

## Evaluation Board for the **AD5171** Digital Potentiometer

### FEATURES

Full-featured in conjunction with low voltage digiPOT motherboard (EVAL-MB-LV-SDZ)  
 Various test circuits  
 Various ac/dc input signals  
 PC control via a separately purchased system demonstration platform (SDP-B or SDP-S)  
 PC software for control

### PACKAGE CONTENTS

**EVAL-AD5171DBZ** board  
**EVAL-MB-LV-SDZ** motherboard  
 CD that includes  
 Self-installing software that allows users to control the board and exercise all functions of the device  
 Electronic version of the **AD5171** data sheet  
 Electronic version of the UG-394 user guide

### GENERAL DESCRIPTION

This user guide describes the evaluation board for evaluating the **AD5171**, a single-channel, 64-position, one-time programmable (OTP) memory digital potentiometer that uses fuse link technology to achieve memory retention of resistance settings.

The on-board socket allows the user to easily replace the device for reprogramming of the OTP memory.

The **AD5171** supports single-supply 2.7 V to 5.5 V operation, making the device suited for battery-powered applications and many other applications with superior low temperature coefficient performance.

In addition, the **AD5171** uses a versatile I<sup>2</sup>C serial interface that operates in fast mode, allowing speeds of up to 400 kHz.

The EVAL-MB-LV-SDZ can operate in single-supply mode and incorporates an internal power supply from the USB.

Complete specifications for the **AD5171** part can be found in the **AD5171** data sheet, which is available from Analog Devices, Inc., and should be consulted in conjunction with this user guide when using the evaluation board.

### **EVAL-AD5171DBZ** WITH MOTHERBOARD AND SDP-B

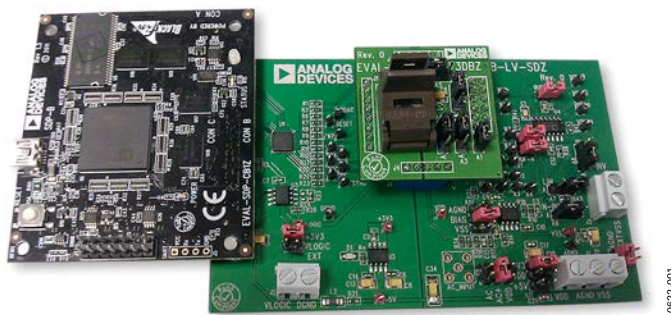


Figure 1. Digital Picture of Evaluation Board with Low Voltage DigiPOT Motherboard and System Demonstration Platform

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REVISION HISTORY

5/12—Revision 0: Initial Version

## EVALUATION BOARD HARDWARE

### POWER SUPPLIES

The EVAL-MB-LV-SDZ supports using single-power supplies.

The evaluation board can be powered either from the SDP port or externally by the J1 and J2 connectors, as described in Table 1.

All supplies are decoupled to ground using 10  $\mu$ F tantalum and 0.1  $\mu$ F ceramic capacitors.

**Table 1. Maximum and Minimum Voltages of the Connectors**

| Connector No. | Label   | Voltage                                                      |
|---------------|---------|--------------------------------------------------------------|
| J1-1          | EXT VDD | Analog positive power supply, $V_{DD}$ , from 2.7 V to 5.5 V |
| J1-2          | GND     | Analog ground                                                |
| J2-1          | VLOGIC  | Digital supply, from 2.7 V to $V_{DD}$                       |
| J2-2          | DGND    | Digital ground                                               |

### Link Options

Several link and switch options are incorporated in the EVAL-MB-LV-SDZ board and should be set up before using the board. Table 2 describes the positions of the links to control the evaluation board by a PC, via the SDP board. The functions of these link options are described in detail in Table 3 through Table 6.

**Table 2. Link Options Setup for SDP Control (Default)**

| Link No. | Option |
|----------|--------|
| A11      | 3.3 V  |
| A12      | AGND   |
| A5       | 3.3 V  |

**Table 3. Link Functions**

| Link No. | Power Supply | Options                                                                                                                                                          |
|----------|--------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| A11      | $V_{DD}$     | This link selects one of the following as the positive power supply:<br>5 V (from SDP).<br>3.3 V (from SDP).<br>EXT VDD (external supply from the J1 connector). |
| A5       | $V_{LOGIC}$  | This link selects one of the following as the digital supply:<br>3.3 V (from SDP).<br>VLOGIC (external supply from the J2 connector).                            |
| A12      | GND          | AGND.                                                                                                                                                            |

## TEST CIRCUITS

The EVAL-AD5171DBZ and EVAL-MB-LV-SDZ incorporate several test circuits to evaluate the performance of the AD5171.

### DAC

The RDAC can be operated as a digital-to-analog converter (DAC), as shown in Figure 2.

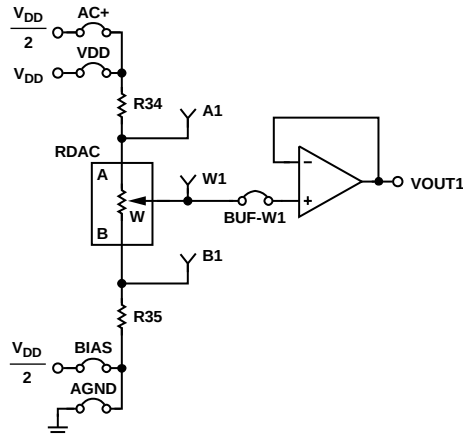


Figure 2. DAC

Table 5 shows the options available for the voltage references.

The output voltage is defined in Equation 1.

$$V_{OUT} = (V_A - V_B) \times \frac{RDAC}{64} \quad (1)$$

where:

RDAC is the code loaded in the RDAC register.

$V_A$  is the voltage applied to the A terminal (A9 link).

