



**Burr-Brown Products**  
from **Texas Instruments**

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# XTR108

## Quick Start System Reference Guide

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High-Precision Linear Products

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# XTR108 Quick Start Contents

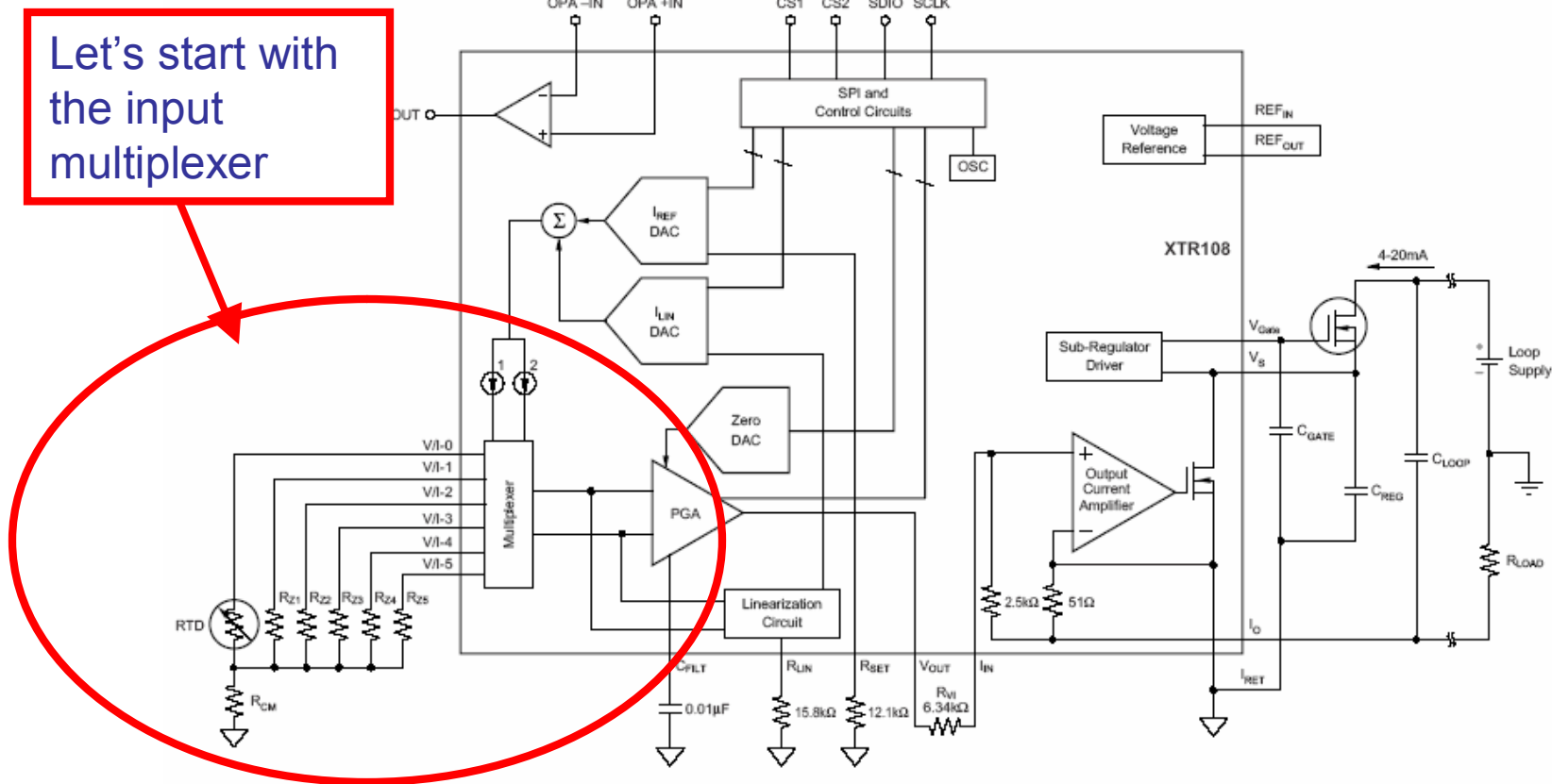
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# Short Background on XTR108

# XTR108 Operation

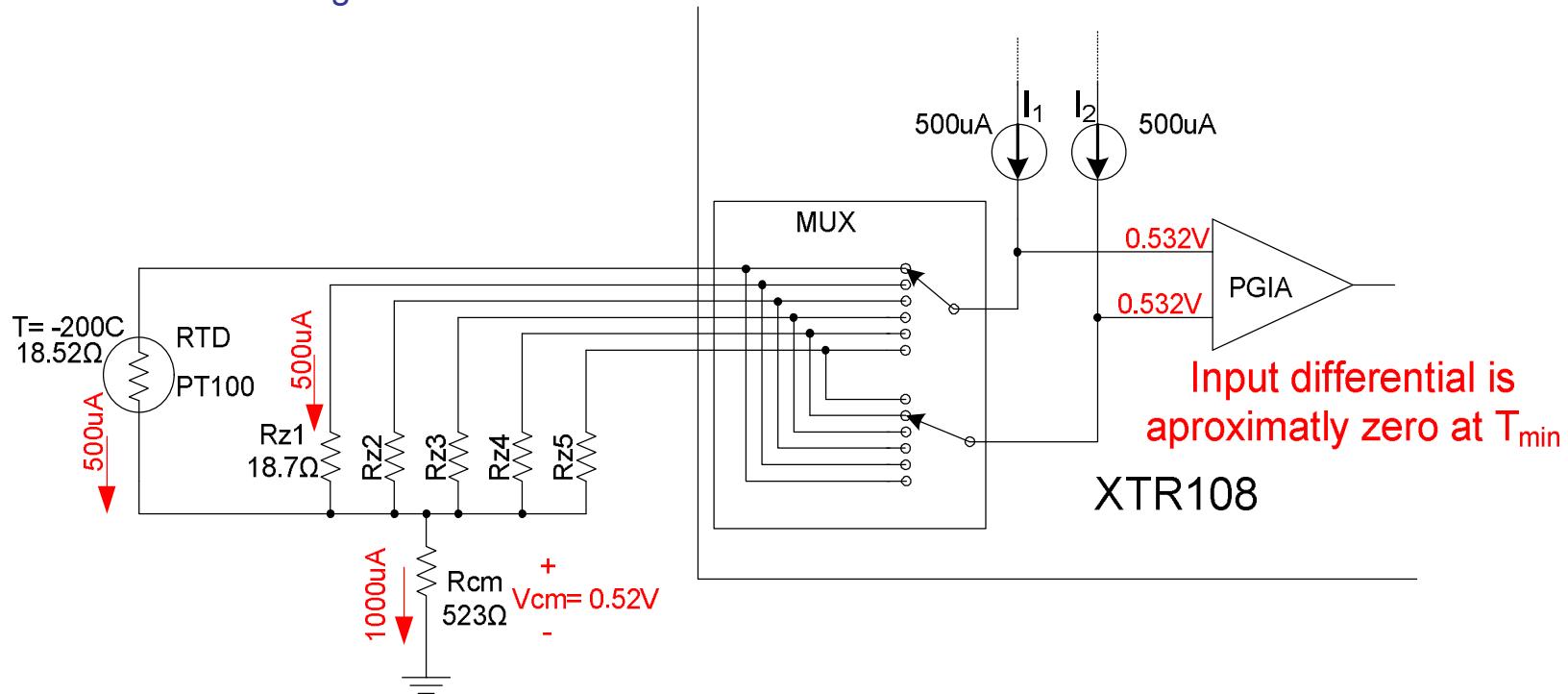
The figure below shows a simple block diagram of the XTR108. This section of the Quick Start Guide will give a brief description of the major sections.





# XTR108 Operation – Input Mux

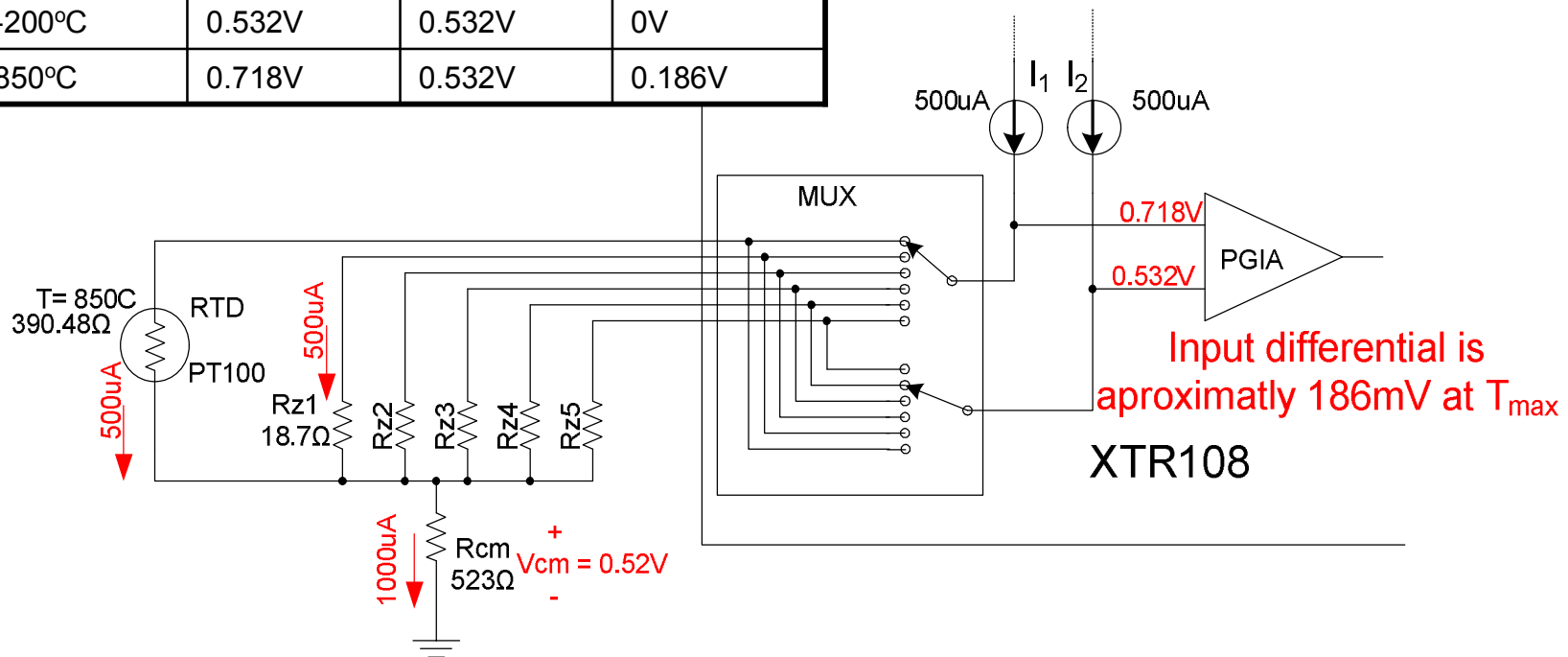
The primary function of the XTR108 Input MUX is to allow a single hardware module to function for multiple RTD ranges, and types. In the typical XTR108 configuration one MUX channel is used for the RTD and five different channels remain for different ranges. Rz1 through Rz5 are used to set the minimum temperature ( $T_{min}$ ) of a particular range. In the example shown below,  $T_{min} = -200^{\circ}\text{C}$ , Rz1 is selected to match the resistance of the RTD at this temperature (i.e.  $18.7\Omega$  closest standard value). This will force the differential input voltage of the PGIA to be approximately zero at  $T_{min}$ .  $R_{cm}$  generates a common mode voltage so that the common mode range of the XTR108 is not violated.



# XTR108 Operation – Input Mux

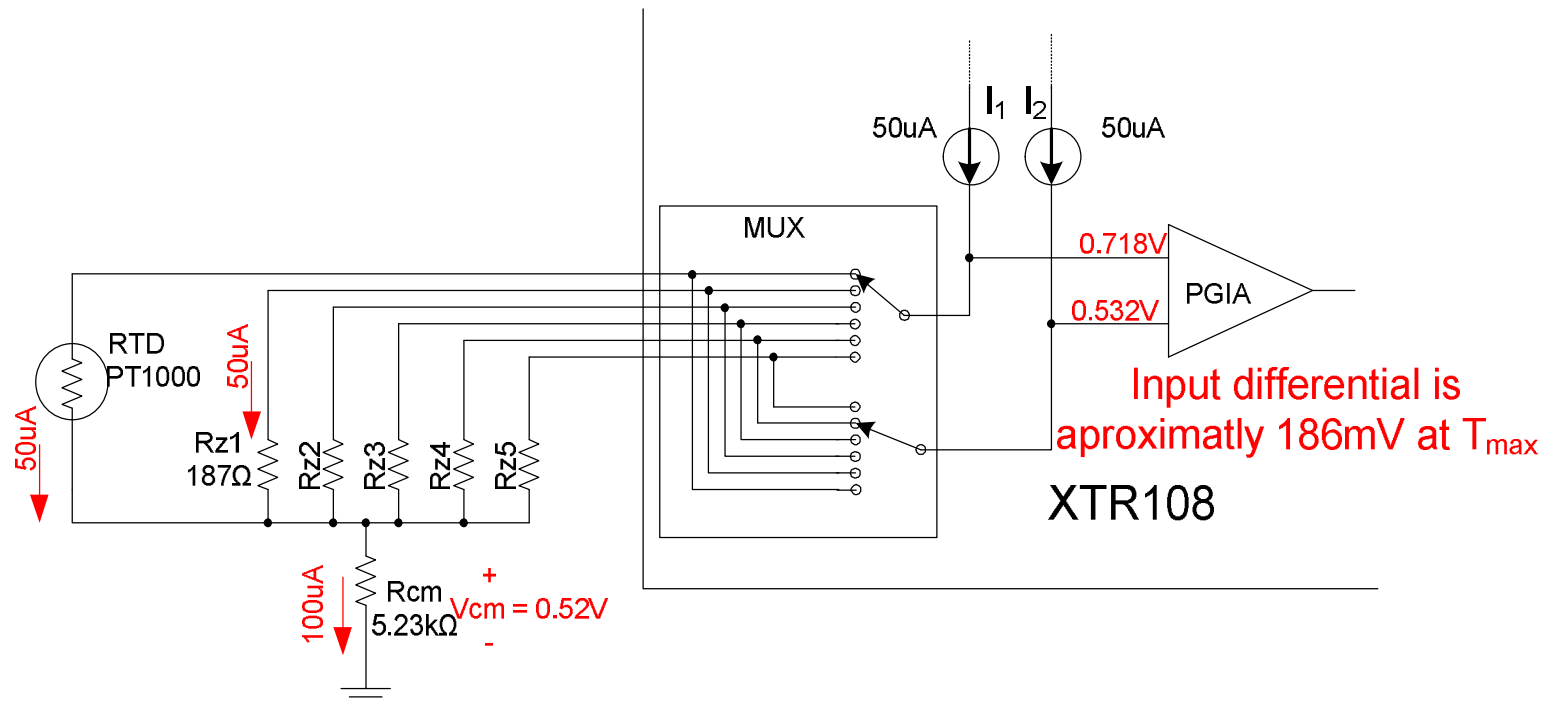
The figure below shows the same multiplexer configuration with the RTD at maximum temperature  $T_{max}=850C$ . At this point the differential input to the PGIA is maximum (e.g. 186mV). This example range is summarized in the table below.

Temperature	$V_{RTD}$ to Ground	$V_{RZ1}$ to Ground	$V_{in}$ to PGIA
-200°C	0.532V	0.532V	0V
850°C	0.718V	0.532V	0.186V



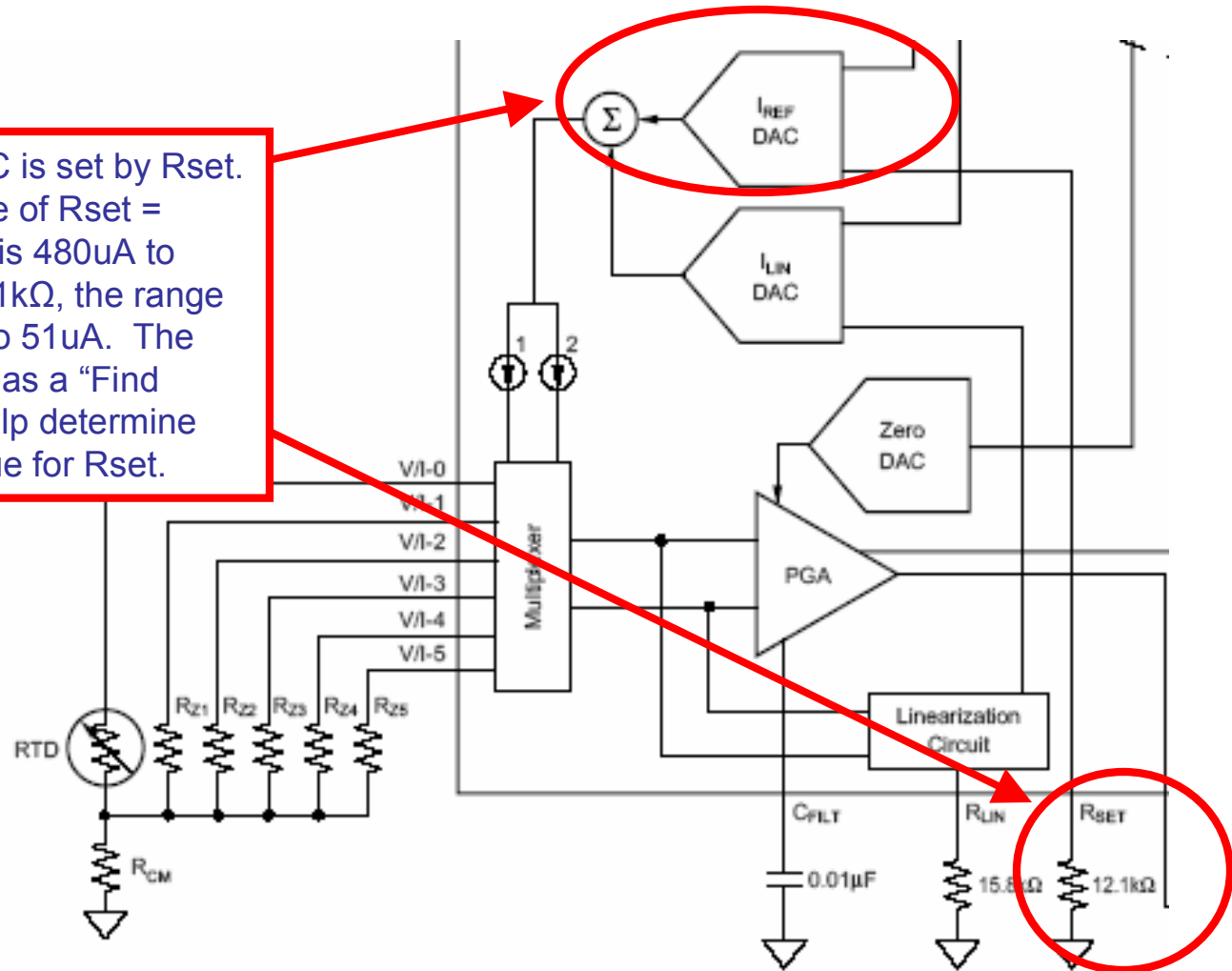
# XTR108 Operation – Input Mux

The figure below shows how the current sources can be programmed to accommodate different types of RTD's. The previous example used a 100Ω RTD (PT100). In this example we changed the RTD to 1000Ω (i.e. PT1000). The current sources  $I_1$  and  $I_2$  are scaled to accommodate this new resistor (i.e. they are changed from 500uA to 50uA).  $R_{z1}$  and  $R_{cm}$  are also scaled to accommodate this new RTD type. Note that  $I_1$  and  $I_2$  are matched current sources programmed by one set of DACs (7 bit plus sign CoarseDac, 7 bit plus sign FineDac). These current sources will be programmed during calibration.



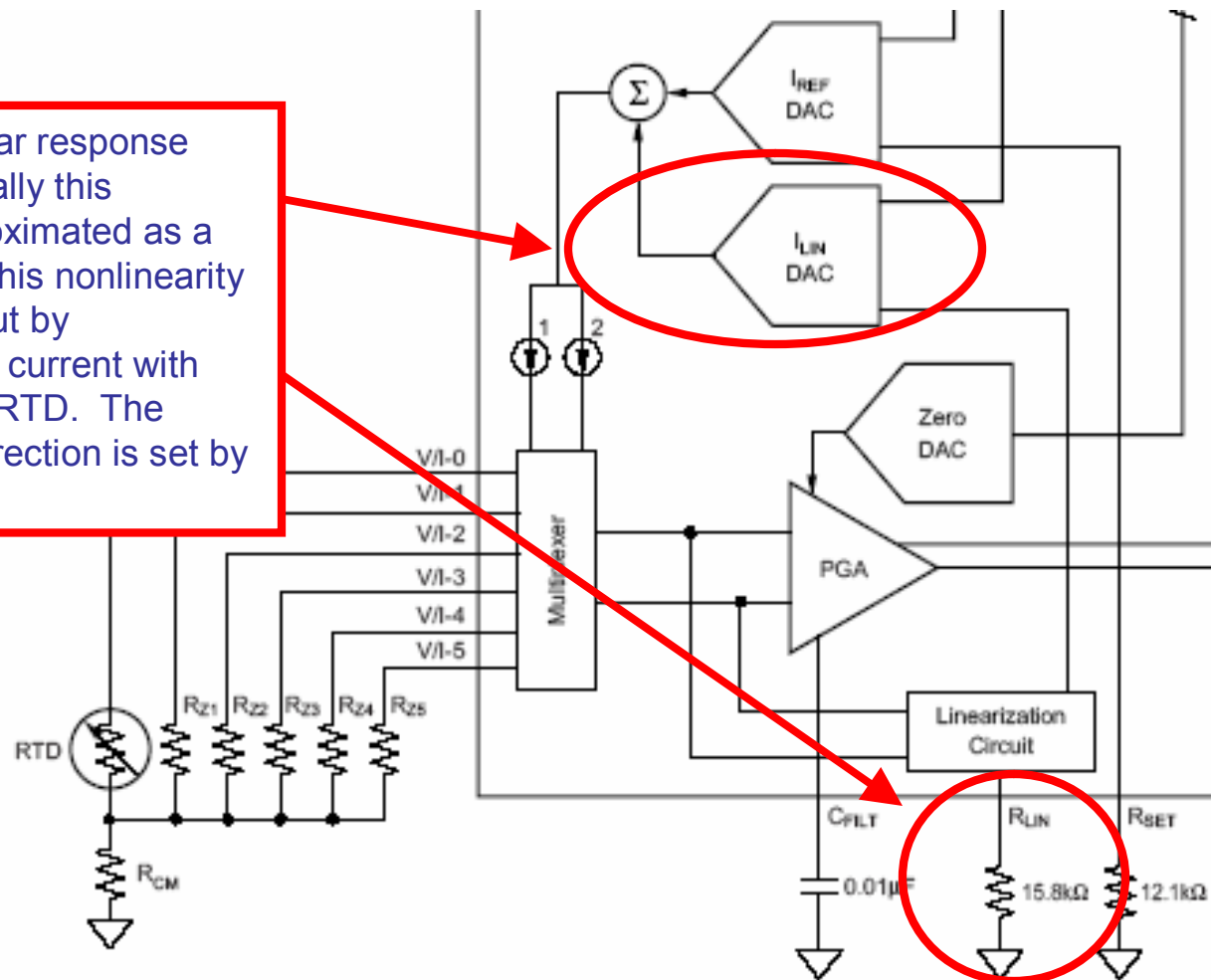
# XTR108 Operation – Rset

The range of the  $I_{ref}$  DAC is set by  $R_{set}$ . For example, with a value of  $R_{set} = 12.1k\Omega$ , the range of  $I_{ref}$  is  $480\mu A$  to  $510\mu A$ . Using  $R_{set} = 121k\Omega$ , the range of  $I_{ref}$  changes to  $48\mu A$  to  $51\mu A$ . The XTR108 EVM Software has a “Find Resistors” tab that will help determine what the appropriate value for  $R_{set}$ .



# XTR108 Operation – R<sub>lin</sub>

All RTD's have a nonlinear response over temperature. Typically this nonlinearity can be approximated as a second order function. This nonlinearity error can be calibrated out by modulating the excitation current with the input signal from the RTD. The range of this linearity correction is set by R<sub>lin</sub>.

