



Configuration Programming of UCD Devices

This document describes techniques that can be used to download a device configuration to a Texas Instruments UCD device. While this document references version 1.8.18 of the Fusion Digital Power Designer software, you can use versions newer than 1.8.18 as well.

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1 INTRODUCTION

This document describes how configuration data can be written (programmed) to select Texas Instruments UCD devices. Currently this covers UCD92xx digital power controller and UCD90xx sequencers and system health controllers. Generally, any device that is configured with the Fusion Digital Power Designer software and is a UCD device should support the programming options described here. For example, the UCD908x power supply sequencer and monitor is not supported. The UCD908x does not support PMBus and is configured by a different GUI.

Both UCD92xx and UCD90xx device families use the same IC underlying memory, ROM, and PMBus architecture. This IC architecture, generically referred to as the UCD30xx, comes in four different pin/package configurations: 40, 48, 64, and 80 pins. Most devices only come in a single pin package. For example, the UCD9248 uses an 80 pin package. A few, such as the UCD9240, come in multiple packages. As you will see later, there is a unique device identifier (DEVICE_ID) for each UCD device. It normally has the package (# pins) embedded within it. For example, "UCD9240-64|3.25.0.8662|081105" represents a UCD9240 device, 64-pin package, firmware version 3.25.0.8662, compiled on November 5 2008.

Programming techniques described in this document can also be used to program device configuration to custom devices that use the UCD30xx IC family. For example, Texas Instruments works with merchant power customers who develop their own firmware for Isolated power applications. While these customers usually download both firmware and configuration to their devices, some customers may need to download configuration data separately using the techniques described in this document.

2 CONFIGURATION BASICS

UCD devices have two types of flash (EEPROM) memory: program flash and data flash. Program flash is written during Texas Instrument's manufacturing process. It is the firmware that makes the device a UCD9220, UCD9240, UCD90120, etc. The factory does not program any configuration, even a default configuration, into data flash during manufacturing. Thus, devices arrive from the factory un-configured.

When power is first applied to a device that is in the factory un-configured state – technically data flash has been filled with a 1010... bit pattern as part of the test process – the device will load a default configuration referred to as the HARDCODED PARMS configuration:

- UCD92xx: no voltage rails have been configured; global parameters are set to default values by the firmware
- UCD90xx: no rails, GPIs, GPOs, PWMs, or fans have been configured; global parameters are set to default values by the firmware

An un-configured device can therefore be placed on a system board without concern that the device would power an output rail or turn on a sequence. If you use active low polarity for any GPOs defined by your device, note they could be active due to this un-configured state. Contact your Texas Instruments representative for assistance.

3 AN OVERVIEW OF CONFIGURATION PROGRAMMING OPTIONS

There are a number of options that affect how a UCD device will be programmed. Some of the programming permutations include:

- **Serial bus or JTAG:**
UCD devices support programming via serial bus or JTAG.

The [PMBus](#) (Power Management Bus) protocol uses the [SMBus](#) (System Management Bus) protocol to communicate with a controller over serial bus. SMBus in turn is a wrapper around the [I²C](#) (Inter-Integrated Circuit) serial bus protocol. A programmer must have access to I²C clock and data lines to write a configuration via PMBus.

Devices can also be programmed via [JTAG](#) (Joint Test Action Group). This allows an in-circuit tester (ICT) or dedicated JTAG programmer to write a configuration using existing JTAG TMS, TDI, TDO, and TCK pins.

- **Command-based configuration or data flash image:**
When the device is in its normal program mode state, a host can change the configuration by issuing a series of PMBus commands. For example, to configure the voltage setpoint on a 4 rail system, a GUI or host writes to the command VOUT_COMMAND along with a special command PAGE that selects the output rail that is configured. This type of configuration will be referred to as PMBus-based configuration in this document.

An alternative to PMBus-based configuration is to write directly to the data flash of the device. This is the EEPROM area where configuration data is stored.

- **On board or off board:**
You can pre-program a configuration before the UCD IC is soldered onto your board. Or you can download a configuration once the IC has mounted.
- **Fusion tools or 3rd party programmers:**
Texas Instruments provides a number of tools to write configuration, either via PMBus or by writing directly to data flash. Tools include the standard Fusion Digital Power Design (Fusion GUI) software, the Fusion Manufacturing Tool (MFR GUI), and command line tools. These can be used off board or on board. For the later, access to the system board's I²C bus is required, which will be routed to the TI USB adapter.

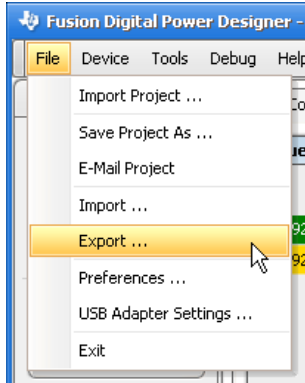
Dedicated programmers can program via serial bus or JTAG. Dedicated programmers always write configuration directly to data flash.

This document will not describe every possible permutation, but instead focus on common tools and programming use cases.

4 CONFIGURATION EXPORT OVERVIEW

4.1 Export Using the Fusion GUI

The Fusion GUI is normally used to export device configuration data. To begin, you select Export from the File menu:



The export tool has two modes of operation:

- Multiple format: export more than one file/format with a single click.
- Single format: export only one format at a time.

The formats available:

- Text File
Tab or comma separated list of PMBus settings and readings. This file can be opened by Microsoft Excel or a text editor. Most PMBus parameters – such as VOUT_COMMAND, READ_VOUT, and IOUT_CAL_GAIN – will be listed, one per line. In the case of a multi-rail or multi-phase device, there will be separate entries for each rail/phase.

If your device contains some configuration items that cannot be presented by a single command, a summary of said item will be included in the export. For example, on UCD92xx devices CLA gains are read and written to the device using a series of commands issued by the Fusion GUI. A text export of a UCD92xx device will include pseudo command entries for CLA_GAINS_BANK_0, CLA_GAINS_BANK_1, and CLA_GAINS_BANK_2.

This mode is available in online or offline mode.

- Project File
A project file contains a device's PMBus configuration and readings in XML format. It is the primary data file of the Fusion GUI, and allows you to edit a device's configuration and design in 'offline' mode: without a live connection to your device. A project file also contains information about your design and sequencing that is not stored on the device. For example, a definition of the voltage divider network on your system board. Unlike File->Save Project, you can choose not to include non-command data such as UCD92xx designs or UCD90xx pin names. When this information is not included, the project file is smaller and may be easier for you to review/understand.

This mode is available in online or offline mode.

- **Data Flash File**
This export format will read the data flash from the device and save it in S-Record or Intel Hex format. Other modes, such as project and text file modes, export the current RAM configuration. This mode will export the data flash configuration. See section 9.1, [Exporting Configuration Data Flash Hex File](#).

This mode is only available in online mode.

- **Program + Data Flash File**
This export will read the program and data flash from the device and save it in S-Record or Intel Hex format. You can download the program+data flash through any of the Fusion tools that download "firmware", where the Fusion tools define a firmware image as a single file containing program flash and optionally data flash.

Only authorized personnel can export program flash, and this tool is password protected. This mode is only available in online mode.

- **Data Flash SVF/JTAG**
This export format will read the device's data flash from the device and save it in Serial Vector Format (SVF). SVF is a vendor-independent way of representing JTAG test patterns. The SVF file will contain the patterns necessary to write your device's configuration. See section 6.3, [Downloading a Configuration via JTAG](#).

This mode is only available for devices that support JTAG. This is only available in online mode.

- **Program + Data Flash SVF/JTAG**
This export format will read the program flash and optionally data flash from the device and save it in Serial Vector Format (SVF). SVF is a vendor-independent way of representing JTAG test patterns. The SVF file will contain the patterns necessary to write the device's program and optionally data flash.

This mode is only available for devices that support JTAG. This is only available in online mode.

- **PMBus Script**
This will save a "script" detailing the writes necessary to write your current configuration to a device. Writes are done in terms of standard SMBus commands (WriteByte, WriteWord, and WriteBlock) or I²C WriteBlock. This can be easily translated to other environments. See section 6.4.3, [Microcontroller Writes Full Configuration via PMBus](#) and section 6.4.4, [Microcontroller Writes Partial Configuration via PMBus](#).

This mode is available in online or offline mode.

- **Data Flash Script**
This export will read the data flash from the device and save a script that can be used by a microcontroller or other device to download data flash to the device. See section 6.4.2, [SMBus / I2C Script Overview](#).

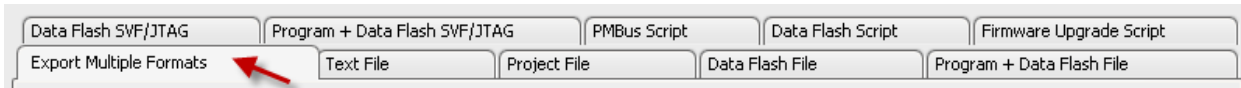
This mode is only available in online mode.

- **Firmware Upgrade Script**
This export will read the program and data flash from the device and save a script that can be used by a microcontroller or other device to download program and data flash to the device. While UCD devices firmware can be upgraded, Texas Instruments does not expect this to be generally done nor necessary.

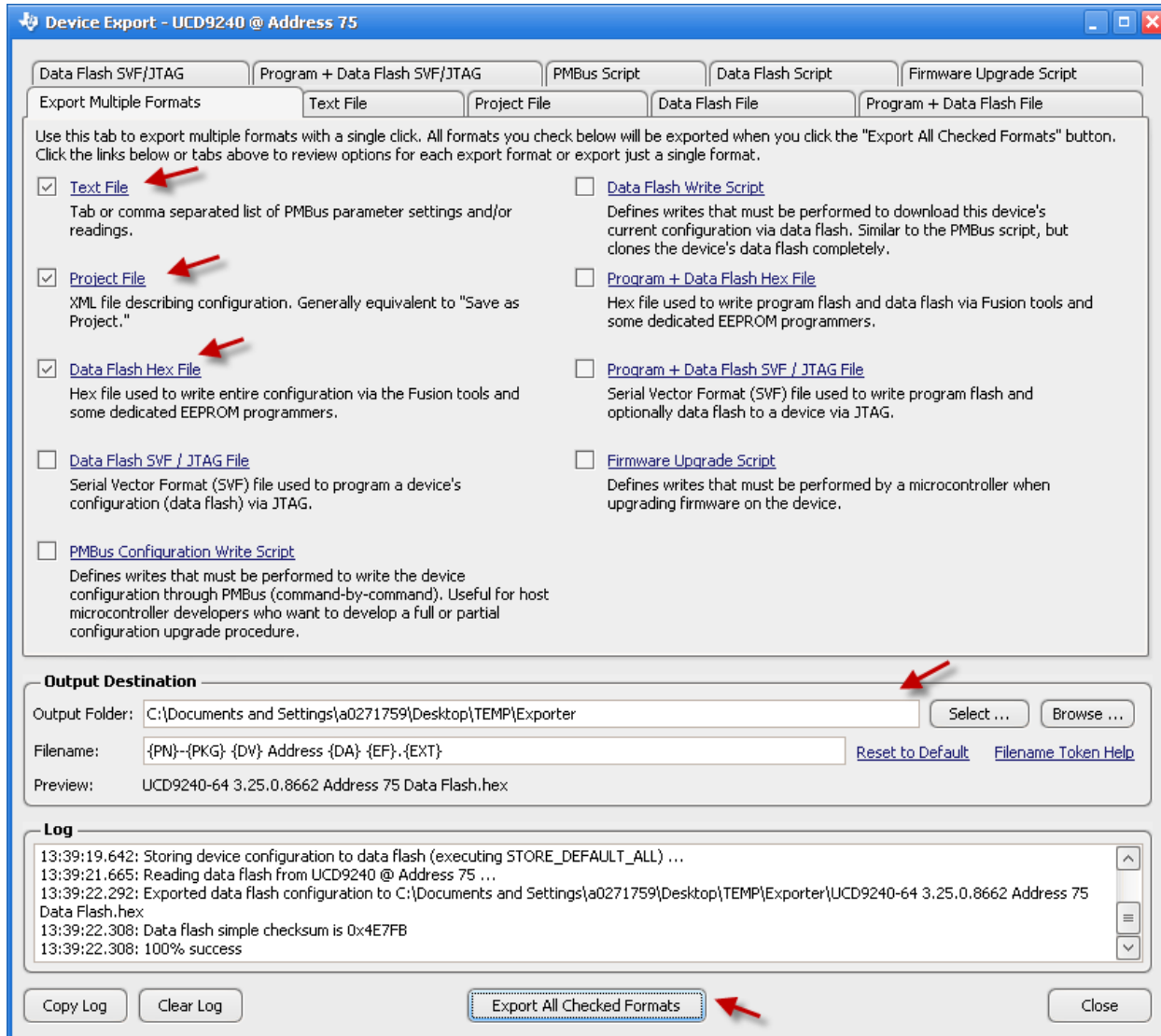
Only authorized personnel can export program flash, and this tool is password protected. This mode is only available in online mode.

4.2 Exporting to Multiple File Formats

To initiate a multiple format export, select the tab shown below:



You then click the checkboxes next to formats that you want to export. For example, even if you are doing a data flash export, it is recommended that you also export your device configuration to a project file and text file at the same time, for archiving and debug.



Note that the filename is not a fixed filename. It uses special “macros” to dynamically create a filename. This is primarily needed because the export multiple format mode will write more than one file. You can change the filename template to suit your project naming conventions; however, it is recommended you keep the {PN}, {PKG}, and {DA} “macros”. In the example above, “210434-02” is a part identifier to be assigned to the programmed IC. You also should keep the {EF} macro if you are exporting multiple formats. It will be used to differentiate between export

formats along with the filename extension, {EXT}. The Preview area shows what the actual filename will be for the selected export format.

Select a folder to write files to via the “Select ...” button and then click “Export All Checked Formats.” This will export using the current settings for each format.

4.3 Configuring Export Options

Most formats have options that control the export. You configure these options by clicking the hyperlink next to the checkbox or the corresponding tab at the top of the form. A description of the format is also available on this tab. For example, the text file format:

Description

This will export your device configuration in a text file that can be opened by Microsoft Excel or a text editor. Most PMBus parameters -- such as VOUT_COMMAND and IOUT_CAL_GAIN -- will be listed, one per line. In the case of a multi-rail or multi-phase device, there will be separate entries for each rail/phase.

If your device contains some configuration items that cannot be presented by a single command, a summary of said item will be included in the export. For example, on UCD92XX devices CLA gains are read and written to the device using a series of commands issued by the Fusion GUI. An text export of a UCD92XX device will include psuedo command entries for CLA_GAINS_BANK_0, CLA_GAINS_BANK_1, and CLA_GAINS_BANK_2.

File Format

CSV

Tab Separated

Hex Format

0xAABB

AABB

AA-BB

Parameters to Include

Read & Writable READ_VOUT is an example of a read-only command.

Read Only

Writable Only

Fields to Include (Columns)

<input type="checkbox"/> SAA Number (Dec)	<input type="checkbox"/> Part Number	<input checked="" type="checkbox"/> Command Code (Hex)	<input checked="" type="checkbox"/> Encoded Value (Hex)
<input type="checkbox"/> Device Address (Hex)	<input checked="" type="checkbox"/> Command ID (with phase)	<input checked="" type="checkbox"/> PAGE (Hex)	<input checked="" type="checkbox"/> Decoded Value
<input type="checkbox"/> Device Address (Dec)	<input type="checkbox"/> Command ID	<input checked="" type="checkbox"/> PHASE (Hex)	<input checked="" type="checkbox"/> Numeric Value

Options are saved to your user preferences and restored the next time you start the Fusion GUI.

