EVAL-ADE7913EBZ User Guide
UG-571

One Technology Way • P.O. Box 9106 • Norwood, MA 02062-9106, U.S.A. • Tel: 781.329.4700 • Fax: 781.461.3113 • www.analog.com

Evaluating the ADE7913 Isolated Sigma-Delta ADC

FEATURES

- Full featured evaluation board for ADE7913/ADE7912
- PC control in conjunction with the system demonstration platform (EVAL-SDP-CB1Z)
- PC software for control and data analysis (time and frequency domain)
- Standalone capability

EVALUATION KIT CONTENTS

- ADE7913 evaluation board
- SDP interface board

ADDITIONAL EQUIPMENT NEEDED

- EVAL-SDP-CB1Z (must order separately)
  - includes a USB cable
- 3 current sensing shunts
- Precision current and voltage signal source
- SMB cables
- PC running Windows XP SP2, Windows Vista, or Windows 7 with USB 2.0 port

ONLINE RESOURCES

- Documents
  - ADE7912/ADE7913 data sheet
  - EVAL-ADE7913EBZ user guide
- Required Software
  - ADE7913 evaluation software (download from product page)
- Design and Integration Files
  - Schematics, layout files, bill of materials

GENERAL DESCRIPTION

The EVAL-ADE7913 evaluation kit includes two boards that work together (along with the EVAL-SDP-CB1Z) to evaluate the performance of the ADE7913 isolated sigma-delta ADC in a context very close to an actual three-phase meter implementation. Although this kit can also be used to test the ADE7912 ADC, the board is populated with only ADE7913 devices and thus only the ADE7913 is referred to in this user guide. Evaluation software, written in LabVIEW® provides access to the registers of every ADE7913 using a PC interface.

TYPICAL SETUP

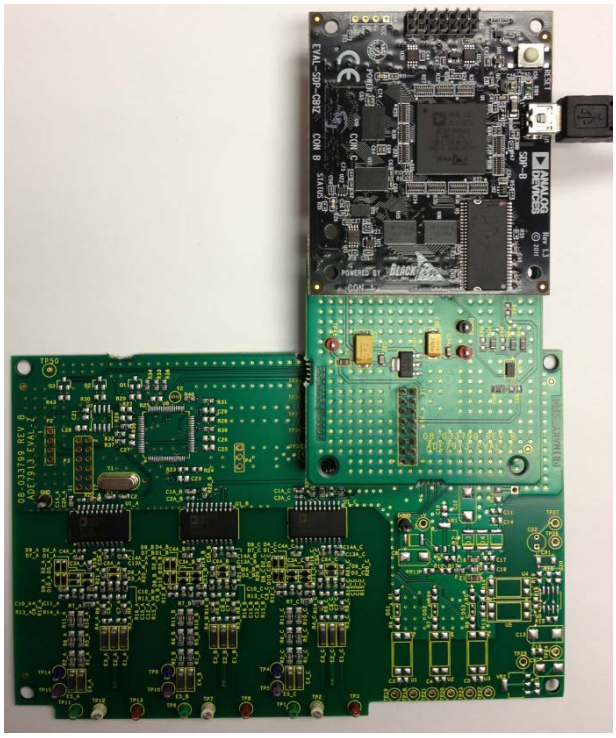


Figure 1. Connected to the SDP Interface and SDP Boards

PLEASE SEE THE LAST PAGE FOR AN IMPORTANT WARNING AND LEGAL TERMS AND CONDITIONS.

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REVISION HISTORY

11/13—Revision 0: Initial Version

EVALUATION BOARD HARDWARE

OVERVIEW

To evaluate the ADE7913, three boards are connected together (see Figure 1). The ADE7913 evaluation board, which is populated with three ADE7913 ADCs, can be used as an implementation example of a three-phase energy meter (see Figure 2).

The SDP interface board is also provided in the evaluation kit. The 20-pin connector (P6) of the SDP interface board is connected to connector P5 of the ADE7913 evaluation board. The SDP interface board is connected to the SDP Blackfin board (also referred to as SDP-B or EVAL-SDP-CB1Z) using the 120-pin connector. Be sure to order EVAL-SDP-CB1Z when ordering your evaluation board kit; the kit and the SDP-B board are purchased and packaged separately, but must be used together.

The SDP Blackfin board consists of an ADSP-BF527 microcontroller that handles all the communications from the PC to the ADE7913 devices populating the evaluation board (see Figure 3).

