

# EV-AD7284 User Guide UG-1010

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

## Evaluation Board for the AD7284 8-Channel, Li-Ion Battery Monitoring System

### **FEATURES**

Full featured evaluation board for the AD7284 Separate master and slave evaluation kits Direct current daisy chain or isolated daisy-chain options Master configuration kit EVAL-SDP-CB1Z compatible Standalone capability Isolated power and interface Slave configuration kit To be used in conjunction with an AD7284 master evaluation kit Direct interface to the AD7284 master board Daisy-chain capability for chains of up to 20 devices PC software for control and data analysis when used with the Analog Devices, Inc.,SDP, EVAL-SDP-CB1Z

### **EVALUATION KIT CONTENTS**

Four evaluation kits are available for the AD7284 Isolated daisy chain kits EV-AD7284TMSDZ kit EV-AD7284TMSDZ master evaluation board USB cable 9 V (2 A) power supply Direct current daisy chain kits EV-AD7284MSDZ kit EV-AD7284xSDZ master evaluation board USB cable 9 V (2 A) power supply EV-AD7284SSDZ kit EV-AD7284SSDZ kit EV-AD7284SSDZ kit EV-AD7284SSDZ kit, containing an AD7284 mini transformer isolated slave board.

### **EQUIPMENT NEEDED**

### EVAL-SDP-CB1Z SDP

### SOFTWARE NEEDED

Evaluation software for the AD7284 (download this software from the EVAL-AD7284 page) AD7284 Application Installer AD7284 Full Installer

### **GENERAL DESCRIPTION**

The AD7284 is a complete, 14-bit resolution, lithium ion (Li-Ion) battery monitoring system, integrating multiple voltage and auxiliary analog-to-digital converter (ADC) input channels. Full details about the device are available in the AD7284 data sheet from Analog Devices, which should be consulted in conjunction with this user guide when using the evaluation kit.

This user guide describes the four evaluation kits for the AD7284: the EV-AD7284MSDZ, EV-AD7284TMSDZ (containing the AD7284 master board), EV-AD7284SSDZ, and EV-AD7284SSSDZ (containing the AD7284 mini transformer isolated slave board).

Figure 1 and Figure 2 show an overview of the evaluation boards.

On-board components on the master board include isolated power and interface using the ADuM1201 and the ADuM5401 digital isolators, and power using the ADP3303 and the ADP7104 regulators.

The AD7284 master board is used in conjunction with the EVAL-SDP-CB1Z system demonstration platform (SDP) board available from Analog Devices, which must be purchased separately from the evaluation board.

# TABLE OF CONTENTS

Features
Evaluation Kit Contents1
Equipment Needed1
Software Needed 1
General Description
Revision History
Functional Block Diagrams
Evaluation Kits Description
Evaluation Board Features
Caution In a High Voltage Condition
Cell Monitor and Balancing Circuits
Temperature Measurement Capability 6
Board to Board Communication

## **REVISION HISTORY**

5/2017—Revision A: Initial Version

Master Board Supply and Communication Options	7
Connectors Summary	8
Master vs. Slave Configuration	8
Evaluation Board Software	9
Software Installation	9
Software Installation Procedures	9
Evaluation Board Setup Procedures	11
Launching the Evaluation Board Software	11
Possible Errors when Launching the Evaluation Board Software	12
Software Operation	13
AD7284 Evaluation GUI	14

## FUNCTIONAL BLOCK DIAGRAMS

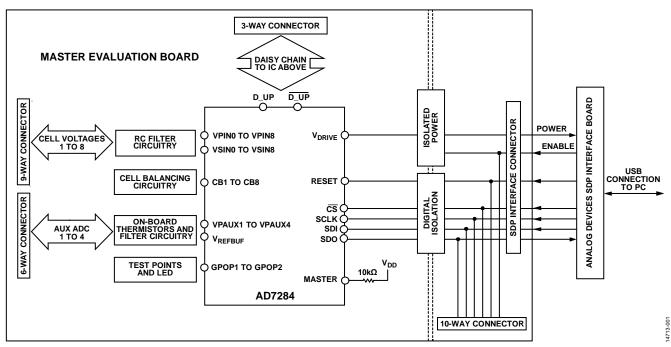


Figure 1. Overview of Master Evaluation Board (Analog Devices SDP Interface Board Sold Separately)

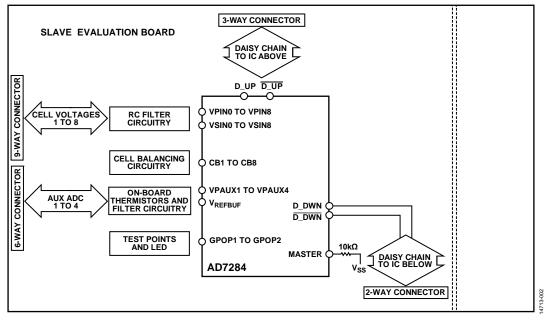


Figure 2. Overview of Slave Evaluation Board

## EV-AD7284 User Guide

## **EVALUATION KITS DESCRIPTION**

Five evaluation kits are available, as described in Table 1.

### Table 1. Evaluation Kits Models

Model	Description
EV-AD7284MSDZ	AD7284 master evaluation kit (direct current daisy-chain configuration)
EV-AD7284TMSDZ	AD7284 master evaluation kit (isolated daisy-chain configuration)
EV-AD7284SSDZ	AD7284 slave evaluation kit (direct current daisy-chain configuration)
EV-AD7284SSSDZ	AD7284 mini transformer isolated slave board

The master evaluation kits contain an AD7284 evaluation board, where the AD7284 device is configured in master mode with a 9 V power supply and a USB cable.

The slave evaluation kits contain an AD7284 evaluation board, where the AD7284 device is configured in the slave mode.

A slave evaluation kit in a direct current daisy-chain configuration must be used in conjunction with a master evaluation kit in the same configuration. A slave evaluation kit with an isolated daisy-chain configuration must be used in conjunction with a master evaluation kit in the same configuration.

The two evaluation boards (master and slave) are based on the same printed circuit board (PCB), populated with a different bill of materials.

Figure 3 shows a master board and slave board connected via the daisy chain in direct current daisy-chain configuration. The master board is responsible for communication with the EVAL-SDP-CB1Z board or with an external digital signal processor (DSP) or microprocessor. The slave board is supplied from the battery cells only and communicates with other boards connected in series in the daisy chain.

The evaluation software communicates with the master via the EVAL-SDP-CB1Z controller board. EVAL-SDP-CB1Z is not available as part of the evaluation kits and is sold separately.

