TMP006EVM User Guide and Software Tutorial

This user's guide describes the characteristics, operation, and use of the TMP006EVM evaluation board. It discusses how to set up and configure the software and hardware, and reviews various aspects of the program operation. Throughout this document, the terms *evaluation board*, *evaluation module*, and *EVM* are synonymous with the TMP006EVM. This document also includes an electrical schematic, printed circuit board (PCB) layout drawings, and a parts list for the EVM.

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1 Overview

The TMP006 is an infrared thermopile sensor with digital output integrated circuit. This device measures the temperature of an object without making contact, making it ideal for many types of applications. The TMP006EVM is a platform for evaluating the performance of the TMP006 under various conditions. The TMP006EVM consists of two PCBs. One board, the SM-USB-DIG, communicates with the user's computer, provides power, and sends and receives appropriate digital signals to communicate with the TMP006. The second PCB, the TMP006_Test_Board, contains the TMP006 as well as support and configuration circuitry. This document gives a general overview of the TMP006EVM, and provides a general description of the features and functions to be considered while using this evaluation module.

1.1 TMP006EVM Kit Contents

Table 1 summarizes the contents of the TMP006EVM kit. Figure 1 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 also check the TMP006 product folder on the TI web site at www.ti.com to verify that you have the latest versions of the related software.

Table 1. TMP006EVM Kit Contents

Item	Quantity
TMP006_Test_Board	1
SM-USB-DIG Board	1
USB Cable	1
CR-ROM with TMP006EVM GUI Software *(not shown)*	1

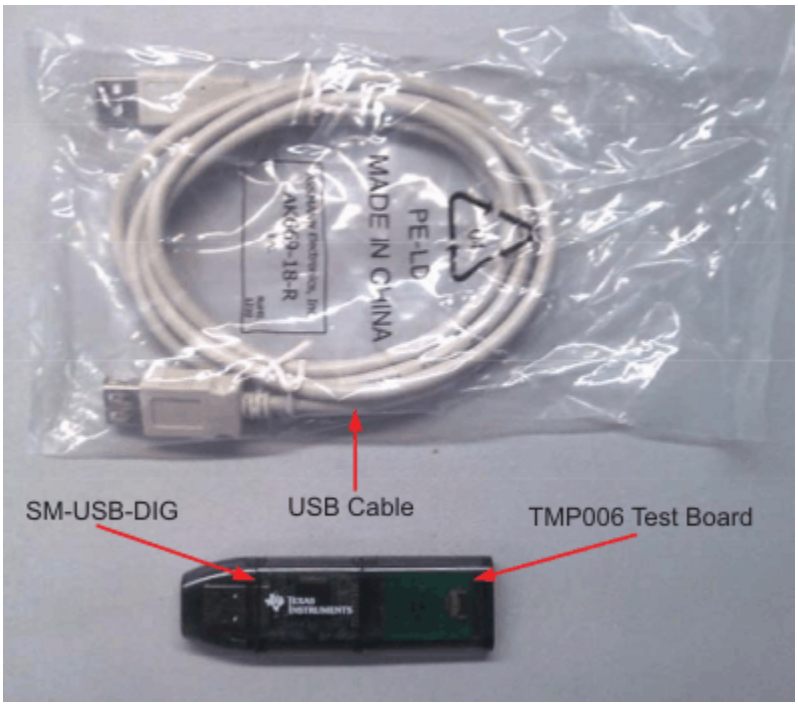

Figure 1. Hardware Included with TMP006EVM Kit

1.2 Related Documentation from Texas Instruments

The following documents provide information regarding Texas Instruments' integrated circuits used in the assembly of the TMP006EVM. This user's guide is available from the TI web site under literature number ***SBOU109A***. 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, 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.

Related Documentation

Document	Literature Number
TMP006 Product Data Sheet	SBOS518
SM-USB-DIG_Platform User Guide	SBOU0958
TMP006 Layout and Assembly Guidelines	SBOU108

2 TMP006EVM Hardware Setup

Figure 2 shows the system setup for the TMP006EVM. The PC runs graphical user interface (GUI) software that communicates with the SM-USB-DIG over a USB connection. The SM-USB-DIG translates the USB commands from the PC into power, I²C™, SPI™, and general-purpose input/output (GPIO) commands for the TMP006_Test_Board. The TMP006EVM does not require any additional components to operate.

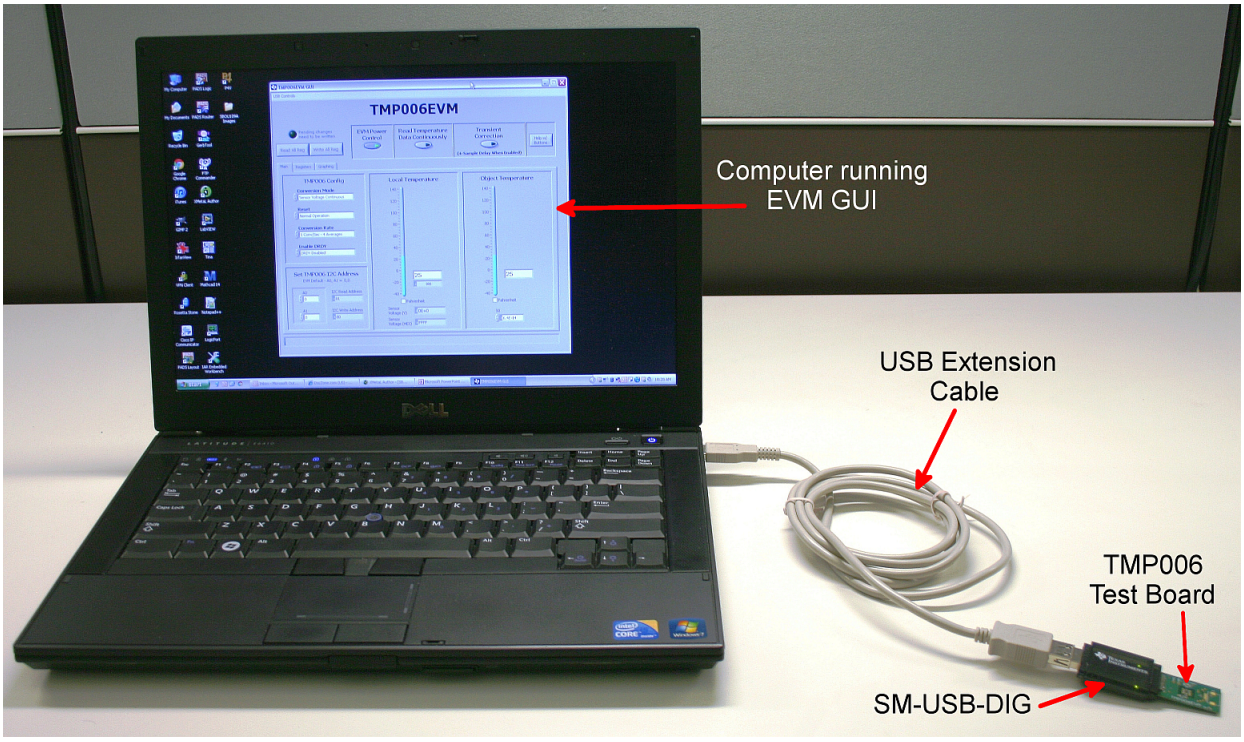

Figure 2. TMP006EVM Hardware Setup

2.1 Theory of Operation for the TMP006 Test Board

A block diagram of the TMP006 test board hardware setup is shown in Figure 3. The TMP006 Test Board contains connections for the power, I^2C, SPI, and GPIO signals from the SM-USB-DIG. It also has a connector that allows other boards to be connected to the TMP006 Test Board to assist with calibrating the TMP006.

