

TMP451EVM User's Guide and Software Tutorial

User's Guide



Literature Number: SBOU131

June 2013

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This user's guide describes the characteristics, operation, and use of the TMP451EVM 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 TMP451EVM. 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.

Overview

The TMP451 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 $\pm 1^{\circ}\text{C}$ for the local and the remote temperature sensors. The two-wire serial interface accepts SMBus communication protocol.

1.1 TMP451EVM Kit Contents

Table 1-1 details the contents of the TMP451EVM kit, and Figure 1-1 below shows all of the included hardware. Contact the Texas Instruments Product Information Center nearest you if any component is missing. It is highly recommended that you check the TI website at <http://www.ti.com> to verify that you have the latest versions of the related software.

Table 1-1. Contents of TMP451EVM Kit

Item	Quantity
TMP451 PCB Test Board	1
NPN 2N2222 Transistor	1
USB SM-DIG Platform PCB	1
USB Cable Extender	1
10-pin Connector Ribbon Cable Extender	1
User's Guide CD	1

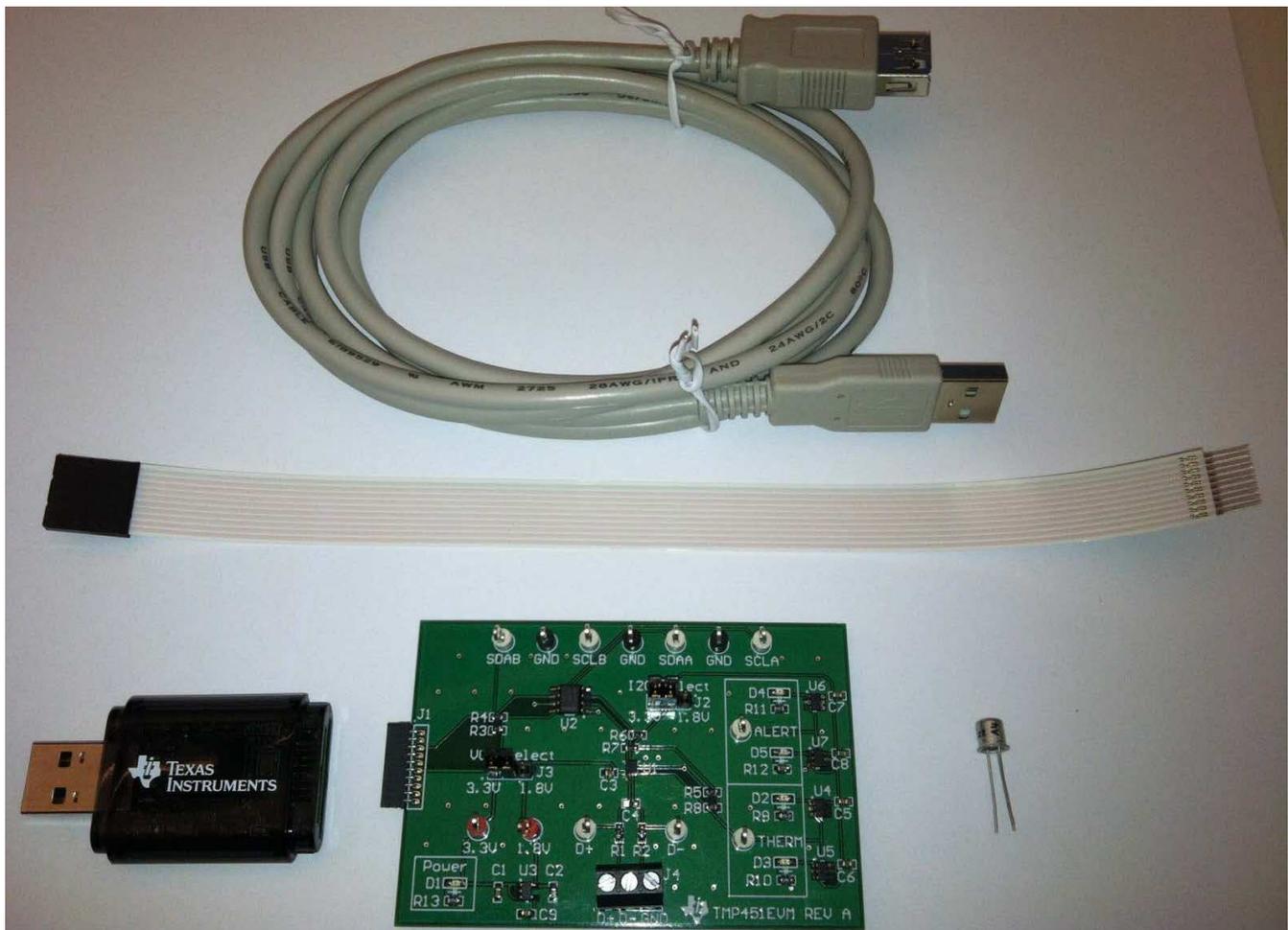


Figure 1-1. Hardware Included with TMP451EVM Kit

1.2 Related Documentation from Texas Instruments

The following document provides information regarding Texas Instruments integrated circuits used in the assembly of the TMP451EVM. This user's guide is available from the TI website under literature number [SBOU131](#). Any letter appended to the literature number corresponds to the document revision that is current at the time of the writing of this document. Newer revisions may be available from the TI website at <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. When ordering, identify the document by both title and literature number

Table 1-2. Related Documentation

Document	Literature Number
TMP451 Product Data Sheet	
USB SM-DIG Platform User's Guide	SBOU098

TMP451EVM Hardware Setup

The TMP451EVM hardware consists of the SM-USB-DIG and TMP451EVM; these are easily connected through a 10 pin board-to-board connector that should be attached to the SM-USB-DIG and TMP451EVM PCBs. Once these two boards are connected, simply plug the USB device from the SM-USB-DIG into the computer as shown in [Figure 2-1](#).

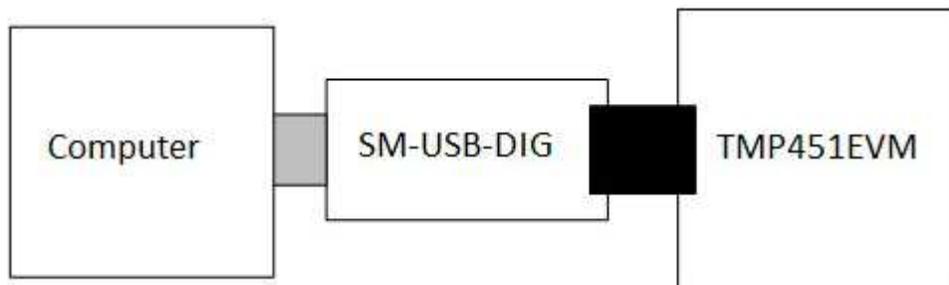


Figure 2-1. TMP451EVM Hardware Setup

2.1 Theory of Operation for TMP451 Hardware

The TMP451EVM only requires the two-wire I²C™ lines (SDA and SCLK) and VDUT/GND to supply a constant 3.3 V and power return as shown in [Figure 2-2](#). The TMP451EVM also has test points to monitor these signal lines, and ground in case the user may want to use their own signals or verify I²C communications.

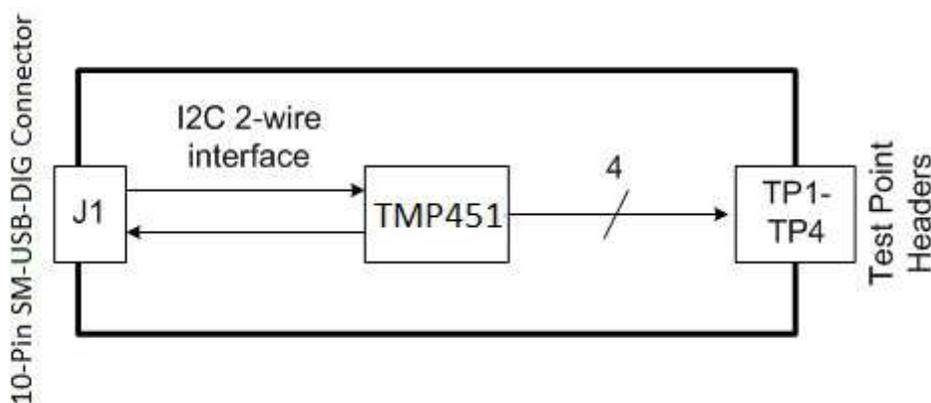


Figure 2-2. TMP451EVM Test Board Block Diagram

2.2 Signal Definitions of H1 (10-Pin Male Connector Socket)

[Table 2-1](#) shows the pin out for the 10-Pin connector socket used to communicate between the TMP451EVM and the SM-DIG. It should be noted that the TMP451EVM only uses the necessary I²C communication lines (pins 1 and 3) and the VDUT and GND (pin 6 and 8) pins to issue commands to the TMP451 sensors.