## EV-AD7284 User Guide

# UG-1010

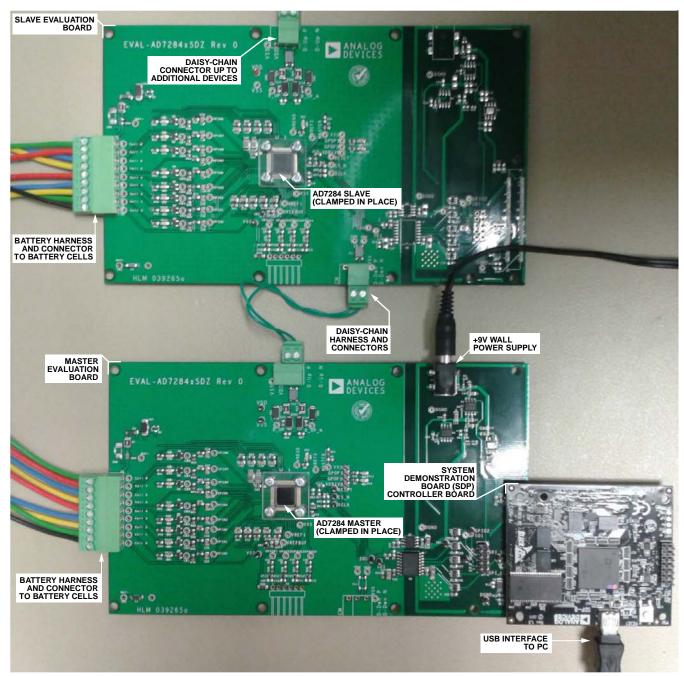


Figure 3. Configuration Showing a Two Device Daisy-Chain Setup



## **EVALUATION BOARD FEATURES** CAUTION IN A HIGH VOLTAGE CONDITION

When multiple boards are daisy-chained together and connected to battery packs, the voltage quickly increases above safe voltage levels. Extreme caution must be taken to ensure safety for the user. It is strongly advised to power down and disconnect the boards from the battery packs when not in use.

## **CELL MONITOR AND BALANCING CIRCUITS**

The evaluation boards connect to the battery cells via the P1 connector. The AD7284 evaluation board is designed to operate over a stack voltage range of 10 V to 40 V.

The slave board is entirely supplied from the battery cells. The master board supply options are discussed in the Master Board Supply and Communication Options section.

Low-pass filters are on the evaluation board for the primary and secondary path.

For demonstration purposes, the cell balancing metal-oxide semiconductor field effect transistor (MOSFET) are connected to LEDs, so activity on the cell balancing circuit is visible. A footprint for resistors is available on the bottom layer of the board.

### TEMPERATURE MEASUREMENT CAPABILITY

### **On-Board Resistance Temperature Detectors (RTDs)**

The VPAUXx inputs are connected by default to on-board 33 k  $\Omega$  RTDs.

### **Off-Board RTDs**

The P2 connector offers the option to connect off-board RTDs, as shown in Table 2.

Pin No.	Connection
1	VREFBUF
2	VPAUX1
3	VPAUX2
4	VPAUX3
5	VPAUX4
6	V <sub>ss</sub>

Capacitor footprints close to the P2 connector can be populated when using an off-board RTD configuration.

### **BOARD TO BOARD COMMUNICATION**

Two configuration options are available: direct current or isolated daisy-chain configuration. The AD7284 evaluation kit is configured for direct current daisy-chain communication. In a chain, the D\_UP and  $\overline{D_UP}$  pins of an AD7284 device must connect to the D\_DWN and  $\overline{D_DWN}$  pins, respectively, of the preceding AD7284 device within that chain, shown in Figure 4.

The pin designations for the P3 and P4 connectors are shown in Table 3 and Table 4.

Table 3. Pin Designations for the Two Way Connector, P3 (Up)	Table 3. Pin	Designations	s for the Two	o Way Connec	tor, P3 (Up)
--	--------------	--------------	---------------	--------------	--------------

Pin No.	Connection
1	D_UP
2	D_UP
3	VDD

# Table 4. Pin Designations for the Two Way Connector, P4 (Down)

Pin No.	Connection
1	ССМ
2	D_DWN
3	D_DWN

P4 is not populated on the master board.

### **Direct Current Daisy-Chain**

Figure 4 shows a direct current daisy-chain configuration.

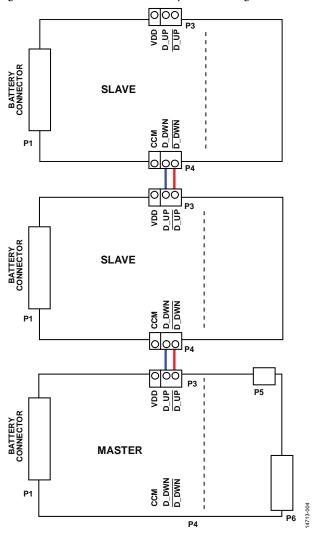


Figure 4. Direct Current Daisy-Chain Configuration of Master with Two Slaves for Direct Current Daisy-Chain Configuration

## Isolated Daisy Chain

Figure 5 shows an isolated daisy-chain configuration.

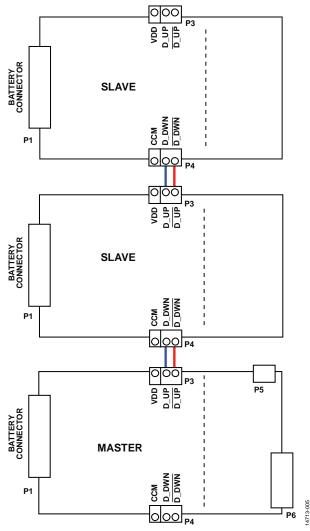


Figure 5. Configuration for Isolated Daisy Chain

# MASTER BOARD SUPPLY AND COMMUNICATION OPTIONS

The master board is responsible for the communication between the chain of AD7284 devices and the host controller. Isolation is provided between the AD7284 master and the host controller through the ADuM5401 and ADuM1201.

A 9 V wall power supply connected to P5 (barrel type) is required to provide power to the low voltage digital circuitry. The serial peripheral interface (SPI) can operate at 3.3 V or 5 V. The default option selected is 5 V, but can be changed via a resistor link (see Table 7). The isolated high voltage side can be powered directly from battery cells or a power supply configured with a resistor stack to emulate battery cells.

The following two options are provided on the master evaluation board to communicate with the chain of AD7284 devices via the SPI:

- Using an Analog Devices controller board (EVAL-SDP-CB1Z).
- In a standalone mode, with connections to an external host.

The master board is configured with the assumption that the Analog Devices controller board is used with the master board.

### Operating with the EVAL-SDP-CB1Z Board

This EVAL-SDP-CB1Z controller board is available from Analog Devices. A standard USB cable is included in the EVAL-SDP-CB1Z package for communication between EVAL-SDP-CB1Z and the PC.

