EVAL-AD5161DBZ User Guide
UG-624

One Technology Way • P.O. Box 9106 • Norwood, MA 02062-9106, U.S.A. • Tel: 781.329.4700 • Fax: 781.461.3113 • www.analog.com

Evaluation Board for the AD5161 Digital Potentiometer

FEATURES

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

EVALUATION KIT CONTENTS

- EVAL-AD5161DBZ evaluation 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 AD5161 data sheet
  - Electronic version of the EVAL-AD5161DBZ user guide

GENERAL DESCRIPTION

This user guide describes the evaluation boards for evaluating the AD5161, a 256-position SPI-/I²C-selectable digital potentiometer.

The AD5161 supports single-supply 2.7 V to 5.5 V operation, making the device suitable for battery-powered applications and many applications requiring superior low temperature coefficient performance.

In addition, the AD5161 has a pin-selectable SPI- or I²C-compatible digital interface, which can be used to control the wiper settings or to read back the wiper register content. In SPI mode, the device can be daisy-chained (SDO to SDI), allowing several parts to share the same control lines. In I²C mode, Address Pin AD0 can be used to place up to two devices on the same bus. In this same mode, command bits are available to reset the wiper position to midscale or to shut down the device into a state of zero power consumption.

The EVAL-AD5161DBZ daughter board and the EVAL-MB-LV-SDZ motherboard can operate in single-supply mode and incorporate an internal power supply from the USB.

Complete specifications for the AD5161 can be found in the AD5161 data sheet, which is available from www.analog.com and should be consulted in conjunction with this user guide when using the evaluation board.

PHOTOGRAPH OF EVAL-AD5161DBZ WITH MOTHERBOARD AND SDP-B

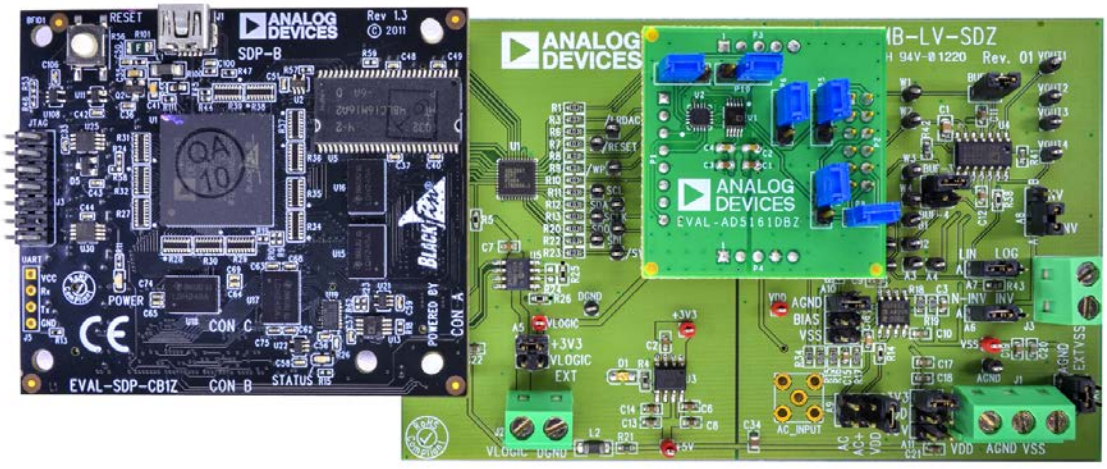

Figure 1. Digital Picture of Evaluation Board with Low Voltage DigiPOT Motherboard and System Demonstration Platform

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REVISION HISTORY

12/13—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 µF and 0.1 µF ceramic capacitors.

LINK OPTIONS

Several link and switch options are incorporated on the EVAL-MB-LV-SDZ and EVAL-AD5161DBZ boards and must be set up before using the evaluation system. The functions of these link options are described in detail in Table 2 through Table 6. By default, the evaluation system is set up to be controlled by a PC via the SDP board.

DIGITAL INTERFACE

The EVAL-AD5161DBZ can be configured as an I^2C or SPI digital interface, depending on the position of the P9 jumper. If the device is configured in I^2C mode, the P10 jumper selects the I^2C address. See Table 3 for further details.

