EVAL-ADE7903EBZ User Guide
UG-797

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Evaluating the ADE7903 Σ-Δ ADC

FEATURES

- Full featured evaluation board for ADE7903
- PC control in conjunction with the EVAL-SDP-CB1Z system demonstration platform (SDP-B)
- PC software for control and data analysis (time and frequency domain)
- Standalone capability

EVALUATION KIT CONTENTS

- EVAL-ADE7903EBZ evaluation board

ADDITIONAL EQUIPMENT NEEDED

- EVAL-SDP-CB1Z (order separately), includes a USB cable
- 1 current sensing shunt
- Precision current and voltage signal source
- Minigrabbers
- PC running Windows XP SP2, Windows Vista, or Windows 7 with USB 2.0 port

ONLINE RESOURCES

- Documents
  - ADE7903 data sheet
  - EVAL-ADE7903EBZ user guide
- Required Software
  - ADE7903 evaluation software (download from product page)
- Design and Integration Files
  - Schematics, layout files, bill of materials

GENERAL DESCRIPTION

The EVAL-ADE7903EBZ evaluation kit includes the evaluation board, which along with the EVAL-SDP-CB1Z SDP-B board, allows users to evaluate the performance of the ADE7903 Σ-Δ ADC in a context very close to an actual single-phase meter implementation. There is an isolated version of the ADE7903 Σ-Δ ADC available, the ADE7913; to evaluate the isolated Σ-Δ ADC, use the ADE7913 evaluation kit (order separately from Analog Devices, Inc.). Evaluation software written in LabVIEW® provides access to the registers of the ADE7903 using a PC interface.

Full specifications on the ADE7903 are available in the product data sheet, which should be consulted in conjunction with this user guide when using this evaluation board.

TYPICAL SETUP

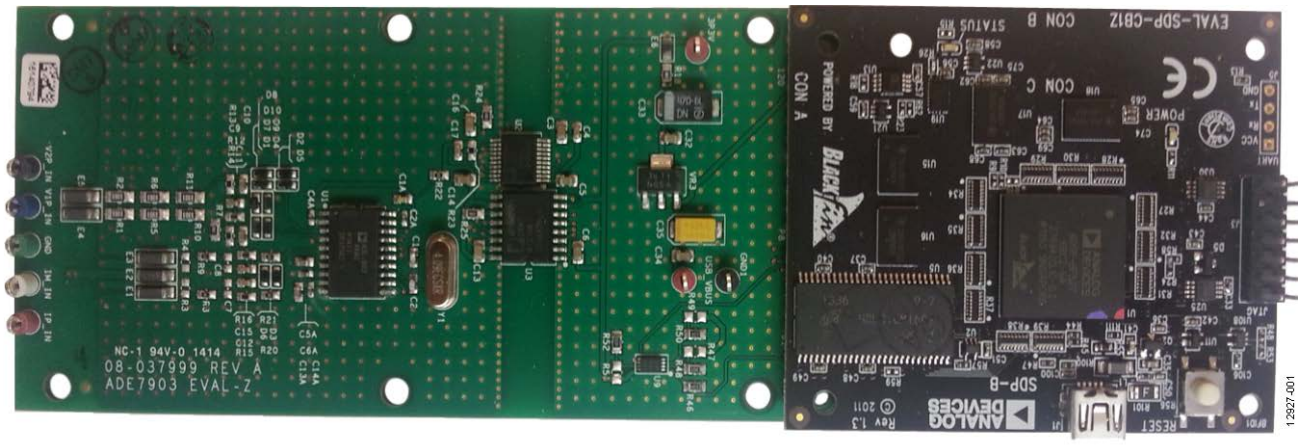


Figure 1. Evaluation Board Connected to the SDP Interface and SDP Boards

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

TABLE OF CONTENTS

Features 1
Evaluation Kit Contents 1
Additional Equipment Needed 1
Online Resources 1
General Description 1
Typical Setup 1
Revision History 2
Evaluation Board Hardware 3
Overview 3
Powering Up the Evaluation Kit Boards 4
Analog Inputs 4
Setting Up the Evaluation Board as an Energy Meter 6
Evaluation Board Software 7
Installing the Drivers 7
Installing and Uninstalling the ADE7903 Evaluation Software 7
Main Window 8
Evaluation Software Functions 9
Start ADE7903 9
Waveform Sampling 10
Temperature Measurement 11
Read and Write Registers 11
Reset the ADE7903 11

REVISION HISTORY

12/14—Revision 0: Initial Version

EVALUATION BOARD HARDWARE

OVERVIEW

To evaluate the ADE7903, connect the evaluation board and the SDP-B board together (see Figure 1). The EVAL-ADE7903EBZ evaluation board, which is populated with one ADE7903 ADC, can be used for evaluation of the standalone ADC or as a possible single-phase meter implementation example (see Figure 3).

The EVAL-ADE7903EBZ evaluation board is connected to the EVAL-SDP-CB1Z SDP-B Blackfin® board using the 120-pin connector. Be sure to order EVAL-SDP-CB1Z when ordering the EVAL-ADE7903EBZ evaluation kit; the evaluation kit and the SDP-B board are purchased and packaged separately, but must be used together.

