TMP461EVM User’s Guide and Software Tutorial

User's Guide

Literature Number: SBOU152A
July 2015–Revised September 2019

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TMP461EVM User's Guide and Software Tutorial

This user's guide describes the characteristics, operation, and use of the TMP461EVM evaluation board. It discusses how to set up and configure the software, reviews the hardware, and reviews various aspects of the software operation. Throughout this document, the terms evaluation board, evaluation module, and EVM are synonymous with the TMP461EVM. This user's guide also includes information regarding operating procedures and input/output connections, an electrical schematic, PCB layout drawings, and a parts list for the EVM.

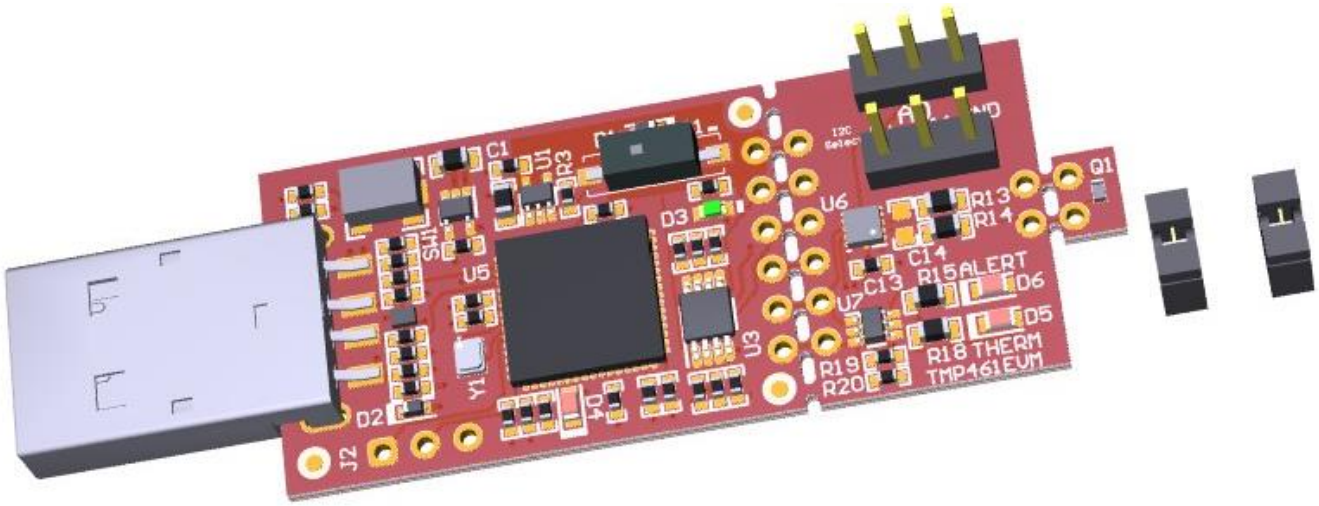


Figure 1. TMP461EVM Hardware

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Overview

The TMP461 is a high-accuracy, low-power remote temperature sensor monitor with a built-in local temperature sensor. The remote temperature sensors are typically low-cost discrete NPN or PNP transistors, or on-die transistor or diode structures that are an integral part of microprocessors, microcontrollers, or FPGAs. The temperature accuracy is ±1°C for the local and the remote temperature sensors. The two-wire serial interface accepts SMBus communication protocol. 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 perforations that allows the temperature sensor, microcontroller, and remote BJT to be isolated and be connected to external systems.

1.1 TMP461EVM Kit Contents

Table 1-1 lists the contents of the TMP461EVM kit. Contact the nearest Texas Instruments Product Information Center if any component is missing. TI highly recommends that engineers check the TI website at http://www.ti.com to verify that they have the latest versions of the related software.

Table 1-1. Contents of the TMP461EVM Kit

ITEM	QUANTITY
TMP461 PCB test board	1
Header, 100mil, 3x1, Gold, TH	2
USB cable extender	1

1.2 Related Documentation From Texas Instruments

The following document provides information on TI's integrated circuits used in the TMP461EVM. This user's guide is available from the TI website under literature number SBOU152. Any letter appended to the literature number corresponds to the document revision that is current at the time of the writing of this document. Customers can either find the latest documentation on http://www.ti.com, or call the Texas Instruments Literature Response Center at (800) 477-8924 or the Product Information Center at (972) 644-5580 for more information. When ordering, identify the document by both title and literature number.

Table 1-2. Related Documentation

DOCUMENT	LITERATURE NUMBER
TMP461 product data sheet	SBOS722

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TMP461EVM Hardware Overview and Setup

This section describes the setup and some of the hardware features present on the TMP461EVM.

WARNING

Many of the components on the TMP461EVM are susceptible to damage by electrostatic discharge (ESD). Customers are advised to observe proper ESD handling precautions when unpacking and handling the EVM, including the use of a grounded wrist strap at an approved ESD workstation.

2.1 Board Connectors and Components

Figure 2-1 shows the top side of the TMP461EVM. Highlighted are the USB connector, breakouts, the TMP461 device, and the remote BJT. The USB connector is directly plugged into the computer for power and communication from the computer to the USB2ANY mircocontroller. The engineer can use the perforated breakouts to break off certain sections of the EVM and connect them to external systems. Headers can also be soldered to the vias to be used as test points. These vias are positioned 100 mils apart to be compatible with a standard breadboard.

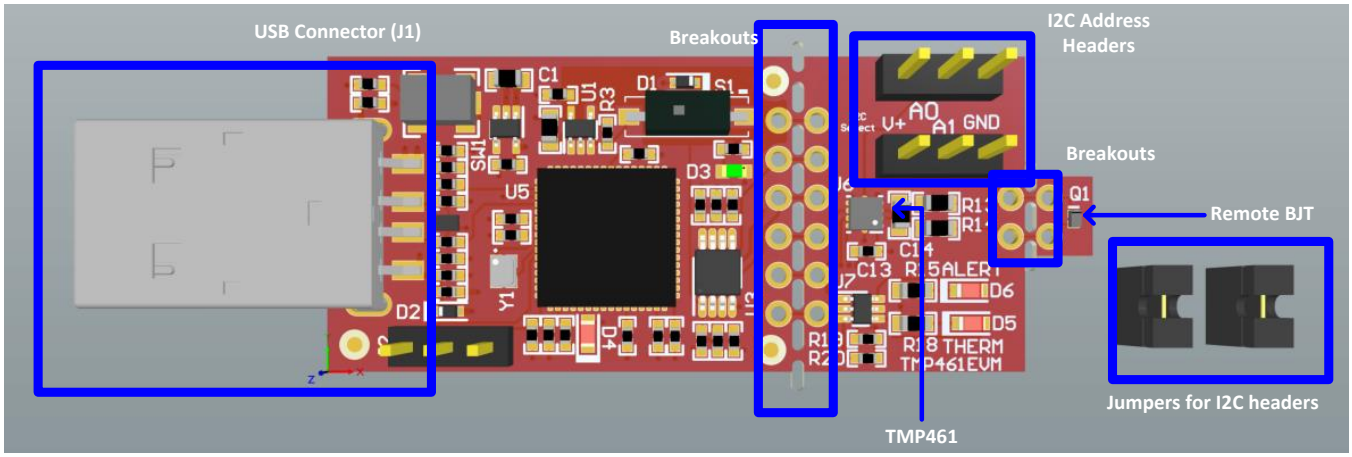


Figure 2-1. TMP461EVM Board Top Side

2.1.1 EVM Power Supply Input – J1

J1 is the USB connector to the PC. The interface is used to access the device's registers and read the conversion data from the TMP461 through I2C communication protocol. The TMP461EVM 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 a switched +5 V.

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2.1.2 Pushbutton Switch – SW1

The SW1 push button can bring the MSP430 into BSL mode and allow the user to upgrade the firmware with the combination of the USB connector. Press and hold the switch SW1 next to the USB connector while plugging the USB cable from the board to the PC to bring the MSP430 into BSL mode.

2.1.3 LEDs – D3, D5, D6

D3 is a green LED that can indicate when the EVM has power and can turn on after plugging in the board. The D5 LED can indicate a THERM fault and will turn on when the device detects a THERM fault and brings the pin LOW. D6 does the same function but for the ALERT/THERM2 pin. Both these LEDs are red.

2.1.4 Remote BJT – Q1

Q1 is a MMBT3904LP NPN BJT. This is used as the remote temperature sensor on the EVM. The MMBT3904LP typically has an N-factor of about 1.0042. The TMP461 assumes an N-Factor of 1.008, which can cause a temperature error in the remote temperature reading. The GUI automatically sets the N-Factor correction register to 1.0042 to compensate for this. If the device is reset, it will set the N-Factor correction register back to the default value or 1.008 and a temperature error may be seen. If a remote temperature error is seen, use the N-Factor correction feature to adjust the temperature reading. The MMBT3904LP can also be broken off to allow the engineer to connect a different temperature remote to the device.

2.1.5 Address Jumpers – J3, J4

J3 and J4 are used for setting the I2C address of the TMP461. J3 is used to set the A0 pin, and J4 is used to set the A1 pin.

2.2 Hardware Setup

The TMP461EVM hardware consists of the USB2ANY Platform and the TMP461 altogether on one single board. The unit is easily connected through a USB connector into the computer, as shown in Figure 2-2. The green LED (D3) should turn on after the EVM is connected to the computer, confirming that the EVM is powered. The engineer can either use the included jumpers to connect the middle pin to one of adjacent headers to set the pin to either V+ or GND, or they can leave the pin floating for the desired I2C address.



Figure 2-2. Hardware Setup

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TMP461EVM Software Overview

This section discusses how to install and use the TMP461EVM software.

3.1 TMP461EVM Software Installation

The EVM software listed here is tested on Microsoft Windows 7 and 10 operating systems (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 redirect to the TI Cloud that has a common repository of all published applications using the GUI Composer framework. The applications can run directly from the Gallery with minimal install, but the engineers can download the applications from the Gallery with Runtime to run the files on a desktop local machine. The application is supported on many platforms (web, Windows, Linux, OSX), but Linux and OSX may require additional drivers. To download the software to your system, follow the instructions below.

3.1.1 Running GUI Online

Go to the TMP461EVM web page on the TI website: http://www.ti.com/tool/TMP461EVM. Scroll down to the “Software” section and click on the hyperlink to download the latest evaluation software, or connect directly to the Gallery through this link: http://dev.ti.com/gallery/. This link may require login user account privileges to use the online version as well as install applications. On the Gallery main page, type 'TMP461EVM' in the search bar as shown in the Figure 3-1 and press enter.

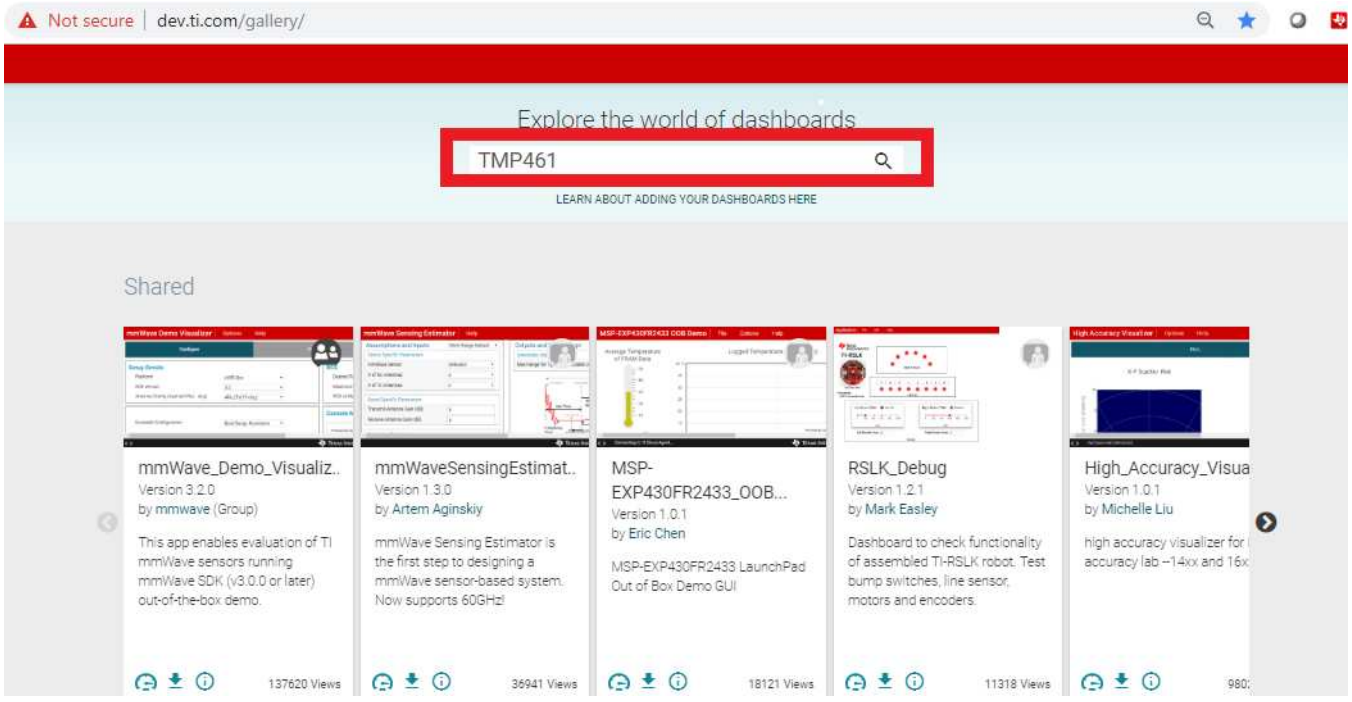


Figure 3-1. Gallery Home Page

Click on the TMP461EVM 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. After this, the TMP461GUI should launch in your browser window.