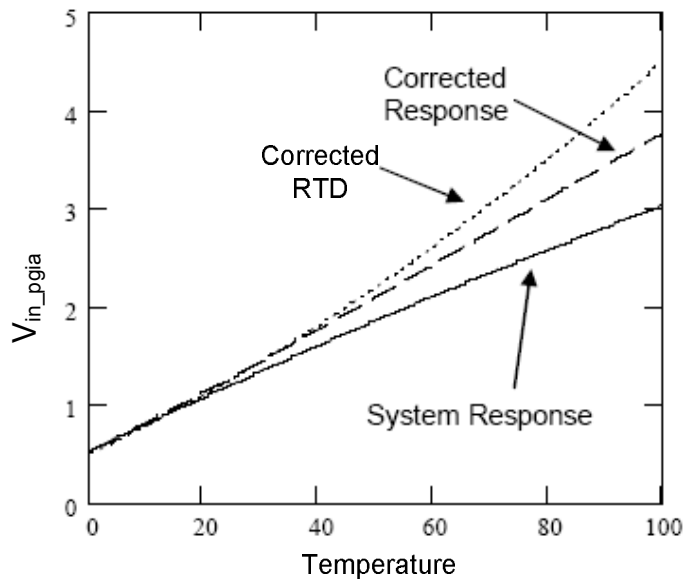


# XTR108 Operation – Linearity Correction



## How it works!

The graph below illustrates how the linearity correction works. The RTD has a system response that is approximately quadratic. The positive feedback of the input signal through the LinDac generates a system response that is also approximately quadratic. The two responses counteract each other to generate a linear output.

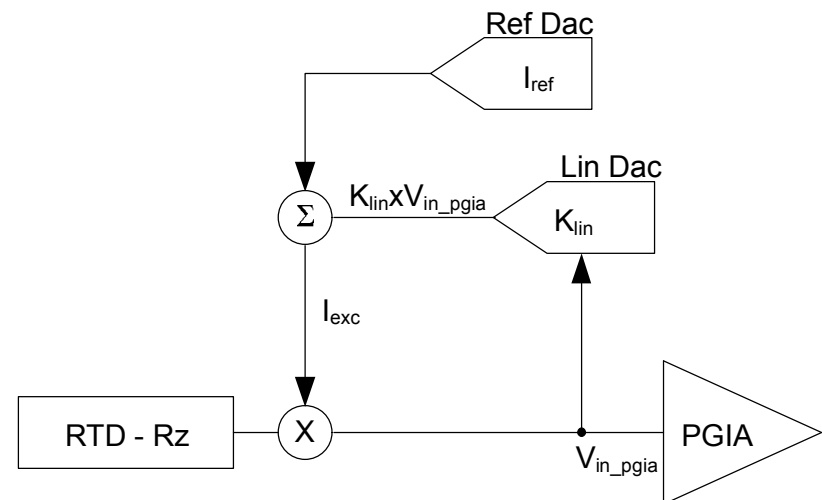


$$V_{in\_pgia} = (K_{lin} \cdot V_{in\_pgia} + I_{ref}) \cdot (RTD - R_z)$$

$$V_{in\_pgia} = \frac{I_{ref}(RTD - R_z)}{1 + K_{lin}(RTD - R_z)}$$

If you do a Taylor Expansion the response can be approximated as a second order

$$V_{in\_pgia} = a + b \cdot (RTD - R_z) + c \cdot (RTD - R_z)^2$$

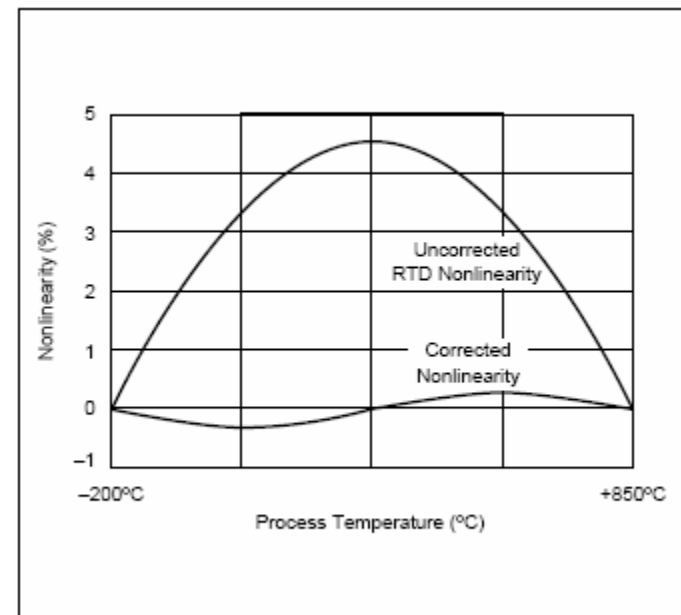
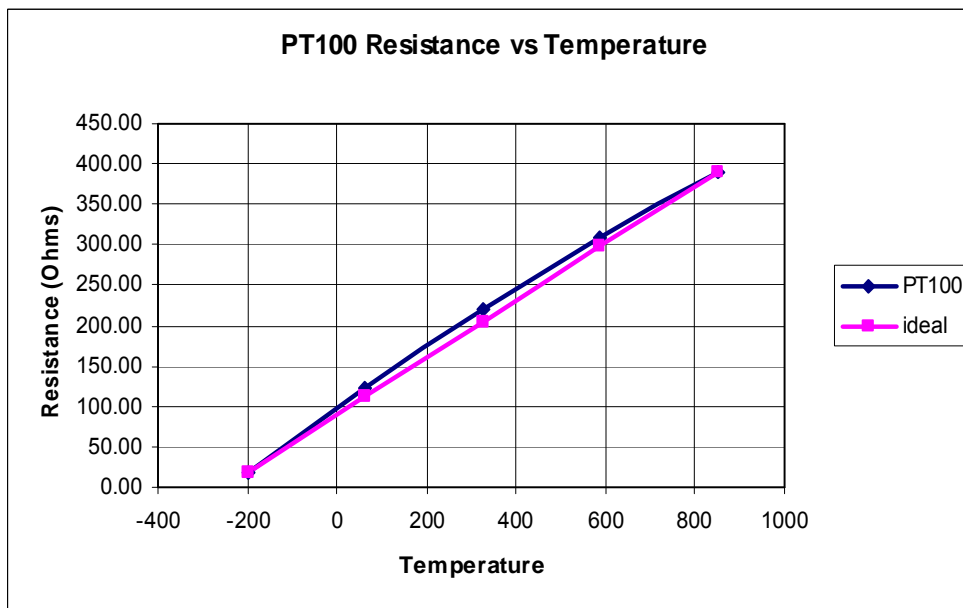


# XTR108 Operation – Linearity Correction



## How much will it improve the nonlinearity?

The graph below shows pre and post correction for a typical RTD. Normally you can expect a 40:1 improvement in linearity.



# Current Output Mode Calibration Example



# Selecting Components for Your Application

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There are several external components that are used to set the type of RTD used, and the temperature range that it can be used over. The XTR108 “Find Resistor” tab on the XTR108 Software is a tool that helps select resistors to accommodate five ranges on the XTR108. These components are located on the XTR108-EVM Sensor Board.

**$R_{z1}$  through  $R_{z5}$**  – sets the zero temperature for the multiplexer channels 1 through 5.

**$R_{LIN}$**  – sets the range of linearity correction.

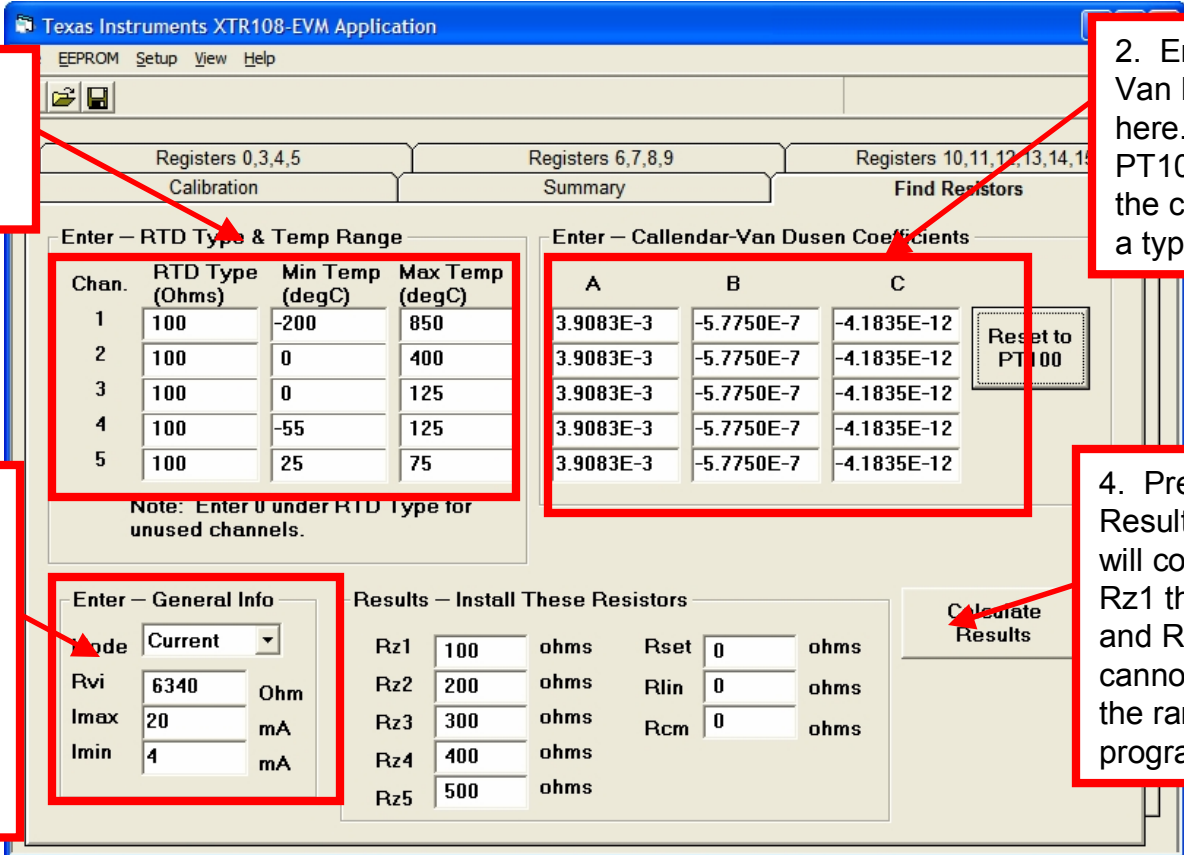
**$R_{cm}$**  – the common mode resistor. This resistor ensures that the lowest common mode voltage is greater than the data sheet specification.

**$R_{set}$**  – this resistor sets the range for the current references.

**$R_{vi}$**  – the voltage to current resistor. This resistor is always selected to be 6.34k by the spreadsheet because this is the optimal value for the zero adjust circuit to work for 4mA to 20mA.

# Selecting Components – Find Resistors

The “Find Resistors” tab on the XTR108 EVM Software can be used to determine what external resistors are required to configure the XTR108 for different RTD ranges.



**1. Enter the RTD resistance at 0 degC and the temperature range.**

Chan.	RTD Type (Ohms)	Min Temp (degC)	Max Temp (degC)
1	100	-200	850
2	100	0	400
3	100	0	125
4	100	-55	125
5	100	25	75

**2. Enter the Callendar-Van Dusen Coefficients here. The “Reset to PT100” button will reset the coefficients to that of a typical PT100 RTD.**

A	B	C
3.9083E-3	-5.7750E-7	-4.1835E-12
3.9083E-3	-5.7750E-7	-4.1835E-12
3.9083E-3	-5.7750E-7	-4.1835E-12
3.9083E-3	-5.7750E-7	-4.1835E-12
3.9083E-3	-5.7750E-7	-4.1835E-12

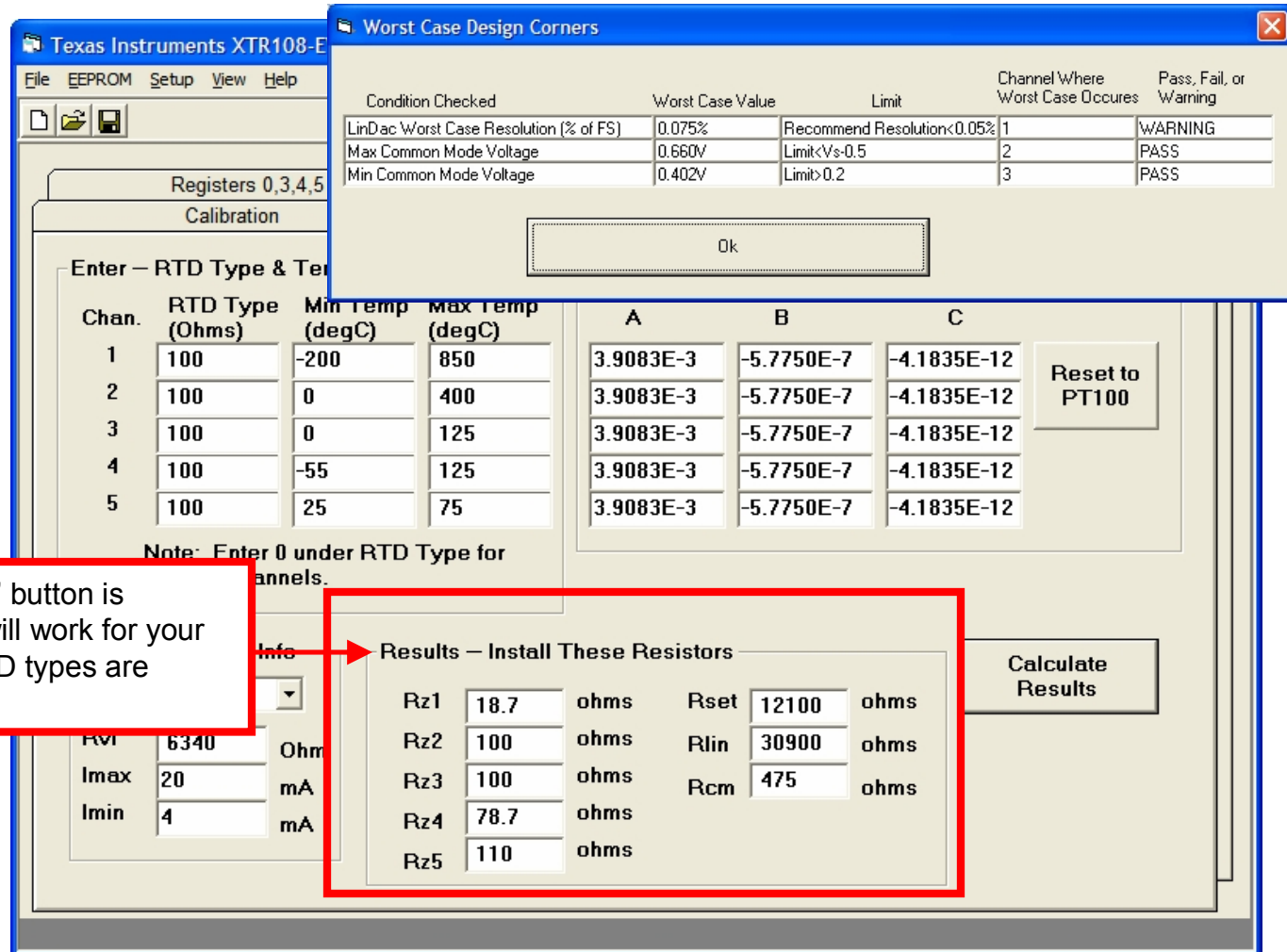
**3. Select current mode or voltage mode. Enter Rvi. Rvi is typically 6340Ω for most applications. The output at Max Temperature (Imax) and the output at minimum temperature (Imin).**

Mode	Rvi	Imax	Imin
Current	6340 Ohm	20 mA	4 mA

**4. Press the “Calculate Results” button. This will compute values for Rz1 through Rz5, Rset, and Rcm. If the XTR108 cannot accommodate all the ranges, then the program will give errors.**

Results – Install These Resistors					
Rz1	100	ohms	Rset	0	ohms
Rz2	200	ohms	Rlin	0	ohms
Rz3	300	ohms	Rcm	0	ohms
Rz4	400	ohms			
Rz5	500	ohms			

# Selecting Components – Find Resistors



The screenshot shows the 'Worst Case Design Corners' dialog box overlaid on the main software interface. The dialog box contains a table with the following data:

Condition Checked	Worst Case Value	Limit	Channel Where Worst Case Occurs	Pass, Fail, or Warning
LinDac Worst Case Resolution (% of FS)	0.075%	Recommend Resolution<0.05%	1	WARNING
Max Common Mode Voltage	0.660V	Limit<Vs-0.5	2	PASS
Min Common Mode Voltage	0.402V	Limit>0.2	3	PASS

Below the table is an 'Ok' button. The main software interface shows a table for RTD types and temperatures:

Chan.	RTD Type (Ohms)	Min Temp (degC)	Max Temp (degC)
1	100	-200	850
2	100	0	400
3	100	0	125
4	100	-55	125
5	100	25	75

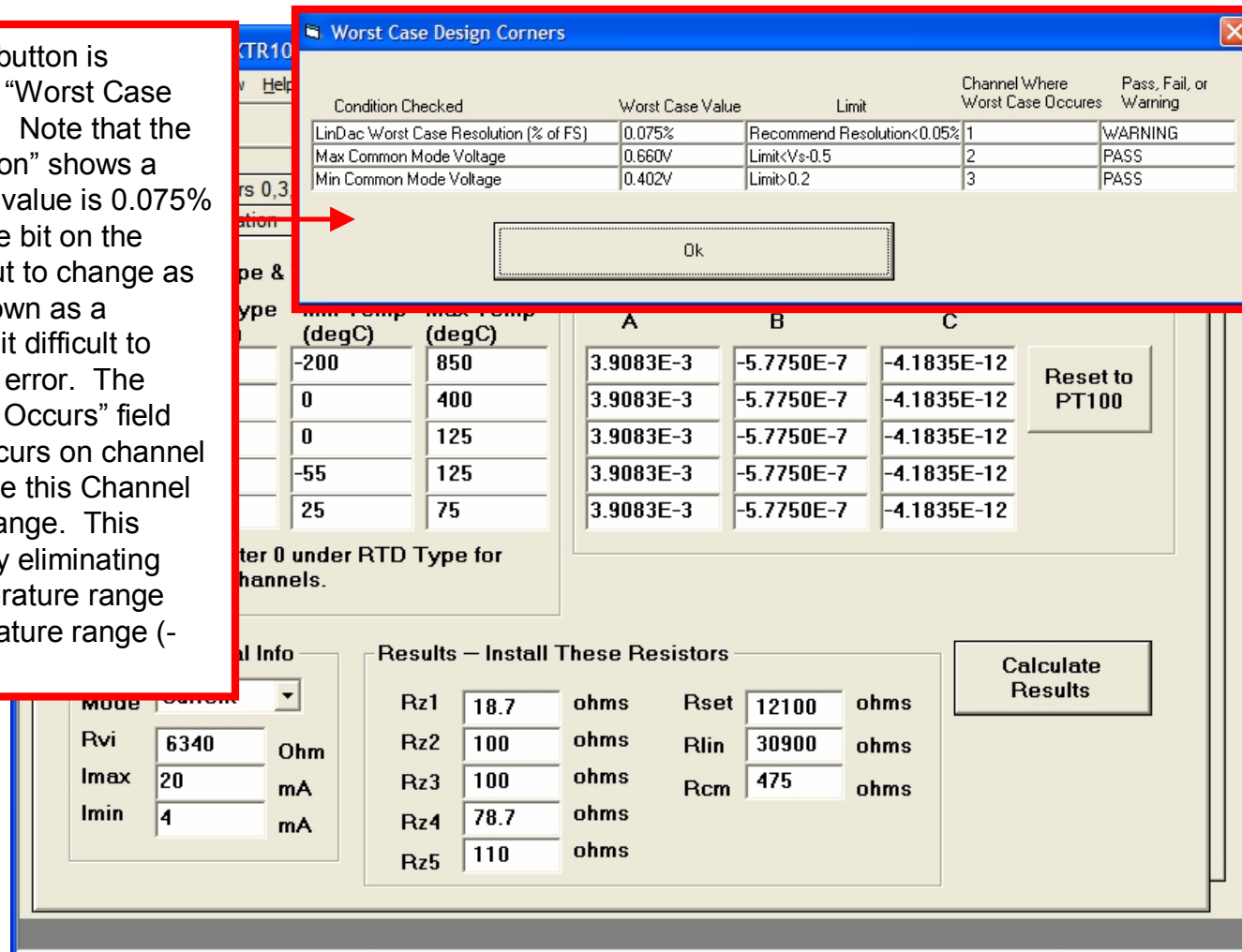
Below this table is a 'Note: Enter 0 under RTD Type for channels.' and a 'Calculate Results' button. The 'Results - Install These Resistors' section is highlighted with a red box and contains the following data:

Resistor	Value	Unit
Rz1	18.7	ohms
Rz2	100	ohms
Rz3	100	ohms
Rz4	78.7	ohms
Rz5	110	ohms
Rset	12100	ohms
Rlin	30900	ohms
Rcm	475	ohms

After the "Calculate Results" button is pressed, the resistors that will work for your temperature ranges and RTD types are calculated.

# Selecting Components – Find Resistors

After the “Calculate Results” button is pressed, this summary of the “Worst Case Design Corners” is displayed. Note that the “LinDac Worst Case Resolution” shows a warning in this example. The value is 0.075% indicates that a change of one bit on the LinDac could cause the output to change as much as 0.075%. This is shown as a warning because it will make it difficult to attain a 0.1% post calibration error. The “Channel Where Worst Case Occurs” field indicates that the problem occurs on channel 1. This makes sense because this Channel has the widest temperature range. This problem can be moderated by eliminating either the most narrow temperature range (25, 75) or the widest temperature range (-200, 850).



Condition Checked	Worst Case Value	Limit	Channel Where Worst Case Occurs	Pass, Fail, or Warning
LinDac Worst Case Resolution (% of FS)	0.075%	Recommend Resolution<0.05%	1	WARNING
Max Common Mode Voltage	0.660V	Limit<Vs-0.5	2	PASS
Min Common Mode Voltage	0.402V	Limit>0.2	3	PASS

min Temp (degC)	max Temp (degC)	A	B	C
-200	850	3.9083E-3	-5.7750E-7	-4.1835E-12
0	400	3.9083E-3	-5.7750E-7	-4.1835E-12
0	125	3.9083E-3	-5.7750E-7	-4.1835E-12
-55	125	3.9083E-3	-5.7750E-7	-4.1835E-12
25	75	3.9083E-3	-5.7750E-7	-4.1835E-12

Results – Install These Resistors	
Rz1	18.7 ohms
Rz2	100 ohms
Rz3	100 ohms
Rz4	78.7 ohms
Rz5	110 ohms
Rset	12100 ohms
Rlin	30900 ohms
Rcm	475 ohms

# Selecting Components – Find Resistors

Texas Instruments XTR108-EVM Application

File EEPROM Setup View Help

Registers 0,3,4,5      Registers 6,7,8,9      Registers 10,11,12,13,14,15

Calibration      Summary      Find Resistors

Enter – RTD Type & Temp Range

Chan.	RTD Type (Ohms)	Min Temp (degC)	Max Temp (degC)
1	100	-200	850
2	100	0	400
3	100	0	125
4	0	-55	125
5	0	25	75

Note: Enter 0 under RTD Type for unused channels.