The 120 way connector on the EVAL-AD7284MSDZ plugs directly into the 120 way connector (CON A) on the EVAL-SDP-CB1Z board. The EVAL-AD7284MSDZ evaluation board provides the power supply for the EVAL-SDP-CB1Z board. Table 5 gives a description of the pins on the 120 way connector that interfaces between the EVAL-SDP-CB1Z board and the EVAL-AD7284MSDZ.

Signal	Description
SPI_SS	SPI chip select. This output is connected to the CS pin of the AD7284, via isolation, to frame the serial data
	transfer.
SPI_CLK	SPI clock. This output is connected to the SCLK pin of the AD7284, via isolation, to clock the serial data transfer.
SPI_MISO	SPI master in, slave out data. This input is connected to the SDO pin of the AD7284 via isolation.
SPI_MOSI	SPI master out, slave in data. This output is connected to the SDI pin of the AD7284 via isolation.
GPIO2	General-purpose input/output. This output is connected to the RESET pin of the AD7284 via isolation.
GPIO4	General-purpose input/output. This output disables the power to the ADuM5401 and ADuM1201 on the evaluation board.
VIN	Digital 5 V supply. This 5 V supply provides power to the EVAL-SDP-CB1Z and to the low voltage side of the master evaluation boards.
DGND	Digital ground. These lines are connected to the ground plane on the low side of the evaluation board.

### Operating with an External Host

The following two options are available for interfacing with the evaluation board:

- P6 (120 way connector)
- P7 (eight way connector, not inserted)

The pin designations for the P7 connector are shown in Table 6.

### Table 6. Pin Designations for the Eight Way Connector, P7

Pin No.	Description
1	<u>cs</u>
2	SCLK
3	SDI
4	SDO
5	RESET; active high
6	Control signals enable; active high
7	External supply option
8	GND
9	V <sub>DRIVE</sub> enable; active high
10	GND

The low voltage digital circuit can be supplied from the 9 V power supply or from a 3.3 V or 5 V (default) external supply on P7.

Supply Voltage	Component	
Cold Side (DVDD)		
5 V	R80 inserted, R81 open (default)	
3.3 V	R81 inserted, R80 open	
Hot Side (V <sub>DRIVE</sub> )		
5 V	R6 inserted, R7 open	
3.3 V	R7 inserted, R6 open	
3.3 V Control Signals on P7, with 5 V Supply on Cold Side	R88 inserted, R84 open	

The V<sub>DRIVE</sub> signal (supply for the SPI interface of the master) is turned on by enabling the regulator output powering up the low side of the *iso*Power<sup>®</sup> ADuM5401. This feature is available from Pin 9 of P7, or GPIO4 from the SDP connector (P6) (see Table 5).

### **Master Board Ground Planes**

Extensive ground planes minimize the effect of high frequency noise interference. One ground plane, DGND, is provided for the low voltage digital circuitry, the ADP3303, ADP7104 regulators, the low side of the ADuM5401, and the ADuM1201 isolators. A separate ground plane, isolated from the DGND plane, is provided for the AD7284 on the evaluation board.

### **CONNECTORS SUMMARY**

There are seven connector footprints on the evaluation boards, as shown in Table 8.

### Table 8. Connector Summary

Reference Designator	Description	Comment
P1	Nine way connector for eight Li-lon battery cells	
P2	Six way connector for four primary auxiliary ADC inputs and VREFBUF bias	
Ρ3	External two way (standard daisy chain) or three way (isolated daisy chain) connector to allow daisy-chaining of evaluation boards	
Ρ4	External two way (standard daisy-chain) or three way (isolated daisy chain) connector to allow daisy-chaining of evaluation boards	Populated on the slave board
P5	9 V wall power supply connector (barrel type) to power the low voltage digital circuitry	Populated on the master board
P6	120 way connector for SDP interface connections	Populated on the master board
P7	Eight way connector on nonisolated side for connection to external host processor	Populated on the master board

## **MASTER vs. SLAVE CONFIGURATION**

Table 9 lists the main differences between the master and slave configurations.

### Table 9. Master vs. Slave Configuration

Function	Master	Slave
MASTER	R24 pulled up to VDD	R5 pulled down to V <sub>ss</sub>
RESET	Controlled by the host	R83 pulled down to V <sub>ss</sub>
VDRIVE	Controlled by the host	R27 shorts V <sub>DRIVE</sub> to VREG5
SPI	Controlled by the host	R22, R20, and R21 links to Vss for CS, SCLK, and SDI
D_D <u>WN</u> and D_DWN	R17 and R18 links to V <sub>ss</sub>	FL1, R10, R11, D1, CR1, C14, and P4 populated

## **EVALUATION BOARD SOFTWARE** SOFTWARE INSTALLATION

The AD7284 evaluation software is available to download from the EVAL-AD7284 page.

The following two files are available to download, depending the user requirements:

- Evaluation software full installation. The AD7284 Full Installer full installation software includes the AD7284 application software, LabVIEW<sup>®</sup> run time software, SDP drivers, and .NET4.
- Evaluation software update; the AD7284 Application Installer applies to the AD7284 application only, and is recommended for software upgrades.

### SOFTWARE INSTALLATION PROCEDURES

The following installation steps are for the evaluation software full installation. There are two parts to the evaluation software full installation, which must be performed in the following order:

- 1. AD7284 Full Installer evaluation software full installation (installed first).
- 2. EVAL-SDP-CB1Z SDP board drivers installation and any required .NET4 components.

### Warning

The evaluation board software and drivers must be installed before connecting the evaluation board and the EVAL-SDP-CB1Z board to the USB port of the PC to ensure the evaluation system is correctly recognized when it is connected to the PC.

### Installation Part 1—AD7284 Evaluation Board Software

- 1. Close all open applications.
- 2. After extracting the files from the compressed files described in the Software Installation section, navigate to the **Setup.exe** file to initiate the installation.
- With the board disconnected from the PC, right click on Setup.exe, select Run as Administrator from the pop-up window, and follow the on screen instructions. On a Windows<sup>®</sup> 7 operating system, a dialog box appears as shown in Figure 6.

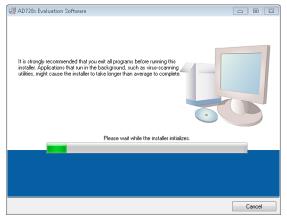


Figure 6. First Step of the Software Installation

4. As the National Instruments run-time engines are installed to support the AD7284 software, a license agreement opens. Read the agreement, then select I accept the License Agreement. and click Next.