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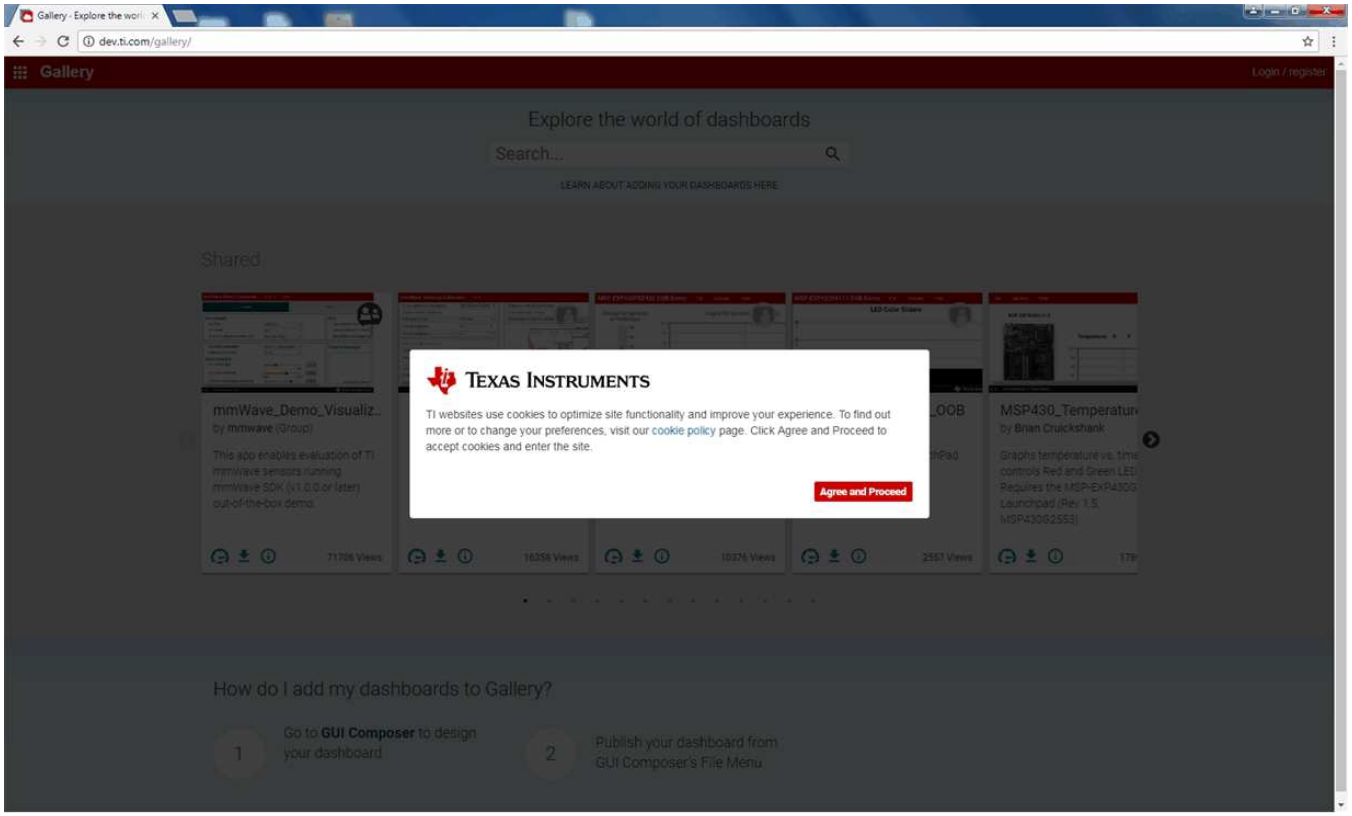


Figure 3-2. Cookies Agreement

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3.1.2 Running GUI on Desktop

In the TMP461EVM GUI icon, click on the download icon to download the TMP461EVM_GUI_installer_win.zip. A pop-up screen appears, and select the desired platform to install into your local machine as shown in Figure 3-3.

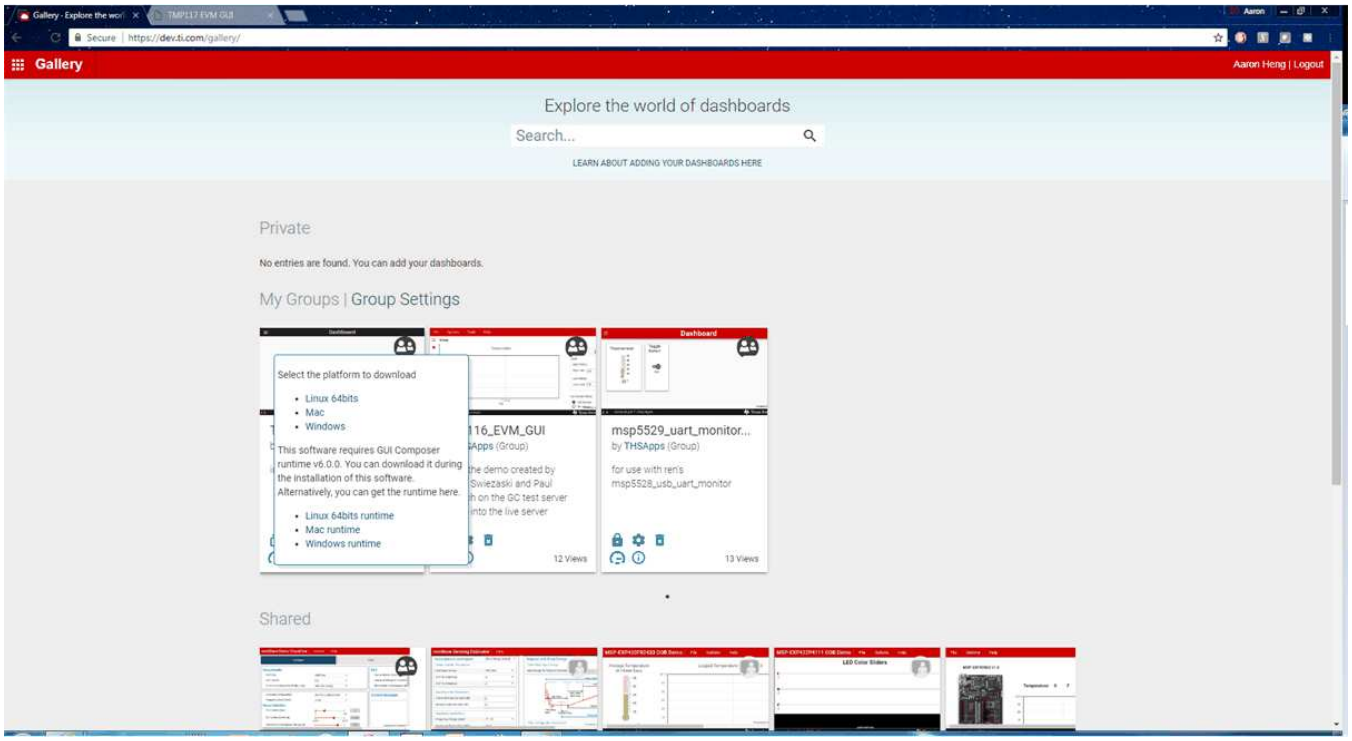


Figure 3-3. TMP461EVM GUI Download From the Gallery

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Unzip the downloaded file into a known directory, and run the “TMP461EVM_GUI-1.0.0.setup-win_7.2.0.exe” file located in [Unzipped location]. The EVM software installer then begins the installation process.

Follow the on-screen instructions by clicking the “Next” button to install the GUI Composer Runtime engine. If it is the first time installation, the TMP461EVM GUI requires GUI Composer Runtime engine v7.2 to operate properly.



Figure 3-4. GUI Composer Runtime Wizard

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Read through the License Agreement and click the checkbox if you agree, then click "Next".

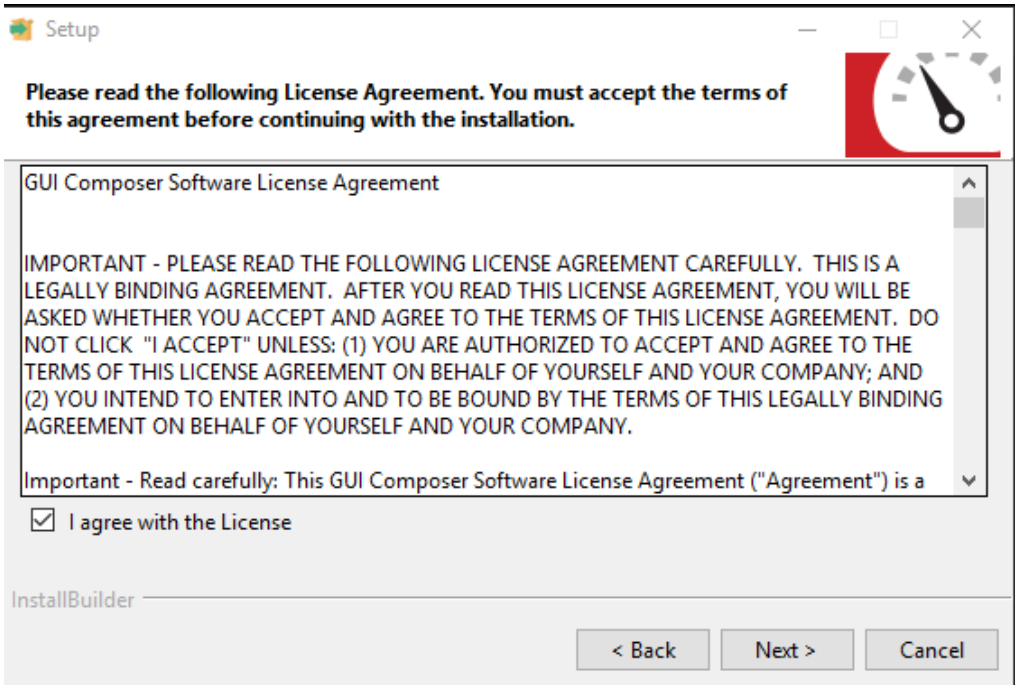


Figure 3-5. TMP461EVM GUI License Agreement

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Click on the "Next" button to accept the default installation directory. Installation takes some time to complete.

