

LMP90100 EVB User's Guide

User's Guide for the LMP90100 Evaluation Board with Sensor AFE Software

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1.0. Introduction

The LMP90100 Design Kit (consisting of the LMP90100 Evaluation Board, the SPIO-4 Digital Controller Board, the Sensor AFE software, and this user's guide) is designed to ease evaluation and design-in of National Semiconductor's LMP90100 24-bit Fully Programmable Low Power $\Sigma\Delta$ ADC with True Continuous Background Calibration.

Data capturing and static evaluations are simplified by connecting the SPIO-4 Digital Controller Board (SPIO-4 board) to a PC via USB and running the Sensor AFE software. The data capture board will generate the SPI signals to communicate to and capture data from the LMP90100. The user will also have the option to evaluate the LMP90100 without using the SPIO-4 board or the Sensor AFE software.

The LMP90100 will digitize the analog input, and the software will display these results in time domain and histogram. The software also allows customers to write to and read from registers, to calibrate the device or the system's gain, offset, and scale settings, and most importantly, to configure and learn about the LMP90100.

This document describes the connection between the boards and PC, provides a quick start for a DC, shorted input, 3-wire RTD, and thermocouple/temperature sensor applications. This document also describes how to evaluate the LMP90100 with and without the SPIO-4 board and provides the schematic, board layouts, and BOM.

2.0. Equipment

1. LMP90100 evaluation board (NSID: LMP90100EB)
2. SPIO-4 digital controller board (NSID: SPIO-4)
3. PC with Sensor AFE software
4. Power supplies (optional) to source VA, VIO, VREFP, or VIN.
5. Multimeter (optional)
6. 3-wire RTD (optional)
7. Thermocouple (optional)

2.1. Connection Diagram

Figure 1 shows the connection between the LMP90100 Evaluation Board (LMP90100EB), SPIO-4 board, and a personal computer with the LMP90100 Sensor AFE software. LMP90100 can be powered using external power supplies or from the SPIO-4 board.

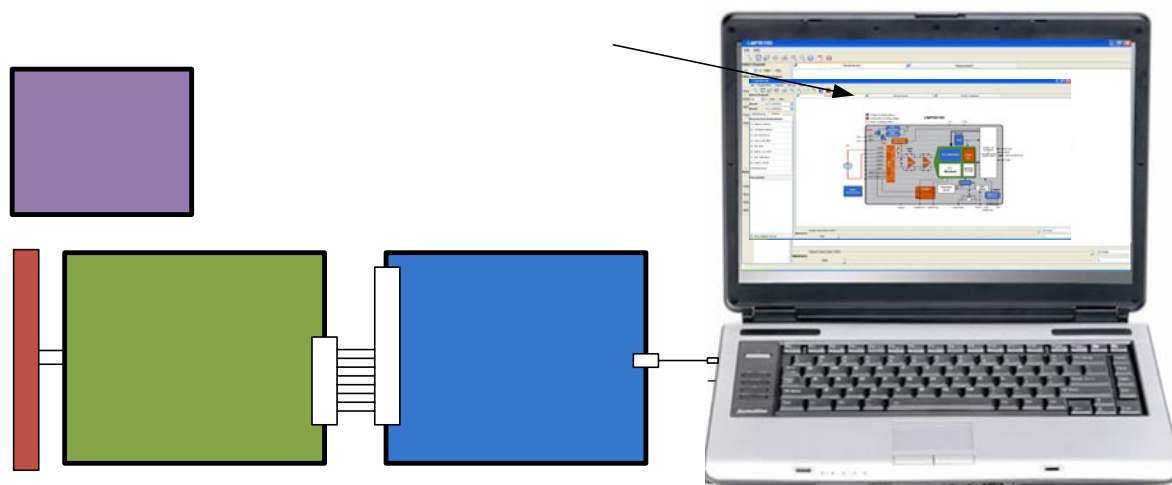


Figure 1 – Connection Diagram

2.2. Board Assembly

The schematic of the evaluation board can be seen in section 10.

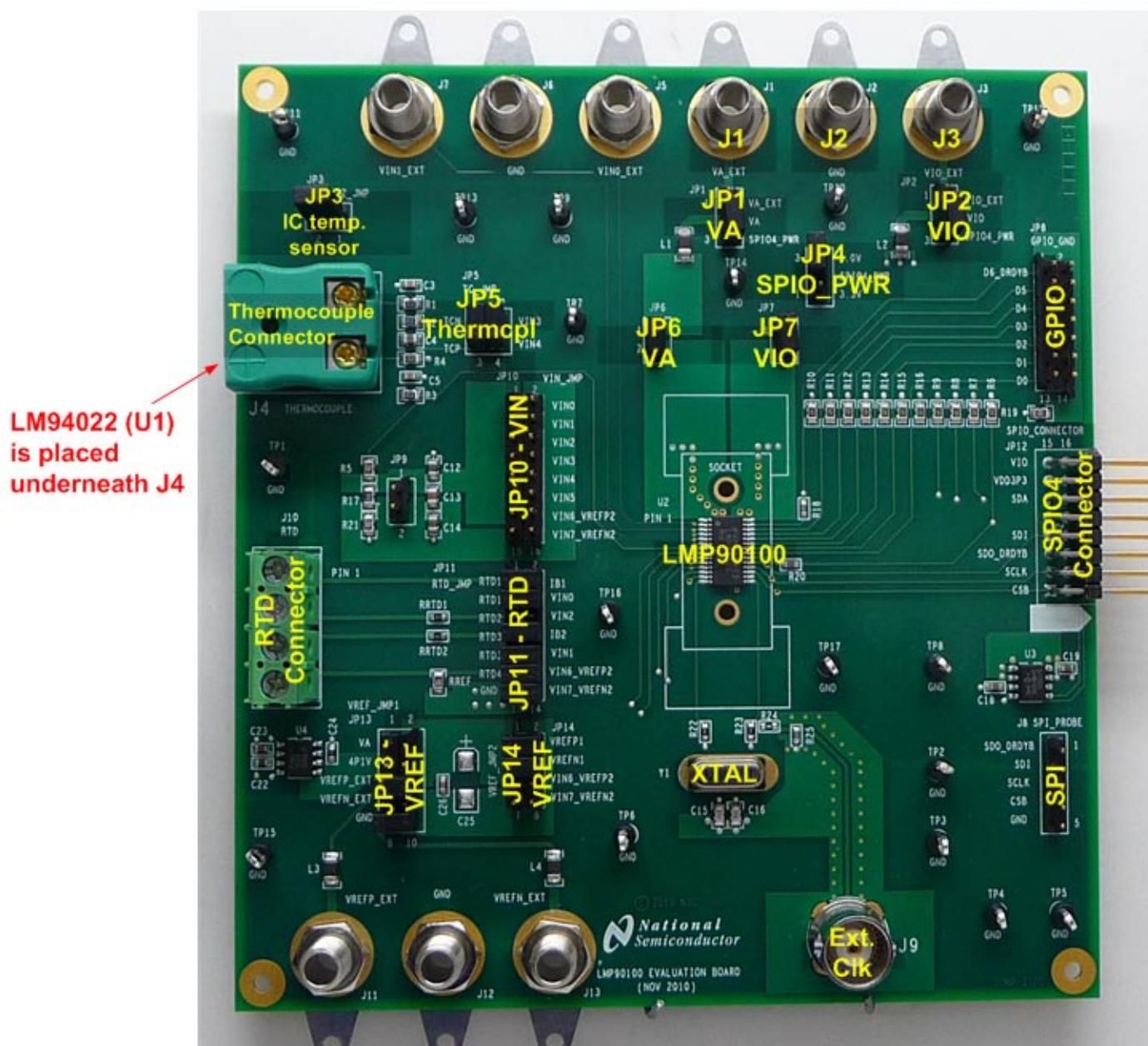


Figure 2 – LMP90100 Evaluation Board Assembly

3.0. Example #1: Quick Start – DC Reading

The following procedures show a quick method to assemble the LMP90100EB and perform a quick DC voltage reading.

A. LMP90100 EB Jumper Connections

1. The jumpers for this example application can be seen in Figure 3 and Table 1. Jumpers not shown can be left unpopulated.
2. The SPIO-4 board is properly setup out of the box (no assembly required).
3. The schematic for the LMP90100EB can be seen section 10.

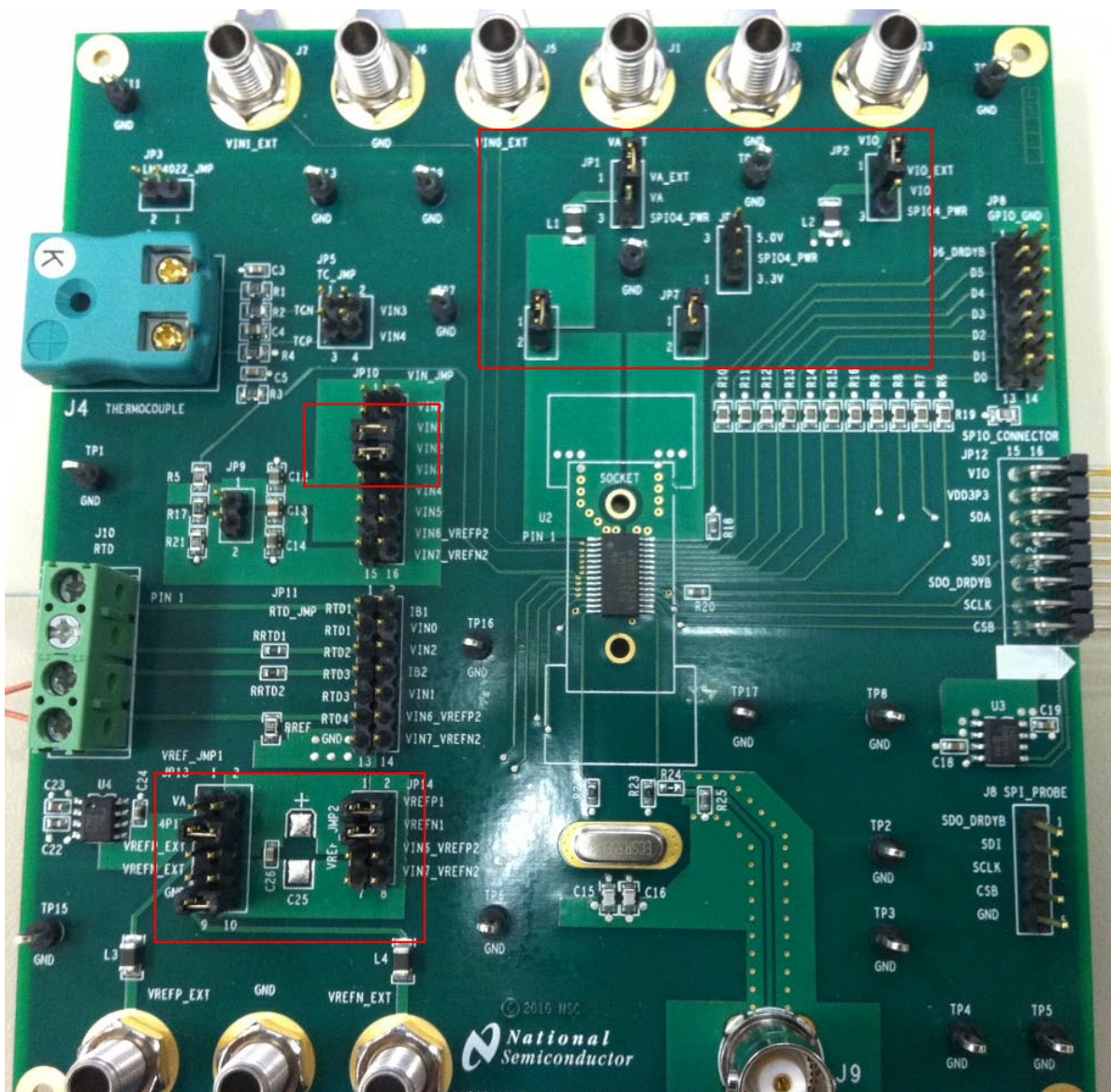


Figure 3 – Jumper Settings (Default) for the DC Test

Jumpers	Pin	Purpose
JP1: VA_EXT	P1-P2	Source VA externally

JP2: VIO_EXT	P1-P2	Source VIO externally
JP6	P1-P2	Connect VA supply to the LMP90100
JP7	P1-P2	Connect VIO supply to the LMP90100
JP10: VIN_JMP	P5-P6	Connect a DC input to VIN2
JP10: VIN_JMP	P7-P8	Connect a DC input to VIN3
JP13: VREF_JMP1	P3-P4	VREFP1 = 4.1V from U4 (LM4140)
JP13: VREF_JMP1	P9-P10	VREFN1 = ground
JP14: VREF_JMP2	P1-P2	Connect VREFP1 source to the LMP90100
JP14: VREF_JMP2	P3-P4	Connect VREFN1 source to the LMP90100

Table 1 - Jumpers for DC Measurement

B. Installing/Opening the Software - follow section 9.0 to install and open the LMP90100 Sensor AFE software.

C. Connecting and Powering the Boards – these steps have to be done in this order.

1. Connect a 5.0V power supply to **J1** (VA_EXT) and GND (J2). Don't turn on the power supply yet.
2. Connect a 5.0V power supply to **J3** (VIO_EXT) and GND (J2). Don't turn on the power supply yet.
3. **Turn on** the power supply that is sourcing VA (J1), and then turn on the power supply that is sourcing VIO (J3).
4. Connect the LMP90100EB's **JP12** to SPIO-4 Board's **J6** (pins 1-16). See Figure 4.

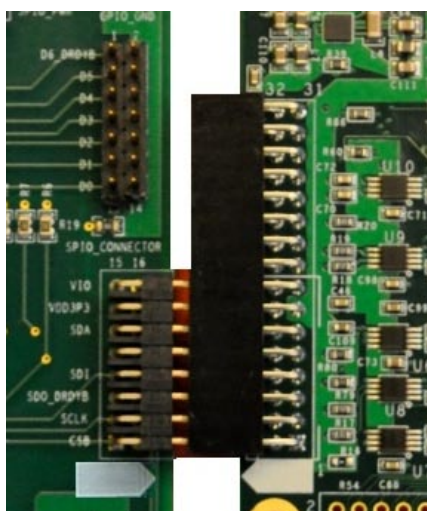


Figure 4 – LMP90100EB-to-SPIO-4 Board Connection

5. Connect SPIO-4 board to a PC via **USB**.
6. Use a multimeter to measure LMP90100EB's JP6, JP7; they should all be approximately 5V. If they are not, check your power supplies and jumpers. Measure JP14.P2; it should be approximately 4.1V. If it's not, check your jumpers and U4.

D. Configuring the LMP90100 Using the Sensor AFE Software

Follow the step-by-step instructions under the **“HelpBar”** mini-tab (left hand side of the GUI) to configure the LMP90100 for this example. These step-by-step instructions are discussed in details below, and the recommended configuration should look similar to the figure below.