The SDP-B board consists of a Blackfin ADSP-BF527 micro-controller that handles all the communications from the PC to the ADE7903 device populating the evaluation board (see Figure 2).

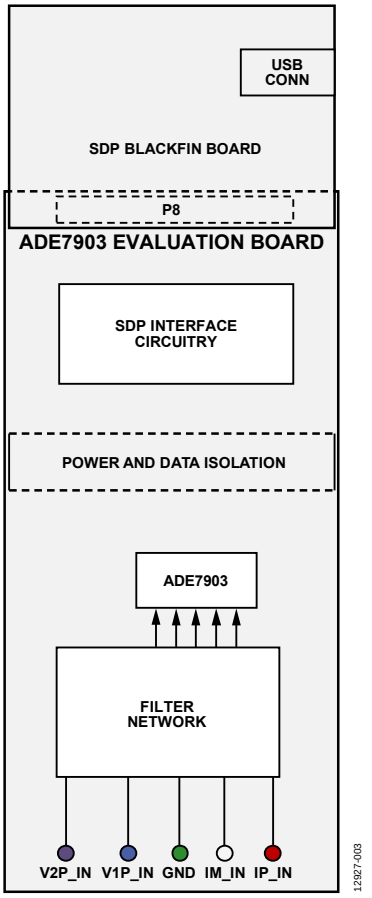


Figure 2. Evaluation Kit Connection Diagram

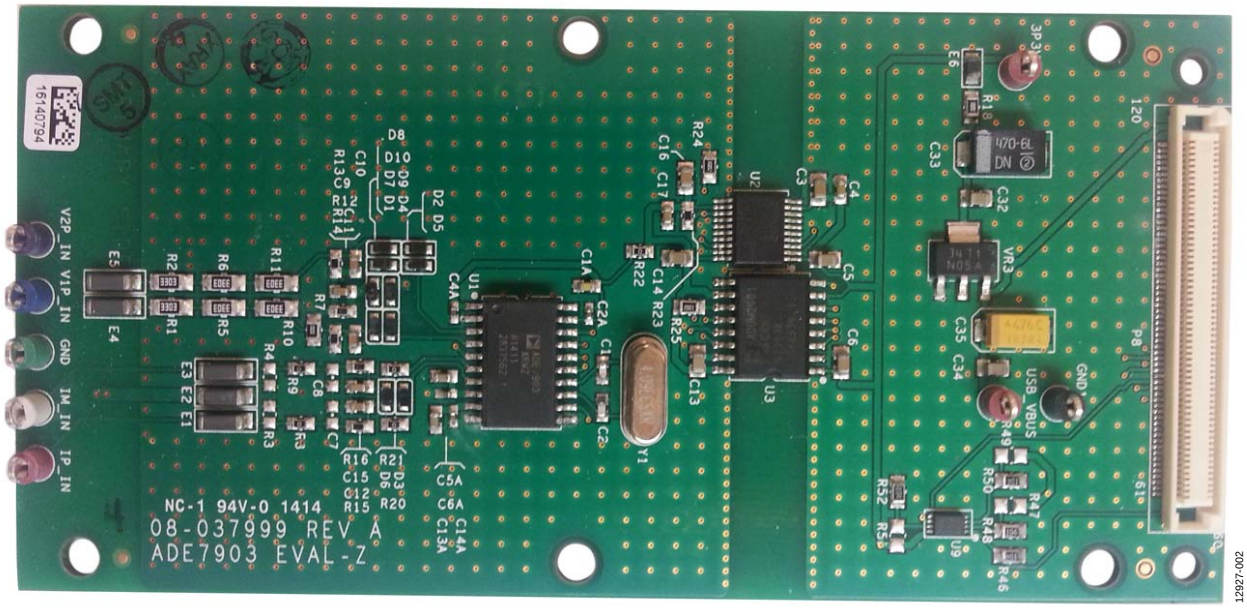


Figure 3. EVAL-ADE7903EBZ Evaluation Board

POWERING UP THE EVALUATION KIT BOARDS

The interface board receives power via the USB cable connected to the PC. A 3.3 V regulator then powers the SDP-B board microcontroller and, across the isolation barrier, the ADE7903 ADC populating the evaluation board. No additional power source is required for the ADE7903 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 ADE7903 ADC. The components used on the board are the values recommended for use with the ADE7903.

Current Sense Inputs (IP_IN and IM_IN Test Pins)

The ADE7903 measures the voltage across a shunt at its IP and IM pins. Figure 4 shows the structure used for the current input.

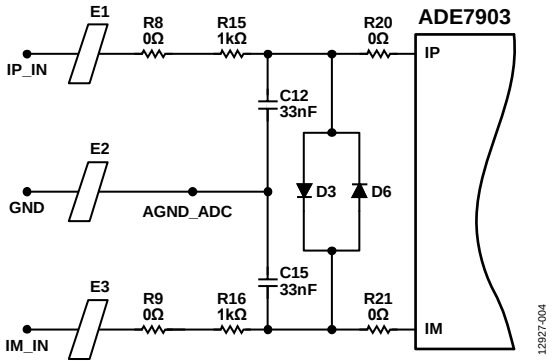


Figure 4. Current Input Structure on the Evaluation Board

R8, R9, R20, and R21 are 0 Ω resistors that do not need to be implemented on a real meter board. 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 ADE7903 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 ADE7903 is ±0.03125 V peak. The signal range must not exceed ±0.03125 V, with respect to AGND_ADC, for specified operation.

