responder supports 12 or more SVIDs then the ***Discover SVIDs*** Command ***Shall*** be executed multiple times until a Discover SVIDs VDO is returned ending either with a SVID value of 0x0000 in the last part of the last VDO or with a VDO containing two SVIDs with values of 0x0000. Each Discover SVID ACK Message, other than the one containing the terminating 0x0000 SVID, ***Shall*** convey 12 SVIDs. The Responder ***Shall*** restart the list of SVIDs each time a ***Discover Identity*** Command request is received from the Initiator.

Note: that since a Cable Plug does not retry Messages if the ***GoodCRC*** Message from the Initiator becomes corrupted the Cable Plug will consider the ***Discover SVIDs*** Command ACK unsent and will send the same list of SVIDs again.

Figure 6-16 shows an example response to the ***Discover SVIDs*** Command request with two VDOs containing three SVIDs. Figure 6-17 shows an example response with two VDOs containing four SVIDs followed by an empty VDO to terminate the response. Figure 6-18 shows an example response with six VDOs containing twelve SVIDs followed by an additional request that returns an empty VDO indicating there are no more SVIDs to return.

Table 6-38 Discover SVIDs Responder VDO

Bit(s)	Field	Description
B31…16	SVID n	16 bit unsigned integer, assigned by the USB-IF or 0x0000 if this is the last VDO and the Responder supports an even number of SVIDs.
B15…0	SVID n+1	16 bit unsigned integer, assigned by the USB-IF or 0x0000 if this is the last VDO and the Responder supports an odd or even number of SVIDs.

Figure 6-16 Example Discover SVIDs response with 3 SVIDs

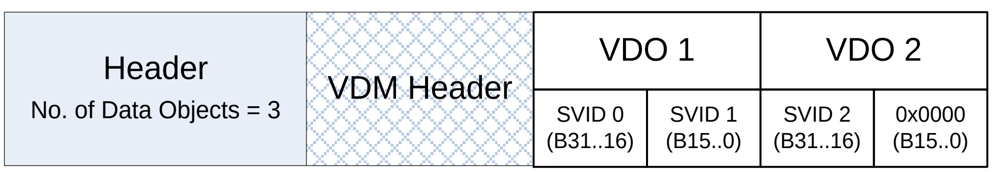


Figure 6-17 Example Discover SVIDs response with 4 SVIDs

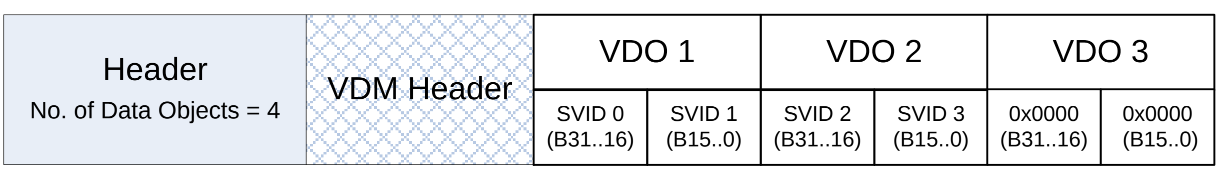


Figure 6-18 Example Discover SVIDs response with 12 SVIDs followed by an empty response

Header No. of Data Objects = 7	VDM Header	VDO 1		VDO 2		VDO 3		VDO 4		VDO 5		VDO 6	
		SVID 0 (B31..16)	SVID 1 (B15..0)	SVID 2 (B31..16)	SVID 3 (B15..0)	SVID 4 (B31..16)	SVID 5 (B15..0)	SVID 6 (B31..16)	SVID 7 (B15..0)	SVID 8 (B31..16)	SVID 9 (B15..0)	SVID 10 (B31..16)	SVID 11 (B15..0)

Header No. of Data Objects = 2	VDM Header	VDO 1	
		0x0000 (B31..16)	0x0000 (B15..0)

6.4.4.3.3 Discover Modes

The ***Discover Modes*** Command is used by an Initiator to determine the Modes a Responder supports for a given SVID.

The SVID in the ***Discover Modes*** Command ***Shall*** be set to the SVID for which Modes are being requested by both the Initiator and the Responder for this Command.

The ***Number of Data Objects*** field in the Message Header in the ***Discover Modes*** Command request ***Shall*** be set to 1 since the ***Discover Modes*** Command request ***Shall Not*** contain any VDOs.

The ***Discover Modes*** Command ACK sent back by the Responder ***Shall*** contain one or more Modes. The ***Discover Modes*** Command ACK ***Shall*** contain a Message Header with the ***Number of Data Objects*** field set to a value of 1 to 7 (the actual value is the number of Mode objects plus one). If the ID is a VID, the structure and content of the VDO is left to the Vendor. If the ID is a SID, the structure and content of the VDO is defined by the relevant Standard.

A Responder that does not support any Modes ***Shall*** return a NAK.

The ***Number of Data Objects*** field in the Message Header in the ***Discover Modes*** Command NAK and BUSY responses ***Shall*** be set to 1 since they ***Shall Not*** contain any VDOs.

Figure 6-19 shows an example of a ***Discover Modes*** Command response from a Responder which supports three Modes for a given SVID.

Figure 6-19 Example Discover Modes response for a given SVID with 3 Modes

Header No. of Data Objects = 4	VDM Header	Mode 1	Mode 2	Mode 3

6.4.4.3.4 Enter Mode Command

The ***Enter Mode*** Command is used by an Initiator (DFP) to command a Responder (UFP or Cable Plug) to enter a specified Mode of operation. Only a DFP is allowed to initiate the Enter Mode Process which it starts after it has successfully completed the Discovery Process.

The value in the Object Position field in the VDM Header ***Shall*** indicate to which Mode in the ***Discover Modes*** Command the VDO refers (see Figure 6-19). The value 1 always indicates the first Mode as it is the first object following the VDM Header. The value 2 refers to the next Mode and so forth.

The ***Number of Data Objects*** field in the Message Header in the Command request ***Shall*** be set to either 1 or 2 since the ***Enter Mode*** Command request ***Shall Not*** contain more than 1 VDO. When a VDO is included in an ***Enter Mode*** Command request the contents of the 32 bit VDO is defined by the Mode.

The ***Number of Data Objects*** field in the Command response ***Shall*** be set to 1 since an ***Enter Mode*** Command response (ACK, NAK, BUSY) ***Shall Not*** contain any VDOs.

Before entering a Mode, by sending the ***Enter Mode*** Command request, that requires the reconfiguring of any pins on entry to that Mode, the Initiator ***Shall*** ensure that those pins being reconfigured are placed into the USB Safe State. Before entering a Mode that requires the reconfiguring of any pins, the Responder ***Shall*** ensure that those pins being reconfigured are placed into either USB operation or the USB Safe State.

A device ***May*** support multiple Modes with one or more active at any point in time. Any interactions between them are the responsibility of the Standard or Vendor. Where there are multiple Active Modes at the same time Modal Operation ***Shall*** start on entry to the first Mode.

On receiving an ***Enter Mode*** Command request the Responder ***Shall*** respond with either an ACK or a NAK response. The Responder is not allowed to return a BUSY response. The value in the Object Position field of the ***Enter Mode*** Command response ***Shall*** contain the same value as the received ***Enter Mode*** Command request.

If the Responder responds to the ***Enter Mode*** Command request with an ACK, the Responder ***Shall*** enter the Mode before sending the ACK. The Initiator ***Shall*** enter the Mode on reception of the ACK. Receipt of the ***GoodCRC*** Message corresponding to the ACK confirms to the Responder that the Initiator is in an Active Mode and is ready to operate.

If the Responder responds to the ***Enter Mode*** Command request with a NAK, the Mode is not entered. If not presently in Modal Operation the Initiator ***Shall*** return to USB operation. If not presently in Modal Operation the Responder ***Shall*** remain in either USB operation or the USB Safe State.

If the Initiator fails to receive a response within ***tVDMWaitModeEntry*** it ***Shall Not*** enter the Mode but return to USB operation.

Figure 6-20 shows the sequence of events during the transition between USB operation and entering a Mode. It illustrates when the Responder's Mode changes and when the Initiator's Mode changes. Figure 6-21 shows a sequence that is Interrupted by a ***Source_Capabilities*** Message, that completes a Contract Negotiation, and then the sequence is Re-run. Figure 6-22 illustrates that when the Responder returns a NAK the transition to a Mode do not take place and the Responder and Initiator remain in their default USB roles.

Figure 6-20 Successful Enter Mode sequence

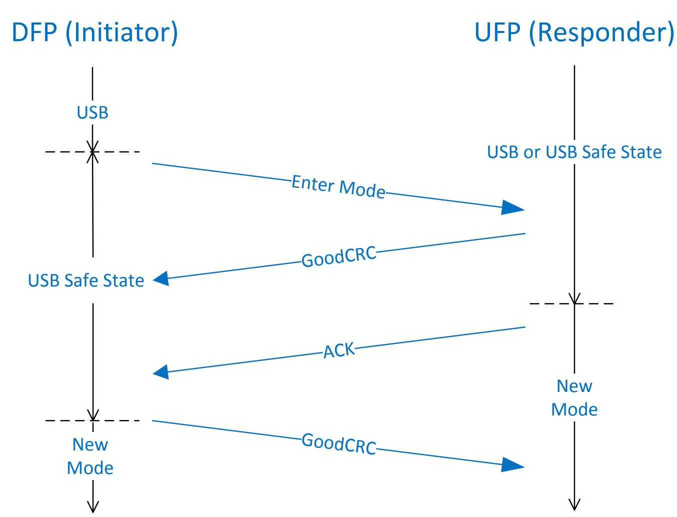


Figure 6-21 Enter Mode sequence Interrupted by Source Capabilities and then Re-run

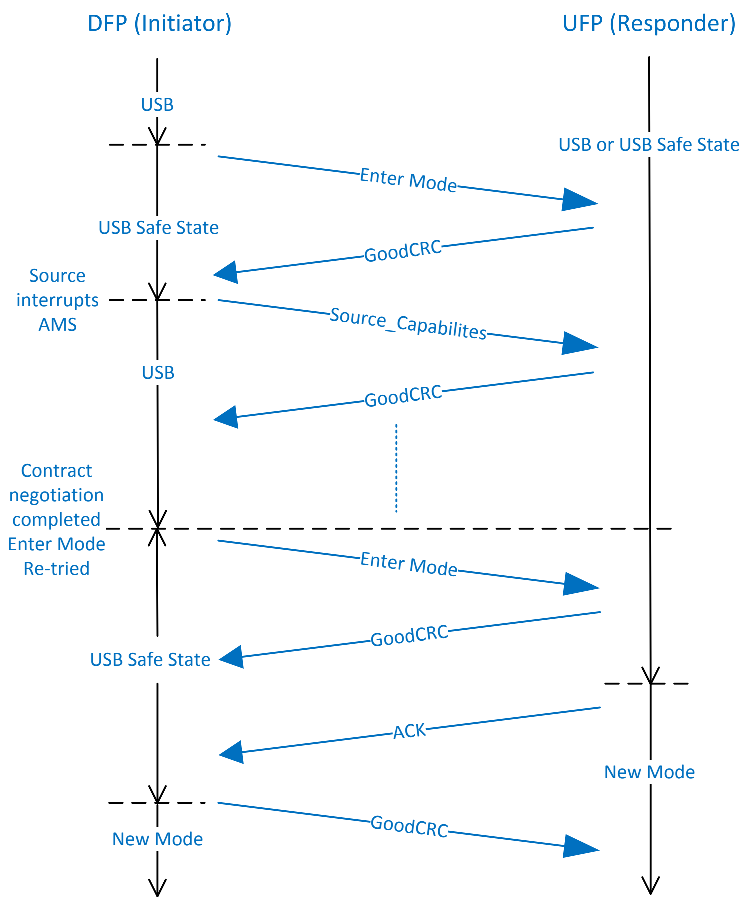
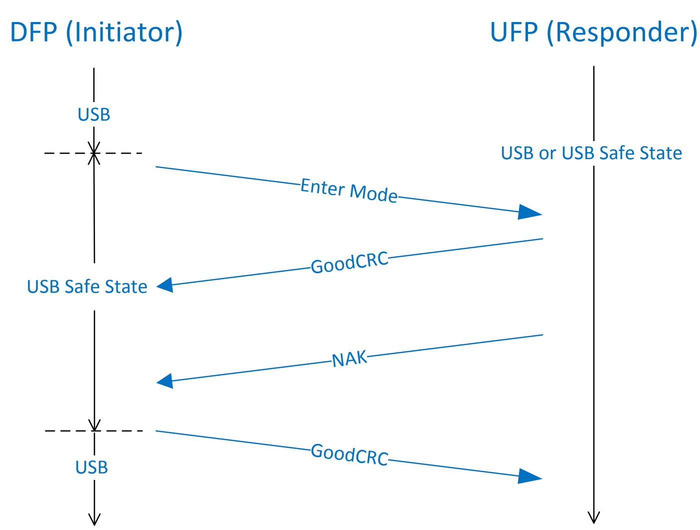


Figure 6-22 Unsuccessful Enter Mode sequence due to NAK



Once the Mode is entered, the device ***Shall*** remain in that Active Mode until the ***Exit Mode*** Command is successful (see Section 6.4.4.3.5).

The following events ***Shall*** also cause the Port Partners and Cable Plug(s) to exit all Active Modes:

- A PD Hard Reset.
- The Port Partners or Cable Plug(s) are Detached.
- A Cable Reset (only exits the Cable Plug's Active Modes).

The Initiator ***Shall*** return to USB Operation within ***tVDMExitMode*** of a disconnect or of ***Hard Reset*** Signaling being detected.

The Responder ***Shall*** return to either USB operation or USB Safe State within ***tVDMExitMode*** of a disconnect or of ***Hard Reset*** Signaling being detected.

A ***DR_Swap*** Message ***Shall Not*** be sent during Modal Operation between the Port Partners (see Section 6.3.9).

6.4.4.3.5 Exit Mode Command

The ***Exit Mode*** Command is used by an Initiator (DFP) to command a Responder (UFP or Cable Plug) to exit its Active Mode and return to normal USB operation. Only the DFP is allowed to initiate the Exit Mode Process.

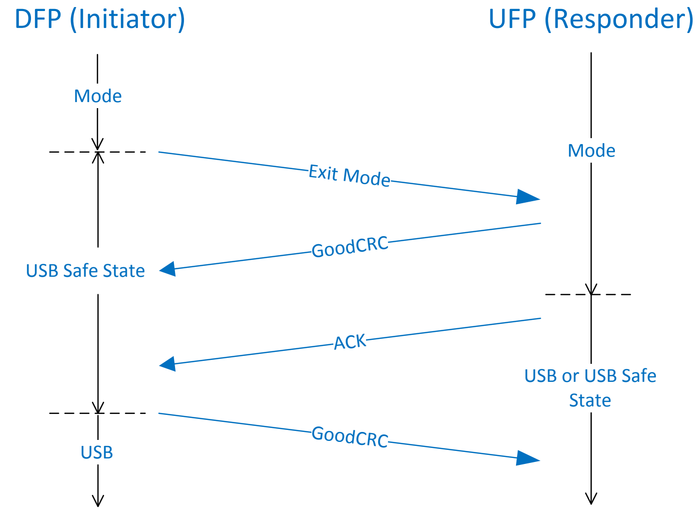
The value in the Object Position field ***Shall*** indicate to which Mode in the ***Discover Modes*** Command the VDO refers (see Figure 6-19) and ***Shall*** have been used previously in an ***Enter Mode*** Command request for an Active Mode. The value 1 always indicates the first Mode as it is the first object following the VDM Header. The value 2 refers to the next Mode and so forth. A value of 111b in the Object Position field ***Shall*** indicate that all Active Modes ***Shall*** be exited.

The ***Number of Data Objects*** field in both the Command request and Command response (ACK, NAK, BUSY) ***Shall*** be set to 1 since an ***Exit Mode*** Command ***Shall Not*** contain any VDOs.

The Responder ***Shall*** exit its Active Mode before sending the response Message. The Initiator ***Shall*** exit its Active Mode before sending ***GoodCRC*** Message in response to the ACK. Receipt of the ***GoodCRC*** Message confirms to the Responder that the Initiator has exited the Mode. The Responder ***Shall Not*** return a BUSY acknowledgement and ***Shall*** only return a NAK acknowledgement to a request not containing an Active Mode (i.e. ***Invalid*** object position). An Initiator which fails to receive an ACK within ***tVDMWaitModeExit*** or receives a NAK or BUSY response ***Shall*** exit its Active Mode.

Figure 6-23 shows the sequence of events during the transition between exiting an Active Mode and USB operation. It illustrates when the Responder's Mode changes and when the Initiator's Mode changes.

Figure 6-23 Exit Mode sequence



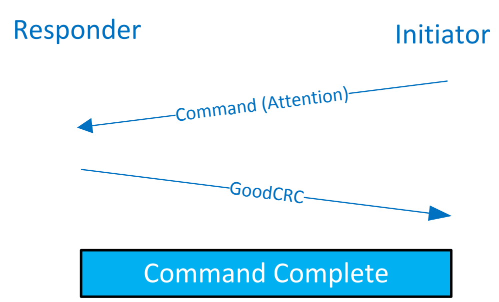
6.4.4.3.6 Attention

The ***Attention*** Command ***May*** be used by the Initiator to notify the Responder that it requires service.

The value in the Object Position field ***Shall*** indicate to which Mode in the ***Discover Modes*** Command the VDO refers (see Figure 6-19) and ***Shall*** have been used previously in an ***Enter Mode*** Command request for an Active Mode. The value 1 always indicates the first Mode as it is the first object following the VDM Header. The value 2 refers to the next Mode and so forth. A value of 000b or 111b in the Object Position field ***Shall Not*** be used by the ***Attention*** Command.

The ***Number of Data Objects*** field in the Message Header ***Shall*** be set to 1 or 2 since the ***Attention*** Command ***Shall Not*** contain more than 1 VDO. When a VDO is included in an ***Attention*** Command the contents of the 32 bit VDO is defined by the Mode.

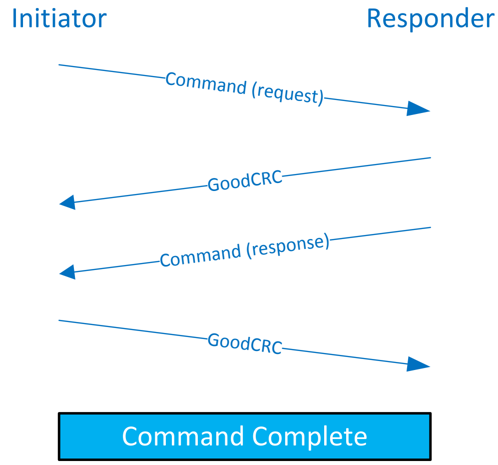
Figure 6-24 Attention Command request/response sequence



6.4.4.4 Command Processes

The Message flow of Commands during a Process is a query followed by a response. Every Command request sent has to be responded to with a ***GoodCRC*** Message. The ***GoodCRC*** Message only indicates the Command request was received correctly; it does not mean that the Responder understood or even supports a particular SVID. Figure 6-25 shows the request/response sequence including the ***GoodCRC*** Messages.

Figure 6-25 Command request/response sequence



In order for the Initiator to know that the Command request was actually consumed, it needs an acknowledgement from the Responder. There are three responses that indicate the Responder received and processed the Command request:

- ACK.
- NAK.
- BUSY.

The Responder ***Shall*** complete:

- Enter Mode requests within ***tVDMEnterMode.***
- Exit Mode requests within ***tVDMExitMode.***
- Other requests within ***tVDMReceiverResponse.***

An Initiator not receiving a response within the following times ***Shall*** timeout and return to either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state (as appropriate):

- Enter Mode requests within ***tVDMWaitModeEntry.***
- Exit Mode requests within ***tVDMWaitModeExit.***
- Other requests within ***tVDMSenderResponse.***

The Responder ***Shall*** respond with:

- ACK if it recognizes the SVID and can process it at this time
- NAK:
  - if it recognizes the SVID but cannot process the Command request
  - or if it does not recognize the SVID
  - or if it does not support the Command
  - or if a VDO has been supplied which is ***Invalid.***
- BUSY if it recognizes the SVID and the Command but cannot process the Command request at this time.

The ACK, NAK or BUSY response ***Shall*** contain the same SVID as the Command request.

6.4.4.4.1 Discovery Process

The Initiator (usually the DFP) always begins the Discovery Process. The Discovery Process has two phases. In the first phase, the ***Discover SVIDs*** Command request is sent by the Initiator to get the list of SVIDs the Responder supports. In the second phase, the Initiator sends a ***Discover Modes*** Command request for each SVID supported by both the Initiator and Responder.

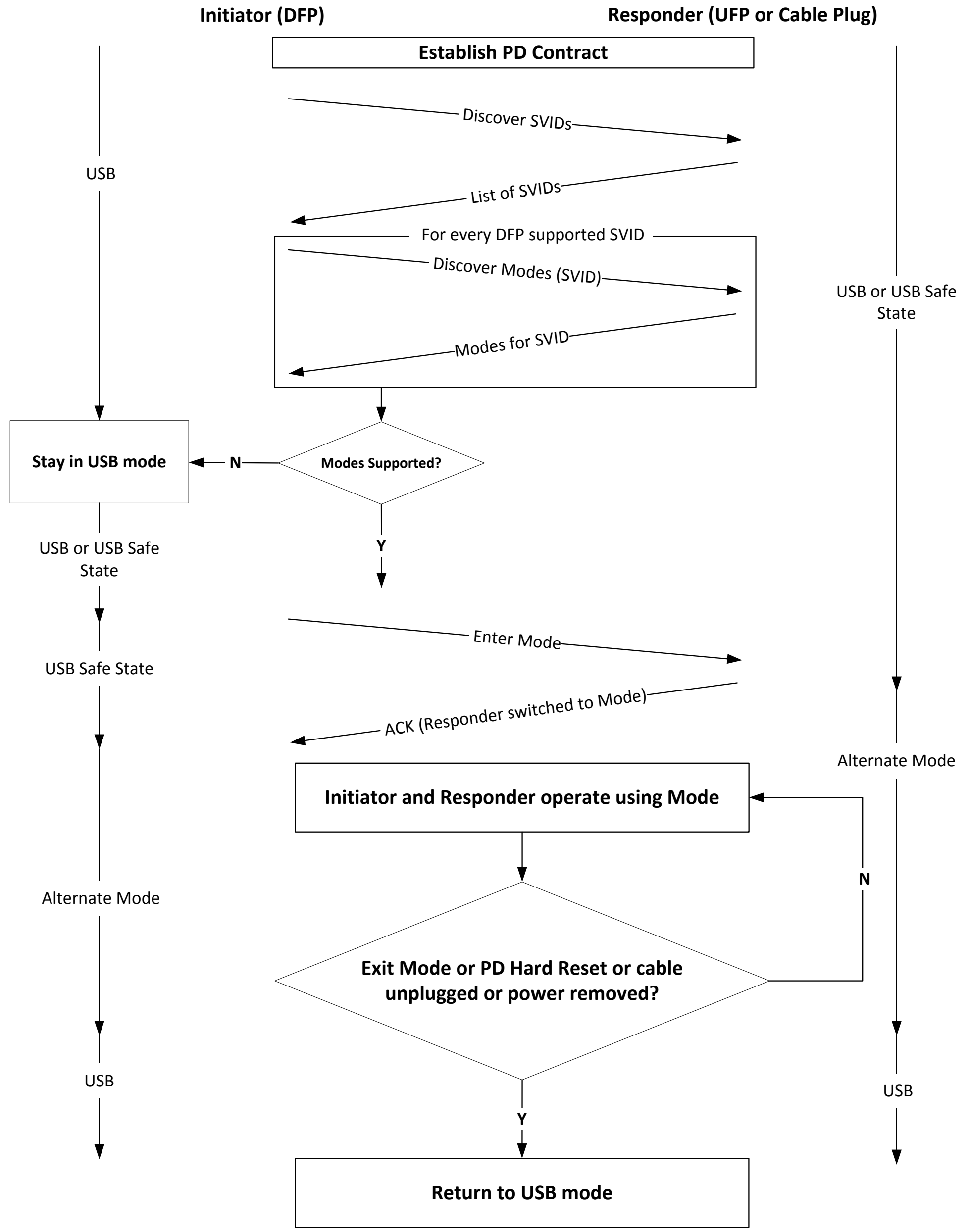
6.4.4.4.2 Enter Vendor Mode / Exit Vendor Mode Processes

The result of the Discovery Process is that both the Initiator and Responder identify the Modes they mutually support. The Initiator (DFP), upon finding a suitable Mode, uses the ***Enter Mode*** Command to enable the Mode.

The Responder (UFP or Cable Plug) and Initiator continue using the Active Mode until the Active Mode is exited. In a managed termination, using the ***Exit Mode*** Command, the Active Mode ***Shall*** be exited in a controlled manner as described in Section 6.4.4.3.5. In an unmanaged termination, triggered by a Power Delivery Hard Reset (i.e. ***Hard Reset*** Signaling sent by either Port Partner) or by cable Detach (device unplugged), the Active Mode ***Shall*** still be exited but there ***Shall Not*** be a transition through the USB Safe State. In both the managed and unmanaged terminations the Initiator and Responder return to USB operation as defined in ***[USB Type-C 1.2]*** following an exit from a Mode.

The overall Message flow is illustrated in Figure 6-26.

Figure 6-26 Enter/Exit Mode Process



6.4.4.5 VDM Message Timing and Normal PD Messages

Any Command Process or other VDM sequence ***May*** be interrupted by any other USB PD Message. The Vendor or Standards defined state operation ***Shall*** comprehend this and continue to operate as expected when processing any other USB PD Messages.

The timing and interspersing of VDMs between regular PD Messages ***Shall*** be done without perturbing the PD Message sequences. This requirement ***Shall*** apply to both Unstructured VDMs and Structured VDMs.

The use of Structured VDMs by an Initiator ***Shall Not*** interfere with the normal PD Message timing requirements nor ***Shall*** either the Initiator or Responder interrupt a PD Message sequence (e.g. Power Negotiation, Power Role Swap, Data Role Swap etc.). The use of Unstructured VDMs ***Shall Not*** interfere with normal PD Message timing.

VDM sequences ***Shall*** be interruptible after the return of a ***GoodCRC*** Message has been completed. In the case where there is an error in transmission of the ***Vendor_Defined*** Message, as for any other PD Message, the ***Vendor_Defined*** Message will not be retried, but instead the incoming Message will be processed by the Policy Engine. This means that the ***Vendor_Defined*** Message sequence will need to be Re-run after the USB PD Message sequence has completed.

6.4.5 Battery_Status Message

The ***Battery_Status*** Message ***Shall*** be sent in response to a ***Get_Battery_Status*** Message. The ***Battery_Status*** Message contains one Battery Status Data Object (BSDO) for one of the Batteries it supports as reported by Battery field in the ***Source_Capabilities_Extended*** Message. The returned BSDO ***Shall*** correspond to the Battery requested in the ***Battery Status Ref*** field contained in the ***Get_Battery_Status*** Message.

The ***Battery_Status*** Message returns a BSDO whose format ***Shall*** be as shown in Figure 6-27 and Table 6-39. The ***Number of Data Objects*** field in the ***Battery_Status*** Message ***Shall*** be set to 1.

Figure 6-27 Battery_Status Message

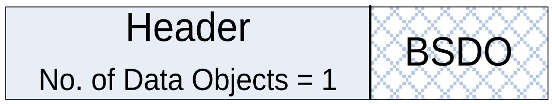


Table 6-39 Battery Status Data Object (BSDO)

Bit(s)	Field	Size	Value	Description
B31…16	Battery Present Capacity	2	1/10 WH	Battery's State of Charge (SoC) Note: 0xFFFF = Battery's SOC unknown
B15…8	Battery Info	1	Bit Field	**Bit** – **Description** 0 – Invalid Battery reference 1 – Battery is present when set 3…2 – When Battery is present ***Shall*** contain the Battery charging status: 00b: Battery is Charging 01b: Battery is Discharging 10b: Battery is Idle 11b: ***Reserved***, ***Shall Not*** be used When Battery is not present: 11b…00b: ***Reserved***, ***Shall Not*** be used 7…4 – ***Reserved*** and ***Shall*** be set to zero
B7…0	***Reserved***	2	Numeric	***Shall*** be set to zero

6.4.5.1 Battery Present Capacity

The Battery Present Capacity field ***Shall*** return either the Battery's State of Charge (SoC) in tenths of WH or indicate that the Battery's present State of Charge (SOC) is unknown.

6.4.5.2 Battery Info

The Battery Info field ***Shall*** be used to report additional information about the Battery's present status. The Battery Info field's bits ***Shall*** reflect the present conditions under which the Battery is operating in the systems.

6.4.5.2.1 Invalid Battery Reference

The Invalid Battery Reference bit ***Shall*** be set when the ***Get_Battery_Status*** Message contains a reference to a Battery that does not exist.

6.4.5.2.2 Battery is Present

The Battery is Present bit ***Shall*** be set whenever the Battery is present. It ***Shall*** always be set for Batteries that are not Hot Swappable Batteries. For Hot Swappable Batteries, Battery is Present bit ***Shall*** indicate whether the Battery is Attached or Detached.

6.4.5.2.3 Battery Charging Status

The Battery charging status bits indicate whether the Battery is being charged, discharged or is idle (neither charging nor discharging). These bits ***Shall*** be set when the Battery is present bit is set. Otherwise when the Battery is present bit is zero the Battery charging status bits ***Shall*** also be zero.

6.4.6 Alert Message

The ***Alert*** Message is provided to allow Port Partners to inform each other when there is a status change event. Some of the events are critical such as OCP, OVP and OTP, while others are informative such as change in a Battery's status from charging to neither charging nor discharging.

The ***Alert*** Message ***Shall*** only be sent when the Source or Sink detects a status change.

The ***Alert*** Message ***Shall*** contain exactly one Alert Data Object (ADO) and the format ***Shall*** be as shown in Figure 6-28 and Table 6-40.

Figure 6-28 Alert Message

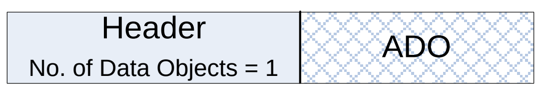


Table 6-40 Alert Data Object

<table>
<tr><th>Bit(s)</th><th>Field</th><th>Value</th><th>Description</th></tr>
<tr><td>B31…24</td><td>Type of Alert</td><td>Bit Field</td><td>
<table>
<tr><th>Bit</th><th>Description</th></tr>
<tr><td>0</td><td>Reserved and Shall be set to zero</td></tr>
<tr><td>1</td><td>Battery Status Change Event(Attach/Detach/charging/discharging/idle)</td></tr>
<tr><td>2</td><td>OCP event when set (Source only, for Sink Reserved and Shall be set to zero)</td></tr>
<tr><td>3</td><td>OTP event when set</td></tr>
<tr><td>4</td><td>Operating Condition Change when set</td></tr>
<tr><td>5</td><td>Source Input Change Event when set</td></tr>
<tr><td>6</td><td>OVP event when set (Sink only, for Source Reserved and Shall be set to zero)</td></tr>
<tr><td>7</td><td>Reserved and Shall be set to zero</td></tr>
</table>
</td></tr>
<tr><td>B23…20</td><td>Fixed Batteries</td><td>Bit Field</td><td>When Battery Status Change bit set indicates which Fixed Batteries have had a status change. B20 corresponds to Battery 0 and B23 corresponds to Battery 3.</td></tr>
<tr><td>B19…16</td><td>Hot Swappable Batteries</td><td>Bit Field</td><td>When Battery Status Change bit set indicates which Hot Swappable Batteries have had a status change. B16 corresponds to Battery 4 and B19 corresponds to Battery 7.</td></tr>
<tr><td>B15…0</td><td>Reserved</td><td>n/a</td><td>Shall be set to zero</td></tr>
</table>

6.4.6.1 Type of Alert

The ***Type of Alert*** field ***Shall*** be used to report Source or Sink status changes. Only one ***Alert*** Message ***Shall*** be generated for each Event or Change; however multiple Type of Alert bits ***May*** be set in one ***Alert*** Message. Once the ***Alert*** Message has been sent the ***Type of Alert*** field ***Shall*** be cleared.

A ***Get_Battery_Status*** Message ***Should*** be sent in response to a Battery status change in an ***Alert*** Message to get the details of the change.

A ***Get_Status*** Message ***Should*** be sent in response to a non-Battery status change in an ***Alert*** Message from to get the details of the change.

6.4.6.1.1 Battery Status Change

The Battery Status Change bit ***Shall*** be set when any Battery's power state changes between charging, discharging, neither. For Hot Swappable Batteries, it ***Shall*** also be set when a Battery is Attached or Detached.

6.4.6.1.2 Over-Current Protection Event

The Over-Current Protection Event bit ***Shall*** be set when a Source detects its output current exceeds its limits triggering its protection circuitry. This bit is ***Reserved*** for a Sink.

6.4.6.1.3 Over-Temperature Protection Event

The Over-Temperature Protection Event bit ***Shall*** be set when a Source or Sink shuts down due to over-temperature triggering its protection circuitry.

6.4.6.1.4 Operating Condition Change

The Operating Condition Change bit ***Shall*** be set when a Source or Sink detects its Operating Condition enters or exits either the 'warning' or 'over temperature' temperature states.

The Operating Condition Change bit ***Shall*** be set when the Source operating in the Programmable Power Supply mode detects it has changed its operating condition between Constant Voltage (CV) and Current Foldback (CF).

6.4.6.1.5 Source Input Change Event

The Source Input Event bit ***Shall*** be set when the Source/Sink's input changes. For example when the AC input is removed and the Source/Sink continues to be powered from one or more of its batteries or when AC returns and the Source/Sink transitions from Battery to AC operation or when the Source/Sink changes operation from one (or more) Battery to another (or more) Battery.

6.4.6.1.6 Over-Voltage Protection Event

The Over-Voltage Protection Event bit ***Shall*** be set when the Sink detects its output voltage exceeds its limits triggering its protection circuitry. This bit is ***Reserved*** for a Source.

6.4.6.2 Fixed Batteries

The ***Fixed Batteries*** field indicates which Fixed Batteries have had a status change. B20 corresponds to Battery 0 and B23 corresponds to Battery 3.

Once the ***Alert*** Message has been sent the ***Fixed Batteries*** field ***Shall*** be cleared.

6.4.6.3 Hot Swappable Batteries

The ***Hot Swappable Batteries*** field indicates which Hot Swappable Batteries have had a status change. B16 corresponds to Battery 0 and B19 corresponds to Battery 3.

Once the ***Alert*** Message has been sent the ***Hot Swappable Batteries*** field ***Shall*** be cleared.

6.4.7 Get_Country_Info Message

The ***Get_Country_Info*** Message ***Shall*** be sent by a port to get country specific information from its port partner using the country's Alpha-2 Country Code defined by ***[ISO 3166]***. The port partner responds with a ***Country_Info*** Message that contains the country specific information. The ***Get_Country_Info*** Message ***Shall*** be as shown in Figure 6-29 and Table 6-41.

For example, if the request is for China information, then the Country Code Data Object would be CCDO[31:0] = 434E0000h for "CN" country code.

Figure 6-29 Get_Country_Info Message

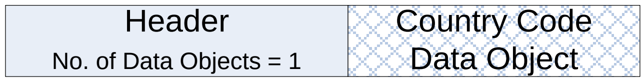


Table 6-41 Country Code Data Object

Bit(s)	Value	Parameter	Description
B31…24		Byte	First character of the Alpha-2 Country Code defined by ***[ISO 3166]***
B23…16		Byte	Second character of the Alpha-2 Country Code defined by ***[ISO 3166]***
B15…0		Reserved	***Shall*** be set to zero.

6.5 Extended Message

An Extended Message ***Shall*** contain an Extended Message Header (indicated by the ***Extended*** field in the Message Header being set) and be followed by zero or more data bytes.

The format of the Extended Message is defined by the Message Header's ***Message Type*** field and is summarized in Table 6-42. The Sent by column indicates entities which ***May*** send the given Message (Source, Sink or Cable Plug); entities not listed ***Shall Not*** issue the corresponding Message. The Valid Start of Packet column indicates the Messages which ***Shall*** only be issued in SOP Packets and the Messages which ***May*** be issued in SOP* Packets.

Table 6-42 Extended Message Types

Bits 4…0	Type	Sent by	Description	Valid Start of Packet
0 0000	***Reserved***		All values not explicitly defined are ***Reserved*** and ***Shall Not*** be used.	
0 0001	***Source_Capabilities_Extended***	Source or Dual-Role Power	See Section 6.5.1	SOP only
0 0010	***Status***	Source or Sink	See Section 6.5.2	SOP only
0 0011	***Get_Battery_Cap***	Source or Sink	See Section 6.5.3	SOP only
0 0100	***Get_Battery_Status***	Source or Sink	See Section 6.5.4	
0 0101	***Battery_Capabilities***	Source or Sink	See Section 6.5.5	SOP only
0 0110	***Get_Manufacturer_Info***	Source or Sink	See Section6.5.6	SOP*
0 0111	***Manufacturer_Info***	Source, Sink or Cable Plug	See Section 6.5.7	SOP*
0 1000	***Security_Request***	Source or Sink	See Section 6.5.8.1	SOP*
0 1001	***Security_Response***	Source, Sink or Cable Plug	See Section 6.5.8.2	SOP*

Bits 4…0	Type	Sent by	Description	Valid Start of Packet
0 1010	***Firmware_Update_Request***	Source or Sink	See Section 6.5.9.1	SOP*
0 1011	***Firmware_Update_Response***	Source, Sink or Cable Plug	See Section 6.5.9.2	SOP*
0 1100	***PPS_Status***	Source	See Section 6.5.10	SOP only
0 1101	***Country_Info***	Source, Sink or Cable Plug	See Section 6.5.12	SOP*
0 1110	***Country_Codes***	Source, Sink or Cable Plug	See Section 6.5.11	SOP*
0 1111 - 1 1111	***Reserved***		All values not explicitly defined are ***Reserved*** and ***Shall Not*** be used.	

6.5.1 Source_Capabilities_Extended Message

The ***Source_Capabilities_Extended*** Message ***Should*** be sent in response to a ***Get_Source_Cap_Extended*** Message. The ***Source_Capabilities_Extended*** Message enables a Source or a DRP to inform the Sink about its capabilities as a Source.

The ***Source_Capabilities_Extended*** Message ***Shall*** return a 24-byte Source Capabilities Extended Data Block (SCEDB) whose format ***Shall*** be as shown in Figure 6-30 and Table 6-43.

Figure 6-30 Source_Capabilities_Extended Message

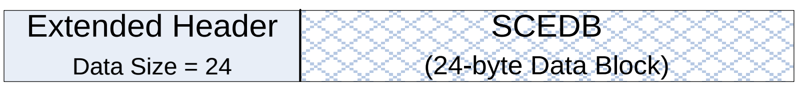


Table 6-43 Source Capabilities Extended Data Block (SCEDB)

Offset	Field	Size	Value	Description
0	VID	2	Numeric	Vendor ID (assigned by the USB-IF)
2	PID	2	Numeric	Product ID (assigned by the manufacturer)
4	XID	4	Numeric	Value provided by the USB-IF assigned to the product
8	FW Version	1	Numeric	Firmware version number
9	HW Version	1	Numeric	Hardware version number
10	Voltage Regulation	1	Bit Field	**Bit** / **Description** 1…0: 00b: 150mA/µs Load Step (default) 01b: 500mA/µs Load Step 11b…10b: ***Reserved*** and ***Shall Not*** be used 2: 0b: 25% IoC (default) 1b: 90% IoC 3…7: ***Reserved*** and ***Shall*** be set to zero
11	Holdup Time	1	Numeric	Output will stay with regulated limits for this number of milliseconds after removal of the AC from the input. 0x00 = feature not supported Note: a value of 3ms ***Should*** be used

Offset	Field	Size	Value	Description
12	Compliance	1	Bit Field	**Bit** / **Description** 0 – LPS compliant when set 1 – PS1 compliant when set 2 – PS2 compliant when set 3…7 – ***Reserved*** and ***Shall*** be set to zero
13	Touch Current	1	Bit Field	**Bit** / **Description** 0 – Low touch Current EPS when set 1 – Ground pin supported when set 2 – Ground pin intended for protective earth when set 3…7 – ***Reserved*** and ***Shall*** be set to zero
14	Peak Current1	2	Bit field	**Bit** / **Description** 0…4 – Percent overload in 10% increments Values higher than 25 (11001b) are clipped to 250%. 5…10 – Overload period in 20ms 11.14 – Duty cycle in 5% increments 15 – V_{BUS} Voltage droop
16	Peak Current2	2	Bit field	**Bit** / **Description** 0…4 – Percent overload in 10% increments Values higher than 25 (11001b) are clipped to 250%. 5…10 – Overload period in 20ms 11.14 – Duty cycle in 5% increments 15 – V_{BUS} Voltage droop
18	Peak Current3	2	Bit field	**Bit** / **Description** 0…4 – Percent overload in 10% increments Values higher than 25 (11001b) are clipped to 250%. 5…10 – Overload period in 20ms 11.14 – Duty cycle in 5% increments 15 – V_{BUS} Voltage droop

<table>
<tr><th>Offset</th><th>Field</th><th>Size</th><th>Value</th><th>Description</th></tr>
<tr><td>20</td><td>Touch Temp</td><td>1</td><td>Value</td><td>Temperature conforms to:
0 = [IEC 60950-1] (default)
1 = [IEC 62368-1] TS1
2 = [IEC 62368-1] TS2
Note: All other values Reserved</td></tr>
<tr><td>21</td><td>Source Inputs</td><td>1</td><td>Bit field</td><td><table>
<tr><th>Bit</th><th>Description</th></tr>
<tr><td>0</td><td>0b: No external supply
1b: External supply present</td></tr>
<tr><td>1</td><td>If bit 0 is set:

0b: External supply is constrained
1b: External supply is unconstrained

If bit 0 is not set Reserved and Shall be set to zero</td></tr>
<tr><td>2</td><td>0b: No internal Battery
1b: Internal Battery present</td></tr>
<tr><td>3…7</td><td>Reserved and Shall be set to zero</td></tr>
</table></td></tr>
<tr><td>22</td><td>Batteries</td><td>1</td><td>Byte</td><td>Upper Nibble = Number of Hot Swappable Batteries (0…4)
Lower Nibble = Number of Fixed Batteries (0…4)</td></tr>
<tr><td>23</td><td>Source PDP</td><td>1</td><td>Byte</td><td>0…6: Source's rated PDP
7: Reserved and Shall be set to zero</td></tr>
</table>

6.5.1.1 Vendor ID (VID) Field

The Vendor ID field ***Shall*** contain the 16-bit Vendor ID (VID) assigned to the Source's vendor by the USB-IF. If the vendor does not have a VID, the Vendor ID field ***Shall*** be set to zero. Devices that have a USB data interface ***Shall*** report the same VID as the idVendor in the Standard Device Descriptor (see ***[USB 2.0]*** and ***[USB 3.1]***).

6.5.1.2 Product ID (PID) Field

The Product ID field ***Shall*** contain the 16-bit Product ID (PID) assigned by the Source's vendor. Devices that have a USB data interface ***Shall*** report the same PID as the idProduct in the Standard Device Descriptor (see ***[USB 2.0]*** and ***[USB 3.1]***).

6.5.1.1 XID Field

The XID field ***Shall*** contain the 32-bit XID provided by the USB-IF to the vendor who in turns assigns it to a product. If the vendor does not have an XID, then it ***Shall*** return zero in this field (see ***[USB 2.0]*** and ***[USB 3.1]***).

6.5.1.2 Firmware Version Field

The Firmware Version field ***Shall*** contain an 8-bit firmware version number assigned to the device by the vendor.

6.5.1.3 Hardware Version Field

The Hardware Version field ***Shall*** contain an 8-bit hardware version number assigned to the device by the vendor.

6.5.1.4 Voltage Regulation Field

The Voltage Regulation field contains bits covering Load Step Slew Rate and Magnitude.

See Section 7.1.12.1 for further details.

6.5.1.4.1 Load Step Slew Rate

The Source ***Shall*** report its load step response capability in bits 0…1 of the Voltage Regulation bit field.

6.5.1.4.2 Load Step Magnitude

The Source ***Shall*** report its load step magnitude rate as a percentage of IoC in bit 2 of the Voltage Regulation field.

6.5.1.5 Holdup Time Field

The Holdup Time field ***Shall*** contain the Source's holdup time (see Section 7.1.12.2).

6.5.1.6 Compliance Field

The Compliance field ***Shall*** contain the standards the Source is compliant with (see Section 7.1.12.3).

6.5.1.7 Touch Current

The Touch Current field reports whether the Source meets certain leakage current levels and if it has a ground pin.

A Source ***Shall*** set the Touch Current bit (bit-0) when their leakage current is less than 65µA rms when Source's maximum capability is less than or equal to 30W, or when their leakage current is less than 100 µA rms when its power capability is between 30W and 100W. The total combined leakage current ***Shall*** be measured in accordance with ***[IEC 60950-1]*** when tested at 250VAC rms at 50 Hz.

A Source with a ground pin ***Shall*** set the Ground pin bit (bit-1).

A Source whose Ground pin is intended to be connected to a protective earth ***Shall*** set both bit1 and bit 2.

6.5.1.8 Peak Current

The Peak Current field ***Shall*** contain the combinations of Peak Current that the Source supports (see Section 7.1.12.4).

Peak Current provides a means for Source report its ability to provide current in excess of the negotiated amount for short periods. The Peak Current descriptor defines up to three combinations of % overload, duration and duty cycle defined as PeakCurrent1, PeakCurrent2 and PeakCurrent3 that the Source supports. A Source ***May*** offer no Peak Current capability. A Source ***Shall*** populate unused Peak Current bit fields with zero.

The Bit Fields within Peak Current1, Peak Current2, and Peak Current3 contain the following subfields:

- **Percentage Overload *Shall*** be the maximum peak current reported in 10% increments as a percentage of the negotiated operating current (IoC) offered by the Source. Values higher than 25 (11001b) are clipped to 250%.
- **Overload Period *Shall*** be the minimum rolling average time window in 20ms increments, where a value of 20ms is recommended.
- **Duty Cycle *Shall*** be the maximum percentage of overload period reported in 5% increments. The values ***Should*** be 5%, 10% and 50% for PeakCurrent1, PeakCurrent2 and PeakCurrent3 respectively.
- **V_{BUS} Droop *Shall*** be set to one to indicate there is an additional 5% voltage droop on V_{BUS} when the overload conditions occur. However, it is recommended that the Source ***Should*** provide V_{BUS} in the range of ***vSrcNew*** when overload conditions occur and set this bit to zero.

6.5.1.9 Touch Temp

The Touch Temp field ***Shall*** report the IEC standard used to determine the surface temperature of the Source's enclosure. Safety limits for the Source's touch temperature are set in applicable product safety standards (e.g. ***[IEC 60950-1]*** or ***[IEC 62368-1]***). The Source ***May*** report when its touch temperature performance conforms to the TS1 or TS2 limits described in ***[IEC 62368-1]***.

6.5.1.10 Source Inputs

The Source Inputs field ***Shall*** identify the possible inputs that provide power to the Source. Note some Sources are only powered by a Battery (e.g. an automobile) rather than the more common mains.

- When bit 0 is set, the Source can be sourced by an external power supply.
- When bits 0 and 1 are set, the Source can be sourced by an external power supply which is assumed to be effectively "infinite" i.e. it won't run down over time.
- When bit 2 is set the Source can be sourced by an internal Battery.

Bit 2 ***May*** be set independently of bits 0 and 1.

6.5.1.11 Batteries

The Batteries field ***Shall*** report the number of batteries the source supports. It ***Shall*** independently report the number of Hot Swappable Batteries and the number of Fixed batteries. The maximum number of each type of Battery ***Shall*** be no more than 4.

6.5.1.12 Source PDP

The Source PDP field ***Shall*** report the Source's rated PDP as defined in Table 10-2.

6.5.2 Status Message

The ***Status*** Message ***Shall*** be sent in response to a ***Get_Status*** Message. The ***Status*** Message enables a Port to inform its Port Partner about the present status of the Source or Sink. Typically a ***Get_Status*** Message will be sent by the Port after receipt of an ***Alert*** Message. Some of the reported events are critical such as OCP, OVP and OTP, while others are informative such as change in a Battery's status from charging to neither charging nor discharging.

The ***Status*** Message returns a 5-byte Status Data Block (SDB) whose format ***Shall*** be as shown in Figure 6-31 and Table 6-44.

Figure 6-31 Status Message

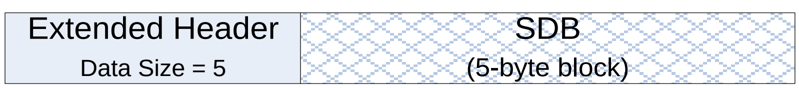


Table 6-44 Status Data Block (SDB)

<table>
<tr><th>Offset (Byte)</th><th>Field</th><th>Size</th><th>Value</th><th>Description</th></tr>
<tr><td>0</td><td>Internal Temp</td><td>1</td><td>Numeric</td><td>Source or Sink's internal temperature in degrees centigrade.
0 = feature not supported
1 = temperature is less than 2°C.
2-255 = temperature in °C.</td></tr>
<tr><td>1</td><td>Present Input</td><td>1</td><td>Bit field</td><td><table>
<tr><th>Bit</th><th>Description</th></tr>
<tr><td>0</td><td>Reserved and Shall be set to zero</td></tr>
<tr><td>1</td><td>External Power when set</td></tr>
<tr><td>2</td><td>External Power AC/DC (Valid when Bit 1 set)
0: DC
1: AC
Reserved when Bit 1 is zero</td></tr>
<tr><td>3</td><td>Internal Power from Battery when set</td></tr>
<tr><td>4</td><td>Internal Power from non-Battery power source when set</td></tr>
<tr><td>5…7</td><td>Reserved and Shall be set to zero</td></tr>
</table></td></tr>
</table>

<table>
<tr><th>Offset (Byte)</th><th>Field</th><th>Size</th><th>Value</th><th>Description</th></tr>
<tr><td>2</td><td>Present Battery Input</td><td>1</td><td>Bit field</td><td>When Present Input field bit 3 set Shall contain the bit corresponding to the Battery or Batteries providing power:

Upper nibble = Hot Swappable Battery (b7…4)
Lower nibble = Fixed Battery (b3…0)

When Present Source Input field bit 3 is not set this field is Reserved and Shall be set to zero.</td></tr>
<tr><td>3</td><td>Event Flags</td><td>1</td><td>Bit field</td><td><table>
<tr><th>Bit</th><th>Description</th></tr>
<tr><td>0</td><td>Reserved and Shall be set to zero</td></tr>
<tr><td>1</td><td>OCP event when set</td></tr>
<tr><td>2</td><td>OTP event when set</td></tr>
<tr><td>3</td><td>OVP event when set (Sink only, for Source Reserved and Shall be set to zero)</td></tr>
<tr><td>4</td><td>CF mode when set, CV mode when cleared</td></tr>
<tr><td>5…7</td><td>Reserved and Shall be set to zero</td></tr>
</table></td></tr>
<tr><td>4</td><td>Temperature Status</td><td>1</td><td>Bit field</td><td><table>
<tr><th>Bit</th><th>Description</th></tr>
<tr><td>0</td><td>Reserved and Shall be set to zero</td></tr>
<tr><td>1…2</td><td>00 – Not Supported
01 – Normal
10 – Warning
11 – Over temperature</td></tr>
<tr><td>3…7</td><td>Reserved and Shall be set to zero</td></tr>
</table></td></tr>
</table>

6.5.2.1 Internal Temp

The Internal Temp field reports the instantaneous temperature of a portion of the Source or Sink.

6.5.2.2 Present Input

The Present Input field indicates which supplies are presently powering the Source or Sink.

The following bits are defined:

- Bit 1 indicates that an external Source is present.
- Bit 2 indicates whether the external unconstrained Source is AC or DC.
- Bit 3 indicates that power is being provided from Battery.
- Bit4 indicates an alternative internal source of power that is not a Battery.

6.5.2.3 Present Battery Input

The Present Battery Input field indicates which Battery or Batteries are presently supplying power to the Source or Sink. The Present Battery Input field is only ***Valid*** when the Present Input field indicates that there is Internal Power from Battery.

The upper nibble of the field indicates which Hot Swappable Battery/Batteries are supplying power with bit 4 in upper nibble corresponding to Battery 4 and bit 7 in the upper nibble corresponding to Battery 7 (see Section 6.5.3 and Section 6.5.4).

The lower nibble of the field indicates which Fixed Battery/Batteries are supplying power with bit 0 in lower nibble corresponding to Battery 0 and bit 3 in the lower nibble corresponding to Battery 3 (see Section 6.5.3 and Section 6.5.4).

6.5.2.4 Event Flags Field

The Event Flags field returns event flags. The OTP, OVP and OCP event flags ***Shall*** be set when there is an event and ***Shall*** only be cleared when read with the ***Get_PPS_Status*** Message.

When the OTP event flag is set the Temperature Status field ***Shall*** also be set to over temperature.

The CF/CV mode bit is only ***Valid*** when operating as a Programmable Power Supply and ***Shall*** be ***Ignored*** otherwise. When the Source is operating as a Programmable Power Supply the CF/CV mode bit ***Shall*** be set when operating in Current Foldback mode (CF mode) and ***Shall*** be cleared when operating in Constant Voltage mode (CV mode).

6.5.2.5 Temperature Status

The Temperature Status field returns the current temperature status of the device either: normal, warning and over temperature. When the Temperature Status field is set to over temperature the OTP event flag ***Shall*** also be set.

6.5.3 Get_Battery_Cap Message

The ***Get_Battery_Cap*** (Get Battery Capabilities) Message is used to request the capability of a Battery present in its Port Partner. The Port ***Shall*** respond by returning a ***Battery_Capabilities*** Message (see Section 6.5.5) containing a Battery Capabilities Data Block (BCDB) for the targeted Battery.

The ***Get_Battery_Cap*** Message contains a 1 byte Get Battery Cap Data Block (GBCDB), whose format ***Shall*** be as shown in Figure 6-32 and Table 6-45. This block defines for which Battery the request is being made.

The ***Data Size*** field in the ***Get_Battery_Cap*** Message ***Shall*** be set to 1.

Figure 6-32 Get_Battery_Cap Message

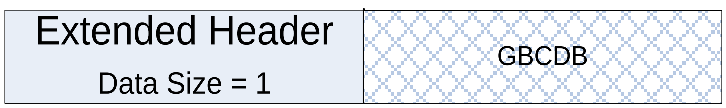


Table 6-45 Get Battery Cap Data Block (GBCDB)

Offset	Field	Size	Value	Description
0	***Battery Cap Ref***	1	Value	Number of the Battery indexed from zero: • Values 0…3 represent the Fixed Batteries. • Values 4…7 represent the Hot Swappable Batteries. • Values 8…255 are ***Reserved*** and ***Shall Not*** be used.

6.5.4 Get_Battery_Status Message

The ***Get_Battery_Status*** (Get Battery Status) Message is used to request the status of a Battery present in its Port Partner. The port ***Shall*** respond by returning a ***Battery_Status*** Message (see Section 6.4.5) containing a Battery Status Data Object (BSDO) for the targeted Battery.

The ***Get_Battery_Status*** Message contains a 1 byte Get Battery Status Data Block (GBSDB) whose format ***Shall*** be as shown in Figure 6-33 and Table 6-46. This block contains details of the requested Battery. The ***Data Size*** field in the ***Get_Battery_Status*** Message ***Shall*** be set to 1.

Figure 6-33 Get_Battery_Status Message

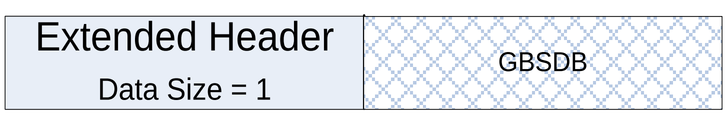


Table 6-46 Get Battery Status Data Block (GBSDB)

Offset	Field	Size	Value	Description
0	***Battery Status Ref***	1	Value	Number of the Battery indexed from zero: • Values 0…3 represent the Fixed Batteries. • Values 4…7 represent the Hot Swappable Batteries. • Values 8…255 are ***Reserved*** and ***Shall Not*** be used.

6.5.5 Battery_Capabilities Message

The ***Battery_Capabilities*** Message is sent in response to a ***Get_Battery_Cap*** Message. The ***Battery_Capabilities*** Message contains one Battery Capability Data Block (BCDB) for one of the Batteries its supports as reported by Battery field in the ***Source_Capabilities_Extended*** Message. The returned BCDB ***Shall*** correspond to the Battery requested in the ***Battery Cap Ref*** field contained in the ***Get_Battery_Cap*** Message.

The ***Battery_Capabilities*** Message returns a 9-byte BCDB whose format ***Shall*** be as shown in Figure 6-34 and Table 6-44.

Figure 6-34 Battery_Capabilities Message

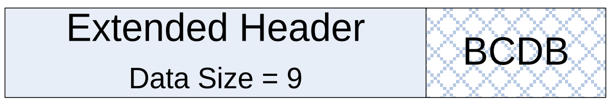


Table 6-47 Battery Capability Data Block (BCDB)

Offset (Byte)	Field	Size	Value	Description
0	VID	2	Numeric	Vendor ID (assigned by the USB-IF)
2	PID	2	Numeric	Product ID (assigned by the manufacturer)
4	Battery Design Capacity	2	1/10 WH	Battery's design capacity Note: 0x0000 = Battery not present 0xFFFF = design capacity unknown
6	Battery Last Full Charge Capacity	2	1/10 WH	Battery's last full charge capacity Note: 0x0000 = Battery not present 0xFFFF = last full charge capacity unknown
8	Battery Type	1	Bit Field	**Bit** – **Description** 0 – Invalid Battery reference 1-7 – ***Reserved***

6.5.5.1 Battery Design Capacity Field

The Battery Design Capacity field ***Shall*** return the Battery's design capacity in tenths of WH. If the Battery is Hot Swappable and is not present, the Battery Design Capacity field ***Shall*** be set to 0. If the Battery is unable to report its Design Capacity, it ***Shall*** return 0xFFFF.

6.5.5.2 Battery Last Full Charge Capacity Field

The Battery Last Full Charge Capacity field ***Shall*** return the Battery's last full charge capacity in tenths of WH. If the Battery is Hot Swappable and is not present, the Battery Last Full Charge Capacity field ***Shall*** be set to 0. If the Battery is unable to report its Design Capacity, the Battery Last Full Charge Capacity field ***Shall*** be set to 0xFFFF.

6.5.5.3 Battery Type Field

The Battery Type Field is used to report additional information about the Battery's capabilities.

6.5.5.3.1 Invalid Battery Reference

The Invalid Battery Reference bit ***Shall*** be set when the ***Get_Battery_Cap*** Message contains a reference to a Battery that does not exist.

6.5.6 Get_Manufacturer_Info Message

The ***Get_Manufacturer_Info*** (Get Manufacturer Info) Message is sent by a Port to request manufacturer specific information relating to its Port Partner or Cable Plug or of a Battery behind a Port. The Port or Cable Plug ***Shall*** respond by returning a ***Manufacturer_Info*** Message (Section 6.5.7) containing a Manufacturer Info Data Block (MIDB).

The ***Get_Manufacturer_Info*** Message contains a 2-byte Get Manufacturer Info Data Block (GMIDB). This block defines whether it is the Device or Battery manufacturer information being requested and for which Battery the request is being made.

The ***Get_Manufacturer_Info*** Message returns a GMIDB whose format ***Shall*** be as shown in Figure 6-33 and Table 6-48.

Figure 6-35 Get_Manufacturer_Info Message

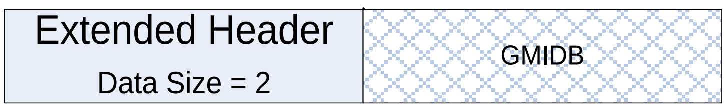


Table 6-48 Get Manufacturer Info Data Block (GMIDB)

Offset	Field	Size	Value	Description
0	***Manufacturer Info Target***	1	Value	0: Port/Cable Plug 1: Battery 255…2: *Reserved* ***Shall Not*** be used.
1	***Manufacturer Info Ref***	1	Value	If ***Manufacturer Info Target*** subfield is Battery (01b) the ***Manufacturer Info Ref*** field ***Shall*** contain the Battery number reference which is the number of the Battery indexed from zero: • Values 0…3 represent the Fixed Batteries. • Values 4…7 represent the Hot Swappable Batteries. Otherwise this field is **Reserved** and *Shall* be set to zero.

6.5.7 Manufacturer_Info Message

The ***Manufacturer_Info*** Message ***Shall*** be sent in response to a ***Get_Manufacturer_Info*** Message. The ***Manufacturer_Info*** Message contains the USB VID and the Vendor's PID to identify the device or Battery and the device or Battery's manufacturer byte array in a variable length Data Block of up to ***MaxExtendedMsgLegacyLen*** .

The ***Manufacturer_Info*** Message returns a Manufacturer Info Data Block (MIDB) whose format ***Shall*** be as shown in Figure 6-34 and Table 6-44.

Figure 6-36 Manufacturer_Info Message

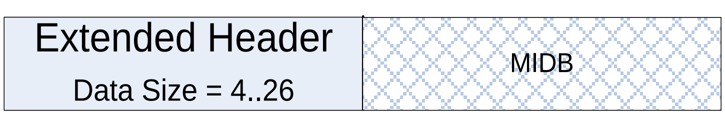


Table 6-49 Manufacturer Info Data Block (MIDB)

Offset	Field	Size	Value	Description
0	VID	2	Numeric	Vendor ID (assigned by the USB-IF)
2	PID	2	Numeric	Product ID (assigned by the manufacturer)
4	Manufacturer String	0…22	String	Vendor defined byte array If the Manufacturer Info Target field or Manufacturer Info Ref field in the ***Get_Manufacturer_Info*** Message is unrecognized return zero bytes.

6.5.7.1 Vendor ID (VID)

This field ***Shall*** contain the device's or Battery's16-bit vendor ID assigned by the USB.

6.5.7.2 Product ID (PID)

This field ***Shall*** contain the device's or Battery's 16-bit product identifier designated by the vendor.

6.5.7.3 Manufacturer String

This field ***Shall*** contain the device's or Battery's manufacturer string as defined by the vendor. If the ***Manufacturer Info Target*** field or ***Manufacturer Info Ref*** field in the ***Get_Manufacturer_Info*** Message is unrecognized the field ***Shall*** return zero bytes.

6.5.8 Security Messages

The authentication process between Port Partners or a Port and Cable Plug is fully described in ***[USBTypeCAuthentication 1.0]***. This specification describes two Extended Messages used by the authentication process when applied to PD.

In the authentication process described in ***[USBTypeCAuthentication 1.0]*** there are three basic exchanges that serve to:

- Get the Port or Cable Plug's certificates.
- Get the Port or Cable Plug's digest.
- Challenge the Port Partner or Cable Plug.

Certificates are used to convey information, attested to by a signer, which attests to the Port Partner's or Cable Plug's authenticity. The Port's or Cable Plug's certificates are needed when a Port encounters a Port Partner or Cable Plug it has not been Attached to before. To minimize calculations after the initial Attachment, a Port can also use a digest consisting of hashes of the certificates rather than the certificates themselves. Once the port has the certificates and has calculated the hashes, it stores the hashes and uses the digest in future exchanges. After the port gets the certificates or digest, it challenges its Port Partner or the Cable Plug to detect replay attacks.

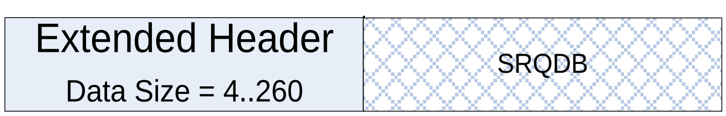
For further details refer to ***[USBTypeCAuthentication 1.0]***.

6.5.8.1 Security_Request

The ***Security_Request*** Message is used by a Port to pass a security data structure to its Port Partner or a Cable Plug.

The ***Security_Request*** Message contains a Security Request Data Block (SRQDB) whose format ***Shall*** be as shown in Figure 6-37. The contents of the SRQDB and its use are defined in ***[USBTypeCAuthentication 1.0]***.

Figure 6-37 Security_Request Message

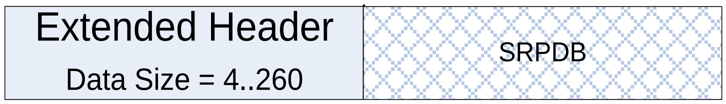


6.5.8.2 Security_Response

The ***Security_Response*** Message is used by a Port or Cable Plug to pass a security data structure to the Port that sent the ***Security_Request*** Message.

The ***Security_Response*** Message contains a Security Response Data Block (SRPDB) whose format ***Shall*** be as shown in Figure 6-38. The contents of the SRPDB and its use are defined in ***[USBTypeCAuthentication 1.0]***.

Figure 6-38 Security_Response Message



6.5.9 Firmware Update Messages

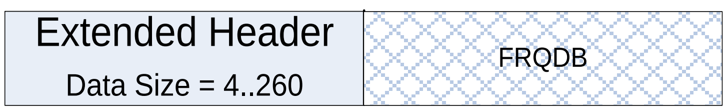
The firmware update process between Port Partners or a Port and Cable Plug is fully described in ***[USBPDFirmwareUpdate 1.0]***. This specification describes two Extended Messages used by the firmware update process when applied to PD.

6.5.9.1 Firmware_Update_Request

The ***Firmware_Update_Request*** Message is used by a Port to pass a firmware update data structure to its Port Partner or a Cable Plug.

The ***Firmware_Update_Request*** Message contains a Firmware Update Request Data Block (FRQDB) whose format ***Shall*** be as shown in Figure 6-39. The contents of the FRQDB and its use are defined in ***[USBPDFirmwareUpdate 1.0]***.

Figure 6-39 Firmware_Update_Request Message

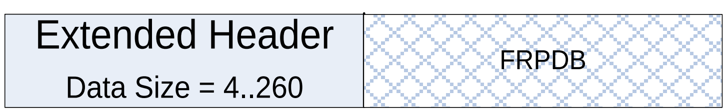


6.5.9.2 Firmware_Update_Response

The ***Firmware_Update_Response*** Message is used by a Port or Cable Plug to pass a firmware update data structure to the Port that sent the ***Firmware_Update_Request*** Message.

The ***Firmware_Update_Response*** Message contains a Firmware Update Response Data Block (FRPDB) whose format ***Shall*** be as shown in Figure 6-40. The contents of the FRPDB and its use are defined in ***[USBPDFirmwareUpdate 1.0]***.

Figure 6-40 Firmware_Update_Response Message



6.5.10 PPS_Status Message

The ***PPS_Status*** Message ***Shall*** be sent in response to a ***Get_PPS_Status*** Message. The ***PPS_Status*** Message enables a Sink to query the Source to get additional information about its operational state. The ***Get_PPS_Status*** Message and the ***PPS_Status*** Message ***Shall*** only be supported when the ***Alert*** Message is also supported.

The ***PPS_Status*** Message ***Shall*** return a 4-byte PPS Status Data Block (PPSSDB) whose format ***Shall*** be as shown in Figure 6-41 and Table 6-50.

Figure 6-41 PPS_Status Message

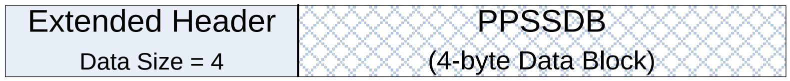


Table 6-50 PPS Status Data Block (PPSSDB)

Offset	Field	Size	Value	Description
0	Output Voltage	1	Word	Source's output voltage in 20mV units. When set to 0xFFFF, the Source does not support this field.
2	Output Current	1	Byte	Source's output current in 50mA units. When set to 0xFF, the Source does not support this field.
3	Real Time Flags	1	Bit Field	**Bit** – **Description** 0 – ***Reserved*** and ***Shall*** be set to zero 1…2 – PTF: 00 – Not Supported PTF: 01 – Normal PTF: 10 – Warning PTF: 11 – Over temperature 3 – OMF set when operating in Current Foldback mode, and cleared when operating in Constant Voltage mode. 4…7 – ***Reserved*** and ***Shall*** be set to zero

6.5.10.1 Output Voltage Field

The Output Voltage field ***Shall*** return the Source's output voltage at the time of the request. It is measured at the Source's receptacle or if the Source has a captive cable, it measured where the voltage is applied to the cable. If the Source does not support this field, it ***Shall*** be set to 0xFFFF.

6.5.10.2 Output Current Field

The Output Current field ***Shall*** return the Source's output current at the time of the request. If the Source does not support this field, it ***Shall*** be set to 0xFF.

6.5.10.3 Real Time Flags Field

Real Time flags provide a real time indication of the Source's operating state.

- The PTF (Present Temperature Flag) ***Shall*** provide a real time indication of the Source's internal thermal status. If the PTF is not supported, it will be set to zero.
  - Normal indicates that that the Source is operating within its normal thermal envelope.
  - Warning indicates that the Source is over-heating, but is not in imminent danger of shutting down.
  - Over Temperature indicates that the Source is over heated and will shut down soon or has already shutdown and has sent an OTP in an ***Alert*** Message.
- The OMF (Operating Mode Flag) ***Shall*** provide a real time indication of the Source's operating mode. When set, the Source is operating in Current Foldback mode; when cleared it is operating Constant Voltage mode.

6.5.11 Country_Codes Message

The ***Country_Codes*** Message ***Shall*** be sent in response to a ***Get_Country_Codes*** Message. The ***Country_Codes*** Message enables a Port to query its Port partner to get a list of alpha-2 country codes as defined in ***[ISO 3166]*** for which the Port Partner has country specific information.

The Country_Codes Message ***Shall*** contain a 4-260 byte Country Code Data Block (CCDB) whose format ***Shall*** be as shown in Figure 6-42 and Table 6-51.

Figure 6-42 Country_Codes Message

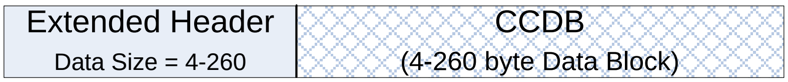


Table 6-51 Country Codes Data Block (CCDB)

Offset	Field	Size	Value	Description
0	Length	1	Word	Number of country codes in the message
2	1st Country Code	2	Bytes	First character of the Alpha-2 Country Code defined by ***[ISO 3166]***
				Second character of the Alpha-2 Country Code defined by ***[ISO 3166]***
4	2nd Country Code	2	Bytes	
	…			
Length * 2n	nth Country Code	2	Bytes	

6.5.11.1 Country Code Field

The Country Code field ***Shall*** contain the Alpha-2 Country Code defined by ***[ISO 3166]***.

6.5.12 Country_Info Message

The ***Country_Info*** Message ***Shall*** be sent in response to a ***Get_Country_Info*** Message. The ***Country_Info*** Message enables a Port to get additional country specific information from its Port Partner.

The ***Country_Info*** Message ***Shall*** contain a 4-260 byte Country Info Data Block (CIDB) whose format ***Shall*** be as shown in Figure 6-43 and Table 6-52.

Figure 6-43 Country_Info Message

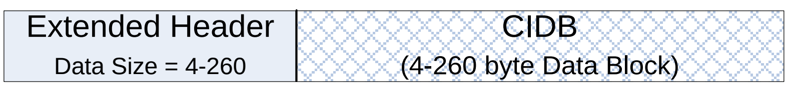


Table 6-52 Country Info Data Block (CIDB)

Offset	Field	Size	Value	Description
0	Country Code	2	Bytes	First character of the Alpha-2 Country Code defined by ***[ISO 3166]***
				Second character of the Alpha-2 Country Code defined by ***[ISO 3166]***

Offset	Field	Size	Value	Description
2	***Reserved***	1	Word	***Shall*** be set to 0.
4	Country Specific Data	0-256	Byte	Content defined by the country's authority.

6.5.12.1 Country Code Field

The Country Code field ***Shall*** contain the Alpha-2 Country Code defined by ***[ISO 3166]***.

6.5.12.2 Country Specific Data Field

The Country Specific Data field ***Shall*** contain content defined by and formatted in a manner determined by an official agency of the country indicated in the Country Code field.

6.6 Timers

All the following timers are defined in terms of bits on the bus regardless of where they are implemented in terms of the logical architecture. This is to ensure a fixed reference for the starting and stopping of timers. It is left to the implementer to ensure that this timing is observed in a real system.

6.6.1 CRCReceiveTimer

The ***CRCReceiveTimer*** ***Shall*** be used by the sender's Protocol Layer to ensure that a Message has not been lost. Failure to receive an acknowledgement of a Message (a ***GoodCRC*** Message) whether caused by a bad CRC on the receiving end or by a garbled Message within ***tReceive*** is detected when the ***CRCReceiveTimer*** expires.

The sender's Protocol Layer response when a ***CRCReceiveTimer*** expires ***Shall*** be to retry ***nRetryCount*** times. Note: that Cable Plugs do not retry Messages and large Extended Messages that are not Chunked are not retried (see Section 6.7.2). Sending of the Preamble corresponding to the retried Message ***Shall*** start within ***tRetry*** of the ***CRCReceiveTimer*** expiring.

The ***CRCReceiveTimer*** ***Shall*** be started when the last bit of the Message ***EOP*** has been transmitted by the Physical Layer. The ***CRCReceiveTimer*** ***Shall*** be stopped when the last bit of the ***EOP*** corresponding to the ***GoodCRC*** Message has been received by the Physical Layer.

The Protocol Layer receiving a Message ***Shall*** respond with a ***GoodCRC*** Message within ***tTransmit*** in order to ensure that the sender's ***CRCReceiveTimer*** does not expire. The ***tTransmit*** ***Shall*** be measured from when the last bit of the Message ***EOP*** has been received by the Physical Layer until the first bit of the Preamble of the ***GoodCRC*** Message has been transmitted by the Physical Layer.

6.6.2 SenderResponseTimer

The ***SenderResponseTimer*** ***Shall*** be used by the sender's Policy Engine to ensure that a Message requesting a response (e.g. ***Get_Source_Cap*** Message) is responded to within a bounded time of ***tSenderResponse***. Failure to receive the expected response is detected when the ***SenderResponseTimer*** expires.

The Policy Engine's response when the ***SenderResponseTimer*** expires ***Shall*** be dependent on the Message sent (see Section 8.3).

The ***SenderResponseTimer*** ***Shall*** be started from the time the last bit of the ***GoodCRC*** Message ***EOP*** (i.e. the ***GoodCRC*** Message corresponding to the Message requesting a response) has been received by the Physical Layer. The ***SenderResponseTimer*** ***Shall*** be stopped when the last bit of the expected response Message ***EOP*** has been received by the Physical Layer.

The receiver of a Message requiring a response ***Shall*** respond within ***tReceiverResponse*** in order to ensure that the sender's ***SenderResponseTimer*** does not expire.

The ***tReceiverResponse*** time ***Shall*** be measured from the time the last bit of the Message ***EOP*** has been received by the Physical Layer until the first bit of the response Message Preamble has been transmitted by the Physical Layer.

6.6.3 Capability Timers

Sources and Sinks use Capability Timers to determine Attachment of a PD Capable device. By periodically sending or requesting capabilities it is possible to determine PD device Attachment when a response is received.

6.6.3.1 SourceCapabilityTimer

Prior to a successful negotiation a Source ***Shall*** use the ***SourceCapabilityTimer*** to periodically send out a ***Source_Capabilities*** Message every ***tTypeCSendSourceCap*** while:

- The Port is Attached.
- The Source is not in an active connection with a PD Sink Port.

Whenever there is a ***SourceCapabilityTimer*** timeout the Source ***Shall*** send a ***Source_Capabilities*** Message. It ***Shall*** then re-initialize and restart the ***SourceCapabilityTimer***. The ***SourceCapabilityTimer Shall*** be stopped when the last bit of the ***EOP*** corresponding to the ***GoodCRC*** Message has been received by the Physical Layer since a PD connection has been established. At this point the Source waits for a ***Request*** Message or a response timeout.

See Section 8.3.3.2 more details of when ***Source_Capabilities*** Messages are transmitted.

6.6.3.2 SinkWaitCapTimer

The Sink ***Shall*** support the ***SinkWaitCapTimer***. When a Sink observes an absence of ***Source_Capabilities*** Messages, after V_{BUS} is present, for a duration of ***tTypeCSinkWaitCap*** the Sink ***Shall*** issue ***Hard Reset*** Signaling in order to restart the sending of ***Source_Capabilities*** Messages by the Source (see Section 6.7.4).

See Section 8.3.3.3 for more details of when the ***SinkWaitCapTimer*** are run.

6.6.3.3 tFirstSourceCap

After Port Partners are Attached or after a Hard Reset or after a Power Role Swap or after a Fast Role Swap a Source ***Shall*** send its first ***Source_Capabilities*** Message within ***tFirstSourceCap*** of V_{BUS} reaching ***vSafe5V***. This ensures that the Sink receives a ***Source_Capabilities*** Message before the Sink's ***SinkWaitCapTimer*** expires.

6.6.4 Wait Timers and Times

6.6.4.1 SinkRequestTimer

The ***SinkRequestTimer*** is used to ensure that the time before the next Sink ***Request*** Message, after a ***Wait*** Message has been received from the Source in response to a Sink ***Request*** Message, is a minimum of ***tSinkRequest*** min (see Section 6.3.12).

The ***SinkRequestTimer Shall*** be started when the ***EOP*** of a ***Wait*** Message has been received and ***Shall*** be stopped if any other Message is received or during a Hard Reset.

The Sink ***Shall*** wait at least ***tSinkRequest,*** after receiving the ***EOP*** of a ***Wait*** Message sent in response to a Sink ***Request*** Message, before sending a new ***Request*** Message. Whenever there is a ***SinkRequestTimer*** timeout the Sink ***May*** send a ***Request*** Message. It ***Shall*** then re-initialize and restart the ***SinkRequestTimer***.

6.6.4.2 tPRSwapWait

The time before the next ***PR_Swap*** Message, after a ***Wait*** Message has been received in response to a ***PR_Swap*** Message is a minimum of ***tPRSwapWait*** min (see Section 6.3.12). The Port ***Shall*** wait at least ***tPRSwapWait*** after receiving the ***EOP*** of a ***Wait*** Message sent in response to a ***PR_Swap*** Message, before sending a new ***PR_Swap*** Message.

6.6.4.3 tDRSwapWait

The time before the next ***DR_Swap*** Message, after a ***Wait*** Message has been received in response to a ***DR_Swap*** Message is a minimum of ***tDRSwapWait*** min (see Section 6.3.12). The Port ***Shall*** wait at least ***tDRSwapWait*** after receiving the ***EOP*** of a ***Wait*** Message sent in response to a ***DR_Swap*** Message, before sending a new ***DR_Swap*** Message.

6.6.4.4 tVconnSwapWait

The time before the next ***VCONN_Swap*** Message, after a ***Wait*** Message has been received in response to a ***VCONN_Swap*** Message is a minimum of ***tVCONNSwapWait*** min (see Section 6.3.12). The Port ***Shall*** wait at least ***tVCONNSwapWait*** after receiving the ***EOP*** of a ***Wait*** Message sent in response to a ***VCONN_Swap*** Message, before sending a new ***VCONN_Swap*** Message.

6.6.5 Power Supply Timers

6.6.5.1 PSTransitionTimer

The ***PSTransitionTimer*** is used by the Policy Engine to timeout on a ***PS_RDY*** Message. It is started when a request for a new Capability has been accepted and will timeout after ***tPSTransition*** if a ***PS_RDY*** Message has not been received. This condition leads to a Hard Reset and a return to USB Default Operation. The ***PSTransitionTimer*** relates to the time taken for the Source to transition from one voltage, or current level, to another (see Section 7.1).

The ***PSTransitionTimer*** ***Shall*** be started when the last bit of an ***Accept*** or ***GotoMin*** Message ***EOP*** has been received by the Physical Layer. The ***PSTransitionTimer*** ***Shall*** be stopped when the last bit of the ***PS_RDY*** Message ***EOP*** has been received by the Physical Layer.

6.6.5.2 PSSourceOffTimer

6.6.5.2.1 Use during Power Role Swap

The ***PSSourceOffTimer*** is used by the Policy Engine in Dual-Role Power Device that is currently acting as a Sink to timeout on a ***PS_RDY*** Message during a Power Role Swap sequence. This condition leads to USB Type-C Error Recovery.

If a ***PR_Swap*** Message request has been sent by the Dual-Role Power Device currently acting as a Source the Sink can respond with an ***Accept*** Message. When the last bit of the ***EOP*** of the ***GoodCRC*** Message corresponding to this ***Accept*** Message is received by the Sink, then the ***PSSourceOffTimer*** ***Shall*** be started.

If a ***PR_Swap*** Message request has been sent by the Dual-Role Power Device currently acting as a Sink the Source can respond with an ***Accept*** Message. When the last bit of the ***EOP*** of this ***Accept*** Message is received by the Sink then the ***PSSourceOffTimer*** ***Shall*** be started.

The ***PSSourceOffTimer*** ***Shall*** be stopped when:

- The last bit of the ***EOP*** of the ***PS_RDY*** Message is received.

The ***PSSourceOffTimer*** relates to the time taken for the remote Dual-Role Power Device to stop supplying power (see also Section 7.3.9 and Section 7.3.10). The timer ***Shall*** time out if a ***PS_RDY*** Message has not been received from the remote Dual-Role Power Device within ***tPSSourceOff*** indicating this has occurred.

6.6.5.2.2 Use during Fast Role Swap

The ***PSSourceOffTimer*** is used by the Policy Engine in Dual-Role Power Device that is the initial Sink (currently providing ***vSafe5V***) to timeout on a ***PS_RDY*** Message during a Fast Role Swap sequence. This condition leads to USB Type-C Error Recovery.

When the ***FR_Swap*** Message request has been sent by the initial Sink, the initial Source ***Shall*** respond with an ***Accept*** Message. When the last bit of the ***EOP*** of the ***GoodCRC*** Message corresponding to this ***Accept*** Message is received by the initial Sink, then the ***PSSourceOffTimer*** ***Shall*** be started.

The ***PSSourceOffTimer*** ***Shall*** be stopped when:

- The last bit of the ***EOP*** of the ***PS_RDY*** Message is received.

The ***PSSourceOffTimer*** relates to the time taken for the initial Source to stop supplying power and for V_{BUS} to revert to ***vSafe5V*** (see also Section 7.2.10 and Section 7.3.15). The timer ***Shall*** time out if a ***PS_RDY*** Message has not been received from the initial Source within ***tPSSourceOff*** indicating this has occurred.

6.6.5.3 PSSourceOnTimer

6.6.5.3.1 Use during Power Role Swap

The ***PSSourceOnTimer*** is used by the Policy Engine in Dual-Role Power Device that has just stopped sourcing power and is waiting to start sinking power to timeout on a ***PS_RDY*** Message during a Power Role Swap. This condition leads to USB Type-C Error Recovery.

The ***PSSourceOnTimer*** ***Shall*** be started when:

- The last bit of the ***EOP*** of the ***GoodCRC*** Message corresponding to the transmitted ***PS_RDY*** Message is received by the Physical Layer.

The ***PSSourceOnTimer*** ***Shall*** be stopped when:

- The last bit of the ***EOP*** of the ***PS_RDY*** Message is received by the Physical Layer.

The ***PSSourceOnTimer*** relates to the time taken for the remote Dual-Role Power Device to start sourcing power (see also Section 7.3.9 and Section 7.3.10) and will time out if a ***PS_RDY*** Message indicating this has not been received within ***tPSSourceOn***.

6.6.5.3.2 Use during Fast Role Swap

The ***PSSourceOnTimer*** is used by the Policy Engine in Dual-Role Power Device that has just stopped sourcing power and is waiting to start sinking power to timeout on a ***PS_RDY*** Message during a Fast Role Swap. This condition leads to USB Type-C Error Recovery.

The ***PSSourceOnTimer*** ***Shall*** be started when:

- The last bit of the ***EOP*** of the ***GoodCRC*** Message corresponding to the transmitted ***PS_RDY*** Message is received by the Physical Layer.

The ***PSSourceOnTimer*** ***Shall*** be stopped when:

- The last bit of the ***EOP*** of the ***PS_RDY*** Message is received by the Physical Layer.

The ***PSSourceOnTimer*** relates to the time taken for the remote Dual-Role Power Device to start sourcing power (see also Section 7.2.10 and Section 7.3.15) and will time out if a ***PS_RDY*** Message indicating this has not been received within ***tPSSourceOn***.

6.6.6 NoResponseTimer

The ***NoResponseTimer*** is used by the Policy Engine in a Source or Sink to determine that its Port Partner is not responding after a Hard Reset. When the ***NoResponseTimer*** times out, the Policy Engine ***Shall*** issue up to ***nHardResetCount*** additional Hard Resets before determining that the Port Partner is non-responsive to USB Power Delivery messaging.

If the Source fails to receive a ***GoodCRC*** Message in response to a ***Source_Capabilities*** Message within ***tNoResponse*** of:

- The last bit of a ***Hard Reset*** Signaling being sent by the PHY Layer if the ***Hard Reset*** Signaling was initiated by the Sink.
- The last bit of a ***Hard Reset*** Signaling being received by the PHY Layer if the ***Hard Reset*** Signaling was initiated by the Source.

Then the Source ***Shall*** issue additional Hard Resets up to ***nHardResetCount*** times (see Section 6.8.2).

For a non-responsive device, the Policy Engine in a Source ***May*** either decide to continue sending ***Source_Capabilities*** Messages or to go to non-USB Power Delivery operation and cease sending ***Source_Capabilities*** Messages.

6.6.7 BIST Timers

6.6.7.1 tBISTMode

tBISTMode is used to define the maximum time that a UUT has to enter a BIST mode when requested by a Tester.

A UUT ***Shall*** enter the appropriate BIST mode within ***tBISTMode*** of the last bit of the ***EOP*** of the ***BIST*** Message used to initiate the test is received by the Physical Layer. In ***BIST Carrier Mode*** when transmitting a continuous carrier signal transmission ***Shall*** start as soon as the UUT enters BIST mode.

6.6.7.2 BISTContModeTimer

The ***BISTContModeTimer*** is used by a UUT to ensure that a Continuous BIST Mode (i.e. ***BIST Carrier Mode***) is exited in a timely fashion. A UUT that has been put into a Continuous BIST Mode ***Shall*** return to normal operation (either ***PE_SRC_Transition_to_default***, ***PE_SNK_Transition_to_default***, or ***PE_CBL_Ready***) within ***tBISTContMode*** of the last bit of the bit of the ***EOP*** of ***GoodCRC*** Message sent in response to the ***BIST*** Message used to enable the Continuous BIST Mode.

6.6.8 Power Role Swap Timers

6.6.8.1 SwapSourceStartTimer

The ***SwapSourceStartTimer*** ***Shall*** be used by the new Source, after a Power Role Swap or Fast Role Swap, to ensure that it does not send ***Source_Capabilities*** Message before the new Sink is ready to receive the ***Source_Capabilities*** Message. The new Source ***Shall Not*** send the ***Source_Capabilities*** Message earlier than ***tSwapSourceStart*** after the last bit of the ***EOP*** of ***GoodCRC*** Message sent in response to the ***PS_RDY*** Message sent by the new Source indicating that its power supply is ready. The Sink ***Shall*** be ready to receive a ***Source_Capabilities*** Message ***tSwapSinkReady*** after having sent the last bit of the ***EOP*** of ***GoodCRC*** Message sent in response to the ***PS_RDY*** Message sent by the new Source indicating that its power supply is ready.

6.6.9 Soft Reset Timers

6.6.9.1 tSoftReset

A failure to see a ***GoodCRC*** Message in response to any Message within ***tReceive*** (after ***nRetryCount*** retries), when a Port Pair is Connected, is indicative of a communications failure. This ***Shall*** cause the Source or Sink to send a ***Soft_Reset*** Message, transmission of which ***Shall*** be completed within ***tSoftReset*** of the ***CRCReceiveTimer*** expiring.

6.6.9.2 tProtErrSoftReset

If the Protocol Error occurs that causes the Source or Sink to send a ***Soft_Reset*** Message, the transmission of the ***Soft_Reset*** Message ***Shall*** be completed within ***tProtErrSoftReset*** of the ***EOP*** of the ***GoodCRC*** sent in response to the Message that caused the Protocol Error.

6.6.10 Hard Reset Timers

6.6.10.1 HardResetCompleteTimer

The ***HardResetCompleteTimer*** is used by the Protocol Layer in the case where it has asked the PHY Layer to send ***Hard Reset*** Signaling and the PHY Layer is unable to send the Signaling within a reasonable time due to a non-idle channel. If the PHY Layer does not indicate that the ***Hard Reset*** Signaling has been sent within ***tHardResetComplete*** of the Protocol Layer requesting transmission, then the Protocol Layer ***Shall*** inform the Policy Engine that the ***Hard Reset*** Signaling has been sent in order to ensure the power supply is reset in a timely fashion.

6.6.10.2 PSHardResetTimer

The ***PSHardResetTimer*** is used by the Policy Engine in a Source to ensure that the Sink has had sufficient time to process ***Hard Reset*** Signaling before turning off its power supply to V_{BUS}.

When a Hard Reset occurs the Source stops driving VCONN, removes Rp from the VCONN pin and starts to transition the V_{BUS} voltage to ***vSafe0V*** either:

- ***tPSHardReset*** after the last bit of the ***Hard Reset*** Signaling has been received from the Sink or
- ***tPSHardReset*** after the last bit of the ***Hard Reset*** Signaling has been sent by the Source.

See Section 7.1.5.

6.6.10.3 tDRSwapHardReset

If a ***DR_Swap*** Message is received during Modal Operation then a Hard Reset ***Shall*** be initiated by the recipient of the unexpected ***DR_Swap*** Message; ***Hard Reset*** Signaling ***Shall*** be generated within ***tDRSwapHardReset*** of the EOP of the ***GoodCRC*** sent in response to the ***DR_Swap*** Message.

6.6.10.4 tProtErrHardReset

If a Protocol Error occurs that directly leads to a Hard Reset, the transmission of the ***Hard Reset*** Signaling ***Shall*** be completed within ***tProtErrHardReset*** of the ***EOP*** of the ***GoodCRC*** sent in response to the Message that caused the Protocol Error.

6.6.11 Structured VDM Timers

6.6.11.1 VDMResponseTimer

The ***VDMResponseTimer*** ***Shall*** be used by the Initiator's Policy Engine to ensure that a Structured VDM Command request needing a response (e.g. ***Discover Identity*** Command request) is responded to within a bounded time of ***tVDMSenderResponse***. The ***VDMResponseTimer*** ***Shall*** be applied to all Structured VDM Commands except the ***Enter Mode*** and ***Exit Mode*** Commands which have their own timers (***VDMModeEntryTimer*** and ***VDMModeExitTimer*** respectively). Failure to receive the expected response is detected when the ***VDMResponseTimer*** expires.

The Policy Engine's response when the ***VDMResponseTimer*** expires ***Shall*** be dependent on the Message sent (see Section 8.3).

The ***VDMResponseTimer*** ***Shall*** be started from the time the last bit of the ***GoodCRC*** Message ***EOP*** (i.e. the ***GoodCRC*** Message corresponding to the VDM Command requesting a response) has been received by the Physical Layer. The ***VDMResponseTimer*** ***Shall*** be stopped when the last bit of the expected VDM Command response ***EOP*** has been received by the Physical Layer.

The receiver of a Message requiring a response ***Shall*** respond within ***tVDMReceiverResponse*** in order to ensure that the sender's ***VDMResponseTimer*** does not expire.

The ***tVDMReceiverResponse*** time ***Shall*** be measured from the time the last bit of the Message ***EOP*** has been received by the Physical Layer until the first bit of the response Message Preamble has been transmitted by the Physical Layer.

6.6.11.2 VDMModeEntryTimer

The ***VDMModeEntryTimer*** ***Shall*** be used by the Initiator's Policy Engine to ensure that the response to a Structured VDM ***Enter Mode*** Command request (ACK or NAK with ACK indicating that the requested Mode has been entered) arrives within a bounded time of ***tVDMWaitModeEntry***. Failure to receive the expected response is detected when the ***VDMModeEntryTimer*** expires.

The Policy Engine's response when the ***VDMModeEntryTimer*** expires is to inform the Device Policy Manager (see Section 8.3.3.20.1).

The ***VDMModeEntryTimer*** ***Shall*** be started from the time the last bit of the ***GoodCRC*** Message ***EOP*** (i.e. the ***GoodCRC*** Message corresponding to the VDM Command request) has been received by the Physical Layer. The ***VDMModeEntryTimer*** ***Shall*** be stopped when the last bit of the expected Structured VDM Command response (ACK, NAK or BUSY) ***EOP*** has been received by the Physical Layer.

The receiver of a Message requiring a response ***Shall*** respond within ***tVDMEnterMode*** in order to ensure that the sender's ***VDMModeEntryTimer*** does not expire.

The ***tVDMEnterMode*** time ***Shall*** be measured from the time the last bit of the Message ***EOP*** has been received by the Physical Layer until the first bit of the response Message Preamble has been transmitted by the Physical Layer.

6.6.11.3 VDMModeExitTimer

The ***VDMModeExitTimer*** ***Shall*** be used by the Initiator's Policy Engine to ensure that the ACK response to a Structured VDM ***Exit Mode*** Command, indicating that the requested Mode has been exited, arrives within a bounded time of ***tVDMWaitModeExit***. Failure to receive the expected response is detected when the ***VDMModeExitTimer*** expires.

The Policy Engine's response when the ***VDMModeExitTimer*** expires is to inform the Device Policy Manager (see Section 8.3.3.20.2).

The ***VDMModeExitTimer*** ***Shall*** be started from the time the last bit of the ***GoodCRC*** Message ***EOP*** (i.e. the ***GoodCRC*** Message corresponding to the VDM Command requesting a response) has been received by the Physical Layer. The ***VDMModeExitTimer*** ***Shall*** be stopped when the last bit of the expected Structured VDM Command response ACK ***EOP*** has been received by the Physical Layer.

The receiver of a Message requiring a response ***Shall*** respond within ***tVDMExitMode*** in order to ensure that the sender's ***VDMModeExitTimer*** does not expire.

The ***tVDMExitMode*** time ***Shall*** be measured from the time the last bit of the Message ***EOP*** has been received by the Physical Layer until the first bit of the response Message Preamble has been transmitted by the Physical Layer.

6.6.11.4 tVDMBusy

The Initiator ***Shall*** wait at least ***tVDMBusy***, after receiving a BUSY Command response, before repeating the Structured VDM request again.

6.6.12 VCONN Timers

6.6.12.1 VCONNOnTimer

The ***VCONNOnTimer*** is used during a VCONN Swap.

The ***VCONNOnTimer*** ***Shall*** be started when:

- The last bit of the ***EOP*** of the ***Accept*** Message is received.
- The last bit of the ***EOP*** of ***GoodCRC*** Message corresponding to the ***Accept*** Message is received.

The ***VCONNOnTimer*** ***Shall*** be stopped when:

- The last bit of the ***EOP*** of the ***PS_RDY*** Message is received.

Prior to sending the ***PS_RDY*** Message, the Port ***Shall*** have turned VCONN On.

6.6.12.2 tVCONNSourceOff

The ***tVCONNSourceOff*** time applies during a Vconn Swap. The initial VCONN Source ***Shall*** cease sourcing VCONN within ***tVCONNSourceOff*** of receipt of the last bit of the ***EOP*** of the ***PS_RDY*** Message.

6.6.13 tCableMessage

Ports compliant with this Revision of the specification ***Shall Not*** wait ***tCableMessage*** before sending an SOP' or SOP'' Packet even when communicating using ***[USBPD 2.0]*** with a Cable Plug. This specification defines collision avoidance mechanisms that obviate the need for this time.

Cable Plugs ***Shall*** only wait ***tCableMessage*** before sending an SOP' or SOP'' Packet when operating at ***[USBPD 2.0]***. When operating at Revisions higher than ***[USBPD 2.0]*** Cable Plugs ***Shall Not*** wait ***tCableMessage*** before sending an SOP' or SOP'' Packet.

6.6.14 DiscoverIdentityTimer

The ***DiscoverIdentityTimer*** is used during an Explicit Contract when discovering whether a Cable Plug is PD Capable using SOP'. When performing cable discovery during an Explicit Contract the ***Discover Identity*** Command request ***Shall*** be sent every ***tDiscoverIdentity***. No more than ***nDiscoverIdentityCount Discover Identity*** Messages without a ***GoodCRC*** Message response ***Shall*** be sent. If no ***GoodCRC*** Message response is received after ***nDiscoverIdentityCount Discover Identity*** Command requests have been sent by a Port, the Port ***Shall Not*** send any further SOP'/SOP'' Messages.

6.6.15 Collision Avoidance Timers

The ***SinkTxTimer*** is used by the Protocol Layer in a Source to allow the Sink to complete its transmission before initiating an AMS.

The Source ***Shall*** wait a minimum of ***tSinkTx*** after changing Rp from ***SinkTxOk*** to ***SinkTxNG*** before initiating an AMS by sending a Message.

A Sink ***Shall*** only initiate an AMS when it has determined that Rp is set to ***SinkTxOk***.

6.6.16 tFRSwapInit

That last bit of the ***EOP*** of the ***FR_Swap*** Message ***Shall*** be transmitted by the new Source no later than ***tFRSwapInit*** after the Fast Role Swap request has been detected (see Section 5.8.6.3).

6.6.17 Chunking Timers

6.6.17.1 ChunkingNotSupportedTimer

The ***ChunkingNotSupportedTimer*** is used by a Source or Sink which does not support multi-chunk Chunking but has received a Message Chunk.

The ***ChunkingNotSupportedTimer*** ***Shall*** be started when:

- The last bit of the EOP of a Message Chunk of a multi-chunk Message is received. The Policy Engine ***Shall Not*** send its Not_Supported Message before the ChunkingNotSupportedTimer expires.

6.6.17.2 ChunkSenderRequestTimer

The ***ChunkSenderRequestTimer*** is used during a Chunked Message transmission.

The ***ChunkSenderRequestTimer*** ***Shall*** be used by the sender's Chunking state machine to ensure that a Chunk Response is responded to within a bounded time of ***tChunkSenderRequest***. Failure to receive the expected response is detected when the ***ChunkSenderRequestTimer*** expires.

The ***ChunkSenderRequestTimer*** ***Shall*** be started when:

- The last bit of the ***EOP*** of the ***GoodCRC*** Message corresponding to the Chunk Response Message is received.

The ***ChunkSenderRequestTimer*** ***Shall*** be stopped when:

- The last bit of the ***EOP*** of the Chunk Request Message is received.

- A Message other than a Chunk Request is received from the Protocol Layer Rx.

The receiver of a Chunk Response requiring a Chunk Request ***Shall*** respond with a Chunk Request within ***tChunkReceiverRequest*** in order to ensure that the sender's ***ChunkSenderRequestTimer*** does not expire.

The ***tChunkReceiverRequest*** time ***Shall*** be measured from the time the last bit of the Message ***EOP*** has been received by the Physical Layer until the first bit of the response Message Preamble has been transmitted by the Physical Layer.

6.6.17.3 ChunkSenderResponseTimer

The ***ChunkSenderResponseTimer*** is used during a Chunked Message transmission.

The ***ChunkSenderResponseTimer*** ***Shall*** be used by the sender's Chunking state machine to ensure that a Chunk Request is responded to within a bounded time of ***tChunkSenderResponse***. Failure to receive the expected response is detected when the ChunkSenderResponseTimer expires.

The ***ChunkSenderResponseTimer*** ***Shall*** be started when:

- The last bit of the EOP of GoodCRC Message corresponding to the Chunk Request Message is received.

The ***ChunkSenderResponseTimer*** ***Shall*** be stopped when:

- The last bit of the EOP of the Chunk Response Message is received.
- A Message other than a Chunk is received from the Protocol Layer.

The receiver of a Chunk Request requiring a Chunk Response ***Shall*** respond with a Chunk Response within ***tChunkReceiverResponse*** in order to ensure that the sender's ***ChunkSenderResponseTimer*** does not expire.

The ***tChunkReceiverResponse*** time ***Shall*** be measured from the time the last bit of the Message ***EOP*** has been received by the Physical Layer until the first bit of the response Message Preamble has been transmitted by the Physical Layer.

6.6.18 Programmable Power Supply Timers

6.6.18.1 SinkPPSPeriodicTimer

The ***SinkPPSPeriodicTimer*** ***Shall*** be used by the Sink's Policy Engine to ensure that a ***Request*** Message requesting a PPS APDO is sent periodically within a bounded time of ***tPPSRequest***.

The ***tPPSRequest*** time ***Shall*** be measured from the time the last bit of the ***EOP*** of the ***GoodCRC*** Message sent by the Source in response to the previous ***Request*** Message. ***SinkPPSPeriodicTimer*** ***Shall*** be re-initialized and restarted when the last bit of the ***EOP*** of the ***GoodCRC*** Message sent in response to a ***Request*** Message for a PPS APDO has been received by the Physical Layer.

The Sink ***Shall*** stop the ***SinkPPSPeriodicTimer*** when:

- The Sink requests something other than PPS APDO.
- There is a Power Role Swap.
- There is a Hard Reset.

6.6.18.2 SourcePPSCommTimer

The ***SourcePPSCommTimer*** ***Shall*** be used by the Source's Policy Engine to ensure that a ***Request*** Message requesting a PPS APDO is received periodically within a bounded time of ***tPPSTimeout***.

The ***tPPSTimeout*** time ***Shall*** be measured from the time the last bit of the ***EOP*** of the ***GoodCRC*** Message sent in response to the previous ***Request*** Message for a PPS APDO has been sent by the Physical Layer.

The ***SourcePPSCommTimer*** ***Shall*** be re-initialized and restarted when the last bit of the ***EOP*** of the ***GoodCRC*** Message sent in response to a ***Request*** Message for a PPS APDO has been sent by the Physical Layer.

The Source ***Shall*** stop the ***SourcePPSCommTimer*** when:

- A ***Request*** Message has been received.
- There is a Power Role Swap.
- There is a Hard Reset.

When the ***SourcePPSCommTimer*** times out the Source ***Shall*** issue ***Hard Reset*** Signaling.

6.6.19 Time Values and Timers

Table 6-53 summarizes the values for the timers listed in this section. For each Timer Value, a given implementation ***Shall*** pick a fixed value within the range specified. Table 6-54 lists the timers.

Table 6-53 Time Values

Parameter	Value (min)	Value (max)	Units	Reference
tBISTContMode	30	60	ms	Section 6.6.7.2
tBISTMode		300	ms	Section 6.6.7.1
tCableMessage	750		µs	Section 6.6.13
tChunkingNotSupported	40	50	ms	Section 6.6.17.1
tChunkSenderRequest	24	30	ms	Section 6.6.17.2
tChunkSenderResponse	24	30	ms	Section 6.6.17.3
tChunkReceiverRequest		15	ms	Section 6.6.17.2
tChunkReceiverResponse		15	ms	Section 6.6.17.3
tDiscoverIdentity	40	50	ms	Section 6.6.13
tDRSwapHardReset		15	ms	Section 6.6.10.3
tDRSwapWait	100		ms	Section 6.6.4.3
tFirstSourceCap		250	ms	Section 6.6.3.3
tFRSwapInit		15	ms	Section 6.3.17
tHardReset		5	ms	Section 6.3.13
tHardResetComplete	4	5	ms	Section 6.6.9
tNoResponse	4.5	5.5	s	Section 6.6.6
tPPSRequest		10	s	Section 6.6.18.1
tPPSTimeout		15	s	Section 6.6.18.2
tProtErrHardReset		15	ms	Section 6.6.10.4
tProtErrSoftReset		15	ms	Section 6.6.9.2
tPRSwapWait	100		ms	Section 6.6.4.2
tPSHardReset	25	35	ms	Section 6.6.10.2
tPSSourceOff	750	920	ms	Section 6.6.5.2
tPSSourceOn	390	480	ms	Section 6.6.5.3
tPSTransition	450	550	ms	Section 6.6.5.1
tReceive	0.9	1.1	ms	Section 6.6.1
tReceiverResponse		15	ms	Section 6.6.2
tRetry		75	µs	Section 6.6.1
tSenderResponse	24	30	ms	Section 6.6.2
tSinkRequest	100		ms	Section 6.6.4.1
tSinkTx	16	20	ms	Section 6.6.15
tSoftReset		15	ms	Section 6.8.1
tSwapSinkReady		15	ms	Section 6.6.8.1
tSwapSourceStart	20		ms	Section 6.6.8.1
tTransmit		195	µs	Section 6.6.1
tTypeCSendSourceCap	100	200	ms	Section 6.6.3.1
tTypeCSinkWaitCap	310	620	ms	Section 6.6.3.2
tVCONNSourceOff		25	ms	Section 6.6.12

Parameter	Value (min)	Value (max)	Units	Reference
tVCONNSourceOn		100	ms	Section 6.6.12
tVCONNSwapWait	100		ms	Section 6.6.4.4
tVDMBusy	50		ms	Section 6.6.11.4
tVDMEnterMode		25	ms	Section 6.6.11.2
tVDMExitMode		25	ms	Section 6.6.11.3
tVDMReceiverResponse		15	ms	Section 6.6.11.1
tVDMSenderResponse	24	30	ms	Section 6.6.11.1
tVDMWaitModeEntry	40	50	ms	Section 6.6.11.2
tVDMWaitModeExit	40	50	ms	Section 6.6.11.3

Table 6-54 Timers

Timer	Parameter	Used By	Reference
BISTContModeTimer	*tBISTContMode*	Policy Engine	Section 6.6.7.2
ChunkingNotSupportedTimer	*tChunkingNotSupported*	Policy Engine	Section 6.6.17.1
ChunkSenderRequestTimer	*tChunkSenderRequest*	Protocol	Section 6.6.17.2
ChunkSenderResponseTimer	*tChunkSenderResponse*	Protocol	Section 6.6.17.3
CRCReceiveTimer	*tReceive*	Protocol	Section 6.6.1
DiscoverIdentityTimer	*tDiscoverIdentity*	Policy Engine	Section 6.6.14
HardResetCompleteTimer	*tHardResetComplete*	Protocol	Section 6.6.9
NoResponseTimer	*tNoResponse*	Policy Engine	Section 6.6.6
PSHardResetTimer	*tPSHardReset*	Policy Engine	Section 6.6.10.2
PSSourceOffTimer	*tPSSourceOff*	Policy Engine	Section 6.6.5.2
PSSourceOnTimer	*tPSSourceOn*	Policy Engine	Section 6.6.5.3
PSTransitionTimer	*tPSTransition*	Policy Engine	Section 6.6.5.1
SenderResponseTimer	*tSenderResponse*	Policy Engine	Section 6.6.2
SinkPPSPeriodicTimer	*tPPSRequest*	Policy Engine	Section 6.6.18.1
SinkRequestTimer	*tSinkRequest*	Policy Engine	Section 6.6.4
SinkWaitCapTimer	*tTypeCSinkWaitCap*	Policy Engine	Section 6.6.3.2
SourceCapabilityTimer	*tTypeCSendSourceCap*	Policy Engine	Section 6.6.3.1
SourcePPSCommTimer	*tPPSTimeout*	Policy Engine	Section 6.6.18.2
SinkTxTimer	*tSinkTx*	Protocol Layer	Section 6.6.15
SwapSourceStartTimer	*tSwapSourceStart*	Policy Engine	Section 6.6.8.1
VCONNOnTimer	*tVCONNSourceOn*	Policy Engine	Section 6.6.12.1
VDMModeEntryTimer	*tVDMWaitModeEntry*	Policy Engine	Section 6.6.11.2
VDMModeExitTimer	*tVDMWaitModeExit*	Policy Engine	Section 6.6.11.3
VDMResponseTimer	*tVDMSenderResponse*	Policy Engine	Section 6.6.11.1

6.7 Counters

6.7.1 MessageID Counter

The ***MessageIDCounter*** is a rolling counter, ranging from 0 to ***nMessageIDCount***, used to detect duplicate Messages. This value is used for the ***MessageID*** field in the Message Header of each transmitted Message.

Each Port ***Shall*** maintain a copy of the last ***MessageID*** value received from its Port Partner. Devices that support multiple ports, such as Hubs, ***Shall*** maintain copies of the last ***MessageID*** on a per Port basis. A Port which communicates using SOP* Packets ***Shall*** maintain copies of the last ***MessageID*** for each type of ***SOP**** it uses.

The transmitter ***Shall*** use the ***MessageID*** in a ***GoodCRC*** Message to verify that a particular Message was received correctly. The receiver ***Shall*** use the ***MessageID*** to detect duplicate Messages.

6.7.1.1 Transmitter Usage

The Transmitter ***Shall*** use the ***MessageID*** as follows:

- Upon receiving either ***Hard Reset*** Signaling, or a ***Soft_Reset*** Message, the transmitter ***Shall*** set its ***MessageIDCounter*** to zero and re-initialize its retry mechanism.
- If a ***GoodCRC*** Message with a ***MessageID*** matching the ***MessageIDCounter*** is not received before the ***CRCReceiveTimer*** expires, it ***Shall*** retry the same packet up to ***nRetryCount*** times using the same ***MessageID***.
- If a ***GoodCRC*** Message is received with a ***MessageID*** matching the current ***MessageIDCounter*** before the ***CRCReceiveTimer*** expires, the transmitter ***Shall*** re-initialize its retry mechanism and increment its ***MessageIDCounter***.
- If the Message is aborted by the Policy Engine, the transmitter ***Shall*** delete the Message from its transmit buffer, re-initialize its retry mechanism and increment its ***MessageIDCounter***.
- The ***MessageID*** is incremented if a ***GoodCRC*** Message is not received and the ***RetryCounter*** has reached ***nRetryCount***.

6.7.1.2 Receiver Usage

The Receiver ***Shall*** use the ***MessageID*** as follows:

- When the first good packet is received after a reset, the receiver ***Shall*** store a copy of the received ***MessageID*** value.
- For subsequent Messages, if ***MessageID*** value in a received Message is the same as the stored value, the receiver ***Shall*** return a ***GoodCRC*** Message with that ***MessageID*** value and drop the Message (this is a retry of an already received Message). Note: this ***Shall Not*** apply to the ***Soft_Reset*** Message which always has a ***MessageID*** value of zero.
- If ***MessageID*** value in the received Message is different than the stored value, the receiver ***Shall*** return a ***GoodCRC*** Message with the new ***MessageID*** value, store a copy of the new ***MessageID*** value and process the Message.

6.7.2 Retry Counter

The ***RetryCounter*** is used by a Port whenever there is a Message transmission failure (timeout of ***CRCReceiveTimer***). If the ***nRetryCount*** retry fails, then the link ***Shall*** be reset using the Soft Reset mechanism.

The following rules apply to retries when there is a Message transmission failure (see also Section 6.11.2.1):

- Cable Plugs ***Shall Not*** retry Messages.
- Extended Messages of ***Data Size*** > ***MaxExtendedMsgLegacyLen*** that are not Chunked (***Chunked*** flag set to zero) ***Shall Not*** be retried .
- Extended Messages of ***Data Size*** ≤ ***MaxExtendedMsgLegacyLen*** (***Chunked*** flag set to zero or one) ***Shall*** be retried.

- Extended Messages of ***Data Size*** > ***MaxExtendedMsgLegacyLen*** that are Chunked (***Chunked*** flag set to one) individual Chunks ***Shall*** be retried.

When messages are not retried, then the ***RetryCounter*** is not used. Higher layer protocols are expected to accommodate message delivery failure or failure to receive a ***GoodCRC*** Message.

6.7.3 Hard Reset Counter

The ***HardResetCounter*** is used to retry the Hard Reset whenever there is no response from the remote device (see Section 6.6.6). Once the Hard Reset has been retried ***nHardResetCount*** times then it ***Shall*** be assumed that the remote device is non-responsive.

6.7.4 Capabilities Counter

The ***CapsCounter*** is used to count the number of ***Source_Capabilities*** Messages which have been sent by a Source at power up or after a Hard Reset. Implementation of the ***CapsCounter*** is ***Optional*** but ***May*** be used by any Source which wishes to preserve power by not sending ***Source_Capabilities*** Messages after a period of time.

When the ***CapsCounter*** is implemented and the Source detects that a Sink is Attached then after ***nCapsCount*** ***Source_Capabilities*** Messages have been sent the Source ***Shall*** decide that the Sink is non-responsive, stop sending ***Source_Capabilities*** Messages and disable PD.

A Sink ***Shall*** use the ***SinkWaitCapTimer*** to trigger the resending of ***Source_Capabilities*** Messages by a USB Power Delivery capable Source which has previously stopped sending ***Source_Capabilities*** Messages. Any Sink which is Attached and does not detect a ***Source_Capabilities*** Message, ***Shall*** issue ***Hard Reset*** Signaling when the ***SinkWaitCapTimer*** times out in order to reset the Source. Resetting the Source ***Shall*** also reset the ***CapsCounter*** and restart the sending of ***Source_Capabilities*** Messages.

6.7.5 Discover Identity Counter

When sending ***Discover Identity*** Messages to a Cable Plug a Port ***Shall*** maintain a count of Messages sent (***DiscoverIdentityCounter***). No more than ***nDiscoverIdentityCount*** ***Discover Identity*** Messages ***Shall*** be sent by the Port receiving a ***GoodCRC*** Message response. A Data Role Swap ***Shall*** reset the ***DiscoverIdentityCounter*** to zero.

6.7.6 VDMBusyCounter

When sending Responder Busy responses to a Structured ***Vendor_Defined*** Message a UFP or Cable Plug ***Shall*** maintain a count of Messages sent (***VDMBusyCounter***). No more than ***nBusyCount*** Responder Busy responses ***Shall*** be sent. The ***VDMBusyCounter*** ***Shall*** be reset on sending a non-Busy response. Products wishing to meet ***[USB Type-C 1.2]*** requirements for Mode entry ***Should*** use an ***nBusyCount*** of 1.

6.7.7 Counter Values and Counters

Table 6-56 lists the counters used in this section and Table 6-55 shows the corresponding parameters.

Table 6-55 Counter parameters

Parameter	Value	Reference
nBusyCount	5	Section 6.7.6
nCapsCount	50	Section 6.7.4
nDiscoverIdentityCount	20	Section 6.7.5
nHardResetCount	2	Section 6.7.3
nMessageIDCount	7	Section 6.7.1
nRetryCount	2	Section 6.7.2

Table 6-56 Counters

Counter	Max	Reference
CapsCounter	*nCapsCount*	Section 6.7.4
DiscoverIdentityCounter	*nDiscoverIdentityCount*	Section 6.7.5
HardResetCounter	*nHardResetCount*	Section 6.7.3
MessageIDCounter	*nMessageIDCount*	Section 6.7.1
RetryCounter	*nRetryCount*	Section 6.7.2
VDMBusyCounter	*nBusyCount*	Section 6.7.6

6.8 Reset

Resets are a necessary response to protocol or other error conditions. USB Power Delivery defines two different types of reset; a Soft Reset, that resets protocol, and a Hard Reset which resets both the power supplies and protocol.

6.8.1 Soft Reset and Protocol Error

A ***Soft_Reset*** Message is used to cause a Soft Reset of protocol communication when this has broken down in some way. It ***Shall Not*** have any impact on power supply operation, but is used to correct a Protocol Error occurring during an Atomic Message Sequence (AMS). The Soft Reset ***May*** be triggered by either Port Partner in response to the Protocol Error.

Protocol Errors are any unexpected Message during an AMS. If the first Message in an AMS has been passed to the Protocol Layer by the Policy Engine but has not yet been sent (***GoodCRC*** Message not received) when the Protocol Error occurs, the Policy Engine ***Shall Not*** issue a Soft Reset but ***Shall*** return to the ***PE_SNK_Ready*** or ***PE_SRC_Ready*** state and then process the incoming Message. If the Protocol Error occurs during an Interruptible AMS then the Policy Engine ***Shall Not*** issue a Soft Reset but ***Shall*** return to the ***PE_SNK_Ready*** or ***PE_SRC_Ready*** state and then process the incoming Message. If the incoming Message is an Unexpected Message received in the ***PE_SNK_Ready*** or ***PE_SRC_Ready*** state the Policy Engine ***Shall*** issue a Soft Reset. If the Protocol Error occurs during a Non-interruptible AMS this ***Shall*** lead to a Soft Reset in order to re-synchronize the Policy Engine state machines (see Section 8.3.3.4) except when the voltage is transition when a Protocol Error ***Shall*** lead to a Hard Reset (see Section 6.6.10.4 and Section 8.3.3.2). Details of Interruptible and Non-interruptible AMS's can be found in Section 8.3.2.1.3.

An unrecognized or unsupported Message received in the ***PE_SNK_Ready*** or ***PE_SRC_Ready*** states, ***Shall Not*** cause a ***Soft_Reset*** Message to be generated but instead a ***Not_Supported*** Message ***Shall*** be generated.

A ***Soft_Reset*** Message ***Shall*** be sent regardless of the Rp value either ***SinkTxOk*** or ***SinkTxNG*** if it is the correct response in that state,

Table 6-57 and Table 6-58 summarize the responses that ***Shall*** be made to an incoming Message including VDMs.

Table 6-57 Response to an incoming Message (except VDM)

Recipient's Power Role	Recipient's state	Incoming Message			
		Recognized			Unrecognized
		Supported		Unsupported	
		Expected	Unexpected		
Source	***PE_SRC_Ready***	Process Message	***Soft_Reset*** Message	***Not_Supported*** Message	***Not_Supported*** Message (except for VDM) See 6.4.4.1 for UVDM, 6.12.4 for SVDM
	During Interruptible AMS	Process Message	return to ***PE_SRC_Ready*** state and process Message		
	During Non-interruptible AMS (not power transitioned)	Process Message	***Soft_Reset*** Message		
	During Non-interruptible AMS (power transitioned)	Process Message	***Hard Reset*** Signaling		
Sink	***PE_SNK_Ready***	Process Message	***Soft_Reset*** Message	***Not_Supported*** Message	***Not_Supported*** Message (except for VDM) See 6.4.4.1 for UVDM, 6.12.4 for SVDM
	During Interruptible AMS	Process Message	return to ***PE_SNK_Ready*** state and process Message		
	During Non-interruptible AMS (not power transitioned)	Process Message	***Soft_Reset*** Message		
	During Non-interruptible AMS (power transitioned)	Process Message	***Hard Reset*** Signaling		

Table 6-58 Response to an incoming VDM

Recipient's Role	Supported UVDM	Unsupported UVDM	Unrecognized UVDM	Supported SVDM	Unsupported SVDM	Unrecognized SVDM
DFP or UFP	Defined by vendor	***Not_Supported*** Message	***Not_Supported*** Message	See 6.12.4	***Not_Supported*** Message	NAK Command
Cable Plug	Defined by vendor	Message ***Ignored***	Message ***Ignored***	See 6.12.4	Message ***Ignored***	NAK Command

A failure to see a ***GoodCRC*** Message in response to any Message within ***tReceive*** (after ***nRetryCount*** retries), when a Port Pair is Connected, is indicative of a communications failure resulting in a Soft Reset (see Section 6.6.9.1).

A Soft Reset ***Shall*** impact the USB Power Delivery layers in the following ways:

- Physical Layer: Reset not required since the Physical Layer resets on each packet transmission/reception.

- Protocol Layer: Reset ***MessageIDCounter***, ***RetryCounter*** and state machines.
- Policy Engine: Reset state dependent behavior by performing an Explicit Contract negotiation.
- Power supply: ***Shall Not*** change.

A Soft Reset is performed using a sequence of protocol Messages (see Table 8-7). Message numbers ***Shall*** be set to zero prior to sending the ***Soft_Reset***/***Accept*** Message since the issue might be with the counters. The sender of a ***Soft_Reset*** Message ***Shall*** reset its ***MessageIDCounter*** and ***RetryCounter***, the receiver of the Message ***Shall*** reset its ***MessageIDCounter*** and ***RetryCounter*** before sending the ***Accept*** Message response. Any failure in the Soft Reset process will trigger a Hard Reset when SOP Packets are being used or Cable Reset for any other SOP* Packets; for example a ***GoodCRC*** Message is not received during the Soft Reset process (see Section 6.8.2 and Section 6.8.3).

6.8.2 Hard Reset

Hard Resets are signaled by an ordered set as defined in Section 5.6.4. Both the sender and recipient ***Shall*** cause their power supplies to return to their default states (see Section 7.3.12 and Section 7.3.13 for details of voltage transitions). In addition their respective Protocol Layers ***Shall*** be reset as for the Soft Reset. This allows the Attached devices to be in a state where they can re-establish USB PD communication. Hard Reset is retried up to ***nHardResetCount*** times (see also Section 6.6.6 and Section 6.7.3). Note: that even though V_{BUS} drops to ***vSafe0V*** during a Hard Reset a Sink will not see this as a disconnect since this is expected behavior.

A Hard Reset ***Shall Not*** cause any change to either the Rp/Rd resistor being asserted.

If there has been a Data Role Swap the Hard Reset ***Shall*** cause the Port Data Role to be changed back to DFP for a Port with the Rp resistor asserted and UFP for a Port with the Rd resistor asserted.

When VCONN is supported (see ***[USB Type-C 1.2]***) the Hard Reset ***Shall*** cause the Port with the Rp resistor asserted to supply VCONN and the Port with the Rd resistor asserted to turn off VCONN.

In effect the Hard Reset will revert the Ports to their default state based on their CC line resistors. Removing and reapplying VCONN from the Cable Plugs also ensures that they re-establish their configuration as either SOP' or SOP'' based on the location of VCONN (see ***[USB Type-C 1.2]***).

If the Hard Reset is insufficient to clear the error condition then the Port ***Should*** use Error Recovery mechanisms as defined in ***[USB Type-C 1.2]***.

A Sink ***Shall*** be able to send ***Hard Reset*** signaling regardless of the value of Rp (see Section 5.7).

6.8.2.1 Cable Plugs and Hard Reset

Cable Plugs ***Shall Not*** generate ***Hard Reset*** Signaling but ***Shall*** monitor for ***Hard Reset*** Signaling between the Port Partners and ***Shall*** reset when this is detected (see Section 8.3.3.22.2.2). The Cable Plugs ***Shall*** perform the equivalent of a power cycle returning to their initial power up state. This allows the Attached products to be in a state where they can re-establish USB PD communication.

6.8.2.2 Modal Operation and Hard Reset

A Hard Reset ***Shall*** cause all Active Modes to be exited by both Port Partners and any Cable Plugs (see Section 6.4.4.3.4).

6.8.3 Cable Reset

Cable Resets are signaled by an ordered set as defined in Section 5.6.5. Both the sender and recipient of ***Cable Reset*** Signaling ***Shall*** reset their respective Protocol Layers. The Cable Plugs ***Shall*** perform the equivalent of a power cycle returning to their initial power up state. This allows the Attached products to be in a state where they can re-establish USB PD communication.

The DFP has to be supplying VCONN prior to a Cable Reset to ensure that the Cable Plugs correctly configure SOP' and SOP'' after the Cable Reset is complete. If VCONN has been turned off the DFP ***Shall*** turn on VCONN prior to generating

Cable Reset Signaling. If there has been a VCONN Swap and the UFP is currently supplying VCONN, the DFP ***Shall*** perform a VCONN Swap such that it is supplying VCONN prior to generating ***Cable Reset*** Signaling.

Only a DFP ***Shall*** generate ***Cable Reset*** Signaling. A DFP ***Shall*** only generate ***Cable Reset*** Signaling within an Explicit Contract.

A Cable Reset ***Shall*** cause all Active Modes in the Cable Plugs to be exited (see Section 6.4.4.3.4).

6.9 Collision Avoidance

In order to avoid message collisions due to asynchronous Messaging sent from the Sink, the Source sets Rp to ***SinkTxOk*** to indicate to the Sink that it is ok to initiate an AMS. When the Source wishes to initiate an AMS it sets Rp to ***SinkTxNG***. When the Sink detects that Rp is set to ***SinkTxOk*** it ***May*** initiate an AMS. When the Sink detects that Rp is set to ***SinkTxNG*** it ***Shall Not*** initiate an AMS and ***Shall*** only send Messages that are part of an AMS the Source has initiated. Note that this restriction applies to SOP* AMS's i.e. for both Port to Port and Port to Cable Plug communications.

Note: a Sink can still send ***Hard Reset*** signaling at any time.

6.10 Message Discarding

On receiving a received Message on SOP, the Protocol Layer ***Shall Discard*** any pending SOP* Messages. A received Message on SOP'/SOP'' ***Shall Not*** cause any pending SOP* Messages to be ***Discarded***.

It is assumed that Messages using SOP'/SOP'' constitute a simple request/response AMS, with the Cable Plug providing the response so there is no reason for a pending SOP* Message to be ***Discarded***. There can only be one AMS between the Port Partners and these also take priority over Cable Plug communications so a Message received on SOP will always cause a Message pending on SOP* to be ***Discarded***.

See Table 6-59 for details of the Messages that ***Shall***/ ***Shall Not*** be ***Discarded***.

Table 6-59 Message discarding

Message pending transmission	Message received	Discard pending transmission?
SOP	SOP	Yes
SOP	SOP'/SOP''	No
SOP'	SOP	Yes
SOP'	SOP'	No
SOP'	SOP''	No
SOP''	SOP	Yes
SOP''	SOP'	No
SOP''	SOP''	No

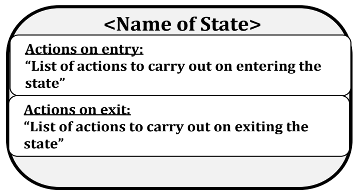
6.11 State behavior

6.11.1 Introduction to state diagrams used in Chapter 6

The state diagrams defined in Section 6.11 are ***Normative*** and ***Shall*** define the operation of the Power Delivery protocol layer. Note that these state diagrams are not intended to replace a well written and robust design.

Figure 6-44 shows an outline of the states defined in the following sections. At the top there is the name of the state. This is followed by "Actions on entry" a list of actions carried out on entering the state and in some states "Actions on exit" a list of actions carried out on exiting the state.

Figure 6-44 Outline of States

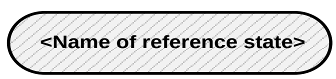


Transitions from one state to another are indicated by arrows with the conditions listed on the arrow. Where there are multiple conditions these are connected using either a logical OR "|" or a logical AND "&". The inverse of a condition is shown with a "NOT" in front of the condition.

In some cases there are transitions which can occur from any state to a particular state. These are indicated by an arrow which is unconnected to a state at one end, but with the other end (the point) connected to the final state.

In some state diagrams it is necessary to enter or exit from states in other diagrams. Figure 6-45 indicates how such references are made. The reference is indicated with a hatched box. The box contains the name of the referenced state.

Figure 6-45 References to states



Timers are included in many of the states. Timers are initialized (set to their starting condition) and run (timer is counting) in the particular state it is referenced. As soon as the state is exited then the timer is no longer active. Timeouts of the timers are listed as conditions on state transitions.

Conditions listed on state transitions will come from one of three sources:

- Messages received from the PHY Layer
- Events triggered within the Protocol Layer e.g. timer timeouts
- Message and related indications passed up to the Policy Engine from the Protocol Layer (Message sent, Message received etc.)

6.11.2 State Operation

The following section details Protocol Layer State Operation when sending and receiving SOP* Packets.

For each SOP* Communication being sent and received there ***Shall*** be separate Protocol Layer Transmission and Protocol Layer Reception and Hard Reset State Machine instances, with their own counter and timer instances. When Chunking is supported there ***Shall*** be separate Chunked Tx, Chunked Tx and Chunked Message Router State Machine instances.

Soft Reset ***Shall*** only apply to the State Machine instances it is targeted at based on the type of SOP* Packet used to send the ***Soft_Reset*** Message. The Hard Reset State Machine (including Cable Reset) ***Shall*** apply simultaneously to all Protocol Layer State Machine instances active in the DFP, UFP and Cable Plug (if present).

6.11.2.1 Protocol Layer Chunking

6.11.2.1.1 Architecture of Device Including Chunking Layer

The Chunking component resides in the Protocol Layer between the Policy Engine and Protocol Tx/Rx. Figure 6-46 illustrates the relationship between components.

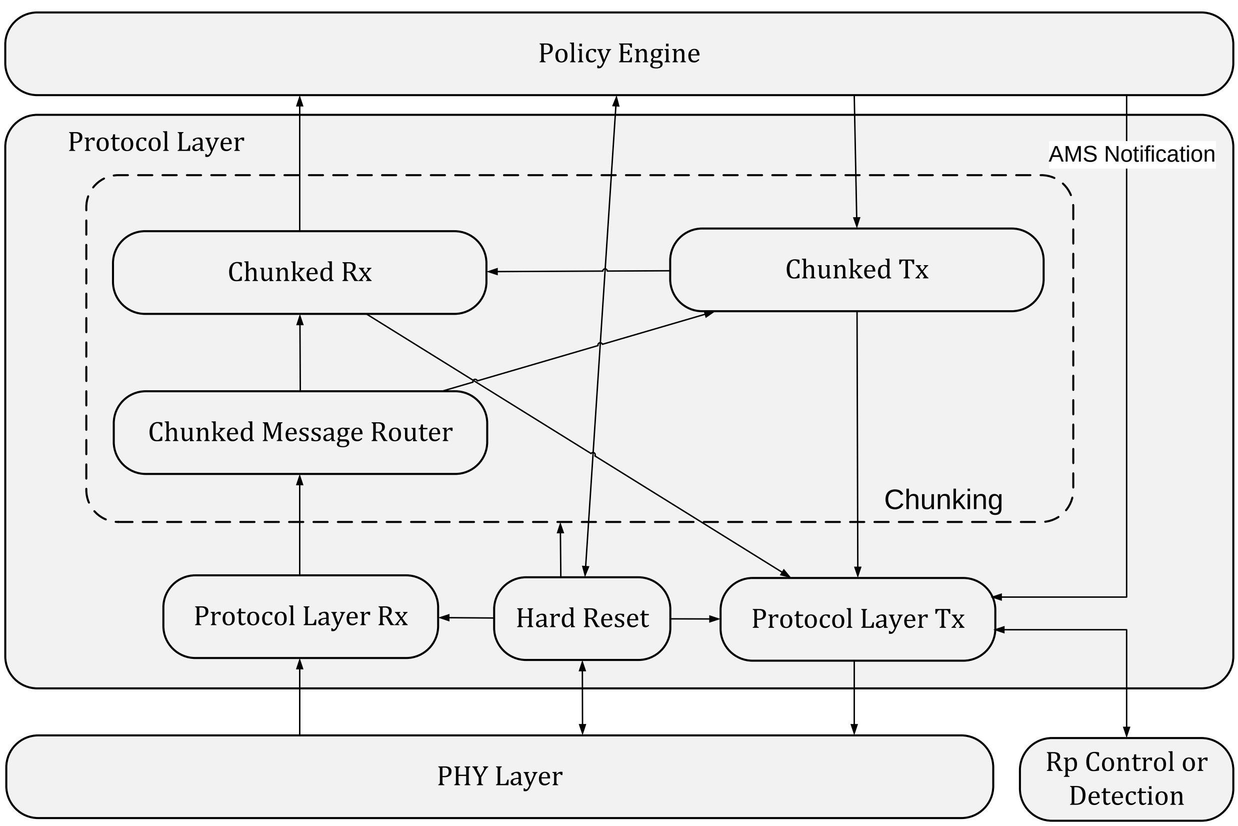
The Chunking Layer comprises three related state machines:

- Chunked Rx.
- Chunked Tx.
- Chunked Message Router.

Note that the consequence of this architecture is that the Policy Engine deals entirely in un-chunked messages. It will not receive (and might not respond to) a message until all the related chunks have been collated.

If a PD Device or Cable Marker has no requirement to handle any message requiring more than one Chunk of any Extended Message, it ***May*** omit the Chunking Layer. In this case it ***Shall*** implement the ***ChunkingNotSupportedTimer*** to ensure compatible operation with partners which support Chunking (see Section 6.6.17.1 and Section 8.3.3.5).

Figure 6-46 Chunking architecture Showing Message and Control Flow



6.11.2.1.1.1 Optional Abort Mechanism

Long Chunked Messages bring with them the potential problem that they could prevent urgent messages from being transmitted in a timely manner. An optional Abort mechanism is provided to remedy this problem.

The Abort Flag referred to in the diagrams below ***May*** be set and examined by the Policy Engine. The specific means are left to the implementer.

6.11.2.1.1.2 Aborting Sending a Long Chunked Message

A long Chunked Message being sent ***May*** be aborted by setting the ***Optional*** Abort Flag. The message ***Shall*** be considered aborted when the Abort Flag is again cleared by the Chunked Tx state machine.

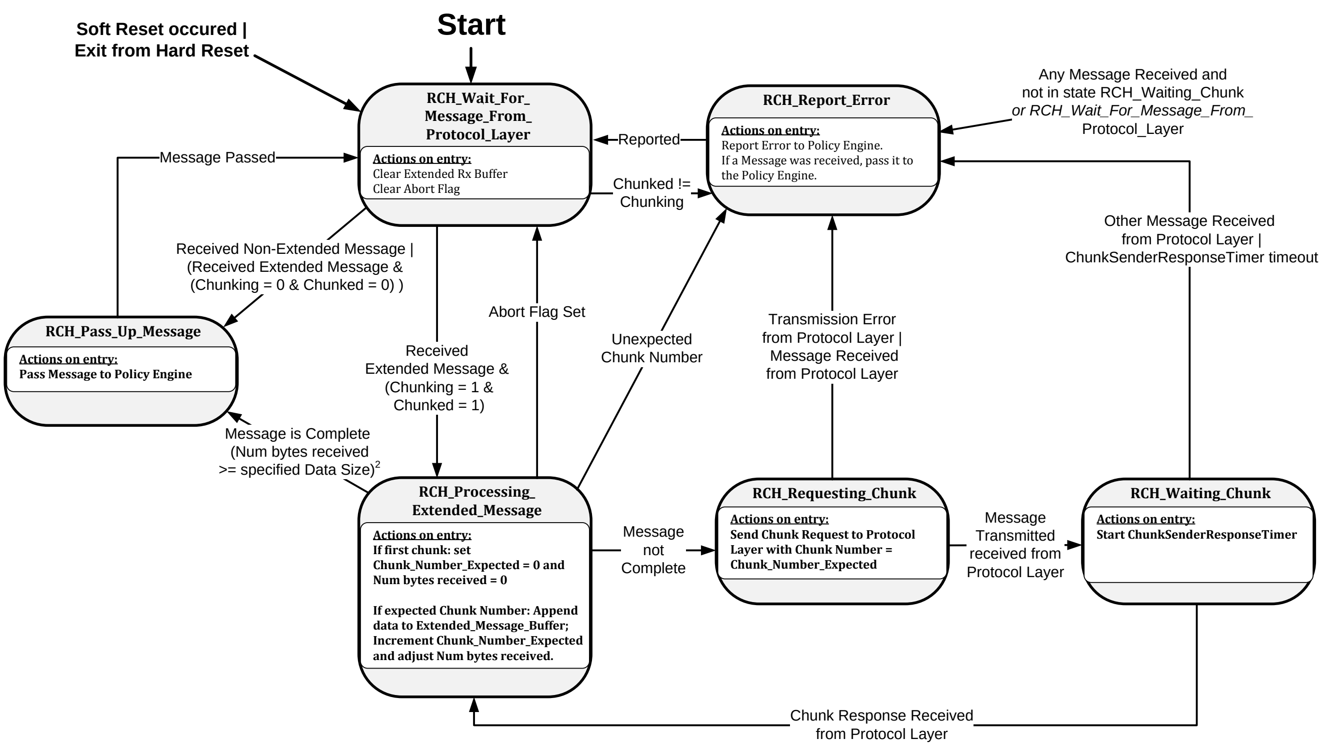
6.11.2.1.1.3 Aborting Receiving a Long Chunked Message

If the optional Abort mechanism has been implemented, any message sent while a Chunked Message receive is in progress will result in an error report being received by the Policy Engine, to indicate that the message request has been ***Discarded***. If the message was urgent the Policy Engine might set the Abort Flag, which will result in the incoming Chunked Message being aborted. The Abort Flag being cleared by the Chunked Rx state machine indicates that the urgent message can now be sent.

6.11.2.1.2 Chunked Rx State Diagram

Figure 6-47 shows the state behavior for the Chunked Rx State Machine. This recognizes whether chunked received messages are involved, and deals with requesting chunks when they are. It also performs validity checks on all messages related to chunking.

Figure 6-47 Chunked Rx State Diagram



[1] Chunking is an internal state that is set to 1 if the 'Unchunked Extended Messages Supported' bit in either Source Capabilities or Request is 0. It defaults to 1 and is set after the first exchange of Source Capabilities and Request. It is also set to 1 for ***SOP'*** or ***SOP''*** communication.

[2] Additional bytes received over specified ***Data Size*** will be as a result of padding in the last chunk.

6.11.2.1.2.1 RCH_Wait_For_Message_From_Protocol_Layer State

The Chunked Rx State Machine ***Shall*** enter the ***RCH_Wait_For_Message_From_Protocol_Layer*** state:

- At startup.
- As a result of a Soft Reset occurring.
- On exit from a Hard Reset.

On entry to the ***RCH_Wait_For_Message_From_Protocol_Layer*** state the Chunked Rx state machine clears the Extended Rx Buffer, and clears the optional Abort Flag.

In the ***RCH_Wait_For_Message_From_Protocol_Layer*** state the Chunked Rx state machine waits until the Chunked Message Router passes up a received message.

The Chunked Rx State Machine ***Shall*** transition to the ***RCH_Pass_Up_Message*** state when:

- A non-Extended Message is passed up from the Chunked Message Router.
- An Extended Message is passed up from the Chunked Message Router, and the Policy Engine has determined that we are not doing Chunking, and the Message has its ***Chunked*** bit set to 0b.

The Chunked Rx State Machine ***Shall*** transition to the ***RCH_Processing_Extended_Message*** state when:

- An Extended Message is passed up from the Chunked Message Router, and the Policy Engine has determined that we are doing Chunking, and the Message has its ***Chunked*** bit set to 1b.

6.11.2.1.2.2 RCH_Pass_Up_Message State

On entry to the ***RCH_Pass_Up_Message*** state the Chunked Rx state machine ***Shall*** pass the received message to the Policy Engine.

The Chunked Rx State Machine ***Shall*** transition to the ***RCH_Wait_For_Message_From_Protocol_Layer*** state when:

- The Message has been passed.

6.11.2.1.2.3 RCH_Processing_Extended_Message State

On entry to the ***RCH_Processing_Extended_Message*** state the Chunked Rx state machine ***Shall***:

- If this is the first chunk:
  - Set Chunk_Number_Expected = 0.
  - Set Num bytes received = 0.
- If chunk contains the expected Chunk Number:
  - Append its data to the Extended_Message_Buffer.
  - Increment Chunk_Number_Expected.
  - Adjust Num bytes received.

The Chunked Rx State Machine ***Shall*** transition to the ***RCH_Pass_Up_Message*** state when:

- The message is complete (i.e. Num bytes received >= specified ***Data Size***. Note that the inequality allows for padding bytes in the last chunk, which are not actually part of the extended message).

The Chunked Rx State Machine ***Shall*** transition to the ***RCH_Requesting_Chunk*** state when:

- The Message is not yet complete.

The Chunked Rx State Machine ***Shall*** transition to the ***RCH_Report_Error*** state when:

- An unexpected Chunk Number is received.

The Chunked Rx State Machine ***Shall*** transition to the ***RCH_Wait_For_Message_From_Protocol_Layer*** state when:

- The optional Abort Flag is set.

6.11.2.1.2.4 RCH_Requesting_Chunk State

On entry to the ***RCH_Requesting_Chunk*** state the Chunked Rx state machine ***Shall***:

- Send Chunk Request to Protocol Layer with ***Chunk Number*** = Chunk_Number_Expected.

The Chunked Rx State Machine ***Shall*** transition to the ***RCH_Waiting_Chunk*** state when:

- Message Transmitted is received from the Protocol Layer.

The Chunked Rx State Machine ***Shall*** transition to the ***RCH_Report_Error*** state when:

- Transmission Error is received from the Protocol Layer, or
- A Message is received from the Protocol Layer.

6.11.2.1.2.5 RCH_Waiting_Chunk State

On entry to the ***RCH_Waiting_Chunk*** state the Chunked Rx state machine ***Shall***:

- Start the ***ChunkSenderResponseTimer.***

The Chunked Rx State Machine ***Shall*** transition to the ***RCH_Processing_Extended_Message*** state when:

- A Chunk is received from the Protocol Layer.

The Chunked Rx State Machine ***Shall*** transition to the ***RCH_Report_Error*** state when:

- A Message, other than a Chunk, is received from the Protocol Layer, or
- The ***ChunkSenderResponseTimer*** expires.

6.11.2.1.2.6 RCH_Report_Error State

The Chunked Rx State Machine ***Shall*** enter the ***RCH_Report_Error*** state:

- When any Message is received and the Chunked Rx State Machine is not in one of the states ***RCH_Waiting_Chunk*** or ***RCH_Wait_For_Message_From_Protocol_Layer.***

On entry to the ***RCH_Report_Error*** state the Chunked Rx state machine ***Shall***:

- Report the error to the Policy Engine.
- If the state was entered because a Message was received, this Message ***Shall*** be passed to the Policy Engine.

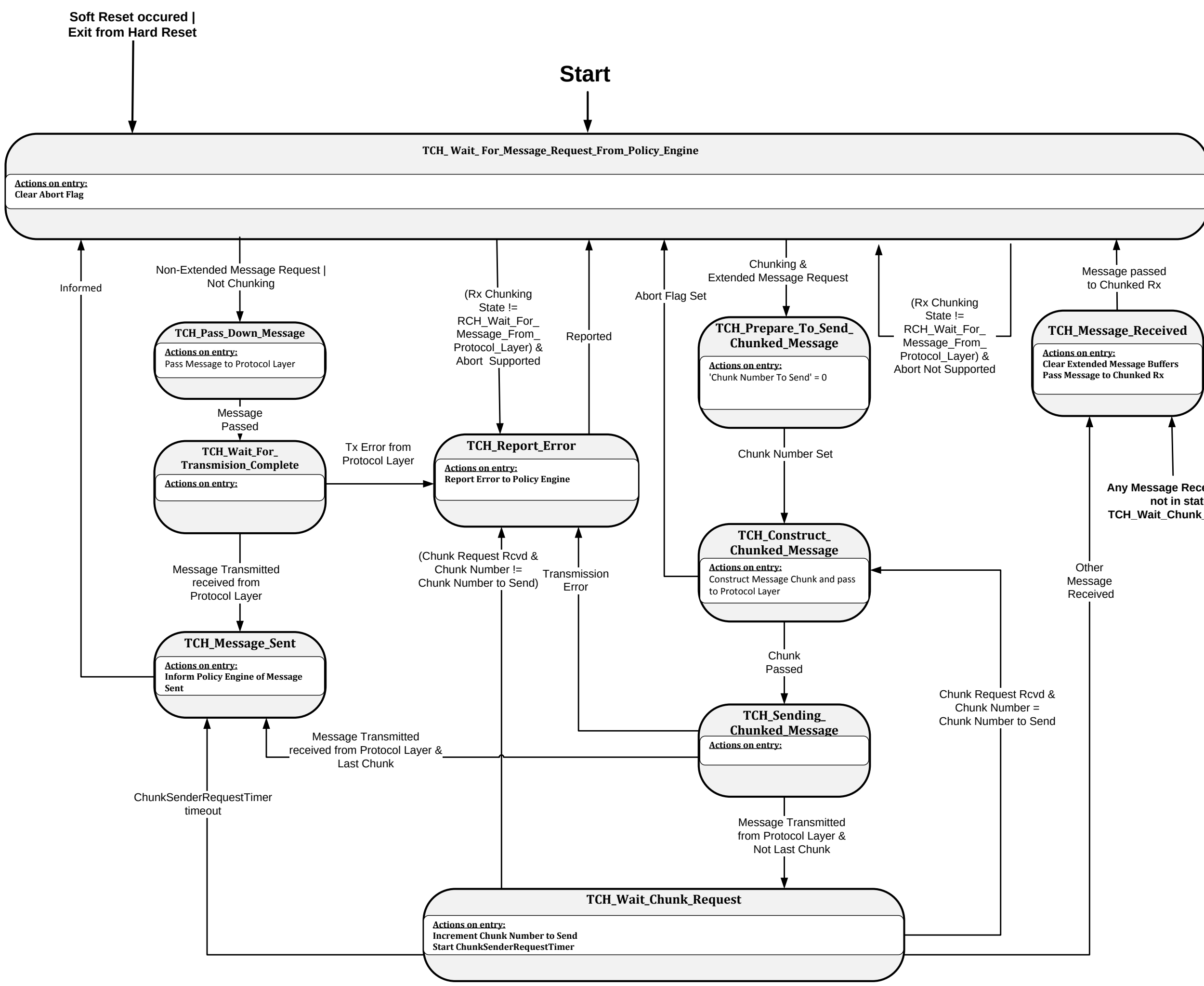
The Chunked Rx State Machine ***Shall*** transition to the ***RCH_Wait_For_Message_From_Protocol_Layer*** state when:

- The error has been reported.
- Any message received was passed to the Policy Engine.

6.11.2.1.3 Chunked Tx State Diagram

Figure 6-48 shows the state behavior for the Chunked Tx State Machine. This recognizes whether chunked transmitted messages are involved, and deals with sending chunks and waiting for chunk requests when they are. It also performs validity checks on all related messages related to chunking.

Figure 6-48 Chunked Tx State Diagram



6.11.2.1.3.1 TCH_Wait_For_Message_Request_From_Policy_Engine State

The Chunked Tx State Machine ***Shall*** enter the ***TCH_Wait_For_Message_Request_From_Policy_Engine*** state:

- At startup.
- As a result of a Soft Reset occurring.
- On exit from a Hard Reset.

On entry to the ***TCH_Wait_For_Message_Request_From_Policy_Engine*** state the Chunked Tx state machine clears the optional Abort Flag.

