User's Guide

SBOU084–February 2010

PGA309EVM-USB

This user's guide describes the characteristics, operation, and use of the PGA309EVM-USB evaluation module (EVM). This EVM is designed to evaluate the performance of the PGA309, a voltage output, programmable sensor conditioner. This document covers all pertinent areas involved to properly use this EVM board, allowing for user evaluation suitable to a variety of applications. This document also includes the physical printed circuit board (PCB) layout and circuit descriptions. A schematic of the PGA309EVM-USB is available as a separate download from the TI web site.

Contents

1 Introduction and Overview ... 2
2 System Setup ... 5
3 PGA309EVM-USB Hardware Setup ... 16
4 PGA309EVM-USB Software Overview ... 25

List of Figures

1 Hardware Included with the INA282-286EVM ... 3
2 PGA309EVM-USB Hardware Setup ... 5
3 PGA309_Test_Board Block Diagram ... 5
4 PGA309_Test_Board Schematic: Input Circuitry ... 7
5 PGA309_Test_Board Schematic: Power, Reference, and Digital Connections ... 8
6 PGA309_Test_Board Schematic: Output Circuitry ... 9
7 PGA309_Test_Board Schematic: Sensor Emulator Circuitry ... 10
8 PGA309_Test_Board Connections to USB-DAQ-Platform and EEPROM ... 11
9 Theory of Operation For USB-DAQ-Platform ... 16
10 PGA309EVM-USB Typical Hardware Connections ... 17
11 Connecting the Two EVM PCBs ... 18
12 Connecting Power to the EVM ... 19
13 Connecting the USB Cable ... 20
14 Default Jumper Settings (PGA309_Test_Board) ... 21
15 Default Jumper Settings (USB-DAQ-Platform) ... 22
16 PGA309EVM-USB Software: Registers Tab ... 26
17 PGA309EVM-USB Software: EEPROM Tab ... 27
18 PGA309EVM-USB Software: Block Diagram ... 28
19 PGA309EVM-USB Software: Auto Calibrate Tab—Sensor Definition ... 29
20 PGA309EVM-USB Software: Sensor Emulator Control Panel Tool ... 30
21 PGA309EVM-USB Software: Auto Calibrate Tab—PGA Setup ... 31
22 PGA309EVM-USB Software: Auto Calibrate Tab—Two-Point Calibration and Linearization ... 32
23 PGA309EVM-USB Software: Auto Calibrate Tab—Temperature Error Compensation ... 33
24 PGA309EVM-USB Software: Auto Calibrate Tab—Post Cal Error Check ... 34
25 PGA309EVM-USB Software: Auto Calibrate Tab—DMM Options ... 35

Microsoft, Windows are registered trademarks of Microsoft Corporation.
I^2C is a trademark of NXP Semiconductors.
All other trademarks are the property of their respective owners.

List of Tables

1	PGA309 Test Board Parts List	12
2	J1 Pinout (25-Pin Male DSUB)	14
3	J2 Pinout (25-Pin Female DSUB)	15
4	PGA309_Test_Board Jumper Functions: General	22
5	PGA309_Test_Board Jumper Functions: Miscellaneous Connections	23
6	PGA309_Test_Board Jumper Functions: Sensor Emulator Section	23
7	USB-DAQ-Platform Jumper Settings	24

1 Introduction and Overview

This document provides the information needed to set up and operate the PGA309EVM-USB evaluation module, a test platform for the PGA309 programmable sensor conditioner. For a more detailed description of the PGA309, refer to the product data sheet (SBOS292) available from the Texas Instruments web site at http://www.ti.com. Additional support documents are listed in the section of this guide entitled *Related Documentation from Texas Instruments*.

The PGA309EVM-USB is an evaluation module that is used to fully evaluate the PGA309. The PGA309 is an integrated circuit that provides temperature compensation and linearization for bridge sensors. The PGA309EVM-USB consists of two PCBs. One board (the USB-DAQ-Platform) generates the digital signals required to communicate with the PGA309. The other board (the PGA309_Test_Board) contains the PGA309 device, as well as support and configuration circuitry.

Throughout this document, the abbreviation *EVM* and the term *evaluation module* are synonymous with the PGA309EVM-USB.

1.1 PGA309EVM-USB Hardware

Figure 1 shows the hardware included with the PGA309EVM-USB kit. Contact the factory 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 software. It is also recommended that you refer to the PGA309 User's Guide if you have questions about the PGA309 device itself.

The complete kit includes the following items:

- PGA309_Test_Board
- USB DAQ Platform Board
- USB cable
- 6V wall power-supply unit
- CD-ROM containing this user's guide and product software

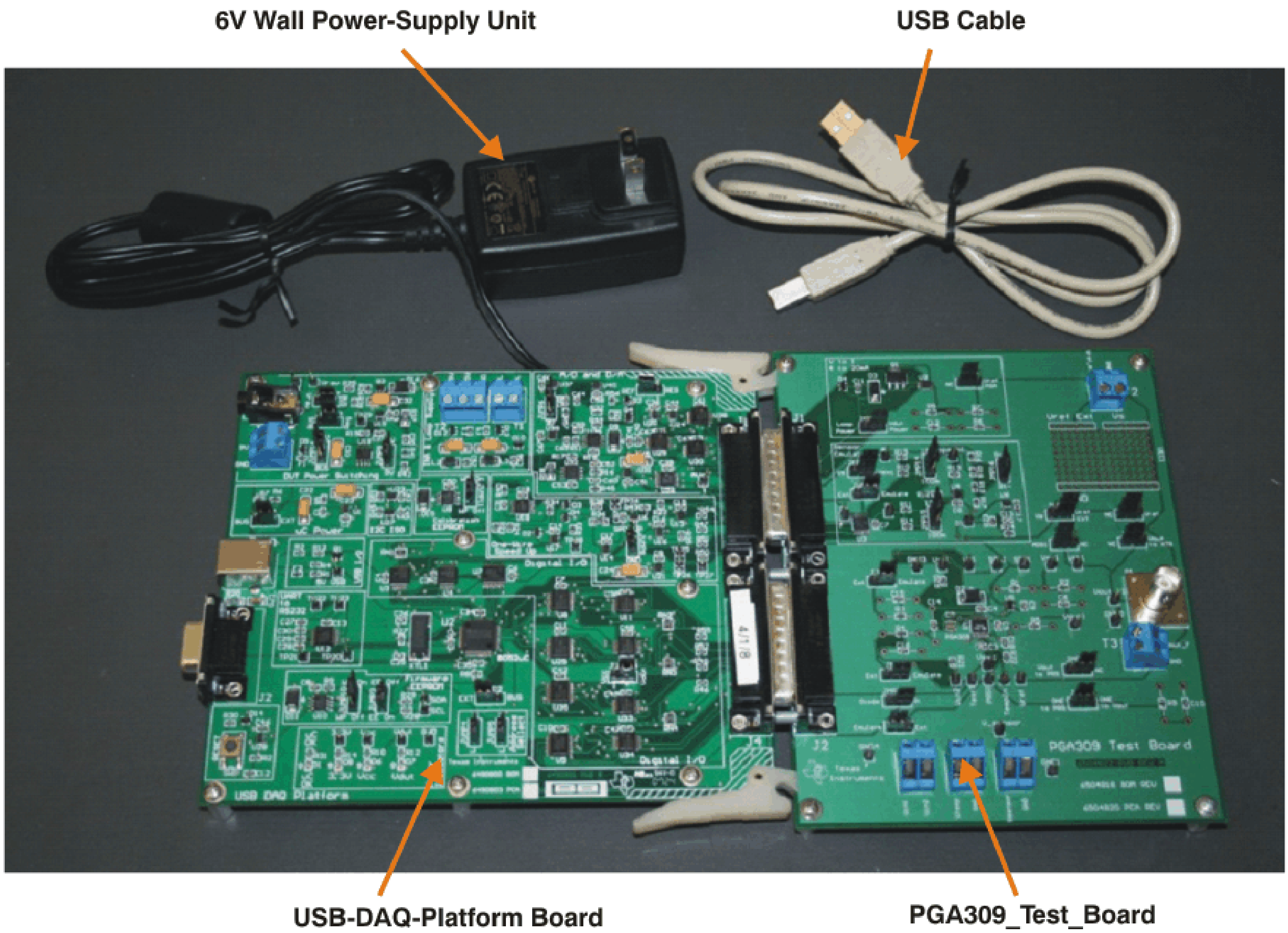

Figure 1. Hardware Included with the INA282-286EVM

1.2 Related Documentation from Texas Instruments

The following documents provides information regarding Texas Instruments integrated circuits used in the assembly of the PGA309EVM-USB. This user's guide is available from the TI web site under literature number SBOU084. 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.

Document	Literature Number
PGA309	SBOS292
USB DAQ Platform Users Guide	SBOU056
PGA309 Users Guide	SBOU024
OPA333 Product Data Sheet	SBOS351
DAC8555 Product Data Sheet	SLAS475
XTR117 Product Data Sheet	SBOS344
PGA309EVM-USB Schematic	SBOR010
Sensor-Emulator EVM Reference Guide	SBOA102

1.3 If You Need Assistance

If you have questions about the PGA309EVM-USB evaluation module, send an e-mail to the Linear Application Team at precisionamps@list.ti.com. Include *PGA309EVM-USB* 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.

2 System Setup

Figure 2 shows the system setup for the PGA309EVM. The PC runs software that communicates with the USB-DAQ-Platform. The USB-DAQ-Platform generates the digital signals used to communicate with the PGA309_Test_Board. Connectors on the PGA309_Test_Board allow for connection to the bridge sensor.

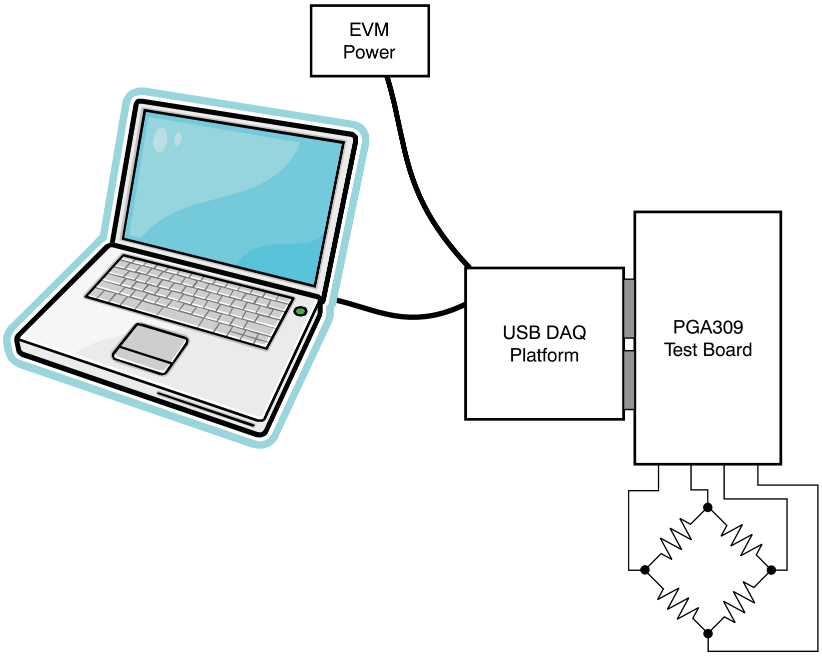

Figure 2. PGA309EVM-USB Hardware Setup

2.1 Theory of Operation for PGA309_Test_Board Hardware

Figure 3 shows the block diagram of the PGA309_Test_Board. The PGA309_Test_Board provides connections to the I^{2}C™, one-wire, analog-to-digital converters (ADCs) and digital-to-analog converters (DACs) on the USB-DAQ-Platform. It also provides connection points for external connection of the bridge sensor. The PGA309_Test_Board has circuitry to convert the PGA309 voltage output to 4mA to 20mA current.

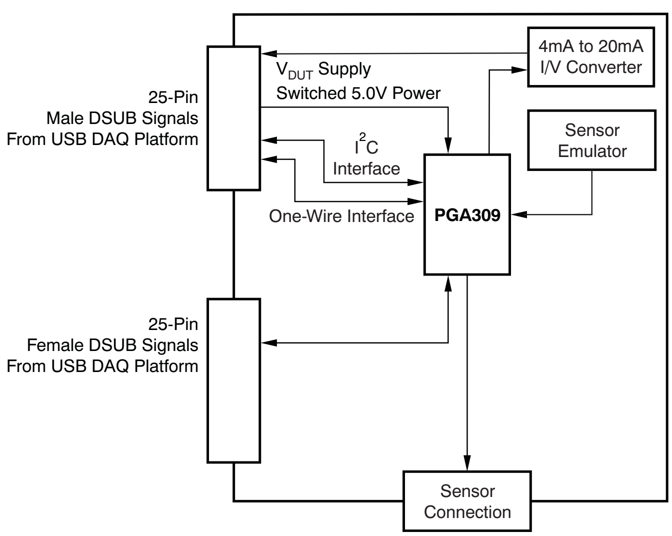

Figure 3. PGA309_Test_Board Block Diagram

The PGA309_Test_Board also has an onboard sensor emulator. The sensor emulator is a circuit that generates the same type of signals generated by a bridge sensor. The sensor emulator circuit is controlled by the PGA309EVM-USB software. Using the sensor emulator allows you to get a deeper understanding of the PGA309EVM-USB software and hardware more quickly. When the capabilities and functions of the PGA309EVM-USB are fully understood, you can connect the real-world sensor to the EVM and perform a full calibration.

Note that calibrations with real-world sensors are time-consuming because devices such as these are normally calibrated at multiple temperatures in an environmental chamber. It is not unusual for temperature calibration to require 12 hours.

2.2 PGA309_Test_Board Connections

See Figure 4 for the input connections on the PGA309_Test_Board schematic. T1 provides the power connection for an external bridge sensor. T4 allows connections to each input of the external bridge sensor. T5 allows connection of the external temperature sensor. JMP7, JMP4, JMP5, and JMP6 allow users to select either the onboard sensor emulator or an external sensor. JMP12 allows users to choose between V_S or V_{EXC} for the sensor power.

The input is filtered with R3, R4, C14, C15, and C16. Note that C14 is ten times larger then C15, and C16 is used for good ac common-mode rejection. The cutoff frequency of this filter is 40.6Hz (f = 1/(2 π R3 C14)). This input filter is recommended in your final design if you have available board space.

V_{EXC} has a 100pF capacitor and TEMPin has a 1nF capacitor. These components are also recommended in your final design.

Refer to Figure 5 to see the power, reference, and digital connections on the PGA309_Test_Board schematic. T2 provides a connection for an external reference voltage. JMP1 and JMP2 allow users to select between the internal reference, an external reference, or power-supply reference. JMP7 and JMP8 allows users to connect the One-Wire signal to the PRG pin directly or through V_{OUT}.

