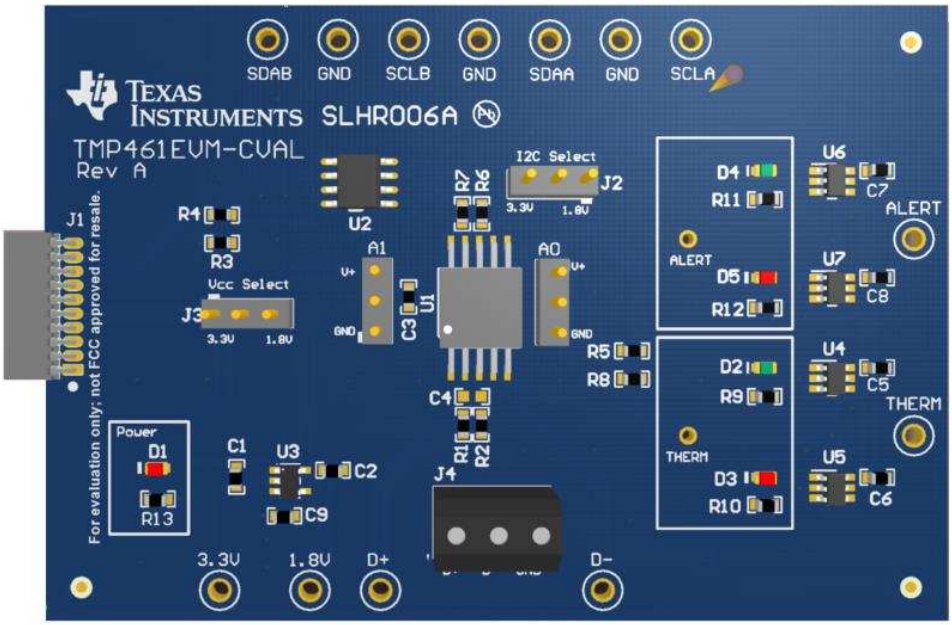
User's Guide

SBOU197–September 2017

TMP461EVM-CVAL Evaluation Module and Software Tutorial

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



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1 Overview

The TMP461-SP 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, substrate thermal transistors, or diodes that are integral parts of microprocessors, microcontrollers, or field-programmable gate arrays (FPGAs). Temperature is represented as a 12-bit digital code for both the local and remote sensors, providing a resolution of 0.0625°C. The two-wire serial interface accepts the SMBus communication protocol with up to nine different pin-programmable addresses.

1.1 TMP461-EVM-CVAL Kit Contents

Table 1 details the contents of the TMP461EVM-CVAL kit, and Figure 1 illustrates 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. TMP461-EVM-CVAL Kit Contents

Item	Quantity
TMP461EVM-CVAL PCB test board	1
NPN 2N3904 transistor	1
USB SM-DIG platform PCB	1
USB cable extender	1

1.2 Related Documentation from Texas Instruments

The following documents provide information regarding Texas Instruments' integrated circuits used in the assembly of the TMP461EVM-CVAL. This user's guide is available from the TI website under literature number SBOU197. 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 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 2. Related Documentation

Document	Literature Number
TMP461-SP product data sheet	SBOS876
SM-USB-DIG platform user's guide	SBOU098

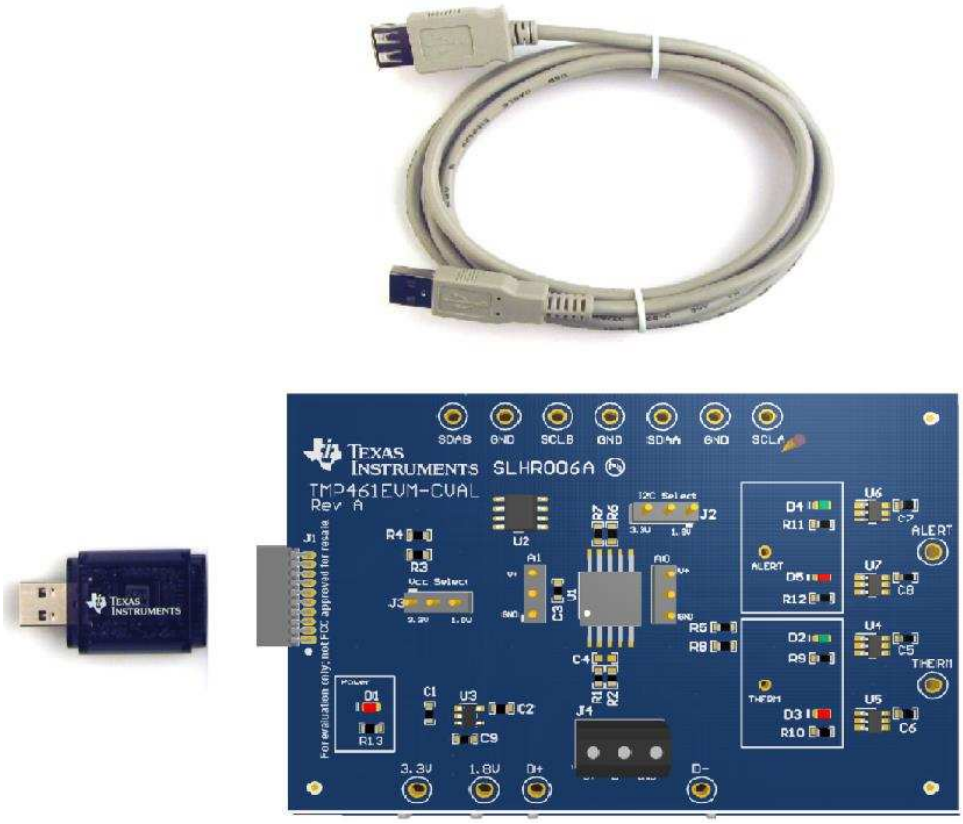


Figure 1. Hardware Included With TMP461EVM-CVAL Kit

2 TMP461EVM-CVAL Hardware Setup

The TMP461EVM-CVAL hardware consists of the SM-USB-DIG and TMP461EVM-CVAL; these are easily connected through a 10-pin board-to-board connector that is attached to the SM-USB-DIG and TMP461EVM-CVAL PCBs. Once these two boards are connected, plug the USB device from the SM-USB-DIG into the computer as shown in Figure 2.

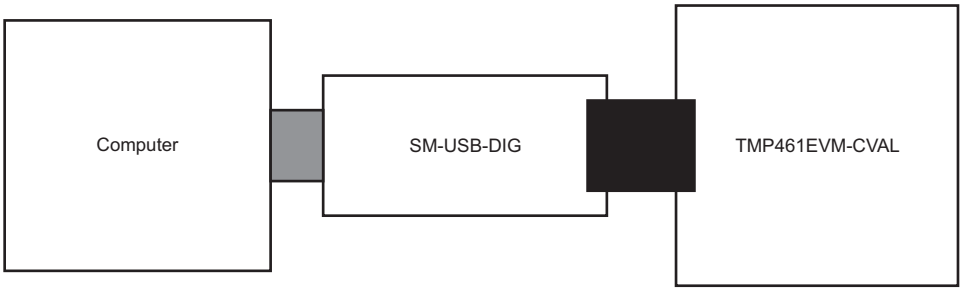


Figure 2. TMP461EVM-CVAL Hardware Setup

2.1 Theory of Operation for the TMP461-SP Hardware

The TMP461EVM-CVAL only requires the two-wire I²C lines (SDA and SCLK) and VDUT and GND to supply a constant 3.3 V and power return, as shown in Figure 3. The TMP461EVM-CVAL also has test points to monitor these signal lines, and a ground in case the user may want to use their own signals or verify I²C communications.

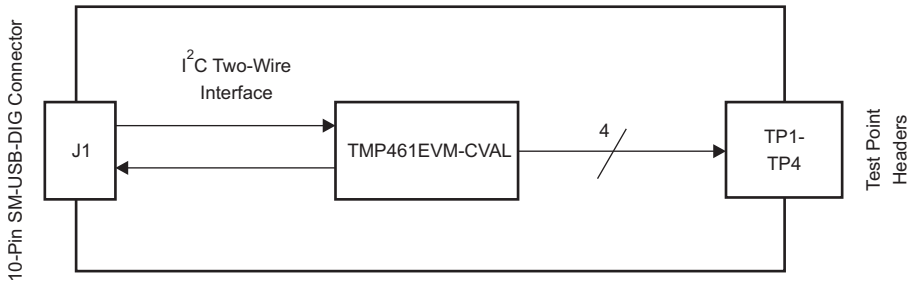


Figure 3. TMP461EVM-CVAL Test Board Block Diagram

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

Table 3 shows the pinout for the 10-pin connector socket used to communicate between the TMP461EVM-CVAL and the SM-DIG. Note that the TMP461EVM-CVAL 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 TMP461-SP sensors.

