User's Guide
SNOU161–June 2018

TMP117EVM User Guide

The TMP117 is part of the ultra high-precision temperature sensor family that is pin-compatible with the TMP116 and has an offset register to compensate and improve the system error. The TMP117 is ready to use out of the box and does not require any additional calibration. It provides up to ±0.1°C accuracy over the range of body temperature 30°C to +42°C, and ±0.2°C accuracy over the −55°C to +150°C range with 16-bit resolution, giving a temperature resolution of 0.0078125°C. The TMP117's accuracy in the human body temperature range makes it ideal for medical applications. The Texas Instruments TMP117EVM (Evaluation Module) provides the user a simple way to get started with TMP117. The module and GUI are designed to provide the user a quick setup to evaluate the system and register map with simply a few click powered by GUI Composer. The EVM features a perforation that allows the temperature sensor to be placed away from the MSP430 for remote temperature measurements and a header to connect multiple TMP117's to the controller. This document provides detailed information about the hardware design and software installation.

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1 Overview

The TMP117EVM allows users to evaluate the performance of the best digital temperature sensor available in very small QFN package. The EVM comes in a USB stick form factor with an onboard MSP430F5528 microcontroller that interfaces with both the host computer and up to four TMP117 devices using I2C interface. The TMP117EVM, however, can only be configured with two devices under addresses 0x48 and 0x49. The module is designed to provide user flexibility separating the TMP117 and MSP430 at the perforation location on the EVM board. The perforation allows the user to connect wires, cable, or header to both ends for remote temperature measurements or connects to desired system as well as connecting additional TMP117s.

2 EVM Kit Contents

Table 1 details the contents of the EVM kit. Contact the Texas Instruments Product Information Center nearest you if any component is missing. TI highly recommends that users check the TI website at http://www.ti.com to verify if they have the latest versions of the related software.

Table 1. EVM Kit Contents

ITEM	QUANTITY
PCB test board: TMP117EVM	1
USB cable extender	1

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3 Board Connectors and Components

The jumpers and connectors on the EVM and how to properly connect, set up, and use the TMP117 Bench Board are described here.

3.1 Input/Output Connector Description and Components

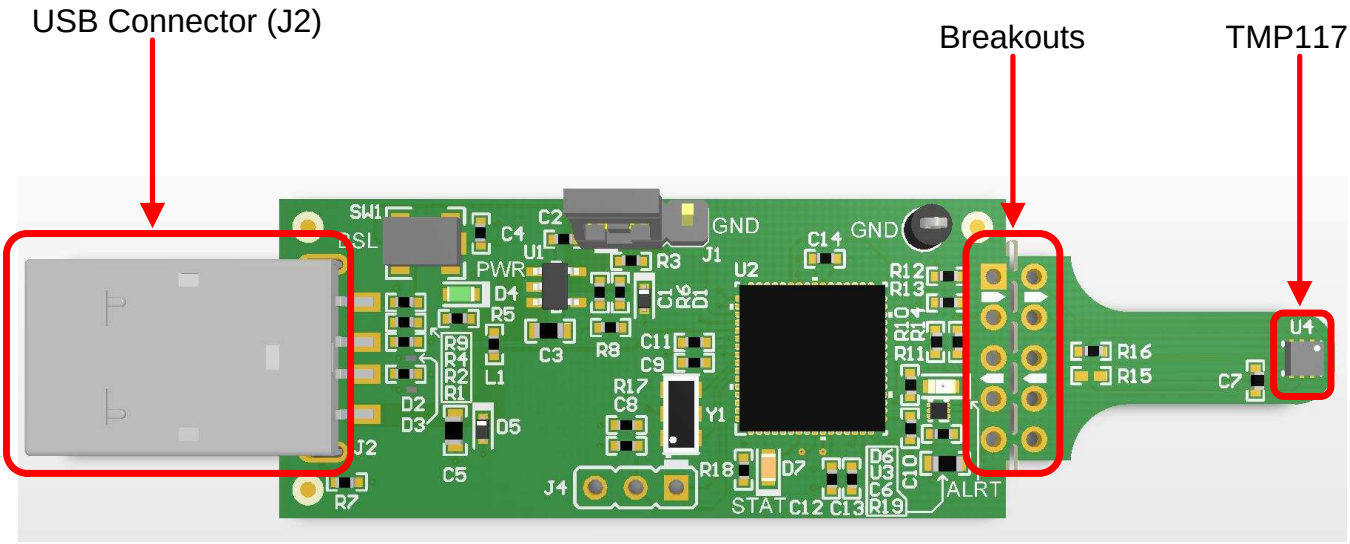

Figure 1. TMP117 Evaluation Board Top Side

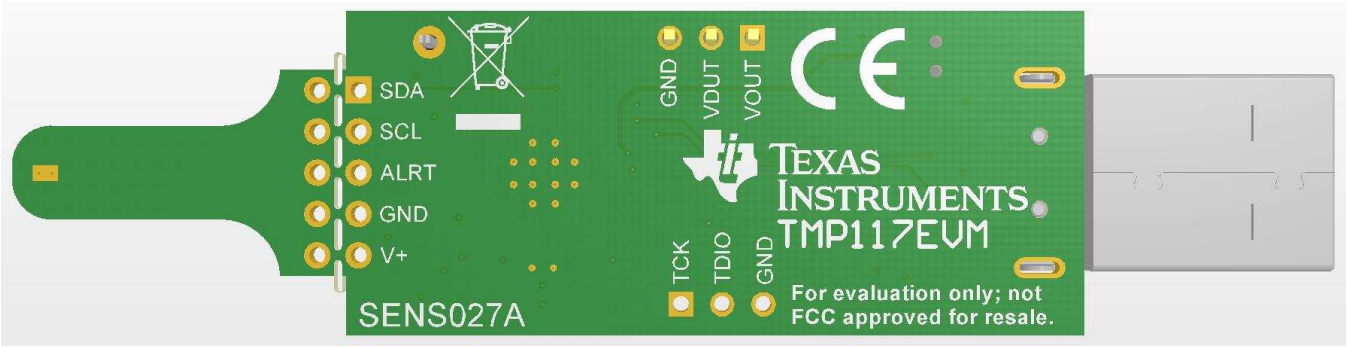

Figure 2. TMP117 Evaluation Board Bottom Side

Table 2. Device and Package Configurations

DEVICE	IC	PACKAGE
U4	TMP117AIDRVR	WSON (6)

3.1.1 EVM Power Supply Input – J1

TMP117EVM uses the +5-V input power supply of the USB connector to power the EVM. The EVM does not require an external power supply. The board is powered by the USB port and provides switched +5 V. It can be powered by shorting the J1 pin 1-2 jumper with a regulated desired voltage based on the Equation 1. The EVM power supply input can be changed to any input power supply range of the TMP117 1.8 V to 5.5 V by removing the shunt and the resistor R3, and applied to the external power supply through the J1 pin 2 (V^+) and pin 3 (ground). Note that MSP430, however, can only support power supply range 2.3 V to 3.6 V with recommends V_OH and V_OL conditions per TMP117 datasheet specifications.

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The resistor adjust R_ADJ can be calculated as given by the Equation 1 where V_REF=1.23 V and desired voltage of V_OUT.

$$V_{OUT} = V_{REF} + \left[V_{REF} \times \left(\frac{R_{ADJ}}{51.1\,k\Omega} \right) \right] \quad (1)$$

$$R_{ADJ} = 51.1\,k\Omega \times \left[\left(\frac{V_{OUT}}{V_{REF}} \right) - 1 \right] \quad (2)$$

3.1.2 Interface Connector – J2

J2 is the USB connector and is used to connect the PC. The interface is used to access the device's registers and read the conversion data from the TMP117 through I2C communication protocol.

3.1.3 Debug Jumper – J4

J4 is the connector that allows debugging the firmware using three wires instead of the standard 14 pins header. This connector is not populated.

3.1.4 Pushbutton Switch – SW1

Basically, the SW1 reference designator is to bring the MSP430 into a BSL mode for upgrading the firmware with combination of the USB connector manually referring to the picture in Figure 1 BSL button (SW1 switch). Press and hold the switch SW1 next to the USB connector while plugging the USB cable from the board to the PC. This will allow bringing the MSP430 into BSL mode.

3.1.5 Header Connector – J3

The purpose of the header connector is to isolate the heat source from coming directly to the TMP117, and the perforation allows user to snap at the break tab. When the TMP117 is separated from the MSP430, it can be connected through wires or header to both ends for remote temperature measurements.

3.1.6 LED – (D4, D6, D7)

There are a total of three LEDs on the board: green (D4), red (D6), and orange (D7). The green LED is the power supply indicator, and it should be turn ON. The orange LED should not blink when the EVM is initially plugged into the PC. The orange LED will blink if the power on reset tests on the MSP430 microcontroller fails on start-up. The red LED is the Alert pin indicator when the Alert pin is pulling LOW.

3.1.7 I2C Slave Addresses – (R15, R16)

TMP117 is capable of supporting four I2C 7-bit addresses. The TMP117 is connected to the bus by a unique slave address to operate data transfer from the master-transmitter to the slave-receiver or slave-transmitter to the master-receiver. The TMP117 can be configured desired four serial bus addresses depending on the state of the ADD0 as Table 3. At default, the resistor R16 is soldered, and configured for 0x48h address. For this TMP117EVM, you can only connect two I^2C addresses: 0x48 and 0x49. For more details information, refer to the *Address Pin and Slave Addresses for the TMP117* table in the *TMP117x High-Accuracy, Low-Power, Digital Temperature Sensor With SMBus- and I2C-Compatible Interface* data sheet (SNOSD82).

Table 3. I2C Slave Addresses

CORRESPONDING EVM RESISTOR	ADD0 PIN CONNECTION	SLAVE ADDRESS	
		BINARY	HEX
R16	GND	1001000	0x48
R15	V+	1001001	0x49

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4 System Setup

The TMP117EVM hardware consists of the USB2ANY Platform and the TMP117 altogether in one single board. The unit is easily connected through USB connector into the computer as shown in Figure 3.

Figure 3. TMP117EVM Hardware Setup

5 Software Installation

5.1 Graphical User Interface (GUI)

The EVM software is tested on the Microsoft Windows 7 and 10 operating system (OS). The software also functions on other Windows operating systems. The EVM software is available through the EVM product folder on the TI website through the hyperlink. The hyperlink will bring to TI Cloud where a common repository of all published applications using GUI Composer framework. The applications can be ran directly from Gallery with minimal install or download the applications from Gallery with runtime to run on desktop local machine. The applications is supported to use on many platforms (web, Windows, Linux, OSX); however, Linux and OSX might require driver. To download the software to your system, simply follows the instructions below.

5.1.1 Run Applications Through Online

1. Go to the TMP117EVM web page on the TI website: http://www.ti.com/tool/TMP117EVM. Scroll down to the “Software” section and click on the hyperlink to download the latest evaluation software or an alternate way is to connect directly to the gallery by clicking on this link http://dev.ti.com/gallery/. It might require to login user account privileges to use the online version as well as installation of the applications.

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2. On the top middle of the gallery main page, navigating to search box and type *TMP117EVM GUI* as shown in the Figure 4.

