User's Guide
SBAU169–April 2010

TMP512/TMP513EVM

This user's guide describes the characteristics, operation, and the use of the TMP513 evaluation module (EVM). It discusses the processes and procedures required to properly use this EVM board. This EVM is designed to evaluate the performance of the TMP512 and TMP513 temperature sensors in a variety of configurations. This document also includes a schematic and a complete bill of materials.

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1 Overview

The TMP513EVM is an evaluation module that is used to fully evaluate the TMP512 or TMP513 temperature sensor and current shunt monitor. These system monitors have the capability of measuring remote temperatures, on-chip temperatures, and system voltage/power/current consumption. The TMP513 is an integrated circuit that provides temperature compensation and linearization for bridge sensors.

The TMP513EVM consists of two printed circuit boards (PCBs). One board (USB_DIG_Platform) generates the digital signals required to communicate with the TMP513. The second PCB (TMP513_Test_Board) contains the TMP513, as well as support and configuration circuitry.

This document provides the information needed to set up and operate the TMP513EVM evaluation module, a test platform for the TMP512 (dual-channel) and TMP513 (triple-channel) system monitors. For a more detailed description of the TMP513 product line, refer to the product data sheet (SBOS491) available from the Texas Instruments website at http://www.ti.com. Support documents are listed in the section of this guide entitled *Related Documentation from Texas Instruments*.

Note that the TMP512 is a device that is functionally the same as the TMP513, except that it has one less channel. The TMP513 device can be de-soldered from the TMP513EVM and replaced with a TMP512 if it is necessary to evaluate the TMP512.

Throughout this document, the abbreviation *EVM* and the term *evaluation module* are synonymous with the TMP513EVM. For clarity of reading, this document refers only to the TMP513EVM, but operation of the EVM with the TMP512 is identical, unless otherwise noted.

1.1 TMP513EVM Kit Hardware

Figure 1 shows the hardware included TMP513EVM. Contact the factory 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 software.

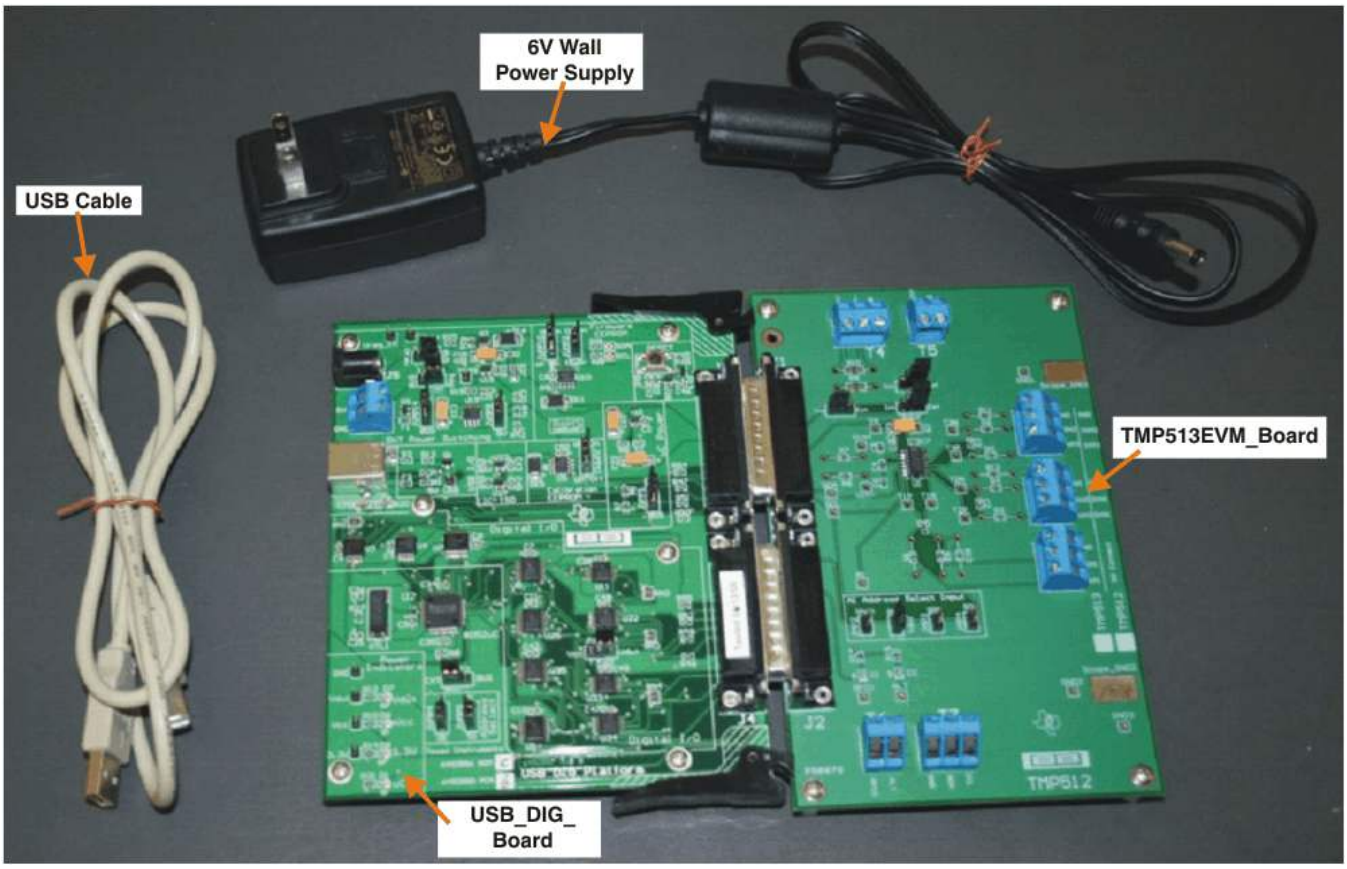


Figure 1. Hardware Included With the TMP513EVM

The complete kit includes the following items:

- TMP513EVM test PCB
- USB Dig Platform PCB
- USB cable
- A copy of this document

1.2 Related Documentation from Texas Instruments

The following document provides information regarding Texas Instruments integrated circuits used in the assembly of the TMP513EVM. This document is available from the TI web site under literature number SBAU169. Any letter appended to the literature number corresponds to the document revision that is current at the time of the writing of this document. Newer revisions may be available from the TI website at http://www.ti.com, or call the Texas Instruments Literature Response Center at (800) 477-8924 or the Product Information Center at (972) 644-5580. When ordering, identify the document by both title and literature number.

Document	Literature Number
TMP512/TMP513 Product Data Sheet	SBOS491

1.3 If You Need Assistance

If you have questions about the TMP513 evaluation module, post a question in the amplifiers forum at http://e2e.ti.com Include *TMP513EVM* in the subject heading.You can also send an e-mail to the Linear Application Team at precisionamps@list.ti.com; include *TMP513EVM* as the subject heading.

1.4 Information About Cautions and Warnings

This document contains caution statements.

CAUTION

This is an example of a caution statement. A caution statement describes a situation that could potentially damage your software or equipment.

The information in a caution or a warning is provided for your protection. Please read each caution and warning carefully.

2 System Setup

Figure 2 shows the system setup for the TMP513EVM. The PC runs software that communicates with the USB_DIG_Platform. The USB_DIG_Platform generates the digital signals used to communicate with the TMP513_Test_Board. Connectors on the TMP513_Test_Board allow for connection to remote diodes an current shunt voltages.

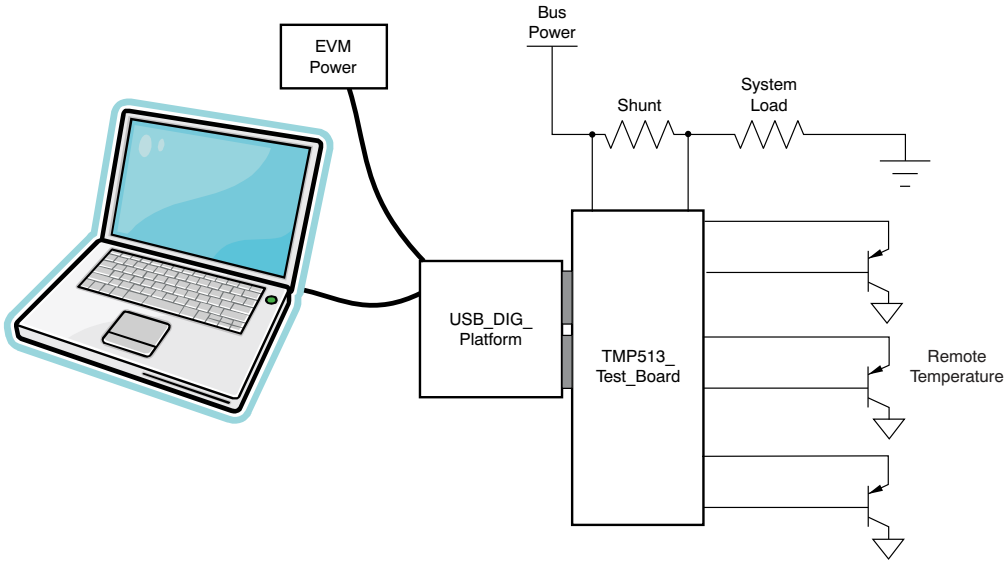


Figure 2. Hardware Setup for the TMP513EVM

Minimim PC operating requirements:

- Microsoft® Windows® XP or higher
- Available USB port
- Works on either US or European regional settings

2.1 Theory of Operation for TMP513_Test_Board Hardware

Figure 3 shows the block diagram of the TMP513_Test_Board. The TMP513_Test_Board provides connections to the I²C™ interface and general-purpose inputs/outputs (GPIOs) on the USB_DIG_Platform. It also provides connection points for external connection of the shunt voltages and remote temperature sensor diodes.

