PRDMRD2+ Reference Guide

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1 Introduction

The Protagd MRD2+ (PRDMRD2+) dual in-line (DIL) module is a 100% drop-in replacement for the Texas Instruments RI-STU-MRD2 reader module.

It is designed to be pin-compatible, however, the Protagd version of the module supports 6 additional unbuffered 3.3V I/O pins which can be used for controlling multiplexers, collecting data, etc.

In terms of Software functions, the Protagd PRDMRD2+ supports the programming of Protagd ReadWrite transponders through a new transponder type and programming commands.

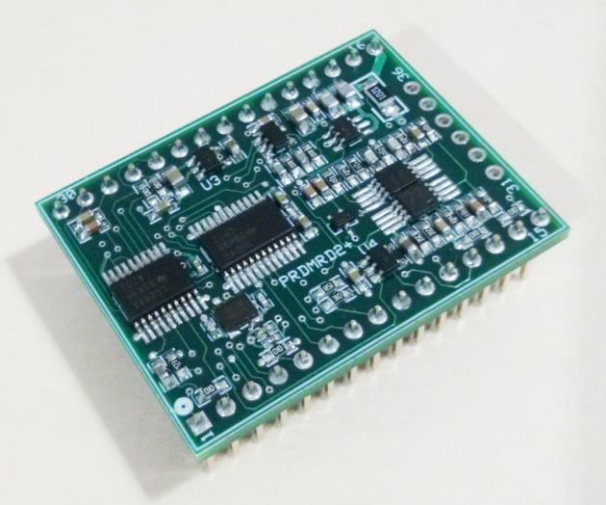

Figure 1 PRDMRD2+ Reader Module

The module communicates with low frequency (LF) half-duplex (HDX) RFID transponders at a downlink frequency of 134.2 kHz using amplitude shift keying (ASK) protocol and uplinks data to the PRDMRD2+ using frequency shift keying (FSK) protocol where 134.2 kHz represents a ZERO and 123.2 kHz represents a ONE.

This document describes the PRDMRD2+ hardware, its hardware application and the additional RW commands compared to the original TI MRD2.

2 Abbreviations

DC	Direct Current
DIL	Dual In-Line
ESD	Electrostatic Discharge
FW	Firmware
I/O	Input/Output
LED	Light Emitting Diode
LF	Low Frequency
MRD	Microreader
OOK	On-Off Keyed
PC	Personal Computer
Q	Quality Factor
RFID	Radio Frequency Identification
RFM	Radio Frequency Module
RO	ReadOnly
RS-232	Computer Serial Interface
RW	ReadWrite
USB	Universal Serial Bus

3 Description

The PRDMRD2+ can act as either a stand-alone reader module, or as a controller for a power reader module such as the PRDRFM007C or PRDRFM008B.

When used as a stand-alone reader, it needs only a power source (5VDC or power from USB), a communications connection (USB or serial), and an antenna.

When used as a controller for a power RFM, the PRDMRD2+ needs an adapter board (Protagd part #: PRDBIF1) which physically mounts the PRDMRD2+ to the RFM, provides 5V power regulation to the PRDMRD2+ while allowing the power RFM to operate at voltages from 7 to 24 VDC. It converts the serial communications of the PRDMRD2+ to RS-232c and presents it at a DB-9F connector. This adapter board also provides a screw-type power connector and a USB-B mini connector.

The antenna which requires the least effort is a 47 µH +/- 0.9 µH air coil, and for best results it should have a quality factor (Q) between 10 and 20. Coils with other inductances can be used by adding series or parallel capacitance.

4 Pin Functions

The DIL module has 30 pins which match the pins of the RI-STU-MRD2 plus 6 additional pins which allow more I/O functionality.

The additional 6 pins DO NOT interfere with the pin-for-pin compatibility to the RI-STU-MRD2. They are 6mA unbuffered 3.3V pins directly from the microcontroller (µC) and care must be taken when connecting to them that they are not forced above VSL or below GND or permanent damage to the µC could occur. These 6 pins have an ESD rating as follows: HBM +/-1000V, and CDM +/-250V.

