EVM User's Guide: TPS12S24FQ1EVM

TPS12S24F-Q1 Evaluation Module

Description

The TPS12SxxF EVM showcases and evaluates features of the smart fuse high-side switch controller portfolio from Texas Instruments. The EVM is designed to work for each variant TPS12S13F, TPS12S23F, TPS12S14F, and TPS12S24F, enabling the use of a single host EVM for a variety of different high-side switches and controllers with varying functionality.

The EVM is designed to be highly configurable, but changes beyond adding DNP values and configurations specified in the datasheet must be verified by TI first. Extreme modifications may not be supported and performance cannot be verified.

Get Started

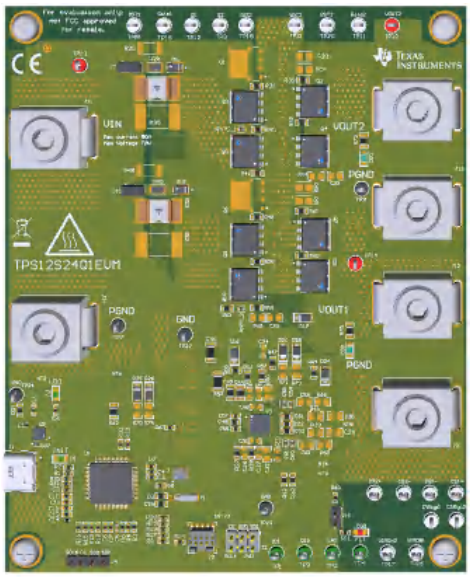
1. Order the TPS12S24FQ1EVM on ti.com.
2. Plug in a USB-C® cable (*J1*) to a Windows®-capable computer.
3. Connect a power supply to the VIN line (*J11*) and connect the ground of the power supply to the ground line of the board (*J14*).
4. Connect the relevant loads to the outputs of the board (*J9, J10, J12,* and *J13*).
5. Download the Smart Fuse Configurator from the EVM product page.
6. Open the Smart Fuse Configurator host program and use as described in this document.

Features

- TPS12SxxF-Q1 family compatible EVM board design
- TM4C123GH6 32-bit Arm Cortex-M4F based MCU: used as a USB to SPI host from the host PC to the attach high-side switch daughtercard
  - 9-pin Cortex-M JTAG port allows for users to program and debug firmware to the TM4C123
- TLV766 500mA, 16V Linear Regulator to derive 3.3V power rail to supply VDD of the high-side switch controller
- Test points: fully accessible test-points and headers, allowing complete access to SPI lines, fault signals, power rails

Applications

- Automotive zone ECU
- Power distribution modules
- Body control modules



TPS12S24FQ1EVM - 3D

1 Evaluation Module Overview

WARNING

PLEASE READ BEFORE USE: The TPS12S24FQ1EVM uses external FETs. The SOA of the FETs must be accounted for in all test conditions. Failure to do so can result in damaged FETs.

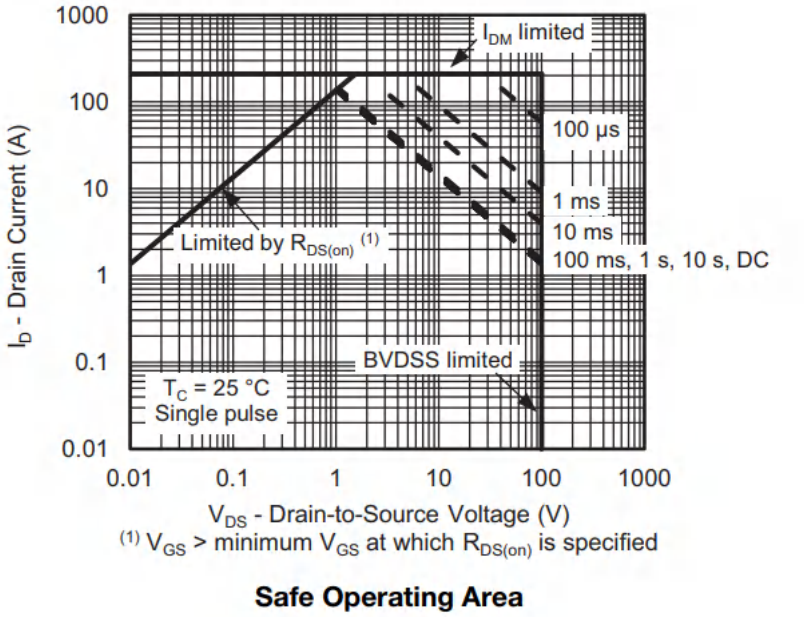


Figure 1-1. FET SOA

1.1 Introduction

The TPS12S24FQ1EVM is a hardware evaluation board used for evaluation and development of the high-side switch controller TPS12SxxF-Q1 portfolio from Texas Instruments. A TPS12SxxF family compatible approach is used in the hardware ecosystem to promote reuse of hardware and software, as well showcases the pin compatibility between different high side switch controllers. A pre-flashed TM4C MCU is included with each EVM to act as a USB-to-SPI bridge and allow the user to seamlessly configure and manipulate the device. This MCU communicates with a Windows host GUI application titled *Smart Fuse Configurator* to allow for full configuration and evaluation of the attached high-side switch controller.

As many of TI's high side switch controllers have digital SPI, this hardware ecosystem is designed to simplify evaluation and development, as well as reduce the need for the user to invest any significant software resources on the host side. The TPS12S24FQ1EVM has an integrated TM4C123 Cortex-M4F USB microcontroller that serves as a USB-to-SPI bridge between a host PC and the attached EVM. A simple Windows GUI program titled *Smart Fuse Configurator* is provided that allows a multitude of features including:

- Reading/graphing load current, input/output voltage, and temperature using the integrated ADC from the high-side switch controller
- Turn on/off channels and set operational settings such as PWM and current limit
- Providing an interface to tune the I2T curve and compare with a customer wire profile for fuse replacement
- Monitor device and channel fault status complete with aggregation statistics
- Setup/configure all register settings of the high-side switch directly from the GUI
- Direct register reads/writes through console view
- Export/import settings as well as export development artifacts such as C configuration arrays/structures
- Save high-side switch configuration data to MCU flash
- Multilingual support, including Japanese and English

The host GUI does not require special drivers, and uses standard Windows USB-HID calls to communicate with the TPS12S24FQ1EVM. Only Windows is supported with this EVM ecosystem. The EVM comes with the TM4C firmware pre-programmed without the need for the user to perform any initial firmware flashing.

1.2 Kit Contents

The EVM kit for the TPS12S24FQ1EVM includes the following:

- One TPS12S24FQ1EVM board with the MCU pre-flashed at the factory with the latest firmware

1.3 Specification

Use the TPS12S24FQ1EVM boards to evaluate automotive applications that use high-side switch controllers to drive primarily off-board loads. This EVM contains a pre-flashed microcontroller with firmware that acts as a SPI to USB bridge between the high-side switch (SPI) and the host PC system running the GUI (USB). The EVM is designed for ease-of-use and all that is needed is to plug-in USB and relevant loads, supply power, and evaluate through the GUI.

The EVM has multiple power rails that are derived from input power sources. The input supply, VIN, functions as the primary power rail for the device and supplies the VBB of the device. A TLV767 LDO is used to derive the 3.3V microcontroller supply from the 5V USB connection through the PC. This same supply is used to power the VDD for SPI operations of the TPS12S24F part.

Note that this board is intended to evaluate the standard functionality of the device. The board is not designed to withstand automotive transients events such as hard short-to-ground events, reverse battery events, and ISO 16750-2 load dumps.

1.4 Device Information

The TPS12S24FQ1EVM uses the following devices from Texas Instruments.

Table 1-1. Devices Used

DEVICE NAME	DESCRIPTION	PURPOSE
TM4C123GH6PMI7R	32-bit Arm Cortex-M4F based MCU with 80MHz, 256KB Flash, 32KB RAM, 2 CAN, RTC, USB, 64-Pin	Acts as USB to SPI bridge between host PC and high-side switch
TLV76633QWDRBRQ1	Fixed-output, 1A, 16V, positive-voltage low-dropout (LDO) linear regulator	Provides 3.3V supply for microcontroller from 5V USB signal
TPS12S24F-Q1	Automotive Dual-Channel, SPI controlled High-Side Switch Controller with low Quiescent Current ON Mode and Integrated I2t Wire Protection	High-side switch controller being evaluated

2 Hardware

2.1 Assembly Instructions

The following resources are required to get started with the TPS12S24FQ1EVM:

- 1× TPS12S24FQ1EVM
  - Firmware is pre-flashed for the EVM and no need for the user to program the EVM initially.
  - Standard USB cable
- Windows host with .NET framework run-time v4.7.2 (included in all Windows 10 versions and later).
  - Download from https://dotnet.microsoft.com/en-us/download/dotnet-framework/net472 for all other versions
- Texas Instruments Smart Fuse Configurator software tool (4MB)

No special drivers or large proprietary frameworks are needed to run the Smart Fuse Configurator.

To get started, plug the USB-C® cable into J1 as Figure 2-1 shows. If successful, the green LED on D2 illuminates and Windows automatically detects and installs the high-side switch EVM.

Note that D1 also illuminates shortly after D1 if the TPS12S24F-Q1 part is successfully identified by the SPI.

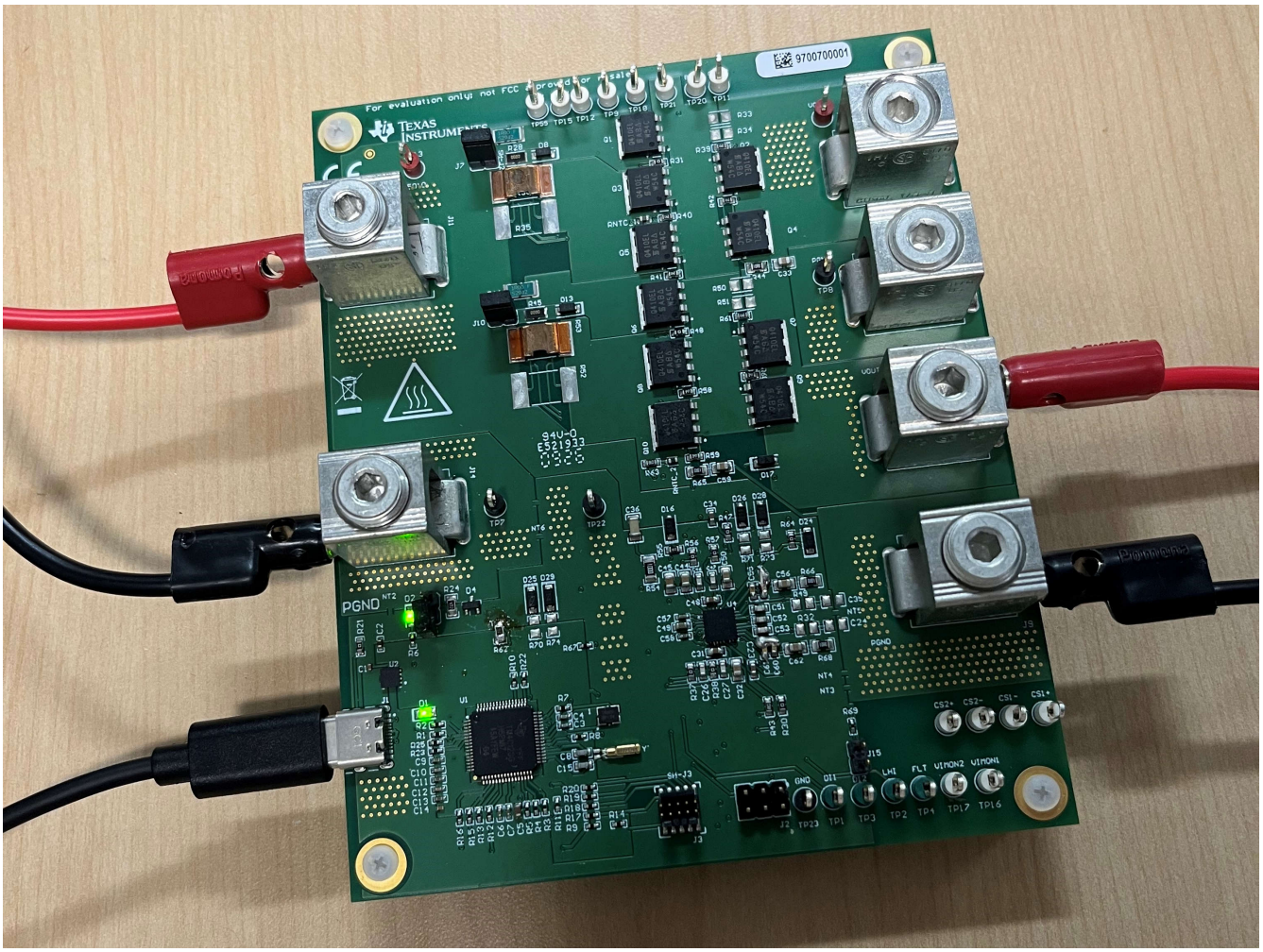


Figure 2-1. USB Connection

Next, plug in the input power supply to J11 and J14 and add a load to one or both output channels using J9, J12, J13, and J15 as seen in Figure 2-2.

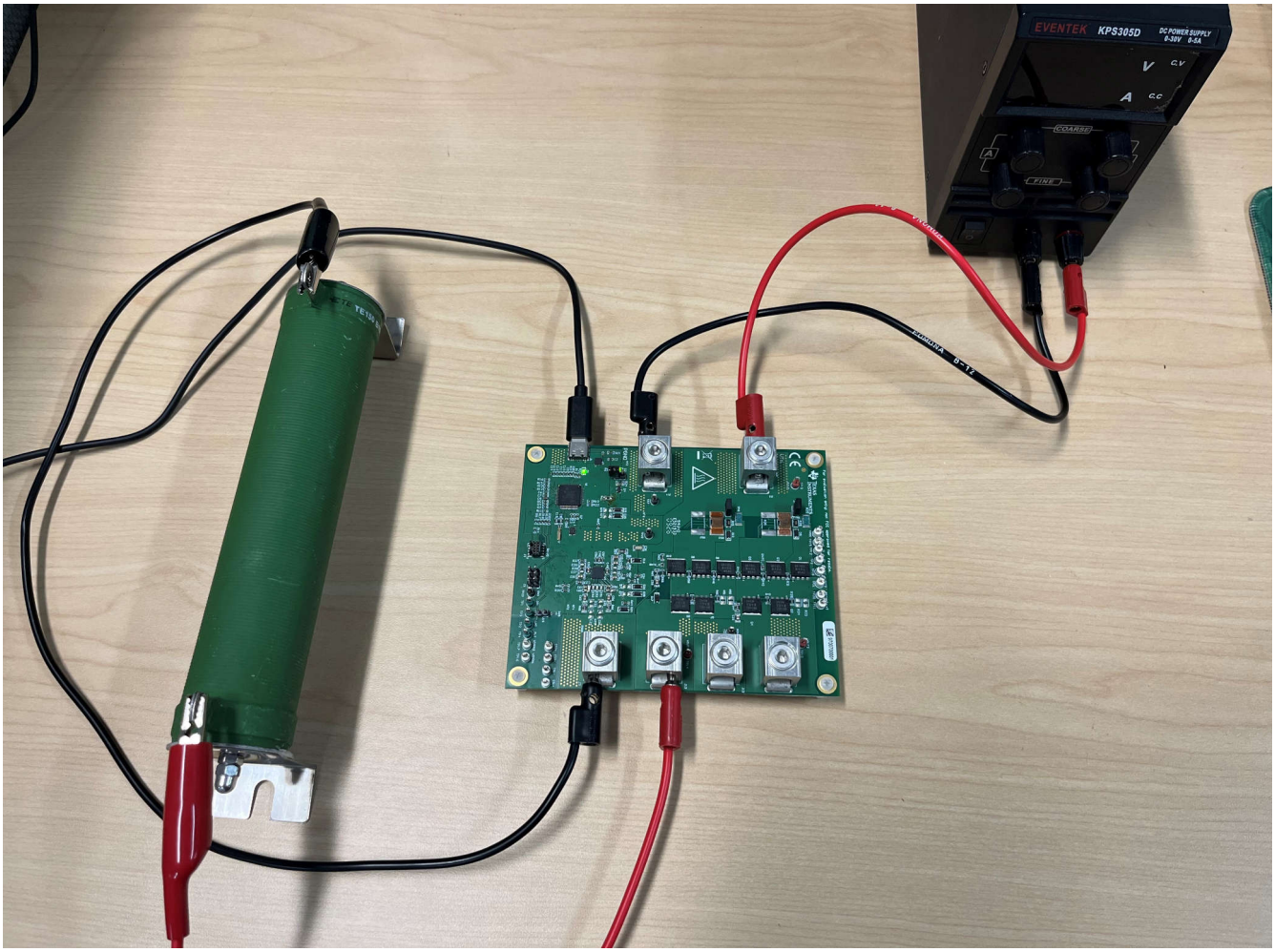


Figure 2-2. Test Setup

With all of the supply, loads, and USB connected, turn on the power supply to the EVM. Note that the high-side switch controller used in this EVM is designed for automotive systems from 12V to 48V, however, refer to the device datasheet for exact details on the input and output conditions supported.