In the ***TCH_Wait_For_Message_Request_From_Policy_Engine*** state the Chunked Tx State Machine waits until the Policy Engine sends it a Message Request.

The Chunked Tx State Machine ***Shall*** transition to the ***TCH_Pass_Down_Message*** state when:

- A non-Extended Message Request is received from the Policy Engine, or
- A Message Request is received from the Policy Engine and the link is not Chunking.

The Chunked Tx State Machine ***Shall*** transition to the ***TCH_Prepare_To_Send_Chunked_Message*** state when:

- An Extended Message Request is received from the Policy Engine, and the link is Chunking.

The Chunked Tx State Machine ***Shall Discard*** the Message Request and remain in the ***TCH_Wait_For_Message_Request_From_Policy_Engine*** state when:

- The Chunked Rx state is any other than ***TCH_Wait_For_Message_Request_From_Policy_Engine***, and the optional Abort Flag has not been implemented.

The Chunked Tx State Machine ***Shall Discard*** the Message Request and enter the ***TCH_Report_Error*** state when:

- The Chunked Rx state is any other than ***TCH_Wait_For_Message_Request_From_Policy_Engine***, and the optional Abort Flag has been implemented.

6.11.2.1.3.2 TCH_Pass_Down_Message State

On entry to the ***TCH_Pass_Down_Message*** state the Chunked Tx State Machine ***Shall*** pass the message to the Protocol Layer.

The Chunked Tx State Machine ***Shall*** transition to the ***TCH_Wait_For_Transmision_Complete*** state when:

- The message has been passed to the Protocol Layer.

6.11.2.1.3.3 TCH_Wait_For_Transmision_Complete State

The Chunked Tx State Machine ***Shall*** transition to the ***TCH_Message_Sent*** state when:

- Message Transmitted has been received from the Protocol Layer.

The Chunked Tx State Machine ***Shall*** transition to the ***TCH_Report_Error*** state when:

- Transmission Error has been received from the Protocol Layer.

6.11.2.1.3.4 TCH_Message_Sent State

On entry to the ***TCH_Message_Sent*** state the Chunked Tx State Machine ***Shall***:

- Inform the Policy Engine that the Message has been sent.

The Chunked Tx State Machine ***Shall*** transition to the ***TCH_Wait_For_Message_Request_From_Policy_Engine*** state when:

- The Policy Engine has been informed.

6.11.2.1.3.5 TCH_Prepare_To_Send_Chunked_Message State

On entry to the ***TCH_Prepare_To_Send_Chunked_Message*** state the Chunked Tx State Machine ***Shall***:

- Set 'Chunk Number To Send' to zero.

The Chunked Tx State Machine ***Shall*** transition to the ***TCH_Construct_Chunked_Message*** state when:

- 'Chunk Number To Send' has been set to zero.

6.11.2.1.3.6 TCH_Construct_Chunked_Message State

On entry to the ***TCH_Construct_Chunked_Message*** state the Chunked Tx State Machine ***Shall***:

- Construct a Message Chunk and pass it to the Protocol Layer.

The Chunked Tx State Machine ***Shall*** transition to the ***TCH_Sending_Chunked_Message*** state when:

- The Message Chunk has been passed to the Protocol Layer.

The Chunked Tx State Machine ***Shall*** transition to the ***TCH_Wait_For_Message_Request_From_Policy_Engine*** state when:

- The optional Abort Flag is set.

6.11.2.1.3.7 TCH_Sending_Chunked_Message State

The Chunked Tx State Machine ***Shall*** transition to the ***TCH_Wait_Chunk_Request*** state when:

- Message Transmitted is received from Protocol Layer and this was not the last chunk.

The Chunked Tx State Machine ***Shall*** transition to the ***TCH_Message_Sent*** state when:

- Message Transmitted is received from Protocol Layer and this was the last chunk.

The Chunked Tx State Machine ***Shall*** transition to the ***TCH_Report_Error*** state when:

- Transmission Error has been received from the Protocol Layer.

6.11.2.1.3.8 TCH_Wait_Chunk_Request State

On entry to the ***TCH_Wait_Chunk_Request*** state the Chunked Tx State Machine ***Shall***:

- Increment Chunk Number to Send.
- Start ***ChunkSenderRequestTimer.***

The Chunked Tx State Machine ***Shall*** transition to the ***TCH_Report_Error*** state when:

- A Chunk Request has been received and the Chunk Number does not equal Chunk Number to Send).

The Chunked Tx State Machine ***Shall*** transition to the ***TCH_Message_Sent*** state when:

- ***ChunkSenderRequestTimer*** has expired.

Note that this is the mechanism which allows the remote port partner or cable marker to omit the chunking layer. The Policy Engine will receive a Message Sent signal if the remote port partner or cable marker is present (***GoodCRC*** Message received) but does not sent a Chunk Request. After this the remote port partner will send a ***Not_Supported*** Message, or the Cable Marker will ***Ignore*** the Chunked Message.

The Chunked Tx State Machine ***Shall*** transition to the ***TCH_Message_Received*** state when:

- Any other message than Chunk Request is received.

6.11.2.1.3.9 TCH_Message_Received State

The Chunked Tx State Machine ***Shall*** enter the ***TCH_Message_Received*** state:

- When any Message is received and the Chunked Tx State Machine is not in the ***TCH_Wait_Chunk_Request*** state.

On entry to the ***TCH_Message_Received*** state the Chunked Tx State Machine ***Shall***:

- Clear the Extended Message Buffers.
- Pass the received Message to Chunked Rx Engine.

The Chunked Tx State Machine ***Shall*** transition to the ***TCH_Wait_For_Message_Request_From_Policy_Engine*** state when:

- The received message has been passed to the Chunked Rx Engine.

6.11.2.1.3.10 TCH_Report_Error State

On entry to the ***TCH_Report_Error*** state the Chunked Tx State Machine ***Shall***:

- Report the error to the Policy Engine.

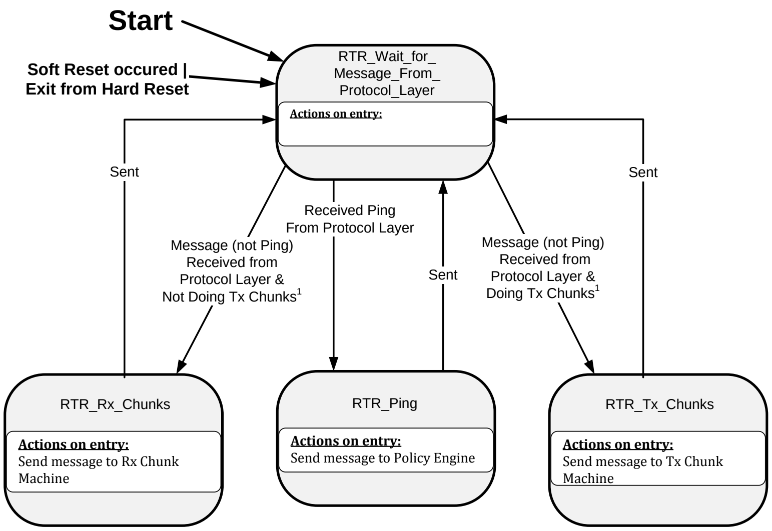
The Chunked Tx State Machine ***Shall*** transition to the ***TCH_Wait_For_Message_Request_From_Policy_Engine*** state when:

- The error has been reported.

6.11.2.1.4 Chunked Message Router State Diagram

Figure 6-49 shows the state behavior for the Chunked Message Router. This determines to which state machine an incoming message is routed to (Chunked Rx, Chunked Tx or direct to Policy Engine).

Figure 6-49 Chunked Message Router State Diagram



[1] Doing Tx Chunks means that Chunked Tx State Machine is not in the ***TCH_Wait_For_Message_Request_From_Policy_Engine*** state

[2] Messages are taken to include notification about transmission success or otherwise of Messages

6.11.2.1.4.1 RTR_Wait_for_Message_From_Protocol_Layer State

In the ***RTR_Wait_for_Message_From_Protocol_Layer*** state the Chunked Message Router waits until the Protocol Layer sends it a received Message.

The Chunked Message Router ***Shall*** transition to the ***RTR_Rx_Chunks*** state when:

- A Message other than a ***Ping*** Message is received from the Protocol Layer, and the combined Chunking is not doing Tx Chunks.

The Chunked Message Router ***Shall*** transition to the ***RTR_Tx_Chunks*** state when:

- A Message other than a ***Ping*** Message is received from the Protocol Layer, and the combined Chunking is doing Tx Chunks.

The Chunked Message Router ***Shall*** transition to the ***RTR_Ping*** state when:

- A ***Ping*** Message is received from the Protocol Layer.

6.11.2.1.4.2 RTR_Rx_Chunks State

On entry to the ***RTR_Rx_Chunks*** state the Chunked Message Router ***Shall***:

- Send the message to the Chunked Rx State Machine.
- Transition to the ***RTR_Wait_for_Message_From_Protocol_Layer*** state.

6.11.2.1.4.3 RTR_Ping State

On entry to the ***RTR_Ping*** state the Chunked Message Router ***Shall***:

- Send the message to the Policy Engine.
- Transition to the ***RTR_Wait_for_Message_From_Protocol_Layer*** state.

6.11.2.1.4.4 RTR_Tx_Chunks State

On entry to the ***RTR_Tx_Chunks*** state the Chunked Message Router ***Shall***:

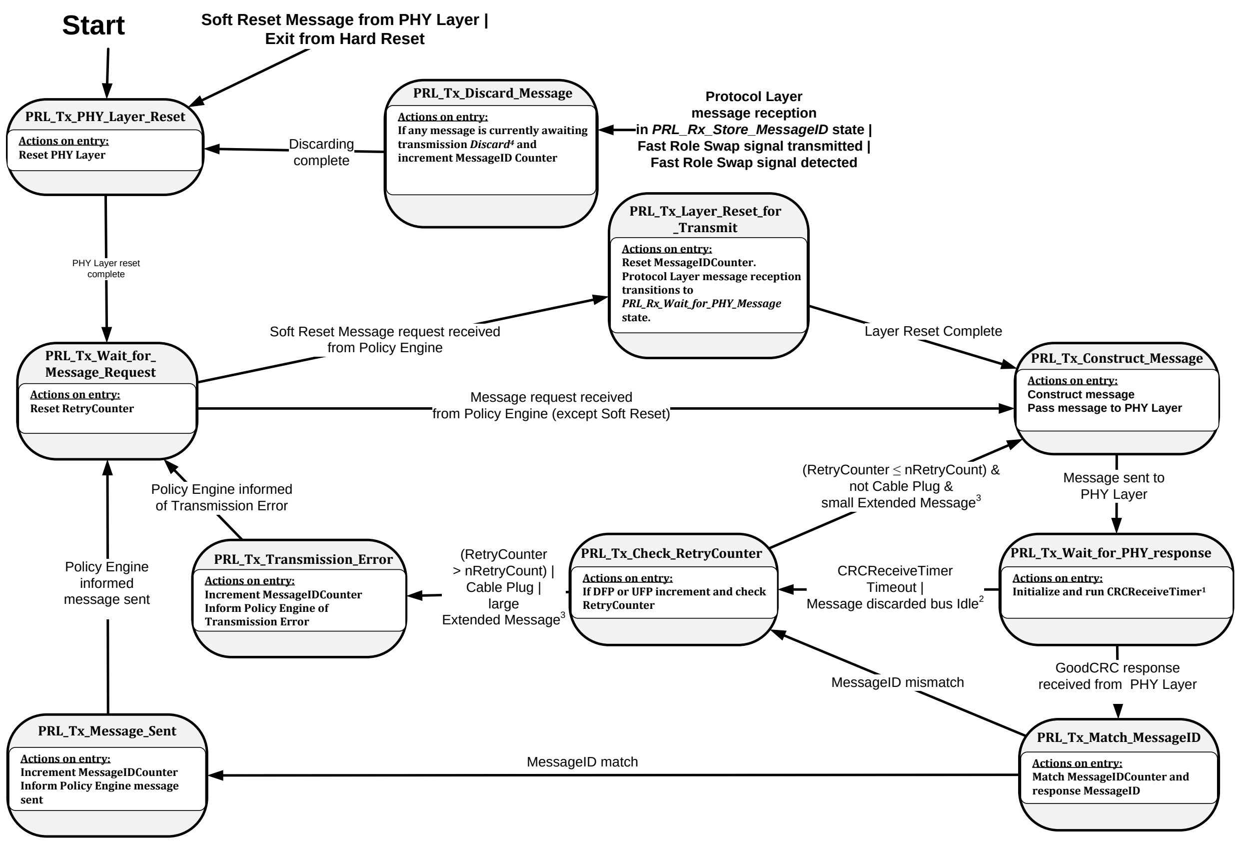
- Send the message to the Chunked Tx State Machine.
- Transition to the ***RTR_Wait_for_Message_From_Protocol_Layer*** state.

6.11.2.2 Protocol Layer Message Transmission

6.11.2.2.1 Common Protocol Layer Message Transmission State Diagram

Figure 6-50 shows the state behavior, common between the Source and the Sink, for the Protocol Layer when transmitting a Message.

Figure 6-50 Common Protocol Layer Message transmission State Diagram



[1] The ***CRCReceiveTimer*** is only started after the PHY has sent the message. If the message is not sent due to a busy channel then the ***CRCReceiveTimer*** will not be started (see Section 6.6.1).

[2] This indication is sent by the PHY Layer when a message has been ***Discarded*** due to CC being busy, and after CC becomes idle again (see Section 5.7). The ***CRCReceiveTimer*** is not running in this case since no message has been sent.

[3] A "small" Extended Message is either an Extended Message with ***Data Size*** ≤ ***MaxExtendedMsgLegacyLen*** bytes or an Extended Message with ***Data Size*** > ***MaxExtendedMsgLegacyLen*** bytes that has been Chunked. A "large" Extended Message is an Extended Message with ***Data Size*** > ***MaxExtendedMsgLegacyLen*** bytes that has not been Chunked.

[4] See Section 6.10 for details of when Messages are ***Discarded***.

6.11.2.2.1.1 PRL_Tx_PHY_Layer_Reset State

The Protocol Layer ***Shall*** enter the ***PRL_Tx_PHY_Layer_Reset*** state:

- At startup.
- As a result of a Soft Reset request being received by the PHY Layer.

- On exit from a Hard Reset.

On entry to the ***PRL_Tx_PHY_Layer_Reset*** state the Protocol Layer ***Shall*** reset the PHY Layer (clear any outstanding Messages and enable communications).

The Protocol Layer ***Shall*** transition to the ***PRL_Tx_Wait_for_Message_Request*** state when:

- When the PHY Layer reset is complete.

6.11.2.2.1.2 PRL_Tx_Wait_for_Message_Request State

In the ***PRL_Tx_Wait_for_Message_Request*** state the Protocol Layer waits until the Policy Engine directs it to send a Message.

On entry to the ***PRL_Tx_Wait_for_Message_Request*** state the Protocol Layer ***Shall*** reset the ***RetryCounter***.

The Protocol Layer ***Shall*** transition to the ***PRL_Tx_Construct_Message*** state when:

- A Message request is received from the Policy Engine which is not a ***Soft_Reset*** Message.

The Protocol Layer ***Shall*** transition to the ***PRL_Tx_Layer_Reset_for_Transmit*** state when:

- A Message request is received from the Policy Engine which is a ***Soft_Reset*** Message.

6.11.2.2.1.3 PRL_Tx_Layer_Reset_for_Transmit State

On entry to the ***PRL_Tx_Layer_Reset_for_Transmit*** state the Protocol Layer ***Shall*** reset the ***MessageIDCounter***. The Protocol Layer ***Shall*** transition Protocol Layer Message reception to the ***PRL_Rx_Wait_for_PHY_Message*** state (see Section 6.11.2.3.1) in order to reset the stored ***MessageID***.

The Protocol Layer ***Shall*** transition to the ***PRL_Tx_Construct_Message*** state when:

- The layer reset actions in this state have been completed.

6.11.2.2.1.4 PRL_Tx_Construct_Message State

On entry to the ***PRL_Tx_Construct_Message*** state the Protocol Layer ***Shall*** construct the Message requested by the Policy Engine, or resend a previously constructed Message, and then pass this Message to the PHY Layer.

The Protocol Layer ***Shall*** transition to the ***PRL_Tx_Wait_for_PHY_Response*** state when:

- The Message has been sent to the PHY Layer.

6.11.2.2.1.5 PRL_Tx_Wait_for_PHY_Response State

On entry to the ***PRL_Tx_Wait_for_PHY_Response*** state, once the Message has been sent, the Protocol Layer ***Shall*** initialize and run the ***CRCReceiveTimer*** (see Section 6.6.1).

The Protocol Layer ***Shall*** transition to the ***PRL_Tx_Match_MessageID*** state when:

- A ***GoodCRC*** Message response is received from the PHY Layer.

The Protocol Layer ***Shall*** transition to the ***PRL_Tx_Check_RetryCounter*** state when:

- The ***CRCReceiveTimer*** times out.
- Or the PHY Layer indicates that a Message has been ***Discarded*** due to the channel being busy but the channel is now idle (see Section 5.7).

6.11.2.2.1.6 PRL_Tx_Match_MessageID State

On entry to the ***PRL_Tx_Match_MessageID*** state the Protocol Layer ***Shall*** compare the ***MessageIDCounter*** and the ***MessageID*** of the received ***GoodCRC*** Message.

The Protocol Layer ***Shall*** transition to the ***PRL_Tx_Message_Sent*** state when:

- The MessageIDCounter and the ***MessageID*** of the received ***GoodCRC*** Message match.

The Protocol Layer ***Shall*** transition to the ***PRL_Tx_Check_RetryCounter*** state when:

- The MessageIDCounter and the ***MessageID*** of the received ***GoodCRC*** Message do not match.

6.11.2.2.1.7 PRL_Tx_Message_Sent State

On entry to the ***PRL_Tx_Message_Sent*** state the Protocol Layer ***Shall*** increment the ***MessageIDCounter*** and inform the Policy Engine that the Message has been sent.

The Protocol Layer ***Shall*** transition to the ***PRL_Tx_Wait_for_Message_Request*** state when:

- The Policy Engine has been informed that the Message has been sent.

6.11.2.2.1.8 PRL_Tx_Check_RetryCounter State

On entry to the ***PRL_Tx_Check_RetryCounter*** state the Protocol Layer in a DFP or UFP ***Shall*** increment the value of the ***RetryCounter*** and then check it in order to determine whether it is necessary to retry sending the Message. Note that Cable Plugs do not retry Messages and so do not use the ***RetryCounter***.

The Protocol Layer ***Shall*** transition to the ***PRL_Tx_Construct_Message*** state in order to retry Message sending when:

- ***RetryCounter*** ≤ ***nRetryCount*** and
- This is not a Cable Plug and
- This is an Extended Message with ***Data Size*** ≤ ***MaxExtendedMsgLegacyLen*** or
- This is an Extended Message that has been Chunked.

The Protocol Layer ***Shall*** transition to the ***PRL_Tx_Transmission_Error*** state when:

- ***RetryCounter*** > ***nRetryCount*** or
- This is a Cable Plug, which does not retry.
- This is an Extended Message with ***Data Size*** > ***MaxExtendedMsgLegacyLen*** that has not been Chunked.

6.11.2.2.1.9 PRL_Tx_Transmission_Error State

On entry to the ***PRL_Tx_Transmission_Error*** state the Protocol Layer ***Shall*** increment the ***MessageIDCounter*** and inform the Policy Engine of the transmission error.

The Protocol Layer ***Shall*** transition to the ***PRL_Tx_Wait_for_Message_Request*** state when:

- The Policy Engine has been informed of the transmission error.

6.11.2.2.1.10 PRL_Tx_Discard_Message State

Protocol Layer Message transmission ***Shall*** enter the ***PRL_Tx_Discard_Message*** state whenever:

- Protocol Layer Message reception receives an incoming Message or
- The Fast Role Swap signal is being transmitted (see Section 5.8.5.6)
- The Fast Role Swap signal is detected (see Section 5.8.6.3).

On entry to the ***PRL_Tx_Discard_Message*** state, if there is a Message queued awaiting transmission, the Protocol Layer ***Shall Discard*** the Message according to the rules in Section 6.10 and increment the ***MessageIDCounter***.

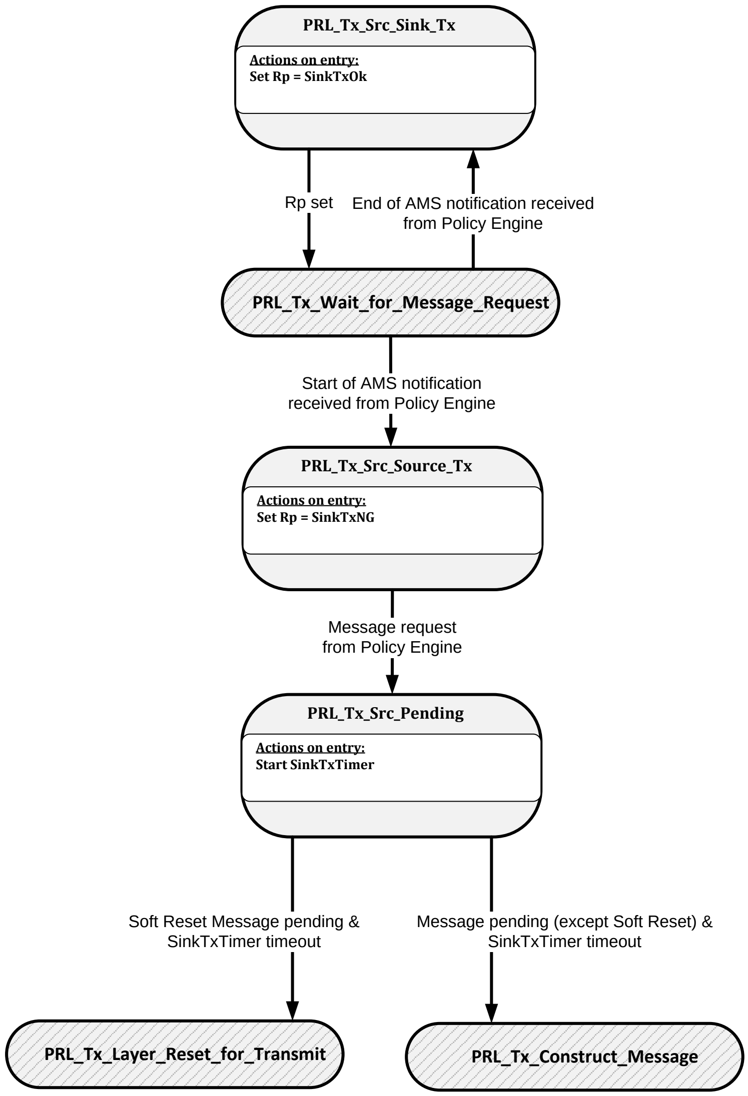
The Protocol Layer ***Shall*** transition to the ***PRL_Tx_PHY_Layer_Reset*** state when:

- Discarding is complete i.e. the Message queue is empty.

6.11.2.2.2 Source Protocol Layer Message Transmission State Diagram

Figure 6-51 shows the state behavior for the Protocol Layer in a Source when transmitting a Message.

Figure 6-51 Source Protocol Layer Message transmission State Diagram



6.11.2.2.2.1 PRL_Tx_Src_Sink_Tx State

In the ***PRL_Tx_Src_Sink_Tx*** state the Source sets Rp to ***SinkTxOk*** allowing the Sink to start an Atomic Message Sequence (AMS).

The Protocol Layer in a Source ***Shall*** transition from the ***PRL_Tx_Wait_for_Message_Request*** state to the ***PRL_Tx_Src_Sink_Tx*** state when:

- A notification is received from the Policy Engine that the end of an AMS has been reached.

On entry to the ***PRL_Tx_Src_Sink_Tx*** state the Protocol Layer ***Shall*** request the PHY Layer to Rp to ***SinkTxOk***.

The Protocol Layer ***Shall*** transition to the ***PRL_Tx_Wait_for_Message_Request*** state when:

- Rp has been set

6.11.2.2.2.2 PRL_Tx_Src_Source_Tx State

In the ***PRL_Tx_Src_Source_Tx*** state the Source sets Rp to ***SinkTxNG*** allowing the Source to start an Atomic Message Sequence (AMS).

The Protocol Layer in a Source ***Shall*** transition from the ***PRL_Tx_Wait_for_Message_Request*** state to the ***PRL_Tx_Src_Source_Tx*** state when:

- A notification is received from the Policy Engine that an AMS will be starting.

On entry to the ***PRL_Tx_Src_Source_Tx*** state the Protocol Layer ***Shall*** set Rp to ***SinkTxNG***.

The Protocol Layer ***Shall*** transition to the ***PRL_Tx_Src_Pending*** state when:

- A Message request is received from the Policy Engine.

6.11.2.2.2.3 PRL_Tx_Src_Pending State

In the ***PRL_Tx_Src_Pending*** state the Protocol Layer has a Message buffered ready for transmission.

On entry to the ***PRL_Tx_Src_Pending*** state the ***SinkTxTimer*** ***Shall*** be initialized and run.

The Protocol Layer ***Shall*** transition to the ***PRL_Tx_Construct_Message*** state when:

- The pending Message request from the Policy Engine is not a ***Soft_Reset*** Message and
- The ***SinkTxTimer*** times out.

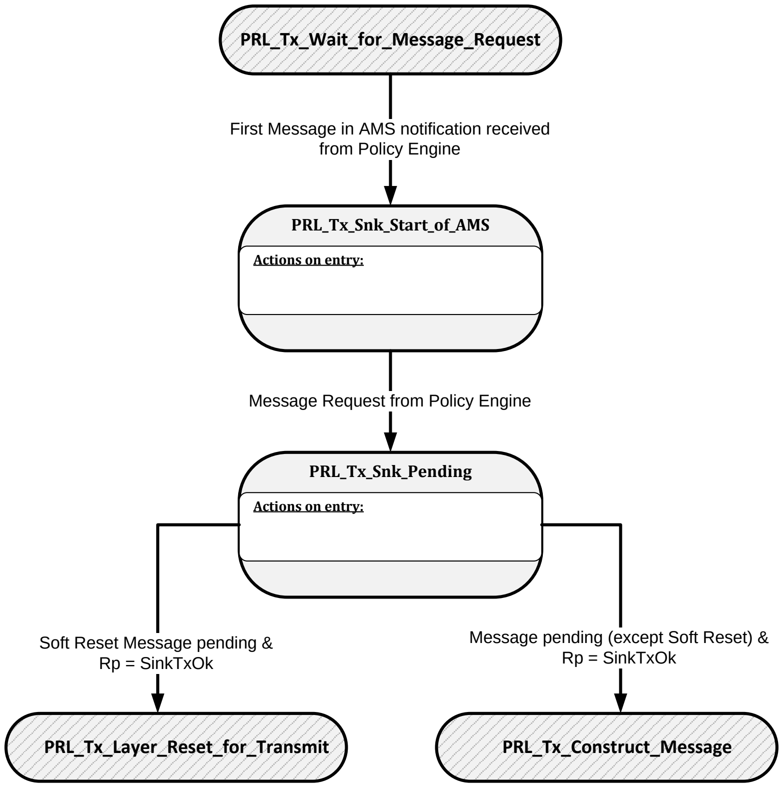
The Protocol Layer ***Shall*** transition to the ***PRL_Tx_Layer_Reset_for_Transmit*** state when:

- The pending Message request from the Policy Engine is a ***Soft_Reset*** Message and
- The ***SinkTxTimer*** times out.

6.11.2.2.3 Sink Protocol Layer Message Transmission State Diagram

Figure 6-52 shows the state behavior for the Protocol Layer in a Source when transmitting a Message.

Figure 6-52 Sink Protocol Layer Message transmission State Diagram



6.11.2.2.3.1 PRL_Tx_Snk_Start_of_AMS State

In the ***PRL_Tx_Snk_Start_of_AMS*** state the Protocol Layer waits for the first Message in a Sink initiated AMS.

The Protocol Layer in a Sink ***Shall*** transition from the ***PRL_Tx_Wait_for_Message_Request*** state to the ***PRL_Tx_Snk_Start_of_AMS*** state when:

- A notification is received from the Policy Engine that the next Message the Sink will send is the start of an AMS.

The Protocol Layer ***Shall*** transition to the ***PRL_Tx_Snk_Pending*** state when:

- A Message request is received from the Policy Engine.

6.11.2.2.3.2 PRL_Tx_Snk_Pending State

In the ***PRL_Tx_Snk_Pending*** state the Protocol Layer has the first Message in a Sink initiated AMS ready to send and is waiting for Rp to transition to ***SinkTxOk*** before sending the Message.

The Protocol Layer ***Shall*** transition to the ***PRL_Tx_Construct_Message*** state when:

- A Message is Pending that is not a ***Soft_Reset*** Message and
- Rp is set to ***SinkTxOk.***

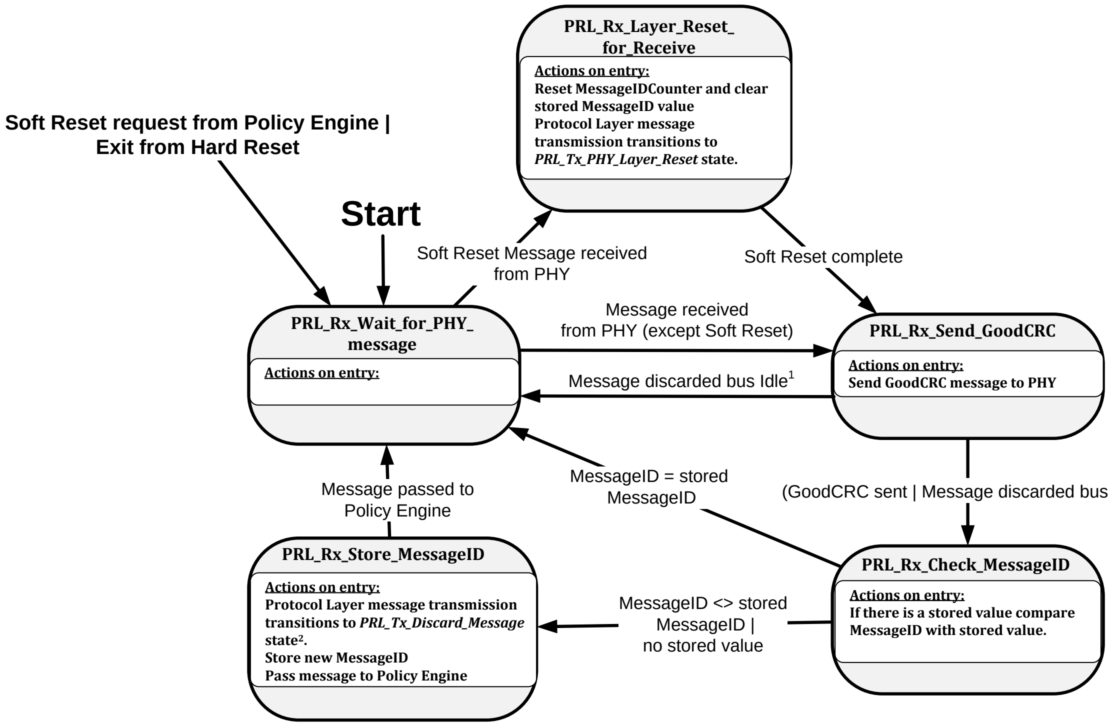
The Protocol Layer ***Shall*** transition to the ***PRL_Tx_Layer_Reset_for_Transmit*** state when:

- A ***Soft_Reset*** Message is pending and
- Rp is set to ***SinkTxOk***.

6.11.2.3 Protocol Layer Message Reception

Figure 6-53 shows the state behavior for the Protocol Layer when receiving a Message.

Figure 6-53 Protocol layer Message reception



[1] This indication is sent by the PHY when a message has been ***Discarded*** due to CC being busy, and after CC becomes idle again (see Section 5.7). Two alternate allowable transitions are shown.

[2] In the case of a Ping message being received, in order to maintain robust communications in the presence of collisions, the outgoing message ***Should Not*** be ***Discarded***.

6.11.2.3.1 PRL_Rx_Wait_for_PHY_Message state

The Protocol Layer ***Shall*** enter the ***PRL_Rx_Wait_for_PHY_Message*** state:

- At startup.
- As a result of a Soft Reset request from the Policy Engine.
- On exit from a Hard Reset.

In the ***PRL_Rx_Wait_for_PHY_Message*** state the Protocol Layer waits until the PHY Layer passes up a received Message.

The Protocol Layer ***Shall*** transition to the ***PRL_Rx_Send_GoodCRC*** state when:

- A Message is passed up from the PHY Layer.

The Protocol Layer ***Shall*** transition to the ***PRL_Rx_Layer_Reset_for_Receive*** state when:

- A ***Soft_Reset*** Message is received from the PHY Layer.

6.11.2.3.2 PRL_Rx_Layer_Reset_for_Receive state

On entry to the ***PRL_Rx_Layer_Reset_for_Receive*** state the Protocol Layer ***Shall*** reset the ***MessageIDCounter*** and clear the stored ***MessageID***. The Protocol Layer ***Shall*** transition Protocol Layer Message transmission to the ***PRL_Tx_Wait_for_Message_Request*** state (see Section 6.11.2.2.1.1).

The Protocol Layer ***Shall*** transition to the ***PRL_Rx_Send_GoodCRC*** State when:

- The Soft Reset actions in this state have been completed.

6.11.2.3.3 PRL_Rx_Send_GoodCRC state

On entry to the ***PRL_Rx_Send_GoodCRC*** state the Protocol Layer ***Shall*** construct a ***GoodCRC*** Message and request the PHY Layer to transmit it.

The Protocol Layer ***Shall*** transition to the ***PRL_Rx_Check_MessageID*** state when:

- The ***GoodCRC*** Message has been passed to the PHY Layer.

When the PHY Layer indicates that a Message has been ***Discarded*** due to CC being busy but CC is now idle (see Section 5.7), the Protocol Layer ***Shall*** either:

- Transition to the ***PRL_Rx_Check_MessageID state*** or
- Transition to the ***PRL_Rx_Wait_for_PHY_Message*** state.

6.11.2.3.4 PRL_Rx_Check_MessageID state

On entry to the ***PRL_Rx_Check_MessageID*** state the Protocol Layer ***Shall*** compare the ***MessageID*** of the received Message with its stored value if a value has previously been stored.

The Protocol Layer ***Shall*** transition to the ***PRL_Rx_Wait_for_PHY_Message*** state when:

- The ***MessageID*** of the received Message equals the stored ***MessageID*** value since this is a Message retry which ***Shall*** be ***Discarded***.

The Protocol Layer ***Shall*** transition to the ***PRL_Rx_Store_MessageID*** state when:

- The ***MessageID*** of the received Message does not equal the stored ***MessageID*** value since this is a new Message or
- This is the first received Message and no ***MessageID*** value is currently stored.

6.11.2.3.5 PRL_Rx_Store_MessageID state

On entry to the ***PRL_Rx_Store_MessageID*** state the Protocol Layer ***Shall*** transition Protocol Layer Message transmission to the ***PRL_Tx_Discard_Message*** state (except when a ***Ping*** Message has been received in which case the ***PRL_Tx_Discard_Message*** state ***Should Not*** be entered), replace the stored value of ***MessageID*** with the value of ***MessageID*** in the received Message and pass the Message up to the Policy Engine.

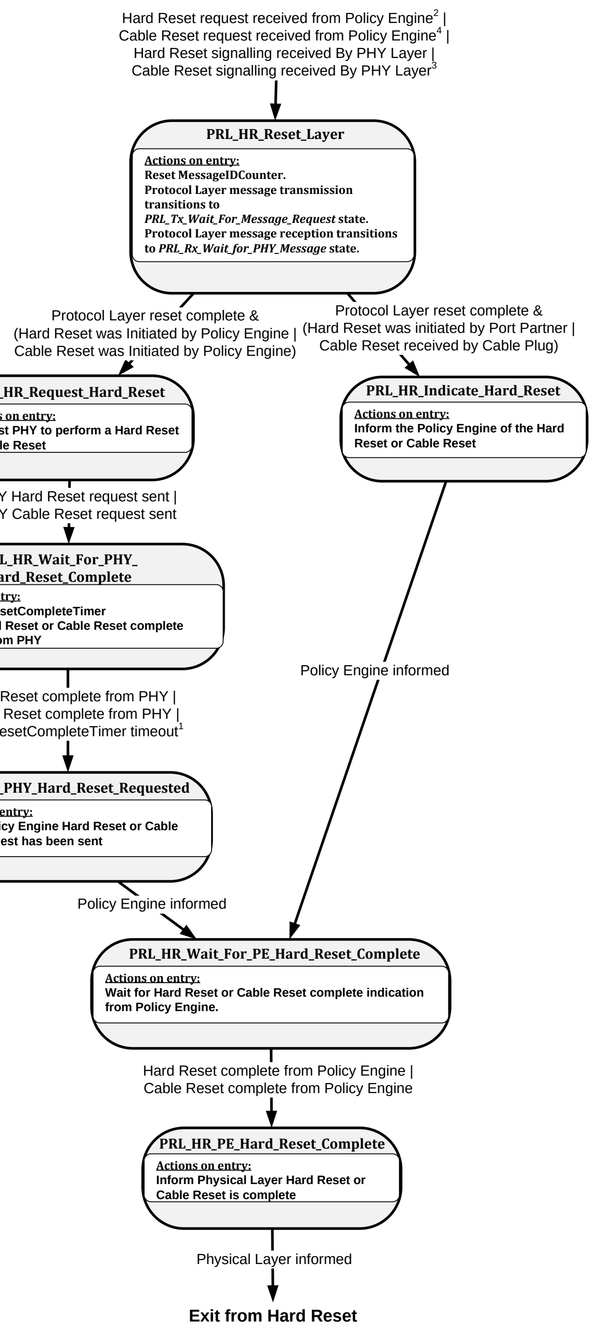
The Protocol Layer ***Shall*** transition to the ***PRL_Rx_Wait_for_PHY_Message*** state when:

- The Message has been passed up to the Policy Engine.

6.11.2.4 Hard Reset operation

Figure 6-54 shows the state behavior for the Protocol Layer when receiving a Hard Reset or Cable Reset request from the Policy Engine or ***Hard Reset*** Signaling or ***Cable Reset*** Signaling from the Physical Layer (see also Section 6.8.2 and Section 6.8.3).

Figure 6-54 Hard/Cable Reset



[1] If the ***HardResetCompleteTimer*** timeout occurs this means that the PHY is still waiting to send the Hard Reset due to a non-idle channel. This condition will be cleared once the PE Hard Reset is completed.

[2] Cable Plugs do not generate ***Hard Reset*** signaling but are required to monitor for ***Hard Reset*** signaling between the Port Partners and respond by resetting.

[3] Cable Reset signaling is only recognized by a Cable Plug.

[4] Cable Reset signaling cannot be generated by Cable Plugs

6.11.2.4.1 PRL_HR_Reset_Layer state

The ***PRL_HR_Reset_Layer*** State defines the mode of operation of both the Protocol Layer transmission and reception state machines during a Hard Reset or Cable Reset. During Hard Reset no USB Power Delivery protocol Messages are sent or received; only ***Hard Reset*** Signaling is present after which the communication channel is assumed to have been disabled by the Physical Layer until completion of the Hard Reset. During Cable Reset no USB Power Delivery protocol Messages are sent to or received by the Cable Plug but other USB Power Delivery communication ***May*** continue.

The Protocol Layer ***Shall*** enter the ***PRL_HR_Reset_Layer*** state from any other state when:

- A Hard Reset Request is received from the Policy Engine or
- ***Hard Reset*** Signaling is received from the Physical Layer or
- A Cable Reset Request is received from the Policy Engine or
- ***Cable Reset*** Signaling is received from the Physical Layer.

On entry to the ***PRL_HR_Reset_Layer*** state the Protocol Layer ***Shall*** reset the ***MessageIDCounter***. It ***Shall*** also reset the states of the Protocol Layer transmission and reception state machines to their starting points. The Protocol Layer transmission state machine ***Shall*** transition to the ***PRL_Tx_Wait_for_Message_Request*** state. The Protocol Layer reception state machine ***Shall*** transition to the ***PRL_Rx_Wait_for_PHY_Message*** state.

The Protocol Layer ***Shall*** transition to the ***PRL_HR_Request_Hard_Reset*** state when:

- The Protocol Layer's reset is complete and
  - The Hard Reset request has originated from the Policy Engine or
  - The Cable Reset request has originated from the Policy Engine.

The Protocol Layer ***Shall*** transition to the ***PRL_HR_Indicate_Hard_Reset*** state when:

- The Protocol Layer's reset is complete and
  - The Hard Reset request has been passed up from the Physical Layer or
  - A Cable Reset request has been passed up from the Physical Layer (Cable Plug only).

6.11.2.4.2 PRL_HR_Indicate_Hard_Reset state

On entry to the ***PRL_HR_Indicate_Hard_Reset*** state the Protocol Layer ***Shall*** indicate to the Policy Engine that either ***Hard Reset*** Signaling or ***Cable Reset*** Signaling has been received.

The Protocol Layer ***Shall*** transition to the ***PRL_HR_Wait_for_PE_Hard_Reset_Complete*** state when:

- The Indication to the Policy Engine has been sent.

6.11.2.4.3 PRL_HR_Request_Hard_Reset state

On entry to the ***PRL_HR_Request_Hard_Reset*** state the Protocol Layer ***Shall*** request the Physical Layer to send either ***Hard Reset*** Signaling or ***Cable Reset*** signaling.

The Protocol Layer ***Shall*** transition to the ***PRL_HR_Wait_for_PHY_Hard_Reset_Complete*** state when:

- The Physical Layer ***Hard Reset*** Signaling request has been sent or
- The Physical Layer ***Cable Reset*** Signaling request has been sent.

6.11.2.4.4 PRL_HR_Wait_for_PHY_Hard_Reset_Complete state

In the ***PRL_HR_Wait_for_PHY_Hard_Reset_Complete*** state the Protocol Layer ***Shall*** start the ***HardResetCompleteTimer*** and wait for the PHY Layer to indicate that the Hard Reset or Cable Reset has been completed.

The Protocol Layer ***Shall*** transition to the ***PRL_HR_PHY_Hard_Reset_Requested*** state when:

- A Hard Reset complete indication is received from the PHY Layer or
- A Cable Reset complete indication is received from the PHY Layer or
- The ***HardResetCompleteTimer*** times out.

6.11.2.4.5 PRL_HR_PHY_Hard_Reset_Requested state

On entry to the ***PRL_HR_PHY_Hard_Reset_Requested*** state the Protocol Layer ***Shall*** inform the Policy Engine that the PHY Layer has been requested to perform a Hard Reset or Cable Reset.

The Protocol Layer ***Shall*** transition to the ***PRL_HR_Wait_for_PE_Hard_Reset_Complete*** state when:

- The Indication to the Policy Engine has been sent.

6.11.2.4.6 PRL_HR_Wait_for_PE_Hard_Reset_Complete state

In the ***PRL_HR_Wait_for_PE_Hard_Reset_Complete*** state the Protocol Layer ***Shall*** wait for the Policy Engine to indicate that the Hard Reset or Cable Reset has been completed.

The Protocol Layer ***Shall*** transition to the ***PRL_HR_PE_Hard_Reset_Complete*** state when:

- A Hard Reset complete indication is received from the Policy Engine or
- A Cable Reset complete indication is received from the Policy Engine.

6.11.2.4.7 PRL_HR_PE_Hard_Reset_Complete

On entry to the ***PRL_HR_PE_Hard_Reset_Complete*** state the Protocol Layer ***Shall*** inform the Physical Layer that the Hard Reset or Cable Reset is complete.

The Protocol Layer ***Shall*** exit from the Hard Reset and return to normal operation when:

- The Physical Layer has been informed that the Hard Reset is complete so that it will re-enable the communications channel. If ***Hard Reset*** Signaling is still pending due to a non-idle channel this ***Shall*** be cleared and not sent or
- The Physical Layer has been informed that the Cable Reset is complete.

6.11.3 List of Protocol Layer States

Table 6-60 lists the states used by the various state machines.

Table 6-60 Protocol Layer States

State name	Reference
Protocol Layer Message Transmission	
Common Protocol Layer Message Transmission	
PRL_Tx_PHY_Layer_Reset	Section 6.11.2.2.1.1
PRL_Tx_Wait_for_Message_Request	Section 6.11.2.2.1.2
PRL_Tx_Layer_Reset_for_Transmit	Section 6.11.2.2.1.3
PRL_Tx_Construct_Message	Section 6.11.2.2.1.4
PRL_Tx_Wait_for_PHY_Response	Section 6.11.2.2.1.5
PRL_Tx_Match_MessageID	Section 6.11.2.2.1.6
PRL_Tx_Message_Sent	Section 6.11.2.2.1.7
PRL_Tx_Check_RetryCounter	Section 6.11.2.2.1.8
PRL_Tx_Transmission_Error	Section 6.11.2.2.1.9
PRL_Tx_Discard_Message	Section 6.11.2.2.1.10
Source Protocol Layer Message Transmission	
PRL_Tx_Src_Sink_Tx	Section 6.11.2.2.2.1
PRL_Tx_Src_Source_Tx	Section 6.11.2.2.2.2
PRL_Tx_Src_Pending	Section 6.11.2.2.2.3
Sink Protocol Layer Message Transmission	
PRL_Tx_Snk_Start_of_AMS	Section 6.11.2.2.3.1
PRL_Tx_Snk_Pending	Section 6.11.2.2.3.2
Protocol Layer Message Reception	
PRL_Rx_Wait_for_PHY_Message	Section 6.11.2.3.1
PRL_Rx_Layer_Reset_for_Receive	Section 6.11.2.3.2
PRL_Rx_Send_GoodCRC	Section 6.11.2.3.3
PRL_Rx_Check_MessageID	Section 6.11.2.3.4
PRL_Rx_Store_MessageID	Section 6.11.2.3.5
Hard Reset Operation	
PRL_HR_Reset_Layer	Section 6.11.2.4.1
PRL_HR_Indicate_Hard_Reset	Section 6.11.2.4.2
PRL_HR_Request_Hard_Reset	Section 6.11.2.4.3
PRL_HR_Wait_for_PHY_Hard_Reset_Complete	Section 6.11.2.4.4
PRL_HR_PHY_Hard_Reset_Requested	Section 6.11.2.4.5
PRL_HR_Wait_for_PE_Hard_Reset_Complete	Section 6.11.2.4.6
PRL_HR_PE_Hard_Reset_Complete	Section 6.11.2.4.7
Chunking	
Chunked Rx	
RCH_Wait_For_Message_From_Protocol_Layer	Section 6.11.2.1.2.1

State name	Reference
RCH_Pass_Up_Message	Section 6.11.2.1.2.2
RCH_Processing_Extended_Message	Section 6.11.2.1.2.3
RCH_Requesting_Chunk	Section 6.11.2.1.2.4
RCH_Waiting_Chunk	Section 6.11.2.1.2.5
RCH_Report_Error	Section 6.11.2.1.2.6
Chunked Tx	
TCH_Wait_For_Message_Request_From_Policy_Engine	Section 6.11.2.1.3.1
TCH_Pass_Down_Message	Section 6.11.2.1.3.2
TCH_Wait_For_Transmision_Complete	Section 6.11.2.1.3.3
TCH_Message_Sent	Section 6.11.2.1.3.4
TCH_Prepare_To_Send_Chunked_Message	Section 6.11.2.1.3.5
TCH_Construct_Chunked_Message	Section 6.11.2.1.3.6
TCH_Sending_Chunked_Message	Section 6.11.2.1.3.7
TCH_Wait_Chunk_Request	Section 6.11.2.1.3.8
TCH_Message_Received	Section 6.11.2.1.3.9
TCH_Report_Error	Section 6.11.2.1.3.10
Chunked Message Router	
RTR_Wait_for_Message_From_Protocol_Layer	Section 6.11.2.1.4.1
RTR_Rx_Chunks	Section 6.11.2.1.4.2
RTR_Ping	Section 6.11.2.1.4.3
RTR_Tx_Chunks	Section 6.11.2.1.4.4

6.12 Message Applicability

The following tables outline the Messages supported by a given port, depending on its capability.

When a Message is supported the feature and Message sequence implied by the Message ***Shall*** also be supported. For example Sinks using power for charging that support the ***GotoMin*** Message ***Shall*** be able to reduce their current draw when requested via a ***GotoMin*** Message.

The following abbreviations are used:

- N – ***Normative***; ***Shall*** be supported by this Port/Cable Plug
- CN – ***Conditional Normative*** ; ***Shall*** be supported by a given Port/Cable Plug based on features
- R – Recommended; ***Should*** be supported by this Port/Cable Plug
- O – ***Optional***; ***May*** be supported by this Port/Cable Plug
- NS – Not Supported; ***Shall*** result in a ***Not_Supported*** Message response by this Port/Cable Plug when received.
- I – ***Ignore***; ***Shall*** be ***Ignored*** by this Port/Cable Plug when received.
- NK – NAK; this Port/Cable Plug ***Shall*** return Responder NAK to this Command when received
- NA – Not allowed; ***Shall Not*** be transmitted by this Port/Cable Plug.
- DR – Don't Recognize; there ***Shall*** no response at all (i.e. not even a ***GoodCRC*** Message) from this Port/Cable Plug when received.

For the case of ***Conditional Normative*** a note has been added to indicate the condition. “CN/” notation is used to indicate the level of support when the condition is not present.

“R/” and “O/” notation is used to indicate the response when the Recommended or ***Optional*** Message is not supported.

Note: that where NS/RJ/NK is indicated for Received Messages this ***Shall*** apply to the ***PE_CBL_Ready***, ***PE_SNK_Ready*** or ***PE_SRC_Ready*** states only since unexpected Messages received during a Message sequence are Protocol Errors (see Section 6.8.1).

This section covers Control and Data Message support for Sources, Sink and Cable Plugs. It also covers VDM Command support for DFPs, UFPs and Cable Plugs.

6.12.1 Applicability of Control Messages

Table 6-61 details Control Messages that ***Shall***/***Should***/ ***Shall Not*** be transmitted and received by a Source, Sink or Cable Plug. Requirements for Dual-Role Power Ports and Dual-Role Data Ports ***Shall*** override any requirements for Source-only or Sink-Only Ports.

Table 6-61 Applicability of Control Messages

Message Type	Source	Sink	Dual-Role Power	Dual-Role Data	Cable Plug
Transmitted Message					
Accept	N	N			N
DR_Swap	O	O		N	NA
FR_Swap	NA	NA	R		NA
Get_Country_Codes	CN[10]/NA	CN[10]/NA			NA
Get_PPS_Status	NA	CN[9]			NA
Get_Sink_Cap	R	NA	N		NA
Get_Source_Cap	NA	R	N		NA
Get_Source_Cap_Extended	NA	R	R		NA
Get_Status	R	R			NA
GoodCRC	N	N			N
GotoMin	CN[1]/O	NA			NA
Ping	O	NA			NA
PR_Swap	NA	NA	N		NA
PS_RDY	N	NA	N		NA
Reject	N	NA	O	O	NA
Soft_Reset	N	N			NA
VCONN_Swap	R	R			NA
Wait	CN[2]/O	NA	O	O	NA
Received Message					
Accept	N	N	N	N	I
DR_Swap	O/NS	O/NS		N	I
FR_Swap	NS	NS	CN[7]/NS		I
Get_Country_Codes	CN[10]/NS	CN[10]/NS			I
Get_PPS_Status	CN[9]/NS	NS			I
Get_Sink_Cap	NS	N	N		I
Get_Source_Cap	N	NS	N		I
Get_Source_Cap_Extended	CN[5]/NS	NS	CN[5]/NS		I
Get_Status	CN[6]/NS	CN[6]/NS	CN[6]/NS		I
GoodCRC	N	N			N
GotoMin	NS	R[3]			I
Ping	NS	I			I
PR_Swap	NS	NS	N		I

Message Type	Source	Sink	Dual-Role Power	Dual-Role Data	Cable Plug
PS_RDY	NS	N	N		I
Reject	CN[8]/NS	N	N	N	I
Soft_Reset	N	N			N
VCONN_Swap	CN[4]/ NS	CN[4]/ NS			I
Wait	CN[8]/NS	N	N	N	I
Note 1: ***Shall*** be supported by a Hub with multiple Downstream Ports. ***Should*** be supported by a Host with multiple Downstream Ports. Note 2: ***Shall*** be supported when transmission of ***GotoMin*** Messages is supported. Note 3: ***Should*** be supported by Sinks which use PD power for charging. Note 4: ***Shall*** be supported by any Port that can operate as a VCONN Source. Note 5: ***Shall*** be supported products that support the ***Source_Capabilities_Extended*** Message. Note 6: ***Shall*** be supported by Sources that support the ***Alert*** Message. Note 7: ***Shall*** be supported when the Fast Role Swap signal is supported. Note 8: ***Shall*** be supported when ***VCONN_Swap*** is supported. Note 9: ***Shall*** be supported when PPS is supported. Note 10: ***Shall*** be supported when required by a country authority.					

6.12.2 Applicability of Data Messages

Table 6-62 details Data Messages (except for VDM Commands) that ***Shall***/***Should***/ ***Shall Not*** be transmitted and received by a Source, Sink or Cable Plug. Requirements for Dual-Role Power Ports ***Shall*** override any requirements for Source-only or Sink-Only Ports.

Table 6-62 Applicability of Data Messages

Message Type	Source	Sink	Dual-Role Power	Cable Plug
Transmitted Message				
Source_Capabilities	N	NA	N	NA
Request	NA	N		NA
Get_Country_Info	CN[5]/O	CN[5]/O		NA
BIST	N[1]	N[1]		NA
Sink_Capabilities	NA	N	N	NA
Battery_Status	CN[2]	CN[2]		NA
Alert	R	R		NA
Received Message				
Source_Capabilities	NS	N	N	I
Request	N	NS		I
Get_Country_Info	CN[5]/NS	CN[5]/NS		I
BIST	N[1]	N[1]		N[1]
Sink_Capabilities	CN[4]	NS	CN[4]	I
Battery_Status	CN[3]/NS	CN[3]/NS		I
Alert	R/NS	R/NS		I

Message Type	Source	Sink	Dual-Role Power	Cable Plug
Note 1: For details of which BIST Modes and Messages ***Shall*** be supported see Section 5.9 and Section 6.4.3. Note 2: ***Shall*** be supported by products that contain batteries. Note 3: ***Shall*** be supported by products that support the ***Get_Battery_Status*** Message. Note 4: ***Shall*** be supported by products that support the ***Get_Sink_Cap*** Message. Note 5: ***Shall*** be supported when required by a country authority.				

6.12.3 Applicability of Extended Messages

Table 6-63 details Extended Messages (except for Extended VDM Commands) that ***Shall***/***Should***/ ***Shall Not*** be transmitted and received by a Source, Sink or Cable Plug. Requirements for Dual-Role Power Ports ***Shall*** override any requirements for Source-only or Sink-Only Ports.

Table 6-63 Applicability of Extended Messages

Message Type	Source	Sink	Dual-Role Power	Cable Plug
Transmitted Message				
Battery_Capabilities	CN[1]/NA	CN[1]/NA		NA
Country_Codes	CN[10]/NA	CN[10]/NA		NA
Country_Info	CN[10]/NA	CN[10]/NA		NA
Firmware_Update_Request	CN[7]/NA	CN[7]/NA		NA
Firmware_Update_Response	CN[7]/NA	CN[7]/NA		CN[7]/NA
Get_Battery_Cap	R	R		NA
Get_Battery_Status	R	R		NA
Get_Manufacturer_Info	R	R		NA
Manufacturer_Info	R	R		R
PPS_Status	CN[8]/NA	NA		NA
Security_Request	CN[6]/NA	CN[6]/NA		NA
Security_Response	CN[6]/NA	CN[6]/NA		CN[6]/NA
Source_Capabilities_Extended	R	NA	R	NA
Status	R	R	R	NA
Received Message				
Battery_Capabilities	CN[4]/NS	CN[4]/NS		I
Country_Codes	CN[10]/NS	CN[10]/NS		I
Country_Info	CN[10]/NS	CN[10]/NS		I
Firmware_Update_Request	CN[7]/NS	CN[7]/NS		CN[7]/I
Firmware_Update_Response	CN[7]/NS	CN[7]/NS		I
Get_Battery_Cap	CN[1]/NS	CN[1]/NS		I
Get_Battery_Status	CN[1]/NS	CN[1]/NS		I
Get_Manufacturer_Info	R/NS	R/NS		R
Manufacturer_Info	CN[5]/NS	CN[5]/NS		I
PPS_Status	NS	CN9/NS		I
Security_Request	CN[6]/NS	CN[6]/NS		CN[6]/I

Message Type	Source	Sink	Dual-Role Power	Cable Plug
Security_Response	CN[6]/NS	CN[6]/NS		I
Source_Capabilities_Extended	NS	CN[2]/NS	CN[2]/NS	I
Status	CN[3]/NS	CN[3]/NS		I
Note 1: ***Shall*** be supported by products that contain batteries. Note 2: ***Shall*** be supported by products that can transmit the ***Get_Source_Cap_Extended*** Message. Note 3: ***Shall*** be supported by products that can transmit the ***Get_Status*** Message. Note 4: ***Shall*** be supported by products that can transmit the ***Get_Battery_Cap*** Message. Note 5: ***Shall*** be supported by products that can transmit the ***Get_Manufacturer_Info*** Message Note 6: ***Shall*** be supported by products that support USB security communication as defined in ***[USBTypeCAuthentication 1.0]*** Note 7: ***Shall*** be supported by products that support USB firmware update communication as defined in ***[USBPDFirmwareUpdate 1.0]*** Note 8: ***Shall*** be supported when PPS is supported. Note 9: ***Shall*** be supported by products that can transmit the ***Get_PPS_Status***. Note 10: ***Shall*** be supported when required by a country authority.				

6.12.4 Applicability of Structured VDM Commands

Table 6-64 details Structured VDM Commands that ***Shall***/***Should***/ ***Shall Not*** be transmitted and received by a DFP, UFP or Cable Plug. If Structured VDMs are not supported, the DFP or UFP receiving a VDM Command ***Shall*** send a ***Not_Supported*** Message in response.

Table 6-64 Applicability of Structured VDM Commands

Command Type	DFP	UFP	Cable Plug
Transmitted Command Request			
Discover Identity	CN[1]/R	R[2]	NA
Discover SVIDs	CN[1]/O	O	NA
Discover Modes	CN[1]/O	O	NA
Enter Mode	CN[1]/NA	NA	NA
Exit Mode	CN[1]/NA	NA	NA
Attention	O	O	NA
Received Command Request/Transmitted Command Response			
Discover Identity	O/NK[3]	CN[1]/R/NK[3]	N
Discover SVIDs	O/NK[3]	CN[1]/NK[3]	CN[1]/NK
Discover Modes	O/NK[3]	CN[1]/NK[3]	CN[1]/NK
Enter Mode	NK[3]	CN[1]/NK[3]	CN[1]/NK
Exit Mode	NK[3]	CN[1]/NK[3]	CN[1]/NK
Attention	O/I[3]	O/I[3]	I
Note 1: ***Shall*** be supported when Modal Operation is supported. Note 2: ***May*** be transmitted by a UFP/Source during discovery (see Section 6.4.4.3.1 and Section 8.3.3.22.3). Note 3: If Structured VDMs are not supported, the DFP or UFP receiving a VDM Command ***Shall*** send a ***Not_Supported*** Message in response.			

6.12.5 Applicability of Reset Signaling

Table 6-65 details Reset Signaling that ***Shall***/***Should***/ ***Shall Not*** be transmitted and received by a DFP/UFP or Cable Plug.

Table 6-65 Applicability of Reset Signaling

Signaling Type	DFP	UFP	Cable Plug
Transmitted Message/Signaling			
Soft_Reset	N	N	NA
Hard Reset	N	N	NA
Cable Reset	CN[1]	NA	NA
Received Message/Signaling			
Soft_Reset	N	N	N
Hard Reset	N	N	N
Cable Reset	DR	DR	N
Note 1: ***Shall*** be supported when transmission of SOP' Packets are supported.			

6.12.6 Applicability of Fast Role Swap signal

Table 6-65 details the Fast Role Swap signal that ***Shall***/***Should***/ ***Shall Not*** be transmitted and received by a Source or Sink.

Table 6-66 Applicability of Fast Role Swap signal

Command Type	Source	Sink	Dual-Role Power
Transmitted Message/Signaling			
Fast Role Swap	NA	NA	R
Received Message/Signaling			
Fast Role Swap	NA	NA	R

6.13 Value Parameters

Table 6-67 contains value parameters used in this section.

Table 6-67 Value Parameters

Parameter	Description	Value	Unit	Reference
MaxExtendedMsgLen	Maximum length of an Extended Message as expressed in the ***Data Size*** field.	260	Byte	Section 6.5
MaxExtendedMsgChunkLen		26	Byte	Section 6.5
MaxExtendedMsgLegacyLen		26	Byte	Section 6.5

7. Power Supply

7.1 Source Requirements

7.1.1 Behavioral Aspects

A USB PD Source exhibits the following behaviors:

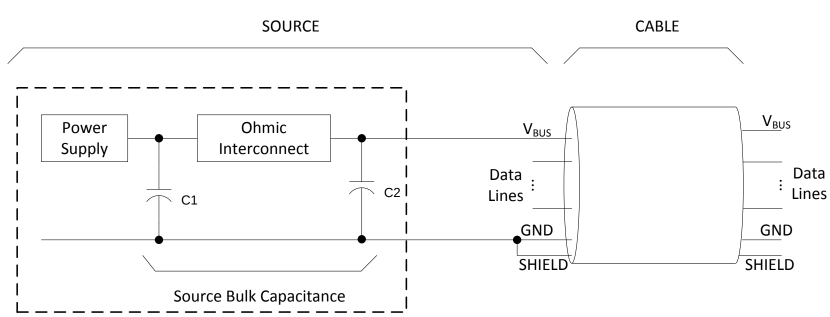
- ***Shall*** be backward compatible with legacy V_{BUS} ports.
- ***Shall*** supply the default ***[USB 2.0]***, ***[USB 3.1]***, ***[USB Type-C 1.2]*** or ***[USBBC 1.2]*** voltage and current to V_{BUS} when the USB cable is Attached (USB Default Operation).
- ***Shall*** supply the default ***[USB 2.0]***, ***[USB 3.1]***, ***[USB Type-C 1.2]*** or ***[USBBC 1.2]*** voltage and current to V_{BUS} when a Contract does not exist (USB Default Operation).
- ***Shall*** return ***vSafe0V*** for some time then return to ***vSafe5V*** when ***Hard Reset*** Signaling is received.
- ***Shall*** control V_{BUS} voltage transitions as bound by undershoot, overshoot and transition time requirements.

7.1.2 Source Bulk Capacitance

The Source bulk capacitance ***Shall Not*** be placed between the transceiver isolation impedance and the USB receptacle. The Source bulk capacitance consists of C1 and C2 as shown in Figure 7-1. The Ohmic Interconnect might consist of PCB traces for power distribution or power switching devices. The capacitance might be a single capacitor, a capacitor bank or distributed capacitance. If the power supply is shared across multiple ports, the bulk capacitance is defined as ***cSrcBulkShared***. If the power supply is dedicated to a single Port, the minimum bulk capacitance is defined as ***cSrcBulk***.

The Source bulk capacitance is allowed to change for a newly negotiated power level. The capacitance change ***Shall*** occur before the Source is ready to operate at the new power level. During a Power Role Swap, the Default Source ***Shall*** transition to Swap Standby before operating as the new Sink. Any change in bulk capacitance required to complete the Power Role Swap ***Shall*** occur during Swap Standby.

Figure 7-1 Placement of Source Bulk Capacitance



7.1.3 Types of Sources

Consistent with the Power Data Objects discussed in Section 6.4.1, the power supply types that are available as Sources in a USB Power Delivery System are:

- The Fixed Supply PDO exposes well-regulated fixed voltage power supplies. Sources ***Shall*** support at least one Fixed Supply capable of supplying ***vSafe5V***. The output voltage of a Fixed Supply ***Shall*** remain within the range defined by the relative tolerance ***vSrcNew*** and the absolute band ***vSrcValid*** as listed in Table 7-19 and described in Section 7.1.8.

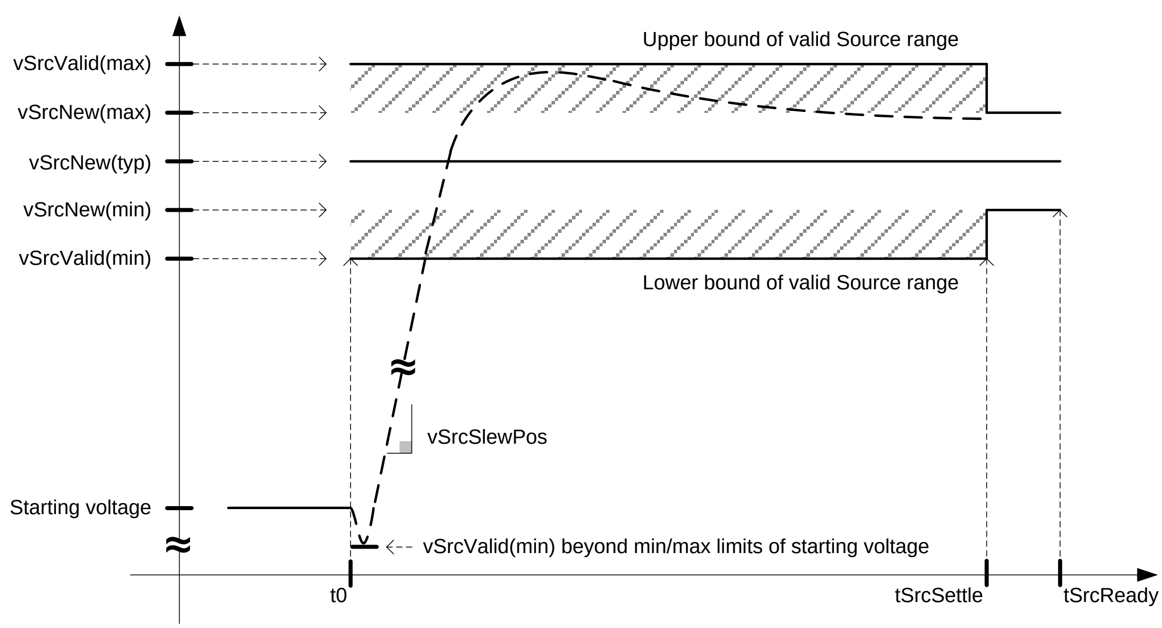
- The Variable Supply (non-Battery) PDO exposes very poorly regulated Sources. The output voltage of a Variable Supply (non-Battery) ***Shall*** remain within the absolute maximum output voltage and the absolute minimum output voltage exposed in the Variable Supply PDO.
- The Battery Supply PDO exposes Batteries than can be connected directly as a Source to V_{BUS}. The output voltage of a Battery Supply ***Shall*** remain within the absolute maximum output voltage and the absolute minimum output exposed in the Battery Supply PDO.
- The Programmable Power Supply (PPS) Augmented PDO (APDO) exposes a Source with an output voltage that can be adjusted programmatically over a defined range. The output voltage of the Programmable Power Supply ***Shall*** remain within a range defined by the relative tolerance ***vPpsNew*** and the absolute band ***vPpsValid***.

7.1.4 Source Transitions

7.1.4.1 Fixed Supply Positive Voltage Transitions

The Source ***Shall*** transition V_{BUS} from the starting voltage to the higher new voltage in a controlled manner. The negotiated new voltage (e.g. 5V, 9V, 15V or 20V) defines the nominal value for ***vSrcNew***. During the positive transition the Source ***Shall*** be able to supply the Sink standby power and the transient current to charge the total bulk capacitance on V_{BUS}. The slew rate of the positive transition ***Shall Not*** exceed ***vSrcSlewPos***. The transitioning Source output voltage ***Shall*** settle within ***vSrcNew*** by ***tSrcSettle***. The Source ***Shall*** be able to supply the negotiated power level at the new voltage by ***tSrcReady***. The positive voltage transition ***Shall*** remain monotonic while the transitioning voltage is below ***vSrcValid*** min and ***Shall*** remain within the ***vSrcValid*** range upon crossing ***vSrcValid*** min as shown in Figure 7-2. The starting time, t0, in Figure 7-2 starts ***tSrcTransition*** after the last bit of the ***EOP*** of the ***GoodCRC*** Message has been received by the Source.

Figure 7-2 Transition Envelope for Positive Voltage Transitions



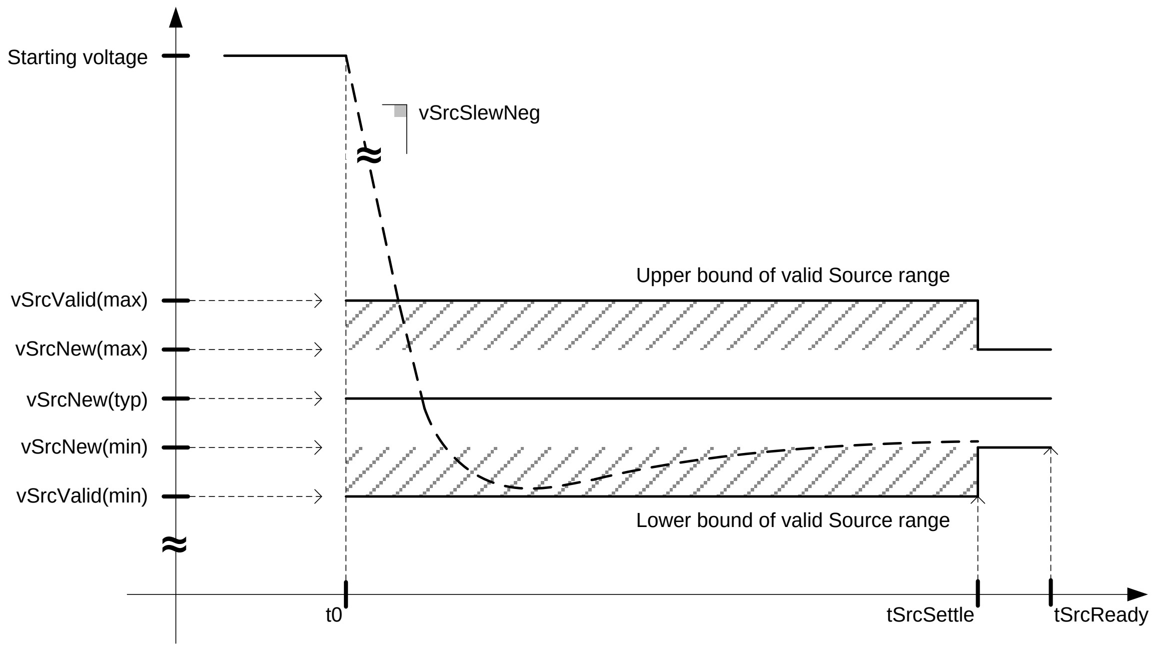
At the start of the positive voltage transition the V_{BUS} voltage level ***Shall Not*** droop ***vSrcValid*** min below either ***vSrcNew*** (i.e., if the starting V_{BUS} voltage level is not ***vSafe5V***) or ***vSafe5V*** as applicable.

7.1.4.2 Fixed Supply Negative Voltage Transitions

Negative voltage transitions are defined as shown in Figure 7-3 and are specified in a similar manner to positive voltage transitions. Figure 7-3 does not apply to ***vSafe0V*** transitions. The slew rate of the negative transition ***Shall***

Not exceed ***vSrcSlewNeg***. The negative voltage transition ***Shall*** remain monotonic while the transitioning voltage is above ***vSrcValid*** max and ***Shall*** remain within the ***vSrcValid*** range upon crossing ***vSrcValid*** max as shown in Figure 7-3. The starting time, t0, in Figure 7-3 starts ***tSrcTransition*** after the last bit of the ***EOP*** of the ***GoodCRC*** Message has been received by the Source.

Figure 7-3 Transition Envelope for Negative Voltage Transitions



If the newly negotiated voltage is ***vSafe5V***, then the ***vSrcValid*** limits ***Shall*** determine the transition window and the transitioning Source ***Shall*** settle within the ***vSafe5V*** limits by ***tSrcSettle***.

7.1.4.3 Programmable Power Supply Voltage Transitions

The Programmable Power Supply (PPS) ***Shall*** transition V_{BUS} over the defined voltage range in a controlled manner. The Output Voltage value in the Programmable RDO defines the nominal value of the PPS output voltage after completing a voltage change and ***Shall*** settle within the limits defined by ***vPpsNew*** by ***tPpsSrcTransition***. Any undershoot or overshoot beyond ***vPpsNew*** ***Shall Not*** exceed ***vPpsValid*** at any time. The PPS output voltage ***May*** change in a step-wise or linear manner and the slew rate of either type of change ***Shall Not*** exceed ***vPpsSlewPos*** for voltage increases or ***vPpsSlewNeg*** for voltage decreases. The nominal requested voltage of all linear voltage changes ***Shall*** equate to an integer number of LSB changes. An LSB change of the PPS output voltage is defined as ***vPpsStep***. A PPS ***Shall*** be able to supply the negotiated current level as it change its output voltage to the requested level. All PPS voltage increases ***Shall*** result in a voltage that is greater than the previous PPS output voltage. Likewise, all PPS voltage decreases ***Shall*** result in a voltage that is less than the previous PPS output voltage.

Figure 7-4 and Figure 7-5 below show the output voltage behavior of a Programmable Power Supply in response to positive and negative voltage change requests while operating with a PPS. The parameters ***vPpsMinVoltage*** and ***vPpsMaxVoltage*** define the lower and upper limits of the PPS range respectively. ***vPpsMinVoltage*** corresponds to Minimum Voltage field in the PPS APDO and ***vPpsMaxVoltage*** corresponds to Maximum Voltage field in the PPS APDO. If the Sink negotiates for a new PPS APDO, then the transition between the two PPS APDOs ***Shall*** occur as described in Section 7.3.18.

Figure 7-4 PPS Positive Voltage Transitions

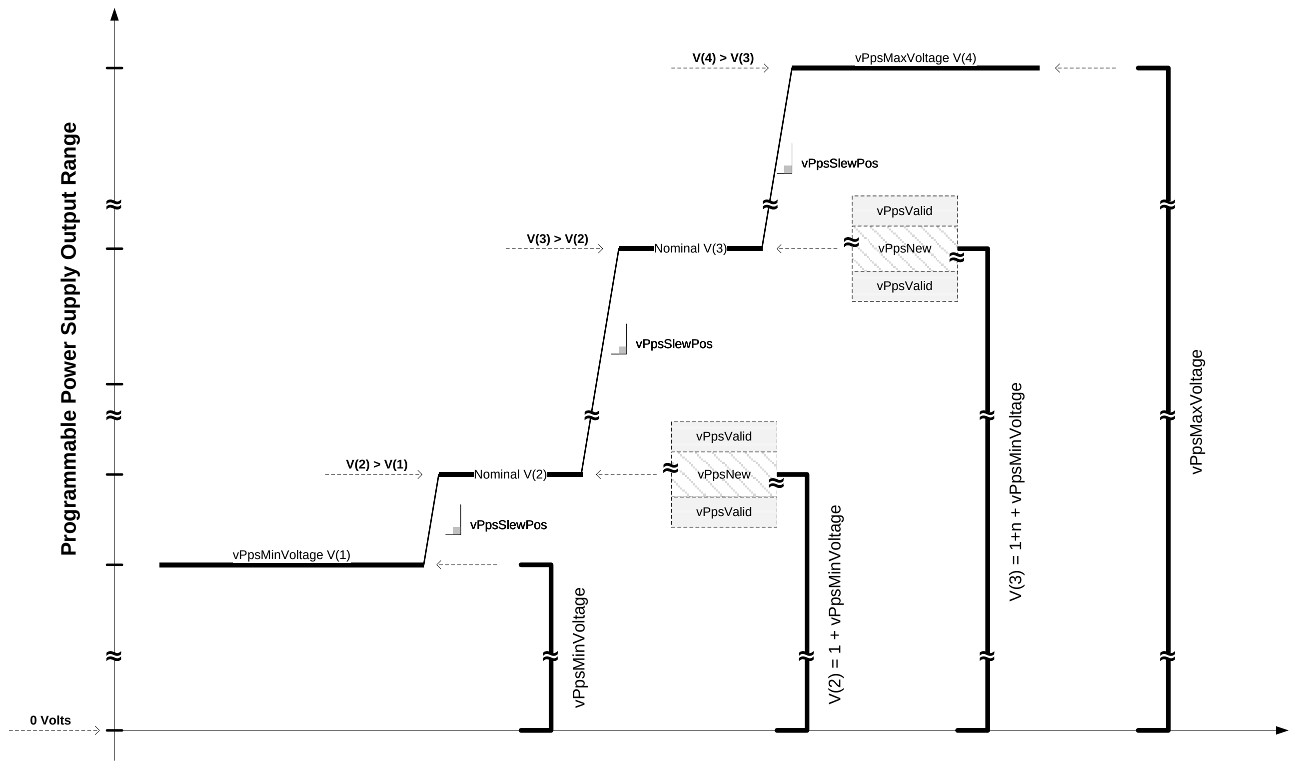
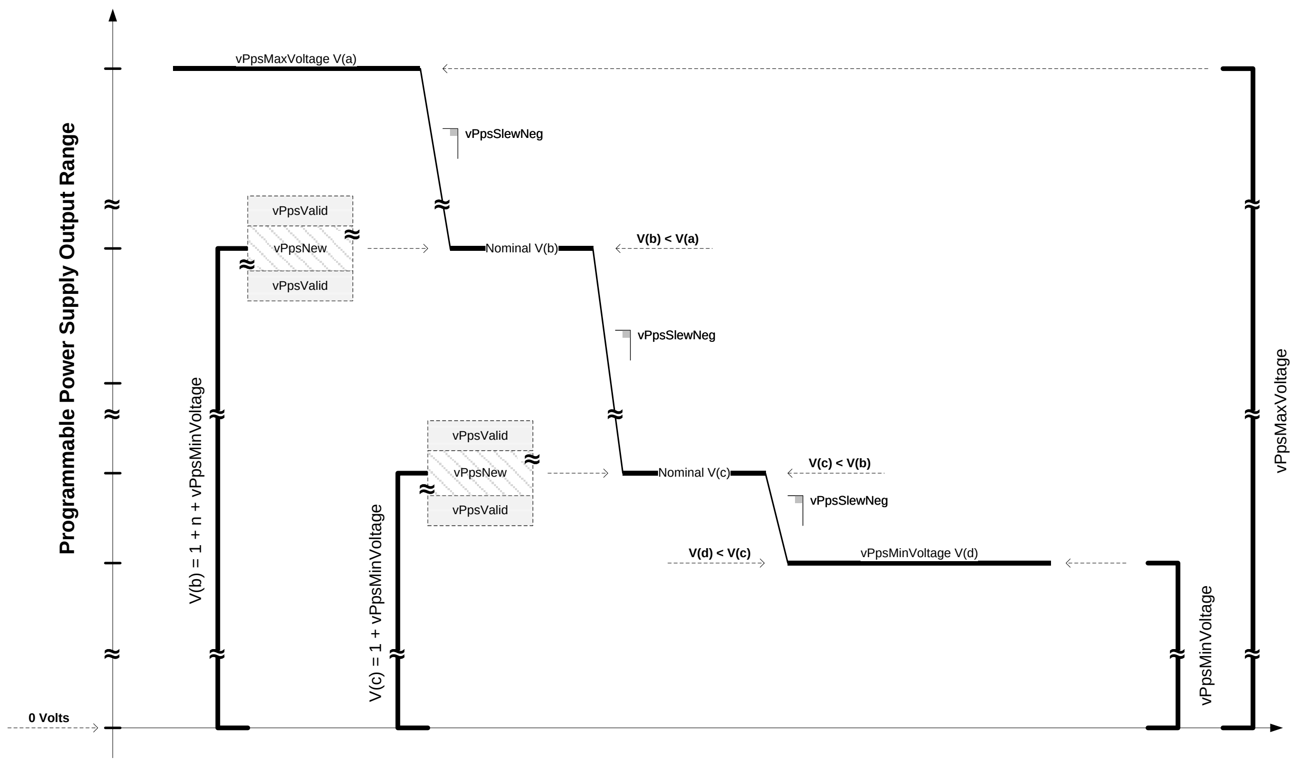
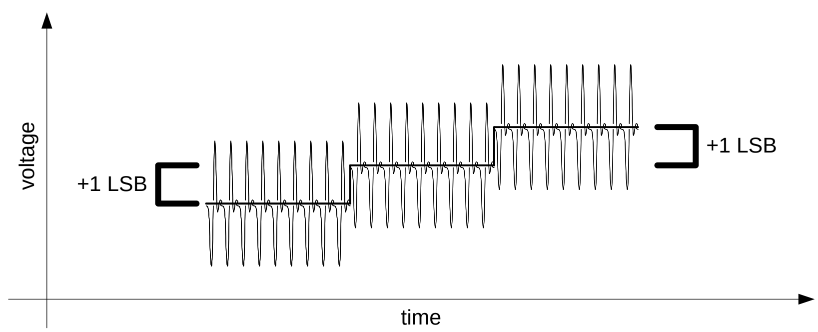


Figure 7-5 PPS Negative Voltage Transitions



The PPS output voltage ripple is expected to exceed the magnitude of one or more LSB as show in the Figure 7-6.

Figure 7-6 Expected PPS Ripple Relative to an LSB



7.1.4.4 Programmable Power Supply Current Foldback

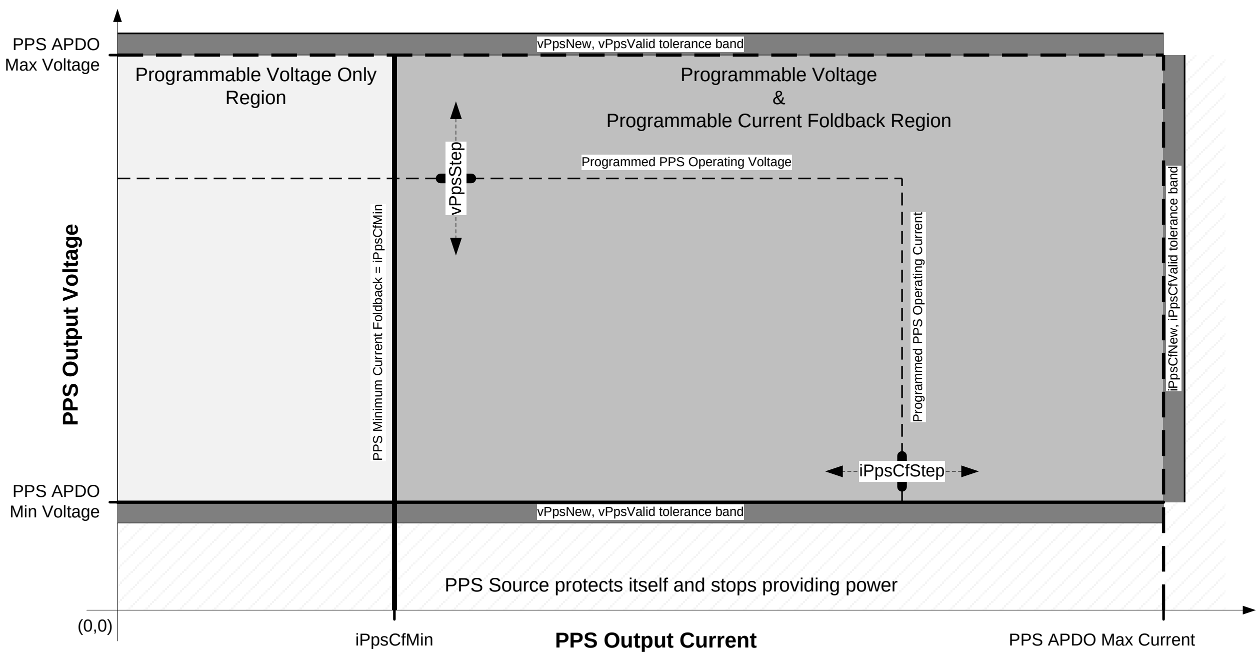
The Programmable Power Supply ***Shall*** foldback its output current to the Operating Current value in the Programmable RDO when the Sink attempts to draw more current than the Output Current level. The programming step size for the Output Current is ***iPpsCfStep***. All programming changes of the Operating Current ***Shall*** settle to the new Operating Current value within ***tPpsCfProgramSettle***. The PPS Operating Current regulation accuracy during current foldback is defined as ***iPpsCfNew***. The minimum programmable foldback level is ***iPpsCfMin***. A Source that supports PPS ***Shall*** support foldback programmability between ***iPpsCfMin*** and the Maximum Current value in the PPS APDO.

Any current overshoot or undershoot that occurs due to a load change during Current Foldback ***Shall Not*** exceed ***iPpsCfTransient*** and ***Shall*** settle to the Operating Current value within ***tPpsCfSettle***. Voltage overshoot or undershoot caused by a transition from Current Foldback mode to Constant Voltage mode ***Shall Not*** exceed ***vPpsCfCvTransient*** and ***Shall*** settle to the Operating Voltage value within ***tPpsCfCvTransient***. Likewise, current overshoot or undershoot caused by a transition from Constant Voltage mode to Current Foldback mode ***Shall Not*** exceed ***iPpsCvCfTransient*** and ***Shall*** settle to the Operating Current value within ***tPpsCvCfTransient***.

The PPS ***Shall*** maintain its output voltage within the Minimum Voltage and Maximum Voltage values advertised in the PPS APDO for all static and dynamic load conditions during Current Foldback operation. The PPS is not expected to deliver power if the load condition results in an output voltage that is lower than the Minimum Voltage value advertised in the PPS APDO. Rather, the Source ***Shall*** send ***Hard Reset*** Signaling and discharge V_{BUS} to ***vSafe0V*** then resume default operation at ***vSafe5V***.

The relationship between PPS programmable output voltage and PPS programmable Current Foldback ***Shall*** be as shown in Figure 7-7.

Figure 7-7 PPS Programmable Voltage and Foldback



7.1.5 Response to Hard Resets

Hard Reset Signaling indicates a communication failure has occurred and the Source ***Shall*** stop driving VCONN, ***Shall*** remove Rp from the VCONN pin and ***Shall*** drive V_{BUS} to ***vSafe0V*** as shown in Figure 7-8. The USB connection ***May*** reset during a Hard Reset since the V_{BUS} voltage will be less than ***vSafe5V*** for an extended period of time. After establishing the ***vSafe0V*** voltage condition on V_{BUS}, the Source ***Shall*** wait ***tSrcRecover*** before re-applying VCONN and restoring V_{BUS} to ***vSafe5V***. A Source ***Shall*** conform to the VCONN timing as specified in ***[USB Type-C 1.2]***.

Device operation during and after a Hard Reset is defined as follows:

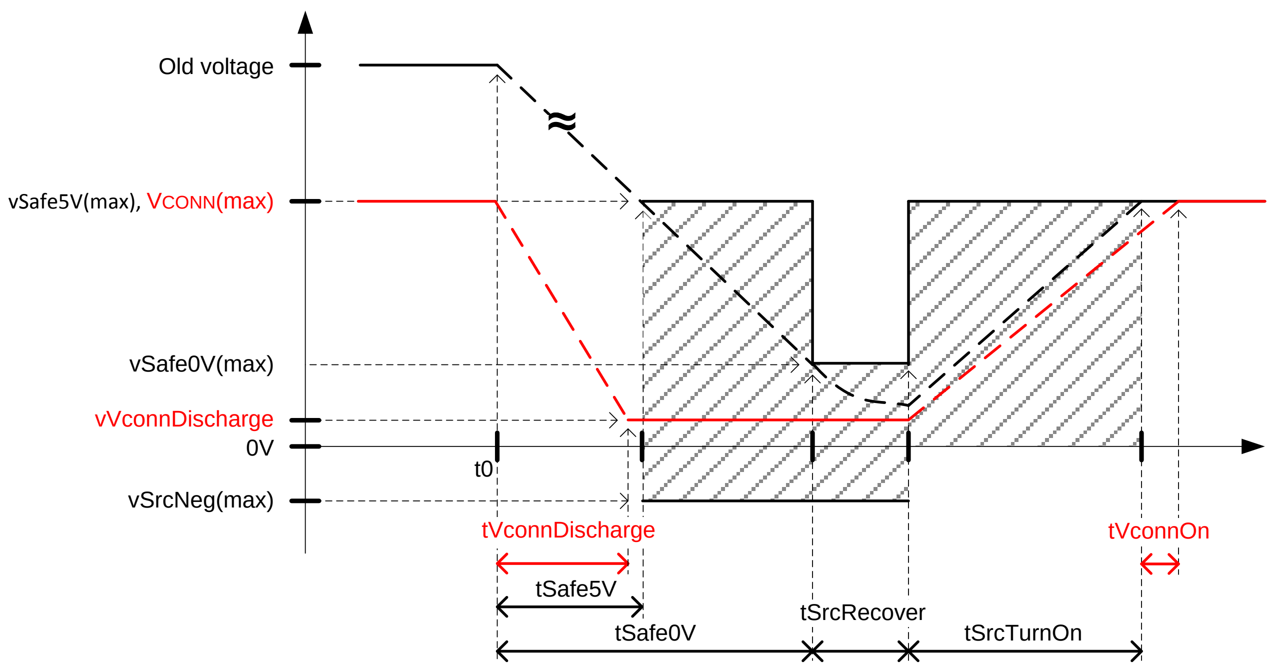
- Self-powered devices ***Should Not*** disconnect from USB during a Hard Reset (see Section 9.1.2).
- Self-powered devices operating at more than ***vSafe5V*** ***May Not*** maintain full functionality after a ***Hard Reset***.
- Bus powered devices will disconnect from USB during a Hard Reset due to the loss of their power source.

When a Hard Reset occurs the Source ***Shall*** stop driving VCONN, ***Shall*** remove Rp from the VCONN pin and ***Shall*** start to transition the V_{BUS} voltage to ***vSafe0V*** either:

- ***tPSHardReset*** after the last bit of the ***Hard Reset*** Signaling has been received from the Sink or
- ***tPSHardReset*** after the last bit of the ***Hard Reset*** Signaling has been sent by the Source.

The Source ***Shall*** meet both ***tSafe5V*** and ***tSafe0V*** relative to the start of the voltage transition as shown in Figure 7-8.

Figure 7-8 Source V_{BUS} and VCONN Response to Hard Reset



VCONN will meet ***tVconnDischarge*** relative to the start of the voltage transition as shown in Figure 7-8 due to the discharge circuitry in the Cable Plug. VCONN ***Shall*** meet ***tVconnOn*** relative to V_{BUS} reaching ***vSafe5V***. Note ***tVconnOn*** and ***tVconnDischarge*** are defined in ***[USB Type-C 1.2]***.

7.1.6 Changing the Output Power Capability

Some USB Power Delivery negotiations will require the Source to adjust its output power capability without changing the output voltage. In this case the Source ***Shall*** be able to supply a higher or lower load current within ***tSrcReady***.

7.1.7 Robust Source Operation

7.1.7.1 Output Over Current Protection

Sources ***Shall*** implement output over current protection to prevent damage from output current that exceeds the current handling capability of the Source. The definition of current handling capability is left to the discretion of the Source implementation and ***Shall*** take into consideration the current handling capability of the connector contacts. The response to over current ***Shall Not*** interfere with the negotiated V_{BUS} current level.

Sources ***Should*** attempt to send a ***Hard Reset*** message when over current protection engages followed by an ***Alert*** Message indicating an OCP event once an Explicit Contract has been established. The over current protection response ***May*** engage at either the port or system level. Systems or ports that have engaged over current protection ***Should*** attempt to resume default operation after determining that the cause of over current is no longer present and ***May*** latch off to protect the port or system. The definition of how to detect if the cause of over current is still present is left to the discretion of the Source implementation.

The Source ***Shall*** renegotiate with the Sink (or Sinks) after choosing to resume default operation. The decision of how to renegotiate after an over current event is left to the discretion of the Source implementation.

The Source ***Shall*** prevent continual system or port cycling if over current protection continues to engage after initially resuming either default operation or renegotiation. Latching off the port or system is an acceptable response to recurring over current.

During the over current response and subsequent system or port shutdown, all affected Source ports operating with V_{BUS} greater than ***vSafe5V*** ***Shall*** discharge V_{BUS} to ***vSafe5V*** by the time ***tSafe5V*** and ***vSafe0V*** by the time ***tSafe0V***.

7.1.7.2 Over Temperature Protection

Sources ***Shall*** implement over temperature protection to prevent damage from temperature that exceeds the thermal capability of the Source. The definition of thermal capability and the monitoring locations used to trigger the over temperature protection are left to the discretion of the Source implementation.

Sources ***Should*** attempt to send a ***Hard Reset*** message when over temperature protection engages followed by an ***Alert*** Message indicating an OTP event once an Explicit Contract has been established. The over temperature protection response ***May*** engage at either the port or system level. Systems or ports that have engaged over temperature protection ***Should*** attempt to resume default operation and ***May*** latch off to protect the port or system.

The Source ***Shall*** renegotiate with the Sink (or Sinks) after choosing to resume default operation. The decision of how to renegotiate after an over temperature event is left to the discretion of the Source implementation.

The Source ***Shall*** prevent continual system or port cycling if over temperature protection continues to engage after initially resuming either default operation or renegotiation. Latching off the port or system is an acceptable response to recurring over temperature.

During the over temperature response and subsequent system or port shutdown, all affected Source ports operating with V_{BUS} greater than ***vSafe5V*** ***Shall*** discharge V_{BUS} to ***vSafe5V*** by the time ***tSafe5V*** and ***vSafe0V*** by the time ***tSafe0V***.

7.1.7.3 vSafe5V Externally Applied to Ports Supplying vSafe5V

Safe operation mandates that Power Delivery Sources ***Shall*** be tolerant of ***vSafe5V*** being present on V_{BUS} when simultaneously applying power to V_{BUS}. Normal USB PD communication ***Shall*** be supported when this ***vSafe5V*** to ***vSafe5V*** connection exists.

7.1.7.4 Detach

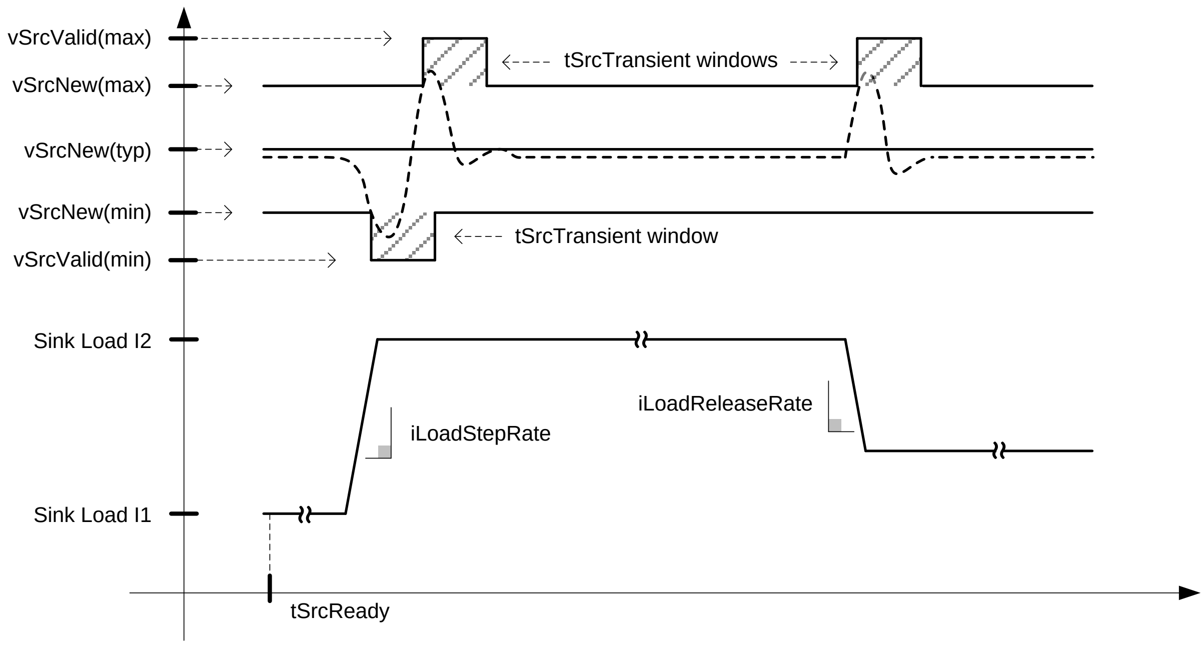
A USB Detach is detected electrically using CC detection on the USB Type-C connector. When the Source is Detached the Source ***Shall*** transition to ***vSafe0V*** by ***tSafe0V*** relative to when the Detach event occurred. During the transition to ***vSafe0V*** the V_{BUS} voltage ***Shall*** be below ***vSafe5V*** max by ***tSafe5V*** relative to when the Detach event occurred and ***Shall Not*** exceed ***vSafe5V*** max after this time.

7.1.8 Output Voltage Tolerance and Range

After a voltage transition is complete (i.e. after ***tSrcReady***) and during static load conditions the Source output voltage ***Shall*** remain within the ***vSrcNew*** or ***vSafe5V*** limits as applicable. The ranges defined by ***vSrcNew*** and ***vSafe5V*** account for DC regulation accuracy, line regulation, load regulation and output ripple. After a voltage transition is complete (i.e. after ***tSrcReady***) and during transient load conditions the Source output voltage ***Shall Not*** go beyond the range specified by ***vSrcValid***. The amount of time the Source output voltage can be in the band between either ***vSrcNew*** or ***vSafe5V*** and ***vSrcValid*** ***Shall Not*** exceed ***tSrcTransient***. Refer to Table 7-19 for the output voltage tolerance specifications. Figure 7-9 illustrates the application of ***vSrcNew*** and ***vSrcValid*** after the voltage transition is complete.

The ***vSrcNew*** and ***vSrcValid*** limits ***Shall Not*** apply to V_{BUS} during the V_{BUS} discharge and switchover that occurs during a Fast Role Swap as described in Section 7.1.13.

Figure 7-9 Application of vSrcNew and vSrcValid limits after tSrcReady



The Source output voltage ***Shall*** be measured at the connector receptacle. The stability of the Source ***Shall*** be tested in 25% load step increments from minimum load to maximum load and also from maximum load to minimum load. The transient behavior of the load current is defined in Section 7.2.6. The time between each step ***Shall*** be sufficient to allow for the output voltage to settle between load steps. In some systems it might be necessary to design the Source to compensate for the voltage drop between the output stage of the power supply electronics and the receptacle contact. The determination of whether compensation is necessary is left to the discretion of the Source implementation.

7.1.8.1 Programmable Power Supply Output Voltage Tolerance and Range

After a voltage transition of a Programmable Power Supply is complete (i.e. after ***tPpsSrcTransition***) and during static load conditions the Source output voltage ***Shall*** remain within the ***vPpsNew*** limits. The range defined by ***vPpsNew*** accounts for DC regulation accuracy, line regulation, load regulation and output ripple. After a voltage transition is complete (i.e. after ***tPpsSrcTransition***) and during transient load conditions the Source output voltage ***Shall Not*** go beyond the range specified by ***vPpsValid***. The amount of time the Source output voltage can be in the band between ***vPpsNew*** and ***vPpsValid*** ***Shall Not*** exceed ***tPpsTransient***.

7.1.9 Charging and Discharging the Bulk Capacitance on V_{BUS}

The Source ***Shall*** charge and discharge the bulk capacitance on V_{BUS} whenever the Source voltage is negotiated to a different value. The charging or discharging occurs during the voltage transition and ***Shall Not*** interfere with the Source's ability to meet ***tSrcReady***.

7.1.10 Swap Standby for Sources

Sources and Sinks of a Dual-Role Power Port ***Shall*** support Swap Standby. Swap Standby occurs for the Source after the Source power supply has discharged the bulk capacitance on V_{BUS} to ***vSafe0V*** as part of the Power Role Swap transition.

While in Swap Standby:

- The Source ***Shall Not*** drive V_{BUS} that is therefore expected to remain at ***vSafe0V***.

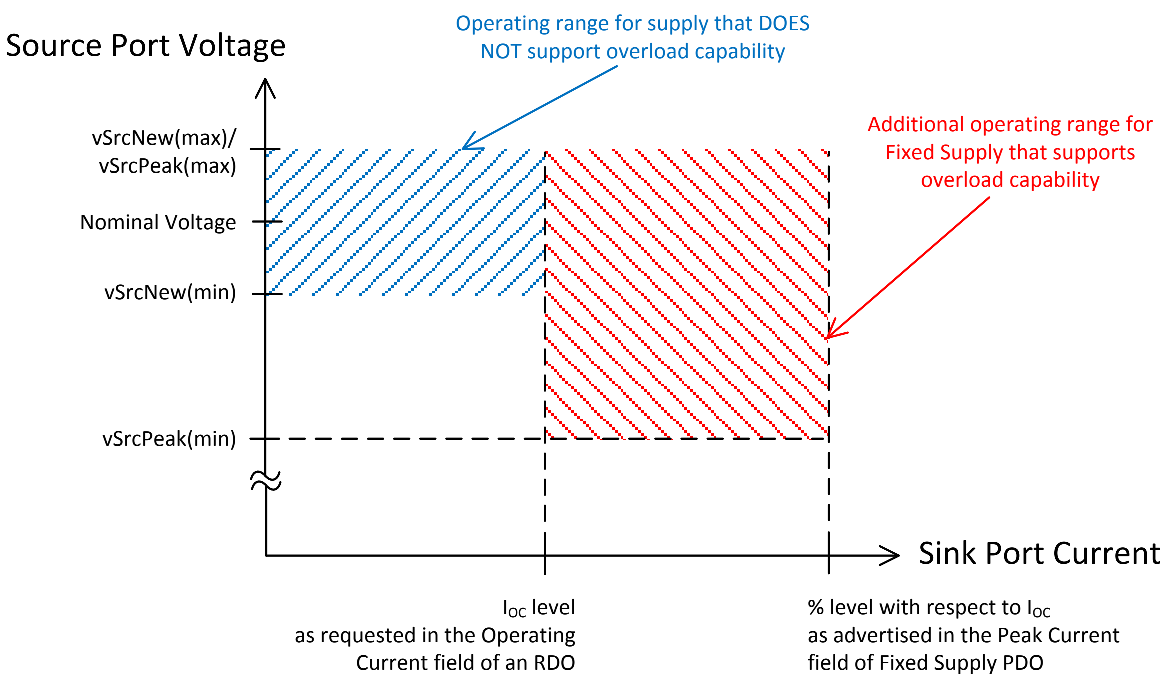
- Any discharge circuitry that was used to achieve ***vSafe0V*** ***Shall*** be removed from V_{BUS}.
- The Dual-Role Power Port ***Shall*** be configured as a Sink.
- The USB connection ***Shall Not*** reset even though ***vSafe5V*** is no longer present on V_{BUS} (see Section 9.1.2).

The ***PS_RDY*** Message associated with the Source being in Swap Standby ***Shall*** be sent after the V_{BUS} drive is removed. The time for the Source to transition to Swap Standby ***Shall Not*** exceed ***tSrcSwapStdby***. Upon entering Swap Standby the Source has relinquished its role as Source and is ready to become the new Sink. The transition time from Swap Standby to being the new Sink ***Shall*** be no more than ***tNewSnk***. The new Sink ***May*** start using power after the new Source sends the ***PS_RDY*** Message.

7.1.11 Source Peak Current Operation

A Source that has the Fixed Supply PDO Peak Current bits set to 01b, 10b and 11b ***Shall*** be designed to support one of the overload capabilities defined in Table 6-10. The overload conditions are bound in magnitude, duration and duty cycle as listed in Table 6-10. Sources are not required to support continuous overload operation. When overload conditions occur, the Source is allowed the range of ***vSrcPeak*** (instead of ***vSrcNew)*** relative to the nominal value (see Figure 7-10). When the overload capability is exceeded, the Source is expected take whatever action is necessary to prevent electrical or thermal damage to the Source. The Source ***May*** send a new ***Source_Capabilities*** Message with the Fixed Supply PDO Peak Current bits set to 00b to prohibit overload operation even if an overload capability was previously negotiated with the Sink.

Figure 7-10 Source Peak Current Overload



7.1.12 Source Capabilities Extended Parameters

Implementers can choose to make available certain characteristics of a USB PD Source as a set of static and/or dynamic parameters to improve interoperability between external power sources and portable computing devices. The complete list of reportable static parameters are described in full in Section 6.5.1 and listed in Figure 6-30. The subset of parameters listed below directly represent Source capabilities and are described in the rest of this section.

- Voltage Regulation.
- Holdup Time.
- Compliance.
- Peak Current.
- Source Inputs.
- Batteries.

7.1.12.1 Voltage Regulation Field

The power consumption of a device can change dynamically. The ability of the Source to regulate its voltage output might be important if the device is sensitive to fluctuations in voltage. The Voltage Regulation bit field is used to convey information about the Sources output regulation and tolerance to various load steps.

7.1.12.1.1 Load Step Slew Rate

The default load step slew rate is established at 150mA/µs. A Source ***Shall*** meet the following requirements under the load step reported in the Extended Source Capabilities:

- The Source ***Shall*** maintain V_{BUS} regulation within the ***vSrcValid*** range.
- The noise on the CC line ***Shall*** remain below ***vNoiseIdle*** and ***vNoiseActive.***

Test conditions require a change in both positive and negative load steps from 1Hz to 5000Hz, up to the advertised Load Step Magnitude of the full load output including from both 10 mA and 10% initial load. The Source ***Shall*** ensure that PD Communications meet the transmit and receive masks as specified in Section 5.8.2 under all load conditions.

7.1.12.1.2 Load Step Magnitude

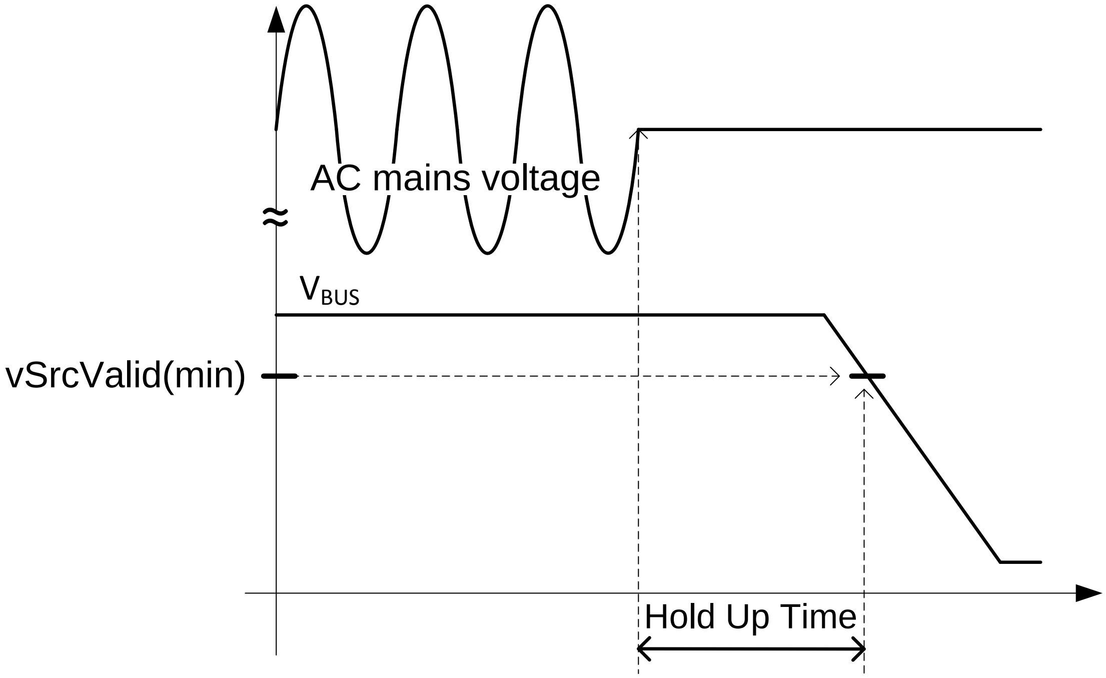
The default load step magnitude rate ***Shall*** be 25% of IoC. The Source ***May*** report higher capability tolerating a load step of 90% of IoC.

7.1.12.2 Holdup Time Field

The Holdup Time field ***Shall*** return a numeric value of the number of milliseconds the output voltage stays in regulation upon a short interruption of AC mains.

A mains supplied Source ***Shall*** report its holdup time in this field. The holdup time is measured with the load at rated maximum, with AC mains at 115VAC rms and 60Hz (or at 230VAC rms and 50Hz for a Source that does not support 115VAC mains). The reported time describes the minimum length of time from the last completed AC mains input cycle (zero degree phase angle) until when the output voltage decays below ***vSrcValid***(min). Power sources are recommended to support a minimum of 3ms and are preferred to support over 10 milliseconds holdup time (equivalent to a half cycle drop from the AC Mains).

Figure 7-11 Holdup Time Measurement



7.1.12.3 Compliance Field

A Source claiming LPS, PS1 or PS2 compliance (see ***[IEC 62368-1]***) ***Shall*** report its capabilities in the Compliance field. Since the Source ***May*** have several potential output voltage and current settings, every Source supply (indicated by a PDO) ***Shall*** be compliant to LPS requirements.

Note: according to the requirements of ***[IEC 60950-1]***, a device tested and certified with an LPS Source is prohibited to use a non-LPS Source. Alternatively, ***[IEC 62368-1]***, classifies power sources according to their maximum, constrained power output (15watts or 100watts).

7.1.12.4 Peak Current

The Source reports its ability to source peak current delivery in excess of the negotiated amount in the Peak Current field. The duration of peak current ***Shall*** be followed by a current consumption below the Operating Current (IoC) in order to maintain average power delivery below the IoC current.

A Source ***May*** have greater capability to source peak current than can be reported using the Peak Current field in the Fixed Supply PDO. In this case the Source ***Shall*** report its additional capability in the Peak Current field in the ***Source_Capabilities_Extended*** Message.

Each overload period ***Shall*** be followed by a period of reduced current draw such that the rolling average current over the Overload Period field value with the specified Duty Cycle field value (see Section 6.5.1.8) ***Shall Not*** exceed the negotiated current. This is calculated as:

*Period of reduced current = (1 – value in Duty Cycle field/100) * value in Overload Period field*

7.1.12.5 Source Inputs

The Source Inputs field identifies the possible inputs that provide power to the Source. Note some Sources are only powered by a Battery (e.g., an automobile) rather than the more common mains.

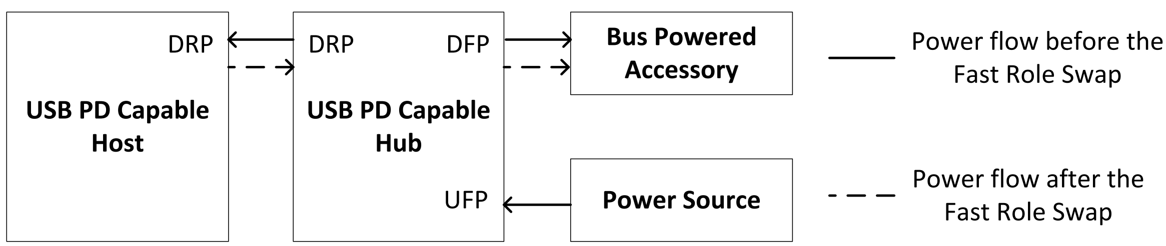
7.1.12.6 Batteries

The Batteries field ***Shall*** report the number of Batteries the Source supports. The Source ***Shall*** independently report the number of Hot Swappable Batteries and the number of Fixed batteries.

7.1.13 Fast Role Swap

A Fast Role Swap limits the interruption of V_{BUS} power to a bus powered accessory connected to a Hub DFP that has a UFP attached to a power source and a DRP attached to a Host port supporting DRP as shown in Figure 7-12 V_{BUS} Power during Fast Role Swap

Figure 7-12 V_{BUS} Power during Fast Role Swap



When the power source connected to the Hub UFP stops sourcing power and V_{BUS} at the Hub DRP connector discharges below ***vSrcValid***(min), if V_{BUS} has been negotiated to a higher voltage than***vSafe5V***, or ***vSafe5V*** (min) the Fast Role Swap signal ***Shall*** be sent from the Hub DRP to the Host DRP and the Hub DRP ***Shall*** sink power. In the Fast Role Swap use case, the Hub DRP behaves like a bidirectional power path. The Hub DRP ***Shall Not*** enable V_{BUS} discharge circuitry when changing operation from initial Source to new Sink.

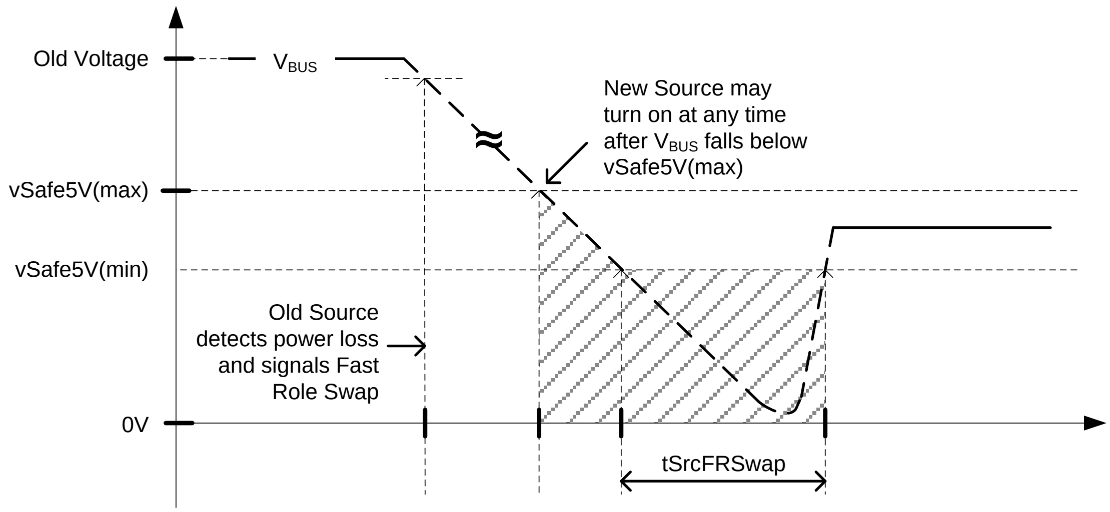
The new Sink ***Shall*** be limited to USB Type-C Current (see ***[USB Type-C 1.2]***) until a new Explicit Contract is negotiated. All Sink requirements ***Shall*** apply to the new Sink after the Fast Role Swap is complete. The Fast Role Swap response of the Host DRP is described in Section 7.2.10 since the Host DRP is operating as the initial Sink prior to the Fast Role Swap.

After the V_{BUS} voltage level at the Hub DRP connector drops below ***vSafe5V*** a ***PS_RDY*** Message ***Shall*** be sent to the Host DRP as shown in the Fast Role Swap transition diagram of Section 7.3.15.

Figure 7-13 shows the V_{BUS} detection and timing for the new Source during a Fast Role Swap after the Fast Role Swap signal has been received. The new Source ***May*** turn on the V_{BUS} output switch once V_{BUS} is below ***vSafe5V*** (max). In this case, the new Source prevents V_{BUS} from falling below ***vSafe5V*** (min). The new source ***Shall*** turn on the V_{BUS} output switch within ***tSrcFRSwap*** of falling below ***vSafe5V*** (min).

Note: V_{BUS} might have started at ***vSafe5V*** or at higher voltage. When the Fast Role Swap Signal is detected, V_{BUS} could therefore be either above ***vSafe5V*** (max), within the ***vSafe5V*** range, or below ***vSafe5V*** (min).

Figure 7-13 V_{BUS} detection and timing during Fast Role Swap



7.1.14 Non-application of V_{BUS} Slew Rate Limits

Scenarios where V_{BUS} slew rate limits do not apply and V_{BUS} ***May*** transition faster than specified are as follows:

- When first applying V_{BUS} to a port operating as DFP.
- When discharging V_{BUS} to ***vSafe0V*** during a Hard Reset.
- When increasing V_{BUS} from ***vSafe0V*** to ***vSafe5V*** during a Hard Reset.
- During a Fast Role Swap when the V_{BUS} power source connected to the Hub UFP stops sourcing power.

7.2 Sink Requirements

7.2.1 Behavioral Aspects

A USB PD Sink exhibits the following behaviors.

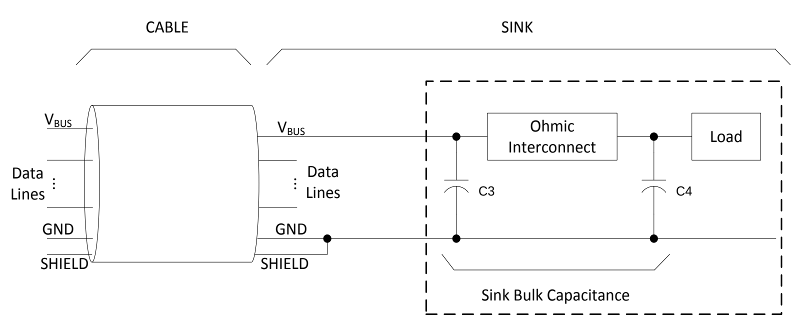
- ***Shall*** be backward compatible with legacy V_{BUS} ports.
- ***Shall*** draw the default ***[USB 2.0]***, ***[USB 3.1]***, ***[USB Type-C 1.2]*** or ***[USBBC 1.2]*** V_{BUS} current when the USB cable is Attached (USB Default Operation).
- ***Shall*** draw the default ***[USB 2.0]***, ***[USB 3.1]***, ***[USB Type-C 1.2]*** or ***[USBBC 1.2]*** V_{BUS} current when a Contract does not exist (USB Default Operation).
- ***Shall*** return to the default ***[USB 2.0]***, ***[USB 3.1]***, ***[USB Type-C 1.2]*** or ***[USBBC 1.2]*** V_{BUS} when responding to a Hard Reset (USB Default Operation).
- ***Shall*** control V_{BUS} in-rush current when increasing current consumption.

7.2.2 Sink Bulk Capacitance

The Sink bulk capacitance consists of C3 and C4 as shown in Figure 7-14. The Ohmic Interconnect might consist of PCB traces for power distribution or power switching devices. The capacitance might be a single capacitor, a capacitor bank or distributed capacitance. An upper bound of ***cSnkBulkPd*** ***Shall Not*** be exceeded so that the transient charging, or discharging, of the total bulk capacitance on V_{BUS} can be accounted for during voltage transitions.

The Sink bulk capacitance that is within the ***cSnkBulk*** max or ***cSnkBulkPd*** max limits is allowed to change to support a newly negotiated power level. The capacitance can be changed when the Sink enters Sink Standby or during a voltage transition or when the Sink begins to operate at the new power level. Changing the Sink bulk capacitance ***Shall Not*** cause a transient current on V_{BUS} that violates the present Contract. During a Power Role Swap the Default Sink ***Shall*** transition to Swap Standby before operating as the new Source. Any change in bulk capacitance required to complete the Power Role Swap ***Shall*** occur during Swap Standby.

Figure 7-14 Placement of Sink Bulk Capacitance



7.2.3 Sink Standby

The Sink ***Shall*** transition to Sink Standby before a positive or negative voltage transition of V_{BUS}. During Sink Standby the Sink ***Shall*** reduce its power draw to ***pSnkStdby.*** This allows the Source to manage the voltage transition as well as supply sufficient operating current to the Sink to maintain PD operation during the transition. The Sink ***Shall*** complete this transition to Sink Standby within ***tSnkStdby*** after evaluating the ***Accept*** Message from the Source. The transition when returning to Sink operation from Sink Standby ***Shall*** be completed within ***tSnkNewPower***. The ***pSnkStdby*** requirement ***Shall*** only apply if the Sink power draw is higher than this level.

See Section 7.3 for details of when ***pSnkStdby*** ***Shall*** be applied for any given transition.

7.2.3.1 Programmable Power Supply Sink Standby

A Sink is not required to transition to Sink Standby when operating within the negotiated PPS APDO. A Sink ***May*** consume the Operating Current value in the Programmable RDO during PPS output voltage changes. However, prior to operating the PPS in current foldback, the Sink ***Shall*** program the PPS Operating Voltage to the lowest practical level that satisfies the Sink load requirement. Doing so will minimize the inrush current that occurs when the transition to current foldback occurs. When operating with a PPS that is in current foldback, the Sink ***Shall Not*** change its load in a manner that exceeds ***iPpsCfLoadStepRate*** or ***iPpsCfLoadReleaseRate***. The load change magnitude ***Shall Not*** exceed ***iPpsCfLoadStep*** or ***iPpsCfLoadRelease***.

If the Sink negotiates for a new PPS APDO, then the Sink ***Shall*** transition to Sink Standby while changing between PPS APDOs as described in Section 7.3.18.

7.2.4 Suspend Power Consumption

When Source has set its USB Suspend Supported flag (see Section 6.4.1.2.2.2), a Sink ***Shall*** go to the lowest power state during USB suspend. The lowest power state ***Shall*** be ***pSnkSusp*** or lower for a PDUSB Peripheral and ***pHubSusp*** or lower for a PDUSB Hub. There is no requirement for the Source voltage to be changed during USB suspend.

7.2.5 Zero Negotiated Current

When a Sink Requests zero current as part of a power negotiation with a Source, the Sink ***Shall*** go to the lowest power state, ***pSnkSusp*** or lower, where it can still communicate using PD signaling.

7.2.6 Transient Load Behavior

When a Sink's operating current changes due to a load step, load release or any other change in load level, the positive or negative overshoot of the new load current ***Shall Not*** exceed the range defined by ***iOvershoot***. For the purposes of measuring ***iOvershoot*** the new load current value is defined as the average steady state value of the load current after the load step has settled. The rate of change of any shift in Sink load current during normal operation ***Shall Not*** exceed ***iLoadStepRate*** (for load steps) and ***iLoadReleaseRate*** (for load releases) as measured at the Sink receptacle.

The Sink's operating current ***Shall Not*** change faster than the value reported in the Source's Load Step Slew Rate field and ***Shall*** ensure that PD Communications meet the transmit and receive masks as specified in Section 5.8.2.

7.2.7 Swap Standby for Sinks

The Sink capability in a Dual-Role Power Port ***Shall*** support Swap Standby. Swap Standby occurs for the Sink after evaluating the ***Accept*** Message from the Source during a Power Role Swap negotiation. While in Swap Standby the Sink's current draw ***Shall Not*** exceed ***iSnkSwapStdby*** from V_{BUS} and the Dual-Role Power Port ***Shall*** be configured as a Source after V_{BUS} has been discharged to ***vSafe0V*** by the existing Initial Source. The Sink's USB connection ***Should Not*** be reset even though ***vSafe5V*** is not present on the V_{BUS} conductor (see Section 9.1.2). The time for the Sink to transition to Swap Standby ***Shall*** be no more than ***tSnkSwapStdby***. When in Swap Standby the Sink has relinquished its role as Sink and will prepare to become the new Source. The transition time from Swap Standby to new Source ***Shall*** be no more than ***tNewSrc***.

7.2.8 Sink Peak Current Operation

Sinks ***Shall*** only make use of a Source overload capability when the corresponding Fixed Supply PDO Peak Current bits are set to 01b, 10b and 11b (see Section 6.4.1.2.2.7). Sinks ***Shall*** manage thermal aspects of the overload event by not exceeding the average negotiated output of a Fixed Supply that supports Peak Current operation.

Sinks that depend on the Peak Current capability for enhanced system performance ***Shall*** also function correctly when Attached to a Source that does not offer the Peak Current capability or when the Peak Current capability has been inhibited by the Source.

7.2.9 Robust Sink Operation

7.2.9.1 Sink Bulk Capacitance Discharge at Detach

When a Source is Detached from a Sink, the Sink ***Shall*** continue to draw power from its input bulk capacitance until V_{BUS} is discharged to ***vSafe5V*** or lower by no longer than ***tSafe5V*** from the Detach event. This safe Sink requirement ***Shall*** apply to all Sinks operating with a negotiated V_{BUS} level greater than ***vSafe5V*** and ***Shall*** apply during all low power and high power operating modes of the Sink.

If the Detach is detected during a Sink low power state, such as USB Suspend, the Sink can then draw as much power as needed from its bulk capacitance since a Source is no longer Attached. In order to achieve a successful Detach detect based on V_{BUS} voltage level droop, the Sink power consumption ***Shall*** be high enough so that V_{BUS} will decay below ***vSrcValid***(min) well within ***tSafe5V*** after the Source bulk capacitance is removed due to the Detach. Once adequate V_{BUS} droop has been achieved, a discharge circuit can be enabled to meet the safe Sink requirement.

To illustrate the point, the following set of Sink conditions will not meet the safe Sink requirement without additional discharge circuitry:

- Negotiated V_{BUS} = 20V.
- Maximum allowable supplied V_{BUS} voltage = 21.5V.
- Maximum bulk capacitance = 30µF.
- Power consumption at Detach = 12.5mW.

When the Detach occurs (hence removal of the Source bulk capacitance) the 12.5mW power consumption will draw down the V_{BUS} voltage from the worst-case maximum level of 21.5V to 17V in approximately 205ms. At this point, with V_{BUS} well below ***vSrcValid*** (min) an approximate 100mW discharge circuit can be enabled to increase the rate of Sink bulk capacitance discharge and meet the safe Sink requirement. The power level of the discharge circuit is dependent on how much time is left to discharge the remaining voltage on the Sink bulk capacitance. If a Sink has the ability to detect the Detach in a different manner and in much less time than ***tSafe5V***, then this different manner of detection can be used to enable a discharge circuit, allowing even lower power dissipation during low power modes such as USB Suspend.

In most applications, the safe Sink requirement will limit the maximum Sink bulk capacitance well below the ***cSnkBulkPd*** limit. A Detach occurring during Sink high power operating modes must quickly discharge the Sink bulk capacitance to ***vSafe5V*** or lower as long as the Sink continues to draw adequate power until V_{BUS} has decayed to ***vSafe5V*** or lower.

7.2.9.2 Input Over Voltage Protection

Sinks ***Shall*** implement input over voltage protection to prevent damage from input voltage that exceeds the voltage handling capability of the Sink. The definition of voltage handling capability is left to the discretion of the Sink implementation. The response to over voltage ***Shall Not*** interfere with the negotiated V_{BUS} voltage level.

Sinks ***Should*** attempt to send a ***Hard Reset*** message when over voltage protection engages followed by an ***Alert*** Message indicating an OVP event once an Explicit Contract has been established. The over voltage protection response ***May*** engage at either the port or system level. Systems or ports that have engaged over voltage protection ***Shall*** resume default operation when the Source has re-established ***vSafe5V*** on V_{BUS}.

The Sink ***Shall*** be able to renegotiate with the Source after resuming default operation. The decision of how to respond to renegotiation after an over voltage event is left to the discretion of the Sink implementation.

The Sink ***Shall*** prevent continual system or port cycling if over voltage protection continues to engage after initially resuming either default operation or renegotiation. Latching off the port or system is an acceptable response to recurring over voltage.

7.2.9.3 Over Temperature Protection

Sinks ***Shall*** implement over temperature protection to prevent damage from temperature that exceeds the thermal capability of the Sink. The definition of thermal capability and the monitoring locations used to trigger the over temperature protection are left to the discretion of the Sink implementation.

Sinks ***Shall*** attempt to send a ***Hard Reset*** message when over temperature protection engages followed by an ***Alert*** Message indicating an OTP event once an Explicit Contract has been established. The over temperature protection response ***May*** engage at either the port or system level. Systems or ports that have engaged over temperature protection ***Should*** attempt to resume default operation after sufficient cooling is achieved and ***May*** latch off to protect the port or system. The definition of sufficient cooling is left to the discretion of the Sink implementation.

The Sink ***Shall*** be able to renegotiate with the Source after resuming default operation. The decision of how to respond to renegotiation after an over temperature event is left to the discretion of the Sink implementation.

The Sink ***Shall*** prevent continual system or port cycling if over temperature protection continues to engage after initially resuming either default operation or renegotiation. Latching off the port or system is an acceptable response to recurring over temperature.

7.2.9.4 Over Current Protection

Sinks that operate with a Programmable Power Supply ***Shall*** implement their own internal current protection mechanism to protect against internal V_{BUS} current faults as well as erratic Source current regulation. The Sink ***Shall*** never draw higher current than the Maximum Current value in the PPS APDO.

7.2.10 Fast Role Swap

As described in Section 7.1.13 a Fast Role Swap limits the interruption of V_{BUS} power to a bus powered accessory connected to a Hub DFP that has a UFP attached to a power source and a DRP attached to a Host port that supports DRP. This configuration is shown in Figure 7-12 V_{BUS} Power during Fast Role Swap

When the Host DRP that supports Fast Role Swap detects the Fast Role Swap signal, the Host DRP ***Shall*** stop sinking current and ***Shall*** be ready and able to source ***vSafe5V*** if the residual V_{BUS} voltage level at the Host DRP connector is greater than ***vSafe5V***. When the residual V_{BUS} voltage level at the Host DRP connector discharges below ***vSafe5V***(min) the Host DRP as the new Source ***Shall*** supply ***vSafe5V*** to the Hub DRP within ***tSrcFRSwap***. The Host DRP ***Shall Not*** enable V_{BUS} discharge circuitry when changing roles from initial Sink to new Source.

The new Source ***Shall*** supply ***vSafe5V*** at USB Type-C Current (see ***[USB Type-C 1.2]***) at the value advertised in the Fast Role Swap USB Type-C Current field (see Section 6.4.1.3.1.6). All Source requirements ***Shall*** apply to the new Source after the Fast Role Swap is complete The Fast Role Swap response of the Hub DRP is described in Section 7.1.13 since the Hub DRP is operating as the initial Source prior to the Fast Role Swap.

After the Host DRP is providing V_{BUS} power to the Hub DRP, a ***PS_RDY*** Message ***Shall*** be sent to the Hub DRP as defined by the Fast Role Swap signaling and messaging sequence detailed in Section 7.3.15.

7.3 Transitions

The following sections illustrate the power supply's response to various types of negotiations. The negotiation cases take into consideration for the examples are as follows:

- Higher Power Transitions
  - Increase the current
  - Increase the voltage
  - Increase the voltage and the current
- Relatively Constant Power Transitions
  - Increase the voltage and decrease the current
  - Decrease the voltage and increase the current
- Lower Power Transitions
  - Decrease the current
  - Decrease the voltage
  - Decrease the voltage and the current
- Power Role Swap Transitions
  - Source requests a Power Role Swap
  - Sink requests a Power Role Swap
- Go To Minimum Current Transition
- Response to ***Hard Reset*** Signaling
  - Source issues ***Hard Reset*** Signaling
  - Sink issues ***Hard Reset*** Signaling
- No change in Current or Voltage.

The transition from ***[USB 2.0]***, ***[USB 3.1]***, ***[USB Type-C 1.2]*** or ***[USBBC 1.2]*** operation into Power Delivery Mode can also lead to a Power Transition since this is the initial Contract negotiation. The following types of Power Transitions ***Shall*** also be applied when moving from ***[USB 2.0]***, ***[USB 3.1]***, ***[USB Type-C 1.2]*** or ***[USBBC 1.2]*** operation into Power Delivery Mode:

- High Power
- Relatively Constant Power
- Lower Power Transitions
- No change in Current or Voltage.

7.3.1 Increasing the Current

The interaction of the System Policy, Device Policy, and power supply that ***Shall*** be followed when increasing the current is shown in Figure 7-15. The sequence that ***Shall*** be followed is described in Table 7-1. The timing parameters that ***Shall*** be followed are listed in Table 7-19 and Table 7-20. Note in this figure, the Sink has previously sent a ***Request*** Message to the Source.

Figure 7-15 Transition Diagram for Increasing the Current

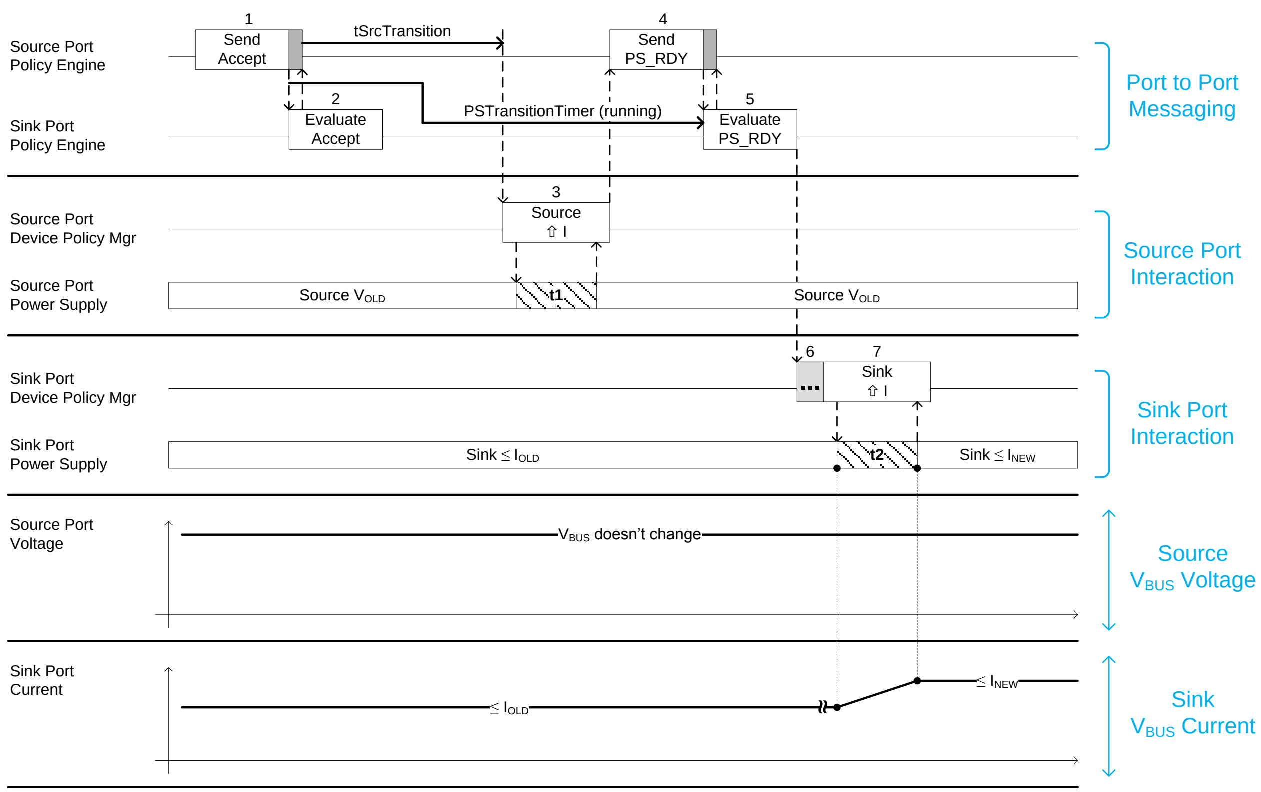


Table 7-1 Sequence Description for Increasing the Current

Step	Source Port	Sink Port
1	Policy Engine sends the ***Accept*** Message to the Sink.	Policy Engine receives the ***Accept*** Message and starts the ***PSTransitionTimer***.
2	Protocol Layer receives the ***GoodCRC*** Message from the Sink. The Policy Engine tells the Device Policy Manager to instruct the power supply to modify its output power.	Protocol Layer sends the ***GoodCRC*** Message to the Source. Policy Engine then evaluates the ***Accept*** Message.
3	***tSrcTransition*** after the ***GoodCRC*** Message was received the power supply starts to change its output power capability. The power supply ***Shall*** be ready to operate at the new power level within ***tSrcReady*** (t1). The power supply informs the Device Policy Manager that it is ready to operate at the new power level. The power supply status is passed to the Policy Engine.	
4	The Policy Engine sends the ***PS_RDY*** Message to the Sink.	The Policy Engine receives the ***PS_RDY*** Message from the Source.
5	Protocol Layer receives the ***GoodCRC*** Message from the Sink.	Protocol Layer sends the ***GoodCRC*** Message to the Source. Policy Engine then evaluates the ***PS_RDY*** Message from the Source and tells the Device Policy Manager it is okay to operate at the new power level.
6		The Sink ***May*** begin operating at the new power level any time after evaluation of the ***PS_RDY*** Message. This time duration is indeterminate.
7		The Sink ***Shall Not*** violate the transient load behavior defined in Section 7.2.6 while transitioning to and operating at the new power level. The time duration (t2) depends on the magnitude of the load change.

7.3.2 Increasing the Voltage

The interaction of the System Policy, Device Policy, and power supply that ***Shall*** be followed when increasing the voltage is shown in Figure 7-16. The sequence that ***Shall*** be followed is described in Table 7-2. The timing parameters that ***Shall*** be followed are listed in Table 7-19, Table 7-20 and Table 7-21. Note in this figure, the Sink has previously sent a ***Request*** Message to the Source.

Figure 7-16 Transition Diagram for Increasing the Voltage

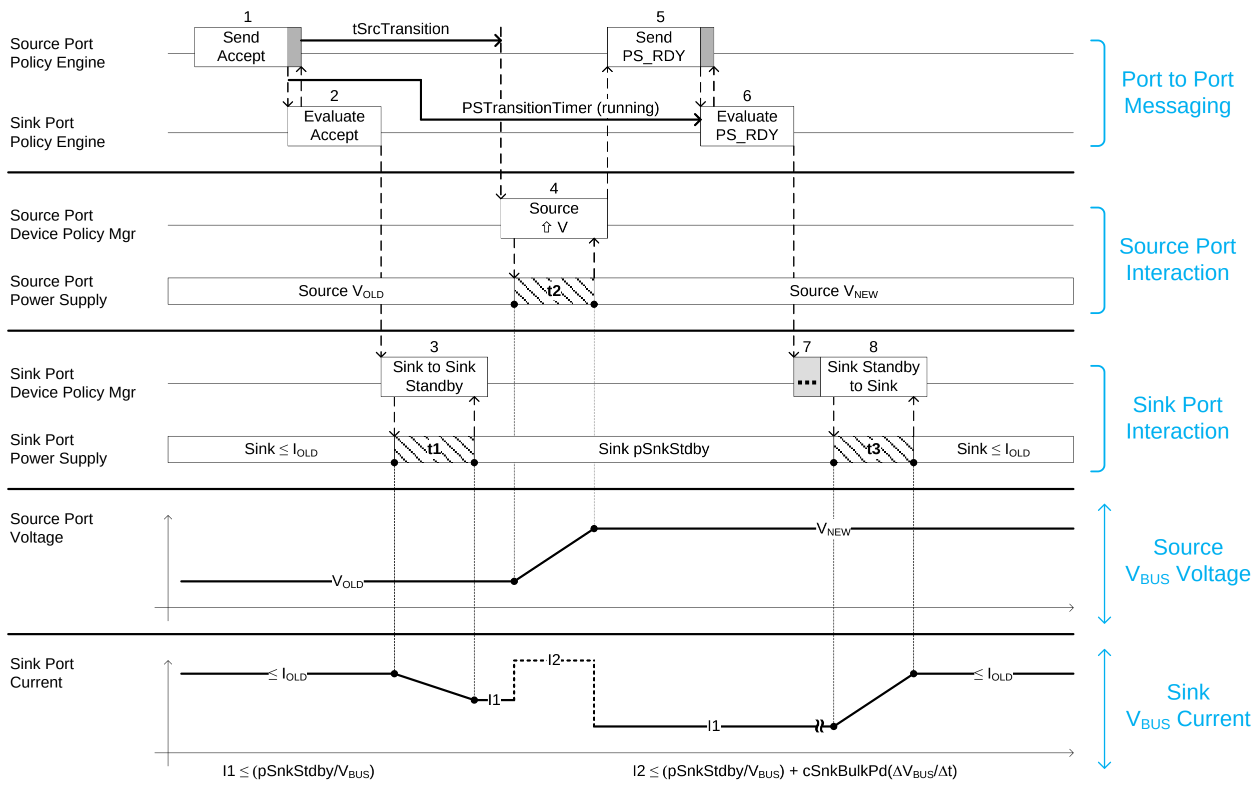


Table 7-2 Sequence Description for Increasing the Voltage

Step	Source Port	Sink Port
1	Policy Engine sends the ***Accept*** Message to the Sink.	Policy Engine receives the ***Accept*** Message and starts the ***PSTransitionTimer***.
2	Protocol Layer receives the ***GoodCRC*** Message from the Sink. The Policy Engine tells the Device Policy Manager to instruct the power supply to modify its output power.	Protocol Layer sends the ***GoodCRC*** Message to the Source. Policy Engine. Policy Engine then evaluates the ***Accept*** Message.
3		Policy Engine tells the Device Policy Manager to instruct the power supply to reduce power consumption to ***pSnkStdby*** within ***tSnkStdby*** (t1); t1 ***Shall*** complete before ***tSrcTransition***. The Sink ***Shall Not*** violate transient load behavior defined in Section 7.2.6 while transitioning to and operating at the new power level.
4	***tSrcTransition*** after the ***GoodCRC*** Message was received the power supply starts to change its output power capability. The power supply ***Shall*** be ready to operate at the new power level within ***tSrcReady*** (t2). The power supply informs the Device Policy Manager that it is ready to operate at the new power level. The power supply status is passed to the Policy Engine.	
5	The Policy Engine sends the ***PS_RDY*** Message to the Sink.	The Policy Engine receives the ***PS_RDY*** Message from the Source.
6	Protocol Layer receives the ***GoodCRC*** Message from the Sink.	Protocol Layer sends the ***GoodCRC*** Message to the Source. Policy Engine then evaluates the ***PS_RDY*** Message from the Source and tells the Device Policy Manager it is okay to operate at the new power level.
7		The Sink ***May*** begin operating at the new power level any time after evaluation of the ***PS_RDY*** Message. This time duration is indeterminate.
8		The Sink ***Shall Not*** violate the transient load behavior defined in Section 7.2.6 while transitioning to and operating at the new power level. The time duration (t3) depends on the magnitude of the load change.

7.3.3 Increasing the Voltage and Current

The interaction of the System Policy, Device Policy, and power supply that ***Shall*** be followed when increasing the voltage and current is shown in Figure 7-17. The sequence that ***Shall*** be followed is described in Table 7-3. The timing parameters that ***Shall*** be followed are listed in Table 7-19, Table 7-20 and Table 7-21. Note in this figure, the Sink has previously sent a ***Request*** Message to the Source.

Figure 7-17 Transition Diagram for Increasing the Voltage and Current

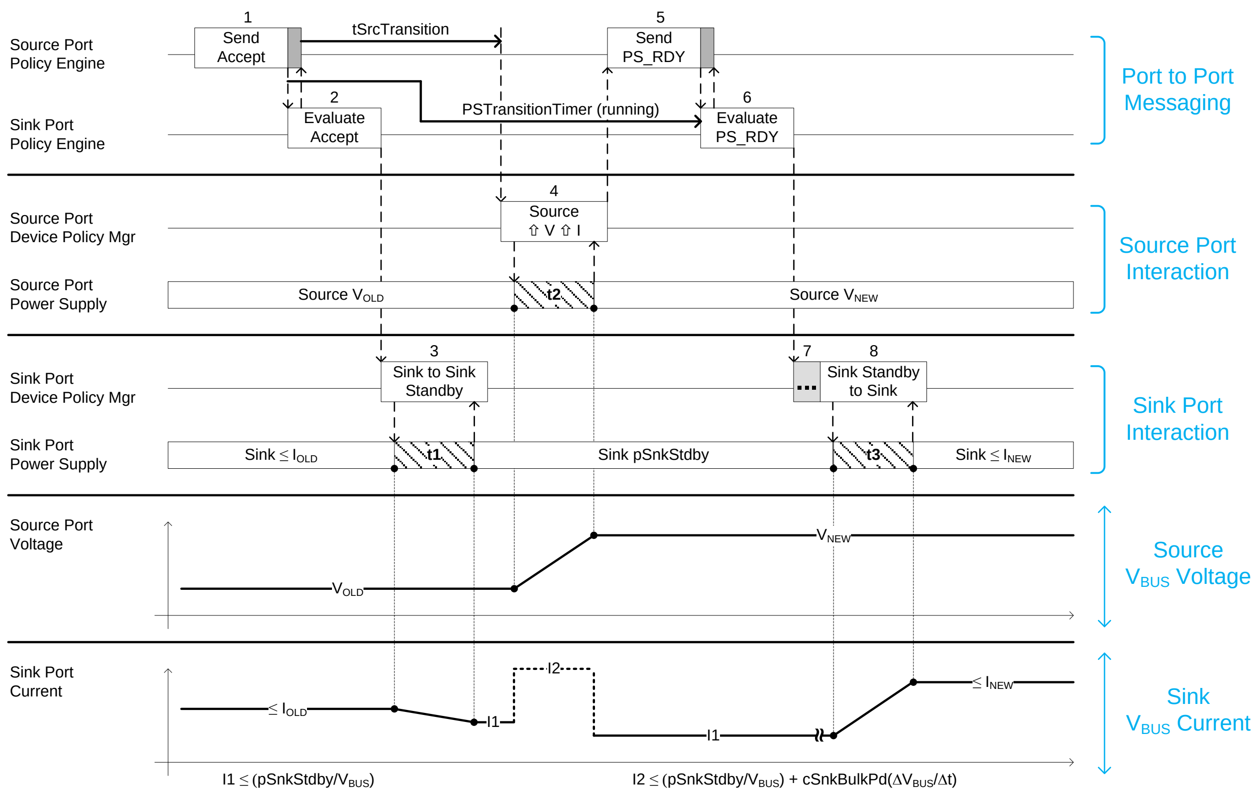


Table 7-3 Sequence Diagram for Increasing the Voltage and Current

Step	Source Port	Sink Port
1	Policy Engine sends the ***Accept*** Message to the Sink.	Policy Engine receives the ***Accept*** Message and starts the ***PSTransitionTimer***.
2	Protocol Layer receives the ***GoodCRC*** Message from the Sink. The Policy Engine tells the Device Policy Manager to instruct the power supply to modify its output power.	Protocol Layer sends the ***GoodCRC*** Message to the Source. Policy Engine then evaluates the ***Accept*** Message.
3		Policy Engine tells the Device Policy Manager to instruct the power supply to reduce power consumption to ***pSnkStdby*** within ***tSnkStdby*** (t1); t1 ***Shall*** complete before ***tSrcTransition***. The Sink ***Shall Not*** violate transient load behavior defined in Section 7.2.6 while transitioning to and operating at the new power level.
4	***tSrcTransition*** after the ***GoodCRC*** Message was received the power supply starts to change its output power capability. The power supply ***Shall*** be ready to operate at the new power level within ***tSrcReady*** (t2). The power supply informs the Device Policy Manager that it is ready to operate at the new power level. The power supply status is passed to the Policy Engine.	
5	The Policy Engine sends the ***PS_RDY*** Message to the Sink.	The Policy Engine receives the ***PS_RDY*** Message from the Source.
6	Protocol Layer receives the ***GoodCRC*** Message from the Sink.	Protocol Layer sends the ***GoodCRC*** Message to the Source. Policy Engine then evaluates the ***PS_RDY*** Message from the Source and tells the Device Policy Manager it is okay to operate at the new power level.
7		The Sink ***May*** begin operating at the new power level any time after evaluation of the ***PS_RDY*** Message. This time duration is indeterminate.
8		The Sink ***Shall Not*** violate the transient load behavior defined in Section 7.2.6 while transitioning to and operating at the new power level. The time duration (t3) depends on the magnitude of the load change.