License Agreement You must accept the licenses displayed belo	w to proceed.	
NATIONAL INSTRUMENTS SO	FTWARE LICENSE AGREEMENT	
INSTALLATION NOTICE: THIS IS A CONTRACT ( NADIOR COMPLETE THE INSTALLATION PROCI DOWNLOADING THE SOFTWARE AND/OR CLU COMPLETE THE INSTALLATION PROCESS, VOL AGREEMENT AND YOU AGREET O BE BOUND E BECOME A PARTY TO THIS AGREEMENT AND B CONDITIONS CLUCK THE APROPRIATE OUT CONDITIONS CLUCK THE APROPRIATE OUT OD NOT INSTALL OR USE THE SOFTWARE ( MULDING WITH THEIR CONTAINERS) TO THE FU SHALL BE SUBJECT TO NIST THE CURRENT F	ESS, CAREFULLY READ THIS AGREEMENT. BY KING THE APPLICABLE BUTTON TO U CONSENT TO THE TERMS OF THIS U CONSENT TO THE TERMS OF THIS BOUND BY ALL OF ITS TERMS AND DE OLVING THE INSTALLATION PROCESS, DETURN THE SOFTWARE WITHIN THIRTY TH ALL ACCOMPANYING WRITTEN MATERIALS, CC YOU OBTINGED THEM ALL FERTURES	-
The software to which this National Instruments license a	<ul> <li>pplies is AD 728x Evaluation Software.</li> <li>I accept the License Agreement.</li> </ul>	
	<ul> <li>I do not accept the License Agreement.</li> </ul>	
	<	

Figure 7. Accepting the National Instruments License Agreement

5. The default location of the installation is shown in Figure 8. It is recommended not to change from this location. Click **Next**.

AD728x Evaluation Software	
Destination Directory Select the primary installation directory.	
All software will be installed in the following locations. To install software into a different location, click the Browne button and select another directory.	
Directory for AD728x E valuation Software C:\Program Files (x86)\Analog Devices\AD7284\	Browse
Directory for National Instruments products [C:\Program Files (d86)National Instruments\	Browse
<< Back Next >	> Cancel

Figure 8. Default Destination Directory

6. A summary of the installation is displayed. Click **Next** to continue.

State (Test-enduring)         Revealed the following summary before continuing.         • AD720x Evaluation Software Files         Click the Next button to begin installation. Click the Back button to change the installation settings.	AD728x Evaluation Software				- • •
		ary before continuing.			
Click the Next button to begin installation. Click the Back button to change the installation settings.	Adding or Changing • AD728x Evaluation Software Files				
	Click the Next button to begin installation	n. Click the Back butto	in to change the inst	allation settings.	

Figure 9. Reviewing a Summary of the Installation

14713-006

7. A dialog box informs the user of the progress of the installation.

🛃 AD728x Evaluation Software	
D verall Progress: 74% Complete	
Copying new files	
<< Back Next >>	Cancel
<< Back Next>>	

Figure 10. Installation in Progress

8. A dialog box informs the user when the installation is complete. Click **Next.** 

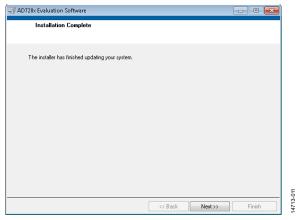


Figure 11. Indication that the Installation Is Complete

9. The software may request to restart the PC at this time. Do not restart the PC until the installation is complete. Click **Restart Later.** 

AD728x	Evaluation Software	
٩	You must restart your computer to complete this operation. If you need to install ha <sup>1</sup> /dware now, shut down the computer. If you choose to restart later, restart your computer before running any of this software.	
	Restart Shut Down Restart Later	14713-012

Figure 12. Starting the Installation

### Installation Part 2—EVAL-SDP-CB1Z Driver Installation

After the installation of the evaluation board software is complete, a welcome window is displayed for the installation of the EVAL-SDP-CB1Z SDP board drivers.

1. With the EVAL-SDP-CB1Z board still disconnected from the USB port of the PC, ensure all other applications are closed and click **Next**.

ADI SDP Drivers 2.2.95.68 Se	tup 🗖 🗖 🗾
	Welcome to the ADI SDP Drivers 2.2.95.68 Setup Wizard This wizard will guide you through the installation of ADI SDP Drivers 2.2.95.68. It is recommended that you close all other applications before starting Setup. This will make it possible to update relevant system files without having to reboot your computer. Click Next to continue.
	Next > Cancel

Figure 13. Beginning the SDP Driver Installation

4713-013

2. Select a location to install the drivers, and then click Next.

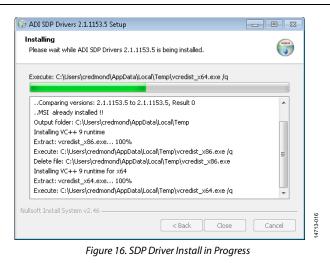
🧟 Microsoft .NET Framework 4 Client Profile Setup	23
Installation Progress Please wait while the .NET Framework is being installed.	Microsoft .NET
File security verification:	
All files were verified successfully.	
Installation progress:	0
	Cancel

Figure 14. Initializing the .NET4 Installation as Part of the SDP Driver Installation

3. Click **Install** to confirm the installation of the drivers.



Figure 15. Grant Permission to Install Drivers



4. To complete the driver installation, click **Close** to close the installation wizard.

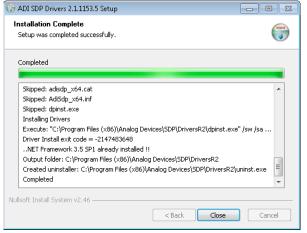


Figure 17. SDP Driver Installation Complete

5. Before using the evaluation board, you must restart the PC.

## **EVALUATION BOARD SETUP PROCEDURES**

The AD7284 evaluation board connects to the EVAL-SDP-CB1Z SDP board. The EVAL-SDP-CB1Z board is the controller board, which is the communication link between the PC and the evaluation board.

After following the instructions in the Software Installation Procedures section, set up the evaluation and SDP boards as detailed in this section.

### Configuring the Evaluation and SDP Boards

After installation is complete, take the following steps:

- 1. Connect the 9 V wall power supply included in the evaluation kit to Connector P5 on the evaluation board.
- 2. Connect the EVAL-SDP-CB1Z board (Connector A) to the AD7284 evaluation board (Connector J8).
- 3. Connect the EVAL-SDP-CB1Z board to the PC USB port using the supplied USB cable.

Allow the new Found Hardware Wizard to run. This detects and loads the drivers for the EVAL-SDP-CB1Z board.

When the evaluation system is detected, proceed through any dialog boxes that appear. This completes the installation.

The AD7284 evaluation software and hardware are designed such that all conversion results can be captured by the EVAL-SDP-CB1Z board and uploaded through the USB port to the PC. If there is a lot of activity on the USB port, the speed of the data transfer can be reduced. In this case, the user must disconnect other external devices that may be using the USB port, increase the conversion loop interval, or decrease the number of samples to ease the requirement on the USB port. Note that the transfer of data from the EVAL-SDP-CB1Z to the PC is slower when connecting to a USB 1.1 port than it is when connecting to a USB 2.0 port.

