FEATURES
Fully featured evaluation board for 10-lead precision ADCs
Versatile analog signal conditioning circuitry
On-board reference, reference buffers, and ADC drivers
PC software for control and data analysis of time and frequency domain
System demonstration platform-compatible (SDP-H1)

EVALUATION BOARD KIT CONTENTS
AD4000/AD4001/AD4002/AD4003/AD4020 evaluation board (see Table 7)
12 V wall adapter power supply

EQUIPMENT NEEDED
PC running Windows 7 or Windows 10
SDP-H1 board (EVAL-SDP-CH1Z) or FMC-compatible controller board
Precision signal source
Cable (SMA input to evaluation board)
One end of cable is standard USB A and other end of cable is mini-B USB
Band-pass filter suitable for 16-bit, 18-bit, and 20-bit testing (value based on signal frequency)
AD40XX evaluation software

GENERAL DESCRIPTION
The AD4000/AD4001/AD4002/AD4003/AD4020 family of evaluation boards enable quick, simplified evaluation of the AD4000 family of 16-/18-/20-bit, precision successive approximation register (SAR) analog-to-digital converters (ADCs). The AD4000/AD4001/AD4002/AD4003/AD4020 are low power, 16-bit/18-bit/20-bit, precision SAR ADCs that offer high performance with throughputs up to 2 MSPS (1.8 MSPS for the AD4020). The evaluation board demonstrates the performance of the AD4000/AD4001/AD4002/AD4003/AD4020 family of ADCs and provides a simplified interface for a variety of system applications.

The EVAL-AD4000FMCZ/EVAL-AD4001FMCZ/EVAL-AD4002FMCZ/EVAL-AD4003FMCZ/EVAL-AD4020FMCZ evaluation boards, accessible from the EVAL-AD400x-FMCZ product page, (see Figure 1) are ideal for use with the Analog Devices, Inc., high speed system demonstration platform (SDP-H1). These evaluation boards interface to the SDP-H1 board via a field-programmable gate array (FPGA) mezzanine card (FMC) low pin count (LPC) connector.

On-board components include a high precision buffered band gap 5.0 V reference (ADR4550), a reference buffer (ADA4807-1), a common-mode buffer (ADA4807-1), a signal conditioning circuit with two op amps (ADA4807-1), and a power supply to derive the necessary voltage levels to supply all voltage needs.

The EVAL-AD4000FMCZ, EVAL-AD4001FMCZ, EVAL-AD4002FMCZ, and EVAL-AD4003FMCZ are populated with the AD4000, AD4001, AD4002, and AD4003, respectively. However, these boards can be used to evaluate the performance of the AD4004, AD4005, AD4006, AD4007, AD4008, AD4010, and AD4011 by limiting the sample rate in the evaluation software to the maximum sample rate of the specific ADC. For example, the AD4000 on the EVAL-AD4000FMCZ can be used to evaluate the performance of the AD4004 if the sample rate is limited to 1 MSPS. See the data sheet of each product for the corresponding evaluation board.

Full descriptions of these products are available in their respective data sheets, which must be consulted when using the corresponding evaluation board. Table 7 shows the models of the AD4000/AD4001/AD4002/AD4003/AD4020 evaluation boards.
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REVISION HISTORY


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Added Identifying the Evaluation Board Section ................................. 5
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Added Getting Started Section, Software Installation
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Added Installing the SDP-H1 Board Drivers Section, Figure 12;
Renumbered Sequentially ................................................................. 9
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Deleted Related Links Table
Changes to Figure 27 Caption
Changes to Figure 28 Caption and Figure 29 Caption
Changes to Figure 30 Caption and Figure 31 Caption
Changes to Figure 32 Caption
Changed Products on this Evaluation Board Section to Ordering Information Section and AD4000/AD4001/AD4002/AD4003/AD4020 Evaluation Board Bill of Materials Section to Evaluation Board Bill of Materials Section
Changes to Table 7

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Added Figure 3 and Table 4; Renumbered Sequentially

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Change to Figure 2
Changes to Table 5

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Changes to Figure 2 and Setting Up the Evaluation Board Section
Changes to Table 6

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Change to General Description Section

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Added EVAL-AD4020FMCZ
Changes to User Guide Title and Subject, Evaluation Board Kit Contents Section, and General Description Section
Moved Evaluation Board Photograph Section
Changes to Figure 2 and Setting Up the Evaluation Board Section
Changes to Table 3
Changes to Table 18
Changes to Description of the User Panel Section
Changes to Table 6

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Added AD4001
Changes to User Guide Title
Changes to User Guide Subject Line
Changes to Figure 2
Changes to Table 3
Moved Troubleshooting Section
Changes to Table 5
Changes to Table 6

11/2016—Rev. 0 to Rev. A
Added Figure 1, Renumbered Sequentially
Changes to General Description Section
Changes to Setting Up the Evaluation Board

10/2016—Revision 0: Initial Version
EVALUATION BOARD PHOTOGRAPH

Figure 1. EVAL-AD400x-FMCZ
EVALUATION BOARD HARDWARE

SETTING UP THE EVALUATION BOARD

Figure 2 shows the simplified evaluation board block diagram. Figure 24 shows the evaluation board schematic. The board consists of the ADC, U1, with a reference, U6 (ADR4550), and ADC drivers, U12 and U14, the ADA4807-1 for the AD4001/AD4002/AD4003/AD4020, and the ADA4805-1 for the AD4000 (see Table 6). The user also has an option to populate U2 with a low power, fully differential ADC driver, such as the ADA4940-1, when evaluating the AD4001/AD4003/AD4020. The evaluation board is a flexible design that enables the user to select components in addition to operating from an adjustable bench top power supply.

Identifying the Evaluation Board

A sticker label included on the bottom side (not pictured) of the EVAL-AD4000FMCZ/EVAL-AD4001FMCZ/EVAL-AD4002FMCZ/EVAL-AD4003FMCZ/EVAL-AD4020FMCZ indicates evaluation board options. For example, the EVAL-AD4020FMCZ evaluation board includes a sticker labeled EVAL-AD4020FMCZ.

POWER SUPPLIES

The system demonstration platform (SDP-H1) board supplies 12 V to power the necessary rails for the EVAL-AD400xFMCZ evaluation boards.