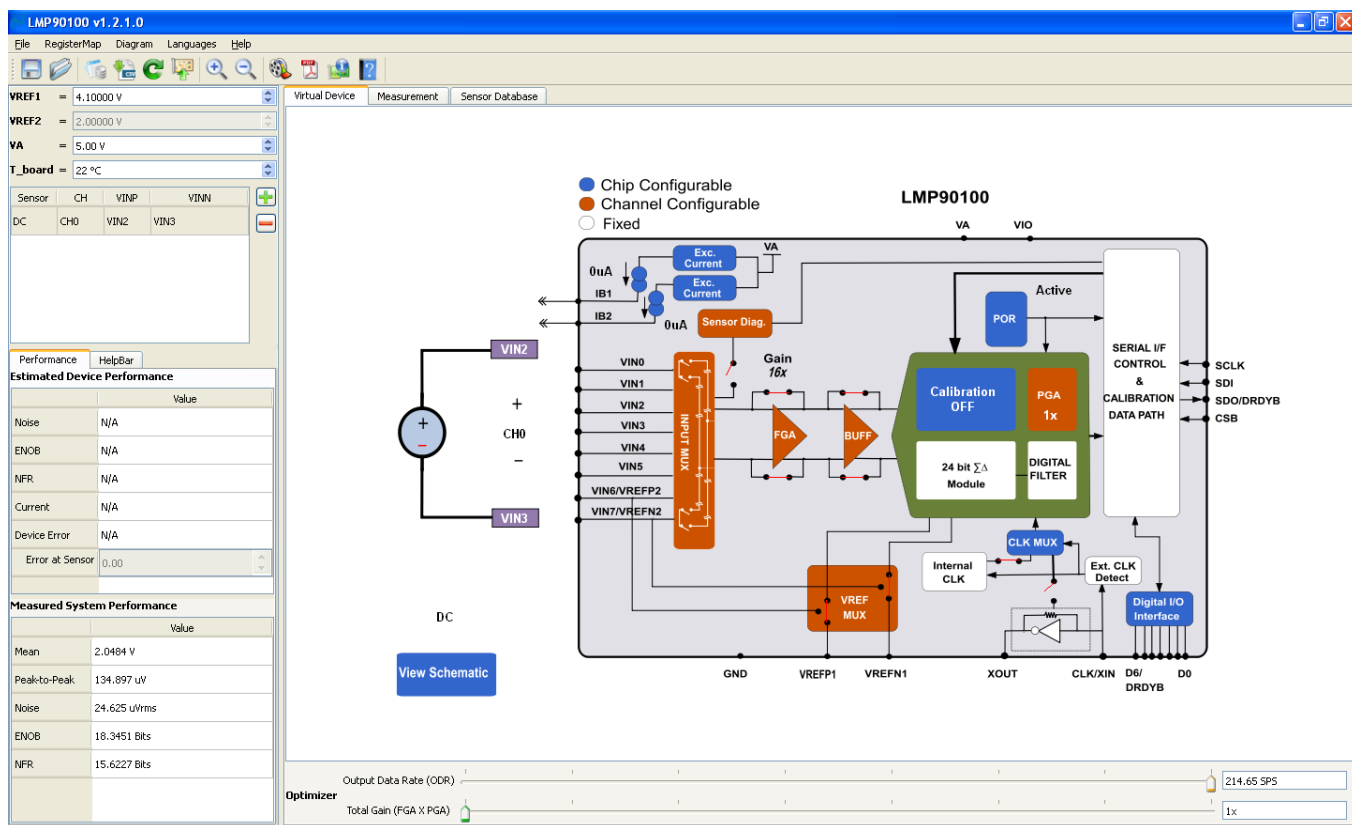


Figure 5 - Recommended LMP90100 Configuration for a DC Reading

1. Step 1: Select a Sensor - select **“DC”** → **“DC”** since the input source is not a sensor.
2. Step 2: Configure Inputs – click on the **“INPUT MUX”** block to set **“VINP = 000: VIN2”** and **“VINN = 001: VIN3”**. Since $VIN0 = (3/4) VREF1$ and $VIN1 = (1/4) VREF1$, the measurement across this channel will be $(1/2) VREF1$.
3. Step 3: Source IB1/IB2? – *this step can be ignored because neither IB1 nor IB2 is connected to the inputs.*
4. Step 4: Select Reference – click on the **“VREF MUX”** block to choose **“VREF_SEL = 0: VREF1”**. Make sure the **VREF1** value on the upper left hand side of the GUI is 4.1V (default).
5. Step 5: Set Gain – since $VIN = (1/2) VREF1$, the maximum gain that can be set is 2 (with buffer disabled). If the buffer is enabled, then the output might rail and enable the **“OFLO_FLAGS”** flag. In this case, set the gain to 1. Click on the **“FGA”** block, **“PGA”** block, or the **“Gain”** slider to select the gain.

6. Step 6: Set Buffer – click on the **“BUFF”** block to include or exclude the buffer from the signal path.
7. Step 7: Set Calibration - click on the **“No Calibration”** block to enable or disable calibration. Refer to the LMP90100 datasheet to more information on the LMP90100’s background calibration types and modes.
8. Step 8: Int/Ext CLK? – click on the **“CLK MUX”** block and make sure the internal clock is selected.
9. Step 9: Performance - click on the **“Performance”** mini-tab. This tab displays the Estimated Device Performance base on the block diagram that you’ve configured, as well as the Measured System Performance if you’ve connected a board and ran the LMP90100.

E. Capturing Data

1. Click on the **“Measurement”** tab and set the **“Scan Mode”** as follows:

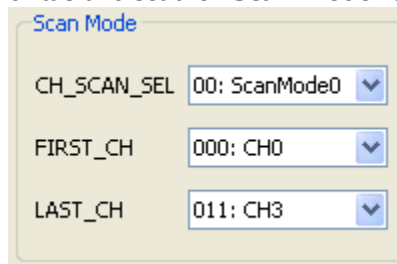


Figure 6 - Scan Mode Settings

2. Under the **“Output Format”** field, select Display as **“Output Voltage (V)”**
3. Under the **“Stop Condition”** field, select Run as **“1000”** samples.
4. Click on the **“Run”** button to view the output voltage results. A reading of approximately $\frac{1}{2}(V_{REF1})$ should be plotted as seen in Figure 7.

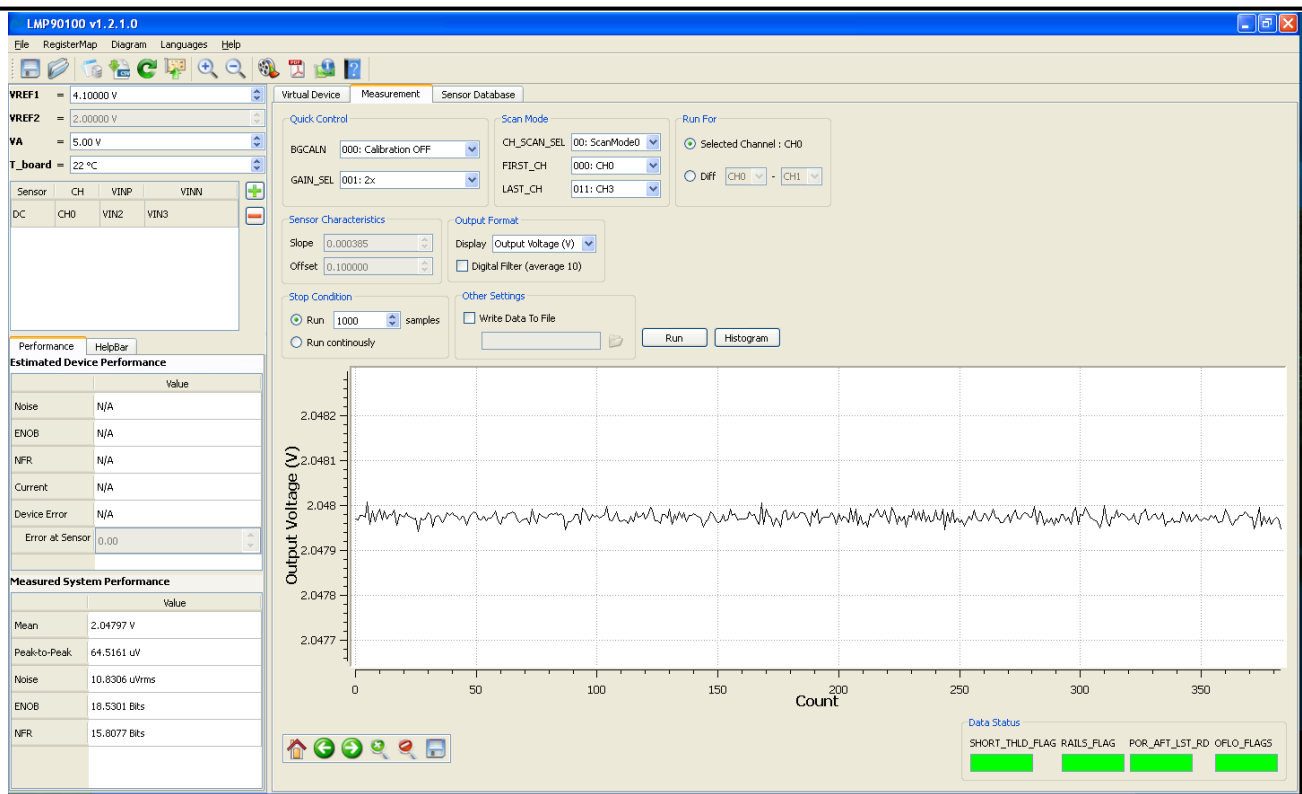


Figure 7 - Results for Example #1 - DC Reading

4.0. Example #2: Shorted Input and Calibration Test

This example demonstrates LMP90100's ability to calibrate for offset error.

A. LMP90100 EB Jumper Connections

1. Connect the LMP90100EB jumpers like the jumpers shown in the figure and table below. Jumpers not mentioned can be left unconnected.
2. The SPIO-4 board is properly setup out of the box (no assembly required).
3. The schematic for the LMP90100EB can be seen in section 10.

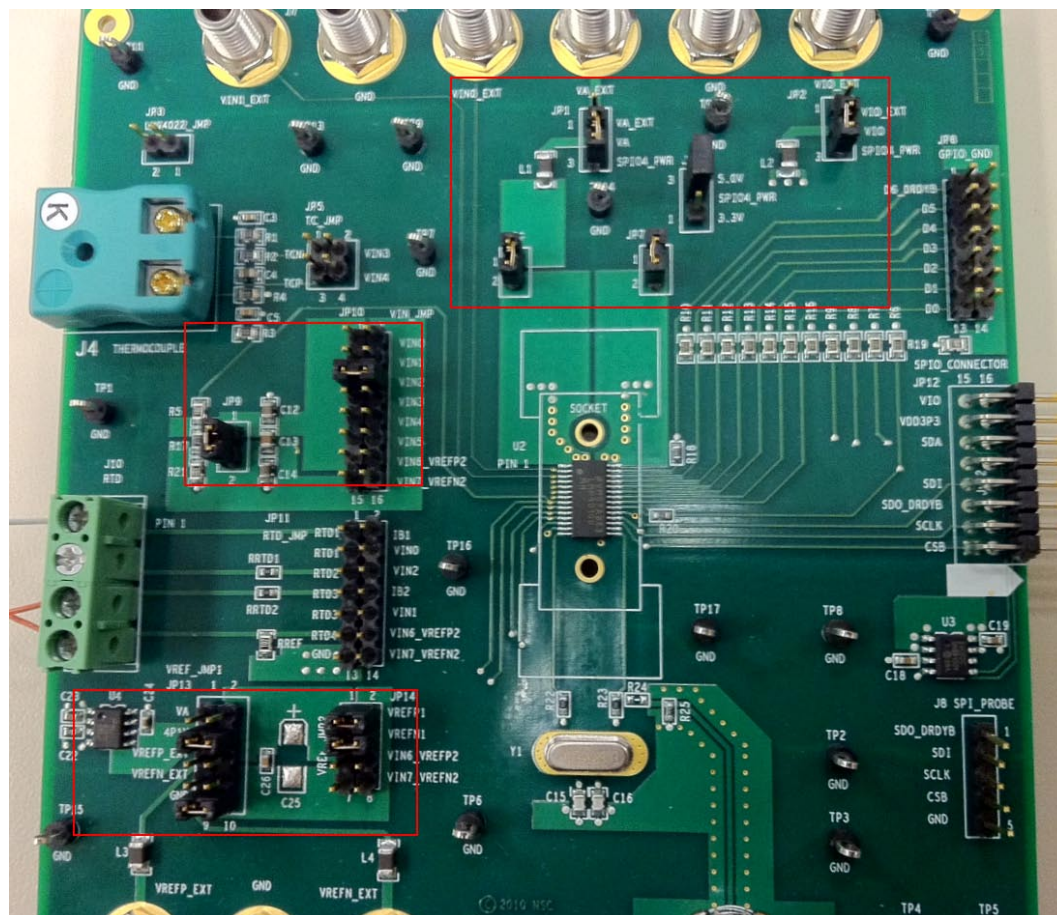


Figure 8 – LMP90100EB Jumper Settings for the Shorted input and Calibration Test

Jumpers	Pin	Purpose
JP1: VA_EXT	P2-P3	Source VA with the 5.0V from the SPIO-4 board.
JP2: VIO_EXT	P2-P3	Source VIO with the 5.0V from the SPIO-4 board.
JP4	P2-P3	Get 5.0V from the SPIO-4 board
JP6	P1-P2	Connect VA supply to the LMP90100
JP7	P1-P2	Connect VIO supply to the LMP90100
JP9	P1-P2	Force the odd pins of JP10 to be midscale (VREF1/2)
JP10: VIN_JMP	P5-P6	Connect a DC (midscale) voltage to VIN2
JP13: VREF_JMP1	P3-P4	VREFP1 = 4.1V from U4 (LM4140)
JP13: VREF_JMP1	P9-P10	VREFN1 = ground

Jumpers	Pin	Purpose
JP14: VREF_JMP2	P1-P2	Connect VREFP1 source to the LMP90100
JP14: VREF_JMP2	P3-P4	Connect VREFN1 source to the LMP90100

Table 2 - Jumpers for the Shorted Input Measurement

B. Installing/Opening the Software – skip this step if it’s already done. If not, follow section 9.0 to install and open the LMP90100 Sensor AFE software.

C. Connecting and Powering the Boards

1. Connect the LMP90100EB to the SPIO-4 board as seen in Figure 4.
2. Connect SPIO-4 board to a PC via **USB**.
3. Use a multimeter to measure LMP90100EB’s JP6 and JP7; they should all be approximately 5V, and JP14.P2 should be 4.1V. If they are not, check your power supplies and jumpers.

D. Configuring the LMP90100 Using the Sensor AFE Software

Follow the step-by-step instructions under the “**HelpBar**” mini-tab (left hand side of the GUI) to configure the LMP90100 for this example. These step-by-step instructions are discussed in details below, and the recommended configuration should look similar to figure 9.

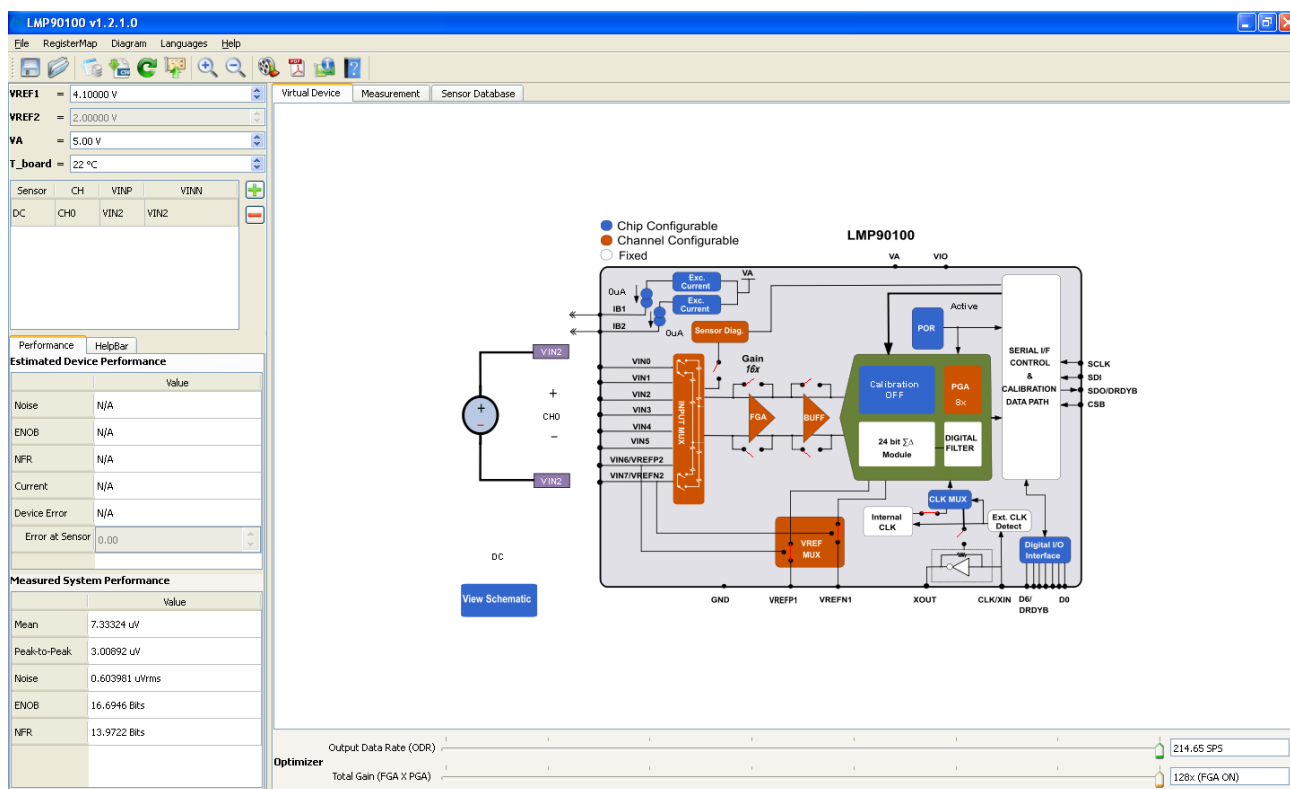


Figure 9 - Recommended LMP90100 Configuration for the Shorted Input and Calibration Test

1. Step 1: Select a Sensor - select “**DC**” → “**DC**” since the input source is a DC voltage

2. Step 2: Configure Inputs – click on the **“INPUT MUX”** block to set **“VINP = 000: VIN2”** and **“VINN = 000: VIN2”**. Since VINP = VINN, a reading of approximately 0V should be read.
3. Step 3: Source IB1/IB2? – *this step can be ignored because neither IB1 nor IB2 is connected to the inputs.*
4. Step 4: Select Reference – click on the **“VREF MUX”** block to choose **“VREF_SEL = 0: VREF1”**. On the left hand side of the GUI, change the VREF1 (left hand side of the GUI) value to 4.1V.
5. Step 5: Set Gain – since $VIN \approx 0V$, the maximum gain that can be set is 128x. Click on the **“FGA”** block, **“PGA”** block, or the **“Gain”** slider to select the gain.
6. Step 6: Set Buffer – click on the **“BUFF”** block to include or exclude the buffer from the signal path.
7. Step 7: Set Calibration - the purpose of this example is to show how the LMP90100 removes the offset error using background calibration. Initially, disable the calibration by selecting **“000: No Calibration”** under the **“No Calibration”** block.