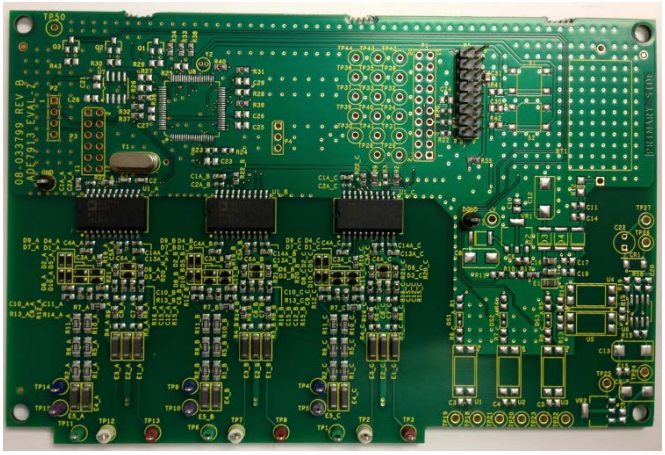


Figure 2. ADE7913 Evaluation Board

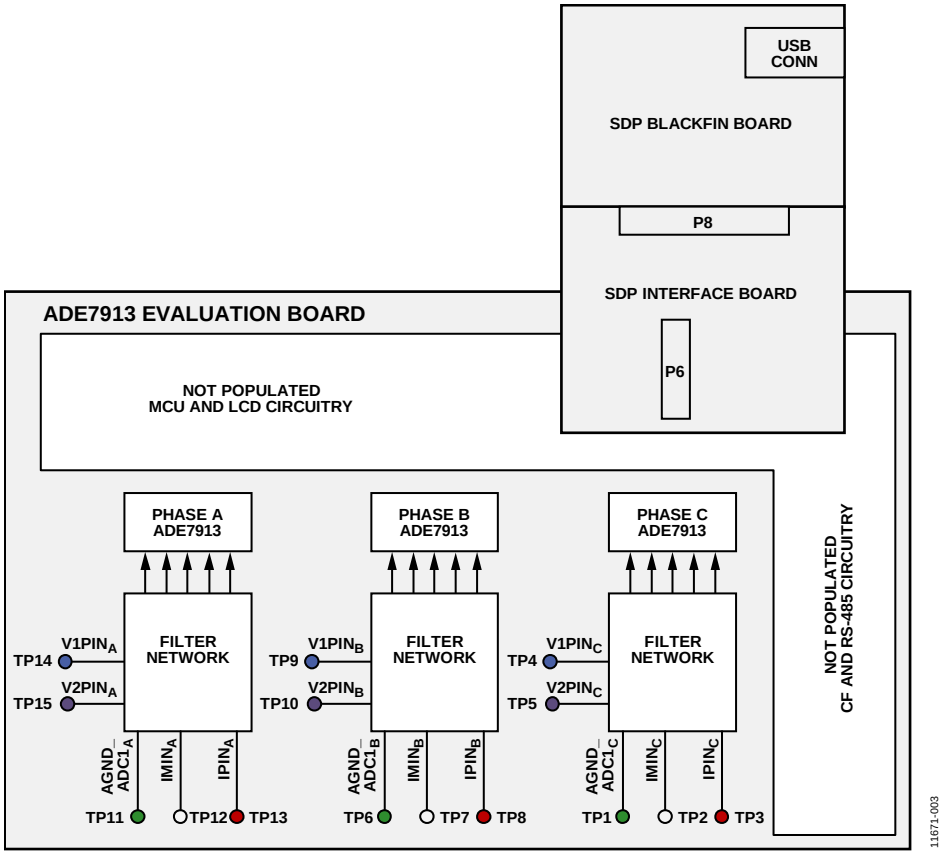


Figure 3. Evaluation Kit Connection Diagram

POWERING UP THE EVALUATION KIT BOARDS

The interface board receives power via the USB cable that is connected to the PC. A 3.3 V regulator then powers the SDP board microcontroller and the ADE7913 ADCs populating the evaluation board. No additional power source is required for the ADE7913 evaluation kit boards.

ANALOG INPUTS

Current and voltage signals are connected at the test pins placed on the evaluation board. All analog input signals are filtered using the on-board antialiasing filters before the signals are connected to the ADE7913 ADCs. The components used on the board are the values recommended for use with the ADE7913.

Current Sense Inputs (TP3 and TP2, TP8 and TP7, TP13 and TP12 Test Pins)

Every ADE7913 measures the voltage across a shunt at its IP and IM pins. Figure 4 shows the structure used for the Phase A current.

The R8, R9, R20, and R21 are 0 Ω resistors that do not need to be implemented on a real meter board. The R15/C12 and R16/C15 RC networks are the antialiasing filters. The default corner frequency of these low-pass filters is 4.8 kHz (1 kΩ/ 33 nF). These filters can easily be adjusted by replacing the components on the evaluation board.

The E1, E2, and E3 ferrite beads filter the high frequency noise that may be induced into the wires.

The absolute maximum voltage on the IP and IM pins of the ADE7913 is ±2 V. The D3 and D6 diodes protect the IP and IM pins against voltages greater than ±1 V. The maximum signal level permissible at the IP pin of the ADE7913 is ±0.03125 V peak. The signal range should not exceed ±0.03125 V, with respect to AGND_ADC, for specified operation.

The Phase A shunt is connected between the TP13 and TP12 test pins.

The other current channels (that is, Phase B and Phase C) have an identical input structure. The Phase B shunt is connected between the TP8 and TP7 test pins and the Phase C shunt is connected between TP3 and TP2.

The shunt maximum value is a function of the maximum current to be measured on every phase:

$$R = \frac{31.25 \times 10^{-3}}{\sqrt{2}} \times \frac{1}{I_{FS}}$$

where:

$$\frac{31.25 \times 10^{-3}}{\sqrt{2}}$$

is the rms value of the full-scale voltage accepted at the ADC input.

I_{FS} is the maximum current to be measured. It is called the full-scale current.

Figure 5 shows how a shunt is connected to the Phase A current input structure. The shunt is connected between P1 and P1' energy meter Phase A line inputs. TP13 and TP12 test pins are connected to the shunt measurement poles, while TP11, the tests pin that is the ground of the Phase A ADE7913 side, is connected to the ground pole of the shunt.

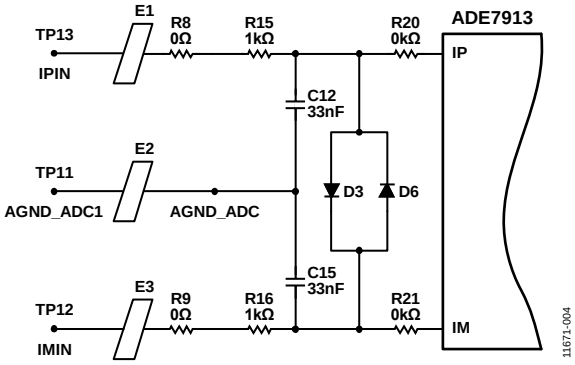


Figure 4. Phase A Current Input Structure on the Evaluation Board

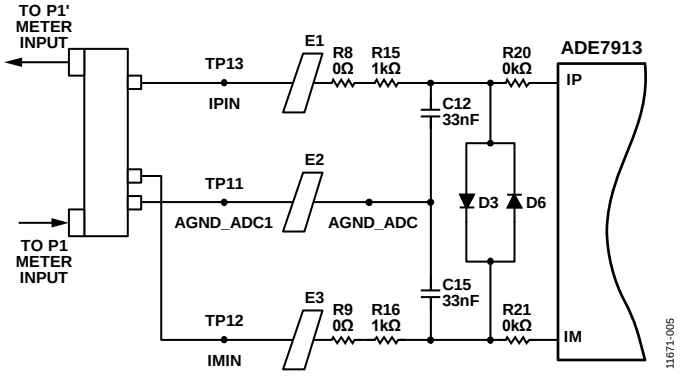


Figure 5. Example of a Shunt Connection

Phase Voltage Sense Inputs (TP4, TP9, and TP14 Tests Pins)