The 7 V amplifier positive rail (+V₆) is generated from U17 (ADP7118). The −2.5 V negative amplifier rail (−V₆) is generated by a combination of U3 (ADP2370), U7 (ADM660), and U21 (ADP7182).

Each supply is decoupled where it enters the board and at each device. A single ground plane is used on this board to minimize the effect of high frequency noise interference.

In addition, the board can be powered from a benchtop power supply. The screw terminals, J2 and J3, are provided for this function. When bench power is used, the on-board power supplies are no longer required. The solder links also must be changed as follows: SL1 = SL2 = SL5 = SL6 = SL7 = SL8 = SL9 = B.

Table 1. Power Supplies Provided on the Board

<table>
<thead>
<tr>
<th>Power Supply (V)</th>
<th>Function</th>
<th>Components Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>5, 7 (Default)³</td>
<td>Positive rail</td>
<td>ADP7118</td>
</tr>
<tr>
<td>−5, −2.5 (Default)³</td>
<td>Negative rail</td>
<td>ADP2370, ADM660, ADP7182</td>
</tr>
<tr>
<td>1.8</td>
<td>ADC power</td>
<td>ADP7118, ADP5300</td>
</tr>
<tr>
<td>3.3</td>
<td>VDD (digital power)</td>
<td>ADP7118</td>
</tr>
</tbody>
</table>

³ See Table 2.

REFERENCE, REFERENCE BUFFER, AND COMMON-MODE BUFFER

An external 5 V reference (U6, ADR4550) is used by default to supply the ADCs directly. The user can also use one of the 2.5 V, 3.3 V, and 4.096 V references by changing the on-board reference device U6 (ADR4525/ADR4533/ADR4540). There is an option to use a lower power reference, U22 (ADR3450). Note that the ADR3450 cannot accept input voltages beyond 5.5 V. The ADA4807-1 is used as a reference buffer (U16) and common-mode buffer (U18) by default. However, U16 can also be replaced by the AD8031 if required without compromising the performance.
SDP-H1 CONTROLLER BOARD

The evaluation board uses a serial port interface (SPI) and is connected to the system demonstration platform (SDP-H1) controller board. The SDP-H1 board requires power from a 12 V wall adapter (included with the SDP-H1). The SDP-H1 has a Xilinx® Spartan 6 and an ADSP-BF527 processor with connectivity to the PC through a USB 2.0 high speed port. The SDP-H1 allows the configuration and capture of data on the evaluation boards from the PC via USB.

The SDP-H1 has an FMC LPC connector with full differential low voltage differential signaling (LVDS) and single-ended low voltage complementary metal-oxide semiconductor (LVCMOS) support. The SDP-H1 also has a 120-pin connector that exposes the Blackfin® processor peripherals. This connector provides a configurable serial, parallel FC and SPI, and general-purpose input/output (GPIO) communications lines to the attached daughter board.

SOLDER LINKS

The three solder link options on the evaluation board are configured depending on the generic of the ADC on the specific evaluation board, as described in Table 3.

The evaluation board supports any amplifier mezzanine card (AMC). Insert this add on card on the 7-pin headers. Figure 3 shows the AMC mounted on the evaluation board. The AMC ADC driver settings are required to use this option, described in Table 4.

Table 2. Jumper Detail with Factory Default Setting

<table>
<thead>
<tr>
<th>Link</th>
<th>Default Position</th>
<th>Function</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>SL1</td>
<td>A</td>
<td>+VDD</td>
<td>Change to Position B if using bench supplies</td>
</tr>
<tr>
<td>SL2</td>
<td>A</td>
<td>−VDD</td>
<td>Change to Position B if using bench supplies</td>
</tr>
<tr>
<td>SL5</td>
<td>A</td>
<td>+VSS</td>
<td>Change to Position B if using bench supplies</td>
</tr>
<tr>
<td>SL5</td>
<td>A</td>
<td>−VSS</td>
<td>Change to Position B if using bench supplies</td>
</tr>
<tr>
<td>SL7</td>
<td>A</td>
<td>VSS for ADC</td>
<td>Change to Position B if using bench supplies</td>
</tr>
<tr>
<td>LK2</td>
<td>A</td>
<td>VREF</td>
<td>Change to Position B if using the ADR3450</td>
</tr>
<tr>
<td>LK5</td>
<td>B</td>
<td>SDI</td>
<td>Change to Position A if using connecting SDI to the VIO voltage (V_DRIVE)</td>
</tr>
<tr>
<td>JP1</td>
<td>B</td>
<td>FSEL (U3)</td>
<td>Change to Position A if selecting a 600 kHZ switching frequency for the ADP2370 (U3)</td>
</tr>
<tr>
<td>JP2</td>
<td>B</td>
<td>ADC drivers</td>
<td>Change to Position A if using the ADA4940-1 fully differential ADC</td>
</tr>
<tr>
<td>JP3</td>
<td>B</td>
<td>ADC drivers</td>
<td>Change to Position A if using the ADA4940-1 fully differential ADC</td>
</tr>
<tr>
<td>JP4</td>
<td>B</td>
<td>ADC drivers</td>
<td>Change to Position A if using the ADA4940-1 fully differential ADC</td>
</tr>
<tr>
<td>JP5</td>
<td>B</td>
<td>ADC drivers</td>
<td>Change to Position A if using the ADA4940-1 fully differential ADC</td>
</tr>
<tr>
<td>JP7</td>
<td>B</td>
<td>V_DRIVE</td>
<td>Change to Position A if using external 3.3 V for V_DRIVE (VIO voltage)</td>
</tr>
<tr>
<td>JP8</td>
<td>B</td>
<td>Stop (U20)</td>
<td>Change to Position A if synchronizing ADP5300 (U20) STOP input with CNV_FMC from SDP-H1 connector</td>
</tr>
</tbody>
</table>

1Setting LK5 to Position A prevents access to the configuration register of the connected device and does not allow features including turbo mode, high-Z mode, and so on, to be enabled.