## LAUNCHING THE EVALUATION BOARD SOFTWARE

To run the software, perform the following steps:

- From the Start menu, Select All Programs > Analog Devices > Analog Devices - AD7284 > AD7284 GUI. The main window of the software graphical user interface (GUI) displays, shown in Figure 24.
- 2. When the software starts running, it searches for hardware connected to the PC. The **Hardware Select** dialog box indicates when the evaluation board and EVAL-SDP-CB1Z board are detected. Click **Select** to continue.

1 matching system matching board.	found. LED1 is flash	iing on	
Press Select to use 1	this board.		
SDPB: AD7284			^
			-

Figure 18. Software Finds the Evaluation Board and EVAL-SDP-CB1Z Board

4712-017

# POSSIBLE ERRORS WHEN LAUNCHING THE EVALUATION BOARD SOFTWARE

If the incorrect version of the LabVIEW run-time system is installed as part of the AD7284 evaluation board software installation, the warning message shown in Figure 19 displays. To resolve this issue, the user must install the evaluation software full installation file (see the Software Installation Procedures section).

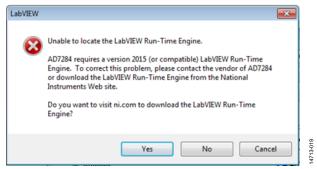


Figure 19. LabVIEW Run-Time Warning Displayed if the National Instruments Support Software is Not Installed Correctly

If the software displays the message shown in Figure 20, the user must reset the EVAL-SDP-CB1Z board by pressing the RESET button on the EVAL-SDP-CB1Z board (next to the USB connector). The window displayed in Figure 20 opens, followed shortly by the window displayed in Figure 18.

System Development Platform Wa	ait 🛛 🖾
Waiting for transfer to Controller	
	Cancel

Figure 20. SDP Platform Transfer Window

If the EVAL-SDP-CB1Z board is not connected to the USB port when the software is launched, a connectivity error displays (see Figure 21). Connect the EVAL-SDP-CB1Z board to the USB port of the PC, wait a few seconds, click **Select**, and follow the instructions, as shown in Figure 18.

 istems found. Please er ectly or press Cancel to	
may be in the process to 40 seconds to boot.	
	•

If the boards cannot be found, disconnect the 9 V supply from the evaluation board and the USB cable from the EVAL-SDP-CB1Z board, reconnect the USB cable, wait a few seconds, reconnect the 9 V supply, and then restart the AD7284 GUI as described in Launching the Evaluation Board Software section.

If power (>10 V) is not supplied to the P1 battery connector, the device does not operate normally after selecting **Connect** on the GUI.

In the event that the AD7284 evaluation board does not have power supplied to the P1 battery connector, clicking the **Connect** button results in the alert show in Figure 22.

If power is available and connected at P1, select **Retry**; the user must select **Connect** to restart the initialization process.

Þ.		X	
	Check the D	UT Supply	
	Retry	Quit	000 0111

Figure 22. Warning to Indicate the AD7284 Board Cannot be Found

If the user continues to experience difficulties detecting the evaluation board, check that the drivers and the SDP board are recognized in the **Device Manager** of the PC. The Device Manager can be found in the following location: **Control Panel** > **System > Device Manager**.

The SDP board appears under **ADI Development Tools** as shown in Figure 23.

🚔 Device Manager 📃 📼 💌
File Action View Help
CREDMOND-L03
ADI Development Tools
Analog Devices System Demonstration Platform SDP-B
🖕 🔊 Batteries
⊳
⊳
🔈 👝 Disk drives
🔈 📲 Display adapters
DVD/CD-ROM drives
> 🕼 Human Interface Devices
Imaging devices
> — Keyboards
b -
Mice and other pointing devices
Monitors
🔉 👷 Network adapters
Portable Devices
Ports (COM & LPT)
Processors
Sound, video and game controllers
Storage controllers
▶ - 🖳 System devices
🔈 🖷 Universal Serial Bus controllers

Figure 23. Confirming the SDP Board is Connected in the Device Manager

## SOFTWARE OPERATION

With the hardware set up, the software can control the EVAL-SDP-CB1Z and the AD7284 evaluation board. From the **Start** menu, select **All Programs** > **Analog Devices** > **Analog Devices** - **AD7284** > **AD7284 GUI**. The main window of the software GUI displays, shown in Figure 24. The main function of this window is to allow the user to read samples from the evaluation board and display them.

/elcome		ETA 2.1	🔵 Data Log	Processing Log	
> Connect	Start Conversions	Cell Balance Control	Diagnostics Log	WD Timer	EXIT
Chart All Data Die Tem	perature Registers Diag	gnostics Data Log Comm	and Log	Period (ms)	Duration (ms)
Display Control	4.000 -				VPIN1 💑
Device	4.000				VPIN2
DUT1	3.800 -				VPIN3
	3.600-				VPIN4
Channel	3				VPIN5 📈
Primary	3.400 -				VPIN6
Туре	3.200 -				VPIN7
Volts	ε				VPIN8
Display Points	.e 3.000 -				VSTK 📇
200	- 000.5 - 000.5 - 008.5 - 008.5				VREF2
					VREG5_1
	2.600-				AUXP1 AUXP2
	2.400-				
	2.200				AUXP4
	2.200-				
	2.000-				VREG5_2
	1 000				
	1.800- <mark>-</mark> 0			127	
		San	nple		

Figure 24. Evaluation Software Main Window

### **AD7284 EVALUATION GUI**

The evaluation software can be divided into the following three main sections:

- Front panel control. This control enables the basic operation of the device.
- Display tabs. These tabs enable the user to view and recall data from the system.
- Menu bar. The menu bar controls data acquisition and the logging of data.

### **Front Panel Control**

The main controls used to operate the AD7284 chain are found on the front panel.

### Connect

Click **Connect** to connect the software to the AD7284 system. This action starts the procedure to detect the EVAL-SDP-CB1Z board and initialize the chain of devices. After the chain is configured, a message similar to that shown in Figure 25 appears. In this example, the master address is the default value of 0x01 and three devices are detected and configured. The additional front panel buttons, **Start Conversions** and **Cell Balance Control**, are now enabled.

14713-024

3 parts	s found, Master i	s 0×01			
$\triangleright$	Connect	$\triangleright$	Start Conversions	Cell Balance Co	ontrol

Figure 25. Message Indicating That a Chain of Three Devices is Detected

### **Start Conversions**

Click **Start Conversions** to initiate the configured conversion sequence.

### **Cell Balance Control**

Click **Cell Balance Control (see** Figure 24) to display the Cell Balance Control window, shown in Figure 26.

The **AD7284 CB Display** window controls the cell balance (CB) functions of the AD7284.