Table 1. Connector Functions

Connector No.	Label	Description	Voltage	
			Min	Max
J1-1	VDD	Analog positive power supply, V_{DD}	2.7 V	5.5 V
J1-2	AGND	Analog ground		
J2-1	VLOGIC	Digital supply	2.7 V	V_{DD}
J2-2	DGND	Digital ground		

Table 2. Link Functions

Link No.	Power Supply	Options	Default Position
A5	V_{LOGIC}	Digital supply select options: 3.3 V (from the SDP board) VLOGIC EXT (external supply from the J2 connector)	3.3 V
A11	V_{DD}	Positive power supply select options: 5 V (from the SDP board) 3.3 V (from the SDP board) VDD (external supply from the J1 connector)	3.3 V
A12	GND	AGND	AGND

Table 3. Digital Interface Link Functions

Link No.	Options	Default Position
P9	Digital interface select options: SPI (use SPI digital interface). I^2C (use I^2C digital interface).	SPI
P10	Chip select options (I^2C mode only): Left side: address pin is connected to AGND. Right side: address pin is connected to V_{LOGIC}. This jumper is unused in SPI mode.	Left

TEST CIRCUITS

The EVAL-AD5161DBZ and EVAL-MB-LV-SDZ incorporate several test circuits to evaluate the performance of the AD5161.

DAC

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

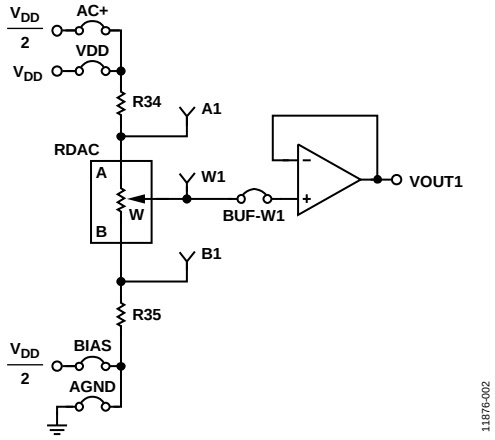

Figure 2. DAC

Table 5 shows the options available for the voltage references.

The output voltage is defined in Equation 1.

$$V_{OUT} = (V_A - V_B) \times \frac{RDAC}{256} \quad (1)$$

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, you 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.

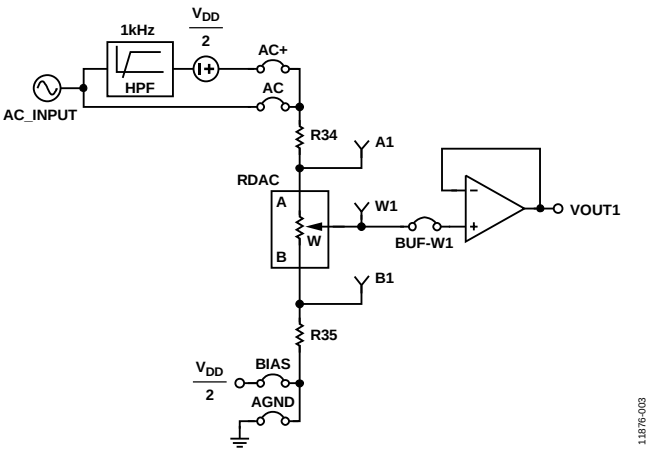

Figure 3. AC Signal Attenuator

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.
		AC signal is outside the voltage supply rails due to the dc offset voltage.
		DC offset voltage ≠ $V_{DD}/2$.[1]
	AC	All other conditions.
A10	BIAS	Use in conjunction with AC+ link.[1]
	AGND	All other conditions.

[1] Recommended to ensure optimal total harmonic distortion (THD) performance.

The signal attenuation is defined in Equation 2.

