

## Evaluation Board for the AD7191 Pin-Programmable, 24-Bit $\Sigma$ - $\Delta$ ADC

### FEATURES

**Full-featured evaluation board for the [AD7191](#)**  
**Standalone interface using microcontroller and LCD display**  
**PC software for control of [AD7191](#) using USB interface**  
**Various linking options**

### INTRODUCTION

This user guide describes the evaluation board for the [AD7191](#), which is a pin-programmable, ultralow noise, 24-bit sigma-delta ( $\Sigma$ - $\Delta$ ) ADC. The [AD7191](#) is a complete analog front end for low frequency measurement applications. It contains two differential inputs and includes a low noise PGA and a low-side power switch.

Full data on the [AD7191](#) is available in the [AD7191](#) data sheet available from Analog Devices, Inc., and should be consulted in conjunction with this user guide when using the evaluation board.

### GENERAL DESCRIPTION

The [AD7191](#) evaluation kit is a powerful tool for exploring and evaluating the [AD7191](#) 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 the user to modify the settings of the [AD7191](#), 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 [AD7191](#). Alternatively, an external microcontroller can be interfaced to the [AD7191](#) 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.

### EVALUATION BOARD CONNECTION DIAGRAM

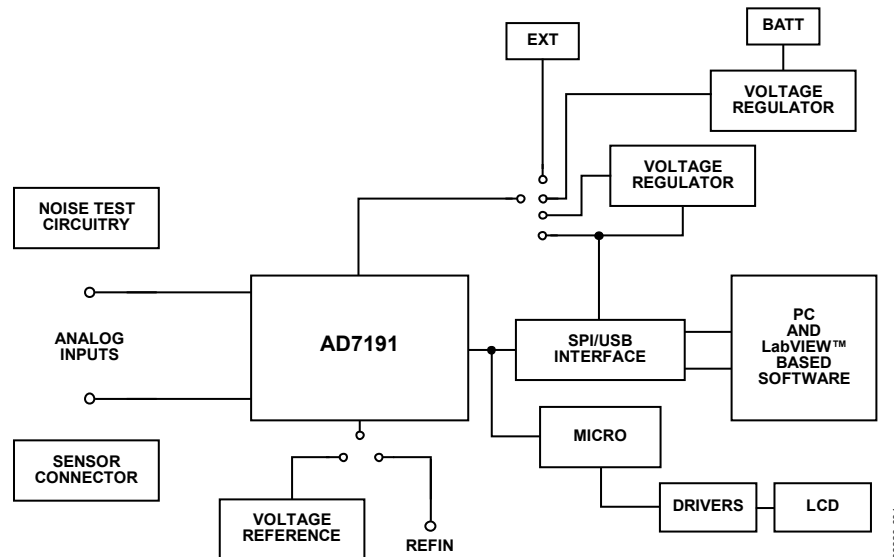


Figure 1. [AD7191](#) Evaluation Board

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## REVISION HISTORY

6/11—Revision 0: Initial Version

## EVALUATION BOARD HARDWARE

### POWER SUPPLIES

There are several power supply options on the [AD7191](#) evaluation board.

#### Connected to USB Connector

The [AD7191](#) evaluation board is powered via the 5 V supply from the USB connector, J51. This 5 V supply can be used to power the [AD7191](#) directly. Link J1 should be placed in the 5 V USB position.

The 5 V supply from the USB connector can be regulated to 3.3 V using the on-board ADP3303-3.3, a high precision, low power, 3.3 V output voltage regulator. Therefore, via Link J1, the 3.3 V can be used as the power supply to the [AD7191](#). Link J1 should be placed in the 3.3 V position.

The [AD7191](#) 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 [ADP3303ARZ-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 [AD7191](#). To use this option, Link J1 should be placed in the 5 V BAT position.

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

#### Standalone Operation

The [AD7191](#) 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 [ADP3303ARZ-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 [AD7191](#). To use this option, place Link J1 in the 5 V BAT position.

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

### SOCKETS

There are five sockets relevant to the operation of the [AD7191](#) on this evaluation board. The functions of these sockets are outlined in Table 1.

**Table 1. Socket Functions**

Socket	Description
REF+	Subminiature BNC (SMB) connector. This socket is used in conjunction with REF– to apply an external reference to the <a href="#">AD7191</a> . The voltage for the REFIN(+) input of the <a href="#">AD7191</a> is applied to this socket.
REF–	Subminiature BNC (SMB) connector. This socket is used in conjunction with REF+ to apply an external reference to the <a href="#">AD7191</a> . The voltage for the REFIN(–) input of the <a href="#">AD7191</a> 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 <a href="#">AD7191</a> using this socket.

**NOISE TEST**

Header J3 allows the user to perform noise testing of the [AD7191](#). With all links in the vertical position (see Figure 2), the analog and reference inputs are applied to the [AD7191](#), as shown in Figure 3.