Table 2-1. Pin Connector

PIN On U1	Signal	Description
1	I2C_SCL	I ² C Clock Signal (SCL)
2	CTRL/MEAS4	GPIO – Control Output or Measure Input
3	I2C_SDA1	I ² C Data Signal (SDA)
4	CTRL/MEAS5	GPIO – Control Output or Measure Input
5	SPI_DOUT1	SPI Data Output (MOSI)
6	VDUT	Switchable DUT Power Supply: 3.3 V, 5 V, Hi-Z (Disconnected). ⁽¹⁾
7	SPI_CLK	SPI Clock Signal (SCLK)
8	GND	Power Return (GND)
9	SPI_CS1	SPI Chip Select Signal (/CS)
10	SPI_DIN1	SPI Data Input (MISO)

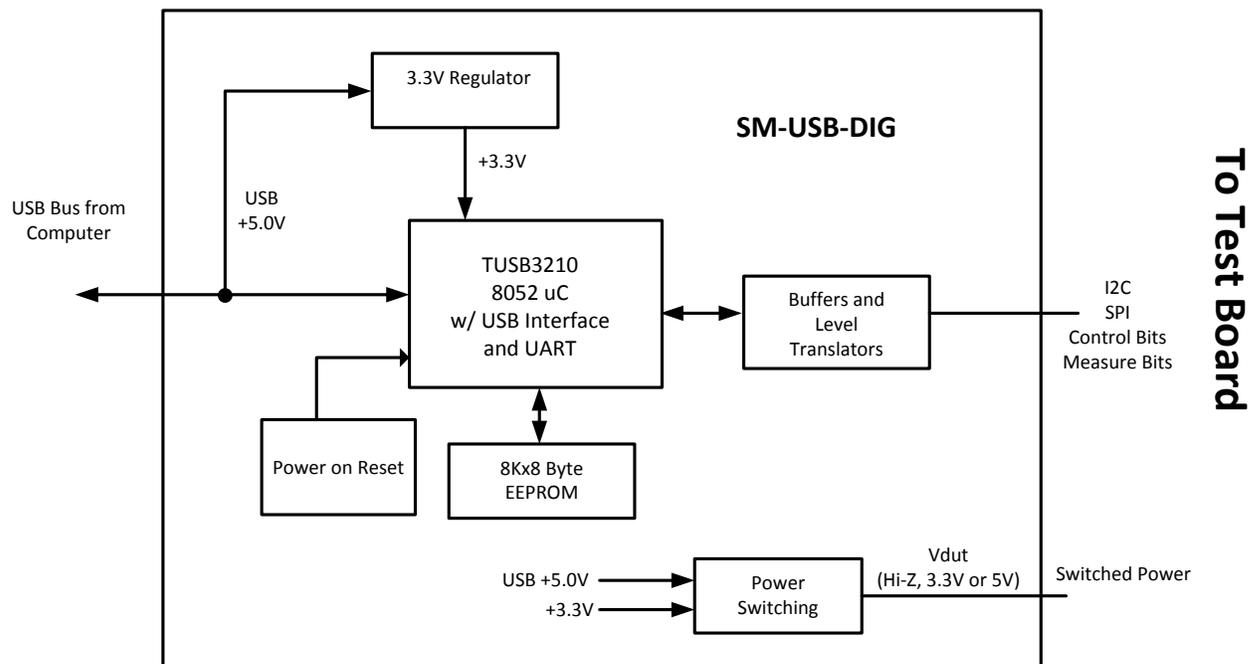
⁽¹⁾ When VDUT is Hi-Z all Digital I/O are Hi-Z as well.

2.3 Theory of Operation for USB DIG Platform

Figure 2-3 shows the block diagram for the SM-USB-DIG platform. This platform is a general purpose data acquisition system that is used on several different Texas Instruments evaluation modules. The details of its operation are included in a separate document. The block diagram shown in Figure 2-3 is given as a brief overview of the platform.

The brain of the SM-USB-DIG Platform is the TUSB3210. The TUSB3210 is an 8052 microcontroller that has a built in USB interface. The microcontroller receives information from the host computer that it interprets into power, I²C, SPI, and other digital I/O patterns. During the digital I/O transaction, the microcontroller reads the response of any device connected to the I/O interface. The response from the device is sent back to the PC where it is interpreted by the host computer.

To Computer and Power Supplies


Figure 2-3. USB DIG Platform Block Diagram

TMP451EVM Hardware Overview

WARNING

Many of the components on the TMP451EVM 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.

3.1 Connecting the Hardware

To connect the TMP451EVM and the SM-USB-DIG Platform together, gently slide the male and female ends of the 10-pin connectors together. Make sure that the two connectors are completely pushed together; loose connections may cause intermittent operation.

3.2 Connecting the USB Cable to the DIG

Figure 3-1 shows the typical response to connecting the SM-USB-DIG platform 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 likely changes to Found New Hardware, USB Human Interface Device. This pop-up indicates that the device is ready to be used. The SM-USB-DIG platform uses the human interface device drivers that are part of the Microsoft Windows® operating system.

In some cases, the Windows Add Hardware Wizard is shown. If this prompt occurs, allow the system device manager to install the human interface drivers by clicking Yes when requested to install drivers. Windows confirms installation of the drivers with the message shown in Figure 3-2.

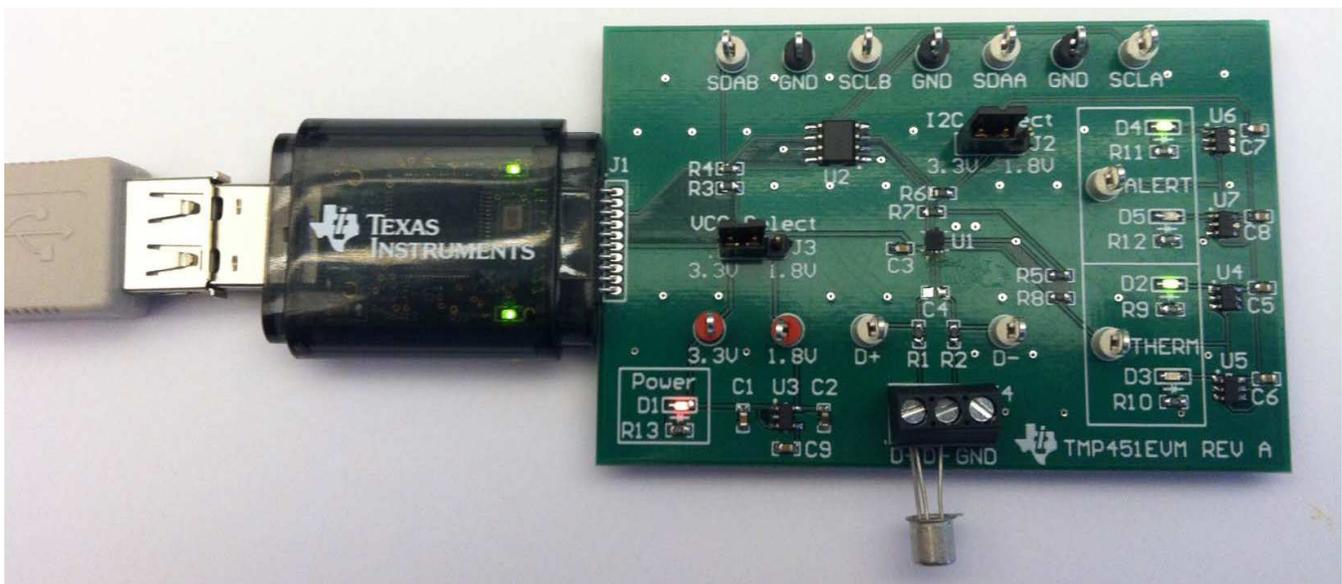


Figure 3-1. Connecting SM-USB-DIG Platform

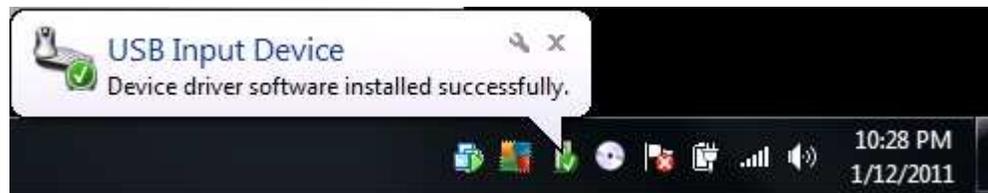


Figure 3-2. Confirmation of SM-USB-DIG Platform Driver Installation

3.2.1 Optional 10-pin Connector Ribbon Extender

The TMP451EVM kit is shipped with an optional ribbon cable for extending the connection between the SM-USB-DIG and the PCB. This can be useful if high temperature tests need to be run on the test board, since the SM-USB-DIG is not rated for high temperatures. To connect the ribbon cable, attach the cable to the EVM and SM-USB-DIG as shown in [Figure 3-3](#).

