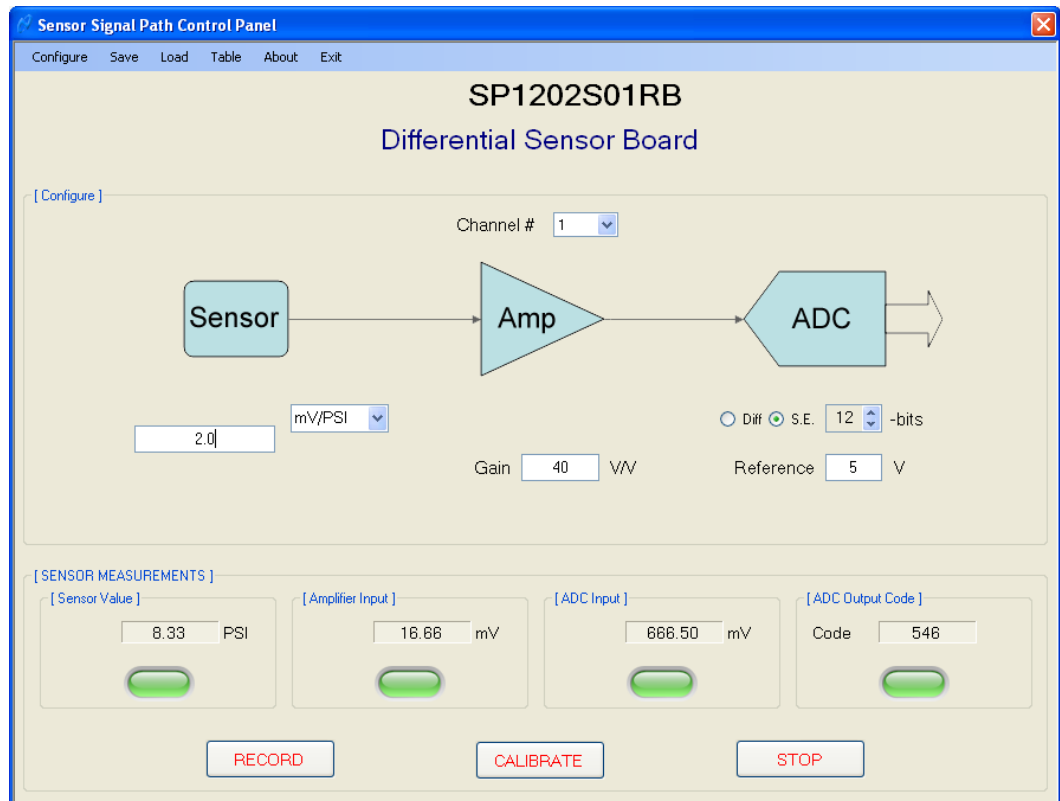


Sensor Signal Path Control Panel Software Manual



Sensor Signal Path Control Panel Software Manual

1 Introduction.

This document explains how to use the National Semiconductor *Sensor Signal Path* Control Panel software, referred to as *SCP* in this document. The *SCP* software allows a system designer to evaluate the signal path performance of various sensor boards such as the *Differential Sensor*, *Photo Diode*, *Thermocouple*, and *Thermopile* Boards using the SPUSI2 Data Capture Board. The sensor boards and SPUSI2 Data Capture board are available for purchase at www.national.com while the *SCP* software is downloadable for free from the same website. The *Sensor Signal Path* Control Panel allows the user to observe and capture the results from any supported sensor types on the board. Please refer to the individual board documentation which supplements this document for additional specifics.

The *Sensor Signal Path* Control Panel works with ADC channels and sensors of the following layout:

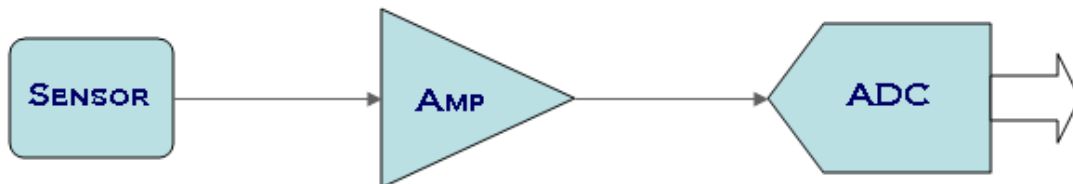


Figure 1-1: ADC Channel.

The *SCP* allows the user to enter the parameters corresponding to the channel of interest and then processes the ADC codes to compute various channel properties, including processing codes from other channels. The values at the different stages, from the right to left, are referred to as Code (at the output of the ADC), ADC In (at the ADC input), Amp In (Amplifier input), and Sensor (Sensor Output). The user may observe and capture any of these values for any channel.

2 Getting Started.

After the *SCP* is installed, it may be run from the Program Menu or a desktop shortcut.

2.1 System Requirements.

The *Sensor Signal Path* Control Panel requires a system running Windows XP with Microsoft .NET Framework 2.0.

Note that the current DLLs only support Windows XP, but Windows Vista will also be supported in a future release.

2.2 Installation.

It is recommended that you completely update your Windows XP and then run NscSVCPinstall.exe. This ensures that you have all the latest changes and patches. Installing a new *SCP* version automatically replaces an existing older version. The *SCP* installation includes a Program Menu selection to uninstall the application. After the installation you may run the *Sensor Signal Path* Control Panel software from the program menu or from the optional desktop icon.