7.3.4 Increasing the Voltage and Decreasing the Current

The interaction of the System Policy, Device Policy, and power supply that ***Shall*** be followed when increasing the voltage and decreasing the current is shown in Figure 7-18. The sequence that ***Shall*** be followed is described in Table 7-4. The timing parameters that ***Shall*** be followed are listed in Table 7-19, Table 7-20 and Table 7-21. Note in this figure, the Sink has previously sent a ***Request*** Message to the Source.

Figure 7-18 Transition Diagram for Increasing the Voltage and Decreasing the Current

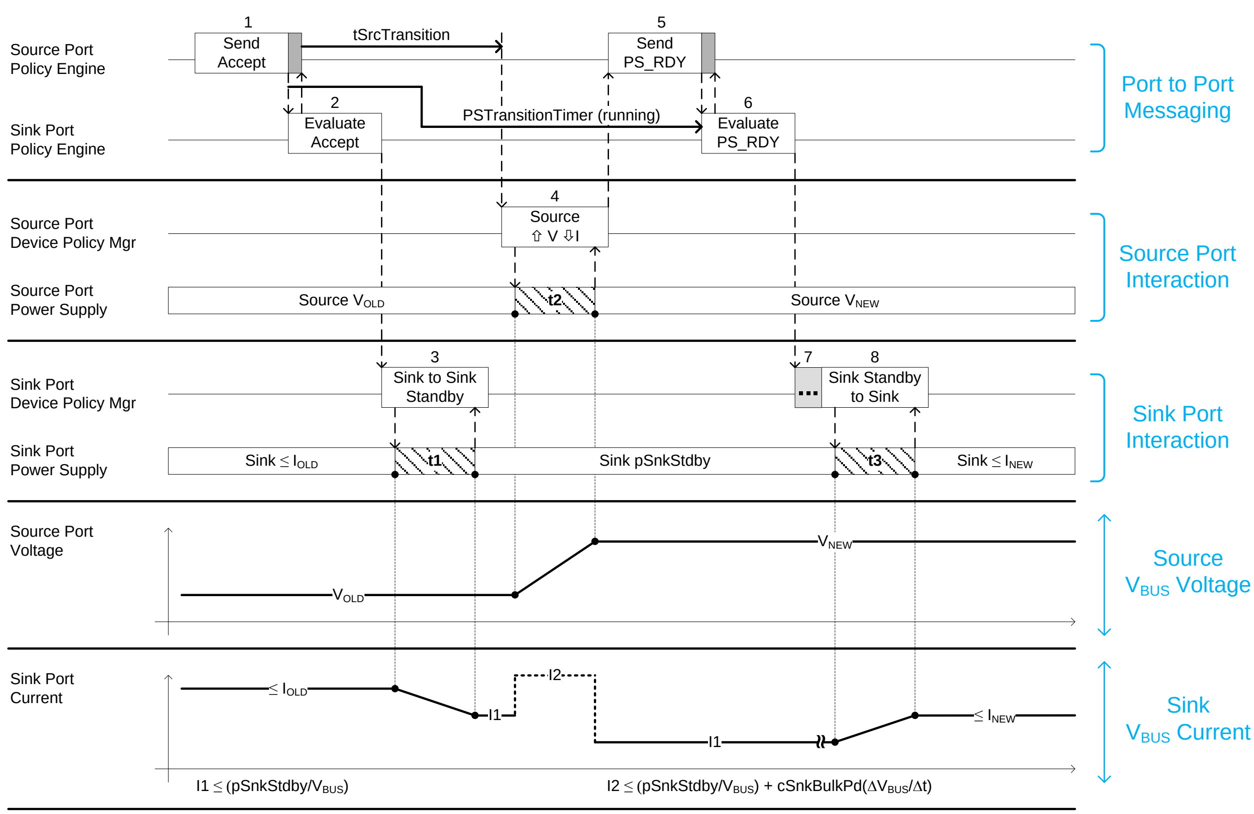


Table 7-4 Sequence Description for Increasing the Voltage and Decreasing the Current

Step	Source Port	Sink Port
1	Policy Engine sends the ***Accept*** Message to the Sink.	Policy Engine evaluates the ***Accept*** Message and starts the ***PSTransitionTimer***.
2	Protocol Layer receives the ***GoodCRC*** Message from the Sink. The Policy Engine tells the Device Policy Manager to instruct the power supply to modify its output power.	Protocol Layer sends the ***GoodCRC*** Message to the Source. Policy Engine then evaluates the ***Accept*** Message.
3		Policy Engine tells the Device Policy Manager to instruct the power supply to reduce power consumption to ***pSnkStdby*** within ***tSnkStdby*** (t1); t1 ***Shall*** complete before ***tSrcTransition***. The Sink ***Shall Not*** violate transient load behavior defined in Section 7.2.6 while transitioning to and operating at the new power level.
4	***tSrcTransition*** after the ***GoodCRC*** Message was received the power supply starts to change its output power capability. The power supply ***Shall*** be ready to operate at the new power level within ***tSrcReady*** (t2). The power supply informs the Device Policy Manager that it is ready to operate at the new power level. The power supply status is passed to the Policy Engine.	
5	The Policy Engine sends the ***PS_RDY*** Message to the Sink.	The Policy Engine receives the ***PS_RDY*** Message from the Source.
6	Protocol Layer receives the ***GoodCRC*** Message from the Sink.	Protocol Layer sends the ***GoodCRC*** Message to the Source. Policy Engine then evaluates the ***PS_RDY*** Message from the Source and tells the Device Policy Manager it is okay to operate at the new power level.
7		The Sink ***May*** begin operating at the new power level any time after evaluation of the ***PS_RDY*** Message. This time duration is indeterminate.
8		The Sink ***Shall Not*** violate the transient load behavior defined in Section 7.2.6 while transitioning to and operating at the new power level. The time duration (t3) depends on the magnitude of the load change.

7.3.5 Decreasing the Voltage and Increasing the Current

The interaction of the System Policy, Device Policy, and power supply that ***Shall*** be followed when decreasing the voltage and increasing the current is shown in Figure 7-19. The sequence that ***Shall*** be followed is described in Table 7-5. The timing parameters that ***Shall*** be followed are listed in Table 7-19, Table 7-20 and Table 7-21. Note in this figure, the Sink has previously sent a ***Request*** Message to the Source.

Figure 7-19 Transition Diagram for Decreasing the Voltage and Increasing the Current

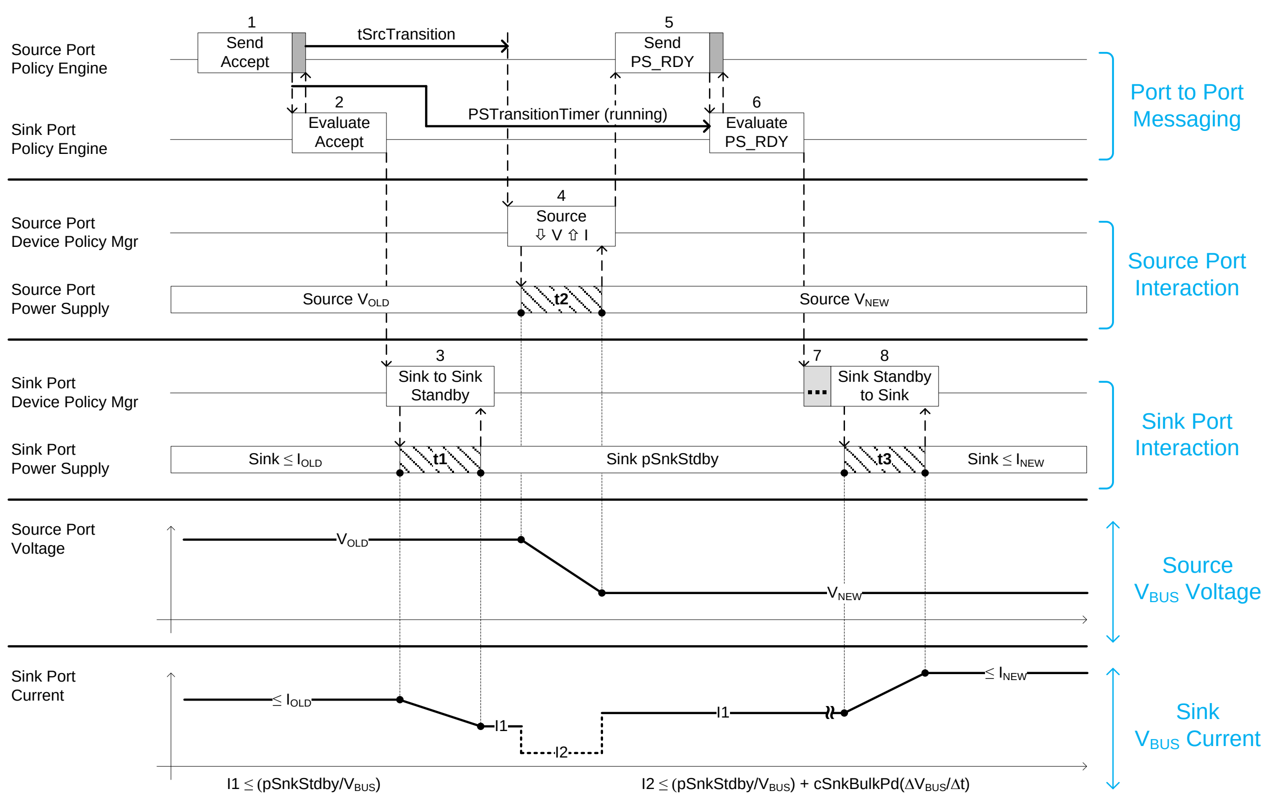


Table 7-5 Sequence Description for Decreasing the Voltage and Increasing the Current

Step	Source Port	Sink Port
1	Policy Engine sends the ***Accept*** Message to the Sink.	Policy Engine receives the ***Accept*** Message and starts the ***PSTransitionTimer***.
2	Protocol Layer receives the ***GoodCRC*** Message from the Sink. The Policy Engine tells the Device Policy Manager to instruct the power supply to modify its output power.	Protocol Layer sends the ***GoodCRC*** Message to the Source. Policy Engine then evaluates the ***Accept*** Message.
3		Policy Engine tells the Device Policy Manager to instruct the power supply to reduce power consumption to ***pSnkStdby*** within ***tSnkStdby*** (t1); t1 ***Shall*** complete before ***tSrcTransition***. The Sink ***Shall Not*** violate transient load behavior defined in Section 7.2.6 while transitioning to and operating at the new power level.
4	***tSrcTransition*** after the ***GoodCRC*** Message was received the power supply starts to change its output power capability. The power supply ***Shall*** be ready to operate at the new power level within ***tSrcReady*** (t2). The power supply informs the Device Policy Manager that it is ready to operate at the new power level. The power supply status is passed to the Policy Engine.	
5	The Policy Engine sends the ***PS_RDY*** Message to the Sink.	The Policy Engine receives the ***PS_RDY*** Message from the Source.
6	Protocol Layer receives the ***GoodCRC*** Message from the Sink.	Protocol Layer sends the ***GoodCRC*** Message to the Source. Policy Engine then evaluates the ***PS_RDY*** Message from the Source and tells the Device Policy Manager it is okay to operate at the new power level.
7		The Sink ***May*** begin operating at the new power level any time after evaluation of the ***PS_RDY*** Message. This time duration is indeterminate.
8		The Sink ***Shall Not*** violate the transient load behavior defined in Section 7.2.6 while transitioning to and operating at the new power level. The time duration (t3) depends on the magnitude of the load change.

7.3.6 Decreasing the Current

The interaction of the System Policy, Device Policy, and power supply that ***Shall*** be followed when decreasing the current is shown in Figure 7-20. The sequence that ***Shall*** be followed is described in Table 7-6. The timing parameters that ***Shall*** be followed are listed in Table 7-19, Table 7-20 and Table 7-21. Note in this figure, the Sink has previously sent a ***Request*** Message to the Source.

Figure 7-20 Transition Diagram for Decreasing the Current

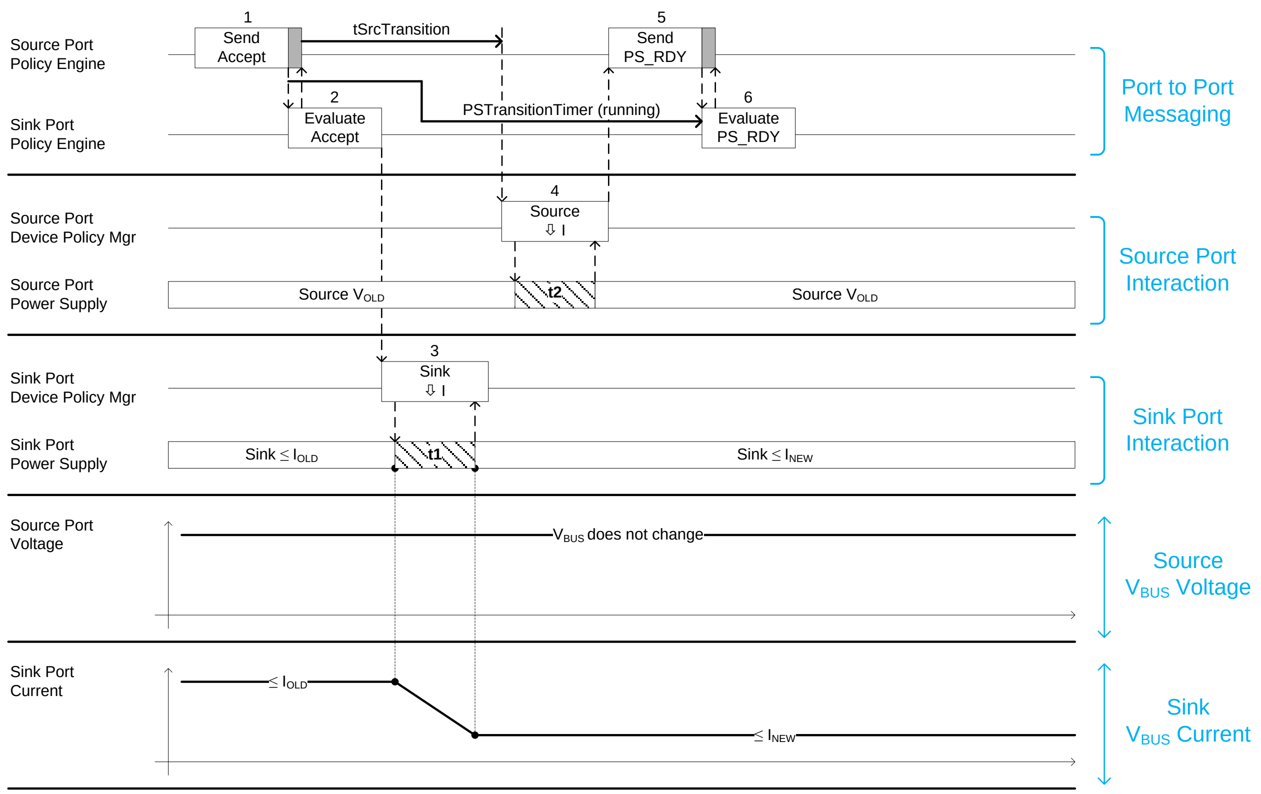


Table 7-6 Sequence Description for Decreasing the Current

Step	Source Port	Sink Port
1	Policy Engine sends the ***Accept*** Message to the Sink.	Policy Engine receives the ***Accept*** Message starts ***PSTransitionTimer***.
2	Protocol Layer receives the ***GoodCRC*** Message from the Sink. The Policy Engine tells the Device Policy Manager to instruct the power supply to modify its output power.	Protocol Layer sends the ***GoodCRC*** Message to the Source. Policy Engine then evaluates the ***Accept*** Message. Policy Engine tells the Device Policy Manager to instruct the power supply to reduce power consumption.
3		The Sink ***Shall Not*** violate the transient load behavior defined in Section 7.2.6 while transitioning to and operating at the new power level. The Sink ***Shall*** be able to operate with lower current within ***tSnkNewPower*** (t1); t1 ***Shall*** complete before ***tSrcTransition***.
4	***tSrcTransition*** after the ***GoodCRC*** Message was received the power supply starts to change its output power capability. The power supply ***Shall*** be ready to operate at the new power level within ***tSrcReady*** (t2). The power supply informs the Device Policy Manager that it is ready to operate at the new power level. The power supply status is passed to the Policy Engine.	
5	The Policy Engine sends the ***PS_RDY*** Message to the Sink.	The Policy Engine receives the ***PS_RDY*** Message from the Source.
6	Protocol Layer receives the ***GoodCRC*** Message from the Sink.	Protocol Layer sends the ***GoodCRC*** Message to the Source. Policy Engine evaluates the ***PS_RDY*** Message from the Source. The Sink is already operating at the new power level so no further action is required.

7.3.7 Decreasing the Voltage

The interaction of the System Policy, Device Policy, and power supply that ***Shall*** be followed when decreasing the voltage is shown in Figure 7-21. The sequence that ***Shall*** be followed is described in Table 7-7. The timing parameters that ***Shall*** be followed are listed in Table 7-19, Table 7-20 and Table 7-21. Note in this figure, the Sink has previously sent a ***Request*** Message to the Source.

Figure 7-21 Transition Diagram for Decreasing the Voltage

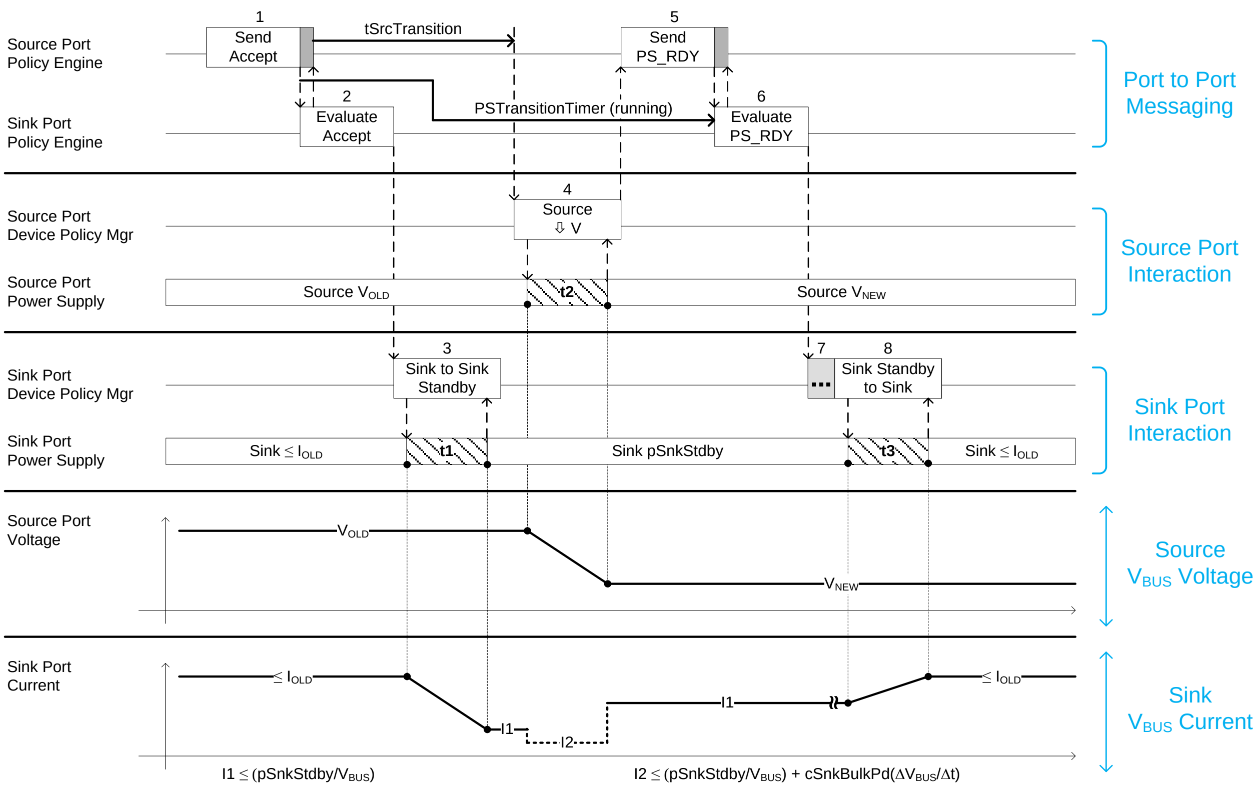


Table 7-7 Sequence Description for Decreasing the Voltage

Step	Source Port	Sink Port
1	Policy Engine sends the ***Accept*** Message to the Sink.	Policy Engine receives the ***Accept*** Message and starts the ***PSTransitionTimer***.
2	Protocol Layer receives the ***GoodCRC*** Message from the Sink. The Policy Engine tells the Device Policy Manager to instruct the power supply to modify its output power.	Protocol Layer sends the ***GoodCRC*** Message to the Source. Policy Engine then evaluates the ***Accept*** Message.
3		Policy Engine tells the Device Policy Manager to instruct the power supply to reduce power consumption to ***pSnkStdby*** within ***tSnkStdby*** (t1); t1 ***Shall*** complete before ***tSrcTransition***. The Sink ***Shall Not*** violate transient load behavior defined in Section 7.2.6 while transitioning to and operating at the new power level.
4	***tSrcTransition*** after the ***GoodCRC*** Message was received the power supply starts to change its output power capability. The power supply ***Shall*** be ready to operate at the new power level within ***tSrcReady*** (t2). The power supply informs the Device Policy Manager that it is ready to operate at the new power level. The power supply status is passed to the Policy Engine.	
5	The Policy Engine sends the ***PS_RDY*** Message to the Sink.	The Policy Engine receives the ***PS_RDY*** Message from the Source.
6	Protocol Layer receives the ***GoodCRC*** Message from the Sink.	Protocol Layer sends the ***GoodCRC*** Message to the Source. Policy Engine then evaluates the ***PS_RDY*** Message from the Source and tells the Device Policy Manager it is okay to operate at the new power level.
7		The Sink ***May*** begin operating at the new power level any time after evaluation of the ***PS_RDY*** Message. This time duration is indeterminate.
8		The Sink ***Shall Not*** violate the transient load behavior defined in Section 7.2.6 while transitioning to and operating at the new power level. The time duration (t3) depends on the magnitude of the load change.

7.3.8 Decreasing the Voltage and the Current

The interaction of the System Policy, Device Policy, and power supply that ***Shall*** be followed when decreasing the voltage and current is shown in Figure 7-22. The sequence that ***Shall*** be followed is described in Table 7-8. The timing parameters that ***Shall*** be followed are listed in Table 7-19, Table 7-20 and Table 7-21. Note in this figure, the Sink has previously sent a ***Request*** Message to the Source.

Figure 7-22 Transition Diagram for Decreasing the Voltage and the Current

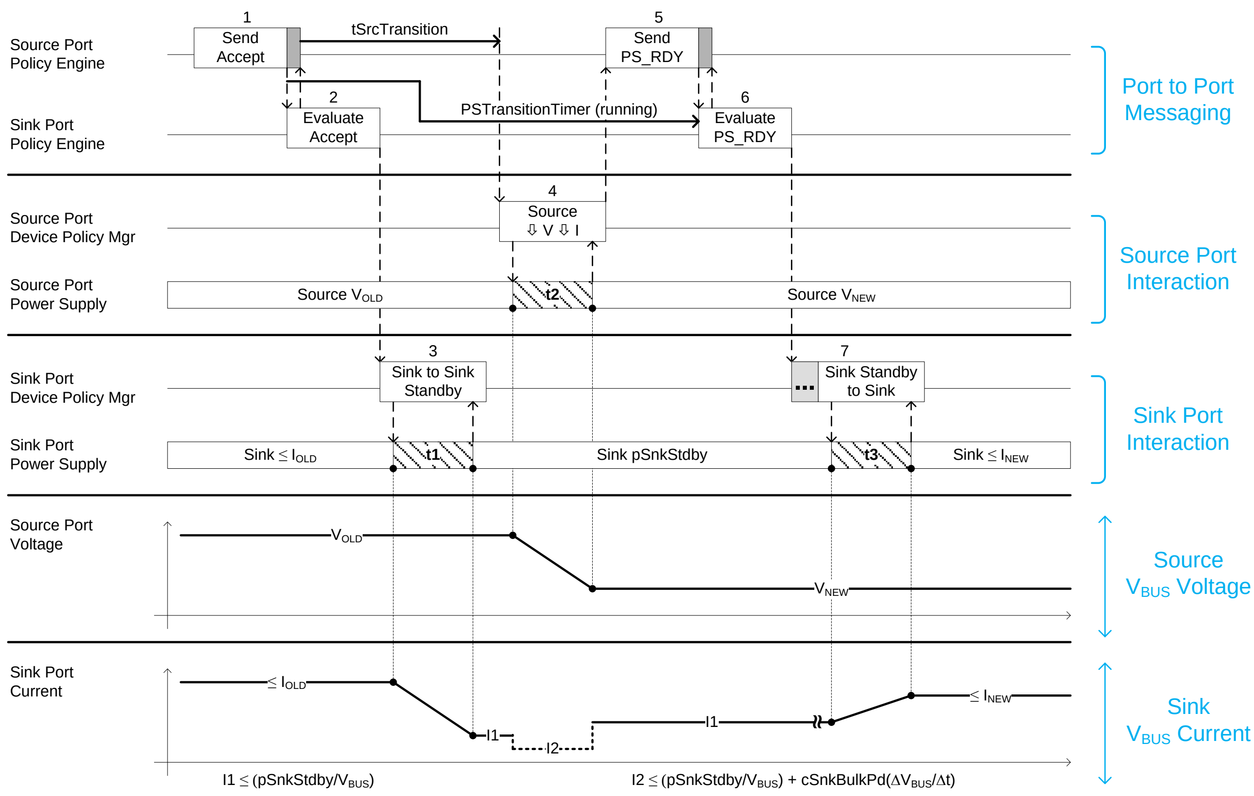


Table 7-8 Sequence Description for Decreasing the Voltage and the Current

Step	Source Port	Sink Port
1	Policy Engine sends the ***Accept*** Message to the Sink.	Policy Engine receives the ***Accept*** Message and starts the ***PSTransitionTimer***.
2	Protocol Layer receives the ***GoodCRC*** Message from the Sink. The Policy Engine tells the Device Policy Manager to instruct the power supply to modify its output power.	Protocol Layer sends the ***GoodCRC*** Message to the Source. Policy Engine then evaluates the ***Accept*** Message.
3		Policy Engine tells the Device Policy Manager to instruct the power supply to reduce power consumption to ***pSnkStdby*** within ***tSnkStdby*** (t1); t1 ***Shall*** complete before ***tSrcTransition***. The Sink ***Shall Not*** violate transient load behavior defined in Section 7.2.6 while transitioning to and operating at the new power level.
4	***tSrcTransition*** after the ***GoodCRC*** Message was received the power supply starts to change its output power capability. The power supply ***Shall*** be ready to operate at the new power level within ***tSrcReady*** (t2). The power supply informs the Device Policy Manager that it is ready to operate at the new power level. The power supply status is passed to the Policy Engine.	
5	The Policy Engine sends the ***PS_RDY*** Message to the Sink.	The Policy Engine receives the ***PS_RDY*** Message from the Source.
6	Protocol Layer receives the ***GoodCRC*** Message from the Sink.	Protocol Layer sends the ***GoodCRC*** Message to the Source. Policy Engine then evaluates the ***PS_RDY*** Message from the Source and tells the Device Policy Manager it is okay to operate at the new power level.
7		The Sink ***May*** begin operating at the new power level any time after evaluation of the ***PS_RDY*** Message. This time duration is indeterminate.
8		The Sink ***Shall Not*** violate the transient load behavior defined in Section 7.2.6 while transitioning to and operating at the new power level. The time duration (t3) depends on the magnitude of the load change.

7.3.9 Sink Requested Power Role Swap

The interaction of the System Policy, Device Policy, and power supply that ***Shall*** be followed during a Sink requested Power Role Swap is shown in Figure 7-23. The sequence that ***Shall*** be followed is described in Table 7-9. The timing parameters that ***Shall*** be followed are listed in Table 7-20. Note in this figure, the Sink has previously sent a ***PR_Swap*** Message to the Source.

Figure 7-23 Transition Diagram for a Sink Requested Power Role Swap

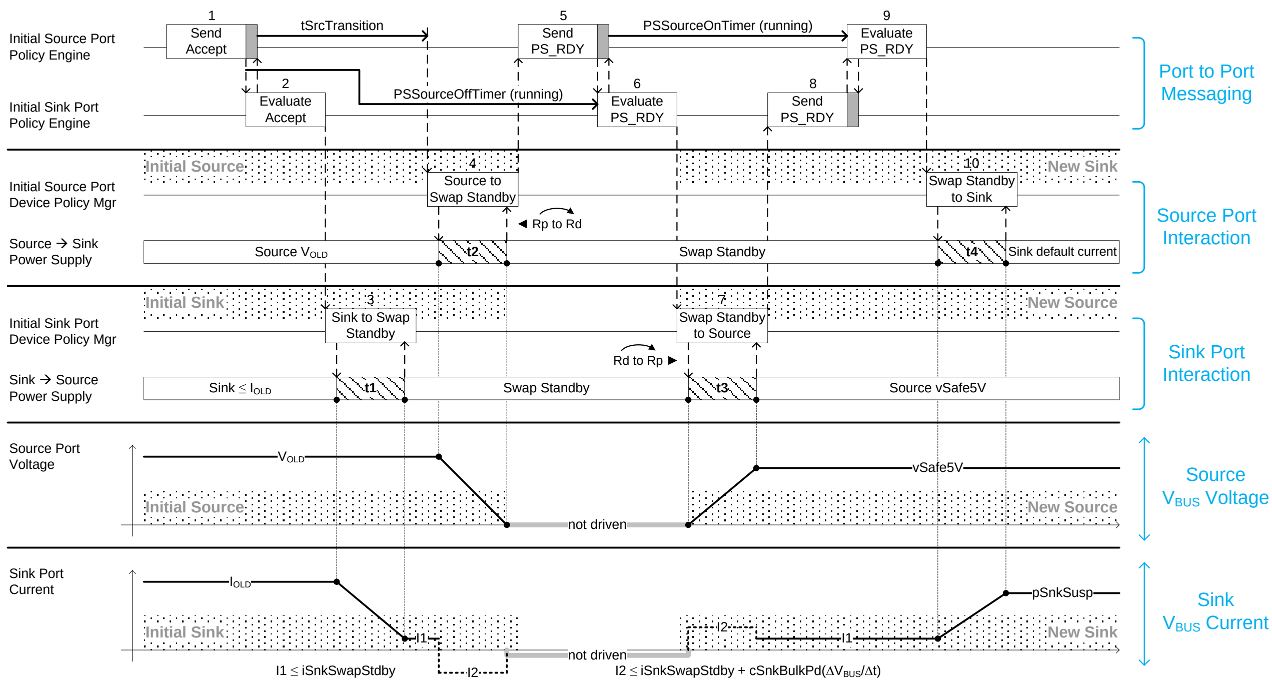


Table 7-9 Sequence Description for a Sink Requested Power Role Swap

Step	Initial Source Port → New Sink Port	Initial Sink Port → New Source Port
1	Policy Engine sends the ***Accept*** Message to the Initial Sink.	Policy Engine receives the ***Accept*** and starts the ***PSSourceOffTimer***.
2	Protocol Layer receives the ***GoodCRC*** Message from the Sink. The Policy Engine tells the Device Policy Manager to instruct the power supply to modify its output power.	Protocol Layer sends the ***GoodCRC*** Message to the Initial Source. Policy Engine then evaluates the ***Accept*** Message.
3		Policy Engine tells the Device Policy Manager to instruct the power supply to transition to Swap Standby within ***tSnkStdby*** (t1); t1 ***Shall*** complete before ***tSrcTransition***. When in Sink Standby the Initial Sink ***Shall Not*** draw more than ***iSnkSwapStdby*** (I1). The Sink ***Shall Not*** violate transient load behavior defined in Section 7.2.6 while transitioning to and operating at the new power level.
4	***tSrcTransition*** after the ***GoodCRC*** Message was received the power supply starts to change its output power capability to Swap Standby (see Section 7.1.10). The power supply ***Shall*** complete the transition to Swap Standby within ***tSrcSwapStdby*** (t2). The power supply informs the Device Policy Manager that it is ready to operate as the new Sink. The CC termination is changed from Rp to Rd (see ***[USB Type-C 1.2]***). The power supply status is passed to the Policy Engine.	
5	The power supply is ready and the Policy Engine sends the ***PS_RDY*** Message to the device that will become the new Source.	
6	Protocol Layer receives the ***GoodCRC*** Message from the device that will become the new Source. Policy Engine starts the ***PSSourceOnTimer***. Upon sending the ***PS_RDY*** Message and receiving the ***GoodCRC*** Message the Initial Source is ready to be the new Sink.	Policy Engine stops the ***PSSourceOffTimer.*** The Protocol Layer sends the ***GoodCRC*** Message to the new Sink. Policy Engine tells the Device Policy to instruct the power supply to operate as the new Source.
7		The CC termination is changed from Rd to Rp (see ***[USB Type-C 1.2]***). The power supply as the new Source transitions from Swap Standby to sourcing default ***vSafe5V*** within ***tNewSrc*** (t3). The power supply informs the Device Policy Manager that it is operating as the new Source.
8	Policy Engine receives the ***PS_RDY*** Message from the Source.	Device Policy Manager informs the Policy Engine the power supply is ready and the Policy Engine sends the ***PS_RDY*** Message to the new Sink.
9	Policy Engine stops the ***PSSourceOnTimer***. Protocol Layer sends the ***GoodCRC*** Message to the new Source. Policy Engine evaluates the ***PS_RDY*** Message from the new Source and tells the Device Policy Manager to instruct the power supply to draw current as the new Sink.	Protocol Layer receives the ***GoodCRC*** Message from the new Sink.

Step	Initial Source Port → New Sink Port	Initial Sink Port → New Source Port
10	The power supply as the new Sink transitions from Swap Standby to drawing ***pSnkSusp*** within ***tNewSnk*** (t4). The power supply informs the Device Policy Manager that it is operating as the new Sink. At this point subsequent negotiations between the new Source and the new Sink ***May*** proceed as normal. The Sink ***Shall Not*** violate the transient load behavior defined in Section 7.2.6 while transitioning to and operating at the new power level. The time duration (t4) depends on the magnitude of the load change.	

7.3.10 Source Requested Power Role Swap

The interaction of the System Policy, Device Policy, and power supply that ***Shall*** be followed during a Source requested Power Role Swap is shown in Figure 7-24. The sequence that ***Shall*** be followed is described in Table 7-10. The timing parameters that ***Shall*** be followed are listed in Table 7-19. Note in this figure, the Sink has previously sent a ***PR_Swap*** Message to the Source.

Figure 7-24 Transition Diagram for a Source Requested Power Role Swap

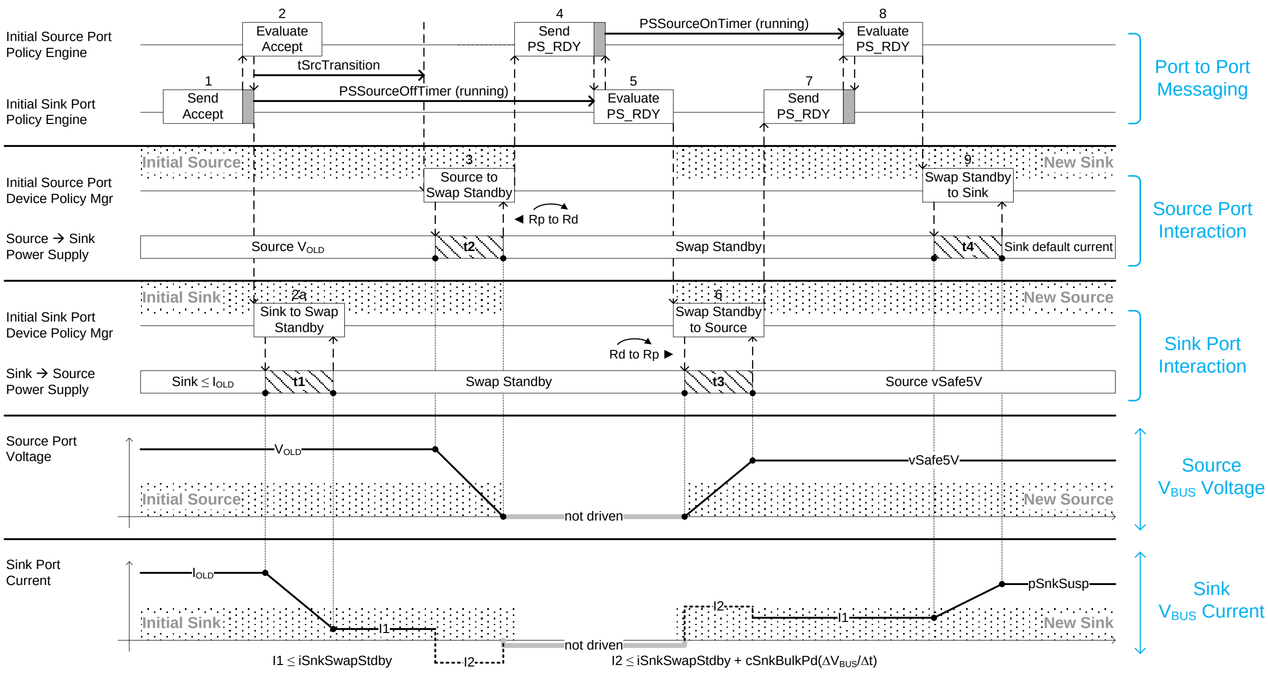


Table 7-10 Sequence Description for a Source Requested Power Role Swap

Step	Initial Source Port→ New Sink Port	Initial Sink Port → New Source Port
1	Policy Engine receives the ***Accept*** Message.	Policy Engine sends the ***Accept*** Message to the Initial Source.
2	Protocol Layer receives the ***GoodCRC*** Message from the Sink. The Policy Engine tells the Device Policy Manager to instruct the power supply to modify its output power.	Protocol Layer receives the ***GoodCRC*** Message from the Initial Source. Policy Engine starts the ***PSSourceOffTimer***.
2a		The Policy Engine tells the Device Policy Manager to instruct the power supply to transition to Swap Standby. The power supply ***Shall*** complete the transition to Swap Standby within ***tSnkStdby*** (t1); t1 ***Shall*** complete before ***tSrcTransition***. The Sink ***Shall Not*** violate the transient load behavior defined in Section 7.2.6 while transitioning to and operating at the new power level. Policy Engine starts ***PSSourceOffTimer***. When in Sink Standby the Initial Sink ***Shall Not*** draw more than ***iSnkSwapStdby*** (I1).
3	***tSrcTransition*** after the ***GoodCRC*** Message was received the power supply starts to change its output power capability to Swap Standby (see Section 7.1.10). The power supply ***Shall*** complete the transition to Swap Standby within ***tSrcSwapStdby*** (t2). The power supply informs the Device Policy Manager that it is ready to operate as the new Sink. The CC termination is changed from Rp to Rd (see ***[USB Type-C 1.2]***). The power supply status is passed to the Policy Engine.	
4	The Policy Engine sends the ***PS_RDY*** Message to the soon to be new Source.	Policy Engine receives the ***PS_RDY*** Message and stops the ***PSSourceOffTimer***.
5	Protocol Layer receives the ***GoodCRC*** Message from the soon to be new Source. Policy Engine starts the ***PSSourceOnTimer***. At this point the Initial Source is ready to be the new Sink.	Protocol Layer sends the ***GoodCRC*** Message to the new Sink. Upon evaluating the ***PS_RDY*** Message the Initial Sink is ready to operate as the new Source. Policy Engine tells the Device Policy to instruct the power supply to operate as the new Source.
6		The CC termination is changed from Rd to Rp (see ***[USB Type-C 1.2]***). The power supply as the new Source transitions from Swap Standby to sourcing default ***vSafe5V*** within ***tNewSrc*** (t3). The power supply informs the Device Policy Manager that it is operating as the new Source.
7	Policy Engine receives the ***PS_RDY*** Message and stops the ***PSSourceOnTimer***.	Device Policy Manager informs the Policy Engine the power supply is ready and the Policy Engine sends the ***PS_RDY*** Message to the new Sink.
8	Protocol Layer sends the ***GoodCRC*** Message to the new Source. Policy Engine evaluates the ***PS_RDY*** Message from the new Source and tells the Device Policy Manager to instruct the power supply to draw current as the new Sink.	Protocol Layer receives the ***GoodCRC*** Message from the new Sink.

Step	Initial Source Port→ New Sink Port	Initial Sink Port → New Source Port
9	The power supply as the new Sink transitions from Swap Standby to drawing ***pSnkSusp*** within ***tNewSnk*** (t4). The power supply informs the Device Policy Manager that it is operating as the new Sink. At this point subsequent negotiations between the new Source and the new Sink ***May*** proceed as normal. The new Sink ***Shall Not*** violate the transient load behavior defined in Section 7.2.6 while transitioning to and operating at the new power level. The time duration (t4) depends on the magnitude of the load change.	

7.3.11 GotoMin Current Decrease

The interaction of the System Policy, Device Policy, and power supply that ***Shall*** be followed during a GotoMin current decrease is shown in Figure 7-25. The sequence that ***Shall*** be followed is described in Table 7-11. The timing parameters that ***Shall*** be followed are listed in Table 7-19 and Table 7-11.

Figure 7-25 Transition Diagram for a GotoMin Current Decrease

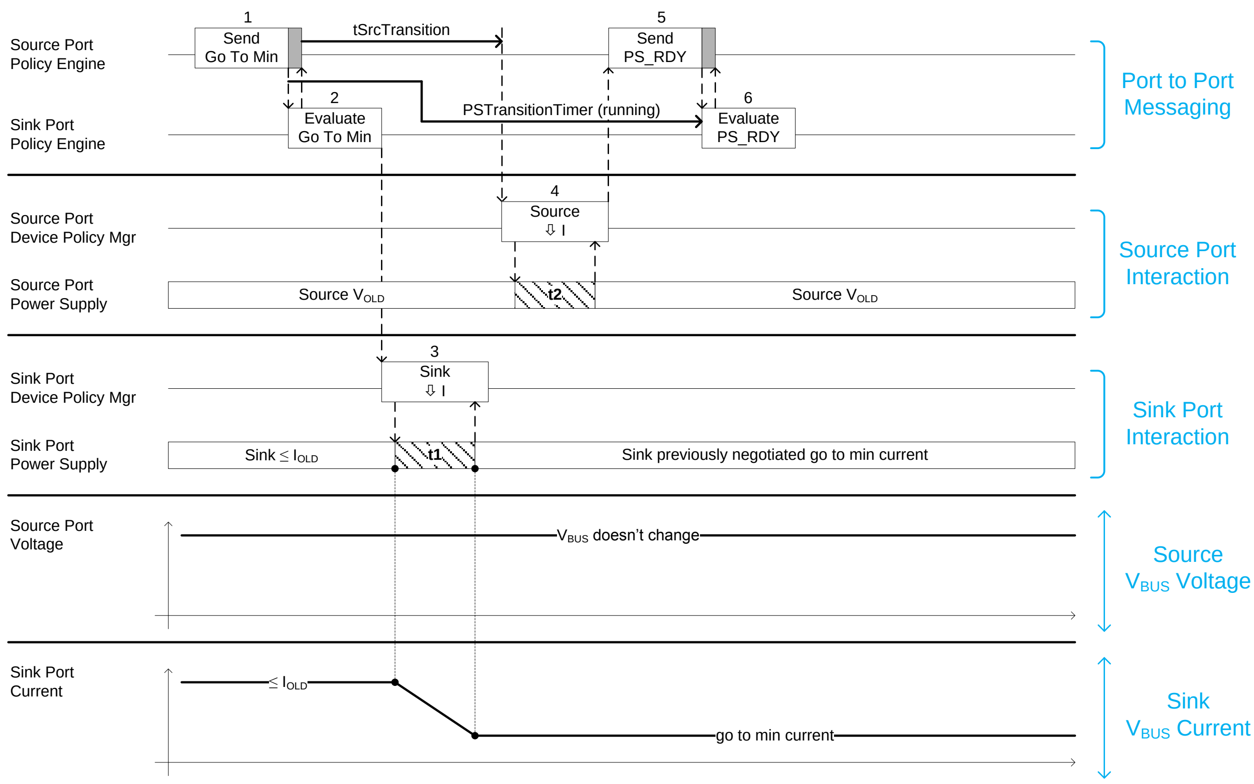


Table 7-11 Sequence Description for a GotoMin Current Decrease

Step	Source Port	Sink Port
1	Policy Engine sends the ***GotoMin*** Message to the Sink.	Policy Engine receives the ***GotoMin*** Message and starts the ***PSTransitionTimer.***
2	Protocol Layer receives the ***GoodCRC*** Message from the Sink. The Policy Engine tells the Device Policy Manager to instruct the power supply to modify its output power.	Protocol Layer sends the ***GoodCRC*** Message to the Source. Policy Engine then evaluates the ***GotoMin*** Message.
3		Policy Engine tells the Device Policy Manager to instruct the power supply to reduce power consumption, within ***tSnkNewPower*** (t1), to the pre-negotiated go to reduced power level); t1 ***Shall*** complete before ***tSrcTransition***. The Sink ***Shall Not*** violate the transient load behavior defined in Section 7.2.6 while transitioning to and operating at the new power level.
4	***tSrcTransition*** after the ***GoodCRC*** Message was received the power supply starts to change its output power capability. The power supply ***Shall*** be ready to operate at the new power level within ***tSrcReady*** (t2). The power supply informs the Device Policy Manager that it is ready to operate at the new power level. The power supply status is passed to the Policy Engine.	
5	The Policy Engine sends the ***PS_RDY*** Message to the Sink.	The Policy Engine receives the ***PS_RDY*** Message.
6	Protocol Layer receives the ***GoodCRC*** Message from the Sink.	Protocol Layer sends the ***GoodCRC*** Message to the Source. Policy Engine evaluates the ***PS_RDY*** Message from the Source and no further action is required.

7.3.12 Source Initiated Hard Reset

The interaction of the System Policy, Device Policy, and power supply that ***Shall*** be followed during a Source Initiated Hard Reset is shown in Figure 7-26. The sequence that ***Shall*** be followed is described in Table 7-12. The timing parameters that ***Shall*** be applied are listed in Table 7-19 and Table 7-20.

Figure 7-26 Transition Diagram for a Source Initiated Hard Reset

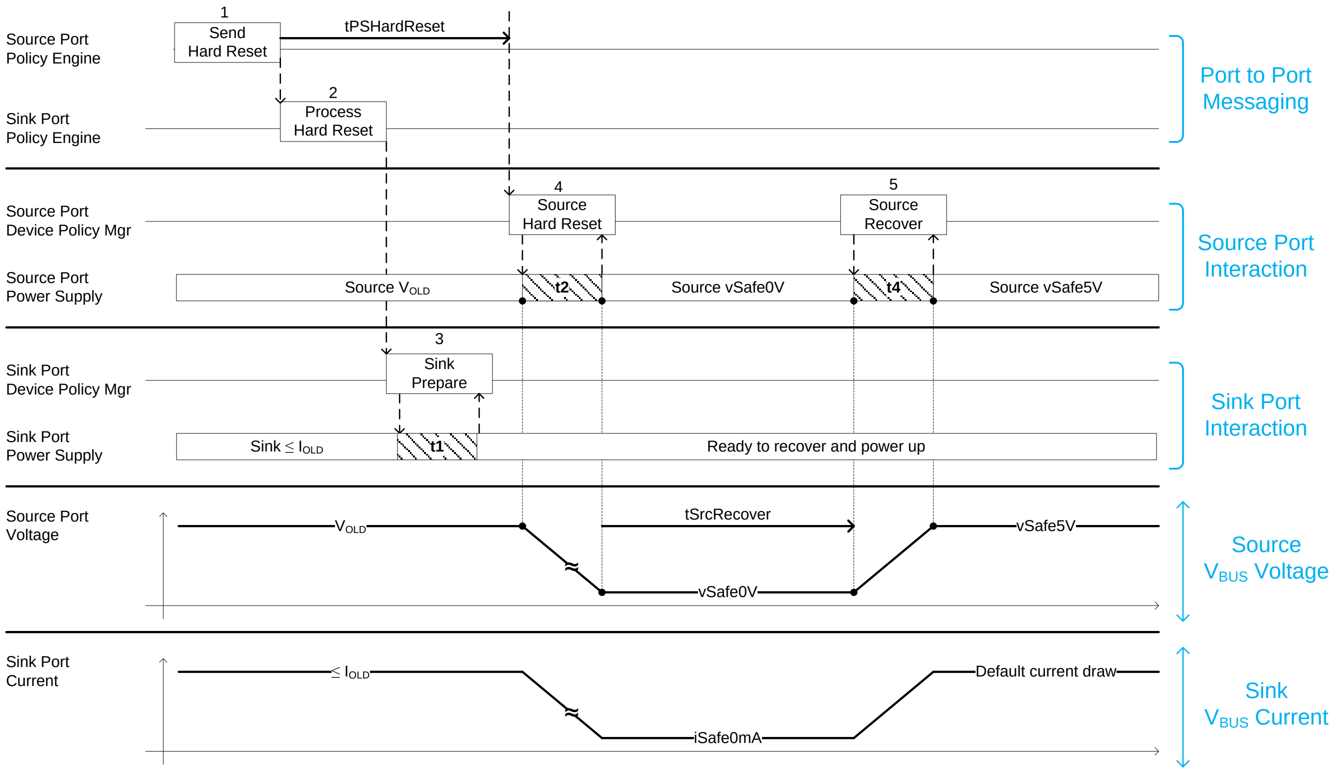


Table 7-12 Sequence Description for a Source Initiated Hard Reset

Step	Source Port	Sink Port
1	Policy Engine sends ***Hard Reset*** Signaling to the Sink.	Sink receives ***Hard Reset*** Signaling.
2		Policy Engine is informed of the Hard Reset. Policy Engine tells the Device Policy Manager to instruct the power supply to prepare for a Hard Reset.
3		The Sink prepares for the Hard Reset within ***tSnkHardResetPrepare*** (t1)) and passes an indication to the Device Policy Manger The Sink ***Shall Not*** draw more than ***iSafe0mA*** when V_{BUS} is driven to ***vSafe0V***.
4	Policy Engine waits ***tPSHardReset*** after sending ***Hard Reset*** Signaling and then tells the Device Policy Manager to instruct the power supply to perform a Hard Reset. The transition to ***vSafe0V*** ***Shall*** occur within ***tSafe0V*** (t2).	
5	After ***tSrcRecover*** the Source applies power to V_{BUS} in an attempt to re-establish communication with the Sink and resume USB Default Operation. The transition to ***vSafe5V*** ***Shall*** occur within ***tSrcTurnOn*** (t4).	The Sink ***Shall Not*** violate the transient load behavior defined in Section 7.2.6 while transitioning to and operating at the new power level.

7.3.13 Sink Initiated Hard Reset

The interaction of the System Policy, Device Policy, and power supply that ***Shall*** be followed during a Sink Initiated Hard Reset is shown in Figure 7-27. The sequence that ***Shall*** be followed is described in Table 7-13. The timing parameters that ***Shall*** be followed are listed in Table 7-19 and Table 7-20.

Figure 7-27 Transition Diagram for a Sink Initiated Hard Reset

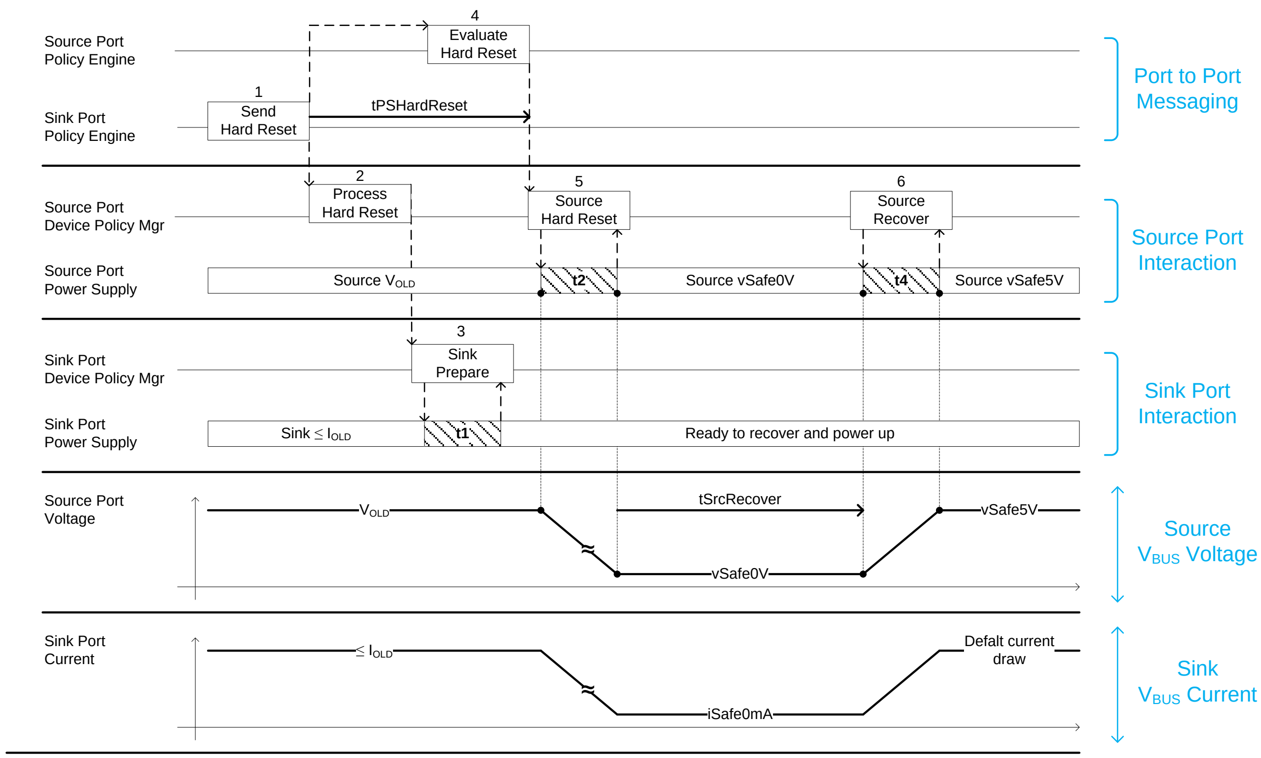


Table 7-13 Sequence Description for a Sink Initiated Hard Reset

Step	Source Port	Sink Port
1		Policy Engine sends ***Hard Reset*** Signaling to the Source.
2		Policy Engine tells the Device Policy Manager to instruct the power supply to prepare for a Hard Reset.
3		The Sink prepares for the Hard Reset within ***tSnkHardResetPrepare*** (t1) and passes an indication to the Device Policy Manger. The Sink ***Shall Not*** draw more than ***iSafe0mA*** when V_{BUS} is driven to ***vSafe0V***.
4	Policy Engine is informed of the Hard Reset.	
5	Policy Engine waits ***tPSHardReset*** after receiving ***Hard Reset*** Signaling and then tells the Device Policy Manager to instruct the power supply to perform a Hard Reset. The transition to ***vSafe0V*** ***Shall*** occur within ***tSafe0V*** (t2).	
6	After ***tSrcRecover*** the Source applies power to V_{BUS} in an attempt to re-establish communication with the Sink and resume USB Default Operation. The transition to ***vSafe5V*** ***Shall*** occur within ***tSrcTurnOn*** (t4).	The Sink ***Shall Not*** violate the transient load behavior defined in Section 7.2.6 while transitioning to and operating at the new power level.

7.3.14 No change in Current or Voltage

The interaction of the System Policy, Device Policy, and power supply that ***Shall*** be followed when the Sink requests the same Voltage and Current as it is currently operating at is shown in Figure 7-28. The sequence that ***Shall*** be followed is described in Table 7-14. The timing parameters that ***Shall*** be followed are listed in Table 7-19 and Table 7-20.

Figure 7-28 Transition Diagram for no change in Current or Voltage

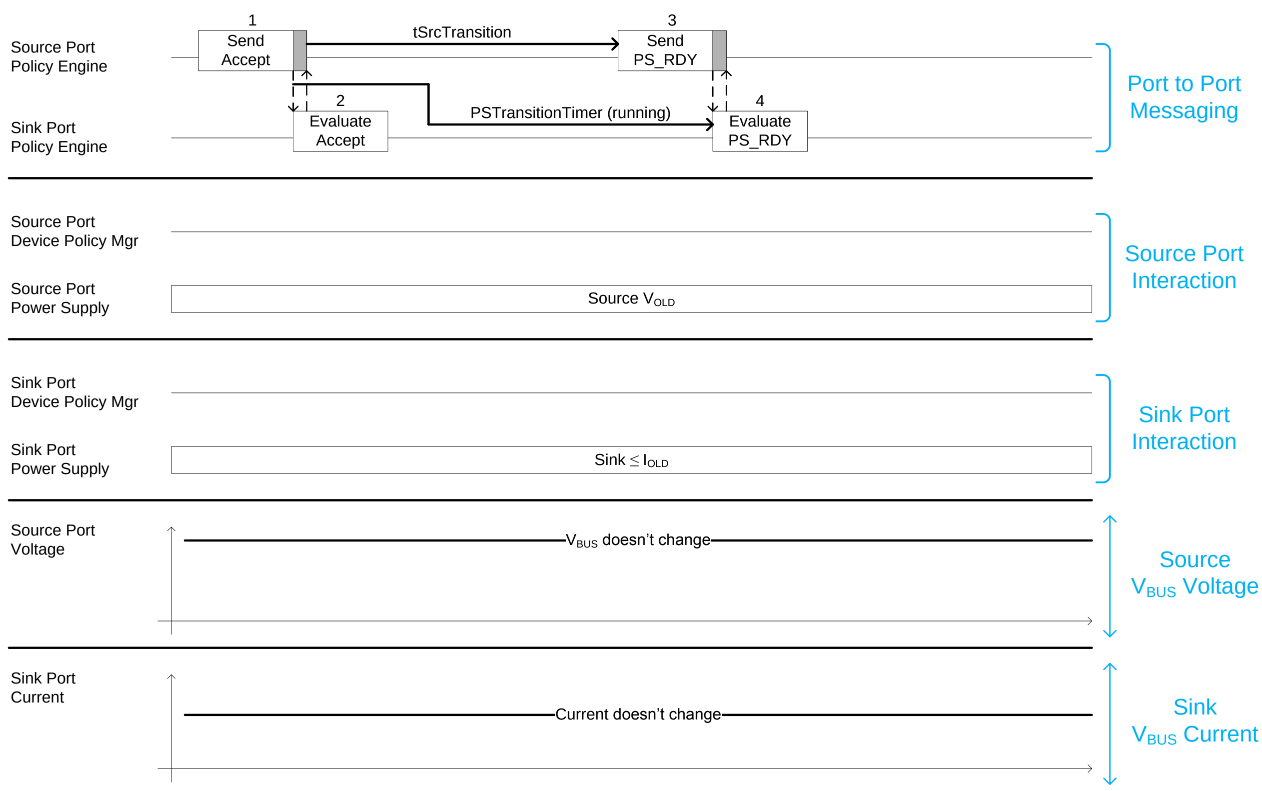


Table 7-14 Sequence Description for no change in Current or Voltage

Step	Source Port	Sink Port
1	Policy Engine sends the ***Accept*** Message to the Sink.	Policy Engine receives the ***Accept*** Message and starts the ***PSTransitionTimer***.
2	Protocol Layer receives the ***GoodCRC*** Message from the Sink.	Protocol Layer sends the ***GoodCRC*** Message to the Source. Policy Engine then evaluates the ***Accept*** Message.
3	The Policy Engine waits ***tSrcTransition*** then sends the ***PS_RDY*** Message to the Sink.	Policy Engine receives the ***PS_RDY*** Message.
4	Policy Engine receives the ***GoodCRC*** Message from the Sink. Note: the decision that no power transition is required could be made either by the Device Policy Manager or the power supply depending on implementation.	Protocol Layer sends the ***GoodCRC*** Message to the Source. Policy Engine evaluates the ***PS_RDY*** Message.

7.3.15 Fast Role Swap

The interaction of the System Policy, Device Policy, and power supply that ***Shall*** be followed during a Fast Role Swap is shown in Figure 7-29. The sequence that ***Shall*** be followed is described in Table 7-15. The timing parameters that ***Shall*** be followed are listed in Table 7-19 and Table 7-20. Negotiations between the new Source and the new Sink ***May*** occur after the new Source sends the final ***PS_RDY*** Message. Note: in Figure 7-29 and Table 7-15 numbers are used to indicate Message related steps and letters are used to indicate other events.

Figure 7-29 Transition Diagram for Fast Role Swap

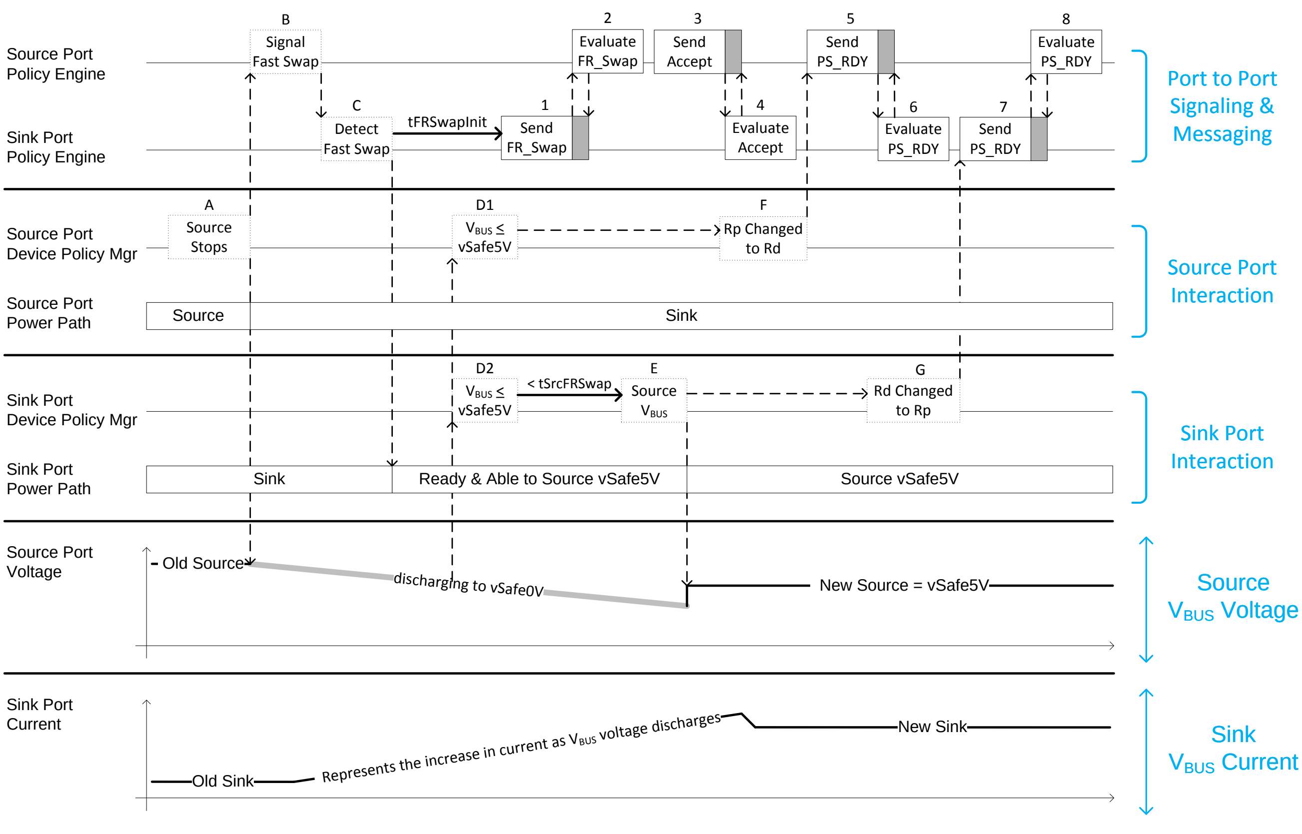


Table 7-15 Sequence Description for Fast Role Swap

Step	Initial Source Port→ New Sink Port	Initial Sink Port → New Source Port
A	The Source connected to the Hub UFP (see Figure 7-12) stops sourcing V_{BUS}.	
B	Policy Engine signals the Fast Role Swap to the initial Sink on the CC wire.	
C		Policy Engine detects the Fast Role swap signal on the CC wire from the initial Source and ***Shall*** send the ***FR_Swap*** Message back to the initial Source (that is no longer powering V_{BUS}) within time ***tFRSwapInit***.
D1	The Policy engine monitors for V_{BUS} ≤ ***vSafe5V*** so that a ***PS_RDY*** Message can be sent to the new Source at Step 5 of the messaging sequence.	
D2		The Policy engine monitors for V_{BUS} ≤ ***vSafe5V*** so the initial Sink can assume the role of new Source and begin to source V_{BUS}.

Step	Initial Source Port→ New Sink Port	Initial Sink Port → New Source Port
E		When V_{BUS} = ***vSafe5V*** the new Source ***May*** provide power to V_{BUS}. When V_{BUS} < ***vSafe5V*** the new Source ***Shall*** provide power to V_{BUS} within ***tSrcFRSwap*** and the ***PS_RDY*** Message can be sent to the new Sink at Step 7 of the messaging sequence.
F	The CC termination is changed from Rp to Rd (see ***[USB Type-C 1.2]***) before the new Sink sends the ***PS_RDY*** Message of Step 5 to the new Source.	
G		The CC termination is changed from Rd to Rp (see ***[USB Type-C 1.2]***) before the new Source sends the ***PS_RDY*** Message of Step 7 to the new Sink.
1	Policy Engine receives the ***FR_Swap*** Message from the initial Sink that is transitioning to be the new Source.	Policy Engine sends the ***FR_Swap*** Message to the initial Source(that is no longer powering V_{BUS}) after detecting the Fast Role Swap signal of Step C.
2	Protocol Layer sends the ***GoodCRC*** Message to the initial Sink. Policy Engine then evaluates the ***FR_Swap*** Message.	Protocol Layer receives the ***GoodCRC*** Message from the initial Source.
3	Policy Engine sends an ***Accept*** Message to the initial Sink that is transitioning to be the new Source.	Policy Engine receives the ***Accept*** Message from the initial Source that is transitioning to be the new Sink.
4	Protocol Layer receives the ***GoodCRC*** Message from the initial Sink that is transitioning to be the new Source.	Protocol Layer sends the ***GoodCRC*** Message to the initial Source that is transitioning to be the new Sink.
5	Policy Engine sends a ***PS_RDY*** Message to the initial Sink that is transitioning to be the new Source. The Policy Engine ***Shall*** wait for Step D1 before sending the ***PS_RDY*** Message.	Policy Engine receives the ***PS_RDY*** Message from the new Sink.
6	Protocol Layer receives the ***GoodCRC*** Message from the new Source.	Protocol Layer sends the ***GoodCRC*** Message from the initial Sink that has completed the transition to new Source. Policy Engine then evaluates the ***PS_RDY*** Message.
7	Policy Engine receives the ***PS_RDY*** Message from the new Source.	Policy Engine sends a ***PS_RDY*** Message to the new Sink. The Policy Engine ***Shall*** wait for Step E before sending the ***PS_RDY*** Message.

7.3.16 Increasing the Programmable Power Supply Voltage

The interaction of the System Policy, Device Policy, and power supply that ***Shall*** be followed when increasing the voltage is shown in Figure 7-30. The sequence that ***Shall*** be followed is described in Table 7-16. The timing parameters that ***Shall*** be followed are listed in Table 7-19 and Table 7-20. Note in this figure, the Sink has previously sent a ***Request*** Message to the Source.

Figure 7-30 Transition Diagram for Increasing the Programmable Power Supply Voltage

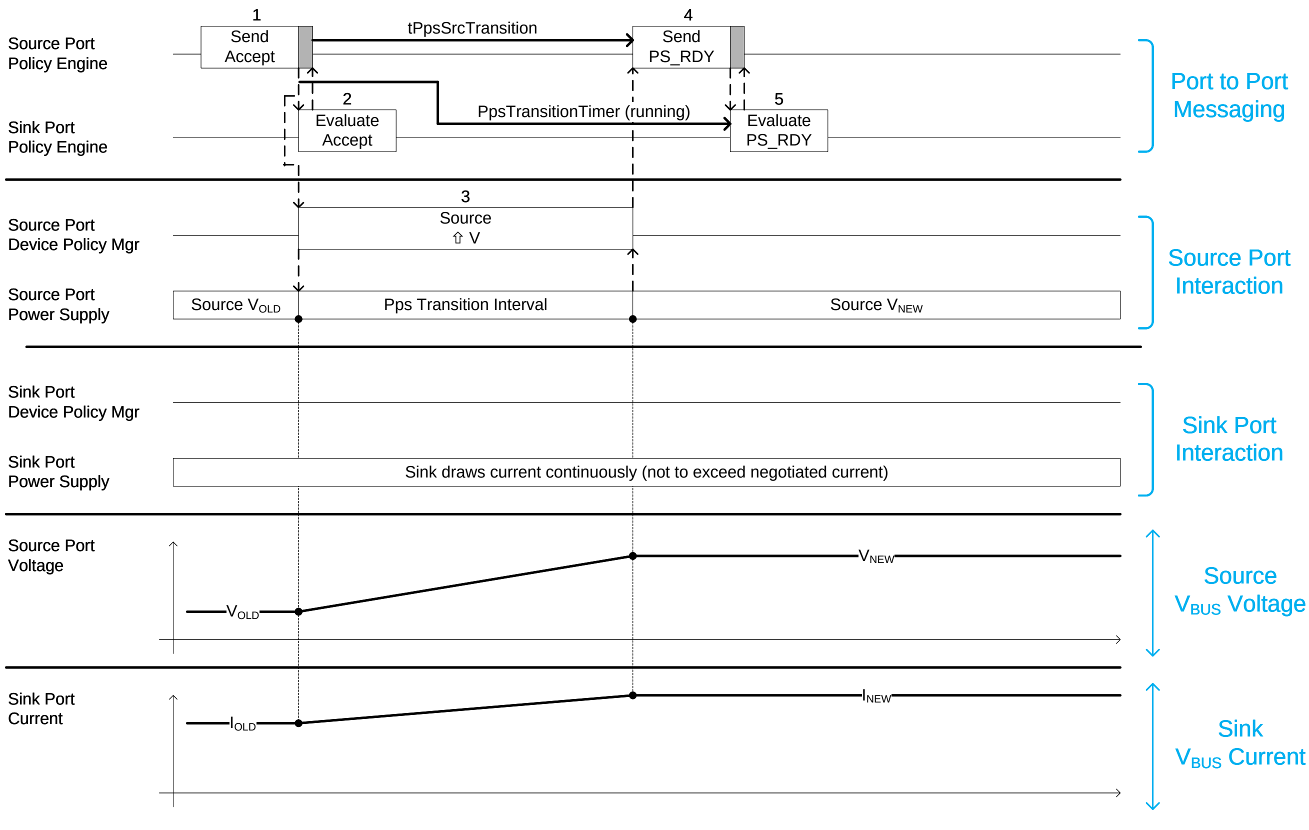


Table 7-16 Sequence Description for Increasing the Programmable Power Supply Voltage

Step	Source Port	Sink Port
1	Policy Engine sends the ***Accept*** Message to the Sink.	Policy Engine receives the ***Accept*** Message and starts the ***PSTransitionTimer***.
2	Protocol Layer receives the ***GoodCRC*** Message from the Sink. The Policy Engine tells the Device Policy Manager to instruct the power supply to increase its output voltage.	Protocol Layer sends the ***GoodCRC*** Message to the Source. Policy Engine. Policy Engine then evaluates the ***Accept*** Message.
3	After sending the ***Accept*** Message, the Programmable Power Supply starts to increase its output voltage. The Programmable Power Supply new voltage ***Shall*** be reached by ***tPpsSrcTransition***. The power supply informs the Device Policy Manager that it is has reached the new level. The power supply status is passed to the Policy Engine.	
4	The Policy Engine sends the ***PS_RDY*** Message to the Sink.	The Policy Engine receives the ***PS_RDY*** Message from the Source.

Step	Source Port	Sink Port
5	Protocol Layer receives the ***GoodCRC*** Message from the Sink.	Protocol Layer sends the ***GoodCRC*** Message to the Source. Policy Engine then evaluates the ***PS_RDY*** Message from the Source and tells the Device Policy Manager that the Programmable Power Supply is operating at the new voltage.

7.3.17 Decreasing the Programmable Power Supply Voltage

The interaction of the System Policy, Device Policy, and power supply that ***Shall*** be followed when decreasing the voltage is shown in Figure 7-31. The sequence that ***Shall*** be followed is described in Table 7-17. The timing parameters that ***Shall*** be followed are listed in Table 7-19 and Table 7-20. Note in this figure, the Sink has previously sent a ***Request*** Message to the Source.

Figure 7-31 Transition Diagram for Decreasing the Programmable Power Supply Voltage

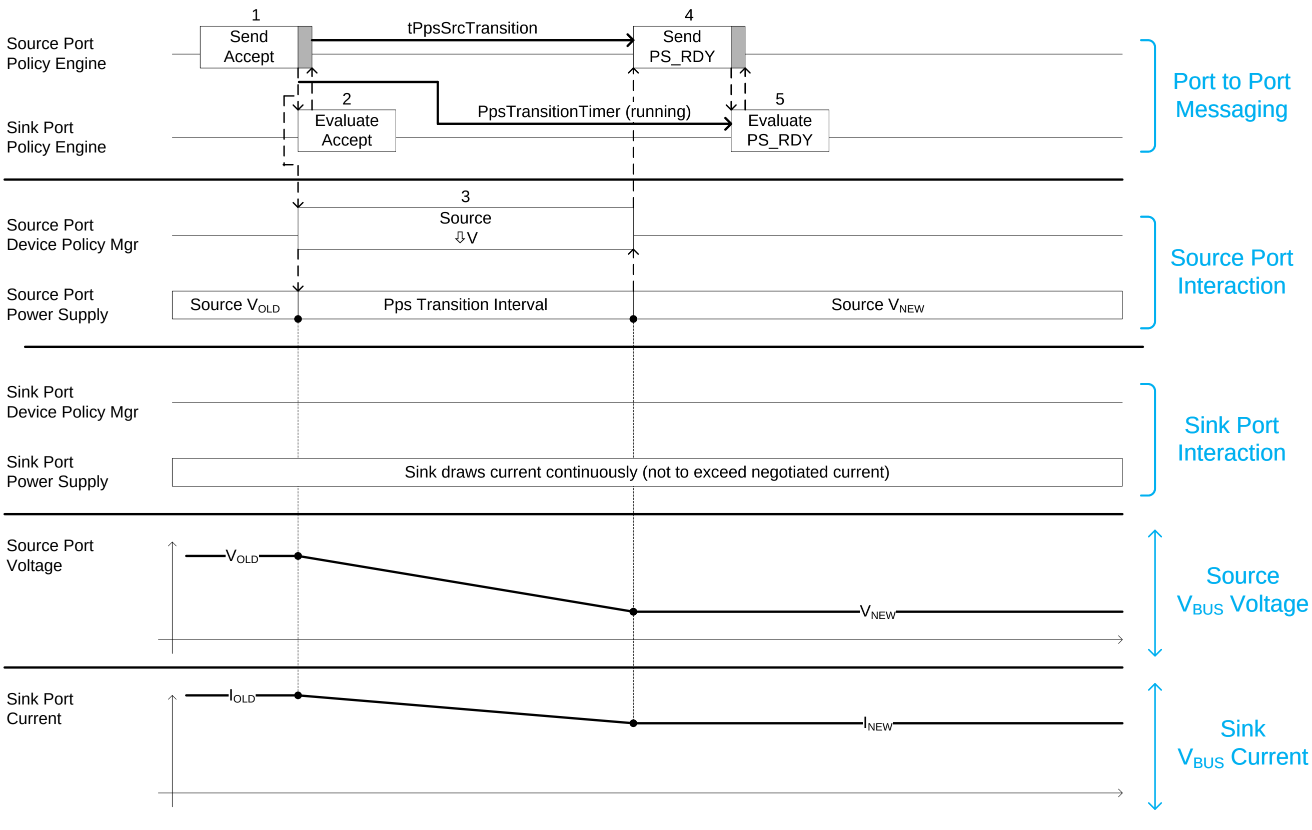


Table 7-17 Sequence Description for Decreasing the Programmable Power Supply Voltage

Step	Source Port	Sink Port
1	Policy Engine sends the ***Accept*** Message to the Sink.	Policy Engine receives the ***Accept*** Message and starts the ***PSTransitionTimer***.
2	Protocol Layer receives the ***GoodCRC*** Message from the Sink. The Policy Engine tells the Device Policy Manager to instruct the power supply to decrease its output voltage.	Protocol Layer sends the ***GoodCRC*** Message to the Source. Policy Engine. Policy Engine then evaluates the ***Accept*** Message.
3	After sending the ***Accept*** Message, the Programmable Power Supply starts to decrease its output voltage. The Programmable Power Supply new voltage ***Shall*** be reached by ***tPpsSrcTransition***. The power supply informs the Device Policy Manager that it is has reached the new level. The power supply status is passed to the Policy Engine.	
4	The Policy Engine sends the ***PS_RDY*** Message to the Sink.	The Policy Engine receives the ***PS_RDY*** Message from the Source.

Step	Source Port	Sink Port
5	Protocol Layer receives the ***GoodCRC*** Message from the Sink.	Protocol Layer sends the ***GoodCRC*** Message to the Source. Policy Engine then evaluates the ***PS_RDY*** Message from the Source and tells the Device Policy Manager that the Programmable Power Supply is operating at the new voltage.

7.3.18 Changing the Source PDO or APDO

The interaction of the Device Policy Manager, the port Policy Engine and the Power Supply when changing *between* Source PDOs and APDOs, as listed below, is shown in Figure 7-32.

- PDO to PDO
- PDO to APDO
- APDO to APDO
- APDO to PDO

The Source voltage as the transition starts ***Shall*** be any voltage within the ***Valid*** V_{BUS} range of the previous Source PDO or APDO. The Source voltage after the transition is complete ***Shall*** be any voltage within the ***Valid*** V_{BUS} range of the new Source PDO or APDO. The sequence that ***Shall*** be followed is described in Table 7-18. The timing parameters that ***Shall*** be followed are listed in Table 7-19 and Table 7-20. Note in this figure, the Sink has previously sent a ***Request*** Message to the Source.

Figure 7-32 Transition Diagram for Changing the Source PDO or APDO

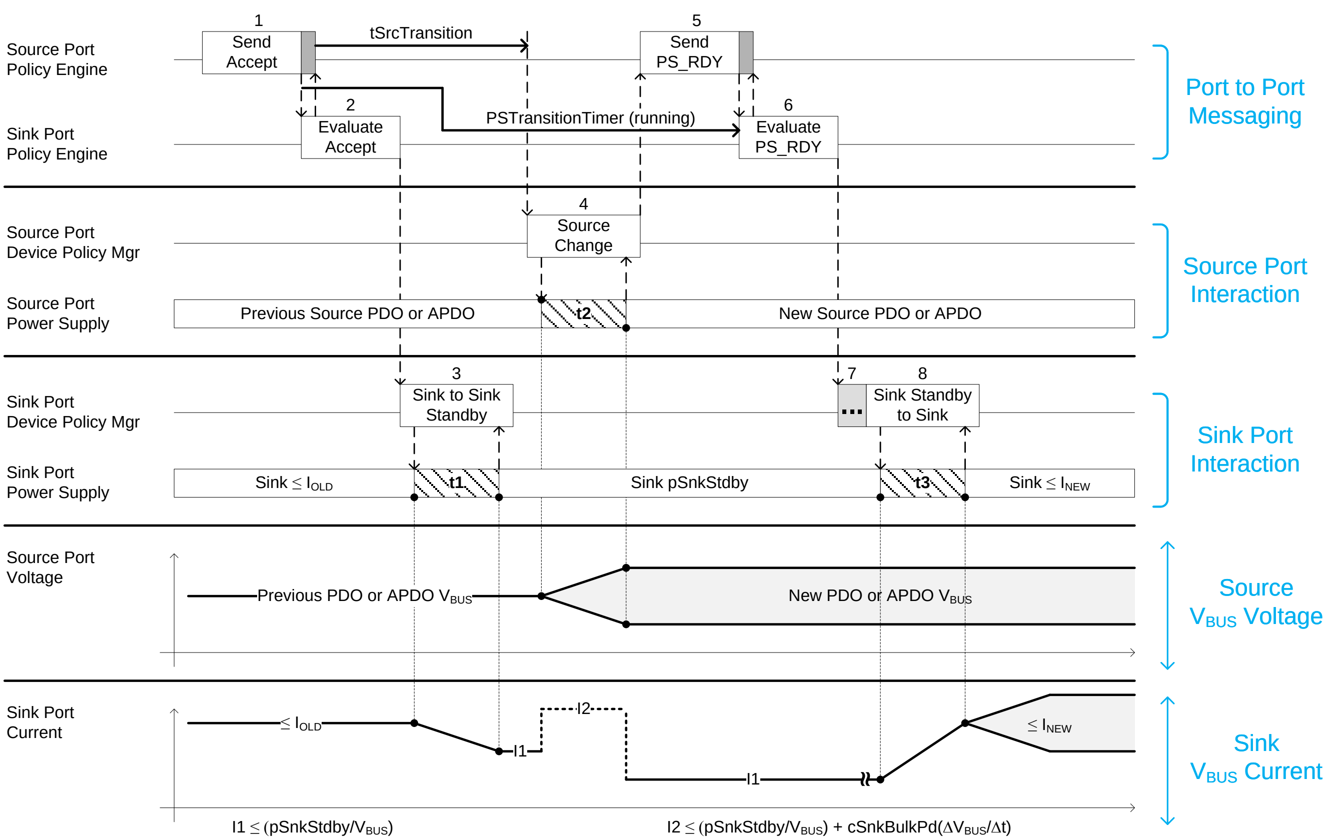


Table 7-18 Sequence Description for Changing the Source PDO or APDO

Step	Source Port	Sink Port
1	Policy Engine sends the ***Accept*** Message to the Sink.	Policy Engine receives the ***Accept*** Message and starts the ***PSTransitionTimer***.
2	Protocol Layer receives the ***GoodCRC*** Message from the Sink. The Policy Engine tells the Device Policy Manager to instruct the power supply to change to the new Source PDO or APDO.	Protocol Layer sends the ***GoodCRC*** Message to the Source. Policy Engine. Policy Engine then evaluates the ***Accept*** Message.

Step	Source Port	Sink Port
3	After sending the ***Accept*** Message, the Source starts to change to the new PDO or APDO. The Source transition to the new PDO or APDO V_{BUS} voltage ***Shall*** be completed by ***tSrcTransition***. The power supply informs the Device Policy Manager that the transition to the new PDO or APDO is complete. The power supply status is passed to the Policy Engine.	
4	The Policy Engine sends the ***PS_RDY*** Message to the Sink.	The Policy Engine receives the ***PS_RDY*** Message from the Source.
5	Protocol Layer receives the ***GoodCRC*** Message from the Sink.	Protocol Layer sends the ***GoodCRC*** Message to the Source. Policy Engine then evaluates the ***PS_RDY*** Message from the Source and tells the Device Policy Manager that the Source is operating at the new PDO or APDO.

7.4 Electrical Parameters

7.4.1 Source Electrical Parameters

The Source Electrical Parameters that ***Shall*** be followed are specified in Table 7-19.

Table 7-19 Source Electrical Parameters

Parameter	Description	MIN	TYP	MAX	UNITS	Reference
cSrcBulk[1]	Source bulk capacitance when a Port is powered from a dedicated supply.	10			µF	Section 7.1.2
cSrcBulkShared[1]	Source bulk capacitance when a Port is powered from a shared supply.	120			µF	Section 7.1.2
iPpsCfMin	Minimum current foldback setting.	1			A	Section 7.1.4.4
iPpsCfNew	Current foldback accuracy					Section 7.1.4.4
	1A ≤ Operating Current ≤ 3A	-150		150	mA	
	Operating current > 3A	-5		5	%	
iPpsCfStep	PPS current foldback programming step size.		50		mA	Section 7.1.4.4
iPpsCfTransient	CF load transient current bounds.	-250		250	mA	Section 7.1.4.4
iPpsCvCfTransient	CV to CF transient current bounds assuming the Operating Voltage reduction of Section 7.2.3.1.	-100		500	mA	Section 7.1.4.4
tNewSnk	Time allowed for an initial Source in Swap Standby to transition new Sink operation.			15	ms	Figure 7-23, Figure 7-24
tPpsCfCvTransient	CF to CV transient voltage settling time.			25	ms	Section 7.1.4.4
tPpsCfProgramSettle	PPS current foldback programming settling time	125		250	ms	Section 7.1.4.4
tPpsCfSettle	CF load transient current settling time.	125		250	ms	Section 7.1.4.4
tPpsCvCfTransient	CV to CF transient settling time.	125		250	ms	Section 7.1.8.1
tPpsSrcTransition	The time the Programmable Power Supply ***Shall*** transition between requested voltages.	0		25	ms	Section 7.3
tPpsTransient	The maximum time for the Programmable power Supply to be between vPpsNew and vPpsValid in response to a load transient			5	ms	Section 7.1.8.1

Parameter	Description	MIN	TYP	MAX	UNITS	Reference
tSrcFRSwap	Time from the initial Sink detecting that V_{BUS} has dropped below ***vSafe5V*** until the initial Sink/new Source is able to supply USB Type-C Current (see ***[USB Type-C 1.2]***)			150	µs	Section 7.1.13
tSrcReady	Time from positive/negative transition start (t0) to when the Source is ready to provide the newly negotiated power level.			285	ms	Figure 7-2, Figure 7-3
tSrcRecover	Time allotted for the Source to recover.	0.66		1	s	Section 7.1.5
tSrcSettle	Time from positive/negative transition start (t0) to when the transitioning voltage is within the range ***vSrcNew.***			275	ms	Figure 7-2
tSrcSwapStdby	The maximum time for the Source to transition to Swap Standby.			650	ms	Table 7-9 Table 7-10
tSrcTransient	The maximum time for the Source output voltage to be between ***vSrcNew*** and ***vSrcValid*** in response to a load transient.			5	ms	Section 7.1.8
tSrcTransition	The time the Source ***Shall*** wait before transitioning the power supply to ensure that the Sink has sufficient time to prepare.	25		35	ms	Section 7.3
tSrcTurnOn	Transition time from ***vSafe0V*** to ***vSafe5V***.			275	ms	Table 7-12 Table 7-13
vPpsCfCvTransient	CF to CV load transient voltage bounds.	Operating Voltage * 0.95 – 0.1V		Operating Voltage * 1.05 + 0.1V	V	Section 7.1.4.4
vPpsCvCfTransient	CV to CF transient voltage bounds assuming the Operating Voltage reduction of Section 7.2.3.1.	Operating Voltage – 1.0V		Operating Voltage + 0.5V	V	Section 7.1.8.1
vPpsMaxVoltage	Maximum Voltage Field in the Programmable Power Supply APDO.	APDO Voltage *0.95		APDO Voltage * 1.05	V	Section 7.1.4.3
vPpsMinVoltage	Minimum Voltage Field in the Programmable Power Supply APDO.	APDO Voltage *0.95		APDO Voltage * 1.05	V	Section 7.1.4.3
vPpsNew	Programmable RDO Output Voltage	RDO Output	RDO Output	RDO Output	V	Section 7.1.8.1

Parameter	Description	MIN	TYP	MAX	UNITS	Reference
	measured at the Source receptacle.	Voltage *0.95	Voltage	Voltage *1.05		
vPpsSlewNeg	Programmable Power Supply maximum slew rate for negative voltage changes			-30	mV/µs	Section 7.1.8.1
vPpsSlewPos	Programmable Power Supply maximum slew rate for positive voltage changes			30	mV/µs	Section 7.1.8.1
vPpsStep	PPS voltage programming step size.		20		mV	Section 7.1.8.1
vPpsValid	The range in addition to ***vPpsNew*** which the Programmable Power Supply output is considered ***Valid*** in response to a load step.	-0.1		0.1	V	Section 7.1.8.1
vSrcNeg	Most negative voltage allowed during transition.			-0.3	V	Figure 7-8
vSrcNew	Fixed Supply output measured at the Source receptacle.	PDO Voltage *0.95	PDO Voltage	PDO Voltage *1.05	V	Figure 7-2 Figure 7-3
	Variable Supply output measured at the Source receptacle.	PDO Minimum Voltage		PDO Maximum Voltage	V	
	Battery Supply output measured at the Source receptacle.	PDO Minimum Voltage		PDO Maximum Voltage	V	
vSrcPeak	The range that a Fixed Supply in Peak Current operation is allowed when overload conditions occur.	PDO Voltage *0.90		PDO Voltage *1.05	V	Table 6-10 Figure 7-10
vSrcSlewNeg	Maximum slew rate allowed for negative voltage transitions. Limits current based on a 3 A connector rating and maximum Sink bulk capacitance of 100 µF.			-30	mV/µs	Section 7.1.4.2 Figure 7-3
vSrcSlewPos	Maximum slew rate allowed for positive voltage transitions. Limits current based on a 3 A connector rating and maximum Sink bulk capacitance of 100 µF.			30	mV/µs	Section 7.1.4 Figure 7-2

Parameter	Description	MIN	TYP	MAX	UNITS	Reference
vSrcValid	The range in addition to ***vSrcNew*** which a newly negotiated voltage is considered ***Valid*** during and after a transition. This range also applies to ***vSafe5V***.	-0.5		0.5	V	Figure 7-2 Figure 7-3
Note 1: The Source ***Shall*** charge and discharge the total bulk capacitance to meet the transition time requirements.						

7.4.2 Sink Electrical Parameters

The Sink Electrical Parameters that ***Shall*** be followed are specified in Table 7-20.

Table 7-20 Sink Electrical Parameters

Parameter	Description	MIN	TYP	MAX	UNITS	Reference
cSnkBulk[1]	Sink bulk capacitance on V_{BUS} at Attach.	1		10	μF	Section 7.2.2
cSnkBulkPd	Bulk capacitance on V_{BUS} a Sink is allowed after a successful negotiation.	1		100	μF	Section 7.2.2
iLoadReleaseRate	Load release di/dt . Refer to ***[USB Type-C 1.2]*** Section 3.7.3.3.2 for cable details.	-150			mA/μs	Section 7.2.6
iLoadStepRate	Load step di/dt . Refer to ***[USB Type-C 1.2]*** Section 3.7.3.3.2 for cable details.			150	mA/μs	Section 7.2.6
iOvershoot	Positive or negative overshoot when a load change occurs less than or equal to ***iLoadStepRate***; relative to the settled value after the load change. Refer to USB ***[USB Type-C 1.2]*** Section 3.7.3.3.2 for cable details.	-230		230	mA	Section 7.2.6
iPpsCfLoadRelease	Maximum load release decrease during Current Foldback.	-500			mA	Section 7.2.3.1
iPpsCfLoadReleaseRate	Maximum load decrease slew rate during Current Foldback.	-150			mA/μs	Section 7.2.3.1
iPpsCfLoadStep	Maximum load step increase during Current Foldback.			500	mA	Section 7.2.3.1
iPpsCfLoadStepRate	Maximum load increase slew rate during Current Foldback.			150	mA/μs	Section 7.2.3.1
iSafe0mA	Maximum current a Sink is allowed to draw when V_{BUS} is driven to ***vSafe0V***.			1.0	mA	Figure 7-26 Figure 7-27
iSnkSwapStdby	Maximum current a Sink can draw during Swap Standby. Ideally this current is very near to 0 mA largely influenced by Port leakage current.			2.5	mA	Section 7.2.7
pHubSusp	Suspend power consumption for a hub. 25mW + 25mW per downstream Port for up to 4 ports.			125	mW	Section 7.2.3
pSnkStdby	Maximum power consumption while in Sink Standby.			2.5	W	Section 7.2.3

Parameter	Description	MIN	TYP	MAX	UNITS	Reference
pSnkSusp	Suspend power consumption for a peripheral device.			25	mW	Section 7.2.3
tNewSrc	Maximum time allowed for an initial Sink in Swap Standby to transition to new Source operation.			275	ms	Section 7.2.7 Table 7-9 Table 7-10
tSnkHardResetPrepare	Time allotted for the Sink power electronics to prepare for a Hard Reset.			15	ms	Table 7-13
tSnkNewPower	Maximum transition time between power levels.			15	ms	Section 7.2.3
tSnkRecover	Time for the Sink to resume USB Default Operation.			150	ms	Table 7-12
tSnkStdby	Time to transition to Sink Standby from Sink.			15	ms	Section 7.2.3
tSnkSwapStdby	Maximum time for the Sink to transition to Swap Standby.			15	ms	Section 7.2.7
Note 1: If more bypass capacitance than ***cSnkBulk*** max or ***cSnkBulkPd*** max is required in the device, then the device ***Shall*** incorporate some form of V_{BUS} surge current limiting as described in ***[USB 3.1]*** Section 11.4.4.1.						

7.4.3 Common Electrical Parameters

Electrical Parameters that are common to both the Source and the Sink that ***Shall*** be followed are specified in Table 7-21.

Table 7-21 Common Source/Sink Electrical Parameters

Parameter	Description	MIN	TYP	MAX	UNITS	Reference
tSafe0V	Time to reach ***vSafe0V*** max.			650	ms	Section 7.1.5 Figure 7-8 Table 7-12 Table 7-13
tSafe5V	Time to reach ***vSafe5V*** max.			275	ms	Section 7.1.4.2 Figure 7-8
vSafe0V	Safe operating voltage at "zero volts".	0		0.8	V	Section 7.1.5
vSafe5V	Safe operating voltage at 5V. See ***[USB 2.0]*** and ***[USB 3.1]*** for allowable V_{BUS} voltage range.	4.75		5.5	V	Section 7.1.5

8. Device Policy

8.1 Overview

This section describes the Device Policy and Policy Engine that implements it. For an overview of the architecture and how the Device Policy Manager fits into this architecture, please see Section 2.7.

8.2 Device Policy Manager

The Device Policy Manager is responsible for managing the power used by one or more USB Power Delivery ports. In order to have sufficient knowledge to complete this task it needs relevant information about the device it resides in. Firstly it has a priori knowledge of the device including the capabilities of the power supply and the receptacles on each Port since these will for example have specific current ratings. It also has to know information from the USB-C Port Control module regarding cable insertion, type and rating of cable etc. It also has to have information from the power supply about changes in its capabilities as well as being able to request power supply changes. With all of this information the Device Policy Manager is able to provide up to date information regarding the capabilities available to a specific Port and to manage the power resources within the device.

When working out the capabilities for a given Source Port the Device Policy Manager will take into account firstly the current rating of the Port's receptacle and whether the inserted cable is PD or non-PD rated and if so what is the capability of the plug. This will set an upper bound for the capabilities which might be offered. After this the Device Policy Manager will consider the available power supply resources since this will bound which voltages and currents might be offered. Finally, the Device Policy Manager will consider what power is currently allocated to other ports, which power is in the Power Reserve and any other amendments to Policy from the System Policy Manager. The Device Policy Manager will offer a set of capabilities within the bounds detailed above.

When selecting a capability for a given Sink Port the Device Policy Manager will look at the capabilities offered by the Source. This will set an upper bound for the capabilities which might be requested. The Device Policy Manager will also consider which capabilities are required by the Sink in order to operate. If an appropriate match for Voltage and Current can be found within the limits of the receptacle and cable then this will be requested from the Source. If an appropriate match cannot be found then a request for an offered voltage and current will be made, along with an indication of a capability mismatch.

For Dual-Role Power Ports the Device Policy Manager manages the functionality of both a Source and a Sink. In addition it is able to manage the Power Role Swap process between the two. In terms of power management this could mean that a Port which is initially consuming power as a Sink is able to become a power resource as a Source. Conversely, Attached Sources might request that power be provided to them.

The functionality within the Device Policy Manager (and to a certain extent the Policy Engine) is scalable depending on the complexity of the device, including the number of different power supply capabilities and the number of different features supported for example System Policy Manager interface or Capability Mismatch, and the number of ports being managed. Within these parameters it is possible to implement devices from very simple power supplies to more complex power supplies or devices such as USB hubs or Hard Drives. Within multiport devices it is also permitted to have a combination of USB Power Delivery and non-USB Power Delivery ports which ***Should*** all be managed by the Device Policy Manager.

As noted in Section 2.7 the logical architecture used in the PD specification will vary depending on the implementation. This means that different implementations of the Device Policy Manager might be relative small or large depending on the complexity of the device, as indicated above. It is also possible to allocate different responsibilities between the Policy Engine and the Device Policy Manager, which will lead to different types of architectures and interfaces.

The Device Policy Manager is responsible for the following:

- Maintaining the Local Policy for the device.
- For a Source, monitoring the present capabilities and triggering notifications of the change.

- For a Sink, evaluating and responding to capabilities related requests from the Policy Engine for a given Port.
- Control of the Source/Sink in the device.
- Control of the USB-C Port Control module for each Port.
- Interface to the Policy Engine for a given Port.

The Device Policy Manager is responsible for the following ***Optional*** features when implemented:

- Communications with the System Policy over USB.
- For Sources with multiple ports monitoring and balancing power requirements across these ports.
- Monitoring of batteries and AC power supplies.
- Managing Modes in its Port Partner and Cable Plug(s).

8.2.1 Capabilities

The Device Policy Manager in a Provider ***Shall*** know the power supplies available in the device and their capabilities. In addition it ***Shall*** be aware of any other PD Sources of power such as batteries and AC inputs. The available power sources and existing demands on the device ***Shall*** be taken into account when presenting capabilities to a Sink.

The Device Policy Manager in a Consumer ***Shall*** know the requirements of the Sink and use this to evaluate the capabilities offered by a Source. It ***Shall*** be aware of its own power sources e.g. Batteries or AC supplies where these have a bearing on its operation as a Sink.

The Device Policy Manager in a Dual-Role Power Device ***Shall*** combine the above capabilities and ***Shall*** also be able to present the dual-role nature of the device to an Attached PD Capable device.

8.2.2 System Policy

A given PD Capable device might have no USB capability, or PD might have been added to a USB device in such a way that PD is not integrated with USB. In these two cases there ***Shall*** be no requirement for the Device Policy Manager to interact with the USB interface of the device. The following requirements ***Shall*** only apply to PD devices that expose PD functionality over USB.

The Device Policy Manager ***Shall*** communicate over USB with the System Policy Manager according to the requirements detailed in ***[USBTypeCBridge 1.0]***. Whenever requested the Device Policy Manager ***Shall*** implement a Local Policy according to that requested by the System Policy Manager. For example the System Policy Manager might request that a battery powered Device temporarily stops charging so that there is sufficient power for a HDD to spin up.

Note: that due to timing constraints, a PD Capable device ***Shall*** be able to respond autonomously to all time-critical PD related requests.

8.2.3 Control of Source/Sink

The Device Policy Manager for a Provider ***Shall*** manage the power supply for each PD Source Port and ***Shall*** know at any given time what the negotiated power is. It ***Shall*** request transitions of the supply and inform the Policy Engine whenever a transition completes.

The Device Policy Manager for a Consumer ***Shall*** manage the Sink for each PD Sink Port and ***Shall*** know at any given time what the negotiated power is.

The Device Policy Manager for a Dual-Role Power Device ***Shall*** manage the transition between Source/Sink roles for each PD Dual-Role Power Port and ***Shall*** know at any given time what operational role the Port is in.

8.2.4 Cable Detection

8.2.4.1 Device Policy Manager in a Provider

The Device Policy Manager in the Provider ***Shall*** control the USB-C Port Control module and ***Shall*** be able to use the USB-C Port Control module to determine the Attachment status.

Note: that it might be necessary for the Device Policy Manager to also initiate additional discovery using the ***Discover Identity*** Command in order to determine the full capabilities of the cabling (see Section 6.4.4.2).

8.2.4.2 Device Policy Manager in a Consumer

The Device Policy Manager in a Consumer controls the USB-C Port Control module and ***Shall*** be able to use the USB-C Port Control module to determine the Attachment status.

8.2.4.3 Device Policy Manager in a Consumer/Provider

The Device Policy Manager in a Consumer/Provider inherits characteristics of Consumers and Providers and ***Shall*** control the USB-C Port Control module in order to support the Dead Battery back-powering case to determine the following for a given Port:

- Attachment of a USB Power Delivery Provider/Consumer which supports Dead Battery back-powering.
- Presence of V_{BUS}.

8.2.4.4 Device Policy Manager in a Provider/Consumer

The Device Policy Manager in a Provider/Consumer inherits characteristics of Consumers and Providers and ***May*** control the USB-C Port Control module in order to support the Dead Battery back-powering case to determine the following for a given Port:

- Presence of V_{BUS}.

8.2.5 Managing Power Requirements

The Device Policy Manager in a Provider ***Shall*** be aware of the power requirements of all devices connected to its Source Ports. This includes being aware of any reserve power that might be required by devices in the future and ensuring that power is shared optimally amongst Attached PD Capable devices. This is a key function of the Device Policy Manager, whose implementation is critical to ensuring that all PD Capable devices get the power they require in a timely fashion in order to facilitate smooth operation. This is balanced by the fact that the Device Policy Manager is responsible for managing the sources of power that are, by definition, finite.

The Consumer's Device Policy Manager ***Shall*** ensure that it takes no more power than is required to perform its functions and gives back unneeded power whenever possible (in such cases the Provider ***Shall*** maintain a Power Reserve to ensure future operation is possible).

8.2.5.1 Managing the Power Reserve

There might be some products where a Device has certain functionality at one power level and a greater functionality at another, for example a Printer/Scanner that operates only as a printer with one power level and as a scanner if it can get more power. Visibility of the linkage between power and functionality will only be apparent at the USB Host; however the Device Policy Manager provides the mechanisms to manage the power requirements of such Devices.

Devices with the GiveBack flag cleared report Operating Current and Maximum Operating Current (see Section 6.4.1.3.4). For many Devices the Operating Current and the Maximum Operating Current will be the same. Devices with highly variable loads, such as Hard Disk Drives, might use Maximum Operating Current.

Devices with the GiveBack flag set report Operating Current and Minimum Operating Current (see Section 6.4.1.3.4). For many Devices the Operating Current and the Minimum Operating Current will be the same. Devices that charge their own batteries might use the Minimum Operating Current and GiveBack flag.

For example in the first case, a mobile device might require 500mA to operate, but would like an additional 1000mA to charge its Battery. The mobile device would set the GiveBack flag (see Section 6.4.2.2) and request 500mA in the Minimum Operating Current field and 1500mA in the Operating Current field (provided that 1500mA was offered by the Source) indicating to the Provider that it could temporarily recover the 1000mA to meet a transitory request.

In the second case, a Hard Disk Drive (HDD) might require 2A to spin-up, but only 1A to operate. At startup the HDD would request Maximum Operating Current of 2A and an Operating Current of 2A. After the drive is spun-up and ready to operate it would make another request of 1A for its Operating Current and 2A for its Maximum Operating Current. Over time, its inactivity timers might expire and the HDD will go to a lower power state. When the HDD is next accessed, it has to spin-up again. So it will request an Operating Current of 2A and a Maximum Operating Current of 2A. The Provider might have the extra power available immediately and can immediately honor the request. If the power is not available, the Provider might have to harvest power, for example use the ***GotoMin*** Message to get back some power before honoring the HDD's request. In such a case, the HDD would be told to wait using a ***Wait*** Message. The HDD continues to Request additional power until the request is finally granted.

It ***Shall*** be the Device Policy Manager's responsibility to allocate power and maintain a Power Reserve so as not to over-subscribe its available power resource. A Device with multiple ports such as a Hub ***Shall*** always be able to meet the incremental demands of the Port requiring the highest incremental power from its Power Reserve.

The ***GotoMin*** Message is designed to allow the Provider to reclaim power from one Port to support a Consumer on another Port that temporarily requires additional power to perform some short term operation. In the example above, the mobile device that is being charged reduces its charge rate to allow a Device Policy Manager to meet a request from an HDD for start-up current required to spin-up its platters. Any power which is available to be reclaimed using a ***GotoMin*** Message ***May*** be counted as part of the Power Reserve.

A Consumer requesting power ***Shall*** take into account its operational requirements when advertising its ability to temporarily return power. For example, a mobile device with a Dead Battery that is being used to make a call ***Should*** make a request that retains sufficient power to continue the call. When the Consumer's requirements change, it ***Shall*** re-negotiate its power to reflect the changed requirements.

8.2.5.2 Power Capability Mismatch

A capability mismatch occurs when a Consumer cannot obtain required power from a Provider (or the Source is not PD Capable) and the Consumer requires such capabilities to operate. Different actions are taken by the Device Policy Manager and the System Policy Manager in this case.

8.2.5.2.1 Local device handling of mismatch

The Consumer's Device Policy Manager ***Shall*** cause a Message to be displayed to the end user that a power capability mismatch has occurred. Examples of such feedback can include:

- For a simple Device an LED ***May*** be used to indicate the failure. For example, during connection the LED could be solid amber. If the connection is successful the LED could change to green. If the connection fails it could be red or alternately blink amber.
- A more sophisticated Device with a user interface, e.g., a mobile device or monitor, ***Should*** provide notification through the user interface on the Device.

The Provider's Device Policy Manager ***May*** cause a Message to be displayed to the user of the power capability mismatch.

8.2.5.2.2 Device Policy Manager Communication with System Policy

In a USB Power Delivery aware system with an active System Policy manager (see Section 8.2.2), the Device Policy Manager ***Shall*** notify the System Policy Manager of the mismatch. This information ***Shall*** be passed back to the System Policy Manager using the mechanisms described in Chapter 0. The System Policy Manager ***Should*** ensure that the user is informed of the condition. When another Port in the system could satisfy the Consumer's power requirements the user ***Should*** be directed to move the Device to the alternate Port.

In order to identify a more suitable Source Port for the Consumer the System Policy Manager ***Shall*** communicate with the Device Policy Manager in order to determine the Consumer's requirements. The Device Policy Manager ***Shall*** use a ***Get_Sink_Cap*** Message (see Section 6.3.8) to discover which power levels can be utilized by the Consumer.

8.2.6 Use of "Unconstrained Power" bit with Batteries and AC supplies

The Device Policy Manager in a Provider or Consumer ***May*** monitor the status of any variable sources of power that could have an impact on its capabilities as a Source such as Batteries and AC supplies and reflect this in the "Unconstrained Power" bit (see Section 6.4.1.2.2.3 and Section 6.4.1.3.1.3) provided as part of the Source or Sink Capabilities Message (see Section 6.4.1). When monitored, and a USB interface is supported, the External Power status (see ***[USBTypeCBridge 1.0]***) and the Battery state (see Section 9.4.1) ***Shall*** also be reported to the System Policy Manager using the USB interface.

8.2.6.1 AC Supplies

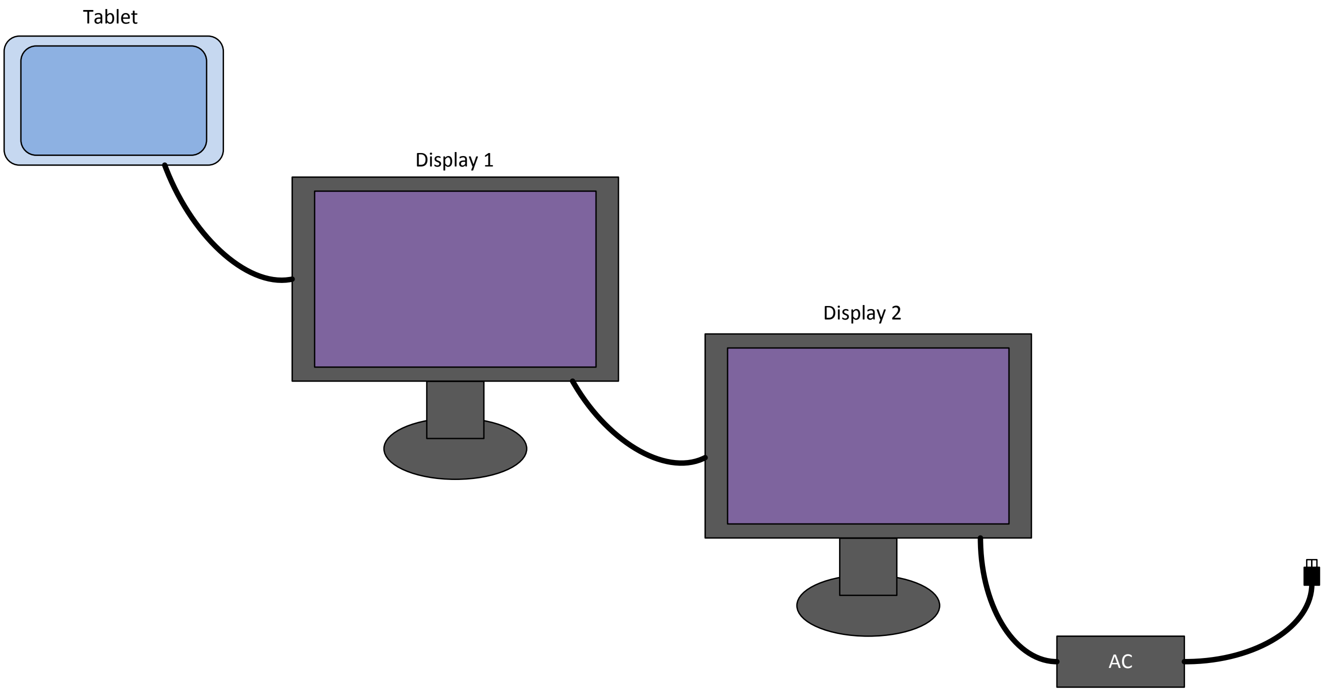
The Unconstrained Power bit provided by Sources and Sinks (see Section 6.4.1.2.2.3 and Section 6.4.1.3.1.3) notifies a connected device that it is acceptable to use the advertised power for charging as well as for what is needed for normal operation. A device that sets the Unconstrained Power bit has either an external source of power that is sufficient to adequately power the system while charging external devices, or expects to charge external devices as a primary state of function (such as a battery pack).

In the case of the external power source, the power can either be from an AC supply directly connected to the device or from an AC supply connected to an Attached device, which is also getting unconstrained power from its power supply. The Unconstrained Power bit is in this way communicated through a PD system indicating that the origin of the power is from a single or multiple AC supplies, from a battery bank, or similar:

- If the "Unconstrained Power" bit is set then that power is originally sourced from an AC supply.
- Devices capable of consuming on multiple ports can only claim that they have "Unconstrained Power" for the power advertised as a provider Port if there is unconstrained power beyond that needed for normal operation coming from external supplies, (e.g. multiple AC supplies).
- This concept applies as the power is routed through multiple provider and Consumer tiers, so, as an example. Power provided out of a monitor that is connected to a monitor that gets power from an AC supply, will claim it has "Unconstrained Power" even though it is not directly connected to the AC supply.

An example use case is a Tablet computer that is used with two USB A/V displays that are daisy chained (see Figure 8-1). The tablet and 1st display are not externally powered, (meaning, they have no source of power outside of USB PD). The 2nd display has an external supply Attached which could either be a USB PD based supply or some other form of external supply. When the displays are connected as shown, the power adapter Attached to the 2nd display is able to power both the 1st display and the tablet. In this case the 2nd display will indicate the presence of a sufficiently-sized wall wart to the 1st display, by setting its "Unconstrained Power" bit. The 1st display will then in turn assess and indicate the presence of the extra power to the tablet by setting its "Unconstrained Power" bit. Power is transmitted through the system to all devices, provided that there is sufficient power available from the external supply.

Figure 8-1 Example of daisy chained displays



Another example use case is a Laptop computer that is attached to both an external supply and a Tablet computer. In this situation, if the external supply is large enough to power the laptop in its normal state as well as charge an external device, the laptop would set its "Unconstrained Power" bit and the tablet will allow itself to charge at its peak rate. If the external supply is small, however, and would not prevent the laptop from discharging if maximal power is drawn by the external device, the laptop would not set its "Unconstrained Power" bit, and the tablet can choose to draw less than what is offered. This amount could be just enough to prevent the tablet from discharging, or none at all. Alternatively, if the tablet determines that the laptop has significantly larger battery with more charge than the tablet has, the tablet can still choose to charge itself, although possibly not at the maximal rate.

In this way, Sinks that do not receive the "Unconstrained Power" bit from the connected Source can still choose to charge their batteries, or charge at a reduced rate, if their policy determines that the impact to the Source is minimal -- such as in the case of a phone with a small battery charging from a laptop with a large battery. These policies can be decided via further USB PD communication.

8.2.6.2 Battery Supplies

When monitored, and a USB interface is supported, the Battery state ***Shall*** be reported to the System Policy Manager using the USB interface.

If the device is battery-powered but is in a state that is primarily for charging external devices, the device is considered to be an unconstrained source of power and thus ***Should*** set the "Unconstrained Power" bit.

A simplified algorithm is detailed below to ensure that Battery powered devices will get charge from non-Battery powered devices when possible, and also to ensure that devices do not constantly Power Role Swap back and forth.

When two devices are connected that do not have Unconstrained Power, they ***Should*** define their own policies so as to prevent constant Power Role Swapping.

This algorithm uses the "Unconstrained Power" bit (see Section 6.4.1.2.2.3 and Section 6.4.1.3.1.3), thus the decisions are based on the availability and sufficiency of an external supply, not the full capabilities of a system or device or product.

Recommendations:

1. Provider/Consumers using large external sources ("Unconstrained Power" bit set) ***Should*** always deny Power Role Swap requests from Consumer/Providers not using external sources ("Unconstrained Power" bit cleared).
2. Provider/Consumers not using large external sources ("Unconstrained Powered" bit cleared) ***Should*** always accept a Power Role Swap request from a Consumer/Provider using large external power sources ("Unconstrained Power" bit set) unless the requester is not able to provide the requirements of the present Provider/Consumer.

8.2.7 Interface to the Policy Engine

The Device Policy Manager ***Shall*** maintain an interface to the Policy Engine for each Port in the device.

8.2.7.1 Device Policy Manager in a Provider

The Device Policy Manager in a Provider ***Shall*** also provide the following functions to the Policy Engine:

- Inform the Policy Engine of changes in cable/ device Attachment status for a given cable.
- Inform the Policy Engine whenever the Source capabilities available for a Port change.
- Evaluate requests from an Attached Consumer and provide responses to the Policy Engine.
- Respond to requests for power supply transitions from the Policy Engine.
- Indication to Policy Engine when power supply transitions are complete.
- Maintain a Power Reserve for devices operating on a Port at less than maximum power.

8.2.7.2 Device Policy Manager in a Consumer

The Device Policy Manager in a Consumer ***Shall*** also provide the following functions to the Policy Engine:

- Inform the Policy Engine of changes in cable/device Attachment status.
- Inform the Policy Engine whenever the power requirements for a Port change.
- Evaluate Source capabilities and provide suitable responses:
  - Request from offered capabilities
  - Indicate whether additional power is required
- Respond to requests for Sink transitions from the Policy Engine.

8.2.7.3 Device Policy Manager in a Dual-Role Power Device

The Device Policy Manager in a Dual-Role Power Device ***Shall*** provide the following functions to the Policy Engine:

- Provider Device Policy Manager
- Consumer Device Policy Manager
- Interface for the Policy Engine to request power supply transitions from Source to Sink and vice versa.
- Indications to Policy Engine during Power Role Swap transitions.

8.2.7.4 Device Policy Manager in a Dual-Role Power Device Dead Battery handling

The Device Policy Manager in a Dual-Role Power Device with a Dead Battery ***Should***:

- Switch Ports to Sink-only or Sinking DFP operation to obtain power from the next Attached Source
- Use V_{BUS} from the Attached Source to power the USB Power Delivery communications as well as charging to enable the negotiation of higher input power.

8.3 Policy Engine

8.3.1 Introduction

There is one Policy Engine instance per Port that interacts with the Device Policy Manager in order to implement the present Local Policy for that particular Port. This section includes:

- Message sequences for various operations.
- State diagrams covering operation of Sources, Sinks and Cable Plugs.

8.3.2 Atomic Message Sequence Diagrams

8.3.2.1 Introduction

The Device Policy Engine drives the Message sequences and responses based on both the expected Message sequences and the present Local Policy.

An AMS ***Shall*** be defined as a Message sequence that starts and/or ends in either the ***PE_SRC_Ready***, ***PE_SNK_Ready*** or ***PE_CBL_Ready*** states (see Section 8.3.3.2, Section 8.3.3.3 and Section 8.3.3.22).

In addition the Cable Plug discovery sequence specified in Section 8.3.3.22.3 ***Shall*** be defined as an AMS.

The Source and Sink indicate to the Protocol Layer when an AMS starts and ends on entry to/exit from ***PE_SRC_Ready*** or ***PE_SNK_Ready*** (see Section 8.3.3.2 and Section 8.3.3.3).

Section 8.3.2.1.3 gives details of which of these AMS's are interruptible or non-interruptible.

This section contains sequence diagrams that highlight some of the more interesting transactions. It is by no means a complete summary of all possible combinations, but is illustrative in nature.

8.3.2.1.1 Basic Message Exchange

Figure 8-2 Basic Message Exchange (Successful) below illustrates how a Message is sent. Note that the sender might be either a Source or Sink while the receiver might be either a Sink or Source. The basic Message sequence is the same. It starts when the Message Sender's Protocol Layer at the behest of its Policy Engine forms a Message that it passes to the Physical Layer.

Figure 8-2 Basic Message Exchange (Successful)

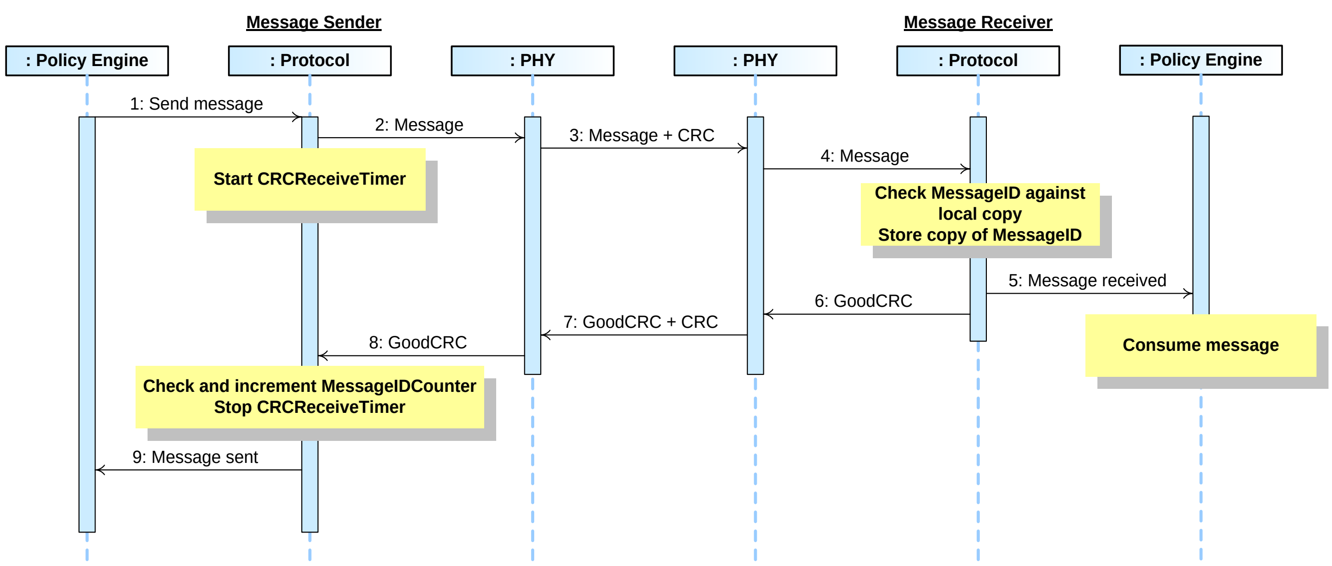


Table 8-1 Basic Message Flow

Step	Message Sender	Message Receiver
1	Policy Engine directs Protocol Layer to send a Message.	
2	Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.	
3	Physical Layer appends a CRC and sends the Message.	Physical Layer receives the Message and checks the CRC to verify the Message.
4		Physical Layer removes the CRC and forwards the Message to the Protocol Layer.
5		Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. Protocol Layer forwards the received Message information to the Policy Engine that consumes it.
6		Protocol Layer generates a ***GoodCRC*** Message and passes it to the Physical Layer.
7	Physical Layer receives the Message and checks the CRC to verify the Message.	Physical Layer appends CRC and sends the ***GoodCRC*** Message.
8	Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer. Protocol Layer checks and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***.	
9	Protocol Layer informs the Policy Engine that the Message was successfully sent.	

8.3.2.1.2 Errors in Basic Message flow

There are various points during the Message flow where failures in communication or other issues can occur. Figure 8-3 is an annotated version of Figure 8-2 indicating at which point issues can occur.

Figure 8-3 Basic Message flow indicating possible errors

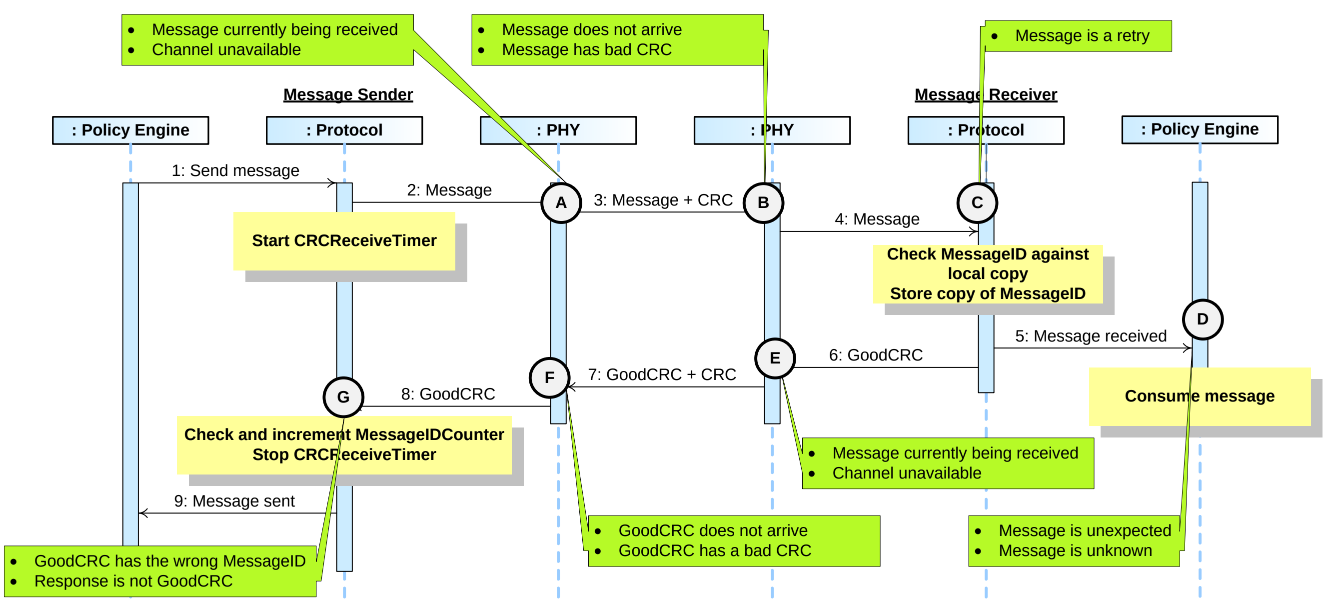


Table 8-2 Potential issues in Basic Message Flow

Point	Possible issues
A	1. There is an incoming Message on the channel meaning that the PHY Layer is unable to send. In this case the outgoing Message is removed from the queue and the incoming Message processed. 2. Due to some sort of noise on the line it is not possible to transmit. In this case the outgoing Message is ***Discarded*** by the PHY Layer. Retransmission is via the Protocol Layer's normal mechanism.
B	1. Message does not arrive at the Physical Layer due to noise on the channel. 2. Message arrives but has been corrupted and has a bad CRC. There is no Message to pass up to the Protocol Layer on the receiver which means a ***GoodCRC*** Message is not sent. This leads to a ***CRCReceiveTimer*** timeout in the Message Sender.
C	1. ***MessageID*** of received Message matches stored ***MessageID*** so this is a retry. Message is not passed up to the Policy Engine.
D	1. Policy Engine receives a known Message that it was not expecting. 2. Policy Engine receives an unknown (unrecognized) Message. These cases are errors in the protocol which leads to the generation of a ***Soft_Reset*** Message.
E	Same as point A but at the Message Receiver side.
F	1. ***GoodCRC*** Message response does not arrive at the Message Sender side due to the noise on the channel. 2. ***GoodCRC*** Message response arrives but has a bad CRC. A ***GoodCRC*** Message is not received by the Message Sender's Protocol Layer. This leads to a ***CRCReceiveTimer*** timeout in the Message Sender.
G	1. ***GoodCRC*** Message is received but does contain the same ***MessageID*** as the transmitted Message. 2. A Message is received but it is not a ***GoodCRC*** Message (similar case to that of an unexpected or unknown Message but this time detected in the Protocol Layer). Both of these issues indicate errors in receiving an expected ***GoodCRC*** Message which will lead to a ***CRCReceiveTimer*** timeout in the Protocol Layer and a subsequent retry (except for communications with Cable Plugs).

Figure 8-4 illustrates one of these cases; the basic Message flow with a retry due to a bad CRC at the Message Receiver. It starts when the Message Sender's Protocol Layer at the behest of its Policy Engine forms a Message that it passes to the Physical Layer. The Protocol Layer is responsible for retries on a "'n' strikes and you are out" basis (***nRetryCount***).

Figure 8-4 Basic Message Flow with Bad CRC followed by a Retry

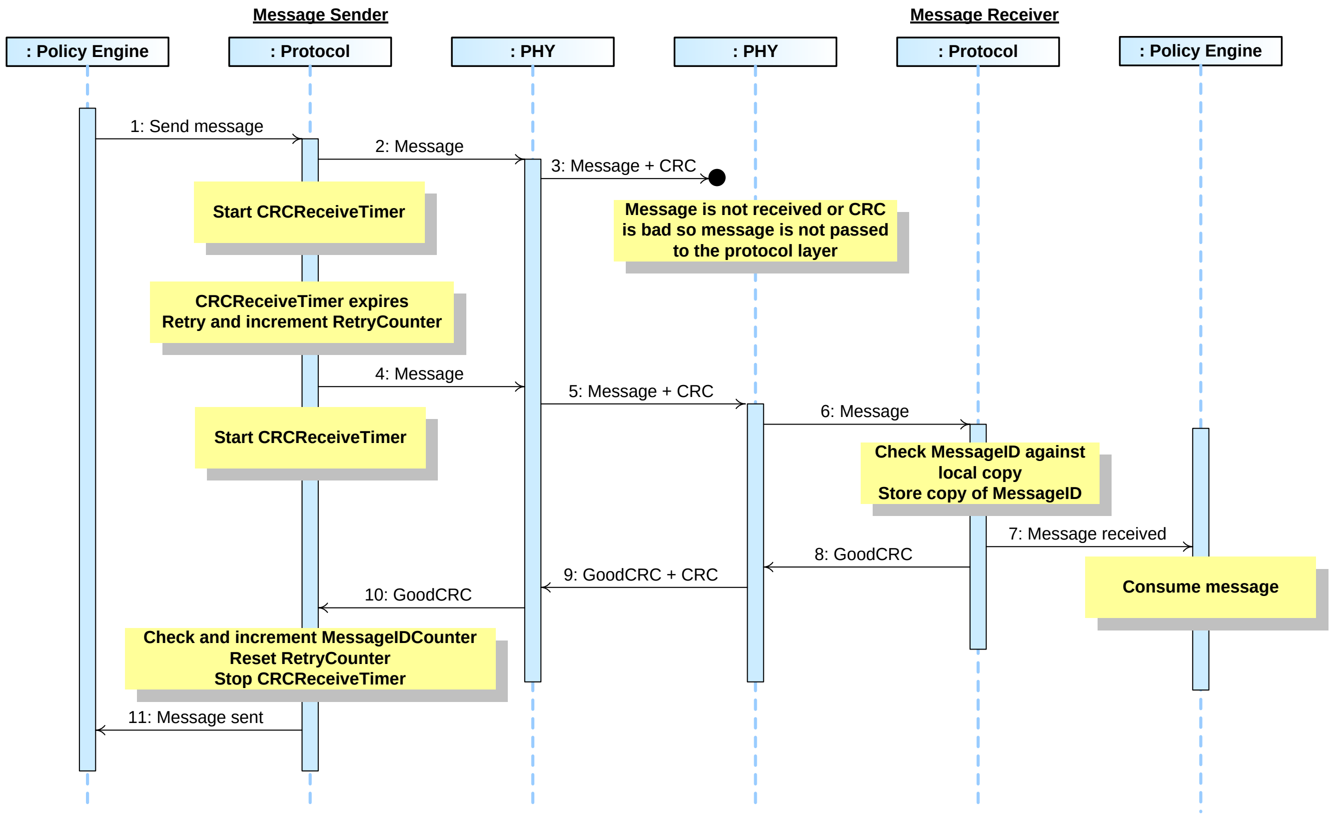


Table 8-3 Basic Message Flow with CRC failure

Step	Message Sender	Message Receiver
1	Policy Engine directs Protocol Layer to send a Message.	
2	Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.	
3	Physical Layer appends a CRC and sends the Message.	Physical Layer receives no Message or a Message with an incorrect CRC. Nothing is passed to Protocol Layer.
4	Since no response is received, the ***CRCReceiveTimer*** will expire and trigger the first retry by the Protocol Layer. The ***RetryCounter*** is incremented. Protocol Layer passes the Message to the Physical Layer. Starts ***CRCReceiveTimer***.	
5	Physical Layer appends a CRC and sends the Message.	Physical Layer receives the Message and checks the CRC to verify the Message.
6		Physical Layer removes the CRC and forwards the Message to the Protocol Layer.
7		Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. Protocol Layer forwards the received Message information to the Policy Engine that consumes it.
8		Protocol Layer generates a ***GoodCRC*** Message and passes it to the Physical Layer.

Step	Message Sender	Message Receiver
9	Physical Layer receives the Message and checks the CRC to verify the Message.	Physical Layer appends CRC and sends the ***GoodCRC*** Message.
10	Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.	
11	Protocol Layer verifies the ***MessageID***, stops ***CRCReceiveTimer*** and resets the ***RetryCounter***. Protocol Layer informs the Policy Engine that the Message was successfully sent.	

8.3.2.1.3 Interruptible and Non-interruptible Atomic Message Sequences

Table 8-4 details which AMS (as defined in Section 8.3.2) ***Shall*** be treated as Interruptible or Non-interruptible during the sequence. Every AMS which starts with the same Message ***Shall*** obey the Interruptible/Non-interruptible requirement. Note that every AMS is Interruptible until the first Message in the sequence has been successfully sent (***GoodCRC*** Message received). Any Sequence of VDMs ***Shall*** be Interruptible. After the AMS that caused the interruption has completed, if the original AMS is still needed the interrupted AMS ***Shall*** be Re-run.

Table 8-4 Interruptible and Non-interruptible AMS

AMS	Interruptible	Reference
Power Negotiation	No	Section 8.3.3.2, 8.3.3.3
GotoMin	No	Section 8.3.3.2, Section 8.3.3.3
Soft Reset	No	Section 8.3.3.4
Hard Reset	No	Section 8.3.3.2, Section 8.3.3.3
Cable Reset	No	Section 8.3.3.22.2.3
Get Source Capabilities	No	Section 8.3.3.2, Section 8.3.3.3
Get Sink Capabilities	No	Section 8.3.3.2, Section 8.3.3.3
Power Role Swap	No	Section 8.3.3.16.3, Section 8.3.3.16.4
Fast Role Swap	No	Section 8.3.3.16.5, Section 8.3.3.16.6
Data Role Swap	No	Section 8.3.3.16.1, Section 8.3.3.16.2
VCONN Swap	No	Section 8.3.3.17
Source Alert	N/A	Section 8.3.3.7
Getting Source Extended Capabilities	No	Section 8.3.3.8
Getting Source/Sink Status	No	Section 8.3.3.9
Getting Battery Capabilities	No	Section 8.3.3.10
Getting Battery Status	No	Section 8.3.3.11
Getting Manufacturer Information	No	Section 8.3.3.12
Security	Yes	Section 8.3.3.13
Firmware Update	Yes	Section 8.3.3.15
Discover Identity	Yes	Section 8.3.3.18.1, Section 8.3.3.19.1
Source startup Cable Plug Discover Identity	Yes	Section 8.3.3.18.1, Section8.3.3.22.3
Discover SVIDs	Yes	Section 8.3.3.18.2, Section 8.3.3.19.2
Discover Modes	Yes	Section 8.3.3.18.3, Section 8.3.3.19.3
DFP to UFP Enter Mode	Yes	Section 8.3.3.20.1, Section 8.3.3.21.1
DFP to UFP Exit Mode	Yes	Section 8.3.3.20.2, Section 8.3.3.21.2
DFP to Cable Plug Enter Mode	Yes	Section 8.3.3.20.1, Section 8.3.3.22.4.1
DFP to Cable Plug Exit Mode	Yes	Section 8.3.3.20.1, Section 8.3.3.22.4.2
Attention	N/A	Section 8.3.3.18.4
Built in Self-Test (BIST)	No	Section 8.3.2.14
Sequence of Unstructured VDMs	Yes	Section 6.4.4.1
Sequence of Structured VDMs using Vendor Commands	Yes	Section 6.4.4.2

8.3.2.2 Power Negotiation

Figure 8-5 illustrates an example of a successful Message flow during Power Negotiation. The negotiation goes through 5 distinct phases:

- The Source sends out its power capabilities in a ***Source_Capabilities*** Message.
- The Sink evaluates these capabilities and in the request phase selects one power level by sending a ***Request*** Message.
- The Source evaluates the request and accepts the request with an ***Accept*** Message.
- The Source transitions to the new power level and then informs the Sink by sending a ***PS_RDY*** Message.
- The Sink starts using the new power level.

Figure 8-5 Successful Power Negotiation

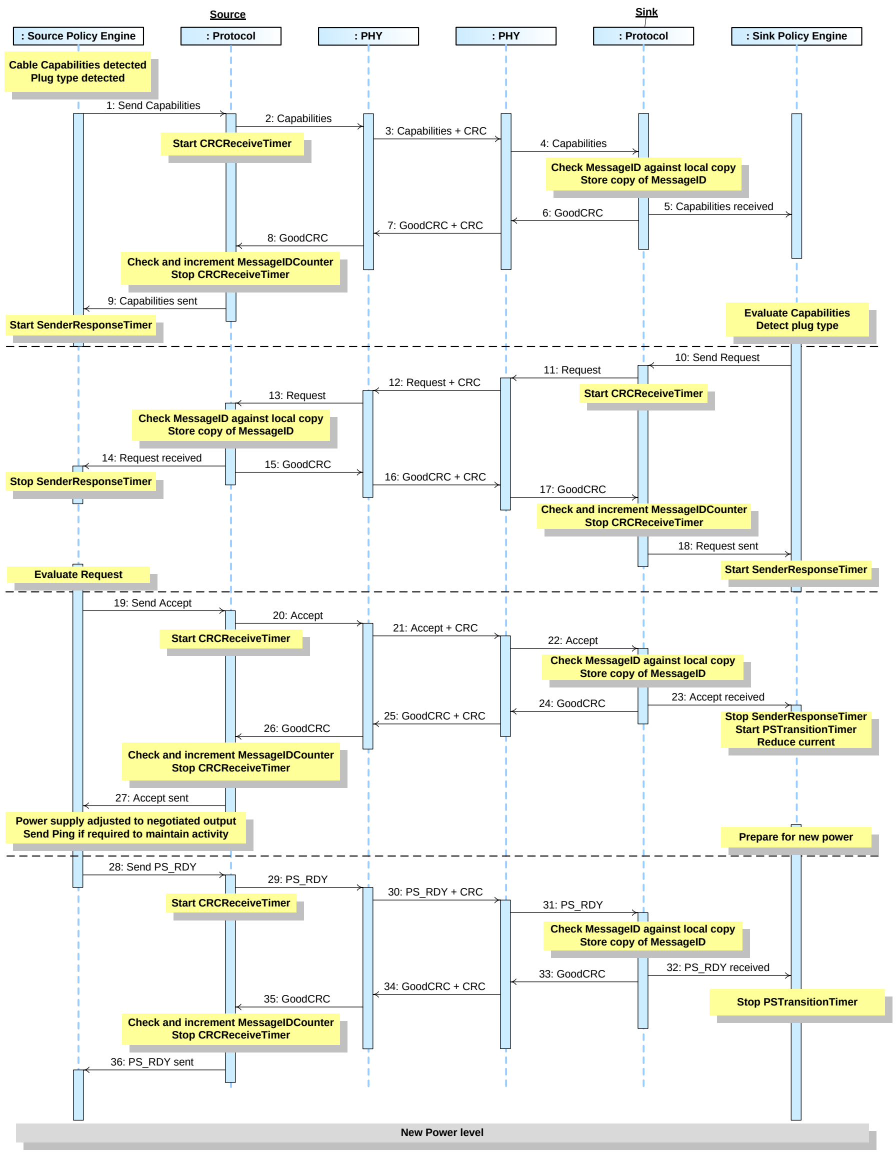


Table 8-5 below provides a detailed explanation of what happens at each labeled step in Figure 8-5 above.

Table 8-5 Steps for a successful Power Negotiation

Step	Source	Sink
1	The Cable Capabilities or Plug Type are detected if these are not already known (see Section 4.4). Policy Engine directs the Protocol Layer to send a ***Source_Capabilities*** Message that represents the power supply's present capabilities.	
2	Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.	
3	Physical Layer appends CRC and sends the ***Source_Capabilities*** Message.	Physical Layer receives the ***Source_Capabilities*** Message and checks the CRC to verify the Message.
4		Physical Layer removes the CRC and forwards the ***Source_Capabilities*** Message to the Protocol Layer.
5		Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Source_Capabilities*** Message information to the Policy Engine that consumes it.
6		Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.
7	Physical Layer receives the ***GoodCRC*** Message and checks the CRC to verify the Message.	Physical Layer appends CRC and sends the ***GoodCRC*** Message.
8	Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.	
9	Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Source_Capabilities*** Message was successfully sent. Policy Engine starts ***SenderResponseTimer***.	
10		Policy Engine evaluates the ***Source_Capabilities*** Message sent by the Source, detects the plug type if this is necessary (see Section 4.4) and selects which power it would like. It tells the Protocol Layer to form the data (e.g. Power Data Object) that represents its Request into a Message.
11		Protocol Layer creates the ***Request*** Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.
12	Physical Layer receives the ***Request*** Message and compares the CRC it calculated with the one sent to verify the Message.	Physical Layer appends a CRC and sends the ***Request*** Message.
13	Physical Layer removes the CRC and forwards the ***Request*** Message to the Protocol Layer.	
14	Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer passes the Request information to the Policy Engine. Policy Engine stops ***SenderResponseTimer***.	
15	The Protocol Layer generates a ***GoodCRC*** Message and passes it to its Physical Layer.	
16	Physical Layer appends CRC and sends the Message.	Physical Layer receives the Message and compares the CRC it calculated with the one sent to verify the Message.

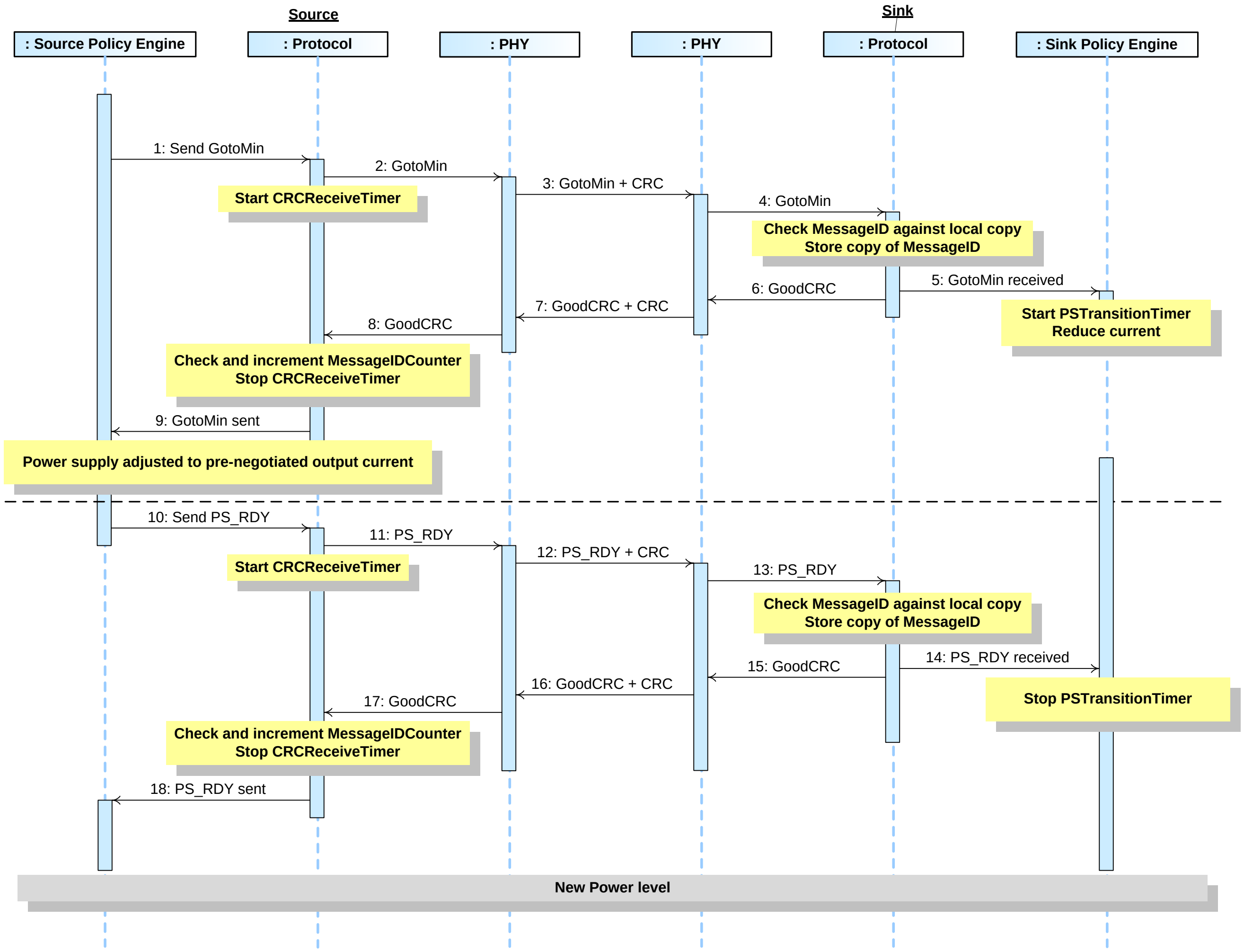
Step	Source	Sink
17		Physical Layer forwards the ***GoodCRC*** Message to the Protocol Layer.
18		The protocol Layer verifies and increments the ***MessageIDCounter***. It informs the Policy Engine that the ***Request*** Message was successfully sent. The Protocol Layer stops the ***CRCReceiveTimer***. The Policy Engine starts ***SenderResponseTimer***.
19	Policy Engine evaluates the ***Request*** Message sent by the Sink and decides if it can meet the request. It tells the Protocol Layer to form an ***Accept*** Message.	
20	The Protocol Layer forms the ***Accept*** Message that is passed to the Physical Layer and starts the ***CRCReceiveTimer***.	
21	Physical Layer appends CRC and sends the ***Accept*** Message.	Physical Layer receives the Message and compares the CRC it calculated with the one sent to verify the Message.
22		Physical Layer forwards the ***Accept*** Message to the Protocol Layer.
23		Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. Protocol Layer informs the Policy Engine that an ***Accept*** Message has been received. The Policy Engine stops ***SenderResponseTimer***, starts the ***PSTransitionTimer*** and reduces its current draw. The Device Policy Manager prepares the Power supply for transition to the new power level.
24		The Protocol Layer generates a ***GoodCRC*** Message and passes it to its Physical Layer.
25	Physical Layer receives the Message and compares the CRC it calculated with the one sent to verify the Message.	Physical Layer appends CRC and sends the Message.
26	Physical Layer forwards the ***GoodCRC*** Message to the Protocol Layer. The Protocol Layer verifies and increments the ***MessageIDCounter*** and stops the ***CRCReceiveTimer***.	
27	The Protocol Layer informs the Policy Engine that an ***Accept*** Message was successfully sent.	
power supply Adjusts its Output to the Negotiated Value		
28	The Device Policy Manager informs the Policy Engine that the power supply has settled at the new operating condition and tells the Protocol Layer to send a ***PS_RDY*** Message.	
29	The Protocol Layer forms the ***PS_RDY*** Message and starts the ***CRCReceiveTimer***.	
30	Physical Layer appends CRC and sends the ***PS_RDY*** Message.	Physical Layer receives the ***PS_RDY*** Message and compares the CRC it calculated with the one sent to verify the Message.
31		Physical Layer forwards the ***PS_RDY*** Message to the Protocol Layer.

