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Evaluation Board for the AD7195, 4.8 kHz, Ultralow Noise, 24-Bit Sigma-Delta ADC

FEATURES

Full featured evaluation board for the AD7195
Standalone interface using microcontroller and LCD display
PC software for control of AD7195 using USB interface
Various linking options

INTRODUCTION

This user guide describes the evaluation board for the AD7195, which is a 4.8 kHz, ultralow noise, 24-bit sigma-delta (Σ-Δ) analog to digital converter (ADC). The AD7195 is a complete analog front end for low frequency measurement applications. It contains two differential inputs, four pseudodifferential inputs, and includes a low noise instrumentation amplifier, a reference detect, and a low-side power switch.

Full data on the AD7195 is available in the AD7195 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 AD7195 evaluation kit is a powerful tool for exploring and evaluating the AD7195 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 the data into a text file, allows the user to modify the internal settings of the AD7195, and generally helps in understanding the part features and performance.

Finally, the flexible interface structure of the board allows it to be connected in several 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 AD7195. Alternatively, an external microcontroller can be interfaced to the AD7195 and, thus, the evaluation board can act as a complete analog front end for creating and debugging software on the user's digital platform.

EVALUATION BOARD CONNECTION DIAGRAM

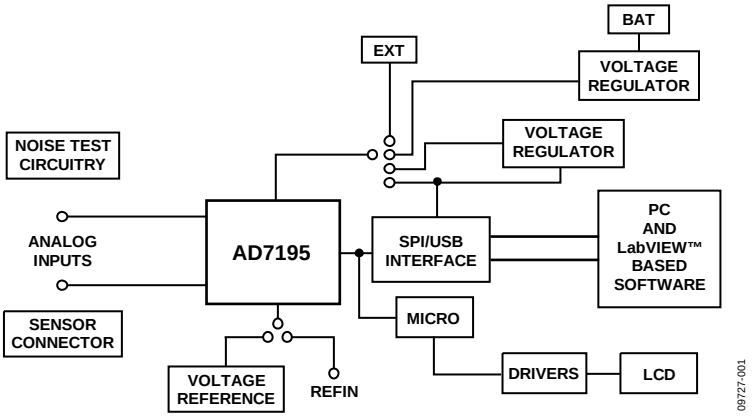


Figure 1.

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

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REVISION HISTORY

12/2018—Rev. 0 to Rev. A

Changes to Table 2 17

5/2011—Revision 0: Initial Version

EVALUATION BOARD HARDWARE

POWER SUPPLIES

There are several power supply options on the AD7195 evaluation board.

Connected to USB Connector

When the USB connector is used, the AD7195 evaluation board can be powered as follows:

- The AD7195 evaluation board is powered via the 5 V supply from the USB connector, J51. This 5 V supply can be used to power the AD7195 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. Using Link J1, the 3.3 V regulator can be used as the power supply to the AD7195. Link J1 should be placed in Position 3.3 V.
- The AD7195can 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 AD7195. 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

When standalone operation is used, the AD7195 evaluation board can be powered as follows:

- The AD7195 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 source 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 AD7195. 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 AD7195 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 AD7195. The voltage for the REFIN(+) input of the AD7195 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 AD7195. The voltage for the REFIN(−) input of the AD7195 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 AD7195 using this socket.

NOISE TEST

Header J3 allows the user to perform noise testing of the AD7195. With all links in the vertical position (see Figure 2), the analog and reference inputs are applied to the AD7195 as shown in Figure 3.

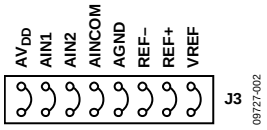


Figure 2. Link Positions for Noise Testing

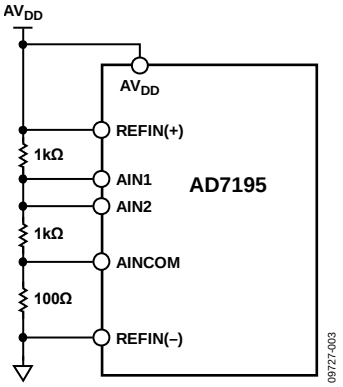


Figure 3. Noise Test Connections

As per Figure 3, inserting the links in Header J3 connects a resistor network to the AD7195. The reference to the ADC is provided by AV_{DD}. The resistor divider generates a bias voltage of $AV_{DD}/2$ approximately. Channel AIN1-AIN2 is connected to this voltage, conversions can be performed using this external short to measure the rms noise, peak-to-peak noise, peak-to-peak resolution.

USING AN ABSOLUTE REFERENCE

An ADR421 is included on the AD7195 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 AD7195 by connecting the links of Header J3 as shown in Figure 4.

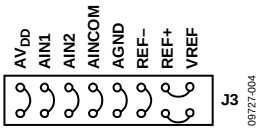


Figure 4. Connecting an Absolute Reference to the AD7195

CONNECTING THE AD7195 TO AN EXTERNAL MICROCONTROLLER

The AD7195 evaluation board can be connected to an external microcontroller using Header J2. With all links in place, the AD7195 is connected to the on-board microcontroller. However, with these links removed, the AD7195 is disconnected from the evaluation board microcontroller. The user can then use a header to interface the AD7195 to the external microcontroller.