The phase-to-neutral voltage input connections on the ADE7913 evaluation board can be directly connected to the line voltage sources between TP14 and TP11 for Phase A-to-neutral voltage, between TP9 and TP6 for Phase B-to-neutral voltage, and between TP4 and TP1 for Phase C-to-neutral voltage. These voltages are attenuated using a simple resistor divider network before they are supplied to the ADE7913. The attenuation network on the voltage channels is designed so that the corner frequency (3 dB frequency) of the network matches that of the antialiasing filters in the current channel inputs. This prevents the occurrence of large energy errors at low power factors.

The V1PIN path in Figure 6 shows a typical connection of the Phase A voltage inputs; the resistor divider consists of three 330 kΩ resistors (R1, R5, and R10) and one 1 kΩ resistor (R14). The antialiasing filter R14/C11 matches the R12/C9 filter in the VM path. The absolute maximum voltages on the V1P and VM pins of the ADE7913 are ±2 V. The D1, D7 and D4, D9 diodes protect the V1P and VM pins against voltages greater than ±2 V. The maximum signal level permissible at the V1P pin of the ADE7913 is ±0.5 V peak. The signal range should not exceed ±0.5 V with respect to AGND_ADC for specified operation.

The E4 ferrite bead filters the high frequency noise that may be induced into the wires.

Auxiliary Voltage Sense Inputs (TP5, TP10, and TP15 Test Pins)

The auxiliary voltage input connections on the ADE7913 evaluation board can be directly connected to the line voltage sources between TP15 and TP11 for Phase A auxiliary voltage, between TP10 and TP6 for Phase B auxiliary voltage, and between TP5 and TP1 for Phase C auxiliary voltage.

The V2PIN path in Figure 6 shows a typical connection of the Phase A auxiliary voltage input. It is very similar to the V1PIN path explained in Phase Voltage Sense Inputs (TP4, TP9, and TP14 Tests Pins) section.

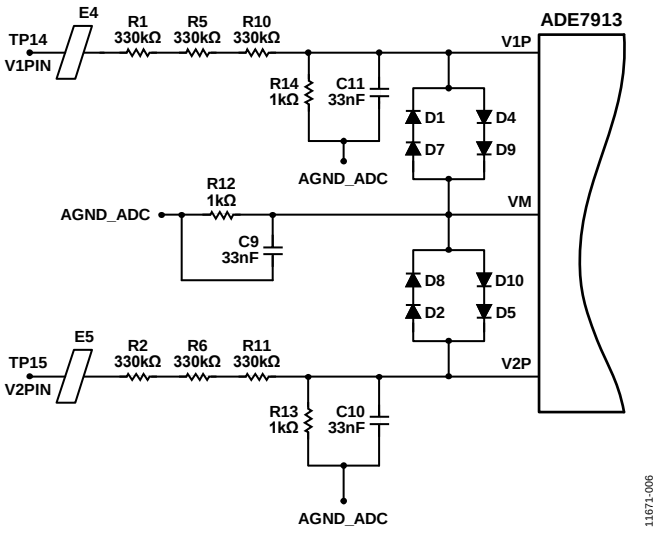


Figure 6. Phase A Voltage Input Structure on the Evaluation Board

Isolated Ground Pins Management

The ADE7913 package has two isolated ground GND_{ISO} pins: Pin 2 and Pin 10. Figure 7 presents their management in the case of a Phase A ADE7913. Internally, Pin 2 is connected to Pin 10. The decoupling capacitors C3 and C4 on the VDD_{ISO} pin are connected to the closest isolated ground pin, Pin 2. The decoupling capacitors, C5 and C6 on the analog LDO pin and C13 and C14 on the voltage reference pin, must be separate from the VDD_{ISO} circuitry and are connected to the isolated ground Pin 10.

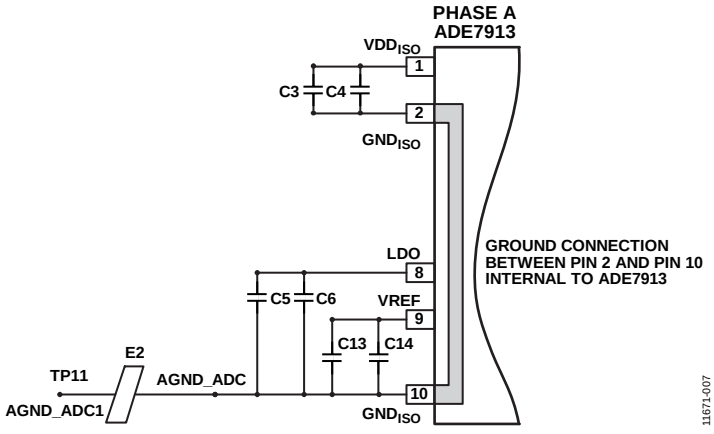


Figure 7. Isolated Ground Pins Management

The P1 meter input constitutes the AGND_ADC1 signal (see also Figure 5). ADC_GND1 is then connected to GND_{ISO} pin (AGND_ADC signal) through a ferrite bead (E2).

SETTING UP THE EVALUATION BOARD AS AN ENERGY METER

Figure 8 shows a typical setup for the ADE7913 evaluation board. In this example, an energy meter for a 3-phase, 4-wire wye distribution system is shown. Shunts are used to sense the phase currents and are connected as shown in Figure 8. The line voltages are connected directly to the board as shown. The board is supplied from one power supply provided by the PC through the USB cable.