D2 is a transient voltage suppressor. It is useful in helping to prevent damage in an electrical overstress (EOS) condition. R5 is useful in preventing EOS damage to the output. C6 filters noise at the output. C5 filters the reference output. These components are recommended for your design if PCB space permits. C4 is a decoupling capacitor; it is required in the final design.

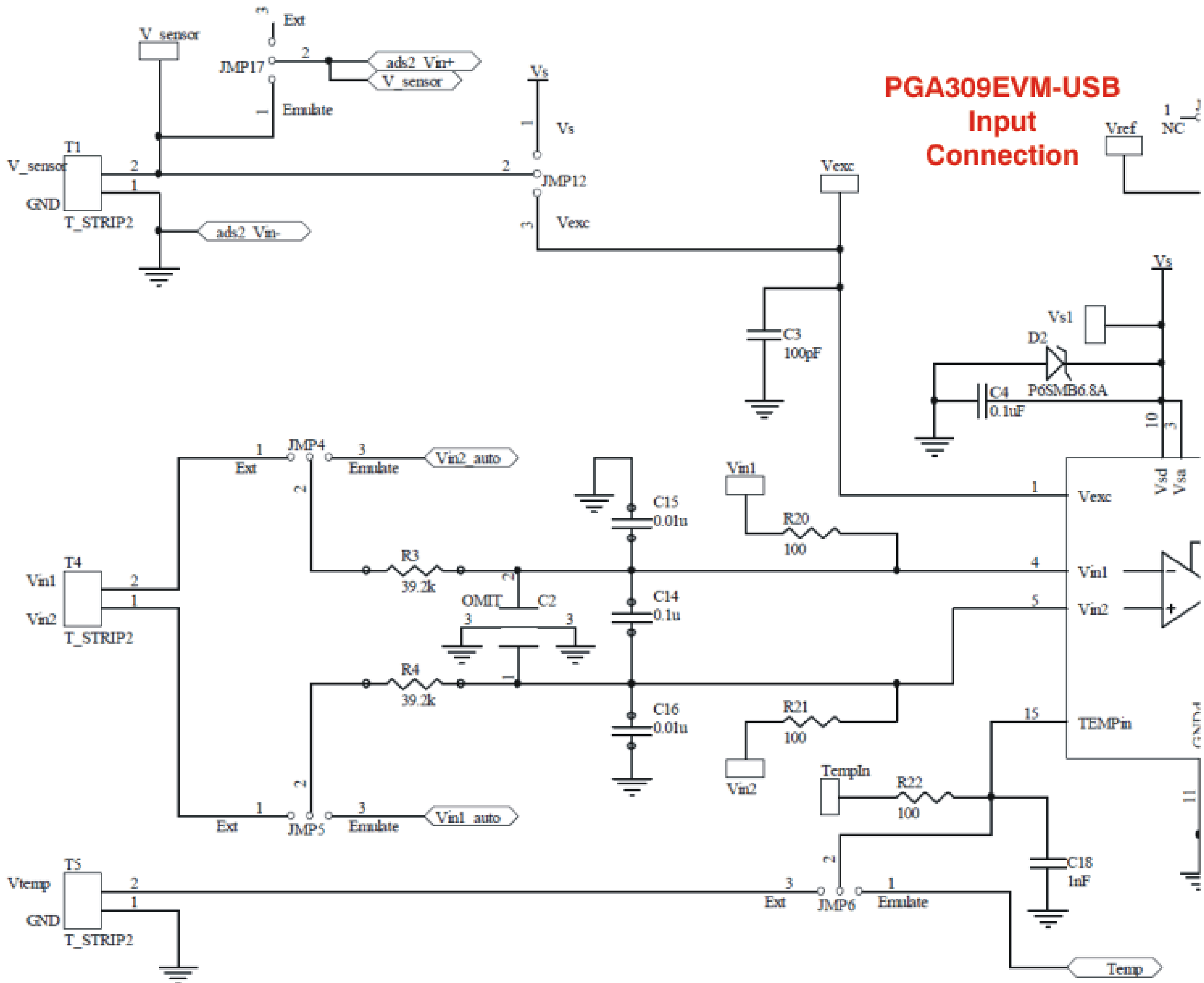

Figure 4. PGA309_Test_Board Schematic: Input Circuitry

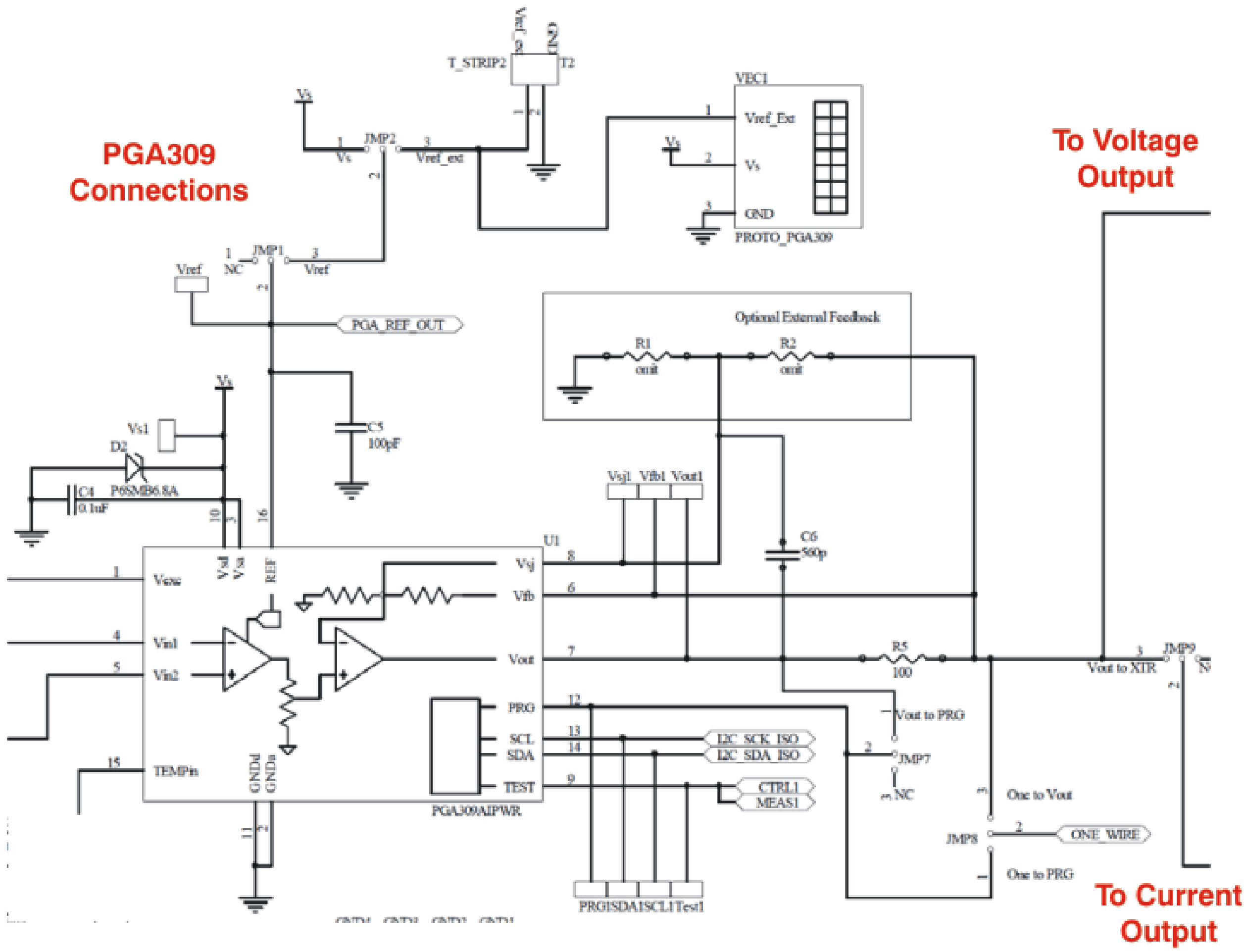

Figure 5. PGA309_Test_Board Schematic: Power, Reference, and Digital Connections

Figure 6 shows the output section of the PGA309EVM_Test_Board. There are two output options: voltage output and current output. The voltage output option is selected by placing JMP9 in the *NC* position. The current output option is selected by moving JMP9 to the *V_{OUT} to XTR* position.

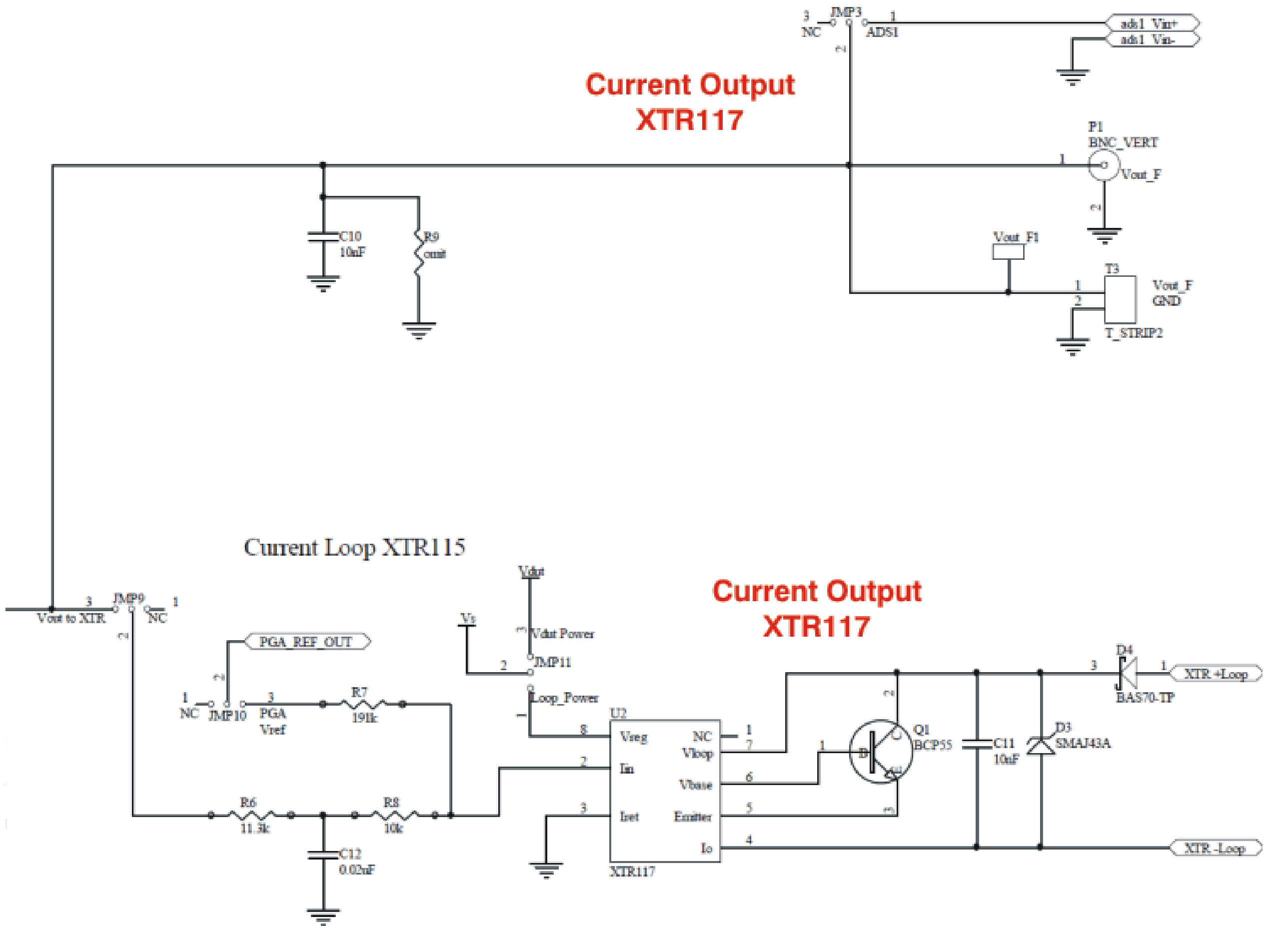

Figure 6. PGA309_Test_Board Schematic: Output Circuitry

In voltage output mode, C10 = 10nF is connected to the PGA309 output. This capacitor is used for radio frequency interference (RFI) and electromagnetic interference (EMI) immunity. This component should be included in your design, if possible.

In current output mode, the PGA309 output is connected to a voltage-to-current (V-I) converter (XTR117). The sum of R6 and R8 convert the output voltage from the PGA309 to an input current for the XTR117. R7 can be used to create an input offset current using the reference. The total input current is $I_{IN} = V_{OUT}$ / (R6 + R8) + V_{REF}/R7. The output current is equal to the input current times the current gain (x 100).

D4 is used for reverse polarity protection. D3 is used for over-voltage transient protection. D3 was selected for low leakage. Leakage on D3 directly contributes to error. C11 is a decoupling capacitor and is required for proper operation. The external transistor, Q1, conducts the majority of the full-scale output current. Power dissipation in this transistor can approach 0.8W with high loop voltage (40V) and 20mA output current.

Figure 7 shows the sensor emulator circuit. The sensor emulator generates signals to help users evaluate the PGA309. No part of this circuit is required in your final design. The sensor emulator uses a DAC8555 (U8) to generate an emulated temperature signal, common-mode signal, and differential signal. These signals can be controlled using software to produce levels that closely match real-world sensors.

