Multi-Cal-PGA309 System

This user's guide describes the characteristics, operation, and the use of the Multi-Cal-PGA309 System evaluation module (EVM). It covers all pertinent areas involved to properly use this EVM board. The document includes the physical printed circuit board layout, schematic diagrams, and circuit descriptions.

Contents

List of Figures

1 Overview

The Multi-Cal-PGA309 System Evaluation Module is a set of EVMs that is used to calibrate multiple PGA309 sensor modules. The PGA309 is a programmable analog sensor signal conditioner. All components in the Multi-Cal-PGA309 can be expanded to calibrate up to 64 sensors simultaneously. For a more detailed description of the PGA309, please refer to the product data sheet (SBOS292) available from the Texas Instruments web site at http://www.ti.com. Additional support documents are listed in the section of this guide entitled *Related Documentation from Texas Instruments* .

The Multi-Cal-PGA309 System Evaluation Module consists of two printed circuit boards (PCBs). One board (the USB DAQ Platform) generates the signals required to communicate with the Multi-Cal-PGA309, which is the second board (Multi-Cal-Master PCA), as well as support and configuration circuitry. The complete Multi-Cal-PGA309 contains a series of PCBs, and can be expanded to meet your specific system requirements.

The PGA309 and the PGA308 sensor modules share the same hardware platform for the Multi-Cal-PGA309. The Multi-Cal-PGA309 Evaluation Module User Guide (SBOU087) describes how to set up and use the hardware with either device.

Throughout this document, the abbreviation *EVM* and the term *evaluation module* are synonymous with the Multi-Cal-PGA309 System Evaluation Module.

1.1 Related Documentation from Texas Instruments

The following document provides information regarding Texas Instruments integrated circuits used in the assembly of the Multi-Cal-PGA309 System EVM. This user's guide is available from the TI website under literature number SBOU104. Any letter appended to the literature number corresponds to the document revision that is current at the time of the writing of this document. Newer revisions may be available from the TI web site at http://www.ti.com/, or call the Texas Instruments Literature Response Center at (800) 477-8924 or the Product Information Center at (972) 644-5580. When ordering, identify the document by both title and literature number.

Document	Literature Number
PGA309 Product Data Sheet	SBOS292
USB DAQ Platform Users Guide	SBOU056
Multi-Cal-System Evaluation Module User Guide	SBOU087
Multi-Cal-Test EVM User's Guide	SBOU088
Multi-Cal-Master EVM User's Guide	SBOU089
Multi-Cal-System Cable User's Guide	SBOU092
Multi-Cal-Slave EVM User's Guide	SBOU094
Multi-Cal-Interface User's Guide	SBOU093

1.2 Information About Cautions and Warnings

This document contains caution statements.

CAUTION

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

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

1.3 Applications Questions

If you have questions about this or other Texas Instruments evaluation modules, post a question in the *Amplifiers* forum at http://e2e.ti.com. Include in the subject heading the product in which you are interested.

2 Multi-Cal-PGA309 System EVM Software Overview

This section discusses how to install and use the Multi-Cal-PGA309 System EVM software.

2.1 Multi-Cal-PGA309 System EVM Software Installation

Follow these steps to install the Multi-Cal-PGA309 System EVM software:

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

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

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

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

2.2 Test the Operation of the Multi-Cal-PGA309 Software

The Multi-Cal-PGA309 software can be operated through the Windows *Start* menu. From Start, select *All Programs*; then select the *Multi-Cal-PGA309 EVM* program. Figure 1 shows how the software should appear if the EVM is functioning properly. If the software does not start normally, check the power and USB connection. See Section 4 of the *Multi-Cal-System Evaluation Module User Guide* (SBOU087) for more detailed troubleshooting tips. Figure 1 also shows the summary tab. When the software is running, this tab displays calibration results.

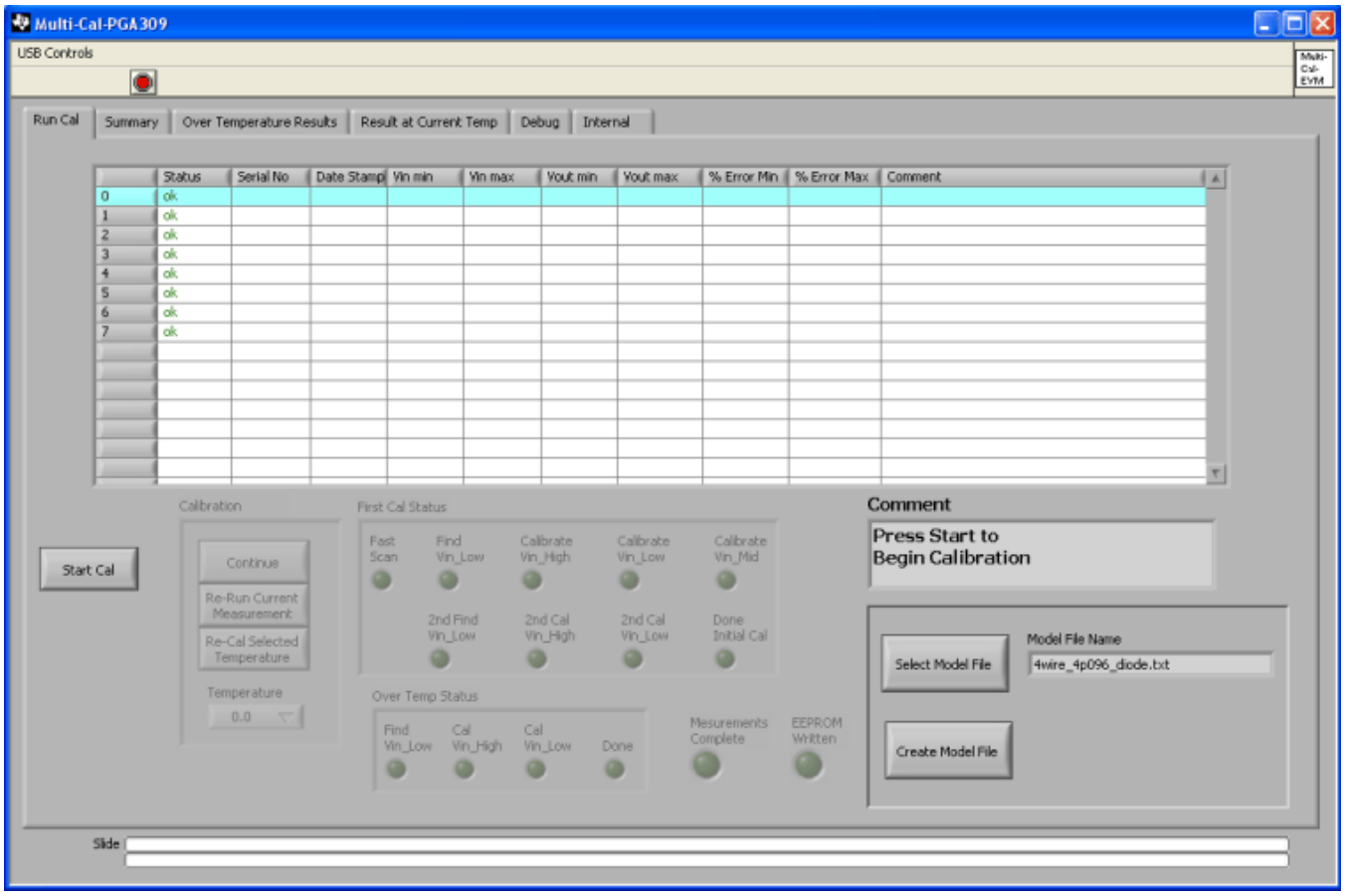

Figure 1. Multi-Cal-PGA309 Software: Functioning Properly

Before starting a calibration, you must set up the software to calibrate according to your sensor module design. For example, the software must be set up differently if you are calibrating a three-wire module, a four-wire module, or a current output module. The output swing, overscale, underscale, and fault setup requirements can also be different according to your system application. This design-specific information is stored in the *model* file. You can select different model files using the **Select Model File** button as shown in Figure 2.

The software includes several example model files for typical configurations. In this document, we will discuss how to create your own custom model file in Section 3.