$V_B$  is the voltage applied to the B terminal (A10 link).

However, by using the R34 and R35 external resistors, the user can reduce the voltage of the voltage references. In this case, use the A1 and B1 test points to measure the voltage applied to the A and B terminals and recalculate  $V_A$  and  $V_B$  in Equation 1.

### AC Signal Attenuation

The RDAC can be used to attenuate an ac signal, which must be provided externally using the AC\_INPUT connector, as shown in Figure 3.

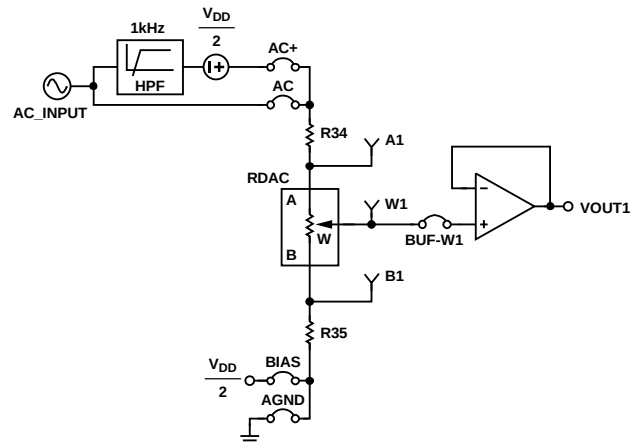


Figure 3. AC Signal Attenuator

Depending on the voltage supply rails and the dc offset voltage of the ac signal, various configurations can be used as described in Table 4.

Table 4. AC Signal Attenuation Link Options

| Link | Options | Conditions                                                                                                                                    |
|------|---------|-----------------------------------------------------------------------------------------------------------------------------------------------|
| A9   | AC+     | No dc offset voltage.<br>AC signal is outside the voltage supply rails due to the dc offset voltage.<br>DC offset voltage $\neq V_{DD}/2^1$ . |
|      | AC      | All other conditions.                                                                                                                         |
| A10  | BIAS    | Use in conjunction with AC+ link <sup>1</sup> .                                                                                               |
|      | AGND    | All other conditions.                                                                                                                         |

<sup>1</sup> Recommended to ensure optimal total harmonic distortion (THD) performance.

The signal attenuation is defined in Equation 2.

$$Attenuation (dB) = 20 \times \log \left( \frac{R_{WB} + R_W}{R_{END-TO-END}} \right) \quad (2)$$

where:

$R_{WB}$  is the resistor between the W and B terminals.

$R_W$  is the wiper resistance.

$R_{END-TO-END}$  is the end-to-end resistance value.

Table 5. DAC Voltage References

| Terminal | Link (Daughter Board) | Link (Motherboard) | Options    | Description                                                            |
|----------|-----------------------|--------------------|------------|------------------------------------------------------------------------|
| A1       | Switch B of A4        | A9                 | AC+<br>VDD | Connects Terminal A1 to $V_{DD}/2$<br>Connects Terminal A1 to $V_{DD}$ |
| W1       | Switch B of A3        | BUF-W1             |            | Connects Terminal W1 to an output buffer                               |
| B1       | Switch B of A2        | A10                | BIAS       | Connects Terminal B1 to $V_{DD}/2$                                     |
|          |                       |                    | AGND       | Connects Terminal B1 to analog ground                                  |
|          | A1 inserted           |                    |            | Closes feedback loop of second op amp in the AD8618                    |

### Signal Amplifier

The RDAC can be operated as an inverting or noninverting signal amplifier supporting linear or pseudologarithmic gains. Table 6 shows the available configurations.

The noninverting amplifier with linear gain is shown in Figure 4, and the gain is defined in Equation 3.

$$G = 1 + \frac{R_{WB}}{R_{38}} \quad (3)$$

where  $R_{WB}$  is the resistor between the W and B terminals.

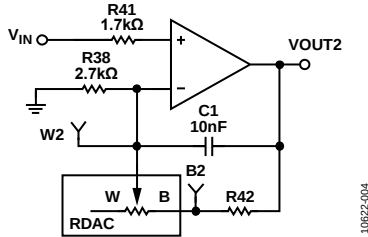


Figure 4. Linear Noninverting Amplifier

The noninverting amplifier with pseudologarithmic gain is shown in Figure 5, and the gain is defined in Equation 4.

$$G = 1 + \frac{R_{WB}}{R_{AW}} \quad (4)$$

where:

$R_{WB}$  is the resistor between the W and B terminals.

$R_{AW}$  is the resistor between the A and W terminals.

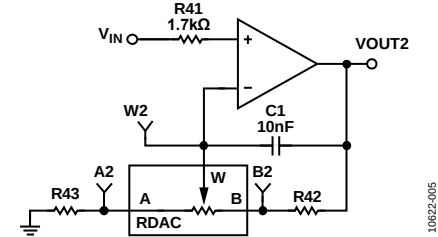


Figure 5. Pseudologarithmic Noninverting Amplifier

R43 and R42 can be used to set the maximum and minimum gain limits.

The inverting amplifier with linear gain is shown in Figure 6, and the gain is defined in Equation 5.

Note that the input signal,  $V_{IN}$ , must be negative.

$$G = -\frac{R_{WB}}{R_{38}} \quad (5)$$

where  $R_{WB}$  is the resistor between the W and B terminals.