Table 3. Pin Connector

Pin On U1	Signal	Description
1	I2C_SCL	I²C clock signal (SCL)
2	CTRL/MEAS4	GPIO: control output or measure input
3	I2C_SDA1	I²C 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 ($\overline{CS}$)
10	SPI_DIN1	SPI data input (MISO)

(1) When VDUT is Hi-Z, all digital I/Os are Hi-Z as well.

2.3 Theory of Operation for the SM-USB-DIG Platform

Figure 4 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 evaluation modules from TI. The details of its operation are included in *SM-USB-DIG Platform*. The block diagram shown in Figure 4 is given as a brief overview of the platform.

The central unit 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, I^2C, 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.

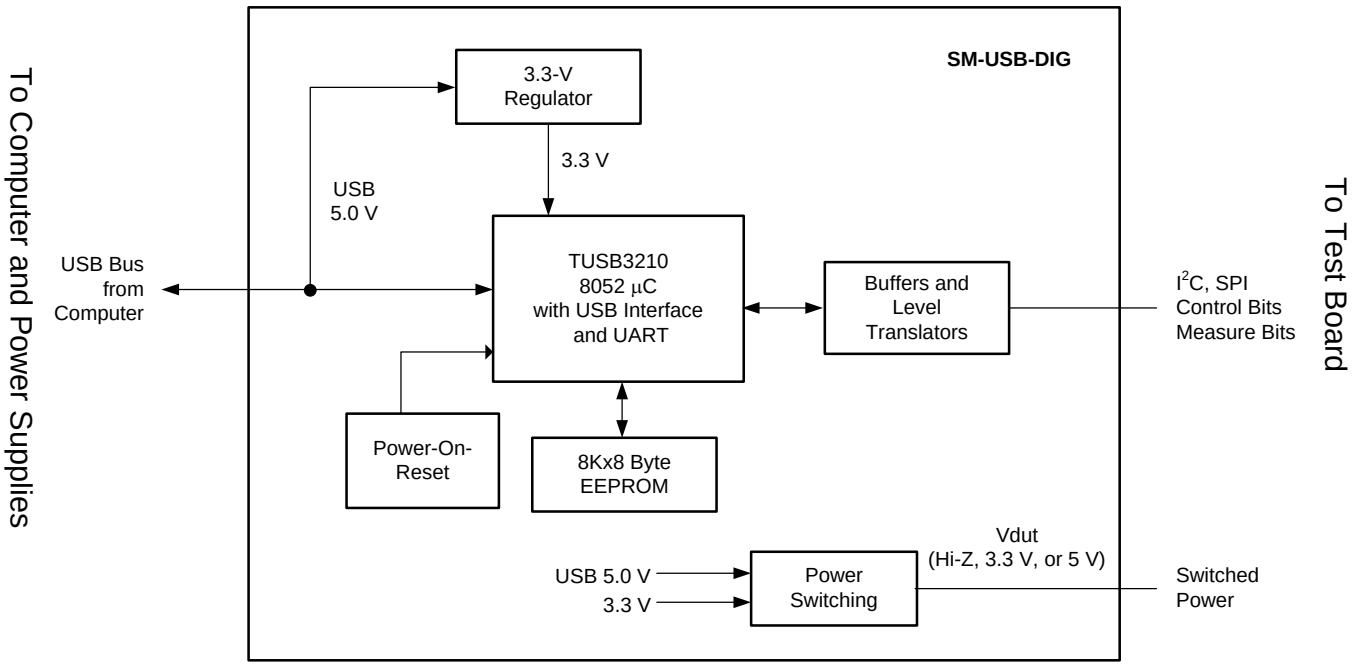


Figure 4. USB DIG Platform Block Diagram

3 TMP461EVM-CVAL Hardware Overview

CAUTION

Many components on the TMP461EVM-CVAL 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 TMP461EVM-CVAL and the SM-USB-DIG platform, gently slide the male and female ends of the 10-pin connectors together (see Figure 5). Make sure that the two connectors are completely pushed together; loose connections may cause intermittent operation.

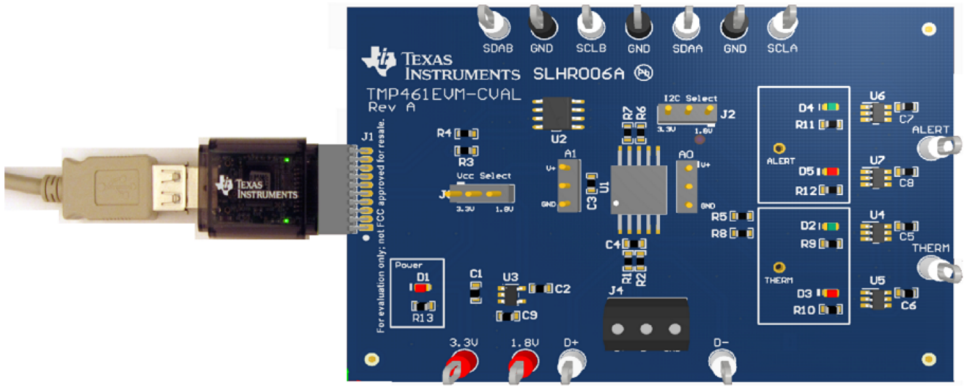


Figure 5. Connecting the SM-USB-DIG Platform

3.2 Connecting the USB Cable to the DIG Platform

Figure 6 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 typically 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 6.

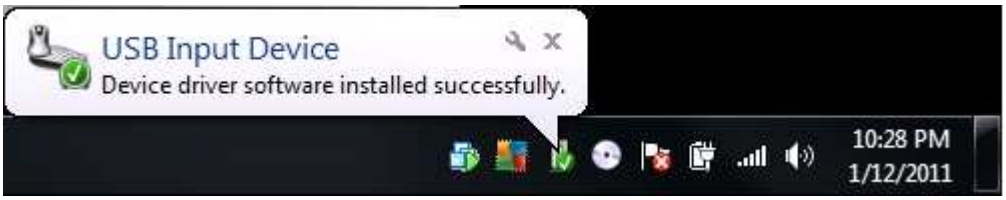


Figure 6. Confirmation of SM-USB-DIG Platform Driver Installation

3.3 TMP461EVM-CVAL Features

This section describes some of the hardware features present on the TMP461EVM-CVAL.

3.3.1 I²C Translator and Test Points

One of the features of the TMP461-SP is the ability of the device to be powered at 1.8 V when the communication is still at 3.3 V. The TMP461EVM-CVAL is equipped with an onboard I²C level translator that allows the TMP461-SP 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 TMP461-SP.

3.3.2 Remote Temperature Terminal Block, J4

The TMP461EVM-CVAL has a terminal block, J4, used for attaching a remote temperature sensor. In this case, an NPN transistor is included in the kit. To connect the transistor, attach the base and collector to D+ and the emitter to D–, as illustrated in Figure 7 and Figure 8.

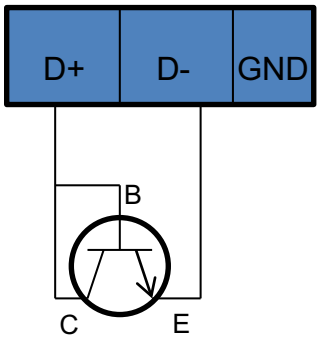


Figure 7. Connection for the NPN Transistor to J4

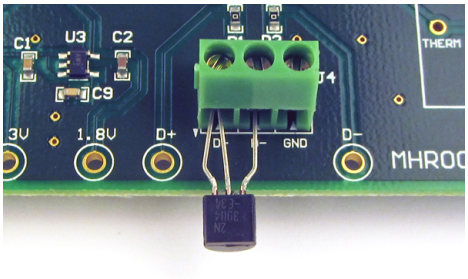


Figure 8. Remote NPN Setup

3.3.3 Serial Bus Address (A0, A1)

The TMP461EVM-CVAL board is equipped with two jumpers, A0 and A1. These jumpers allow the user to select the slave address required for their application by shunting V+ or GND on A0 and A1, or by leaving them floating. To communicate with the TMP461-SP device, the master must first address slave devices using a slave address byte. The slave address byte consists of seven address bits and a direction bit indicating the intent of executing a read or write operation. The TMP461-SP allows up to nine devices to be connected to the SMBus depending on the A0, A1 pin connections, as shown in Table 4. The TMP461-SP default slave address is 4C (hex). The user must ensure that the A0 and A1 jumpers are floating when starting the program for the first time. To leave A0 or A1 floating, disconnect the shunt attached on A0 and A1; see Figure 9.