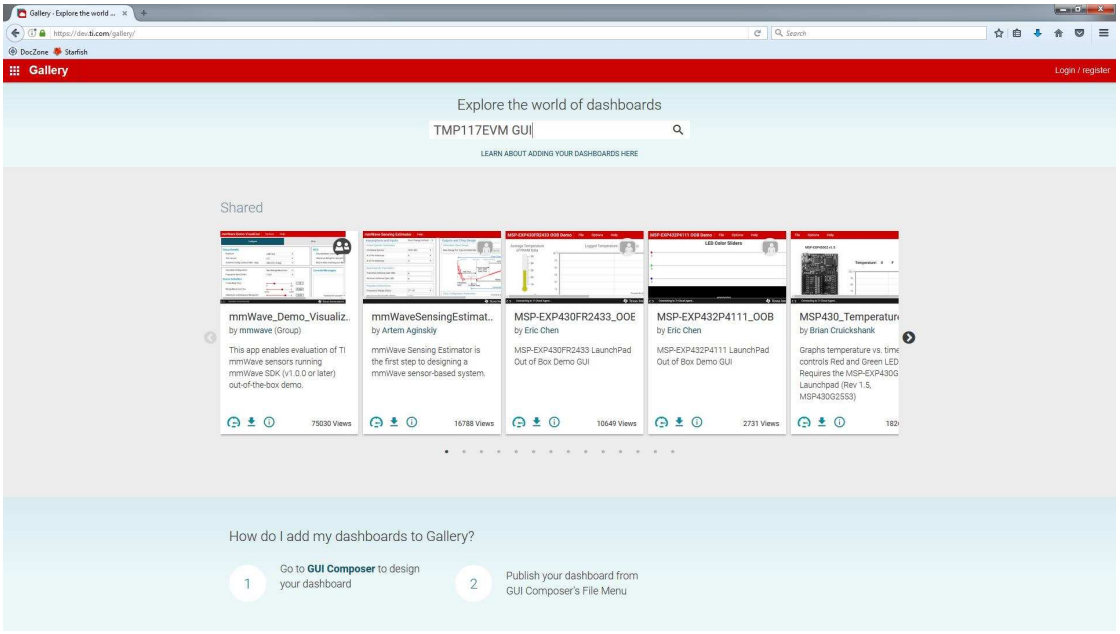

Figure 4. Gallery Home Page

3. Click on the TMP117EVM GUI icon. Users may be prompted to download and install the browser extension for the Firefox or Chrome and TI Cloud Agent Application for the first time. Click on *Agree and Proceed*.

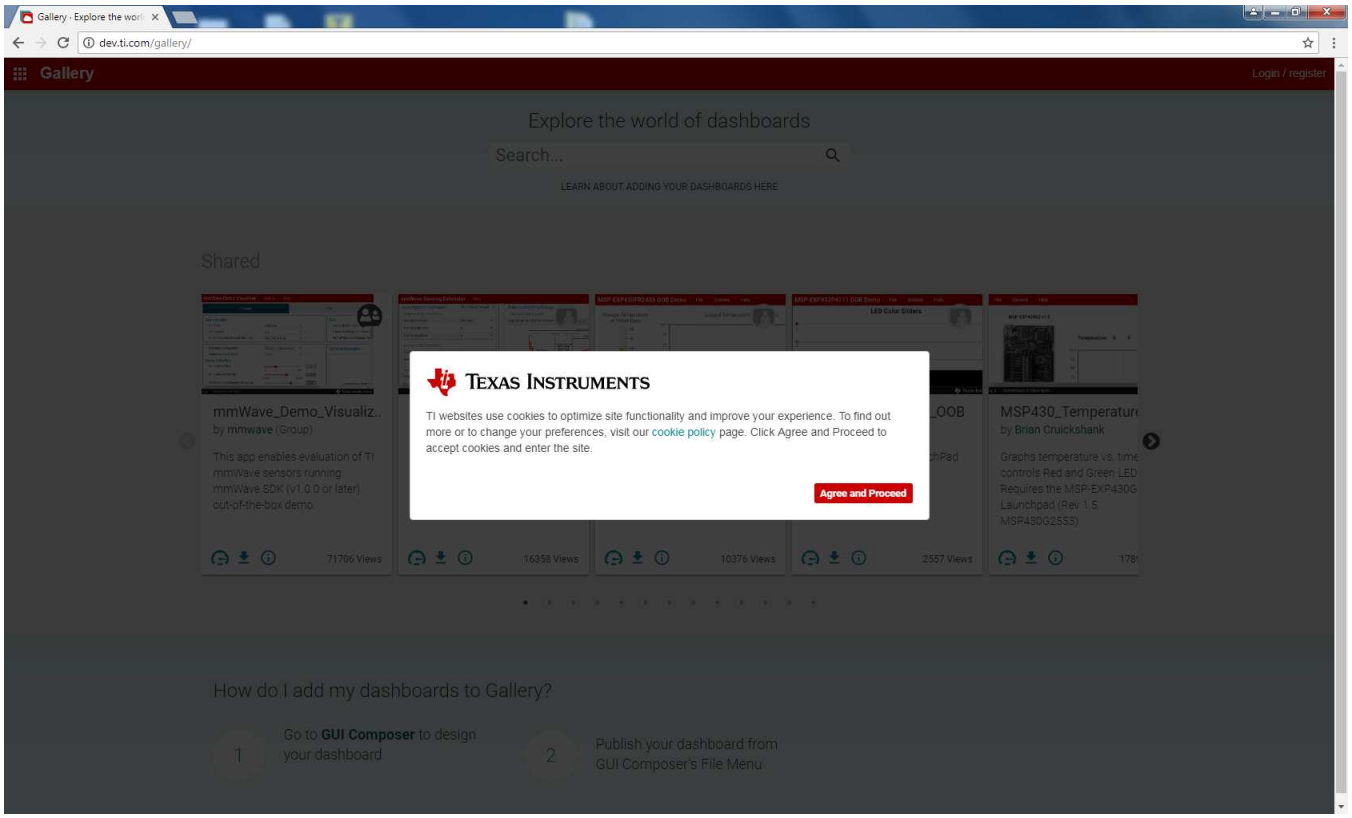

Figure 5. Cookies Agreement

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4. Follow the steps to install the browser extension and TI Cloud Agent Applications in Figure 6.

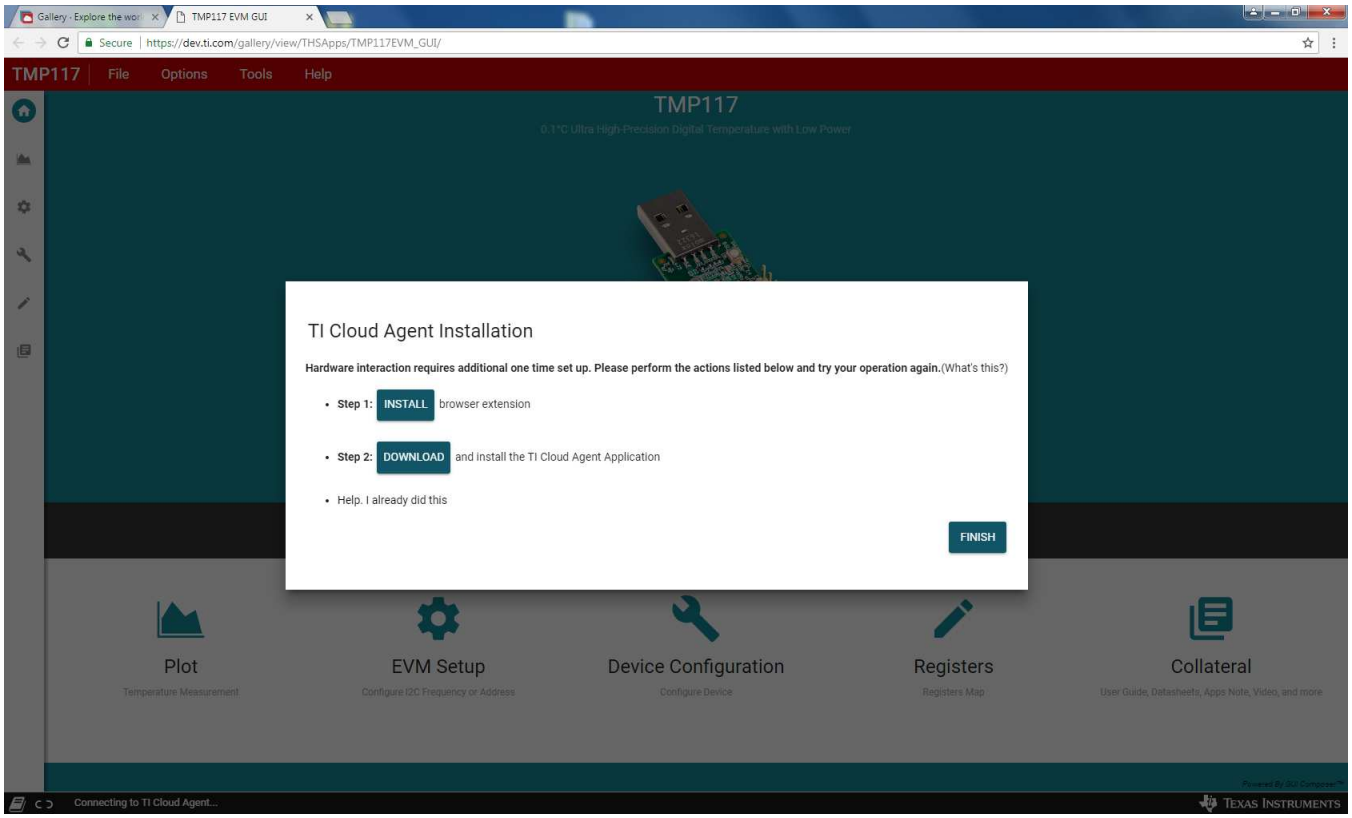

Figure 6. Browser Extension and TI Cloud Installation

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5.1.2 Run Applications on Desktop

1. In TMP117EVM GUI icon, click on the download icon to download the *TMP117EVM_GUI_installer_win.zip*. A pop-up screen shows appear, and select the desired platform to install into your local machine.
2. Unzip the downloaded file into a known directory, and run the “TMP117EVM_GUI-1.0.16.setup-win_6.0.0.exe” file located in [Unzip location]. The EVM software installer then begins the installation process.