Table 3. Jumpers Specific to 10-Lead Precision ADCs

<table>
<thead>
<tr>
<th>Link</th>
<th>Default Position</th>
<th>Configuration</th>
<th>Generic</th>
</tr>
</thead>
<tbody>
<tr>
<td>SL4</td>
<td>A</td>
<td>Differential input</td>
<td>AD4001, AD4003, AD4020</td>
</tr>
<tr>
<td>SL4</td>
<td>B</td>
<td>Single-ended or pseudo differential</td>
<td>AD4000, AD4002</td>
</tr>
</tbody>
</table>
**Table 4. Amplifier Mezzanine Card ADC Driver**

<table>
<thead>
<tr>
<th>Component</th>
<th>Default Position/Values</th>
<th>Function</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>SL8</td>
<td>A</td>
<td>$-V_S$</td>
<td>Change to Position B if using bench supplies for AMC power</td>
</tr>
<tr>
<td>SL9</td>
<td>A</td>
<td>$+V_S$</td>
<td>Change to Position B if using bench supplies for AMC power</td>
</tr>
<tr>
<td>JP4, JP5</td>
<td>B</td>
<td>ADC driver outputs</td>
<td>Must be set to Position B to connect ADC inputs to AMC outputs</td>
</tr>
<tr>
<td>R20, R21</td>
<td>0 Ω</td>
<td>ADC driver outputs</td>
<td>Must not be installed in order to disconnect on-board ADC driver outputs (U12, U14)</td>
</tr>
<tr>
<td>R69, R95</td>
<td>0 Ω</td>
<td>ADC driver inputs</td>
<td>Must not be installed in order to disconnect on-board ADC driver inputs (U12, U14)</td>
</tr>
<tr>
<td>R20, R21</td>
<td>0 Ω, R20, R21, R19, do not install (DNI)</td>
<td>AMC ADC driver analog positive input ($V_{in+}$)</td>
<td>Removed R20 and R21</td>
</tr>
<tr>
<td></td>
<td>0 Ω, R20, R21, R39 DNI</td>
<td>AMC ADC driver analog negative input ($V_{in-}$)</td>
<td>Removed R36 and R40</td>
</tr>
</tbody>
</table>

**ANALOG INPUTS**

The analog inputs to the evaluation board are SMA connectors, J6 and J10. These inputs are buffered with dedicated amplifier circuitry (U12 and U14), as shown in Figure 26. The circuit allows different configurations, input range scaling, filtering, addition of a dc component, and use of different op amp and supplies. The analog input amplifiers are set as unity-gain buffers at the factory.

The optional fully differential amplifier (FDA) can be used with the fully differential AD4000 devices on the EVAL-AD4001FMCZ, EVAL-AD4003FMCZ, and EVAL-AD4020FMCZ boards. Table 2 lists the necessary jumper positions for using the FDA (U2).

The AD4000 family devices require the inputs to be biased at midscale. The default configuration also sets both U12 and U14 at midscale, generated from a buffered reference voltage divider (VCM). The noninverting inputs of both U12 and U14 are connected to the 590 Ω resistor dividers by default. These resistor dividers, R27, R28, R34, and R35, divide the reference voltage in half. The 590 Ω resistor dividers must be taken into account when interfacing with an external source via J6 and J10. The FDA (U2) outputs are biased to midscale with a 10 kΩ resistor divider (R65 and R67).

The EVAL-AD400x-FMCZ evaluation boards are factory configured to provide the appropriate input signal type, single-ended or fully differential, with the SL4 link. See Table 2 and Figure 26 for more information.

To evaluate dynamic performance, a fast Fourier transform (FFT) test can be performed by applying a very low distortion ac source.

For low frequency testing, the audio precision source (such as the SYS-2700 series) can be used directly because the outputs on these are isolated. Set the outputs for balanced and floating ground. Different precision sources can be used with additional filtering.
GETTING STARTED

The EVAL-AD400x-FMCZ evaluation boards can be controlled with the AD40XX Evaluation Software Installer. The following sections provide instructions for installing the supporting software and an overview for connecting the hardware to the PC.

SOFTWARE INSTALLATION PROCEDURES

The AD40XX Evaluation Software Installer installs the AD40XX Evaluation Software Installer and accompanying drivers for the SDP-H1 board. Install this software installer package before connecting the SDP-H1 board to the PC USB port to ensure that the SDP-H1 board is recognized when it connects to the PC.

Installing the AD40XX Evaluation Software Installer

To install the AD40XX Evaluation Software Installer, adhere to the following steps:

1. Start the Windows® operating system and download the software from the EVAL-AD400x-FMCZ product page.
2. Unzip the downloaded file. Run the setup.exe file.
3. Begin installing the evaluation software by clicking the setup.exe file. The software installation window opens as shown in Figure 4.

   Figure 4. AD40XX Evaluation Software Install Window

4. Choose the installation directory and click Next. The default location is C:\Program Files (x86)\Analog Devices).

5. Installing the AD40XX Evaluation Software Installer requires users to accept the license agreement shown in Figure 6. Read the agreement before clicking Next to proceed.

   Figure 5. Destination Directory Window

   Figure 6. License Agreement Window
6. The window shown in Figure 7 provides a summary of the software installation. Click **Next** to install the software listed in the window.

![Figure 7. Start Installation Window](image)

7. A pop-up window opens and displays a bar showing the installation progress, as shown in Figure 8.

![Figure 8. Overall Progress](image)

8. Click **Next** to complete the installation and launch the SDP-H1 driver installation, as shown in Figure 9.

![Figure 9. Installation Complete Window](image)

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**Installing the SDP-H1 Board Drivers**

The AD40XX Evaluation Software Installer uses the ADI SDP drivers (Version 2.3.0.207) to interface with the SDP-H1 controller board. Following the successful software installation, the installer automatically begins installing the ADI SDP drivers (indicated by the pop-up shown in Figure 10).

![Figure 10. SDP-H1 Driver Installation](image)

1. The **ADI SDP Drivers 2.3.0.207 Setup** wizard opens the window, as shown in Figure 11. Click **Next** to install the SDP-H1 drivers.

![Figure 11. ADI SDP Drivers 2.3.0.207 Setup Window](image)

2. Installing the ADI SDP Drivers 2.3.0.207 requires the user to accept the license agreement that appears in Figure 12. Read the agreement before clicking **I Agree** to proceed.

![Figure 12. ADI SDP Drivers (v2.3.0.207) License Agreement Window](image)
3. Choose the destination folder for the ADI SDP drivers and click **Install**. The default folder is shown in Figure 13.