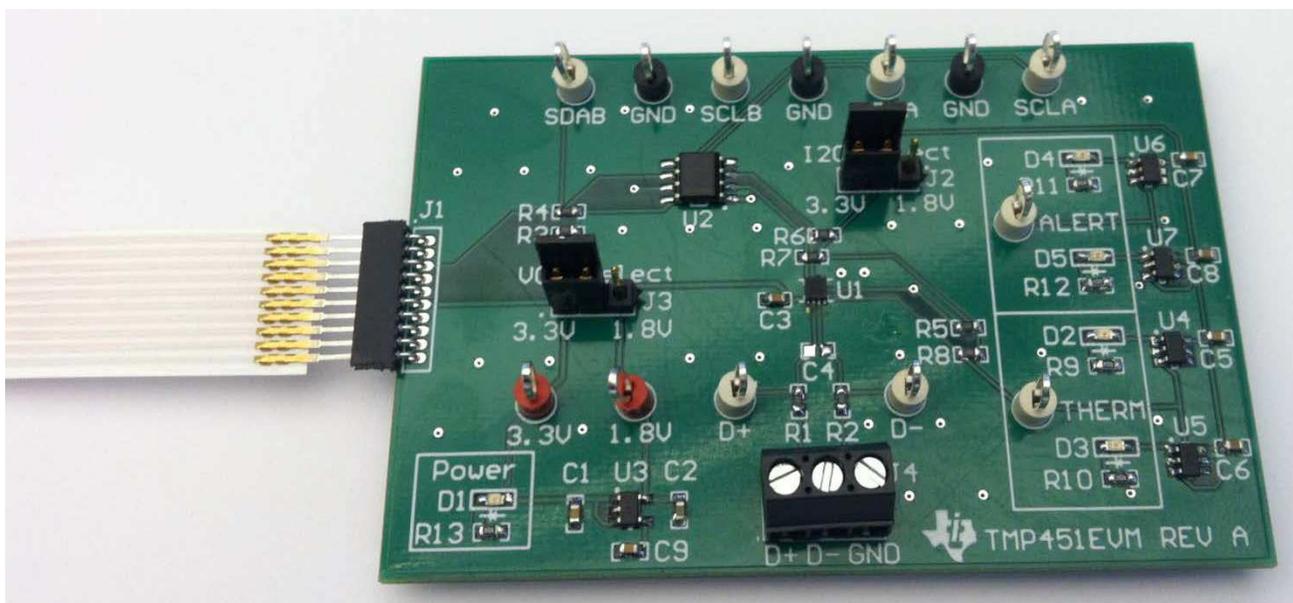


Figure 3-3. 10-Pin Ribbon Cable Extender

3.3 TMP451EVM Features

This section describes some of the hardware features present on the TMP451EVM.

3.3.1 I²C Translator and Test Points

One of the features of the TMP451 is the ability of the part to be powered at 1.8 V while the communication is still at 3.3 V. The TMP451EVM is equipped with an on board I²C level translator. This allows the TMP451 and the I²C to be operated at 3.3 V or 1.8 V by shunting 3.3 V or 1.8 V on J3 and J2. The I²C test points SDAB and SCLB are connected to the I²C line of the SM-USB-DIG and run to the input of the level translator, U2. The I²C test points SDAA and SCLA are connected to the output of the level translator, U2, and run to the clock and data lines of the TMP451.

3.3.2 Remote Temperature Terminal Block, J4

The TMP451EVM has a terminal block, J4, used for attaching a remote temperature sensor, in this case a NPN transistor which is included in the kit. To connect the transistor, attach the base and collector to D+ and the emitter to D- as shown in [Figure 3-4](#).

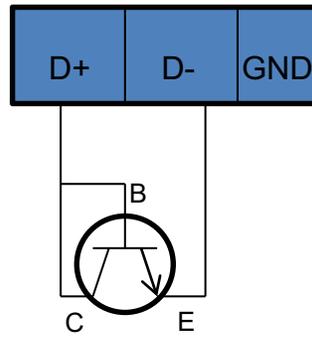


Figure 3-4. Connection for NPN Transistor to J4



Figure 3-5. Remote NPN Setup

TMP451EVM Software Setup

This section discusses how to install the TMP451EVM software.

4.1 Operating Systems for TMP451EVM Software

The TMP451EVM software has been tested on the Microsoft Windows XP® operating system (OS) with United States and European regional settings. The software should also function on other Windows operating systems.

4.2 TMP451EVM Software Installation

The TMP451EVM software is included on the CD that is shipped with the EVM kit. It is also available through the TMP451EVM product folder on the TI website. To download the software to your system, insert the disc into an available CD-ROM drive. Navigate to the drive contents and open the TMP451EVM software folder. Locate the compressed file (TMP451EVM.zip) and open it. Using WinZIP® or a similar file compression program; extract the TMP451EVM files into a specific TMP451EVM folder (for example, C:\TMP451\TMP451EVM) on your hard drive.

Once the files are extracted, navigate to the TMP451EVM folder you created on your hard drive. Locate the setup.exe file and execute it to start the installation. The TMP451 software installer should begin the installation process as shown in [Figure 4-1](#).

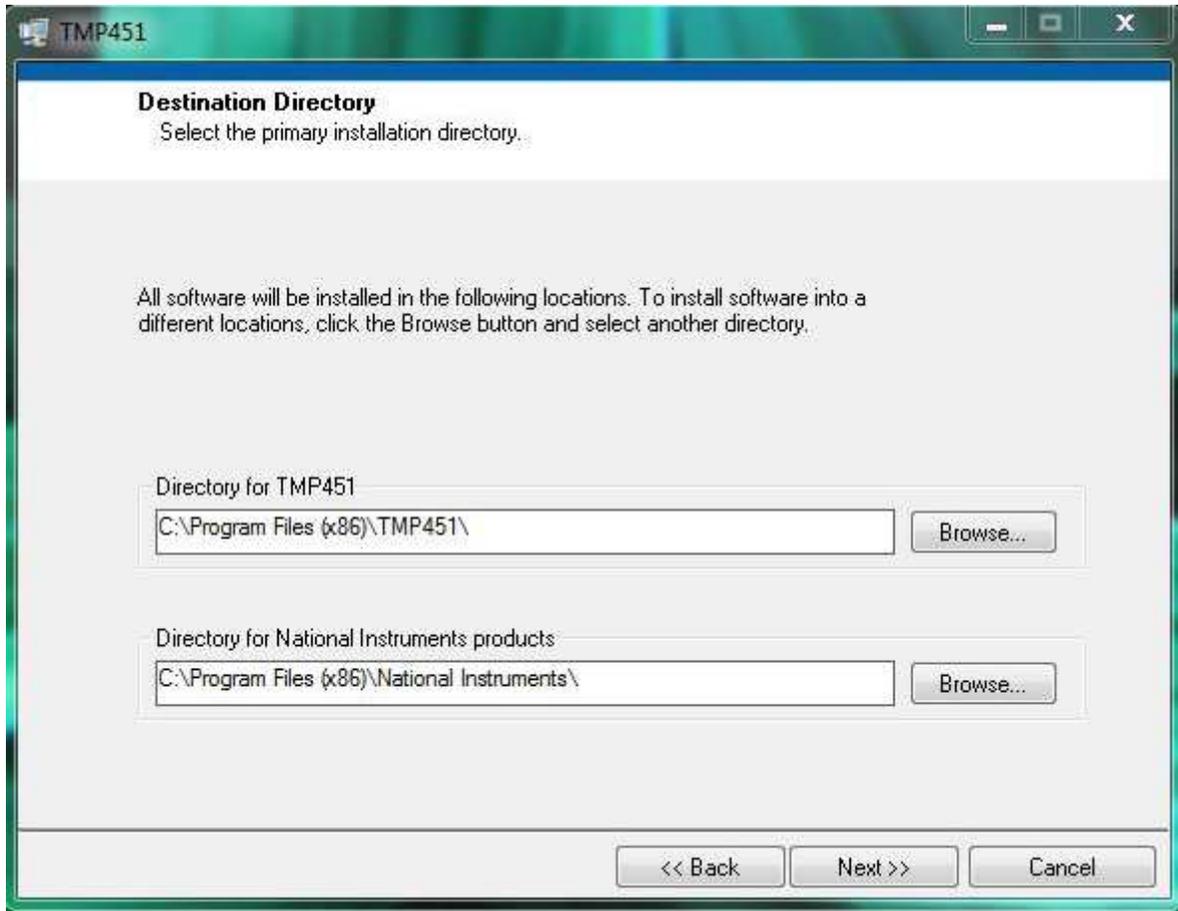


Figure 4-1. TMP451EVM Software Install Window

After the install initializes the user is given the choice of selecting the directory to install the program, usually defaulting to C:\Program Files\TMP451EVM and C:\Program Files\National Instruments. Following this option, two license agreements are presented that must be accepted as shown in [Figure 4-2](#). After accepting the Texas Instruments and National Instruments license agreements, the progress bar opens and shows the installation of the software. Once the installation process is completed click Finish.