4.4 Exporting One File at a Time

You can also export or preview the export of a single format at a time once you have jumped to the format's tab:

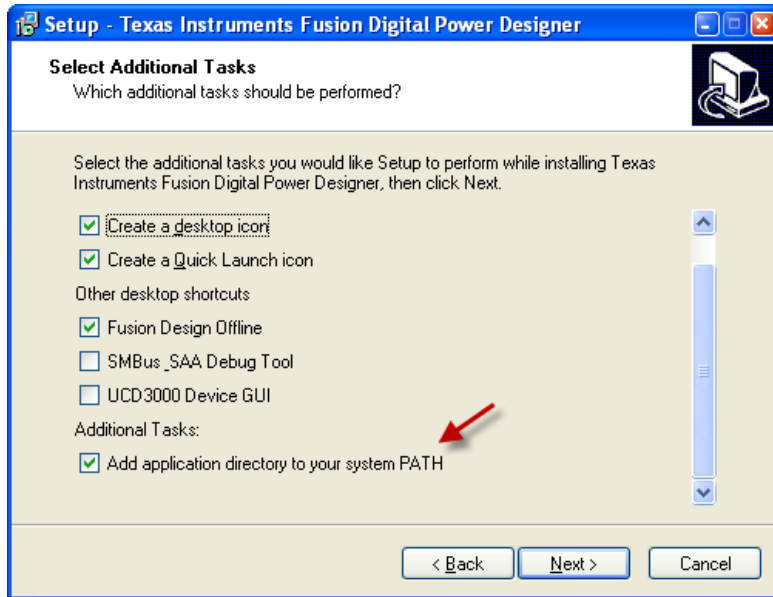


The export option will use the filename template defined on the main tab. The preview option exports to a temporary file and opens up the output in a window. This is handy when you are poking around with different options and file formats.

Section 6.3.4, [Exporting Data Flash Configuration as SVF](#), lists specific instructions for SVF export. Section 9.1, [Exporting Configuration Data Flash Hex File](#), has instructions for data flash hex file export.

4.5 Export Using the FusionDeviceExporter Command Line Tool

A number of command line (aka console aka DOS prompt) tools are bundled with the Fusion GUI. All tools are named FusionSOMETHING. By default, the folder where the tools were installed to was added to your PC's PATH environment variable when you ran the GUI's installer:



If this was not checked, you can re-run the installer and check this option.

The FusionDeviceExporter command line tool that is bundled with the Fusion GUI can export a subset of the formats supported by the export tool described in section 4.1, [Export Using the Fusion GUI](#).

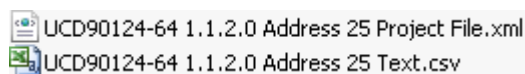
FusionDeviceExporter can export the following formats:

- Text file
- Project file
- Data flash hex file
- Data flash script
- PMBus script

Examples:

- FusionDeviceExporter --address 126 --text
Dumps the device configuration and readings for the device at address 126 to the console (standard output).
- FusionDeviceExporter --scan --text --project --outfile '{PN}-{PKG} {DV} Address {DA} {EF}.{EXT}'
Exports configuration/readings for all supported devices found on the bus. Text and project file formats will be exported. The output will be saved to two different files, each defined by the outfile template specified.

For example, after running on a UCD90124, the following files might be created:



Like all Fusion command line tools, you can get detailed help by typing FusionDeviceExporter --help on the command line.

5 DATA FLASH CONSIDERATIONS

Data flash refers to a section of the device's EEPROM that holds non-volatile device configuration and other operational data. Many UCD devices store more than just configuration information in data flash. For example, UCD92xx and UCD90xx devices log information about faults that occur to data flash.

Each device (UCD9240-64, UCD9240-80, UCD9248, UCD90120, etc.) and possibly the specific firmware release for a given device (UCD9248-80-5.6.0.1123, etc.) will have a "memory map" that defines where in the flash the data that the device maintains is stored. As a device's firmware is updated, the location in data flash where a particular piece of data is stored may change. For example, say that the data flash layout for a device looks like this:

- Address 0x18800: Fault logging information
 - Address 0x18800: Rail #1 faults
 - Address 0x18802: Rail #2 faults
 - Etc.
- Address 0x18A00: Configuration information
 - Address 0x18A00: VOUT_COMMAND rail #1
 - Address 0x18A02: VOUT_OV_FAULT_LIMIT rail #1
 - Etc.

But what if, on a new firmware release, the amount of data that was saved in the fault logged was changed? Or the "memory map" of configuration data was changed, perhaps to optimize the firmware in some way? In either case, the data flash between firmware releases would no longer be compatible.

Another complication is that devices often store information in non-volatile and volatile memory differently than they are passed back and forth via PMBus. For example, the GUI writes VOUT_COMMAND as a 16 bit signed mantissa. The exponent is configured through another command, VOUT_CONFIG. The device does not store this in RAM or flash in the PMBus format. It stores it in a fixed point (Q math) representation. This is only one example of the PMBus → device translation. Different commands use other encoding schemes, and these schemes can change between major releases.

PMBus hides the memory map and command encoding issues by providing a command-based front end for reading and writing a device's configuration. In the case of TI UCD devices, special "manufacturing specific" (custom) PMBus commands are also used to read and reset fault logs and other flash-based logged data.

The Fusion GUI normally reads and writes configuration via PMBus and thus avoids these issues. All the GUI needs to worry about between firmware releases is whether a command has been added, removed, or data format modified between firmware releases. The underlying memory map of the device is not tracked by the GUI.

Data flash-based configuration is much more brute force. It is ultimately a bit-by-bit copy of a source data flash image to a target device. Great care must therefore be taken to ensure that the firmware loaded on the "source" – the device that will be used to generate the configuration export – matches the firmware loaded on the "target" device. Because of this, if your target device version changes, you should normally create a new configuration export from a live device.

Depending on the method you are using to write data flash, the target device may be validated before flash programming starts. For example, a JTAG SVF data flash programming file will validate that the target device is compatible with the SVF being executed. In the case of SVF, the validation works as follows:

- Engineer connects to a device in “online” mode with the Fusion GUI. The device should have the same firmware loaded that will be on the ICs received from Texas Instruments. For example, if the customer had previously been developing/validating their design with pre-production firmware, the final firmware should be loaded on lab devices.
- Engineer selects File->Export from the Fusion GUI.
- The GUI reads the data flash image from the device.
- The GUI converts this data flash image to a series of SVF instructions that can be used to program data flash on other devices.
- The engineer or contract manufacturer tests the SVF.
- When the SVF is run, one of the first tasks it performs is to read the contents of the device’s DEVICE_ID register. DEVICE_ID is a read-only Texas Instruments PMBus command (MFR_SPECIFIC_45, command code 0xFD, read block) that returns the device part, firmware version, and release date. An example DEVICE_ID is “UCD9240-64|3.25.0.8662”. The GUI normally reads DEVICE_ID via PMBus when it scans for devices during startup. In the case of SVF, the SVF will read DEVICE_ID from program flash memory via JTAG. DEVICE_ID is always stored at a fixed location on TI devices. The SVF will read DEVICE_ID and compare it to what it expects the target to be (the device the export was done on). If there is a mismatch, the SVF will abort with an error.

In section 6, [Programming Options and Instructions](#), device validation – if any – will be described for each programming option.

6 PROGRAMMING OPTIONS AND INSTRUCTIONS

6.1 Downloading a Configuration via Fusion Tools

All Fusion tools use the TI USB adapter for I²C communication. Tools can write via PMBus (project files) or write a data flash image.

Project files are described more fully in the Fusion Digital Power Designer user manual, section 9. A project file is an XML file that contains a device's configuration on a command-by-command basis. Project files may also contain additional GUI-centric information about a device that is not actually stored on a device. For example, the Fusion GUI provides a design tool that is used to create compensation coefficients for a device. Design components are criteria are stored in the project file. This GUI-centric data is not used in the configuration process.

See section 9.1, [Exporting Configuration Data Flash Hex File](#), for instructions on how to export a device configuration to a data flash hex file.

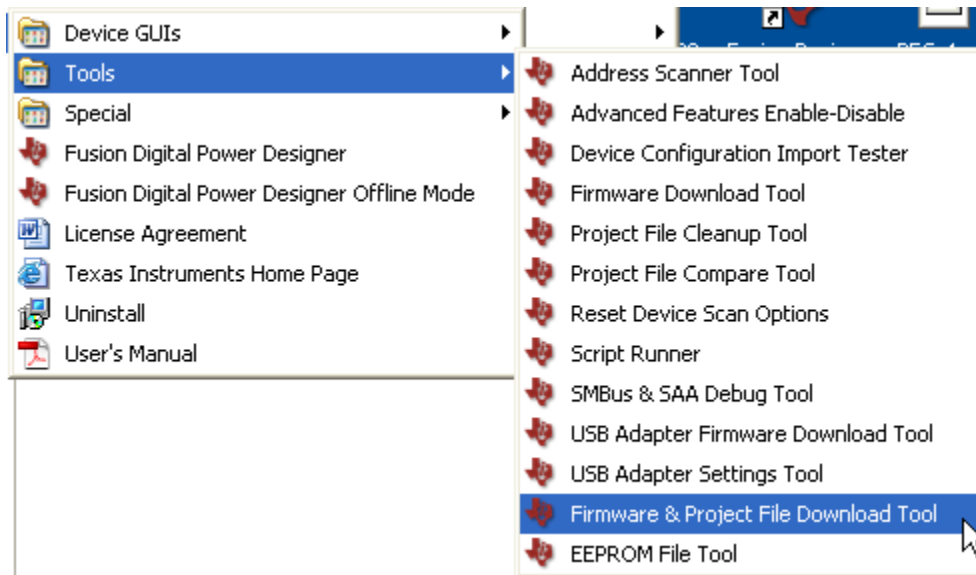
When using Fusion tools, for optimal performance you should hook the TI USB adapter directly to your PC. Do not use a hub/dock of any kind, as this will significantly slow down write times.

6.1.1 Fusion Digital Power Designer

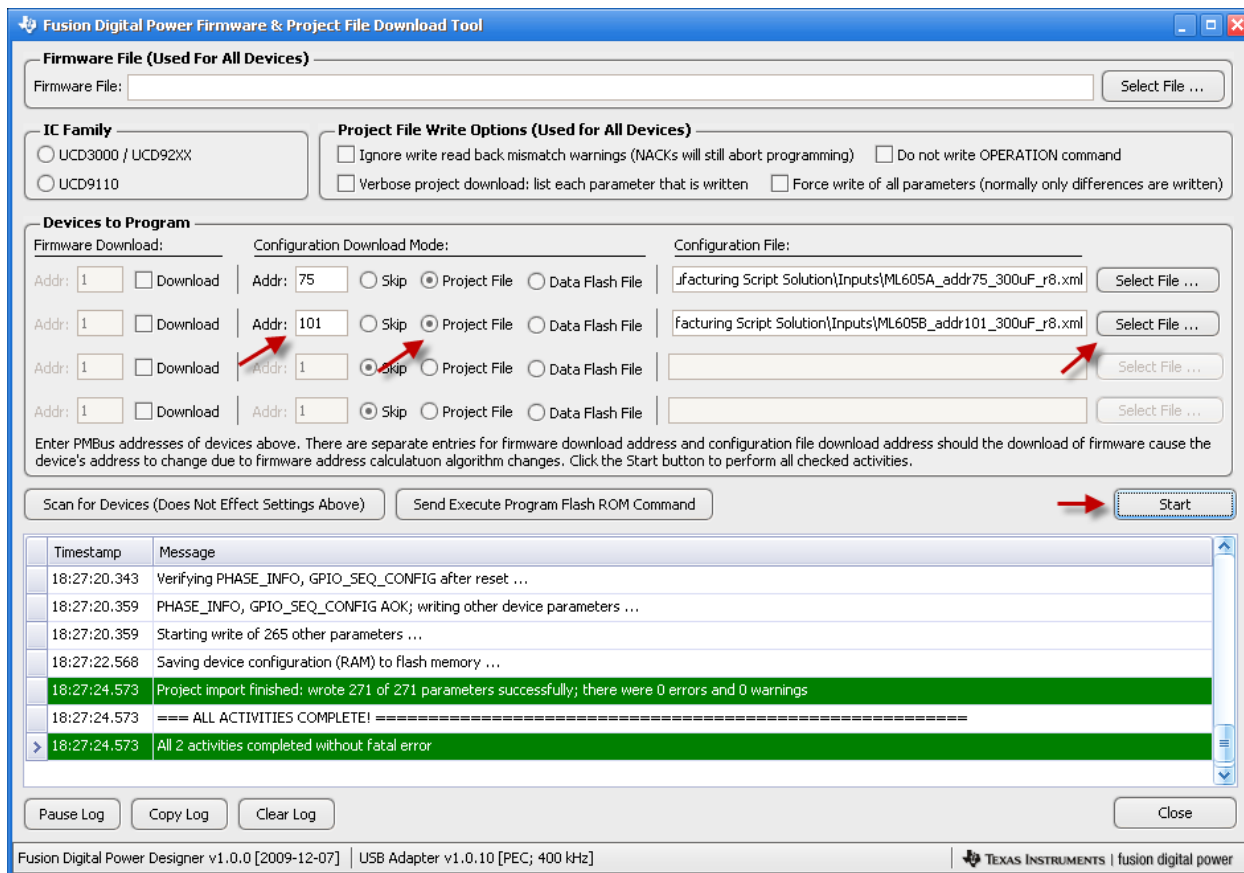
The Fusion GUI can be used to write a configuration for small batch runs. The File->Import tool can be used to import a project file or a data flash image. Normally you will want to stick with project files for the reasons described in section 5, [Data Flash Considerations](#).

6.1.2 Firmware and Project File Download Tool

If you have a number of devices to program, this simple tool that comes bundled with the Fusion GUI may be helpful. You launch the tool from the Start Menu under Texas Instruments Fusion Digital Power Designer:



It can download firmware and/or configuration to more than one device on the bus. It can download a project file (PMBus) or data flash file. For example:



Because only configuration is being downloaded, firmware and IC information did not need to be filled in. Only the PMBus address, configuration mode, and configuration file need to be filled in before clicking the Start button.

Your settings are remembered when you exit and restored the next time you run the tool.

6.1.3 FusionConfigWriter Command Line Tool

The Fusion GUI comes bundled with a number of command line (aka console, batch mode) tools. The FusionConfigWriter tool can be used to download a project or data flash file to a device. This tool would be helpful if you have an existing manufacturing test executive such as National Instruments TestStand and want to integrate UCD configuration into your process flow.

The options of these tools are similar to the Firmware and Project File Download Tool described above. If writing a project file:

```
FusionConfigWriter [ scan options ] --project --infile project-file
[ --skip-operation --force-write --project-file-warnings-ok --device-exact-version version --quiet ]
```

The --skip-operation, --force-write, --project-file-warnings, and --quiet arguments are optional. Scan options is a place holder for arguments used to define the device you are targeting. While you can only write to a single device in each call to FusionConfigWriter, you can invoke the program any number of times if you have multiple UCD devices on the bus. For example:

```
FusionConfigWriter --address 75 --project --infile ML605A_addr75_300uF_r8.xml
FusionConfigWriter --address 101 --project --infile ML605B_addr101_300uF_r8.xml
```


The syntax when writing a data flash image is similar:

```
FusionConfigWriter [ scan options ] --dflash --infile eeprom-file [ --device-exact-version version --quiet ]
```

The `--device-exact-version version` argument is recommended when writing data flash if you are deploying this as part of a larger manufacturing process. When specified, if the device that is targeted does not match the exact firmware version specified, the tool will exit with an error.

For example:

```
FusionConfigWriter --address 75 --device-exact-version 3.25.0.8663 --dflash --infile UCD9240-64-3.25.0.8662-Address75-DataFlash.hex
```

```
FusionConfigWriter --address 101 --device-exact-version 3.25.0.8663 --dflash --infile UCD9240-64-3.25.0.8662-Address101-DataFlash.hex
```

Example output in data flash mode:

```
Sending the device to ROM mode ...
Waiting for ROM mode via ROM version fetch ...
Device in ROM mode; UCD3000 ROM v0.2; IC v0.2
Mass erasing data flash
Writing data flash ...
Wrote data flash without error
Verifying data flash through read back ...
Reading data flash ...
Data flash verified!
Recreating program flash checksum ...
ROM is calculating program flash checksum ...
Reading last segment of existing program flash ...
Erasing last segment of program flash ...
Downloading new segment of program flash ...
Program flash update 100% successful; program will run on device power-up
Executing program flash and waiting for device to come online ...
Device in program mode after 250.8208 msec wait, DEVICE_ID is 'UCD9240-64|3.25.0.8662|081105'
```

Note there are two ways to specify devices to target on the bus. If you have multiple devices on the bus, then `--address` must be used as shown above. If you have only a single device, you could use the `--scan` option instead to have the tool use whatever device is found on the bus. This might be useful in a single device setup where the address is not fixed.

The FusionPMBusScan tool can be used to list what devices are on the bus. For example:

```
FusionPMBusScan
```

```
Starting scan for SAA #1 from 1-11,13-127
Found device @ address 88d: ReadBlock DEVICE_ID [0xFD] returned UCD3000ISO1|0.0.0|110609
[0x5543443330303049534F317C302E302E307C313130363039 ]
Found device @ address 103d: ReadBlock DEVICE_ID [0xFD] returned UCD9224-48|5.6.0.11224|090922
[0x554344393232342D34387C352E362E302E31313232347C30393039323200 ]
```

```
Found 2 device(s)
```

All Fusion command line tools return exit status code of 0 on success and non-0 on failure. This is a DOS/UNIX convention. So you can check for this return status code and simply log the results.