Step	Source	Sink
32		Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. Protocol Layer informs the Policy Engine that a RS_RDY has been received. The Policy Engine stops the ***PSTransitionTimer***.
33		The Protocol Layer generates a ***GoodCRC*** Message and passes it to its Physical Layer.
34	Physical Layer receives the Message and compares the CRC it calculated with the one sent to verify the Message.	Physical Layer appends CRC and sends the Message.
35	Physical Layer forwards the ***GoodCRC*** Message to the Protocol Layer. The Protocol Layer verifies and increments the ***MessageIDCounter***. Stops the ***CRCReceiveTimer***.	
36	The Protocol Layer informs the Policy Engine that the ***PS_RDY*** Message was successfully sent.	

8.3.2.3 Reclaiming Power with GotoMin Message

This is an example of a GotoMin operation. Figure 8-6 shows the Messages as they flow across the bus and within the devices to accomplish the GotoMin.

Figure 8-6 Successful GotoMin operation



The table below provides a detailed explanation of what happens at each labeled step in Figure 8-6 above.

Table 8-6 Steps for a GotoMin Negotiation

Step	Source	Sink
1	Policy Engine tells the Protocol Layer to form a ***GotoMin*** Message.	
2	The Protocol Layer forms the ***GotoMin*** Message that is passed to the Physical Layer and starts the ***CRCReceiveTimer***.	
3	Physical Layer appends CRC and sends the ***GotoMin*** Message.	Physical Layer receives the Message and compares the CRC it calculated with the one sent to verify the Message.
4		Physical Layer forwards the ***GotoMin*** Message to the Protocol Layer.

Step	Source	Sink
5		Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. Protocol Layer informs the Policy Engine that a ***GotoMin*** Message has been received. The Policy starts the ***PSTransitionTimer*** and reduces its current draw. The Policy Engine prepares the Power supply for transition to the new power level.
6		The Protocol Layer generates a ***GoodCRC*** Message and passes it to its Physical Layer.
7	Physical Layer receives the Message and compares the CRC it calculated with the one sent to verify the Message.	Physical Layer appends CRC and sends the Message.
8	Physical Layer forwards the ***GoodCRC*** Message to the Protocol Layer. The Protocol Layer verifies and increments the ***MessageIDCounter*** and stops the ***CRCReceiveTimer***.	
9	The Protocol Layer informs the Policy Engine that a ***GotoMin*** Message was successfully sent.	
power supply Adjusts its Output to the Negotiated Value		
10	Policy Engine sees the power supply has settled at the new operating condition and tells the Protocol Layer to send a ***PS_RDY*** Message.	
11	The Protocol Layer forms the ***PS_RDY*** Message and starts the ***CRCReceiveTimer***.	
12	Physical Layer appends CRC and sends the ***PS_RDY*** Message.	Physical Layer receives the Message and compares the CRC it calculated with the one sent to verify the Message.
13		Physical Layer forwards the ***PS_RDY*** Message to the Protocol Layer.
14		Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. Protocol Layer informs the Policy Engine that a ***PS_RDY*** Message has been received. The Policy Engine stops the ***PSTransitionTimer***.
15		The Protocol Layer generates a ***GoodCRC*** Message and passes it to its Physical Layer.
16	Physical Layer receives the Message and compares the CRC it calculated with the one sent to verify the Message.	Physical Layer appends CRC and sends the Message.
17	Physical Layer forwards the ***GoodCRC*** Message to the Protocol Layer. The Protocol Layer verifies and increments the ***MessageIDCounter*** and stops the ***CRCReceiveTimer***.	
18	The Protocol Layer informs the Policy Engine that the ***PS_RDY*** Message was successfully sent.	

8.3.2.4 Soft Reset

This is an example of a Soft Reset operation. Figure 8-7 shows the Messages as they flow across the bus and within the devices to accomplish the Soft Reset.

Figure 8-7 Soft Reset

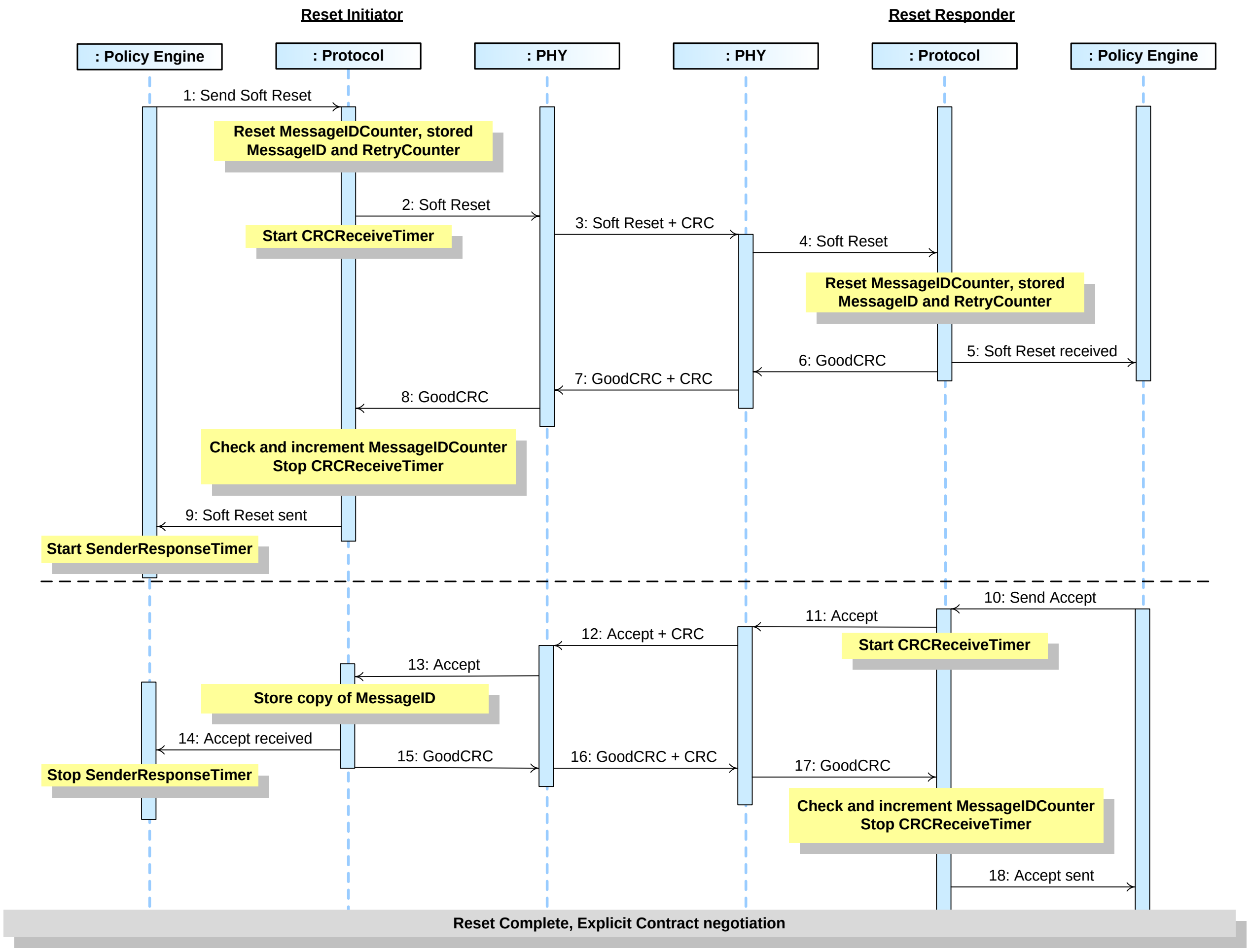


Table 8-7 below provides a detailed explanation of what happens at each labeled step in Figure 8-7 above.

Table 8-7 Steps for a Soft Reset

Step	Reset Initiator	Reset Responder
1	The Policy Engine directs the Protocol Layer to generate a ***Soft_Reset*** Message to request a Soft Reset.	
2	Protocol Layer resets ***MessageIDCounter***, stored ***MessageID*** and ***RetryCounter***. Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.	
3	Physical Layer appends CRC and sends the ***Soft_Reset*** Message.	Physical Layer receives the ***Soft_Reset*** Message and compares the CRC it calculated with the one sent to verify the Message.
4		Physical Layer removes the CRC and forwards the ***Soft_Reset*** Message to the Protocol Layer.

Step	Reset Initiator	Reset Responder
5		Protocol Layer does not check the ***MessageID*** in the incoming Message and resets ***MessageIDCounter***, stored ***MessageID*** and ***RetryCounter***. The Protocol Layer forwards the received ***Soft_Reset*** Message information to the Policy Engine that consumes it.
6		Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.
7	Physical Layer receives the ***GoodCRC*** and checks the CRC to verify the Message.	Physical Layer appends CRC and sends the ***GoodCRC*** Message.
8	Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.	
9	Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Soft_Reset*** Message was successfully sent. Policy Engine starts ***SenderResponseTimer***.	
10		Policy Engine tells the Protocol Layer to form an ***Accept*** Message.
11		Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.
12	Physical Layer receives the Message and compares the CRC it calculated with the one sent to verify the Message.	Physical Layer appends a CRC and sends the Message.
13	Protocol Layer stores the ***MessageID*** of the incoming Message.	
14	The Protocol Layer forwards the received ***Accept*** Message information to the Policy Engine that consumes it.	
15	Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.	
16	Physical Layer appends a CRC and sends the ***GoodCRC*** Message.	Physical Layer receives ***GoodCRC*** Message and compares the CRC it calculated with the one sent to verify the Message.
17		Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.
18		Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Accept*** Message was successfully sent.
	The reset is complete and protocol communication can restart. Port Partners perform an Explicit Contract negotiation to re-synchronize their state machines.	

8.3.2.5 Hard Reset

The following sections describe the steps required for a USB Power Delivery Hard Reset. The Hard Reset returns the operation of the USB Power Delivery to default role and operating voltage/current. During the Hard Reset USB Power Delivery PHY Layer communications ***Shall*** be disabled preventing communication between the Port partners.

Note: Hard Reset, in this case, is applied to the USB Power Delivery capability of an individual Port on which the Hard Reset is requested. A side effect of the Hard Reset is that it might reset other functions on the Port such as USB.

8.3.2.5.1 Source Initiated Hard Reset

This is an example of a Hard Reset operation when initiated by a Source. Figure 8-8 shows the Messages as they flow across the bus and within the devices to accomplish the Hard Reset.

Figure 8-8 Source initiated Hard Reset

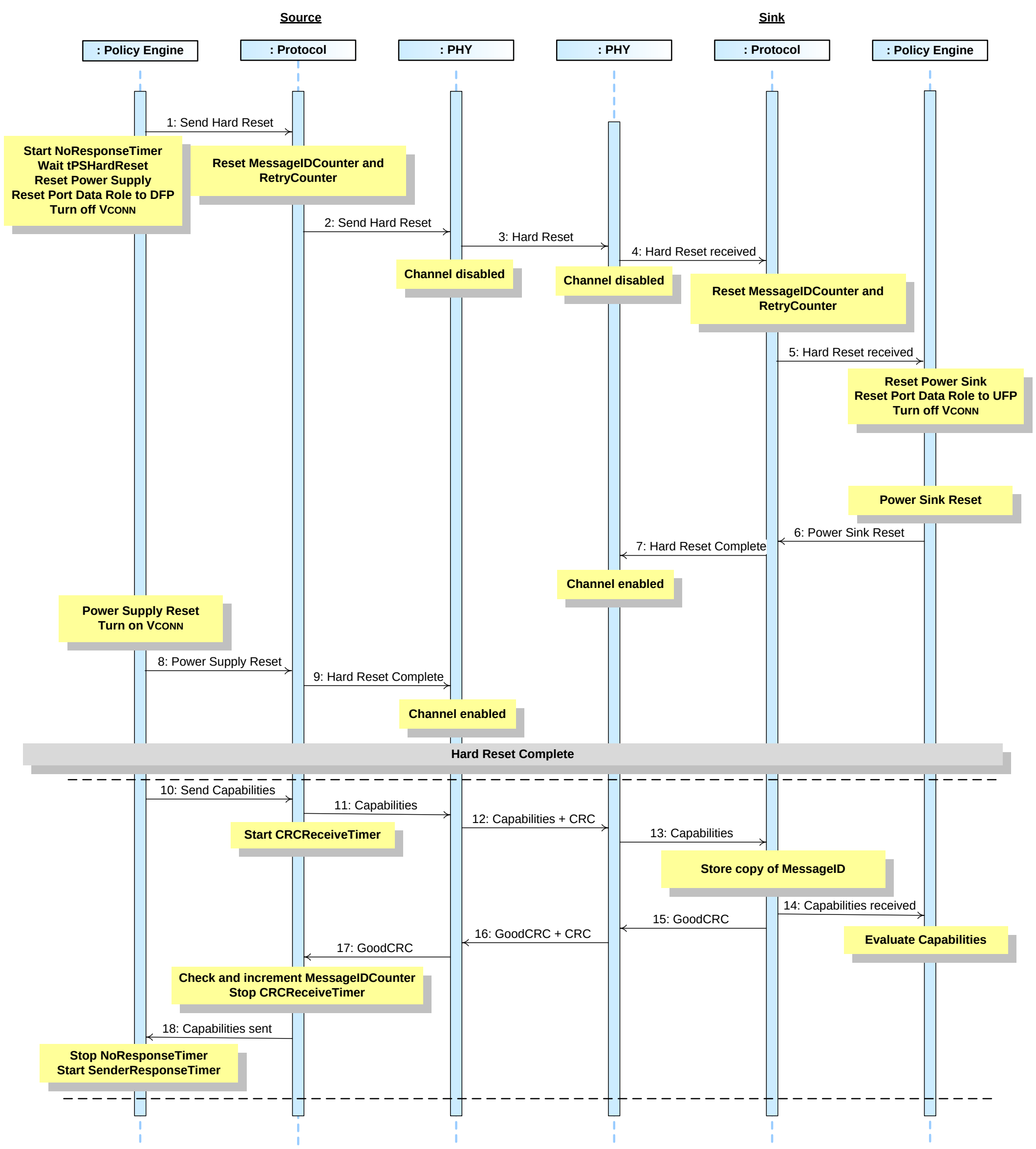


Table 8-8 Steps for Source initiated Hard Reset

Step	Source	Sink
1	The Policy Engine directs the Protocol Layer to generate ***Hard Reset*** Signaling. The Policy Engine starts the ***NoResponseTimer*** and requests the Device Policy Manager to reset the power supply to USB Default Operation. The Policy Engine requests the Device Policy Manager to reset the Port Data Role to DFP and to turn off VCONN if this is on.	
2	Protocol Layer resets ***MessageIDCounter*** and ***RetryCounter.*** Protocol Layer requests the Physical Layer send ***Hard Reset*** Signaling.	
3	Physical Layer sends ***Hard Reset*** Signaling and then disables the PHY Layer communications channel for transmission and reception.	Physical Layer receives the ***Hard Reset*** Signaling and disables the PHY Layer communications channel for transmission and reception.
4		Physical Layer informs the Protocol Layer of the Hard Reset. Protocol Layer resets ***MessageIDCounter*** and ***RetryCounter***.
5		The Protocol Layer informs the Policy Engine of the Hard Reset. The Policy Engine requests the Device Policy Manager to reset the Power Sink to default operation. The Policy Engine requests the Device Policy Manager to reset the Port Data Role to UFP and to turn off VCONN if this is on.
6		The Power Sink returns to default operation. The Policy Engine informs the Protocol Layer that the Power Sink has been reset.
7		The Protocol Layer informs the PHY Layer that the Hard Reset is complete. The PHY Layer enables the PHY Layer communications channel for transmission and reception.
8	The power supply is reset to default operation and VCONN is turned on. The Policy Engine informs the Protocol Layer that the power supply has been reset.	
9	The Protocol Layer informs the PHY Layer that the Hard Reset is complete. The PHY Layer enables the PHY Layer communications channel for transmission and reception.	
	The reset is complete and protocol communication can restart.	
10	Policy Engine directs the Protocol Layer to send a ***Source_Capabilities*** Message that represents the power supply's present capabilities.	
11	Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.	
12	Physical Layer appends CRC and sends the ***Source_Capabilities*** Message.	Physical Layer receives the ***Source_Capabilities*** Message and checks the CRC to verify the Message.
13		Physical Layer removes the CRC and forwards the ***Source_Capabilities*** Message to the Protocol Layer.

Step	Source	Sink
14		Protocol Layer stores the ***MessageID*** of the incoming Message. The Protocol Layer forwards the received ***Source_Capabilities*** Message information to the Policy Engine that consumes it.
15		Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.
16	Physical Layer receives the ***GoodCRC*** Message and checks the CRC to verify the Message.	Physical Layer appends CRC and sends the ***GoodCRC*** Message.
17	Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.	
18	Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Source_Capabilities*** Message was successfully sent. Policy Engine stops the ***NoResponseTimer*** and starts the ***SenderResponseTimer***.	
	USB Power Delivery communication is re-established.	

8.3.2.5.2 Sink Initiated Hard Reset

This is an example of a Hard Reset operation when initiated by a Sink. Figure 8-9 shows the Messages as they flow across the bus and within the devices to accomplish the Hard Reset.

Figure 8-9 Sink Initiated Hard Reset

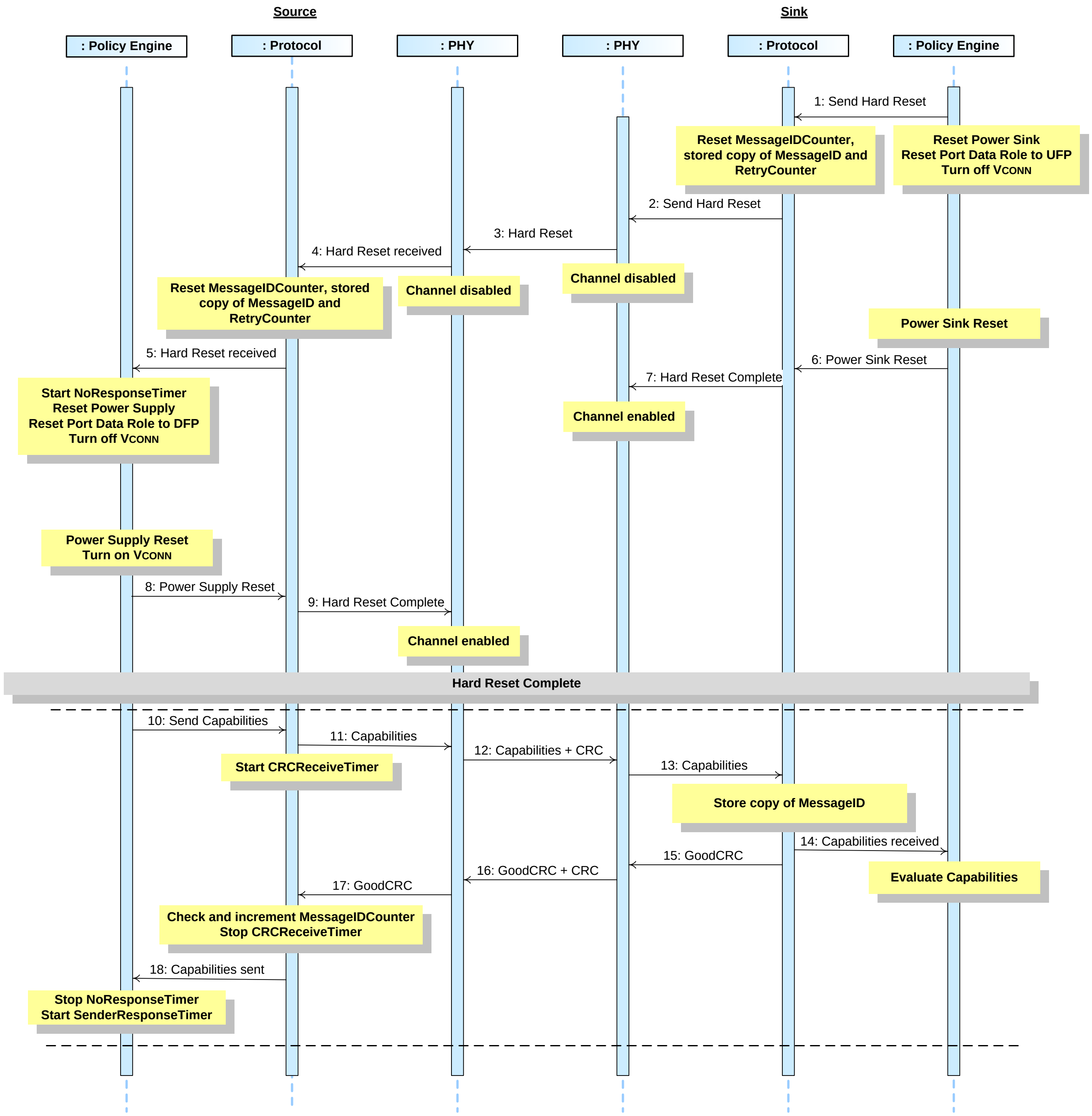


Table 8-9 Steps for Sink initiated Hard Reset

Step	Source	Sink
1		The Policy Engine directs the Protocol Layer to generate ***Hard Reset*** Signaling. The Policy Engine requests the Device Policy Manager to reset the power supply to USB Default Operation. The Policy Engine requests the Device Policy Manager to reset the Port Data Role to UFP and to turn off VCONN if this is on.
2		Protocol Layer resets ***MessageIDCounter***, stored copy of ***MessageID*** and ***RetryCounter***. Protocol Layer requests the Physical Layer send ***Hard Reset*** Signaling.
3	Physical Layer receives the ***Hard Reset*** Signaling and disables the PHY Layer communications channel for transmission and reception.	Physical Layer sends the ***Hard Reset*** Signaling and then disables the PHY Layer communications channel for transmission and reception.
4	Physical Layer informs the Protocol Layer of the Hard Reset. Protocol Layer resets ***MessageIDCounter***, stored copy of ***MessageID*** and ***RetryCounter***.	
5	The Protocol Layer Informs the Policy Engine of the Hard Reset. The Policy Engine starts the ***NoResponseTimer*** and requests the Device Policy Manager to reset the Power Sink to default operation. The Policy Engine requests the Device Policy Manager to reset the Port Data Role to DFP and to turn off VCONN if this is on.	
6		The Power Sink returns to USB Default Operation. The Policy Engine informs the Protocol Layer that the Power Sink has been reset.
7		The Protocol Layer informs the PHY Layer that the Hard Reset is complete. The PHY Layer enables the PHY Layer communications channel for transmission and reception.
8	The power supply is reset to USB Default Operation and VCONN is turned on. The Policy Engine informs the Protocol Layer that the power supply has been reset.	
9	The Protocol Layer informs the PHY Layer that the Hard Reset is complete. The PHY Layer enables the PHY Layer communications channel for transmission and reception.	
	The reset is complete and protocol communication can restart.	
10	Policy Engine directs the Protocol Layer to send a ***Source_Capabilities*** Message that represents the power supply's present capabilities.	
11	Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.	
12	Physical Layer appends CRC and sends the ***Source_Capabilities*** Message.	Physical Layer receives the ***Source_Capabilities*** Message and checks the CRC to verify the Message.
13		Physical Layer removes the CRC and forwards the ***Source_Capabilities*** Message to the Protocol Layer.

Step	Source	Sink
14		Protocol Layer stores the ***MessageID*** of the incoming Message. The Protocol Layer forwards the received ***Source_Capabilities*** Message information to the Policy Engine that consumes it.
15		Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.
16	Physical Layer receives the ***GoodCRC*** Message and checks the CRC to verify the Message.	Physical Layer appends CRC and sends the ***GoodCRC*** Message.
17	Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.	
18	Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Source_Capabilities*** Message was successfully sent. Policy Engine stops the ***NoResponseTimer*** and starts the ***SenderResponseTimer***.	
	USB Power Delivery communication is re-established.	

8.3.2.5.3 Source Initiated Hard Reset – Sink Long Reset

This is an example of a Hard Reset operation when initiated by a Source. In this example the Sink is slow responding to the reset causing the Source to send multiple ***Source_Capabilities*** Messages before it receives a ***GoodCRC*** Message response. Figure 8-10 shows the Messages as they flow across the bus and within the devices to accomplish the Hard Reset.

Figure 8-10 Source initiated reset - Sink long reset

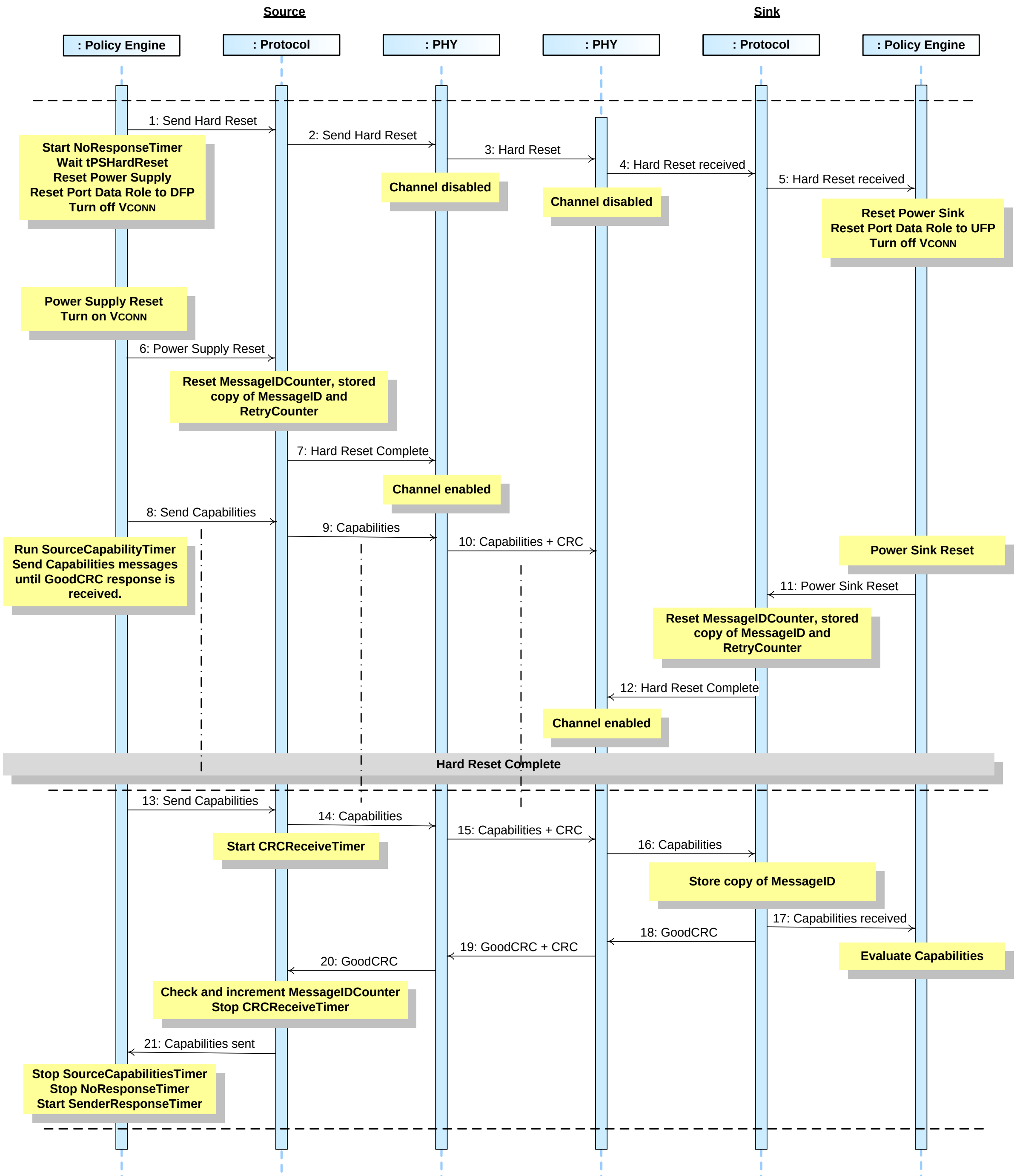


Table 8-10 Steps for Source initiated Hard Reset – Sink long reset

Step	Source	Sink
1	The Policy Engine directs the Protocol Layer to generate ***Hard Reset*** Signaling. The Policy Engine starts the ***NoResponseTimer*** and requests the Device Policy Manager to reset the power supply to USB Default Operation. The Policy Engine requests the Device Policy Manager to reset the Port Data Role to DFP and to turn off VCONN if this is on.	
2	Protocol Layer resets ***MessageIDCounter***, stored copy of ***MessageID*** and ***RetryCounter***. Protocol Layer requests the Physical Layer send ***Hard Reset*** Signaling.	
3	Physical Layer sends the ***Hard Reset*** Signaling and then disables the PHY Layer communications channel for transmission and reception.	Physical Layer receives the ***Hard Reset*** Signaling and disables the PHY Layer communications channel for transmission and reception.
4		Physical Layer informs the Protocol Layer of the Hard Reset. Protocol Layer resets ***MessageIDCounter***, stored copy of ***MessageID*** and ***RetryCounter***.
5		The Protocol Layer Informs the Policy Engine of the Hard Reset. The Policy Engine requests the Device Policy Manager to reset the Power Sink to default operation. The Policy Engine requests the Device Policy Manager to reset the Port Data Role to UFP and to turn off VCONN if this is on.
6	The power supply is reset to USB Default Operation and VCONN is turned on. The Policy Engine informs the Protocol Layer that the power supply has been reset.	
7	The Protocol Layer informs the PHY Layer that the Hard Reset is complete. The PHY Layer enables the PHY Layer communications channel for transmission and reception.	
	The reset is complete and protocol communication can restart.	
8	Policy Engine directs the Protocol Layer to send a ***Source_Capabilities*** Message that represents the power supply's present capabilities. Policy Engine starts the ***SourceCapabilityTimer***. The ***SourceCapabilityTimer*** times out one or more times until a ***GoodCRC*** Message response is received.	
9	Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.	
10	Physical Layer appends CRC and sends the ***Source_Capabilities*** Message.	Note: ***Source_Capabilities*** Message not received since channel is disabled.
11		The Power Sink returns to USB Default Operation. The Policy Engine informs the Protocol Layer that the Power Sink has been reset.
12		The Protocol Layer informs the PHY Layer that the Hard Reset is complete. The PHY Layer enables the PHY Layer communications channel for transmission and reception.

Step	Source	Sink
	The reset is complete and protocol communication can restart.	
13	Policy Engine directs the Protocol Layer to send a ***Source_Capabilities*** Message that represents the power supply's present capabilities. Starts the ***SourceCapabilityTimer***.	
14	Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.	
15	Physical Layer appends CRC and sends the ***Source_Capabilities*** Message.	Physical Layer receives the ***Source_Capabilities*** Message and checks the CRC to verify the Message.
16		Physical Layer removes the CRC and forwards the ***Source_Capabilities*** Message to the Protocol Layer.
17		Protocol Layer stores the ***MessageID*** of the incoming Message. The Protocol Layer forwards the received ***Source_Capabilities*** Message information to the Policy Engine that consumes it.
18		Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.
19	Physical Layer receives the ***GoodCRC*** Message and checks the CRC to verify the Message.	Physical Layer appends CRC and sends the ***GoodCRC*** Message.
20	Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.	
21	Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Source_Capabilities*** Message was successfully sent. Policy Engine stops the ***SourceCapabilityTimer***, stops the ***NoResponseTimer*** and starts the ***SenderResponseTimer***.	
	USB Power Delivery communication is re-established.	

8.3.2.6 Power Role Swap

8.3.2.6.1 Source Initiated Power Role Swap without subsequent Power Negotiation

This is an example of a successful Power Role Swap operation initiated by a Port which initially, at the start of this Message sequence, is acting as a Source and therefore has Rp pulled up on its CC wire. It does not include any subsequent Power Negotiation which is required in order to establish an Explicit Contract (see Section 8.3.2.2).

There are four distinct phases to the Power Role Swap negotiation:

1. A ***PR_Swap*** Message is sent.
2. An ***Accept*** Message in response to the ***PR_Swap*** Message.
3. The new Sink sets its power output to ***vSafe0V***, then asserts Rd and sends a ***PS_RDY*** Message when this process is complete.
4. The new Source asserts Rp, then sets its power output to ***vSafe5V*** and sends a ***PS_RDY*** Message when it is ready to supply power.

Figure 8-11 shows the Messages as they flow across the bus and within the devices to accomplish the Power Role Swap sequence.

Figure 8-11 Successful Power Role Swap Sequence Initiated by the Source

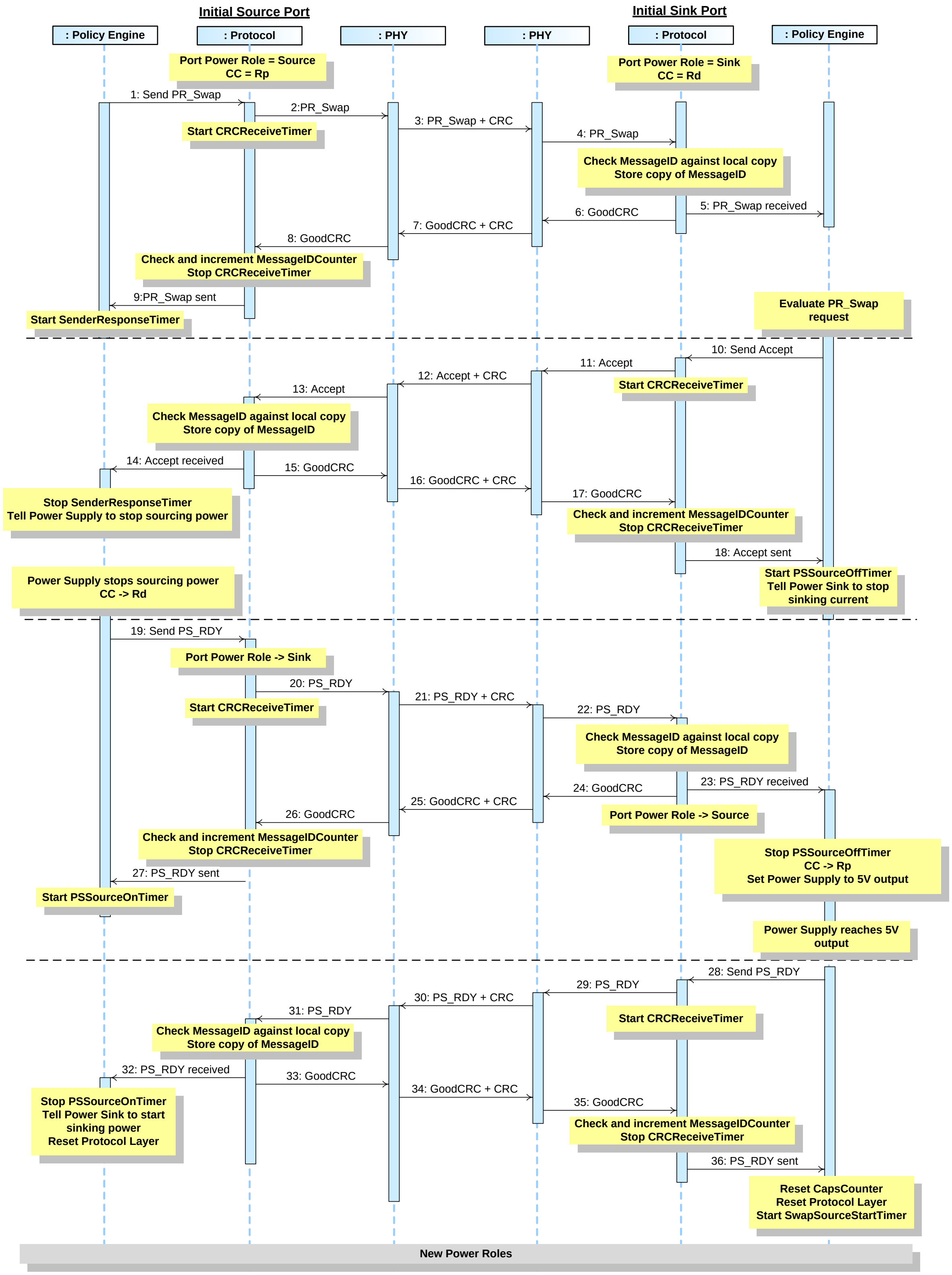


Table 8-11below provides a detailed explanation of what happens at each labeled step in Figure 8-11 above.

Table 8-11 Steps for a Successful Source Initiated Power Role Swap Sequence

Step	Initial Source Port	Initially Sink Port
1	The Port has ***Port Power Role*** set to Source and the Rp pull up on its CC wire. Policy Engine directs the Protocol Layer to send a ***PR_Swap*** Message.	The Port has ***Port Power Role*** set to Sink with the Rd pull down on its CC wire.
2	Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.	
3	Physical Layer appends CRC and sends the ***PR_Swap*** Message.	Physical Layer receives the ***PR_Swap*** Message and checks the CRC to verify the Message.
4		Physical Layer removes the CRC and forwards the ***PR_Swap*** Message to the Protocol Layer.
5		Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***PR_Swap*** Message information to the Policy Engine that consumes it.
6		Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.
7	Physical Layer receives the ***GoodCRC*** Message and checks the CRC to verify the Message.	Physical Layer appends CRC and sends the ***GoodCRC*** Message.
8	Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.	
9	Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***PR_Swap*** Message was successfully sent. Policy Engine starts ***SenderResponseTimer***.	
10		Policy Engine evaluates the ***PR_Swap*** Message sent by the Source and decides that it is able and willing to do the Power Role Swap. It tells the Protocol Layer to form an ***Accept*** Message.
11		Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.
12	Physical Layer receives the Message and compares the CRC it calculated with the one sent to verify the ***Accept*** Message.	Physical Layer appends a CRC and sends the ***Accept*** Message.
13	Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***PR_Swap*** Message information to the Policy Engine that consumes it.	
14	The Policy Engine requests its power supply to stop supplying power and stops the ***SenderResponseTimer***.	
15	Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.	
16	Physical Layer appends a CRC and sends the ***GoodCRC*** Message.	Physical Layer receives ***GoodCRC*** Message and compares the CRC it calculated with the one sent to verify the Message.

Step	Initial Source Port	Initially Sink Port
17		Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.
18		Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Accept*** Message was successfully sent. The Policy Engine starts the ***PSSourceOffTimer*** and tells the power supply to stop sinking current.
19	The Policy Engine determines its power supply is no longer supplying V_{BUS}. The Policy Engine requests the Device Policy Manager to assert the Rd pull down on the CC wire. The Policy Engine then directs the Protocol Layer to generate a ***PS_RDY*** Message, with the ***Port Power Role*** bit in the Message Header set to "Sink", to tell its Port Partner that it can begin to Source V_{BUS}.	
20	Protocol Layer sets the ***Port Power Role*** bit in the Message Header set to "Sink", creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.	
21	Physical Layer appends CRC and sends the ***PS_RDY*** Message.	Physical Layer receives the ***PS_RDY*** Message and checks the CRC to verify the Message.
22		Physical Layer removes the CRC and forwards the ***PS_RDY*** Message to the Protocol Layer.
23		Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***PS_RDY*** Message information to the Policy Engine that consumes it. The Policy Engine stops the ***PSSourceOffTimer***, directs the Device Policy Manager to apply the Rp pull up and then starts switching the power supply to ***vSafe5V*** Source operation.
24		Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.
25	Physical Layer receives the ***GoodCRC*** Message and checks the CRC to verify the Message.	Physical Layer appends CRC and sends the ***GoodCRC*** Message.
26	Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.	
27	Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***PS_RDY*** Message was successfully sent. Policy Engine starts ***PSSourceOnTimer***.	
28		Policy Engine, when its power supply is ready to supply power, tells the Protocol Layer to form a ***PS_RDY*** Message. The ***Port Power Role*** bit used in this and subsequent Message Headers is now set to "Source".
29		Protocol Layer creates the ***PS_RDY*** Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.
30	Physical Layer receives the ***PS_RDY*** Message and compares the CRC it calculated with the one sent to verify the Message.	Physical Layer appends a CRC and sends the ***PS_RDY*** Message.

Step	Initial Source Port	Initially Sink Port
31	Physical Layer removes the CRC and forwards the ***PS_RDY*** Message to the Protocol Layer.	
32	Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***PS_RDY*** Message information to the Policy Engine that consumes it.	
33	Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.	
34	Physical Layer appends a CRC and sends the ***GoodCRC*** Message. The Policy Engine stops the ***PSSourceOnTimer***, informs the power supply it can now Sink power and resets the Protocol Layer.	Physical Layer receives ***GoodCRC*** Message and compares the CRC it calculated with the one sent to verify the Message.
35		Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.
36		Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***PS_RDY*** Message was successfully sent. The Policy Engine resets the ***CapsCounter***, resets the Protocol Layer and starts the ***SwapSourceStartTimer*** which must timeout before sending any ***Source_Capabilities*** Messages.
	The Power Role Swap is complete, the roles have been reversed and the Port Partners are free to negotiate for more power.	

8.3.2.6.2 Sink Initiated Power Role Swap without subsequent Power Negotiation

This is an example of a successful Power Role Swap operation initiated by a Port which initially, at the start of this Message sequence, is acting as a Sink and therefore has Rd pulled down on its CC wire. It does not include any subsequent Power Negotiation which is required in order to establish an Explicit Contract (see Section 8.3.2.2).

There are four distinct phases to the Power Role Swap negotiation:

1. A ***PR_Swap*** Message is sent.
2. An ***Accept*** Message in response to the ***PR_Swap*** Message.
3. The new Sink sets its power output to ***vSafe0V***, then asserts Rd and sends a ***PS_RDY*** Message when this process is complete.
4. The new Source asserts Rp, then sets its power output to ***vSafe5V*** and sends a ***PS_RDY*** Message when it is ready to supply power.

Figure 8-12 shows the Messages as they flow across the bus and within the devices to accomplish the Power Role Swap.

Figure 8-12 Successful Power Role Swap Sequence Initiated by the Sink

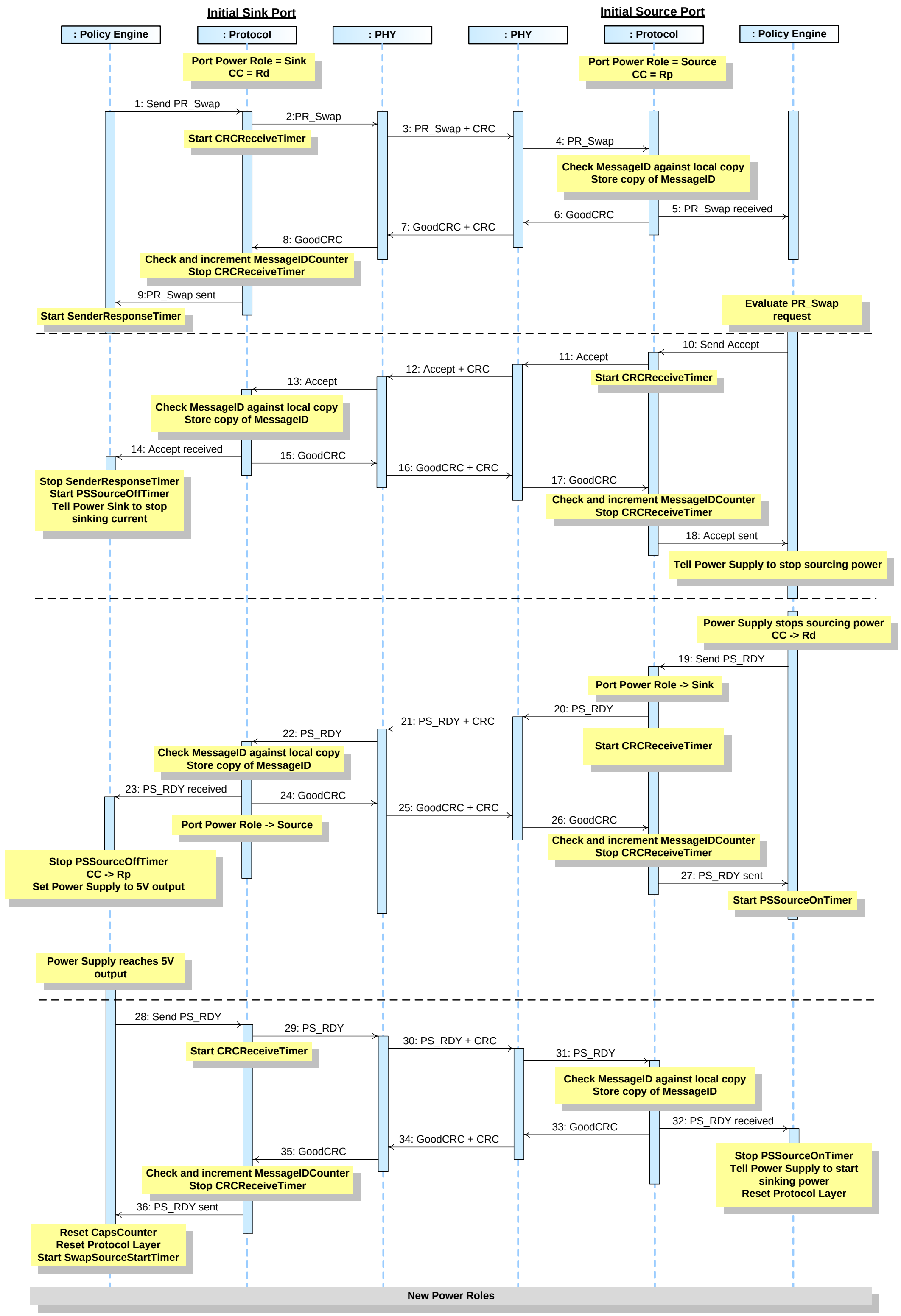


Table 8-12 Steps for a Successful Sink Initiated Power Role Swap Sequence

Step	Initial Sink Port	Initial Source Port
1	The Port has ***Port Power Role*** set to Sink with the Rd pull down on its CC wire. Policy Engine directs the Protocol Layer to send a ***PR_Swap*** Message.	The Port has ***Port Power Role*** set to Source and the Rp pull up on its CC wire.
2	Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.	
3	Physical Layer appends CRC and sends the ***PR_Swap*** Message.	Physical Layer receives the ***PR_Swap*** Message and checks the CRC to verify the Message.
4		Physical Layer removes the CRC and forwards the ***PR_Swap*** Message to the Protocol Layer.
5		Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***PR_Swap*** Message information to the Policy Engine that consumes it.
6		Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.
7	Physical Layer receives the ***GoodCRC*** Message and checks the CRC to verify the Message.	Physical Layer appends CRC and sends the ***GoodCRC*** Message.
8	Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.	
9	Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***PR_Swap*** Message was successfully sent. Policy Engine starts ***SenderResponseTimer***.	
10		Policy Engine evaluates the ***PR_Swap*** Message sent by the Sink and decides that it is able and willing to do the Power Role Swap. It tells the Protocol Layer to form an ***Accept*** Message.
11		Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.
12	Physical Layer receives the Message and compares the CRC it calculated with the one sent to verify the ***Accept*** Message.	Physical Layer appends a CRC and sends the ***Accept*** Message.
13	Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***PR_Swap*** Message information to the Policy Engine that consumes it.	
14	The Policy Engine stops the ***SenderResponseTimer***, starts the ***PSSourceOffTimer*** and tells the power supply to stop sinking current.	
15	Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.	
16	Physical Layer appends a CRC and sends the ***GoodCRC*** Message.	Physical Layer receives ***GoodCRC*** Message and compares the CRC it calculated with the one sent to verify the Message.
17		Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.

Step	Initial Sink Port	Initial Source Port
18		Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Accept*** Message was successfully sent. The Policy Engine tells the power supply to stop supplying power.
19		The Policy Engine determines its power supply is no longer supplying V_{BUS}. The Policy Engine requests the Device Policy Manager to assert the Rd pull down on the CC wire. The Policy Engine then directs the Protocol Layer to generate a ***PS_RDY*** Message, with the ***Port Power Role*** bit in the Message Header set to “Sink”, to tell its Port Partner that it can begin to Source V_{BUS}.
20		Protocol Layer sets the ***Port Power Role*** bit in the Message Header set to “Sink”, creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.
21	Physical Layer receives the ***PS_RDY*** Message and checks the CRC to verify the Message.	Physical Layer appends CRC and sends the ***PS_RDY*** Message.
22	Physical Layer removes the CRC and forwards the ***PS_RDY*** Message to the Protocol Layer.	
23	Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***PS_RDY*** Message information to the Policy Engine that consumes it. The Policy Engine stops the ***PSSourceOffTimer***, directs the Device Policy Manager to apply the Rp pull up and then starts switching the power supply to ***vSafe5V*** Source operation.	
24	Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.	
25	Physical Layer appends CRC and sends the ***GoodCRC*** Message.	Physical Layer receives the ***GoodCRC*** Message and checks the CRC to verify the Message.
26		Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.
27		Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***PS_RDY*** Message was successfully sent. Policy Engine starts ***PSSourceOnTimer***.
28	Policy Engine, when its power supply is ready to supply power, tells the Protocol Layer to form a ***PS_RDY*** Message. The ***Port Power Role*** bit used in this and subsequent Message Headers is now set to “Source”.	
29	Protocol Layer creates the ***PS_RDY*** Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.	
30	Physical Layer appends a CRC and sends the ***PS_RDY*** Message.	Physical Layer receives the ***PS_RDY*** Message and compares the CRC it calculated with the one sent to verify the Message.
31		Physical Layer removes the CRC and forwards the ***PS_RDY*** Message to the Protocol Layer.

Step	Initial Sink Port	Initial Source Port
32		Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***PS_RDY*** Message information to the Policy Engine that consumes it. The Policy Engine stops the ***PSSourceOnTimer***, informs the power supply that it can start consuming power.
33		Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.
34	Physical Layer receives ***GoodCRC*** Message and compares the CRC it calculated with the one sent to verify the Message.	Physical Layer appends a CRC and sends the ***GoodCRC*** Message. The Policy Engine stops the ***PSSourceOnTimer***, informs the power supply it can now Sink power and resets the Protocol Layer.
35	Physical Layer removes the CRC and forwards the ***GoodCRC*** to the Protocol Layer.	
36	Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***PS_RDY*** Message was successfully sent. The Policy Engine resets the ***CapsCounter***, resets the Protocol Layer and starts the ***SwapSourceStartTimer*** which must timeout before sending any ***Source_Capabilities*** Messages.	
	The Power Role Swap is complete, the roles have been reversed and the Port Partners are free to negotiate for more power.	

8.3.2.7 Fast Role Swap

This is an example of a successful Fast Role Swap operation initiated by a Port that is initially a Source and therefore has Rp pulled up on its CC Wire and which has lost power and needs to get ***vSafe5V*** quickly. It does not include any subsequent Power Negotiation which is required in order to establish an Explicit Contract (see Section 8.3.2.2).

There are several distinct phases to the Fast Role Swap negotiation:

1. The initial Source stops driving its power output which starts transitioning to ***vSafe0V*** and signals Fast Role Swap on the CC Wire.
2. The initial Sink stops Sinking power. At this point the new Source still has Rd asserted and the new Sink still has Rp asserted.
3. An ***FR_Swap*** Message is sent by the new Source within ***tFRSwapInit*** of detecting the Fast Swap signal.
4. An ***Accept*** Message is sent by the new Sink in response to the ***FR_Swap*** Message.
5. The new Sink asserts Rd and sends a ***PS_RDY*** Message indicating that the voltage on V_{BUS} is at or below ***vSafe5V***.
6. The new Source asserts Rp and sends a ***PS_RDY*** Message indicating that it is acting as a Source and is supplying ***vSafe5V***. Note: that the new Source can start applying at any point V_{BUS} is at or below ***vSafe5V*** but will start driving V_{BUS} to ***vSafe5V*** no later than ***tSrcFRSwap*** after detecting that V_{BUS} has dropped below ***vSafe5V***. This can happen at any point after the Fast Role Swap signal is detected.

Figure 8-13 shows the Messages as they flow across the bus and within the devices to accomplish the Fast Role Swap.

Figure 8-13 Successful Fast Role Swap Sequence

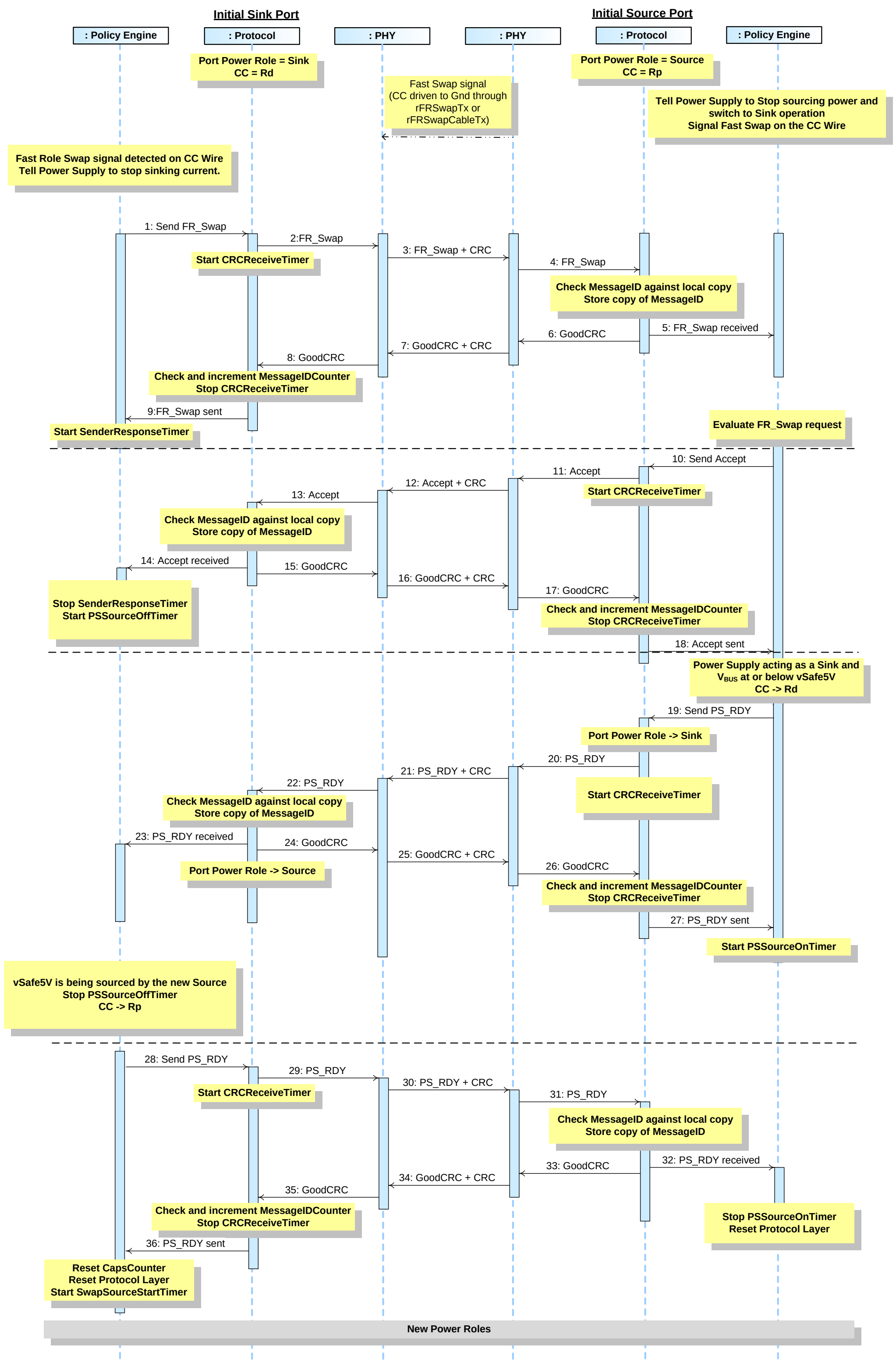


Table 8-13 Steps for a Successful Fast Role Swap Sequence

Step	Initial Sink Port	Initial Source Port
1	The Port has ***Port Power Role*** set to Sink with the Rd pull down on its CC wire. The Device Policy Manager detects Fast Swap on the CC Wire and tells the power supply to stop sinking current.	The Port has ***Port Power Role*** set to Source and the Rp pull up on its CC wire. The Device Policy Manager tells the Power Supply to stop sourcing power and switch to Sink operation. The Device Policy Manager signals Fast Swap on the CC Wire by driving CC to ground with a resistance of less than ***rFRSwapTx*** for at least ***tFRSwapTx***.
2	Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.	
3	Physical Layer appends CRC and sends the ***FR_Swap*** Message.	Physical Layer receives the ***FR_Swap*** Message and checks the CRC to verify the Message.
4		Physical Layer removes the CRC and forwards the ***PR_Swap*** Message to the Protocol Layer.
5		Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***FR_Swap*** Message information to the Policy Engine that consumes it.
6		Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.
7	Physical Layer receives the ***GoodCRC*** Message and checks the CRC to verify the Message.	Physical Layer appends CRC and sends the ***GoodCRC*** Message.
8	Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.	
9	Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***FR_Swap*** Message was successfully sent. Policy Engine starts ***SenderResponseTimer***.	
10		Policy Engine evaluates the ***PR_Swap*** Message sent by the Sink and decides that it is able and willing to do the Power Role Swap. It tells the Protocol Layer to form an ***Accept*** Message.
11		Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.
12	Physical Layer receives the Message and compares the CRC it calculated with the one sent to verify the ***Accept*** Message.	Physical Layer appends a CRC and sends the ***Accept*** Message.
13	Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***PR_Swap*** Message information to the Policy Engine that consumes it.	
14	The Policy Engine stops the ***SenderResponseTimer***, starts the ***PSSourceOffTimer***.	
15	Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.	
16	Physical Layer appends a CRC and sends the ***GoodCRC*** Message.	Physical Layer receives ***GoodCRC*** Message and compares the CRC it calculated with the one sent to verify the Message.

Step	Initial Sink Port	Initial Source Port
17		Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.
18		Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Accept*** Message was successfully sent.
19		The Policy Engine determines its power supply is no longer supplying V_{BUS} and is acting as a Sink. The Policy Engine requests the Device Policy Manager to assert the Rd pull down on the CC wire. The Policy Engine then directs the Protocol Layer to generate a ***PS_RDY*** Message, with the ***Port Power Role*** bit in the Message Header set to "Sink", to tell its Port Partner that it can begin to Source V_{BUS}.
20		Protocol Layer sets the ***Port Power Role*** bit in the Message Header set to "Sink", creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.
21	Physical Layer receives the ***PS_RDY*** Message and checks the CRC to verify the Message.	Physical Layer appends CRC and sends the ***PS_RDY*** Message.
22	Physical Layer removes the CRC and forwards the ***PS_RDY*** Message to the Protocol Layer.	
23	Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***PS_RDY*** Message information to the Policy Engine that consumes it. The Policy Engine stops the ***PSSourceOffTimer***.	
24	Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.	
25	Physical Layer appends CRC and sends the ***GoodCRC*** Message.	Physical Layer receives the ***GoodCRC*** Message and checks the CRC to verify the Message.
26		Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.
27		Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***PS_RDY*** Message was successfully sent. Policy Engine starts ***PSSourceOnTimer***.
28	The Policy Engine directs the Device Policy Manager to apply the Rp pull up. Note: at some point (either before or after receiving the ***PS_RDY*** Message) the new Source has applied ***vSafe5V*** no later ***tSrcFRSwap*** after detecting that V_{BUS} has dropped below ***vSafe5V***. When the Source output reaches ***vSafe5V*** the Policy Engine directs the Protocol Layer to send an ***FR_Swap*** Message within ***tFRSwapInit*** of detecting the Fast Swap signal. Policy Engine, when its power supply is ready to supply power, tells the Protocol Layer to form a ***PS_RDY*** Message. The ***Port Power Role*** bit used in this and subsequent Message Headers is now set to "Source".	

Step	Initial Sink Port	Initial Source Port
29	Protocol Layer creates the ***PS_RDY*** Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.	
30	Physical Layer appends a CRC and sends the ***PS_RDY*** Message.	Physical Layer receives the ***PS_RDY*** Message and compares the CRC it calculated with the one sent to verify the Message.
31		Physical Layer removes the CRC and forwards the ***PS_RDY*** Message to the Protocol Layer.
32		Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***PS_RDY*** Message information to the Policy Engine that consumes it. The Policy Engine stops the ***PSSourceOnTimer***.
33		Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.
34	Physical Layer receives ***GoodCRC*** Message and compares the CRC it calculated with the one sent to verify the Message.	Physical Layer appends a CRC and sends the ***GoodCRC*** Message. The Policy Engine resets the Protocol Layer.
35	Physical Layer removes the CRC and forwards the ***GoodCRC*** to the Protocol Layer.	
36	Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***PS_RDY*** Message was successfully sent. The Policy Engine resets the ***CapsCounter***, resets the Protocol Layer and starts the ***SwapSourceStartTimer*** which must timeout before sending any ***Source_Capabilities*** Messages.	
	The Fast Role Swap is complete, the roles have been reversed and the Port Partners are free to negotiate for more power.	

8.3.2.8 Data Role Swap

8.3.2.8.1 Data Role Swap, Initiated by UFP Operating as Sink

Figure 8-14 shows an example sequence between a Port, which is initially a UFP (Device) and a Sink (Rd asserted), and a Port which is initially a DFP (Host) and a Source (Rp asserted). A Data Role Swap is initiated by the UFP. During the process the Port Partners maintain their operation as either a Source or a Sink (power and Rp/Rd remain constant) but exchange data roles between DFP (Host) and UFP (Device).

Figure 8-14 Data Role Swap, UFP operating as Sink initiates

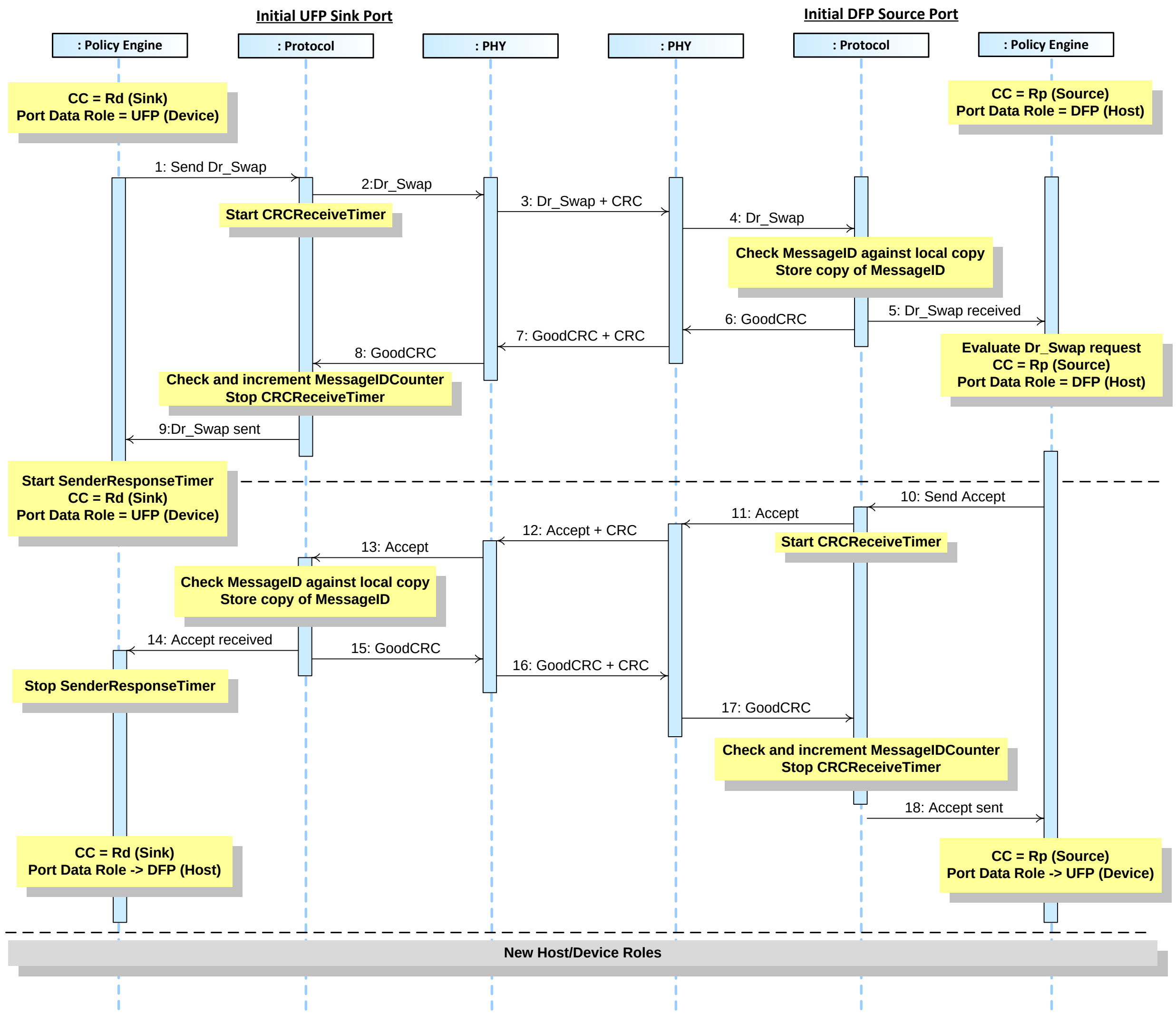


Table 8-14 below provides a detailed explanation of what happens at each labeled step in Figure 8-14 above.

Table 8-14 Steps for Data Role Swap, UFP operating as Sink initiates

Step	Initial UFP Sink Port	Initial DFP Source Port
1	Port starts as a UFP (Device) operating as a Sink with Rd asserted and ***Port Data Role*** set to UFP. The Policy Engine directs the Protocol Layer to send a ***DR_Swap*** Message.	Port starts as a DFP (Host) operating as Source with Rp asserted and ***Port Data Role*** set to DFP.
2	Protocol Layer creates the ***DR_Swap*** Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.	
3	Physical Layer appends CRC and sends the ***DR_Swap*** Message.	Physical Layer receives the ***DR_Swap*** Message and checks the CRC to verify the Message.
4		Physical Layer removes the CRC and forwards the ***DR_Swap*** Message to the Protocol Layer.
5		Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***DR_Swap*** Message information to the Policy Engine that consumes it.
6		Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.
7	Physical Layer receives the ***GoodCRC*** Message and checks the CRC to verify the Message.	Physical Layer appends CRC and sends the ***GoodCRC*** Message.
8	Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.	
9	Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***DR_Swap*** Message was successfully sent. Policy Engine starts ***SenderResponseTimer***.	
10		Policy Engine evaluates the ***DR_Swap*** Message and decides that it is able and willing to do the Data Role Swap. It tells the Protocol Layer to form an ***Accept*** Message.
11		Protocol Layer creates the ***Accept*** Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.
12	Physical Layer receives the ***Accept*** Message and checks the CRC to verify the Message.	Physical Layer appends a CRC and sends the ***Accept*** Message.
13	Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Accept*** Message information to the Policy Engine that consumes it.	
14	The Policy Engine stops the ***SenderResponseTimer***.	
15	Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.	
16	Physical Layer appends a CRC and sends the ***GoodCRC*** Message.	Physical Layer receives ***GoodCRC*** Message and compares the CRC it calculated with the one sent to verify the Message.
17		Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.

Step	Initial UFP Sink Port	Initial DFP Source Port
18	The Policy Engine requests that Data Role is changed from UFP (Device) to DFP (Host). The Power Delivery role is now a DFP (Host), with ***Port Data Role*** set to DFP, still operating as a Sink (Rd asserted).	Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Accept*** Message was successfully sent. The Policy Engine requests that the Data Role is changed to UFP (Device), with ***Port Data Role*** set to UFP and continues supplying power as a Source (Rp asserted).
	The Data Role Swap is complete; the data roles have been reversed while maintaining the direction of power flow.	

8.3.2.8.2 Data Role Swap, Initiated by UFP Operating as Source

Figure 8-15 shows an example sequence between a Port, which is initially a UFP (Device) and a Source (Rp asserted), and a Port which is initially a DFP (Host) and a Sink (Rd asserted). A Data Role Swap is initiated by the UFP. During the process the Port Partners maintain their operation as either a Source or a Sink (power and Rp/Rd remain constant) but exchange data roles between DFP (Host) and UFP (Device).

Figure 8-15 Data Role Swap, UFP operating as Source initiates

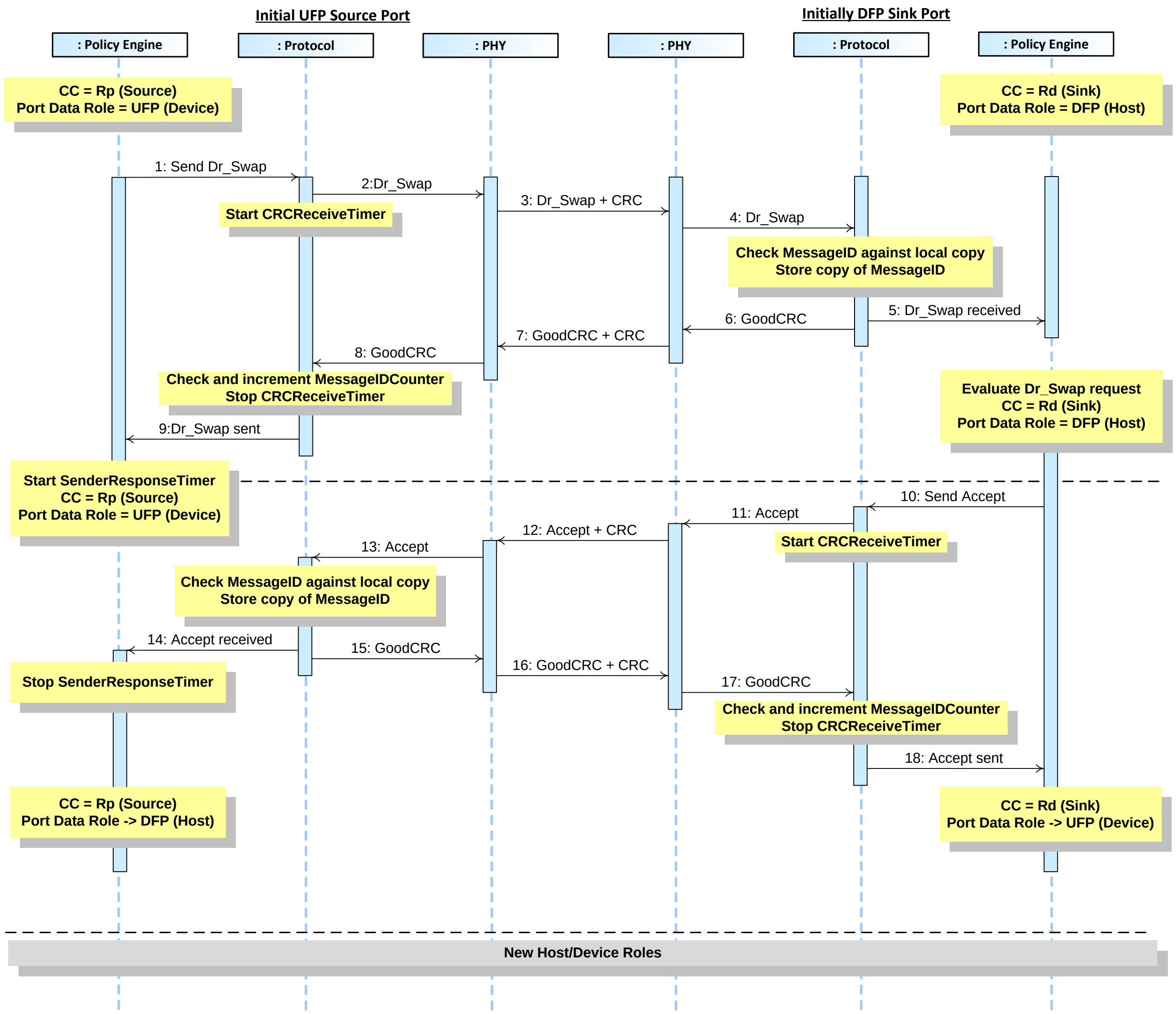


Table 8-15 below provides a detailed explanation of what happens at each labeled step in Figure 8-15 above.

Table 8-15 Steps for Data Role Swap, UFP operating as Source initiates

Step	Initial UFP Source Port	Initial DFP Sink Port
1	Port starts as a UFP (Device) operating as Source with Rp asserted and ***Port Data Role*** set to UFP. The Policy Engine directs the Protocol Layer to send a ***DR_Swap*** Message.	Port starts as a DFP (Host) operating as a Sink with Rd asserted and ***Port Data Role*** set to DFP.
2	Protocol Layer creates the ***DR_Swap*** Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.	

Step	Initial UFP Source Port	Initial DFP Sink Port
3	Physical Layer appends CRC and sends the ***DR_Swap*** Message.	Physical Layer receives the ***DR_Swap*** Message and checks the CRC to verify the Message.
4		Physical Layer removes the CRC and forwards the ***DR_Swap*** Message to the Protocol Layer.
5		Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***DR_Swap*** Message information to the Policy Engine that consumes it.
6		Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.
7	Physical Layer receives the ***GoodCRC*** Message and checks the CRC to verify the Message.	Physical Layer appends CRC and sends the ***GoodCRC*** Message.
8	Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.	
9	Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***DR_Swap*** Message was successfully sent. Policy Engine starts ***SenderResponseTimer***.	
10		Policy Engine evaluates the ***DR_Swap*** Message and decides that it is able and willing to do the Data Role Swap. It tells the Protocol Layer to form an ***Accept*** Message.
11		Protocol Layer creates the ***Accept*** Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.
12	Physical Layer receives the ***Accept*** Message and checks the CRC to verify the Message.	Physical Layer appends a CRC and sends the ***Accept*** Message.
13	Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Accept*** Message information to the Policy Engine that consumes it.	
14	The Policy Engine stops the ***SenderResponseTimer***.	
15	Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.	
16	Physical Layer appends a CRC and sends the ***GoodCRC*** Message.	Physical Layer receives ***GoodCRC*** Message and compares the CRC it calculated with the one sent to verify the Message.
17		Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.
18	The Policy Engine requests that Data Role is changed from UFP (Device) to DFP (Host). The Power Delivery role is now a DFP (Host), and ***Port Data Role*** set to DFP, and continues supplying power as a Source (Rp asserted).	Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Accept*** Message was successfully sent. The Policy Engine requests that the Data Role is changed to UFP (Device), with ***Port Data Role*** set to UFP and still operating as a Sink (Rp asserted).
	The Data Role Swap is complete; the data roles have been reversed while maintaining the direction of power flow.	

8.3.2.8.3 Data Role Swap, Initiated by DFP Operating as Source

Figure 8-16 shows an example sequence between a Port, which is initially a UFP (Device) and a Sink (Rd asserted), and a Port which is initially a DFP and a Source (Rp asserted). A Data Role Swap is initiated by the DFP. During the process the Port Partners maintain their operation as either a Source or a Sink (power and Rp/Rd remain constant) but exchange data roles between DFP (Host) and UFP (Device).

Figure 8-16 Data Role Swap, DFP operating as Source initiates

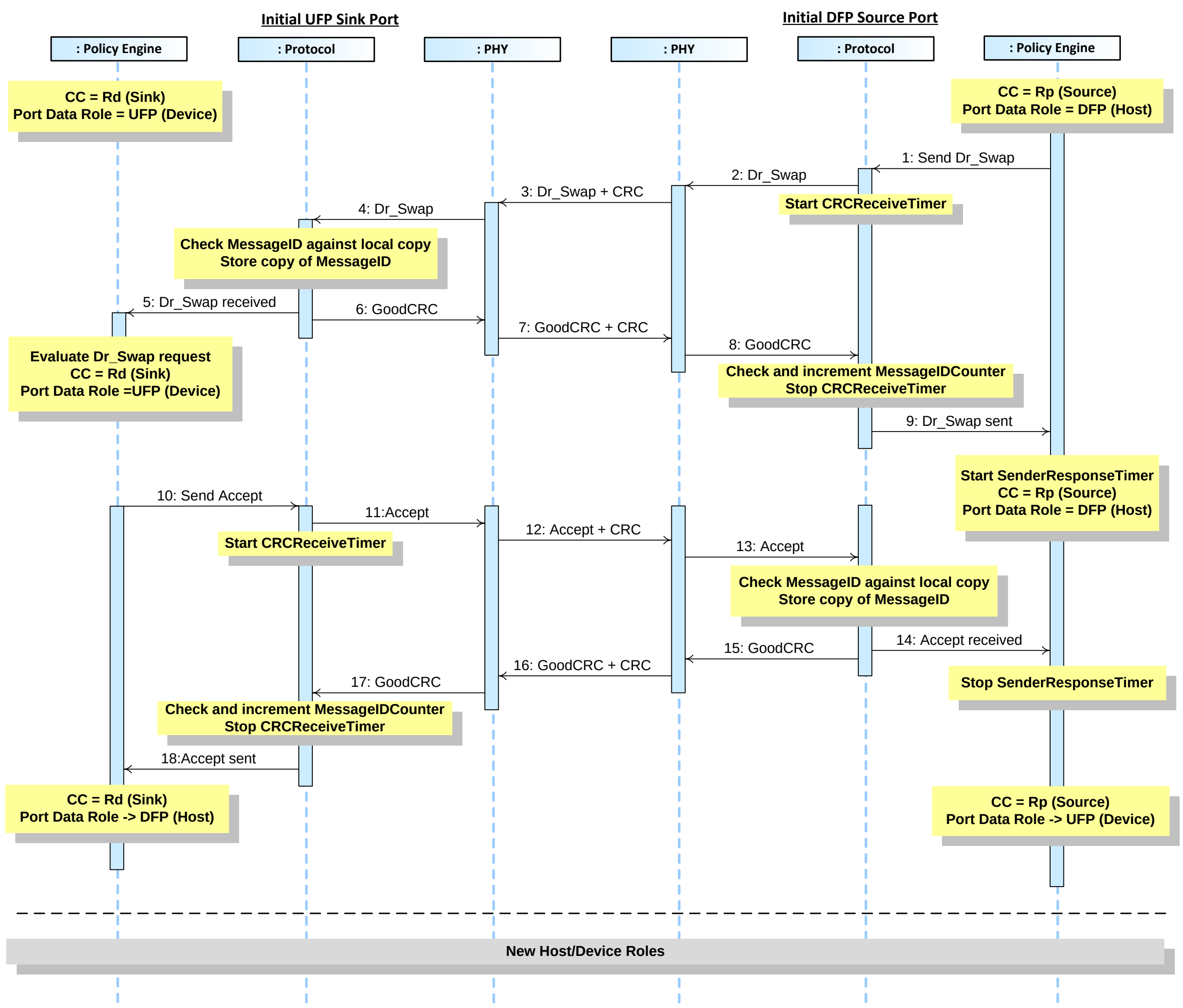


Table 8-16 below provides a detailed explanation of what happens at each labeled step in Figure 8-16 above.

Table 8-16 Steps for Data Role Swap, DFP operating as Source initiates

Step	Initial UFP Sink Port	Initial DFP Source Port
1	Port starts as a UFP (Device) operating as a Sink with Rd asserted and ***Port Data Role*** set to UFP.	Port starts as a DFP (Host) operating as Source with Rp asserted and ***Port Data Role*** set to DFP. The Policy Engine directs the Protocol Layer to send a ***DR_Swap*** Message.
2		Protocol Layer creates the ***DR_Swap*** Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.

Step	Initial UFP Sink Port	Initial DFP Source Port
3	Physical Layer receives the ***DR_Swap*** Message and checks the CRC to verify the Message.	Physical Layer appends CRC and sends the ***DR_Swap*** Message.
4	Physical Layer removes the CRC and forwards the ***DR_Swap*** Message to the Protocol Layer.	
5	Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***DR_Swap*** Message information to the Policy Engine that consumes it.	
6	Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.	
7	Physical Layer appends CRC and sends the ***GoodCRC*** Message.	Physical Layer receives the ***GoodCRC*** Message and checks the CRC to verify the Message.
8		Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.
9		Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***DR_Swap*** Message was successfully sent. Policy Engine starts ***SenderResponseTimer***.
10	Policy Engine evaluates the ***DR_Swap*** Message and decides that it is able and willing to do the Data Role Swap. It tells the Protocol Layer to form an ***Accept*** Message.	
11	Protocol Layer creates the ***Accept*** Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.	
12	Physical Layer appends a CRC and sends the ***Accept*** Message.	Physical Layer receives the ***Accept*** Message and checks the CRC to verify the Message.
13		Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Accept*** Message information to the Policy Engine that consumes it.
14		The Policy Engine stops the ***SenderResponseTimer***.
15		Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.
16	Physical Layer receives ***GoodCRC*** Message and compares the CRC it calculated with the one sent to verify the Message.	Physical Layer appends a CRC and sends the ***GoodCRC*** Message.
17	Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.	
18	Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Accept*** Message was successfully sent. . The Policy Engine requests that the Data Role is changed to DFP (Host), with ***Port Data Role*** set to DFP, still operating as a Sink (Rd asserted).	The Policy Engine requests that Data Role is changed from DFP (Host) to UFP (Device). The Power Delivery role is now a UFP (Device), with ***Port Data Role*** set to UFP, and continues supplying power as a Source (Rp asserted).
	The Data Role Swap is complete; the data roles have been reversed while maintaining the direction of power flow.	

8.3.2.8.4 Data Role Swap, Initiated by DFP Operating as Sink

Figure 8-17 shows an example sequence between a Port, which is initially a UFP (Device) and a Source (Rp asserted), and a Port which is initially a DFP (Host) and a Sink (Rd asserted). A Data Role Swap is initiated by the DFP. During the process the Port Partners maintain their operation as either a Source or a Sink (power and Rp/Rd remain constant) but exchange data roles between DFP (Host) and UFP (Device).

Figure 8-17 Data Role Swap, DFP operating as Sink initiates

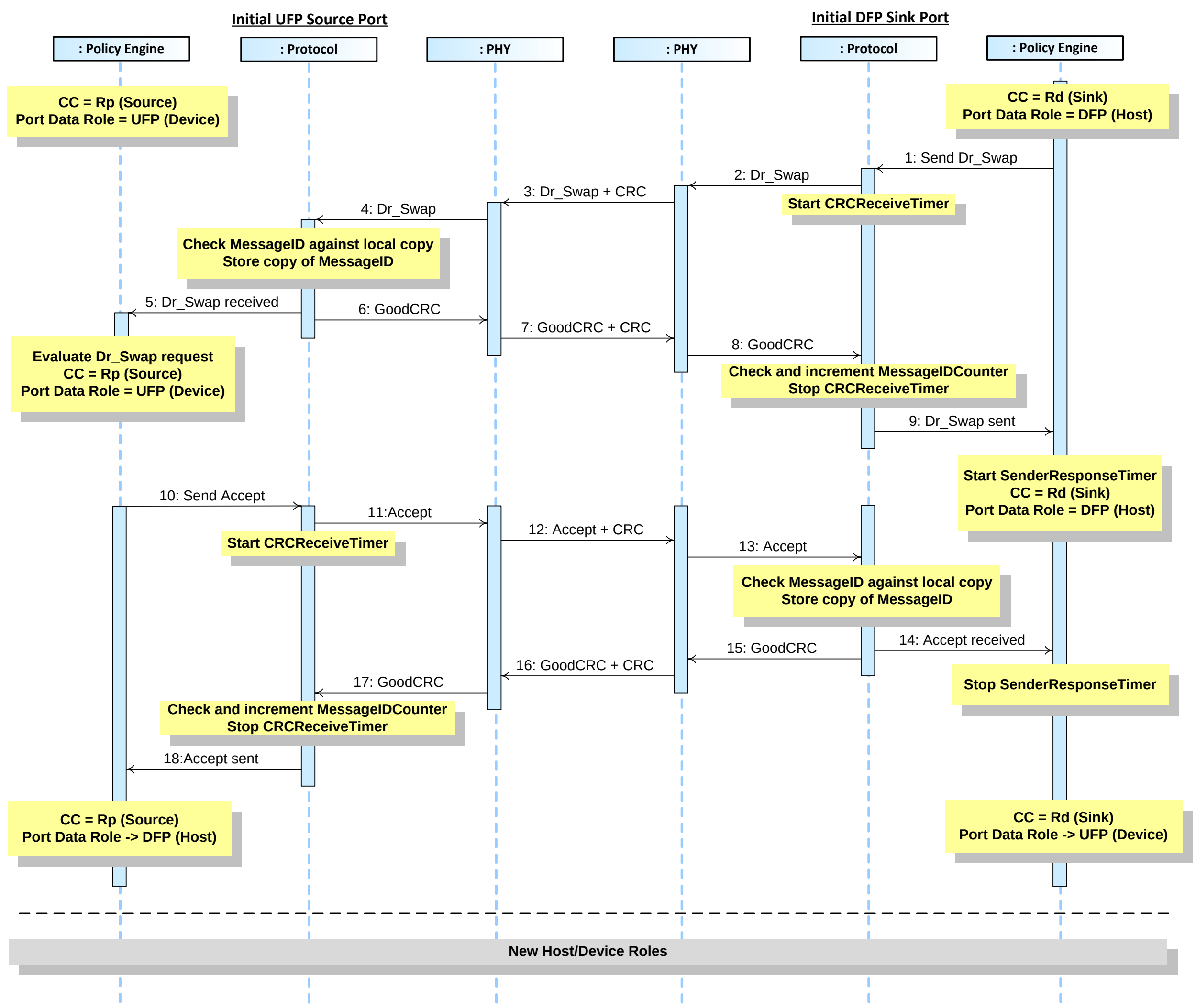


Table 8-17 below provides a detailed explanation of what happens at each labeled step in Figure 8-17 above.

Table 8-17 Steps for Data Role Swap, DFP operating as Sink initiates

Step	Initial UFP Source Port	Initial DFP Sink Port
1	Port starts as a UFP (Device) operating as Source with Rp asserted and ***Port Data Role*** set to UFP.	Port starts as a DFP (Host) operating as a Sink with Rd asserted and ***Port Data Role*** set to DFP. The Policy Engine directs the Protocol Layer to send a ***DR_Swap*** Message.
2		Protocol Layer creates the ***DR_Swap*** Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.

Step	Initial UFP Source Port	Initial DFP Sink Port
3	Physical Layer receives the ***DR_Swap*** Message and checks the CRC to verify the Message.	Physical Layer appends CRC and sends the ***DR_Swap*** Message.
4	Physical Layer removes the CRC and forwards the ***DR_Swap*** Message to the Protocol Layer.	
5	Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***DR_Swap*** Message information to the Policy Engine that consumes it.	
6	Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.	
7	Physical Layer appends CRC and sends the ***GoodCRC*** Message.	Physical Layer receives the ***GoodCRC*** Message and checks the CRC to verify the Message.
8		Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.
9		Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***DR_Swap*** Message was successfully sent. Policy Engine starts ***SenderResponseTimer***.
10	Policy Engine evaluates the ***DR_Swap*** Message and decides that it is able and willing to do the Data Role Swap. It tells the Protocol Layer to form an ***Accept*** Message.	
11	Protocol Layer creates the ***Accept*** Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.	
12	Physical Layer appends a CRC and sends the ***Accept*** Message.	Physical Layer receives the ***Accept*** Message and checks the CRC to verify the Message.
13		Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Accept*** Message information to the Policy Engine that consumes it.
14		The Policy Engine stops the ***SenderResponseTimer***.
15		Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.
16	Physical Layer receives ***GoodCRC*** Message and compares the CRC it calculated with the one sent to verify the Message.	Physical Layer appends a CRC and sends the ***GoodCRC*** Message.
17	Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.	
18	Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Accept*** Message was successfully sent. The Policy Engine requests that the Data Role is changed to DFP (Host), with ***Port Data Role*** set to DFP, and continues supplying power as a Source (Rp asserted).	The Policy Engine requests that Data Role is changed from DFP (Host) to UFP (Device). The Power Delivery role is now a UFP (Device), with ***Port Data Role*** set to UFP, still operating as a Sink (Rd asserted).
	The Data Role Swap is complete; the data roles have been reversed while maintaining the direction of power flow.	

8.3.2.9 VCONN Swap

8.3.2.9.1 Source to Sink VCONN Source Swap

Figure 8-18 shows an example sequence between a Source and Sink, where the Source is initially supplying VCONN and then tells the Sink to supply VCONN. During the process the Port Partners, keep their role as Source or Sink, maintain their operation as either a Source or a Sink (power remains constant) but exchange the VCONN Source from the Source to the Sink.

Figure 8-18 Source to Sink VCONN Source Swap

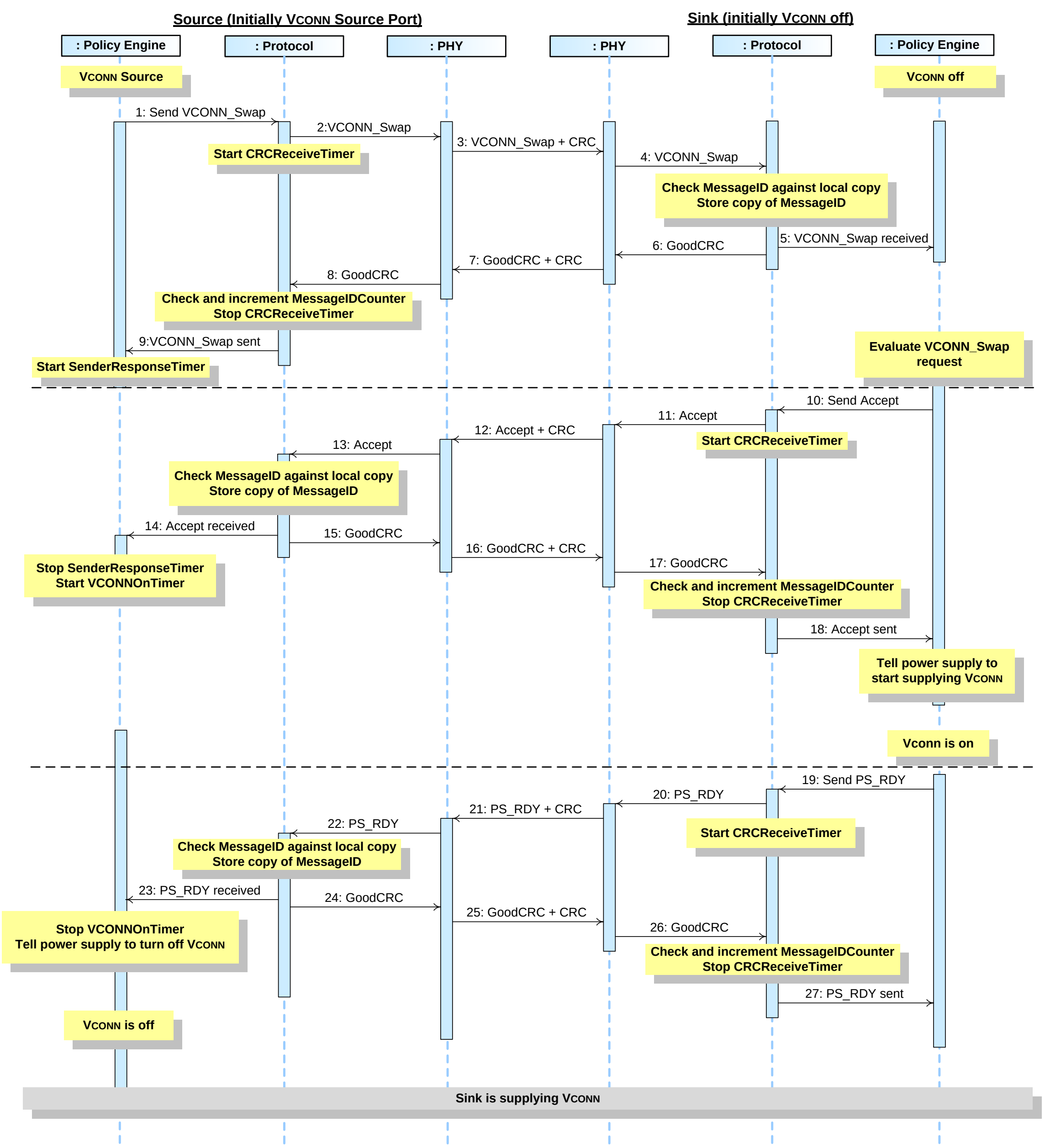


Table 8-18 below provides a detailed explanation of what happens at each labeled step in Figure 8-18 above.

Table 8-18 Steps for Source to Sink VCONN Source Swap

Step	Source (initially VCONN Source)	Sink (Initially VCONN off)
1	The Source starts as the VCONN Source. The Policy Engine directs the Protocol Layer to send a ***VCONN_Swap*** Message.	The Sink starts with VCONN off.
2	Protocol Layer creates the ***VCONN_Swap*** Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.	
3	Physical Layer appends CRC and sends the ***VCONN_Swap*** Message.	Physical Layer receives the ***VCONN_Swap*** Message and checks the CRC to verify the Message.
4		Physical Layer removes the CRC and forwards the ***VCONN_Swap*** Message to the Protocol Layer.
5		Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***VCONN_Swap*** Message information to the Policy Engine that consumes it.
6		Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.
7	Physical Layer receives the ***GoodCRC*** Message and checks the CRC to verify the Message.	Physical Layer appends CRC and sends the ***GoodCRC*** Message.
8	Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.	
9	Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***VCONN_Swap*** Message was successfully sent. Policy Engine starts ***SenderResponseTimer***.	
10		Policy Engine evaluates the ***VCONN_Swap*** Message sent by the Source and decides that it is able and willing to do the VCONN Swap. It tells the Protocol Layer to form an ***Accept*** Message.
11		Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.
12	Physical Layer receives the ***Accept*** Message and compares the CRC it calculated with the one sent to verify the Message.	Physical Layer appends a CRC and sends the ***Accept*** Message.
13	Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Accept*** Message information to the Policy Engine that consumes it.	
14	The Policy Engine stops the ***SenderResponseTimer*** and starts the ***VCONNOnTimer***.	
15	Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.	
16	Physical Layer appends a CRC and sends the ***GoodCRC*** Message.	Physical Layer receives ***GoodCRC*** Message and compares the CRC it calculated with the one sent to verify the Message.
17		Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.

Step	Source (initially VCONN Source)	Sink (Initially VCONN off)
18		Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Accept*** Message was successfully sent. The Policy Engine asks the Device Policy Manager to turn on VCONN.
19		The Device Policy Manager informs the Policy Engine that its power supply is supplying VCONN. The Policy Engine directs the Protocol Layer to generate a ***PS_RDY*** Message to tell the Source it can turn off VCONN.
20		Protocol Layer creates the ***PS_RDY*** Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.
21	Physical Layer receives the ***PS_RDY*** Message and compares the CRC it calculated with the one sent to verify the Message.	Physical Layer appends a CRC and sends the ***PS_RDY*** Message.
22	Physical Layer removes the CRC and forwards the ***PS_RDY*** Message to the Protocol Layer.	
23	Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***PS_RDY*** Message information to the Policy Engine that consumes it.	
24	Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.	
25	Physical Layer appends a CRC and sends the ***GoodCRC*** Message. The Policy Engine stops the ***VCONNOnTimer***, and tells the power supply to stop sourcing VCONN.	Physical Layer receives ***GoodCRC*** Message and compares the CRC it calculated with the one sent to verify the Message.
26		Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.
27	VCONN is off.	Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***PS_RDY*** Message was successfully sent.
	The Sink is now the VCONN Source and the Source has VCONN turned off.	

8.3.2.9.2 Sink to Source VCONN Source Swap

Figure 8-19 shows an example sequence between a Source and Sink, where the Sink is initially supplying VCONN and then the Source tells the Sink that it will become the VCONN Source. During the process the Port Partners, keep their role as Source or Sink, maintain their operation as either a Source or a Sink (power remains constant) but exchange the VCONN Source from the Sink to the Source.

Figure 8-19 Sink to Source VCONN Source Swap

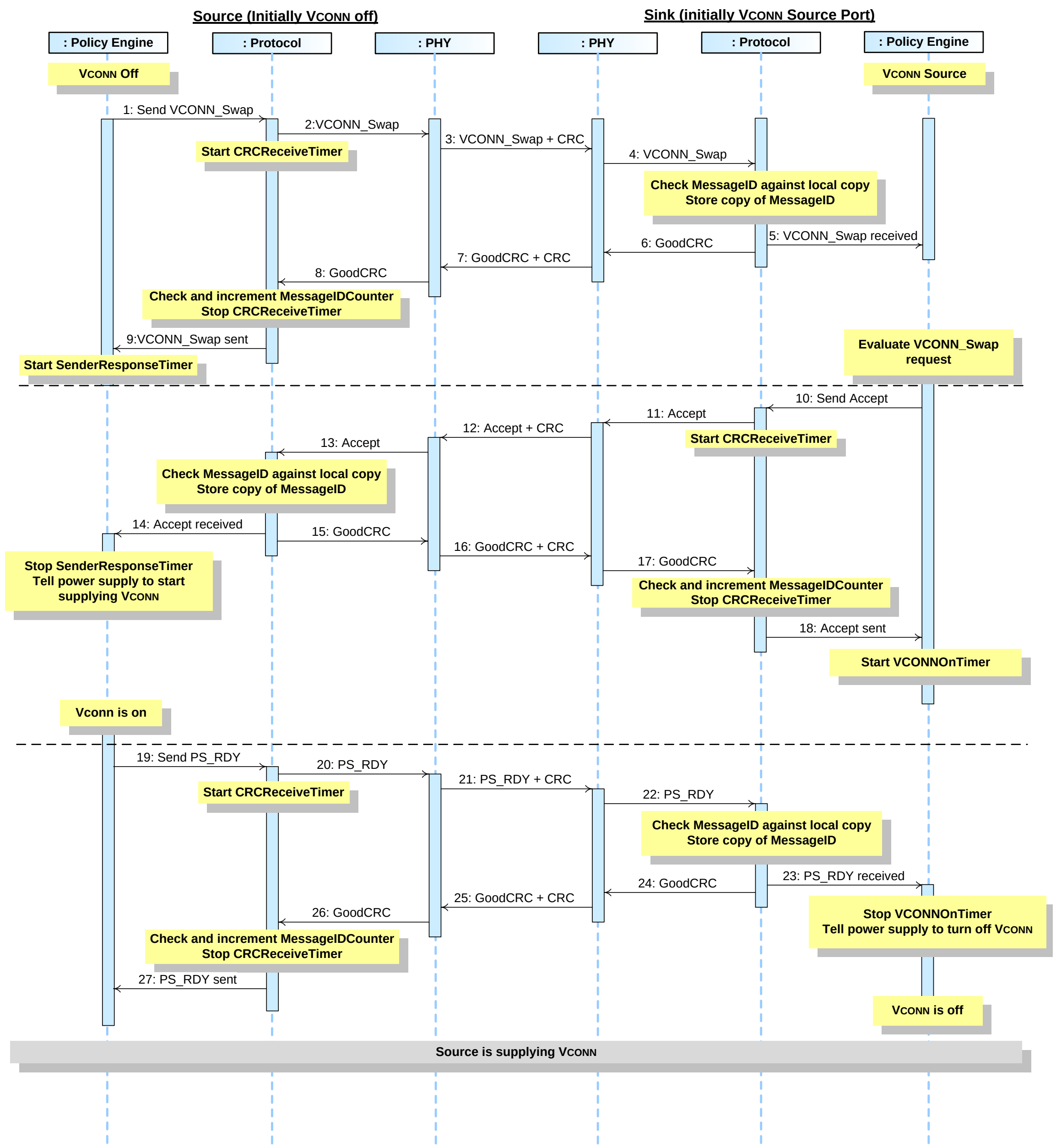


Table 8-19 below provides a detailed explanation of what happens at each labeled step in Figure 8-19 above.

Table 8-19 Steps for Sink to Source VCONN Source Swap

Step	Source	Sink
1	The Source starts with VCONN off. The Policy Engine directs the Protocol Layer to send a ***VCONN_Swap*** Message.	The Sink starts as the VCONN Source.
2	Protocol Layer creates the ***VCONN_Swap*** Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.	
3	Physical Layer appends CRC and sends the ***VCONN_Swap*** Message.	Physical Layer receives the ***VCONN_Swap*** Message and checks the CRC to verify the Message.
4		Physical Layer removes the CRC and forwards the ***VCONN_Swap*** Message to the Protocol Layer.
5		Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***VCONN_Swap*** Message information to the Policy Engine that consumes it.
6		Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.
7	Physical Layer receives the ***GoodCRC*** Message and checks the CRC to verify the Message.	Physical Layer appends CRC and sends the ***GoodCRC*** Message.
8	Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.	
9	Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***VCONN_Swap*** Message was successfully sent. Policy Engine starts ***SenderResponseTimer***.	
10		Policy Engine evaluates the ***VCONN_Swap*** Message sent by the Source and decides that it is able and willing to do the VCONN Swap. It tells the Protocol Layer to form an ***Accept*** Message.
11		Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.
12	Physical Layer receives the ***Accept*** Message and compares the CRC it calculated with the one sent to verify the Message.	Physical Layer appends a CRC and sends the ***Accept*** Message.
13	Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Accept*** Message information to the Policy Engine that consumes it.	
14	The Policy Engine stops the ***SenderResponseTimer***. The Policy Engine tells the Device Policy Manger to turn on VCONN.	
15	Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.	
16	Physical Layer appends a CRC and sends the ***GoodCRC*** Message.	Physical Layer receives ***GoodCRC*** Message and compares the CRC it calculated with the one sent to verify the Message.
17		Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.

Step	Source	Sink
18		Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Accept*** Message was successfully sent. The Policy Engine starts the ***VCONNOnTimer***.
19	The Device Policy Manager tells the Policy Engine that its power supply is supplying VCONN. The Policy Engine directs the Protocol Layer to generate a ***PS_RDY*** Message to tell the Sink it can turn off VCONN.	
20	Protocol Layer creates the ***PS_RDY*** Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.	
21	Physical Layer appends a CRC and sends the ***PS_RDY*** Message.	Physical Layer receives the ***PS_RDY*** Message and compares the CRC it calculated with the one sent to verify the Message.
22		Physical Layer removes the CRC and forwards the ***PS_RDY*** Message to the Protocol Layer.
23		Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***PS_RDY*** Message information to the Policy Engine that consumes it.
24		Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.
25	Physical Layer receives ***GoodCRC*** Message and compares the CRC it calculated with the one sent to verify the Message.	Physical Layer appends a CRC and sends the ***GoodCRC*** Message. The Policy Engine stops the ***VCONNOnTimer***, and tells the power supply to stop sourcing VCONN.
26	Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.	
27	Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***PS_RDY*** Message was successfully sent.	VCONN is off.
	The Source is now the VCONN Source and the Sink has VCONN turned off.	

8.3.2.10 **Additional Capabilities, Status and Information**

8.3.2.10.1 Alert

8.3.2.10.1.1 Source sends Alert to a Sink

Figure 8-20 shows an example sequence between a Source and a Sink where the Source alerts the Sink that there has been a status change. This AMS will be followed by getting the Source status to determine further details of the alert (see Section 8.3.2.10.2).

Figure 8-20 Source Alert to Sink

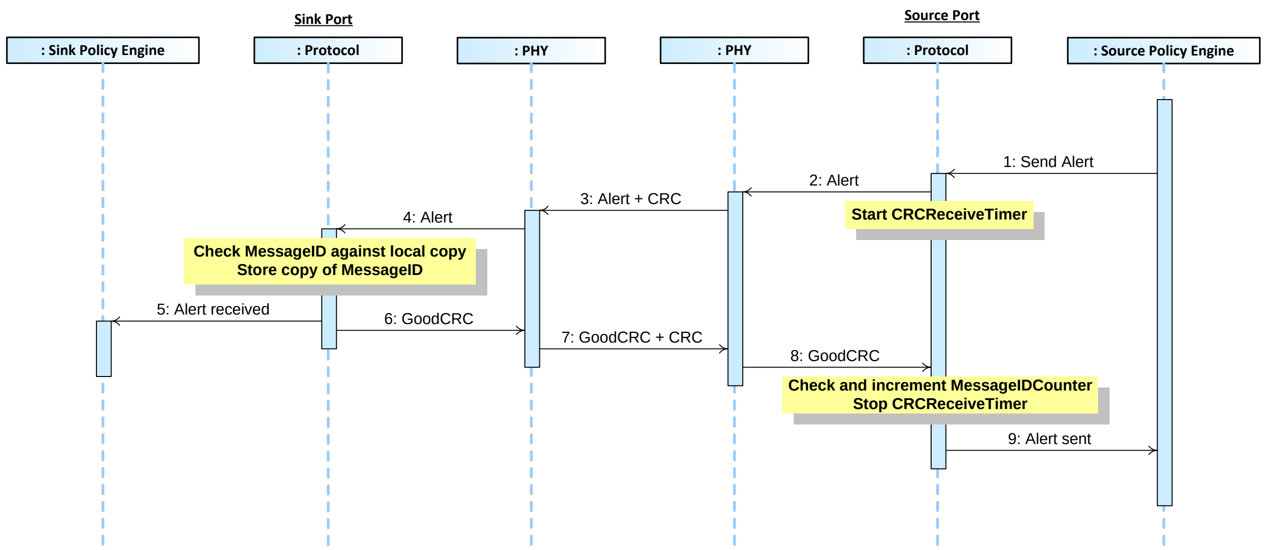


Table 8-59 below provides a detailed explanation of what happens at each labeled step in Figure 8-20 above.

Table 8-20 Steps for Source Alert to Sink

Step	Sink	Source
1		The Device Policy Manager indicates a Source alert condition. The Policy Engine tells the Protocol Layer to form an ***Alert*** Message.
2		Protocol Layer creates the ***Alert*** Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.
3	Physical Layer receives the ***Alert*** Message and compares the CRC it calculated with the one sent to verify the Message.	Physical Layer appends a CRC and sends the ***Alert*** Message.
4	Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Alert*** Message to the Policy Engine that consumes it.	
5	The Policy Engine informs the Device Policy Manager.	
6	Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.	

Step	Sink	Source
7	Physical Layer appends a CRC and sends the ***GoodCRC*** Message.	Physical Layer receives ***GoodCRC*** Message and compares the CRC it calculated with the one sent to verify the Message.
8		Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.
9		Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Alert*** Message was successfully sent.

8.3.2.10.1.1 Sink sends Alert to a Source

Figure 8-20 shows an example sequence between a Source and a Sink where the Sink alerts the Source that there has been a status change. This AMS will be followed by getting the Sink status to determine further details of the alert (see Section 8.3.2.10.2).

Figure 8-21 Sink Alert to Source

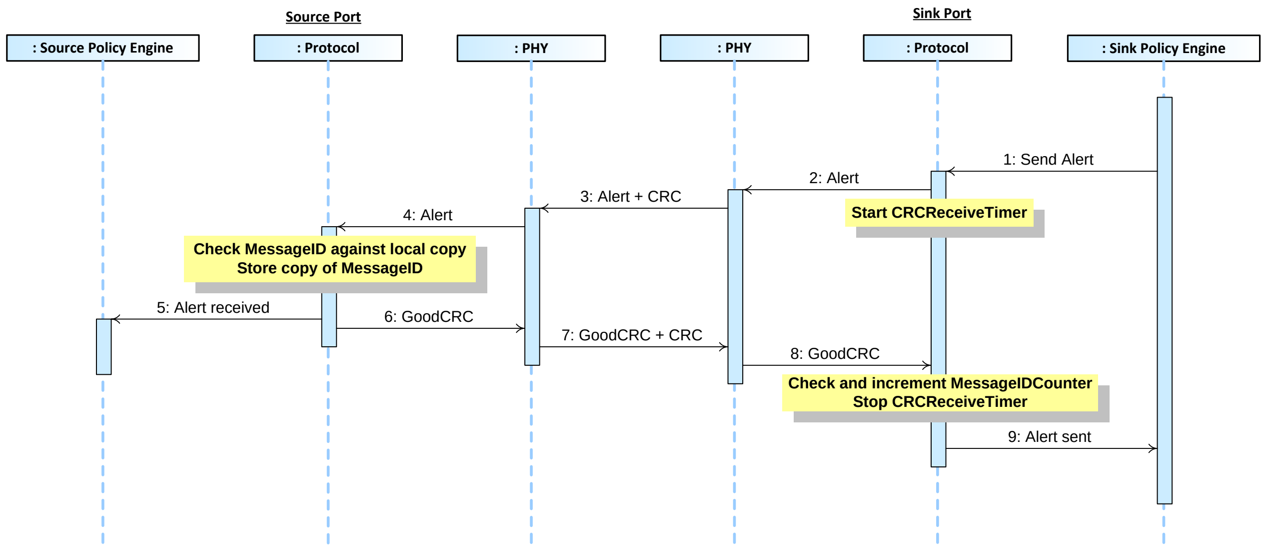


Table 8-59 below provides a detailed explanation of what happens at each labeled step in Figure 8-20 above.

Table 8-21 Steps for Sink Alert to Source

Step	Source	Sink
1		The Device Policy Manager indicates a Sink alert condition. The Policy Engine tells the Protocol Layer to form an ***Alert*** Message.
2		Protocol Layer creates the ***Alert*** Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.
3	Physical Layer receives the ***Alert*** Message and compares the CRC it calculated with the one sent to verify the Message.	Physical Layer appends a CRC and sends the ***Alert*** Message.
4	Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Alert*** Message to the Policy Engine that consumes it.	
5	The Policy Engine informs the Device Policy Manager.	
6	Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.	
7	Physical Layer appends a CRC and sends the ***GoodCRC*** Message.	Physical Layer receives ***GoodCRC*** Message and compares the CRC it calculated with the one sent to verify the Message.
8		Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.

Step	Source	Sink
9		Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Alert*** Message was successfully sent.

8.3.2.10.2 Status

8.3.2.10.2.1 Sink Gets Source Status

Figure 8-22 shows an example sequence between a Source and a Sink where, after the Sink has received an alert (see Section 8.3.2.10.1) that there has been a status change, the Sink gets more details on the change.

Figure 8-22 Sink Gets Source Status

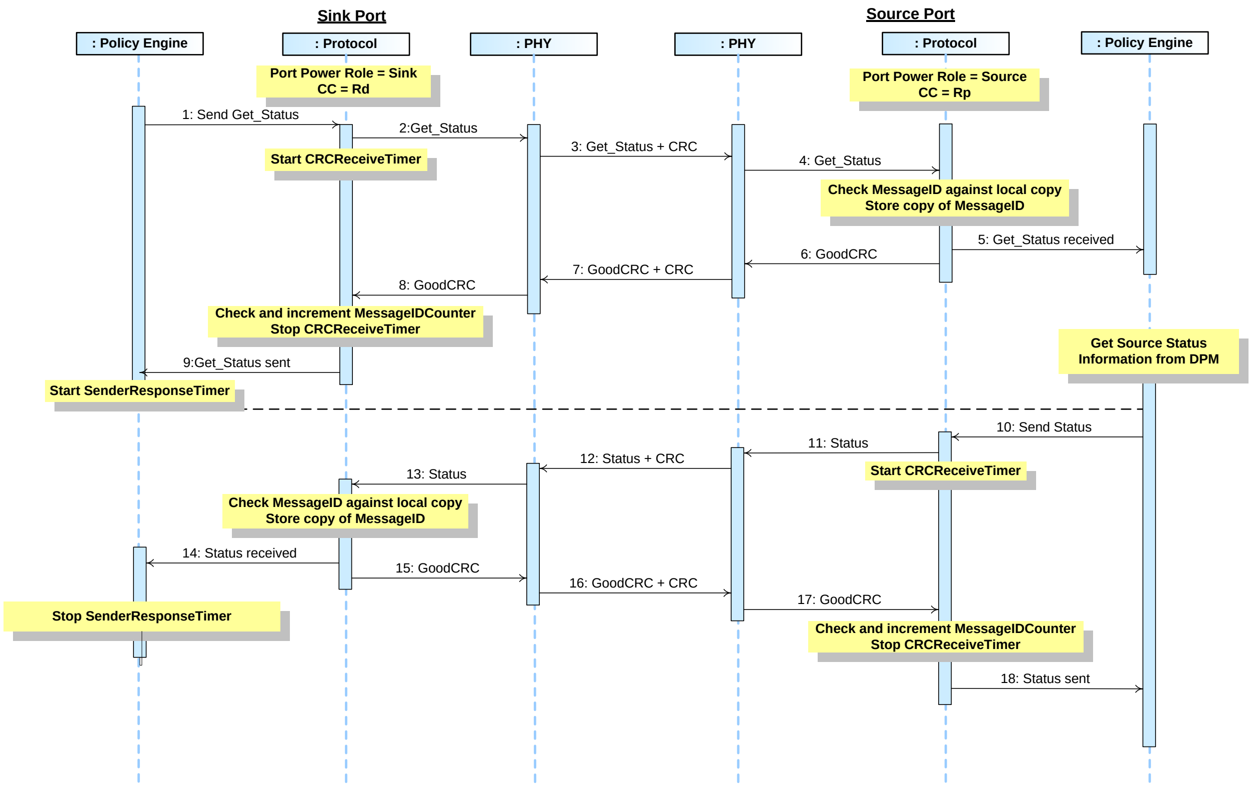


Table 8-22below provides a detailed explanation of what happens at each labeled step in Figure 8-22 above.

Table 8-22 Steps for a Sink getting Source status Sequence

Step	Sink Port	Source Port
1	The Port has ***Port Power Role*** set to Sink with the Rd pull down on its CC wire. Policy Engine directs the Protocol Layer to send a ***Get_Status*** Message.	The Port has ***Port Power Role*** set to Source and the Rp pull up on its CC wire.
2	Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.	
3	Physical Layer appends CRC and sends the ***Get_Status*** Message.	Physical Layer receives the ***Get_Status*** Message and checks the CRC to verify the Message.
4		Physical Layer removes the CRC and forwards the ***Get_Status*** Message to the Protocol Layer.

Step	Sink Port	Source Port
5		Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Get_Status*** Message information to the Policy Engine that consumes it.
6		Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.
7	Physical Layer receives the ***GoodCRC*** Message and checks the CRC to verify the Message.	Physical Layer appends CRC and sends the ***GoodCRC*** Message.
8	Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.	
9	Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Get_Status*** Message was successfully sent. Policy Engine starts ***SenderResponseTimer***.	
10		Policy Engine requests the DPM for the present Source status which is provided. The Policy Engine tells the Protocol Layer to form a ***Status*** Message.
11		Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.
12	Physical Layer receives the Message and compares the CRC it calculated with the one sent to verify the ***Status*** Message.	Physical Layer appends a CRC and sends the ***Status*** Message.
13	Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Status*** Message information to the Policy Engine that consumes it.	
14	The Policy Engine stops the ***SenderResponseTimer***.	
15	Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.	
16	Physical Layer appends a CRC and sends the ***GoodCRC*** Message.	Physical Layer receives ***GoodCRC*** Message and compares the CRC it calculated with the one sent to verify the Message.
17		Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.
18		Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Status*** Message was successfully sent.
	The Source has informed the Sink of its present status.	

8.3.2.10.2.2 Source Gets Sink Status

Figure 8-22 shows an example sequence between a Source and a Sink where, after the Source has received an alert (see Section 8.3.2.10.1) that there has been a status change, the Source gets more details on the change.

Figure 8-23 Source Gets Sink Status

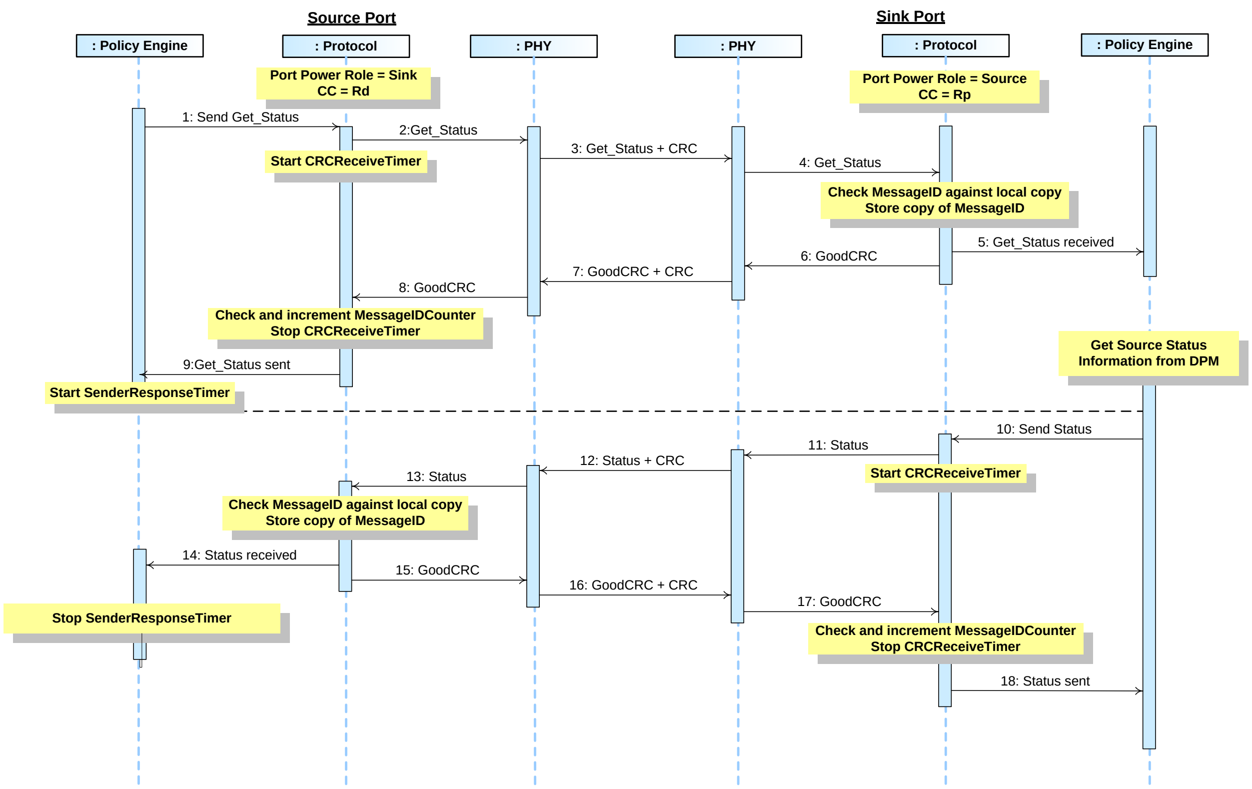


Table 8-22below provides a detailed explanation of what happens at each labeled step in Figure 8-22 above.

Table 8-23 Steps for a Source getting Sink status Sequence

Step	Source Port	Sink Port
1	The Port has ***Port Power Role*** set to Source and the Rp pull up on its CC wire. Policy Engine directs the Protocol Layer to send a ***Get_Status*** Message.	The Port has ***Port Power Role*** set to Sink with the Rd pull down on its CC wire.
2	Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.	
3	Physical Layer appends CRC and sends the ***Get_Status*** Message.	Physical Layer receives the ***Get_Status*** Message and checks the CRC to verify the Message.
4		Physical Layer removes the CRC and forwards the ***Get_Status*** Message to the Protocol Layer.
5		Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Get_Status*** Message information to the Policy Engine that consumes it.

Step	Source Port	Sink Port
6		Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.
7	Physical Layer receives the ***GoodCRC*** Message and checks the CRC to verify the Message.	Physical Layer appends CRC and sends the ***GoodCRC*** Message.
8	Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.	
9	Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Get_Status*** Message was successfully sent. Policy Engine starts ***SenderResponseTimer***.	
10		Policy Engine requests the DPM for the present Source status which is provided. The Policy Engine tells the Protocol Layer to form a ***Status*** Message.
11		Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.
12	Physical Layer receives the Message and compares the CRC it calculated with the one sent to verify the ***Status*** Message.	Physical Layer appends a CRC and sends the ***Status*** Message.
13	Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Status*** Message information to the Policy Engine that consumes it.	
14	The Policy Engine stops the ***SenderResponseTimer***.	
15	Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.	
16	Physical Layer appends a CRC and sends the ***GoodCRC*** Message.	Physical Layer receives ***GoodCRC*** Message and compares the CRC it calculated with the one sent to verify the Message.
17		Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.
18		Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Status*** Message was successfully sent.
	The Sink has informed the Source of its present status.	

8.3.2.10.2.3 Sink Gets Source PPS Status

Figure 8-24 shows an example sequence between a Source and a Sink where, after the Sink has received an alert (see Section 8.3.2.10.1) that there has been a PPS status change, the Sink gets more details on the change.

Figure 8-24 Sink Gets Source PPS Status

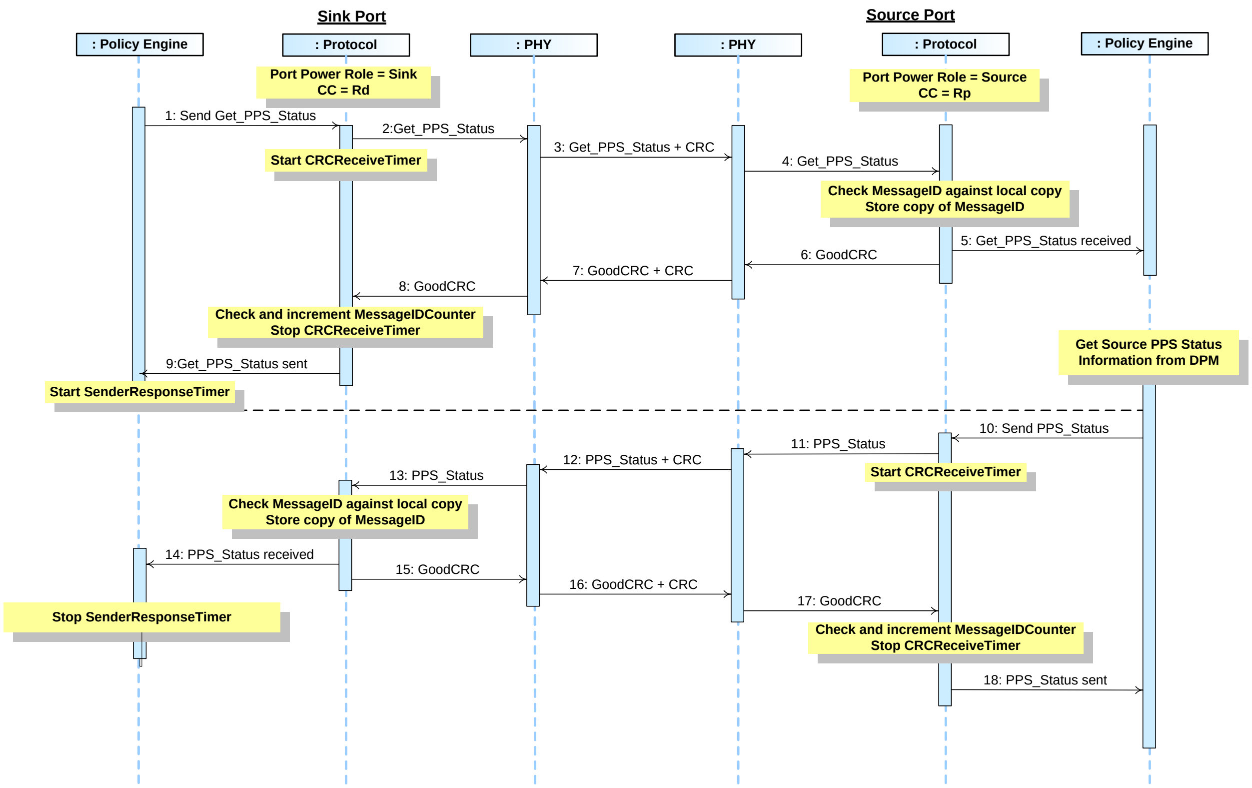


Table 8-24below provides a detailed explanation of what happens at each labeled step in Figure 8-24 above.

Table 8-24 Steps for a Sink getting Source PPS status Sequence

Step	Sink Port	Source Port
1	The Port has ***Port Power Role*** set to Sink with the Rd pull down on its CC wire. Policy Engine directs the Protocol Layer to send a ***Get_PPS_Status*** Message.	The Port has ***Port Power Role*** set to Source and the Rp pull up on its CC wire.
2	Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.	
3	Physical Layer appends CRC and sends the ***Get_PPS_Status*** Message.	Physical Layer receives the ***Get_PPS_Status*** Message and checks the CRC to verify the Message.
4		Physical Layer removes the CRC and forwards the ***Get_Status*** Message to the Protocol Layer.
5		Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Get_PPS_Status*** Message information to the Policy Engine that consumes it.
6		Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.
7	Physical Layer receives the ***GoodCRC*** Message and checks the CRC to verify the Message.	Physical Layer appends CRC and sends the ***GoodCRC*** Message.
8	Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.	

Step	Sink Port	Source Port
9	Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Get_PPS_Status*** Message was successfully sent. Policy Engine starts ***SenderResponseTimer***.	
10		Policy Engine requests the DPM for the present Source status which is provided. The Policy Engine tells the Protocol Layer to form a ***PPS_Status*** Message.
11		Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.
12	Physical Layer receives the Message and compares the CRC it calculated with the one sent to verify the ***PPS_Status*** Message.	Physical Layer appends a CRC and sends the ***PPS_Status*** Message.
13	Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***PPS_Status*** Message information to the Policy Engine that consumes it.	
14	The Policy Engine stops the ***SenderResponseTimer***.	
15	Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.	
16	Physical Layer appends a CRC and sends the ***GoodCRC*** Message.	Physical Layer receives ***GoodCRC*** Message and compares the CRC it calculated with the one sent to verify the Message.
17		Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.
18		Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***PPS_Status*** Message was successfully sent.
	The Source has informed the Sink of its present PPS status.	

8.3.2.10.3 Source/Sink Capabilities

8.3.2.10.3.1 Sink Gets Source Capabilities

Figure 8-25 shows an example sequence between a Source and a Sink when the Sink gets the Source's capabilities.

Figure 8-25 Sink Gets Source's Capabilities

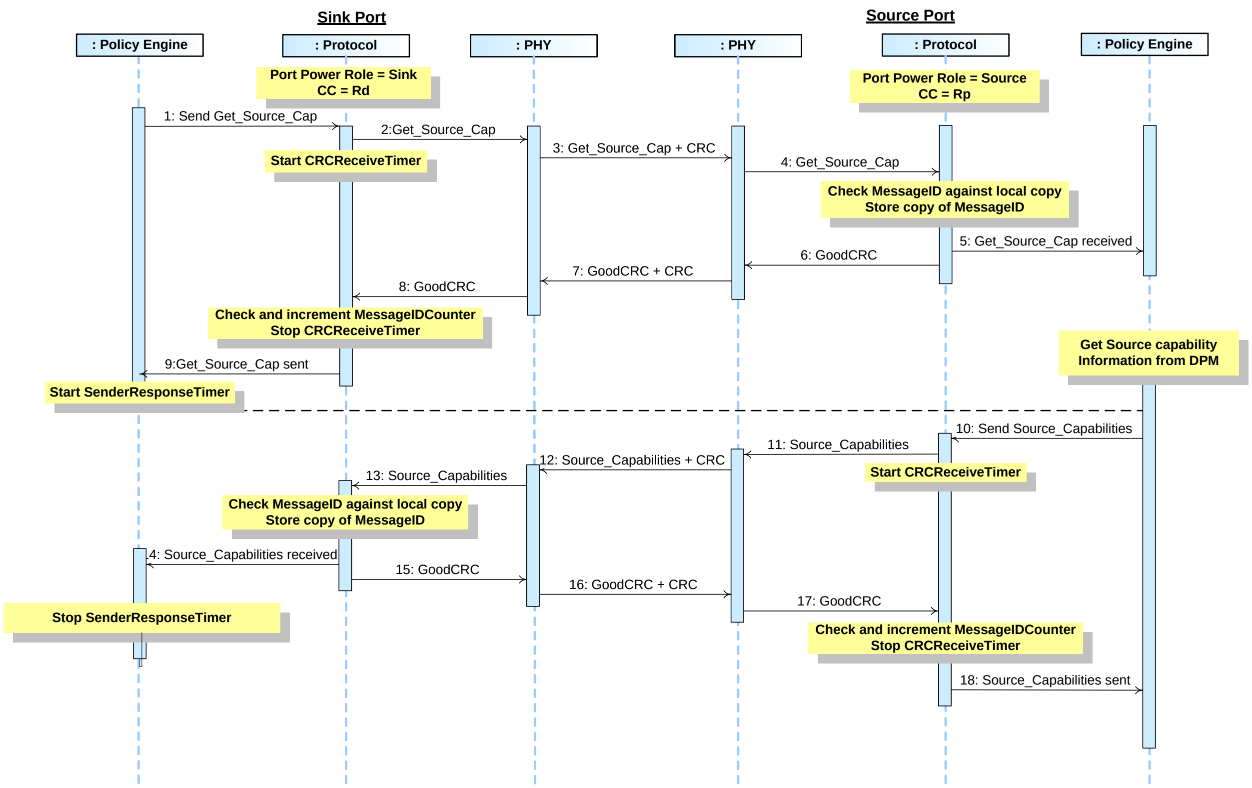


Table 8-25 below provides a detailed explanation of what happens at each labeled step in Figure 8-25 above.

Table 8-25 Steps for a Sink getting Source capabilities Sequence

Step	Sink Port	Source Port
1	The Port has ***Port Power Role*** set to Sink with the Rd pull down on its CC wire. Policy Engine directs the Protocol Layer to send a ***Get_Source_Cap*** Message.	The Port has ***Port Power Role*** set to Source and the Rp pull up on its CC wire.
2	Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.	
3	Physical Layer appends CRC and sends the ***Get_Source_Cap*** Message.	Physical Layer receives the ***Get_Source_Cap*** Message and checks the CRC to verify the Message.
4		Physical Layer removes the CRC and forwards the ***Get_Source_Cap*** Message to the Protocol Layer.
5		Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Get_Source_Cap*** Message information to the Policy Engine that consumes it.

Step	Sink Port	Source Port
6		Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.
7	Physical Layer receives the ***GoodCRC*** Message and checks the CRC to verify the Message.	Physical Layer appends CRC and sends the ***GoodCRC*** Message.
8	Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.	
9	Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Get_Source_Cap*** Message was successfully sent. Policy Engine starts ***SenderResponseTimer***.	
10		Policy Engine requests the DPM for the present Source capabilities which are provided. The Policy Engine tells the Protocol Layer to form a ***Source_Capabilities*** Message.
11		Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.
12	Physical Layer receives the Message and compares the CRC it calculated with the one sent to verify the ***Source_Capabilities*** Message.	Physical Layer appends a CRC and sends the ***Source_Capabilities*** Message.
13	Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Source_Capabilities*** Message information to the Policy Engine that consumes it.	
14	The Policy Engine stops the ***SenderResponseTimer***.	
15	Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.	
16	Physical Layer appends a CRC and sends the ***GoodCRC*** Message.	Physical Layer receives ***GoodCRC*** Message and compares the CRC it calculated with the one sent to verify the Message.
17		Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.
18		Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Source_Capabilities*** Message was successfully sent.
	The Source has informed the Sink of its capabilities.	

8.3.2.10.3.2 Dual-Role Source Gets Source Capabilities from a Dual-Role Sink

Figure 8-26 shows an example sequence between a Dual-Role Source and a Dual-Role Sink when the Source gets the Sink's capabilities as a Source.

Figure 8-26 Dual-Role Source Gets Dual-Role Sink's Capabilities as a Source

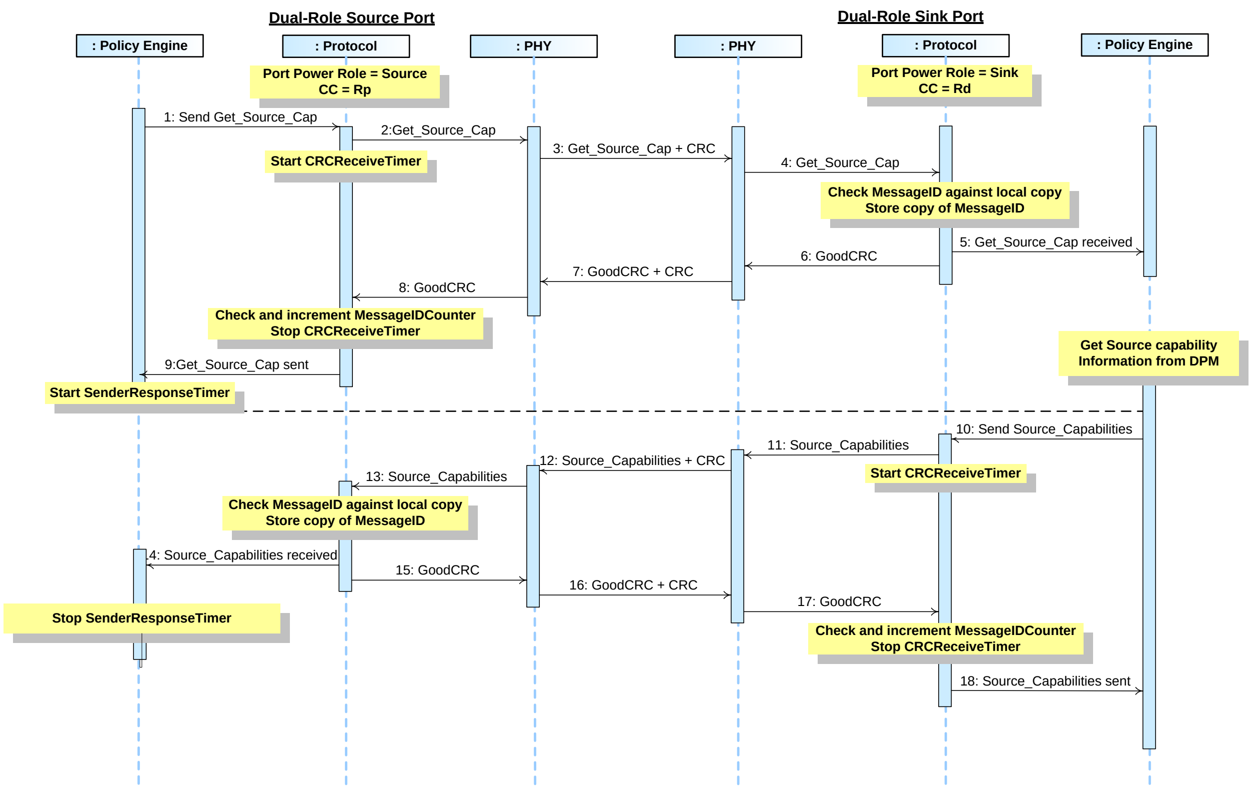


Table 8-26 below provides a detailed explanation of what happens at each labeled step in Figure 8-26 above.

Table 8-26 Steps for a Dual-Role Source getting Dual-Role Sink's capabilities as a Source Sequence

Step	Dual-Role Source Port	Dual-Role Sink Port
1	The Port has ***Port Power Role*** set to Source and the Rp pull up on its CC wire. Policy Engine directs the Protocol Layer to send a ***Get_Source_Cap*** Message.	The Port has ***Port Power Role*** set to Sink with the Rd pull down on its CC wire.
2	Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.	
3	Physical Layer appends CRC and sends the ***Get_Source_Cap*** Message.	Physical Layer receives the ***Get_Source_Cap*** Message and checks the CRC to verify the Message.
4		Physical Layer removes the CRC and forwards the ***Get_Source_Cap*** Message to the Protocol Layer.
5		Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Get_Source_Cap*** Message information to the Policy Engine that consumes it.

Step	Dual-Role Source Port	Dual-Role Sink Port
6		Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.
7	Physical Layer receives the ***GoodCRC*** Message and checks the CRC to verify the Message.	Physical Layer appends CRC and sends the ***GoodCRC*** Message.
8	Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.	
9	Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Get_Source_Cap*** Message was successfully sent. Policy Engine starts ***SenderResponseTimer***.	
10		Policy Engine requests the DPM for the present Source capabilities which are provided. The Policy Engine tells the Protocol Layer to form a ***Source_Capabilities*** Message.
11		Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.
12	Physical Layer receives the Message and compares the CRC it calculated with the one sent to verify the ***Source_Capabilities*** Message.	Physical Layer appends a CRC and sends the ***Source_Capabilities*** Message.
13	Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Source_Capabilities*** Message information to the Policy Engine that consumes it.	
14	The Policy Engine stops the ***SenderResponseTimer***.	
15	Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.	
16	Physical Layer appends a CRC and sends the ***GoodCRC*** Message.	Physical Layer receives ***GoodCRC*** Message and compares the CRC it calculated with the one sent to verify the Message.
17		Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.
18		Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Source_Capabilities*** Message was successfully sent.
	The Dual-Role Sink has informed the Dual-Role Source of its capabilities.	

8.3.2.10.3.3 Source Gets Sink Capabilities

Figure 8-27 shows an example sequence between a Source and a Sink when the Source gets the Sink's capabilities.

Figure 8-27 Source Gets Sink's Capabilities

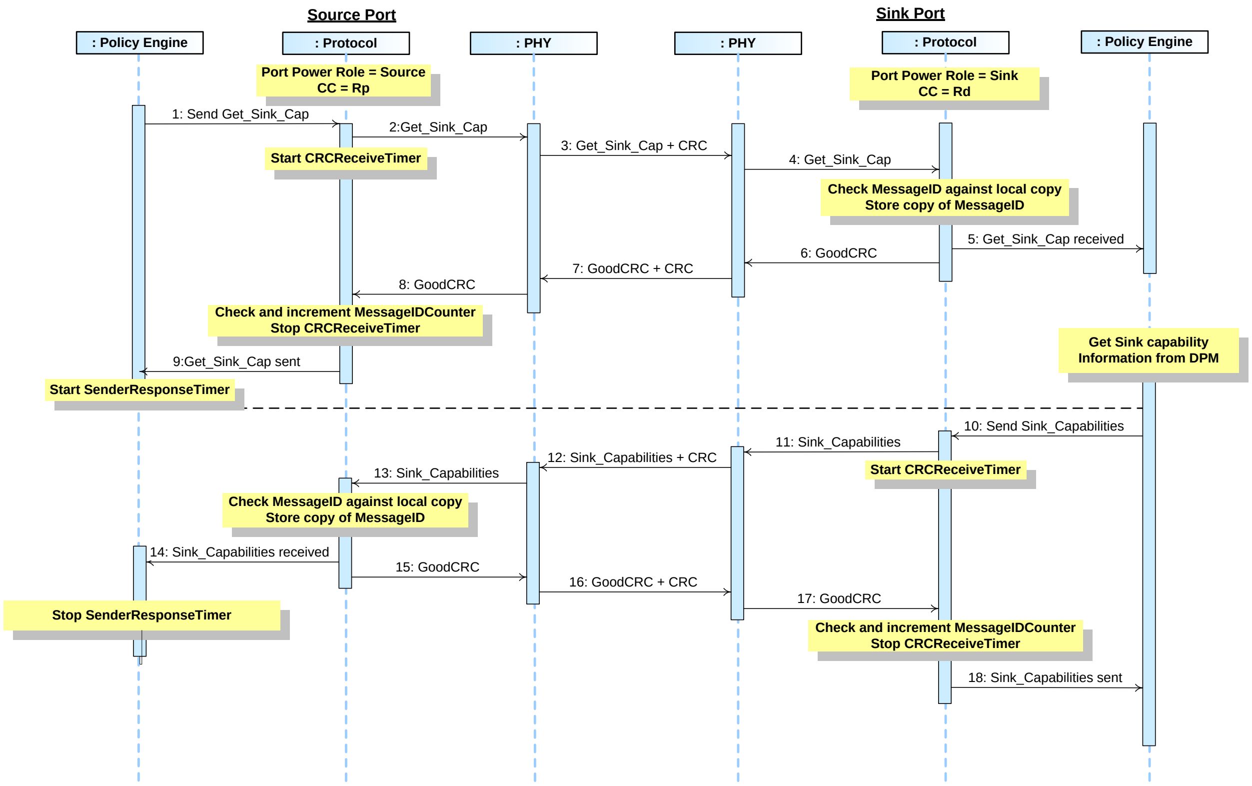


Table 8-27 below provides a detailed explanation of what happens at each labeled step in Figure 8-27 above.

Table 8-27 Steps for a Source getting Sink capabilities Sequence

Step	Source Port	Sink Port
1	The Port has ***Port Power Role*** set to Source and the Rp pull up on its CC wire. Policy Engine directs the Protocol Layer to send a ***Get_Sink_Cap*** Message.	The Port has ***Port Power Role*** set to Sink with the Rd pull down on its CC wire.
2	Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.	
3	Physical Layer appends CRC and sends the ***Get_Sink_Cap*** Message.	Physical Layer receives the ***Get_Sink_Cap*** Message and checks the CRC to verify the Message.
4		Physical Layer removes the CRC and forwards the ***Get_Sink_Cap*** Message to the Protocol Layer.
5		Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Get_Sink_Cap*** Message information to the Policy Engine that consumes it.
6		Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.

Step	Source Port	Sink Port
7	Physical Layer receives the ***GoodCRC*** Message and checks the CRC to verify the Message.	Physical Layer appends CRC and sends the ***GoodCRC*** Message.
8	Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.	
9	Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Get_Sink_Cap*** Message was successfully sent. Policy Engine starts ***SenderResponseTimer***.	
10		Policy Engine requests the DPM for the present Sink capabilities which are provided. The Policy Engine tells the Protocol Layer to form a ***Sink_Capabilities*** Message.
11		Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.
12	Physical Layer receives the Message and compares the CRC it calculated with the one sent to verify the ***Sink_Capabilities*** Message.	Physical Layer appends a CRC and sends the ***Sink_Capabilities*** Message.
13	Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Sink_Capabilities*** Message information to the Policy Engine that consumes it.	
14	The Policy Engine stops the ***SenderResponseTimer***.	
15	Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.	
16	Physical Layer appends a CRC and sends the ***GoodCRC*** Message.	Physical Layer receives ***GoodCRC*** Message and compares the CRC it calculated with the one sent to verify the Message.
17		Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.
18		Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Sink_Capabilities*** Message was successfully sent.
	The Sink has informed the Source of its capabilities.	

8.3.2.10.3.4 Dual-Role Sink Get Sink Capabilities from a Dual-Role Source

Figure 8-28 shows an example sequence between a Dual-Role Source and a Dual-Role Sink when the Dual-Role Sink gets the Dual-Role Source's capabilities as a Sink.

Figure 8-28 Dual-Role Sink Gets Dual-Role Source's Capabilities as a Sink

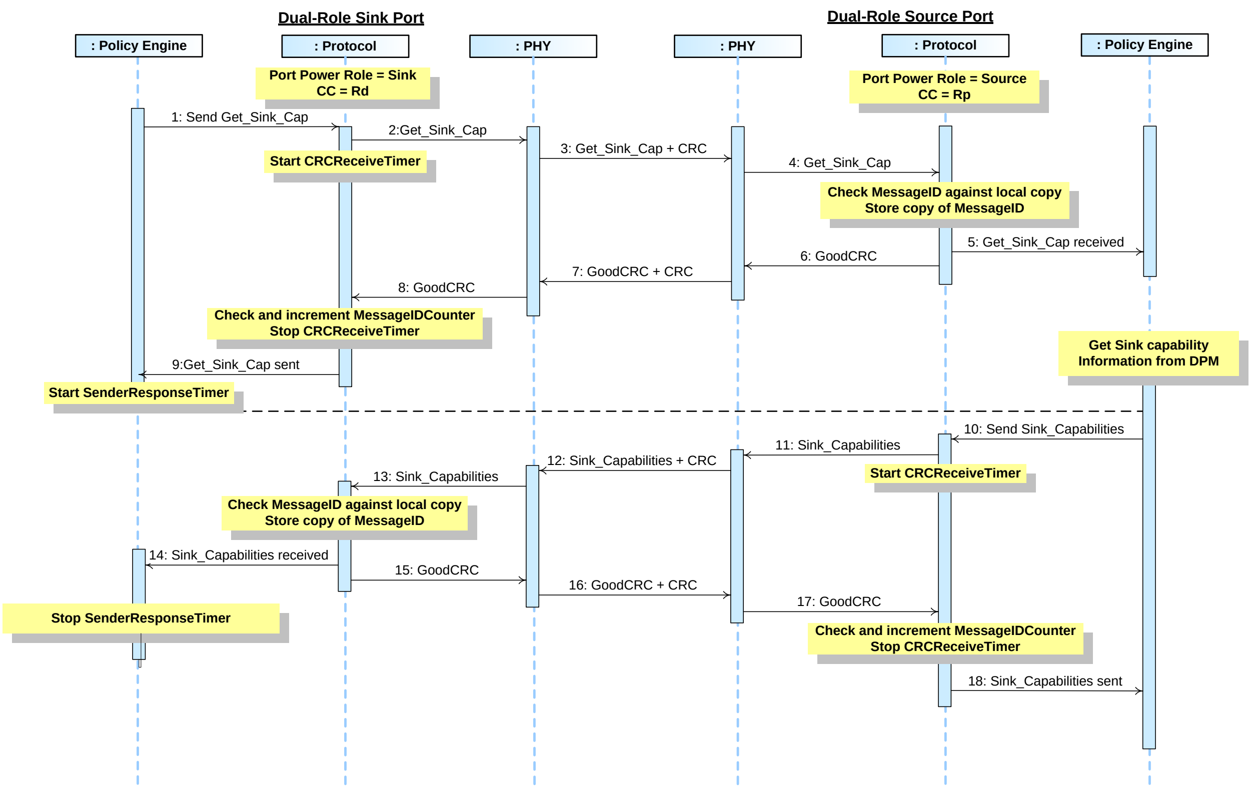


Table 8-28 below provides a detailed explanation of what happens at each labeled step in Figure 8-28 above.

