



Burr-Brown Products
from Texas Instruments

PGA309

Quick Start System Reference Guide

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High-Precision Linear Products

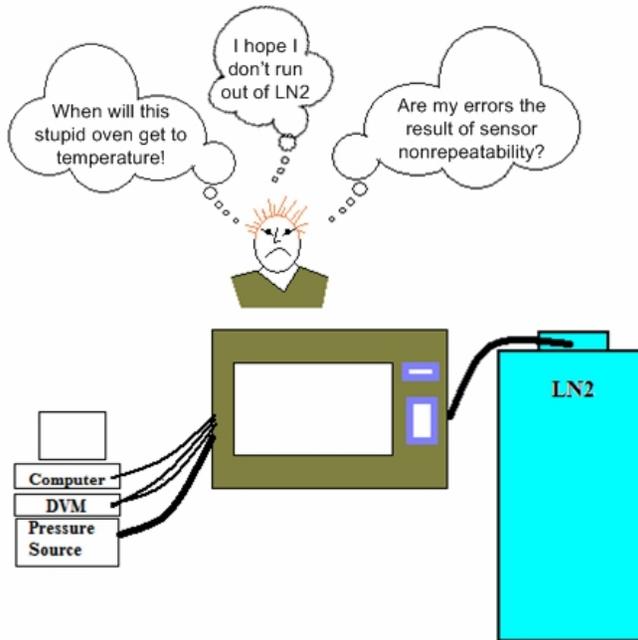
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Jan 2006



PGA309 Quick Start

Bridge Sensor Signal Conditioning Made Easy!

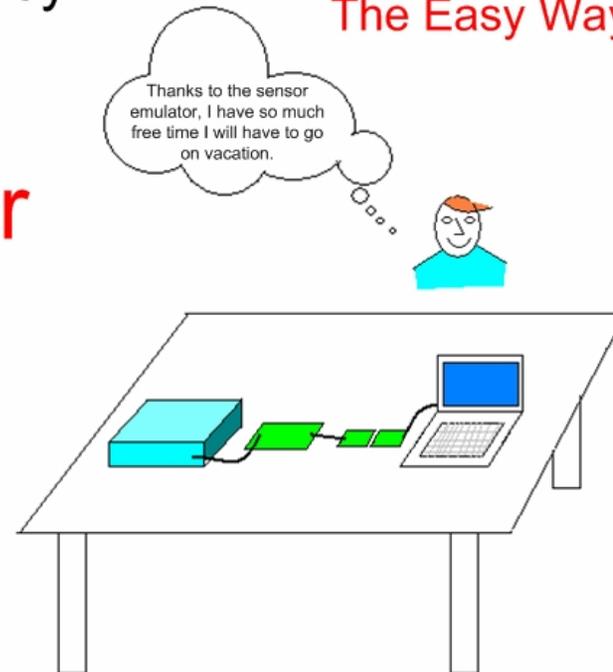
The Hard Way



Would you rather be in a noisy, uncomfortable lab dealing with oven settling time, and sensor non-repeatability.

or

The Easy Way



Would you rather use the Sensor-Emulator-EVM to quickly emulate a repeatable sensor at your desk.

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Required items for Quick Start

Hardware

- **PGA309EVM** – This is an evaluation kit that allows you to communicate with and interface to the PGA309. It contains a PC Interface Board and a Sensor Interface Board combined with a PGA309 and EEPROM.
- **Sensor-Emulator-EVM** – This is an evaluation kit that uses rotary switches and trim potentiometers to generate voltage excited bridge sensor output signals and temperature sensor output signals.
- **+/-12V supply** – Any low noise dc supply for the sensor emulator.
- **Precision DVM** – Any five or six digit meter that can read into microvolts (e.g., HP3458, HP34401).
- **Slotted Jeweler's Screwdriver** – The best tool to quickly adjust the potentiometer.



Software

- **PGA309DK Board Interface** – This software is used to communicate with the PGA309EVM. See <http://focus.ti.com/docs/toolsw/folders/print/pga309evm-eu.html> under support software for free download.
- **PGA309 Calculator** – This software is used to do initial gain scaling and verify that the design does not violate any PGA309 specifications. Software is bundled with PGA309DK Board Interface software.
- **PGA309 Calibration Spreadsheet** – This spreadsheet uses PGA309 / Sensor readings over temperature and at different applied stimulus levels to generate the calibration table used to correct for the sensor errors. Software is bundled with PGA309DK Board Interface software.
- **Generate_Emulator_Values.xls** – This spreadsheet translates sensor specifications into voltage settings for the Sensor-Emulator-EVM. See <http://focus.ti.com/docs/toolsw/folders/print/sensor-emulator-evm.html> under support software for free download.

Specifications

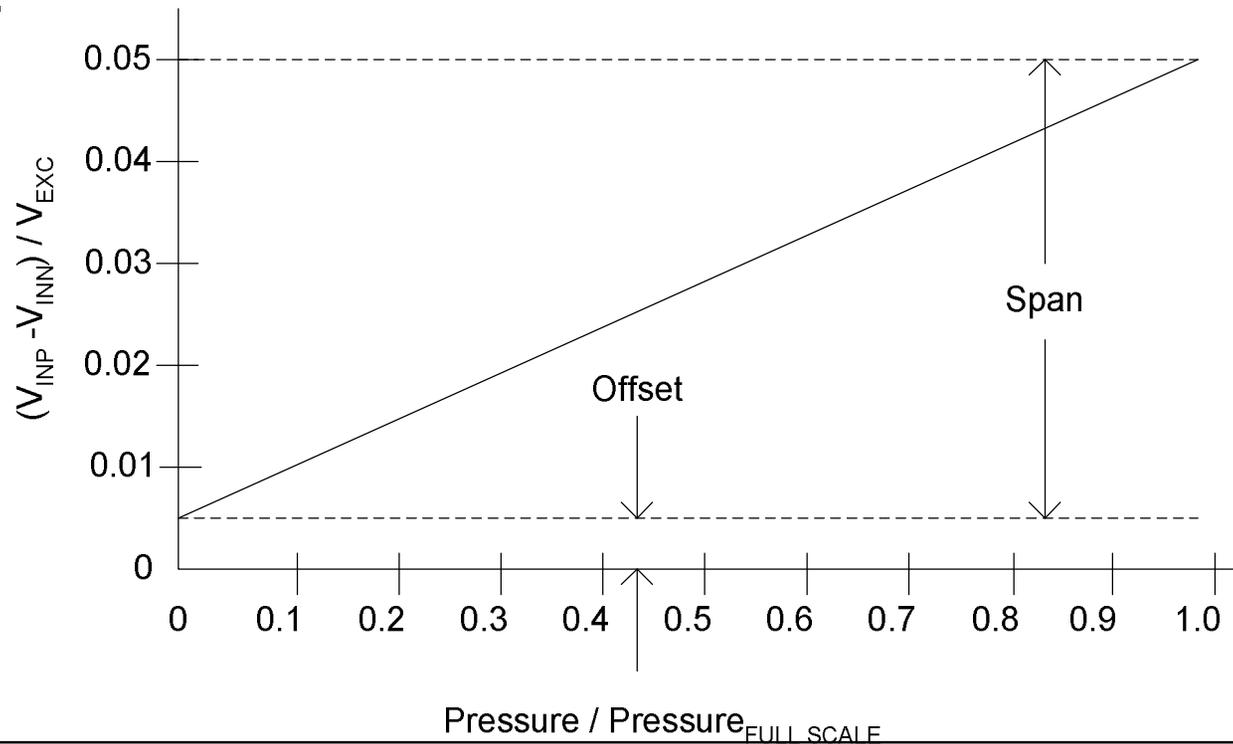
There are several key specifications that are used throughout our literature.

The mathematical definitions are listed below.

- **Offset** – the normalized output of a sensor (in V/V) with no applied stimulus.
- **OffsetTC1** – The linear drift of the sensors' offset given in % of span/°C.
- **NonlinOffsetDrift** – The second order (quadratic) drift of the offset. This coefficient is in % of span at room temperature.
- **OffsetTC2** – The second order (quadratic) drift of the offset. This coefficient is in % of span/°C² at room temperature.
- **Span** – the amount of change in normalized output voltage (in V/V) of the sensor over the entire range of applied stimulus.
- **SpanTC1** – The linear drift of the sensors' span given in % of span/°C.
- **NonlinSpanDrift** – The second order (quadratic) drift of the offset. This coefficient is in % of span at room temperature.
- **SpanTC2** – The second order (quadratic) drift of the span. This coefficient is in % of span/°C² at room temperature.
- **PressureNonlinearity** – The second order (quadratic) nonlinearity versus applied signal given in % of span.

Span – the amount of change in normalized output voltage (in V/V) of the sensor over the entire range of applied stimulus.

Offset – the normalized output of a sensor (in V/V) with no applied stimulus.

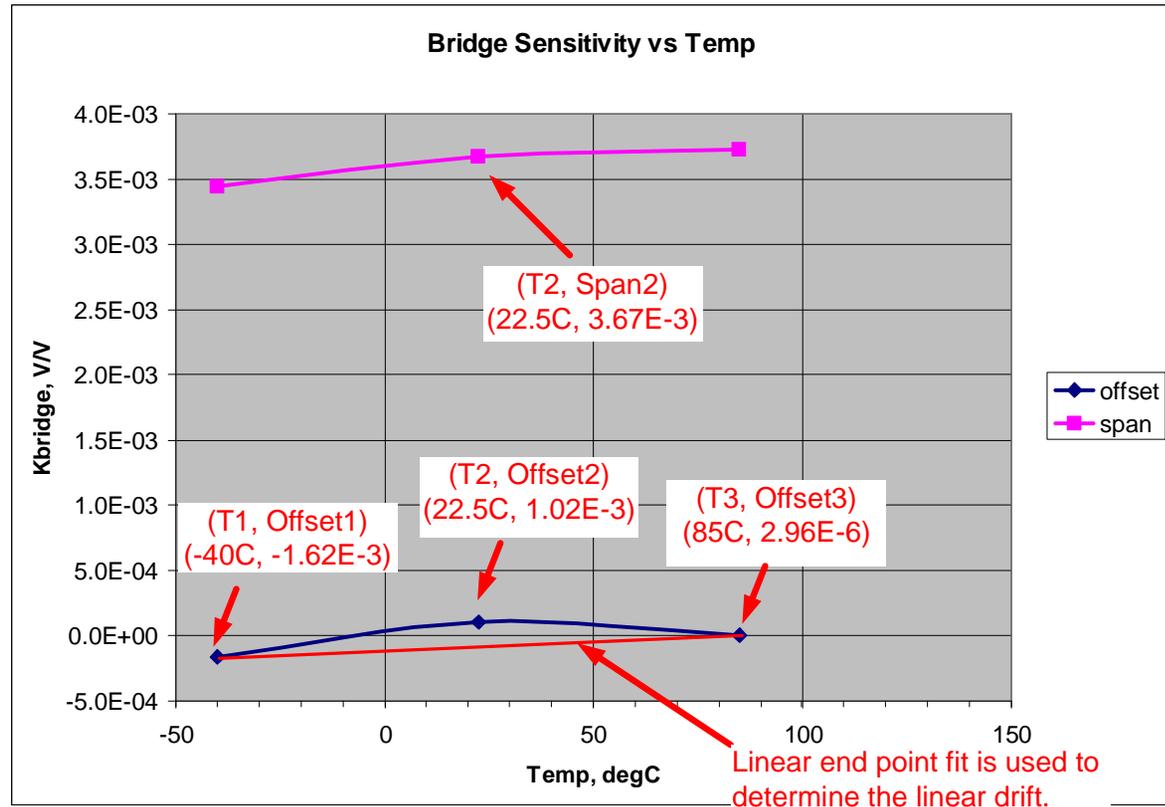


OffsetTC1

The linear drift of the sensor's offset given in % of span/°C.

$$\text{OffsetTC1} = \frac{(\text{Offset}_3 - \text{Offset}_1)}{\text{Span}_2 \cdot (T_3 - T_1)}$$

$$\text{OffsetTC1} = \frac{[2.963 \times 10^{-6} - (-1.624 \times 10^{-4})]}{3.673 \times 10^{-3} \cdot [85 - (-40)]} = 3.602 \times 10^{-4} \quad \% \text{ of span}/^\circ\text{C}$$



NonlinOffsetDrift OffsetTC2

$$\text{NonLinOffsetDrift} = \frac{\left[\text{Offset}_2 - \frac{(\text{Offset}_1 + \text{Offset}_3)}{2} \right]}{\text{Span}_2}$$

$$\text{NonLinOffsetDrift} = \frac{1.023 \times 10^{-4} - \frac{[(-1.624 \times 10^{-4}) + (2.963 \times 10^{-6})]}{2}}{3.673 \times 10^{-3}} = 4.956 \times 10^{-2} \quad \% \text{ of span}$$

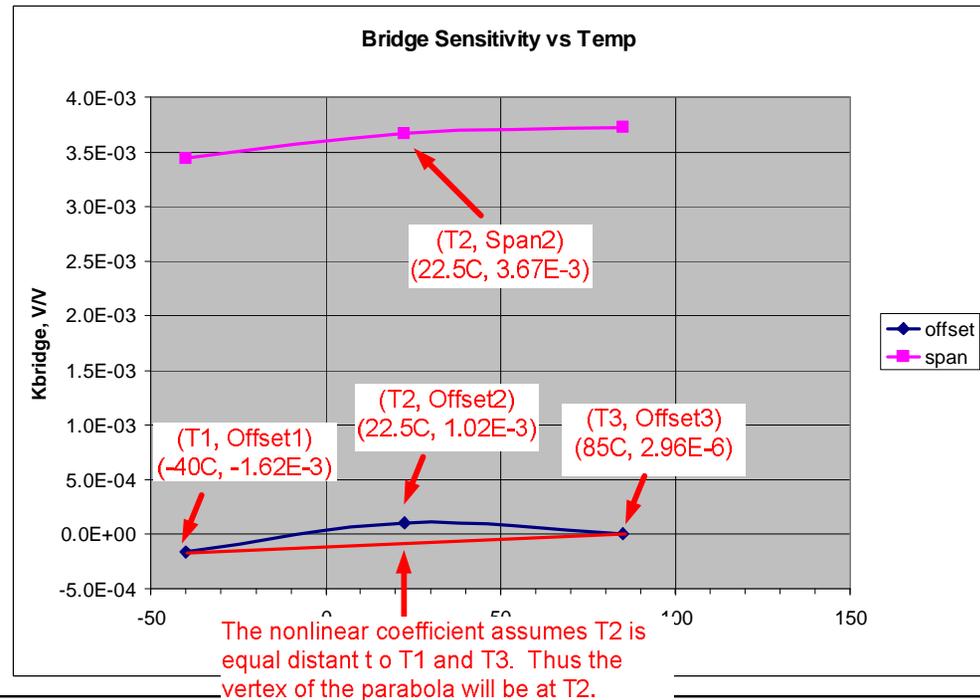
NonlinOffsetDrift:

The second order (quadratic) drift of the offset. This coefficient is in **% of span at room temperature.**

$$\text{OffsetTC2} = \frac{\text{NonLinOffsetDrift}}{\left[\frac{(T_3 - T_1)}{2} \right]^2} = \frac{4.956 \times 10^{-2}}{\left[\frac{[85 - (-40)]}{2} \right]^2} = 1.269 \times 10^{-5} \quad \% \text{ of span}/^\circ\text{C}^2$$

OffsetTC2:

The second order (quadratic) drift of the offset. This coefficient is in **% of span/°C² at room temperature.**



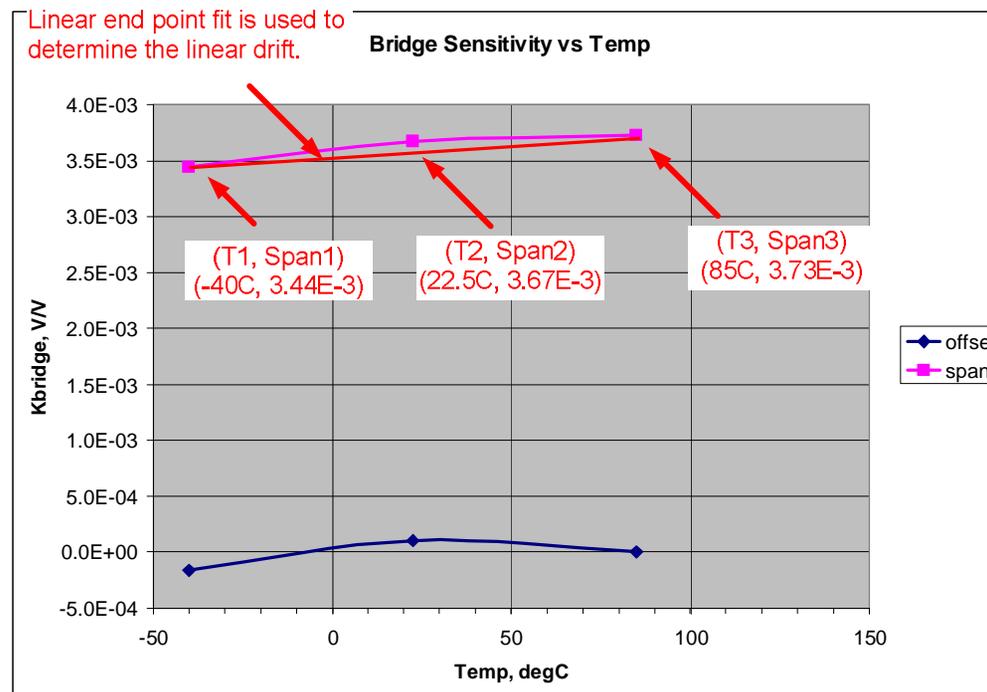
SpanTC1



$$\text{SpanTC1} = \frac{(\text{Span}_3 - \text{Span}_1)}{\text{Span}_2 \cdot (T_3 - T_1)}$$

The linear drift of the sensors' span given in % of span/°C.

$$\text{SpanTC1} = \frac{(3.7284 \times 10^{-3} - 3.4412 \times 10^{-3})}{3.6734 \times 10^{-3} \cdot [85 - (-40)]} = 6.255 \times 10^{-4} \quad \% \text{ of span}/^\circ\text{C}$$



NonlinSpanDrift

SpanTC2

$$\text{NonLinSpanDrift} = \frac{\left[\text{Span}_2 - \frac{(\text{Span}_1 + \text{Span}_3)}{2} \right]}{\text{Span}_2}$$

$$\text{NonLinSpanDrift} = \frac{3.6734 \times 10^{-3} - \frac{[(3.4412 \times 10^{-3}) + (3.7284 \times 10^{-3})]}{2}}{3.6734 \times 10^{-3}} = 2.412 \times 10^{-2} \quad \% \text{ of span}$$

NonlinSpanDrift:

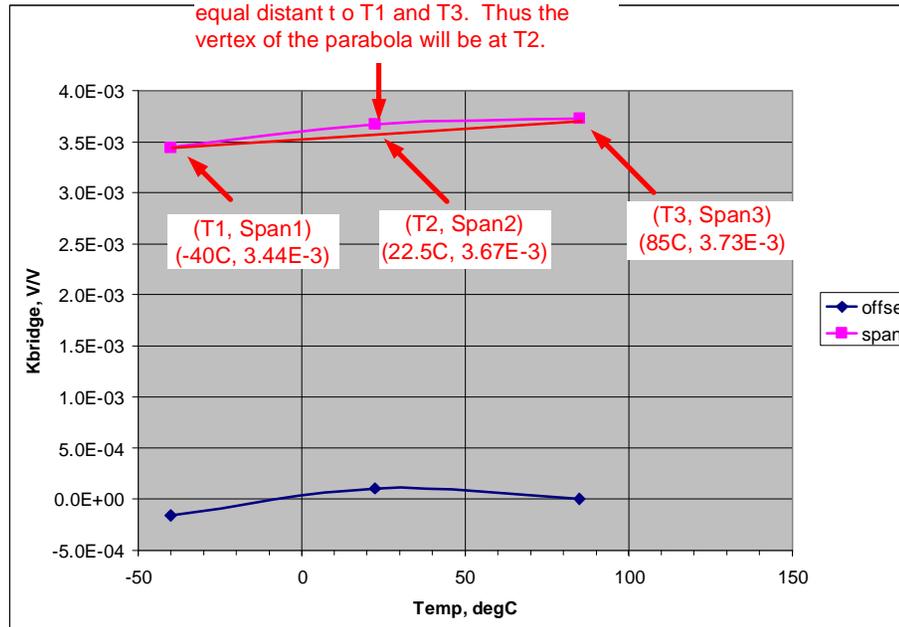
The second order (quadratic) drift of the offset. This coefficient is in **% of span at room temperature.**

$$\text{SpanTC2} = \frac{\text{NonLinSpanDrift}}{\left[\frac{(T_3 - T_1)}{2} \right]^2} = \frac{2.412 \times 10^{-2}}{\left[\frac{[85 - (-40)]}{2} \right]^2} = 6.175 \times 10^{-6} \quad \% \text{ of span}/^\circ\text{C}^2$$

SpanTC2:

The second order (quadratic) drift of the span. This coefficient is in **% of span/°C² at room temperature.**

The nonlinear coefficient assumes T2 is equal distant to T1 and T3. Thus the vertex of the parabola will be at T2.



Pressure Nonlinearity

The second order (quadratic) nonlinearity versus applied signal given in % of span.

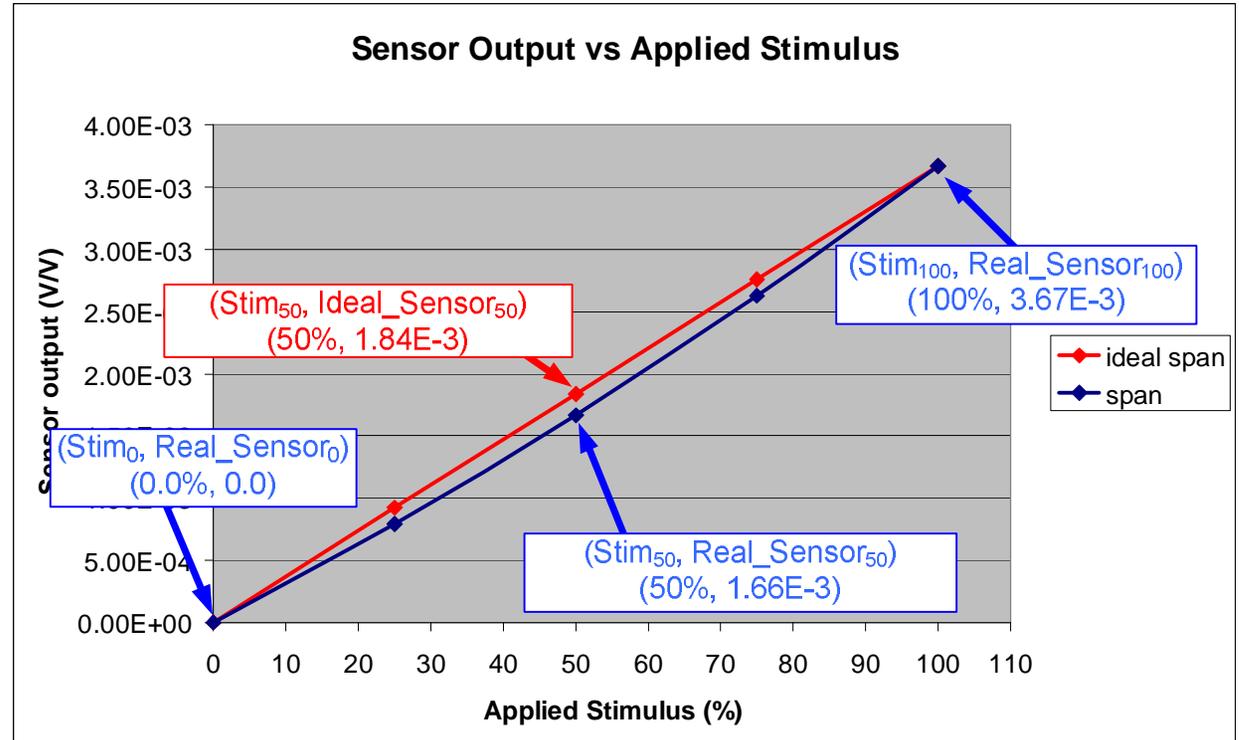
Note: These readings were all taken at room temperature. So, **real_sensor100** is the span of the sensor at room temperature.

$$\text{slope} = \frac{(\text{real_sensor}_{100} - \text{real_sensor}_0)}{(\text{stim}_{100} - \text{stim}_0)} = \frac{(3.67 \cdot 10^{-3} - 0)}{(100 - 0)} = 3.67 \times 10^{-5}$$

$$\text{ideal_sensor}(\text{stim}) = \text{slope} \cdot \text{stim}$$

$$\text{ideal_sensor}(50) = (3.67 \times 10^{-5}) \cdot 50 = 1.835 \times 10^{-3}$$

$$\text{PressureNonlinearity} = \frac{(\text{real_sensor}_{50} - \text{ideal_sensor}_{50})}{\text{real_sensor}_{100}} \cdot 100 = \frac{(1.66 \times 10^{-3} - 1.835 \times 10^{-3})}{(3.67 \times 10^{-3})} \cdot 100 = -4.768\%$$



Sensor Output Equations

The equations use the constants defined on the previous slides. These equations are used in the *generate_emu_settings.xls* spreadsheet* to compute the voltage settings for the Sensor-Emulator-EVM.

$$P_{\text{nonlin}}(P) = P + 4 \cdot \text{Nonlinearity_pct} \cdot 100 \left[\frac{P}{100} - \left(\frac{P}{100} \right)^2 \right]$$

$$\text{Span_TC}(T) = \text{SpanTC1} \cdot (T - T_{\text{room}}) - \text{SpanTC2} \cdot (T - T_{\text{room}})^2$$

$$\text{Offset_TC}(T) = \text{OffsetTC1} \cdot (T - T_{\text{room}}) - \text{OffsetTC2} \cdot (T - T_{\text{room}})^2$$

$$\text{SensorOutput}(P, T) = \left[\text{Offset}_{\text{room}} + \text{Span}_{\text{room}} \cdot \text{Offset_TC}(T) + \text{Span} \cdot \left[\frac{\text{Nonlinearity_pct}}{100} \cdot (1 + \text{Span_TC}(T)) \right] \right]$$

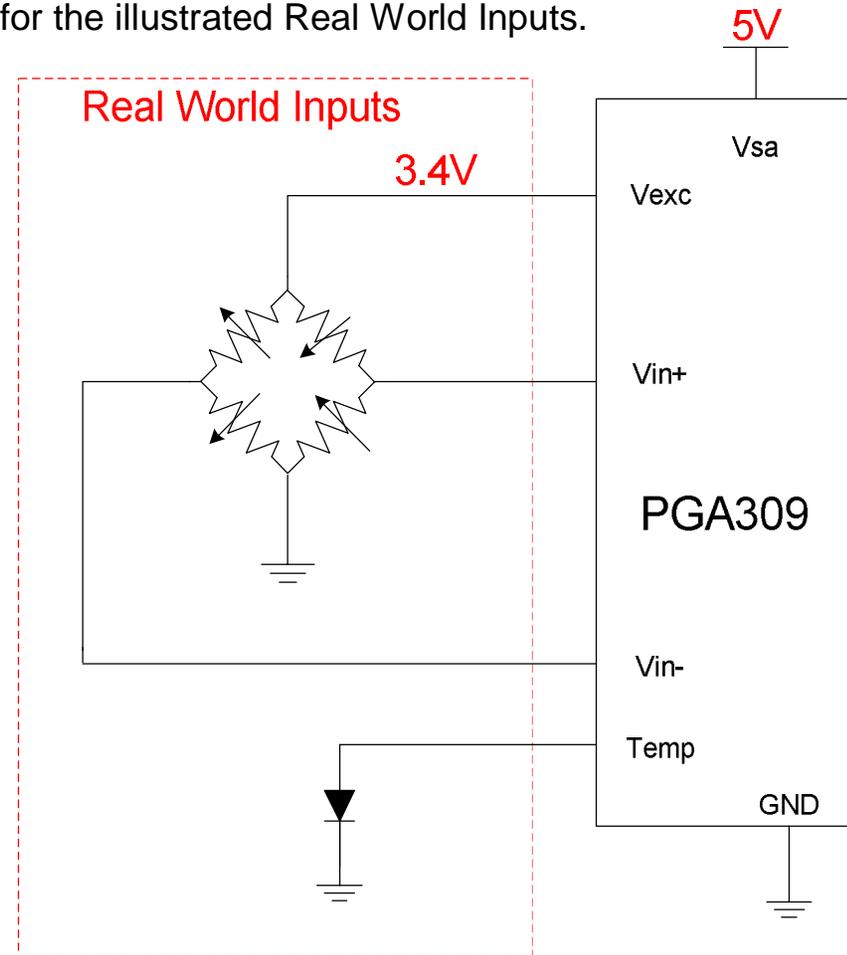
* Available for download at www.ti.com as SBOC065

PGA309 Absolute Calibration Example



For this quick start example the specifications below and the example hardware configuration will be used. The Sensor-Emulator-EVM will create an equivalent for the illustrated Real World Inputs.