Figure 9 shows a setup for the ADE7913 evaluation board as an energy meter for a 3-phase, 3-wire, delta distribution system. The Phase B voltage is considered as reference and the V1PIN test pins of Phase A and Phase C ADE7913 ADCs are connected to it.

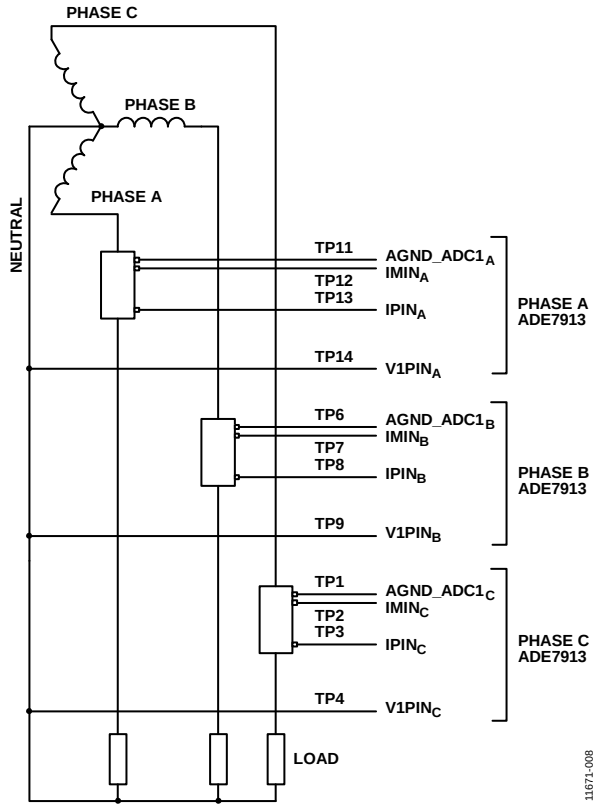


Figure 8. Typical Setup for the ADE7913 Evaluation Board for 3-Phase, 4-Wire, Wye Distribution System

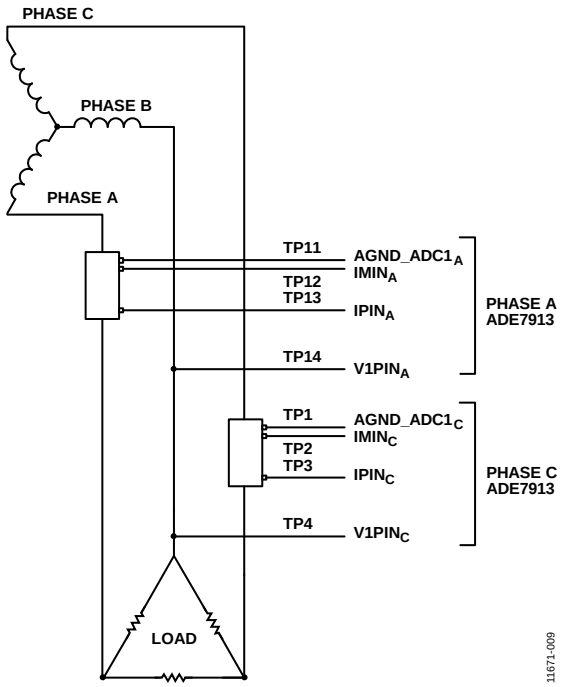


Figure 9. Typical Setup for the ADE7913 Evaluation Board for 3-Phase, 3-Wire Delta Distribution Systems

Using the Evaluation Board with Another Microcontroller

It is possible to manage the ADE7913 evaluation board with a different microcontroller mounted on another board. The evaluation board can be connected to this second board through the P5 connector. The SDP interface and the SDP Blackfin boards are, in this case, unused.

EVALUATION BOARD SOFTWARE

The ADE7913 evaluation board is supported by Windows® based software that allows the user to access all the functionality of the ADE7913.

The software communicates with the microcontroller placed on the interface board using the USB port. The software communicates with the SDP Blackfin board using the USB. The microcontroller communicates with the ADE7913 ADCs placed on the evaluation board to process the requests that are sent from the PC.

IMPORTANT DISCLAIMER

The evaluation board contains three ADE7913 ADCs, labeled Phase A ADE7913, Phase B ADE7913, and Phase C ADE7913. The software can work with boards containing up to four ADE7913 ADCs. For this reason, it contains settings referring to Phase N ADE7913, the eventual fourth ADE7913 (such as shown in Figure 16, for example). It is safe to disregard any warnings that may be generated stating that the Phase N ADE7913 is not populated on board.

INSTALLING THE DRIVERS

When using the ADE7913 evaluation tools for the first time, a driver must be installed to allow successful communication. The driver **SDPDriversNET.exe** can be found in the evaluation software package in the **SDP drivers** folder.

To install the driver, follow this procedure:

1. When the Setup Wizard appears, click **Next,** and follow the installation instructions.

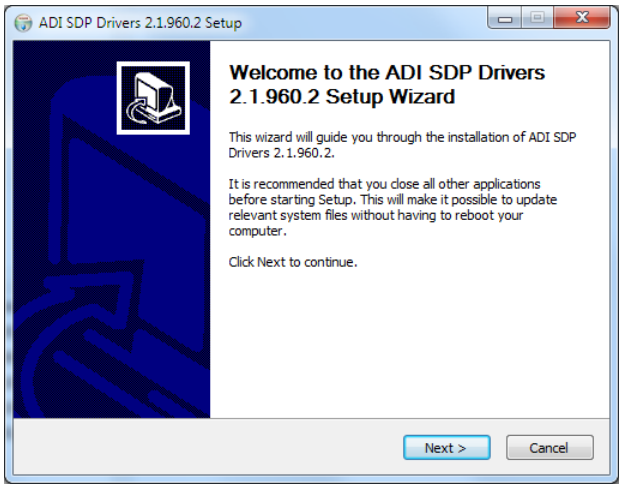


Figure 10. SDP Drivers Setup

2. When installation is complete, click **Finish** to close the window.

Connect the USB cable from the PC to the Blackfin SDP board. Windows detects the device and locates the correct driver automatically.