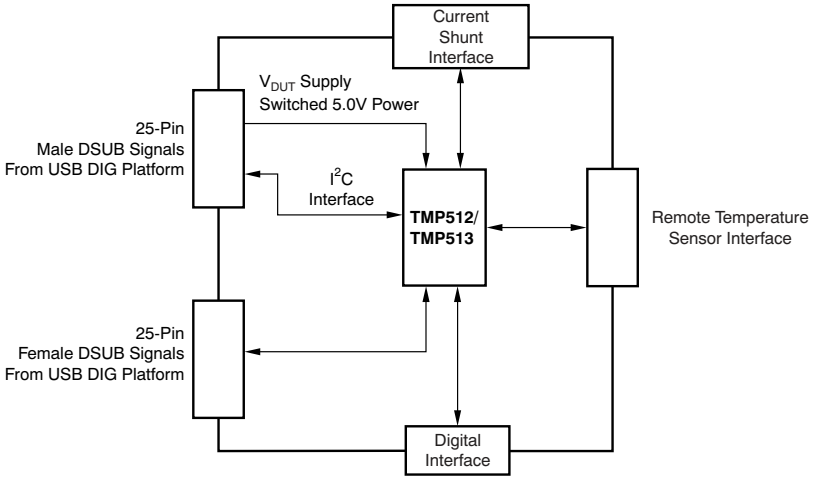


Figure 3. Block Diagram of TMP513_Test_Board

Figure 4 illustrates the input connections on the TMP513_Test_Board schematic. T1, T2, and T3 provide connections to the remote temperature sensor diodes. Note that each temperature sensor channel has two 50Ω series resistors and a 50pF common-mode capacitor. These components filter noise pickup (for example, switching noise from adjacent digital circuits). R11, R12, and R13 can convert the differential voltage measurements to single-ended measurements.

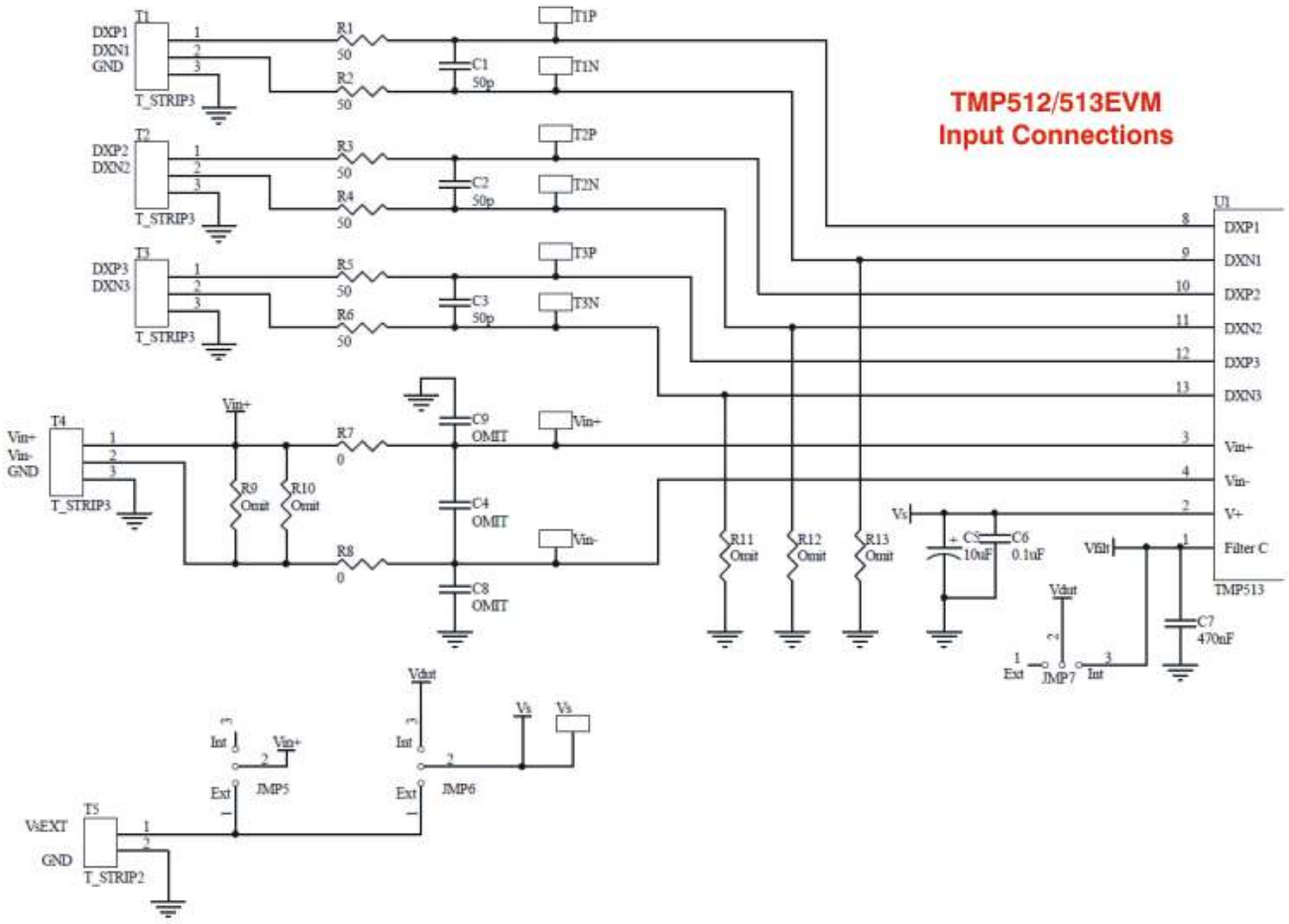


Figure 4. TMP513_Test_Board Input Circuitry Schematic

Figure 5 shows the connection to the I²C interface, the I²C address configuration, GPIOs, and Alert on the TMP513_Test_Board schematic. T6 provides a connection GPIO and the Alert function (ALT). The GPIO pin can be configured as an input or output. In cases where the GPIO pin is an input, the USB_DIG_Platform can be used to generate a digital signal. JMP8 connects the digital control line from the USB_DIG_Platform to the GPIO pin when it is in the *Dout* position.

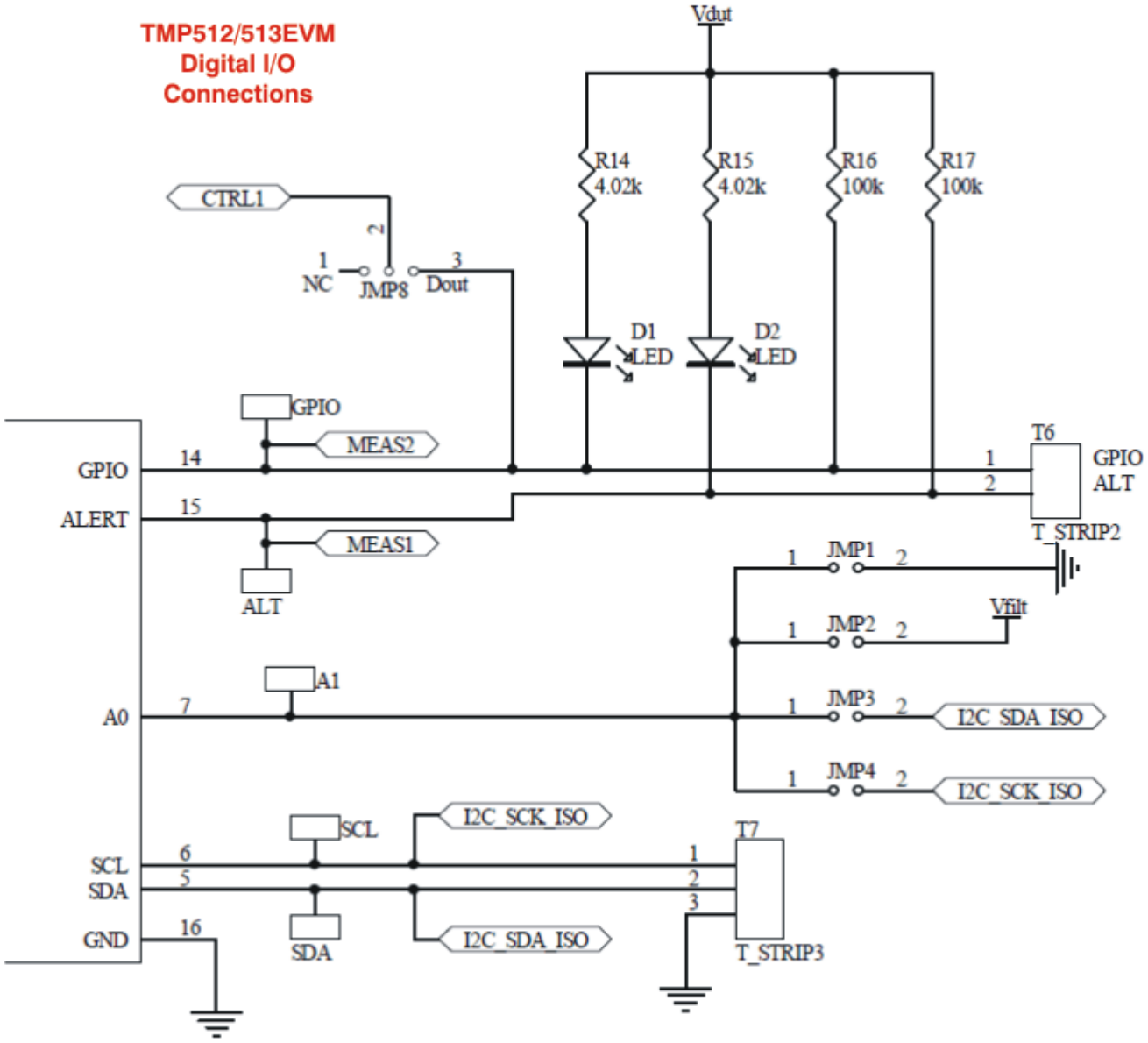


Figure 5. TMP513_Test_Board Power, Reference, and Digital Connections

Figure 6 shows the connections to the USB_DIG_Platform on the TMP513_Test_Board schematic. J1 provides the I^2C connections, and J2 provides the general-purpose I/O.