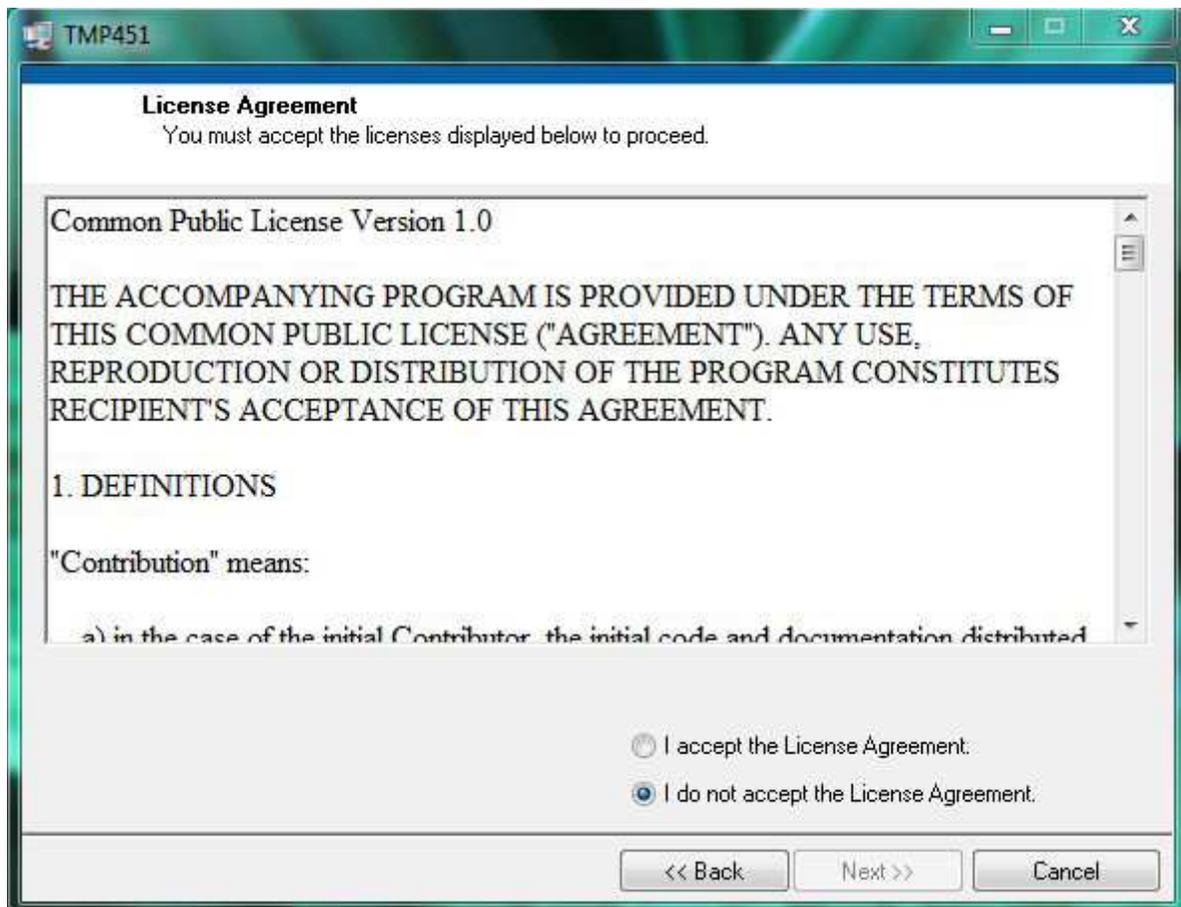


Figure 4-2. TMP451EVM License Agreements

TMP451EVM Software Overview

This section discusses how to use the TMP451EVM software.

5.1 Starting the TMP451EVM Software

The TMP451EVM software can be operated through the Start menu in Windows. From the Start menu, select All Programs, highlight the TMP451 folder, and then select the TMP451EVM program. Figure 5-1 illustrates how the software should appear if the TMP451EVM is functioning properly.

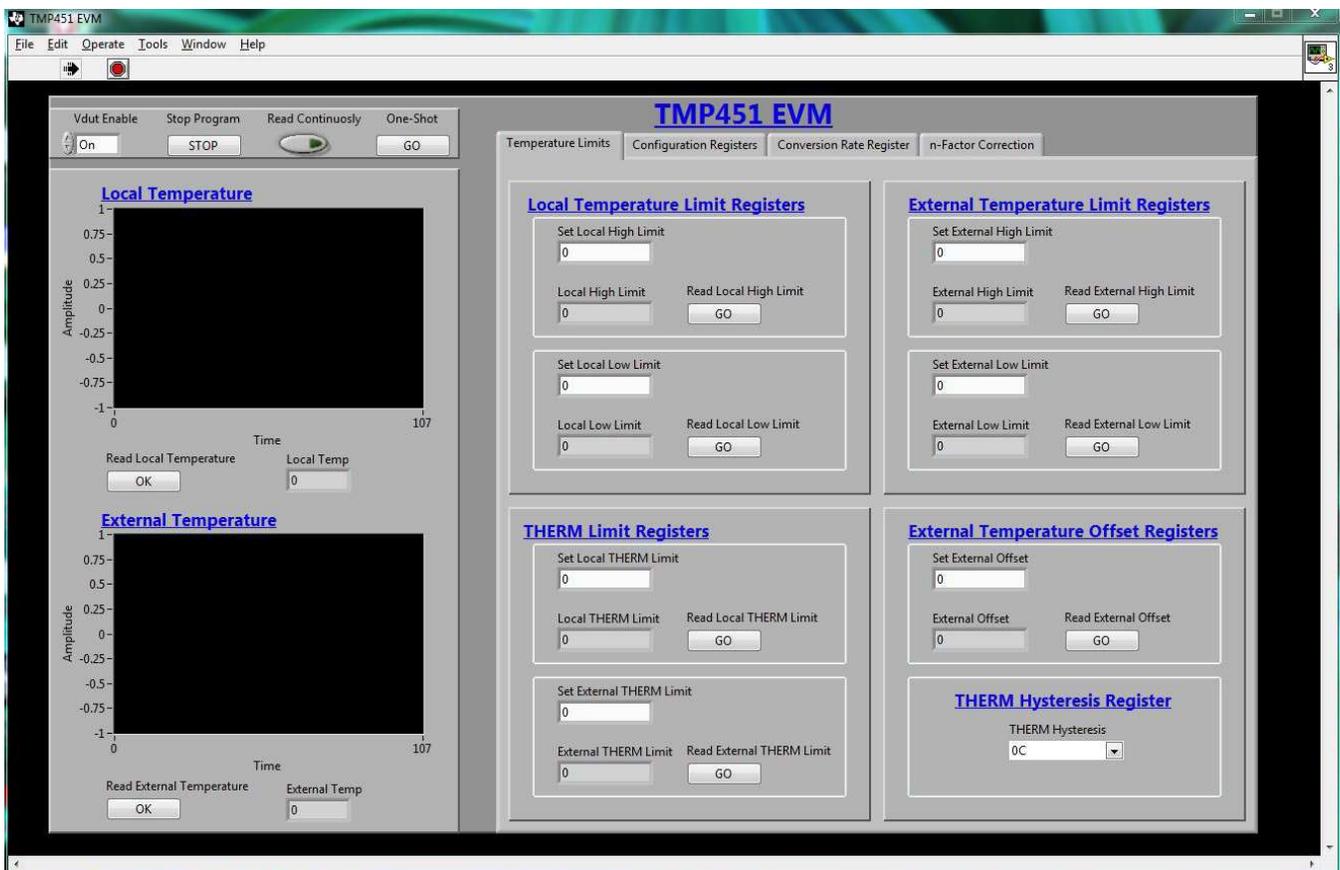


Figure 5-1. TMP451EVM Software Interface

Figure 5-2 shows an error that pops up if the computer cannot communicate with the EVM. In the event you receive this error, first ensure that the USB cable is properly connected on both ends. Another possible source for this error is a problem with the USB human interface device driver of the computer. Make sure that the device is recognized when the USB cable is plugged in, as indicated by a Windows-generated confirmation sound.

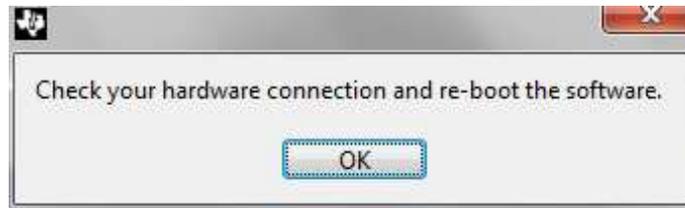


Figure 5-2. Communication Error with USB DIG Platform

5.2 Using the TMP451EVM Software

5.2.1 Reading from Registers

When first starting the TMP451EVM software, it is advised that the user confirm connections to the board by toggling the Read Continuously button shown in Figure 5-3. If all devices are communicating correctly, the user should be able to see temperature change over time in the TMP451 local temperature box.