![Figure 13. Choose Install Location](image)

4. The installation begins, and a progress bar shown in Figure 14 is displayed.

![Figure 14. Installing](image)

5. Click the **Close** button shown in Figure 15 when the installation is complete.

![Figure 15. Installation Complete](image)

When plugging in the SDP-H1 board via the provided USB cable, allow the **Found New Hardware Wizard** to run. Check that the drivers are installed and the SDP-H1 board are connected properly by checking the **Device Manager** of the PC. If the drivers and board are connected, **Analog Devices System Development Platform (32MB)** appears under **ADI Development Tools** (see Figure 16).

![Figure 16. Device Manager Menu](image)
Uninstalling the Software
To uninstall the AD40XX Evaluation Software Installer, take the following steps:

1. Launch the uninstall wizard by navigating to Start > Control Panel > Programs and Features > AD40XX Customer Evaluation Software to open a window with the Uninstall button.
2. Click Yes in the confirmation window that appears.

To uninstall the SDP drivers, adhere to the following steps:

1. Launch the uninstall wizard by navigating to Start > Control Panel > Programs and Features > ADI SDP Drivers 2.3.0.207 to open a window with the Uninstall button.
2. Click Yes in the confirmation window that appears.

EVALUATION HARDWARE SETUP PROCEDURES
The EVAL-AD400x-FMCZ evaluation boards connect to the SDP-H1 via the FMC connector (J5). The SDP-H1 is the controller board and functions as the communication link between the PC and connected EVAL-AD400x-FMCZ evaluation board.

Connecting the Evaluation Hardware to a PC
To connect the EVAL-AD400x-FMCZ evaluation board and SDP-H1 board to a PC:

1. Before connecting power, connect the FMC connector of the EVAL-AD400x-FMCZ evaluation board (J5) to the FMC connector on the SDP-H1 board (J4).
2. Power the SDP-H1 with the appropriate supply, as described in the Power Supplies section.
3. Connect the SDP-H1 to the PC with the USB cable.

Verifying Hardware Connection
To verify the AD4000 family evaluation board is properly connected to the PC, take the following steps:

1. Allow the Found New Hardware Wizard to finish running after the SDP-H1 board is connected to the PC via the USB cable. Choose the automatically search for the appropriate drivers option for the SDP drivers if prompted.
2. Verify the hardware to PC connection by navigating to the Device Manager via the Control Panel. If the hardware is properly connected, Analog Devices SDP-H1 appears under ADI Development Tools.
SOFTWARE OPERATION

RUNNING THE EVALUATION SOFTWARE
After installing the AD40XX Evaluation Software Installer (see the Software Installation Procedures section), run the software with either of the following methods:

- Navigate to the destination folder of the AD40XX Evaluation Software Installer selected during the installation procedure and run the EVAL-AD40xx.exe file.
- Click Start > All Programs > Analog Devices > AD40XX Evaluation Software > AD40xx Evaluation Software.

ESTABLISHING HARDWARE CONNECTION
After the AD40XX Evaluation Software Installer initializes, the software front panel appears, and the software automatically connects to any EVAL-AD400x-FMCZ evaluation board connected to the PC. The detected evaluation board is displayed in the Eval Board Connected indicator on the front panel (see Label 7 in Figure 17).

If the software does not detect a valid EVAL-AD400x-FMCZ evaluation board, a connectivity error dialog box appears (see Figure 18). Clicking the Rescan button instructs the software to try to detect the hardware again. Clicking the Offline Mode button causes the software to boot in offline mode. See the Saving and Loading Sessions section for the functions provided in offline mode.

OVERVIEW OF THE FRONT PANEL
The AD40XX Evaluation Software Installer front panel is shown in Figure 17. The following sections describe the various software controls accessible on the front panel.

File Menu
The File menu (Label 1 in Figure 17) provides the following options:

- Save Captured Data (Ctrl + S): saves the current AD40XX Evaluation Software Installer session in a .csv file. The user is prompted to either choose or enter the path of the file in the Save As dialog box. This saved file can be loaded by the software at a future time to display previously captured data.
• **Load Captured Data** (Ctrl + O): opens the Load File dialog box and the user is prompted to load the previously saved evaluation software session files (.csv).

• **Take Screenshot**: saves the current front panel display as an image file (.jpg). The user is prompted to either choose or enter the path of the file in a Save As dialog box.

• **Print Screenshot**: sends a screenshot of the current front panel display directly to the default printer identified by the operating system for printing.

• **Exit**: closes the AD40XX Evaluation Software Installer front panel and exits the software.

**Edit Menu**
The Edit (Label 1 in Figure 17) menu provides the following option:

• **Reinitialize Default Values**: resets a subset of the AD40XX Evaluation Software Installer front panel controls to the default state.

**Help Menu**
The Help menu (Label 1 in Figure 17) provides the following options:

• **Analog Devices Website**: opens the Analog Devices webpage (www.analog.com) in the default browser of the PC.

• **AD4000 Evaluation Hardware Info**: opens the AD4000 family evaluation board EVAL-AD400x-FMCZ product page in the default browser of the PC.

• **Context Help** (Ctrl + H): displays a context help dialog box, which displays information about the various software controls when the mouse hovers over them.

• **About** (Ctrl + A): displays version and copyright information of the AD40XX Evaluation Software Installer in a dialog box.

**Display Tabs**
The following five tabs are located at the top of the front panel (Label 2 in Figure 17): **Configure**, **Waveform**, **Histogram**, **FFT**, and **Summary**. These tabs select various front panel views.

**Single Capture Button**
Click **Single Capture** (Label 3 in Figure 17) to perform a single set of conversions. The number of conversions performed is set with the **Samples** dropdown list, which is located to the left of the **Single Capture** control.

**Continuous Capture Button**
Click **Continuous Capture** (Label 4 in Figure 17) to perform repeated sets of conversions. The number of conversions performed per set is set with the **Samples** dropdown list.

**Samples Dropdown List**
The **Samples** drop-down list (Label 5 in Figure 17) sets the number of conversions that are performed when **Single Capture** is clicked. The button also sets the number of conversions per set when **Continuous Capture** is clicked.

**Status Bar**
The status bar (Label 6 in Figure 17) displays information about the current process being completed by the AD40XX Evaluation Software Installer. The **Status Bar** includes a **Busy** indicator, which displays if the software is busy performing a task such as performing conversions, analyzing results, and so on.