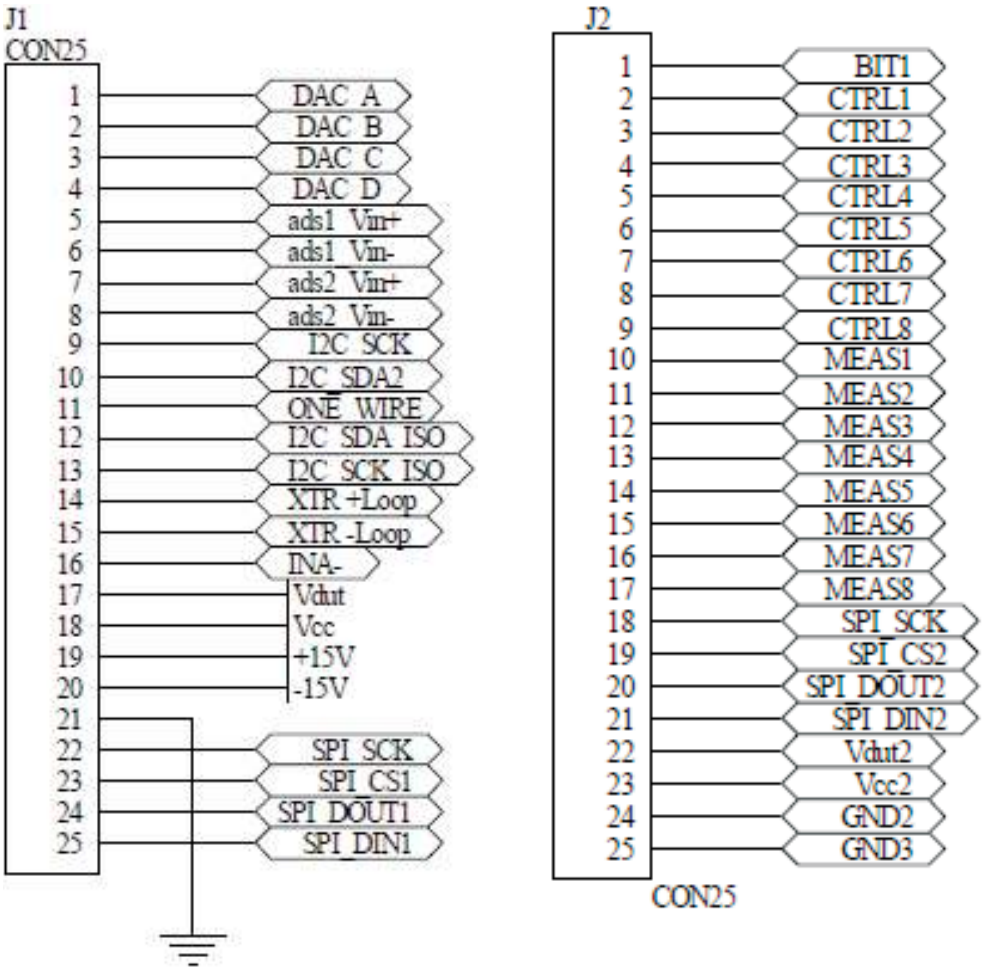


Figure 6. TMP513_Test_Board Connections to USB_DIG_Platform and EEPROM Schematic

2.2 Signal Definition of J1 (25-Pin Male DSUB) on TMP513_Test_Board

Table 1 shows the different signals connected to J1 on the TMP513_Test_Board. This table also identifies signals connected to pins on J1 that are not used on TMP513_Test_Board.

Table 1. Signal Definition of J1 (25-Pin Male DSUB) on TMP513_Test_Board

Pin on J1	Signal	Used on This EVM	TMP513 Pin
1	DAC A	No	
2	DAC B	No	
3	DAC C	No	
4	DAC D	No	
5	ADS1+	No	
6	ADS1–	No	
7	ADS2+	No	
8	ADS2–	No	
9	I2C_SCK	No	
10	I2C_SDA2	No	
11	ONE_WIRE	No	
12	I2C_SCK_ISO	Yes	SCL
13	I2C_SDA_ISO	Yes	SDA
14	XTR_LOOP+	No	
15	XTR_LOOP–	No	
16	INA–	No	
17	V_{DUT}	Yes	V_S
18	V_{CC}	No	
19	+15V	No	
20	–15V	No	
21	GND	Yes	GND
22	SPI_SCK	No	
23	SPI_CS1	No	
24	SPI_DOUT	No	
25	SPI_DIN1	No	

2.3 Signal Definition of J2 (25-Pin Female DSUB) on TMP513_Test_Board

Table 2 shows the different signals connected to J2 on the TMP513_Test_Board. This table also identifies the signals connected to pins on J2 that are not used on TMP513_Test_Board.

Table 2. Signal Definition of J2 (25-Pin Female DSUB) on TMP513_Test_Board

Pin on J2	Signal	Used on This EVM	TMP513 Pin
1	NC	No	
2	CTRL1	Yes	Convert
3	CTRL2	Yes	GPIO
4	CTRL3	No	
5	CTRL4	No	
6	CTRL5	No	
7	CTRL6	No	
8	CTRL7	No	
9	CTRL8	No	
10	MEAS1	Yes	Warning
11	MEAS2	Yes	GPIO
12	MEAS3	Yes	Overlimit
13	MEAS4	Yes	Critical
14	MEAS5	Yes	ALT
15	MEAS6	No	
16	MEAS7	No	
17	MEAS8	No	
18	SPI_SCK	No	
19	SPI_CS2	No	
20	SPI_DOUT2	No	
21	SPI_DIN2	No	
22	V_{DUT}	No	V_S
23	V_{CC}	No	
24	GND	Yes	GND
25	GND	Yes	GND

2.4 Theory of Operation For the USB_DIG_Platform

Figure 7 shows the block diagram for the USB_DIG_Platform. This platform is a general-purpose data acquisition system that is used on several different Texas Instruments' evaluation modules. The block diagram shown in Figure 7 illustrates the general platform outline.

The core component of the USB_DIG_Platform is the TUSB3210.

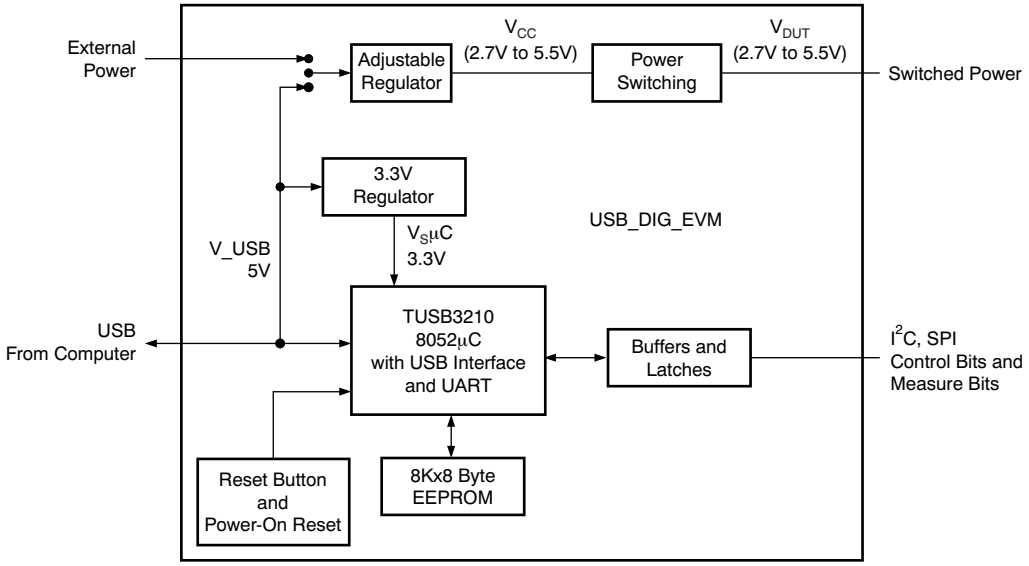


Figure 7. Theory of Operation For the USB_DIG_Platform

3 TMP513EVM Hardware Setup

Setting up the TMP513EVM hardware involves connecting the two halves of the EVM together, applying power, connecting the USB cable, and setting the jumpers. This section covers the details of this procedure.

3.1 Electrostatic Discharge Warning

Many of the components on the TMP513EVM 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.

CAUTION

Failure to observe ESD handling procedures may result in damage to EVM components.

3.2 Typical Hardware Connections

A typical TMP513EVM hardware setup connects the two EVM PCBs, then supplies power, and connects an external shunt and load. The external connections may be the real-world system to which the TMP513 will be connected. Figure 8 shows the typical hardware connections.