Refer to the LMP90100 datasheet to more information on the LMP90100’s background calibration types and modes.

8. Step 8: Int/Ext CLK? – click on the **“CLK MUX”** block and make sure the internal clock is selected.
9. Step 9: Performance - click on the **“Performance”** mini-tab. This tab displays the Estimated Device Performance base on the block diagram that you’ve configured, as well as the Measured System Performance if you’ve connected a board and ran the LMP90100.

E. Capturing Data without Calibration

1. Click on the **“Measurement”** tab and set the **“Scan Mode”** as follows:

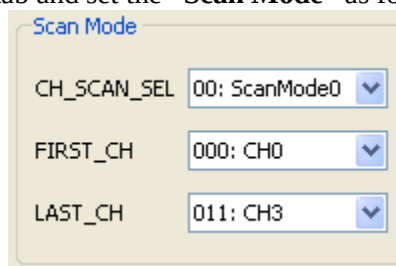


Figure 10 - Scan Mode Settings

2. Under the **“Output Format”** field, select Display **“Output Voltage (V)”**
3. Under the **“Stop Condition”** field, select Run **“500”** samples.
4. Click on the **“Run”** button to view the output voltage results. A reading in the hundreds of μV should be plotted similar to Figure 11.

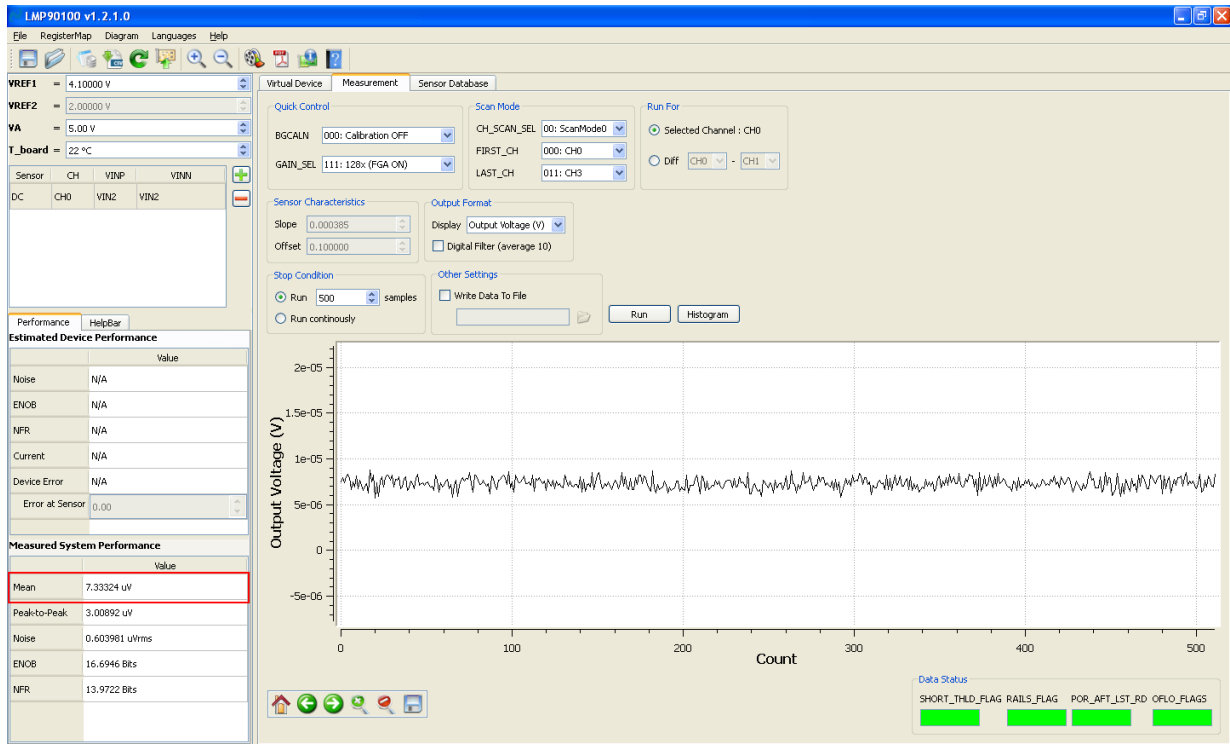


Figure 11 - Results for Shorted Input Test without Calibration

F. Capturing Data with Calibration

1. In the “**Measurement**” tab, go to “**Quick Control → BGCAL_MODE**” and change the background calibration to “**001: Offset Cor / Gain Est**”.
2. Click on the “**Run**” button again to view the output voltage results. A mean output reading closer to 0V should be plotted similar to Figure 12. This decrease in the mean output reading demonstrates the LMP90100 offset calibration feature.

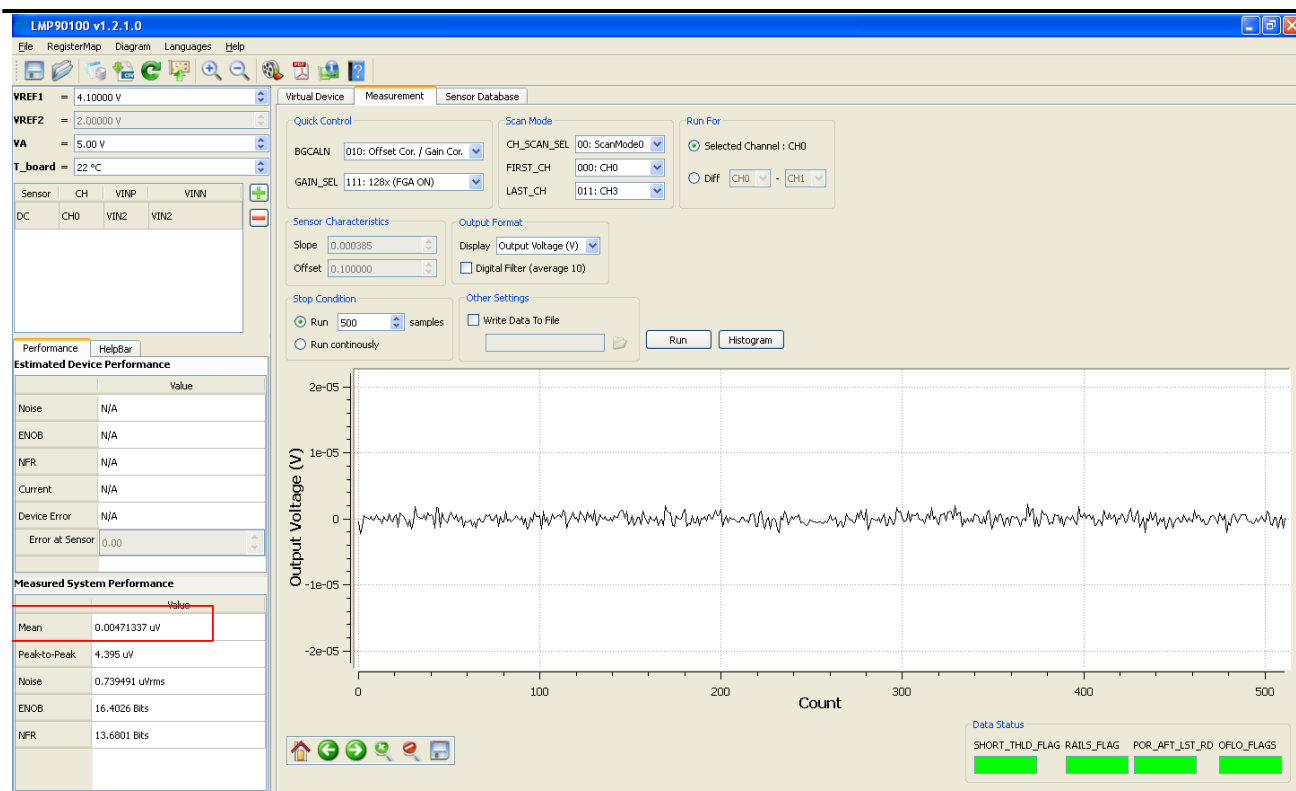


Figure 12 - Results for Shorted Input Test with Calibration

5.0. Example #3 - 3-wire RTD Application

A 3-wire RTD has a typical configuration shown in Figure 13. This section will explain how to configure the LMP90100EB and software tool to evaluate a 3-wire RTD.

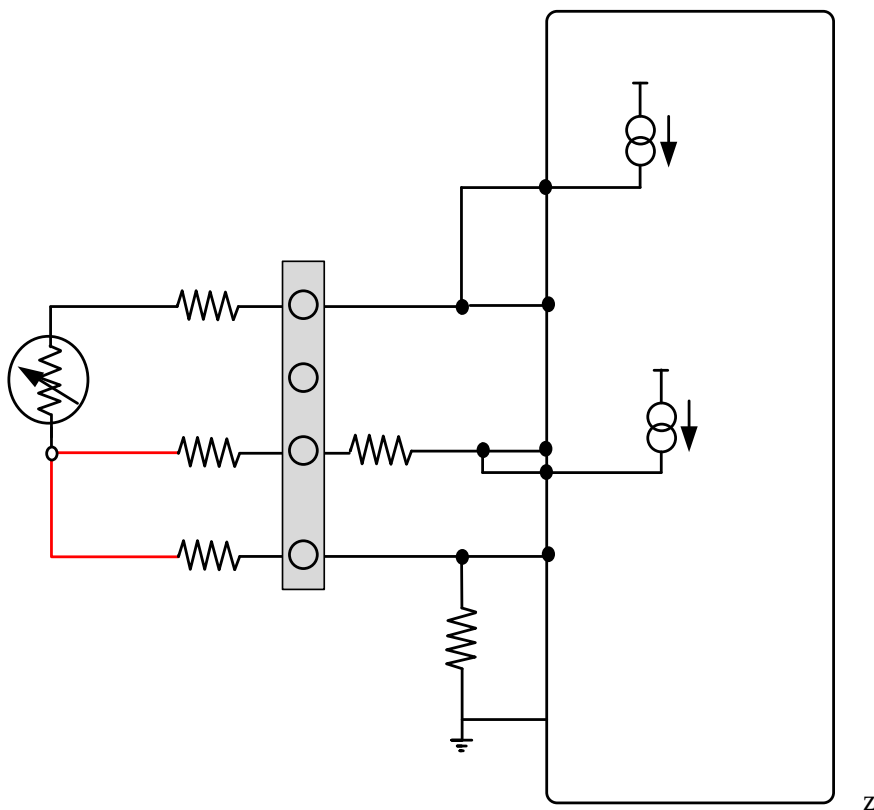


Figure 13 - 3-Wire RTD Configuration

A. LMP90100EB Jumper Connections

1. The jumper settings for this application are shown below. The jumpers not mentioned can be left unconnected.
2. The SPIO-4 board is properly setup out of the box (no assembly required).
3. The schematic for the LMP90100EB can be seen in section 10.

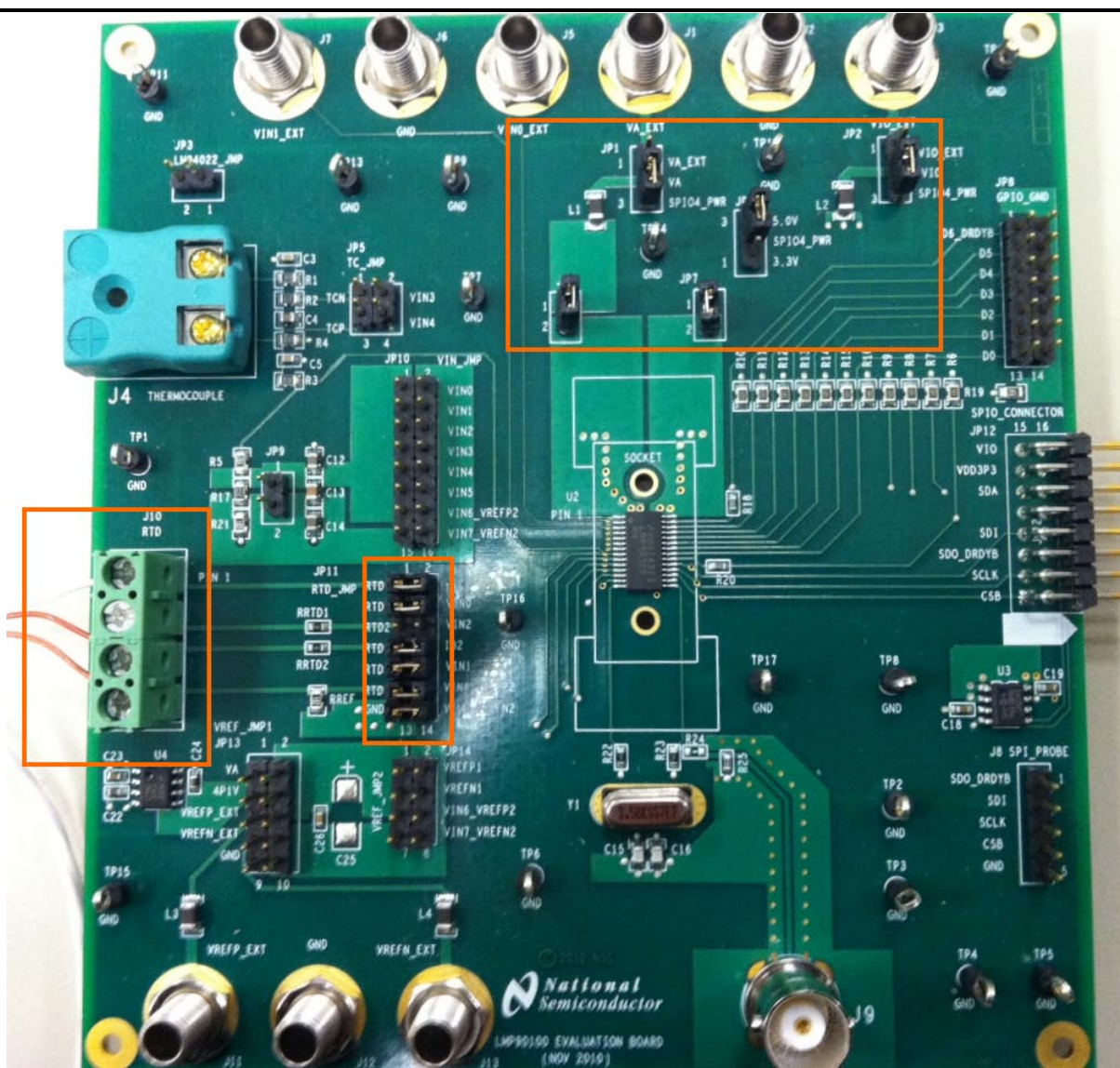


Figure 14 – Jumper Settings (Default) for the 3-wire RTD Example

Jumpers	Pin	Purpose
JP1: VA_EXT	P2-P3	Source VA with the 5.0V from the SPIO-4 board.
JP2: VIO_EXT	P2-P3	Source VIO with the 5.0V from the SPIO-4 board.
JP4	P2-P3	Get 5.0V from the SPIO-4 board
JP6	P1-P2	Connect VA supply to the LMP90100
JP7	P1-P2	Connect VIO supply to the LMP90100
JP11: RTD_JMP	P1-P2	Connect IB1 to the RTD
JP11: RTD_JMP	P3-P4	Connect the RTD to VIN0
JP11: RTD_JMP	P7-P8	Connect IB2 to the RTD
JP11: RTD_JMP	P9-P10	Connect the RTD to VIN1
JP11: RTD_JMP	P11-P12	Connect the RTD to VREFP2
JP11: RTD_JMP	P13-P14	Connect VREFN2 to ground

Table 3 – LMP90100EB Jumpers for the RTD Application

B. Installing/Opening the Software – skip this step if it’s already done. If not, follow section 9.0 to install and open the LMP90100 Sensor AFE software.