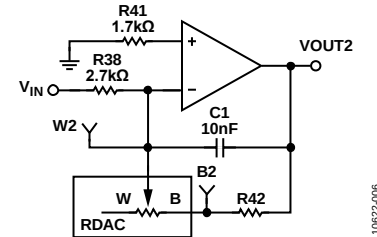


Figure 6. Linear Inverting Amplifier

Table 6. Amplifier Selection Link Options

| Amplifier    | Gain              | Link (Daughter Board)      | Link (Motherboard) | Label          | $V_{IN}$ Range   |
|--------------|-------------------|----------------------------|--------------------|----------------|------------------|
| Noninverting | Linear            | Switch A of A2, A3, and A4 | A7                 | LIN            | 0 V to $V_{DD}$  |
|              |                   | A1 not inserted            | A6<br>A8           | N-INV<br>N-INV |                  |
|              | Pseudologarithmic | Switch A of A2, A3, and A4 | A7                 | LOC            | 0 V to $V_{DD}$  |
|              |                   | A1 not inserted            | A6<br>A8           | N-INV<br>N-INV |                  |
| Inverting    | Linear            | Switch A of A2, A3, and A4 | A7                 | LIN            | $-V_{DD}$ to 0 V |
|              |                   | A1 not inserted            | A6<br>A8           | INV<br>INV     |                  |

## EVALUATION BOARD SOFTWARE

### INSTALLING THE SOFTWARE

The [EVAL-AD5171DBZ](#) kit includes evaluation board software provided on a CD. The software is compatible with Windows® XP, Windows Vista, and Windows 7 (both 32 bits and 64 bits).

Install the software before connecting the [SDP board](#) to the USB port of the PC to ensure that the SDP board is recognized when it is connected to the PC.

1. Start the Windows operating system and insert the CD.
2. The installation software opens automatically. If it does not, run the **setup.exe** file from the CD.
3. After installation is completed, power up the evaluation board as described in the Power Supplies section.
4. Connect the [EVAL-AD5171DBZ](#) and the EVAL-MB-LV-SDZ to the SDP board and the SDP board to the PC using the USB cable included in the evaluation kit.
5. When the software detects the evaluation board, follow the instructions that appear to finalize the installation.

### RUNNING THE SOFTWARE

To run the program, do the following:

1. Click **Start > All Programs > Analog Devices > AD5171 > AD5171 Eval Board**. To uninstall the program, click **Start > Control Panel > Add or Remove Programs > AD5171 Eval Board**.

2. If the SDP board is not connected to the USB port when the software is launched, a connectivity error displays (see Figure 7). Simply connect the evaluation board to the USB port of the PC, wait a few seconds, click **Rescan**, and follow the instructions.

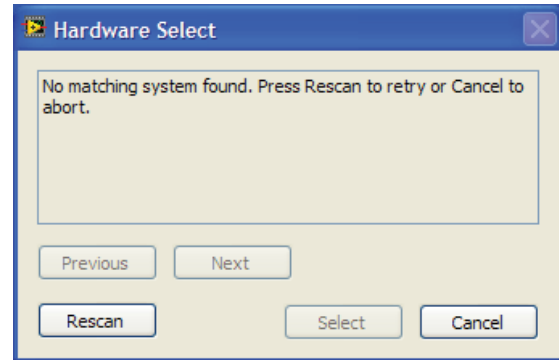


Figure 7. Pop-Up Window Error

The main window of the [EVAL-AD5171DBZ](#) evaluation software then opens, as shown in Figure 8.

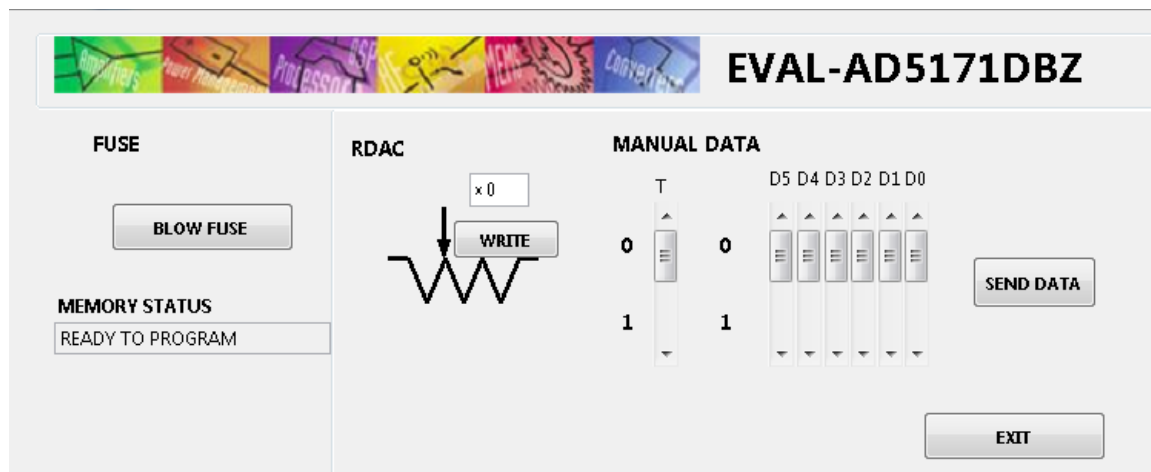


Figure 8. [EVAL-AD5171DBZ](#) Software Main Window

## SOFTWARE OPERATION

The main window of the [EVAL-AD5171DBZ](#) software is divided into the following sections: **FUSE**, **RDAC**, and **MANUAL DATA**.

**FUSE** has the following options:

- **BLOW FUSE** allows you to program the fuses. The A11 link must be connected to 5 V. If the board is operated at a different supply, close the program, change the link, and rerun the software. Due to the supply voltage limitations of the SDP board, the logic digital levels operate below a recommended value (2.5 V), and proper communication is not guaranteed.
- **MEMORY STATUS** shows the fuse status.

**RDAC** has the following option:

- Enter a desired value into the text box to update the RDAC registers and click **WRITE**. When **WRITE** is clicked, a write/read operation is performed, and the value displayed in this section is updated with the actual RDAC register value. This function can be used to verify whether the write operation was completed successfully.

