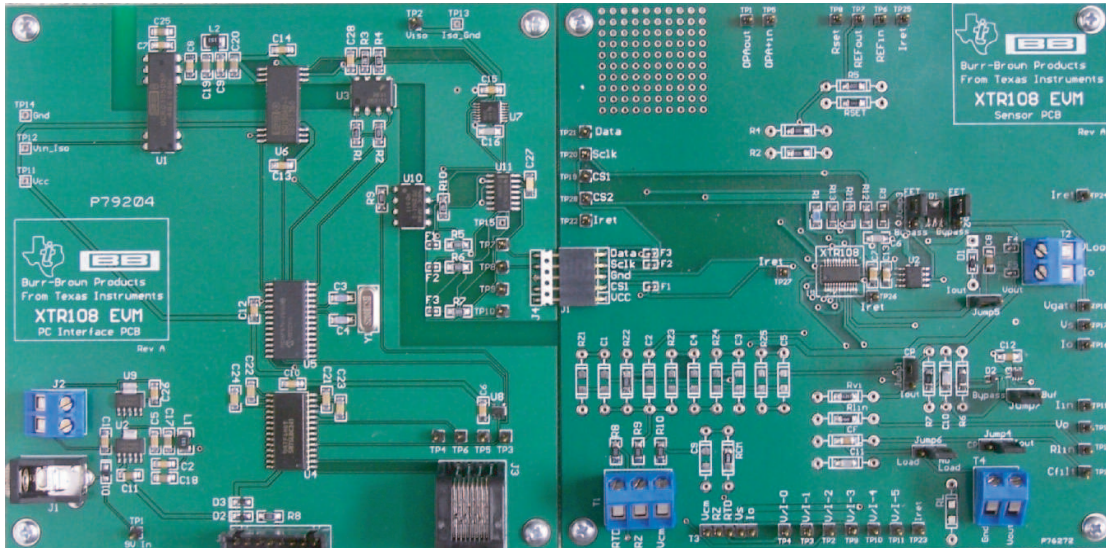# XTR108EVM - Designer's Kit for XTR108

Complete evaluation tool for the XTR108:

- XTR108 hardware Designer's Kit
  - Evaluate XTR108 and User's RTD
  - Fully configurable

- Software control for Designer's Kit:
  - Program XTR108 for evaluation
  - Program XTR108 and User's RTD in final module
  - Calibrate most types of RTDs over wide temperature ranges
  - Software tool helps to select resistor values

Contents

Windows is a trademark of Microsoft Corporation.
SPI is a trademark of Motorola, Inc.
All trademarks are the property of their respective owners.

List of Figures

1 Introduction

The XTR108EVM demonstration board was designed to provide an evaluation and test environment for the XTR108 4-20mA two-wire transmitter. This document provides the information needed to set up and operate the XTR108 evaluation module (EVM). For a more detailed description of the XTR108, please refer to the product datasheet available from the Texas Instruments web site at http://www.ti.com. Additional support documents are listed in the **XTR108EVM Parts List** section of this guide. Throughout this document, the acronym *EVM* and the phrases *evaluation module* and *demonstration board* are synonymous with the XTR108EVM. This user's guide includes setup and configuration instructions, information regarding operating procedures and input/output connections, an electrical schematic, printed circuit board (PCB) layout drawings, and a parts list for the demonstration board.

1.1 XTR108EVM Parts List (XTR108EVM-US and XTR108EVM-EU)

The following documentation and devices provide information regarding Texas Instruments' integrated circuits used in the assembly of the XTR108EVM. Information regarding these items is available through the TI web site at http://www.ti.com.

Device

XTR108 PC Interface Board

XTR108 Sensor Interface Board

PC Cable (8-position RJ45 plug to 9-position female DB9)

Document	Literature Number
XTR108EVM Software CDROM (Rev 1.0.5 or newer)	XTR108DK
XTR108 Designer's Kit Board Control Software	SBOC026
XTR108 Designer's Kit Source Code	SBOC071
XTR108EVM User's Manual	SBOU014
XTR108 Quick Start System Reference Guide	SBOA106
XTR108 Data Sheet	SBOS187

1.2 XTR108 Designer's Kit Board Control Software - Operating System Compatibility

The board control software runs on Microsoft Windows™ Win98, Win2000 and WinXP. Additionally, the regional PC settings should be set to *English (United States)*, with the decimal symbol set to a period (**.**). More information on issues related to changing regional settings is given in the **Regional Settings** section. Contact the factory for compatibility with other operating systems.

2 Description

The XTR108EVM key hardware consists of two boards (see Figure 1), the XTR108 Sensor Interface Board and the XTR108 PC Interface Board. The XTR108 Sensor Interface Board contains the XTR108, an external SOIC EEPROM, and several jumpers for ease of bridge sensor configuration. The XTR108 PC Interface Board contains an RS-232 serial interface, a PIC16F876 Microcontroller, a dc-to-dc converter, and optical isolation circuitry.
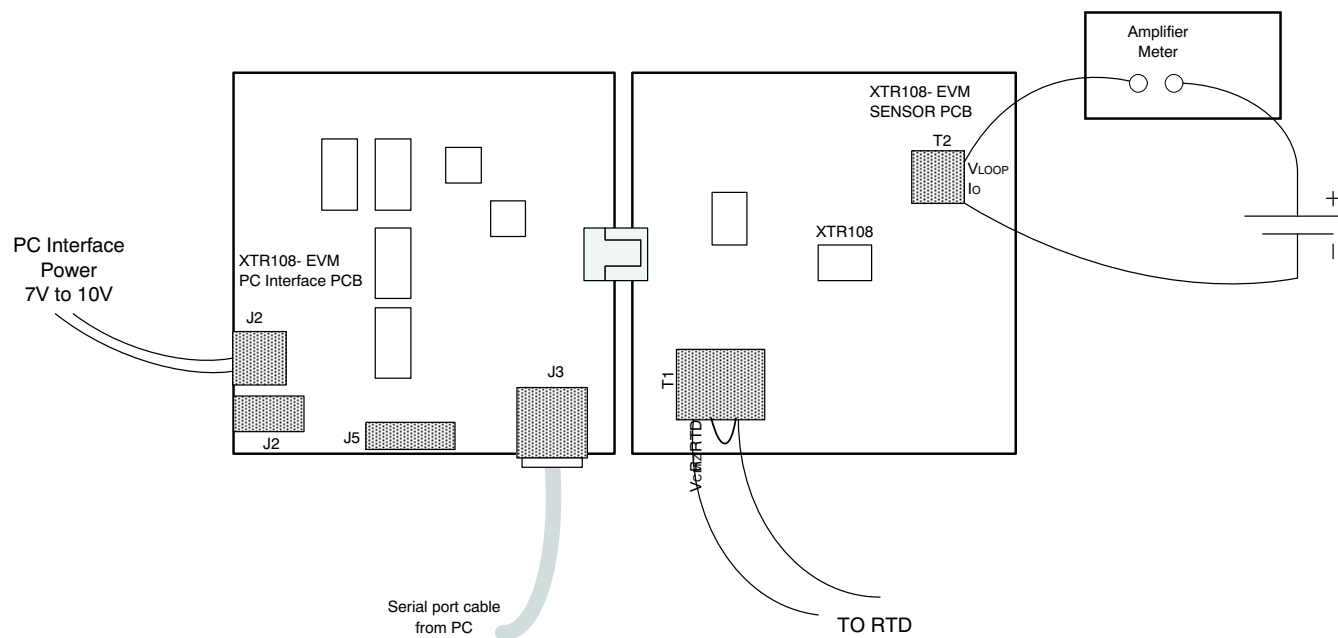
Figure 1. XTR108EVM Typical System Set-up

3 XTR108 Sensor Interface Board Overview

See the XTR108 Sensor Interface Board Schematic (Figure 38) for additional information.

3.1 Input/Output

The connections from the XTR108 Sensor Interface Board to the XTR108 PC Interface Board are provided through J1 on the sensor interface board, a five-position plug.

3.2 Jumper Configuration

JUMP1, JUMP2, JUMP3, JUMP4, JUMP5, JUMP6 and JUMP7 allow flexibility in the configuration of the connection to an RTD. Specifically, the jumpers can be used to place the XTR108 into voltage output mode or current output mode.

3.3 XTR108 and External SOIC-8 EEPROM

U1 is the XTR108 for evaluation. A 4k-bit, external, SOIC-8, industry-standard SPI™, EEPROM, U2 is also included on-board.

3.4 Protection and Filtering

The XTR108 Sensor Interface Board is configured with components to prevent mis-wiring mishaps. D1 is used to prevent damage from a reverse polarity connection. In some applications, it is desirable to bypass the FET transistor Q1, and apply power directly to the XTR108. In this case, it is important to be careful not to apply more than the 5V supply. Note that in the FET bypass mode of operation, the drop across the diode D1 becomes significant.

Input noise filtering of the zero resistor is provided by C1–C5. C9 is used to filter the noise developed on the common-mode resistor, and a capacitor can be connected directly across the RTD. See Figure 2.
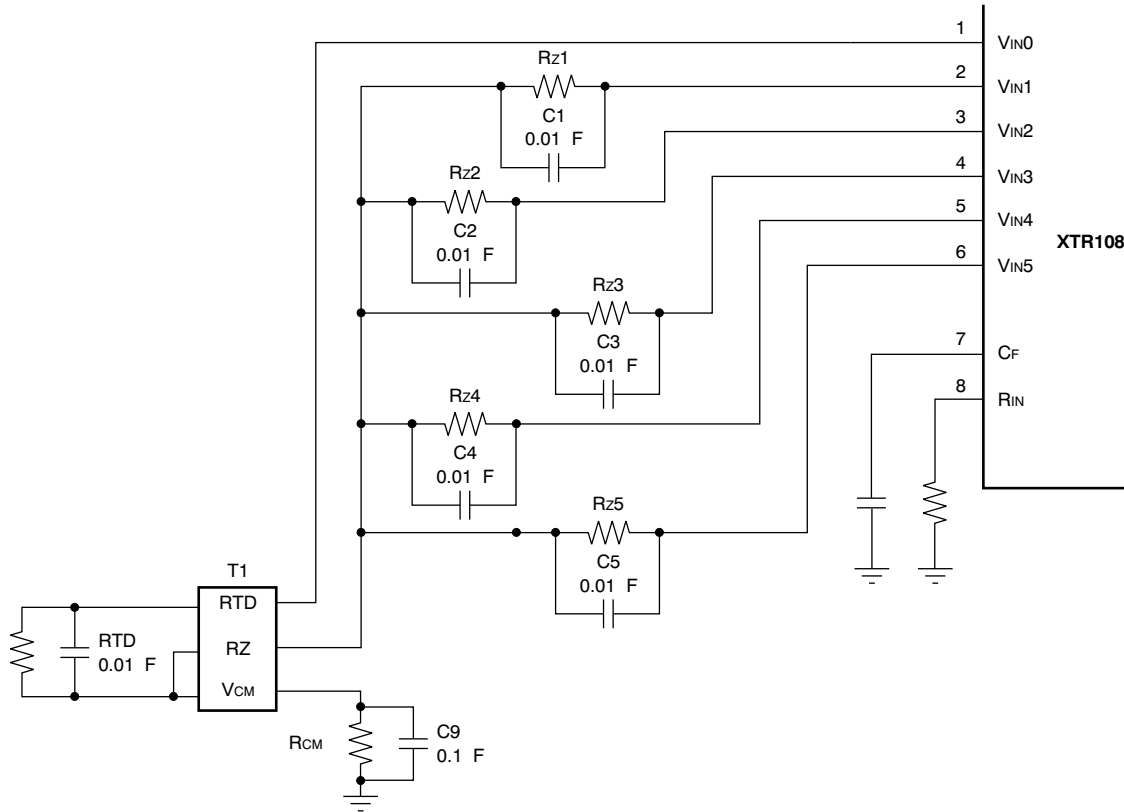
Figure 2. XTR108EVM Sensor Interface Board Filter Configuration

3.5 Test Points and Miscellaneous Breadboard Area

There are several test points, including several connections to I_{RET}. I_{RET} is common for most XTR108 applications, and is provided for ease of measuring analog signals. Reserved areas with plated-through, standard-spacing, 0.1in holes for miscellaneous proof-of-concept breadboarding as desired are provided for a given application. Most of the surface mount components have *pin sockets* associated with them. These pin sockets allow the replacement of a surface mount component with a through-hole component.

The pin sockets provide good contact with the leads of a component without solder, enabling quick reconfiguration of the board for many different XTR108 designs. See Figure 3.

Figure 3. Pin Socket Mechanical Description

4   XTR108 PC Interface Board Overview

See the XTR108 PC Interface Board schematic (Figure 37) for additional information.
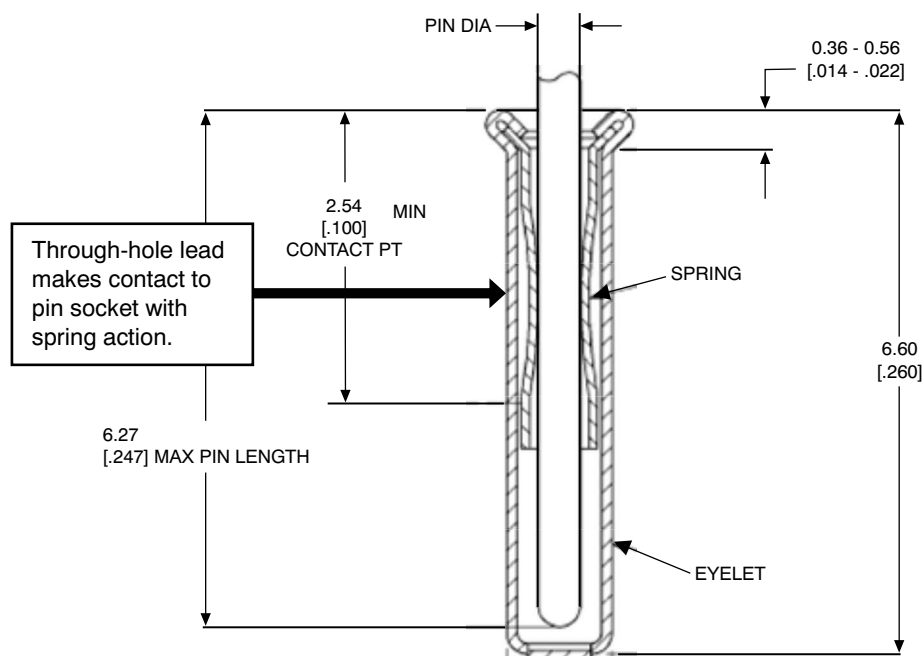
4.1   Input/Output

The connections from the XTR108 PC Interface Board to the XTR108 Sensor Interface Board are provided through J4 on the PC Interface Board.