C. Connecting and Powering the Boards

1. Connect the LMP90100EB to the SPIO-4 board as seen in Figure 4.
2. Connect SPIO-4 board to a PC via **USB**.
3. Use a multimeter to measure LMP90100EB’s JP6 and JP7; they should all be approximately 5.0V. If they are not, check your power supplies and jumpers.

D. Connecting the Sensor to the LMP90100EB

1. Connect a 3-wire RTD to J10 as seen in the image below. The white wire should be at J10.P1, and the red wires should be at J10.P3 and J10.P4.

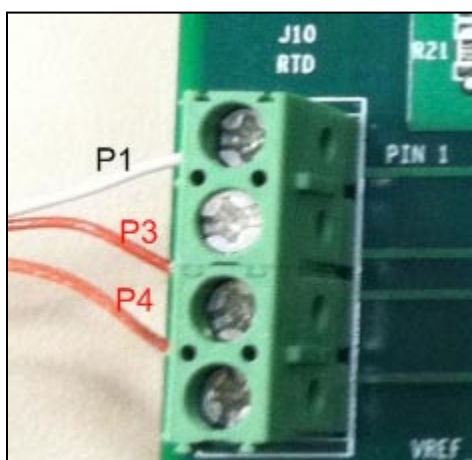


Figure 15 – Jumper Settings (Default) for the 3-wire RTD Example

E. Configuring the LMP90100 Using the Sensor AFE Software

Follow the step-by-step instructions under the **“HelpBar”** mini-tab (left hand side of the GUI) to configure the LMP90100 for this example. These step-by-step instructions are discussed in details below, and the recommended configuration should look similar to Figure 16.

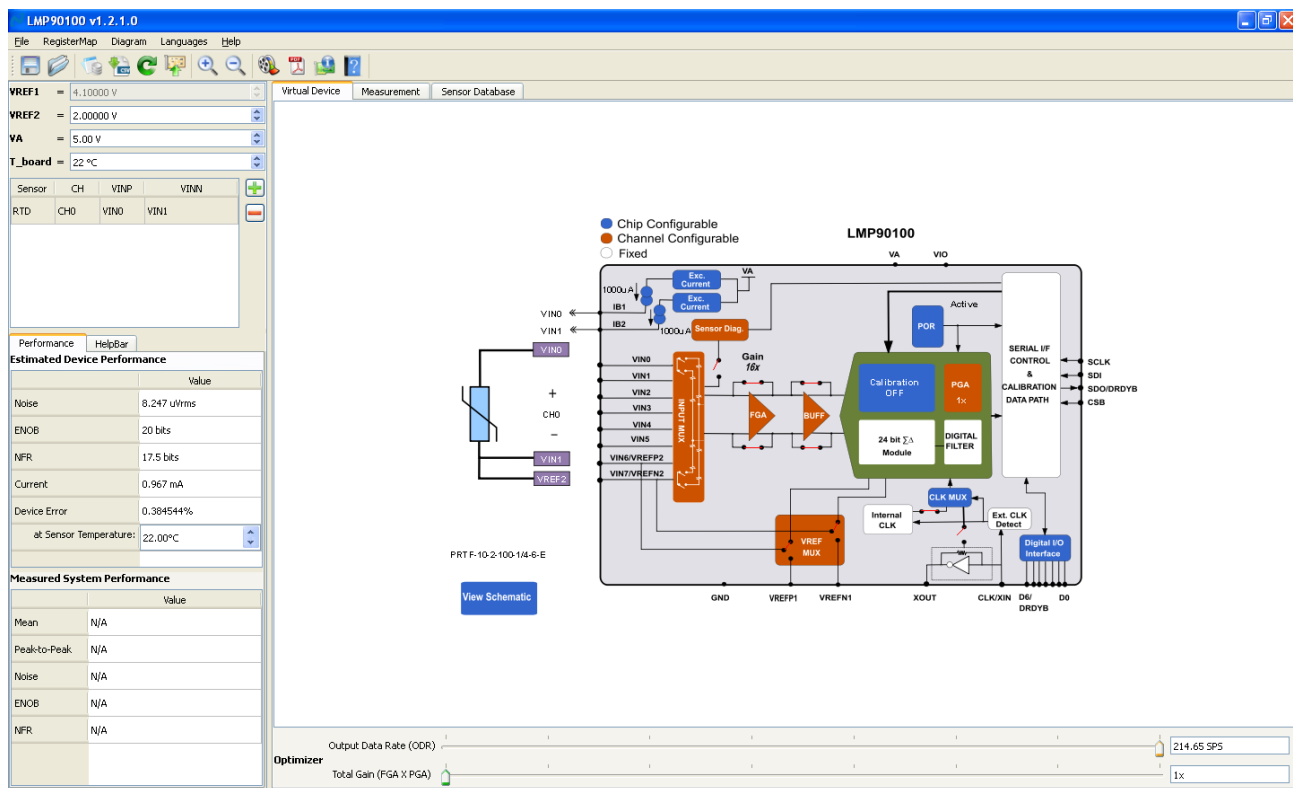


Figure 16 - Recommended LMP90100 Configuration for a PT-100 RTD

- Step 1: Select a Sensor - select **"RTD"** → **"PRTF-10-2-100-1/4-6-E"**.
- Step 2: Configure Inputs – click on the **"INPUT MUX"** block to set **"VINP = 000: VIN0"** and **"VINN = 001: VIN1"**. Click on the **"Eval. Board Settings"** button located next to the block diagram. This should open up a PDF of the schematic and calculation for this 3-wire RTD example.
- Step 3: Source IB1/IB2? – click on the **"EXC. Current"** block to set **"RTD_CUR_SEL = 1010: 1000 uA"**.
- Step 4: Select Reference – click on the **"VREF MUX"** block to choose **"VREF_SEL = 1: VREF2"**. Make sure the value for VREF2 (upper left hand side of the GUI) is 2.0V = $[RREF * (IB1+IB2)] = [1k * (1mA + 1mA)]$.
- Step 5: Set Gain – since VIN = 0.109 V at room temperature for IB1 = IB2 = 1000 uA, the maximum gain can be 16x. Click on the **"FGA"** block, **"PGA"** block, or the **"Gain"** slider to select the gain. (For this exercise, the gain can be set to 1x).
- Step 6: Set Buffer – click on the **"BUFF"** block to include or exclude the buffer from the signal path. (For this exercise, the buffer can be disabled).

7. Step 7: Set Calibration - click on the **“No Calibration”** block to enable or disable calibration. Refer to the LMP90100 datasheet to more information on the LMP90100’s background calibration types and modes. *(For this exercise, the calibration can be OFF).*
8. Step 8: Int/Ext CLK? – click on the **“CLK MUX”** block and make sure the internal clock is selected.
9. Step 9: Performance - click on the **“Performance”** mini-tab. This tab displays the Estimated Device Performance base on the block diagram that you’ve configured, as well as the Measured System Performance if you’ve connected a board and ran the LMP90100.

F. Capturing Data

1. Click on the **“Measurement”** tab and set the **“Scan Mode”** as follows:

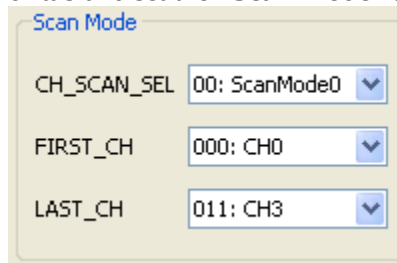
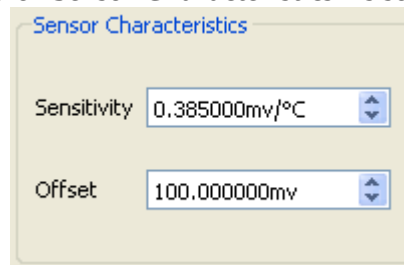


Figure 17 - Scan Mode Settings

2. Under the **“Output Format”** field, select Display **“Temperature (°C)”**
3. Make sure the **“Sensor Characteristics”** is set as:



4. Under the **“Stop Condition”** field, select **“Run Continuously”**.
5. Click on the **“Run”** button to view the output temperature reading. A reading of approximately 23°C to 25°C (room temperature) should be plotted.

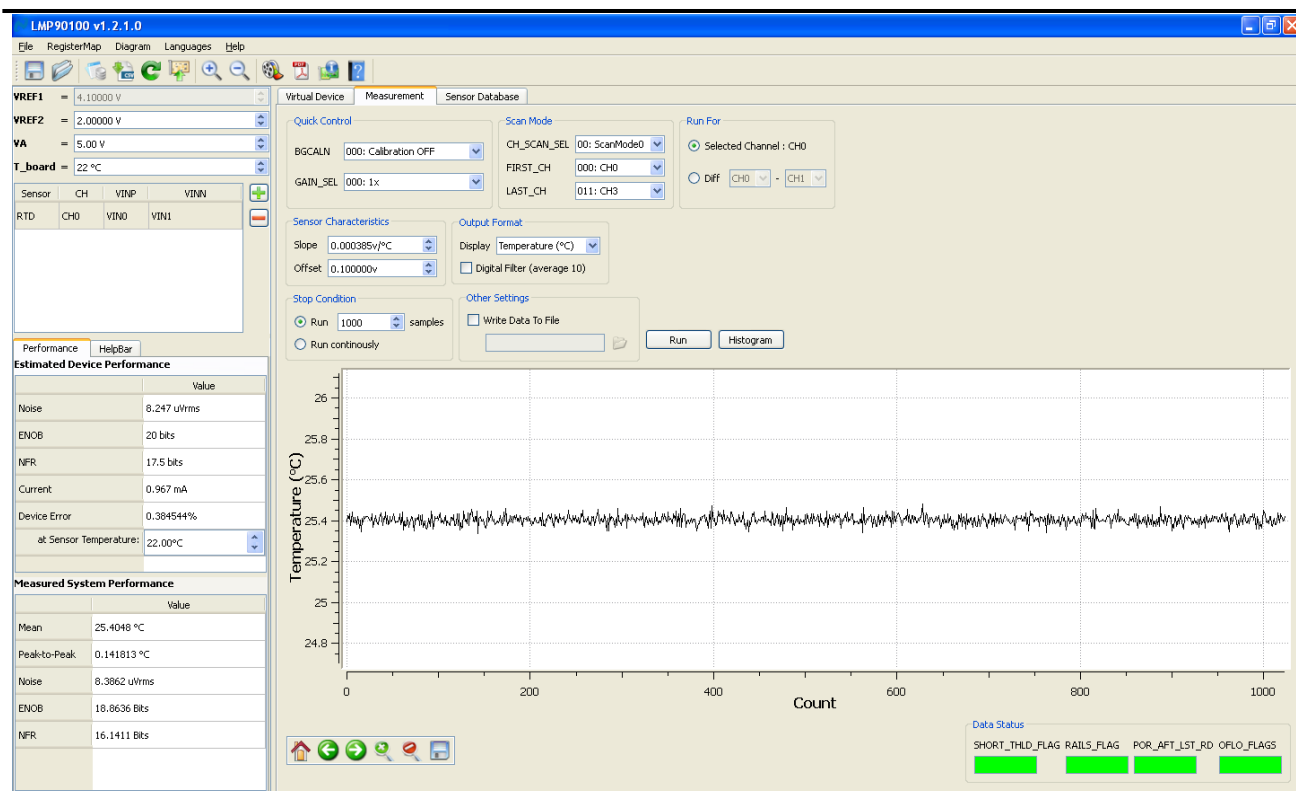


Figure 18 – Reading of Room Temperature Using the 3-Wire RTD

6.0. Example #4: Thermocouple and LM94022 Application

A. Thermocouple and Cold Junction Compensation Background

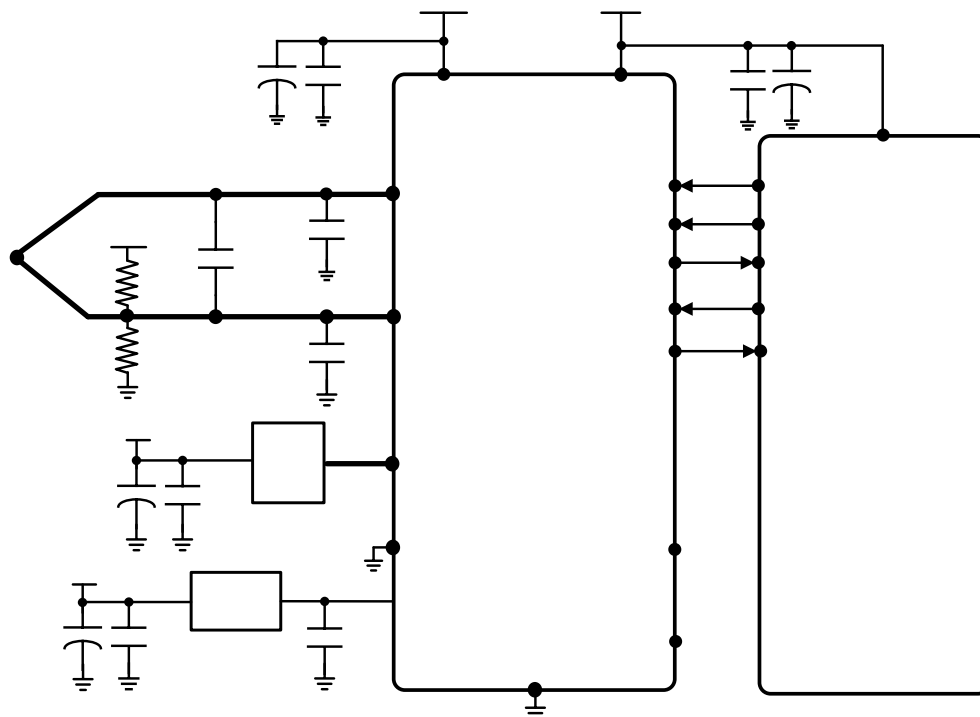


Figure 19 – Thermocouple and Temperature Sensor Connection

As described in section 17.6.2. of the LMP90100 datasheet, because a thermocouple can only measure a voltage difference and thus a temperature difference (relative temperature), it does not have the ability to measure absolute temperature. To determine the absolute temperature of the measured environment, a technique known as cold junction compensation (CJC) must be used.