Temp range:	degC
Tmin=	-45.00
Tmax=	90.00
Troom=	22.50
Vexc (V)	3.400E+00
Span (V/V)	3.509E-03
Offset (V/V)	-2.945E-04
NonlinSpanDrift (% of Span)	-5.031E-02
NonlinOffsetDrift (% of Span)	-3.077E-02
PressureNonlin (% of Span)	-3.976E-02
GainTC1 (% of Span/C)	4.682E-04
OffsetTC1 (% of Span/C)	-5.205E-04
GainTCNonlin(TC2) (% of Span/C ²)	-1.104E-05
OffsetTCNonlin(TC2) (% of Span/C ²)	-6.753E-06



“generate_sim_values.xls
“Offset and Span” Tab

Step 1: Will the PGA309 work for my sensor?



- Use your sensor's specifications with the PGA309 Calculator software tool (SLVC073) to see if the PGA309 has the gain and offset adjustment range required to accommodate your sensor.
- Use the PGA309 Calculator software tool to verify that your design does not violate any of the most critical PGA309 specifications (internal or external nodes).

Enter your sensor parameters and your PGA309 configuration parameters to get the gain scaling.



Enter information here. For example, enter the values shown.

The image shows the PGA309 Calculator software interface. It is divided into several sections: Reference Select, Bridge Excitation, Bridge Resistance, Desired PGA Output Swing, Sensor Output, and Calculated PGA Settings. The Reference Select section has 'Enable Internal Vref' checked and 'Ref Val' set to 4.096. Bridge Excitation has 'Enable Vexc' checked and 'Internal Vexc' set to 3.4. Bridge Resistance has 'Rbridge' set to 1.000K, 'Rt+' set to 0, and 'Rt-' set to 0. Desired PGA Output Swing has 'PGA Zero Scale Output' set to 0.5 and 'PGA Full Scale Output' set to 4.5. Sensor Output has 'Normalized Sensor Data' selected, 'Offset in V/V' set to -294.500u, and 'Span in V/V' set to 3.509m. Calculated PGA Settings shows 'Coarse Offset (mV)' as -13.926m, 'Front End PGA (V/V)' as 128, 'Zero DAC (V)' as 2.102, 'Gain DAC (V/V)' as 727.588m, and 'Output Amp Gain (V/V)' as 3.6. At the bottom, there are three buttons: 'Compute Constants', 'Set Additional Constraints', and 'Simulate Device'. A red dotted line highlights the input fields, and a green dashed line highlights the calculated settings.

Press **Compute Constants** and the resulting gain settings will be displayed here.

If your design generates values for gain and offset that are out of the PGA309's range, the software will flag the problem.

The program selects values to allow the Gain DAC and Zero DAC to have the maximum adjustable range. The *Set Additional Constraints* button is a way to force the front end gain or coarse offset to a constant. For this example, set the coarse offset zero to minimize noise. Click *Apply Constraints* and then click *Compute Constants*. In this case the range of adjustment for the Zero DAC is reduced but is still adequate to correct for the sensor drift.

PGA309 Calculator Rev. 1.4.1

Reference Select

Enable Internal Vref

Ref Val: 4.096

Bridge Excitation

Enable Vexc

Internal Vexc: 3.4

Bridge Resistances

Rbridge: 1.000K

Rt Note

Rt+ 0

Rt- 0

Desired PGA Output Swing

PGA Zero Scale Output: 0.5

PGA Full Scale Output: 4.5

Sensor Output

Normalized Sensor Data

Offset in V/V: -294.500u

Span in V/V: 3.509m

Measured Sensor Data

Offset in V: -1.001m

Full Scale Output in V: 10.929m

Vsa (PGA analog supply): 5

Calculated PGA Settings

Coarse Offset (mV): 0.000

Front End PGA (V/V): 128

Zero DAC (V): 319.056m

Gain DAC (V/V): 727.588m

Output Amp Gain (V/V): 3.6

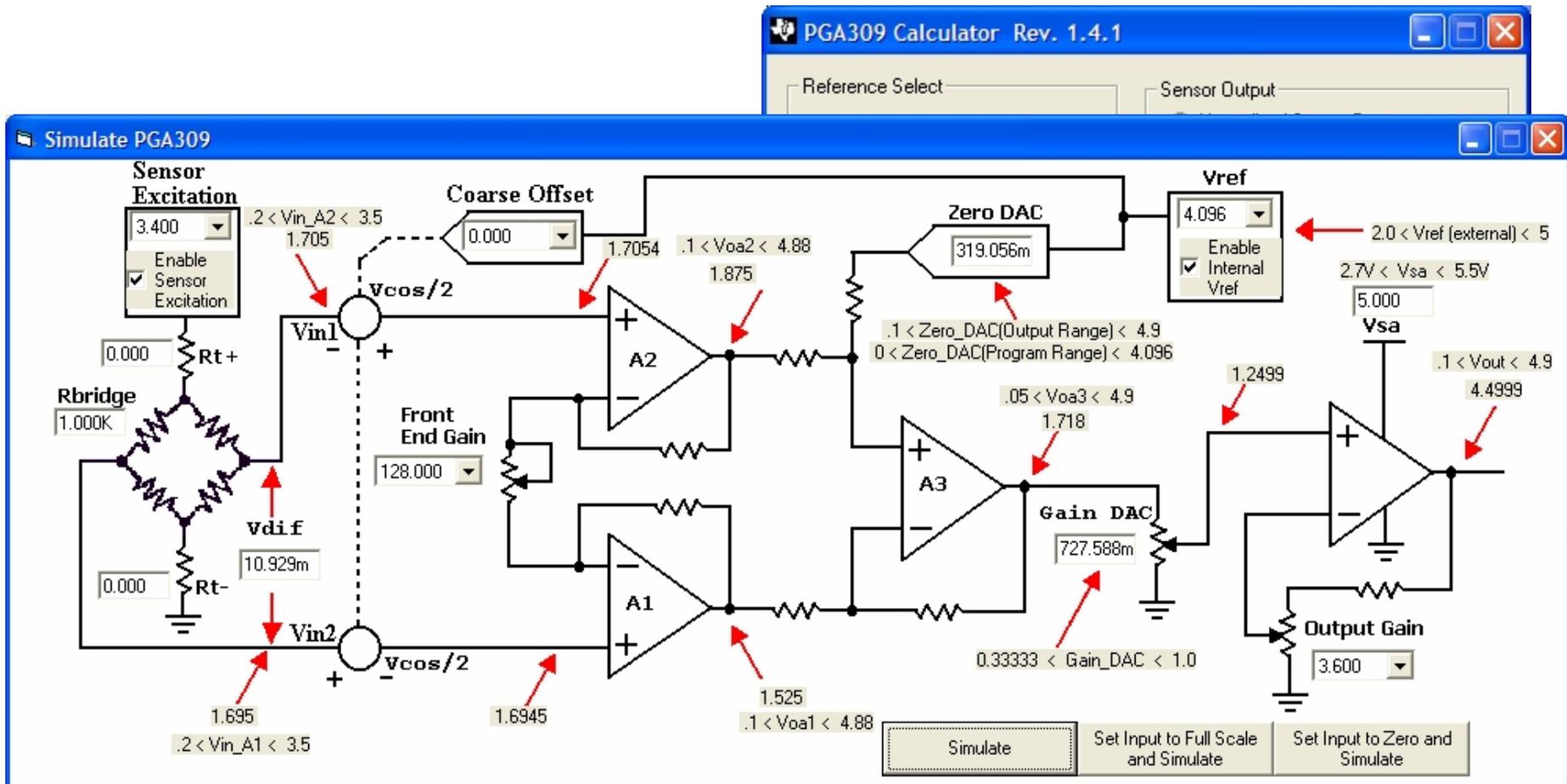
Buttons: Compute Constants, Set Additional Constraints, Simulate Device

Add Constraints

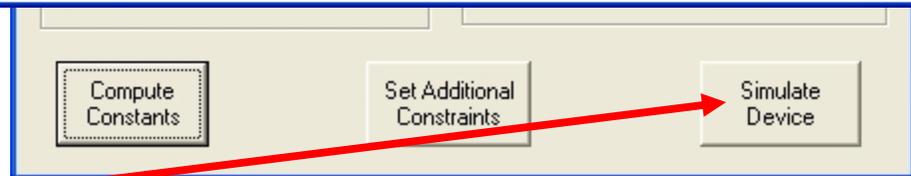
Front End Gain

Coarse Offset: 0.000

Apply Constraints

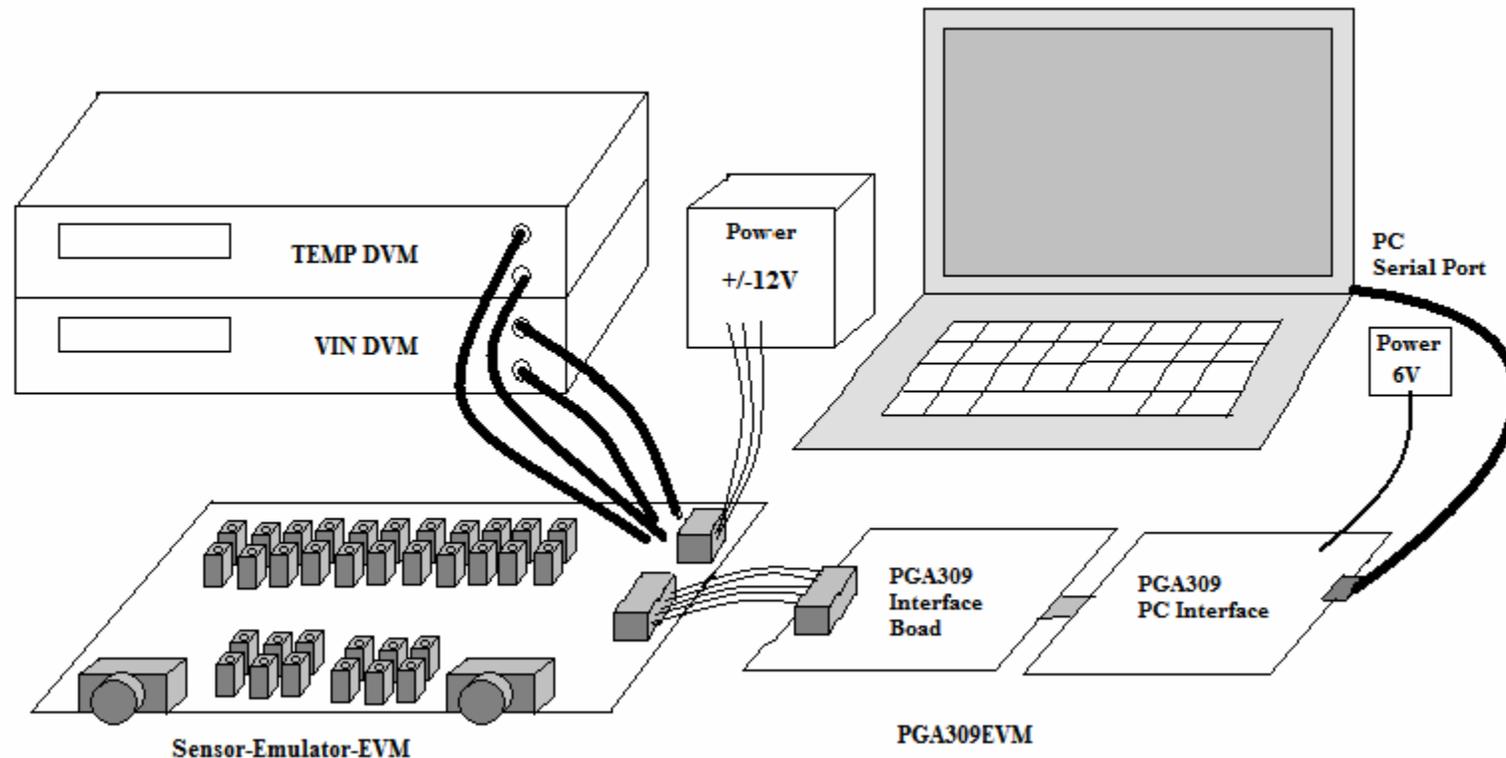


After the gains and offsets of the PGA309 have been calculated, press *Simulate Device* to see if any internal nodes are out of range.



Step 2: Connect the hardware

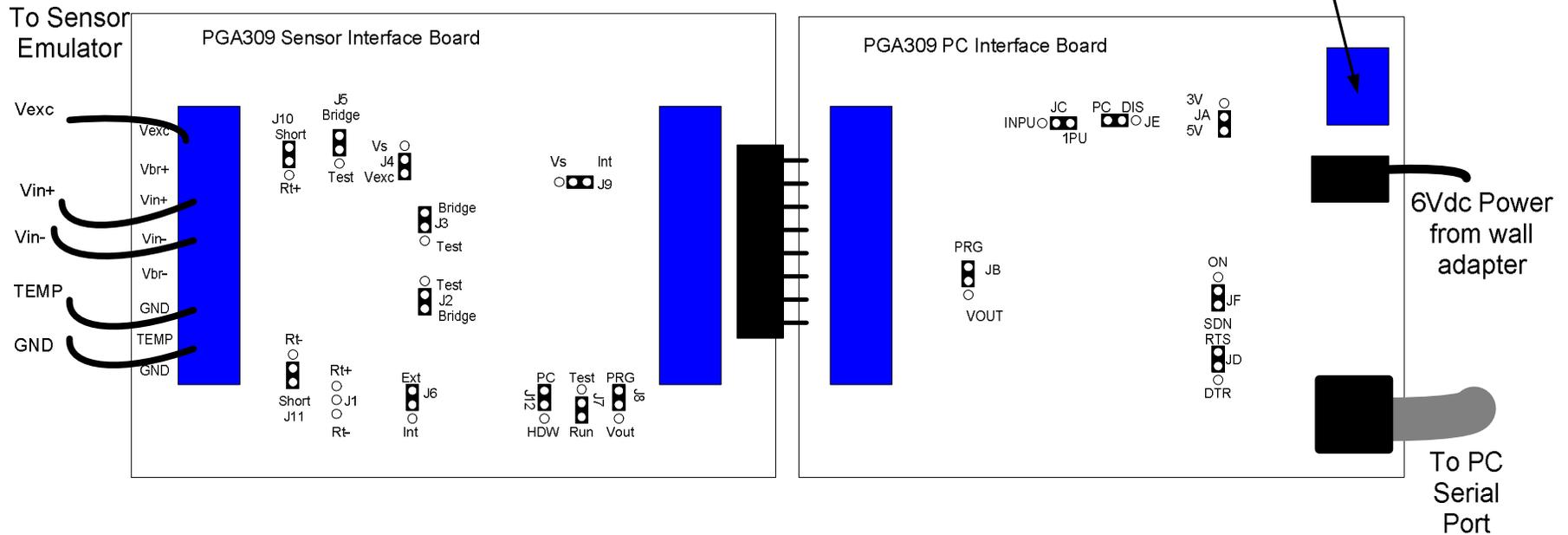
Example of a Typical Engineering Bench Setup Using the Sensor Emulator



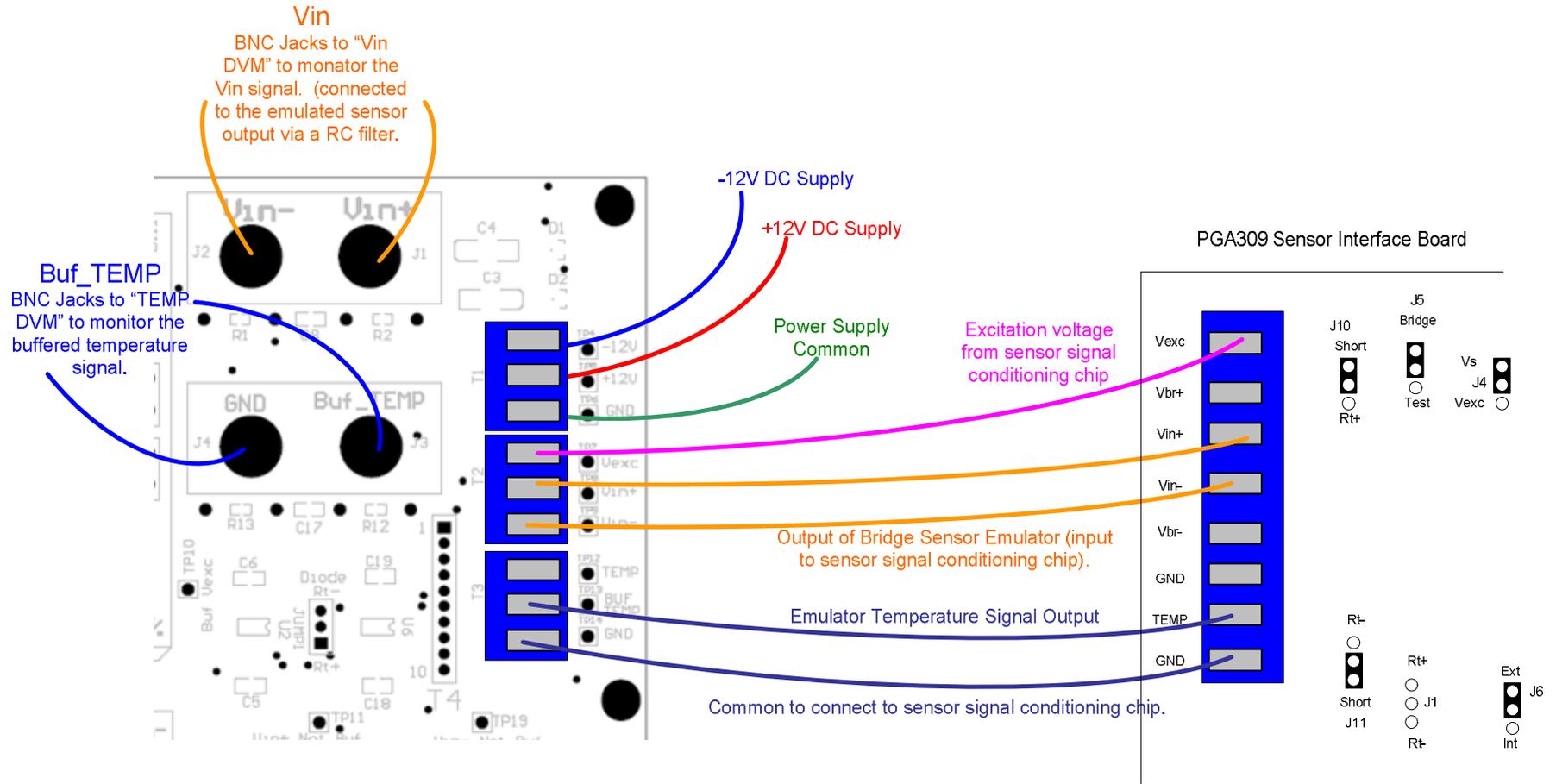
This diagram illustrates an example of how the Sensor-Emulator-EVM would be used in an engineering bench setup. The PGA309 is a programmable sensor signal conditioning chip. The Sensor-Emulator-EVM can be used in conjunction with the PGA309EVM (both versions) to facilitate the development of the PGA309 application.

Jumper setup of PGA309EVM-xx and connections to PC, power, and the Sensor-Emulator-EVM

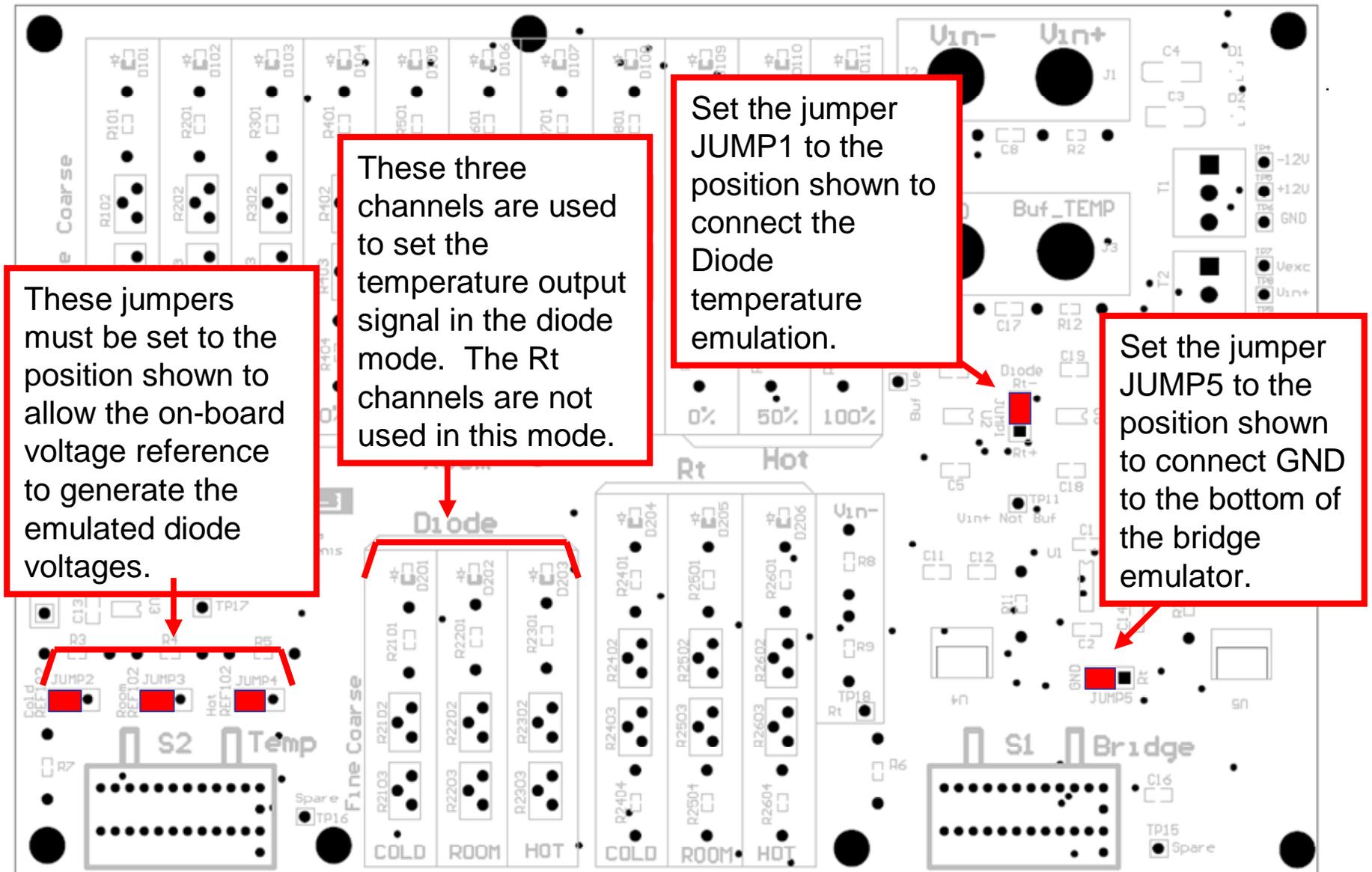
Power connection if the 6V dc wall adapter is not used.



Required Electrical Connections to Sensor-Emulator-EVM



Sensor-Emulator-EVM Jumper Setup



Step 3: Do initial setup of the PGA309 using the PGA309 DK



Program

- Copy the PGA309 Calculator results into the PGA309DK software.
- Configure the PGA309 Temp ADC
- Calibrate the ADS1100 (ADC on PGA309EVM-xx PC Interface Board Used to read the PGA309 output; read via software).

Start the *PGA309 Designer's Kit Control Program*. When it starts, a message box will ask if you want to load from the EEPROM (Press No). Another box will indicate that **“the PGA309 EVM was detected using the One-Wire interface.”** If the PGA309EVM does not work properly, refer to the PGA309EVM Users Guide.

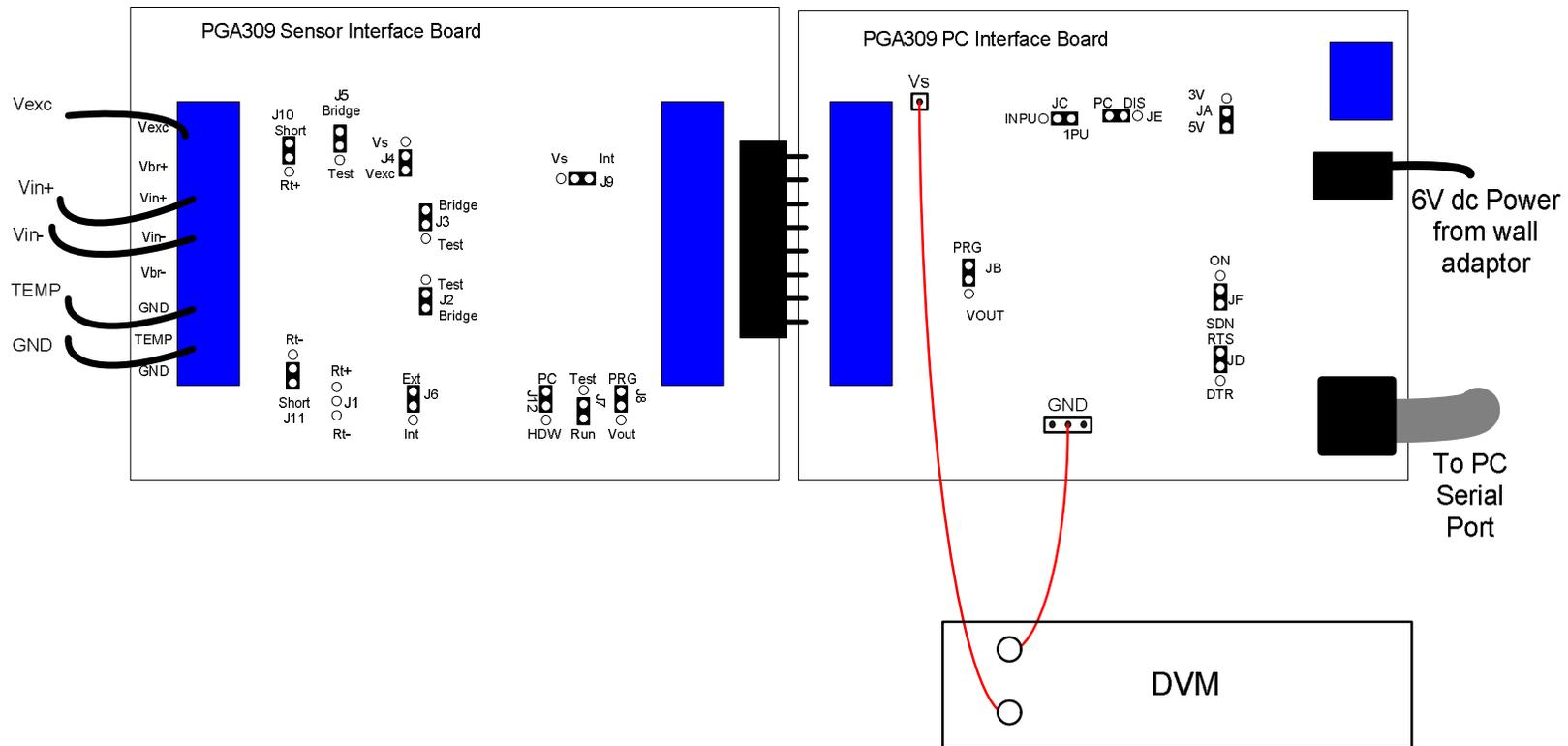
The screenshot shows the 'Kit Control Program' window with various settings for the PGA309. A dialog box titled 'PGA309 Designer's Kit' is open, displaying a question mark icon and the text: 'The PC Interface Board appears to be connected. Do you want to load the EEPROM and register contents into the PC memory?'. The dialog has 'Yes' and 'No' buttons. A red arrow points from the text in the callout box to the 'No' button. The background interface includes sections for 'PGA Settings', 'Interface Board and ADS1100', and a 'Lookup Table'.