Full documentation of the tool is available by launching a DOS (or similar shell) window and typing FusionConfigWriter --help.

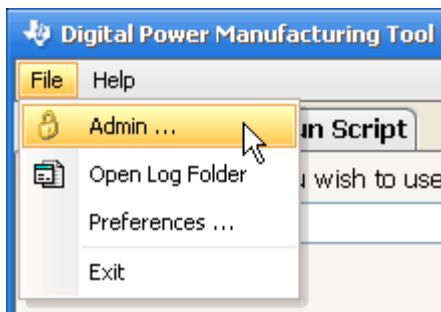
6.1.4 Fusion Manufacturing GUI (MFR GUI)

The MFR GUI provides a framework to perform a variety of manufacturing activities on Texas Instruments UCD device(s) in a lab or factory setting. You can create “scripts” that can:

- Download firmware
- Download configuration (project file or data flash)
- Write serial numbers and date
- Calibrate device (manual or instrumented)
- Test device
- Other: open API for customer to add their own custom processes

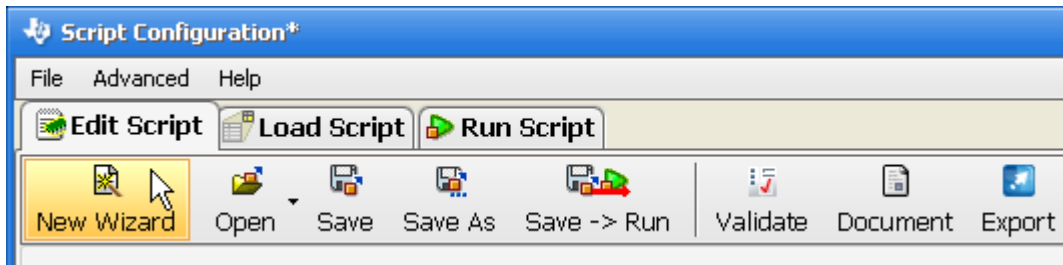
The MFR GUI is driven off of a special XML file called a “manufacturing script.” It defines the devices in your system and the activities – called tasks – you want to perform on each device. Tasks are listed in order that they should be executed. If a task fails, the script will stop for the device. Tasks can also have configurable retry. If you are familiar with [TestStand](#), think of the MFR GUI as a mini-TestStand, highly optimized for UCD devices.

The MFR GUI has two distinct operating modes: script editing and script running. Script editing is a one time or maintenance activity where you define the tasks that will be performed on your devices. After you have launched the MFR GUI from the Start Menu, you should enter the “Admin” mode to create a new script:



The password is “texas”. A script can be created/edited in Admin mode only. This password prevents an “operator” – someone running the script with limited knowledge of the tool/device(s) – from accidentally changing the script.

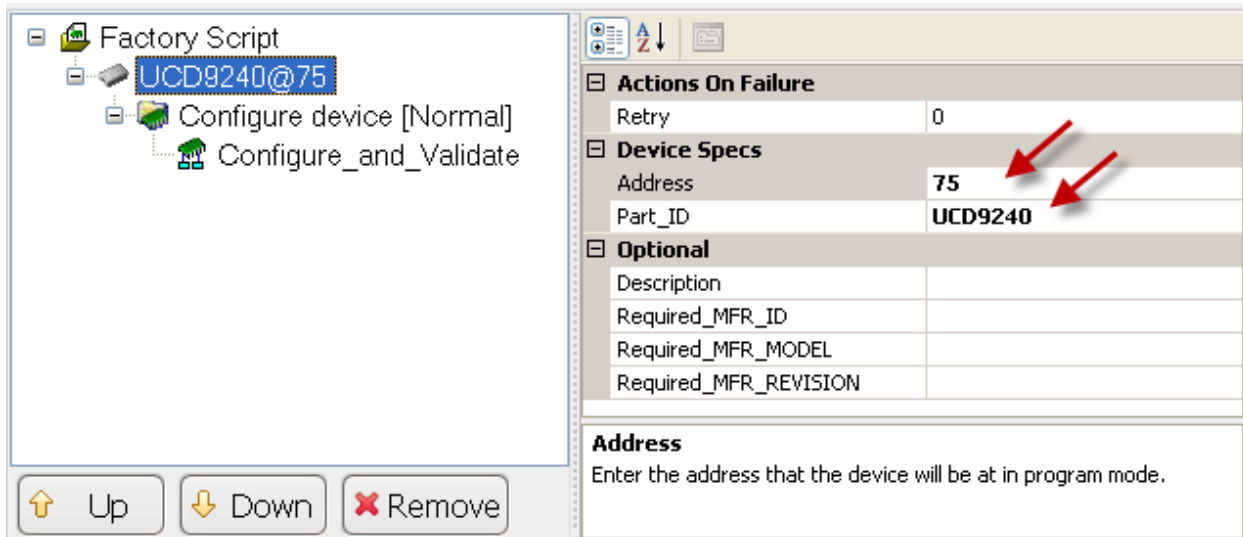
For the purposes of this document, two very simple MFR GUI scripts will be created to download configuration to a device. One script will use project files. The other will use data flash images. To jump start the script creation process, click the “New Wizard” icon in the toolbar:



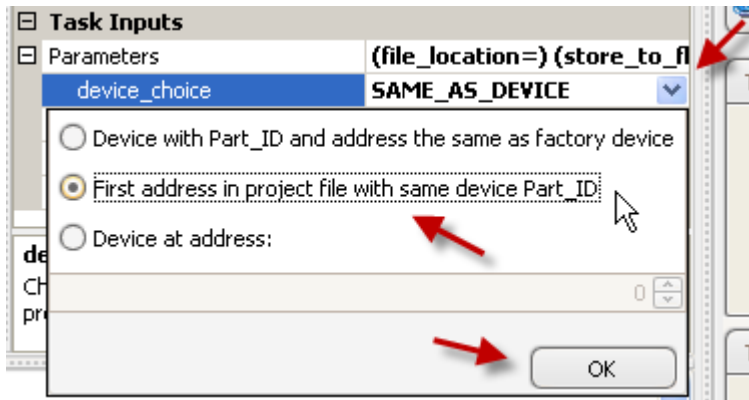
Select the "Configure_With_Project_File" template and click the Create button. This will yield this simple script:



Scripts are organized by device, then by activity, and then by task. In the case of the wizard, a place holder device was defined. Click the "Discovery@6" node in the tree. You'll notice that the properties area to the right changes after you select the device. You define properties about the selected node in this area. For example, to target a UCD9240 at address 75:

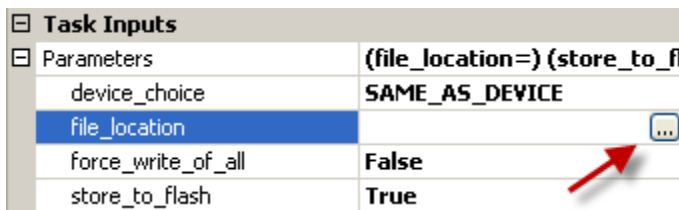


Next, click on the "Configure_and_Validate" node. Click on cell to the right of device_choice – SAME_AS_DEVICE is the default – and change the selection to "First address in project file with the same device Part_ID" and click OK:

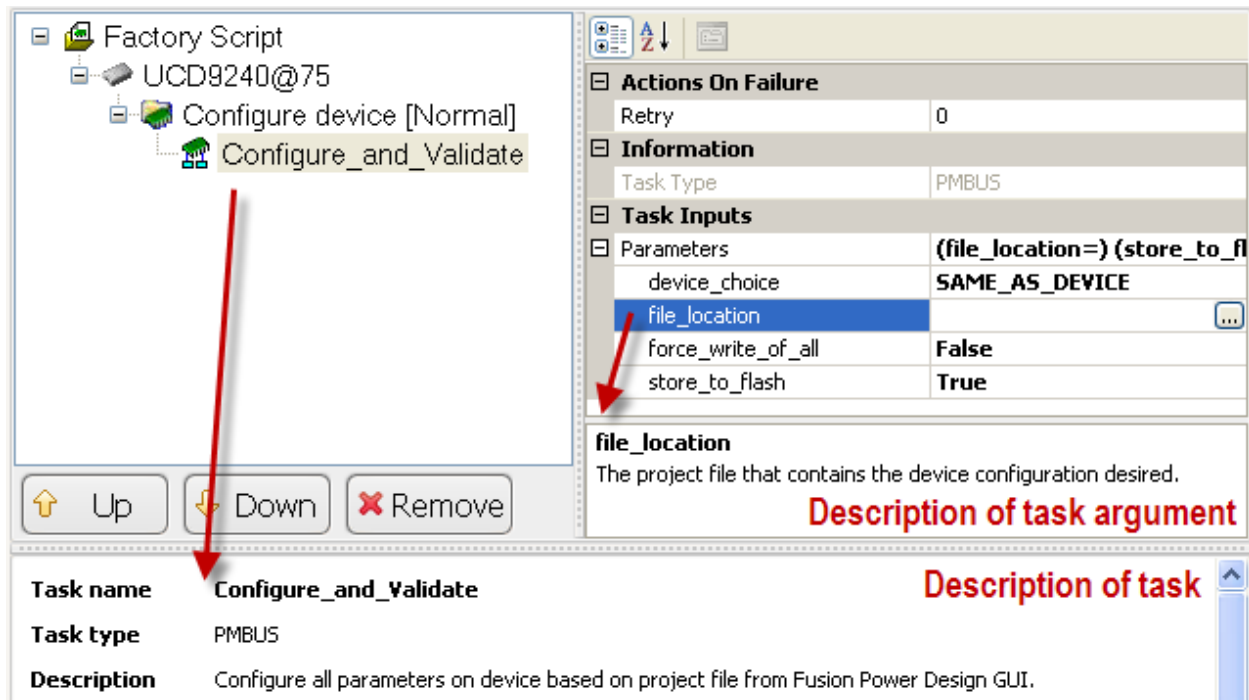


This is usually needed because the PMBus address defined in your project file is often different from the address you are targeting. If, however, yours match up, you can keep the default. In this mode the MFR GUI will enforce that the device address in the project file is an exact match to the device this task is under (address 75).

Next, click on the cell to the right of “file_location” and find the XML project file you want to write:



Keep the default values for force_write_of_all (False) and store_to_flash (True). Context sensitive help on the current task argument is always available below the properties grid. And full documentation of the currently selected task is shown at the bottom of the screen:



Next, click the "Save -> Run" button on the toolbar:



You'll be prompted to select a location for your MFR GUI "script." Note that the extension is the same as project files: .xml. After the save is done, the MFR GUI will jump to the script runner tab. Click the Start button to execute the script. The MFR GUI shows PASS/FAIL via a banner at the bottom of the run tab:

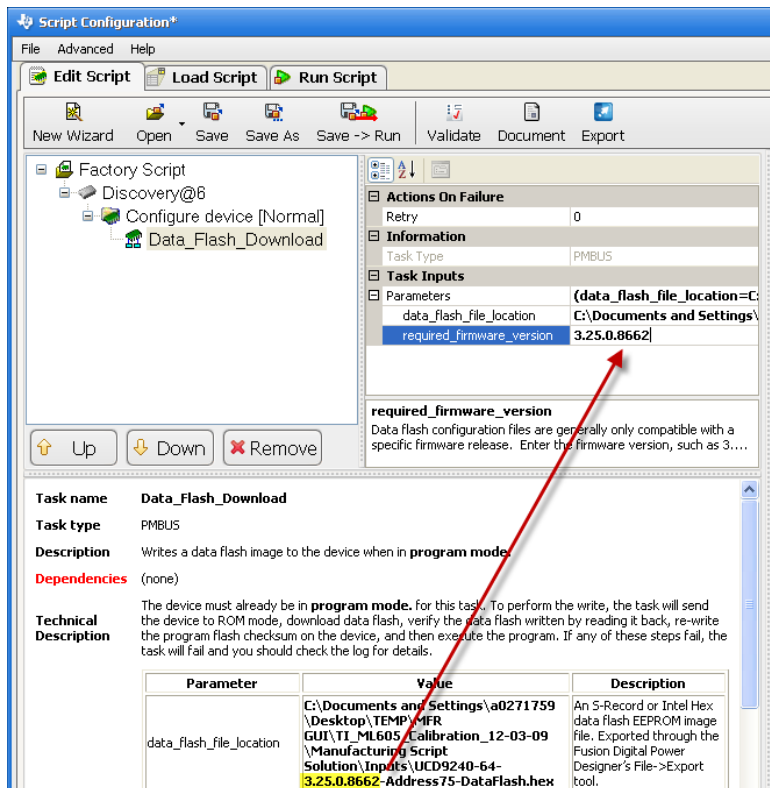
Manufacturing Passed

When you are ready to program another part, you do not need to quit the MFR GUI. Simply swap out devices and click the Start button again. The log area will be cleared and the script will restart from the top, including standard device discovery to verify that a device is present.

Detailed log files are saved for each script "run". See the MFR GUI user manual for complete instructions and details. The MFR GUI can do much more than download configuration files.

If you need to program a data flash image instead, select the "Configure_With_Data_Flash_File" template in the "New Wizard". Follow the steps above to set the device part/address. Then click the "Data_Flash_Download" task and select the data flash hex file to program. Optionally, you can have the MFR GUI validate that the firmware version of the target device is a specific version. One easy way to determine this version is to look at the filename of the data flash hex file.

If you used the default and recommended file name template when you exported your data flash image in the Fusion GUI, the filename will contain the firmware version that the data flash was exported from. In the following example the data flash file was exported from firmware version 3.25.0.8662:



6.2 Downloading a Configuration Using a Dedicated EEPROM Programmer

You should inquire about support for your target device as soon as possible. Each EEPROM programming vendor must add support for UCD devices. Some will add generic support, which will work for almost any UCD3000-based device (for example, UCD9240 or UCD90120). Others need to add support for each unique TI device. Section 9.3, [Gang Programmer Notes](#), lists distributors and vendors that TI has worked with to add programming support for UCD devices.

You should perform a sample programming run as early as possible, even before a final device configuration is locked down.

Follow the instructions in section 9.1, [Exporting Configuration Data Flash Hex File](#), to create a hex file for your programming vendor.

6.3 Downloading a Configuration via JTAG

JTAG ([Joint Test Action Group](#)) is the common name for the IEEE 1149.1 Standard Test Access Port and Boundary-Scan Architecture. In UCD devices JTAG provides debug facilities for device development within TI and EEPROM download by TI customers.

6.3.1 System Board Requirements

The JTAG pins (TMS, TDI, TDO, TCK) from the device must be accessible to the JTAG controller. The control and data lines (TMS, TDI, TDO) should be pulled high on the board.

If the device has a TRCK (return clock) pin and the JTAG controller supports that pin as well, the two should be connected. If the JTAG controller has a TRCK pin, but the device does not, the TRCK signal should be connected to the TCK signal on the board.

The nTRST signal should be high with programming the device via JTAG. It should be low for normal operation.

6.3.2 Overview of SVF

SVF ([Serial Vector Format](#)) is an ASCII-based standard for expressing test patterns that represent the stimulus, expected response, and mask data for JTAG-based configuration. SVF was selected because it allows Texas Instruments to create vendor-independent JTAG configuration patterns that are transportable across a wide selection of programming software and equipment.

For additional information, please refer to [IEEE 1149.1 Testability Primer](#).

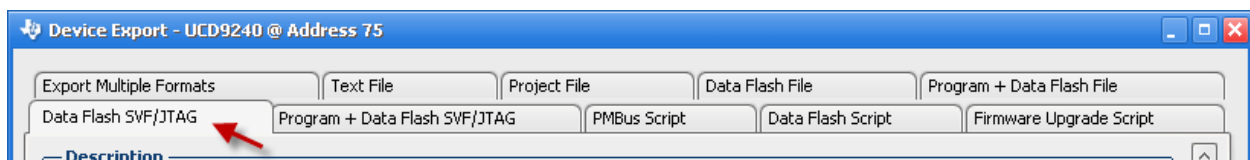
6.3.3 Differences Between IC Packages

Most UCD devices support JTAG. Typically, the PMBus address pins must be shorted to ground to enable the JTAG interface. Some exceptions are noted here:

- It is not necessary to short the PMBus address pins to ground when using the UCD9248
- Any 40 pin package does not support JTAG
- UCD3028 does not support JTAG
- The UCD device can be set to PMBus address 126 to leave JTAG always enabled. Note – using this method will disable use of the JTAG pins as GPIO in devices that support multiplexing of these pins. You must also ensure that no other device on the same PMBus could end up at address 126. For example, do not use this method when there are multiple UCD devices on the same PMBus.

