EVM User's Guide: TPS389387EVM

TPS389387EVM Joint Evaluation Module

Description

The TPS389387EVM demonstrates the functionality of the TPS38700S-Q1 sequencer and TPS389006 voltage monitoring device. If needed, then connectors and pins are provided to give the user access for oscilloscope or multi-meter measurements.

The EVM comes pre-populated with two devices: a TPS389006 I2C programmable 6 channel supervisor and a TPS38700S-Q1 I2C programmable 6 channel sequencer. The EVM is intended to be operated with an up to 12 rail programmable virtual power tree generated from MSP430 launchpad dev board. This EVM must be used with the MSP430 MCU variant, MSP430FR2355.

Get Started

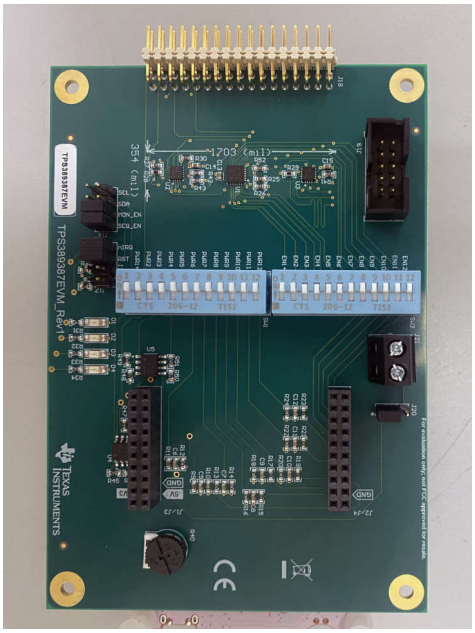
1. Order the TPS3839387EVM.
2. Order additional components
   a. MSP430 MCU variant, MSP430FR2355 (MSP-EXP430FR2355).
   b. USB-TO-GPIO2 connector (USB-TO-GPIO2).
3. Download Code Composer Studio™ integrated development environment (IDE).
4. Download the Fusion Digital Power Designer Platform GUI originally designed for the TPS38700Q1EVM.
5. Download the zip file containing the .C code referenced in TPS389387EVM Evaluation Instructions.
6. Download the comprehensive reference design files.
7. See the latest Design & development pages for MSP430™.

Features

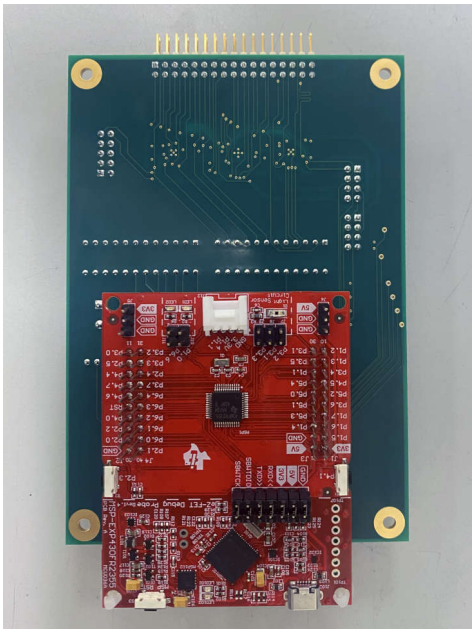
- TPS3839387EVM is a USB-powered EVM, but has additional provision for external power.
- There is a connector available to interface with different power tree types.

Applications

- Wired networking
- Data center & enterprise computing
- Motor drives
- Factory automation & control
- Grid infrastructure
- Advanced driver assistance system (ADAS)



TPS389387EVM Board Top



TPS389387EVM Board Bottom with MSP430

1 Evaluation Module Overview

1.1 Introduction

This User's Guide describes how to use the TPS389387EVM joint evaluation module (EVM) for engineering demonstration and evaluation of the combined monitor and sequencer devices of TPS389006 Multichannel Voltage Supervisor and the TPS38700S-Q1 Sequencer. This User's Guide contains the EVM schematic, bill of materials (BOM), assembly drawing, top and bottom board layouts, and setup instructions.

Additional functionality of the TPS38700S-Q1 sequencer can be tested through the TPS38700-Q1 GUI. To use this EVM, the MSP-EXP430FR2355 MSP430 launchpad andUSB-TO-GPIO2 connector is required.

1.2 Kit Contents

The package includes:

- The USS evaluation module (EVM) with both TPS38700S-Q1 and TPS389006 devices pre-populated.
- The graphical user interface (GUI) to control the configurable parameters of the sequencer IC, TPS38700S-Q1.
- A zip file contained editable code that controls the TPS389387EVM. This is run through Code Composer Studio IDE (CCS), and can be downloaded here.

Not included:

- MSP430, a microcontroller development kit for rapid prototyping. The variant, MSP430FR2355, can be ordered on ti.com through the product page (MSP-EXP430FR2355).
- USB-TO-GPIO2 connector for I2C communication between the GUI and devices. The USB-TO-GPIO2 can be ordered on ti.com through the product page (USB-TO-GPIO2).

1.3 Specification

This sequencer and voltage monitoring device is intended for use in any application with multiple rails that require a specific configuration or series of triggers. TPS38700S-Q1 has a maximum of six enables that can be independently configured or triggered in any sequence through the use of I2C.

In this EVM, the TPS38700S-Q1 is used in tandem with TPS389006. The TPS389006-Q1 uses its sequence logging feature to monitor and assign timestamps/log for the power rails turning on and off. Through the SYNC pin, TPS38700S-Q1 is able to detect the status of the voltage monitoring channels of the TPS389006, and can use this information to verify proper sequencing. This means the sequencer will know the state of all monitor channels and can 'wait' until the channel status changes before sending out another signal, ensuring further sequencing accuracy.

This EVM connects a single TPS38700S-Q1 to a TPS389006. However, in other applications, the TPS389006 SYNC feature allows for communication across multiple devices. If more than 6 rails require monitoring, multiple TPS389006 ICs could be connected and sequenced (ie. if 18 Rails need sequencing, 3 TPS389006 ICs can be used).

1.4 Device Information

The TPS389006 IC variant on this EVM is configured for six integrated multichannel window inputs to monitor six distinct input voltage rails. The device also includes internal glitch immunity and noise filters to eliminate false resets resulting from erroneous signals. The TPS389006 device does not require any external resistors for setting overvoltage and undervoltage reset thresholds which optimizes and improves the reliability for safety systems.

TPS389006 has full I2C functionality which gives flexibility in selecting thresholds, reset delays, glitch filters, and pin functionality. This device offers CRC error checking, sequence logging during turn ON or turn OFF, and a built-in ADC for voltage readouts to provide redundant error checking. In addition to these features, TPS389006 offers a sync feature for rail tagging. Rail tagging works across multiple instances of TPS389006 devices. If users need a different TPS389006 variant, the currently attached device must be removed from the board. The EVM board is designed to support all variants of TPS389006.

The TPS38700S-Q1 IC variant on this EVM is a programmable 6 channel sequencer. The device offers the option of battery backup power and the ability to communicate faults via I2C. The NIRQ pin serves as an interrupt flag to alert the system to possible faults, and the NRST pin asserts logic high under reset condition.

1.5 Sync Function

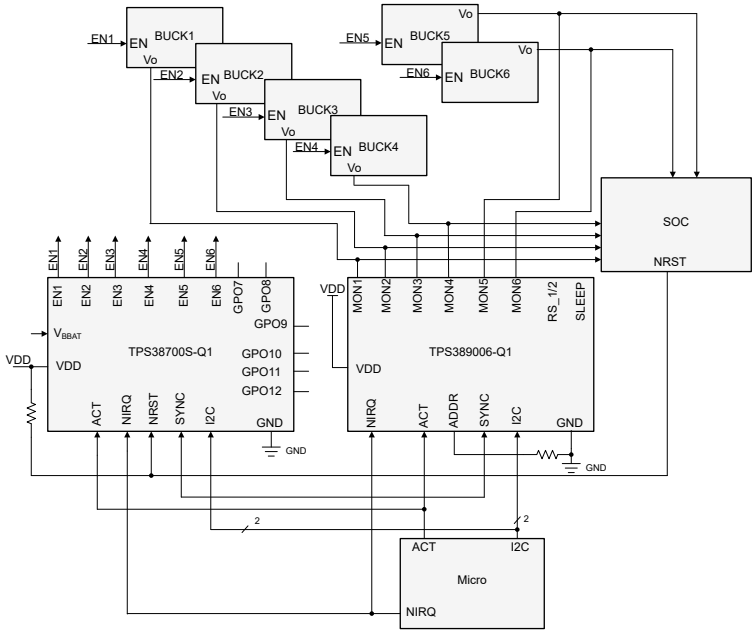


Figure 1-1. Typical Sync Configuration

The TPS389006 is equipped with a SYNC pin as shown in Figure 1-1. It also has a sequence logging feature to monitor and assign timestamps/log for the power rails turning on and off. It can perform sequence logging on a single device or across multiple devices on a board. When either the ACT or SLEEP pin transitions from low to high or high to low, the sequence logging function becomes active until the expiry of the sequence timeout (SEQ_TOUT). During the sequence timeout, the UV faults can be masked (Automask - AMSK) to allow the power rails to rise without triggering a fault. The TPS389006 is designed to assert active low output signals (NIRQ) when the monitored voltage is outside the safe window.

In this EVM, when ACT is driven high, the first EN signal in the power up sequence is turned on by TPS38700S-Q1. Then, the MON1 voltage rises and triggers TPS389006 to send the first SYNC signal which causes TPS38700S-Q1 to turn on the second EN voltage. This process repeats until all Enable voltages turn on. Note that the TPS389006 defaults to using UV thresholds for sending the SYNC pulse when sequencing up. When ACT is driven low, the first EN signal in the power down sequence is immediately driven low. When the corresponding MON voltage drops below the threshold, TPS389006 sends a SYNC pulse. The SYNC pulse causes TPS38700S-Q1 to turn off the second EN signal. This process also repeats until all voltages have been turned off. By default, SYNC voltage thresholds for TPS389006 are based on the OFF voltage. The voltage thresholds can be changed to UV voltage thresholds for both sequencing up and down. Note that the TPS389006 defaults to using OFF voltage threshold (MONx<140mV) for sending the SYNC pulse when sequencing down.

2 Hardware

2.1 Setup

This section describes all the parts of the EVM as well as how to connect, set up, and properly use the EVM. Each device has an independent power supply connection, but all grounds are interconnected on the board.

2.2 Connectors, Headers, and LEDs

Table 2-1 defines the location and function of all connectors, headers, jumpers and LEDs on the EVM. Use Figure 6-1 or the labeled diagram for further reference of pin numbers.

Table 2-1. Connectors, Headers, LEDs of TPS389387EVM

Location	Pins/Silkscreen Label	Function/Description
J1/J2/J3/J4		Connector to MSP430.
J16		Pins 1-4: Connects I2C to MSP430. Pins 5-8; Connects MSP430 to sequencer & monitor enables.
J17		Pins 1-2: Connects interrupts to MSP430. Pins 3-4: Connects resets to MSP430. Pins 5-8: Adds pull-up resistors to I2C. Not necessary if USB-to-I2C connector is used (J19).