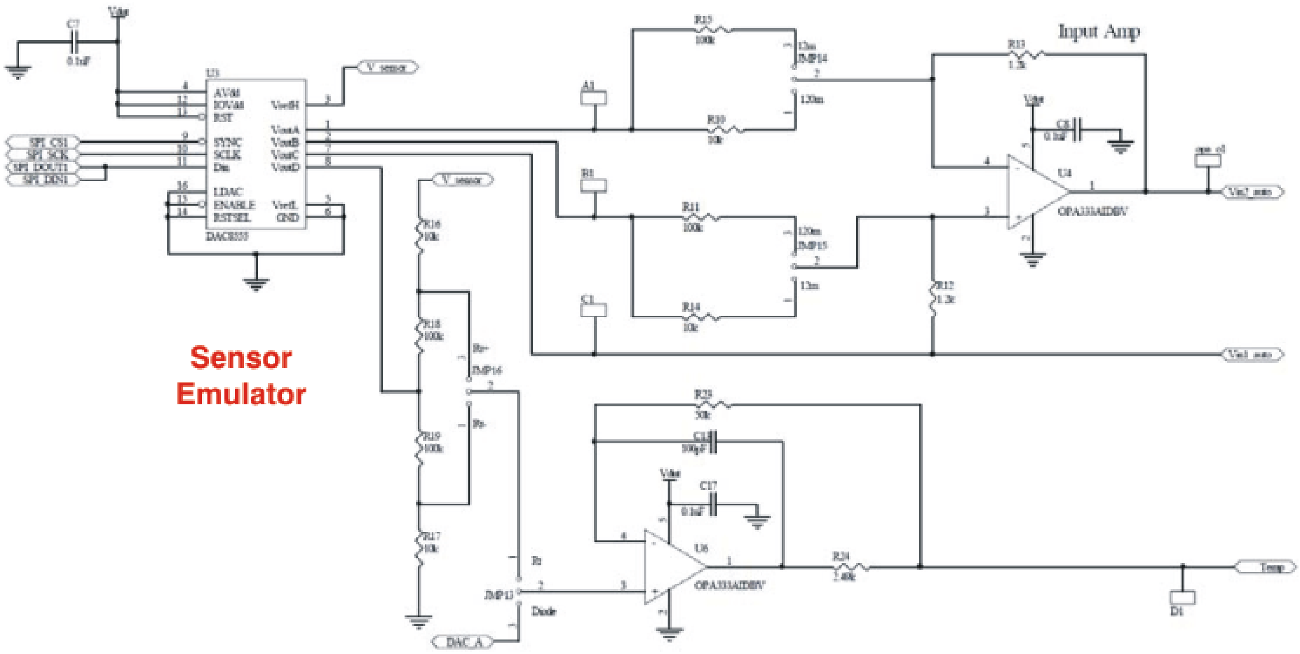

Figure 7. PGA309_Test_Board Schematic: Sensor Emulator Circuitry

The operational amplifier U4 and associated resistors is a differential amplifier with jumper selectable attenuation. The possible attenuations are 0.12 and 0.012. The attenuation produces a more accurate and stable emulated sensor output. For example, when the DAC outputs 3V, the sensor emulator outputs 3V × 0.012 = 36mV (assuming that attenuation is set in the 0.012 position). Thus, the maximum output of the sensor emulator is 120mV/V and 12mV/V.

The op amp U6 buffers the emulated temperature signal. Resistors R16, R17, R18, and R19 are used to attenuate the DAC output for temperature emulation and to reference the temperature signal to supply or ground. JMP13 allows the resistor network to be bypassed for direct connection to the DAC (diode temperature sensor mode).

Figure 8 illustrates the two 25-pin D-SUB connectors J1 and J2. These connectors provide all the signals necessary to communicate with the PGA309. U5 is the EEPROM used to store the calibration look-up table used with the PGA309.

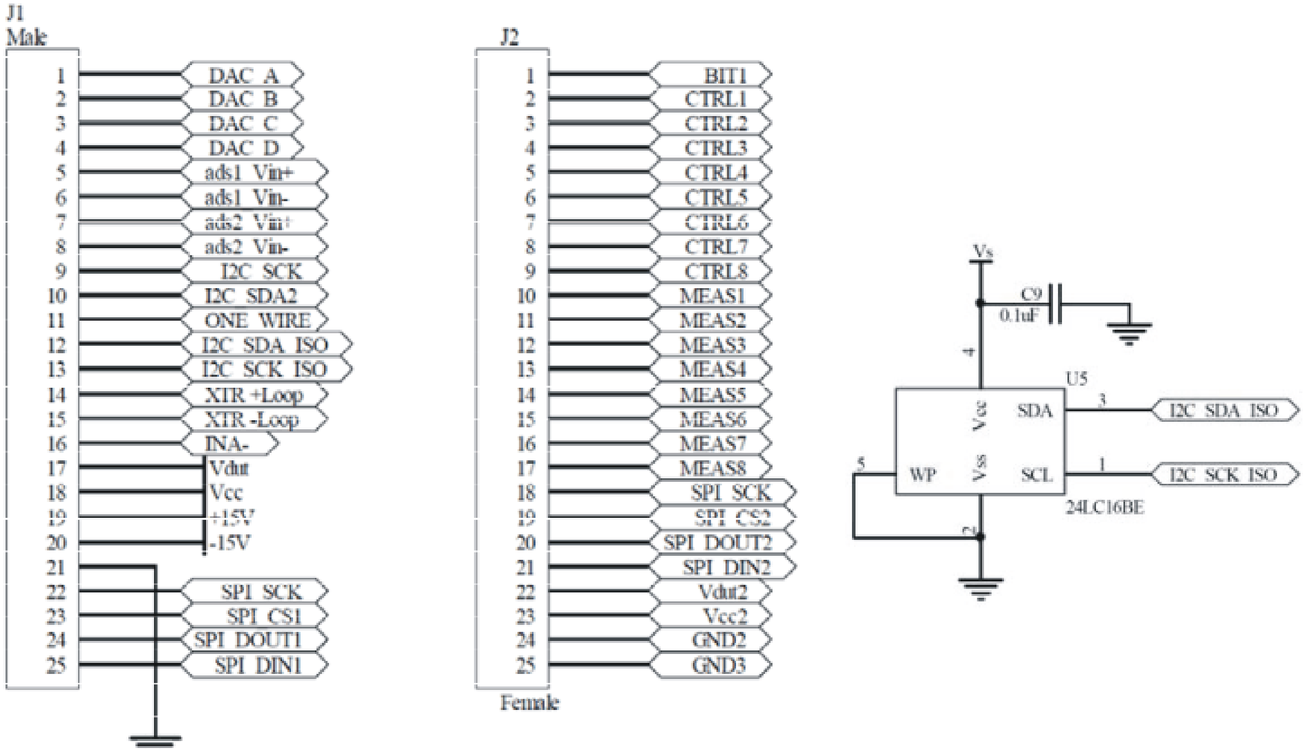

Figure 8. PGA309_Test_Board Connections to USB-DAQ-Platform and EEPROM

2.3 PGA309_Test_Board Parts List

Table 1 describes the parts list for the PGA309_Test_Board.

Table 1. PGA309 Test Board Parts List

Qty	Value	Ref Des	Description	Vendor	Part Number
1	560pF	C6	Capacitor, ceramic 560pF 50V NP0 0603	Panasonic - ECG	ECJ-1VC1H561J
3	100pF	C3 C5, C13	Capacitor, ceramic 560pF 50V NP0 0603		ECJ-1VC2A101J
6	0.1µF	C4, C7, C8, C9, C14, C17	Capacitor, 0.1µF 25V, ceramic Y5V 0603	Kemet	CC0603ZRY5V8BB104
2	.01µF	C15, C16	Capacitor, ceramic .01µF 10% 100V X7R 0603	AVX	06031C103KAT2A
1	1nF	C18	Capacitor, 1000pF, 100V, ceramic X7R 0603	Panasonic - ECG	ECJ-1VB2A102K
2	10nF	C10, C11	Capacitor, 10000pF, 50V, ceramic X7R 0603	Kemet	C0603C103K5RACTU
1	0.02µF	C12	Capacitor, ceramic 22000pF, 100V X7R 10%0603	TDK Corporation	C1608X7R2A223K
1	1000pF	C2	Omit; not installed	JOHANSON DIELECTRICS	501R18W102KV4E
4	100kΩ	R11, R15, R18, R19	Resistor, 100kΩ 1/6W 0.1% 0603 SMD	Susumu Co Ltd	RGH1608-2C-P-104-B
2	1.2kΩ	R12, R13	Resistor, 1.2kΩ 1/6W 0.1% 0603 SMD	Susumu Co Ltd	RGH1608-2C-P-122-B
5	10kΩ	R8, R10, R14, R16, R17	Resistor, 10.0kΩ 1/6W 0.1% 0603 SMD	Susumu Co Ltd	RGH1608-2C-P-103-B
4	100Ω	R5, R20, R21, R22	Resistor, 100kΩ 1/10W 1% 0603 SMD	Yageo Corporation	RC0603FR-07100RL
1	191kΩ	R7	Resistor, 191kΩ 1/10W 1% 0603 SMD	Yageo Corporation	ERJ-3EKF1913V
1	11.3kΩ	R6	Resistor, 11.3kΩ 1/10W 1% 0603 SMD	Yageo Corporation	ERJ-3EKF1132V
2	39.2kΩ	R3, R4	Resistor, 39.2kΩ 1/10W 1% 0603 SMD	Yageo Corporation	RC0603FR-0739K2L
1	50kΩ	R23	Resistor, 49.9kΩ 1/16W .5% 0603 SMD	Sunsuma	RR0816P-4992-D-68C
1	2.49kΩ	R24	Resistor, 2.49kΩ 1/16W .5% 0603 SMD	Sunsuma	RR0816P-2491-D-39H
0	omit	R1, R2, R9	Omit; not installed		
1	PGA309	U1	Smart Programmable Sensor	Texas Instruments	PGA309AIPWT
1	BNC	P1	Connector, Jack BNC Vertical 50Ω PCB	Tyco Electronics/Amp	5227699-1
2	OPA333AID BVT	U4 U6	IC Op Amp 1.8V 0-DRIFT SOT23-5	Texas Instruments	OPA333AIDBVT
1	DAC8555	U3	IC DAC 16BIT QUAD 16-TSSOP	Texas Instruments	DAC8555IPW
1	24LC16BT	U5	IC SRL EEPROM 16K 2.5V SOT23-5	Microchip Technology	24LC16BT-I/OT
1	XTR117	U2	IC 4mA-20mA Current-Loop TX 8-MSOP	Texas Instruments	XTR117AIDGKT
1	6.8V transzorb	D2	TVS Zener Unidirectional 600W 6.8V SMB	ON Semiconductor	P6SMB6.8AT3G
1	SMAJ43A	D3	TVS 400W 43V Unidirectional SMA	Micro Commercial Components	SMAJ43A-TP
1	BAS70TP	D4	Diode, Schottky 70V 200mA SOT23	Micro Commercial Components	BAS70TPMSCT-ND
1	NPN	Q1	IC, Transistor NPN SS GP 1.5A SOT223-4	Fairchild Semiconductor	BCP55
5	ED300/2	T1, T2, T3, T4, T5	2-Position Terminal Strip, Cage Clamp, 45º, 15A, Dove-tailed	On-Shore Technology Inc	ED300/2

Table 1. PGA309 Test Board Parts List (continued)

Qty	Value	Ref Des	Description	Vendor	Part Number
17	JUMP2 Cut to Size	JMP1, JMP2, JMP3, JMP4, JMP5, JMP6, JMP7, JMP8, JMP9, JMP10, JMP11, JMP12, JMP13, JMP14, JMP15, JMP16, JMP17,	Terminal strip, 3-position, .100 centers, .025 square pins	Samtec	TSW-103-07-G-S
24	TP Cut to Size	V_Sensor, OPA_O1, C1, B1, A,1 TempIn, GND1, D1, GND2, V_{EXC}, V_{REF}, V_{OUT}_F1, V_{IN}2, PRG1, V_{OUT}1, V_{FB}1, V_S1, SCL1, V_{SJ}1, GND4, V_{IN}1, SDA1, GND3, Test1,	Terminal strip, 1-position, .100 centers, .025 square pins	Samtec	TSW-101-07-G-S
17	Jumper Shunts	JMP1, JMP2, JMP3, JMP4, JMP5, JMP6, JMP7, JMP8, JMP9, JMP10, JMP11, JMP12, JMP13, JMP14, JMP15, JMP16, JMP17,	Shunt LP w/Handle 2-position, 30AU	Tyco Electronics Amp	881545-2
1	DSUB25M	J1	Connector, D-SUB PLUG R/A 25POS 30GOLD (with Threaded Inserts and Board locks)	AMP/Tyco Electronics	5747842-4
1	DSUB25F	J2	Connector, D-SUB RCPT R/A 25POS 30GOLD (with Threaded Inserts and Board locks)	AMP/Tyco Electronics	5747846-4
4	Standoffs		Standoffs, Hex , 4-40 Threaded, 0.500" length, 0.250" OD, Aluminum Iridite Finish	Keystone	2203
4	Screws		Machine Screw, 4-40x3/8" Phillips PanHead, Steel, Zinc Plated	Building Fasteners	PMS 440 0038 PH

2.4 PGA309_Test_Board: Signal Definitions and Pinouts

This section provides the signal definitions for the PGA309_Test_Board.

2.4.1 J1 (25-Pin Male DSUB)

Table 2 shows the different signals connected to J1 on the PGA309_Test_Board. This table also identifies signals connected to pins on J1 that are not used on the PGA309_Test_Board.

Table 2. J1 Pinout (25-Pin Male DSUB)

Pin on J1	Signal	Used on This EVM	PGA309 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	

2.4.2 J2 (25-Pin Female DSUB)

Table 3 shows the different signals connected to J2 on the PGA309_Test_Board. This table also identifies signals connected to pins on J2 that are not used on PGA309_Test_Board.

Table 3. J2 Pinout (25-Pin Female DSUB)

Pin on J2	Signal	Used on This EVM	PGA309 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

2.5 Theory of Operation for USB-DAQ-Platform

Figure 9 shows the block diagram for the USB-DAQ-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 (available for download at www.ti.com). The block diagram shown in Figure 9 gives a brief overview of the platform. The primary control device on the USB-DAQ-Platform is the TUSB3210.

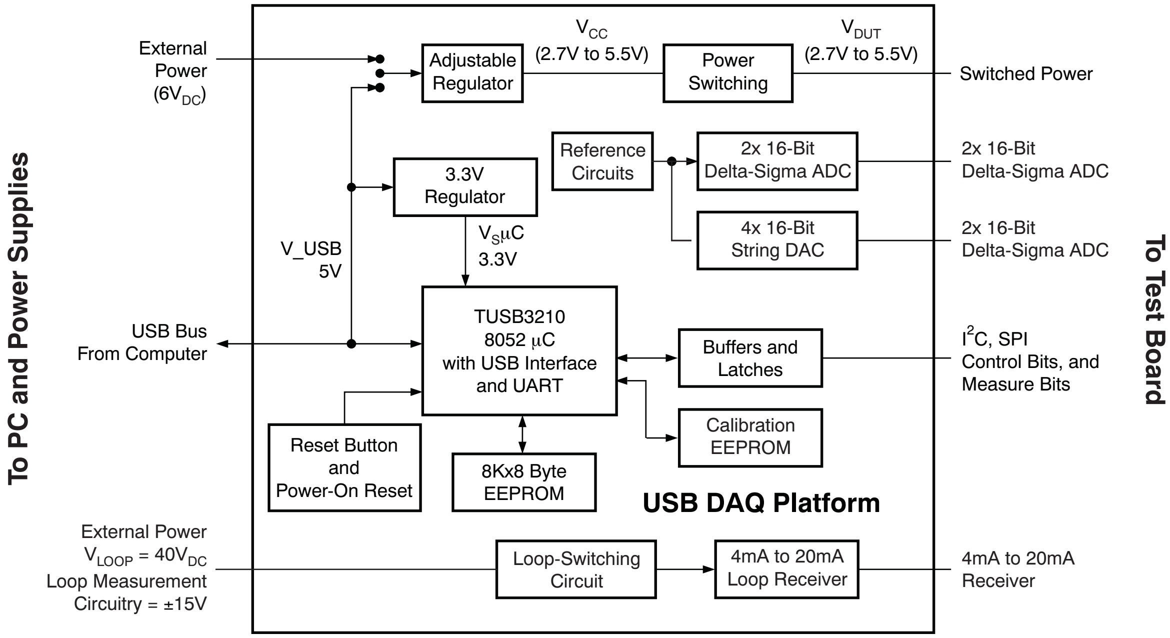

Figure 9. Theory of Operation For USB-DAQ-Platform

3 PGA309EVM-USB Hardware Setup

The PGA309EVM-USB Hardware setup 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 PBA309EVM-USB 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

To set up the PGA309EVM-USB hardware, connect the two halves of the EVM together, apply power, and then connect the external sensor. Figure 10 shows the typical hardware connections.