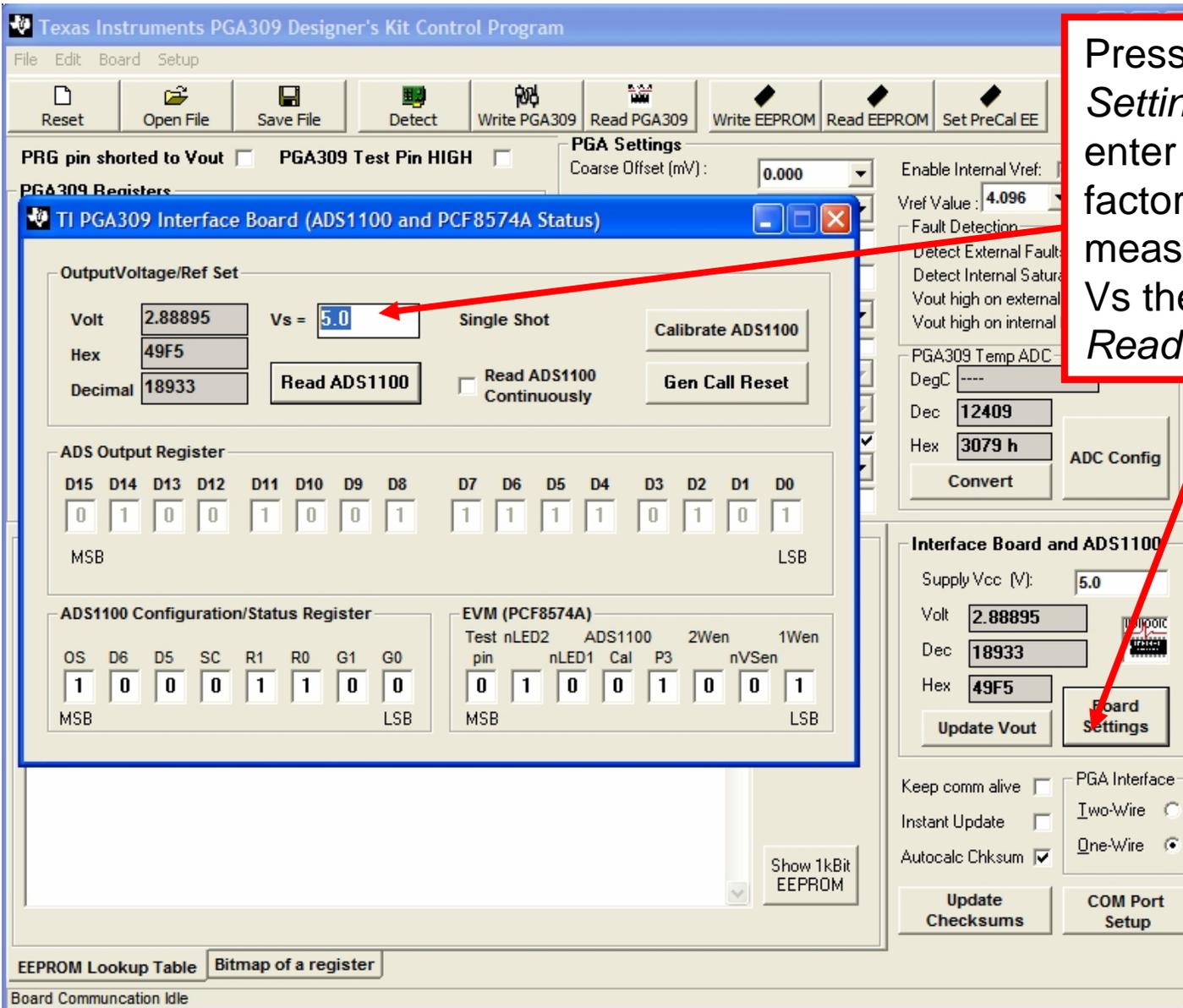
PGA Settings	Interface Board and ADS1100
Coarse Offset (mV): 0.000	Supply Vcc (V): 5.0
FrontEnd PGA Gain (V/V): 4.000	Volt: 0
Zero DAC (V): 0.000	Dec: 0
Gain DAC (V/V): 333.333m	Hex: 0
Output Amp Gain (V/V): 2.000	Board Settings
Enable Over/Under-Scale Limits: <input type="checkbox"/>	Update Vout
Overscale Limit: 4.854	Keep comm alive: <input type="checkbox"/>
Underscale Limit: 127.000m	Instant Update: <input type="checkbox"/>
	Autocalc Chksum: <input checked="" type="checkbox"/>
	PGA Interface
	Iwo-Wire: <input type="radio"/>
	One-Wire: <input checked="" type="radio"/>
	Update Checksums
	COM Port Setup

EEPROM Lookup Table Bitmap of a register

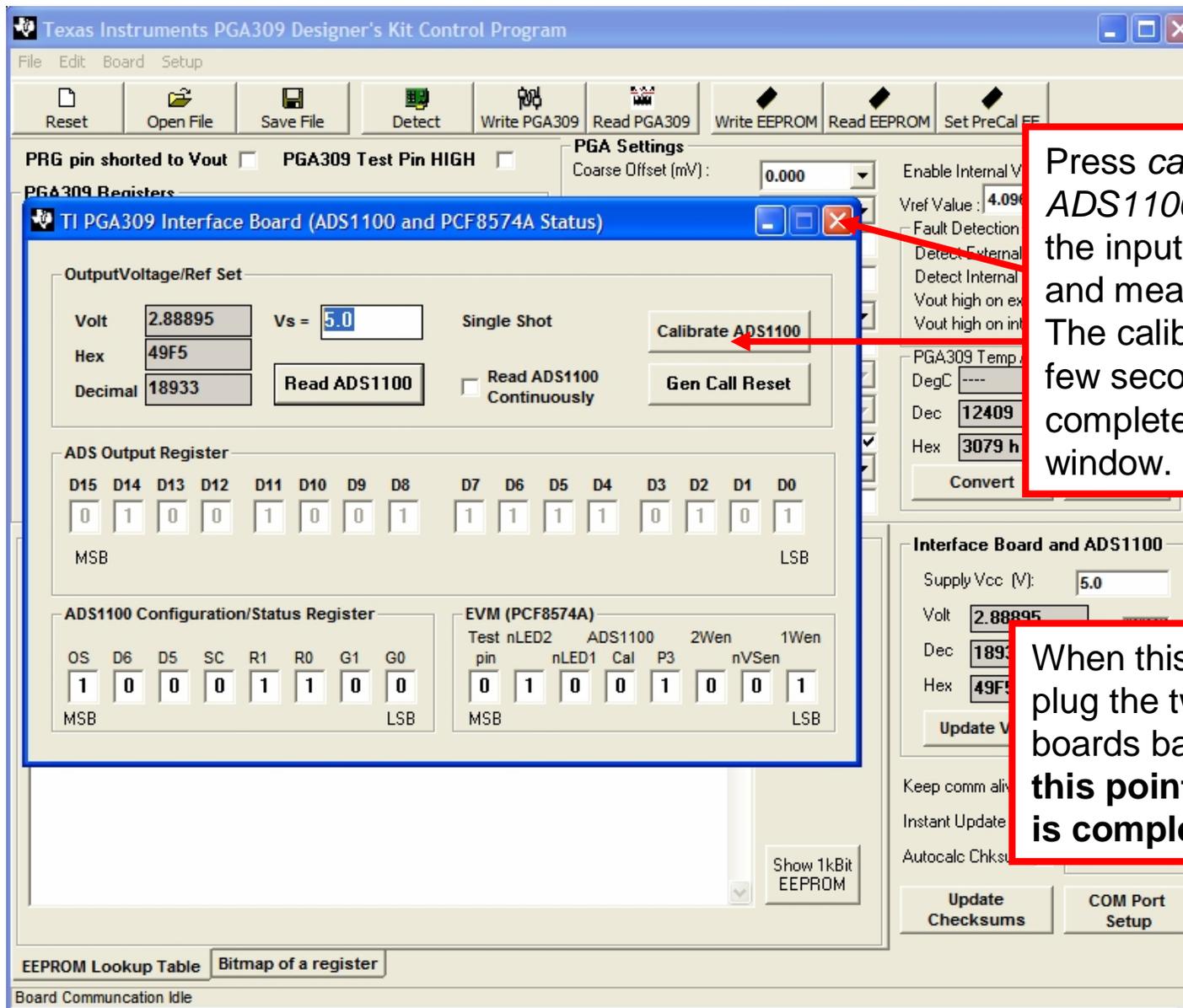
Detecting PGA309 board. Please stand by.

For this example, we will measure the PGA309 output voltage using an delta-sigma A/D converter on the PGA309 PC Interface Board (the ADS1100). For optimal accuracy the ADS1100 should be calibrated. To calibrate the ADS1100, measure the supply voltage V_s on the PGA309 PC Interface Board (this should be close to 5V).





Press the *Board Settings* button to enter the calibration factors. Enter the measured value for Vs then click *Read ADS1100*.



Press *calibrate* ADS1100. This will short the input to the ADS1100 and measure the offset. The calibration will take a few seconds. When it is complete close the window.

When this step is done, plug the two PGA309EVM boards back together. **At this point the calibration is complete.**

Texas Instruments PGA309 Designer's Kit Control Program

PGA309 Calculator Rev. 1.4.1

Reference Select

- Enable Internal Vref
- Ref Val: 4.096

Bridge Excitation

- Enable Vexc
- Internal Vexc: 3.4

Bridge Resistance

- Rbridge: 1.000K

Sensor Output

- Normalized Sensor Data
- Offset in V/V: -294.500u
- Span in V/V: 3.509m
- Measured Sensor Data
- Offset in V: -1.001m
- Full Scale Output in V: 10.929m

Vsa (PGA analog supply): 5

PGA Settings

- Coarse Offset (mV): 0.000
- FrontEnd PGA Gain (V/V): 128.000
- Zero DAC (V): 319.000m
- Gain DAC (V/V): 727.569m
- Output Amp Gain (V/V): 3.600
- Enable Over/Under-Scale Limits:
- Overscale Limit: 3.976
- Underscale Limit: 104.038m
- Enable Sensor Excitation:
- Vexc: 3.400
- Linearization Coef (V/V): 0.000

Enable Internal Vref:

Vref Value: 4.096

Fault Detection

- Detect External Faults:
- Detect Internal Saturation:
- Vout high on external fault:
- Vout high on internal fault:

PGA309 Temp ADC

- DegC: -----
- Dec: 12409
- Hex: 3079 h

ADC Config

Convert

Interface Board and ADS1100

- Supply Vcc (V): 5.0
- Volt: 2.88895
- Dec: 18933
- Hex: 49F5
- Update Vout
- Board Settings
- Keep comm alive:
- Instant Update:
- Autocalc Chksum:
- Update Checksums
- PGA Interface
- Iwo-Wire:
- One-Wire:
- COM Port Setup

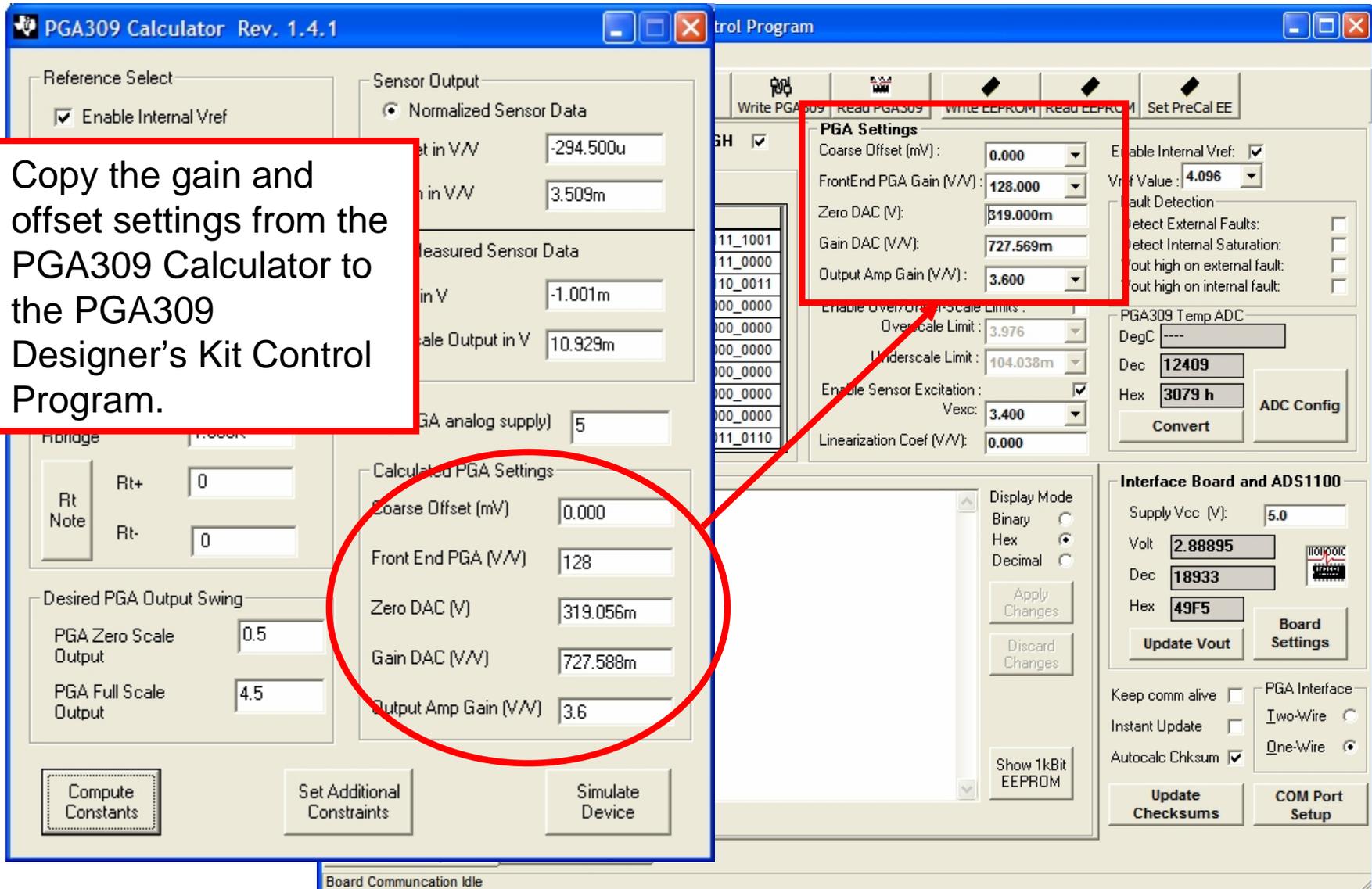
Compute Constants

Set Additional Constraints

Simulate Device

Board Communication Idle

Set the reference and bridge excitation voltage to the proper values used in the PGA309 Calculator.



Copy the gain and offset settings from the PGA309 Calculator to the PGA309 Designer's Kit Control Program.

Step C:
Press *Write PGA309* to copy all the information entered in the program into the registers of the PGA309.

Step A:
Configure the temperature ADC by pressing the *ADC Config* button. The example settings shown are good for a diode measurement.

Step B:
Enter the example settings shown for a diode temperature measurement. Press **OK** when done.

PGA Settings

	Hex	Binary
RO)	0x3079	0x0011_0000_0111_1001
C	0x13F0	0x0001_0011_1111_0000
C	0x9763	0x1001_0111_0110_0011
	0x0500	0x0000_0101_0000_0000
Cfg	0x3700	0x0011_0111_0000_0000
Under	0x0000	0x0000_0000_0000_0000

Temp. ADC Config

Move your mouse cursor over the choices to see corresponding register bits

Select Signal Source:

External (TEMPin pin)

Internal on-chip temp

Resolution, without sign
11b 13b 14b 15b

Enable Itemp (~7uA):

Continuous conv:

Single Shot conv:

ADC Configuration with External Source

Enable ADC 2x Turbo:

Ref select

ADC built-in 2.048V

Vref pin:

Vexc pin:

Vsa pin:

Reserved:

Note: Bits RV[1:0] do not have effect when the built-in Vref is selected

(*) Vout-GNDA input is not compatible with the stand-alone look-up table PGA309 mode. Pull Test pin high.

ADC Pre-gain

Select

1 V/V

2 V/V

4 V/V

8 V/V

Diff input

TEMPin - GNDA

Vexc - TEMPin

(*) Vout - GNDA

Vref - TEMPin

Interface Board and ADS1100

Supply Vcc (V): 5.0

Volt 2.88895

Dec 18933

Hex 49F5

Update Vout

Board Settings

Keep comm alive

Instant Update

Autocalc Chksum

Update Checksums

PGA Interface

Two-Wire

One-Wire

COM Port Setup

Show 1kBit EEPROM

Display Mode

Binary

Hex

Decimal

Apply Changes

Discard Changes

Bitmap of a register

Step 4: Configure Sensor-Emulator-EVM to Emulate the Bridge Sensor

1. In order to use the Sensor-Emulator-EVM, you have to adjust a number of trim potentiometers to configure the Sensor-Emulator-EVM so that it acts like your sensor. If the sensor's raw output characteristics are known, this step is simple: you adjust the Sensor-Emulator-EVM output to mimic your sensor.
2. In the case where you want to use a sensor data sheet to configure the Sensor-Emulator-EVM, you can use the ***generate_emu_settings.xls*** to translate your specifications to Sensor-Emulator-EVM settings. Unfortunately, sensor manufacturers may have specifications that do not conform to a standard, and sometimes the specifications are difficult to understand. For our tools we will mathematically define the specifications. You may have to translate your particular specifications to our format.

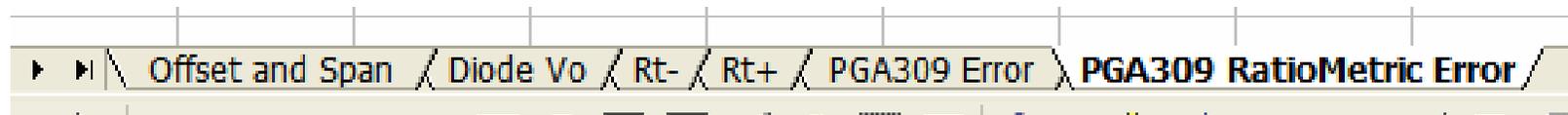
Configuring the Emulator to Emulate a Real World Sensor



If the raw output of the sensor is not known, the “Generate_Sim_Values.xls” spreadsheet can be used to translate the specifications of your bridge sensor and temperature sensor to system voltage levels. The spreadsheet contains five sections (Offset and Span, Diode V_o , R_t^- , R_t^+ , PGA309 Error, Ratiometric Error):

1. Offset and Span: Generates the bridge output voltages.
2. Diode V_o : Generates the temperature sensor output voltages for the diode method.
3. R_t^- : Generates the temperature sensor voltages for the R_t^- method.
4. R_t^+ : Generates the temperature sensor voltages for the R_t^+ method.
5. PGA309 Error: Allows you to read the PGA309 via the ADS1100 (The ADS1100 is the delta-sigma A/D converter that is a part of the PGA309EVM-xx).
6. PGA309 RatioMetric Error: Allows you to read and compute error for a ratiometric PGA309 setup.

The temperature measurement methods, Diode, R_t^- , and R_t^+ are described in detail in the Sensor-Emulator-EVM System Reference Guide (SBOA102) and the PGA309 Users Guide (SBOU024).



Offset and Span:

Generates the bridge output voltages from sensor specifications (“Generate_Sim_Values.xls”)

All the areas shown in light blue are either sensor specifications or system requirements. Enter these values and the spreadsheet will generate output voltage settings for each channel on the sensor emulator. The next several pages will show how the voltages listed in the spreadsheet are used to program the Sensor-Emulator-EVM.

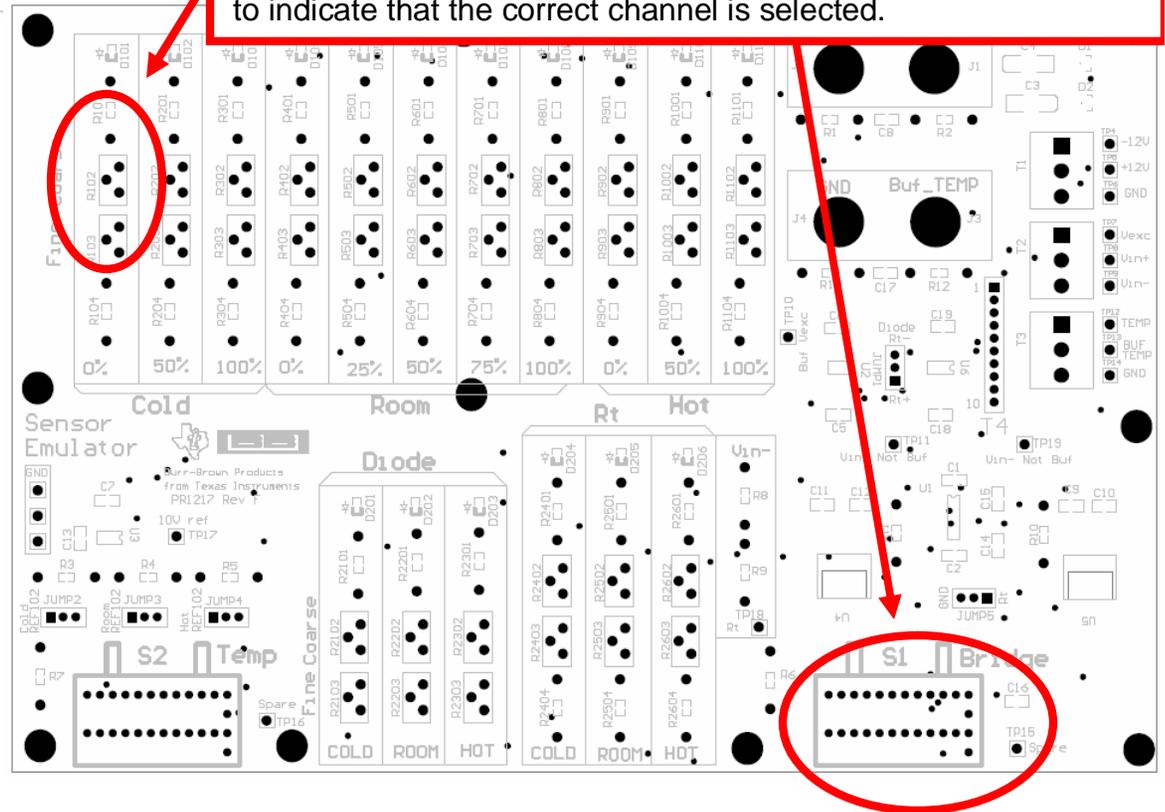
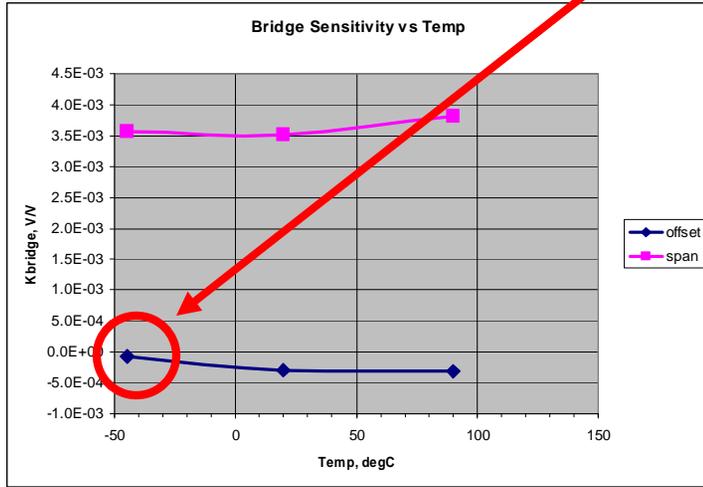
		B	C	D	E	F	G	H	I	J
1	Temp	degC								
2	Tmin=	-45.00		Precalibration Sensor Simulator Settings (LinDac = 0)						
3	Tmax=	90.00		Cold						
4	Troom=	22.50		Pressure Input	0%	50%	100%			
5				Sensor Output (mV)	-0.215	5.379	11.939			
6	Vexc (V)	3.400E+00								
7										
8	Span (V/V)	3.509E-03		Pressure Input	0%	25%	50%	75%	100%	
9	Offset (V/V)	-2.945E-04		Sensor Output (mV)	-1.001	1.626	4.490	7.591	10.929	
10										
11										
12										
13	NonlinSpanDrift (% of Span)	-5.031E-02		Pressure Input	0%	50%	100%			
14	NonlinOffsetDrift (% of Span)	-3.077E-02		Sensor Output (mV)	-1.053	4.887	11.855			
15	PressureNonlin (% of Span)	-3.976E-02								
16										
17	GainTC1 (% of Span/C)	4.682E-04								
18	OffsetTC1 (% of Span/C)	-5.205E-04								
19	GainTCNonlin(TC2) (% of Span/C ²)	-1.104E-05								
20	OffsetTCNonlin(TC2) (% of Span/C ²)	-6.753E-06								
21										
22	Note: % of Span is represented as a decimal number									
23	i.e. OffsetTC1 (% of Span) = 0.1 is 10%									
24										
25										
26										

Enter these for our example

Set Sensor-Emulator-EVM potentiometers to generate these voltages as detailed in pages 35-36

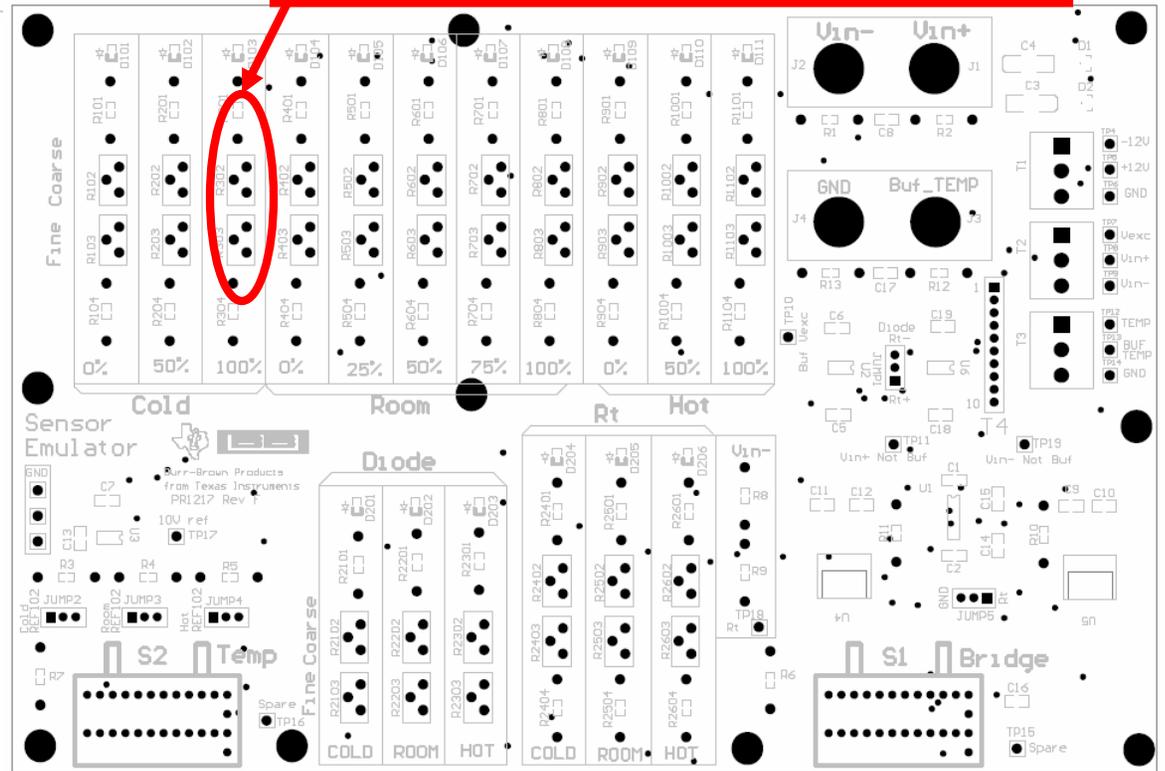
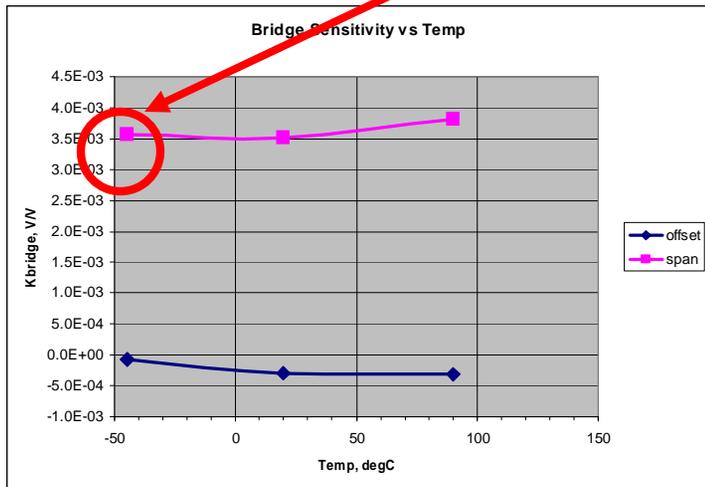
Precalibration Sensor Simulator Settings (LinDac = 0)					
Cold					
Pressure Input	0%	50%	100%		
Sensor Output (mV)	-0.215	5.379	11.939		
Room					
Pressure Input	0%	25%	50%	75%	100%
Sensor Output (mV)	-1.001	1.626	4.490	7.591	10.929
Hot					
Pressure Input	0%	50%	100%		
Sensor Output (mV)	-1.053	4.887	11.855		

Each channel on the top section of the sensor emulator represents a applied stimulus and temperature combination for the sensor. Adjust the potentiometers coarse first, then fine, to match the values computed by the **Generate_Sim_Values.xls** spreadsheet for cold (0%, 50%, 100%), room (0%, 25%, 50%, 75%, 100%), and hot (0%, 50%, 100%). For example, the sensor output at cold temperature and 0% of applied stimulus is emulated by this channel. The rotary switch S1 is used to select this channel. When the channel is selected, LED D101 will light to indicate that the correct channel is selected.