USING THE AD7195 EVALUATION BOARD IN STANDALONE MODE

The AD7195 evaluation board can be operated in standalone mode. In this mode, the evaluation board functions as a dc excited weigh scale demonstration. Channel AIN3-AIN4 is the analog input channel. The AIN3 and AIN4 pins along with AV_{DD} and AGND are connected to the J4 header. This header allows the user to connect a load cell to the AD7195. 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. The three reference links on Header J3 must be removed (see Figure 6).

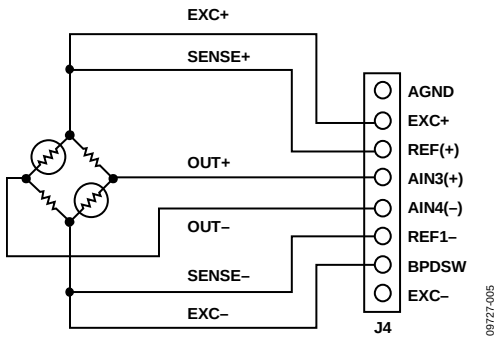


Figure 5. Load Cell Connection to Header J4

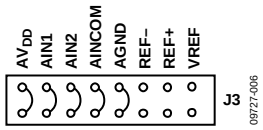


Figure 6. Link Positions for Standalone Mode

The AD7195 is configured for an update rate of 4.69 Hz, and the gain is programmed to 128. Channel AIN3-AIN4 is selected as the active channel.

The conversions from the AD7195 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 5. Apply power to the AD7195 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, perform an offset calibration. Then, place the expected full-scale weight on the load cell, and perform the full-scale calibration. Next, 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 AD7195, scales the conversions appropriately, and displays the resulting weight on the LCD display.

EVALUATION BOARD SOFTWARE

SOFTWARE INSTALLATION

The AD7195 evaluation board software should be installed before connecting the AD7195 evaluation board to the PC.

INSTALLING THE EVALUATION SOFTWARE

To install the evaluation board software, use the following steps:

1. Insert the AD7195 evaluation kit CD in the CD 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 AD7195 evaluation kit CD on your PC and run **Setup.exe**.
2. At the prompt, select a destination directory, which is **C:\Program Files\Analog Devices\AD7195** 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 **AD7195** in the **Start** menu of the taskbar.
3. Once the installation procedure is complete, double-click the AD7195 icon to start the program.

CONFIGURING THE EVALUATION BOARD

To install the evaluation board, use the following steps:

1. Connect the AD7195 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 the 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 AD7195 evaluation software on your PC by clicking the Windows **Start** button, select **All Programs** > **Analog Devices** > **AD7195** > **AD7195 evaluation software**.

The software allows the user to configure the AD7195, gather samples, and analyze the data. Consult the AD7195 data sheet for more information on the register bits and their functions.

Figure 7 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.

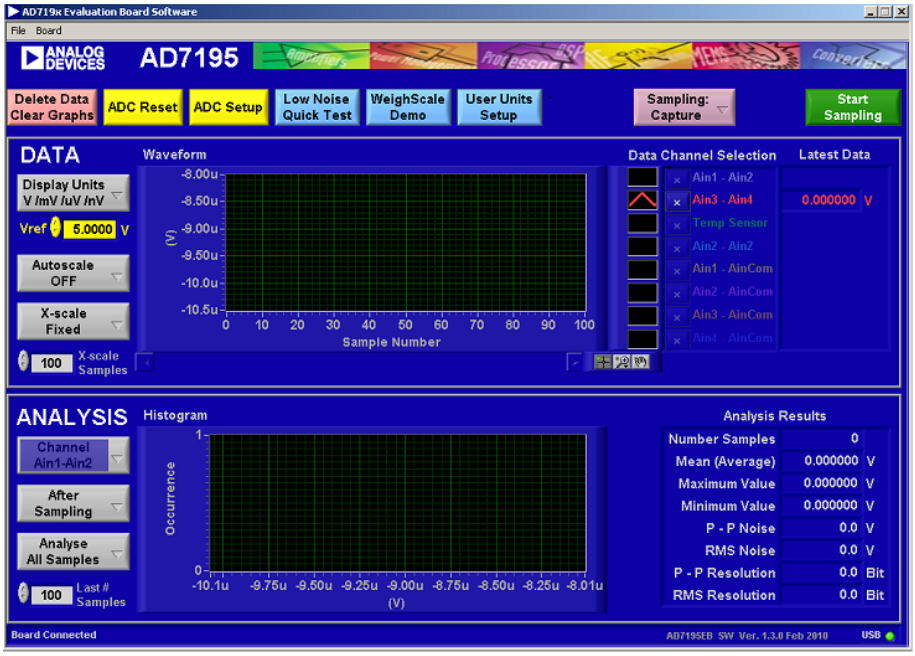


Figure 7. AD7195 Evaluation Software Main Window

MAIN WINDOW

Menu Bar

File

The **File** menu allows the user to write the current set of data to a file for later use, log data as it is gathered, and exit the program.

