

# TMP103EVM

This user's guide describes the characteristics, operation, and use of the TMP103EVM evaluation board. It provides a detailed description of the hardware design. It discusses how to set up and configure the evaluation module (EVM) software, and reviews the hardware and various aspects of the software operation. This document 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 TMP103EVM. Throughout this document, the terms *evaluation board*, *evaluation module*, and *EVM* are synonymous with the TMP103EVM.

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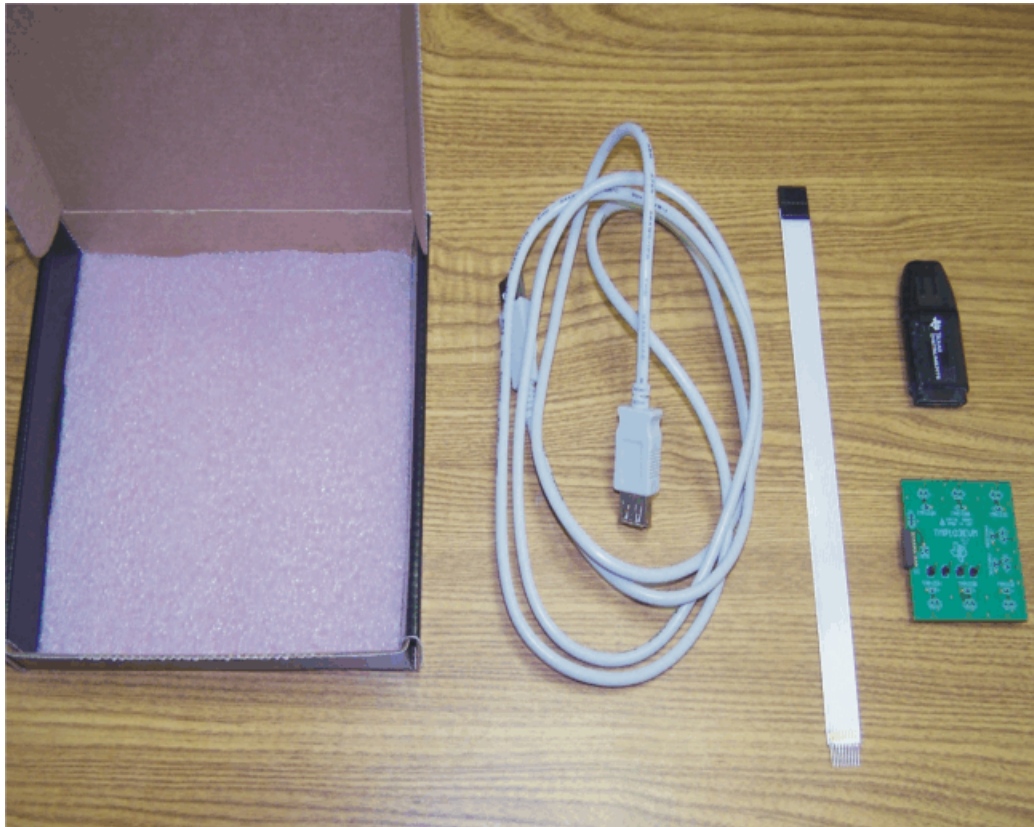
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## 1 Overview

The [TMP103](#) is a digital output temperature sensor capable of reading temperatures to 1°C resolution. The TMP103 uses a two-wire I<sup>2</sup>C™ and SMBus interface that supports global commands. These global commands allow the user to communicate with up to eight TMP103 devices on the bus without having to send individual addresses. The TMP103 is ideal for environments with constrained space or power-sensitive applications. The TMP103 is also specified to operate between -40°C and +125°C.

### 1.1 TMP103EVM Kit Contents

[Figure 1](#) illustrates the typical hardware included the TMP103EVM. [Table 1](#) details the contents of the TMP103EVM kit, Contact the [Texas Instruments Product Information Center \(PIC\)](#) nearest you if any component is missing. It is highly recommended that you check the TI web site at <http://www.ti.com> to verify that you have the latest versions of the related software.



**Figure 1. Typical Hardware Included with the TMP103EVM Kit**

**Table 1. TMP103EVM Kit Contents**

Item	Quantity
TMP103 PCB Test Board	1
SM-USB-DIG Platform PCB	1
USB Cable Extender	1
10-pin Connector Ribbon Cable Extender	1
User's Guide CD	1

## 1.2 If You Need Assistance

If you have questions about the TMP103EVM, contact the Linear Amplifiers Applications Team at [precisionamps@list.ti.com](mailto:precisionamps@list.ti.com). Include *TMP103EVM* as the subject heading.

## 1.3 Related Documentation

The following documents provide information regarding Texas Instruments integrated circuits used in the assembly of the TMP103EVM. This user's guide is available from the TI web site under literature number **SBOU099**. 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 web site 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 2. Related Documentation**

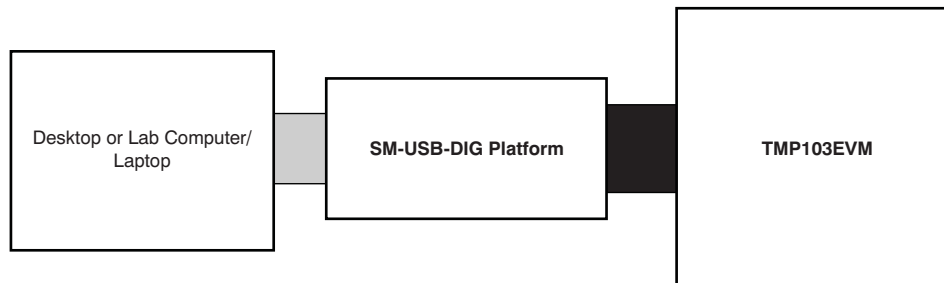
Document	Literature Number
TMP103 Product Data Sheet	<a href="#">SBOS545</a>
SM-USB-DIG Platform User's Guide	<a href="#">SBOU098</a>

## 1.4 FCC Warning

This equipment is intended for use in a laboratory test environment only. It generates, uses, and can radiate radio frequency energy and has not been tested for compliance with the limits of computing devices pursuant to subpart J of part 15 of FCC rules, which are designed to provide reasonable protection against radio frequency interference. Operation of this equipment in other environments may cause interference with radio communications, in which case the user at his own expense is required to take whatever measures may be required to correct this interference.