The shunt is connected between the IP_IN and IM_IN test pins.

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 current input structure. The shunt is connected between the P1 and P1' energy meter line inputs. The IP_IN and IM_IN test pins are connected to the shunt measurement poles, while GND, the test pin that is the ground of the ADE7903, is connected to the ground pole of the shunt.

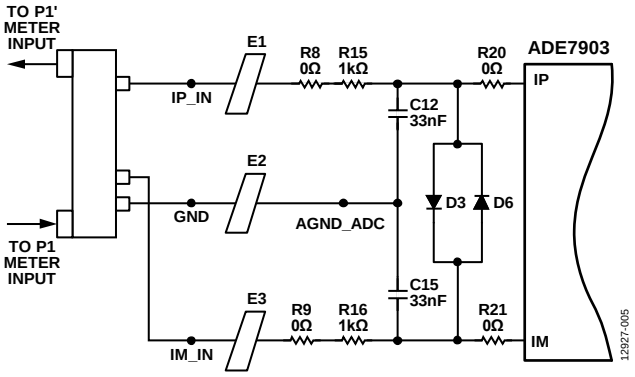


Figure 5. Example of a Shunt Connection

Phase Voltage Sense Inputs (V1P_ IN Test Pin)

The phase-to-neutral voltage input connections on the EVAL-ADE7903EBZ evaluation board can be directly connected to the line voltage source between the GND and V1P_IN test points for phase-to-neutral voltage. These voltages are attenuated using a simple resistor divider network before they are supplied to the ADE7903. 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 design prevents the occurrence of large energy errors at low power factors.

The V1P_IN path in Figure 6 shows a typical connection of the 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 ADE7903 are ±2 V. The D1, D7, D4, and 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 ADE7903 is ±0.5 V peak. The signal range must not exceed ±0.5 V with respect to GND for specified operation.

The E4 and E5 ferrite beads filter the high frequency noise that may be induced into the wires.

Auxiliary Voltage Sense Inputs (V2P_IN Test Pin)

The auxiliary voltage input connections on the EVAL-ADE7903EBZ evaluation board can be directly connected to the line voltage sources between V2P_IN and GND for the auxiliary voltage.

The V2P_IN path in Figure 6 shows a typical connection of the Phase A auxiliary voltage input. It is very similar to the V1P_IN path explained in Phase Voltage Sense Inputs (V1P_ IN Test Pin) section.

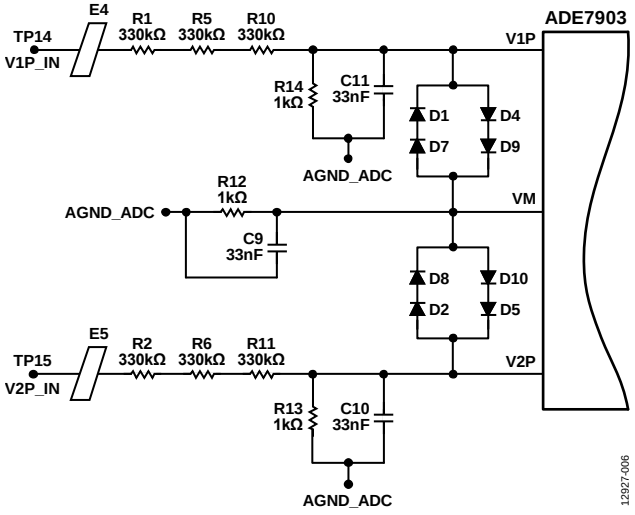


Figure 6. Phase Voltage Input Structure on the Evaluation Board

VDD and Ground Pin Management

The ADE7903 package has four ground pins (GND): Pin 2, Pin 10, Pin 11, and Pin 20. Figure 7 presents their management, on the side of the current and voltage inputs, in the case of an ADE7903. It is important to note that Pin 11 (GND) must be connected to either Pin 2 or Pin 10 (GND) outside the package. Similarly, Pin 19 (VDD) must be connected directly to Pin 1 (VDD) in the shortest path outside of the package because they are not internally connected. The C1A, C2A, and C4A decoupling capacitors on the VDD pins are connected to the closest ground pin. The decoupling capacitors, C5A and C6A on the analog LDO pin and C13A and C14A on the voltage reference pin, must be separate from the VDD circuitry and are connected to ground (Pin 10).