**CONFIGURE TAB**
Figure 17 shows the **Configure** tab view. The **Configure** tab provides controls for configuring the connected AD4000 family device and software settings. The **Configure** tab view contains the following controls and indicators:

• **Eval Board Connected** (Label 7 in Figure 17): indicates that the EVAL-AD400x-FMCZ board is connected to the software.

• **Reference Voltage (VREF)** (Label 8 in Figure 17): sets the VREF used in data analysis such as when calculating LSB Size (see Label 2 in Figure 19), or measured voltage in the waveform graph (see the Waveform Tab View section. This control must be set to match the VREF used on the connected AD4000 family evaluation board.

• **Oversampling Ratio** (Label 9 in Figure 17): sets the oversampling ratio applied to the captured data. After this control is set to any value other than **None**, the software sums up the consecutive conversion results together to increase effective resolution. The number of conversions summed together is set by the **Oversampling Ratio** control.

• **Throughput (kSPS)** (Label 10 in Figure 17): sets the throughput of the connected AD4000 family device. The maximum value of this control is automatically set to reflect the maximum achievable throughput of the connected device, given the state of the **Status Bits** and **Turbo Mode** controls. See the relevant AD4000 family device data sheet for more information on maximum achievable throughput.

• **Device Config Settings** (Label 11 in Figure 17): configures the connected AD4000 family device user configuration register settings. See the relevant AD4000 family device data sheet for a detailed description of the user configuration register and the device features.
  
  • **Status Bits**: enables or disables the status bits for the connected device.
  
  • **Span Compression**: enables or disables span compression for the connected device.
  
  • **High-Z Mode**: enables or disables high-Z mode.
  
  • **Turbo Mode**: enables or disables turbo mode for the connected device.

• **Read Register** (Label 12 in Figure 17): reads the AD4000 family device user register. When **Read Register** is clicked, the contents of the connected AD4000 family device register are read to update the **Device Config Settings** items accordingly.

• **Device configuration settings display** (Label 13 in Figure 17): displays the status of the user register when
**Read Register** is clicked. Each of the following indicators displays the state of the corresponding settings:

- **Status Bits, Span Compression, High-Z Mode, and Turbo Mode** status indicators indicate whether the corresponding AD4000 family device are reported as enabled or disabled in the user configuration register of the connected AD4000 family device.

- **Overvoltage Clamp Flag**: indicates the status of the OV clamp flag in the user configuration register of the connected device. When this indicator is red, the OV flag is low, indicating the presence of an overvoltage event.

- **Status Bits Indicators** (Label 14 in Figure 17): displays the configuration settings of the device as indicated by the status bits. The status bits are enabled with the Status Bits control in the Device Config Settings pane (Label 11 in Figure 17). The Status Bits Indicators are only updated after conversions are performed with the Single Capture or Continuous Capture controls when the status bits are enabled on the connected AD4000 family device. The status bit functionality is described in the relevant AD4000 family device data sheet.

- The **Span Compression, High-Z Mode, and Turbo Mode** status indicators indicate whether features of the corresponding AD4000 family device is reported as enabled or disabled by the status bits of the connected AD4000 family device.

- **Overvoltage Clamp Flag**: displays whether the OV clamp flag in the status bits indicated an overvoltage event in any of the conversions in the most recently displayed results. When this indicator is red, the OV flag is low, indicating the presence of an overvoltage event. See the AD4000 family data sheets for more details on the OV clamp flag.
Figure 19 shows the Waveform tab view. The Waveform tab view shows the time domain representation of the conversion results from the connected AD4000 family device, as well as several analysis items. The Waveform tab view contains the following controls and indicators:

- **Waveform graph** (Label 1 in Figure 19): displays the time domain plot of the most recently captured or loaded conversion results. The scale and range of the waveform graph can be set in the Waveform Analysis box by double clicking on the Minimum Value and Maximum Value fields and entering the desired values. The waveform graph also includes viewing tools that are described in Table 5.

- **Waveform Analysis** (Label 2 in Figure 19): shows the following analysis items for the currently displayed data.
  - **Number of Samples**: displays the number of captured samples in the data displayed in the waveform graph. The displayed value factors in the oversampling ratio that is set with the OSR control.
  - **Pk-Pk Amplitude**: displays the peak-to-peak amplitude of the captured data (the difference between the Maximum Value and the Minimum Value).
  - **Maximum Value**: displays the maximum value measured in the captured data.
  - **Minimum Value**: displays the minimum value measured in the captured data.
  - **OSR**: displays the oversampling ratio applied to the captured data. The OSR can be changed using the Oversampling Ratio control in the Configure tab view.

- **Graph Configuration** pane (Label 3 in Figure 19): sets the following waveform graph axis properties.
  - **X units**: sets the x-axis units of the waveform graph. The x-axis units can be either set to samples or seconds. The time step size, when Seconds is selected, is calculated from the selected Throughput and Oversampling Ratio controls in the Configure tab view.
  - **Y units**: sets the y-axis units of the waveform graph. The y-axis units can be either set to codes or volts. The voltage values, displayed when Volts is selected, is calculated from the LSB Size in the Waveform Analysis items.
  - **X-axis: autoscale**: sets whether the x-axis range of the waveform graph autoscales as new data is plotted or remains at a fixed scale.
  - **Y-axis: autoscale**: sets whether the y-axis range of the waveform graph autoscales as new data is plotted or remains at a fixed scale.
HISTOGRAM TAB VIEW

Figure 20 shows the Histogram tab view. The Histogram tab is useful for performing statistical analysis of the AD4000 family device conversion results, especially when measuring dc signals. The histogram graph shows the distribution of the conversion results as well as various statistical analysis items. The Histogram tab contains the following controls and indicators:

- **Histogram graph** (Label 1 in Figure 20): displays histogram of the most recently captured or loaded conversion results. The scale and range of the histogram graph can be set by double-clicking on the minimum and maximum axis values and entering the desired values. The histogram graph also includes viewing tools, described in Table 5.