## 2 System Setup

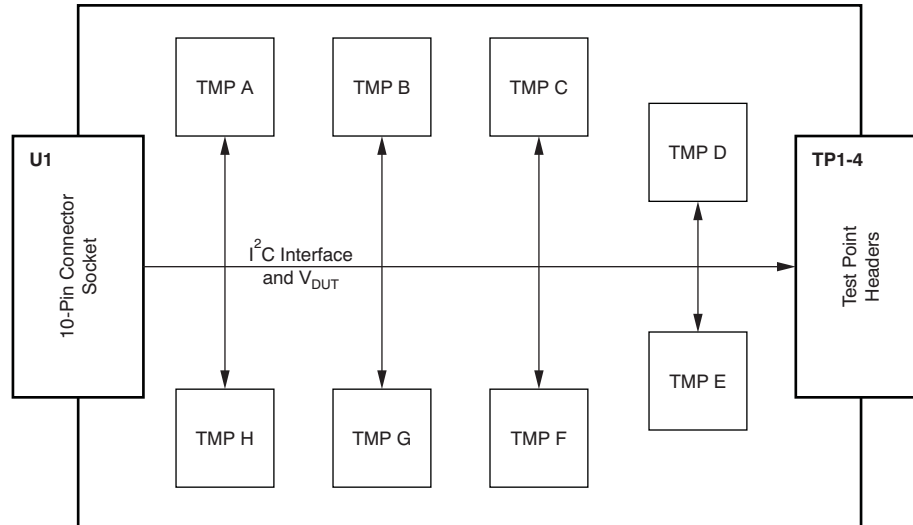
The TMP103EVM hardware consists of the SM-USB-DIG Platform and the TMP103EVM; these units are easily connected through a 10-pin board-to-board connector that should be attached to the SM-USB-DIG and TMP103EVM PCBs. Once these two boards are connected, simply plug the USB device from the SM-DIG into the computer as shown in [Figure 2](#).



**Figure 2. TMP103EVM Hardware Setup**

### 3 Theory of Operation

The TMP103EVM is very modest in its design, and only requires the two-wire I<sup>2</sup>C lines (SDA and SCLK) and  $V_{DUT}/GND$  to supply a constant 3.3V and power return, as shown in Figure 3. The TMP103EVM also has several test points to monitor these signal lines, and ground, in case users may want to use their own signals or verify I<sup>2</sup>C communications.



**Figure 3. TMP103 Test Board Block Diagram**

#### 3.1 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 TMP103EVM and the SM-USB-DIG. It should be noted that the TMP103EVM only uses the necessary I<sup>2</sup>C communication lines (Pins 1 and 3) and the  $V_{DUT}$  and GND (Pins 6 and 8) pins to issue commands to the TMP103 sensors.

**Table 3. Pin Connector**

Pin on U1	Signal	Description
1	I2C_SCL	I <sup>2</sup> C clock signal (SCL)
2	CTRL/MEAS4	GPIO: Control output or measure input
3	I2C_SDA1	I <sup>2</sup> C data signal (SDA)
4	CTRL/MEAS5	GPIO: Control output or measure input
5	SPI_DOUT1	SPI data output (MOSI)
6	$V_{DUT}$	Switchable DUT power supply: +3.3V, +5V, Hi-Z (disconnected). <sup>(1)</sup>
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)

<sup>(1)</sup> When  $V_{DUT}$  is Hi-Z, all digital I/Os are Hi-Z as well.

### 3.2 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 Texas Instruments' evaluation modules. The details of its operation are included in a separate document (SBOU098, available for download at [www.ti.com](http://www.ti.com)). The block diagram in Figure 4 is presented as a brief overview of the Platform.

The core of the SM-USB-DIG Platform is the TUSB3210, an 8052 microcontroller ( $\mu\text{C}$ ) that has a built-in USB interface. The microcontroller receives information from the host computer that it translates into I<sup>2</sup>C, SPI, or 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 then sent back to the PC where it is interpreted by the host computer.

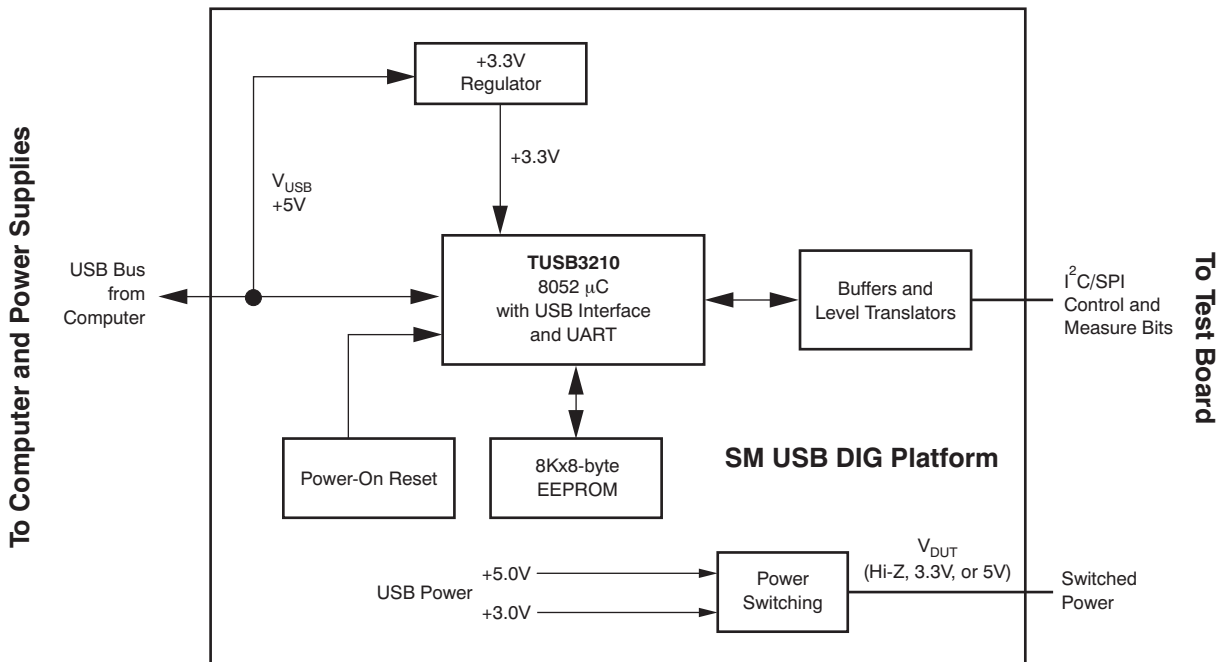


Figure 4. SM-USB-DIG Platform Block Diagram

## 4 TMP103EVM Hardware Overview

### 4.1 Electrostatic Discharge Warning

#### CAUTION

Many of the components on the TMP103EVM 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.

### 4.2 Connecting the Hardware

To connect the TMP103 Test Board 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.

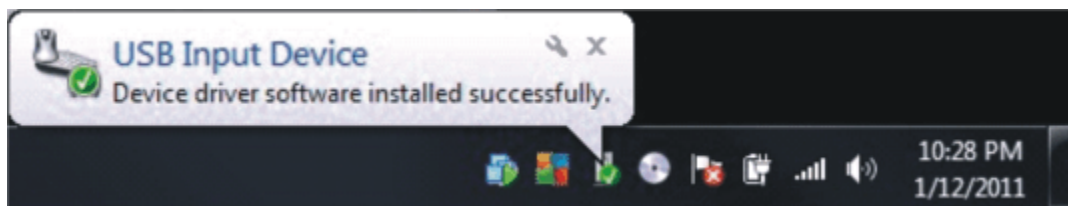
### 4.3 Connecting the USB Cable to the SM-USB-DIG Platform

Figure 5 depicts the USB cable connected to the SM-USB-DIG Platform. Be careful when inserting the connectors.