🔚 AD7284 CB Display	<b>_X</b>
	CB Enable State
Timers: Set(min) CB State (min)	Power
0.00	GOE
0.00	
	CB Pattern
0.00	<ul> <li>Odd Channels</li> <li>Even Channels</li> <li>All OFF</li> </ul>
0.00	Device
0.00	All
0.00	DUT
0.00	
Timer Mode	
Application (2 minutes)	End CB

Figure 26. Cell Balance Control Pop-Up Window

The CB function is enabled by selecting the CB output (CB1 to CB8), time to balance, and the CB enable state.

To enable power to the CBx outputs, select **Power** and **GOE** (see to the AD7284 data sheet for a more detailed explanation of the CBx function).

To select a CBx output,

- 1. Choose which device to control.
  - By default, All is selected, mirroring the configuration across all devices in the chain.
  - Deselecting All enables the DUT spin box and only the device that is selected is affected by further changes to the CB control.
- 2. To select individual CBx outputs,
  - a. Configure the time that the CBx output remains on using the **Configure Set Time** and **Elapsed Time** control for the appropriate CBx port. The **Timer Mode** spin box enables a demonstration mode to enable a fast counter to be enabled. This function is not supported for customer applications.
  - b. Enable the CBx port by selecting the appropriate green LED.
  - c. Use the **CB Pattern** options to quickly create a checker board pattern or to deselect all CBx ports.
- 3. To finish the CB operation, click **End CB** to disable the CBx outputs and turn off power to the CBx ports.

### Exit

Click **Exit** to power down the chain and exit the software in a controlled manner.

### Display Tabs

### Chart Tab

4713-026

The **Chart** tab displays the current conversion data. Controls are available to select the device under test (DUT) and data type to be displayed.

The **Display Control** area only affects the amount of data shown on the trace; it has no effect on the logging function. Right clicking on the chart displays functions to clear the chart or export data.

	AD7284 B	ETA 2.1	🔵 Data Log	Processing Log		
> Connect	Stop Conversions	Cell Balance Control	Diagnostics Log	WD Timer	EXIT	
Chart All Data Die Te	mperature Registers Diag	gnostics Data Log Com	mand Log	Period (ms)	Duration (ms) 72	
Display Control Device	3.400 3.390 3.300 3.370 3.360 3.370 3.360 3.350 3.300 3.320 3.300 3.300 3.290 3.200 3.200 3.200 41	Anamakana subaringana an Si	imple	нарбия Фадирони ок 174	✓ VPIN1         Image: Second Sec	

Figure 27. Measurements Window Showing Current Conversion Results

Converti	ing								Data L	-	~	cessing Log	(	
>	Connect	Stop C	Conversion	s	> C	ell Balanc	e Control		Diagno	ostics Log	e we	) Timer	DAL	
Chart	All Data Die Ter	nperature	Registe	ers Dia	ignostics	Data L	og   Co	m m and L	og			Period (ms)	) 117 Duration (ms) 97	
	[	DUT1	DUT2	DUT3	DUT4	DUT5	DUT6	DUT7	DUT8	DUT9	DUT10	DUTA		L
	VPIN1-VSIN1	0.0027	0.0037	0.0003	0.0021	0.0049	0.0046	0.0006	0.0027	0.0006	0.0052	0.00		
	VPIN2-VSIN2	0.0021	0.0015	0.0015	0.0067	0.0024	0.0012	0.0015	0.0024	0.0015	0.0018	0.00		
	VPIN3-VSIN3	0.0040	0.0049	0.0009	0.0003	0.0009	0.0000	0.0003	0.0003	0.0006	0.0052	0.00		
	VPIN4-VSIN4	0.0024	0.0037	0.0031	0.0034	0.0043	0.0037	0.0037	0.0043	0.0037	0.0037	0.00	Display	
	VPIN5-VSIN5	0.0037	0.0021	0.0034	0.0021	0.0037	0.0021	0.0018	0.0027	0.0024	0.0079	0.00	VPIN-VSIN	
	VPIN6-VSIN6	0.0015	0.0021	0.0018	0.0024	0.0034	0.0021	0.0024	0.0027	0.0024	0.0027	0.00		
	VPIN7-VSIN7	0.0018	0.0043	0.0012	0.0003	0.0003	0.0009	0.0043	0.0003	0.0006	0.0049	0.00	Function	
	VPIN8-VSIN8	0.0006	0.0024	0.0000	0.0037	0.0061	0.0018	0.0040	0.0009	0.0027	0.0000	0.00		
	Sum VPIN - Stack		-0.0241	-0.0134	-0.0131	-0.0131	-0.0049	-0.0113	-0.0085	-0.0134	-0.0174	-0.0:	Raw	
	Vref1 - Vref2	-0.0009	-0.0055	0.0009	-0.0006	-0.0012	0.0000	-0.0003	-0.0009	-0.0003	-0.0064	-0.01		
	L											-111		
														L
	4													
	<u> </u>			_	_			_	_	_	_			

Figure 28. All Data Tab Showing the Conversions Results

## EV-AD7284 User Guide

### All Data Tab

The **All Data** tab, shown in Figure 28, displays data from all devices in the chain.

The **Display** spin box enables the user to view primary conversion data, secondary conversion data, or the difference between primary and secondary data (with the addition of a stack minus sum of VPINx and  $V_{REF1} - V_{REF2}$ ).

The **Function** spin box allows the user to view the raw data or a peak hold value (maximum absolute value measured).

### **Die Temperature Tab**

The **Die Temperature** tab (see Figure 29) displays the current die temperature for each device in the stack. The die temperature is displayed in degrees Celsius. The voltage returned by the temperature sensor can also be seen on the **Chart** tab.

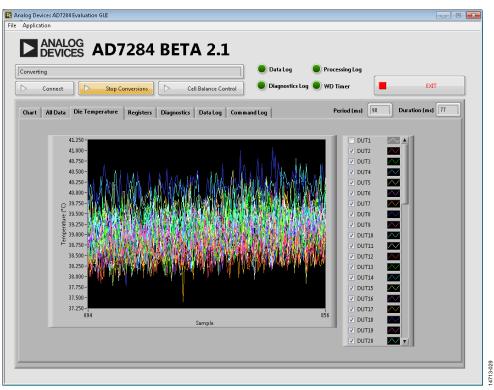


Figure 29. Die Temperature Display Showing the Current Die Temperature Measurement (in Degrees Celsius)

### **Registers** Tab

The **Registers** tab gives access to the registers of each device in the chain.

The main table displays the contents of the registers after **Read All Registers** is selected; this function is only available when the device is not in a conversion cycle.

The **Save Register Data** control enables the user to save the contents of the register table to a .csv text file.

The **Write Register Control** area (see Figure 30) enables the user to write to a specific register in either all devices or a unique device in the chain.

Select **All Parts** to address all devices in the chain, With **All Parts** deselected, the **Device** selects a specific device.

The addressed register can be selected with the **Register** spin box. The **Value** spin box is the hexadecimal value written to a register.