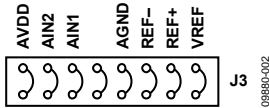


Figure 2. Link Positions for Noise Testing

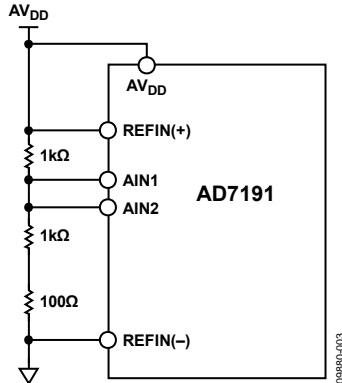


Figure 3. Noise Test Connections

As shown in Figure 3, inserting the links in Header J3 connects a resistor network to the [AD7191](#). 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. Thus, conversions can be performed using this external short to measure the rms noise, peak-to-peak noise, and peak-to-peak resolution. The ADC is configured using the DIP switch (S6) on the board. The [AD7191](#) should be configured as follows:

- Output Data Rate* = 10 Hz
- Gain* = 128
- Channel* = AIN1 – AIN2

Figure 4 shows the positions of the switches on S6.

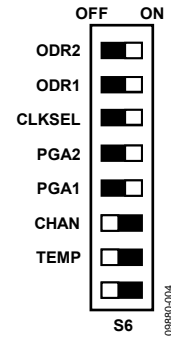


Figure 4. Switch S6 Positions

**USING AN ABSOLUTE REFERENCE**

An [ADR421](#) is included on the [AD7191](#) evaluation board so that the part can also be evaluated using an absolute reference. The reference can be connected to the REFIN(±) pins of the [AD7191](#) by connecting the links of Header J3 as shown in Figure 5.

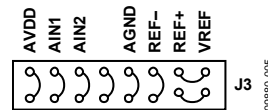


Figure 5. Connecting an Absolute Reference to the [AD7191](#)

**CONNECTING THE AD7191 TO AN EXTERNAL MICROCONTROLLER**

The [AD7191](#) evaluation board can be connected to an external microcontroller using Header J2. With all links in place, the [AD7191](#) is connected to the on-board microcontroller. However, with these links removed, the [AD7191](#) is disconnected from the evaluation board microcontroller. The user can then use a header to interface the [AD7191](#) to the external microcontroller.

## USING THE AD7191 EVALUATION BOARD IN STANDALONE MODE

The AD7191 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. The AIN3 and AIN4 pins, along with REFIN(+), REFIN(-), AV<sub>DD</sub>, and AGND, are connected to the J4 header. This header allows the user to connect a load cell to the AD7191. The load cell should be connected to the header as shown in Figure 6. A 6-wire load cell is shown, but a 4-wire load cell can also be connected.

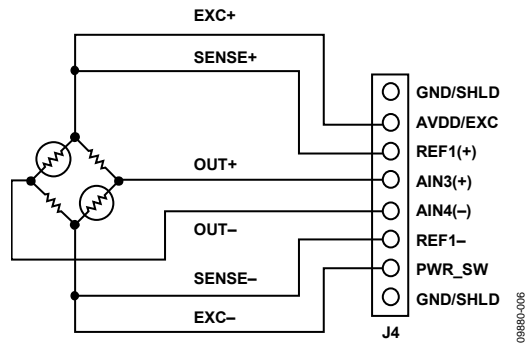


Figure 6. Load Cell Connection to Header J4

The AD7191 is configured for an update rate of 10 Hz. The gain is programmed to 128. Channel AIN3/AIN4 is selected as the active channel. Figure 7 shows the positions of the switches on S6.

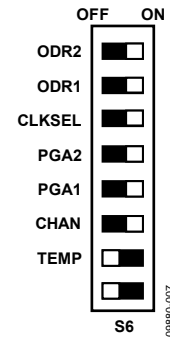


Figure 7. Switch S6 Positions for Load Cell Connection

The conversions from the AD7191 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 read the offset and gain registers. 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 6. Apply power to the AD7191 evaluation board using either a 9 V battery or a 9 V DC power source. Ensure that Link J1 is in the 5 V BAT/EXT position. 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 the 5 V USB position 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 because the weigh scale demonstration supports full-scale weights of 500 g to 10 kg. The software then continuously reads conversions from the AD7191, scales the conversions appropriately, and displays the resulting weight on the LCD display.

## USING THE AD7191 EVALUATION BOARD WITH THE PC SOFTWARE

### SOFTWARE INSTALLATION

The [AD7191](#) evaluation board software should be installed before connecting the AD7191 evaluation board to the PC.

### EVALUATION SOFTWARE INSTALLATION

1. Insert the [AD7191](#) 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 [AD7191](#) evaluation kit CD on your PC and start the **Setup.exe** file.
2. At the prompt, select a destination directory, which is **C:\Program Files\Analog Devices\AD7191** by default. When 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 **AD7191** in the **Start** menu of the taskbar.
3. After the installation procedure is complete, double-click the [AD7191](#) icon to start the program.

### EVALUATION BOARD INSTALLATION

1. Connect the [AD7191](#) 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 [AD7191](#) evaluation software on the PC.

Click on the Windows® **Start** button, then click **All Programs**, **Analog Devices**, **AD7191**, and finally **AD7191 evaluation software**.

The software allows you to configure the [AD7191](#), gather samples, and analyze the data. Consult the [AD7191](#) data sheet for further information on the register bits and their functions.