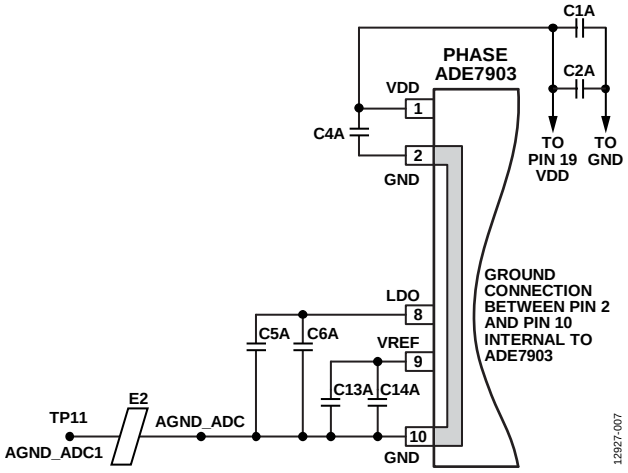


Figure 7. Isolated Ground Pins Management

The P1 meter input constitutes the AGND_ADC1 signal (see also Figure 5). AGND_ADC1 is then connected to GND (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 EVAL-ADE7903EBZ evaluation board. In this example, an energy meter for a 1-phase, 2-wire distribution system is shown. A shunt is used to sense the phase current and is connected as depicted in Figure 8. The line voltage is connected directly to the board, and the board is supplied from one power supply provided by the PC through the USB cable.

The ADE7903 can be used in conjunction with the ADE7913/ADE7912 in a single-phase system to monitor both the line and the neutral, if needed. In an alternative application where isolation from the neutral line is not required, the ADE7903 can be used on the neutral in a 3-phase distribution system, along with three ADE7913/ADE7912 devices. The isolated ADC allows isolation from the line, while the ADE7903 can be used on the neutral where isolation may not be required. To evaluate the ADE7913, refer to the ADE7913 product page.

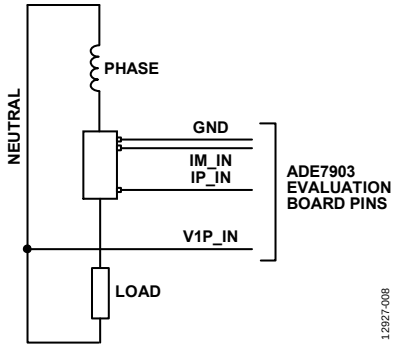


Figure 8. Typical Setup for the EVAL-ADE7903EBZ Evaluation Board for 1-Phase Distribution System

Using the Evaluation Board with Another Microcontroller

It is possible to manage the EVAL-ADE7903EBZ evaluation board with a different microcontroller mounted on another board. The evaluation board can be connected to this second board through the P8 connector, shown in Figure 9. In this case, the SDP-B Blackfin board is unused.