Table 2-1. Connectors, Headers, LEDs of TPS389387EVM (continued)

Location	Pins/Silkscreen Label	Function/Description
J18	Pin 1	Allows user to monitor TPS389006 Power Rail 12.
	Pin 2	Allows user to monitor TPS38700S-Q1 Enable 12.
	Pin 3	Allows user to monitor TPS389006 Power Rail 11.
	Pin 4	Allows user to monitor TPS38700S-Q1 Enable 11.
	Pin 5	Allows user to monitor TPS389006 Power Rail 10.
	Pin 6	Allows user to monitor TPS38700S-Q1 Enable 10.
	Pin 7	Allows user to monitor TPS389006 Power Rail 9.
	Pin 8	Allows user to monitor TPS38700S-Q1 Enable 9.
	Pin 9	Allows user to monitor TPS389006 Power Rail 8.
	Pin 10	Allows user to monitor TPS38700S-Q1 Enable 8.
	Pin 11	Allows user to monitor TPS389006 Power Rail 7.
	Pin 12	Allows user to monitor TPS38700S-Q1 Enable 7.
	Pin 13	Allows user to monitor TPS389006 Power Rail 6.
	Pin 14	Allows user to monitor TPS38700S-Q1 Enable 6.
	Pin 15	Allows user to monitor TPS389006 Power Rail 5.
	Pin 16	Allows user to monitor TPS38700S-Q1 Enable 5.
	Pin 17	Allows user to monitor TPS389006 Power Rail 4.
	Pin 18	Allows user to monitor TPS38700S-Q1 Enable 4.
	Pin 19	Allows user to monitor TPS389006 Power Rail 3.
	Pin 20	Allows user to monitor TPS38700S-Q1 Enable 3.
	Pin 21	Allows user to monitor TPS389006 Power Rail 2.
	Pin 22	Allows user to monitor TPS38700S-Q1 Enable 2.
	Pin 23	Allows user to monitor TPS389006 Power Rail 1.
	Pin 24	Allows user to monitor TPS38700S-Q1 Enable 1.
	Pin 25	I2C SCL.
	Pin 26	TPS38700S-Q1 Sequencer Enable.
	Pin 27	I2C SDA.
	Pin 28	nIRQ or Interrupt.
	Pin 29	TPS38900 Monitor Enable.
	Pin 30	TPS38700S-Q1 Reset.
	Pin 31	Ground.
	Pin 32	Ground.
	Pin 33	Ground.
	Pin 34	Ground.
J19		Header for USB-TO-GPIO2 connector; Used for TPS38700-Q1 GUI and I2C communication.
J20		Selection between external power connector & MSP430 Power.
J21		External Power Connector.

Table 2-1. Connectors, Headers, LEDs of TPS389387EVM (continued)

Location	Pins/Silkscreen Label	Function/Description
SW1	PWR1	Switch for TPS389006 Power Rail 1.
	PWR2	Switch for TPS389006 Power Rail 2.
	PWR3	Switch for TPS389006 Power Rail 3.
	PWR4	Switch for TPS389006 Power Rail 4.
	PWR5	Switch for TPS389006 Power Rail 5.
	PWR6	Switch for TPS389006 Power Rail 6.
	PWR7	Switch for TPS389006 Power Rail 7.
	PWR8	Switch for TPS389006 Power Rail 8.
	PWR9	Switch for TPS389006 Power Rail 9.
	PWR10	Switch for TPS389006 Power Rail 10.
	PWR11	Switch for TPS389006 Power Rail 11.
	PWR12	Switch for TPS389006 Power Rail 12.
SW2	EN1	Switch for TPS38700S-Q1 Enable 1.
	EN2	Switch for TPS38700S-Q1 Enable 2.
	EN3	Switch for TPS38700S-Q1 Enable 3.
	EN4	Switch for TPS38700S-Q1 Enable 4.
	EN5	Switch for TPS38700S-Q1 Enable 5.
	EN6	Switch for TPS38700S-Q1 Enable 6.
	EN7	Switch for TPS38700S-Q1 Enable 7.
	EN8	Switch for TPS38700S-Q1 Enable 8.
	EN9	Switch for TPS38700S-Q1 Enable 9.
	EN10	Switch for TPS38700S-Q1 Enable 10.
	EN11	Switch for TPS38700S-Q1 Enable 11.
	EN12	Switch for TPS38700S-Q1 Enable 12.
D1		LED 1; Turns on for nirQ/Interrupt.
D2		LED 2; Turns on for Enable 1.
D3		LED 3; Turns on for Enable 2.
D4		LED 4; Turns on for Enable 3.

2.3 EVM Jumpers

Table 2-2 lists the jumpers on the TPS389387EVM. The EVM has five jumpers installed.

Table 2-2. Jumper Configuration

Jumper	Pins/Silkscreen Label	Jumper Configuration
J16	SCL	Open
J16	DA	Open
J16	MON_EN	Shunted
J16	SEQ_EN	Shunted
J17	nIRQ	Shunted
J17	RST	Shunted
J17	I2C Pullup	Open
J20	1-2	If Shunted, then external power supply is 5 V.
J20	2-3	If Shunted, then external power supply is 6 V.

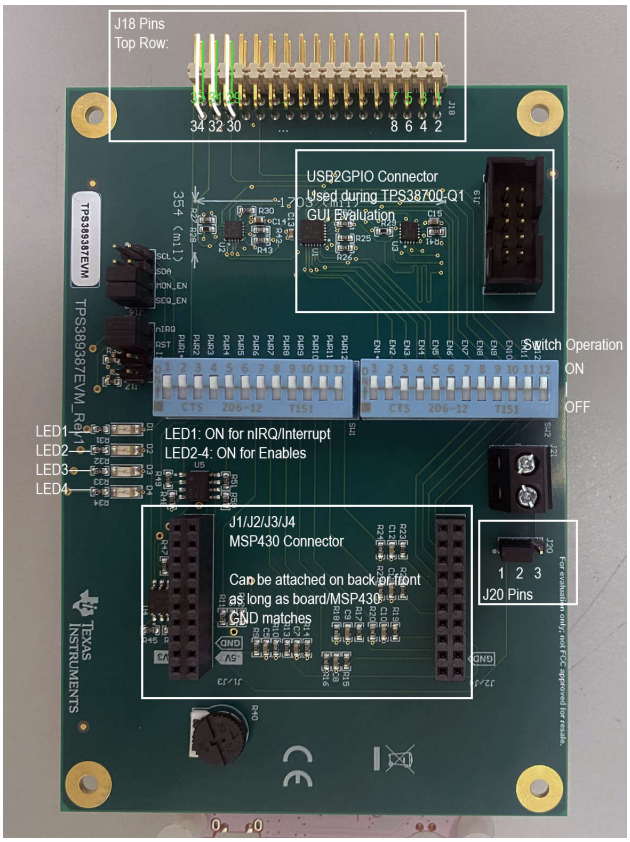


Figure 2-1. Labeled TPS389387EVM Pins and Connector Locations

3 Software

3.1 Software Description

This section describes the software functionality and operation of this EVM. Refer to the TPS389006 and TPS38700S-Q1 data sheet for details on the electrical characteristics of the respective devices.

The EVM comes pre-populated with a TPS389006 I2C programmable 6 channel supervisor and a TPS38700S-Q1 I2C programmable 6 channel sequencer, and a 12 rail programmable virtual power tree generated from the MSP430 launchpad dev board. This EVM is capable of different configurations to fully evaluate the functionality and interactions between the TPS389006 and TPS38700S-Q1 device variants. With the current devices, the EVM can monitor and sequence up to 6 channels.

The default configuration of the EVM Jumpers is referenced in Table 2-2.Consult the Device Threshold Table in the TPS389006-Q1 data sheet to verify proper voltage monitored values.

To test the functionality of TPS389387EVM, go to TPS389387EVM Evaluation Instructions.

To communicate with the TPS38700S-Q1 and TPS389387EVM, including reading and writing to the registers, as well as clearing interrupts, follow TPS38700-Q1 GUI instructions.

Software Usage Guide

This table lists actions that the EVM user may wish to perform and the corresponding software interfaces.

Table 3-1. Software Usage Guide

Action	User interface
Change the voltage level for voltage outputs 1-6	MSP430 .C code in Code Composer Studio
Change the threshold voltages of the TPS389006 device	Fusion Digital Power Designer I2C GUI
Change the power up and power down sequence of the TPS38700S-Q1 device	Fusion Digital Power Designer I2C GUI
Change MSP430 generated output power rails to respond to enable inputs	MSP430 .C code in Code Composer Studio
Clear TPS389006 or TPS38700S-Q1 fault interrupts	Fusion Digital Power Designer I2C GUI

4 TPS389387EVM Evaluation Instructions

Equipment Needed

Hardware Equipment Needed for TPS389387EVM Evaluation:

- TPS389387EVM
- MSP430 LaunchPad™, MSP-EXP430FR2355
- MSP430 connector/power cable (USB to micro-USB)
- Multi-channel oscilloscope to review evaluation waveforms
- Jumper cables for additional evaluation

Software Needed for TPS389387EVM Evaluation:

- A zip file contained editable code that controls the TPS389387EVM. This can be downloaded here.
- Code Composer Studio IDE (CCS), CCS v8.0 or higher. Code Composer Studio Desktop is a professional integrated development environment that supports TI's Microcontroller and Embedded Processors portfolio. Code Composer Studio is comprised of a suite of tools used to develop and debug embedded applications. Code Composer Studio includes an optimizing C/C++ compiler, source code editor, project build environment, debugger, profiler, and many other features. Learn more about CCS and download at Code Composer Studio.

Hardware Setup

Follow the steps below for the hardware setup:

1. Attach the MSP430 to the pins at the bottom side of the TPS389387EVM. The orientation is detailed in TPS389387EVM Board Bottom with MSP430. Make sure that the GND pins match the corresponding board connector.
2. Connect the power cable to the MSP430 and USB port of the computer.
3. Make sure all jumpers are connected as per the guidelines in Table 2-2.

Software Setup

1. Download Code Composer Studio IDE (CCS) to edit the code for this EVM.
   a. There is a cloud composer available, but this is not necessary.
   b. CCS can ask if additional components are needed. Please select the MSP430 option before proceeding to download.
2. Download the code required to evaluate the EVM.
3. Launch CCS and import the code into the workspace. Refer to the CCS Getting Started instructions on ti.com for additional help.
   a. When CCS has been launched, select a workspace directory. This defines the location of your project on your operating system.

b. Use Project>Import Existing CCS Eclipse Project. Go to the desired demo project directory that contains main.c. This is illustrated in Figure 4-1.

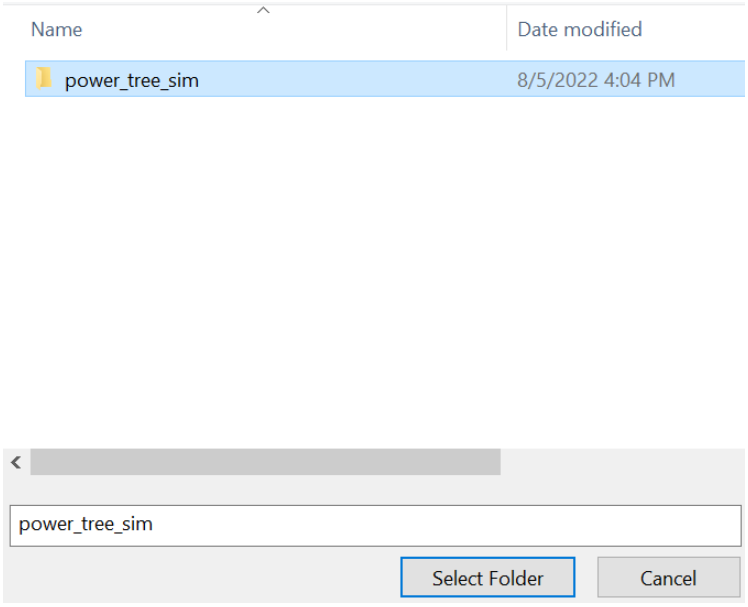


Figure 4-1. Selecting the Project Directory in CCS

c. Click *OK*.

d. CCS recognizes the project and allows the user to import. Check to make sure the CCS has found the project, by looking for a checkmark to the left of the project name. This is shown in Figure 4-2.

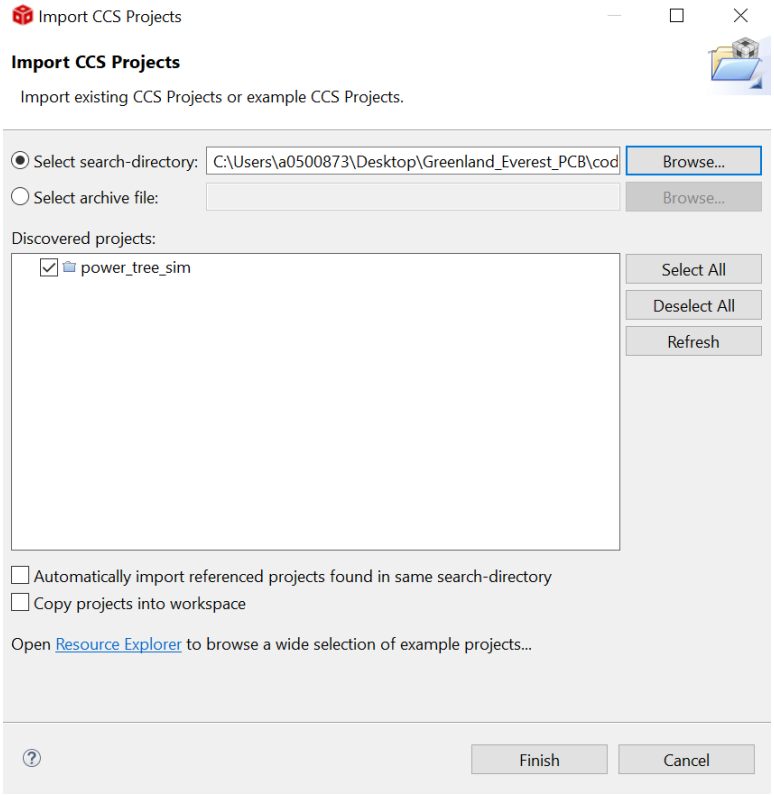


Figure 4-2. Recognizing the Project in CCS

e. If CCS does not show a checkmark, then this means that your workspace already has a project by that name. Resolve this by renaming or deleting that project.

f. At this point, the code is fully uploaded to CCS. The workspace looks like Figure 4-1.