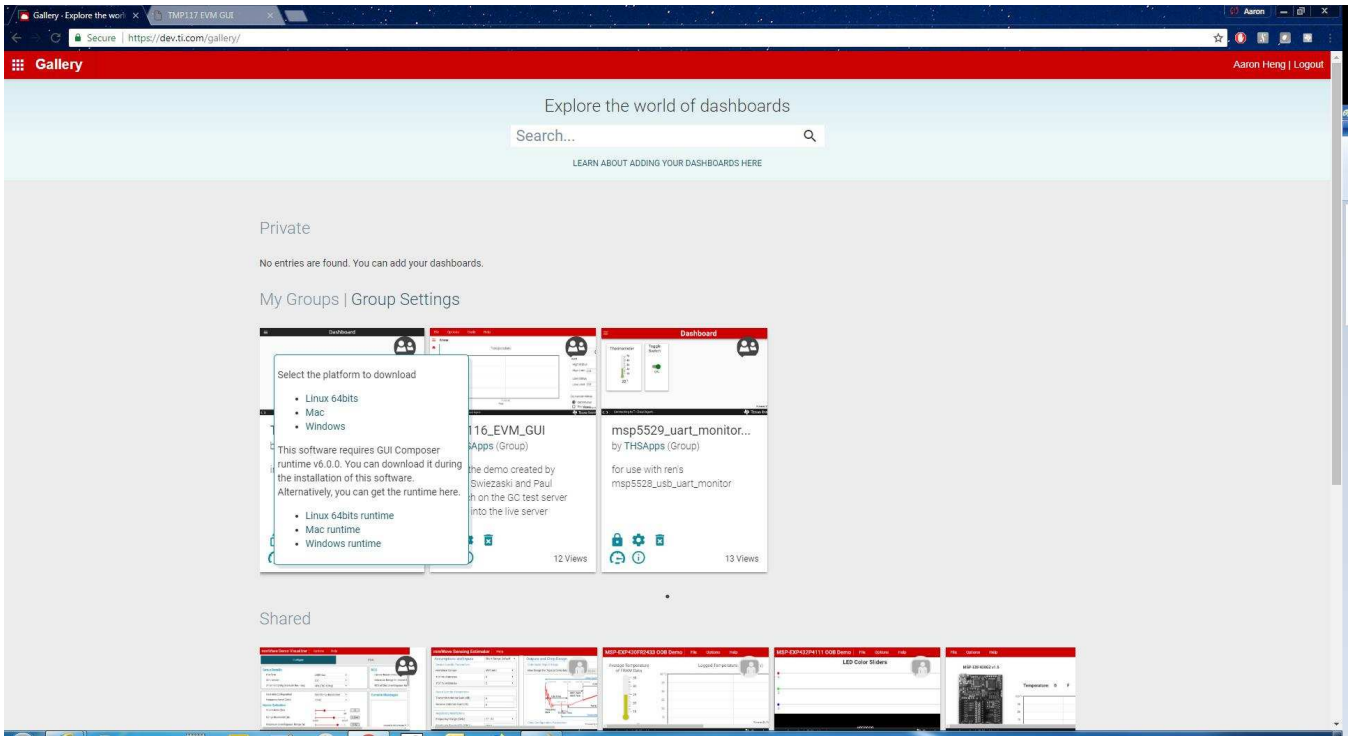

Figure 7. TMP117EVM GUI Download Platform

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3. Follow the on-screen instructions by clicking the “Next” button to install the GUI Composer runtime engine. If it is the first time installation, TMP117EVM GUI is required GUI Composer runtime engine v6.0 in order proper operation.

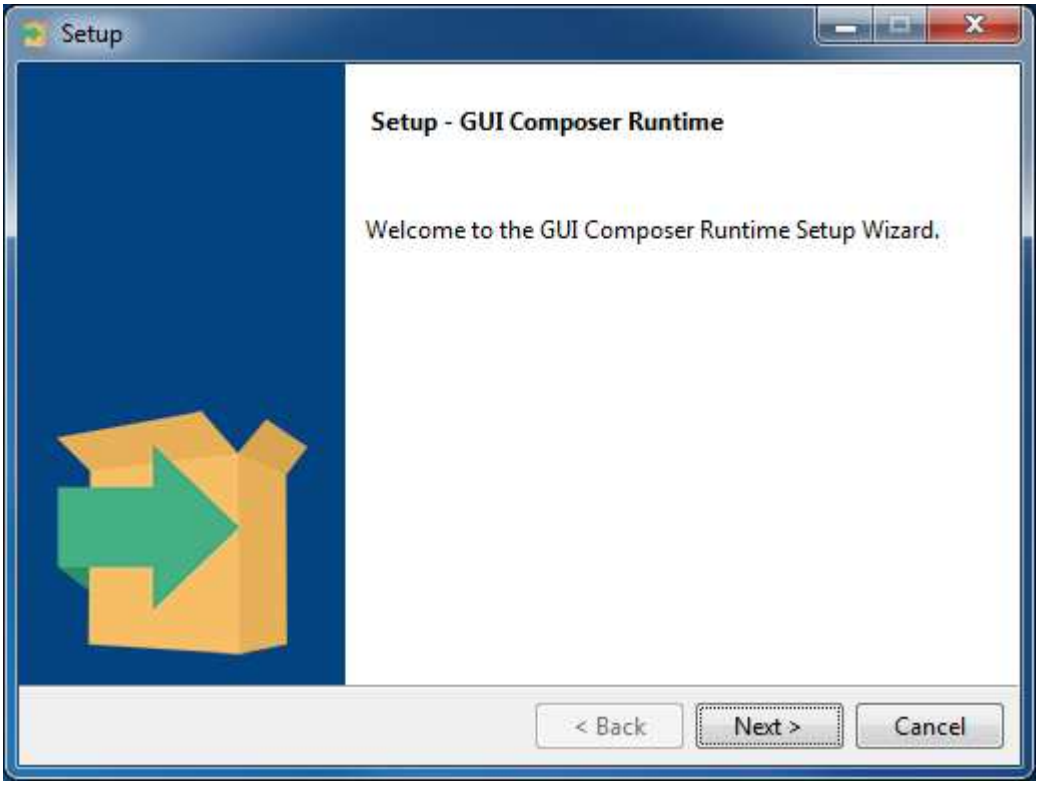

Figure 8. GUI Composer Runtime Wizard

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Figure 9. GUI Composer Installation Directory

4. Click on the "Next" button to accept the default installation directory. It takes sometimes to complete the setup GUI Composer Runtime installation.

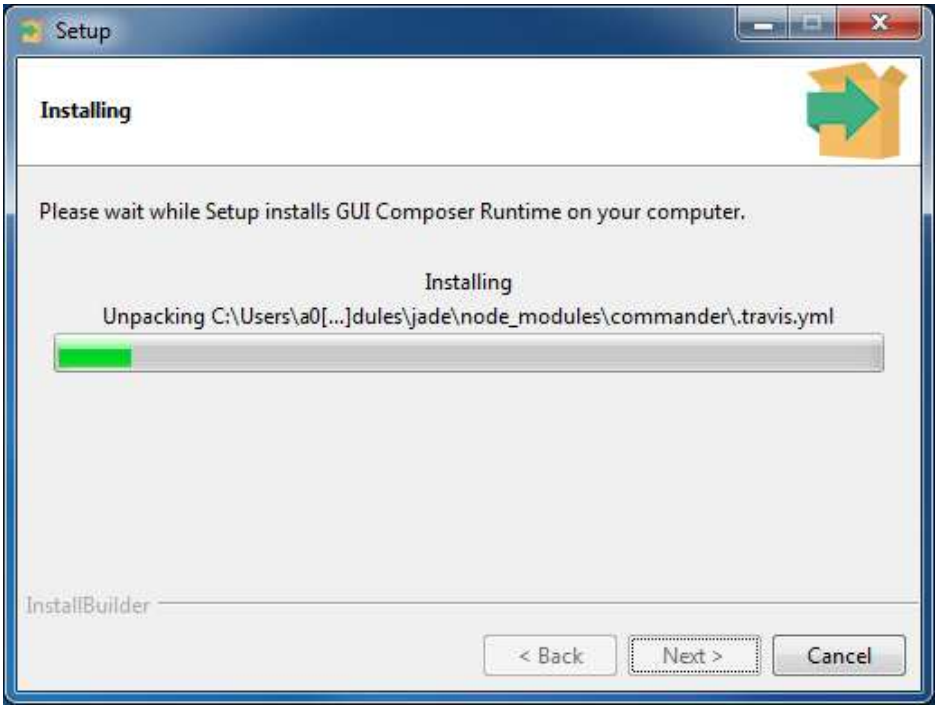

Figure 10. Installing GUI Composer Runtime

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5. If the GUI Composer Runtime reports an error installing drivers that are missing signatures, click on *Install this driver software anyway* to clear the unsigned signature driver issues.

Figure 11. Driver Signature

6. After the GUI Composer installation, it continues to install TMP117EVM GUI as shown in Figure 12. Follow the on-screen instructions by clicking the *Next* button to install the software. Accept the license agreements presented in Figure 13 to continue.

Figure 12. TMP117EVM Installation Finish

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Figure 13. TMP117EVM GUI License Agreement

7. Wait for the EVM software installer to start the installation process as shown in Figure 14.

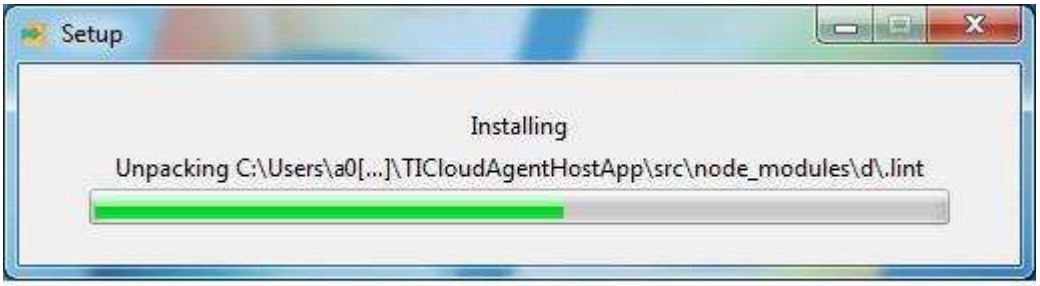

Figure 14. Installing TMP117EVM GUI

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8. Uncheck the *View readme file* checkbox and click *Finish* when the installation process is complete.

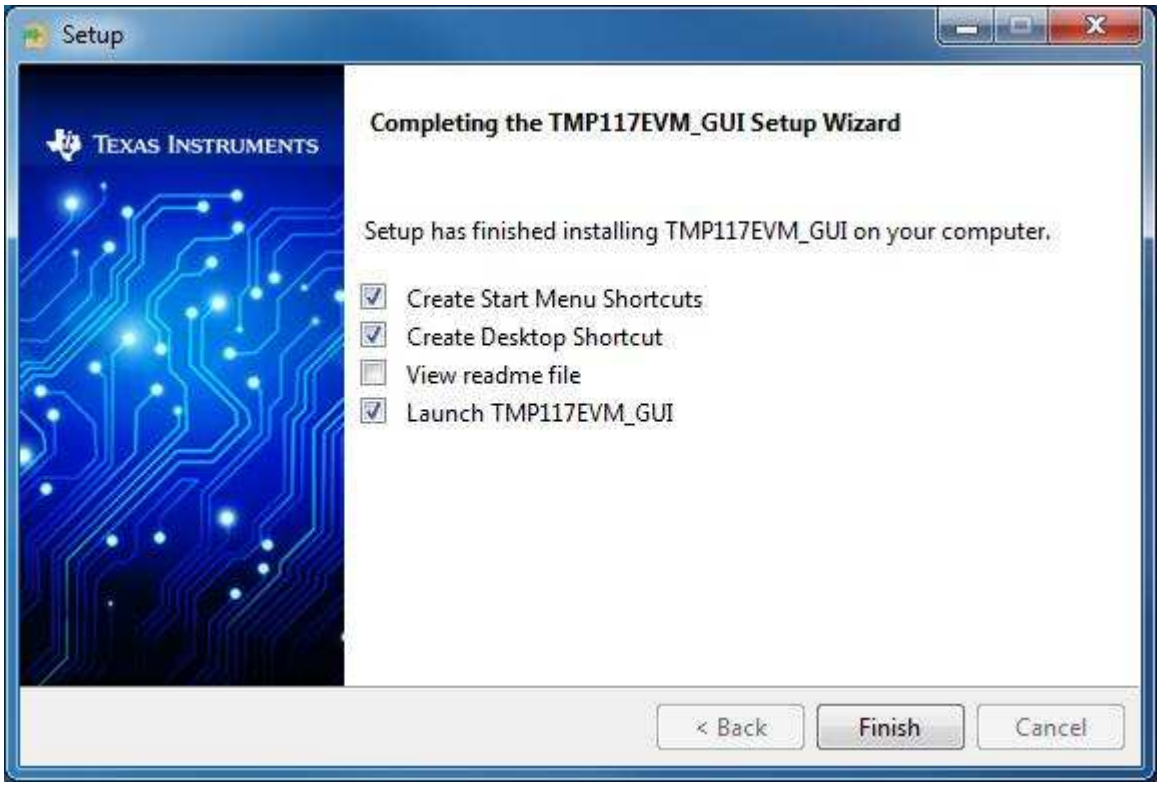

Figure 15. TMP117EVM Installation Finish

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6 Upgrading the Firmware

There are two ways to upgrade or program the firmware of the TMP117EVM board. However, this document will only show one method because the resonator is unable to bring the MSP430 into BSL mode.