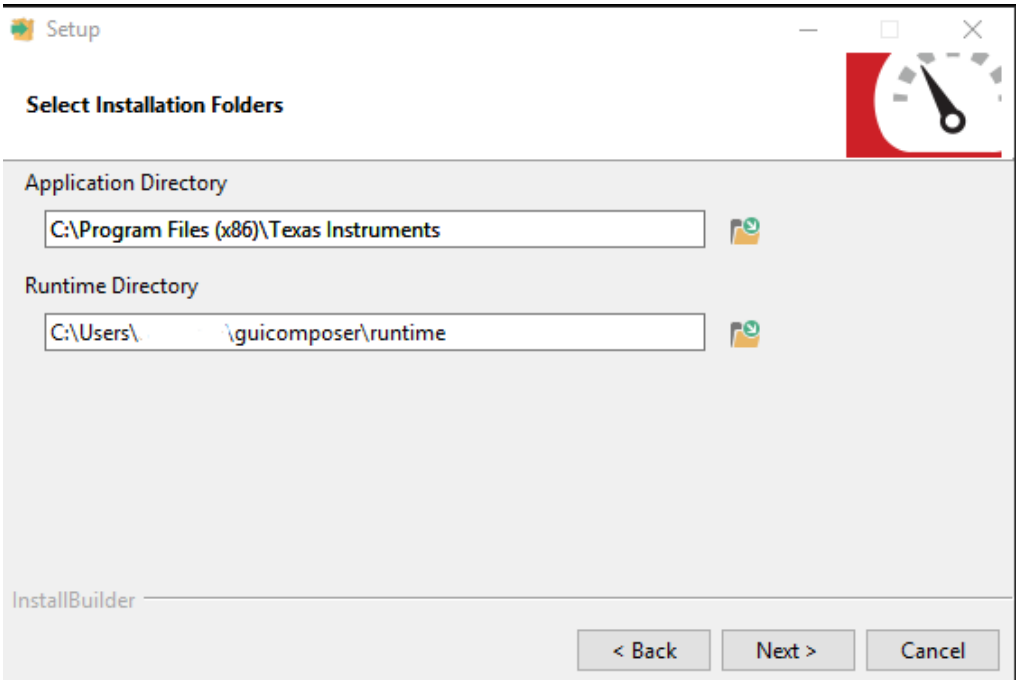


Figure 3-6. GUI Composer Installation Directory

Click "Next" to start installation.

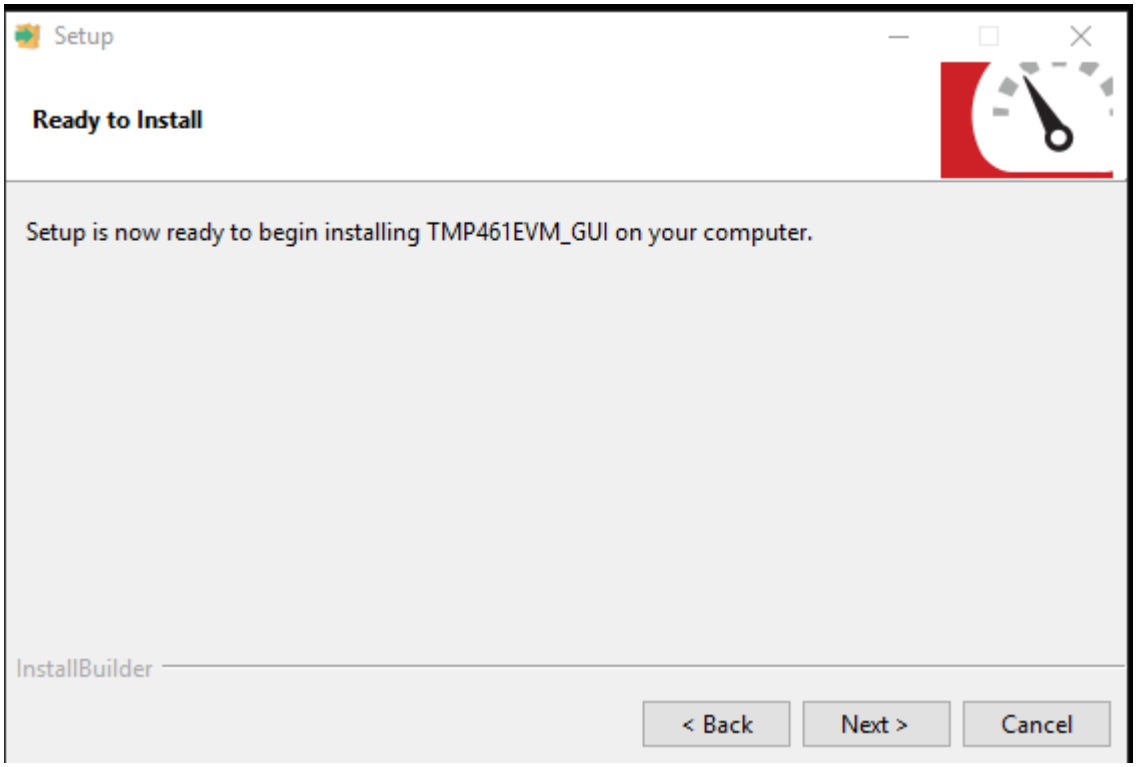


Figure 3-7. Ready to Install

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The TMP461EVM GUI will start to install as shown in Figure 3-8.

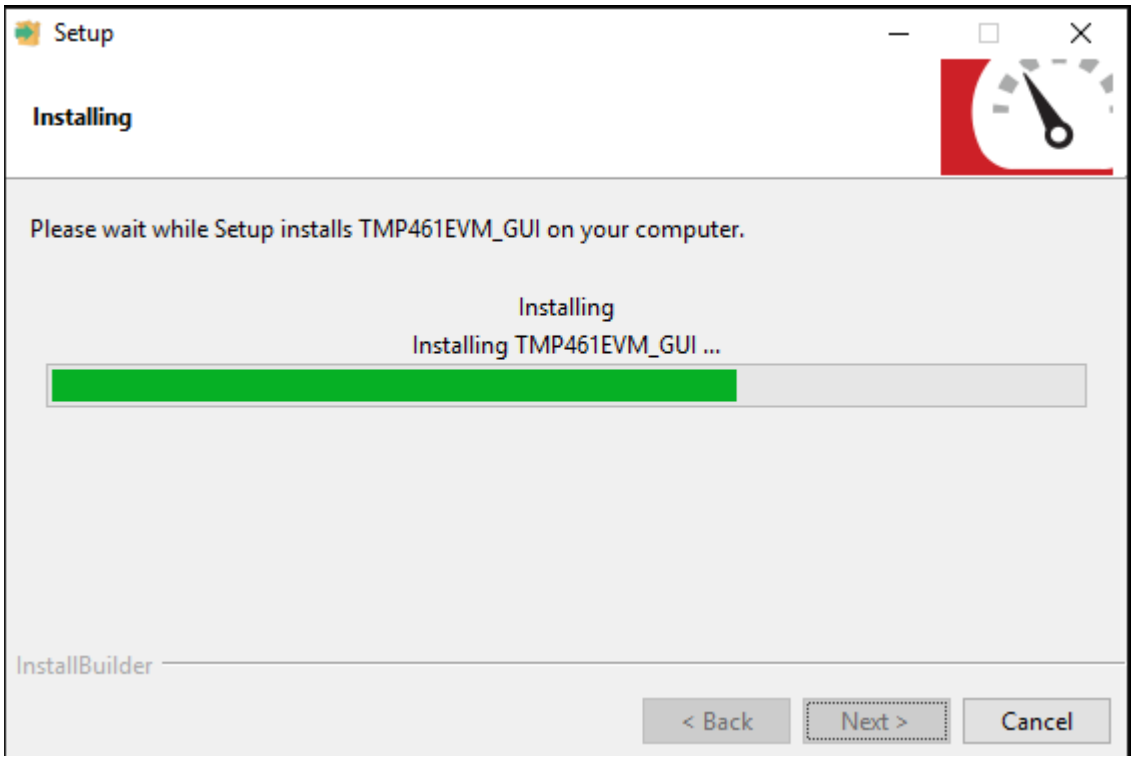


Figure 3-8. Installing GUI Composer Runtime

After installation, click "Finish".

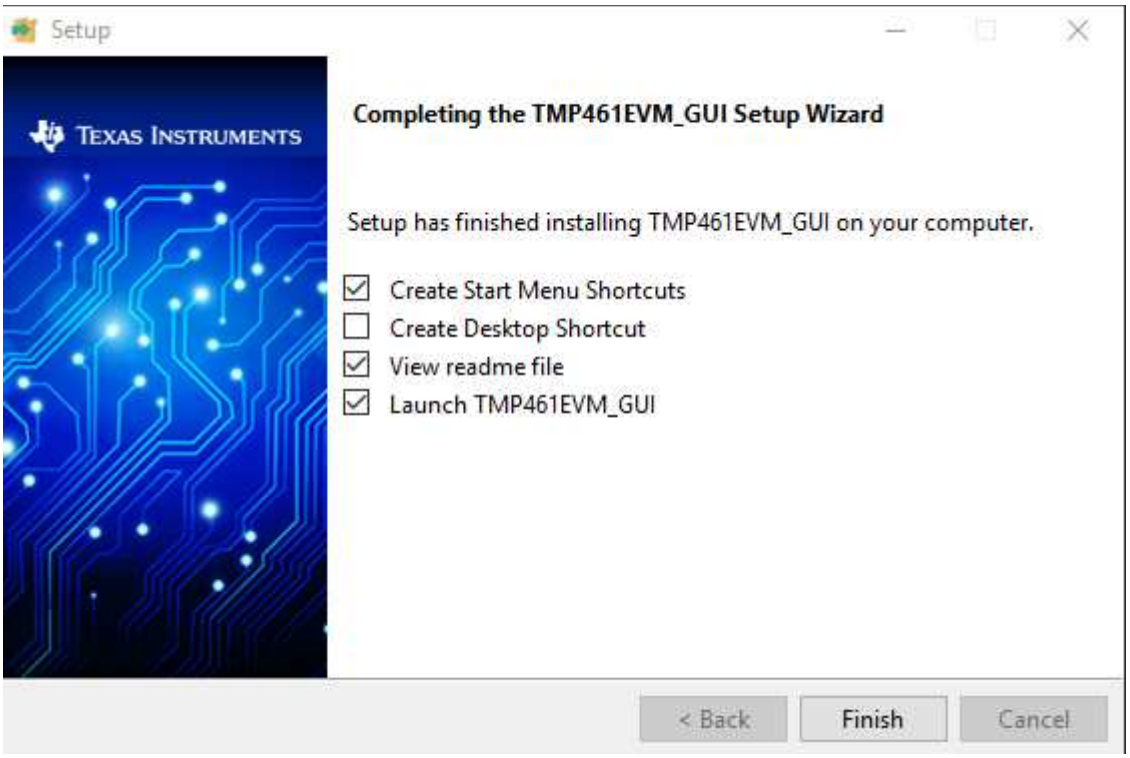


Figure 3-9. TMP461EVM Installation Finish

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Read the readme file and close it out after you are done. If you choose to Launch TMP461_GUI, it should launch shortly after closing the readme file.

3.2 Using the TMP461EVM Software

3.2.1 Launching and Running the Software

The TMP461EVM GUI can be run from TI Cloud repository http://dev.ti.com/gallery/ through either the Firefox or Chrome browser or from the Windows desktop offline.

Connect the TMP461EVM to a USB port on a PC as shown in Figure 2-2.

Launch the TMP461EVM software by clicking on the TMP461EVM GUI icon in the Gallery or launching the offline app from Windows. The TMP461EVM 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 TMP461EVM has an established connection with the PC. The status indicator will show a fail connection as “HARDWARE NOT CONNECTED”.

3.2.2 Home Tab

When the TMP461EVM GUI is launched, the Home tab is selected and shown by default. From this page, you can navigate to any one of the other 5 tabs. The tab bar is available on the left under every tab in the GUI. Clicking on a tab icon will bring you to the respective tab. The same list of icons with a short description of each of the tabs also appears on the bottom of screen. Similarly to the tab bar icons, these icons are clickable and will bring you to the respective tab.