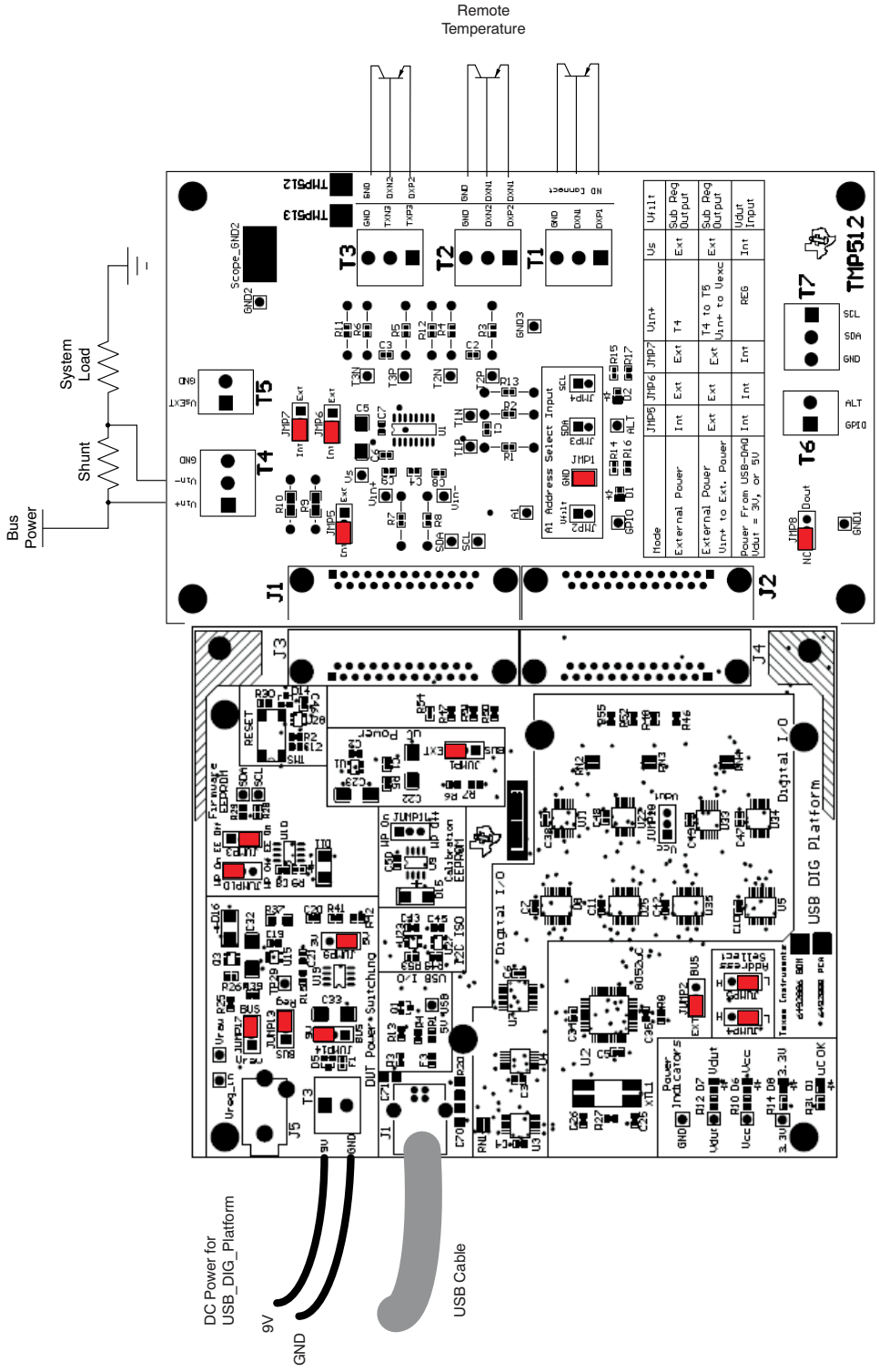


Figure 8. Typical Hardware Connections

3.3 Connecting the Hardware

The best and easiest way to connect the two halves of the TMP513EVM together is to gently push on both sides of the D-SUB connectors, as shown in Figure 9. Make sure that the two connectors are completely pushed together; loose connections may cause intermittent EVM operation otherwise.

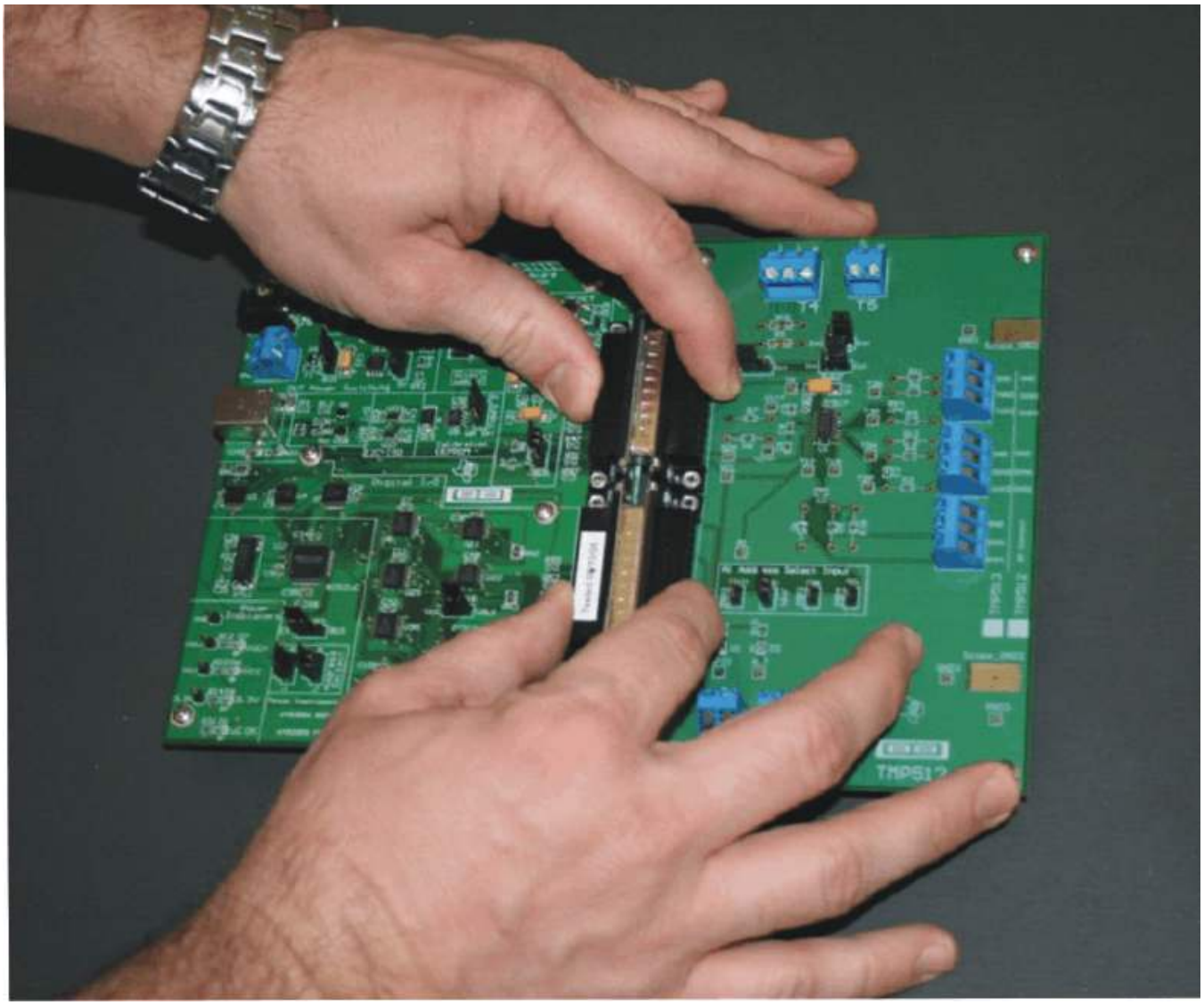


Figure 9. Connecting the Two Halves of the EVM

3.4 Connecting Power

Connect the two TMP513EVM PCBs before connecting a power source, as Figure 10 shows. ***Always connect power before connecting the USB cable.*** If the USB cable is connected before the power is supplied, the computer will attempt to communicate with an unpowered device, and the device will not be able to respond.

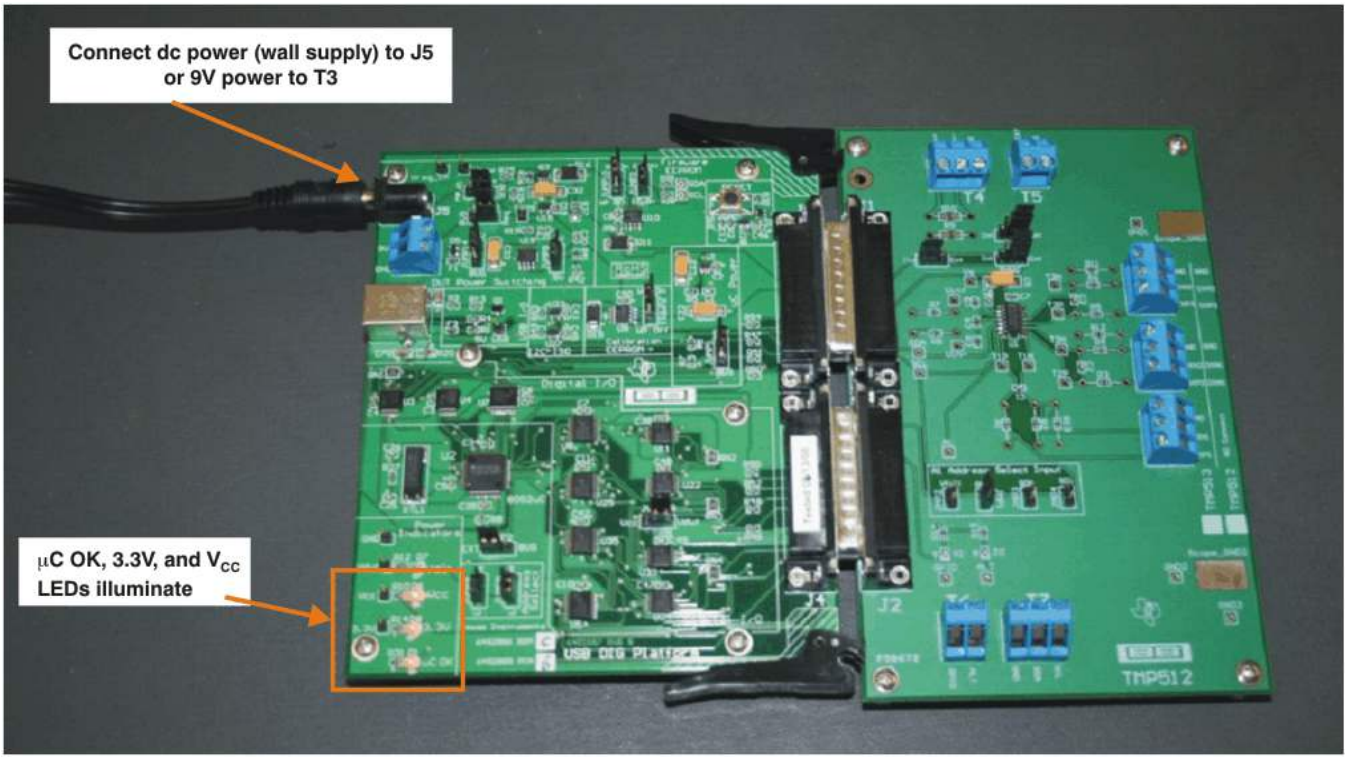


Figure 10. Connecting Power to the EVM

3.5 Connecting the USB Cable to the TMP513EVM

Figure 11 shows the typical behavior of connection the USB_DIG_Platform to the USB port of a PC for the first time. Note that the EVM must be powered before connecting the USB cable. Typically, the computer responds with a *Found New Hardware, USB Device* pop-up. The pop-up typically changes to *Found New Hardware, USB Human Interface Device*. This pop-up indicates that the device is ready to be used. The 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* also pops up. If this prompt occurs, allow the system device manager to install the *Human Interface Drivers* by clicking ***Yes*** when requested to install drivers.