With the device powered, open the auto_hss_configurator.exe executable that ships with the Smart Fuse Configurator software package. Note that the software package from TI.com is a portable zip file and does not need any specific installer to operate. Once opened, the software program automatically detects the EVM and updates the connection status to *Connected*, as seen in Figure 2-3.

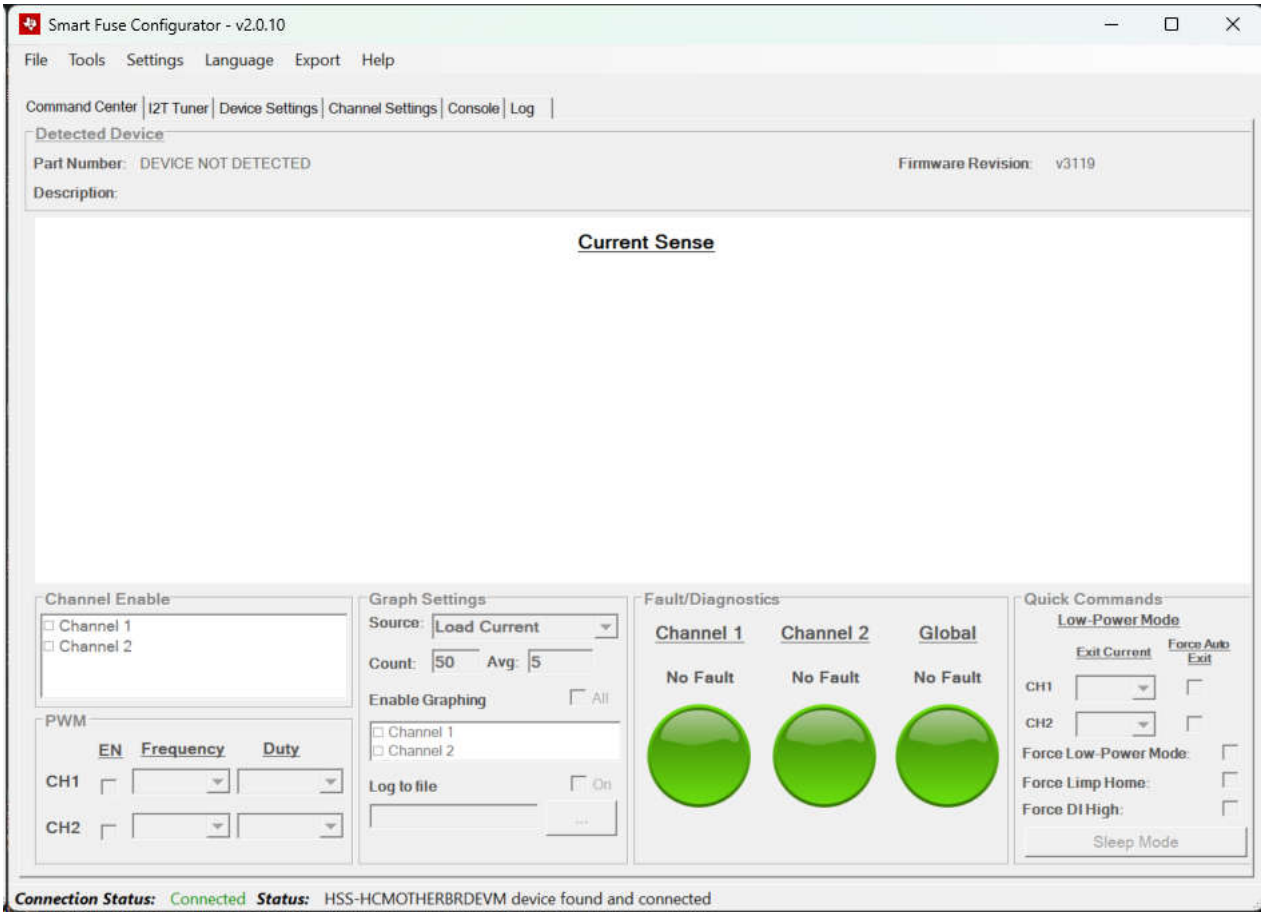


Figure 2-3. USB Interface Detected

If the EVM is not connected, then the Connection Status shows up as *Disconnected*. In this state, the main elements of the GUI are disabled until the device is connected.

Note that even though the USB connection to the EVM is detected, the software interface does not enable until an active TPS12SxxF-Q1 part is detected on the board. A background thread on the GUI automatically polls and checks for a valid device through a read to device register 0x00 (device ID register). If a valid ID is read, the GUI automatically enables and populates the relevant device information, shown in Figure 2-4. The GUI automatically switched from the Command Center tab to the Log tab. Upon first device connection the GUI outputs the current/default register dump for all device registers.

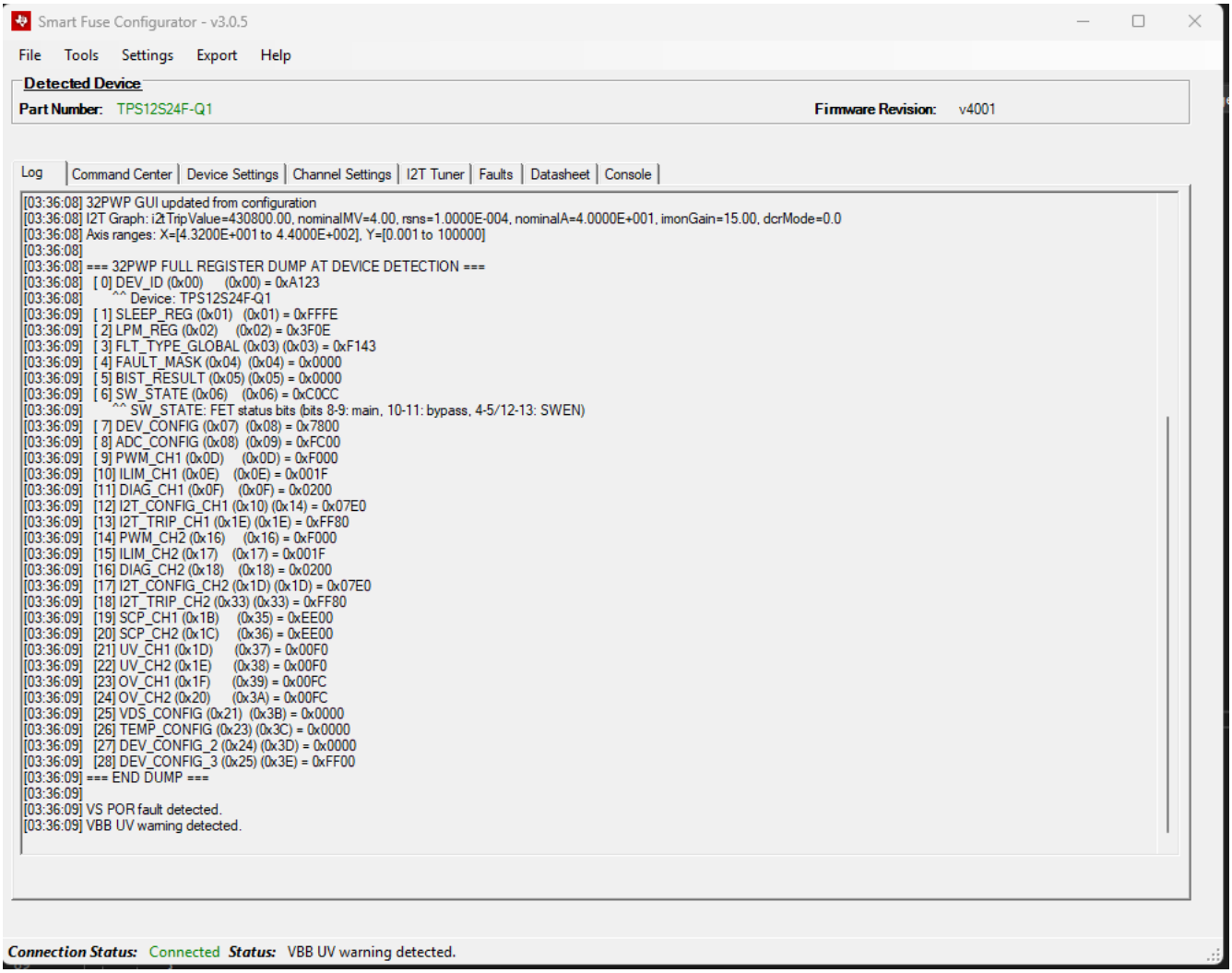


Figure 2-4. Device Detected

On the main interface, the status bar displays the latest command/status event that happened on the GUI. In this case, the status bar message shows that the high-side switch device is connected and the current status shows "VBB_UV warning detected" because the device power supply is not turned on. Whenever a setting change on the device or a significant setting changes on the GUI, the status bar displays a message. See a timestamped list of all previous events in the Log tab as seen in Figure 2-4.

The detailed usage guide for each of the tabs in the software is found in the following sections.

2.2 Jumper Information

The TPS12S24FQ1EVM is compatible with every part in the TPS12SxxF-Q1 family and has several different jumper and DNP configurations that can configure the device for different device pins and functions. The TPS12S24F-Q1 part is the only part available to be evaluated at this time, but Table 2-1 includes the summary of these jumper configurations.

Table 2-1. Jumper Configurations

JUMPER NO.	PURPOSE	TPS12SxxF-Q1 VARIANT
J10	Supplies VBB1 with VIN.	TPS12S14F-Q1 and TPS12S24F-Q1
J7	Supplies VBB2 with VIN.	TPS12S24F-Q1
R46	External bypass resistor for CH1 (DNP). Populate and remove J10 to enable low-power mode for external LPM only devices.	TPS12S13F-Q1 and TPS12S23F-Q1

Table 2-1. Jumper Configurations (continued)

JUMPER NO.	PURPOSE	TPS12SxxF-Q1 VARIANT
R29	External bypass resistor for CH2 (DNP). Populate and remove J7 to enable low-power mode for external LPM only devices.	TPS12S13F-Q1 and TPS12S23F-Q1
J15	Pull up for FLT_GD pin on single channel devices only (DNP).	TPS12S14F-Q1 and TPS12S13F-Q1
R71 and R73	External BST supply for CH1 and CH2 (DNP)	All

2.3 Interfaces

The TPS12S24FQ1EVM has several different power, programming, and diagnostic interfaces available.

The power interfaces are summarized below.

Table 2-2. Power Interfaces

IDENTIFIER	NAME	DESCRIPTION
J11	VIN	Primary battery supply voltage.
J12, J15	VOUT1 and VOUT2	Channel outputs that go to the desired loading conditions.
J14, J13, J9	GND	Ground connections.

The EVM also has the following digital interfaces.

Table 2-3. Digital Interfaces

IDENTIFIER	DESCRIPTION
J1	USB connection to host that is used to communicate with the Smart Fuse Configurator software. Note that the 3.3V power supply for the MCU derives from USB with a 3.3V LDO.
J2	Used if an external SPI primary device wants to be used. In this scenario, connect the SPI primary device to the signals on this header and keep the USB port unplugged.
J3	JTAG used for programming the TM4C microcontroller. A source code package is provided, or the user can write MCU code from scratch.

2.4 Test Points

The TPS12S24FQ1EVM has the following test points available:

Table 2-4. Test Points

IDENTIFIER	DESCRIPTION
VIN (TP13)	Power source of the device
VOUT1 and VOUT2	Outputs to the desired loads
GND	Ground connection
BST1, Gate1, SRC1, G1, BST2, Gate2, SRC2, G2	Gate drive output signals
CS1+, CS1-, CS2+, CS2-, VIMON1, VIMON2	Current sense pin and analog current sense outputs.
FLT, DI1, DI2, LHI	Probe points for the digital signals of the high-side switch. FLT is an open-drain output with a pull-up resistor connected to the 3.3V rail of the MCU.

3 Software

3.1 Software Usage

The Smart Fuse Configurator software is a companion software used to accompany the TPS12S24FQ1EVM. This software can be downloaded from the product page of the TPS12S24FQ1EVM and comes in the format of a packaged zip file. Simply unzip the downloaded package and open the software on a Windows host machine. As the EVM uses USB-HID, there are no drivers that are required to be installed and Windows automatically detects/installs the EVM without the need to download proprietary software packages. The sections below describe the functionality of the Smart Fuse Configurator in detail.

3.1.1 Command Center View

The Command Center View provides quick access to some of the common configuration and run-time settings of the attached TPS12SxxF-Q1. The user has the ability to turn on and off individual channels, plot, and graph ADC readings such as current sense, configure PWM settings, and put the device into several diagnostic states. Note that by default, the device is set to auto-persist changes made in the GUI. This means that when the user changes a setting on the interface, the command is sent through USB and translated as a SPI command to persist to the high-side switch controller.

To enable or disable individual channels, simply select the desired channel in the *Channel Enable* box. This causes the corresponding channel to turn on and conduct current if there is a load on the output. Likewise, to enable current sense/graphing for a particular channel, select the desired channel on the *Graph Settings* box. This causes the GUI to start a polling thread that periodically reads the current sense register. When a channel is enabled for graphing, the microcontroller automatically enables the relevant ADC bits in the register settings.