Enter – Callendar-Van Dusen Coefficients

A	B	C
3.9083E-3	-5.7750E-7	-4.1835E-12
3.9083E-3	-5.7750E-7	-4.1835E-12
3.9083E-3	-5.7750E-7	-4.1835E-12
3.9083E-3	-5.7750E-7	-4.1835E-12
3.9083E-3	-5.7750E-7	-4.1835E-12

Reset to PT100

Enter – General Info

Mode: Current

Rvi: 6340 Ohm

I<sub>max</sub>: 20 mA

I<sub>min</sub>: 4 mA

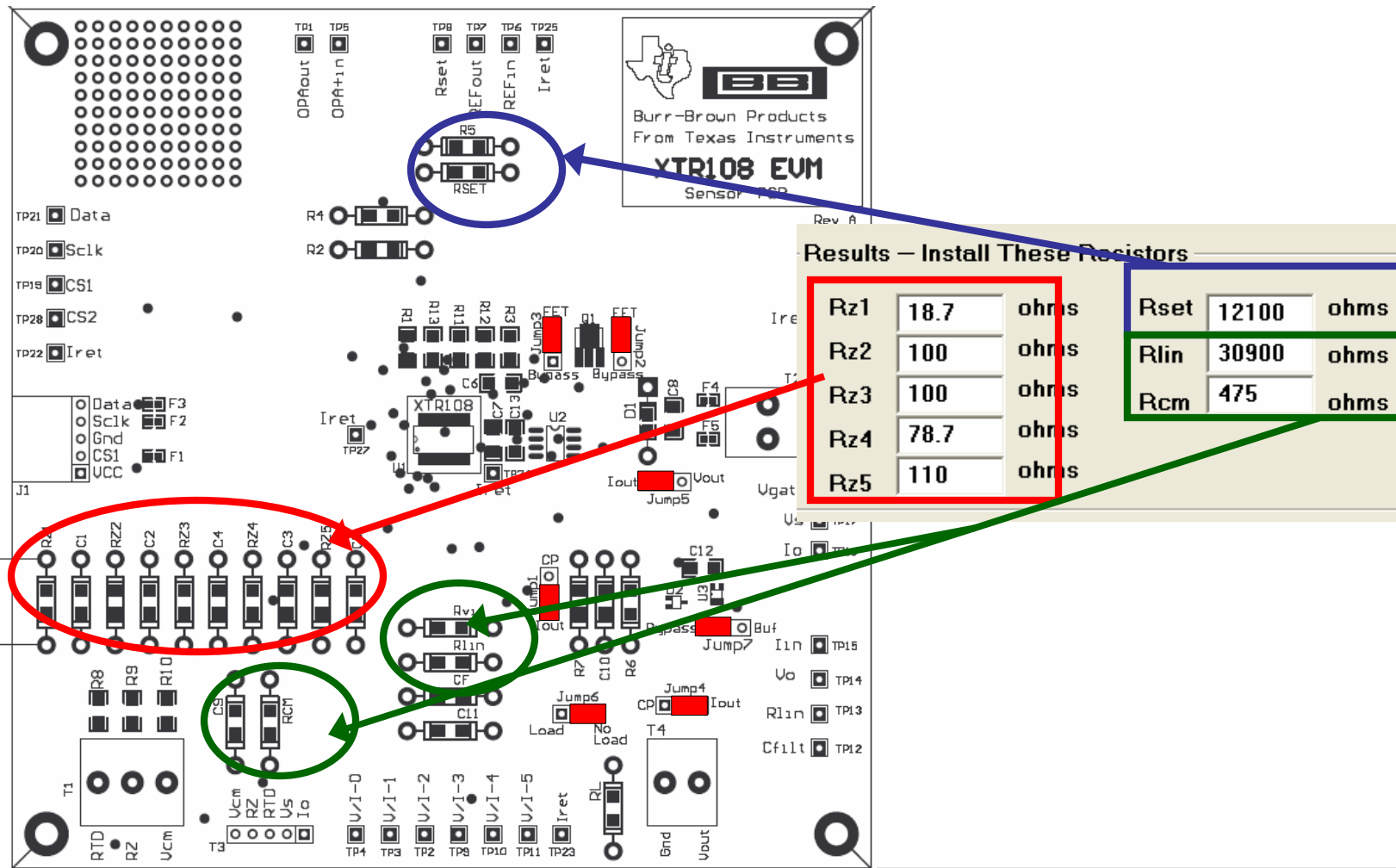
Results – Install These Resistors

Rz1	18.7	ohms	Rset	12100	ohms
Rz2	100	ohms	Rlin	30900	ohms
Rz3	100	ohms	Rcm	475	ohms
Rz4	78.7	ohms			
Rz5	110	ohms			

Calculate Results

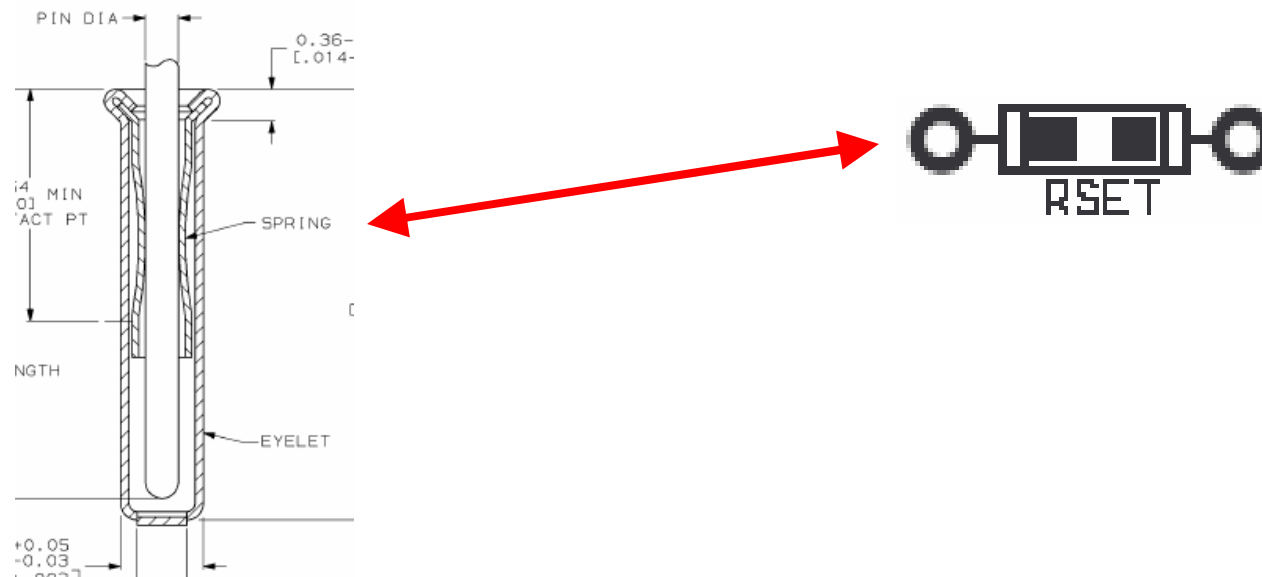
In some cases, you may not want to use all of the channels available on the XTR108. In this case, you can enter 0 for the RTD Type. This will disable the channel.

# Install The Resistors

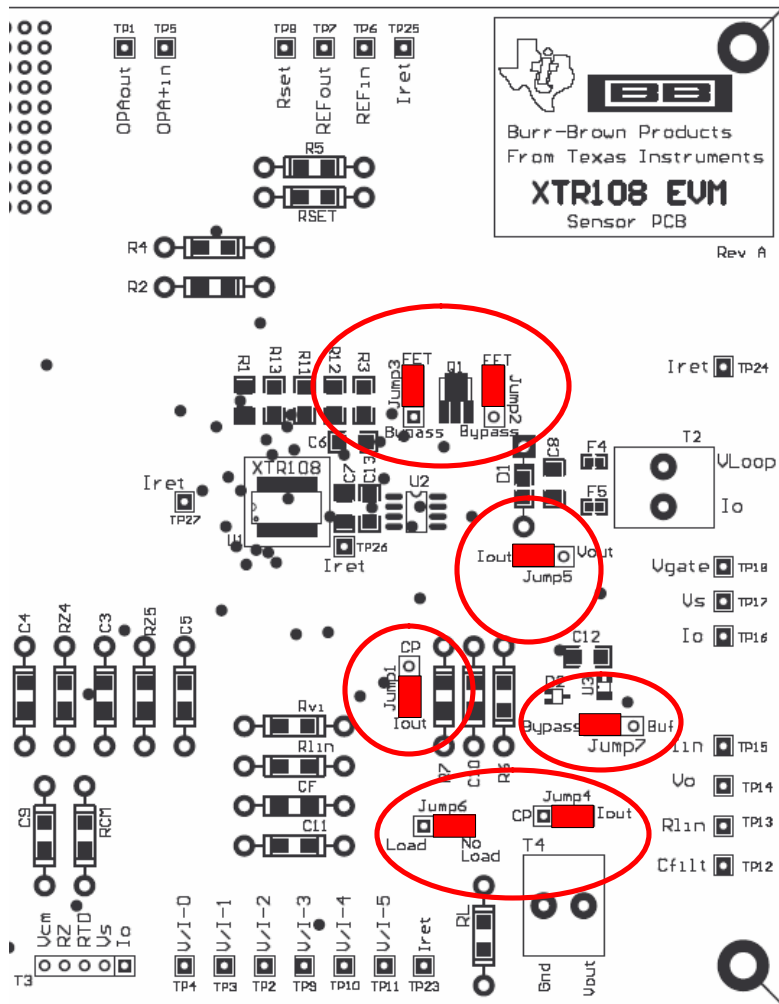


# Install The Resistors

The figure below shows a typical component footprint on the XTR108 Sensor Board. The footprint is a surface mount resistor inside of a through hole resistor. The through hole resistor pads have “pin sockets” installed in them to allow easy replacement of the resistors. The pin sockets have gold plated springs internally that provide excellent contact with the resistor leads. The XTR108 EVM has surface mount resistors installed for a typical PT100 application. If you want to change the configuration, de-solder these surface mount resistors and connect the through hole resistors via the pin sockets.



# Set the Jumpers

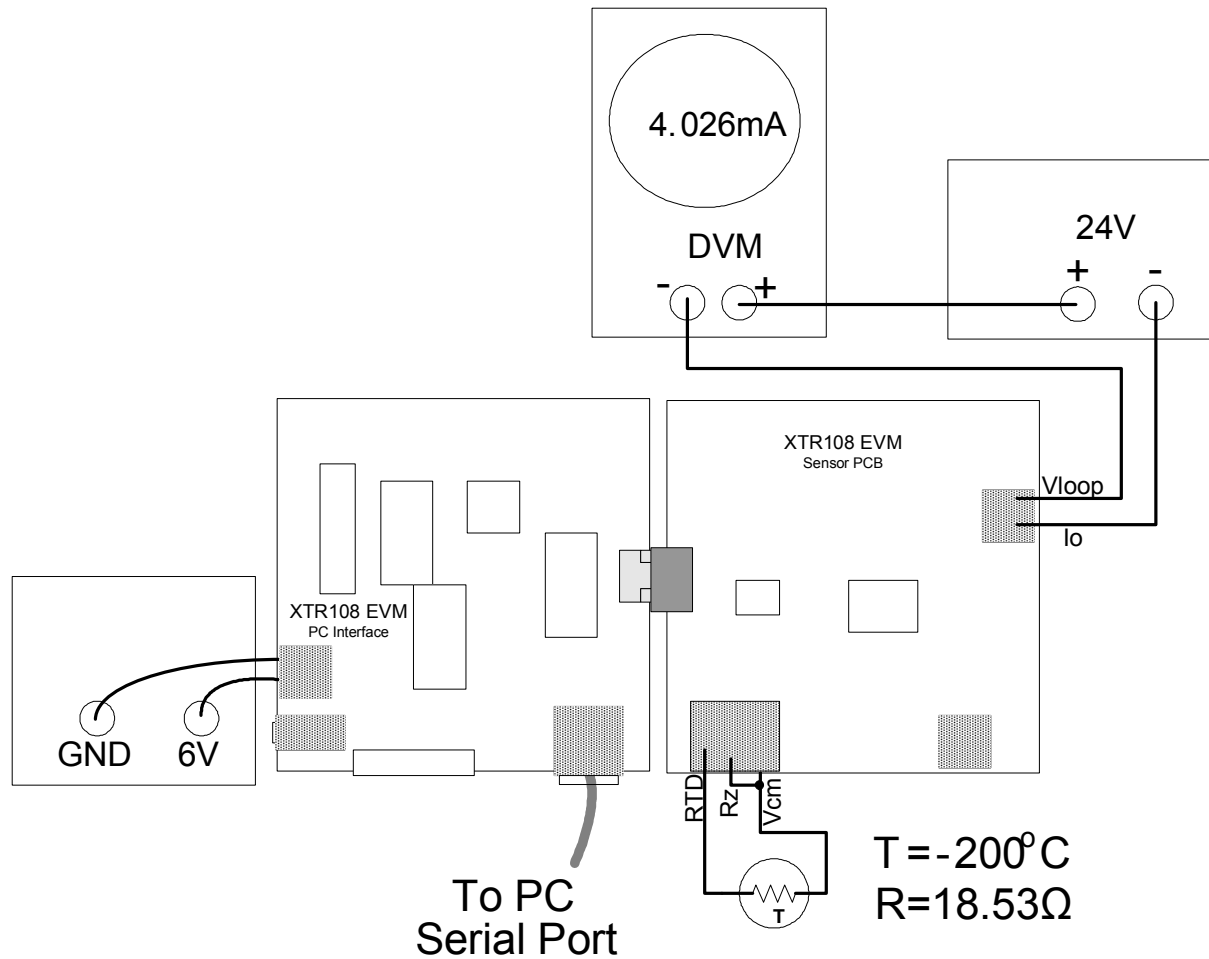


The table below and the figure illustrate the jumper settings for current output mode calibration.

<i>XTR108 Sensor Interface Board – Factory Jumper Settings</i>		
<b>Jumper</b>	<b>Position</b>	
JUMP1	Iout	Use current output mode
JUMP2	FET	Use FET Subregulator
JUMP3	FET	Use FET Subregulator
JUMP4	Iout	Use current output mode
JUMP5	Iout	Use current output mode
JUMP6	No Load	Do not connect load to Voltage Output
JUMP7	Bypass	Bypass Voltage Mode Charge Pump



# Connect the power



# Example Calibration: Step by Step Calibration Enter The Resistor Values



Note that the values of the resistors computed in the find resistors tab are automatically copied to the calibration tab. Resistors can be entered manually if you are not using the Find Resistors feature.

Results – Install These Resistors

Rz1	18.7	ohms	Rset	12100	ohms
Rz2	100	ohms	Rlin	30900	ohms
Rz3	100	ohms	Rcm	475	ohms
Rz4	78.7	ohms			
Rz5	110	ohms			

# Example Calibration: Enter the temperature range and Press “Step1: Initial Calculation”.



Enter the RTD resistance at 0 degC.

Enter the temperature range that you want to calibrate over.

Press “Step 1: Initial Calculation”. This will calculate register values for the XTR108 (e.g. the MUX channel, gain, Iref).

Press “Write XTR” and “Write EEPROM”. This will copy all the calculated register values into the XTR108 and into the EEPROM.

# Example Calibration: The Callendar-Van Dusen Coefficients are taken from the table in the “Find Resistors” Tab



Registers 10,11,12,13,14,15

RTD ohms @ 0 degC  
100

Step 1: Initial Calculations

Temp deg C Current

Min -200 4 ma

Max 850 20 ma

Step 2: First Correction

At Min Temp At Max Temp

0 ma 0 ma

Step 3: 2nd Correction

At Max Temp ma

Step 1: Initial Calculation Write XTR

Step 2: Corrections Write EEPROM

Step 3: 2nd Correction Reset Calibration

struments XTR108-EVM Application

Setup View Help

Registers 0,3,4,5 Calibration

Registers 6,7,8,9 Summary

Registers 10,11,12,13,14,15 Find Resistors

RTD Type & Temp Range

RTD Type (Ohms)	Min Temp (degC)	Max Temp (degC)	A	B	C
100	-200	850	3.9083E-3	-5.7750E-7	-4.1835E-12
100	0	400	3.9083E-3	-5.7750E-7	-4.1835E-12
100	0	125	3.9083E-3	-5.7750E-7	-4.1835E-12
100	-55	125	3.9083E-3	-5.7750E-7	-4.1835E-12
100	25	75	3.9083E-3	-5.7750E-7	-4.1835E-12

Enter – Callendar-Van Dusen Coefficients

Reset to PT100

Note: Enter 0 under RTD Type for unused channels.

General Info

Results – Install These Resistors

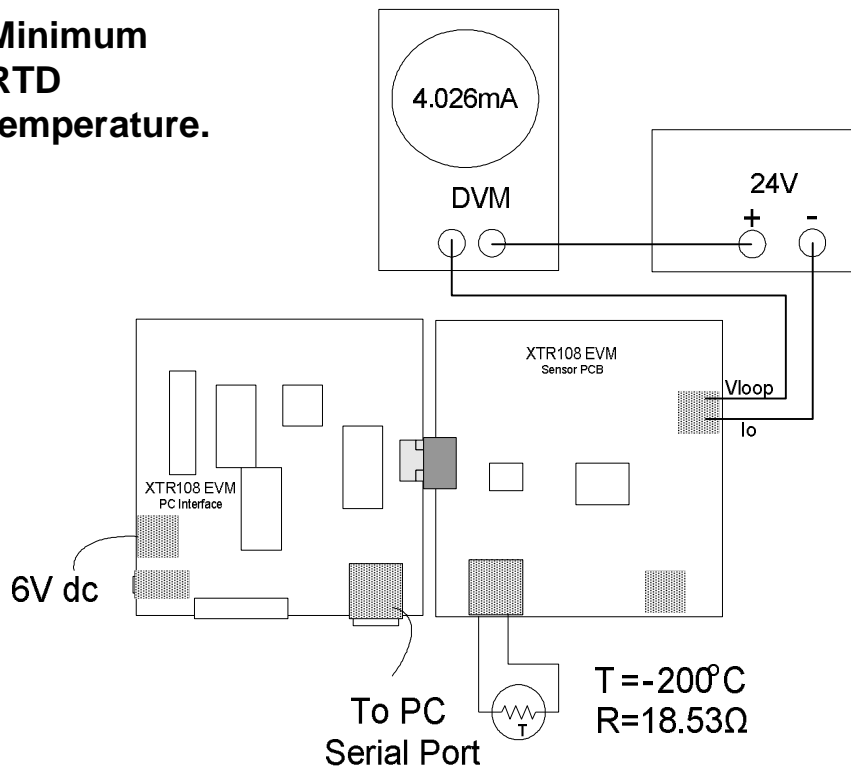
RTD Type	Value	Unit	Rset	Value	Unit
Current	100	ohms	Rset	0	ohms
6340	200	ohms	Rlin	0	ohms
20	300	ohms	Rcm	0	ohms

Calculate Results

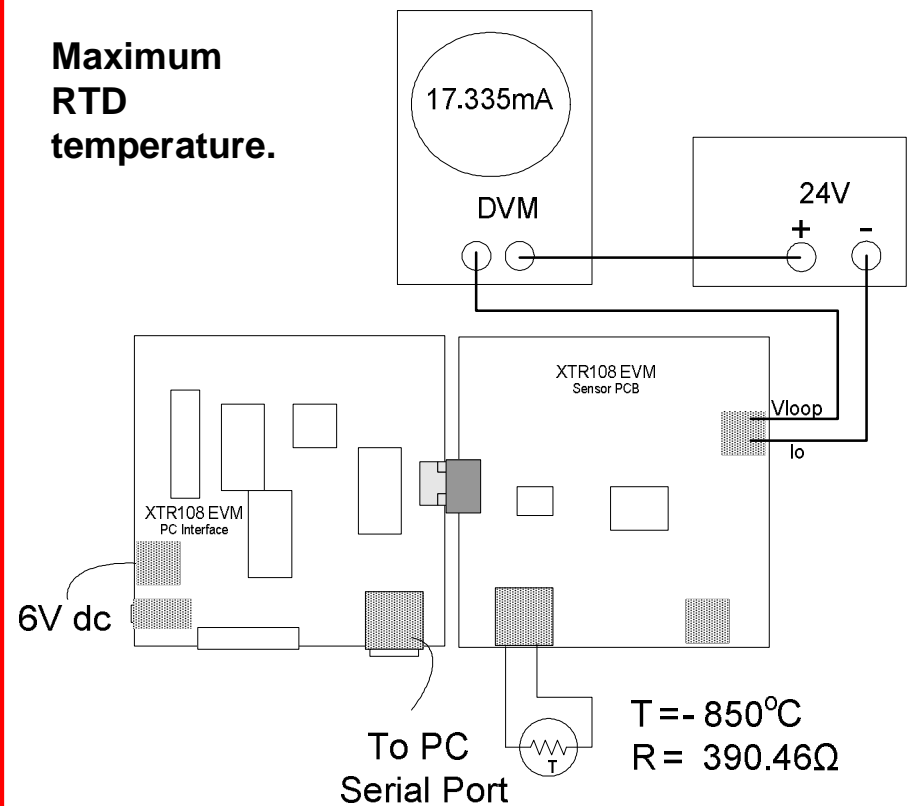
# Measure the Output

After the “Step 1: Initial Calculation” results are written into the XTR108, you will need to read the output at minimum and maximum RTD temperature. Note that linearity correction is turned off during this step and so, you should not expect to see an accurate 4mA to 20mA.

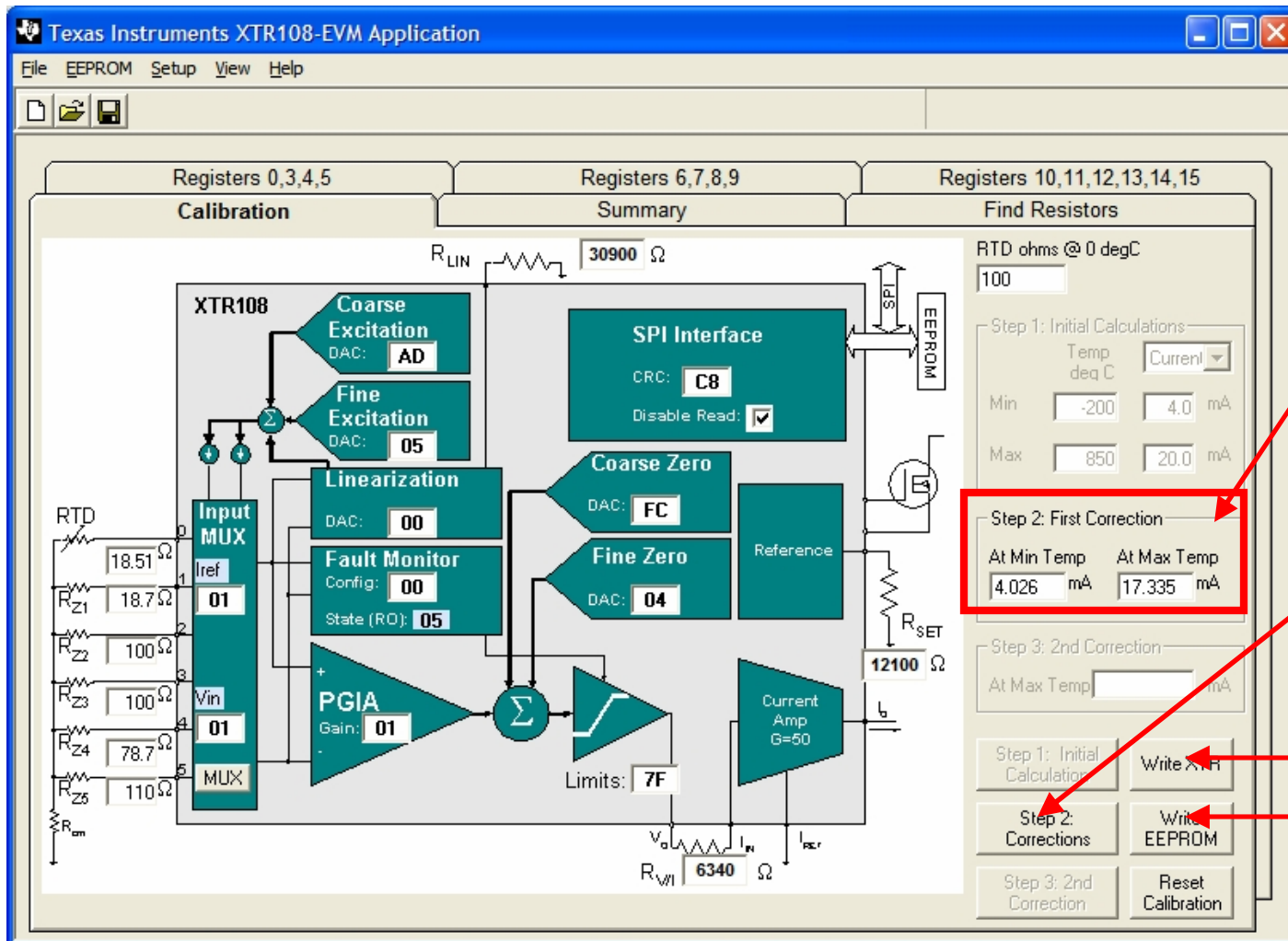
**Minimum  
RTD  
temperature.**



**Maximum  
RTD  
temperature.**



# Example Calibration: Enter First Correction

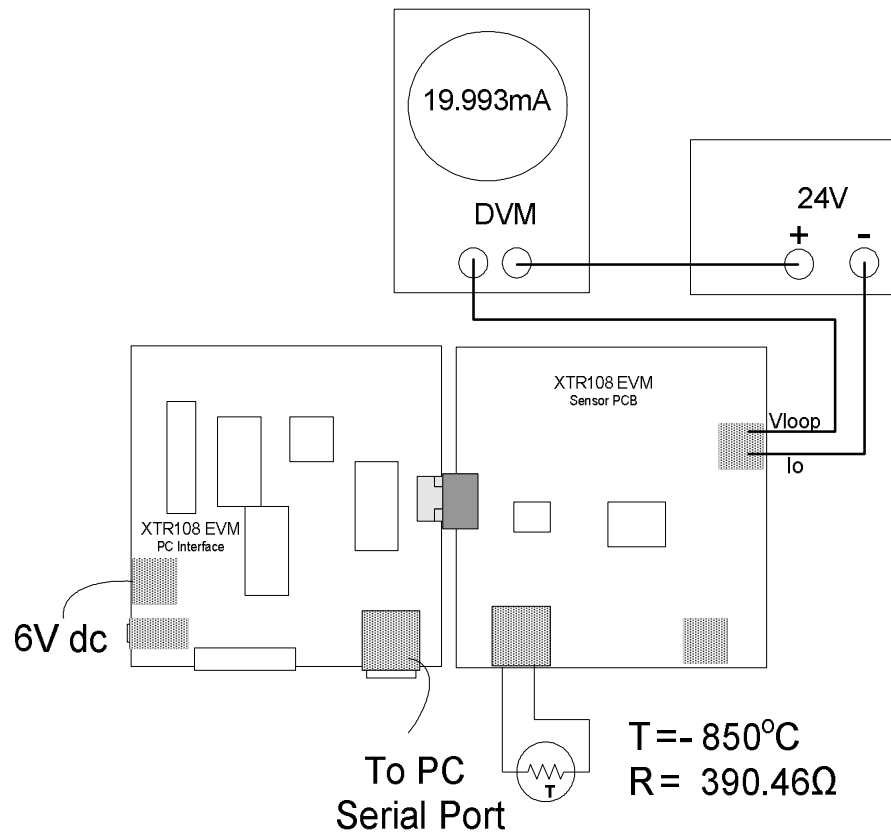


Enter the current measurements at min and max temperature.