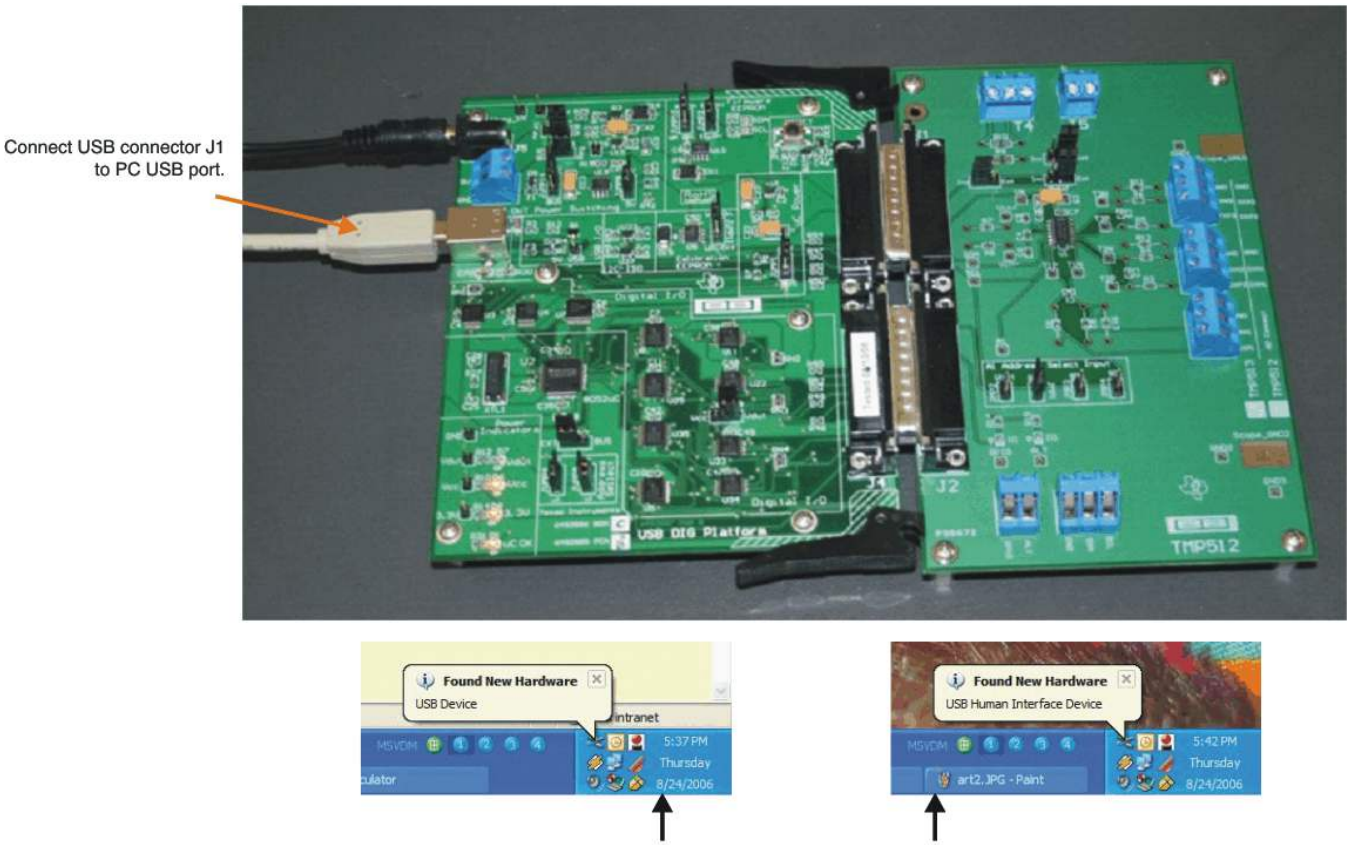
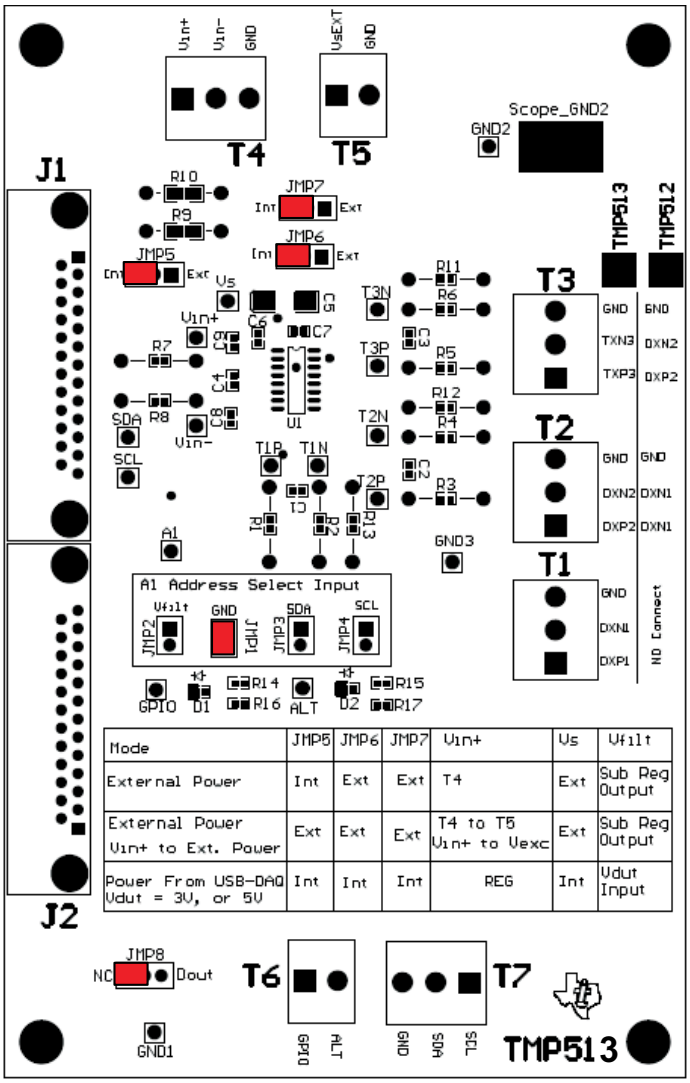


Figure 11. Connecting the USB Cable

3.6 TMP513 Jumper Settings

Figure 12 shows the default jumpers configuration for the TMP513EVM test board. In general, the jumper settings of the USB_DIG_Platform will not need to be changed. You may want to change some of the jumpers on the TMP513_Test_Board to match your specific design requirements.



Mode	JMP5	JMP6	JMP7	Vin+	Vs	Vfilt
External Power	Int	Ext	Ext	T4	Ext	Sub Reg Output
External Power Vin+ to Ext. Power	Ext	Ext	Ext	T4 to T5 Vin+ to Vexc	Ext	Sub Reg Output
Power From USB-DAQ Vdut = 3V, or 5V	Int	Int	Int	REG	Int	Vdut Input

Figure 12. Default Jumper Settings (TMP513_Test_Board)

Figure 13 shows the default jumpers configuration for the USB_DIG_Platform. In general, the jumper settings of the USB_DIG_Platform will not need to be changed.

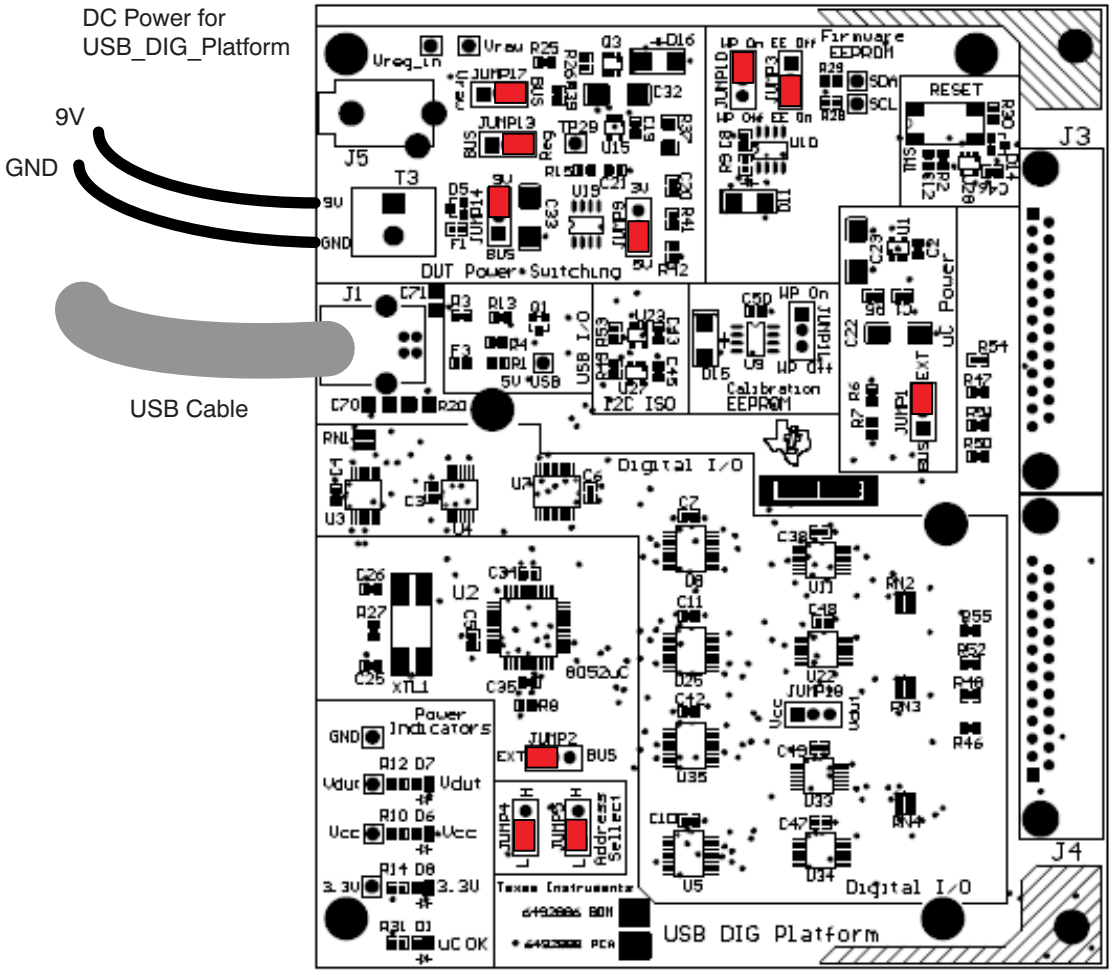


Figure 13. Default Jumper Settings (USB_DIG_Platform)

Table 3 explains the function of the jumpers in the XTR117 section of the TMP513_Test_Board.