Precalibration Sensor Simulator Settings (LinDac = 0)					
Cold					
Pressure Input	0%	50%	100%		
Sensor Output (mV)	-0.215	5.379	11.939		
Room					
Pressure Input	0%	25%	50%	75%	100%
Sensor Output (mV)	-1.001	1.626	4.490	7.591	10.929
Hot					
Pressure Input	0%	50%	100%		
Sensor Output (mV)	-1.053	4.887	11.855		

This is another example illustrating how a particular channel on the sensor emulator represents an applied stimulus and temperature combination for the sensor. In this example, the sensor output at cold temperature and 100% of applied stimulus is emulated by this channel. The rotary switch S1 is used to select this channel. When the channel is selected, LED D103 will light to indicate that the correct channel is selected.



Diode Vo: Generate Diode Voltages based on Operating Temperature Range



The second tab in the *Generate_Sim_Values.xls* spreadsheet allows the user to enter the temperature range and room temperature diode voltage (light blue areas). The spreadsheet calculates the diode voltages and displays the results in the yellow areas. Note that the *Temp ADC* areas are specific to the PGA309 sensor signal conditioning chip. The Temp ADC values will be used in the computation of the *Counts* for the temp ADC. The next several pages will show how the diode voltages are used to program the sensor Sensor-Emulator-EVM.

	A	B	C	D	E	F	G
10							
11	Temp range:	degC		Temp(degC)	Diode Vbe (V)	Counts	
12	Tmin=	-45.00		-45.00	0.755	24160	
13	Troom=	22.50		22.50	0.62	19840	
14	Tmax=	90.00		90.00	0.485	15520	
15							
16	Diode	Volts					
17	Room Temp Vbe=	0.62					
18							
19	Temp ADC						
20	Vref (in V) =	4.096					
21	Numb Bits	15	bits (sign bit not included)				
22	Gain=	4					
23							
24							
25							

Adjust the *Diode* section potentiometer on the *Sensor-Emulator-EVM* to generate the counts as detailed on page 38.

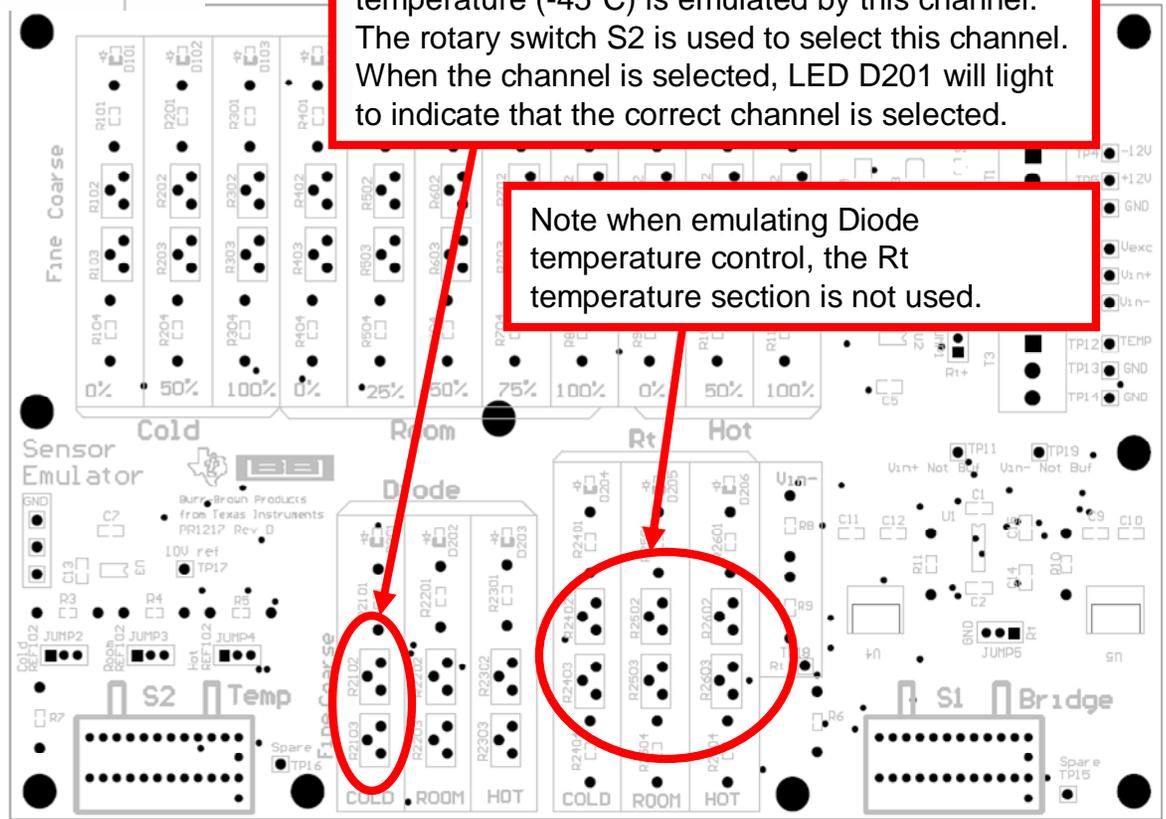
PGA309 Temp ADC

generate_sim_values.xls
Diode Vo Tab

	D	E	F	G
	Temp(degC)	Diode Vbe (V)	Counts	
	-45.00	0.755	24160	
	22.50	0.62	19840	
	90.00	0.485	15520	

Each channel on the bottom section of the Sensor-Emulator-EVM represents the output of the emulated temperature sensor. Using the Temp DVM, adjust the respective potentiometers, coarse first, the fine, to match the values computed by the **Generate_Sim_Values.xls** spreadsheet for Diode/Cold, Diode/Room, and Diode/Hot. For this example, the temperature output signal at cold temperature (-45°C) is emulated by this channel. The rotary switch S2 is used to select this channel. When the channel is selected, LED D201 will light to indicate that the correct channel is selected.

Note when emulating Diode temperature control, the Rt temperature section is not used.



Step 5: Use the PGA309 Calibration Spreadsheet

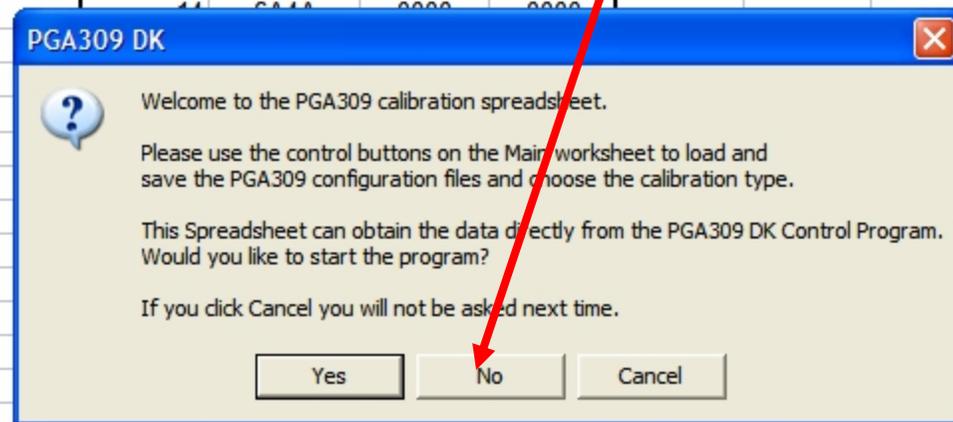


- Select the calibration algorithm
- Copy the PGA309 registers into the spreadsheet
- Use the Sensor-Emulator-EVM to generate the sensor outputs over temperature.
- Store calibration results into a file. Load this into the PGA309 external EEPROM.
- Measure the post-calibration error. Perform a second calibration to improve accuracy.

For this example, use the PGA309 Calibration Spreadsheet. This tool uses measured data (pressure and temperature) to create a lookup table that the PGA309 will use to compensate for offset and gain drift. The spreadsheet will also generate a coefficient that the PGA309 will use to correct for nonlinearity verses applied pressure. **Note: you will need to enable macros and load the analysis toolpack to get this Excel sheet to work properly.** Information regarding configuration of Excel is detailed in the *PGA309EVM Users' Guide*.

8	5 * Cfg2_OverUnder	0000_1010_0000_0111
9	6 * Cfg3 (ADC)	0001_0100_0000_1011
10	7 OutEnbl Counter	0000_0000_0000_0000
11	8 AlarmStatus(RO)	0000_0000_0000_0000
12	Config Checksum	0110_1111_0100_1010
13		
14		
15	Load Registers from File	
16		
17		
18	Load Registers From PGA309	
19		
20		
21	Prepare Calibration Sheet	
22		
23		
24	Save Registers+Lookup Table	
25		
26		
27	PGA309DK Calibration Spreadsheet	
28	Version 1.2.4	
29	© 2004 Texas Instruments	
30		

When you bring up the spreadsheet, it will ask you if you want to start the program. Press **No**, because the program should already be up from Step 2.



PGA309 Calibration Spreadsheet, Main Tab

PGA309 Configuration Registers				PGA309 Calibrated Lookup Table			
Reg. Addr	Name	Binary value		Position	Temp	ZM	GM
0	ADC Out(RO)	0111_1000_0100_1100		0	47E8	70A4	4000
1	ZeroDAC	0111_0000_1010_0100		1	4A5C	0000	0000
2	GainDAC	0100_0000_0000_0000		2	4CD1	0000	0000
3	* Ref&Lin	0000_0111_0101_1010		3	4F46	0000	0000
4	* Gain,Vos,Cfg1	0001_0111_0000_0000		4	51BB	0000	0000
5	* Cfg2,OverUnder	0000_1010_0000_0111		5	542F	0000	0000
6	* Cfg3 (ADC)	0001_0100_0000_1011		6	56A4	0000	0000
7	OutEnbl Counter	0000_0000_0000_0000		7	5919	0000	0000
8	AlarmStatus(RO)	0000_0000_0000_0000		8	5B8E	0000	0000
	Config Checksum	0110_1111_0100_1010		9	5E02	0000	0000
				10	6077	0000	0000
				11	62EC	0000	0000
				12	6560	0000	0000
				13	67D5	0000	0000
				14	6A4A	0000	0000
				15	6CBF	0000	0000
				16	6F33	0000	0000
				ChSum	7FFF	0	BAF6

15	Load Registers from File
18	Load Registers From PGA309
21	Prepare Calibration Sheet
24	Save Registers+Lookup Table

27	PGA309DK Calibration Spreadsheet
28	Version 1.2.4
29	© 2004 Texas Instruments

Press *Load registers* from *PGA309* to copy the registers from the evaluation fixture into the spreadsheet.

PGA309 Calibration Spreadsheet, Main Tab

Press *Prepare Calibration Sheet* to select the algorithm. In this example, we will do a *3 temperature 3 pressure* calibration.

PGA309 Configuration Registers				PGA309 Calibrated	
Reg. Addr	Name	Binary value	Position	Temp	
0	ADC Out(RO)	0101_0000_0001_0011	0	4ECB	
1	ZeroDAC	0001_0100_0000_1111	1	50F3	
2	GainDAC	1001_1000_0001_1011	2	531A	
3	* Ref&Lin	0000_0101_0000_0000	3	5541	
4	* Gain, Vols, Cfg1	0011_0111_0000_0000	4	5768	
5	* Cfg2, OverUnder	0000_0000_0000_0000	5	598F	
6	* Cfg3 (ADC)	0001_0100_0000_1011	6	5BB6	
7	OutEnbl Counter	0000_0000_0000_0000	7	5DDE	
8	AlarmStatus(RO)	0000_0000_0000_0000	8	6005	
	Config Checksum	0101_1011_1010_1011	9	622C	
			10	6453	
			11	667A	
			12	68A1	
			13	6AC9	
			14	6CF0	
			15	6F17	
			16	713E	
			ChSum	7FFF	

PGA309 Calibration

Please select the calibration algorithm:

One of the following three templates can be used for the pressure sensor calibration

3 Temperatures and 3 Pressures

Select this when you do not know the 2nd order non-linearities of output vs. pressure and of temperature drifts of span and offset. The module output must be measured at three different temperatures with min and full-scale pressure applied plus mid-scale pressure at one of the temperatures.

2 Temperatures and 2 Pressures

All 2nd order coefficients are entered based on pre-characterization, only the positions of curves must be fitted. The output must be measured at only two temperatures, each with min and full-scale pressure applied.

OK Cancel

Press **OK** after you have selected *3 Temperature 3 Pressure* calibration.

PGA309 Calibration Spreadsheet, Main Tab

Next the program will ask what type of *Temperature Measurement Method* you want to use. For this example, we use the diode method.

(during calibration) settings:

2.500 V	Initial settings of the Fine Adjust DACs:		Use
0.830 V/V	GainDAC1=	4000 hex, ==>>	0.5000 V/V Extr:
128 V/V	ZeroDAC1=	70A4 hex, ==>>	1.1000 V Extr:
2.4 V/V			
0.00E+00 V			

Initial settings of the Fine Adjust DACs:

GainDAC1=	4000 hex, ==>>	0.5000 V/V	Extr:
ZeroDAC1=	70A4 hex, ==>>	1.1000 V	Extr:

Temp range

Tmin=

Tmax=

Troom= 22.5

Vexc= 2.075 V, with LinDAC=0

Insert TempADC reading in active cell

Insert V

Measurement Temperatures:

Temp	Pressure	TempADC Reading	Tmeas
20	0	24744	decimal
85	100	20498	decimal
-40	100	28668	

Measured Data (assuming the sensor directly):

Measurement Conditions	Measured Data	RTISpan, V
Temp	Pressure	VoutMeas
20	0	5.00E-01
20	50	2.50E+00
20	100	4.50E+00
85	0	5.00E-01
85	100	4.50E+00
-40	0	5.00E-01
-40	100	4.50E+00

Choose Temperature Measurement Method

Use Internal, or Diode Temperature Measurement

Use Rt Temperature Measurement with Quadratic fit

Use Rt Temperature measurement with 1/(aT^2 + bT + c) fit

Ok

Room Temp Gain Error: 1 PGA_Min_Output_Room

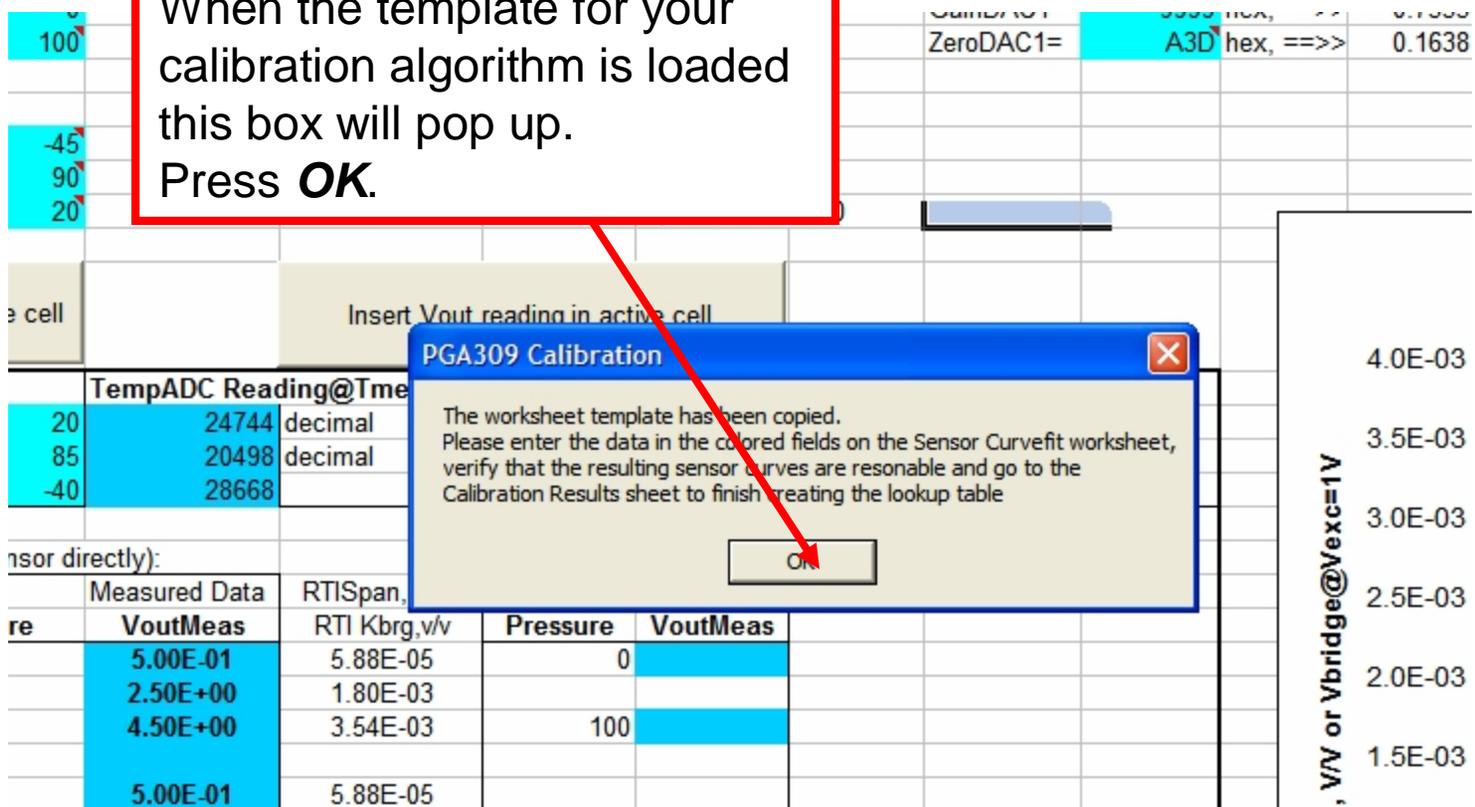
Temp Cor Gain Dac: 1 PGA_Max_Output_Room

al RTI Khr(Pin_min): 0.0053386 GainDAC Correction: 1

Kbridge, V/V or Vbridge@Vexc=1V

PGA309 Calibration Spreadsheet, Sensor Curvefit Tab

When the template for your calibration algorithm is loaded this box will pop up. Press **OK**.



TempADC Reading@Tme

20	24744	decimal
85	20498	decimal
-40	28668	

Measured Data

RTISpan,	Pressure	VoutMeas
5.88E-05	0	
1.80E-03		
3.54E-03	100	
5.88E-05		

PGA309 Calibration

The worksheet template has been copied. Please enter the data in the colored fields on the Sensor Curvefit worksheet, verify that the resulting sensor curves are reasonable and go to the Calibration Results sheet to finish creating the lookup table

OK

PGA309 Calibration Spreadsheet, Sensor Curvefit Tab

3	Uses 2nd-order (quadrature) equations for pressure non-linearity and temp drifts of offset and span								
4	$K_{bridge}(P,T)=k_{o0}+k_{o1}*T+k_{o2}*T^2+(k_{o3}*p+k_{o4}*p^2)*[1+k_{o5}*T+k_{o6}*T^2]$								
5									
6	Fill out the highlighted cells			PGA309 n					
7	Pressure values:								
8	Pmin=	0		Vref=					
9	Pmax=	100		Kexc=					
10				FrontEnd P					
11	Temp range:				Output Am				
12	Tmin=	-45		Coarse Off					
13	Tmax=	90							
14	Troom=	27		Vexc=					
15									
16	Insert TempADC reading in active cell		Insert Vout reading in active cell						
17	Measurement Temperatures:		TempADC Reading@Tmeas						
18	Tmeas1=	22.5	19839	decimal	: @ this Temp 3 pressure levels are applied				
19	Tmeas2=	90	15520	decimal					
20	Tmeas3=	-45	24160						
21									
22	Measured Data (assuming the sensor directly):								
23	Measurement Conditions		Measured Data	RTISp					
24	Temp	Pressure	VoutMeas	RTI K					
25	22.5	0	3.55E-01	-2.89					
26	22.5	50	2.19E+00	1.32					
27	22.5	100	4.33E+00	3.20					
28									
29	90	0	3.38E-01	-3.04					
30	90	100	4.64E+00	3.47					
31									
32	-45	0	6.19E-01	-5.73E-05					
33	-45	100	4.67E+00	3.49E-03					
34				Room Temp Gain Error:	1				
35				Room Temp Cor Gain Dac:	1				
36				Post Cal RTI Kbrg(Pin_min):	-0.0009647	GainDAC Correction:	1		
37				Post Cal RTI Kbrg(Pin_max):	0.00912834	ZeroDAC Correction:	0		

The appropriate values need to be entered manually for the temperature range. This is the range that the curve fit is done over. Enter the values shown for our example.

The appropriate values need to be entered manually for the measurement temperatures. The measurement temperatures are the temperatures that the calibration measurements are made at.

PGA309 Calibration Spreadsheet, Sensor Curvefit Tab

3	Uses 2nd-order (quadrature) equations for pressure non-linearity and temp drifts of offset and span			
4	$K_{bridge}(P,T)=k_{o0}+k_{o1}*T+k_{o2}*T^2+(k_{o3}*p+k_{o4}*p^2)*[1+k_{o5}*T+k_{o6}*T^2]$			
5				
6	Fill out the highlighted cells		PGA309 non-variable (during calibration)	
7	Pressure values:			
8	Pmin=	0	Vref=	4.096 V
9	Pmax=	100	Kexc=	0.830 V/V
10			FrontEnd PGA=	128 V/V
11	Temp range:		Output Amp=	5.6 V/V
12	Tmin=	-45	Coarse Offset=	0.00E+00 V
13	Tmax=	90		
14	Troom=	27	Vexc=	3.400 V, with L
15	Insert TempADC reading in active cell		Insert Vout reading in active cell	
16				
17	Measurement Temperatures:		TempADC Reading@Tmeas	
18	Tmeas1=	22.5	10839	decimal : @ this Temp 3 pressure levels are applied
19	Tmeas2=	90	15520	decimal
20	Tmeas3=	-45	24160	
21				
22	Measured Data (assuming the sensor directly):			
23	Measurement Conditions	Measured Data	RTISpan, V/V	Pos
24	Temp	Pressure	VoutMeas	RTI Kbrg,v/v
25	22.5	0	3.55E-01	-2.89E-04
26	22.5	50	2.19E+00	1.32E-03
27	22.5	100	4.33E+00	3.20E-03
28				
29	90	0	3.38E-01	-3.04E-04
30	90	100	4.64E+00	3.47E-03
31				
32	-45	0	6.19E-01	-5.73E-05
33	-45	100	4.67E+00	3.49E-03
34	Room Temp Gain Error			
35	Room Temp Cor Gain			
36	Post Cal RTI Kbrg(Pin_min): -0.0009047 GainDAC Correction: 1			
37	Post Cal RTI Kbrg(Pin_max): 0.00912834 ZeroDAC Correction: 0			

The easiest way of doing this is to select a cell and press the *Insert TempADC reading in active cell* button. This will insert a PGA309 Temp ADC in counts into that cell.

The measured PGA309 Temp ADC readings need to be recorded at the respective applied temperatures. Use the temperature selector switch on the Sensor-Emulator-EVM to generate room, hot, and cold readings for this example.

PGA309 Calibration Spreadsheet, Sensor Curvefit Tab

3	Uses 2nd-order (quadrature) equations for pressure non-linearity and temp drifts of offset and span			
4	$K_{bridge}(P,T)=k_{o0}+k_{o1}*T+k_{o2}*T^2+(k_{o3}*p+k_{o4}*p^2)*[1+k_{o5}*T+k_{o6}*T^2]$			
5				
6	Fill out the highlighted cells			PGA309 non-variable (during calibration)
7	Pressure values:			
8	Pmin=	0	Vref=	4.096 V
9	Pmax=	100	Kexc=	0.830 V/V
10			FrontEnd PGA=	128 V/V
11	Temp range:		Output Amp=	3.6 V/V
12	Tmin=	-45	Coarse Offset=	0.00E+00 V
13	Tmax=	90		
14	Troom=	27	Vexc=	3.400 V, with LimDAC
15	Insert TempADC reading in active cell		Insert Vout reading in active cell	
16				
17	Measurement Temperatures:		TempADC Reading@Tmeas	
18	Tmeas1=	22.5	19839	decimal : @ this Temp 3 pressure le
19	Tmeas2=	90	15520	decimal
20	Tmeas3=	-45	24160	
21				
22	Measured Data (assuming the sensor directly):			
23	Measurement Conditions		Measured Data	RTI Span, V/V
24	Temp	Pressure	VoutMeas	RTI Kbrg,v/v
25	22.5	0	3.55E-01	2.89E-04
26	22.5	50	2.19E+00	1.32E-03
27	22.5	100	4.33E+00	5.20E-03
28				
29	90	0	3.38E-01	3.04E-04
30	90	100	4.64E+00	3.47E-03
31				
32	-45	0	6.19E-01	5.73E-05
33	-45	100	4.67E+00	3.49E-03
34	Room Temp Gain E			
35	Room Temp Cor Ga			
36	Post Cal RTI Kbrg(Pin_min): -0.0005047 GainDAC Correction:			
37	Post Cal RTI Kbrg(Pin_max): 0.00912834 ZeroDAC Correction: 0			

The easiest way of doing this is to select a cell and press the *Insert Vout reading in active cell* button. This will insert a PGA309 output voltage reading from the ADS1100 delta sigma ADC into that cell.

The PGA309 output voltage needs to be recorded at the appropriate applied pressure and temperature. Use the bridge selector switch on the Sensor-Emulator-EVM to generate the respective room (0%, 50%, 100%), hot (0%, 25%, 50%, 75%, 100%), and cold (0%, 50%, 100%).

PGA309 Calibration Spreadsheet, Sensor Curvefit Tab

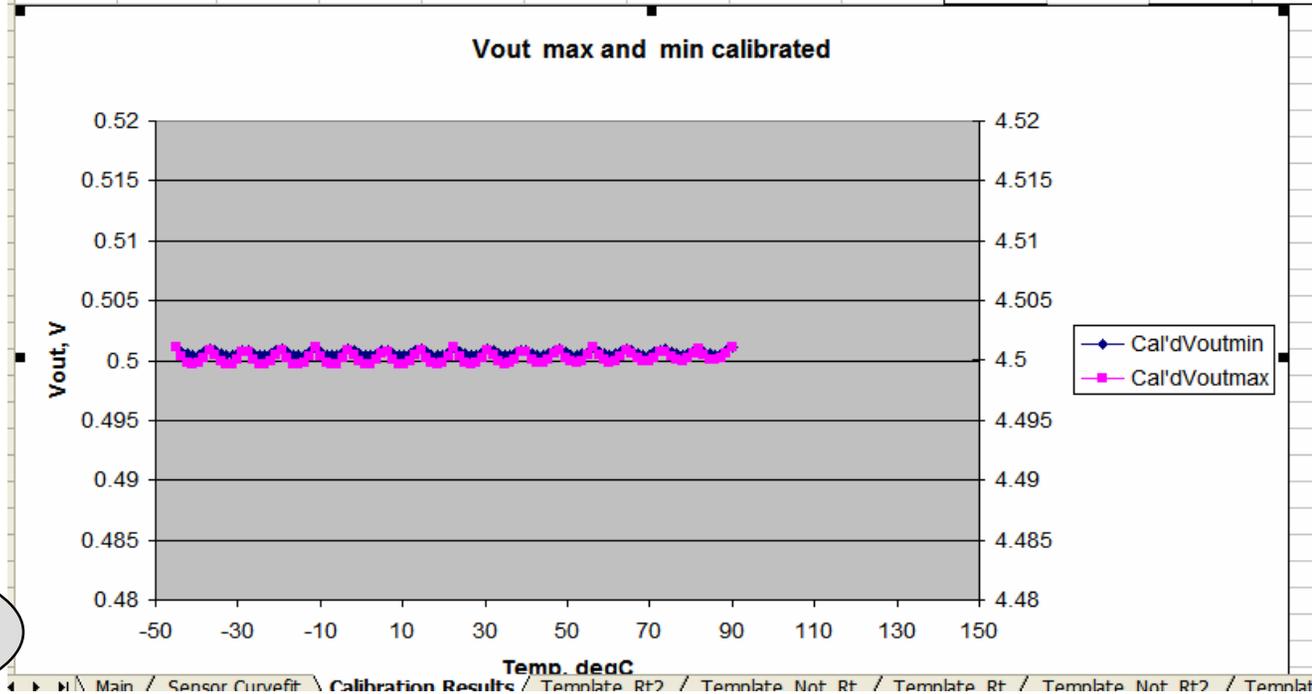
Enter the output voltage scale, the number of points in the table, and the look up table temperature range. For our example, enter the values shown.