Table 8-28 Steps for a Dual-Role Sink getting Dual-Role Source capabilities as a Sink Sequence

Step	Dual-Role Sink Port	Dual-Role Source Port
1	The Port has ***Port Power Role*** set to Dual-Role Sink with the Rd pull down on its CC wire. Policy Engine directs the Protocol Layer to send a ***Get_Sink_Cap*** Message.	The Port has ***Port Power Role*** set to Dual-Role Source and the Rp pull up on its CC wire.
2	Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.	
3	Physical Layer appends CRC and sends the ***Get_Sink_Cap*** Message.	Physical Layer receives the ***Get_Sink_Cap*** Message and checks the CRC to verify the Message.
4		Physical Layer removes the CRC and forwards the ***Get_Sink_Cap*** Message to the Protocol Layer.
5		Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Get_Sink_Cap*** Message information to the Policy Engine that consumes it.

Step	Dual-Role Sink Port	Dual-Role Source Port
6		Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.
7	Physical Layer receives the ***GoodCRC*** Message and checks the CRC to verify the Message.	Physical Layer appends CRC and sends the ***GoodCRC*** Message.
8	Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.	
9	Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Get_Sink_Cap*** Message was successfully sent. Policy Engine starts ***SenderResponseTimer***.	
10		Policy Engine requests the DPM for the present Dual-Role Source capabilities which are provided. The Policy Engine tells the Protocol Layer to form a ***Sink_Capabilities*** Message.
11		Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.
12	Physical Layer receives the Message and compares the CRC it calculated with the one sent to verify the ***Sink_Capabilities*** Message.	Physical Layer appends a CRC and sends the ***Sink_Capabilities*** Message.
13	Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Sink_Capabilities*** Message information to the Policy Engine that consumes it.	
14	The Policy Engine stops the ***SenderResponseTimer***.	
15	Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.	
16	Physical Layer appends a CRC and sends the ***GoodCRC*** Message.	Physical Layer receives ***GoodCRC*** Message and compares the CRC it calculated with the one sent to verify the Message.
17		Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.
18		Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Sink_Capabilities*** Message was successfully sent.
	The Dual-Role Source has informed the Dual-Role Sink of its capabilities as a Sink.	

8.3.2.10.4 Extended Capabilities

8.3.2.10.4.1 Sink Gets Source Extended Capabilities

Figure 8-29 shows an example sequence between a Source and a Sink when the Sink gets the Source's extended capabilities.

Figure 8-29 Sink Gets Source's Extended Capabilities

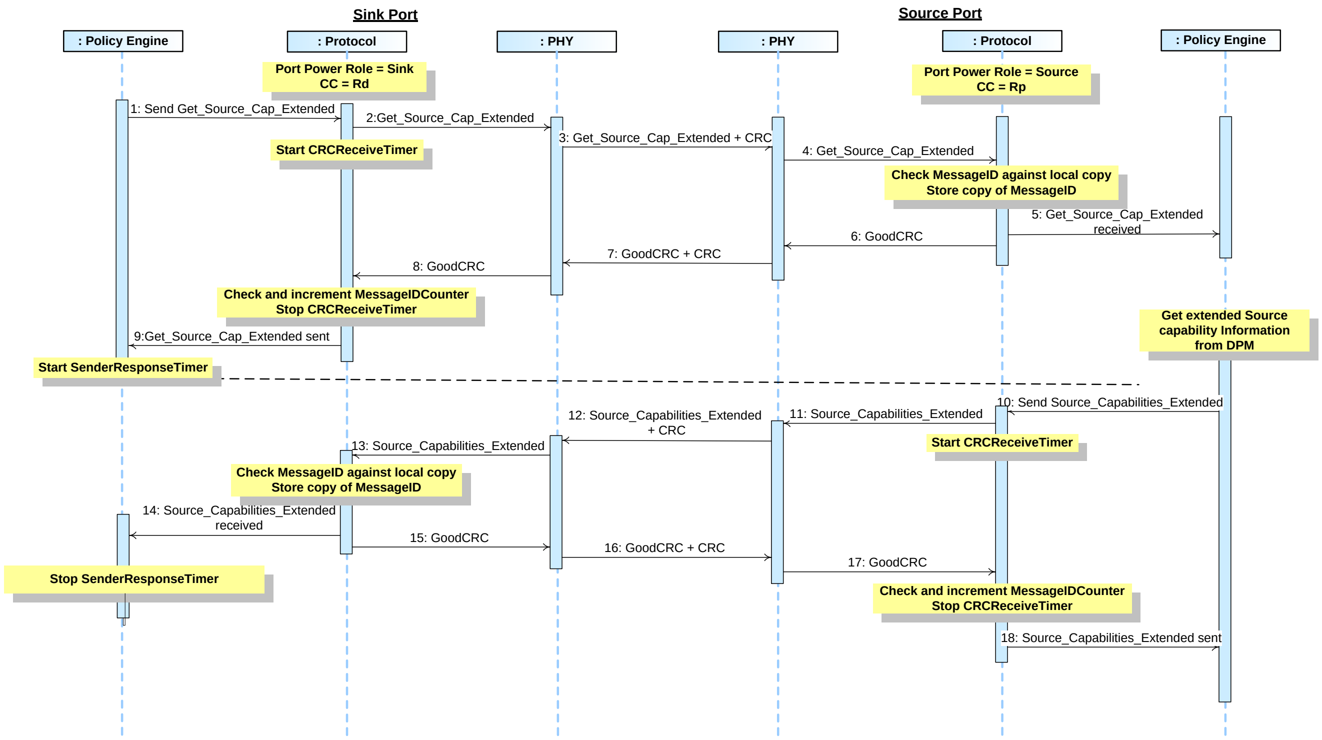


Table 8-29 below provides a detailed explanation of what happens at each labeled step in Figure 8-29 above.

Table 8-29 Steps for a Sink getting Source extended capabilities Sequence

Step	Sink Port	Source Port
1	The Port has ***Port Power Role*** set to Sink with the Rd pull down on its CC wire. Policy Engine directs the Protocol Layer to send a ***Get_Source_Cap_Extended*** Message.	The Port has ***Port Power Role*** set to Source and the Rp pull up on its CC wire.
2	Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.	
3	Physical Layer appends CRC and sends the ***Get_Source_Cap_Extended*** Message.	Physical Layer receives the ***Get_Source_Cap_Extended*** Message and checks the CRC to verify the Message.
4		Physical Layer removes the CRC and forwards the ***Get_Source_Cap_Extended*** Message to the Protocol Layer.

Step	Sink Port	Source Port
5		Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Get_Source_Cap_Extended*** Message information to the Policy Engine that consumes it.
6		Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.
7	Physical Layer receives the ***GoodCRC*** Message and checks the CRC to verify the Message.	Physical Layer appends CRC and sends the ***GoodCRC*** Message.
8	Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.	
9	Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Get_Source_Cap_Extended*** Message was successfully sent. Policy Engine starts ***SenderResponseTimer***.	
10		Policy Engine requests the DPM for the present extended Source capabilities which are provided. The Policy Engine tells the Protocol Layer to form a ***Source_Capabilities_Extended*** Message.
11		Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.
12	Physical Layer receives the Message and compares the CRC it calculated with the one sent to verify the ***Source_Capabilities_Extended*** Message.	Physical Layer appends a CRC and sends the ***Source_Capabilities_Extended*** Message.
13	Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Source_Capabilities_Extended*** Message information to the Policy Engine that consumes it.	
14	The Policy Engine stops the ***SenderResponseTimer***.	
15	Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.	
16	Physical Layer appends a CRC and sends the ***GoodCRC*** Message.	Physical Layer receives ***GoodCRC*** Message and compares the CRC it calculated with the one sent to verify the Message.
17		Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.
18		Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Source_Capabilities_Extended*** Message was successfully sent.
	The Source has informed the Sink of its extended capabilities.	

8.3.2.10.4.2 Dual-Role Source Gets Source Capabilities Extended from a Dual-Role Sink

Figure 8-29 shows an example sequence between a Source and a Sink when the Dual-Role Source gets the Dual-Role Sink's extended capabilities as a Source.

Figure 8-30 Dual-Role Source Gets Dual-Role Sink's Extended Capabilities

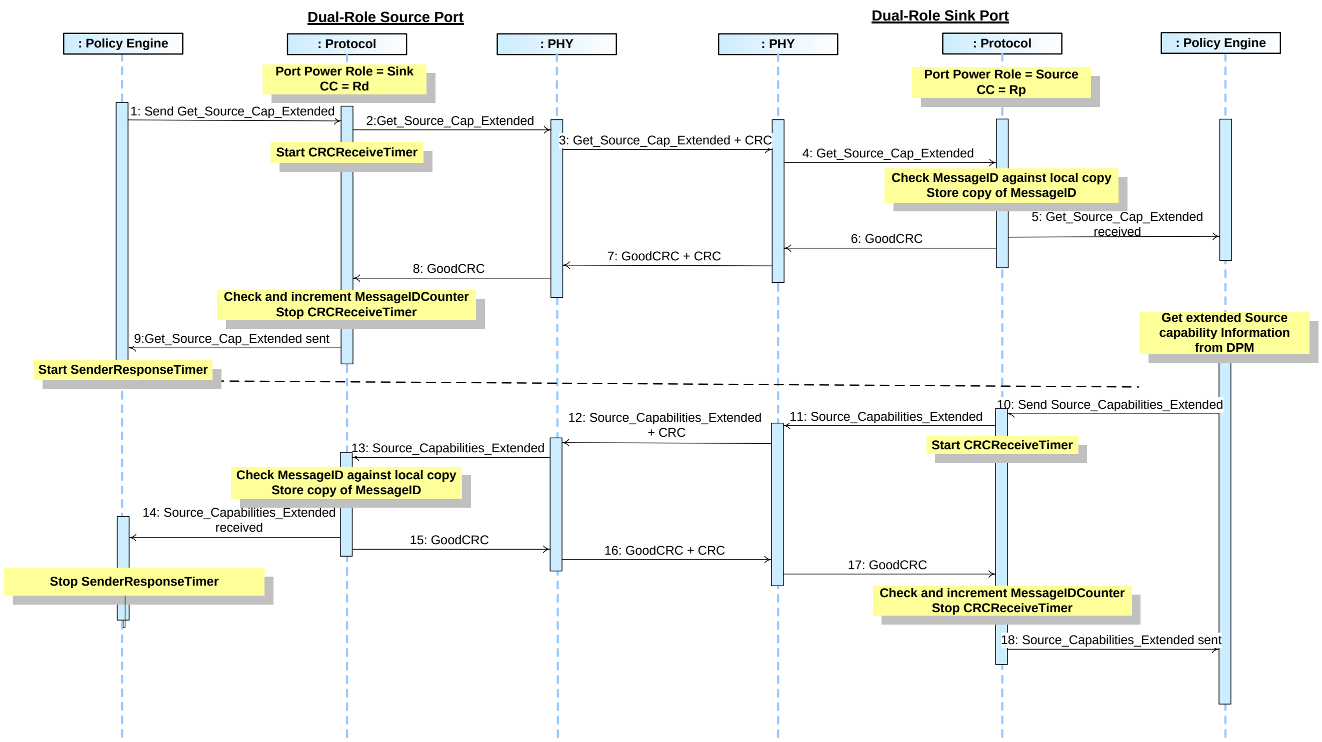


Table 8-29 below provides a detailed explanation of what happens at each labeled step in Figure 8-29 above.

Table 8-30 Steps for a Dual-Role Source getting Dual-Role Sink extended capabilities Sequence

Step	Dual-Role Source Port	Dual-Role Sink Port
1	The Port has ***Port Power Role*** set to Source and the Rp pull up on its CC wire. Policy Engine directs the Protocol Layer to send a ***Get_Source_Cap_Extended*** Message.	The Port has ***Port Power Role*** set to Sink with the Rd pull down on its CC wire.
2	Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.	
3	Physical Layer appends CRC and sends the ***Get_Source_Cap_Extended*** Message.	Physical Layer receives the ***Get_Source_Cap_Extended*** Message and checks the CRC to verify the Message.
4		Physical Layer removes the CRC and forwards the ***Get_Source_Cap_Extended*** Message to the Protocol Layer.
5		Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Get_Source_Cap_Extended*** Message information to the Policy Engine that consumes it.

Step	Dual-Role Source Port	Dual-Role Sink Port
6		Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.
7	Physical Layer receives the ***GoodCRC*** Message and checks the CRC to verify the Message.	Physical Layer appends CRC and sends the ***GoodCRC*** Message.
8	Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.	
9	Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Get_Source_Cap_Extended*** Message was successfully sent. Policy Engine starts ***SenderResponseTimer***.	
10		Policy Engine requests the DPM for the present extended Source capabilities which are provided. The Policy Engine tells the Protocol Layer to form a ***Source_Capabilities_Extended*** Message.
11		Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.
12	Physical Layer receives the Message and compares the CRC it calculated with the one sent to verify the ***Source_Capabilities_Extended*** Message.	Physical Layer appends a CRC and sends the ***Source_Capabilities_Extended*** Message.
13	Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Source_Capabilities_Extended*** Message information to the Policy Engine that consumes it.	
14	The Policy Engine stops the ***SenderResponseTimer***.	
15	Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.	
16	Physical Layer appends a CRC and sends the ***GoodCRC*** Message.	Physical Layer receives ***GoodCRC*** Message and compares the CRC it calculated with the one sent to verify the Message.
17		Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.
18		Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Source_Capabilities_Extended*** Message was successfully sent.
	The Dual-Role Sink has informed the Dual-Role Source of its extended capabilities as a Source.	

8.3.2.10.5 Battery Capabilities and Status

8.3.2.10.5.1 Sink Gets Battery Capabilities

Figure 8-31 shows an example sequence between a Source and a Sink when the Sink gets the Source's Battery capabilities for a given Battery.

Figure 8-31 Sink Gets Source's Battery Capabilities

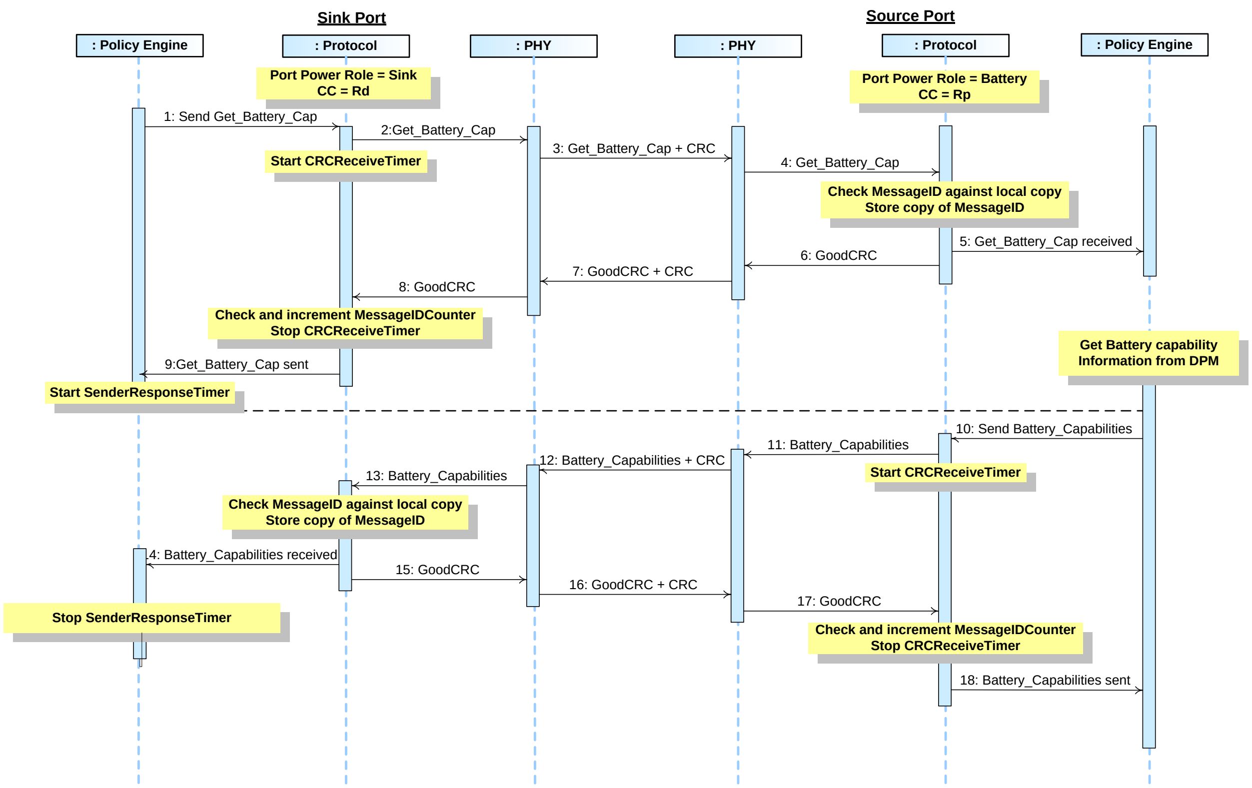


Table 8-31 below provides a detailed explanation of what happens at each labeled step in Figure 8-31 above.

Table 8-31 Steps for a Sink getting Source Battery capabilities Sequence

Step	Sink Port	Source Port
1	The Port has ***Port Power Role*** set to Sink with the Rd pull down on its CC wire. Policy Engine directs the Protocol Layer to send a ***Get_Battery_Cap*** Message containing the number of the Battery for which capabilities are being requested.	The Port has ***Port Power Role*** set to Source and the Rp pull up on its CC wire.
2	Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.	
3	Physical Layer appends CRC and sends the ***Get_Battery_Cap*** Message.	Physical Layer receives the ***Get_Battery_Cap*** Message and checks the CRC to verify the Message.
4		Physical Layer removes the CRC and forwards the ***Get_Battery_Cap*** Message to the Protocol Layer.

Step	Sink Port	Source Port
5		Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Get_Battery_Cap*** Message information to the Policy Engine that consumes it.
6		Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.
7	Physical Layer receives the ***GoodCRC*** Message and checks the CRC to verify the Message.	Physical Layer appends CRC and sends the ***GoodCRC*** Message.
8	Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.	
9	Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Get_Battery_Cap*** Message was successfully sent. Policy Engine starts ***SenderResponseTimer***.	
10		Policy Engine requests the DPM for the present Source Battery capabilities, for the requested Battery number, which are provided. The Policy Engine tells the Protocol Layer to form a ***Battery_Capabilities*** Message.
11		Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.
12	Physical Layer receives the Message and compares the CRC it calculated with the one sent to verify the ***Battery_Capabilities*** Message.	Physical Layer appends a CRC and sends the ***Battery_Capabilities*** Message.
13	Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Battery_Capabilities*** Message information to the Policy Engine that consumes it.	
14	The Policy Engine stops the ***SenderResponseTimer***.	
15	Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.	
16	Physical Layer appends a CRC and sends the ***GoodCRC*** Message.	Physical Layer receives ***GoodCRC*** Message and compares the CRC it calculated with the one sent to verify the Message.
17		Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.
18		Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Battery_Capabilities*** Message was successfully sent.
	The Source has informed the Sink of the Battery capabilities for the requested Battery.	

8.3.2.10.5.2 Source Gets Battery Capabilities

Figure 8-32 shows an example sequence between a Source and a Sink when the Source gets the Sink's Battery capabilities for a given Battery.

Figure 8-32 Source Gets Sink's Battery Capabilities

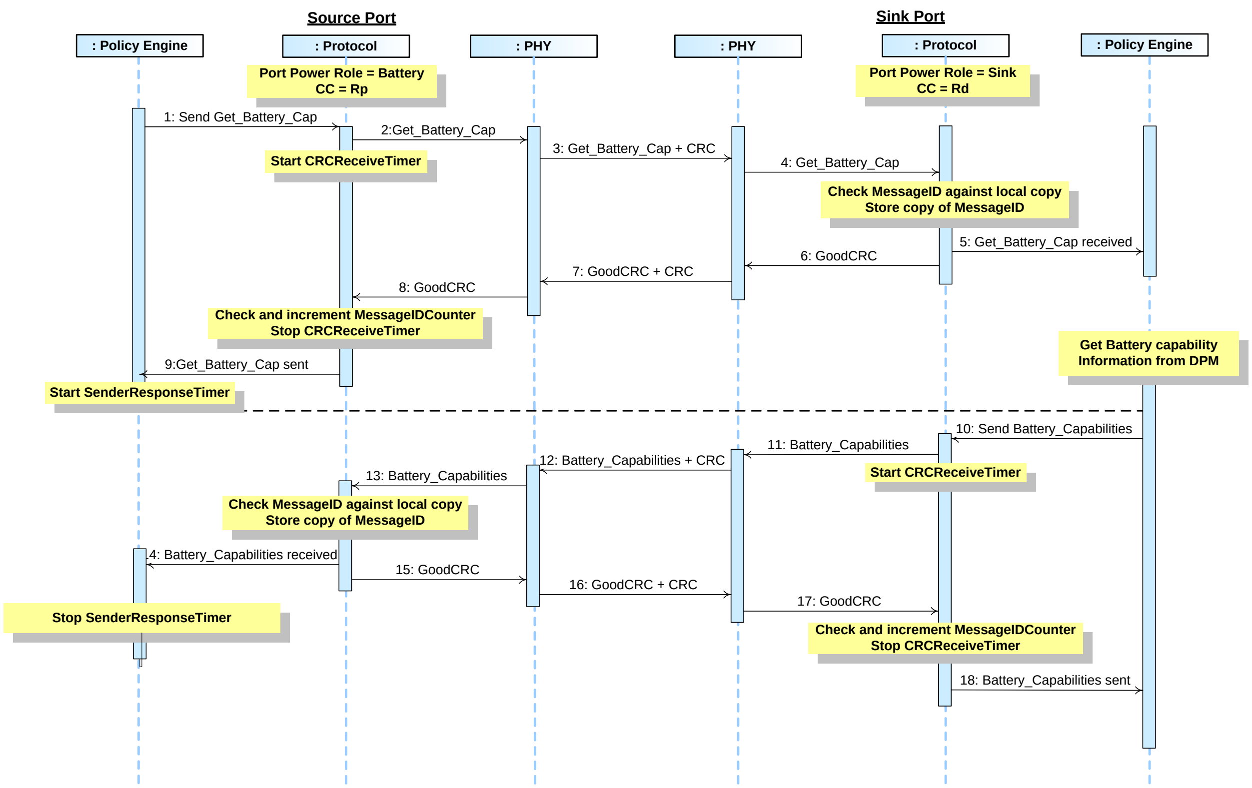


Table 8-32 below provides a detailed explanation of what happens at each labeled step in Figure 8-32 above.

Table 8-32 Steps for a Source getting Sink Battery capabilities Sequence

Step	Source Port	Sink Port
1	The Port has ***Port Power Role*** set to Source and the Rp pull up on its CC wire. Policy Engine directs the Protocol Layer to send a ***Get_Battery_Cap*** Message containing the number of the Battery for which capabilities are being requested.	The Port has ***Port Power Role*** set to Sink with the Rd pull down on its CC wire.
2	Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.	
3	Physical Layer appends CRC and sends the ***Get_Battery_Cap*** Message.	Physical Layer receives the ***Get_Battery_Cap*** Message and checks the CRC to verify the Message.
4		Physical Layer removes the CRC and forwards the ***Get_Battery_Cap*** Message to the Protocol Layer.

Step	Source Port	Sink Port
5		Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Get_Battery_Cap*** Message information to the Policy Engine that consumes it.
6		Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.
7	Physical Layer receives the ***GoodCRC*** Message and checks the CRC to verify the Message.	Physical Layer appends CRC and sends the ***GoodCRC*** Message.
8	Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.	
9	Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Get_Battery_Cap*** Message was successfully sent. Policy Engine starts ***SenderResponseTimer***.	
10		Policy Engine requests the DPM for the present Source Battery capabilities, for the requested Battery number, which are provided. The Policy Engine tells the Protocol Layer to form a ***Battery_Capabilities*** Message.
11		Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.
12	Physical Layer receives the Message and compares the CRC it calculated with the one sent to verify the ***Battery_Capabilities*** Message.	Physical Layer appends a CRC and sends the ***Battery_Capabilities*** Message.
13	Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Battery_Capabilities*** Message information to the Policy Engine that consumes it.	
14	The Policy Engine stops the ***SenderResponseTimer***.	
15	Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.	
16	Physical Layer appends a CRC and sends the ***GoodCRC*** Message.	Physical Layer receives ***GoodCRC*** Message and compares the CRC it calculated with the one sent to verify the Message.
17		Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.
18		Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Battery_Capabilities*** Message was successfully sent.
	The Sink has informed the Source of the Battery capabilities for the requested Battery.	

8.3.2.10.5.3 Sink Gets Battery Status

Figure 8-33 shows an example sequence between a Source and a Sink when the Sink gets the Source's Battery status for a given Battery.

Figure 8-33 Sink Gets Source's Battery Status

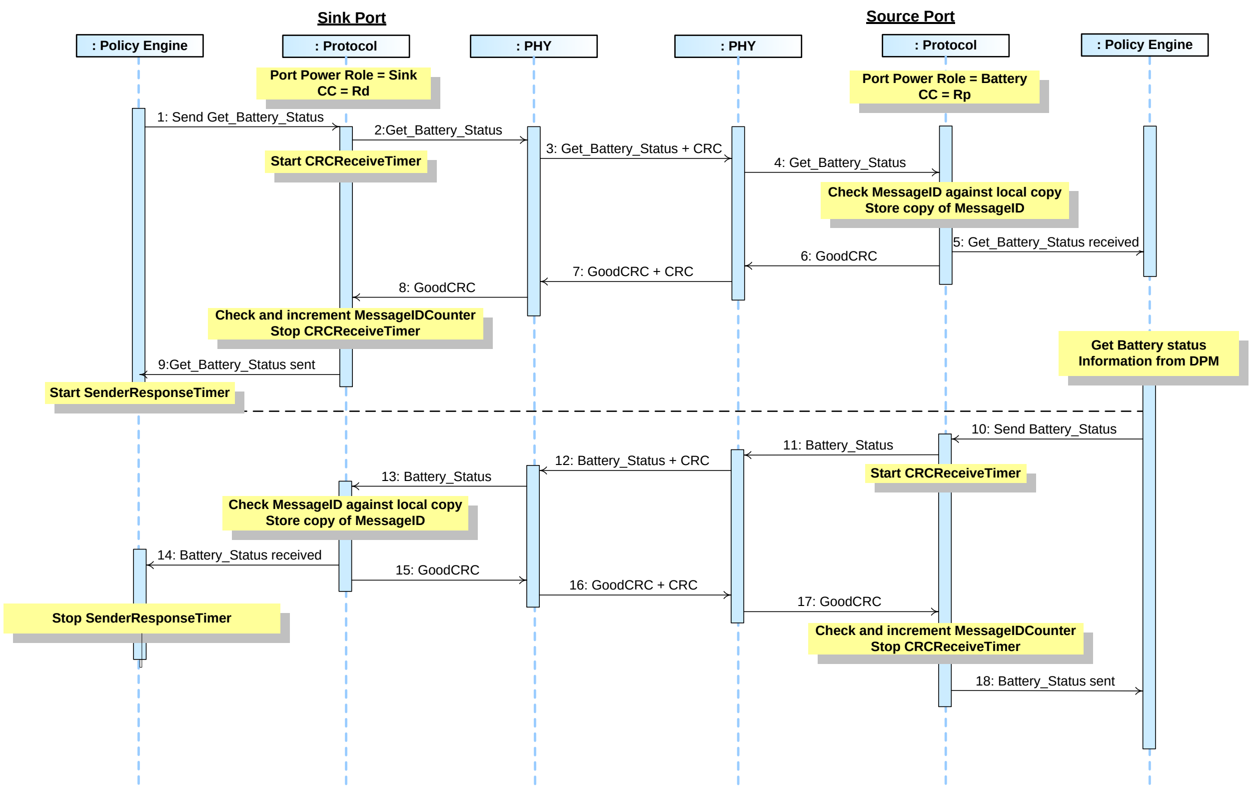


Table 8-33 below provides a detailed explanation of what happens at each labeled step in Figure 8-33 above.

Table 8-33 Steps for a Sink getting Source Battery status Sequence

Step	Sink Port	Source Port
1	The Port has ***Port Power Role*** set to Sink with the Rd pull down on its CC wire. Policy Engine directs the Protocol Layer to send a ***Get_Battery_Status*** Message containing the number of the Battery for which status is being requested.	The Port has ***Port Power Role*** set to Source and the Rp pull up on its CC wire.
2	Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.	
3	Physical Layer appends CRC and sends the ***Get_Battery_Status*** Message.	Physical Layer receives the ***Get_Battery_Status*** Message and checks the CRC to verify the Message.
4		Physical Layer removes the CRC and forwards the ***Get_Battery_Status*** Message to the Protocol Layer.
5		Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Get_Battery_Status*** Message information to the Policy Engine that consumes it.

Step	Sink Port	Source Port
6		Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.
7	Physical Layer receives the ***GoodCRC*** Message and checks the CRC to verify the Message.	Physical Layer appends CRC and sends the ***GoodCRC*** Message.
8	Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.	
9	Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Get_Battery_Status*** Message was successfully sent. Policy Engine starts ***SenderResponseTimer***.	
10		Policy Engine requests the DPM for the present Source Battery status, for the requested Battery number, which are provided. The Policy Engine tells the Protocol Layer to form a ***Battery_Status*** Message.
11		Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.
12	Physical Layer receives the Message and compares the CRC it calculated with the one sent to verify the ***Battery_Status*** Message.	Physical Layer appends a CRC and sends the ***Battery_Status*** Message.
13	Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Battery_Status*** Message information to the Policy Engine that consumes it.	
14	The Policy Engine stops the ***SenderResponseTimer***.	
15	Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.	
16	Physical Layer appends a CRC and sends the ***GoodCRC*** Message.	Physical Layer receives ***GoodCRC*** Message and compares the CRC it calculated with the one sent to verify the Message.
17		Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.
18		Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Battery_Status*** Message was successfully sent.
	The Source has informed the Sink of the Battery status for the requested Battery.	

8.3.2.10.5.4 Source Gets Battery Status

Figure 8-34 shows an example sequence between a Source and a Sink when the Source gets the Sink's Battery status for a given Battery.

Figure 8-34 Source Gets Sink's Battery Status

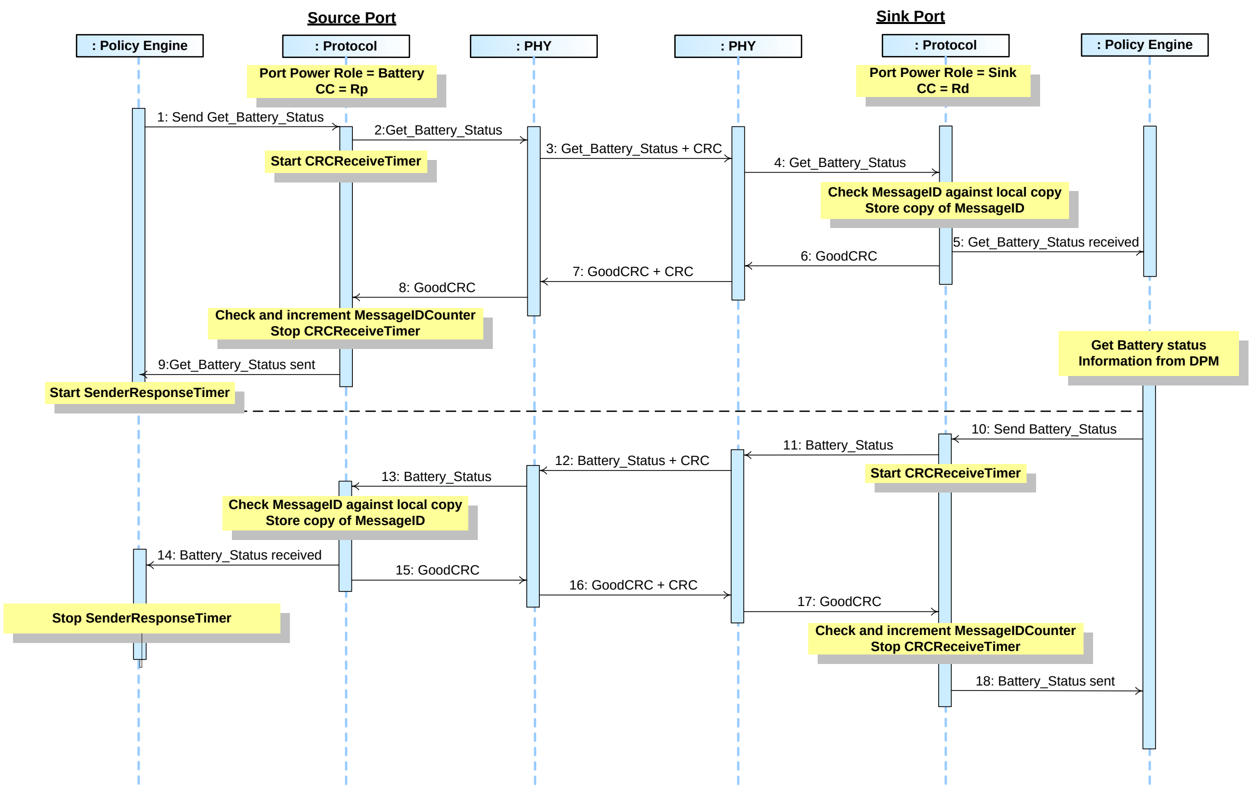


Table 8-34 below provides a detailed explanation of what happens at each labeled step in Figure 8-34 above.

Table 8-34 Steps for a Source getting Sink Battery status Sequence

Step	Source Port	Sink Port
1	The Port has ***Port Power Role*** set to Source and the Rp pull up on its CC wire. Policy Engine directs the Protocol Layer to send a ***Get_Battery_Status*** Message containing the number of the Battery for which status is being requested.	The Port has ***Port Power Role*** set to Sink with the Rd pull down on its CC wire.
2	Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.	
3	Physical Layer appends CRC and sends the ***Get_Battery_Status*** Message.	Physical Layer receives the ***Get_Battery_Status*** Message and checks the CRC to verify the Message.
4		Physical Layer removes the CRC and forwards the ***Get_Battery_Status*** Message to the Protocol Layer.
5		Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Get_Battery_Status*** Message information to the Policy Engine that consumes it.

Step	Source Port	Sink Port
6		Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.
7	Physical Layer receives the ***GoodCRC*** Message and checks the CRC to verify the Message.	Physical Layer appends CRC and sends the ***GoodCRC*** Message.
8	Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.	
9	Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Get_Battery_Status*** Message was successfully sent. Policy Engine starts ***SenderResponseTimer***.	
10		Policy Engine requests the DPM for the present Source Battery status, for the requested Battery number, which are provided. The Policy Engine tells the Protocol Layer to form a ***Battery_Status*** Message.
11		Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.
12	Physical Layer receives the Message and compares the CRC it calculated with the one sent to verify the ***Battery_Status*** Message.	Physical Layer appends a CRC and sends the ***Battery_Status*** Message.
13	Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Battery_Status*** Message information to the Policy Engine that consumes it.	
14	The Policy Engine stops the ***SenderResponseTimer***.	
15	Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.	
16	Physical Layer appends a CRC and sends the ***GoodCRC*** Message.	Physical Layer receives ***GoodCRC*** Message and compares the CRC it calculated with the one sent to verify the Message.
17		Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.
18		Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Battery_Status*** Message was successfully sent.
	The Sink has informed the Source of the Battery status for the requested Battery.	

8.3.2.10.6 Manufacturer Information

8.3.2.10.6.1 Source Gets Port Manufacturer Information from a Sink

Figure 8-35 shows an example sequence between a Source and a Sink when the Source gets the Sink's Manufacturer information for the Port.

Figure 8-35 Source Gets Sink's Port Manufacturer Information

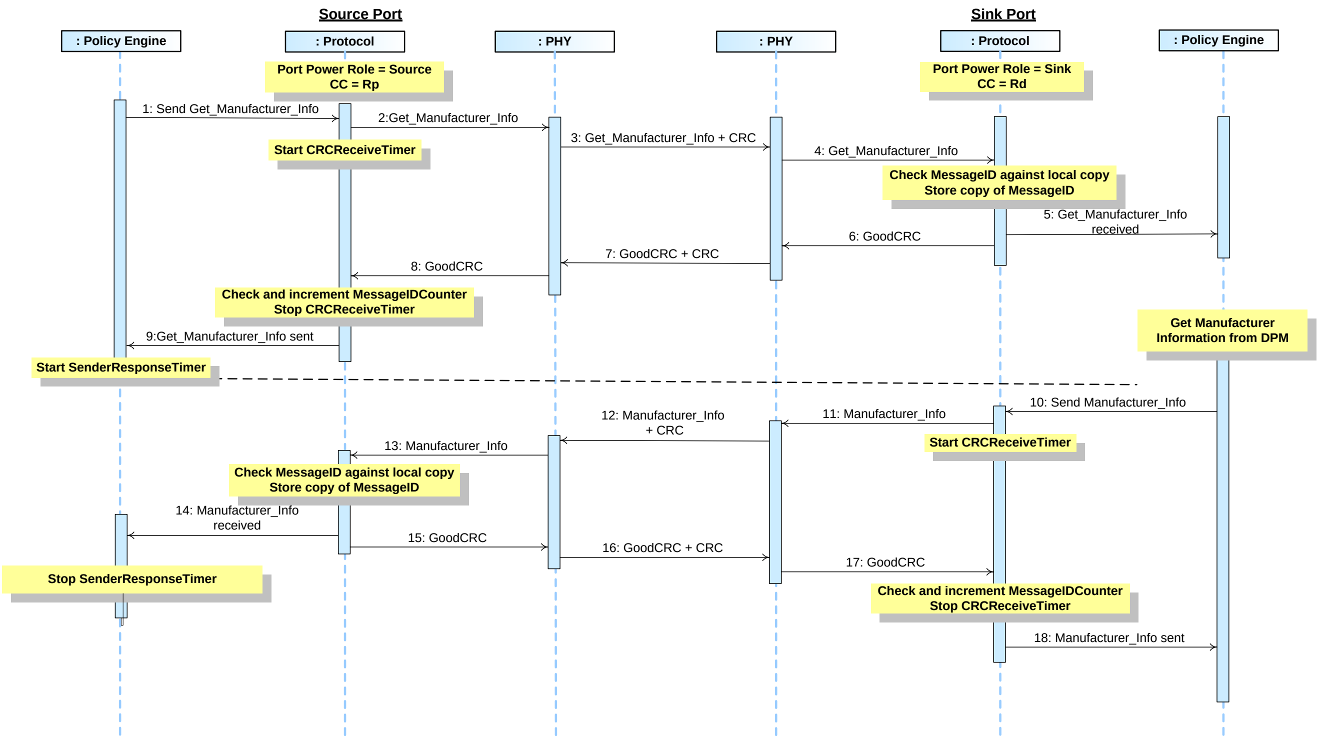


Table 8-32 below provides a detailed explanation of what happens at each labeled step in Figure 8-35 above.

Table 8-35 Steps for a Source getting Sink's Port Manufacturer information Sequence

Step	Source Port	Sink Port
1	The Port has ***Port Power Role*** set to Source and the Rp pull up on its CC wire. Policy Engine directs the Protocol Layer to send a ***Get_Manufacturer_Info*** Message with a request for Port information.	The Port has ***Port Power Role*** set to Sink with the Rd pull down on its CC wire.
2	Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.	
3	Physical Layer appends CRC and sends the ***Get_Manufacturer_Info*** Message.	Physical Layer receives the ***Get_Manufacturer_Info*** Message and checks the CRC to verify the Message.
4		Physical Layer removes the CRC and forwards the ***Get_Manufacturer_Info*** Message to the Protocol Layer.

Step	Source Port	Sink Port
5		Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Get_Manufacturer_Info*** Message information to the Policy Engine that consumes it.
6		Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.
7	Physical Layer receives the ***GoodCRC*** Message and checks the CRC to verify the Message.	Physical Layer appends CRC and sends the ***GoodCRC*** Message.
8	Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.	
9	Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Get_Manufacturer_Info*** Message was successfully sent. Policy Engine starts ***SenderResponseTimer***.	
10		Policy Engine requests the DPM for the Port's manufacturer information which is provided. The Policy Engine tells the Protocol Layer to form a ***Manufacturer_Info*** Message.
11		Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.
12	Physical Layer receives the Message and compares the CRC it calculated with the one sent to verify the ***Manufacturer_Info*** Message.	Physical Layer appends a CRC and sends the ***Manufacturer_Info*** Message.
13	Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Manufacturer_Info*** Message information to the Policy Engine that consumes it.	
14	The Policy Engine stops the ***SenderResponseTimer***.	
15	Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.	
16	Physical Layer appends a CRC and sends the ***GoodCRC*** Message.	Physical Layer receives ***GoodCRC*** Message and compares the CRC it calculated with the one sent to verify the Message.
17		Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.
18		Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Manufacturer_Info*** Message was successfully sent.
	The Sink has informed the Source of the manufacturer information for the Port.	

8.3.2.10.6.2 Sink Gets Port Manufacturer Information from a Source

Figure 8-36 shows an example sequence between a Source and a Sink when the Source gets the Sink's Manufacturer information for the Port.

Figure 8-36 Sink Gets Source's Port Manufacturer Information

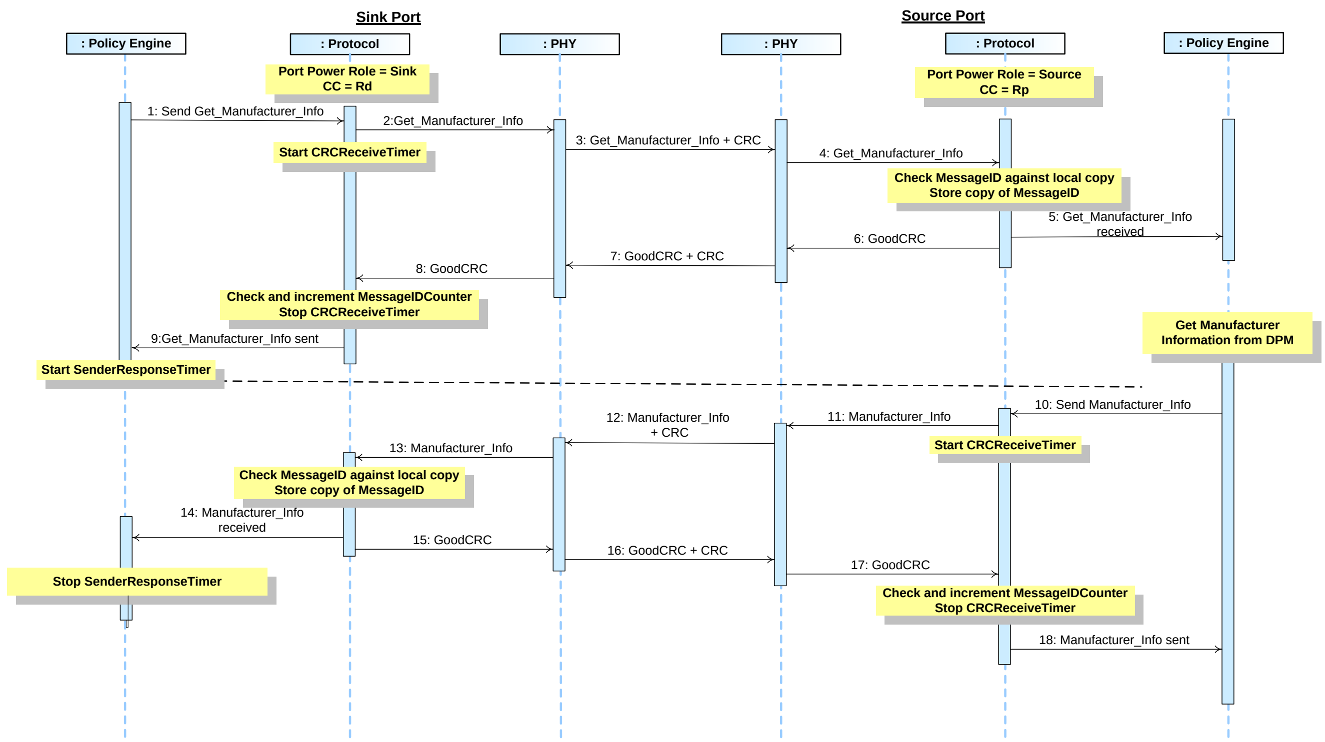


Table 8-36 below provides a detailed explanation of what happens at each labeled step in Figure 8-36 above.

Table 8-36 Steps for a Source getting Sink's Port Manufacturer information Sequence

Step	Sink Port	Source Port
1	The Port has ***Port Power Role*** set to Sink with the Rd pull down on its CC wire. Policy Engine directs the Protocol Layer to send a ***Get_Manufacturer_Info*** Message with a request for Port information.	The Port has ***Port Power Role*** set to Source and the Rp pull up on its CC wire.
2	Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.	
3	Physical Layer appends CRC and sends the ***Get_Manufacturer_Info*** Message.	Physical Layer receives the ***Get_Manufacturer_Info*** Message and checks the CRC to verify the Message.
4		Physical Layer removes the CRC and forwards the ***Get_Manufacturer_Info*** Message to the Protocol Layer.
5		Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Get_Manufacturer_Info*** Message information to the Policy Engine that consumes it.

Step	Sink Port	Source Port
6		Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.
7	Physical Layer receives the ***GoodCRC*** Message and checks the CRC to verify the Message.	Physical Layer appends CRC and sends the ***GoodCRC*** Message.
8	Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.	
9	Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Get_Manufacturer_Info*** Message was successfully sent. Policy Engine starts ***SenderResponseTimer***.	
10		Policy Engine requests the DPM for the Port's manufacturer information which is provided. The Policy Engine tells the Protocol Layer to form a ***Manufacturer_Info*** Message.
11		Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.
12	Physical Layer receives the Message and compares the CRC it calculated with the one sent to verify the ***Manufacturer_Info*** Message.	Physical Layer appends a CRC and sends the ***Manufacturer_Info*** Message.
13	Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Manufacturer_Info*** Message information to the Policy Engine that consumes it.	
14	The Policy Engine stops the ***SenderResponseTimer***.	
15	Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.	
16	Physical Layer appends a CRC and sends the ***GoodCRC*** Message.	Physical Layer receives ***GoodCRC*** Message and compares the CRC it calculated with the one sent to verify the Message.
17		Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.
18		Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Manufacturer_Info*** Message was successfully sent.
	The Sink has informed the Source of the manufacturer information for the Port.	

8.3.2.10.6.3 Source Gets Battery Manufacturer Information from a Sink

Figure 8-37 shows an example sequence between a Source and a Sink when the Source gets the Sink's Manufacturer information for one of its Batteries.

Figure 8-37 Source Gets Sink's Battery Manufacturer Information

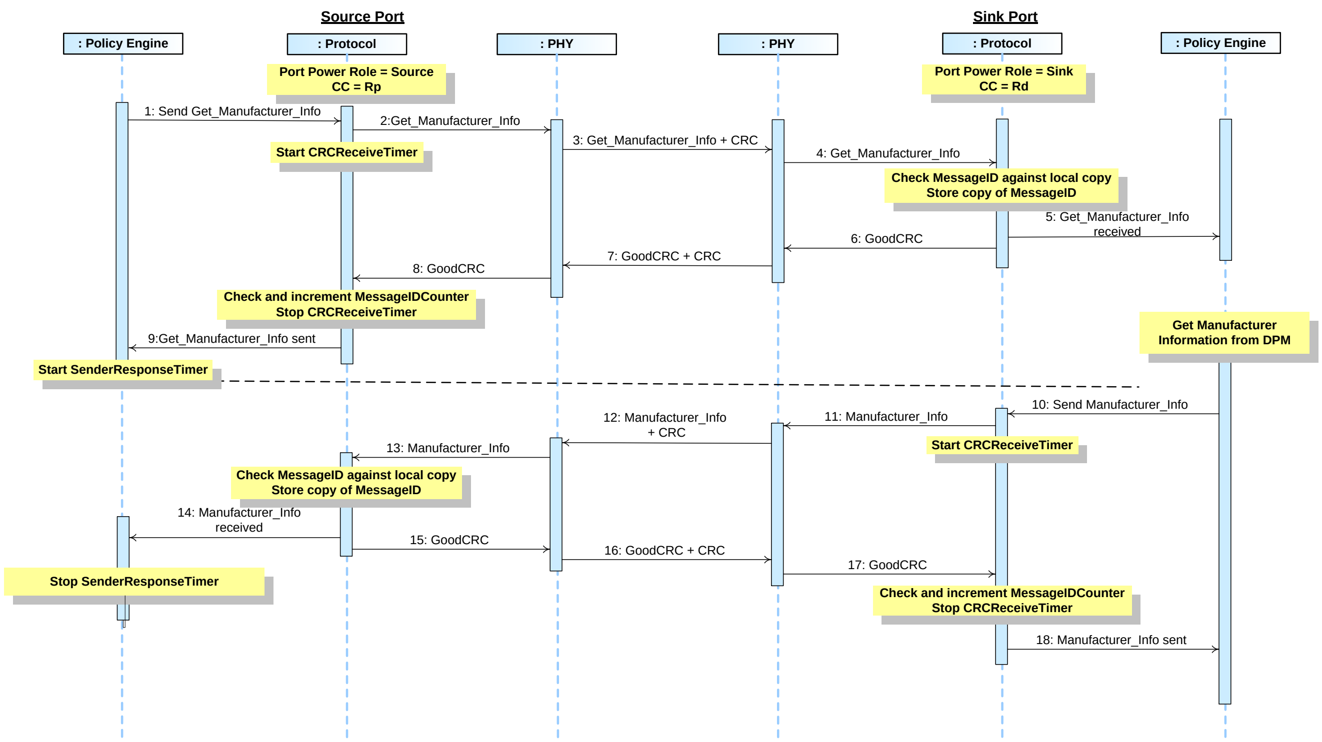


Table 8-37 below provides a detailed explanation of what happens at each labeled step in Figure 8-37 above.

Table 8-37 Steps for a Source getting Sink's Battery Manufacturer information Sequence

Step	Source Port	Sink Port
1	The Port has ***Port Power Role*** set to Source and the Rp pull up on its CC wire. Policy Engine directs the Protocol Layer to send a ***Get_Manufacturer_Info*** Message with a request for Battery information for a given Battery.	The Port has ***Port Power Role*** set to Sink with the Rd pull down on its CC wire.
2	Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.	
3	Physical Layer appends CRC and sends the ***Get_Manufacturer_Info*** Message.	Physical Layer receives the ***Get_Manufacturer_Info*** Message and checks the CRC to verify the Message.
4		Physical Layer removes the CRC and forwards the ***Get_Manufacturer_Info*** Message to the Protocol Layer.
5		Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Get_Manufacturer_Info*** Message information to the Policy Engine that consumes it.

Step	Source Port	Sink Port
6		Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.
7	Physical Layer receives the ***GoodCRC*** Message and checks the CRC to verify the Message.	Physical Layer appends CRC and sends the ***GoodCRC*** Message.
8	Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.	
9	Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Get_Manufacturer_Info*** Message was successfully sent. Policy Engine starts ***SenderResponseTimer***.	
10		Policy Engine requests the DPM for the Battery's manufacturer information for a given Battery which is provided. The Policy Engine tells the Protocol Layer to form a ***Manufacturer_Info*** Message.
11		Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.
12	Physical Layer receives the Message and compares the CRC it calculated with the one sent to verify the ***Manufacturer_Info*** Message.	Physical Layer appends a CRC and sends the ***Manufacturer_Info*** Message.
13	Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Manufacturer_Info*** Message information to the Policy Engine that consumes it.	
14	The Policy Engine stops the ***SenderResponseTimer***.	
15	Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.	
16	Physical Layer appends a CRC and sends the ***GoodCRC*** Message.	Physical Layer receives ***GoodCRC*** Message and compares the CRC it calculated with the one sent to verify the Message.
17		Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.
18		Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Manufacturer_Info*** Message was successfully sent.
	The Sink has informed the Source of the manufacturer information for the requested Battery.	

8.3.2.10.6.4 Sink Gets Battery Manufacturer Information from a Source

Figure 8-38 shows an example sequence between a Source and a Sink when the Source gets the Sink's Manufacturer information for the Port.

Figure 8-38 Sink Gets Source's Battery Manufacturer Information

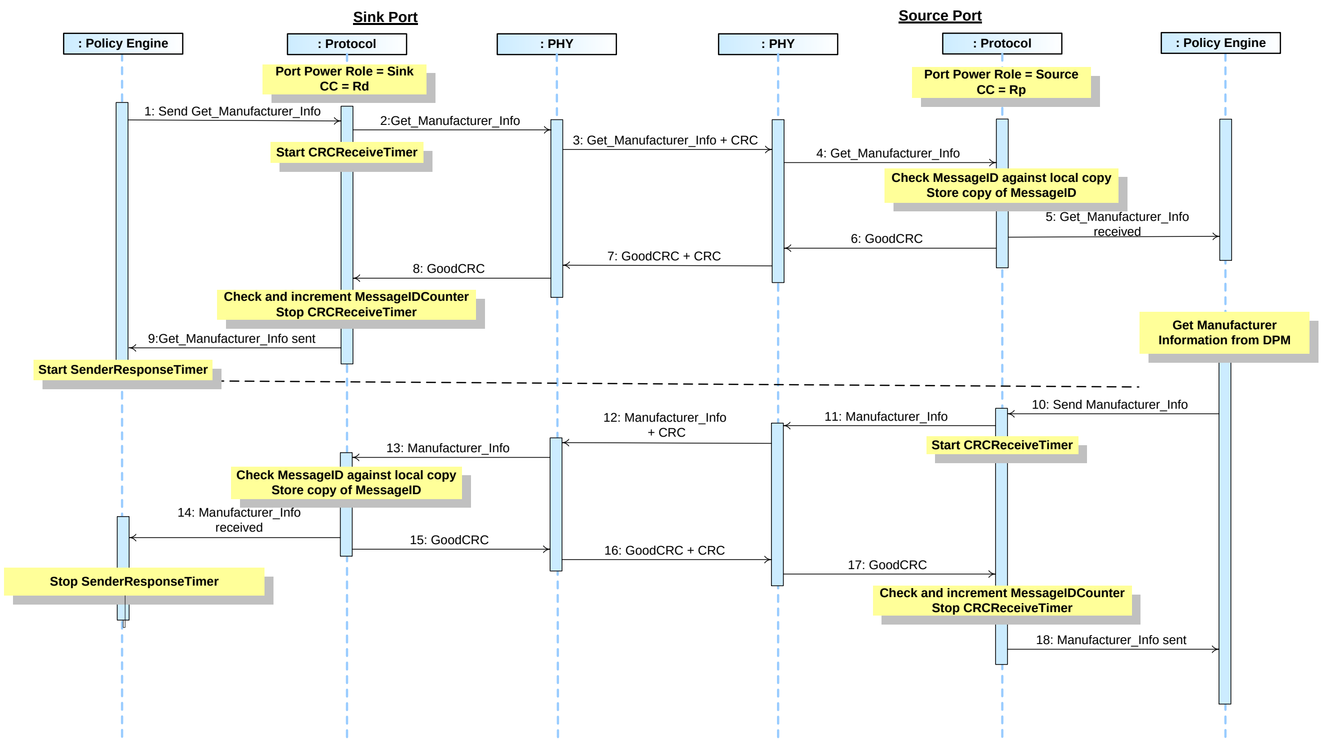


Table 8-38 below provides a detailed explanation of what happens at each labeled step in Figure 8-38 above.

Table 8-38 Steps for a Source getting Sink's Battery Manufacturer information Sequence

Step	Sink Port	Source Port
1	The Port has ***Port Power Role*** set to Sink with the Rd pull down on its CC wire. Policy Engine directs the Protocol Layer to send a ***Get_Manufacturer_Info*** Message with a request for Battery information for a given Battery.	The Port has ***Port Power Role*** set to Source and the Rp pull up on its CC wire.
2	Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.	
3	Physical Layer appends CRC and sends the ***Get_Manufacturer_Info*** Message.	Physical Layer receives the ***Get_Manufacturer_Info*** Message and checks the CRC to verify the Message.
4		Physical Layer removes the CRC and forwards the ***Get_Manufacturer_Info*** Message to the Protocol Layer.
5		Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Get_Manufacturer_Info*** Message information to the Policy Engine that consumes it.

Step	Sink Port	Source Port
6		Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.
7	Physical Layer receives the ***GoodCRC*** Message and checks the CRC to verify the Message.	Physical Layer appends CRC and sends the ***GoodCRC*** Message.
8	Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.	
9	Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Get_Manufacturer_Info*** Message was successfully sent. Policy Engine starts ***SenderResponseTimer***.	
10		Policy Engine requests the DPM for the Battery's manufacturer information for a given Battery which is provided. The Policy Engine tells the Protocol Layer to form a ***Manufacturer_Info*** Message.
11		Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.
12	Physical Layer receives the Message and compares the CRC it calculated with the one sent to verify the ***Manufacturer_Info*** Message.	Physical Layer appends a CRC and sends the ***Manufacturer_Info*** Message.
13	Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Manufacturer_Info*** Message information to the Policy Engine that consumes it.	
14	The Policy Engine stops the ***SenderResponseTimer***.	
15	Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.	
16	Physical Layer appends a CRC and sends the ***GoodCRC*** Message.	Physical Layer receives ***GoodCRC*** Message and compares the CRC it calculated with the one sent to verify the Message.
17		Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.
18		Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Manufacturer_Info*** Message was successfully sent.
	The Sink has informed the Source of the manufacturer information for the requested Battery.	

8.3.2.10.6.5 VCONN Source Gets Manufacturer Information from a Cable Plug

Figure 8-39 shows an example sequence between a VCONN Source (Source or Sink) and a Cable Plug when the VCONN Source gets the Cable Plug's Manufacturer information.

Figure 8-39 VCONN Source Gets Cable Plug's Manufacturer Information

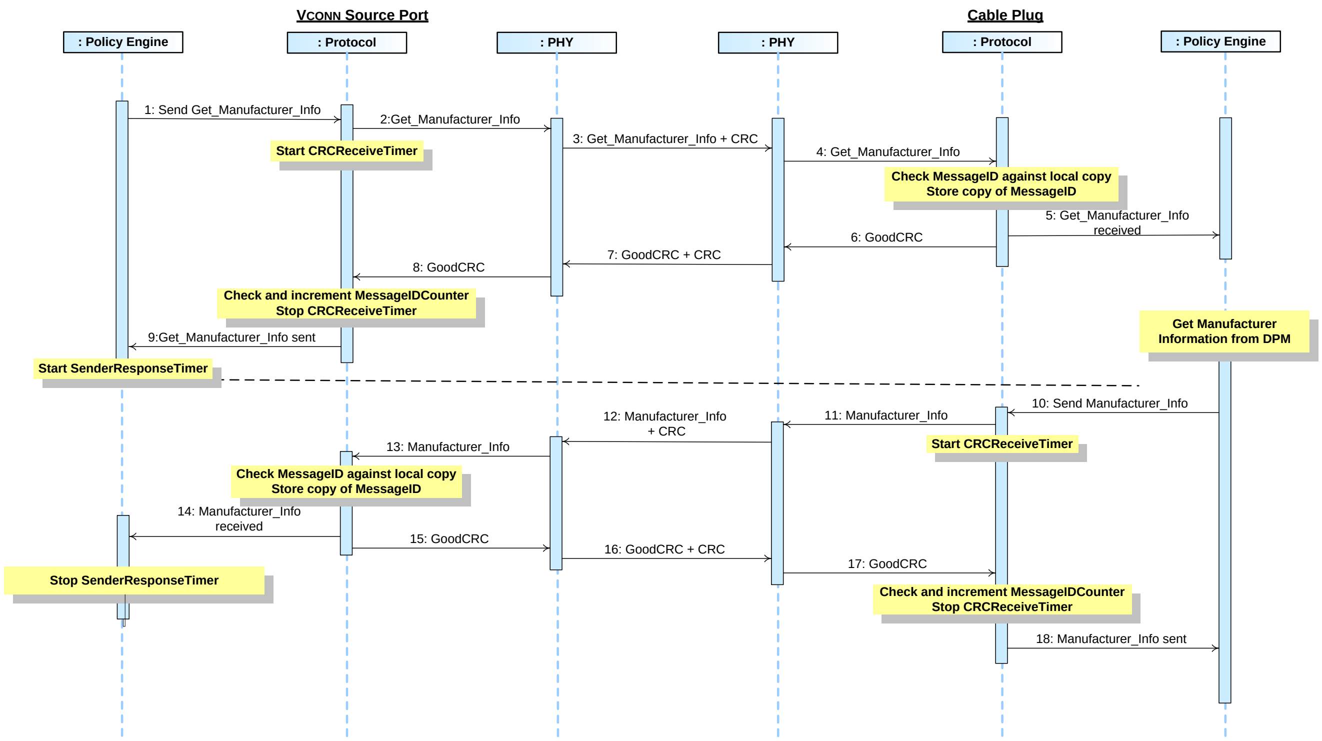


Table 8-39 below provides a detailed explanation of what happens at each labeled step in Figure 8-39 above.

Table 8-39 Steps for a VCONN Source getting Sink's Port Manufacturer information Sequence

Step	VCONN Source	Cable Plug
1	The Port is currently acting as the VCONN Source. Policy Engine directs the Protocol Layer to send a ***Get_Manufacturer_Info*** Message with a request for Port information.	
2	Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.	
3	Physical Layer appends CRC and sends the ***Get_Manufacturer_Info*** Message.	Physical Layer receives the ***Get_Manufacturer_Info*** Message and checks the CRC to verify the Message.
4		Physical Layer removes the CRC and forwards the ***Get_Manufacturer_Info*** Message to the Protocol Layer.
5		Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Get_Manufacturer_Info*** Message information to the Policy Engine that consumes it.

Step	VCONN Source	Cable Plug
6		Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.
7	Physical Layer receives the ***GoodCRC*** Message and checks the CRC to verify the Message.	Physical Layer appends CRC and sends the ***GoodCRC*** Message.
8	Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.	
9	Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Get_Manufacturer_Info*** Message was successfully sent. Policy Engine starts ***SenderResponseTimer***.	
10		Policy Engine requests the DPM for the Cable Plug's manufacturer information which is provided. The Policy Engine tells the Protocol Layer to form a ***Manufacturer_Info*** Message.
11		Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.
12	Physical Layer receives the Message and compares the CRC it calculated with the one sent to verify the ***Manufacturer_Info*** Message.	Physical Layer appends a CRC and sends the ***Manufacturer_Info*** Message.
13	Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Manufacturer_Info*** Message information to the Policy Engine that consumes it.	
14	The Policy Engine stops the ***SenderResponseTimer***.	
15	Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.	
16	Physical Layer appends a CRC and sends the ***GoodCRC*** Message.	Physical Layer receives ***GoodCRC*** Message and compares the CRC it calculated with the one sent to verify the Message.
17		Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.
18		Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Manufacturer_Info*** Message was successfully sent.
	The Cable Plug has informed the Source of its manufacturer information.	

8.3.2.10.7 Country Codes

8.3.2.10.7.1 Source Gets Country Codes from a Sink

Figure 8-40 shows an example sequence between a Source and a Sink when the Source gets the Sink's Country Codes.

Figure 8-40 Source Gets Sink's Country Codes

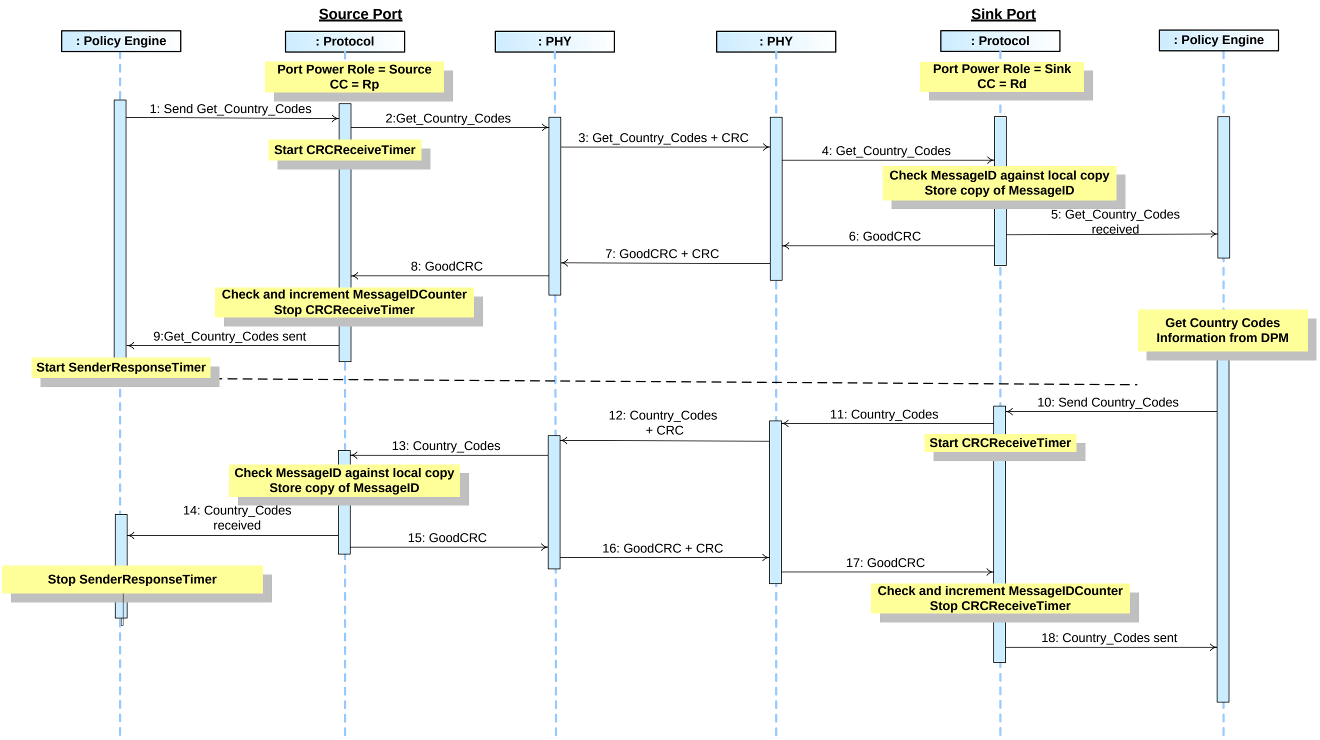


Table 8-40 below provides a detailed explanation of what happens at each labeled step in Figure 8-40 above.

Table 8-40 Steps for a Source getting Country Codes Sequence

Step	Source Port	Sink Port
1	The Port has ***Port Power Role*** set to Source and the Rp pull up on its CC wire. Policy Engine directs the Protocol Layer to send a ***Get_Country_Codes*** Message with a request for Port information.	The Port has ***Port Power Role*** set to Sink with the Rd pull down on its CC wire.
2	Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.	
3	Physical Layer appends CRC and sends the ***Get_Country_Codes*** Message.	Physical Layer receives the ***Get_Country_Codes*** Message and checks the CRC to verify the Message.
4		Physical Layer removes the CRC and forwards the ***Get_Country_Codes*** Message to the Protocol Layer.
5		Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Get_Country_Codes*** Message information to the Policy Engine that consumes it.

Step	Source Port	Sink Port
6		Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.
7	Physical Layer receives the ***GoodCRC*** Message and checks the CRC to verify the Message.	Physical Layer appends CRC and sends the ***GoodCRC*** Message.
8	Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.	
9	Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Get_Country_Codes*** Message was successfully sent. Policy Engine starts ***SenderResponseTimer***.	
10		Policy Engine requests the DPM for the Port's manufacturer information which is provided. The Policy Engine tells the Protocol Layer to form a ***Country_Codes*** Message.
11		Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.
12	Physical Layer receives the Message and compares the CRC it calculated with the one sent to verify the ***Country_Codes*** Message.	Physical Layer appends a CRC and sends the ***Country_Codes*** Message.
13	Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Country_Codes*** Message information to the Policy Engine that consumes it.	
14	The Policy Engine stops the ***SenderResponseTimer***.	
15	Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.	
16	Physical Layer appends a CRC and sends the ***GoodCRC*** Message.	Physical Layer receives ***GoodCRC*** Message and compares the CRC it calculated with the one sent to verify the Message.
17		Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.
18		Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Country_Codes*** Message was successfully sent.
	The Sink has informed the Source of the country codes.	

8.3.2.10.7.2 Sink Gets Country Codes from a Source

Figure 8-41 shows an example sequence between a Source and a Sink when the Source gets the Sink's country codes.

Figure 8-41 Sink Gets Source's Country Codes

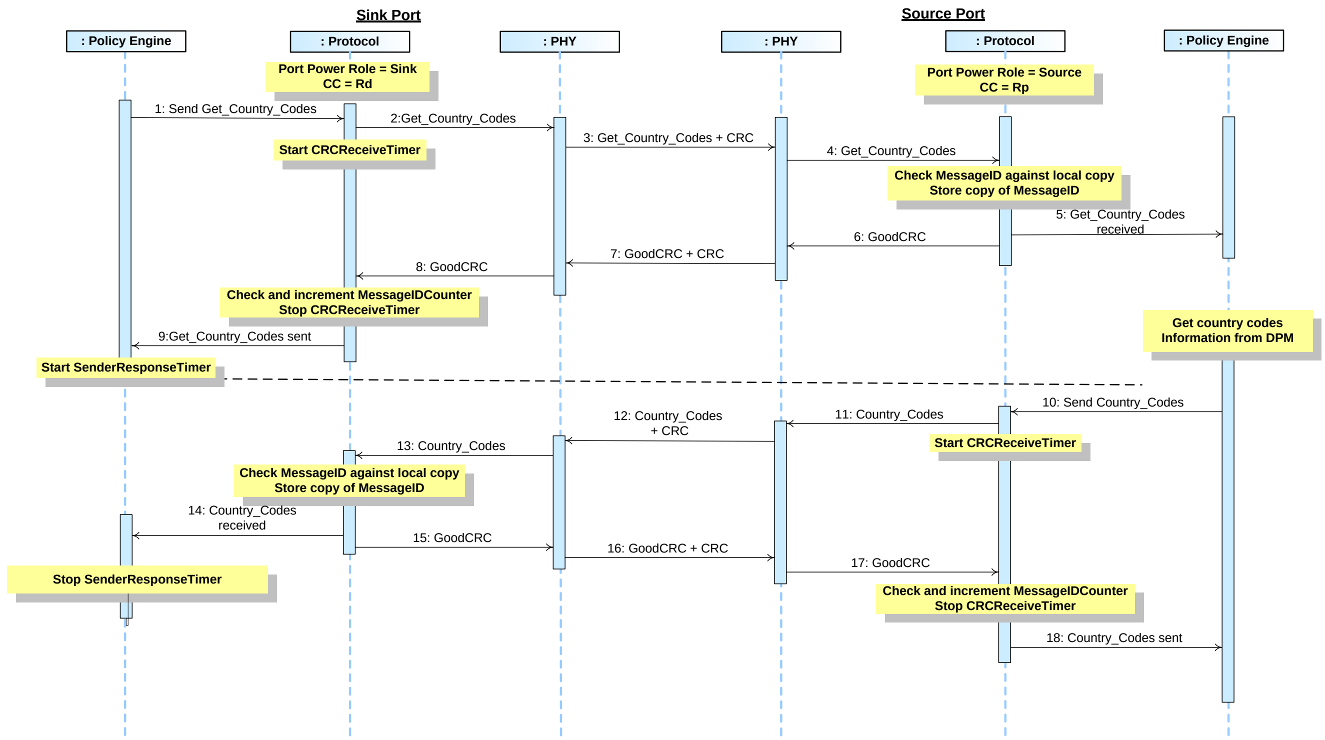


Table 8-41 below provides a detailed explanation of what happens at each labeled step in Figure 8-41 above.

Table 8-41 Steps for a Source getting Sink's Country Codes Sequence

Step	Sink Port	Source Port
1	The Port has ***Port Power Role*** set to Sink with the Rd pull down on its CC wire. Policy Engine directs the Protocol Layer to send a ***Get_Country_Codes*** Message with a request for Port information.	The Port has ***Port Power Role*** set to Source and the Rp pull up on its CC wire.
2	Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.	
3	Physical Layer appends CRC and sends the ***Get_Country_Codes*** Message.	Physical Layer receives the ***Get_Country_Codes*** Message and checks the CRC to verify the Message.
4		Physical Layer removes the CRC and forwards the ***Get_Country_Codes*** Message to the Protocol Layer.
5		Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Get_Country_Codes*** Message information to the Policy Engine that consumes it.
6		Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.

Step	Sink Port	Source Port
7	Physical Layer receives the ***GoodCRC*** Message and checks the CRC to verify the Message.	Physical Layer appends CRC and sends the ***GoodCRC*** Message.
8	Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.	
9	Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Get_Country_Codes*** Message was successfully sent. Policy Engine starts ***SenderResponseTimer***.	
10		Policy Engine requests the DPM for the Port's manufacturer information which is provided. The Policy Engine tells the Protocol Layer to form a ***Country_Codes*** Message.
11		Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.
12	Physical Layer receives the Message and compares the CRC it calculated with the one sent to verify the ***Country_Codes*** Message.	Physical Layer appends a CRC and sends the ***Country_Codes*** Message.
13	Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Country_Codes*** Message information to the Policy Engine that consumes it.	
14	The Policy Engine stops the ***SenderResponseTimer***.	
15	Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.	
16	Physical Layer appends a CRC and sends the ***GoodCRC*** Message.	Physical Layer receives ***GoodCRC*** Message and compares the CRC it calculated with the one sent to verify the Message.
17		Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.
18		Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Country_Codes*** Message was successfully sent.
	The Sink has informed the Source of the country codes.	

8.3.2.10.7.3 VCONN Source Gets Country Codes from a Cable Plug

Figure 8-42 shows an example sequence between a VCONN Source (Source or Sink) and a Cable Plug when the VCONN Source gets the Cable Plug's Country Codes.

Figure 8-42 VCONN Source Gets Cable Plug's Country Codes

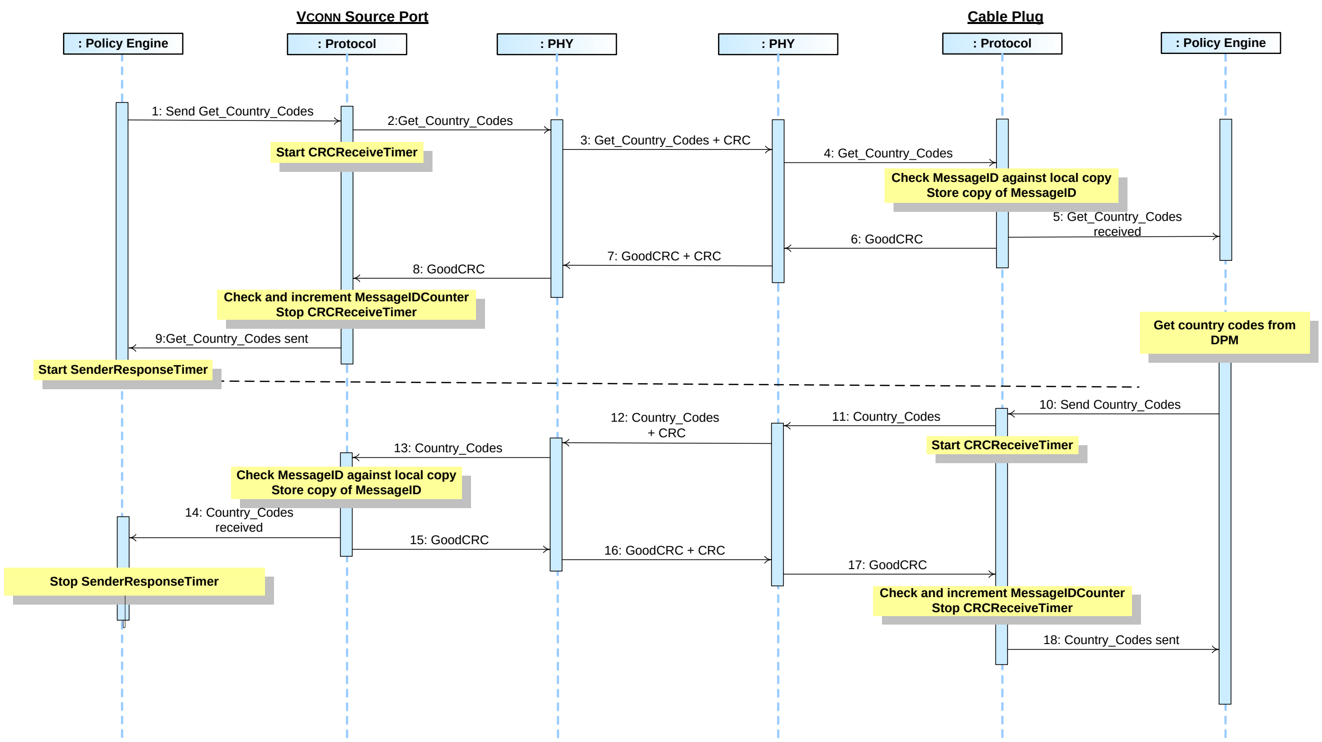


Table 8-42 below provides a detailed explanation of what happens at each labeled step in Figure 8-42 above.

Table 8-42 Steps for a VCONN Source getting Sink's Country Codes Sequence

Step	VCONN Source	Cable Plug
1	The Port is currently acting as the VCONN Source. Policy Engine directs the Protocol Layer to send a ***Get_Country_Codes*** Message with a request for Port information.	
2	Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.	
3	Physical Layer appends CRC and sends the ***Get_Country_Codes*** Message.	Physical Layer receives the ***Get_Country_Codes*** Message and checks the CRC to verify the Message.
4		Physical Layer removes the CRC and forwards the ***Get_Country_Codes*** Message to the Protocol Layer.
5		Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Get_Country_Codes*** Message information to the Policy Engine that consumes it.
6		Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.

Step	VCONN Source	Cable Plug
7	Physical Layer receives the ***GoodCRC*** Message and checks the CRC to verify the Message.	Physical Layer appends CRC and sends the ***GoodCRC*** Message.
8	Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.	
9	Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Get_Country_Codes*** Message was successfully sent. Policy Engine starts ***SenderResponseTimer***.	
10		Policy Engine requests the DPM for the Cable Plug's manufacturer information which is provided. The Policy Engine tells the Protocol Layer to form a ***Country_Codes*** Message.
11		Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.
12	Physical Layer receives the Message and compares the CRC it calculated with the one sent to verify the ***Country_Codes*** Message.	Physical Layer appends a CRC and sends the ***Country_Codes*** Message.
13	Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Country_Codes*** Message information to the Policy Engine that consumes it.	
14	The Policy Engine stops the ***SenderResponseTimer***.	
15	Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.	
16	Physical Layer appends a CRC and sends the ***GoodCRC*** Message.	Physical Layer receives ***GoodCRC*** Message and compares the CRC it calculated with the one sent to verify the Message.
17		Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.
18		Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Country_Codes*** Message was successfully sent.
	The Cable Plug has informed the Source of its country codes.	

8.3.2.10.8 Country Information

8.3.2.10.8.1 Source Gets Country Information from a Sink

Figure 8-43 shows an example sequence between a Source and a Sink when the Source gets the Sink's country information.

Figure 8-43 Source Gets Sink's Country Information

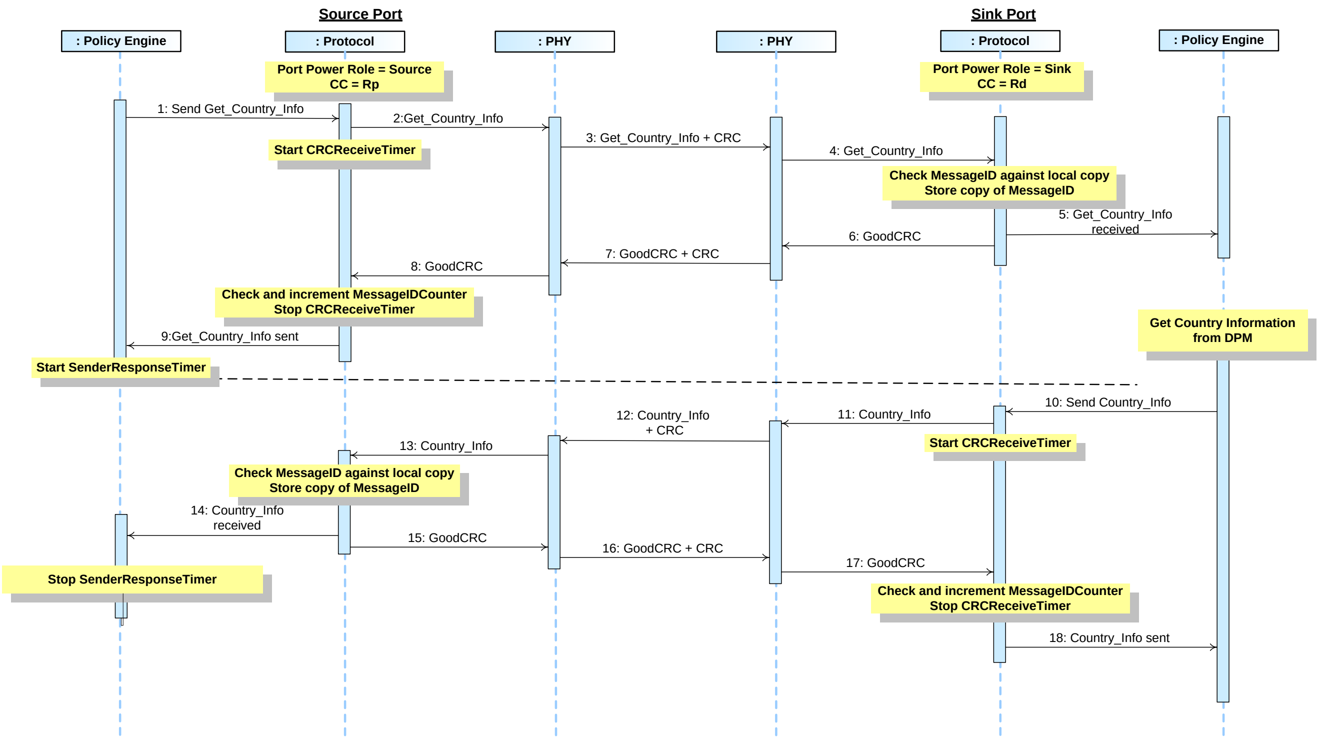


Table 8-43 below provides a detailed explanation of what happens at each labeled step in Figure 8-43 above.

Table 8-43 Steps for a Source getting Country Information Sequence

Step	Source Port	Sink Port
1	The Port has ***Port Power Role*** set to Source and the Rp pull up on its CC wire. Policy Engine directs the Protocol Layer to send a ***Get_Country_Info*** Message with a request for Port information for a specific Country Code.	The Port has ***Port Power Role*** set to Sink with the Rd pull down on its CC wire.
2	Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.	
3	Physical Layer appends CRC and sends the ***Get_Country_Info*** Message.	Physical Layer receives the ***Get_Country_Info*** Message and checks the CRC to verify the Message.
4		Physical Layer removes the CRC and forwards the ***Get_Country_Info*** Message to the Protocol Layer.

Step	Source Port	Sink Port
5		Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Get_Country_Info*** Message information to the Policy Engine that consumes it.
6		Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.
7	Physical Layer receives the ***GoodCRC*** Message and checks the CRC to verify the Message.	Physical Layer appends CRC and sends the ***GoodCRC*** Message.
8	Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.	
9	Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Get_Country_Info*** Message was successfully sent. Policy Engine starts ***SenderResponseTimer***.	
10		Policy Engine requests the DPM for the Port's manufacturer information which is provided. The Policy Engine tells the Protocol Layer to form a ***Country_Info*** Message.
11		Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.
12	Physical Layer receives the Message and compares the CRC it calculated with the one sent to verify the ***Country_Info*** Message.	Physical Layer appends a CRC and sends the ***Country_Info*** Message.
13	Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Country_Info*** Message information to the Policy Engine that consumes it.	
14	The Policy Engine stops the ***SenderResponseTimer***.	
15	Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.	
16	Physical Layer appends a CRC and sends the ***GoodCRC*** Message.	Physical Layer receives ***GoodCRC*** Message and compares the CRC it calculated with the one sent to verify the Message.
17		Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.
18		Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Country_Info*** Message was successfully sent.
	The Sink has informed the Source of the country information.	

8.3.2.10.8.2 Sink Gets Country Information from a Source

Figure 8-44 shows an example sequence between a Source and a Sink when the Source gets the Sink's country codes.

Figure 8-44 Sink Gets Source's Country Information

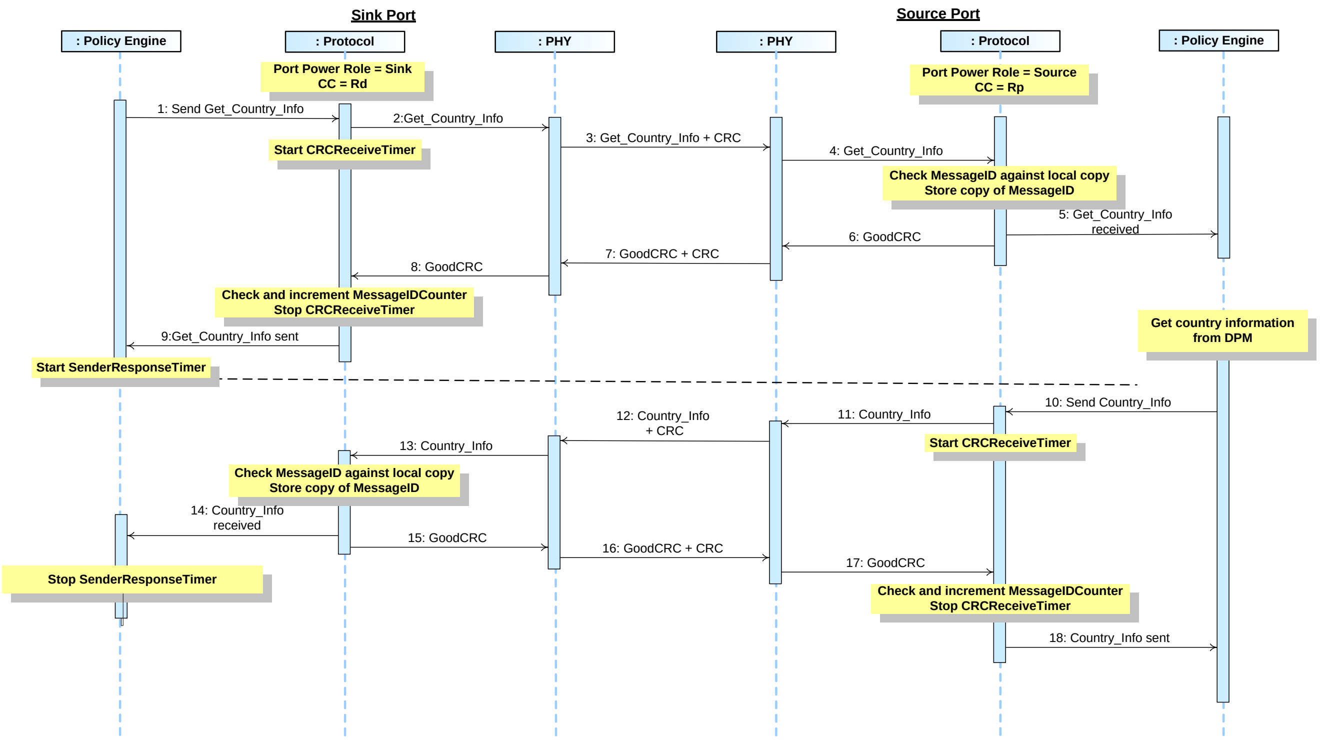


Table 8-44 below provides a detailed explanation of what happens at each labeled step in Figure 8-44 above.

Table 8-44 Steps for a Source getting Sink's Country Information Sequence

Step	Sink Port	Source Port
1	The Port has ***Port Power Role*** set to Sink with the Rd pull down on its CC wire. Policy Engine directs the Protocol Layer to send a ***Get_Country_Info*** Message with a request for Port information for a specific country code.	The Port has ***Port Power Role*** set to Source and the Rp pull up on its CC wire.
2	Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.	
3	Physical Layer appends CRC and sends the ***Get_Country_Info*** Message.	Physical Layer receives the ***Get_Country_Info*** Message and checks the CRC to verify the Message.
4		Physical Layer removes the CRC and forwards the ***Get_Country_Info*** Message to the Protocol Layer.
5		Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Get_Country_Info*** Message information to the Policy Engine that consumes it.
6		Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.

Step	Sink Port	Source Port
7	Physical Layer receives the ***GoodCRC*** Message and checks the CRC to verify the Message.	Physical Layer appends CRC and sends the ***GoodCRC*** Message.
8	Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.	
9	Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Get_Country_Info*** Message was successfully sent. Policy Engine starts ***SenderResponseTimer***.	
10		Policy Engine requests the DPM for the Port's manufacturer information which is provided. The Policy Engine tells the Protocol Layer to form a ***Country_Info*** Message.
11		Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.
12	Physical Layer receives the Message and compares the CRC it calculated with the one sent to verify the ***Country_Info*** Message.	Physical Layer appends a CRC and sends the ***Country_Info*** Message.
13	Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Country_Info*** Message information to the Policy Engine that consumes it.	
14	The Policy Engine stops the ***SenderResponseTimer***.	
15	Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.	
16	Physical Layer appends a CRC and sends the ***GoodCRC*** Message.	Physical Layer receives ***GoodCRC*** Message and compares the CRC it calculated with the one sent to verify the Message.
17		Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.
18		Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Country_Info*** Message was successfully sent.
	The Sink has informed the Source of the country information.	

8.3.2.10.8.1 VCONN Source Gets Country Information from a Cable Plug

Figure 8-45 shows an example sequence between a VCONN Source (Source or Sink) and a Cable Plug when the VCONN Source gets the Cable Plug's country information.

Figure 8-45 VCONN Source Gets Cable Plug's Country Information

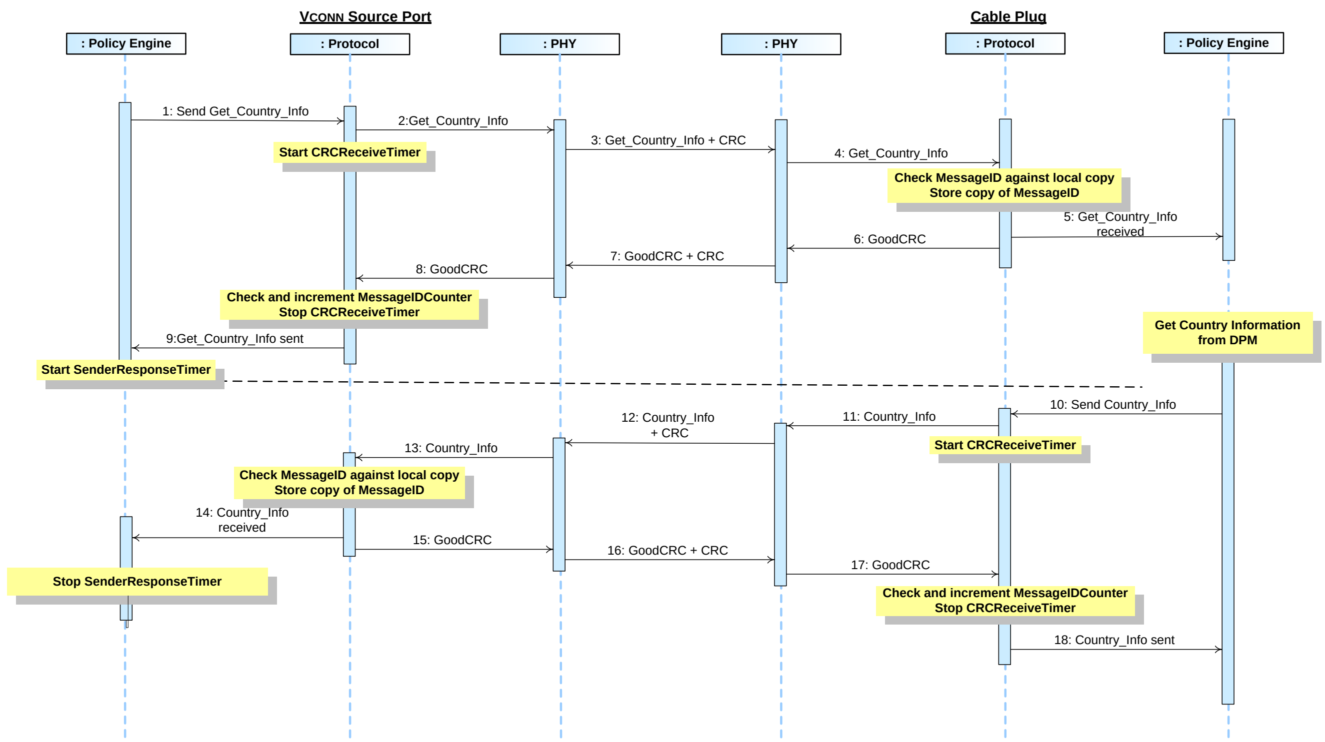


Table 8-45 below provides a detailed explanation of what happens at each labeled step in Figure 8-45 above.

Table 8-45 Steps for a VCONN Source getting Sink's Country Information Sequence

Step	VCONN Source	Cable Plug
1	The Port is currently acting as the VCONN Source. Policy Engine directs the Protocol Layer to send a ***Get_Country_Info*** Message with a request for Port information for a specific country code.	
2	Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.	
3	Physical Layer appends CRC and sends the ***Get_Country_Info*** Message.	Physical Layer receives the ***Get_Country_Info*** Message and checks the CRC to verify the Message.
4		Physical Layer removes the CRC and forwards the ***Get_Country_Info*** Message to the Protocol Layer.
5		Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Get_Country_Info*** Message information to the Policy Engine that consumes it.
6		Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.

Step	VCONN Source	Cable Plug
7	Physical Layer receives the ***GoodCRC*** Message and checks the CRC to verify the Message.	Physical Layer appends CRC and sends the ***GoodCRC*** Message.
8	Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.	
9	Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Get_Country_Info*** Message was successfully sent. Policy Engine starts ***SenderResponseTimer***.	
10		Policy Engine requests the DPM for the Cable Plug's manufacturer information which is provided. The Policy Engine tells the Protocol Layer to form a ***Country_Info*** Message.
11		Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.
12	Physical Layer receives the Message and compares the CRC it calculated with the one sent to verify the ***Country_Info*** Message.	Physical Layer appends a CRC and sends the ***Country_Info*** Message.
13	Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Country_Info*** Message information to the Policy Engine that consumes it.	
14	The Policy Engine stops the ***SenderResponseTimer***.	
15	Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.	
16	Physical Layer appends a CRC and sends the ***GoodCRC*** Message.	Physical Layer receives ***GoodCRC*** Message and compares the CRC it calculated with the one sent to verify the Message.
17		Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.
18		Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Country_Info*** Message was successfully sent.
	The Cable Plug has informed the Source of its country information.	

8.3.2.11 Security

8.3.2.11.1 Source requests security exchange with Sink

Figure 8-46 shows an example sequence for a security exchange between a Source and a Sink.

Figure 8-46 Source requests security exchange with Sink

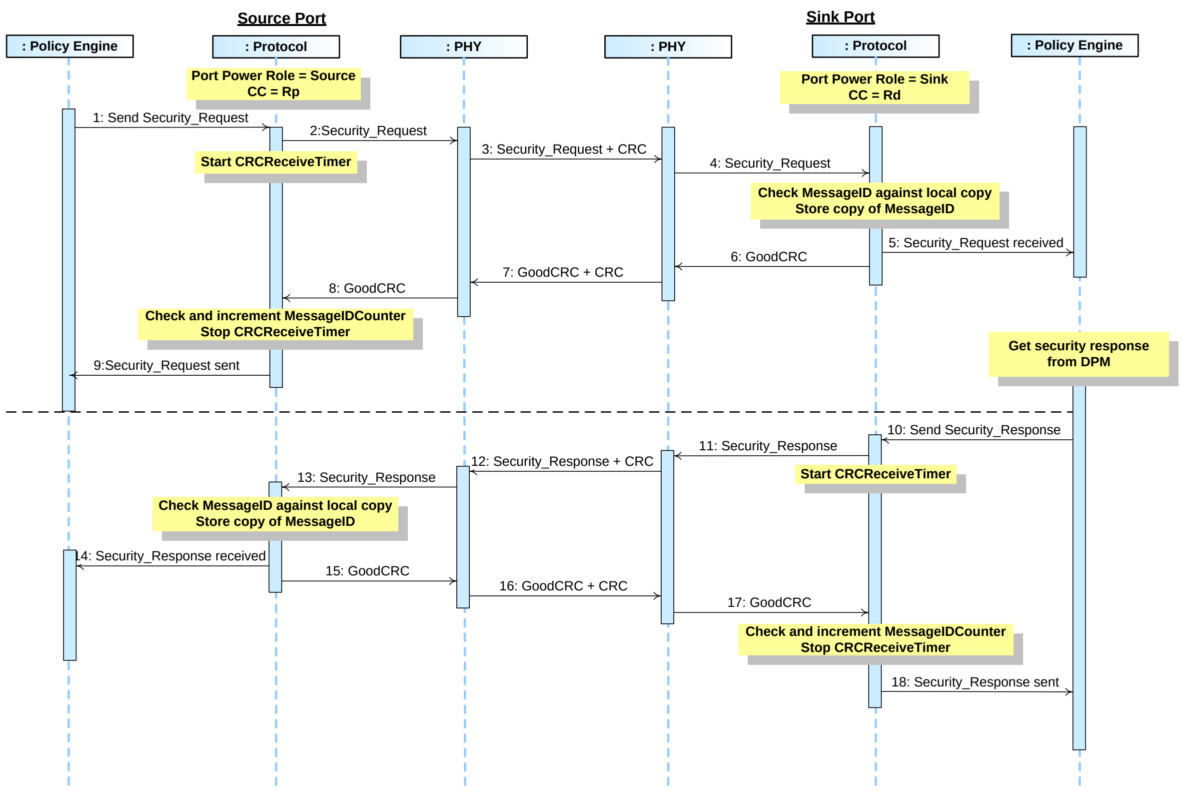


Table 8-46 below provides a detailed explanation of what happens at each labeled step in Figure 8-46 above.

Table 8-46 Steps for a Source requesting a security exchange with a Sink Sequence

Step	Source Port	Sink Port
1	The Port has ***Port Power Role*** set to Source and the Rp pull up on its CC wire. Policy Engine directs the Protocol Layer to send a ***Security_Request*** Message using a payload supplied by the DPM.	The Port has ***Port Power Role*** set to Sink with the Rd pull down on its CC wire.
2	Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.	
3	Physical Layer appends CRC and sends the ***Security_Request*** Message.	Physical Layer receives the ***Security_Request*** Message and checks the CRC to verify the Message.
4		Physical Layer removes the CRC and forwards the ***Security_Request*** Message to the Protocol Layer.

Step	Source Port	Sink Port
5		Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Security_Request*** Message information to the Policy Engine that consumes it.
6		Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.
7	Physical Layer receives the ***GoodCRC*** Message and checks the CRC to verify the Message.	Physical Layer appends CRC and sends the ***GoodCRC*** Message.
8	Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.	
9	Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Security_Request*** Message was successfully sent.	
10		Policy Engine requests the DPM for the response to the security request which is provided. The Policy Engine tells the Protocol Layer to form a ***Security_Response*** Message.
11		Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.
12	Physical Layer receives the Message and compares the CRC it calculated with the one sent to verify the ***Security_Response*** Message.	Physical Layer appends a CRC and sends the ***Security_Response*** Message.
13	Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Security_Response*** Message information to the Policy Engine that consumes it.	
14	Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.	
15	Physical Layer appends a CRC and sends the ***GoodCRC*** Message.	Physical Layer receives ***GoodCRC*** Message and compares the CRC it calculated with the one sent to verify the Message.
16		Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.
17		Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Security_Response*** Message was successfully sent.
	The security exchange is complete.	

8.3.2.11.2 Sink requests security exchange with Source

Figure 8-47 shows an example sequence for a security exchange between a Sink and a Source.

Figure 8-47 Sink requests security exchange with Source

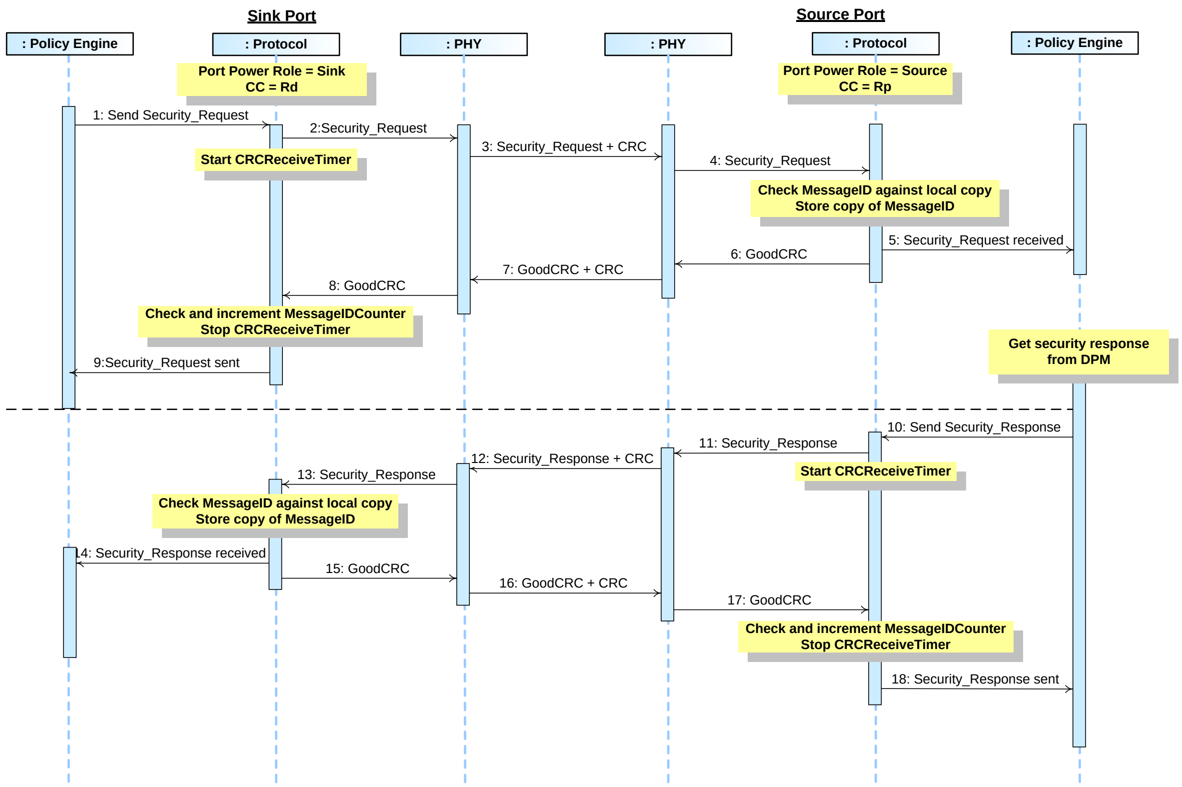


Table 8-47 below provides a detailed explanation of what happens at each labeled step in Figure 8-47 above.

Table 8-47 Steps for a Sink requesting a security exchange with a Source Sequence

Step	Sink Port	Source Port
1	The Port has ***Port Power Role*** set to Sink with the Rd pull down on its CC wire. Policy Engine directs the Protocol Layer to send a ***Security_Request*** Message using a payload supplied by the DPM.	The Port has ***Port Power Role*** set to Source and the Rp pull up on its CC wire.
2	Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.	
3	Physical Layer appends CRC and sends the ***Security_Request*** Message.	Physical Layer receives the ***Security_Request*** Message and checks the CRC to verify the Message.
4		Physical Layer removes the CRC and forwards the ***Security_Request*** Message to the Protocol Layer.
5		Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Security_Request*** Message information to the Policy Engine that consumes it.

Step	Sink Port	Source Port
6		Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.
7	Physical Layer receives the ***GoodCRC*** Message and checks the CRC to verify the Message.	Physical Layer appends CRC and sends the ***GoodCRC*** Message.
8	Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.	
9	Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Security_Request*** Message was successfully sent.	
10		Policy Engine requests the DPM for the response to the security request which is provided. The Policy Engine tells the Protocol Layer to form a ***Security_Response*** Message.
11		Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.
12	Physical Layer receives the Message and compares the CRC it calculated with the one sent to verify the ***Security_Response*** Message.	Physical Layer appends a CRC and sends the ***Security_Response*** Message.
13	Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Security_Response*** Message information to the Policy Engine that consumes it.	
14	Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.	
15	Physical Layer appends a CRC and sends the ***GoodCRC*** Message.	Physical Layer receives ***GoodCRC*** Message and compares the CRC it calculated with the one sent to verify the Message.
16		Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.
17		Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Security_Response*** Message was successfully sent.
	The security exchange is complete.	

8.3.2.11.3 Vconn Source requests security exchange with Cable Plug

Figure 8-48 shows an example sequence for a security exchange between a Vconn Source and a Cable Plug.

Figure 8-48 Vconn Source requests security exchange with Cable Plug

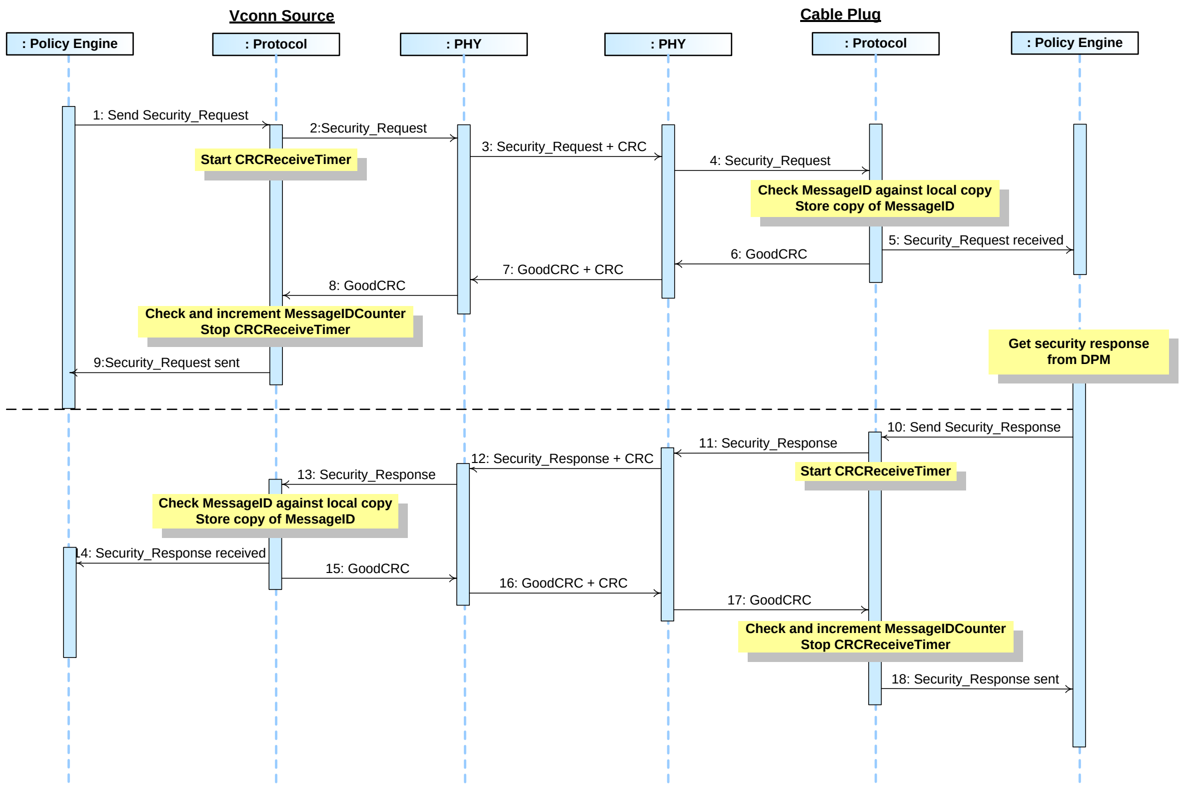


Table 8-48 below provides a detailed explanation of what happens at each labeled step in Figure 8-48 above.

Table 8-48 Steps for a Vconn Source requesting a security exchange with a Cable Plug Sequence

Step	Vconn Source	Cable Plug
1	Policy Engine directs the Protocol Layer to send a ***Security_Request*** Message using a payload supplied by the DPM.	
2	Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.	
3	Physical Layer appends CRC and sends the ***Security_Request*** Message.	Physical Layer receives the ***Security_Request*** Message and checks the CRC to verify the Message.
4		Physical Layer removes the CRC and forwards the ***Security_Request*** Message to the Protocol Layer.
5		Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Security_Request*** Message information to the Policy Engine that consumes it.
6		Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.

Step	Vconn Source	Cable Plug
7	Physical Layer receives the ***GoodCRC*** Message and checks the CRC to verify the Message.	Physical Layer appends CRC and sends the ***GoodCRC*** Message.
8	Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.	
9	Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Security_Request*** Message was successfully sent.	
10		Policy Engine requests the DPM for the response to the security request which is provided. The Policy Engine tells the Protocol Layer to form a ***Security_Response*** Message.
11		Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.
12	Physical Layer receives the Message and compares the CRC it calculated with the one sent to verify the ***Security_Response*** Message.	Physical Layer appends a CRC and sends the ***Security_Response*** Message.
13	Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Security_Response*** Message information to the Policy Engine that consumes it.	
14	Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.	
15	Physical Layer appends a CRC and sends the ***GoodCRC*** Message.	Physical Layer receives ***GoodCRC*** Message and compares the CRC it calculated with the one sent to verify the Message.
16		Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.
17		Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Security_Response*** Message was successfully sent.
	The security exchange is complete.	

8.3.2.12 Firmware Update

8.3.2.12.1 Source requests firmware update exchange with Sink

Figure 8-49 shows an example sequence for a firmware update exchange between a Source and a Sink.

Figure 8-49 Source requests firmware update exchange with Sink

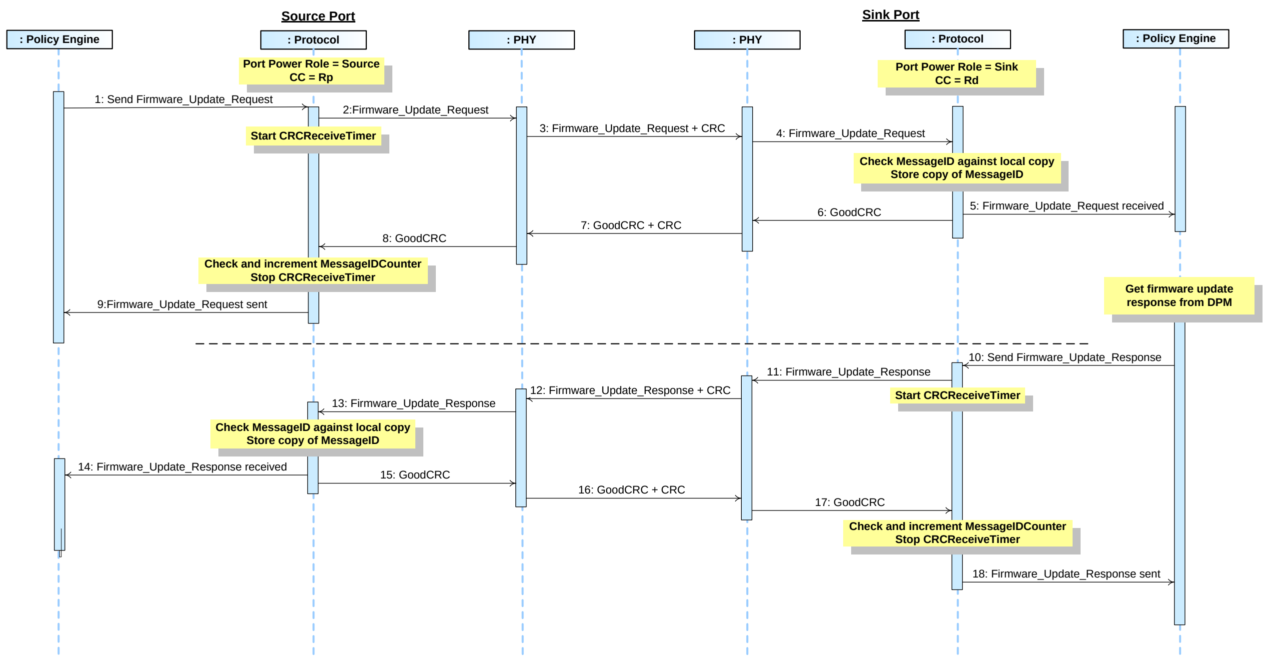


Table 8-49 below provides a detailed explanation of what happens at each labeled step in Figure 8-49 above.

Table 8-49 Steps for a Source requesting a firmware update exchange with a Sink Sequence

Step	Source Port	Sink Port
1	The Port has ***Port Power Role*** set to Source and the Rp pull up on its CC wire. Policy Engine directs the Protocol Layer to send a ***Firmware_Update_Request*** Message using a payload supplied by the DPM.	The Port has ***Port Power Role*** set to Sink with the Rd pull down on its CC wire.
2	Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.	
3	Physical Layer appends CRC and sends the ***Firmware_Update_Request*** Message.	Physical Layer receives the ***Firmware_Update_Request*** Message and checks the CRC to verify the Message.
4		Physical Layer removes the CRC and forwards the ***Firmware_Update_Request*** Message to the Protocol Layer.
5		Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Firmware_Update_Request*** Message information to the Policy Engine that consumes it.

Step	Source Port	Sink Port
6		Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.
7	Physical Layer receives the ***GoodCRC*** Message and checks the CRC to verify the Message.	Physical Layer appends CRC and sends the ***GoodCRC*** Message.
8	Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.	
9	Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Firmware_Update_Request*** Message was successfully sent.	
10		Policy Engine requests the DPM for the response to the firmware update request which is provided. The Policy Engine tells the Protocol Layer to form a ***Firmware_Update_Response*** Message.
11		Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.
12	Physical Layer receives the Message and compares the CRC it calculated with the one sent to verify the ***Firmware_Update_Response*** Message.	Physical Layer appends a CRC and sends the ***Firmware_Update_Response*** Message.
13	Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Firmware_Update_Response*** Message information to the Policy Engine that consumes it.	
14	Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.	
15	Physical Layer appends a CRC and sends the ***GoodCRC*** Message.	Physical Layer receives ***GoodCRC*** Message and compares the CRC it calculated with the one sent to verify the Message.
16		Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.
17		Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Firmware_Update_Response*** Message was successfully sent.
	The firmware update exchange is complete.	

8.3.2.12.2 Sink requests firmware update exchange with Source

Figure 8-50 shows an example sequence for a firmware update exchange between a Sink and a Source.

Figure 8-50 Sink requests firmware update exchange with Source

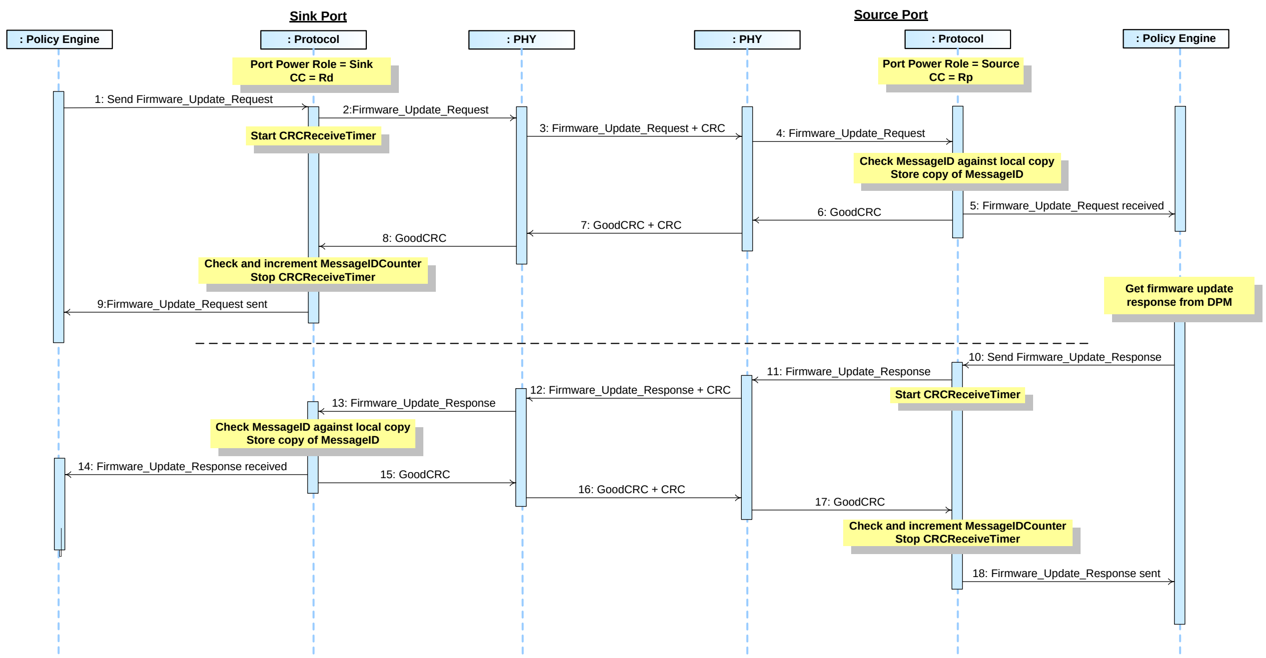


Table 8-50 below provides a detailed explanation of what happens at each labeled step in Figure 8-50 above.

Table 8-50 Steps for a Sink requesting a firmware update exchange with a Source Sequence

Step	Sink Port	Source Port
1	The Port has ***Port Power Role*** set to Sink with the Rd pull down on its CC wire. Policy Engine directs the Protocol Layer to send a ***Firmware_Update_Request*** Message using a payload supplied by the DPM.	The Port has ***Port Power Role*** set to Source and the Rp pull up on its CC wire.
2	Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.	
3	Physical Layer appends CRC and sends the ***Firmware_Update_Request*** Message.	Physical Layer receives the ***Firmware_Update_Request*** Message and checks the CRC to verify the Message.
4		Physical Layer removes the CRC and forwards the ***Firmware_Update_Request*** Message to the Protocol Layer.
5		Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Firmware_Update_Request*** Message information to the Policy Engine that consumes it.
6		Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.
7	Physical Layer receives the ***GoodCRC*** Message and checks the CRC to verify the Message.	Physical Layer appends CRC and sends the ***GoodCRC*** Message.

Step	Sink Port	Source Port
8	Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.	
9	Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Firmware_Update_Request*** Message was successfully sent.	
10		Policy Engine requests the DPM for the response to the firmware update request which is provided. The Policy Engine tells the Protocol Layer to form a ***Firmware_Update_Response*** Message.
11		Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.
12	Physical Layer receives the Message and compares the CRC it calculated with the one sent to verify the ***Firmware_Update_Response*** Message.	Physical Layer appends a CRC and sends the ***Firmware_Update_Response*** Message.
13	Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Firmware_Update_Response*** Message information to the Policy Engine that consumes it.	
14	Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.	
15	Physical Layer appends a CRC and sends the ***GoodCRC*** Message.	Physical Layer receives ***GoodCRC*** Message and compares the CRC it calculated with the one sent to verify the Message.
16		Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.
17		Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Firmware_Update_Response*** Message was successfully sent.
	The firmware update exchange is complete.	

8.3.2.12.3 Vconn Source requests firmware update exchange with Cable Plug

Figure 8-51 shows an example sequence for a firmware update exchange between a Vconn Source and a Cable Plug.

Figure 8-51 Vconn Source requests firmware update exchange with Cable Plug

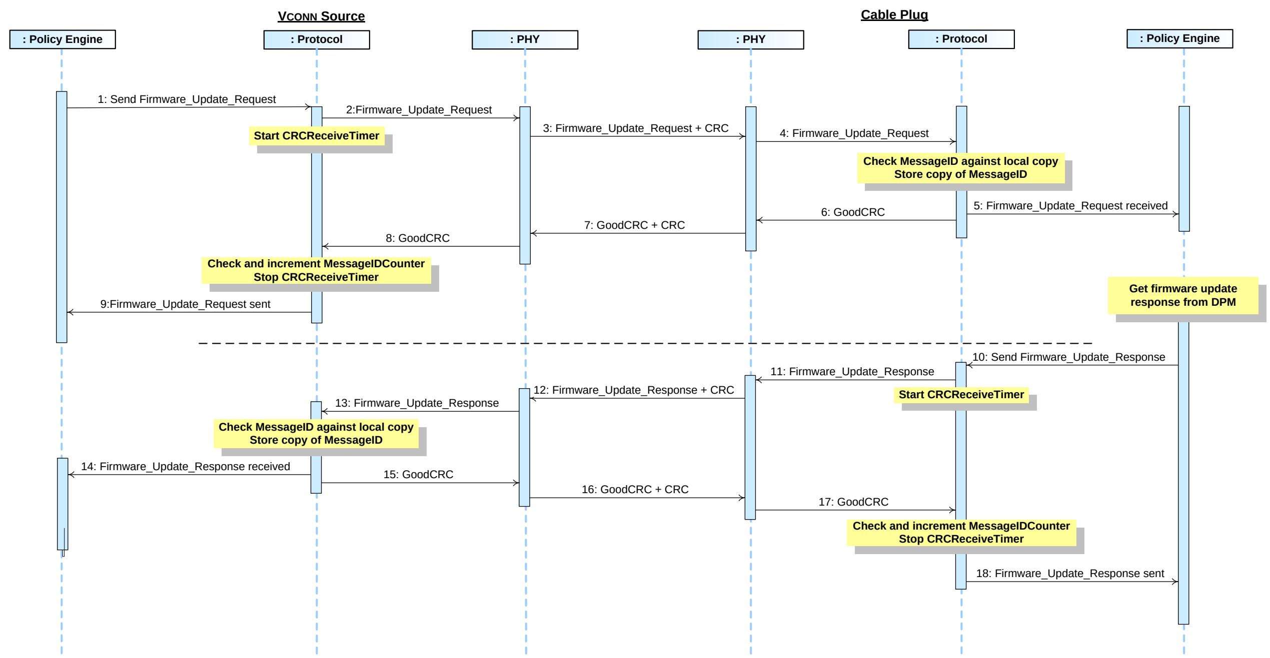


Table 8-51 below provides a detailed explanation of what happens at each labeled step in Figure 8-51 above.

Table 8-51 Steps for a Vconn Source requesting a firmware update exchange with a Cable Plug Sequence

Step	Vconn Source	Cable Plug
1	Policy Engine directs the Protocol Layer to send a ***Firmware_Update_Request*** Message using a payload supplied by the DPM.	
2	Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.	
3	Physical Layer appends CRC and sends the ***Firmware_Update_Request*** Message.	Physical Layer receives the ***Firmware_Update_Request*** Message and checks the CRC to verify the Message.
4		Physical Layer removes the CRC and forwards the ***Firmware_Update_Request*** Message to the Protocol Layer.
5		Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Firmware_Update_Request*** Message information to the Policy Engine that consumes it.
6		Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.
7	Physical Layer receives the ***GoodCRC*** Message and checks the CRC to verify the Message.	Physical Layer appends CRC and sends the ***GoodCRC*** Message.

Step	Vconn Source	Cable Plug
8	Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.	
9	Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Firmware_Update_Request*** Message was successfully sent.	
10		Policy Engine requests the DPM for the response to the firmware update request which is provided. The Policy Engine tells the Protocol Layer to form a ***Firmware_Update_Response*** Message.
11		Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.
12	Physical Layer receives the Message and compares the CRC it calculated with the one sent to verify the ***Firmware_Update_Response*** Message.	Physical Layer appends a CRC and sends the ***Firmware_Update_Response*** Message.
13	Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Firmware_Update_Response*** Message information to the Policy Engine that consumes it.	
14	Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.	
15	Physical Layer appends a CRC and sends the ***GoodCRC*** Message.	Physical Layer receives ***GoodCRC*** Message and compares the CRC it calculated with the one sent to verify the Message.
16		Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.
17		Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Firmware_Update_Response*** Message was successfully sent.
	The firmware update exchange is complete.	

8.3.2.13 Structured VDM

8.3.2.13.1 DFP to UFP Discover Identity

Figure 8-52 shows an example sequence between a DFP and UFP, where both Port Partners are in an Explicit Contract and the DFP attempts to discover identity information from the UFP.

Figure 8-52 DFP to UFP Discover Identity

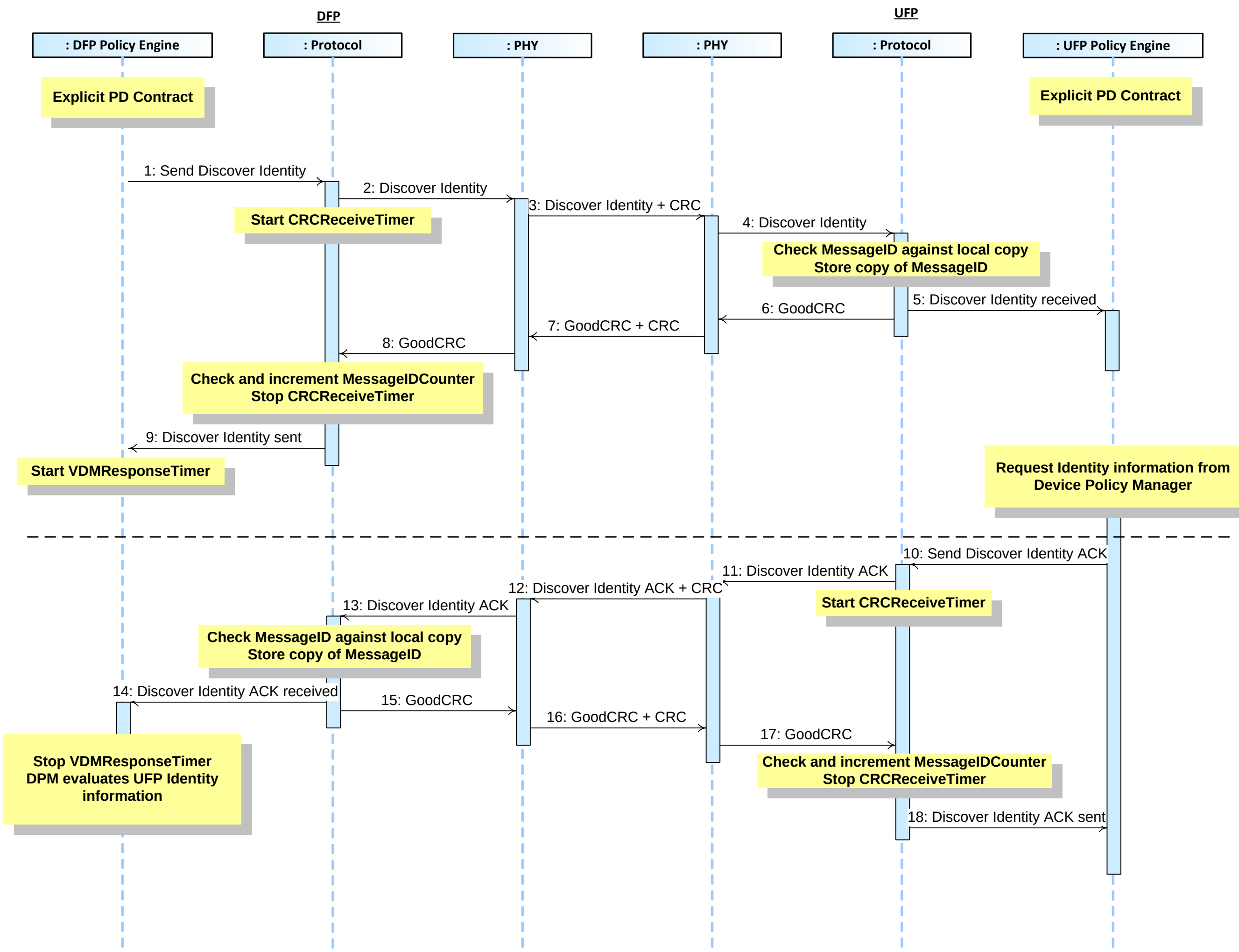


Table 8-52 below provides a detailed explanation of what happens at each labeled step in Figure 8-52 above.

Table 8-52 Steps for DFP to UFP Discover Identity

Step	DFP	UFP
1	The DFP has an Explicit Contract. The Policy Engine directs the Protocol Layer to send a ***Discover Identity*** Command request.	The UFP has an Explicit Contract.
2	Protocol Layer creates the ***Discover Identity*** Command request and passes to Physical Layer. Starts ***CRCReceiveTimer***.	

Step	DFP	UFP
3	Physical Layer appends CRC and sends the ***Discover Identity*** Command request.	Physical Layer receives the ***Discover Identity*** Command request and checks the CRC to verify the Message.
4		Physical Layer removes the CRC and forwards the ***Discover Identity*** Command request to the Protocol Layer.
5		Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Discover Identity*** Command request information to the Policy Engine that consumes it.
6		Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.
7	Physical Layer receives the ***GoodCRC*** Message and checks the CRC to verify the Message.	Physical Layer appends CRC and sends the ***GoodCRC*** Message.
8	Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.	
9	Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Discover Identity*** Command request was successfully sent. Policy Engine starts the ***VDMResponseTimer***.	
10		Policy Engine requests the identity information from the Device Policy Manager. The Policy Engine tells the Protocol Layer to form a ***Discover Identity*** Command ACK response.
11		Protocol Layer creates the ***Discover Identity*** Command ACK response and passes to Physical Layer. Starts ***CRCReceiveTimer***.
12	Physical Layer receives the ***Discover Identity*** Command ACK response and compares the CRC it calculated with the one sent to verify the Message.	Physical Layer appends a CRC and sends the ***Discover Identity*** Command ACK response.
13	Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Discover Identity*** Command ACK response information to the Policy Engine that consumes it.	
14	The Policy Engine stops the ***VDMResponseTimer*** and passed the Identity information to the Device Policy Manager for evaluation.	
15	Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.	
16	Physical Layer appends a CRC and sends the ***GoodCRC*** Message.	Physical Layer receives ***GoodCRC*** Message and compares the CRC it calculated with the one sent to verify the Message.
17		Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.
18		Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Discover Identity*** Command ACK response was successfully sent.

8.3.2.13.2 Source Port to Cable Plug Discover Identity

Figure 8-53 shows an example sequence between Source and a Cable Plug, where the Source attempts to discover identity information from the Cable Plug prior to establishing an Explicit Contract with its Port Partner.

Figure 8-53 Source Port to Cable Plug Discover Identity

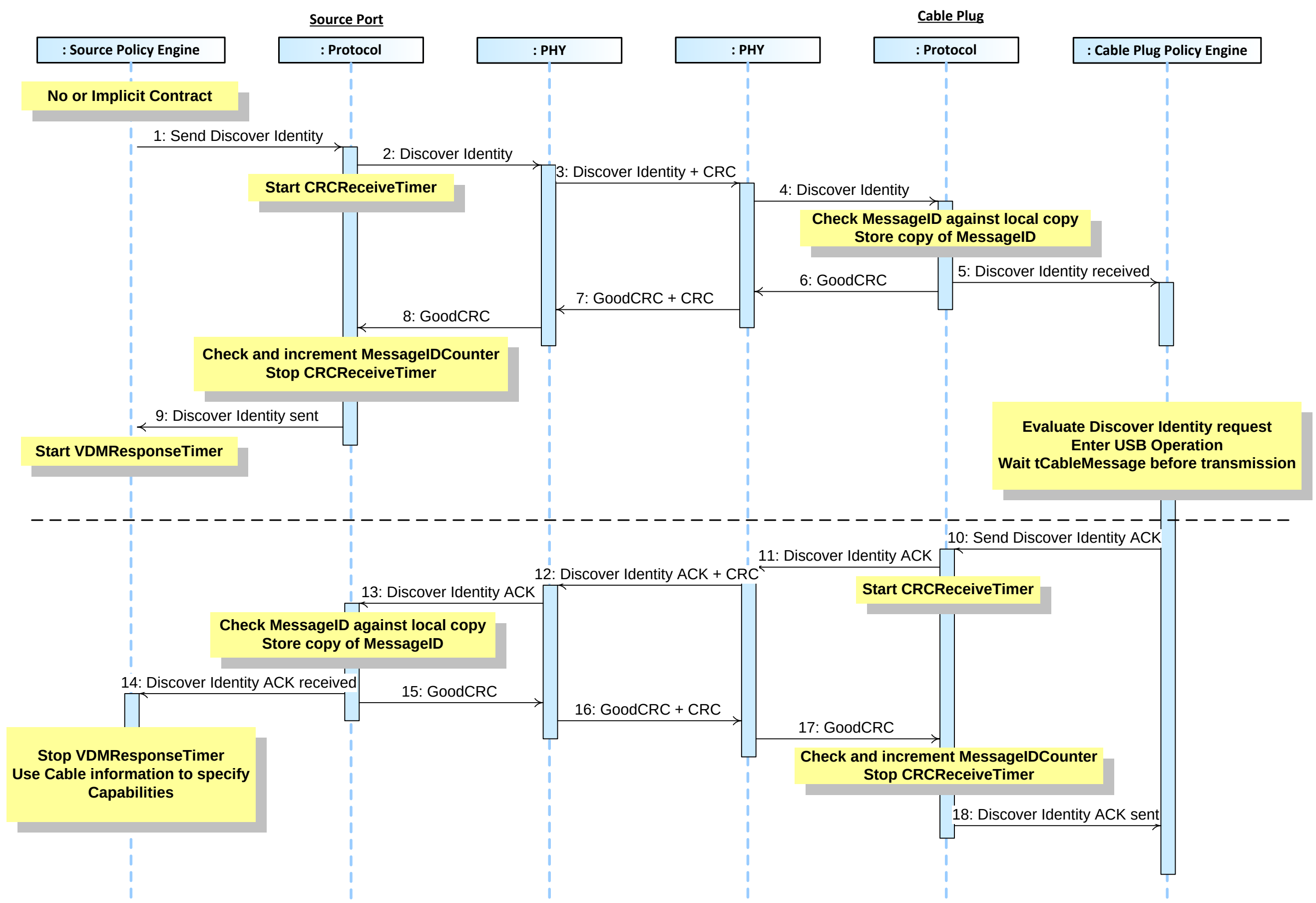


Table 8-53 below provides a detailed explanation of what happens at each labeled step in Figure 8-53 above.

Table 8-53 Steps for Source Port to Cable Plug Discover Identity

Step	Source Port	Cable Plug
1	The Source has no Contract or an Implicit Contract with its Port Partner. The Policy Engine directs the Protocol Layer to send a ***Discover Identity*** Command request.	
2	Protocol Layer creates the ***Discover Identity*** Command request and passes to Physical Layer. Starts ***CRCReceiveTimer***.	
3	Physical Layer appends CRC and sends the ***Discover Identity*** Command request.	Physical Layer receives the ***Discover Identity*** Command request and checks the CRC to verify the Message.
4		Physical Layer removes the CRC and forwards the ***Discover Identity*** Command request to the Protocol Layer.

Step	Source Port	Cable Plug
5		Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Discover Identity*** Command request information to the Policy Engine that consumes it.
6		Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.
7	Physical Layer receives the ***GoodCRC*** Message and checks the CRC to verify the Message.	Physical Layer appends CRC and sends the ***GoodCRC*** Message.
8	Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.	
9	Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Discover Identity*** Command request was successfully sent. Policy Engine starts the ***VDMResponseTimer***.	
10		Policy Engine requests the identity information from the Device Policy Manager. . ***tCableMessage*** after the ***GoodCRC*** Message was sent the Policy Engine tells the Protocol Layer to form a ***Discover Identity*** Command ACK response.
11		Protocol Layer creates the ***Discover Identity*** Command ACK response and passes to Physical Layer. Starts ***CRCReceiveTimer***.
12	Physical Layer receives the ***Discover Identity*** Command ACK response and compares the CRC it calculated with the one sent to verify the Message.	Physical Layer appends a CRC and sends the ***Discover Identity*** Command ACK response.
13	Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Discover Identity*** Command ACK response information to the Policy Engine that consumes it.	
14	The Policy Engine stops the ***VDMResponseTimer*** and passes the identity information to the Device Policy Manager for evaluation.	
15	Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.	
16	Physical Layer appends a CRC and sends the ***GoodCRC*** Message.	Physical Layer receives ***GoodCRC*** Message and compares the CRC it calculated with the one sent to verify the Message.
17		Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.
18	The Source uses the Cable Plug information as input to its offered capabilities.	Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Accept*** Message was successfully sent.

8.3.2.13.3 DFP to Cable Plug Discover Identity

Figure 8-54 shows an example sequence between a DFP and a Cable Plug, where the DFP attempts to discover identity information from the Cable Plug.

Figure 8-54 DFP to Cable Plug Discover Identity

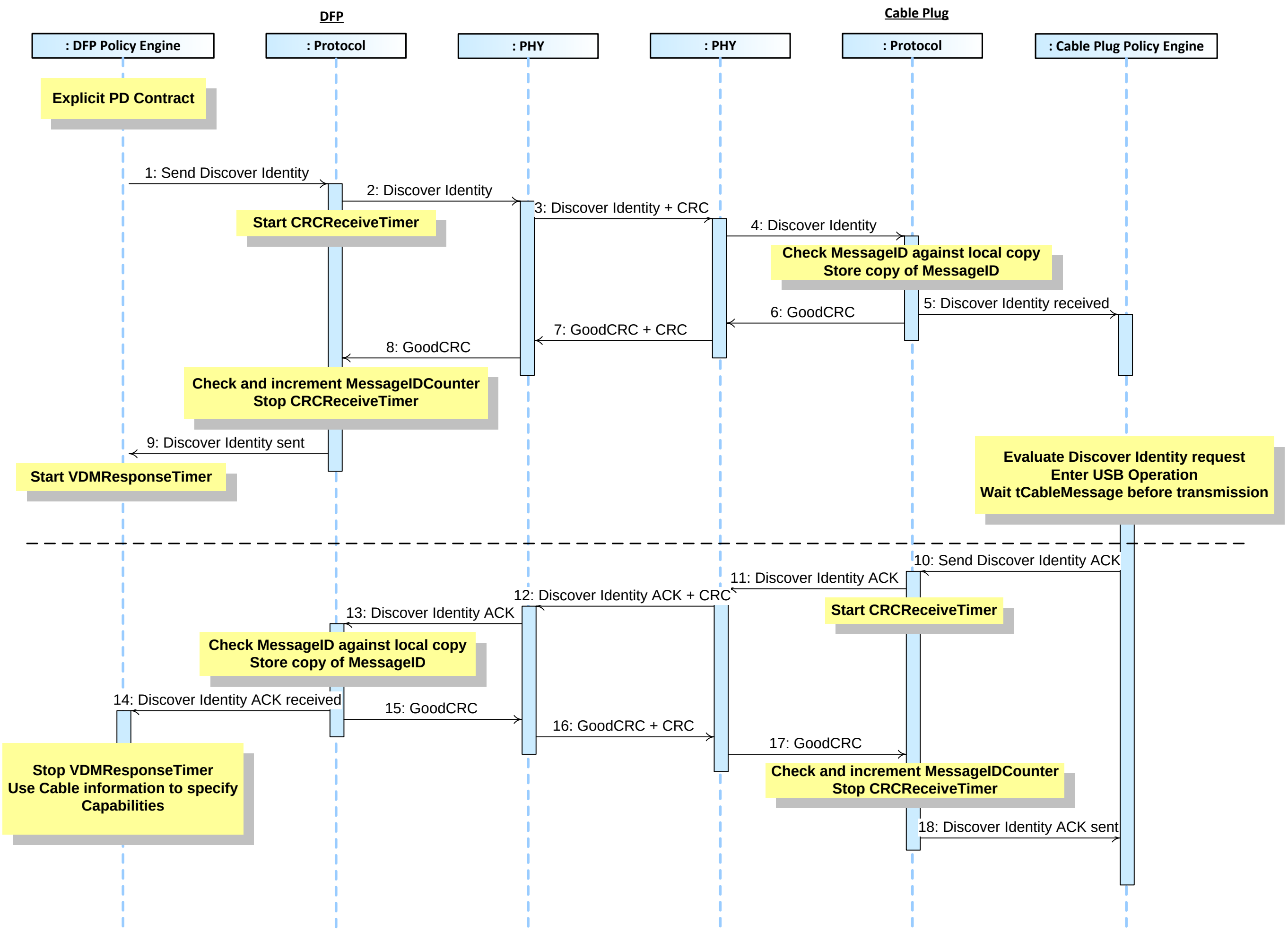


Table 8-54 below provides a detailed explanation of what happens at each labeled step in Figure 8-54 above.

Table 8-54 Steps for DFP to Cable Plug Discover Identity

Step	DFP	Cable Plug
1	The DFP has an Explicit Contract with its Port Partner. The Policy Engine directs the Protocol Layer to send a ***Discover Identity*** Command request.	
2	Protocol Layer creates the ***Discover Identity*** Command request and passes to Physical Layer. Starts ***CRCReceiveTimer***.	
3	Physical Layer appends CRC and sends the ***Discover Identity*** Command request.	Physical Layer receives the ***Discover Identity*** Command request and checks the CRC to verify the Message.

Step	DFP	Cable Plug
4		Physical Layer removes the CRC and forwards the ***Discover Identity*** Command request to the Protocol Layer.
5		Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Discover Identity*** Command request information to the Policy Engine that consumes it.
6		Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.
7	Physical Layer receives the ***GoodCRC*** Message and checks the CRC to verify the Message.	Physical Layer appends CRC and sends the ***GoodCRC*** Message.
8	Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.	
9	Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Discover Identity*** Command request was successfully sent. Policy Engine starts the ***VDMResponseTimer***.	
10		Policy Engine requests the identity information from the Device Policy Manager. ***tCableMessage*** after the ***GoodCRC*** Message was sent the Policy Engine tells the Protocol Layer to form a ***Discover Identity*** Command ACK response.
11		Protocol Layer creates the ***Discover Identity*** Command ACK response and passes to Physical Layer. Starts ***CRCReceiveTimer***.
12	Physical Layer receives the ***Discover Identity*** Command ACK response and compares the CRC it calculated with the one sent to verify the Message.	Physical Layer appends a CRC and sends the ***Discover Identity*** Command ACK response.
13	Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Discover Identity*** Command ACK response information to the Policy Engine that consumes it.	
14	The Policy Engine stops the ***Discover Identity*** Command ACK response and passes the identity information to the Device Policy Manager for evaluation.	
15	Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.	
16	Physical Layer appends a CRC and sends the ***GoodCRC*** Message.	Physical Layer receives ***GoodCRC*** Message and compares the CRC it calculated with the one sent to verify the Message.
17		Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.
18	The DFP when acting as a Source uses the Cable Plug information as input to its offered capabilities.	Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Accept*** Message was successfully sent.

8.3.2.13.4 DFP to UFP Enter Mode

Figure 8-55 shows an example sequence between a DFP and a UFP that occurs after the DFP has discovered supported SVIDs and Modes at which point it selects and enters a Mode.

Figure 8-55 DFP to UFP Enter Mode

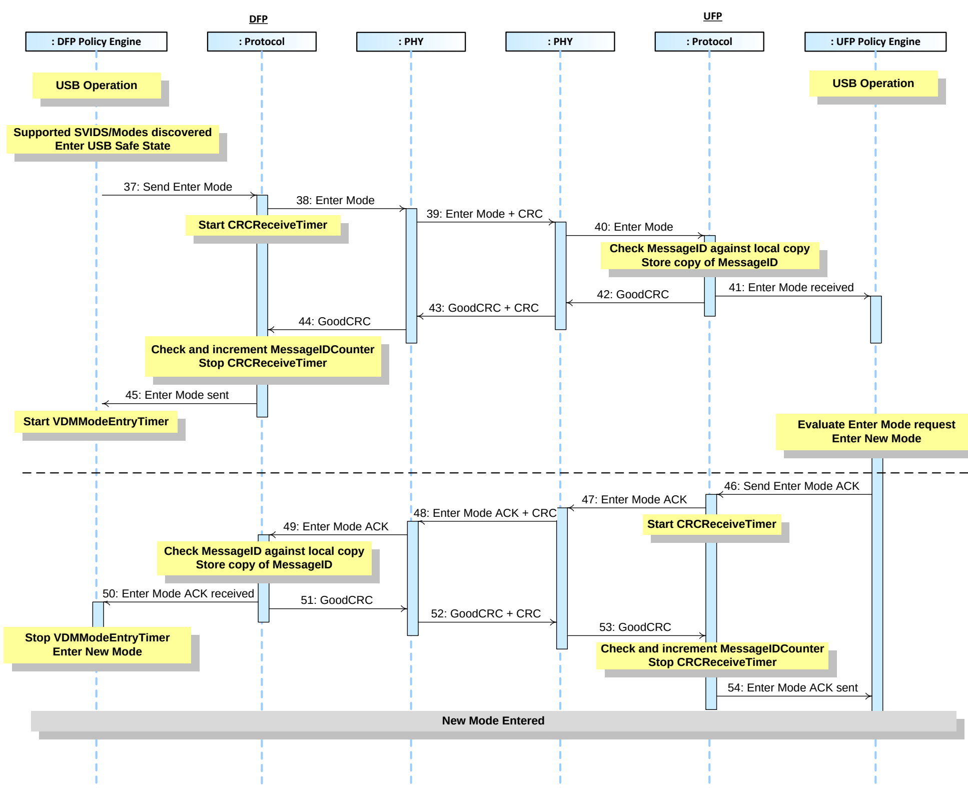


Table 8-55 below provides a detailed explanation of what happens at each labeled step in Figure 8-55 above.

Table 8-55 Steps for DFP to UFP Enter Mode

Step	DFP	UFP
1	The DFP has an Explicit Contract The DFP has discovered the supported SVIDS using the ***Discover SVIDs*** Command request and the supported Modes using the ***Discover Modes*** Command request The DFP goes to USB Safe State. The Device Policy Manager requests the Policy Engine to enter a Mode. The Policy Engine directs the Protocol Layer to send an ***Enter Mode*** Command request.	The UFP has an Explicit Contract.
2	Protocol Layer creates the ***Enter Mode*** Command request and passes to Physical Layer. Starts ***CRCReceiveTimer***.	
3	Physical Layer appends CRC and sends the ***Enter Mode*** Command request.	Physical Layer receives the ***Enter Mode*** Command request and checks the CRC to verify the Message.
4		Physical Layer removes the CRC and forwards the ***Enter Mode*** Command request to the Protocol Layer.