4.2   RS-232 Interface and PIC16F876 Microcontroller

The PIC16F876 Microcontroller (U5) is used to perform the SPI communications with the XTR108. The PIC firmware is factory-programmed; however, this source code is downloadable from the web for the benefit of engineers who want to develop custom firmware. RS-232 communications are initiated via the serial port (RS-232) on the PC using Visual Basic software. The Visual Basic software source code is also downloadable from the web. As part of the serial port interface, an 75LBC241 (U4) is used to translate the RS-232 logic levels to 5V logic levels.

4.3   DC Power

DC power (7V to 10V) is applied to the XTR108 PC Interface Board through J2. Diode D1 is used to prevent inadvertent damage caused by a reverse polarity connection. Regulators U9 and U2 are used to convert the unregulated input power to a regulated 5V.

4.4   DC-to-DC Converter and Optical Isolation of Digital Signals

A DCR01050 dc-to-dc converter (U1) is used to convert the regulated 5V supply to an isolated regulated 5V supply. This isolated 5V supply provides power for all of the optical isolators U6, U3, AND U10. Optical isolation is used to allow the SPI signals to float to the ground reference of the XTR108 (I_{RET}). This configuration prevents possible grounding issues where the loop supply (V_{LOOP}) is not a floating supply.

One issue with the dc-to-dc converter is that it has a fairly noisy output voltage. The noise is generated by the switching action used to generate the isolated output voltage. If this noise is allowed to feed-through to the XTR108, it can significantly affect the device performance. To avoid this problem, the dc-to-dc converter is only turned on during communications to the XTR108. Normally the dc-to-dc converter is disabled and the digital I/O is disconnected using a 74HC4066 FET switch (U7). Note that the power for the FET switch and its associated optically isolated control signal is derived from the XTR108. This power supply design allows these circuits to function without the power from the dc-to-dc converter.

5 Initial Setup and Check-Out

5.1 *XTR108 Sensor Interface Board – Factory Jumper Settings*

Confirm and/or set the jumpers on the XTR108 Sensor Interface Board as shown in Figure 4. The desired jumper settings are also described in Table 1.
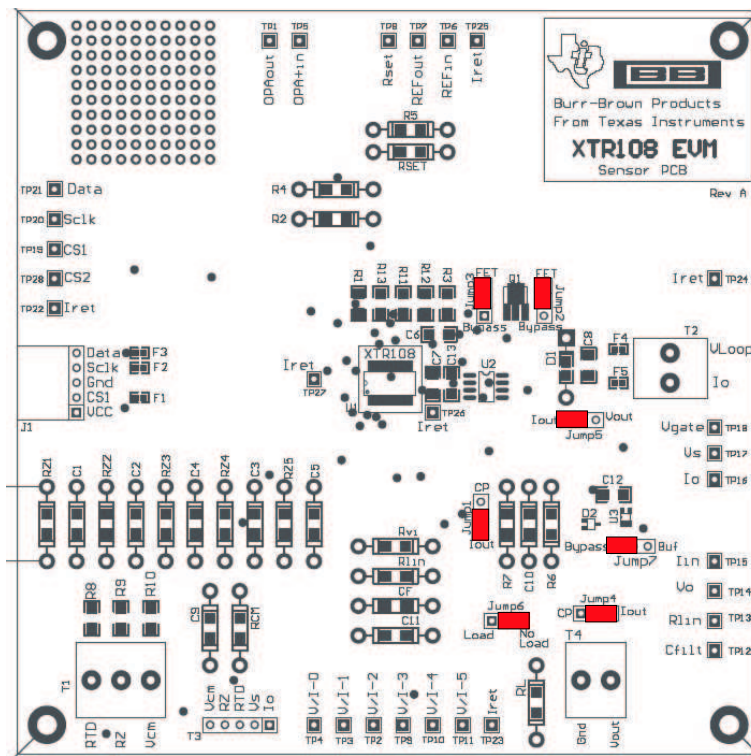

Figure 4. XTR108EVM Sensor Interface Board—Factory Jumper Settings

Table 1. XTR108 Sensor Interface Board—Factory Jumper Settings

Jumper	Position	Comments
JUMP1	I_{OUT}	Use Current Output mode
JUMP2	FET	Use FET subregulator
JUMP3	FET	Use FET subregulator
JUMP4	I_{OUT}	Use current output mode
JUMP5	I_{OUT}	Use current output mode
JUMP6	No load	Do not connect load to voltage output
JUMP7	Bypass	Bypass Voltage Mode Charge Pump

5.2 Hardware Set-up

For additional information, see Figure 5. Connect the XTR108 Sensor Interface Board to the XTR108 PC Interface Board. On the XTR108 PC Interface Board, connect a $7V_{DC}$ ($7V_{DC}$-$10V_{DC}$) Lab Supply. Connect the XTR108EVM PC Cable from P_{PC} (an RJ-45 jack) on the XTR108 PC Interface Board to an RS-232 serial port on the test computer.
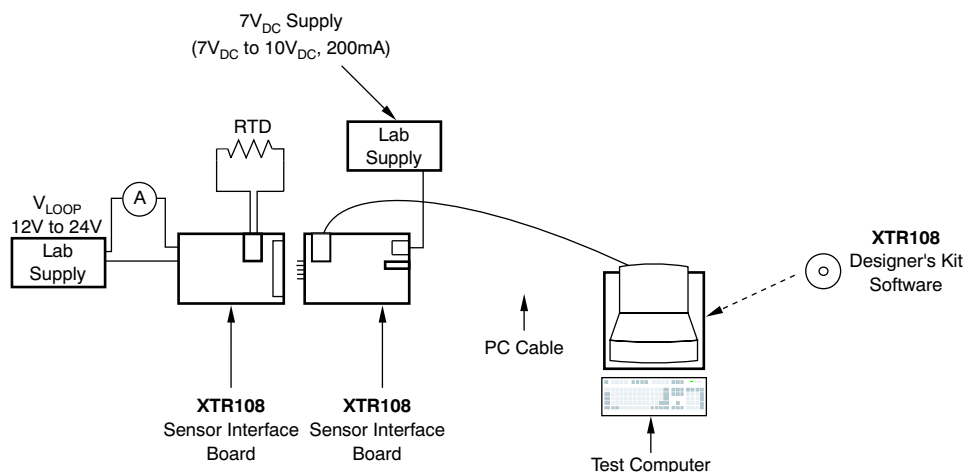

Figure 5. Hardware Setup - Initial Checkout

5.3 Board Control Software Installation

Install the EVM control software using this procedure:

- The XTR108EVM Board Control Software is installed in the normal Microsoft Windows manner. Close all other applications. From **Start** button on the Windows taskbar, select *Run*.
- In the Run dialog box, type: **d:\setup**, where *d* is the letter designating the CD-ROM drive on the PC that contains the XTR108EVM Software CD-ROM.
- Follow the on-screen prompts to install the software.
- To remove the XTR108EVM application, use the Windows Control Panel utility, *Add/Remove Software*.

5.4   Software Start-up

Start the XTR108EVM Board Control Software by clicking on the *XTR108 DK Board Interface* under **Start /All Programs/XTR108 Designer's Kit** as shown in Figure 6.
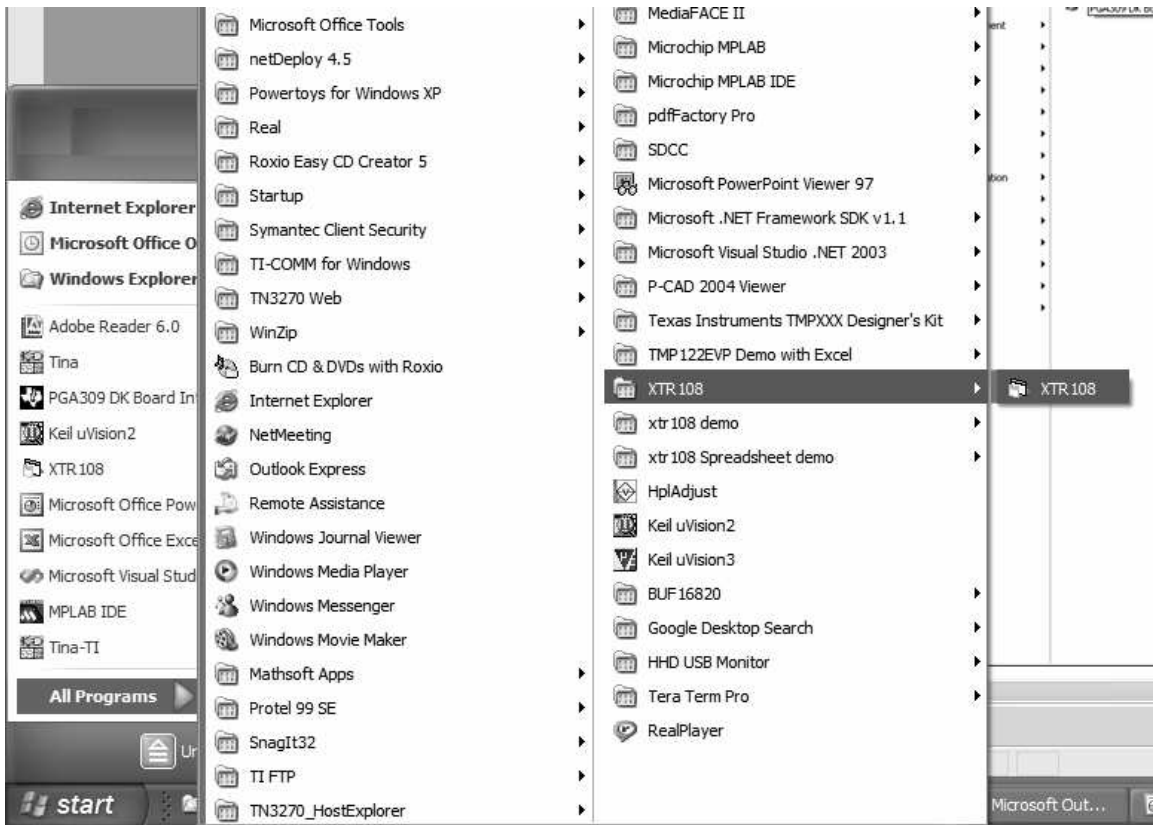

Figure 6. XTR108EVM Board Control Software Start-up

5.5 *Default Software Board Communication Setup*

On initial software startup, a main window appears with a smaller pop-up window in the middle of the main window. If the initial software start-up does not look like Figure 7, then proceed directly to Section 5.7.
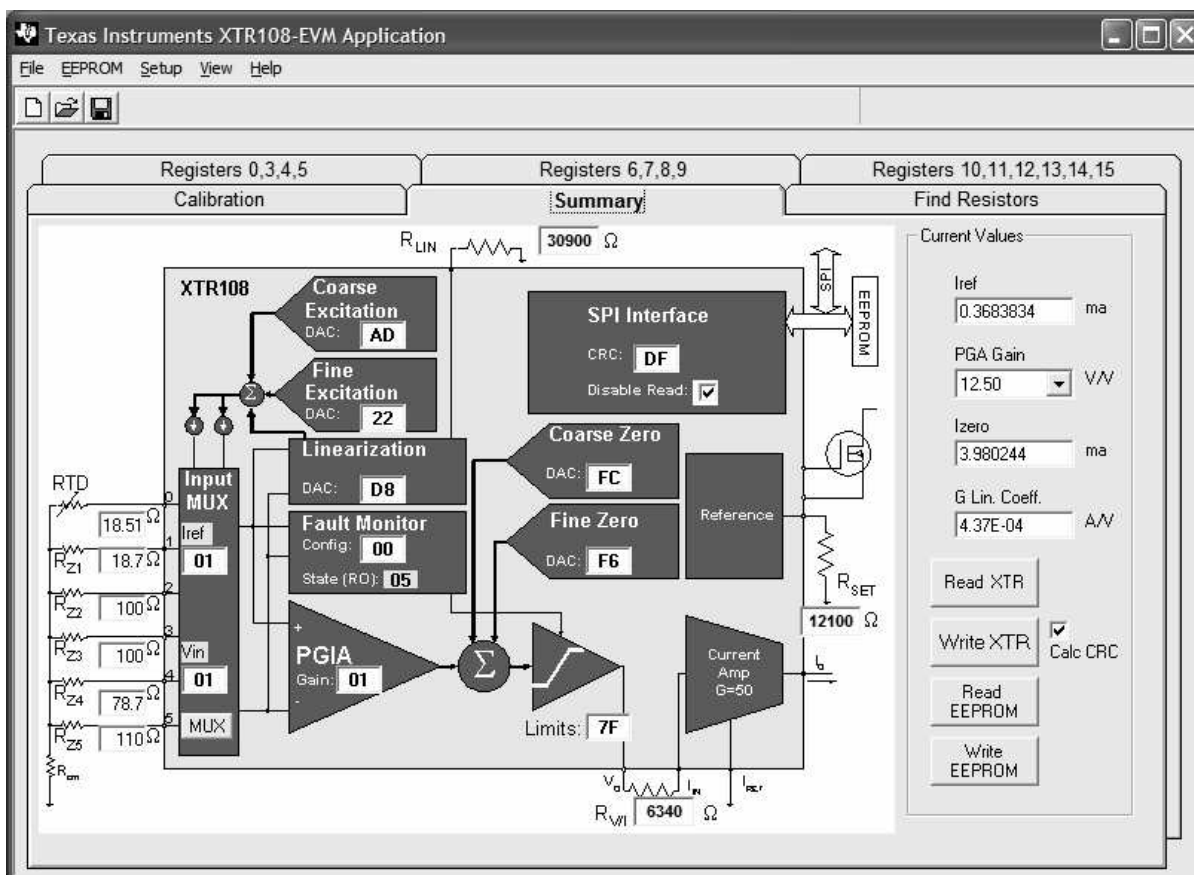