CAUTION

TMP117EVM software must be installed before performing any tasks.

Figure 16. TMP117EVM Connection Diagram

To update the firmware of the TMP117EVM, complete the procedure below:

1. Short the J1 header connector pin 1-2 with a shunt. Plug the USB cable to the PC to power the TMP117EVM.
2. Connect another USB cable to MSP-EXP430F5529LP board
3. Remove the SBW RST and SBW TST jumpers on MSP-EXP430F5529LP board
4. Create wiring harness shown by connecting jumper wires to SBW RST, SBW TST and GND as shown in Figure 17.
5. Connect the header to the TMP117EVM on J4 connector by tilting header to make contact to the TMP117EVM J4 connector. Connect the wires according to this label SBW RST = TDIO, SBW TST = TCK, and GND = GND. Refer to Figure 2 for more detailed information.
6. Install offline UniFlash from http://www.ti.com/tool/UNIFLASH or navigate to http://dev.ti.com/gallery/ running off online version.

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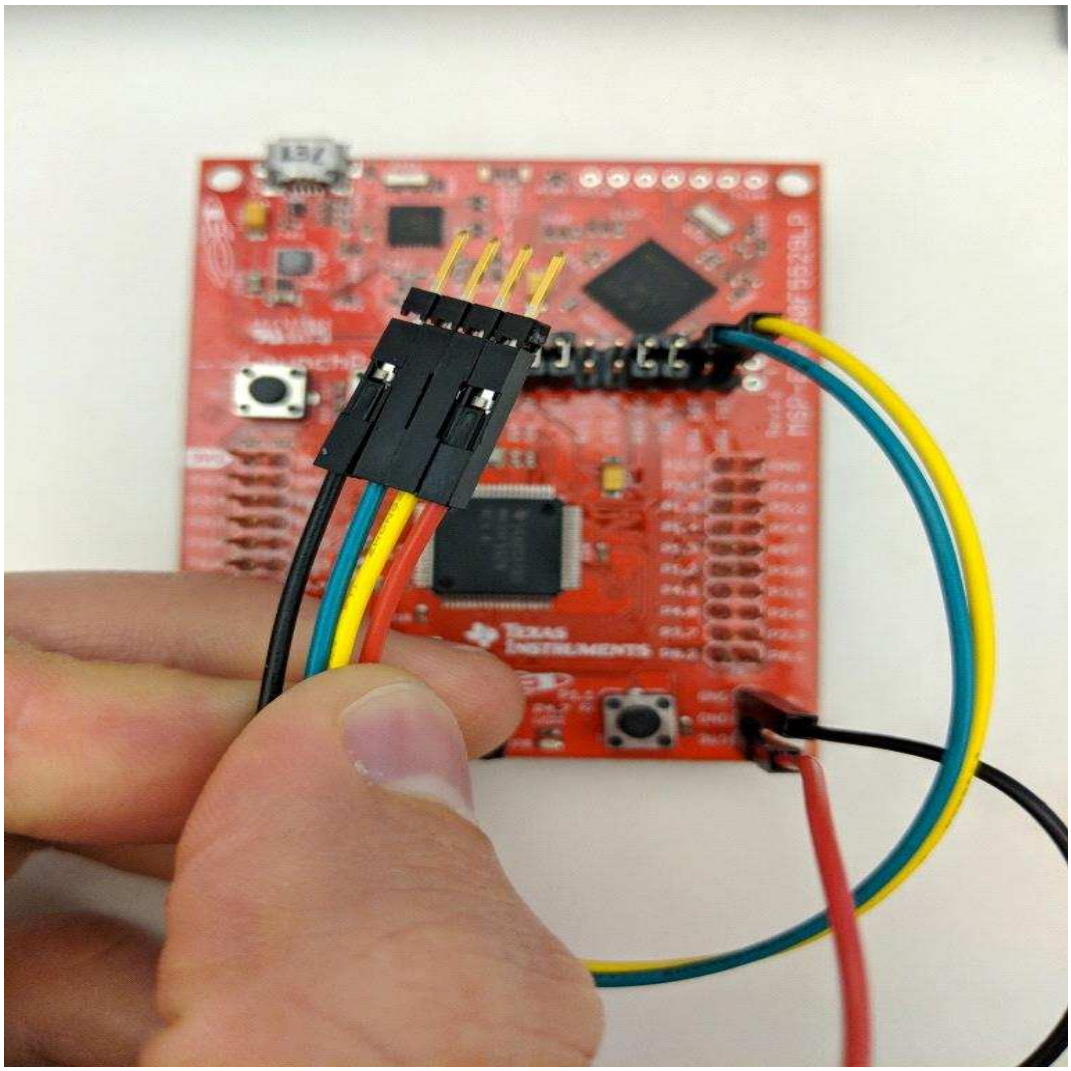

Figure 17. Wiring Connection

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7. Connect your MSP Debugger to the PC.
8. Select MSP430FR5528 as the target and click *Start*

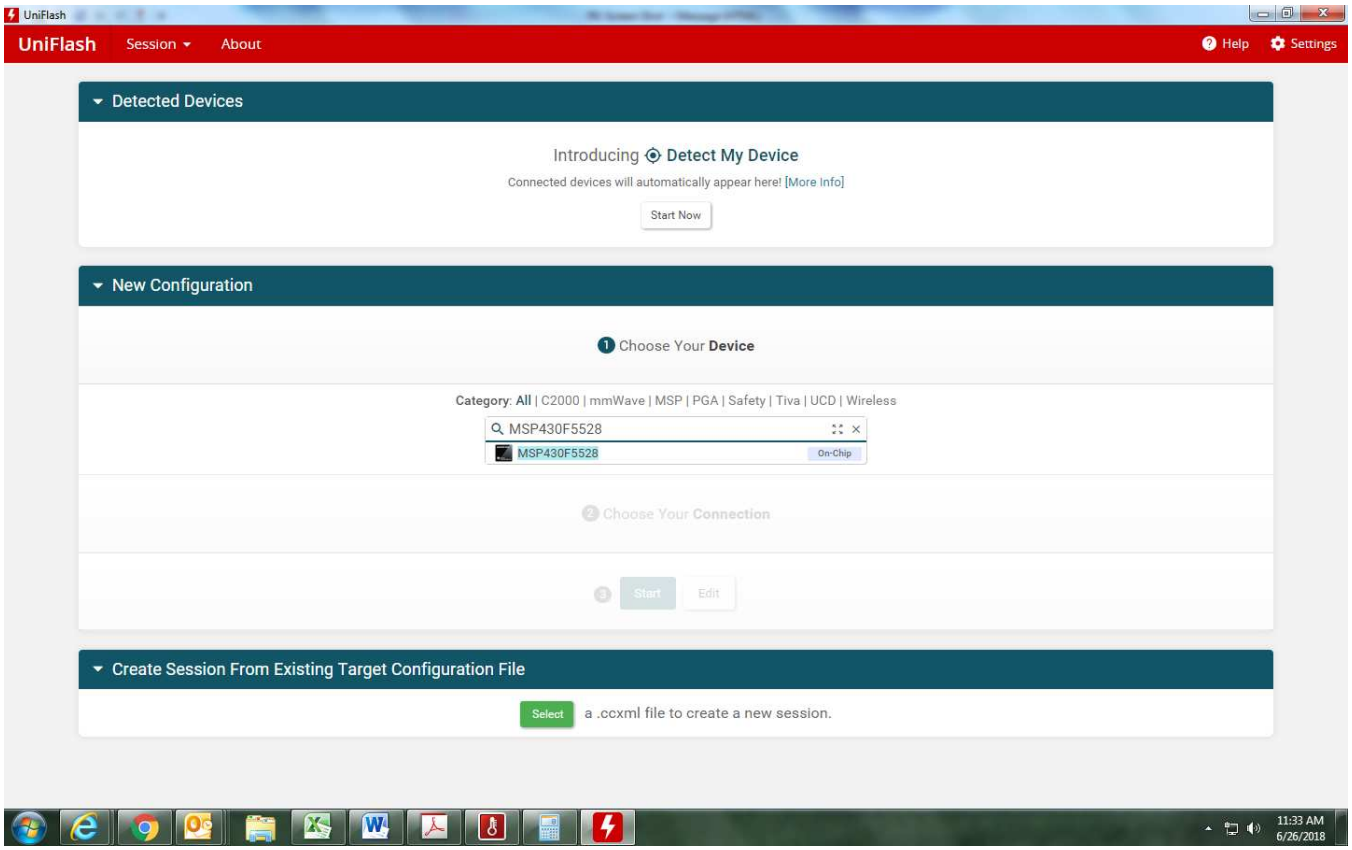

Figure 18. UniFlash GUI

9. Browse to the firmware file name is *USB2ANY_F5528.txt* version v2.7.16. The firmware image is programmed, and the TMP117EVM restarts automatically. The new firmware is now ready to use as shown in Figure 19.

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7 TMP117EVM Setup and Operation

CAUTION

Do not exceed the power supply rating of the MSP430.

7.1 Launching and Running the Software

The TMP117EVM is recognized by the host as a generic human interface device (HID), so there is no proprietary driver is required to install on your PC. It shows the typical response to connecting the USB-to-I2C converter board to a PC USB port for the first time. Typically, the computer responds with a Found New Hardware, USB device pop-up dialog. The pop-up window then typically changes to Found New Hardware, USB Human Interface Device. This pop-up indicates that the device is ready to be used. The USB-to-I2C Converter uses the human interface device drivers that are part of the Microsoft Windows® operating system.

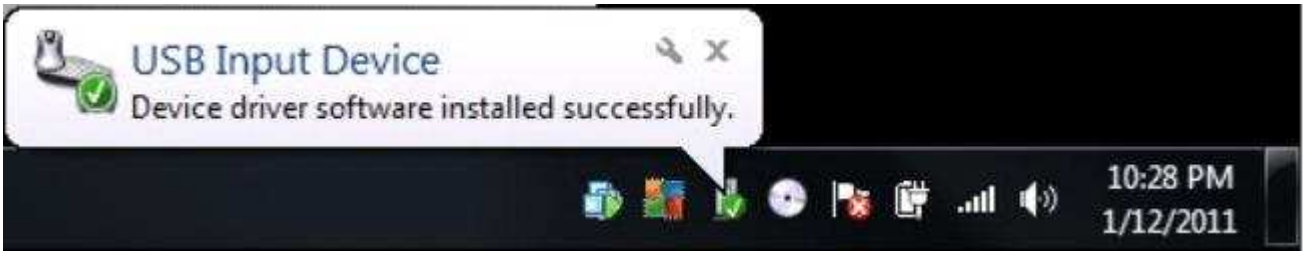

Figure 19. Confirmation of USB-to-I2C Converter Driver Installation

The TMP117EVM GUI can be run from TI Cloud repository http://dev.ti.com/gallery/ via Firefox or Chrome browser or from Windows desktop offline.

1. Connect the TMP117EVM to a USB port on a PC as shown in Figure 19.
2. Launch the TMP117EVM software by clicking on the TMP117EVM GUI icon in gallery. The TMP117 EVM GUI should automatically initialize and connect to the HID port. A successful connection will show “HARDWARE CONNECTED” on the bottom of the GUI status indicator. If there is a connection problem, verify if the TMP117EVM has an established connection with the PC. A fail connection if the status indicator shows as “*HARDWARE NOT CONNECTED*”.