Step	DFP	UFP
5		Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Enter Mode*** Command request information to the Policy Engine that consumes it.
6		Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.
7	Physical Layer receives the ***GoodCRC*** Message and checks the CRC to verify the Message.	Physical Layer appends CRC and sends the ***GoodCRC*** Message.
8	Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.	
9	Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Enter Mode*** Command request was successfully sent. Policy Engine starts the ***VDMModeEntryTimer***.	
10		Policy Engine requests the Device Policy Manager to enter the new Mode. The Policy Engine tells the Protocol Layer to form an ***Enter Mode*** Command ACK response.
11		Protocol Layer creates the ***Enter Mode*** Command ACK response and passes to Physical Layer. Starts ***CRCReceiveTimer***.
12	Physical Layer receives the ***Enter Mode*** Command ACK response and compares the CRC it calculated with the one sent to verify the Message.	Physical Layer appends a CRC and sends the ***Enter Mode*** Command ACK response.
13	Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Enter Mode*** Command ACK response information to the Policy Engine that consumes it.	
14	The Policy Engine stops the ***VDMModeEntryTimer*** and requests the Device Policy Manager to enter the new Mode.	
15	Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.	
16	Physical Layer appends a CRC and sends the ***GoodCRC*** Message.	Physical Layer receives ***GoodCRC*** Message and compares the CRC it calculated with the one sent to verify the Message.
17		Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.
18		Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Enter Mode*** Command ACK response was successfully sent.
	DFP and UFP are operating in the new Mode	

8.3.2.13.5 DFP to UFP Exit Mode

Figure 8-56 shows an example sequence between a DFP and a UFP, where the DFP commands the UFP to exit the only Active Mode.

Figure 8-56 DFP to UFP Exit Mode

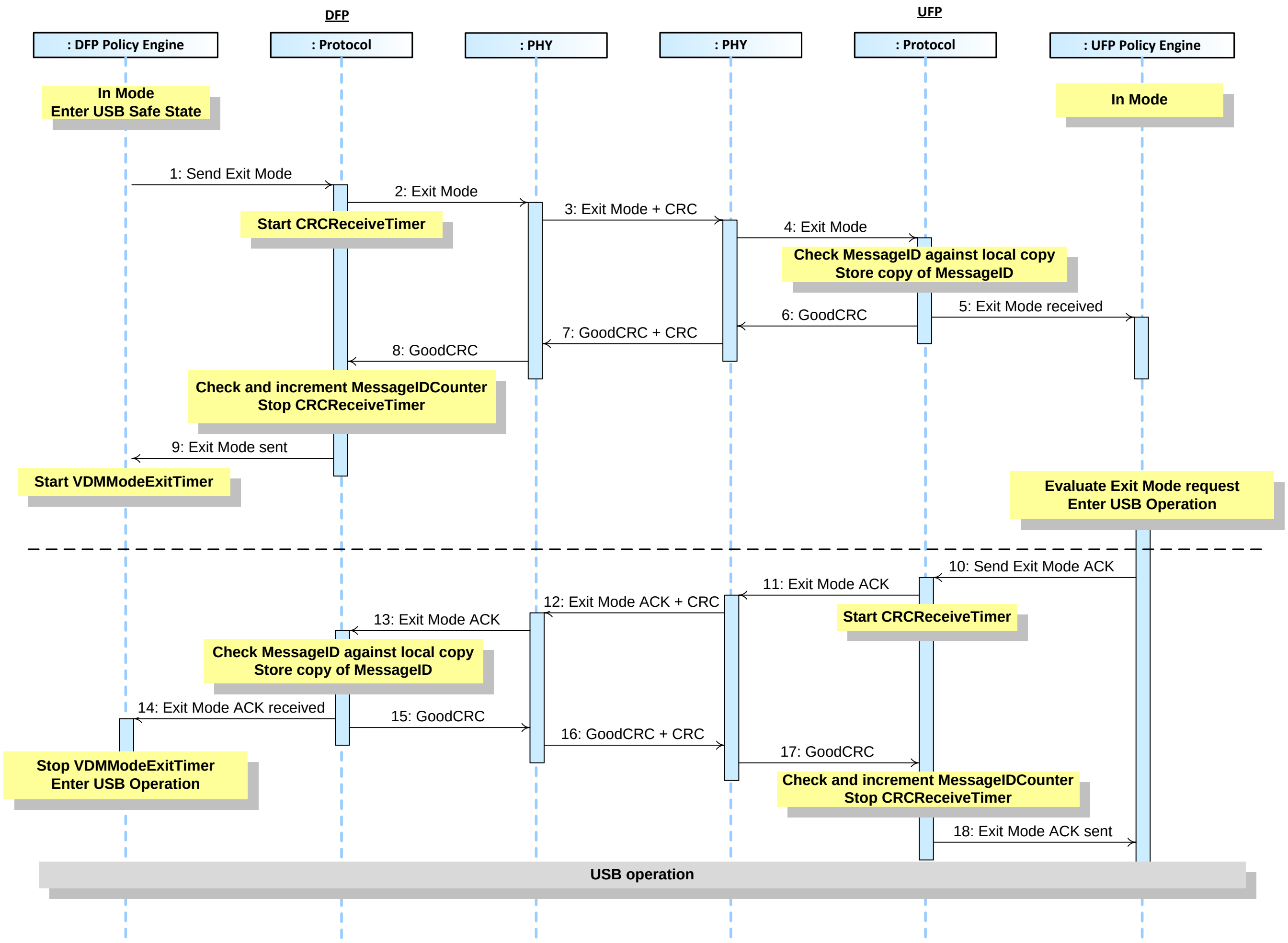


Table 8-56 below provides a detailed explanation of what happens at each labeled step in Figure 8-56 above.

Table 8-56 Steps for DFP to UFP Exit Mode

Step	DFP	UFP
1	The DFP is in a Mode and then enters USB Safe State. The Policy Engine directs the Protocol Layer to send an ***Exit Mode*** Command request.	The UFP is in a Mode.
2	Protocol Layer creates the ***Exit Mode*** Command request and passes to Physical Layer. Starts ***CRCReceiveTimer***.	
3	Physical Layer appends CRC and sends the ***Exit Mode*** Command request.	Physical Layer receives the ***Exit Mode*** Command request and checks the CRC to verify the Message.
4		Physical Layer removes the CRC and forwards the ***Exit Mode*** Command request to the Protocol Layer.

Step	DFP	UFP
5		Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Exit Mode*** Command request information to the Policy Engine that consumes it.
6		Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.
7	Physical Layer receives the ***GoodCRC*** Message and checks the CRC to verify the Message.	Physical Layer appends CRC and sends the ***GoodCRC*** Message.
8	Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.	
9	Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Exit Mode*** Command request was successfully sent. Policy Engine starts the ***VDMModeExitTimer***.	
10		Policy Engine requests the Device Policy Manager to enter USB operation. The Policy Engine tells the Protocol Layer to form an ***Exit Mode*** Command ACK response.
11		Protocol Layer creates the ***Exit Mode*** Command ACK response and passes to Physical Layer. Starts ***CRCReceiveTimer***.
12	Physical Layer receives the ***Exit Mode*** Command ACK response and compares the CRC it calculated with the one sent to verify the Message.	Physical Layer appends a CRC and sends the ***Exit Mode*** Command ACK response.
13	Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Exit Mode*** Command ACK response information to the Policy Engine that consumes it.	
14	The Policy Engine stops the ***VDMModeExitTimer*** and requests the Device Policy Manager to enter USB Operation.	
15	Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.	
16	Physical Layer appends a CRC and sends the ***GoodCRC*** Message.	Physical Layer receives ***GoodCRC*** Message and compares the CRC it calculated with the one sent to verify the Message.
17		Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.
18		Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Exit Mode*** Command ACK response was successfully sent.
	Both DFP and UFP are in USB Operation	

8.3.2.13.6 DFP to Cable Plug Enter Mode

Figure 8-57 shows an example sequence between a DFP and a Cable Plug that occurs after the DFP has discovered supported SVIDs and Modes at which point it selects and enters a Mode.

Figure 8-57 DFP to Cable Plug Enter Mode

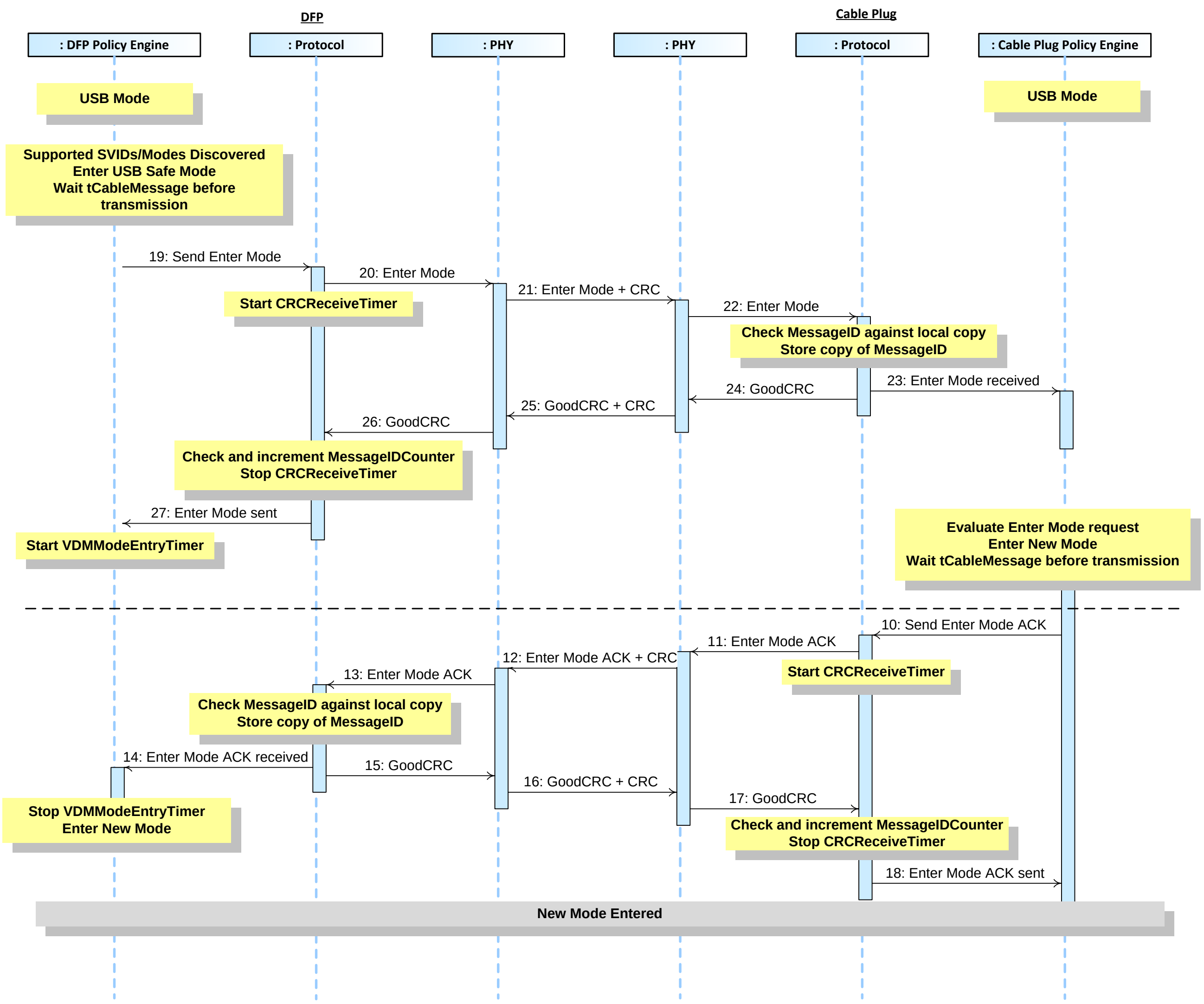


Table 8-57 below provides a detailed explanation of what happens at each labeled step in Figure 8-57 above.

Table 8-57 Steps for DFP to Cable Plug Enter Mode

Step	DFP	Cable Plug
1	The DFP has an Explicit Contract The DFP has discovered the supported SVIDS using the ***Discover SVIDs*** Command request and the supported Modes using the ***Discover Modes*** Command request The DFP goes to USB Safe State. The Device Policy Manager requests the Policy Engine to enter a Mode. ***tCableMessage*** after the last ***GoodCRC*** Message was sent the Policy Engine directs the Protocol Layer to send an ***Enter Mode*** Command request.	
2	Protocol Layer creates the ***Enter Mode*** Command request and passes to Physical Layer. Starts ***CRCReceiveTimer***.	
3	Physical Layer appends CRC and sends the ***Enter Mode*** Command request.	Physical Layer receives the ***Enter Mode*** Command request and checks the CRC to verify the Message.
4		Physical Layer removes the CRC and forwards the ***Enter Mode*** Command request to the Protocol Layer.
5		Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Enter Mode*** Command request information to the Policy Engine that consumes it.
6		Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.
7	Physical Layer receives the ***GoodCRC*** Message and checks the CRC to verify the Message.	Physical Layer appends CRC and sends the ***GoodCRC*** Message.
8	Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.	
9	Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Enter Mode*** Command request was successfully sent. Policy Engine starts the ***VDMModeEntryTimer***.	
10		Policy Engine requests the Device Policy Manager to enter the new Mode. ***tCableMessage*** after the ***GoodCRC*** Message was sent the Policy Engine tells the Protocol Layer to form an ***Enter Mode*** Command ACK response.
11		Protocol Layer creates the ***Enter Mode*** Command ACK response and passes to Physical Layer. Starts ***CRCReceiveTimer***.
12	Physical Layer receives the ***Enter Mode*** Command ACK response and compares the CRC it calculated with the one sent to verify the Message.	Physical Layer appends a CRC and sends the ***Enter Mode*** Command ACK response.
13	Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Enter Mode*** Command ACK response information to the Policy Engine that consumes it.	

Step	DFP	Cable Plug
14	The Policy Engine stops the ***VDMModeEntryTimer*** and requests the Device Policy Manager to enter the new Mode.	
15	Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.	
16	Physical Layer appends a CRC and sends the ***GoodCRC*** Message.	Physical Layer receives ***GoodCRC*** Message and compares the CRC it calculated with the one sent to verify the Message.
17		Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.
18		Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Enter Mode*** Command ACK response was successfully sent.
	DFP and Cable Plug are operating in the new Mode	

8.3.2.13.7 DFP to Cable Plug Exit Mode

Figure 8-58 shows an example sequence between a USB Type-C DFP and a Cable Plug, where the DFP commands the Cable Plug to exit an Active Mode.

Figure 8-58 DFP to Cable Plug Exit Mode

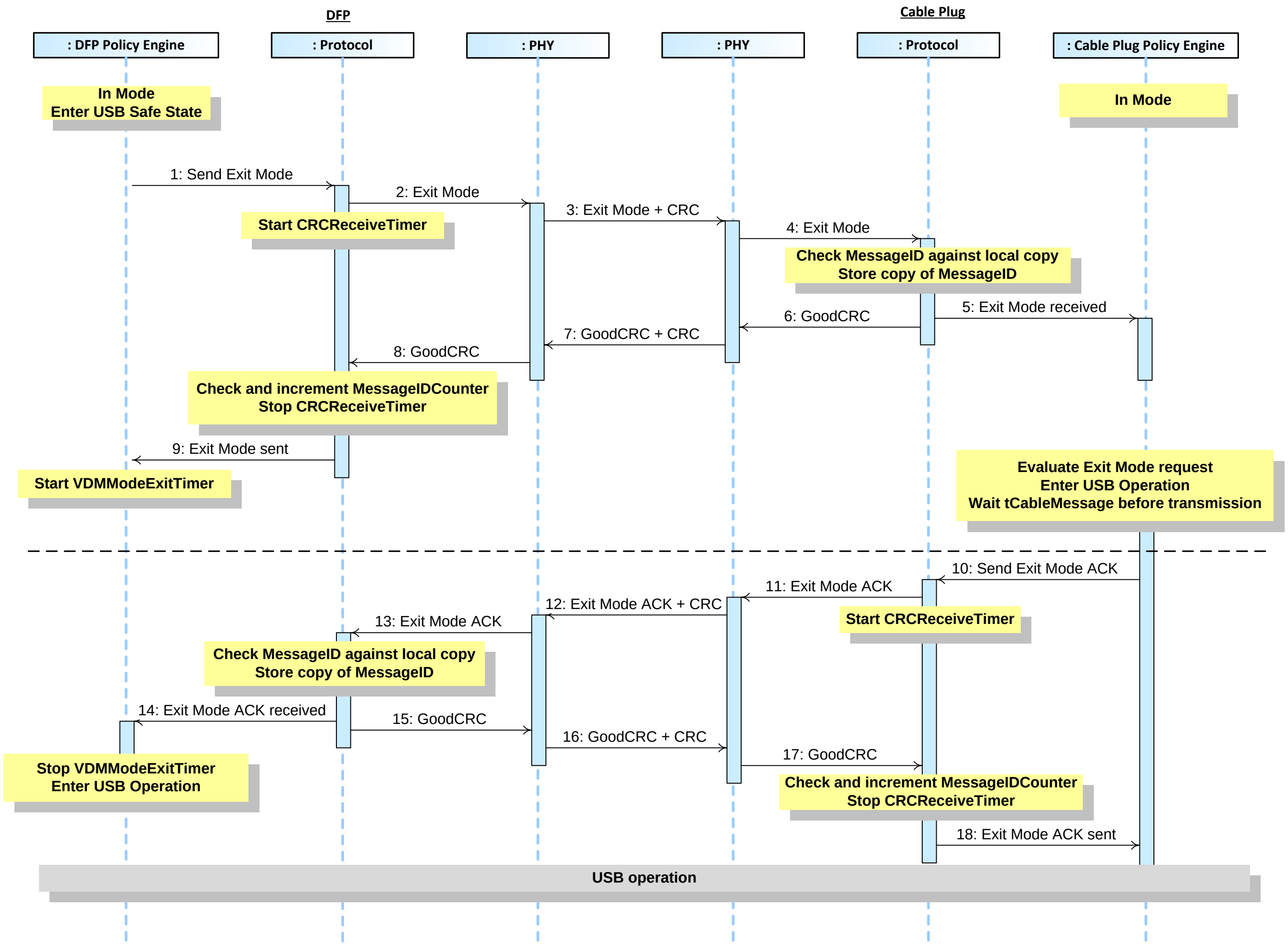


Table 8-58 below provides a detailed explanation of what happens at each labeled step in Figure 8-58 above.

Table 8-58 Steps for DFP to Cable Plug Exit Mode

Step	DFP	Cable Plug
1	The DFP is in a Mode and then enters USB Safe State. The Policy Engine directs the Protocol Layer to send an ***Exit Mode*** Command request.	The Cable Plug is in a Mode.
2	Protocol Layer creates the ***Exit Mode*** Command request and passes to Physical Layer. Starts ***CRCReceiveTimer***.	
3	Physical Layer appends CRC and sends the ***Exit Mode*** Command request.	Physical Layer receives the ***Exit Mode*** Command request and checks the CRC to verify the Message.
4		Physical Layer removes the CRC and forwards the ***Exit Mode*** Command request to the Protocol Layer.

Step	DFP	Cable Plug
5		Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Exit Mode*** Command request information to the Policy Engine that consumes it.
6		Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.
7	Physical Layer receives the ***GoodCRC*** Message and checks the CRC to verify the Message.	Physical Layer appends CRC and sends the ***GoodCRC*** Message.
8	Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.	
9	Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Exit Mode*** Command request was successfully sent. Policy Engine starts the ***VDMModeExitTimer***.	
10		Policy Engine requests the Device Policy Manager to enter USB operation. ***tCableMessage*** after the ***GoodCRC*** Message was sent the Policy Engine tells the Protocol Layer to form an ***Exit Mode*** Command ACK response.
11		Protocol Layer creates the ***Exit Mode*** Command ACK response and passes to Physical Layer. Starts ***CRCReceiveTimer***.
12	Physical Layer receives the ***Exit Mode*** Command ACK response and compares the CRC it calculated with the one sent to verify the Message.	Physical Layer appends a CRC and sends the ***Exit Mode*** Command ACK response.
13	Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Exit Mode*** Command ACK response information to the Policy Engine that consumes it.	
14	The Policy Engine stops the ***VDMModeExitTimer*** and requests the Device Policy Manager to enter USB Operation.	
15	Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.	
16	Physical Layer appends a CRC and sends the ***GoodCRC*** Message.	Physical Layer receives ***GoodCRC*** Message and compares the CRC it calculated with the one sent to verify the Message.
17		Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.
18		Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Exit Mode*** Command ACK response was successfully sent.
	Both DFP and Cable Plug are in USB Operation	

8.3.2.13.8 UFP to DFP Attention

Figure 8-59 shows an example sequence between a USB Type-C DFP and a UFP, where the UFP requests attention from the DFP.

Figure 8-59 UFP to DFP Attention

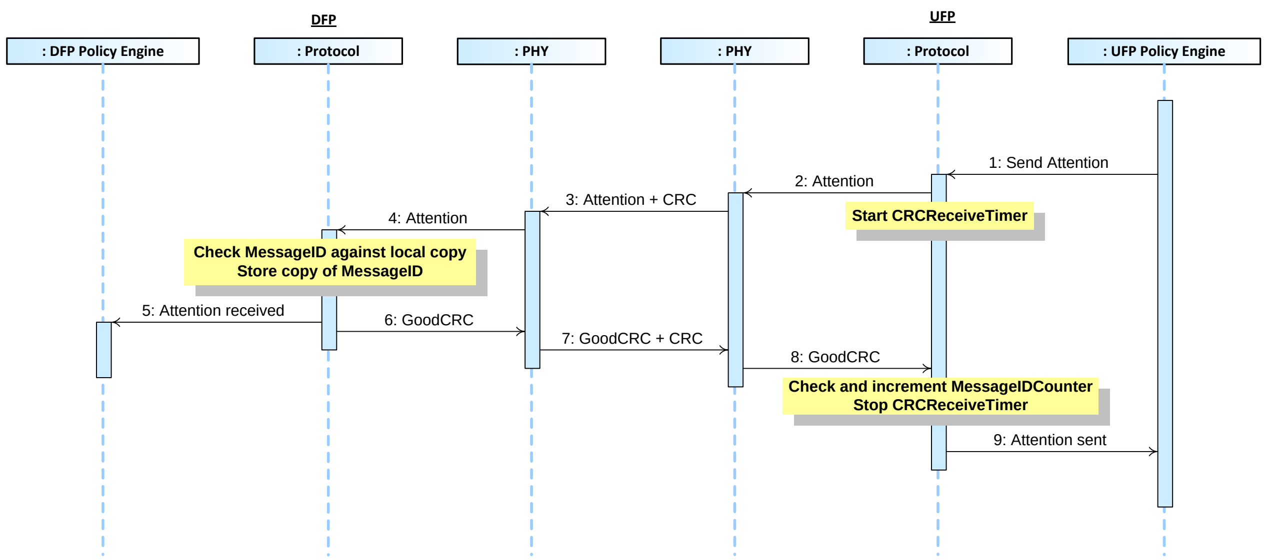


Table 8-59 below provides a detailed explanation of what happens at each labeled step in Figure 8-59 above.

Table 8-59 Steps for UFP to DFP Attention

Step	DFP	UFP
1		The Device Policy Manager requests attention. The Policy Engine tells the Protocol Layer to form an ***Attention*** Command request.
2		Protocol Layer creates the ***Attention*** Command request and passes to Physical Layer. Starts ***CRCReceiveTimer***.
3	Physical Layer receives the ***Attention*** Command request and compares the CRC it calculated with the one sent to verify the Message.	Physical Layer appends a CRC and sends the ***Attention*** Command request.
4	Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***Attention*** Command request information to the Policy Engine that consumes it.	
5	The Policy Engine informs the Device Policy Manager	
6	Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.	
7	Physical Layer appends a CRC and sends the ***GoodCRC*** Message.	Physical Layer receives ***GoodCRC*** Message and compares the CRC it calculated with the one sent to verify the Message.
8		Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.

Step	DFP	UFP
9		Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***Attention*** Command request was successfully sent.

8.3.2.14 Built in Self-Test (BIST)

8.3.2.14.1 BIST Carrier Mode

The following is an example of a ***BIST Carrier Mode*** test between a Tester and a UUT. When the UUT is connected to the Tester the sequence below is executed.

Figure 8-60 shows the Messages as they flow across the bus and within the devices. This test enables the measurement of power supply noise and frequency drift.

1. Connection is established and stable.
2. Tester sends a ***BIST*** Message with a ***BIST Carrier Mode*** BIST Data Object.
3. UUT answers with a ***GoodCRC*** Message.
4. UUT starts sending the Test Pattern.
5. Operator does the measurements.
6. The test ends after ***tBISTContMode***.

See also Section 5.9.1 and Section 6.4.3.1.

Figure 8-60 BIST Carrier Mode Test

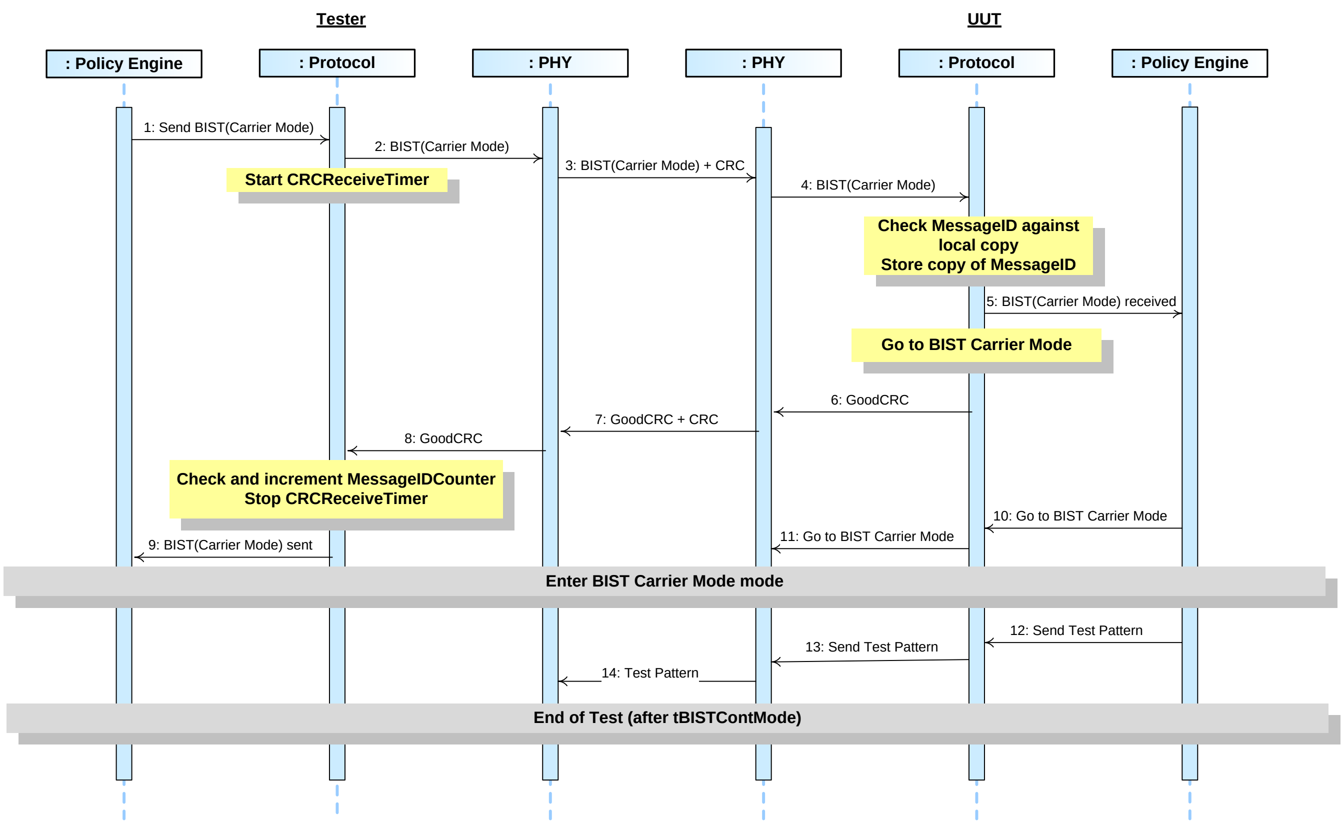


Table 8-60 Steps for BIST Carrier Mode Test

Step	Tester	UUT
1	The Policy Engine directs the Protocol Layer to generate a ***BIST*** Message, with a BIST Data Object of ***BIST Carrier Mode***, to put the UUT into BIST Carrier Mode test mode.	
2	Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.	
3	Physical Layer appends CRC and sends the ***BIST*** Message.	Physical Layer receives the ***BIST*** Message and checks the CRC to verify the Message.
4		Physical Layer removes the CRC and forwards the ***BIST*** Message to the Protocol Layer.
5		Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***BIST*** Message information to the Policy Engine that consumes it.
6		Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.
7	Physical Layer receives the ***GoodCRC*** and checks the CRC to verify the Message.	Physical Layer appends CRC and sends the ***GoodCRC*** Message.
8	Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.	
9	Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***BIST*** Message was successfully sent.	
10		Policy Engine tells Protocol Layer to go into ***BIST Carrier Mode***. The Policy Engine goes to ***BIST Carrier Mode***.
11		Protocol Layer tells Physical Layer to go into ***BIST Carrier Mode***.
	UUT enters ***BIST Carrier Mode***	
12		The Policy Engine directs the Protocol Layer to start generation of the Test Pattern.
13		Protocol Layer directs the PHY Layer to generate the Test Pattern.
14	Physical Layer receives the Test Pattern stream.	Physical Layer generates a continuous Test Pattern stream.
	The UUT exits ***BIST Carrier Mode*** after ***tBISTContMode.***	

8.3.2.14.2 BIST Test Data

The following is an example of a ***BIST Test Data*** test between a Tester and a UUT. When the UUT is connected to the Tester the sequence below is executed.

Figure 8-60 shows the Messages as they flow across the bus and within the devices.

1. Connection is established and stable.
2. Tester sends a ***BIST*** Message with a ***BIST Test Data*** BIST Data Object.
3. UUT answers with a ***GoodCRC*** Message.
4. Steps 2and 3 are repeated any number of times.
5. The test ends after ***Hard Reset*** Signaling is issued.

See also Section 5.9.2 and Section 6.4.3.2.

Figure 8-61 BIST Test Data Test

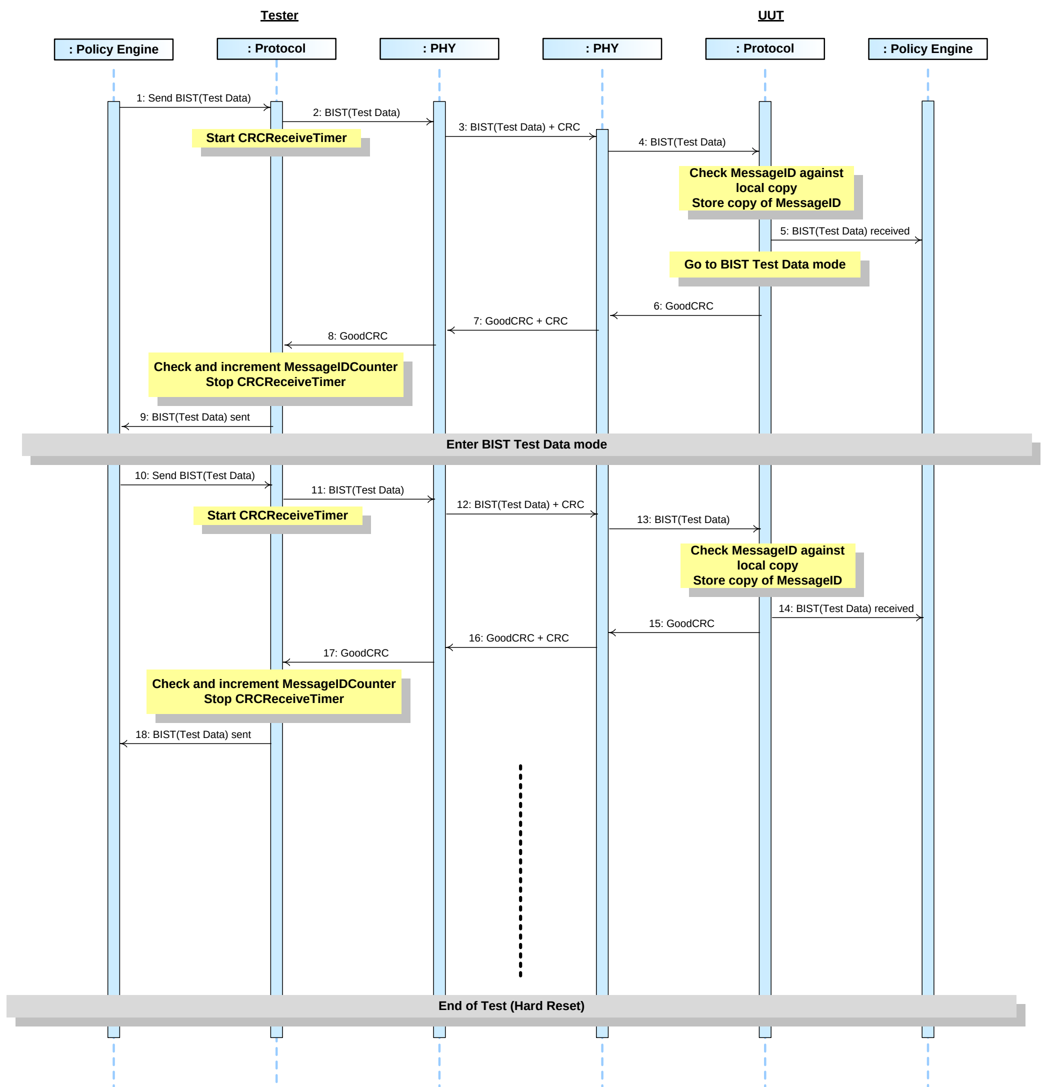


Table 8-61 Steps for BIST Test Data Test

Step	Tester	UUT
1	The Policy Engine directs the Protocol Layer to generate a ***BIST*** Message, with a BIST Data Object of ***BIST Test Data***, to put the UUT into BIST Test Data test mode.	
2	Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.	
3	Physical Layer appends CRC and sends the ***BIST*** Message.	Physical Layer receives the ***BIST*** Message and checks the CRC to verify the Message.
4		Physical Layer removes the CRC and forwards the ***BIST*** Message to the Protocol Layer.
5		Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***BIST*** Message information to the Policy Engine that consumes it. The Policy Engine goes into BIST Test Data Mode where it sends no further Messages except for ***GoodCRC*** Messages in response to received Messages (see Section 6.4.3.2).
6		Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.
7	Physical Layer receives the ***GoodCRC*** and checks the CRC to verify the Message.	Physical Layer appends CRC and sends the ***GoodCRC*** Message.
8	Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.	
9	Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***BIST*** Message was successfully sent.	
	UUT enters BIST Test Data test mode	
10	The Policy Engine directs the Protocol Layer to generate a ***BIST*** Message, with a BIST Data Object of ***BIST Test Data***, to put the UUT into BIST Test Data test mode.	
11	Protocol Layer creates the Message and passes to Physical Layer. Starts ***CRCReceiveTimer***.	
12	Physical Layer appends CRC and sends the ***BIST*** Message.	Physical Layer receives the ***BIST*** Message and checks the CRC to verify the Message.
13		Physical Layer removes the CRC and forwards the ***BIST*** Message to the Protocol Layer.
14		Protocol Layer checks the ***MessageID*** in the incoming Message is different from the previously stored value and then stores a copy of the new value. The Protocol Layer forwards the received ***BIST*** Message information to the Policy Engine that consumes it. The Policy Engine goes into BIST Test Data Mode where it sends no further Messages except for ***GoodCRC*** Messages in response to received Messages (see Section 6.4.3.2).
15		Protocol Layer generates a ***GoodCRC*** Message and passes it Physical Layer.

Step	Tester	UUT
16	Physical Layer receives the ***GoodCRC*** and checks the CRC to verify the Message.	Physical Layer appends CRC and sends the ***GoodCRC*** Message.
17	Physical Layer removes the CRC and forwards the ***GoodCRC*** Message to the Protocol Layer.	
18	Protocol Layer verifies and increments the ***MessageIDCounter*** and stops ***CRCReceiveTimer***. Protocol Layer informs the Policy Engine that the ***BIST*** Message was successfully sent.	
	Repeat steps 10-18 any number of times	
	The UUT exits BIST Test Data test mode after a Hard Reset	

8.3.3 State Diagrams

8.3.3.1 Introduction to state diagrams used in Chapter 8

The state diagrams defined in Section 8.3.3 are ***Normative*** and ***Shall*** define the operation of the Power Delivery Policy Engine. Note that these state diagrams are not intended to replace a well written and robust design.

Figure 8-62 Outline of States

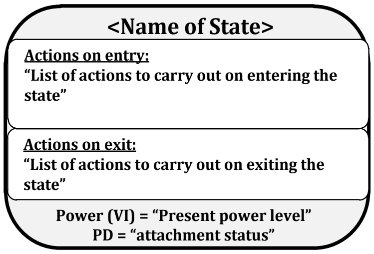


Figure 8-62 shows an outline of the states defined in the following sections. At the top there is the name of the state. This is followed by "Actions on entry" a list of actions carried out on entering the state. If there are also "Actions on exit" a list of actions carried out on exiting the state then these are listed as well; otherwise this box is omitted from the state. At the bottom the status of PD is listed:

- "Power" which indicates the present output power for a Source Port or input power for a Sink Port.
- "PD" which indicates the present Attachment status either "Attached", "Detached", or "unknown".

Transitions from one state to another are indicated by arrows with the conditions listed on the arrow. Where there are multiple conditions these are connected using either a logical OR "**|**" or a logical AND "&".

In some cases there are transitions which can occur from any state to a particular state. These are indicated by an arrow which is unconnected to a state at one end, but with the other end (the point) connected to the final state.

In some state diagrams it is necessary to enter or exit from states in other diagrams (e.g. Source Port or Sink Port state diagrams). Figure 8-63 indicates how such references are made. The reference is indicated with a hatched box. The box contains the name of the state and whether the state is a DFP or UFP. It has also been necessary to indicate conditional entry to either Source Port or Sink Port state diagrams. This is achieved by the use of a bulleted list indicating the pre-conditions (see example in Figure 8-64). It is also possible that the entry and return states are the same. Figure 8-65 indicates a state reference where each referenced state corresponds to either the entry state or the exit state.

Figure 8-63 References to states

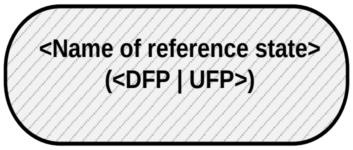


Figure 8-64 Example of state reference with conditions

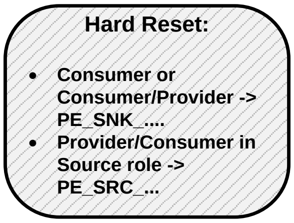
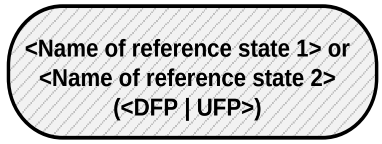


Figure 8-65 Example of state reference with the same entry and exit



Timers are included in many of the states. Timers are initialized (set to their starting condition) and run (timer is counting) in the particular state it is referenced. As soon as the state is exited then the timer is no longer active. Where the timers continue to run outside of the state (such as the ***NoResponseTimer***), this is called out in the text. Timeouts of the timers are listed as conditions on state transitions.

Conditions listed on state transitions will come from one of three sources and, when there is a conflict, ***Should*** be serviced in the following order:

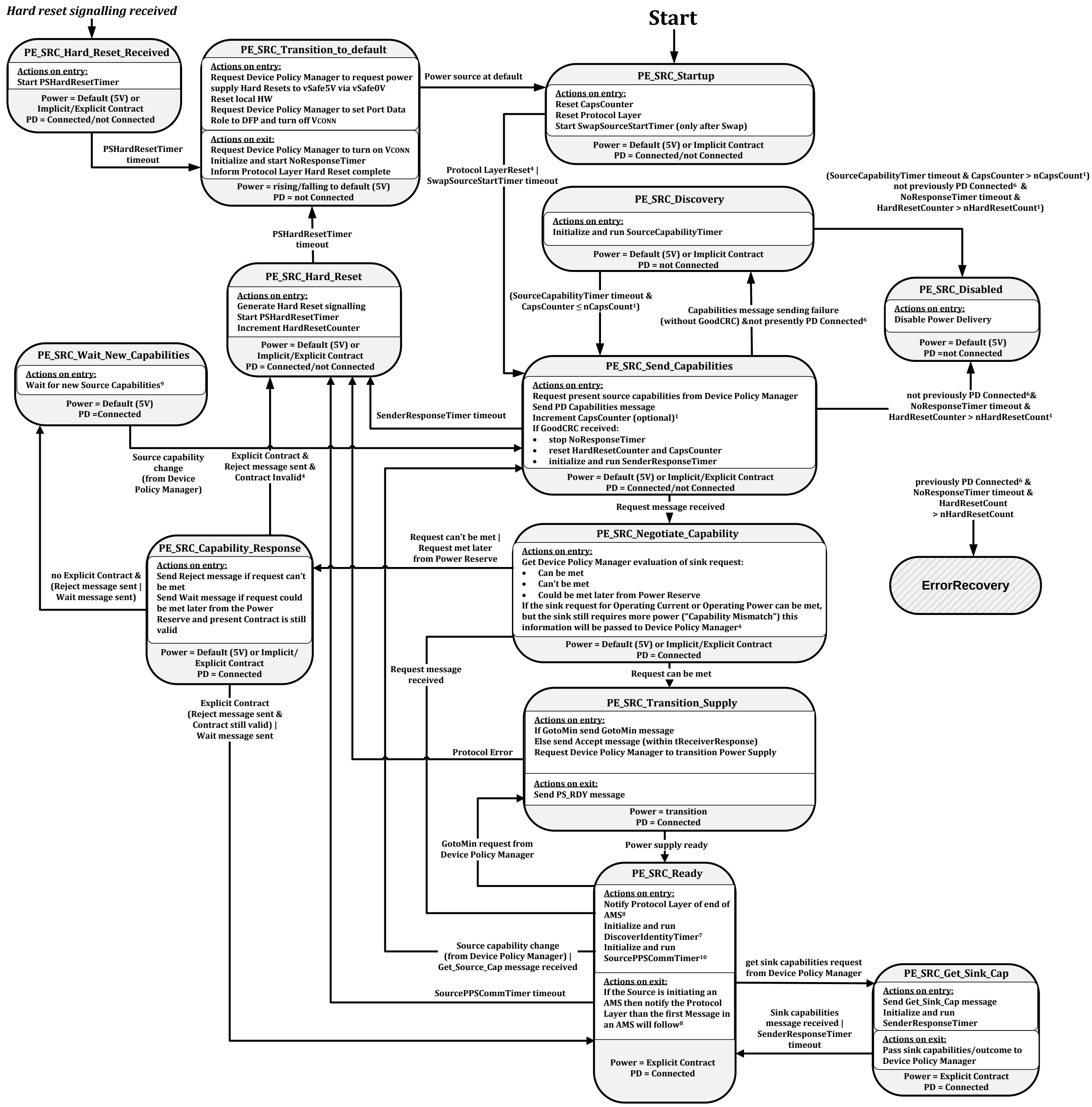
1. Message and related indications passed up to the Policy Engine from the Protocol Layer (Message sent, Message received etc.)
2. Events triggered within the Policy Engine e.g. timer timeouts.
3. Information and requests coming from the Device Policy manager relating either to Local Policy, or to other modules which the Device Policy Manager controls such as power supply and USB-C Port Control.

Note: The following state diagrams are not intended to cover all possible corner cases that could be encountered. For example where an outgoing Message is ***Discarded***, due to an incoming Message by the Protocol Layer (see Section 6.11.2.3) it will be necessary for the higher layers of the system to handle a retry of the Message sequence that was being initiated, after first handling the incoming Message.

8.3.3.2 Policy Engine Source Port State Diagram

Figure 8-66 below shows the state diagram for the Policy Engine in a Source Port. The following sections describe operation in each of the states.

Figure 8-66 Source Port Policy Engine State Diagram



[1] Implementation of the ***CapsCounter*** is ***Optional***. In the case where this is not implemented the Source ***Shall*** continue to send ***Source_Capabilities*** Messages each time the ***SourceCapabilityTimer*** times out.

[2] Since the Sink is required to make a ***Valid*** request from the offered capabilities the expected transition is via "Request can be met" unless the Source capabilities have changed since the last offer.

[3] "Contract ***Invalid***" means that the previously negotiated Voltage and Current values are no longer included in the Source's new Capabilities. If the Sink fails to make a ***Valid*** Request in this case then Power Delivery operation is no longer possible and Power Delivery mode is exited with a Hard Reset.

[4] After a Power Swap the new Source is required to wait an additional ***tSwapSourceStart*** before sending a ***Source_Capabilities*** Message. This delay is not required when first starting up a system.

[5] PD Connected is defined as a situation when the Port Partners are actively communicating. The Port Partners remain PD Connected after a Swap until there is a transition to Disabled or the connector is able to identify a Detach.

[6] Port Partners are no longer PD Connected after a Hard Reset but consideration needs to be given as to whether there has been a PD Connection while the Ports have been Attached to prevent unnecessary USB Type-C Error Recovery.

[7] The ***DiscoverIdentityTimer*** is run when this is a VCONN Source and a PD Connection with a Cable Plug needs to be established i.e. no ***GoodCRC*** Message has yet been received in response to a ***Discover Identity*** Command.

[8] If transition into the ***PE_SRC_Ready*** state will result in an immediate transition out of the ***PE_SRC_Ready*** state e.g. it is due to a Protocol Error that has not resulted in a Soft Reset then the notifications of the end of AMS and first Message in an AMS ***May Not*** be sent to avoid changing the Rp value unnecessarily.

[9] In the ***PE_SRC_Wait_New_Capabilities*** State the Device Policy Manager ***Should*** either decide to send no further Source Capabilities or ***Should*** send a different set of Source Capabilities. Continuing to send the same set of Source Capabilities could result in a live lock situation.

[10] The ***SourcePPSCommTimer*** is only initialized and run when the present Explicit Contract is for a PPS APDO. Source's that do not support PPS do not need to implement the ***SourcePPSCommTimer***.

8.3.3.2.1 PE_SRC_Startup State

PE_SRC_Startup Shall be the starting state for a Source Policy Engine either on power up or after a Hard Reset. On entry to this state the Policy Engine ***Shall*** reset the ***CapsCounter*** and reset the Protocol Layer. Note that resetting the Protocol Layer will also reset the ***MessageIDCounter*** and stored ***MessageID*** (see Section 6.11.2.3).

The Policy Engine ***Shall*** transition to the ***PE_SRC_Send_Capabilities*** state:

- When the Protocol Layer reset has completed if the ***PE_SRC_Startup*** state was entered due to the system first starting up.
- When the ***SwapSourceStartTimer*** times out if the ***PE_SRC_Startup*** state was entered as the result of a Power Role Swap.

Note: Sources ***Shall*** remain in the ***PE_SRC_Startup*** state, without sending any ***Source_Capabilities*** Messages until a plug is Attached.

8.3.3.2.2 PE_SRC_Discovery State

On entry to the ***PE_SRC_Discovery*** state the Policy Engine ***Shall*** initialize and run the ***SourceCapabilityTimer*** in order to trigger sending a ***Source_Capabilities*** Message.

The Policy Engine ***Shall*** transition to the ***PE_SRC_Send_Capabilities*** state when:

- The ***SourceCapabilityTimer*** times out and ***CapsCounter*** ≤ ***nCapsCount***.

The Policy Engine ***May Optionally*** go to the ***PE_SRC_Disabled*** state when:

- The Port Partners are not presently PD Connected
- And the ***SourceCapabilityTimer*** times out
- And ***CapsCounter*** > ***nCapsCount***.

The Policy Engine ***Shall*** go to the ***PE_SRC_Disabled*** state when:

- The Port Partners have not been PD Connected (the Source Port remains Attached to a Port it has not had a PD Connection with during this Attachment)

- And the ***NoResponseTimer*** times out
- And the ***HardResetCounter*** > ***nHardResetCount.***

Note in the ***PE_SRC_Disabled*** state the Attached device is assumed to be unresponsive. The Policy Engine operates as if the device is Detached until such time as a Detach/re-Attach is detected.

8.3.3.2.3 PE_SRC_Send_Capabilities State

Note: this state can be entered from the ***PE_SRC_Soft_Reset*** state.

On entry to the ***PE_SRC_Send_Capabilities*** state the Policy Engine ***Shall*** request the present Port capabilities from the Device Policy Manager. The Policy Engine ***Shall*** then request the Protocol Layer to send a ***Source_Capabilities*** Message containing these capabilities and increment the ***CapsCounter*** (if implemented).

If a ***GoodCRC*** Message is received then the Policy Engine ***Shall***:

- Stop the ***NoResponseTimer*** .
- Reset the ***HardResetCounter*** and ***CapsCounter*** to zero. Note that the ***HardResetCounter*** ***Shall*** only be set to zero in this state and at power up; its value ***Shall*** be maintained during a Hard Reset.
- Initialize and run the ***SenderResponseTimer***.

Once a ***Source_Capabilities*** Message has been received and acknowledged by a ***GoodCRC*** Message, the Sink is required to then send a ***Request*** Message within ***tSenderResponse***.

The Policy Engine ***Shall*** transition to the ***PE_SRC_Negotiate_Capability*** state when:

- A ***Request*** Message is received from the Sink.

The Policy Engine ***Shall*** transition to the ***PE_SRC_Discovery*** state when:

- The Protocol Layer indicates that the Message has not been sent and we are presently not Connected. This is part of the Capabilities sending process whereby successful Message sending indicates connection to a PD Sink Port.

The Policy Engine ***Shall*** transition to the ***PE_SRC_Hard_Reset*** state when:

- The ***SenderResponseTimer*** times out. In this case a transition back to USB Default Operation is required.

When:

- The Port Partners have not been PD Connected (the Source Port remains Attached to a Port it has not had a PD Connection with during this Attachment)
- And the ***NoResponseTimer*** times out
- And the ***HardResetCounter*** > ***nHardResetCount.***

The Policy Engine ***Shall*** do one of the following:

- Transition to the ***PE_SRC_Discovery*** state.
- Transition to the ***PE_SRC_Disabled*** state.

Note that in either case the Attached device is assumed to be unresponsive. The Policy Engine ***Should*** operate as if the device is Detached until such time as a Detach/re-Attach is detected.

The Policy Engine ***Shall*** go to the ***ErrorRecovery*** state when:

- The Port Partners have previously been PD Connected (the Source Port remains Attached to a Port it has had a PD Connection with during this Attachment)
- And the ***NoResponseTimer*** times out.
- And the ***HardResetCounter*** > ***nHardResetCount.***

8.3.3.2.4 PE_SRC_Negotiate_Capability State

On entry to the ***PE_SRC_Negotiate_Capability*** state the Policy Engine ***Shall*** ask the Device Policy Manager to evaluate the Request from the Attached Sink. The response from the Device Policy Manager ***Shall*** be one of the following:

- The Request can be met.
- The Request cannot be met
- The Request could be met later from the Power Reserve.

The Policy Engine ***Shall*** transition to the ***PE_SRC_Transition_Supply*** state when:

- The Request can be met.

The Policy Engine ***Shall*** transition to the ***PE_SRC_Capability_Response*** state when:

- The Request cannot be met.
- Or the Request can be met later from the Power Reserve.

8.3.3.2.5 PE_SRC_Transition_Supply State

The Policy Engine ***Shall*** be in the ***PE_SRC_Transition_Supply*** state while the power supply is transitioning from one power to another.

On entry to the ***PE_SRC_Transition_Supply*** state, the Policy Engine ***Shall*** request the Protocol Layer to either send a ***GotoMin*** Message (if this was requested by the Device Policy Manager) or otherwise an ***Accept*** Message and inform the Device Policy Manager that it ***Shall*** transition the power supply to the Requested power level. Note: that if the power supply is currently operating at the requested power no change will be necessary.

On exit from the ***PE_SRC_Transition_Supply*** state the Policy Engine ***Shall*** request the Protocol Layer to send a ***PS_RDY*** Message.

The Policy Engine ***Shall*** transition to the ***PE_SRC_Ready*** state when:

- The Device Policy Manager informs the Policy Engine that the power supply is ready.

The Policy Engine ***Shall*** transition to the ***PE_SRC_Hard_Reset*** state when:

- A Protocol Error occurs.

8.3.3.2.6 PE_SRC_Ready State

In the ***PE_SRC_Ready*** state the PD Source ***Shall*** operating at a stable power with no ongoing negotiation. It ***Shall*** respond to requests from the Sink, events from the Device Policy Manager.

On entry to the ***PE_SRC_Ready*** state the Source ***Shall*** notify the Protocol Layer of the end of the Atomic Message Sequence (AMS). If the transition into ***PE_SRC_Ready*** is the result of Protocol Error that has not caused a Soft Reset (see Section 8.3.3.4.1) then the notification to the Protocol Layer of the end of the AMS ***Shall Not*** be sent since there is a Message to be processed.

On entry to the ***PE_SRC_Ready*** state if this is a DFP which needs to establish communication with a Cable Plug, the DFP ***Shall***:

- Initialize and run the ***DiscoverIdentityTimer*** (no ***GoodCRC*** Message response yet received to ***Discover Identity*** Message).

On entry to the ***PE_SNK_Ready*** state if the current Explicit Contract is for a PPS APDO, then the Policy Engine ***Shall*** do the following:

- Initialize and run the ***SourcePPSCommTimer***.

On exit from the ***PE_SRC_Ready***, if the Source is initiating an AMS then the Policy Engine ***Shall*** notify the Protocol Layer that the first Message in an AMS will follow.

The Policy Engine ***Shall*** transition to the ***PE_SRC_Send_Capabilities*** state when:

- The Device Policy Manager indicates that Source Capabilities have changed or
- A ***Get_Source_Cap*** Message is received.

The Policy Engine ***Shall*** transition to the ***PE_SRC_Transition_Supply*** state when:

- A GotoMin request is received from the Device Policy Manager for the Attached Device to go to minimum power.

The Policy Engine ***Shall*** transition to the ***PE_SRC_Get_Sink_Cap*** state when:

- The Device Policy Manager asks for the Sink's capabilities.

8.3.3.2.7 PE_SRC_Disabled State

In the ***PE_SRC_Disabled*** state the PD Source supplies default power and is unresponsive to USB Power Delivery messaging, but not to ***Hard Reset*** Signaling.

8.3.3.2.8 PE_SRC_Capability_Response State

The Policy Engine ***Shall*** enter the ***PE_SRC_Capability_Response*** state if there is a Request received from the Sink that cannot be met based on the present capabilities. When the present Contract is not within the present capabilities it is regarded as ***Invalid*** and a Hard Reset will be triggered.

On entry to the ***PE_SRC_Capability_Response*** state the Policy Engine ***Shall*** request the Protocol Layer to send one of the following:

- ***Reject*** Message – if the request cannot be met or the present Contract is ***Invalid***.
- ***Wait*** Message – if the request could be met later from the Power Reserve. A ***Wait*** Message ***Shall Not*** be sent if the present Contract is ***Invalid***.

The Policy Engine ***Shall*** transition to the ***PE_SRC_Ready*** state when:

- There is an Explicit Contract and
- A ***Reject*** Message has been sent and the present Contract is still ***Valid*** or
- A ***Wait*** Message has been sent.

The Policy Engine ***Shall*** transition to the ***PE_SRC_Hard_Reset*** state when:

- There is an Explicit Contract and
- The ***Reject*** Message has been sent and the present Contract is ***Invalid*** (i.e. the Sink had to request a new value so instead we will return to USB Default Operation).

The Policy Engine ***Shall*** transition to the ***PE_SRC_Wait_New_Capabilities*** state when:

- There is no Explicit Contract and
- A ***Reject*** Message has been sent or
- A ***Wait*** Message has been sent.

8.3.3.2.9 PE_SRC_Hard_Reset State

On entry to the ***PE_SRC_Hard_Reset*** state the Policy Engine ***Shall*** request the generation of ***Hard Reset*** Signaling by the PHY Layer, initialize and run the ***PSHardResetTimer*** and increment the ***HardResetCounter***. Note that the ***NoResponseTimer*** ***Shall*** continue to run in every state until it is stopped or times out.

The Policy Engine ***Shall*** transition to the ***PE_SRC_Transition_to_default*** state when:

- The ***PSHardResetTimer*** times out.

8.3.3.2.10 PE_SRC_Hard_Reset_Received State

The Policy Engine ***Shall*** transition from any state to the ***PE_SRC_Hard_Reset_Received*** state when:

- ***Hard Reset*** Signaling is detected.

On entry to the ***PE_SRC_Hard_Reset_Received*** state the Policy Engine ***Shall*** initialize and run the ***PSHardResetTimer***.

The Policy Engine ***Shall*** transition to the ***PE_SRC_Transition_to_default*** state when:

- The ***PSHardResetTimer*** times out.

8.3.3.2.11 PE_SRC_Transition_to_default State

On entry to the ***PE_SRC_Transition_to_default*** state the Policy Engine ***Shall***:

- indicate to the Device Policy Manager that the power supply ***Shall*** Hard Reset (see Section 7.1.5)
- request a reset of the local hardware
- request the Device Policy Manager to set the Port Data Role to DFP and turn off VCONN.

On exit from the ***PE_SRC_Transition_to_default*** state the Policy Engine ***Shall***:

- request the Device Policy Manager to turn on VCONN
- initialize and run the ***NoResponseTimer*****.** Note that the ***NoResponseTimer*** ***Shall*** continue to run in every state until it is stopped or times out.
- inform the Protocol Layer that the Hard Reset is complete**.**

The Policy Engine ***Shall*** transition to the ***PE_SRC_Startup*** state when:

- The Device Policy Manager indicates that the power supply has reached the default level.

8.3.3.2.12 PE_SRC_Get_Sink_Cap State

In this state the Policy Engine, due to a request from the Device Policy Manager, ***Shall*** request the capabilities from the Attached Sink.

On entry to the ***PE_SRC_Get_Sink_Cap*** state the Policy Engine ***Shall*** request the Protocol Layer to send a ***Get_Sink_Cap*** Message in order to retrieve the Sink's capabilities. The Policy Engine ***Shall*** then start the ***SenderResponseTimer***.

On exit from the ***PE_SRC_Get_Sink_Cap*** state the Policy Engine ***Shall*** inform the Device Policy Manager of the outcome (capabilities or response timeout).

The Policy Engine ***Shall*** transition to the ***PE_SRC_Ready*** state when:

- A ***Sink_Capabilities*** Message is received.
- Or ***SenderResponseTimer*** times out.

8.3.3.2.13 PE_SRC_Wait_New_Capabilities State

In this state the Policy Engine has been unable to negotiate an Explicit Contract and is waiting for new Capabilities from the Device Policy Manager.

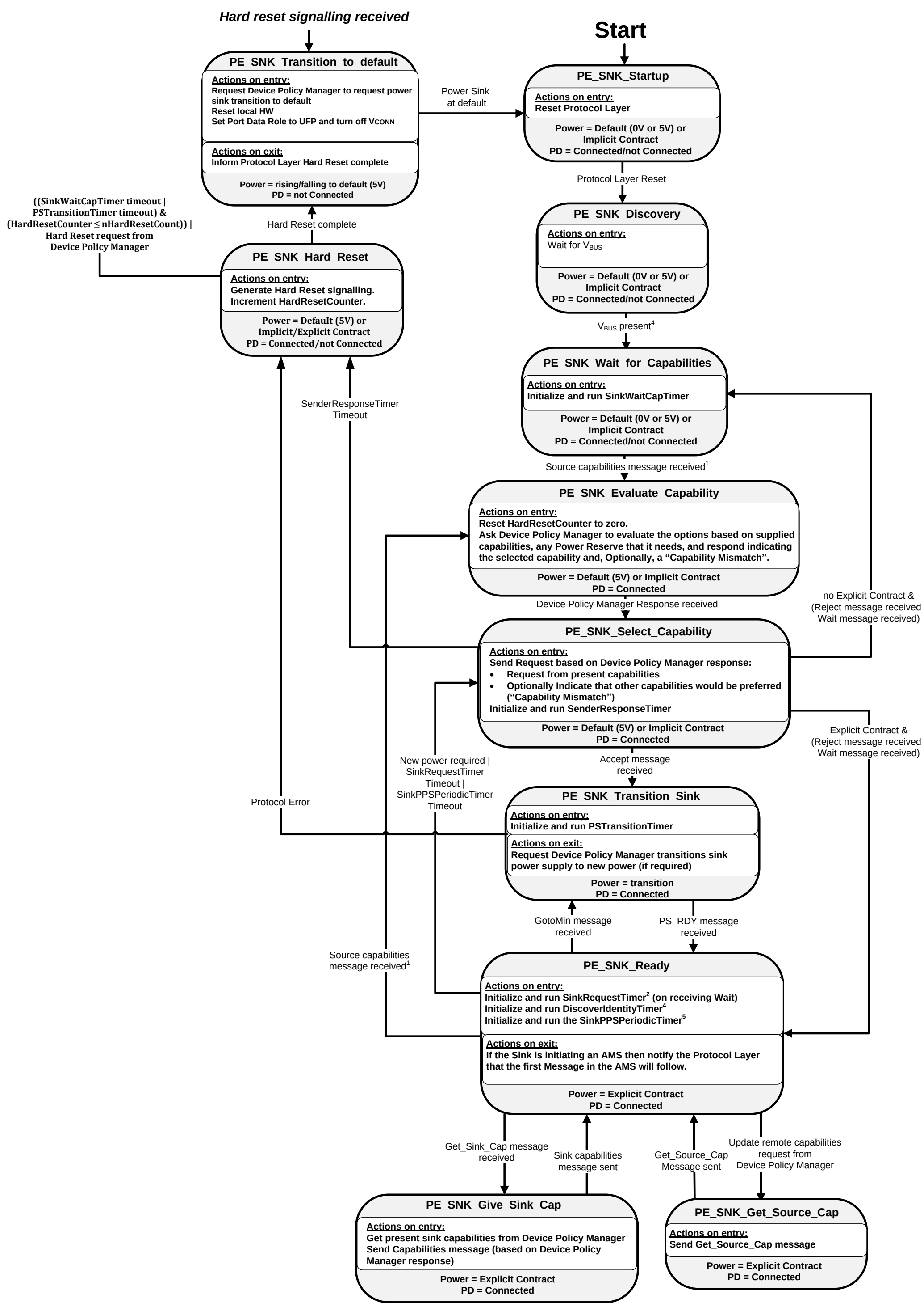
The Policy Engine ***Shall*** transition to the ***PE_SRC_Send_Capabilities*** state when:

- The Device Policy Manager indicates that Source Capabilities have changed.

8.3.3.3 Policy Engine Sink Port State Diagram

Figure 8-67 below shows the state diagram for the Policy Engine in a Sink Port. The following sections describe operation in each of the states.

Figure 8-67 Sink Port State Diagram



[1] Source capabilities messages received in states other than ***PE_SNK_Wait_for_Capabilities*** and ***PE_SNK_Ready*** constitute a Protocol Error.

[2] The ***SinkRequestTimer*** ***Should Not*** be stopped if a ***Ping*** Message is received in the ***PE_SNK_Ready*** state since it represents the maximum time between requests after a ***Wait*** Message which is not reset by a ***Ping*** Message.

[3] During a Hard Reset the Source voltage will transition to ***vSafe0V*** and then transition to ***vSafe5V***. Sinks need to ensure that V_{BUS} present is not indicated until after the Source has completed the Hard Reset process by detecting both of these transitions.

[4] The ***DiscoverIdentityTimer*** is run when this is a VCONN Source and a PD Connection with a Cable Plug needs to be established i.e. no ***GoodCRC*** Message has yet been received in response to a ***Discover Identity*** Command.

[5] The ***SinkPPSPeriodicTimer*** is only initialized and run when the present Explicit Contract is for a PPS APDO. Sink's that do not support PPS do not need to implement the ***SinkPPSPeriodicTimer***.

8.3.3.3.1 PE_SNK_Startup State

PE_SNK_Startup ***Shall*** be the starting state for a Sink Policy Engine either on power up or after a Hard Reset. On entry to this state the Policy Engine ***Shall*** reset the Protocol Layer. Note that resetting the Protocol Layer will also reset the ***MessageIDCounter*** and stored ***MessageID*** (see Section 6.11.2.3).

Once the reset process completes, the Policy Engine ***Shall*** transition to the ***PE_SNK_Discovery*** state.

8.3.3.3.2 PE_SNK_Discovery State

In the ***PE_SNK_Discovery*** state the Sink Policy Engine waits for V_{BUS} to be present.

The Policy Engine ***Shall*** transition to the ***PE_SNK_Wait_for_Capabilities*** state when:

- The Device Policy Manager indicates that V_{BUS} has been detected.

8.3.3.3.3 PE_SNK_Wait_for_Capabilities State

On entry to the ***PE_SNK_Wait_for_Capabilities*** state the Policy Engine ***Shall*** initialize and start the ***SinkWaitCapTimer***.

The Policy Engine ***Shall*** transition to the ***PE_SNK_Evaluate_Capability*** state when:

- A ***Source_Capabilities*** Message is received.

When the ***SinkWaitCapTimer*** times out, the Policy Engine will perform a Hard Reset.

8.3.3.3.4 PE_SNK_Evaluate_Capability State

The ***PE_SNK_Evaluate_Capability*** state is first entered when the Sink receives its first ***Source_Capabilities*** Message from the Source. At this point the Sink knows that it is Attached to and communicating with a PD capable Source.

On entry to the ***PE_SNK_Evaluate_Capability*** state the Policy Engine ***Shall*** request the Device Policy Manager to evaluate the supplied Source capabilities based on Local Policy. The Device Policy Manager ***Shall*** indicate to the Policy Engine the new power level required, selected from the present offered capabilities. The Device Policy Manager ***Shall*** also indicate to the Policy engine a Capability Mismatch if the offered power does not meet the device's requirements.

The Policy Engine ***Shall*** transition to the ***PE_SNK_Select_Capability*** state when:

- A response is received from the Device Policy Manager.

8.3.3.3.5 PE_SNK_Select_Capability State

On entry to the ***PE_SNK_Select_Capability*** state the Policy Engine ***Shall*** request the Protocol Layer to send a response Message, based on the evaluation from the Device Policy Manager. The Message ***Shall*** be one of the following:

- A Request from the offered Source Capabilities.
- A Request from the offered Source Capabilities with an indication that another power level would be preferred ("Capability Mismatch" bit set).

The Policy Engine ***Shall*** initialize and run the ***SenderResponseTimer***.

The Policy Engine ***Shall*** transition to the ***PE_SNK_Transition_Sink*** state when:

- An ***Accept*** Message is received from the Source.

The Policy Engine ***Shall*** transition to the ***PE_SNK_Wait_for_Capabilities*** state when:

- There is no Explicit Contract in place and
- A ***Reject*** Message is received from the Source or
- A ***Wait*** Message is received from the Source.

The Policy Engine ***Shall*** transition to the ***PE_SNK_Ready*** state when:

- There is an Explicit Contract in place and
- A ***Reject*** Message is received from the Source or
- A ***Wait*** Message is received from the Source.

The Policy Engine ***Shall*** transition to the ***PE_SNK_Hard_Reset*** state when:

- A ***SenderResponseTimer*** timeout occurs.

8.3.3.3.6 PE_SNK_Transition_Sink State

On entry to the ***PE_SNK_Transition_Sink*** state the Policy Engine ***Shall*** initialize and run the ***PSTransitionTimer*** (timeout will lead to a Hard Reset see Section 8.3.3.3.8 and ***Shall*** then request the Device Policy Manager to transition the Sink's power supply to the new power level. Note that if there is no power level change the Device Policy Manager ***Should Not*** affect any change to the power supply.

On exit from the ***PE_SNK_Transition_Sink*** state the Policy Engine ***Shall*** request the Device Policy Manager to transition the Sink's power supply to the new power level.

The Policy Engine ***Shall*** transition to the ***PE_SNK_Ready*** state when:

- A ***PS_RDY*** Message is received from the Source.

The Policy Engine ***Shall*** transition to the ***PE_SNK_Hard_Reset*** state when:

- A Protocol Error occurs.

8.3.3.3.7 PE_SNK_Ready State

In the ***PE_SNK_Ready*** state the PD Sink ***Shall*** be operating at a stable power level with no ongoing negotiation. It ***Shall*** respond to requests from the Source, events from the Device Policy Manager and ***May*** monitor for ***Ping*** Messages to maintain the PD link.

On entry to the ***PE_SNK_Ready*** state as the result of a wait the Policy Engine ***Should*** do the following:

- Initialize and run the ***SinkRequestTimer***.

On entry to the ***PE_SNK_Ready*** state if this is a DFP which needs to establish communication with a Cable Plug, then the Policy Engine ***Shall*** do the following:

- Initialize and run the ***DiscoverIdentityTimer*** (no ***GoodCRC*** Message response yet received to ***Discover Identity*** Message).

On entry to the ***PE_SNK_Ready*** state if the current Explicit Contract is for a PPS APDO, then the Policy Engine ***Shall*** do the following:

- Initialize and run the ***SinkPPSPeriodicTimer***.

On exit from the ***PE_SNK_Ready*** state, if the transition is as a result of a DPM request to start a new Atomic Message Sequence (AMS) then the Policy Engine ***Shall*** notify the Protocol Layer that the first Message in an AMS will follow.

The Policy Engine ***Shall*** transition to the ***PE_SNK_Evaluate_Capability*** state when:

- A ***Source_Capabilities*** Message is received.

The Policy Engine ***Shall*** transition to the ***PE_SNK_Select_Capability*** state when:

- A new power level is requested by the Device Policy Manager.
- A ***SinkRequestTimer*** timeout occurs.

The Policy Engine ***Shall*** transition to the ***PE_SNK_Transition_Sink*** state when:

- A ***GotoMin*** Message is received.

The Policy Engine ***Shall*** transition back to the ***PE_SNK_Ready*** state when:

- A ***Ping*** Message is received. Note this ***Should Not*** cause the ***SinkRequestTimer*** to be reinitialized.

The Policy Engine ***Shall*** transition to the ***PE_SNK_Give_Sink_Cap*** state when:

- A ***Get_Sink_Cap*** Message is received from the Protocol Layer.

The Policy Engine ***Shall*** transition to the ***PE_SNK_Get_Source_Cap*** state when:

- The Device Policy Manager requests an update of the remote Source's capabilities.

8.3.3.3.8 PE_SNK_Hard_Reset State

The Policy Engine ***Shall*** transition to the ***PE_SNK_Hard_Reset*** state from any state when:

- ((***SinkWaitCapTimer*** timeout **|**
- ***PSTransitionTimer*** timeout **|**
- ***NoResponseTimer*** timeout) &
- (***HardResetCounter*** ≤ ***nHardResetCount***)) **|**
- Hard Reset request from Device Policy Manager.

Note: if the ***NoResponseTimer*** times out and the ***HardResetCounter*** is greater than ***nHardResetCount*** the Sink ***Shall*** assume that the Source is non-responsive.

Note: The ***HardResetCounter*** is reset on a power cycle or Detach.

On entry to the ***PE_SNK_Hard_Reset*** state the Policy Engine ***Shall*** request the generation of ***Hard Reset*** Signaling by the PHY Layer and increment the ***HardResetCounter***.

The Policy Engine ***Shall*** transition to the ***PE_SNK_Transition_to_default*** state when:

- The Hard Reset is complete.

8.3.3.3.9 PE_SNK_Transition_to_default State

The Policy Engine ***Shall*** transition from any state to ***PE_SNK_Transition_to_default*** state when:

- ***Hard Reset*** Signaling is detected.

When ***Hard Reset*** Signaling is received or transmitted then the Policy Engine ***Shall*** transition from any state to ***PE_SNK_Transition_to_default***. This state can also be entered from the ***PE_SNK_Hard_Reset*** state.

On entry to the ***PE_SNK_Transition_to_default*** state the Policy Engine ***Shall***:

- indicate to the Device Policy Manager that the Sink ***Shall*** transition to default

- request a reset of the local hardware
- request the Device Policy Manger that the Port Data Role is set to UFP.

The Policy Engine ***Shall*** transition to the ***PE_SNK_Startup*** state when:

- The Device Policy Manager indicates that the Sink has reached the default level.

8.3.3.3.10 PE_SNK_Give_Sink_Cap State

On entry to the ***PE_SNK_Give_Sink_Cap*** state the Policy Engine ***Shall*** request the Device Policy Manager for the current system capabilities. The Policy Engine ***Shall*** then request the Protocol Layer to send a ***Sink_Capabilities*** Message containing these capabilities.

The Policy Engine ***Shall*** transition to the ***PE_SNK_Ready*** state when:

- The ***Sink_Capabilities*** Message has been successfully sent.

8.3.3.3.11 PE_SNK_Get_Source_Cap State

In the ***PE_SNK_Get_Source_Cap*** state the Policy Engine, due to a request from the Device Policy Manager, ***Shall*** request the capabilities from the Attached Source.

On entry to the ***PE_SNK_Get_Source_Cap*** state the Policy Engine ***Shall*** request the Protocol Layer to send a ***Get_Source_Cap*** Message in order to retrieve the Source's capabilities.

The Policy Engine ***Shall*** transition to the ***PE_SNK_Ready*** state when:

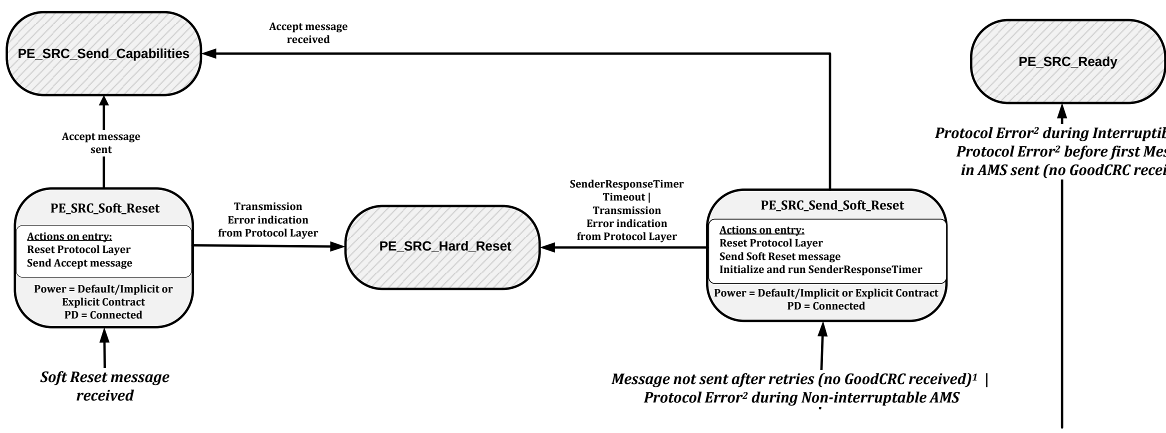
- The ***Get_Source_Cap*** Message is sent.

8.3.3.4 Soft Reset and Protocol Error State Diagrams

8.3.3.4.1 Source Port Soft Reset and Protocol Error State Diagram

Figure 8-68 below shows the state diagram for the Policy Engine in a Source Port when performing a Soft Reset of its Port Partner. The following sections describe operation in each of the states.

Figure 8-68 Source Port Soft Reset and Protocol Error State Diagram



[1] Excludes the ***Soft_Reset*** Message itself.

[2] An unrecognized or unsupported Message will result in a ***Not_Supported*** Message response being generated (see Section 6.3.14).

8.3.3.4.1.1 PE_SRC_Send_Soft_Reset State

The ***PE_SRC_Send_Soft_Reset*** state ***Shall*** be entered from any state when a Protocol Error is detected by the Protocol Layer during a Non-interruptible AMS (see Section 6.8.1) or when a Message has not been sent after retries to the Sink. The main exceptions to this rule are when:

- The source is in the ***PE_SRC_Send_Capabilities*** state, there is a ***Source_Capabilities*** Message sending failure (without GoodCRC) and the source is not presently Attached (as indicated in Figure 8-66). In this case, the ***PE_SRC_Discovery*** state is entered (see Section 8.3.3.2.3).
- When the voltage is in transition due to a new Explicit Contract being negotiated (see Section 8.3.3.2). In this case a Hard Reset will be generated.
- During a Power Role Swap when the power supply is in transition (see Section 8.3.3.16.3 and Section 8.3.3.16.4). In this case USB Type-C Error Recovery will be triggered directly.
- During a Data Role Swap when there is a mismatch in the Port Date Role field (see Section 6.2.1.1.6). In this case USB Type-C Error Recovery will be triggered directly.

Note that Protocol Errors occurring in the following situations ***Shall Not*** lead to a Soft Reset, but ***Shall*** result in a transition to the ***PE_SRC_Ready*** state where the Message received will be handled as if it had been received in the ***PE_SRC_Ready*** state:

- Protocol Errors occurring during an Interruptible AMS.
- Protocol Errors occurring during any AMS where the first Message in the sequence has not yet been sent i.e. an unexpected Message is received instead of the expected ***GoodCRC*** Message response.

On entry to the ***PE_SRC_Send_Soft_Reset*** state the Policy Engine ***Shall*** request the Protocol Layer to perform a Soft Reset, then ***Shall*** send a ***Soft_Reset*** Message to the Sink, and initialize and run the ***SenderResponseTimer***.

The Policy Engine ***Shall*** transition to the ***PE_SRC_Send_Capabilities*** state when:

- An ***Accept*** Message has been received.

The Policy Engine ***Shall*** transition to the ***PE_SRC_Hard_Reset*** state when:

- A ***SenderResponseTimer*** timeout occurs.
- Or the Protocol Layer indicates that a transmission error has occurred.

8.3.3.4.1.2 PE_SRC_Soft_Reset State

The ***PE_SRC_Soft_Reset*** state ***Shall*** be entered from any state when a ***Soft_Reset*** Message is received from the Protocol Layer.

On entry to the ***PE_SRC_Soft_Reset*** state the Policy Engine ***Shall*** reset the Protocol Layer and ***Shall*** then request the Protocol Layer to send an ***Accept*** Message.

The Policy Engine ***Shall*** transition to the ***PE_SRC_Send_Capabilities*** state (see Section 8.3.3.2.3) when:

- The ***Accept*** Message has been sent.

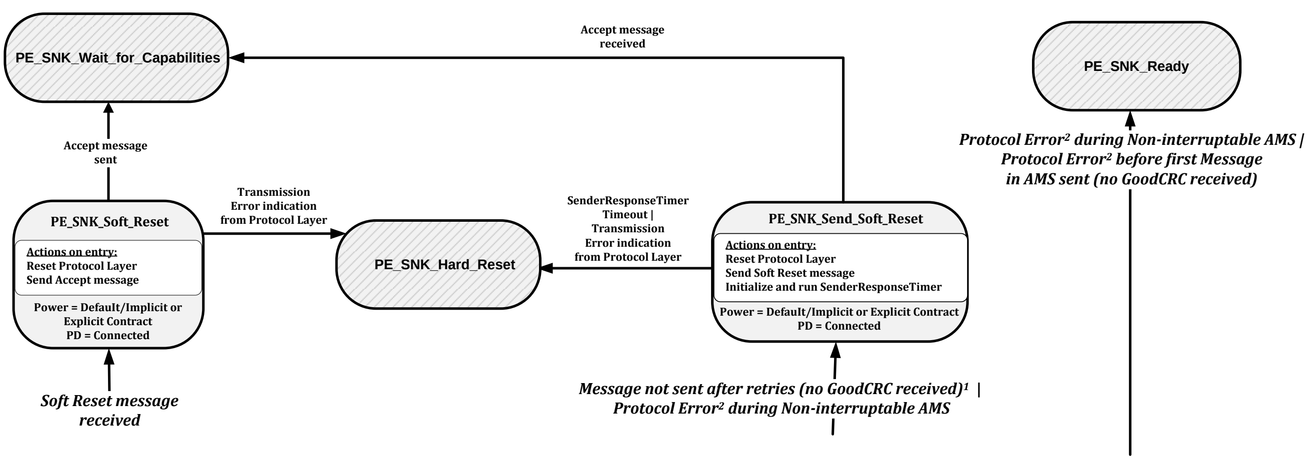
The Policy Engine ***Shall*** transition to the ***PE_SRC_Hard_Reset*** state when:

- The Protocol Layer indicates that a transmission error has occurred.

8.3.3.4.2 Sink Port Soft Reset and Protocol Error State Diagram

Figure 8-69 below shows the state diagram for the Policy Engine in a Sink Port when performing a Soft Reset of its Port Partner. The following sections describe operation in each of the states.

Figure 8-69 Sink Port Soft Reset and Protocol Error Diagram



[1] Excludes the ***Soft_Reset*** Message itself.

[2] An unrecognized or unsupported Message will result in a ***Not_Supported*** Message response being generated (see Section 6.3.14).

8.3.3.4.2.1 PE_SNK_Send_Soft_Reset State

The ***PE_SNK_Send_Soft_Reset*** state ***Shall*** be entered from any state when a Protocol Error is detected by the Protocol Layer during a Non-interruptible AMS (see Section 6.8.1) or when a Message has not been sent after retries to the Source. The main exceptions to this rule are when:

- When the voltage is in transition due to a new Explicit Contract being negotiated (see Section 8.3.3.3). In this case a Hard Reset will be generated.

- During a Power Role Swap when the power supply is in transition (see Section 8.3.3.16.3 and Section 8.3.3.16.4). In this case a hard reset will be triggered directly.
- During a Data Role Swap when the DFP/UFP roles are changing. In this case USB Type-C Error Recovery will be triggered directly.

Note that Protocol Errors occurring in the following situations ***Shall Not*** lead to a Soft Reset, but ***Shall*** result in a transition to the ***PE_SNK_Ready*** state where the Message received will be handled as if it had been received in the ***PE_SNK_Ready*** state:

- Protocol Errors occurring during an Interruptible AMS.
- Protocol Errors occurring during any AMS where the first Message in the sequence has not yet been sent i.e. an unexpected Message is received instead of the expected ***GoodCRC*** Message response.

On entry to the ***PE_SNK_Send_Soft_Reset*** state the Policy Engine ***Shall*** request the Protocol Layer to perform a Soft Reset, then ***Shall*** send a ***Soft_Reset*** Message to the Source, and initialize and run the ***SenderResponseTimer***.

The Policy Engine ***Shall*** transition to the ***PE_SNK_Wait_for_Capabilities*** state when:

- An ***Accept*** Message has been received.

The Policy Engine ***Shall*** transition to the ***PE_SNK_Hard_Reset*** state when:

- A ***SenderResponseTimer*** timeout occurs.
- Or the Protocol Layer indicates that a transmission error has occurred.

8.3.3.4.2.2 PE_SNK_Soft_Reset State

The ***PE_SNK_Soft_Reset*** state ***Shall*** be entered from any state when a ***Soft_Reset*** Message is received from the Protocol Layer.

On entry to the ***PE_SNK_Soft_Reset*** state the Policy Engine ***Shall*** reset the Protocol Layer and ***Shall*** then request the Protocol Layer to send an ***Accept*** Message.

The Policy Engine ***Shall*** transition to the ***PE_SNK_Wait_for_Capabilities*** state when:

- The ***Accept*** Message has been sent.

The Policy Engine ***Shall*** transition to the ***PE_SNK_Hard_Reset*** state when:

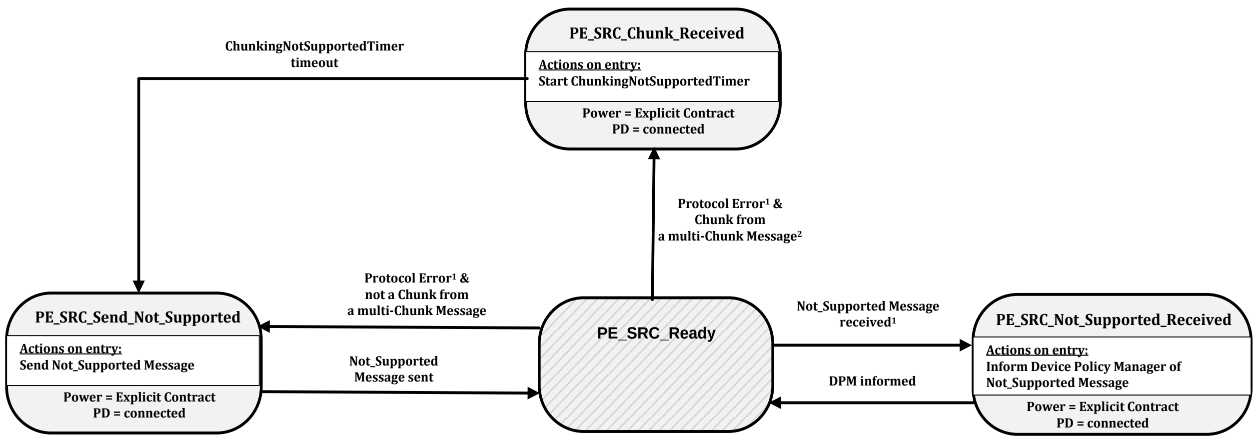
- The Protocol Layer indicates that a transmission error has occurred.

8.3.3.5 Not Supported Message State Diagrams

8.3.3.5.1 Source Port Not Supported Message State Diagram

Figure 8-70 shows the state diagram for a ***Not_Supported*** Message sent or received by a Source Port.

Figure 8-70 Source Port Not Supported Message State Diagram



[1] Transition can either be the result of a Protocol Error during an interruptible AMS or as a result of an unsupported Message being received in the ***PE_SRC_Ready*** state directly (see also Section 8.3.3.4.1).

[2] Transition can only occur where a manufacturer has opted not to implement a Chunking state machine (see Section 6.11.2.1) and is communicating with a system which is attempting to send it Chunks.

8.3.3.5.1.1 PE_SRC_Send_Not_Supported State

The ***PE_SRC_Send_Not_Supported*** state ***Shall*** be entered from the ***PE_SRC_Ready*** state either as the result of a Protocol Error received during an interruptible AMS or as a result of an unsupported Message being received in the ***PE_SRC_Ready*** state directly except for the first Chunk in a multi-Chunk Message (see also Section 6.11.2.1 and Section 8.3.3.4.1).

On entry to the ***PE_SRC_Send_Not_Supported*** state (from the ***PE_SRC_Ready*** state) the Policy Engine ***Shall*** request the Protocol Layer to send a ***Not_Supported*** Message.

The Policy Engine ***Shall*** transition back to the previous state (***PE_SRC_Ready*** see Figure 8-70) when:

- The ***Not_Supported*** Message has been successfully sent.

8.3.3.5.1.2 PE_SRC_Not_Supported_Received State

The ***PE_SRC_Not_Supported_Received*** state ***Shall*** be entered from the ***PE_SRC_Ready*** state when a ***Not_Supported*** Message is received.

On entry to the ***PE_SRC_Not_Supported_Received*** state the Policy Engine ***Shall*** inform the Device Policy Manager.

The Policy Engine ***Shall*** transition back to the previous state (***PE_SRC_Ready*** see Figure 8-70) when:

- The Device Policy Manager has been informed.

8.3.3.5.1.3 PE_SRC_Chunk_Received State

The ***PE_SRC_Chunk_Received*** state ***Shall*** be entered from the ***PE_SRC_Ready*** state either as the result of a Protocol Error received during an interruptible AMS or as a result of an unsupported Message being received in the

PE_SRC_Ready state directly where the Message is a Chunk in a multi-Chunk Message (see also Section 6.6.17.1 and Section 8.3.3.4.1).

On entry to the ***PE_SRC_Chunk_Received*** state (from the ***PE_SRC_Ready*** state) the Policy Engine ***Shall*** initialize and run the ***ChunkingNotSupportedTimer***.

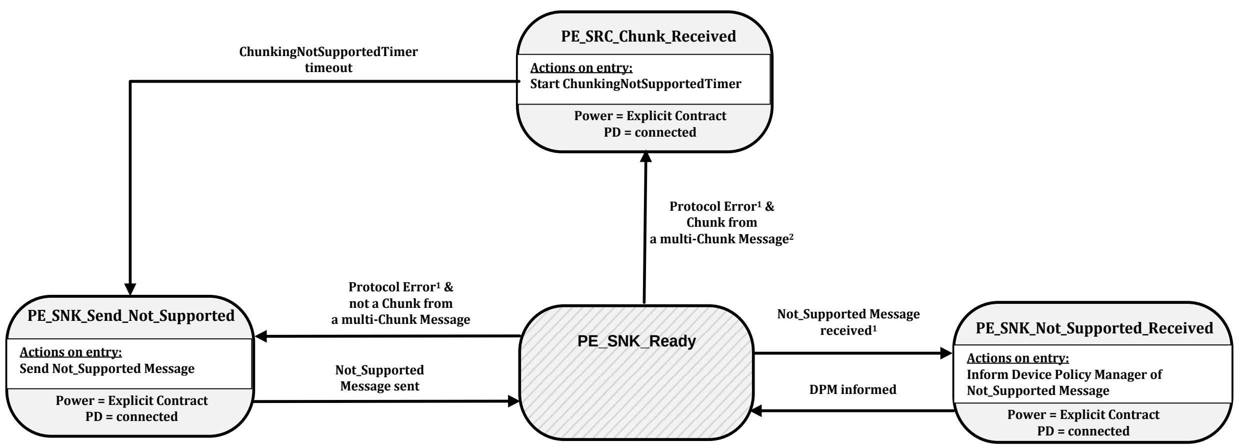
The Policy Engine ***Shall*** transition to ***PE_SRC_Send_Not_Supported*** when:

- The ***ChunkingNotSupportedTimer*** has timed out.

8.3.3.5.2 Sink Port Not Supported Message State Diagram

Figure 8-71 shows the state diagram for a ***Not_Supported*** Message sent or received by a Sink Port.

Figure 8-71 Sink Port Not Supported Message State Diagram



[1] Transition can either be the result of a Protocol Error during an interruptible AMS or as a result of an unsupported Message being received in the ***PE_SNK_Ready*** state directly (see also Section 8.3.3.4.2).

8.3.3.5.2.1 PE_SNK_Send_Not_Supported State

The ***PE_SNK_Send_Not_Supported*** state ***Shall*** be entered from the ***PE_SNK_Ready*** state either as the result of a Protocol Error received during an interruptible AMS or as a result of an unsupported Message being received in the ***PE_SNK_Ready*** state directly except for the first Chunk in a multi-Chunk Message (see also Section 6.11.2.1 and Section 8.3.3.4.1).

On entry to the ***PE_SNK_Send_Not_Supported*** state (from the ***PE_SNK_Ready*** state) the Policy Engine ***Shall*** request the Protocol Layer to send a ***Not_Supported*** Message.

The Policy Engine ***Shall*** transition back to the previous state (***PE_SNK_Ready*** see Figure 8-71) when:

- The ***Not_Supported*** Message has been successfully sent.

8.3.3.5.2.2 PE_SNK_Not_Supported_Received State

The ***PE_SNK_Not_Supported_Received*** state ***Shall*** be entered from the ***PE_SNK_Ready*** state when a ***Not_Supported*** Message is received.

On entry to the ***PE_SNK_Not_Supported_Received*** state the Policy Engine ***Shall*** inform the Device Policy Manager.

The Policy Engine ***Shall*** transition back to the previous state (***PE_SNK_Ready*** see Figure 8-71) when:

- The Device Policy Manager has been informed.

8.3.3.5.2.1 PE_SNK_Chunk_Received State

The ***PE_SNK_Chunk_Received*** state ***Shall*** be entered from the ***PE_SNK_Ready*** state either as the result of a Protocol Error received during an interruptible AMS or as a result of an unsupported Message being received in the ***PE_SNK_Ready*** state directly where the Message is a Chunk in a multi-Chunk Message (see also Section 6.6.17.1 and Section 8.3.3.4.1).

On entry to the ***PE_SNK_Chunk_Received*** state (from the ***PE_SNK_Ready*** state) the Policy Engine ***Shall*** initialize and run the ***ChunkingNotSupportedTimer***.

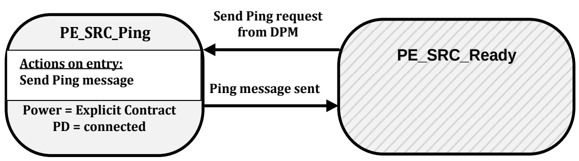
The Policy Engine ***Shall*** transition to ***PE_SNK_Send_Not_Supported*** when:

- The ***ChunkingNotSupportedTimer*** has timed out.

8.3.3.6 Source Port Ping State Diagram

Figure 8-70 shows the state diagram for a ***Ping*** Message from a Source Port.

Figure 8-72 Source Port Ping State Diagram



8.3.3.6.1 PE_SRC_Ping State

On entry to the ***PE_SRC_Ping*** state (from the ***PE_SRC_Ready*** state) the Policy Engine ***Shall*** request the Protocol Layer to send a ***Ping*** Message.

The Policy Engine ***Shall*** transition back to the previous state (***PE_SRC_Ready)*** (see Figure 8-66) when:

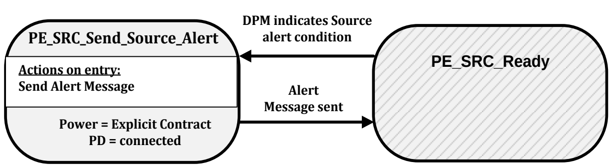
- The ***Ping*** Message has been successfully sent.

8.3.3.7 Source Alert State Diagrams

8.3.3.7.1 Source Port Source Alert State Diagram

Figure 8-73 shows the state diagram for an Alert Message sent by a Source Port.

Figure 8-73 Source Port Source Alert State Diagram



8.3.3.7.1.1 PE_SRC_Send_Source_Alert State

The ***PE_SRC_Send_Source_Alert*** state ***Shall*** be entered from the ***PE_SRC_Ready*** state when the Device Policy Manager indicates that there is a Source alert condition to be reported.

On entry to the ***PE_SRC_Send_Source_Alert*** state the Policy Engine ***Shall*** request the Protocol Layer to send an Alert Message.

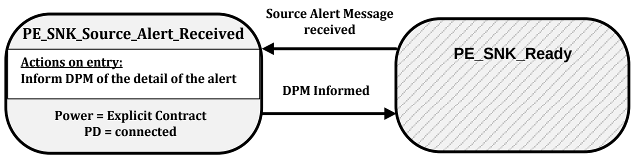
The Policy Engine ***Shall*** transition back to ***PE_SRC_Ready*** (see Figure 8-66) when:

- The ***Alert*** Message has been successfully sent.

8.3.3.7.2 Sink Port Source Alert State Diagram

Figure 8-74 shows the state diagram for an Alert Message received by a Sink Port.

Figure 8-74 Sink Port Source Alert State Diagram



8.3.3.7.2.1 PE_SNK_Source_Alert_Received State

The ***PE_SNK_Source_Alert_Received*** state ***Shall*** be entered from the ***PE_SNK_Ready*** state when an Alert Message is received.

On entry to the ***PE_SNK_Source_Alert_Received*** state the Policy Engine ***Shall*** inform the Device Policy Manager of the details of the Source alert.

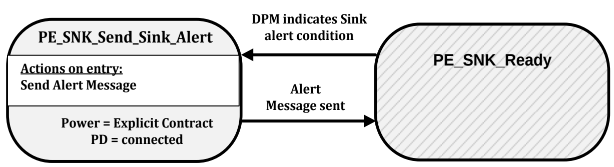
The Policy Engine ***Shall*** transition back to ***PE_SNK_Ready*** (see Figure 8-67) when:

- The DPM has been informed.

8.3.3.7.3 Sink Port Sink Alert State Diagram

Figure 8-75 shows the state diagram for an Alert Message sent by a Sink Port.

Figure 8-75 Sink Port Sink Alert State Diagram



8.3.3.7.3.1 PE_SNK_Send_Sink_Alert State

The ***PE_SNK_Send_Sink_Alert*** state ***Shall*** be entered from the ***PE_SNK_Ready*** state when the Device Policy Manager indicates that there is a Source alert condition to be reported.

On entry to the ***PE_SNK_Send_Sink_Alert*** state the Policy Engine ***Shall*** request the Protocol Layer to send an Alert Message.

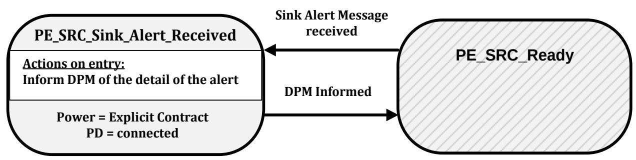
The Policy Engine ***Shall*** transition back to ***PE_SNK_Ready*** (see Figure 8-67) when:

- The ***Alert*** Message has been successfully sent.

8.3.3.7.4 Source Port Sink Alert State Diagram

Figure 8-76 shows the state diagram for an Alert Message received by a Source Port.

Figure 8-76 Source Port Sink Alert State Diagram



8.3.3.7.4.1 PE_SRC_Sink_Alert_Received State

The ***PE_SRC_Sink_Alert_Received*** state ***Shall*** be entered from the ***PE_SRC_Ready*** state when an Alert Message is received.

On entry to the ***PE_SRC_Sink_Alert_Received*** state the Policy Engine ***Shall*** inform the Device Policy Manager of the details of the Source alert.

The Policy Engine ***Shall*** transition back to ***PE_SRC_Ready*** (see Figure 8-66) when:

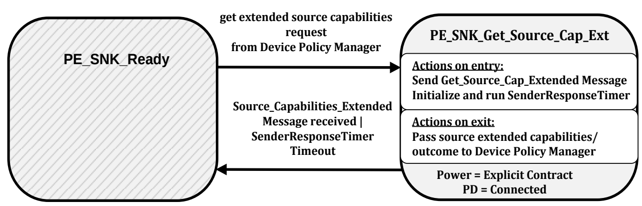
- The DPM has been informed.

8.3.3.8 Source Capabilities Extended State Diagrams

8.3.3.8.1 Sink Port Get Source Capabilities Extended State Diagram

Figure 8-77 shows the state diagram for a Sink on receiving a request from the Device Policy Manager to get the Port Partner's extended Source capabilities. See also Section 6.5.1.

Figure 8-77 Sink Port Get Source Capabilities Extended State Diagram



8.3.3.8.1.1 PE_SNK_Get_Source_Cap_Ext State

The Policy Engine ***Shall*** transition to the ***PE_SNK_Get_Source_Cap_Ext*** state, from the ***PE_SNK_Ready*** state, due to a request to get the remote extended source capabilities from the Device Policy Manager.

On entry to the ***PE_SNK_Get_Source_Cap_Ext*** state the Policy Engine ***Shall*** send a ***Get_Source_Cap_Extended*** Message and initialize and run the ***SenderResponseTimer***.

On exit from the ***PE_SNK_Get_Source_Cap_Ext*** state the Policy Engine ***Shall*** inform the Device Policy Manager of the outcome (capabilities or response timeout).

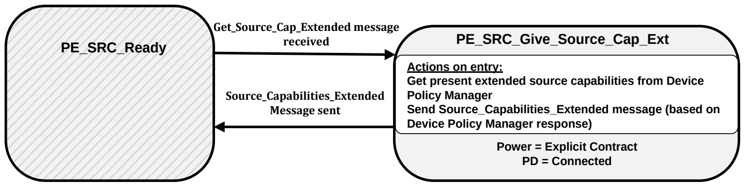
The Policy Engine ***Shall*** transition back to the ***PE_SNK_Ready*** state (see Figure 8-67) when:

- A ***Source_Capabilities_Extended*** Message is received
- Or ***SenderResponseTimer*** times out.

8.3.3.8.2 Source Give Source Capabilities Extended State Diagram

Figure 8-78 shows the state diagram for a Source on receiving a ***Get_Source_Cap_Extended*** Message. See also Section 6.5.1.

Figure 8-78 Source Give Source Capabilities Extended State Diagram



8.3.3.8.2.1 PE_SRC_Give_Source_Cap_Ext State

The Policy Engine ***Shall*** transition to the ***PE_SRC_Give_Source_Cap_Ext*** state, from the ***PE_SRC_Ready*** state, when a ***Get_Source_Cap_Extended*** Message is received.

On entry to the ***PE_SRC_Give_Source_Cap_Ext*** state the Policy Engine ***Shall*** request the present extended Source capabilities from the Device Policy Manager and then send a ***Source_Capabilities_Extended*** Message based on these capabilities.

The Policy Engine ***Shall*** transition back to the ***PE_SRC_Ready*** state (see Figure 8-66) when:

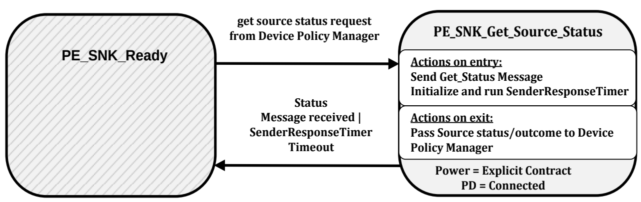
- The ***Source_Capabilities_Extended*** Message has been successfully sent.

8.3.3.9 Status State Diagrams

8.3.3.9.1 Sink Port Get Source Status State Diagram

Figure 8-79 shows the state diagram for a Sink on receiving a request from the Device Policy Manager to get the Port Partner's Source status. See also Section 6.5.2.

Figure 8-79 Sink Port Get Source Status State Diagram



8.3.3.9.1.1 PE_SNK_Get_Source_Status State

The Policy Engine ***Shall*** transition to the ***PE_SNK_Get_Source_Status*** state, from the ***PE_SNK_Ready*** state, due to a request to get the remote source status from the Device Policy Manager.

On entry to the ***PE_SNK_Get_Source_Status*** state the Policy Engine ***Shall*** send a ***Get_Status*** Message and initialize and run the ***SenderResponseTimer***.

On exit from the ***PE_SNK_Get_Source_Status*** state the Policy Engine ***Shall*** inform the Device Policy Manager of the outcome (status or response timeout).

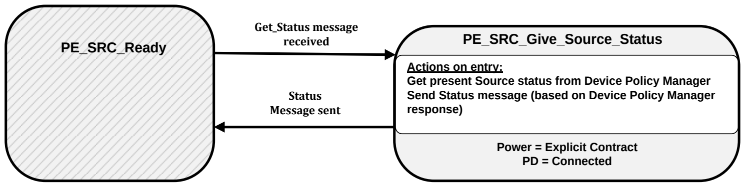
The Policy Engine ***Shall*** transition back to the ***PE_SNK_Ready*** state (see Figure 8-67) when:

- A ***Status*** Message is received
- Or ***SenderResponseTimer*** times out.

8.3.3.9.2 Source Give Source Status State Diagram

Figure 8-80 shows the state diagram for a Source on receiving a ***Get_Status*** Message. See also Section 6.5.1.

Figure 8-80 Source Give Source Status State Diagram



8.3.3.9.2.1 PE_SRC_Give_Source_Status State

The Policy Engine ***Shall*** transition to the ***PE_SRC_Give_Source_Status*** state, from the ***PE_SRC_Ready*** state, when a ***Get_Status*** Message is received.

On entry to the ***PE_SRC_Give_Source_Status*** state the Policy Engine ***Shall*** request the present Source status from the Device Policy Manager and then send a ***Status*** Message based on these capabilities.

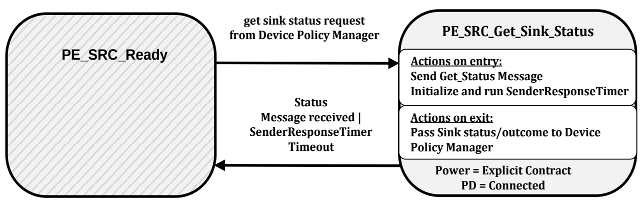
The Policy Engine ***Shall*** transition back to the ***PE_SRC_Ready*** state (see Figure 8-66) when:

- The ***Status*** Message has been successfully sent.

8.3.3.9.3 Source Port Get Sink Status State Diagram

Figure 8-81 shows the state diagram for a Source on receiving a request from the Device Policy Manager to get the Port Partner's Sink status. See also Section 6.5.2.

Figure 8-81 Source Port Get Sink Status State Diagram



8.3.3.9.3.1 PE_SRC_Get_Sink_Status State

The Policy Engine ***Shall*** transition to the ***PE_SRC_Get_Sink_Status*** state, from the ***PE_SRC_Ready*** state, due to a request to get the remote source status from the Device Policy Manager.

On entry to the ***PE_SRC_Get_Sink_Status*** state the Policy Engine ***Shall*** send a ***Status*** Message and initialize and run the ***SenderResponseTimer***.

On exit from the ***PE_SRC_Get_Sink_Status*** state the Policy Engine ***Shall*** inform the Device Policy Manager of the outcome (status or response timeout).

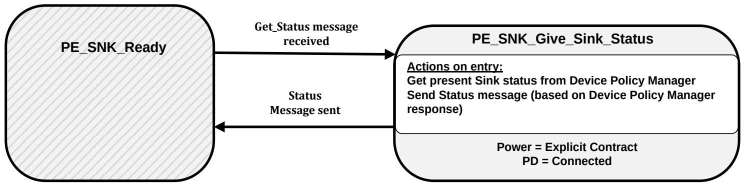
The Policy Engine ***Shall*** transition back to the ***PE_SRC_Ready*** state (see Figure 8-66) when:

- A ***Status*** Message is received
- Or ***SenderResponseTimer*** times out.

8.3.3.9.4 Sink Give Sink Status State Diagram

Figure 8-82 shows the state diagram for a Source on receiving a ***Get_Status*** Message. See also Section 6.5.1.

Figure 8-82 Sink Give Sink Status State Diagram



8.3.3.9.4.1 PE_SNK_Give_Sink_Status State

The Policy Engine ***Shall*** transition to the ***PE_SNK_Give_Sink_Status*** state, from the ***PE_SNK_Ready*** state, when a ***Get_Status*** Message is received.

On entry to the ***PE_SNK_Give_Sink_Status*** state the Policy Engine ***Shall*** request the present extended Source capabilities from the Device Policy Manager and then send a ***Status*** Message based on these capabilities.

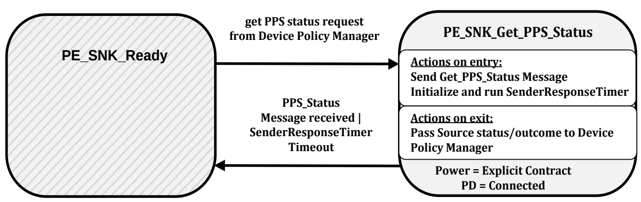
The Policy Engine ***Shall*** transition back to the ***PE_SNK_Ready*** state (see Figure 8-67) when:

- The ***Status*** Message has been successfully sent.

8.3.3.9.5 Sink Port Get Source PPS Status State Diagram

Figure 8-83 shows the state diagram for a Sink on receiving a request from the Device Policy Manager to get the Port Partner's Source status when operating as a PPS. See also Section 6.5.10.

Figure 8-83 Sink Port Get Source PPS Status State Diagram



8.3.3.9.5.1 PE_SNK_Get_PPS_Status State

The Policy Engine ***Shall*** transition to the ***PE_SNK_Get_PPS_Status*** state, from the ***PE_SNK_Ready*** state, due to a request to get the remote source PPS status from the Device Policy Manager.

On entry to the ***PE_SNK_Get_PPS_Status*** state the Policy Engine ***Shall*** send a ***Get_PPS_Status*** Message and initialize and run the ***SenderResponseTimer***.

On exit from the ***PE_SNK_Get_PPS_Status*** state the Policy Engine ***Shall*** inform the Device Policy Manager of the outcome (status or response timeout).

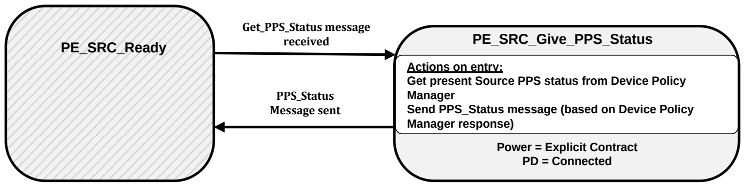
The Policy Engine ***Shall*** transition back to the ***PE_SNK_Ready*** state (see Figure 8-67) when:

- A ***PPS_Status*** Message is received
- Or ***SenderResponseTimer*** times out.

8.3.3.9.6 Source Give Source PPS Status State Diagram

Figure 8-84 shows the state diagram for a Source on receiving a ***Get_PPS_Status*** Message. See also Section 6.5.1.

Figure 8-84 Source Give Source PPS Status State Diagram



8.3.3.9.6.1 PE_SRC_Give_PPS_Status State

The Policy Engine ***Shall*** transition to the ***PE_SRC_Give_PPS_Status*** state, from the ***PE_SRC_Ready*** state, when a ***Get_PPS_Status*** Message is received.

On entry to the ***PE_SRC_Give_PPS_Status*** state the Policy Engine ***Shall*** request the present Source PPS status from the Device Policy Manager and then send a ***PPS_Status*** Message based on these capabilities.

The Policy Engine ***Shall*** transition back to the ***PE_SRC_Ready*** state (see Figure 8-66) when:

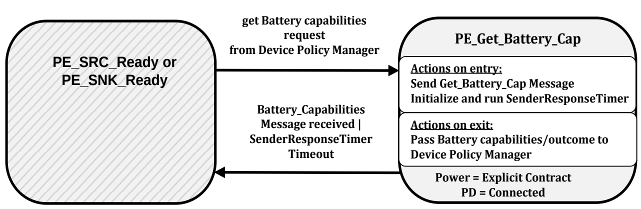
- The ***PPS_Status*** Message has been successfully sent.

8.3.3.10 Battery Capabilities State Diagrams

8.3.3.10.1 Get Battery Capabilities State Diagram

Figure 8-85 shows the state diagram for a Source or Sink on receiving a request from the Device Policy Manager to get the Port Partner's Battery capabilities for a specified Battery. See also Section 6.5.5.

Figure 8-85 Get Battery Capabilities State Diagram



8.3.3.10.1.1 PE_Get_Battery_Cap State

The Policy Engine ***Shall*** transition to the ***PE_Get_Battery_Cap*** state, from either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state, due to a request to get the remote Battery capabilities, for a specified Battery, from the Device Policy Manager.

On entry to the ***PE_Get_Battery_Cap*** state the Policy Engine ***Shall*** send a ***Get_Battery_Cap*** Message and initialize and run the ***SenderResponseTimer***.

On exit from the ***PE_Get_Battery_Cap*** state the Policy Engine ***Shall*** inform the Device Policy Manager of the outcome (capabilities or response timeout).

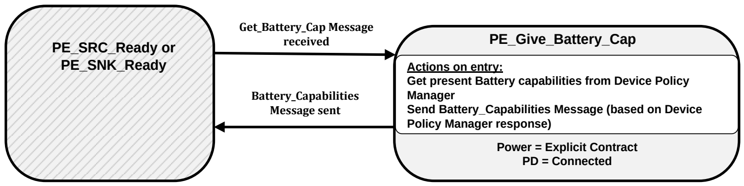
The Policy Engine ***Shall*** transition back to either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state as appropriate (see Figure 8-66 and Figure 8-67) when:

- A ***Battery_Capabilities*** Message is received
- Or ***SenderResponseTimer*** times out.

8.3.3.10.2 Give Battery Capabilities State Diagram

Figure 8-86 shows the state diagram for a Source or Sink on receiving a ***Get_Battery_Cap*** Message. See also Section 6.5.5.

Figure 8-86 Give Battery Capabilities State Diagram



8.3.3.10.2.1 PE_Give_Battery_Cap State

The Policy Engine ***Shall*** transition to the ***PE_Give_Battery_Cap*** state, from either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state, when a ***Get_Battery_Cap*** Message is received.

On entry to the ***PE_Give_Battery_Cap*** state the Policy Engine ***Shall*** request the present Battery capabilities, for the requested Battery, from the Device Policy Manager and then send a ***Source_Capabilities_Extended*** Message based on these capabilities.

The Policy Engine ***Shall*** transition back to either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state as appropriate (see Figure 8-66 and Figure 8-67) when:

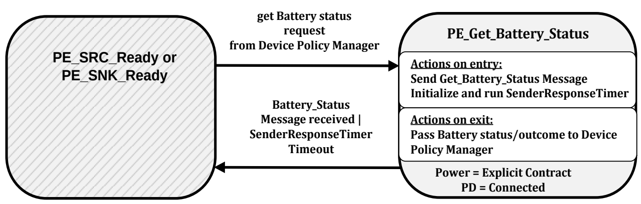
- The ***Battery_Capabilities*** Message has been successfully sent.

8.3.3.11 Battery Status State Diagrams

8.3.3.11.1 Get Battery Status State Diagram

Figure 8-87 shows the state diagram for a Source or Sink on receiving a request from the Device Policy Manager to get the Port Partner's Battery status for a specified Battery. See also Section 6.5.4.

Figure 8-87 Get Battery Status State Diagram



8.3.3.11.1.1 PE_Get_Battery_Status State

The Policy Engine ***Shall*** transition to the ***PE_Get_Battery_Status*** state, from either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state, due to a request to get the remote Battery status, for a specified Battery, from the Device Policy Manager.

On entry to the ***PE_Get_Battery_Status*** state the Policy Engine ***Shall*** send a ***Get_Battery_Status*** Message and initialize and run the ***SenderResponseTimer***.

On exit from the ***PE_Get_Battery_Status*** state the Policy Engine ***Shall*** inform the Device Policy Manager of the outcome (status or response timeout).

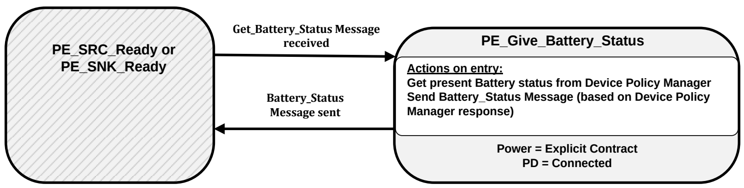
The Policy Engine ***Shall*** transition back to either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state as appropriate (see Figure 8-66 and Figure 8-67) when:

- A ***Battery_Status*** Message is received
- Or ***SenderResponseTimer*** times out.

8.3.3.11.2 Give Battery Status State Diagram

Figure 8-88 shows the state diagram for a Source or Sink on receiving a ***Get_Battery_Status*** Message. See also Section 6.5.4.

Figure 8-88 Give Battery Status State Diagram



8.3.3.11.2.1 PE_Give_Battery_Status State

The Policy Engine ***Shall*** transition to the ***PE_Give_Battery_Status*** state, from either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state, when a ***Get_Battery_Status*** Message is received.

On entry to the ***PE_Give_Battery_Status*** state the Policy Engine ***Shall*** request the present Battery status, for the requested Battery, from the Device Policy Manager and then send a ***Battery_Status*** Message based on this status.

The Policy Engine ***Shall*** transition back to either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state as appropriate (see Figure 8-66 and Figure 8-67) when:

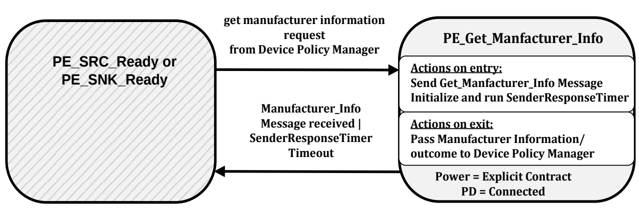
- The ***Battery_Status*** Message has been successfully sent.

8.3.3.12 Manufacturer Information State Diagrams

8.3.3.12.1 Get Manufacturer Information State Diagram

Figure 8-89 shows the state diagram for a Source or Sink on receiving a request from the Device Policy Manager to get the Port Partner's Manufacturer Information. See also Section 6.5.6.

Figure 8-89 Get Manufacturer Information State Diagram



8.3.3.12.1.1 PE_Get_Manufacturer_Info State

The Policy Engine ***Shall*** transition to the ***PE_Get_Manufacturer_Info*** state, from either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state, due to a request to get the remote Manufacturer Information from the Device Policy Manager.

On entry to the ***PE_Get_Manufacturer_Info*** state the Policy Engine ***Shall*** send a ***Get_Manufacturer_Info*** Message and initialize and run the ***SenderResponseTimer***.

On exit from the ***PE_Get_Manufacturer_Info*** state the Policy Engine ***Shall*** inform the Device Policy Manager of the outcome (status or response timeout).

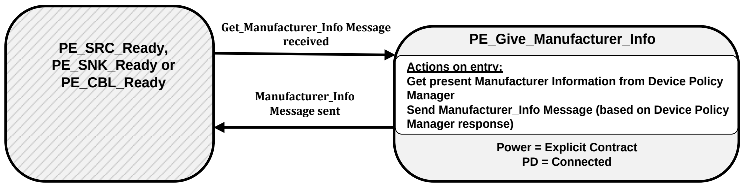
The Policy Engine ***Shall*** transition back to either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state as appropriate (see Figure 8-66 and Figure 8-67) when:

- A ***Manufacturer_Info*** Message is received
- Or ***SenderResponseTimer*** times out.

8.3.3.12.2 Give Manufacturer Information State Diagram

Figure 8-90 shows the state diagram for a Source, Sink or Cable Plug on receiving a ***Get_Manufacturer_Info*** Message. See also Section 6.5.6.

Figure 8-90 Give Manufacturer Information State Diagram



8.3.3.12.2.1 PE_Give_Manufacturer_Info State

The Policy Engine ***Shall*** transition to the ***PE_Give_Manufacturer_Info*** state, from either the ***PE_SRC_Ready, PE_SNK_Ready*** or ***PE_CBL_Ready*** state, when a ***Get_Manufacturer_Info*** Message is received.

On entry to the ***PE_Give_Manufacturer_Info*** state the Policy Engine ***Shall*** request the manufacturer information from the Device Policy Manager and then send a ***Manufacturer_Info*** Message based on this status.

The Policy Engine ***Shall*** transition back to either the ***PE_SRC_Ready, PE_SNK_Ready*** or ***PE_CBL_Ready*** state as appropriate (see Figure 8-66, Figure 8-67and Figure 8-126) when:

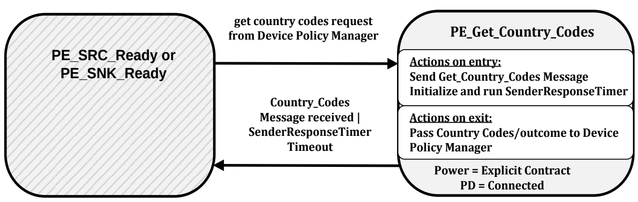
- The ***Manufacturer_Info*** Message has been successfully sent.

8.3.3.13 Country Codes and Information State Diagrams

8.3.3.13.1 Get Country Codes State Diagram

Figure 8-91 shows the state diagram for a Source or Sink on receiving a request from the Device Policy Manager to get the Port Partner's Manufacturer Information. See also Section 6.5.11.

Figure 8-91 Get Country Codes State Diagram



8.3.3.13.1.1 PE_Get_Country_Codes State

The Policy Engine ***Shall*** transition to the ***PE_Get_Country_Codes*** state, from either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state, due to a request to get the remote Manufacturer Information from the Device Policy Manager.

On entry to the ***PE_Get_Country_Codes*** state the Policy Engine ***Shall*** send a ***Get_Country_Codes*** Message and initialize and run the ***SenderResponseTimer***.

On exit from the ***PE_Get_Country_Codes*** state the Policy Engine ***Shall*** inform the Device Policy Manager of the outcome (status or response timeout).

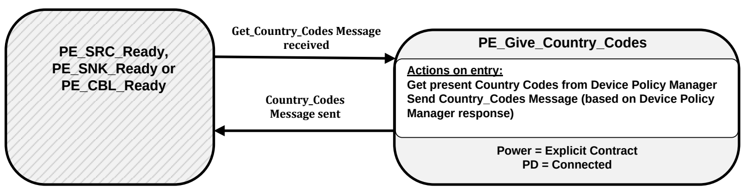
The Policy Engine ***Shall*** transition back to either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state as appropriate (see Figure 8-66 and Figure 8-67) when:

- A ***Country_Codes*** Message is received
- Or ***SenderResponseTimer*** times out.

8.3.3.13.2 Give Country Codes State Diagram

Figure 8-92 shows the state diagram for a Source, Sink or Cable Plug on receiving a ***Get_Country_Codes*** Message. See also Section 6.5.11.

Figure 8-92 Give Country Codes State Diagram



8.3.3.13.2.1 PE_Give_Country_Codes State

The Policy Engine ***Shall*** transition to the ***PE_Give_Country_Codes*** state, from either the ***PE_SRC_Ready, PE_SNK_Ready*** or ***PE_CBL_Ready*** state, when a ***Get_Country_Codes*** Message is received.

On entry to the ***PE_Give_Country_Codes*** state the Policy Engine ***Shall*** request the country codes from the Device Policy Manager and then send a ***Country_Codes*** Message containing these codes.

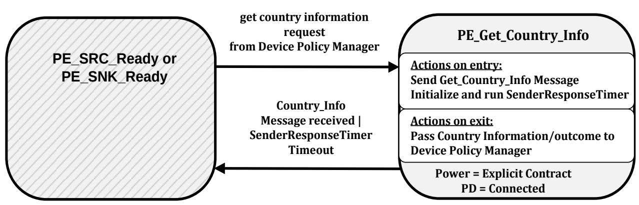
The Policy Engine ***Shall*** transition back to either the ***PE_SRC_Ready, PE_SNK_Ready*** or ***PE_CBL_Ready*** state as appropriate (see Figure 8-66, Figure 8-67and Figure 8-126) when:

- The ***Country_Codes*** Message has been successfully sent.

8.3.3.13.3 Get Country Information State Diagram

Figure 8-93 shows the state diagram for a Source or Sink on receiving a request from the Device Policy Manager to get the Port Partner's Country Information. See also Section 6.5.12.

Figure 8-93 Get Country Information State Diagram



8.3.3.13.3.1 PE_Get_Country_Info State

The Policy Engine ***Shall*** transition to the ***PE_Get_Country_Info*** state, from either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state, due to a request to get the remote Manufacturer Information from the Device Policy Manager.

On entry to the ***PE_Get_Country_Info*** state the Policy Engine ***Shall*** send a ***Get_Manufacturer_Info*** Message and initialize and run the ***SenderResponseTimer***.

On exit from the ***PE_Get_Country_Info*** state the Policy Engine ***Shall*** inform the Device Policy Manager of the outcome (country information or response timeout).

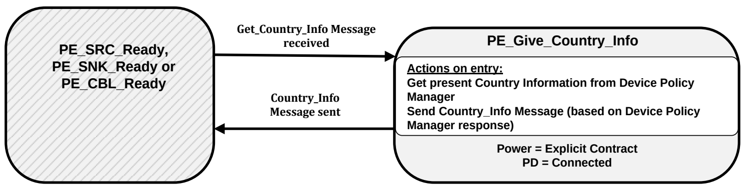
The Policy Engine ***Shall*** transition back to either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state as appropriate (see Figure 8-66 and Figure 8-67) when:

- A ***Country_Info*** Message is received
- Or ***SenderResponseTimer*** times out.

8.3.3.13.4 Give Country Information State Diagram

Figure 8-90 shows the state diagram for a Source, Sink or Cable Plug on receiving a ***Get_Country_Info*** Message. See also Section 6.5.12.

Figure 8-94 Give Country Information State Diagram



8.3.3.13.4.1 PE_Give_Country_Info State

The Policy Engine ***Shall*** transition to the ***PE_Give_Country_Info*** state, from either the ***PE_SRC_Ready, PE_SNK_Ready*** or ***PE_CBL_Ready*** state, when a ***Get_Country_Info*** Message is received.

On entry to the ***PE_Give_Country_Info*** state the Policy Engine ***Shall*** request the country information from the Device Policy Manager and then send a ***Country_Info*** Message containing this country information.

The Policy Engine ***Shall*** transition back to either the ***PE_SRC_Ready, PE_SNK_Ready*** or ***PE_CBL_Ready*** state as appropriate (see Figure 8-66, Figure 8-67and Figure 8-126) when:

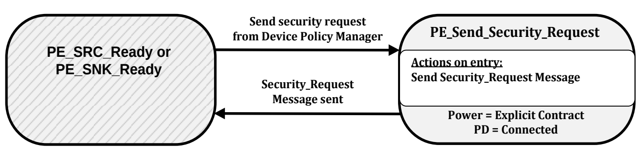
- The ***Country_Info*** Message has been successfully sent.

8.3.3.14 Security State Diagrams

8.3.3.14.1 Send Security Request State Diagram

Figure 8-95 shows the state diagram for a Source or Sink on receiving a request from the Device Policy Manager to send a security request. See also Section 6.5.8.

Figure 8-95 Send security request State Diagram



8.3.3.14.1.1 PE_Send_Security_Request State

The Policy Engine ***Shall*** transition to the ***PE_Send_Security_Request*** state, from either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state, due to a request to send a security request from the Device Policy Manager.

On entry to the ***PE_Send_Security_Request*** state the Policy Engine ***Shall*** send a ***Security_Request*** Message.

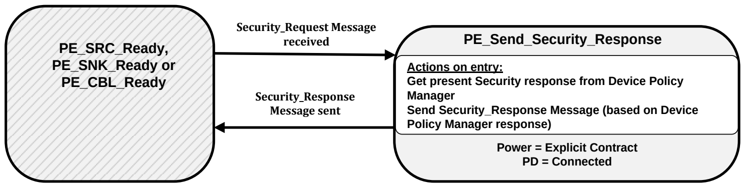
The Policy Engine ***Shall*** transition back to either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state as appropriate (see Figure 8-66 and Figure 8-67) when:

- The ***Security_Request*** Message has been sent.

8.3.3.14.2 Send Security Response State Diagram

Figure 8-96 shows the state diagram for a Source, Sink or Cable Plug on receiving a ***Security_Request*** Message. See also Section 6.5.8.

Figure 8-96 Send security response State Diagram



8.3.3.14.2.1 PE_Send_Security_Response State

The Policy Engine ***Shall*** transition to the ***PE_Send_Security_Response*** state, from either the ***PE_SRC_Ready, PE_SNK_Ready*** or ***PE_CBL_Ready*** state, when a ***Security_Request*** Message is received.

On entry to the ***PE_Send_Security_Response*** state the Policy Engine ***Shall*** request the appropriate response from the Device Policy Manager and then send a ***Security_Response*** Message based on this status.

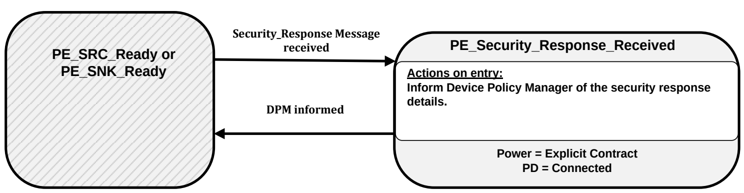
The Policy Engine ***Shall*** transition back to either the ***PE_SRC_Ready, PE_SNK_Ready*** or ***PE_CBL_Ready*** state as appropriate (see Figure 8-66, Figure 8-67and Figure 8-126) when:

- The ***Security_Response*** Message has been successfully sent.

8.3.3.14.3 Security Response Received State Diagram

Figure 8-97 shows the state diagram for a Source or Sink on receiving a ***Security_Response*** Message. See also Section 6.5.8.

Figure 8-97 Security response received State Diagram



8.3.3.14.3.1 PE_Security_Response_Received State

The Policy Engine ***Shall*** transition to the ***PE_Security_Response_Received*** state, from either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** when a ***Security_Response*** Message is received.

On entry to the ***PE_Security_Response_Received*** state the Policy Engine ***Shall*** inform the Device Policy Manager of the details of the security response.

The Policy Engine ***Shall*** transition back to either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state as appropriate (see Figure 8-66, Figure 8-67 and Figure 8-126) when:

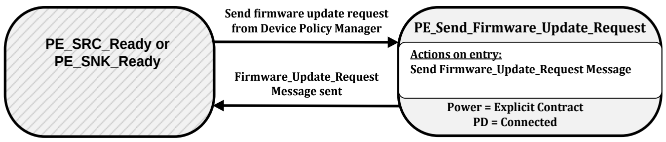
- The Device Policy Manager has been informed.

8.3.3.15 Firmware Update State Diagrams

8.3.3.15.1 Send Firmware Update Request State Diagram

Figure 8-98 shows the state diagram for a Source or Sink on receiving a request from the Device Policy Manager to send a firmware update request. See also Section 6.5.9.

Figure 8-98 Send firmware update request State Diagram



8.3.3.15.1.1 PE_Send_Firmware_Update_Request State

The Policy Engine ***Shall*** transition to the ***PE_Send_Firmware_Update_Request*** state, from either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state, due to a request to send a firmware update request from the Device Policy Manager.

On entry to the ***PE_Send_Firmware_Update_Request*** state the Policy Engine ***Shall*** send a ***Firmware_Update_Request*** Message.

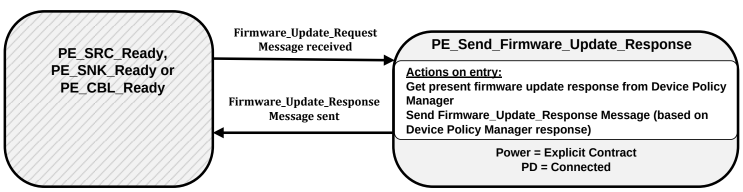
The Policy Engine ***Shall*** transition back to either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state as appropriate (see Figure 8-66 and Figure 8-67) when:

- The ***Firmware_Update_Request*** Message has been sent.

8.3.3.15.2 Send Firmware Update Response State Diagram

Figure 8-99 shows the state diagram for a Source, Sink or Cable Plug on receiving a ***Firmware_Update_Request*** Message. See also Section 6.5.9.

Figure 8-99 Send firmware update response State Diagram



8.3.3.15.2.1 PE_Send_Firmware_Update_Response State

The Policy Engine ***Shall*** transition to the ***PE_Send_Firmware_Update_Response*** state, from either the ***PE_SRC_Ready, PE_SNK_Ready*** or ***PE_CBL_Ready*** state, when a ***Firmware_Update_Request*** Message is received.

On entry to the ***PE_Send_Firmware_Update_Response*** state the Policy Engine ***Shall*** request the appropriate response from the Device Policy Manager and then send a ***Firmware_Update_Response*** Message based on this status.

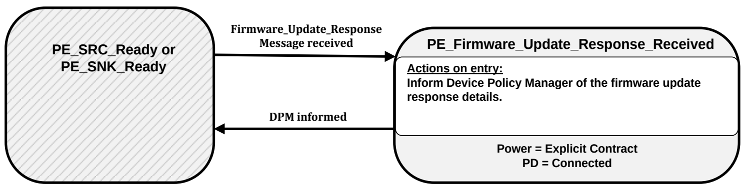
The Policy Engine ***Shall*** transition back to either the ***PE_SRC_Ready, PE_SNK_Ready*** or ***PE_CBL_Ready*** state as appropriate (see Figure 8-66, Figure 8-67and Figure 8-126) when:

- The ***Firmware_Update_Response*** Message has been successfully sent.

8.3.3.15.3 Firmware Update Response Received State Diagram

Figure 8-100 shows the state diagram for a Source or Sink on receiving a ***Firmware_Update_Response*** Message. See also Section 6.5.9.

Figure 8-100 Firmware update response received State Diagram



8.3.3.15.3.1 PE_Firmware_Update_Response_Received State

The Policy Engine ***Shall*** transition to the ***PE_Firmware_Update_Response_Received*** state, from either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** when a ***Firmware_Update_Response*** Message is received.

On entry to the ***PE_Firmware_Update_Response_Received*** state the Policy Engine ***Shall*** inform the Device Policy Manager of the details of the firmware update response.

The Policy Engine ***Shall*** transition back to either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state as appropriate (see Figure 8-66, Figure 8-67 and Figure 8-126) when:

- The Device Policy Manager has been informed.

8.3.3.16 Dual-Role Port State Diagrams

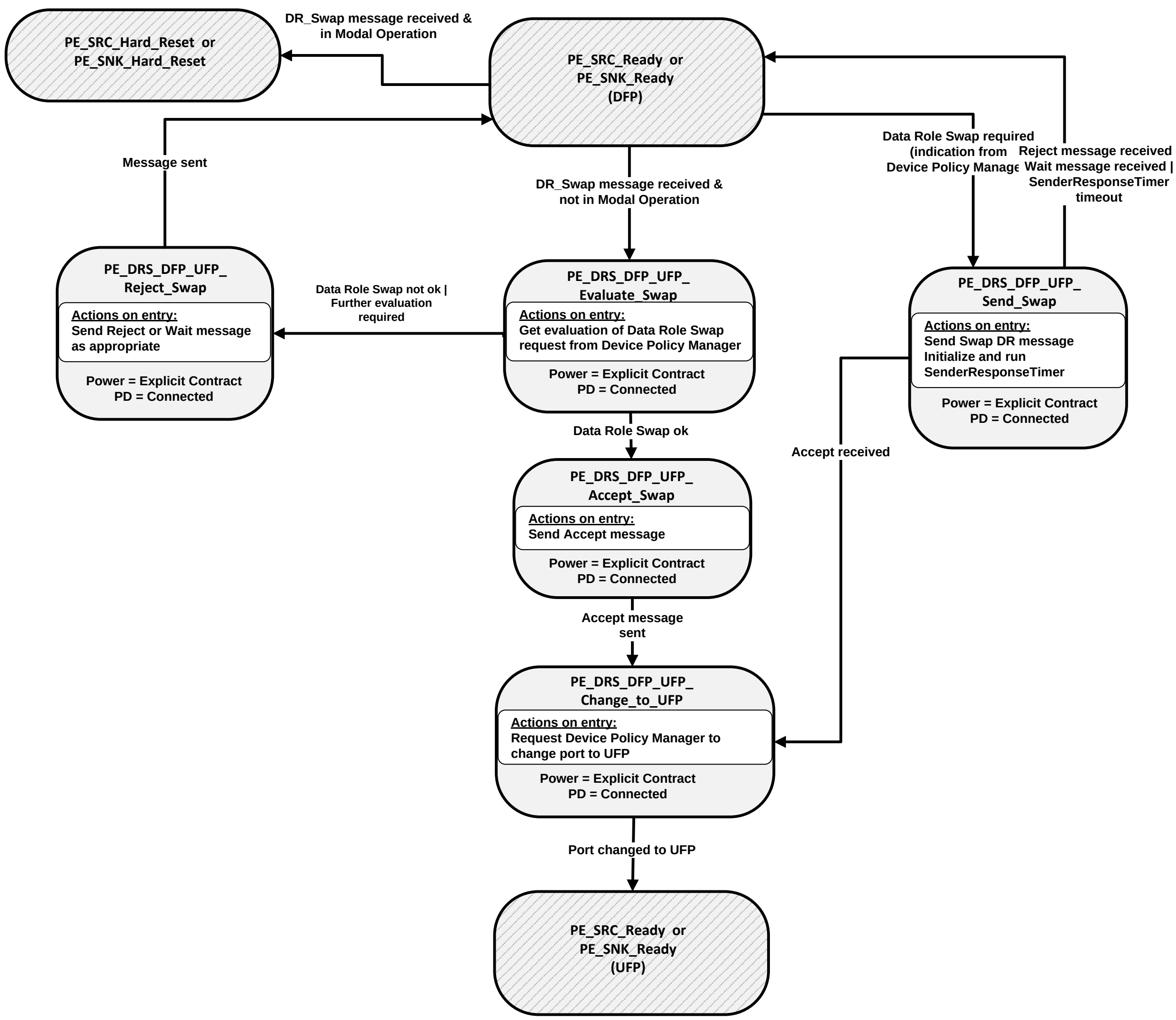
Dual-Role Ports that combine Source and Sink capabilities ***Shall*** comprise Source and Sink Policy Engine state machines. In addition they ***Shall*** have the capability to perform a Power Role Swap from the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** states and ***Shall*** return to USB Default Operation on a Hard Reset.

The State Diagrams in this section ***Shall*** apply to every ***[USB Type-C 1.2]*** DRP.

8.3.3.16.1 DFP to UFP Data Role Swap State Diagram

Figure 8-101 shows the additional state diagram required to perform a Data Role Swap from DFP to UFP operation and the changes that ***Shall*** be followed for error and Hard Reset handling.

Figure 8-101: DFP to UFP Data Role Swap State Diagram



8.3.3.16.1.1 PE_SRC_Ready or PE_SNK_Ready State

The Data Role Swap process ***Shall*** start only from either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state where power is stable.

The Policy Engine ***Shall*** transition to the ***PE_DRS_DFP_UFP_Evaluate_Swap*** state when:

- A ***DR_Swap*** Message is received and
- There are no Active Modes (not in Modal Operation).

The Policy Engine ***Shall*** transition to either the ***PE_SRC_Hard_Reset*** or ***PE_SNK_Hard_Reset*** states when:

- A ***DR_Swap*** Message is received and

- There are one or more Active Modes (Modal Operation).

The Policy Engine ***Shall*** transition to the ***PE_DRS_DFP_UFP_Send_Swap*** state when:

- The Device Policy Manager indicates that a Data Role Swap is required.

8.3.3.16.1.2 PE_DRS_DFP_UFP_Evaluate_Swap State

On entry to the ***PE_DRS_DFP_UFP_Evaluate_Swap*** state the Policy Engine ***Shall*** ask the Device Policy Manager whether a Data Role Swap can be made.

The Policy Engine ***Shall*** transition to the ***PE_DRS_DFP_UFP_Accept_Swap*** state when:

- The Device Policy Manager indicates that a Data Role Swap is ok.

The Policy Engine ***Shall*** transition to the ***PE_DRS_DFP_UFP_Reject_Swap*** state when:

- The Device Policy Manager indicates that a Data Role Swap is not ok.
- Or further evaluation of the Data Role Swap request is needed.

8.3.3.16.1.3 PE_DRS_DFP_UFP_Accept_Swap State

On entry to the ***PE_DRS_DFP_UFP_Accept_Swap*** state the Policy Engine ***Shall*** request the Protocol Layer to send an ***Accept*** Message.

The Policy Engine ***Shall*** transition to the ***PE_DRS_DFP_UFP_Change_to_UFP*** state when:

- The ***Accept*** Message has been sent.

8.3.3.16.1.4 PE_DRS_DFP_UFP_Change_to_UFP State

On entry to the ***PE_DRS_DFP_UFP_Change_to_UFP*** state the Policy Engine ***Shall*** request the Device Policy Manager to change the Port from a DFP to a UFP.

The Policy Engine ***Shall*** transition to either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state when:

- The Device Policy Manager indicates that the Port has been changed to a UFP.

8.3.3.16.1.5 PE_DRS_DFP_UFP_Send_Swap State

On entry to the ***PE_DRS_DFP_UFP_Send_Swap*** state the Policy Engine ***Shall*** request the Protocol Layer to send a ***DR_Swap*** Message and ***Shall*** start the ***SenderResponseTimer***.

On exit from the ***PE_DRS_DFP_UFP_Send_Swap*** state the Policy Engine ***Shall*** stop the ***SenderResponseTimer***.

The Policy Engine ***Shall*** continue as a DFP and ***Shall*** transition to either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state when:

- A ***Reject*** Message is received.
- Or a ***Wait*** Message is received.
- Or the ***SenderResponseTimer*** times out.

The Policy Engine ***Shall*** transition to the ***PE_DRS_DFP_UFP_Change_to_UFP*** state when:

- An ***Accept*** Message is received.

8.3.3.16.1.6 PE_DRS_DFP_UFP_Reject_Swap State

On entry to the ***PE_DRS_DFP_UFP_Reject_Swap*** state the Policy Engine ***Shall*** request the Protocol Layer to send:

- A ***Reject*** Message if the device is unable to perform a Data Role Swap at this time.
- A ***Wait*** Message if further evaluation of the Data Role Swap request is required. Note: in this case it is expected that one of the Port Partners will send a ***DR_Swap*** Message at a later time (see Section 6.3.12.3).

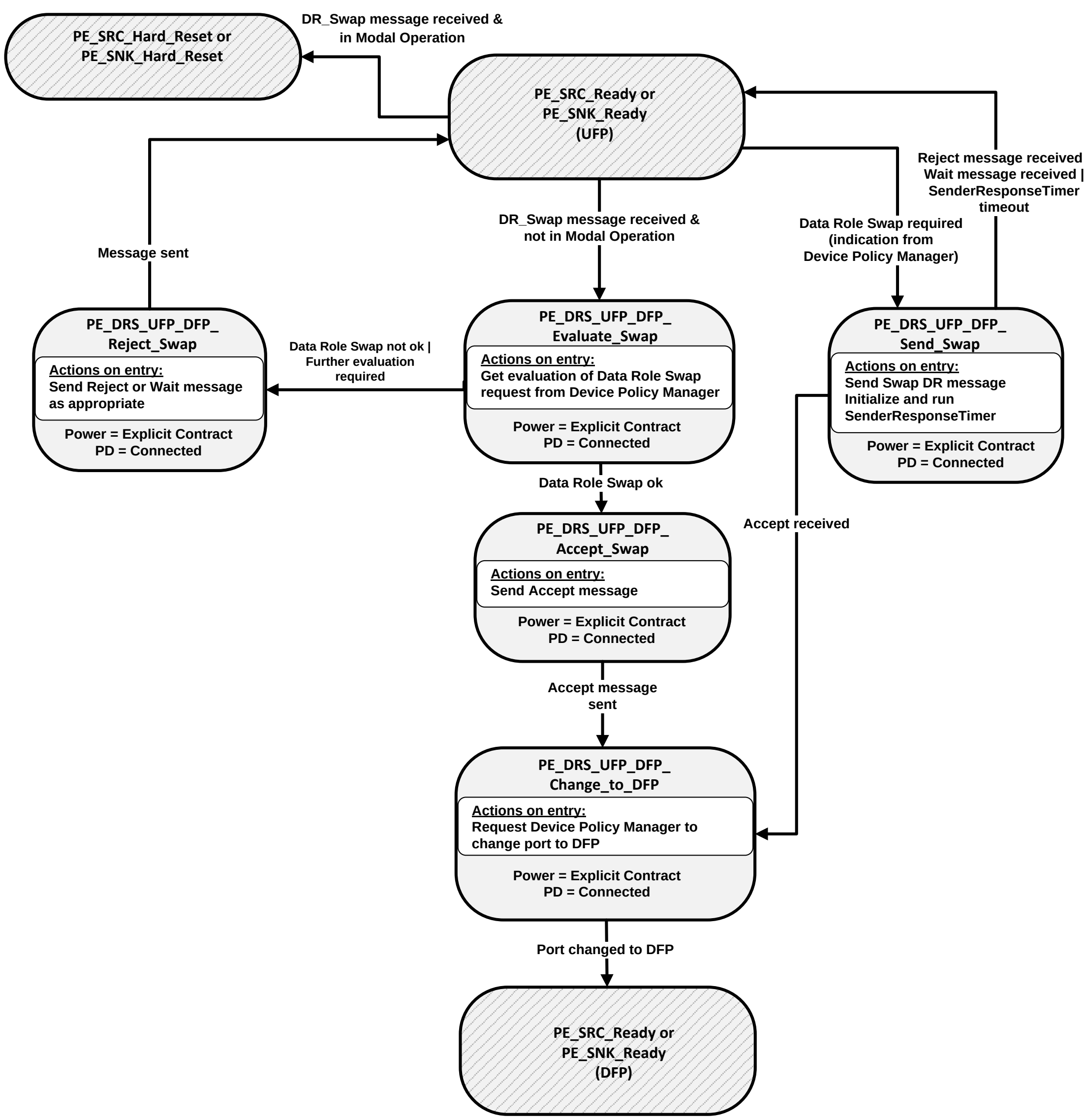
The Policy Engine ***Shall*** continue as a DFP and ***Shall*** transition to either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state when:

- The Reject or Wait Message has been sent.

8.3.3.16.2 UFP to DFP Data Role Swap State Diagram

Figure 8-102 shows the additional state diagram required to perform a Data Role Swap from DRP UFP to DFP operation and the changes that ***Shall*** be followed for error and Hard Reset handling.

Figure 8-102: UFP to DFP Data Role Swap State Diagram



8.3.3.16.2.1 PE_SRC_Ready or PE_SNK_Ready State

The Data Role Swap process ***Shall*** start only from the either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state where power is stable.

The Policy Engine ***Shall*** transition to the ***PE_DRS_UFP_DFP_Evaluate_Swap*** state when:

- A ***DR_Swap*** Message is received and
- There are no Active Modes (not in Modal Operation).

The Policy Engine ***Shall*** transition to either the ***PE_SRC_Hard_Reset*** or ***PE_SNK_Hard_Reset*** states when:

- A ***DR_Swap*** Message is received and
- There are one or more Active Modes (Modal Operation).

The Policy Engine ***Shall*** transition to the ***PE_DRS_UFP_DFP_Send_Swap*** state when:

- The Device Policy Manager indicates that a Data Role Swap is required.

8.3.3.16.2.2 PE_DRS_UFP_DFP_Evaluate_Swap State

On entry to the ***PE_DRS_UFP_DFP_Evaluate_Swap*** state the Policy Engine ***Shall*** ask the Device Policy Manager whether a Data Role Swap can be made.

The Policy Engine ***Shall*** transition to the ***PE_DRS_UFP_DFP_Accept_Swap*** state when:

- The Device Policy Manager indicates that a Data Role Swap is ok.

The Policy Engine ***Shall*** transition to the ***PE_DRS_UFP_DFP_Reject_Swap*** state when:

- The Device Policy Manager indicates that a Data Role Swap is not ok.
- Or further evaluation of the Data Role Swap request is needed.

8.3.3.16.2.3 PE_DRS_UFP_DFP_Accept_Swap State

On entry to the ***PE_DRS_UFP_DFP_Accept_Swap*** state the Policy Engine ***Shall*** request the Protocol Layer to send an ***Accept*** Message.