Table 4. TMP461-SP Slave Address Options

A1 Connection	A0 Connection	Slave Address (Hex)
GND	GND	48
GND	Float	49
GND	V+	4A
Float	GND	4B
Float	Float	4C
Float	V+	4D
V+	GND	4E
V+	Float	4F
V+	V+	50

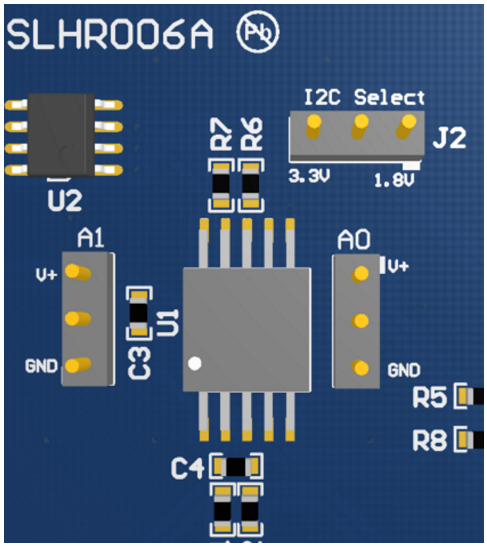


Figure 9. Slave Address Connections (A0, A1)

4 TMP461EVM-CVAL Software Setup

4.1 Operating Systems for the TMP461EVM Software

This section discusses how to install the TMP461EVM software.

The TMP461EVM-CVAL software is tested on the Microsoft Windows 7 operating system (OS) with United States and European regional settings. The software also functions on other Windows operating systems.

4.2 TMP461EVM-CVAL Software Installation

The TMP461EVM-CVAL software is available through the TMP461EVM-CVAL product folder on the TI website. Download the software to your system and locate the compressed file (*TMP461EVM-CVAL.zip*) . Using WinZIP®, or a similar file compression program, extract the TMP461EVM-CVAL files into a specific TMP461EVM-CVAL folder (for example, *C:\TMP461-SP\TMP461EVM-CVAL*) on your hard drive.

When the files are extracted, navigate to the TMP461EVM-CVAL folder you created on your hard drive. Locate the *setup.exe* file and execute it to start the installation. The TMP461EVM software installer then begins the installation process, as shown in Figure 10.

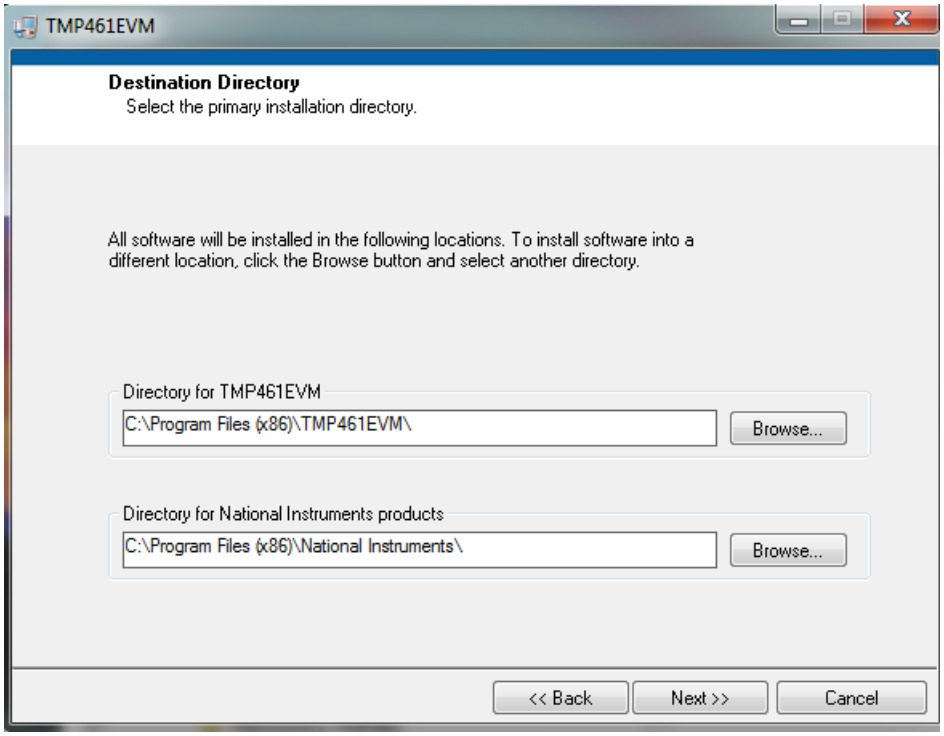


Figure 10. TMP461EVM-CVAL Software Install Window

After the install initializes, the user is given the choice of selecting the directory to install the program, typically defaulting to *C:\Program Files\TMP461EVM* and *C:\Program Files\National Instruments*. Following this option, two license agreements are presented that must be accepted, as shown in Figure 11. After accepting the TI and National Instruments license agreements, the progress bar opens and shows the installation of the software. When the installation process is completed, click **Finish**.

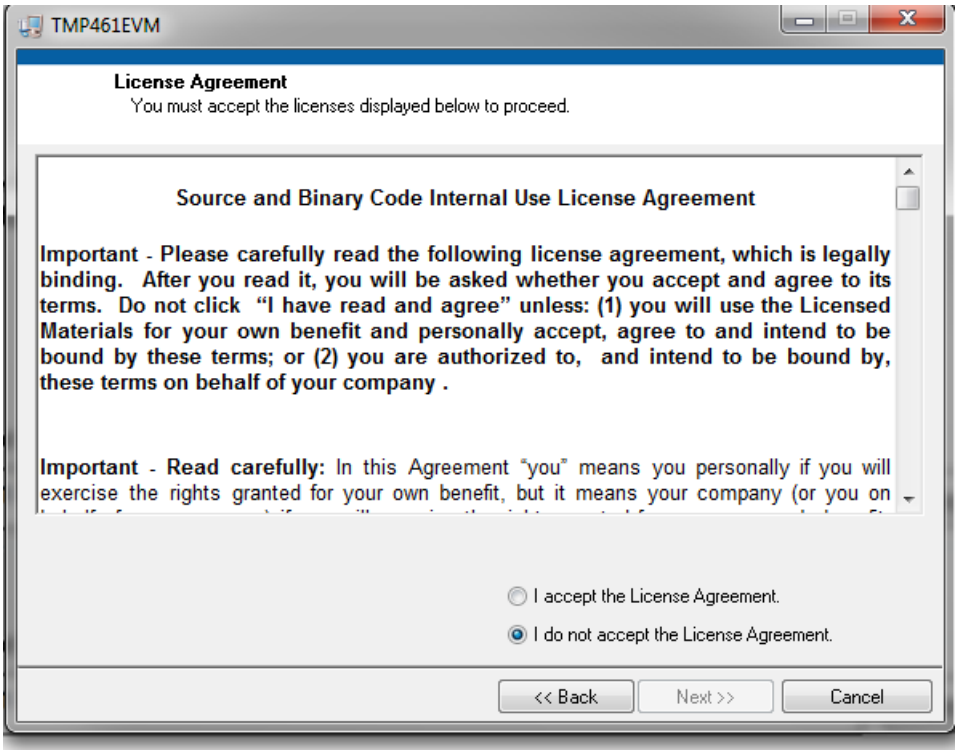


Figure 11. TMP461EVM-CVAL License Agreements

4.3 Starting the TMP461EVM Software

This section discusses how to use the TMP461EVM software.

The TMP461EVM software can be operated through the *Start* menu in Windows. From the *Start* menu, select *All Programs*, highlight the *TMP461* folder, and then select the *TMP461EVM* program. Figure 12 shows how the software appears if the TMP461EVM is functioning properly.