PGA309 Desired output and its look-up table

Enter Output Scale:		Lookup Table Parameters:	
Vout_max:	4.5 V	# of points:	17
Vout_min:	0.5 V	Optional:	
		LUT_Tmin:	-45 degC
		LUT_Tmax:	90 degC

Result Sanity Check:
 ZeroDAC is OK: values are in Range.
 GainDAC is OK: values are in Range.
 TempADC is OK: values are ascending and in Range.

Resulting Look-up Table			
Point#	Temp	Gfine,V/V	GainS
1	90	0.777603	-0.00
2	81.5625	0.790315	-0.00
3	73.125	0.802222	-0.00
4	64.6875	0.813229	-0.00
5	56.25	0.823249	-0.00
6	47.8125	0.832196	-0.00
7	39.375	0.839992	-0.00
8	30.9375	0.846568	-0.00
9	22.5	0.851861	-0.00
10	14.0625	0.855822	-0.00
11	5.625	0.858412	-0.00
12	-2.8125	0.859608	-0.00
13	-11.25	0.859396	2.51E
14	-19.6875	0.857779	0.00E
15	-28.125	0.854773	0.00E
16	-36.5625	0.850406	0.00E
17	-45	0.844722	0.00E
18	-45	0.844722	



PGA309 Calibration Spreadsheet, Calibration Results Tab

Note about the temperature ranges



Range1: This is the range of the mathematical model of the sensor that is developed by the spreadsheet.

Range2: This is the range that the look up table is developed over. This range must be a subset of Range1. It is ok for Range2 and Range3 to be equivalent. This range over which the calibrated sensor will correct for temperature drift.

10			
11	Temp range:		
12	Tmin=	-45	
13	Tmax=	90	
14	Troom=	27	
15			
16	Insert TempADC reading in active cell		
17	Measurement Temperatures:	TempADC Rea	
18	Tmeas1=	22.5	19839
19	Tmeas2=	90	15520
20	Tmeas3=	-45	24160

PGA			
Enter Output Scale:		# of points:	
Vout_max=	4.5 V	Ntemp=	17
Vout_min=	0.5 V	Optional:	
		LUT_Tmin=	-45 degC
		LUT_Tmax=	90 degC

Range3: This is the range of measurements made during calibration. This range must be a subset of Range1. It is OK for range 1 and range 3 to be equivalent.

Result Sanity Check:
 ZeroDAC is OK: values are in Range.
 GainDAC is OK: values are in Range.
 TempADC is OK: values are ascending and in Range.

PGA309 Calibration Spreadsheet, Calibration Results Tab

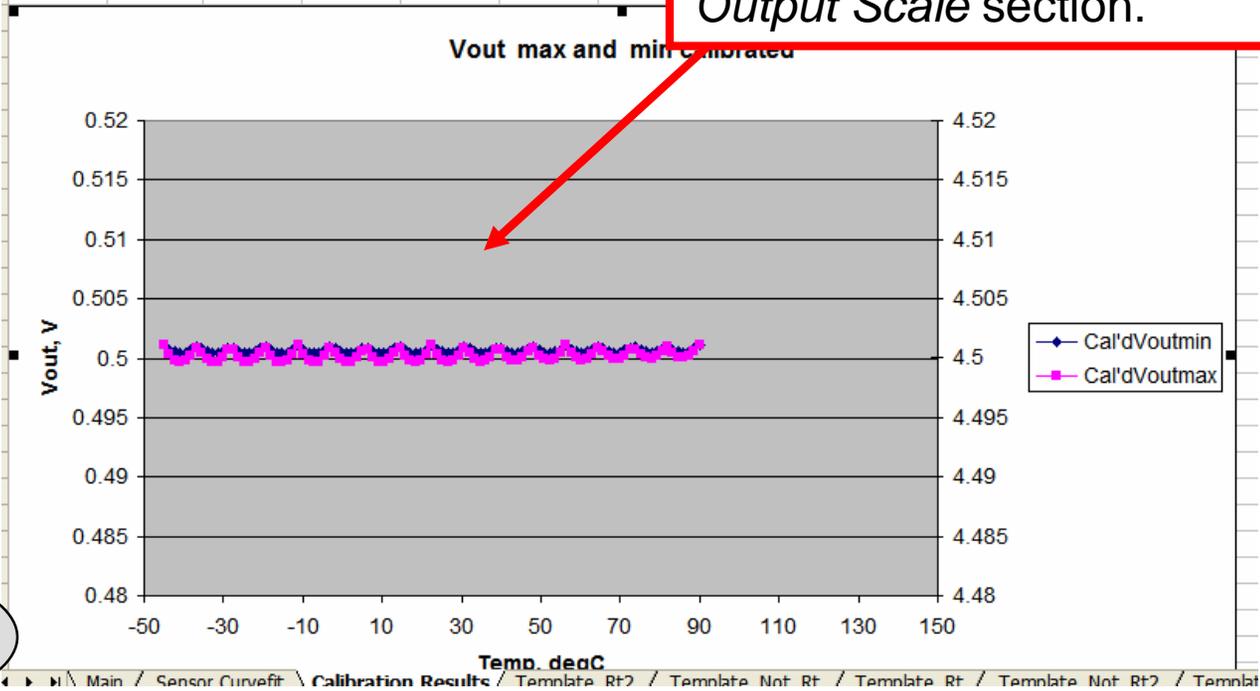
PGA309 Calibration Spreadsheet, Sensor Curvefit Tab

PGA309 Desired output and its look-up table		Lookup Table Parameters:		Resulting Look-up Table	
Enter Output Scale:		# of points:			
Vout_max=	4.5 V	Ntemp=	17		
Vout_min=	0.5 V	Optional:			
		LUT_Tmin=	-45 degC		
		LUT_Tmax=	90 degC		

The *Result Sanity Check* will flag any problems with gain and offset ranges in the calibration table.

Result Sanity Check:
 ZeroDAC is OK: values are in Range.
 GainDAC is OK: values are in Range.
 TempADC is OK: values are ascending and in Range.

The *Vout max and min calibrated* result graph gives an idea of what errors you will see based on the resolution of internal components. Note the output should approximately match the values entered in the *Enter Output Scale* section.

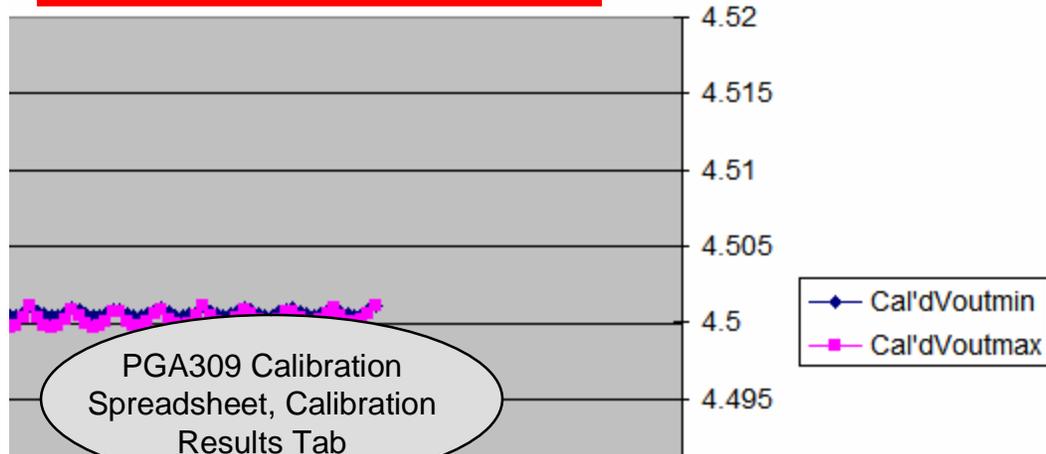


PGA309 Calibration Spreadsheet, Calibration Results Tab

e Parameters:

Resulting Look-up Table							Look-up table Hex		
Point#	Temp	Gfine, V/V	GainSlope	Vzero, V	ZeroSlope	Temp	ZM	GM	
1	90	0.777603		0.301346		4225	12D6	AA99	
2	81.5625	0.790315	-0.00151	0.304481	-0.00037	446B	0016	0226	
3	73.125	0.802222	-0.00141	0.306193	-0.0002	46B1	000C	0203	
4	64.6875	0.813229	-0.0013	0.306482	-3.4E-05	48F6	0002	01DC	
5	56.25	0.823249	-0.00119	0.305348	0.000134	4B3C	FFF8	01B2	
6	47.8125	0.832196	-0.00106	0.302791	0.000303	4D82	FFEE	0183	
7	39.375	0.839992	-0.00092	0.29881	0.000472	4FC7	FFE4	0152	
8	30.9375	0.846568	-0.00078	0.293407	0.00064	520D	FFDA	011C	
9	22.5	0.851861	-0.00063	0.28658	0.000809	5453	FFD0	00E5	
10	14.0625	0.855822	-0.00047	0.27833	0.000978	5698	FFC6	00AC	
11	5.625	0.858412	-0.00031	0.268657	0.001146	58DE	FFBC	0070	
12	-2.8125	0.859608	-0.00014	0.257561	0.001315	5B24	FFB2	0034	
13	-11.25	0.859396	2.51E-05	0.245042	0.001484	5D69	FFA8	FFF7	
14	-19.6875	0.857779	0.000192	0.231099	0.001652	5FAF	FF9E	FFBA	
15	-28.125	0.854773	0.000356	0.215734	0.001821	61F5	FF94	FF7E	
16	-36.5625	0.850406	0.000517	0.198945	0.00199	643A	FF8A	FF43	
17	-45	0.844722	0.000674	0.180733	0.002158	6680	FF80	FF0A	
18	-45	0.844722	0	0.180733	0	7FFF	0000	0000	

The calibration table that will be loaded into the EEPROM is displayed on the *Calibration Results* tab on the spreadsheet. At this point the initial calibration is complete and the table can be uploaded into the PGA309 EEPROM.



PGA309 Calibration Spreadsheet, Calibration Results Tab

Press the *Save Registers + Lookup Table* button. This will store the lookup table into a file that can be loaded into the PGA309 EEPROM.

PGA309 Configuration Reg	Reg. Addr	Name	Binary Value	Hex	Comp	Err	Sm
	0	ADC Out(RO)	0101_0000_0001_0011	0	4ECB	12F6	B10C
	1	ZeroDAC	0001_0100_0000_1111	1	50F3	0014	01EE
	2	GainDAC	1001_1000_0001_1011	2	531A	000B	01CB
	3	* Ref&Lin	0000_0101_0000_0000	3	5541	0001	01A4
	4	* Gain,Vos,Cfg1	0011_0111_0000_0000	4	5768	FFF8	017B
	5	* Cfg2,OverUnder	0000_0000_0000_0000	5	598F	FFEF	014E
	6	* Cfg3 (ADC)	0001_0100_0000_1011	6	5BB6	FFE6	0120
	7	OutEnbl Counter	0000_0000_0000_0000	7	5DDE	FFDD	00EE
	8	AlarmStatus(RO)	0000_0000_0000_0000	8	6005	FFD4	00BB
		Config Checksum	0101_1011_1010_1011	9	622C	FFCA	0086
				10	6453	FFC1	0050
				11	667A	FFB8	001A
				12	68A1	FFAF	FFE3
				13	6AC9	FFA6	FFAC
				14	6CF0	FF9D	FF77
				15	6F17	FF94	FF42
				16	713E	FF8A	FF0F
				ChSum	7FFF	0	5586

Load Registers from File

Load Registers From Bench

Prepare Calibration Sheet

Save Registers+Lookup Table

PGA309 Calibration Spreadsheet, Main Tab

Step A

Press the *Open File* button to get the file containing the calibration results.

Step D

Press the *Read PGA309* to see the updated register values.

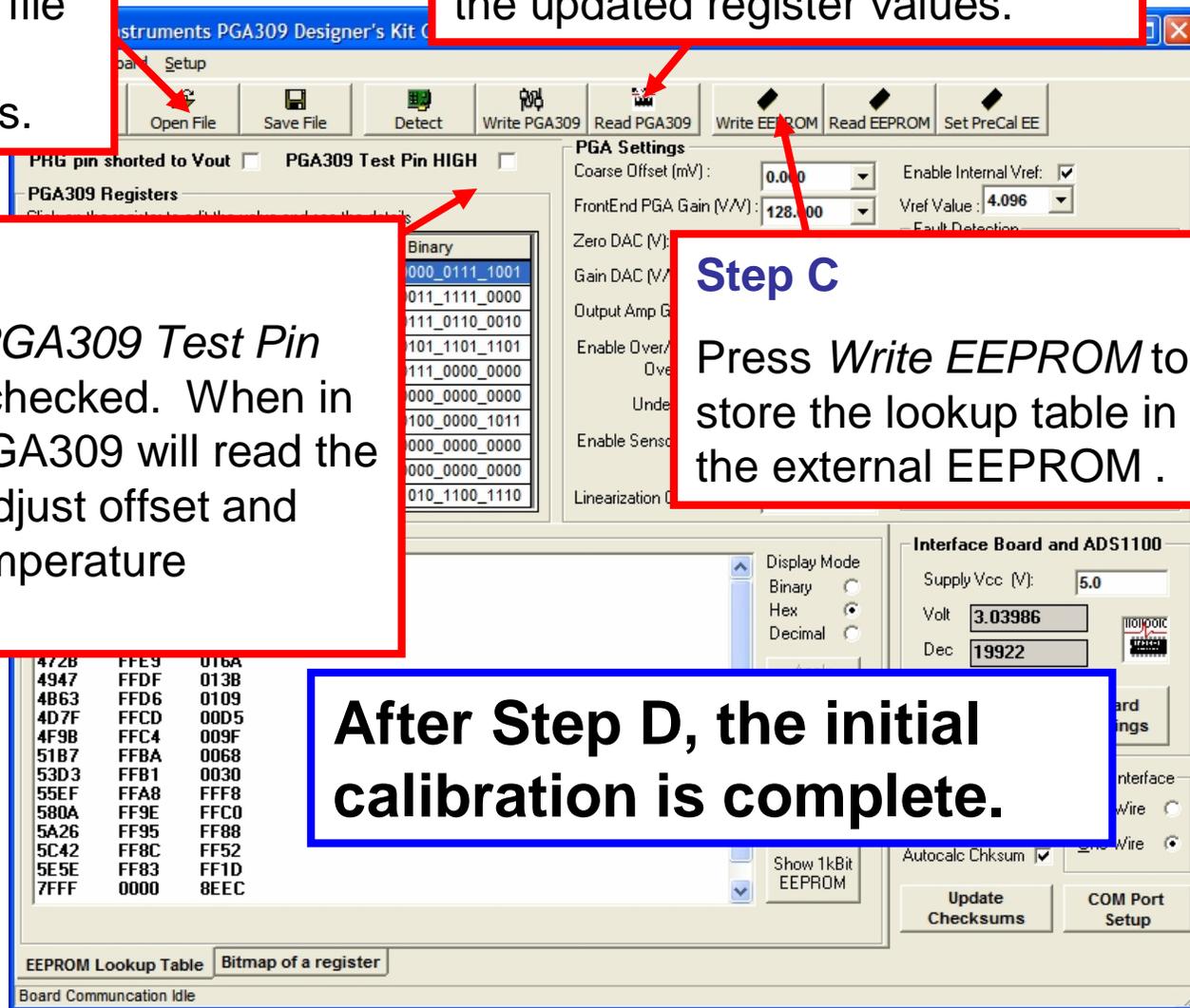
Step B

Make sure the *PGA309 Test Pin High* box is not checked. When in this mode the PGA309 will read the EEPROM and adjust offset and gain for each temperature conversion

Step C

Press *Write EEPROM* to store the lookup table in the external EEPROM .

After Step D, the initial calibration is complete.



The *PGA309 Error* tab on the ***generate_sim_values.xls*** is a convenient way to do a post calibration error analysis. To use it select the blue cell corresponding to the current setup, and press the *Insert Vout reading in active cell* button. This will insert the PGA309 output reading from the ADS1100.

The initial post calibration results will typically have errors ranging from 0.1% to 0.3%.

generate_sim_values.xls,
PGA309 Error Tab

Insert Vout reading in active cell					
Post First Calibration Results					
Temperature	Pressure	Ideal Result	Measured Result	Error	
cold	0%	0.5	0.49684	0.03	
cold	50%	2.5	2.50072	0.02	
cold	100%	4.5	4.5049	0.12	
Room	0%	0.5	0.4982	-0.05	
Room	25%	1.5	1.49445	-0.14	
Room	50%	2.5	2.50087	0.02	
Room	75%	3.5	3.50835	0.21	
Room	100%	4.5	4.50687	0.17	
Hot	0%	0.5	0.49941	-0.01	
Hot	50%	2.5	2.50229	0.06	
Hot	100%	4.5	4.50748	0.19	
				stdev=	0.11
				average=	0.06
Insert Vout reading in active cell					
Post Second Calibration Results					
Temperature	Pressure	Ideal Result	Measured Result	Error	
cold	0%	0.5	0.49886	-0.03	
cold	50%	2.5	2.49859	-0.04	
cold	100%	4.5	4.49859	-0.04	
Room	0%	0.5	0.49959	-0.01	
Room	25%	1.5	1.49445	-0.14	
Room	50%	2.5	2.49905	-0.02	
Room	75%	3.5	3.5044	0.11	
Room	100%	4.5	4.50111	0.03	
Hot	0%	0.5	0.50026	0.01	
Hot	50%	2.5	2.50026	0.01	
Hot	100%	4.5	4.50096	0.02	
				stdev=	0.06
				average=	-0.01

The post first calibration results are made at room temperature and entered here. For this example, use the Sensor-Emulator-EVM to generate 0% and 100% pressure at room temperature.

Insert Vout reading in active cell

16	Insert		
17	Measu		
18	Tmeas		
19	Tmeas		
20	Tmeas		
21			
22	Measu		
23			
24			
25			
26			
27			
28			
29			
30	85	100	4.86E+00
31			
32	-40		
33	-40		

ding@Tmeas	: @ this Temp 3 pressure levels are applied
decimal	
78 decimal	
18	

Post First Cal Correction	
Pressure	VoutMeas
0	4.98E-01
100	4.51E+00

Note the correction factors are developed based on these readings. These are used to calibrate the Lin_Dac errors not previously accounted for.

mp Gain Error:	1.0021675	GainDAC Correction:	0.9978372
mp Cor Gain Dac:	0.85317503	ZeroDAC Correction:	0.000586
RTI Kbrg(Pin_min):	-0.0009446		
RTI Kbrg(Pin_max):	0.00920732		

ResultVector1	Solution (coef's vals):
-2.95E-04	ko0= -2.322E-04
-2.83E-04	ko1= -3.093E-06
-6.41E-05	ko2= 2.774E-08

PGA309 Calibration Spreadsheet, Sensor Curvefit Tab

After making the secondary calibration measurements, store the calibration results into a file and load them into the PGA309 as with the first calibration. The file for this example calibration is saved on the **PGA309 Quick Start Disk** and is called *quick_start_second.txt*. Your results should be similar to this file.

13	
14	
15	Load Registers from File
16	
17	
18	Load Registers From Bench
19	
20	
21	Prepare Calibration Sheet
22	
23	
24	Save Registers+Lookup Table
25	
26	

PGA309 Calibration Spreadsheet, Main Tab

The secondary calibration can be done to significantly reduce the error. Post-secondary calibration errors are typically on the order of 0.05%. The secondary calibration involves making two measurements at room temperature.

generate_sim_values.xls,
PGA309 Error Tab

6	Insert Vout reading in active cell				
7	Insert Vout reading in active cell				
8	Insert Vout reading in active cell				
9	Post First Calibration Results				
10	Temperature	Pressure	Ideal Result	Measured Result	Error
11	cold	0%	0.5	0.49684	0.03
12	cold	50%	2.5	2.50072	0.02
13	cold	100%	4.5	4.5049	0.12
14	Room	0%	0.5	0.4982	-0.05
15	Room	25%	1.5	1.49445	-0.14
16	Room	50%	2.5	2.50087	0.02
17	Room	75%	3.5	3.50835	0.21
18	Room	100%	4.5	4.50687	0.17
19	Hot	0%	0.5	0.49941	-0.01
20	Hot	50%	2.5	2.50229	0.06
21	Hot	100%	4.5	4.50748	0.19
22					
23				stdev=	0.11
24				average=	0.06
25					
26					
27					
28	Insert Vout reading in active cell				
29	Insert Vout reading in active cell				
30	Insert Vout reading in active cell				
31	Post Second Calibration Results				
32	Temperature	Pressure	Ideal Result	Measured Result	Error
33	cold	0%	0.5	0.49886	-0.03
34	cold	50%	2.5	2.49859	-0.04
35	cold	100%	4.5	4.49859	-0.04
36	Room	0%	0.5	0.49959	-0.01
37	Room	25%	1.5	1.49445	-0.14
38	Room	50%	2.5	2.49905	-0.02
39	Room	75%	3.5	3.5044	0.11
40	Room	100%	4.5	4.50111	0.03
41	Hot	0%	0.5	0.50026	0.01
42	Hot	50%	2.5	2.50026	0.01
43	Hot	100%	4.5	4.50096	0.02
44					
45				stdev=	0.06
46				average=	-0.01
47					

PGA309 Ratiometric Calibration Example

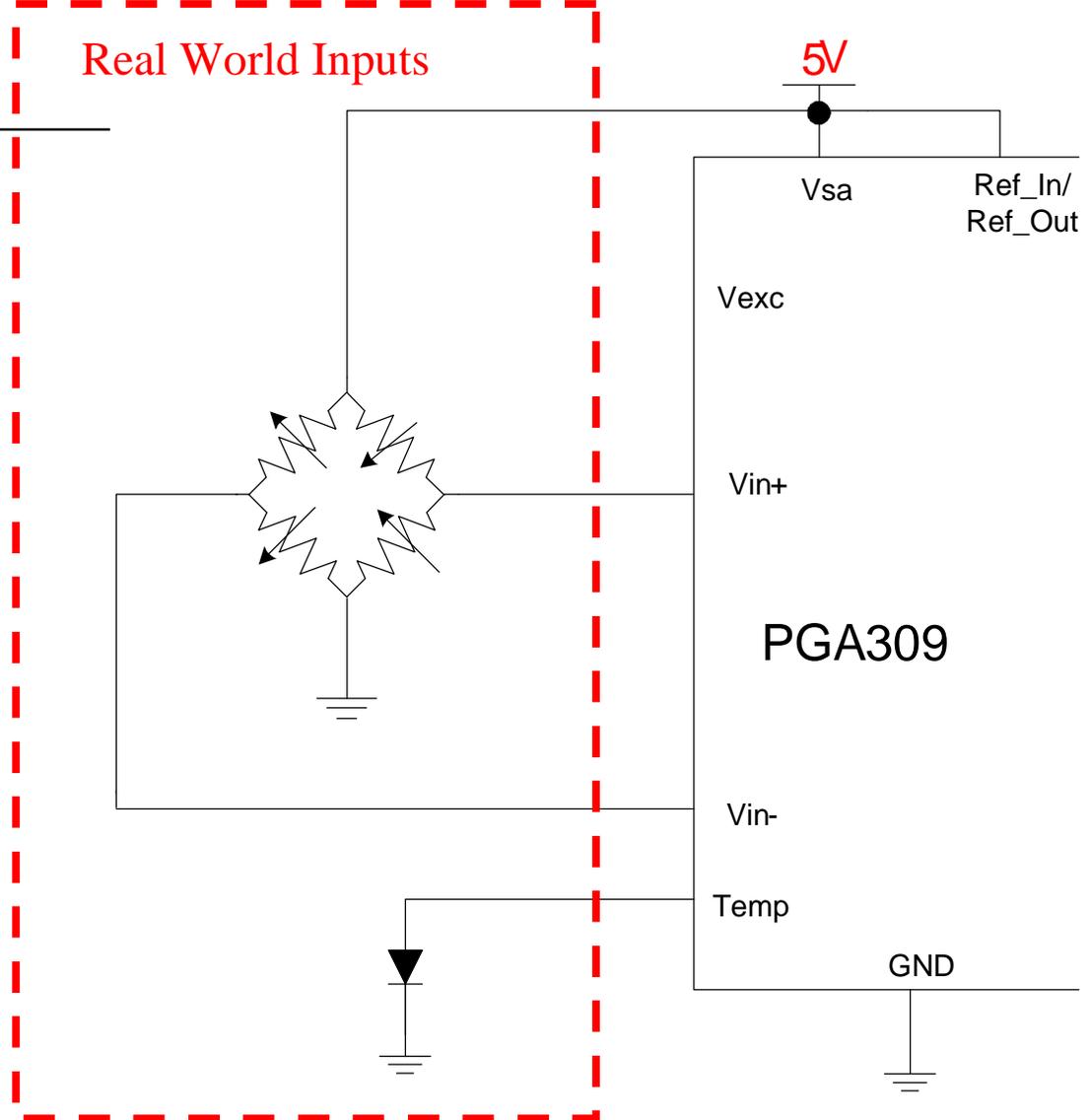


This example walks through the PGA309 ratiometric calibration technique. The PGA309 Absolute Calibration example is a more detailed description of a calibration, and so, it is recommended that you review this example first. This document describes the key elements that are required in a ratiometric calibration, but does not fully explain how to use the PGA309 Gain Calculator, Sensor-Emulator-EVM, or the Designers Kit Control Program.

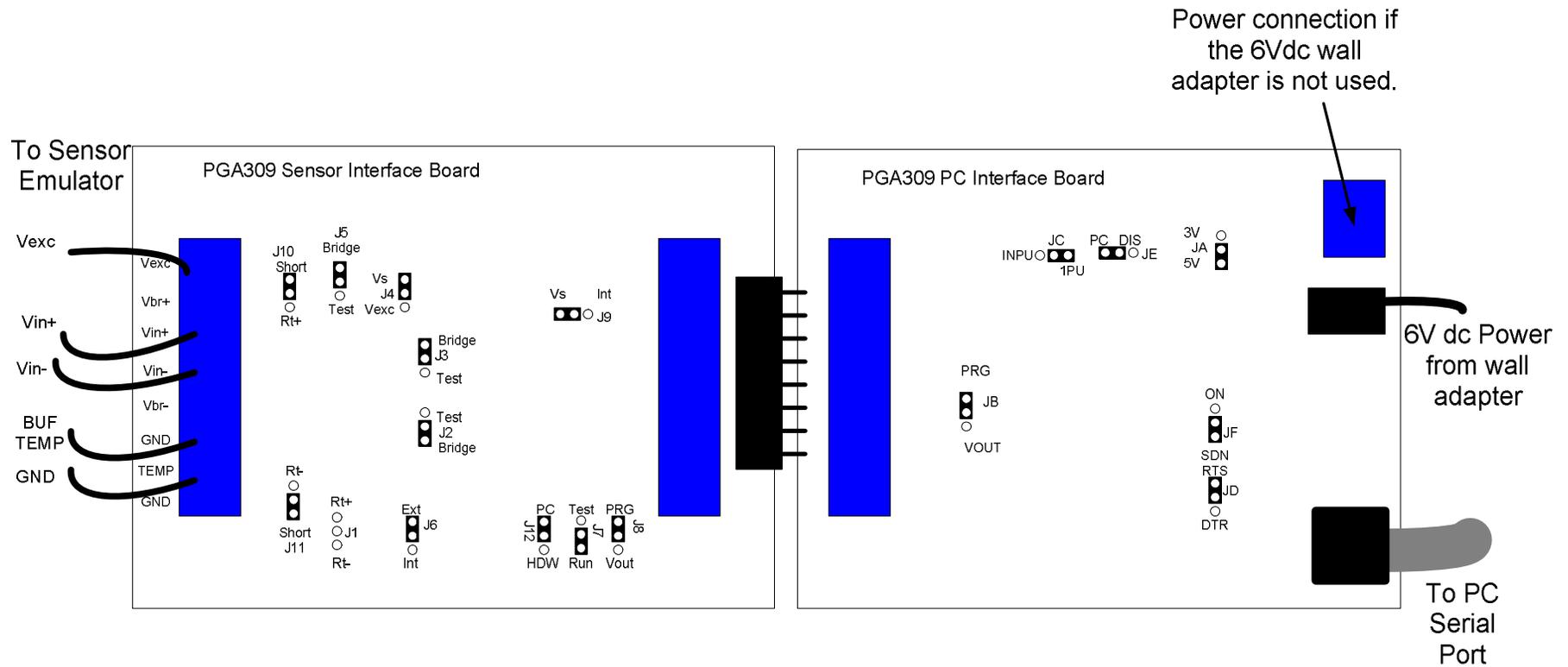
For information on these development tools, please see the PGA309 Product Folder on the TI website, at www.ti.com.