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7.2 Tab Pages Selection

The tab pages selection consists of six tabs, *Home*, *Data Capture (Temperature Graph)*, *EVM Setup*, *Device Configuration*, *Registers*, and *Collateral*. Launching the software will take you to the *Home* window GUI display. By clicking on the page tab allows switching between pages of the tab control as shown in Figure 20.

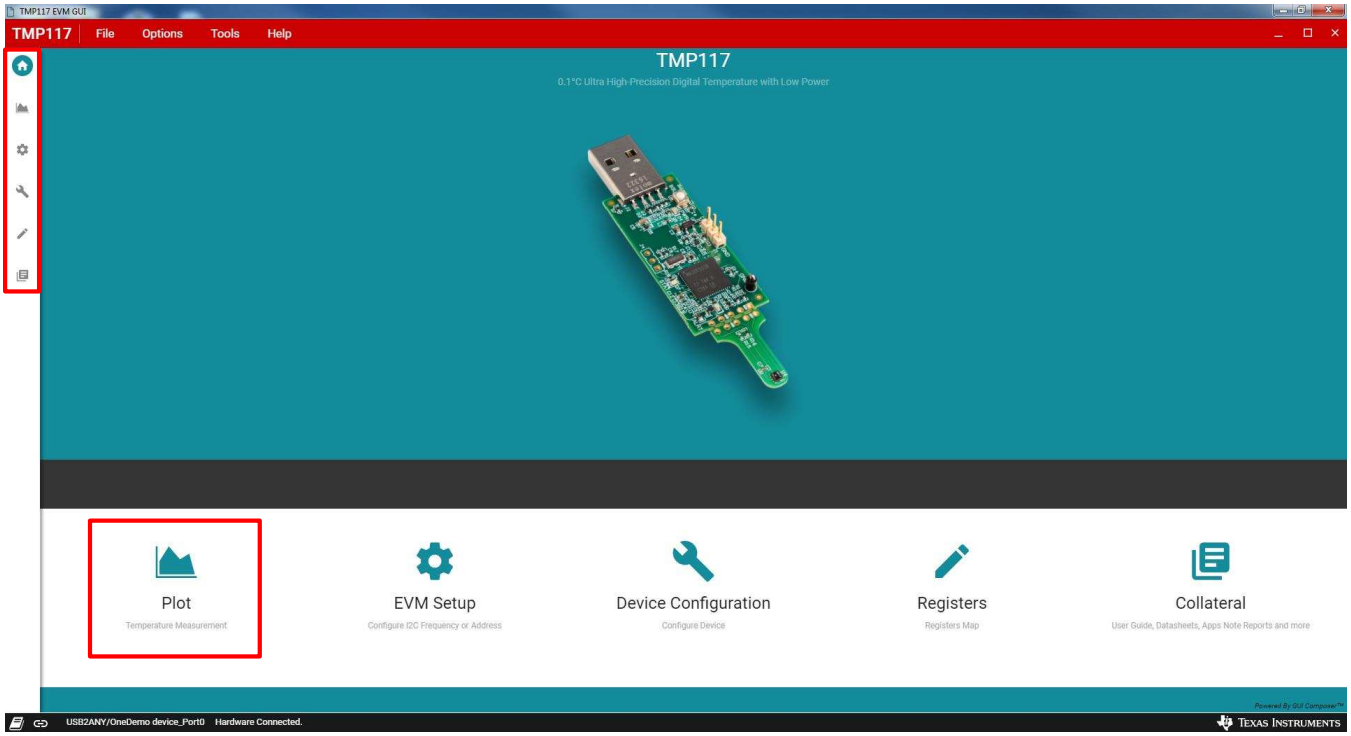

Figure 20. TMP117EVM Default Tab

7.3 Home Tab

When the TMP117EVM GUI launched, the *HOME* page will be appeared as shown in Figure 20. There are two ways that each tab can be navigated. On the bottom half of the *HOME* page contains icons where it links to the five other GUI pages. The icons are identical features to those locked in the left-most border of the TMP117EVM GUI. If TMP117EVM is powered and connected to the PC that has the correct firmware loaded, the *Hardware Connected* will appear at the left corner of the status bar as well as the connected icon shows solid.

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7.4 Data Capture Tab

The *Data Capture* tab provides graphing the temperature result as well as other features as shown in Figure 21. The temperature result will be fetched automatically according to the conversion cycle setting bits in the configuration register. It displays and processes the register value into a converted human readable format for the GUI. The two modes of graphing can be displayed Celsius or Fahrenheit.

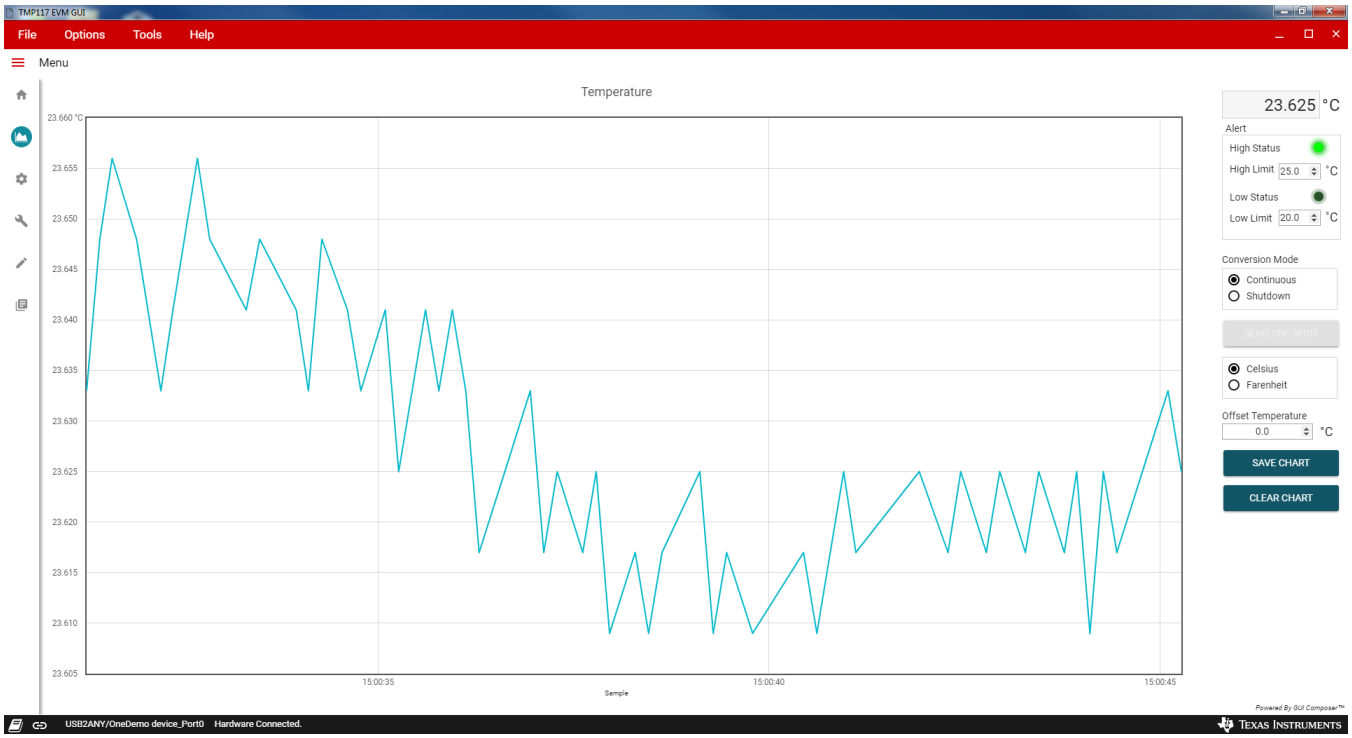

Figure 21. Data Capture Tab

Clear Chart erases the contents of the Temperature Chart box

Save Chart prompts for a file name, and then saves the contents of the current Temperature graph box to *.csv file.

Current Value shows the current temperature of the TMP117 on the top right.

Celsius or Fahrenheit is to toggle the temperature conversion Celsius to Fahrenheit.

One Shot is available on the Temperature Chart tab. The *One Shot* button writes to the TMP117 configuration register with the one-shot in conversion mode. This setting initiates a temperature conversion within the TMP117 device that updates the temperature result registers when the radio button is selected. After the one-shot conversion finishes, the device goes into shutdown, and wait for the time based on the averaging bits setting written in the configuration register.

Continuous performs the temperature conversion continuously when the MOD[1:0] bits are configured in the configuration register to 00. Each temperature conversion consists of an active conversion period followed by a standby period based on the time of the conversion cycle and conversion averaging configuration.

Alert High and Low Limit Register can be set by entering the value in °C or °F based on °C/°F control on Main tab that stores the high and low limit for comparison with the temperature result.

Offset Temperature is allowed to program the offset temperature to compensate and improve the system error. This register will be cleared when power down unless the *LOCK* is set.

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7.5 EVM Setup Tab

It is necessary to configure the TMP117 slave address as 0x48 for communication with the EVM-GUI. This is the default slave address.

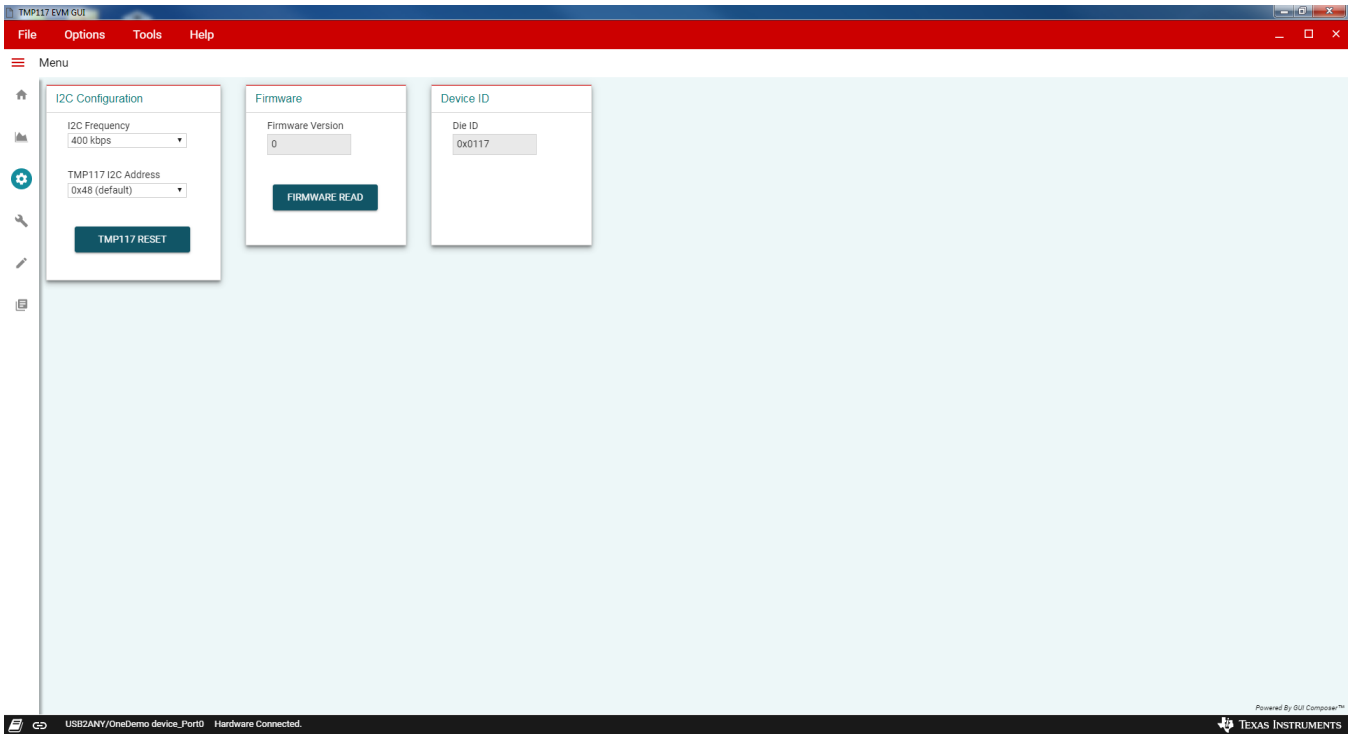

Figure 22. TMP117 Setup Tab

Firmware Read is allowed to check the firmware revision on the MSP430F5528 microcontroller.