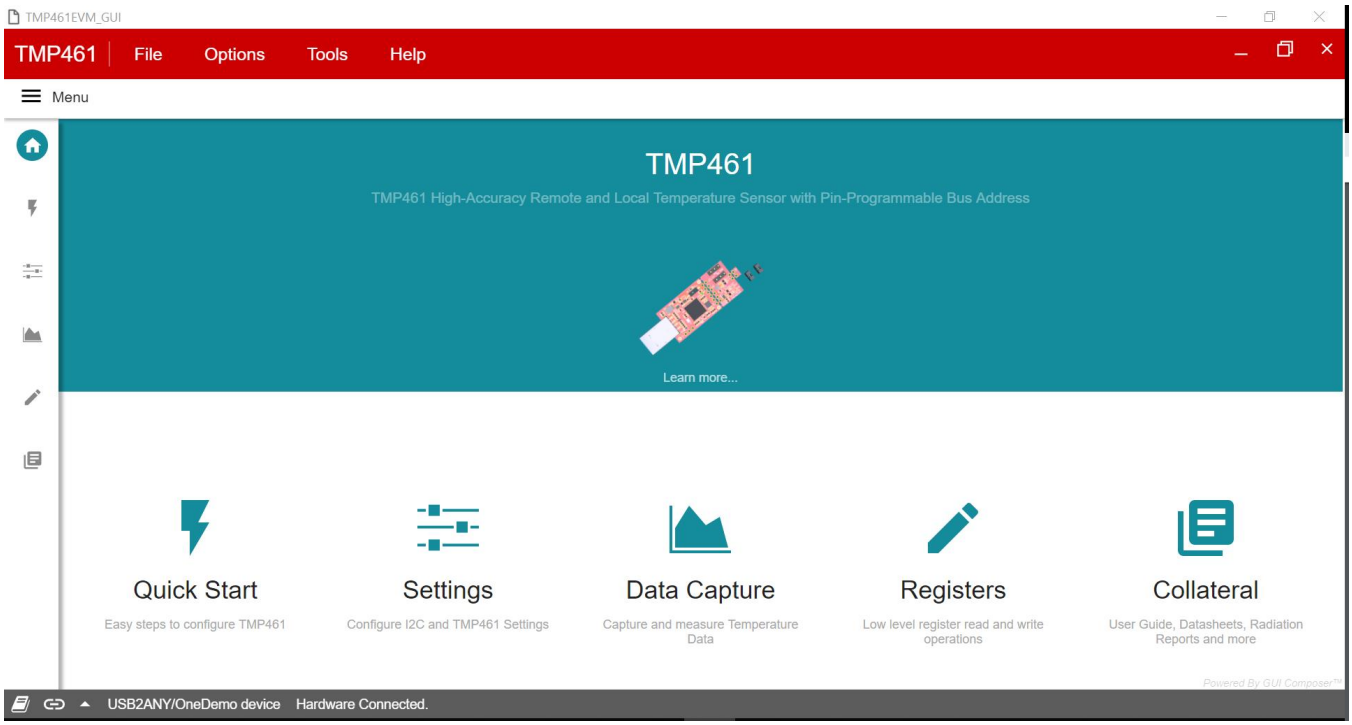


Figure 3-10. TMP461EVM Home Tab

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3.2.3 Quick Start Tab

The Quick Start Tab is used to guide you through the basic settings of the TMP461EVM. You can either set up the EVM under the default settings, or be guided through the setup. If you decide to use the default settings, you will go straight to the Data Capture tab. After selecting the default settings, you can choose to go back to the Quick Start Tab to be guided through the setup again, or you change the device settings in the Basic Settings Tab.

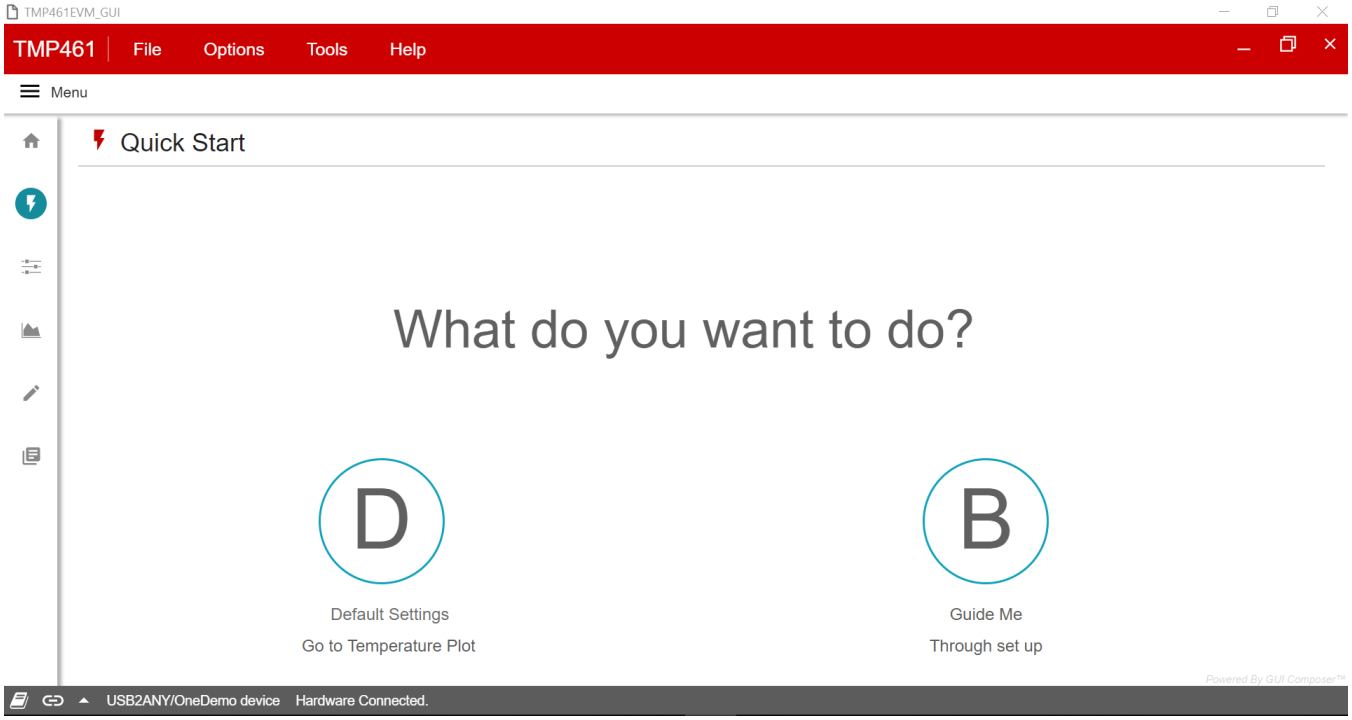


Figure 3-11. TMP461EVM Quick Start Tab

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If you are guided through the setup, you will see a page that will make sure the TMP461EVM is connected correctly. Select the I2C address that correlates with the A0 and A1 pin settings. If the EVM is connected correctly, click the "YES" button to review and change a high-level list of configure settings shown in Figure 3-13.

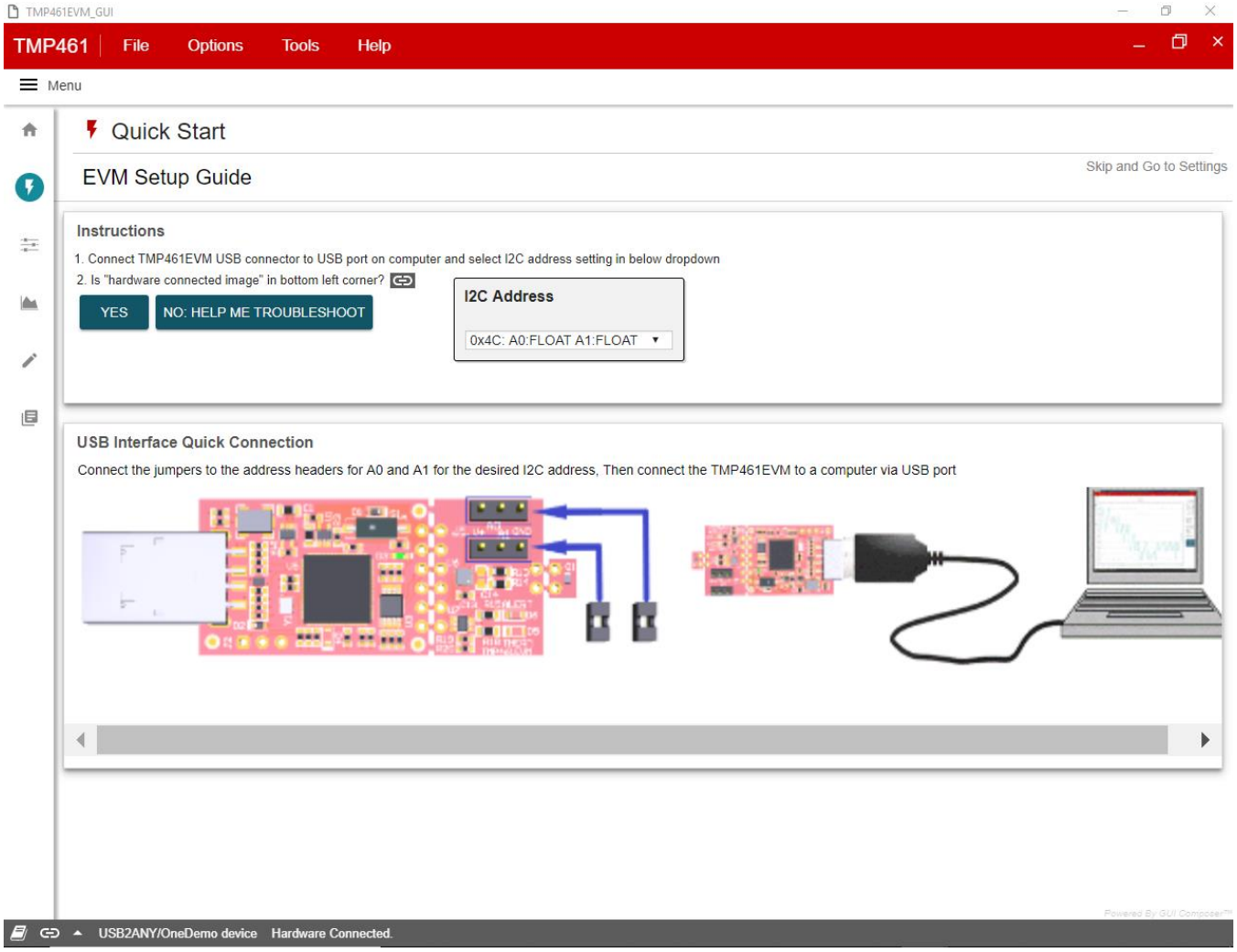


Figure 3-12. Quick Start Connection Check

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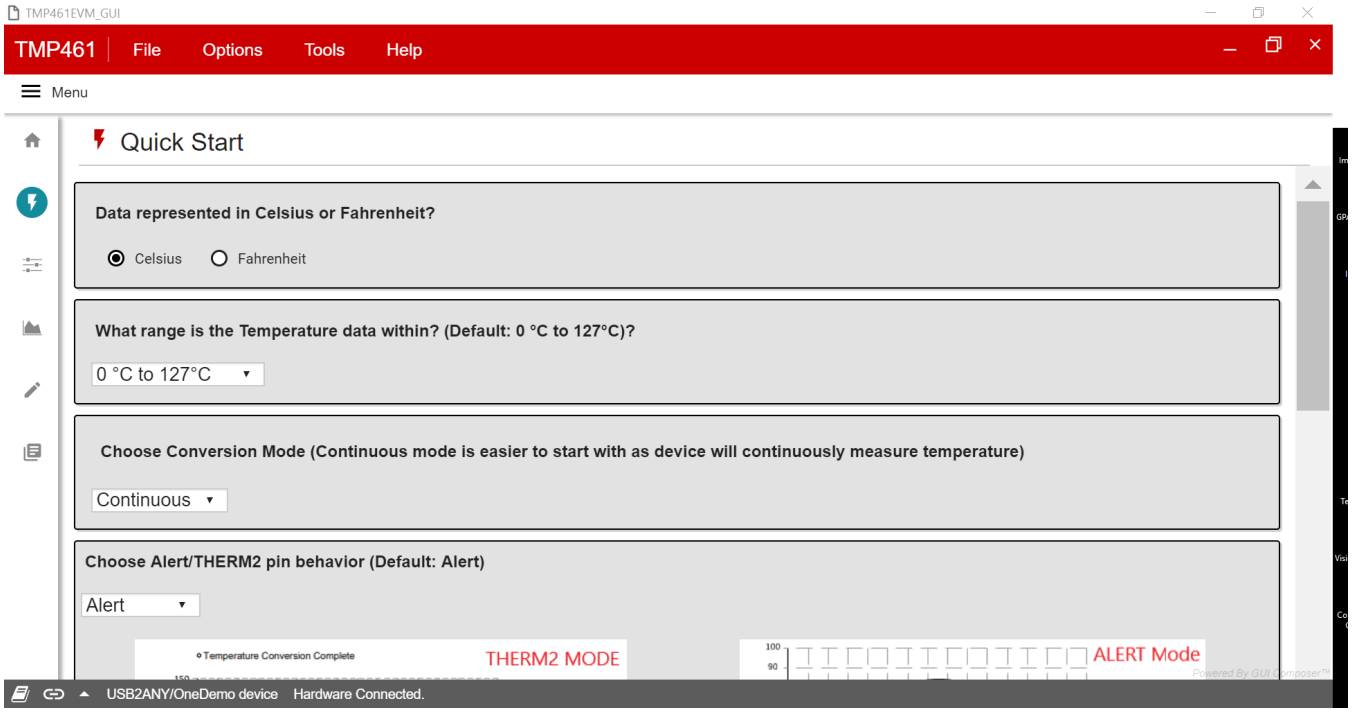


Figure 3-13. Quick Start Guide

At the bottom of the screen, you can either go to the Basic Settings tab to see a more extensive list of settings, or go the Data Capture tab if you're finished.