Figure 8 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.

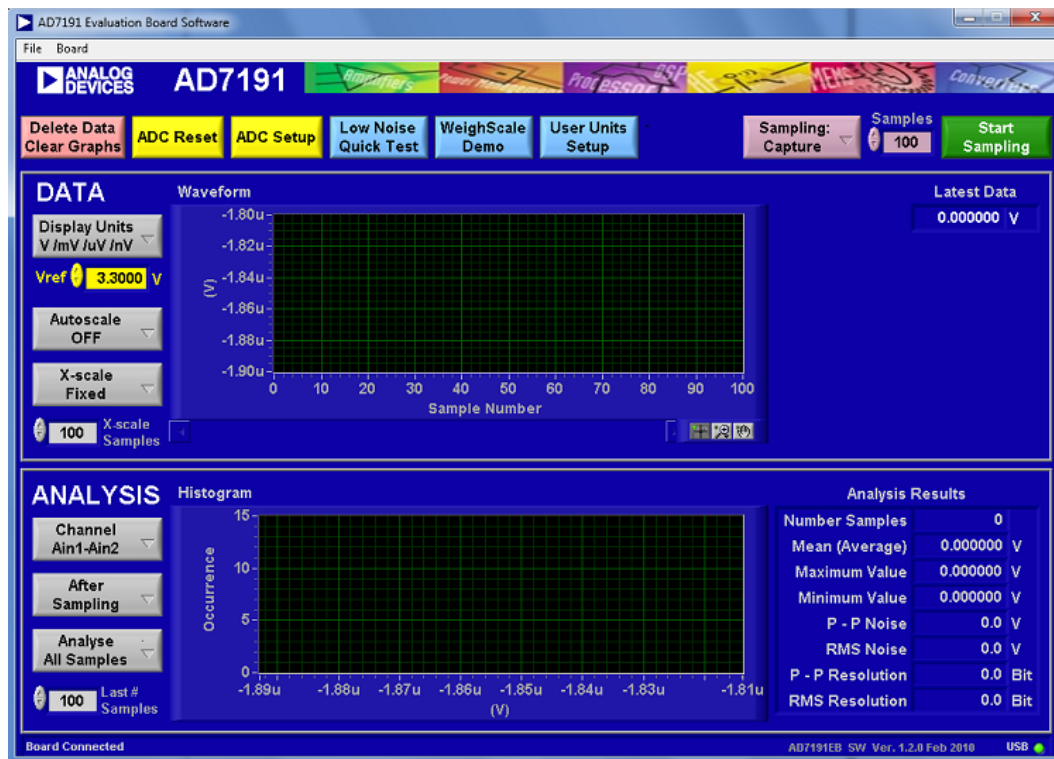


Figure 8. [AD7191](#) Evaluation Software Main Window

## 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 graph.

#### ADC Reset

This allows you to reset the [AD7191](#) to its default (power-on) settings.

#### ADC Setup

This opens the **ADC Setup** window, which reflects the current status of Switch S6.

#### 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 [AD7191](#).

### Data

#### Display Units

This allows you to display the conversions in hexadecimal, decimal, volts, or 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 must be 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 allows you to process all samples gathered. Alternatively, you can fix the sample size used for analyzing by selecting **Analyse Last # Samples**. When **Analyse Last # Samples** is selected, the sample size must be entered in the **Last # Samples** box.

The software captures all samples generated by the [AD7191](#). If the software fails to gather all samples, the message shown in Figure 9 appears.



Figure 9. 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**

The **ADC Setup** window reflects the current setup of the **AD7191**. The channel, gain, output data rate, and clock source are selected using the DIP switch, S6. The **Setup Pins** section indicates the polarity of the ODR2, ODR1, CLKSEL, PGA1,

PGA2, CHAN, and TEMP pins. The resulting gain, channel, and clock source are shown in the **ADC Setup** section. The value of the voltage reference applied to the **AD7191** can also be programmed.