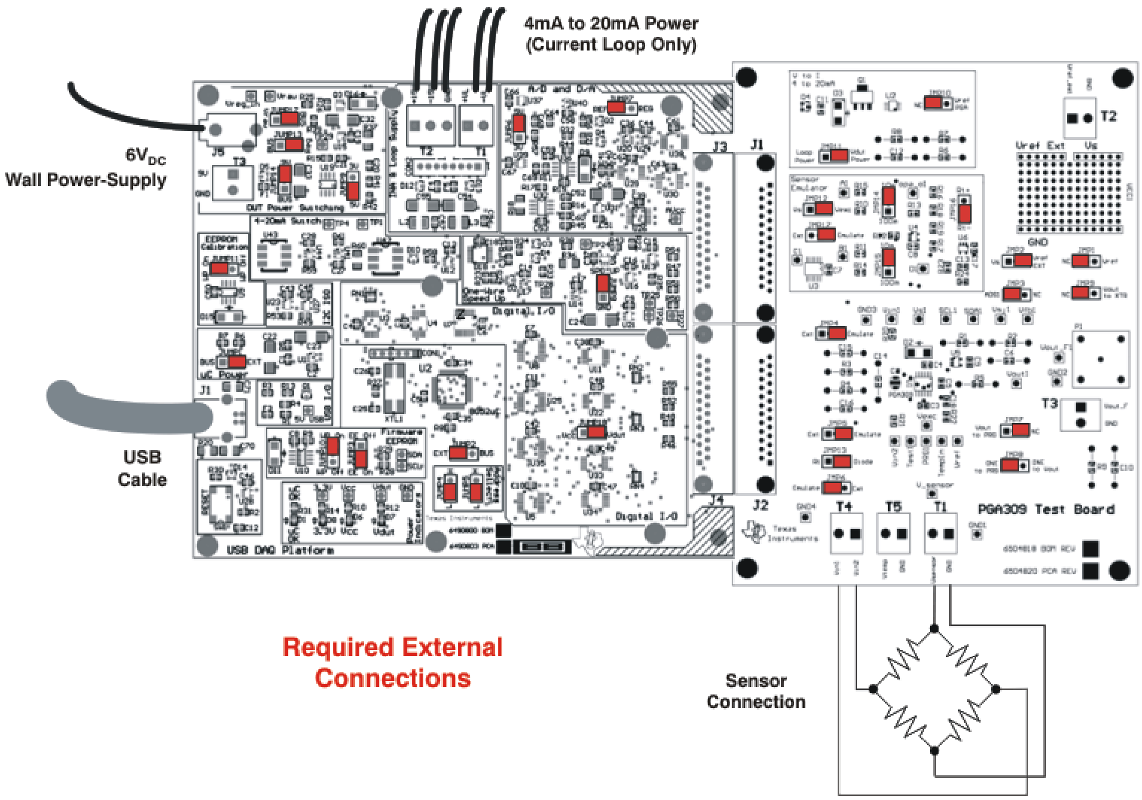

Figure 10. PGA309EVM-USB Typical Hardware Connections

3.3 Connecting the Hardware

To connect the two PCBs of the PGA309EVM-USB together, gently push on both sides of the D-SUB connectors (as shown in Figure 11). Make sure that the two connectors are completely pushed together; that is, loose connections may cause intermittent operation.

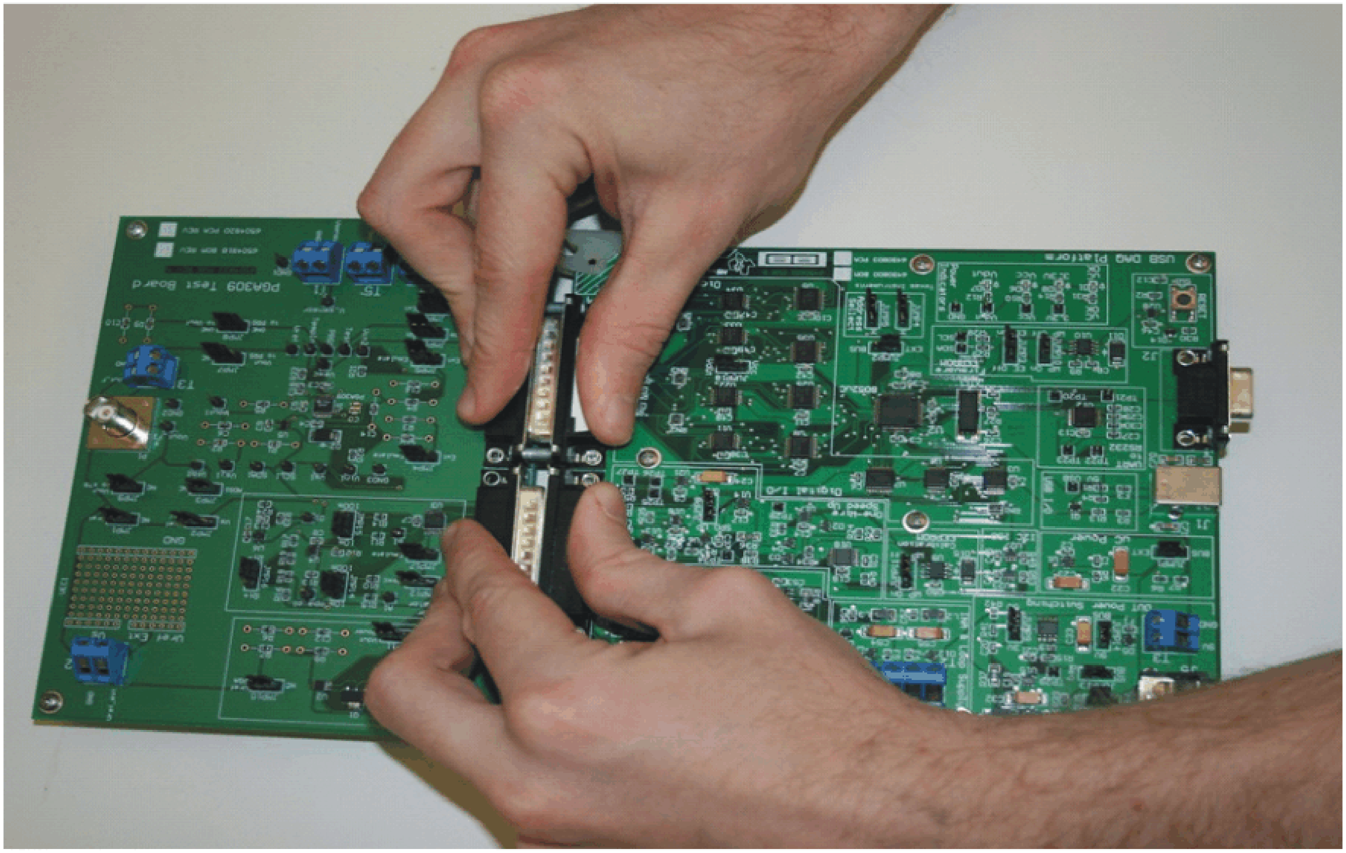

Figure 11. Connecting the Two EVM PCBs

3.4 Connecting Power

After the two parts of the PGA309EVM-USB are connected, as shown in Figure 12, connect the power to the EVM. Always connect power before connecting the USB cable. If you connect the USB cable before connecting the power, the computer will attempt to communicate with an unpowered device that will not be able to respond.

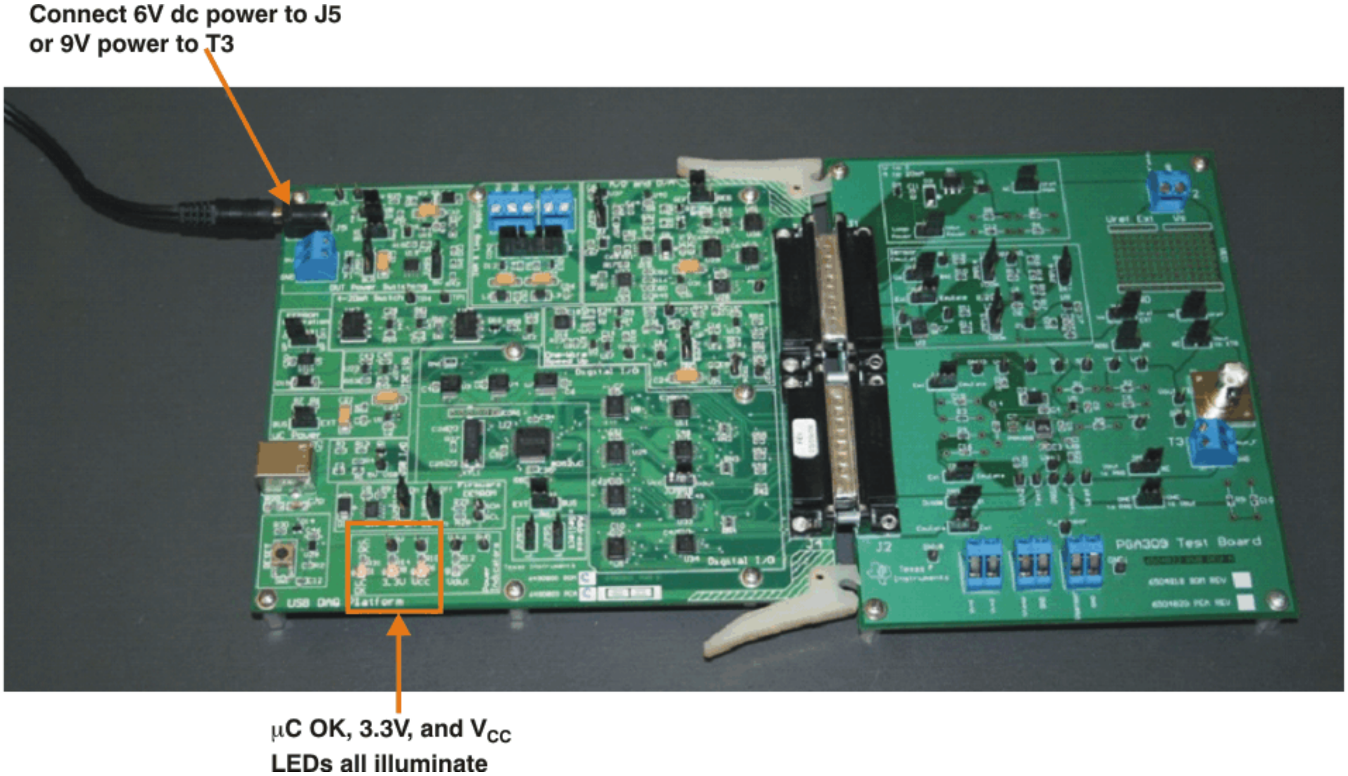

Figure 12. Connecting Power to the EVM

3.5 Connecting the USB Cable to the PGA309EVM-USB

Figure 13 shows the typical response to connecting the USB-DAQ-Platform to a PC USB port for the first time. Note that the EVM must be powered on before connecting the USB cable. Typically, the computer will respond 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 DAQ platform uses the *Human Interface Device Drivers* that are part of the Microsoft® Windows® operating system.

In some cases, the Windows *Add Hardware Wizard* will pop up. If this prompt occurs, allow the system device manager to install the *Human Interface Drivers* by clicking **Yes** when requested to install drivers.

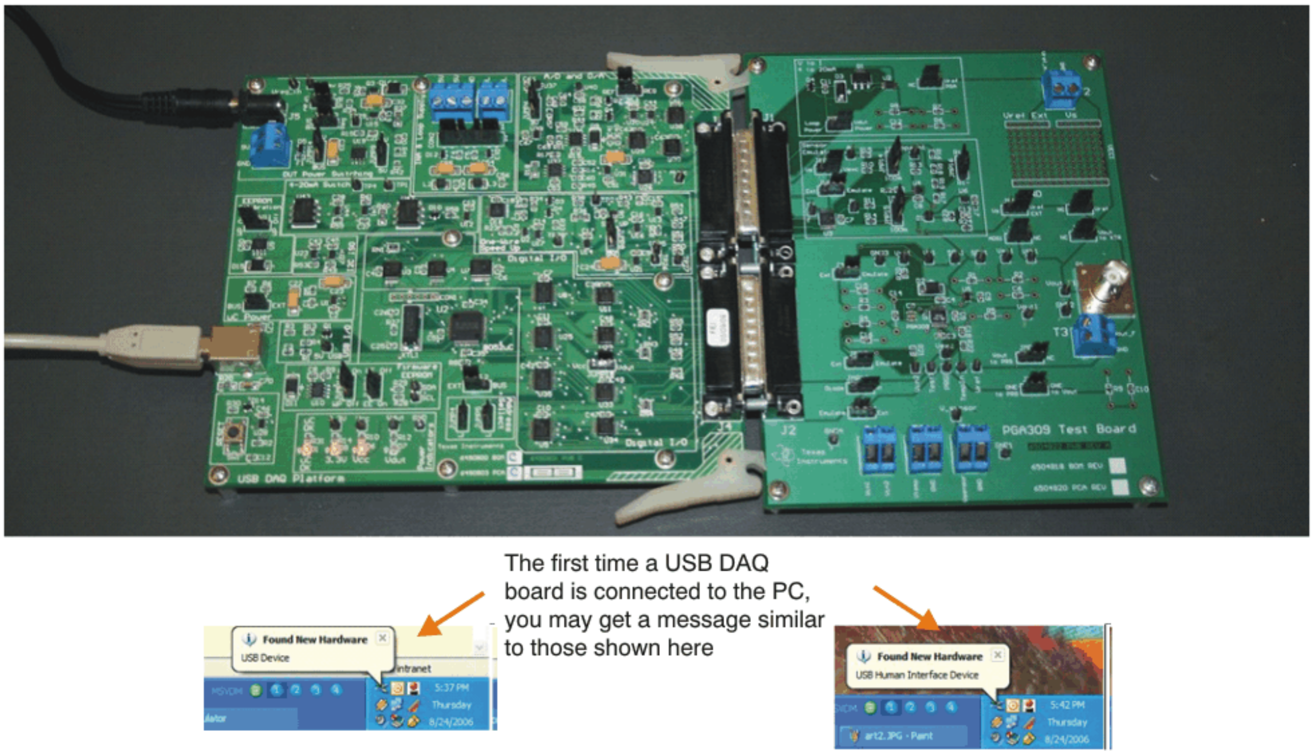

Figure 13. Connecting the USB Cable

3.6 PGA309EVM-USB Jumper Settings

Figure 14 illustrates the default jumpers configuration for the PGA309_Test_Board. In general, the jumper settings of the USB-DAQ-Platform do not need to be changed. You may want to change some of the jumpers on the PGA309_Test_Board to match your specific sensor conditioning design.