Figure 7. Software Start-up—Main Window and Initial Program View

5.6   *Software Board Communication Setup – Manual COM Port Setup*

On initial software startup, if the correct COM port on the PC is not selected automatically, then the first screen will look like Figure 8 or Figure 9. If you are getting a different error, your problem could be related to the PC-specific regional settings. More information on regional settings is given in the **Regional Settings** section.
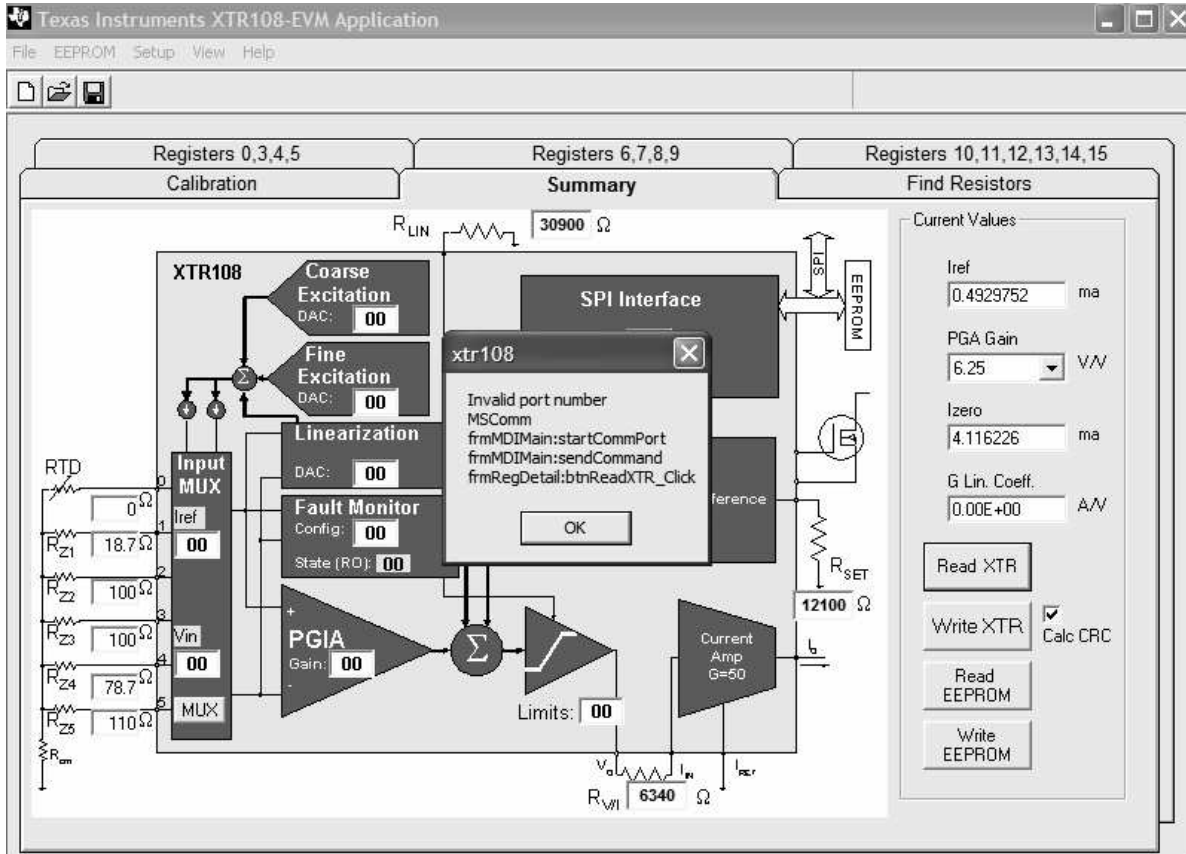

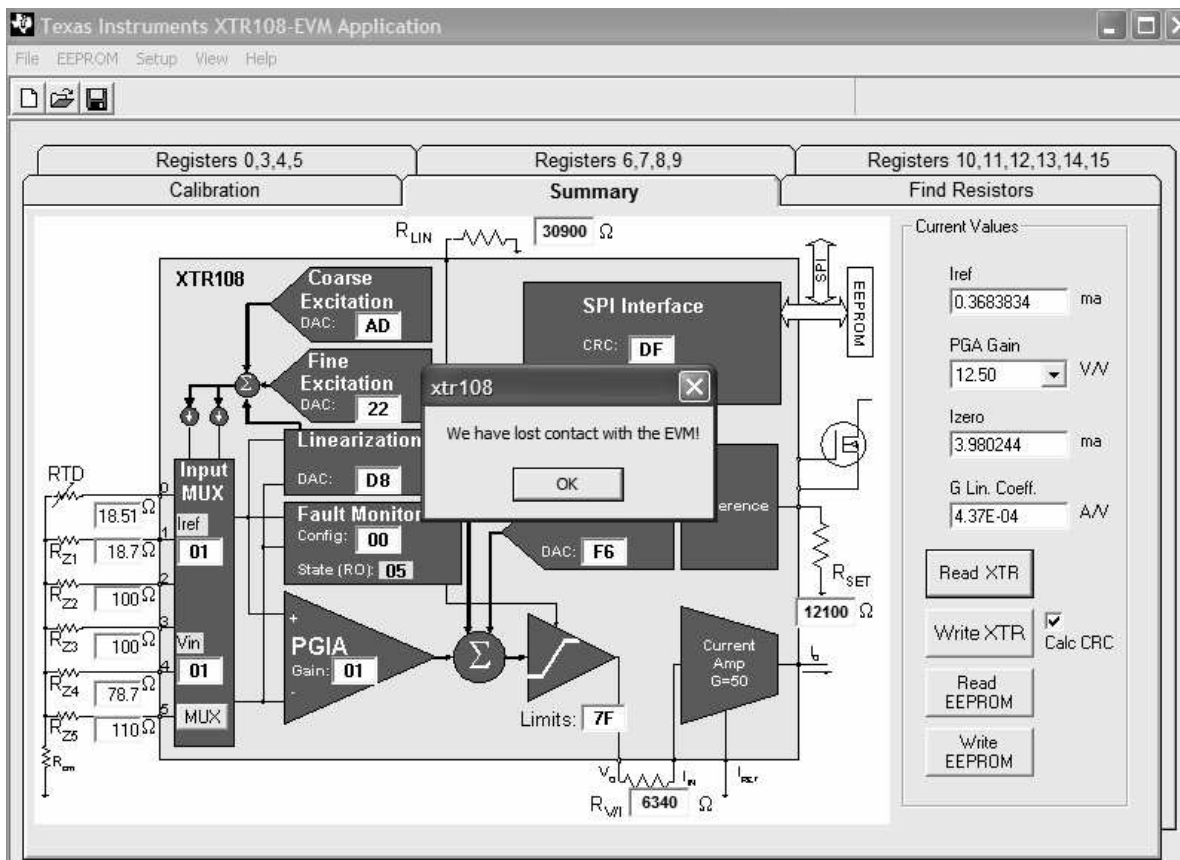**Figure 8. Software Start-up: Wrong COM Port**

Figure 9. Software Start-up: General Communication Problem

Click on **OK** in the pop-up window shown in Figure 8 or Figure 9. Verify that the power and RS-232 cables are connected. If all connections are secure, you may need to select a different COM Port. To change the COM port, click on *Setup* in the Main Window Menu. Select the *Communication Setup* option from the **Setup** menu. A new pop-up window will appear, as shown in Figure 10. Select the serial port where the board is connected, then click *OK*.
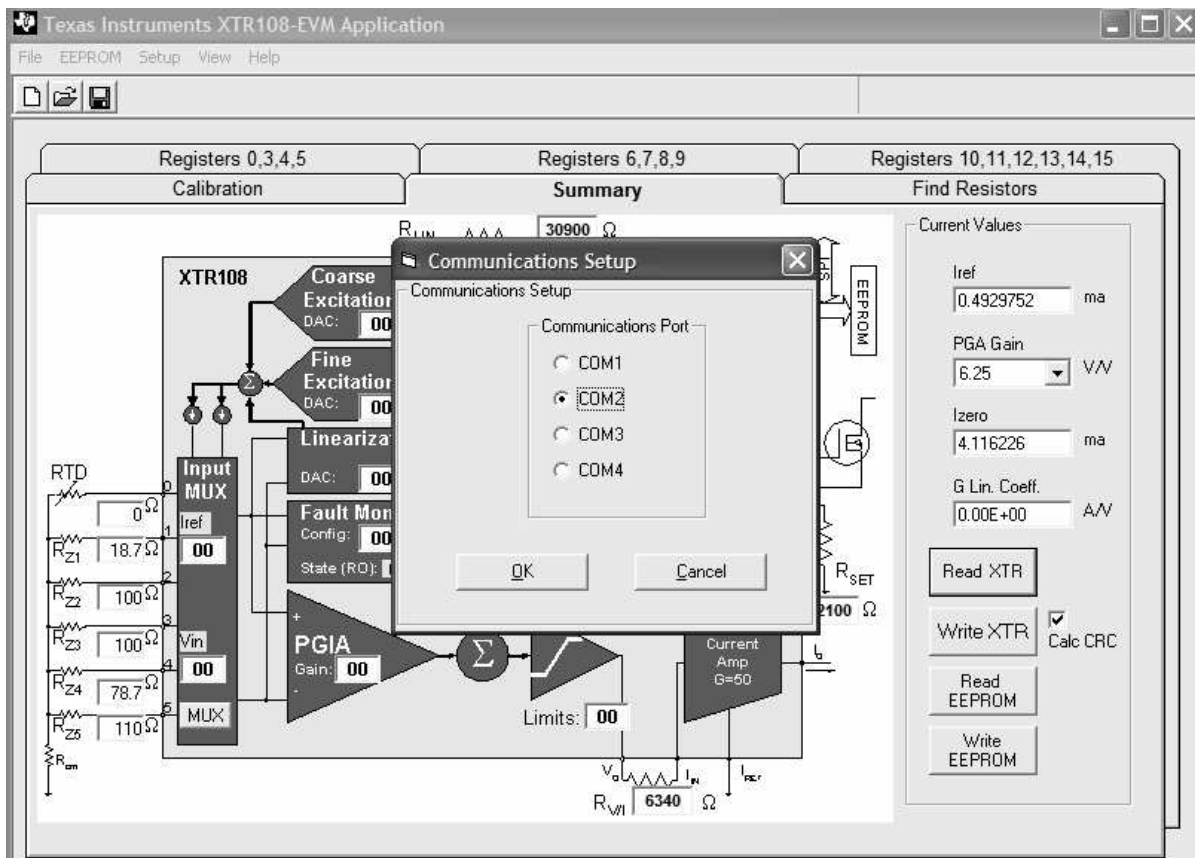
Figure 10. COM Port Pop-up Dialog Window

5.7 Hardware Check-out

In the main window, click on **File/Load Setup**. A pop-up dialog window appears, as shown in Figure 11.

Figure 11. Load Setup Pop-up Dialog

Select *XTR108_DK_setup.txt* and open this file (located in the XTR108EVM Software directory – typically, C:\Program Files\XTR108 Designer's Kit).

Then press *Write XTR*, *Write EEPROM*, and *Read XTR*. The main window appears as illustrated in Figure 12.

Figure 12. Main Window (with XTR108_DK_Test.txt file open)