	ANAL DEVI		A	D7	284	BE	:T/	2.1							
	ing									0	)ata Log		Processing	Log	
	Connect	) (		0.0			<u> </u>	l Balance Coi			)iagnosti	ts Log	WD Timer		ÐŒT
_	Connect			stop Co	nversions		Cei	I Balance Col	ntrol		,				
rt	All Data	Di	e Tempera	ature	Registers	Diagno	ostics	Data Log	Comma	nd Log			Period	(ms) 116	Duration (ms) 97
						-				-					
F	DevID	01	02	03	04	05	06	07	08	09	0A	0B		D Re	ad All Registers
	FAULT	00	00	00	00	00	00	00	00	00	00	00	- âl III	-	
	CBCNT	00	00	00	00	00	00	00	00	00	00	00		D Sa	ve Register Data
	PDCNT	00	00	00	00	00	00	00	00	00	00	00			-
	WDCNT	00	00	00	00	00	00	00	00	00	00	00			
lt	CTRL1	00	00	00	00	00	00	00	00	00	00	00		[	
lli	CTRL2	00	00	00	00	00	00	00	00	00	00	00		Wr	ite Register
	CTRL3	00	00	00	00	00	00	00	00	00	00	00		All Parts	Device
	CTRL4	06	06	06	06	06	06	06	06	06	06	06		All Parts	
I	CBCTRL	00	00	00	00	00	00	00	00	00	00	00			DUT1
	OISCTRL	00	00	00	00	00	00	00	00	00	00	00		Register	
	OISGPOP	00	00	00	00	00	00	00	00	00	00	00		DevID	
	PDT	00	00	00	00	00	00	00	00	00	00	00		Uevid	
	CBT1	00	00	00	00	00	00	00	00	00	00	00		Value	
	CBT2	00	00	00	00	00	00	00	00	00	00	00		÷ × 00	
	CBT3	00	00	00	00	00	00	00	00	00	00	00			
	CBT4 CBT5	00	00	00	00	00	00	00	00	00	00	00			
	CB15 CBT6	00	00	00	00	00	00	00	00	00	00	00			
	CBT6 CBT7	00	00	00	00	00	00	00	00	00	00	00			
	CBT/ CBT8	00	00	00	00	00	00	00	00	00	00	00	- <b>v</b>		
		00	00	00	00	00	00	00	00	00	00	00	P I		
Ľ	-														
	_	-	_	-		_		_	_	_	_	_			

Figure 30. Registers Displaing the Current Value

### **Diagnostics** Tab

The **Diagnostics** tab shows the calculation of diagnostics since the start of the conversion sequence. The levels to control the diagnostics are found under the **Internal Voltage Limits** option in the **Application** menu in the menu bar (see Figure 38). Further details on the diagnostics can be found in the AD7284 Safety Manual and the AD7284 data sheet.

ANALOG DEVICES A	<b>D7</b> 2	284	BE	T	<b>4 2.</b> ]	L									
erting		. )					Š	)ata Log )iaqnostics	log		sing Log			ĐŒ	r
Connect	Stop Con	versions	$\triangleright$	Ce	ll Balance Co	ntrol		nignostics	Log		in ci				
t All Data Die Temper	ature	Registers	Diagnos	stics	Data Log	Comm	and Log			Pe	riod (ms)	220	Dura	tion (ms)	204
				0		0	0		0	0		0	0	0.0	
Vreg2/3 Under (SM6) Vreg2/3 Over (SM6)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Vreg2/3 Over (SM6) Vref2 Under (SM6)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Vref2 Over (SM6)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Vrefbuf Under (SM6)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Vrefbuf Over (SM6)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Vreg4/5 Under (SM6)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Vreg4/5 Over (SM6)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Vref1 Under (SM6)	0	0	0	0	0	0	0	0	0	ů.	Û	0	0	0	
Vref1 Over (SM6)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
VPIN-VSIN (SM18)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Vref1-Vref2 (SM5)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
64bit CRC (SM13b)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
32 bit CRC (SM13a)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Stack Error (SM4)	0	5	0	0	0	0	0	0	0	0	0	0	0	3	
Address = 0 (SM12)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
PORFLAG (SM8b)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
WDFAULT (SM14)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
LDOFAULT (SM8a)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
FUSECRC (SM1b)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
DCMFAULT (SM10)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
CFGFAULT (SM16)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
OSCDRIFT (SM15b)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
(						_									

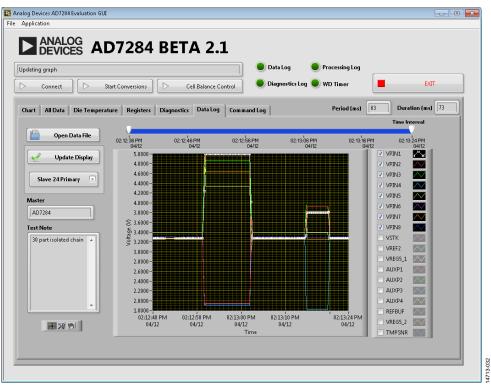
Figure 31. Diagnostics Window Showing the Accumulation of Events Since the Last Conversion Sequence

### Data Log Tab

The GUI provides a basic interface to recall data saved using the logging function.

- 1. Select the data to display by clicking **Open Data File**.
- 2. After a file is selected, the **Time Interval** slider shows the extent of the data captured during a test. Use the sliders to select the portion of data to display, useful for larger files. The **Master** field and **Test Note** list box are also populated.
- 3. Select **Update Display** to update the graph with the selected data.
- 4. Right clicking on the graph opens additional graph functions. For example, right clicking the graph offers the option to clear the graph (**Clear Data**) or to send all the data to an Excel file (**Export to Excel**).

For larger technical data management solution (TDMS) files, a TDMS file viewer such as National Instruments DIAdem<sup>™</sup> allows easy opening, navigation, and viewing (see Figure 33).



### Figure 32. Recall Data

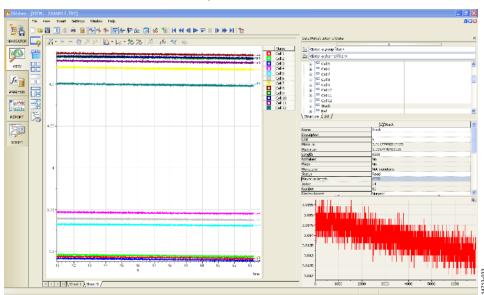


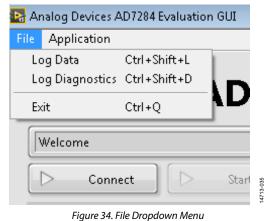
Figure 33. TDMS Data Viewed National Instruments DIAdem

### **Command Log Tab**

The **Command Log** tab enables the user to capture snapshots of the register read and writes to the AD7284 (see Figure 35). It is not recommended to enable this feature for long periods while continuously converting due to the volume of data that the code attempts to capture.