In a CJC technique, the “cold” junction temperature, T_{cold} (Figure 19), is sensed by using an IC temperature sensor, such as the LM94022. The temperature sensor should be placed within close proximity of the reference junction. The LM94022 is placed underneath the thermocouple connector J4 on the LMP90100 evaluation board.

The technique to calculate for T_{hot} using the CJC method can be found in the LMP90100 datasheet.

The Sensor AFE software does have the ability to display the relative thermocouple temperature using a Type K look-up-table (<http://www.intech.co.nz/products/temperature/typek.html>). In addition, if the LM94022 (or any other temperature sensors) is connected to the LMP90100, then the software can also read its temperature (T_{cold}). However, the user has to manually enter this T_{cold} value in the $T_{board} =$ field located on the upper left hand side of the GUI. The software will use this T_{board} value to calculate for T_{hot} .

B. Thermocouple and LM94022 Schematic on the LMP90100EB

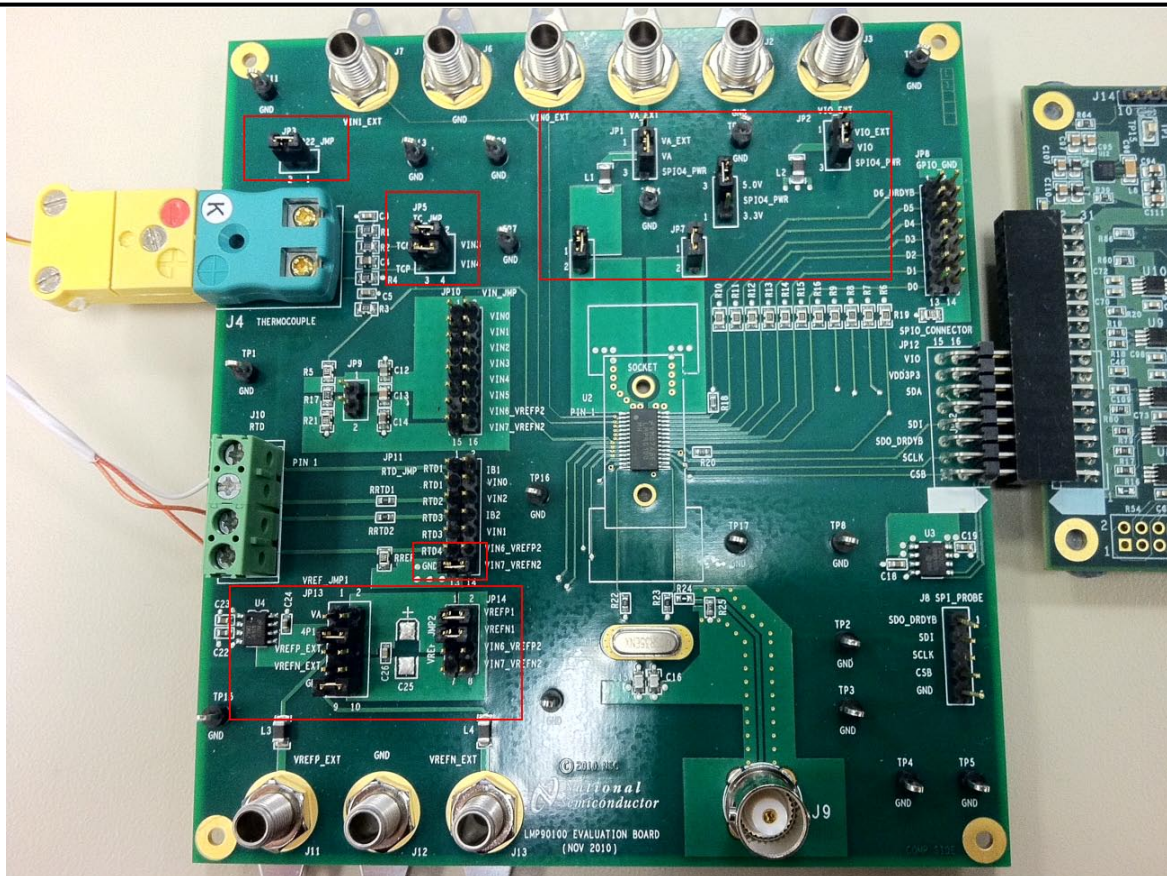


Figure 21 – Jumper Settings for the Thermocouple and LM94022 Example

Jumpers	Pin	Purpose
JP1: VA_EXT	P2-P3	Source VA with the 5.0V from the SPIO-4 board.
JP2: VIO_EXT	P2-P3	Source VIO with the 5.0V from the SPIO-4 board.
JP4	P2-P3	Get 5.0V from the SPIO-4 board
JP6	P1-P2	Connect VA supply to the LMP90100
JP7	P1-P2	Connect VIO supply to the LMP90100
JP5: TC_JMP	P1-P2	Connect TCN to VIN3
JP5: TC_JMP	P3-P4	Connect TCP to VIN4
JP3: LM94022_JMP	P1-P2	Connect the output of LM94022 to VIN5
JP13: VREF_JMP1	P3-P4	VREFP1 = 4.1V from U4 (LM4140)
JP13: VREF_JMP1	P9-P10	VREFN1 = ground
JP14: VREF_JMP2	P1-P2	Connect VREFP1 source to the LMP90100
JP14: VREF_JMP2	P3-P4	Connect VREFN1 source to the LMP90100

Table 4 – LMP90100EB Jumpers for the RTD Application

D. Installing/Opening the Software – skip this step if it's already done. If not, follow section 9.0 to install and open the LMP90100 Sensor AFE software.

E. Connecting and Powering the Boards

1. Connect the LMP90100EB to the SPIO-4 board as seen in Figure 4.

2. Connect SPIO-4 board to a PC via **USB**.
3. Use a multimeter to measure LMP90100EB's JP6, JP7, and JP14.P2; they should all be approximately 5V. If they are not, check your power supplies and jumpers.

F. Connect a K type thermocouple to J4. Note that the thermocouple's positive input (TCP) = VIN4 and negative input (TCN) = VIN3.

G. Configuring the LMP90100 for the LM94022 Using the Sensor AFE Software

Follow the step-by-step instructions under the **"HelpBar"** mini-tab (left hand side of the GUI) to configure the LMP90100 for the LM94022 IC sensor. These step-by-step instructions are discussed in details below, and the recommended configuration should look similar to Figure 22.

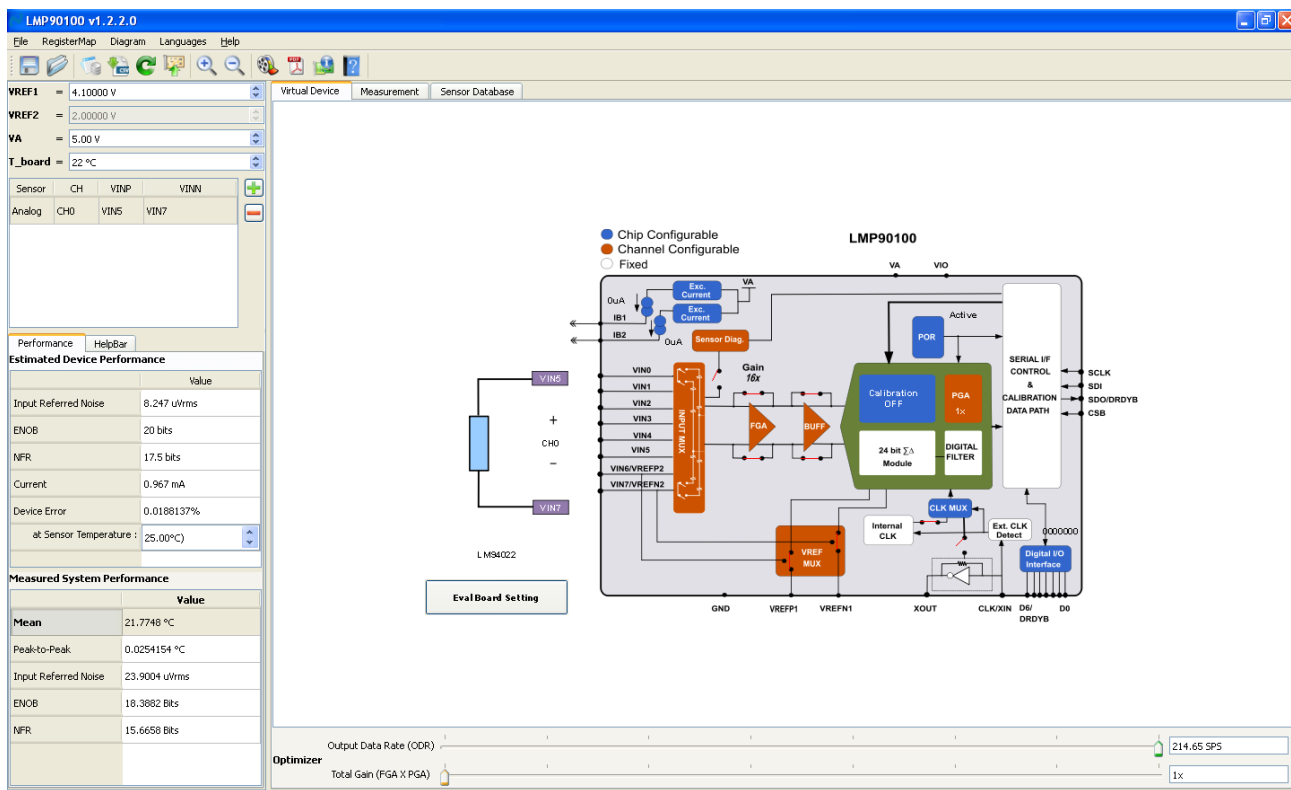


Figure 22 - Recommended LMP90100 Configuration for the LM94022

1. Step 1: Select a Sensor – click on the **"+"** button to enter the **"Sensor Database"** tab. Select **"Analog" → "LM94022"**.
2. Step 2: Configure Inputs – click on the **"INPUT MUX"** block to set **"VINP = 101: VIN5"** and **"VINN = 111: VIN7"**. Click on the **"Eval. Board Settings"** button located next to the block diagram. This should open up a PDF of the schematic of the thermocouple and LM94022 application.
3. Step 3: Source IB1/IB2? – *this step can be ignored because neither IB1 nor IB2 is connected to the inputs.*

4. Step 4: Select Reference – click on the “**VREF MUX**” block to choose “**VREF_SEL = 0: VREF1**”. Make sure the value for VREF1 = 4.1V.
5. Step 5: Set Gain – click on the “**FGA**” block, “**PGA**” block, or the “**Gain**” slider to select the gain. *The gain can be set to 1 in this example.*
6. Step 6: Set Buffer – click on the “**BUFF**” block to include or exclude the buffer from the signal path. *The buffer can be excluded from the signal path in this example.*
7. Step 7: Set Calibration - click on the “**No Calibration**” block to enable or disable calibration. Refer to the LMP90100 datasheet to more information on the LMP90100’s background calibration types and modes. *The calibration can be OFF for this example.*
8. Step 8: Int/Ext CLK? – click on the “**CLK MUX**” block and make sure the internal clock is selected.
9. Step 9: Performance - click on the “**Performance**” mini-tab. This tab displays the Estimated Device Performance base on the block diagram that you’ve configured, as well as the Measured System Performance if you’ve connected a board and ran the LMP90100.

H. Configuring the LMP90100 for the Thermocouple Using the Sensor AFE Software

Follow the step-by-step instructions under the “**HelpBar**” mini-tab (left hand side of the GUI) to configure the LMP90100 for the thermocouple. These step-by-step instructions are discussed in details below, and the recommended configuration should look similar to the figure below.

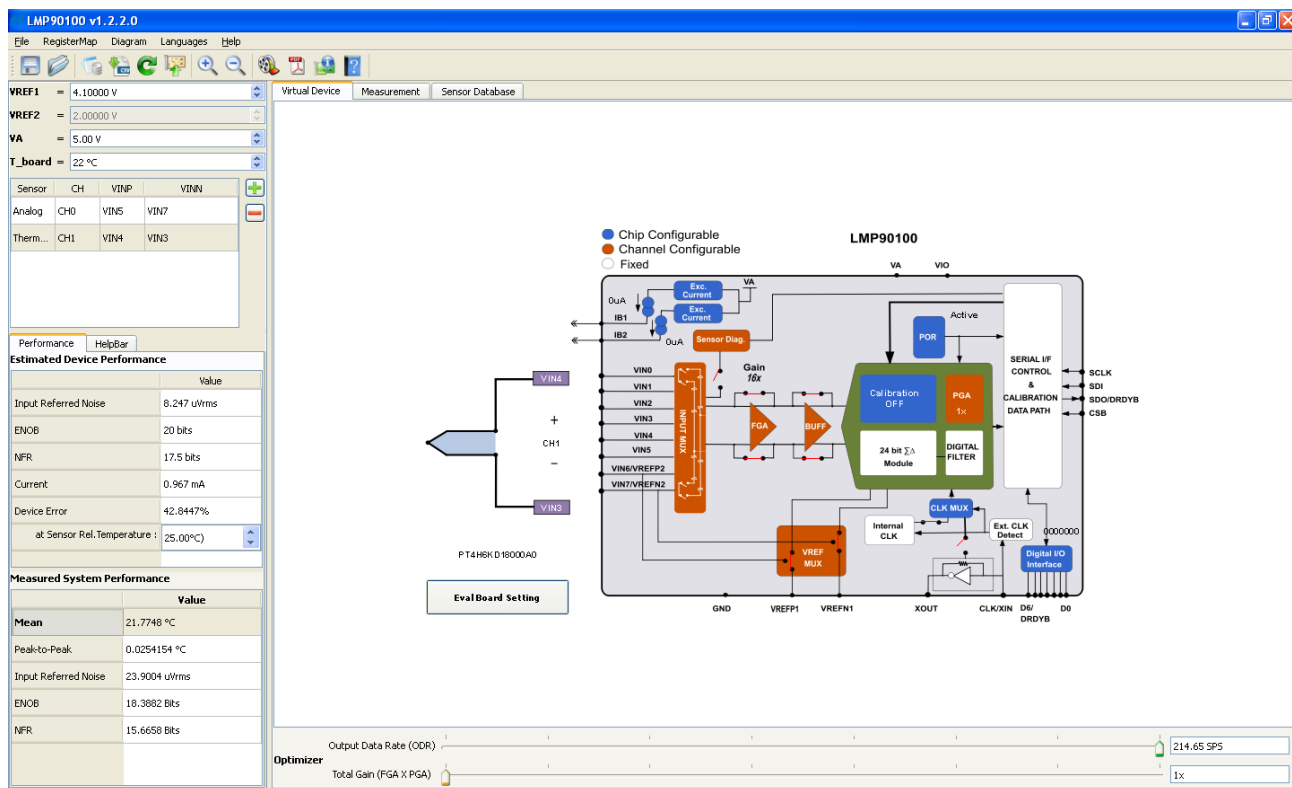


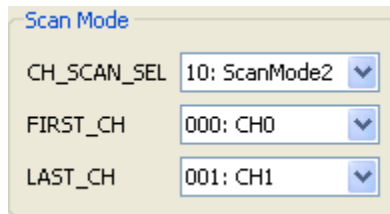
Figure 23 - Recommended LMP90100 Configuration for a Thermocouple

1. Step 1: Select a Sensor - select **"Thermocouple"** → *select the thermocouple of your choice or add your own thermocouple by clicking on "New"*.
2. Step 2: Configure Inputs – click on the **"INPUT MUX"** block to set **"VINP = 100: VIN4"** and **"VINN = 011: VIN3"**. Click on the **"Eval. Board Settings"** button located next to the block diagram. This should open up a PDF of the schematic for a thermocouple.
3. Step 3: Source IB1/IB2? – *this step can be ignored because neither IB1 nor IB2 is connected to the inputs.*
4. Step 4: Select Reference – click on the **"VREF MUX"** block to choose **"VREF_SEL = 0: VREF1"**. Make sure the value for VREF1 = 4.1V.
5. Step 5: Set Gain – since the differential junction across a thermocouple is low, the maximum gain can be 128x. Click on the **"FGA"** block, **"PGA"** block, or the **"Gain"** slider to select the gain. *In this example, the gain can be 1x.*
6. Step 6: Set Buffer – click on the **"BUFF"** block to include or exclude the buffer from the signal path. *The buffer can be excluded from the signal path in this example.*
7. Step 7: Set Calibration - click on the **"No Calibration"** block to enable or disable calibration. Refer to the LMP90100 datasheet to more information on the LMP90100's background calibration types and modes. *In this example, the calibration can be OFF.*

8. Step 8: Int/Ext CLK? – click on the “CLK MUX” block and make sure the internal clock is selected.
9. Step 9: Performance - click on the “Performance” mini-tab. This tab displays the Estimated Device Performance base on the block diagram that you’ve configured, as well as the Measured System Performance if you’ve connected a board and ran the LMP90100.