Board

The **Board** menu allows the user to alter the contrast on the LCD display.

Buttons

Delete Data/Clear Graphs

This button allows the user to delete the data displayed in the graph.

ADC Reset

This button allows the user to reset the AD7195 to its default (power on) settings.

ADC Setup

This button opens the **ADC Setup** window, which allows the user to configure the AD7195.

Low Noise Quick Test

This button allows the user to access the noise testing software.

WeighScale Demo

This button allows the user to access the weigh scale demonstration software.

User Units Setup

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

Sampling

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

Start Sampling

This button allows the user to read samples from the AD7195.

Data Section

Display Units

This button allows the user to display the conversions in hex, 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** text box.

Autoscale

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

X-scale

This button allows the user 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** text box.

Analysis Section

Channel

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

After Sampling During Sampling

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

Analyse All Samples/Analyse Last # Samples

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

The software captures all samples generated by the AD7195. If the software fails to gather all samples, then the message shown in Figure 8 appears. The software may drop samples because

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



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Figure 8. Error Message When Samples Are not Captured

ADC SETUP WINDOW

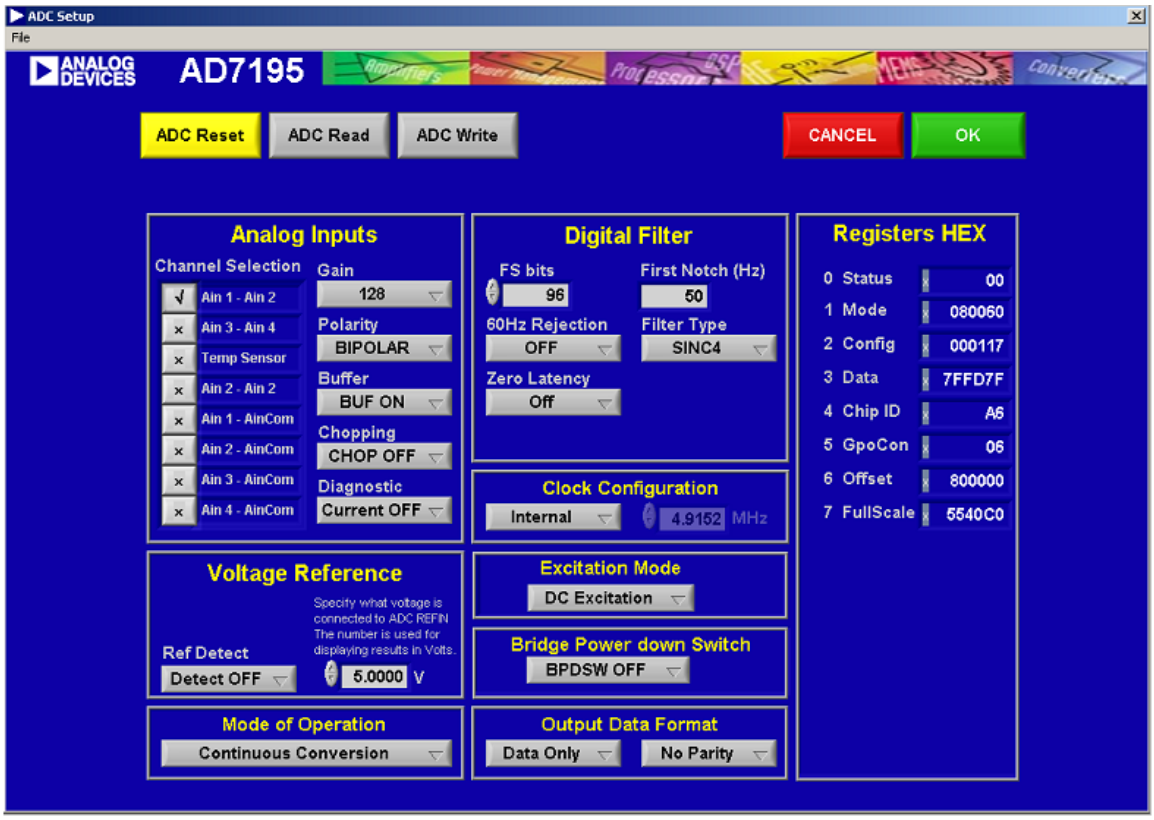


Figure 9. ADC Setup Window

The **ADC Setup** window gives the user access to the AD7195 registers (see Figure 9). The user can write to the registers and read from the registers. This window operates even when an AD7195 evaluation board is not connected to the software. It operates as an AD7195 configuration tool.

Buttons

ADC Reset

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

ADC Read

Using this button allows the values of the registers on the AD7195 to be read. The **ADC Setup** window displays the hexadecimal values returned from the AD7195. Sections such as **Analog Inputs** and **Digital Filter** are also updated to reflect the AD7195 configuration.