Table 3. TMP513_Test_Board Jumper Functions

Jumper	Default	Purpose
JMP1	GND	These jumpers are used to set the I^2C address. A jumper shunt (short) can only be placed across one of the four positions. Note that you must change the I^2C address in software when you change the hardware address. Refer to Table 4.
JMP2		
JMP3		
JMP4		
JMP5	INT	This jumper connects and disconnects V_{IN+} to the external power supply. When in the *INT* position, the external power supply is disconnected from V_{IN+}. When in the *EXT* position, the external power supply is connected to the V_{IN+} pin. This option is useful if you want to measure the bus and shunt voltage of the external power supply using the current shunt monitor capability.
JMP6	INT	This jumper connects either the external power supply or the power supply from the USB-DIG (V_{DUT}). When in the *INT* position, the V_{DUT} power supply is connected. The V_{DUT} power supply can be jumper-configured to either 3V or 5V on the USB_DIG_Platform board. When in the *EXT* position, the external power supply is connected via T5.
JMP7	INT	This jumper can connect the V_{FILT} pin to the USB_DIG power supply (V_{DUT}). When in the *INT* position, V_{FILT} is connected to the USB_DIG V_{DUT} power supply. This configuration effectively disables the internal subregulator. In this case, V_{FILT} is a power input on the device. When in the *EXT* position, V_{FILT} is the subregulator output. The subregulator output is V_{FILT} = 3.3V.
JMP8	NC	This jumper allows you to connect or disconnect a digital output pin from the USB_DIG. When in the *NC* position, the digital output from the USB_DIG is disconnected from the GPIO pin. This jumper position is normally used when the GPIO pin is configured as an output. Note that Meas2 pin from the USB_DIG allows you to read the state of the output. When in the D_{OUT} position, the digital output from the USB_DIG (CTRL1) is connected to the GPIO pin. This jumper position is normaly used when the GPIO pin is configured as an input. In this case, the CTRL1 pin can output a logic '1' or '0' to the GPIO pin on the TMP513.

Table 4 summarizes the settings for Control A0 that set the I^2C address.

Table 4. Control A0 Settings

Name	Function	Address
JMP1	GND	1011100
JMP2	V_{FILT}	1011101
JMP3	SDA	1011110
JMP4	SCL	1011111

Table 5 explains the function of the USB_DIG_Platform jumpers. For most applications, the default jumper positions should be used. A separate document (SBOU058) gives details regarding the operation and design of the USB_DIG_Platform.

Table 5. USB_DIG_Platform Jumper Settings

Mode	Jumper	Comment
External Power 5V (Default Jumper Settings: 5V)	JUMP17 = BUS (Not Used)	In this mode, all power is supplied to the PLATFORM via J5 or T3. The external supply must be between 5.8V and 10.4V for proper operation. All digital I/O is regulated to 5V using U19 (REG101). This is the default configuration.
	JUMP13 = REG	
	JUMP14 = 9V	
	JUMP9 = 5V	
	JUMP1 = EXT	
	JUMP2 = EXT	
	JUMP6 = 5V	
External Power 3V (Typical Jumper Settings: 3V)	JUMP17 = BUS (Not Used)	In this mode, all power is supplied to the PLATFORM via J5 or T3. The external supply must be between 5.8V and 10.4V for proper operation. All digital I/O is regulated to 5V using U19 (REG101). This is a very common configuration.
	JUMP13 = REG	
	JUMP14 = 9V	
	JUMP9 = 3.3V	
	JUMP1 = EXT	
	JUMP2 = EXT	
	JUMP6 = 3V	
External Power Variable Supply	JUMP17 = V_{RAW}	In this mode, all digital I/Os are referenced to the supply attached to either J5 or T3. It is absolutely critical that you do not exceed 5.5V supply voltage in this mode. The supply will be directly applied to devices with 5.5V absolute maximum ratings. This mode of operation is useful when you need a device supply other than 3.0V or 5.0V. **CAUTION** Do not exceed 5.5V supply voltage in this mode.
	JUMP13 = BUS	
	JUMP14 = 9V (Not Used)	
	JUMP9 = 5V (Not Used)	
	JUMP1 = EXT	
	JUMP2 = EXT	
	JUMP6 = 5V (Not Used)	
Bus Power 5V	JUMP17 = BUS	In this mode, the USB Bus will completely power the PLATFORM. The USB bus is regulated by the master (computer) to be 5V. This mode relies upon the external regulation. This mode is recommended only when an external 9V supply is not available. If an external 9V supply is available, use the *External Power 9V* mode.
	JUMP13 = BUS	
	JUMP14 = 9V (Not Used)	
	JUMP9 = 5V (Not Used)	
	JUMP1 = BUS	
	JUMP2 = BUS	
	JUMP6 = 5V (Not Used)	
Bus Power 3V	JUMP17 = BUS (Not Used)	In this mode, the USB Bus will completely power the PLATFORM. The regulator (U19 REG101) is used to generate a 3V supply for all digital I/Os.
	JUMP13 = REG	
	JUMP14 = BUS	
	JUMP9 = 3.3V	
	JUMP1 = BUS	
	JUMP2 = BUS	
	JUMP6 = 3V	

4 TMP513 Software Overview

This section discusses how to install and use the TMP513EVM software.

4.1 Operating Systems for TMP513EVM Software

The TMP513EVM software has been tested on Windows XP with United States and European regional settings. The software should also function on other Windows operating systems.

4.2 TMP513EVM Software Install

Install the TMP513EVM software by following these steps:

1. Software can be downloaded from the TMP513EVM web page, or from the disk included with the TMP513EVM, which contains a folder called *Install_software/*.
2. Find the file called *setup.exe*. Double-click the file to start the installation process.
3. Follow the on-screen prompts to install the software.
4. To remove the application use the windows control panel utility, *Add/Remove Software*.

4.3 Starting the TMP513EVM Software

Use the Windows *Start* menu to run the TMP513EVM software. From start, select *All Programs*, then select the *TMP513EVM* program. See Figure 14 for an image of the software display if the EVM is functioning properly.

4.4 Using the TMP513EVM Software

The TMP513EVM software has five different primary function tabs that allow users to access different features of the TMP513. Each of the tabs has an intuitive graphical interface that helps users to gain a better understanding of the device.

NOTE: More details on these options are explained in the TMP513 data sheet.

4.4.1 Block Diagram Tab

Figure 14 shows the Block Diagram tab in the EVM software. This tab can access and configure the major features in the TMP513 device. Press the button associated with the feature that you want to configure and a separate configuration window pops up. For example, pressing the **TMP_ADC** button brings up a window with the ADC range, resolution, and averaging information. Note that the control ***A0*** sets the I^2C address in the software. This control must correspond to the jumper setting of jumpers JMP1, JMP2, JMP3, and JMP4 on the board; refer to Table 4.

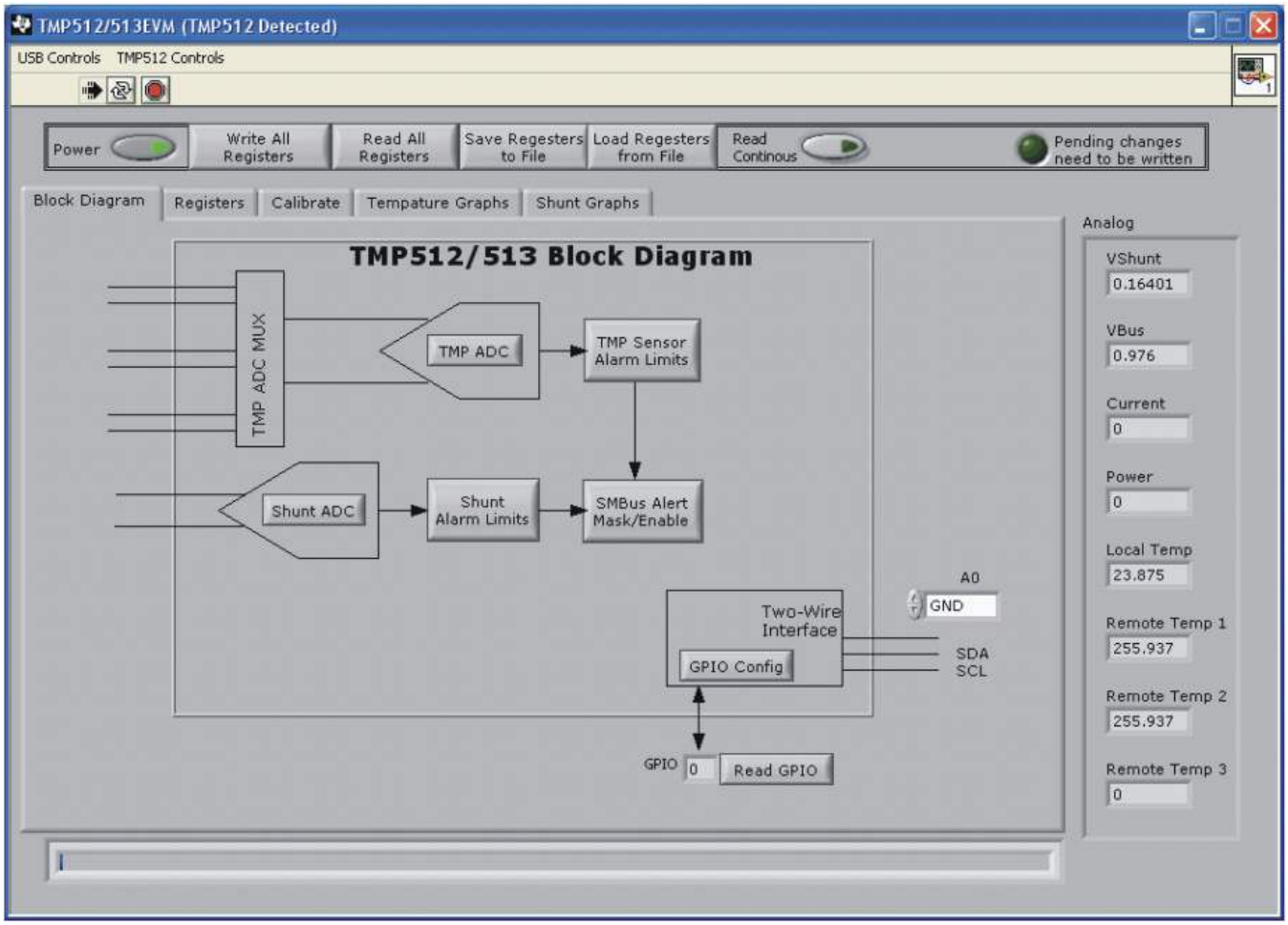


Figure 14. Block Diagram Tab

The toolbar located at the top of the software interface is also shown in Figure 14. The toolbar allows you to read and write registers on the TMP513EVM and in the device itself. When any change is made to the block diagram or to any other feature in the software, the registers in the TMP513 are changed. However, these changes do not take effect until the **Write All Registers** button is pressed. The *Pending changes need to be written* LED indicator illuminates whenever a register has been edited (but not written to). The *Pending changes need to be written* LED indicator turns off when the **Write All Registers** button is pressed to indicate that the registers are up to date.