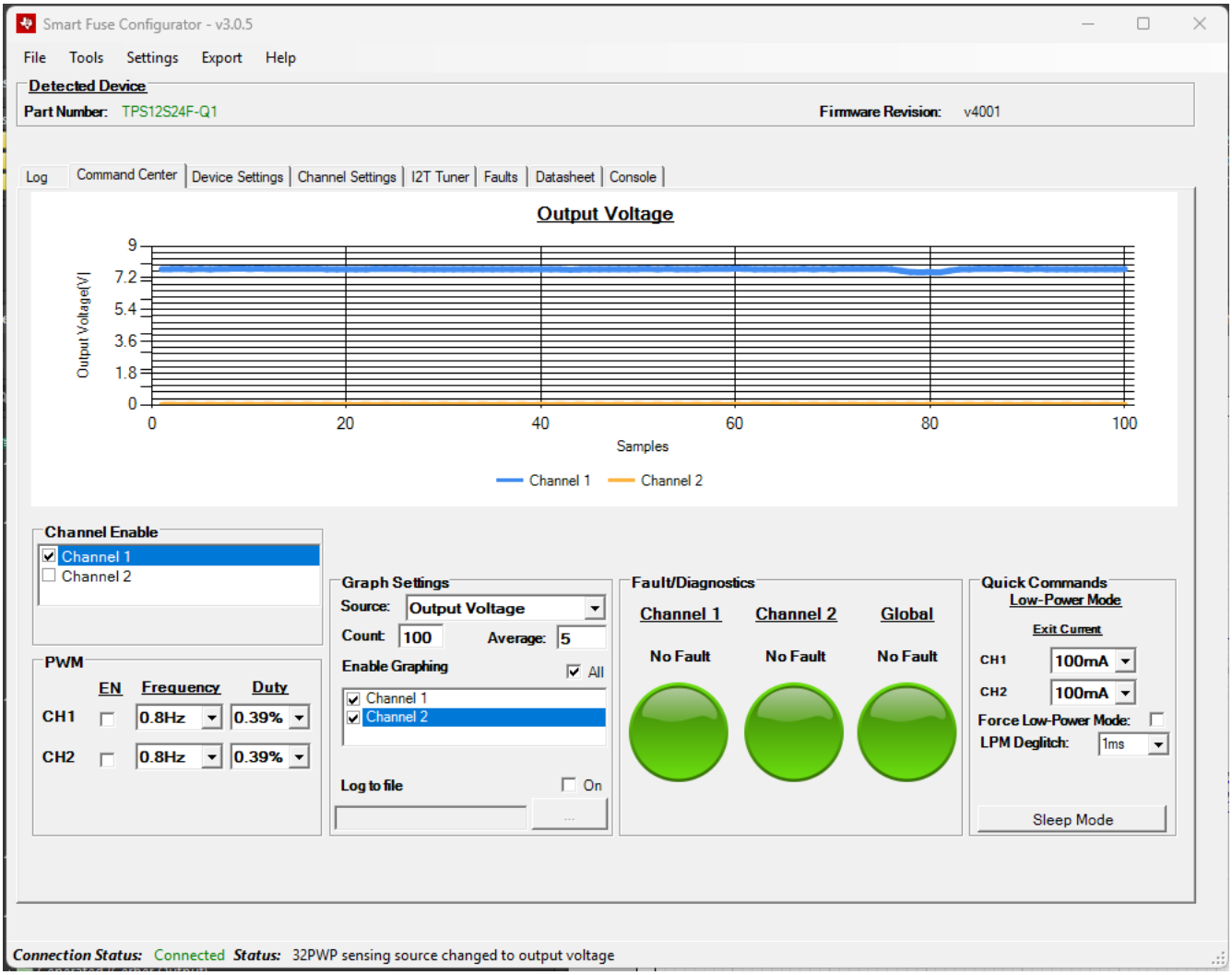


Figure 3-1. Output Voltage Graph

Note that by default the device is set to collect and average a specified number of values before plotting the values on the graph. Change the maximum number of samples to collect through the *Count* setting and change the average number of samples with the *Avg* setting. In addition to load current, configure the device to graph and report FET temperature and output voltage. Change this setting through the *Source* box.

The *Log to File* button gives the user the ability to dump any sense readings to a specified comma separated value (CSV) file. When selecting this box, the program prompts for a location to save and start recording files if that location is valid. The log file closes and saves if the *Log to File* button turns off or if the program closes.

The *Quick Commands* box provides various settings and diagnostic commands. The LPM exit current can quickly be configured per-channel and the device can be forced into low-power mode through the *Low-Power Mode* box. Once in low-power mode, if the load current on a corresponding channel exceeds what is configured in the settings the device exits the low-power mode (or if the low-power mode box is unchecked). Refer to the device datasheet for exact operation behavior for low-power mode.

The *Force DI HIGH* check-boxes uses the MCU control to externally pull these pins HIGH. This forces the pins to act as *OUT_DIS pins*. Forcing HIGH shuts off the respective channel.

The *Sleep Mode* button prompts a dialog to put the device in sleep mode. In sleep mode, the device enters an inactive state with minimal power consumption. In this mode, all device configurations are reset to the reset values. The Smart Fuse Configurator software, however, has logic that restores the configured values after exiting sleep mode. By selecting the sleep mode button, a prompt occurs to warn the user about the state change.

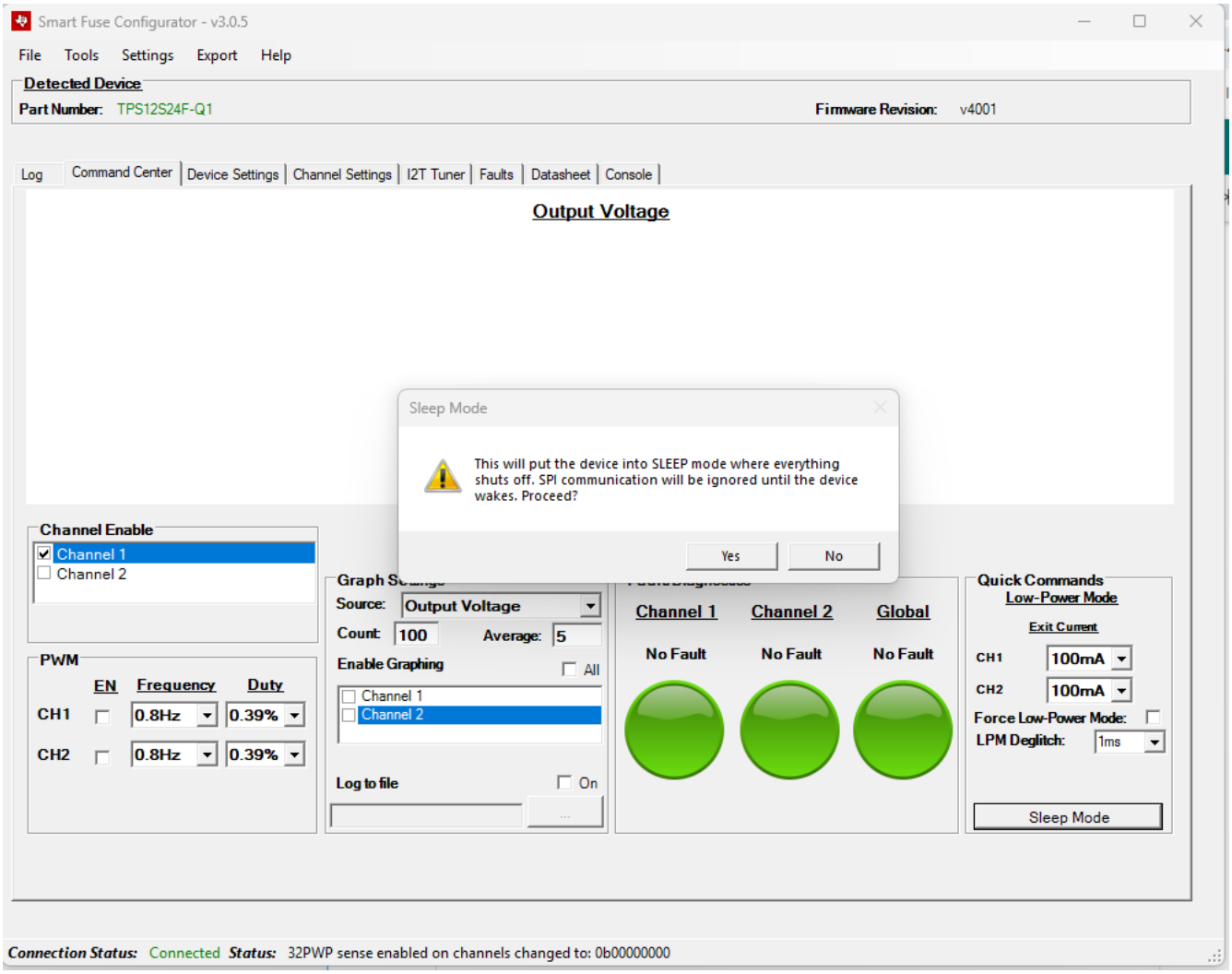


Figure 3-2. Entering Sleep Mode

Once *Yes* is selected, the device goes into sleep mode by a SPI write to the corresponding SLEEP register. The device stays in sleep mode until the user selects *OK* on the GUI.

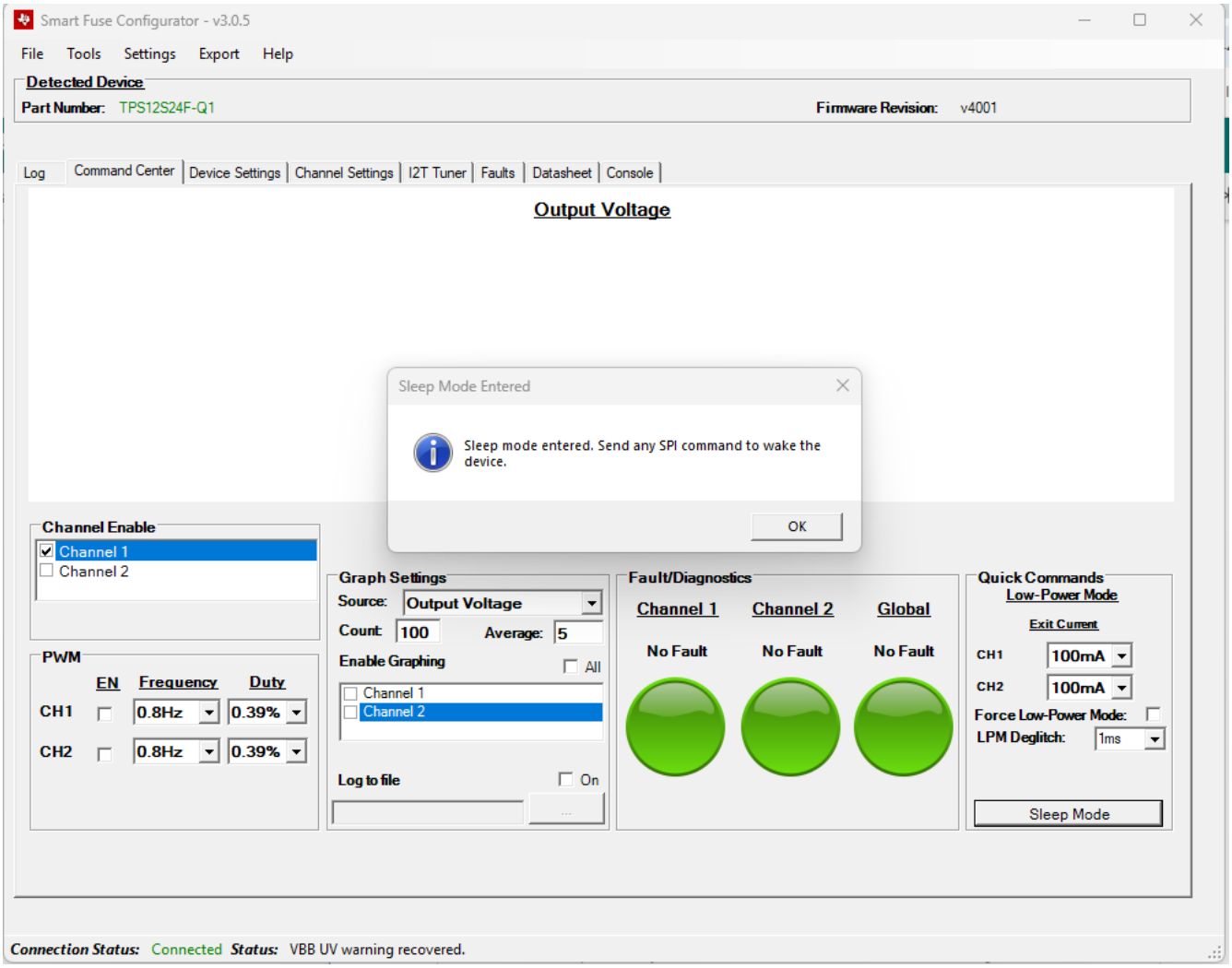


Figure 3-3. Device in Sleep Mode

Once *OK* is selected, a dummy-write occurs that takes the device out of sleep mode. Once out of sleep mode, the GUI takes the current configuration settings from the GUI and writes the setting back to the device.

3.1.2 I2T Tuner

The *I2T Tuner* tab allows the user to configure or tune the I2T settings of the high-side switch and visualize the resulting curve versus a custom wire profile. On the *I2T Curve* sub-tab, configure the I2T curve of the device in real time with a provided and custom wire model.

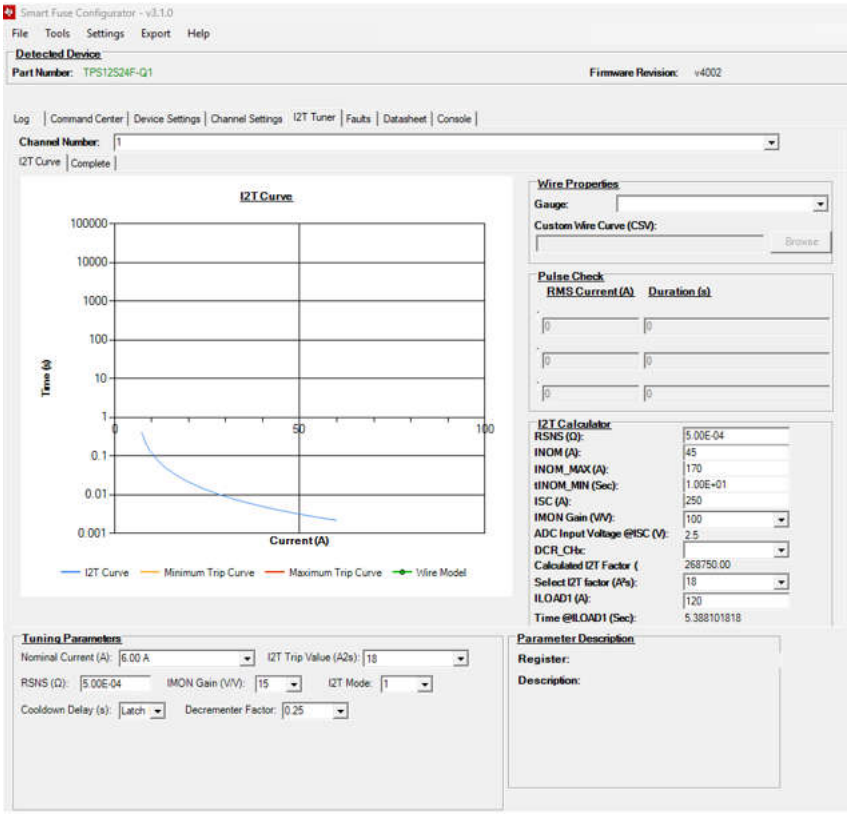


Figure 3-4. I2T Curve Tuner

There are two main sections in this tab. The I2T Calculator section is a helpful tool to adjust I2T Factor and Gain settings to accomplish target current thresholds. This section is purely theoretical and does not impact the actual TPS12S24F-Q1 part.

Using the values adjusted in the I2T Calculator section, the user can apply the values to the Tuning Parameters section to implement the calculations in the I2T Curve in real time. Once satisfied with selected values and ready to test I2T on the TPS12S24F-Q1, use the I2T Parameters section in the Channel Settings tab described below.

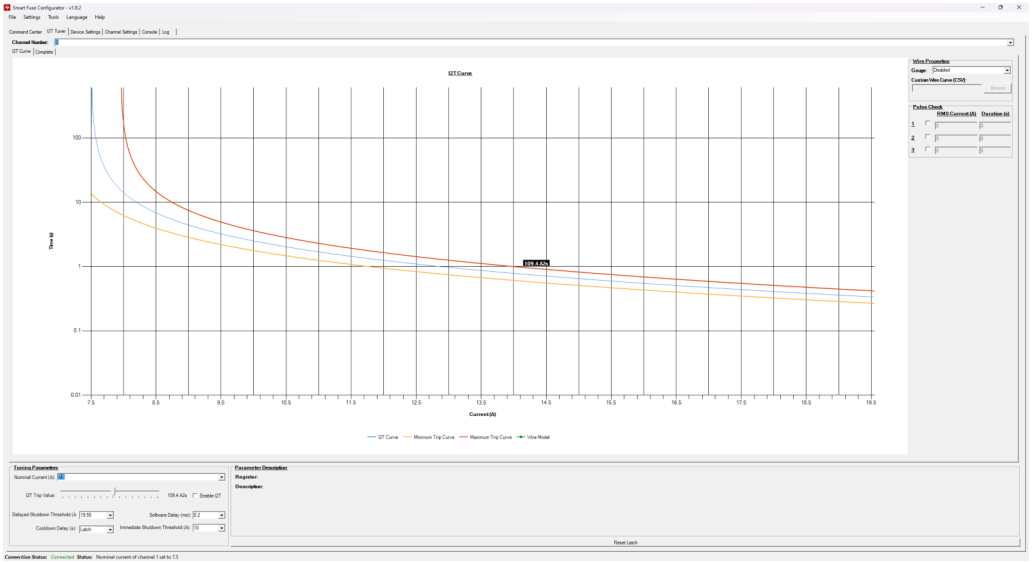


Figure 3-5. Adjusting I2T Trip Value

In the *Wire Properties* box, the user can plot a wire model against the current I2T graph. A couple of different example or sample models are provided, however the user has the ability to provide a wire model in CSV format. This format is a simple CSV format that contains current and time values. For example, the following CSV file:

```
Current,Time
5,100
8,80
10,50
13,40
15,30
17,20
18,10
19,5
```

In the *Complete* sub-tab, the user can examine the full fuse current profile as described in the datasheet.