ADC Write

The information displayed in the **Registers HEX** section is written to the AD7195.

Sections of the ADC Setup Window

Analog Inputs

Using the options within this section, the analog input channels can be selected. Gain, polarity, chopping can also be selected. The analog inputs can be buffered or unbuffered using the **Buffer** drop-down menu. Finally, the **Diagnostic** drop-down menu enables/disables the burnout currents.

Digital Filter

The output data rate, first filter notch, order of the sinc filter, zero latency, and enabling/disabling Bit REJ60 are programmed using the options within this section. The user 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, the user can enter the FS[9:0] value in decimal, and the software calculates the first filter notch. The user can also select the $sinc^3$/$sinc^4$ filter and enable/disable zero latency.

The value to be written to the AD7195 is displayed in the **Registers HEX** section.

Clock Configuration

The clock to be used by the AD7195 is selected in this section. When an external master clock is selected, the clock frequency must be entered in the **MHz** text box.

Voltage Reference

The reference source and reference value are programmed in this section. The user can enable/disable the reference detect function and set the voltage of the reference.

When the reference setup is changed, the changes needed to the Configuration Register are shown in the **Registers HEX** section.

Excitation Mode

Use this drop-down menu to select ac excitation or dc excitation.

Bridge Power Down Switch

The low-side power switch is enabled or disabled using this drop-down menu.

Mode of Operation

This drop-down menu allows the user to select different modes of operation such as continuous conversion, single cycle conversion and calibration.

Output Data Format

This drop-down menu allows the user to select the output format of the data conversions and to enable the parity. When several analog inputs are enabled, the **Data + Status** feature should be enabled.

Registers HEX

This section displays the values to be written to the AD7195 registers. When features such as the analog input channel, gain, and mode of operation are changed, the values in the **Registers HEX** section are updated automatically. The user can write directly to the **Registers HEX** section, altering the contents of any register. The sections such as **Analog Inputs** and **Digital Filter** are updated to reflect the changes in the **Registers HEX** section.

CONFIGURATION ASSIST TOOL

The AD7195 evaluation software can be used as a configuration assist tool, even when an AD7195 evaluation board is not connected. When the AD7195 evaluation board software is open, click **ADC Setup**. The message in Figure 10 appears. Click **Ignore**. The **ADC Setup** window opens. Use the **ADC Setup** window to determine the values to be written to the AD7195 on-chip registers for different configurations.

The **Registers HEX** section can be used. When the values in this section are altered, the other sections of the **ADC Setup** window are updated so that the user can easily see the impact of the register changes. Alternatively, the user can modify the other sections of the **ADC Setup** window and the **Registers HEX** section is updated with the changes. Therefore, the user can easily calculate the values to be written to the AD7195 for different configurations.

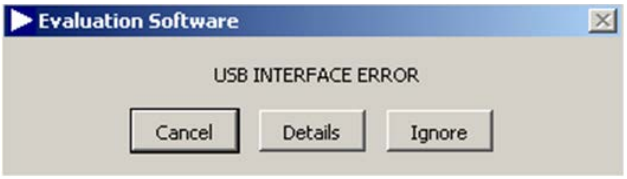


Figure 10. Configuration Tool

LOW NOISE QUICK TEST



Figure 11. Low Noise Quick Test

When **Low Noise Quick Test** is clicked in the main window, the user can quickly and easily measure the rms noise of the AD7195. The software configures the AD7195 to have a gain of 128 and an output data rate of 4.7 Hz. In addition, 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 AD7195). The software also provides instructions on the link positions for the AD7195 evaluation board. When the instructions given on each window are completed, click **OK**. The AD7195 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.

WEIGH SCALE DEMO



Figure 12. Weigh Scale Demo Window

A load cell can be connected directly to the AD7195 evaluation board. When **WeighScale Demo** is clicked in the main window, the user is guided through a series of windows that provide information about connecting the load cell to the AD7195 evaluation board. The AD7195 is automatically configured to have a gain of 128 and an output data rate of 10 Hz. In addition, Channel AIN3-AIN4 and dc excitation re selected. When the instructions given on each window are completed, click **OK**. The AD7195 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 altered using the **Last # Samples** text box.

USER UNITS SETUP



Figure 13. User Units Setup Window

In the main window, click **User Units Setup** and the **User Units Setup** window shown in Figure 13 appears. This window allows the user to define the display units for the conversions. For example, if a load cell is connected to the AD7195, the conversions from the ADC can be displayed in grams. The offset and gain error of the system can also be calibrated. The user can perform a system offset and system full-scale calibration. The resulting coefficients are held in memory—they are not written to the calibration registers of the ADC.