I2C Configuration is to change the bus frequency and slave address.

Device ID is automatically read device identification.

Software Reset performs software reset on the TMP117 device by issuing a general call. After software reset, the values displayed in the EVM software may be out of sync with the device register contents. To sync register contents after TMP117 reset, click Read All in the Registers tab page.

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7.6 Configuration Tab

The *Device Configuration* allows user to configure the device's setting.

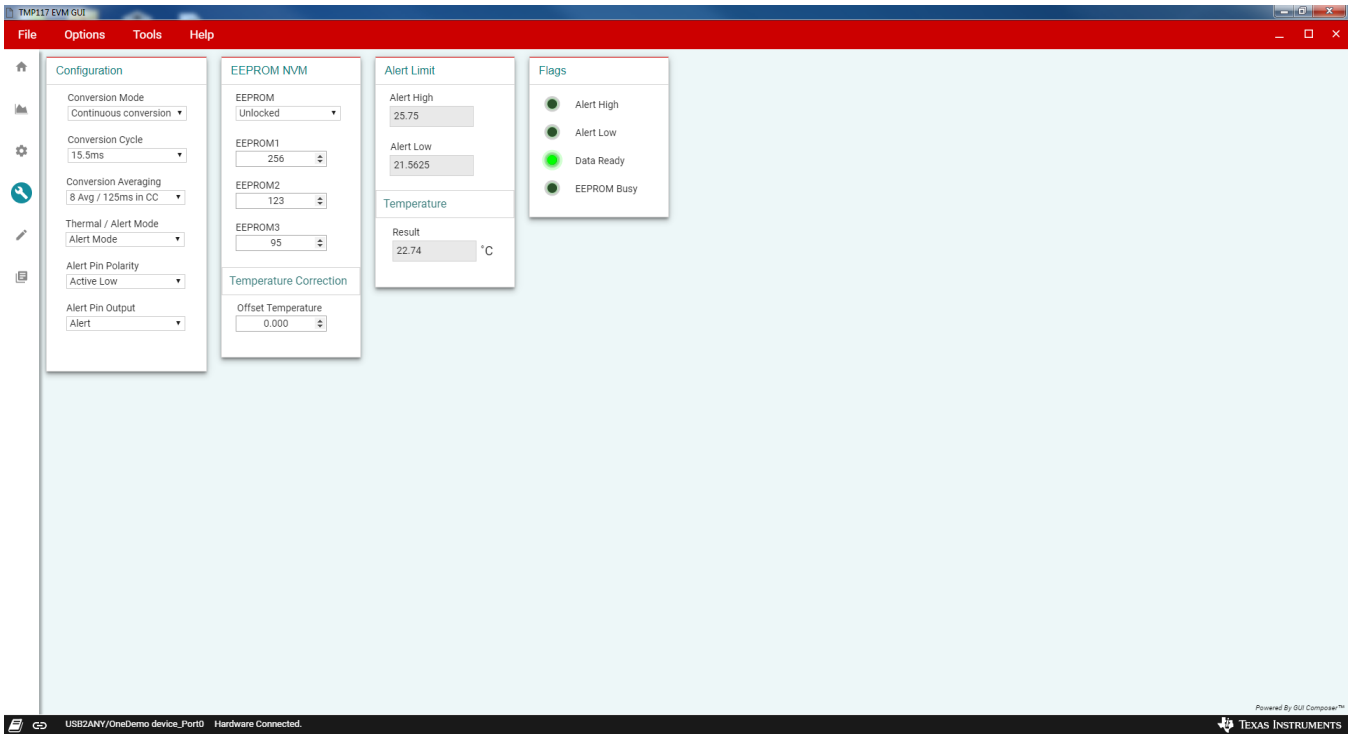

Figure 23. Configuration Tab

Configuration register can be set to desired value by selecting the drop-down menu.

Non-volatile memory can be programmed by entering the value at the location 1 to 3 then use the *EEPROM* dropdown menu to lock the value. This *LOCK* bit will also lock the value of the offset temperature register.

Alert High and Low Limit register can be set by entering the value in °C/°F. In Fahrenheit mode, it converts Fahrenheit to Celsius before it sends to the TMP117.

Status indicator displays the outputs based on the status bits.

Temperature displays the current temperature of the TMP117.

Offset Temperature is allowed to program the offset temperature to compensate and improve the system error. This register will be cleared when power down unless the *LOCK* is set.

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7.7 Register Tab

The Register Map page shown in Figure 24 allows low-level access to all I²C registers of the TMP117 device. Clicking on the question mark to the right of the Register Name will bring up an extraction short version from the datasheet describing that register. Clicking on a specific Register Name will populate the Field View to on the right side of the screen. The Field View describes each bit field within that register. The “Registers” tab provides access to the registers raw data of the TMP117, performing read and writes commands. Changes to the configuration page are mirrored here, and vice versa.

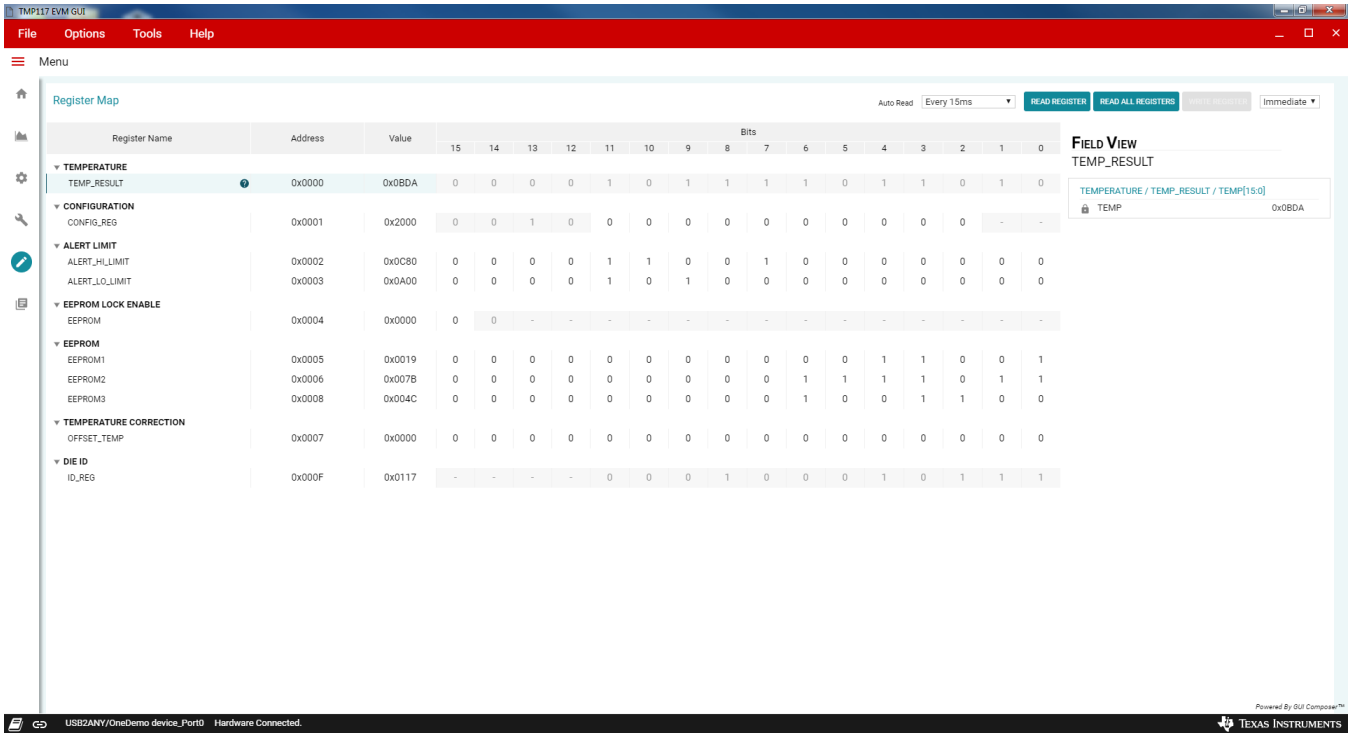

Figure 24. Registers Tab

Read Registers is performed one single for the selected register.

Read All Registers performs a read for all registers contents.

Auto Read is allowed user to set desired time frame fetching each data.

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7.8 Collateral Tab

The last page of the GUI is the Collateral page in Figure 25 which contains links to web documents pertinent to the TMP117 and its EVM. The page is divided into four sections: (1) User Guide, (2) Datasheet, (3) Application Notes, (4) Video.