PGA309 Ratiometric Example

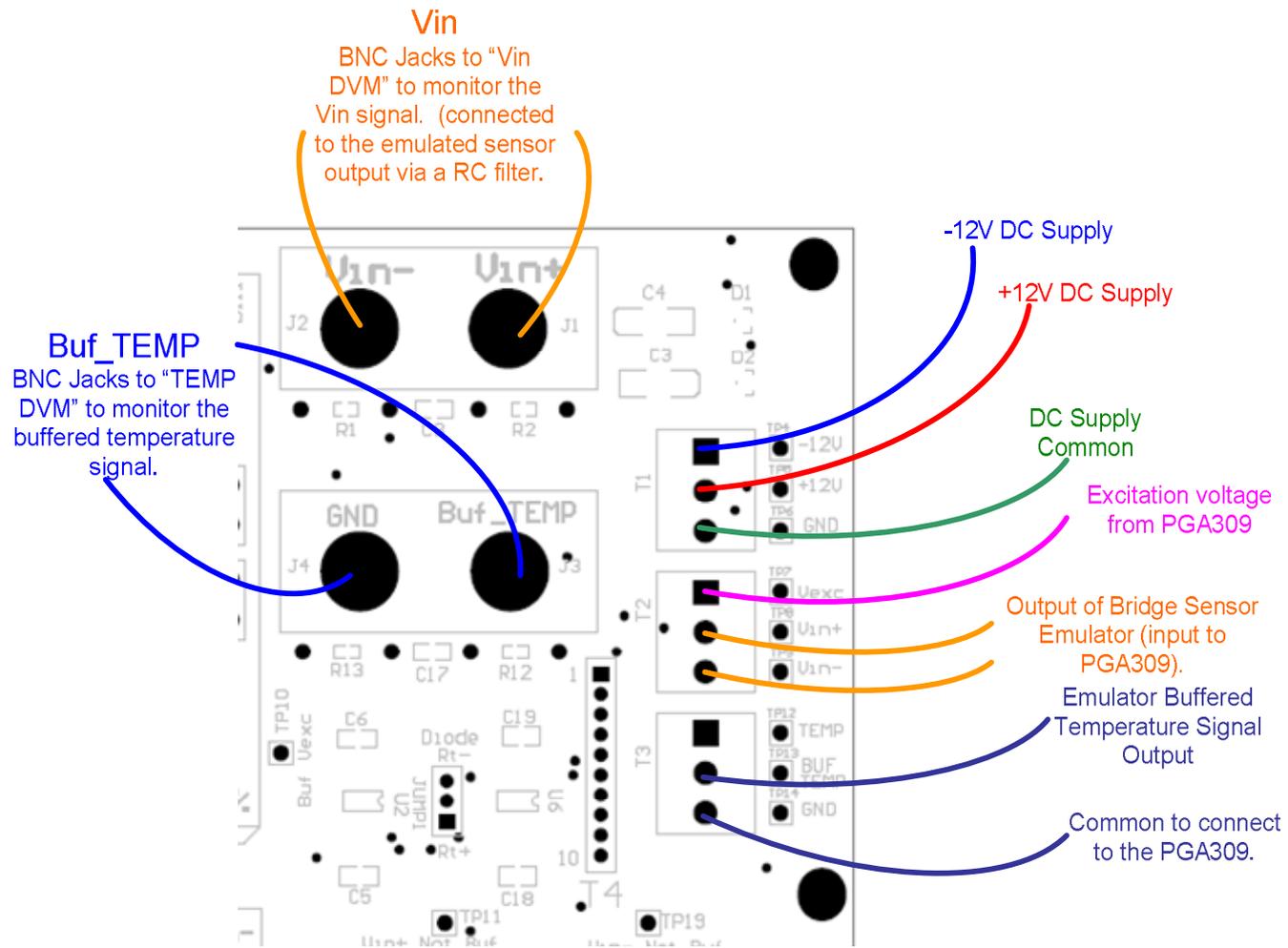
This is the hardware configuration that this ratiometric calibration example details. In this example, the Sensor-Emulator-EVM is used to emulate the bridge sensor and the Diode. Note that the device power supply is used to provide excitation for the sensor. So for this configuration, the Vexc pin on the PGA309 is not used and consequently, the PGA309 cannot correct for nonlinearity verses applied stimulus. Temperature nonlinearities of span and offset will still be corrected.



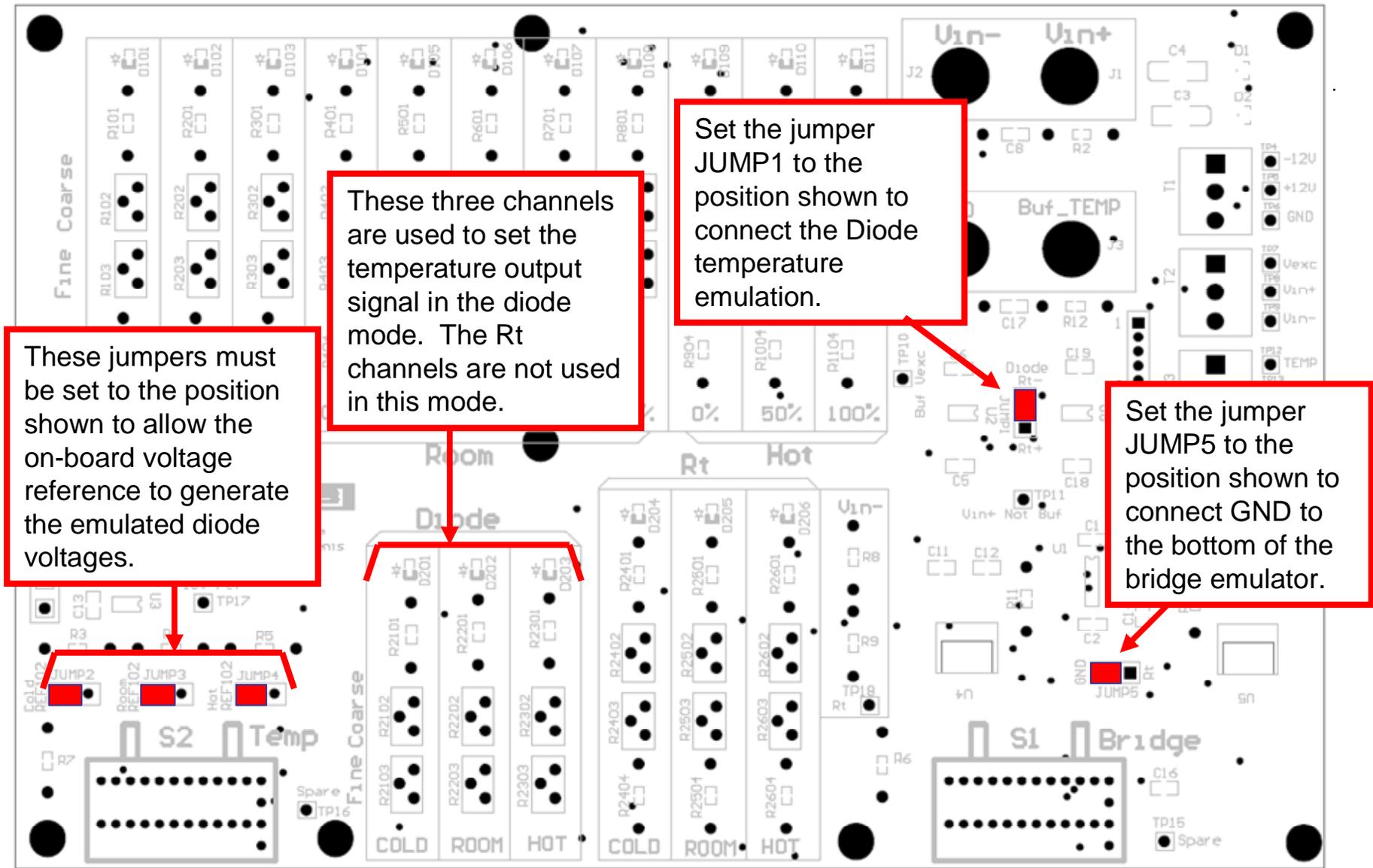
This diagram illustrates PGA309EVM jumper settings for a ratiometric system. Sensor-Emulator-EVM connections and power connections are also shown.



Required Electrical Connections to Sensor-Emulator-EVM



Sensor-Emulator-EVM Jumper Setup



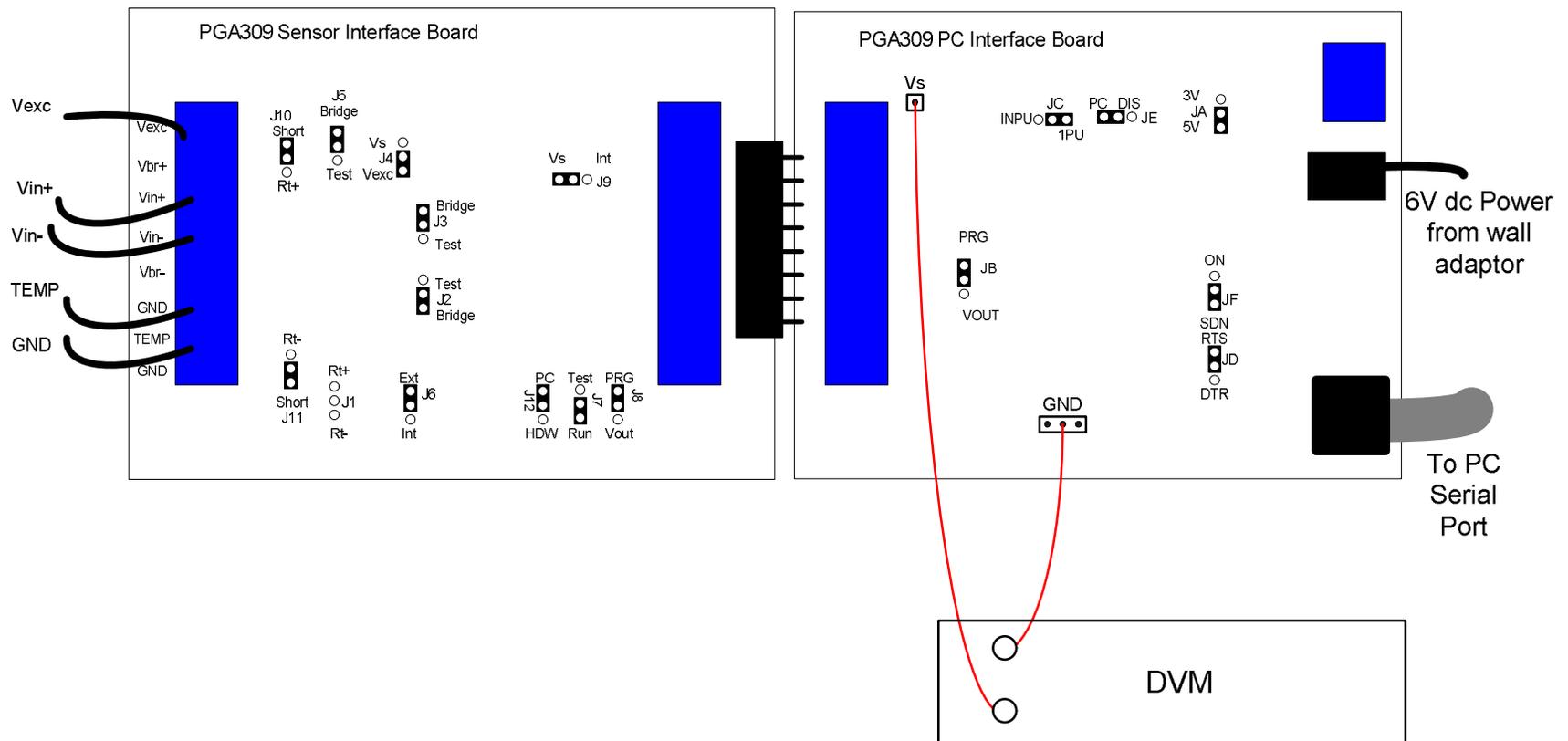
The PGA309 Calculator can be used to compute the gain and offset settings for the PGA309. These are the values used for this ratiometric example configuration.

The screenshot shows the 'PGA309 Calculator Rev. 1.4.1' window. It is divided into several sections:

- Reference Select:** Enable Internal Vref, Ref Val: 5
- Bridge Excitation:** Enable Vexc, External Vbridge: 5
- Bridge Resistance:** Rbridge: 1.000K, Rt Note: Rt+: 0, Rt-: 0
- Desired PGA Output Swing:** PGA Zero Scale Output: 0.5, PGA Full Scale Output: 4.5
- Sensor Output:** Normalized Sensor Data, Offset in V/V: -290.000u, Span in V/V: 3.500m; Measured Sensor Data, Offset in V: -1.450m, Full Scale Output in V: 16.050m
- Vsa (PGA analog supply):** 5
- Calculated PGA Settings:** Coarse Offset (mV): 0.000, Front End PGA (V/V): 128, Zero DAC (V): 465.600m, Gain DAC (V/V): 744.048m, Output Amp Gain (V/V): 2.4

Buttons at the bottom: Compute Constants, Set Additional Constraints, Simulate Device.

In the ratiometric configuration, the power supply (V_s) is being used as the reference. Thus, it is very important that the supply is measured during calibration.



Configure the initial settings of the PGA309

Step A

During calibration, the *PGA309 Test Pin High* must be checked to prevent the PGA309 from reading the EEPROM during calibration.

Step B

The gain and offset values computed by the calculator need to be written into the PGA309 using the *PGA309 Designer's Kit Control Program*.

Step C

The value measured for V_s must be typed in here. After all the values are entered, press *Write PGA309*.

PGA309 Designer's Kit Control Program

Save File Detect Write PGA309 Read PGA309 Write EEPROM Read EEPROM Set PreCal EE

PGA309 Test Pin HIGH

Hex	Binary
0x0000	0x0000_0000_0000_0000
0x1803	0x0001_1000_0000_0011
0x9DB2	0x1001_1101_1011_0010
0x0000	0x0000_0000_0000_0000
0x1700	0x0001_0111_0000_0000
0x0000	0x0000_0000_0000_0000
0x94B6	0x1001_0100_1011_0110

PGA Settings

Coarse Offset (mV): 0.000

FrontEnd PGA Gain (V/V): 128.000

Zero DAC (V): 465.508m

Gain DAC (V/V): 744.004m

Output Amp Gain (V/V): 2.400

Linearization Coef (V/V): 0.000

Enable Internal Vref:

Vref Value: 4.963

PGA309 Temp ADC

DegC: ----

Dec: 0

Hex: 0 h

Convert ADC Config

Interface Board and ADS1100

Supply Vcc (V): 4.963

Volt: 3.03986

Dec: 19922

Hex: 1.508680

Update Vout Board Settings

Keep comm alive PGA Interface

Instant Update Iwo-Wire

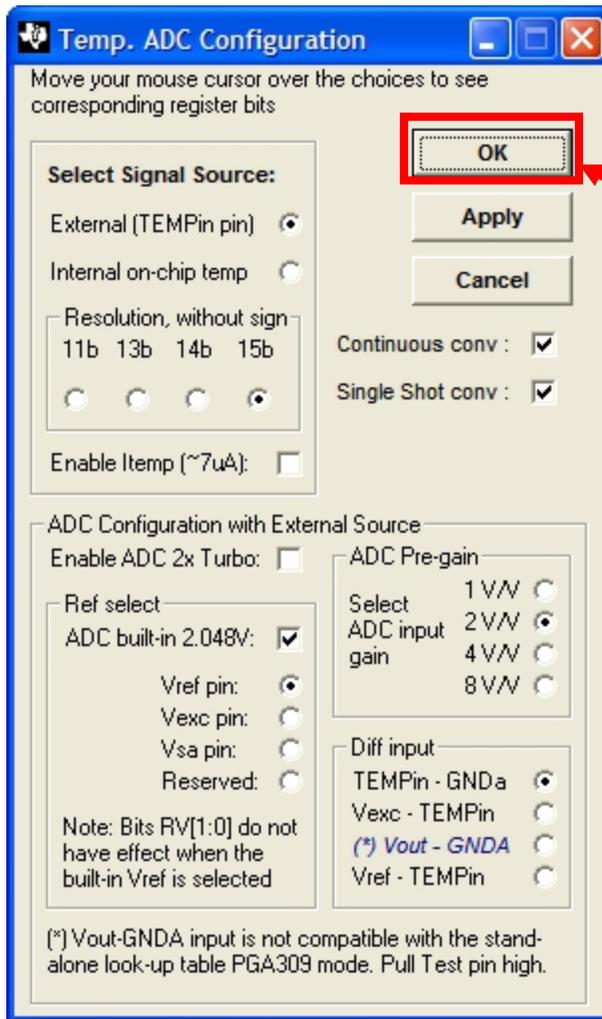
Autocalc Chksum One-Wire

Update Checksums COM Port Setup

Show 1kBit EEPROM

Board Communication Idle

Set up the PGA309 Temperature ADC



Configure the Temp ADC as shown and click **OK**. From the main window, press *Write PGA309*.

The configuration shown was selected for this example (diode measurement using the built-in 2.048V reference). It is important to use the built in ADC reference because the diode measurement is absolute and all the other references are relative to the power supply for this configuration.

The sensor specifications are entered here. The definitions of the different parameters is described earlier in this document.

The sensor's raw output is computed and displayed here. These values are used to setup the sensor emulator. The sensor emulator EVM will need to be adjusted to these levels.

	A	B	C	D	E	F	G	H	I	J
1	Temp range:	degC								
2	Tmin=	-40.00								
3	Tmax=	85.00								
4	Troom=	22.50								
5										
6	Vexc (V)	5.000E+00								
7										
8		3.509E-03								
9		-2.945E-04								
10										
11										
12										
13	NonlinSpanDrift (% of Span)	-5.031E-02								
14	NonlinOffsetDrift (% of Span)	-3.077E-02								
15	PressureNonlin (% of Span)	0.000E+00								
16										
17	GainTC1 (% of Span/C)	4.682E-04								
18	OffsetTC1 (% of Span/C)	-5.205E-04								
19	GainTCNonlin(TC2) (% of Span/C ²)	-1.288E-05								
20	OffsetTCNonlin(TC2) (% of Span/C ²)	-7.877E-06								
21										
22	Note: % of Span is represented as a decimal number									
23	i.e. OffsetTC1 (% of Span) = 0.1 is 10%									
24										
25	Rev B, Dec 10, 2004									

Precalibration Sensor Simulator Settings (LinDac = 0)				
Cold				
Pressure Input	0%	50%	100%	
Sensor Output (mV)	-0.362	8.595	17.552	
Room				
Pressure Input	0%	25%	50%	75%
Sensor Output (mV)	-1.473	2.914	7.300	11.686
				16.07
Hot				
Pressure Input	0%	50%	100%	
Sensor Output (mV)	-1.503	7.967	17.438	

Enter these for our example.

Note that $V_{exc} = V_s$ for ratiometric.

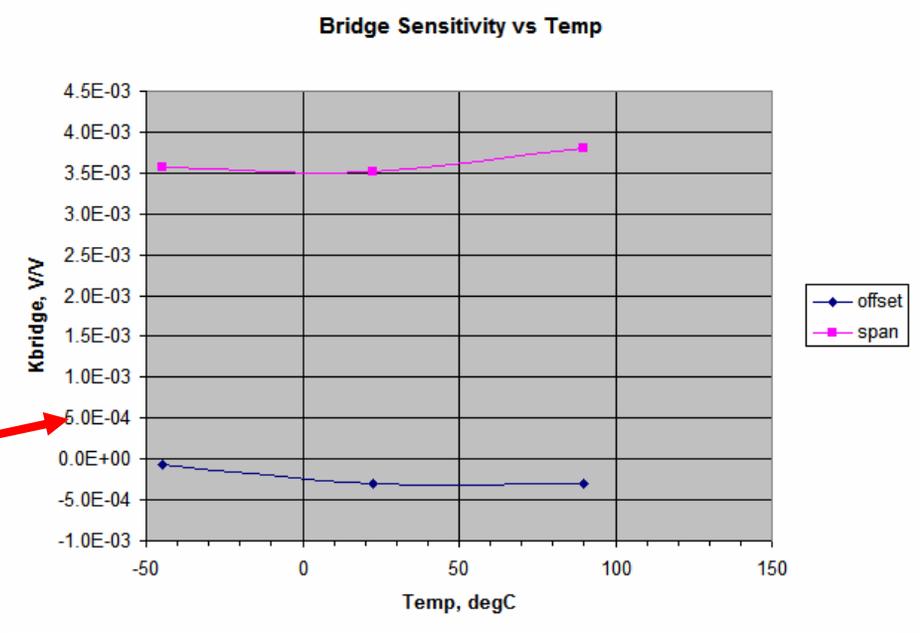
Note that **Pressure Nonlin** is zero. The sensor must be linear for this configuration because the sensor excitation is the power supply and so the nonlinearity correction circuit cannot be used.

generate_sim_values.xls,
Offset and Span Tab

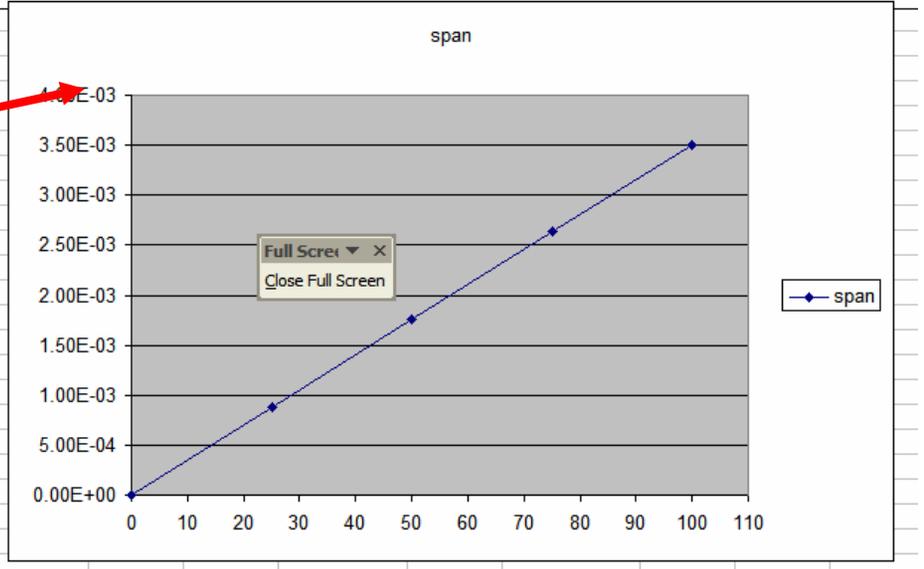
-6.324E-05 0.001724077 0.003511 -0.00029 0.000583 0.00146 0.002337 0.0032145 -0.00031 0.001588 0.003487

offset	span
-6.32E-05	3.57E-03
-2.95E-04	3.51E-03
-3.10E-04	3.80E-03

When the sensor's specifications have been entered, the spreadsheet will display the bridge output versus temperature.



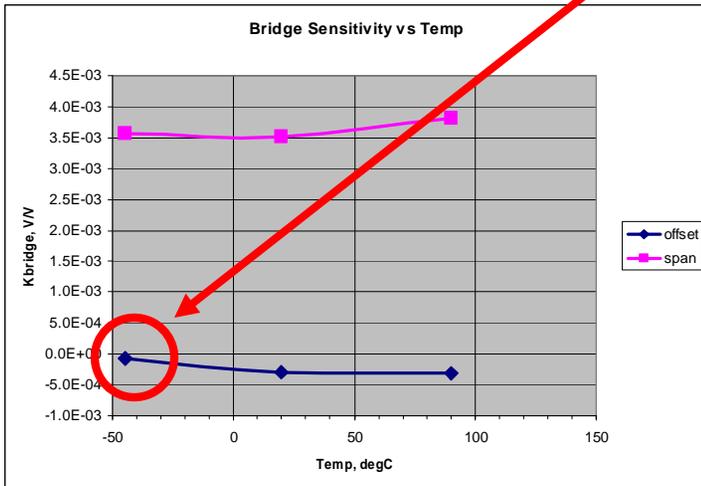
The bridge output versus applied stimulus is also displayed. This must be a linear function for a ratiometric setup that does not use Vexc for bridge excitation.



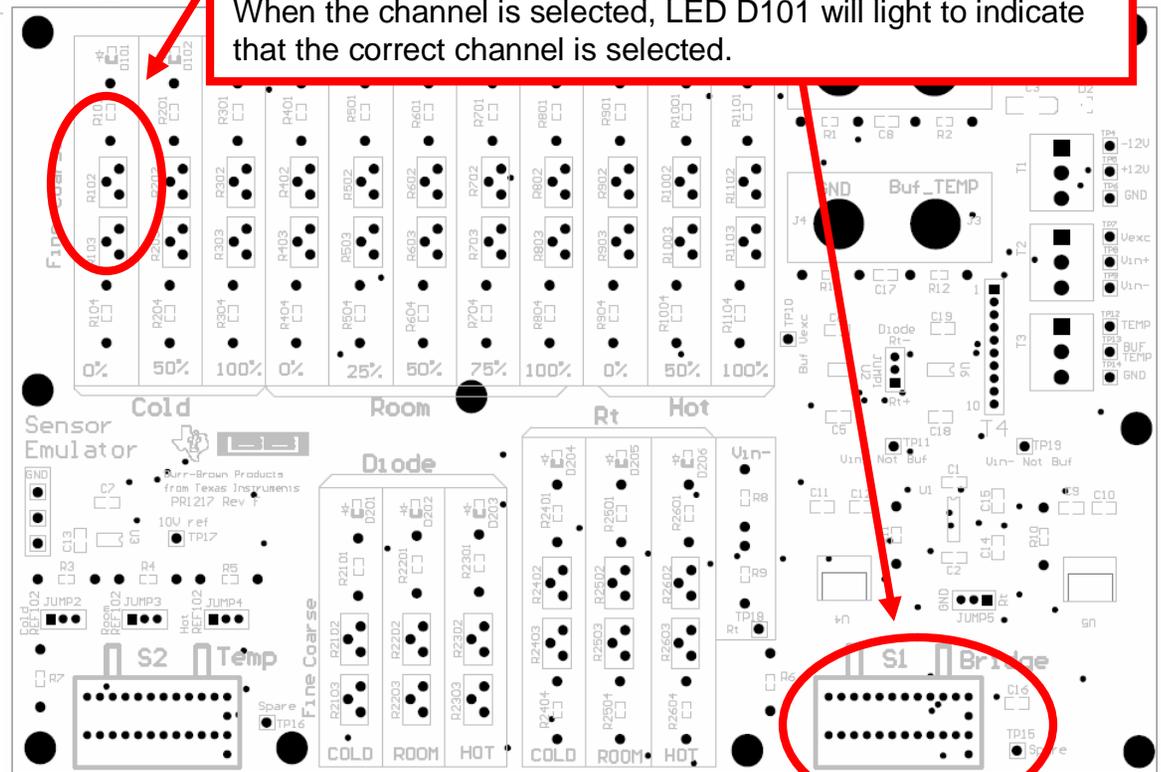
generate_sim_values.xls,
Offset and Span Tab

Precalibration Sensor Simulator Settings (LinDac = 0)

Cold					
Pressure Input	0%	50%	100%		
Sensor Output (mV)	-0.215	5.379	11.939		
Room					
Pressure Input	0%	25%	50%	75%	100%
Sensor Output (mV)	-1.001	1.626	4.490	7.591	10.929
Hot					
Pressure Input	0%	50%	100%		
Sensor Output (mV)	-1.053	4.887	11.855		



Each channel on the top section of the sensor emulator represents a applied stimulus and temperature combination for the sensor. Adjust the potentiometers coarse first, then fine, to match the values computed by the **Generate_Sim_Values.xls** spreadsheet for cold (0%, 50%, 100%), room (0%, 25%, 50%, 75%, 100%), and hot (0%, 50%, 100%). For example, the sensor output at cold temperature and 0% of applied stimulus is emulated by this channel. The rotary switch S1 is used to select this channel. When the channel is selected, LED D101 will light to indicate that the correct channel is selected.