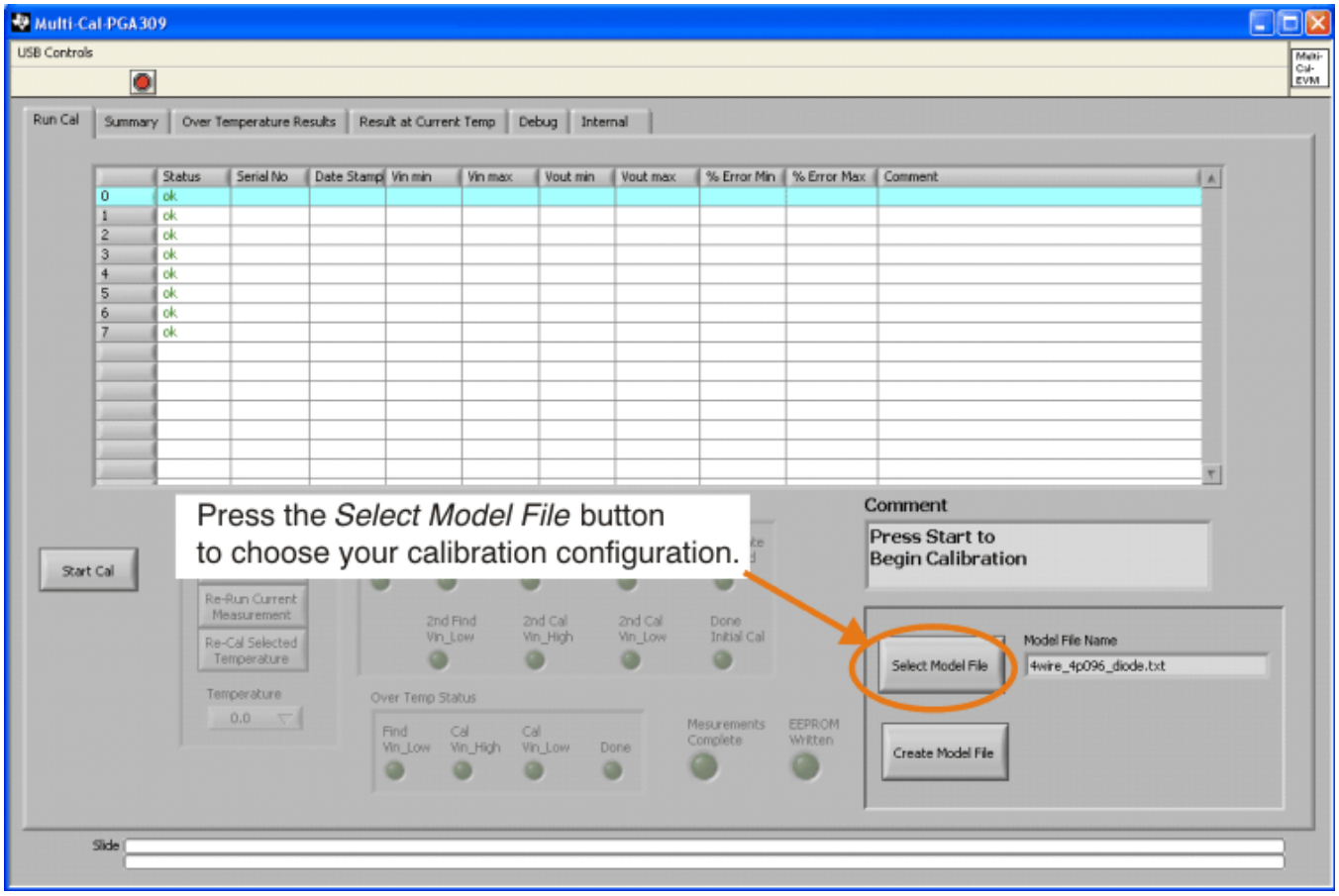

Figure 2. Multi-Cal-PGA309 Software: Select Sensor Model

Figure 3 shows the window that appears when you press the **Load Sensor Model Configuration** button in the *Config Cal* tab. Note that the example files are given to demonstrate the three common PGA309 configurations (specifically, *iout.csv*, *Vout_3_wire.csv*, and *Vout_4_wire.csv*). Note that the three sensor model files can be used to calibrate the Multi-Cal-Test PCA boards with the jumper settings given in Table 3 of the *Multi-Cal-System Evaluation Board User Guide* (SBOU087).

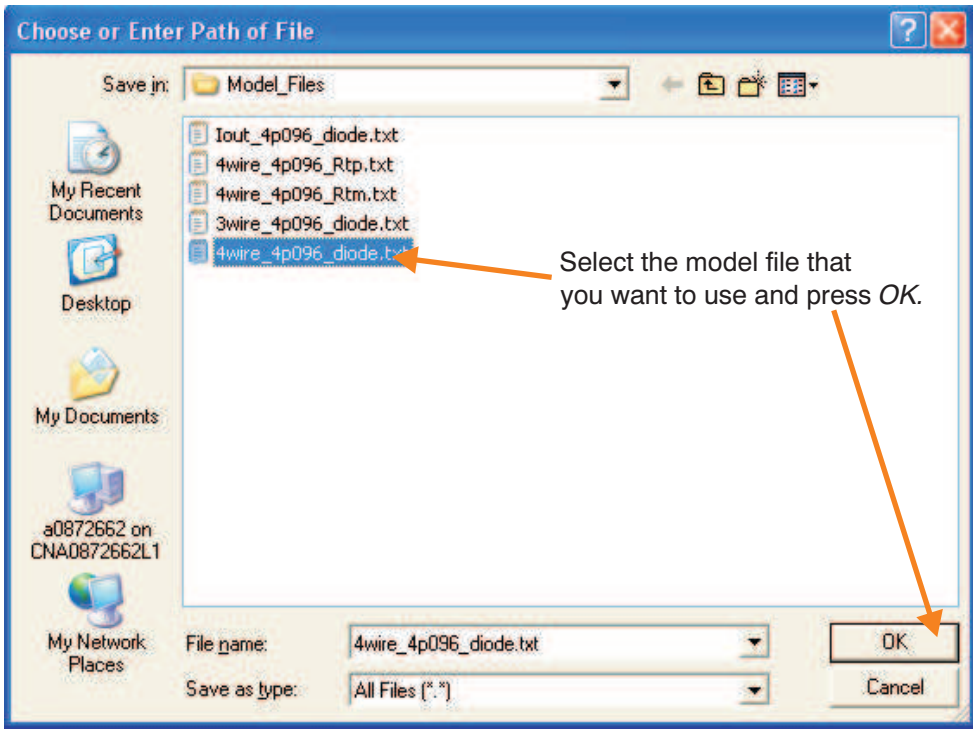

Figure 3. Multi-Cal-PGA309 Software: Select Model File

After the selecting the specific sensor model file, the *Sensor Model Selected* field updates. To edit the sensor model file, press the **Create Model File** button as shown in Figure 4.

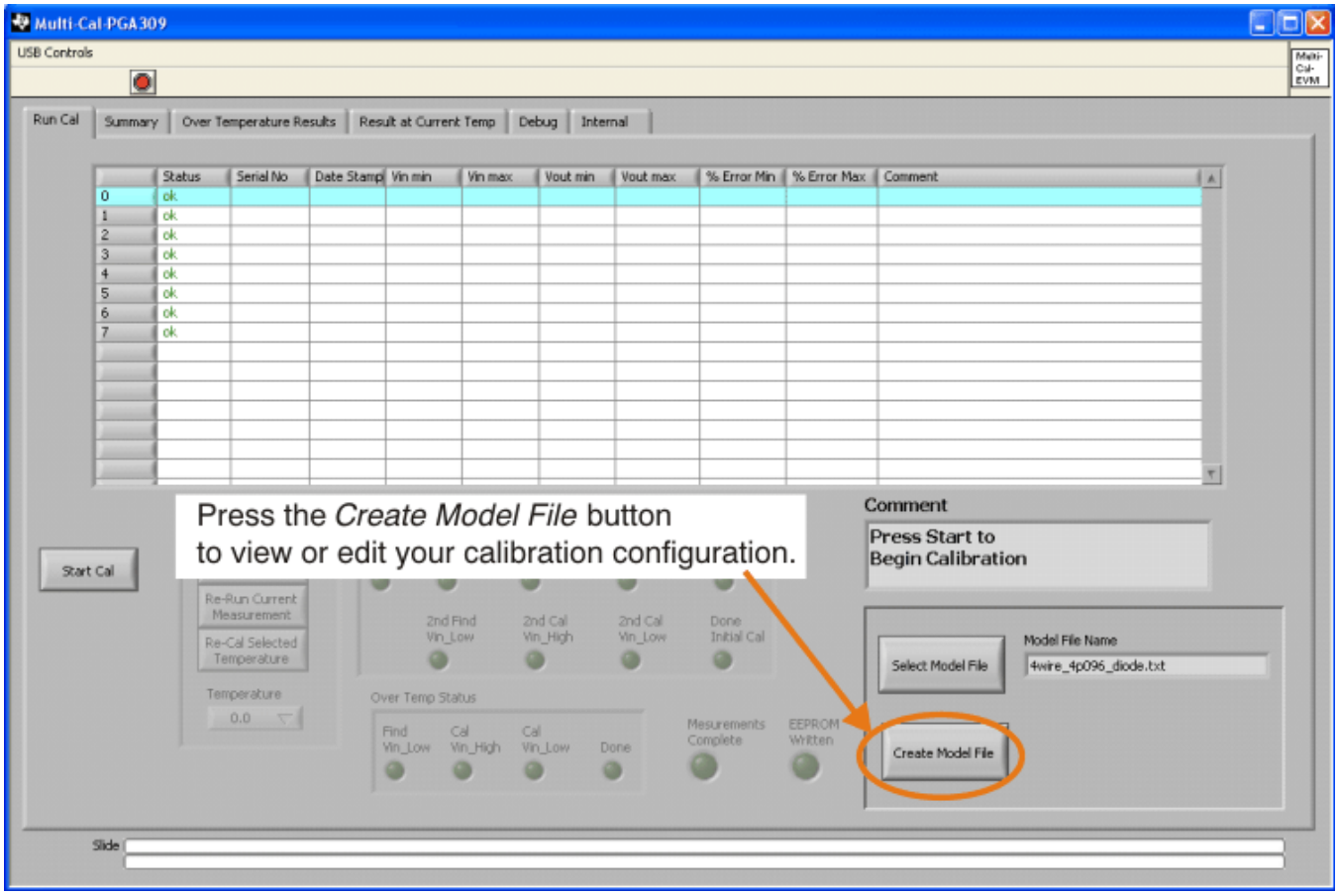

Figure 4. Multi-Cal-PGA309 Software: Create Model File

Figure 5 shows the *Create Model File* window. The model file contains the key information that makes a model unique. For example, the model file determines if the sensor module is a *voltage output* or *current output* module. Each field in the Create Model File window is discussed in detail in Section 3.