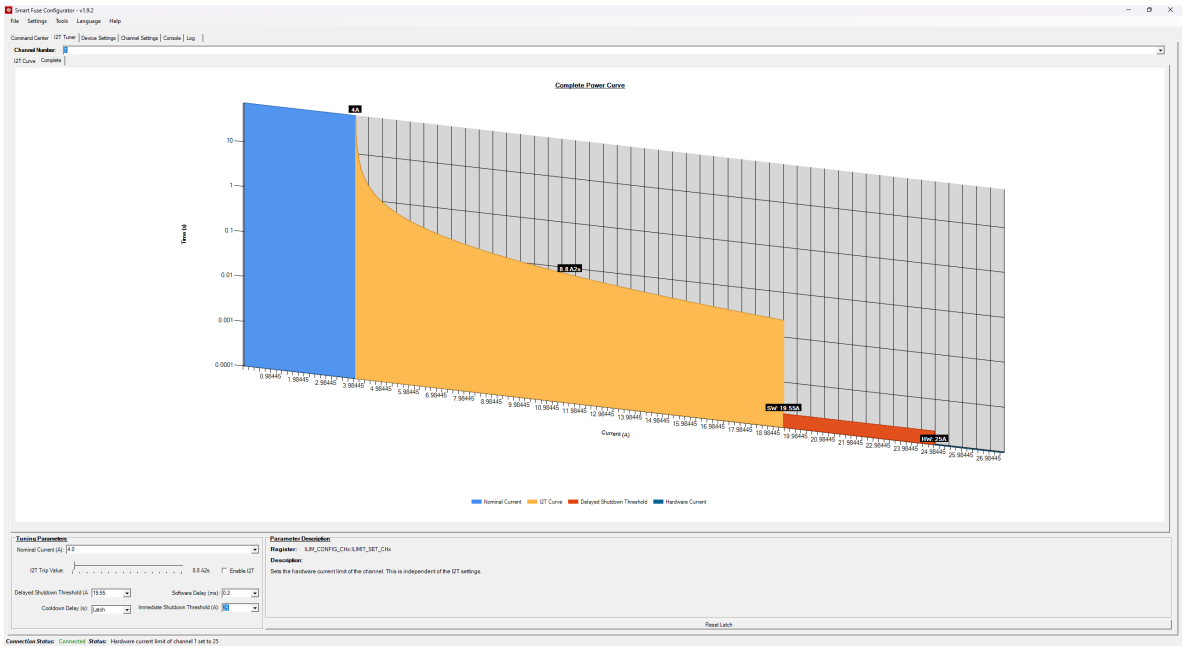


Figure 3-6. Full Current Profile

When any of the controls under the *Tuning Parameters* box change, the graph updates in real time to show the updated parameters.

3.1.3 Device Settings

The *Device Settings* tab allows the user to change device level settings that are not specific to one channel of the device. Additionally in the *Device Settings* tab, adjust ADC configurations and outputs, including per channel values.

Note there are several instances of duplicate controls that are shown in both the Command Center tab and other tabs, such as the Device Settings tab. For example, the Low Power Mode Exit Current can be set and is displayed in both. These items are linked and update based on the most recent selection regardless of what tab the user are in.

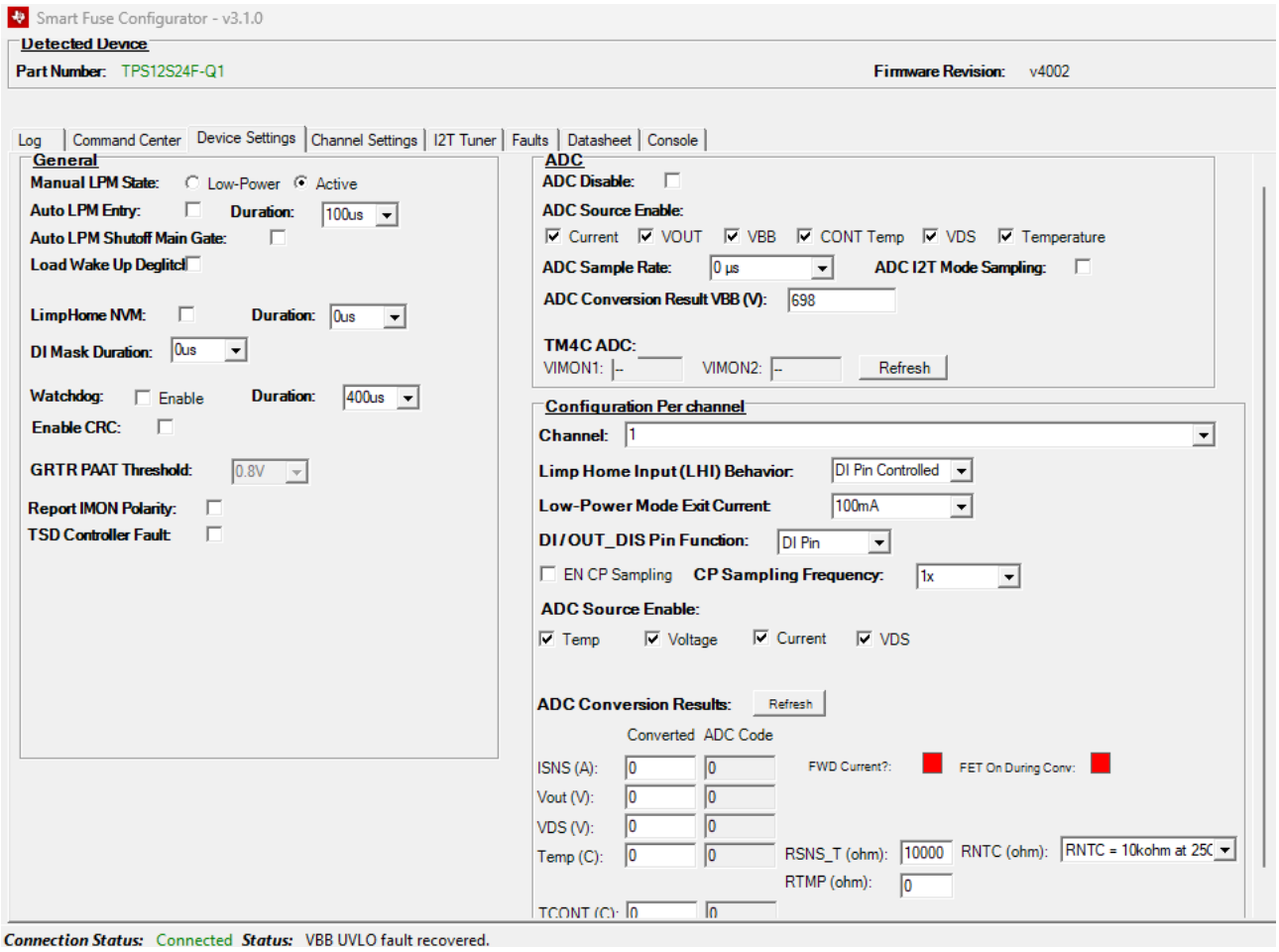


Figure 3-7. Device View

From here, the user can select and change any setting in the *General* box and the corresponding device setting change. Additionally, this tab contains ADC configurations and temperature sensing functions.

The user can use the Configuration Per Channel section for individual controls that relate to the ADC, DI pin control, and low-power mode.

ADC values update when pressing the Refresh button. The Configuration per Channel section this displays the raw ADC code value and the converted code value using the datasheet equations. The TM4C ADC: VIMON1 and TM4C ADC: VIMON2 are the values reported directly from the TPS12S24F-Q1 analog VIMON pins and sent to the on-board TM4C MCU. The values displayed are also the converted ADC value in volts. The VIMON1 and VIMON2 outputs are used as a design example to showcase possible connections reading from the device internal ADC or externally using the analog VIMON outputs.

Confirm that the design of the VIMON output includes the correct GAIN settings to establish that the VIMON voltage does not exceed TM4C 3.3V.

3.1.4 Channel Settings

The Channel Settings tab includes most of the per channel functions for this device. Use the Channel selector drop-down box at the top of the tab to use controls for a specific channel.

The *Operational* box includes the primary means of enabling the gate of each channel from the SWEN register. This includes indicators that turn green when the FET is successfully turned on. One indicator is for the MAIN FET and one indicator is for the Bypass FET.

The *Open Load, Overvoltage, and Undervoltage* box includes settings for tests and temperatures sensing. The values include enabling and duration settings.

The *Capacitive Charging / PWM* box includes settings for different capacitive charging methods and all PWM settings for each capacitive charging methods.

The *Overcurrent Protection / Short Circuit Protection* box includes settings related to current sensing including forward and reverse-current threshold, and output current sense monitoring.

The *I2T Parameters* box includes settings for enabling I2T and setting thresholds and shutoff times. Use this box in conjunction with the I2T Tuner tab functions. The Copy from I2T Tuner button copies existing values from the Tuning Parameters sections into the respective fields in the Channel Settings tab.

Channel Settings tab with CH1 Main FET enabled

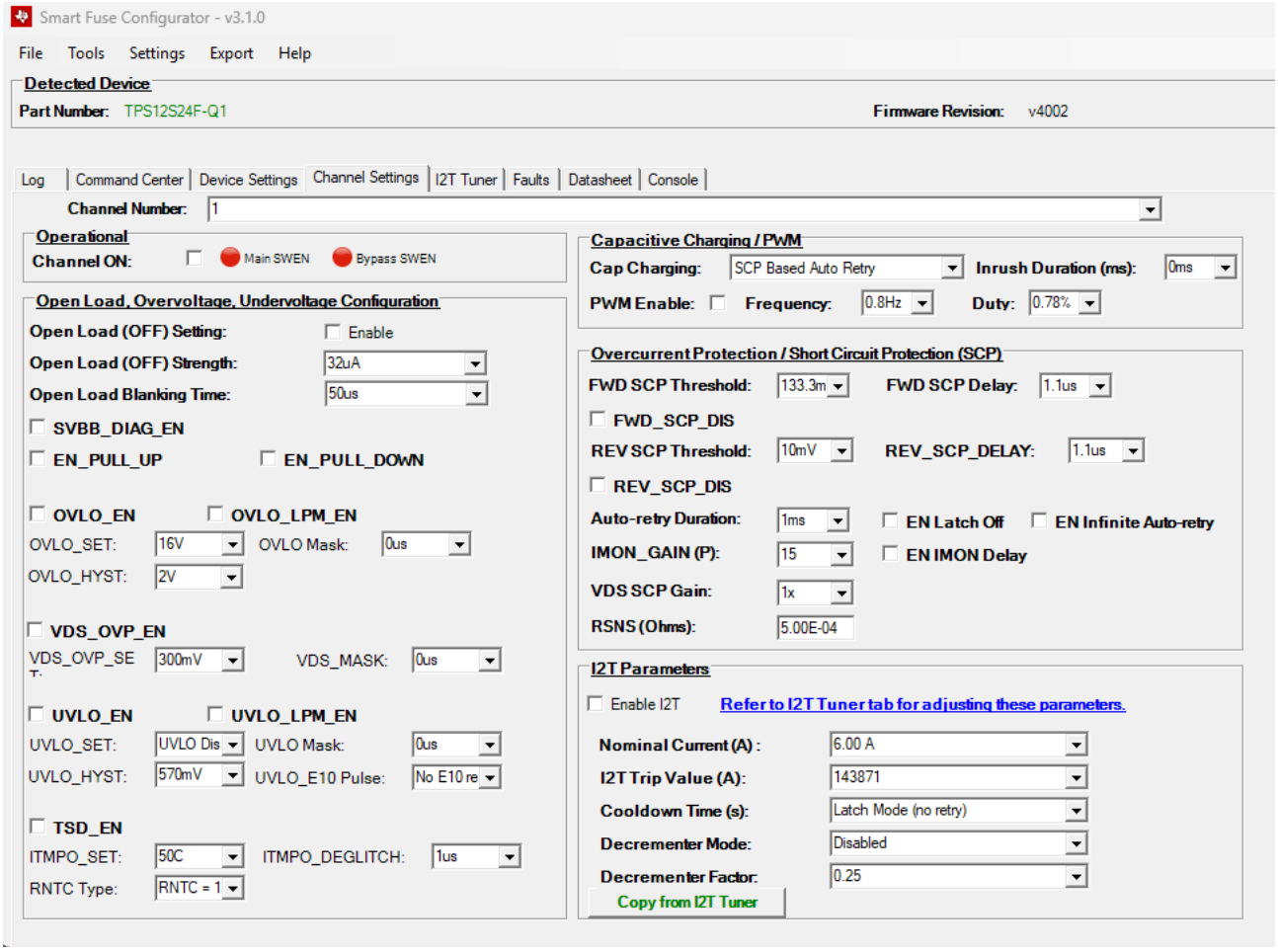


Figure 3-8. Channel Settings

3.1.5 Faults

The *Faults* tab shows a list of settings, warnings, and indicators for all fault related items.

The *Global Faults* box contains all non- channel specific faults including the *Clear Limp Home* button and the Global Fault Mask checkbox, which can be used to mask all Global Faults.

The *Fault Masks* box contains every mask option for most per channel faults. The mask applies to both channels.

The *Channel Faults* box contains all warnings associated with individual channels. All warnings are simultaneously displayed for ease of debug and warning.

The *Indicators* box contains items that serve primarily as notifications rather than a specific fault. Users can look here for an example to identify which channel main FET is on or whether I2T is currently accumulating.

Figure 3-9. Faults Tab

3.1.6 Console View

The *Console View* tab gives the user the ability to perform raw SPI reads/writes to the attached high-side switch controller. This mode is intended to be an advanced super-user mode and does not place any protections on data validation or verify that invalid configuration settings are not sent. The console supports two commands: raw reads and raw writes. For a read command, simply enter "READ XX", where XX is replaced with the register in hex that is desired to be read. Similarly, for write commands, simply enter "WRITE X1X2" where X1 is the register to write and X2 is the value to write, both in hex. Note that letter case, number of digits, and the presence of '0x' do not matter here, as the GUI parses in the relevant format. There is also a Dump Registers button that dumps all current register values to the console.