2.3 Board Connection.

The SPUSI2 data capture board can be connected to any Windows XP system USB 1.0 or 2.0 port using a standard USB cable. When connecting the board for the first time refer to the **Appendix** for **SPUSI2 Setup Procedure**. The SPUSI2 board should not be connected or removed while the *Sensor Signal Path* Control Panel is running. If the board is connected to a running system, Windows generates a short tone to notify the user that a new USB device has been detected or removed.

2.3.1 Running Demo Mode Without Any Hardware.

Note that the board must be connected before the software is started. Otherwise, the software comes up in a demo mode where it uses random data to simulate channel hardware. If this occurs, simply exit and restart the software with the board connected.

2.4 Software Execution.

The *SCP* software can be run using the Windows program menu or by double-clicking on the corresponding desktop icon *after* the board is connected. The program normally starts by bringing up a board query panel which allows the user to specify their board from a list of available devices; this step may be skipped if the board type can be identified from the EEPROM.

Before the board query is displayed, the user is notified that the board is not identified:

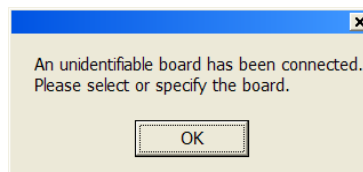


Figure 2-1: Unknown board message.

This optional prompt is followed by a board name query:

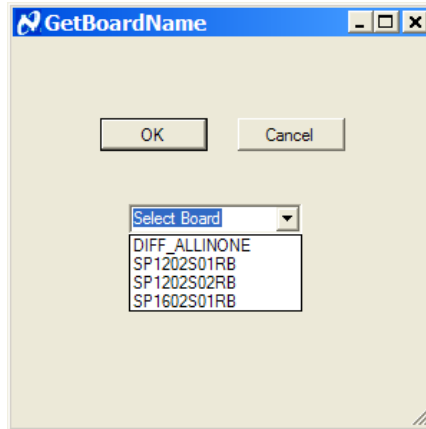


Figure 2-2: Board Selection.

After the board has been identified, the corresponding board configuration script is loaded and the *Sensor Signal Path* Control Panel is brought up on the screen. The SP1202S01RB Control Panel is shown below. Note that other boards contain different board configuration fields.

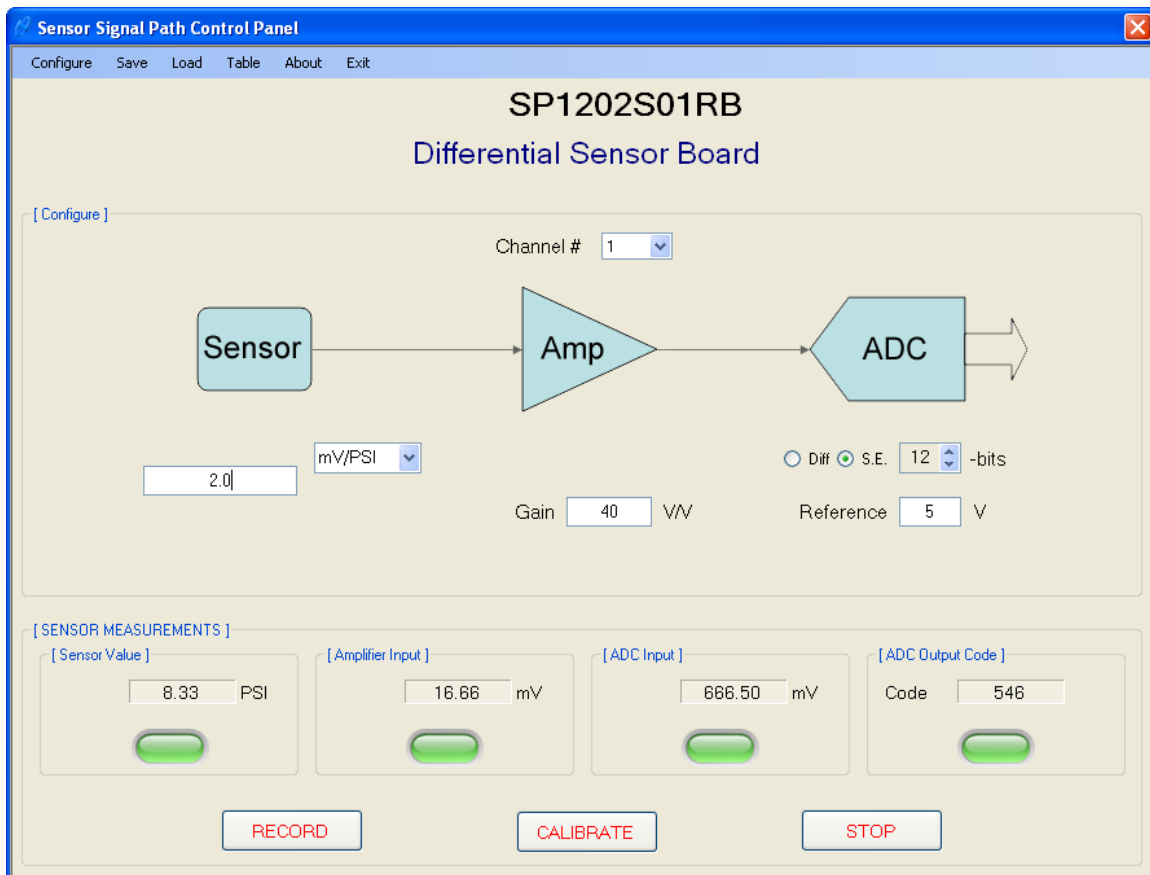


Figure 2-3: SP1202S01RB

The top portion of the panel provides access to the configuration corresponding to the channel selected in the Channel # window in the top middle of the control panel. The lower portion of the panel provides the sensor measurements for all enabled channels.