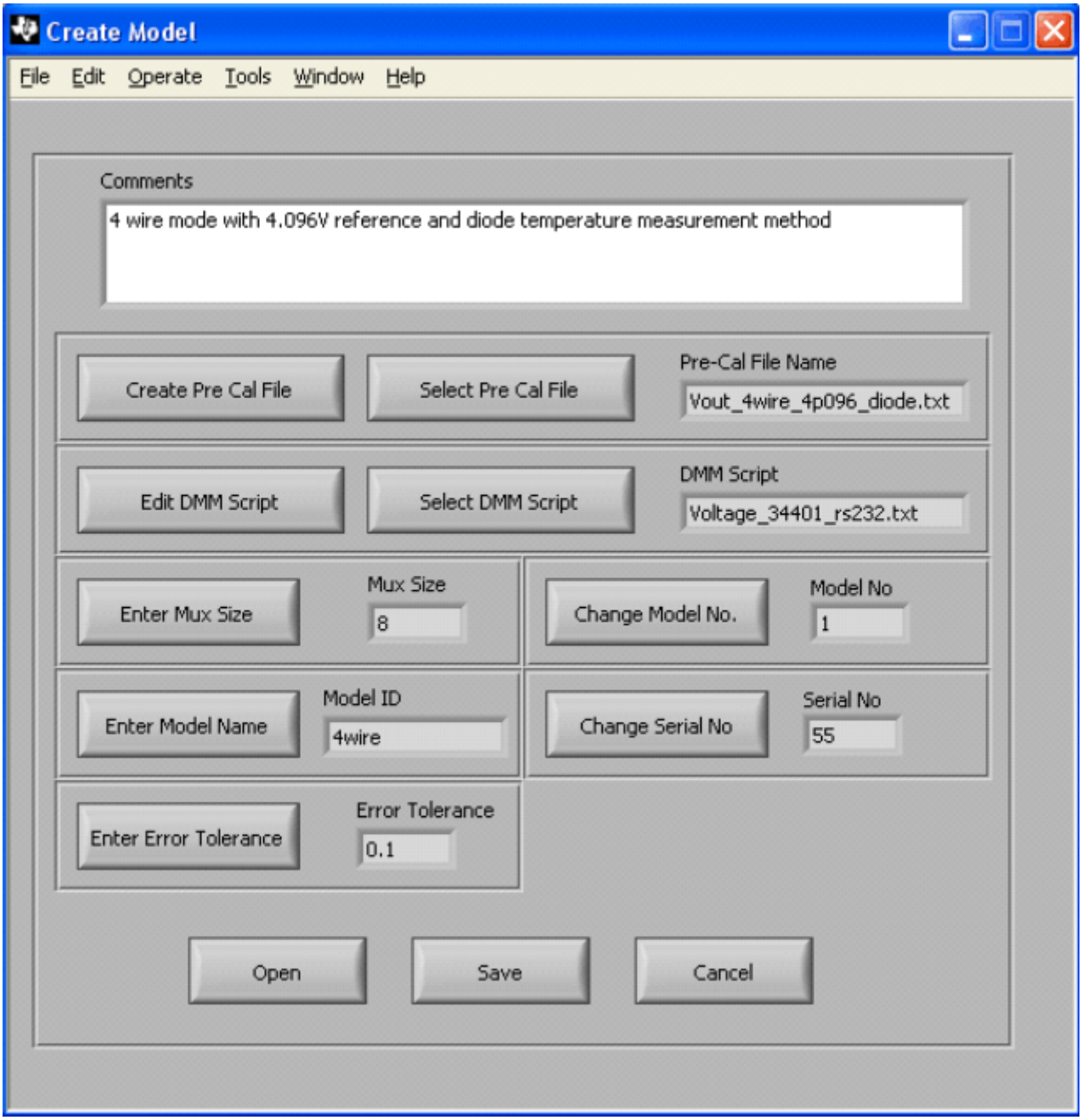

Figure 5. Multi-Cal-PGA309 Software: Create Model File Window

2.3 Starting a Calibration

The Multi-Cal-PGA309 software is used to calibrate PGA309 bridge sensor modules. The calibration automatically determines the sensor output over temperature and adjusts the gain and offset of the PGA309 to achieve the desired output swing. The user of the calibration software must only adjust the stimulus (for example, pressure) as prompted by the software. The measurements, calculations, and adjustments are performed automatically by the software.

Figure 6 shows how to start the calibration sequence. Throughout the calibration process, the software prompts you to adjust the stimulus (pressure) to a maximum, minimum, or a 50% level. This adjustment can be automated if your stimulus (pressure) source can be controlled with IEEE488 or through an RS-232 interface. Throughout the calibration process, the software also prompts you to adjust the temperature. The temperature changes can also be automated if your oven can be controlled with IEEE488 or through an RS-232 interface. The *Test Sequence* LEDs shown in the screenshot illuminate as the calibration progresses.

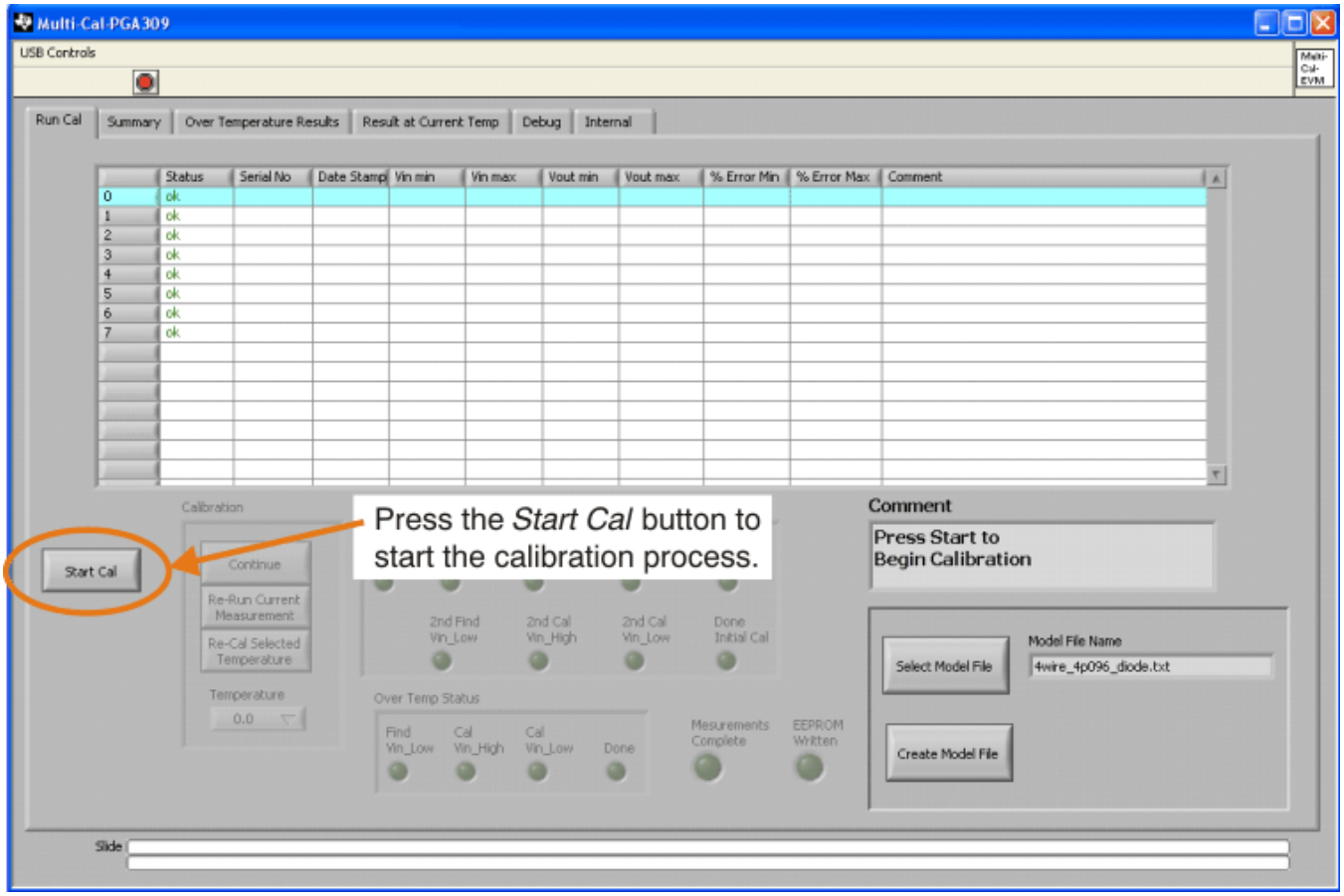

Figure 6. Multi-Cal-PGA309 Software: Start Calibration Process

After pressing the **Start Calibration** button, the Start Calibration window appears (as shown in Figure 7). This window allows you to confirm several critical file parameters: the Serial Number, Date Code, Cal File, and Report File. The serial number and date code will be written into an EEPROM if you use this feature. The file names are automatically generated based on the date code and serial numbers. See Section 3.3 for a complete description of the file naming scheme.