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

where:
R_{WB} is the resistance 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 Settings		Description
	Daughter Board	Motherboard	
A1	P5: A1 position	A9: AC+ position	Connects Terminal A1 to $V_{DD}/2$
		A9: VDD position	Connects Terminal A1 to V_{DD}
W1	P6: W1 position	BUF-W1: inserted	Connects Terminal W1 to an output buffer
B1	P7: B1 position	A10: BIAS position	Connects Terminal B1 to $V_{DD}/2$
		A10: AGND position	Connects Terminal B1 to analog ground
	P8: inserted		Closes the feedback loop of the second op amp in the AD8618

Signal Amplifier

The RDAC can be operated as an inverting or noninverting signal amplifier and can support linear or pseudologarithmic gain. 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.

$$G = 1 + \frac{R_{WB}}{R38} \quad (3)$$

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

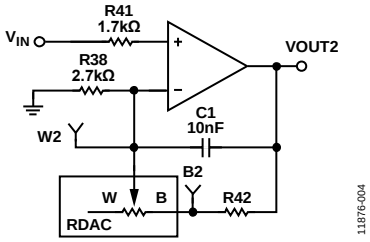

Figure 4. Noninverting Amplifier with Linear Gain

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 resistance between the W and B terminals.
R_{AW} is the resistance between the A and W terminals.

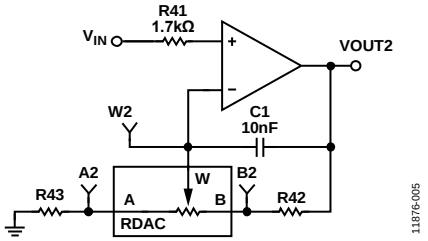

Figure 5. Noninverting Amplifier with Pseudologarithmic Gain

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.

$$G = -\frac{R_{WB}}{R38} \quad (5)$$

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

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

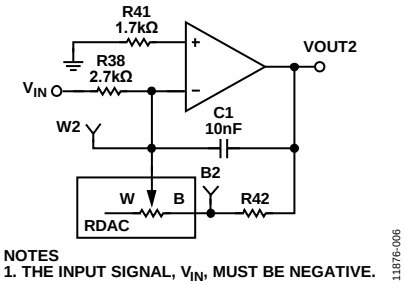

Figure 6. Inverting Amplifier with Linear Gain

Table 6. Amplifier Selection Link Settings

		Link Settings		
Amplifier	**Gain**	**Daughter Board**	**Motherboard**	**V_{IN} Range**
Noninverting	Linear	P5: A2 position, P6: W2 position, P7: B2 position, P8: not inserted	A7: LIN position, A6: N-INV position, A8: N-INV position	0 V to V_{DD}
	Pseudologarithmic	P5: A2 position, P6: W2 position, P7: B2 position, P8: not inserted	A7: LOG position, A6: N-INV position, A8: N-INV position	0 V to V_{DD}
Inverting	Linear	P5: A2 position, P6: W2 position, P7: B2 position, P8: not inserted	A7: LIN position, A6: INV position, A8: INV position	$-V_{DD}$ to 0 V

EVALUATION BOARD SOFTWARE

INSTALLING THE SOFTWARE

The EVAL-AD5161DBZ kit includes evaluation board software provided on a CD. The software is compatible with Windows® XP, Windows Vista, and Windows 7 (both 32-bit and 64-bit versions).

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 the installation is complete, power up the evaluation board as described in the Power Supplies section.
4. Connect the EVAL-AD5161DBZ and EVAL-MB-LV-SDZ to the SDP board and the SDP board to the PC.
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** > **AD5161** > **AD5161 Eval Board**. (To uninstall the program, click **Start** > **Control Panel** > **Add or Remove Programs** > **AD5161 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). If a connectivity error is displayed, connect the evaluation board to the USB port of the PC and wait a few seconds, and then click **Rescan** and follow the instructions that appear on-screen.

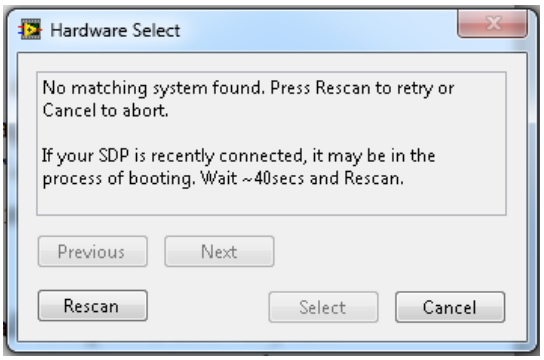

Figure 7. Pop-Up Window Error

The main window of the EVAL-AD5161DBZ software then opens, as shown in Figure 8.