Press "Step 2: Corrections" to calculate minor corrections in the register values.

Press "Write XTR" and "Write EEPROM". This will copy all the calculated register values into the XTR108 and into the EEPROM.

# Measure the Output at Full Scale to Correct for Linearity DAC Errors



# Measure the Output at Full Scale to Correct for Linearity DAC Errors

**Registers 0,3,4,5 Calibration**

**Registers 6,7,8,9 Summary**

**Registers 10,11,12,13,14,15 Find Resistors**

RTD ohms @ 0 degC: 100

Step 1: Initial Calculations

Temp deg C	Current
Min: -200	4.0 mA
Max: 850	20.0 mA

Step 2: First Correction

At Min Temp	At Max Temp
4.026 mA	17.335 mA

Step 3: 2nd Correction

At Max Temp	19.933 mA
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Buttons: Step 1: Initial Calculation, Step 2: Correction, Step 3: 2nd Correction, Write XTR, Write EEPROM, Reset Calibration



# Calibrating the Over/Under Scale

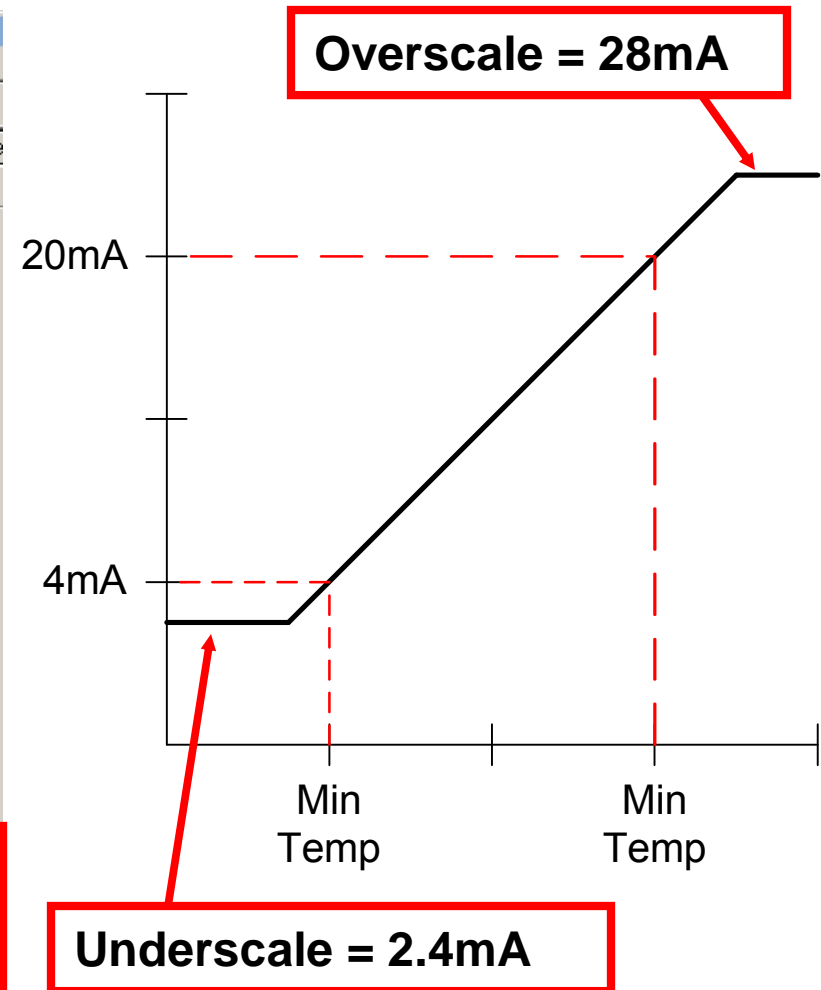
Texas Instruments XTR108-EVM Application

File EEPROM Setup View Help

Summary Find Resistors Calibration Error Calculator **Reg 0, 3, 4, 5** Re

XTR Registers 0,3,4,5

	D7	D6	D5	D4	D3	D2	D1	D0	HEX
<b>Reg 0: Control Register 1</b>	RST False	Chksum Err False	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	
	0	0	0	0	0	0	0	0	00
<b>Reg 3: Fault Status</b>	Reserved	Reserved	Reserved	Reserved	NONE				
	0	0	0	0	0	0	0	0	00
<b>Reg 4: Control Register 2</b>	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Single EE Read	
	0	0	0	0	0	0	0	1	01
<b>Reg 5: Over/Under Scale</b>	FD Enable	Vo Undrth 300mV	Io Undrth-Rvi=6.25kohm 2.4mA	Vo Ovrth 3.5V	Io Ovrth-Rvi=6.25kohm 28.0mA				
	0	1	1	1	1	1	1	1	7F



The underscale, and overscale is a programmable limit for the min and maximum value of the XTR108.

# Calibrating the Over/Under Scale



Texas Instruments XTR108-EVM Application

File EEPROM Setup View Help

Summary Find Resistors Calibration Error Calculator **Reg 0, 3, 4, 5** Reg 6 - 9 Reg 10 - 15

XTR Registers 0,3,4,5

	D7	D6	D5	D4	D3	D2	D1	D0	HEX
<b>Reg 0: Control Register 1</b>	RST False	Chksum Err False	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	
	0	0	0	0	0	0	0	0	00
<b>Reg 3: Fault Status</b>									
<b>Reg 4: Control Register 2</b>								Read	
	0	0	0	0	0	0	0	1	01
<b>Reg 5: Over/Under Scale</b>	FD Enable	Vo Undrth 300mV	Io Undrth-Rvi=6.25kohm 2.4mA	Vo Ovrth 3.5V	Io Ovrth-Rvi=6.25kohm 28.0mA				
	0	1	1	1	1	1	1	1	7F

The XTR108 overscale and underscale limits are set to maximum (2.4mA, 28mV) during calibration. This prevents the overscale and underscale limits from affecting any calibration results.

Write Reg 0

Write XTR

Write EEPROM

Calibrate Over/ Under

# Calibrating the Over/Under Scale



Texas Instruments XTR108-EVM Application

File EEPROM Setup View Help

Summary Find Resistors Calibration Error Calculator **Reg 0, 3, 4, 5** Reg 6 - 9 Reg 10 - 15

XTR Registers 0,3,4,5

	D7	D6	D5	D4	D3	D2	D1	D0	HEX
<b>Reg 0: Control Register 1</b>	RST False	Chksum Err False	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	
	0	0	0	0	0	0	0	0	00
<b>Reg 3: Fault Status</b>									00
<b>Reg 4: Control Register 2</b>	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Single EE Read	
	0	0	0	0	0	0	0	1	01
<b>Reg 5: Over/Under Scale</b>	FD Enable	Vo Undrth 300mV	Io Undrth-Rvi=6.25kohm 2.4mA	Vo Ovrth 3.5V	Io Ovrth-Rvi=6.25kohm 28.0mA				
	0	1	1	1	1	1	1	1	7F

Write Reg 0

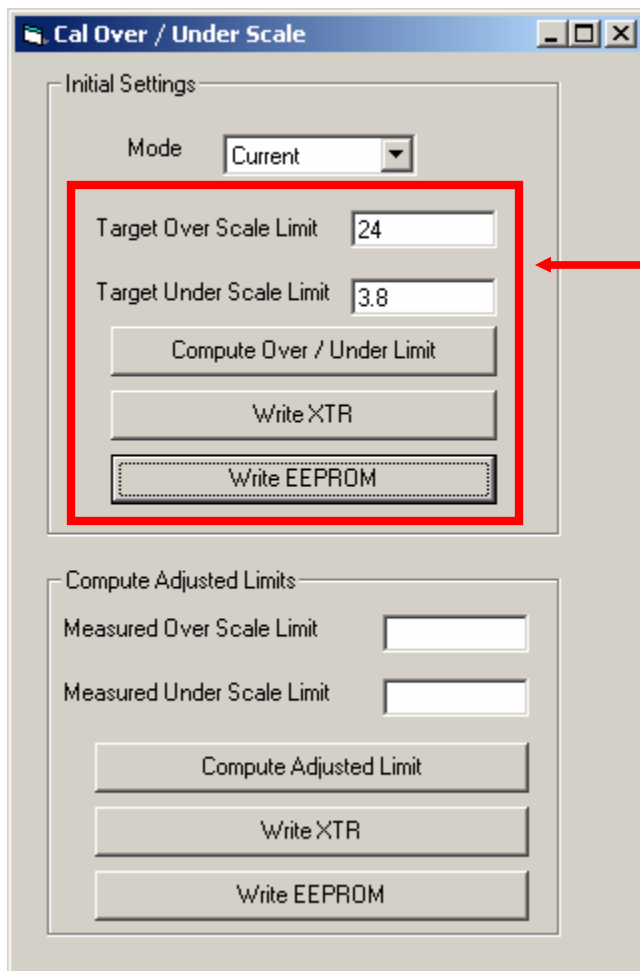
Write XTR

Write EEPROM

Calibrate Over/ Under

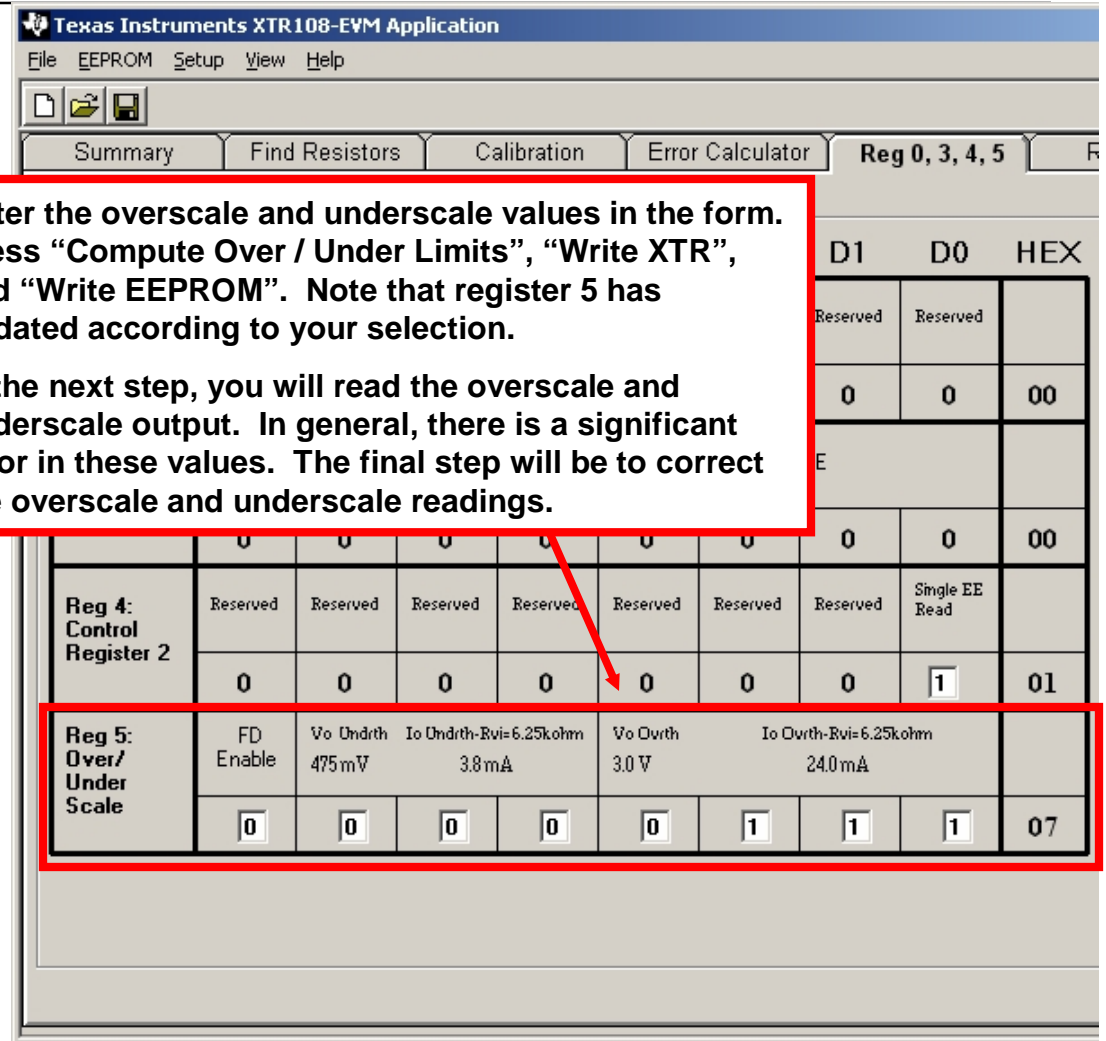
The absolute accuracy of the overscale and underscale limits is not very good. An calibration is required get accurate settings.

# Calibrating the Over/Under Scale



Enter the overscale and underscale values in the form. Press “Compute Over / Under Limits”, “Write XTR”, and “Write EEPROM”. Note that register 5 has updated according to your selection.

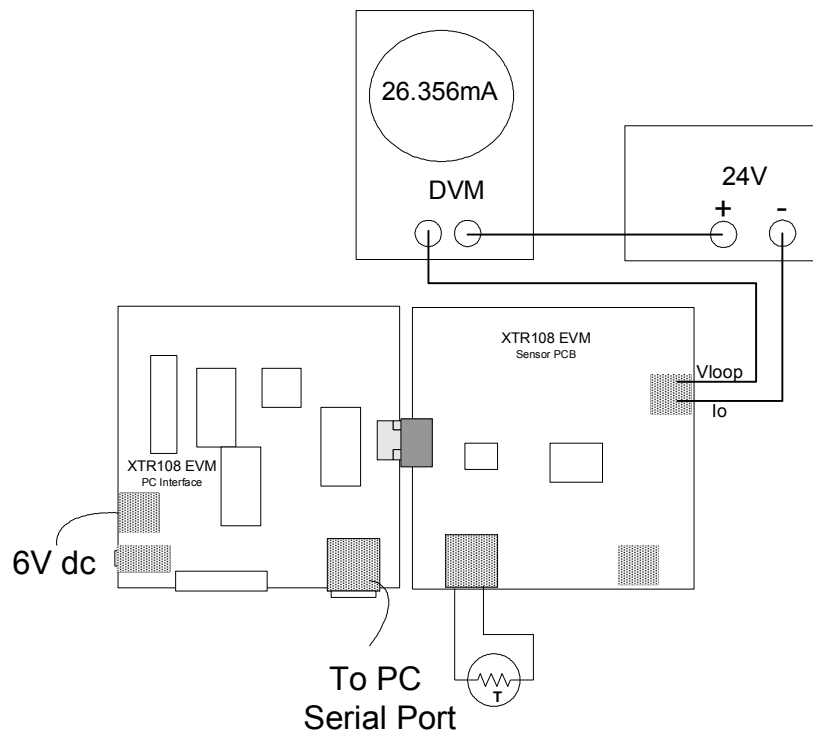
In the next step, you will read the overscale and underscale output. In general, there is a significant error in these values. The final step will be to correct the overscale and underscale readings.



	D1	D0	HEX
Reserved	Reserved		
0	0		00
E			
0	0		00
Reg 4: Control Register 2	Reserved	Reserved	Reserved
	0	0	00
Reg 5: Over/Under Scale	FD Enable	Vo Undrth 475mV	Io Undrth-Rvi=6.25kohm 3.8mA
	0	0	00
	Vo Ovrth 3.0V	Io Ovrth-Rvi=6.25kohm 24.0mA	
	0	1	01
	1	1	03
	1	1	07

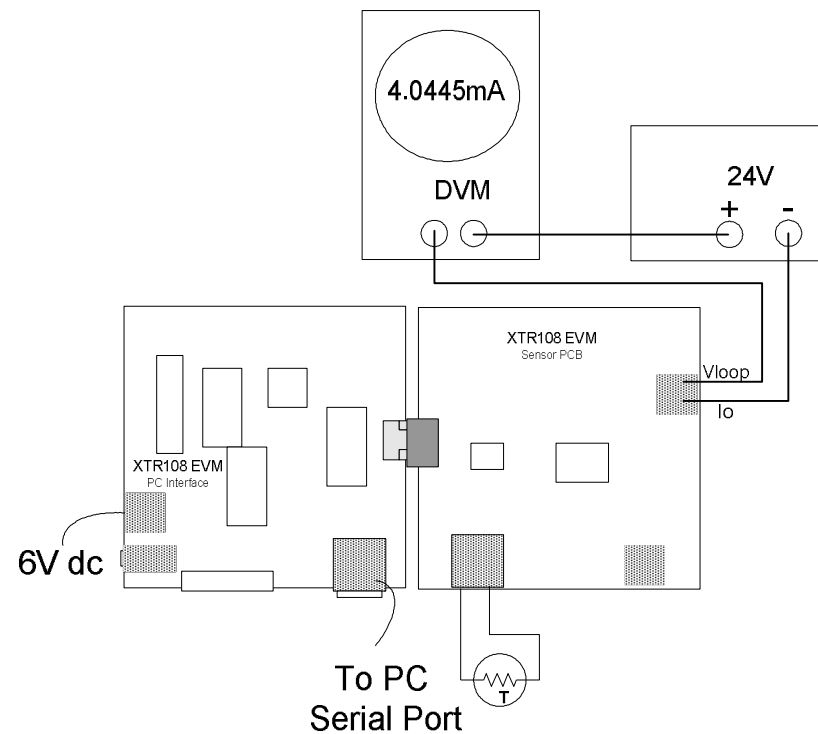
# Calibrating the Over/Under Scale

## Read Overscale



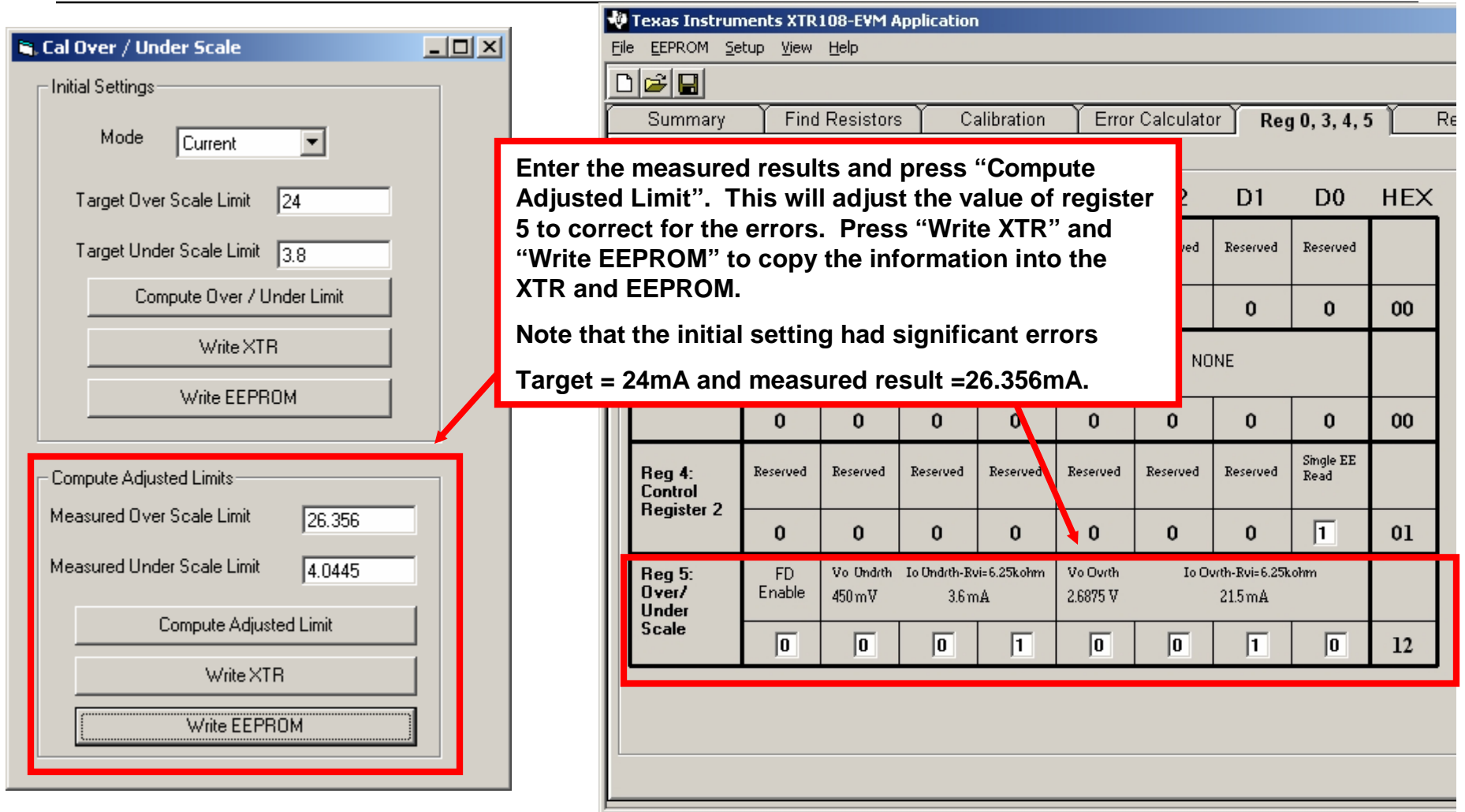
**Set RTD to Overscale Value**

## Read Underscale



**Set RTD to Underscale Value**

# Calibrating the Over/Under Scale



**Cal Over / Under Scale**

Initial Settings

Mode:

Target Over Scale Limit:

Target Under Scale Limit:

---

**Compute Adjusted Limits**

Measured Over Scale Limit:

Measured Under Scale Limit:

---

**Texas Instruments XTR108-EVM Application**

File EEPROM Setup View Help

Summary Find Resistors Calibration Error Calculator **Reg 0, 3, 4, 5**

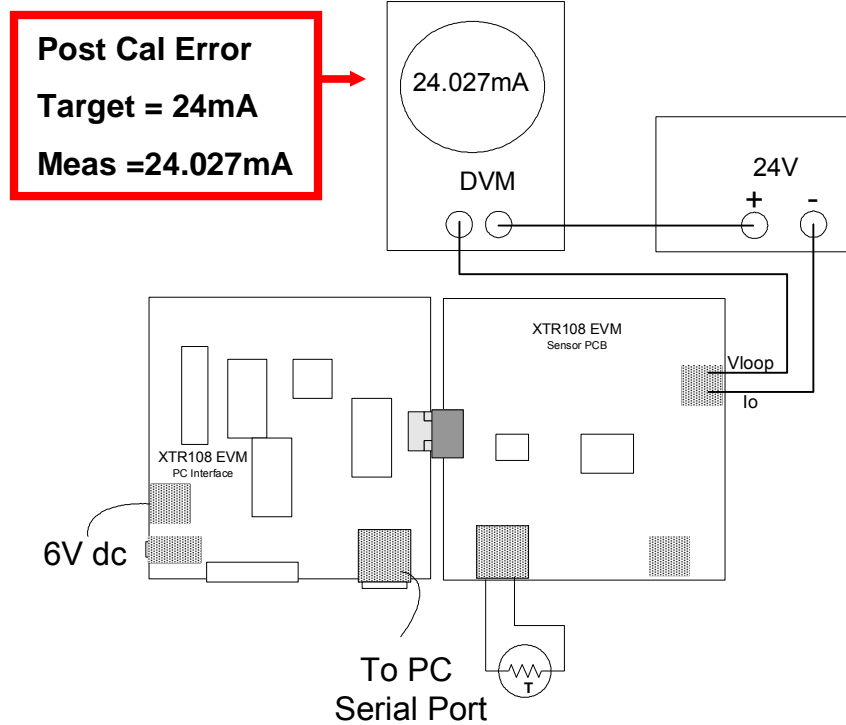
	D7	D6	D5	D4	D3	D2	D1	D0	HEX
Reg 0	0	0	0	0	0	0	0	0	00
Reg 1	0	0	0	0	0	0	0	0	00
Reg 2	0	0	0	0	0	0	0	0	00
Reg 3	0	0	0	0	0	0	0	0	00
Reg 4: Control Register 2	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Single EE Read	
	0	0	0	0	0	0	0	1	01
Reg 5: Over/Under Scale	FD Enable	Vo Undrth 450 mV	Io Undrth-Rvi=6.25kohm 3.6 mA	Vo Ovrth 2.6875 V	Io Ovrth-Rvi=6.25kohm 21.5 mA				
	0	0	0	1	0	0	1	0	12