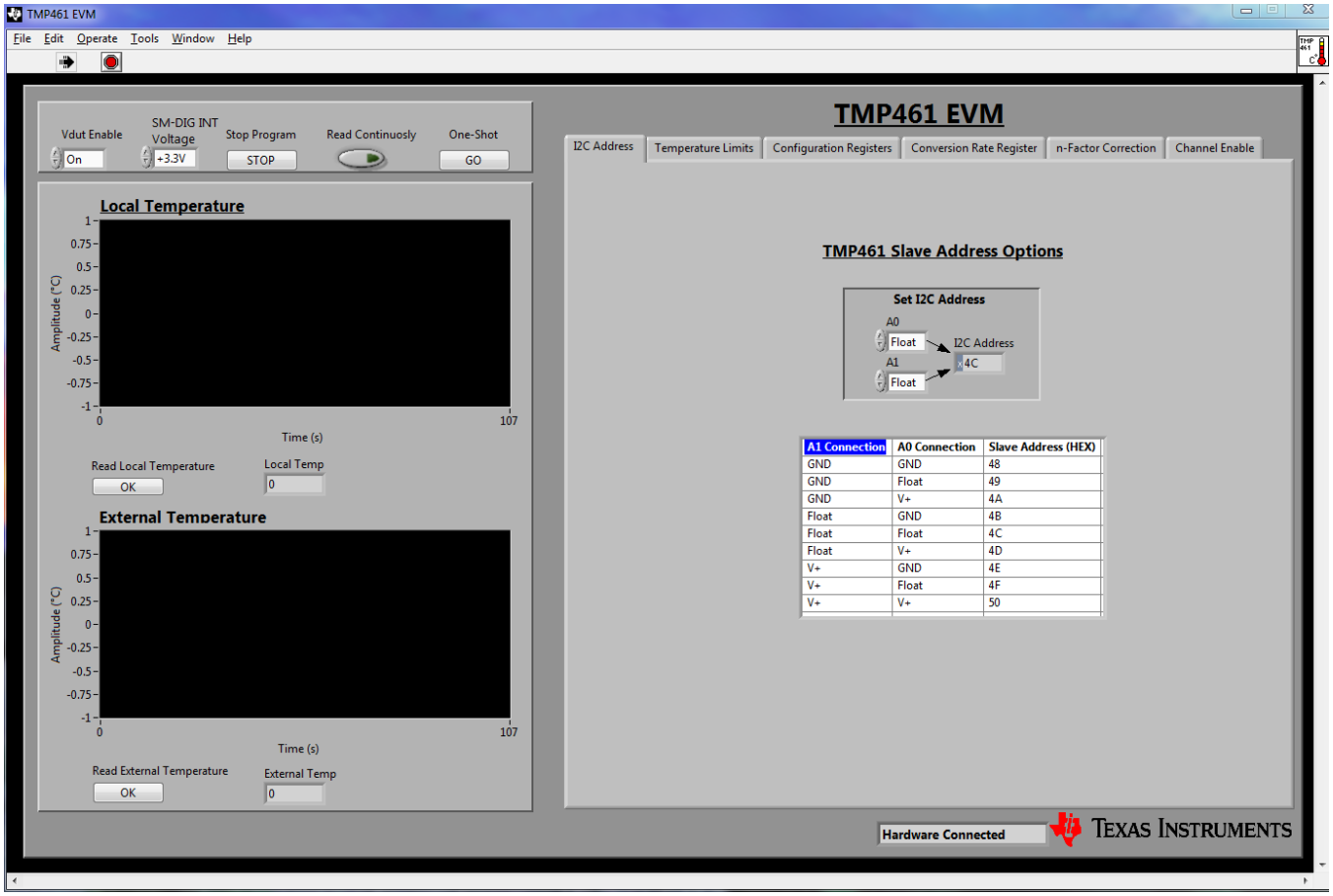


Figure 12. TMP461EVM Software Interface

Figure 13 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.

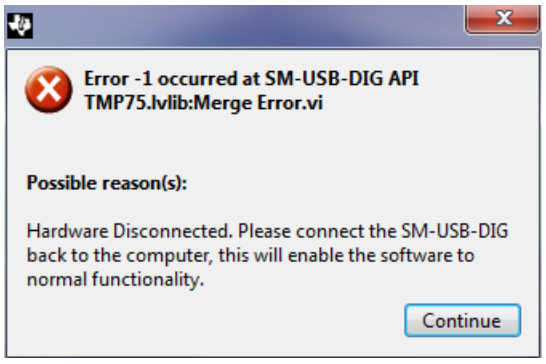


Figure 13. Communication Error With the USB DIG Platform

4.4 Using the TMP461EVM Software

4.4.1 Reading from Registers

When first starting the TMP461EVMsoftware, it is advised that the user confirm connections to the board by toggling the **Read Continuously** button shown in Figure 14. Also, the TMP461-SP default slave address is 4C (hex). The user must ensure that the A0 and A1 jumpers are floating when starting the program for the first time. If all devices are communicating correctly, the user should be able to see temperature change over time in the TMP461-SP local temperature box.

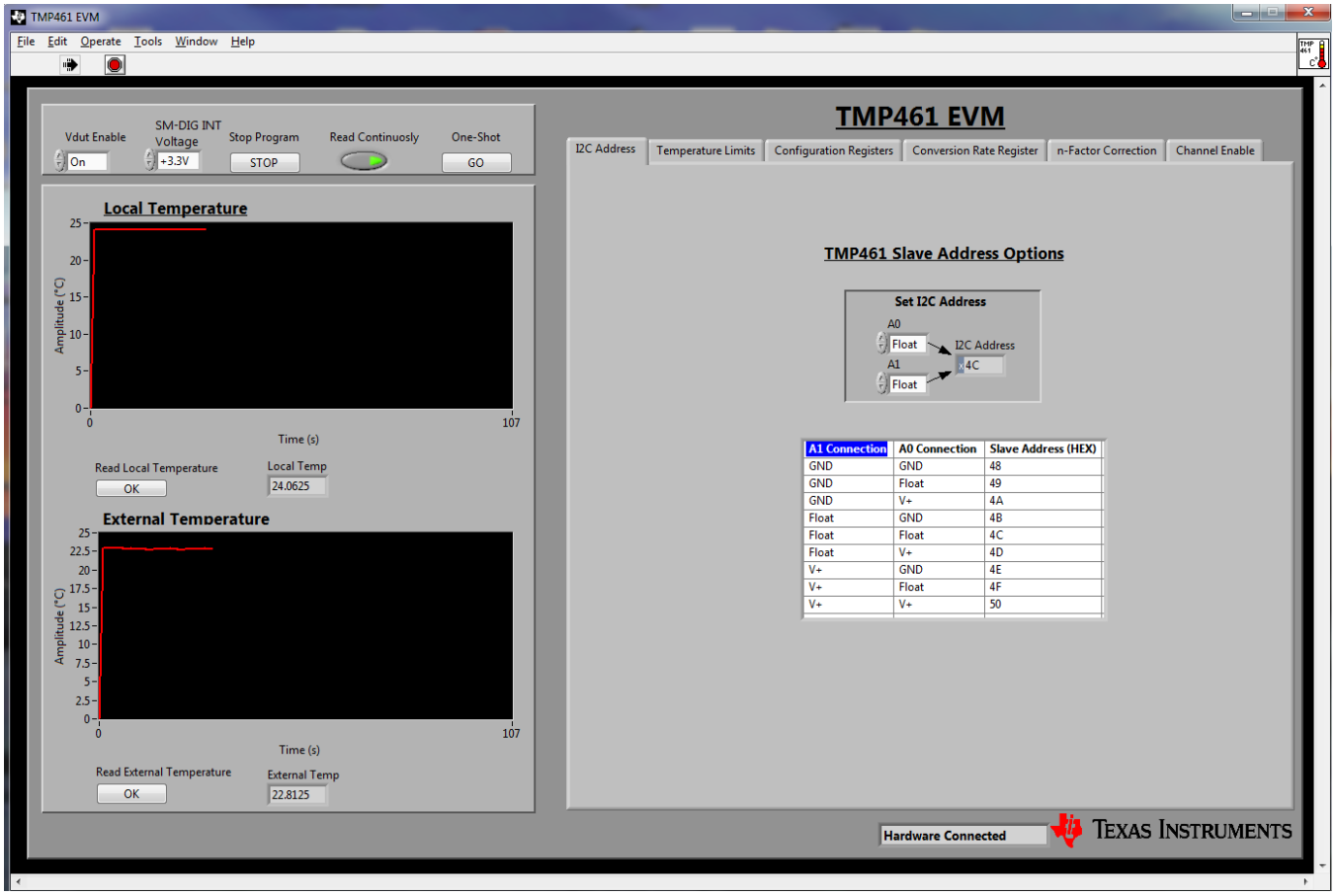
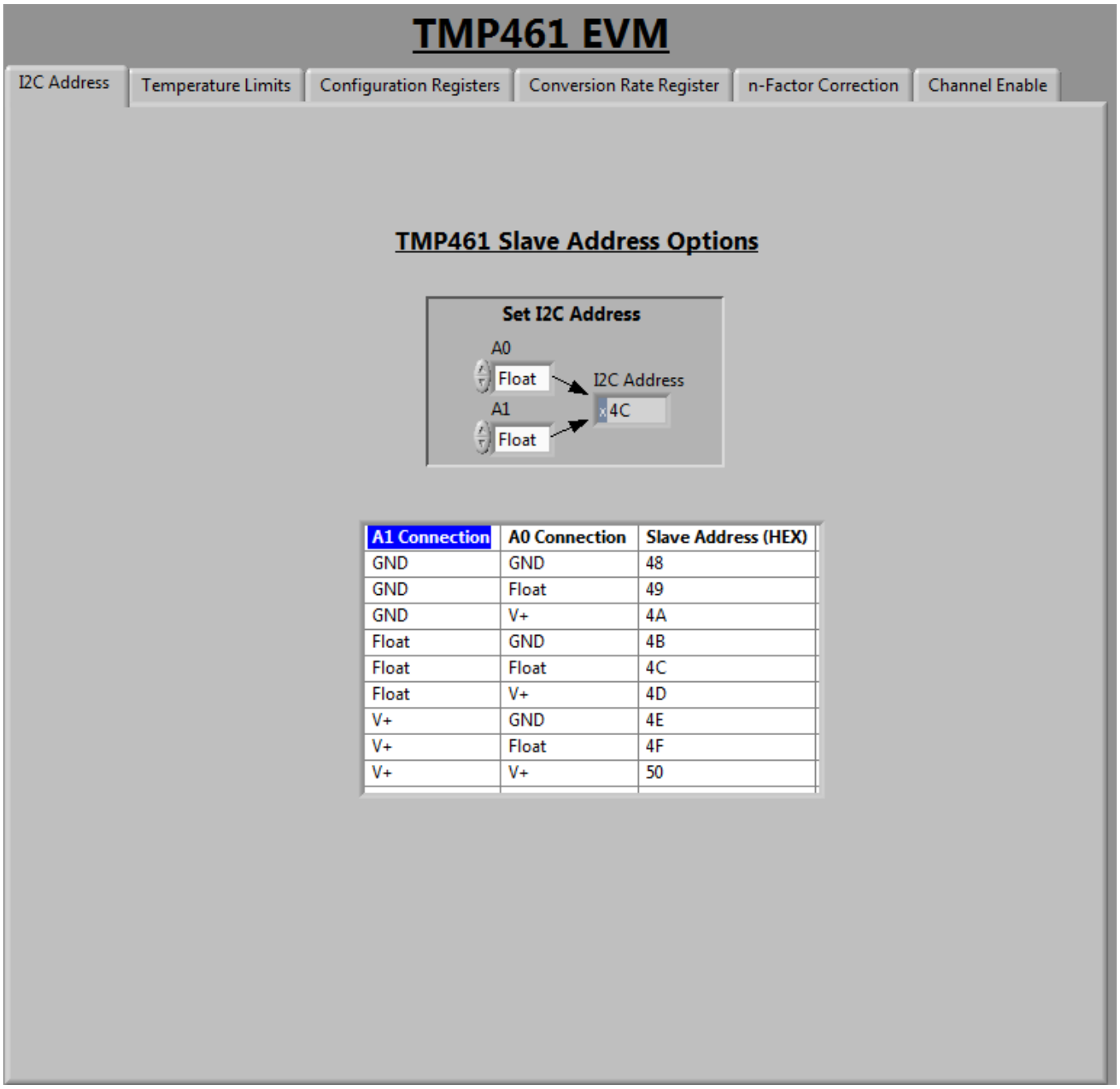