INSTALLING AND UNINSTALLING THE ADE7913 SOFTWARE

The ADE7913 software is supplied with the evaluation software package. It contains the LabVIEW™-based program that runs on the PC. This program must be installed.

Before using LabView 2010 on the PC for the first time, run an installer prior to executing the LabVIEW-based program. This installer is available in the **installation_files** folder. If a copy of LabView 2010 is available on the PC, the executable is provided in the **executable** folder. The LabView source files are provided in the **LabView_project\source** folder.

1. To install the ADE7913 software, double-click **installation_files\setup.exe**. This launches the setup program that automatically installs all the software components, including the uninstall program, and creates the required directories.
2. To launch the software, go to the **Start/Programs/ ADE7913 Eval Software** menu and click **ADE7913 Eval Software**.

Both the ADE7913 evaluation software program and the NI run-time engine are easily uninstalled by using the **Add/ Remove Programs** option in the control panel.

1. Before installing a new version of the ADE7913 evaluation software, first uninstall the previous version.
2. Select the **Add/Remove Programs** option in the Windows control panel.
3. Select the program to uninstall and click the **Add/Remove** button.

FRONT PANEL

When the software is launched, the **Front Panel** is opened. This panel contains two areas: the main menu on the left, and a box that displays the name of the communication port used by the PC to connect to the interface port on the right (see Figure 11).

The software automatically detects the SDP Blackfin board. If the port detection is successful, the SDP label appears in the **IO Board** field, as shown in Figure 11.

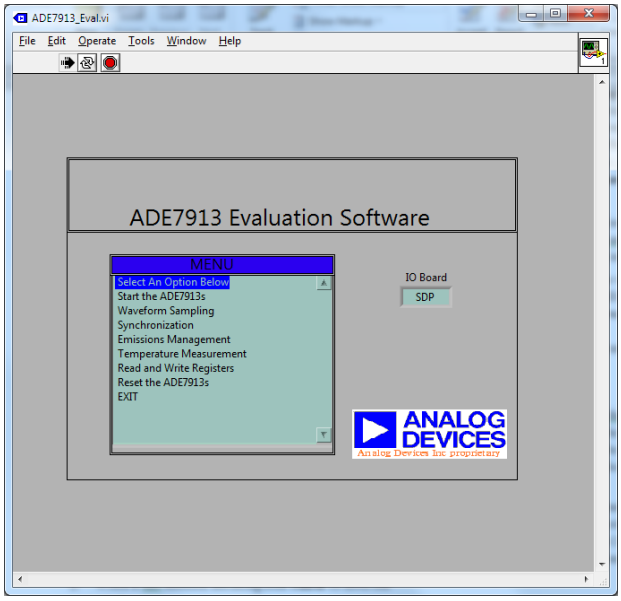


Figure 11. Front Panel of the ADE7913 Software

Troubleshooting the COM Port Detection

If the software does not detect the SDP Blackfin board, the message shown in Figure 12 is displayed.

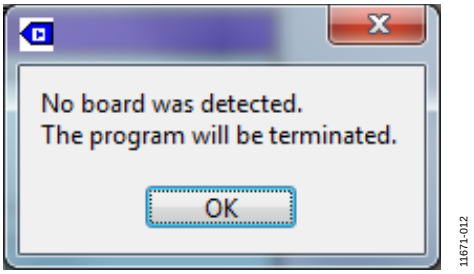


Figure 12. SDP Blackfin Board Not Detected Message

If this message appears, the following steps should be taken:

1. Click **OK** to terminate the program (see Figure 11).
2. Verify that the SDP Blackfin board is connected to the PC using the USB cable.
3. Ensure that the required drivers are installed as described in the Installing the Drivers section.
4. Using the **Device Manager** tool, ensure that the SDP Blackfin board was recognized by the PC and appears under the **ADI Development Tool**s entry as **Analog Devices System Demonstration Platform SDP-B**.
5. Launch the ADE7913 evaluation software once more.

EVALUATION SOFTWARE FUNCTIONS

The ADE7913 evaluation software allows access to all registers and features of the ADE7913. The menu options available are

- Start the ADE7913s
- Waveform Sampling
- Synchronization
- Emissions Management
- Temperature Measurement
- Read and Write Registers
- Reset the ADE7913s
- EXIT (stops LabView)

The options provide access to all internal registers and allow the evaluation of the ADC performance. To access these functions, click the desired option in the **MENU** (see Figure 11).

Clicking an option in the **MENU** displays a window where the specific function can be accessed. Each window includes an **EXIT** button used to return to the main window.

Note that only one option from the **MENU** can be open at a time; click **EXIT** to return to the main window before choosing another option from the **MENU**.

START THE ADE7913

The **Start the ADE7913s** window is shown in Figure 13. The Phase A ADE7913 is clocked from a 4.096 MHz crystal. It then generates clock output to the other Phase B and Phase C ADE7913 ADCs at its CLKOUT pin. The software automatically sets the Phase A ADE7913 to generate clock output and start all three ADE7913 ADCs with the following default settings:

- ADC output frequency set at 8 kHz. Note that in order to ensure complete coherency of the waveform samples coming out from all three ADCs, this output frequency should be the same on all ADCs.
- The bandwidth of the digital low-pass filter of the ADC is set at 3.3 kHz.
- The third ADC measures the auxiliary voltage instead of the temperature sensor.
- The Phase C ADE7913 generates a $\overline{\text{DREADY}}$ signal at its CLKOUT/$\overline{\text{DREADY}}$ pin. This signal is used by the microcontroller as an external interrupt to start the acquisition of coherent waveform samples from all ADE7913 ADCs populating the evaluation board.