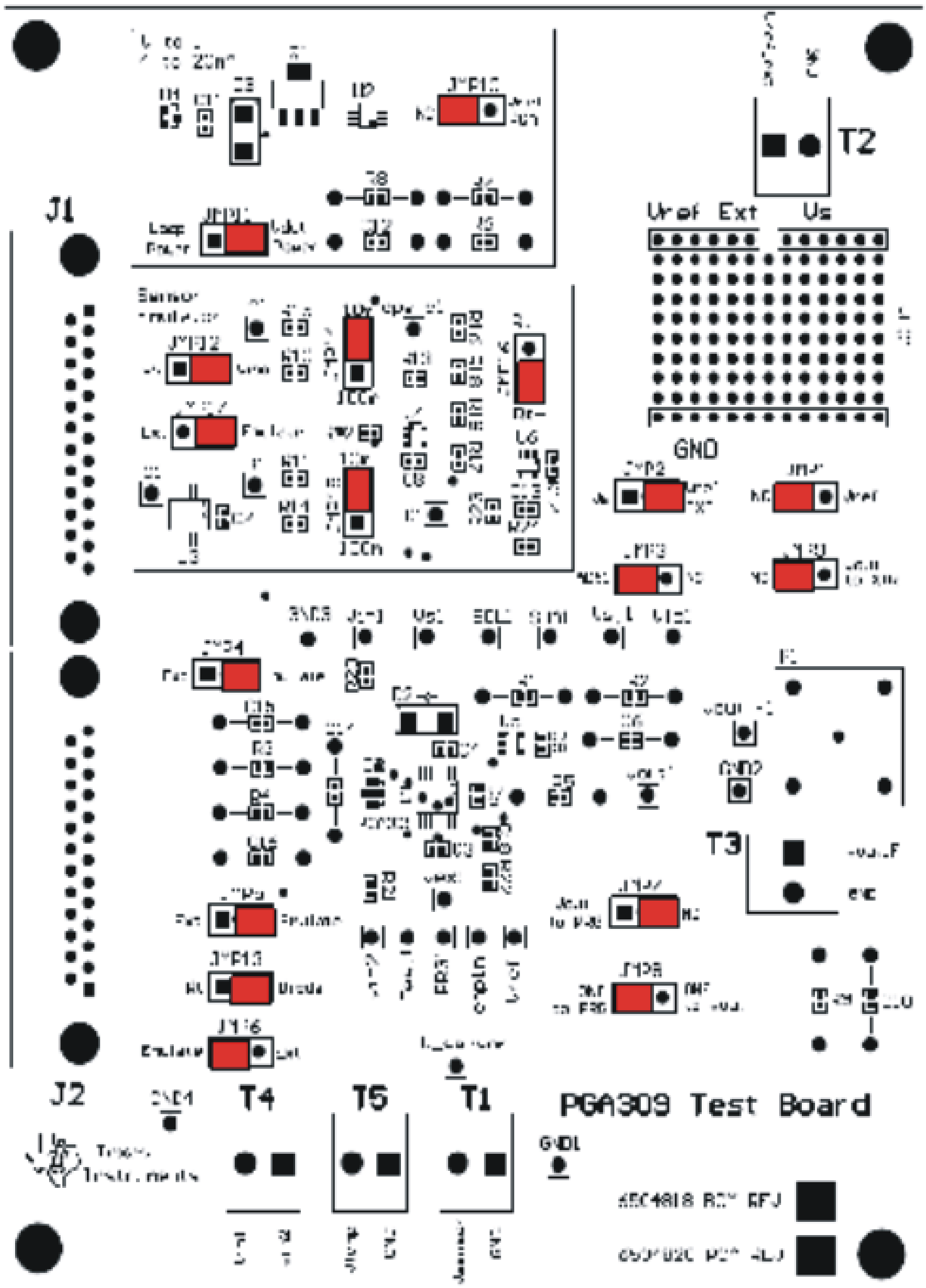

Figure 14. Default Jumper Settings (PGA309_Test_Board)

[Figure 15](#) shows the default jumpers configuration for the USB-DAQ-Platform. In general, the jumper settings of the USB-DAQ-Platform do not need to be changed.

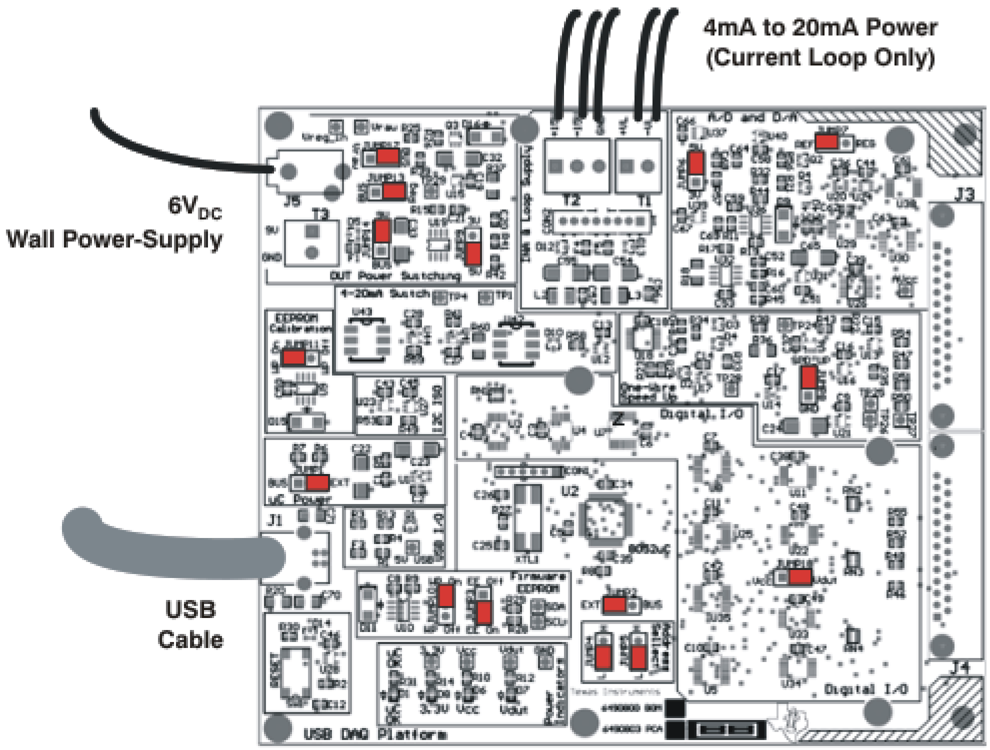

Figure 15. Default Jumper Settings (USB-DAQ-Platform)

[Table 4](#) explains the function of the jumpers on the PGA309_Test_Board.

Table 4. PGA309_Test_Board Jumper Functions: General

Jumper	Default	Purpose
JMP10	NC	This jumper is used to connect the current loop output (XTR117). For voltage output modules, set this jumper to the *NC* (no connect) position. For current-loop modules, set this jumper to the *Vref PGA* position.
JMP11	V_{DUT} power	This jumper is used to connect the current-loop output (XTR117). For voltage output modules, set this jumper to the *Vdut Power* (5V connected to power) position. For current-loop modules, set this jumper to the *Loop Powe*r (power to loop supply) position.
JMP9	NC	This jumper connects the V_{OUT} pin on the PGA309 to the XTR117 input. For voltage output modules, set this jumper to the *NC* (no connect) position. For current-loop modules, set this jumper to the *Vout to XTR* position.

Table 5 describes the function of the jumpers in the Miscellaneous connections section of the PGA309 Test Board.

Table 5. PGA309_Test_Board Jumper Functions: Miscellaneous Connections

Jumper	Default	Purpose
JMP1, JMP2	NC	For JMP1 = *NC*, JMP2 = V_{REF} *EXT*: The REF pin on the PGA309 is configured for internal reference. In this mode, JMP2 is not connected, so its position does not matter.
	V_{REF} EXT	For JMP1 = V_{REF} , JMP2 = V_S: The REF pin is configured for external reference and is connected to V_S.
		For JMP1 = V_{REF}, and JMP2 = V_{REF} *EXT*: The REF pin is configured for external reference and is connected to T2 (terminal for external reference connection).
JMP3	ADS1	For JMP3 = *ADS1,* it connects the analog-to-digital converter (ADC) on the USB-DAQ-Platform to the output of the PGA309. The ADC on the USB-DAQ-Platform allows full measurement and calibration of the PGA309 without any additional instruments.
		For JMP3 = *NC*, the ADC on the USB-DAQ-Platform is not connected to the PGA309. This mode is useful if you want to use an external DMM in place of the USB-DAQ ADC.
JMP7, JMP8	NC	For JMP7 = *NC*, and JMP8 = *One to PRG*: In this mode, the one-wire signal from the USB-DAQ-Platform is connected directly to the PRG pin on the PGA309. This mode is commonly called *Four-wire mode* because only four connections are required (Power, GND, V_{OUT}, and PRG).
	One to PRG	For JMP7 = V_{OUT} *to PRG*, and JMP8 = *One to* V_{OUT}: In this mode, the one-wire signal from the USB-DAQ-Platform is connected to the V_{OUT}/PRG pin on the PGA309. This mode is commonly called *Three-wire mode* because only three connections are required (Power, GND, and V_{OUT}/PRG).

Table 6 explains the function of the jumpers in the sensor emulator section connections section of the PGA309 Test Board.

Table 6. PGA309_Test_Board Jumper Functions: Sensor Emulator Section

Jumper	Default	Purpose
JMP12	V_{EXC}	This jumper selects V_S or V_{EXC} as the reference for the sensor emulator. Using V_S as the reference is commonly called *ratiometric mode*.
JMP17, JMP4, JMP5, JMP6	Emulate	These jumpers select the sensor emulator when in the Emulate position. When the jumper is in the *EXT* position, it selects the external sensor.
JMP14, JMP15	10mV	These jumpers select the range of the sensor emulator.
		This jumper is used for the sensor emulator only; its position is not important for externally-connected, real-world sensors.
		10m = maximum emulator output is 10mV/V.
		100m = maximum emulator output is 100mV/V.
JMP13, JMP16	RT–, Diode	This jumper selects the type of temperature sensor you will emulate on the EVM. This jumper is used for the sensor emulator only; its position is not important for externally-connected, real-world sensors.
		JMP13 = *Diode*, JMP16 = *RT-*. In this position, the temperature sensor emulation is set for diode type temperature sensor. When JMP13 = *Diode*, the position of JMP16 does not matter.
		JMP13 = *RT*, JMP16 = *RT-*. In this position, the temperature sensor emulation is set for RT–.
		JMP13 = *RT*, JMP16 = *RT+*. In this position, the temperature sensor emulation is set for RT+.

Table 7 explains the function of the USB-DAQ-Platform jumpers. For most applications the default jumper position should be used. A separate document gives details regarding the operation and design of the USB-DAQ-Platform.

Table 7. USB-DAQ-Platform Jumper Settings

Jumper	Default	Purpose
JUMP1	EXT	This jumper selects external power or bus power. External power is applied on J5 or T3 (9V dc). Bus power is 5V from the USB bus. External power is typically used because the USB bus power is noisy.
JUMP2	EXT	Same as JUMP1.
JUMP3	EE ON	This jumper determines where the PGA309 gets its power supply. In the V_{DUT} position, the EVM provides power. The default is the V_{DUT} position. In the V_{S_Ext} position, the power is connected externally.
JUMP4, JUMP5	L, L	This jumper sets the address for the USB board. The only reason to change from the default is if multiple boards are being used.
JUMP9	5V	This jumper selects the voltage of the device under test supply (V_{DUT} = 5V or 3V)
JUMP10	WP ON	This jumper write-protects the firmware EEPROM.
JUMP11	WP ON	This jumper write-protects the calibration EEPROM
JUMP13	Reg	This jumper configures the regulator output to generate the V_{DUT} supply. The USB bus can be used as the V_{DUT} supply.
JUMP14	9V	This jumper configures the external power (9V as apposed to the bus)
JUMP17	BUS	While in the BUS position V_{DUT} operation is normal. While in the V_{RAW} position, the V_{DUT} supply is connected to an external source. This allows for any value of V_{DUT} between 3V and 5V.
JUMP18	V_{DUT}	Connects the pull-up resistor on GPIO to the V_{DUT} supply or the V_{CC} supply.

CAUTION

Adjusting the value of V_{DUT} beyond the range of 3V to 5V will damage the EVM.

4 PGA309EVM-USB Software Overview

This section discusses how to install and use the PGA309EVM-USB software.

4.1 Operating Systems for PGA309 Software

The PGA309EVM-USB 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. Please report any OS compatibility issues to precisionamps@list.ti.com.

4.2 PGA309EVM-USB Software Install

Follow these steps to install the PGA309EVM-USB software:

Step 1. Software can be downloaded from the PGA309EVM-USB web page, or from the disk included with the PGA309EVM-USB, which contains a folder called *Install_software/*.

Step 2. Find the file called *setup.exe*. Double-click the file to start the installation process.

Step 3. Follow the on-screen prompts to install the software.

Step 4. To remove the application, use the Windows Control Panel utility, *Add/Remove Software*.

4.3 Starting the PGA309EVM-USB Software

The PGA309EVM-USB software can be operated through the Windows *Start* menu. From Start, select *All Programs*; then select the PGA309EVM-USB program. Refer to Figure 16 for a screenshot of how the software should appear if the EVM is functioning properly.

4.4 Using the PGA309EVM-USB Software

The PGA309EVM-USB software has five different primary tabs that allow users to access different features of the PGA309 itself. Each tab is designed to provide an intuitive graphical interface that will help users to gain a better understanding of the device.

4.5 Registers Tab

Figure 16 illustrates the Registers tab.