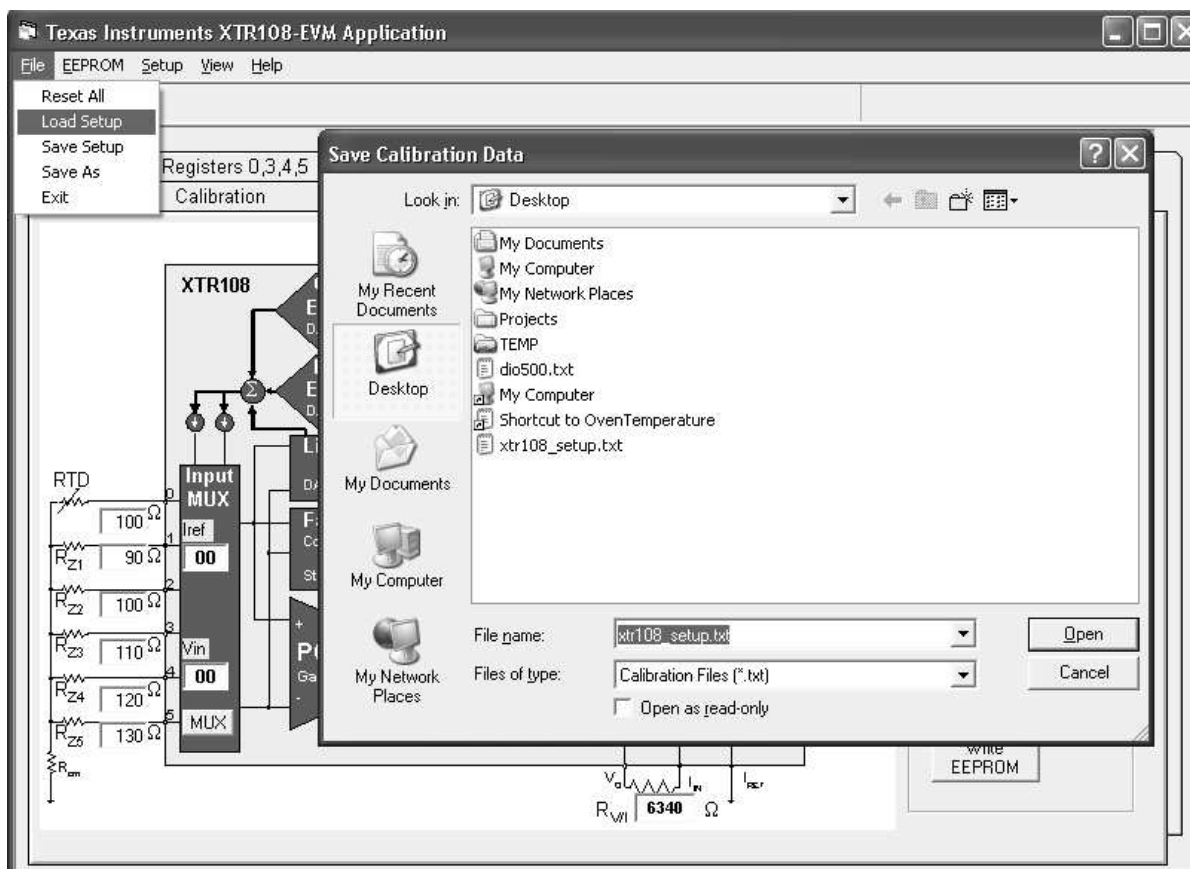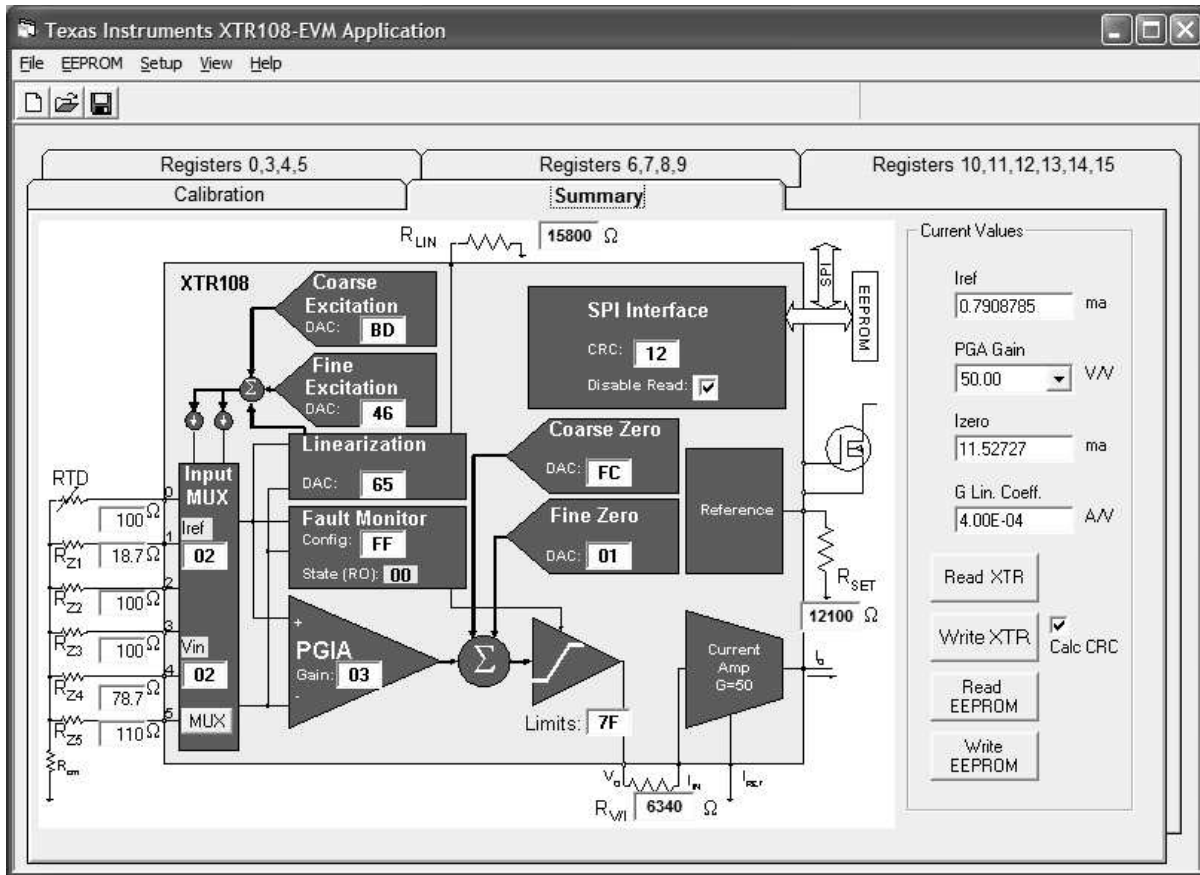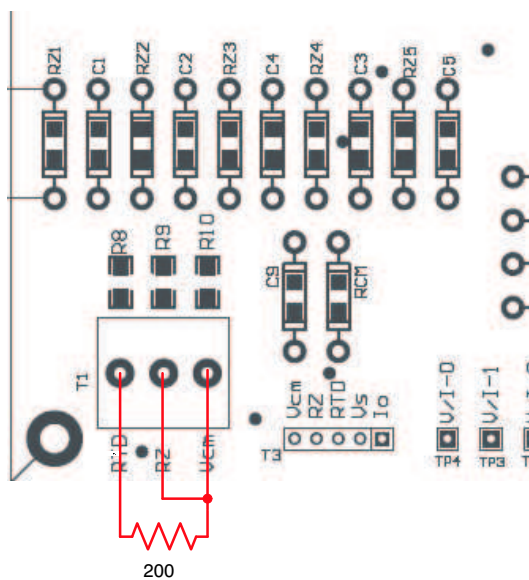Connecting a 200Ω resistor across the RTD terminal T1 should produce a 20mA output. See Figure 13.

Figure 13. Resistor for 20mA Output

Connecting a 100Ω resistor across the RTD terminal T1 should produce a 4mA output. See Figure 14.
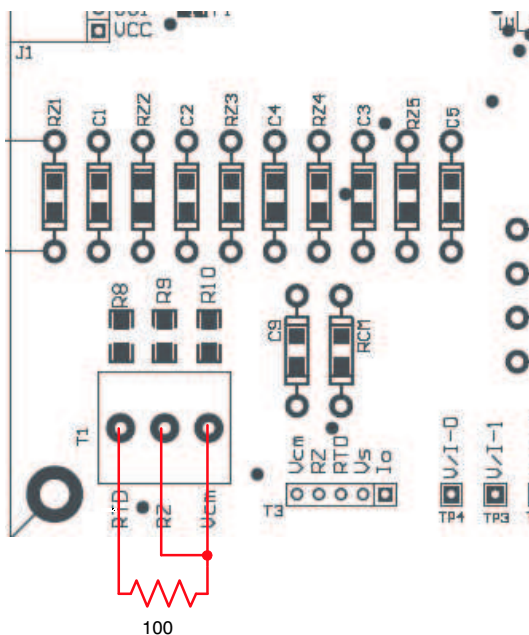
Figure 14. Resistor for 4mA Output

6 Software Overview

6.1 Summary Tab

The summary tab (see Figure 15) allows access to the key registers through an intuitive graphical interface. This screen also allows you to change the values of the external resistors that are used to select the range over which the XTR108 will calibrate RTDs. Note that the configuration of the external resistors will be saved in a file when the software is closed for user convenience.

This tab also has four buttons that conveniently allow the displayed registers to be written to or read from the XTR108 and the XTR108 EEPROM.
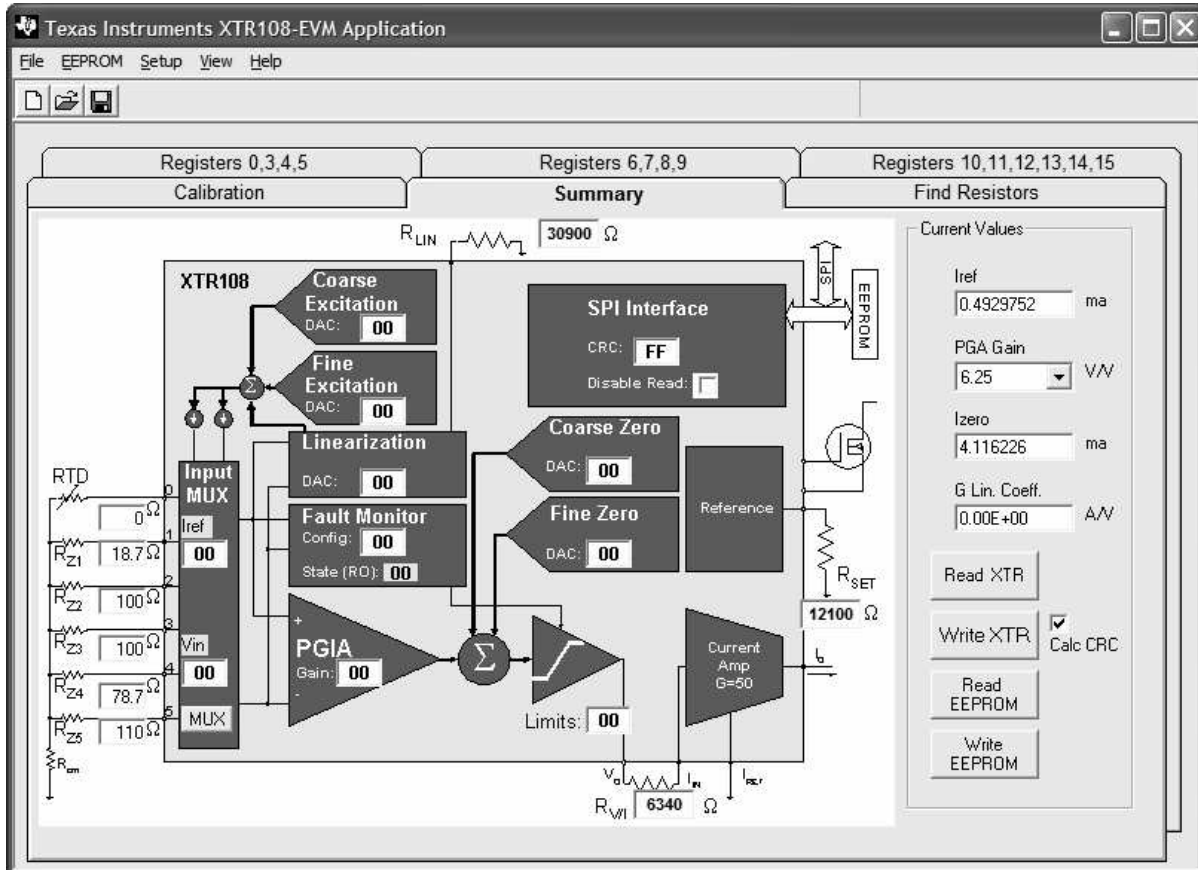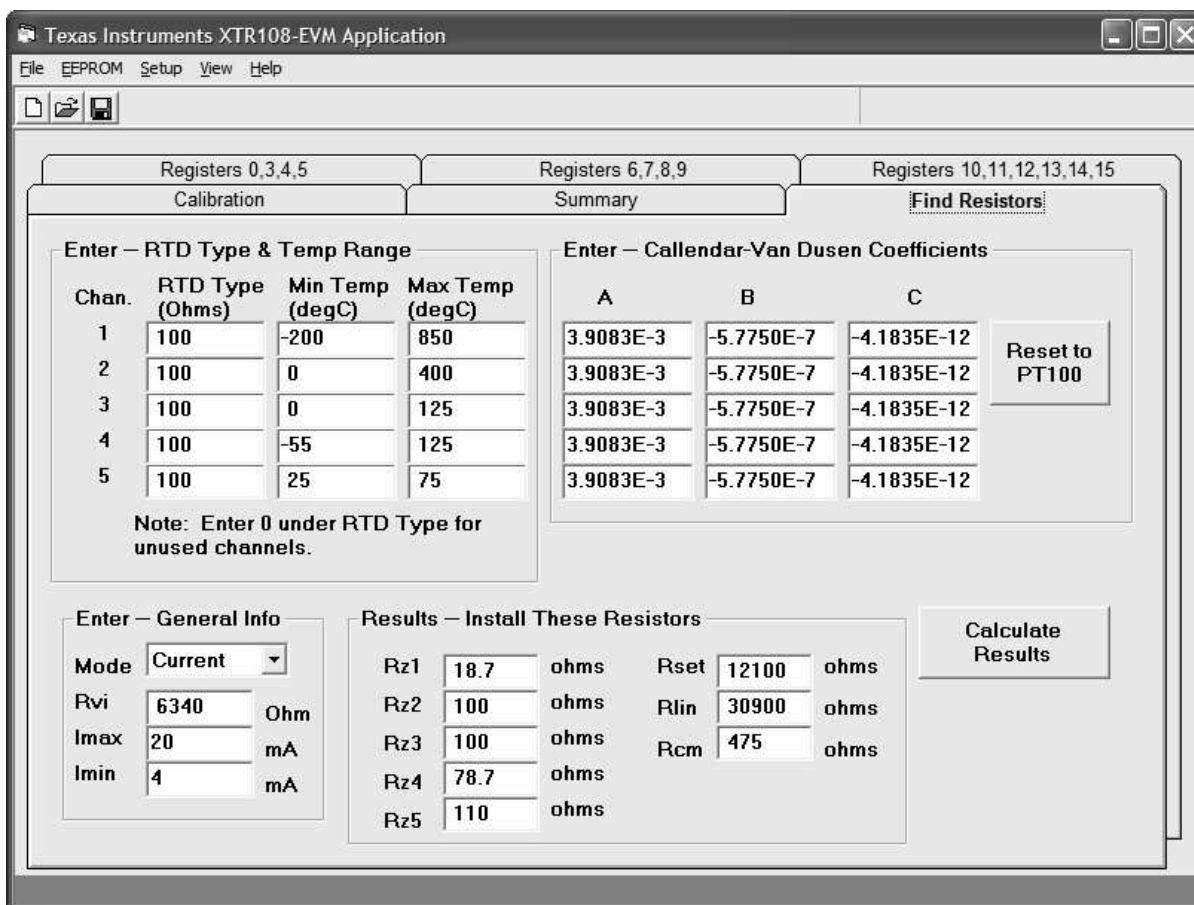
Figure 15. XTR108EVM Board Control Software: Summary Tab

6.2 Find Resistors Tab

The XTR108 has five channels that allow for five different RTD types or temperature ranges. In order to set up the XTR108 so that it can accommodate these ranges, external components must be selected (see Figure 16). This tab allows the user to enter the RTD type, the temperature range, the Callendar-Van Dusen Coefficients, and the XTR108 output range. Pressing the *Calculate Results* button will compute all the resistors that are required to configure the XTR108 for your specific application. These resistance values will also be copied into the Calibration Tab of the software tool. A more detailed description of this function and a step-by-step calibration example is given in the XTR108 Quick Start System Reference Guide.