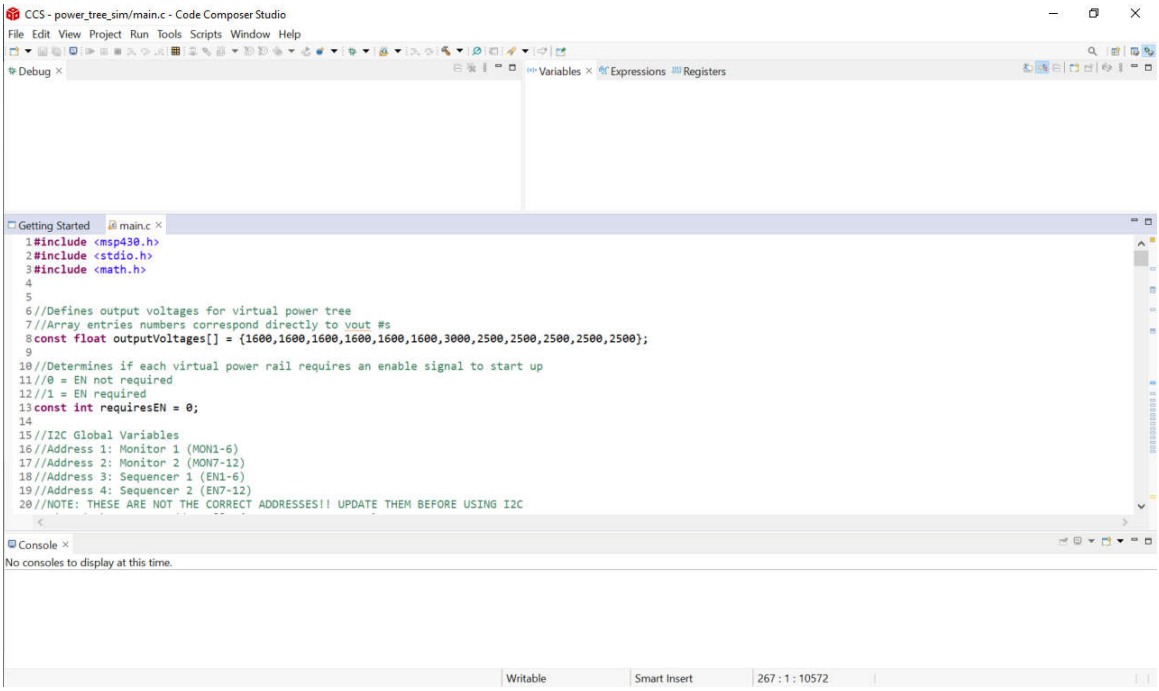


Figure 4-3. CCS Workspace with Code Uploaded

4. Edit the code to confirm correct operation.
   a. To change the output voltages for virtual power tree, edit line 8. This line reads as follows:

      const float outputVoltages[] = {1600,1600,1600,1600,1600,1600,3000,2500,2500,2500,2500,2500};

      Each of the values within the brackets correspond to the Vout for the TPS389006's power monitor rails. These values are all in millivolts.
   b. To change whether each virtual power rail requires an enable signal from the sequencer to start up, edit line 13. This line reads as follows:

      const int requiresEN = 0;

      If the value after the "=" is a 0, then an enable signal from the sequencer is not required. If this value is set to 1, then an enable signal from the sequencer is required to start up.

5. Run the code by selecting *Run> Start Debugging* in the CCS workspace. See Figure 4-4 for more information.

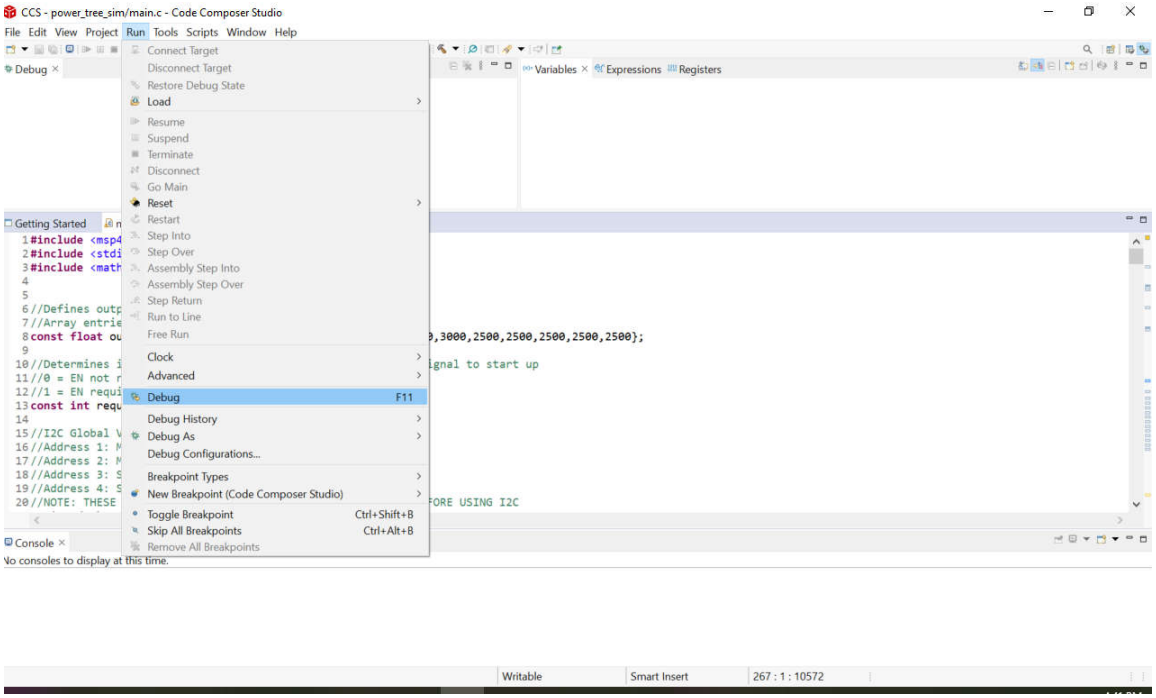


Figure 4-4. Run Code in CCS

6. Once the code is run, confirm correct operation.
   a. Check output voltages by measuring waveforms resultant from connections between pins in the header (J18) and oscilloscope. For more clarity on the pin locations, look at the schematic or Figure 2-1.
   b. Determine correct operation of Enables and Interrupts by examining the LEDs on the EVM. See LED functionality in Table 2-1.
   c. By pressing and holding button S1 on the MSP430 launchpad, the sequencer powers down the voltage rails in sequence. Releasing the button causes the power rails to power up in sequence. The power up and power down sequence can be checked by connecting an oscilloscope to the enable outputs of header J18.
   d. Figure 4-5 shows correct operation of the first three enable signals in the power up sequence and the corresponding sync pulses from the TPS389006.

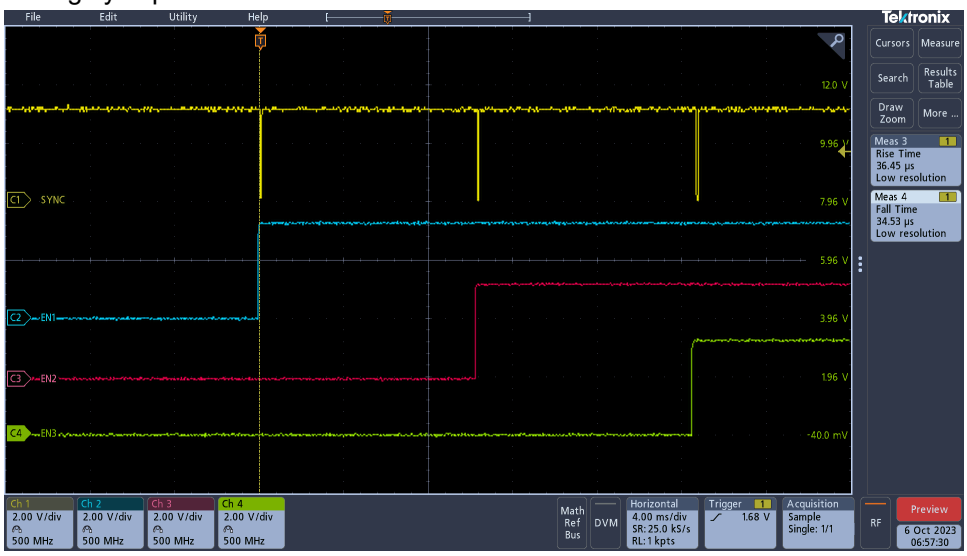


Figure 4-5. Power Sequence Up with Sync

e. Figure 4-6 shows correct operation of the first three enable signals in the power down sequence and the corresponding sync pulses from the TPS389006.

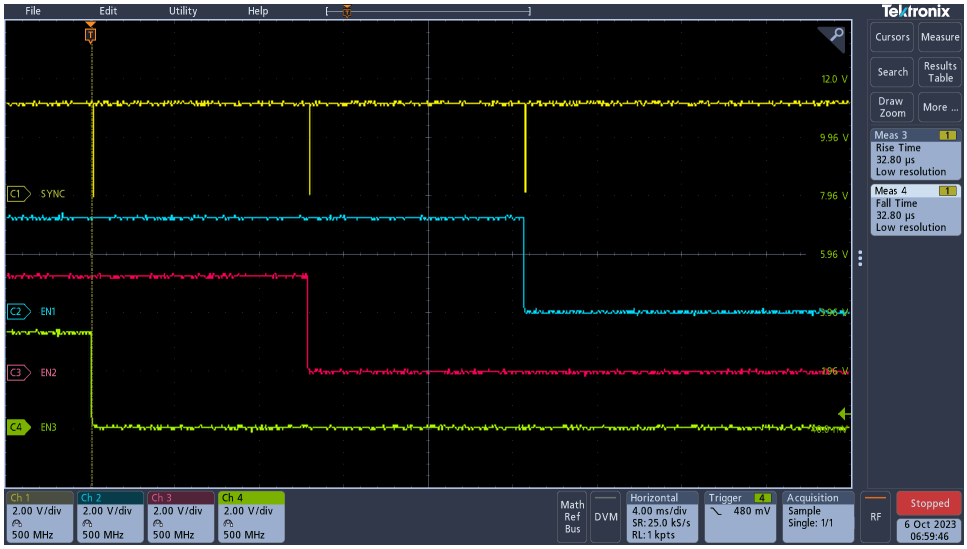


Figure 4-6. Power Sequence Down with Sync

f. Figure 4-7 shows where to place the oscilloscope probe on the EVM to view the sync signal. Place the probe on the terminal of R30 closest to device U2.