- **Histogram Analysis** (Label 2 in Figure 20): shows the following analysis items for the currently displayed data.
  - **Number of Samples**: displays the number of captured samples in the data displayed in the histogram graph. The displayed value factors in the oversampling ratio shown in the OSR indicator.
  - **Pk-Pk Amplitude**: displays the peak-to-peak amplitude of the captured data (the difference between the Maximum Value and the Minimum Value).
  - **Maximum Value**: displays the maximum value measured in the captured data.
  - **Minimum Value**: displays the minimum value measured in the captured data.
  - **OSR**: displays the oversampling ratio applied to the captured data. The OSR can be changed using the Oversampling Ratio control in the Configure tab view.
  - **LSB Size**: displays the effective size (in μV) of each LSB given the resolution of the connected AD4000 family device, and the Reference Voltage (VREF) and Oversampling Ratio values selected in the Configure tab.
  - **Mean**: displays the arithmetic mean of the captured data.
  - **Standard Deviation**: displays the standard deviation of the captured data.
Figure 21 shows the FFT tab view. The FFT tab displays the calculated FFT representation of the conversions results from the connected AD4000 family device and common ac performance metrics. The FFT tab contains the following controls and indicators:

- **FFT graph** (Label 1 in Figure 21): displays an FFT of the most recently captured or loaded conversion results. Set the scale and range of the FFT graph by double clicking on the minimum and maximum values along the x-axis and y-axis and entering the desired values. The FFT graph also includes viewing tools that described in Table 5.

- **FFT Analysis** (Label 2 in Figure 21): displays common ac performance metrics of the captured data. Results are calculated from the FFT spectrum, typically ignoring the first six frequency bins.

- **Throughput**: displays the effective throughput (sample rate) of the captured data. The displayed value factors in the oversampling ratio displayed in the **OSR** indicator.

- **Bin Width**: displays the size of the frequency bins in the FFT graph x-axis. The bin width is a function of both the **Throughput (kSPS)** control (Label 10 in Figure 17) and the number of samples in the captured data.

- **OSR**: displays the oversampling ratio applied to the captured data. The **OSR** can be changed using the **Oversampling Ratio** control in the **Configure** tab.

- **LSB Size**: displays the effective size (in μV) of each LSB. The LSB size is a function of the resolution of the connected AD4000 family device, the **Reference Voltage** (VREF), and the **Oversampling Ratio** values selected in the **Configure** tab view.

- **Dynamic Range**: displays the calculated dynamic range.

- **SNR**: displays the calculated signal-to-noise ratio (SNR).

- **THD**: displays calculated total harmonic distortion (THD), up to the fifth harmonic.

- **SINAD**: displays the calculated single-to-noise and distortion ratio (SINAD).

- **SFDR**: displays the calculated spurious-free dynamic range (SFDR).

- **Fund. Frequency**: displays the frequency identified as fundamental, the frequency bin with the largest signal.

- **Fund. Amplitude**: displays amplitude of the fundamental frequency, the frequency bin with the largest signal.

- **RMS Noise**: displays the measured rms voltage noise.

- **Avg. Noise Floor**: displays the average amplitude of noise frequency bins, more specifically, bins not identified as fundamental or harmonic.

- **Show Harmonic Content**: contains **Frequency** and **Amplitude** information for the fundamental and harmonic tones identified in the FFT. These displays are only visible when toggled by the **Show Harmonic Content** control and are not displayed in Figure 21.

- **Frequency**: frequency bins identified as fundamental and harmonic.

- **Amplitude**: amplitude of the fundamental and harmonic frequencies.

- **Graph Configuration**: sets the following FFT graph axis properties.

  - **X-axis**: autoscale: sets whether the FFT graph x-axis range autoscales as new data is plotted or remains at a fixed scale.
• Y-axis: autoscale: sets whether the FFT graph y-axis range autoscales as new data is plotted or remains at a fixed scale.
• X-axis scale: sets whether the FFT graph x-axis scaling is linear or logarithmic.
Figure 22 shows the **Summary** tab view. The **Summary** tab simultaneously displays the waveform, histogram, and FFT graphs and analysis for the AD4000 family device conversion results on the screen. The **Summary** tab contains the following controls and indicators:

- **Waveform graph** (Label 1 in Figure 22): displays the time domain plot of the most recently captured or loaded conversion results. The scale and range of the waveform graph can be set by double-clicking on the minimum and maximum axis values along the x-axis and y-axis and entering the desired values. The waveform graph also includes viewing tools that are described in Table 5.

- **Histogram graph** (Label 2 in Figure 22): displays the histogram of the most recently captured or loaded conversion results. The scale and range of the histogram graph can be set by double-clicking on the minimum and maximum values along the x-axis and y-axis and entering the desired values. The histogram graph also includes viewing tools that are described in Table 5.

- **FFT graph** (Label 3 in Figure 22): displays an FFT of the most recently captured or loaded conversion results. The scale and range of the FFT graph can be set by double-clicking on the minimum and maximum axis values and entering the desired values. The FFT graph also includes viewing tools that are described in Table 5.

- **Analysis Summary** (Label 4 in Figure 22): shows the following analysis items for the currently displayed data.
  - **Pk-Pk Amp**: displays the peak-to-peak amplitude of the captured data.
  - **Mean**: displays the arithmetic mean of the captured data.
  - **Standard Deviation**: displays the standard deviation of the captured data.
  - **Fund. Freq.**: displays frequency identified as the fundamental (the frequency bin with the largest signal).
  - **Fund. Amp.**: displays the amplitude of the Fund. Freq.
  - **RMS Noise**: displays the measured rms voltage noise of the captured data.
  - **LSB Size**: displays the effective size (in μV) of each LSB. The LSB size is a function of the resolution of the connected AD4000 family device, the Reference Voltage (VREF), and Oversampling Ratio values selected in the **Configure** tab.
  - **Dynamic Range**: displays the calculated dynamic range of the captured data.
  - **SNR**: displays the calculated SNR of the captured data.
  - **THD**: displays the calculated THD of the captured data (up to the fifth harmonic).
  - **SINAD**: displays the calculated SINAD of the captured data.
  - **SFDR**: displays the calculated SFDR of the captured data.
GRAPH VIEWING CONTROLS

The tools described in Table 5 allow users to control the different chart displays within any of the chart panels in the graphical user interface (GUI) tabs.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>![Cursor Tool]</td>
<td>This tool controls the cursor, if present.</td>
</tr>
<tr>
<td>![Zoom Tool]</td>
<td>This tool zooms in and out of the data on the graph.</td>
</tr>
<tr>
<td>![Pan Tool]</td>
<td>This tool is used for panning.</td>
</tr>
</tbody>
</table>

Table 5. GUI Tools

SAVING AND LOADING SESSIONS

The AD40XX Evaluation Software Installer allows users to save and load data to quickly recall previous results.