F. Capturing Data

1. Click on the “Measurement” tab and set the “Scan Mode” as follows:



Scan Mode

CH_SCAN_SEL: 10: ScanMode2

FIRST_CH: 000: CH0

LAST_CH: 001: CH1

Figure 24 - Scan Mode Settings

2. Under the “Output Format” field, select Display “Temperature (C)”
3. Under the “Run For” field, plot the “Selected Channel: CH0”
4. Under the “Stop Condition” field, select Run “1000 Samples”.
5. Click on the “Run” button to capture the temperature (Tcold) reading from the LM94022 (see figure below).

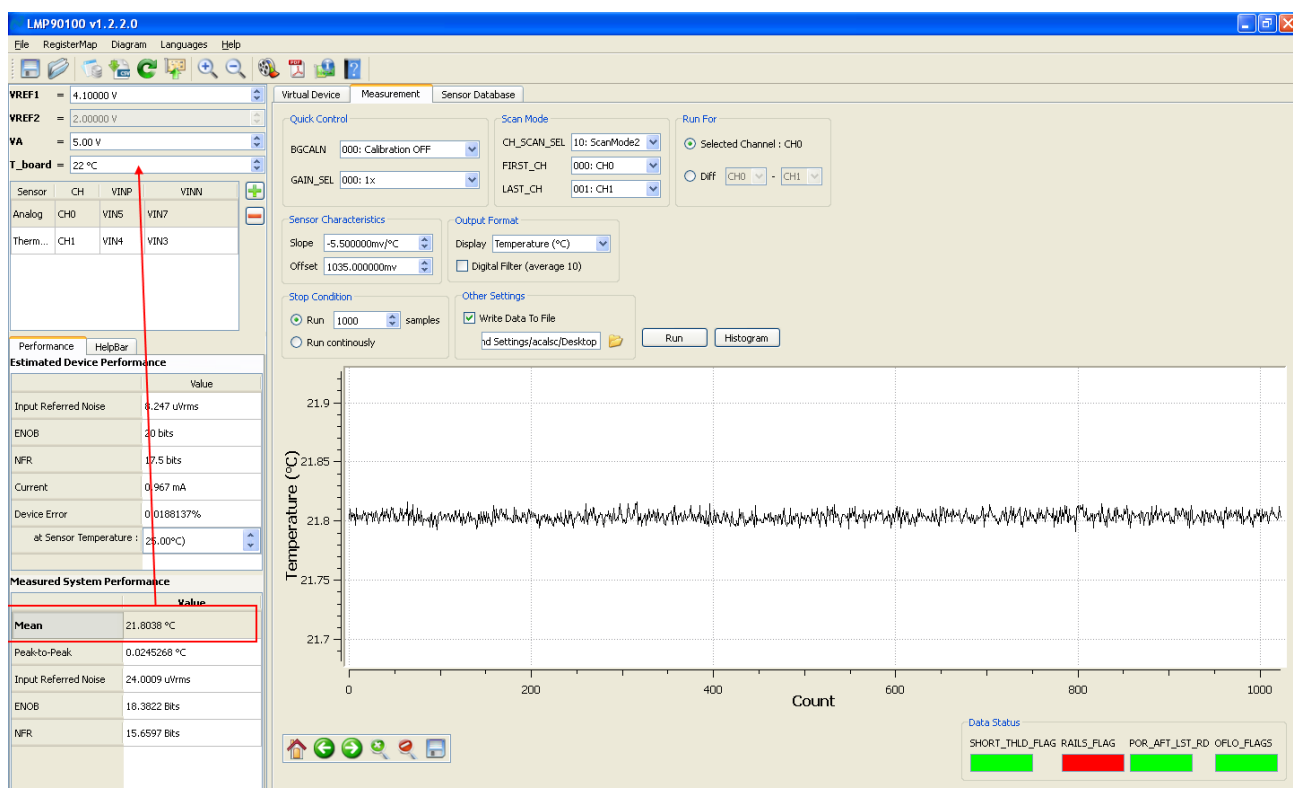


Figure 25 – Temperature Sensor Reading for Tcold

- Enter the LM94022's mean temperature (see red box in the figure above) in the “**T_board**” field located on the upper left hand side of the GUI. The software will use this “T_board” value to calculate for the thermocouple's absolute temperature (Thot).

If the LM94022 or any other temperature sensor is not connected to do cold junction compensation, then the user can still manually enter a Tcold value in the “T_board” field box.

- In the Sensor Window, click on CH1 to read the thermocouple's voltage and temperature.

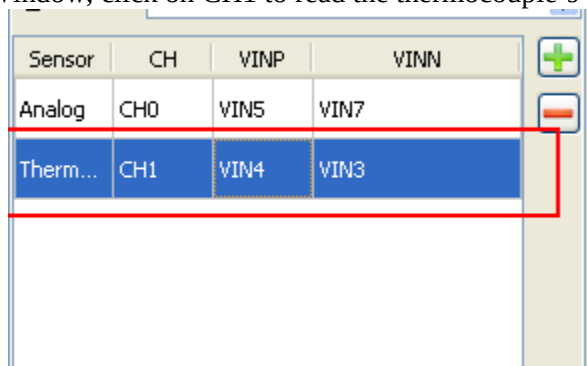


Figure 26 – Sensor Window

- In the “**Measurement**” tab, choose the “**Output Format**” as “**Output Voltage (V)**”, and click “**Run**” to capture the thermocouple relative voltage.

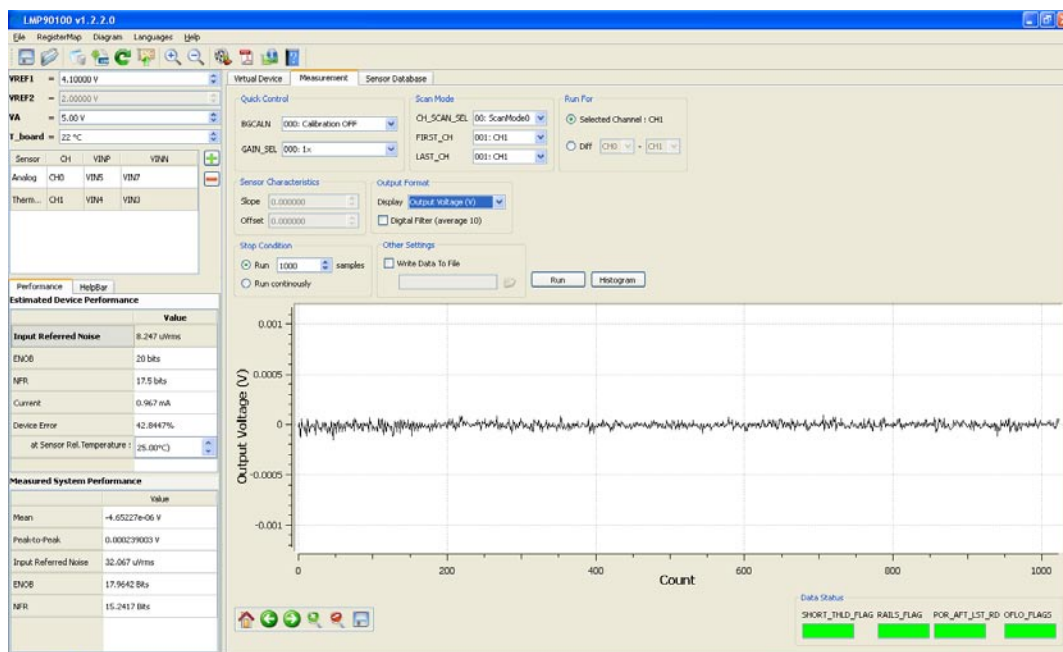


Figure 27 – Thermocouple Voltage Relative Reading

9. In the “**Output Format**” field, choose to Display “**Rel. Temp (C)**”. This shows the relative temperature of the thermocouple. This reading is not factoring in the cold junction compensation.

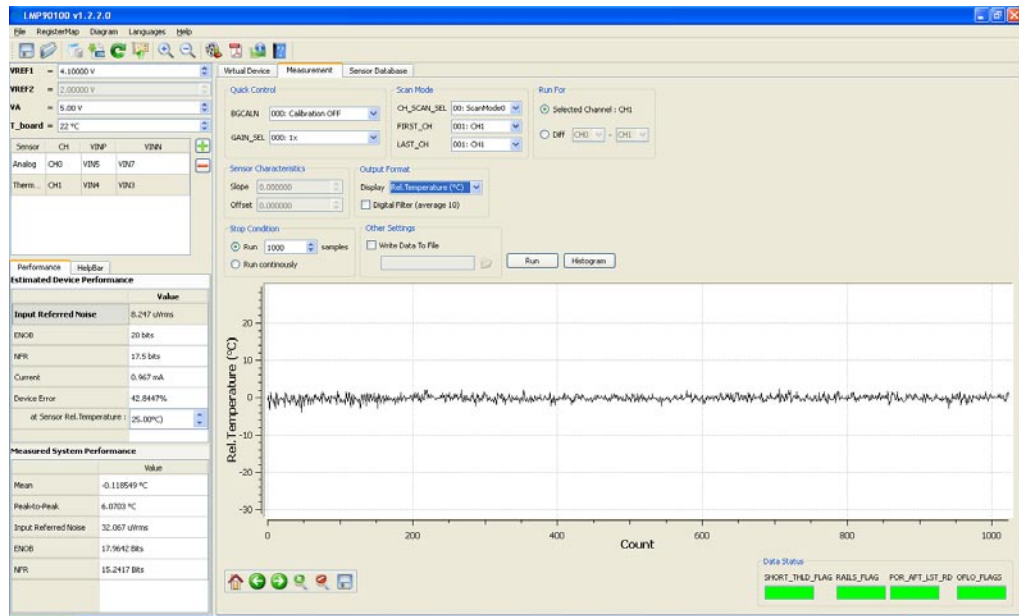


Figure 28 – Thermocouple Relative Temperature Reading

10. In the “**Output Format**” field, choose to Display “**Abs. Temp (C)**”. This uses the “T_{board}” temperature and factor in the cold junction compensation method to display the absolute temperature (T_{hot}) of the thermocouple.

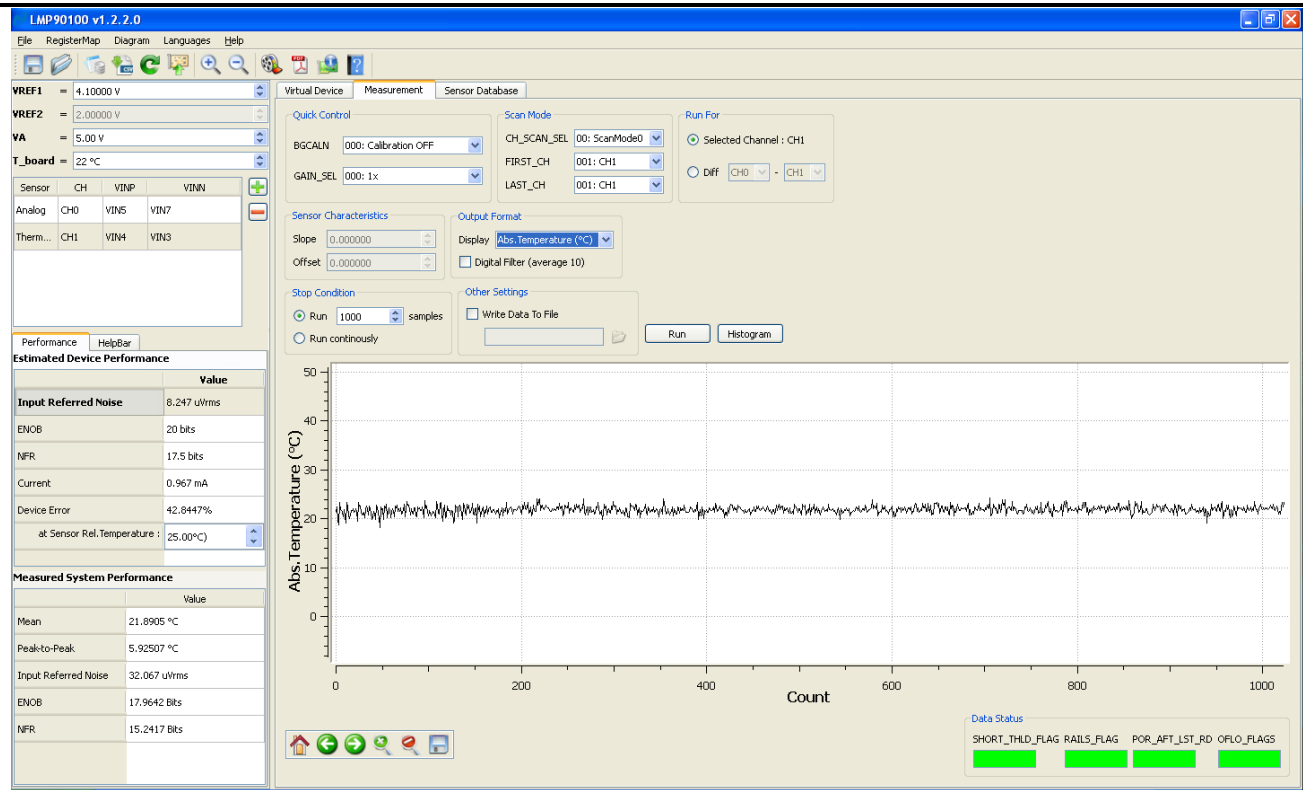


Figure 29 – Thermocouple Absolute Temperature Reading

7.0. Powering the LMP90100EB

There are two ways in which VA and VIO can be sourced: external supplies or SPIO-4 power.

If using external power supplies to source VA and VIO, then do the following:

1. Connect an external power supply to J1 for VA. Jumper pins 1 and 2 of JP1 to select this option.
2. Connect an external power supply to J2 for VIO. Jumper pins 1 and 2 of JP2 to select this option.
3. Jumper JP6 to connect the external power to VA.
4. Jumper JP7 to connect the external power to VIO.

If using the SPIO-4 power to source VA and VIO, then do the following:

1. Jumper pins 1 and 2 of JP4 to select 3.3V for VA and VIO, or jumper pins 2 and 3 of JP4 to select 5.0V for VA and VIO.
2. Jumper pins 2 and 3 of JP1 to select the SPIO-4 power for VA.
3. Jumper pins 2 and 3 of JP2 to select the SPIO-4 power for VIO.
4. Jumper JP6 to connect the SPIO-4 power to VA.
5. Jumper JP7 to connect the SPIO-4 power to VIO.

The schematic for the LMP90100EB can be seen in section 10.

8.0. Evaluating the LMP90100 without the SPIO-4 Board.

The SPIO-4 digital controller board is used to generate the SPI signals to communicate to the LMP90100. Without the SPIO-4 board, the Sensor AFE software for the LMP90100 cannot be used to capture and analyze data from the LMP90100EB.

If the SPIO-4 board is not available but LMP90100 evaluation is desirable, then connect your own SPI signals to J8 of the LMP90100EB as seen below.

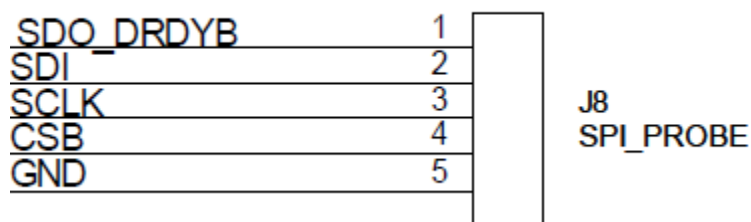


Figure 30 - LMP90100EB's J8 for SPI Signals

Refer to the LMP90100 datasheet for more information on the LMP90100's SPI protocol.

