

Evaluation Board for the AD7190/AD7192 4.8 kHz Ultralow Noise 24-Bit Sigma-Delta ADCs

FEATURES

- Full-featured evaluation board for the AD7190/AD7192**
- Standalone interface using microcontroller and LCD display**
- PC software for control of AD7190/AD7192 using USB interface**
- Various linking options**

INTRODUCTION

This user guide describes the evaluation board for the AD7190/AD7192, which are 4.8 kHz ultralow noise 24-bit sigma-delta ($\Sigma\text{-}\Delta$) ADCs. The AD7190/AD7192 are complete analog front ends for low frequency measurement applications. The parts contain two differential inputs/four pseudo differential inputs, and include a low noise instrumentation amplifier, reference detect, and a low-side power switch.

Full data on the AD7190/AD7192 is available in the [AD7190](#) and [AD7192](#) data sheets available from Analog Devices, Inc., and should be consulted in conjunction with this user guide when using the evaluation board.

GENERAL DESCRIPTION

The AD7190/AD7192 evaluation kit is a powerful tool for exploring and evaluating the AD7190/AD7192 features.

The evaluation board can be operated in complete standalone, battery-powered mode. The LCD display is used to display the conversion data.

When the board is connected to (and possibly powered from) a PC via a standard USB interface, the PC software allows the graphical display of real-time data, logs them into a text file, allows you to modify the AD7190/AD7192 internal settings, and generally helps in understanding the part features and performance.

Finally, the board's flexible interface structure allows it to be connected in a number of useful configurations. For example, the digital section of the evaluation board can be used independently as a convenient digital interface for a user's own sensor design PCB or module containing the AD7190/AD7192. Alternatively, an external microcontroller can be interfaced to the AD7190/AD7192 and thus the evaluation board can act as a complete analog front end for creating and debugging software on the user's own digital platform.

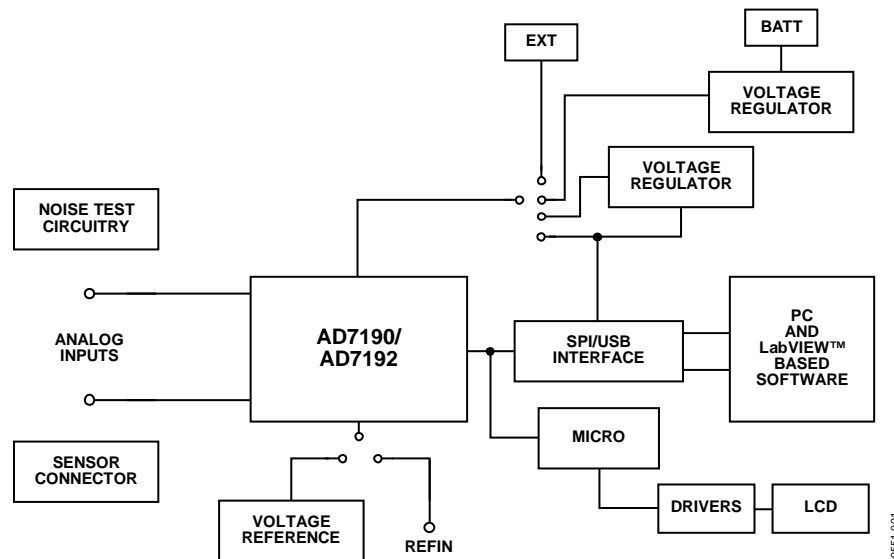


Figure 1. AD7190/AD7192 Evaluation Board

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REVISION HISTORY

12/10—Revision 0: Initial Version

EVALUATION BOARD HARDWARE

POWER SUPPLIES

There are several power supply options on the [AD7190/AD7192](#) evaluation board.

Connected to USB Connector

The AD7190/AD7192 evaluation board is powered via the 5 V supply from the USB connector, J51. This 5 V supply can be used to power the AD7190/AD7192 directly. Link J1 should be placed in Position 5 V USB.

The 5 V supply from the USB connector can be regulated to 3.3 V using the on-board [ADP3303-3](#), a high precision, low power, 3.3 V output voltage regulator. Therefore, using Link J1, the 3.3 V can be used as the power supply to the AD7190/AD7192. Link J1 should be placed in Position 3.3 V.

The AD7190/AD7192 can be powered using a 9 V battery, B1, or using an external 9 V dc source connected at J31. The 9 V is regulated down to 5 V using the on-board ADP3303-5, a high precision, low power 5 V output regulator. Using Link J1, this

regulated 5 V can be used as the supply to the AD7190/AD7192. To use this option, Link J1 should be placed in Position 5 V BAT.

An external power supply can be applied via J10. Link J1 should be placed in Position EXT.

Standalone Operation

The AD7190/AD7192 evaluation board can be powered using a 9 V battery, B1, or using an external 9 V dc source connected at J31. The 9 V is regulated down to 5 V using the on-board ADP3303-5, a high precision, low power 5 V output regulator. Using Link J1, this regulated 5 V can be used as the supply to the AD7190/AD7192. To use this option, Link J1 should be placed in Position 5 V BAT.

An external power supply can be applied via J10. Link J1 should be placed in Position EXT.

SOCKETS

There are five sockets relevant to the operation of the AD7190/AD7192 on this evaluation board. The functions of these sockets are outlined in Table 1.

Table 1. Socket Functions

Socket	Description
REF2+	Subminiature BNC (SMB) connector. This socket is used in conjunction with REFIN2– to apply an external reference to the AD7190/AD7192. The voltage for the REFIN2(+) input of the AD7190/AD7192 is applied to this socket.
REF2–	Subminiature BNC (SMB) connector. This socket is used in conjunction with REFIN2+ to apply an external reference to the AD7190/AD7192. The voltage for the REFIN2(–) input of the AD7190/AD7192 is applied to this socket.
AIN1	Subminiature BNC (SMB) connector. This socket is used to apply an analog input signal to AIN1.
AIN2	Subminiature BNC (SMB) connector. This socket is used to apply an analog input signal to AIN2.
MCLK	Subminiature BNC (SMB) connector. An external clock source can be applied to the AD7190/AD7192 using this socket.

NOISE TEST

Header J3 allows the user to perform noise testing of the [AD7190/AD7192](#). With all links in the vertical position (see Figure 2), the analog and reference are applied to the AD7190/AD7192, as shown in Figure 3.

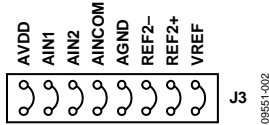


Figure 2. Link Positions for Noise Testing

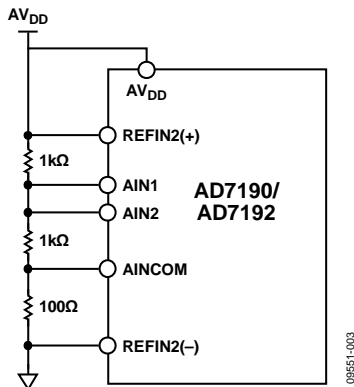


Figure 3. Noise Test Connections

As shown in Figure 3, inserting the links in Header J3 connects a resistor network to the AD7190/AD7192. The reference to the ADC is provided by AV_{DD} . The resistor divider generates a bias voltage of approximately $AV_{DD}/2$. Channel AIN1 and Channel AIN2 are connected to this voltage. Therefore, conversions can now be performed using this external short to measure the rms noise, peak-to-peak noise, and peak-to-peak resolution.