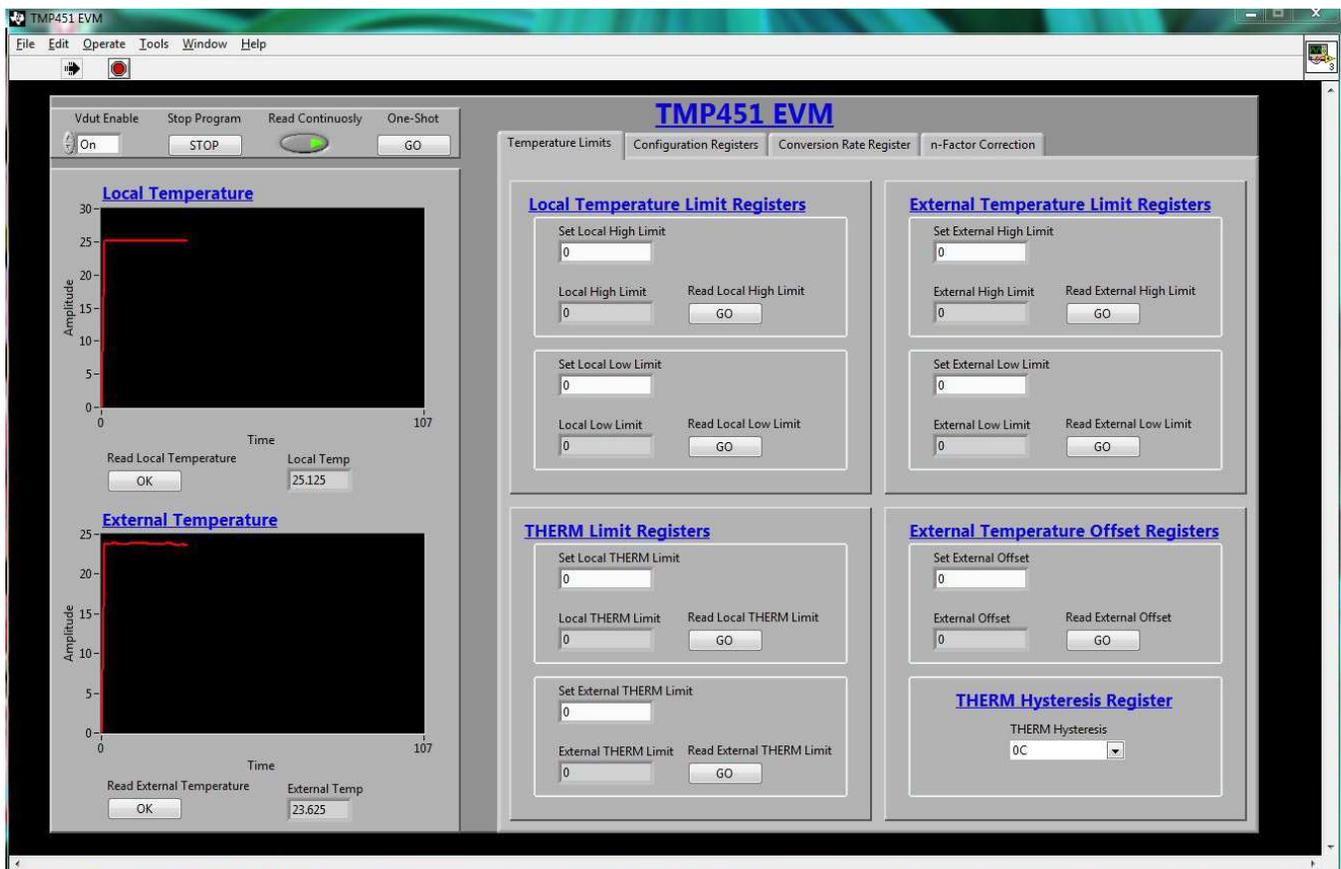
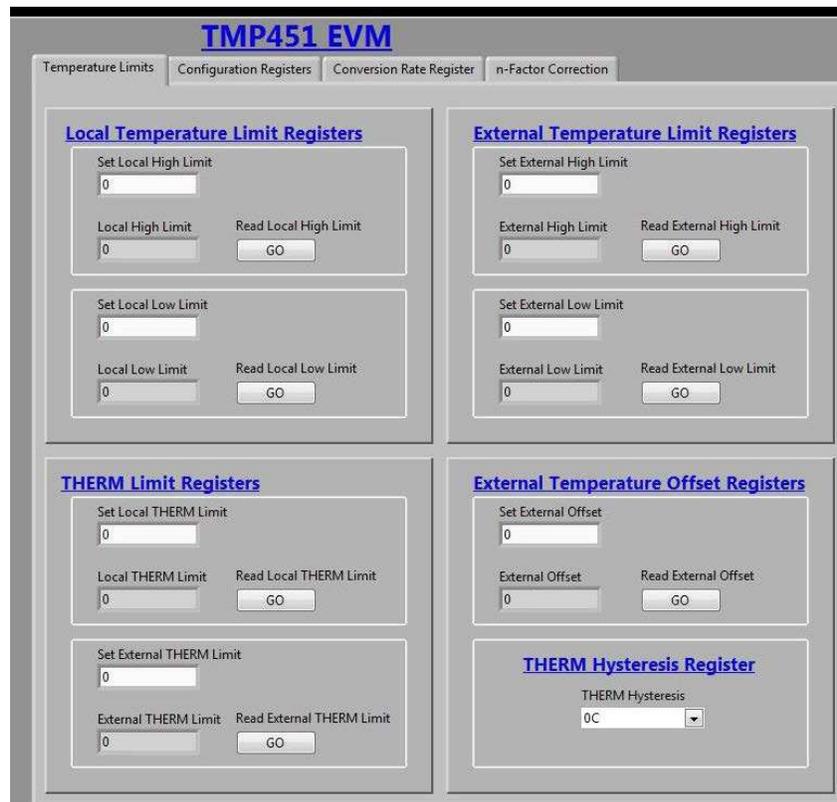


Figure 5-3. TMP451 Read Continuously

5.2.2 Temperature ALERT and THERM Limits

The first tab on the TMP451EVM software is Temperature Limits. In this tab you can read or set the ALERT and THERM limits for the TMP451. You can also set a temperature offset for the remote temperature sensor and enable a THERM hysteresis. Changing values in these controls automatically writes them. The Temperature Limits tab is shown in Figure 5-4.



The screenshot shows the 'Temperature Limits' tab in the TMP451 EVM software. At the top, there are navigation tabs: 'Temperature Limits', 'Configuration Registers', 'Conversion Rate Register', and 'n-Factor Correction'. The main content area is divided into four panels:

- Local Temperature Limit Registers:** Contains two sub-sections. The first is for the High Limit, with a 'Set Local High Limit' field (value 0), a 'Local High Limit' field (value 0), and a 'Read Local High Limit' button labeled 'GO'. The second is for the Low Limit, with a 'Set Local Low Limit' field (value 0), a 'Local Low Limit' field (value 0), and a 'Read Local Low Limit' button labeled 'GO'.
- External Temperature Limit Registers:** Contains two sub-sections. The first is for the High Limit, with a 'Set External High Limit' field (value 0), an 'External High Limit' field (value 0), and a 'Read External High Limit' button labeled 'GO'. The second is for the Low Limit, with a 'Set External Low Limit' field (value 0), an 'External Low Limit' field (value 0), and a 'Read External Low Limit' button labeled 'GO'.
- THERM Limit Registers:** Contains two sub-sections. The first is for the Local THERM Limit, with a 'Set Local THERM Limit' field (value 0), a 'Local THERM Limit' field (value 0), and a 'Read Local THERM Limit' button labeled 'GO'. The second is for the External THERM Limit, with a 'Set External THERM Limit' field (value 0), an 'External THERM Limit' field (value 0), and a 'Read External THERM Limit' button labeled 'GO'.
- External Temperature Offset Registers:** Contains one sub-section for the External Offset, with a 'Set External Offset' field (value 0), an 'External Offset' field (value 0), and a 'Read External Offset' button labeled 'GO'.

At the bottom right, there is a **THERM Hysteresis Register** with a 'THERM Hysteresis' dropdown menu currently set to '0C'.

Figure 5-4. Temperature Limits Tab

5.2.3 Configuration Register Tab

The TMP451EVM software contains a tab for the configuration register, consecutive alert register, and status register. Changing values in this register automatically writes them. In the Configuration register the bit MASK1 masks the ALERT pin when enabled. R/S stands for RUN/STOP, when enabled this sets the TMP451 to standby. AL/TH stands for ALERT/THERM2. When this bit is enabled ALERT becomes a second THERM. The TRange bit switches the TMP451 from its normal temperature range of 0°C–127°C to its extended temperature range of –64°C–191°C. For the Consecutive Alert register the bit SMBus enables a 30-ms timeout while bits 1–3 determine how many out-of-limit measurements are needed to trigger an ALERT. [Figure 5-5](#) shows the Configuration Register tab in the TMP451EVM software. See the data sheet for more information.