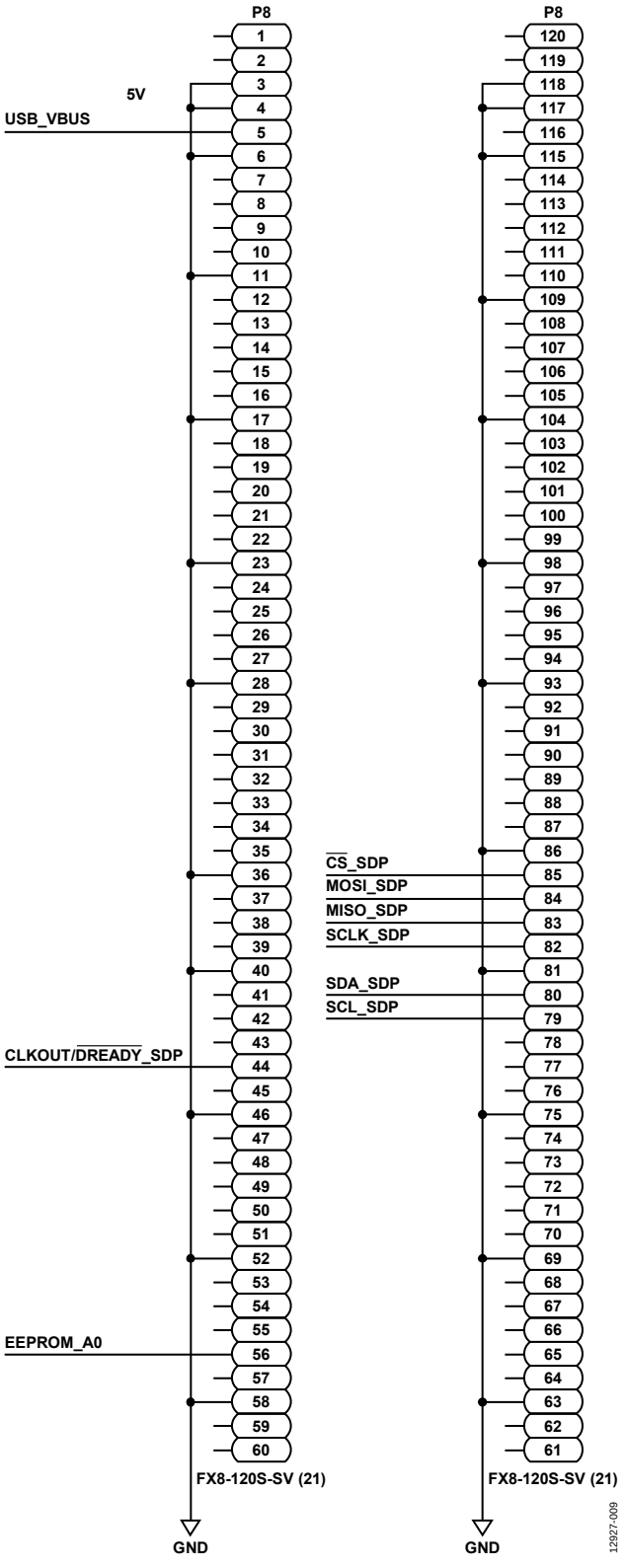


Figure 9. SDP Interface P8 Connector

EVALUATION BOARD SOFTWARE

The EVAL-ADE7903EBZ evaluation board is supported by Windows®-based software that allows the user to access all the functionality of the ADE7903.

The software communicates with the SDP-B Blackfin board using the USB. The microcontroller communicates with the ADE7903 ADC on the evaluation board to process the requests sent from the PC.

INSTALLING THE DRIVERS

When using the ADE7903 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 the installation is complete, click **Finish** to close the window.

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

INSTALLING AND UNINSTALLING THE ADE7903 EVALUATION SOFTWARE

The ADE7903 evaluation 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 the evaluation software on the PC for the first time, run the installer. 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 ADE7903 evaluation software, double-click **installation_files\setup.exe** to launch 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 **Start** > **Programs** > **ADE7903 Evaluation Software** and click **ADE7903 Evaluation Software**.

Both the ADE7903 evaluation software program and the NI run-time engine can be uninstalled using the **Add/Remove Programs** option in Control Panel.

1. Before installing a new version of the ADE7903 evaluation software, first uninstall the previous version.
2. From the Windows Control Panel, click **Add/Remove Programs**.
3. Select the program to uninstall and click **Add/Remove**.

MAIN WINDOW

When the software is launched, the main window opens. This window contains two areas: the main menu on the left, and a box that verifies that the PC is connected to the SDP-B board on the right (see Figure 11).

The software automatically detects the SDP-B Blackfin board. If the port detection is successful, the box on the right displays **Connected**, as shown in Figure 11.

The **Function** menu, shown in Figure 12 at the top of the window, appears in every window throughout the software. With this menu, navigate from any main menu selection to another main menu selection at any time.

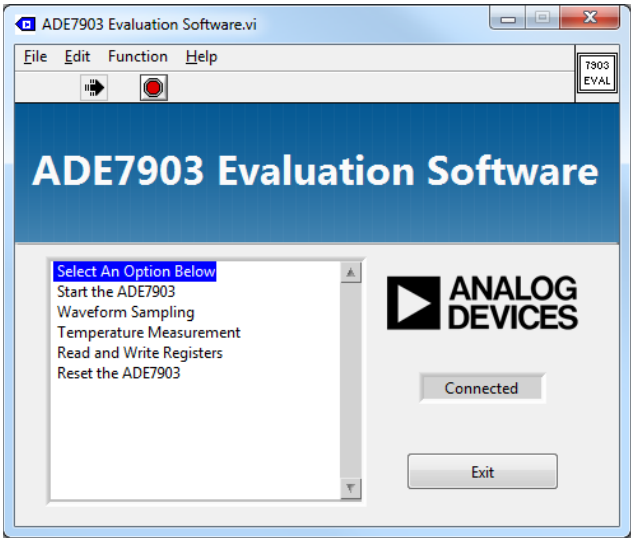


Figure 11. Main Window of the ADE7903 Evaluation Software

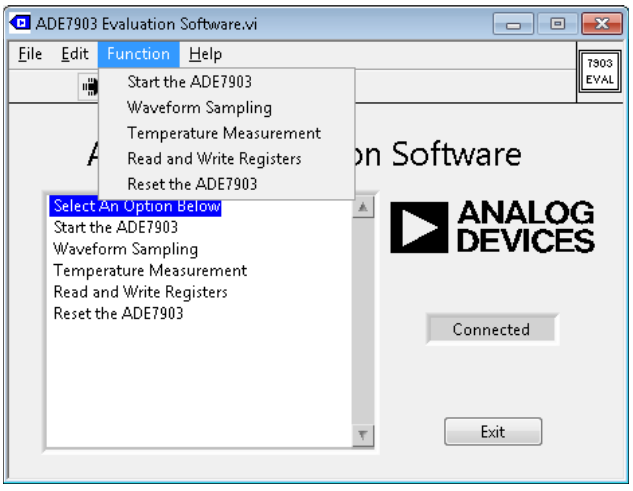


*Figure 12. **Function** Menu on Main Window*

Troubleshooting the COM Port Detection

If the software does not detect the SDP-B Blackfin board, the message shown in Figure 13 displays.