3 Board Configuration.

The board **Configure** menu option at the top of the Control Panel is actually channel specific and consists of many parameters that change across the various boards and channels. The software contains a configuration panel which is discussed separately. The individual board documentation explains these parameters in more detail.

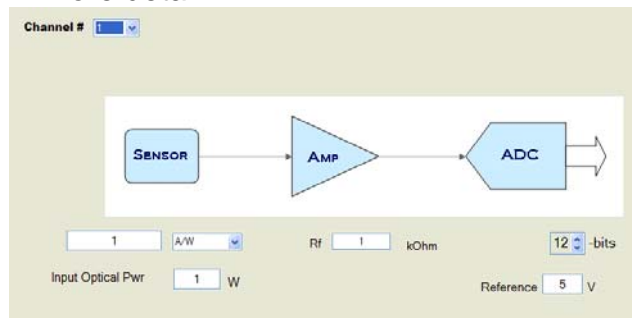


Figure 3-1: Channel Specific Board Configuration.

3.1 Channels.

Each board consists of one or more physical channels which are mapped to the channel panes in the lower part of the control panel. Generally the board channels are programmed to correspond to their respective pane channels 1 through 4. However, certain boards may use multiple panes to display the values of the different stages of the signal path for a respective physical channel. For example, in the case of the SP1202S01RB, pane 1 is used to display the Sensor output value in terms of its own sensor units, pane 2 displays the sensor's output voltage in terms of volts, pane 3 displays the ADC input voltage level, and pane 4 displays the ADC's output code value (refer to Figure 3-2: SP1202S01RB). All of these measurements are referenced to the ADC output value of physical channel 1.

3.1.1 Channel Pane Selection.

A channel is selected by clicking on it in the channel id list window in the top left corner of the panel, or by clicking in the channel panel. Note that the channel selection options may be limited to configurable channels on the board.



Figure 3-3: Channel Selection list of present channels.



Figure 3-4: Selected Channel.

All channel specific actions such as Configuration Panel settings and calibration correspond to the selected channel. The term current channel is also used in this document to refer to this selected channel.

3.1.2 Channel Enable.

Any present channel pane may be enabled or disabled for gathering and displaying the channel sensor measurements. The initial enable or disable state is determined by the board configuration. A channel may be enabled or disabled at any time by clicking on the color channel state indicator in its respective pane.



Figure 3-5: Disabled Channel with Grey Indicator.

3.2 Channel Properties.

Each channel has various properties that must be defined for proper measurement display. These properties are defined in more detail in the board specific documentation.

3.2.1 Sensitivity.

The sensitivity value is entered in the corresponding window, along with the suitable units such as mV/C. When the sensitivity value is not applicable, it is not displayed on the Control Panel.



Figure 3-5: Sensitivity Window with Units.

Some applications may use a fixed sensitivity value or predetermined device properties and not allow the user to make changes to the value.



Figure 3-6: Sensitivity Window disabled with device name

Computations generally use either the sensitivity value or an endpoint calibration, whichever is provided last. A user entered sensitivity value is ignored if the user calibrates the board and switches to using calibration based computations.

The sensitivity units window is also used to select from lists for applications such as the Thermocouple Sensor types.

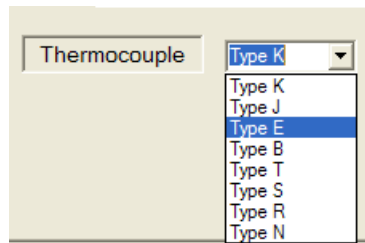


Figure 3-7: Thermocouple Type Selection.

3.2.2 Responsivity.

The responsivity value is entered in the corresponding window and has fixed units such A/W. When the responsivity value is not applicable, the window may not be shown or display a sensor name and will not accept any user data.

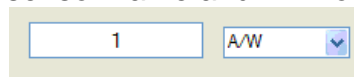


Figure 3-8: Responsivity Window with Units.

3.2.3 Gain.

The amplifier gain value is used in computations according to the board specific documentation. It may be provided in the board configuration or in the Control Panel gain window.

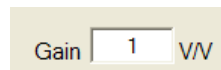


Figure 3-9: User entered value in Gain Window.

3.2.4 Differential/Single-Ended.

For calculation purposes, this determines whether the ADC on the reference board is a differential ADC or a single-ended ADC. This parameter should be pre-selected by the factory to the proper state. If it were set incorrectly, a user would notice an error in calculations of a factor of 2.

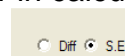


Figure 3-10: Selecting between Differential and Single-Ended Amplifiers.

3.2.5 RDivide.

The RDivide resistance value is used for applications such as the Thermopile Sensor Board.

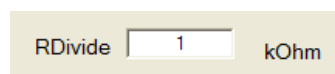
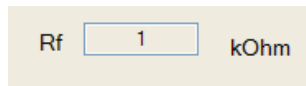


Figure 3-6: RDivide Resistance.

3.2.6 Rf.

The Rf resistance value is used for applications such as the Photo Diode Sensor Board.

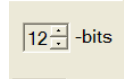


A screenshot of a software interface showing a text input field for 'Rf' with the value '1' and the unit 'kOhm' to its right.

Figure 3-7: Rf Resistance.

3.2.7 ADC Resolution.

This selects the ADC resolution in bits which is used for computations.



A screenshot of a software interface showing a dropdown menu for ADC resolution with '12' selected and '-bits' to its right.

Figure 3-8: ADC resolution selection in number of bits.