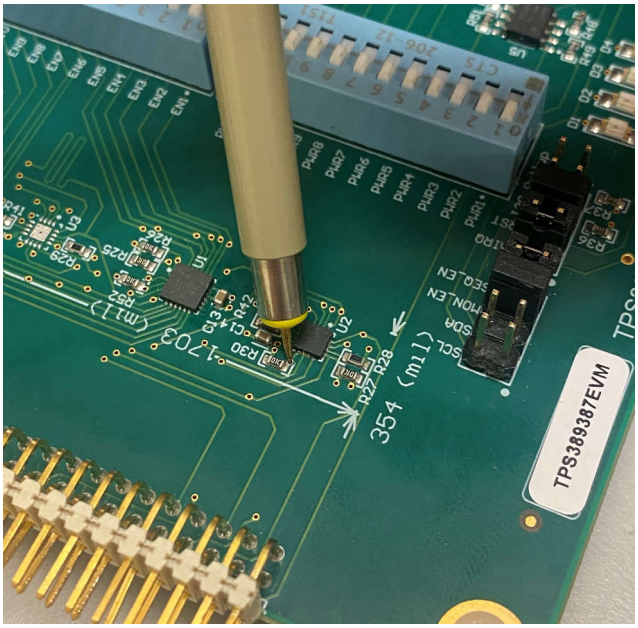


Figure 4-7. Sync Signal Probe

7. The dipswitches can also be used to manually test the functionality of the device interrupts and enables.
   a. LED1 (D1) turns on in the case of an interrupt. This can be tested by using the dipswitches that control the TPS389006 power rail (SW1). When these dipswitches are flipped to the off position, the respective rail is manually turned off, resulting in an interrupt and turning on LED1.
   b. LED2 (D2) turns on when Enable 1 is activated. This can be tested using the dipswitches that control the TPS38700S-Q1 Enables (SW2). When these dipswitches are flipped to the off position, the respective EN is manually turned off, resulting in LED2 to turn off.
   c. LED3 (D3) and LED4 (D4) turn on when Enable 2 and Enable 3 are activated, respectively. This can be verified in the same way as LED2.

5 TPS38700-Q1 GUI instructions

Equipment Needed:

- TPS389387EVM
- USB-TO-GPIO2 connector
- MSP430 LaunchPad™, MSP-EXP430FR2355
- MSP430 connector/power cable (USB to micro-USB)
- Multi-channel oscilloscope to review evaluation waveforms
- Jumper cables for additional evaluation

5.1 GUI Installation

Follow the steps below for GUI installation:

1. Install the GUI.
   a. Download the Fusion Digital Power Designer Platform GUI for TPS38700Q1EVM.
   b. Open the downloaded file.
   c. In the Welcome Wizard window, click *Next*.

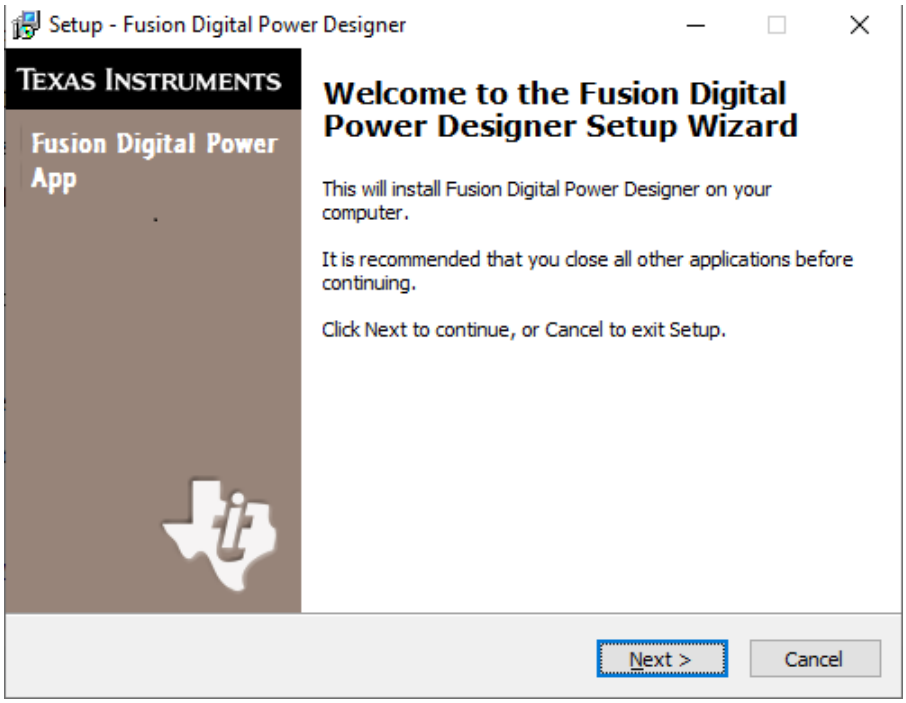


Figure 5-1. Welcome Setup Window

d. Accept the license agreement and then click *Next*.

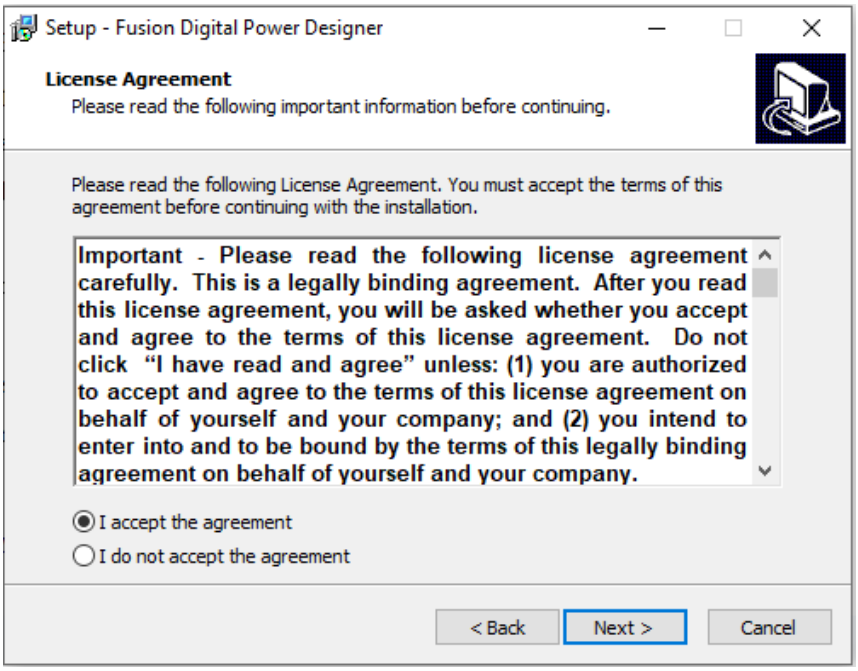


Figure 5-2. Setup License Agreement Window

e. The default destination folder works best. Click *Next*.

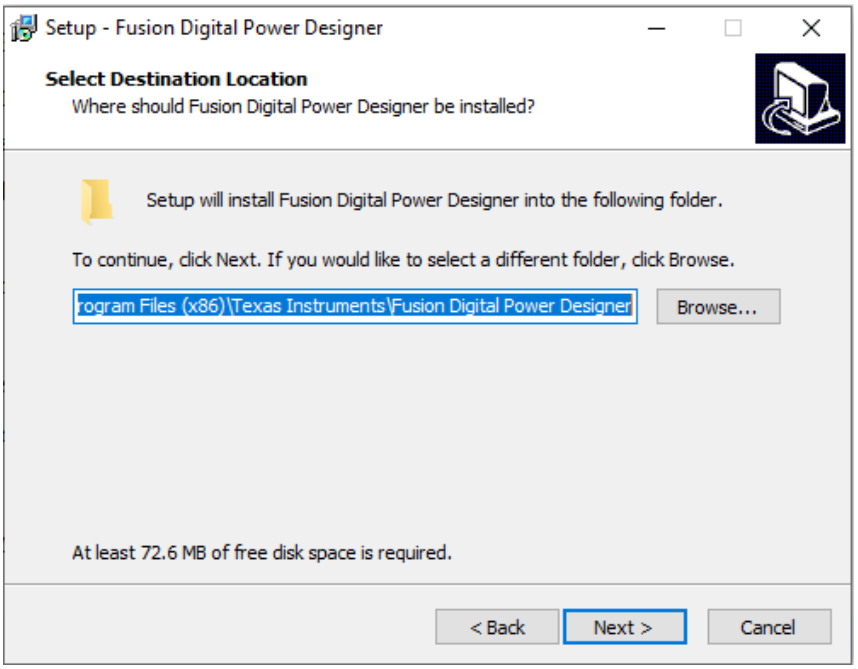


Figure 5-3. Setup Destination Window

f. Click *Next* for the *Select Start Menu Folder* option.

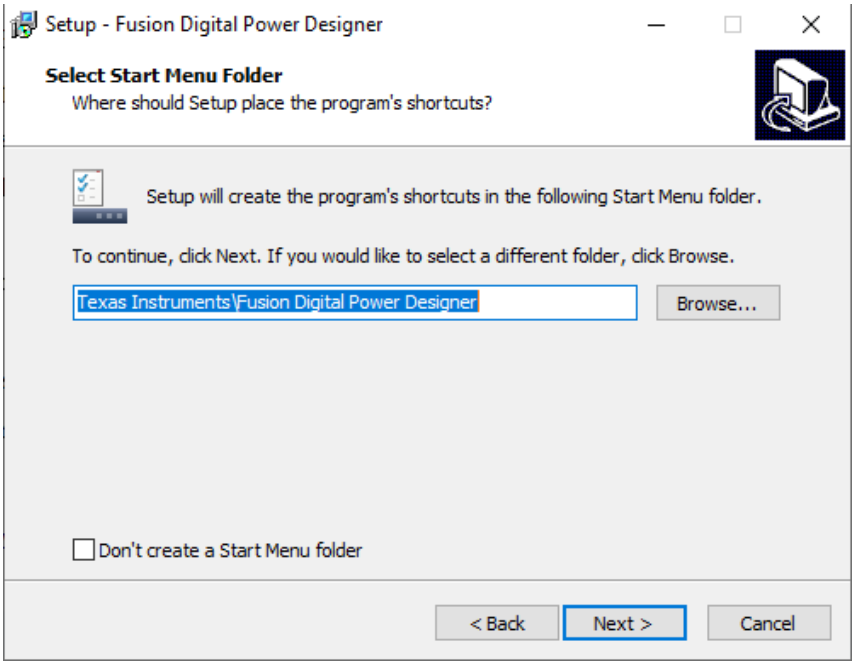


Figure 5-4. Setup Window - Start Menu Selection

g. There is no need to install additional options for this EVM. Click *Next*.

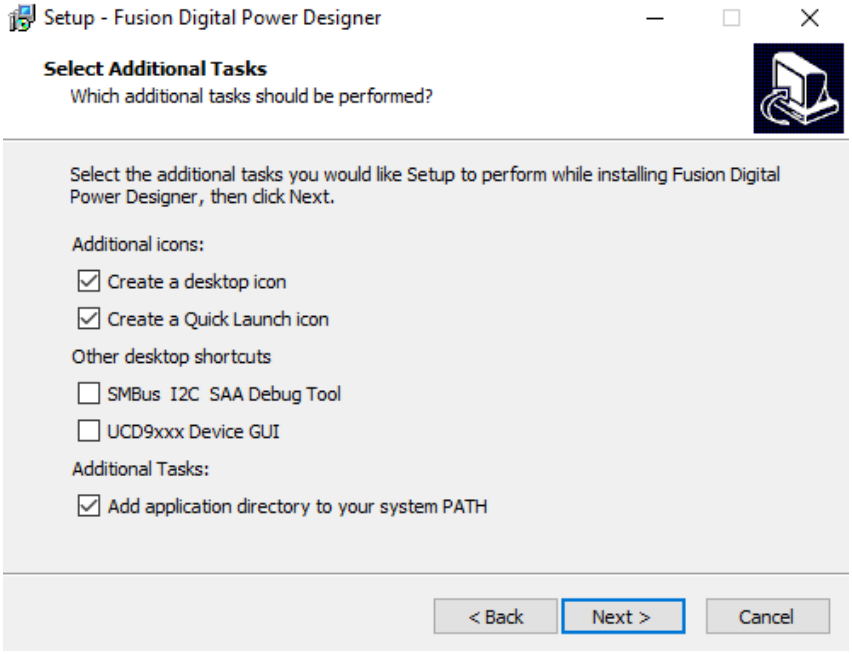


Figure 5-5. Setup Window - Additional Tasks

h. Click *Install* to install the Fusion software.