**MANUAL DATA** has the following option:

- A customized I<sup>2</sup>C data-word can be sent by manually switching the scroll bars from 0 to 1 or from 1 to 0 as desired and then clicking **SEND DATA**.

**EXIT** closes the program.

# EVALUATION BOARD SCHEMATICS AND ARTWORK

## MOTHERBOARD

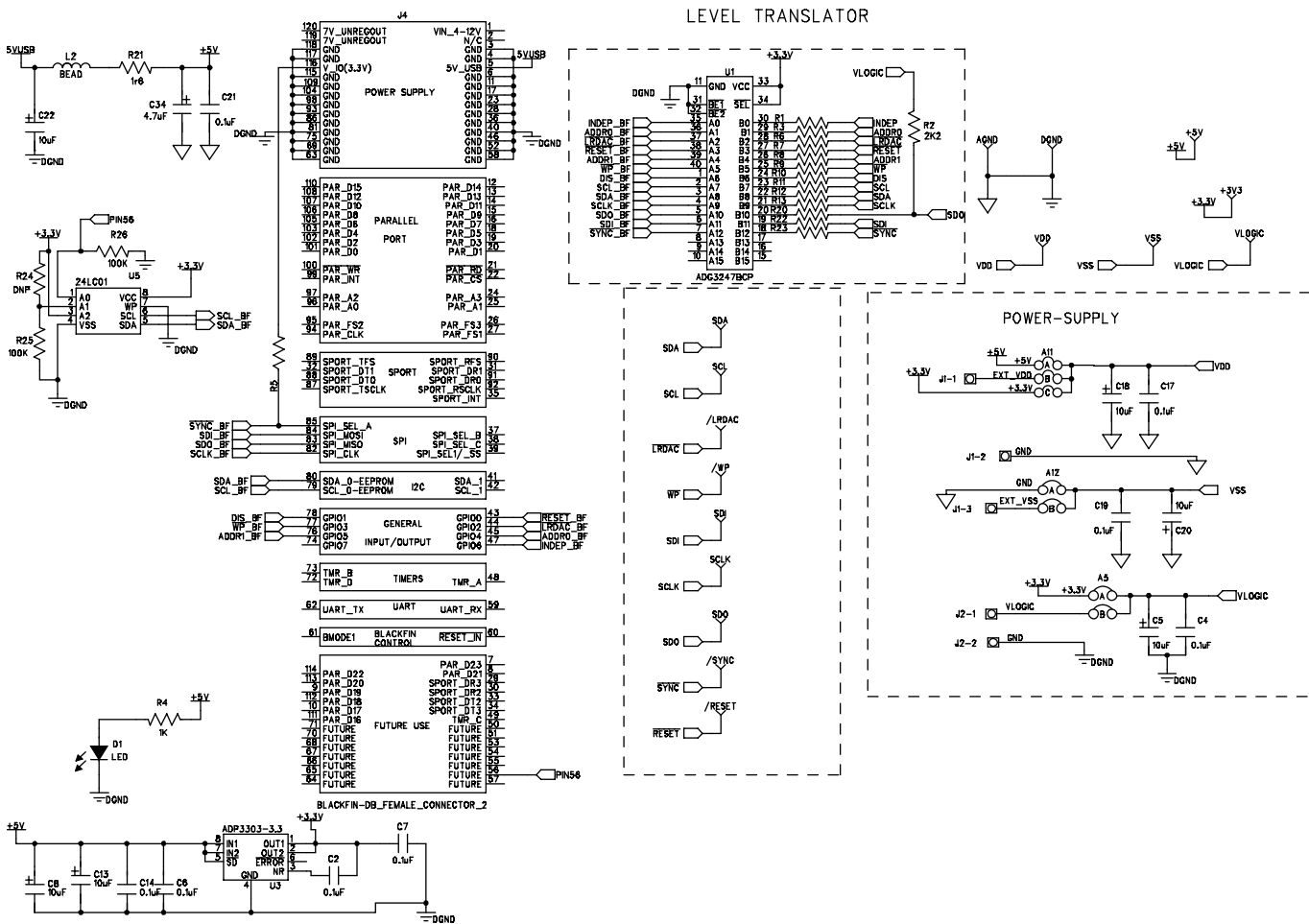