USING AN ABSOLUTE REFERENCE

An [ADR421](#) is included on the AD7190/AD7192 evaluation board so that the part can also be evaluated using an absolute reference. The reference can be connected to the REFIN2(+) and REFIN2(-) pins of the AD7190/AD7192 by connecting the links of Header J3, as shown in Figure 4.

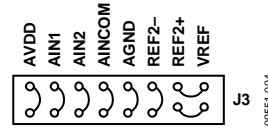


Figure 4. Connecting an Absolute Reference to the AD7190/AD7192

CONNECTING THE AD7190/AD7192 TO AN EXTERNAL MICROCONTROLLER

The AD7190/AD7192 evaluation board can be connected to an external microcontroller using Header J2. With all links in place, the AD7190/AD7192 are connected to the on-board microcontroller. However, with these links removed, the AD7190/AD7192 are disconnected from the evaluation board microcontroller. The user can then use a header to interface the AD7190/AD7192 to the external microcontroller.

USING THE AD7190/AD7192 EVALUATION BOARD IN STANDALONE MODE

The AD7190/AD7192 evaluation board can be operated in standalone mode. In this mode, the evaluation board functions as a weigh scale demonstration. Channel AIN3/AIN4 is the analog input channel with REFIN1(+)/REFIN1(−) as the reference source. These analog input pins and reference pins are connected to the J4 header along with AVDD and GND. This header allows the user to connect a load cell to the AD7190/AD7192. The load cell should be connected to the header, as shown in Figure 5. A 6-wire load cell is shown, but a 4-wire load cell can also be connected.

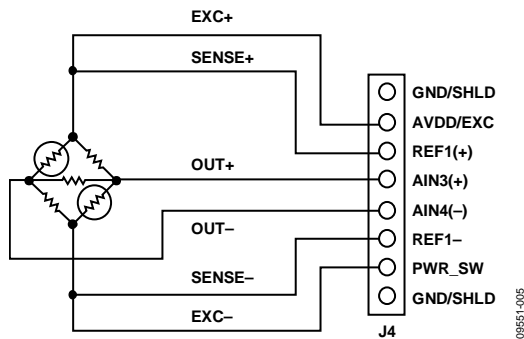


Figure 5. Load Cell Connection to Header J4

The AD7190/AD7192 are configured for an output data rate of 4.69 Hz. The gain is programmed to 128. Channel AIN3/AIN4 is selected as the active channel with REFIN1(+)/REFIN1(−) selected as the reference source.

The conversions from the AD7190/AD7192 are displayed on the LCD display. The four buttons beneath the LCD display allow the user to calibrate the weigh scale system, adjust the LCD contrast, and display the results in code or weight. The function of each button is listed at the bottom of the LCD display.

To operate the weigh scale demonstration, connect the load cell to Header J4 as shown in Figure 5. Apply power to the AD7190/AD7192 evaluation board using either a 9 V battery or a 9 V dc power source. Ensure that Link J1 is in Position 5 V BAT/EXT. The weigh scale demonstration can also be powered from the USB connector if the board is connected to a PC. Link J1 should be in Position 5 V USB in this case.

With no weight on the weigh scale, an offset calibration should be performed (selectable from the buttons below the LCD display). The expected full-scale weight should then be placed on the load cell and the full-scale calibration performed. The user should select the corresponding full-scale weight on the LCD display as the weigh scale demonstration supports full-scale weights of 500 g to 10 kg. The software then continuously reads conversions from the AD7190/AD7192, scales the conversions appropriately, and displays the resulting weight on the LCD display.

USING THE AD7190/AD7192 EVALUATION BOARD WITH THE PC SOFTWARE

SOFTWARE INSTALLATION

The [AD7190/AD7192](#) evaluation board software should be installed before connecting the AD7190/AD7192 evaluation board to the PC.

EVALUATION SOFTWARE INSTALLATION

To install the evaluation software, perform the following steps:

1. Insert the AD7190/AD7192 evaluation kit CD in the CD-ROM drive of your PC. The **Evaluation software installation wizard** should start automatically after inserting the CD. If the wizard does not start, navigate to the AD7190/AD7192 evaluation kit CD on your PC and start **Setup.exe**.
2. At the prompt, select a destination directory, which is **C:\Program Files\Analog Devices\AD7190\AD7192** by default. After the directory is selected, the installation procedure copies the files into the relevant directories on the hard drive. The installation program creates a program group called **Analog Devices** with the subgroup **AD7190/AD7192** in the **Start** menu of the taskbar.
3. When the installation procedure is complete, double-click the AD7190/AD7192 icon to start the program.

EVALUATION BOARD INSTALLATION

To install the evaluation board,

1. Connect the AD7190/AD7192 evaluation board to your PC USB connector using the USB cable included in the evaluation kit. The **POWER LED** on the evaluation board should turn on and **Found new hardware wizard** should start automatically on the PC.
2. Follow the steps in the wizard until the installation is completed.

USING THE SOFTWARE

Start the AD7190/AD7192 evaluation software on the PC. Click on the Windows® **Start** button, then click **All Programs, Analog Devices, AD7190/AD7192**, and finally **AD7190/AD7192 evaluation software**.

The software allows you to configure the AD7190/AD7192, gather samples, and analyze the data. Consult the AD7190/AD7192 data sheets for further information on the register bits and their functions. Figure 6 shows the main window that is displayed when the program starts. The Main Window section briefly describes the various menu and button options in the main window.

The data that has been read can be exported to other packages, such as MathCAD™ or Microsoft® Excel®, for further analysis.