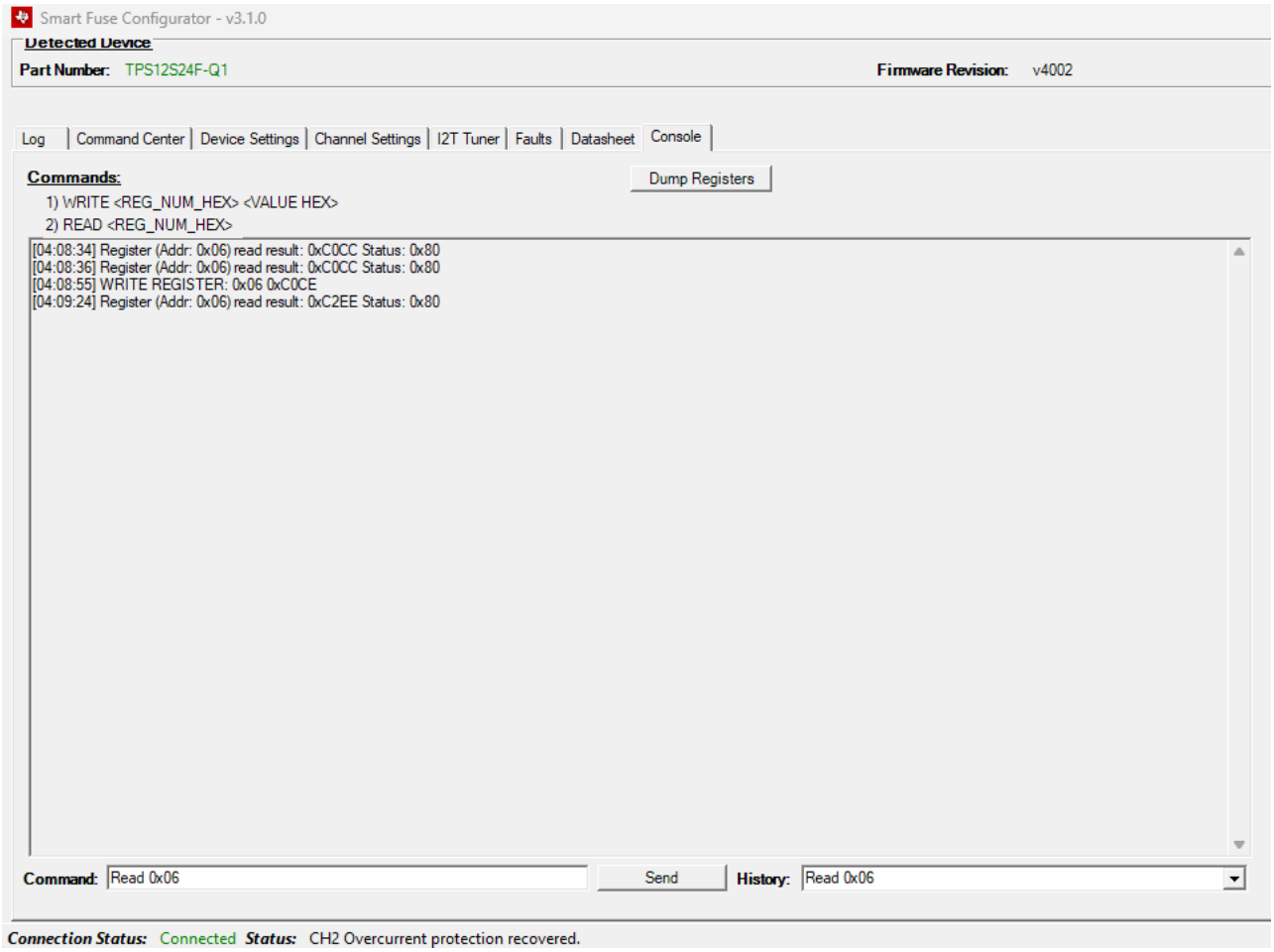


Figure 3-10. Console View

The status byte that returns on a read/write corresponds to the SWEN register. See the SPI read/write format section in the datasheet for more information.

3.1.7 Importing/Exporting

The Smart Fuse Configurator tool has the ability to import/export settings into the GUI so that the user can quickly load a previous configuration upon loading the program. The import/ export settings are accessed through the ***Save Settings*** and ***Load Settings*** prompts from the ***File*** menu. Settings can only be saved and loaded when the high-side switch controller EVM is connected. When saved, the settings are in a simple ASCII format such as follows:

```
TPSHCSCONFIGURATOR
/* TPS2HCS08_LPM */
3,65408
/* TPS2HCS08_FAULT_MASK */
5,65408
/* TPS2HCS08_SW_STATE */
7,65532
/* TPS2HCS08_DEV_CONFIG */
9,256
/* TPS2HCS08_ADC_CONFIG */
10,65338
/* TPS2HCS08_PWM_CH1 */
14,61440
/* TPS2HCS08_ILIM_CONFIG_CH1 */
15,7
/* TPS2HCS08_CH1_CONFIG */
16,49166
/* TPS2HCS08_I2T_CONFIG_CH1 */
```

```
21,32832
/* TPS2HCS08_PWM_CH2 */
23,61440
/* TPS2HCS08_ILIM_CONFIG_CH2 */
24,0
/* TPS2HCS08_CH2_CONFIG */
25,49154
/* TPS2HCS08_I2T_CONFIG_CH2 */
30,0
```

3.1.8 Firmware Updates

The TPS12S24FQ1EVM has the ability to update the firmware on the TM4C microcontroller over USB. To enable this, the microcontroller leverages the *DFU ecosystem* developed by TI. To put the device into firmware update mode, select *Tools* then *Enter DFU Mode*.

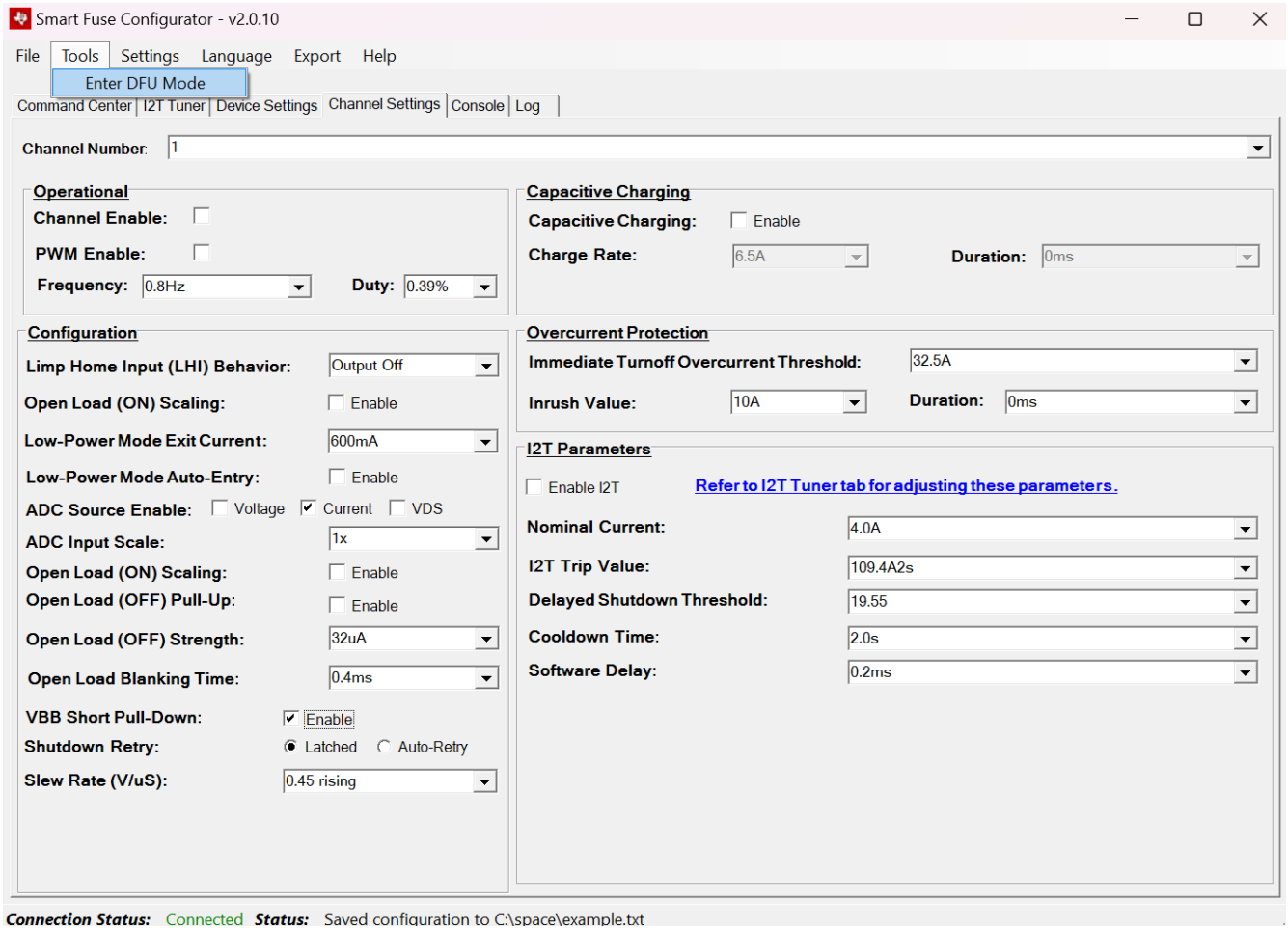


Figure 3-11. Enter Firmware Update Mode

Once in DFU mode, the high-side switch disconnects and the device enumerates as a DFU compatible USB device. Note that DFU drivers must be installed to support this mode of operation. These drivers are included with the standard TivaWare™ software installation. The firmware update tool dfutool.exe is also included within the TivaWare software installation. Use this tool to download a binary to the on-board microcontroller of the device.

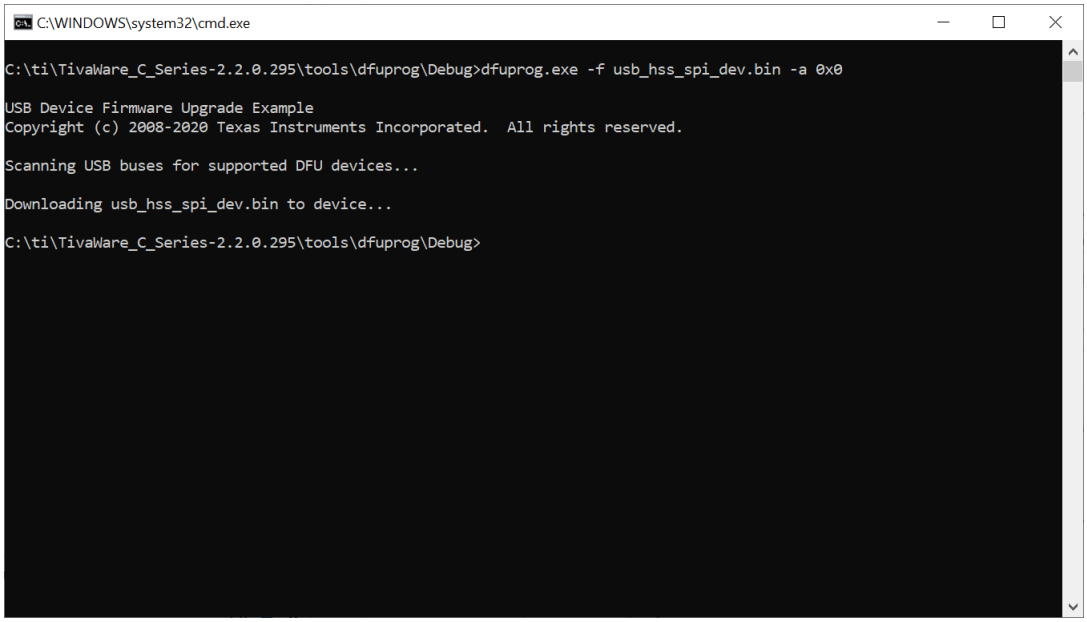


Figure 3-12. dfuprog Invocation

3.1.9 Persist Settings

By default, the Smart Fuse Configurator is set to automatically persist when a change is made on the GUI interface. Likewise, when a fault occurs in the system or a tab page is changes, the GUI automatically pings the high-side switch controller for the latest configuration data and update accordingly. Change this behavior to a manual mode by selecting or deselecting the *Settings* then *Auto-Persist/Refresh settings* as Figure 3-13 shows. Note that "persist" refers to a write operation to the register configuration of the high-side switch and "refresh" refers to a reach from the register map of the high-side switch controller.

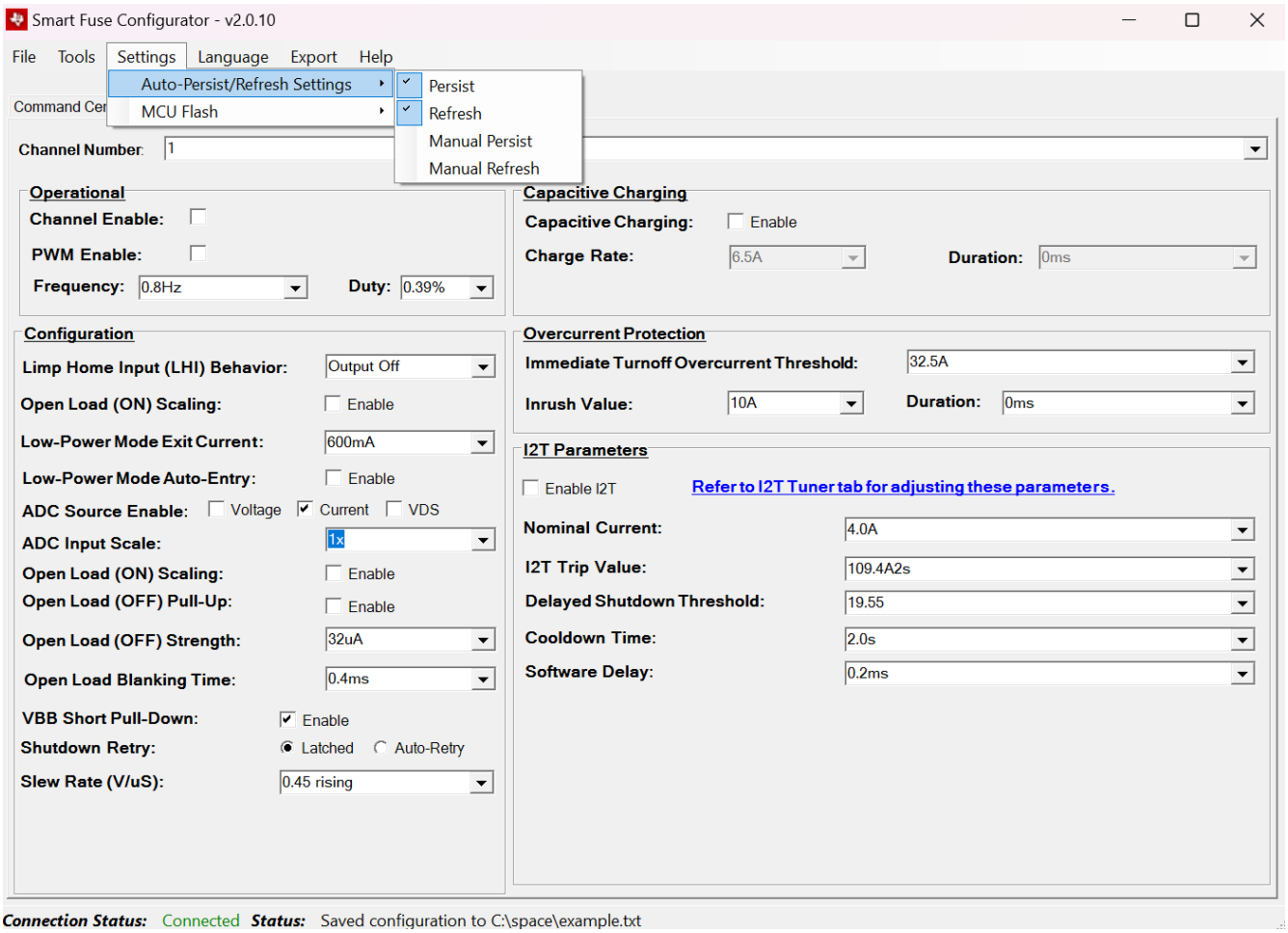


Figure 3-13. Persist Settings

Once deselected, the device enters manual persist and refresh mode. This mode enables the corresponding button in the *Settings* menu. Once selected, these buttons initiate a manual refresh of the GUI (pinging the high-side switch for the latest data) or a manual persist of the settings. Note in manual refresh mode, the fault diagnostics are automatically set to manual refresh mode in the device settings tab.