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3.2.4 Basic Settings Tab

The Basic Settings tab is where all the device settings and I2C settings are configured.

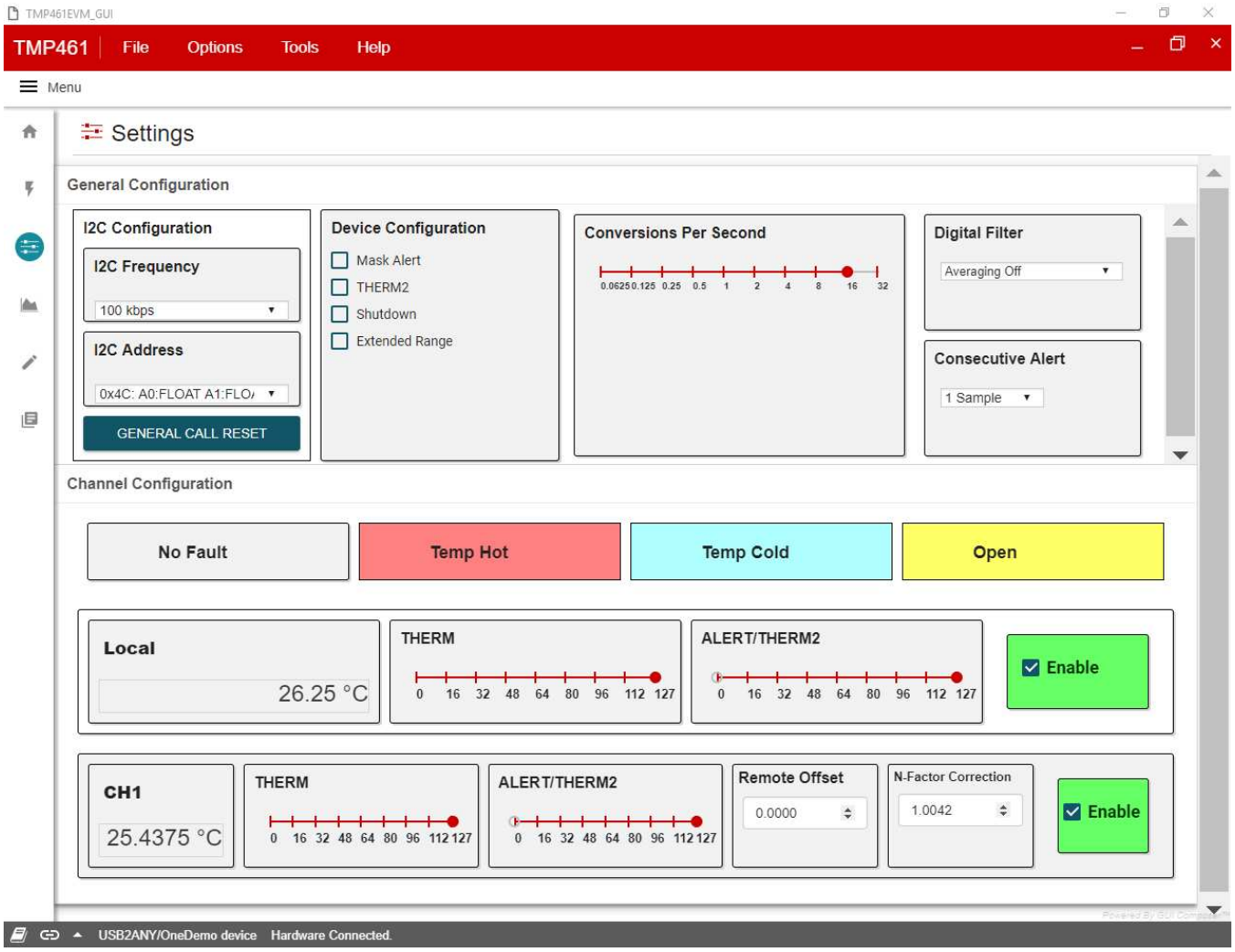


Figure 3-14. TMP461EVM Basic Settings Tab

3.2.4.1 I2C Configuration

I2C Frequency: this drop-down sets the I2C clock frequency to either 100 kbps or 400 kbps

I2C Address: this displays the I2C address of the TMP461

General Call Reset: clicking this push button will send a General Call Reset of the device

3.2.4.2 Device Configuration

Mask Alert: setting this checkbox masks the ALERT pin output

THERM2: setting this checkbox configures pin 6 to the THERM2 output

Shutdown: setting this checkbox will place the device into shutdown mode

Extended Range: setting this checkbox will configure the TMP461 for the extended measurement range

Conversion per second: this slider will set how many temperature conversions the TMP461 will perform per second

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THERM Hysteresis: this slider will set the THERM hysteresis value

Digital Filter: this drop-down will set the digital filter to average either 4 or 8 samples, or turn off the filter

Consecutive Alert: this drop-down will set the number of limit violations before the ALERT pin is tripped.

3.2.4.3 Channel Configuration

The TMP461EVM has one local channel and one remote channel. The Channel Configuration section shows the specific configuration settings listed under each channel.

3.2.4.3.1 Local

Temperature Reading: displays the temperature of the channel

THERM Limit: this slider sets the THERM limit threshold

ALERT_THERM2 Limit: this slider sets the High and Low ALERT limit threshold. When pin 6 is configured to THERM2, this will set the THERM2 limit threshold.

Enable: this checkbox will enable this channel to calculate new temperature data during a conversion cycle

3.2.4.3.2 Remote

Temperature Reading: displays the temperature of the channel

THERM Limit: this slider sets the THERM limit threshold

ALERT_THERM2 Limit: this slider sets the High and Low ALERT limit threshold. When pin 6 is configured to THERM2, this will set the THERM2 limit threshold.

Remote Offset: this number spinner will set the temperature offset of the remote channel temperature reading

N-Factor Correction: this number spinner is used to adjust for the N-factor of the remote BJT. Set this spinner to the N-factor of the remote BJT that is connected to the TMP461EVM

Enable: this checkbox will enable this channel to calculate new temperature data during a conversion cycle

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3.2.5 Data Capture Tab

The Data Capture Tab is where the temperature readings and set temperature thresholds are graphed.

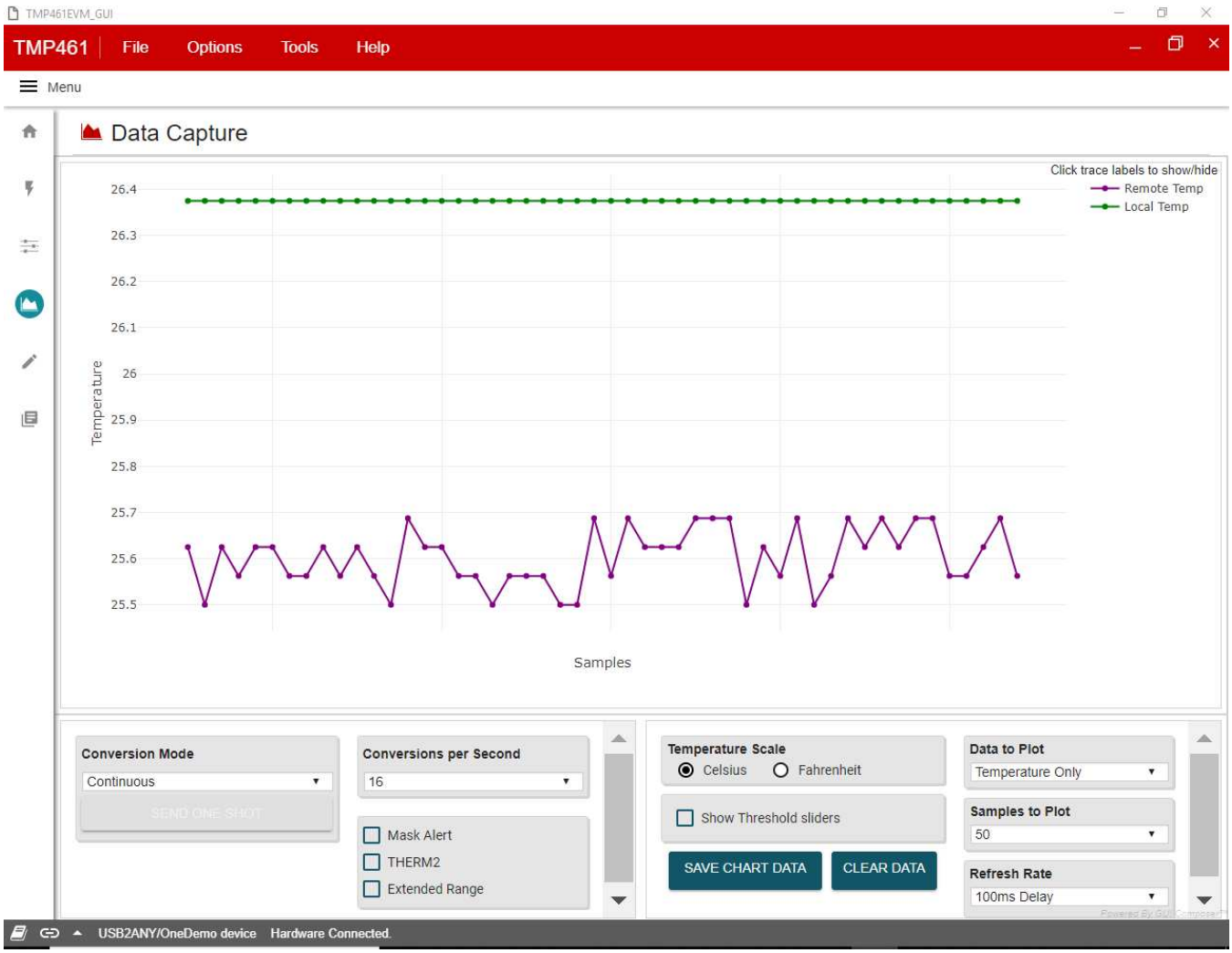


Figure 3-15. TMP461EVM Data Capture Tab

In the bottom left of the Data Capture tab, there is a list of some device configurations that are also found on the Basic Settings tab with the addition of the "SEND ONE SHOT" button. This button will enable only when the conversion mode is set to "Shutdown." When this button is clicked, a One Shot command is sent to the device and a single temperature conversion is done.

At the bottom right of the Data Capture tab, there are the GUI settings. These settings do not configure the TMP461EVM, but can change how the GUI will handle the data collected from the TMP461EVM.

Temperature Scale: this radio button group sets the units the temperature information is displayed

Show Threshold Sliders: setting this checkbox will show the threshold sliders to the right of the graph as well as displays for the temperature readings

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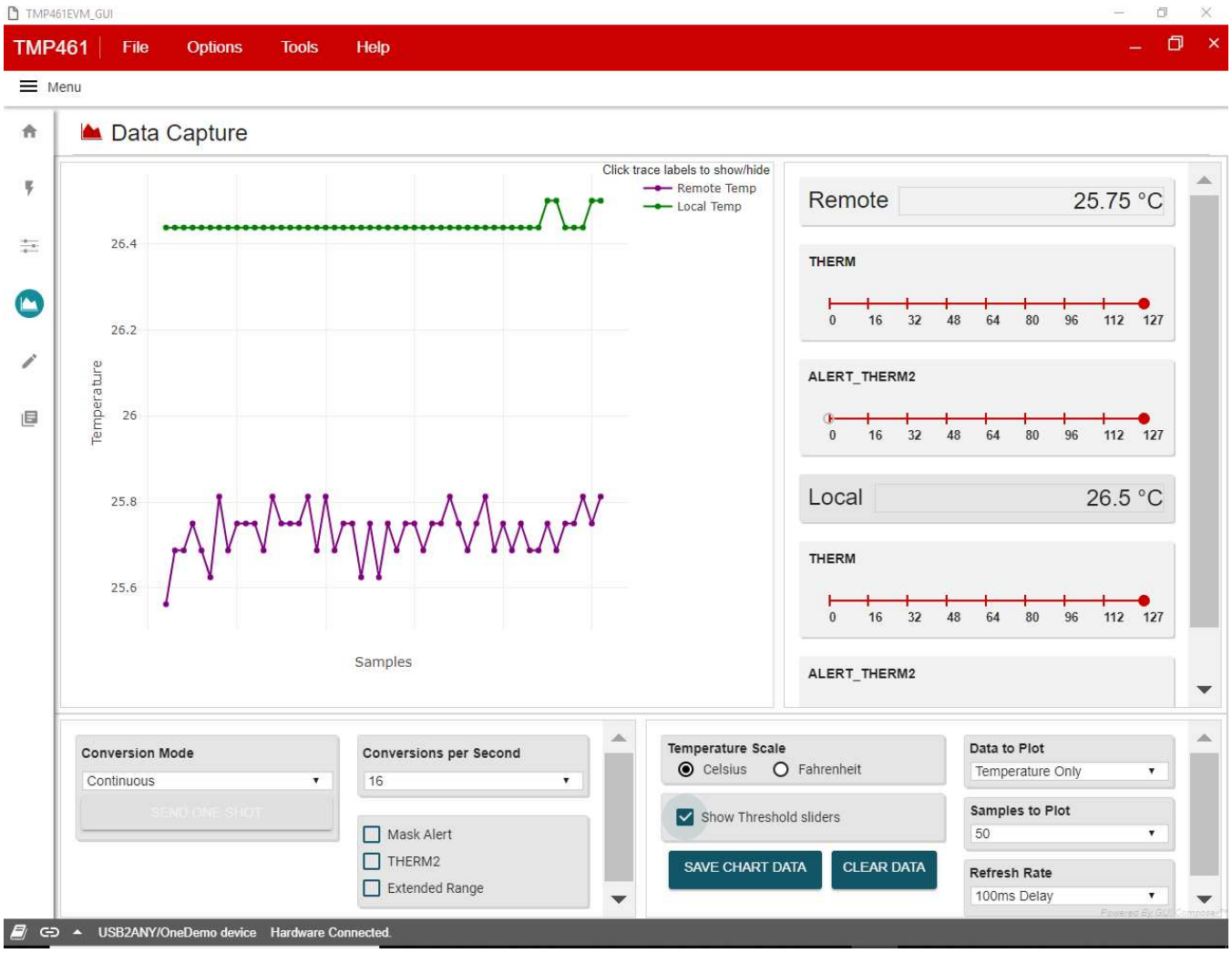