Figure 14 also shows the *Analog* values measured by the TMP513. These values are updated each time the **Read All Registers** button is pressed. Note that some values read '0' if the device has not been calibrated (see Section 4.4.3).

4.4.2 Registers Tab

In the Registers tab, shown in Figure 15, users can select any row in the *Register Table* by clicking on it. When a row is selected, it is highlighted in blue. The individual 16 bits in the selected register are then 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 arrows to the left of the bit. Any changes to the bit are displayed in the table and in the block diagram. Additionally, any changes to the block diagram are shown in the table.

The **Help w Reg** button can be pressed to see detailed help information about the register that is currently selected (that is, highlighted in blue in the table). This Help feature gives detailed information regarding the meaning of each bit.

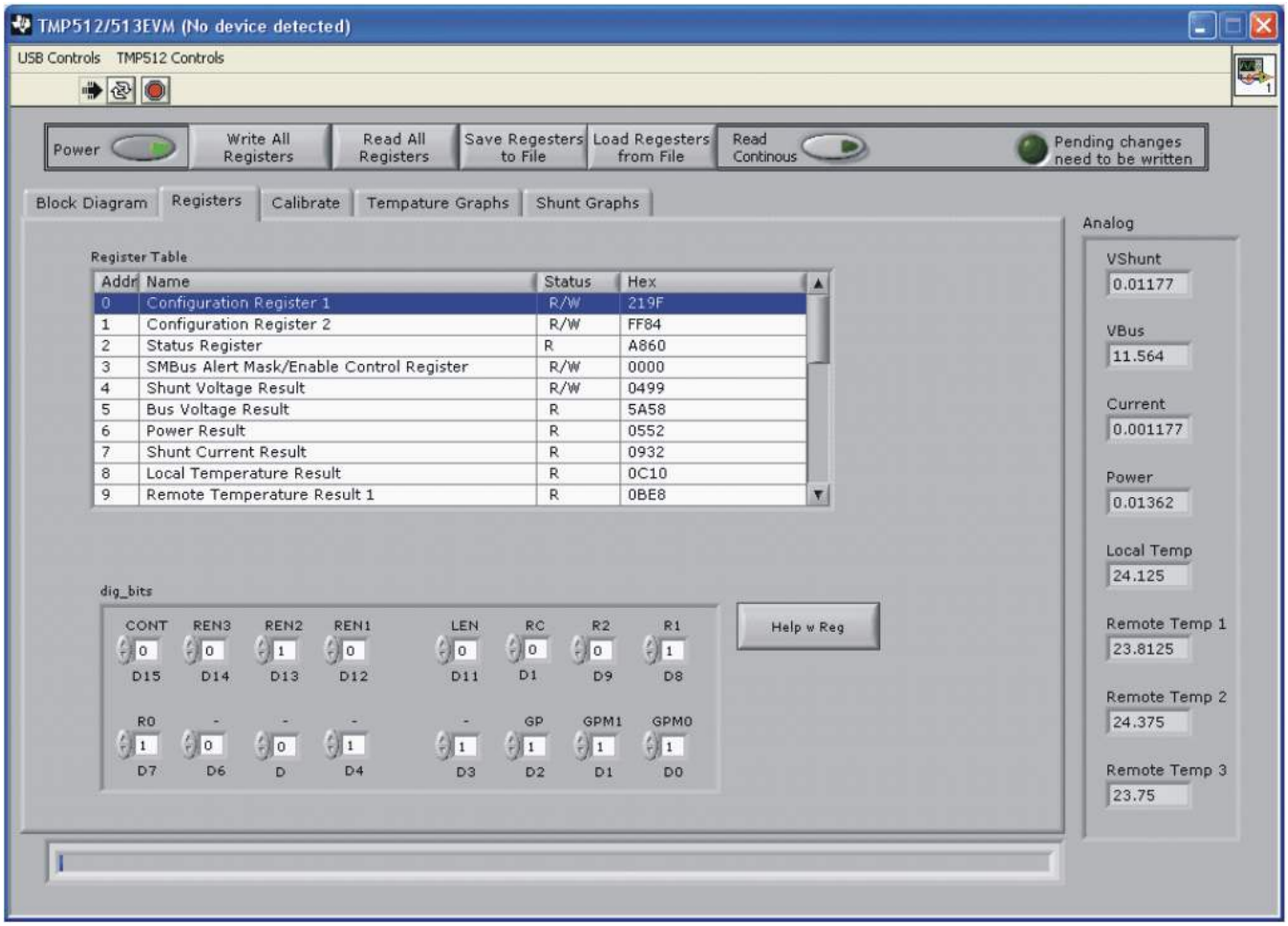


Figure 15. Registers Tab

4.4.3 Calibrate Tab

The Calibrate tab enables users to calibrate the TMP513. The calibration process is described in detail in the TMP513 data sheet. The goal of the calibration process is to generate a value for the *Cal Register* and a scaling factor to compute the power and current analog values. Figure 16 shows the Calibrate Tab.

Follow this procedure to calibrate the TMP513 device:

Step 1. Select the *Bus Voltage Range* and the *Max Shunt Voltage*. Enter the value of your shunt resistor in ohms. Press **Enter Shunt Resistance** when you are done entering the data.

Step 2. Enter the *Max Expected Current*. This value must be less than or equal to the *Max Possible Current*. Press **Enter Max Expected Current** when you are done entering the data.

Step 3. Enter the LSB in the *Enter LSB* field. The LSB must be between the *Min Current LSB* and the *Max Current LSB* values. Press **Enter Current LSB** when you are done entering the data.

Step 4. The summary shows all the key information calculated in this step. At this point, the *Pending changes need to be written* LED indicator is illuminated. Press **Write All Registers** to copy your calculations into the TMP513 device.

The device is now calibrated. If you press **Read All Registers**, the *Analog* section at the right-hand side of the window updates with the correct analog results.

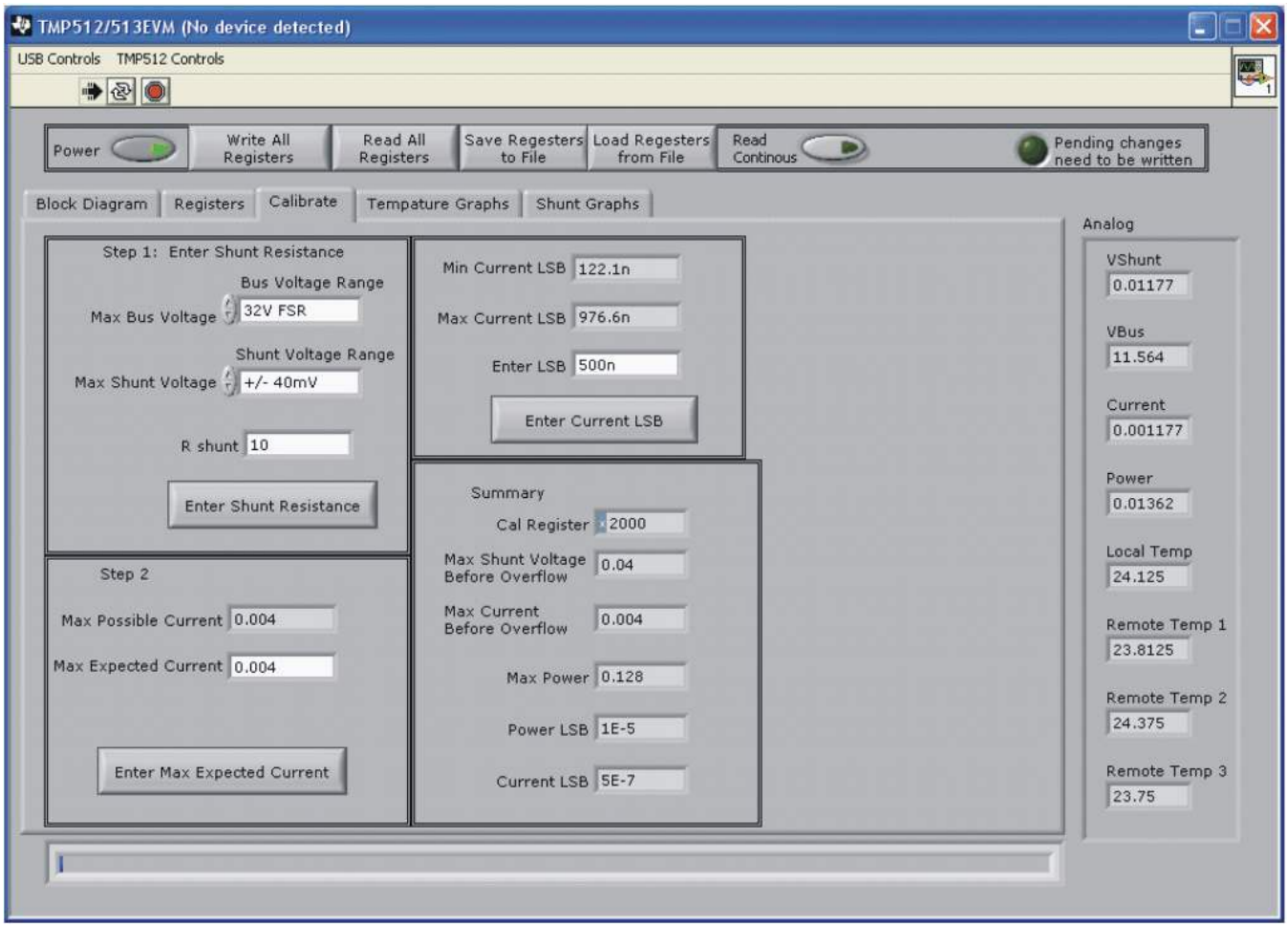


Figure 16. Calibrate Tab

4.4.4 Temperature Graph Tab

Use this tab (shown in Figure 17) to graph the temperature sensor results. To start the graph, you must first press the **Read Continuous** button. After pressing this button, it will be displayed in green and the graph starts to update. Press the **Read Continuous** button again to turn off this function.