**Enter the measured results and press "Compute Adjusted Limit". This will adjust the value of register 5 to correct for the errors. Press "Write XTR" and "Write EEPROM" to copy the information into the XTR and EEPROM.**

**Note that the initial setting had significant errors  
Target = 24mA and measured result =26.356mA.**

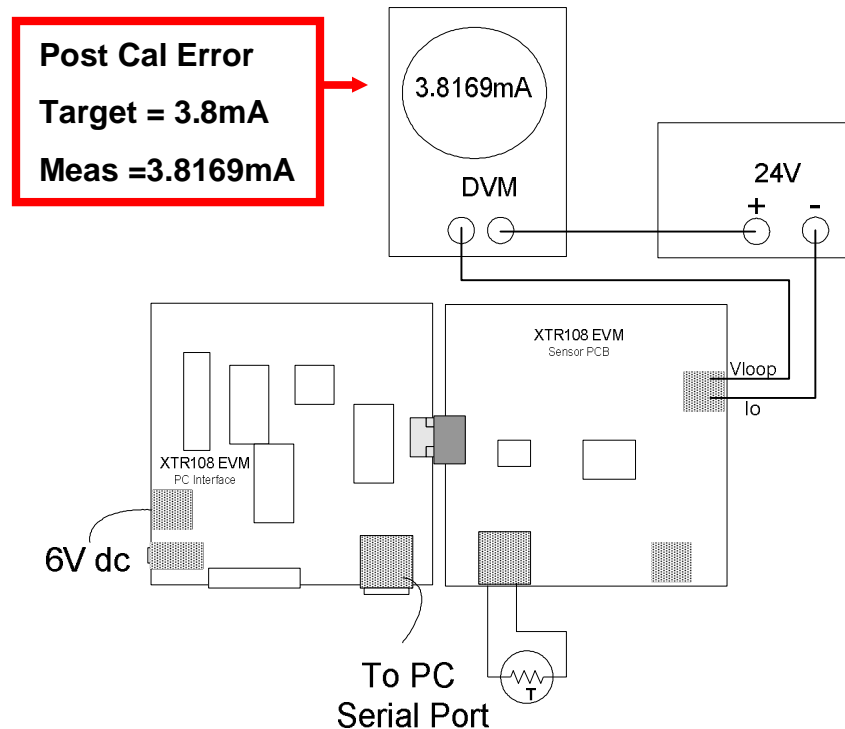
# Calibrating the Over/Under Scale

## Read Corrected Overscale



**Set RTD to Overscale Value**

## Read Corrected Underscale

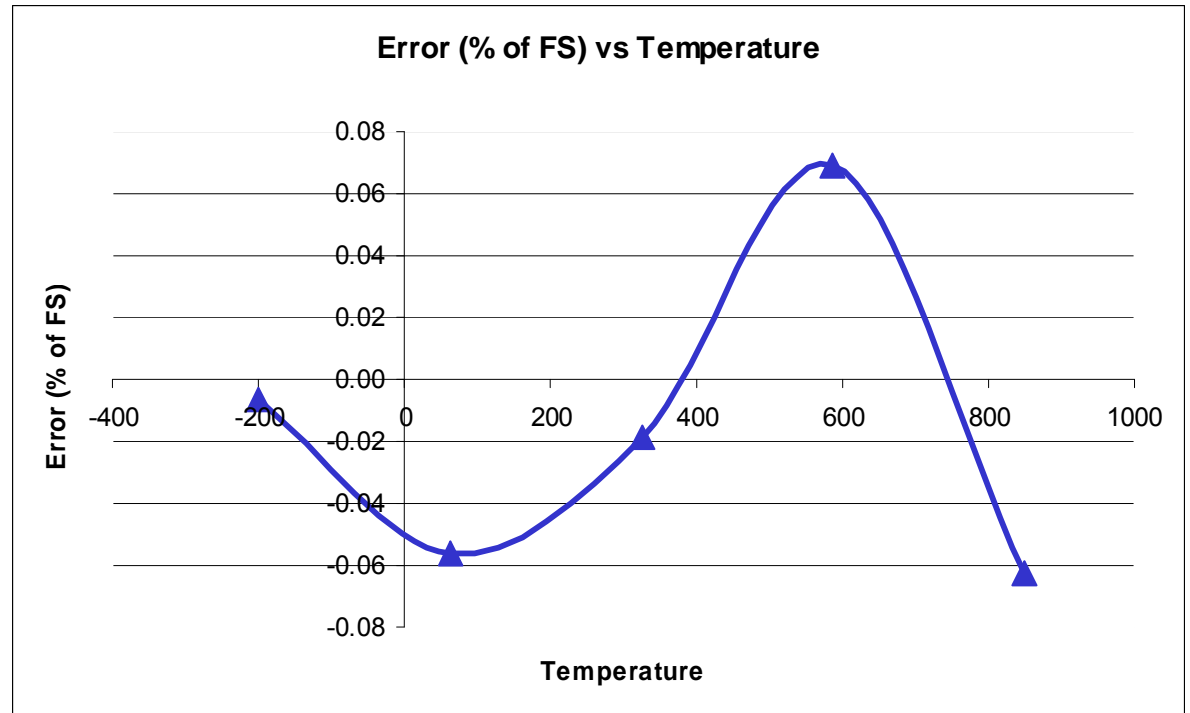


**Set RTD to Underscale Value**

# Example Calibration Done: Post Calibration Error is less than 0.1%



Temp	I_meas	I_ideal	error (%)
-200	4.00	4.00	-0.01
62.5	7.99	8.00	-0.06
325	12.00	12.00	-0.02
587.5	16.01	16.00	0.07
850	19.99	20.00	-0.06





# Example Calibration Done: Post Calibration Error is less than 0.1%



**Error Calculator**

RTD Type:

RTD to Temperature

RTD:  Temp:

Temperature to RTD

Temp:  RTD:

**Error Calculator**

Min Temp:  Min Out:

Max Temp:  Max Out:

Percent	Temp	RTD Val	Ideal Out	Meas Out	Error
<input type="text" value="0"/>	<input type="text" value="-200"/>	<input type="text" value="18.52"/>	<input type="text" value="4"/>	<input type="text" value="4.002"/>	<input type="text" value="0.01"/>
<input type="text" value="25"/>	<input type="text" value="62.5"/>	<input type="text" value="124.20"/>	<input type="text" value="8"/>	<input type="text" value="7.990"/>	<input type="text" value="-0.06"/>
<input type="text" value="50"/>	<input type="text" value="325"/>	<input type="text" value="220.92"/>	<input type="text" value="12"/>	<input type="text" value="12.004"/>	<input type="text" value="0.02"/>
<input type="text" value="75"/>	<input type="text" value="587.5"/>	<input type="text" value="309.68"/>	<input type="text" value="16"/>	<input type="text" value="16.011"/>	<input type="text" value="0.07"/>
<input type="text" value="100"/>	<input type="text" value="850"/>	<input type="text" value="390.48"/>	<input type="text" value="20"/>	<input type="text" value="19.990"/>	<input type="text" value="-0.06"/>

1. Use the "RTD calculator" tab to compute the error.

2. Enter the temperature range and the output range.

3. Press Update table to fill in the Temp, RTD Val, and Ideal Out.

4. Enter the measured output signal and press update table. This will compute the error.

# Example Calibration Done: Post Calibration Error is less than 0.1%



Another useful feature in the “Error Calculator” tab is the “RTD to Temperature” calculator. This converts the RTD value entered to its associated temperature.

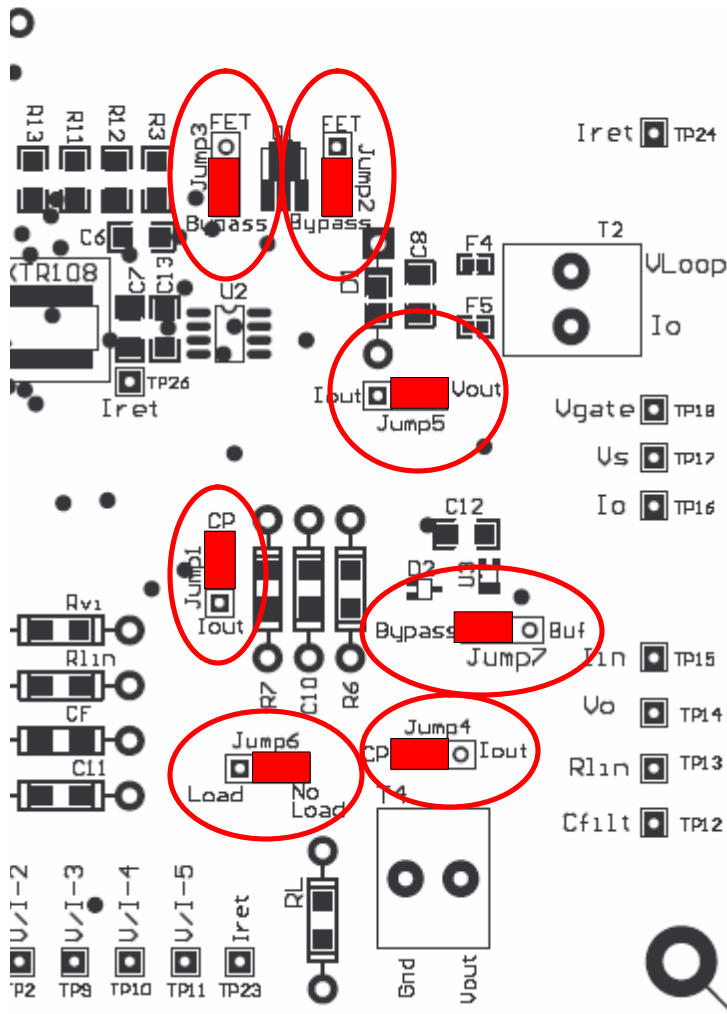
This feature computes RTD values based on temperature.

Percent	Temp	RTD Val	Ideal Out	Meas Out	Error
0					
25					
50					
75					
100					

# Voltage Output Mode Calibration Example

# Voltage Output Mode

## Set the Jumpers



The table below illustrates a typical Voltage output mode jumper configuration. Note that Jump2 and Jump3 are configured so that the sub-regulator is not being used. In this mode, the supply must be adjusted to 5V. Keep in mind that the diode D1 will drop  $V_{loop}$  by approximately 0.7V. It is recommended that a small negative voltage is connected to the input of the XTR108 V/I amplifier when the XTR108 is used in voltage output mode. The jumper configuration shown generates this voltage (-50mV) by connecting a small discrete charge pump to the clock signal. The XTR108 must be put in “continuous EE read mode” (see register 4, D0).

<i>XTR108 Sensor Interface Board – Factory Jumper Settings</i>		
Jumper	Position	
JUMP1	Vout	Use current output mode
JUMP2	Bypass	Bypass FET Sub-regulator
JUMP3	Bypass	Bypass FET Sub-regulator
JUMP4	CP	Use current output mode
JUMP5	Vout	Use current output mode
JUMP6	No Load	Do not connect load to Voltage Output
JUMP7	Bypass	Bypass Voltage Mode Charge Pump

# Voltage Output Mode: Continuous Read Mode to Generate Charge Pump Voltage



1. Set D0 = '0'.
2. Press "Write EEPROM".
3. Press "Write XTR".

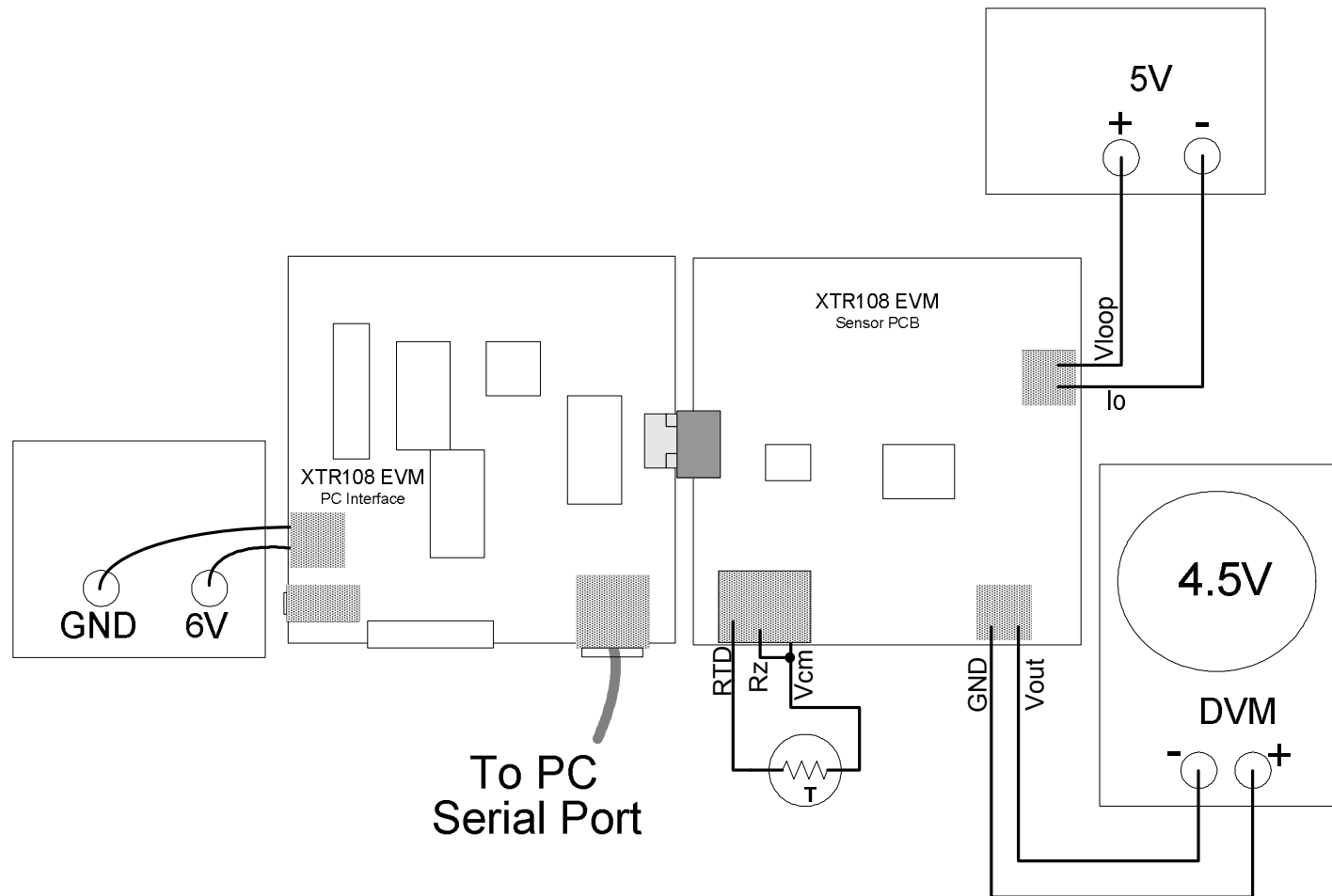
The screenshot shows the Texas Instruments XTR108-EVM Application software interface. The main window displays a table of registers with columns for bits D7 through D0 and a HEX column. The registers are grouped into Calibration (Registers 0,3,4,5), Summary (Registers 6,7,8,9), and Find Resistors (Registers 10,11,12,13,14,15). The table shows the following data:

Register	D7	D6	D5	D4	D3	D2	D1	D0	HEX
Register 1	0	0	0	0	0	0	0	0	00
Reg 3: Fault Status	0	0	0	0	0	1	0	1	00
Reg 4: Control Register 2	0	0	0	0	0	0	0	0	00
Reg 5: Over/Under Scale	0	0	0	0	0	0	0	0	00

On the right side of the interface, there are buttons for "Write Reg 0", "Read XTR", "Write XTR", and "Write EEPROM". A red arrow points from the instruction box to the D0 bit in Register 4, which is currently set to 0.

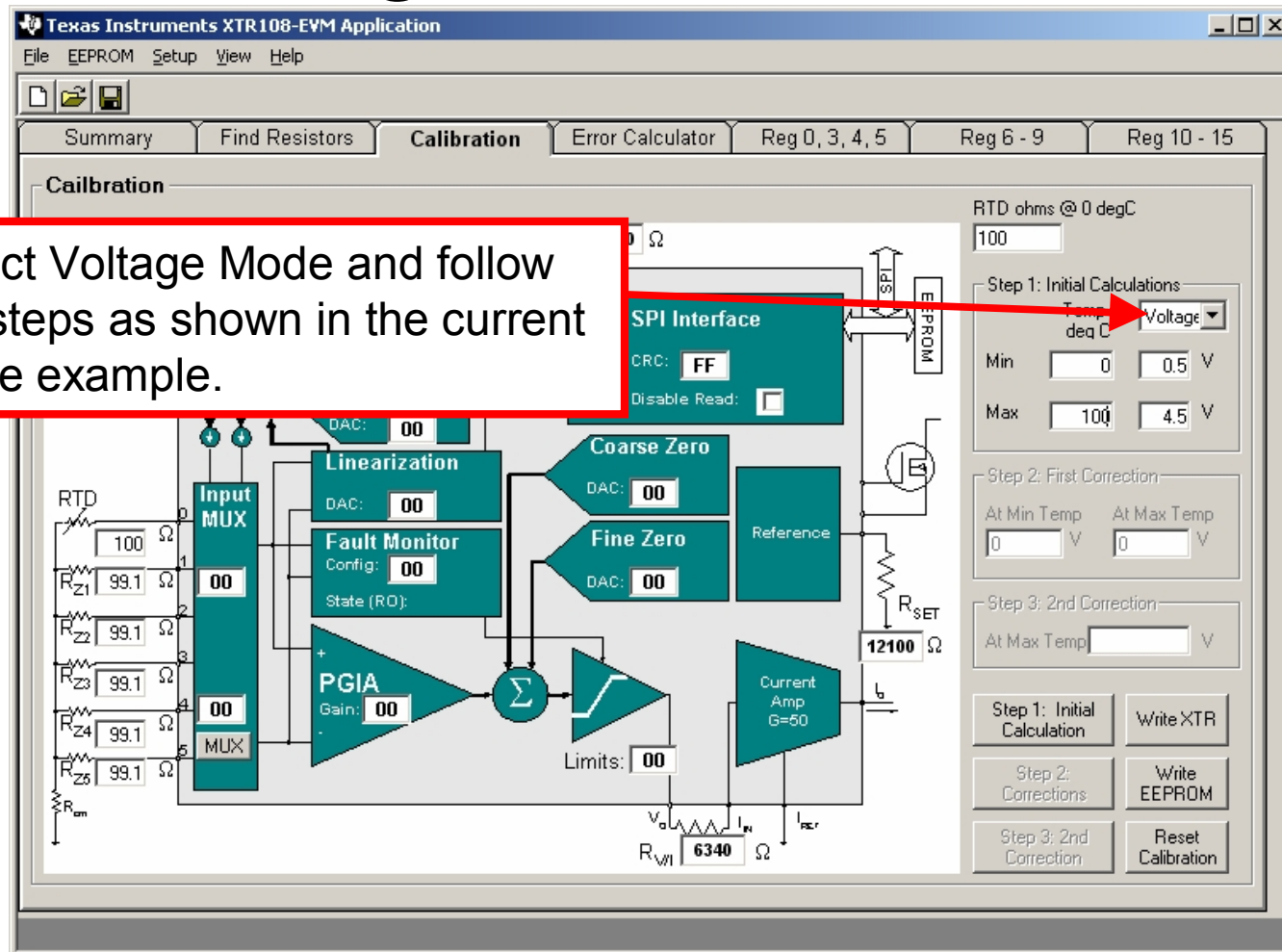
# Voltage Mode

## Connect the power



# Select Voltage Mode

Select Voltage Mode and follow the steps as shown in the current mode example.



The screenshot shows the 'Texas Instruments XTR108-EVM Application' software. The 'Calibration' tab is active, displaying a block diagram of the XTR108 circuit and a configuration panel. The configuration panel includes the following sections:

- RTD ohms @ 0 degC:** 100
- Step 1: Initial Calculations:** Mode set to 'Voltage'. Min: 0 V, Max: 4.5 V.
- Step 2: First Correction:** At Min Temp: 0 V, At Max Temp: 0 V.
- Step 3: 2nd Correction:** At Max Temp: [ ] V.
- Buttons:** Step 1: Initial Calculation, Write XTR, Step 2: Corrections, Write EEPROM, Step 3: 2nd Correction, Reset Calibration.

The block diagram shows the XTR108 circuit with various components and their values:

- Input MUX:** DAC: 00
- Linearization:** DAC: 00
- Fault Monitor:** Config: 00, State (RO): [ ]
- PGIA:** Gain: 00
- Coarse Zero:** DAC: 00
- Fine Zero:** DAC: 00
- Reference:** [ ]
- Current Amp:** G=50
- Limits:** 00
- Resistors:** RTD (100  $\Omega$ ),  $R_{Z1}$  (99.1  $\Omega$ ),  $R_{Z2}$  (99.1  $\Omega$ ),  $R_{Z3}$  (99.1  $\Omega$ ),  $R_{Z4}$  (99.1  $\Omega$ ),  $R_{Z5}$  (99.1  $\Omega$ ),  $R_{Z6}$  (99.1  $\Omega$ ),  $R_{em}$ ,  $R_{SET}$  (12100  $\Omega$ ),  $R_{V1}$  (6340  $\Omega$ ).

# Appendix 1: General Software Information



# Software Note: When Ranges Don't Match the table, Use the Default Coefficients



In some cases you may wish to use the program to calibrate an RTD without using the “Find Resistors” tab. In this case, the program will display the error message shown below. The default Callendar-Van Dusen Coefficients can be entered through the “Setup” menu.

The screenshot shows the 'Texas Instruments XTR108-EVM Application' window. The 'Find Resistors' tab is active, showing a table for RTD Type and Temp Range. A red circle highlights the table and the 'Find Resistors' tab. A dialog box titled 'xtr108' is displayed, containing the following text:

The information you entered for the RTD, and Temperature Range don't match the table under the 'find resistors' tab. The default Callendar-Van Dusen Coefficients will be used.

The background window shows the 'Find Resistors' tab with the following table:

RTD Type (Ohms)	Min Temp (degC)	Max Temp (degC)	A	B	C
100	-200	850	3.9083E-3	-5.7750E-7	-4.1835E-12
100	0	400	3.9083E-3	-5.7750E-7	-4.1835E-12
100	0	125	3.9083E-3	-5.7750E-7	-4.1835E-12
100	-55	125	3.9083E-3	-5.7750E-7	-4.1835E-12
100	25	75	3.9083E-3	-5.7750E-7	-4.1835E-12

The 'Find Resistors' tab also shows a table for 'RTD ohms @ 0 degC' with values 100, -55, and 150. The 'Step 1: Initial Calculations' section shows 'Temp deg C' set to 4.0 and 'Current mA' set to 20.0. The 'Step 2: First Correction' section shows 'At Max Temp' set to 0 mA. The 'Step 3: 2nd Correction' section shows 'At Max Temp' set to 0 mA. The 'Write XTR' and 'Write EEPROM' buttons are visible.

# Calibration Note: When Ranges Don't Match the table, Use the Default Coefficients



The "Enter Callendar-Van Dusen Coefficients" option under "Setup" allows you to change the default coefficients.

The default coefficients that the software uses is for a PT100 RTD. The "Enter Callendar-Van Dusen Coefficients" option under "Setup" allows you to change the coefficients.

Registers 6,7,8,9      Registers 10,11,12,13,14,15

Callendar-Van Dusen Coefficients		
	B	C
	-5.7750E-7	-4.1835E-12
	-5.7750E-7	-4.1835E-12
	-5.7750E-7	-4.1835E-12
	-5.7750E-7	-4.1835E-12
	-5.7750E-7	-4.1835E-12

Reset to PT100

Enter - RTD Type & T...  
Chan. RTD Type (Ohms)  
1 100  
2 100  
3 100  
4 0  
5 0  
Note: Enter 0 u unused channel

Enter - General Info  
Mode Current  
Rvi 6340 Ohm  
Imax 20 mA  
Imin 4 mA  
Rz2 100 ohms  
Rz3 100 ohms  
Rz4 78.7 ohms  
Rz5 110 ohms  
Rset 12100 ohms  
Rlin 30900 ohms  
Rcm 475 ohms

Calculate Results

# Software Note: Reset to Default



The XTR108EVM Software “remembers” the resistor values, temperature ranges, and Callendar-Van Dusen Coefficients after it has been shut down. If you want to reset it to the default values that it had when it was installed, you can use this option.

The screenshot shows the 'Texas Instruments XTR108-EVM Application' software. The 'Setup' menu is open, with 'Reset to Default Values' selected. The main interface displays a circuit diagram of the XTR108 with various DACs and registers. A 'Find Resistors' panel on the right shows RTD ohms @ 0 degC set to 100, and temperature range settings (Min: -55, Max: 150) and current settings (4.0 mA, 20.0 mA).