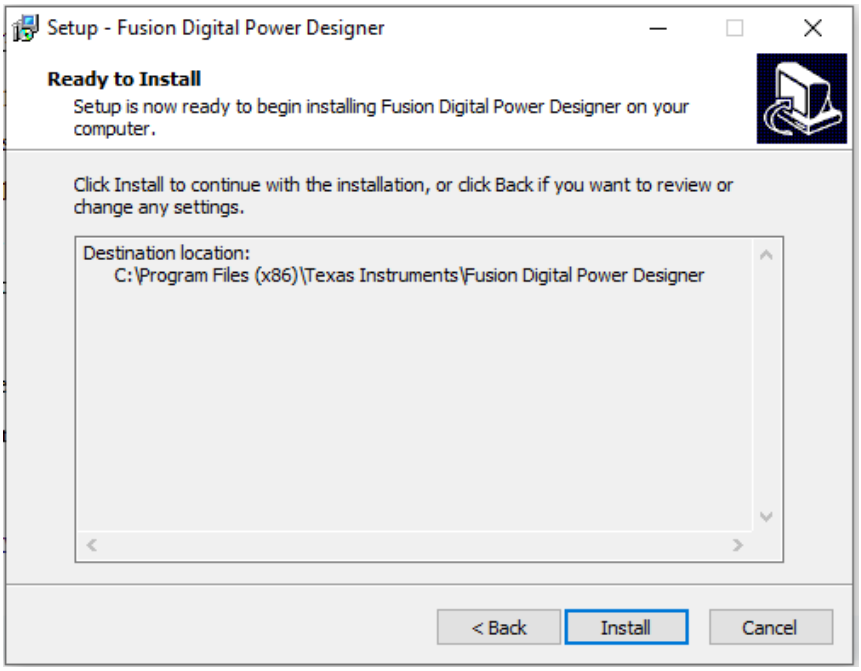


Figure 5-6. Setup Installation Window

i. Click on *Finish* to complete the installation setup and launch the software.

Figure 5-7. Installation Complete Window

5.2 Quick Start for TPS38700-Q1 GUI

Follow the steps below precisely to quickly evaluate the TPS38700S-Q1 on the TPS389387EVM. In this quick start, Enable 1 and Enable 2 signals after the ACT pin is triggered are detailed.

1. Install the GUI based on Section 5.1. Skip this section if the TPS38700Q1EVM GUI is already installed.
2. Attach the MSP430 to the pins at the bottom side of the TPS389387EVM. The orientation is detailed in TPS389387EVM Board Bottom with MSP430. Make sure that the GND pins match the corresponding board connector.
3. Connect the MSP430 power cable to the MSP430 and USB port of the computer.
4. Make sure all jumpers are connected as per the guidelines in Table 2-2.
5. Connect TI's USB-TO-GPIO2 connector to J19 of the EVM and to the USB port of the computer.
6. Once the TI's USB-TO-GPIO2 connector is connected to the EVM and the computer, launch the evaluation software Fusion Digital Power Designer.
7. Click on *I2C GUI* in the bottom right.