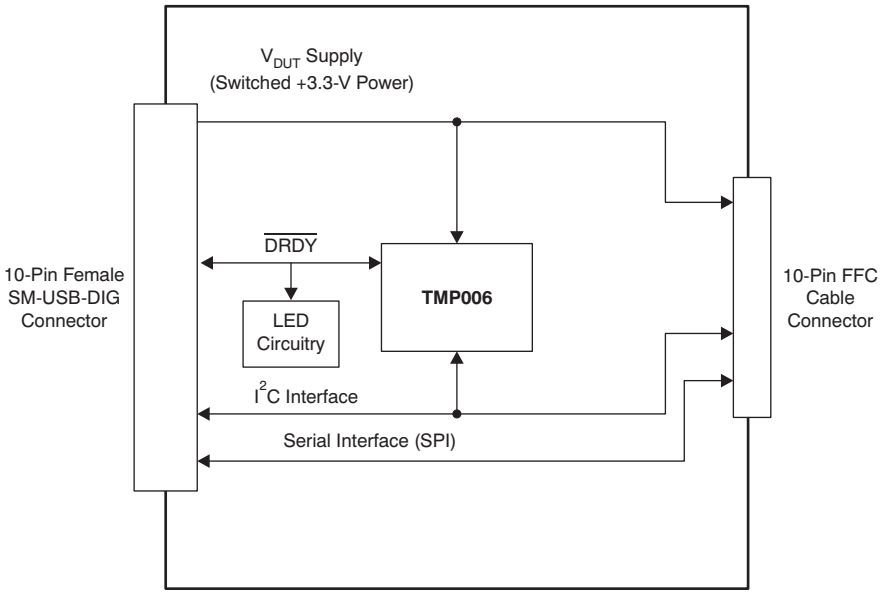

Figure 3. TMP006EVM Board Block Diagram

Figure 4 shows the complete schematic of the TMP006 Test Board. The ferrite bead and input capacitor, FB_1 and C_1 respectively, filter the power coming into the TMP006 test board from the SM-USB-DIG. The I^2C pull-up resistors, R_3 and R_4, and the $\overline{DRDY}$ pull-up, R_5, are required for the open-drain outputs to operate correctly. The Q_1 and R_6 components drive the LED (D_1) so current is not provided from the TMP006 that would cause the device to self-heat. Power, I^2C, and SPI signals are provided to the calibration header, H2, for use with the TMP006 calibration tools.

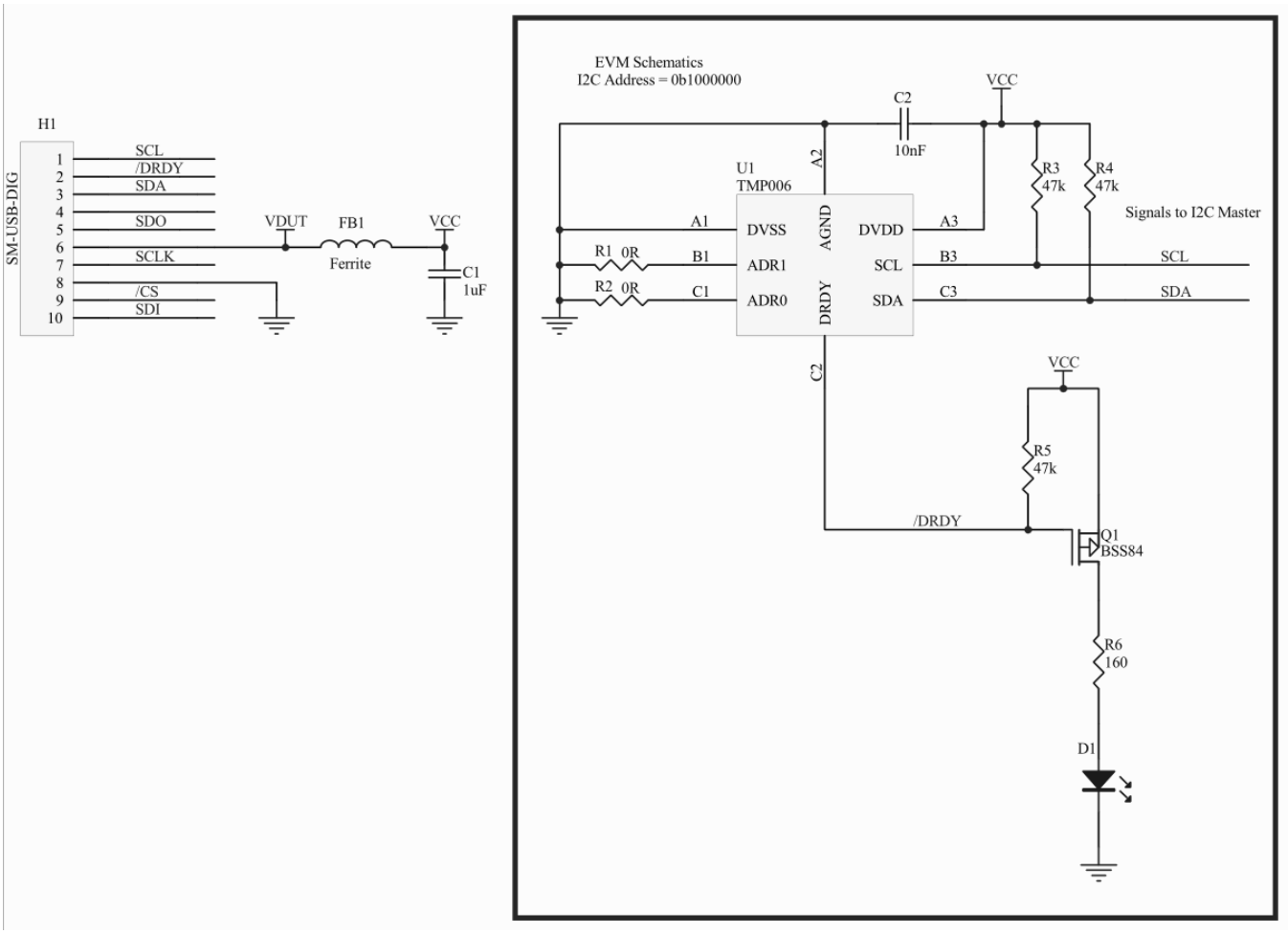

Figure 4. TMP006 Test Board Schematic

2.2 Bill of Materials for the TMP006 Test Board

Table 2 lists the bill of materials for the TMP006EVM board.

Table 2. TMP006 Test Board Parts List

Qty	RefDes	Value	Description	Part Number	MFR
1	C1	1µF	Capacitor, Ceramic 1.0µF 16V X7R 10% 0603	C1608X7R1C105K	TDK
1	C2	0.01µF	Capacitor, Ceramic 10000pF 25V X7R 10% 0402	C1005X7R1E103K	TDK
1	D1		LED Alingap Grn Wht Diff 0603SMD	SML-LX0603SUGW-TR	Lumex
1	FB1		Ferrite Bead 300Ω .2A 0402	74279272	Wurth
1	H1		Connector, Socket 50-Pl .050 R/A Sngl	851-43-050-20-001000	Mill-Max
1	H2		Connector, FPC/FFC 10-Pos .5mm Horz SMD	FH12-10S-0.5SH(55)	Hirose
1	Q1		MOSFET P-CH 50V 130mA SC70-3	BSS84W-7-F	Diodes Inc
2	R1, R2	0Ω	Resistor, 0.0Ω 1/16W 0402 SMD	MCR01MZPJ000	Rohm
3	R3, R4, R5	47k	Resistor, 47.0kΩ 1/16W 1% 0402 SMD	MCR01MZPF4702	Rohm
1	R6	160Ω	Resistor, 160Ω 1/16W 1% 0402 SMD	MCR01MZPF1600	Rohm
1	U1		Infrared Sensor with Digital Interface	TMP006	Texas Instruments

2.3 Signal Definition of H1 (10-Pin Female Socket)

Table 3 identifies the signals connected to the H1 connector on the TMP006 Test Board. This summary also identifies the signals that are used with the TMP006EVM along with the respective signal names.