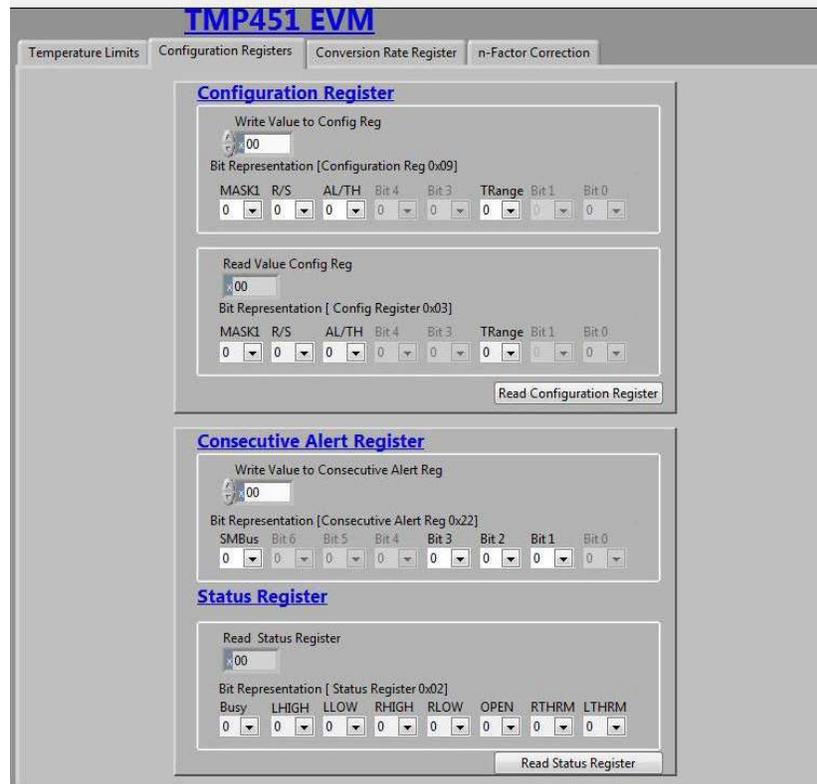


Figure 5-5. TMP451 Configuration Register

5.2.4 Conversion Rate Register Tab

The Conversion Rate Register tab contains both the Conversion Rate register and the Digital Filter Control register. Changing values in these registers automatically writes them. Table 5-1 shows the conversion rate register codes. For the Digital Filter register there are three options, Disabled (default), Level 1, and Level 2. This filter maintains a running average of 4 samples (level 1) or 8 samples (level 2).

Table 5-1. Conversion Rate Register Codes

Code	Conversion/Second	Time (Second)
0x00	0.0625	16
0x01	0.125	8
0x02	0.25	4
0x03	0.5	2
0x04	1	1
0x05	2	500 m
0x06	4	250 m
0x07	8	125 m
0x08	16	62.5 m
0x09	32	31.25 m

5.2.5 n-Factor Correction Tab

The TMP451 allows for a different n-factor value for converting remote channel measurements to temperature. Table 5-2 shows the n-factor correction register codes.

Table 5-2. n-Factor Correction Register Codes

Binary	Hex	Decimal	N
01111111	7F	127	1.747977
00001010	0A	10	1.042759
00001000	08	8	1.035616
00000110	06	6	1.028571
00000100	04	4	1.021622
00000010	02	2	1.014765
00000001	01	1	1.011371
00000000	00	0	1.008
11111111	FF	-1	1.004651
11111110	FE	-2	1.001325
11111100	FC	-4	0.994737
11111010	FA	-6	0.988235
11111000	F8	-8	0.981818
11110110	F6	-10	0.975484
10000000	80	-128	0.706542

5.2.6 Reading the Temperature Gauge

The temperature box on the TMP451EVM software displays the measured values of the TMP451 device Local Temperature and External Temperature registers in a graphical format as shown in [Figure 5-6](#). These values are displayed in Celsius. A continuous reading can be displayed by toggling the Read Continuously control.

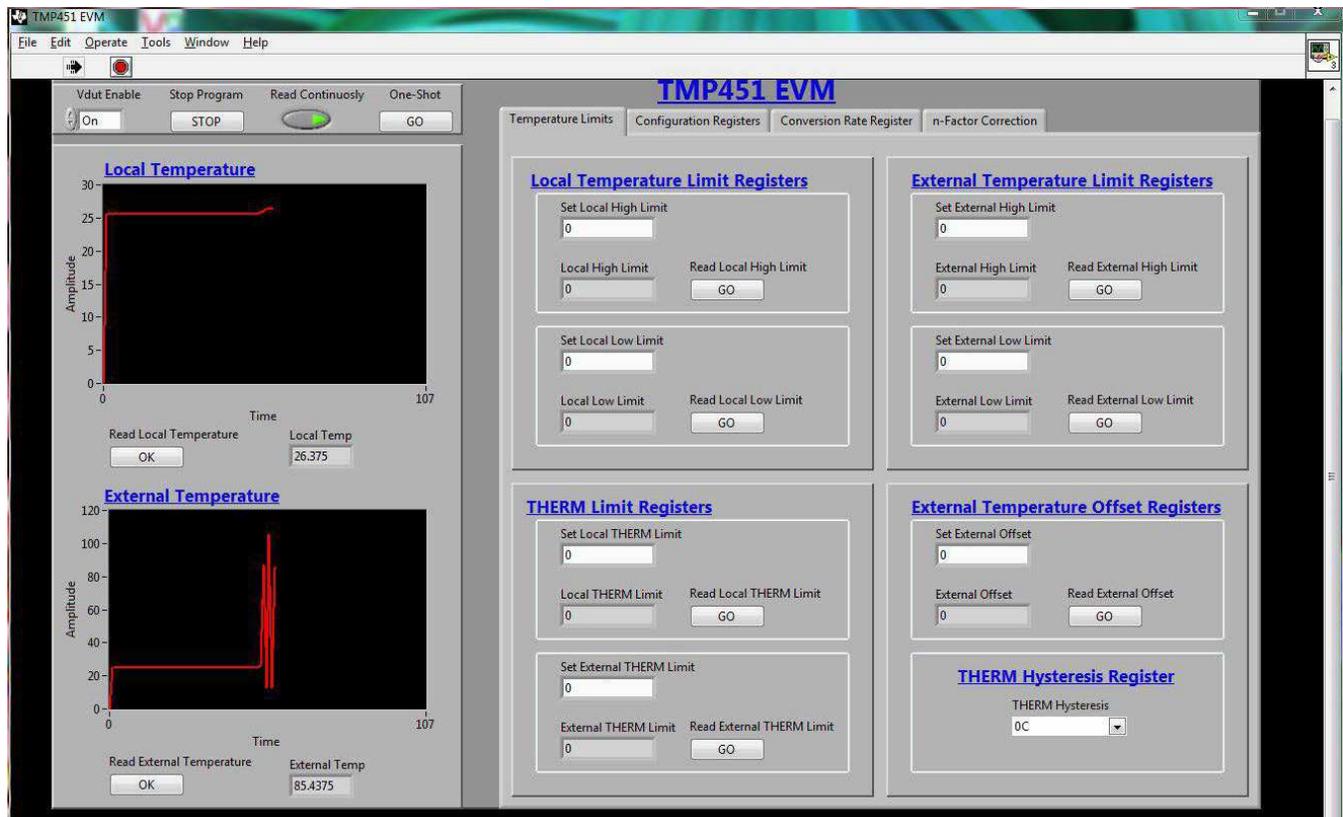


Figure 5-6. Reading the Temperature Gauge

TMP451EVM Documentation

This section contains the complete bill of materials and schematic diagram for the TMP451EVM. Documentation information for the SM-USB-DIG platform can be found in the SM-USB-DIG platform User's Guide, [SBOU098](#), available at the TI website at <http://www.ti.com>.

6.1 TMP451EVM Board Schematic

Figure 6-1 shows the schematic for the TMP451EVM board.