The Policy Engine ***Shall*** transition to the ***PE_DRS_UFP_DFP_Change_to_DFP*** state when:

- The ***Accept*** Message has been sent.

8.3.3.16.2.4 PE_DRS_UFP_DFP_Change_to_DFP State

On entry to the ***PE_DRS_UFP_DFP_Change_to_DFP*** state the Policy Engine ***Shall*** request the Device Policy Manager to change the Port from a UFP to a DFP.

The Policy Engine ***Shall*** transition to either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state when:

- The Device Policy Manager indicates that the Port has been changed to a DFP.

8.3.3.16.2.5 PE_DRS_UFP_DFP_Send_Swap State

On entry to the ***PE_DRS_UFP_DFP_Send_Swap*** state the Policy Engine ***Shall*** request the Protocol Layer to send a ***DR_Swap*** Message and ***Shall*** start the ***SenderResponseTimer***.

On exit from the ***PE_DRS_UFP_DFP_Send_Swap*** state the Policy Engine ***Shall*** stop the ***SenderResponseTimer***.

The Policy Engine ***Shall*** continue as a UFP and ***Shall*** transition to either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state when:

- A ***Reject*** Message is received.
- Or a ***Wait*** Message is received.
- Or the ***SenderResponseTimer*** times out.

The Policy Engine ***Shall*** transition to the ***PE_DRS_UFP_DFP_Change_to_DFP*** state when:

- An ***Accept*** Message is received.

8.3.3.16.2.6 PE_DRS_UFP_DFP_Reject_Swap State

On entry to the ***PE_DRS_UFP_DFP_Reject_Swap*** state the Policy Engine ***Shall*** request the Protocol Layer to send:

- A ***Reject*** Message if the device is unable to perform a Data Role Swap at this time.
- A ***Wait*** Message if further evaluation of the Data Role Swap request is required. Note: in this case it is expected that one of the Port Partners will send a ***DR_Swap*** Message at a later time (see Section 6.3.12.3).

The Policy Engine ***Shall*** continue as a UFP and ***Shall*** transition to the either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state when:

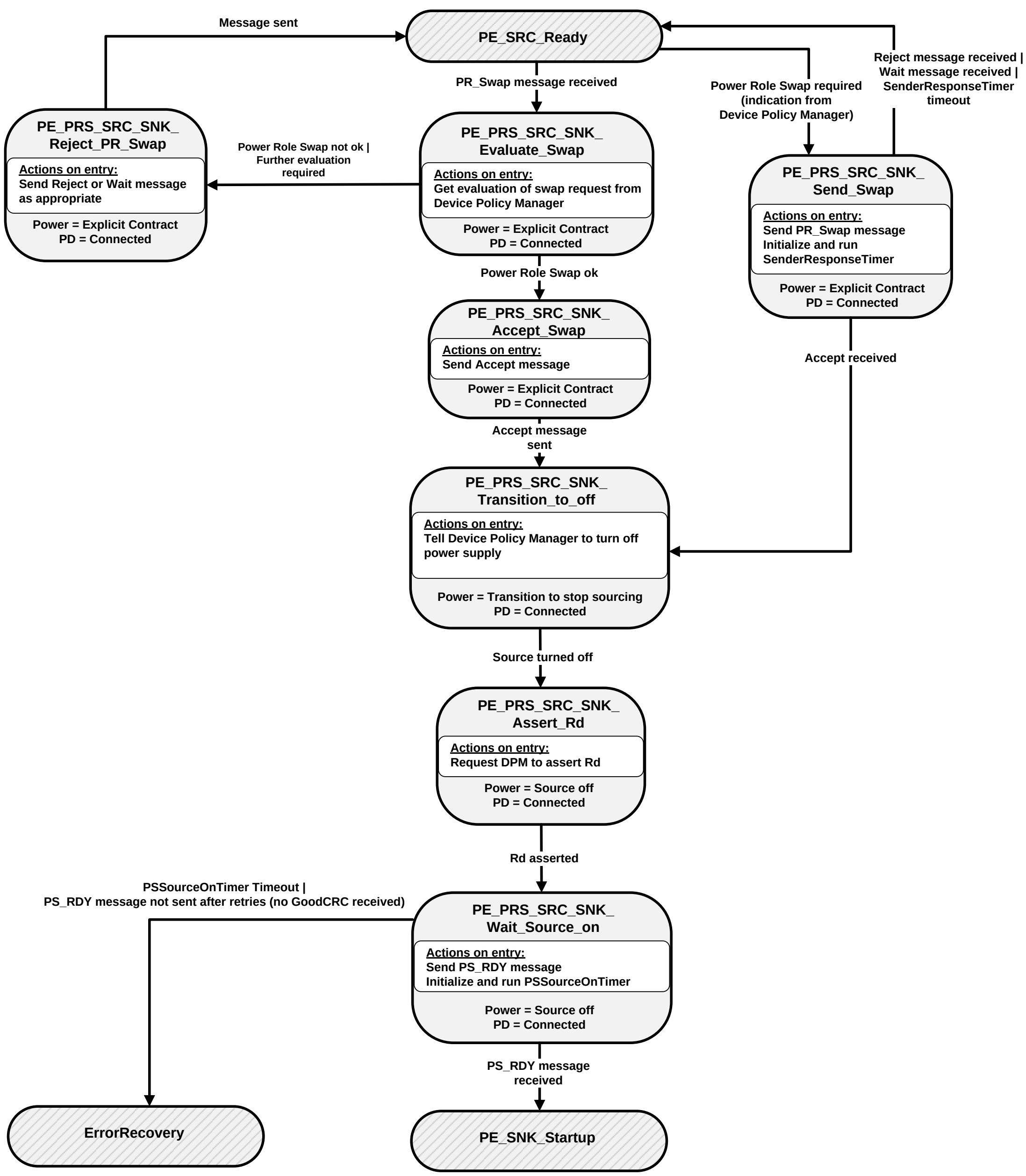
- The ***Reject*** or ***Wait*** Message has been sent.

8.3.3.16.3 Policy Engine in Source to Sink Power Role Swap State Diagram

Dual-Role Ports that combine Source and Sink capabilities ***Shall*** comprise Source and Sink Policy Engine state machines. In addition they ***Shall*** have the capability to do a Power Role Swap from the ***PE_SRC_Ready*** state and ***Shall*** return to USB Default Operation on a Hard Reset.

Figure 8-103 shows the additional state diagram required to perform a Power Role Swap from Source to Sink roles and the changes that ***Shall*** be followed for error handling.

Figure 8-103: Dual-Role Port in Source to Sink Power Role Swap State Diagram



8.3.3.16.3.1 PE_SRC_Ready State

The Power Role Swap process ***Shall*** start only from the ***PE_SRC_Ready*** state where power is stable.

The Policy Engine ***Shall*** transition to the ***PE_PRS_SRC_SNK_Evaluate_Swap*** state when:

- A ***PR_Swap*** Message is received.

The Policy Engine ***Shall*** transition to the ***PE_PRS_SRC_SNK_Send_Swap*** state when:

- The Device Policy Manager indicates that a Power Role Swap is required.

8.3.3.16.3.2 PE_PRS_SRC_SNK_Evaluate_Swap State

On entry to the ***PE_PRS_SRC_SNK_Evaluate_Swap*** state the Policy Engine ***Shall*** ask the Device Policy Manager whether a Power Role Swap can be made.

The Policy Engine ***Shall*** transition to the ***PE_PRS_SRC_SNK_Accept_Swap*** state when:

- The Device Policy Manager indicates that a Power Role Swap is ok.

The Policy Engine ***Shall*** transition to the ***PE_PRS_SRC_SNK_Reject_Swap*** state when:

- The Device Policy Manager indicates that a Power Role Swap is not ok.
- Or further evaluation of the Power Role Swap request is needed.

8.3.3.16.3.3 PE_PRS_SRC_SNK_Accept_Swap State

On entry to the ***PE_PRS_SRC_SNK_Accept_Swap*** state the Policy Engine ***Shall*** request the Protocol Layer to send an ***Accept*** Message.

The Policy Engine ***Shall*** transition to the ***PE_PRS_SRC_SNK_Transition_to_off*** state when:

- The ***Accept*** Message has been sent.

8.3.3.16.3.4 PE_PRS_SRC_SNK_Transition_to_off State

On entry to the ***PE_PRS_SRC_SNK_Transition_to_off*** state the Policy Engine ***Shall*** request the Device Policy Manager to turn off the Source.

The Policy Engine ***Shall*** transition to the ***PE_PRS_SRC_SNK_Assert_Rd*** state when:

- The Device Policy Manager indicates that the Source has been turned off.

8.3.3.16.3.5 PE_PRS_SRC_SNK_Assert_Rd State

On entry to the ***PE_PRS_SRC_SNK_Assert_Rd*** state the Policy Engine ***Shall*** request the Device Policy Manager to change the resistor asserted on the CC wire from Rp to Rd.

The Policy Engine ***Shall*** transition to the ***PE_PRS_SRC_SNK_Wait_Source_on*** state when:

- The Device Policy Manager indicates that Rd is asserted.

8.3.3.16.3.6 PE_PRS_SRC_SNK_Wait_Source_on State

On entry to the ***PE_PRS_SRC_SNK_Wait_Source_on*** state the Policy Engine ***Shall*** request the Protocol Layer to send a ***PS_RDY*** Message and ***Shall*** start the ***PSSourceOnTimer***.

On exit from the Source off state the Policy Engine ***Shall*** stop the ***PSSourceOnTimer***.

The Policy Engine ***Shall*** transition to the ***PE_SNK_Startup*** when:

- A ***PS_RDY*** Message is received indicating that the remote Source is now supplying power.

The Policy Engine ***Shall*** transition to the ***ErrorRecovery*** state when:

- The ***PSSourceOnTimer*** times out or

- The ***PS_RDY*** Message is not sent after retries (a ***GoodCRC*** Message has not been received). Note: a soft reset ***Shall Not*** be initiated in this case.

8.3.3.16.3.7 PE_PRS_SRC_SNK_Send_Swap State

On entry to the ***PE_PRS_SRC_SNK_Send_Swap*** state the Policy Engine ***Shall*** request the Protocol Layer to send a ***PR_Swap*** Message and ***Shall*** start the ***SenderResponseTimer***.

On exit from the ***PE_PRS_SRC_SNK_Send_Swap*** state the Policy Engine ***Shall*** stop the ***SenderResponseTimer***.

The Policy Engine ***Shall*** transition to the ***PE_SRC_Ready*** state when:

- A ***Reject*** Message is received.
- Or a ***Wait*** Message is received.
- Or the ***SenderResponseTimer*** times out.

The Policy Engine ***Shall*** transition to the ***PE_PRS_SRC_SNK_Transition_to_off*** state when:

- An ***Accept*** Message is received.

8.3.3.16.3.8 PE_PRS_SRC_SNK_Reject_Swap State

On entry to the ***PE_PRS_SRC_SNK_Reject_Swap*** state the Policy Engine ***Shall*** request the Protocol Layer to send:

- A ***Reject*** Message if the device is unable to perform a Power Role Swap at this time.
- A ***Wait*** Message if further evaluation of the Power Role Swap request is required. Note: in this case it is expected that one of the Port Partners will send a ***PR_Swap*** Message at a later time (see Section 6.3.12.2).

The Policy Engine ***Shall*** transition to the ***PE_SRC_Ready*** when:

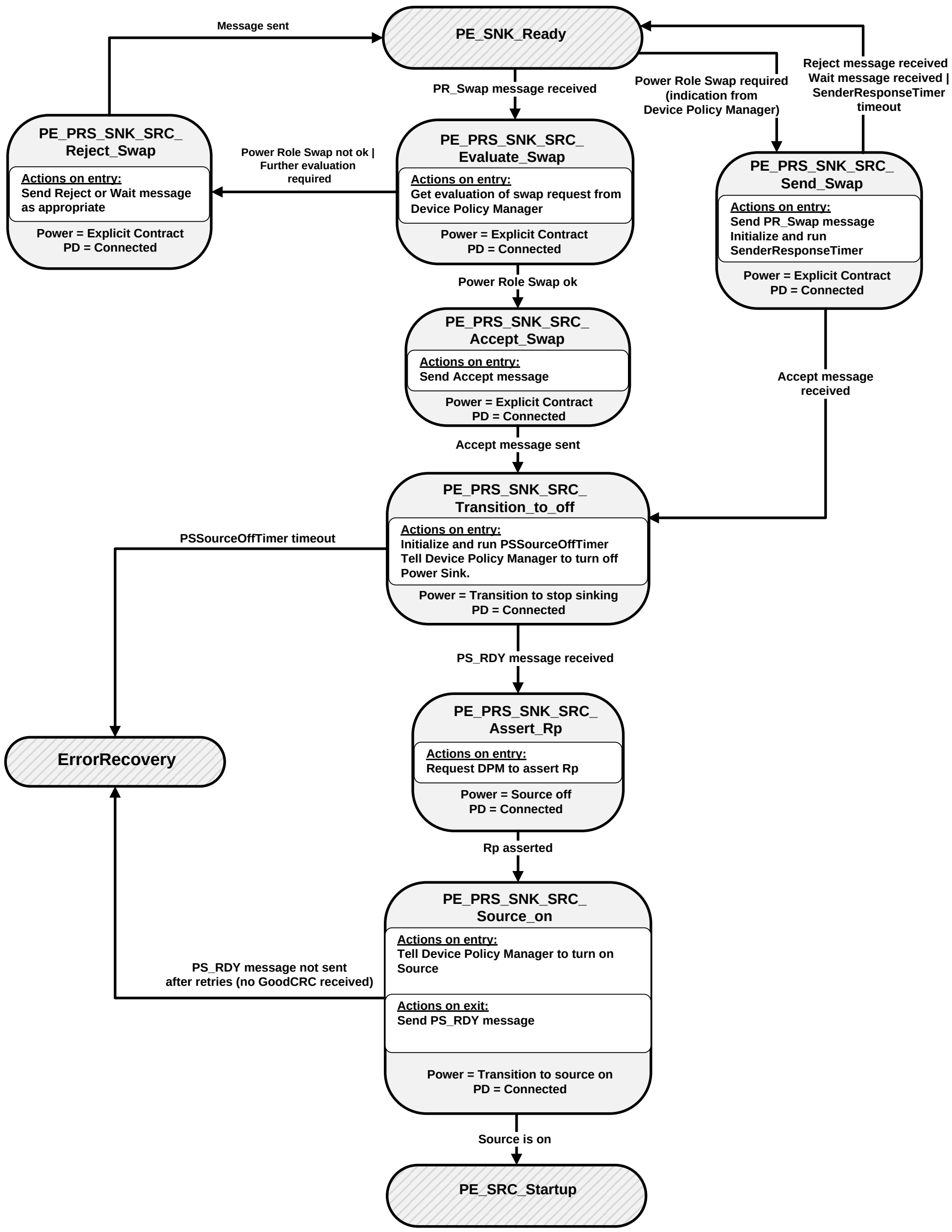
- The ***Reject*** or ***Wait*** Message has been sent.

8.3.3.16.4 Policy Engine in Sink to Source Power Role Swap State Diagram

Dual-Role Ports that combine Sink and Source capabilities ***Shall*** comprise Sink and Source Policy Engine state machines. In addition they ***Shall*** have the capability to do a Power Role Swap from the ***PE_SNK_Ready*** state and ***Shall*** return to USB Default Operation on a Hard Reset.

Figure 8-104 shows the additional state diagram required to perform a Power Role Swap from Sink to Source roles and the changes that ***Shall*** be followed for error handling.

Figure 8-104: Dual-role Port in Sink to Source Power Role Swap State Diagram



8.3.3.16.4.1 PE_SNK_Ready State

The Power Role Swap process ***Shall*** start only from the ***PE_SNK_Ready*** state where power is stable.

The Policy Engine ***Shall*** transition to the ***PE_PRS_SNK_SRC_Evaluate_Swap*** state when:

- A ***PR_Swap*** Message is received.

The Policy Engine ***Shall*** transition to the ***PE_PRS_SNK_SRC_Send_Swap*** state when:

- The Device Policy Manager indicates that a Power Role Swap is required.

8.3.3.16.4.2 PE_PRS_SNK_SRC_Evaluate_Swap State

On entry to the ***PE_PRS_SNK_SRC_Send_Swap*** state the Policy Engine ***Shall*** ask the Device Policy Manager whether a Power Role Swap can be made.

The Policy Engine ***Shall*** transition to the ***PE_PRS_SNK_SRC_Accept_Swap*** state when:

- The Device Policy Manager indicates that a Power Role Swap is ok.

The Policy Engine ***Shall*** transition to the ***PE_PRS_SNK_SRC_Reject_Swap*** state when:

- The Device Policy Manager indicates that a Power Role Swap is not ok.

8.3.3.16.4.3 PE_PRS_SNK_SRC_Accept_Swap State

On entry to the ***PE_PRS_SNK_SRC_Accept_Swap*** state the Policy Engine ***Shall*** request the Protocol Layer to send an ***Accept*** Message.

The Policy Engine ***Shall*** transition to the ***PE_PRS_SNK_SRC_Transition_to_off*** state when:

- The ***Accept*** Message has been sent.

8.3.3.16.4.4 PE_PRS_SNK_SRC_Transition_to_off State

On entry to the ***PE_PRS_SNK_SRC_Transition_to_off*** state the Policy Engine ***Shall*** initialize and run the ***PSSourceOffTimer*** and then request the Device Policy Manager to turn off the Sink.

The Policy Engine ***Shall*** transition to the ***ErrorRecovery*** state when:

- The ***PSSourceOffTimer*** times out.

The Policy Engine ***Shall*** transition to the ***PE_PRS_SNK_SRC_Assert_Rp*** state when:

- A ***PS_RDY*** Message is received.

8.3.3.16.4.5 PE_PRS_SNK_SRC_Assert_Rp State

On entry to the ***PE_PRS_SNK_SRC_Assert_Rp*** state the Policy Engine ***Shall*** request the Device Policy Manager to change the resistor asserted on the CC wire from Rd to Rp.

The Policy Engine ***Shall*** transition to the ***PE_PRS_SNK_SRC_Source_on*** state when:

- The Device Policy Manager indicates that Rd is asserted.

8.3.3.16.4.6 PE_PRS_SNK_SRC_Source_on State

On entry to the ***PE_PRS_SNK_SRC_Source_on*** state the Policy Engine ***Shall*** request the Device Policy Manager to turn on the Source.

On exit from the ***PE_PRS_SNK_SRC_Source_on*** state the Policy Engine ***Shall*** send a ***PS_RDY*** Message.

The Policy Engine ***Shall*** transition to the ***PE_SRC_Startup*** state when:

- The Source Port has been turned on.

The Policy Engine ***Shall*** transition to the ***ErrorRecovery*** state when:

- The ***PS_RDY*** Message is not sent after retries (a ***GoodCRC*** Message has not been received). A soft reset ***Shall Not*** be initiated in this case.

8.3.3.16.4.7 PE_PRS_SNK_SRC_Send_Swap State

On entry to the ***PE_PRS_SNK_SRC_Send_Swap*** state the Policy Engine ***Shall*** request the Protocol Layer to send a ***PR_Swap*** Message and ***Shall*** initialize and run the ***SenderResponseTimer***.

The Policy Engine ***Shall*** transition to the ***PE_SNK_Ready*** state when:

- A ***Reject*** Message is received.
- Or a ***Wait*** Message is received.
- Or the ***SenderResponseTimer*** times out.

The Policy Engine ***Shall*** transition to the ***PE_PRS_SNK_SRC_Transition_to_off*** state when:

- An ***Accept*** Message is received.

8.3.3.16.4.8 PE_PRS_SNK_SRC_Reject_Swap State

On entry to the ***PE_PRS_SNK_SRC_Reject_Swap*** state the Policy Engine ***Shall*** request the Protocol Layer to send:

- A ***Reject*** Message if the device is unable to perform a Power Role Swap at this time.
- A ***Wait*** Message if further evaluation of the Power Role Swap request is required. Note: in this case it is expected that one of the Port Partners will send a ***PR_Swap*** Message at a later time (see Section 6.3.12.2).

The Policy Engine ***Shall*** transition to the ***PE_SNK_Ready*** state when:

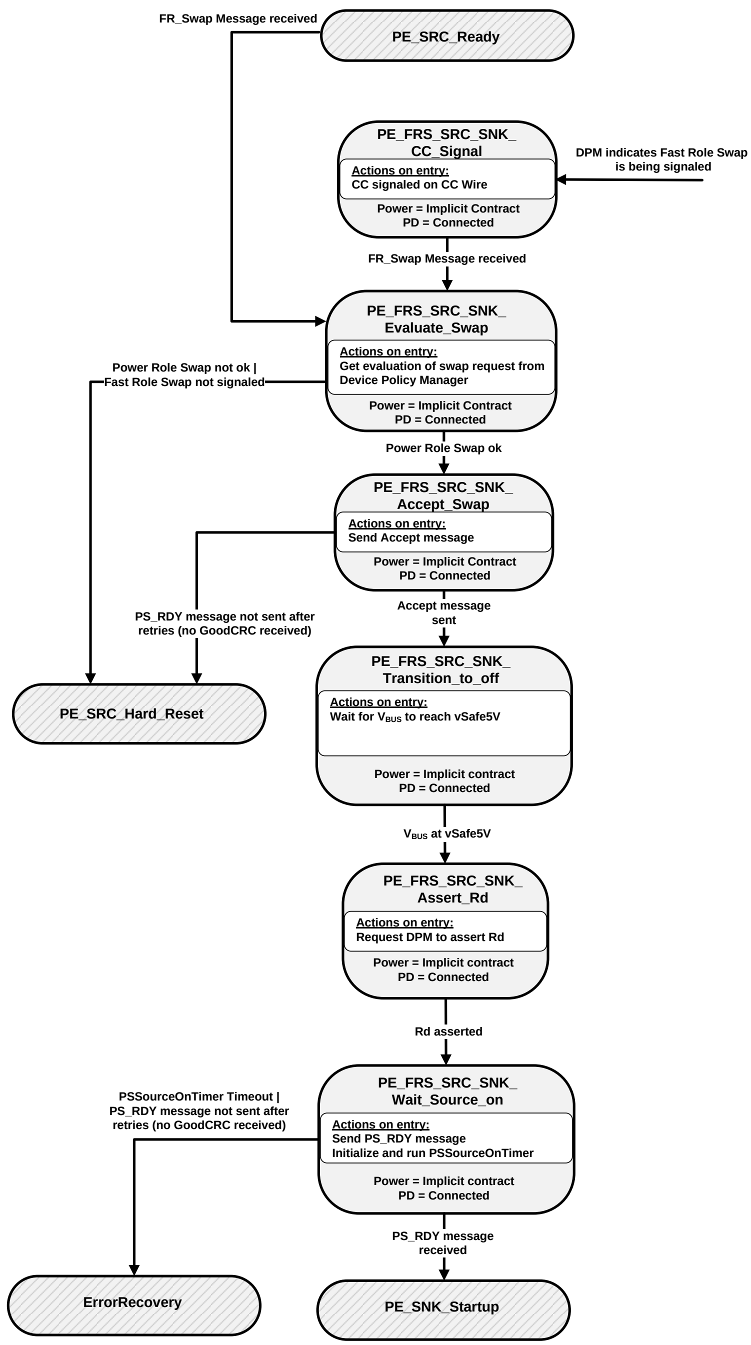
- The ***Reject*** or ***Wait*** Message has been sent.

8.3.3.16.5 Policy Engine in Source to Sink Fast Role Swap State Diagram

Dual-Role Ports that combine Source and Sink capabilities ***Shall*** comprise Source and Sink Policy Engine state machines. In addition they ***Should*** have the capability to do a Fast Role Swap from the ***PE_SRC_Ready*** state and ***Shall*** return to USB Default Operation on a Hard Reset.

Figure 8-103 shows the additional state diagram required to perform a Fast Role Swap from Source to Sink roles and the changes that ***Shall*** be followed for error handling.

Figure 8-105: Dual-Role Port in Source to Sink Fast Role Swap State Diagram



8.3.3.16.5.1 PE_SRC_Ready State

The Fast Role Swap process ***Shall*** start only from the ***PE_SRC_Ready*** state where power is stable.

The Policy Engine ***Shall*** transition to the ***PE_FRS_SRC_SNK_Evaluate_Swap*** state when:

- An ***FR_Swap*** Message is received.

8.3.3.16.5.2 PE_FRS_SRC_SNK_CC_Signal State

The Policy Engine ***Shall*** transition to the ***PE_FRS_SRC_SNK_CC_Signal*** state from any other state provided there is an Explicit Contract in place when:

- The Device Policy Manager indicates that Fast Role Swap signaling is being applied to the CC Wire.

In the ***PE_FRS_SRC_SNK_CC_Signal*** state the Policy Engine waits for an ***FR_Swap*** Message from the new Source.

The Policy Engine ***Shall*** transition to the ***PE_FRS_SRC_SNK_Evaluate_Swap*** state when:

- An ***FR_Swap*** Message is received.

8.3.3.16.5.3 PE_FRS_SRC_SNK_Evaluate_Swap State

On entry to the ***PE_FRS_SRC_SNK_Evaluate_Swap*** state the Policy Engine ***Shall*** ask the Device Policy Manager whether a Fast Role Swap can be made.

The Policy Engine ***Shall*** transition to the ***PE_FRS_SRC_SNK_Accept_Swap*** state when:

- The Device Policy Manager indicates that a Fast Role Swap is ok.

The Policy Engine ***Shall*** transition to the ***PE_SRC_Hard_Reset*** state when:

- The Device Policy Manager indicates that a Fast Role Swap is not ok or
- The Device Policy Manager indicates that a Fast Role Swap is not being signaled.

8.3.3.16.5.4 PE_FRS_SRC_SNK_Accept_Swap State

On entry to the ***PE_FRS_SRC_SNK_Accept_Swap*** state the Policy Engine ***Shall*** request the Protocol Layer to send an ***Accept*** Message.

The Policy Engine ***Shall*** transition to the ***PE_FRS_SNK_SRC_Transition_to_off*** state when:

- The ***Accept*** Message has been sent.

The Policy Engine ***Shall*** transition to the ***PE_SRC_Hard_Reset*** state when:

- The ***Accept*** Message is not sent after retries (a ***GoodCRC*** Message has not been received). Note: a soft reset ***Shall Not*** be initiated in this case.

8.3.3.16.5.5 PE_FRS_SRC_SNK_Transition_to_off State

On entry to the ***PE_FRS_SNK_SRC_Transition_to_off*** state the Policy Engine ***Shall*** until V_{BUS} has discharged to ***vSafe5V***.

The Policy Engine ***Shall*** transition to the ***PE_PRS_SRC_SNK_Assert_Rd*** state when:

- The Device Policy Manager indicates that V_{BUS} has discharged to ***vSafe5V***.

8.3.3.16.5.6 PE_FRS_SRC_SNK_Assert_Rd State

On entry to the ***PE_PRS_SRC_SNK_Assert_Rd*** state the Policy Engine ***Shall*** request the Device Policy Manager to change the resistor asserted on the CC wire from Rp to Rd.

The Policy Engine ***Shall*** transition to the ***PE_PRS_SRC_SNK_Wait_Source_on*** state when:

- The Device Policy Manager indicates that Rd is asserted.

8.3.3.16.5.7 PE_FRS_SRC_SNK_Wait_Source_on State

On entry to the ***PE_PRS_SRC_SNK_Wait_Source_on*** state the Policy Engine ***Shall*** request the Protocol Layer to send a ***PS_RDY*** Message and ***Shall*** start the ***PSSourceOnTimer***.

On exit from the Source off state the Policy Engine ***Shall*** stop the ***PSSourceOnTimer***.

The Policy Engine ***Shall*** transition to the ***PE_SNK_Startup*** when:

- A ***PS_RDY*** Message is received indicating that the new Source is now applying Rp.

The Policy Engine ***Shall*** transition to the ***ErrorRecovery*** state when:

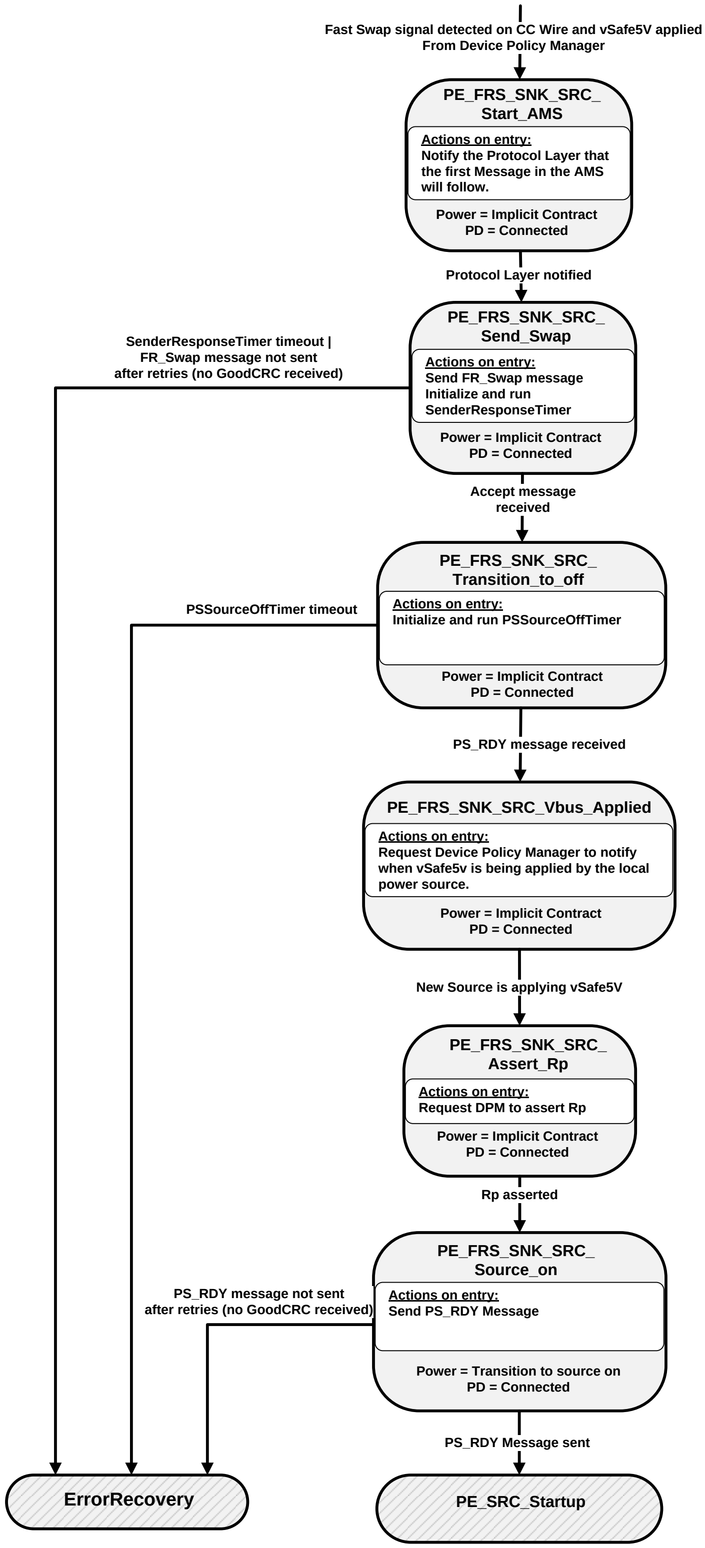
- The ***PSSourceOnTimer*** times out or
- The ***PS_RDY*** Message is not sent after retries (a ***GoodCRC*** Message has not been received). Note: a soft reset ***Shall Not*** be initiated in this case.

8.3.3.16.6 Policy Engine in Sink to Source Fast Role Swap State Diagram

Dual-Role Ports that combine Sink and Source capabilities ***Shall*** comprise Sink and Source Policy Engine state machines. In addition they ***Should*** have the capability to do a Fast Role Swap from the ***PE_SNK_Ready*** state and ***Shall*** return to USB Default Operation on a Hard Reset.

Figure 8-104 shows the additional state diagram required to perform a Fast Role Swap from Sink to Source roles and the changes that ***Shall*** be followed for error handling.

Figure 8-106: Dual-role Port in Sink to Source Fast Role Swap State Diagram



8.3.3.16.6.1 PE_FRS_SNK_SRC_Start_AMS State

The Policy Engine ***Shall*** transition to the ***PE_FRS_SNK_SRC_Send_Swap*** state from any other state provided there is an Explicit Contract in place when:

- The Device Policy Manager indicates that a Fast Role Swap signal has been detected on the CC Wire and ***vSafe5V*** has been applied to V_{BUS}.

On entry to the ***PE_FRS_SNK_SRC_Start_AMS*** state the Policy Engine ***Shall*** notify the Protocol Layer that the first Message in an AMS will follow.

The Policy Engine ***Shall*** transition to the ***PE_FRS_SNK_SRC_Send_Swap*** state when:

- The Protocol Layer has been notified.

8.3.3.16.6.2 PE_FRS_SNK_SRC_Send_Swap State

On entry to the ***PE_FRS_SNK_SRC_Send_Swap*** state the Policy Engine ***Shall*** request the Protocol Layer to send an ***FR_Swap*** Message and ***Shall*** initialize and run the ***SenderResponseTimer***.

The Policy Engine ***Shall*** transition to the ***PE_FRS_SNK_SRC_Transition_to_off*** state when:

- An ***Accept*** Message is received.

The Policy Engine ***Shall*** transition to the ***ErrorRecovery*** state when:

- The ***SenderResponseTimer*** times out or
- The ***FR_Swap*** Message is not sent after retries (a ***GoodCRC*** Message has not been received). A soft reset ***Shall Not*** be initiated in this case.

8.3.3.16.6.3 PE_FRS_SNK_SRC_Transition_to_off State

On entry to the ***PE_FRS_SNK_SRC_Transition_to_off*** state the Policy Engine ***Shall*** initialize and run the ***PSSourceOffTimer*** and then request the Device Policy Manager to turn off the Sink.

The Policy Engine ***Shall*** transition to the ***ErrorRecovery*** state when:

- The ***PSSourceOffTimer*** times out.

The Policy Engine ***Shall*** transition to the ***PE_FRS_SNK_SRC_Vbus_Applied*** state when:

- A ***PS_RDY*** Message is received.

8.3.3.16.6.4 PE_FRS_SNK_SRC_Vbus_Applied State

On entry to the ***PE_FRS_SNK_SRC_Vbus_Applied*** state the Policy Engine waits for a notification from the Device Policy Manager that the local power source has applied ***vSafe5V*** to V_{BUS} (see Section5.8.6.3). Note this could have already been applied prior to entering this state or could be applied while waiting in this state.

The Policy Engine ***Shall*** transition to the ***PE_FRS_SNK_SRC_Assert_Rp*** state when:

- The Device Policy Manager indicates that ***vSafe5V*** is being applied.

8.3.3.16.6.5 PE_FRS_SNK_SRC_Assert_Rp State

On entry to the ***PE_FRS_SNK_SRC_Assert_Rp*** state the Policy Engine ***Shall*** request the Device Policy Manager to change the resistor asserted on the CC wire from Rd to Rp.

The Policy Engine ***Shall*** transition to the ***PE_FRS_SNK_SRC_Source_on*** state when:

- The Device Policy Manager indicates that Rp is asserted.

8.3.3.16.6.6 PE_FRS_SNK_SRC_Source_on State

On entry to the ***PE_FRS_SNK_SRC_Source_on*** state the Policy Engine ***Shall*** request the Device Policy Manager to turn on the Source.

On exit from the ***PE_FRS_SNK_SRC_Source_on*** state (except if the exit is to send a ***Ping*** Message) the Policy Engine ***Shall*** send a ***PS_RDY*** Message.

The Policy Engine ***Shall*** transition to the ***PE_SRC_Startup*** state when:

- The ***PS_RDY*** Message has been sent.

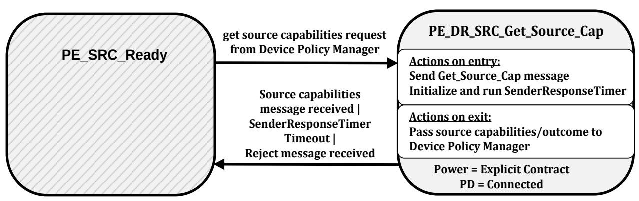
The Policy Engine ***Shall*** transition to the ***ErrorRecovery*** state when:

- The ***PS_RDY*** Message is not sent after retries (a ***GoodCRC*** Message has not been received). A soft reset ***Shall Not*** be initiated in this case.

8.3.3.16.7 Dual-Role (Source Port) Get Source Capabilities State Diagram

Figure 8-107 shows the state diagram for a Dual-Role device, presently operating as a Source, on receiving a request from the Device Policy Manager to get the Port Partner's Source capabilities. See also Section 6.4.1.1.3.

Figure 8-107 Dual-Role (Source) Get Source Capabilities diagram



8.3.3.16.7.1 PE_DR_SRC_Get_Source_Cap State

The Policy Engine ***Shall*** transition to the ***PE_DR_SRC_Get_Source_Cap*** state, from the ***PE_SRC_Ready*** state, due to a request to get the remote source capabilities from the Device Policy Manager.

On entry to the ***PE_DR_SRC_Get_Source_Cap*** state the Policy Engine ***Shall*** send a ***Get_Source_Cap*** Message and initialize and run the ***SenderResponseTimer***.

On exit from the ***PE_DR_SRC_Get_Source_Cap*** state the Policy Engine ***Shall*** inform the Device Policy Manager of the outcome (capabilities or response timeout).

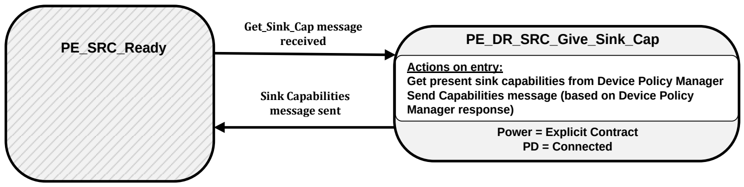
The Policy Engine ***Shall*** transition back to the ***PE_SRC_Ready*** state (see Figure 8-66) when:

- A ***Source_Capabilities*** Message is received
- Or ***SenderResponseTimer*** times out
- Or a ***Reject*** Message is received.

8.3.3.16.8 Dual-Role (Source Port) Give Sink Capabilities State Diagram

Figure 8-108 shows the state diagram for a Dual-Role device, presently operating as a Source, on receiving a ***Get_Sink_Cap*** Message. See also Section 6.4.1.1.3.

Figure 8-108 Dual-Role (Source) Give Sink Capabilities diagram



8.3.3.16.8.1 PE_DR_SRC_Give_Sink_Cap State

The Policy Engine ***Shall*** transition to the ***PE_DR_SRC_Give_Sink_Cap*** state, from the ***PE_SRC_Ready*** state, when a ***Get_Sink_Cap*** Message is received.

On entry to the ***PE_DR_SRC_Give_Sink_Cap*** state the Policy Engine ***Shall*** request the present capabilities from the Device Policy Manager and then send a ***Sink_Capabilities*** Message based on these capabilities.

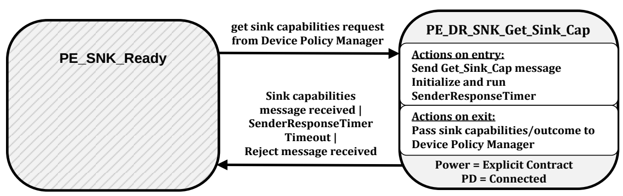
The Policy Engine ***Shall*** transition back to the ***PE_SRC_Ready*** state (see Figure 8-66) when:

- The ***Sink_Capabilities*** Message has been successfully sent.

8.3.3.16.9 Dual-Role (Sink Port) Get Sink Capabilities State Diagram

Figure 8-109 shows the state diagram for a Dual-Role device, presently operating as a Sink, on receiving a request from the Device Policy Manager to get the Port Partner's Sink capabilities. See also Section 6.4.1.1.3.

Figure 8-109 Dual-Role (Sink) Get Sink Capabilities State Diagram



8.3.3.16.9.1 PE_DR_SNK_Get_Sink_Cap State

The Policy Engine ***Shall*** transition to the ***PE_DR_SNK_Get_Sink_Cap*** state, from the ***PE_SNK_Ready*** state, due to a request to get the remote source capabilities from the Device Policy Manager.

On entry to the ***PE_DR_SNK_Get_Sink_Cap*** state the Policy Engine ***Shall*** send a ***Get_Sink_Cap*** Message and initialize and run the ***SenderResponseTimer***.

On exit from the ***PE_DR_SNK_Get_Sink_Cap*** state the Policy Engine ***Shall*** inform the Device Policy Manager of the outcome (capabilities or response timeout).

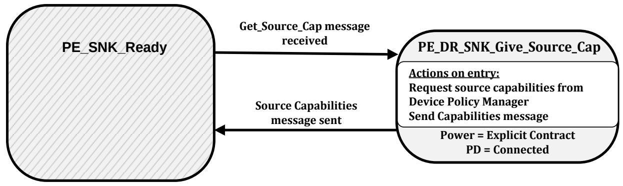
The Policy Engine ***Shall*** transition back to the ***PE_SNK_Ready*** state (see Figure 8-67) when:

- A ***Source_Capabilities*** Message is received
- Or ***SenderResponseTimer*** times out
- Or a ***Reject*** Message is received.

8.3.3.16.10 Dual-Role (Sink Port) Give Source Capabilities State Diagram

Figure 8-110 shows the state diagram for a Dual-Role device, presently operating as a Sink, on receiving a ***Get_Source_Cap*** Message. See also Section 6.4.1.1.3.

Figure 8-110 Dual-Role (Sink) Give Source Capabilities State Diagram



8.3.3.16.10.1 PE_DR_SNK_Give_Source_Cap State

The Policy Engine ***Shall*** transition to the ***PE_DR_SNK_Give_Source_Cap*** state, from the ***PE_SNK_Ready*** state, when a ***Get_Source_Cap*** Message is received.

On entry to the ***PE_DR_SNK_Give_Source_Cap*** state the Policy Engine ***Shall*** request the present capabilities from the Device Policy Manager and then send a ***Source_Capabilities*** Message based on these capabilities.

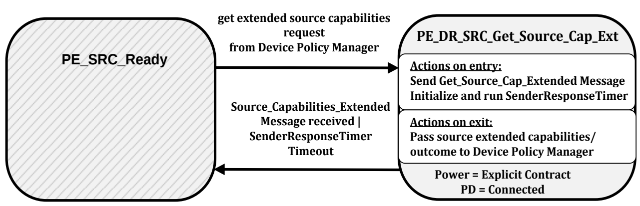
The Policy Engine ***Shall*** transition back to the ***PE_SNK_Ready*** state (see Figure 8-67) when:

- The ***Source_Capabilities*** Message has been successfully sent.

8.3.3.16.11 Dual-Role (Source Port) Get Source Capabilities Extended State Diagram

Figure 8-111 shows the state diagram for a Dual-Role device, presently operating as a Source, on receiving a request from the Device Policy Manager to get the Port Partner's extended Source capabilities. See also Section 6.5.1.

Figure 8-111 Dual-Role (Source) Get Source Capabilities Extended State Diagram



8.3.3.16.11.1 PE_DR_SRC_Get_Source_Cap_Ext State

The Policy Engine ***Shall*** transition to the ***PE_DR_SRC_Get_Source_Cap_Ext*** state, from the ***PE_SRC_Ready*** state, due to a request to get the remote extended source capabilities from the Device Policy Manager.

On entry to the ***PE_DR_SRC_Get_Source_Cap_Ext*** state the Policy Engine ***Shall*** send a ***Get_Source_Cap_Extended*** Message and initialize and run the ***SenderResponseTimer***.

On exit from the ***PE_DR_SRC_Get_Source_Cap_Ext*** state the Policy Engine ***Shall*** inform the Device Policy Manager of the outcome (capabilities or response timeout).

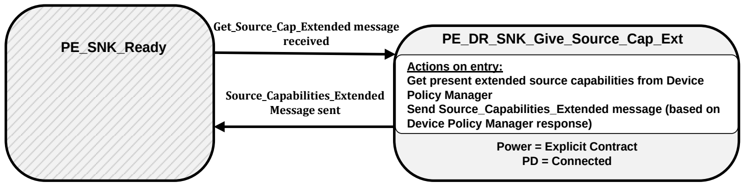
The Policy Engine ***Shall*** transition back to the ***PE_SRC_Ready*** state (see Figure 8-66) when:

- A ***Source_Capabilities_Extended*** Message is received
- Or ***SenderResponseTimer*** times out.

8.3.3.16.12 Dual-Role (Sink Port) Give Source Capabilities Extended State Diagram

Figure 8-112 shows the state diagram for a Dual-Role device, presently operating as a Sink, on receiving a ***Get_Source_Cap_Extended*** Message. See also Section 6.5.1.

Figure 8-112 Dual-Role (Source) Give Sink Capabilities diagram



8.3.3.16.12.1 PE_DR_SNK_Give_Source_Cap_Ext State

The Policy Engine ***Shall*** transition to the ***PE_DR_SNK_Give_Source_Cap_Ext*** state, from the ***PE_SNK_Ready*** state, when a ***Get_Source_Cap_Extended*** Message is received.

On entry to the ***PE_DR_SNK_Give_Source_Cap_Ext*** state the Policy Engine ***Shall*** request the present extended Source capabilities from the Device Policy Manager and then send a ***Source_Capabilities_Extended*** Message based on these capabilities.

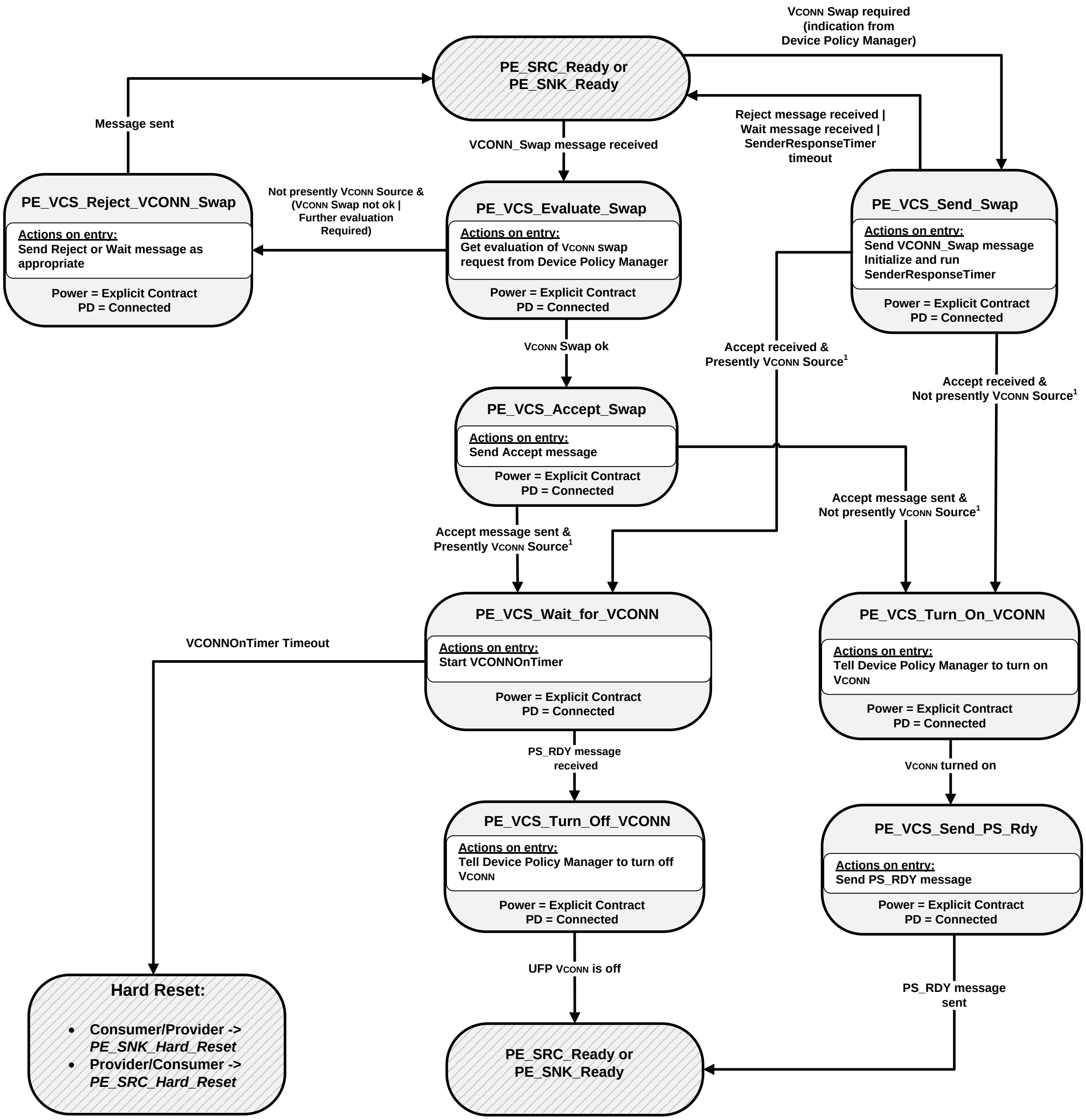
The Policy Engine ***Shall*** transition back to the ***PE_SNK_Ready*** state (see Figure 8-67) when:

- The ***Source_Capabilities_Extended*** Message has been successfully sent.

8.3.3.17 VCONN Swap State Diagram

The State Diagram in this section ***Shall*** apply to Ports that supply VCONN. Figure 8-113 shows the state operation for a Port on sending or receiving a VCONN Swap request.

Figure 8-113 VCONN Swap State Diagram



[1] A Port is presently the VCONN Source if it has the responsibility for supplying VCONN even if VCONN has been turned off.

8.3.3.17.1.1 PE_VCS_Send_Swap State

The *PE_VCS_Send_Swap* state is entered from either the *PE_SRC_Ready* or *PE_SNK_Ready* state when the Policy Engine receives a request from the Device Policy Manager to perform a VCONN Swap.

On entry to the ***PE_VCS_Send_Swap*** state the Policy Engine ***Shall*** send a ***VCONN_Swap*** Message and start the ***SenderResponseTimer***.

The Policy Engine ***Shall*** transition to the ***PE_VCS_Wait_For_VCONN*** state when:

- An ***Accept*** Message is received and
- DFP current has VCONN turned on.

The Policy Engine ***Shall*** transition to the ***PE_VCS_Turn_On_VCONN*** state when:

- An ***Accept*** Message is received and
- DFP current has VCONN turned off.

The Policy Engine ***Shall*** transition back to either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state for a DFP when:

- A ***Reject*** Message is received or
- A ***Wait*** Message is received or
- The ***SenderResponseTimer*** times out.

8.3.3.17.1.2 PE_VCS_Evaluate_Swap State

The ***PE_VCS_Evaluate_Swap*** state is entered from either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state when the Policy Engine receives a ***VCONN_Swap*** Message.

On entry to the ***PE_VCS_Evaluate_Swap*** state the Policy Engine ***Shall*** request the Device Policy Manager for an evaluation of the VCONN Swap request. Note: Ports that are presently the VCONN Source must always accept a VCONN swap request (see Section 6.3.11).

The Policy Engine ***Shall*** transition to the ***PE_VCS_Accept_Swap*** state when:

- The Device Policy Manager indicates that a VCONN Swap is ok.

The Policy Engine ***Shall*** transition to the ***PE_VCS_Reject_Swap*** state when:

- The Port is not presently the VCONN Source and
- The Device Policy Manager indicates that a VCONN Swap is not ok or
- The Device Policy Manager indicates that a VCONN Swap cannot be done at this time.

8.3.3.17.1.3 PE_VCS_Accept_Swap State

On entry to the ***PE_VCS_Accept_Swap*** state the Policy Engine ***Shall*** send an ***Accept*** Message.

The Policy Engine ***Shall*** transition to the ***PE_VCS_Wait_For_VCONN*** state when:

- The ***Accept*** Message has been sent and
- The UFP's VCONN is on.

The Policy Engine ***Shall*** transition to the ***PE_VCS_Turn_On_VCONN*** state when:

- The ***Accept*** Message has been sent and
- The UFP's VCONN is off.

8.3.3.17.1.4 PE_VCS_Reject_Swap State

On entry to the ***PE_VCS_Reject_Swap*** state the Policy Engine ***Shall*** request the Protocol Layer to send:

- A ***Reject*** Message if the device is unable to perform a VCONN Swap at this time.
- A ***Wait*** Message if further evaluation of the VCONN Swap request is required. Note: in this case it is expected that the DFP will send a ***VCONN_Swap*** Message at a later time.

The Policy Engine ***Shall*** transition back to either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state when:

- The ***Reject*** or ***Wait*** Message has been sent.

8.3.3.17.1.5 PE_VCS_UFP_Wait_for_VCONN State

On entry to the ***PE_VCS_Wait_For_VCONN*** state the Policy Engine ***Shall*** start the ***VCONNOnTimer***.

The Policy Engine ***Shall*** transition to the ***PE_VCS_Turn_Off_VCONN*** state when:

- A ***PS_RDY*** Message is received.

The Policy Engine ***Shall*** transition to either the ***PE_SRC_Hard_Reset*** or ***PE_SNK_Hard_Reset*** state when:

- The ***VCONNOnTimer*** times out.

8.3.3.17.1.6 PE_VCS_Turn_Off_VCONN State

On entry to the ***PE_VCS_Turn_Off_VCONN*** state the Policy Engine ***Shall*** tell the Device Policy Manager to turn off VCONN.

The Policy Engine ***Shall*** transition back to either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state for a UFP when:

- The UFP's VCONN is off.

8.3.3.17.1.7 PE_VCS_Turn_On_VCONN State

On entry to the ***PE_VCS_Turn_On_VCONN*** state the Policy Engine ***Shall*** tell the Device Policy Manager to turn on VCONN.

The Policy Engine ***Shall*** transition to the ***PE_VCS_Send_Ps_Rdy*** state when:

- The UFP's VCONN is on.

8.3.3.17.1.8 PE_VCS_Send_PS_Rdy State

On entry to the ***PE_VCS_Send_Ps_Rdy*** state the Policy Engine ***Shall*** send a ***PS_RDY*** Message.

The Policy Engine ***Shall*** transition back to either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state for a UFP when:

- The ***PS_RDY*** Message has been sent.

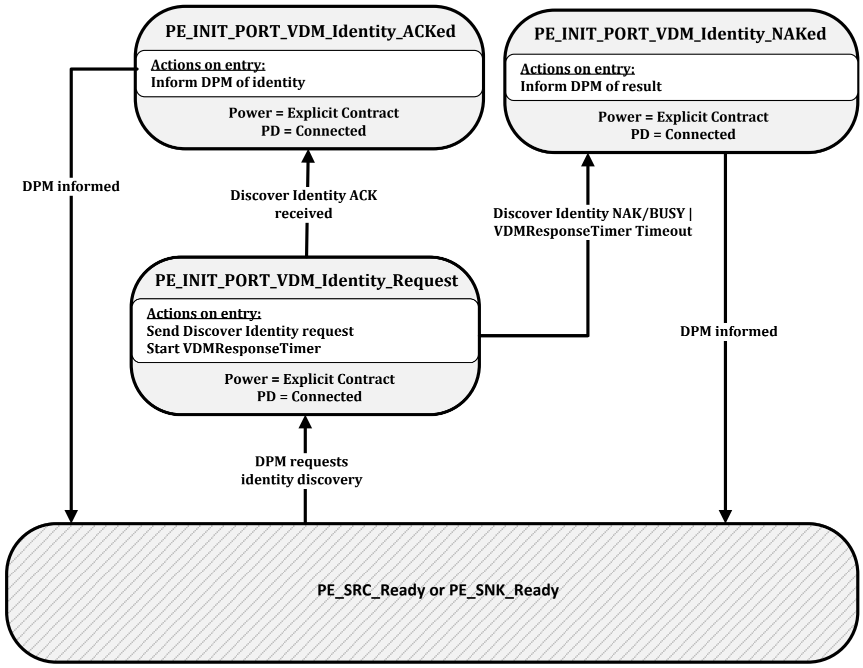
8.3.3.18 Initiator Structured VDM State Diagrams

The State Diagrams in this section ***Shall*** apply to all Initiators.

8.3.3.18.1 Initiator Structured VDM Discover Identity State Diagram

Figure 8-114 shows the state diagram for an Initiator when discovering the identity of its Port Partner or Cable Plug.

Figure 8-114 Initiator to Port VDM Discover Identity State Diagram



8.3.3.18.1.1 PE_INIT_PORT_VDM_Identity_Request State

The Policy Engine transitions to the ***PE_INIT_PORT_VDM_Identity_Request*** state from either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state when:

- The Device Policy Manager requests the discovery of the identity of the Port Partner.

On entry to the ***PE_INIT_PORT_VDM_Identity_Request*** state the Policy Engine ***Shall*** send a Structured VDM ***Discover Identity*** Command request and ***Shall*** start the ***VDMResponseTimer***.

The Policy Engine ***Shall*** transition to the ***PE_INIT_PORT_VDM_Identity_ACKed*** state when:

- A Structured VDM ***Discover Identity*** ACK Command response is received.

The Policy Engine ***Shall*** transition to the ***PE_INIT_PORT_VDM_Identity_NAKed*** state when:

- A Structured VDM ***Discover Identity*** NAK or BUSY Command response is received or
- The ***VDMResponseTimer*** times out.

8.3.3.18.1.2 PE_INIT_PORT_VDM_Identity_ACKed State

On entry to the ***PE_INIT_PORT_VDM_Identity_ACKed*** state the Policy Engine ***Shall*** inform the Device Policy Manager of the Identity information.

The Policy Engine ***Shall*** transition to either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state when:

- The Device Policy Manager has been informed.

8.3.3.18.1.3 PE_INIT_PORT_VDM_Identity_NAKed State

On entry to the ***PE_INIT_PORT_VDM_Identity_NAKed*** state the Policy Engine ***Shall*** inform the Device Policy Manager of the result (NAK, BUSY or timeout).

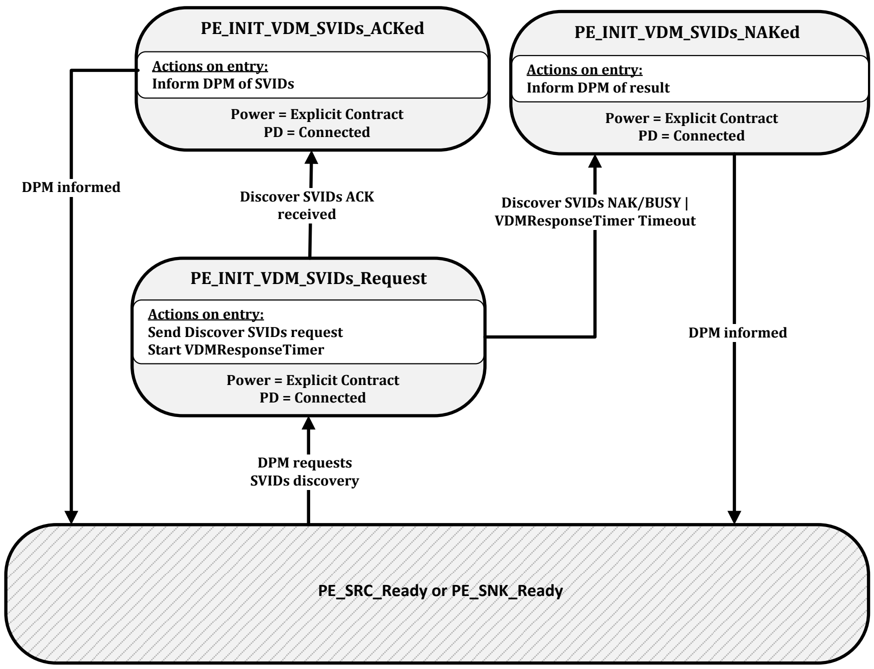
The Policy Engine ***Shall*** transition to either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state when:

- The Device Policy Manager has been informed.

8.3.3.18.2 Initiator Structured VDM Discover SVIDs State Diagram

Figure 8-115 shows the state diagram for an Initiator when discovering SVIDs of its Port Partner or Cable Plug.

Figure 8-115 Initiator VDM Discover SVIDs State Diagram



8.3.3.18.2.1 PE_INIT_VDM_SVIDs_Request State

The Policy Engine transitions to the ***PE_INIT_VDM_SVIDs_Request*** state from either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state when:

- The Device Policy Manager requests the discovery of the SVIDs of the Port Partner or a Cable Plug.

On entry to the ***PE_INIT_VDM_SVIDs_Request*** state the Policy Engine ***Shall*** send a Structured VDM ***Discover SVIDs*** Command request and ***Shall*** start the ***VDMResponseTimer***.

The Policy Engine ***Shall*** transition to the ***PE_INIT_VDM_SVIDs_ACKed*** state when:

- A Structured VDM ***Discover SVIDs*** ACK Command response is received.

The Policy Engine ***Shall*** transition to the ***PE_INIT_VDM_SVIDs_NAKed*** state when:

- A Structured VDM ***Discover SVIDs*** NAK or BUSY Command response is received or
- The ***VDMResponseTimer*** times out.

8.3.3.18.2.2 PE_INIT_VDM_SVIDs_ACKed State

On entry to the ***PE_INIT_VDM_SVIDs_ACKed*** state the Policy Engine ***Shall*** inform the Device Policy Manager of the SVIDs information.

The Policy Engine ***Shall*** transition to either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state when:

- The Device Policy Manager has been informed.

8.3.3.18.2.3 PE_INIT_VDM_SVIDs_NAKed State

On entry to the ***PE_INIT_VDM_SVIDs_NAKed*** state the Policy Engine ***Shall*** inform the Device Policy Manager of the result (NAK, BUSY or timeout).

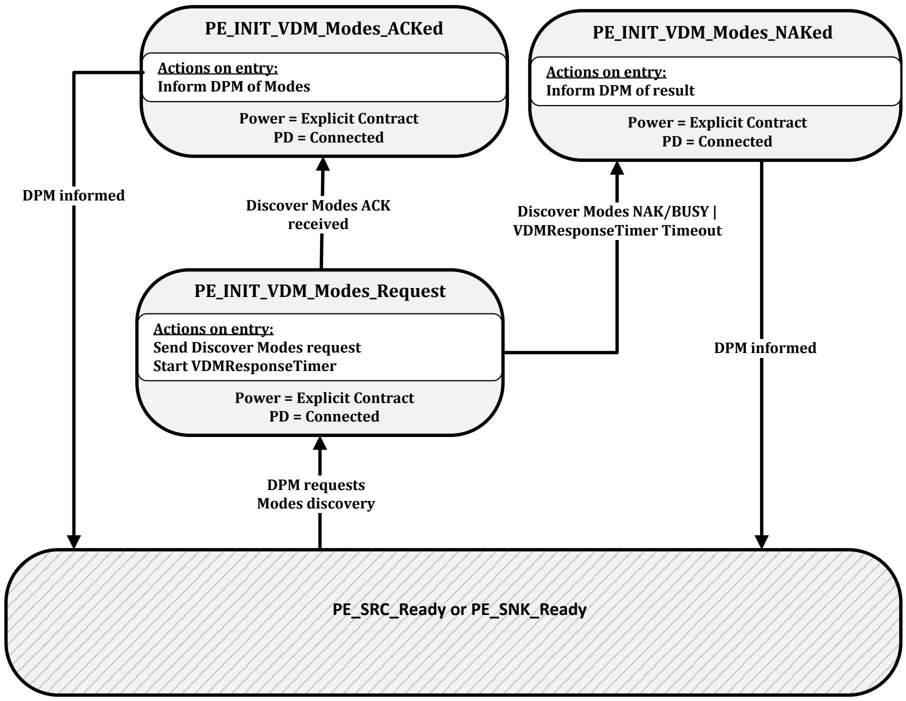
The Policy Engine ***Shall*** transition to either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state when:

- The Device Policy Manager has been informed.

8.3.3.18.3 Initiator Structured VDM Discover Modes State Diagram

Figure 8-116 shows the state diagram for an Initiator when discovering Modes of its Port Partner or Cable Plug.

Figure 8-116 Initiator VDM Discover Modes State Diagram



8.3.3.18.3.1 PE_INIT_VDM_Modes_Request State

The Policy Engine transitions to the ***PE_INIT_VDM_Modes_Request*** state from either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state when:

- The Device Policy Manager requests the discovery of the Modes of the Port Partner or a Cable Plug.

On entry to the ***PE_INIT_VDM_Modes_Request*** state the Policy Engine ***Shall*** send a Structured VDM ***Discover Modes*** Command request and ***Shall*** start the ***VDMResponseTimer***.

The Policy Engine ***Shall*** transition to the ***PE_INIT_VDM_Modes_ACKed*** state when:

- A Structured VDM ***Discover Modes*** ACK Command response is received.

The Policy Engine ***Shall*** transition to the ***PE_INIT_VDM_Modes_NAKed*** state when:

- A Structured VDM ***Discover Modes*** NAK or BUSY Command response is received or
- The ***VDMResponseTimer*** times out.

8.3.3.18.3.2 PE_INIT_VDM_Modes_ACKed State

On entry to the ***PE_INIT_VDM_Modes_ACKed*** state the Policy Engine ***Shall*** inform the Device Policy Manager of the Modes information.

The Policy Engine ***Shall*** transition to either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state for a DFP when:

- The Device Policy Manager has been informed.

8.3.3.18.3.3 PE_INIT_VDM_Modes_NAKed State

On entry to the ***PE_INIT_VDM_Modes_NAKed*** state the Policy Engine ***Shall*** inform the Device Policy Manager of the result (NAK, BUSY or timeout).

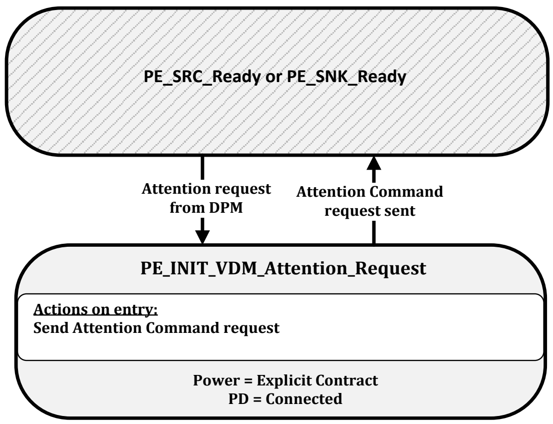
The Policy Engine ***Shall*** transition to either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state for a DFP when:

- The Device Policy Manager has been informed.

8.3.3.18.4 Initiator Structured VDM Attention State Diagram

Figure 8-121 shows the state diagram for an Initiator when sending an ***Attention*** Command request.

Figure 8-117 Initiator VDM Attention State Diagram



8.3.3.18.4.1 PE_INIT_VDM_Attention_Request State

The Policy Engine transitions to the ***PE_INIT_VDM_Attention_Request*** state from either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state when:

- When the Device Policy Manager requests attention from its Port Partner.

On entry to the ***PE_INIT_VDM_Attention_Request*** state the Policy Engine ***Shall*** send an ***Attention*** Command request.

The Policy Engine ***Shall*** transition to either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state when:

- The ***Attention*** Command request has been sent.

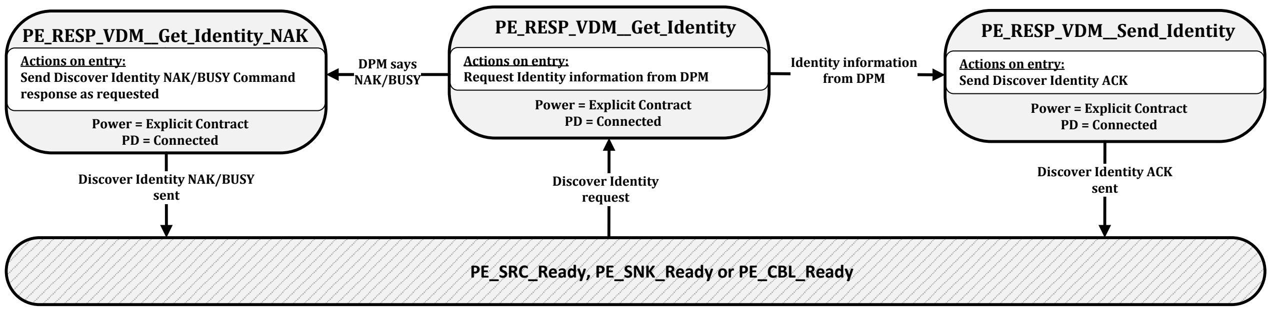
8.3.3.19 Responder Structured VDM State Diagrams

The State Diagrams in this section ***Shall*** apply to all Responders that are not Cable Plugs.

8.3.3.19.1 Responder Structured VDM Discover Identity State Diagram

Figure 8-118 shows the state diagram for a Responder receiving a ***Discover Identity*** Command request.

Figure 8-118 Responder Structured VDM Discover Identity State Diagram



8.3.3.19.1.1 PE_RESP_VDM_Get_Identity State

The Policy Engine transitions to the ***PE_RESP_VDM_Get_Identity*** state from either the ***PE_SRC_Ready***, ***PE_SNK_Ready*** or ***PE_CBL_Ready*** state when:

- A Structured VDM ***Discover Identity*** Command request is received.

On entry to the ***PE_RESP_VDM_Get_Identity*** state the Responder ***Shall*** request identity information from the Device Policy Manager.

The Policy Engine ***Shall*** transition to the ***PE_RESP_VDM_Send_Identity*** state when:

- Identity information is received from the Device Policy Manager.

The Policy Engine ***Shall*** transition to the ***PE_RESP_VDM_Get_Identity_NAK*** state when:

- The Device Policy Manager indicates that the response to the ***Discover Identity*** Command request is NAK or BUSY.

8.3.3.19.1.2 PE_RESP_VDM_Send_Identity State

On entry to the ***PE_RESP_VDM_Send_Identity*** state the Responder ***Shall*** send the Structured VDM ***Discover Identity*** ACK Command response.

The Policy Engine ***Shall*** transition to either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state for a UFP when:

- The Structured VDM ***Discover Identity*** ACK Command response has been sent.

8.3.3.19.1.3 PE_RESP_VDM_Get_Identity_NAK State

On entry to the ***PE_RESP_VDM_Get_Identity_NAK*** state the Policy Engine ***Shall*** send a Structured VDM ***Discover Identity*** NAK or BUSY Command response as indicated by the Device Policy Manager.

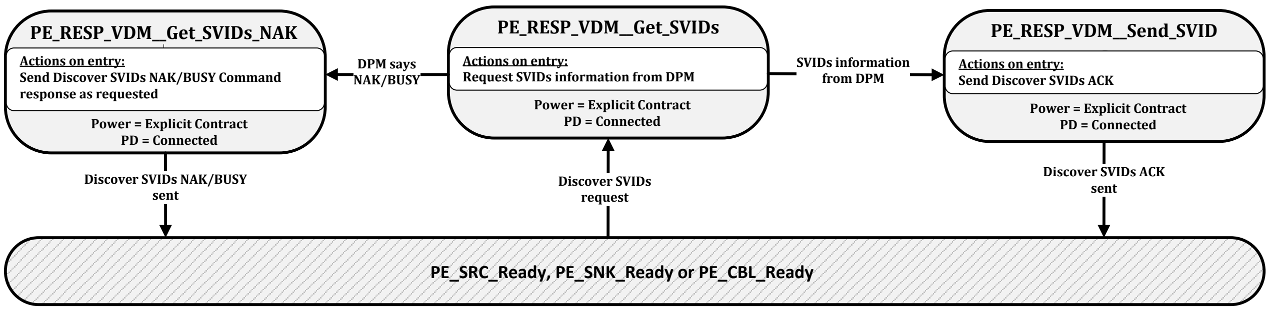
The Policy Engine ***Shall*** transition to either the ***PE_SRC_Ready, PE_SNK_Ready*** or ***PE_CBL_Ready*** state when:

- The Structured VDM ***Discover Identity*** NAK or BUSY Command response has been sent.

8.3.3.19.2 Responder Structured VDM Discover SVIDs State Diagram

Figure 8-119 shows the state diagram for a Responder when receiving a ***Discover SVIDs*** Command.

Figure 8-119 Responder Structured VDM Discover SVIDs State Diagram



8.3.3.19.2.1 PE_RESP_VDM_Get_SVIDs State

The Policy Engine transitions to the *PE_RESP_VDM_Get_SVIDs* state from either the *PE_SRC_Ready, PE_SNK_Ready* or *PE_CBL_Ready* state when:

- A Structured VDM *Discover SVIDs* Command request is received.

On entry to the *PE_RESP_VDM_Get_SVIDs* state the Responder ***Shall*** request SVIDs information from the Device Policy Manager.

The Policy Engine ***Shall*** transition to the *PE_RESP_VDM_Send_SVIDs* state when:

- SVIDs information is received from the Device Policy Manager.

The Policy Engine ***Shall*** transition to the *PE_RESP_VDM_Get_SVIDs_NAK* state when:

- The Device Policy Manager indicates that the response to the *Discover SVIDs* Command request is NAK or BUSY.

8.3.3.19.2.2 PE_UFP_VDM_Send_SVIDs State

On entry to the *PE_RESP_VDM_Send_SVIDs* state the Responder ***Shall*** send the Structured VDM *Discover SVIDs* ACK Command response.

The Policy Engine ***Shall*** transition to either the *PE_SRC_Ready, PE_SNK_Ready* or *PE_CBL_Ready* state when:

- The Structured VDM *Discover SVIDs* ACK Command response has been sent.

8.3.3.19.2.3 PE_UFP_VDM_Get_SVIDs_NAK State

On entry to the *PE_RESP_VDM_Get_SVIDs_NAK* state the Policy Engine ***Shall*** send a Structured VDM *Discover SVIDs* NAK or BUSY Command response as indicated by the Device Policy Manager.

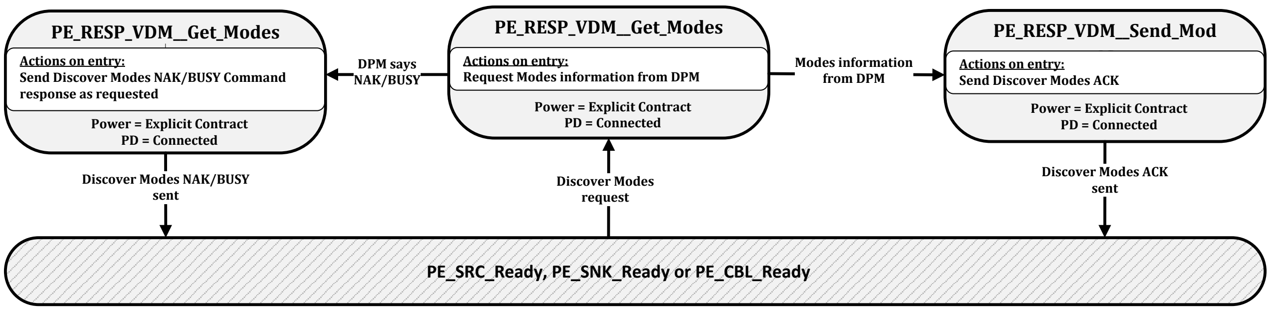
The Policy Engine ***Shall*** transition to either the *PE_SRC_Ready* or *PE_SNK_Ready* state when:

- The Structured VDM *Discover SVIDs* NAK or BUSY Command response has been sent.

8.3.3.19.3 Responder Structured VDM Discover Modes State Diagram

Figure 8-120 shows the state diagram for a Responder on receiving a *Discover Modes* Command.

Figure 8-120 Responder Structured VDM Discover Modes State Diagram



8.3.3.19.3.1 PE_RESP_VDM_Get_Modes State

The Policy Engine transitions to the ***PE_RESP_VDM_Get_Modes*** state from either the ***PE_SRC_Ready, PE_SNK_Ready*** or ***PE_CBL_Ready*** state when:

- A Structured VDM ***Discover Modes*** Command request is received.

On entry to the ***PE_RESP_VDM_Get_Modes*** state the Responder ***Shall*** request Modes information from the Device Policy Manager.

The Policy Engine ***Shall*** transition to the ***PE_RESP_VDM_Send_Modes*** state when:

- Modes information is received from the Device Policy Manager.

The Policy Engine ***Shall*** transition to the ***PE_RESP_VDM_Get_Modes_NAK*** state when:

- The Device Policy Manager indicates that the response to the ***Discover Modes*** Command request is NAK or BUSY.

8.3.3.19.3.2 PE_RESP_VDM_Send_Modes State

On entry to the ***PE_RESP_VDM_Send_Modes*** state the Responder ***Shall*** send the Structured VDM ***Discover Modes*** ACK Command response.

The Policy Engine ***Shall*** transition to either the ***PE_SRC_Ready, PE_SNK_Ready*** or ***PE_CBL_Ready*** state when:

- The Structured VDM ***Discover Modes*** ACK Command response has been sent.

8.3.3.19.3.3 PE_RESP_VDM_Get_Modes_NAK State

On entry to the ***PE_RESP_VDM_Get_Modes_NAK*** state the Policy Engine ***Shall*** send a Structured VDM ***Discover Modes*** NAK or BUSY Command response as indicated by the Device Policy Manager.

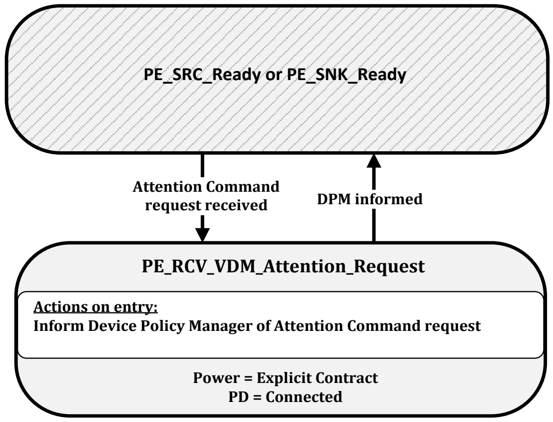
The Policy Engine ***Shall*** transition to either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state when:

- The Structured VDM ***Discover Modes*** NAK or BUSY Command response has been sent.

8.3.3.19.4 Receiving a Structured VDM Attention State Diagram

Figure 8-121 shows the state diagram when receiving an ***Attention*** Command request.

Figure 8-121 Receiving a Structured VDM Attention State Diagram



8.3.3.19.4.1 PE_RCV_VDM_Attention_Request State

The Policy Engine transitions to the ***PE_RCV_VDM_Attention_Request*** state from either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state when:

- An ***Attention*** Command request is received.

On entry to the ***PE_RCV_VDM_Attention_Request*** state the Policy Engine ***Shall*** inform the Device Policy Manager of the ***Attention*** Command request.

The Policy Engine ***Shall*** transition to either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state when:

- The Device Policy Manager has been informed.

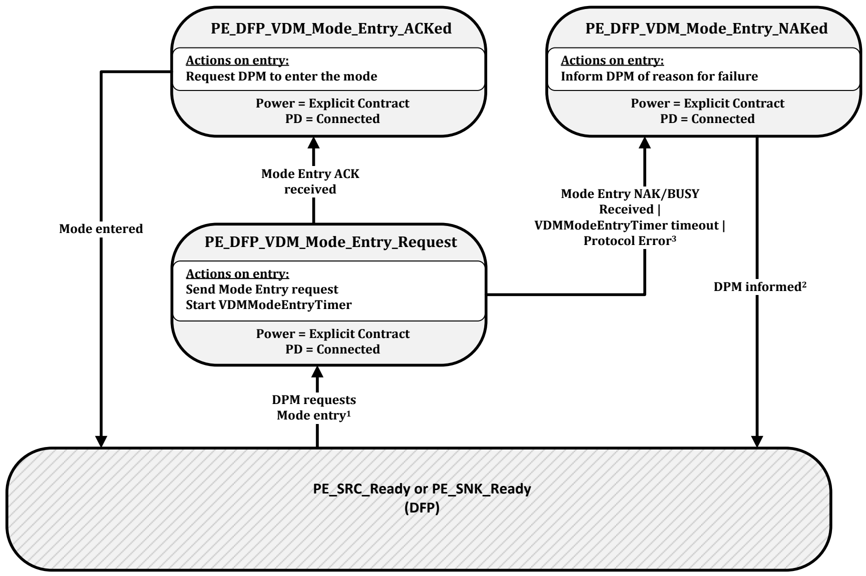
8.3.3.20 DFP Structured VDM State Diagrams

The State Diagrams in this section ***Shall*** apply to all DFPs that support Structured VDMs.

8.3.3.20.1 DFP Structured VDM Mode Entry State Diagram

Figure 8-122 shows the state operation for a DFP when entering a Mode.

Figure 8-122 DFP VDM Mode Entry State Diagram



[1] The Device Policy Manager ***Shall*** have placed the system into USB Safe State before issuing this request when entering Modal operation.

[2] The Device Policy Manager ***Shall*** have returned the system to USB operation if not in Modal operation at this point.

[3] Protocol Errors are handled by informing the DPM, returning to USB Safe State and then processing the Message once the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state has been entered.

8.3.3.20.1.1 PE_DFP_VDM_Mode_Entry_Request State

The Policy Engine transitions to the ***PE_DFP_VDM_Mode_Entry_Request*** state from either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state for a DFP when:

- The Device Policy Manager requests that the Port Partner or a Cable Plug enter a Mode.

On entry to the ***PE_DFP_VDM_Mode_Entry_Request*** state the Policy Engine ***Shall*** send a Structured VDM ***Enter Mode*** Command request and ***Shall*** start the ***VDMModeEntryTimer***.

The Policy Engine ***Shall*** transition to the ***PE_DFP_VDM_Mode_Entry_ACKed*** state when:

- A Structured VDM ***Enter Mode*** ACK Command response is received.

The Policy Engine ***Shall*** transition to the ***PE_DFP_VDM_Mode_Entry_NAKed*** state when:

- A Structured VDM ***Enter Mode*** NAK or BUSY Command response is received or
- The ***VDMModeEntryTimer*** times out.

8.3.3.20.1.2 PE_DFP_VDM_Mode_Entry_ACKed State

On entry to the ***PE_DFP_VDM_Mode_Entry_ACKed*** state the Policy Engine ***Shall*** request the Device Policy Manager to enter the Mode.

The Policy Engine ***Shall*** transition to either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state for a DFP when:

- The Mode has been entered.

8.3.3.20.1.3 PE_DFP_VDM_Mode_Entry_NAKed State

On entry to the ***PE_DFP_VDM_Mode_Entry_NAKed*** state the Policy Engine ***Shall*** inform the Device Policy Manager of the reason for failure (NAK, BUSY, timeout or Protocol Error).

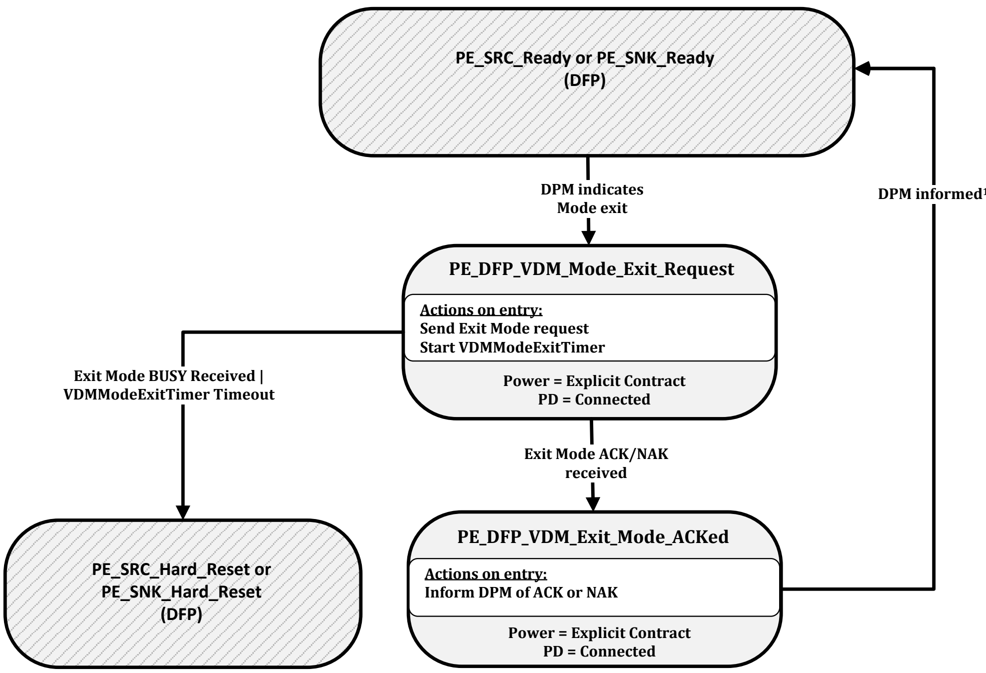
The Policy Engine ***Shall*** transition to either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state for a DFP when:

- The Device Policy Manager has been informed.

8.3.3.20.2 DFP Structured VDM Mode Exit State Diagram

Figure 8-123 shows the state diagram for a DFP when exiting a Mode.

Figure 8-123 DFP VDM Mode Exit State Diagram



[1] The Device Policy Manager is required to return the system to USB operation at this point when exiting Modal Operation.

8.3.3.20.2.1 PE_DFP_VDM_Mode_Exit_Request State

The Policy Engine transitions to the ***PE_DFP_VDM_Mode_Exit_Request*** state from either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state for a DFP when:

- The Device Policy Manager requests that the Port Partner or a Cable Plug exit a Mode.

On entry to the ***PE_DFP_VDM_Mode_Exit_Request*** state the Policy Engine ***Shall*** send a Structured VDM ***Exit Mode*** Command request and ***Shall*** start the ***VDMModeExitTimer***.

The Policy Engine ***Shall*** transition to the ***PE_DFP_VDM_Mode_Exit_ACKed*** state when:

- A Structured VDM ***Exit Mode*** ACK or NAK Command response is received.

The Policy Engine ***Shall*** transition to either the ***PE_SRC_Hard_Reset*** or ***PE_SNK_Hard_Reset*** state depending on the present Power Role when:

- A Structured VDM ***Exit Mode*** BUSY Command response is received or

- The ***VDMModeExitTimer*** times out.

8.3.3.20.2.2 PE_DFP_VDM_DFP_Mode_Exit_ACKed State

On Exit to the ***PE_DFP_VDM_Mode_Exit_ACKed*** state the Policy Engine ***Shall*** inform the Device Policy Manager Of the result: ACK or NAK.

The Policy Engine ***Shall*** transition to either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state for a DFP when:

- The Device Policy Manager has been informed.

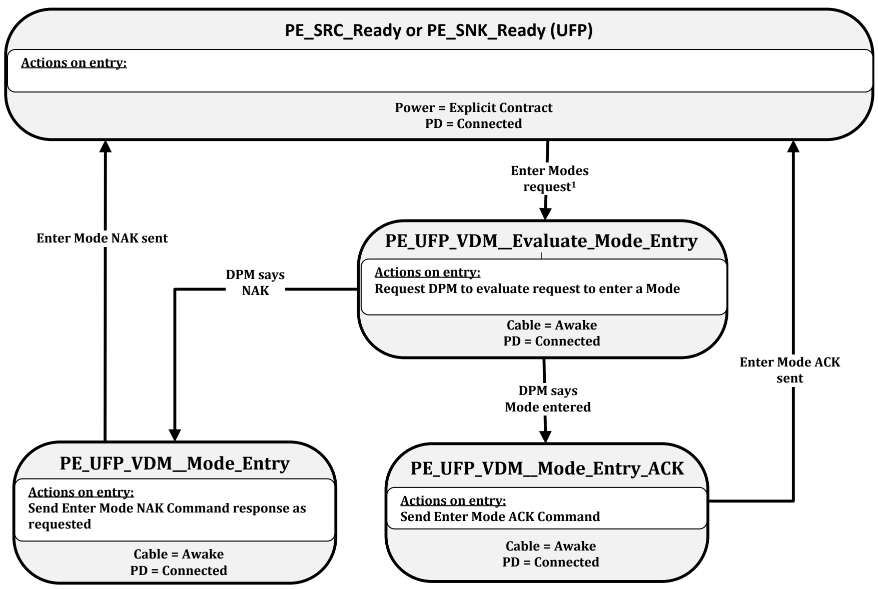
8.3.3.21 UFP Structured VDM State Diagrams

The State Diagrams in this section ***Shall*** apply to all UFPs that support Structured VDMs.

8.3.3.21.1 UFP Structured VDM Enter Mode State Diagram

Figure 8-124 shows the state diagram for a UFP in response to an ***Enter Mode*** Command.

Figure 8-124 UFP Structured VDM Enter Mode State Diagram



[1] The UFP is required to be in USB operation or USB Safe State at this point.

8.3.3.21.1.1 PE_UFP_VDM_Evaluate_Mode_Entry State

The Policy Engine transitions to the ***PE_UFP_VDM_Evaluate_Mode_Entry*** state from either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state for a UFP when:

- A Structured VDM ***Enter Mode*** Command request is received from the DFP.

On Entry to the ***PE_UFP_VDM_Evaluate_Mode_Entry*** state the Policy Engine ***Shall*** request the Device Policy Manager to evaluate the ***Enter Mode*** Command request and enter the Mode indicated in the Command request if the request is acceptable.

The Policy Engine ***Shall*** transition to the ***PE_UFP_VDM_Mode_Entry_ACK*** state when:

- The Device Policy Manager indicates that the Mode has been entered.

The Policy Engine ***Shall*** transition to the ***PE_UFP_VDM_Mode_Entry_NAK*** state when:

- The Device Policy Manager indicates that the response to the Mode request is NAK.

8.3.3.21.1.2 PE_UFP_VDM_Mode_Entry_ACK State

On entry to the ***PE_UFP_VDM_Mode_Entry_ACK*** state the Policy Engine ***Shall*** send a Structured VDM ***Enter Mode*** ACK Command response.

The Policy Engine ***Shall*** transition to either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state for a UFP when:

- The Structured VDM ***Enter Mode*** ACK Command response has been sent.

8.3.3.21.1.3 PE_UFP_VDM_Mode_Entry_NAK State

On entry to the ***PE_UFP_VDM_Mode_Entry_NAK*** state the Policy Engine ***Shall*** send a Structured VDM ***Enter Mode*** NAK Command response as indicated by the Device Policy Manager.

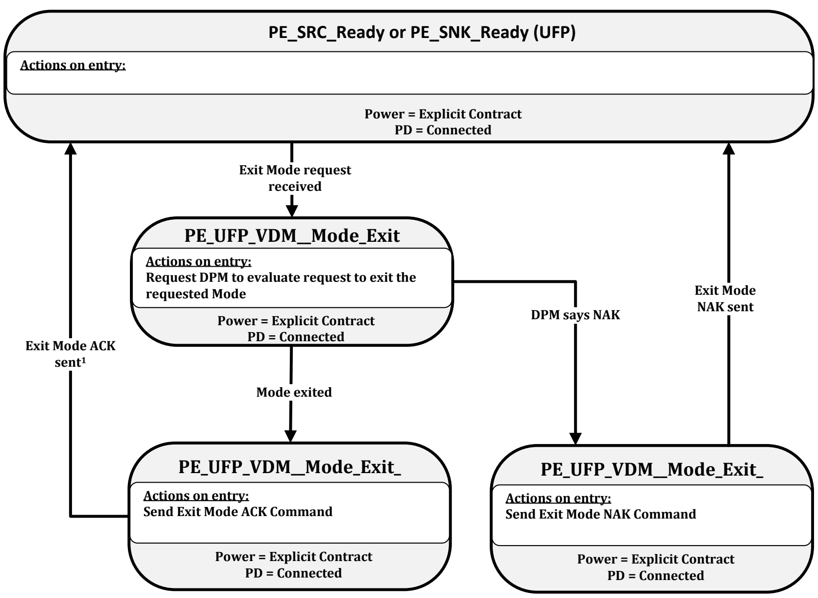
The Policy Engine ***Shall*** transition to either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state for a UFP when:

- The Structured VDM ***Enter Mode*** NAK Command response has been sent.

8.3.3.21.2 UFP Structured VDM Exit Mode State Diagram

Figure 8-125 shows the state diagram for a UFP in response to an ***Exit Mode*** Command.

Figure 8-125 UFP Structured VDM Exit Mode State Diagram



[1] The UFP is required to be in USB operation or USB Safe State at this point.

8.3.3.21.2.1 PE_UFP_VDM_Mode_Exit State

The Policy Engine transitions to the ***PE_UFP_VDM_Mode_Exit*** state from either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state for a UFP when:

- A Structured VDM ***Exit Mode*** Command request is received from the DFP.

On entry to the ***PE_UFP_VDM_Mode_Exit*** state the Policy Engine ***Shall*** request the Device Policy Manager to exit the Mode indicated in the Command.

The Policy Engine ***Shall*** transition to the ***PE_UFP_VDM_Mode_Exit_ACK*** state when:

- The Device Policy Manger indicates that the Mode has been exited.

The Policy Engine ***Shall*** transition to the ***PE_UFP_VDM_Mode_Exit_NAK*** state when:

- The Device Policy Manager indicates that the Command response to the ***Exit Mode*** Command request is NAK.

8.3.3.21.2.2 PE_CBL_Mode_Exit_ACK State

On entry to the ***PE_UFP_VDM_Mode_Exit_ACK*** state the Policy Engine ***Shall*** send a Structured VDM ***Exit Mode*** ACK Command response.

The Policy Engine ***Shall*** transition to either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state for a UFP when:

- The Structured VDM ***Exit Mode*** ACK Command response has been sent.

8.3.3.21.2.3 PE_UFP_VDM_Mode_Exit_NAK State

On entry to the ***PE_UFP_VDM_Mode_Exit_NAK*** state the Policy Engine ***Shall*** send a Structured VDM ***Exit Mode*** NAK Command response as indicated by the Device Policy Manager.

The Policy Engine ***Shall*** transition to either the either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state for a UFP when:

- The Structured VDM ***Exit Mode*** NAK Command response has been sent.

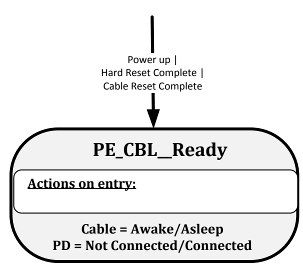
8.3.3.22 Cable Plug Specific State Diagrams

The State Diagrams in this section ***Shall*** apply to all Cable Plugs that support Structured VDMs.

8.3.3.22.1 Cable Plug Cable Ready State Diagram

Figure 8-126 shows the Cable Ready state diagram for a Cable Plug.

Figure 8-126 Cable Ready VDM State Diagram



8.3.3.22.1.1 PE_CBL_Ready State

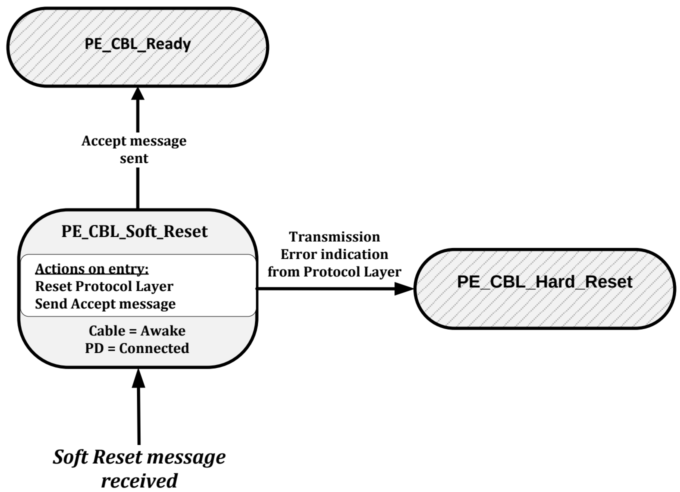
The ***PE_CBL_Ready*** state shown in the following sections is the normal operational state for a Cable Plug and where it starts after power up or a Hard/Cable Reset.

8.3.3.22.2 Soft/Hard/Cable Reset

8.3.3.22.2.1 Cable Plug Soft Reset State Diagram

Figure 8-127 shows the Cable Plug state diagram on reception of a ***Soft_Reset*** Message.

Figure 8-127 Cable Plug Soft Reset State Diagram



8.3.3.22.2.1.1 PE_CBL_Soft_Reset State

The ***PE_CBL_Soft_Reset*** state ***Shall*** be entered from any state when a Reset Message is received from the Protocol Layer.

On entry to the ***PE_CBL_Soft_Reset*** state the Policy Engine ***Shall*** reset the Protocol Layer in the Cable Plug and ***Shall*** then request the Protocol Layer to send an ***Accept*** Message.

The Policy Engine ***Shall*** transition to the ***PE_CBL_Ready*** state when:

- The ***Accept*** Message has been sent.

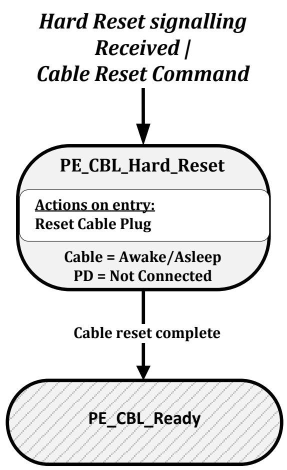
The Policy Engine ***Shall*** transition to the ***PE_CBL_Hard_Reset*** state when:

- The Protocol Layer indicates that a transmission error has occurred.

8.3.3.22.2.2 Cable Plug Hard Reset State Diagram

Figure 8-128 shows the Cable Plug state diagram for a Hard Reset or Cable Reset.

Figure 8-128 Cable Plug Hard Reset State Diagram



8.3.3.22.2.2.1 PE_CBL_Hard_Reset State

The ***PE_CBL_Hard_Reset*** state ***Shall*** be entered from any state when either ***Hard Reset*** Signaling or ***Cable Reset*** Signaling is detected.

On entry to the ***PE_CBL_Hard_Reset*** state the Policy Engine ***Shall*** reset the Cable Plug (equivalent to a power cycle).

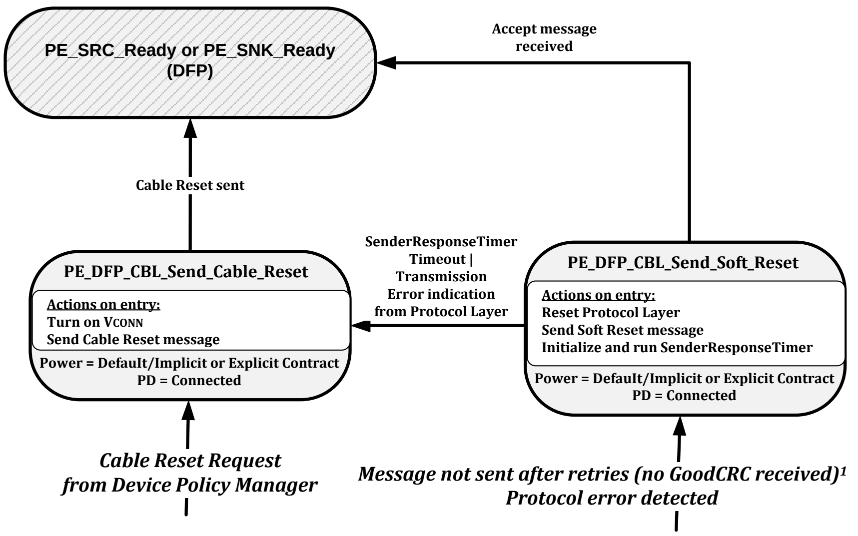
The Policy Engine ***Shall*** transition to the ***PE_CBL_Ready*** state when:

- The Cable Plug reset is complete.

8.3.3.22.2.3 DFP Soft Reset or Cable Reset of a Cable Plug State Diagram

Figure 8-129 below shows the state diagram for the Policy Engine in a DFP when performing a Soft Reset or Cable Reset of a Cable Plug. The following sections describe operation in each of the states.

Figure 8-129 DFP Soft Reset or Cable Reset of a Cable Plug State Diagram



[1] Excludes the ***Soft_Reset*** Message itself.

8.3.3.22.2.3.1 PE_DFP_CBL_Send_Soft_Reset State

The ***PE_DFP_CBL_Send_Soft_Reset*** state ***Shall*** be entered from any state when a Protocol Error is detected by the Protocol Layer (see Section 6.8.1) when a Message has not been sent after retries while communicating with a Cable Plug or whenever the Device Policy Manager directs a Soft Reset.

On entry to the ***PE_DFP_CBL_Send_Soft_Reset*** state the Policy Engine ***Shall*** request the Protocol Layer to perform a Soft Reset, then ***Shall*** send a ***Soft_Reset*** Message to the Cable Plug, and initialize and run the ***SenderResponseTimer***.

The Policy Engine ***Shall*** transition to either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state, depending on the DFP's Power Role, when:

- An ***Accept*** Message has been received.

The Policy Engine ***Shall*** transition to the ***PE_DFP_CBL_Send_Cable_Reset*** state when:

- A ***SenderResponseTimer*** timeout occurs
- Or the Protocol Layer indicates that a transmission error has occurred.

8.3.3.22.2.3.2 PE_DFP_CBL_Send_Cable_Reset State

The ***PE_DFP_CBL_Send_Cable_Reset*** state ***Shall*** be entered from any state when the Device Policy Manager requests a Cable Reset.

On entry to the ***PE_DFP_CBL_Send_Cable_Reset*** state the Policy Engine ***Shall*** request the Protocol Layer to send ***Cable Reset*** Signaling.

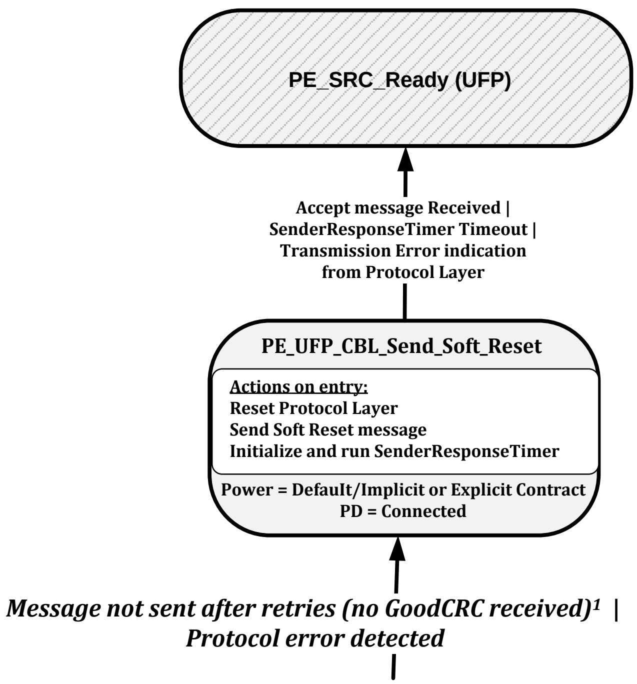
The Policy Engine ***Shall*** transition to either the ***PE_SRC_Ready*** or ***PE_SNK_Ready*** state, depending on the DFP's Power Role, when:

- ***Cable Reset*** Signaling has been sent.

8.3.3.22.2.4 UFP Source Soft Reset of a Cable Plug State Diagram

Figure 8-130 below shows the state diagram for the Policy Engine in a UFP Source, prior to an Explicit Contract, when performing a Soft Reset of a Cable Plug. The following sections describe operation in each of the states.

Figure 8-130 UFP Source Soft Reset of a Cable Plug State Diagram



[1] Excludes the ***Soft_Reset*** Message itself.

8.3.3.22.2.4.1 PE_UFP_CBL_Send_Soft_Reset State

The ***PE_UFP_CBL_Send_Soft_Reset*** state ***Shall*** be entered from any state when a Protocol Error is detected by the Protocol Layer, when a Message has not been sent after retries while communicating with a Cable Plug or whenever the Device Policy Manager directs a Soft Reset.

Note that there are corner cases that are not shown in the defined state diagrams that could be handled without generating a Protocol Error.

On entry to the ***PE_UFP_CBL_Send_Soft_Reset*** state the Policy Engine ***Shall*** request the Protocol Layer to perform a Soft Reset, then ***Shall*** send a ***Soft_Reset*** Message to the Cable Plug, and initialize and run the ***SenderResponseTimer***.

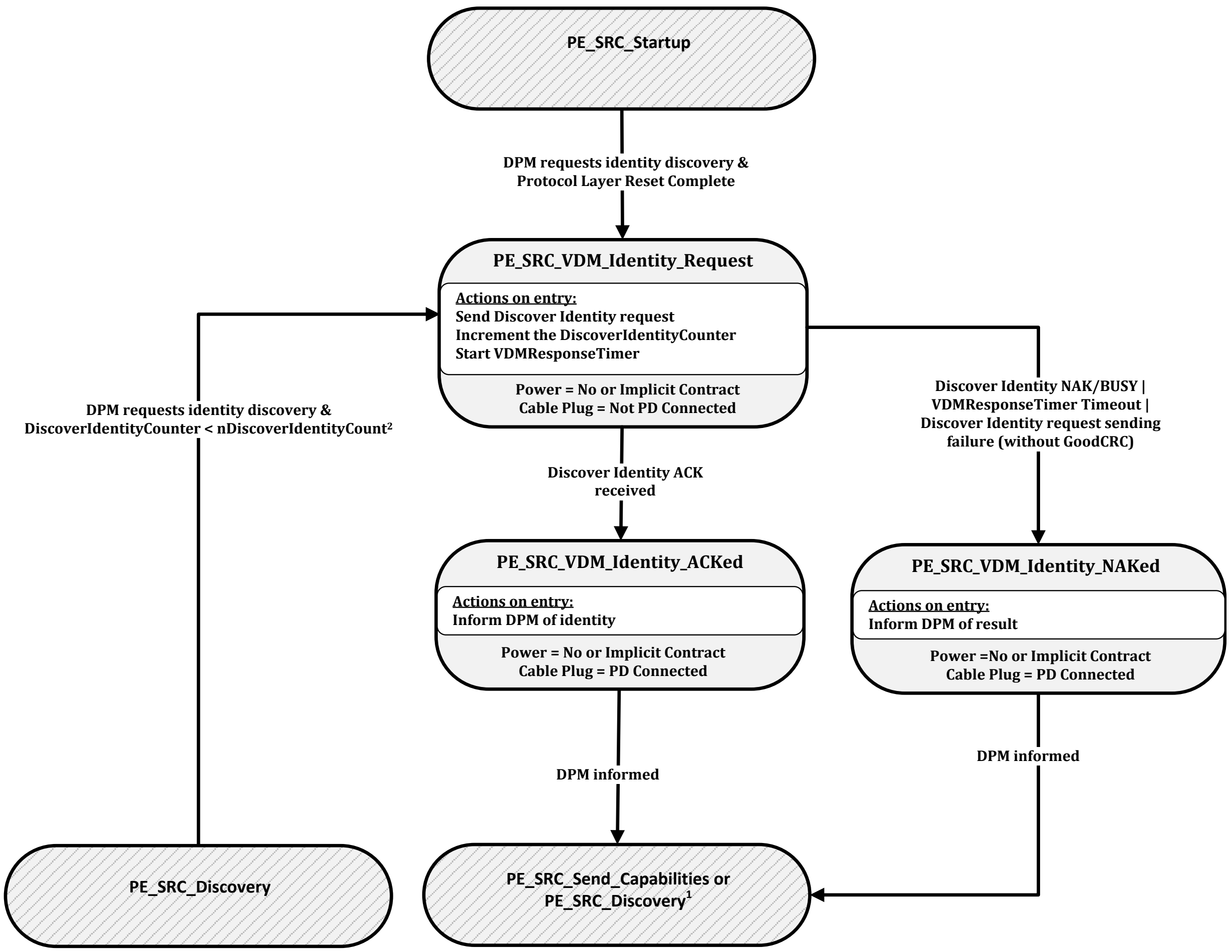
The Policy Engine ***Shall*** transition to the ***PE_SRC_Ready*** state when:

- An ***Accept*** Message has been received
- Or a ***SenderResponseTimer*** timeout occurs
- Or the Protocol Layer indicates that a transmission error has occurred.

8.3.3.22.3 Source Startup Structured VDM Discover Identity of a Cable Plug State Diagram

Figure 8-131 shows the state diagram for Source discovery of identity information from a Cable Plug during the startup sequence.

Figure 8-131 Source Startup Structured VDM Discover Identity State Diagram



[1] If the ***Discover Identity*** Command is being sent at startup then the Policy Engine will subsequently transition to the ***PE_SRC_Send_Capabilities*** state as normal. Otherwise the Policy Engine will transition to the ***PE_SRC_Discovery*** state.

[2] The ***SourceCapabilityTimer*** continues to run during the states defined in this diagram even though there has been an exit from the ***PE_SRC_Discovery*** state. This ensures that ***Source_Capabilities*** Messages are sent out at a regular rate.

8.3.3.22.3.1 PE_SRC_VDM_Identity_Request State

The Policy Engine ***Shall*** transition to the ***PE_SRC_VDM_Identity_Request*** state from the ***PE_SRC_Startup*** state when:

- The Device Policy Manager requests the discovery of the identity of the Cable Plug.

The Policy Engine ***Shall*** transition to the ***PE_SRC_VDM_Identity_Request*** state from the ***PE_SRC_Discovery*** state when:

- The Device Policy Manager requests the discovery of the identity of the Cable Plug and
- The ***DiscoverIdentityCounter*** < ***nDiscoverIdentityCount***.

Even though there has been a transition out of the ***PE_SRC_Discovery*** state the ***SourceCapabilityTimer*** ***Shall*** continue to run during the states shown in Figure 8-131 and ***Shall Not*** be initialized on re-entry to ***PE_SRC_Discovery***.

On entry to the ***PE_SRC_VDM_Identity_Request*** state the Policy Engine ***Shall*** send a Structured VDM ***Discover Identity*** Command request, ***Shall*** increment the ***DiscoverIdentityCounter*** and ***Shall*** start the ***VDMResponseTimer***.

The Policy Engine ***Shall*** transition to the ***PE_SRC_VDM_Identity_ACKed*** state when:

- A Structured VDM ***Discover Identity*** ACK Command response is received.

The Policy Engine ***Shall*** transition to the ***PE_SRC_VDM_Identity_NAKed*** state when:

- A Structured VDM ***Discover Identity*** NAK or BUSY Command response is received or
- The ***VDMResponseTimer*** times out or
- The Structured VDM ***Discover Identity*** Command request Message sending fails (no ***GoodCRC*** Message received after retries).

8.3.3.22.3.2 PE_SRC_VDM_Identity_ACKed State

On entry to the ***PE_SRC_VDM_Identity_ACKed*** state the Policy Engine ***Shall*** inform the Device Policy Manager of the Identity information.

The Policy Engine ***Shall*** transition back to either the ***PE_SRC_Send_Capabilities*** or ***PE_SRC_Discovery*** state when:

- The Device Policy Manager has been informed.

8.3.3.22.3.3 PE_SRC_VDM_Identity_NAKed State

On entry to the ***PE_SRC_VDM_Identity_NAKed*** state the Policy Engine ***Shall*** inform the Device Policy Manager of the result (NAK, BUSY or timeout).

The Policy Engine ***Shall*** transition back to either the ***PE_SRC_Send_Capabilities*** or ***PE_SRC_Discovery*** state when:

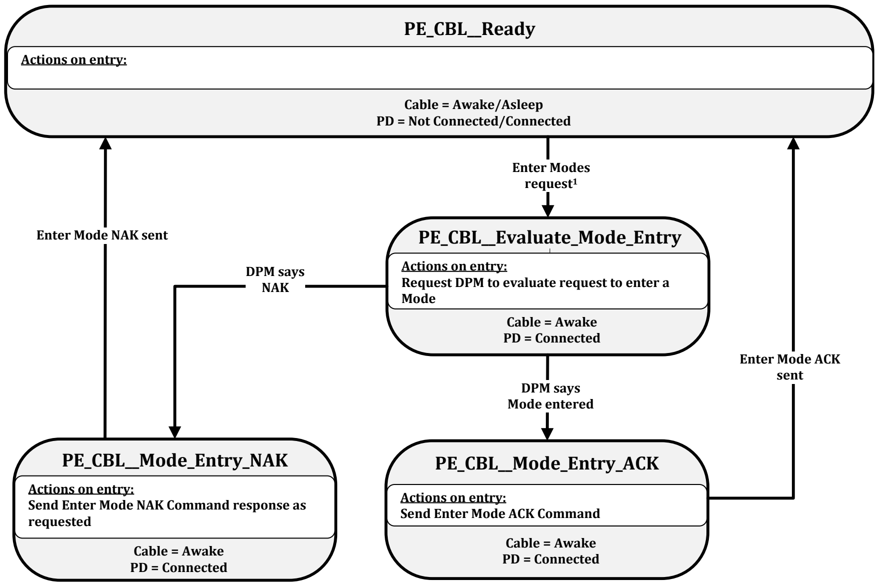
- The Device Policy Manager has been informed.

8.3.3.22.4 Cable Plug Mode Entry/Exit

8.3.3.22.4.1 Cable Plug Structured VDM Enter Mode State Diagram

Figure 8-132 shows the state diagram for a Cable Plug in response to an ***Enter Mode*** Command.

Figure 8-132 Cable Plug Structured VDM Enter Mode State Diagram



[1] The Cable is required to be in USB operation or USB Safe State at this point.

8.3.3.22.4.1.1 PE_CBL_Evaluate_Mode_Entry State

The Policy Engine transitions to the ***PE_CBL_Evaluate_Mode_Entry*** state from the ***PE_CBL_Ready*** state when:

- A Structured VDM ***Enter Mode*** Command request is received from the DFP.

On Entry to the ***PE_CBL_Evaluate_Mode_Entry*** state the Policy Engine ***Shall*** request the Device Policy Manager to evaluate the ***Enter Mode*** Command request and enter the Mode indicated in the Command request if the request is acceptable.

The Policy Engine ***Shall*** transition to the ***PE_CBL_Mode_Entry_ACK*** state when:

- The Device Policy Manager indicates that the Mode has been entered.

The Policy Engine ***Shall*** transition to the ***PE_CBL_Mode_Entry_NAK*** state when:

- The Device Policy Manager indicates that the response to the Mode request is NAK.

8.3.3.22.4.1.2 PE_CBL_Mode_Entry_ACK State

On entry to the ***PE_CBL_Mode_Entry_ACK*** state the Policy Engine ***Shall*** send a Structured VDM ***Enter Mode*** ACK Command response.

The Policy Engine ***Shall*** transition to the ***PE_CBL_Ready*** state when:

- The Structured VDM ***Enter Mode*** ACK Command response has been sent.

8.3.3.22.4.1.3 PE_CBL_Mode_Entry_NAK State

On entry to the ***PE_CBL_Mode_Entry_NAK*** state the Policy Engine ***Shall*** send a Structured VDM ***Enter Mode*** NAK Command response as indicated by the Device Policy Manager.

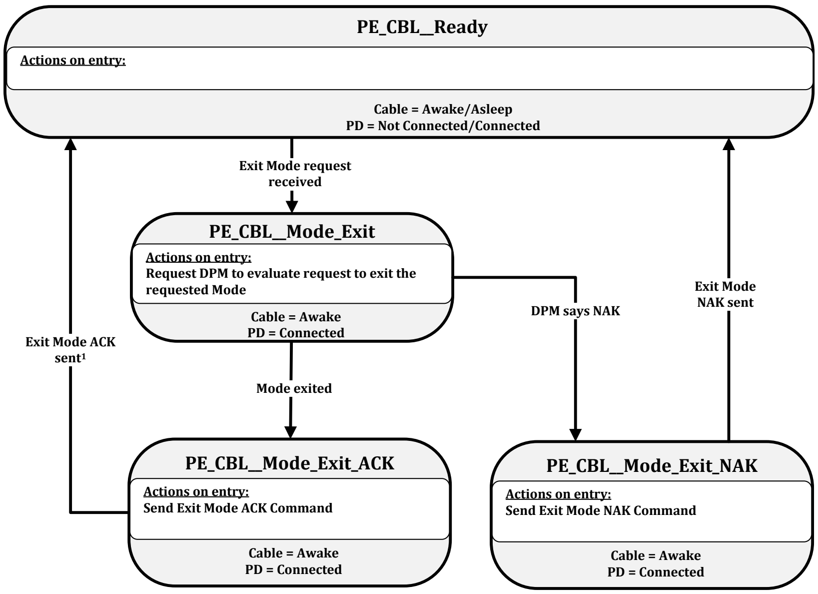
The Policy Engine ***Shall*** transition to the ***PE_CBL_Ready*** state when:

- The Structured VDM ***Enter Mode*** NAK Command response has been sent.

8.3.3.22.4.2 Cable Plug Structured VDM Exit Mode State Diagram

Figure 8-133 shows the state diagram for a Cable Plug in response to an ***Exit Mode*** Command.

Figure 8-133 Cable Plug Structured VDM Exit Mode State Diagram



[1] The Cable is required to be in USB operation or USB Safe State at this point.

8.3.3.22.4.2.1 PE_CBL_Mode_Exit State

The Policy Engine transitions to the ***PE_CBL_Mode_Exit*** state from the ***PE_CBL_Ready*** state when:

- A Structured VDM ***Exit Mode*** Command request is received from the DFP.

On entry to the ***PE_CBL_Mode_Exit*** state the Policy Engine ***Shall*** request the Device Policy Manager to exit the Mode indicated in the Command.

The Policy Engine ***Shall*** transition to the ***PE_CBL_Mode_Exit_ACK*** state when:

- The Device Policy Manger indicates that the Mode has been exited.

The Policy Engine ***Shall*** transition to the ***PE_CBL_Mode_Exit_NAK*** state when:

- The Device Policy Manager indicates that the Command response to the ***Exit Mode*** Command request is NAK.

8.3.3.22.4.2.2 PE_CBL_Mode_Exit_ACK State

On entry to the ***PE_CBL_Mode_Exit_ACK*** state the Policy Engine ***Shall*** send a Structured VDM ***Exit Mode*** ACK Command response.

The Policy Engine ***Shall*** transition to the ***PE_CBL_Ready*** state when:

- The Structured VDM ***Exit Mode*** ACK Command response has been sent.

8.3.3.22.4.2.3 PE_CBL_Mode_Exit_NAK State

On entry to the ***PE_CBL_Mode_Exit_NAK*** state the Policy Engine ***Shall*** send a Structured VDM ***Exit Mode*** NAK Command response as indicated by the Device Policy Manager.

The Policy Engine ***Shall*** transition to the ***PE_CBL_Ready*** state when:

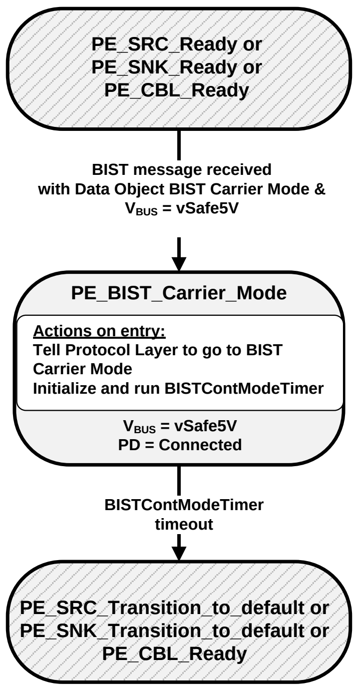
- The Structured VDM ***Exit Mode*** NAK Command response has been sent.

8.3.3.23 BIST State diagrams

8.3.3.23.1 BIST Carrier Mode State Diagram

Figure 8-134 shows the state diagram required by a UUT, which can be either a Source, Sink or Cable Plug, when operating in ***BIST Carrier Mode***. Transitions ***Shall*** be from either the ***PE_SRC_Ready, PE_SNK_Ready*** or ***PE_CBL_Ready*** states.

Figure 8-134 BIST Carrier Mode State Diagram



8.3.3.23.1.1 PE_BIST_Carrier_Mode State

The Source, Sink or Cable Plug ***Shall*** enter the ***PE_BIST_Carrier_Mode*** state from either the ***PE_SRC_Ready***, ***PE_SNK_Ready*** or ***PE_CBL_Ready*** state when:

- A ***BIST*** Message is received with a ***BIST Carrier Mode*** BIST Data Object and
- V_{BUS} is at ***vSafe5V***.

On entry to the ***PE_BIST_Carrier_Mode*** state the Policy Engine ***Shall*** tell the Protocol Layer to go to BIST Carrier Mode and ***Shall*** initialize and run the ***BISTContModeTimer***.

The Policy Engine ***Shall*** transition to either the ***PE_SRC_Transition_to_default*** state, ***PE_SNK_Transition_to_default*** state or ***PE_CBL_Ready*** state (as appropriate) when:

- The ***BISTContModeTimer*** times out.

8.3.3.24 USB Type-C Referenced States

This section contains states cross-referenced from the ***[USB Type-C 1.2]*** specification.

8.3.3.24.1 ErrorRecovery state

The ***ErrorRecovery*** state is used to electronically disconnect Port Partners using the USB Type-C connector. The ***ErrorRecovery*** state ***Shall*** be entered when there are errors on USB Type-C Ports which cannot be recovered by Hard Reset. The ***ErrorRecovery*** state ***Shall*** map to USB Type-C ErrorRecovery state operation as defined in the ***[USB Type-C 1.2]*** specification, including any other state transitions mandated in cases where USB Type-C ErrorRecovery is not supported.

On entry to the ***ErrorRecovery*** state the Contract and PD Connection ***Shall*** be ended.

On exit from the ***ErrorRecovery*** state a new Explicit Contract ***Should*** be established once the Port Partners have re-connected over the CC wire.

8.3.3.25 Policy Engine States

Table 8-62 lists the states used by the various state machines.

Table 8-62 Policy Engine States

State name	Reference
Source Port	
PE_SRC_Startup	Section 8.3.3.2.1
PE_SRC_Discovery	Section 8.3.3.2.2
PE_SRC_Send_Capabilities	Section 8.3.3.2.3
PE_SRC_Negotiate_Capability	Section 8.3.3.2.4
PE_SRC_Transition_Supply	Section 8.3.3.2.5
PE_SRC_Ready	Section 8.3.3.2.6
PE_SRC_Disabled	Section 8.3.3.2.7
PE_SRC_Capability_Response	Section 8.3.3.2.8
PE_SRC_Hard_Reset	Section 8.3.3.2.9
PE_SRC_Hard_Reset_Received	Section 8.3.3.2.10
PE_SRC_Transition_to_default	Section 8.3.3.2.11
PE_SRC_Get_Sink_Cap	Section 8.3.3.2.12
PE_SRC_Wait_New_Capabilities	Section 8.3.3.2.13
Sink Port	
PE_SNK_Startup	Section 8.3.3.3.1
PE_SNK_Discovery	Section 8.3.3.3.2
PE_SNK_Wait_for_Capabilities	Section 8.3.3.3.3
PE_SNK_Evaluate_Capability	Section 8.3.3.3.4
PE_SNK_Select_Capability	Section 8.3.3.3.5
PE_SNK_Transition_Sink	Section 8.3.3.3.6
PE_SNK_Ready	Section 8.3.3.3.7
PE_SNK_Hard_Reset	Section 8.3.3.3.8
PE_SNK_Transition_to_default	Section 8.3.3.3.9
PE_SNK_Give_Sink_Cap	Section 8.3.3.3.10
PE_SNK_Get_Source_Cap	Section 8.3.3.3.11
Soft Reset and Protocol Error	
Source Port Soft Reset	
PE_SRC_Send_Soft_Reset	Section 8.3.3.4.1.1
PE_SRC_Soft_Reset	Section 8.3.3.4.1.2
Sink Port Soft Reset	
PE_SNK_Send_Soft_Reset	Section 8.3.3.4.2.1
PE_SNK_Soft_Reset	Section 8.3.3.4.2.2
Not Supported Message	
Source Port Not Supported	
PE_SRC_Send_Not_Supported	Section 8.3.3.5.1.1

State name	Reference
PE_SRC_Not_Supported_Received	Section 8.3.3.5.1.2
PE_SRC_Chunk_Received	Section 8.3.3.5.1.3
Sink Port Not Supported	
PE_SNK_Send_Not_Supported	Section 8.3.3.5.2.1
PE_SNK_Not_Supported_Received	Section 8.3.3.5.2.2
PE_SNK_Chunk_Received	Section 8.3.3.5.2.1
Source Port Ping	
PE_SRC_Ping	Section 8.3.3.6.1
Source Alert	
Source Port Source Alert	
PE_SRC_Send_Source_Alert	Section 8.3.3.7.1.1
Sink Port Source Alert	
PE_SNK_Source_Alert_Received	Section 8.3.3.7.2.1
Sink Port Sink Alert	
PE_SNK_Send_Sink_Alert	Section 8.3.3.7.3.1
Source Port Sink Alert	
PE_SRC_Sink_Alert_Received	Section 8.3.3.7.4.1
Source Extended Capabilities	
Sink Port Get Source Capabilities Extended	
PE_SNK_Get_Source_Cap_Ext	Section 8.3.3.8.1.1
Source Port Give Source Capabilities Extended	
PE_SRC_Give_Source_Cap_Ext	Section 8.3.3.8.2.1
Source Status	
Sink Port Get Source Status	
PE_SNK_Get_Source_Status	Section 8.3.3.9.1.1
Source Port Give Source Status	
PE_SRC_Give_Source_Status	Section 8.3.3.9.2.1
Source Port Get Sink Status	
PE_SRC_Get_Sink_Status	Section 8.3.3.9.3.1
Sink Port Give Sink Status	
PE_SNK_Give_Sink_Status	Section 8.3.3.9.4.1
Sink Port Get PPS Status	
PE_SNK_Get_PPS_Status	Section 8.3.3.9.5.1
Source Port Give PPS Status	
PE_SRC_Give_PPS_Status	Section 8.3.3.9.6.1
Battery Capabilities	
Get Battery Capabilities	
PE_Get_Battery_Cap	Section 8.3.3.10.1.1
Give Battery Capabilities	
PE_Give_Battery_Cap	Section 8.3.3.10.2.1
Battery Status	
Get Battery Status	
PE_Get_Battery_Status	Section 8.3.3.11.1.1

State name	Reference
Give Battery Status	
PE_Give_Battery_Status	Section 8.3.3.11.2.1
Manufacturer Information	
Get Manufacturer Information	
PE_Get_Manufacturer_Info	Section 8.3.3.12.1
Give Manufacturer Information	
PE_Give_Manufacturer_Info	Section 8.3.3.12.2
Country Codes and Information	
Get Country Codes	
PE_Get_Country_Codes	Section 8.3.3.13.1.1
Give Country Codes	
PE_Give_Country_Codes	Section 8.3.3.13.2.1
Get Country Information	
PE_Get_Country_Info	Section 8.3.3.13.3.1
Give Country Information	
PE_Give_Country_Info	Section 8.3.3.13.4.1
Security Request/Response	
Send Security Request	
PE_Send_Security_Request	Section 8.3.3.14.1
Send Security Response	
PE_Send_Security_Response	Section 8.3.3.14.2
Security Response Received	
PE_Security_Response_Received	Section 8.3.3.14.3
Firmware Update Request/Response	
Send Firmware Update Request	
PE_Send_Firmware_Update_Request	Section 8.3.3.15.1.1
Send Firmware Update Response	
PE_Send_Firmware_Update_Response	Section 8.3.3.15.2.1
Firmware Update Response Received	
PE_Firmware_Update_Response_Received	Section 8.3.3.15.3.1
Dual-Role Port	
DFP to UFP Data Role Swap	
PE_DRS_DFP_UFP_Evaluate_Swap	Section 8.3.3.16.1.2
PE_DRS_DFP_UFP_Accept_Swap	Section 8.3.3.16.1.3
PE_DRS_DFP_UFP_Change_to_UFP	Section 8.3.3.16.1.4
PE_DRS_DFP_UFP_Send_Swap	Section 8.3.3.16.1.5
PE_DRS_DFP_UFP_Reject_Swap	Section 8.3.3.16.1.6
UFP to DFP Data Role Swap	
PE_DRS_UFP_DFP_Evaluate_Swap	Section 8.3.3.16.2.2
PE_DRS_UFP_DFP_Accept_Swap	Section 8.3.3.16.2.3
PE_DRS_UFP_DFP_Change_to_DFP	Section 8.3.3.16.2.4
PE_DRS_UFP_DFP_Send_Swap	Section 8.3.3.16.2.5

State name	Reference
PE_DRS_UFP_DFP_Reject_Swap	Section 8.3.3.16.2.6
Source to Sink Power Role Swap	
PE_PRS_SRC_SNK_Evaluate_Swap	Section 8.3.3.16.3.2
PE_PRS_SRC_SNK_Accept_Swap	Section 8.3.3.16.3.3
PE_PRS_SRC_SNK_Transition_to_off	Section 8.3.3.16.3.4
PE_PRS_SRC_SNK_Assert_Rd	Section 8.3.3.16.3.5
PE_PRS_SRC_SNK_Wait_Source_on	Section 8.3.3.16.3.6
PE_PRS_SRC_SNK_Send_Swap	Section 8.3.3.16.3.7
PE_PRS_SRC_SNK_Reject_Swap	Section 8.3.3.16.3.8
Sink to Source Power Role Swap	
PE_PRS_SNK_SRC_Evaluate_Swap	Section 8.3.3.16.4.2
PE_PRS_SNK_SRC_Accept_Swap	Section 8.3.3.16.4.3
PE_PRS_SNK_SRC_Transition_to_off	Section 8.3.3.16.4.4
PE_PRS_SNK_SRC_Assert_Rp	
PE_PRS_SNK_SRC_Source_on	Section 8.3.3.16.4.5
PE_PRS_SNK_SRC_Send_Swap	Section 8.3.3.16.4.7
PE_PRS_SNK_SRC_Reject_Swap	Section 8.3.3.16.4.8
Source to Sink Fast Role Swap	
PE_FRS_SRC_SNK_CC_Signal	Section 8.3.3.16.5.2
PE_FRS_SRC_SNK_Evaluate_Swap	Section 8.3.3.16.5.3
PE_FRS_SRC_SNK_Accept_Swap	Section 8.3.3.16.5.4
PE_FRS_SRC_SNK_Transition_to_off	Section 8.3.3.16.5.5
PE_FRS_SRC_SNK_Assert_Rd	Section 8.3.3.16.5.6
PE_FRS_SRC_SNK_Wait_Source_on	Section 8.3.3.16.5.7
Sink to Source Fast Role Swap	
PE_FRS_SNK_SRC_Start_AMS	Section 8.3.3.16.6.1
PE_FRS_SNK_SRC_Send_Swap	Section 8.3.3.16.6.2
PE_FRS_SNK_SRC_Transition_to_off	Section 8.3.3.16.6.3
PE_FRS_SNK_SRC_Vbus_Applied	Section 8.3.3.16.6.4
PE_FRS_SNK_SRC_Assert_Rp	Section 8.3.3.16.6.5
PE_FRS_SNK_SRC_Source_on	Section 8.3.3.16.6.6
Dual-Role Source Port Get Source Capabilities	
PE_DR_SRC_Get_Source_Cap	Section 8.3.3.16.7.1
Dual-Role Source Port Give Sink Capabilities	
PE_DR_SRC_Give_Sink_Cap	Section 8.3.3.16.8.1
Dual-Role Sink Port Get Sink Capabilities	
PE_DR_SNK_Get_Sink_Cap	Section 8.3.3.16.9.1
Dual-Role Sink Port Give Source Capabilities	
PE_DR_SNK_Give_Source_Cap	Section 8.3.3.16.10.1

State name	Reference
Dual-Role Source Port Get Source Capabilities Extended	
PE_DR_SRC_Get_Source_Cap_Ext	Section 8.3.3.16.11.1
Dual-Role Sink Port Give Source Capabilities Extended	
PE_DR_SNK_Give_Source_Cap_Ext	Section 8.3.3.16.12.1
USB Type-C VCONN Swap	
PE_VCS_Send_Swap	Section 8.3.3.17.1.1
PE_VCS_Evaluate_Swap	Section 8.3.3.17.1.2
PE_VCS_Accept_Swap	Section 8.3.3.17.1.3
PE_VCS_Reject_Swap	Section 8.3.3.17.1.4
PE_VCS_Wait_For_VCONN	Section 8.3.3.17.1.5
PE_VCS_Turn_Off_VCONN	Section 8.3.3.17.1.6
PE_VCS_Turn_On_VCONN	Section 8.3.3.17.1.7
PE_VCS_Send_Ps_Rdy	Section 8.3.3.17.1.8
Initiator Structured VDM	
Initiator to Port Structured VDM Discover Identity	
PE_INIT_PORT_VDM_Identity_Request	Section 8.3.3.18.1.1
PE_INIT_PORT_VDM_Identity_ACKed	Section 8.3.3.18.1.2
PE_INIT_PORT_VDM_Identity_NAKed	Section 8.3.3.18.1.3
Initiator Structured VDM Discover SVIDs	
PE_INIT_VDM_SVIDs_Request	Section 8.3.3.18.2.1
PE_INIT_VDM_SVIDs_ACKed	Section 8.3.3.18.2.2
PE_INIT_VDM_SVIDs_NAKed	Section 8.3.3.18.2.3
Initiator Structured VDM Discover Modes	
PE_INIT_VDM_Modes_Request	Section 8.3.3.18.3.1
PE_INIT_VDM_Modes_ACKed	Section 8.3.3.18.3.2
PE_INIT_VDM_Modes_NAKed	Section 8.3.3.18.3.3
Initiator Structured VDM Attention	
PE_INIT_VDM_Attention_Request	Section 8.3.3.18.4.1
Responder Structured VDM	
Responder Structured VDM Discovery Identity	
PE_RESP_VDM_Get_Identity	Section 8.3.3.19.1.1
PE_RESP_VDM_Send_Identity	Section 8.3.3.19.1.2
PE_RESP_VDM_Get_Identity_NAK	Section 8.3.3.19.1.3
Responder Structured VDM Discovery SVIDs	
PE_RESP_VDM_Get_SVIDs	Section 8.3.3.19.2.1
PE_RESP_VDM_Send_SVIDs	Section 8.3.3.19.2.2
PE_RESP_VDM_Get_SVIDs_NAK	Section 8.3.3.19.2.3
Responder Structured VDM Discovery Modes	
PE_RESP_VDM_Get_Modes	Section 8.3.3.19.3.1
PE_RESP_VDM_Send_Modes	Section 8.3.3.19.3.2
PE_RESP_VDM_Get_Modes_NAK	Section 8.3.3.19.3.3

State name	Reference
Receiving a Structured VDM Attention	
PE_RCV_VDM_Attention_Request	Section 8.3.3.19.4.1
DFP Structured VDM	
DFP Structured VDM Mode Entry	
PE_DFP_VDM_Mode_Entry_Request	Section 8.3.3.20.1.1
PE_DFP_VDM_Mode_Entry_ACKed	Section 8.3.3.20.1.2
PE_DFP_VDM_Mode_Entry_NAKed	Section 8.3.3.20.1.3
DFP Structured VDM Mode Exit	
PE_DFP_VDM_Mode_Exit_Request	Section 8.3.3.20.2.1
PE_DFP_VDM_Mode_Exit_ACKed	Section 8.3.3.20.2.2
UFP Structure VDM	
UFP Structured VDM Enter Mode	
PE_UFP_VDM_Evaluate_Mode_Entry	Section 8.3.3.21.1.1
PE_UFP_VDM_Mode_Entry_ACK	Section 8.3.3.21.1.2
PE_UFP_VDM_Mode_Entry_NAK	Section 8.3.3.21.1.3
UFP Structured VDM Exit Mode	
PE_UFP_VDM_Mode_Exit	Section 8.3.3.21.2.1
PE_UFP_VDM_Mode_Exit_ACK	Section 8.3.3.21.2.2
PE_UFP_VDM_Mode_Exit_NAK	Section 8.3.3.21.2.3
Cable Plug Specific	
Cable Ready	
PE_CBL_Ready	Section 8.3.3.22.1.1
Mode Entry	
PE_CBL_Evaluate_Mode_Entry	Section 8.3.3.22.4.1.1
PE_CBL_Mode_Entry_ACK	Section 8.3.3.22.4.1.2
PE_CBL_Mode_Entry_NAK	Section 8.3.3.22.4.1.3
Mode Exit	
PE_CBL_Mode_Exit	Section 8.3.3.22.4.2.1
PE_CBL_Mode_Exit_ACK	Section 8.3.3.22.4.2.2
PE_CBL_Mode_Exit_NAK	Section 8.3.3.22.4.2.3
Cable Soft Reset	
PE_CBL_Soft_Reset	Section 8.3.3.22.2.1.1
Cable Hard Reset	
PE_CBL_Hard_Reset	Section 8.3.3.22.2.2.1
DFP Soft Reset or Cable Reset	
PE_DFP_CBL_Send_Soft_Reset	Section 8.3.3.22.2.3.1
PE_DFP_CBL_Send_Cable_Reset	Section 8.3.3.22.2.3.2
UFP Source Soft Reset	
PE_UFP_CBL_Send_Soft_Reset	Section 8.3.3.22.2.4
Source Startup Structured VDM Discover Identity	
PE_SRC_VDM_Identity_Request	Section 8.3.3.22.3.1
PE_SRC_VDM_Identity_ACKed	Section 8.3.3.22.3.2

State name	Reference
PE_SRC_VDM_Identity_NAKed	Section 8.3.3.22.3.3
BIST Carrier Mode	
PE_BIST_Carrier_Mode	Section 8.3.3.23.1.1
USB Type-C referenced states	
ErrorRecovery	Section 8.3.3.24.1

9. States and Status Reporting

9.1 Overview

This chapter describes the Status reporting mechanisms for devices with data connections (e.g. D+/D- and or SSTx+/- and SSRx+/-). It also describes the corresponding USB state a device that supports USB PD ***Shall*** transition to as a result of changes to the USB PD state that the device is in.

This chapter does not define the System Policy or the System Policy Manager. That is defined in ***[USBTypeCBridge 1.0]***. In addition the Policies themselves are not described here; these are left to the implementers of the relevant products and systems to define.

All PD Capable USB (PDUSB) Devices ***Shall*** report themselves as self-powered devices (over USB) when plugged into a PD capable Port even if they are entirely powered from $V_{BUS.}$ However, there are some differences between PD and ***[USB 2.0]*** / ***[USB 3.1]***; for example, the presence of V_{BUS} alone does not mean that the device (Consumer) moves from the USB Attached state to the USB Powered state. Similarly the removal of V_{BUS} alone does not move the device (Consumer) from any of the USB states to the Attached state. See Section 9.1.2 for details.

PDUSB Devices ***Shall*** follow the PD requirements when it comes to suspend (see Section 6.4.1.2.2.2), configured, and operational power. The PD requirements when the device is configured or operational are defined in this section (see Table 9-4). Note that the power requirements reported in the PD Consumer Port descriptor of the device ***Shall*** override the power draw reported in the *bMaxPower* field in the configuration descriptor. A PDUSB Device ***Shall*** report zero in the *bMaxPower* field after successfully negotiating a mutually agreeable Contract and ***Shall*** disconnect and re-enumerate when it switches operation back to operating in standard ***[USB 2.0]***, ***[USB 3.1]***, ***[USB Type-C 1.2]*** or ***[USBBC 1.2]*** When operating in ***[USB 2.0]***, ***[USB 3.1]***, ***[USB Type-C 1.2]*** or ***[USBBC 1.2]*** mode it ***Shall*** report its power draw via the *bMaxPower* field.

As shown in Figure 9-1, each Provider and Consumer will have their own Local Policies which operate between directly connected ports. An example of a typical PD system is shown in Figure 9-1. This example consists of a Provider, Consumer/Providers and Consumers connected together in a tree topology. Between directly connected devices there is both a flow of Power and also Communication consisting of both Status and Control information.

Figure 9-1 Example PD Topology

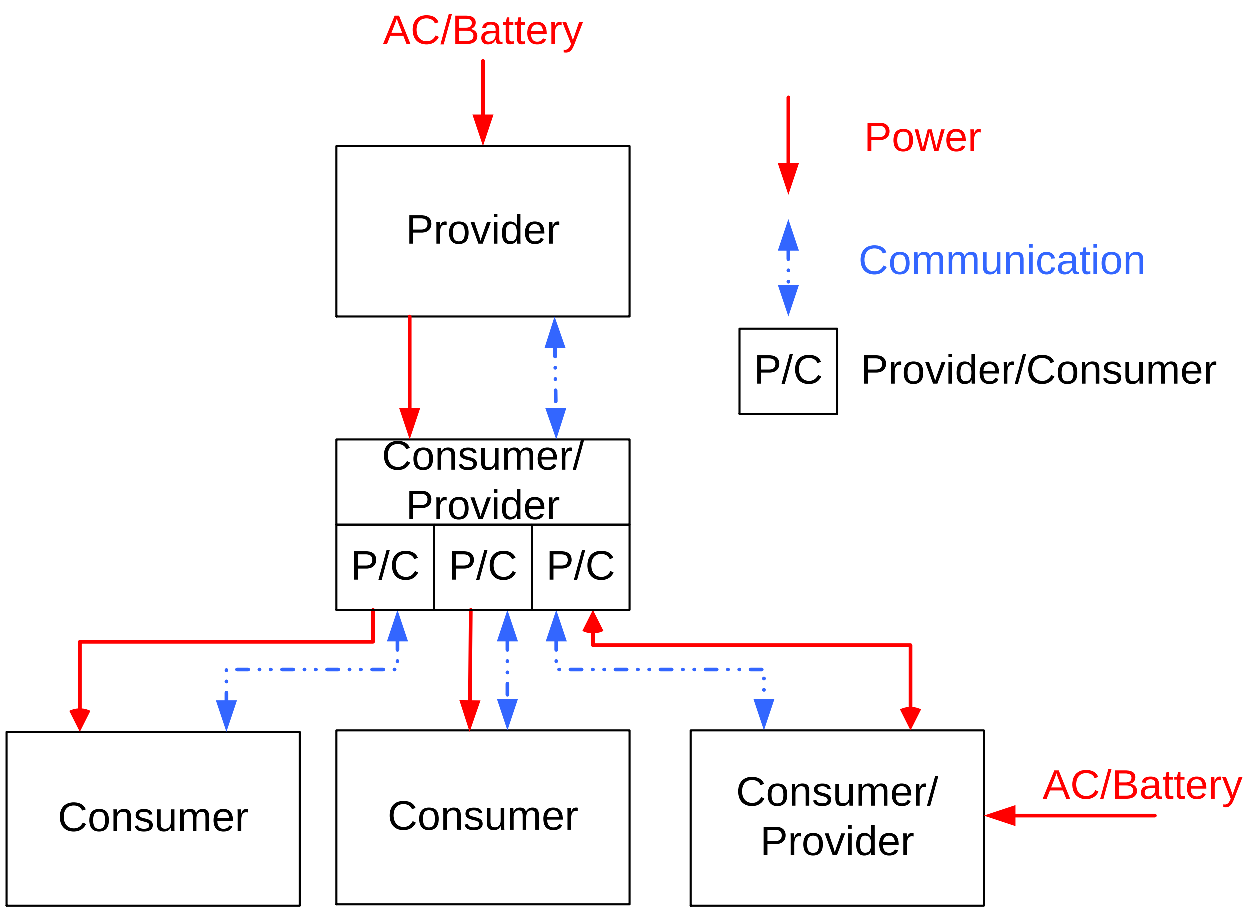
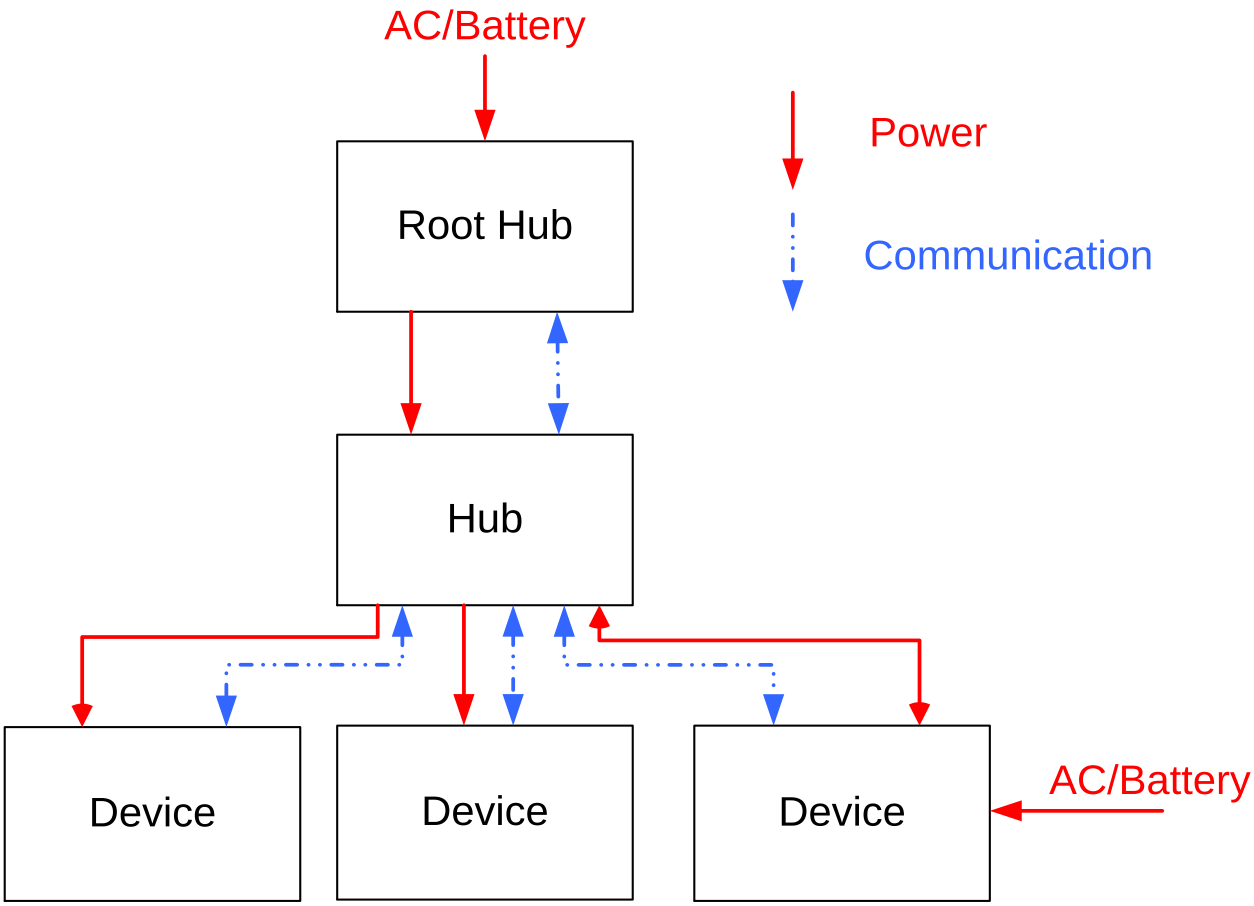


Figure 9-2 shows how this same topology can be mapped to USB. In a USB based system, policy is managed by the host and communication of system level policy information is via standard USB data line communication. This is a separate mechanism to the USB Power Delivery V_{BUS} protocol which is used to manage Local Policy. When USB data line communication is used, status information and control requests are passed directly between the System Policy Manager (SPM) on the host and the Provider or Consumer.