# Software Note:

## DC to DC Converter.

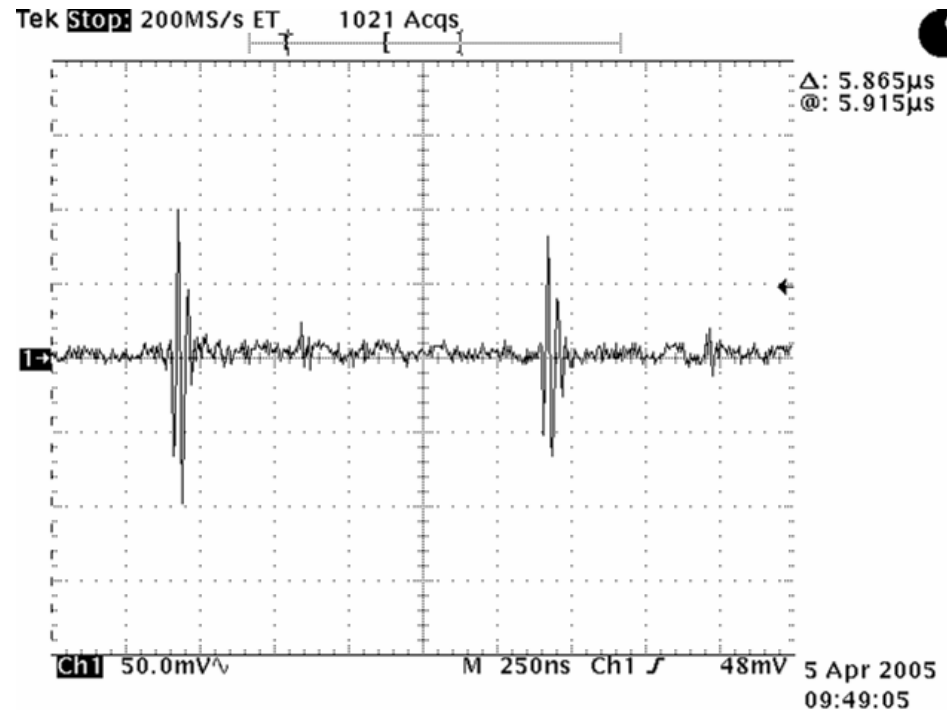


The XTR108EVM Hardware uses a DC to DC converter to isolate the digital communications section on the PC Interface PCB. The DC to DC converter is very noisy, and consequently, it is only turned on during communications. This mode will turn on the supply continuously. This mode is not recommended for normal operation, but may be useful for debug.

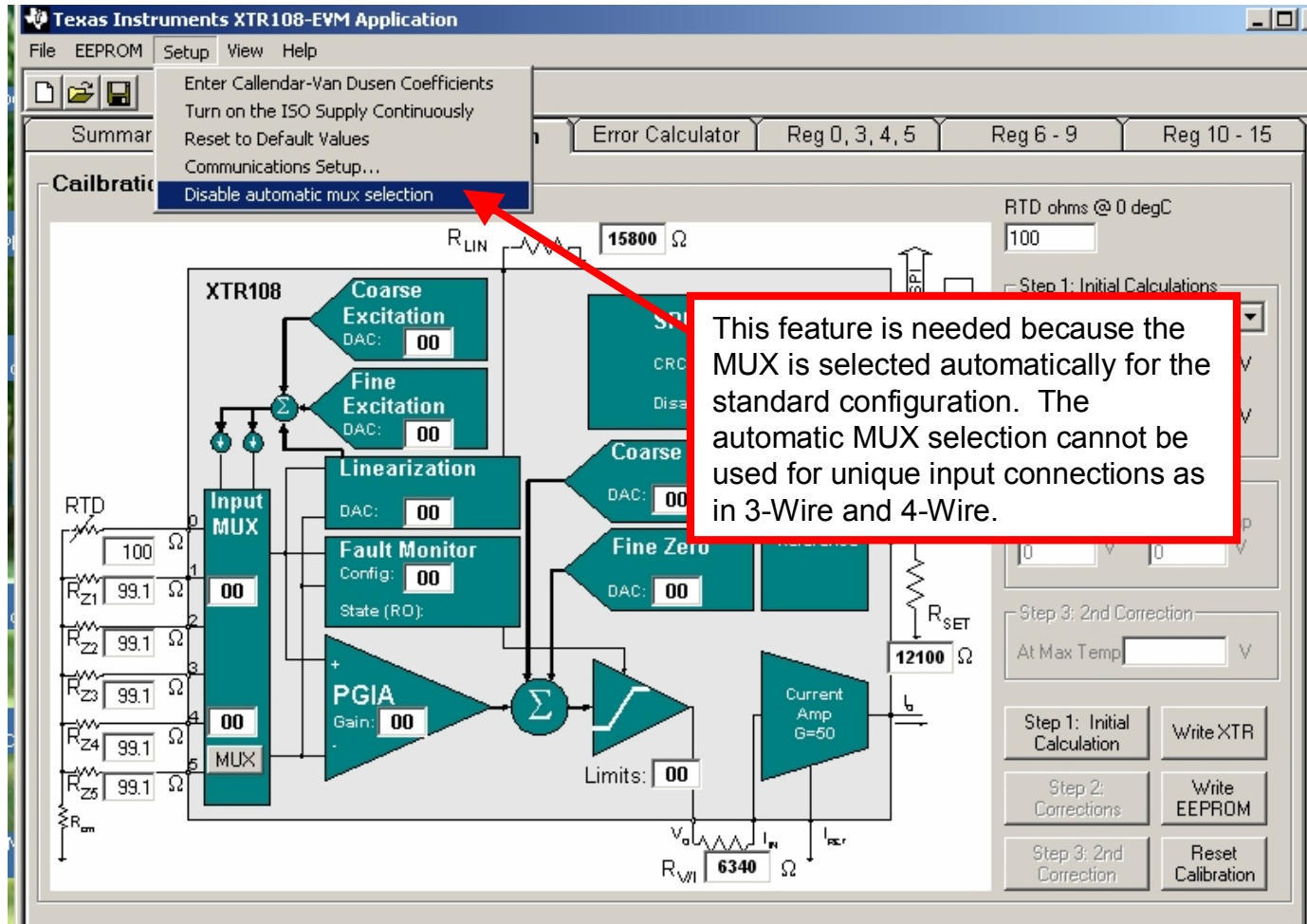
# Noise from the DCR010505P



This scope shot illustrates the noise at the output of the DC/DC Converter (DCR01505P on the PC Interface Board) when turned on.

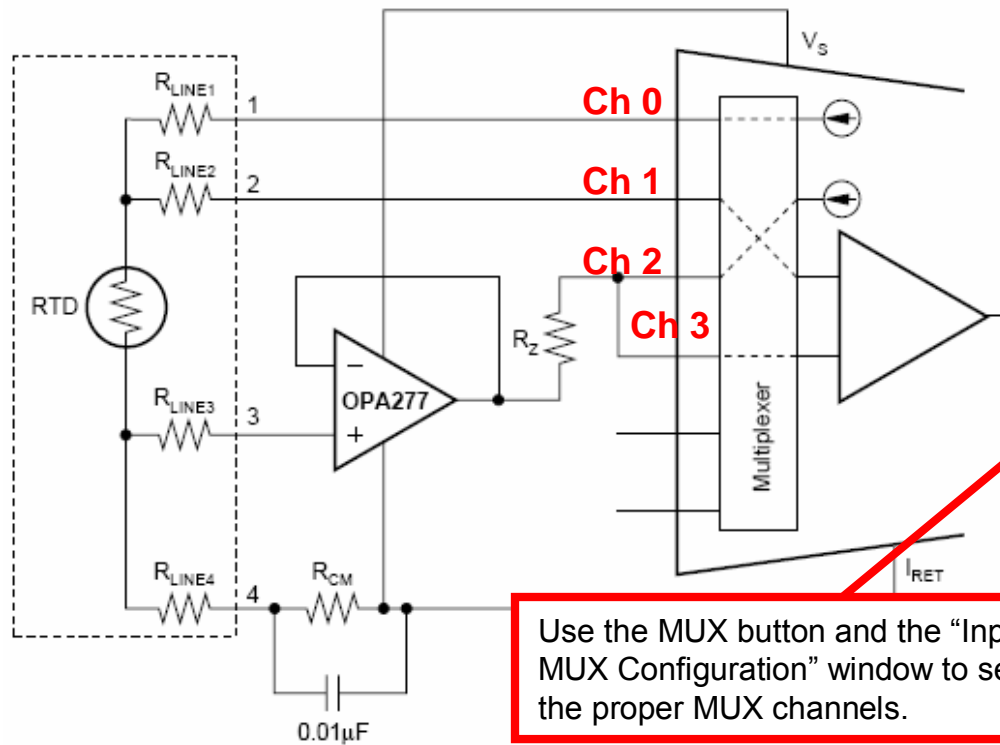


# Unique MUX Setup: 3-Wire and 4-Wire



This feature is needed because the MUX is selected automatically for the standard configuration. The automatic MUX selection cannot be used for unique input connections as in 3-Wire and 4-Wire.

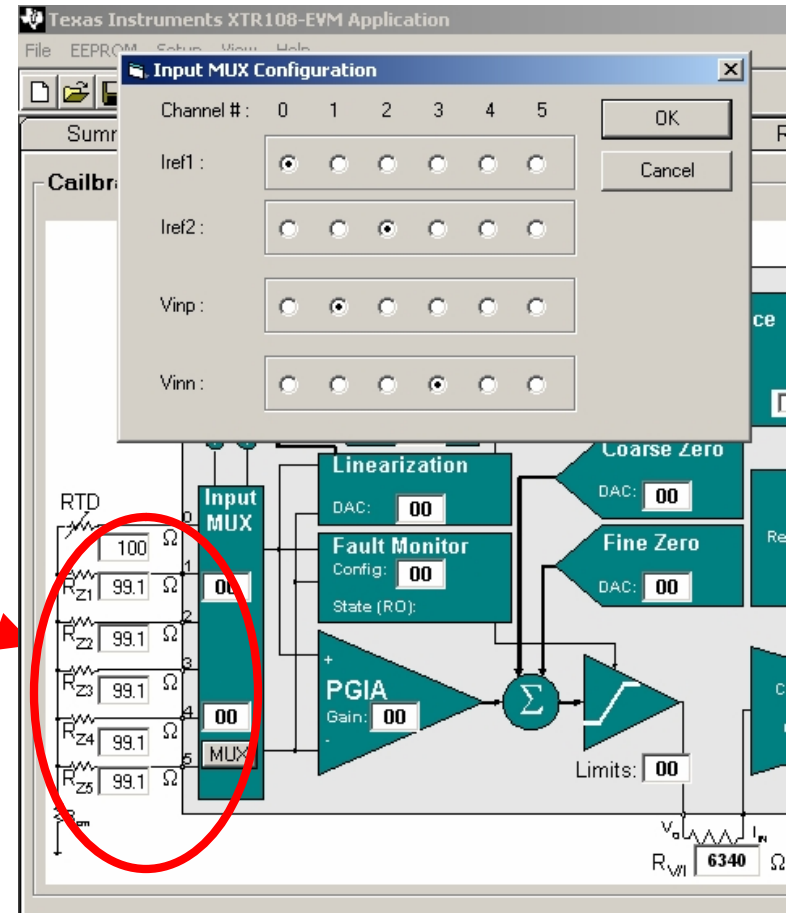
# 4 – Wire Manually Select Channels





# Rz Selection with Automatic MUX Selection Off

When automatic MUX selection is off, you must enter the same value for all values of Rz. This forces Rz to be the correct value regardless of the MUX channel used.





# Appendix 2: Equations Used in Software

## Step 1: Calculate Initial XTR108 Settings

# RTD resistance as a function of Temperature in deg C



$$A_0 := 3.908310^{-3} \quad R_0 := 100$$

$$B_0 := -5.77510^{-7}$$

$$C_0 := -4.18310^{-12}$$

$$\text{RTD}(T) := \begin{cases} R_0 \cdot \left[ 1 + A_0 \cdot T + B_0 \cdot T^2 + C_0 \cdot (T - 100) \cdot T^3 \right] & \text{if } T < 0 \\ R_0 \cdot \left( 1 + A_0 \cdot T + B_0 \cdot T^2 \right) & \text{otherwise} \end{cases}$$

# Enter Temperature Range / Select Rz



Choose Temperature range

$$T_{\min} := -2.3$$

$$T_{\max} := 100$$

$$T_{\text{mid}} := \frac{T_{\max} + T_{\min}}{2} \quad T_{\text{mid}} = 48.85$$

Calculate RTD at T<sub>min</sub>, T<sub>mid</sub>, T<sub>max</sub>

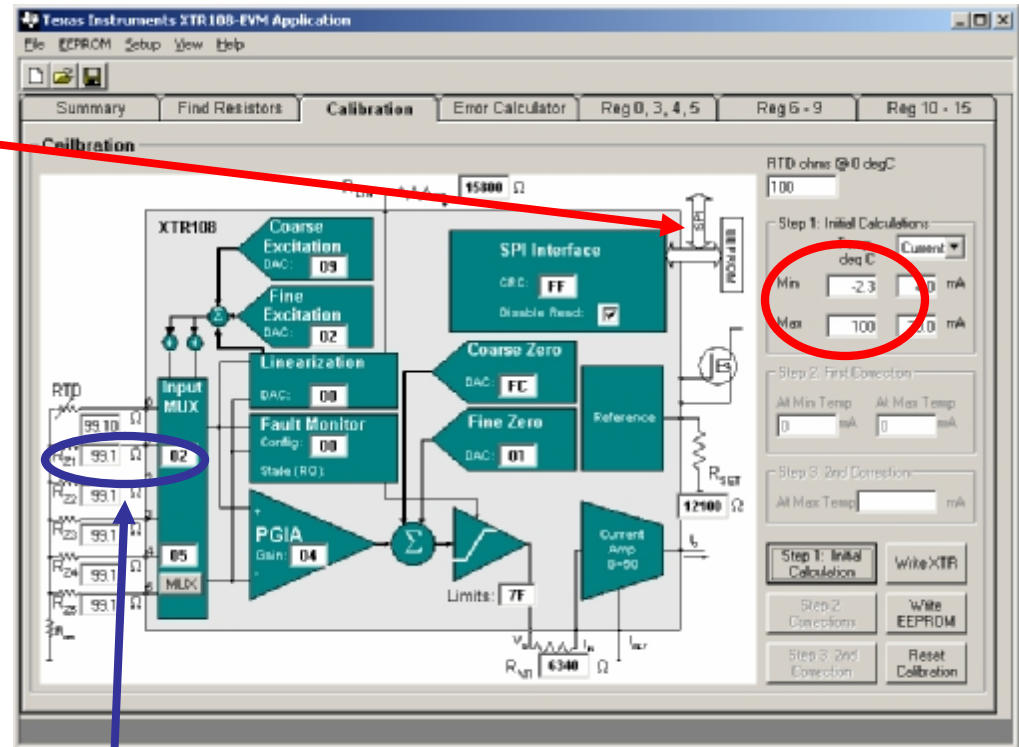
$$RTD_{\min} := RTD(T_{\min}) \quad RTD_{\min} = 99.101$$

$$RTD_{\text{mid}} := RTD(T_{\text{mid}}) \quad RTD_{\text{mid}} = 118.954$$

$$RTD_{\max} := RTD(T_{\max}) \quad RTD_{\max} = 138.505$$

Choose R<sub>z</sub> as closest standard value.

$$R_z := 99.1$$



# Compute Nonlinearity

---

$$B_V := \frac{RTD_{mid} - \frac{RTD_{max} + RTD_{min}}{2}}{RTD_{max} - RTD_{min}}$$

$$B_V = 3.834 \times 10^{-3}$$

$$G_{lin} := \frac{2 \cdot B_V}{(0.5 + B_V) \cdot RTD_{max} - (0.5 - B_V) \cdot RTD_{min} - 2 \cdot B_V \cdot R_Z}$$

# Iref as a function of Front End Voltage Gain (Av)

$R_{set} := 12100$	$I_{out\_min} := 0.004$	$I_{out\_max} := 0.02$
$R_{vi} := 6340$	$R_{lin} := 2.94 \times 10^4$	$V_{ref} := 1.193$

$$I_{set} := \frac{V_{ref}}{R_{set}}$$

$$I_{set} = 98.595 \times 10^{-6}$$

$$V_{out\_max} := \frac{I_{out\_max} \cdot R_{vi}}{50}$$

$$V_{out\_max} = 2.536$$

$$V_{out\_min} := \frac{I_{out\_min} \cdot R_{vi}}{50}$$

$$V_{out\_min} = 0.507$$

Values in this example.

$$I_{ref}(A_v) := \frac{(V_{out\_max} - V_{out\_min}) \cdot [1 - G_{lin} \cdot (RTD_{max} - R_z)]}{A_v \cdot (RTD_{max} - RTD_{min})}$$

# Find $A_v$ that gives good $I_{ref}$ Range

$$I_{ref\_max} := 1.35(5 \cdot I_{set})$$

$$I_{ref\_min} := 0.65(5 \cdot I_{set})$$

$$I_{ref\_max} = 665.517 \times 10^{-6}$$

$$I_{ref\_min} = 320.434 \times 10^{-6}$$

$$I_{ref}(6.25) = 8.112 \times 10^{-3}$$

$$I_{ref}(12.5) = 4.056 \times 10^{-3}$$

$$I_{ref}(25) = 2.028 \times 10^{-3}$$

$$I_{ref}(50) = 1.014 \times 10^{-3}$$

$$I_{ref}(100) = 507.025 \times 10^{-6}$$

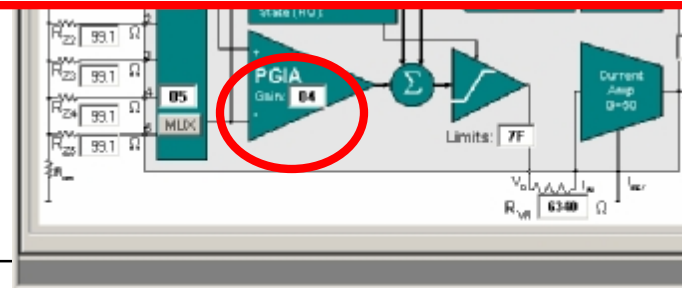
Choose  $A_{v\_sel} := 100$

$$I_{ref}(200) = 253.513 \times 10^{-6}$$

$$I_{ref}(400) = 126.756 \times 10^{-6}$$

The PGA gain should be chosen such that the  $I_{ref}$  value is within +/-35% of  $5 \cdot I_{set}$  to allow for room for calibration adjustments without having to go to another span step. The values  $I_{ref\_max}$  and  $I_{ref\_min}$  define the range.

Note that  $I_{ref\_min} < I_{ref}(100) < I_{ref\_max}$



# Find initial values for Reg11, and Reg10

$$I_{ref} := I_{ref}(100) \quad I_{ref} = 5.07 \times 10^{-4}$$

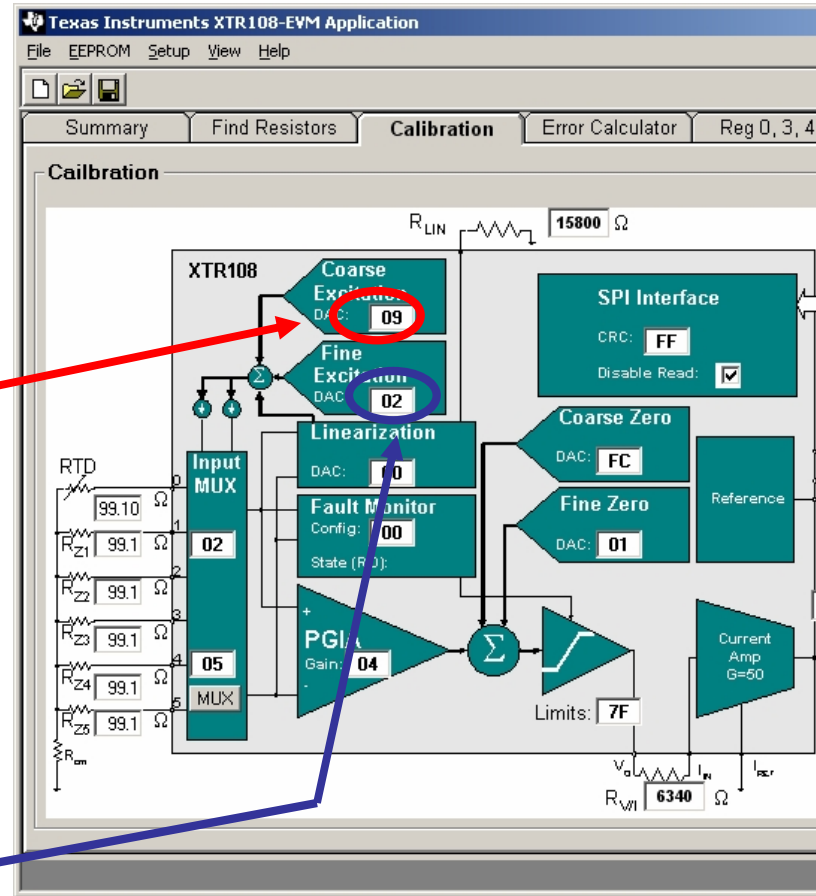
$$Reg11 := \text{round} \left[ \frac{64 \cdot (I_{ref} - 5 \cdot I_{set})}{I_{set}} \right]$$

$$Reg11 = 9$$

$$Reg10 := \text{round} \left[ \frac{1024 \left[ I_{ref} - 5 \cdot I_{set} - \left( \frac{Reg11 \cdot I_{set}}{64} \right) \right]}{I_{set}} \right]$$

$$Reg10 = 2$$

SBOA106C  
May 2008



# Compute Registers Reg12 and Reg13

$$I_o := I_{out\_min} - \frac{50 \cdot A_{V\_sel} \cdot I_{ref} \cdot (RTD_{min} - R_z)}{R_{vi}}$$

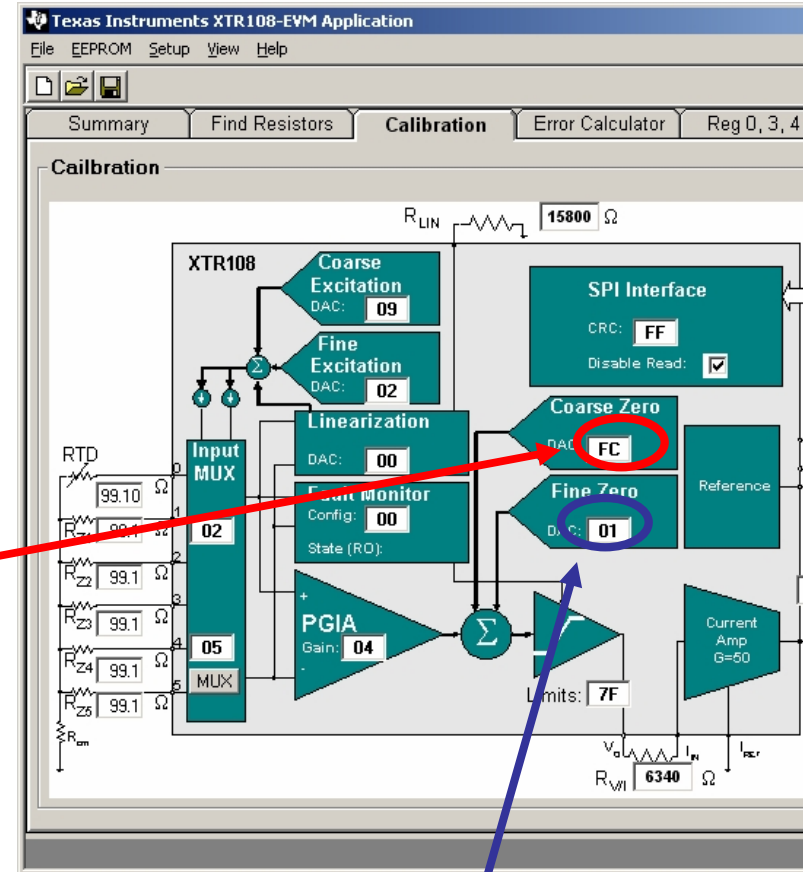
$$I_o = 4 \times 10^{-3}$$

$$I_{zpgm} := \frac{5V_{ref}}{8 \cdot R_{vi}}$$

$$Reg13 := \text{round} \left[ \frac{4(I_o - 35 \cdot I_{zpgm})}{I_{zpgm}} \right]$$

$$Reg13 = -4 = FCh$$

$$Reg12 := \text{round} \left[ \frac{64 \left[ I_o - 35 \cdot I_{zpgm} - \left( I_{zpgm} \cdot \frac{Reg13}{4} \right) \right]}{I_{zpgm}} \right]$$





# Done With Step 1: See Results



Texas Instruments XTR108-EVM Application

File EEPROM Setup View Help

Summary Find Resistors Calibration Error Calculator Reg 0, 3, 4, 5 Reg 6 - 9 Reg 10 - 15