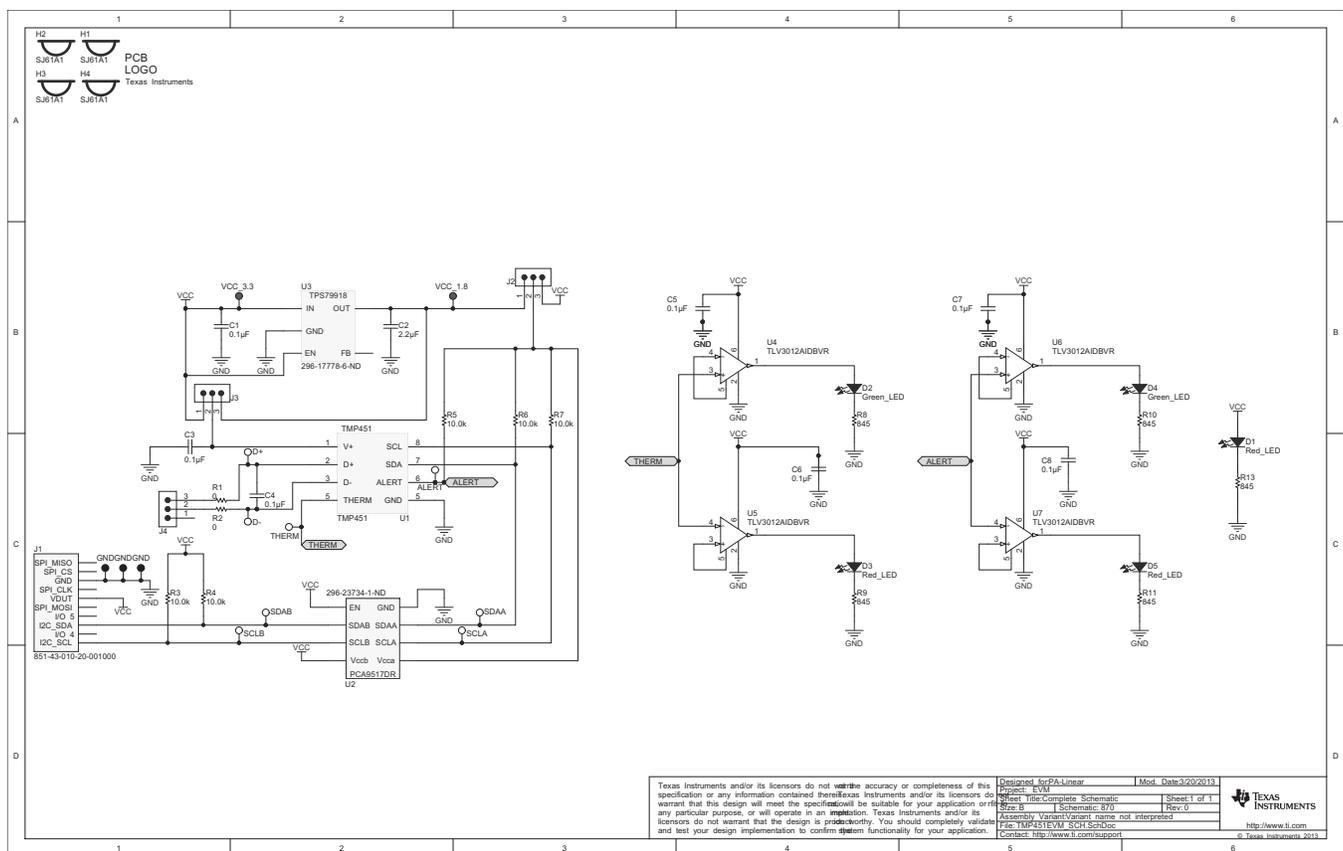


Figure 6-1. TMP451EVM Board Schematic

6.2 TMP451EVM PCB Components Layout

Figure 6-2 shows the layout of the components for the TMP451EVM board.

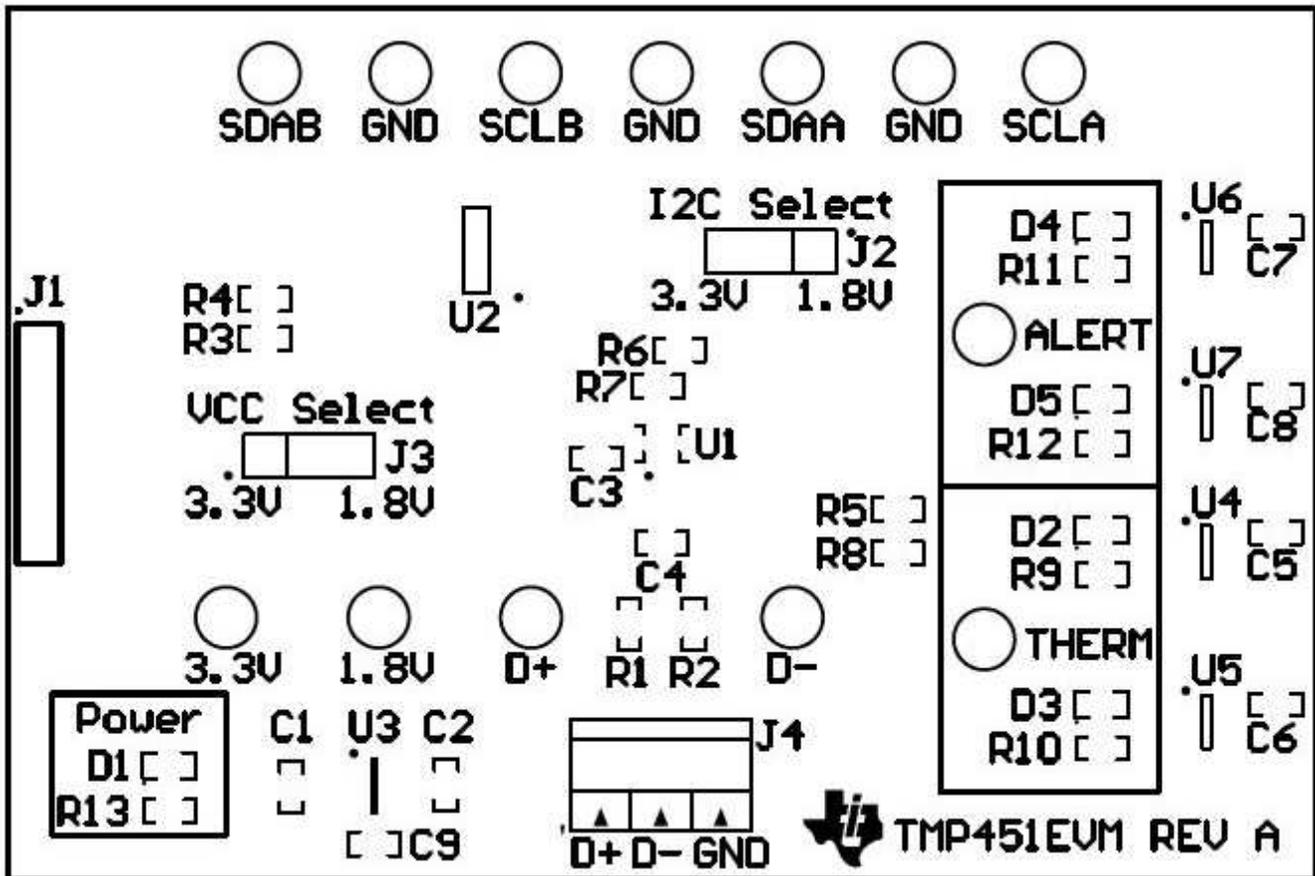


Figure 6-2. TMP451EVM Components Layout

6.3 TMP451 Test Board Bill of Materials

Table 6-1 lists the bill of materials for the TMP451EVM Test Board.

Table 6-1. TMP451EVM Test Board Bill of Materials⁽¹⁾

Item No.	Qty	Value	Ref Des	Description	Manufacturer	Digi-Key Part No.	Manufacturer Part No.	Unit Price	Ext Price	Notes
1	7	0.1 μ F	C1, C3, C5, C6, C7, C8, C9	CAP, CERM, 0.1 μ F, 16 V, \pm 5%, X7R, 0603	AVX	478-3726-1-ND	0603YC104 JAT2A	\$0.250	\$1.750	
2	1	2.2 μ F	C2	CAP, CERM, 2.2 μ F, 6.3 V, \pm 10%, X5R, 0603	Kemet	399-3362-1-ND	C0603C225 K9PACTU	\$0.160	\$0.160	
3	3	Red LED	D1, D3, D5	Red LED LTST-C190EKT	Lite-On Inc	160-1182-6-ND	LTST-C190EKT	\$0.320	\$0.960	
4	2	Green LED	D2, D4	LTST-C190GKT	Lite-On Inc	160-1183-1-ND	LTST-C190GKT	\$0.290	\$0.580	
5	8	White Test Point	ALERT, THERM, SCLA, SCLB, SDAA, SDAB, D+, D-	Test Point, TH, Multipurpose, White	Keystone	5012K-ND	5012	\$0.350	\$2.800	
6	3	Black Test Point	GND	Test Point, TH, Multipurpose, Black	Keystone	5011K-ND	5011	\$0.350	\$1.050	
7	2	Red Test Point	3.3 V, 1.8 V	Test Point, TH, Multipurpose, Red	Keystone	5010K-ND	5010	\$0.350	\$0.70	
8	4	Bump on	H1, H2, H3, H4	Bump on, Hemisphere, 0.44 X 0.20, Clear	3M	SJ5303-7-ND	SJ-5303 (CLEAR)	\$0.061	\$0.243	
9	1	NPN Transistor for Remote Temperature	NA	TRANS NPN 40V 600MA TO-18	STMicroelectronics	497-2598-ND	2N2222A	\$1.260	\$1.260	Connect to J4. See Test procedure
10	1	Super Mini DIG connector or Socket ⁽²⁾	J1	CONN SOCKET RT ANG 1POS .050	Mill-Max Manufacturing Corp.	ED8850-ND	851-43-010-20-001000	\$10.140	\$2.535	Ext Price = unitprice / 4
11	1	Terminal Block	J4	Terminal Block, 6-A, 3.5-mm Pitch, 3-Pos, TH	On-Shore Technology, Inc	ED1515-ND	ED555/3DS	\$0.860	\$0.860	
12	2	Pin Jumper	J2, J3	CONN HEADER 3POS .100" SGL GOLD	Samtec Inc	SAM1029-03-ND	TSW-103-07-G-S	\$0.610	\$1.220	
13	DNP	0603 Generic Capacitor	C4	0603 Generic Capacitor				DNP	DNP	
14	2	0	R1, R2	RES, 0 Ω , 5%, 0.1 W, 0603	Rohm	RHM0.0GCT-ND	MCR03EZPJ000	\$0.100	\$0.10	

⁽¹⁾ Substitutions permissible as long as all characteristics are identical.