The ADC resolution maximum corresponds to the physical ADC but may be reduced by the user. Lowering the resolution in the panel reduces the number of ADC code bits that are used in the computations. The reduced code bits are simply discarded allowing the user to observe performance of their sensor with a lower resolution ADC.

3.2.8 ADC Reference Voltage.

This is the ADC reference voltage measured according to the board specific documentation.

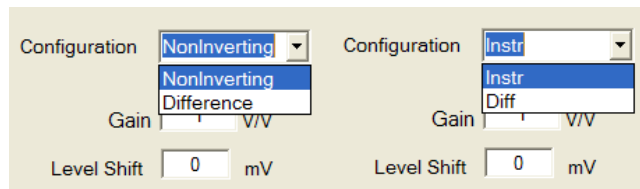


A screenshot of a software interface showing a text input field for 'Reference' with the value '4.94' and the unit 'V' to its right.

Figure 3-9: Board Specific ADC Reference Voltage.

3.2.9 Amplifier Configuration and Level Shift.

The amplifier configuration selection is used in specific applications which support a Level Shift value, such as the Thermocouple Sensor. It is used to determine at what amplifier stage the Level Shift effects the computations. Different boards use different types of configuration such as *Nonlinear/Difference* or *Instrumentation/Difference*.

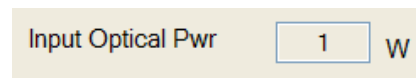


A screenshot of a software interface showing two amplifier configuration sections. Each section has a 'Configuration' dropdown menu, a 'Gain' input field with 'V/V' units, and a 'Level Shift' input field with 'mV' units. The left section shows 'NonInverting' selected in the dropdown and '0' in the Level Shift field. The right section shows 'Instr' selected in the dropdown and '0' in the Level Shift field.

Figure 3-10: Amplifier Selection and Level Shift Value.

3.2.10 Input Optical Power.

The Input Optical Power is used for optical applications such as the Photo Diode Sensor.



A screenshot of a software interface showing a text input field for 'Input Optical Pwr' with the value '1' and the unit 'W' to its right.

Figure 3-11: Input Optical Power.

4 Channel Sensor Measurements.

The lower portion of the Control Panel displays the channel sensor measurements for enabled channels when the MEASURE button is selected. It also has three buttons which control the panel behavior.

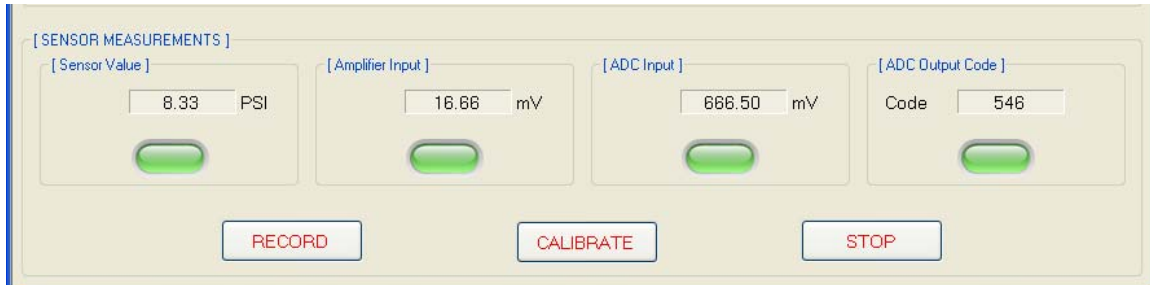


Figure 4-1: Sensor Measurements Panel.

4.1 Channel Pane.

There are four individual channel panes displaying measurements which may be programmed to correspond to any physical board channel. The channel panes may correspond to independent physical channels or have more complex interactions with other channels.

4.1.1 Channel Name.

This is the channel name shown above the sensor measurement value. It can be a simple label such as "CHANNEL 1" or a description such as "Cold Junc Ref" or "FLUID COLUMN".

4.1.2 Channel Quantity.

This is the measured quantity, displayed to the left of the sensor measurement, such as Temperature or Height.

4.1.3 Channel Value.

This is generally the computed sensor input value corresponding to the selected units, but can also be the simple ADC code value, a computed mV value, or mapped to more useful units such as degrees-Celsius or inches.

Some applications, such as the *Photo Diode*, may use intermediate computational values for the displayed channel value in the Units mode.

4.1.4 Channel Units.

These are the channel display units. In the code and mV display modes the field will be empty to indicate no units or set to mV, respectively. In the units display mode the field will display the units selected for the Sensitivity or Calibration values. Certain applications simply use fixed channel units.

4.1.5 Channel State Indicator Colors.

The color indicator in the lower center of the channel pane indicates the channel state. A gray indicator corresponds to a disabled or absent channel. A green indicator corresponds to a channel with valid measurements. A red indicator corresponds to a channel with invalid measurements that have been persistent for more than a programmed acceptable level, i.e. they are continuously outside the valid minimum and maximum values. This generally indicates a disconnected channel and the channel value field will eventually be cleared to avoid confusion. An orange indicator corresponds to invalid values that have not been held. Invalid values are generally caused by a loss of communication with the hardware and can also occur if the application is running on a busy system and becomes starved for computational resources.

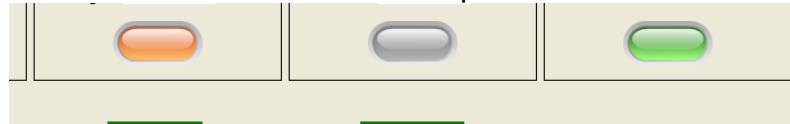


Figure 4-2: Channel State Indicator Colors.