Figure 16. XTR108EVM Board Control Software: Find Resistors Tab

6.3 Calibration Tab

This tab contains the dialogs that are needed to facilitate the calibration of an XTR108 and an RTD; see Figure 17. The Visual Basic software contains an algorithm that uses the entered XTR108 configuration resistor values, the temperature range, and the measured results to compute the XTR108 register values. The calibration algorithm works for both the Current Output mode and Voltage Output mode. The Visual Basic source code for this software can be downloaded from the Texas Instruments web site in case you want to adapt this software for production programming of XTR108 modules. A full step-by-step description of how this process works is described in the XTR108 Quick Start System Reference Guide.
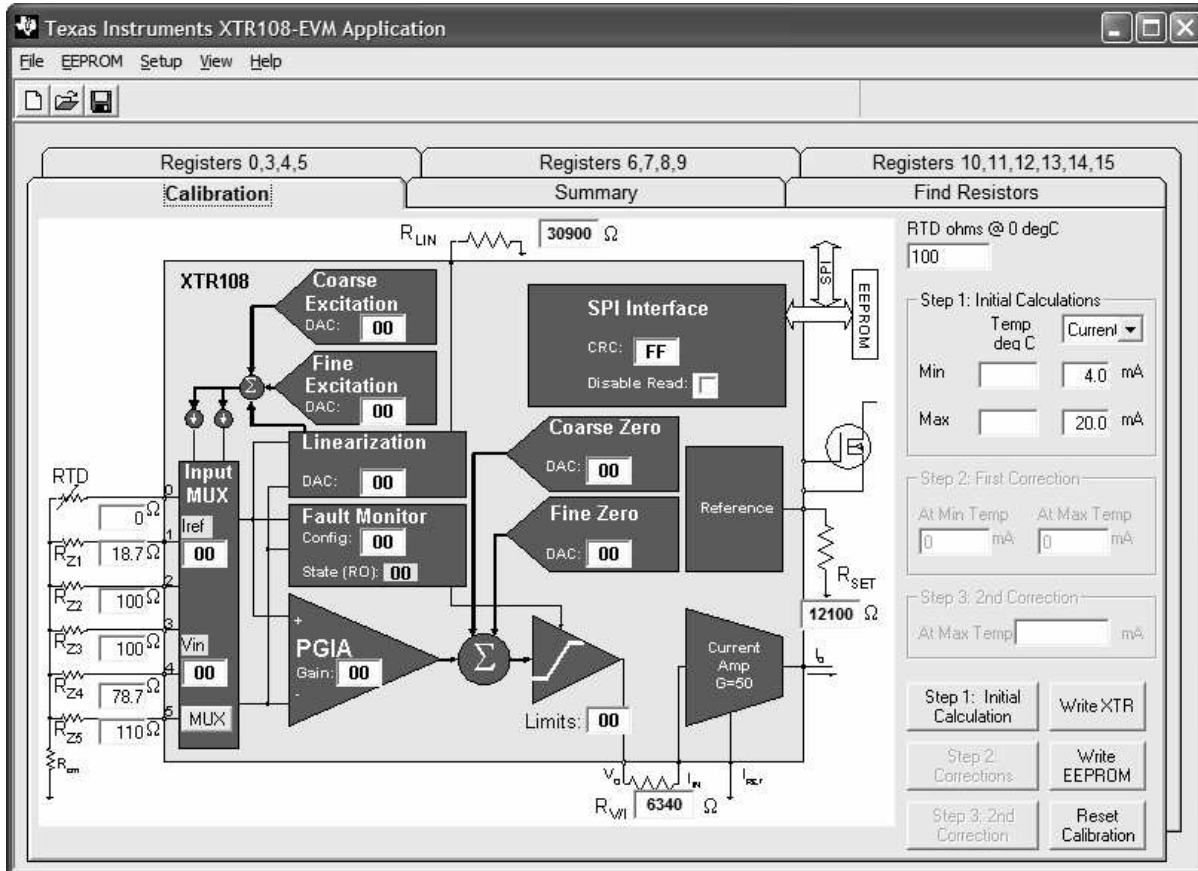
Figure 17. XTR108EVM Board Control Software: Calibration Tab

6.4 Registers 0, 3, 4, and 5

Register 0: The RST feature in Register 0 allows the XTR108 to be reset. The checksum error bit indicates whether checksum passed or not.

Register 3: None of the bits in Register 3 are used.

Register 4: Allows the user to control the Continuous EEPROM read mode. This feature is required if the discrete charge pump is used.

Register 5: Allows the over-scale and under-scale limits to be adjusted. FD disables the over-scale and under-scale limits.

See Figure 18 for an example of the tab window display.
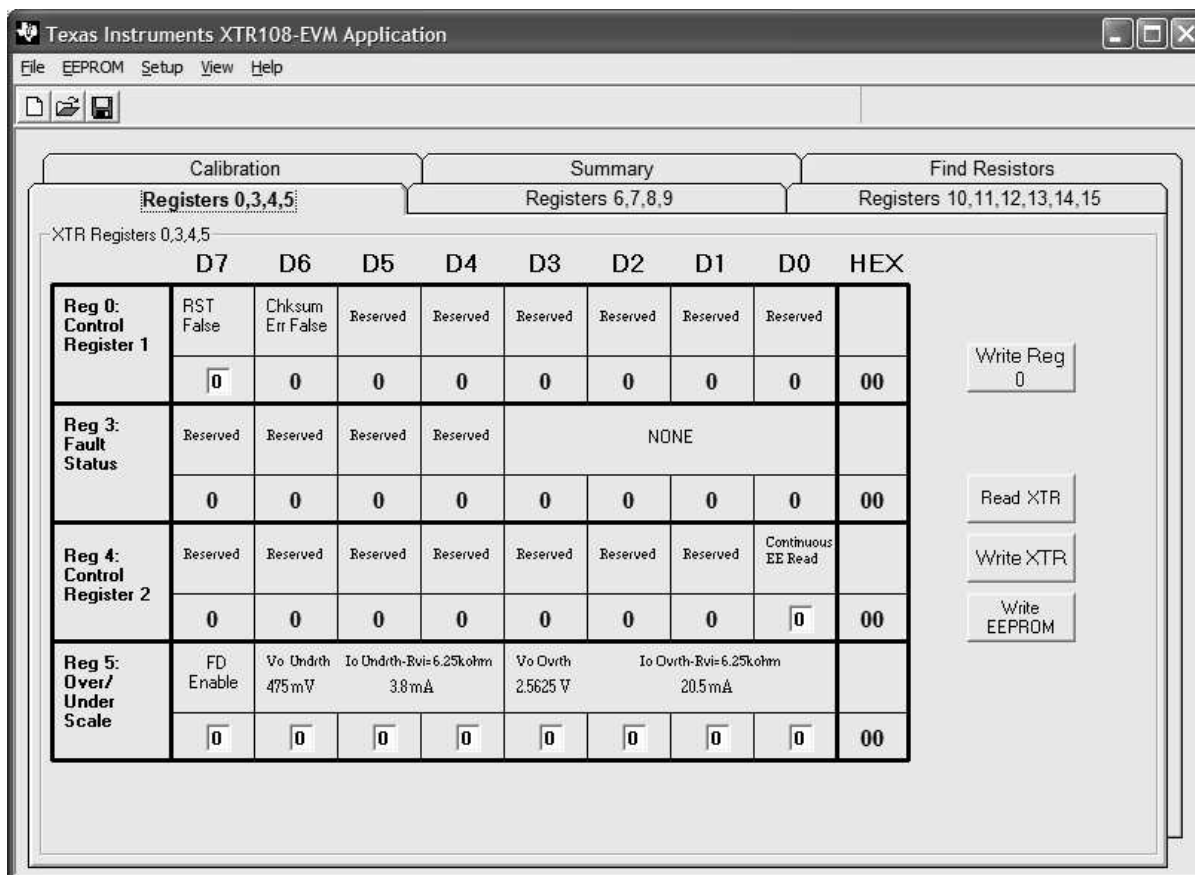
Figure 18. XTR108EVM Board Control Software: Registers 1, 3, 4, 5 Tab

6.5 Registers 6, 7, 8, and 9

Register 6: Sets the PGIA gain. This register is set typically during calibration.

Register 7: Allows configuration of the alarm register. This register determines if the XTR108 will go into over-scale or under-scale for various fault conditions.

Register 8: Controls the input multiplexer. This feature is set typically during calibration.

Register 9: Controls the I_{REF} multiplexer. This feature is set typically during calibration.

See Figure 19 for an example of the tab window display.
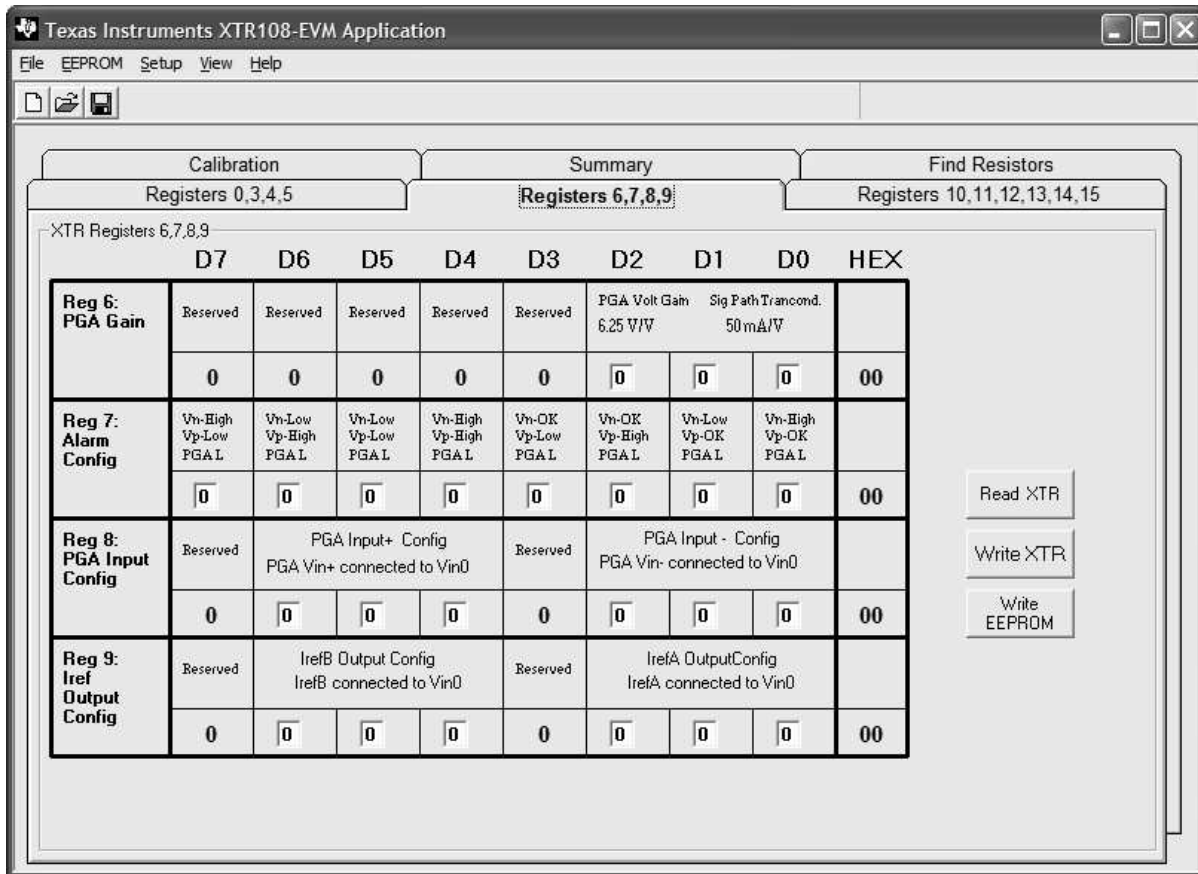
Figure 19. XTR108EVM Board Control Software: Registers 6, 7, 8, 9 Tab

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

Registers 10 to 14: These registers control the various digital-to-analog converter (DAC) settings in the PGA309. These features are set typically during calibration.

See Figure 20 for an example of the tab window display.
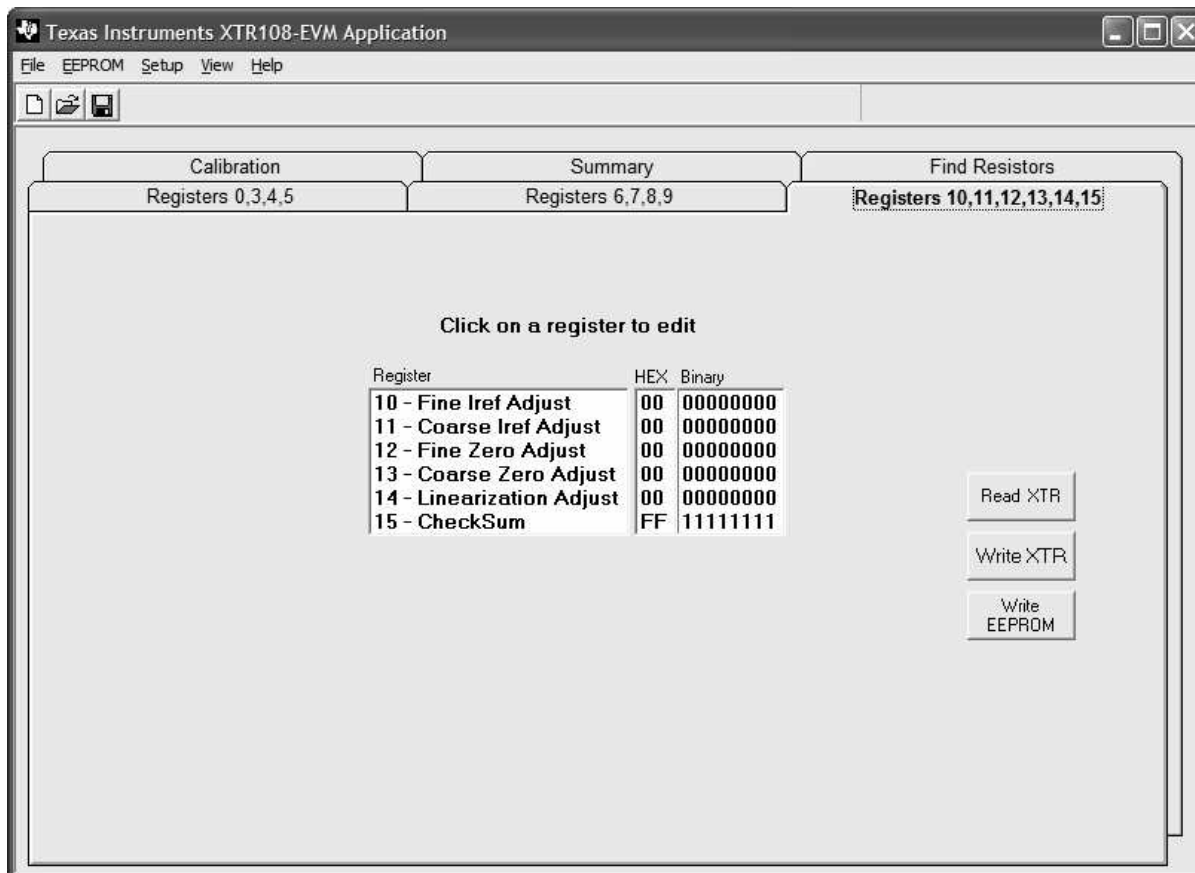
Figure 20. XTR108EVM Board Control Software: Registers 10, 11, 12, 13, 14, 15 Tab