Pin	Name	Direction	Description
1	SYNC	O	Wired SYNC output. Generally, drives yellow LED.
2	nRDEN	I	Wired SYNC & single read trigger input.
3	no connect	reserved	Reserved for future use. Do not connect.
4	nRESET	I	Holds PRDMRD2+ in reset until released high.
5	RXD	I	Serial com input to PRDMRD2+ from host.
6	TXD	O	Serial com output from MRD2 to host.
7	USBD-	IO	USB low-true bidirectional data signal.
8	USBD+	IO	USB high-true bidirectional data signal.
9	Vcore33	Power	Output from 3.3V core voltage regulator. Do not load.
10	no connect	reserved	Reserved for future use. Do not connect.
11	SIGOUT0	O	GP Output. User programmed.
12	SIGOUT1	O	GP Output, or RFM nTXCT signal.
13	SIGIN0	I	GP Input, or RFM RXDT signal.
14	SIGIN1	I	GP Input, or RFM RXCK signal.
15	GND		Logic reference ground. Connect with other grounds.
16	ANT1	analog	Antenna 1 connection.
17	ANTCAP	analog	Terminal for increasing resonant capacitance.
18	no connect	reserved	Reserved for future use. Do not connect.
19	ANT2	analog	Antenna 2 connection.
20	no connect	reserved	Reserved for future use. Do not connect.
21	GNDP		Power ref ground. Connect with other grounds.
22	VSP	P	+5V power input to antenna driver.
23	USBPUR	O	USB pullup resistor
24	VSL	P	+5V logic power input.
25	GND		Logic reference ground. Connect with other grounds.
26	CRDM	I	Continuous read mode enable when high.
27	WLS	I	Wireless SYNC mode enable when high.
28	USBVBUS	P	+5V power input to USB logic.
29	OKT	O	Indicator of good read. Generally drives green LED.
30	STAT	O	Indicates IDLE mode of transmitter. Drives red LED.
31 - 36	GPIO0 through GPIO5	IO	General purpose input/output signals. SW controlled.

Table 1 Pin Functions

Pins 31 through 36 are PCB holes only. Optionally, a 6-pin male header (Sullins PRPC006SAAN-RC) can be soldered in the board facing downward, or a 6-pin female socket (Sullins PPPC061LFBN-RC) can be soldered in facing upward.

4.1 Functional Description of Module Pins

In the pin descriptions below, the terms ‘high’ and ‘low’ generally refer to the logic levels ‘1’ and ‘0’ and can be interpreted as meaning, ‘connected to VSL’ and ‘connected to GND’, respectively. [ ] indicates module pin number.

[1] – SYNC

Wired synchronization pulse output. Normally low. At the beginning of a read cycle, this pin is driven high for the duration of the read, lock, or program cycle. It is typically

connected to a yellow LED. The LED must have a series current-limiting resistor such as 330 ohms.

This is the wired synchronization output. See the *Wired Synchronization* section for additional details.

[2] – nRDEN

Read Enable, active low. Normally held low (enabled) by a weak pulldown of 100K ohms. When held high, transmission is disabled. nRDEN is sampled at the start of its own read cycle; therefore, toggling this input during an ongoing read, lock, or program cycle will not interrupt the current cycle.

This is the SYNC input pin. Pulsing this pin high for at least 100 µs triggers a read on the falling edge. See the *Wired Synchronization* section for additional details.

[3] – reserved

This pin is internally connected to facilitate production testing. It should not be connected on the user's PCB.

[4] - nRESET

Module reset pin, low true. Normally held high by a 47K ohm pullup resistor. Pulsing this pin low for at least 1 ms initiates a reset. Holding this input low keeps the module in reset until released. The PRDMRD2+ requires up to 132 ms after the rising edge of nRESET before it can begin receiving instructions through one of the communications interfaces.

[5] - RXD

Serial data input, normally held low by a 100K ohm pulldown. By default, the PRDMRD2+ module's UART is configured to 9600 baud, 8 data bits, one stop bit, and no parity bit. It can be configured to other baud rates via software (SW) command.

[6] – TXD

Serial data output. By default, the PRDMRD2+ module's UART is configured to 9600 baud, 8 data bits, one stop bit, and no parity bit. It can be configured to other baud rates via software (SW) command.

[7, 8] – USBD- & USBD+

Bidirectional USB data lines.

[9] – VCCcore33

Microcontroller voltage regulator output. Nominally 3.3 VDC. Do not load this pin or possible damage to the on-board voltage regulator could occur.

[10] - reserved

This pin is internally connected to facilitate production testing. It should not be connected on the user's PCB.

[11] – SIGOUT0

General purpose output pin under SW control which can source and sink up to 15mA. No-load voltage swing is from GND to VSL.