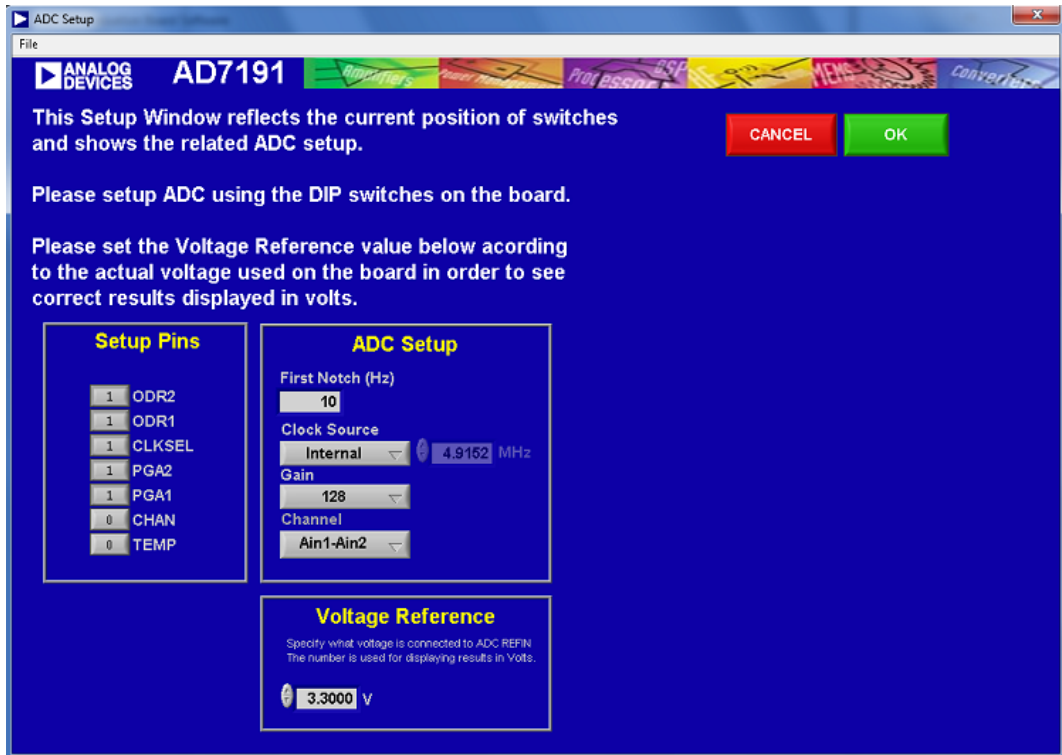


Figure 10. ADC Setup Window



## LOW NOISE QUICK TEST



Figure 11. Low Noise Quick Test

When the **Low Noise Quick Test** button is clicked, you can quickly and easily measure the rms noise of the [AD7191](#). The software provides instructions on the configuration of the [AD7191](#). When the instructions given on each window are completed, click the ok button, The [AD7191](#) 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