**Calibration**

RTD ohms @ 0 degC: 100

Step 1: Initial Calculations

Temp: deg C Current

Min: -2.3 4.0 mA

Max: 100 20.0 mA

Step 2: First Correction

At Min Temp: 0 mA At Max Temp: 0 mA

Step 3: 2nd Correction

At Max Temp: mA

Step 1: Initial Calculation Write XTR

Step 2: Corrections Write EEPROM

Step 3: 2nd Correction Reset Calibration

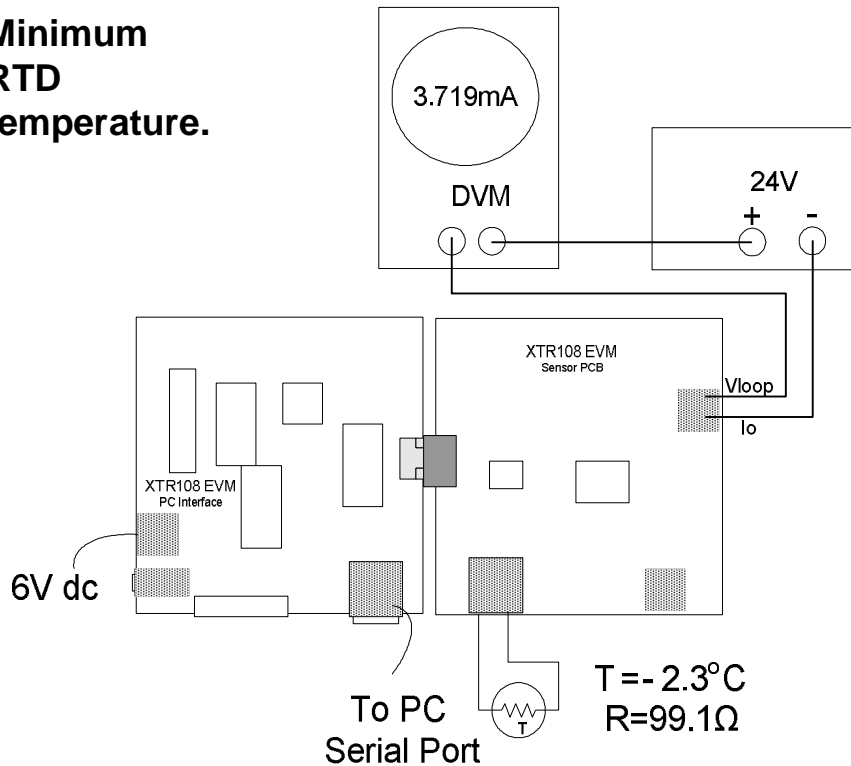
---

# Step 2: Measure and correct Gain and Offset

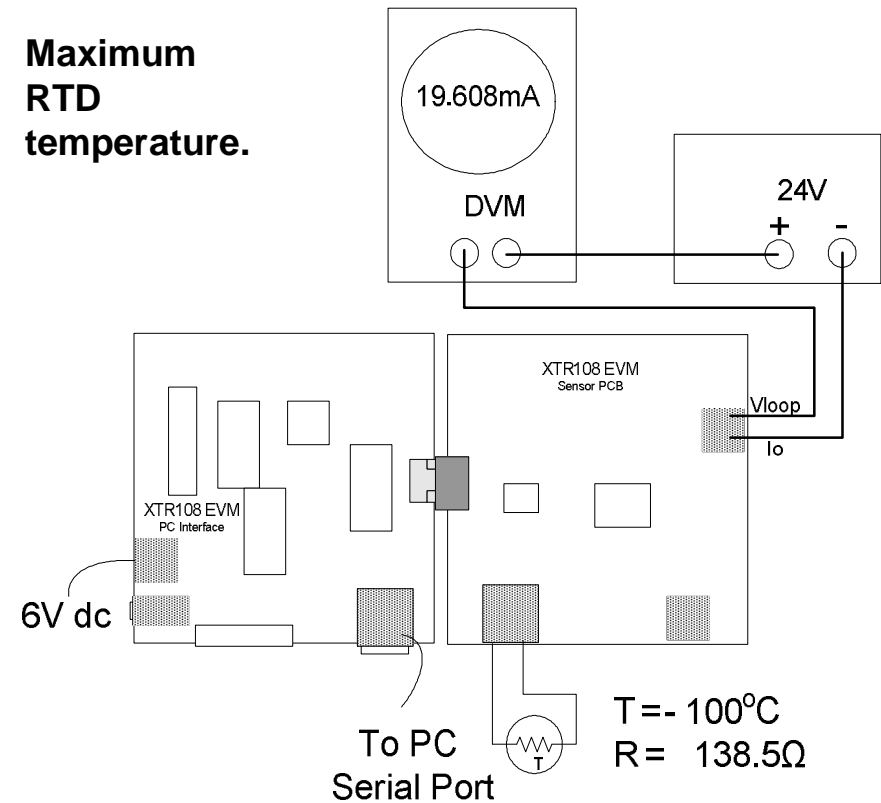
# Step 2: Measure Output at Minimum and Maximum



Minimum  
RTD  
temperature.



Maximum  
RTD  
temperature.



# Step 2: Uses Registers Calculated in Step 1 with Linearity Dac Turned off



**Calibration**

RTD ohms @ 0 degC: 100

Step 1: Initial Calculations

Temp deg C: Current

Min: -2.3 4.0 mA

Max: 100 20.0 mA

Step 2: First Correction

At Min Temp: 3.719 mA

At Max Temp: 19.608 mA

Step 3: 2nd Correction

At Max Temp: \_\_\_\_\_ mA

Step 1: Initial Calculations [Write XTR]

Step 2: Corrections [Write EEPROM]

Step 3: 2nd Correction [Reset Calibration]

Display before pressing button.

# This is the settings after step 2 calculations

**Calibration**

RTD ohms @ 0 degC: 100

Step 1: Initial Calculations  
 Temp deg C: Current  
 Min: -2.3 mA, 4.0 mA  
 Max: 100 mA, 20.0 mA

Step 2: First Correction  
 At Min Temp: 3.719 mA, At Max Temp: 19.608 mA

Step 3: 2nd Correction  
 At Max Temp: \_\_\_\_\_ mA

Buttons: Step 1: Initial Calculation, Write XTR, Step 2: Corrections, Write EEPROM, Step 3: 2nd Correction, Reset Calibration

**Block Diagram Parameters:**

- Coarse Excitation DAC: 09
- Fine Excitation DAC: D4
- Linearization DAC: 62
- Fault Monitor Config: 00
- State (RD):
- Coarse Zero DAC: 06
- Fine Zero DAC: F8
- Reference
- PGIA Gain: 04
- Limits: 7F
- Current Amp G=50
- $R_{LIN}$ : 15800  $\Omega$
- $R_{SET}$ : 12100  $\Omega$
- Input MUX: 02
- MUX: 05
- RTD: 99.10  $\Omega$
- $R_{Z1}$ : 99.1  $\Omega$
- $R_{Z2}$ : 99.1  $\Omega$
- $R_{Z3}$ : 99.1  $\Omega$
- $R_{Z4}$ : 99.1  $\Omega$
- $R_{Z5}$ : 99.1  $\Omega$
- $R_{em}$

Display after pressing button. Registers are updated and Lin DAC is set.

# Step 2: Compute $I_{A_{refAdj}}$

---

Measure I<sub>out</sub> min and max

$$I_{out\_min\_meas} := 3.719 \cdot 10^{-3}$$

$$I_{out\_max\_meas} := 19.608 \cdot 10^{-3}$$

$$I_{ref\_reg} := I_{set} \cdot \left( 5 + \frac{Reg11}{64} + \frac{Reg10}{1024} \right)$$

$$I_{ref\_reg} = 5.07 \times 10^{-4}$$

$$I_{A_{RefAdj}} := \frac{(I_{out\_max\_meas} - I_{out\_min\_meas}) \cdot R_{vi}}{50 \cdot A_{v\_sel} \cdot (RTD_{max} - RTD_{min})}$$

$$I_{A_{RefAdj}} = 5.113 \times 10^{-4}$$

# Step 2: $R_{Z\_adj}$ and $G_{lin\_adj}$

---

$$dRz := \frac{(I_o - I_{out\_min\_meas}) \cdot R_{vi}}{50 \cdot A_{V\_sel} \cdot IA_{RefAdj}}$$

$$dRz = 0.696$$

$$R_{Z\_adj} := RTD_{min} + dRz$$

$$R_{Z\_adj} = 99.797$$

$$G_{lin\_adj} := \frac{2 \cdot B_V}{(0.5 + B_V) \cdot RTD_{max} - (0.5 - B_V) \cdot RTD_{min} - 2 \cdot B_V \cdot R_{Z\_adj}}$$

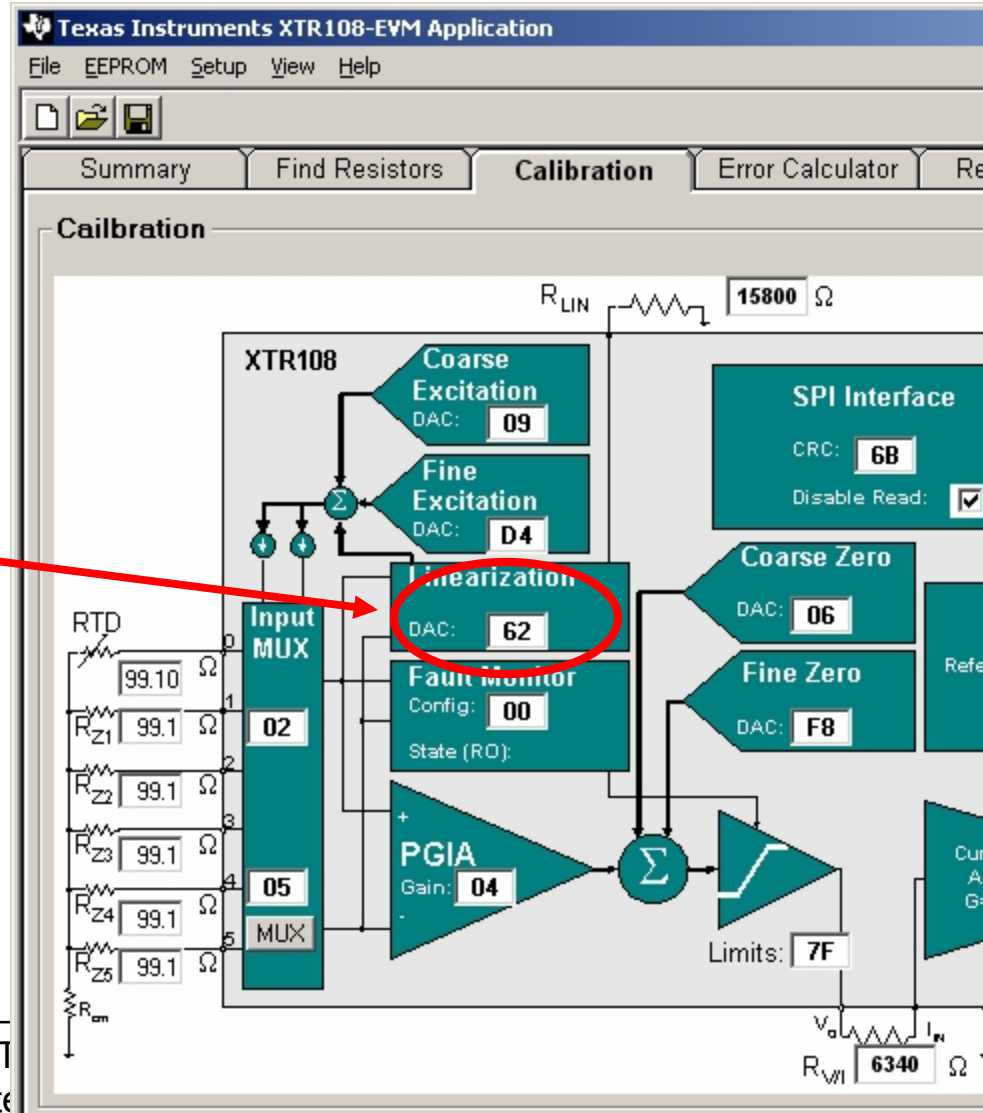
$$G_{lin\_adj} = 3.864 \times 10^{-4}$$

$$Reg14 := \text{round}(16 \cdot G_{lin\_adj} \cdot R_{lin})$$

$$G_{lin\_adj} = 3.863 \times 10^{-4}$$

$$Reg14 := \text{round}(16 \cdot G_{lin\_adj} \cdot R_{lin})$$

$$Reg14 = 98 = 62h$$





# Step 2: Compute $I_{BrefAdj}$ and $dIref$

---

$$I_{BrefAdj} := \frac{(I_{out\_max} - I_{out\_min}) \cdot [1 - G_{lin\_adj} \cdot (RTD_{max} - R_{z\_adj})] \cdot R_{vi}}{50 \cdot A_{V\_sel} \cdot (RTD_{max} - RTD_{min})}$$

$$I_{BrefAdj} = 5.072 \times 10^{-4}$$

$$dIref := (I_{ref\_reg} - I_{ARefAdj}) + (I_{ref\_reg} - I_{BRefAdj})$$

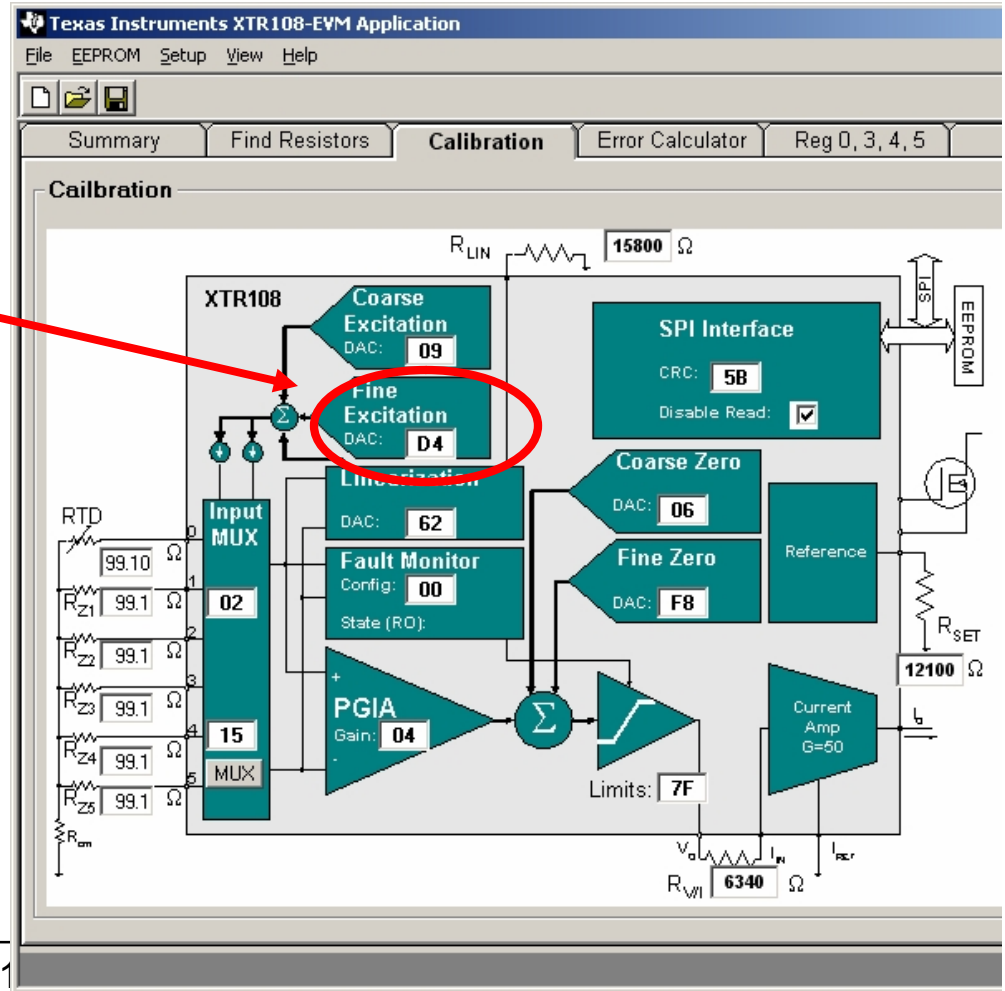
$$dIref = -4.387 \times 10^{-6}$$

# Step 2: New Value for Reg 10



$$\text{Reg10}_{\text{adj}} := \text{Reg10} + \text{round} \left( 1024 \text{dIref} \cdot \frac{R_{\text{set}}}{V_{\text{ref}}} \right)$$

**Reg10<sub>adj</sub> = -44 = D4h**



# Step 2: New Value for Reg10, Reg11

$$\text{Reg10}_{\text{adj}} := \text{Reg10} + \text{round} \left( 1024 \cdot \text{dIref} \cdot \frac{R_{\text{set}}}{V_{\text{ref}}} \right)$$

$$\text{Reg10}_{\text{adj}} = -44$$

Note that the change in Iref required in this case was relatively small, so Reg11 (coarse ref adjust) was not adjusted. If the adjusted value of Reg10 out of range (i.e.  $\text{Reg10} < -127$  or  $\text{Reg10} > 128$ ), both Reg10 and Reg11 are adjusted as shown below.

if  $\text{Reg10}_{\text{adj}} < -127$  or  $\text{Reg10}_{\text{adj}} > 128$  then

$$I_{\text{refadj}} = I_{\text{ref\_reg}} + \text{dIref}$$

$$\text{Reg11}_{\text{adj}} = \text{round} \left[ \frac{64 \cdot (I_{\text{refadj}} - 5 \cdot I_{\text{set}})}{I_{\text{set}}} \right]$$

$$\text{Reg10}_{\text{adj}} = \text{round} \left[ \frac{1024 \cdot \left[ I_{\text{refadj}} - 5 \cdot I_{\text{set}} - \left( \frac{\text{Reg11}_{\text{adj}} \cdot I_{\text{set}}}{64} \right) \right]}{I_{\text{set}}} \right]$$

end if

# Step 2: If the R10, R11 adjustment doesn't ~~may be necessary to adjust Gain~~

if Reg10adj>128 then

$$A_{v\_sel} = (A_{v\_sel}) \cdot 2$$

$$\text{Reg11}_{adj2} = \text{round} \left[ \frac{64 \cdot \left[ \left( \frac{I_{refadj}}{2} \right) - 5 \cdot I_{set} \right]}{I_{set}} \right]$$

$$\text{Reg10}_{adj2} = \text{round} \left[ \frac{1024 \cdot \left[ \left( \frac{I_{refadj}}{2} \right) - 5 \cdot I_{set} - \left( \frac{\text{Reg11}_{adj2} \cdot I_{set}}{64} \right) \right]}{I_{set}} \right]$$

end if

if Reg10adj<128 then

$$A_{v\_sel} = \frac{A_{v\_sel}}{2}$$

$$\text{Reg11}_{adj2} = \text{round} \left[ \frac{64 \cdot \left[ (I_{refadj}) \cdot 2 - 5 \cdot I_{set} \right]}{I_{set}} \right]$$

$$\text{Reg10}_{adj2} = \text{round} \left[ \frac{1024 \cdot \left[ (I_{refadj}) \cdot 2 - 5 \cdot I_{set} - \left( \frac{\text{Reg11}_{adj2} \cdot I_{set}}{64} \right) \right]}{I_{set}} \right]$$

# Step 2: Compute $dI_{\text{zero}}$

---

$$dI_{\text{zero}} := I_{\text{out\_min}} - I_o - \frac{50 \cdot A_{v\_sel} \cdot I_{B_{\text{RefAdj}}} \cdot (RTD_{\text{min}} - R_{Z\_adj})}{R_{vi}}$$

$$dI_{\text{zero}} = 2.787 \times 10^{-4}$$

# Step 2: Compute Reg12, Reg13

$$\text{Reg12}_{\text{adj}} := \text{round} \left( \text{Reg12} + \frac{512 \cdot dI_{\text{zero}} \cdot R_{\text{vi}}}{5 \cdot V_{\text{ref}}} \right)$$

$$\text{Reg12}_{\text{adj}} = 153$$

If  $\text{Reg12}_{\text{adj}} < -127$  or  $\text{Reg12}_{\text{adj}} > 128$  Then

Note that the change in  $I_{\text{zero}}$  required in this case was relatively large, so Reg12 (coarse lo adjust) needs to be adjusted. i.e. in this case  $\text{Reg12} < -127$  or  $\text{Reg12} > 128$ .

$$\text{Reg13}_{\text{adj}} := \text{round} \left[ \frac{4(I_{\text{o}} + dI_{\text{zero}} - 35 \cdot I_{\text{zpgm}})}{I_{\text{zpgm}}} \right]$$

$$\text{Reg13}_{\text{adj}} = 6$$

$$\text{Reg12}_{\text{adj}2} := \text{round} \left[ \frac{64 \left[ I_{\text{o}} + dI_{\text{zero}} - 35 \cdot I_{\text{zpgm}} - \left( I_{\text{zpgm}} \cdot \frac{\text{Reg13}_{\text{adj}}}{4} \right) \right]}{I_{\text{zpgm}}} \right]$$

$$\text{Reg12}_{\text{adj}2} = -8 = \text{F8h}$$

# Step 2: Compute Reg12, Reg13

$$\text{Reg12}_{\text{adj}} := \text{round} \left( \text{Reg12} + \frac{512 \cdot dI_{\text{zero}} \cdot R_{\text{vi}}}{5 \cdot V_{\text{ref}}} \right)$$

$$\text{Reg12}_{\text{adj}} = 153$$

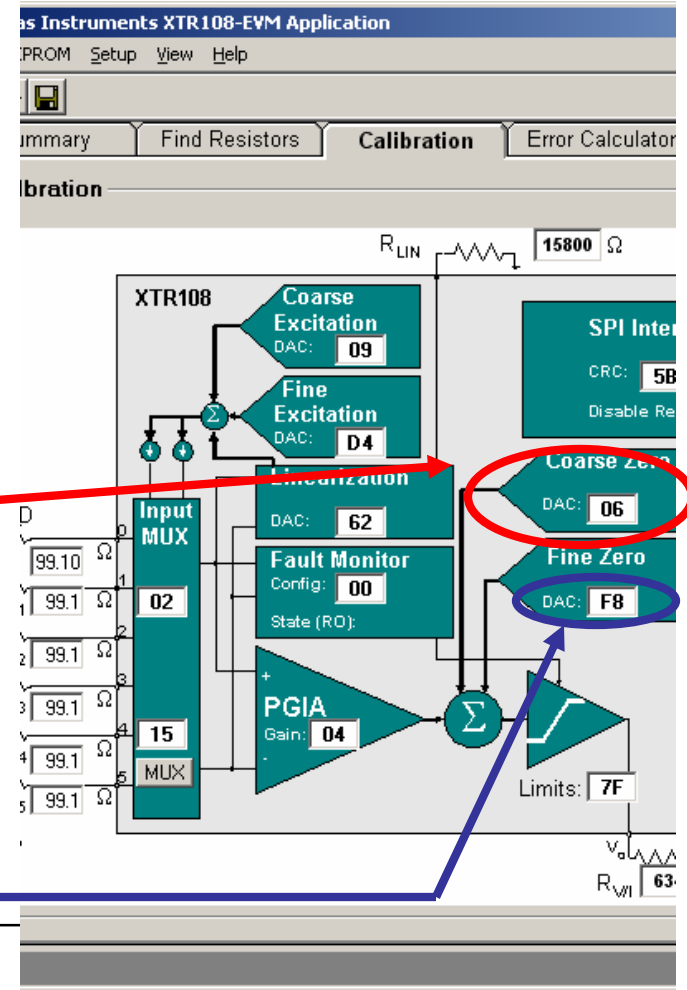
If  $\text{Reg12}_{\text{adj}} < -127$  or  $\text{Reg12}_{\text{adj}} > 128$  Then

$$\text{Reg13}_{\text{adj}} := \text{round} \left[ \frac{4(I_o + dI_{\text{zero}} - 35 \cdot I_{\text{zpgm}})}{I_{\text{zpgm}}} \right]$$

$$\text{Reg13}_{\text{adj}} = 6$$

$$\text{Reg12}_{\text{adj}2} := \text{round} \left[ \frac{64 \left[ I_o + dI_{\text{zero}} - 35 \cdot I_{\text{zpgm}} - \left( I_{\text{zpgm}} \cdot \frac{\text{Reg13}_{\text{adj}}}{4} \right) \right]}{I_{\text{zpgm}}} \right]$$