[12] – SIGOUT1

General purpose output pin under SW control which can source and sink up to 15mA. No-load voltage swing is from GND to VSL. This pin can also be used to drive the nTXCT pin on power reader modules such as the remote antenna PRDRFM008B or the local antenna PRDRFM007C.

[13] – SIGIN0

General purpose input pin. Can be driven by signals between GND and VSL. This pin has a 100K ohm pulldown resistor to GND. This pin can also be used to input the RXDT signal on power reader modules such as the remote antenna PRDRFM008B or the local antenna PRDRFM007C.

[14] – SIGIN1

General purpose input pin. Can be driven by signals between GND and VSL. This pin has a 100K ohm pulldown resistor to GND. This pin can also be used to input the RXCK signal on power reader modules such as the remote antenna PRDRFM008B or the local antenna PRDRFM007C.

[15, 25] – GND

These are the ground pins for the PRDMRD2+ logic and receiver sections. They must be tied together on the user's PCB along with the GNDP pin and the board supply ground.

[16] – ANT1

Antenna connection. One of the two 47 uH antenna coil's lead wires connects here. The other antenna lead must be connected to ANT2. ANT1 is also the receiver input signal and should be guarded against excessive noise sources such as lead wires from switching power supplies.

[17] – ANTCAP

Optional antenna capacitor connection pin. If an antenna of lower inductance is connected, then additional capacitance is needed to tune the antenna. The additional capacitance is connected between ANTACP and ANT1.

[18, 20] – reserved

These pins are not internally connected in the current version of the PRDMRD2+ module. They should not be connected on the user's PCB in order to support backward compatibility of future versions of the PRDMRD2+ module.

[19] – ANT2

Antenna connection. Second of the two 47 uH antenna coil's lead wires connects here. The other antenna lead must be connected to ANT1. This pin is at ground level but should not be connected to ground.

[21] – GNDP

This is the ground pin for the PRDMRD2+ power transmitter section. It must be tied together on the user's PCB along with the two GND pins and the board supply ground.

[22] – VSP

Positive supply voltage input to the transmitter section. It must be the same voltage as VSL. VSP and VSL must be tied together on the user's PCB along with the board's +5V supply. USBVBUS must also be tied to VSP, VSL, and the board's +5V supply if USB is to be used.

[23] – USBPUR

This signal is no longer needed for proper operation of USB. Leave open.

[24] – VSL

Positive supply voltage input to the logic section. It must be the same voltage as VSP. VSL and VSP must be tied together on the user's PCB along with the board's +5V supply. USBVBUS must also be tied to VSP, VSL, and the board's +5V supply if USB is to be used.

[26] – CRDM

Continuous charge-only read mode enable when driven high. Normally pulled low by a 100K ohm resistor. When left open or driven low, the PRDMRD2+ is in an idle state, waiting for either a command from one of the communication ports or a trigger pulse to the nRDEN pin.

[27] – WLSC

Wireless synchronization enable when driven high. Normally pulled low by a 100K ohm resistor. When WLSC is high, the PRDMRD2+ attempts to synchronize its transmit signals with any other readers in range. When WLSC is left open or driven low, wireless sync is disabled. Wireless synchronization can also be enabled and disabled by SW command which has priority over the WLSC signal state.

[28] – USBVBUS

Positive supply voltage input to the USB section. If USB is used, tie this supply voltage input to VSL and VSP along with the board's +5V supply.

[29] – OKT

Output to indicate a good read of a transponder. Normally low, if a transponder is read and the resultant read is good, this pin goes high for 60mS. It is typically connected to a green LED to indicate a good read. The LED must have a series current-limiting resistor such as 330 ohms.

[30] - STAT

Idle mode indicator. Normally high when in idle mode. Goes low during transmission. It is typically connected to a red LED. The LED must have a series current-limiting resistor such as 330 ohms.