Figure 9. SDP Connector and Power Supply



# DAC + FLOATING DAC + BW

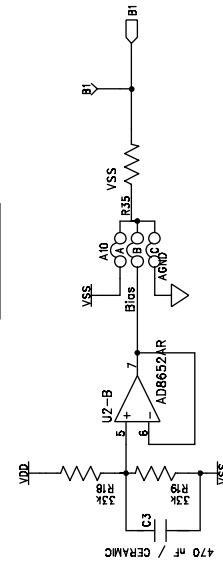
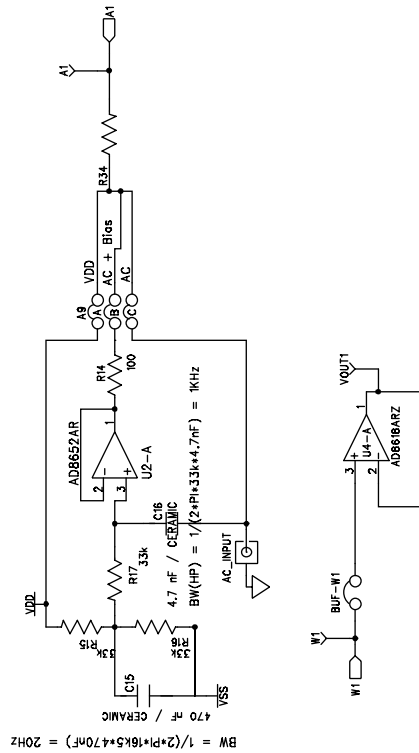
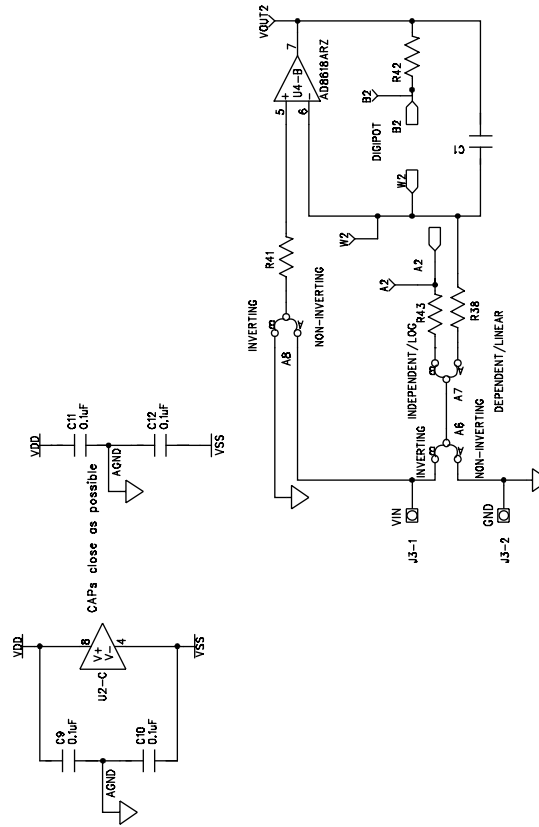
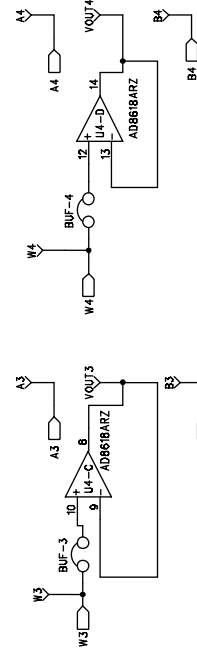


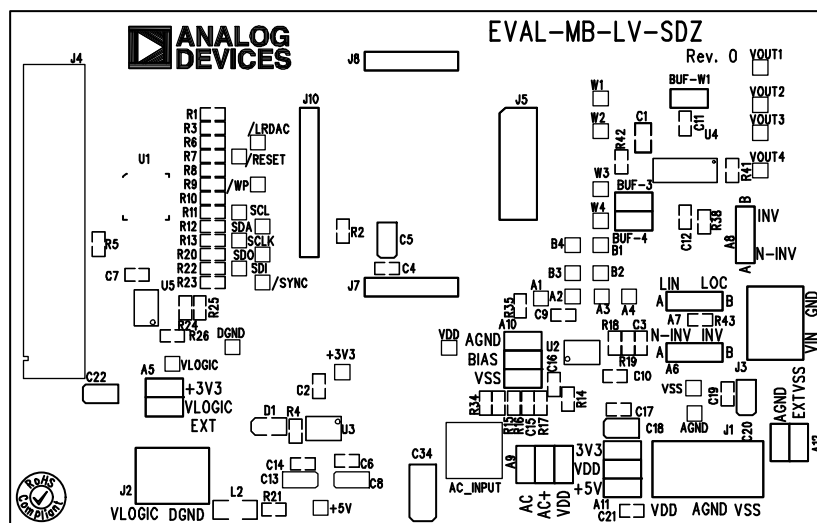
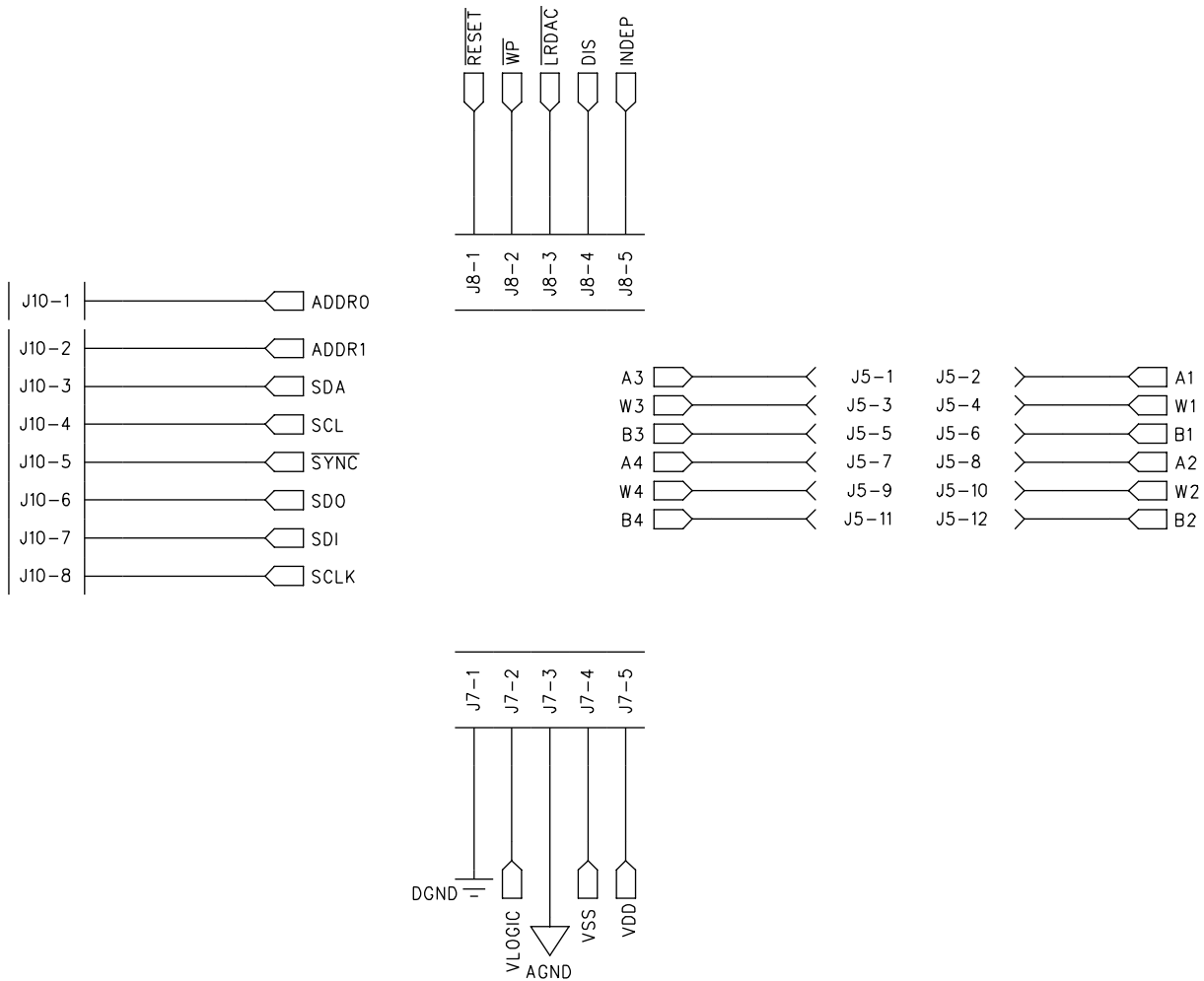
Figure 10. Schematic of Test Circuits