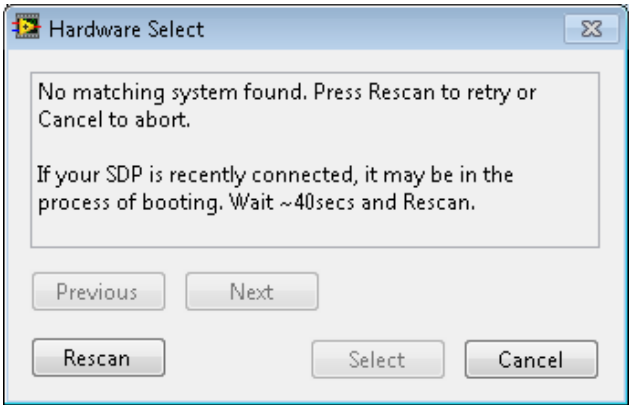


Figure 13. SDP-B Blackfin Board Not Detected Message

Wait approximately 40 seconds and click **Rescan** to retry connecting to the SDP-B board. If a message stating **1 matching system found** does not appear, take the following steps:

1. Click **Cancel** and **Exit** out of the evaluation software.
2. Verify that the ADE7903 board is connected to the SDP-B Blackfin board and that the SDP-B 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. Some drivers are automatically installed during the first startup of the board. Drivers only need to be installed once for a particular PC.
4. Using the **Device Manager** tool, ensure that the SDP-B Blackfin board was recognized by the PC and appears under the **ADI Development Tools** entry as **Analog Devices System Demonstration Platform SDP-B**.
5. Launch the ADE7903 evaluation software again.

EVALUATION SOFTWARE FUNCTIONS

The ADE7903 evaluation software allows access to all the registers and features of the ADE7903. The main menu options available are

- **Start the ADE7903**
- **Waveform Sampling**
- **Temperature Measurement**
- **Read and Write Registers**
- **Reset the ADE7903**
- **Exit** button (closes the software)

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

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

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

START ADE7903

Figure 14 shows the **Start ADE7903** window. The ADE7903 is clocked from a 4.096 MHz crystal. The software automatically starts the ADE7903 ADC with the following default settings:

- The bandwidth of the digital low-pass filter of the ADC is set at 3.3 kHz.
- The ADC output frequency is set at 8 kHz.
- The CLKOUT/$\overline{\text{DREADY}}$ pin is set to generate a $\overline{\text{DREADY}}$ signal at the output frequency to signal when the data is ready from the ADC.
- The secondary voltage channel is set to read from the V2P input rather than from the temperature sensor.

If different settings are desired, select them from the boxes in the right half of the window. Click **Configure** to update the ADE7903.

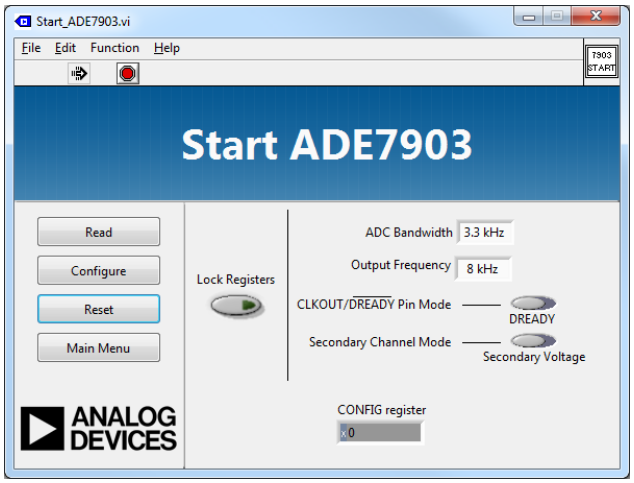


*Figure 14. **Start ADE7903** Window*

The **CONFIG register** box shows the current value of the CONFIG register, and can be used to verify the changes made to the ADE7903.

The **Lock Registers** button can be used to protect the configuration registers in the ADE7903. This button writes directly to the lock register (0xA). When the registers are protected, the boxes on the right are greyed and the **Lock Registers** light turns on. 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 ADE7903 ADC while keeping the registers protection disabled.

Click **Read** to read the current configuration. Click **Configure** to write the new settings. Click **Reset** to reset the ADE7903. Click **Main Menu** to close this window and open the main window.

WAVEFORM SAMPLING

Figure 15 shows the **Waveform Sampling** window. This window provides full access to the ADC outputs (waveforms) of the ADE7903 ADC on the board. To display waveforms, follow these steps:

1. Enter an acquisition time in the **Accumulation Time (ms)** box, expressed in milliseconds.
2. Select the **Channels** of the ADE7903 to be visualized by checking any combination of the **Current**, **Voltage1**, and **Voltage2** boxes. The color of each waveform can be changed as desired by clicking the color next to the check box.
3. Click **Capture** to display the waveforms on the plot. After the data is captured, the check boxes under **Channels** can be modified to display any combination of waveforms from that data capture.

The SDP-B Blackfin board acquires the waveform samples using the ADE7903 $\overline{\text{DREADY}}$ signal as an interrupt. The blue bar above the plot shows the acquisition progress.

To save the waveforms to a file,

1. Click the folder icon below **Save File To** to select the folder for the file to be saved.
2. Click **Save As .txt** to save the waveform data to a file.