Figure 14. TMP461-SP Read Continuously

4.4.2 I2C Address Tab

The first tab on the TMP461EVM software is the *I2C Address* tab, as shown in Figure 15. In this tab, the slave address can be set for the TMP461-SP. Select the slave address needed and make sure A0 and A1 are connected according on the TMP461EVM-CVAL hardware board.



A1 Connection	A0 Connection	Slave Address (HEX)
GND	GND	48
GND	Float	49
GND	V+	4A
Float	GND	4B
Float	Float	4C
Float	V+	4D
V+	GND	4E
V+	Float	4F
V+	V+	50

Figure 15. I2C Address Tab

4.4.3 Temperature ALERT and THERM Limits

The second tab on the TMP461EVM software is the *Temperature Limits* tab. In this tab, the ALERT and THERM limits can be read or set for the TMP461-SP. 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 16.

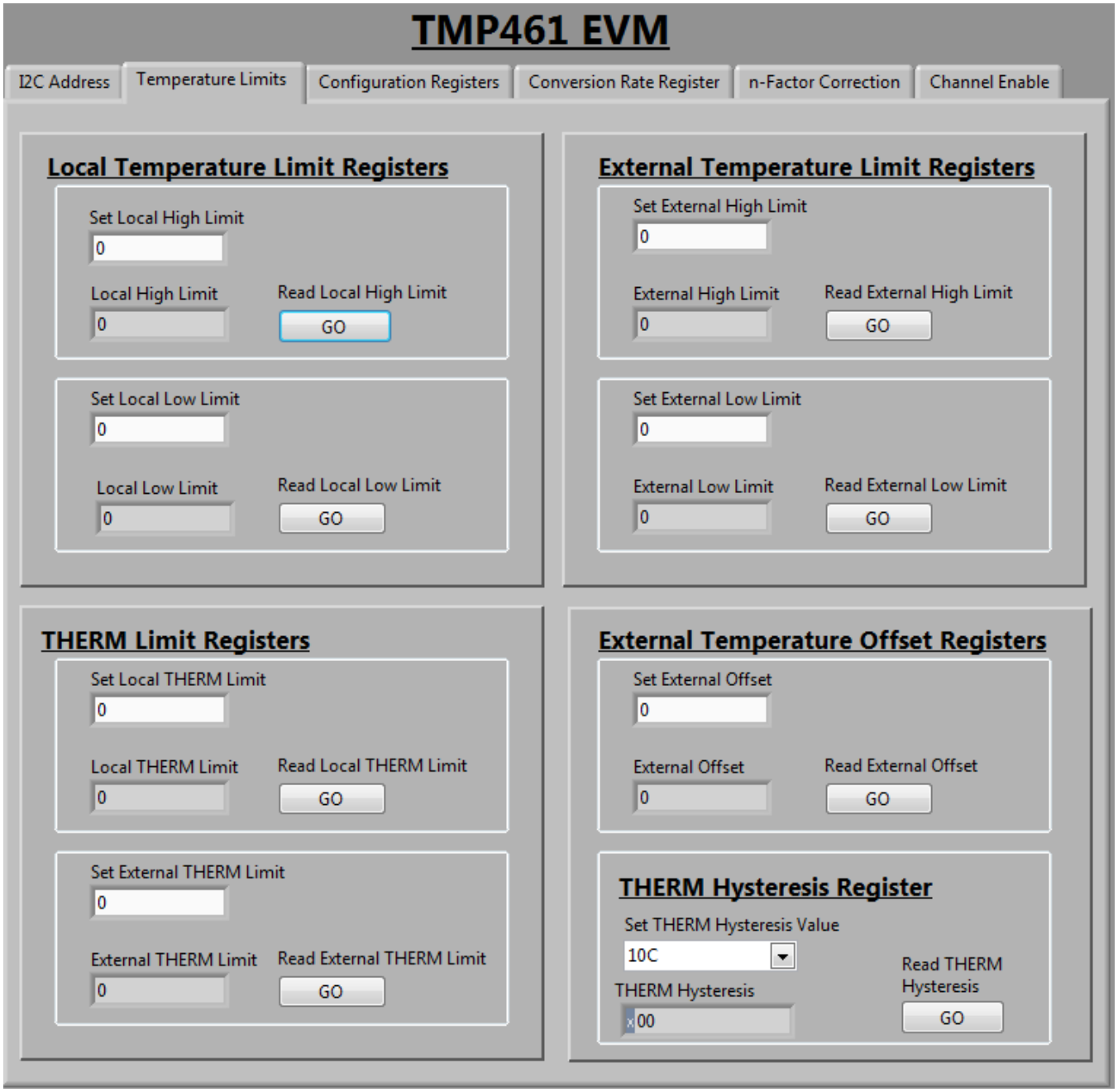


Figure 16. Temperature Limits Tab

4.4.4 Configuration Registers Tab

The TMP461EVM 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 MASK1 bit masks the ALERT pin when enabled. R/S stands for RUN/STOP; when enabled, this bit sets the TMP461-SP to standby. AL/TH stands for ALERT/THERM2. When this bit is enabled, ALERT becomes a second THERM. The TRange bit switches the TMP461-SP from its normal temperature range of 0°C to 127°C to its extended temperature range of –64°C to 191°C. For the consecutive alert register, the SMBus bit enables a 30-ms timeout and bits 1 to 3 determine how many out-of-limit measurements are needed to trigger an ALERT. Figure 17 shows the *Configuration Registers* tab in the TMP461EVM software; see *TMP461-SP Radiation Tolerant Remote and Local Digital Temperature Sensor* for more information. The status register reports the state of the temperature ADC, the temperature limit comparators, and the connection to the remote sensor. The status register is read-only and is read by accessing pointer address 02h; see *TMP461-SP Radiation Tolerant Remote and Local Digital Temperature Sensor* for status register bit descriptions.