# INVERTING AND NON-INVERTING WITH LINEAR AND PSEUDO-LOG GAIN



10622-010



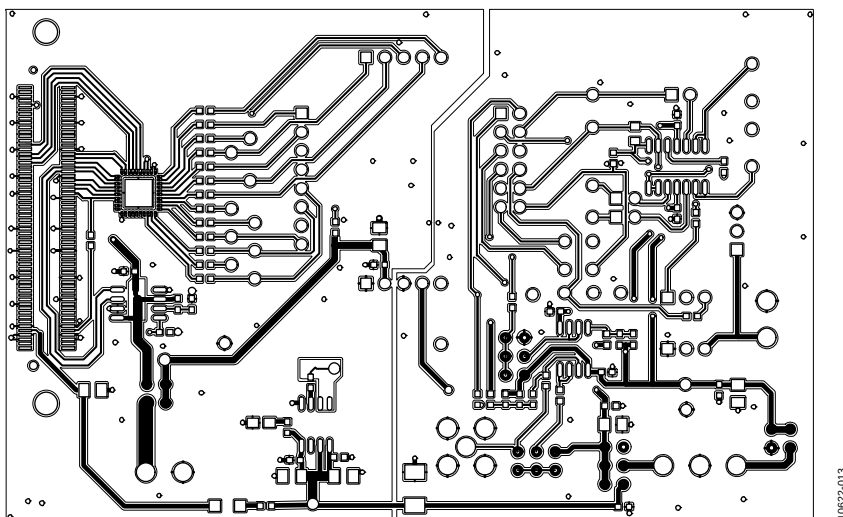


Figure 13. Component Placement Drawing

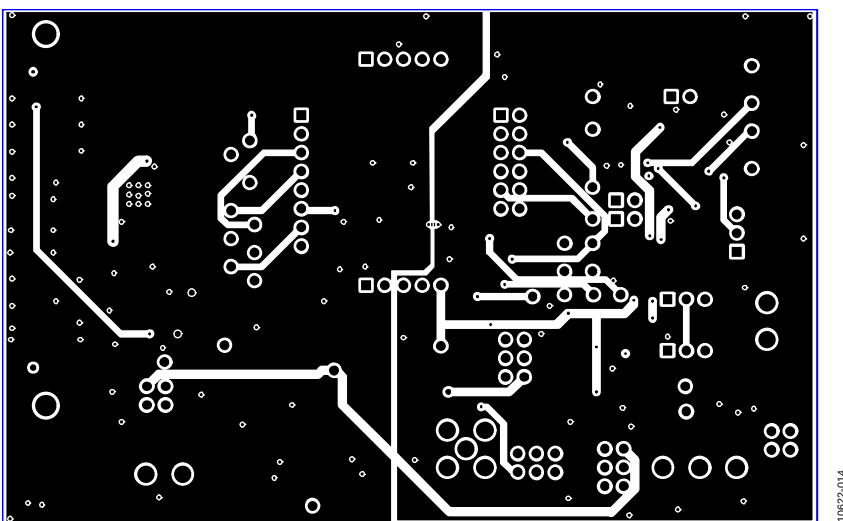


Figure 14. Layer 2 Side PCB Drawing

DAUGHTER BOARD

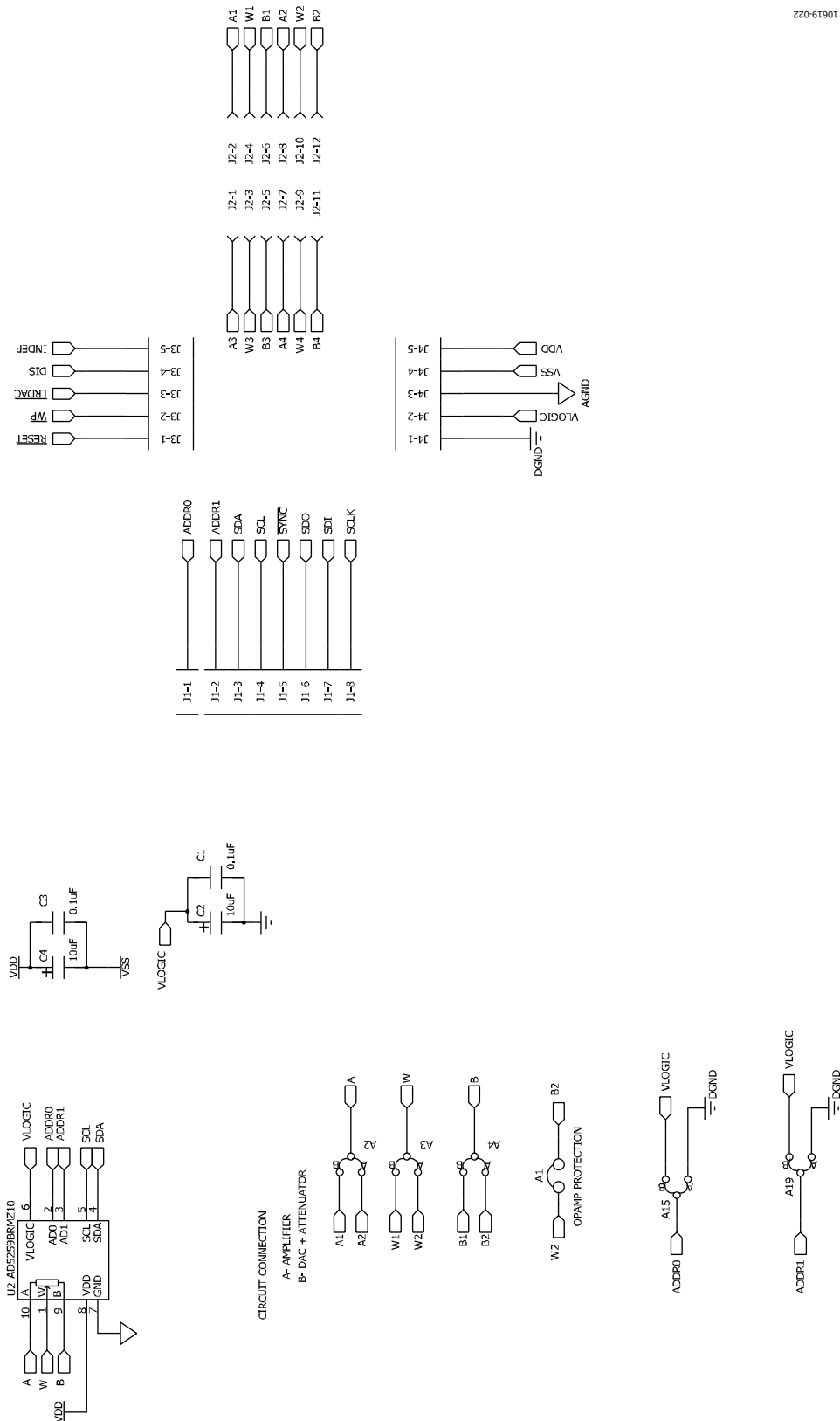


Figure 15. Schematic of Daughter Board

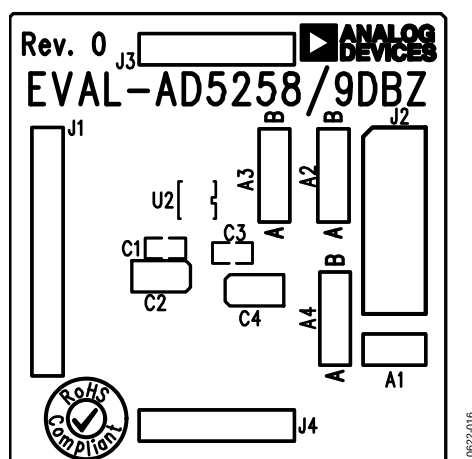


Figure 16. Component Side View

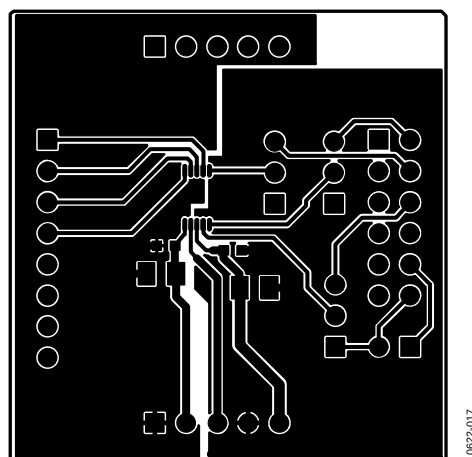


Figure 17. Component Placement Drawing

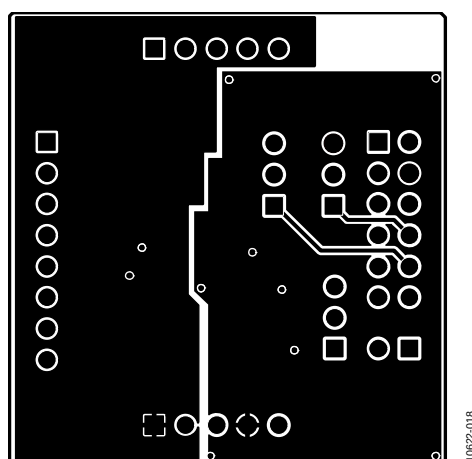


Figure 18. Layer 2 Side PCB Drawing

## ORDERING INFORMATION

## BILL OF MATERIALS

Table 7. Motherboard

| Qty | Reference Designator                                                                             | Description                                        | Supplier <sup>1</sup> /Part Number     |
|-----|--------------------------------------------------------------------------------------------------|----------------------------------------------------|----------------------------------------|
| 3   | BUF-3, BUF-4, BUF-W1                                                                             | 2-pin (0.1" pitch) header and shorting shunt       | FEC 1022247 and 150-411                |
| 3   | A6, A7, A8                                                                                       | 3-pin SIL header and shorting link                 | FEC 1022248 and 150410                 |
| 5   | A5, A9, A10, A11, A12                                                                            | 6-pin (3 × 2), 0.1" header and shorting block      | FEC 148-535 and 150-411 (36-pin strip) |
| 1   | J1                                                                                               | 3-pin terminal block (5 mm pitch)                  | FEC 151790                             |
| 2   | J7, J8                                                                                           | 4-pin SIL header                                   | FEC 1098035                            |
| 1   | J4                                                                                               | Receptacle, 0.6 mm, 120-way                        | Digi-Key H1219-ND                      |
| 1   | J10                                                                                              | 8-pin inline header; 100 mil centers               | FEC 1098038                            |
| 1   | J5                                                                                               | 12-pin (2 × 6), 0.1" pitch header                  | FEC 1098051                            |
| 2   | J2, J3                                                                                           | 2-pin terminal block (5 mm pitch)                  | FEC 151789                             |
| 17  | R1, R3, R6, R7, R8, R9, R10, R11, R12, R13, R20, R22, R23, R34, R35, R42, R43                    | SMD resistor, 0 Ω, 0.01, 0603                      | FEC 9331662                            |
| 1   | R2                                                                                               | SMD resistor, 2.2 kΩ, 0.01, 0603                   | FEC 1750676                            |