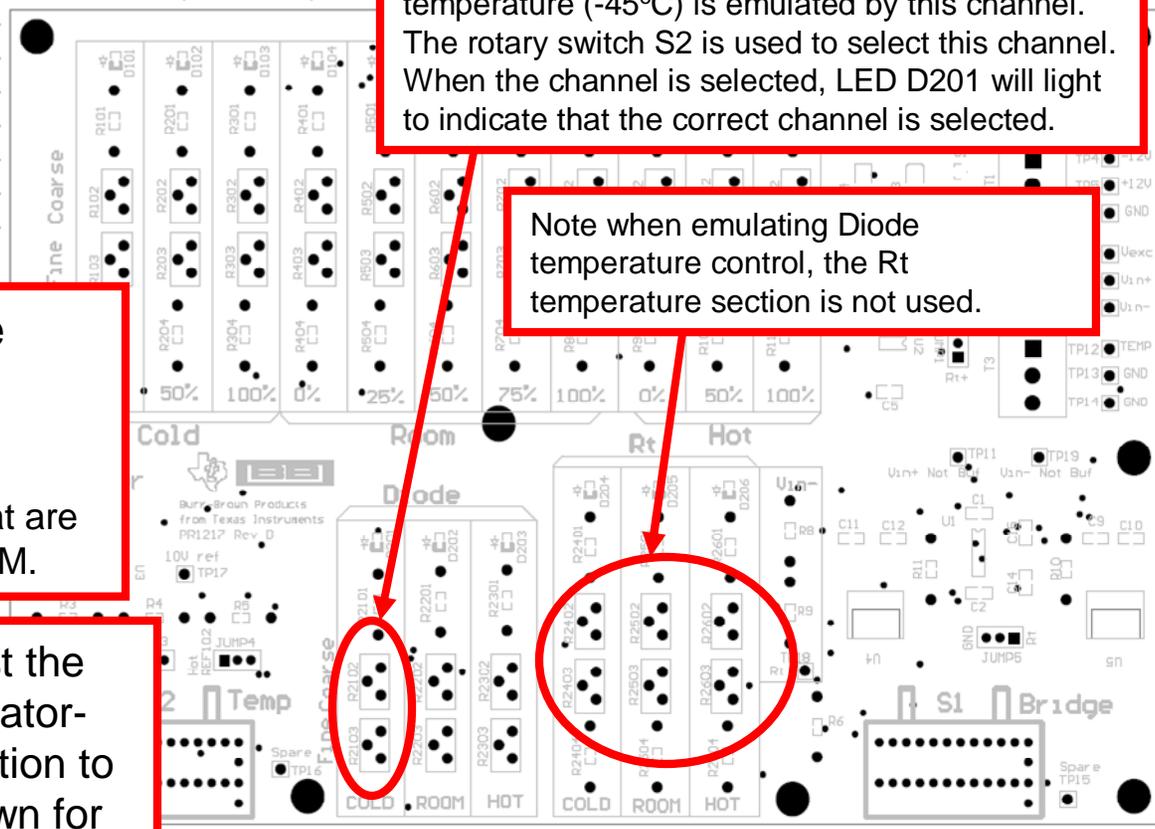
For this ratiometric example adjust the potentiometer on the Sensor-Emulator-EVM to the bridge section to produce the respective voltages shown.

	A	B	C	D	E	F
10						
11	Temp range:	degC		Temp(degC)	Diode Vbe (V)	Counts
12	Tmin=	-40.00		-40.00	0.745	23840
13	Troom=	22.50		22.50	0.62	19840
14	Tmax=	85.00		85.00	0.495	15840
15						
16	Diode	Volts				
17	Room Temp Vbe=	0.62				
18						
19	Temp ADC					
20	Vref (in V) =	2.048				
21	Numb Bits	15 bits (sign bit not included)				
22	Gain=	2				
23						
24						

Each channel on the bottom section of the Sensor-Emulator-EVM represents the output of the emulated temperature sensor. Using the *Temp DVM* adjust the respective potentiometers, coarse first, the fine, to match the values computed by the **Generate_Sim_Values.xls** spreadsheet for Diode/Cold, Diode/Room, and Diode/Hot. For this example, the temperature output signal at cold temperature (-45°C) is emulated by this channel. The rotary switch S2 is used to select this channel. When the channel is selected, LED D201 will light to indicate that the correct channel is selected.

This is the *Diode Vo* tab on the **Generate_Sim_Values.xls** spreadsheet. It is used to compute diode voltages that are used to set up the Sensor-Emulator-EVM.

For this ratiometric example, adjust the potentiometer on the Sensor-Emulator-EVM to the diode temperature section to produce the respective counts shown for temperature.



Note when emulating Diode temperature control, the Rt temperature section is not used.

For this ratiometric example, use the **PGA309 Calibration Spreadsheet**. This tool uses measured data (pressure and temperature) to create a lookup table that the PGA309 will use to compensate for offset and gain drift. The spreadsheet will also generate a coefficient that the PGA309 will use to correct for nonlinearity verses applied pressure. **Note: you will need to enable macros and load the analysis toolpack to get this Excel sheet to work properly.** Information regarding configuration of Excel is detailed in the **PGA309EVM Users Guide**.

7	4	* Gain,Vos,Cfg1	0011_0111_0000_0000	4	4510	FFF2	0197
8	5	* Cfg2,OverUnder	0000_0000_0000_0000	5	472B	FFE9	016A
9	6	* Cfg3 (ADC)	0001_0100_0000_1011	6	4947	FFDF	013B
10	7	OutEnbl Counter	0000_0000_0000_0000	7	4B63	FFD6	0109
11	8	AlarmStatus(RO)	0000_0000_0000_0000	8	4D7F	FFCD	00D5
12		Config Checksum	0101_1011_1010_1011	9	4F9B	FFC4	009F
13				10	51B7	FFBA	0068
14				11	53D3	FFB1	0030
15				12	55EF	FFA8	FFF8
16				13	580A	FF9E	FFC0
17				14	5A26	FF95	FF88
18				15	5C42	FF8C	FF52
19				16	5E5E	FF83	FF1D
20				ChSum	7FFF	0	8EEC
21							
22							
23							
24							
25							
26							
27							
28							
29							
30							

Press Load registers from PGA309 to copy the registers from the evaluation fixture into the spreadsheet.

- Load Registers from File
- Load Registers From PGA309
- Prepare Calibration Sheet
- Save Registers+Lookup Table

PGA309 Calibration Spreadsheet, Main Tab

Press *Prepare Calibration Sheet* to select the algorithm. In this example, we will do a *3 pressure 3 temperature* calibration.

PGA309 Configuration Registers				PGA309 Calibrated	
Reg. Addr	Name	Binary value	Position	Temp	
0	ADC Out(RO)	0101_0000_0001_0011	0	4ECB	
1	ZeroDAC	0001_0100_0000_1111	1	50F3	
2	GainDAC	1001_1000_0001_1011	2	531A	
3	* Ref&Lin	0000_0101_0000_0000	3	5541	
4	* Gain,Vols,Cfg1	0011_0111_0000_0000	4	5768	
5	* Cfg2,OverUnder	0000_0000_0000_0000	5	598F	
6	* Cfg3 (ADC)	0001_0100_0000_1011	6	5BB6	
7	OutEnbl Counter	0000_0000_0000_0000	7	5DDE	
8	AlarmStatus(RO)	0000_0000_0000_0000	8	6005	
	Config Checksum	0101_1011_1010_1011	9	622C	
			10	6453	
			11	667A	
			12	68A1	
			13	6AC9	
			14	6CF0	
			15	6F17	
			16	713E	
			ChSum	7FFF	

PGA309 Calibration

Please select the calibration algorithm:

One of the following three templates can be used for the pressure sensor calibration

3 Temperatures and 3 Pressures

Select this when you do not know the 2nd order non-linearities of output vs. pressure and of temperature drifts of span and offset. The module output must be measured at three different temperatures with min and full-scale pressure applied plus mid-scale pressure at one of the temperatures.

2 Temperatures and 2 Pressures

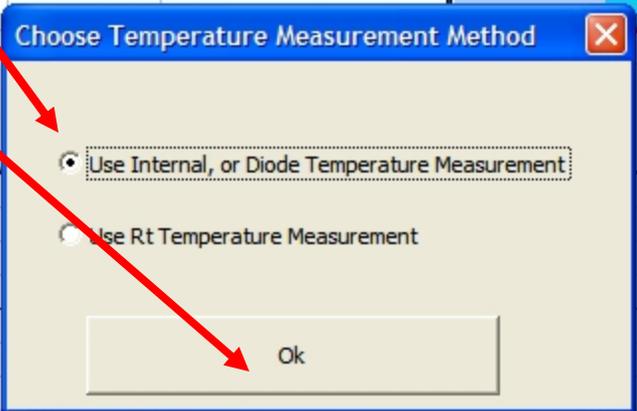
All 2nd order coefficients are entered based on pre-characterization, only the positions of curves must be fitted. The output must be measured at only two temperatures, each with min and full-scale pressure applied.

Press **OK** after you have selected *3 Temperature 3 Pressure* calibration.

PGA309 Calibration Spreadsheet, Main Tab

	A	B	C	D	E	F	G	H	I	
1	PGA309 Calibration Algorithm									
2	The target sensor approximation equation:									
3	Uses 2nd-order (quadrature) equations for pressure non-linearity and temp drifts of offset and span									
4	$K_{bridge}(P,T) = k_0 + k_1 * T + k_2 * T^2 + (k_3 + k_4 * T + k_5 * T^2) * P + k_6 * T^2 * P$									
5										
6	Fill out the high				Initial settings of the Fine A					
7	Pressure values:				Initial settings of the Fine A					
8	Pmin=				GainDAC1=				9999	
9	Pmax=				ZeroDAC1=				A3D	
10										
11	Temp range:									
12	Tmin=									
13	Tmax=									
14	Troom=								Rt=	
15									No. of Bits=	
16	Insert TempADC reading in active cell				Insert Vout					
17	Measurement Temperatures:		TempADC Reading@Tmeas							
18	Tmeas1=	20	24744	decimal						
19	Tmeas2=	85	20498	decimal						
20	Tmeas3=	-40	28668							
21										
22	Measured Data (assuming the sensor directly):									
23	Measurement Conditions		Measured Data		RTISpan, V/V					
24	Temp	Pressure	VoutMeas	RTI Kbrg,w/v	Pressure	VoutMeas				
25	20	0	5.00E-01	5.88E-05	0					
26	20	50	2.50E+00	1.80E-03						
27	20	100	4.50E+00	3.54E-03	100					

Next, the program will ask what type of *Temperature Measurement Method* you want to use. For this example, we use the diode method.



PGA309 Calibration Spreadsheet, Sensor Curvefit Tab

2 The target sensor approximation equation:
 3 Uses 2nd-order (quadrature) equations for pressure non-linearities:

This are contains the PGA309 settings. These settings are loaded into these cells when the *Load Registers From PGA309* button was pressed from the main tab.

The temperature ranges and pressure ranges need to be entered by hand.

10			
11	Temp range:		
12	Tmin=	-45	
13	Tmax=	90	
14	Troom=	22.5	
15			
	Insert TempADC reading in active cell		

PGA309 non-variable (during calibration) settings:

Vref=	4.963 V	Initial settings of the Fine Adjust DACs:	
Kexc=	1.000 V/V	GainDAC1=	9DB5 hex,
FrontEnd PGA=	128 V/V	ZeroDAC1=	1804 hex,
Output Amp=	2.4 V/V	Temperature ADC Settings:	
Coarse Offset=	0.00E+00 V	Rt=	Leave this cell blank
		No. of Bits=	15
Vexc=	4.963 V, with LinDAC=0	AdcGain=	2
		AdcVref=	2.048

The TempADC readings and VoutMeas values need to be measured. This can be done using the *Insert TempADC reading in active cell* and *Insert Vout reading in active cell* buttons.

16					
17	Temperatures:	TempADC Reading@Tmeas			
18	22.5	19839	decimal		@ this Temp 3 pressure levels are applied
19	85	15839	decimal		
20	-40	23838			
21					
22	Assuming the sensor directly):				
23	Conditions	Measured Data	RTISpan, V/V	Post First Cal Correction	
24	Pressure	VoutMeas	RTI Kbrg,v/v	Pressure	VoutMeas
25	0	5.25E-01	-2.70E-04	0	
26	50	2.53E+00	1.49E-03		
27	100	4.53E+00	3.26E-03	100	
28	0	5.04E-01	-2.88E-04		
29	100	4.84E+00	3.53E-03		
30	0	7.89E-01	-3.71E-05		
31	100	4.86E+00	3.55E-03		
32	-40				
33	-40				
34					

PGA309 Calibration Spreadsheet, Sensor Curvefit Tab

Note that the 3 pressure 3 temperature calibration algorithm will compute values for nonlinearity error. This value needs to be very small for this configuration because nonlinearity correction is not used. This value will not be used to generate the calibration tables in the EEPROM.

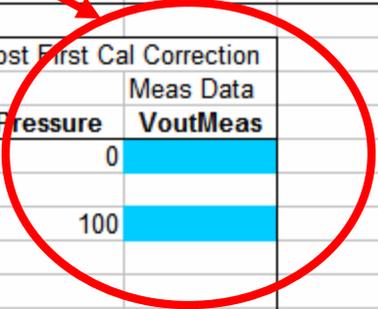
The value of Klin stored in the EEPROM will be zero for this mode because Vexc is disabled.

				ResultsVector3	Solution		
50	1	85	7225	3.82E-03	3.51E-03		
51	1	-40	1600	3.59E-03	-1.29E-07	k5=	-3.681E-05
52	1	22.5	506.25	3.53E-03	4.41E-08	k6=	1.256E-05
53							
54	Calculated value:						
55	Sensor Pressure non-linearity @Troom:						
56	Bv=	-0.000737266	=>>	-0.073726625 %	=>>>	Klin=	0
57	TempADC linear parameters:						
58	ktemp=	-64					
59	btemp=	21279					
60	GainDAC correction factor						
61	Gdac_factor=	1					
62	ZeroDAC correction factor						
63	Zdac_factor=	0					
64							
65	Calculated gain non-linearity:						

PGA309 Calibration
Spreadsheet, Sensor
Curvefit Tab

4	$V_{out}(P, T) = K_{00} + K_{01} T + K_{02} T^2 + (K_{03} P + K_{04} P^2) [1 + K_{05} T + K_{06} T^2]$						
5							
6	Fill out the highlighted cells			PGA309 non-variable (during calibration) settings:			
7	Pressure values:			Initial settings of the Fine Adjust I			
8	Pmin=	0	Vref=	4.963 V	GainDAC1=	9DB5 hex, ==	
9	Pmax=	100	Kexc=	1.000 V/V	ZeroDAC1=	1804 hex, ==	
10			FrontEnd PGA=	128 V/V			
11	Temp range:		Output Amp=	2.4 V/V	Temperature ADC Settings.		
12	Tmin=	-45	Coarse Offset=	0.00E+00 V	Rt=	Leave this cell blank	
				4.963 V, with LinDAC=0	No. of Bits=	15	
					AdcGain=	2	
					AdcVref=	2.048	
	Insert Vout reading in active cell						
	Vout Meas				: @ this Temp 3 pressure levels are applied		
20	Vout Meas						
21							
22	Measured Data (assuming the sensor directly):				Post First Cal Correction		
23	Measurement Conditions		Measured Data	RTISpan, V/V	Pressure	Meas Data	
24	Temp	Pressure	VoutMeas	RTI Kbrg, v/v	Pressure	VoutMeas	
25	22.5	0	5.25E-01	-2.70E-04	0		
26	22.5	50	2.53E+00	1.49E-03			
27	22.5	100	4.53E+00	3.26E-03	100		
28							
29	85	0	5.04E-01	-2.88E-04			
30	85	100	4.84E+00	3.53E-03			
31							
32	-40	0	7.89E-01	-3.71E-05			
33	-40			3.55E-03			

For the ratiometric calibration method, the secondary calibration is not necessary. The secondary calibration is used to correct for errors introduced by the LinDac. So, for this example, this section is left blank.



PGA309 Calibration Spreadsheet, Sensor Curvefit Tab

Select the desired post-calibration output range.

Select the temperature range of the look-up-table.

Make sure the *Result Sanity Check* passes.

4	Vout_max=	4.5 V	Ntemp=	17				1	90	0.679747		0.484677
5	Vout_min=	0.5 V	Optional:					2	81.5625	0.690988	-0.00133	0.48753
6			LUT_Tmin=	-45 degC				3	73.125	0.701426	-0.00124	0.488401
7			LUT_Tmax	90 degC				4	64.6875	0.710972	-0.00113	0.48729
8								5	56.25	0.719539	-0.00102	0.484196
9								6	47.8125	0.727047	-0.00089	0.479121
10	Result Sanity Check:							7	39.375	0.733423	-0.00076	0.472063
11	ZeroDAC is OK: values are in Range.							8	30.9375	0.738603	-0.00061	0.463024
12	GainDAC is OK: values are in Range.							9	22.5	0.742534	-0.00047	0.452002
13	TempADC is OK: values are ascending and in Range.							10	14.0625	0.745175	-0.00031	0.438998
14								11	5.625	0.746498	-0.00016	0.424012
15								12	-2.8125	0.746489	1.11E-06	0.407043
16								13	-11.25	0.745147	0.000159	0.388093
17								14	-19.6875	0.742488	0.000315	0.367161
18								15	-28.125	0.738539	0.000468	0.344246
19								16	-36.5625	0.733342	0.000616	0.319349
20								17	-45	0.726949	0.000758	0.292471
21								18	-45	0.726949	0	0.292471

PGA309 Calibration Spreadsheet, Calibration Results Tab

PGA309 Configuration Registers				PGA309 Calibrated Lookup Table			
Reg. Addr	Name	Binary value		Position	Temp	ZM	GM
0	ADC Out(RO)	0011	1101 1101 1111	0	3C9F	1900	8506
1	ZeroDAC	0001	1000 0000 0100	1	3EBB	0012	020C
2	GainDAC	1001	1101 1011 0101	2	40D7	0005	01E6
3	* Ref&Lin	0000	0000 0000 0000	3	42F3	FFF9	01BD
4	* Gain,Vos,Cfg1	0001	0111 0000 0000	4	450F	FFED	0190
5	* Cfg2,OverUnder	0000	0000 0000 0000	5	472B	FFE0	015E
6	* Cfg3 (ADC)	0001	0101 0000 0111	6	4947	FFD4	0129
7	OutEnbl Counter	0000	0000 0000 0000				
8	AlarmStatus(RO)	0000	0000 0000 0000				
	Config Checksum	0111	1111 1010 0000				

The spreadsheet will let you know that **Excitation is Disabled**. This is normal for the ratiometric method.

Press Save Registers+Lookup Table.

PGA309 DK

Please notice the warnings and adjustments that have been made based on the values:

- Excitation is disabled.

OK

PGA309 Calibration Spreadsheet, Main Tab

Step A

Press the *Open File* button to get the file containing the calibration results.

Step D

Press the *Read PGA309* to see the updated register values.

Step B

Make sure the *PGA309 Test Pin High* box is not checked. When in this mode, the PGA309 will read the EEPROM and adjust offset and gain for each temperature conversion

Step C

Press *Write EEPROM* to store the table on the EEPROM .

PGA309 Registers

01_1101_0101
11_1101_1110
00_1001_1000
00_0000_0000
11_0000_0000
00_0000_0000
01_0000_0111
00_0000_0000
00_0000_0000
11_1010_1111

PGA Settings

Coarse Offset (mV): 0.00

FrontEnd PGA Gain (V/V): 128.000

Zero DAC (V)

Gain DAC (V)

Output Amp

Enable Over

Enable Sens

Linearization Coef (V/V): 0.000

Interface Board and ADS1100

Supply Vcc (V): 4.457

Volt: 4.04065

Dec: 29707

Hex: 740B

Display Mode: Binary, Hex, Decimal

Board Settings

PGA Interface: Two-Wire, One-Wire

Update Checksums

COM Port Setup

EEPROM Lookup Table

Bitmap of a register

Board Communication Idle

After Step D, the calibration is complete.

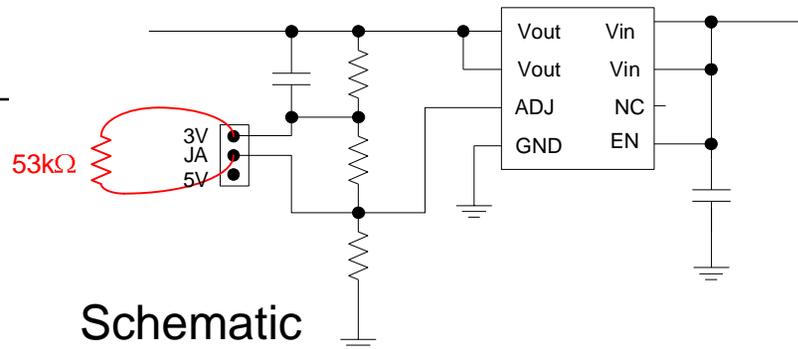
The *PGA309 RatioMetric Error* tab on the ***generate_sim_values.xls*** is a convenient way to do a post-calibration error analysis. To use it, select the blue cell corresponding to the current setup, and press the *Insert Vout reading in active cell* button. This will insert the PGA309 output reading from the ADS1100. This spreadsheet page provides for error calculations at two different power supply voltages. The initial supply is $V_s = 4.963V$ (you need to enter your measured V_s).

The post-calibration results will typically have errors less than 0.1%.

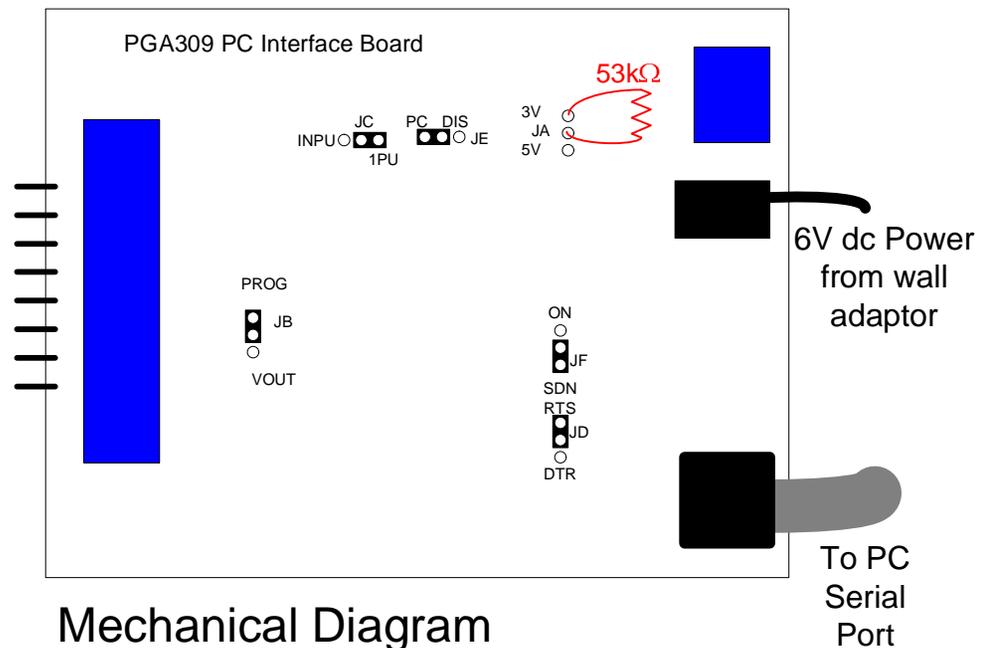
	A	B	C	D	E	F
1						
2						
3						
4						
5						
6						
7						
8						
9		Temperatu	Pressure	Ideal Resu	Measured	Error
10		cold	0%	0.5	0.49739	-0.07
11		cold	50%	2.5	2.49543	-0.11
12		cold	100%	4.5	4.49636	-0.09
13		Room	0%	0.5	0.49921	-0.02
14		Room	25%	1.5	1.4949	-0.13
15		Room	50%	2.5	2.49619	-0.10
16		Room	75%	3.5	3.49567	-0.11
17		Room	100%	4.5	4.49878	-0.03
18		Hot	0%	0.5	0.49997	0.00
19		Hot	50%	2.5	2.49998	0.00
20		Hot	100%	4.5	4.49954	-0.01
21						
22					stdev=	0.05
23					average=	-0.06
24						

generate_sim_values.xls,
PGA309 Ratiometric
Error Tab

For the ratiometric calibration method it is useful to adjust the power supply to see how PSR affects the PGA309 calibrated accuracy. A 10% power supply deviation is used in this example because it is a typical worst case deviation for ratiometric systems. Connecting a 53kΩ resistor between the 3V pin and the center pin on JA will cause the power supply to shift from 5V to 4.5V. You can adjust the value of the shunt resistance to get more or less power supply deviation. A short will cause the power supply to deviate from 5V to 3V.



Schematic



Mechanical Diagram

Texas Instruments PGA309 Designer's Kit Control Program

File Edit Board Setup

Reset Open File Save File Detect Write PGA309 Read PGA309 Write EEPROM Read EEPROM

PRG pin shorted to Vout PGA309 Test Pin HIGH

PGA309 Registers
Click on the register to edit the value and see the details

Addr	Name	Hex	Binary
0000	ADC Out(RO)	0x3DD5	0x0011_1101_1101_0101
0001	ZeroDAC	0x0FDE	0x0000_1111_1101_1110
0010	GainDAC	0x9898	0x1001_1000_1001_1000
0011	* Ref&Lin	0x0000	0x0000_0000_0000_0000
0100	* Gain,Vos,Cfg1	0x1700	0x0001_0111_0000_0000
0101	* Cfg2,OverUnder	0x0000	0x0000_0000_0000_0000
0110	* Cfg3 (ADC)	0x1507	0x0001_0101_0000_0111
0111	OutEnbl Counter	0x0000	0x0000_0000_0000_0000
1000	AlarmStatus(RO)	0x0000	0x0000_0000_0000_0000
	Config Checksum	0x7FAF	0x0111_1111_1010_1111

PGA Settings

Coarse Offset (mV): 0.000

FrontEnd PGA Gain (V/V): 128.000

Zero DAC (V): 276.250m

Gain DAC (V/V): 730.713r

Output Amp Gain (V/V): 2.400

Enable Over/Under-Scale Limits:

Overscale Limit: 4.326

Underscale Limit: 113.208

Enable Sensor Excitation:

Vexc: 3.699

Linearization Coef (V/V): 0.000

Enable Internal Vref:

Vref Value: 4.457

Fault Detection:

Detect External Faults:

Convert

Lookup Table

3C9F	1900	8506
3EBB	0012	020C
40D7	0005	01E6
42F3	FFF9	01BD
450F	FFED	0190
472B	FFE0	015E
4947	FFD4	0129
4B63	FFC7	00F2
4D7F	FFB8	00B7
4F9B	FFAE	007B
51B7	FFA2	003E
53D3	FF96	0000
55EF	FF89	FFC1
580B	FF7D	FF84
5A27	FF71	FF48
5C43	FF64	FF0E
5E5F	FF58	FED6
7FFF	0000	B8A6

Display Mode: Binary Hex Decimal

Apply Changes Discard Changes Show 1kBit EEPROM

Interface Board and ADS1100

Supply Vcc (V): 4.457

Volt: 4.04065

Dec: 29707

Hex: 740B

Update Vout Board Settings

Keep comm alive PGA Interface: Iwo-Wire One-Wire

Instant Update

Autocalc Chksum

Update Checksums COM Port Setup

EEPROM Lookup Table Bitmap of a register

Board Communication Idle

Make sure that you measure the supply voltage (Vs) and enter it into the **PGA309 Designer's Kit Control Program**.

Measure the PGA309 post calibration error at a different supply voltage to see the affect of PSR on error. For this example, the supply was changed from $V_s = 4.963V$ to $V_s = 4.457V$ and the average error changed from -0.06% to -0.03% .

insert Vout reading in active cell

30						
31						
32		Different Vsupply=		4.457		
33	Temperatu	Pressure	Ideal Resu	Measured	Error	
34	cold	0%	0.449023	0.44872	-0.01	
35	cold	50%	2.245114	2.24305	-0.06	
36	cold	100%	4.041205	4.0412	0.00	
37	Room	0%	0.449023	0.44967	0.02	
38	Room	25%	1.347068	1.34385	-0.09	
39	Room	50%	2.245114	2.24292	-0.06	
40	Room	75%	3.143159	3.14022	-0.08	
41	Room	100%	4.041205	4.03858	-0.07	
42	Hot	0%	0.449023	0.44967	0.02	
43	Hot	50%	2.245114	2.2455	0.01	
44	Hot	100%	4.041205	4.04065	-0.02	
45						
46				stdev=	0.04	
47				average=	-0.03	
48						
49						
50						

Make sure that you measure the supply voltage (V_s) and enter it into the **PGA309 Designer's Kit Control Program**.