6.3.4 Exporting Data Flash Configuration as SVF

The Fusion GUI's File->Export tool is used to generate an SVF file. You should use the "Data Flash SVF/JTAG" export mode:



The default options are:

Automatically save configuration to EEPROM before data flash export
 Checking this box will automatically perform a STORE_DEFAULT_ALL before every program + data flash export (but not before other exports).

Target controller/programmer:

Asset RIC-1000
 Asset USB-100
 Corelis
 GOEPEL electronic
 JTAG Technologies
 Teradyne
 Other / Custom

Enable scan chain shifting:

Instruction Register Shift: bits

Data Register Shift: bits

Create SVF that will FAIL validation
 The SVF will write a compliment of the flash image. Thus, the programming should fail during the write validation phase. Use this option to verify that your programmer halts with an error condition in this case.

Device validation:

Exact DEVICE_ID match (UCD90120|1.1.2.0000|091120)
 Major.Minor.Revision version match (UCD90120|1.1.2)
 Major.Minor version match (UCD90120|1.1)
 Major version match (UCD90120|1)
 Part/Package match only (UCD90120)
 Custom DEVICE_ID match:

The SVF file will verify that the device it is trying to program is compatible with the data flash image. When the SVF is executed, it will read the target device's DEVICE_ID and compare it against what you have selected above. We recommend you stick with the default, exact DEVICE_ID match. This will require that the exact same device/firmware version that you are currently connected to will be your programming target. You should only select one of the other choices if you have contacted Texas Instruments and verified that the memory map for your target device is compatible with the attached source device.

The diagram shows a central box labeled 'UCD90120'. To its left is a 'Pre Shift' register with a '0' and 'bits' label. To its right is a 'Post Shift' register with a '0' and 'bits' label. Below the Pre Shift register is an 'Instruction Register Shift' label with a '0' and 'bits' label. Below the Post Shift register is a 'Data Register Shift' label with a '0' and 'bits' label. The TDI pin is on the left and the TDO pin is on the right.

The SVF file will verify that the device it is trying to program is compatible with the data flash image. When the SVF is executed, it will read the target device's DEVICE_ID and compare it against what you have selected above. We recommend you stick with the default, exact DEVICE_ID match. This will require that the exact same device/firmware version that you are currently connected to will be your programming target. You should only select one of the other choices if you have contacted Texas Instruments and verified that the memory map for your target device is compatible with the attached source device.

It is recommend you export your configuration as a project file and data flash hex file at the same time you export SVF. See section 4.2, [Exporting to Multiple File Formats](#), for additional information. While the Fusion tools do not support importing SVF, they can import a data flash file, allowing write to data flash directly.

6.3.5 SVF Flow

The SVF performs the following steps when downloading configuration data:

- Erase data flash
- Write data flash
- Verify data flash

6.3.6 BSDL File

A BSDL ([Boundary Scan Description Language](#)) file is available for all UCD30xx-based devices that support JTAG. The file, ucd30xx.bsdl, is located in the misc folder within the Fusion GUI program directory. This is normally C:\Program Files\Texas Instruments Fusion Digital Power Designer\misc.

6.3.7 Supported TCK Frequencies

TCK frequencies up to 5 MHz have been tested using ASSET ScanWorks on a RIC-1000. 4 MHz has been tested on JTAG Technologies boundary scan controllers. For other programmers, you should start at 1 MHz and increase clock frequency until you experience programming errors. Thoroughly test the selected frequency, and consider decreasing the clock speed further to allow for variation in your manufacturing environment.

6.3.8 List of Tested Programmers

The following controllers have been tested and used to configure a device via JTAG (in alphabetical order):

- [ASSET](#)
Tested against USB-100 and RIC-1000 programmers.
- [Corelis](#)
Tested against all currently supported Corelis JTAG controllers, as of August 2010.
- [GOPEL Electronic](#)
Tested against SFX/USL1149-B controller. All SCANFLEX and ScanBooster controllers will support UCD devices. Requires SYSTEM CASCON software version 4.5.3c or higher.
- [JTAG Technologies](#)
Tested with JT 37x7 / TSI boundary scan controller. Other solutions should work as well.
- [Teradyne](#)
The SVF must be converted to a JTAG control language used by Teradyne. The conversion tool is called ISP 3.0.0. This is a tool written and maintained by Teradyne. SVF produced by the Fusion GUI has been tested and confirmed to work on the 2287LX test system, but should work on any of the Teradyne Test Station systems or the older GenRad 228X systems. While not tested, Teradyne Test Station SE and Spectrum systems should also accept converted files.
- Other In-Circuit Test (ICT) equipment
Most ICT equipment requires conversion from SVF to a proprietary format. Contact your ICT vendor for assistance.

6.3.9 Troubleshooting

If you are experiencing problems programming via JTAG, please review these troubleshooting hints and steps:

- Have you shorted the address lines to ground during JTAG programming?
- Is the nTRST signal high during JTAG programming?
- If the TRCK is used by the JTAG controller, is it connected to the TRCK signal on the device or the TCK signal?

6.3.10 Additional Information & Help

JTAG vendors should reference Appendix 8.6, Miscellaneous JTAG Questions, for additional information about device memory. Customers who need JTAG programming assistance should contact their TI representative.

6.4 Downloading Configuration Data Using a Microcontroller

Your system board microcontroller (μ c) could download a full or partial configuration to a device. This programming would be performed via I²C. The μ c could download one of the following:

- [A full configuration via data flash](#). More recent devices like the UCD90160, UCD9222, and UCD9244 permit update of the device's data flash while the device is operating normally. The device is reset to load the new configuration when download is complete. Other UCD devices require the device be sent to ROM mode before the data flash can be written. Thus, normal device operation is not possible in these devices during data flash download. [Section 6.4.2](#) lists which devices support Normal Mode data flash download and which require ROM Mode download.
- [A full configuration via PMBus](#). The μ c will assume the device configuration is in an unknown state or a factory virgin state. The full configuration will be written to the device through standard PMBus commands.
- [A partial configuration via PMBus](#). Your μ c assumes that some baseline configuration is in the device and writes an "update" to the device using PMBus commands.

It is recommended you read this entire section to understand the pros and cons of each approach.

6.4.1 SMBus / I²C Script Overview

Texas Instruments has developed a generic, platform independent method of describing the steps necessary to perform some of the above actions. This is dubbed a "script" and can take one of two forms:

- SMBus Script: describe a series of bus transactions in terms of the high-level System Management Bus (SMBus) protocol. This means "Send Byte", "Write Byte", etc.
- I²C Script: describes bus transactions in terms of the lower level I²C protocol.

Which you will use will depend on your microcontroller firmware development environment and APIs. You may already have an API stack that abstracts communication with devices like a UCD9240 in terms of SMBus. For example, to set the OPERATION command to 0x80 (On, No Margin) would mean issuing a Write Byte to command code 0x01 with data byte 0x80. And of course an address of the device is needed. A microcontroller SMBus API might define a function such as:

```
bool write_byte(byte address, byte cmd_code, byte data)
{
    ...
}
```

So sending the sample OPERATION command to address 12d would mean calling:

```
write_byte(0x0C, 0x01, 0x80);
```

Not shown here is specification of a Packet Error Check (PEC) byte. This might be an optional argument or some type of global construct: i.e. always attach PEC byte to writes for devices on the bus.

Any SMBus stack will ultimately communicate with the device in terms of I²C reads and writes. SMBus is simply a protocol layer on top of I²C. I²C packs the addressing information, command code, data, and optional PEC byte into a block of data. A bit is used to determine whether the request is a read or write.

In our example above, the OPERATION write byte with PEC appended would translate to an I2C write of:

Address, R/W Bit	Command Code	Data Byte	PEC Byte
0x18	0x01	0x80	0x6F

Scripts are created using the File->Export tool. All script export formats have the following options:

Script Style	Whether to output a script that performs writes in terms of high-level SMBus or low-level I ² C.
Store RAM to Flash?	Checking this box will automatically perform a STORE_DEFAULT_ALL before every firmware script export. If this is not checked, any changes you recently made to your config but did not write to non-volatile memory (dflash) will <u>not</u> be included in the script.
PEC	Only used for the I ² C format. Checking this will include the Packed Error Code byte in each I ² C write.
File Format	Choose between Comma Separated Value (CSV) and tab separated formats.
Hex Format	A variety of hex formats are supported.
Comment Style	A number of comment styles are supported. A comment proceeds each major section of the script, such as "Downloading data flash ..."
How to Handle Multiple Data Bytes	How to format the data field for an SMBus or I ² C write command. For example, WriteBlock accepts an array of 1+ bytes. By default – "compact together into one field" – this block of data is concatenated together in one field using the Hex Format style. As an alternative, you can select "break apart into separate fields" to break out the data bytes into different fields (columns).
Security	For devices that support Texas Instruments enhanced command security, you can chose to write a security password to data flash before doing the export. See the Security section of the Fusion Digital Power Designer User's Guide for more information about security.
Embedded Device Address	This option allows you to create a script that targets the device address used "in the field," should it differ from the device you are currently attached to.
Add block length byte to read block and write block commands in SMBus mode	Earlier versions of the GUI did not add block length to block reads/writes, and your parser would have to compute them. Export now includes block length by default. The option can be unchecked to create files in the old format.

See section 4, Configuration Export Overview, for additional tips on using the export tool.

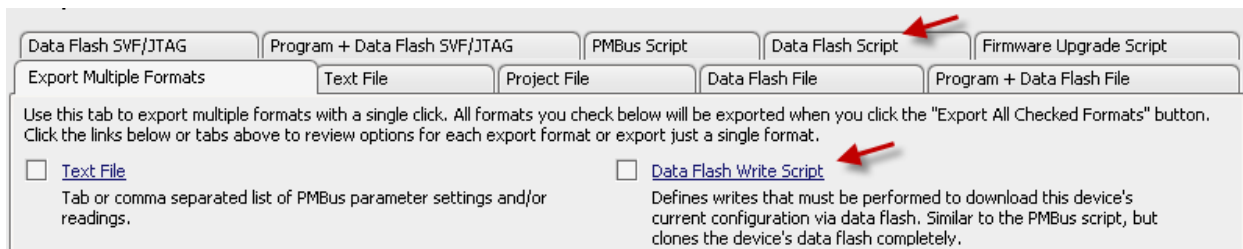
6.4.2 Microcontroller Writes Data Flash

Some UCD devices do not support data flash download while in normal operating mode. These devices must be sent to ROM mode to download a new data flash image. When in ROM mode, the device is not executing its normal firmware program and will not perform its primary function(s): power regulation, sequencing, monitoring, etc. The device will also not respond to system stimulus, such as a GPI state change or a fault condition. Thus, if your microcontroller or other critical component is powered by a rail on the UCD device, this configuration update process is not appropriate. See section 6.4.3 [Microcontroller Writes Full Configuration via PMBus](#) and section 6.4.4 [Microcontroller Writes Partial Configuration via PMBus](#) for alternatives that allow in-process configuration update on these devices.

Consult the following table to determine which data flash download scheme is supported by your device:

	ROM Mode	Normal Mode
Controllers		
UCD9211	✓	
UCD9212	✓	
UCD9220	✓	
UCD9222	✓	✓
UCD9224	✓	
UCD9240	✓	
UCD9244	✓	✓
UCD9246	✓	
UCD9248	✓	
Other Devices	✓	TBD
Sequencers		
UCD9090	✓	✓
UCD90120	✓	
UCD90124	✓	
UCD90120M	✓	
UCD90160	✓	✓
UCD90910	✓	✓
Other Devices	✓	✓

The “Data Flash Script” export format can be used to generate the recipe needed to write data flash to a device. The Export tool is launched from the Fusion GUI’s File menu, under “Export ...” The data flash script format is in the upper right corner of the form:



The data flash config script can only be generated in online mode. All the usual [caveats about firmware versioning](#) apply. The GUI will read the device’s current configuration from EEPROM and create a “script” detailing the steps your microcontroller must perform to update data flash. The GUI will automatically select the appropriate scheme – Normal Mode or ROM Mode – based on the device that is attached.

6.4.2.1 Microcontroller Writes Data Flash, Normal Mode Scheme

In this scheme, a new data flash image is written to the device while it continues to operate. The general recipe for writing data flash using this scheme is:

- Disable data flash write protection (normally the device does not allow data flash to be written to).
- Erase data flash.
- Write data flash.
- Verify data flash (read back).
- Reset the device.
- Verify that the device is running again (DEVICE_ID or other check).

The device will operate normally during the data flash download with one exception: data flash logging will not occur. For example, if your device supports fault logging, is configured to log a certain fault, and that fault occurs, the device will not log the fault to data flash. It will, however, continue to update status registers such as STATUS_VOUT.

An abbreviated example script is in section 9.5, [Data Flash Download Script Example – Normal Mode](#).

6.4.2.2 Microcontroller Writes Data Flash, ROM Mode Scheme

In this scheme, the device must be sent to ROM mode to write data flash. When in ROM mode, the device will not perform normal operations, such as power conversion, monitoring, or sequencing. The general recipe of writing to data flash is:

- Send the device to ROM mode.
- Erase data flash.
- Write data flash.
- Verify data flash (read back).
- Recreate the program flash checksum.
- Verify the program flash by comparing ROM calculated checksum against the checksum that was written.
- Issue a ROM command to execute the device program.
- Verify that the device is running again (DEVICE_ID or other check).

The sequence is complicated because of the need to send the device to ROM mode.

The firmware gets the device to ROM mode by clearing the program flash checksum and then resetting the device. After reset, the device will stay in ROM mode. UCD devices provide a MFR_SPECIFIC PMBus command to do this, ENABLE_ROM. When in ROM mode, the device responds at a hard coded address, 11d. You should therefore not use address 11 for any other devices on the same bus. When data flash write is completed, the program flash checksum will need to be recreated. Because flash memory can only be written when it is in an “erased” state, the script will erase an entire segment of program flash and then recreate it.

The UCD ROM requires a PEC byte on writes and always sends a PEC byte on reads. While devices in program mode (UCD9240, UCD9240, UCD90120, etc) do not require PEC, it is recommended if your I2C bus has excessive noise or other limitations.

An abbreviated example script for data flash download via ROM is in section 9.5, [Data Flash Download Script Example – ROM Mode](#).

6.4.3 Microcontroller Writes Full Configuration via PMBus

The Fusion GUI loads project files by writing to the device using PMBus commands. Your μc could do the same. The PMBus Script export format is used to generate the series of PMBus writes necessary to configure a device. The script generated is very “dumb”: it assumes the device is in a completely unconfigured state. For UCD92xx devices, the script will even reset the device, as this is required after setting the rail/phase configuration of the device.

A PMBus config script for a UCD9224 with two rails follows is included in section 9.7, [UCD9224 PMBus Config Script Example](#). A UCD90124 example is listed in section 9.7.2, [UCD90124 PMBus Config Script Example](#). PMBus scripts can be generated online or offline.

6.4.4 Microcontroller Writes Partial Configuration via PMBus

While updating a configuration in the field using the “full” configuration scripts described in section [6.4.2](#) and [6.4.3](#) is possible, with UCD92xx parts the device must be taken offline for a short period during the write sequence (to perform a soft reset). It is also likely that only a small number of parameters need to be updated. Thus, you may want to use a subset of the script export when writing a configuration update via your μc .

It is recommended you use one of the MFR_ commands to store a unique configuration identifier in each UCD device. For example, MFR_REVISION may have a configuration ID embedded within it, such as REVC. The μc firmware can use this to determine whether it needs to upgrade a configuration on a UCD device. The μc could store a “script” that would take the device from REVA or REVB to REVC.

The GUI does not include any tools to assist in generating such a configuration upgrade script. But generating a script for REVA and REVC, then doing a “diff” between the two will provide clues on what the upgrade script should do. [KDiff3](#) is an open-source, free file compare tool you can use.