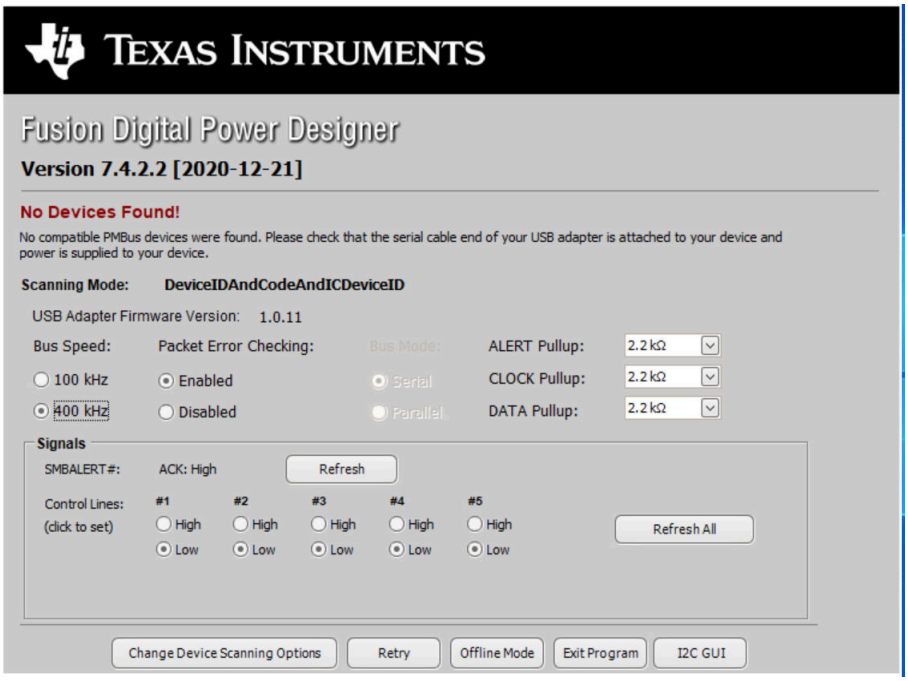


Figure 5-8. Fusion Welcome Window

8. Click on Change Scan Mode to select TPS38700x and then click *OK*.

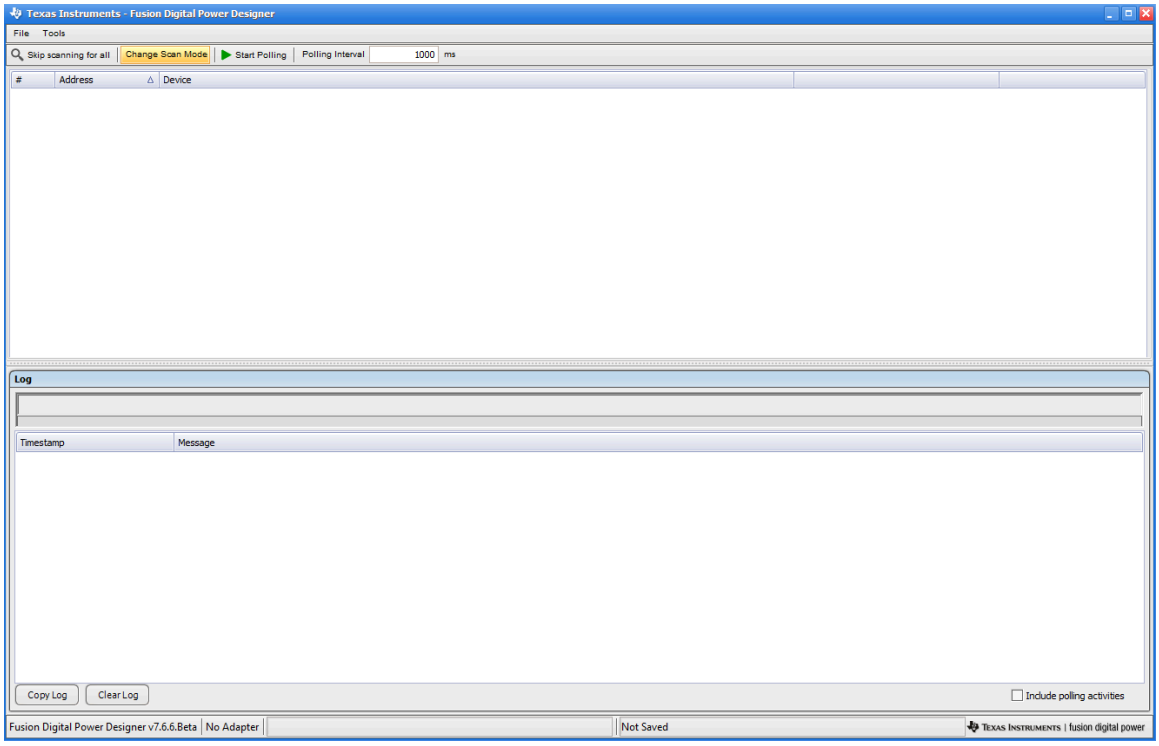


Figure 5-9. Fusion Scan Window

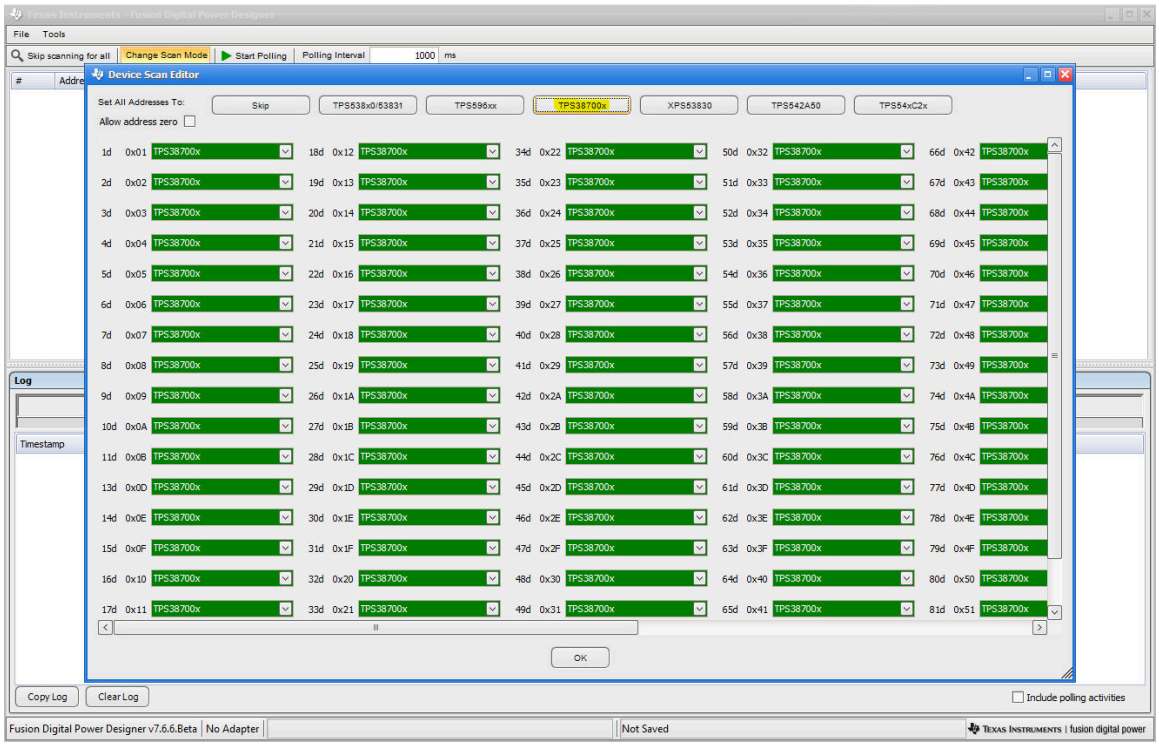


Figure 5-10. Fusion Scan Selection Window

9. Scan for the TPS38700-Q1 by clicking on *Scan for TPS38700x* on top left of the window.

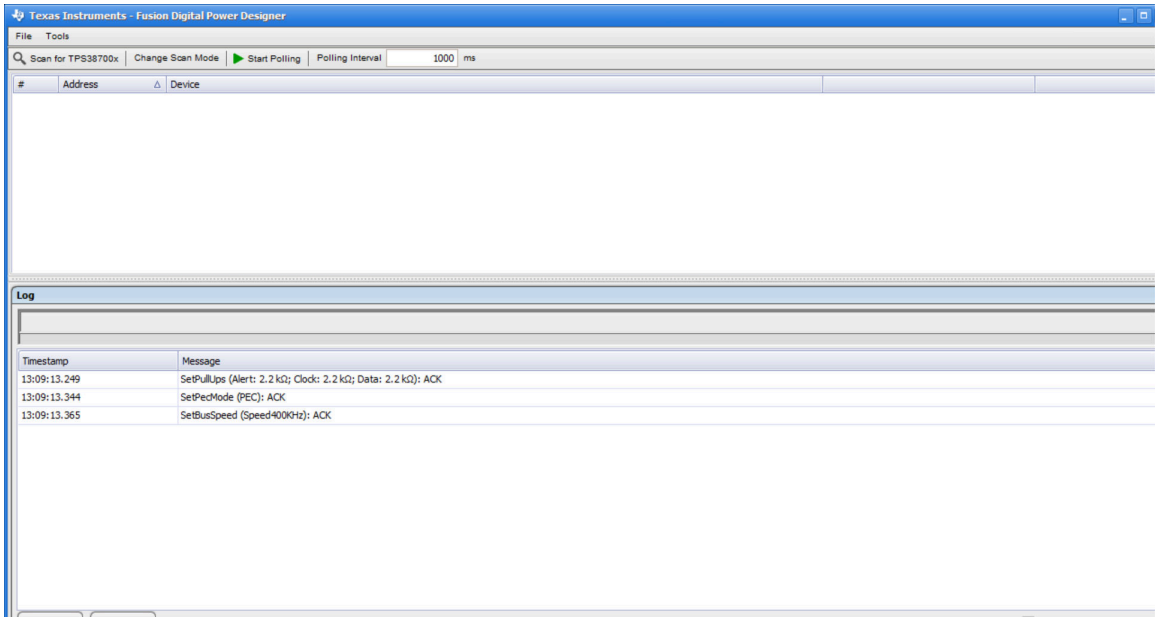


Figure 5-11. Fusion Scan Window - Scanning for TPS38700Q1EVM

10. Once the EVM is discovered, select *Click to Configure* (text in blue).

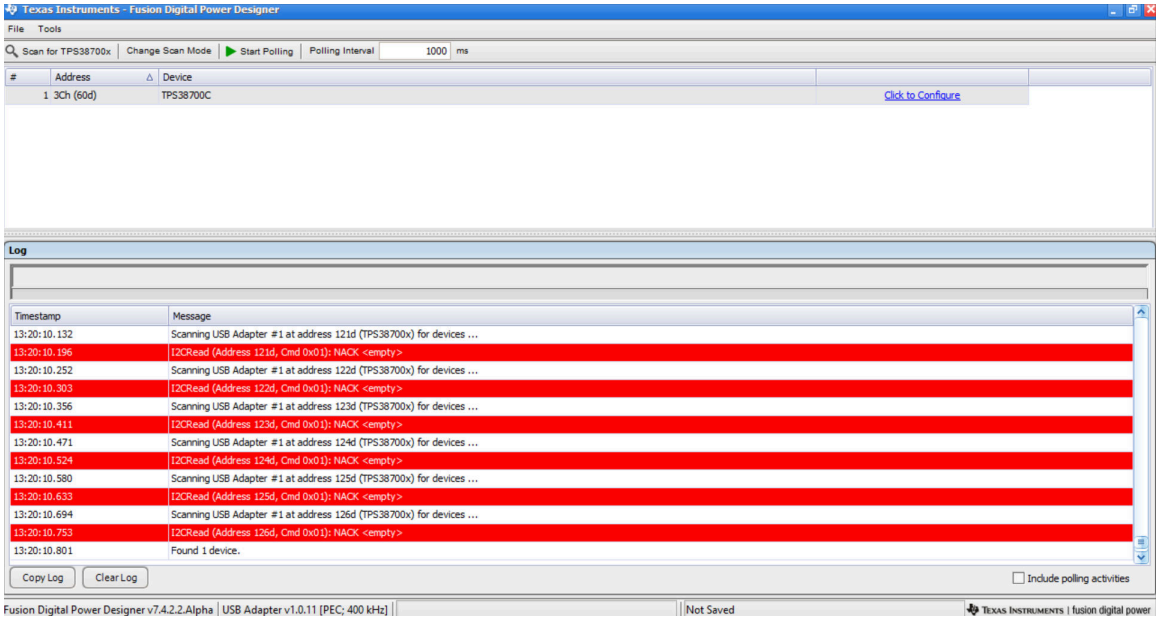


Figure 5-12. Fusion Scan Window - Scan for TPS38700Q1EVM Completed

11. Select Refresh All to update the GUI to the preprogrammed device configuration.

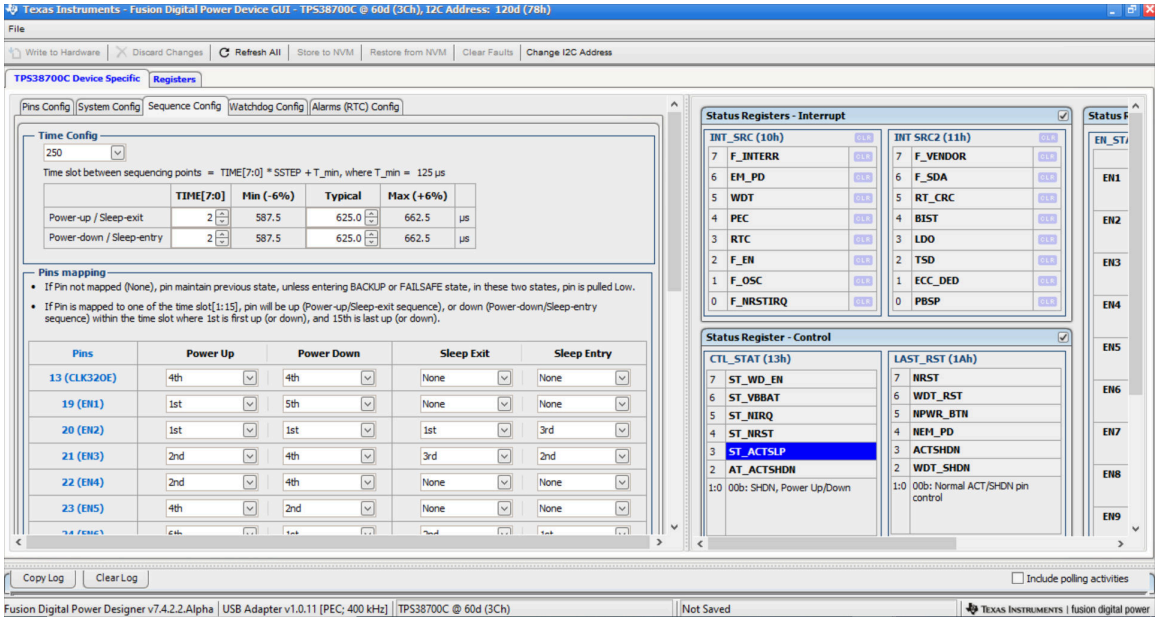


Figure 5-13. TPS38700 GUI Window - Sequence Config Tab

5.3 GUI

This section shows the graphical user interface (GUI) to use to interact with the EVM. This was originally designed for the TPS38700-Q1, but all GUI functionality is applicable for the TPS38700S-Q1. Refer to the TPS38700-Q1 Multichannel I2C Programmable Voltage Sequencer data sheet for details on the register description of the device.