Clicking File > Save Captured Data or using the shortcut Ctrl + S saves the capture data and relevant sampling parameters for the currently displayed AD4000 family device in a .csv file. These saved files can be loaded at a later time by clicking File > Load Captured Data or using the shortcut Ctrl + O.

Upon loading these .csv files, the evaluation software displays the data in the Waveform, Histogram, FFT, and Summary tabs.

The evaluation software also allows the user to export the raw data of any of the graphs into a generic text file by right clicking them and selecting Export > Export Data to Excel, as shown in Figure 23. The exported data can be used for additional postprocessing, but the generated text file cannot be loaded back into the AD40XX Evaluation Software Installer.

OFFLINE MODE

The AD40XX Evaluation Software Installer can be operated without an accompanying EVAL-AD400x-FMCZ evaluation board. If no EVAL-AD400x-FMCZ evaluation board is detected when the software initializes, the dialog box in Figure 18 is displayed. Clicking Offline Mode causes the evaluation software to boot in offline mode.

In offline mode, new conversion results cannot be captured, but previously saved AD40XX Evaluation Software Installer sessions can be loaded to view previously captured data. See the Saving and Loading Sessions section for instructions on loading previously saved data.
TROUBLESHOOTING

SOFTWARE
To troubleshoot the software, take the following steps:

1. Always install the software before connecting the hardware to the PC.
2. Always allow the install to fully complete (the software is a two-part installation, the ADC evaluation software and the SDP-H1 drivers). A restart is recommended after installation is finished.
3. When the user first plugs in the SDP-H1 board via the provided USB cable, allow the **Found New Hardware Wizard** to run, which can take several seconds. However, allow this to happen before starting the software.
4. If the **EVAL-AD400x-FMCZ** evaluation boards or **SDP-H1** board are connected to the PC via the USB port but are not being detected by the **AD40XX Evaluation Software Installer**, ensure that the board is being recognized in the **Device Manager**, as shown in Figure 16.
5. If connected to a slower USB port where the **SDP-H1** cannot read as quickly as it needs to, a timeout error can result. In this case, it is advised not to read continuously, or alternatively, to lower the number of samples taken.

HARDWARE
To troubleshoot the hardware, take the following steps:

1. If the software does not read back any data, do the following:
   a. Check that the power is applied within the power ranges described in the Power Supplies section.
   b. Using a voltmeter, measure the voltage present at each of the test points: +V_S, −V_S, 1P8V_VDD, VDD_1P8V, +3P3V, +5V, and REF1, and common-mode voltages (REF/2) at IN+ and IN− to ensure that they are accurate. The **SDP-H1** board **LED1** must be illuminated.
   c. Launch the software and read the data. If nothing happens, exit the software.
   d. Power down the board and relaunch the software.
   e. If no data is read back, confirm that the ADC evaluation board is connected to the **SDP-H1** board and that the board is being recognized in the **Device Manager**, as shown in Figure 16.
2. When the user is working with the software in standalone/ offline mode (no hardware connected) and later chooses to connect hardware, close and relaunch the software.
EVALUATION BOARD SCHEMATICS AND ARTWORK

Power supply for Amplifiers

+12V Supply from SDP-H1

VIN = 4.5V, VOUT = 4.18V

VIN = 412V, VOUT = -2.5V

VIN = 412V, VOUT = 47V/5V/3.3V

Secondary Power Connectors

Figure 24. EVAL-AD400x-FMCZ, Power Supplies
Figure 25. EVAL-AD400x-FMCZ, Voltage Reference, Common-Mode and Reference Buffers
Figure 26. EVAL-AD400x-FMCZ, ADC Drivers, and ADC
Figure 27. EVAL-AD400x-FMCZ, EVAL-SDP-CH1Z Connector
Figure 28. EVAL-AD400x-FMCZ Silkscreen, Top Layer

Figure 29. EVAL-AD400x-FMCZ, Layer 1
Figure 30. EVAL-AD400x-FMCZ, Layer 2

Figure 31. EVAL-AD400x-FMCZ, Layer 3
Figure 32. EVAL-AD400x-FMCZ, Layer 4
## Ordering Information

### Evaluation Board Bill of Materials

<table>
<thead>
<tr>
<th>Reference Designator</th>
<th>Description</th>
<th>Manufacturer</th>
<th>Part Number</th>
<th>Stock Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>U1</td>
<td>16-/18-bit, 2 MSPS or 20-bit, 1.8 MSPS precision SAR ADC in 10-lead mini small outline package (MSOP)</td>
<td>Analog Devices</td>
<td>See Table 7</td>
<td>See Table 7</td>
</tr>
<tr>
<td>U2</td>
<td>Ultralow power, low distortion ADC driver, 4 nV/√Hz</td>
<td>Analog Devices</td>
<td>ADA4940-1</td>
<td>Do not place</td>
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<td>U3</td>
<td>High voltage, 1.2 MHz/600 kHz, 800 mA, low quiescent current buck regulator</td>
<td>Analog Devices</td>
<td>ADP2370</td>
<td>ADP2370ACPZ-5.0-R7</td>
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<td>ADP7118</td>
<td>ADP7118AUJZ-3.3-R7</td>
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<tr>
<td>U6</td>
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<td>ADR4550BRZ</td>
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<td>U7</td>
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<td>ADM660ARZ</td>
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<td>U8</td>
<td>IC EEPROM, 2 kb, 400 kHz, 8-lead small outline integrated circuit (SOIC)</td>
<td>ST</td>
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<td>GRM21BR71C225KA12L</td>
<td>FEC 1828829</td>
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<td>4.7 µF, 16 V, X7R, 0805 ceramic capacitor</td>
<td>Taiyo Yuden</td>
<td>EMK21B7475KG-T</td>
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<td>Murata</td>
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<td>GRM21BR71H05KA12L</td>
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<td>TDK</td>
<td>C2012X7R1H225K125AC</td>
<td>FEC 2346945</td>
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<td>C186</td>
<td>SMD capacitor</td>
<td>EPCOS</td>
<td>B37921C9104K60</td>
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<td>L1</td>
<td>1000 Ω at 100 MHz, 1206, WE-CBF SMD, EMI suppression ferrite</td>
<td>Wurth</td>
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<td>Wurth 742792141</td>
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<td>Coilcraft</td>
<td>XAL4040-103ME</td>
<td>XAL4040-103ME</td>
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<td>L4</td>
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### Reference Designator Description