Figure 3-16. Threshold Sliders

Graph: this is where the temperature data and thresholds are plotted. Clicking on traces in the legend in the top right will hide/show different traces. Hovering over the graph will display different point information, and other feature icons will appear in the top right.

Data to Plot: this drop-down determines which data is plotted on the graph

Samples to Plot: this drop-down sets how many samples are plotted on the graph

Refresh Rate: this drop-down sets the desired time frame to fetch the register data. This is directly tied to the Auto-read drop-down on the Register Tab

Save Data: clicking this button will save the plotted data into an .csv file

Clear Data: clicking this button will clear all the data that is plotted on the graph

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3.2.6 Register Tab

The Register Map page shown in Figure 3-17 allows low-level access to all the I2C registers of the TMP461 device. Clicking on the question mark to the right of the Register Name will pull a short description of that register from the data sheet. 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 TMP461. Changes to the configuration page are mirrored here, and vice versa.

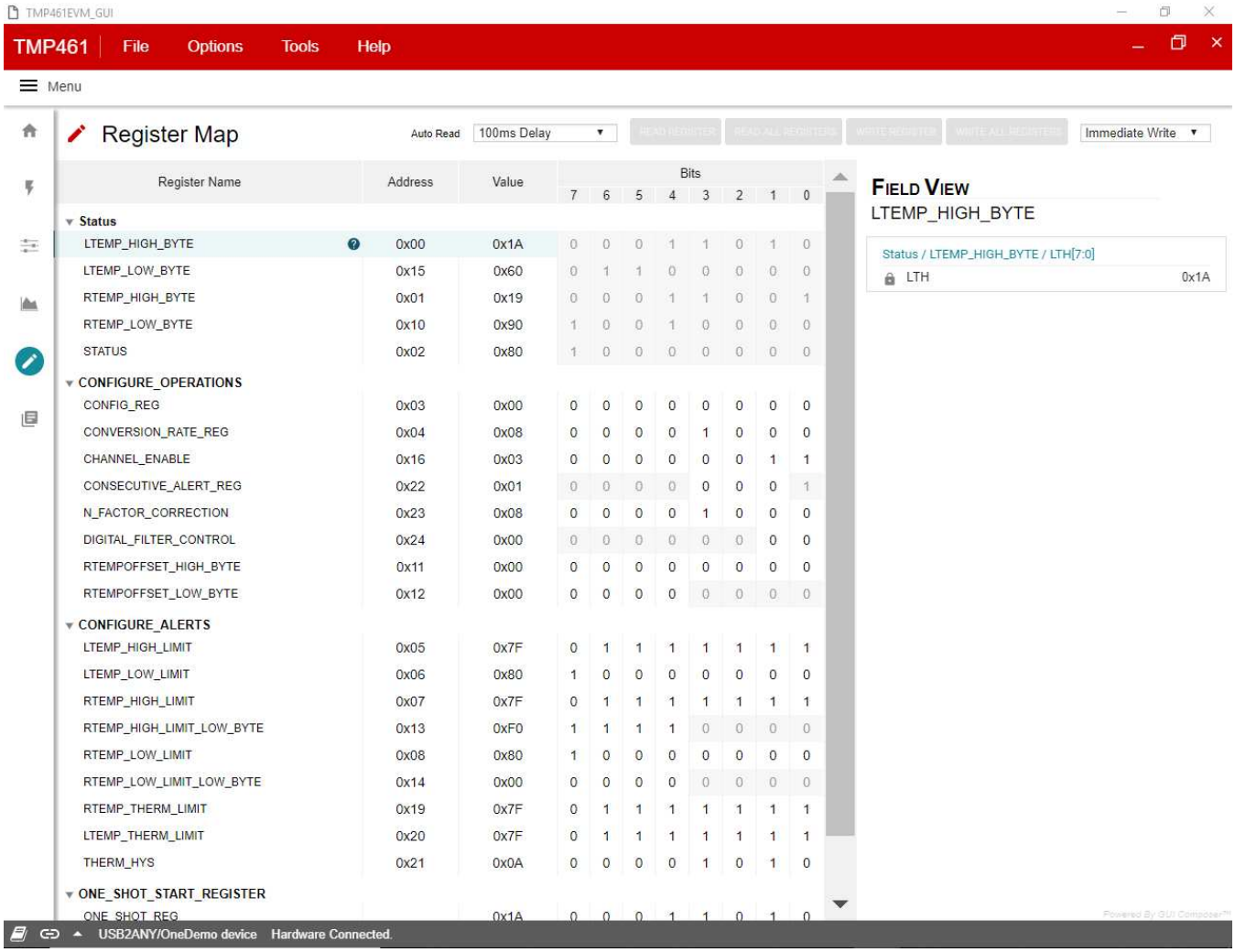


Figure 3-17. TMP461EVM Register Tab

Read Registers: performs a single read for the selected register.

Read All Registers: performs a read for all registers contents.

Auto Read: allows the user to set the desired time frame to fetch the register data.

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3.2.7 Collateral

The Collateral Tab, as shown in Figure 3-18, contains links to web documents pertinent to the TMP461EVM. The page is divided into four sections: (1) User Guide, (2) Data sheet, (3) Application Notes, and (4) MSP432 Firmware.

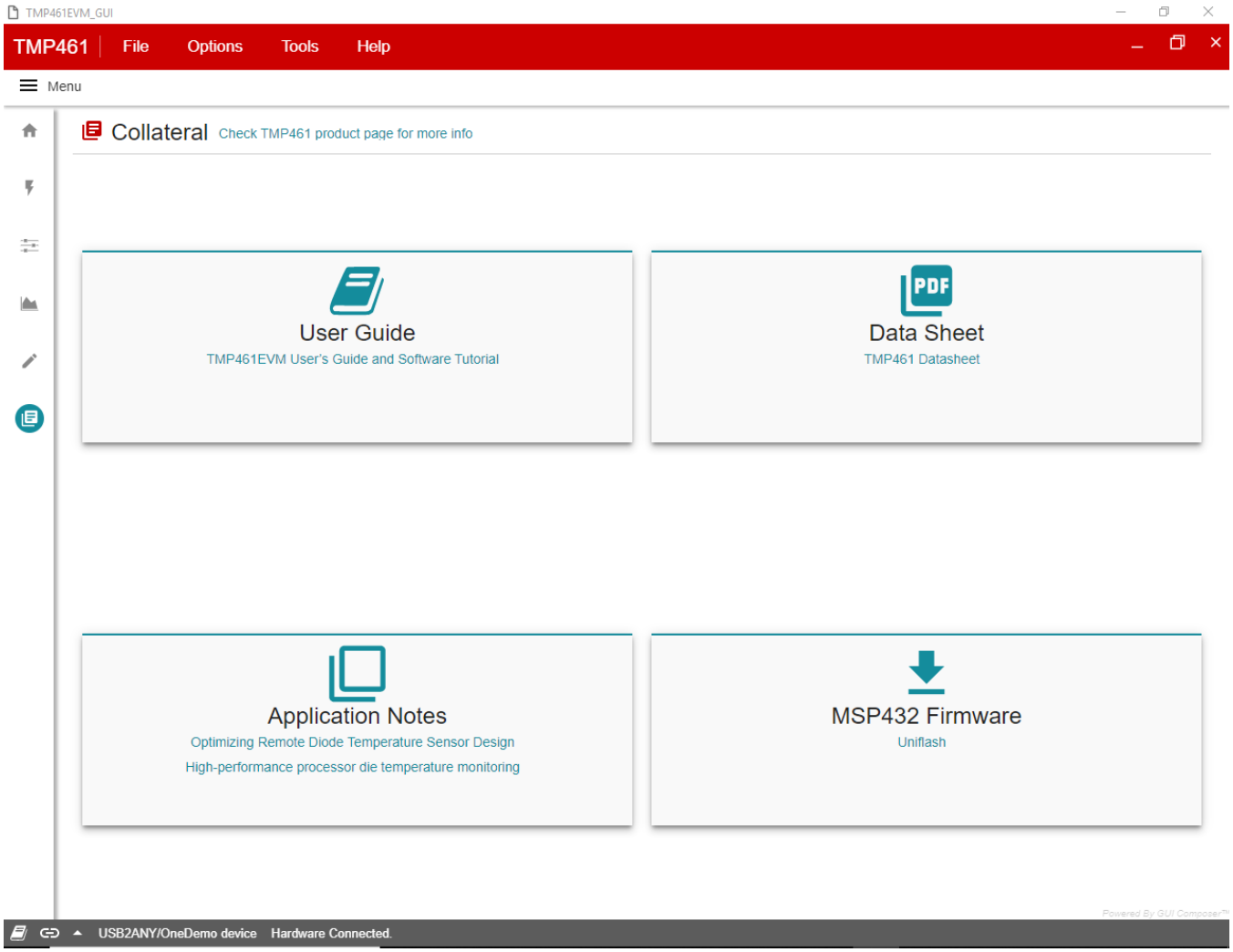


Figure 3-18. TMP461EVM Collateral Tab

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This section contains the complete bill of materials, schematic diagram, and layout for the TMP461EVM.

4.1 TMP461EVM Board Schematic

Figure 4-1 shows the board schematic for the TMP461EVM board.