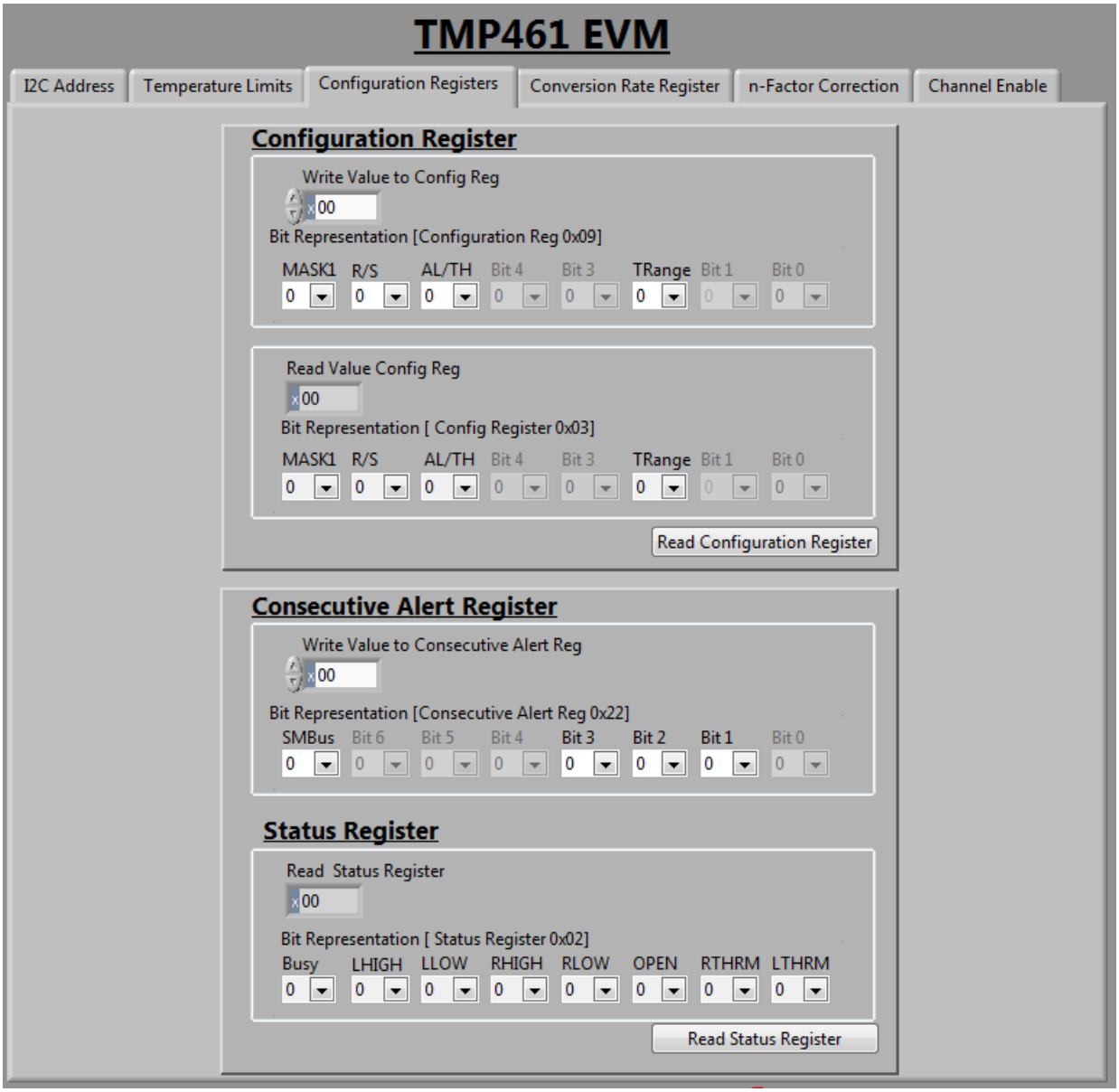


Figure 17. TMP461-SP Configuration Registers Tab

4.4.5 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 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 four samples (level 1) or eight samples (level 2).

Table 5. Conversion Rate Register Codes

Value	Conversions per Second	Time (Seconds)
00h	0.0625	16
01h	0.125	8
02h	0.25	4
03h	0.5	2
04h	1	1
05h	2	0.5
06h	4	0.25
07h	8	0.125
08h	16	0.0625 (default)
09h	32	0.03125

4.4.6 n-Factor Correction Tab

The TMP461-SP allows for a different n-factor value for converting remote channel measurements to temperature. Table 6 shows the n-factor correction register codes.

Table 6. n-Factor Correction Register Codes

Binary	Hex	Decimal	N
01111111	7F	127	0.950198
00001010	0A	10	1.003195
00001000	08	8	1.004152
00000110	06	6	1.005111
00000100	04	4	1.006072
00000010	02	2	1.007035
00000001	01	1	1.007517
00000000	00	0	1.008
11111111	FF	–1	1.008483
11111110	FE	–2	1.008967
11111100	FC	–4	1.009935
11111010	FA	–6	1.010905
11111000	F8	–8	1.011877
11110110	F6	–10	1.012851
10000000	80	–128	1.073837

4.4.7 Channel Enable Tab

The TMP461EVM software contains a tab for the channel enable register. Changing values in this register automatically writes them. The channel enable register (read address 16h, write address 16h) enables or disables the temperature conversion of remote and local temperature sensors. LEN (bit 0) of the channel enable register enables and disables the conversion of local temperatures. REN (bit 1) of the channel enable register enables and disables the conversion of remote temperatures. Both LEN and REN are set to 1 (default), which enables the ADC to convert both local and remote temperatures. If LEN is set to 0, the local temperature conversion is disabled and, similarly, if REN is set to 0 the remote temperature conversion is disabled. Figure 18 shows the *Channel Enable Register* tab in the TMP461EVM software; see *TMP461-SP Radiation Tolerant Remote and Local Digital Temperature Sensor* for more information.

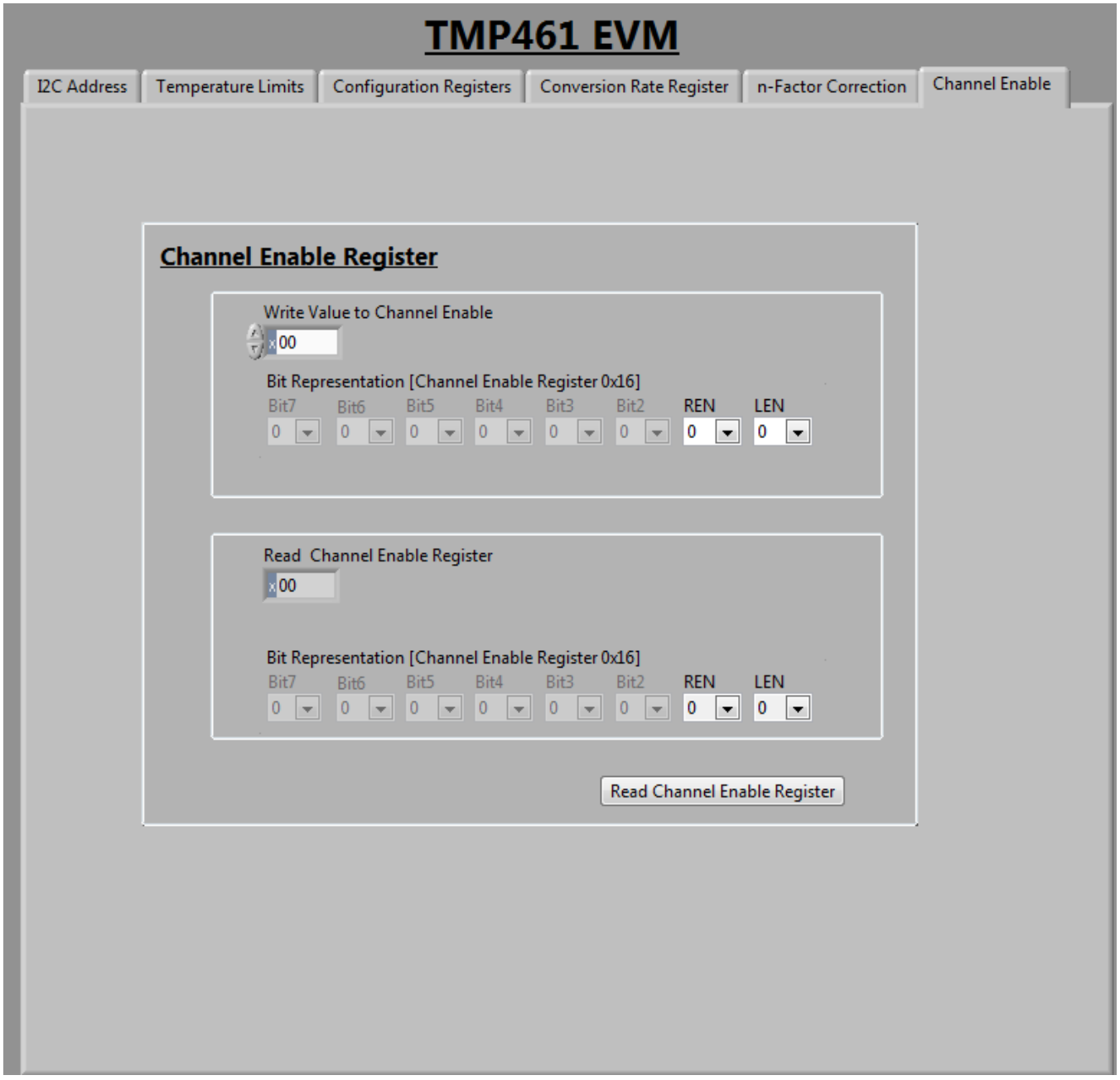


Figure 18. TMP461-SP Channel Enable Register Tab

4.4.8 Reading the Temperature Gauge

The temperature box on the TMP461EVM software displays the measured values of the TMP461-SP device local temperature and external temperature registers in a graphical format, as shown in Figure 19. These values are displayed in Celsius. A continuous reading can be displayed by toggling the *read continuously* control.