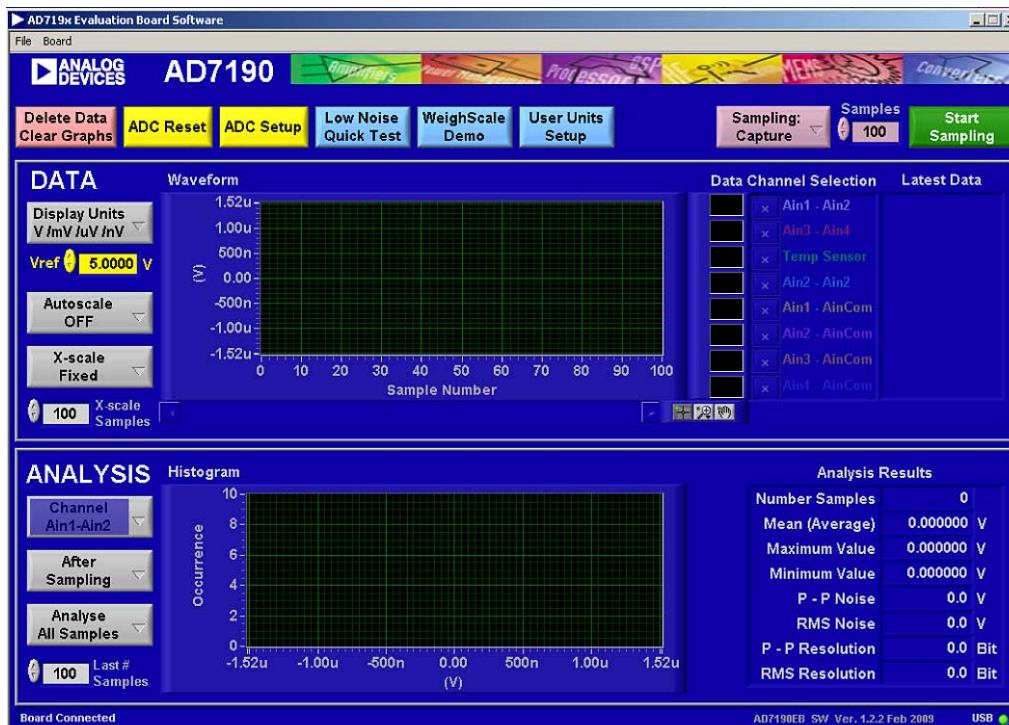


Figure 6. AD7190/AD7192 Evaluation Software Main Window

MAIN WINDOW

Menu Bar

File

This allows you to write the current set of data to a file for later use, log data as it is gathered, and exit the program.

Board

This allows you to alter the contrast on the LCD display.

Buttons

Delete Data/Clear Graphs

This allows you to delete the data displayed in the graphs.

ADC Reset

This allows you to reset the [AD7190/AD7192](#) to its default (power-on) settings.

ADC Setup

This opens the **ADC Setup** window, which allows you to configure the AD7190/AD7192.

Low Noise Quick Test

This allows you to access the noise testing software.

WeighScale Demo

This allows you to access the weigh scale demonstration software.

User Units Setup

This allows you to change the display units on the graph and histogram.

Sampling

This allows you to sample continuously or to sample a specific number of samples. When the **Sampling: Capture Defined Sample Set** option is selected, the sample size is entered in the **Samples** box.

Start Sampling

This allows you to read samples from the AD7190/AD7192.

DATA

Display Units

This allows you to display the conversions in hexadecimal, decimal, volts or in user-specified units. If the conversions are displayed in volts, the value of the reference voltage must be entered in the **Vref** box.

Autoscale

This allows you to enable or disable the autoscale function on the waveform plot.

X-scale

This allows you to have a fixed x-axis or a dynamic x-axis. When the x-axis is fixed, the number of samples to display is entered in the **X-Scale Samples** box.

ANALYSIS

Channel

The data channel to be analyzed is selected using this button.

After Sampling

The software can process the conversions as they are being gathered or it can process the samples when the ADC has completed the selected number of conversions.

Analyse All Samples

This feature allows you to fix the sample size used for analyzing. Alternatively, the software can process all samples gathered. When the **Analyse Last # Samples** option is selected, the sample size must be entered in the **Last # Samples** box.

The software captures all samples generated by the AD7190/AD7192. If the software fails to gather all samples, then the message shown in Figure 7 appears.



Figure 7. Error Message When Samples Not Captured

The software may drop samples for the following reasons:

- The data is being analyzed in parallel with the gathering of samples. You should delay the analysis until the samples are gathered.
- Other programs are running on the PC.
- The PC is too slow.

ADC SETUP

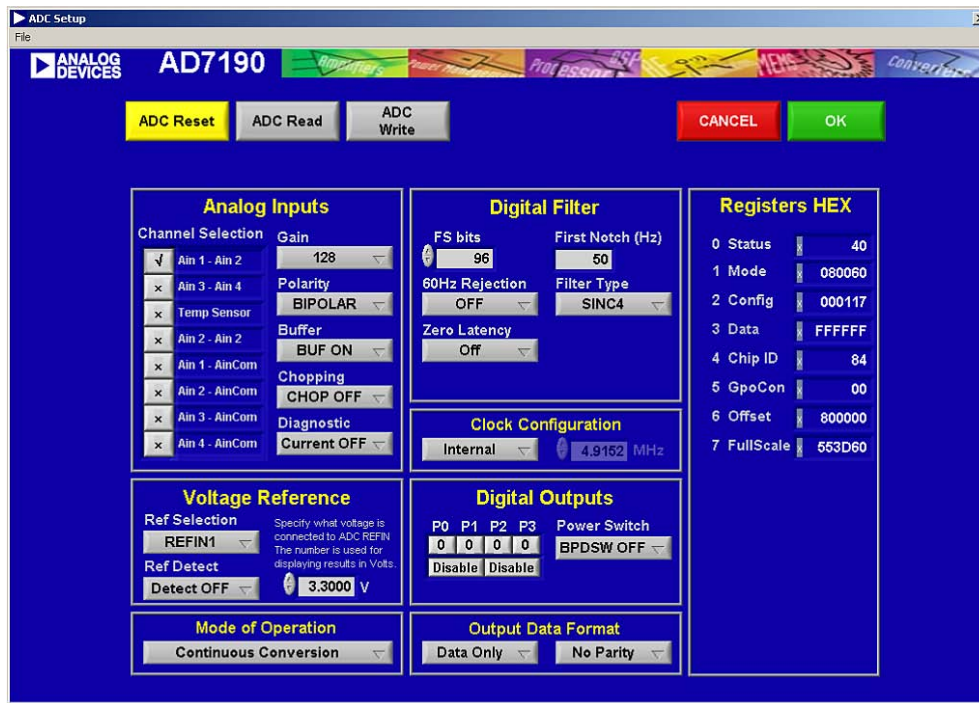


Figure 8. ADC Setup Window

The **ADC Setup** window gives you access to the [AD7190/AD7192](#) registers. You can write to the registers and read from the registers. This window operates even when an AD7190/AD7192 evaluation board is not connected to the software. It operates as an AD7190/AD7192 configuration tool.

ADC Reset

The ADC is reset to its default condition using this button.

ADC Read

Click this button to read the values of the registers on the AD7190/AD7192. The **ADC Setup** window displays the hexadecimal values returned from the AD7190/AD7192. The other sections of the **ADC Setup** window are also updated to reflect the AD7190/AD7192 configuration.

ADC Write

Click this button to write the information displayed in the **Registers HEX** window to the AD7190/AD7192.

Analog Inputs

Select the analog input channels using the **Channel Selection** buttons. The gain, polarity, and chopping can also be selected. The analog inputs can be buffered or unbuffered using the **Buffer** button. Finally, the **Diagnostic** button enables/disables the burnout currents.