4.2 Control Buttons.

The lower portion of the *Sensor Signal Path* Control Panel contains three control buttons below the channel panes. The Start/Stop Measurements and Record buttons correspond to all channels simultaneously. The Calibrate button calibrates the measurements for the current channel selected in the board configuration.

4.2.1 Start/Stop Measurements.

The right button is the MEASURE button. It is used to start and stop the measurements on all enabled channels simultaneously. The MEASURE button is highlighted when the cursor is held above it and changes to STOP when measurements are being made. Starting measurements when no channels are enabled is not allowed.

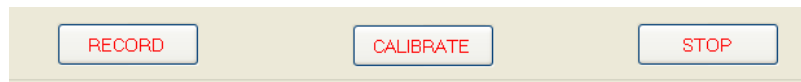


Figure 4-3: Start/Stop Measurements.

4.2.2 Record Measurements.

The left button is used to record channel codes and measurements in a text log file. The values are not written until the recording is completed and the button is automatically reset to its initial state to indicate that another recording can be made. The SCP software is set to record 100 samples each time the RECORD button is selected.



Figure 4-4: Record Measurements.

The button normally reads RECORD but changes to PAUSE while recording. It may then be used to PAUSE the recording. The button changes to RESUME while paused and may be used to resume the recording.

Note that the pause behavior may not be allowed on all applications and the button will then simply indicate that you can stop recording. If you stop recording in this mode all values are discarded when recording is stopped before completion.



Figure 4-5: Record Button when pause is not allowed.

The Record operation requires channel measurements but may be controlled independently. Recording automatically starts and stops when measurements are started or stopped. If recording is enabled when measurements are stopped, the following message is shown to the user:

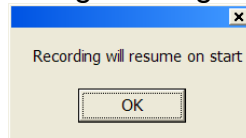


Figure 4-6: Message indicating record enabled during stopped measurements.

4.2.3 Calibrate Button.

The center button is used to bring up the calibrate panel for the current channel which is used to enter the calibration data end points. The computations use either calibration points or theoretical values as selected in the configuration panel.

For best results, the sensor should be calibrated using the two segment data points in the desired range. Calibration consists of setting the sensor to known values and capturing the output code. To calibrate the selected channel click on the CALIBRATE button in the lower left part of the pane. This opens the corresponding window shown in the figure below.

The calibration information consists of two sensor code values along with user entered physical sensor values. These are used as two data points to compute the slope and intercept for linear extrapolation.

The initial window shows the current calibration properties if they are valid. The window changes to the current properties after the user enters a data point.

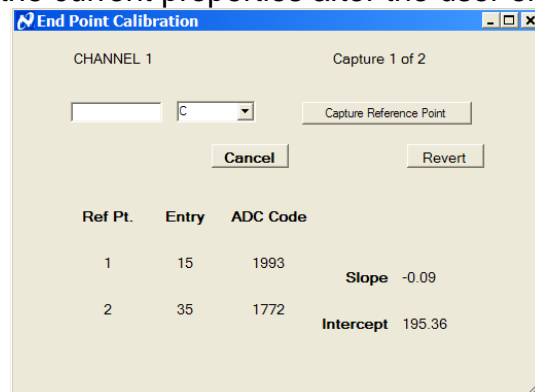


Figure 4-7: Calibration Window with previous Data Points in Display.

4.2.3.1 Calibrating End Points.

To calibrate the sensor to reference end points, first select the proper units in the calibrate window. Then enter the expected sensor value, such as degrees or inches, from an independent reference measurement. Then click on the corresponding button to “Capture Reference Point.”

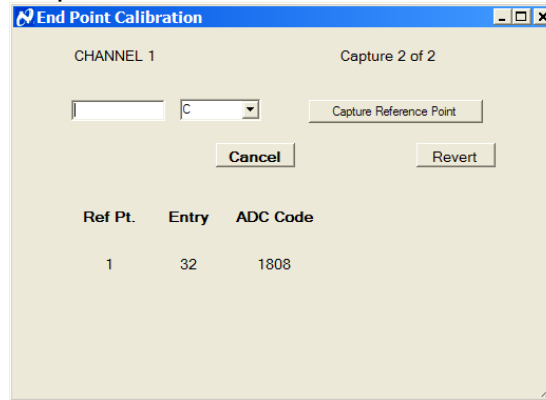


Figure 4-8: Window after first capture.

Repeat the process for a second data point.

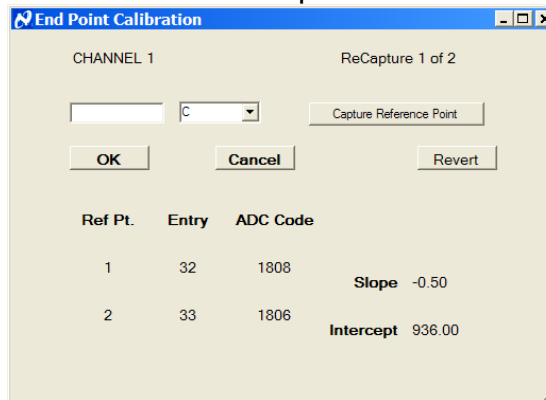


Figure 4-9: Window after second capture.

Note that the two data points *must* read different ADC codes.

Data points can be reentered and simply replace the previous entry.

The slope and intercept values from the entered data are displayed immediately unless both have the same ADC code which is invalid. An OK button appears when a valid calibration data pair has been entered.

The user may select Revert or Cancel to keep to the original values.