Register 15: The checksum is computed automatically when any register is changed, provided that the *Calculate CRC* box is checked in the Summary tab. If a checksum error is detected, the XTR108 programs itself to the lowest under-scale error level. See Figure 21.
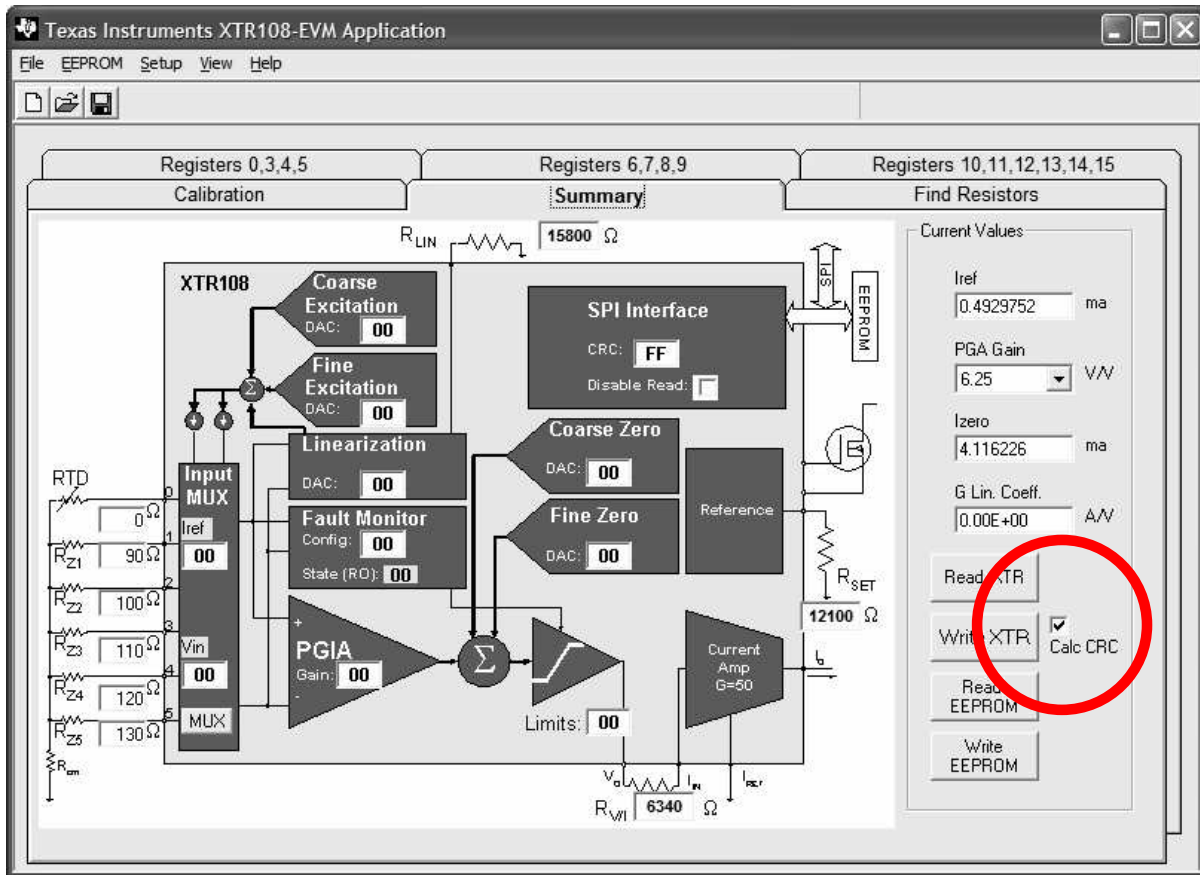
Figure 21. XTR108EVM Board Control Software: Calc CRC Box Checked

7 General Operating Tips

7.1 DC-to-DC Converter

On the PC Interface Board (see Figure 37), a dc-to-dc converter is used in conjunction with optical isolation to allow the ground reference of the digital drive circuitry for the SPI signal to float to the ground reference of the XTR108. This configuration prevents ground contentions. The problem with this scheme is that the dc-to-dc converter is very noisy. This problem can be circumvented by shutting down the dc-to-dc converter when it is not being used. The dc-to-dc converter is turned on only during communications.

It is possible, however, to get the dc-to-dc converter to run in a continuous mode if power is cycled on the XTR108 EVM and communications have not been re-established. In this case, noise will feed-through to the sensor board and can significantly affect the performance of the XTR108. Figure 22 shows how the noise feed-through appears on an oscilloscope. Keep in mind that this feed-through is normally not a problem.
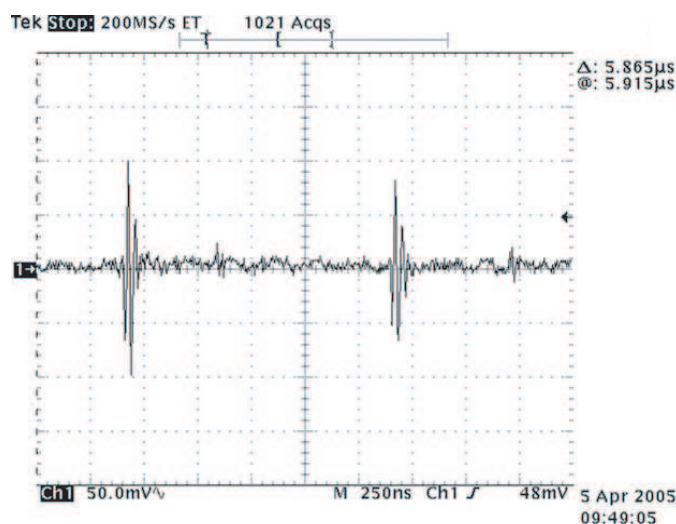
Figure 22. Noise on DCR010505 DC-to-DC Converter

7.2 Charge Pump

On the Sensor Interface Board, a simple discrete charge pump can be used to generate a small negative voltage. When the XTR108 is in Voltage Output mode, a negative voltage must be applied to the XTR108 I_{IN} pin to prevent the input offset voltage of the XTR108 current output stage from turning on the output stage. This circuit is a convenient way of providing this negative voltage. The input for the charge pump is the clock to the XTR108.

Figure 23 illustrates the charge pump confiiguration.
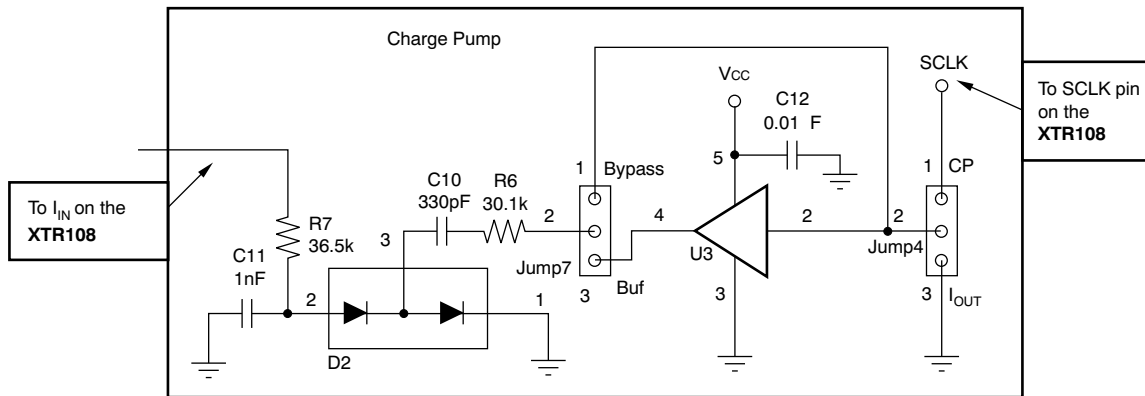
Figure 23. Discrete Charge Pump on Sensor Interface Board

For this circuit to work, the XTR108 clock must toggle continuously. This toggling can be accomplished by keeping the XTR108 in continuous EEPROM read mode. JUMP7 can be used to connect or disconnect an external buffer the clock signal of the XTR108. More information regarding this charge pump is located in the XTR108 data sheet and the XTR108 Quick Start System Reference Guide.

7.3 Voltage Output Mode

In many applications, it is desirable to bypass the FET and connect the XTR108 directly to the power supply. This configuration can be completed by positioning jumpers JUMP2 and JUMP3 in the *Bypass* position.

Note: You must be careful in this mode to not apply an over-voltage to the XTR108. The XTR108 maximum supply voltage is 5.5V. The voltage drop across D1 reduces the XTR108 supply voltage by approximately 0.7V. To get an accurate idea of the XTR108 supply voltage while in this mode, you should measure at the V_S pin of the XTR108 (TP17 on the EVM).

7.4 Regional Settings

Problem:

In some European PC systems, an error is reported when the XTR108DK Control Software is started, as illustrated in Figure 24.
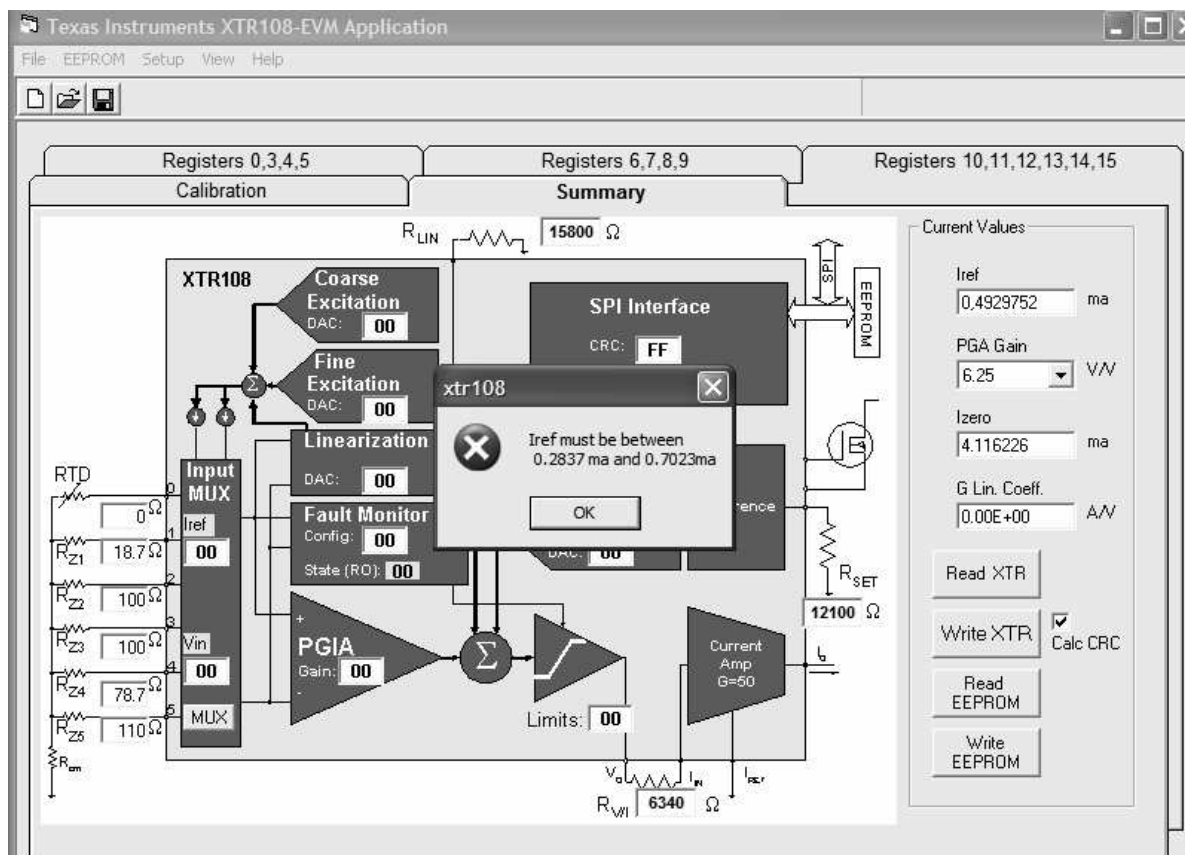
Figure 24. XTR108EVM Board Software: Run-Time Error

Cause:

This error [Runtime Error 13 – Type Mismatch Error] is usually caused by the decimal representation of non-English language computers which use a "**,**" (comma) instead of a "**.**" (period) for the decimal separator [that is, *100.89* represented as *100,89*] .

Solution:

PC-unique regional settings must be changed in two different places on the specific PC system. For Windows XP or NT, you must be logged on as an Administrator or a Member of the Administrators Group in order to complete this procedure.

1. From the Windows **Start** Menu, select *Control Panel*. (See Figure 25.) The Control Panel opens in a new window, as shown in Figure 26.

Figure 25. Control Panel Selection
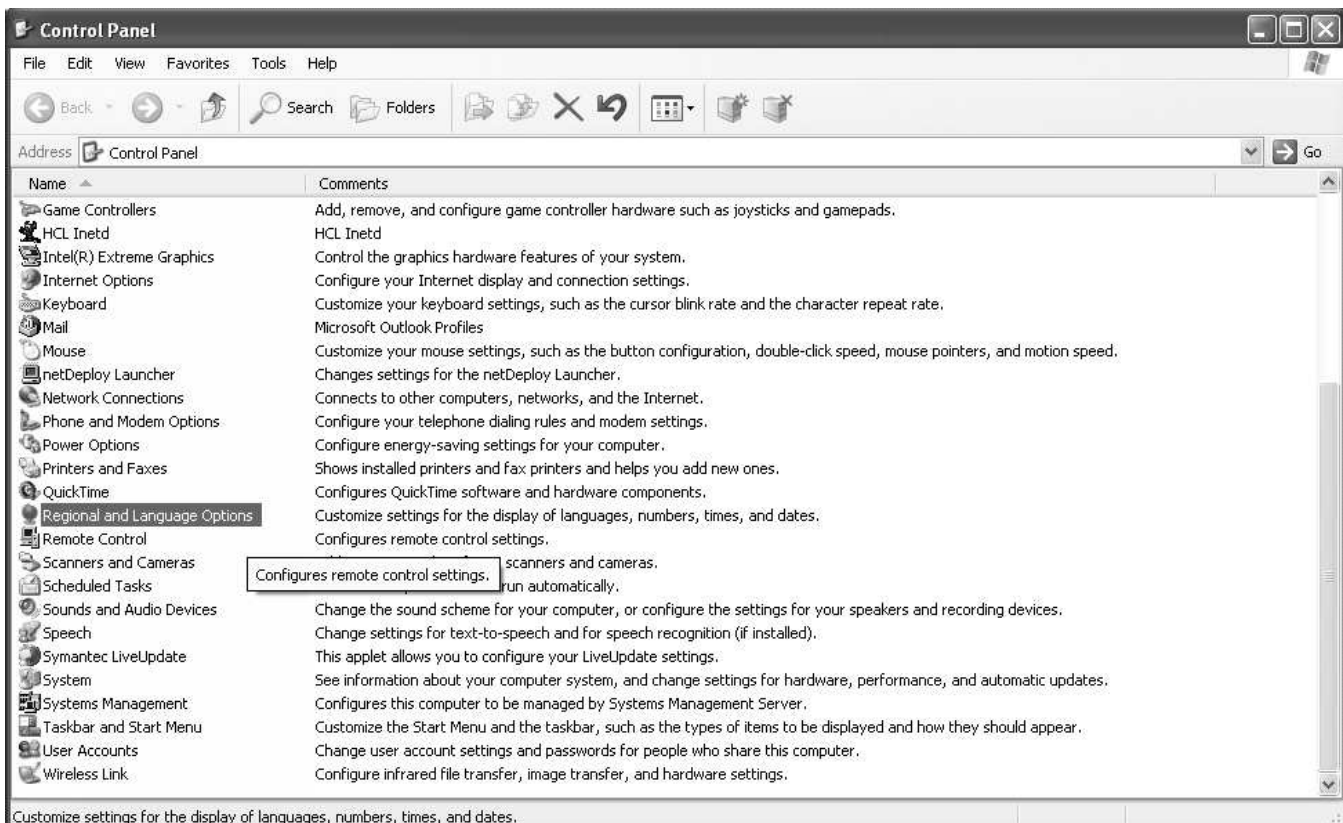
Figure 26. Windows Control Panel

2. Select *Regional and Language Options* in the Control Panel. A new pop-up window, **Regional and Language Options** appears, as Figure 27 shows.