Digital Filter

The output data rate, first filter notch, the order of the sinc filter, zero latency, and enabling/disabling the REJ60 bit are programmed using these buttons. You can enter the frequency

of the first filter notch and the software calculates the value to be written to Bits FS[9:0] of the mode register. Alternatively, you can enter the FS[9:0] value in decimal and the software calculates the first filter notch.

The value to be written to the AD7190/AD7192 is displayed in the **Registers HEX** section.

Voltage Reference

The reference source and reference value are programmed in this section. You can select **REFIN1** or **REFIN2**, enable or disable the reference detect function, and set the voltage of the reference.

When the reference setup is changed, the changes to the configuration register are shown in the **Registers HEX** section.

Clock Configuration

The clock to be used by the AD7190/AD7192 is selected in this section. When an external master clock is selected, the clock frequency must be entered in the **MHz** box.

Digital Outputs

The four digital outputs, P0 to P3, are programmed and enabled/disabled in this section. The low-side power switch is also controlled in this section using the **Power Switch** button.

Mode of Operation

This button allows you to select various modes of operation, including continuous conversion, single cycle conversion, and calibration.

Output Data Format

This section allows you to select the output format of the data conversions and to enable the parity. When several analog inputs are enabled, the **Data + Status** option should be selected under **Data Only**.

Registers HEX

This window displays the values to be written to the [AD7190/AD7192](#) registers. When features such as the analog input channel, gain, and mode of operation are changed, the values in the **Register HEX** section are updated automatically. You can write directly to the **Registers HEX** section, altering the contents of any register. When the values in this section are altered, the other sections of the **ADC Setup** window are updated to reflect the changes.

CONFIGURATION ASSIST TOOL

The AD7190/AD7192 evaluation software can be used as a configuration assist tool, even when an AD7190/AD7192 evaluation board is not connected. When the AD7190/AD7192 evaluation board software is open, click the **ADC Setup** button.

The message shown in Figure 9 appears. Click the **Ignore** button. The **ADC Setup** window opens. You can use the **ADC Setup** window to determine the values to be written to the AD7190/AD7192 on-chip registers for different configurations. When you change the configuration (for example, the gain or channel), the values in the **Register HEX** section are updated automatically. You can manually alter the values in the **Registers HEX** section as well. When the values in this section are altered, the other sections of the **ADC Setup** window are updated so that you can easily see the impact of the register changes.

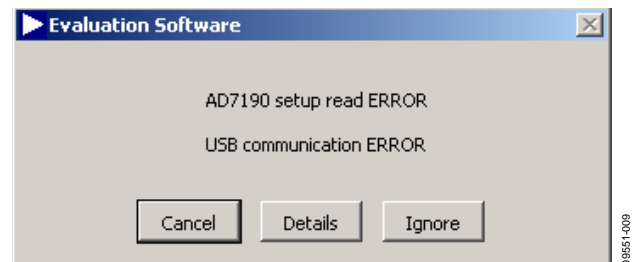


Figure 9. Configuration Tool

LOW NOISE QUICK TEST



Figure 10. Low Noise Quick Test

When the **Low Noise Quick Test** button in the main window (see Figure 6) is clicked, you can quickly and easily measure the rms noise of the AD7190/AD7192. The software configures the AD7190/AD7192 to have a gain of 128 and an output data rate of 4.7 Hz, Channel AIN1/AIN2 is selected, and the reference voltage is set to 5 V. (The software assumes that the 5 V from the USB is used as the reference to the AD7190/AD7192.) The software also provides instructions on the link positions for the

AD7190/AD7192 evaluation board. When the instructions given in each window are completed, click the **OK** button. The AD7190/AD7192 software gathers 100 samples, displays the results in the waveform, and analyzes the data to calculate the maximum conversion, minimum conversion, and average conversion. The rms noise, peak-to-peak noise, and resolution are also calculated.