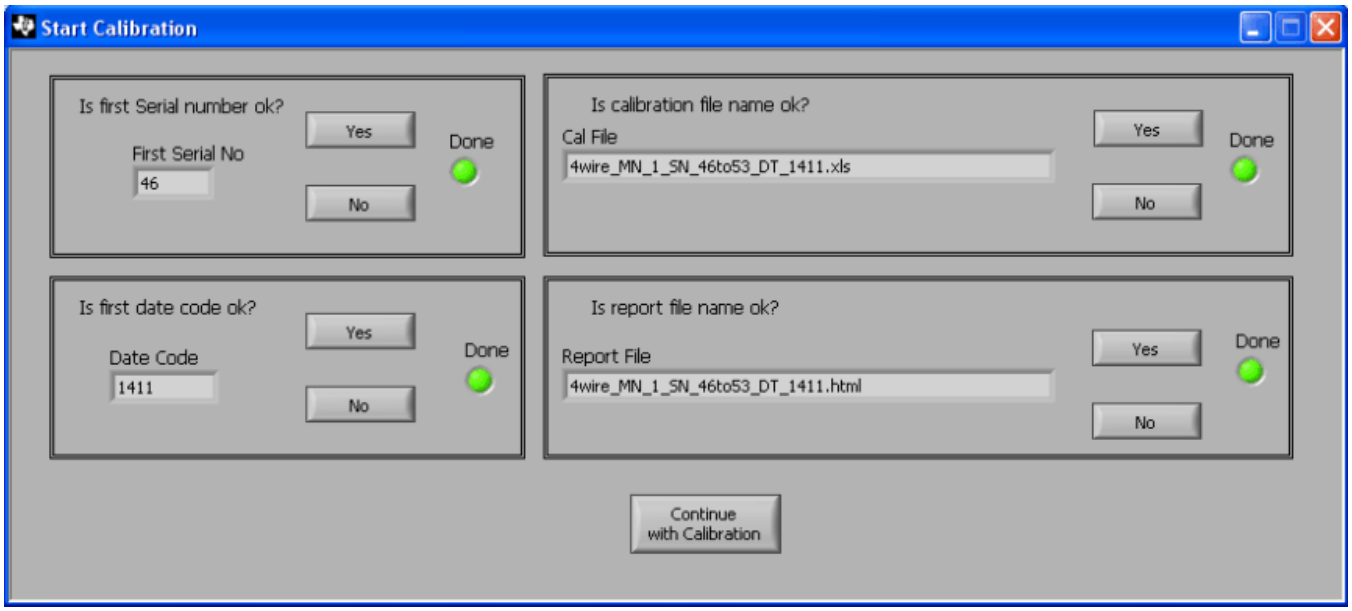

Figure 7. Multi-Cal-PGA309 Software: Confirm Calibration Script

In order to proceed with the calibration, you must press **Yes** to accept the entry for each field. You can change the values that are automatically generated, if necessary, by pressing **No**. Once you have accepted all the field entries, press the **Continue with Calibration** button to continue.

Note that the default values are written into an EEPROM during calibration. This option makes it easy to match the sensor module with its associated file. For example, if you read the serial number and date code out of the EEPROM, you can easily search the filenames for the corresponding file.

Figure 8 shows the software waiting for the user to continue the calibration process. When the software is in the wait mode, the **Continue** button blinks. To continue the calibration process, press the **Continue** button. The Comment section tells the user how the pressure and temperature must be set before pressing the **Continue** button. In the example shown here, the user should adjust the pressure to minimum and the temperature to 0.0°C before pressing the **Continue** button.

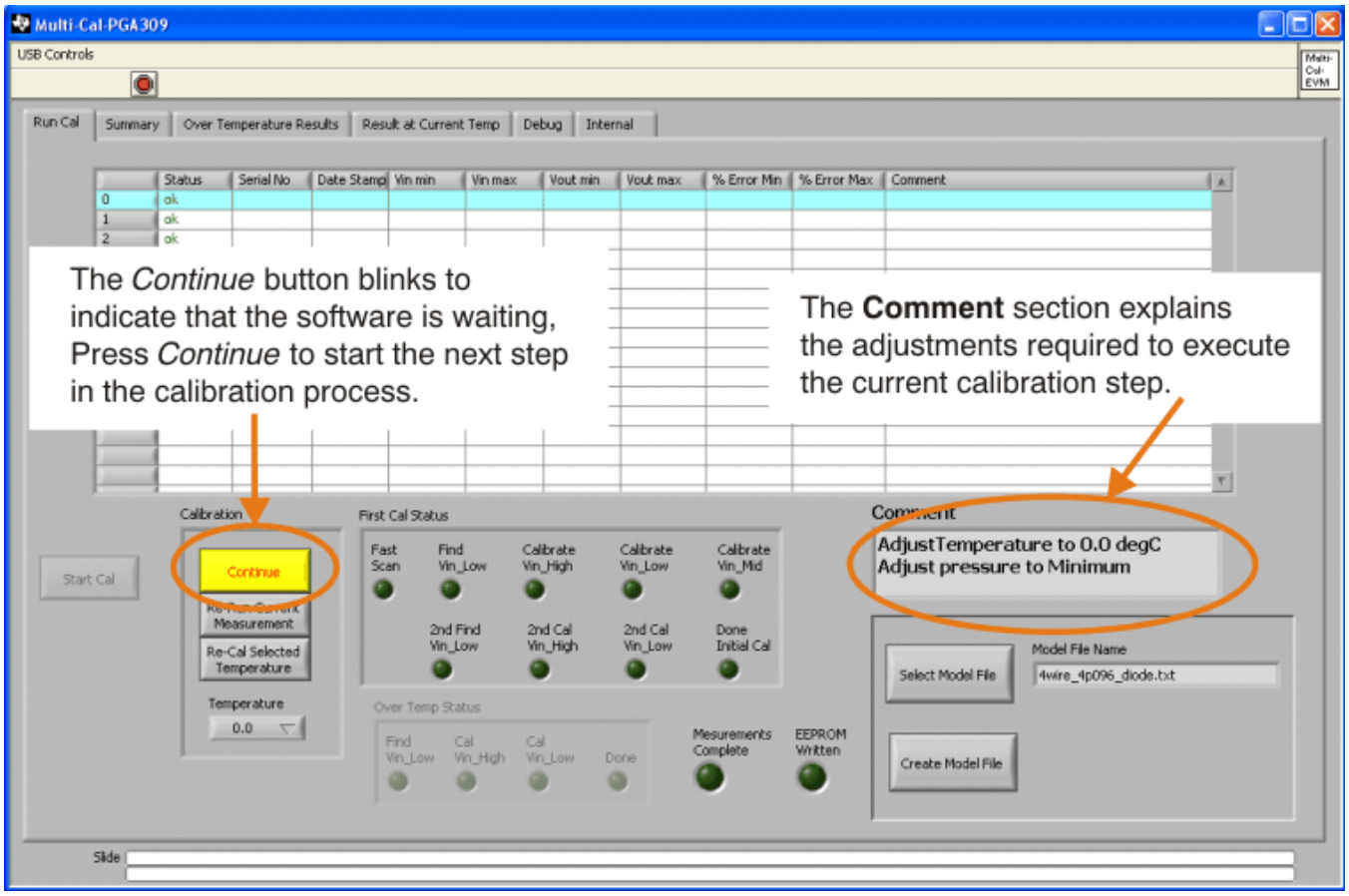

Figure 8. Multi-Cal-PGA309 Software: Continue Calibration Process

Figure 9 shows the software running the first part of the calibration process (the Fast Scan). The Fast Scan applies power to only one sensor module at a time and tests to see whether that module functions. If the sensor module fails this test, the module is not powered during the calibration. When the Fast Scan completes, power is then simultaneously applied to all of the functional modules.