If different settings are desired, select them from the boxes in the upper half of the window. Then, click **START PHASE A ADE7913 FIRST** to update the Phase A ADE7913.

Note that the Phase A ADE7913 clocks the other ADE7913 ADCs populating the evaluation board by enabling CLKOUT functionality at the CLKOUT/$\overline{\text{DREADY}}$ pin (Bit 0, CLKOUT_EN, in the CONFIG register set to 1). Always enable CLKOUT if functional Phase B and Phase C ADE7913 ADCs are required for evaluation.

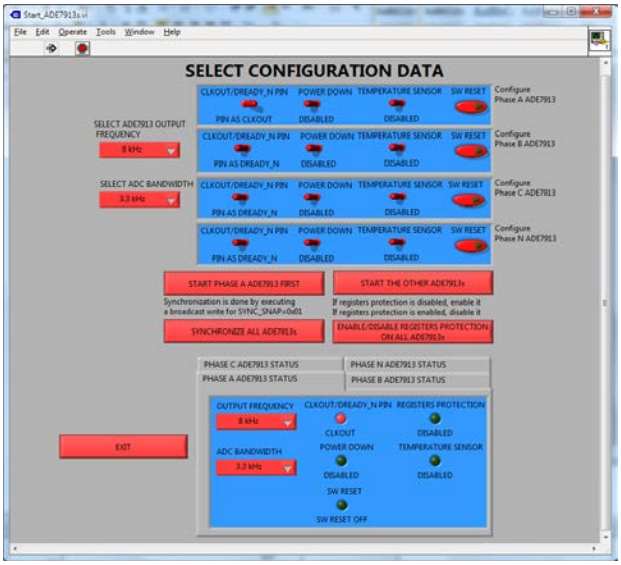


Figure 13. Start the ADE7913s

After the Phase A ADE7913 is started correctly, click **START THE OTHER ADE7913s** to configure the other ADE7913 ADCs on the evaluation board.

SYNCHRONIZE ALL ADE7913s executes a broadcast write to the SYNC_SNAP register equal to 0x01 to synchronize all ADE7913 ADCs of the evaluation board.

ENABLE/DISABLE REGISTERS PROTECTION ON ALL ADE7913s manages the registers protection of the ADE7913 ADCs. If at least one ADE7913 has the registers protected, then pressing this option disables the protection by executing a broadcast write to the Lock register equal to 0x9C. If all ADE7913 ADCs have the registers unprotected, then pressing this option enables the protection by executing a broadcast write to Lock register equal to 0xCA. Note that when the registers are protected, no register can be further written until the protection is disabled. It is therefore recommended to evaluate the ADE7913 ADCs while maintaining the registers protection disabled.

The bottom half of the window is composed by stacked windows, each showing the configuration settings of each ADE7913.

WAVEFORM SAMPLING

The Waveform Sampling window is shown in Figure 14. It provides full access to the ADC outputs (waveforms) of the ADE7913 ADCs that populate the board.

1. Enter an acquisition time (**ACCUMULATION TIME**) expressed in milliseconds.
2. Select the ADE7913 ADCs to be analyzed by checking the **A**, **B**, and **C** boxes. Leave the **N** box unchecked because the ADE7913 evaluation board contains only three ADE7913 ADCs.
3. Select **START ANALYSIS**.

The SDP Blackfin board acquires the waveform samples using the Phase C ADE7913 $\overline{\text{DREADY}}$ signal as an interrupt. The green bar under the plot shows the acquisition progress. A box under the **START ANALYSIS** button selects which waveform is visualized in the plot. By default, all the waveforms acquired from all ADE7913 ADCs selected for analysis are displayed.

- For single waveform visualization, select the desired waveform under **SELECT WAVEFORMS**.
- For multiple waveform visualization, select the desired waveforms under **SELECT WAVEFORMS** while pressing the CTRL key.

To write the waveforms into files,

1. Select the folder for file storage **(SELECT FOLDER)**.
2. Select **WRITE WAVEFORMS TO FILES**.

The program stores every waveform into a file called Waveform_sample_X.dat, where X is a number between 0 or 8. The order of the waveforms listed in the **SELECT WAVEFORMS** box is reflected in the file name identification number. As the default selects all waveforms to be acquired, Waveform_sample_0.dat contains Phase A current waveform, Waveform_sample_1.dat contains Phase A voltage 1 waveform, Waveform_sample_2.dat contains Phase A voltage 2 waveform, and so on.

The plot always visualizes 100 ms worth of waveform samples. If the acquisition time is greater, a scroll bar below the plot allows the visualization of an additional 100 ms periods.

A Fourier analysis of the acquired waveforms may be enabled by changing the position of the **SELECT ANALYSIS** switch. In this case, the window shown in Figure 15 is enabled. Only one waveform at a time is visualized in the plot.

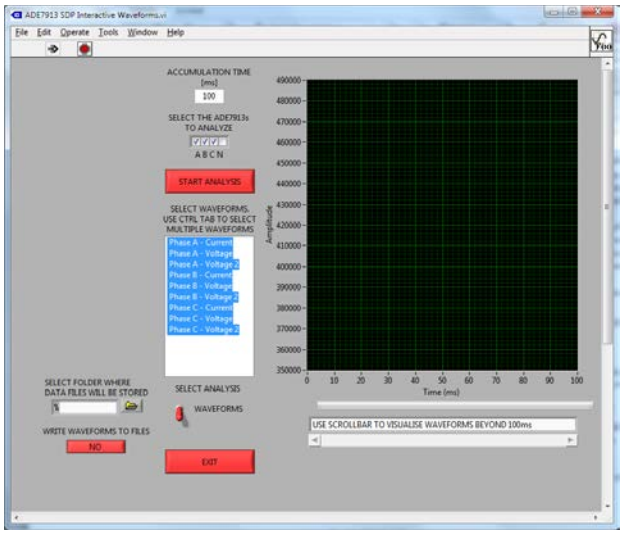
The type of windowing may be selected: **Hanning**, **Blackman-Harris**, or **none**.