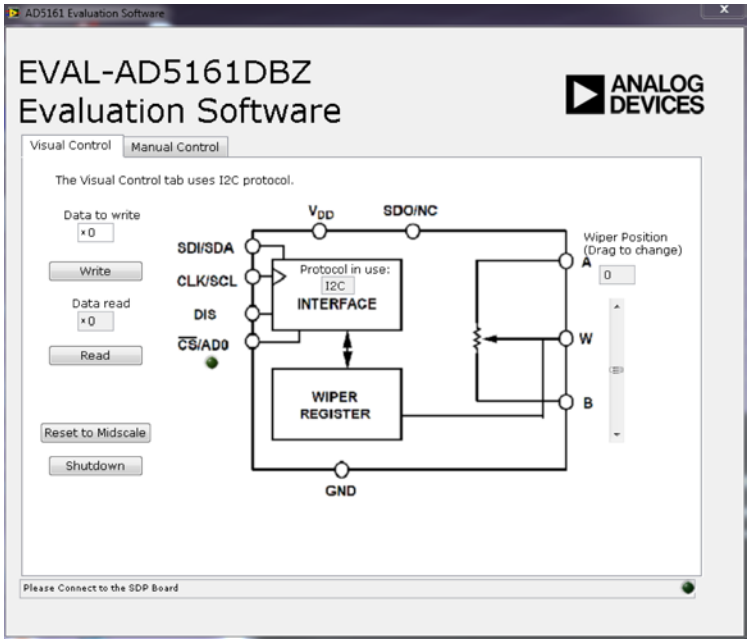

Figure 8. EVAL-AD5161DBZ Software Main Window, Visual Control Tab

OPERATING THE SOFTWARE

The main window of the EVAL-AD5161DBZ software is divided into two tabs: **Visual Control** and **Manual Control**.

Visual Control Tab

The **Visual Control** tab, as shown in Figure 8, contains a block diagram that allows inputting data in hexadecimal format to be written to or read from the device. To write data to the device, type a hexadecimal value into the **Data to write** box and click **Write**. To read data from the device, click **Read**; the data is displayed in hexadecimal format in the **Data read** box. A slider control, located on the right side of the window, allows changing the wiper setting.

Manual Control Tab

The **Manual Control** tab, as shown in Figure 9, allows customizing an I²C or SPI data-word by manually switching each serial data-word from 0 to 1 or from 1 to 0, as desired, and then clicking **I2C Write** or **SPI Write/Read**. Similarly, data can also be read from either I²C or SPI using the corresponding controls.

The **I2C Data Written** or **SPI Data Written** box shows the value that is written to the evaluation board. It is set using the sliders in the **I2C – Write** or **SPI – Write / Read** section.

Exiting the window closes the program.