WEIGHSCALE DEMO

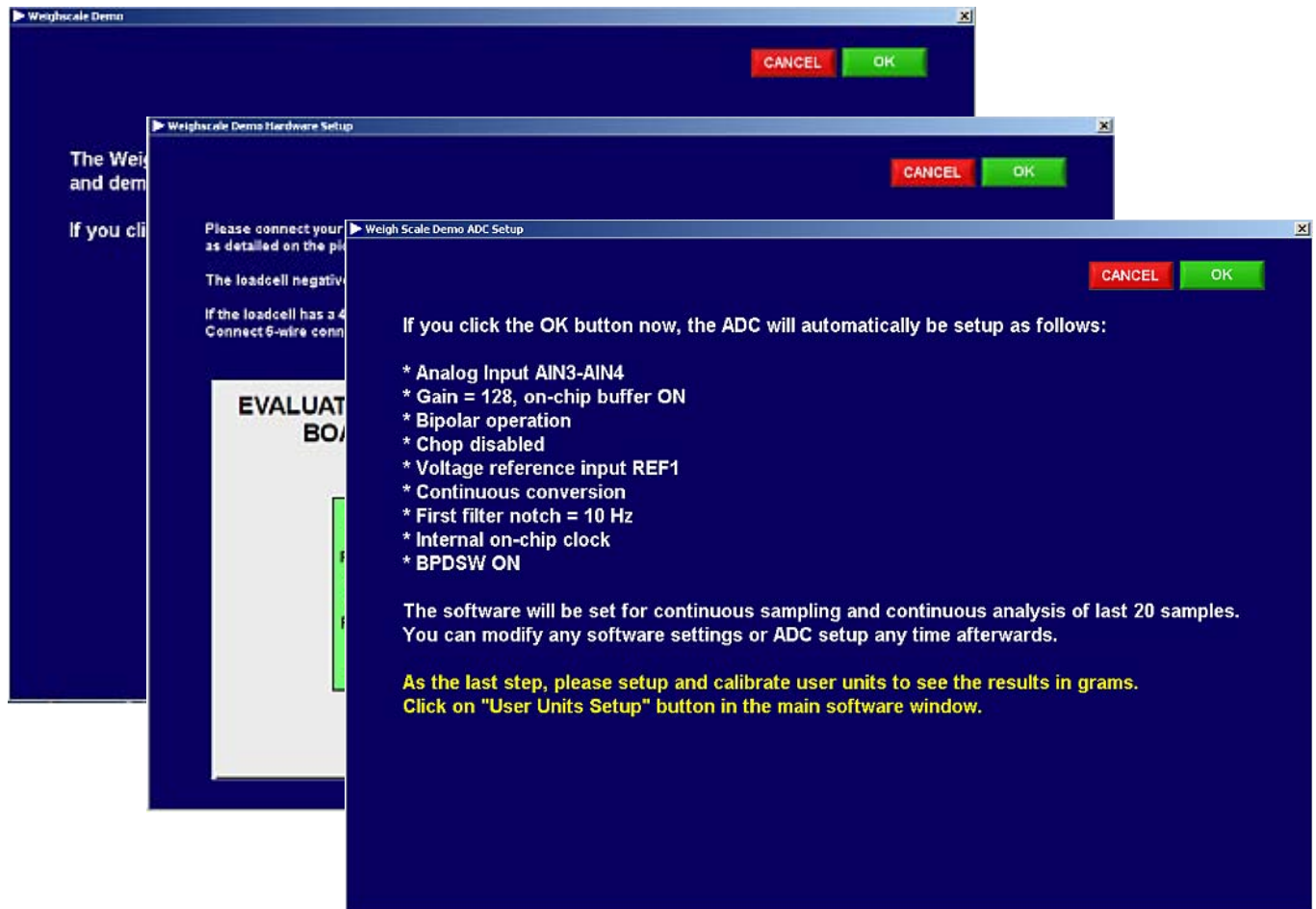


Figure 11. Weigh Scale Demo

A load cell can be connected directly to the [AD7190/AD7192](#) evaluation board. When the **WeighScale Demo** button in the main window (see Figure 6) is clicked, you are guided through a series of windows that give information on connecting the load cell to the AD7190/AD7192 evaluation board. The AD7190/AD7192 device is automatically configured to have a gain of 128, Channel AIN3/AIN4 is selected, and the output data rate is