5 Mechanical

The PRDMRD2+ is a dual in-line (DIL) module with the following nominal physical properties:

Pins	
Pin pitch	2.54 mm (0.1")
Row spacing	25.4 mm (1.0")
Length below board	8.65 mm (0.34")
Gold-flash pins	0.635 mm (0.025") square
PCB Dimensions	
Length	38.4 mm (1.51")
Width	29.6 mm (1.165")
Total height including pins	12 mm (0.473")

Table 2 Mechanical dimensions

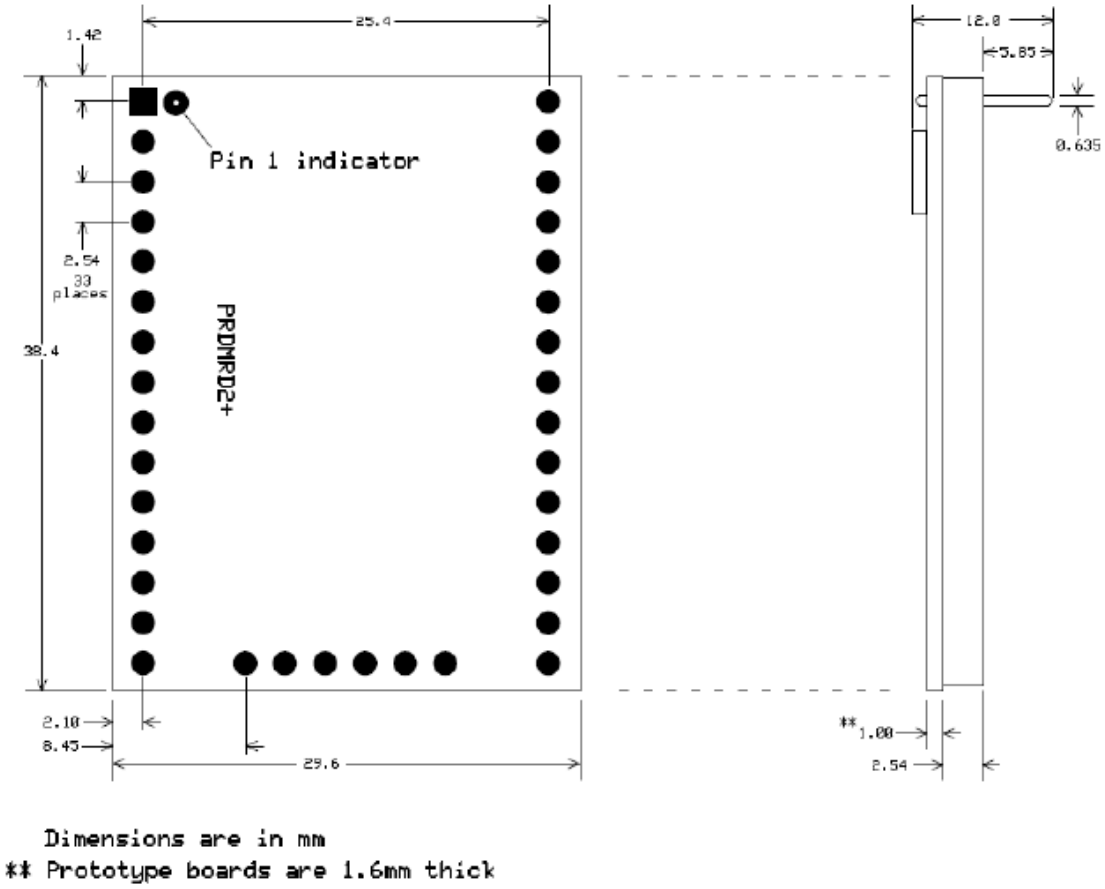

Figure 2 PRDMRD2+ Mechanical Drawing

6 Communication with a PC

Either the serial port or the USB port or both can be used to communicate with the PRDMRD2+ module. Both ports can be used simultaneously with the PRDMRD2+ module's reply returned to the port which requested the operation.

The USB port configuration at the PC is installed as Communication Device Class (CDC) which means the PRDMRD2+ will appear as a COM port to the user.

If communication is through the PRDMRD2+ module's serial port, it will first need to be converted to a protocol which PC hardware supports such as RS-232 or RS-422 and will most likely be further converted to USB as most modern PCs no longer support RS-232. In any case, the serial port will eventually show up as a COM port just as in the case of USB.

Data between the host computer and the PRDMRD2+ module is performed in binary so that no ASCII characters are accepted except for the control characters XON (0x13) and XOFF (0x11) which are used by the PRDMRD2+ as flow control. Upon receipt of XOFF, the

PRDMRD2+ immediately stops its current operation and pauses serial communication until it receives XON.

6.1 Easy Code Mode (ECM)

For programming the Protagd RW transponders, two new commands have been added to the ECM command library.