6.4.5 Testing the Export Using the Script Runner Tool

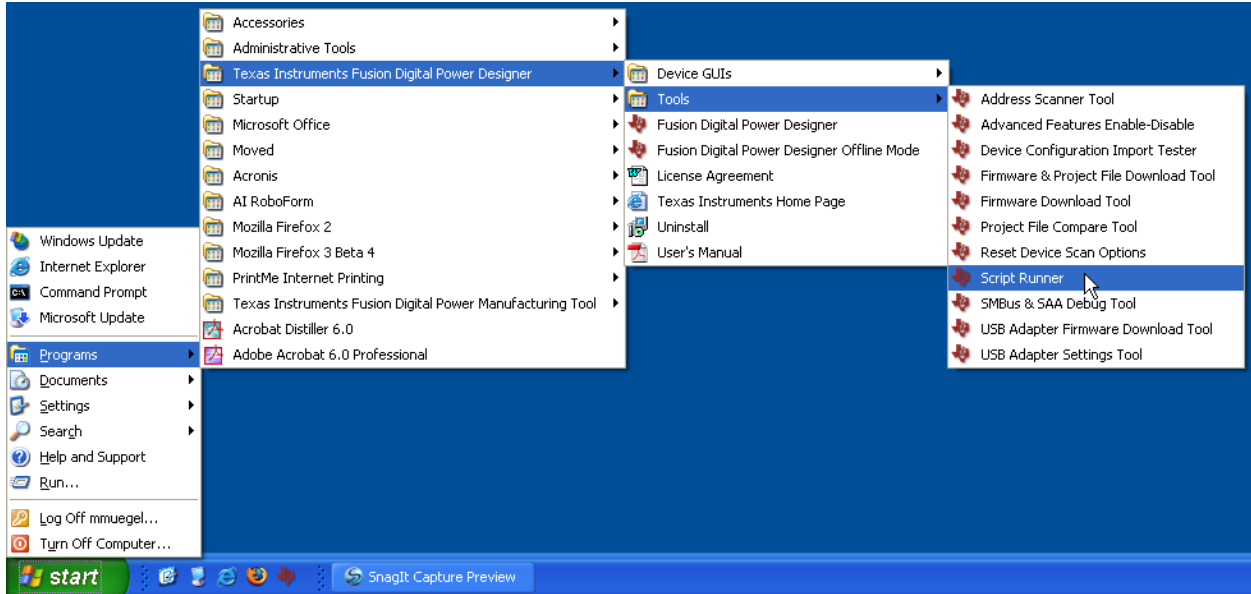
You can run scripts three ways:

- The File->Import wizard has a script option
- Use the stand alone Script Runner tool that is bundled in the Fusion GUI
- Use the FusionScriptRunner command line tool

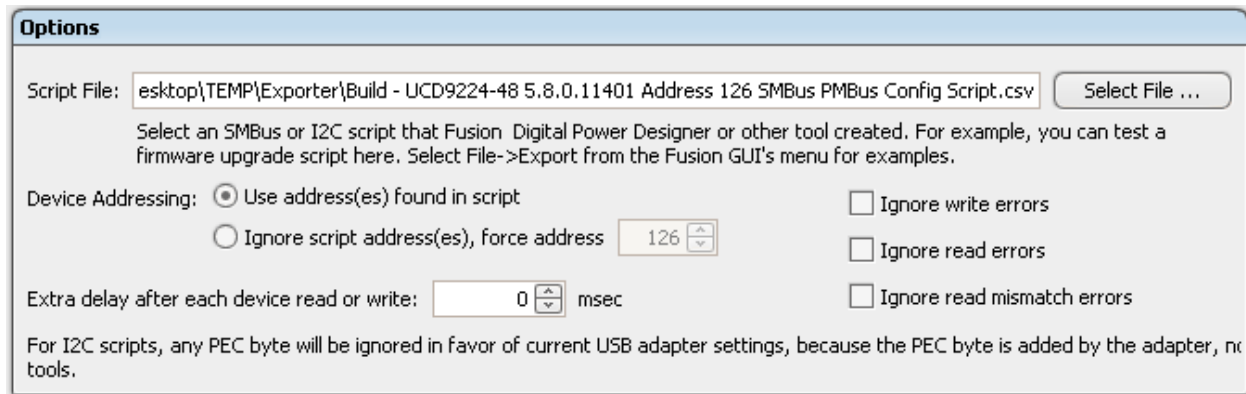
These tools will execute any script matching one of the SMBus/I²C script formats supported by the File→Export tool.

6.4.5.1 Script Runner GUI Tool

Launch the It is available from the GUI's Start Menu Tools folder:



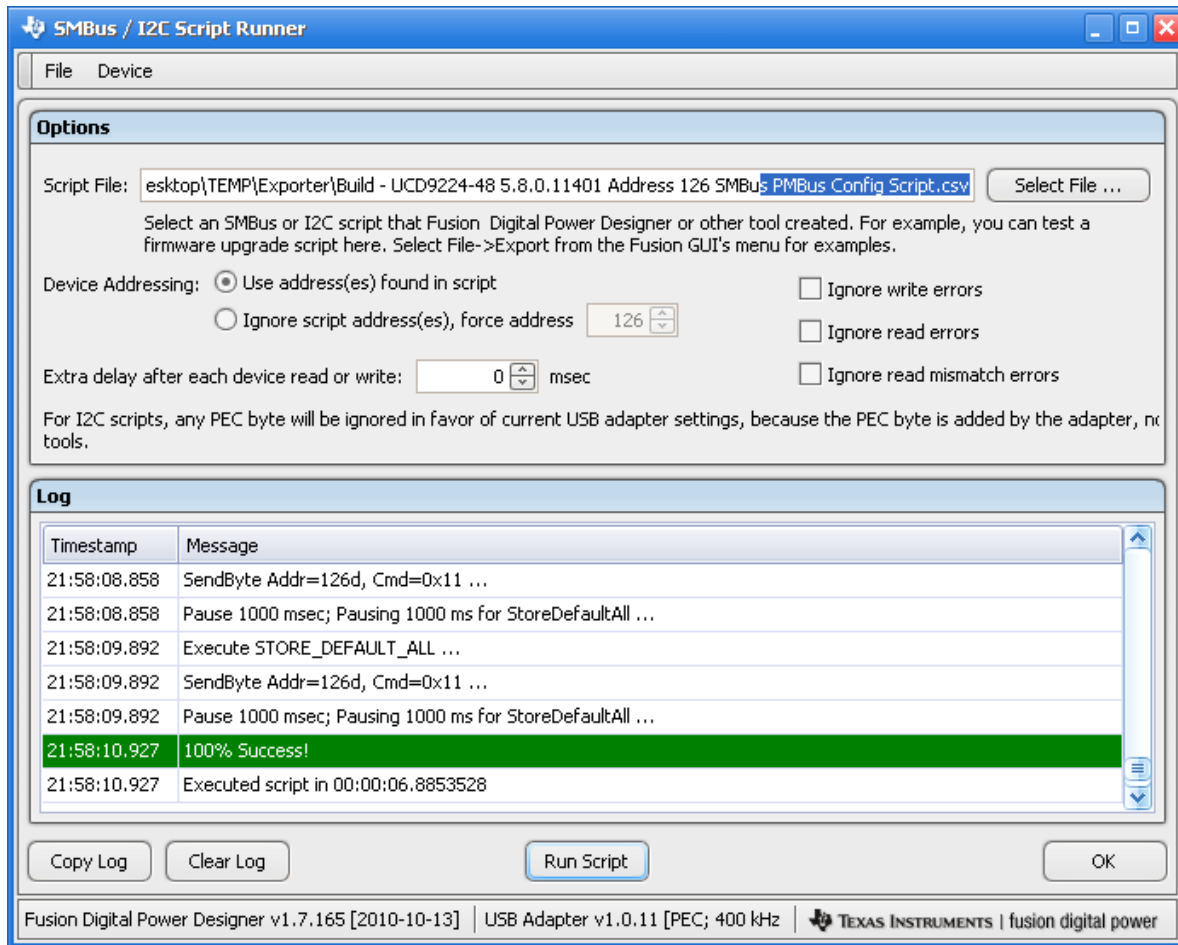
The tool has options to control how the script is executed:



The device address option will not work with [ROM mode data flash configuration](#) download scripts, because this mode uses two addresses:

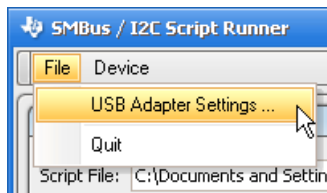
- One for the address the device runs on when in program mode
- A second, fixed at address 11d, for the address the device runs at when in ROM mode

As the script is run, a progress bar indicates how many of the script's steps have been performed. At the end of script execution, a log of every script action that was performed will be written to the log area. An example run is shown below:

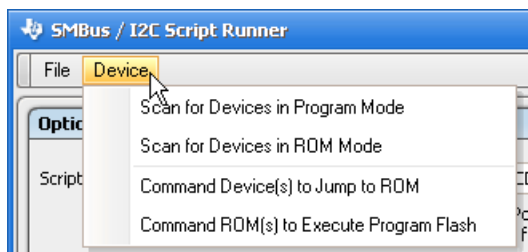


Scripts cannot be cancelled once they have started execution.

Although an I²C script may include a PEC byte, the PEC byte is actually ignored by the Script Runner. This is because the TI USB adapter handles adding the PEC byte to all SMBus and I2C writes. You can globally turn PEC mode on and off by adjusting the USB adapter's settings from the File menu:

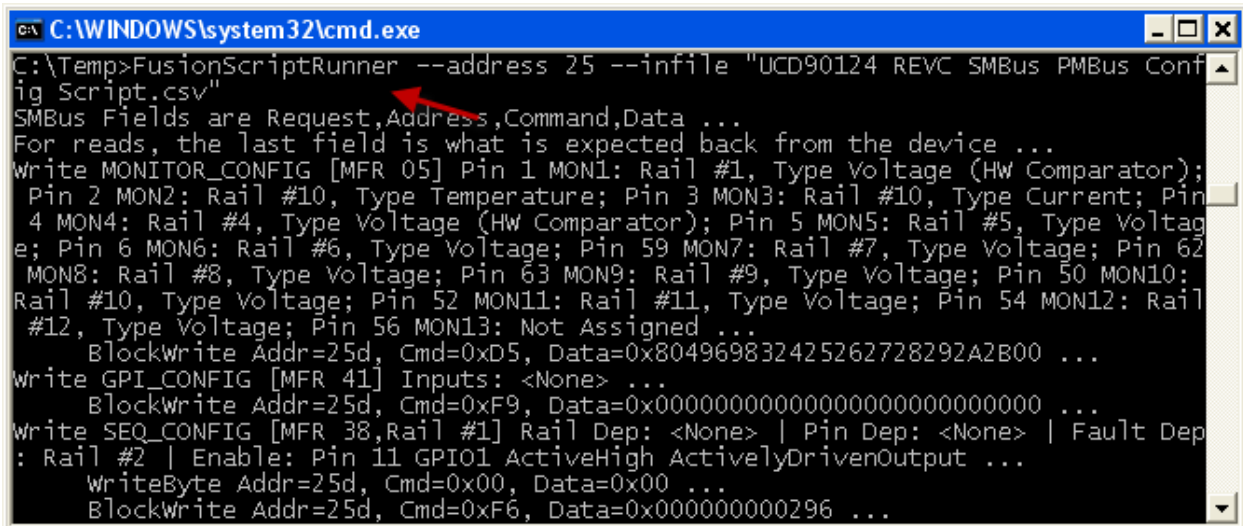


Script Runner also has several tools to scan for devices and command devices to jump to and from program/ROM modes:



6.4.5.2 FusionScriptRunner Command Line Tool

You can type FusionScriptRunner --help (two dashes) to display documentation. The tool accepts an optional --address argument similar to the Script Runner GUI. For example:



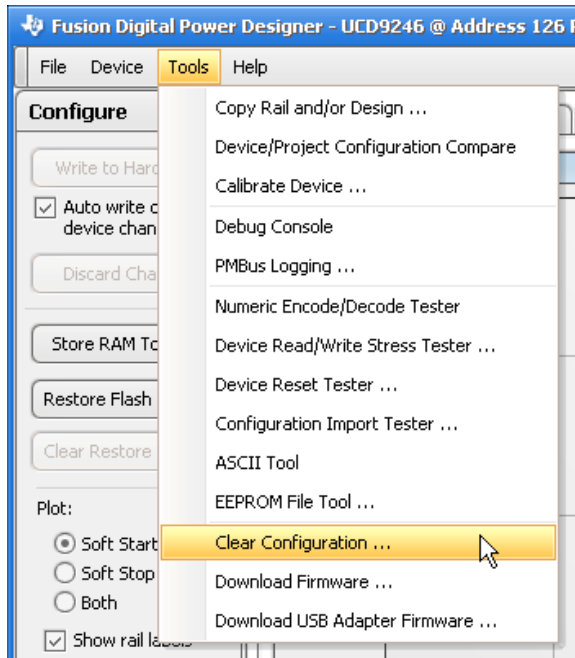
```
C:\WINDOWS\system32\cmd.exe
C:\Temp>FusionScriptRunner --address 25 --infile "UCD90124 REVC SMBus PMBus Config Script.csv"
SMBus Fields are Request,Address,Command,Data ...
For reads, the last field is what is expected back from the device ...
Write MONITOR_CONFIG [MFR 05] Pin 1 MON1: Rail #1, Type Voltage (HW Comparator);
Pin 2 MON2: Rail #10, Type Temperature; Pin 3 MON3: Rail #10, Type Current; Pin
4 MON4: Rail #4, Type Voltage (HW Comparator); Pin 5 MON5: Rail #5, Type Voltage; Pin 6 MON6: Rail #6, Type Voltage; Pin 59 MON7: Rail #7, Type Voltage; Pin 62
MON8: Rail #8, Type Voltage; Pin 63 MON9: Rail #9, Type Voltage; Pin 50 MON10:
Rail #10, Type Voltage; Pin 52 MON11: Rail #11, Type Voltage; Pin 54 MON12: Rail
#12, Type Voltage; Pin 56 MON13: Not Assigned ...
BlockWrite Addr=25d, Cmd=0xD5, Data=0x804969832425262728292A2B00 ...
Write GPI_CONFIG [MFR 41] Inputs: <None> ...
BlockWrite Addr=25d, Cmd=0xF9, Data=0x0000000000000000000000000000 ...
Write SEQ_CONFIG [MFR 38,Rail #1] Rail Dep: <None> | Pin Dep: <None> | Fault Dep
: Rail #2 | Enable: Pin 11 GPIO1 ActiveHigh ActivelyDrivenOutput ...
WriteByte Addr=25d, Cmd=0x00, Data=0x00 ...
BlockWrite Addr=25d, Cmd=0xF6, Data=0x000000000296 ...
```

If you do a lot of work with command line tools, we recommend you review the [Cygwin](#) toolset. It provides a Linux/UNIX-like environment for DOS, including a much-improved command shell.

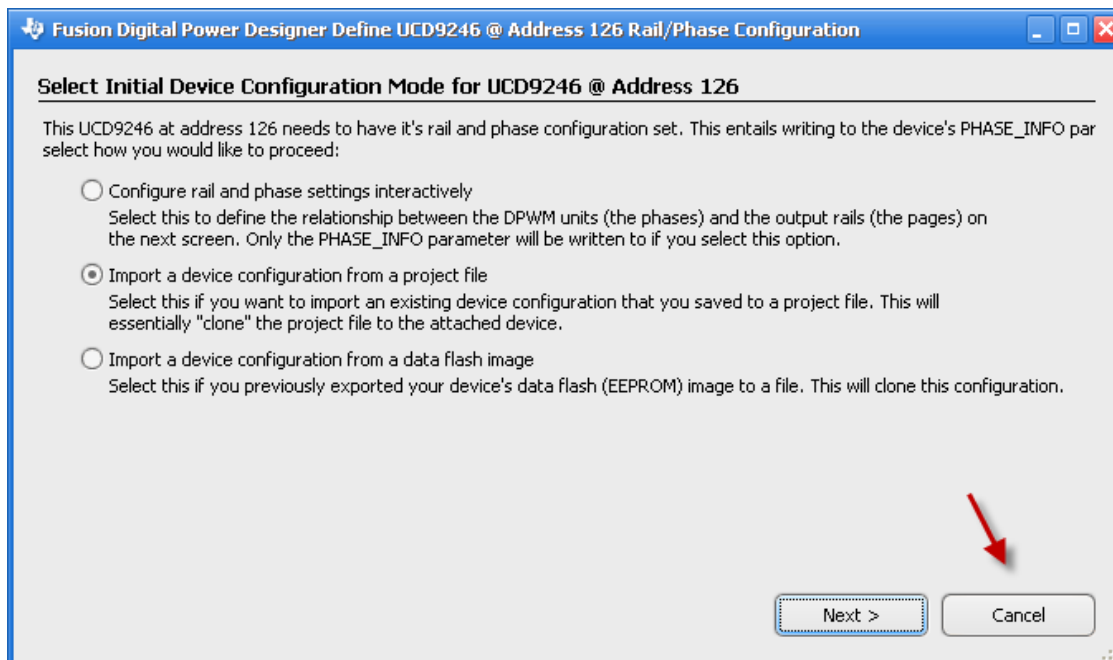
7 TIPS

When using Fusion tools, for optimal performance you should hook the TI USB adapter directly to your PC. Do not use a hub/dock of any kind, as this will significantly slow down write times.