programmed to 10 Hz. When the instructions given in each window are completed, click **OK**. The AD7190/AD7192 evaluation board gathers samples continuously and uses batches of 20 samples to analyze the data. The software displays the maximum voltage measured, the average voltage, the minimum voltage, the rms noise, and resolution. The sample size used to process the data can be altered using the **Last # Samples** box.

USER UNITS SETUP

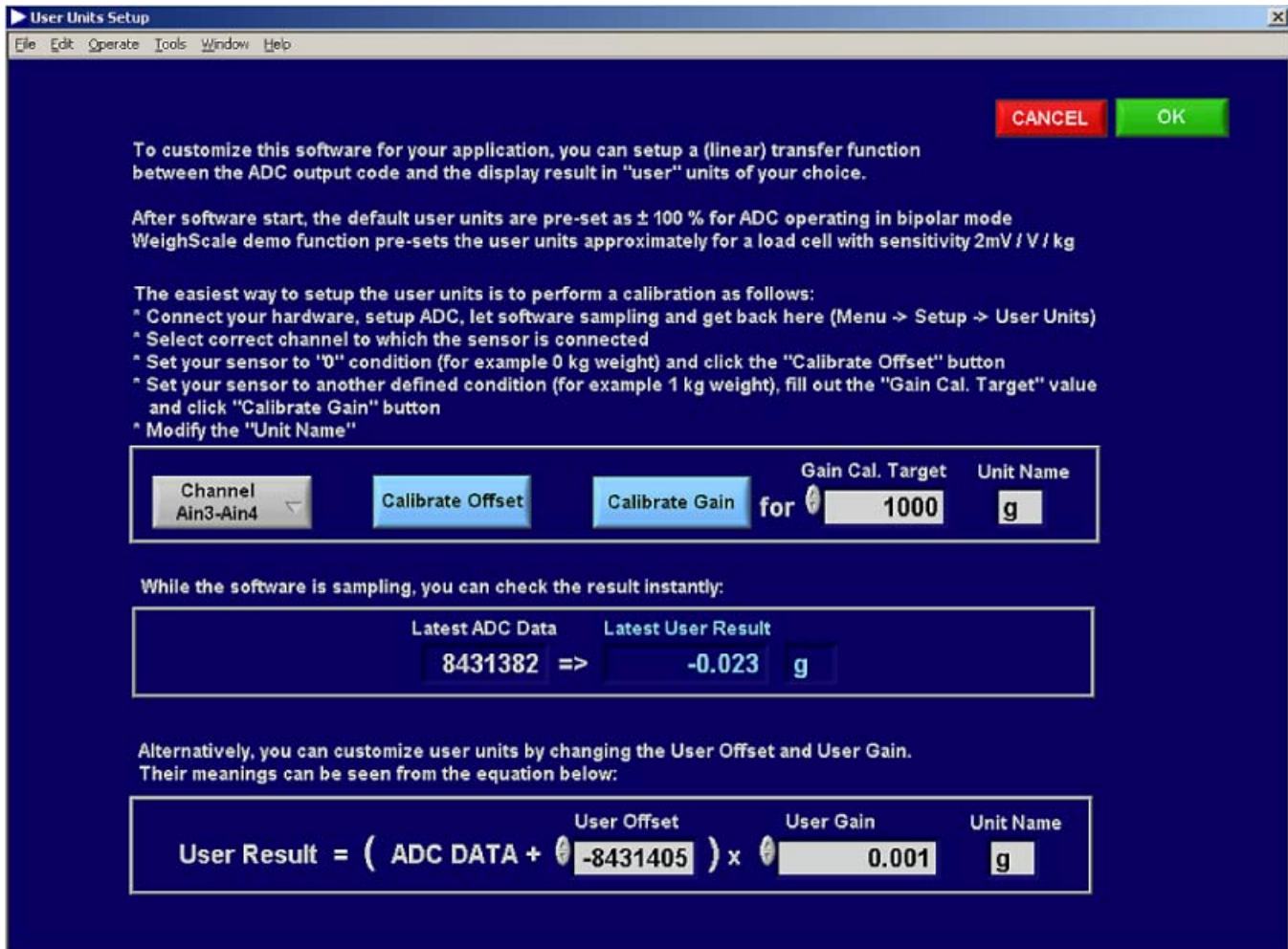
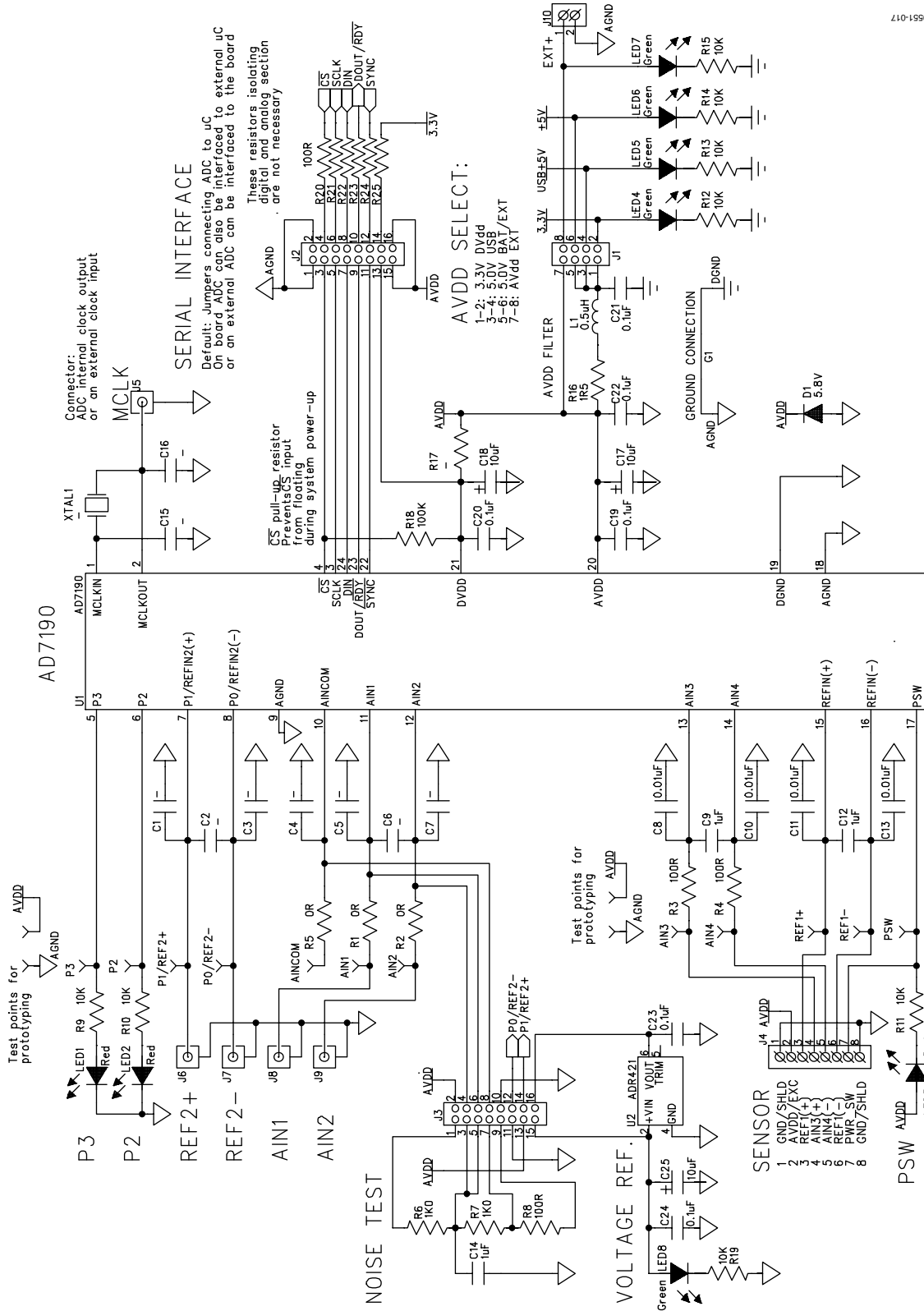