3.1.10 Language Settings

The Smart Fuse Configurator has the ability to switch between the language used for parameters and labels. To switch between languages, select the desired language from the Language menu option.

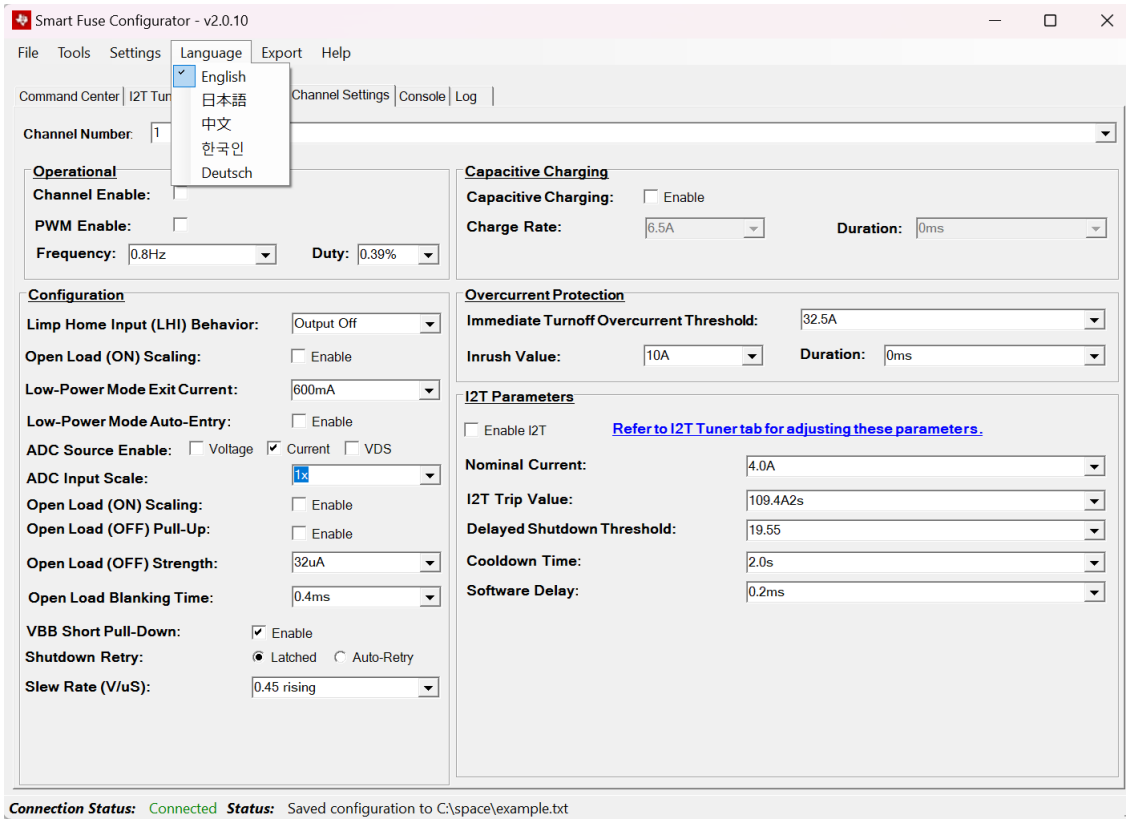


Figure 3-14. Language Settings

Currently English, Japanese, Korean, German, and simplified Chinese are supported.