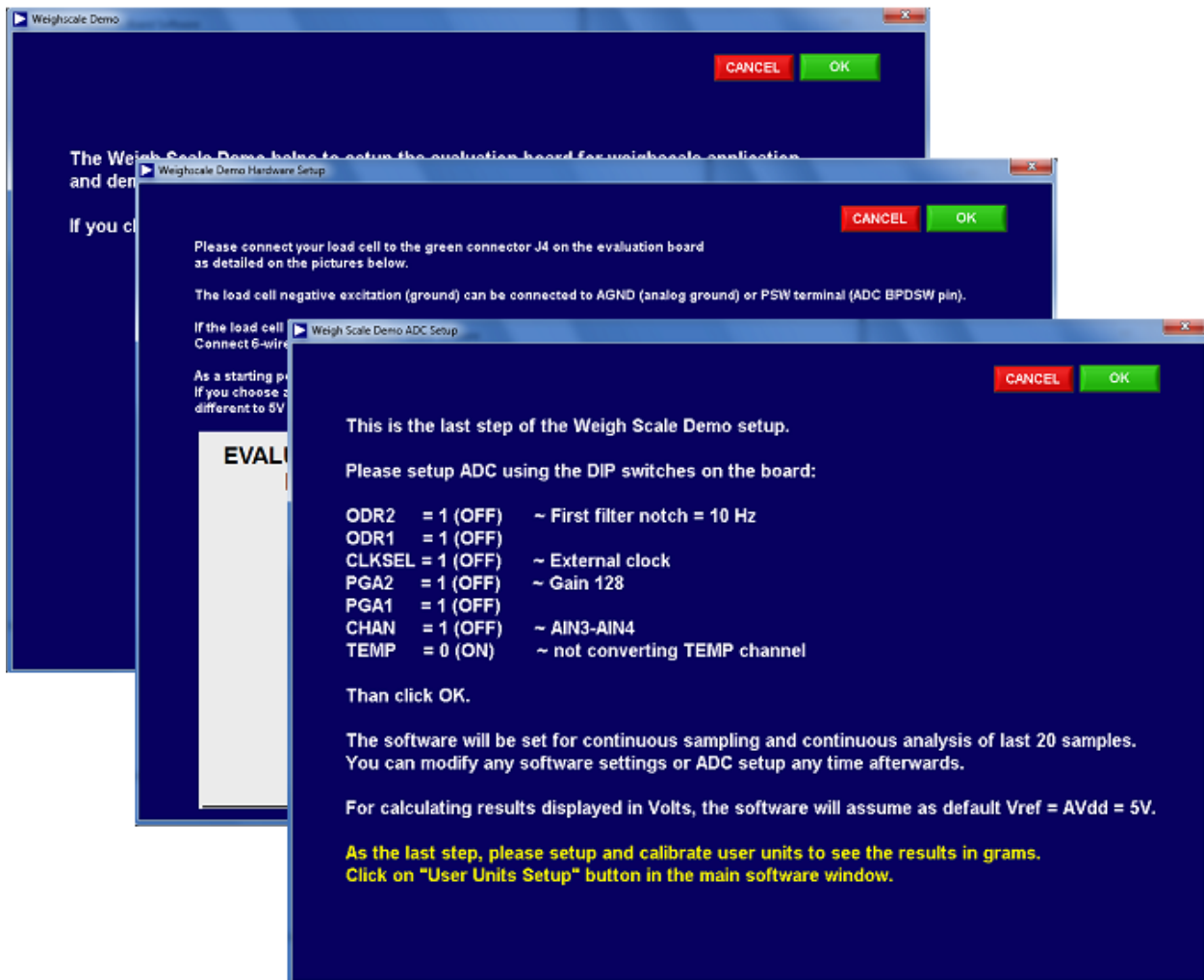


Figure 12. Weigh Scale Demo

A load cell can be connected directly to the [AD7191](#) evaluation board. When the **WeighScale Demo** button is clicked, you are guided through a series of windows that give information on connecting the load cell to the [AD7191](#) evaluation board. The last window gives instructions on configuring the [AD7191](#). When the instructions given on each window are completed,

click **OK**. The [AD7191](#) 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 the resolution. The sample size used to process the data can be changed using the **Last # Samples** box in the main window.

**USER UNITS SETUP**



Figure 13. User Units Setup Window

The **User Units Setup** window allows you to define the display units for the conversions. For example, if a load cell is connected to the [AD7191](#), 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.

EVALUATION BOARD SCHEMATICS AND ARTWORK

410-08860

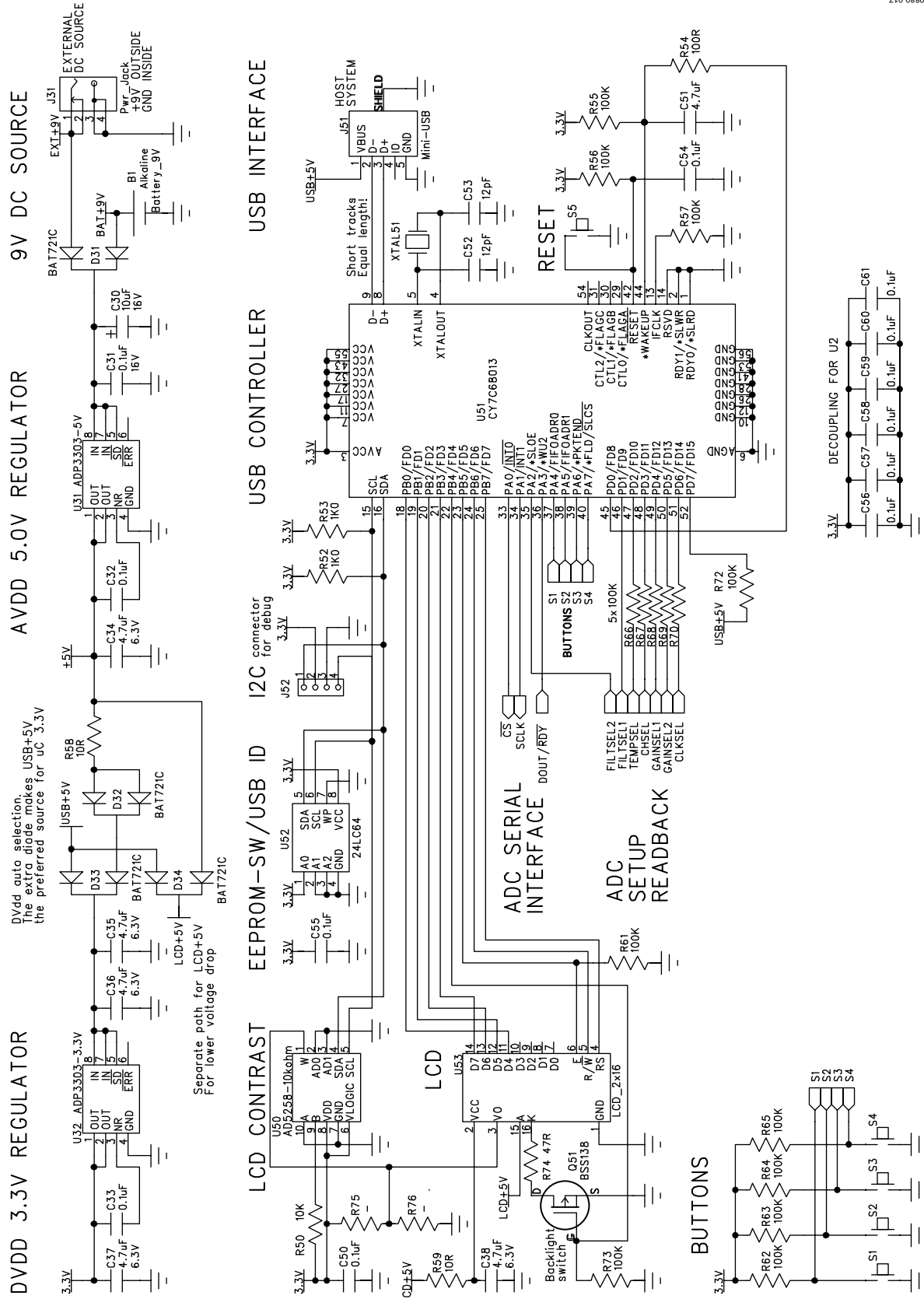


Figure 14. EVAL-AD7191EBZ, Schematic (Digital Section)