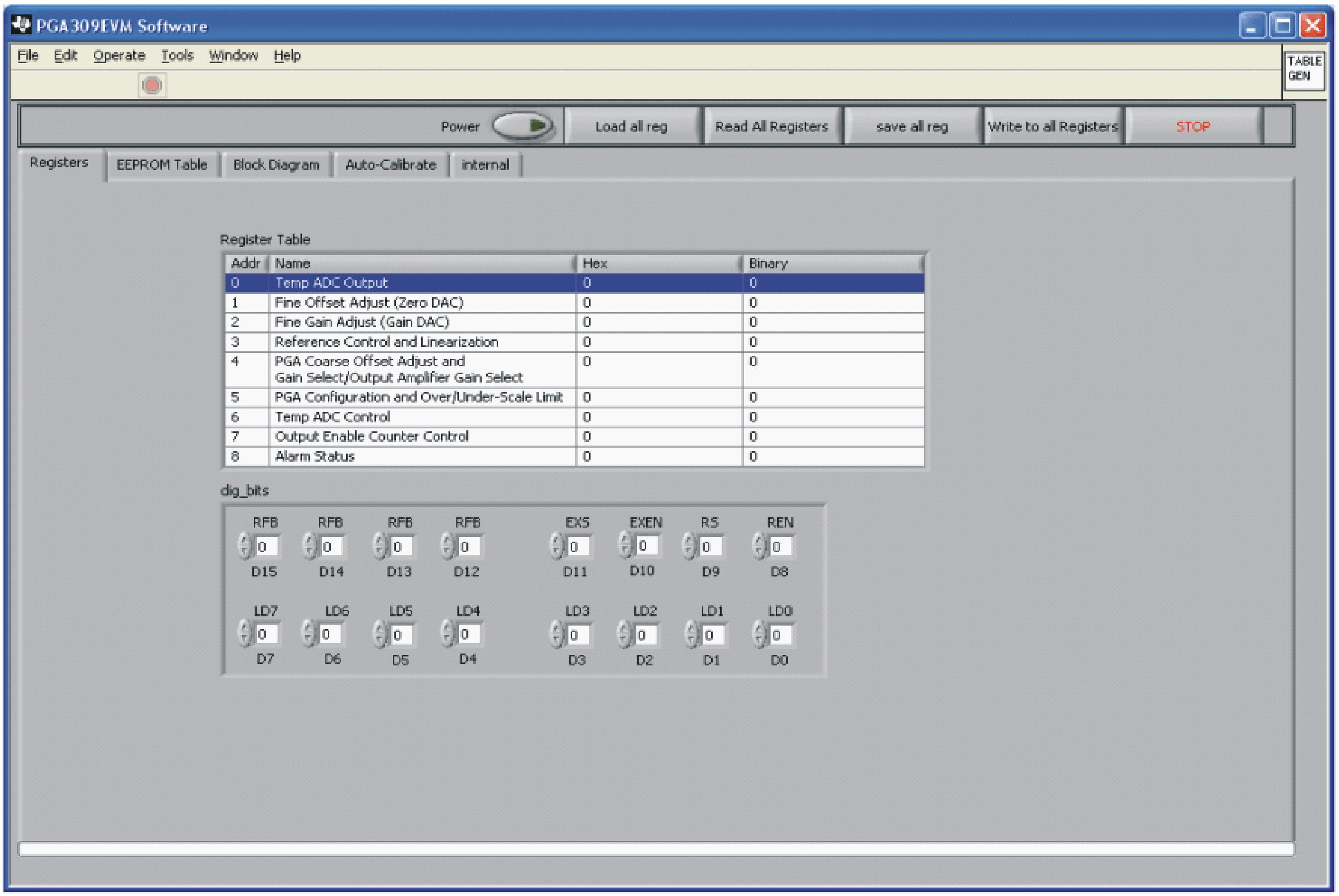

Figure 16. PGA309EVM-USB Software: Registers Tab

This tab presents a *Register Table* that shows a summary of the PGA309 device registers. You can select and toggle various sections of the table by clicking on the table with your mouse. For example, when a row is selected, it will be highlighted in blue in the table. The 16 individual bits in the selected register are displayed below the register table. Note that each bit has descriptive text above the bit that identifies or defines the function of that bit. You can edit the bit value by using the up (↑) or down (↓) arrow to the left of the bit. Any changes made to the bit are displayed in the table. Additionally, changes to the device registers initiated on other tabs in the software will also update the Registers tab.

4.6 EEPROM Table Tab

The EEPROM Table tab is shown in Figure 17.

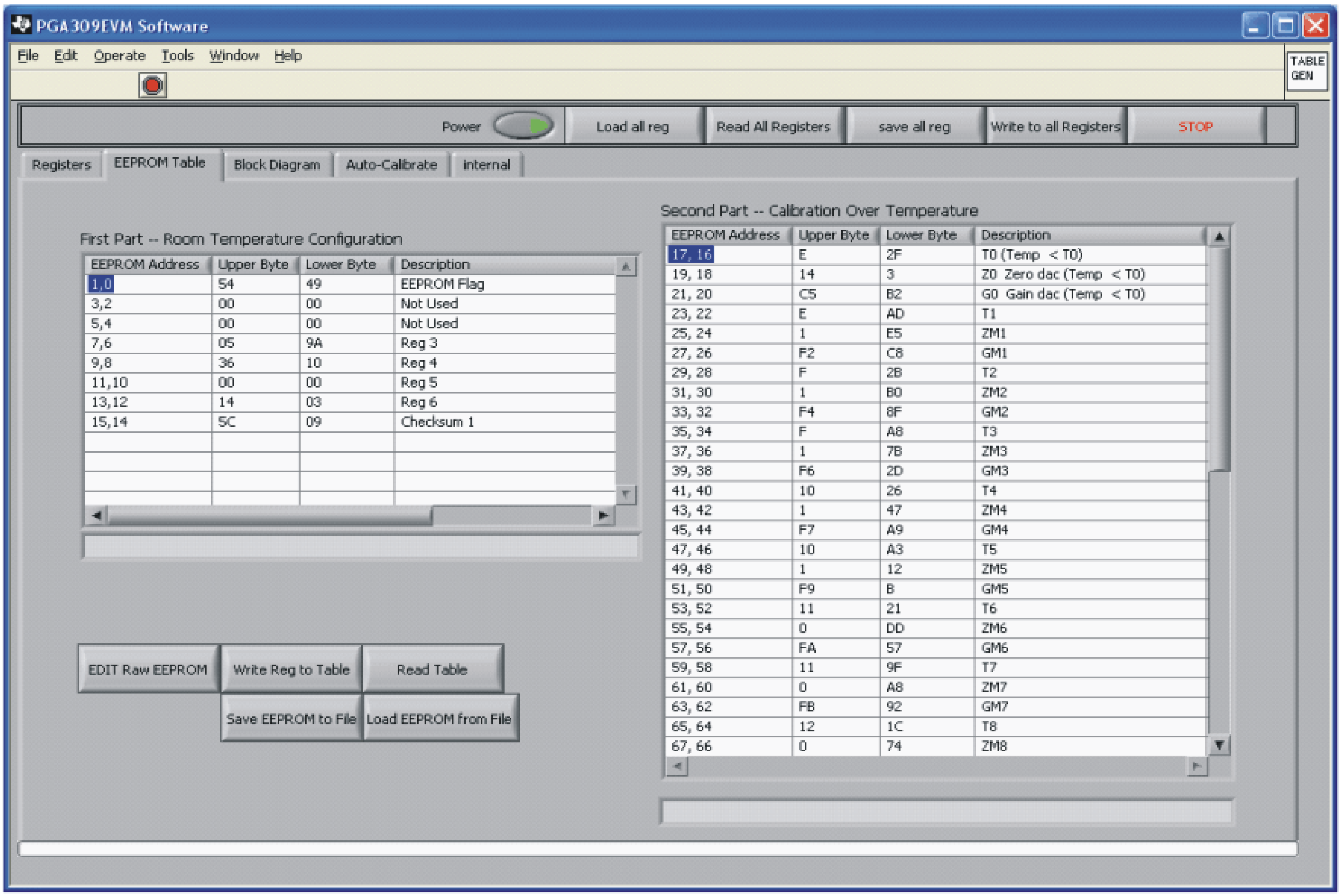

Figure 17. PGA309EVM-USB Software: EEPROM Tab

This tab offers a debug utility that allows you to view, load, edit, and save various EEPROM values. This tab also contains displays for the two different sections of the PGA309 EEPROM. However, most users will create the EEPROM table itself using the features of the *Auto-Calibrate* tab.

4.7 Block Diagram Tab

The Block Diagram tab (shown in Figure 18) gives you full access to all the elements in the PGA309. Making a change to the block diagram is reflected in the Register Table (see Section 4.5). This feature is helpful when experimenting with your specific setup.

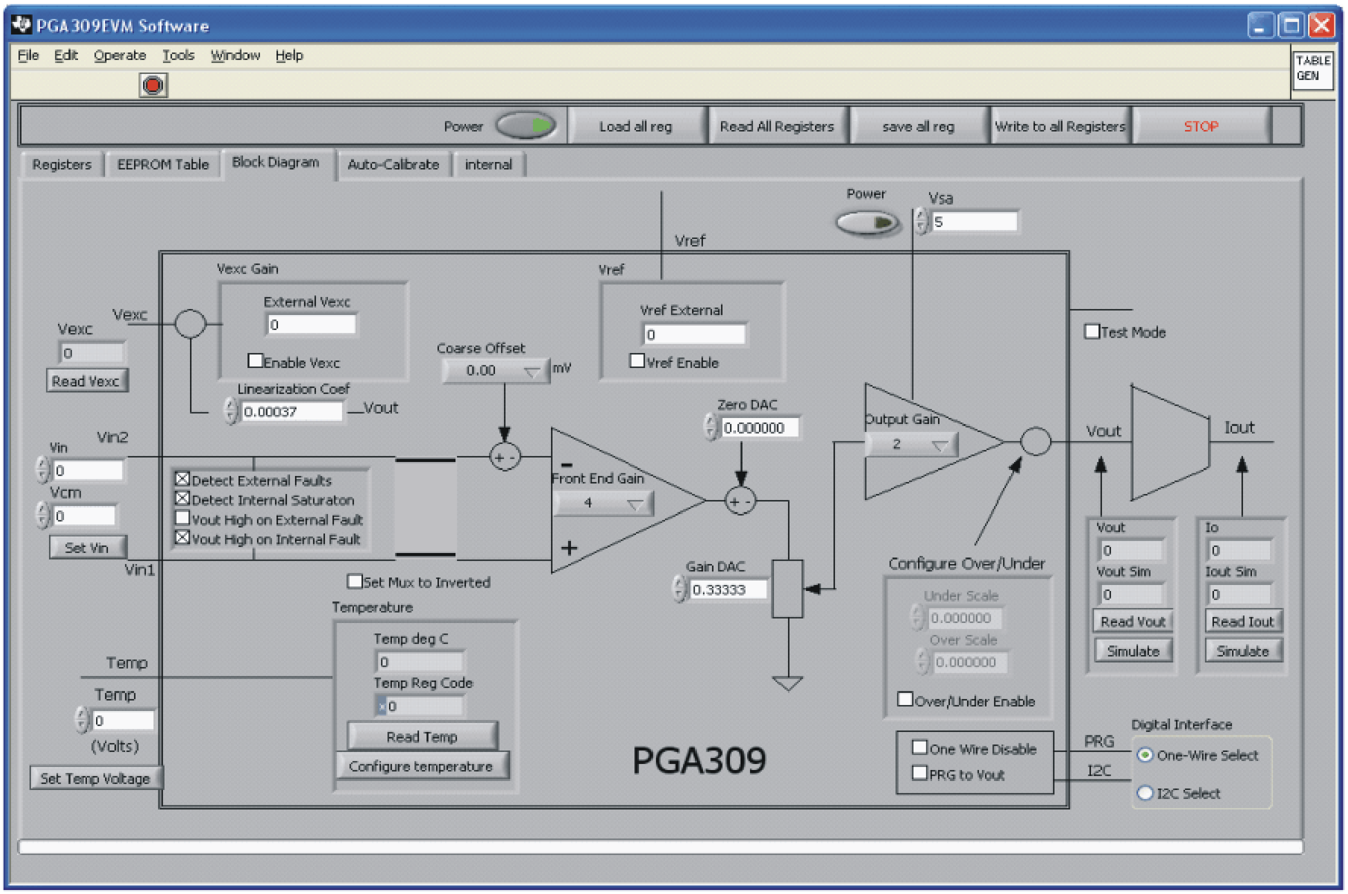

Figure 18. PGA309EVM-USB Software: Block Diagram

4.8 Auto Calibrate Tab

The Auto Calibrate tab is used to calibrate a PGA309 module over temperature. This process can be done with a real-world sensor or with an emulated sensor. It is recommended that you first become familiar with the calibration process by using the sensor emulator. Once the user completely understands the calibration process, the user can connect a real-world sensor to the EVM.

Additionally, this tab contains several sub-tabs that are used to configure the PGA309 device for particular test applications. This section explains each sub-tab in detail.

4.8.1 Sensor Definition Functions

Figure 19 shows the Sensor Definition sub-tab.

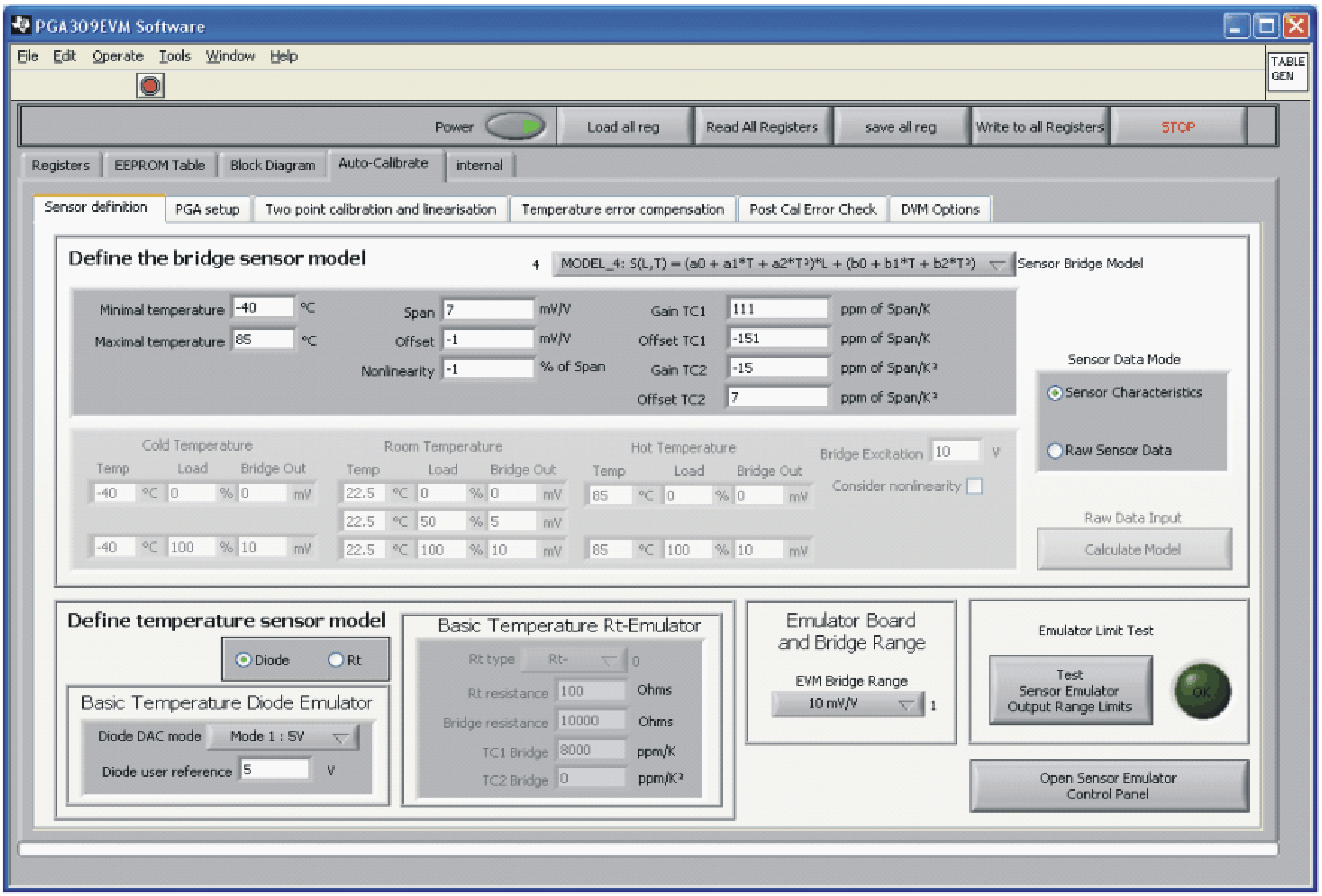

Figure 19. PGA309EVM-USB Software: Auto Calibrate Tab—Sensor Definition

Use the *Sensor Definition* sub-tab to configure the sensor emulator before starting the calibration process. If you are not using the sensor emulator, you can skip this tab. If you are using the sensor emulator, enter your sensor information in one of two different formats using the *Select Data Mode* option box.