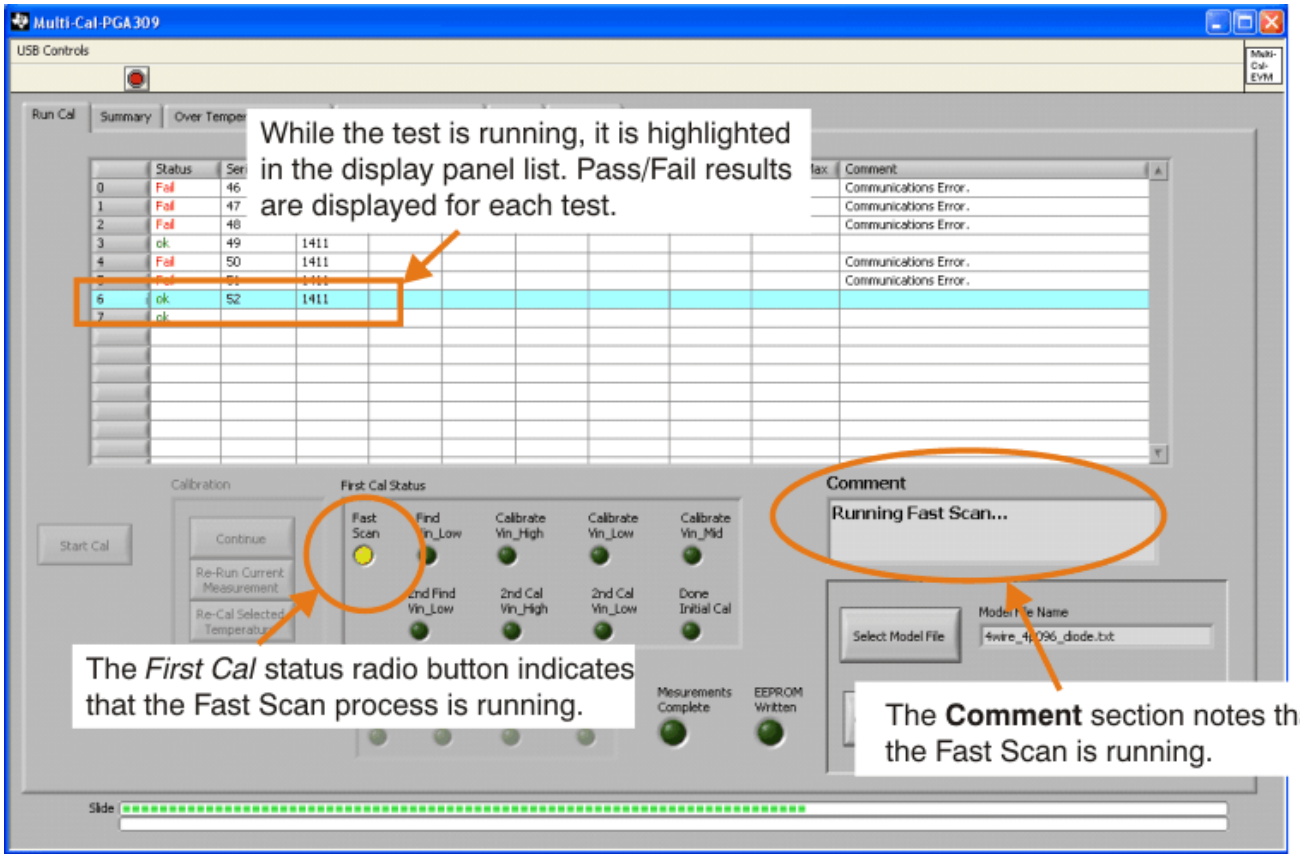

Figure 9. Multi-Cal-PGA309 Software: Fast Scan Process

After the Fast Scan is done, the user must apply the specified pressure and temperature before pressing the **Continue** button. In the example shown in Figure 9 and Figure 10, you must apply low pressure at 0°C. After pressing the **Continue** button, the software executes the *Find Vin_Low* calibration step. During this step, the software measures the output and back-calculates the input signal. The back calculation involves dividing by the gain and subtracting out the PGA309 offsets. Figure 10 shows the software running the *Find Vin_Low* step.

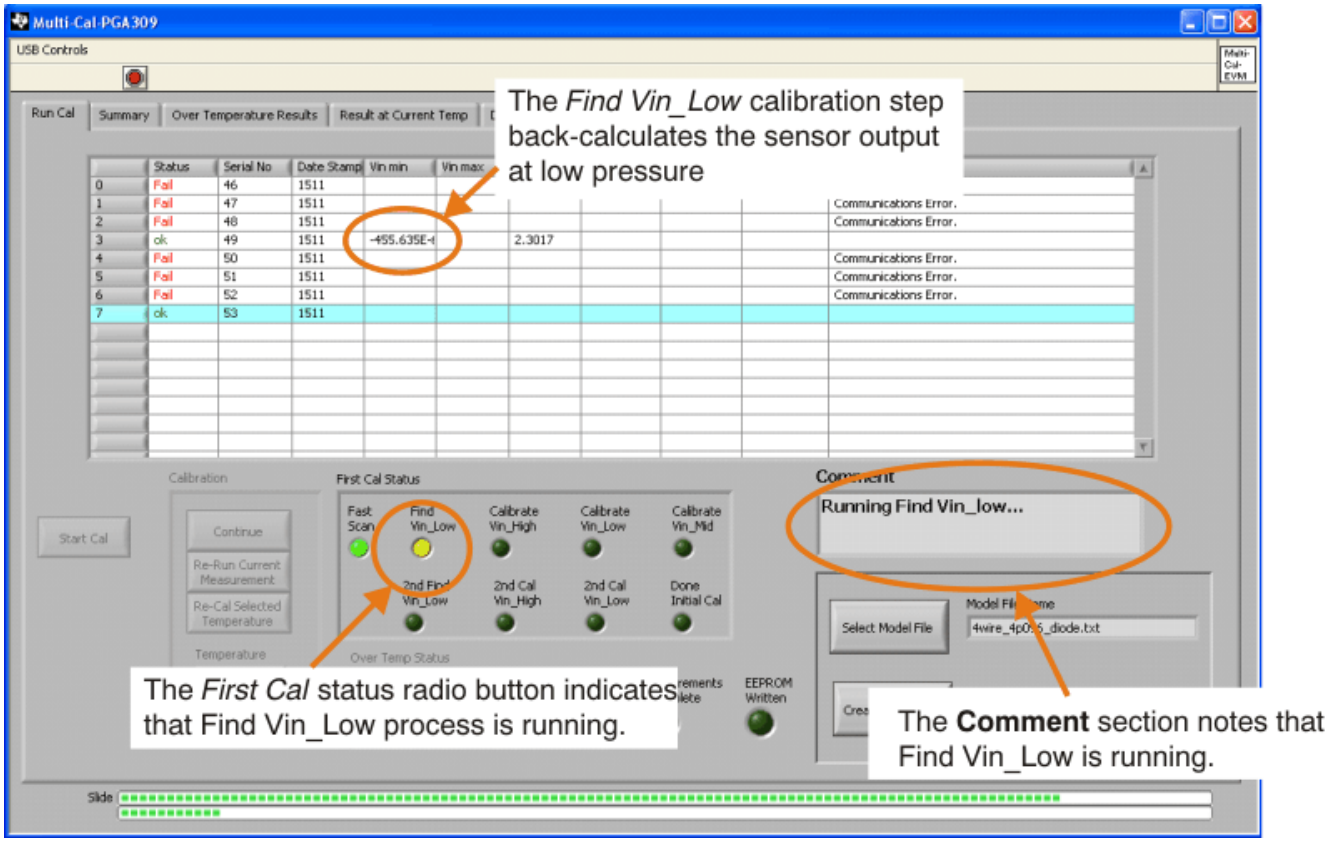

Figure 10. Multi-Cal-PGA309 Software: Find Vin_Low Calibration Step

After each step of the calibration, the program pauses and waits for the user to adjust the pressure and temperature as appropriate. Note that the calibration process itself is separated into two status areas: *First Cal* and *Over Temp Cal*. The *First Cal* process involves additional measurements that are required to calibrate sensor nonlinearity versus applied stimulus (pressure). This calibration involves measuring the sensor seven different times (minimum, pressure, maximum pressure, and 50% pressure with subsequent re-measurements required). The *Over Temp Cal* process involves measuring the sensor at three pressures for each temperature measurement (that is, at minimum pressure, at maximum pressure, and a re-measurement at minimum pressure).

Figure 11 shows the *First Cal Status* (orange box) and the *Over Temperature Status* (blue box). Note that the status LED displays are enabled when active and disabled (grayed out) when the step is not active.

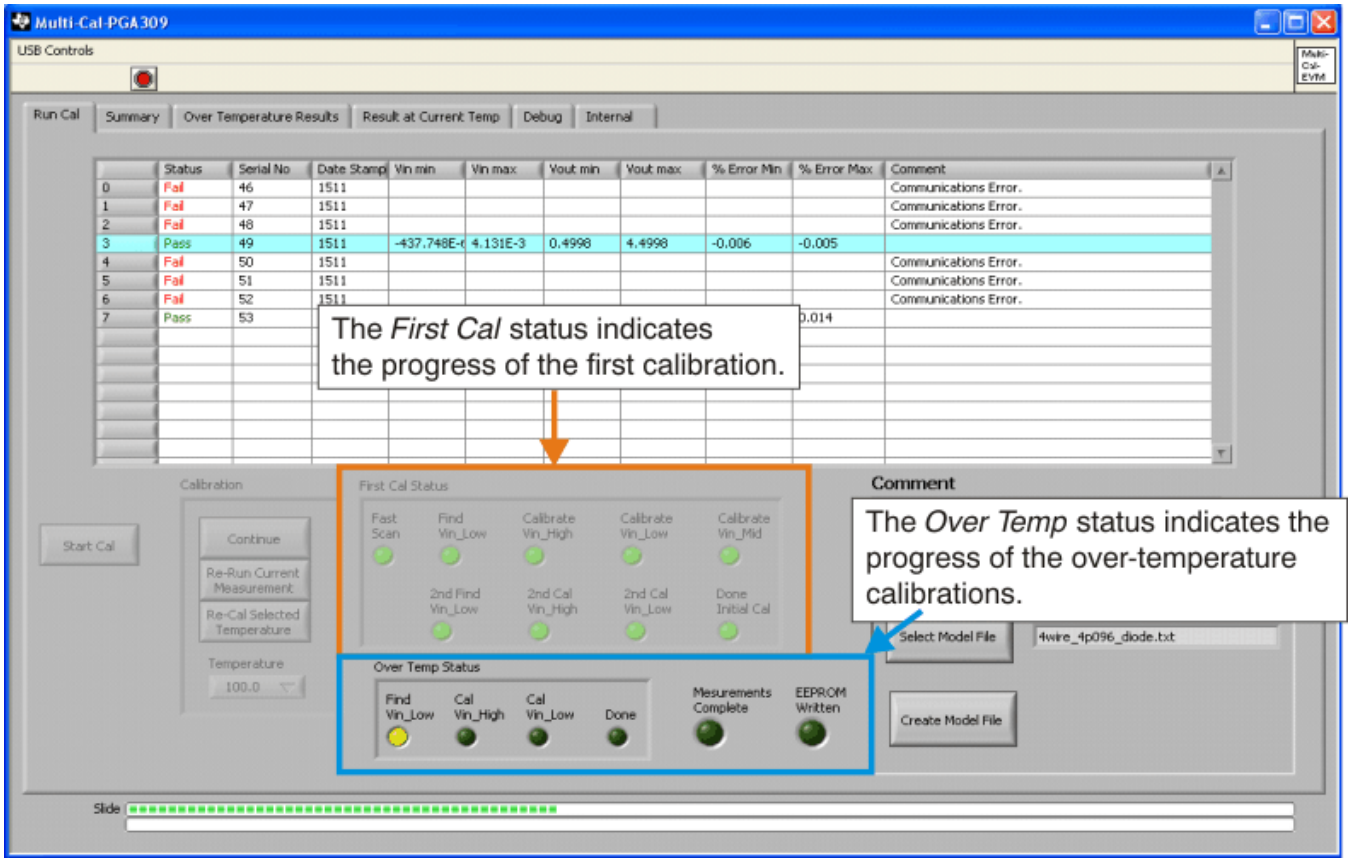

Figure 11. Multi-Cal-PGA309 Software: First Cal and Over Temperature Status Displays

When all of the calibration measurements are complete, the software appears as shown in Figure 12. At this point in the calibration process, the only remaining step is to write the calibration table into the PGA309 EEPROM.