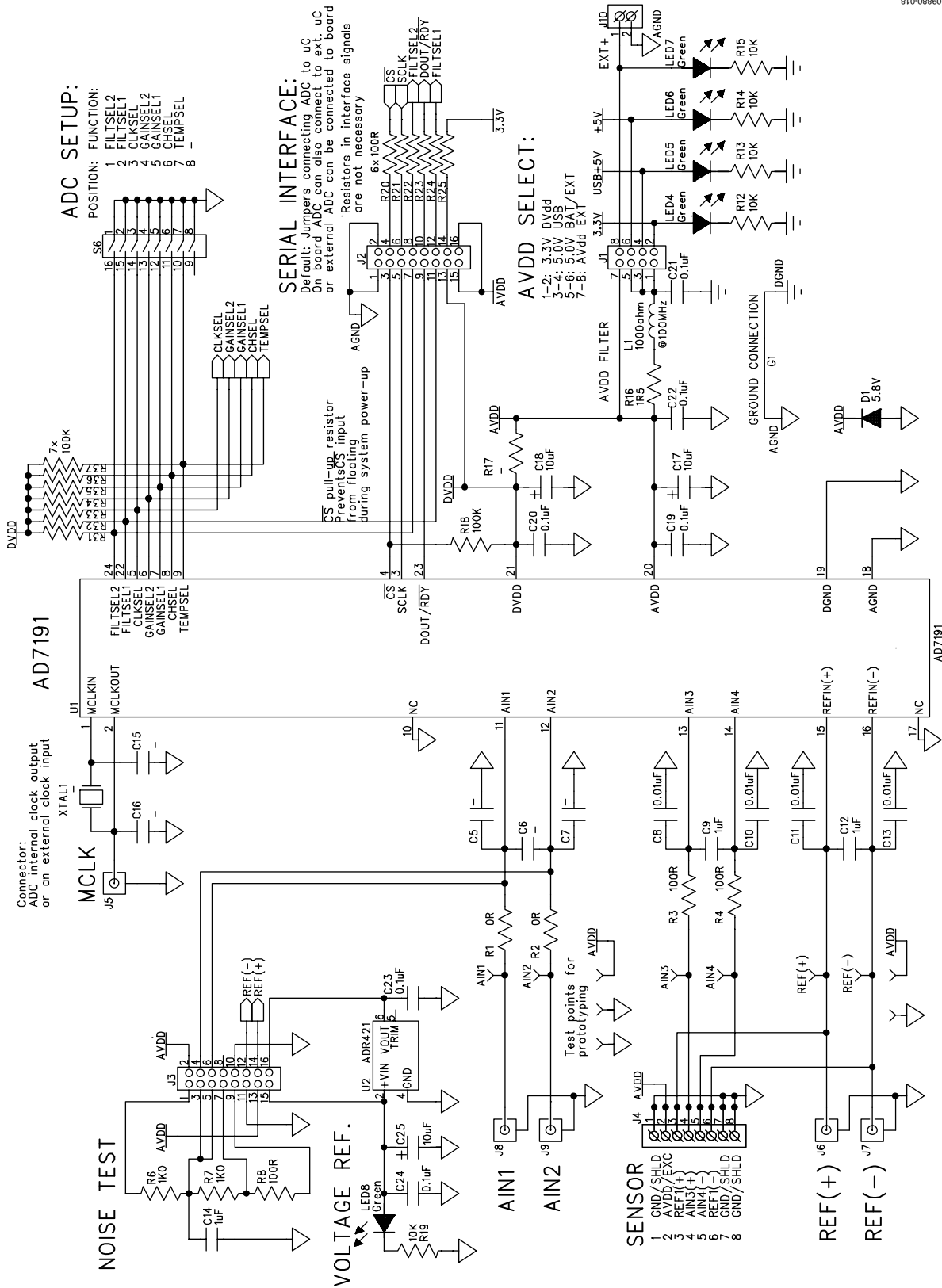


Figure 15. EVAL-AD7191EBZ, Schematic (Analog Section)