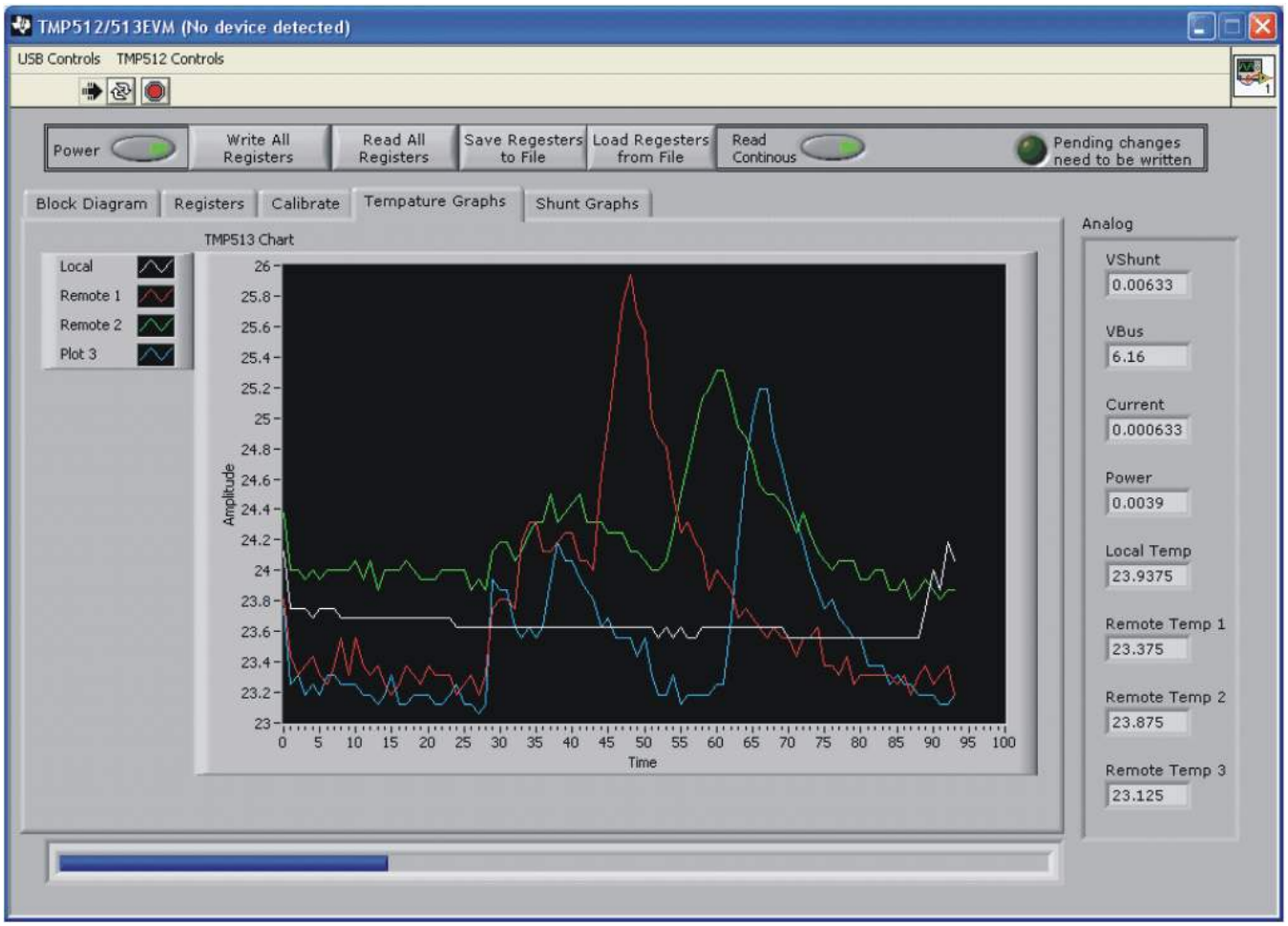


Figure 17. Temperature Graph Tab

4.4.5 Shunt Graph Tab

This tab allows you to graph the current shunt monitor results. To start the graph, press the **Read Continuous** button. After pressing this button, it will be illuminated green, and the graph starts to update. Press the **Read Continuous** button again to turn off this function. Figure 18 shows the shunt graph tab.

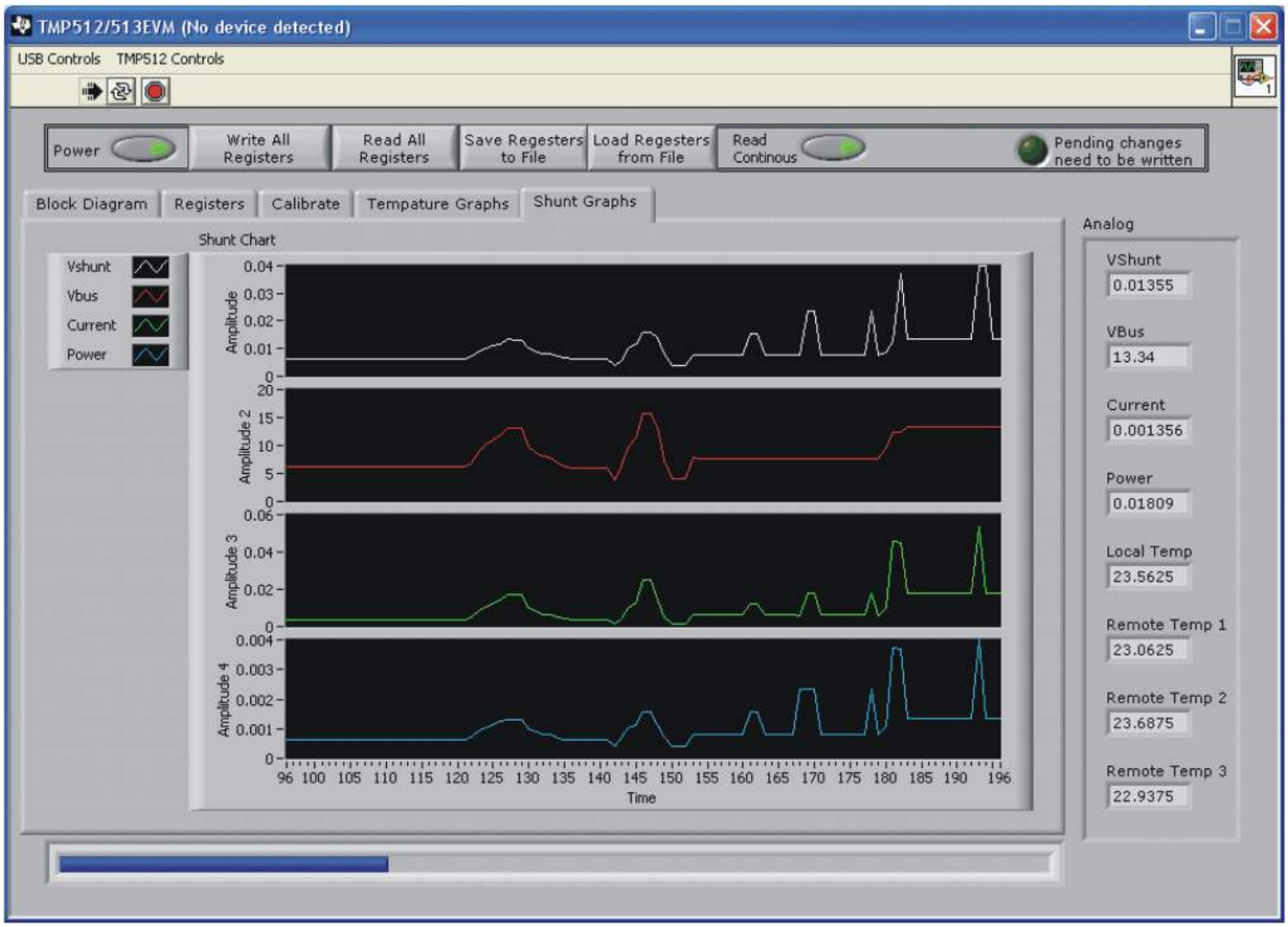


Figure 18. Shunt Graph Tab

5 Bill of Materials

Table 6 shows the parts list for the TMP513_Test_Board.

Table 6. Parts List for the TMP513_Test_Board

Qty	Value	Ref Des	Description	Vendor	Part Number
1	0.1µF	C6	Capacitor 0.10µF, 25V, Ceramic Y5V 0603	KEMET	C0603C104M3VACTU
1	10µF	C5	Capacitor Tantalum 10µF, 25V, 20% SMD	Nichicon	F931E106MCC
1	470nF	C7	Capacitor Ceramic .47µF, 25V, Y5V 0603	Taiyo Yuden	TMK107F474ZA-T
3	50pF	C1, C2, C3	Capacitor Ceramic 51pF, 50V, 5% C0G 0603	Murata Electronics North America	GRM1885C1H510JA01D
2	0Ω	R7, R8	Resistor 0.0Ω 1/10W 0603 SMD	Stackpole Electronics Inc	RMCF 1/16 0 R
7	50Ω	R0, R1, R2, R3, R4, R5, R6	Resistor 49.9Ω 1/10W 1% 0603 SMD	Panasonic - ECG	ERJ-3EKF49R9V
2	4.02kΩ	R14, R15	Resistor 4.02kΩ 1/10W 1% 0603 SMD	Panasonic - ECG	ERJ-3EKF4021V
2	100kΩ	R16, R17	Resistor 100kΩ 1/10W 5% 0603 SMD	Panasonic - ECG	ERJ-3GEYJ104V
4	Omit	R7, R8, R9, R10			
1	TMP513	U1	Temp Sensor / Current Shunt monitor	Texas Instruments	TMP513
5	3-Pos	T1, T2, T3, T4, T7	Terminal Block 5mm 3-Pos	ON SHORE TECHNOLOGY	ED300/3
2	2-Pos	T5, T6	Terminal Block 5mm 2-Pos	ON SHORE TECHNOLOGY	ED300/2
2	LED	D1, D2	Ultra-Bright Red Diffused LED, 0603 pkg	Panasonic	LNJ208R8ARA
4	Header strip	JMP5, JMP6, JMP7, JMP8	Conn Header .100 single 3-pos	Samtec	TSW-103-07-G-S
4	Header strip	JMP1, JMP2, JMP3, JMP4	Conn Header .100 single 2-pos	Samtec	TSW-102-07-G-S

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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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