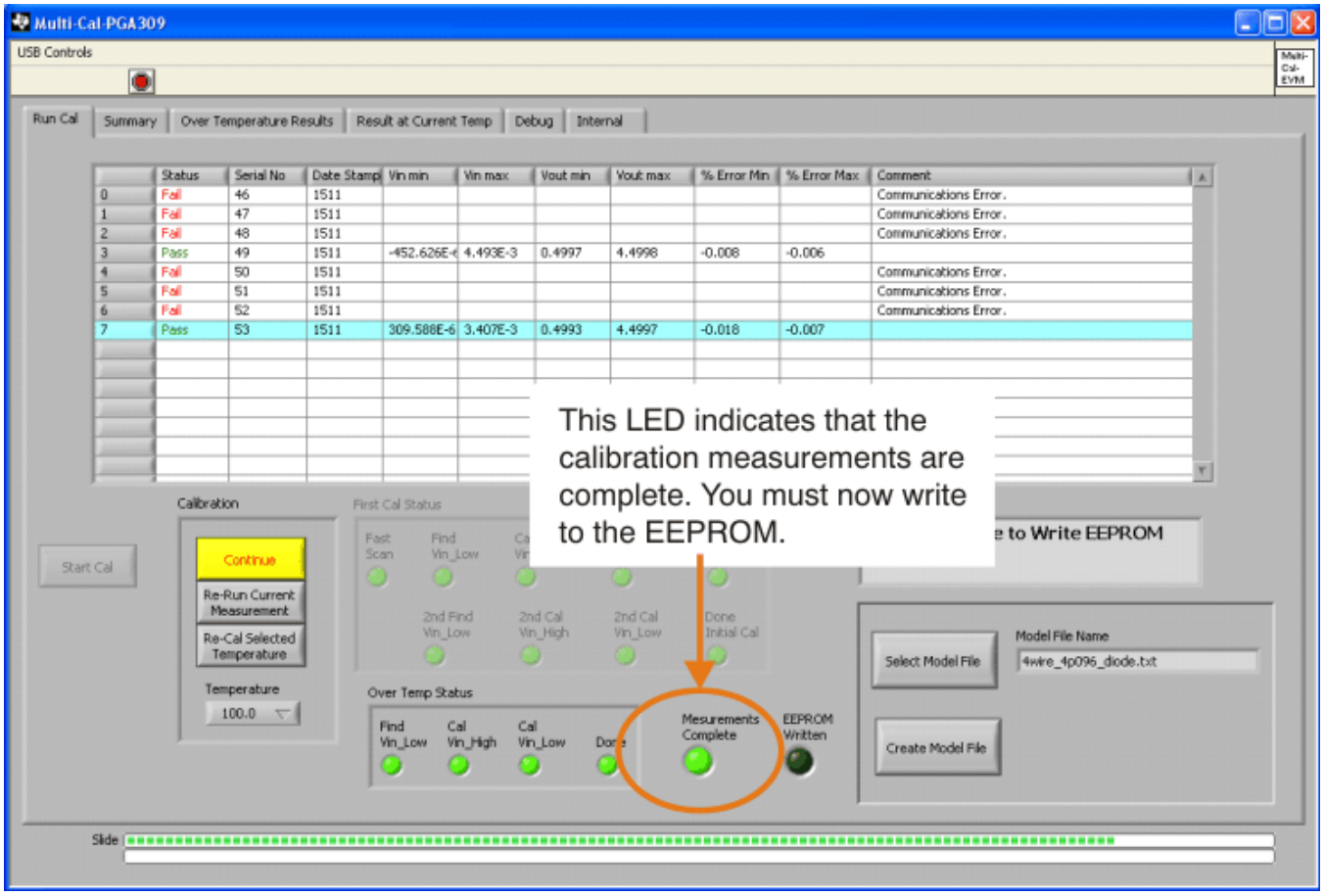

Figure 12. Multi-Cal-PGA309 Software: Calibration Complete, Write to EEPROM

Figure 13 shows the final software state when the calibration is complete and the EEPROM is written. At this point, the sensor modules correct for any nonlinearity and temperature drift.

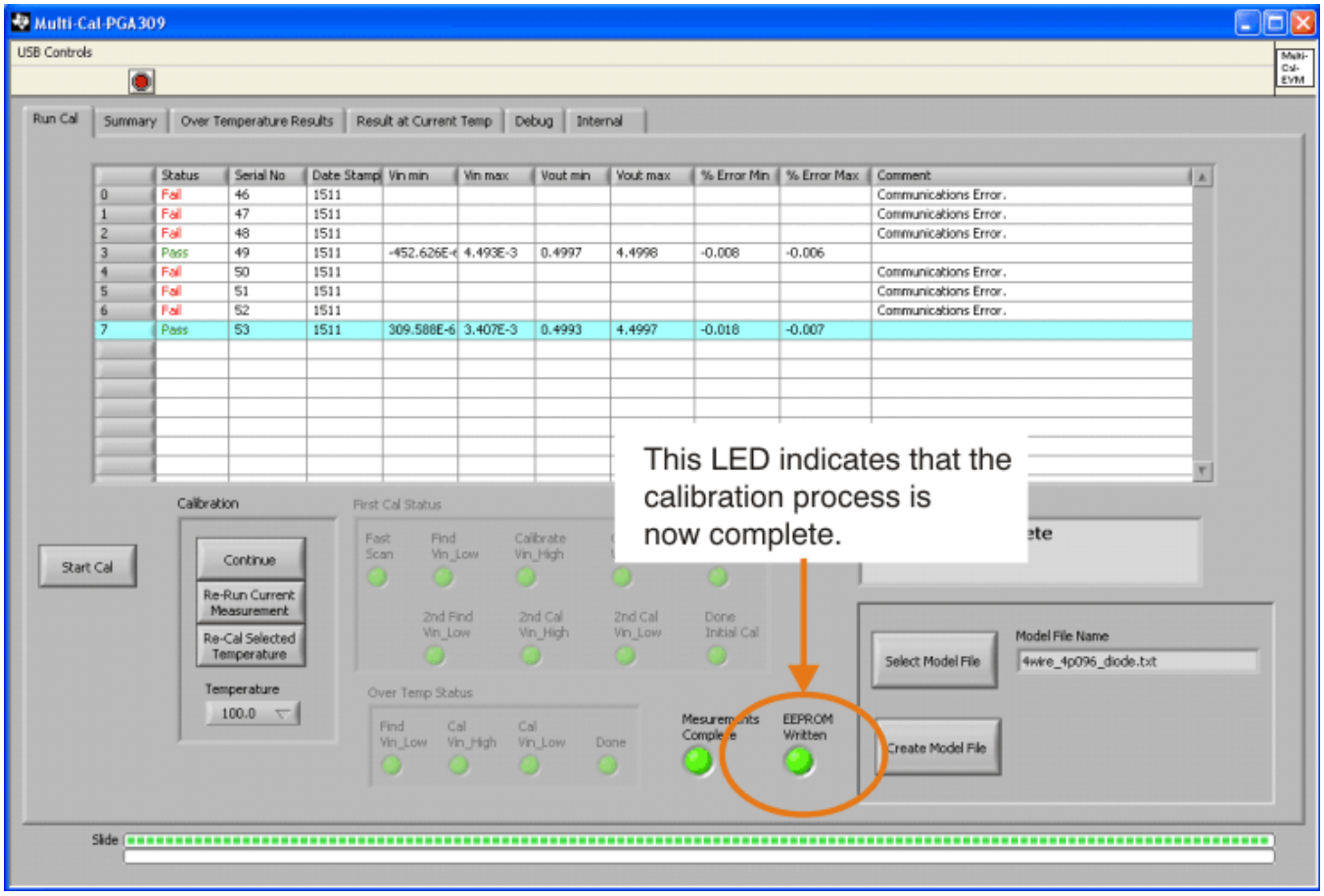

Figure 13. Multi-Cal-PGA309 Software: Calibration Complete

3 Model File: Detailed Description

The model file utility was introduced earlier; see Figure 5. In this section, we will look at each part of this utility and learn how to customize your own model file.

Figure 14 shows the *Create Model* display in the Create Model File editor window.