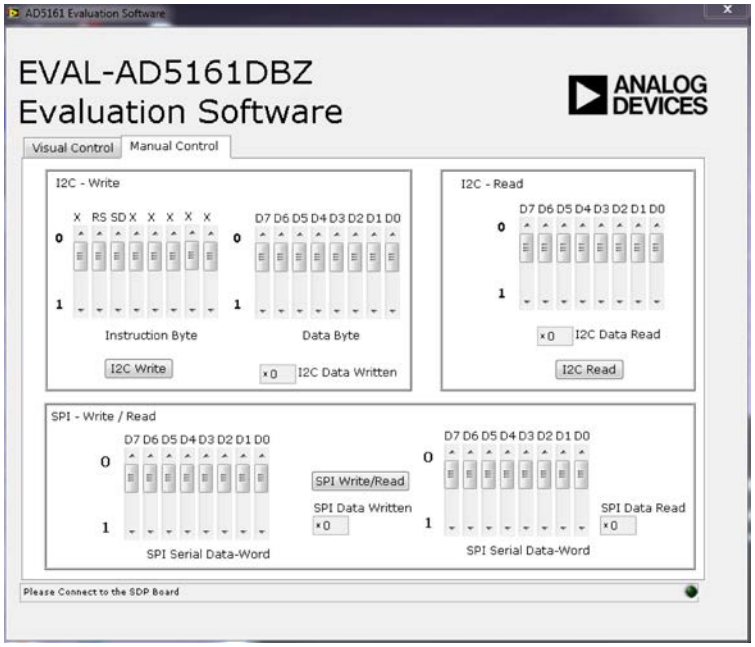

Figure 9. EVAL-AD5161DBZ Software Main Window, Manual Control Tab

EVALUATION BOARD SCHEMATICS AND ARTWORK