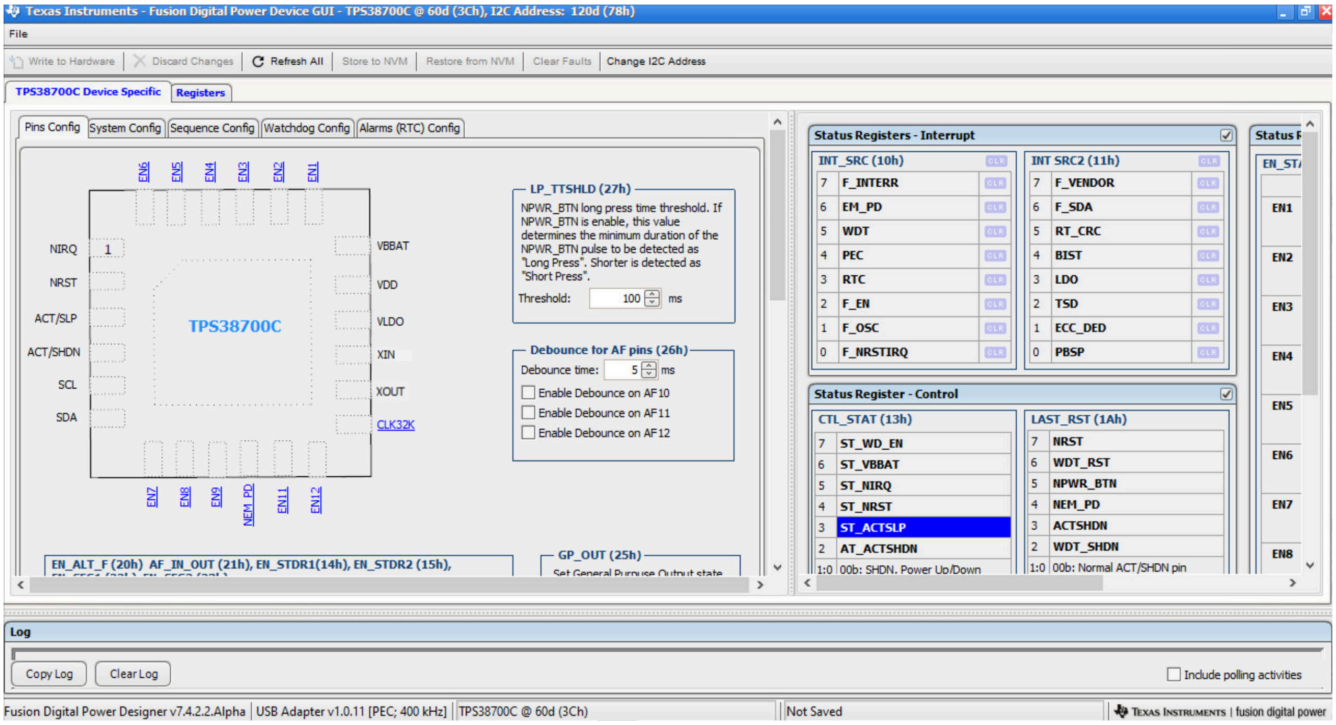


Figure 5-14. Main GUI Screen

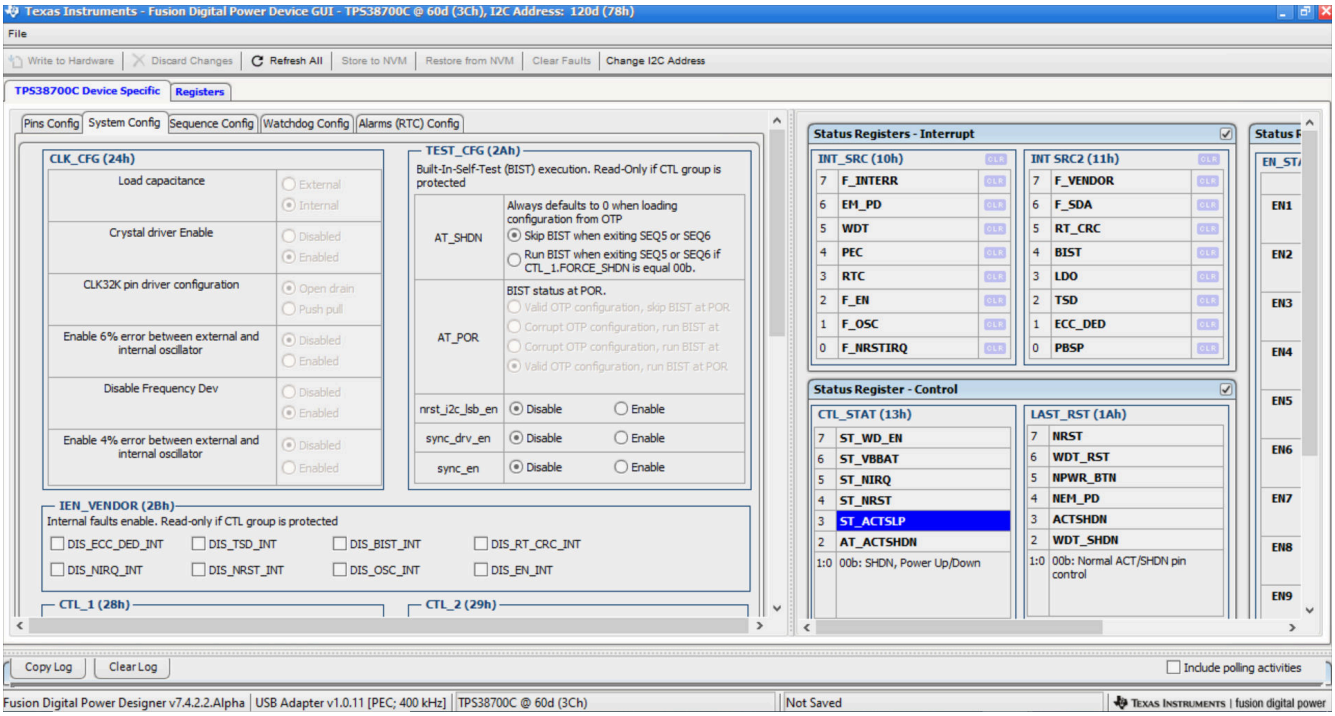


Figure 5-15. System Config

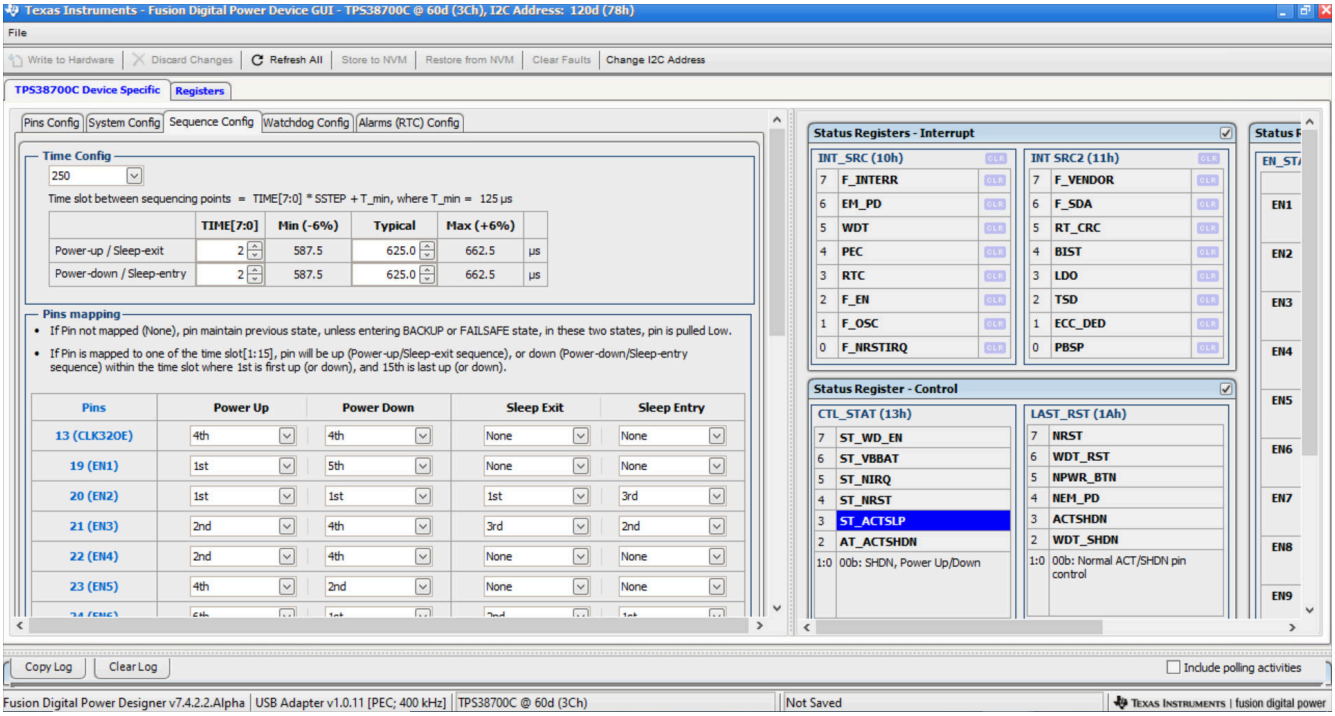


Figure 5-16. Sequence Config

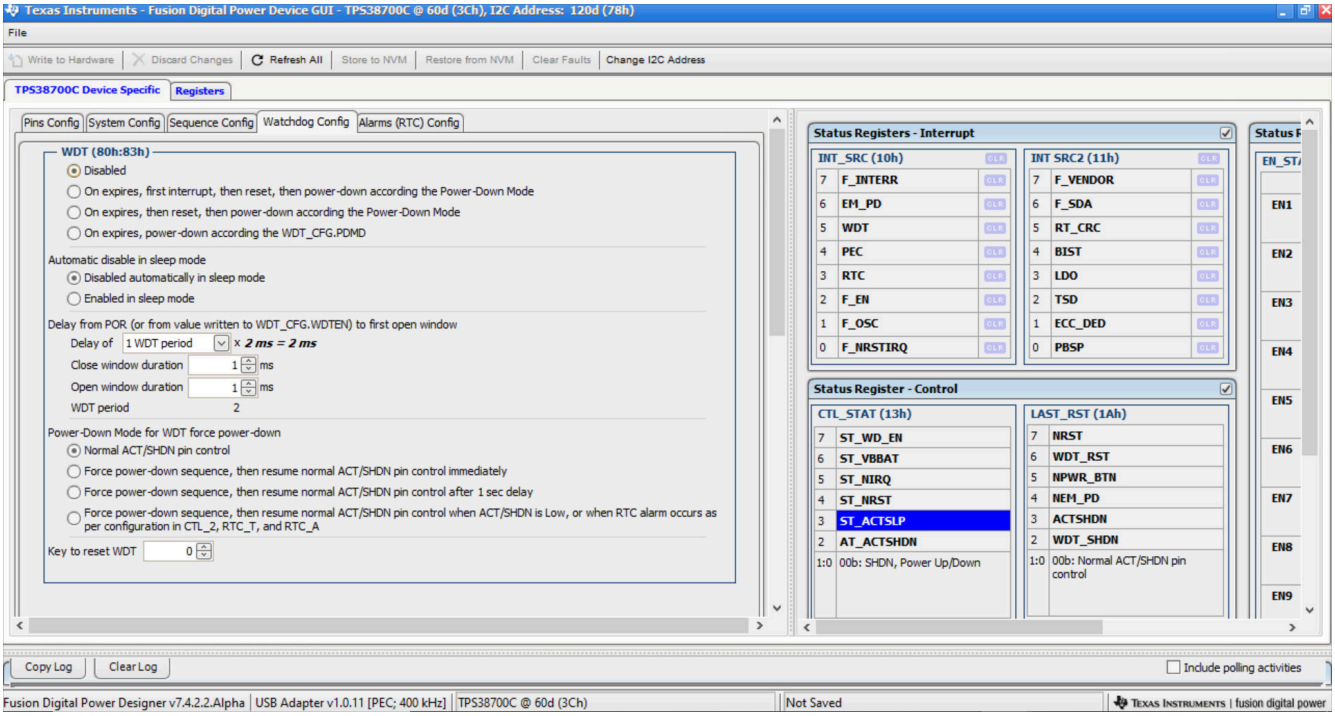


Figure 5-17. Watchdog Config

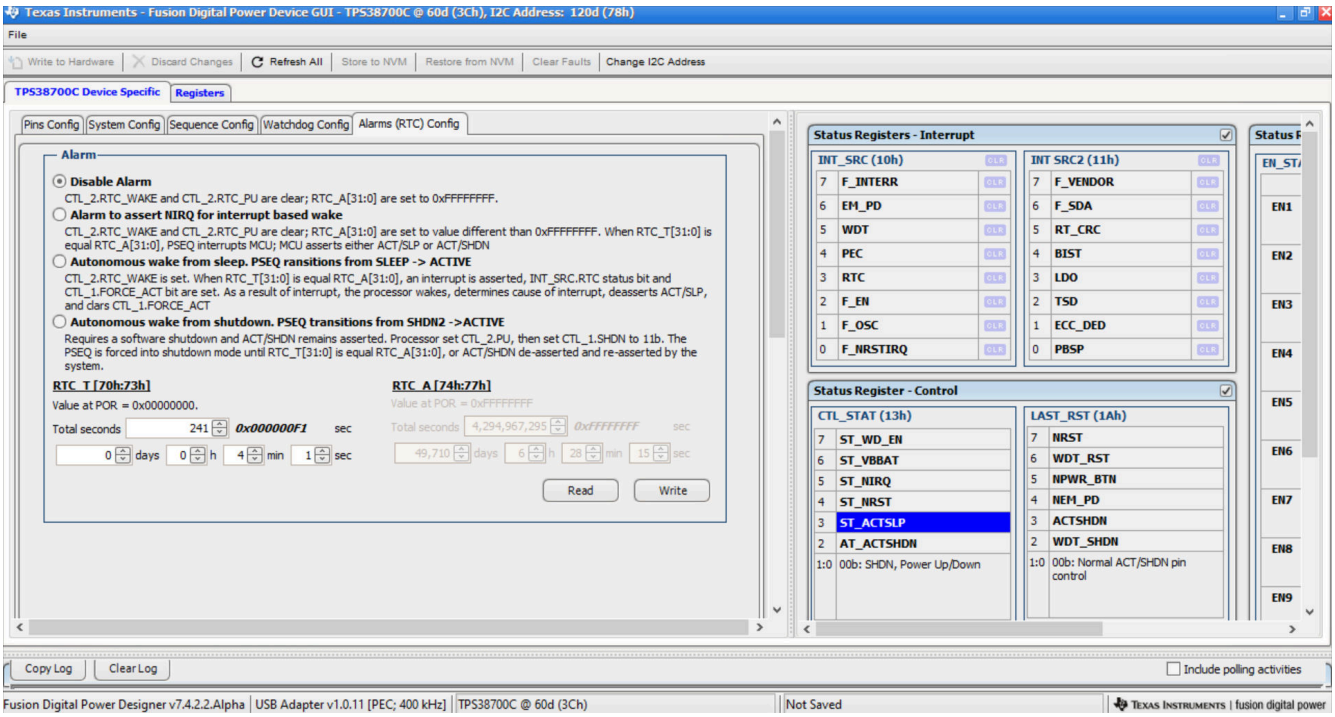


Figure 5-18. Alarms Config

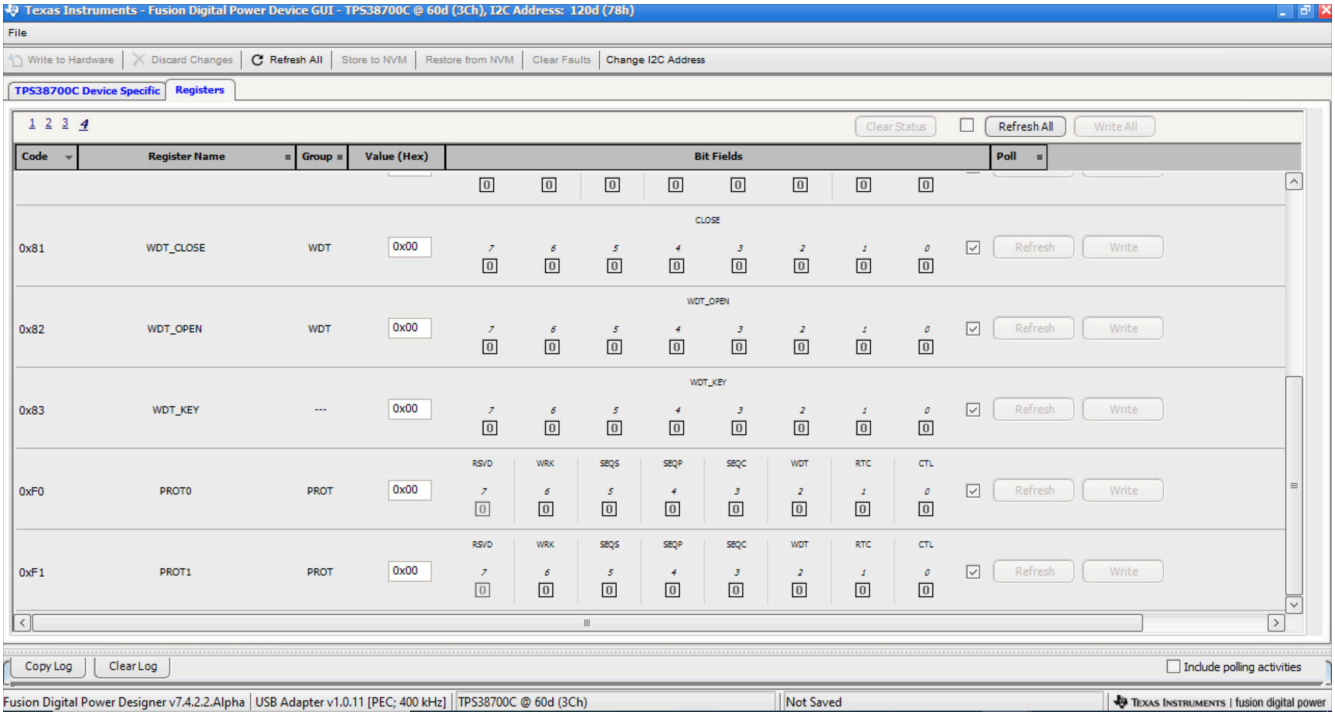


Figure 5-19. Registers

6 Hardware Design Files

6.1 Schematic

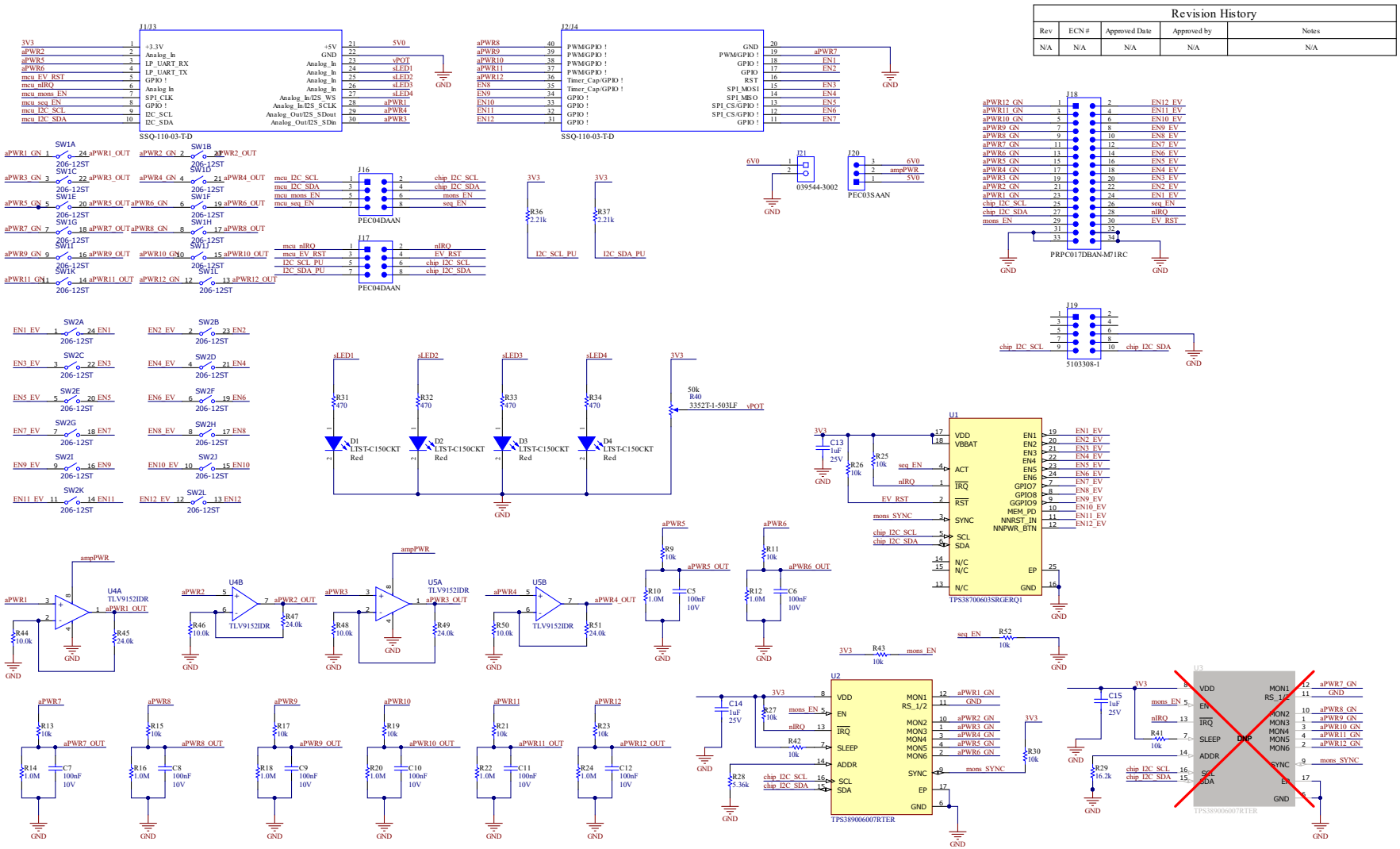


Figure 6-1. TPS389387EVM Schematic

6.2 PCB Layout

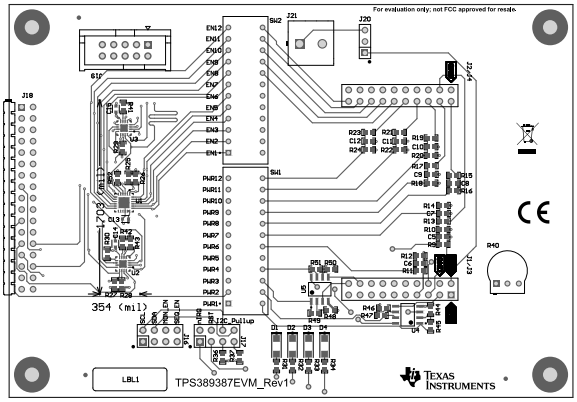


Figure 6-2. Layout—Top

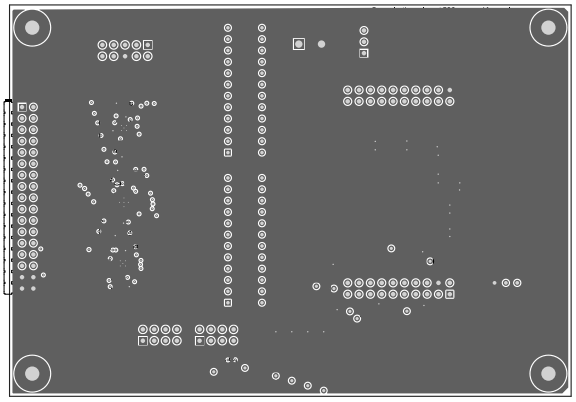


Figure 6-3. Layout—Middle 1

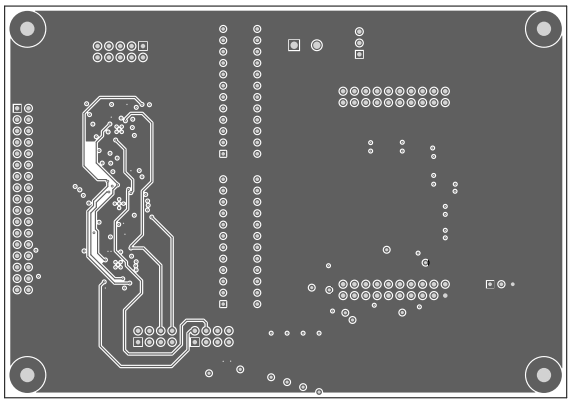


Figure 6-4. Layout—Middle 2

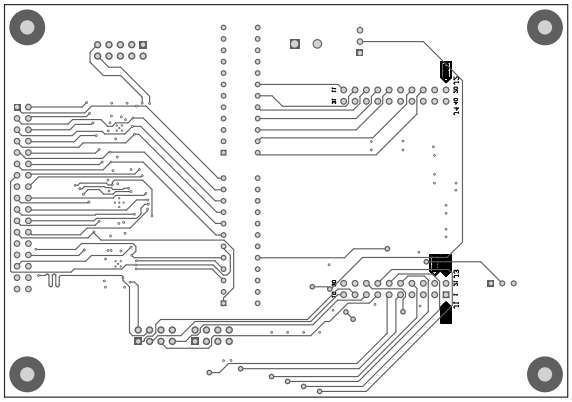


Figure 6-5. Layout—Bottom

6.3 Bill of Materials

Table 6-1. Bill of Materials

Designator	Qty	Description	Comment	Footprint	LibRef
C5, C6, C7, C8, C9, C10, C11, C12	8	CAP, CERM, 0.1 uF, 10 V, +/- 10%, X7R, 0603	C0603X104K8RACTU	0603	CMP-0006981-4
C13, C14, C15	3	1 µF ±10% 25 V Ceramic Capacitor X5R 0603 (1608 Metric)	GRM188R61E105KAADD	FP-GRM188R61E105KAADD_0603-MFG	CMP-0094239-1
D1, D2, D3, D4	4	LED, Red, SMD	LTST-C150CKT	LTST-C150CKT_Red	CMP-0003043-3
J1/J3	1	Receptacle, 2.54mm, 10x2, Tin, TH	SSQ-110-03-T-D	BoosterPack_40pin_J1J3	CMP-0003837-4
J2/J4	1	Receptacle, 2.54mm, 10x2, Tin, TH	SSQ-110-03-T-D	BoosterPack_40pin_J2J4	CMP-0078266-4
J16, J17	2	Header, 100mil, 4x2, Tin, TH	PEC04DAAN	CONN_PEC04DAAN	CMP-0054542-2
J18	1	Header, 100mil, 17x2, Gold, R/A, TH	TSW-117-08-G-D-RA	Sullins_PRxC017DBAN-M71RC	CMP-0054606-1
J19	1	Header (shrouded), 100mil, 5x2, Gold, TH	5103308-1	CONN_5103308-1	CMP-0054834-2
J20	1	Header, 100mil, 3x1, Tin, TH	PEC03SAAN	CONN_PEC03SAAN	CMP-0002338-1
J21	1	Terminal Block, 5.08mm, 2x1, TH	039544-3002	Molex_039544-3002	CMP-0055345-1
R9, R11, R13, R15, R17, R19, R21, R23, R25, R26, R27, R30, R41, R42, R43, R52	16	RES, 10 k, 5%, 0.1 W, 0603	RC1608J103CS	0603	CMP-0025945-3
R10, R12, R14, R16, R18, R20, R22, R24	8	RES, 1.0 M, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	CRCW06031M00JNEA	0603	CMP-0025736-4
R28	1	RES, 5.36 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	CRCW06035K36FKEA	0603	CMP-0022511-4
R29	1	RES, 16.2 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	CRCW060316K2FKEA	0603	CMP-0022079-4