- Sensor Data Mode: Sensor Characteristics

  Enter the sensor characteristics as they are typically given in product data sheets (that is, span, offset, drift, and nonlinearity values).

- Sensor Data Mode: Raw Sensor Data

  Enter sensor data that has been measured at three temperatures (room or ambient, hot, and cold).

Select the type of temperature sensor that you want to emulate using the ***Define Temperature Sensor Model*** control. Depending on the type of temperature sensor selected, you may need to provide some additional information about the sensor (for example, R_T resistance, Bridge Resistance, and drift). You may also need to set the sensor emulator range. The sensor emulator has two jumper-selected ranges (10mV/V and 100mV/V). The software must be set to match the jumper setting. Observe the sensor emulator graphs using the **Open Sensor Emulator Control Panel** button.

Figure 20 shows the sensor emulator control tool.

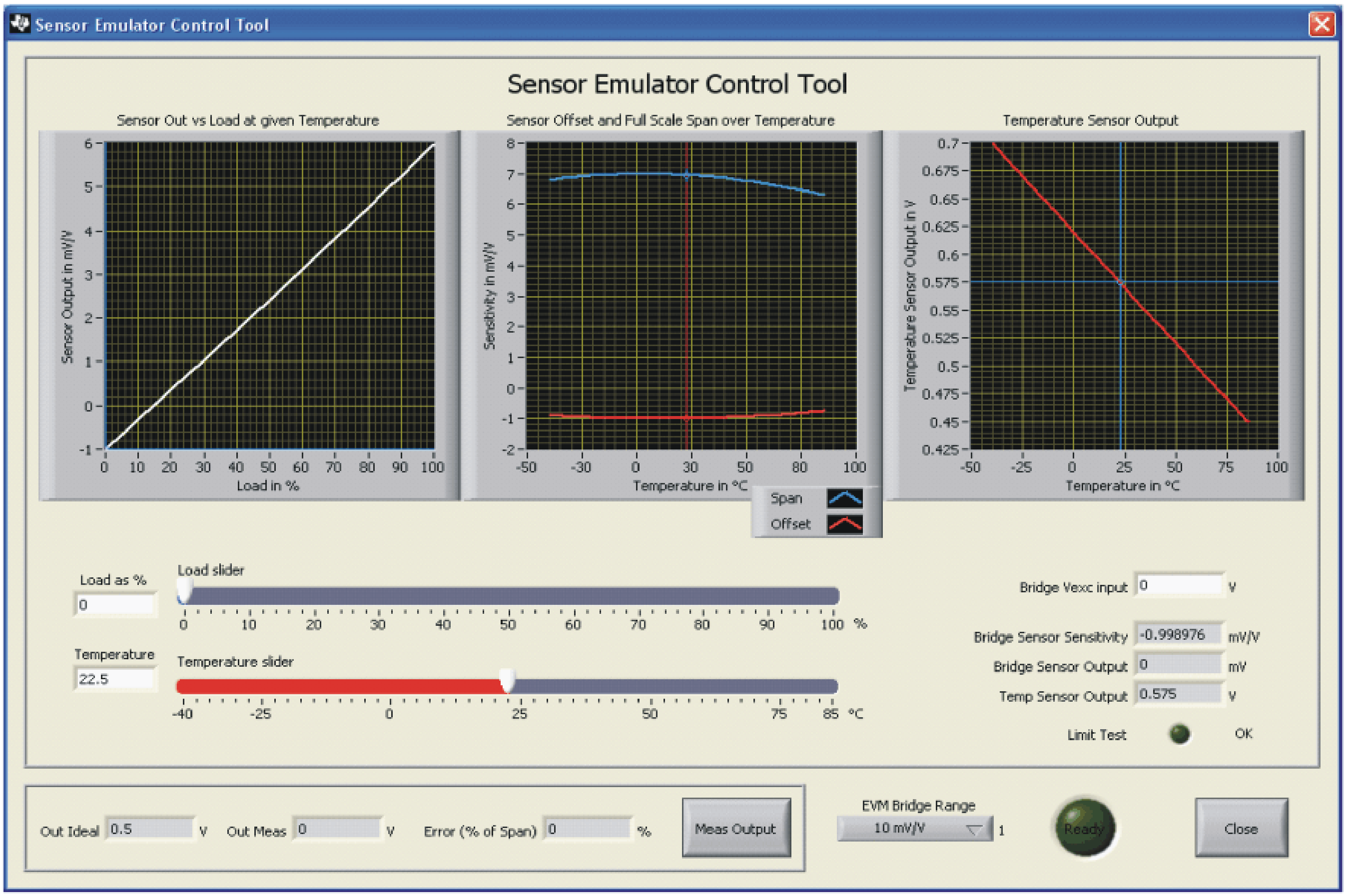

Figure 20. PGA309EVM-USB Software: Sensor Emulator Control Panel Tool

The Sensor Emulator Control Tool is a pop-up window that can be accessed from the Sensor Definition sub-tab. It displays three graphs that show the operation of the emulated sensor under different pressures and at different temperatures. The two sliders below the graphs adjust the operating point of the sensor emulator. When you adjust the sliders, the cursors on the graph move accordingly to the new operating point. The sensor output (in mV/V) is displayed to the right of the sliders. You can test your calibration at any temperature and pressure using this tool.

4.8.2 PGA Setup Functions

Figure 21 illustrates the PGA Setup sub-tab.

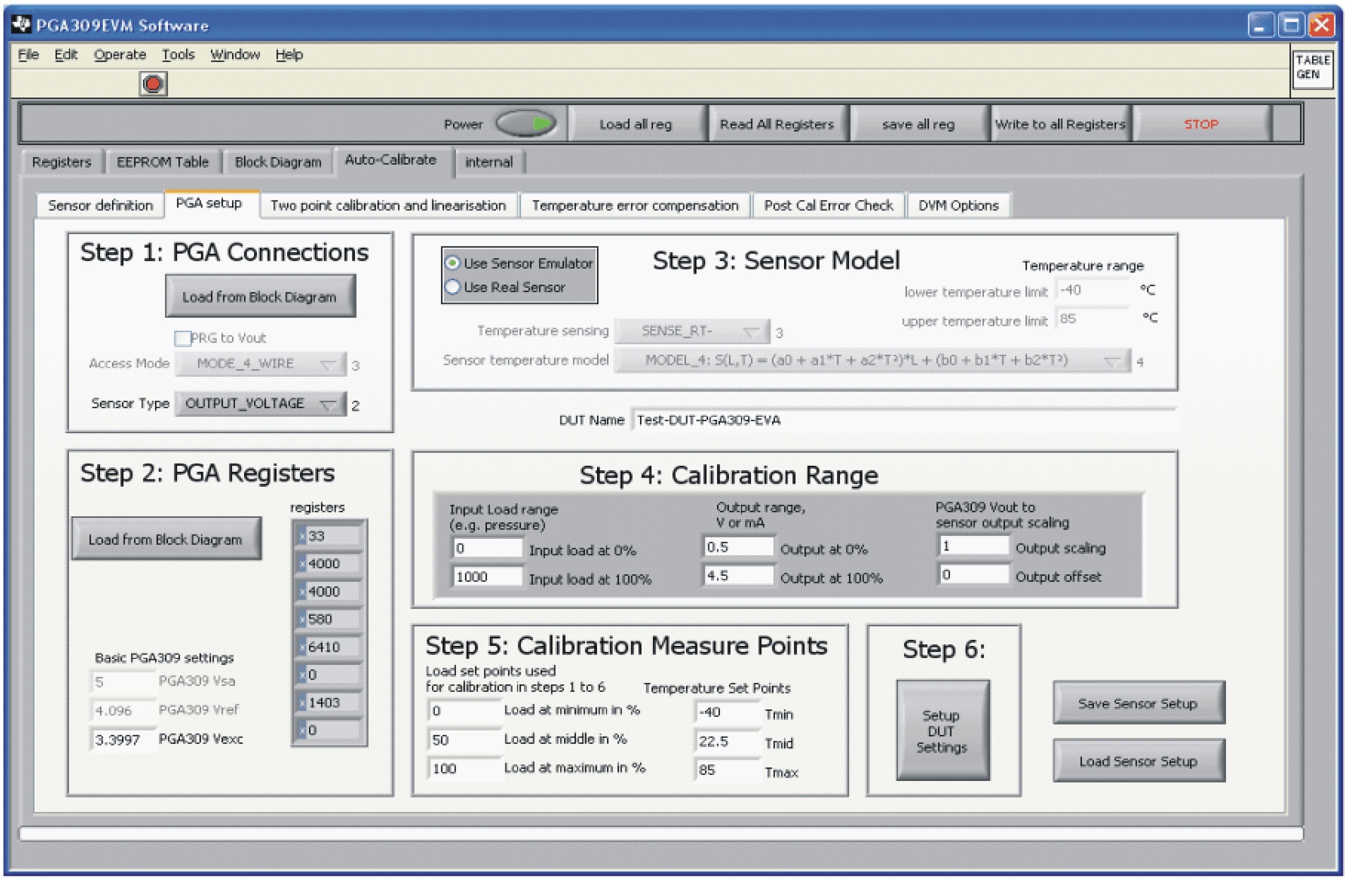

Figure 21. PGA309EVM-USB Software: Auto Calibrate Tab—PGA Setup

The PGA Setup sub-tab is divided into six sections. Each section is identified as a sequential step:

Step 1. PGA309 Hardware Connections

Step 2. PGA309 Initial Register Settings

Step 3. Sensor Model (temperature sensor connection, temperature range)

Step 4. Calibration Range (output voltage or current range)

Step 5. Calibration Measure Points (temperature and nonlinearity)

Step 6. Step 6 confirms the previous entries and configures the DUT settings.

The last procedure in the setup process is to save the settings from this tab. If you have already made a sensor setup file, you can skip Steps 1 to 6 and simply load the file; select the **Load Sensor Setup** button at the lower right-hand side of the window.

4.8.3 Two-Point Calibration and Linearization Functions

The Two-Point Calibration and Linearization sub-tab is illustrated in Figure 22.

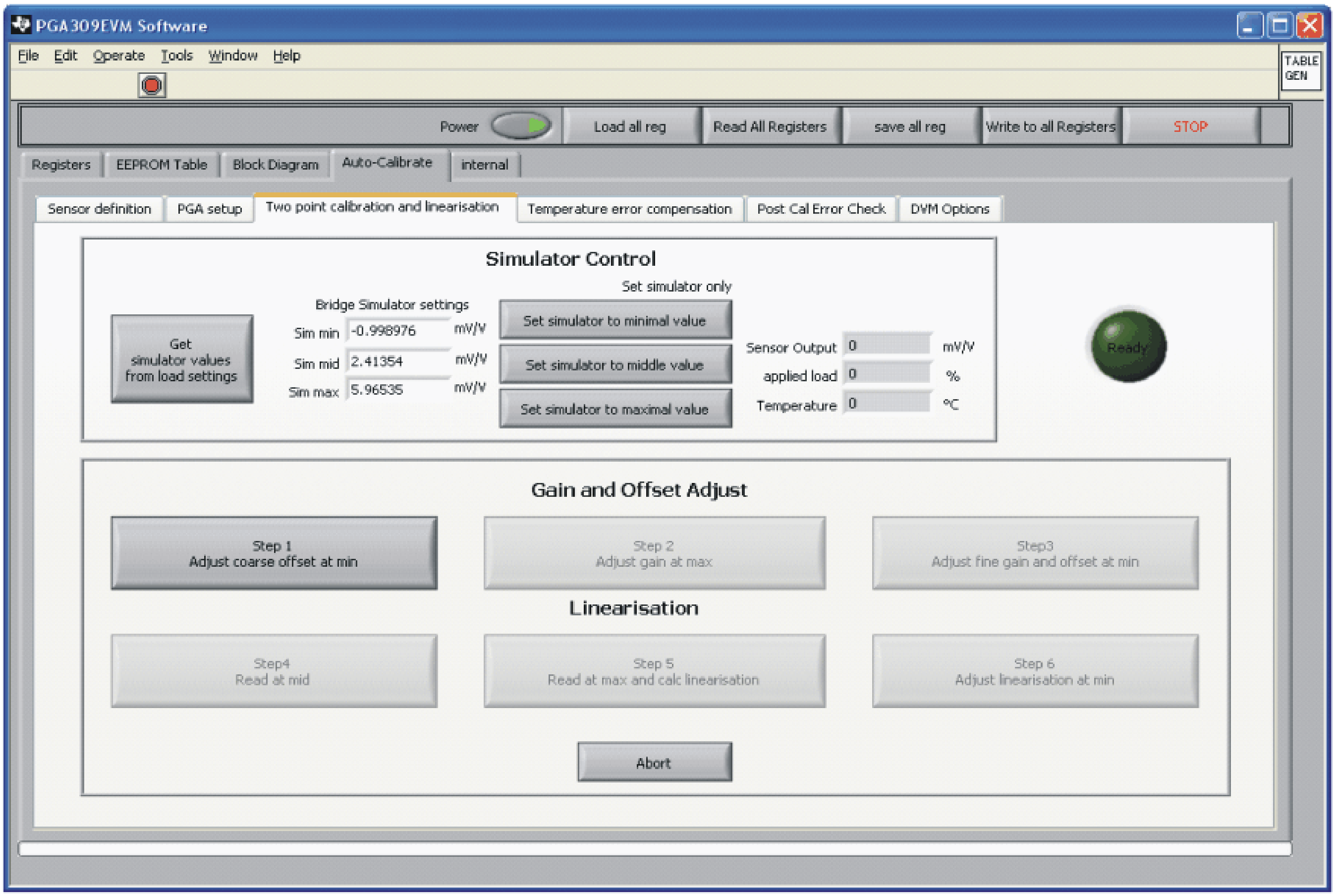

Figure 22. PGA309EVM-USB Software: Auto Calibrate Tab—Two-Point Calibration and Linearization

This sub-tab performs the room temperature calibration. To perform this calibration with the sensor emulator, press the buttons labeled **Step 1** through **Step 6**, respectively. The sensor emulator automatically adjusts the simulated load according to what is required for each step. To perform the calibration using a real-world sensor, you must adjust the load applied to the sensor before pressing each button. For example, adjust the load (that is, decrease the pressure) to the minimum level before pressing the **Step 1** button. The software will take readings and adjust the gain and offset in order to obtain the desired output swing.