Various **FFT Settings** may be selected: 0 dB level reference may be at the signal peak, the theoretical maximum, or at a manual entry. When selecting **Signal Peak**, the plot uses the amplitude of the maximum peak of the waveform as the 0 dB level and writes it in the **Manual** entry box.

Other selection include the **Bandwidth** under analysis (default is between 10 Hz and 4000 Hz), the **Fundamental Frequency** (the default is 50 Hz), the width of the FFT bins, **Fund/Harm Sideband Bins**, (the default is 10 Hz), and the **Number of Harmonics** used in the ADC specifications visualized under the plot (default is 6).

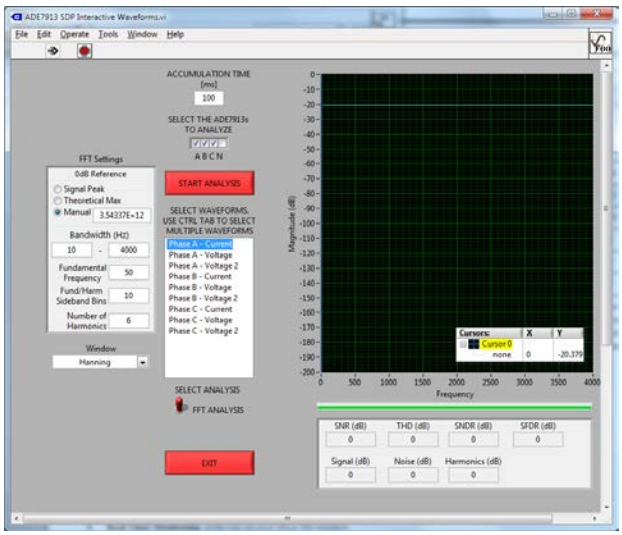
When the FFT plot is visualized, the program calculates and visualizes the following ADC specifications:

- **SNR** (signal-to-noise ratio)
- **THD** (total harmonic distortion)
- **SNDR** (signal-to-noise and distortion ratio)
- **SFDR** (spurious-free dynamic range)
- **Signal** (rms of the fundamental component)
- **Noise** (rms of the noise)
- **Harmonics** (rms value of all harmonics)



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Figure 14. Waveform Sampling



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Figure 15. Fourier Analysis

SYNCHRONIZATION WINDOW

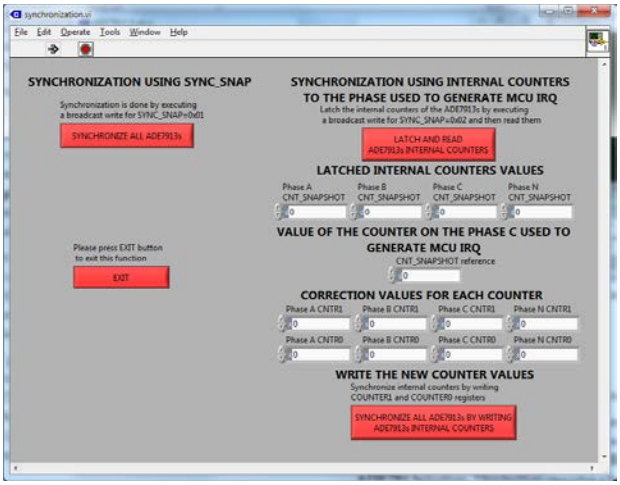
The Synchronization window is shown in Figure 16. It manages the synchronization process of all ADE7913 ADCs populating the board.

SYNCHRONIZE ALL ADE7913s executes a broadcast write to the SYNC_SNAP register equal to 0x01 to synchronize all ADE7913 ADCs of the evaluation board.

Another second synchronization method uses the internal counters of every ADE7913 to synchronize them. When pressed, **LATCH AND READ ADE7913s INTERNAL COUNTERS** broadcasts a write to the SYNC_SNAP register equal to 0x02, latching the counters and then visualizing them into the **CNT_SNAPSHOT** boxes. The software then uses the counter of the ADE7913 used to generate $\overline{\text{DREADY}}$ interrupts as a reference to calculate corrections values for each counter.

SYNCHRONIZE ALL ADE7913s BY WRITING ADE7913s INTERNAL COUNTERS then writes new values into the internal counters of each ADE7913, synchronizing all ADE7913 ADCs.

LATCH AND READ ADE7913s INTERNAL COUNTERS can then be used to read again the internal counters to verify the achieved synchronization degree.

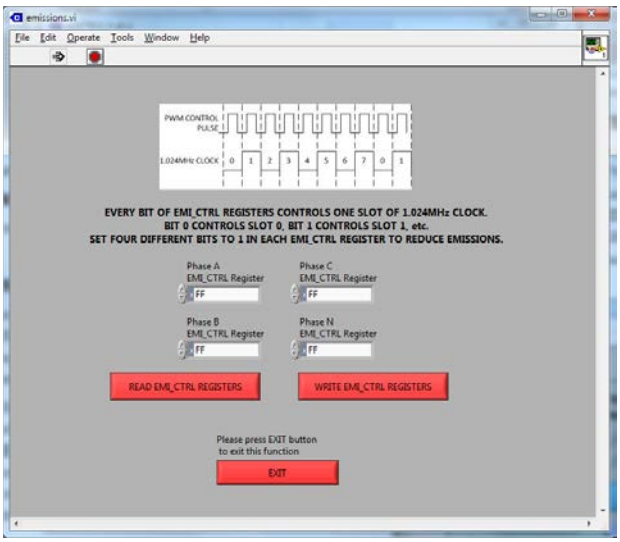


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Figure 16. ADE7913s Synchronization

EMISSIONS MANAGEMENT

The Emissions Management window is shown in Figure 17. It manages the EMI_CTRL register that controls the isolated dc-to-dc converter integrated in the ADE7913 ADCs.



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Figure 17. Emissions Management

The window displays a picture showing the relation between the bits of the EMI_CTRL register, the 1.024 MHz clock, and the PWM control pulses. In the middle section of the window, the program can read and write the EMI_CTRL registers of all ADE7913 ADCs populating the evaluation board.