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<th>Reference Designator</th>
<th>Description</th>
<th>Manufacturer</th>
<th>Part Number</th>
<th>Stock Code</th>
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<td>LED1</td>
<td>LED, SMD, green</td>
<td>OSRAM</td>
<td>LGQ971</td>
<td>Digi-Key 475-1409-1-ND</td>
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<td>R1</td>
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<td>MC0063W060312K4</td>
<td>FEC 9330879</td>
</tr>
<tr>
<td>R2</td>
<td>100 kΩ, 0.1 W, 1%, 0805 resistor</td>
<td>Multicomp</td>
<td>MC01W08051100K</td>
<td>FEC 9332405</td>
</tr>
<tr>
<td>R3, R11, R12, R13, R14, R20, R21, R23, R25, R36, R38, R40, R42, R44, R46, R48, R50, R51, R52, R53, R59, R66, R68, R69, R73, R74, R75, R77, R78, R79, R85, R86, R90, R91, R95, R96, R99, R100</td>
<td>0 Ω, SMD resistor</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R4, R5, R8, R9</td>
<td>1 kΩ, 0.063 W, 1%, 0603 resistor</td>
<td>Multicomp</td>
<td>MC0063W060311K</td>
<td>FEC 9330380</td>
</tr>
<tr>
<td>R7</td>
<td>88.7 kΩ, 1%, 0805 resistor</td>
<td>Vishay Draloric</td>
<td>CRCW080588K7FKEA</td>
<td>FEC 2139026</td>
</tr>
<tr>
<td>R10</td>
<td>1%, 0805 resistor</td>
<td>Multicomp</td>
<td>MC01W08050R</td>
<td>FEC 9333681</td>
</tr>
<tr>
<td>R17, R22, R32, R37</td>
<td>49.9 Ω, 0.1 W, 0.1%, 0805 resistor</td>
<td>Panasonic</td>
<td>RN73C2A49R98BTG</td>
<td>FEC 1140694</td>
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<tr>
<td>R24, R41</td>
<td>200 Ω, 0.1 W, 1%, 0805 resistor</td>
<td>Multicomp</td>
<td>MC01W08051200R</td>
<td>FEC 9332758</td>
</tr>
<tr>
<td>R27, R28, R34, R35</td>
<td>Thick film, chip, resistor</td>
<td>Vishay Draloric</td>
<td>CRCW0805590RFKEA</td>
<td>FEC 1653021</td>
</tr>
<tr>
<td>R45, R65, R67</td>
<td>10 kΩ, 0.1 W, 1%, 0805 resistor</td>
<td>Multicomp</td>
<td>MC01W0805110K</td>
<td>FEC 9332391</td>
</tr>
<tr>
<td>R93</td>
<td>20 kΩ, 0.063 W, 1%, 0603 resistor</td>
<td>Multicomp</td>
<td>MC0063W0603120K</td>
<td>FEC 9330771</td>
</tr>
<tr>
<td>R6, R15, R16, R18, R19, R26, R29, R30, R31, R33, R39, R43, R49, R54, R55, R56, R57, R58, R60, R70, R71, R72, R76, R80, R84, R87, R88, R89, R92, R94, R97, R98, R101</td>
<td>SMD resistor, 0603</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>J2, J3</td>
<td>3-pin terminal block (5 mm pitch)</td>
<td>CamdenBoss</td>
<td>CB50000/3</td>
<td>FEC 151790</td>
</tr>
<tr>
<td>J5</td>
<td>160-pin, 10 mm male, VITA 57 connector</td>
<td>Samtec</td>
<td>ASP-134604-01</td>
<td>Samtec ASP-134604-01</td>
</tr>
<tr>
<td>J6, J10</td>
<td>Connector, jack end launch PC gold SMA</td>
<td>Emerson</td>
<td>142-0701-851</td>
<td>Digikey J658-ND</td>
</tr>
<tr>
<td>J8</td>
<td>7-way, SSW, 2.54 mm, vertical socket</td>
<td>Samtec</td>
<td>SSW-107-01-T-S</td>
<td>FEC 1803478</td>
</tr>
<tr>
<td>J9</td>
<td>7-way, SIP, 2.54 mm, TH header</td>
<td>Samtec</td>
<td>TLW-107-05-G-S</td>
<td>FEC 1668499</td>
</tr>
</tbody>
</table>

### Table 7. Evaluation Board Models

<table>
<thead>
<tr>
<th>Product</th>
<th>Ordering Model</th>
<th>Maximum Throughput (MSPS)</th>
<th>Input Type</th>
<th>Sample Rate (MSPS)</th>
<th>Resolution (Bits)</th>
<th>Package Used on Evaluation Board</th>
</tr>
</thead>
<tbody>
<tr>
<td>AD4000BRMZ</td>
<td>EVAL-AD4000FMCZ</td>
<td>2</td>
<td>Pseudo differential</td>
<td>2</td>
<td>16</td>
<td>10-lead MSOP</td>
</tr>
<tr>
<td>AD4001BRMZ</td>
<td>EVAL-AD4001FMCZ</td>
<td>2</td>
<td>Fully differential</td>
<td>2</td>
<td>16</td>
<td>10-lead MSOP</td>
</tr>
<tr>
<td>AD4002BRMZ</td>
<td>EVAL-AD4002FMCZ</td>
<td>2</td>
<td>Pseudo differential</td>
<td>2</td>
<td>18</td>
<td>10-lead MSOP</td>
</tr>
<tr>
<td>AD4003BRMZ</td>
<td>EVAL-AD4003FMCZ</td>
<td>2</td>
<td>Fully differential</td>
<td>2</td>
<td>18</td>
<td>10-lead MSOP</td>
</tr>
<tr>
<td>AD4020BRMZ</td>
<td>EVAL-AD4020FMCZ</td>
<td>1</td>
<td>Fully differential</td>
<td>1.8</td>
<td>20</td>
<td>10-lead MSOP</td>
</tr>
</tbody>
</table>
NOTES

I2C refers to a communications protocol originally developed by Philips Semiconductors (now NXP Semiconductors).

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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