⁽²⁾ The connector for the Super Mini DIG cannot usually be found on Digikey. Instead a 50-pin connector must be used and separated into individual strips. Each strip can be divided four times into strips of 10.

Table 6-1. TMP451EVM Test Board Bill of Materials⁽¹⁾ (continued)

Item No.	Qty	Value	Ref Des	Description	Manufacturer	Digi-Key Part No.	Manufacturer Part No.	Unit Price	Ext Price	Notes
15	6	10k	R3, R4, R5, R6, R7, R8	RES, 10 kΩ, 1%, 0.1 W, 0603	Vishay-Dale	541-10.0KHCT-ND	CRCW060310K0FKEA	\$0.081	\$0.49	Minimum order quantity is 10
16	5	845	R9, R10, R11, R12, R13	RES, 845 Ω, 1%, 0.1 W, 0603	Yageo America	311-845HRCT-ND	RC0603FR-07845RL	\$0.100	\$0.50	
17	1	Temperature Sensor	U1	IC TEMP SENSR	Texas Instruments	NA	NA	NA	NA	NA
18	1	I ² C Translator	U2	IC LVL-TRANSL I ² C BUS REP 8-SOIC	Texas Instruments	296-23734-1-ND	PCA9517DR	\$3.010	\$3.010	
19	1	LDO	U3	IC REG LDO 1.8 V .2 A TSOT-23-5	Texas Instruments	296-17778-1-ND	"TPS79918 DDCR"	\$0.960	\$0.960	
20	4	Comparator	U4, U5, U6, U7	IC COMPARATOR 1.8 V W/REF SOT23-6	Texas Instruments	296-16830-1-ND	TLV3012AIDBVR	\$2.580	\$10.32	
21	2	Shunt	J2, J4	CONN JUMPER SHORTING .100" GOLD	Sullins Connector Solutions	S9341-ND	NPC02SXON-RC	\$0.190	\$0.380	

EVALUATION BOARD/KIT/MODULE (EVM) ADDITIONAL TERMS

Texas Instruments (TI) provides the enclosed Evaluation Board/Kit/Module (EVM) under the following conditions:

The user assumes all responsibility and liability for proper and safe handling of the goods. Further, the user indemnifies TI from all claims arising from the handling or use of the goods.

Should this evaluation board/kit not meet the specifications indicated in the User's Guide, the board/kit may be returned within 30 days from the date of delivery for a full refund. THE FOREGOING LIMITED WARRANTY IS THE EXCLUSIVE WARRANTY MADE BY SELLER TO BUYER AND IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED, IMPLIED, OR STATUTORY, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE. EXCEPT TO THE EXTENT OF THE INDEMNITY SET FORTH ABOVE, NEITHER PARTY SHALL BE LIABLE TO THE OTHER FOR ANY INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES.

Please read the User's Guide and, specifically, the Warnings and Restrictions notice in the User's Guide prior to handling the product. This notice contains important safety information about temperatures and voltages. For additional information on TI's environmental and/or safety programs, please visit www.ti.com/esh or contact TI.

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REGULATORY COMPLIANCE INFORMATION

As noted in the EVM User's Guide and/or EVM itself, this EVM and/or accompanying hardware may or may not be subject to the Federal Communications Commission (FCC) and Industry Canada (IC) rules.

For EVMs **not** subject to the above rules, this evaluation board/kit/module is intended for use for ENGINEERING DEVELOPMENT, DEMONSTRATION OR EVALUATION PURPOSES ONLY and is not considered by TI to be a finished end product fit for general consumer use. It generates, uses, and can radiate radio frequency energy and has not been tested for compliance with the limits of computing devices pursuant to part 15 of FCC or ICES-003 rules, which are designed to provide reasonable protection against radio frequency interference. Operation of the equipment may cause interference with radio communications, in which case the user at his own expense will be required to take whatever measures may be required to correct this interference.

General Statement for EVMs including a radio

User Power/Frequency Use Obligations: This radio is intended for development/professional use only in legally allocated frequency and power limits. Any use of radio frequencies and/or power availability of this EVM and its development application(s) must comply with local laws governing radio spectrum allocation and power limits for this evaluation module. It is the user's sole responsibility to only operate this radio in legally acceptable frequency space and within legally mandated power limitations. Any exceptions to this are strictly prohibited and unauthorized by Texas Instruments unless user has obtained appropriate experimental/development licenses from local regulatory authorities, which is responsibility of user including its acceptable authorization.

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

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

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.

For EVMs annotated as IC – INDUSTRY CANADA Compliant

This Class A or B digital apparatus complies with Canadian ICES-003.

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

Concerning EVMs including radio transmitters

This device complies with Industry Canada licence-exempt RSS standard(s). 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.

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.

Cet appareil numérique de la classe A ou B est conforme à la norme NMB-003 du Canada.

Les changements ou les modifications pas expressément approuvés par la partie responsable de la conformité ont pu vider l'autorité de l'utilisateur pour actionner l'équipement.

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.

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.

【Important Notice for Users of EVMs for RF Products in Japan】

This development kit is NOT certified as Confirming to Technical Regulations of Radio Law of Japan

If you use this product in Japan, you are required by Radio Law of Japan to follow the instructions below with respect to this product:

1. Use this product 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 this product only after you obtained the license of Test Radio Station as provided in Radio Law of Japan with respect to this product, or
3. Use of this product only after you obtained the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to this product. Also, please do not transfer this product, unless you give the same notice above to the transferee. Please note that if you could not follow the instructions above, you will be subject to penalties of Radio Law of Japan.

Texas Instruments Japan Limited
(address) 24-1, Nishi-Shinjuku 6 chome, Shinjuku-ku, Tokyo, Japan

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日本テキサス・インスツルメンツ株式会社
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西新宿三井ビル

<http://www.tij.co.jp>

EVALUATION BOARD/KIT/MODULE (EVM) WARNINGS, RESTRICTIONS AND DISCLAIMERS

For Feasibility Evaluation Only, in Laboratory/Development Environments. Unless otherwise indicated, this EVM is not a finished electrical equipment and not intended for consumer use. It is intended solely for use for preliminary feasibility evaluation in laboratory/development environments by technically qualified electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems and subsystems. It should not be used as all or part of a finished end product.

Your Sole Responsibility and Risk. You acknowledge, represent and agree that:

1. You have unique knowledge concerning Federal, State and local regulatory requirements (including but not limited to Food and Drug Administration regulations, if applicable) which relate to your products and which relate to your use (and/or that of your employees, affiliates, contractors or designees) of the EVM for evaluation, testing and other purposes.
2. You have full and exclusive responsibility to assure the safety and compliance of your products with all such laws and other applicable regulatory requirements, and also to assure the safety of any activities to be conducted by you and/or your employees, affiliates, contractors or designees, using the EVM. Further, you are responsible to assure 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.
3. Since the EVM is not a completed product, it may not meet all applicable regulatory and safety compliance standards (such as UL, CSA, VDE, CE, RoHS and WEEE) which may normally be associated with similar items. You assume full responsibility to determine and/or assure compliance with any such standards and related certifications as may be applicable. You will employ reasonable safeguards to ensure that your use of the EVM will not result in any property damage, injury or death, even if the EVM should fail to perform as described or expected.
4. You will take care of proper disposal and recycling of the EVM's electronic components and packing materials.

Certain Instructions. It is important to operate this EVM within TI's recommended specifications and environmental considerations per the user guidelines. Exceeding the specified EVM ratings (including but not limited to input and output voltage, current, power, and environmental ranges) may cause property damage, personal injury or death. If there are questions concerning these ratings please 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 result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM User's 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, some circuit components may have case temperatures greater than 60°C as long as the input and output are maintained at a normal ambient operating temperature. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors which can be identified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during normal operation, please be aware that these devices may be very warm to the touch. As with all electronic evaluation tools, only qualified personnel knowledgeable in electronic measurement and diagnostics normally found in development environments should use these EVMs.

Agreement to Defend, Indemnify and Hold Harmless. You agree to 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 use of the EVM that is not in accordance with the terms of the agreement. This obligation shall apply whether Claims arise under law of tort or contract or any other legal theory, and even if the EVM fails to perform as described or expected.

Safety-Critical or Life-Critical Applications. If you intend to evaluate the components for possible use in safety critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, such as devices which are classified as FDA Class III or similar classification, then you must specifically notify TI of such intent and enter into a separate Assurance and Indemnity Agreement.

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In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI's goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

Only those TI components which TI has specifically designated as military grade or "enhanced plastic" are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have **not** been so designated is solely at the Buyer's risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.

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