Initialize the Phase A ADE79133 EMI_CTRL register as follows for best emissions performance:

- EMI_CTRL_A to 0x55
- EMI_CTRL_B to 0xAA
- EMI_CTRL_C to 0x55
- EMI_CTRL_N to 0xAA

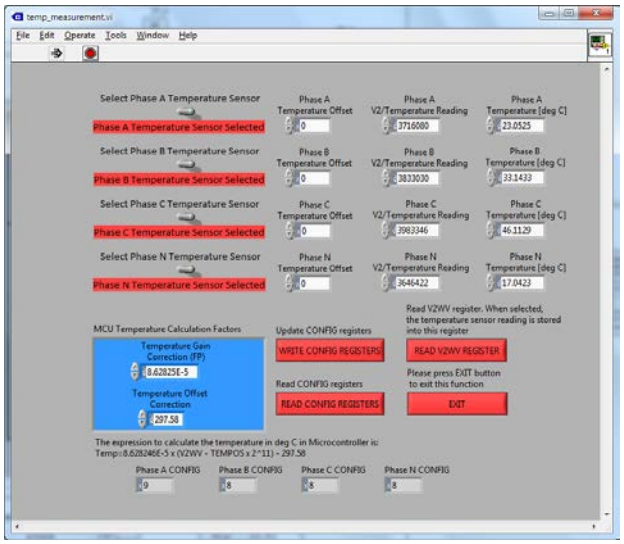
TEMPERATURE MEASUREMENT

The Temperature Measurement window is shown in Figure 18. The left half of the window selects the temperature sensor measurement on each ADE7913. The **Temperature Offset** boxes display the content of the TEMPOS register of each ADE7913.

After selecting the temperature sensor, press **WRITE CONFIG REGISTERS** to write the new selection into the CONFIG registers. **READ CONFIG REGISTERS** reads the CONFIG registers and visualizes the state of Bit 3 (TEMP_EN) into the temperature sensor selection switch and the CONFIG register value into the boxes at the bottom of the window.

READ V2WV REGISTER reads the V2WV registers of each ADE7913 and displays its content into the V2/Temperature reading boxes. The software computes the temperature in °C and displays it in the **Temperature [deg C]** boxes on the right side of the window.

The **Temperature Gain Correction (FP)** and the **Temperature Offset Correction** factors are introduced in floating point format into the boxes placed on the lower left side of the window. They are used by the software to compute the temperature of each ADE7913.



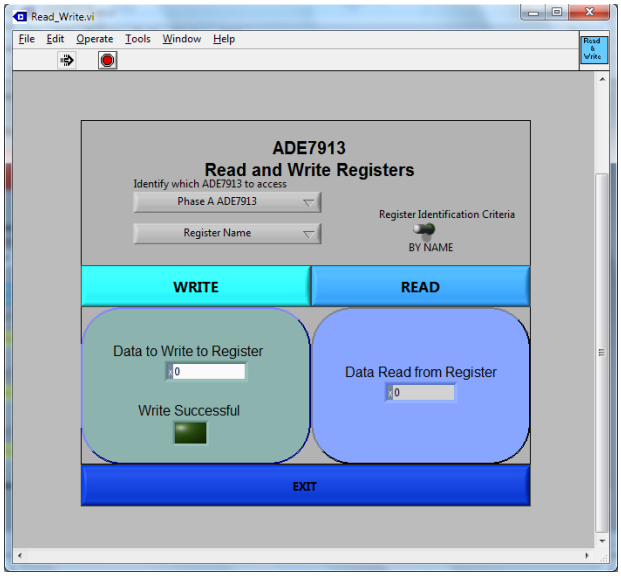
11671-018

Figure 18. Temperature Measurement

READ AND WRITE REGISTERS

The **Read and Write Registers** window is shown in Figure 19. Every register of each ADE7913 populating the board can be accessed using the boxes beneath **Identify which ADE7913 to access** and then clicking **WRITE** or **READ**.

The registers can be accessed by name or address using the **Register Identification Criteria** switch.



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Figure 19. Read and Write Registers

RESET THE ADE7913

The **Reset the ADE7913s** window is shown in Figure 20.

Use **SELECT ADE7913 TO RESET** to select which ADE7913 to reset. An individual ADE7913 or all ADE7913 ADCs may be selected. **RESET** then resets the selected ADE7913 by writing 10 bytes with a value of 0x00 at Address 0x00.

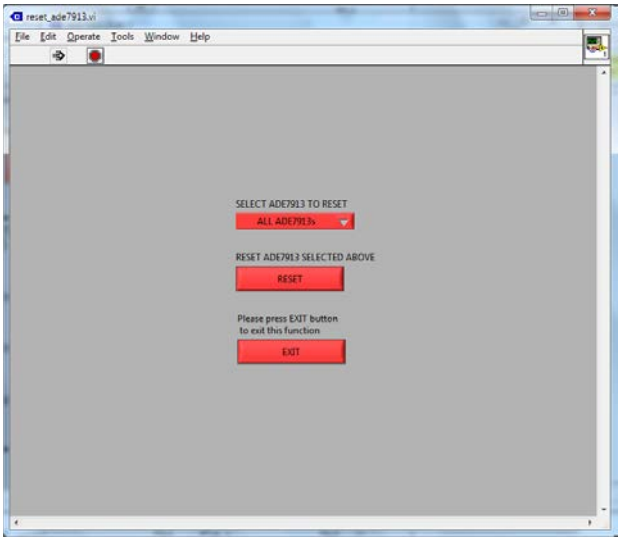


Figure 20. Reset the ADE7913s

NOTES

NOTES



ESD Caution

ESD (electrostatic discharge) sensitive device. Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary protection circuitry, damage may occur on devices subjected to high energy ESD. Therefore, proper ESD precautions should be taken to avoid performance degradation or loss of functionality.

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