R31, R32, R33, R34	4	RES, 470, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	CRCW0603470RJNEA	0603	CMP-0025813-4
R36, R37	2	RES, 2.21 k, 0.1%, 0.1 W, 0603	RT0603BRD072K21L	0603	CMP-0024063-3
R40	1	Trimming Potentiometer, 50K, 0.5W, TH	3352T-1-503LF	Bourns_3352T	CMP-0001777-2
R44, R46, R48, R50	4	RES, 10.0 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	CRCW060310K0FKEA	0603	CMP-0021998-4
R45, R47, R49, R51	4	RES, 24.0 k, 1%, 0.1 W, 0603	RC0603FR-0724KL	0603	CMP-0022945-5
SW1, SW2	2	Dip Switch SPST 12 Position Through Hole Slide (Standard) Actuator 50 mA 24VDC	206-12ST	FP-206-12ST_DIP24-MFG	CMP-0086642-1

Table 6-1. Bill of Materials (continued)

Designator	Qty	Description	Comment	Footprint	LibRef
SH-J1, SH-J2, SH-J3, SH-J4, SH-J5, SH-J6, SH-J7, SH-J8, SH-J9	9	Shunt, 2.54mm, Gold, Black	60900213421	Shunt, 2.54mm, Black	
U1	1	ASIL-A Multichannel I2C Programmable Voltage Sequencer	TPS38700603SRGERQ1	VQFN24	
U2	1	SIL-3 Multichannel Overvoltage and Undervoltage I2C Programmable Voltage Supervisor and Monitor	TPS389006007RTER	WQFN16	
U4, U5	2	General Purpose Amplifier 2 Circuit Rail-to-Rail 8-SOIC	TLV9152IDR	D0008A-MFG	CMP-0091916-1

7 Additional Information

Warning - External Connections: All external connections to the hardware must stay within the recommended operating conditions and intended usage for all hardware/components connected in the system.

7.1 Related Documentation

TPS38700S-Q1 data sheet: *TPS38700S-Q1 Multichannel I2C Programmable Voltage Sequencer*

TPS389006 data sheet: *TPS389006 Multichannel I2C Programmable Voltage Supervisor and Monitor*

MSP-EXP430FR2355: *MSP430FR2355 LaunchPad™ development kit*

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8 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Revision * (October 2023) to Revision A (February 2024)	Page
• Added the TPS3839387EVM zip file link containing the .C code	1

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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3. 技術基準適合証明を取得後ご使用いただく。

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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

電力線搬送波通信についての開発キットをお使いになる際の注意事項については、次のところをご覧ください。https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-for-power-line-communication.html

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:*

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