You can clear a device's data flash through the Fusion GUI to simulate how a device will arrive from TI (un-configured). Select "Clear Configuration" from the Tools menu:



The GUI will restart after erasing data flash and writing the factory 1010... bit pattern. If you wanted to experiment with using tools other than the GUI to import data flash, simply Cancel the wizard that will appear after restart:



8 FREQUENTLY ASKED QUESTIONS (FAQs)

8.1 Why do I need to be connected to a device to export hex or SVF?

Texas Instruments digital power controllers and sequencers use the PMBus protocol to configure devices. This protocol acts as a middleman between the device's volatile memory (RAM), non-volatile memory (flash), and the host (GUI). The GUI writes a device configuration through a series of PMBus commands. For example, output voltage may be configured by the PMBus VOUT_COMMAND command, while turn on delay is configured by the PMBus TON_DELAY command.

When the host writes a configuration, it is actually not writing directly to flash memory. It is writing to volatile RAM memory. The device accepts incoming "write" requests for commands, and maps these to an area in RAM, possibly translating the configuration data written via PMBus to an internal device-specific format.

Because PMBus command writes are to volatile RAM memory, an engineer can test changes safely. If there is an error, they can recover their previous configuration by issuing a device reset. When the engineer determines that a configuration is valid, they can commit the configuration to non-volatile flash memory. This is done by issuing the special PMBus STORE_DEFAULT_ALL command. The device handles copying parts of RAM to flash memory.

Devices often store information in non-volatile and volatile memory differently than they are passed back and forth via PMBus. For example, the GUI writes VOUT_COMMAND as a 16 bit signed mantissa. The exponent is configured through another command, VOUT_CONFIG. The device does not store this in RAM or flash in the PMBus format. It stores it in a fixed point (Q math) representation.

This is only one example of the PMBus → device translation. Devices may change what information they store to flash, where they store it, and what the encoding of that information is between device release cycles. Due to this complexity, it is not possible for the Fusion tools to translate a project file to a data flash hex or SVF file.

See section 5, [Data Flash Considerations](#), for additional information.

8.2 Do I need to be connected to my system board to export data flash or SVF, or will any board do?

Normally you can export flash by connecting to any device that has the exact same IC package (pin count) and firmware version load that will be present at manufacturing. This can be an "open loop" board with a compatible UCD IC on it, with the production firmware loaded.

For example, if you are targeting a UCD9246 (64 pin) but have a UCD9240-64 open loop board available, you can:

- Download the production UCD9246 firmware to this board using the Firmware Download Tool
- Launch the Fusion GUI
- Import your project file
- Export data flash

Please contact your Texas Instruments representative if you need an open loop board to assist in programming activities.

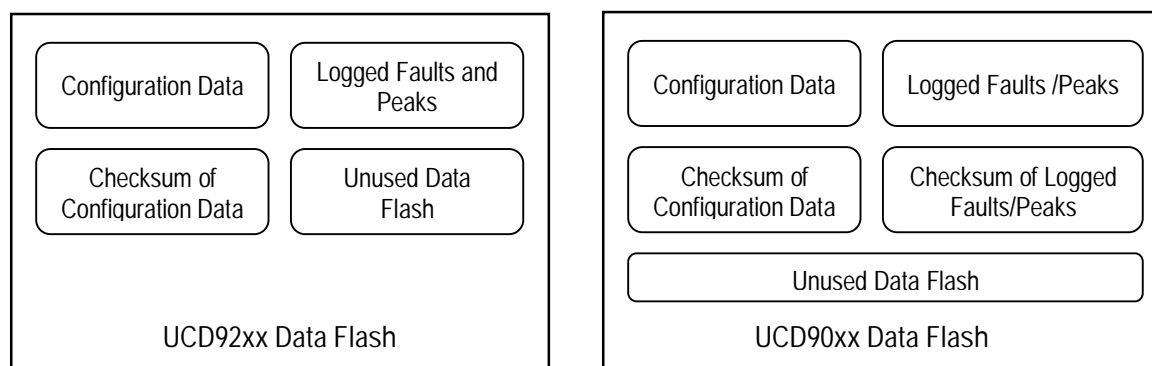
8.3 Is there a data flash checksum I can read to validate that the flash has been programmed correctly?

A checksum for the entire contents of data flash cannot be used to validate flash-based configuration programming. The UCD92xx and UCD90xx devices update data flash as part of their normal operation. For example, both have facilities to log faults and peak readings to data flash. Once the data flash has been downloaded and the device resumes normal operation, it is likely that the device will update flash on its own to log new peak readings. Thus, any data flash checksum calculated would be different from the checksum for the flash image that was downloaded.

Please see FAQ 8.4 and 8.5 for an explanation of internal (not host addressable) data flash checksum(s) that UCD devices maintain to ensure integrity of data flash. These FAQs also describe how the device responds to corrupt data flash conditions.

8.4 How does the device validate that its data flash has not been corrupted?

Each device maintains a checksum for the configuration section of data flash. Generically, data flash is segmented in the following way:



When the device powers up and executes its program, it computes the checksum of the configuration section of data flash. It compares this to the checksum section. If there is no match, this is an error condition and the device does the following:

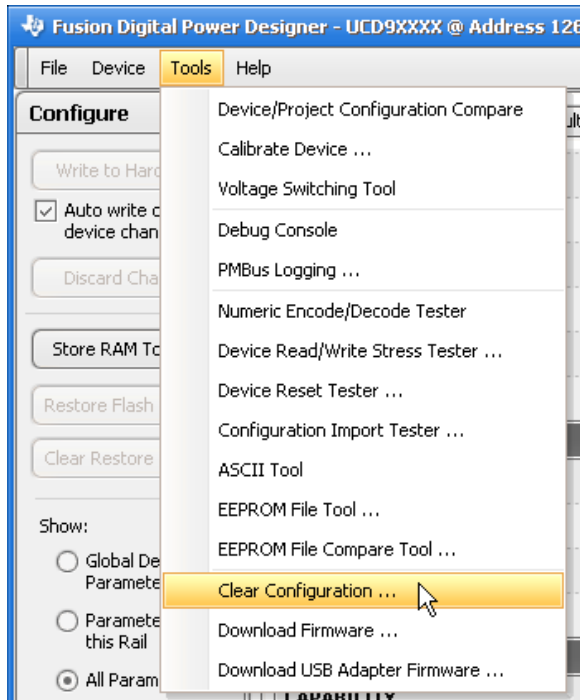
- The device loads a default configuration into operational memory (RAM). This is the configuration that is read and written via PMBus. This configuration is referred to as the HARDCODED PARMS configuration. The HARDCODED PARMS config does not have any rails, fans, GPOs, or GPIs defined (UCD92xx and UCD90xx) nor any monitors or PWMs defined (UCD90xx only). On the UCD92xx, the device will not convert power because no rails are defined. On the UCD90xx, the device will not perform any monitoring or sequencing operations because no rails/monitors have been defined.
- The configuration also loads default values for the MFR_XXX commands. For example:

<u>Command</u>	<u>Code</u>	<u>HARDCODED PARMS Value</u>
MFR_DATE	0x9D	YYMMDD
MFR_ID	0x99	MFR_ID
MFR_LOCATION	0x9C	MFR_LOCATION
MFR_MODEL	0x9A	MFR_MODEL
MFR_REVISION	0x9B	MFR_REVISION
MFR_SERIAL	0x9E	000000

These commands are implemented as read/write block commands. The text is ASCII encoded. Depending on the device, the defaults may be spaced padded to fill in the maximum size of the string.

- On the UCD92xx, bit 2 (“Hardcoded Parms”) in STATUS_MFR_SPECIFIC is asserted. On the UCD90xx, bit 2 (“Hardcoded Parms”) in MFR_STATUS is asserted.

You can force HARDCODED PARMS condition by erasing the device’s data flash. Fusion Digital Power Designer provides a built-in tool to erase data flash:



The GUI will restart after data flash is erased. Note that the GUI will detect that the device does not have any rails defined or configured. While you cannot launch the GUI in a full HARDCODED PARMS config, you can add a single rail and inspect/review the default configuration that was loaded into device RAM. For example, even if you add a single rail to the device, VOUT_COMMAND is still 0.0 V, no coefficients are loaded (UCD92xx), etc.

The data flash checksum is recreated each time STORE_DEFAULT_ALL is executed.

UCD90xx Sequencer and Health Monitor devices also have a checksum for the logged fault and peak reading data that it stores in data flash. The device updates this checksum whenever it logs a new fault or peak reading, or if the host clears faults or peaks through PMBus. The device validates this checksum at power-up. If the checksum does not match what it calculates, it will clear all logged faults and peak readings and assert bit 7 in MFR_STATUS, “Invalid Logs.”

8.5 How can I verify that my configuration programming process downloaded the correct file and the configuration was loaded by the device without error?

All of the configuration download techniques described in section 6, [Programming Options and Instructions](#), validate the programming:

- Fusion download tools:
 - During project file download, each command (VOUT_COMMAND, MFR_REVISION, etc.) is verified by reading the command back after the write and comparing against what was written.
 - During data flash hex file download, the data flash is read back and a bit-by-bit comparison is done to validate the data flash write.
- Dedicated EEPROM programmer: all devices listed in section 9.3, [Gang Programmer Notes](#), validate the programming by reading back the flash and comparing against the input hex file.
- JTAG/SVF: the SVF file that Fusion Digital Power Designer generates validates the flash write by reading back the contents of flash via JTAG and doing a bit-by-bit comparison against the downloaded flash image.

Per FAQ 8.4, on startup the device validates the configuration data using a checksum. If the checksum is not correct, the device loads a HARDCODED PARMS configuration and sets the MFR “Hardcoded Parms” status bit. Your microcontroller could look for this condition in any situation where the UCD device could be reset.

Another best practice is to save a unique ID for your configuration in one of the MFR_XXX PMBus commands. MFR_REVISION and MFR_MODEL are recommended. Your microcontroller or test system could inspect one or both of these commands to verify that the correct configuration has been loaded onto a UCD device. If you have multiple UCD devices in your system, you should put a device identifier of some kind in one of these MFR_XXX commands, to catch situations where a configuration was loaded on the wrong device.

As long as you set one of the MFR_XXX commands to a value that differs from the HARDCODED PARMS defaults defined in FAQ 8.4, validating one or more MFR_XXX command values is sufficient to validate that the device configuration data is 100% valid. Why? If the data flash was corrupt in any way, the HARDCODED PARMS config would have been loaded by the device and the MFR_XXX commands would contain the HARDCODED PARMS defaults.

8.6 Miscellaneous JTAG Questions

Q: What is the start address of RAM and the size?

From the ARM's point of view, the RAM is located at 0x19000. It is 4kB in size.

Q: Is there cache in the ARM core?

A: No. The program flash, data flash, and RAM are all single-cycle access – so, in a way, it is all cache.

Q: What are the address ranges for flash memory?

A: See table below:

Program Flash	0x00000000, 32kB	(Program Mode)
Program Flash	0x00010000, 32k	(ROM Mode)
Data Flash	0x00018800, 2kB	

Q: What registers control flash read/write?

A: See table below.

Program Flash Control Register (PFLASHCTRL)

Address FFFFFFFE60

Bit Number	11	10	9	8	7:5	4:0
Bit Name	BUSY	INFO_BLOCK_ENA	PAGE_ERASE	MASS_ERASE	RESERVED	PAGE_SEL
Access	R	R/W	R/W	R/W	R/W	R/W
Default	-	0	0	0	000	00000

Bit 11: BUSY – Program Flash Busy Indicator

0 = Program Flash available for read/write/erase access

1 = Program Flash unavailable for read/write/erase access

Bit 10: INFO_BLOCK_ENA – Program Flash Information Block Enable. Test use only.

0 = Access enabled to main memory block (Default)

1 = Access enabled to information block

Bit 9: PAGE_ERASE – Program Flash Page Erase Enable

0 = No Page Erase initiated on Program Flash (Default)

1 = Page Erase on Program Flash enabled. Page erased is based on PAGE_SEL (Bits 4-0). This bit is cleared upon completion of Page Erase cycle.

Bit 8: MASS_ERASE – Program Flash Mass Erase Enable

0 = No Mass Erase initiated on Program Flash (Default)

1 = Mass Erase of Program Flash enabled. This bit is cleared upon completion of Mass Erase cycle.

Bits 4-0: PAGE_SEL – Selects page to be erased during Page Erase Cycle

Data Flash Control Register (DFLASHCTRL)

Address FFFFFFFE64

Bit Number	11	10	9	8	7:6	5:0
Bit Name	BUSY	INFO_BLOCK_ENA	PAGE_ERASE	MASS_ERASE	RESERVED	PAGE_SEL
Access	R	R/W	R/W	R/W	-	R/W
Default	-	0	0	0	-	000000

Bit 11: BUSY – Data Flash Busy Indicator

0 = Data Flash available for read/write/erase access

1 = Data Flash unavailable for read/write/erase access

Bit 10: INFO_BLOCK_ENA – Data Flash Information Block Enable. Test use only.

0 = Access enabled to main memory block (Default)

1 = Access enabled to information block

Bit 9: PAGE_ERASE – Data Flash Page Erase Enable

0 = No Page Erase initiated on Data Flash (Default)

1 = Page Erase Cycle on Data Flash enabled. Page erased is based on PAGE_SEL (Bits 4-0). This bit is cleared upon completion of Page Erase cycle.

Bit 8: MASS_ERASE – Data Flash Mass Erase Enable

0 = No Mass Erase initiated on Data Flash (Default)

1 = Mass Erase of Data Flash enabled. Bit is cleared upon completion of mass erase.

Bits 5-0: PAGE_SEL – Selects page to be erased during Page Erase Cycle

Program Flash Interlock Register (PFLASHILOCK)

Address FFFFFFFE68

Bit Number	31:0
Bit Name	INTERLOCK_KEY
Access	R/W
Default	0000_0000_0000_0000_0000_0000_0000_0000

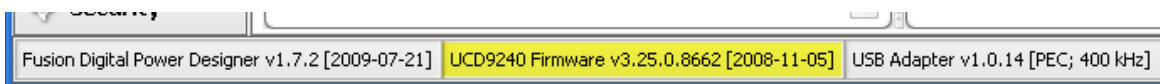
Bit 31-0: INTERLOCK_KEY – Program Flash Interlock Key. Register must be set to 0x42DC157E prior to every Program Flash write. If the Interlock Key is not set, the write to the Program Flash will not proceed. This register will clear upon the completion of a write to the Program Flash.

9 APPENDICES

9.1 Exporting Configuration Data Flash Hex File

If you will be doing data flash-based configuration programming, you will normally need to prepare a data flash file. This can only be done by connecting to a UCD IC device in “online” mode. There is no way to convert an XML project file to a data flash hex file. Please follow these steps:

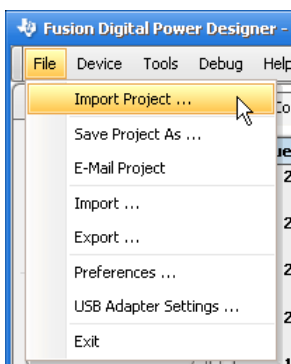
1. Attach the TI USB-TO-GPIO adapter to your PC.
2. Launch the Fusion Digital Power Designer software.
3. Verify that the device and firmware version reported in the footer of the GUI matches the device that will ultimately be programmed:



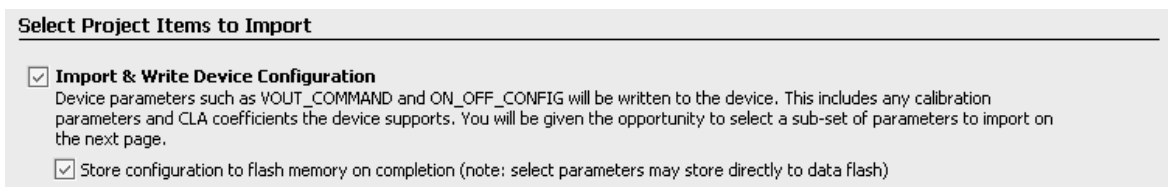
Section [9.2](#) lists the firmware version numbers for all production (released to manufacturing) UCD devices that the GUI supports. If you do not see your device listed or the firmware version on your device does not match what is listed in the table, please contact your Texas Instruments representative immediately and do not proceed further. Per section 5, [Data Flash Considerations](#), configuration “layout” in data flash varies for each device and can vary for different firmware builds within a device. For example, if you have prototype boards running pre-production firmware, may not be able to use data flash exported from this board and program on production ICs.