**Save Log** enables the user to export the contents of the display log to a text file.

### File Dropdown Menu



📴 Analog Devices AD7284 Evaluation GUI

#Disable WD Timer WRITE32 0xFFE013B2 WRITE32 0xFE100F8E WRITE32 0xFE100F8E WRITE32 0xFE100F8E

WRITE32 0xFE00F82 WRITE32 0xFFE013B2 WRITE32 0xFFE013B2 WRITE32 0xFE013B2 WRITE32 0xFE100F82 #Disable WD Timer WRITE32 0xFE00F82 WRITE32 0xFE00F82 #Disable WD Timer

The **File** dropdown menu contains the function to save conversion data.

The **Exit** option closes the software immediately; it does not shut down the chain of devices prior to exit and must only be used as a last resort.

### Log Data Command

The log data command enables the user to record all the conversions from a chain of AD7284 devices in a chain (see Figure 36).

### **Start Logging Data**

Select File > Log Data to start logging data.

Selecting the **Log Data** option opens a dialog box that prompts the user to select the root directory for the results file as well as the option to record a system identifier (**System ID**) and a note (**Log Note**).

ÐŒ

14713-034

riod (ms) 83 Duration (ms) 73

onfigure Chain - 31 parts found, Ma				
	ister is uxul		Data	Log
> Connect	tart Conversions	Cell Balance Con	trol Diag	nostics Log
Chart All Data Die Temperat	ure Registers Diagno	stics Data Log	Com mand Log	
		sucs Data Log		
Log				
#Set WD timer to 0.100 ms WRITE32 0xFFE013B2	<u>^</u>		nable Command Logo	nina
WRITE32 0×FE10CC9C	E			
#Set WD timer to 0.100 ms WRITE32 0xFEE013B2			ar Log	

Figure 35. Command Log Tab

Device	Revision	Configuration Note	System ID ADI_EVAL 1
AD7284			Log Note
Device	Revision	Configuration Note	Logitote
		Standard	
Device	Revision	Configuration Note	
		Standard	

Figure 36. Log Data Command

After the dialog box closes, the **Data Log** indicator flashes green and orange and a tick appears next to the **Log Data** option.

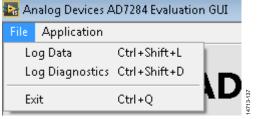


Figure 37. Log Data Started

### **Stop Logging**

When data logging is in progress, select **File** > **Log Data** (removing the tick) to stop logging data.

The following events occur in order, without action by the user, when the logging is stopped:

- 1. The Data Log indicator stops flashing.
- 2. The **Processing Log** indicator starts to flash, indicating that a post processing step is initiated.
- 3. After post processing completes, the data file path is shown in the **Message** window.

Data is stored in TDMS form. Files in this format can be viewed using the following:

- The National Instruments TDM Excel Add-In
- The Recall Data window of the AD7284 GUI
- DIAdem or other third party packages

### Application Dropdown Menu

The **Application** menu contains the main functions used to control the conversion loop.

File	Application	
	Master Address	Ctrl+Shift+M
	<b>Conversion Control</b>	Ctol+Shift+C
	Acquisition Time	Ctol+Shift+T
	Current Matching	Ctd+Shift+I
- 4	ADC Delay	Cbl+ShiR+C
10	WatchDog Timer	Col+Shift+W
Ŀ	Internal Voltage Limits	Ctrl+Shift+V

Figure 38. Application Dropdown Menu

### **Master Address**

The **Master Address** window allows the user to enter the address of the master device in hexadecimal format. When selecting **OK**, the chain is reinitialized with the new master address.



Figure 39. Master Address Control

4713-038

### **Conversion Control**

The **Conversion Control** window gives the user control over the acquisition cycle (see Figure 40).

With **Fixed Samples Count** disabled, the system operates in continuous conversion mode. When **Start Conversions** is selected, **Fixed Samples Count** being disabled is the default setting.

With **Fixed Samples Count** enabled, the system runs through the number of cycles specified using the **Number of Samples** spin box when **Start Conversions** is selected.

The target loop period, in milliseconds, is defined using the **Period (ms)** spin box.

## EV-AD7284 User Guide

4713-042

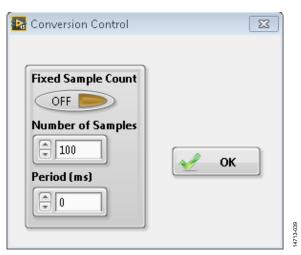


Figure 40. Conversion Control Pop-Up Window

### **Acquisition Times**

The **Acquisition Times** window enables the ADC acquisition time to be controlled.

💀 ADC Delay	83	
Delay Mode	1	
<b>№</b> ОК		

Figure 41. Acquisition Time Control

### **Current Matching**

The **Current Matching** window allows the best device current matching options to be selected for each device in a chain. See the AD7284 data sheet for further details on current matching.

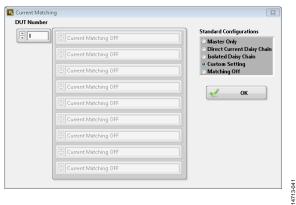


Figure 42. Current Matching Setup Window

### ADC Delay

The **ADC Delay** window allows the user the select the ADC delay type used for the whole chain. The default value is **No Delay**; options are available to enable the delay mode between the primary and secondary conversions. See the AD7284 data sheet for further details.

	Mode	
Ho I	Delay	
<b>√</b>	ок	

Figure 43. ADC Delay Mode Pop-Up Window

### Watchdog Timer

The **WatchDog Timer** window enables the user to set the maximum time allowed to service the watchdog timer before the device powers down. See the AD7284 data sheet for further details.

Ti	meout (ms)	Enab	
4	100	О К	OFF

Figure 44. Watchdog Timer Control

When the **Enable** switch is toggled to **ON**, the **WD** Timer LED indicator on the main window is illuminated.

### **Internal Voltage Limits**

The **Internal Voltage Limits** window sets the levels to control the diagnostics. See the Diagnostics Tab section and the AD7284 data sheet for more details.

Primary Limits			🖌 ок
Vreg 2/3	Vref2	Vrefbuf Stack	
Min	Min	Min 🔹 30m	
3.197	2.485	2.54	
Max	Max	Max	
3.466	2.518	2.454	
Secondary Lim	its		
Vreg 4/5	Vref1	Cross Check	
Min	Min	Vref1 - Vref2	
	2.495	2.495	
3.84		2.495	
	Max		
3.84 Max	Max	VPIN - VSIN	

Figure 45. Internal Voltage Limits for Diagnostics Calculations

## 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.

©2017 Analog Devices, Inc. All rights reserved. Trademarks and registered trademarks are the property of their respective owners. UG14713-0-5/17(A)



www.analog.com