The program stores every waveform into a file named **ADE7903_WAVEFORM_xxxx.txt**, where xxxx is a number starting at 0000 and incremented by 1 to keep from overwriting a past waveform file. The file includes the raw data with the columns being time, current channel, Voltage Channel 1, and Voltage Channel 2. The file is semicolon (;) delimited and can easily be imported into a spreadsheet.

To shift and zoom in on the plot, use the buttons in the bottom left-hand corner of the plot area.

To enable a Fourier analysis of the acquired waveforms, change the position of the **Select Analysis** switch from **Waveforms** to **FFT**. In this case, the window shown in Figure 16 is enabled. Only one waveform at a time is visualized in this plot; select the **Channels** boxes accordingly.

Select the type of windowing from the **Window** drop-down menu: **Hanning**, **Blackman-Harris**, or **none**.

Various **FFT Settings** can 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 selections 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 signals extracted for SNR analysis, **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)
- **SINAD** (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)

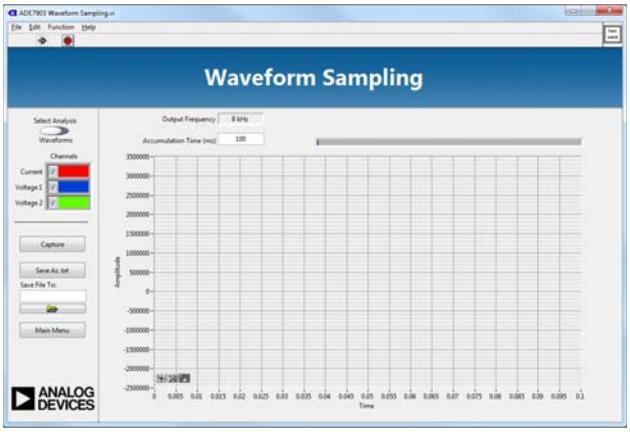


Figure 15. Waveform Sampling

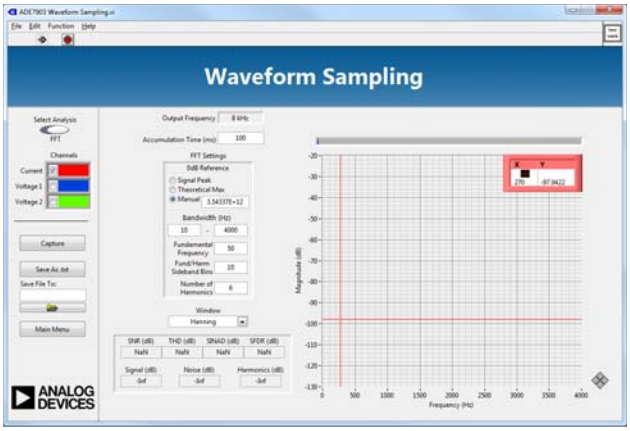


Figure 16. Fourier Analysis

TEMPERATURE MEASUREMENT

Figure 17 shows the **Temperature Measurement** window. The **Temperature Sensor Select** switch controls whether the ADE7903 measures the V2 channel inputs or the temperature sensor.

After selecting the temperature sensor, the new value of the CONFIG register can be seen in the **CONFIG** indicator box. The **Read** button then reads the value of either the temperature sensor or V2 voltage, depending on the **Temperature Sensor Select** switch, and displays it in **V2/Temperature Reading**. The **Read** button also displays the **Temperature Offset** stored in the ADE7903; this value cannot be changed.

In the **MCU Calculations** area, the recommended equation with **Temperature Gain Correction** and **Temperature Offset Correction** from the data sheet is displayed and used by the software to acquire a temperature reading in degrees Celsius in the **Temperature [deg C]** box. The gain and offset correction values can be modified if a different equation is desired.

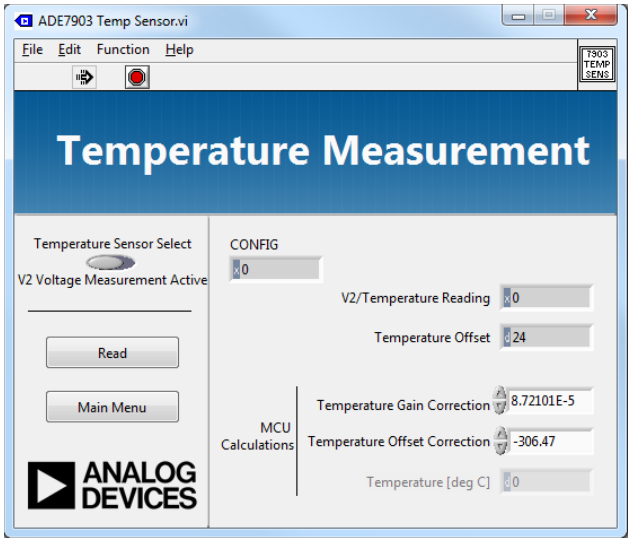


Figure 17. Temperature Measurement

READ AND WRITE REGISTERS

Figure 18 shows the **Read and Write Registers** window. Every register of the ADE7903 populating the board can be accessed by using the boxes on the right-hand side of the window and then clicking **Write** or **Read**.