Table 3. Signal Definitions for H1 (10-Pin Female Socket) on TMP006EVM Board

Pin No.	Signal	Used on the TMP006EVM?	TMP006 Test Board Signal
1	I2C_SCL	Yes	SCL
2	CTRL/MEAS4	Yes	$\overline{\text{DRDY}}$
3	I2C_SDA1	Yes	SDA
4	CTRL/MEAS5	No	—
5	SPI_DOUT1	Yes	SDO
6	VDUT	Yes	VCC
7	SPI_CLK	Yes	SCLK
8	GND	Yes	GND
9	SPI_CS1	Yes	$\overline{\text{CS}}$
10	SPI_DIN1	Yes	SDI

2.4 Signal Definition of H2 (10-Pin FFC Connector)

Table 4 shows the signals connected to the H2 connector on the TMP006 Test Board.

Table 4. Signal Definition for H2 (10-Pin FFC Connector) on TMP006EVM Board

Pin No.	Signal
1	SCL
2	VCC
3	SDA
4	VCC
5	SDO
6	GND
7	SCLK
8	GND
9	$\overline{CS}$
10	SDI

3 TMP006EVM Hardware Overview

If not already assembled, the basic hardware setup for the TMP006EVM involves connecting the TMP006 Test Board to the SM-USB-DIG and then connecting the USB cable. This section presents the details of this procedure.

3.1 Electrostatic Discharge Warning

CAUTION

Many of the components on the TMP006EVM 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.

3.2 Typical TMP006EVM Hardware Setup

Connect the right-angle female socket (H1) on the TMP006 Test Board to the right-angle male header (H2) on the SM-USB-DIG. Take special care to ensure that the two 10-pin sockets directly align with each other. Plug the female USB-A cable to the SM-USB-DIG and then plug the male USB-A cable into the computer.

Always connect the two boards together before connecting the USB cable to avoid any issues if the connectors are misaligned.

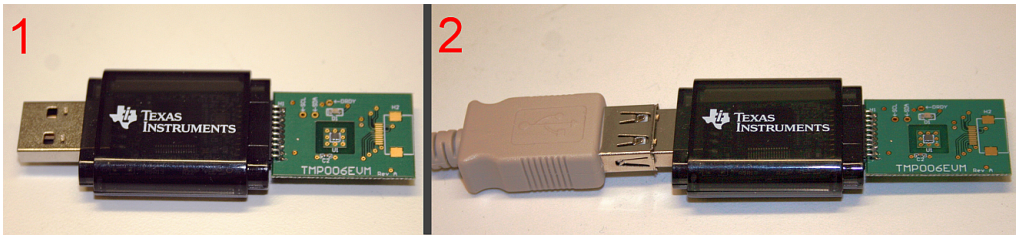

Figure 5. Typical Hardware Connection

Figure 6 shows the typical behavior when the SM-USB-DIG is plugged into the USB port of a PC for the first time. Typically, the computer will respond 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 uses the human interface device drivers that are part of the Microsoft® Windows® operating system.

Figure 6. Typical PC Behavior After Connecting TMP006EVM

In some cases, the Windows *Add Hardware* wizard appears. If this installation prompt occurs, allow the Device Manager to install the human interface drivers by clicking ***Yes*** at each request to install the drivers.

4 TMP006EVM Software Overview

This section describes the installation and use of the TMP006EVM software.

4.1 Hardware Requirements

The TMP006EVM software has been tested on the Microsoft Windows XP operating system (OS) with United States and European regional settings. The software should function correctly on other Windows-based OSs.

4.2 GUI Software Installation

The TMP006EVM software is included on the CD that is shipped with the EVM kit. It is also available through the TMP006EVM product folder on the TI web site. To install the software to a computer, insert the disc into an available CD-ROM drive. Navigate to the drive contents and open the TMP006EVM software folder. Locate and launch the TMP006EVM installation file, *setup.exe*, as shown in Figure 7. It is in the *Installer* directory.

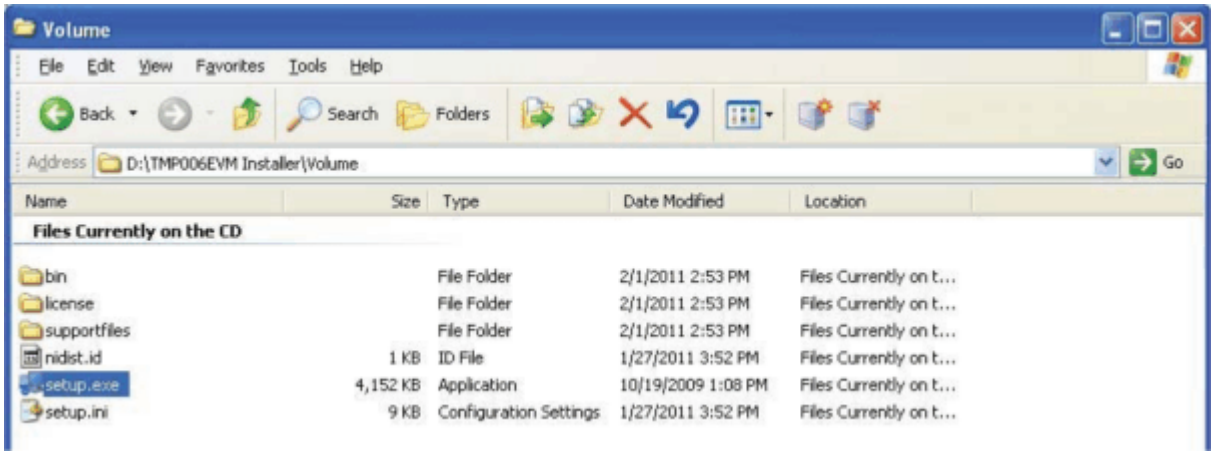

Figure 7. TMP006EVM Software Installation Files

The TMP006EVM software installer file then begins the installation process as shown in Figure 8.

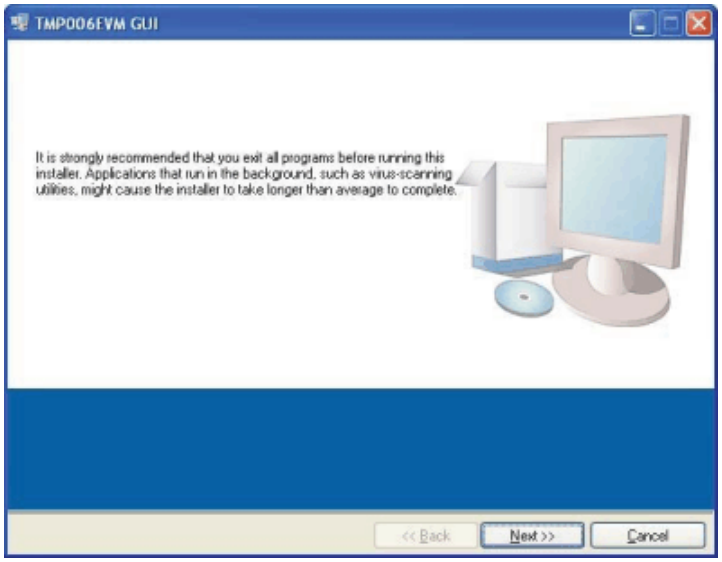

Figure 8. TMP006EVM Software Installation Launch

Follow the prompts as shown in Figure 9 to install the TMP006EVM GUI software.