| 1   | R41                                                                                              | SMD resistor, 1.7 kΩ, 1%, 0603                     | FEC 1170811                            |
| 1   | R21                                                                                              | Resistor, surge, 1.6 Ω, 1%, 0603                   | FEC 1627674                            |
| 1   | R38                                                                                              | SMD resistor, 2.7 kΩ, 1%, 0603                     | FEC 1750678                            |
| 1   | R14                                                                                              | SMD resistor, 100 Ω, 1%, 0603                      | FEC 9330364                            |
| 1   | R4                                                                                               | SMD resistor, 1 kΩ, 0.01, 0603                     | FEC 9330380                            |
| 3   | R5, R25, R26                                                                                     | SMD resistor, 100 kΩ, 1%, 0603                     | FEC 9330402                            |
| 5   | R15, R16, R17, R18, R19                                                                          | SMD resistor, 33 kΩ, 1%, 0603                      | FEC 9331034                            |
| 1   | C1                                                                                               | SMD capacitor, 100 nF, 10%, 0805                   | FEC 165-0863                           |
| 8   | C4, C9, C10, C11, C12, C17, C19, C21                                                             | SMD capacitor, 0.1 μF, ±10%, 0603                  | FEC 1759122                            |
| 4   | C2, C6, C7, C14                                                                                  | SMD capacitor, 0.1 μF, ±10%, 0603                  | FEC 301-9482                           |
| 2   | C8, C13                                                                                          | SMD capacitor, 10 μF, ±10%                         | FEC 197-130                            |
| 4   | C18, C20, C22, C5                                                                                | Capacitor, 10 μF, ±20%                             | FEC 1190107                            |
| 2   | C3, C15                                                                                          | Capacitor, 470 nF, ±10%, 0603                      | FEC 1414037                            |
| 1   | C16                                                                                              | Capacitor, 4.7 nF, ±10%, 0603                      | FEC 1414642                            |
| 1   | C34                                                                                              | Capacitor, 4.7 nF, ±20%                            | FEC 1432350                            |
| 1   | L2                                                                                               | Inductor, SMD, 600Z                                | FEC 9526862                            |