The registers can be accessed either by **Address** or by **Register Name**, via the **Data to Write to Register** and **Data to Read from Register** fields.



Figure 18. Read and Write Registers

RESET THE ADE7903

Clicking **Reset the ADE7903** from the main menu resets the device, and the window shown in Figure 19 appears to confirm that the ADE7903 has been reset. Click **OK** to return to the **Main Menu.**

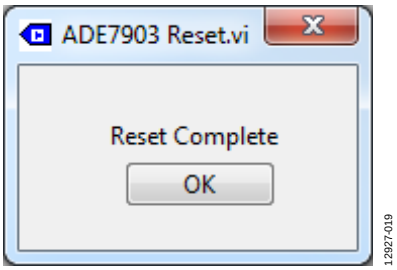


Figure 19. ADE7903 Reset

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.

Legal Terms and Conditions

By using the evaluation board discussed herein (together with any tools, components documentation or support materials, the "Evaluation Board"), you are agreeing to be bound by the terms and conditions set forth below ("Agreement") unless you have purchased the Evaluation Board, in which case the Analog Devices Standard Terms and Conditions of Sale shall govern. Do not use the Evaluation Board until you have read and agreed to the Agreement. Your use of the Evaluation Board shall signify your acceptance of the Agreement. This Agreement is made by and between you ("Customer") and Analog Devices, Inc. ("ADI"), with its principal place of business at One Technology Way, Norwood, MA 02062, USA. Subject to the terms and conditions of the Agreement, ADI hereby grants to Customer a free, limited, personal, temporary, non-exclusive, non-sublicensable, non-transferable license to use the Evaluation Board FOR EVALUATION PURPOSES ONLY. Customer understands and agrees that the Evaluation Board is provided for the sole and exclusive purpose referenced above, and agrees not to use the Evaluation Board for any other purpose. Furthermore, the license granted is expressly made subject to the following additional limitations: Customer shall not (i) rent, lease, display, sell, transfer, assign, sublicense, or distribute the Evaluation Board; and (ii) permit any Third Party to access the Evaluation Board. As used herein, the term "Third Party" includes any entity other than ADI, Customer, their employees, affiliates and in-house consultants. The Evaluation Board is NOT sold to Customer; all rights not expressly granted herein, including ownership of the Evaluation Board, are reserved by ADI. CONFIDENTIALITY. This Agreement and the Evaluation Board shall all be considered the confidential and proprietary information of ADI. Customer may not disclose or transfer any portion of the Evaluation Board to any other party for any reason. Upon discontinuation of use of the Evaluation Board or termination of this Agreement, Customer agrees to promptly return the Evaluation Board to ADI. ADDITIONAL RESTRICTIONS. Customer may not disassemble, decompile or reverse engineer chips on the Evaluation Board. Customer shall inform ADI of any occurred damages or any modifications or alterations it makes to the Evaluation Board, including but not limited to soldering or any other activity that affects the material content of the Evaluation Board. Modifications to the Evaluation Board must comply with applicable law, including but not limited to the RoHS Directive. TERMINATION. ADI may terminate this Agreement at any time upon giving written notice to Customer. Customer agrees to return to ADI the Evaluation Board at that time. LIMITATION OF LIABILITY. THE EVALUATION BOARD PROVIDED HEREUNDER IS PROVIDED "AS IS" AND ADI MAKES NO WARRANTIES OR REPRESENTATIONS OF ANY KIND WITH RESPECT TO IT. ADI SPECIFICALLY DISCLAIMS ANY REPRESENTATIONS, ENDORSEMENTS, GUARANTEES, OR WARRANTIES, EXPRESS OR IMPLIED, RELATED TO THE EVALUATION BOARD INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTY OF MERCHANTABILITY, TITLE, FITNESS FOR A PARTICULAR PURPOSE OR NONINFRINGEMENT OF INTELLECTUAL PROPERTY RIGHTS. IN NO EVENT WILL ADI AND ITS LICENSORS BE LIABLE FOR ANY INCIDENTAL, SPECIAL, INDIRECT, OR CONSEQUENTIAL DAMAGES RESULTING FROM CUSTOMER'S POSSESSION OR USE OF THE EVALUATION BOARD, INCLUDING BUT NOT LIMITED TO LOST PROFITS, DELAY COSTS, LABOR COSTS OR LOSS OF GOODWILL. ADI'S TOTAL LIABILITY FROM ANY AND ALL CAUSES SHALL BE LIMITED TO THE AMOUNT OF ONE HUNDRED US DOLLARS ($100.00). EXPORT. Customer agrees that it will not directly or indirectly export the Evaluation Board to another country, and that it will comply with all applicable United States federal laws and regulations relating to exports. GOVERNING LAW. This Agreement shall be governed by and construed in accordance with the substantive laws of the Commonwealth of Massachusetts (excluding conflict of law rules). Any legal action regarding this Agreement will be heard in the state or federal courts having jurisdiction in Suffolk County, Massachusetts, and Customer hereby submits to the personal jurisdiction and venue of such courts. The United Nations Convention on Contracts for the International Sale of Goods shall not apply to this Agreement and is expressly disclaimed.

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