4 Hardware Design Files

4.1 Schematics

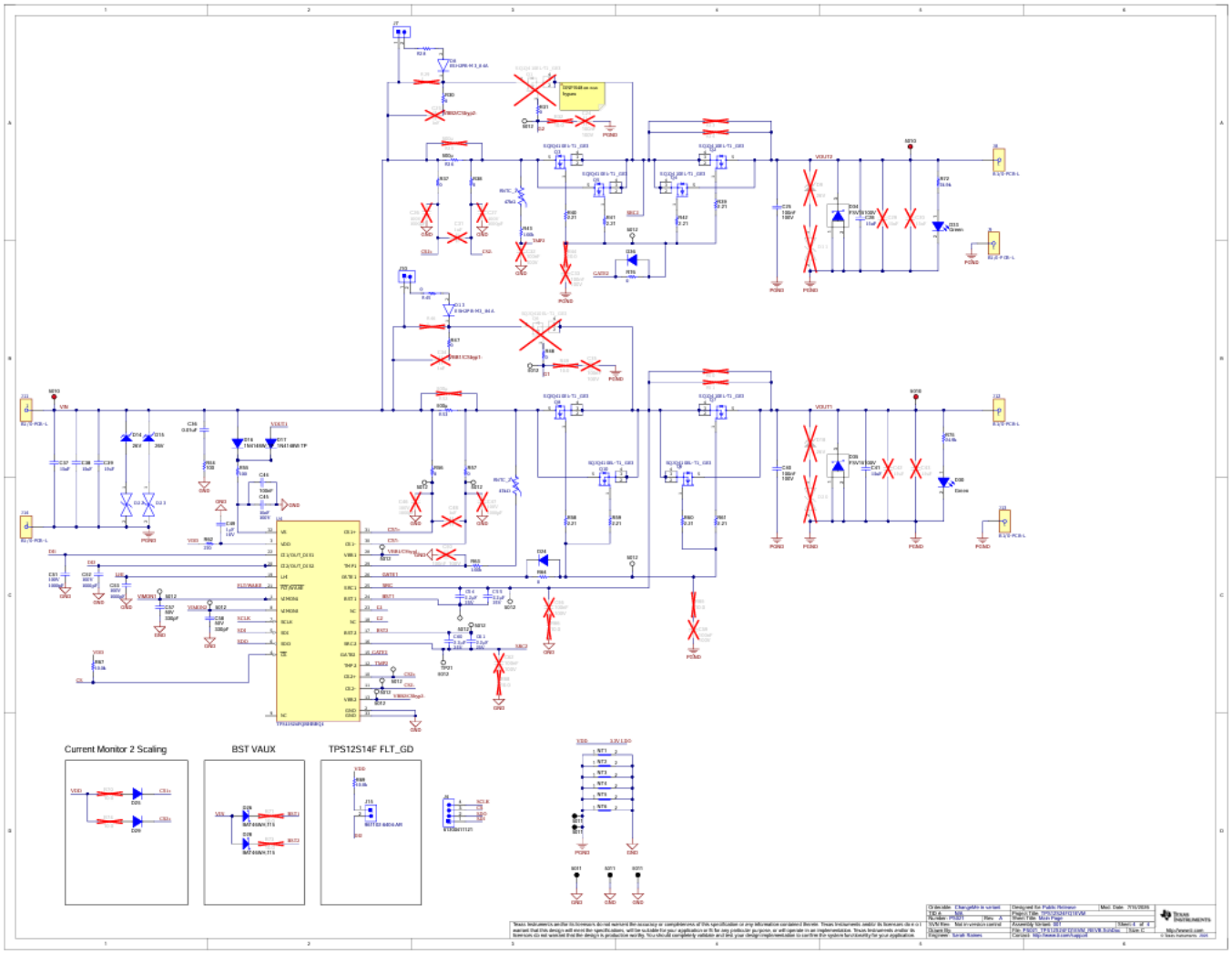


Figure 4-1. TPS12S24F-Q1 Schematic

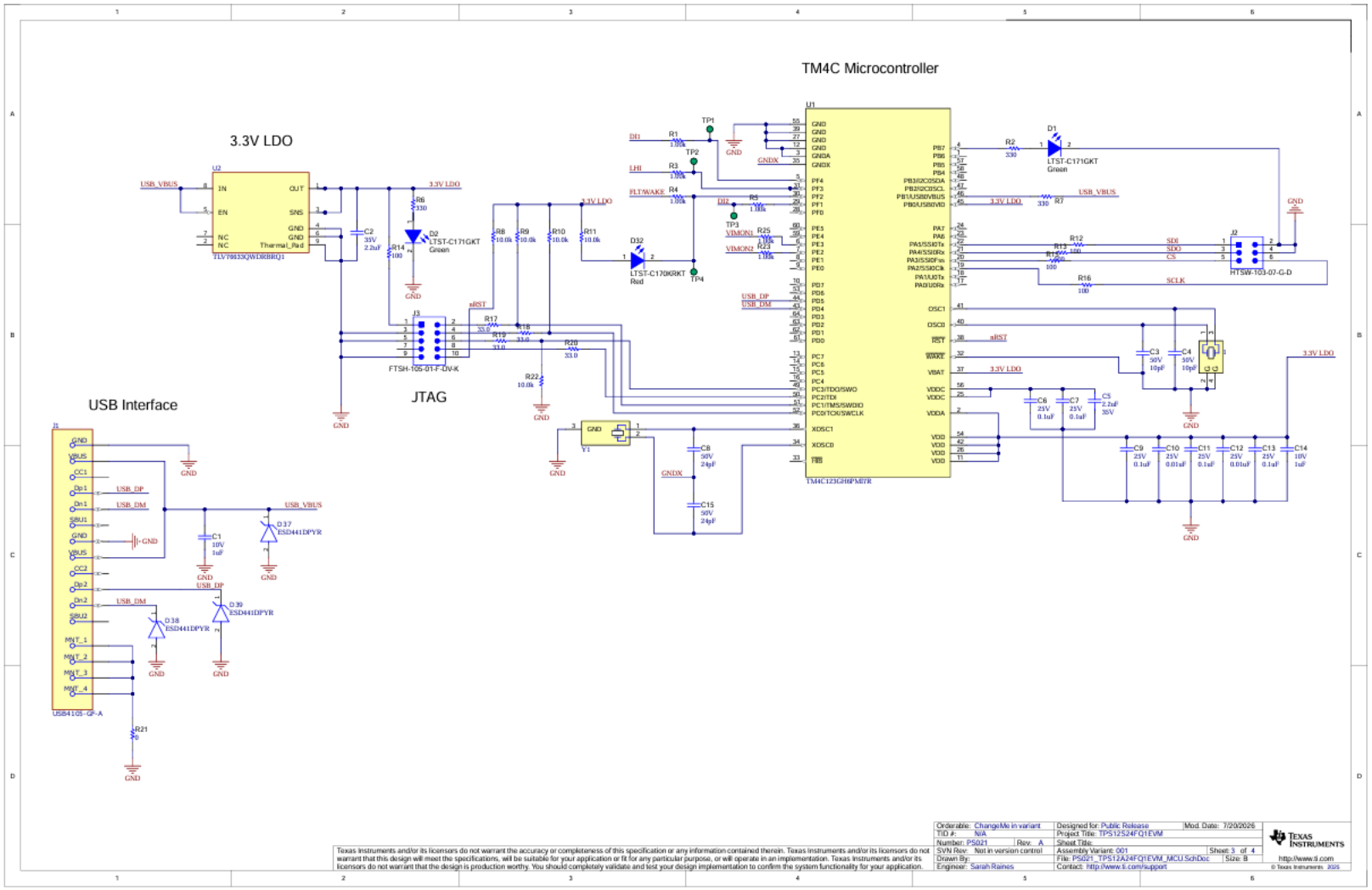


Figure 4-2. MCU Schematic

4.2 PCB Layouts

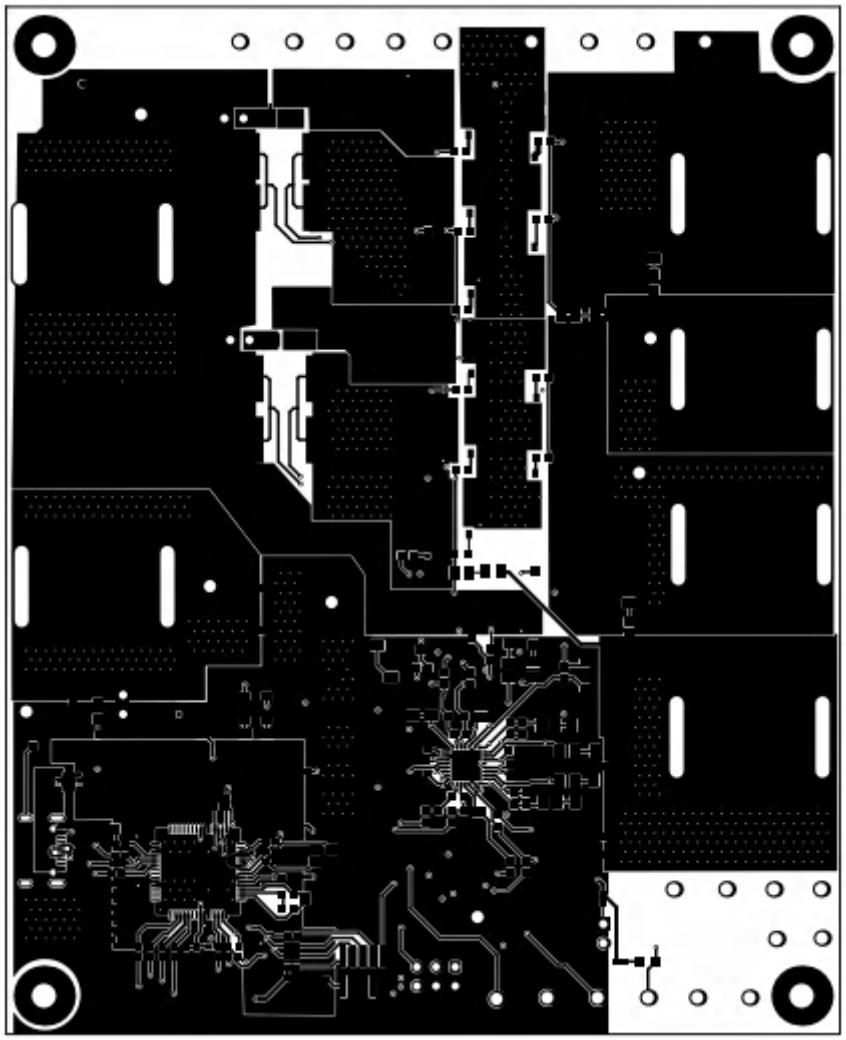


Figure 4-3. TPS12S24FQ1EVM Top Layer

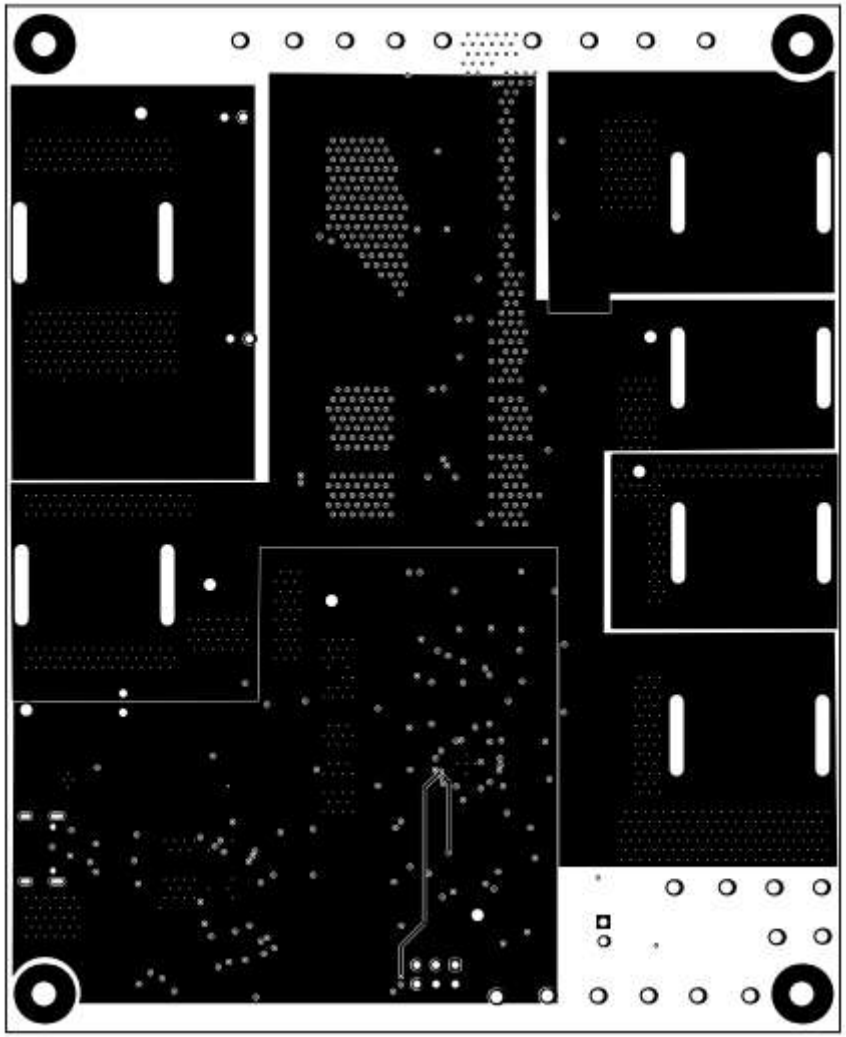


Figure 4-4. TPS12S24FQ1EVM Ground Layer

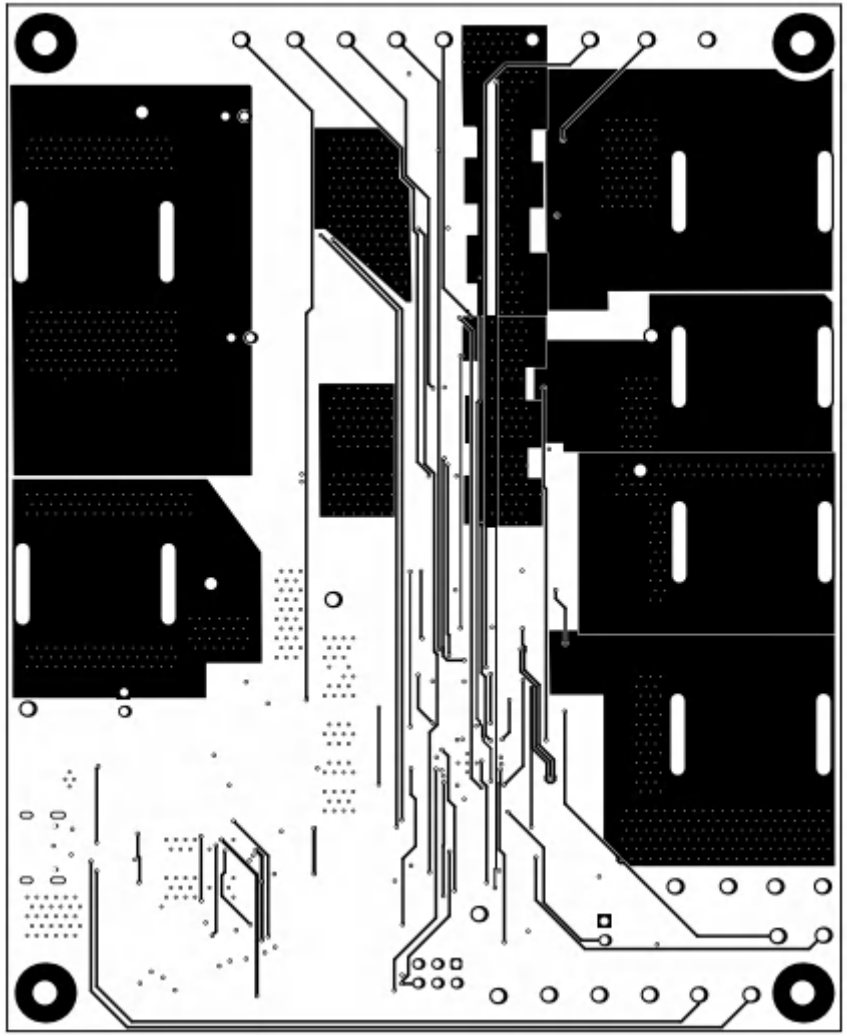


Figure 4-5. TPS12S24FQ1EVM Signal Layer 3

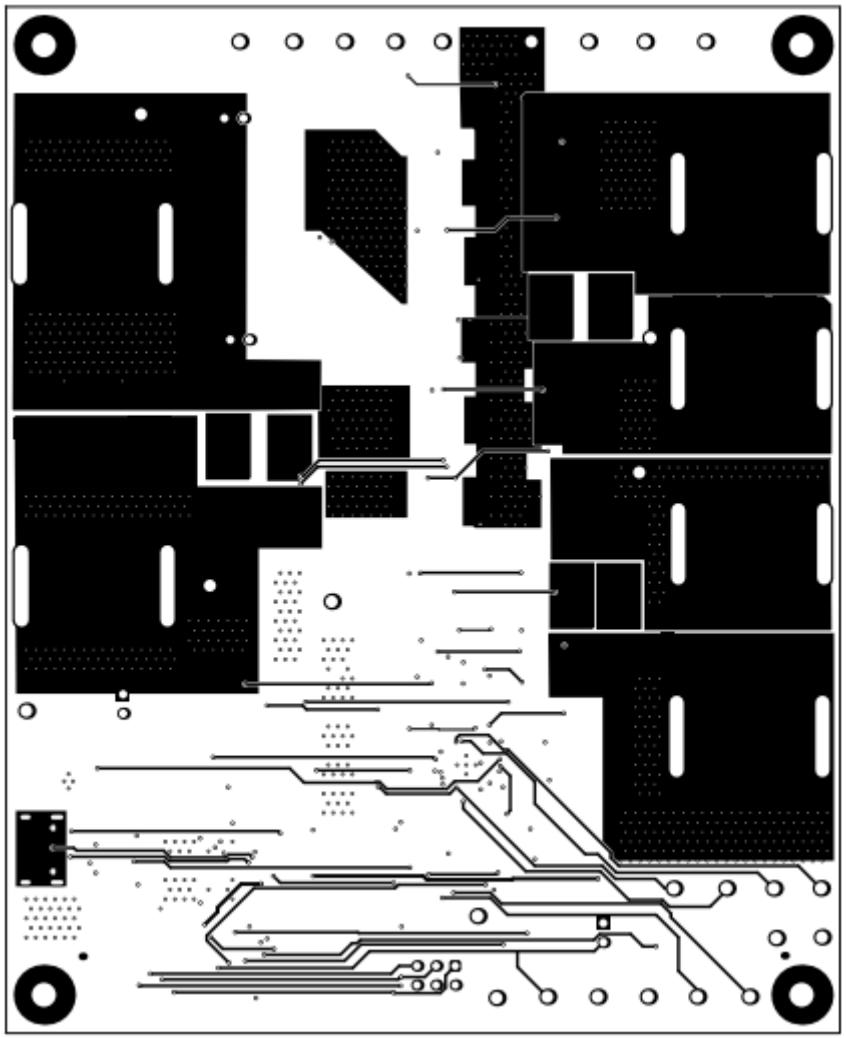


Figure 4-6. TPS12S24FQ1EVM Bottom Layer

4.3 Bill of Materials (BOM)

The table below is the bill of materials for the TPS12S24FQ1EVM:

Table 4-1. Bill of Materials

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
1	1		Crystal, 16MHz, 8pF, SMD	3.2x0.75x2.5mm	NX3225GA-16.000M-STD-CRG-1	NDK
C1, C14	2	1uF	CAP, CERM, 1uF, 10V, ± 10%, X7S, AEC-Q200 Grade 1, 0402	0402	GCM155C71A105KE38D	MuRata
C2	1	2.2uF	CAP, CERM, 2.2uF, 35V, ± 10%, X5R, 0402	0402	C1005X5R1V225K050BC	TDK
C3, C4	2	10pF	CAP, CERM, 10pF, 50V,± 1%, C0G/NP0, 0402	0402	GRM1555C1H100FA01D	MuRata
C5	1	2.2µF	2.2µF ±10% 35V Ceramic Capacitor X6S 0603 (1608 Metric)	0603	GRT188C8YA225KE13D	Murata
C6, C7, C9, C11, C13	5	0.1uF	CAP, CERM, 0.1uF, 25V, ± 10%, X5R, 0402	0402	GRM155R61E104KA87D	MuRata
C8, C15	2	24pF	CAP, CERM, 24pF, 50V, ± 5%, C0G/NP0, 0603	0603	GRM1885C1H240JA01D	MuRata
C10, C12	2	0.01uF	CAP, CERM, 0.01uF, 25V, ± 10%, X7R, 0402	0402	GCM155R71E103KA37D	MuRata
C25, C40, C44	3	0.1uF	CAP, CERM, 0.1uF, 100V, ± 10%, X7R, AEC-Q200 Grade 1, 0805	0805	CGA4J2X7R2A104K125AA	TDK
C28, C37, C38, C39, C41	5	15uF	CAP, CERM, 15uF, 100V, ± 20%, X7R, Stacked 2220	Stacked 2220	KCM55WR72A156MH01K	MuRata
C36	1	0.01uF	CAP, CERM, 0.01uF, 100V, ± 10%, X7R, 1206	1206	12061C103KAT2A	AVX
C45	1	0.01uF	CAP, CERM, 0.01uF, 100V, ± 10%, X7R, 0805	0805	08051C103KAT2A	AVX
C49	1	1uF	CAP, CERM, 1 µF, 16V,± 10%, X7R, AEC-Q200 Grade 1, 0603	0603	CGA3E1X7R1C105K080AC	TDK

Table 4-1. Bill of Materials (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
C51, C52, C53	3	1000pF	CAP, CERM, 1000pF, 100V, ± 5%, C0G/NP0, 0603	0603	C1608C0G2A102J080AA	TDK
C54, C55, C60, C61	4	2.2µF	Chip Multilayer Ceramic Capacitors for General Purpose, 0603, 2.2uF, X7R, 15%, 10%, 25V	0603	GRM188Z71E225KE43D	Murata
C57, C58	2	330pF	CAP, CERM, 330pF, 50V, ± 10%, X7R, 0402	0402	GRM155R71H331KA01D	MuRata
CS1-, CS1+, CS2-, CS2+, CSByp1, CSByp2, TP9, TP11, TP12, TP15, TP16, TP17, TP18, TP20, TP21, TP55	16		Test Point, Multipurpose, White, TH	White Multipurpose Testpoint	5012	Keystone
D1, D2	2	Green	LED, Green, SMD	0805 LED	LTST-C171GKT	Lite-On
D8, D13	2		Diode Standard 100V 2A Surface Mount DO-220AA (SMP)	DO-220AA	ESH2PB-M3_84A	Vishay
D14, D15	2	26V	Diode, TVS, Uni, 26V, 42.1 Vc, 1500W, 37A, SMC	SMC	SMCJ26A-TR	STMicroelectronics
D16, D17, D24, D25, D29, D36	6	100V	Diode, Switching, 100V, 0.15A, SOD-123	SOD-123	1N4148W-TP	Micro Commercial Components
D22, D23	2		87.1V Clamp 17.2A Ipp Tvs Diode Surface Mount DO-214AB (SMCJ)	DO-214AB	SMCJ54CA-E3/9AT	Vishay Semiconductor Diodes Division
D26, D28	2	100V	Diode, Schottky, 100V, 0.25A, SOD-123F	SOD-123F	BAT46WH,115	Nexperia
D30, D33	2	Green	LED, Green, SMD	LED_0805	LTST-C170KGKT	Lite-On
D32	1	Red	LED, Red, SMD	Red 0805 LED	LTST-C170KRKT	Lite-On
D34, D35	2	100V	Diode, Schottky, 100V, 15A, AEC-Q101, TO-277A	TO-277A	FSV15100V	ON Semiconductor

Table 4-1. Bill of Materials (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
D37, D38, D39	3		1pF, 5.5V, 30-KV ESD protection device in 0201 package 2X1SON -40 to 125	X1SON2	ESD441DPYR	Texas Instruments
H1, H2, H3, H4	4		Machine Screw, Round, #4-40x 1/4, Nylon, Philips panhead	Screw	NY PMS 440 0025 PH	B&F Fastener Supply
H5, H6, H7, H8	4		Standoff, Hex, 0.5"L #4-40 Nylon	Standoff	1902C	Keystone
J1	1		USB - C (Type - C) USB 2.0 Receptacle Connector 24 Position Surface Mount, Right Angle; Through Hole	CONN_USB_9MM58_7MM53	USB4105-GF-A	GCT
J2	1		Header, 2.54mm, 3x2, Gold, TH	Header, 2.54mm, 3x2, Gold, TH	HTSW-103-07G-D	Samtec
J3	1		Header (Shrouded), 1.27mm, 5x2, Gold, SMT	Header(Shrouded), 1.27mm, 5x2, SMT	FTSH-105-01F-DV-K	Samtec
J4	1		Header, 2.54mm, 4x1, Gold, TH	Header, 2.54mm, 4x1, TH	61300411121	Wurth Elektronik
J7, J10, J15	3		Header, 2.54mm, 2x1, TH	Header, 2.54mm, 2x1, TH	961102-6404-AR	3M
J8, J9, J11, J12, J13, J14	6		1/0 AWG High AMP PCB Wire Lugs 1/0-8 AWG	WIRE_LUG_150A_1-0AWG	B1/0-PCB-L	INTERNATIONAL HYDRAULICS
Q2, Q3, Q4, Q5, Q7, Q8, Q9, Q10	8		N-Channel 100V 135A (Tc) 136W (Tc) Surface Mount PowerPAK® 8x 8	PowerPAK 8x8L	SQJQ410EL-T1_GE3	Vishay
R1, R3, R4, R5, R23, R25	6	1.00k	RES, 1.00k, 1%, 0.063W, AEC-Q200 Grade 0, 0402	0402	CRCW04021K00FKED	Vishay-Dale
R2, R6, R7	3	330	RES, 330, 1%, 0.063W, AEC-Q200 Grade 0, 0402	0402	CRCW0402330RFKED	Vishay-Dale
R8, R9, R10, R11, R22, R67, R69	7	10.0k	RES, 10.0k, 1%, 0.063W, 0402	0402	RC0402FR-0710KL	Yageo America
R12, R13, R14, R15, R16	5	100	RES, 100, 1%, 0.1W, 0402	0402	ERJ-2RKF1000X	Panasonic

Table 4-1. Bill of Materials (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
R17, R18, R19, R20	4	33	RES, 33.0, 1%, 0.063W, AEC-Q200 Grade 0, 0402	0402	RMCF0402FT33R0	Stackpole Electronics Inc
R21	1	0	RES, 0, 5%, 0.1W, 0603	0603	ERJ-3GEY0R00V	Panasonic
R28, R45	2	0	0Ω Jumper 1W Chip Resistor 1206 (3216 Metric) Automotive AEC-Q200, Current Sense Thick Film	1206	PMR18EZPJ000	Rohm Semiconductor
R30, R31, R37, R38, R47, R48, R56, R57, R64, R76	10	0	RES, 0, 5%, 0.1W, AEC-Q200 Grade 0, 0603	0603	CRCW06030000Z0EA	Vishay-Dale
R36, R53	2	500µ	Res Metal Strip 3921 0.0005 Ohm 1% 3W ±175ppm/°C Molded SMD SMD Embossed Plastic T/R	3921	WSL3921L5000FEA	Vishay Dale
R39, R40, R41, R42, R58, R59, R60, R61	8	2.21	RES, 2.21, 1%, 0.1W, 0603	0603	RC0603FR-072R21L	Yageo
R43, R63	2	1.00k	RES, 1.00k, 1%, 0.1W, 0603	0603	RC0603FR-071KL	Yageo
R54	1	100	RES, 100, 1%, 0.5W, AEC-Q200 Grade 0, 1206	1206	CRCW1206100RFKEAHP	Vishay-Dale
R55	1	100	RES, 100, 1%, 0.1W, AEC-Q200 Grade 0, 0603	0603	ERJ-3EKF1000V	Panasonic
R62	1	220	RES, 220, 5%, 0.125W, AEC-Q200 Grade 0, 0805	0805	CRCW0805220RJNEA	Vishay-Dale
R72, R75	2	24.9k	RES, 24.9k, 1%, 0.125W, 0805	0805	CRCW080524K9FKEA	Vishay-Dale
RNTC_1, RNTC_2	2	47kΩ	NTC Thermistor for Temperature Sensor, Automotive, 0603, 47kΩ, 5%, 0.046mA, 5V	0603	NCU18WB473J6SRB	Murata
SH-J1, SH-J2, SH-J3, SH-J4, SH-J5, SH-J6	6	1x2	Shunt, 100mil, Flash Gold, Black	Closed Top 100mil Shunt	SPC02SYAN	Sullins Connector Solutions