**Figure 5. Connecting the USB Cable to the SM-USB-DIG Platform**

Figure 6 shows the typical system response when the SM-USB-DIG Platform board connects to a PC USB port for the first time. Typically, the computer will respond with a *Found New Hardware, USB Device* pop-up dialog. The pop-up window then generally changes to *Found New Hardware, USB Human Interface Device*. This pop-up screen 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.



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

## 4.4 TMP103EVM Features

This section describes some of the hardware features present on the TMP103 test board.

### 4.4.1 Populating 0Ω Resistors

The TMP103 test board contains 0Ω resistors (R1 to R16) that connect the individual TMP103 sensors to the I<sup>2</sup>C bus lines. When these resistors are populated, they become available for communication in general calls. If the 0Ω resistors are not populated for certain TMP103 devices on the board, they are not able to communicate with the software or receive any external I<sup>2</sup>C commands. Leaving the resistors unpopulated could be useful if one of the TMP103 units becomes damaged or fewer than eight TMP103s are populated.

### 4.4.2 Multiple TMP103 Sensors

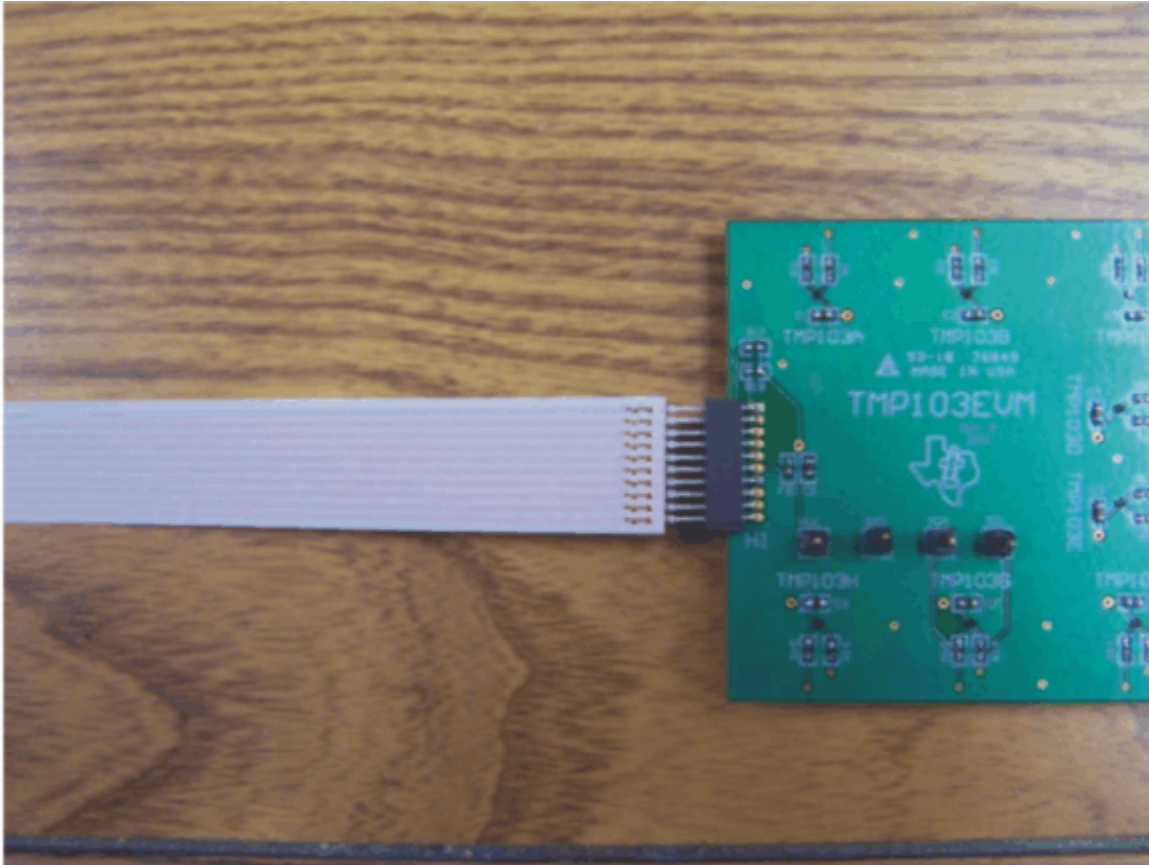
The TMP103EVM board was designed to take advantage of the I<sup>2</sup>C general call described in the TMP103 product data sheet. This feature allows the software to communicate with all the TMP103s simultaneously without requiring individual commands with separate pointer addresses to the sensors. The maximum number of sensors on the TMP103 test board is eight; all devices have separate hardware address, so a board of eight populated TMP103 devices requires eight different part types. For assignment of the pointer addresses and a more detailed description, consult the [TMP103 product data sheet](#).

### 4.4.3 I<sup>2</sup>C Test Points

I<sup>2</sup>C test points are included on the TMP103 test board for user convenience. These test points can be used to monitor the two-wire lines of the I<sup>2</sup>C interface or to run the TMP103 test board externally without the use of the SM-USB-DIG.

#### 4.4.4 Optional 10-Pin Connector Ribbon Extender

The TMP103EVM kit ships with an optional ribbon cable to extend the connection between the SM-USB-DIG and the TMP103EVM PCB. This cable can be useful if high temperature tests must be run on the test board, because the SM-USB-DIG platform is not rated for high temperatures. To connect the ribbon cable, attach the cable to the EVM and SM-USB-DIG Platform board as shown in [Figure 7](#).



**Figure 7. 10-Pin Ribbon Cable Extender**

## 5 TMP103EVM Software Setup

This section discusses how to install the TMP103EVM software.

### 5.1 Operating Systems Compatibility

The TMP103EVM 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.



## 5.2 TMP103EVM Software Installation

The TMP103EVM software is included on the CD that is shipped with the EVM kit. It is also available through the [TMP103EVM product folder](#) on the TI web site. To download the software to your system, insert the disc into an available CD-ROM drive. Navigate to the drive contents and open the TMP103EVM software folder. Locate the compressed file (*TMP103EVM.zip*) and open it. Using WinZIP® or a similar file compression program, extract the TMP103EVM files into a specific TMP103EVM folder (for example, *C:\TMP103\TMP103EVM*) on your hard drive.

Once the files are extracted, navigate to the TMP103EVM folder you created on your hard drive. Locate the **setup.exe** file and execute it to start the installation. The TMP103 software installer should begin the installation process as shown in [Figure 8](#).