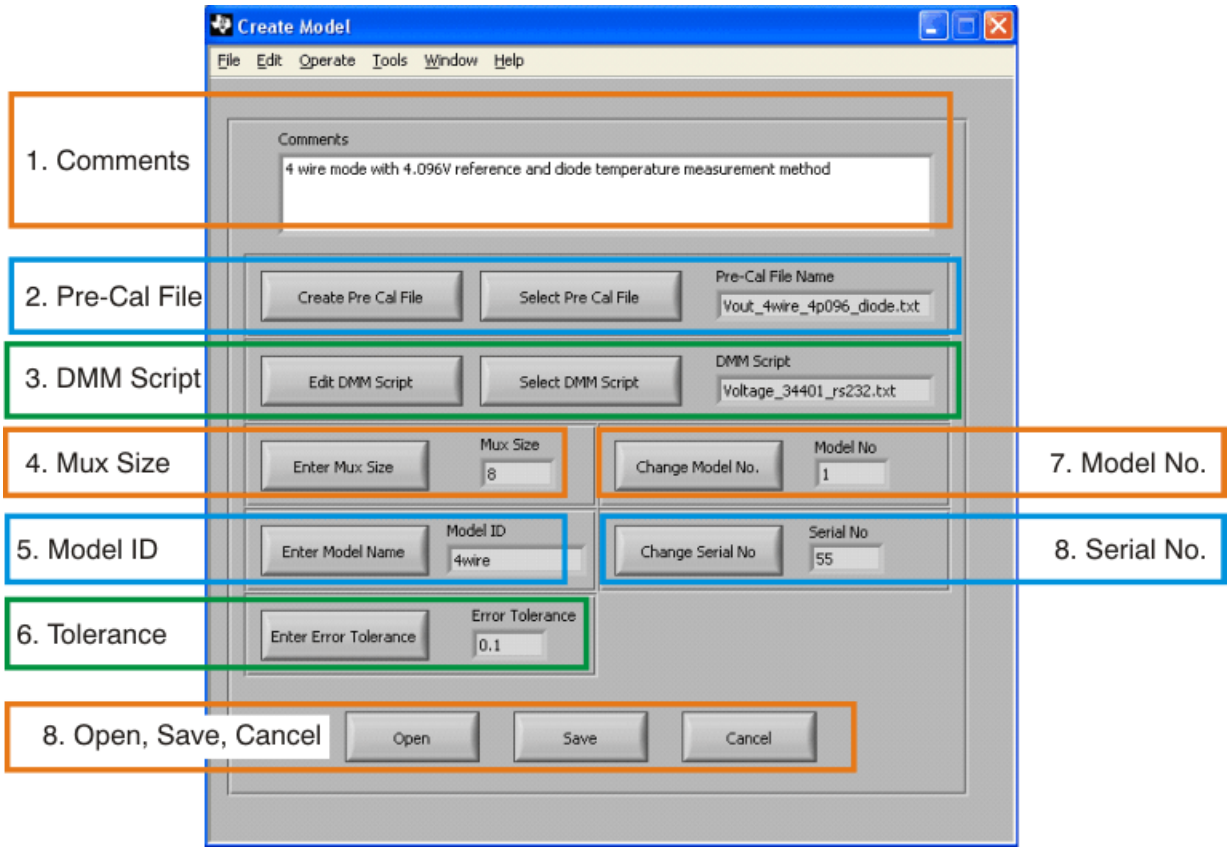

Figure 14. Multi-Cal-PGA309 Software Model File: Power-Supply Script

The various sections of the Create Model File window are:

1. **Comments:** This section contains user comments that you can use to document the model file. This field can be left blank if you prefer, or you can add notes to record details of a specific model configuration.
2. **Pre-Cal-File:** This section allows you select an existing file, edit an existing file, or create a new Pre-Cal-File. The Pre-Cal-File defines the initial registers for the PGA309 as well as other conditions such as temperature range and output targets. Details about creating a Pre-Cal-File are given in Section 3.1.
3. **DMM Script:** This section allows you to select, edit, or create a DMM script. A DMM script is a text file containing GPIB commands that enable you to configure and read your multi-meter (that is, a voltmeter or current meter).
4. **Mux Size:** The mux size is the number of channels in the Multi-Cal-System. This number can be set between 1 and 64. For an eight-channel system, this number is set to 8.
5. **Model ID:** This text is incorporated into the calibration filename and report filename that is generated at the end of each calibration. Section 3.3 explains the filename structure.
6. **Tolerance:** This field shows the *Pass/Fail* limit for sensor measurement results. A typical post cal accuracy result is 0.1%.
7. **Model No.:** You can use this number to identify the model of your sensor. For example, if you have five different products, you can assign each a different number (1 through 5). This number is written into the EEPROM. This number is also incorporated into the calibration filename and report filename that is generated at the end of the calibration process.

8. **Serial No.:** This number is the first of the sequence of serial numbers during a calibration. In the example given in Figure 14, the serial numbers would be 55 through 62 for an eight-channel system. Note that this number is updated at the end of each calibration so that you do not have overlapping serial numbers. This number is also written into the EEPROM, and incorporated into the calibration filename and reportname that is generated at the end of calibration sequence.
9. **Open, Save, Cancel:**
   - *Open* allows you to view an existing model file.
   - *Save* allows you to create a new model file or to overwrite an existing model file.
   - *Cancel* allows you exit the utility without changing the model file.

3.1 Create Pre-Cal File

The *Create Pre-Cal File* utility is a unique feature of the Multi-Cal-PGA309 software. This section explains how to use this utility. Figure 15 shows a screenshot of the Create Pre-Cal File utility.

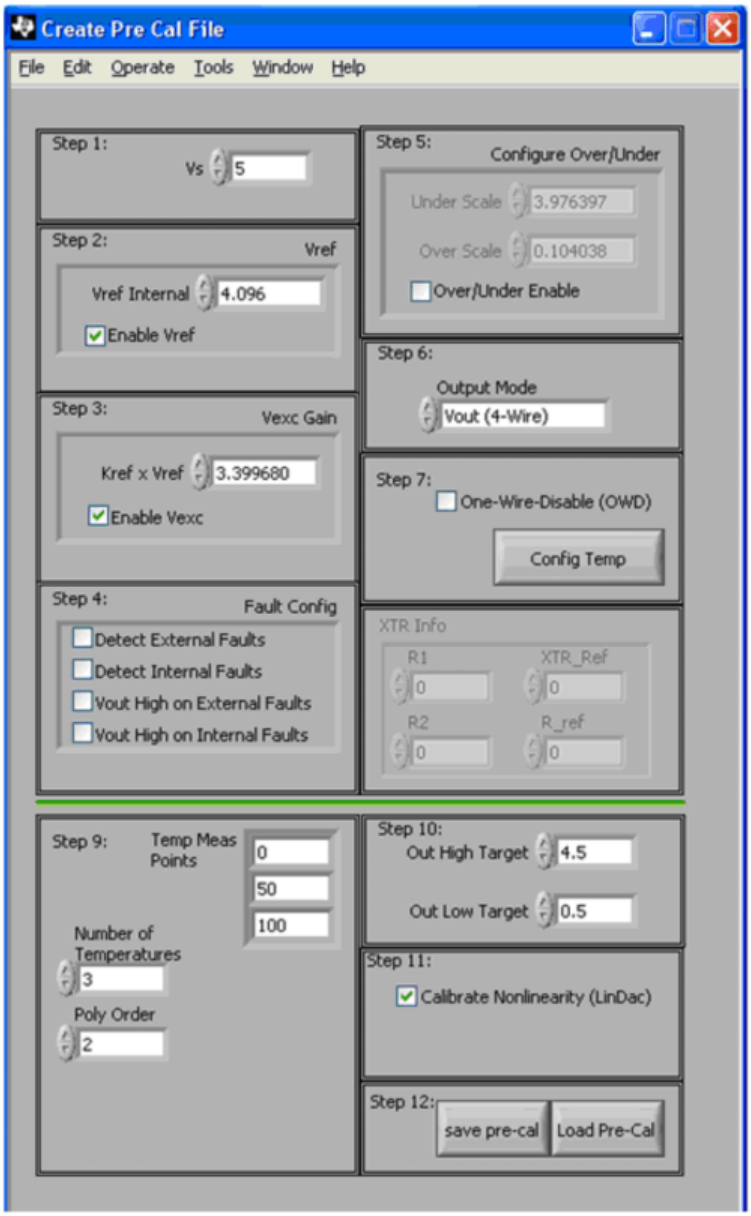

Figure 15. Multi-Cal-PGA309 Software Model File: Create Pre-Cal File Utility

Follow these steps to create a pre-cal file using this utility.

Step 1. **Vs:** This box allows you to select the analog power-supply voltage (that is, 2.7V to 5.5V for the PGA309).

Step 2. **Vref:** This value can be an internal reference (2.5V or 4.096V). You can also select an external reference (used in ratiometric mode).

Step 3. **Vexc Gain:** When this option is enabled, the value here can be used to drive the sensor (that is, determine the sensor power). When iit is enabled, two different reference-dependent values can be selected. Vexc is disabled for ratiometric mode.

Step 4. **Fault Config:** The Fault Configuration section allows you to turn fault detection off and on. During calibration, fault detection is disabled regardless of the selections made in this step. The selections are only activated at the end of calibration.

Step 5. **Configure Over / Under:** These settings allow you to enable over-/underscale limits. During calibration, the limits are disabled regardless of the selections made in this step. The selections are only activated at the end of calibration.

Step 6. **Output Mode:** Here, users can enable one of the three possible output modes (*Vout 4-wire*, *Vout 3-wire*, or *Iout*).