EVALUATION BOARD SCHEMATICS AND ARTWORK

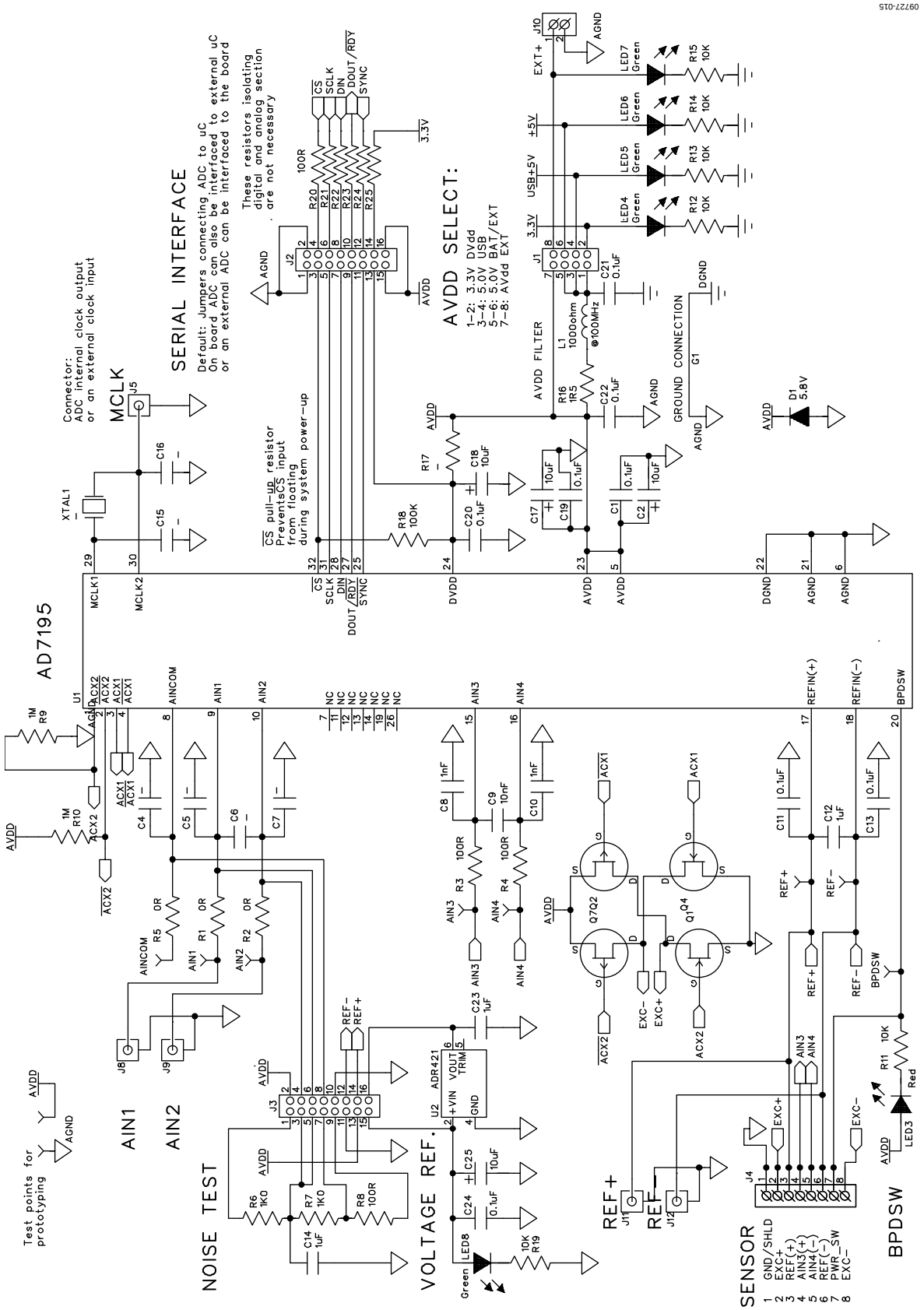


Figure 14. AD7195 Evaluation Board Schematic, Analog

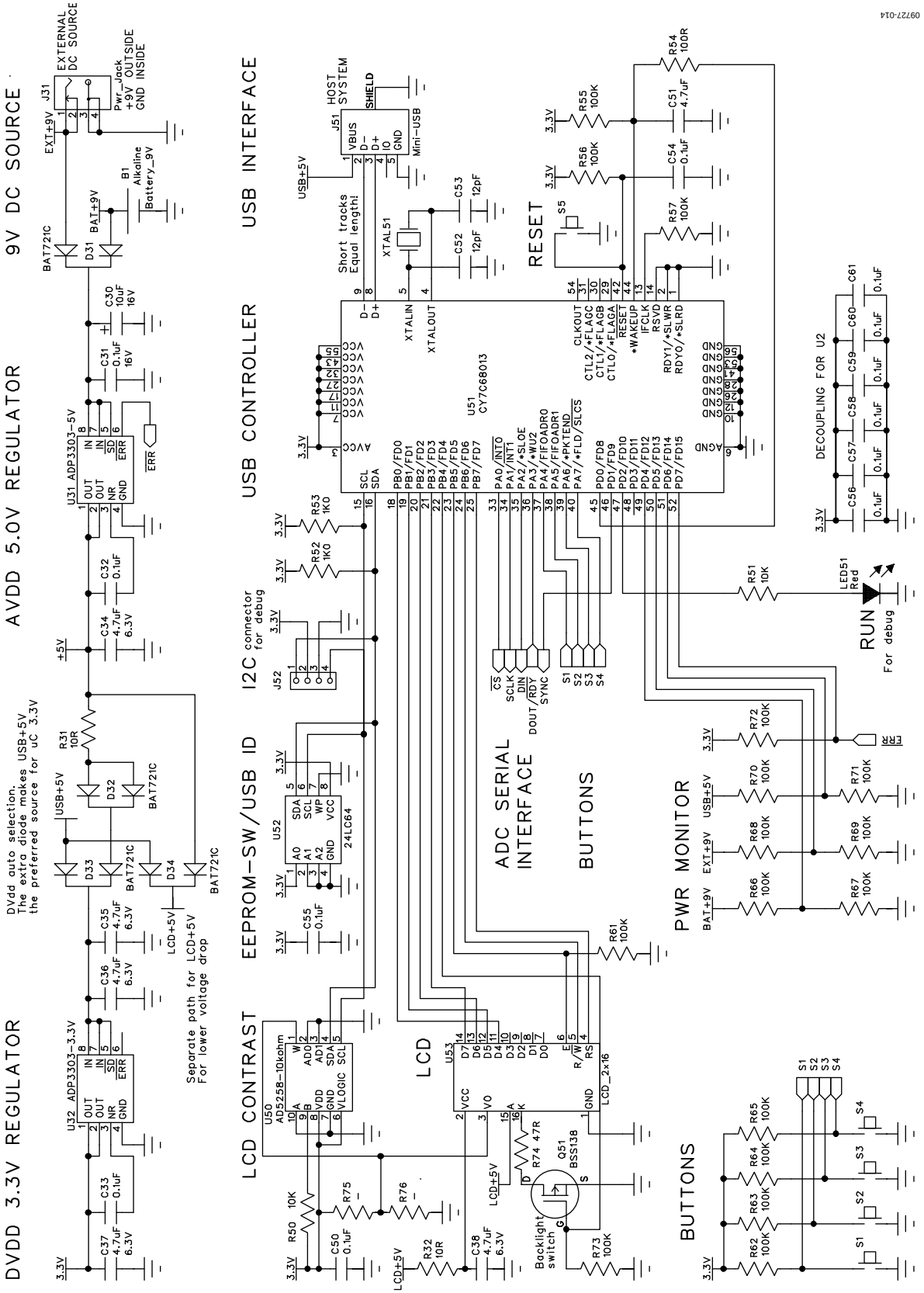


Figure 15. AD7195 Evaluation Board Schematic, Digital

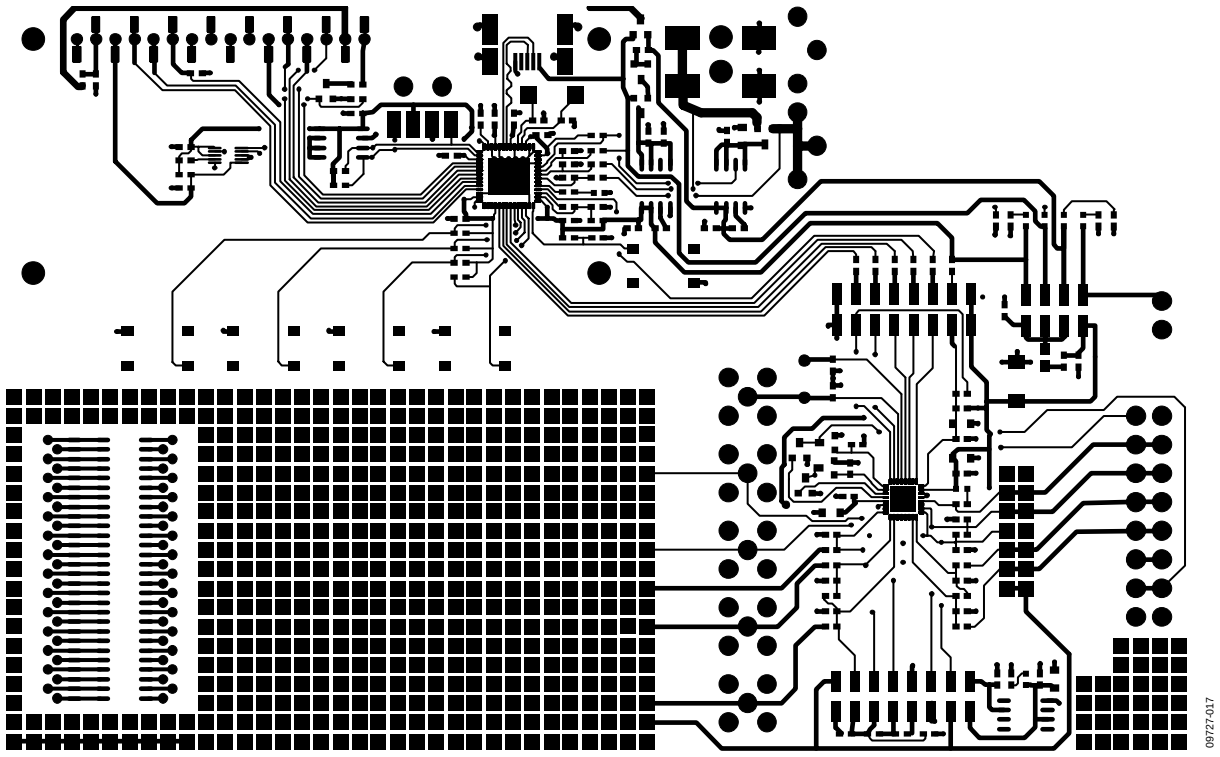


Figure 16. AD7195 Evaluation Board Component Side View

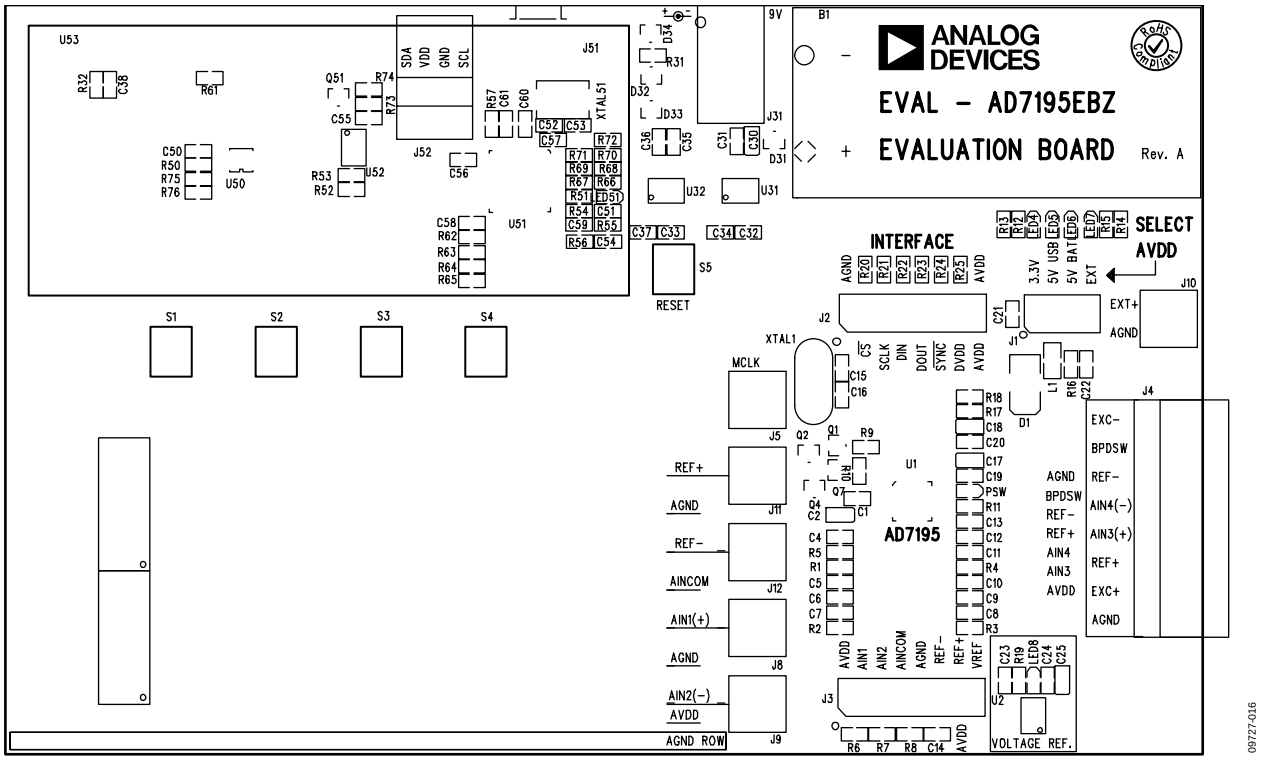


Figure 17. AD7195 Evaluation Board Silkscreen

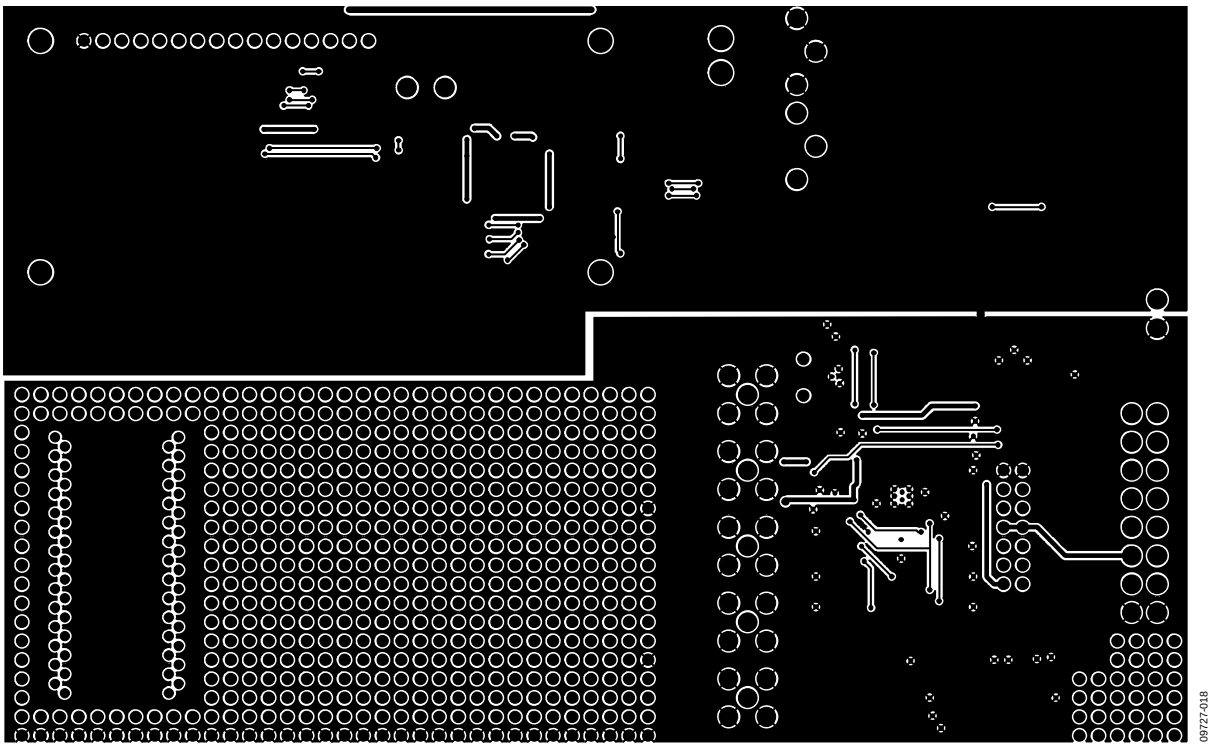


Figure 18. AD7195 Evaluation Board Solder Side View

ORDERING INFORMATION

BILL OF MATERIALS

Table 2.

Qty.	Designator	Description	Manufacturer/Supplier	Order No.
1	U1	AD7195	Analog Devices	AD7195BCPZ