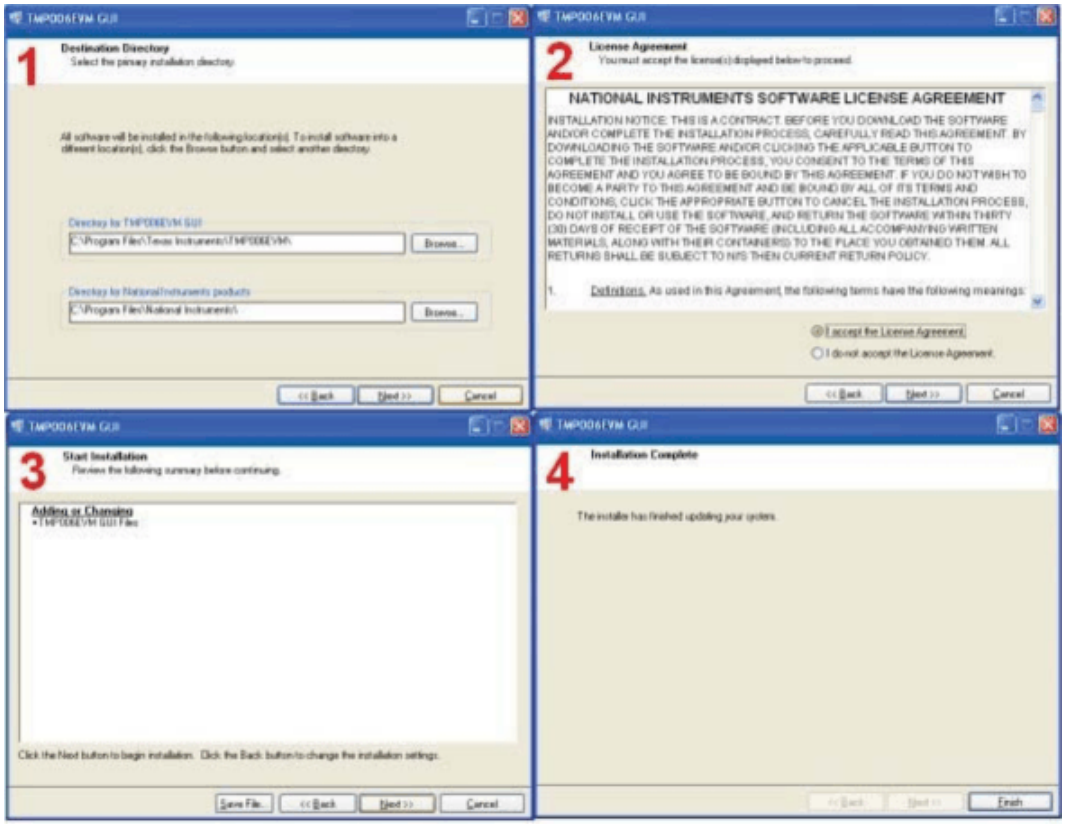

Figure 9. TMP006EVM GUI Software Installation Prompts

The TMP006EVM GUI software is now installed.

4.3 Launching the TMP006EVM GUI Software

With the TMP006EVM properly connected (see Figure 5), launch the EVM GUI software from the *Start* menu. It is located in a folder titled, *TMP006EVM GUI Installer*. The software should launch with a screen similar to that shown in Figure 10.

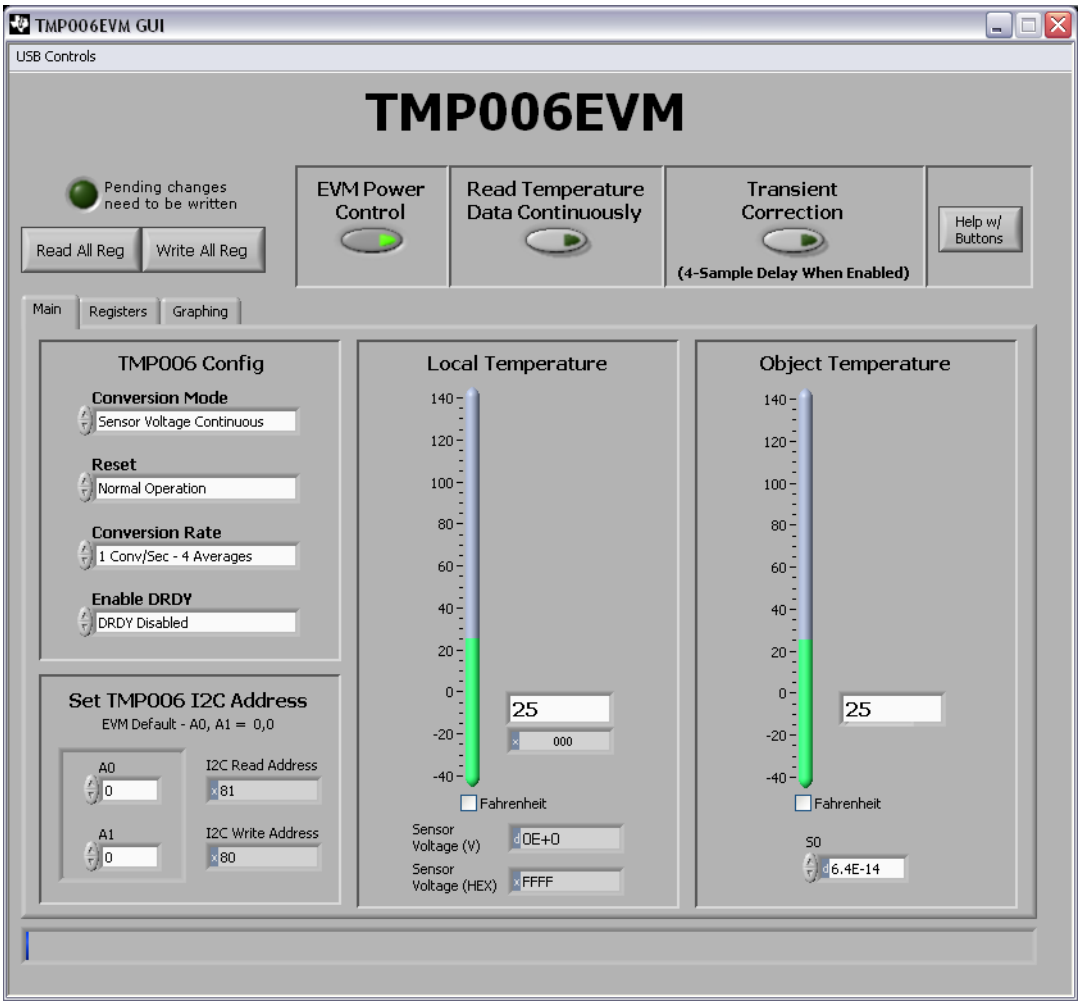

Figure 10. TMP006EVM GUI Software Default Configuration

If the message shown in Figure 11 appears when the TMP006EVM GUI software is launched, disconnect all components of the TMP006EVM kit, and repeat the hardware assembly instructions in Section 3.2.