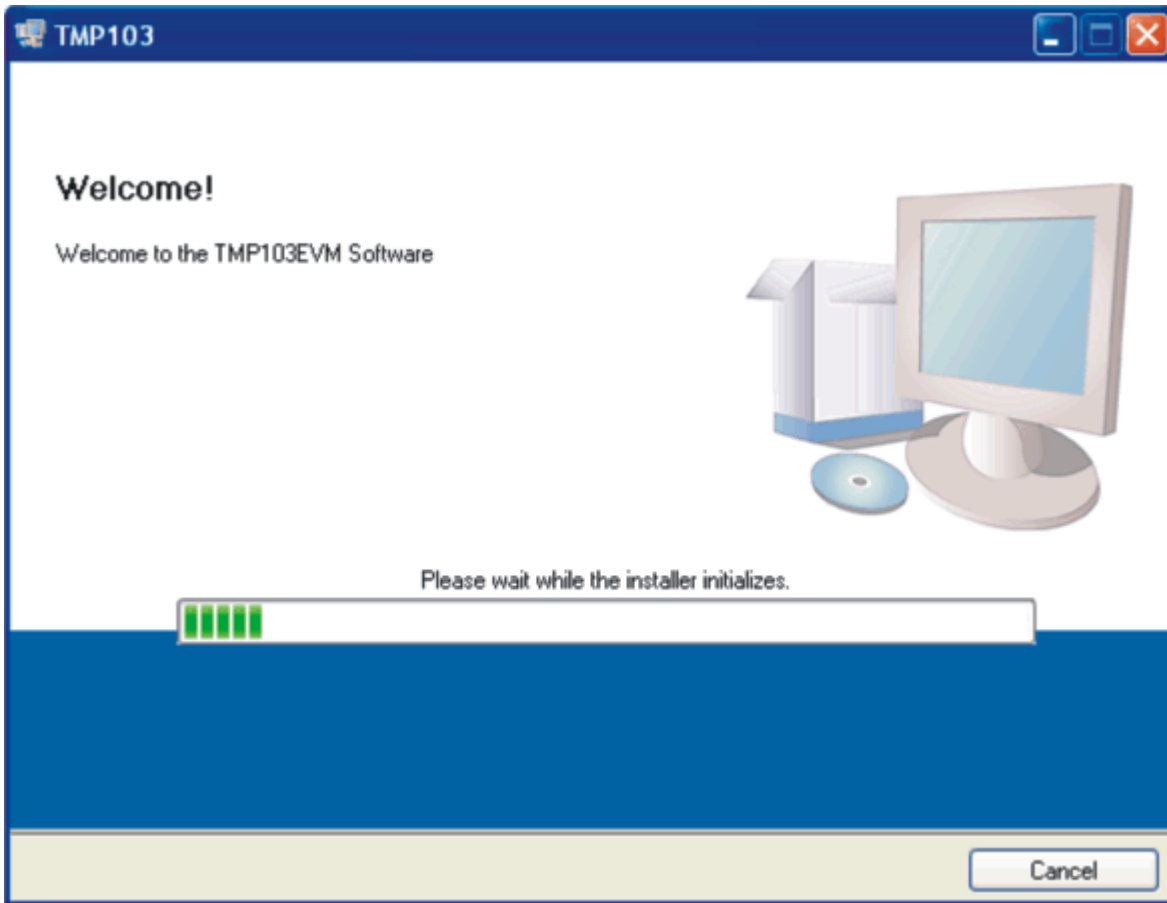
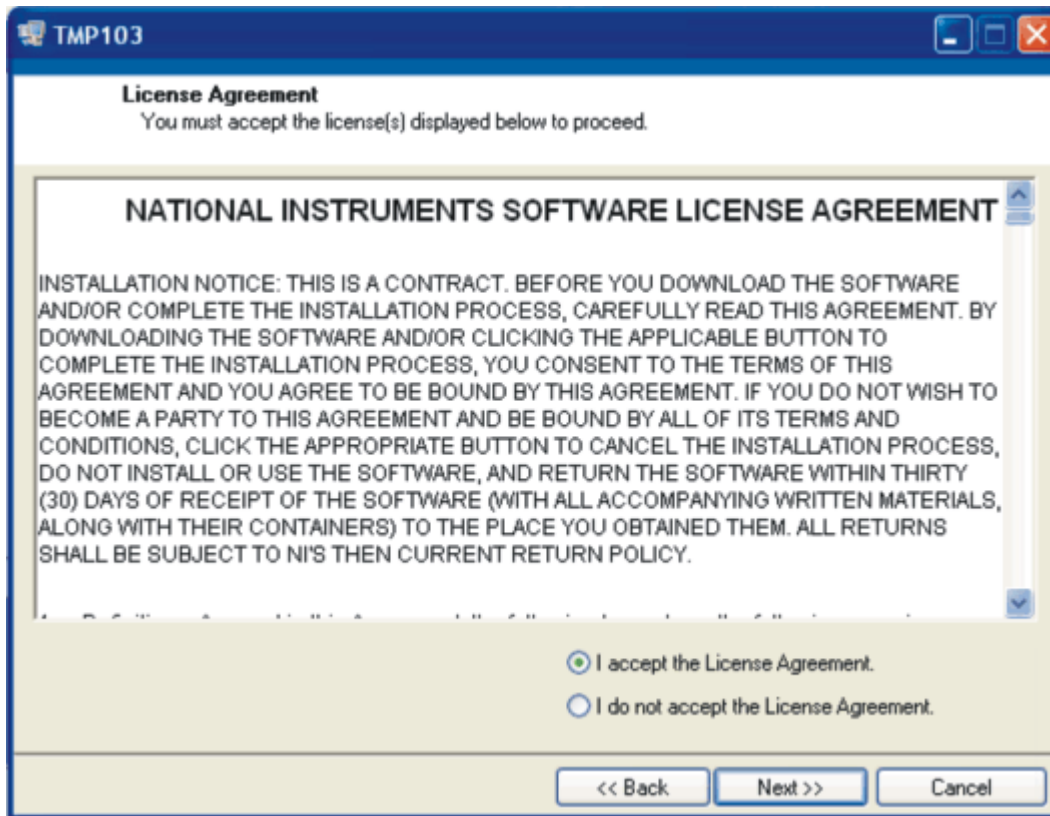


Figure 8. TMP10EVM Software Install Window

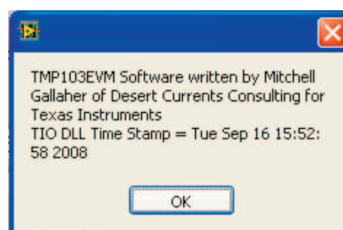
After the installation begins, the user is given the choice of selecting the directory to install the program; usually, it is recommended to default to *C:\Program Files\TMP103EVM* and *C:\Program Files\National Instruments*. Following this option, two license agreements are presented (as shown in [Figure 9](#)) that must be accepted. After accepting both 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 9. TMP103EVM License Agreements**

### 5.3 Software Description and Set-Up

The TMP103EVM software allows the user to monitor temperatures from eight separate TMP103 sensor units. [Figure 10](#) shows the screen that displays when you press the **About** button to verify that you have the latest version of the software.