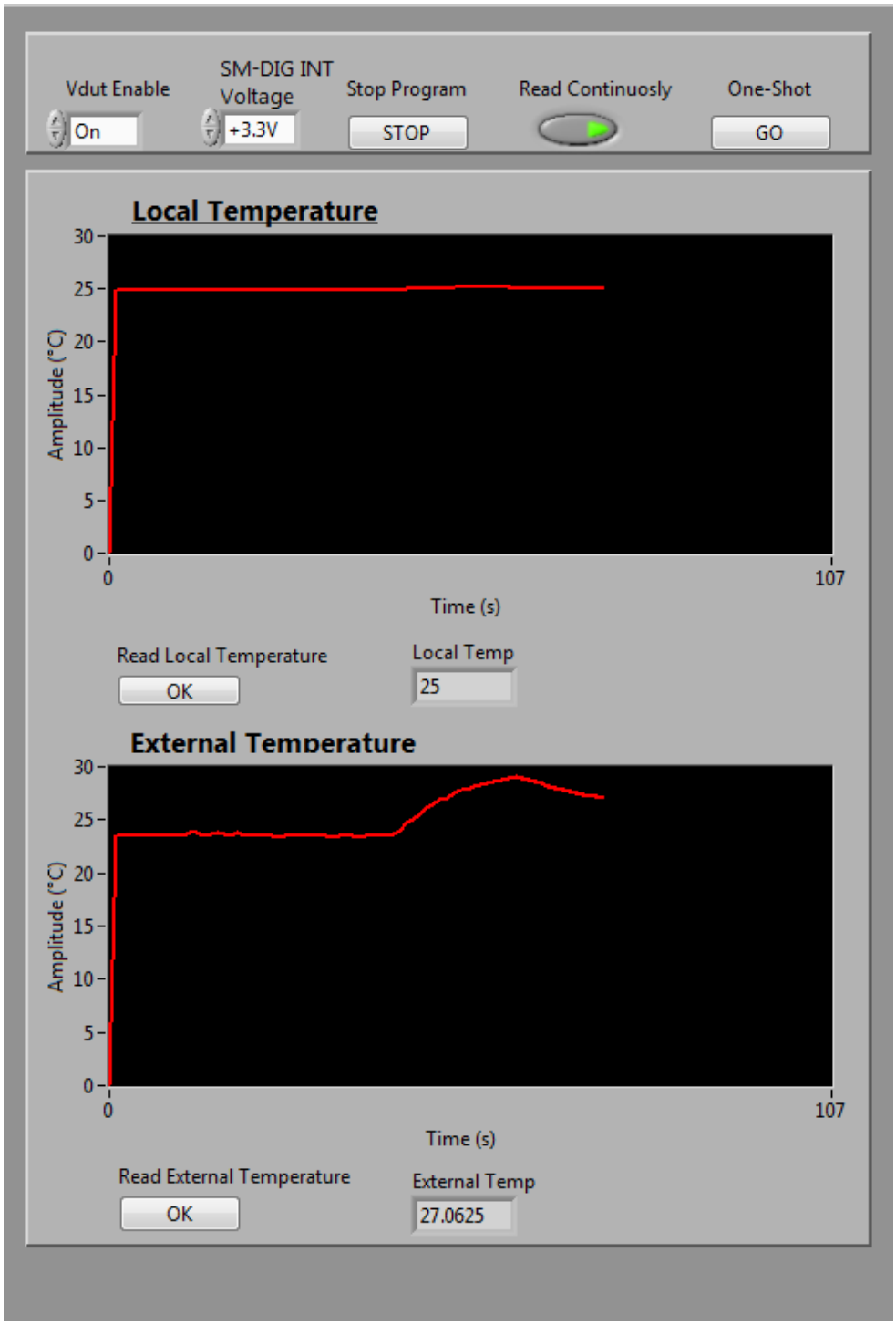


Figure 19. Reading the Temperature Gauge

5 TMP461EVM-CVAL Documentation

5.1 TMP461EVM-CVAL Board Schematic

This section contains the complete bill of materials and schematic diagram for the TMP461EVM-CVAL. Documentation information for the SM-USB-DIG platform is found in *SM-USB-DIG Platform*, available at the TI website at www.ti.com.

Figure 20 shows the schematic for the TMP461EVM-CVAL board.

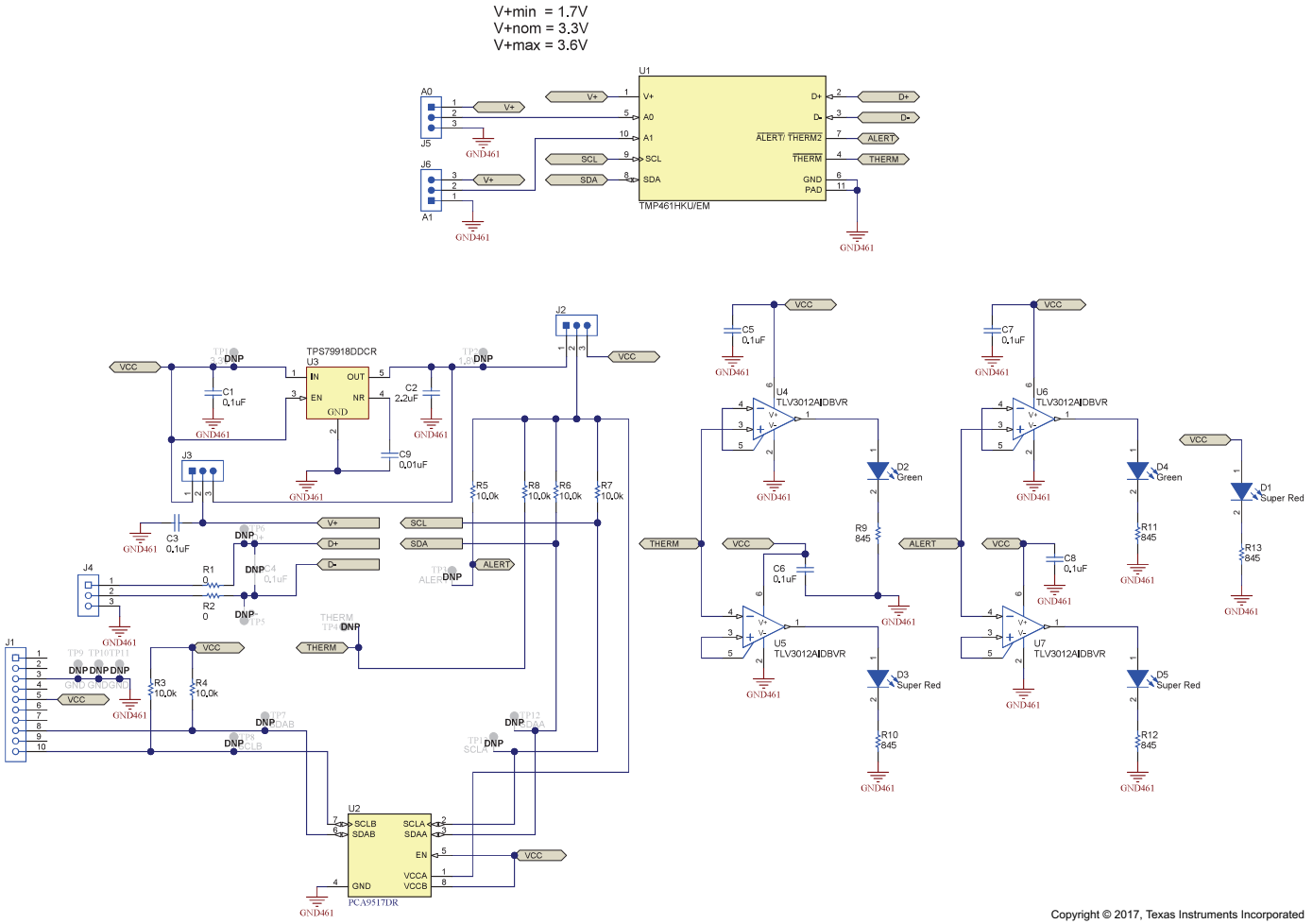


Figure 20. TMP461EVM-CVAL Board Schematic

5.2 TMP461EVM-CVAL PCB Components Layout

Figure 21 shows the layout of the components for the TMP461EVM-CVAL board.