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 kΩ, 64-step digipot	Analog Devices	AD5258BRMZ10
1	U51	USB controller	Cypress Semiconductor	CY7C68013A-56LFXC
1	U52	64K I^2C 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	
1	XTAL51	24 MHz crystal	AVX	CX5032GB24000H0PESZZ
1	D1	Diode	ON Semiconductor	P6SMB6.8AT3G
4	D31 to D34	Diode	Philips	BAT721C
1	Q51	N-MOSFET	Infineon	BSS138N
9	C1 to C7, C15, C16	Ceramic capacitor	Not inserted	
2	C52, C53	12 pF ceramic capacitor	Phycomp	2238 867 15129
2	C8, C10	1 nF ceramic capacitor	AVX	06035A102JAT2A
1	C9	10 nF ceramic capacitor	Yageo	CC0603KRX7R9BB103
17	C11, C13, C19 to C24, C31 to C33, C54 to C61	0.1 µF ceramic capacitor	Phycomp	2238 786 15649
3	C12, C14	1 µF ceramic capacitor	Yageo	CC0603KRX5R6BB105
6	C34 to C37, C50 to C51	4.7 µF ceramic capacitor	Phycomp	2255 206 13672
4	C17, C18, C25, C30	10 µF tantalum capacitor	AVX	TAJA106M016R
1	L1	Ferrite bead	Tyco	BMB2A1000LN2
3	R1, R2, R5	0.0 Ω resistor	Phycomp	232270296001
9	R3 to R4, R8, R20 to R25	100 Ω resistor	Phycomp	232270461001
5	R6 to R7, R52 to R54	1 kΩ resistor	Phycomp	232270461002
10	R9 to R15, R19, R50 to R51	10 kΩ resistor	Phycomp	232270461003
1	R16	1.5 Ω resistor	Phycomp	232270461508
	R17, R75 to R76	Resistor	Not inserted	
16	R18, R55 to R57, R62 to R73	100 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 × 4 way header	Tyco/Amp	1241050-4
2	J2, J3	2 × 8 way header	Tyco/Amp	1241050-8
1	J4	1 × 8 way header	Phoenix Contact	1803332
	J5 to J9	Connector, 50 Ω, straight, SMB	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	
1		LCD module 2 × 16 char, 1 × 16-pin, top	Everbouquet	MC1602C-SYR
1		LCD header	Tyco	1-826629-6
2	Q1, Q4	N-FET transistor	NPX	BSH112
2	Q2, Q7	P-FET transistor	NPX	BSH201

NOTES

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NOTES



ESD Caution

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

Legal Terms and Conditions

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

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