Status information comes from a Provider or Consumer to the SPM so it can better manage the resources on the host and provide feedback to the end user.

Real systems will be a mixture of devices which in terms of power management support might have implemented PD, ***[USB 2.0]***, ***[USB 3.1]***, ***[USB Type-C 1.2]*** or ***[USBBC 1.2]*** or they might even just be non-compliant Power Sucking Devices. The level of communication of system status to the SPM will therefore not necessarily be comprehensive. The aim of the status mechanisms described here is to provide a mechanism whereby each connected entity in the system provides as much information as possible on the status of itself.

Figure 9-2 Mapping of PD Topology to USB



Information described in this section that is communicated to the SPM is as follows:

- Versions of USB Type-C Current, PD and BC supported.
- Capabilities as a Provider/Consumer.
- Current operational state of each Port e.g. Standard, USB Type-C Current, BC, PD and negotiated power level.
- Status of AC or Battery Power for each PDUSB Device in the system.

The SPM can negotiate with Providers or Consumers in the system in order to request a different Local Policy, or to request the amount of power to be delivered by the Provider to the Consumer. Any change in Local Policy could trigger a renegotiation of the Contract, using USB Power Delivery protocols, between a directly connected Provider and Consumer. A change in how much power is to be delivered will, for example, cause a renegotiation.

9.1.1 PDUSB Device and Hub Requirements

All PDUSB Devices ***Shall*** return all relevant descriptors mentioned in this chapter. PDUSB Hubs ***Shall*** also support a PD bridge as defined in ***[USBTypeCBridge 1.0]***.

9.1.2 Mapping to USB Device States

As mentioned in Section 9.1 a PDUSB Device reports itself as a self-powered device. However, the device ***Shall*** determine whether or not it is in the USB Attached or USB Powered states as described in Figure 9-3, Figure 9-4 and Figure 9-5. All other USB states of the PDUSB Device ***Shall*** be as described in Chapter 9 of ***[USB 2.0]*** and ***[USB 3.1]***.

Figure 9-3 shows how a PDUSB Device determines when to transition from the USB Attached to the USB Powered state. USB Type-C Dead Battery operation does not require special handling since the default state at Attach or after a Hard Reset is that the USB Device is a Sink.

Figure 9-3 USB Attached to USB Powered State Transition

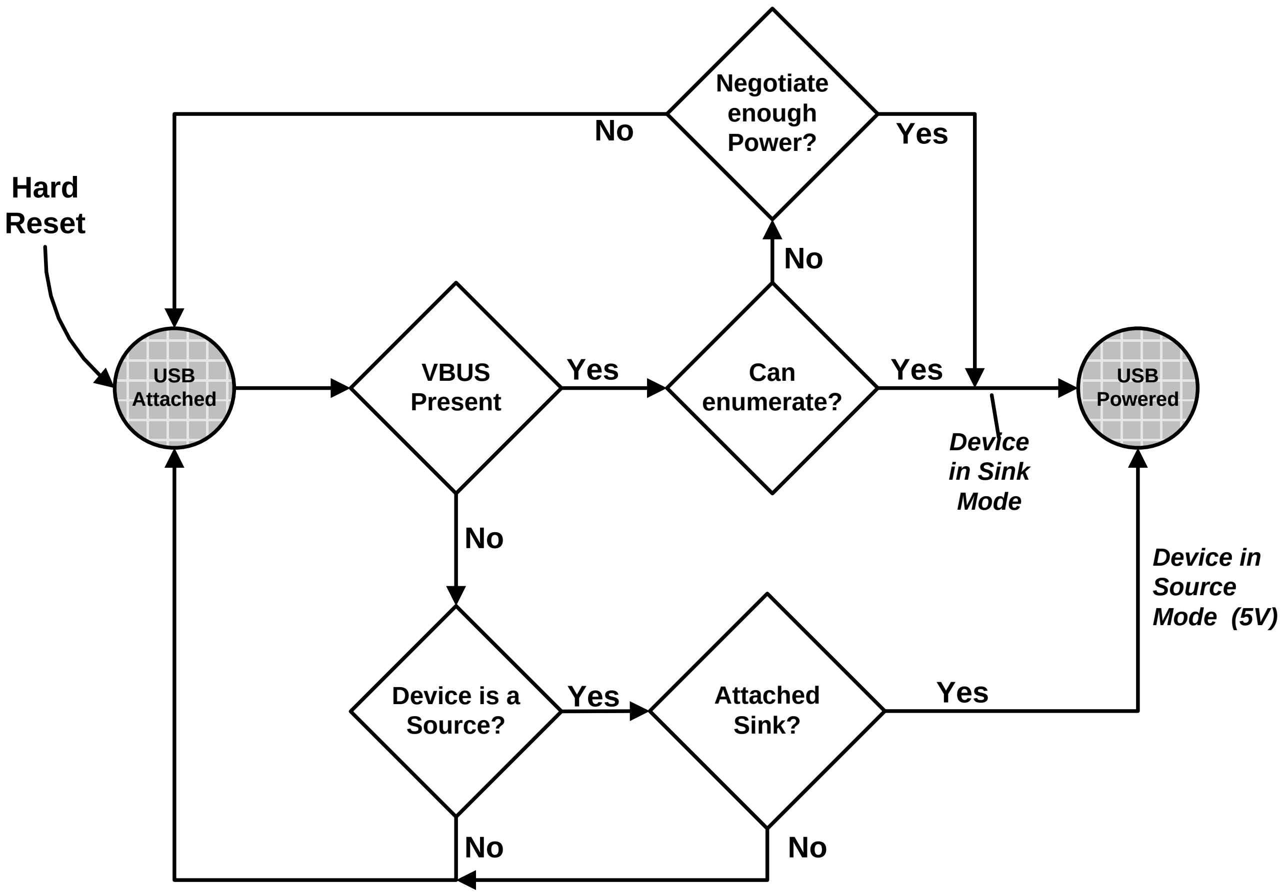


Figure 9-4 shows how a PDUSB Device determines when to transition from the USB Powered state to the USB Attached state when the device is a Consumer. A PDUSB Device determines that it is performing a Power Role Swap as described in Section 8.3.3.16.3 and Section 8.3.3.16.4. See Section 7.1.5 for additional information on device behavior during Hard Resets.

Figure 9-4 Any USB State to USB Attached State Transition (When operating as a Consumer)

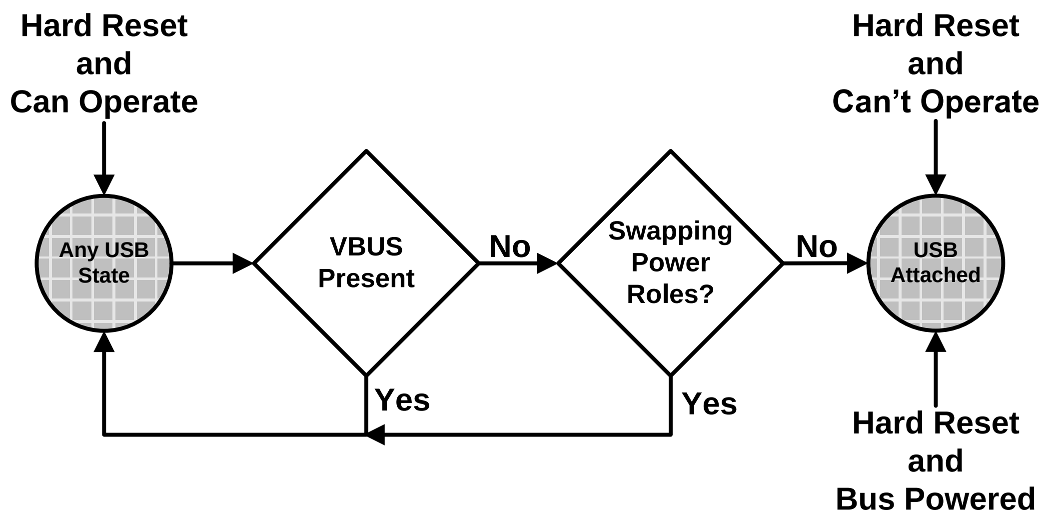


Figure 9-5 shows how a PDUSB Device determines when to transition from the USB Powered state to the USB Attached state when the device is a Provider.

Figure 9-5 Any USB State to USB Attached State Transition (When operating as a Provider)

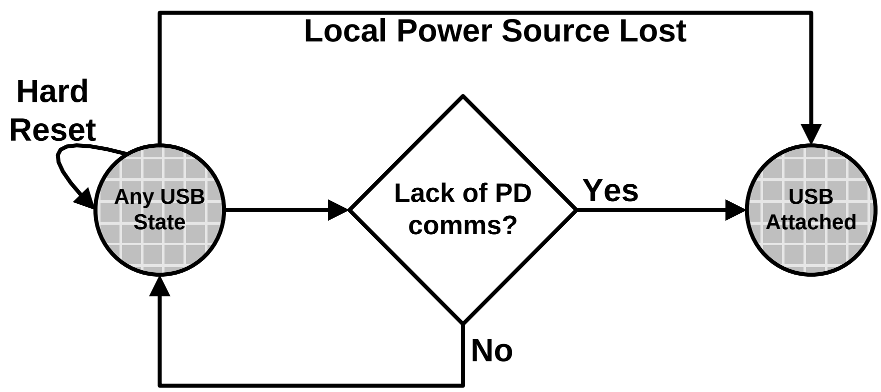
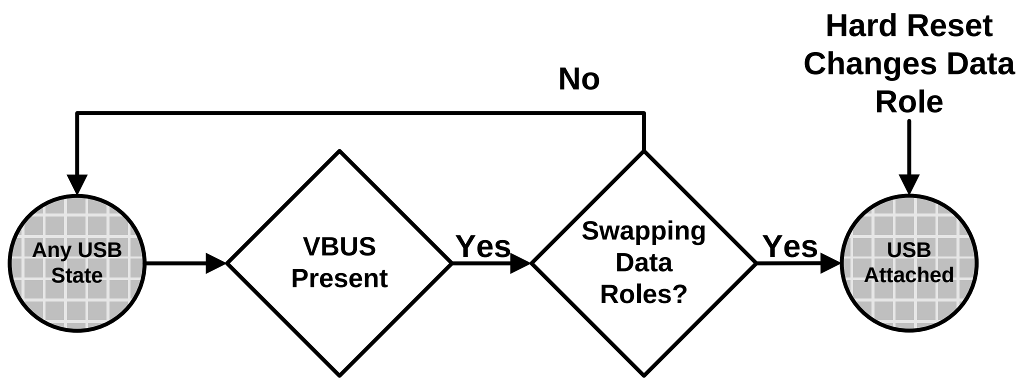


Figure 9-6 shows how a PDUSB Device using the USB Type-C connector determines when to transition from the USB Powered state to the USB Attached state after a Data Role Swap has been performed i.e. it has just changed from operation as a PDUSB Host to operation as a PDUSB Device. The Data Role Swap is described in Section 6.3.9. A Hard Reset will also return a Sink acting as a PDUSB Host to PDUSB Device operation as described in Section 6.8.2. See Section 7.1.5 for additional information on device behavior during Hard Resets.

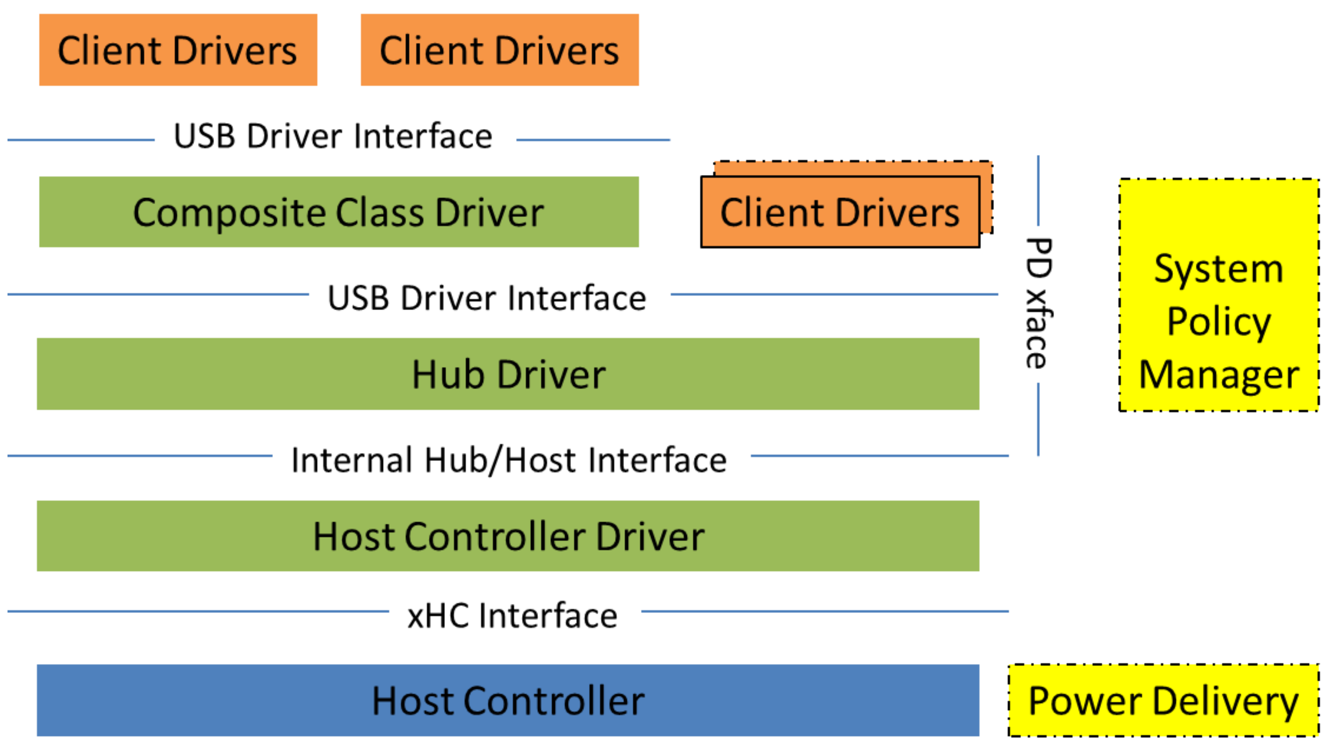
Figure 9-6 Any USB State to USB Attached State Transition (After a USB Type-C Data Role Swap)



9.1.3 PD Software Stack

Figure 9-7 gives an example of the software stack on a PD aware OS. In this stack we are using the example of a system with an xHCI based controller. The USB Power Delivery hardware ***May*** or ***May Not*** be a part of the xHC.

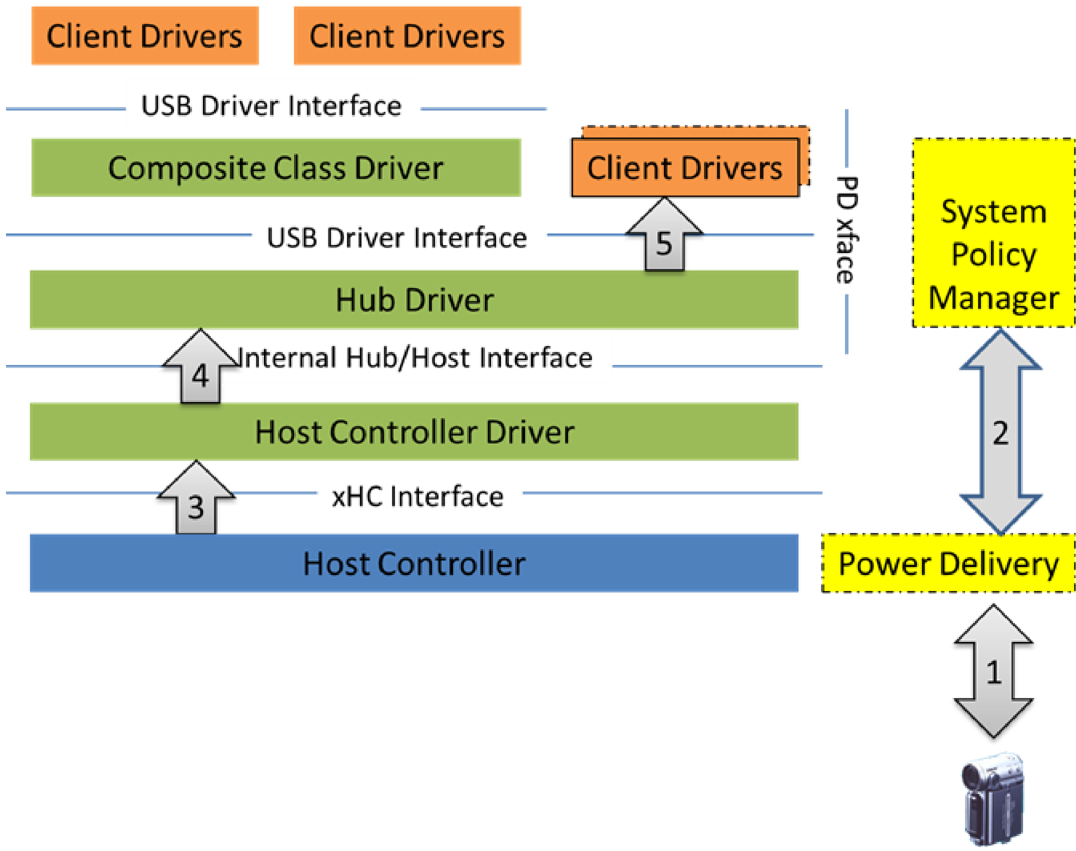
Figure 9-7 Software stack on a PD aware OS



9.1.4 PDUSB Device Enumeration

As described earlier, a PDUSB Device acts as a self-powered device with some caveats with respect to how it transitions from the USB Attached state to USB Powered state. Figure 9-8 gives a high level overview of the enumeration steps involved due to this change. A PDUSB Device will first (Step1) interact with the Power Delivery hardware and the Local Policy manager to determine whether or not it can get sufficient power to enumerate/operate. Note: PD is likely to have established a Contract prior to enumeration. The SPM will be notified (Step 2) of the result of this negotiation between the Power Delivery hardware and the PDUSB Device. After successfully negotiating a mutually agreeable Contract the device will signal a connect to the xHC. The standard USB enumeration process (Steps 3, 4 and 5) is then followed to load the appropriate driver for the function(s) that the PDUSB Device exposes.

Figure 9-8 Enumeration of a PDUSB Device



If a PDUSB Device cannot perform its intended function with the amount of power that it can get from the Port it is connected to then the host system ***Should*** display a Message (on a PD aware OS) about the failure to provide sufficient power to the device. In addition the device ***Shall*** follow the requirements listed in Section 8.2.5.2.1.

9.2 PD Specific Descriptors

A PDUSB Device ***Shall*** return all relevant descriptors mentioned in this section.

The device ***Shall*** return its capability descriptors as part of the device's Binary Object Store (BOS) descriptor set. Table 9-1 lists the type of PD device capabilities.

Table 9-1 USB Power Delivery Type Codes

Capability Code	Value	Description
POWER_DELIVERY_CAPABILITY	06H	Defines the various PD Capabilities of this device
BATTERY_INFO_CAPABILITY	07H	Provides information on each Battery supported by the device
PD_CONSUMER_PORT_CAPABILITY	08H	The Consumer characteristics of a Port on the device
PD_PROVIDER_PORT_CAPABILITY	09H	The provider characteristics of a Port on the device

9.2.1 USB Power Delivery Capability Descriptor

Table 9-2 USB Power Delivery Capability Descriptor

Offset	Field	Size	Value	Description
0	*bLength*	1	Number	Size of descriptor
1	*bDescriptorType*	1	Constant	DEVICE CAPABILITY Descriptor type
2	*bDevCapabilityType*	1	Constant	Capability type: ***POWER_DELIVERY_CAPABILITY***
3	*bReserved*	1	Reserved	***Shall*** be set to zero.
4	*bmAttributes*	4	Bitmap	Bitmap encoding of supported device level features. A value of one in a bit location indicates a feature is supported; a value of zero indicates it is not supported. Encodings are: Bit Description 0 ***Reserved***. ***Shall*** be set to zero. 1 Battery Charging. This bit ***Shall*** be set to one to indicate this device supports the Battery Charging Specification as per the value reported in the *bcdBCVersion* field. 2 USB Power Delivery. This bit ***Shall*** be set to one to indicate this device supports the USB Power Delivery Specification as per the value reported in the *bcdPDVersion* field. 3 Provider. This bit ***Shall*** be set to one to indicate this device is capable of providing power. This field is only ***Valid*** if Bit 2 is set to one. 4 Consumer. This bit ***Shall*** be set to one to indicate that this device is a consumer of power. This field is only ***Valid*** if Bit 2 is set to one. 5 This bit ***Shall*** be set to 1 to indicate that this device supports the feature ***CHARGING_POLICY***. Note that supporting the ***CHARGING_POLICY*** feature does not require a BC or PD mechanism to be implemented. 6 USB Type-C Current. This bit ***Shall*** be set to one to indicate this device supports power

Offset	Field	Size	Value	Description
				capabilities defined in the USB Type-C Specification as per the value reported in the bcdUSBTypeCVersion field 7 ***Reserved***. ***Shall*** be set to zero. 15:8 bmPowerSource. At least one of the following bits 8, 9 and 14 ***Shall*** be set to indicate which power sources are supported. **Bit** / **Description**: 8 – AC Supply 9 – Battery 10 – Other 13:11 – NumBatteries. This field ***Shall*** only be ***Valid*** when the Battery field is set to one and ***Shall*** be used to report the number of batteries in the device. 14 – Uses V_{BUS} 15 – ***Reserved*** and ***Shall*** be set to zero. 31:16 ***Reserved*** and ***Shall*** be set to zero.
8	*bcdBCVersion*	2	BCD	Battery Charging Specification Release Number in Binary-Coded Decimal (e.g., V1.20 is 120H). This field ***Shall*** only be ***Valid*** if the device indicates that it supports BC in the *bmAttributes* field.
10	*bcdPDVersion*	2	BCD	USB Power Delivery Specification Release Number in Binary-Coded Decimal. This field ***Shall*** only be ***Valid*** if the device indicates that it supports PD in the *bmAttributes* field.
12	*bcdUSBTypeCVersion*	2	BCD	USB Type-C Specification Release Number in Binary-Coded Decimal. This field ***Shall*** only be ***Valid*** if the device indicates that it supports USB Type-C in the *bmAttributes* field.

9.2.2 Battery Info Capability Descriptor

A PDUSB Device ***Shall*** support this capability descriptor if it reported that one of its power sources was a Battery in the *bmPowerSource* field in its Power Deliver Capability Descriptor. It ***Shall*** return one Battery Info Descriptor per Battery it supports.

Table 9-3 Battery Info Capability Descriptor

Offset	Field	Size	Value	Description
0	*bLength*	1	Number	Size of descriptor
1	*bDescriptorType*	1	Constant	DEVICE CAPABILITY Descriptor type
2	*bDevCapabilityType*	1	Constant	Capability type: ***BATTERY_INFO_CAPABILITY***
3	*iBattery*	1	Index	Index of string descriptor ***Shall*** contain the user friendly name for this Battery.
4	*iSerial*	1	Index	Index of string descriptor ***Shall*** contain the Serial Number String for this Battery.
5	*iManufacturer*	1	Index	Index of string descriptor ***Shall*** contain the name of the Manufacturer for this Battery.

Offset	Field	Size	Value	Description
6	*bBatteryId*	1	Number	Value ***Shall*** be used to uniquely identify this Battery in status Messages.
7	*bReserved*	1	Number	***Reserved*** and ***Shall*** be set to zero.
8	*dwChargedThreshold*	4	mWh	***Shall*** contain the Battery Charge value above which this Battery is considered to be fully charged but not necessarily "topped off."
12	*dwWeakThreshold*	4	mWh	***Shall*** contain the minimum charge level of this Battery such that above this threshold, a device can be assured of being able to power up successfully (see Battery Charging 1.2).
16	*dwBatteryDesignCapacity*	4	mWh	***Shall*** contain the design capacity of the Battery.
20	*dwBatteryLastFullchargeCapacity*	4	mWh	***Shall*** contain the maximum capacity of the Battery when fully charged.

9.2.3 PD Consumer Port Capability Descriptor

A PDUSB Device ***Shall*** support this capability descriptor if it is a Consumer.

Table 9-4 PD Consumer Port Descriptor

<table>
<tr><th>Offset</th><th>Field</th><th>Size</th><th>Value</th><th>Description</th></tr>
<tr><td>0</td><td>bLength</td><td>1</td><td>Number</td><td>Size of descriptor</td></tr>
<tr><td>1</td><td>bDescriptorType</td><td>1</td><td>Constant</td><td>DEVICE CAPABILITY Descriptor type</td></tr>
<tr><td>2</td><td>bDevCapabilityType</td><td>1</td><td>Constant</td><td>Capability type: PD_CONSUMER_PORT_CAPABILITY</td></tr>
<tr><td>3</td><td>bReserved</td><td>1</td><td>Number</td><td>Reserved and Shall be set to zero.</td></tr>
<tr><td>4</td><td>bmCapabilities</td><td>2</td><td>Bitmap</td><td>Capability: This field Shall indicate the specification the Consumer Port will operate under.
<table>
<tr><th>Bit</th><th>Description</th></tr>
<tr><td>0</td><td>Battery Charging (BC)</td></tr>
<tr><td>1</td><td>USB Power Delivery (PD)</td></tr>
<tr><td>2</td><td>USB Type-C Current</td></tr>
<tr><td>15:3</td><td>Reserved and Shall be set to zero.</td></tr>
</table></td></tr>
<tr><td>6</td><td>wMinVoltage</td><td>2</td><td>Number</td><td>Shall contain the minimum voltage in 50mV units that this Consumer is capable of operating at.</td></tr>
<tr><td>8</td><td>wMaxVoltage</td><td>2</td><td>Number</td><td>Shall contain the maximum voltage in 50mV units that this Consumer is capable of operating at.</td></tr>
<tr><td>10</td><td>wReserved</td><td>2</td><td>Number</td><td>Reserved and Shall be set to zero.</td></tr>
<tr><td>12</td><td>dwMaxOperatingPower</td><td>4</td><td>Number</td><td>Shall contain the maximum power in 10mW units this Consumer can draw when it is in a steady state operating mode.</td></tr>
<tr><td>16</td><td>dwMaxPeakPower</td><td>4</td><td>Number</td><td>Shall contain the maximum power in 10mW units this Consumer can draw for a short duration of time (dwMaxPeakPowerTime) before it falls back into a steady state.</td></tr>
<tr><td>20</td><td>dwMaxPeakPowerTime</td><td>4</td><td>Number</td><td>Shall contain the time in 100ms units that this Consumer can draw peak current.
A device Shall set this field to 0xFFFF if this value is unknown.</td></tr>
</table>

9.2.4 PD Provider Port Capability Descriptor

A PDUSB Device ***Shall*** support this capability descriptor if it is a Provider.

Table 9-5 PD Provider Port Descriptor

Offset	Field	Size	Value	Description
0	*bLength*	1	Number	Size of descriptor
1	*bDescriptorType*	1	Constant	DEVICE CAPABILITY Descriptor type
2	*bDevCapabilityType*	1	Constant	Capability type: ***PD_PROVIDER_PORT_CAPABILITY***
3	*bReserved*	1	Number	***Reserved*** and ***Shall*** be set to zero.
4	*bmCapabilities*	2	Bitmap	This field ***Shall*** indicate the specification the Provider Port will operation under. **Bit** – **Description** 0 – Battery Charging (BC) 1 – USB Power Delivery (PD) 2 – USB Type-C Current 15:3 – ***Reserved***. ***Shall*** be set to zero.
6	*bNumOfPDObjects*	1	Number	***Shall*** indicate the number of Power Data Objects.
7	*bReserved*	1	Number	***Reserved*** and ***Shall*** be set to zero.
8	*wPowerDataObject1*	4	Bitmap	***Shall*** contain the first Power Data Object supported by this Provider Port. See Section 6.4.1 for details of the Power Data Objects.
…	…	…	…	…
N+4	*wPowerDataObjectN*	4	Bitmap	***Shall*** contain the 2nd and subsequent Power Data Objects supported by this Provider Port. See Section 6.4.1 for details of the Power Data Objects.

9.3 PD Specific Requests and Events

A PDUSB Device that is compliant to this specification ***Shall*** support the Battery related requests if it has a battery.

A PDUSB Hub that is compliant to this specification ***Shall*** support a USB PD Bridge as described in ***[USBTypeCBridge 1.0]*** irrespective of whether the PDUSB Hub is a Provider, a Consumer, or both.

9.3.1 PD Specific Requests

PD defines requests to which PDUSB Devices ***Shall*** respond as outlined in Table 9-6. All ***Valid*** requests in Table 9-6 ***Shall*** be implemented by PDUSB Devices.

Table 9-6 PD Requests

Request	bmRequestType	bRequest	wValue	wIndex	wLength	Data
GetBatteryStatus	10000000B	***Get_Battery_Status***	Zero	Battery ID	Eight	Battery Status
SetPDFeature	00000000B	SET_FEATURE	Feature Selector	Feature Specific	Zero	None

Table 9-7 gives the bRequest values for commands that are not listed in the hub/device framework chapters of ***[USB 2.0]***, ***[USB 3.1]***.

Table 9-7 PD Request Codes

bRequest	Value
GET_BATTERY_STATUS	21

Table 9-8 gives the ***Valid*** feature selectors for the PD class. Refer to Section 9.4.2.1, and Section 9.4.2.2 for a description of the features.

Table 9-8 PD Feature Selectors

Feature Selector	Recipient	Value
BATTERY_WAKE_MASK	Device	40
CHARGING_POLICY	Device	54

9.4 PDUSB Hub and PDUSB Peripheral Device Requests

9.4.1 GetBatteryStatus

This request returns the current status of the Battery in a PDUSB Hub/Peripheral.

bmRequestType	bRequest	wValue	wIndex	wLength	Data
10000000B	*Get_Battery_Status*	Zero	Battery ID	Eight	Battery Status

The PDUSB Hub/Peripheral ***Shall*** return the Battery Status of the Battery identified by the value of *wIndex* field.

Every PDUSB Device that has a Battery ***Shall*** return its Battery Status when queried with this request. For Providers or Consumers with multiple batteries, the status of each Battery ***Shall*** be reported per Battery.

Table 9-9 Battery Status Structure

<table>
<tr><th>Offset</th><th>Field</th><th>Size</th><th>Value</th><th>Description</th></tr>
<tr><td>0</td><td>bBatteryAttributes</td><td>1</td><td>Number</td><td>Shall indicate whether a Battery is installed and whether this is charging or discharging.
<table>
<tr><th>Value</th><th>Description</th></tr>
<tr><td>0</td><td>There is no Battery</td></tr>
<tr><td>1</td><td>The Battery is charging</td></tr>
<tr><td>2</td><td>The Battery is discharging</td></tr>
<tr><td>3</td><td>The Battery is neither discharging nor charging</td></tr>
<tr><td>255-4</td><td>Reserved and Shall Not be used</td></tr>
</table></td></tr>
<tr><td>1</td><td>bBatterySOC</td><td>1</td><td>Number</td><td>Shall indicate the Battery State of Charge given as percentage value from Battery Remaining Capacity.</td></tr>
<tr><td>2</td><td>bBatteryStatus</td><td>1</td><td>Number</td><td>If a Battery is present Shall indicate the present status of the Battery.
<table>
<tr><th>Value</th><th>Meaning</th></tr>
<tr><td>0</td><td>No error</td></tr>
<tr><td>1</td><td>Battery required and not present</td></tr>
<tr><td>2</td><td>Battery non-chargeable/wrong chemistry</td></tr>
<tr><td>3</td><td>Over-temp shutdown</td></tr>
<tr><td>4</td><td>Over-voltage shutdown</td></tr>
<tr><td>5</td><td>Over-current shutdown</td></tr>
<tr><td>6</td><td>Fatigued Battery</td></tr>
<tr><td>7</td><td>Unspecified error</td></tr>
<tr><td>255-8</td><td>Reserved and Shall Not be used</td></tr>
</table></td></tr>
<tr><td>3</td><td>bRemoteWakeCapStatus</td><td>1</td><td>Bitmap</td><td>If the device supports remote wake, then the device Shall support Battery Remote wake events. The default value for the Remote wake events Shall be turned off (set to zero) and can be enable/disabled by the host as required. If set to one the device Shall generate a wake event when a change of status occurs. See Section 9.4.2 for more details.
<table>
<tr><th>Bit</th><th>Description</th></tr>
<tr><td>0</td><td>Battery present event</td></tr>
<tr><td>1</td><td>Charging flow</td></tr>
<tr><td>2</td><td>Battery error</td></tr>
<tr><td>7:3</td><td>Reserved and Shall be set to zero</td></tr>
</table></td></tr>
</table>

Offset	Field	Size	Value	Description
4	*wRemainingOperatingTime*	2	Number	***Shall*** contain the operating time (in minutes) until the Weak Battery threshold is reached, based on Present Battery Strength and the device's present operational power needs. Note: this value ***Shall*** exclude any additional power received from charging. A Battery that is not capable of returning this information ***Shall*** return a value of 0xFFFF.
6	*wRemainingChargeTime*	2	Number	***Shall*** contain the remaining time (in minutes) until the Charged Battery threshold is reached based on Present Battery Strength, charging power and the device's present operational power needs. Value ***Shall*** only be ***Valid*** if the Charging Flow is "Charging". A Battery that is not capable of returning this information ***Shall*** return a value of 0xFFFF.

If *wValue* or *wLength* are not as specified above, then the behavior of the PDUSB Device is not specified.

If *wIndex* refers to a Battery that does not exist, then the PDUSB Device ***Shall*** respond with a Request Error.

If the PDUSB Device is not configured, the PDUSB Hub's response to this request is undefined.

If the PDUSB Hub is not configured, the PDUSB Hub's response to this request is undefined.

9.4.2 SetPDFeature

This request sets the value requested in the PDUSB Hub/Peripheral.

bmRequestType	bRequest	wValue	wIndex	wLength	Data
00000000B	SET_ FEATURE	Feature Selector	Feature Specific	Zero	None

Setting a feature enables that feature or starts a process associated with that feature; see Table 9-8 for the feature selector definitions. Features that ***May*** be set with this request are:

- ***BATTERY_WAKE_MASK.***
- ***CHARGING_POLICY.***

9.4.2.1 BATTERY_WAKE_MASK Feature Selector

When the feature selector is set to ***BATTERY_WAKE_MASK***, then the *wIndex* field is structured as shown in the following table.

Table 9-10 Battery Wake Mask

Bit	Description
0	**Battery Present**: When this bit is set then the PDUSB Device ***Shall*** generate a wake event if it detects that a Battery has been Attached.
1	**Charging Flow**: When this bit is set then the PDUSB Device ***Shall*** generate a wake event if it detects that a Battery switched from charging to discharging or vice versa.
2	**Battery Error**: When this bit is set then the PDUSB Device ***Shall*** generate a wake event if the Battery has detected an error condition.
15:3	***Reserved*** and ***Shall Not*** be used.

The SPM ***May*** Enable or Disable the wake events associated with one or more of the above events by using this feature.

If the PDUSB Hub is not configured, the PDUSB Hub's response to this request is undefined.

9.4.2.2 CHARGING_POLICY Feature Selector

When the feature selector is set to ***CHARGING_POLICY***, the wIndex field ***Shall*** be set to one of the values defined in Table 9-11. If the device is using USB Type-C Current above the default value or is using PD then this feature setting has no effect and the rules for power levels specified in the ***[USB Type-C 1.2]*** or USB PD specifications ***Shall*** apply.

Table 9-11 Charging Policy Encoding

Value	Description
00H	The device ***Shall*** follow the default current limits as defined in the USB 2.0 or USB 3.1 specification, or as negotiated through other USB mechanisms such as BC. This is the default value.
01H	The Device ***May*** draw additional power during the unconfigured and suspend states for the purposes of charging. For charging the device itself, the device ***Shall*** limit its current draw to the higher of these two values: ICCHPF as defined in the USB 2.0 or USB 3.1 specification, regardless of its USB state. Current limit as negotiated through other USB mechanisms such as BC.
02H	The Device ***May*** draw additional power during the unconfigured and suspend states for the purposes of charging. For charging the device itself, the device ***Shall*** limit its current draw to the higher of these two values: ICCLPF as defined in the USB 2.0 or USB 3.1 specification, regardless of its USB state. Current limit as negotiated through other USB mechanisms such as BC.
03H	The device ***Shall Not*** consume any current for charging the device itself regardless of its USB state.
04H-FFFFH	***Reserved*** and ***Shall Not*** be used

This is a ***Valid*** command for the PDUSB Hub/Peripheral in the Address or Configured USB states. Further, it is only ***Valid*** if the device reports a USB PD capability descriptor in its BOS descriptor and Bit 5 of the bmAttributes in that descriptor is set to 1. The device will go back to the wIndex default value of 0 whenever it is reset.

10. Power Rules

10.1 Introduction

The flexibility of power provision on USB Type-C is expected to lead to adapter re-use and the increasingly widespread provision of USB power outlets in domestic and public places and in transport of all kinds. Environmental considerations could result in unbundled adapters. Rules are needed to avoid incompatibility between the Sources and the Sinks they are used to power, in order to avoid user confusion and to meet user expectations. This section specifies a set of rules that Sources and Sinks ***Shall*** follow. These rules provide a simple and consistent user experience.

10.2 Source Power Rules

10.2.1 Source Power Rule Considerations

The Source power rules are designed to:

- Ensure the PD Power (PDP) of an adapter specified in watts explicitly defines the voltages and currents at each voltage the adapter supports
- Ensure that adapters with a large PDP are always capable of providing the power to devices designed for use with adapters with a smaller PDP
- Enable an ecosystem of adapters that are interoperable with the devices in the ecosystem.

The considerations that lead to the Source power rules are based are summarized in Table 10-1.

Table 10-1 Considerations for Sources

Considerations	Rationale	Consequence
Simple to identify capability	A user going into an electronics retailer knows what they need	Cannot have a complex identification scheme
Higher power Sources are a superset of smaller ones	Bigger is always better in user's eyes – don't want a degradation in performance	Higher power Sources do everything smaller ones do
Unambiguous Source definitions	Sources with the same power rating but different VI combinations might not interoperate	To avoid user confusion, any given power rating has a single definition
A range of power ratings	Users and companies will want freedom to pick appropriate Source ratings	Fixed profiles at specific power levels don't provide adequate flexibility, e.g. profiles as defined in previous versions of PD.
5V@3A USB Type-C Source is defined by ***[USB Type-C 1.2]***	5V@3A USB Type-C Source is considered	All > 15W adapters must support 5V@3A or superset consideration is violated
Maximize 3A cable utilization	3A cables will be ubiquitous	Increase to maximum voltage (20V) before increasing current beyond 3A
Optimize voltage rail count	More rails are a higher burden for Sources, particularly in terms of testing	5V is a basic USB requirement. 20V provides the maximum capability.
Some Sources are not able to provide significant power	Some small Battery operated Sources e.g. mobile devices, are able to provide more power directly from their Battery than from a regulated 5V supply	In addition to the minimal 5V advertisement are able to advertise more power from their Battery
Some Sources share power between multiple Ports (Hubs)	Hubs have to be supported	See Section 10.2.4

10.2.2 Normative Voltages and Currents

The voltages and currents a Source with a PDP of x Watts ***Shall*** support are as defined in Table 10-2.

Table 10-2 Normative Voltages and Currents

PDP (W)	Current at 5V (A)	Current at 9V (A)	Current at 15V (A)	Current at 20V (A)
0.5 ≤ x ≤ 15	x ÷ 5			
15 < x ≤ 27	3	x ÷ 9		
27 < x ≤ 45	3	3	x ÷ 15	
45 < x ≤ 60	3	3	3	x ÷ 20
60 < x ≤ 100	3	3	3	x ÷ 20[1]
[1] Requires a 5A cable.				

Figure 10-1 illustrates the maximum current and power rails that a Source ***Shall*** support at each voltage for a given PDP.

Figure 10-1 Source Power Rule Illustration

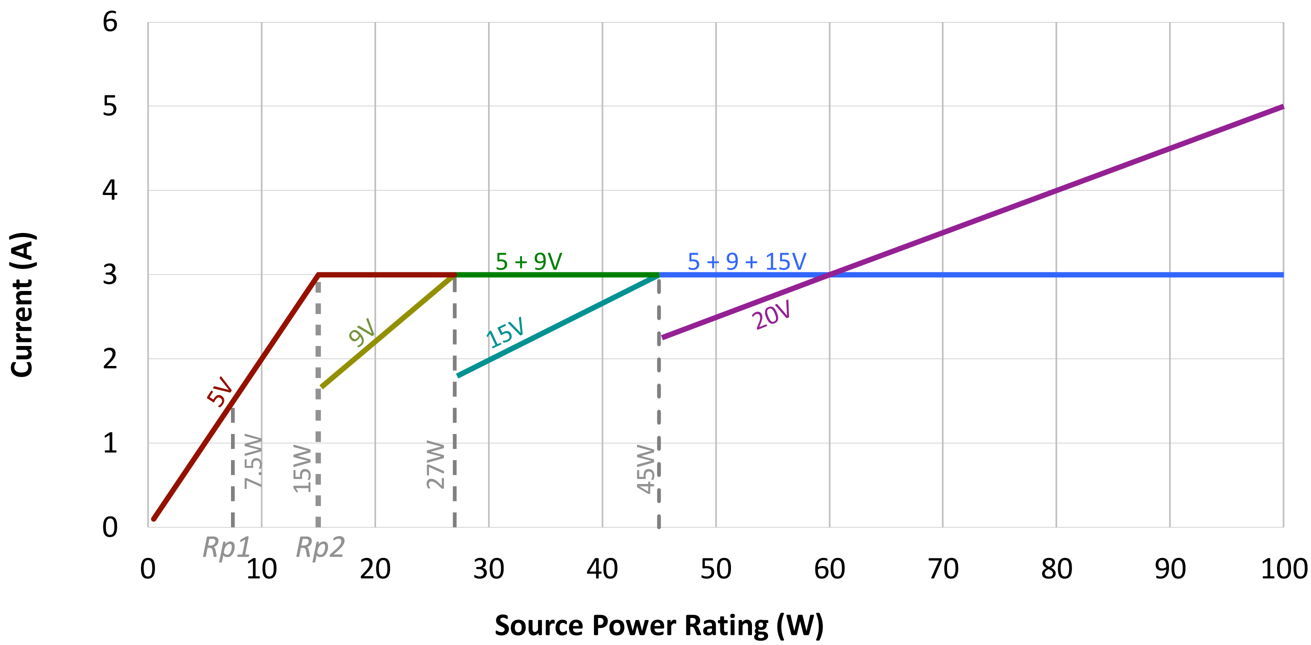


Figure 10-2 shows an example of an adapter with a rating at 50W. The adapter is required to support 20V at 2.5A, 15V at 3A, 9V at 3A and 5V at 3A.

Figure 10-2 Source Power Rule Example

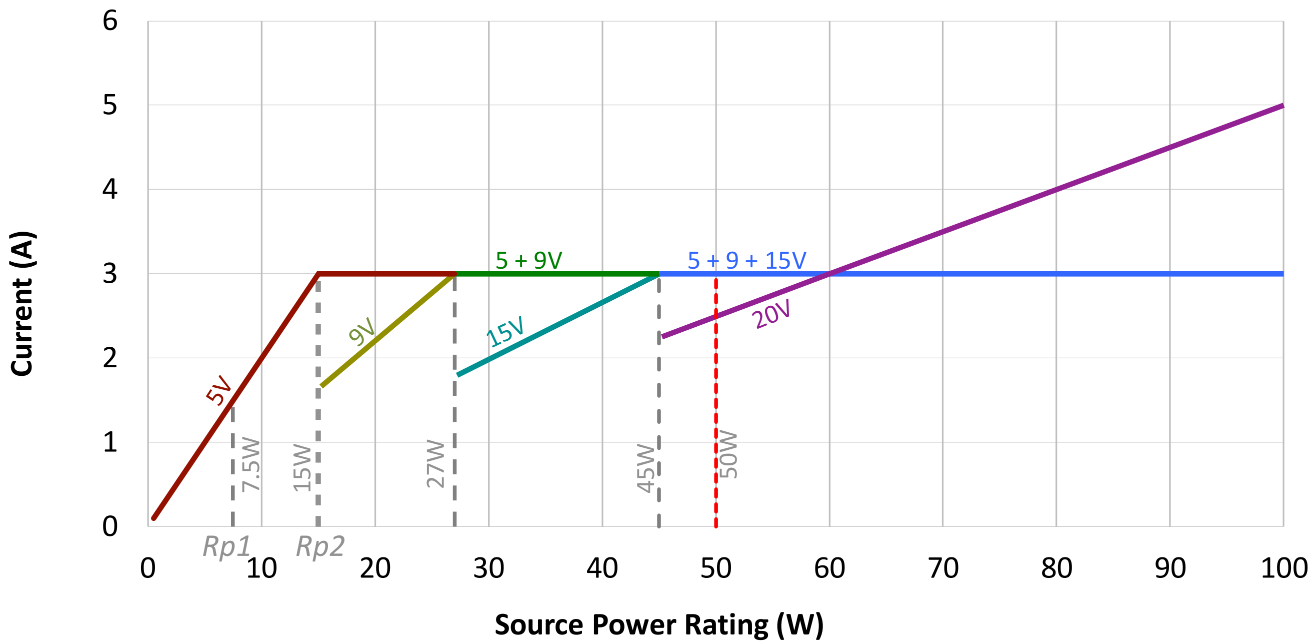


Table 10-3, Table 10-4, Table 10-5 and Table 10-6 show the Fixed Supply PDOs that ***Shall*** be supported for each of the ***Normative*** voltages defined in Table 10-2.

Table 10-3 Fixed Supply PDO – Source 5V

Bit(s)	Description
B31…30	Fixed supply
B29	Dual-Role Power
B28	USB Suspend Supported
B27	Unconstrained Power
B26	USB Communications Capable
B25	Dual-Role Data
B24…22	***Reserved*** – ***Shall*** be set to zero.
B21…20	Peak Current
B19…10	5V
B9…0	<table><tr><th>PDP (x)</th><th>Current (A)</th></tr><tr><td>0.5 ≤ x ≤ 15</td><td>x ÷ 5</td></tr><tr><td>15 < x ≤ 100</td><td>3</td></tr></table>

Table 10-4 Fixed Supply PDO – Source 9V

<table>
<tr><th>Bit(s)</th><th>Description</th></tr>
<tr><td>B31…30</td><td>Fixed Supply</td></tr>
<tr><td>B29…22</td><td>Reserved – Shall be set to zero.</td></tr>
<tr><td>B21…20</td><td>Peak Current</td></tr>
<tr><td>B19…10</td><td>9V</td></tr>
<tr><td>B9…0</td><td><table>
<tr><th>PDP (x)</th><th>Current (A)</th></tr>
<tr><td>0.5 ≤ x ≤ 15</td><td>PDO not required</td></tr>
<tr><td>15 < x ≤ 27</td><td>x ÷ 9</td></tr>
<tr><td>27 < x ≤ 100</td><td>3</td></tr>
</table></td></tr>
</table>

Table 10-5 Fixed Supply PDO – Source 15V

<table>
<tr><th>Bit(s)</th><th>Description</th></tr>
<tr><td>B31…30</td><td>Fixed Supply</td></tr>
<tr><td>B29…22</td><td>Reserved – Shall be set to zero.</td></tr>
<tr><td>B21…20</td><td>Peak Current</td></tr>
<tr><td>B19…10</td><td>15V</td></tr>
<tr><td>B9…0</td><td><table>
<tr><th>PDP (x)</th><th>Current (A)</th></tr>
<tr><td>0.5 ≤ x ≤ 27</td><td>PDO not required</td></tr>
<tr><td>27 < x ≤ 45</td><td>x ÷ 15</td></tr>
<tr><td>45 < x ≤ 100</td><td>3</td></tr>
</table></td></tr>
</table>

Table 10-6 Fixed Supply PDO – Source 20V

<table>
<tr><th>Bit(s)</th><th>Description</th></tr>
<tr><td>B31…30</td><td>Fixed Supply</td></tr>
<tr><td>B29…22</td><td>Reserved – Shall be set to zero.</td></tr>
<tr><td>B21…20</td><td>Peak Current</td></tr>
<tr><td>B19…10</td><td>20V</td></tr>
<tr><td>B9…0</td><td><table>
<tr><th>PDP (x)</th><th>Current (A)</th></tr>
<tr><td>0.5 ≤ x ≤ 45</td><td>PDO not required</td></tr>
<tr><td>45 < x ≤ 100</td><td>x ÷ 20</td></tr>
</table></td></tr>
</table>

More current ***May*** be offered in the PDOs when ***Optional*** voltages/currents are supported and a 5A cable is being used (see Section 10.2.3).

10.2.3 Optional Voltages/Currents

10.2.3.1 Optional Normative Fixed, Variable and Battery Supply

In addition to the voltages and currents specified in Section 10.2.2 a Source that is optimized for use with a specific Sink or a specific class of Sinks ***May Optionally*** supply additional voltages and increased currents. When ***Optional*** voltages and increased currents are provided, the following requirements ***Shall*** apply:

- The Source ***Shall*** be able to meet its PDP at the ***Normative*** voltages and currents as specified in Section 10.2.2.
- A Source ***Shall Not*** advertise Fixed Supply PDO ***Optional*** voltages and currents that exceed the PDP.
- A Source ***Shall Not*** advertise Variable Supply PDO ***Optional*** maximum voltages and currents that exceed the PDP.
- A Source ***Shall Not*** advertise a Battery Supply PDO ***Optional*** maximum allowable power that exceeds the PDP.

10.2.3.2 Optional Normative Programmable Power Supply

In addition to the voltages and currents specified in Section 10.2.2 a Source that is optimized for use with a specific Sink or a specific class of Sinks ***May Optionally*** offer a Programmable Power Supply. The Programmable Power Supply's PDP ***Shall*** be calculated as the product of the Nominal Voltage times the Maximum Current.

When ***Optional*** Programmable Power Supply APDOs are offered, the following requirements ***Shall*** apply:

- A Source that advertises ***Optional*** Programmable Power Supply APDOs ***Shall*** advertise the PDOs and APDOs shown in Table 10-7.
- A Source ***Shall*** advertise ***Optional*** Programmable Power Supply APDOs with Maximum Voltage and Minimum Voltages for nominal voltage as defined in Table 10-8.
- A Source that advertises Programmable Power Supply APDOs other than the ones listed in Table 10-8 ***Shall Not*** advertise additional APDO's with a Maximum Voltage * Maximum Current that exceeds the adapter's PDP.
- In no case ***Shall*** a Source advertise a current that exceeds the attached cable's current rating.

Table 10-7 shows the Programmable Power Supply APDOs that ***Shall*** be offered for a given PDP.

Table 10-7 Programmable Power Supply PDOs and APDOs based on the PDP

PDP (W)	5V fixed	9V fixed	15V fixed	20V fixed	5V Prog	9V Prog	15V Prog	20V Prog
x <= 15W	PDP/5	-	-	-	PDP/5	-	-	-
15 < x <= 27W	3A	PDP/9	-	-	3A or PDP/5[2]	PDP/9	-	-
27 < x <= 45W	3A	3A	PDP/15	-	PDP/5[1]	3A or PDP/9[2]	PDP/15	-
45 < x <= 100W	3A	3A	3A	PDP/20	-	PDP/9[1]	3A or PDP/15[2]	PDP/20[2]

Notes:
1. This PPS APDO is Optional.
2. The PPS ***May*** offer more than 3A when a 5A cable is present.

10.2.3.2.1 Programmable Power Supply Voltage Ranges

The Programmable Power Supply voltage ranges map to the Fixed Supply Voltages. For each Fixed Voltage there is a defined voltage range for the matching Programmable Power Supply APDO. Table 10-8 shows the Minimum and Maximum voltage for the Programmable Power Supply that corresponds to the Fixed nominal voltage.

Table 10-8 Programmable Power Supply Voltage Ranges

	Fixed Nominal Voltage			
	5V Prog	**9V Prog**	**15V Prog**	**20V Prog**
Maximum Voltage	5.9V	11V	16V	21V
Minimum Voltage	3V	3V	3V	3V

The voltage output at the Source's connector ***Shall*** be +/-5% for both the Maximum Voltage and the Minimum Voltage.

10.1.2.2 Examples of the use of the Programmable Power Supplies

The following examples illustrate what a power adapter that advertises a particular PDP ***May*** offer:

1. PDP 15W
   - 5V @ 3A and 5V Prog @ 3A is the baseline
2. PDP 25W
   - 5V @ 3A, 9V @ 2.8A, 5V Prog @ 3A and 9V Prog @ 2.8A is the baseline
   - 5V @ 3A, 9V @ 2.8A, 5V Prog @ >3A up to 5A and 9V Prog @ 2.8A (with a 5A cable)
3. PDP 27W
   - 5V @ 3A, 9V @ 3A, 9V Prog @ 3A is the baseline
   - 5V @ 3A, 9V @ 3A, 5V Prog @ 3A and 9V Prog @ 3A can offer 5V Prog, but it is covered by the 9V Prog
   - 5V @ 3A, 9V @ 3A, 5V Prog @ >3A up to 5A and 9V Prog @ 3A (with a 5A cable)
4. PDP 36W
   - 5V @ 3A, 9V @ 3A, 15 @ 2.4A, 9V Prog @ 3 A and 15V Prog @ 2.4A is the baseline
   - 5V @ 3A, 9V @ 3A, 15 @ 2.4A, 5V Prog @ >3A up to 5A, 9V Prog @ >3A up to 4A and 15V Prog @ 2.4A (with a 5A cable)

The first example is a simple single output voltage supply. Both the Fixed and Programmable outputs supply 3A.

The second example illustrates that there are multiple ways to meet the requirements. The first sub-bullet is the power that the power rules require. The second sub-bullet illustrates that the power supply can offer more power at a particular voltage so long as it does not violate the power rules. In this case it offers 25W at both 5V and 9V.

The third example illustrates that there are multiple ways a 27W PDP power adapter can be implemented and meet the power rules. The first sub-bullet shows that the 9V Prog @ 3A fully covers the 5V Prog @3A range so it is not necessary to advertise both. The second and third sub-bullets illustrate that the power adapter can advertise lower voltages at higher currents than required so long as the power does not exceed the PDP.

The fourth example illustrates as the PDP goes higher there are more possible combinations that meet the power rules. Although there are multiple ways to meet the power rules, no more than a combination of seven PDO and APDOs can be offered.

10.2.4 Power sharing between ports

The Source power rules defined in Section 10.2.2 and Section 10.2.3 ***Shall*** apply independently to each port on a system with multiple ports.

10.3 Sink Power Rules

10.3.1 Sink Power Rule Considerations

The Sink power rules are designed to ensure the best possible user experience when a given Sink used with a compliant Source of arbitrary Output Power Rating that only supplies the ***Normative*** voltages and currents.

The Sink Power Rules are based on the following considerations:

- Low power Sources (e.g., 5V) are expected to be very common and will be used with Sinks designed for a higher PDP.
- Optimizing the user experience when Sources with a high PDP are used with low power Sinks.
- Preventing Sinks that only function well (or at all) when using ***Optional*** voltages and currents.

10.3.2 Normative Sink Rules

Sinks designed to use Sources with a PDP of x W ***Shall***:

- Either operate or charge from Sources that have a PDP ≥ x W.
- Either operate, charge or indicate a capability mismatch (see Section 6.4.2.3) from Sources that have a PDP < x W and ≥ 0.5W.

A Sink optimized for a Source with ***Optional*** voltages and currents or power as described in Section 10.2.3 with a PDP of x W ***Shall*** provide a similar user experience when powered from a Source with a PDP of ≥ x W that supplies only the ***Normative*** voltages and currents as specified in Section 10.2.2.

The following requirements ***Shall*** apply to the advertised Sink Capabilities:

- A Sink ***Shall Not*** advertise Fixed Supply PDO maximum voltages and currents that exceed the PDP they were designed to use.
- A Sink ***Shall Not*** advertise Variable Supply PDO maximum voltages and currents that exceed the PDP they were designed to use.
- A Sink ***Shall Not*** advertise a Battery Supply PDO maximum allowable power that exceeds the PDP they were designed to use.

A. CRC calculation

A.1 C code example

```
//
// USB PD CRC Demo Code.
//
#include <stdio.h>

int crc;

//----------------------------------------------------------------------------

void crcBits(int x, int len) {

  const int poly = 0x04C11DB6;  //spec 04C1 1DB7h
  int newbit, newword, rl_crc;

  for(int i=0; i<len; i++) {

    newbit = ((crc>>31) ^ ((x>>i)&1)) & 1;
    if(newbit) newword=poly; else newword=0;
    rl_crc = (crc<<1) | newbit;
    crc = rl_crc ^ newword;
    printf("%2d newbit=%d, x>>i=0x%x, crc=0x%x\n", i, newbit,(x>>i),crc);
  }
}

int crcWrap(int c){

  int ret = 0;
  int j, bit;

  c = ~c;
  printf("~crc=0x%x\n", c);

  for(int i=0;i<32;i++) {
    j = 31-i;

    bit = (c>>i) & 1;
    ret |= bit<<j;
```

```
  }
  return ret;

}

//--------------------------------------------------------------------------------

int main(){

  int txCrc=0,rxCrc=0,residue=0,data;

  printf("using packet data 0x%x\n", data=0x0101);

  crc = 0xffffffff;
  crcBits(data,16);
  txCrc = crcWrap(crc);

  printf("crc=0x%x, txCrc=0x%x\n", crc, txCrc);



  printf("received packet after decode= 0x%x, 0x%x\n", data, txCrc);

  crc = 0xffffffff;
  crcBits(data,16);
  rxCrc = crcWrap(crc);

  printf("Crc of the received packet data is (of course) =0x%x\n", rxCrc);

  printf("continue by running the transmit crc through the crc\n");
  crcBits(rxCrc,32);

  printf("Now the crc residue is 0x%x\n", crc);

  printf("should be 0xc704dd7b\n");

}
```

A.2 Table showing the full calculation over one Message

Function	Nibble	Symbol	Bits	CRC register transmitter	CRC register receiver	bit nr.
Preamble			0	FFFFFFFF	FFFFFFFF	1
			1	FFFFFFFF	FFFFFFFF	2
			0	FFFFFFFF	FFFFFFFF	3
			1	FFFFFFFF	FFFFFFFF	4
			0	FFFFFFFF	FFFFFFFF	5
			1	FFFFFFFF	FFFFFFFF	6
			0	FFFFFFFF	FFFFFFFF	7
			1	FFFFFFFF	FFFFFFFF	8
			0	FFFFFFFF	FFFFFFFF	9
			1	FFFFFFFF	FFFFFFFF	10
			0	FFFFFFFF	FFFFFFFF	11
			1	FFFFFFFF	FFFFFFFF	12
			0	FFFFFFFF	FFFFFFFF	13
			1	FFFFFFFF	FFFFFFFF	14
			0	FFFFFFFF	FFFFFFFF	15
			1	FFFFFFFF	FFFFFFFF	16
			0	FFFFFFFF	FFFFFFFF	17
			1	FFFFFFFF	FFFFFFFF	18
			0	FFFFFFFF	FFFFFFFF	19
			1	FFFFFFFF	FFFFFFFF	20
			0	FFFFFFFF	FFFFFFFF	21
			1	FFFFFFFF	FFFFFFFF	22
			0	FFFFFFFF	FFFFFFFF	23
			1	FFFFFFFF	FFFFFFFF	24
			0	FFFFFFFF	FFFFFFFF	25
			1	FFFFFFFF	FFFFFFFF	26
			0	FFFFFFFF	FFFFFFFF	27
			1	FFFFFFFF	FFFFFFFF	28
			0	FFFFFFFF	FFFFFFFF	29
			1	FFFFFFFF	FFFFFFFF	30
			0	FFFFFFFF	FFFFFFFF	31
			1	FFFFFFFF	FFFFFFFF	32
			0	FFFFFFFF	FFFFFFFF	33
			1	FFFFFFFF	FFFFFFFF	34
			0	FFFFFFFF	FFFFFFFF	35
			1	FFFFFFFF	FFFFFFFF	36
			0	FFFFFFFF	FFFFFFFF	37
			1	FFFFFFFF	FFFFFFFF	38
			0	FFFFFFFF	FFFFFFFF	39
			1	FFFFFFFF	FFFFFFFF	40
			0	FFFFFFFF	FFFFFFFF	41
			1	FFFFFFFF	FFFFFFFF	42
			0	FFFFFFFF	FFFFFFFF	43
			1	FFFFFFFF	FFFFFFFF	44
			0	FFFFFFFF	FFFFFFFF	45
			1	FFFFFFFF	FFFFFFFF	46
			0	FFFFFFFF	FFFFFFFF	47
			1	FFFFFFFF	FFFFFFFF	48
			0	FFFFFFFF	FFFFFFFF	49
			1	FFFFFFFF	FFFFFFFF	50
			0	FFFFFFFF	FFFFFFFF	51
			1	FFFFFFFF	FFFFFFFF	52
			0	FFFFFFFF	FFFFFFFF	53
			1	FFFFFFFF	FFFFFFFF	54
			0	FFFFFFFF	FFFFFFFF	55
			1	FFFFFFFF	FFFFFFFF	56
			0	FFFFFFFF	FFFFFFFF	57
			1	FFFFFFFF	FFFFFFFF	58
			0	FFFFFFFF	FFFFFFFF	59
			1	FFFFFFFF	FFFFFFFF	60
			0	FFFFFFFF	FFFFFFFF	61
			1	FFFFFFFF	FFFFFFFF	62
			0	FFFFFFFF	FFFFFFFF	63
			1	FFFFFFFF	FFFFFFFF	64
SOP		Sync1 (#18)	0	FFFFFFFF	FFFFFFFF	65
			0	FFFFFFFF	FFFFFFFF	66
			0	FFFFFFFF	FFFFFFFF	67
			1	FFFFFFFF	FFFFFFFF	68
			1	FFFFFFFF	FFFFFFFF	69
		Sync1 (#18)	0	FFFFFFFF	FFFFFFFF	70
			0	FFFFFFFF	FFFFFFFF	71
			0	FFFFFFFF	FFFFFFFF	72
			1	FFFFFFFF	FFFFFFFF	73
			1	FFFFFFFF	FFFFFFFF	74
		Sync1 (#18)	0	FFFFFFFF	FFFFFFFF	75
			0	FFFFFFFF	FFFFFFFF	76
			0	FFFFFFFF	FFFFFFFF	77
			1	FFFFFFFF	FFFFFFFF	78
			1	FFFFFFFF	FFFFFFFF	79
		Sync2 (#11)	1	FFFFFFFF	FFFFFFFF	80
			0	FFFFFFFF	FFFFFFFF	81
			0	FFFFFFFF	FFFFFFFF	82
			0	FFFFFFFF	FFFFFFFF	83
			1	FFFFFFFF	FFFFFFFF	84

Function	Nibble	Symbol	Bits	CRC register transmitter	CRC register receiver	bit nr.
GoodCRC Header #0101	#1	#09	1	FFFFFFFF	FFFFFFFF	85
			0	FFFFFFFE	FFFFFFFF	86
			0	FB3EE24B	FFFFFFFF	87
			1	F2BCD921	FFFFFFFF	88
			0	E1B8AFF5	FFFFFFFF	89
	#0	#1E	0	E1B8AFF5	FFFFFFFF	90
			1	C7B0425D	FFFFFFFE	91
			1	8BA1990D	FB3EE24B	92
			1	13822FAD	F2BCD921	93
			1	27045F5A	E1B8AFF5	94
	#1	#09	1	27045F5A	E1B8AFF5	95
			0	4AC9A303	C7B0425D	96
			0	95934606	8BA1990D	97
			1	2FE791BB	13822FAD	98
			0	5FCF2376	27045F5A	99
	#0	#1E	0	5FCF2376	27045F5A	100
			1	BF9E46EC	4AC9A303	101
			1	7BFD906F	95934606	102
			1	F7FB20DE	2FE791BB	103
			1	EB375C0B	5FCF2376	104
CRC-32 = swapped and inverted EB375C0B = 2FC51328	#8	#12	0	EB375C0B	5FCF2376	105
			1	EB375C0B	BF9E46EC	106
			0	EB375C0B	7BFD906F	107
			0	EB375C0B	F7FB20DE	108
			1	EB375C0B	EB375C0B	109
	#2	#14	0	EB375C0B	EB375C0B	110
			0	EB375C0B	D2AFA5A1	111
			1	EB375C0B	A19E56F5	112
			0	EB375C0B	47FDB05D	113
			1	EB375C0B	8B3A7D0D	114
	#3	#15	1	EB375C0B	8B3A7D0D	115
			0	EB375C0B	12B5E7AD	116
			1	EB375C0B	21AAD2ED	117
			0	EB375C0B	4355A5DA	118
			1	EB375C0B	86AB4BB4	119
	#1	#09	1	EB375C0B	86AB4BB4	120
			0	EB375C0B	0D569768	121
			0	EB375C0B	1E6C3367	122
			1	EB375C0B	3CD866CE	123
			0	EB375C0B	79B0CD9C	124
	#5	#0B	1	EB375C0B	79B0CD9C	125
			1	EB375C0B	F7A0868F	126
			0	EB375C0B	EB8010A9	127
			1	EB375C0B	D3C13CE5	128
			0	EB375C0B	A343647D	129
	#C	#1A	0	EB375C0B	A343647D	130
			1	EB375C0B	4686C8FA	131
			0	EB375C0B	8D0D91F4	132
			1	EB375C0B	1A1B23E8	133
			1	EB375C0B	343647D0	134
	#F	#1D	1	EB375C0B	343647D0	135
			0	EB375C0B	686C8FA0	136
			1	EB375C0B	D0D91F40	137
			1	EB375C0B	A1B23E80	138
			1	EB375C0B	43647D00	139
	#2	#14	0	EB375C0B	43647D00	140
			0	EB375C0B	8209E7B7	141
			1	EB375C0B	0413CF6E	142
			0	EB375C0B	0CE6836B	143
			1	EB375C0B	1D0C1B61	144
EOP		#0D	1	EB375C0B	1D0C1B61	145
			0	EB375C0B	3A1836C2	146
			1	EB375C0B	70F17033	147
			1	EB375C0B	E1E2E066	148
			0	EB375C0B	C704DD7B	149

Note: CRC transmitter is calculated over data bytes only, in casu marked nibbles, and calculation results are available one (bit-) clock later

Note: CRC receiver is calculated over data bytes and received CRC bytes, in casu marked nibbles, and calculation results are available five (bit-) clocks later

Fixed residual

B. PD Message Sequence Examples

The following examples are intended to show how the Device Policy Manager might operate and the sequence of Power Delivery messaging which will result. The aim of this section is to inform implementer's how some of the mechanisms detailed in this specification might be applied; it does not contain any ***Normative*** requirements.

All ports are assumed to be Enhanced SuperSpeed capable, with a default operating voltage of 5V and a unit load of 150mA. This 0.75W is assumed to be enough power to enable an externally powered device to maintain communication over USB and is enough to allow such a device to enumerate but not operate until more power is negotiated.

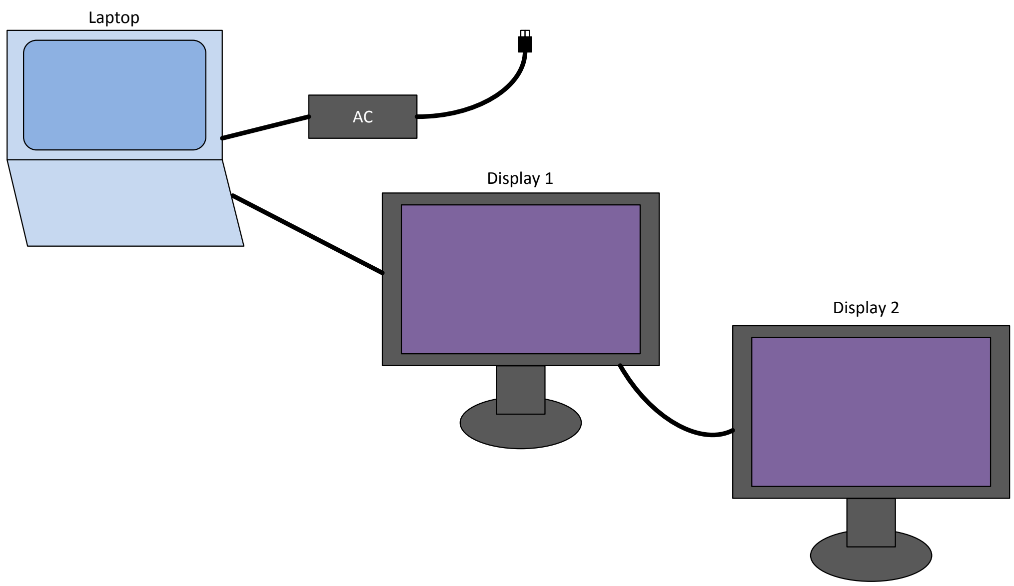
Although the Hubs in these illustrations support Power Delivery on both their UFPs and DFPs this is only one possible Hub implementation.

HDDs are assumed to spin up immediately after they are Attached. This follows the typical operation of current systems.

Ideal power transmission is assumed so that there are no power losses through a device; in practice these would need to be taken into account when requesting power.

B.1 External power is supplied downstream

Figure B-1 External Power supplied downstream



Configuration:

1. Laptop with an AC supply. AC supply provides sufficient power to charge the laptop and, in addition, to provide up to 60W downstream via its Enhanced SuperSpeed Port. According to the Source Power Rules described in Section 10.2 this means that the Port has a PD Power of 60W and so can supply: 5V@3A, 9V@3A, 15V@3A and 20V@3A.
2. Display 1 requires 30W to display and therefore a PD Power of 60W to operate itself plus Display 2 connected downstream. Display 1 initially uses 15V@2A to operate itself, since this also allows operation with a Source of 30W PD Power. On connection of Display 2, Display 1 will move to operation at 20V@3A to allow operation of the additional 30W ganged display. According to the Sink Power Rules described in Section 10.3 this means that Display 1

requires a Source with a PD Power of 60W to fully operate. Display 1 contains a Hub allowing Display 2 to be connected to Display 1.

3. Display 2 requires 30W operate itself and does not support an additional display connected downstream. Display 1 uses 15V@2A to operate itself from a Source of 30W PD Power.
4. In USB suspend Display 1 and Display 2 will power down but can maintain USB connection using the PD power provided.

Table B-1 External power is supplied downstream

Step	Laptop	Display 1	Display 2	Device Policy Manager	Power (W)
Display 1					
1	Connected to wall supply	Detached	Detached		0
2	Display 1 Attached, V_{BUS} powered.	Attached, drawing 5V@150mA.	Detached		0.75
3	Set of Source Capabilities sent including: 5V@3A (15W), 9V@3A (27W), 15V@3A(45W) and 20V@3A (60W). The Unconstrained Power and USB suspend bits are set.	Source Capabilities received	Detached	Laptop determines its Source Capabilities based on its needs and the presence of a wall supply.	0.75
4	Request received	Requests 15V@2A (30W) from laptop	Detached	Display 1 knows it needs 20v@1.5A (30W) for its own operation, evaluates the supplied capabilities and determines that this is available.	0.75
5	Sends Accept	Accept received	Detached	Waiting for PS_RDY before drawing additional power.	0.75
6	Sends PS_RDY	PS_RDY received. Starts drawing 15V@2A. Display 1 turns on and starts operating.	Detached	Laptop evaluates the request, finds that it can meet this and so sends an accept.	30
Display 2					
7	Powering Display 1	Detects Attach	Attached, no V_{BUS}		30

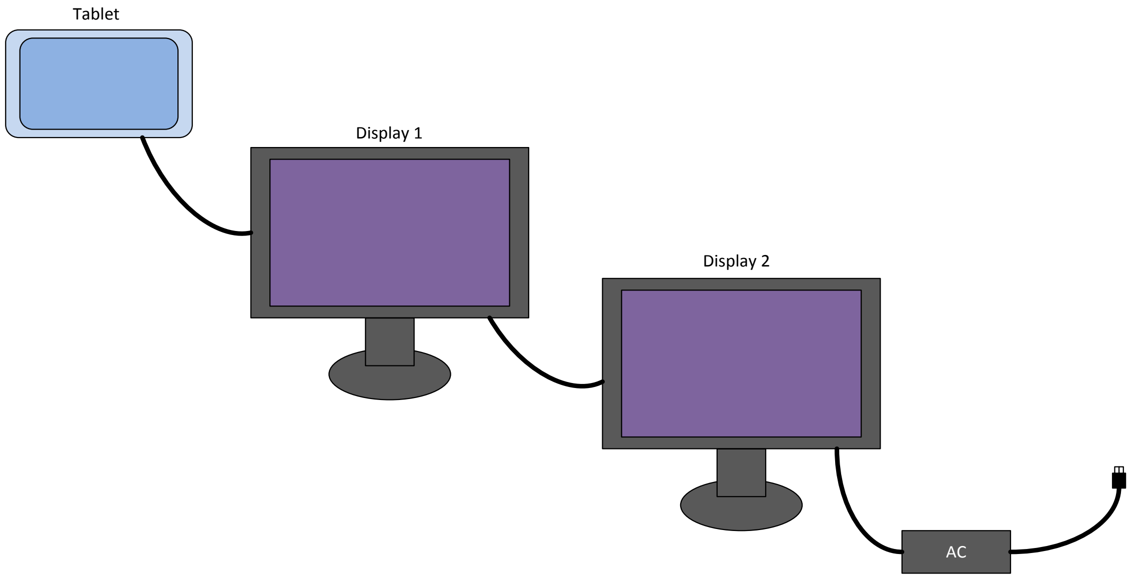
Step	Laptop	Display 1	Display 2	Device Policy Manager	Power (W)
8	Request received	Display 1 requests 20V@1.73A (34.6W) from Laptop.	Attached, no V_{BUS}	Display 1 detects Attach and requests additional 4.5W of power for USB 3.1 Port.	30
9	Sends Accept	Accept received.	Attached, no V_{BUS}		34.6
10	Sends PS_RDY	PS_RDY received	Attached, no V_{BUS}		
11		Powers V_{BUS}	Attached, drawing 5V@150mA.		34.6
12		Sends out Source Capabilities including: 5V@0.9A to Display 2. The Unconstrained Power and USB suspend bits are set.	Source Capabilities received	Display 1 has 4.5W to allocate to Display 1. This is offered as a standard USB 3.1 Port.	34.6
13		Request received	Display 2 requests 5V@0.15A but indicates a Capability Mismatch. Display 2 remains off.	Display 2 decides it can manage to run its USB/PD function with 1 unit load but needs more power to function as a display.	34.6
14		Sends Accept	Accept received		34.6
15		Sends PS_RDY	PS_RDY received	Display 2 indicates a capability mismatch to the user.	34.6
16		Get Sink Capabilities sent	Get Sink Capabilities received	Display 1 needs to assess the capability mismatch by first determining what Display 2 actually needs.	34.6
17		Sink Capabilities received	Display 2 returns Sink Capabilities indicating operation at 15V@2A.		34.6

Step	Laptop	Display 1	Display 2	Device Policy Manager	Power (W)
18	Request received	Display 1 requests 20V@3A (60W) from Laptop.		Display1 now knows what Display 2 needs and requests the additional power from the laptop.	34.6
19	Sends Accept	Accept received.			34.6
20	Sends PS_RDY	PS_RDY received		An additional 30W is now available to Display 1 to offer to Display 2.	60
21		Sends out Source Capabilities including: 5V@0.9A and 20V@1.5A to Display 2. The Unconstrained Power and USB suspend bits are set.	Source Capabilities received	Now that Display 1 can power Display 2 correctly this power is offered by Display 1 via a new capabilities Message.	60
22		Request received	Display 2 requests 15V@2A.		60
23		Sends Accept	Accept received	Display 1 determines that the request by Display 2 is within the offered capabilities so the request is accepted.	60
24		Sends PS_RDY. Drawing 20V@3A from laptop.	PS_RDY received. Starts drawing 15V@2A, turns on and starts operating.	Display 2 now has the power it needs and can start working.	60
USB Suspend					
25	Laptop OS goes into suspend (S3), V_{BUS} remains on but USB bus is also suspended.	Display 1 turns off but draws 50mW, 25mW to maintain PDUSB Hub functions. The additional 25mW is used to supply the Port used by Display 2.	Display 2 turns off but draws 25mW to maintain USB/PD functions.	No changes in Contract. This is a power reduction purely based on the USB state.	60

Step	Laptop	Display 1	Display 2	Device Policy Manager	Power (W)
26	Laptop OS wakes up. USB is woken up.	Display 1 turns on and returns to drawing 20V@3A.	Display 2 turns on and returns to drawing 15V@2A.	No changes in PD Contract. This purely relates to USB bus state.	60

B.2 External power is supplied upstream

Figure B-2 External Power supplied upstream



Configuration:

1. Tablet with no AC supply. Tablet is a USB host and can use 5V@0.2A (1W) during normal operation and up to 5V@2.4A (12W) in order to charge.
2. Display 1 requires 30W to operate and therefore a PD Power of 42W to operate itself and charge the tablet. Display 1 uses 15V@2A to operate itself, since this allows operation with a Source of 30W PD Power and then moves to operation at 20V@2.1A to allow charging of the laptop. According to the Sink Power Rules described in Section 10.3 this means that the Display 1 requires a Source with a PD Power of 42W to fully operate.
3. Display 2 has an AC supply connected. AC supply provides sufficient power to power Display 2 and, in addition, to provide up to 60W PD Power upstream.

Table B-2 External power is supplied upstream

Step	Tablet	Display 1	Display 2	Device Policy Manager	Power (W)
Display 1 - Dead Battery					
1	Detached	Detached	Connected to the wall supply.		0

Step	Tablet	Display 1	Display 2	Device Policy Manager	Power (W)
2		Attached to Display 2	Display 1 Attached		0
3		USB Type-C Power drawn 5V@1.5A	USB Type-C Power advertised 5V@1.5A		0
4		Attached to Display 2, drawing 5V@1.5A (7.5W)	Providing 1 unit load to Display 1.		7.5
5		Source Capabilities received	Display2 sends out a set of capabilities including: 5V@3A (15W), 9V@3A (27W), 15V@3A (45W) and 20V@3A (60W). The Unconstrained Power and USB suspend bits are set.	Based on the capabilities of the wall supply and its own needs Display 2 calculates what it can offer upstream.	7.5
6		Display 1 requests 15V@2A (30W) from Display 2.	Request received	Display 1 knows it needs 30W to operate so it requests this amount.	7.5
7		Accept received	Sends Accept	Display 2 accepts the offer since it is within its capabilities.	7.5
8		PS_RDY received. Display 1 starts drawing power and turns on.	Sends PS_RDY	Display 2 indicates its power supply is ready to offer the power.	30
Tablet – Power Role Swap					
9	Tablet is Attached to Display 1.	Attached, V_{BUS} powered.			30
10	Tablet sends out a set of capabilities including: 5V@0.5A (2.5W). The Unconstrained Power bit cleared and USB suspend bit set.	Capabilities received			30

Step	Tablet	Display 1	Display 2	Device Policy Manager	Power (W)
11	Request received	Display 1 requests 5V@0A from the Tablet. The Unconstrained Power and Dual-Role Power bits are set.		Display 1 has external power providing everything it needs so it does not request any more.	30
12	Sends Accept	Accept received.		No power has been requested from the Tablet so the tablet has no reason to Reject this.	30
13	Sends PS_RDY	PS_RDY received.		Table completes the Explicit Contract by sending PS_RDY.	30
14	Get Sink Capabilities received.	Sends Get Sink Capabilities		Display 1 has access to an external supply so it needs to check whether the Tablet upstream, which has no external supply, could use some power. Display 1 also knows that there is excess capacity, based on the last capabilities it received, which it is not currently using from Display 2.	30
15	The Tablet returns Sink Capabilities indicating that it is a Dual-Role and that it can use 5V@0.2A (1W) as a Sink.	Sink Capabilities received			30
16		Display 1 requests 15V@2.1A (31.5W) from Display 2.	Request received		30
17		Accept received	Sends Accept	Request is within the available power so Display 2 sends an accept.	30

Step	Tablet	Display 1	Display 2	Device Policy Manager	Power (W)
18		PS_RDY received	Sends PS_RDY	Display 2 indicates that the power supply is ready to supply the power.	31.5
19	PR_Swap received	Requests PR_Swap from Tablet.		Display 1 now offers to provide power to the Tablet by initiating a Power Role Swap.	31.5
20	Accept sent. Tablet turns off its V_{BUS} supply.	Accept received.		Tablet is happy to accept a Power Role Swap from any device offering it power.	31.5
21	Send PS_RDY	PS_RDY received. Display 1 turns on its V_{BUS} supply		Tablet indicates that its supply has been turned off.	31.5
22	PS_RDY received.	PS_RDY sent.		Display 1 indicates that its power supply is ready so the Tablet starts drawing power.	31.5
23	Source Capabilities received	Display 1 sends out a set of capabilities to the Tablet including: 5V@0.48A (2.4W), 12V@0.2A (2.4W) and 20V@0.12 (2.4W). The Unconstrained Power and USB suspend bits are set.			31.5
24	The Tablet requests 12V@0.2A.	Request received.		Tablet can now request the power it needs.	31.5
25	Accept received	Accept sent		Power is within the capabilities of Display 1 so it accepts the request.	31.5
26	PS_RDY received. The Tablet starts drawing 12V@0.2A.	PS_RDY sent		Display 1 indicates that its power supply is ready so the tablet starts drawing the power.	31.5

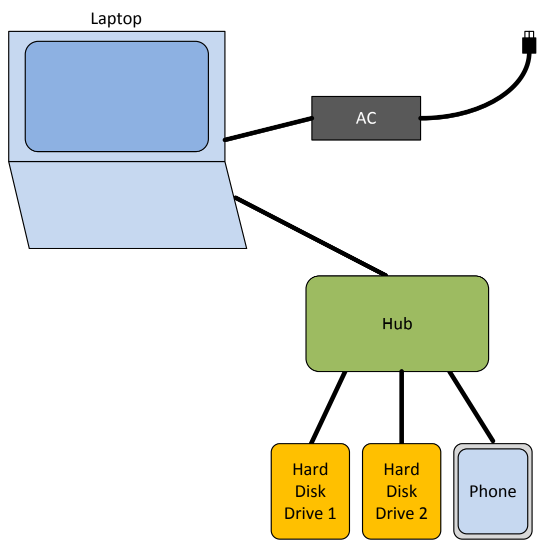
Step	Tablet	Display 1	Display 2	Device Policy Manager	Power (W)
Tablet – Charge					
27	Tablet requests 12V@0.2A (2.4W) from Display 1. The Tablet needs to charge and so sets the Capability Mismatch bit and the No USB Suspend bit.	Request received.		Tablet needs to charge but the power offered is not sufficient. Since Display 1 claims to have an external supply the Tablet will try to get more power using the Capability Mismatch Flag.	31.5
28	Accept received	Accept sent		A ***Valid*** request has been made so Display 1 accepts the request.	31.5
29	PS_RDY received	PS_RDY received		Tablet indicates a capability mismatch to the user.	31.5
30	Get Sink Capabilities received.	Get Sink Capabilities sent		Due to the Capability Mismatch Flag Display 1 requests Sink Capabilities from the Tablet?	31.5
31	The Tablet returns Sink capabilities containing: 5V@2.4A (12W). The Unconstrained Power bit is cleared.	Sink Capabilities received			31.5

Step	Tablet	Display 1	Display 2	Device Policy Manager	Power (W)
32		Display 1 requests 15V@2.8A (42W) from Display 2. The No Suspend Bit is set to reflect the request from the Tablet.	Request received	Since the Tablet requires an additional 12W of power, and Display 1 knows that this is available from Display 2 based on the last Capabilities received so it requests it. In addition the Request from the Tablet indicated that it wanted No Suspend so this is reflected upwards.	31.5
33		Accept received	Sends Accept	Display 2 has 42W available and so accepts the request.	42
34		PS_RDY received	Sends PS_RDY	Display 2 completes the Explicit Contract but at this point has not accepted that power can be drawn during suspend.	42
35		Source Capabilities received	Display2 sends out a new set of capabilities including: 5V@3A (15W), 9V@3A (27W), 15V@3A (45W) and 20V@3A (60W). The Unconstrained Power and USB suspend bits is now set to zero.	Based on the capabilities of the wall supply and its own needs Display 2 calculates what it can offer upstream. It decides that it can continue to supply the power even during USB suspend and so resets the USB suspend bit.	42

Step	Tablet	Display 1	Display 2	Device Policy Manager	Power (W)
36		Display 1 requests 15V@2.8A (42W) from Display 2. The No Suspend Bit is set to reflect the request from the Tablet.	Request received	Display 1 repeats its request since a new set of Capabilities have been sent out.	42
37		Accept received	Sends Accept	Display 2 has 42W available, even during suspend, and so accepts the request.	42
38		PS_RDY received	Sends PS_RDY	Display 2 completes the Explicit Contract.	42
39	Capabilities received	Display 1 sends out a set of capabilities to the Tablet including: 5V@2.4A (12W). The Unconstrained Power bit is set and USB suspend bit is cleared.		Display 1 now has the additional power available and so offers this to the Tablet.	42
40	Tablet requests 5V@2.4A (12W) from Display 1.	Request received.		Tablet is being offered the power it needs to charge and so the Tablet requests this from Display 1.	42
41	Accept received	Sends Accept		Request is within the available Display 1's available power and so it accepts the request.	42
42	PS_RDY received. Tablet starts drawing 5V@2.4A (12W) Display 1 and starts to charge.	Sends PS_RDY		Display 1 indicates its supply is ready to supply power.	42

B.3 Giving back power

Figure B-3 Giving Back Power



Configuration:

1. Laptop with an AC supply. AC supply provides sufficient power to charge the laptop and, in addition, to provide up to 60W PD Power downstream.
2. A Hub with 4 downstream ports which initially provides 1 unit load (150mA) per Port plus 1 unit load for its internal functions.
3. Two Hard Disk Drives both of which require 5V@2A (10W) to spin up and 5V@1A (5W) while being accessed.
4. A phone which uses 5V@2A (10W) to charge and can give back all of this power when requested.

Table B-3 Giving back power

Step	Laptop	Hub	Peripherals	Device Policy Manager	Hub Power (W)
Connect Hub					
1	Connected to wall supply	Detached	Detached		Default
2	Hub is Attached	Attached, V_{BUS} powered			Default

Step	Laptop	Hub	Peripherals	Device Policy Manager	Hub Power (W)
3	Laptop sends out a set of capabilities including: 5V@3A (15W), 12V@3A (36W), and 20V@3A (60W). The Unconstrained Power and USB suspend bits are set.	Source Capabilities received		Laptop sends out details of all available power via external supply	Default
4	The Hub requests 5V@0.15A. This is the power for the Hubs internal operation.	Request received		Hub needs 1 unit load for its own operation and so requests this amount.	Default
5	Send Accept	Accept received		Laptop evaluates request and it is within its available power.	0.75
6	Send PS_RDY	PS_RDY received. Starts to draw 5V@0.15A		Laptop indicates that its power supply is ready.	0.75
Connect Hard Disk Drive 1					
7		Attached detected.	Hard Disk Drive 1 is Attached to one of the downstream ports of the Hub.		0.75
8	Request received	The Hub requests 5V@0.3A (1.5W) from the Laptop.		Hub needs 0.75W for its own operation plus 0.75W for USB communication on one Port.	0.75
9	Accept sent	Accept received		Request is within available power so the laptop accepts.	1.5
10	PS_RDY sent	PS_RDY received		Laptop indicates that its power supply is ready	1.5

Step	Laptop	Hub	Peripherals	Device Policy Manager	Hub Power (W)
11		Hub turns on V_{BUS} and sends out a set of capabilities to Hard Disk Drive 1 including: 5V@0.15A. The Unconstrained Power and USB suspend bits are set.	Source Capabilities received		1.5
12		Request received	Hard Disk Drive 1 requests 5V@0.15A from the Hub.	Hard Disk Drive 1 only needs one unit load when not operating so requests this.	1.5
13		Accept sent	Accept received	Request is within available power so the Hub accepts.	1.5
14		PS_RDY sent	PS_RDY received. The Hard Disk Drive starts drawing 1 unit load 5V@0.15A.	Laptop indicates its power supply is ready and the Hard Disk Drive starts drawing power.	1.5
Hard Disk Drive 1 spin up					
15		Request received	Hard Disk Drive 1 requests 5V@0.15A from the Hub but sets the Capability Mismatch bit.	Hard Disk Drive 1 needs 20V@0.5A to spin up but this is not available so it re-requests the available power flagging a capability mismatch.	1.5
16		Accept sent	Accept received	Request is within available power so the Hub accepts.	1.5
17		PS_RDY sent	PS_RDY received	Hard Disk Drive 1 indicates a capability mismatch to the user.	1.5

Step	Laptop	Hub	Peripherals	Device Policy Manager	Hub Power (W)
18		The Hub requests the Sink Capabilities from Hard Disk Drive 1.	Get Sink Capabilities received	Due to the Capability Mismatch the Hub needs to determine what Hard Disk Drive 1 actually needs	1.5
19		Sink Capabilities received	Hard Disk Drive 1 returns capabilities indicating that it requires 5V@2A.		1.5
20	Request received	The Hub requests 5V@2.2A (11W) from the Laptop.		The Hub evaluates that it now needs 0.75W for the Hub and 10W for Hard Disk Drive 1.	1.5
21	Accept sent	Accept received		Power request from the Hub is within the Laptop's capabilities so the Laptop accepts the request.	11
22	PS_RDY sent	PS_RDY received		Laptop completes the Explicit Contract.	11
23		Hub sends out a set of capabilities to Hard Disk Drive 1 including: 5V@2A. The Unconstrained Power and USB suspend bits are set.	Source Capabilities received	Hub now offers Hard Disk Drive 1 what it needs.	11
24		Request received	Hard Disk Drive 1 requests 5V@2A operating current and indicates 5V@2A maximum current.	Hard Disk Drive 1 is operating at its maximum current to spin up so sets operating current = maximum current.	11
25		Accept sent	Accept received	Request is within the Hubs capabilities so it accepts.	11

Step	Laptop	Hub	Peripherals	Device Policy Manager	Hub Power (W)
26		PS_RDY sent	PS_RDY received. Hard Disk Drive 1 starts to draw 5V@2A and spins up.	Hub indicates its power supply is ready so Hard Disk Drive 1 starts to draw power.	11
27		Request received	Once spun up Hard Disk Drive 1 requests 5V@1A operating current and 5V@2A maximum current.	Hard Disk Drive 1 is operating at a lower current so sets operating current < maximum current.	11
28		Accept sent	Accept received	The Hub will maintain a Power Reserve of 5V@1A (5W) for Hard Disk Drive 1 in addition to the 5V@1A (5W) it is currently using.	11
29		PS_RDY sent	PS_RDY received	Hub completes the Explicit Contract.	11
Hard Disk Drive 2 spin up					
30		Attach detected	Hard Disk Drive 2 is Attached to one of the downstream ports of the Hub.		11
31	Request received	The Hub requests 5V@2.3A (11.5W) from the Laptop.		The Hub needs 0.75W for itself, 0.75W for USB communication on one Port, 5W for Hard Disk Drive 1 operation and 5W for the Power Reserve.	11
32	Accept sent	Accept received		Power request from the Hub is within the Laptop's capabilities so it accepts the request.	11

Step	Laptop	Hub	Peripherals	Device Policy Manager	Hub Power (W)
33	PS_RDY sent	PS_RDY received		Laptop indicates its power supply is ready.	11.5
34		Hub sends out a set of capabilities to Hard Disk Drive 2 including: 5V@0.15A. The Unconstrained Power and USB suspend bits are set.	Source Capabilities received by Hard Disk Drive 2	Hub offers Hard Disk Drive 2 enough power to enumerate.	11.5
35		Request received	Hard Disk Drive 2 requests 5V@0.15A from the Hub.		11.5
36		Accept sent to Hard Disk Drive 2	Accept received by Hard Disk Drive 2	Request is within available capabilities so the Hub accepts	11.5
37		PS_RDY sent to Hard Disk Drive 2.	PS_RDY received. Hard Disk Drive 2 starts drawing 5V@0.15A.	Hard Disk Drive 2 takes the power that it needs	11.5
Phone charge					
38		Attach detected	The phone is Attached to one of the downstream ports of the Hub.		11.5
39	Request received	The Hub Requests 5V@2.5A (12.5W) from the Laptop.		The Hub needs 0.75W for itself, 1.5W for USB communications on two ports (Hard Disk Drive 1 and the Phone), 5W for Hard Disk Drive 1 operation and 5W for the Power Reserve.	11.5

Step	Laptop	Hub	Peripherals	Device Policy Manager	Hub Power (W)
40	Accept sent	Accept received		Request is within available capabilities so the Laptop accepts	12.5
41	PS_RDY sent	PS_RDY received		Laptop indicates that its power supply is ready.	12.5
42		The Hub powers V_{BUS} and sends out a set of capabilities to the Phone including: 5V@0.15A. The Unconstrained Power and USB suspend bits are set.	Source Capabilities received by the Phone	The Hub offers the Phone 1 unit load to enumerate.	12.5
43		Request received from the Phone	The Phone requests 5V@0.15A from the Hub but sets the Capability Mismatch bit.	The Phone would like to charge and so indicates this fact through the Capability Mismatch bit.	12.5
44		Accept sent	Accept received	Request is within available capabilities so the Hub accepts	12.5
45		PS_RDY sent	PS_RDY received	Hub indicates that its power supply is ready	12.5
46		The Hub requests the Sink Capabilities from the phone.	Get Sink Capabilities received by the Phone	Due to the Capability Mismatch the Hub needs to determine what the Phone actually needs	12.5
47		Sink Capabilities received from the Phone	The Phone returns capabilities indicating that it requires 5V@2A.	Phone returns the Capabilities it needs to charge	12.5

Step	Laptop	Hub	Peripherals	Device Policy Manager	Hub Power (W)
48	Request received	The Hub Requests 9V@2.4A (21.6W) from the Laptop.		The Hub needs 0.75W for itself, 0.75W for Hard Disk Drive 2, 10W for the phone, 5W for Hard Disk Drive 1 operation and 5W for the Power Reserve.	12.5
49	Accept sent	Accept received		Request is within available capabilities so the Laptop accepts	12.5
50	PS_RDY sent	PS_RDY received		Laptop indicates that its power supply is ready.	21.6
51		The Hub sends out a set of capabilities to the Phone including: 5V@2A. The Unconstrained Power and USB suspend bits are set.	Source Capabilities received by the Phone	The Hub now has the power that the Phone needs and so sends out a new set of Capabilities.	21.6
52		Request received from the Phone	The Phone requests 5V@2A from the Hub and sets the No USB Suspend bit since it needs to charge constantly. It sets the GiveBack flag and sets the Minimum Operating Current to 5V@0A.	The Phone requests the power it needs to charge. It asks for the USB Suspend requirement to be removed.	21.6
53		Accept sent to the Phone	Accept received by the Phone		21.6
54		PS_RDY sent to the phone.	PS_RDY received by the phone. Phone starts to charge 5V@2A but has to follow USB Suspend rules		21.6

Step	Laptop	Hub	Peripherals	Device Policy Manager	Hub Power (W)
55	Request received	The Hub Requests 9V@1.9A (17.1W) from the Laptop but sets the No USB Suspend bit.		The Hub needs 0.75W for itself, 0.75W for Hard Disk Drive 2, 10W for the phone (includes the Power Reserve of 5W), and 5W for Hard Disk Drive 1 operation. It requests for USB Suspend rule to be removed.	21.6
56	Accept sent	Accept received		Request is within available capabilities so the Laptop accepts. Note that the request for No Suspend has not been acted on by the Laptop. USB Suspend rules apply until the Laptop sends out new Source Capabilities with the USB Suspend bit cleared.	21.6
57	PS_RDY sent	PS_RDY received		Laptop indicates that its power supply is ready.	17.1
Hard Disk Drive 2 spin up					
58		Request received from Hard Disk Drive 2	Hard Disk Drive 2 requests 5V@0.15A from the Hub but sets the Capability Mismatch bit.	Hard Disk Drive 2 needs more power to spin up and so indicates a Capability Mismatch	17.1
59		Accept sent	Accept received	The request is within its capabilities so the Hub accepts.	17.1
60		PS_RDY sent	PS_RDY received	The Hub indicates that its power supply is ready.	17.1

Step	Laptop	Hub	Peripherals	Device Policy Manager	Hub Power (W)
61		The Hub requests the Sink Capabilities from Hard Disk Drive 2.	Get Sink Capabilities received by Hard Disk Drive 2	Due to the Capability Mismatch the Hub has to determine what Hard Disk Drive 2 needs	17.1
62		Sink Capabilities received	Hard Disk Drive 2 returns capabilities indicating that it requires 20V@0.5A maximum current.		17.1
63		The Hub instructs the Phone to Goto Minimum operation.	Goto Min received by the Phone	Hub assess that there is additional power available from the Phone and so tells it to Goto Min. In this case it is reallocating the Phone's Charging power as the Power Reserve for the Hard Disk Drives.	17.1
64			The Phone drops to zero current draw.		17.1
65		PD_RDY sent	PS_RDY received.	Hub indicates that its power supply has changed to the new level.	17.1
66	Request received	The Hub Requests 9V@2.4A (21.6W) from the Laptop		The Hub has an additional 10W from the Phone but needs 5W more to maintain its Power Reserve. The Hub needs 0.75W for itself, 10W for Hard Disk Drive 2, 5W for the Power Reserve, 5W for Hard Disk Drive 1 operation.	17.1

Step	Laptop	Hub	Peripherals	Device Policy Manager	Hub Power (W)
67	Accept sent	Accept received		Request is within available capabilities so the Laptop accepts.	17.1
68	PS_RDY sent	PS_RDY received		Laptop indicates that its power supply is ready.	21.6
69		Hub sends out a set of capabilities to Hard Disk Drive 2 including: 5V@0.5A and 20V@0.5A. The Unconstrained Power and USB suspend bits are set.	Source Capabilities received by Hard Disk Drive 2	The Hub now has the power that Hard Disk Drive 2 needs so it sends out new Capabilities.	21.6
70		Request received from Hard Disk Drive 2	Hard Disk Drive 2 requests 20V@0.5A operating current and 20V@0.5A.	Hard Disk Drive 2 requests what it needs to spin up.	21.6
71		Accept sent to Hard Disk Drive 2	Accept received by Hard Disk Drive 2	The Hub assesses that the request is within its Capabilities so it accepts.	21.6
72		PS_RDY sent.	PS_RDY sent. Hard Disk Drive 2 starts to draw 20V@0.5A and spins up.		21.6
73		Request received from Hard Disk Drive 2	Once spun up Hard Disk Drive 2 requests 20V@0.25A operating current and 20V@0.5A maximum current.	Hard Disk Drive 2 no longer needs the additional power so it gives back what it does not need.	21.6
74		Accept sent to Hard Disk Drive 2	Accept received by Hard Disk Drive 2	The Hub assesses that the request is within its Capabilities so it accepts.	21.6
75		PS_RDY sent to Hard Disk Drive 2.	PS_RDY received by Hard Disk Drive 2.	The Hub indicates that its power supply is ready.	21.6

Step	Laptop	Hub	Peripherals	Device Policy Manager	Hub Power (W)
76		The Hub sends out a set of capabilities to the Phone including: 5V@2A. The Unconstrained Power bit is set and the USB suspend bit is set.	Source Capabilities received by the Phone	The Hub now has the power available to charge the phone so it sends out new Capabilities	21.6
77		Request received from the Phone	The Phone requests 5V@2A operating current from the Hub and sets the No USB Suspend bit since it needs to charge constantly. It sets the GiveBack flag and sets the Minimum Operating Current to 5V@0A.	The Phone requests the power it needs to charge. It asks for the USB Suspend requirement to be removed.	21.6
78		Accept sent to the Phone	Accept received by the Phone	The Hub assesses that the request is within its Capabilities so it accepts but maintains USB Suspend rules.	21.6
79		PS_RDY sent to the Phone.	PS_RDY received by the Phone. The phone starts to draw 5V@2A but has to follow USB Suspend.	The Hub has allocated 0.75W for itself, 5W for Hard Disk Drive 2, 10W for the Phone (including 5W for the Power Reserve), and 5W for Hard Disk Drive 1 operation.	21.6

C. VDM Command Examples

C.1 Discover Identity Example

C.1.1 Discover Identity Command request

Table C-1 below shows the contents of the key fields in the Message Header and VDM header for an Initiator sending a ***Discover Identity*** Command request.

Table C-1 Discover Identity Command request from Initiator Example

Bit(s)	Field	Value
Message Header		
15	***Reserved***	0
14…12	***Number of Data Objects***	1 (VDM Header)
11…9	***MessageID***	0…7
8	***Port Power Role***	0 or 1
7…6	***Specification Revision***	10b (Revision 3.0)
5…4	***Reserved***	0
3…0	***Message Type***	1111b (Vendor Defined Message)
VDM Header		
B31…16	Standard or Vendor ID (SVID)	0xFF00 (***PD SID***)
B15	VDM Type	1 (Structured VDM)
B14…13	Structured VDM Version	01b (Version 2.0)
B12…11	***Reserved***	00b
B10…8	Object Position	000b
B7…6	Command Type	00b (Initiator)
B5	***Reserved***	0
B4…0	Command[1]	1 (***Discover Identity***)

C.1.2 Discover Identity Command response – Active Cable

Table C-2 shows the contents of the key fields in the Message Header and VDM header for a Responder returning VDOs in response to a ***Discover SVIDs*** Command request. In this illustration, the responder is an active Gen2 cable which supports Modal Operation.

Table C-2 Discover Identity Command response from Active Cable Responder Example

Bit(s)	Field	Value
Message Header		
15	***Reserved***	0
14…12	***Number of Data Objects***	5 (VDM Header + ID Header VDO + Cert Stat VDO + Product VDO + Cable VDO)
11…9	***MessageID***	0…7
8	***Cable Plug***	1
7…6	***Specification Revision***	10b (Revision 3.0)
5…4	***Reserved***	0
3…0	***Message Type***	1111b (Vendor Defined Message)

Bit(s)	Field	Value
VDM Header		
B31…16	Standard or Vendor ID (SVID)	0xFF00 (***PD SID***)
B15	VDM Type	1 (Structured VDM)
B14…13	Structured VDM Version	01b (Version 2.0)
B12…11	***Reserved***	00b
B10…8	Object Position	000b
B7…6	Command Type	01b (Responder ACK)
B5	***Reserved***	0
B4…0	Command	2 (***Discover Identity***)
ID Header VDO		
B31	Data Capable as USB Host	0 (not data capable as a Host)
B30	Data Capable as a USB Device	0 (not data capable as a Device)
B29…27	Product Type	100b (Active Cable)
B26	Modal Operation Supported	1 (supports Modes)
B25…16	***Reserved***. ***Shall*** be set to zero.	0
B15…0	16-bit unsigned integer. USB Vendor ID	USB-IF assigned VID for this cable vendor
Cert Stat VDO		
B31…0	32-bit unsigned integer	USB-IF assigned XID for this cable
Product VDO		
B31…16	16-bit unsigned integer. USB Product ID	Product ID assigned by the cable vendor
B15…0	16-bit unsigned integer. bcdDevice	Device version assigned by the cable vendor
Cable VDO (returned for Product Type "Active Cable")		
B31…28	HW Version	Cable HW version number (vendor defined)
B27…24	Firmware Version	Cable FW version number (vendor defined)
B23…21	VDO Version	00b (Version 1.0)
B20	***Reserved***	0
B19…18	USB Type-C plug to USB Type-C/Captive	10b (USB Type-C)
B17	***Reserved***	0
B16…13	Cable Latency	0001b (<10ns (~1m))
B12…11	Cable Termination Type	11b (Both ends Active, VCONN required)
B10…9	Maximum V_{BUS} Voltage	00b (20V)
B8…7	***Reserved***	0
B6…5	V_{BUS} Current Handling Capability	01b (3A)
B4	V_{BUS} through cable	1 (Yes)
B3	SOP" controller present?	1 (SOP" controller present)
B2…0	USB SuperSpeed Signaling Support	010b (***[USB 3.1]*** Gen1 and Gen2)

C.1.3 Discover Identity Command response – Hub

Table C-2 shows the contents of the key fields in the Message Header and VDM header for a Responder returning VDOs in response to a ***Discover SVIDs*** Command request. In this illustration, the responder is a Hub

Table C-3 Discover Identity Command response from Hub Responder Example

Bit(s)	Field	Value
Message Header		
15	***Reserved***	0
14…12	***Number of Data Objects***	4 (VDM Header + ID Header VDO + Cert Stat VDO + Product VDO)
11…9	***MessageID***	0…7
8	***Port Power Role***	0 or 1
7…6	***Specification Revision***	10b (Revision 3.0)
5…4	***Reserved***	0
3…0	***Message Type***	1111b (Vendor Defined Message)
VDM Header		
B31…16	Standard or Vendor ID (SVID)	0xFF00 (***PD SID***)
B15	VDM Type	1 (Structured VDM)
B14…13	Structured VDM Version	01b (Version 2.0)
B12…11	***Reserved***	00b
B10…8	Object Position	000b
B7…6	Command Type	01b (Responder ACK)
B5	***Reserved***	0
B4…0	Command	2 (***Discover Identity***)
ID Header VDO		
B31	Data Capable as USB Host	0 (not data capable as a Host)
B30	Data Capable as a USB Device	1 (data capable as a Device)
B29…27	Product Type	001b (Hub)
B26	Modal Operation Supported	0 (doesn't support Modes)
B25…16	***Reserved***. ***Shall*** be set to zero.	0
B15…0	16-bit unsigned integer. USB Vendor ID	USB-IF assigned VID for this hub vendor
Cert Stat VDO		
B31…0	32-bit unsigned integer	USB-IF assigned XID for this hub
Product VDO		
B31…16	16-bit unsigned integer. USB Product ID	Product ID assigned by the hub vendor
B15…0	16-bit unsigned integer. bcdDevice	Device version assigned by the hub vendor

C.2 Discover SVIDs Example

C.2.1 Discover SVIDs Command request

Table C-4 below shows the contents of the key fields in the Message Header and VDM header for an Initiator sending a ***Discover SVIDs*** Command request.

Table C-4 Discover SVIDs Command request from Initiator Example

Bit(s)	Field	Value
Message Header		
15	***Reserved***	0
14…12	***Number of Data Objects***	1 (VDM Header)
11…9	***MessageID***	0…7
8	***Port Power Role***	0 or 1
7…6	***Specification Revision***	10b (Revision 3.0)
5…4	***Reserved***	0
3…0	***Message Type***	1111b (Vendor Defined Message)
VDM Header		
B31…16	Standard or Vendor ID (SVID)	0xFF00 (***PD SID***)
B15	VDM Type	1 (Structured VDM)
B14…13	Structured VDM Version	01b (Version 2.0)
B12…11	***Reserved***	00b
B10…8	Object Position	000b
B7…6	Command Type	00b (Initiator)
B5	***Reserved***	0
B4…0	Command[1]	2 (***Discover SVIDs***)

C.2.1 Discover SVIDs Command response

Table C-5 shows the contents of the key fields in the Message Header and VDM Header for a Responder returning VDOs in response to a ***Discover SVIDs*** Command request. In this illustration, the value 3 in the Message Header indicates that one VDO containing the supported SVIDs would be returned followed by a terminating VDO. Note that the last VDO returned (the terminator of the transmission) contains zero value SVIDs. If a SVID value is zero, it is not used.

Table C-5 Discover SVIDs Command response from Responder Example

Bit(s)	Field	Value
Message Header		
15	***Reserved***	0
14…12	***Number of Data Objects***	3 (VDM Header + 2*VDO)
11…9	***MessageID***	0…7
8	***Port Power Role***	0 or 1
7…6	***Specification Revision***	10b (Revision 3.0)
5…4	***Reserved***	0
3…0	***Message Type***	1111b (Vendor Defined Message)
VDM Header		
B31…16	Standard or Vendor ID (SVID)	0xFF00 (***PD SID***)
B15	VDM Type	1 (Structured VDM)

Bit(s)	Field	Value
B14…13	Structured VDM Version	01b (Version 2.0)
B12…11	***Reserved***	00b (***Reserved***)
B10…8	Object Position	000b
B7…6	Command Type	01b (Responder ACK)
B5	***Reserved***	0
B4…0	Command	2 (***Discover SVIDs***)
VDO 1		
B31…16	SVID 0	SVID value
B15…0	SVID 1	SVID value
VDO 2		
B31…16	SVID 2	0x0000
B15…0	SVID 3	0x0000

C.3 Discover Modes Example

C.3.1 Discover Modes Command request

Table C-6 shows the contents of the key fields in the Message Header and VDM header for an Initiator sending a ***Discover Modes*** Command request. The Initiator of the ***Discover Modes*** Command sequence sends a Message Header with the ***Number of Data Objects*** field set to 1 followed by a VDM Header with the Command Type (B7…6) set to zero indicating the Command is from an Initiator and the Command (B4…0) is set to 3 indicating Mode discovery.

Table C-6 Discover Modes Command request from Initiator Example

Bit(s)	Field	Value
Message Header		
15	***Reserved***	0
14…12	***Number of Data Objects***	1 (VDM Header)
11…9	***MessageID***	0…7
8	***Port Power Role***	0 or 1
7…6	***Specification Revision***	10b (Revision 3.0)
5…4	***Reserved***	0
3…0	***Message Type***	1111b (Vendor Defined Message)
VDM Header		
B31…16	Standard or Vendor ID (SVID)	SVID for which Modes are being requested
B15	VDM Type	1 (Structured VDM)
B14…13	Structured VDM Version	01b (Version 2.0)
B12…11	***Reserved***	00b
B10…8	Object Position	000b
B7…6	Command Type	00b (Initiator)
B5	***Reserved***	0
B4…0	Command[1]	3 (***Discover Modes***)

C.3.2 Discover Modes Command response

The Responder to the ***Discover Modes*** Command request returns a Message Header with the ***Number of Data Objects*** field set to a value of 1 to 7 (the actual value is the number of Mode objects plus one) followed by a VDM Header with the Message Source (B5) set to 1 indicating the Command is from a Responder and the Command (B4…0) set to 2 indicating the following objects describe the Modes the device supports. If the ID is a VID, the structure and content of the VDO is left to the vendor. If the ID is a SID, the structure and content of the VDO is defined by the Standard.

Table C-7 shows the contents of the key fields in the Message Header and VDM Header for a Responder returning VDOs in response to a ***Discover Modes*** Command request. In this illustration, the value 2 in the Message Header indicates that the device is returning one VDO describing the Mode it supports. It is possible for a Responder to report up to six different Modes.

Table C-7 Discover Modes Command response from Responder Example

Bit(s)	Field	Value
Message Header		
15	***Reserved***	0
14…12	***Number of Data Objects***	2 (VDM Header + 1 Mode VDO)
11…9	***MessageID***	0…7
8	***Port Power Role***	0 or 1

Bit(s)	Field	Value
7…6	***Specification Revision***	10b (Revision 3.0)
5…4	***Reserved***	0
3…0	Message Type	1111b (Vendor Defined Message)
VDM Header		
B31…16	Standard or Vendor ID (SVID)	SVID for which Modes were requested
B15	VDM Type	1 (Structured VDM)
B14…13	Structured VDM Version	01b (Version 2.0)
B12…11	***Reserved***	00b
B10…8	Object Position	000b
B7…6	Command Type	01b (Responder ACK)
B5	***Reserved***	0
B4…0	Command	3 (***Discover Modes***)
Mode VDO		
B31…0	Mode 1	Standard or Vendor defined Mode value

C.4 Enter Mode Example

C.4.1 Enter Mode Command request

The Initiator of the ***Enter Mode*** Command request sends a Message Header with the ***Number of Data Objects*** field set to 1 followed by a VDM Header with the Message Source (B5) set to zero indicating the Command is from an Initiator and the Command (B4…0) set to 4 to request the Responder to enter its mode of operation and sets the Object Position field to the desired functional VDO based on its offset as received during Discovery.

Table C-8 shows the contents of the key fields in the Message Header and VDM Header for an Initiator sending an ***Enter Mode*** Command request.

Table C-8 Enter Mode Command request from Initiator Example

Bit(s)	Field	Value
Message Header		
15	***Reserved***	0
14…12	***Number of Data Objects***	1 (VDM Header)
11…9	***MessageID***	0…7
8	***Port Power Role***	0 or 1
7…6	***Specification Revision***	10b (Revision 3.0)
5…4	***Reserved***	0
3…0	***Message Type***	1111b (Vendor Defined Message)
VDM Header		
B31…16	Standard or Vendor ID (SVID)	SVID for the Mode being entered
B15	VDM Type	1 (Structured VDM)
B14…13	Structured VDM Version	01b (Version 2.0)
B12…11	***Reserved***	00b
B10…8	Object Position	001b (a one in this field indicates a request to enter the first Mode in list returned by Discover Modes)
B7…6	Command Type	00b (Initiator)
B5	***Reserved***	0
B4…0	Command	4 (***Enter Mode***)

C.4.2 Enter Mode Command response

The Responder that is the target of the ***Enter Mode*** Command request sends a Message Header with the ***Number of Data Objects*** field set to a value of 1 followed by a VDM Header with the Command Source (B5) set to 1 indicating the response is from a Responder and the Command (B4…0) set to 4 indicating the Responder has entered the Mode and is ready to operate.

Table C-9 shows the contents of the key fields in the Message Header and VDM Header for a Responder sending an ***Enter Mode*** Command response with an ACK.

Table C-9 Enter Mode Command response from Responder Example

Bit(s)	Field	Value
Message Header		
15	***Reserved***	0
14…12	***Number of Data Objects***	1 (VDM Header)
11…9	***MessageID***	0…7
8	***Port Power Role***	0 or 1

Bit(s)	Field	Value
7…6	***Specification Revision***	10b (Revision 3.0)
5…4	***Reserved***	0
3…0	***Message Type***	1111b (Vendor Defined Message)
VDM Header		
B31…16	Standard or Vendor ID (SVID)	SVID for the Mode entered
B15	VDM Type	1 (Structured VDM)
B14…13	Structured VDM Version	01b (Version 2.0)
B12…11	***Reserved***	00b
B10…8	Object Position	001b (offset of the Mode entered)
B7…6	Command Type	01b (Responder ACK)
B5	***Reserved***	0
B4…0	Command	4 (***Enter Mode***)

C.4.1 Enter Mode Command request with additional VDO

The Initiator of the ***Enter Mode*** Command request sends a Message Header with the ***Number of Data Objects*** field set to 2 indicating an additional VDO followed by a VDM Header with the Message Source (B5) set to zero indicating the Command is from an Initiator and the Command (B4…0) set to 4 to request the Responder to enter its mode of operation and sets the Object Position field to the desired functional VDO based on its offset as received during Discovery.

Table C-8 shows the contents of the key fields in the Message Header and VDM Header for an Initiator sending an ***Enter Mode*** Command request with an additional VDO.

Table C-10 Enter Mode Command request from Initiator Example

Bit(s)	Field	Value
Message Header		
15	***Reserved***	0
14…12	***Number of Data Objects***	1 (VDM Header)
11…9	***MessageID***	0…7
8	***Port Power Role***	0 or 1
7…6	***Specification Revision***	10b (Revision 3.0)
5…4	***Reserved***	0
3…0	***Message Type***	1111b (Vendor Defined Message)
VDM Header		
B31…16	Standard or Vendor ID (SVID)	SVID for the Mode being entered
B15	VDM Type	1 (Structured VDM)
B14…13	Structured VDM Version	01b (Version 2.0)
B12…11	***Reserved***	00b
B10…8	Object Position	001b (a one in this field indicates a request to enter the first Mode in list returned by Discover Modes)
B7…6	Command Type	00b (Initiator)
B5	***Reserved***	0
B4…0	Command	4 (***Enter Mode***)
Including *Optional* Mode specific VDO		
B31…0	Mode specific	

C.5 Exit Mode Example

C.5.1 Exit Mode Command request

The Initiator of the ***Exit Mode*** Command request sends a Message Header with the ***Number of Data Objects*** field set to 1 followed by a VDM Header with the Message Source (B5) set to zero indicating the Command is from an Initiator and the Command (B4…0) set to 5 to request the Responder to exit its Mode of operation.

Table C-11 shows the contents of the key fields in the Message Header and VDM header for an Initiator sending an ***Exit Mode*** Command request.

Table C-11 Exit Mode Command request from Initiator Example

Bit(s)	Field	Value
Message Header		
15	***Reserved***	0
14…12	***Number of Data Objects***	1 (VDM Header)
11…9	***MessageID***	0…7
8	***Port Power Role***	0 or 1
7…6	***Specification Revision***	10b (Revision 3.0)
5…4	***Reserved***	0
3…0	***Message Type***	1111b (Vendor Defined Message)
VDM Header		
B31…16	Standard or Vendor ID (SVID)	SVID for the Mode being exited
B15	VDM Type	1 (Structured VDM)
B14…13	Structured VDM Version	01b (Version 2.0)
B12…11	***Reserved***	00b
B10…8	Object Position	001b (identifies the previously entered Mode by its Object Position that is to be exited)
B7…6	Command Type	00b (Initiator)
B5	***Reserved***	0
B4…0	Command	5 (***Exit Mode***)

C.5.2 Exit Mode Command response

The Responder that receives the ***Exit Mode*** Command request sends a Message Header with the ***Number of Data Objects*** field set to a value of 1 followed by a VDM Header with the Message Source (B5) set to 1 indicating the Command is from a Responder and the Command (B4…0) set to 5 indicating the Responder has exited the Mode and has returned to normal USB operation.

Table C-12 shows the contents of the key fields in the Message Header and VDM header for a Responder sending an ***Exit Mode*** Command ACK response.

Table C-12 Exit Mode Command response from Responder Example

Bit(s)	Field	Value
Message Header		
15	***Reserved***	0
14…12	***Number of Data Objects***	1 (VDM Header)
11…9	***MessageID***	0…7
8	***Port Power Role***	0 or 1

Bit(s)	Field	Value
7…6	***Specification Revision***	10b (Revision 3.0)
5…4	***Reserved***	0
3…0	***Message Type***	1111b (Vendor Defined Message)
VDM Header		
B31…16	Standard or Vendor ID (SVID)	SVID for the Mode exited
B15	VDM Type	1 (Structured VDM)
B14…13	Structured VDM Version	01b (Version 2.0)
B12…11	***Reserved***	00b
B10…8	Object Position	001b (offset of the Mode to be exited)
B7…6	Command Type	01b (Responder ACK)
B5	***Reserved***	0
B4…0	Command	5 (***Exit Mode***)

C.6 Attention Example

C.6.1 Attention Command request

The Initiator of the ***Attention*** Command request sends a Message Header with the ***Number of Data Objects*** field set to 1 followed by a VDM Header with the Message Source (B5) set to zero indicating the Command is from an Initiator and the Command (B4…0) set to 6 to request attention from the Responder.

Table C-11 shows the contents of the key fields in the Message Header and VDM header for an Initiator sending an ***Attention*** Command request.

Table C-13 Attention Command request from Initiator Example

Bit(s)	Field	Value
Message Header		
15	***Reserved***	0
14…12	***Number of Data Objects***	1 (VDM Header)
11…9	***MessageID***	0…7
8	***Port Power Role***	0 or 1
7…6	***Specification Revision***	10b (Revision 3.0)
5…4	***Reserved***	0
3…0	***Message Type***	1111b (Vendor Defined Message)
VDM Header		
B31…16	Standard or Vendor ID (SVID)	SVID for which attention is being requested
B15	VDM Type	1 (Structured VDM)
B14…13	Structured VDM Version	01b (Version 2.0)
B12…11	***Reserved***	00b
B10…8	Object Position	001b (offset of the Mode requesting attention)
B7…6	Command Type	000b (Initiator)
B5	***Reserved***	0
B4…0	Command	6 (***Attention***)

C.6.2 Attention Command request with additional VDO

The Initiator of the ***Attention*** Command request sends a Message Header with the ***Number of Data Objects*** field set to 2 indicating an additional VDO followed by a VDM Header with the Message Source (B5) set to zero indicating the Command is from an Initiator and the Command (B4…0) set to 6 to request attention from the Responder.

Table C-11 shows the contents of the key fields in the Message Header and VDM header for an Initiator sending an ***Attention*** Command request with an additional VDO.

Table C-14 Attention Command request from Initiator with additional VDO Example

Bit(s)	Field	Value
Message Header		
15	***Reserved***	0
14…12	***Number of Data Objects***	2 (VDM Header + VDO)
11…9	***MessageID***	0…7
8	***Port Power Role***	0 or 1
7…6	***Specification Revision***	10b (Revision 3.0)
5…4	***Reserved***	0

Bit(s)	Field	Value
3…0	***Message Type***	1111b (Vendor Defined Message)
VDM Header		
B31…16	Standard or Vendor ID (SVID)	SVID for which attention is being requested
B15	VDM Type	1 (Structured VDM)
B14…13	Structured VDM Version	01b (Version 2.0)
B12…11	***Reserved***	00b
B10…8	Object Position	001b (offset of the Mode requesting attention)
B7…6	Command Type	000b (Initiator)
B5	***Reserved***	0
B4…0	Command	6 (***Attention***)
Including *Optional* **Mode specific VDO**		
B31…0	Mode specific	

D. BMC Receiver Design Examples

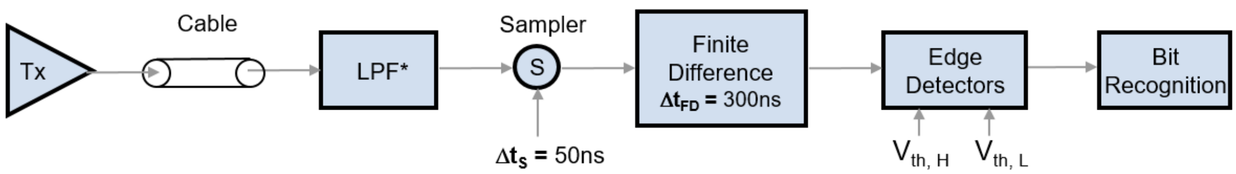
The BMC signal is DC-coupled so that the voltage level is affected by the ground IR drop. The DC offset of the BMC signal at Power Source and Power Sink are in the opposite directions. When the V_{BUS} current is increased from 0A, the BMC signal waveform shifts downward at Power Sink and shifts upward at Power Source. This section introduces two sample BMC receiver circuit implementations, which are immune from DC offset and high current load step. They can be used in Power Source, Power Sink and inside cables.

D.1 Finite Difference Scheme

D.1.1 Sample Circuitry

The sample Finite Difference BMC receiver shown in Figure D-1 consists of the Rx bandwidth limiting filter with the time constant tRxFilter, a sampler with the sampling step Δt_S, 50ns, a Finite Difference Calculator which calculates the voltage difference between the time interval of Δt_{FD}, 300ns, an edge detector controlled by two voltage thresholds, $V_{th,H}$ and $V_{th,L}$ and a logic block for bit recognition.

Figure D-1 Circuit Block of BMC Finite Difference Receiver



D.1.2 Theory

This section describes the fundamental theory of Finite Difference Scheme to recover the received BMC signal with the input and output signal waveforms of the circuit blocks shown in Figure D-1. To illustrate the robustness of the implementation, the V_{BUS} current load step rate is intentionally increased to 2A/µs at the sink load. In Figure D-2(a), the red curve represents the V_{BUS} current measured at the Power Sink when the current is increased at 9 µs from 0A to 5A and the blue dash curve represents the V_{BUS} current measured at the USB Type-C connector of the power sink. In this example, the peak current overshoot with larger load step rate is increased to 518 mA which exceeds iOvershoot. Figure D-2(b) shows the total BMC noise at Power Sink, coupled from V_{BUS} and D+/D- through the worst ***[USB Type-C 1.2]*** compliant cable, after the Rx bandwidth limiting filter with the time constant tRxFilter is applied. The noise can be decomposed into 3 components. The first is the DC offset, $I_{V_{BUS}}(t)*R_{GND}$, while $I_{V_{BUS}}$ is the V_{BUS} current and R_{GND} is the ground DC resistance of the cable. The offset is negative in Power Sink and positive at Power Source. The second noise component is the inductive V_{BUS} noise, M*d $I_{V_{BUS}}(t)$/dt, while M is the mutual inductance between the V_{BUS} and CC wires in the cable and d $I_{V_{BUS}}(t)$/dt is the load step rate. The third component is ***[USB 2.0]*** Full Speed SE0 coupling noise which would normally occur randomly but was assumed to occur periodically in the simulation to account for the crosstalk in any phase between the BMC and ***[USB 2.0]*** signals. In Figure D-3, the blue dash curve represents the BMC signal when there is no V_{BUS} current and the red solid curve represents the BMC signal affected by the V_{BUS} coupling noise shown in Figure D-2(b). The green solid curve is the sample ***[USB 2.0]*** noise, after the Rx bandwidth limiting filter with the time constant tRxFilter is applied.

Figure D-2 BMC AC and DC noise from VBUS at Power Sink

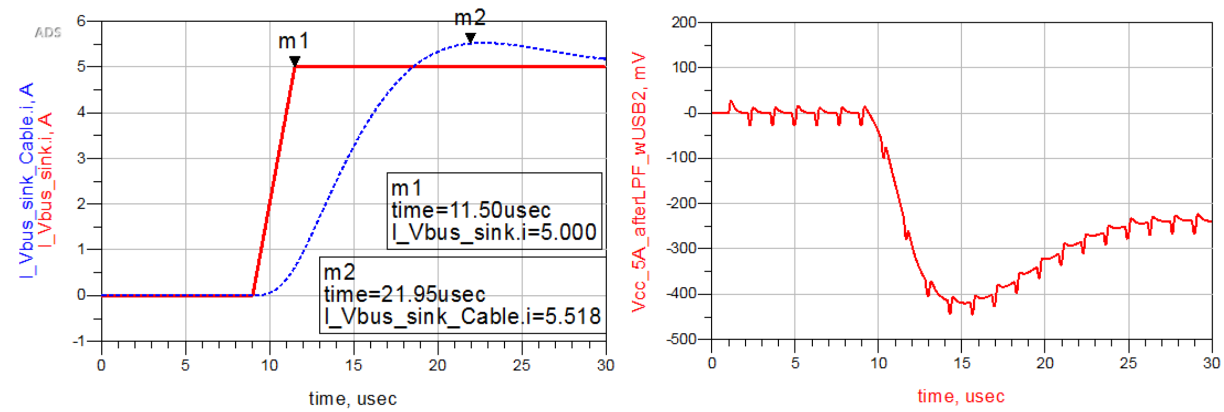
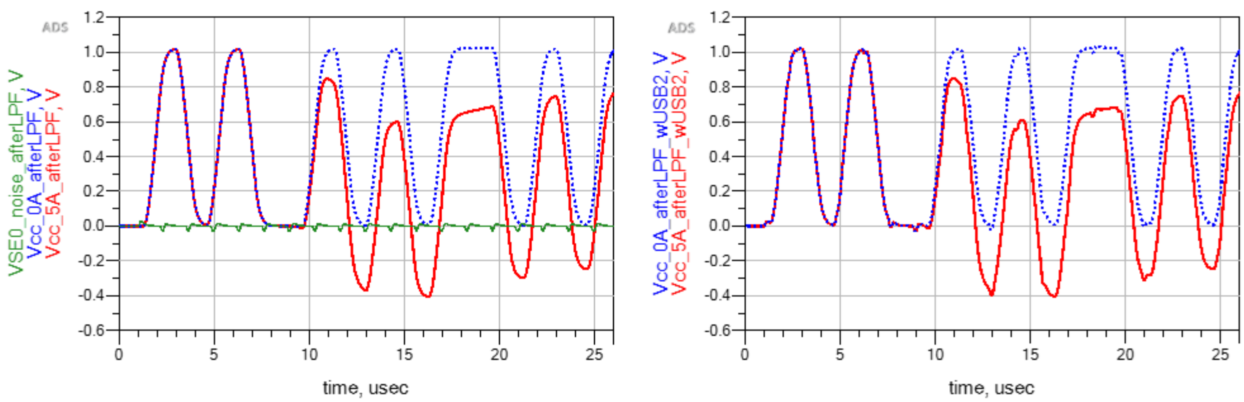


Figure D-3 Sample BMC Signals (a) without *[USB 2.0]* SE0 Noise (b) with *[USB 2.0]* SE0 Noise

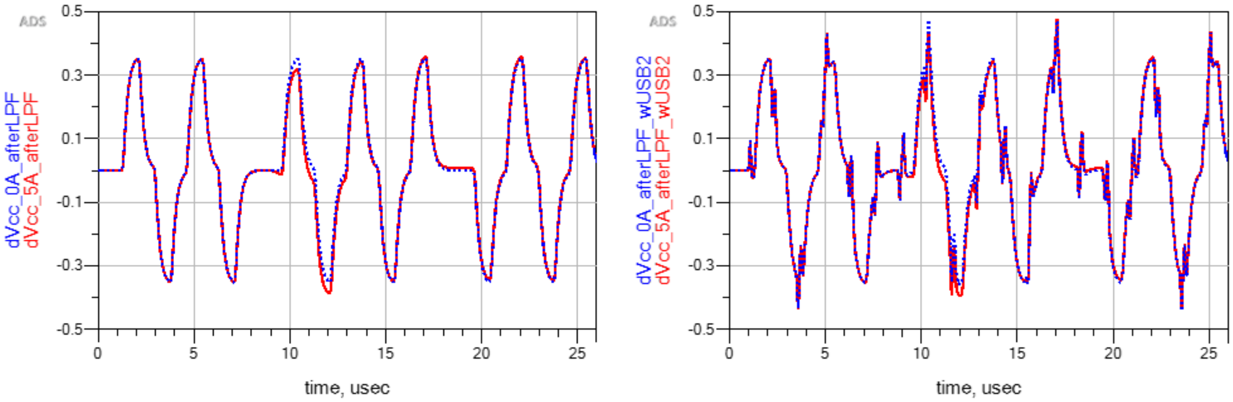


(a) (b)

The BMC signals shown in Figure D-3 are sampled every 50ns and the scaled derivative waveforms, Vcc(t) - Vcc(t - 50ns), without and with ***[USB 2.0]*** noise are shown in Figure D-4(a) and D-4(b), respectively. In Figure D-4(a), if there is no ***[USB 2.0]*** noise, the derivative waveform just changes slightly before and after the V_{BUS} current transition. That means, the slope of the BMC waveform is not sensitive to the DC offset and is very useful to be used to design a robust receiver against a large DC offset. However, the derivative waveforms with ***[USB 2.0]*** noise have large perturbation as shown in Figure D-4(b).

Figure D-4 Scaled BMC Signal Derivative with 50ns Sampling Rate

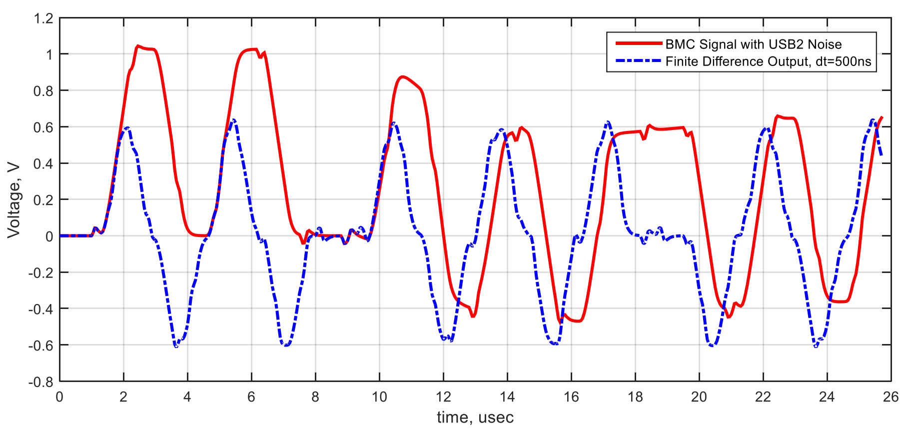
(a) without *[USB 2.0]* Noise (b) with *[USB 2.0]* Noise



(a) (b)

To remove the high frequency content of the ***[USB 2.0]*** noise, Finite Difference technique with the proper time interval is applied to the BMC waveform with ***[USB 2.0]*** noise in Figure D-3(b). Using Backward Finite Difference Calculator, ΔVcc = Vcc (t) - Vcc(t-Δt), Figure D-5 shows the Finite Difference Output while Δt = 500ns. The larger the time interval Δt is, the larger the peak-to-peak magnitude of the Finite Difference Output will be. However, the time interval is bounded by the rise time of the BMC signal so that 300ns to 500ns is a good range of the time interval.

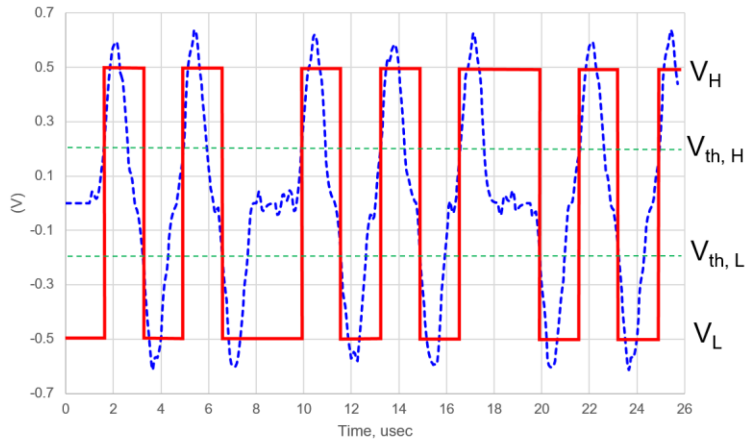
Figure D-5 BMC Signal and Finite Difference Output with Various Time Steps



D.1.3 Data Recovery

The edge detection is followed by the Finite Difference Calculation. At the input of the edge detector, if the voltage is larger than $V_{th,\,H}$ at the rising edge, the output will become high voltage level, V_H, if the voltage is smaller than $V_{th,\,L}$ at the falling edge, the output will become low voltage level, V_L. In this example, $V_{th,\,H}$ and $V_{th,\,L}$ are 0.2V and -0.2V, respectively. The solid curve in Figure D-6 represents the output of the edge detector, where V_H is 0.5V and V_L is -0.5V.

Figure D-6 Output of Finite Difference in dash line and Edge Detector in solid line



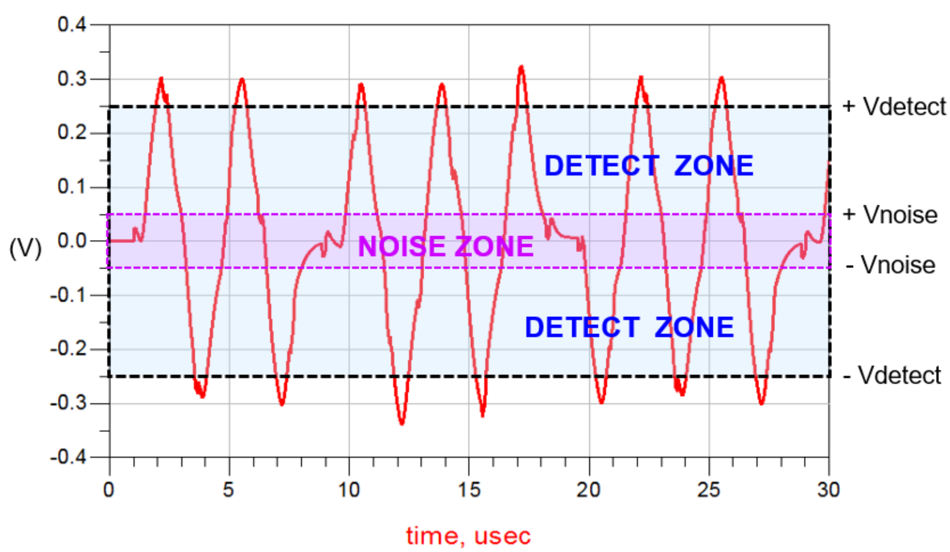
The duty cycle of the output signal from the edge detector varies depending on the thresholds, $V_{th,\,H}$ and $V_{th,\,L}$, as well as jitter and noise from silicon and channel. The techniques such as integrating receiver can be used to recover the BMC signal.

D.1.4 Noise Zone and Detection Zone

Figure D-7 shows the output of Finite Difference when the time interval of Finite Difference is set to 300ns. The noise Zone is defined in between +Vnoise and –Vnoise, in which the noise glitches occur. The detect zone is defined in between +Vdetect and –Vdetect, excluding the noise zone. The thresholds of the edge detectors, $V_{th,\,H}$ and $V_{th,\,L}$, ***Shall*** be properly set within the detect zone so that the data can be recovered successfully.

In this example, Vdetect is 250mV and Vnoise is 50mV. It is highly recommended that the product implemented with the similar techniques indicates the performance with the range of Vnoise and Vdetect in the electrical specification.

Figure D-7 Noise Zone and Detect Zone of BMC Receiver

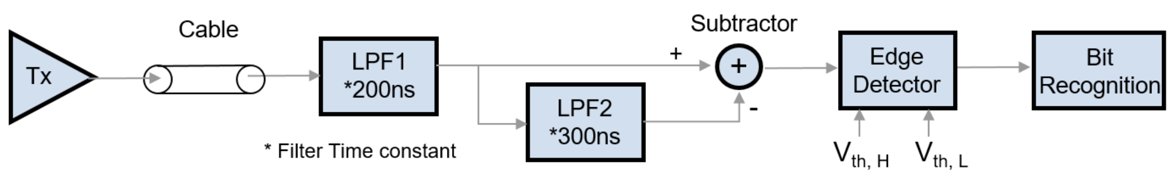


D.2 Subtraction Scheme

D.2.1 Sample Circuitry

The sample Subtraction BMC receiver shown in Figure D-8 consists of the two Low Pass Filters (LPF1 and LPF2), a Subtractor, an Edge Detector and a logic block for bit recognition. The time constant of the first and second LPF are 200ns and 300ns, respectively. The Subtractor subtracts the LPF1 output from the LPF2 output. The Edge Detector controlled by two voltage thresholds, $V_{th, H}$ and $V_{th, L}$ to recover the data.

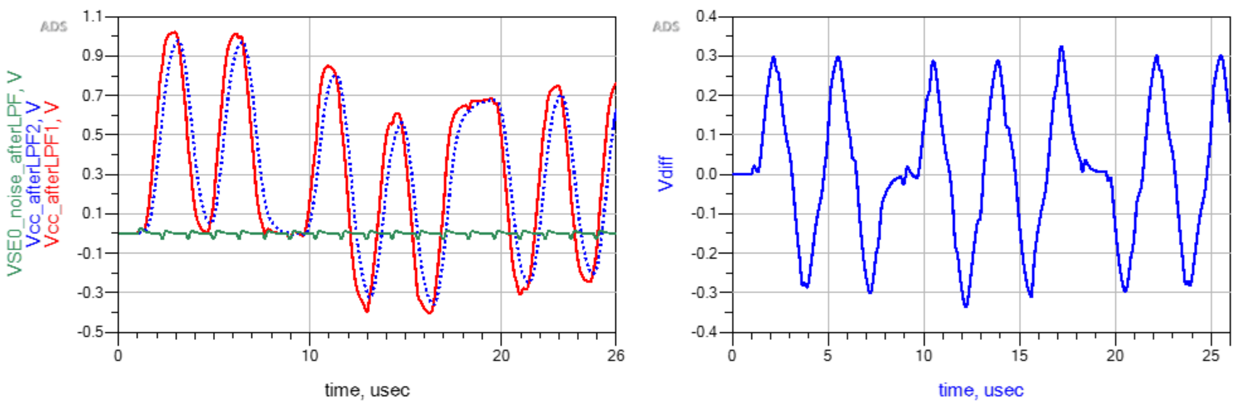
Figure D-8 Circuit Block of BMC Subtraction Receiver



D.2.2 Output of Each Circuit Block

Figure D-9(a) shows the output of LPF1 as the red solid line and LPF2 as the blue dash line as well as the ***[USB 2.0]*** noise in green solid line. Figure D-9(b) shows the voltage difference between the two output filters, Vdiff = Vcc_afterLPF1 – Vcc_afterLPF2. The Vdiff waveform looks very similar to the Finite Difference output waveform shown in Figure D-6 so that the data recovery method through the edge detector is the same as described in Section D.1.3.

Figure D-9 (a) Output of LPF1 and LPF2 (b) Subtraction of LPF1 and LPF2 Output



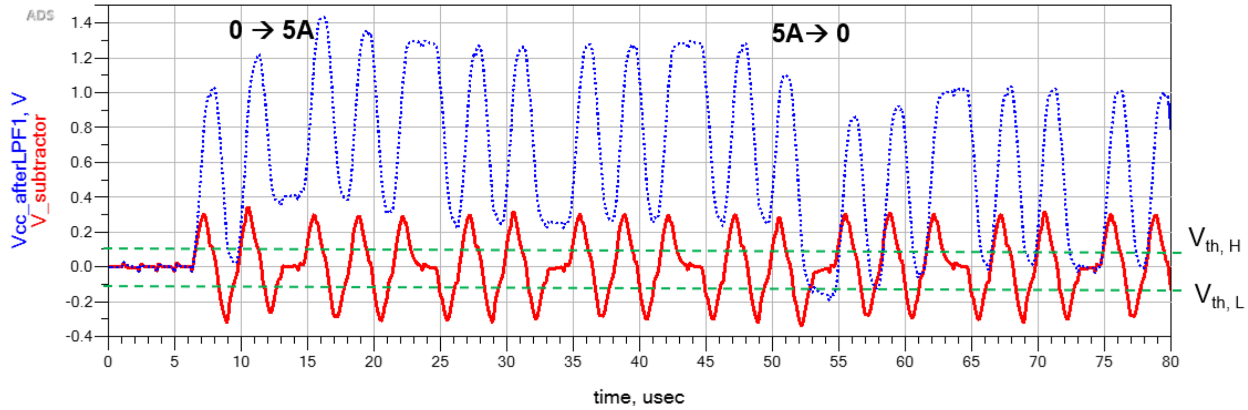
(a) **(b)**

D.2.3 Subtractor Output at Power Source and Power Sink

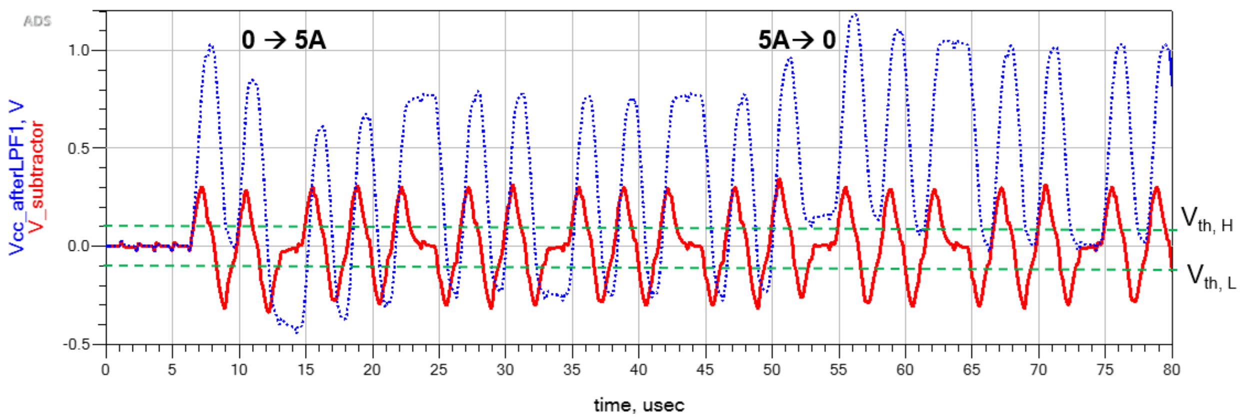
The following figures shows the example when the VBUS current increases from 0A to 5A and then decreases to 0A with high load step rate. The output of the LPF1 and the Subtractor at Power Source and Power Sink are shown in Figure D-10 (a) and (b), respectively. Although the BMC signals at Power Source and Power Sink shift toward the opposite direction, the Subtractor outputs at Power Source and Power Sink are almost identical disregard of the opposite direction of the DC offset.

Figure D-10 Output of the BMC LPF1 in blue dash curve and the Subtractor in red solid curve

(a) at Power Source (b) at Power Sink



(a)



(b)

D.2.4 Noise Zone and Detection Zone

The zone definition is the same as defined in Section D.1.7. The sizes of the noise zone and detection zone of the Subtraction Scheme are dependent on the filter time constant. When the time constant of the first and second LPF are 200ns and 300ns, respectively, Vdetect is 250mV and Vnoise is 50mV. It is highly recommended that the product implemented with the similar techniques indicates the performance with the range of Vnoise and Vdetect in the electrical specification.