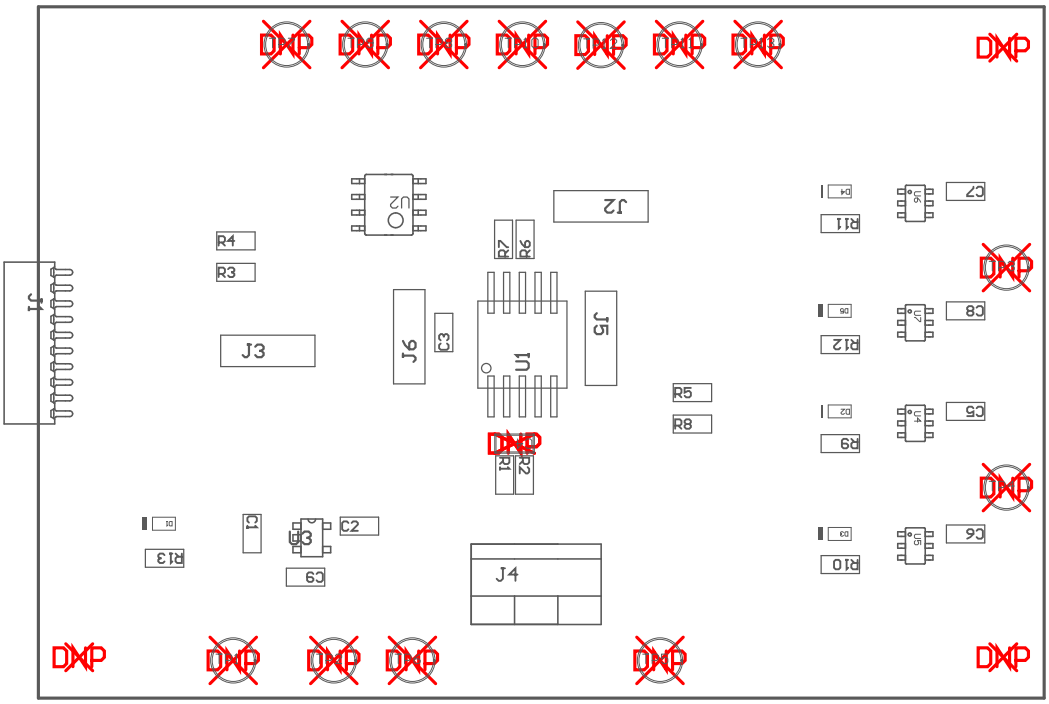


Figure 21. TMP461EVM-CVAL Components Layout

5.3 TMP461EVM-CVAL Bill of Materials

Table 7 lists the bill of materials for the TMP461EVM-CVAL test board.

Table 7. TMP461-EVM-CVAL Test Board Bill of Materials(1)

Designator	Qty	Value	Description	Package Reference	Part Number	Manufacturer	Alternate Part Number	Alternate Manufacturer
!PCB	1		Printed Circuit Board		SLHR006	Any		
C1, C3, C5, C6, C7, C8	6	0.1uF	CAP, CERM, 0.1 uF, 16 V, ±5%, X7R, 0603	0603	0603YC104JAT2A	AVX		
C2	1	2.2uF	CAP, CERM, 2.2 uF, 10 V, ±10%, X5R, 0603	0603	C0603C225K8PACTU	Kemet		
C9	1	0.01uF	CAP, CERM, 0.01 uF, 100 V, ±5%, X7R, 0603	0603	06031C103JAT2A	AVX		
D1, D3, D5	3	Super Red	LED, Super Red, SMD	LED, 1.6x.6x.8mm	SML-LX0603SRW-TR	Lumex		
D2, D4	2	Green	LED, Green, SMD	0603 LED	SM0603GCL	Bivar		
H1, H2, H3, H4	4		Bumpon, Hemisphere, 0.44 X 0.20, Clear	Transparent Bumpon	SJ-5303 (CLEAR)	3M		
H6	1		TRANS NPN 40V 0.2A TO92	Used in PnP output	2N3904-AP	Micro Commercial	-	-
J1	1		Receptacle, 50mil, 10x1, Gold, R/A, TH	receptacle 10x1, 50mil	851-43-010-20-001000	Mill-Max		
J2, J3, J5, J6	4		Header, 100mil, 3x1, TH	Header, 3x1, 100mil, TH	800-10-003-10-001000	Mill-Max		
J4	1		Terminal Block, 3.5mm Pitch, 3x1, TH	10.5x8.2x6.5mm	ED555/3DS	On-Shore Technology		
R1, R2	2	0	RES, 0, 5%, 0.1 W, 0603	0603	CRCW06030000Z0EA	Vishay-Dale		
R3, R4, R5, R6, R7, R8	6	10.0k	RES, 10.0 k, 1%, 0.1 W, 0603	0603	CRCW060310K0FKEA	Vishay-Dale		
R9, R10, R11, R12, R13	5	845	RES, 845, 1%, 0.1 W, 0603	0603	RC0603FR-07845RL	Yageo America		
U1	1		Space Grade High-Accuracy Remote and Local Temperature Sensor with Pin-Programmable Bus Address, HKU0010A (CFP-10)	HKU0010A	TMP461HKU/EM	Texas Instruments		Texas Instruments
U2	1		Level-Translating I2C Bus Repeater, 2 Channel Width, 0.9 to 5.5 V, -40 to 85 degC, 8-pin SOIC (D), Green (RoHS & no Sb/Br)	D0008A	PCA9517DR	Texas Instruments	Equivalent	None
U3	1		Single Output High PSRR LDO, 200 mA, Fixed 1.8 V Output, 2.7 to 6.5 V Input, with Low IQ, 5-pin SOT (DDC), -40 to 85 degC, Green (RoHS & no Sb/Br)	DDC0005A	TPS79918DDCR	Texas Instruments		
U4, U5, U6, U7	4		Nanopower, 1.8V, SOT23 Push-Pull Comparator with Voltage Reference, DBV0006A (SOT-23-6)	DBV0006A	TLV3012AIDBVR	Texas Instruments	TLV3012AIDBVT	Texas Instruments
C4	0	0.1uF	CAP, CERM, 0.1 uF, 16 V, ±5%, X7R, 0603	0603	0603YC104JAT2A	AVX		
FID1, FID2, FID3	0		Fiducial mark. There is nothing to buy or mount.	Fiducial	N/A	N/A		
H5	0		USB A MALE TO MICRO B MALE 6'	Used in PnP output	AE9934-ND	Assmann	-	-
TP1, TP2	0		Test Point, Multipurpose, Red, TH	Red Multipurpose Testpoint	5010	Keystone		
TP3, TP4, TP5, TP6, TP7, TP8, TP12, TP13	0		Test Point, Multipurpose, White, TH	White Multipurpose Testpoint	5012	Keystone		
TP9, TP10, TP11	0		Test Point, Multipurpose, Black, TH	Black Multipurpose Testpoint	5011	Keystone		

(1) Unless otherwise noted in the *Alternate Part Number* or *Alternate Manufacturer* columns, all parts may be substituted.

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.

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.

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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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東京都新宿区西新宿６丁目２４番１号

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3.4 *European Union*

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

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

4 *EVM Use Restrictions and Warnings:*

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

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

4.3 *Safety-Related Warnings and Restrictions:*

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

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

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

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

6. *Disclaimers:*

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

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

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

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.

   8.2 *Specific Limitations.* IN NO EVENT SHALL TI'S AGGREGATE LIABILITY FROM ANY USE OF AN EVM PROVIDED HEREUNDER, INCLUDING FROM ANY WARRANTY, INDEMITY OR OTHER OBLIGATION ARISING OUT OF OR IN CONNECTION WITH THESE TERMS, , EXCEED THE TOTAL AMOUNT PAID TO TI BY USER FOR THE PARTICULAR EVM(S) AT ISSUE DURING THE PRIOR TWELVE (12) MONTHS WITH RESPECT TO WHICH LOSSES OR DAMAGES ARE CLAIMED. THE EXISTENCE OF MORE THAN ONE CLAIM SHALL NOT ENLARGE OR EXTEND THIS LIMIT.

9. *Return Policy.* Except as otherwise provided, TI does not offer any refunds, returns, or exchanges. Furthermore, no return of EVM(s) will be accepted if the package has been opened and no return of the EVM(s) will be accepted if they are damaged or otherwise not in a resalable condition. If User feels it has been incorrectly charged for the EVM(s) it ordered or that delivery violates the applicable order, User should contact TI. All refunds will be made in full within thirty (30) working days from the return of the components(s), excluding any postage or packaging costs.

10. *Governing Law:* These terms and conditions shall be governed by and interpreted in accordance with the laws of the State of Texas, without reference to conflict-of-laws principles. User agrees that non-exclusive jurisdiction for any dispute arising out of or relating to these terms and conditions lies within courts located in the State of Texas and consents to venue in Dallas County, Texas. Notwithstanding the foregoing, any judgment may be enforced in any United States or foreign court, and TI may seek injunctive relief in any United States or foreign court.

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