Figure 27. Regional and Language Options Window

3. Click on the *Advanced* tab in the Regional and Language Options dialog. The pop-up window will change as shown in Figure 28.
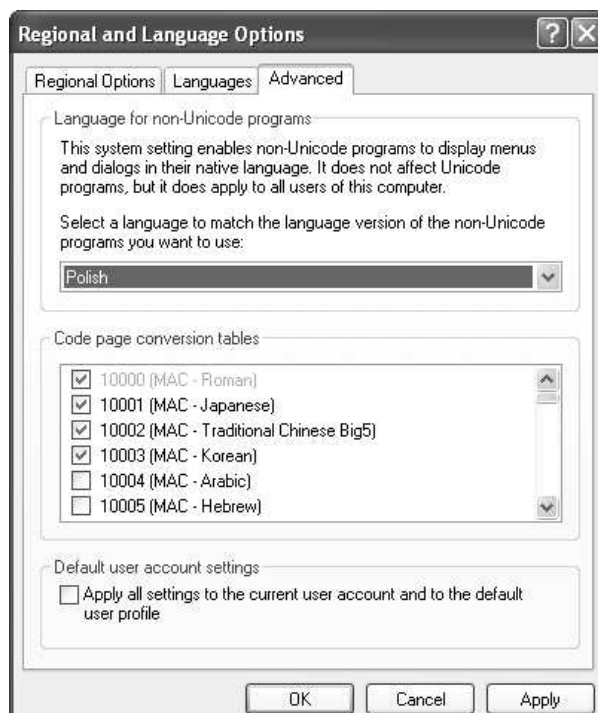
Figure 28. Regional and Language Options: Advanced Tab View

4. In the *Language for non-Unicode Programs* section, click on the drop-down menu arrow and select **English (United States)** as shown in Figure 29. If your computer is already configured for English (United States) as the Language for non-Unicode Programs, skip to Step 6.
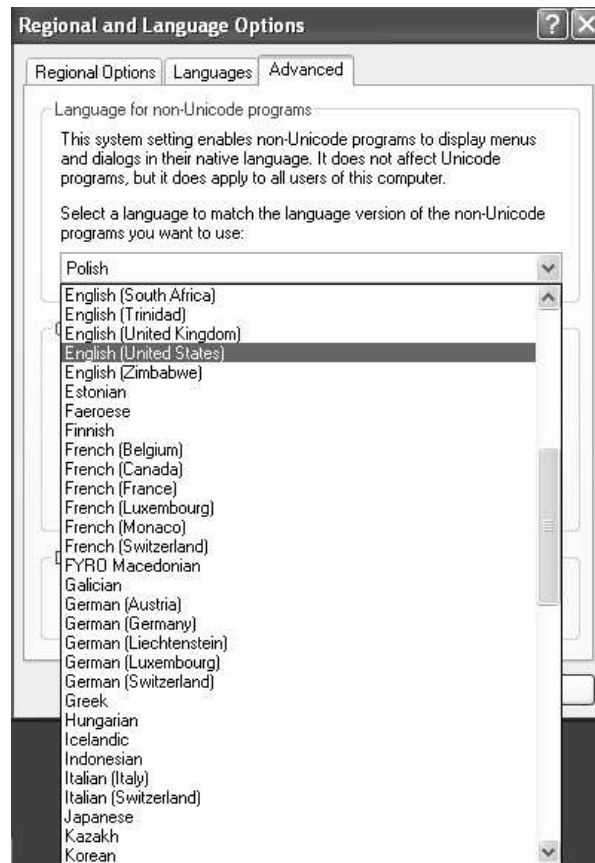
Figure 29. Regional and Language Options, Advanced Tab: Language for Non-Unicode Programs Dialog

5. Click on **Apply**. You will be instructed to restart your computer. (See Figure 30.) Restart your computer, and repeat Step 1 and Step 2 above; then continue with Step 6.
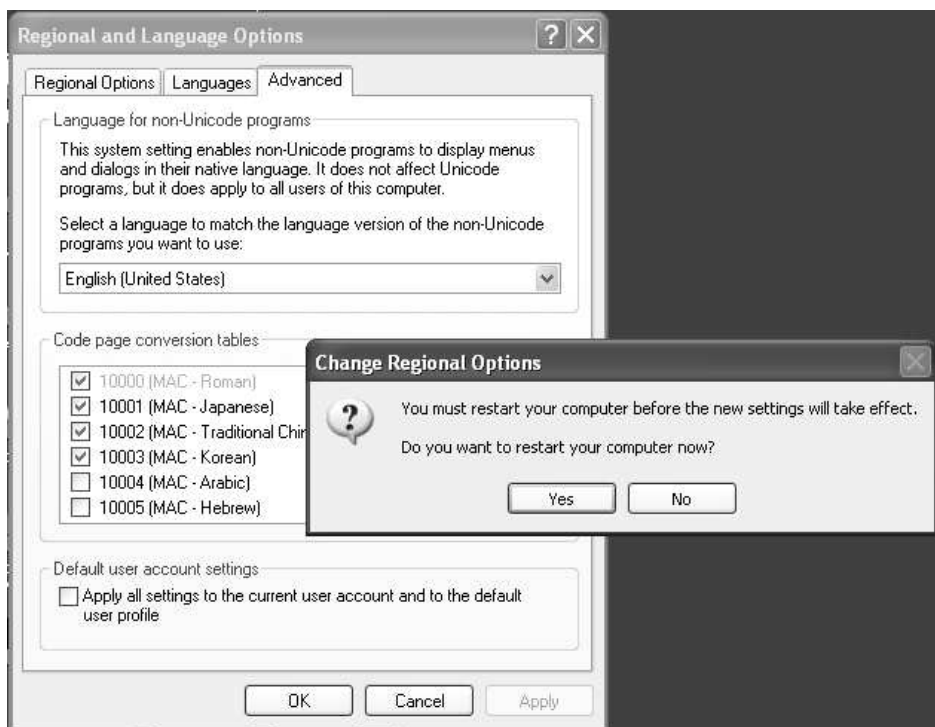
Figure 30. Restart PC Dialog

6. In the Regional and Language Options pop-up window, click on the *Regional Options* tab as shown in Figure 31.

Figure 31. Regional and Language Options Window: Regional Options Tab

7. Click on the **Customize** button in the Regional Options tab of the Regional Language Options pop-up window. See Figure 32.
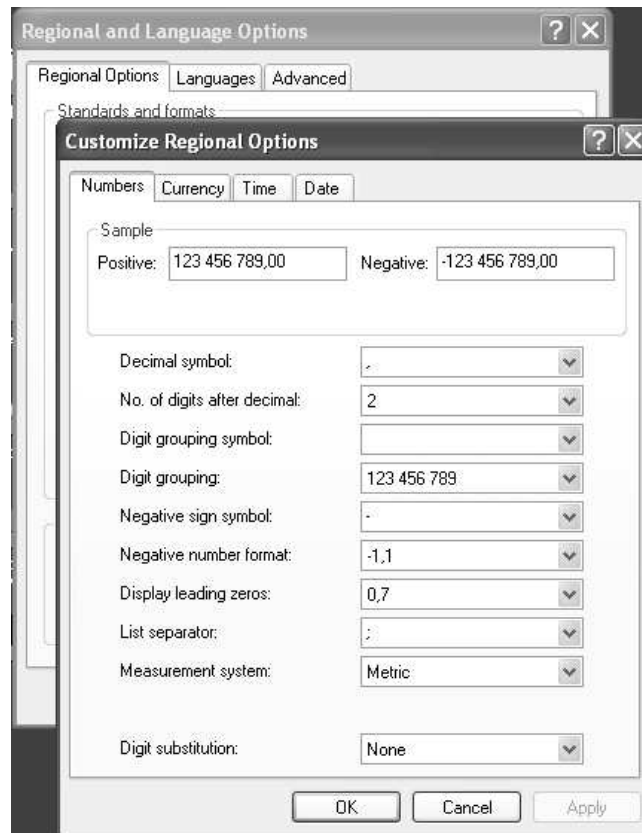
Figure 32. Regional and Language Options Window, Regional Options Tab: Customize Regional Options Dialog

8. In the Customize Regional Options dialog, under the *Decimal symbol* option, select "**.**" from the drop-down menu, as shown in Figure 33. Click **OK** in the Customize Regional Options window, which returns you to the Regional and Language Options Window as shown in Figure 34. Notice that under the Number section in this window, the decimal separator of the number displayed is shown as a "**.**" (period) instead of its original setting as "**,**" (comma).
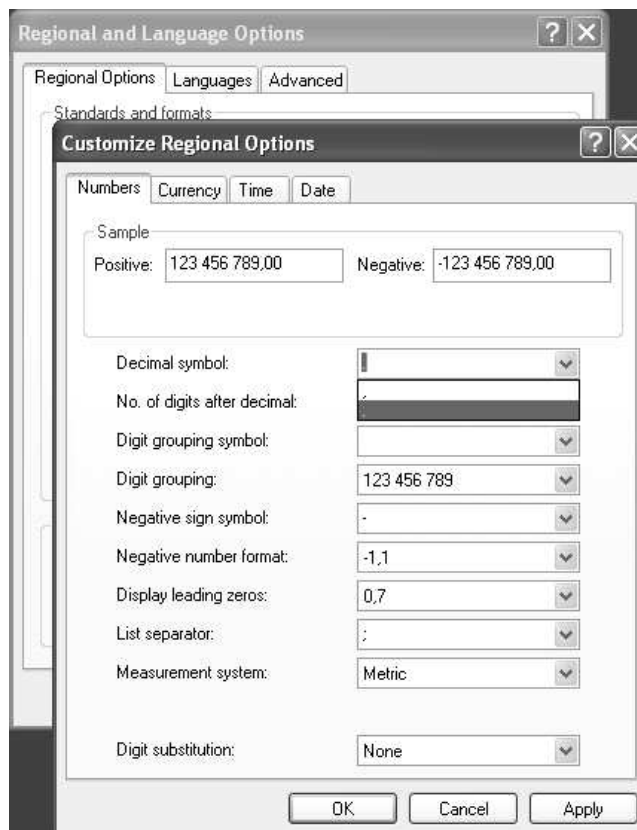
Figure 33. Regional and Language Options Window, Regional Options Tab, Customize Regional Options Dialog: Decimal Symbol Selected

Figure 34. Regional and Language Options Window after Customized Regional Options are Selected

9. In the Regional and Language Options window, as in Figure 34, click on **OK**. This closes all pop-up windows and returns to the main Control Panel window on the desktop. Close this window by clicking on the **X** in the upper right-hand corner of this window, as shown in Figure 35.
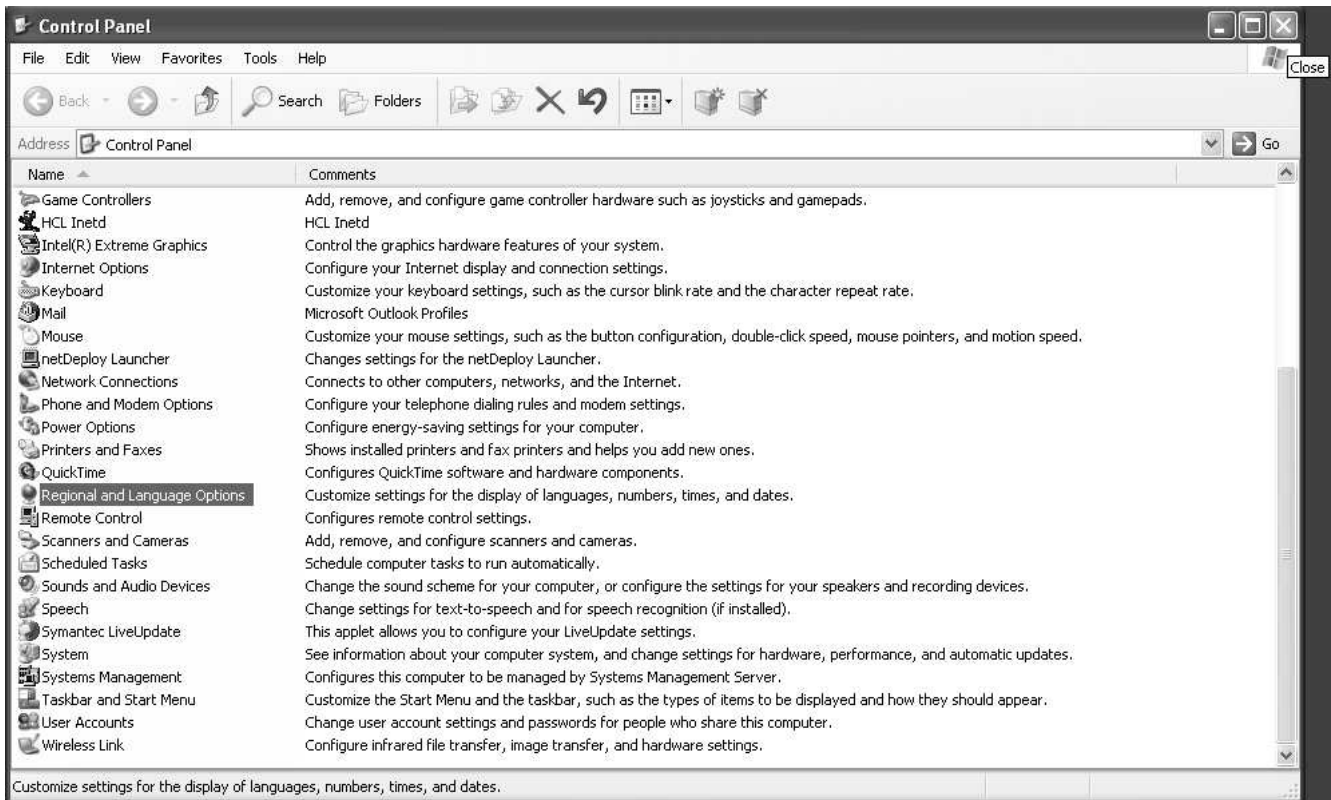
Figure 35. Windows Control Panel

10. Start the XTR108DK Control Software. All features of the XTR108DK software should now work correctly.

8 XTR108EVM PC Cable Drawing

Figure 36 shows the recommended cabling for the XTR108EVM.