4. Optionally, if this device’s configuration does not match the configuration you want to export, you should import/write your project file to the device.

Select File->Import Project:

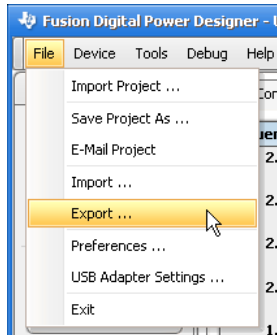


Select your file and click Next. Ensure that the following options are checked:

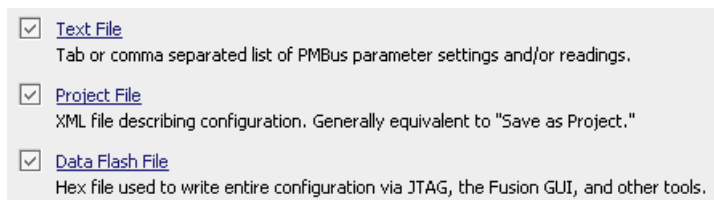


Click Next. On the next screen, click the “Write Check” button. This will update the device’s configuration to match the project file.

5. Export your configuration to data flash. Select File->Export:

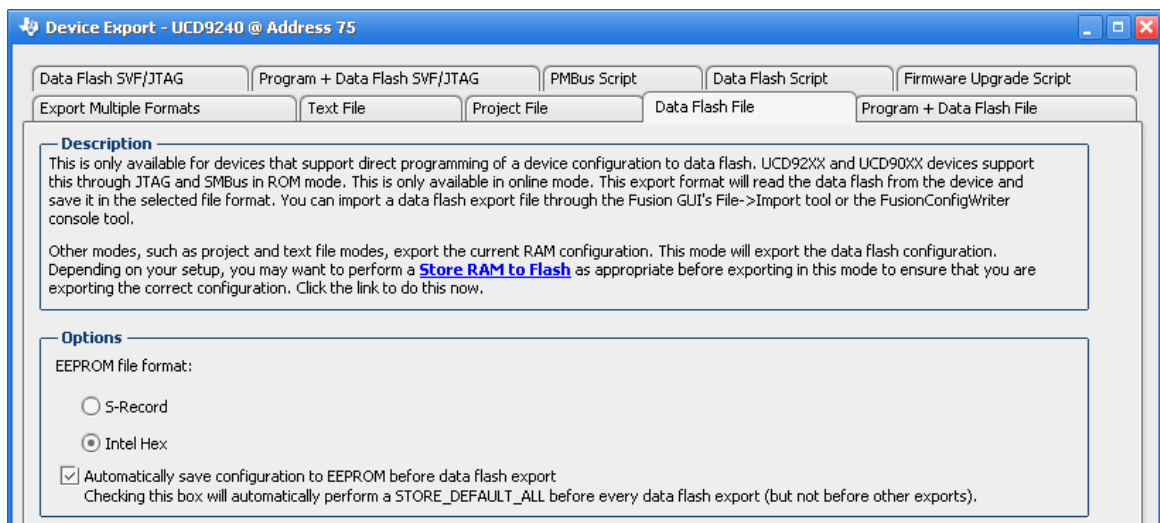


The export tool has a number of export formats. You want to export the “Data Flash File” format. The first tab, “Export Multiple Formats,” allows for the easy export of more than one format. For example, a text file summary, a project file, and a data flash file. We recommend doing this so you can archive all three ways of describing the device configuration:



Before proceeding, you need to configure the data flash export. Your vendor may require the hex be formatted in a certain format. The GUI supports Motorola S-Record and Intel Hex formats. The default is S-Record. See section 9.3 for a list of recommended formats for gang programmers that are known to support UCD devices. If you do not know what gang programmer will be used or it is not listed, please have your vendor contact your Texas Instruments representative.

To change the data flash format, click the “Data Flash File” tab:



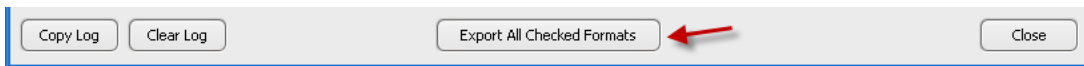
The checkbox can be left checked. In the previous step of importing the project file, the configuration was written to data flash, but doing so a second time will not have any negative effect and will slow the export minimally.

You can also review the Text and Project File export options.

One final area to review is the output folder and filename template. This is in the “Output Destination” area of the form:

Change the filename template to suit your project naming conventions; however, it is recommended you keep the {PN}, {PKG}, and {DA} “macros”. In the example above, “210434-02” is a part identifier to be assigned to the programmed IC. You also should keep the {EF} macro if you are exporting multiple formats. It will be used to differentiate between export formats along with the filename extension, {EXT}. The Preview area shows what the actual filename will be for the selected export format.

When ready, click back to the “Export Multiple Formats” tab and click the this button:



In the example above, three files will be saved on the Desktop:

Address		
C:\Documents and Settings\{a0271759}\Desktop		
Name	Size	Type
210434-02 (UCD9240-64 3.25.0.8662) DataFlash.hex	5 KB	HEX File
210434-02 (UCD9240-64 3.25.0.8662) Text.csv	22 KB	Microsoft Office Exc...
210434-02 (UCD9240-64 3.25.0.8662) Project.xml	415 KB	XML Document

Archive these files and send your vendor the hex file.

9.2 Firmware Versions, Program Flash Checksums for Released Devices

Device	Pkg	Program Flash Checksum	DEVICE_ID
UCD9211	40	0x0031618B	UCD9211-40 4.43.0.11457 091207 0x554344393231312D34307C342E34332E302E31313435377C30393132303700
UCD9212	40	0x002F48CB	UCD9212-40 4.42.0.11412 091113 0x554344393231322D34307C342E34322E302E31313431327C30393131313300
UCD9220	48	0x002F90AE	UCD9220-48 3.26.0.9077 090127 0x554344393232302D34387C332E32362E302E393037377C30393031323700
UCD9224	48	0x002D4975	UCD9224-48 5.8.0.11401 091112 0x554344393232342D34387C352E382E302E31313430317C30393131313200
UCD9240-64	64	0x002D320F	UCD9240-64 3.25.0.8662 081105 0x554344393234302D36347C332E32352E302E383636327C30383131303500
UCD9240-80	80	0x002D2539	UCD9240-80 3.24.0.8163 080915 0x554344393234302D38307C332E32342E302E383136337C30383039313500
UCD9246	64	0x002C4FDB	UCD9246-64 5.7.0.11359 091029 0x554344393234362D36347C352E372E302E31313335397C30393130323900
UCD9248	80	0x002C5D61	UCD9248-80 5.8.0.11400 091112 0x554344393234382D38307C352E382E302E31313430307C30393131313200
UCD90120	64	0x0037EA60	UCD90120 1.1.2.0000 091120 0x55434439303132307C312E312E322E303030307C30393131323000
UCD90124	64	0x002F8A04	UCD90124 1.1.2.0000 091120 0x55434439303132347C312E312E322E303030307C30393131323000

9.3 Gang Programmer Notes

Vendor	Notes
System General	<p>Support UCD9240-64 and UCD9240-80 data flash programming. Also support program flash + data flash programming to UCD92xx, UCD3020, and any UCD3000-based IC. Export in Intel Hex format.</p> <p>Known supported models: T9x00 (T9200, T9600, T9800, etc); APxxx (AP600, AP700, AP900, etc). In general if the socket is supported, SG programmer should support with up-to-date SG software release.</p>

9.4 Comparison of Write Times

Target device: UCD9240.

Tool	Write Time	Read Back Validation Performed?
FusionConfigWriter console tool --df flash mode --project mode	6.8 sec 5.0 sec	Yes
MFR GUI task Data flash task Project file task	5.5 sec 10.2 sec	Yes
ASSET USB-100	~ 30 sec	Yes
ASSET RIC-1000	~ 10 sec	Yes
System General 9x00	22 sec	Yes

9.5 Data Flash Download Script Example – Normal Mode

```

Comment,Format=CSV; Hex=CoderUpper; BreakOutBytes=False; IncludeBlockLength=True [DO NOT
REMOVE THIS LINE IF YOU WANT TO IMPORT USING A FUSION TOOL]
Comment,"SMBus Fields are Request,Address,Command,Data"
Comment,"For reads, the last field is what is expected back from the device"
Comment,"Verifying DEVICE_ID matches expected firmware [""UCD90160|2.2.15.0000|100924""]"
BlockRead,0x7E,0xFD,0x1C55434439303136307C322E322E31352E303030307C31303039323400
Comment,Clearing data flash write protect bit; any flash logging will be disabled until device reset ...
BlockWrite,0x7E,0xE2,0x050400000104
BlockWrite,0x7E,0xE3,0x0400008820
Comment,Erasing data flash ...
Pause,250,Pausing 250 ms
BlockWrite,0x7E,0xE2,0x050414000104
BlockWrite,0x7E,0xE3,0x0400000100
Pause,250,Pausing 250 ms
Comment,Writing data flash in 4 byte chunks ...
BlockWrite,0x7E,0xE2,0x050200000104
BlockWrite,0x7E,0xE3,0x04064D4652
Pause,0.2,Pausing 0.2 ms for UCD3000FlashWrite
BlockWrite,0x7E,0xE2,0x050201000104
BlockWrite,0x7E,0xE3,0x045F494420
...
BlockWrite,0x7E,0xE2,0x0502FE010104
BlockWrite,0x7E,0xE3,0x04FFFFFFFF
Pause,0.2,Pausing 0.2 ms for UCD3000FlashWrite
BlockWrite,0x7E,0xE2,0x0502FF010104
BlockWrite,0x7E,0xE3,0x04FFFFFFFF
Pause,0.2,Pausing 0.2 ms for UCD3000FlashWrite
Comment,Verifying data flash
BlockWrite,0x7E,0xE2,0x050200001001
BlockRead,0x7E,0xE3,0x10064D46525F49442020202020202020
BlockWrite,0x7E,0xE2,0x050210001001
BlockRead,0x7E,0xE3,0x10202020084D554547454C20334C202020
...
BlockWrite,0x7E,0xE2,0x0502E0071001
BlockRead,0x7E,0xE3,0x10FFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF
BlockWrite, 0x7E,0xE2,0x0502F0071001
BlockRead, 0x7E,0xE3,0x10FFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF
Comment,Resetting the device
SendByte,0x7E,0xDB
Pause,1500,Waiting for UCD90160 program to startup
Comment,"Verifying DEVICE_ID matches expected firmware [""UCD90160|2.2.15.0000|100924""]"
BlockRead,0x7E,0xFD,0x1C55434439303136307C322E322E31352E303030307C31303039323400

```


Pause,0.2,Pausing 0.2 ms for UCD3000FlashWrite
Comment,Having ROM calculate the program flash checksum ...
BlockWrite,0x0B,0xEF,0x0800017FFC00000004
Pause,1000,Give ROM time to read flash
Comment,Verifying checksum ROM calculated matches what we wrote ...
BlockWrite,0x0B,0xFD,0x0400017FFC
BlockRead,0x0B,0xFA,0x04002C55D6
Comment,Sending the device to program mode via ROM mode command
Comment,Executing program ...
SendByte,0x0B,0xF0
Pause,1500,Waiting for UCD9246 program to startup
Comment,"Verifying DEVICE_ID matches expected firmware [""UCD9246-64|5.6.0.11220|090922""]"
BlockRead,0x7E,0xFD,0x1E554344393234362D36347C352E362E302E31313232307C30393039323200


```
WriteByte,0x7E,0xD6,0x00
Comment,"Write DRIVER_MIN_PULSE [MFR 15,Rail #1] 50 ns"
WriteWord,0x7E,0xDF,0x20E3
Comment,"Write EADC_SAMPLE_TRIGGER [MFR 07,Rail #1] 228 ns"
WriteWord,0x7E,0xD7,0x90F3
Comment,"Write FAST_OC_FAULT_LIMIT [MFR 39,Rail #1] 15.00 A/Phase"
WriteWord,0x7E,0xF7,0xC0D3
Comment,Write IOUT_OC_FAULT_LIMIT [Rail #1] 12.50 A
WriteWord,0x7E,0x46,0x20D3
Comment,"Write IOUT_OC_FAULT_RESPONSE [Rail #1] Response=2,Restart=0,Delay=0"
WriteByte,0x7E,0x47,0x80
Comment,Write IOUT_OC_LV_FAULT_LIMIT [Rail #1] 2.175 V
WriteWord,0x7E,0x48,0xCC22
Comment,"Write IOUT_OC_LV_FAULT_RESPONSE [Rail #1] Response=2,Restart=0,Delay=0"
WriteByte,0x7E,0x49,0x80
Comment,Write IOUT_OC_WARN_LIMIT [Rail #1] 10.50 A
WriteWord,0x7E,0x4A,0xA0D2
Comment,Write IOUT_UC_FAULT_LIMIT [Rail #1] -5.00 A
WriteWord,0x7E,0x4B,0x80CD
Comment,"Write IOUT_UC_FAULT_RESPONSE [Rail #1] Response=0,Restart=0,Delay=0"
WriteByte,0x7E,0x4C,0x00
Comment,"Write LIGHT_LOAD_CONFIG [MFR 29,Rail #1] CLA Gain Control: NormalLoad; Phase Control:
NormalLoad; Num Light Load Phases: 1"
WriteByte,0x7E,0xED,0x00
Comment,"Write LIGHT_LOAD_LIMIT_HIGH [MFR 27,Rail #1] 0.00 A"
WriteWord,0x7E,0xEB,0x0080
Comment,"Write LIGHT_LOAD_LIMIT_LOW [MFR 38,Rail #1] 0.00 A"
WriteWord,0x7E,0xF6,0x0080
Comment,Write OT_FAULT_LIMIT [Rail #1] 125 C
WriteWord,0x7E,0x4F,0xE8EB
Comment,"Write OT_FAULT_RESPONSE [Rail #1] Response=2,Restart=0,Delay=0"
WriteByte,0x7E,0x50,0x80
Comment,Write OT_WARN_LIMIT [Rail #1] 85 C
WriteWord,0x7E,0x51,0xA8EA
Comment,"Write PHASE_DROP_CAL [MFR 42,Rail #1] 1.000 "
WriteWord,0x7E,0xFA,0x00BA
Comment,Write POWER_GOOD_OFF [Rail #1] 2.125 V
WriteWord,0x7E,0x5F,0x0022
Comment,Write POWER_GOOD_ON [Rail #1] 2.250 V
WriteWord,0x7E,0x5E,0x0024
Comment,"Write SEQ_TIMEOUT [MFR 00,Rail #1] 0.0 ms"
WriteWord,0x7E,0xD0,0x0080
Comment,"Write SYNC_OFFSET [MFR 43,Rail #1] 0 ns"
WriteWord,0x7E,0xFB,0x0000
Comment,"Write TEMP_BALANCE_IMIN [MFR 37,Rail #1] 511.50 A"
WriteWord,0x7E,0xF5,0xFFFFB
Comment,"Write THERMAL_COEFF [MFR 13,Rail #1] 0.000 %/C"
WriteWord,0x7E,0xDD,0x0080
Comment,Write TOFF_DELAY [Rail #1] 0.0 ms
WriteWord,0x7E,0x64,0x0080
Comment,Write TOFF_FALL [Rail #1] 10.0 ms
```

```
WriteWord,0x7E,0x65,0x80D2
Comment,Write TOFF_MAX_WARN_LIMIT [Rail #1] <No Limit>
WriteWord,0x7E,0x66,0xFF7F
Comment,Write TON_DELAY [Rail #1] 0.0 ms
WriteWord,0x7E,0x60,0x0080
Comment,Write TON_MAX_FAULT_LIMIT [Rail #1] <No Limit>
WriteWord,0x7E,0x62,0x0080
Comment,"Write TON_MAX_FAULT_RESPONSE [Rail #1] Response=3,Restart=0,Delay=0"
WriteByte,0x7E,0x63,0xC0
Comment,Write TON_RISE [Rail #1] 10.0 ms
WriteWord,0x7E,0x61,0x80D2
Comment,"Write TRACKING_MODE [MFR 22,Rail #1] Off"
WriteByte,0x7E,0xE6,0x80
Comment,"Write TRACKING_SCALE_MONITOR [MFR 23,Rail #1] 1.000 "
WriteWord,0x7E,0xE7,0x00BA
Comment,"Write VOUT_CAL_MONITOR [MFR 01,Rail #1] -0.010 V"
WriteWord,0x7E,0xD1,0xD9FF
Comment,Write VOUT_CAL_OFFSET [Rail #1] 0.020 V
WriteWord,0x7E,0x23,0x5300
Comment,Write VOUT_COMMAND [Rail #1] 2.500 V
WriteWord,0x7E,0x21,0x0028
Comment,Write VOUT_MARGIN_HIGH [Rail #1] 2.625 V
WriteWord,0x7E,0x25,0x002A
Comment,Write VOUT_MARGIN_LOW [Rail #1] 2.375 V
WriteWord,0x7E,0x26,0x0026
Comment,Write VOUT_OV_FAULT_LIMIT [Rail #1] 2.875 V
WriteWord,0x7E,0x40,0x002E
Comment,"Write VOUT_OV_FAULT_RESPONSE [Rail #1] Response=0,Restart=0,Delay=0"
WriteByte,0x7E,0x41,0x00
Comment,Write VOUT_OV_WARN_LIMIT [Rail #1] 2.750 V
WriteWord,0x7E,0x42,0x002C
Comment,Write VOUT_SCALE_LOOP [Rail #1] 0.439
WriteWord,0x7E,0x29,0x84AB
Comment,Write VOUT_SCALE_MONITOR [Rail #1] 0.441
WriteWord,0x7E,0x2A,0x87AB
Comment,Write VOUT_TRANSITION_RATE [Rail #1] 0.303 mV/us
WriteWord,0x7E,0x27,0x6CAA
Comment,Write VOUT_UV_FAULT_LIMIT [Rail #1] 2.125 V
WriteWord,0x7E,0x44,0x0022
Comment,"Write VOUT_UV_FAULT_RESPONSE [Rail #1] Response=0,Restart=0,Delay=0"
WriteByte,0x7E,0x45,0x00
Comment,Write VOUT_UV_WARN_LIMIT [Rail #1] 2.250 V
WriteWord,0x7E,0x43,0x0024
Comment,Write IOUT_CAL_GAIN_1 [Rail #1] 128.25 mohm
WriteWord,0x7E,0x38,0x01F2
Comment,Write IOUT_CAL_OFFSET_1 [Rail #1] 0.00 A
WriteWord,0x7E,0x39,0x0080
Comment,"Write TEMPERATURE_CAL_GAIN_1 [MFR 20,Rail #1] 125.0 C/V"
WriteWord,0x7E,0xE4,0xE8EB
Comment,"Write TEMPERATURE_CAL_OFFSET_1 [MFR 21,Rail #1] -65.00 C"
WriteWord,0x7E,0xE5,0xF8ED
```

```
// Begin write of rail #2 parameters
Comment,Write VOUT_MAX [Rail #2] 1.380 V
// Set PAGE to rail #2
WriteByte,0x7E,0x00,0x01
WriteWord,0x7E,0x24,0x1416
Comment,"Write ON_OFF_CONFIG [Rail #2] OperationOnly, UseDelay, ActiveHigh"
WriteByte,0x7E,0x02,0x1A
...
Comment,Store configuration to data flash
Comment,Execute STORE_DEFAULT_ALL
SendByte,0x7E,0x11
Pause,1000,Pausing 1000 ms for StoreDefaultAll
Comment,Execute STORE_DEFAULT_ALL
SendByte,0x7E,0x11
Pause,1000,Pausing 1000 ms for StoreDefaultAll
```