4.8.4 Temperature Error Compensation Functions

Figure 23 shows the Temperature Error Compensation sub-tab.

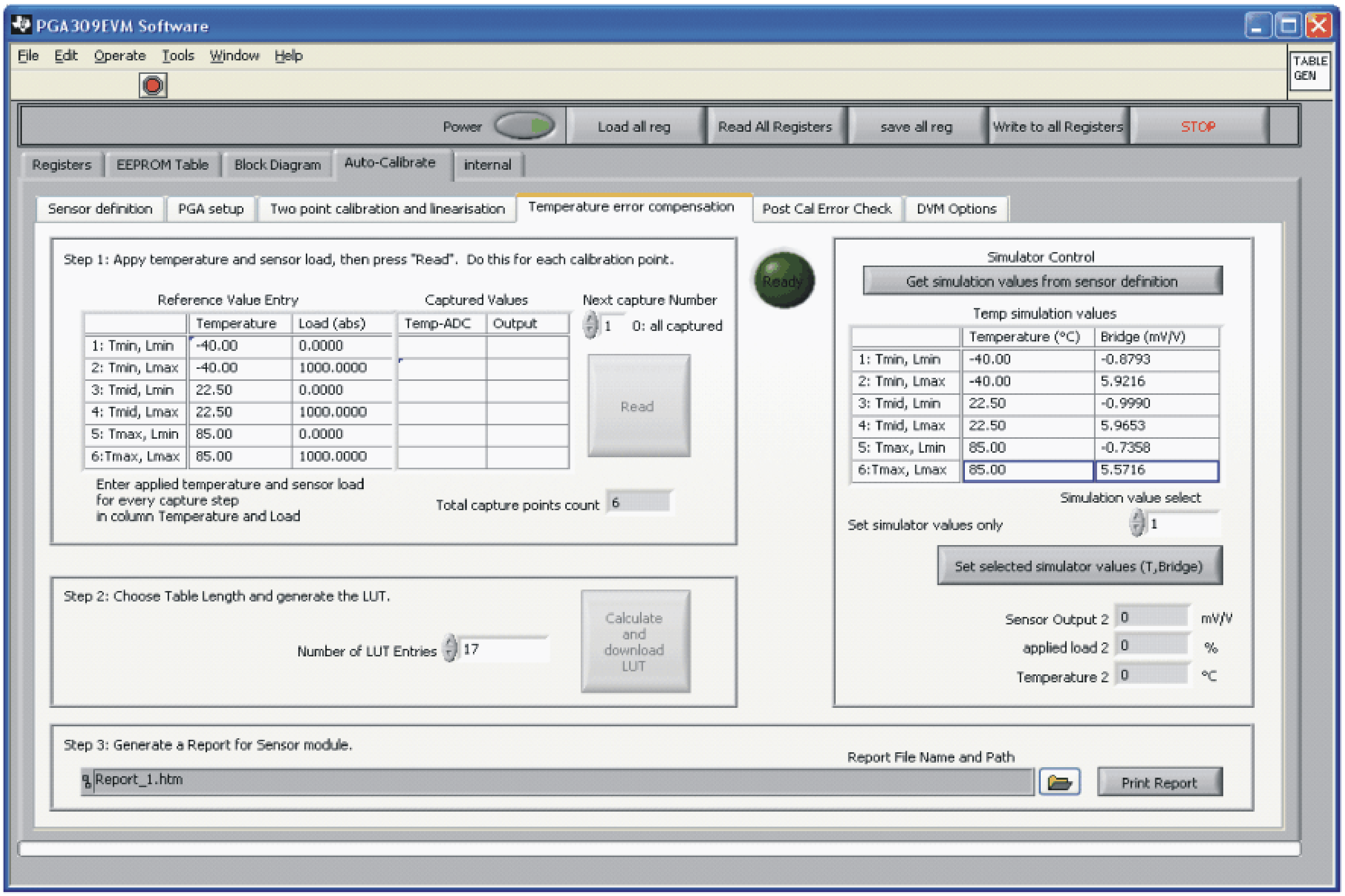

Figure 23. PGA309EVM-USB Software: Auto Calibrate Tab—Temperature Error Compensation

The Temperature Error Compensation sub-tab is divided into six separate measurements (refer to Figure 23). When using the sensor emulator option, you can complete the calibration by pressing the **Read** button six times. Each time the **Read** button is pressed, the sensor emulator adjusts the temperature signal and the bridge signal automatically to correspond to the temperature and load required. For real-world sensors, however, the EVM must be physically placed in an environmental chamber; the user must then adjust the temperature and applied load as required by the table. When all six measurements are completed, press the **Calculate and download LUT** button to update the EEPROM look-up table (LUT). After pressing the **Calculate and download LUT** button, the module is calibrated, and should output the desired voltage according to the specified load and temperature.

4.8.5 Post Cal Error Check

The Post Cal Error Check sub-tab is illustrated in Figure 24.

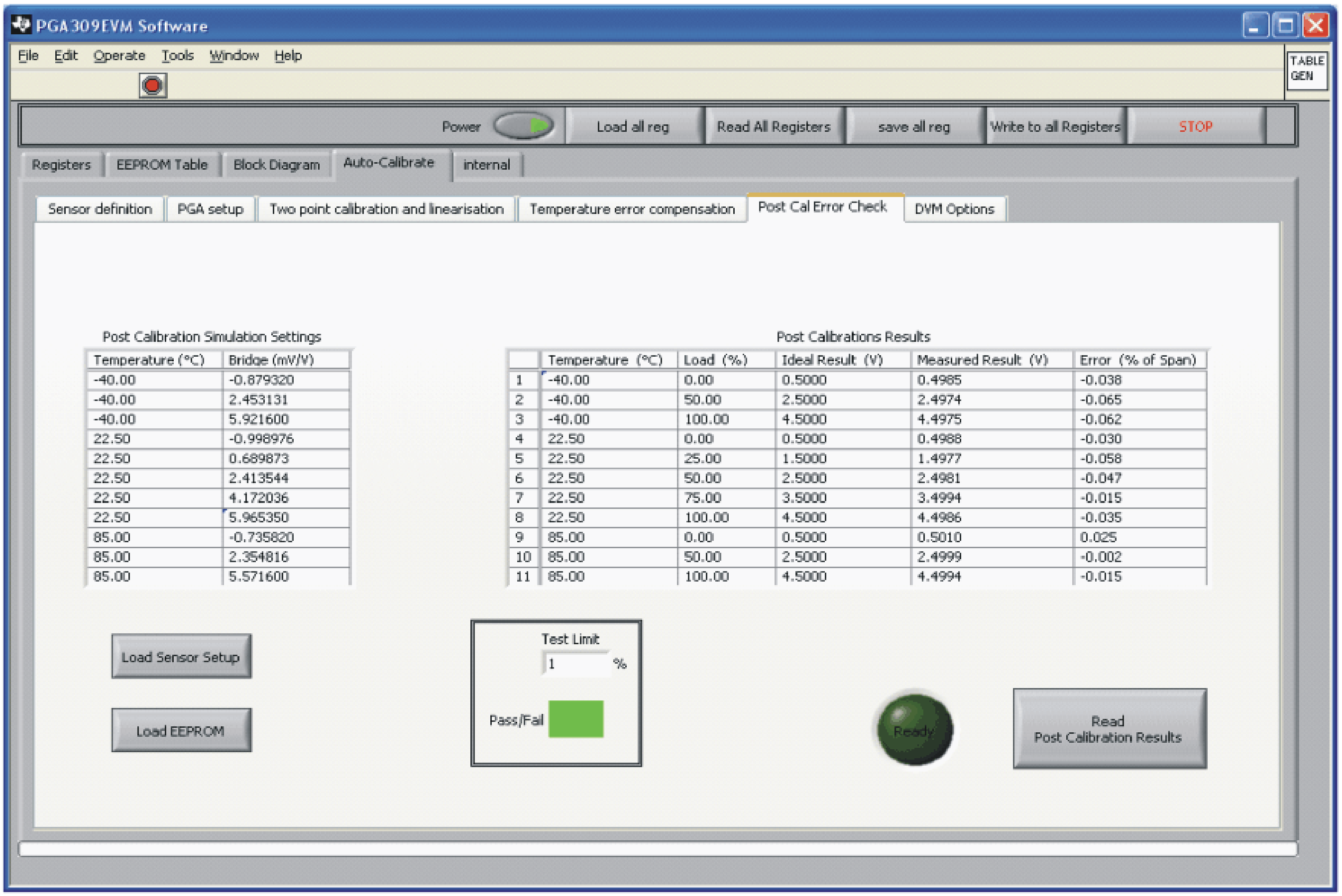

Figure 24. PGA309EVM-USB Software: Auto Calibrate Tab—Post Cal Error Check

This sub-tab is used to test post-calibration accuracy. This feature only works for the sensor emulator mode. Press the **Read Post Calibration Results** button, and the software automatically adjusts the sensor emulator to read the output over the calibration range. (Typical error is less than 0.1%.)

4.8.6 DMM Options

Figure 25 shows the DMM Options sub-tab.

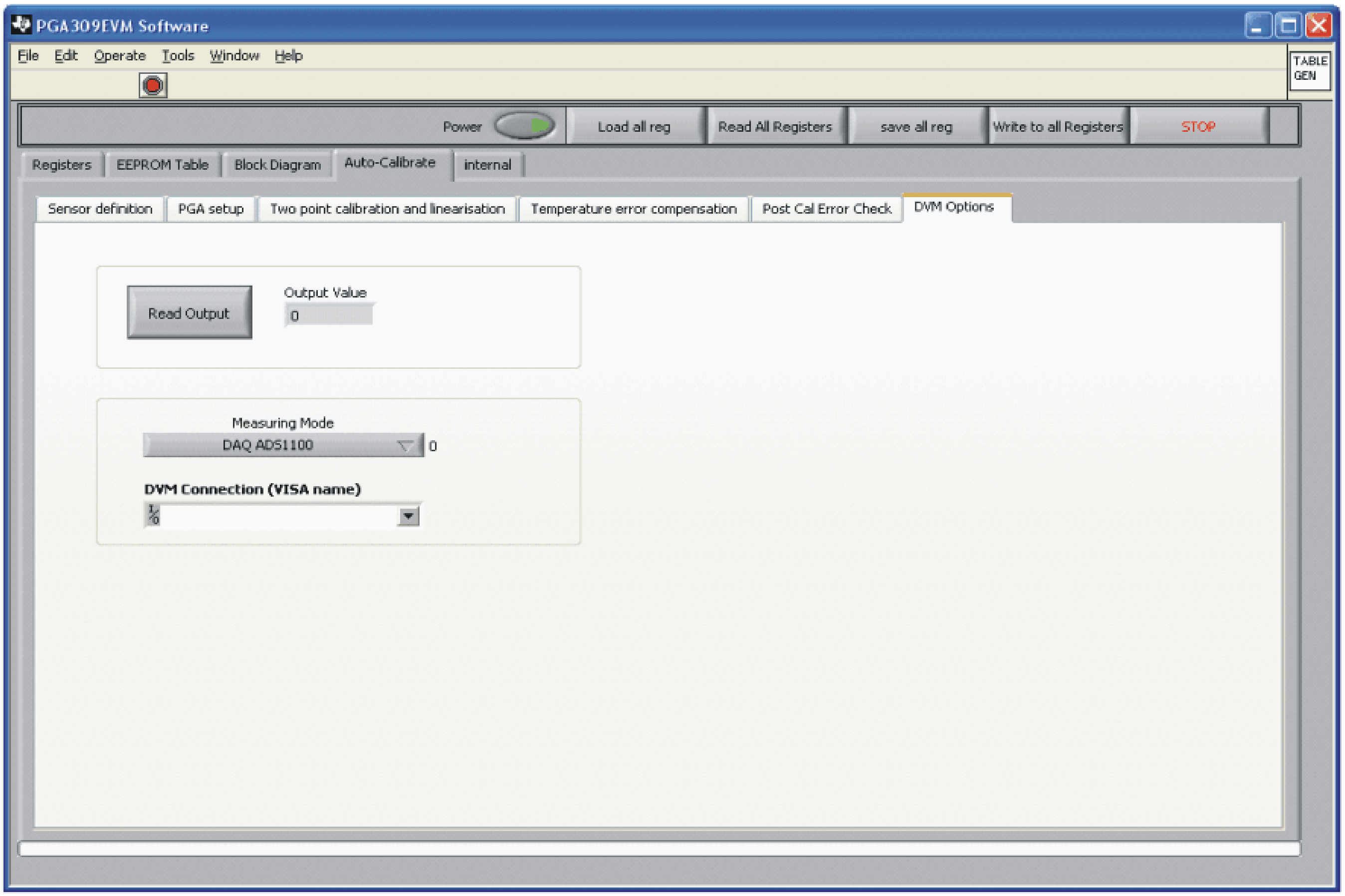

Figure 25. PGA309EVM-USB Software: Auto Calibrate Tab—DMM Options

It is possible to use an external digital multimeter (or DMM) to calibrate sensor modules. The current version of the PGA309EBM-USB software provides the capability for the Agilent 34401A DMM combined with a National Instruments GPIB-USB- HS. To change the external DMM settings, select the **Measuring Mode** button and choose the desired measurement tool. Then select the **DVM Connection (VISA name)** to choose the IEEE488 address.

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.

EXCEPT TO THE EXTENT OF THE INDEMNITY SET FORTH ABOVE, NEITHER PARTY SHALL BE LIABLE TO THE OTHER FOR ANY INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES.

TI currently deals with a variety of customers for products, and therefore our arrangement with the user **is not exclusive.**

TI assumes **no liability for applications assistance, customer product design, software performance, or infringement of patents or services described herein.**

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

No license is granted under any patent right or other intellectual property right of TI covering or relating to any machine, process, or combination in which such TI products or services might be or are used.

FCC Warning

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. It generates, uses, and can radiate radio frequency energy and has not been tested for compliance with the limits of computing devices pursuant to part 15 of FCC 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 will be required to take whatever measures may be required to correct this interference.

EVM Warnings and Restrictions

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

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 +50°C. The EVM is designed to operate properly with certain components above +125°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.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265