9.0. Installing the LMP90100 Sensor AFE Software

Each Sensor AFE product will have its own software. To access the Sensor AFE software for LMP90100, follow the steps below.

1. Getting the Zip Files

- a. You can find the latest downloadable Sensor AFE software at www.ti.com/sensorafe → Tools
- b. Download the zip file onto your local harddrive. Unzip this folder.

2. Installing the Driver - skip this step if you don't have the LMP90100EB and SPIO4 digital controller board.

- a. Connect the LMP90100EB to SPIO4 board
- b. Connect the SPIO4 board to your PC.
- c. Follow the steps below to install the driver:



Figure 31 - Click on "No, not this time"

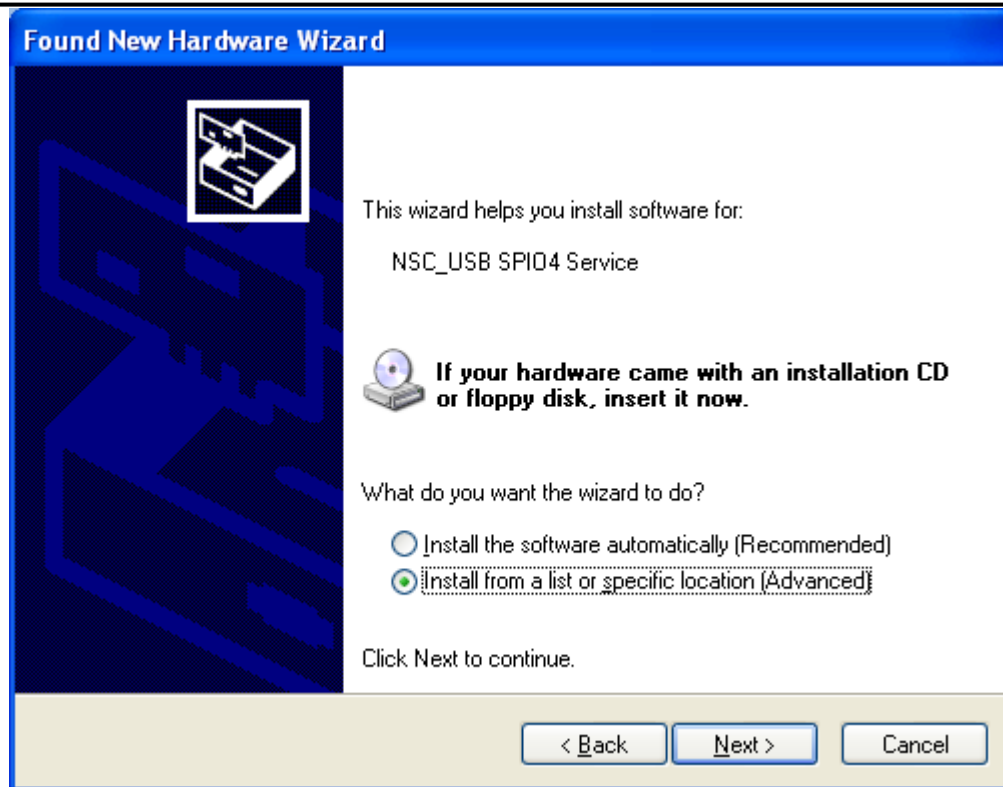
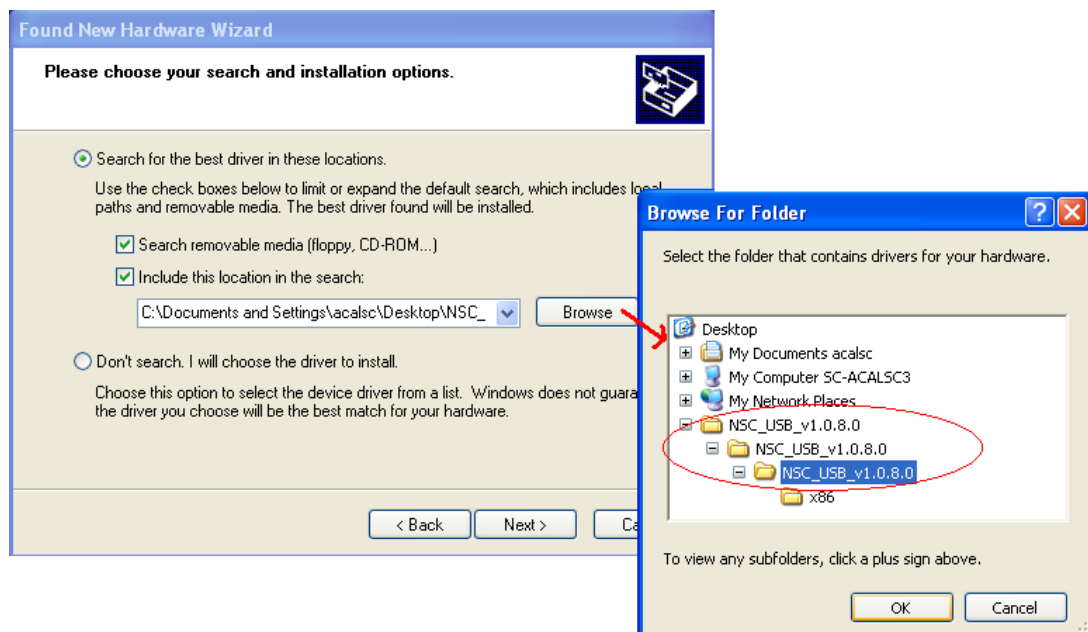


Figure 32 – Choose to “install from a list or specific location (Advanced)”



**Figure 33 – Find the driver in the “NSC_USB_v1.0.8.0” folder
(it should be located in the unzipped folder)**

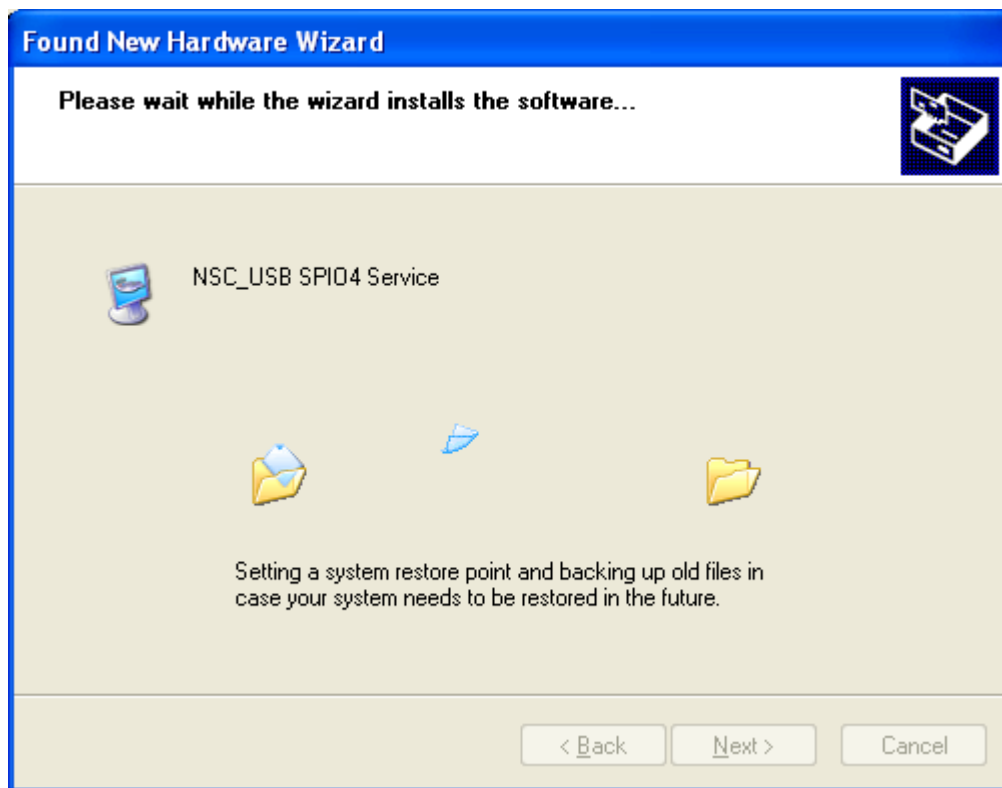


Figure 34 – Waiting for the computer to install the driver

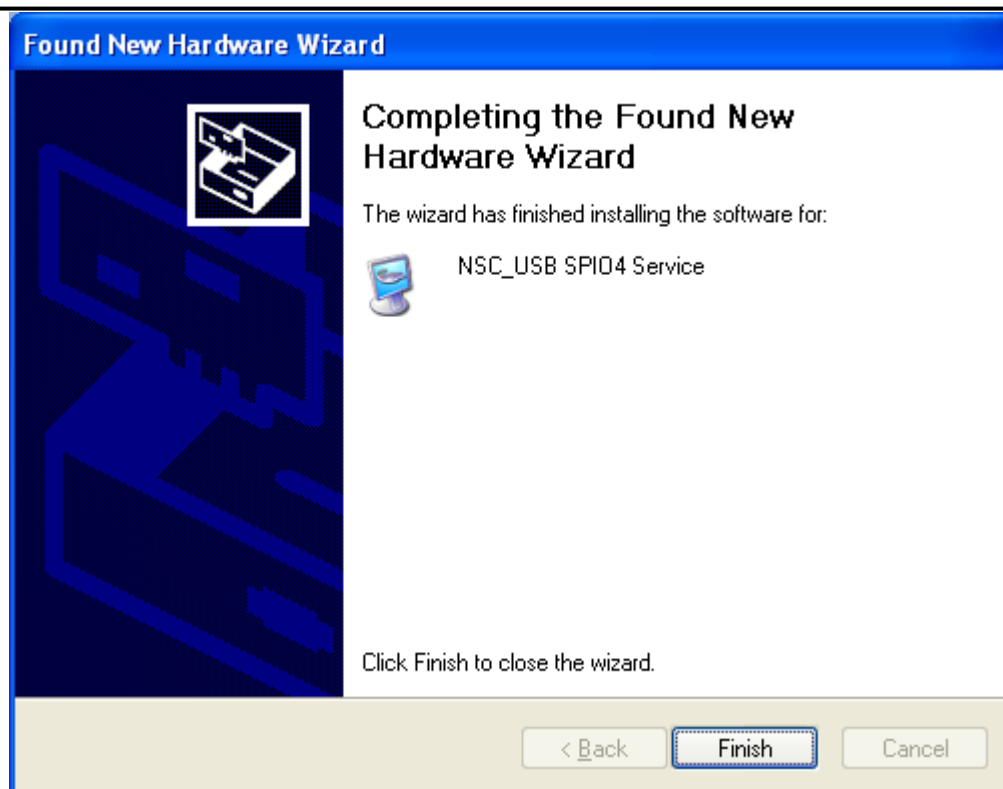


Figure 35 – Installation is complete

3. Open the un-zipped folder and click on "**Imp90100.exe**" to start the software. If you don't have the boards, you'll get an error message. Ignore that error message and click "Ok" to continue.