4.2.3.2 Calibration Computations.

The calibration computations are used for linear extrapolation.

From the user data –

$$\text{Slope } m = (\text{RefVal2} - \text{RefVal1}) / (\text{Code2} - \text{Code1})$$

$$\text{Intercept } b = \text{RefVal1} - m * \text{Code1}$$

This allows any code value to be mapped to sensor values:

$$\text{SensorIn} = m * \text{code} + b$$

As an example, assume the user reads the codes 2433 and 2133, corresponding to 15 and 35 degrees, respectively.

$$m = - (35-15) / (2433 - 2163) = -1/35 = -0.074$$

$$b = 15 - (-1/35) (2433) = 195.22$$

$$\text{SensorIn} = -0.074 \times \text{Code} + 195.22$$

5 Menu Selections.

The top of the *Sensor Signal Path* Control Panel has various menu items which allow the user to control the software behavior.

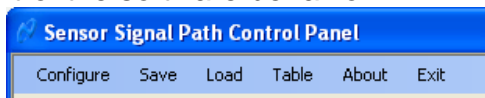


Figure 5-1: Menu Selections.

5.1 Configuration Panel.

The top left menu selection in the Control Panel is “Configure” which opens the configuration panel shown in the figure below for the currently selected channel. Changes are effective and visible immediately but reverted if the Cancel button is selected.

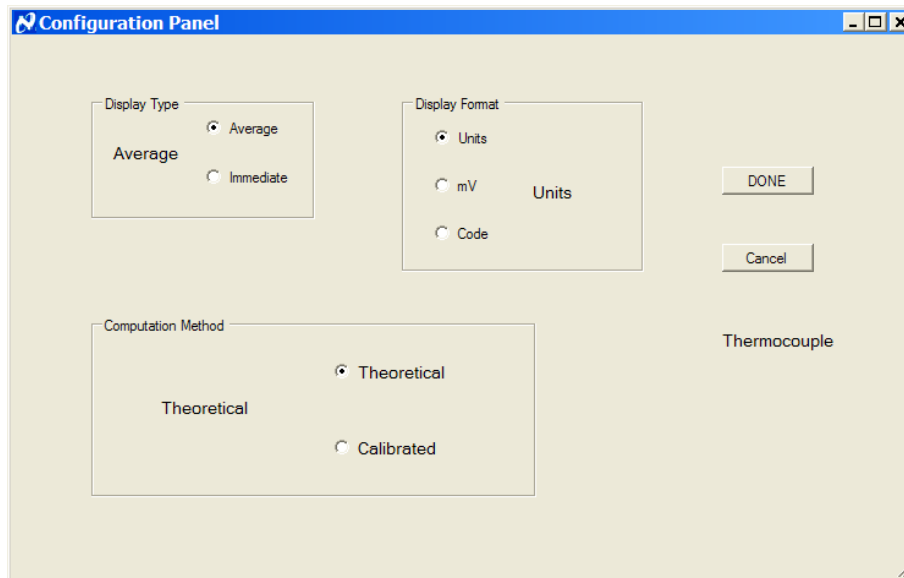


Figure 5-2: Configuration Panel for selected channel.

The Configuration Panel allows the user to define the following properties.

5.1.1 Display Type.

You can choose to select immediate sensor readings or a sliding average with a depth programmed in the board configuration script. Values are

continuously buffered for this average and available immediately when this mode is selected.

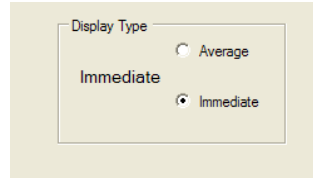


Figure 5-3: Selecting between Average and Immediate display types.

5.1.2 Display Format.

The display format can either be the simple sensor code values, the sensor mV values, or computed channel units.

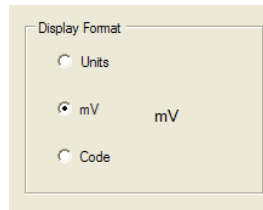


Figure 5-4: Selecting Display Format.

Note that the value displayed in the Units mode actually depends on the programmed board configuration. The mV is generally ADC In but may also be programmed to read amp In for certain applications.

5.1.3 Computation Method.

The computation method can be Theoretical or Calibrated. The theoretical selection uses a lookup table value with linear extrapolation between the table values. The calibrated mode uses a linear extrapolation based on two user data points as described in the calibration computations section of this document.

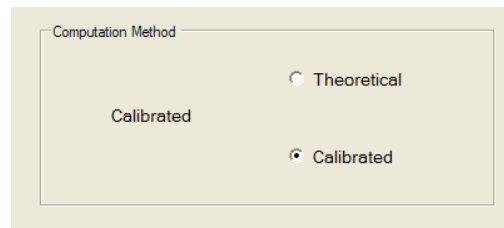


Figure 5-5: Selecting a Computation Method.

5.2 Load/Save Configuration Scripts.

The *Sensor Signal Path* Control Panel Configuration can be saved and restored in a simple text file using the Load and Save items in the top menu. The user is prompted to name the saved script which consists of a series of text strings for each channel, defined in another section of this document. The saved script is automatically given a “.txt” suffix unless one is provided.