Table 4-1. Bill of Materials (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
TP1, TP2, TP3, TP4	4		Test Point, Multipurpose, Green, TH	Green Multipurpose Testpoint	5126	Keystone
TP7, TP8, TP22, TP23, TP24	5		Test Point, Multipurpose, Black, TH	Black Multipurpose Testpoint	5011	Keystone
TP10, TP13, TP14	3		Test Point, Multipurpose, Red, TH	Red Multipurpose Testpoint	5010	Keystone
U1	1		High performance 32-bit ARM(R) Cortex(R)-M4F based MCU, PM0064A (LQFP-64)	PM0064A	TM4C123GH6PMI7R	Texas Instruments
U2	1		500mA, 17V linear voltage regulator	VSON8	TLV76633QWDRBRQ1	Texas Instruments
U4	1		TPS12S24FQRHBRQ1	VQFN32	TPS12S24FQRHBRQ1	Texas Instruments
Y1	1		Crystal, 32.768kHz, 12.5pF, SMD	1.4x1.4x5.0mm SMD	MS3V-T1R 32.768KHZ ±20PPM 12.5PF	Micro Crystal AG
C23, C31, C34, C48	0	1000pF	CAP, CERM, 1000pF, 50V, ± 10%, X7R, 0603	0603	C0603X102K5RACTU	Kemet
C24, C32, C33, C35, C50, C56, C59, C62	0	0.1uF	CAP, CERM, 0.1uF, 100V, ± 10%, X7R, AEC-Q200 Grade 1, 0805	0805	CGA4J2X7R2A104K125AA	TDK
C26, C27, C46, C47	0	1000pF	CAP, CERM, 1000pF, 100V, ± 5%, C0G/NP0, 0603	0603	C1608C0G2A102J080AA	TDK
C29, C30, C42, C43	0	15uF	CAP, CERM, 15uF, 100V, ± 20%, X7R, Stacked 2220	Stacked 2220	KCM55WR72A156MH01K	MuRata
D9, D18	0	26V	Diode, TVS, Uni, 26V, 42.1 Vc, 1500W, 37A, SMC	SMC	SMCJ26A-TR	STMicroelectronics
D11, D20	0		87.1V Clamp 17.2A Ipp Tvs Diode Surface Mount DO-214AB (SMCJ)	DO-214AB	SMCJ54CA-E3/9AT	Vishay Semiconductor Diodes Division
FID1, FID2, FID3	0		Fiducial mark. There is nothing to buy or mount.	N/A	N/A	N/A

Table 4-1. Bill of Materials (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
Q1, Q6	0		N-Channel 100V 135A (Tc) 136W (Tc) Surface Mount PowerPAK® 8x 8	PowerPAK 8x8L	SQJQ410EL-T1_GE3	Vishay
R29, R46	0	1	1Ω ±1% 3W Chip Resistor 2010 (5025 Metric) Automotive AEC-Q200, Current Sense, Moisture Resistant, Pulse Withstanding	2010	VMP-1R00-1.0U	Isabellenhuette
R32, R44, R49, R65, R66, R68, R70, R71, R73, R74	0	10	RES, 10.0, 1%, 0.125W, 0805	0805	RC0805FR-0710RL	Yageo America
R33, R34, R50, R51	0	0	0Ω Jumper 1W Chip Resistor 1206 (3216 Metric) Automotive AEC-Q200, Current Sense Thick Film	1206	PMR18EZPJ000	Rohm Semiconductor
R35, R52	0	500µ	Res Metal Strip 3921 0.0005Ω 1% 3W ±175ppm/°C Molded SMD SMD Embossed Plastic T/R	3921	WSL3921L5000FEA	Vishay Dale

5 Additional Information

5.1 Trademarks

TivaWare™ is a trademark of Texas Instruments.
USB-C® is a registered trademark of USB Implementers Forum.
Windows® is a registered trademark of Microsoft Corporation.
All trademarks are the property of their respective owners.

STANDARD TERMS FOR EVALUATION MODULES

1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, and/or documentation which may be provided together or separately (collectively, an “EVM” or “EVMs”) to the User (“User”) in accordance with the terms set forth herein. User's acceptance of the EVM is expressly subject to the following terms.

   1.1 EVMs are intended solely for product or software developers for use in a research and development setting to facilitate feasibility evaluation, experimentation, or scientific analysis of TI semiconductors products. EVMs have no direct function and are not finished products. EVMs shall not be directly or indirectly assembled as a part or subassembly in any finished product. For clarification, any software or software tools provided with the EVM (“Software”) shall not be subject to the terms and conditions set forth herein but rather shall be subject to the applicable terms that accompany such Software

   1.2 EVMs are not intended for consumer or household use. EVMs may not be sold, sublicensed, leased, rented, loaned, assigned, or otherwise distributed for commercial purposes by Users, in whole or in part, or used in any finished product or production system.

2 *Limited Warranty and Related Remedies/Disclaimers*:

   2.1 These terms do not apply to Software. The warranty, if any, for Software is covered in the applicable Software License Agreement.

   2.2 TI warrants that the TI EVM will conform to TI's published specifications for ninety (90) days after the date TI delivers such EVM to User. Notwithstanding the foregoing, TI shall not be liable for a nonconforming EVM if (a) the nonconformity was caused by neglect, misuse or mistreatment by an entity other than TI, including improper installation or testing, or for any EVMs that have been altered or modified in any way by an entity other than TI, (b) the nonconformity resulted from User's design, specifications or instructions for such EVMs or improper system design, or (c) User has not paid on time. Testing and other quality control techniques are used to the extent TI deems necessary. TI does not test all parameters of each EVM. User's claims against TI under this Section 2 are void if User fails to notify TI of any apparent defects in the EVMs within ten (10) business days after delivery, or of any hidden defects with ten (10) business days after the defect has been detected.

   2.3 TI's sole liability shall be at its option to repair or replace EVMs that fail to conform to the warranty set forth above, or credit User's account for such EVM. TI's liability under this warranty shall be limited to EVMs that are returned during the warranty period to the address designated by TI and that are determined by TI not to conform to such warranty. If TI elects to repair or replace such EVM, TI shall have a reasonable time to repair such EVM or provide replacements. Repaired EVMs shall be warranted for the remainder of the original warranty period. Replaced EVMs shall be warranted for a new full ninety (90) day warranty period.

WARNING

Evaluation Kits are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems.

User shall operate the Evaluation Kit within TI’s recommended guidelines and any applicable legal or environmental requirements as well as reasonable and customary safeguards. Failure to set up and/or operate the Evaluation Kit within TI’s recommended guidelines may result in personal injury or death or property damage. Proper set up entails following TI’s instructions for electrical ratings of interface circuits such as input, output and electrical loads.

NOTE:

EXPOSURE TO ELECTROSTATIC DISCHARGE (ESD) MAY CAUSE DEGREDATION OR FAILURE OF THE EVALUATION KIT; TI RECOMMENDS STORAGE OF THE EVALUATION KIT IN A PROTECTIVE ESD BAG.

3 *Regulatory Notices:*

3.1 *United States*

3.1.1 *Notice applicable to EVMs not FCC-Approved:*

FCC NOTICE: This kit is designed to allow product developers to evaluate electronic components, circuitry, or software associated with the kit to determine whether to incorporate such items in a finished product and software developers to write software applications for use with the end product. This kit is not a finished product and when assembled may not be resold or otherwise marketed unless all required FCC equipment authorizations are first obtained. Operation is subject to the condition that this product not cause harmful interference to licensed radio stations and that this product accept harmful interference. Unless the assembled kit is designed to operate under part 15, part 18 or part 95 of this chapter, the operator of the kit must operate under the authority of an FCC license holder or must secure an experimental authorization under part 5 of this chapter.

3.1.2 *For EVMs annotated as FCC – FEDERAL COMMUNICATIONS COMMISSION Part 15 Compliant:*

CAUTION

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

FCC Interference Statement for Class A EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

FCC Interference Statement for Class B EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- *Reorient or relocate the receiving antenna.*
- *Increase the separation between the equipment and receiver.*
- *Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.*
- *Consult the dealer or an experienced radio/TV technician for help.*

3.2 *Canada*

3.2.1 *For EVMs issued with an Industry Canada Certificate of Conformance to RSS-210 or RSS-247*

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-exempt RSSs. Operation is subject to the following two conditions:

(1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Concernant les EVMs avec appareils radio:

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes: (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Concerning EVMs Including Detachable Antennas:

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication. This radio transmitter has been approved by Industry Canada to operate with the antenna types listed in the user guide with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Concernant les EVMs avec antennes détachables

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante. Le présent émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés dans le manuel d'usage et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur

3.3 *Japan*

3.3.1 *Notice for EVMs delivered in Japan:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page 日本国内に輸入される評価用キット、ボードについては、次のところをご覧ください。

https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-delivered-in-japan.html

3.3.2 *Notice for Users of EVMs Considered "Radio Frequency Products" in Japan:* EVMs entering Japan may not be certified by TI as conforming to Technical Regulations of Radio Law of Japan.

If User uses EVMs in Japan, not certified to Technical Regulations of Radio Law of Japan, User is required to follow the instructions set forth by Radio Law of Japan, which includes, but is not limited to, the instructions below with respect to EVMs (which for the avoidance of doubt are stated strictly for convenience and should be verified by User):

1. Use EVMs in a shielded room or any other test facility as defined in the notification #173 issued by Ministry of Internal Affairs and Communications on March 28, 2006, based on Sub-section 1.1 of Article 6 of the Ministry's Rule for Enforcement of Radio Law of Japan,
2. Use EVMs only after User obtains the license of Test Radio Station as provided in Radio Law of Japan with respect to EVMs, or
3. Use of EVMs only after User obtains the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to EVMs. Also, do not transfer EVMs, unless User gives the same notice above to the transferee. Please note that if User does not follow the instructions above, User will be subject to penalties of Radio Law of Japan.

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1. 電波法施行規則第6条第1項第1号に基づく平成18年3月28日総務省告示第173号で定められた電波暗室等の試験設備でご使用いただく。
2. 実験局の免許を取得後ご使用いただく。
3. 技術基準適合証明を取得後ご使用いただく。

なお、本製品は、上記の「ご使用にあたっての注意」を譲渡先、移転先に通知しない限り、譲渡、移転できないものとします。

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東京都新宿区西新宿 6 丁目 2 4 番 1 号

西新宿三井ビル

3.3.3 *Notice for EVMs for Power Line Communication:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_02.page

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3.4 *European Union*

3.4.1 *For EVMs subject to EU Directive 2014/30/EU (Electromagnetic Compatibility Directive)*:

This is a class A product intended for use in environments other than domestic environments that are connected to a low-voltage power-supply network that supplies buildings used for domestic purposes. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.

4 *EVM Use Restrictions and Warnings:*

4.1 EVMS ARE NOT FOR USE IN FUNCTIONAL SAFETY AND/OR SAFETY CRITICAL EVALUATIONS, INCLUDING BUT NOT LIMITED TO EVALUATIONS OF LIFE SUPPORT APPLICATIONS.

4.2 User must read and apply the user guide and other available documentation provided by TI regarding the EVM prior to handling or using the EVM, including without limitation any warning or restriction notices. The notices contain important safety information related to, for example, temperatures and voltages.

4.3 *Safety-Related Warnings and Restrictions:*

4.3.1 User shall operate the EVM within TI's recommended specifications and environmental considerations stated in the user guide, other available documentation provided by TI, and any other applicable requirements and employ reasonable and customary safeguards. Exceeding the specified performance ratings and specifications (including but not limited to input and output voltage, current, power, and environmental ranges) for the EVM may cause personal injury or death, or property damage. If there are questions concerning performance ratings and specifications, User should contact a TI field representative prior to connecting interface electronics including input power and intended loads. Any loads applied outside of the specified output range may also result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM user guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative. During normal operation, even with the inputs and outputs kept within the specified allowable ranges, some circuit components may have elevated case temperatures. These components include but are not limited to linear regulators, switching transistors, pass transistors, current sense resistors, and heat sinks, which can be identified using the information in the associated documentation. When working with the EVM, please be aware that the EVM may become very warm.

4.3.2 EVMs are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems. User assumes all responsibility and liability for proper and safe handling and use of the EVM by User or its employees, affiliates, contractors or designees. User assumes all responsibility and liability to ensure that any interfaces (electronic and/or mechanical) between the EVM and any human body are designed with suitable isolation and means to safely limit accessible leakage currents to minimize the risk of electrical shock hazard. User assumes all responsibility and liability for any improper or unsafe handling or use of the EVM by User or its employees, affiliates, contractors or designees.

4.4 User assumes all responsibility and liability to determine whether the EVM is subject to any applicable international, federal, state, or local laws and regulations related to User's handling and use of the EVM and, if applicable, User assumes all responsibility and liability for compliance in all respects with such laws and regulations. User assumes all responsibility and liability for proper disposal and recycling of the EVM consistent with all applicable international, federal, state, and local requirements.

5. *Accuracy of Information:* To the extent TI provides information on the availability and function of EVMs, TI attempts to be as accurate as possible. However, TI does not warrant the accuracy of EVM descriptions, EVM availability or other information on its websites as accurate, complete, reliable, current, or error-free.

6. *Disclaimers:*

6.1 EXCEPT AS SET FORTH ABOVE, EVMS AND ANY MATERIALS PROVIDED WITH THE EVM (INCLUDING, BUT NOT LIMITED TO, REFERENCE DESIGNS AND THE DESIGN OF THE EVM ITSELF) ARE PROVIDED "AS IS" AND "WITH ALL FAULTS." TI DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, REGARDING SUCH ITEMS, INCLUDING BUT NOT LIMITED TO ANY EPIDEMIC FAILURE WARRANTY OR IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF ANY THIRD PARTY PATENTS, COPYRIGHTS, TRADE SECRETS OR OTHER INTELLECTUAL PROPERTY RIGHTS.

6.2 EXCEPT FOR THE LIMITED RIGHT TO USE THE EVM SET FORTH HEREIN, NOTHING IN THESE TERMS SHALL BE CONSTRUED AS GRANTING OR CONFERRING ANY RIGHTS BY LICENSE, PATENT, OR ANY OTHER INDUSTRIAL OR INTELLECTUAL PROPERTY RIGHT OF TI, ITS SUPPLIERS/LICENSORS OR ANY OTHER THIRD PARTY, TO USE THE EVM IN ANY FINISHED END-USER OR READY-TO-USE FINAL PRODUCT, OR FOR ANY INVENTION, DISCOVERY OR IMPROVEMENT, REGARDLESS OF WHEN MADE, CONCEIVED OR ACQUIRED.

7. *USER'S INDEMNITY OBLIGATIONS AND REPRESENTATIONS.* USER WILL DEFEND, INDEMNIFY AND HOLD TI, ITS LICENSORS AND THEIR REPRESENTATIVES HARMLESS FROM AND AGAINST ANY AND ALL CLAIMS, DAMAGES, LOSSES, EXPENSES, COSTS AND LIABILITIES (COLLECTIVELY, "CLAIMS") ARISING OUT OF OR IN CONNECTION WITH ANY HANDLING OR USE OF THE EVM THAT IS NOT IN ACCORDANCE WITH THESE TERMS. THIS OBLIGATION SHALL APPLY WHETHER CLAIMS ARISE UNDER STATUTE, REGULATION, OR THE LAW OF TORT, CONTRACT OR ANY OTHER LEGAL THEORY, AND EVEN IF THE EVM FAILS TO PERFORM AS DESCRIBED OR EXPECTED.

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