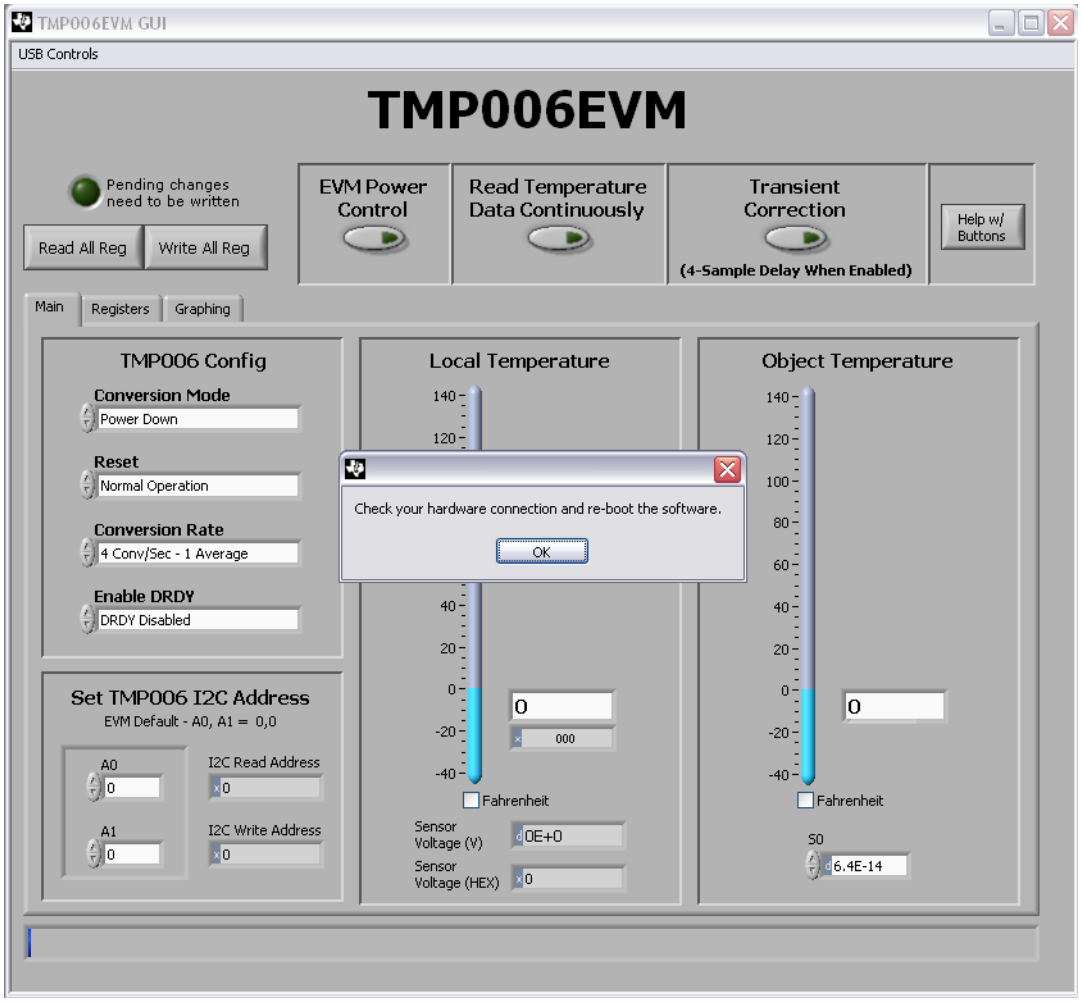

Figure 11. Hardware Error Message

5 TMP006EVM Software Use

This section discusses how to use the TMP006EVM software. The TMP006EVM GUI software has a primary window that is used to configure and read from the TMP006, along with two other windows that are used to access different features of the TMP006. Basic GUI functionality and a description of the tabs are also presented in this section.

5.1 Reading from the TMP006

On the primary GUI window (see Figure 10), press the **Read All Reg** button to read the TMP006 registers and begin collecting temperature measurement data. Figure 12 illustrates this action. Raw temperature and configuration register values can be found in the *Registers* tab (refer to Section 5.3).

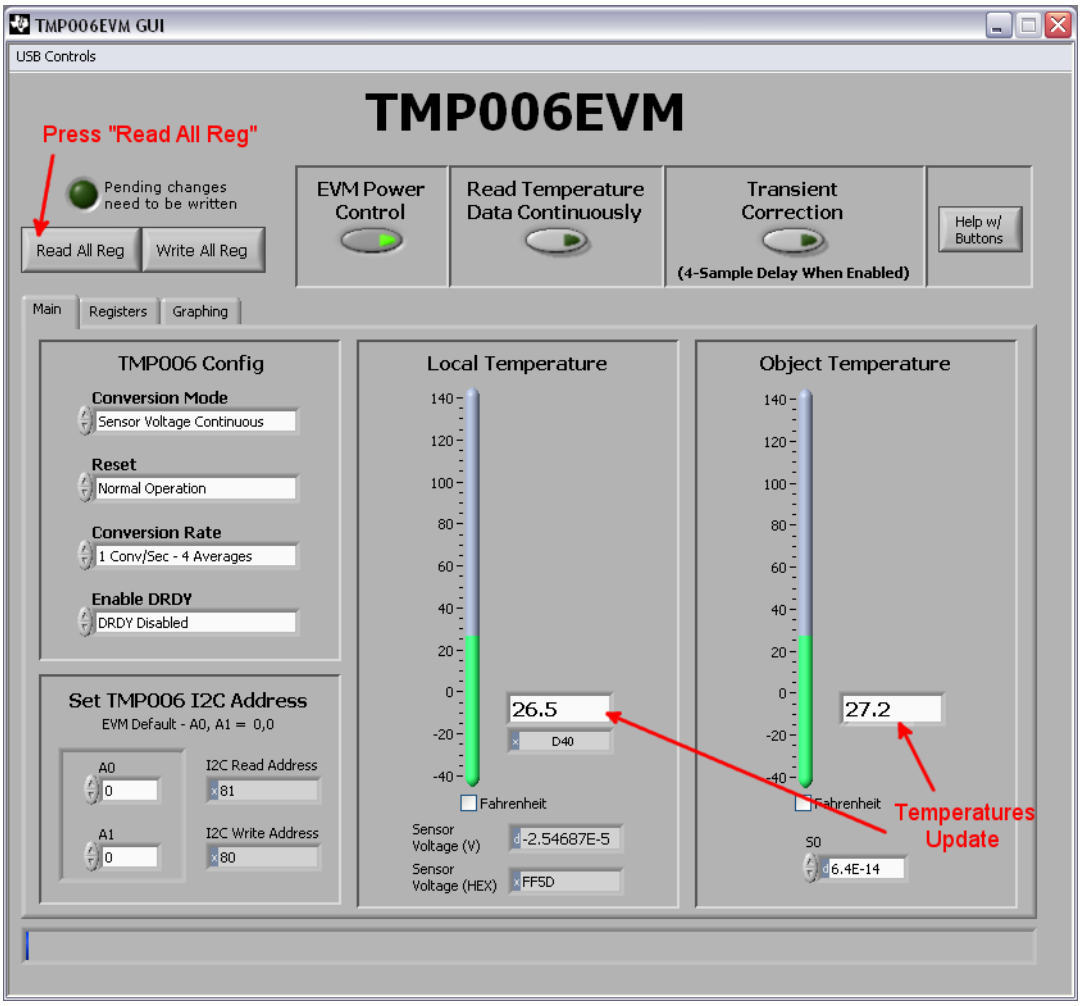

Figure 12. Read All Registers to Update Temperature

5.2 Writing to the TMP006

To modify the TMP006 configuration register, make any desired changes on the *Block Diagram* tab and then press the **Write All Reg** button, as shown in Figure 13.