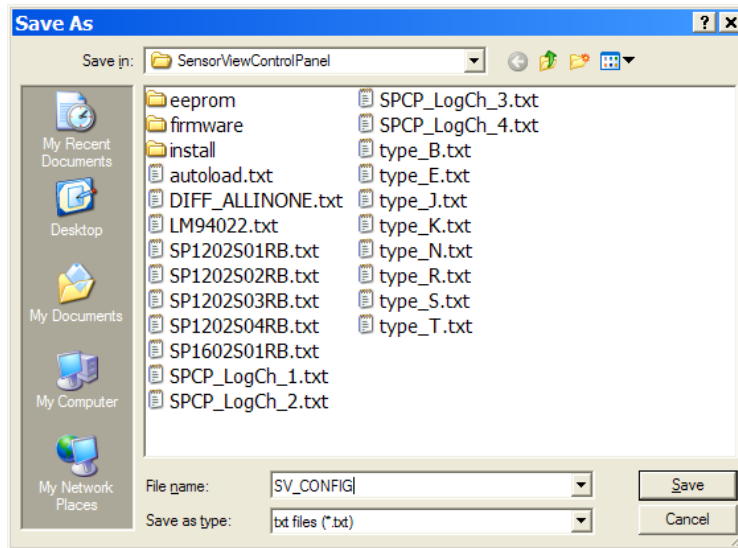


Figure 5-6: Save Configuration in file.

Note that the saved scripts are very verbose as they list almost all the channels individually and contain definitions for all the Channel-Variables.

Similarly the Load command also prompts the user for a text file selection for loading a saved or edited configuration script.

5.3 Table Load.

The table selection brings up a file open menu to load a user lookup table. This allows the user to select or enter a table file name.

Tables are normally loaded automatically based on the board configuration and this feature is not required for most applications.

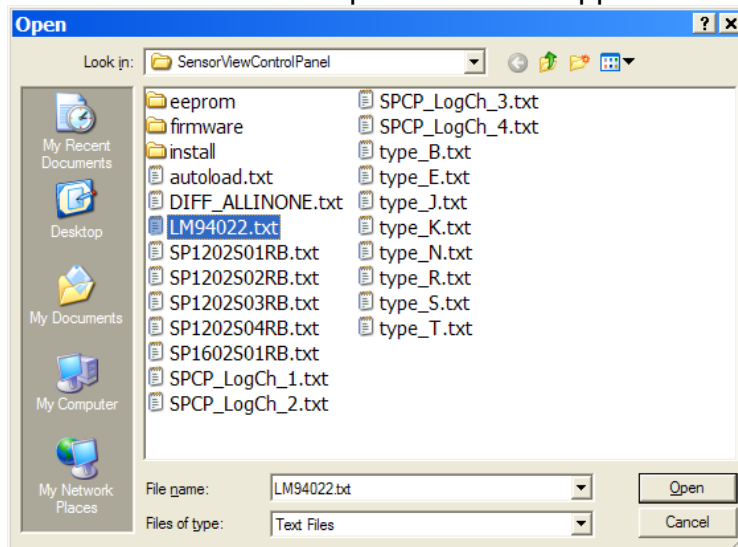


Figure 5-7: Load Table File.

Note that automatic table loading, such as for the thermocouple tables, is disabled once the user enters a table. The automatic table loading can be re-enabled by doing a table load and doing a Cancel instead of entering a file name.

5.4 About.

The About selection displays a window with the current software and hardware versions.

5.5 Exit.

The right most menu selection is Exit. The application may be terminated by selecting this or by closing the window with the X in the right corner of the windows application display panel.

The configuration script may require that the user confirm the exit which brings up the following dialog:



Figure 5-8: Exit Confirmation Dialog.

The user may then choose to exit, cancel to exit, or to save the configuration before exit. If the save option is selected, a Save File dialog is opened to complete the process.

6 Some Reference Computations.

The display computations map the ADC code values to desired channel units using the provided channel properties. These computations contain all the variables and work for all boards. Some boards have fixed values for specific properties which may simplify the computations.

Code refers to the read sensor code value.

Vref is the ADC reference voltage in mV.

2ⁿ is the ADC resolution where n is the number of ADC bits.

k is 1 or 2 for single-ended and differential amplifiers, respectively.

The **gain** is specific to the board and provided by the user.

The **Level Shift** is used to skew data.

Sensitivity is explained in a dedicated section of this document.

Rpy is the responsivity for relevant optical applications.

Rf and **Rdevice** are resistance values for relevant applications.

Variables such as **Level Shift** and **refOffset** are used to skew data.

milliConversion variables are using to multiply or divide by 1000

6.1 Generic Computation steps.

The differential board computations correspond to physical components and begin with the channel code which eventually maps to a physical channel unit such as temperature or pressure. This is referred to as the sensorIn value.

6.1.1 Channel Code.

All measurements begin with a channel code consisting of the ADC resolution, the number of bits supported by the board sensor. The user may select to reduce the resolution to evaluate the computations with a lower resolution. The user may also select to use the immediate channel code or a sliding average.

6.1.2 Amplifier Out Voltage.

The channel code is used to compute the AmpOut voltage using this equation:

$$\text{ampOut} = \text{chCode} * \text{Vref} * k * \text{milliConversion} / (\text{adcRes} - \text{RThermCode}) + \text{refOffset}$$

For thermocouple boards with difference amplifiers there is an additional step:

$$\text{ampOut} = \text{ampOut} - \text{Level Shift}$$

6.1.3 Amplifier In Voltage.

The ampOut voltage can be used to compute the ampIn voltage:

$$\text{ampIn} = \text{ampOut} / (\text{ampGainValue} * \text{Rf} * \text{Rpy} * \text{milliConversion})$$

For thermocouple boards with NonInverting amplifiers there is an additional step:

$$\text{ampIn} = \text{ampIn} - \text{Level Shift}$$

6.1.4 Sensor Reading.

The final computational step determines the sensor input value using variations of one of the following three methods. Calculations for some boards may be more complex and involve data from other channels.