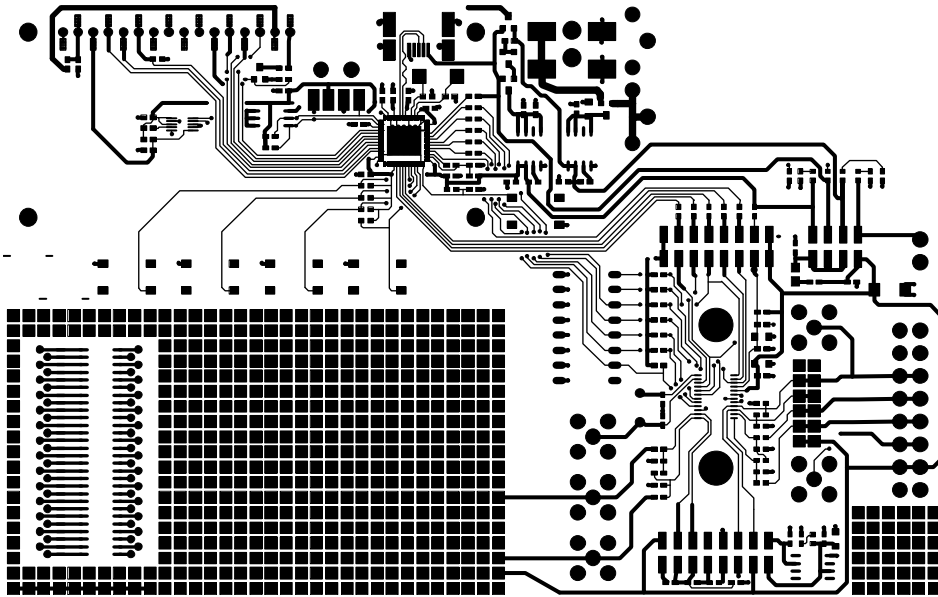


Figure 16. EVAL-AD7191EBZ, Component Side

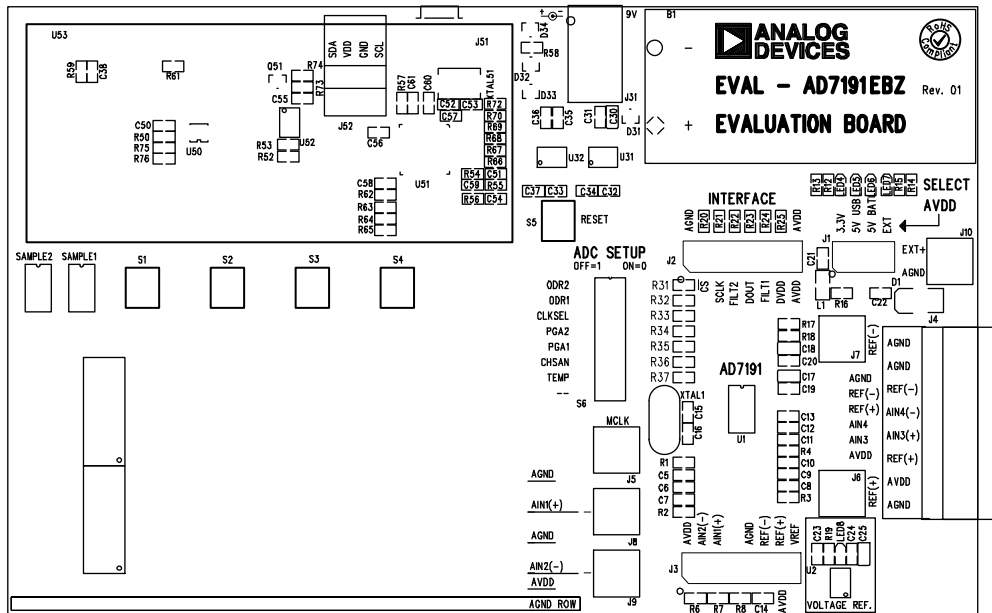


Figure 17. EVAL-AD7191EBZ Silkscreen

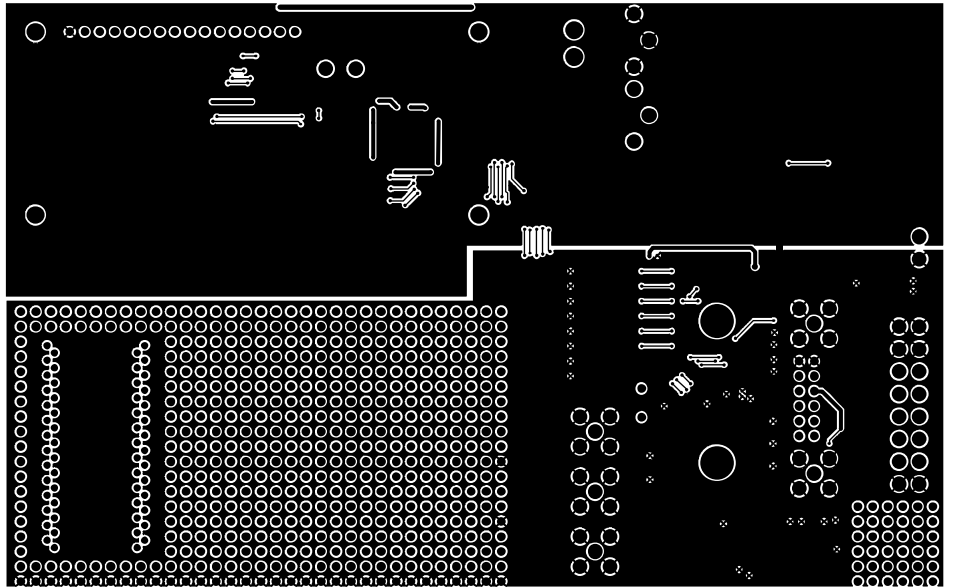


Figure 18. EVAL-AD7191EBZ, Solder Side

## ORDERING INFORMATION

## BILL OF MATERIALS

Table 2.