**Figure 10. TMP103EVM Software About Button**

## 6 TMP103EVM Software Overview

This section discusses how to use the TMP103EVM software.

### 6.1 Starting the TMP103EVM Software

The TMP103EVM software can be operated through the *Start* menu in Windows. From the *Start* menu, select *All Programs*; highlight the TMP103 folder, and then select the TMP103EVM program. Figure 11 illustrates how the software should appear if the TMP103EVM is functioning properly.

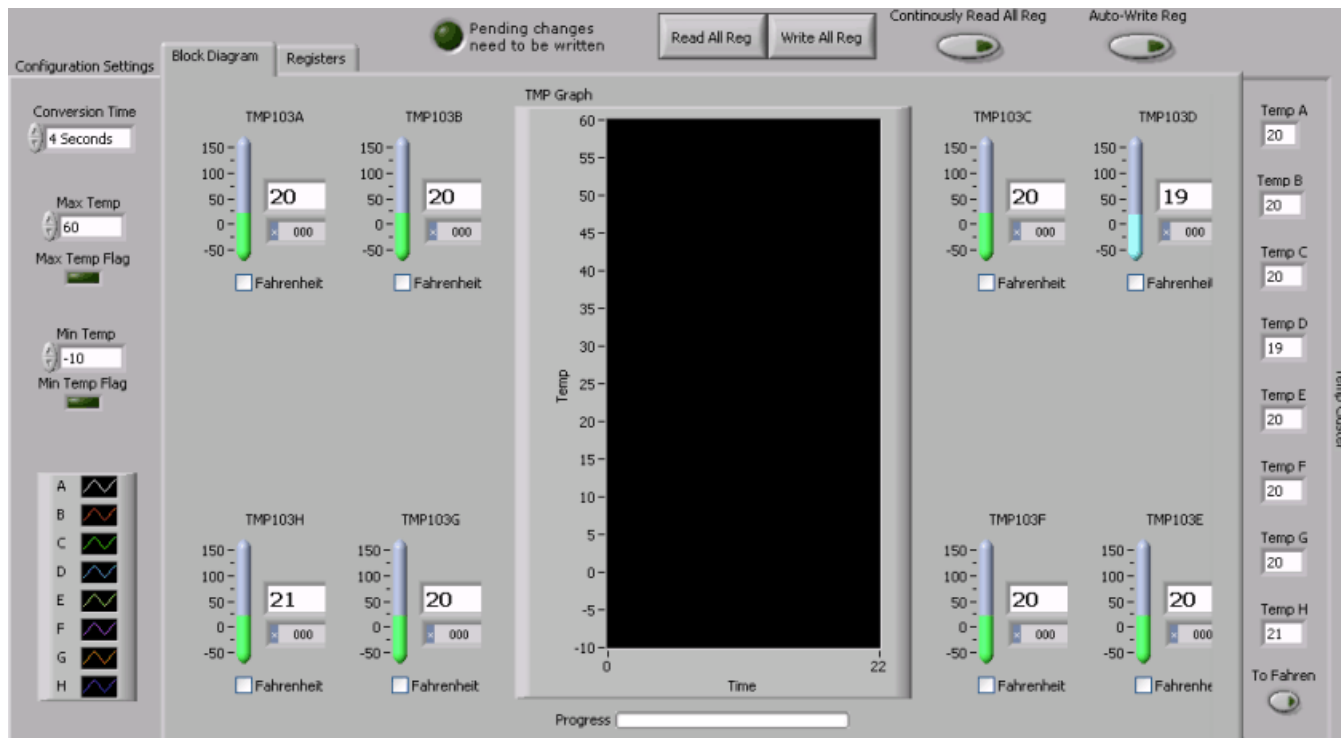


Figure 11. TMP103EVM Software Interface: Proper Operation

Figure 12 shows an error that pops up if the computer cannot communicate with the EVM. If 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 your computer USB Human Interface Device driver. Make sure that the device is recognized when the USB cable is plugged in; recognition is indicated by a Windows-generated confirmation sound.

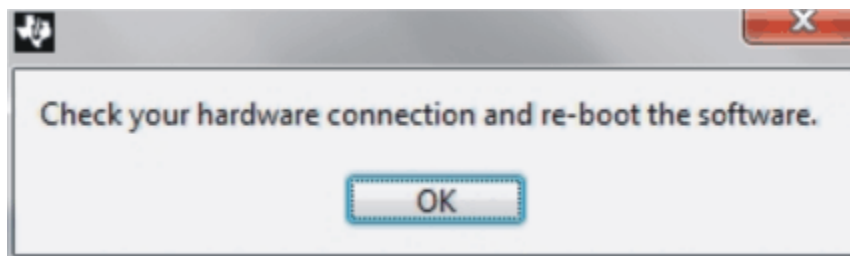


Figure 12. Communication Error with USB DIG Platform

## 6.2 Using the TMP103EVM Software

### 6.2.1 Reading from Registers

When first starting the TMP103EVM software, users are advised to confirm connections to the board by toggling the **Continuously Read All Register** button (highlighted in Figure 13). If all devices are communicating correctly, the user should be able to see temperature change over time in the TMP Graph and the individual TMP103 thermometers. A legend is provided in the Configuration Settings column on the left for the temperature graph; refer to Figure 14.



Figure 13. TMP103EVM Software: Reading from Registers

An alternative method for acquiring data is the **Read All Reg** button, also indicated in Figure 13. This button is useful while the **Auto-Write Reg** button is toggled, or if the user wants to take individual measurements on a non-standard time interval.

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**NOTE:** The user cannot continuously press either the **Read All Registers** or the **Auto-Write Registers** button.

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### 6.2.2 Writing to Registers

The TMP103EVM software contains two different methods for writing data: **Write All Reg** and **Auto-Write Reg**. Individually writing the registers without Auto-Write can be useful when adjusting large numbers of the configuration registers on the left. Also, if the user wishes to change some of the configuration settings on the left while continuously reading registers, he or she will be prompted with a blinking **Write All Registers** button. Until the **Write All Registers** button has been selected, the program stops polling data from the TMP103 sensors. Conversely, the **Auto-Write Registers** feature automatically makes changes to the configuration register whenever one of the configuration settings on the left changes, as indicated in Figure 14.