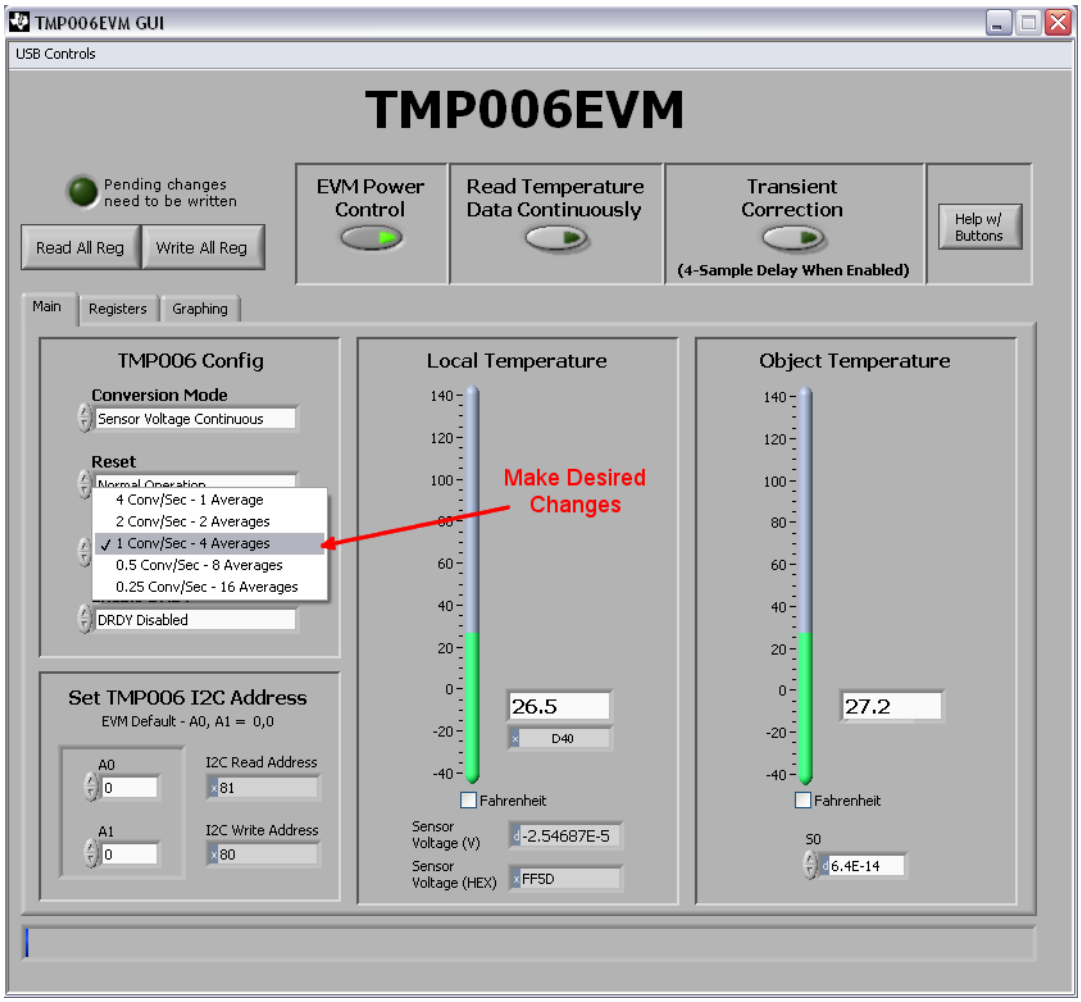

Figure 13. Make Changes to TMP006 Registers

The *Pending changes need to be written* LED illuminates when there are changes that have not been written to the TMP006, as shown in Figure 14.

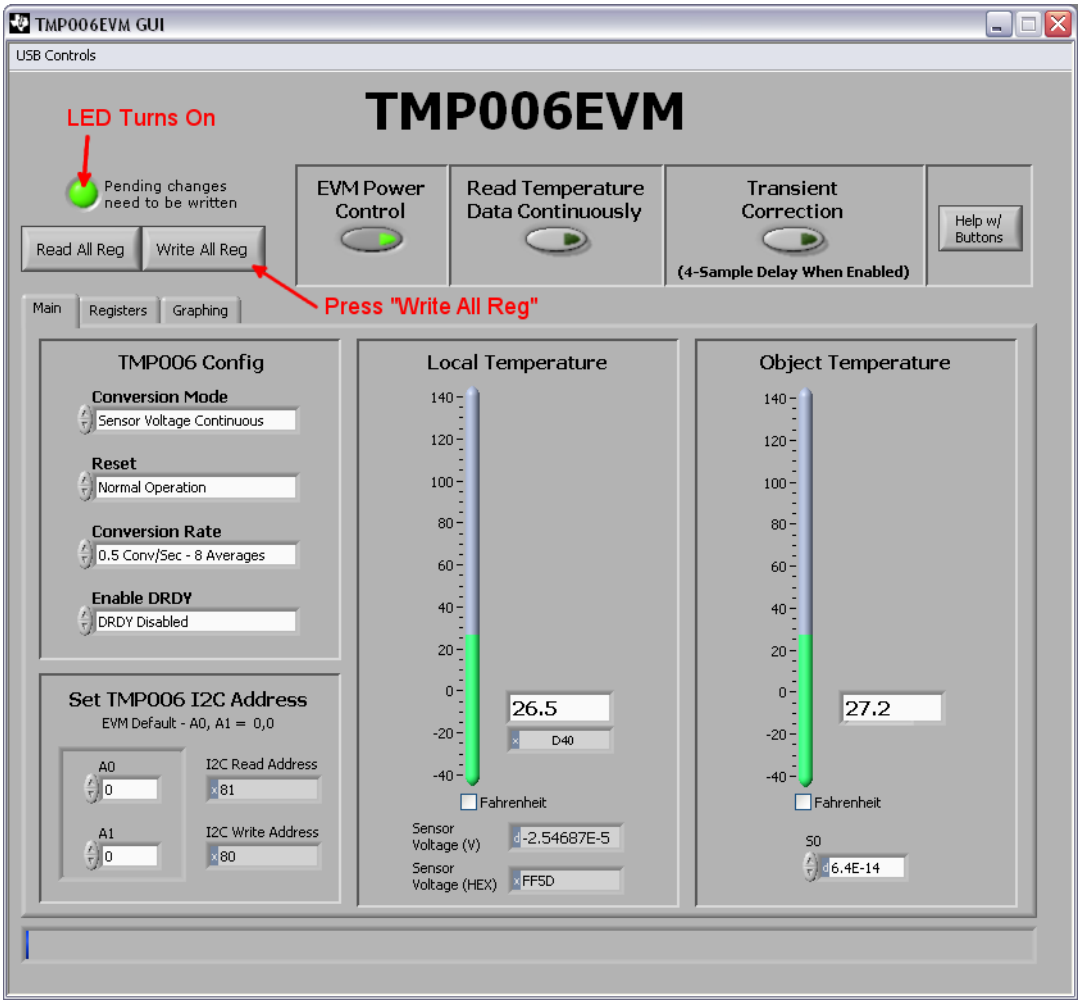

Figure 14. Write Changes to TMP006 Registers

5.3 Registers Tab

In this tab, you can select any row in the *Register* table by clicking on it with your mouse. When a row is selected, it becomes highlighted in blue in the table. The individual 16 bits in the selected register are displayed below the Register table. Note that each bit has descriptive text above the bit that identifies the function of the bit. You can edit the bit value using the up (↑) or down (↓) arrow to the left of the bit. Any changes on the bit are displayed in the table and in the block diagram. Additionally, any changes in the block diagram are reflected in the table.

The **Help w Reg** button can be pressed to see detailed help about the register that is currently selected. This feature gives detailed information regarding the meaning of each bit. The Registers tab on the TMP006EVM GUI software is illustrated in Figure 15.