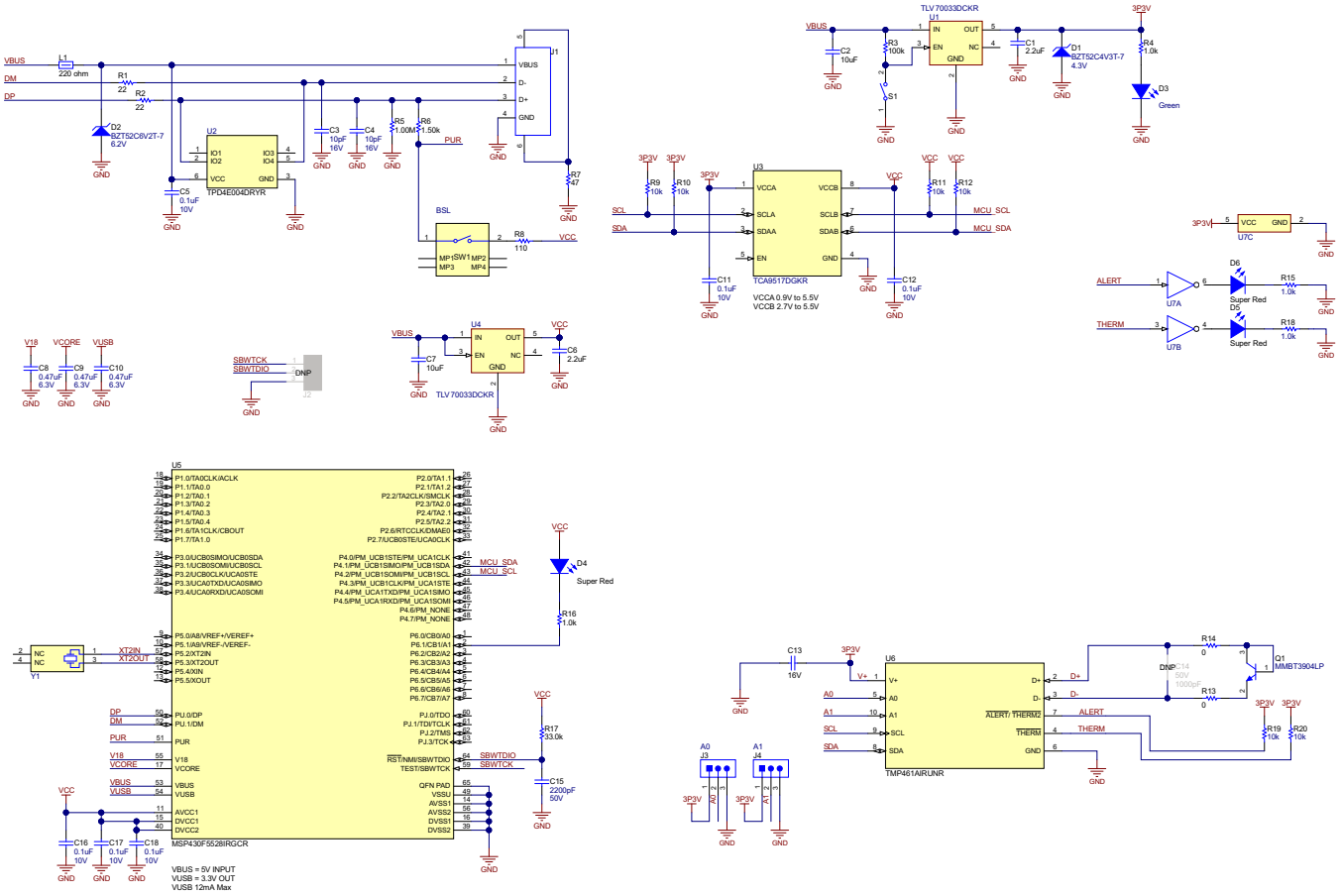


Figure 4-1. TMP461EVM Schematic

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4.2 TMP461EVM Board Layout

These figures show the board layout for the TMP461EVM board.

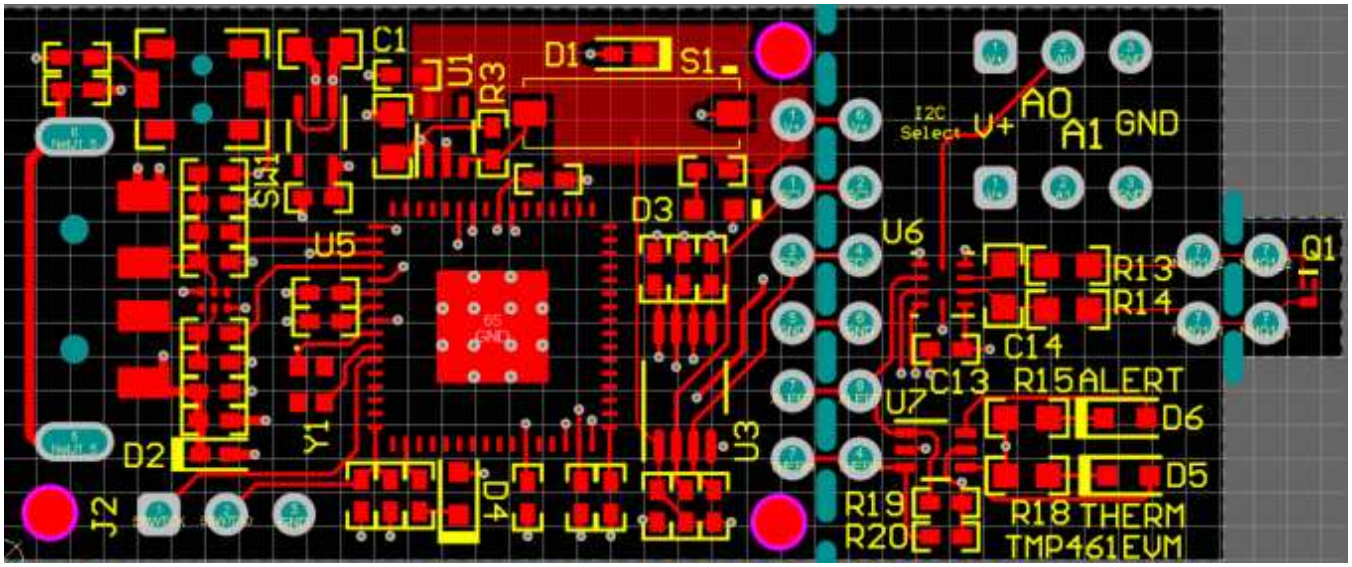


Figure 4-2. Top Assembly Layer

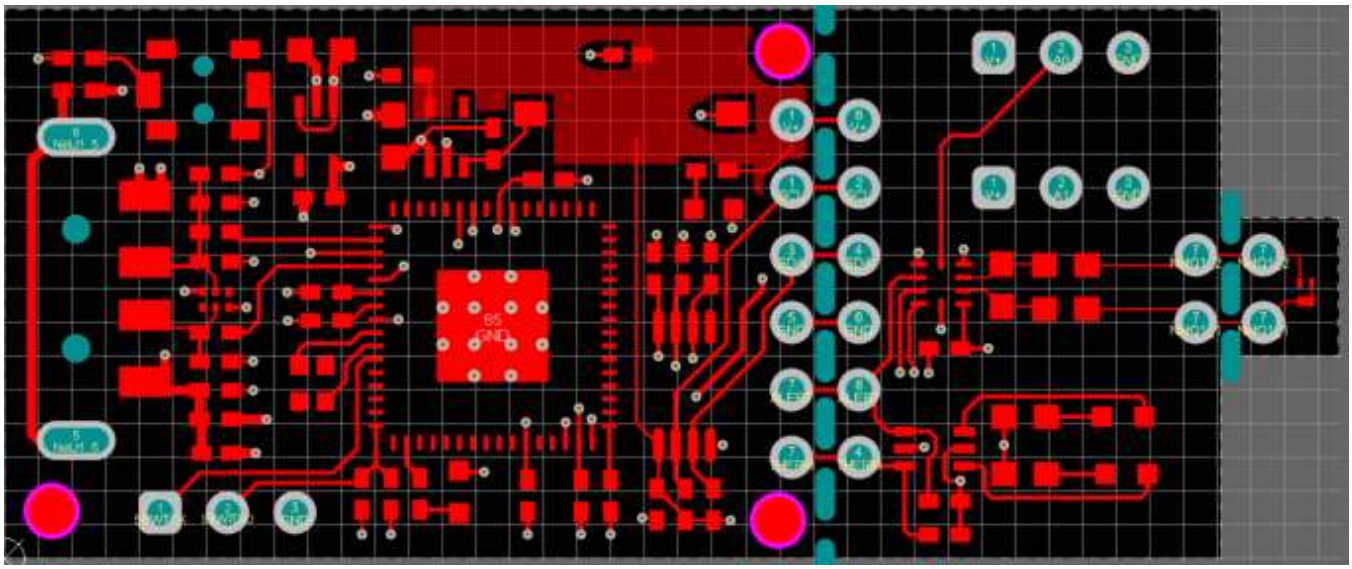


Figure 4-3. Top Routing Layer

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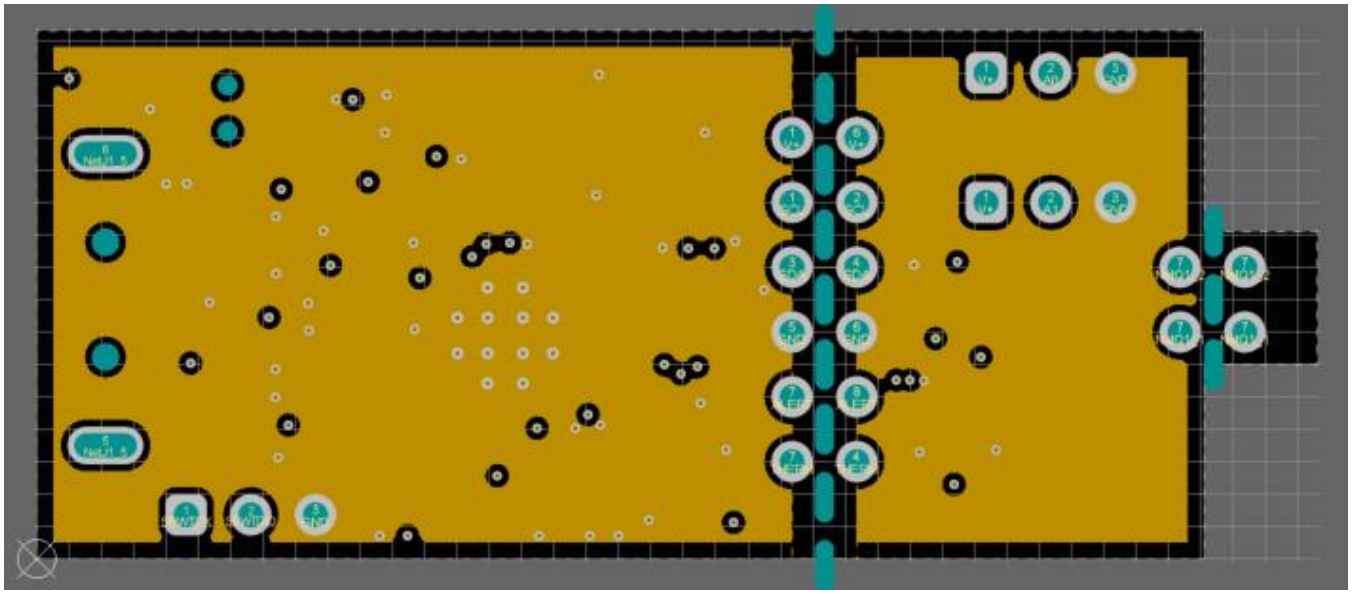