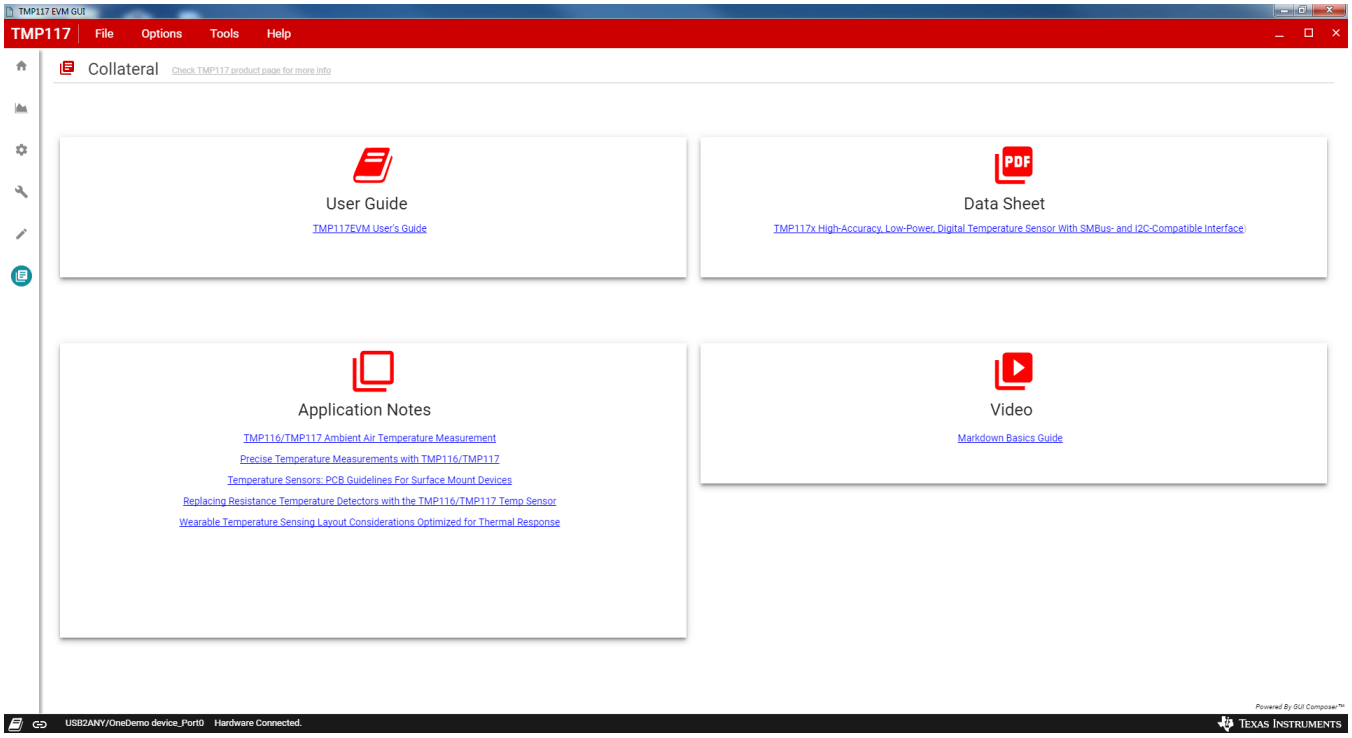

Figure 25. Collateral Tab

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8 Board Layout

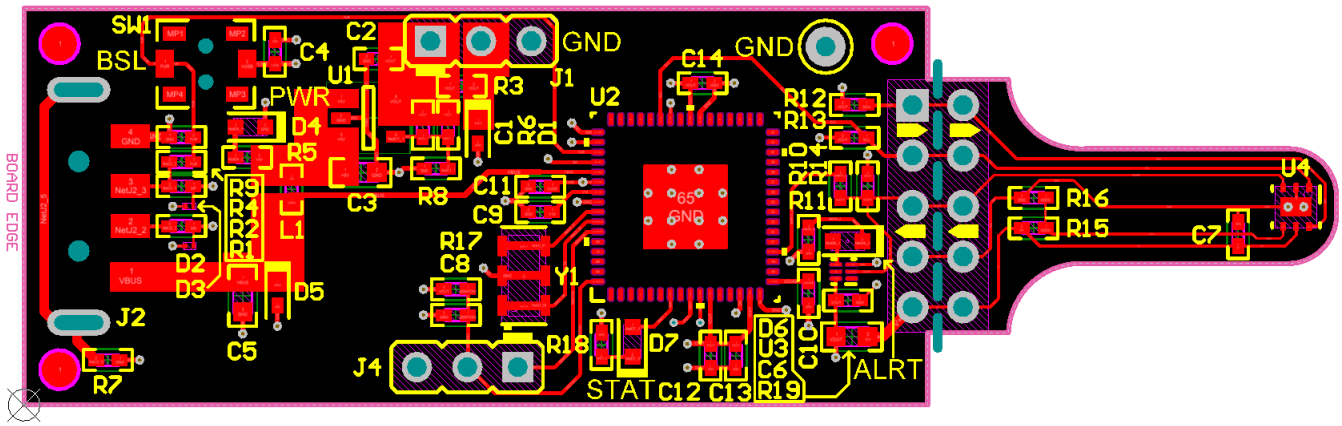

Figure 26. Top Assembly Layer

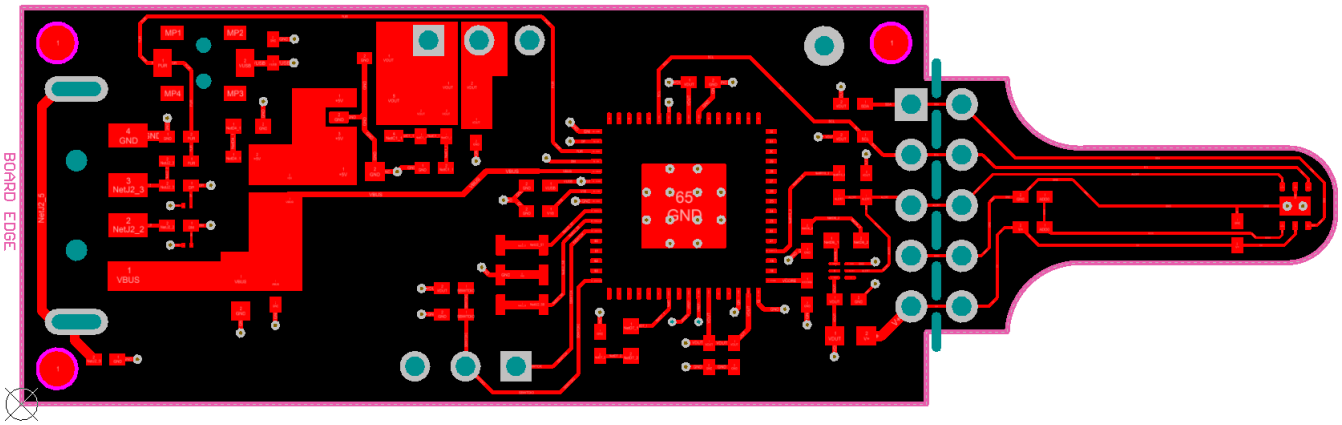

Figure 27. Top Layer Routing

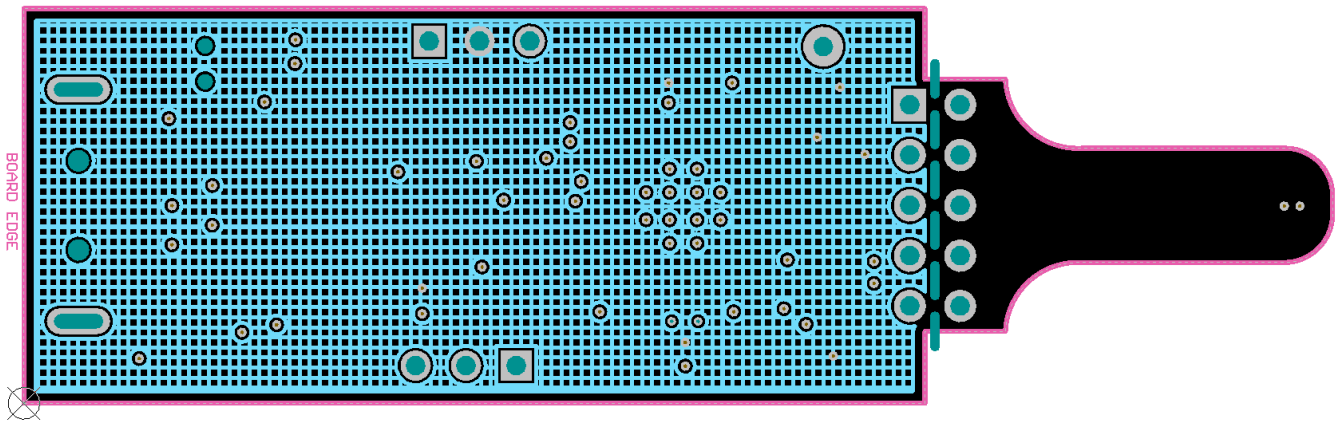

Figure 28. Power Layer Routing

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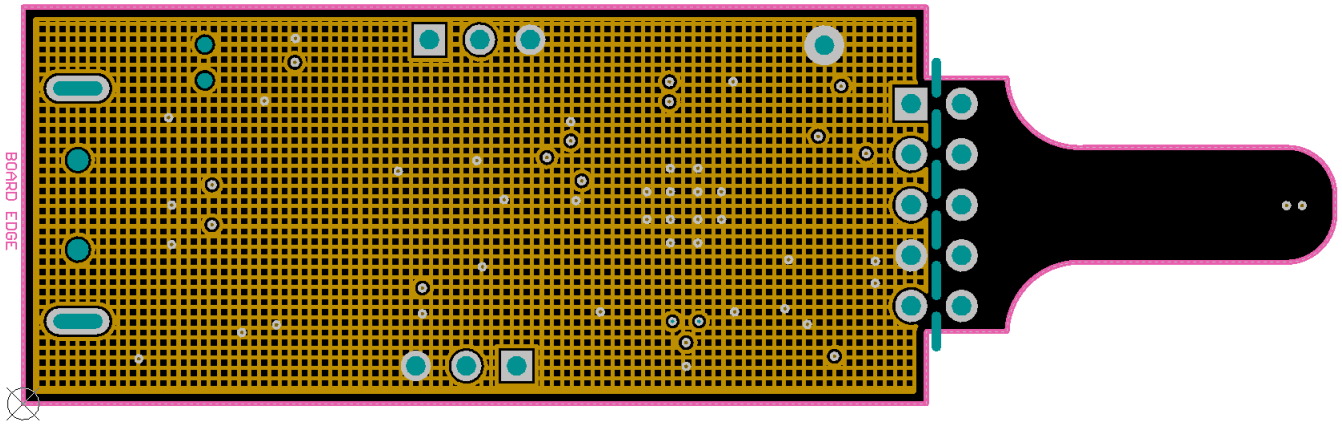

Figure 29. Ground Layer Routing

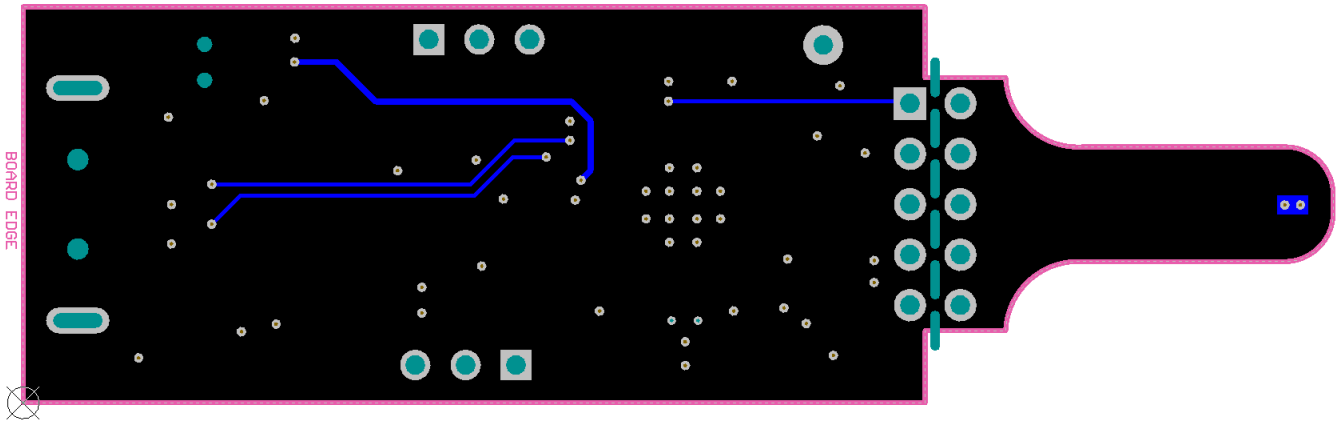

Figure 30. Bottom Layer Routing

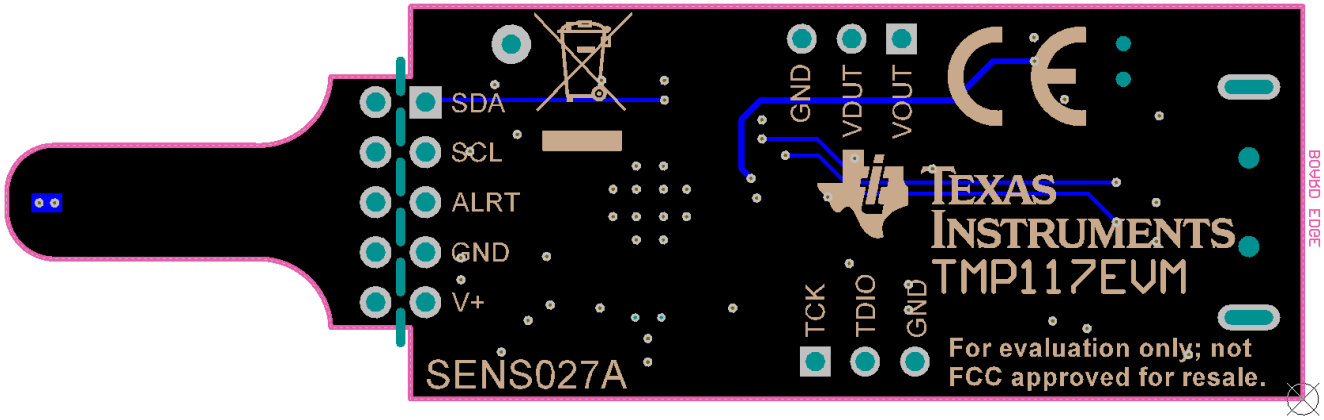

Figure 31. Bottom Assembly Layer

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9 Schematic and Bill of Materials