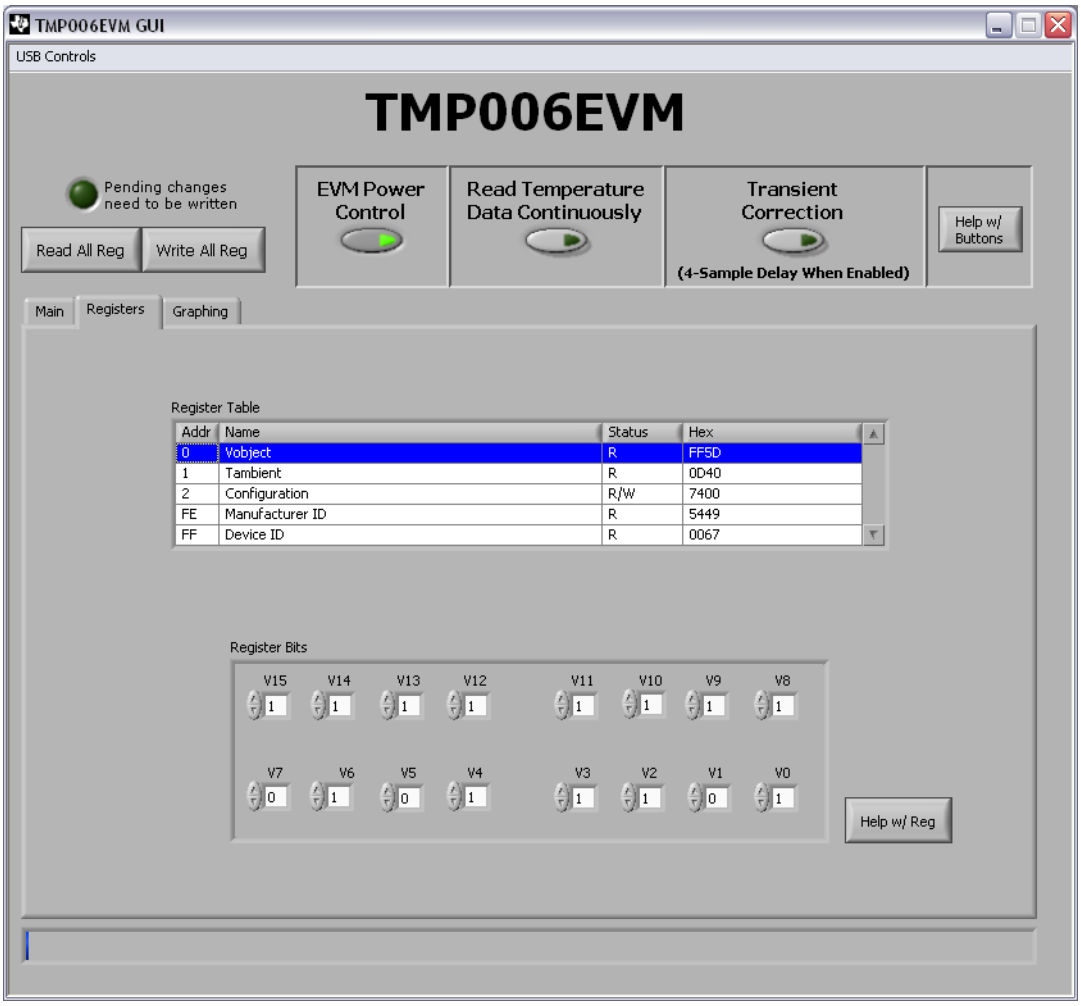

Figure 15. TMP006EVM GUI Software Registers Tab

5.4 Graphing Tab

The Graphing tab allows you to graph the temperature sensor results. To start the graphing process, you must press the **Read Continuous** button. After pressing this button, it turns green and the graph starts to update. Press the **Read Continuous** button again to turn off this function. Figure 16 shows this process.

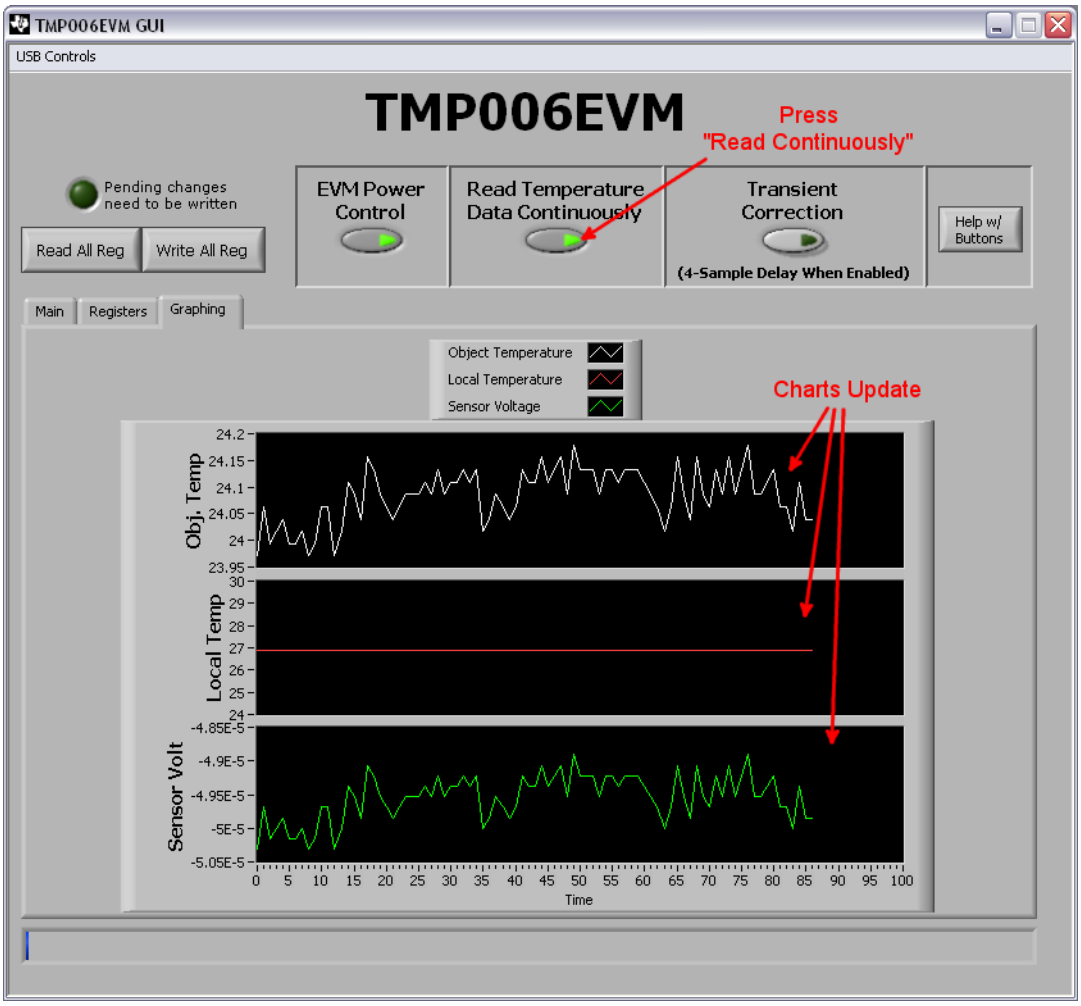

Figure 16. Read Registers Continuously to Update Graphs

5.5 Transient Correction Algorithm

The accurate performance of the TMP006EVM is highly dependent on a stable local temperature. Degraded performance can be observed when local temperature transients are introduced into the system, because the infrared (IR) thermopile in the TMP006 is sensitive to conducted and radiated IR energy from below the sensor as well as radiated IR energy that comes from above the sensor.

When the TMP006EVM experiences a local temperature transient event, the PCB temperature and the TMP006 die temperature drift apart from each other as a result of the thermal time constant of the TMP006 thermopile. This difference in temperatures causes a heat transfer between the IR sensor and the PCB to occur. Because of the small distance between the PCB and the bottom of the sensor, this heat energy is conducted (as opposed to radiated) through the thin layer of air between the IR sensor and the PCB below it. This conducted heat energy causes an offset in the IR sensor voltage reading, and ultimately leads to unwanted temperature calculation error.

The additional error that results from local temperature transient events can be suppressed in the software by using a transient correction algorithm. This algorithm monitors the TMP006 die temperature over a four-second interval and uses the die temperature data to calculate a local temperature slope, as shown in Equation 1.

$$T_{SLOPE} = -(0.3 \times T_{DIE1}) - (0.1 \times T_{DIE2}) + (0.1 \times T_{DIE3}) + (0.3 \times T_{DIE4}) \quad (1)$$

The local temperature slope and the known thermal resistance and capacitance of the TMP006 thermopile are then applied to Equation 2 to correct the sensor voltage reading.

$$V_{OBJ\_CORRECTED} = V_{OBJ} + T_{SLOPE} \times 2.96 \times 10^{-4} \quad (2)$$

The corrected sensor voltage value is then substituted for the *raw* sensor voltage, and the object temperature is calculated using the normal methods.

To enable the transient correction algorithm, simply click the **Transient Correction** button in the TMP006EVM GUI as shown in Figure 17. When transient correction is first enabled, a delay of four conversions will be observed while the local temperature slope is being calculated.