ECM command structure:

Device Code	Command	Parameters and Data

ECM response structure:

Status Information	Data

6.2 Protagd Transponder Device Code

The Protagd RW transponders are implemented as device code 0x21.

6.3 Protagd Transponder Commands

6.3.1 Program Protagd ReadWrite Transponder - Downlink

To program the Protagd transponders, two additional commands are implemented in the PRDMRD2+. Programming of all 10 bytes is done using the command 0x11, while programming of 8 bytes with the PRDMRD2+ calculating the CRC automatically is done using the command 0x15.

Start Byte	Length	CMD1	Device Code	Command	Parameter, Data	CMD BCC
0x01	0x0D	0x80	0x21	0x11	10 Bytes	1 Byte
0x01	0x0B	0x80	0x21	0x15	8 Bytes	1 Byte

Examples

Programming of 10Bytes without using a Data BCC:

```
0x01-0D-80-21-11-FF-EE-DD-CC-BB-AA-99-88-77-66-AC
```

Programming of 8Bytes with BCC calculated by MRD2+:

```
0x01-0B-80-21-15-00-11-22-33-44-55-66-77-BF
```

6.3.2 Program Protagd ReadWrite Transponder – Response (Uplink)

The response is identical to the TI RW response format. After the start and length byte it returns two status bytes followed by the 10 data/BCC Bytes.

Start Byte	Length	Status1	Status2	Data/Data BCC	CMD BCC
0x01	0x0C	1 Byte	1 Byte	10 Bytes	1 Byte

Examples

Programming of 10Bytes without using a Data BCC from above- Response:

```
0x01-0C-00-00-FF-EE-DD-CC-BB-AA-99-88-77-66-1D
```

Programming of 8Bytes with BCC calculated by MRD2+ from above- Response:

```
0x01-0C-00-00-03-1E-00-11-22-33-44-55-66-77-11
```

7 Demodulation Threshold

The Protagd RW transponder shows differences in its protocol implementation that requires a change in the demodulation threshold setting. For best performance, this threshold must be fixed to the nominal value of 130.2kHz. This is needed only for the programming commands; the read function is not affected.

7.1 Set fix demodulation threshold

The MRD2+ command is as follows.

Start Byte	Length	CMD1	CMD2	Data	CMD BCC
0x01	0x03	0x83	0x4C	0x01	0xCD

The Data field with the value of 0x01 sets a fixed demodulation treshhold.

Changing back to an auto demodulation threshold is done by the same command with the data field being 0x00.

8 Wired Synchronization

Wired synchronization can be accomplished in different ways. If only two modules are to be synchronized then one becomes a master and its software is set to make it read every 200mS. The master's SYNC signal is connected to the nRDEN pin of the slave module. Each time the master transmits its SYNC signal will go low and will trigger the slave via nRDEN to start its read as well.

9 Demonstration Circuit

The circuit below demonstrates the basic features of the PRDMRD2+. The 3 LEDs are handy but not required. If you know the mode you will operate in, then the 3 mode pins (nRDEN,

WLS, CRDM) can be hard-wired. In this schematic, R2, R7, & R8 are optional resistors used to extend the ESD performance.