6.1.5 Theoretical mode.

For the theoretical computational mode this involves merely looking up the value corresponding to the ampIn in a device specific lookup table.

6.1.6 End Point Calibration Mode.

For the end point calibrated mode, explained in detail in the Calibration section of this document, the following equation is used:

$$\text{sensorIn} = \text{chCode} * \text{slope} + \text{intercept}$$

Once calibrated, the values may be saved and reloaded by the startup script for subsequent use.

6.1.7 Computational Calibration Mode.

The sensor value may also be computed without an end point calibration using the device sensitivity:

$$\text{sensorIn} = \text{ampIn} / \text{Sensitivity}$$

This is not really a calibrated mode, but defined as such here as it is a part of the calibrated (versus theoretical) menu selection.

6.2 Board Specific Computations.

The generic computations have been derived to support as many boards as possible by providing different variable values and are a superset of the corresponding individual board equations. By setting non-relevant variables to passive values, such as 0 during addition or 1 during multiplication or division, the generic equation can be reduced to the individual board computations.

6.2.1 Differential Sensor Board Computations.

The differential board output code is used in the following computations:

$$\text{ampOut} = \text{Code} * \text{Vref} * k * 1000 / 2^n$$

$$\text{ampIn} = \text{ampPout} / \text{gain}$$

$$\text{sensorIn} = \text{ampIn} / \text{Sensitivity}$$

or using a table lookup: $\text{sensorIn} = f^{-1}(\text{ampIn})$

6.2.2 Thermocouple Board Computations.

The thermocouple computations are a slight variation:

NonInverrrting Amp:

$$\text{Thermo} = (\text{Code} * \text{Vref}) / (2^n * \text{gain}) - \text{LevelShift}$$

Difference Amp:

$$\text{Thermo} = (\text{Code} * \text{Vref} / 2^n - \text{LevelShift}) * 1/\text{gain}$$

$$\text{ThermoC} = \text{TcTypeTable}^{-1}(\text{Thermo})$$

The final step computes the value relative to another channel:

$$\text{ThermoCoupleTempC} = \text{ThermoC} + \text{SensorIn}[\text{ReferenceChannel}]$$

6.2.3 Thermopile Board Computations.

The Thermopile computations are a slight variation.

6.2.4 Photo Diode Board Computations.

The Photo Diode computations are a slight variation.

$$\text{ThermoCoupleTempC} = \text{ThermoC} + \text{SensorIn}[\text{ReferenceChannel}]$$

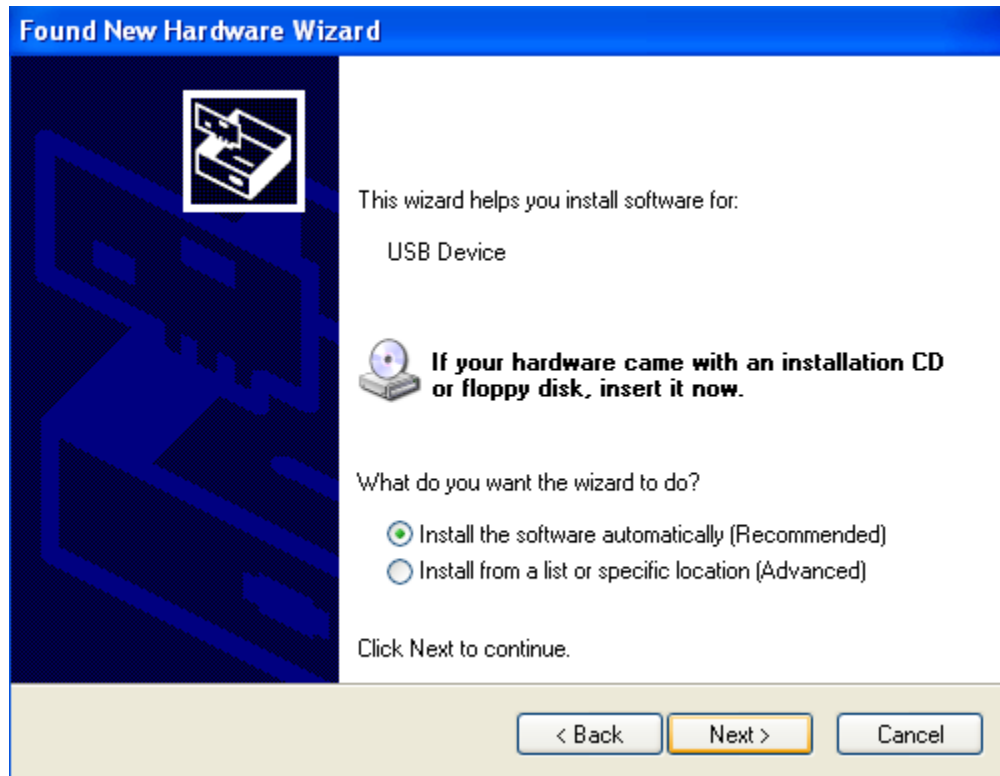
Appendix

1.0 SPUSI2 Setup Procedure.

1. Download Sensor Path Control Panel Software onto your computer prior to connecting board to computer.
2. Connect board to computer. The *Found New Hardware Wizard* will popup. Select *Yes, this time only* and click *Next*.



3. Select *Install the software automatically (Recommended)* and click *Next*.



4. Wizard begins to install software for Sensor Signal Path 2008 Board. Click *Continue Anyway* on the *Hardware Installation* pop-up.



5. Click *Finish*.