The extra STORE_DEFAULT_ALL provides a work around for a UCD9220/UCD9240 bug. When data flash was in its factory default state, the first STORE_DEFAULT_ALL would not function properly. The second STORE_DEFAULT_ALL would. This double STORE_DEFAULT_ALL is done in a low-level API and may therefore be done more than necessary.


```
WriteByte,0x7E,0xF5,0x00
...
Comment,"Write MARGIN_CONFIG [MFR 37,Rail #12] Margin Enable: False; Calibrated: False; Ignore Faults: False;
PWM Pin: ID 0, # 17 FPWM1_GPIO5"
WriteByte,0x7E,0x00,0x0B
WriteByte,0x7E,0xF5,0x00
Comment,Write GPIO_CONFIG_0 [MFR 43] Enable: False; Out_Enable: False; Out_Value: False; Status: False
WriteByte,0x7E,0xFA,0x00
WriteByte,0x7E,0xFB,0x00
...
Comment,Write GPIO_CONFIG_17 [MFR 43] Enable: False; Out_Enable: False; Out_Value: False; Status: False
WriteByte,0x7E,0xFA,0x11
WriteByte,0x7E,0xFB,0x00
// VOUT_MODE defines the exponent for VOUT related commands on each rail
Comment,Write VOUT_MODE [Rail #1] EXP -12
WriteByte,0x7E,0x00,0x00
WriteByte,0x7E,0x20,0x14
...
Comment,Write VOUT_MODE [Rail #12] EXP -12
WriteByte,0x7E,0x00,0x0B
WriteByte,0x7E,0x20,0x14
Comment,Write FAN_COMMAND_1 0.0 %
WriteWord,0x7E,0x3B,0x0088
Comment,Write FAN_COMMAND_2 0.0 %
WriteWord,0x7E,0x3C,0x0088
Comment,Write FAN_COMMAND_3 0.0 %
WriteWord,0x7E,0x3E,0x0088
Comment,Write FAN_COMMAND_4 0.0 %
WriteWord,0x7E,0x3F,0x0088
Comment,"Write LOGGED_FAULT_DETAIL_ENABLES [MFR 31] Common:
LOG_NOT_EMPTY,RESERVED1,RESEQUENCE_ERROR,WATCHDOG_TIMEOUT,FAN_1,FAN_2,FAN_3,FAN_4;
Rail #1:
VOUT_OV,VOUT_UV,TON_MAX,IOUT_OC,IOUT_UC,TEMPERATURE_OT,SEQ_TIMEOUT,SLAVED_FAULT; Rail
#2: VOUT_OV,VOUT_UV,TON_MAX,IOUT_OC,IOUT_UC,TEMPERATURE_OT,SEQ_TIMEOUT,SLAVED_FAULT;
Rail #3:
VOUT_OV,VOUT_UV,TON_MAX,IOUT_OC,IOUT_UC,TEMPERATURE_OT,SEQ_TIMEOUT,SLAVED_FAULT; Rail
#4: VOUT_OV,VOUT_UV,TON_MAX,IOUT_OC,IOUT_UC,TEMPERATURE_OT,SEQ_TIMEOUT,SLAVED_FAULT;
Rail #5:
VOUT_OV,VOUT_UV,TON_MAX,IOUT_OC,IOUT_UC,TEMPERATURE_OT,SEQ_TIMEOUT,SLAVED_FAULT; Rail
#6: VOUT_OV,VOUT_UV,TON_MAX,IOUT_OC,IOUT_UC,TEMPERATURE_OT,SEQ_TIMEOUT,SLAVED_FAULT;
Rail #7:
VOUT_OV,VOUT_UV,TON_MAX,IOUT_OC,IOUT_UC,TEMPERATURE_OT,SEQ_TIMEOUT,SLAVED_FAULT; Rail
#8: VOUT_OV,VOUT_UV,TON_MAX,IOUT_OC,IOUT_UC,TEMPERATURE_OT,SEQ_TIMEOUT,SLAVED_FAULT;
Rail #9:
VOUT_OV,VOUT_UV,TON_MAX,IOUT_OC,IOUT_UC,TEMPERATURE_OT,SEQ_TIMEOUT,SLAVED_FAULT; Rail
#10:
VOUT_OV,VOUT_UV,TON_MAX,IOUT_OC,IOUT_UC,TEMPERATURE_OT,SEQ_TIMEOUT,SLAVED_FAULT; Rail
#11:
VOUT_OV,VOUT_UV,TON_MAX,IOUT_OC,IOUT_UC,TEMPERATURE_OT,SEQ_TIMEOUT,SLAVED_FAULT; Rail
#12:
VOUT_OV,VOUT_UV,TON_MAX,IOUT_OC,IOUT_UC,TEMPERATURE_OT,SEQ_TIMEOUT,SLAVED_FAULT"
```

```
BlockWrite,0x7E,0xEF,0x0DFFFFFFFFFFFFFFFFFFFFFFFFF
// Begin write of common (not PAGED) parameters
Comment,Write MFR_DATE 090401
BlockWrite,0x7E,0x9D,0x06303930343031
Comment,Write MFR_ID TEXAS_INSTRUMENTS
BlockWrite,0x7E,0x99,0x1254455841535F494E535452554D454E545320
Comment,Write MFR_LOCATION DALLAS
BlockWrite,0x7E,0x9C,0x0C44414C4C4153202020202020
Comment,Write MFR_MODEL PR651_REVA
BlockWrite,0x7E,0x9A,0x0C50523635315F524556412020
Comment,Write MFR_REVISION REV_F
BlockWrite,0x7E,0x9B,0x0C5245565F4620202020202020
Comment,Write MFR_SERIAL 000000
BlockWrite,0x7E,0x9E,0x0C303030303030202020202020
Comment,Write MISC_CONFIG [MFR 44] Time Between Resequences: 0 msec; Resequenece Abort: no; Max
Resequences: 1; FIFO Mode: Disabled; Brownout Enable: no
BlockWrite,0x7E,0xFC,0x020000
Comment,Write RUN_TIME_CLOCK_TRIM [MFR 08] 0.00 %
WriteWord,0x7E,0xD8,0x0088
Comment,Write SYSTEM_RESET_CONFIG [MFR 02] Disabled
BlockWrite,0x7E,0xD2,0x0400000000
Comment,Write SYSTEM_WATCHDOG_CONFIG [MFR 03] Disabled
BlockWrite,0x7E,0xD3,0x0400000000
// Begin write of rail #1 parameters
Comment,"Write ON_OFF_CONFIG [Rail #1] ControlOnly, UseDelay, ActiveHigh"
WriteByte,0x7E,0x00,0x00
WriteByte,0x7E,0x02,0x16
Comment,"Write FAULT_RESPONSES [MFR 25,Rail #1] Retry Time: 255 msec| Max Volt Glitch Time: 98.0 msec|
Max Other Glitch Time: 25,500 msec| VOUT_OV: Resequenece: Disabled; Glitch filter: Disabled; Response: Ignore;
Restart: N/A| VOUT_UV: Resequenece: Disabled; Glitch filter: Disabled; Response: Ignore; Restart: N/A| IOUT_OC:
Resequenece: Disabled; Glitch filter: Disabled; Response: Shut down with delay; Restart: Do not restart| IOUT_UC:
Resequenece: Disabled; Glitch filter: Disabled; Response: Ignore; Restart: N/A| OT: Resequenece: Disabled; Glitch
filter: Disabled; Response: Ignore; Restart: N/A| TON_MAX: Resequenece: Disabled; Glitch filter: Disabled; Response:
Ignore; Restart: N/A"
BlockWrite,0x7E,0xE9,0x090000A0000000FFF5FF
Comment,Write IOUT_CAL_GAIN [Rail #1] 33.875 mohm
WriteWord,0x7E,0x38,0x1EE2
Comment,Write IOUT_CAL_OFFSET [Rail #1] -18.06 A
WriteWord,0x7E,0x39,0xBEDD
Comment,Write IOUT_OC_FAULT_LIMIT [Rail #1] 8.00 A
WriteWord,0x7E,0x46,0x00D2
Comment,Write IOUT_OC_WARN_LIMIT [Rail #1] 52.50 A
WriteWord,0x7E,0x4A,0x48E3
Comment,Write IOUT_UC_FAULT_LIMIT [Rail #1] -12.50 A
WriteWord,0x7E,0x4B,0xE0D4
Comment,Write OT_FAULT_LIMIT [Rail #1] 80 C
WriteWord,0x7E,0x4F,0x80EA
Comment,Write OT_WARN_LIMIT [Rail #1] 75 C
WriteWord,0x7E,0x51,0x58EA
Comment,Write POWER_GOOD_OFF [Rail #1] 3.000 V
WriteWord,0x7E,0x5F,0x0030
```



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Comment,Write POWER_GOOD_ON [Rail #1] 3.177 V
WriteWord,0x7E,0x5E,0xD432
Comment,"Write SEQ_TIMEOUT [MFR 00,Rail #1] 0.0 ms"
WriteWord,0x7E,0xD0,0x0080
Comment,"Write TEMPERATURE_CAL_GAIN [MFR 20,Rail #1] 200.0 C/V"
WriteWord,0x7E,0xE4,0x20F3
Comment,"Write TEMPERATURE_CAL_OFFSET [MFR 21,Rail #1] -50.00 C"
WriteWord,0x7E,0xE5,0xE0E4
Comment,Write TOFF_DELAY [Rail #1] 550.0 ms
WriteWord,0x7E,0x64,0x2602
Comment,Write TOFF_MAX_WARN_LIMIT [Rail #1] <No Limit>
WriteWord,0x7E,0x66,0xFF7F
Comment,Write TON_DELAY [Rail #1] 5.0 ms
WriteWord,0x7E,0x60,0x80CA
Comment,Write TON_MAX_FAULT_LIMIT [Rail #1] <No Limit>
WriteWord,0x7E,0x62,0x0080
Comment,"Write VOUT_CAL_MONITOR [MFR 01,Rail #1] 0.000 V"
WriteWord,0x7E,0xD1,0x0000
Comment,Write VOUT_COMMAND [Rail #1] 3.530 V
WriteWord,0x7E,0x21,0x7A38
Comment,Write VOUT_MARGIN_HIGH [Rail #1] 3.707 V
WriteWord,0x7E,0x25,0x4F3B
Comment,Write VOUT_MARGIN_LOW [Rail #1] 3.353 V
WriteWord,0x7E,0x26,0xA535
Comment,Write VOUT_OV_FAULT_LIMIT [Rail #1] 4.060 V
WriteWord,0x7E,0x40,0xF540
Comment,Write VOUT_OV_WARN_LIMIT [Rail #1] 3.883 V
WriteWord,0x7E,0x42,0x203E
Comment,Write VOUT_SCALE_MONITOR [Rail #1] 0.500
WriteWord,0x7E,0x2A,0x00B2
Comment,Write VOUT_UV_FAULT_LIMIT [Rail #1] 3.000 V
WriteWord,0x7E,0x44,0x0030
Comment,Write VOUT_UV_WARN_LIMIT [Rail #1] 3.177 V
WriteWord,0x7E,0x43,0xD432
// Begin write of rail #2 parameters
Comment,"Write ON_OFF_CONFIG [Rail #2] ControlOnly, UseDelay, ActiveHigh"
// Set PAGE to rail #2
WriteByte,0x7E,0x00,0x01
WriteByte,0x7E,0x02,0x16
Comment,"Write FAULT_RESPONSES [MFR 25,Rail #2] Retry Time: 0 msec| Max Volt Glitch Time: 0.0 msec| Max
Other Glitch Time: 0 msec| VOUT_OV: Resequene: Disabled; Glitch filter: Disabled; Response: Ignore; Restart:
N/A| VOUT_UV: Resequene: Disabled; Glitch filter: Disabled; Response: Ignore; Restart: N/A| IOUT_OC:
Resequene: Disabled; Glitch filter: Disabled; Response: Ignore; Restart: N/A| IOUT_UC: Resequene: Disabled;
Glitch filter: Disabled; Response: Ignore; Restart: N/A| OT: Resequene: Disabled; Glitch filter: Disabled; Response:
Ignore; Restart: N/A| TON_MAX: Resequene: Disabled; Glitch filter: Disabled; Response: Ignore; Restart: N/A"
BlockWrite,0x7E,0xE9,0x09000000000000000000
...
Comment,Write VOUT_UV_WARN_LIMIT [Rail #12] 1.728 V
WriteWord,0x7E,0x43,0xA51B
Comment,Store configuration to data flash
Comment,Execute STORE_DEFAULT_ALL

```

SendByte,0x7E,0x11

Pause,1500,Pausing 1500 ms for StoreDefaultAll