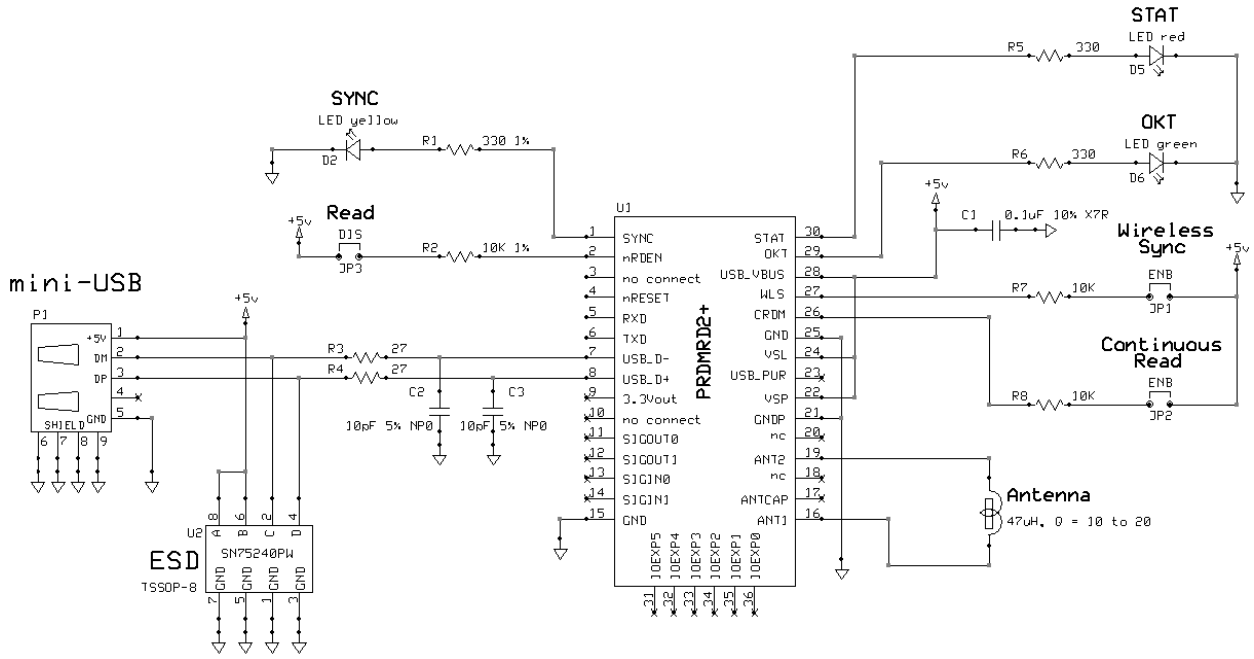

Figure 3 PRDMRD2+ Application Schematic

If USB is not needed, P1, U2, R3, R4, C2, & C3 can be omitted and the serial communication pins (RXD & TXD) can be used to interface to a microcontroller or a serial-to-RS-232c converter chip. RXD is the input data to the PRDMRD2+ and TXD is the output data from the PRDMRD2+.

10 Operating Conditions

Recommended operating conditions for the PRDMRD2+ are listed in the table below.

Symbol	Parameter	Min	Typ	Max	Units
T_oper	Operating free-air temperature	-40		85	ºC
T_stor	Storage Temperature	-40		85	ºC
VSP	Supply voltage for power stage	2.7		5.5	VDC
VSL	Supply voltage for logic	2.7		5.5	V
I_VSP	Supply current for power stage		100		mA
I_VSL	Supply current for logic		30		mA
I_sink	Output pin sink current			15	mA
I_src	Output pin source current			-15	mA
I_sinkt	Total sink current by all pins			60	mA
I_srct	Total source current by all pins			-60	mA
V_rst	VSL supply voltage to guarantee good reset			0.3	V
V_purt	VSL power up rise time to guarantee reset	0.1			V/mS
I_quies	Quiescent supply current (idle mode)			2	mA
I_USBVBUS	Quiescent supply current when connected to USB			8	mA
I_act	Active supply current		100		mA
Vih	High-level input voltage	0.8*VSL		VSL+0.3	V
Vil	Low-level input voltage	-0.3		0.2*VSL	V
Voh	High-level Output voltage	VSL-0.7		VSL	V
Vol	Low-level output voltage	GND		0.6	V
Q_antenna	Antenna quality factor	10		20	
L_antenna	Antenna inductance	46.1		47.9	uH
f_carrier	Charge burst frequency (antenna resonant freq)	134.1	134.2	134.3	KHz

Table 3 Operating Conditions

11 Transponder Downlink Timing

The default values for the transponder downlink timing are shown in Table 4 below. All times are in microseconds.

Modulation	Bit H		Bit L		SOF		EOF	
	toffH	tonH	toffL	tonL	toffSOF	tonSOF	toffEOF	tonEOF
PWM (R/W & MPT)	1000	1000	300	1700	_	_	_	_
PWM (auto)	480	520	170	330	_	_	_	_
PPM	170	350	170	230	_	_	_	_
BLC (HDX+)	149	238	149	171	298	499	149	373
BLC (auto)	170	350	170	230	170	460	170	580

Table 4 Default Transponder Downlink Timing

Burst Type	Burst length
Charge burst	50 mS
Program burst	17 mS

Table 5 Default Power Burst Timing

12 Document Version Control

Version 0.0	1st edition	May 23rd, 2017	Jim Childers
Version 0.1	Formatting	May 24th, 2017	Klaus Seiberts
Version 1.0	Initial Release	May 24th, 2017	
Version 1.1	RW Commands	September 7th, 2017	Klaus Seiberts