1 - No Connection
2 - RD
3 - TD
4 - DTR
5 - GND
6 - DSR
7 - RTS
8 - CTS
9 - No Connection

**XTR108 EVM
PC Cable Drawing**

THG   January 16, 2004

Figure 36. XTR108EVM Cables

9 Schematics

This section describes the physical characteristics of the XTR108EVM-DK. Figure 37 illustrates the PCI section of the XTR108EVM. Figure 38 shows the Sensor Interface Board portion of the XTR108EVM.
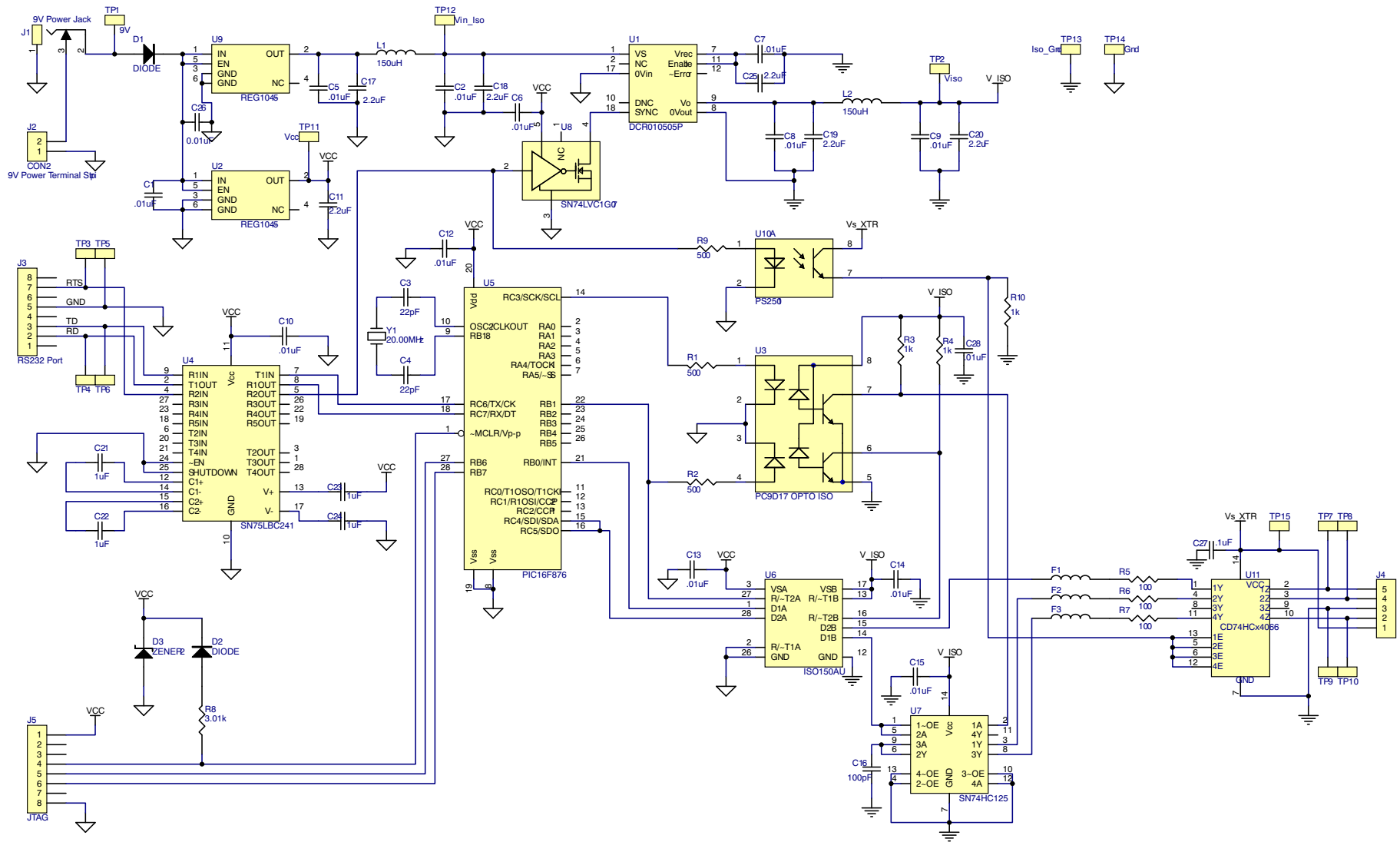
Figure 37. XTR108EVM PCI Interface Board
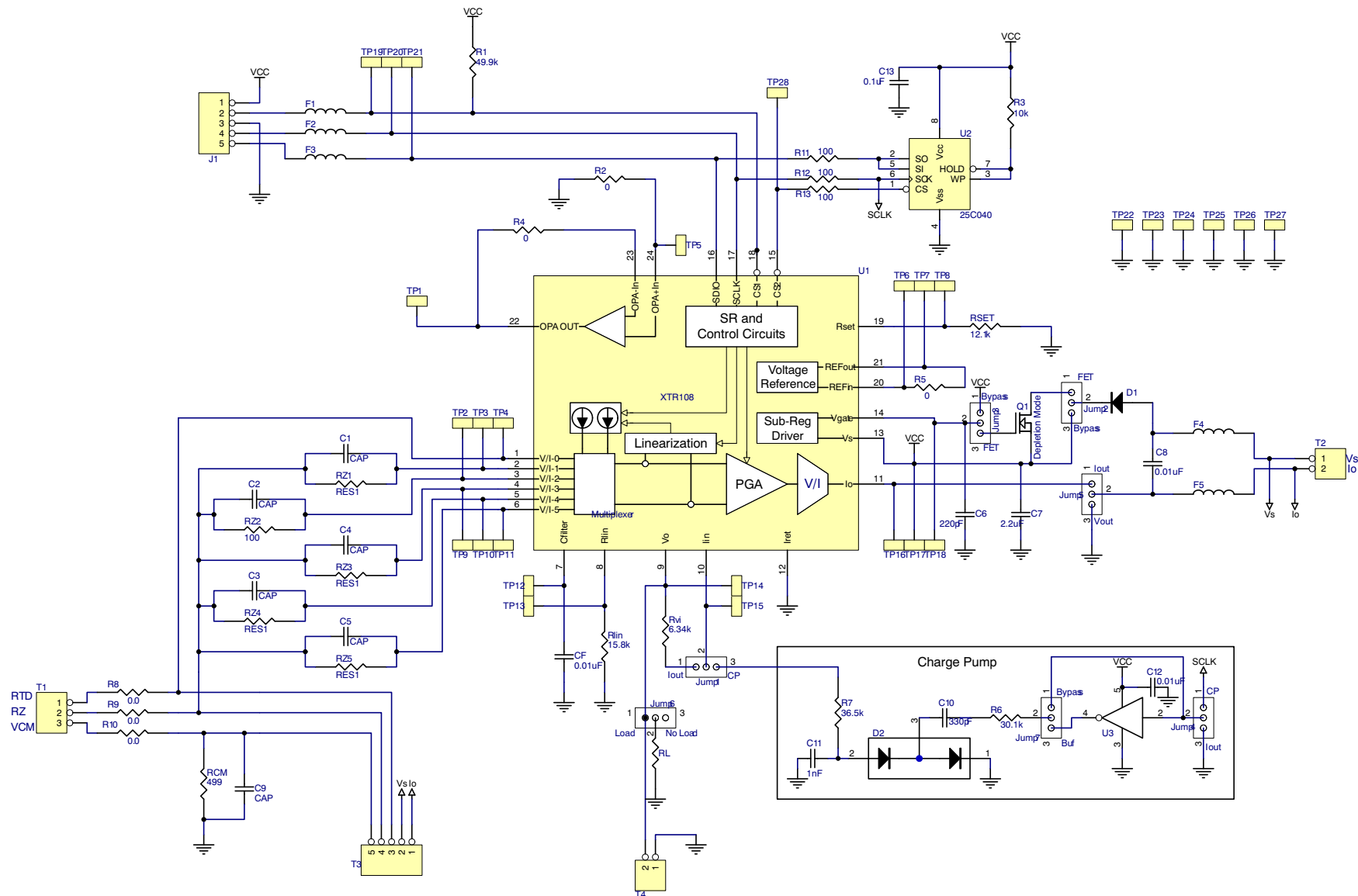
Figure 38. XTR108EVM Sensor Interface Board

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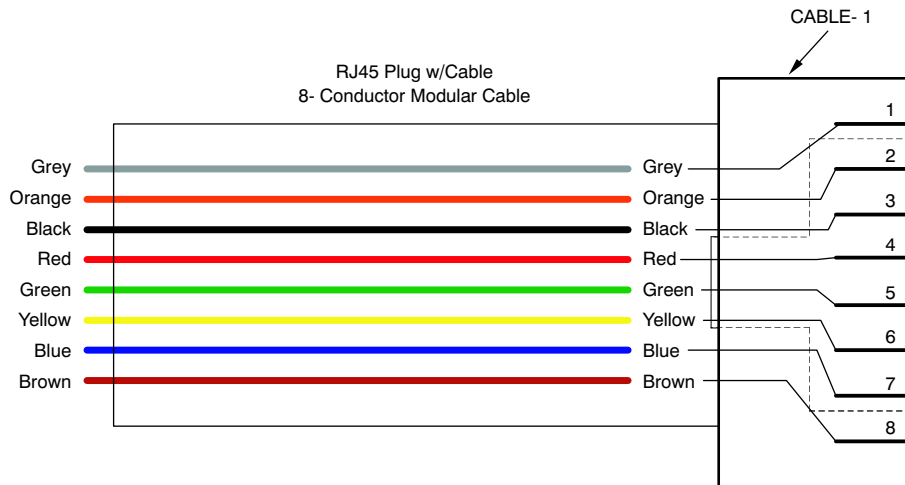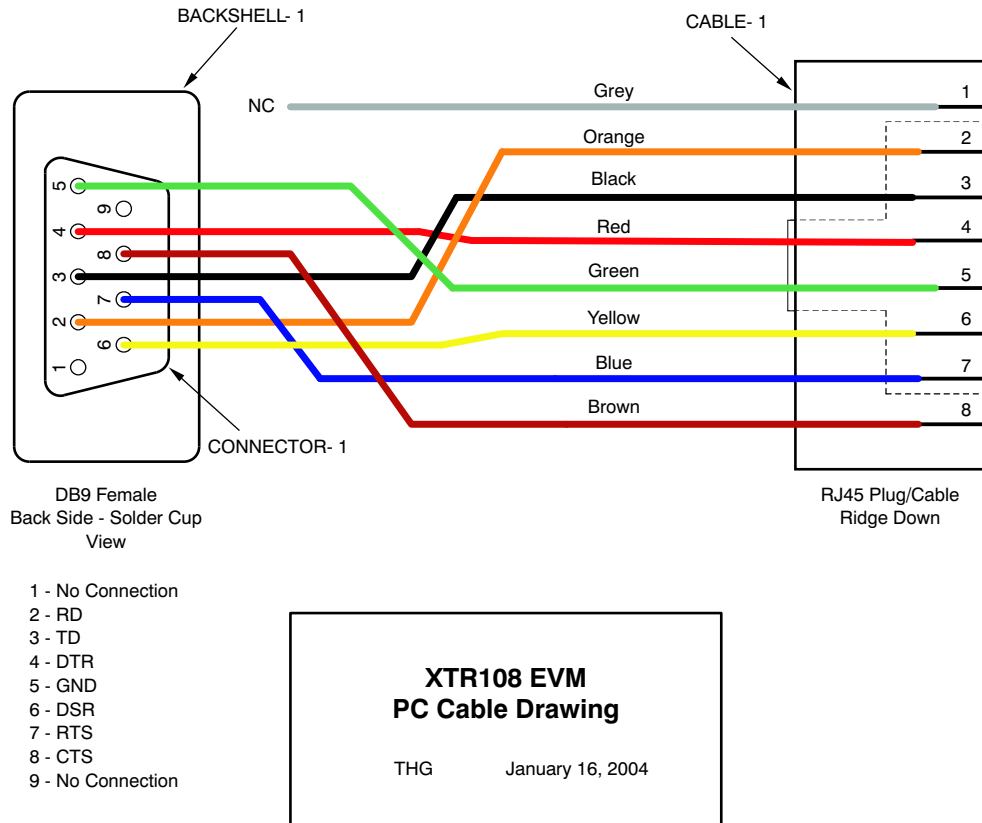
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The PC Interface Board dc supply (J2) input range is 7V to 10V. The loop supply (T2) input voltage range is (5.5V + VD1) when in voltage mode. When operating in Current Loop Output mode, you must consider the power dissipated in the external transistor and the operating temperature of the transistor in order to determine the maximum loop voltage and current. This calculation is determined in the XTR108 data sheet.

Exceeding the specified input range may cause unexpected operation and/or irreversible damage to the EVM. If there are questions concerning the input range, please contact a TI field representative prior to connecting the input power.

Applying loads outside of the specified output range may result in unintended operation and/or possible permanent damage to the EVM. Please consult the EVM User's Guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative.

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