Designator	Qty.	Description	Manufacturer	Order No.
U1	1	AD7191	Analog Devices	AD7191BRUZ
U2	1	ADR421 reference	Analog Devices	ADR421BRZ
U31	1	5 V voltage regulator	Analog Devices	ADP3303ARZ-5
U32	1	3.3 V voltage regulator	Analog Devices	ADP3303ARZ-3.3
U50	1	10 k $\Omega$ , 64-step digital potentiometer	Analog Devices	AD5258BRMZ10
U51	1	USB controller	Cypress Semiconductor	CY7C68013A-56LFXC
U52	1	64k I <sup>2</sup> C EEPROM	Microchip Technology, Inc.	24LC64-I/SN
U53	1	LCD connector	FCI	76341-308LF
LED4 to LED8	5	LED green, high intensity (>50 mCd), 0603	Avago Technology	HSME-C191
XTAL1		4.9152 MHz crystal	Not inserted	
XTAL51	1	24 MHz crystal	AVX	CX5032GB24000H0PESZZ
D1	1	Diode	ON Semiconductor	P6SMB6.8AT3G
D31 to D34	4	Diode	Philips	BAT721C
Q51	1	N-MOSFET	Infineon	BSS138N
C5 to C7, C15, C16	5	Capacitor ceramic	Not inserted	
C52, C53	2	12 pF ceramic capacitor	Phycomp	2238 867 15129
C8, C10, C11, C13	4	0.01 $\mu$ F ceramic capacitor	Phycomp	2238 586 15636
C19 to C24, C31 to C33, C50, C54 to C61	18	0.1 $\mu$ F ceramic capacitor	Phycomp	2238 786 15649
C9, C12, C14	3	1 $\mu$ F ceramic capacitor	Phycomp	2238 246 13663
C34 to C38, C51	6	4.7 $\mu$ F ceramic capacitor	Phycomp	2255 206 13672
C17, C18, C25, C30	4	10 $\mu$ F tantalum capacitor	AVX	TAJA106M016R
L1	1	Ferrite bead	Tyco	BMB2A1000LN2
R1, R2	2	0 $\Omega$ resistor	Phycomp	232270296001
R3 to R4, R8, R20 to R25, R54	10	100 $\Omega$ resistor	Phycomp	232270461001
R6, R7, R52, R53	4	1 k $\Omega$ resistor	Phycomp	232270461002
R12 to R15, R19, R50	10	10 k $\Omega$ resistor	Phycomp	232270461003
R16	1	1.5 $\Omega$ resistor	Phycomp	232270461508
R17, R75, R76		Resistor	Not inserted	
R18, R31 to R37, R55 to R57, R61 to R70, R72, R73	23	100 k $\Omega$ resistor	Phycomp	232270461004
R58, R59	2	10 $\Omega$ resistor	Phycomp	232270461009
R74	1	47 $\Omega$ resistor	Phycomp	232270464709
S1 to S5	5	Switch	Omron	B3S-1000
S6	1	Switch, 8-way	Omron	A6S-8102-H
B1	1	Clip for 9 V battery	Keystone	593+594
J1	1	2 $\times$ 4 way header	Tyco/Amp	1241050-4
J2, J3	2	2 $\times$ 8 way header	Tyco/Amp	1241050-8
J4	1	1 $\times$ 8 way header	Phoenix Contact	1803332
J5 to J9		Connector, 50 $\Omega$ , straight, SMB	Not inserted	
J10	1	Screw terminal block	Phoenix Contact	1727010
J31	1	Connector, power jack, barrel, 2.1 mm, SMD	Lumberg	1613_14
J51	1	Connector, USB Mini-B, SMD	Molex	548190572
J52		Header	Not inserted	
	1	LCD module 2 $\times$ 16 char, 1 $\times$ 16-pin, top	Everbouquet	MC1602C-SYR
	1	LCD header	Tyco	1-826629-6



**RELATED LINKS**

<b>Resource</b>	<b>Description</b>
<a href="#">AD7191</a>	Product Page, Pin-Programmable, Ultralow Noise, 24-Bit, Sigma-Delta ADC for Bridge Sensors
<a href="#">ADR421</a>	Product Page, Ultraprecision, Low Noise, 2.500 V XFET® Voltage References
<a href="#">ADP3303</a>	Product Page, High Accuracy anyCAP® 200 mA Low Dropout Linear Regulator
<a href="#">AD5258</a>	Product Page, Nonvolatile, I <sup>2</sup> C®-Compatible 64-Position, Digital Potentiometer

**NOTES**

## NOTES

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I<sup>2</sup>C 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.

**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 (\$100,000). EXPORT. Customer agrees that it will not directly or indirectly export the Evaluation Board to another country, and that it will comply with all applicable United States federal laws and regulations relating to exports. GOVERNING LAW. This Agreement shall be governed by and construed in accordance with the substantive laws of the Commonwealth of Massachusetts (excluding conflict of law rules). Any legal action regarding this Agreement will be heard in the state or federal courts having jurisdiction in Suffolk County, Massachusetts, and Customer hereby submits to the personal jurisdiction and venue of such courts. The United Nations Convention on Contracts for the International Sale of Goods shall not apply to this Agreement and is expressly disclaimed.

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