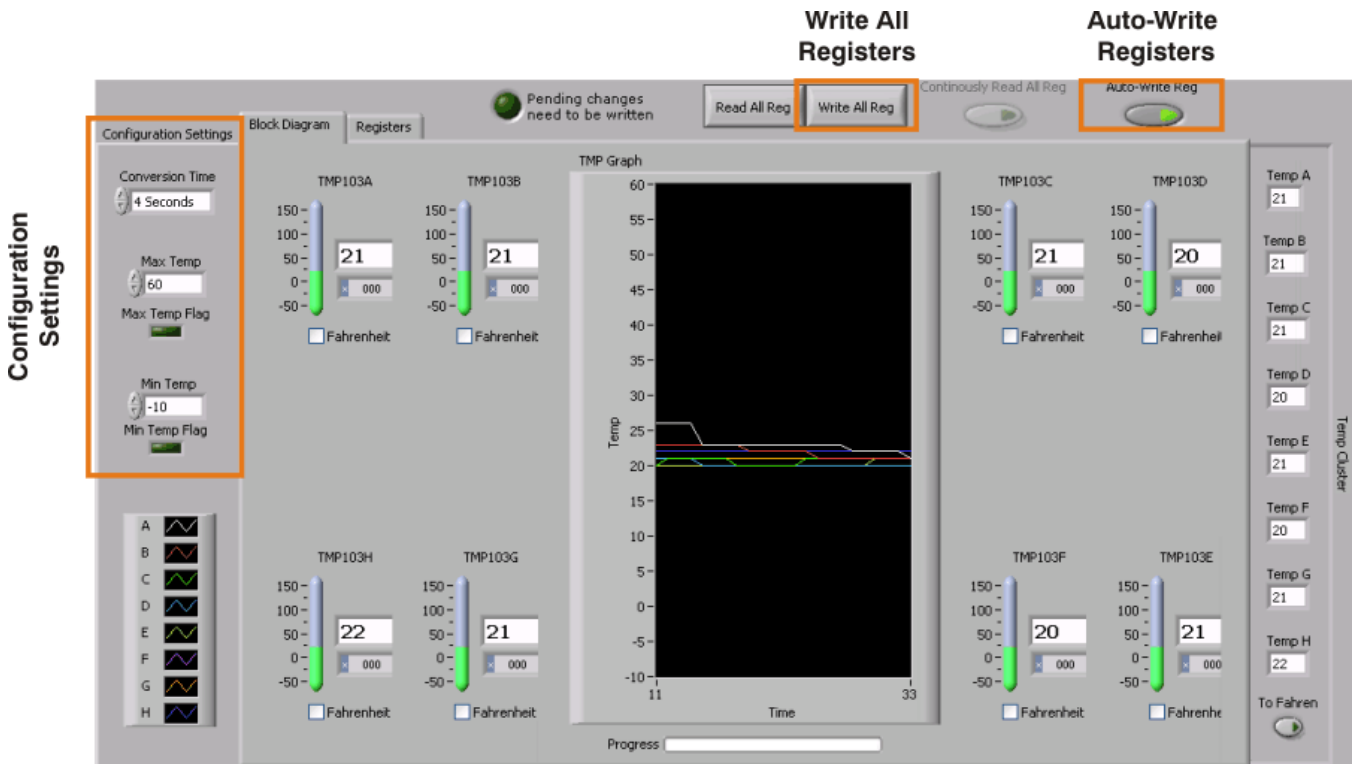


Figure 14. TMP103EVM Software: Writing to Registers

### 6.2.3 Conversion Time

The *Conversion Time* selection box, shown in [Figure 15](#), is used to change the speed at which the TMP103 sensors measure the ambient temperature around them. A user may want to set the conversion speed faster if data must be gathered faster. The user should be aware that increasing the conversion speed also increases the power consumed by the devices. While this increase in power consumption may not cause any issues for the TMP103EVM, users may want to reduce power consumption on certain applications or custom boards. Users should be cautious of this feature.

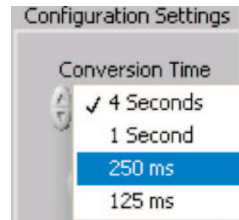


Figure 15. Conversion Time Selection Dialog

### 6.2.4 Max\Min Temp and the Max\Min Temp Flag

The TMP103 sensor has a built-in flag to indicate when a device is measuring temperatures above or below a set range. This flag can be useful to notify the user when ambient temperatures go beyond a desired range. The TMP103 sensor maximum measurable values are from  $-40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ . When a temperature violates the max or min temp flag, the respective temp toggles on and remains on until the temperatures return to the designated range. The TMP103A is shown signaling a flag by violating the max temperature in [Figure 16](#).

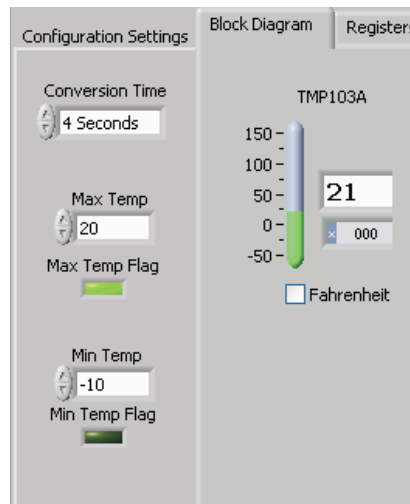


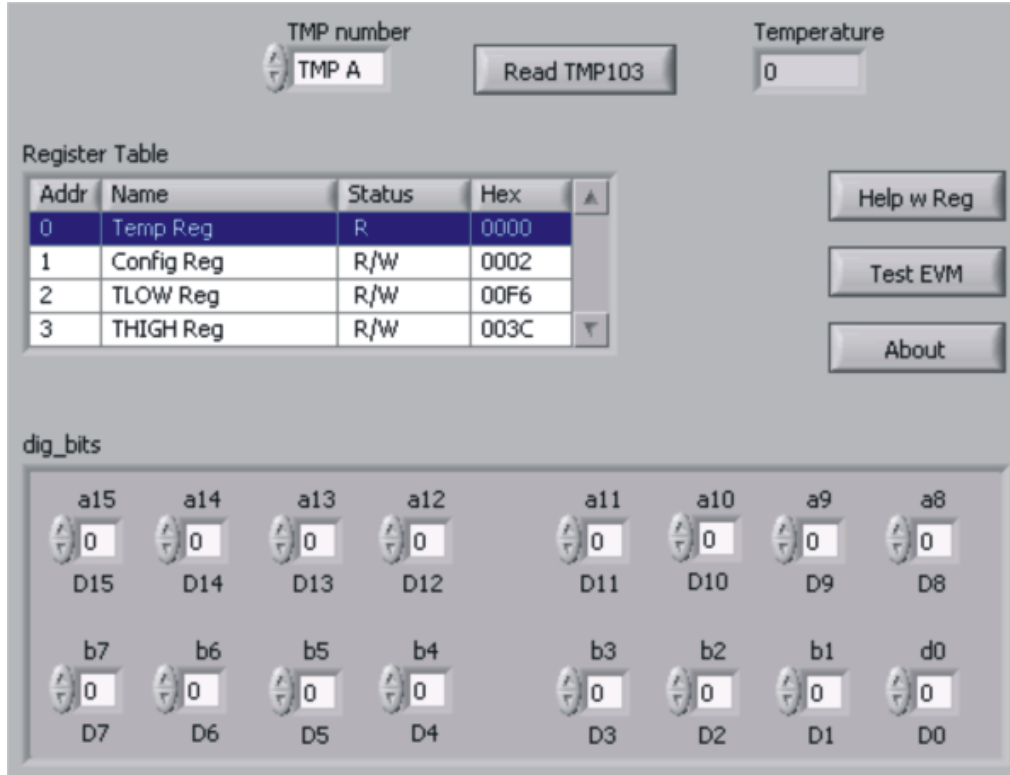
Figure 16. Max Temp Flag Trigger

### 6.2.5 Conversion To Fahrenheit

If the user desires the temperature thermometers to perform measurements in degrees Fahrenheit, this setting can be changed individually by clicking the checkbox beneath the thermometer. If the user desires to change all of these settings at once, simply toggle the **To Fahren** button in the bottom right-hand corner of the software display. See [Figure 13](#).