11.0. Layout

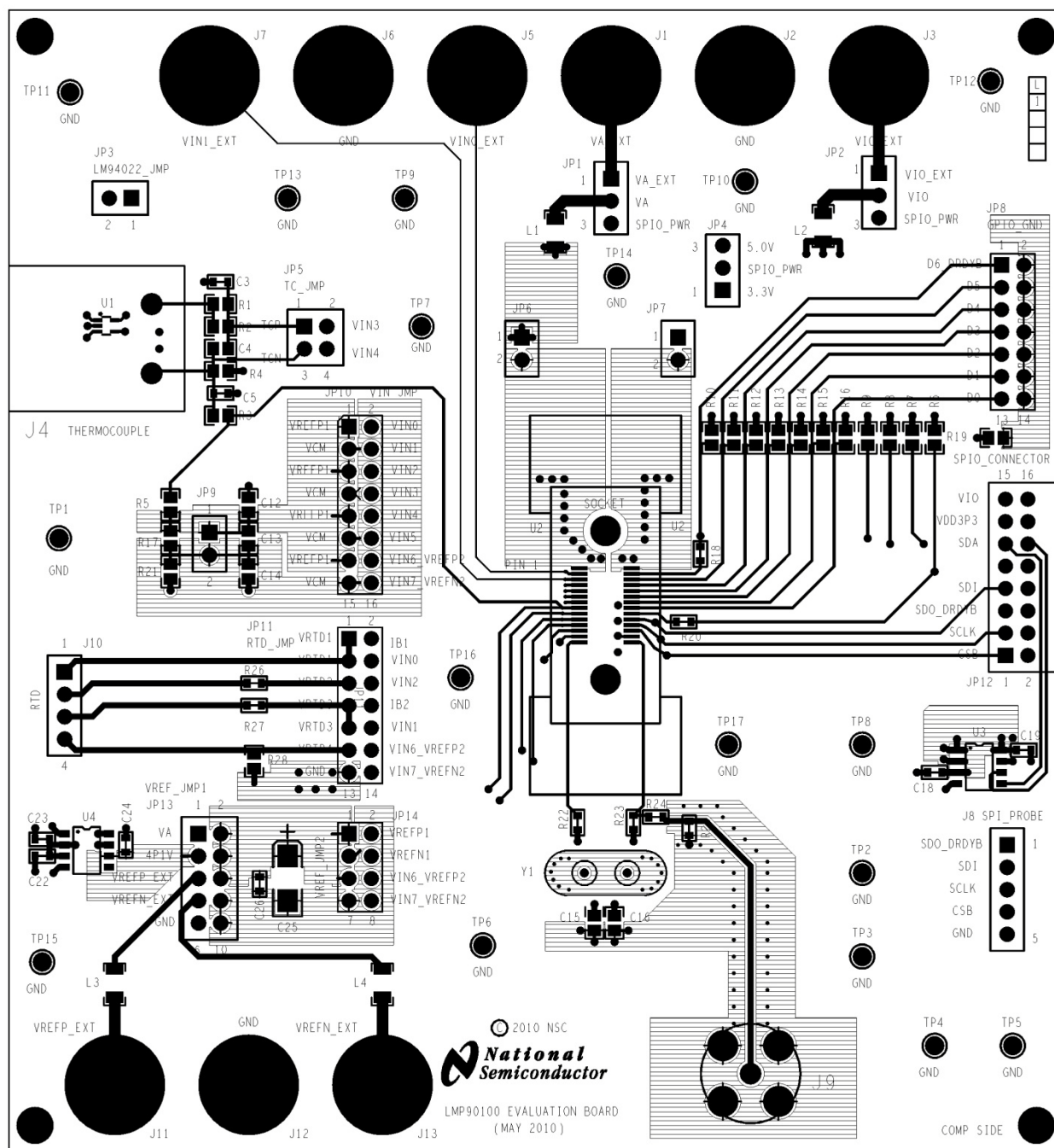


Figure 37 - Layout – Top Layer

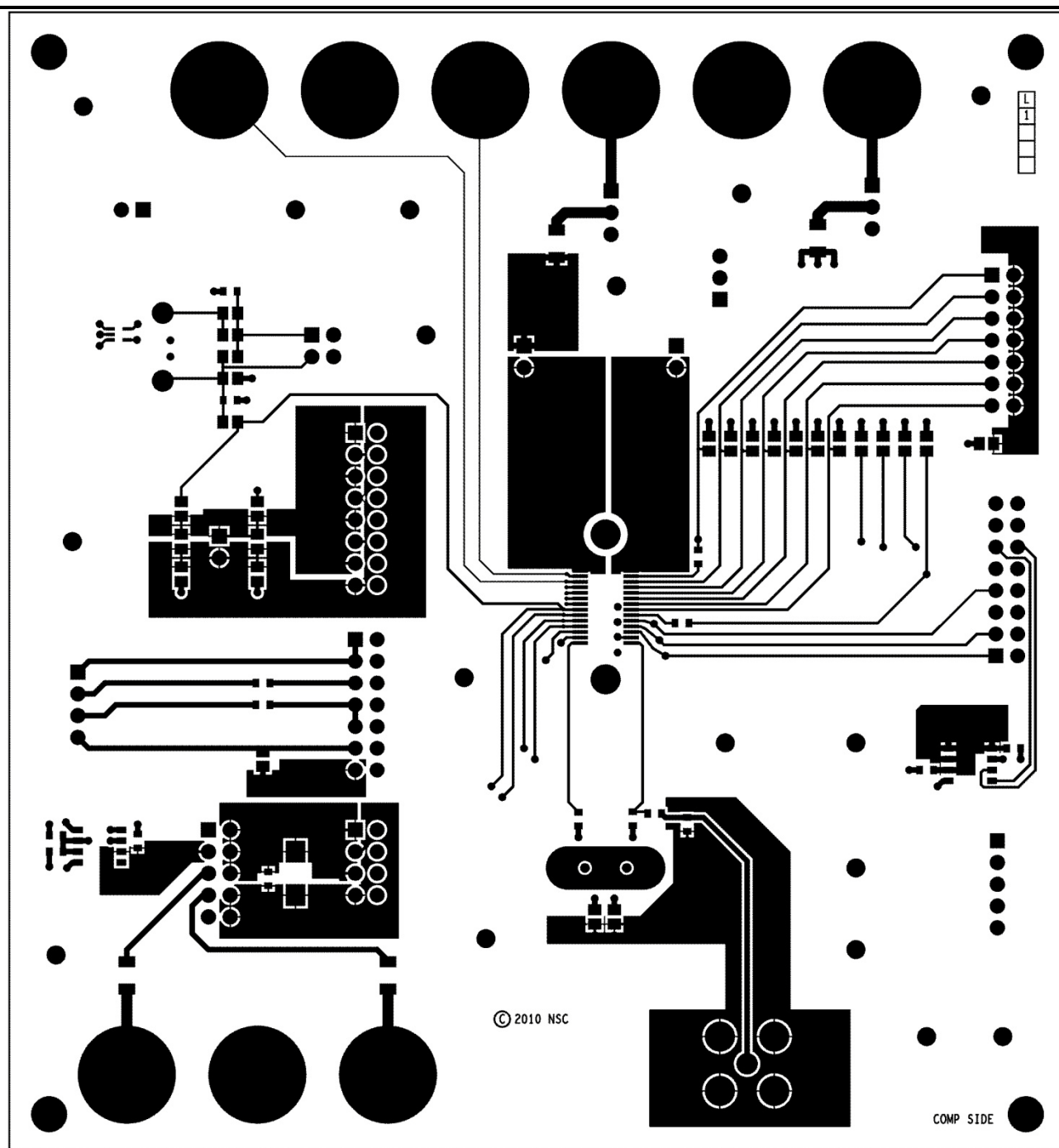


Figure 38 - Layout 3rd Layer

12.0. BOM

Item	Quantity	Reference	Value	Description	Source	Source Part #
1	5	C1,C7,C10,C22,C24	1.0 uF	CAP CER 1.0UF 10V Y5V 0603	Digikey	490-1585-1-ND
2	10	C2,C8,C11,C18,C19,C20, C21,C23,C29,C30	0.1 uF	CAP CER .1UF 0603	Digikey	490-4779-1-ND
3	4	C3,C5,C17,C26	10nF	CAP CER 10000PF 50V 10% X7R 0603	Digikey	490-1512-1-ND
4	3	C4,C12,C14	2.2uF	CAP CER 2.2UF 10V Y5V 0805	Digikey	490-1743-1-ND
6	3	C13,C27,C28	10 uF	CAP CER 10UF 10V Y5V 0805	Digikey	445-1371-1-ND
7	2	C15,C16	12pF	CAP 12PF 50V CERM CHIP 0805 SMD	Digikey	PCC120CNCT-ND
9	1	JP1	VA_SELECT	CONN HEADER .100 SINGL STR 36POS	Digikey	S1011E-36-ND
10	1	JP2	VIO_SELECT	CONN HEADER .100 SINGL STR 36POS	Digikey	S1011E-36-ND
11	1	JP3	LM94022_JMP	CONN HEADER .100 SINGL STR 36POS	Digikey	S1011E-36-ND
12	1	JP4	SPIO4_PWR_SELECT	CONN HEADER .100 SINGL STR 36POS	Digikey	S1011E-36-ND
13	1	JP5	TC_SEL	CONN HEADER .100 SINGL STR 36POS	Digikey	S1011E-36-ND
14	1	JP6	VA_JMP	CONN HEADER .100 SINGL STR 36POS	Digikey	S1011E-36-ND
15	1	JP7	VIO_JMP	CONN HEADER .100 SINGL STR 36POS	Digikey	S1011E-36-ND
16	1	JP8	GPIO_2_GND	CONN HEADER .100 SINGL STR 36POS	Digikey	S1011E-36-ND
17	1	JP9	VIN_SHORT	CONN HEADER .100 SINGL STR 36POS	Digikey	S1011E-36-ND
18	1	JP10	INPUT_SELECT	CONN HEADER .100 SINGL STR 36POS	Digikey	S1011E-36-ND
19	1	JP11	RTD_SELECT	CONN HEADER .100 SINGL STR 36POS	Sullins Connector	S1011E-36-ND
20	1	JP12	SPIO4 CONNECTOR	CONN HEADR BRKWAY .100 80POS R/A	Digikey	A34278-40-ND
21	1	JP13	VREF_SELECT1	CONN HEADER .100 SINGL STR 36POS	Digikey	S1011E-36-ND
22	1	JP14	VREF_SELECT2	CONN HEADER .100 SINGL STR 36POS	Digikey	S1011E-36-ND
23	1	J1	VA_EXT	CONN JACK BANANA UNINS PANEL MOU	Digikey	J147-ND
24	3	J2,J6,J12	GND	CONN JACK BANANA UNINS PANEL MOU	Digikey	J147-ND
25	1	J3	VIO_EXT	CONN JACK BANANA UNINS PANEL MOU	Digikey	J147-ND
26	1	J4	THERMOCOUPLE	THERMOCOUPLE CLASS K SOCKET	RS Mobile	381-7564
27	1	J5	VIN0	CONN JACK BANANA UNINS PANEL MOU	Digikey	J147-ND

28	1	J7	VIN1	CONN JACK BANANA UNINS PANEL MOU	Digikey	J147-ND
29	1	J8	SPI_PROBE	CONN HEADER .100 SINGL STR 36POS	Digikey	S1011E-36-ND
30	1	J9	EXT_CLK	CONN BNC FEM JACK PC MNT STRGHT	Digikey	ACX1051-ND
31	1	J10	RTD	TERM BLOCK PCB 4POS 5.0MM GREEN	Digikey	277-1579-ND
32	1	J11	VREFP_EXT	CONN JACK BANANA UNINS PANEL MOU	Digikey	J147-ND
33	1	J13	VREFN_EXT	CONN JACK BANANA UNINS PANEL MOU	Digikey	J147-ND
34	4	L1,L2,L3,L4	100 uH	INDUCTOR 100UH 140MA 10% SMD	Digikey	587-2038-1-ND
35	4	R5,R19,R21,RREF	1k, 0.1%	RES 1.0K OHM 1/8W .1% 0805 SMD	Digikey	RG20P1.0KBCT-ND
36	4	RRTD1,RRTD2,R22,R23	0	RES 0.0 OHM 1/10W 0603 SMD	Digikey	RMCF1/160RCT-ND
37	5	R1,R2,R3,R4,R17	2k, 0.1%	RES 2.0K OHM 1/8W .1% 0805 SMD	Digikey	P2.0KDACT-ND
38	11	R6,R7,R8,R9,R10,R11,R12, R13,R14,R15,R16	1M	RES 1.0M OHM 1/8W 5% 0805 SMD	Digikey	RHM1.0MARCT-ND
39	3	R18,R20,R25	51	RES 51 OHM 1/10W 5% 0603 SMD	Digikey	P51GCT-ND
41	17	TP1,TP2,TP3,TP4,TP5,TP6, TP7,TP8,TP9,TP10,TP11, TP12,TP13,TP14,TP15,TP16, TP17	GND	TEST POINT PC MULTI PURPOSE BLK	Digikey	5011K-ND
42	1	U1	LM94022BIMG	ANALOG TEMPERATURE SENSOR	NSC	LM94022BIMG
43	1	U2	LMP90100	LMP90100	NSC	LMP90100
44	1	U3	24C02 EEPROM	EEPROM 256x8	Mouser	579-24C02CSN
45	1	U4	LM4140C-4.1	4.1 V Voltage Reference	NSC	LM4140C-4.1
46	1	Y1	3.57 MHz	CRYSTAL 3.579545 MHZ 18PF 49US	Digikey	XC1707-ND
47	4	N/A	N/A	BUMPON HEMISPHERE .44X.20 BLACK	Digikey	SJ5003-0-ND

Table 5 - BOM

EVALUATION BOARD/KIT/MODULE (EVM) ADDITIONAL TERMS

Texas Instruments (TI) provides the enclosed Evaluation Board/Kit/Module (EVM) under the following conditions: The user assumes all responsibility and liability for proper and safe handling of the goods. Further, the user indemnifies TI from all claims arising from the handling or use of the goods.

Should this evaluation board/kit not meet the specifications indicated in the User's Guide, the board/kit may be returned within 30 days from the date of delivery for a full refund. THE FOREGOING LIMITED WARRANTY IS THE EXCLUSIVE WARRANTY MADE BY SELLER TO BUYER AND IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED, IMPLIED, OR STATUTORY, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE. EXCEPT TO THE EXTENT OF THE INDEMNITY SET FORTH ABOVE, NEITHER PARTY SHALL BE LIABLE TO THE OTHER FOR ANY INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES.

Please read the User's Guide and, specifically, the Warnings and Restrictions notice in the User's Guide prior to handling the product. This notice contains important safety information about temperatures and voltages. For additional information on TI's environmental and/or safety programs, please visit www.ti.com/esh or contact TI.

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REGULATORY COMPLIANCE INFORMATION

As noted in the EVM User's Guide and/or EVM itself, this EVM and/or accompanying hardware may or may not be subject to the Federal Communications Commission (FCC) and Industry Canada (IC) rules.

For EVMs **not** subject to the above rules, this evaluation board/kit/module is intended for use for ENGINEERING DEVELOPMENT, DEMONSTRATION OR EVALUATION PURPOSES ONLY and is not considered by TI to be a finished end product fit for general consumer use. It generates, uses, and can radiate radio frequency energy and has not been tested for compliance with the limits of computing devices pursuant to part 15 of FCC or ICES-003 rules, which are designed to provide reasonable protection against radio frequency interference. Operation of the equipment may cause interference with radio communications, in which case the user at his own expense will be required to take whatever measures may be required to correct this interference.

General Statement for EVMs including a radio

User Power/Frequency Use Obligations: This radio is intended for development/professional use only in legally allocated frequency and power limits. Any use of radio frequencies and/or power availability of this EVM and its development application(s) must comply with local laws governing radio spectrum allocation and power limits for this evaluation module. It is the user's sole responsibility to only operate this radio in legally acceptable frequency space and within legally mandated power limitations. Any exceptions to this are strictly prohibited and unauthorized by Texas Instruments unless user has obtained appropriate experimental/development licenses from local regulatory authorities, which is responsibility of user including its acceptable authorization.

For EVMs annotated as FCC – FEDERAL COMMUNICATIONS COMMISSION Part 15 Compliant

Caution

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

FCC Interference Statement for Class A EVM devices

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

FCC Interference Statement for Class B EVM devices

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

For EVMs annotated as IC – INDUSTRY CANADA Compliant

This Class A or B digital apparatus complies with Canadian ICES-003.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

Concerning EVMs including radio transmitters

This device complies with Industry Canada licence-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Concerning EVMs including detachable antennas

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication.

This radio transmitter has been approved by Industry Canada to operate with the antenna types listed in the user guide with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Cet appareil numérique de la classe A ou B est conforme à la norme NMB-003 du Canada.

Les changements ou les modifications pas expressément approuvés par la partie responsable de la conformité ont pu vider l'autorité de l'utilisateur pour actionner l'équipement.

Concernant les EVMs avec appareils radio

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes : (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Concernant les EVMs avec antennes détachables

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but

de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante.

Le présent émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés dans le manuel d'usage et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur.

【Important Notice for Users of this Product in Japan】

This development kit is NOT certified as Confirming to Technical Regulations of Radio Law of Japan

If you use this product in Japan, you are required by Radio Law of Japan to follow the instructions below with respect to this product:

1. Use this product in a shielded room or any other test facility as defined in the notification #173 issued by Ministry of Internal Affairs and Communications on March 28, 2006, based on Sub-section 1.1 of Article 6 of the Ministry's Rule for Enforcement of Radio Law of Japan,
2. Use this product only after you obtained the license of Test Radio Station as provided in Radio Law of Japan with respect to this product, or
3. Use of this product only after you obtained the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to this product. Also, please do not transfer this product, unless you give the same notice above to the transferee. Please note that if you could not follow the instructions above, you will be subject to penalties of Radio Law of Japan.

Texas Instruments Japan Limited
(address) 24-1, Nishi-Shinjuku 6 chome, Shinjuku-ku, Tokyo, Japan

<http://www.tij.co.jp>

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EVALUATION BOARD/KIT/MODULE (EVM) WARNINGS, RESTRICTIONS AND DISCLAIMERS

For Feasibility Evaluation Only, in Laboratory/Development Environments. Unless otherwise indicated, this EVM is not a finished electrical equipment and not intended for consumer use. It is intended solely for use for preliminary feasibility evaluation in laboratory/development environments by technically qualified electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems and subsystems. It should not be used as all or part of a finished end product.

Your Sole Responsibility and Risk. You acknowledge, represent and agree that:

1. You have unique knowledge concerning Federal, State and local regulatory requirements (including but not limited to Food and Drug Administration regulations, if applicable) which relate to your products and which relate to your use (and/or that of your employees, affiliates, contractors or designees) of the EVM for evaluation, testing and other purposes.
2. You have full and exclusive responsibility to assure the safety and compliance of your products with all such laws and other applicable regulatory requirements, and also to assure the safety of any activities to be conducted by you and/or your employees, affiliates, contractors or designees, using the EVM. Further, you are responsible to assure that any interfaces (electronic and/or mechanical) between the EVM and any human body are designed with suitable isolation and means to safely limit accessible leakage currents to minimize the risk of electrical shock hazard.
3. You will employ reasonable safeguards to ensure that your use of the EVM will not result in any property damage, injury or death, even if the EVM should fail to perform as described or expected.
4. You will take care of proper disposal and recycling of the EVM's electronic components and packing materials.

Certain Instructions. It is important to operate this EVM within TI's recommended specifications and environmental considerations per the user guidelines. Exceeding the specified EVM ratings (including but not limited to input and output voltage, current, power, and environmental ranges) may cause property damage, personal injury or death. If there are questions concerning these ratings please contact a TI field representative prior to connecting interface electronics including input power and intended loads. Any loads applied outside of the specified output range may result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. 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 60°C as long as the input and output are maintained at a normal ambient operating temperature. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors which can be identified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during normal operation, please be aware that these devices may be very warm to the touch. As with all electronic evaluation tools, only qualified personnel knowledgeable in electronic measurement and diagnostics normally found in development environments should use these EVMs.

Agreement to Defend, Indemnify and Hold Harmless. You agree to defend, indemnify and hold TI, its licensors and their representatives harmless from and against any and all claims, damages, losses, expenses, costs and liabilities (collectively, "Claims") arising out of or in connection with any use of the EVM that is not in accordance with the terms of the agreement. This obligation shall apply whether Claims arise under law of tort or contract or any other legal theory, and even if the EVM fails to perform as described or expected.

Safety-Critical or Life-Critical Applications. If you intend to evaluate the components for possible use in safety critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, such as devices which are classified as FDA Class III or similar classification, then you must specifically notify TI of such intent and enter into a separate Assurance and Indemnity Agreement.

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TI warrants performance of its components to the specifications applicable at the time of sale, in accordance with the warranty in TI's terms and conditions of sale of semiconductor products. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by applicable law, testing of all parameters of each component is not necessarily performed.

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