$$\text{Reg12}_{\text{adj}2} = -8 = \text{F8h}$$

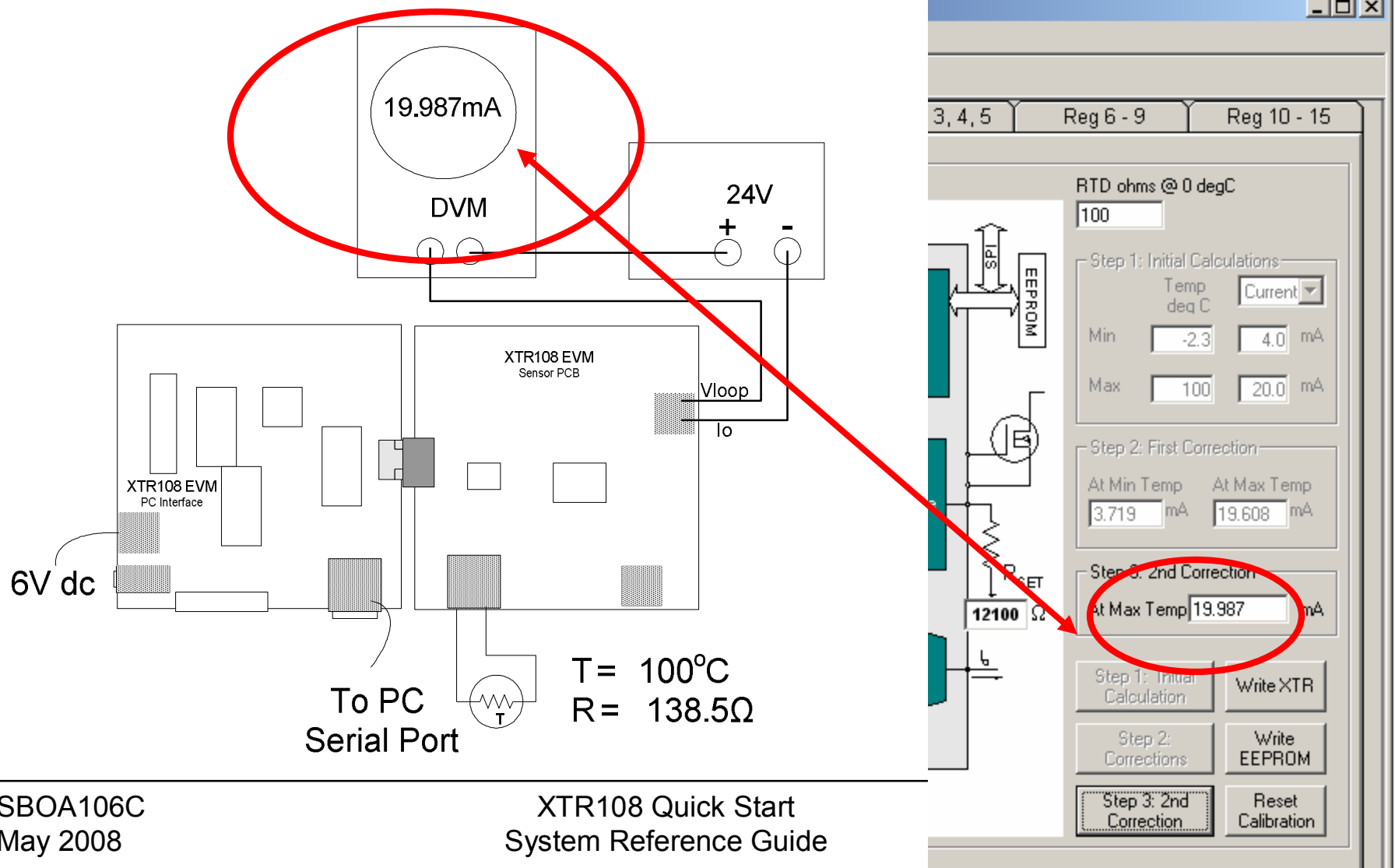


---

# Step 3: Measure and correct for Lin-DAC Error



# Measure Full Scale Output



# Step 3: Measure I<sub>out</sub> Full Scale and ~~compute factors used in Lin-Dac correction~~



part 3 calibration

$$I_{\text{max\_post\_cal\_meas}} := 0.019987$$

$$I_{\text{cat}} := \frac{I_{B_{\text{RefAdj}}} \cdot A_{v_{\text{sel}}} \cdot 50 \cdot (RTD_{\text{max}} - RTD_{\text{min}})}{R_{vi}}$$

$$I_{\text{cat}} = 15.761 \times 10^{-3}$$

$$I_{\text{dog}} := I_{\text{max\_post\_cal\_meas}} - I_{\text{out\_min}}$$

$$I_{\text{dog}} = 15.987 \times 10^{-3}$$

# Step 3: Calculate Reg14

$$\text{Meas\_G}_{\text{linadj}} := \frac{I_{\text{dog}} - I_{\text{cat}}}{(\text{RTD}_{\text{max}} - R_{\text{z\_adj}}) \cdot (I_{\text{max\_post\_cal\_meas}} - I_{\text{out\_min}})}$$

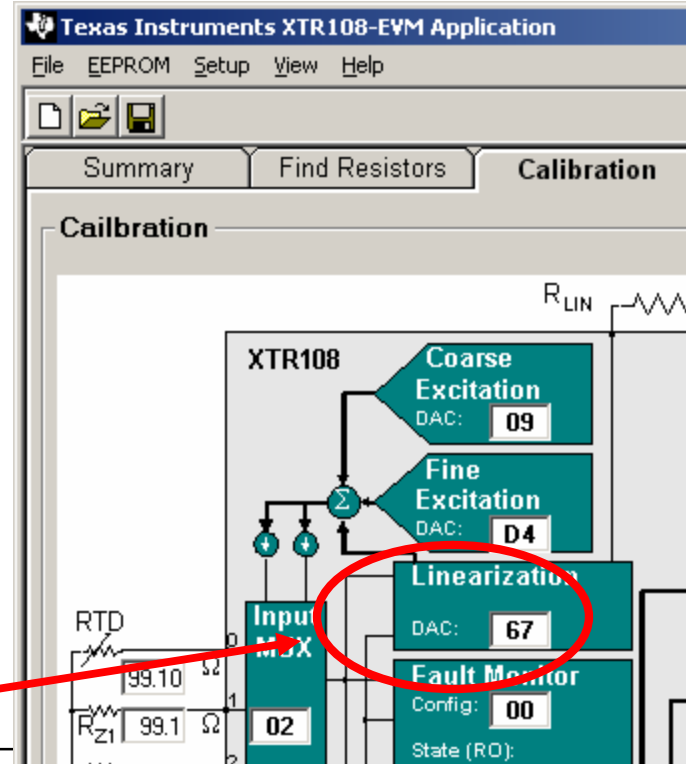
$$\text{Meas\_G}_{\text{linadj}} = 3.657 \times 10^{-4}$$

$$G_{\text{lin\_final}} := \frac{G_{\text{lin\_adj}}}{\text{Meas\_G}_{\text{linadj}}} \cdot G_{\text{lin\_adj}}$$

$$G_{\text{lin\_final}} = 4.082 \times 10^{-4}$$

$$\text{Reg14}_{\text{adj}} := \text{round}(16 \cdot G_{\text{lin\_final}} \cdot R_{\text{lin}})$$

$$\text{Reg14}_{\text{adj}} = 103 = 67\text{h}$$



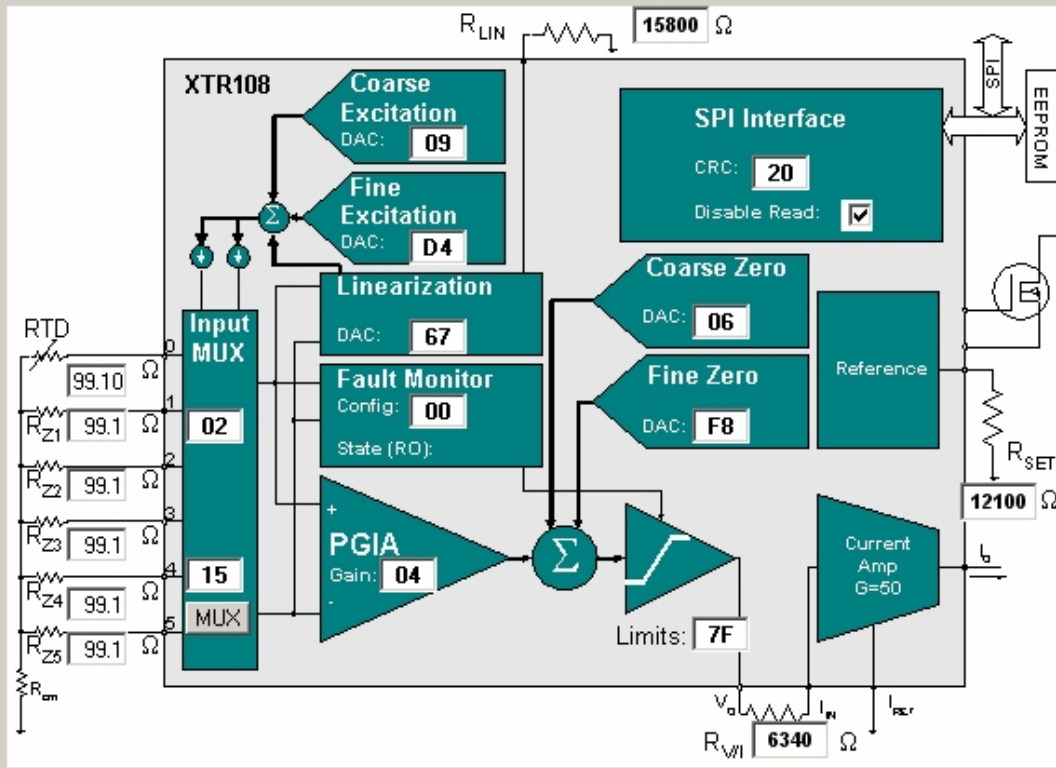
# Step 3: Final Result

Texas Instruments XTR108-EVM Application

File EEPROM Setup View Help

Summary Find Resistors **Calibration** Error Calculator Reg 0, 3, 4, 5 Reg 6 - 9 Reg 10 - 15

**Calibration**



RTD ohms @ 0 degC: 100

Step 1: Initial Calculations

Temp deg C: Current

Min: -2.3 4.0 mA

Max: 100 20.0 mA

Step 2: First Correction

At Min Temp: 3.719 mA

At Max Temp: 19.608 mA

Step 3: 2nd Correction

At Max Temp: 19.987 mA

Step 1: Initial Calculation Write XTR

Step 2: Corrections Write EEPROM

Step 3: 2nd Correction Reset Calibration

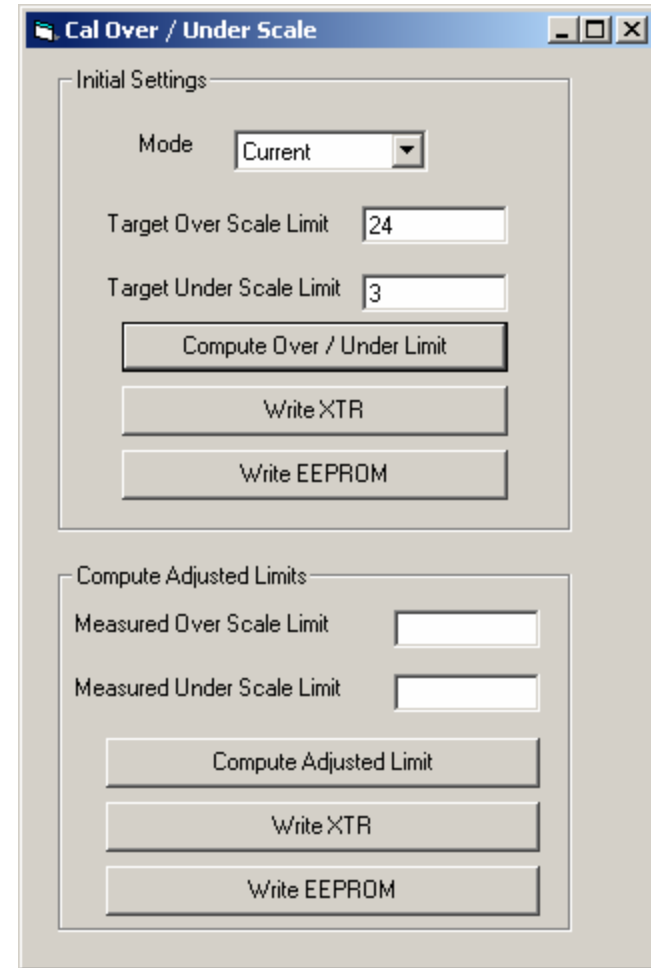
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# Step 4: (optional) Calibrate Over/Under Scale Limit

# Choose Overscale and Underscale

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INSTRUMENTS

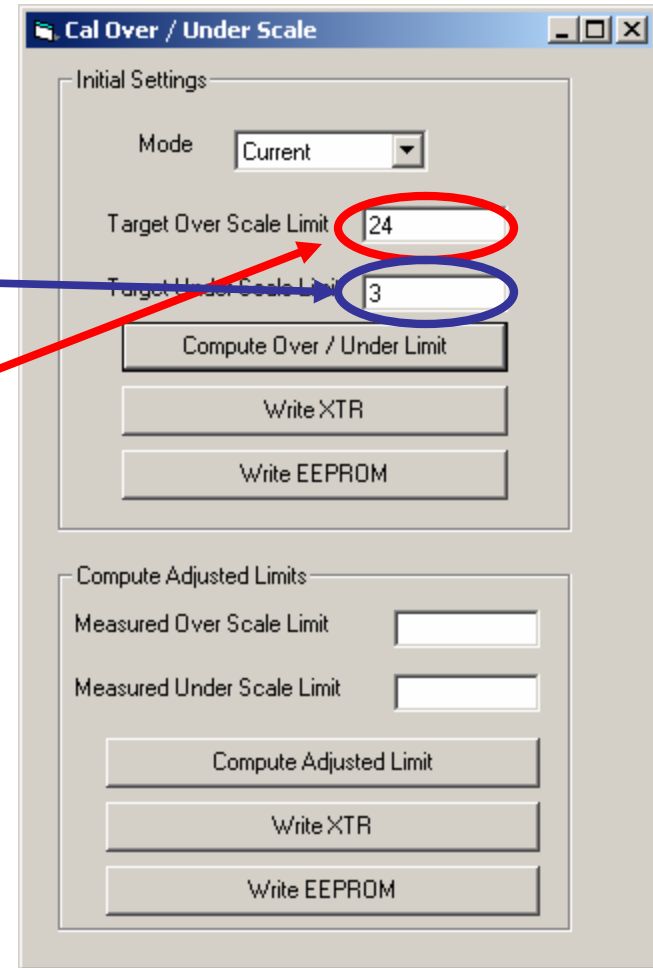
## Target



# Choose Overscale and Underscale Target

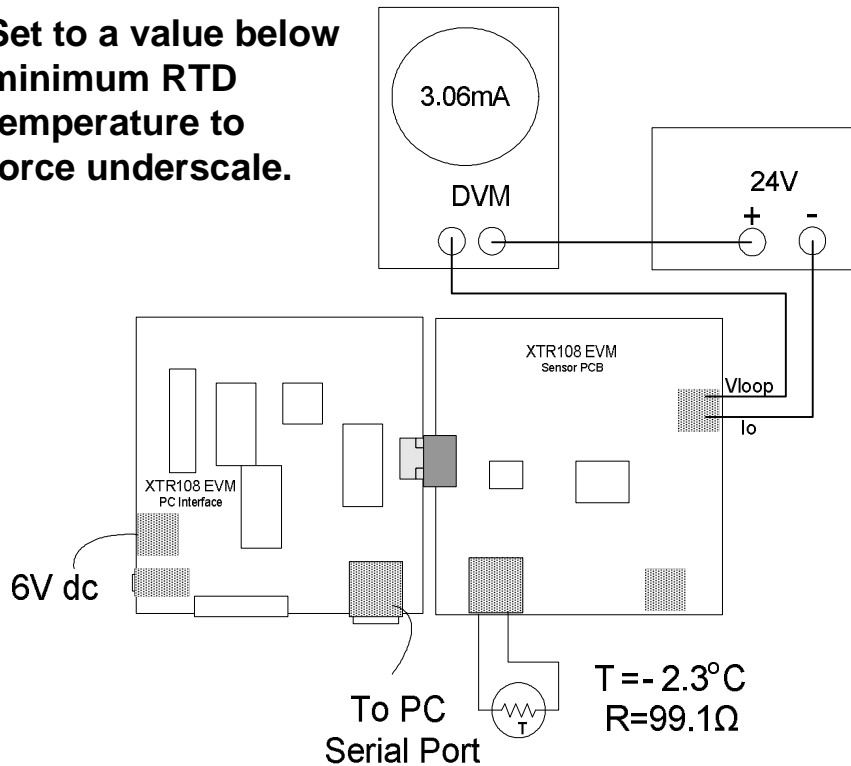


Underscale	Overscale
3.55	20.7
3.35	21.2
3.15	21.7
2.96	22.2
2.76	22.7
2.56	23.2
2.37	23.7
2.17	24.2
	24.6
	25.1
	25.6
	26.1
	26.6
	27.1
	27.6
SBOA106C	28.1
May 2008	

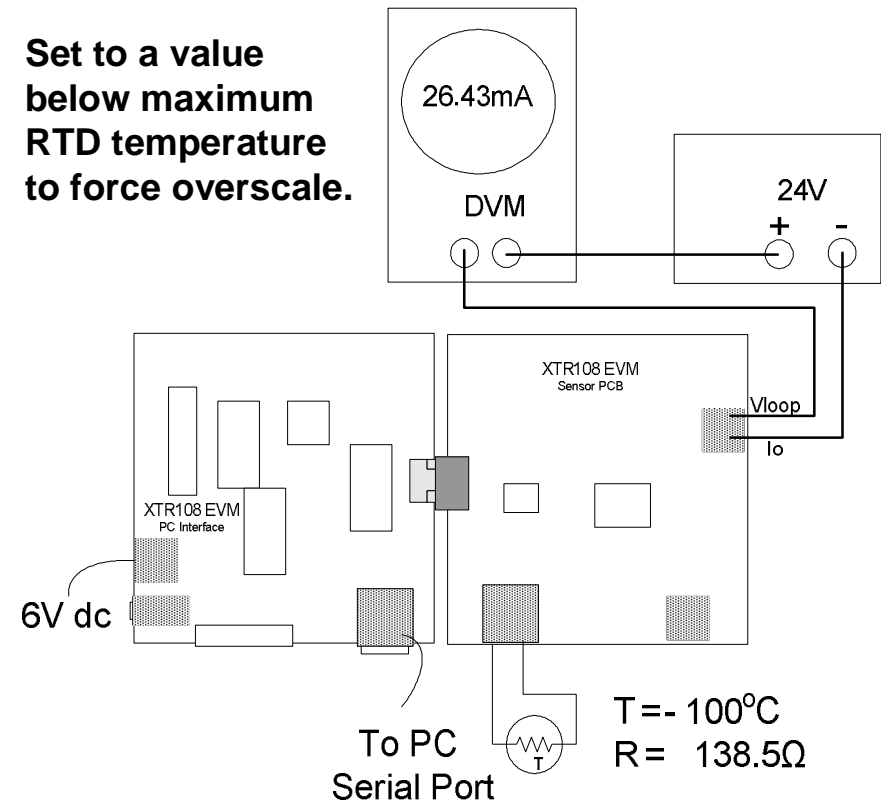


# Measure Overscale / Underscale Limit

Set to a value below minimum RTD temperature to force underscale.



Set to a value below maximum RTD temperature to force overscale.





# Compute the Adjusted Target

$$\text{Overscale\_Targ} = 24$$

$$\text{Overscale\_Meas} = 26.43$$

$$\text{AdjOverTarget} = \text{Overscale\_Targ} - (\text{Overscale\_Meas} - \text{Overscale\_Targ})$$

$$\text{AdjOverTarget} = 21.57$$

$$\text{Underscale\_Targ} = 3$$

$$\text{Underscale\_Meas} = 3.06$$

$$\text{AdjUnderTarget} = \text{Underscale\_Targ} - (\text{Underscale\_Meas} - \text{Underscale\_Targ})$$

$$\text{AdjUnderTarget} = 2.94$$

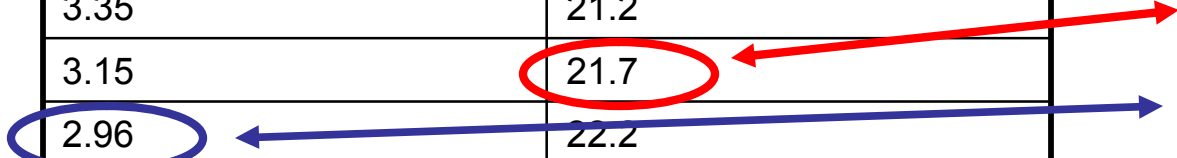
# Choose Overscale and Underscale Target



Underscale	Overscale
3.55	20.7
3.35	21.2
3.15	21.7
2.96	22.2
2.76	22.7
2.56	23.2
2.37	23.7
2.17	24.2
	24.6
	25.1
	25.6
	26.1
	26.6
	27.1
	27.6
SBOA106C	28.1
May 2008	

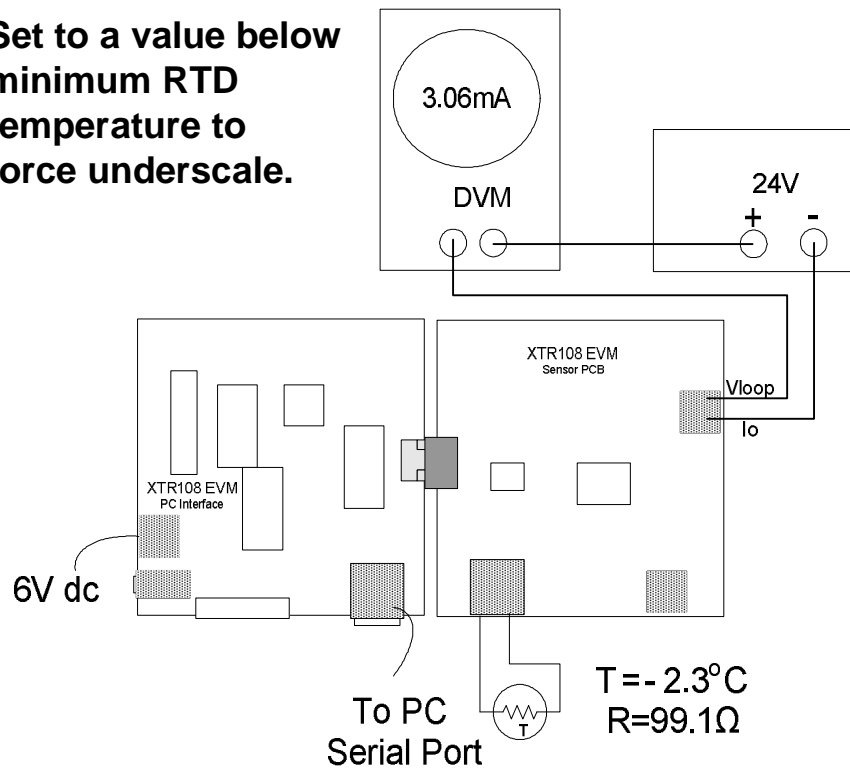
AdjOverTarget = 21.57

AdjUnderTarget = 2.94



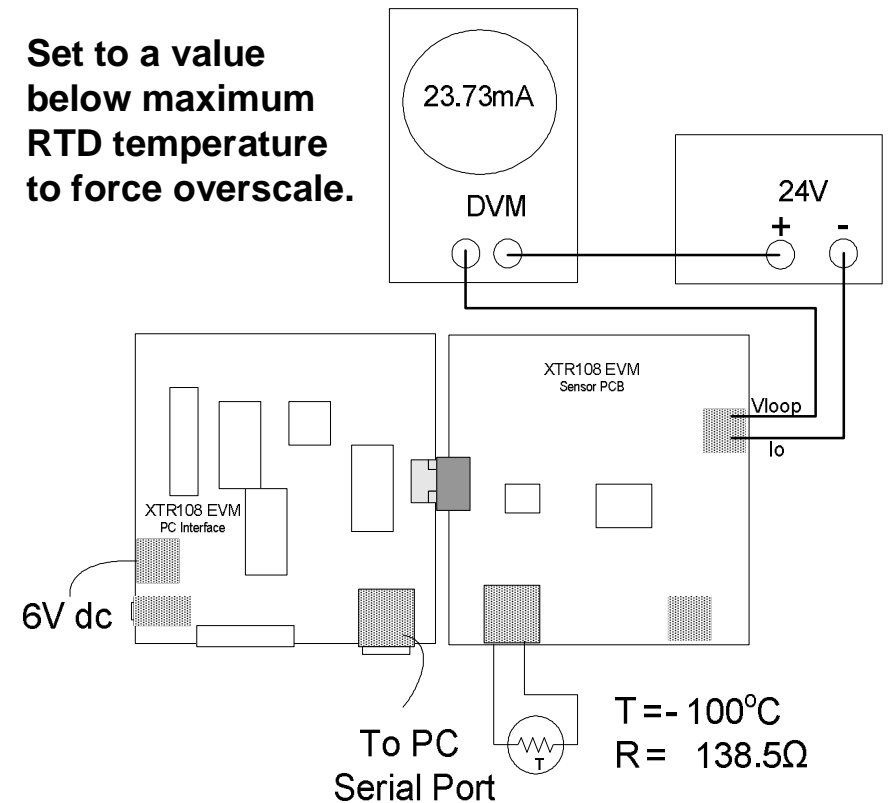
# Check Error

Set to a value below minimum RTD temperature to force undervoltage.



**Target = 3mA**

Set to a value below maximum RTD temperature to force overscale.



**Target = 24mA**

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