### 6.2.6 Registers Tab

The Registers tab displays the individual register setting for the TMP103 sensors. It should be noted that the TMP103EVM software keeps all the configuration registers,  $T_{LOW}$  registers, and  $T_{HIGH}$  registers identical. For more information on the individual registers and the bit meanings, simply highlight the desired register and hit the **Help with Reg** button shown in [Figure 17](#).



**Figure 17. TMP103EVM Software: Register Tab**

The Registers tab also includes two other features: the *dig\_bits* table and the individual temp read feature. The *dig\_bits* table allows the user to monitor and change individual bits by highlighting the desired register and toggling the bit controls beneath it.

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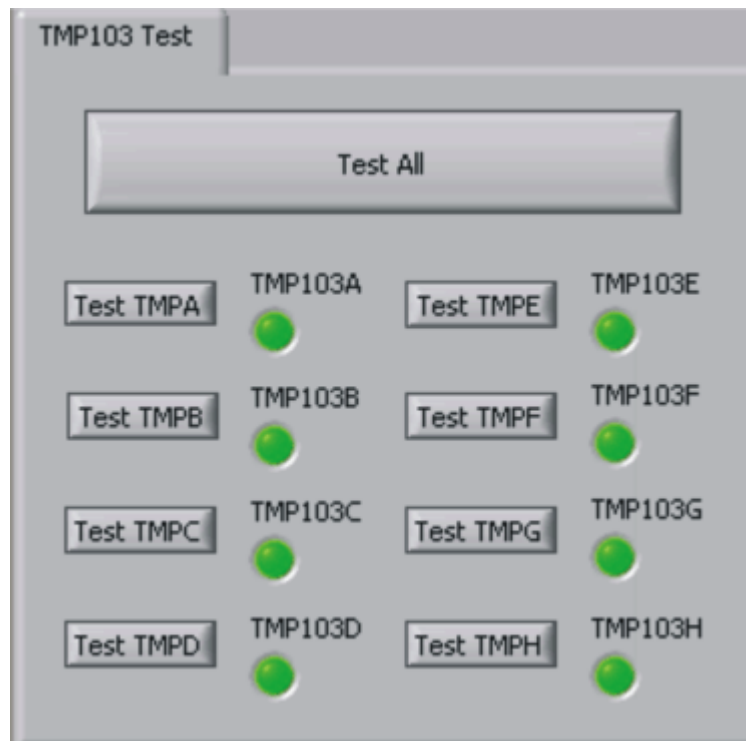
**NOTE:** Only writable register bits can be toggled.

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It is also possible to individually read the temperature sensors on the board using the **Read TMP103** button in the Registers tab. This action yields the same result as the general-call Read All Registers, but does not require the other sensors to be read. The individual read of a TMP sensor is mainly included for reference; it is recommended that the **Read All Reg** button be used when performing evaluations with the TMP103EVM software.

### 6.2.7 Register Tab: Test EVM

The Register tab for the TMP103EVM test software also includes a sub-routine program to verify communication with the TMP103 devices and run the TMP103 test procedures. By clicking on the **Test EVM** button (refer to [Figure 17](#)), a new window appears as shown in [Figure 18](#).



**Figure 18. TMP103EVM Software: Test Procedure**

This secondary program reads each register individually and verifies that the TMP103 sensors produce the required number of *Acknowledges* from the general call and individual communication. To test the general call, use the **Test All** button. To test the sensors individually, use the **Test TMPx** button next to the corresponding LED.



## 7 TMP103EVM Documentation

This section contains the complete bill of materials and a partial schematic diagram for the TMP103EVM. The [complete schematic for the TMP103EVM \(SBOR013\)](#) is available for download through the TI website. Additional documentation for the SM-USB-DIG Platform can be found in the [SM-USB-DIG Platform User's Guide \(SBOU098\)](#) available through the TI website.

### 7.1 TMP103EVM Board Schematic

Figure 19 shows the TMP103EVM board schematic.