Figure 12. User Units Setup Window

The **User Units Setup** window, which is accessed by clicking the **User Units Setup** button in the main window (see Figure 6), allows you to define the display units for the conversions. For example, if a load cell is connected to the [AD7190/AD7192](#), the conversions from the ADC can be displayed in grams. The

offset and gain error of the system can also be calibrated. You can perform a system offset and system full-scale calibration. The resulting coefficients are held in memory; they are not written to the ADC calibration registers.

EVALUATION BOARD SCHEMATICS AND ARTWORK



410-15560

Figure 13. EVAL-AD7190EBZ/EVAL-AD7192EBZ Schematic, Analog

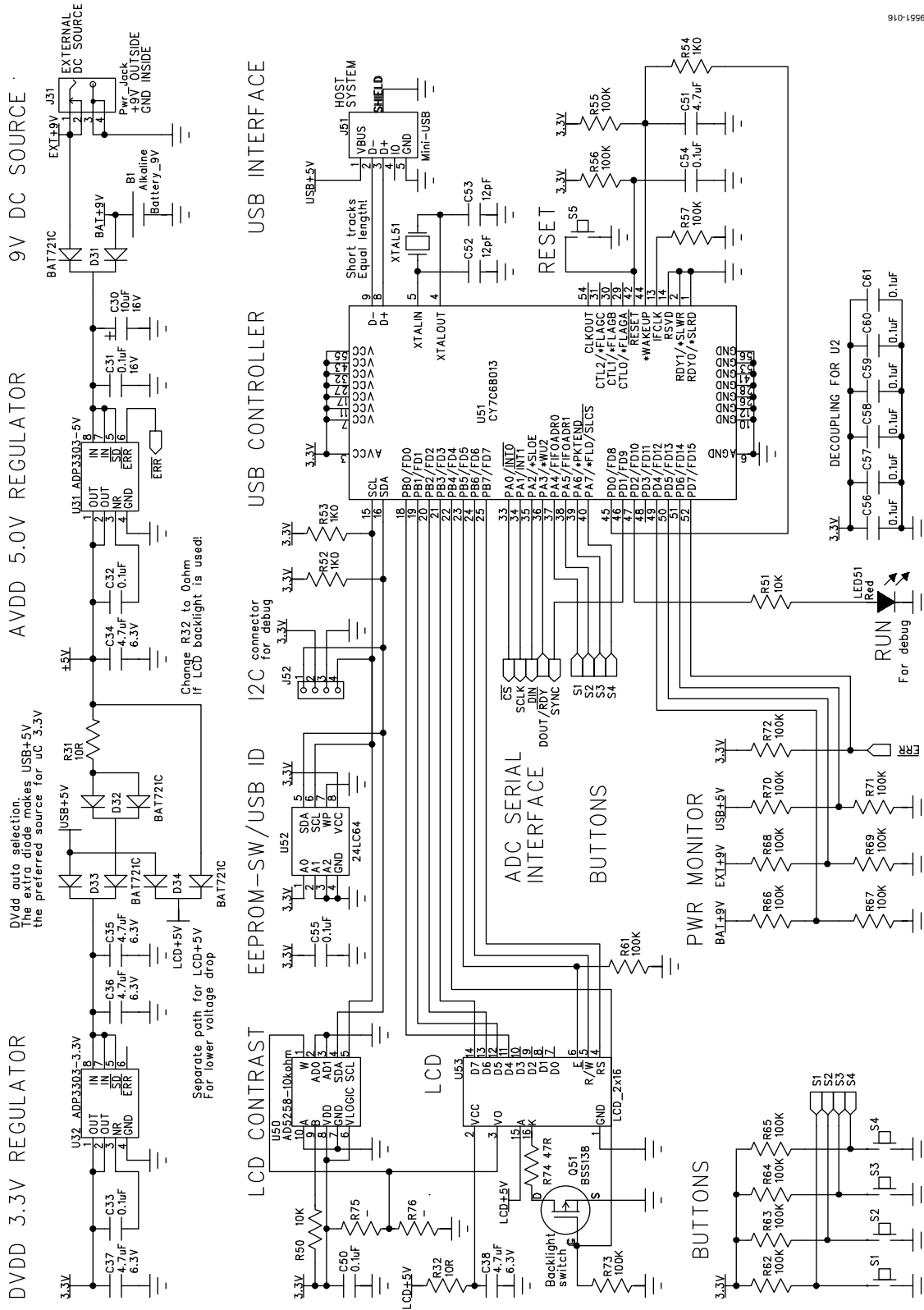


Figure 14. EVAL-AD7190EBZ/EVAL-AD7192EBZ Schematic, Digital

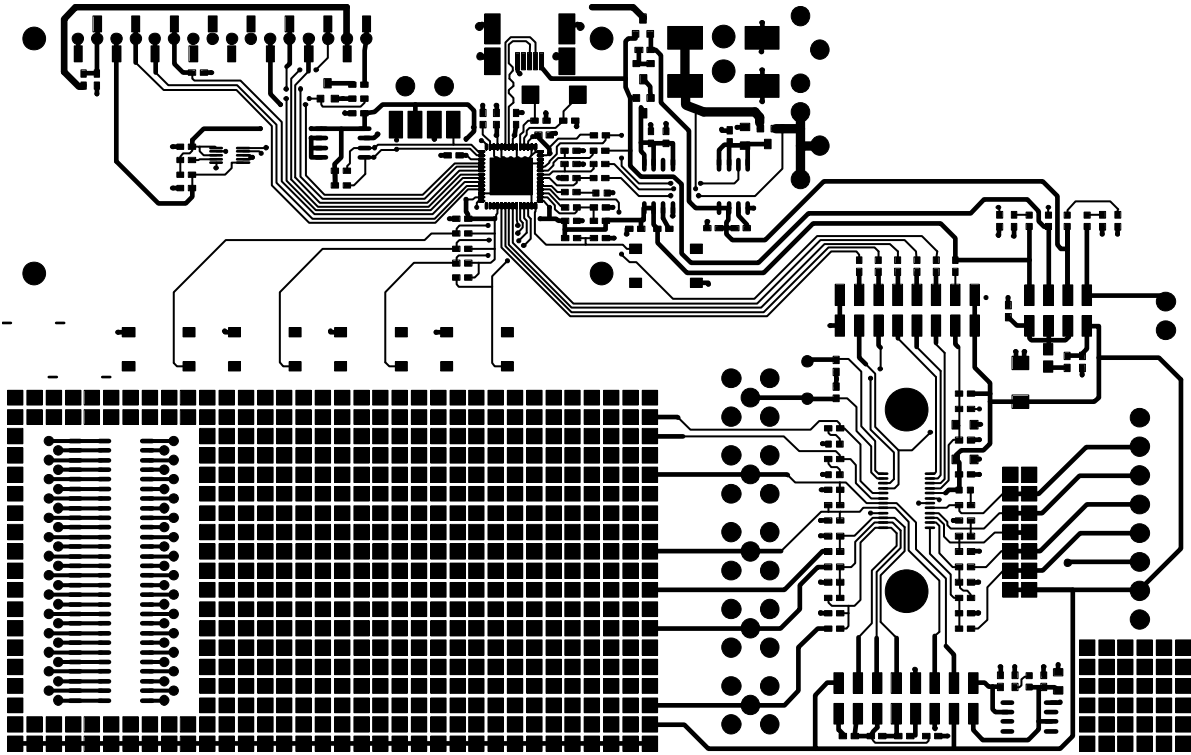


Figure 15. EVAL-AD7190EBZ/EVAL-AD7192EBZ Component Side View

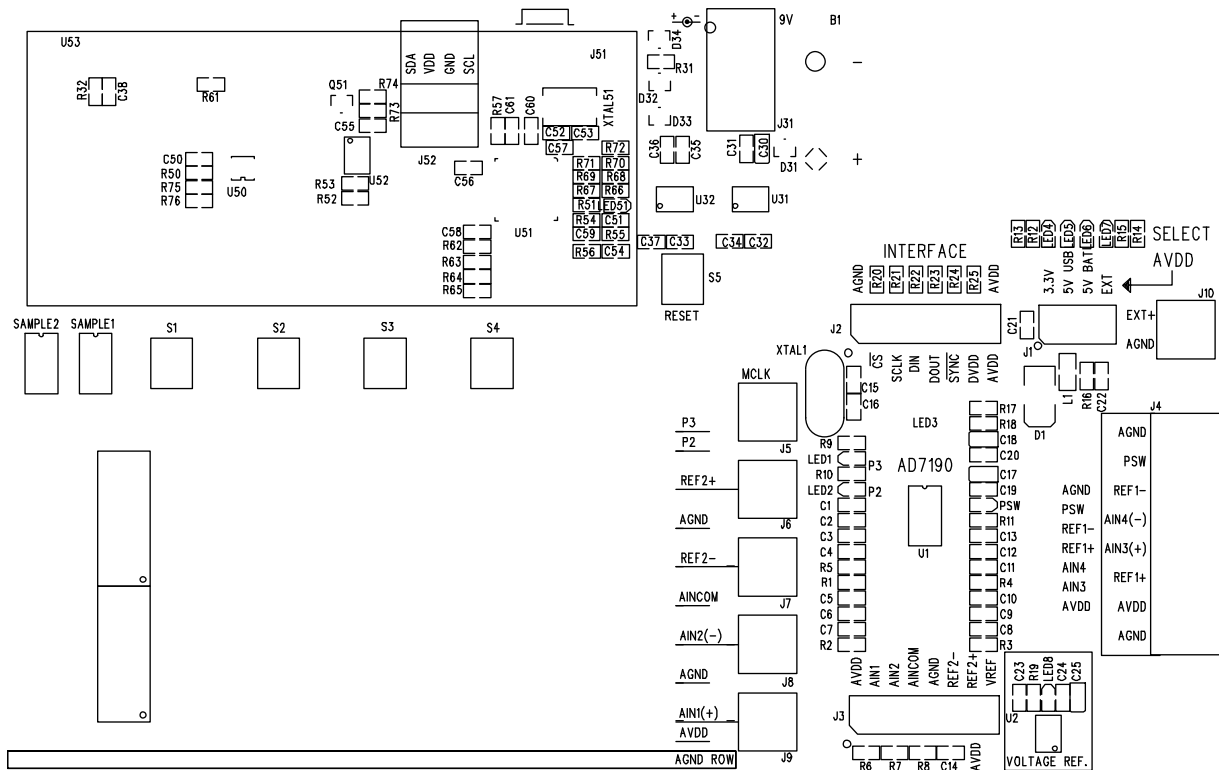


Figure 16. EVAL-AD7190EBZ/EVAL-AD7192EBZ Silkscreen

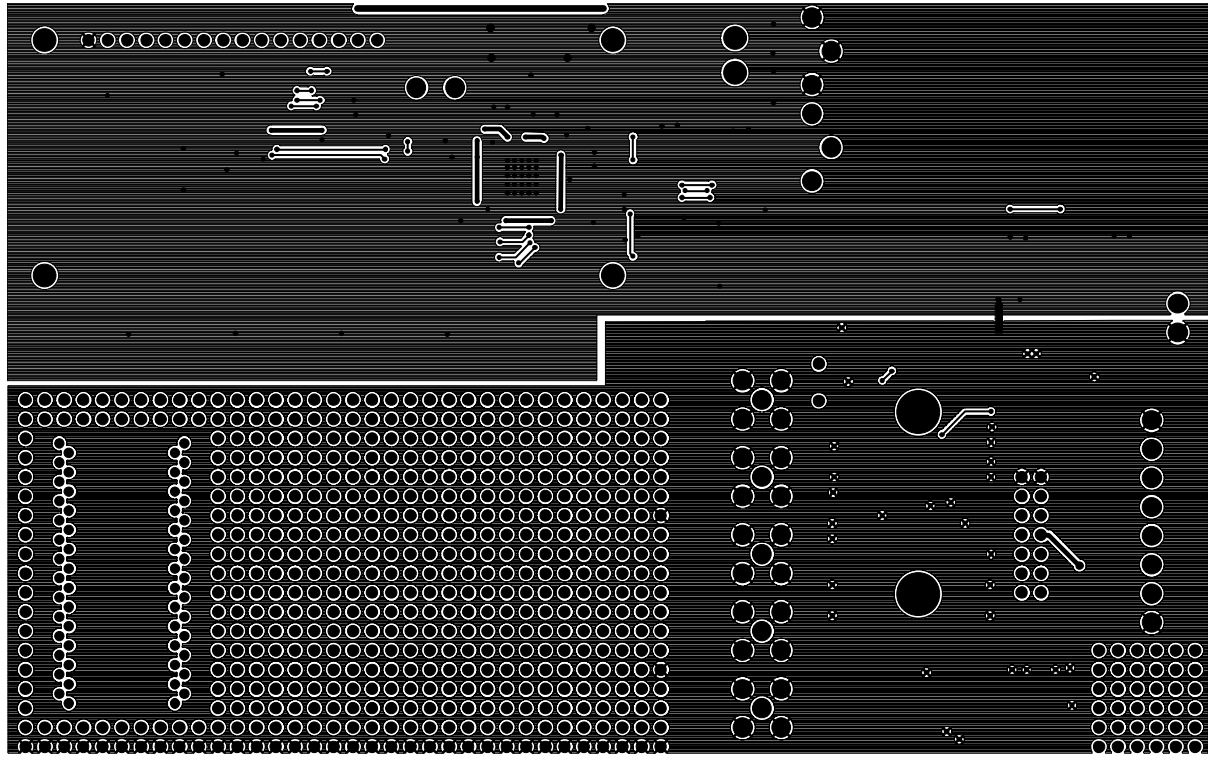


Figure 17. EVAL-AD7190EBZ/EVAL-AD7192EBZ Solder Side View

ORDERING INFORMATION

BILL OF MATERIALS

Table 2.

Qty.	Reference Designator	Description	Manufacturer	Order No.
1	U1	AD7190/AD7192	Analog Devices	AD7190BRUZ/AD7192BRUZ
1	U2	ADR421 reference	Analog Devices	ADR421BRZ
1	U31	5 V voltage regulator	Analog Devices	ADP3303ARZ-5
1	U32	3.3 V voltage regulator	Analog Devices	ADP3303ARZ-3.3
1	U50	10 k Ω , 64-step digital potentiometer	Analog Devices	AD5258BRMZ10
1	U51	USB controller	Cypress Semiconductor	CY7C68013A-56LFXC
1	U52	64K I ² C EEPROM	Microchip Technology, Inc.	24LC64-I/SN
1	U53	LCD connector	FCI	76341-308LF
4	LED1 to LED3, LED51	LED red, high intensity (>90 mCd), 0603	Avago Technology	HSMC-C191
5	LED4 to LED8	LED green, high intensity (>50 mCd), 0603	Avago Technology	HSME-C191
	XTAL1	4.9152 MHz crystal	Not inserted	Not inserted
1	XTAL51	24 MHz crystal	AVX	CX5032GB24000H0PESZZ
1	D1	Diode	On Semiconductor	P6SMB68AT3G
4	D31 to D34	Diode	Philips	BAT721C
1	Q51	N-MOSFET	Infineon	BSS138N
9	C1 to C7, C15, C16	Capacitor ceramic	Not inserted	Not inserted
2	C52, C53	12 pF ceramic capacitor	Phycomp	2238 867 15129