Figure 4-4. Ground Layer Routing

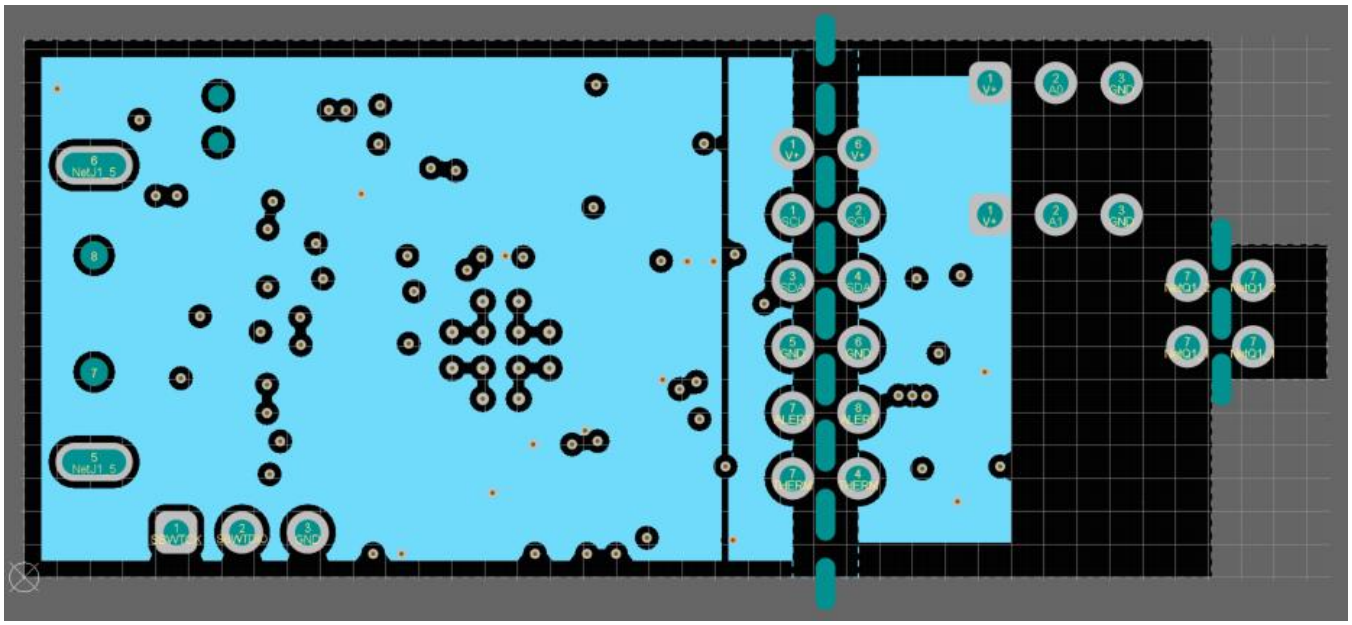


Figure 4-5. Power Layer Routing

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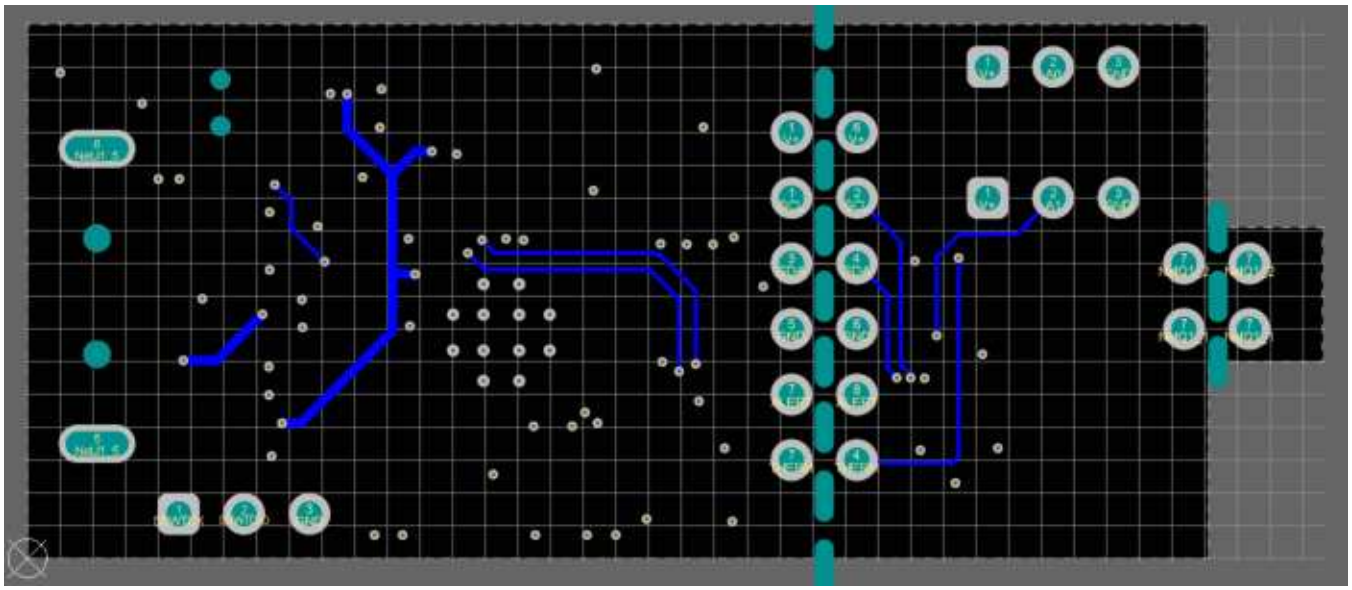


Figure 4-6. Bottom Layer Routing



Figure 4-7. Bottom Assembly Layer

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4.3 TMP461 Test Board Bill of Materials

Table 4-1 lists the bill of materials for the TMP461EVM Test Board.

Table 4-1. TMP461EVM Bill of Materials (BOM)

DESIGNATOR	QUANTITY	VALUE	DESCRIPTION	PACKAGE REFERENCE	PART NUMBER	MANUFACTURER	ALTERNATE PART NUMBER	ALTERNATE MANUFACTURER
!PCB1	1		Printed Circuit Board		MHR007	Any		
C1, C6	2	2.2uF	CAP, CERM, 2.2 uF, 16 V, +/- 10%, X5R, 0402	0402	GRM155R61C225KE11D	MuRata		
C2, C7	2	10uF	CAP, CERM, 10 uF, 10 V, +/- 20%, X5R, 0603	0603	C1608X5R1A106M080AC	TDK		
C3, C4	2	10pF	CAP, CERM, 10 pF, 16 V,+/- 10%, C0G, 0402	0402	C0402C100K4GACTU	Kemet		
C5, C11, C12, C16, C17, C18	6	0.1uF	CAP, CERM, 0.1 uF, 10 V,+/- 10%, X5R, 0402	0402	LMK105BJ104KV-F	Taiyo Yuden		
C8, C9, C10	3	0.47uF	CAP, CERM, 0.47 uF, 6.3 V, +/- 10%, X7R, 0402	0402	JMK105B7474KVHF	Taiyo Yuden		
C13	1	0.1uF	CAP, CERM, 0.1 uF, 16 V, +/- 10%, X7R, 0402	0402	ATC530L104KT16T	AT Ceramics		
C15	1	2200pF	CAP, CERM, 2200 pF, 50 V, +/- 5%, X7R, 0402	0402	CL05B222JB5NNNC	Samsung Electro-Mechanics		
D1	1	4.3V	Diode, Zener, 4.3 V, 300 mW, SOD-523	SOD-523	BZT52C4V3T-7	Diodes Inc.		
D2	1	6.2V	Diode, Zener, 6.2 V, 300 mW, SOD-523	SOD-523	BZT52C6V2T-7	Diodes Inc.		
D3	1	Green	LED, Green, SMD	LED, GREEN, 0603	SML-LX0603GW-TR	Lumex		
D4, D5, D6	3	Super Red	LED, Super Red, SMD	LED_0603	150060SS75000	Wurth Elektronik		
J1	1		Connector, Plug, USB Type A, R/A, Top Mount SMT	USB Type A right angle	48037-1000	Molex		

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Table 4-1. TMP461EVM Bill of Materials (BOM) (continued)

DESIGNATOR	QUANTITY	VALUE	DESCRIPTION	PACKAGE REFERENCE	PART NUMBER	MANUFACTURER	ALTERNATE PART NUMBER	ALTERNATE MANUFACTURER
J3, J4	2		Header, 100mil, 3x1, Gold, TH	3x1 Header	TSW-103-07-G-S	Samtec		
L1	1	220 ohm	Ferrite Bead, 220 ohm @ 100 MHz, 0.45 A, 0402	0402	BLM15AG221SN1D	MuRata		
Q1	1	40 V	Transistor, NPN, 40 V, 0.2 A, 3-UFDFN	3-UFDFN	MMBT3904LP	Diodes Inc.		
R1, R2	2	22	RES, 22, 5%, 0.1 W, AEC-Q200 Grade 0, 0402	0402	ERJ-2GEJ220X	Panasonic		
R3	1	100k	RES, 100 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0402	0402	ERJ-2GEJ104X	Panasonic		
R4, R16	2	1.0k	RES, 1.0 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0402	0402	ERJ-2GEJ102X	Panasonic		
R5	1	1.00Meg	RES, 1.00 M, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	RMCF0402FT1M00	Stackpole Electronics Inc		
R6	1	1.50k	RES, 1.50 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	RMCF0402FT1K50	Stackpole Electronics Inc		
R7	1	47	RES, 47, 5%, 0.1 W, AEC-Q200 Grade 0, 0402	0402	ERJ-2GEJ470X	Panasonic		
R8	1	110	RES, 110, 1%, 0.1 W, AEC-Q200 Grade 0, 0402	0402	ERJ-2RKF1100X	Panasonic		
R9, R10, R11, R12, R19, R20	6	10k	RES, 10 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0402	0402	ERJ-2GEJ103X	Panasonic		
R13, R14	2	0	RES, 0, 0%, 0.25 W, AEC-Q200 Grade 0, 0603	0603	RCS06030000Z0EA	Vishay-Dale		
R15, R18	2	1.0k	RES, 1.0 k, 5%, 0.1 W, 0603	0603	RC0603JR-071KL	Yageo		
R17	1	33.0k	RES, 33.0 k, 1%, 0.063 W, 0402	0402	RC0402FR-0733KL	Yageo America		

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Table 4-1. TMP461EVM Bill of Materials (BOM) (continued)

DESIGNATOR	QUANTITY	VALUE	DESCRIPTION	PACKAGE REFERENCE	PART NUMBER	MANUFACTURER	ALTERNATE PART NUMBER	ALTERNATE MANUFACTURER
S1	1		Switch, Slide, SPST, Top Slide, SMT	Switch, Single Top Slide, 2.5x8x2.5mm	CHS-01TB	Copal Electronics		
SH-J1, SH-J2	2		Single Operation 2.54mm Pitch Open Top Jumper Socket	Single Operation 2.54mm Pitch Open Top Jumper Socket	M7582-05	Harwin		
SW1	1		Switch, SPST-NO, Off-Mom, 0.05A, 12VDC, SMD	3.9x2.9mm	PTS820 J20M SMTR LFS	C&K Components		
U1, U4	2		Single Output LDO, 200 mA, Fixed 3.3 V Output, 2 to 5.5 V Input, with Low IQ, 5-pin SC70 (DCK), -40 to 125 degC, Green (RoHS & no Sb/Br)	DCK0005A	TLV70033DCKR	Texas Instruments		
U2	1		4-Channel ESD Protection Array for High-Speed Data Interfaces, DRY0006A (USON-6)	DRY0006A	TPD4E004DRYR	Texas Instruments		
U3	1		Level-Shifting I2C Bus Repeater, DGK0008A (VSSOP-8)	DGK0008A	TCA9517DGKR	Texas Instruments		Texas Instruments
U5	1		16-Bit Ultra-Low-Power Microcontroller, 128KB Flash, 8KB RAM, USB, 12Bit ADC, 2 USCIs, 32Bit HW MPY, RGC0064B (VQFN-64)	RGC0064B	MSP430F5528IRGCR	Texas Instruments		
U6	1		High-Accuracy Remote and Local Temperature Sensor with Pin-Programmable Bus Address, RUN0010A (WQFN-10)	RUN0010A	TMP461AIRUNR	Texas Instruments	TMP461AIRUNT	Texas Instruments

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Table 4-1. TMP461EVM Bill of Materials (BOM) (continued)

DESIGNATOR	QUANTITY	VALUE	DESCRIPTION	PACKAGE REFERENCE	PART NUMBER	MANUFACTURER	ALTERNATE PART NUMBER	ALTERNATE MANUFACTURER
U7	1		Dual Inverter, DCK0006A (SOT-SC70-6)	DCK0006A	SN74LVC2G04DCKR	Texas Instruments		
Y1	1		Crystal, 24 MHz, SMD	2x1.6mm	XRCGB24M000F2P00R0	MuRata		
C14	0	1000pF	CAP, CERM, 1000 pF, 50 V, +/- 5%, C0G/NP0, 0603	0603	C0603C102J5GACTU	Kemet		
J2	0		Header, 100mil, 3x1, Gold, TH	3x1 Header	TSW-103-07-G-S	Samtec		

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Revision History

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

Changes from Original (July 2015) to A Revision	Page
• Changed *Contents of the TMP461EVM Kit* table	6
• Combined *TMP461EVM Hardware Setup* and *TMP461EVM Hardware Overview* sections	7
• Combined *TMP461EVM Software Setup* and *TMP461EVM Software Overview* sections	9
• Changed *TMP461EVM Board Schematic* section	26
• Changed *TMP461EVM Board Layout* section	27
• Changed *TMP461EVM Bill of Materials (BOM)* table	30

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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。
http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page

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.

【無線電波を送信する製品の開発キットをお使いになる際の注意事項】 開発キットの中には技術基準適合証明を受けていないものがあります。 技術適合証明を受けていないもののご使用に際しては、電波法遵守のため、以下のいずれかの措置を取っていただく必要がありますのでご注意ください。

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。

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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
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。http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_02.page

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.

8. *Limitations on Damages and Liability:*

   8.1 *General Limitations*. IN NO EVENT SHALL TI BE LIABLE FOR ANY SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL, OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF THESE TERMS OR THE USE OF THE EVMS , REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. EXCLUDED DAMAGES INCLUDE, BUT ARE NOT LIMITED TO, COST OF REMOVAL OR REINSTALLATION, ANCILLARY COSTS TO THE PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES, RETESTING, OUTSIDE COMPUTER TIME, LABOR COSTS, LOSS OF GOODWILL, LOSS OF PROFITS, LOSS OF SAVINGS, LOSS OF USE, LOSS OF DATA, OR BUSINESS INTERRUPTION. NO CLAIM, SUIT OR ACTION SHALL BE BROUGHT AGAINST TI MORE THAN TWELVE (12) MONTHS AFTER THE EVENT THAT GAVE RISE TO THE CAUSE OF ACTION HAS OCCURRED.

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