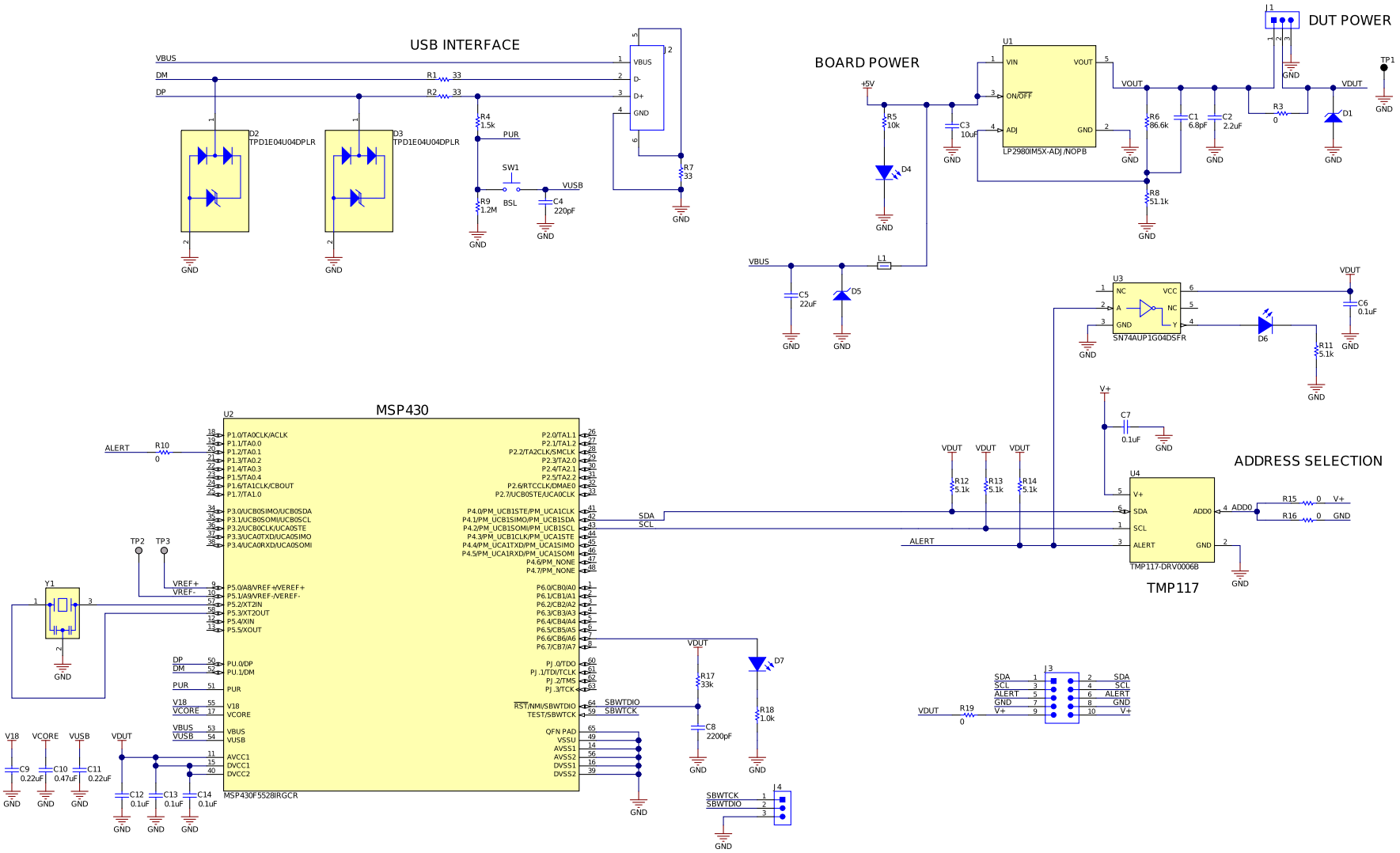

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Figure 32. TMP117EVM Schematic

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Table 4. TMP117EVM Bill of Materials

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer	Alternate Part Number	Alternate Manufacturer
C1	1	6.8pF	CAP, CERM, 6.8 pF, 25 V, +/- 5%, C0G/NP0, 0402	0402	GRM1555C1E6R8CA01D	MuRata		
C2	1	2.2uF	CAP, CERM, 2.2 uF, 16 V, +/- 10%, X5R, 0402	0402	GRM155R61C225KE11D	MuRata		
C3	1	10uF	CAP, CERM, 10 uF, 10 V, +/- 20%, X5R, 0603	0603	C1608X5R1A106M080AC	TDK		
C4	1	220pF	CAP, CERM, 220 pF, 50 V, +/- 10%, X7R, 0402	0402	GRM155R71H221KA01D	MuRata		
C5	1	22uF	CAP, CERM, 22 uF, 10 V, +/- 20%, X5R, 0603	0603	C1608X5R1A226M080AC	TDK		
C6, C7	2	0.1uF	CAP, CERM, 0.1 uF, 16 V, +/- 5%, X7R, 0402	0402	GRM155R71C104JA88D	MuRata		
C8	1	2200pF	CAP, CERM, 2200 pF, 100 V, +/- 10%, X7S, AEC-Q200 Grade 1, 0402	0402	CGA2B3X7S2A222K050BB	TDK		
C9, C11	2	0.22uF	CAP, CERM, 0.22 uF, 16 V, +/- 10%, X5R, 0402	0402	C1005X5R1C224K050BB	TDK		
C10	1	0.47uF	CAP, CERM, 0.47 uF, 10 V, +/- 10%, X5R, 0402	0402	GRM155R61A474KE15D	MuRata		
C12, C13, C14	3	0.1uF	CAP, CERM, 0.1 uF, 10 V, +/- 10%, X5R, 0402	0402	C1005X5R1A104K050BA	TDK		
D1	1	4.3V	Diode, Zener, 4.3 V, 300 mW, SOD-523	SOD-523	BZT52C4V3T-7	Diodes Inc.		
D2, D3	2		1-Channel ESD Protection Diode With Low Dynamic Resistance for HDMI 2.0 and USB 3.0, DPL0002A (X2SON-2)	DPL0002A	TPD1E04U04DPLR	Texas Instruments	TPD1E04U04DPLT	Texas Instruments
D4	1	Green	LED, Green, SMD	LED_0603	LTST-C191TGKT	Lite-On		
D5	1	6.2V	Diode, Zener, 6.2 V, 300 mW, SOD-523	SOD-523	BZT52C6V2T-7	Diodes Inc.		
D6	1	Red	LED, Red, SMD	LED_0603	LTST-C191KRKT	Lite-On		
D7	1	Orange	LED, Orange, SMD	LED_0603	LTST-C191KFKT	Lite-On		
J1	1		Header, 2.54 mm, 3x1, Gold, TH	Header, 2.54 mm, 3x1, TH	GBC03SAAN	Sullins Connector Solutions		
J2	1		Connector, Plug, USB Type A, R/A, Top Mount SMT	Edge mount USB A CONN	48037-2200	Molex		
L1	1	120 ohm	Ferrite Bead, 120 ohm at 100 MHz, 0.55 A, 0402	0402	BLM15AG121SN1D	MuRata		
R1, R2, R7	3	33	RES, 33, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW040233R0JNED	Vishay-Dale		

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Table 4. TMP117EVM Bill of Materials (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer	Alternate Part Number	Alternate Manufacturer
R3, R10, R16	3	0	RES, 0, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW04020000Z0ED	Vishay-Dale		
R4	1	1.5k	RES, 1.5 k, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW04021K50JNED	Vishay-Dale		
R5	1	10k	RES, 10 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0402	0402	ERJ-2GEJ103X	Panasonic		
R6	1	86.6k	RES, 86.6 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW040286K6FKED	Vishay-Dale		
R8	1	51.1k	RES, 51.1 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW040251K1FKED	Vishay-Dale		
R9	1	1.2Meg	RES, 1.2 M, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW04021M20JNED	Vishay-Dale		
R11, R12, R13, R14	4	5.1k	RES, 5.1 k, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW04025K10JNED	Vishay-Dale		
R17	1	33k	RES, 33 k, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW040233K0JNED	Vishay-Dale		
R18	1	1.0k	RES, 1.0 k, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW04021K00JNED	Vishay-Dale		
R19	1	0	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW06030000Z0EA	Vishay-Dale		
SH-J1	1		Shunt, 100mil, Tin plated, Black	Shunt Connector Black Open Top, 2x1	SNT-100-BK-T-H	Samtec		
SW1	1		Switch, SPST-NO, Off-Mom, 0.05A, 12VDC, SMD	3.9x2.9mm	PTS820 J20M SMTR LFS	C and K Components		
TP1	1		Test Point, Miniature, Black, TH	Black Miniature Testpoint	5001	Keystone		
U1	1		Micropower 50 mA Ultra Low-Dropout Adjustable Voltage Regulator in SOT-23, DBV0005A (SOT-23-5)	DBV0005A	LP2980IM5X-ADJ/NOPB	Texas Instruments	LP2980IM5-ADJ/NOPB	Texas Instruments
U2	1		25 MHz Mixed Signal Microcontroller with 128 KB Flash, 8192 B SRAM and 47 GPIOs, -40 to 85 degC, 64-pin QFN (RGC), Green (RoHS and no Sb/Br)	RGC0064B	MSP430F5528IRGCR	Texas Instruments		
U3	1		Low-Power Single Inverter Gate, DSF0006A, LARGE T and R	DSF0006A	SN74AUP1G04DSFR	Texas Instruments		
U4	1		High-Accuracy, Low-Power, Digital Temperature Sensor With SMBus- and I2C-Compatible Interface, DRV0006B (WSON-6)	DRV0006B	TMP117-DRV0006B	Texas Instruments		

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Table 4. TMP117EVM Bill of Materials (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer	Alternate Part Number	Alternate Manufacturer
Y1	1		Resonator, 4 MHz, 5000 ppm, AEC-Q200 Grade 1, SMD	4.5x2mm	PBRV4.00MR50Y000	AVX		
FID1, FID2, FID3	0		Fiducial mark. There is nothing to buy or mount.	N/A	N/A	N/A		
J3	0		Header, 100mil, 5x2, Tin, TH	Header, 5x2, 100mil, Tin	PEC05DAAN	Sullins Connector Solutions		
J4	0		Header, 2.54 mm, 3x1, Gold, TH	Header, 2.54 mm, 3x1, TH	GBC03SAAN	Sullins Connector Solutions		
R15	0	0	RES, 0, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW04020000Z0ED	Vishay-Dale		

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