| 1   | D1                                                                                               | Green SMD LED                                      | FEC 5790852                            |
| 1   | U1                                                                                               | Two-port level translating bus switch              | <a href="#">ADG3247BCPZ</a>            |
| 1   | U2                                                                                               | Dual op amp                                        | <a href="#">AD8652ARZ</a>              |
| 1   | U3                                                                                               | Precision low dropout voltage regulator            | <a href="#">ADP3303ARZ-3.3</a>         |
| 1   | U4                                                                                               | Operational amplifier                              | <a href="#">AD8618ARZ</a>              |
| 1   | U5                                                                                               | I <sup>2</sup> C serial EEPROM, 64k, 2.5 V, MSOP-8 | FEC 1331335                            |
| 27  | LRDAC, RESET, SYNC, WP, A1, A2, A3, A4, AGND, B1, VOUT_C1, VOUT_C2, VOUT3, VOUT4, W1, W2, W3, W4 | Terminal, PCB, black, PK100, test point            | FEC 8731128                            |
| 5   | +3.3V, +5V, EXT_VDD, VLOGIC, EXT_VSS                                                             | Terminal, PCB, red, PK100                          | FEC 8731144                            |

<sup>1</sup> FEC refers to Farnell Electronic Component Distributors; Digi-Key refers to Digi-Key Corporation.

Table 8. Daughter Board

| Qty | Reference Designator | Description                                               | Supplier <sup>1</sup> /Part Number |
|-----|----------------------|-----------------------------------------------------------|------------------------------------|
| 1   | U1                   | 256-position digital potentiometer                        | <a href="#">AD5171BRJZ10-R2</a>    |
| 1   | A1                   | 2-pin (0.1" pitch) header and shorting shunt              | FEC 1022247 and 150-411            |
| 4   | A2, A3, A4, A5       | 3-pin SIL header and shorting link                        | FEC 1022248 and 150410             |
| 1   | C6                   | 6.3 V tantalum capacitor (Case A), 10 $\mu$ F, $\pm$ 20%  | FEC 1190107                        |
| 1   | C3                   | 50 V, X7R ceramic capacitor, 0.1 $\mu$ F, $\pm$ 10%, 0603 | FEC 1759122                        |
| 1   | J1                   | Header, 2.54 mm, PCB, 1 $\times$ 8-way                    | FEC 1766172                        |
| 1   | J2                   | 12-pin (2 $\times$ 6), 0.1" pitch header                  | FEC 1804099                        |
| 2   | J3, J4               | 5-pin SIL header                                          | FEC 1929016                        |

<sup>1</sup> FEC refers to Farnell Electronic Component Distributors.

## NOTES

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 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.