4	C8, C10, C11, C13	0.01 μ F ceramic capacitor	Phycomp	2238 586 15636
17	C19 to C24, C31 to C33, C54 to C61	0.1 μ F ceramic capacitor	Phycomp	2238 786 15649
3	C9, C12, C14	1 μ F ceramic capacitor	Phycomp	2238 246 13663
6	C34 to C37, C50, C51	4.7 μ F ceramic capacitor	Phycomp	2255 206 13672
4	C17, C18, C2, C30	10 μ F tantalum capacitor	AVX	TAJA106M016R
1	L1	Ferrite bead	Tyco	BMB2A1000LN2
3	R1, R2, R5	0 Ω resistor	Phycomp	232270296001
9	R3, R4, R8, R20 to R25	100 Ω resistor	Phycomp	232270461001
5	R6, R7, R52 to R54	1 k Ω resistor	Phycomp	232270461002
10	R9 to R15, R19, R50, R51	10 k Ω resistor	Phycomp	232270461003
1	R16	1.5 Ω resistor	Phycomp	232270461508
	R17, R75, R76	Resistor	Not inserted	Not inserted
16	R18, R55 to R57, R62 to R73	100 k Ω resistor	Phycomp	232270461004
2	R31, R32	10 Ω resistor	Phycomp	232270461009
1	R74	47 Ω resistor	Phycomp	232270464709
5	S1 to S5	Switch	Omron	B3S-1000
1	B1	Clip for 9 V battery	Keystone	593+594
1	J1	2 \times 4-way header	Tyco Electronics/Amp	1241050-4
2	J2, J3	2 \times 8-way header	Tyco Electronics/Amp	1241050-8
1	J4	1 \times 8-way header	Phoenix Contact	1803332
	J5 to J9	Connector, 50 Ω , straight, SMB	Not inserted	Not inserted
1	J10	Screw terminal block	Phoenix Contact	1727010
1	J31	Connector, power jack, barrel, 2.1 mm, SMD	Lumberg	1613_14
1	J51	Connector, USB Mini-B, SMD	Molex	548190572
	J52	Header	Not inserted	Not inserted
1	U53	LCD module 2 \times 16 character count, 1 \times 16-pin, top	Everbouquet	MC1602C-SYR
1	N/A	LCD header	Tyco	1-826629-6

RELATED LINKS

Resource	Description
AD7190	Product Page, AD7190 4.8 kHz Ultralow Noise 24-Bit Sigma-Delta ADC with PGA
AD7192	Product Page, AD7192 4.8 kHz Ultralow Noise 24-Bit Sigma-Delta ADC with PGA
ADP3303	Product Page, ADP3303 High Accuracy anyCAP® 200 mA Low Dropout Linear Regulator
ADR421	Product Page, ADR421 Ultraprecision, Low Noise, 2.500 V XFET® Voltage References
AD5258	Product Page, AD5258 Nonvolatile, I ² C®-Compatible 64-Position, Digital Potentiometer

NOTES

NOTES

**ESD Caution**

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

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 NON-INFRINGEMENT 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.