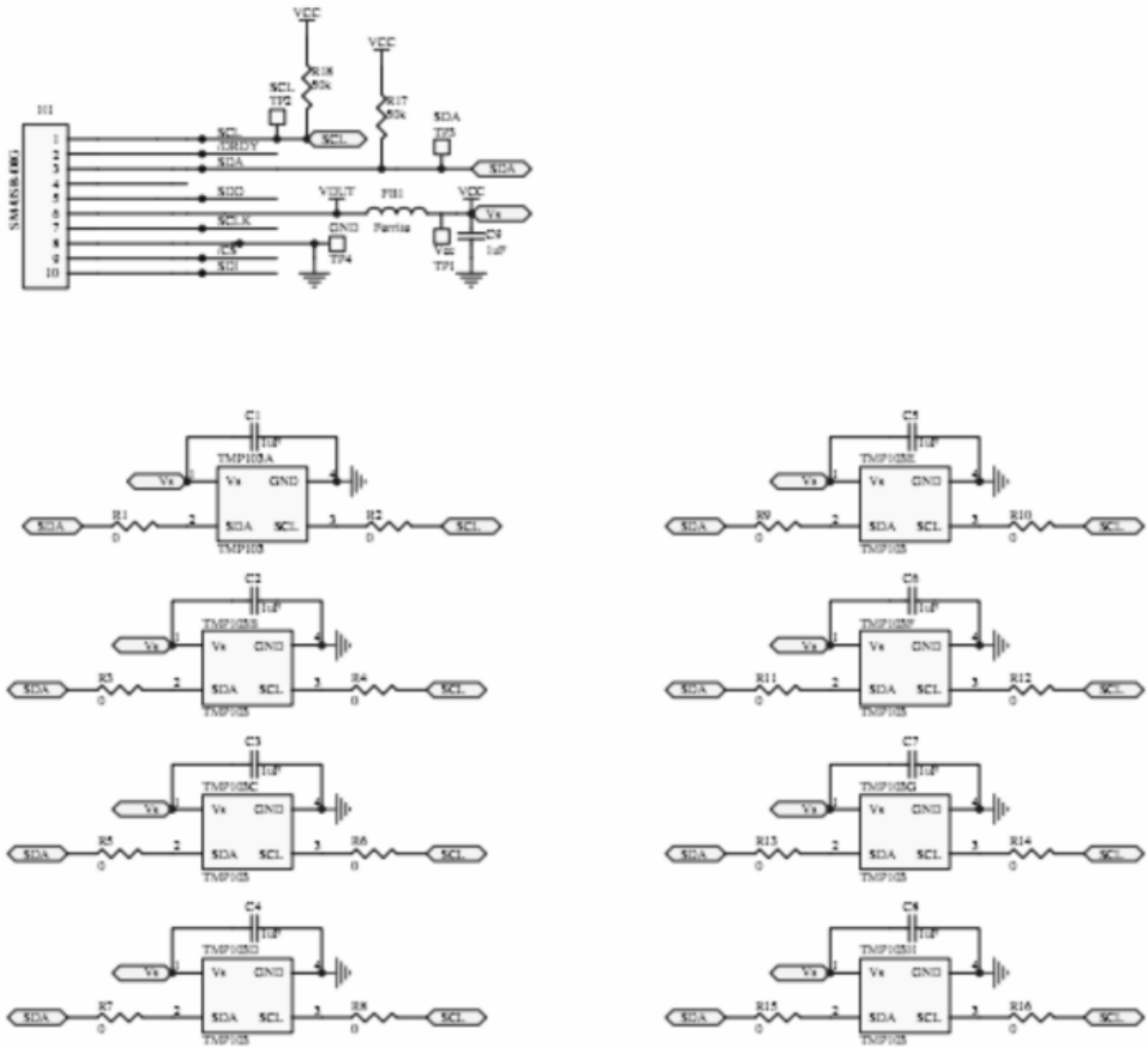


Figure 19. TMP103EVM Schematic

## 7.2 TMP103EVM PCB Components Layout

Figure 20 illustrates the layout of the components for the TMP103EVM board.

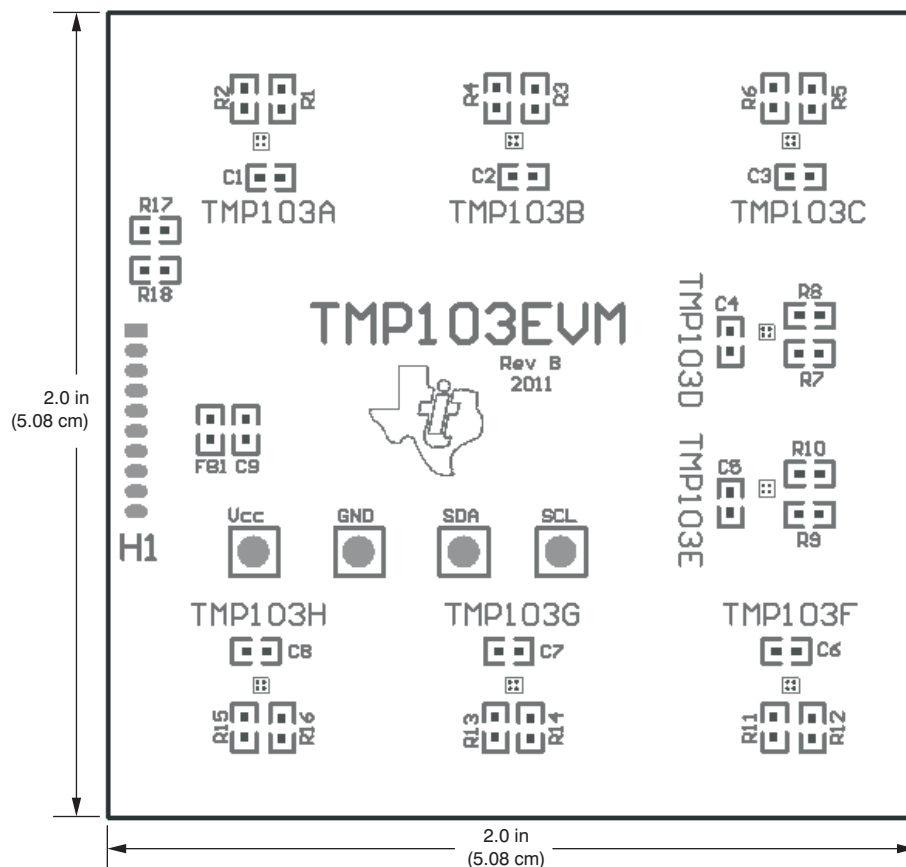


Figure 20. TMP103EVM Component Layout

## 8 Bill of Materials

Table 4 shows the parts list.

**Table 4. Bill of Materials**

Item	Qty	Ref Des	Value	Description	Manufacturer	Part No
1	16	R1 - R16	0Ω	Resistor, 0.0 OHM 1/16W 0402 SMD	Stackpole Electronics	RMCF0402ZT0R00
2	2	R17, R18	51kΩ	Resistor, 51K OHM 1/10W 5% 0402 SMD	Panasonic	ERJ-2GEJ513X
3	9	C1 - C9	0.1μF	Capacitor, ceramic 0.1μF 25V Y5V 0402	Yageo	CC0402ZRY5V8BB104
4	1	FB1	–	Ferrite bead 300Ω .2A 0402	Würth	74279272
5	8	TMP103A-H	–	TMP103	Texas Instruments	
6	4	Bumpons	–	Bumpon hemisphere .50x.14 clear	3M	SJ-5312 (CLEAR)
7	1	Super Mini DIG connector Socket	–	Conn socket RT Ang 50POS	–	–
	1	Super Mini DIG connector Socket	–	Conn socket RT Ang 50POS .050	Mill-Max Manufacturing	851-93-050-20-001000

## Evaluation Board/Kit Important Notice

Texas Instruments (TI) provides the enclosed product(s) under the following conditions:

This evaluation board/kit 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. Persons handling the product(s) must have electronics training and observe good engineering practice standards. As such, the goods being provided are not intended to be complete in terms of required design-, marketing-, and/or manufacturing-related protective considerations, including product safety and environmental measures typically found in end products that incorporate such semiconductor components or circuit boards. This evaluation board/kit does not fall within the scope of the European Union directives regarding electromagnetic compatibility, restricted substances (RoHS), recycling (WEEE), FCC, CE or UL, and therefore may not meet the technical requirements of these directives or other related directives.

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 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.**

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. Due to the open construction of the product, it is the user's responsibility to take any and all appropriate precautions with regard to electrostatic discharge.

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## EVM Warnings and Restrictions

It is important to operate this EVM within the input voltage range of 5.7V (min) to 9V (max) and the output voltage range of 0V (min) to 5V (max).

Exceeding the specified input range may cause unexpected operation and/or irreversible damage to the EVM. If there are questions concerning the input range, please contact a TI field representative prior to connecting the input power.

Applying loads outside of the specified output range may result in unintended operation and/or possible permanent damage to the EVM. 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 +25°C. The EVM is designed to operate properly with certain components above +25°C as long as the input and output ranges are maintained. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors. These types of devices can be identified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during operation, please be aware that these devices may be very warm to the touch.

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