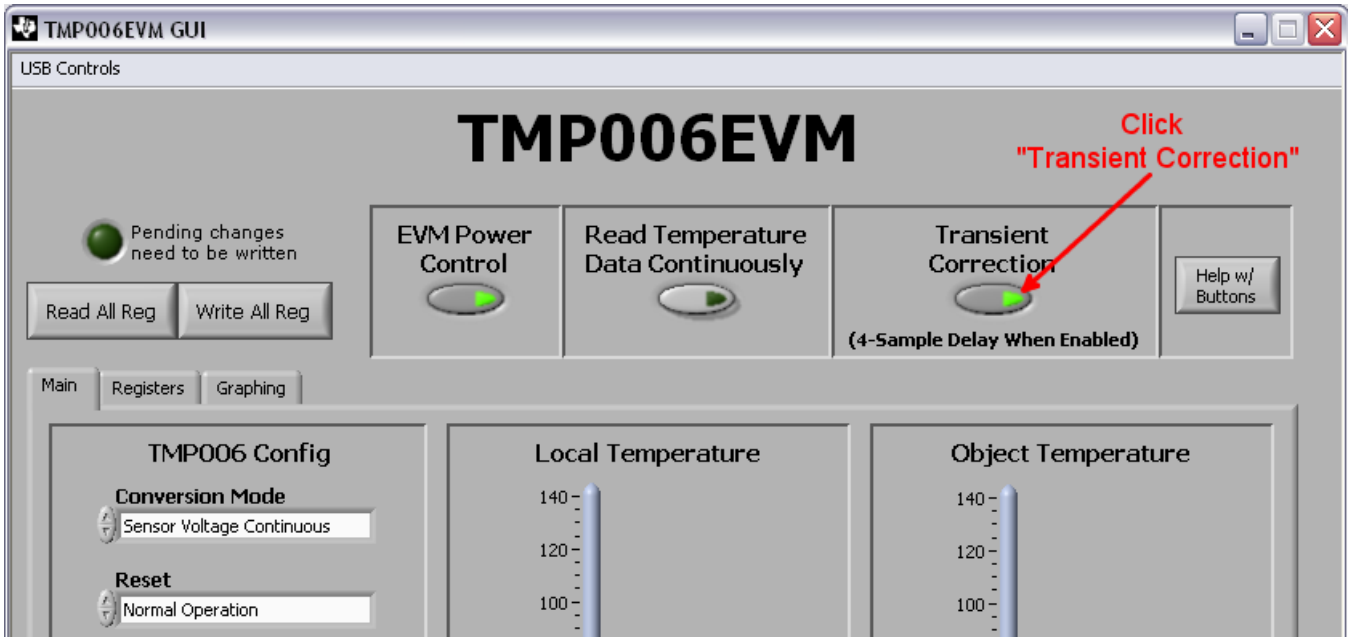

Figure 17. Enable Transient Correction Algorithm

5.6 Logging Data from the TMP006EVM

The TMP006EVM software has the ability to save data collected by the TMP006 into a comma-separated value (.CSV) format file. To save data in this format, select *Save Temperature Data* from the *USB Controls* drop-down menu. Figure 18 shows the steps required to begin logging temperature data with the TMP006EVM.

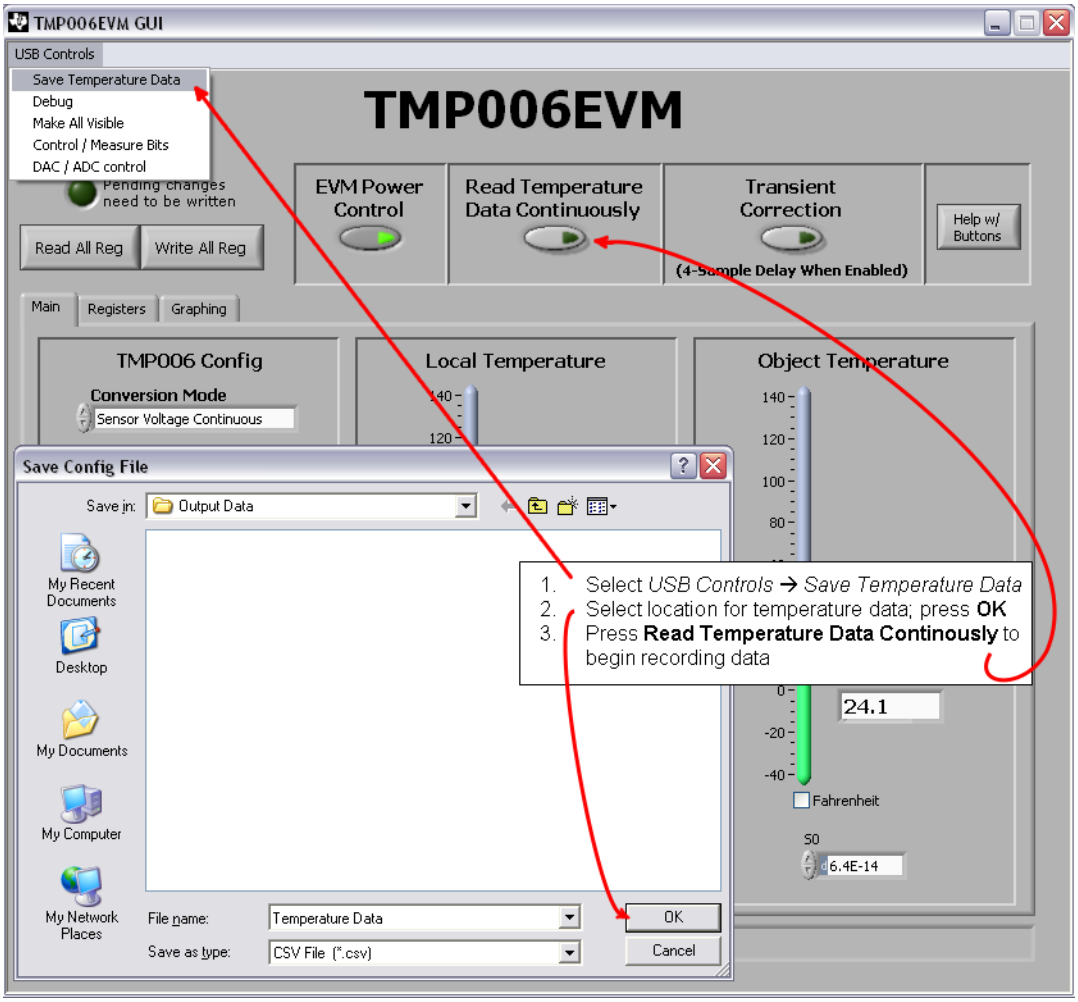

Figure 18. Start Data Logging

Figure 19 displays an example of how the output file can appear after minimal formatting by the user.

	A	B	C	D
1	Time	Local Temp	Object Voltage	Object Temp
2	1.297	27.719	-6.83E-05	22.2
3	2.266	27.75	-6.61E-05	22.6
4	3.328	27.75	-6.34E-05	23
5	4.297	27.75	-6.13E-05	23.3
6	5.266	27.75	-5.97E-05	23.6
7	6.234	27.719	-5.86E-05	23.7
8	7.297	27.719	-5.80E-05	23.8
9	8.266	27.719	-5.69E-05	23.9
10	9.234	27.719	-5.61E-05	24.1
11	10.281	27.687	-5.53E-05	24.1
12	11.25	27.687	-5.55E-05	24.1
13	12.312	27.687	-5.50E-05	24.2
14	13.281	27.687	-5.53E-05	24.1
15	14.25	27.656	-5.48E-05	24.2
16	15.219	27.656	-5.47E-05	24.2
17	16.25	27.656	-5.44E-05	24.2
18	17.281	27.625	-5.47E-05	24.2
19	18.25	27.625	-5.44E-05	24.2
20	19.281	27.625	-5.44E-05	24.2
21	20.234	27.594	-5.39E-05	24.2
22	21.281	27.594	-5.42E-05	24.2
23	22.25	27.594	-5.44E-05	24.2
24	23.203	27.594	-5.42E-05	24.2
25	24.234	27.562	-5.39E-05	24.2
26	25.203	27.562	-5.42E-05	24.2
27	26.266	27.562	-5.41E-05	24.2
28	27.234	27.562	-5.39E-05	24.2
29	28.203	27.531	-5.42E-05	24.1
30	29.25	27.531	-5.42E-05	24.1
31				

Figure 19. Example .CSV Output File (Formatted and Displayed in Microsoft Excel®)

Revision History

Changes from Original (May, 2011) to A Revision **Page**

- Updated document to reflect new software functionality 1
- Revised Figure 2 for improved clarity 3
- Updated Figure 4 to reflect unpopulated connector H2 5
- Changed Figure 5 to reflect new SM-USB-DIG casing 7
- Corrected typos and updated Figure 10 through Figure 16 to reflect new software functionality 8
- Added *Transient Correction Algorithm* section 17
- Updated Figure 18 to reflect new software functionality 18
- Revised Figure 19 for improved clarity 19

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

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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 2.7V (min) to 5.5V (max) and the output voltage range of 2.7V (min) to 5.5V (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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