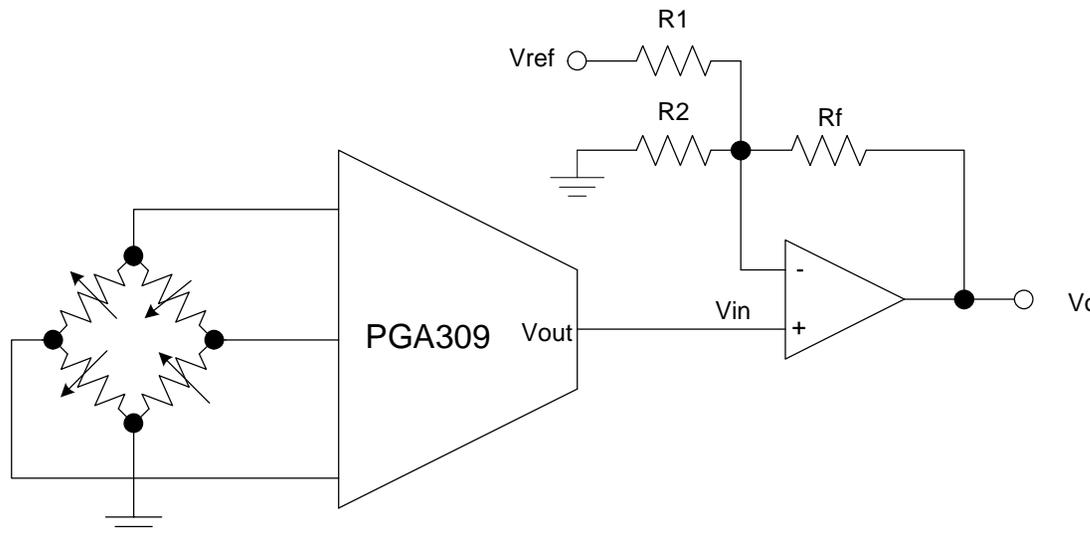
generate_sim_values.xls,
PGA309 Ratiometric
Error Tab

PGA309 With Output Scaling

(0 to 10V)



In many applications an external gain stage is used to get an output swing beyond the range of the PGA309. The circuit shown below is a typical example of gain scaling with an offset shift. The PGA309 calibration spreadsheet can accommodate external gain and offset scaling. Doing the calibration by measuring the output of the external gain stage will calibrate out errors caused by resistor tolerance in the external stage.



$$V_o = \left(\frac{R_f}{R_1} + \frac{R_f}{R_2} + 1 \right) \cdot V_{in} - \left(\frac{R_f}{R_1} \right) \cdot V_{ref}$$

$$V_o = (\text{ExtraGain}) \cdot V_{in} + (\text{ExtraOffset}) \cdot V_{ref}$$

PGA309 With Output Scaling

(0 to 10V)



This calculation shows how the example configuration shown on the previous page can be used to take the 0.5V to 4.5V output of the PGA309 and re-scale it to 0V to 10V.

Let $R_1 := 10 \cdot 10^3$

$$0 = \left(\frac{R_f}{10 \cdot 10^3} + \frac{R_f}{R_2} + 1 \right) \cdot 0.5 - \left(\frac{R_f}{10 \cdot 10^3} \right) \cdot 2.5$$

Equation 1: $V_{in} = 0.5V, V_o = 0V$

$$R_f = 2500 \cdot \frac{R_2}{R_2 - 2500}$$

Equation 2: solve Equation 1 for R_f

$$10 = \left(\frac{R_f}{10 \cdot 10^3} + \frac{R_f}{R_2} + 1 \right) \cdot 4.5 - \left(\frac{R_f}{10 \cdot 10^3} \right) \cdot 2.5$$

Equation 3: $V_{in}=4.5V, V_o = 10V$

$R_2 = 5000.$

$R_f = 5000.$

Equation 1: $V_{in} = 0.5V, V_o = 0V$

Equation 2: solve Equation 1 for R_f

Equation 3: $V_{in}=4.5V, V_o = 10V$

Substitute equation 2 into equation 3 and solve for R_2

Substitute the value of R_2 into equation 2 to solve for R_f

This equation must be broken down into an "ExtraGain" and "ExtraOffset" factor for the spreadsheet.

For the spreadsheet you need to break the function into "extra gain" and "extra offset" as shown below.

$$\text{ExtraGain} := \left(\frac{R_f}{R_1} + \frac{R_f}{R_2} + 1 \right)$$

ExtraGain = 2.5

$$\text{ExtraOffset} := \frac{-R_f}{10 \cdot 10^3}$$

ExtraOffset = -0.5

PGA309 With Output Scaling

(0 to 10V)



Initial settings of the Fine Adjust DACs:				Used For Additional Gain Scaling	
GainDAC1=	8000	hex, ==>>	0.6667 V/V	ExtraGain	2.5
ZeroDAC1=	8000	hex, ==>>	2.5000 V	ExtraOffset	-0.5
Temperature ADC Settings -- Used For Rt Calc Only					
Rt=	Leave this cell blank -- Rt is not used in this configuration				
No. of Bits=	11				
AdcGain=	1				
AdcVref=					

Bridge sensitivity	
8.0E-02	
6.0E-02	
4.0E-02	
2.0E-02	
0.0E+00	

The "ExtraGain" and "ExtraOffset" factor are entered here on the spreadsheet. Normally these are set to ExtraGain = 1.0 and ExtraOffset = 0.0.

PGA309 Calibration Spreadsheet, Sensor Curvefit Tab

PGA309 With Output Scaling

(0 to 10V)



16						
17	Measurement Temperatures:		TempADC Reading@Tmeas			
18	Tmeas1 (room)=	20	24744	decimal	: @ this Temp 3 pressure levels are app	
19	Tmeas2 (hot)=	85	20498	decimal		
20	Tmeas3 (cold)=	-40	28668			
21						
22	Measured Data (assuming the sensor directly):				Post First Cal Correction	
23	Measurement Conditions		Measured Data	RTISpan, V/V	Meas Data	
24	Temp	Pressure	VoutMeas	RTI Kbrg,v/v	Pressure	VoutMeas
25	20	0	1.00E-01	-1.05E-01	0	2.00E-02
26	20	50	4.30E+00	-4.18E-02		
27	20	100	9.90E+00	4.23E-02	100	9.94E+00
28						
29	85	0	2.00E-01	-1.03E-01		
30	85	100	1.01E+01	4.53E-02		
31						
32	-40	0	-1.00E-01	-1.05E-01		
33	-40	100	9.80E+00	4.68E-02		
34					Room Temp Gain Error:	2.48E-02
35					Room Temp Cor Gain Dac:	0.10972131
36					Post Cal RTI Kbrg(Pin_min):	-0.52375
37					Post Cal RTI Kbrg(Pin_max):	0.21125
38	Set Pressure = 0 and measurements at 3 temperatures:					
39	Matrix1:			ResultVector1		
40	1	0	0	7225	-1.03E-01	S
41	0	1	0	400	-1.05E-01	k1

The data that is measured at the output of the external amplifier is entered directly into the spreadsheet.

PGA309 Calibration Spreadsheet, Sensor Curvefit Tab

PGA309 With Output Scaling (0 to 10V)



1	PGA309 Desired output and its look-up table	
2		Lookup Table Parameters:
3	Enter Output Scale:	# of points:
4	V _{out_max} = 10 V	Ntemp= 17
5	V _{out_min} = 0 V	Optional:
6		LUT_Tmin= -45 degC
7		LUT_Tmax= 90 degC
8		
9		
10	Result Sanity Check:	
11	ZeroDAC is OK: values are in Range.	
12	GainDAC is OK: values are in Range.	
13	TempADC is OK: values are ascending and in Range.	
14		
15		
16		
17		
18		
19		
20		
21		
22		
23	Vout max and min calibrated	
24		
25		
26	0.52	
27		

Other than these few minor changes, the calibration method is the same as the other examples.

Result Sanity Check:
ZeroDAC is OK: values are in Range.
GainDAC is OK: values are in Range.
TempADC is OK: values are ascending and in Range.

The output range must be include the scaling stage.

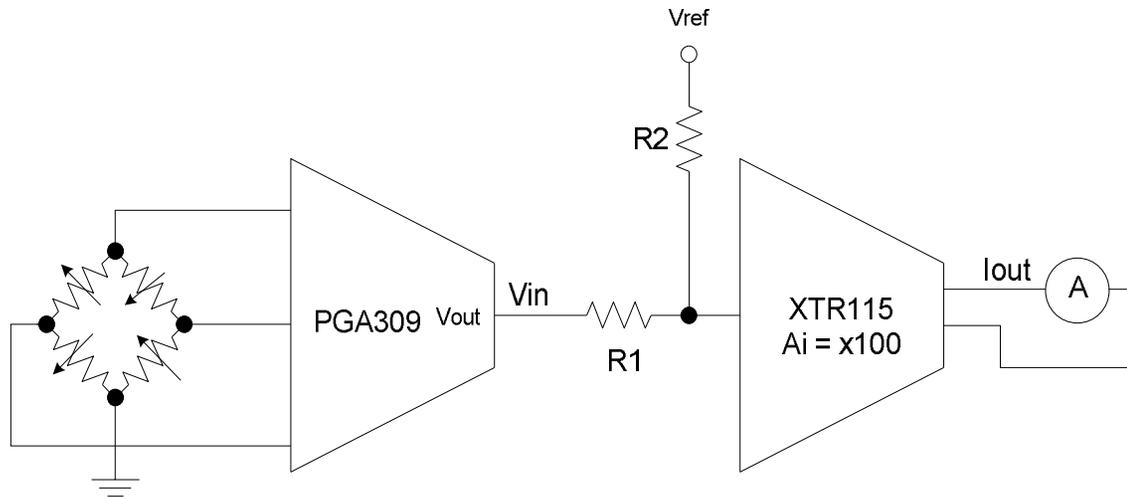
PGA309 Calibration Spreadsheet, Calibration Results Tab

PGA309 With Output Scaling

(4mA to 20mA)



The spreadsheet can also be used to calibrate a system using a PGA309 with a 4mA to 20mA output scaling.



$$I_{out} = (I_{in} + I_{ref}) \cdot 100$$

$$I_{out} = \left(\frac{V_{in}}{R_1} + \frac{V_{ref}}{R_2} \right) \cdot 100$$

$$I_{out} = \left(\frac{100}{R_1} \right) \cdot V_{in} + \left(\frac{100}{R_2} \right) \cdot V_{ref}$$

$$I_{out} = (\text{ExtraGain}) \cdot V_{in} + (\text{ExtraOffset}) \cdot 2.5$$

PGA309 With Output Scaling

(4mA to 20mA)



This calculation shows how the example configuration shown on the previous page can be used to take the 0.5V to 4.5V output of the PGA309 and re-scale it to 4mA to 20mA.

$$4 \cdot 10^{-3} = \left(\frac{0.5}{R_1} + \frac{2.5}{R_2} \right) \cdot 100$$

Equation 1: $V_{in} = 0.5V, I_{out} = 4mA$

$$R_1 = 12500 \cdot \frac{R_2}{R_2 - 62500}$$

Equation 2: solve Equation 1 for R_1

$$20 \cdot 10^{-3} = \left(\frac{4.5}{R_1} + \frac{2.5}{R_2} \right) \cdot 100$$

Equation 3: $V_{in}=4.5V, I_{out} = 20mA$

$$R_2 = 125 \cdot 10^3$$

Substitute equation 2 into equation 3 and solve for R_2

$$R_1 = 25 \cdot 10^3$$

Substitute the value of R_2 into equation 2 to solve for R_1

This equation must be broken down into an "ExtraGain" and "ExtraOffset" factor for the spreadsheet.

For the spreadsheet you need to break the function into "extra gain" and "extra offset" as shown below.

$$I_{out} = \left(\frac{100}{R_1} \right) \cdot V_{in} + \left(\frac{100}{R_2} \right) \cdot V_{ref}$$

$$I_{out} = \left(\frac{100}{25 \cdot 10^3} \right) \cdot V_{in} + \left(\frac{100}{125 \cdot 10^3} \right) \cdot 2.5$$

$$I_{out} = (\text{ExtraGain}) \cdot V_{in} + (\text{ExtraOffset}) \cdot 2.5$$

$$I_{out} = (4 \times 10^{-3}) \cdot V_{in} + (800 \times 10^{-6}) \cdot 2.5$$

PGA309 With Output Scaling

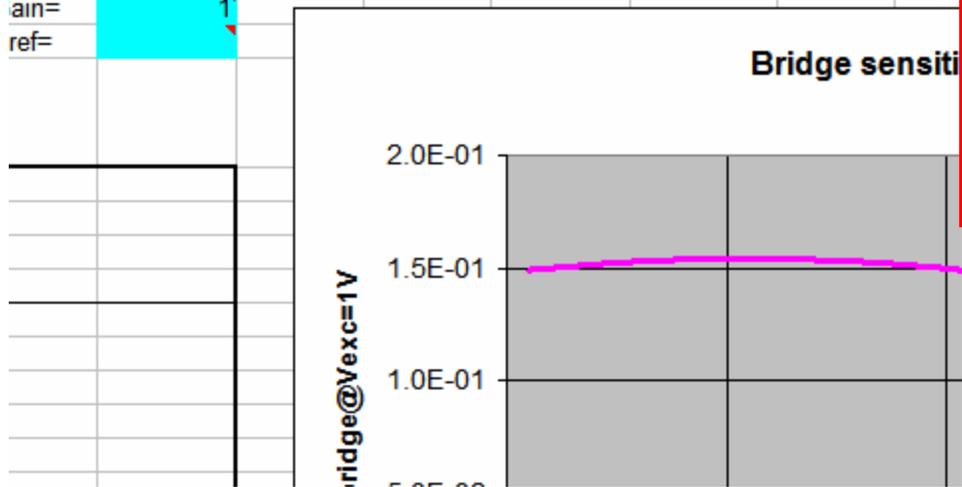
(4mA to 20mA)



settings of the Fine Adjust DACs:			
IA1=	8000	hex, ==>>	0.6667 V/V
IA2=	8000	hex, ==>>	2.5000 V
			Used For Additional Gain Sc
			ExtraGain 4.00E-03
			ExtraOffset 8.00E-04

Temperature ADC Settings -- Used For Rt Calc Only			
Leave this cell blank -- Rt is not used in this configuration			
Bits=	11		
Gain=	1		
Ref=			

The "ExtraGain" and "ExtraOffset" factor are entered here on the spreadsheet. Normally these are set to ExtraGain = 1.0 and ExtraOffset = 0.0.



PGA309 Calibration Spreadsheet, Sensor Curvefit Tab

PGA309 With Output Scaling

(4mA to 20mA)



Output range:		Frontend PGA=	4 V/V	Temperature ADC	
Min	-45	Output Amp=	2 V/V	Rt=	Leave
Max	90	Coarse Offset=	0.00E+00 V	No. of Bits=	
Span	20	Vexc=	5.000 V, with LinDAC=0	AdcGain=	
				AdcVref=	
TempADC reading in active cell		Insert Vout reading in active cell			
Measurement Temperatures:	TempADC Reading@Tmeas				
s1 (room)=	20	24744	decimal	: @ this Temp 3 pressure levels are applied	
s2 (hot)=	85	20498	decimal		
s3 (cold)=	-40	28668			
Measured Data (assuming the sensor directly):				Post First Cal Correction	
Measurement Conditions	Measured Data	RT Span, V/V		Meas Data	
Temp	Pressure	VoutMeas	RTI Kbrg, v/v	Pressure	VoutMeas
20	0	4.10E-03	-8.66E-02	0	4.00E-03
20	50	1.23E-02	-9.72E-03		
20	100	2.05E-02	6.72E-02	100	2.00E-02
85	0	4.00E-03	-8.75E-02		
85	100	1.90E-02	5.37E-02		
-40	0	4.10E-03	-8.66E-02		
-40	100	2.01E-02	6.34E-02		
		Room Temp Gain Error:	1.0005 P		
		Room Temp Cor Gain Dac:	0.65008146 P		

PGA309 Calibration Spreadsheet, Sensor Curvefit Tab

The data that is measured at the output of the voltage to current converter is entered directly into the spreadsheet (in Amps).

PGA309 With Output Scaling

(4mA to 20mA)



1	PGA309 Desired output and its look-up table		
2			Lookup Table Parameters:
3	Enter Output Scale:		# of points:
4	Vout_max=	2.00E-02 V	Ntemp= 17
5	Vout_min=	4.00E-03 V	Optional:
6		<input type="text"/>	LUT_Tmin= -45 degC
7			LUT_Tmax= 90 degC
8			
9			
10	Result Sanity Check:		
11	ZeroDAC is OK: values are in Range.		
12	GainDAC is OK: values are in Range.		
13	TempADC is OK: values are ascending and in Range.		
14			
15			
16			
17			
18			
19			
20			
21			
22			
23	Vout max and min calibrated		
24			
25			
26	0.52		
27			
28	PGA309 Calibration Spreadsheet, Calibration Results Tab		
29			
30			
31			

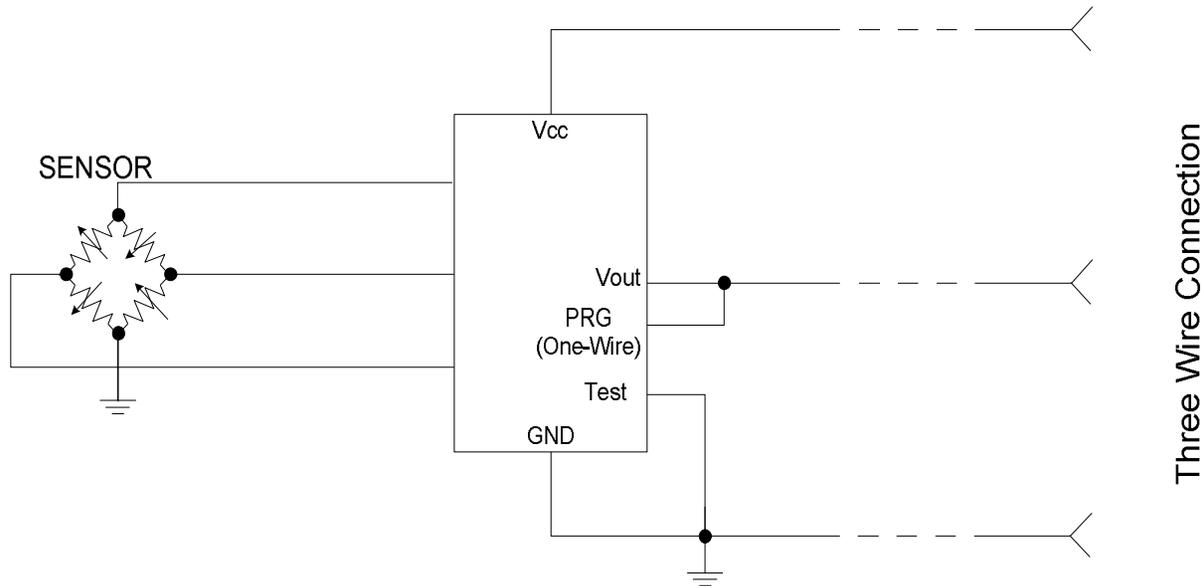
Other than these few minor changes, the calibration method is the same as the other examples.

The output range must be include the scaling stage (in Amps).

PGA309 In Three Wire Mode



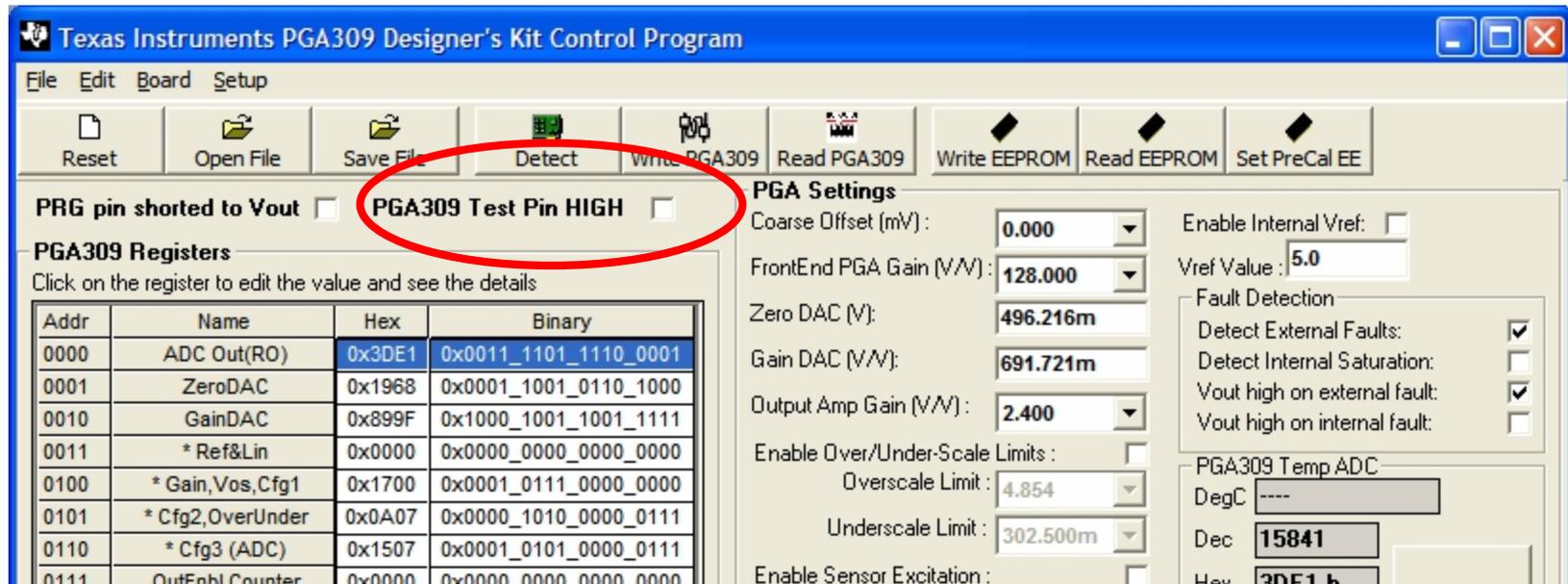
In many cases the PGA309 is connected in a configuration referred to as a three wire connection. In this configuration the only wires that need to connect to the sensor module are power, ground, and Vout. In this configuration the One-Wire digital communication line is connected to the Vout pin. When the PGA309 is initially powered up, the Vout pin is placed in a high impedance mode for 15mS. If communication is established using the One-Wire during this time, the PGA309 will keep Vout in high impedance until the communications is complete. After the communication is complete the PGA309 Vout pin will become active and remain active until power is cycled again. While using the EVM to communicate in Three Wire Mode, the EVM will cycle power before each One-Wire communication.



PGA309 In Three Wire Mode



If the “Set PreCal EE” feature is used the test pin is normally grounded (leave “PGA309 Test Pin HIGH” box unchecked).

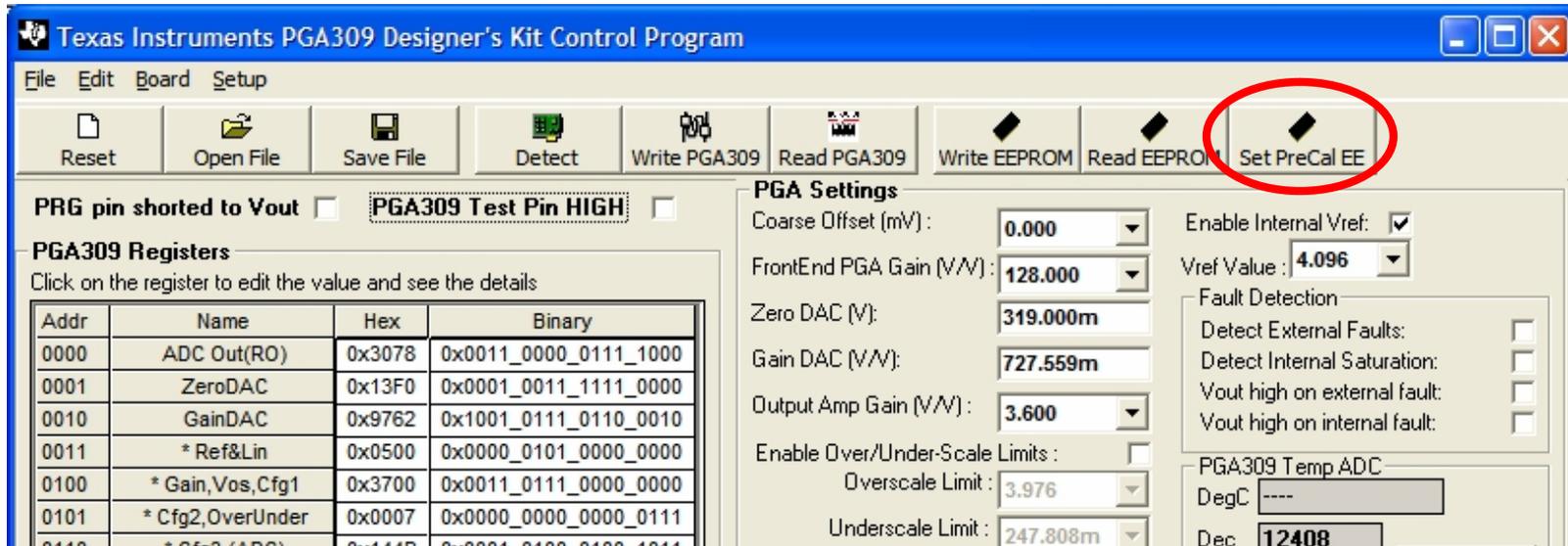


PGA309 In Three Wire Mode



A key technique used in calibration is to use the test pin on the PGA309. The test pin is typically used during calibration to place the PGA309 into test mode. The main benefit of test mode is that the Gain DAC and Offset DAC are forced to remain at the last values written to their respective registers.

In the case of three wire mode the test pin is grounded and cannot be used. In this case, an EEPROM table can be built that will force that Gain DAC and Offset DAC to be constant. The PGA309 Designers Kit Control Program “Set Precal EE” feature simplifies the creation of this table.



PGA309 In Three Wire Mode



When using this feature, first set all the registers to values your application requires. Then press the “Set PreCal EE” button.

Step 2

Step 1

Addr	Name	Hex	Binary
0000	ADC Out(RO)	0x3078	0x0011_0000_0111_1000
0001	ZeroDAC	0x13F0	0x0001_0011_1111_0000
0010	GainDAC	0x9762	0x1001_0111_0110_0010
0011	* Ref&Lin	0x0500	0x0000_0101_0000_0000
0100	* Gain,Vos,Cfg1	0x3700	0x0011_0111_0000_0000
0101	* Cfg2,OverUnder	0x0007	0x0000_0000_0000_0111
0110	* Cfg3 (ADC)	0x144B	0x0001_0100_0100_1011
0111	OutEnbl Counter	0x0000	0x0000_0000_0000_0000
1000	AlarmStatus(RO)	0x0000	0x0000_0000_0000_0000
	Config Checksum	0x5B64	0x0101_1011_0110_0100

0800	13F0	9761
7FFF	0000	CCAF

PGA309 In Three Wire Mode



After Pressing the “Set PreCal EE” a dialogue box will pop up that verifies the value of the Zero DAC and Gain Dac you want in your EEPROM configuration. After creating the EEPROM table, the PGA309 Designer’s Kit Control Program is ready for to be used with the calibration spreadsheet.

After pressing Generate and Write EEPROM Table, the lookup table will be updated to force a constant Gain Dac and Zero Dac for PreCal settings.

The screenshot shows the Texas Instruments PGA309 Designer's Kit Control Program interface. A "Pre Cal EEPROM Setup" dialog box is open, displaying "Zero Dac: 319.000m" and "Gain Dac: 727.559m". A red circle highlights the "Generate And Write EEPROM Table" button. Below the dialog, the "Lookup Table" is updated with the following values:

Addr	Name	Hex	Binary
0000	ADC Out(RO)	0x3078	0x0011_0000_0111
0001	ZeroDAC	0x13F0	0x0001_0011_1111
0010	GainDAC	0x9762	0x1001_0111_0110
0011	* Ref&Lin	0x0500	0x0000_0101_0000
0100	* Gain,Vos,Cfg1	0x3700	0x0011_0111_0000
0101	* Cfg2,OverUnder	0x0007	0x0000_0000_0000
0110	* Cfg3 (ADC)	0x144B	0x0001_0100_0100
0111	OutEnbl Counter	0x0000	0x0000_0000_0000
1000	AlarmStatus(RO)	0x0000	0x0000_0000_0000
	Config Checksum	0x5864	0x0101_1011_0110

The "Lookup Table" section of the interface shows the following values:

0800	13F0	9762
7FFF	0000	CCAE

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