Step 7. **One Wire Disable and Temperature Sensor:** This section allows you to activate the one-wire-disable (OWD) bit. This configuration is commonly used in three-wire mode to prevent accidental writing to the EEPROM. This section also allows you to configure the temperature sensor. Refer to Section 3.2 for a detailed explanation of temperature sensor configuration.

Step 8. **XTR Info:** This section is only enabled for Iout output mode. When in this mode of operation, enter the current scaling resistors and XTR reference values in this section.

Step 9. **Temperature:** This section allows you to edit the number of temperatures used in the calibration and the polynomial order used in the curve fit. It is typical that the polynomial order is equal to the number of temperatures minus one. In this step, you also must enter the actual temperatures that calibration measurements are taken at.

Step 10. **Targets:** these are the minimum and maximum values that we want to achieve during calibration. In the example shown here, the output will swing between 0.5V and 4.5V for the minimum and maximum applied stimuli.

Step 11. **Calibrate Nonlinearity:** This option allows you perform or skip the nonlinearity calibration. The nonlinearity calibration requires additional measurements.

Step 12. **Load / Save Files:** Use this step to load or save the pre-cal file.

3.2 Configure Temperature ADC

The *Configure Temperature ADC* utility is another feature of the Multi-Cal-PGA309 software. This section explains how to use this utility. Figure 16 shows the Configure Temperature ADC utility.

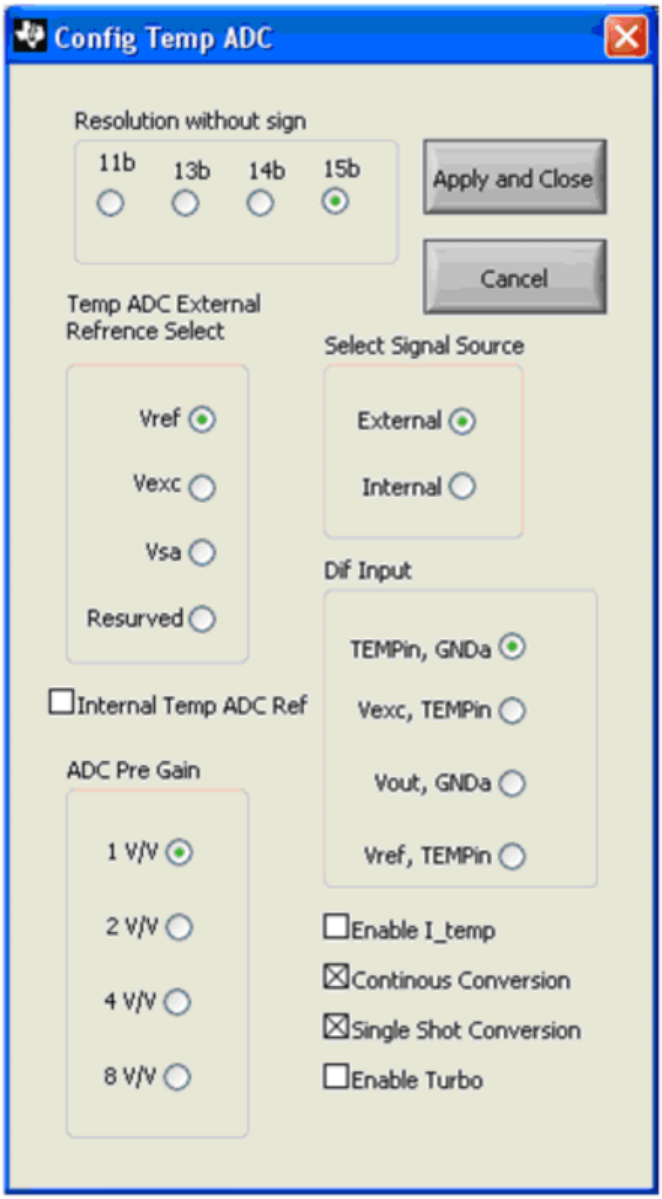

Figure 16. Multi-Cal-PGA309 Software Model File: Configure Temperature ADC Utility

There are several sections of the Configure Temperature ADC utility GUI:

- **Resolution without sign:** This value is the resolution of the analog-to-digital converter (ADC). A higher resolution produces more accurate results, but increases conversion time.
- **Temp ADC External Reference Select:** This section allows users to select the appropriate reference for the specific application. *Vref* is used for diode mode; *Vexc* is used for R_T mode; and *Vsa* is used for ratiometric mode.
- **Internal Temp ADC Ref:** Toggle this checkbox to use the internal reference.
- **ADC Pre Gain:** Gain can be used to amplify the temperature signal. This option is most often used in R_T measurement mode because the signal may be small.
- **Select Signal Source:** Use these choices to select if the internal temperature sensor is to be used.

The internal temperature sensor gives an absolute temperature in degrees Celsius (°C). The external temperature sensor connection allows you to measure an external signal.

- **Dif Input:** This option allows you to connect the mux to different locations. The *Tempin-GND* connection is used for both diode and R_{T-} modes. The *Vexc-Tempin* connection is used for R_{T+} mode. The *Vout-GND* measurement is a special mode that allows you to read the output voltage with the ADC. The *Vref-Tempin* connection is used for R_{T+} ratiometric mode.

The final four checkboxes determine the type of conversion to be used and offer a setting for diode mode measurement:

- **Enable I_temp:** This option turns on a current source that can be used for diode mode.
- **Continuous Conversion:** This mode is used in all standalone calibrated solutions. In this mode, the system continuously reads the temperature sensor and makes adjustments to accommodate for drift.
- **Single Shot Conversion:** This mode performs a single conversion. This configuration is useful if you are using the PGA309 with a microcontroller.
- **Enable Turbo:** Turbo mode increases the conversion rate. When turbo mode is on, you may see accuracy decrease.

3.3 File Name Scheme

Figure 17 illustrates how the file names for the Calibration Results File and the Report File are created. The file name is generated automatically. The information contained in the file name is also written into the EEPROM of the sensor module. That is, the model number, serial number, and date code are written into EEPROM on the sensor. Thus, you can read the EEPROM of the sensor module and easily find the specific file associated with it.

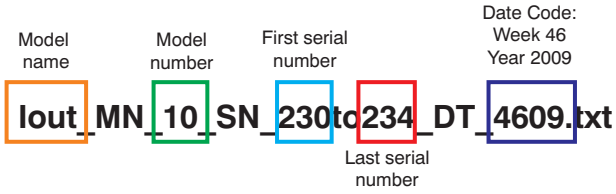

Figure 17. Multi-Cal-PGA309 Software Model: File Name Scheme

4 Understanding the Instrument Script

The Multi-Cal-PGA309 must communicate automatically to instruments in order to perform an automatic calibration. All Multi-Cal-PGA309 EVMs must control the volt / ammeter automatically. The software can also be used to control the power supply and pressure source remotely. The script language was developed to allow you to customize the communication process to a variety of instruments without having to edit the LabView™ software.

The scripts allow you to communicate using RS-232 or IEEE488. The script shown in Table 1 is an example of RS-232 communication. Note that each line in a script file contains a script command followed by an RS-232 or IEEE488 command. For example, the script command *write*> is followed by *MEAS:VOLT:DC? 10,0.00001*. The *write*> part of the command indicates that the string that follows will be written using RS-232. The *MEAS:VOLT:DC? 10,0.00001* part of the command was taken directly from the equipment user guide (see the Agilent 34401a DMM user guide). In general, the command to the right of the *greater than* symbol (>) can be edited according to your specific instrument requirements. Table 1 and Table 2 give comments that illustrate the meaning of each command.

Table 1. Script Reads Voltage on Agilent 34401A with RS-232 Port on the Computer

Row	Command	Comments
1	RS-232_COM_port>1	The COM port on your computer that is used for RS-232 communications (in this case, COM port = 1).
2	write>SYSTem:REMote	Places the instrument into remote mode for communications.
3	pause>2.0	Wait 2.0 seconds before communicating.
4	parity>0	RS-232 parity set to 0.
5	baud_rate>9600	RS-232 baud rate set to 0.
6	num_bits>8	RS-232 number of bits 0.
7	flow_control>0	RS-232 flow control 0.
8	num_stopbits>20	RS-232 number of stop bits 2 (34401a interprets 20 as 2 for this command).
9	term_char>10	RS-232 term character 10.
10	write> MEAS:VOLT:DC? 10,0.00001	IEEE write to the instrument on COM port 1. This setting is taken from the Agilent 34401A user guide. This command causes the DMM to take a current reading.
11	read_dbl> 64	IEEE read of the results of the read taken in the previous command (row 3). The read is a double precision number 64 bytes long.

Table 2 shows an example of a script that uses the IEEE488 card to communicate with the Agilent 34401A.

Table 2. Script Reads Voltage on Agilent 34401A with IEEE488 Card

Row	Command	Comments
1	IEEE488_address> 3	IEEE address of the instrument you are communicating with
2	pause>1.0	Wait 1 second before the next command.
3	write> MEAS:CURR:DC? 50E-3,0.1E-6	IEEE write to the instrument at address 3. This setting is taken from the Agilent 34401A user guide. This command causes the DMM to take a current reading.
4	read_dbl> 64	IEEE read of the results of the read taken in the previous command (row 3). The read is a double precision number 64 bytes long.

Evaluation Board/Kit Important Notice

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EVM Warnings and Restrictions

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

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

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

During normal operation, some circuit components may have case temperatures greater than +25°C. The EVM is designed to operate properly with certain components above +25°C as long as the input and output ranges are maintained. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors. These types of devices can be identified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during operation, please be aware that these devices may be very warm to the touch.

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