MOTHERBOARD

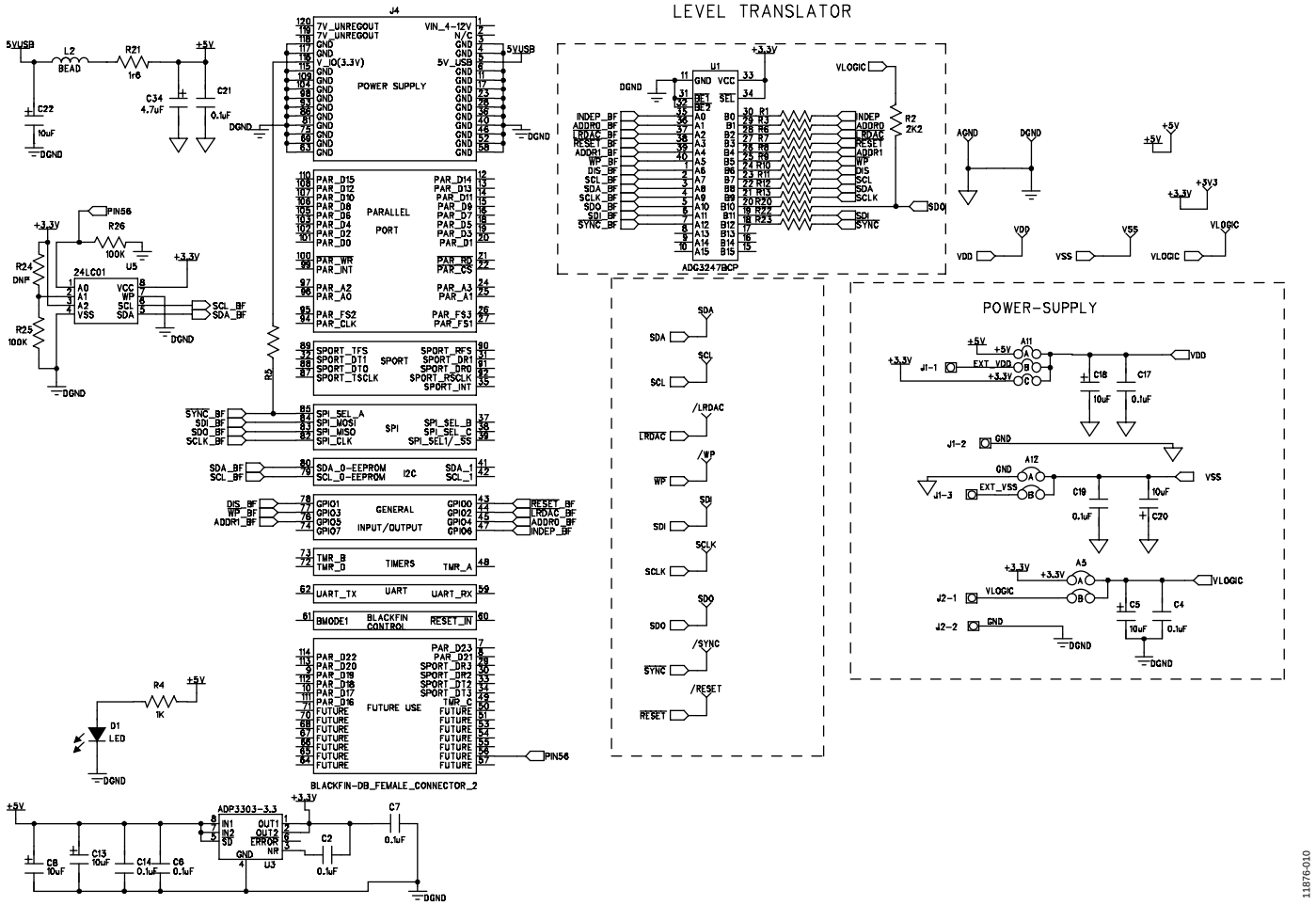

Figure 10. SDP Connector and Power Supply

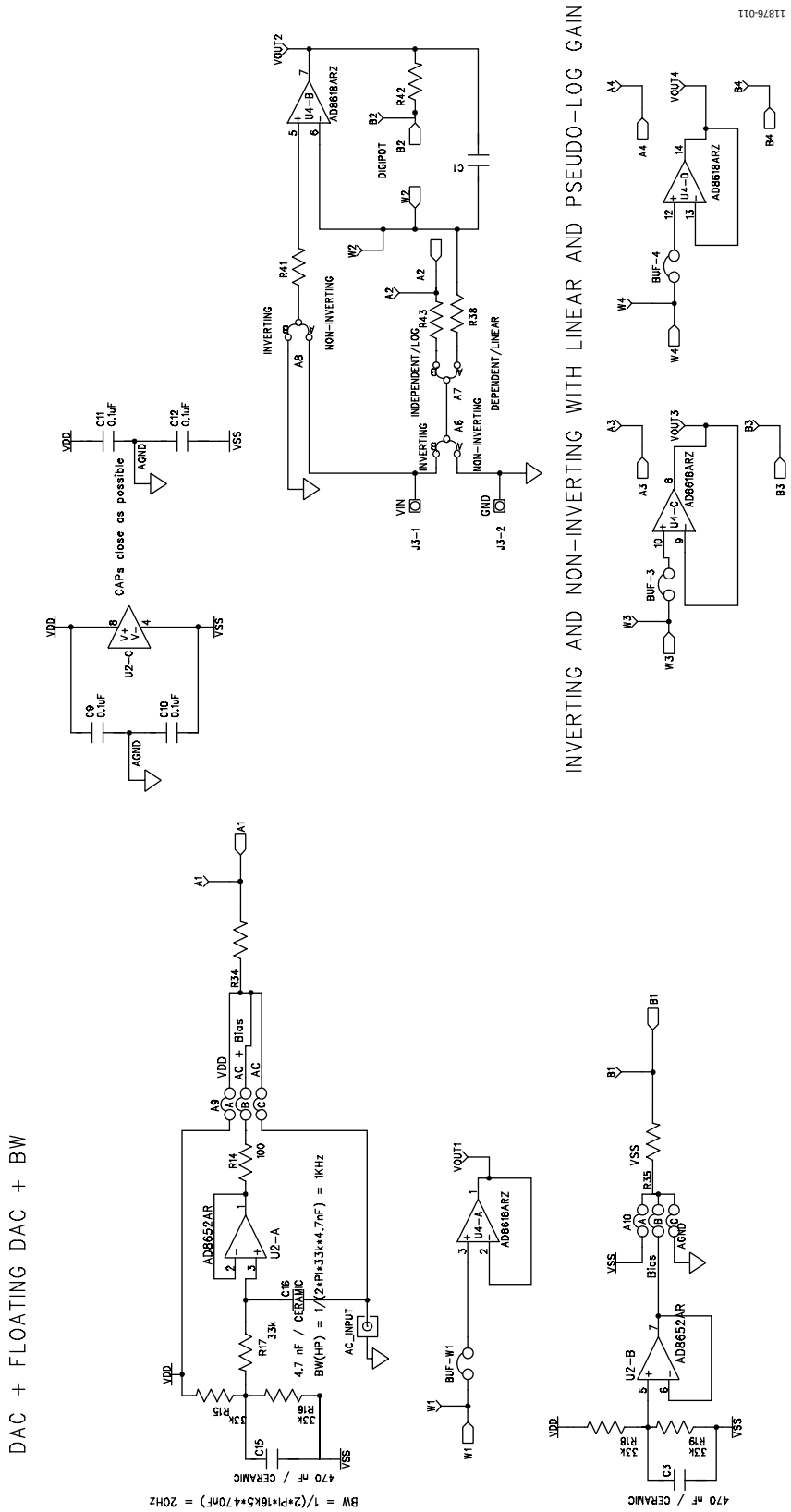

Figure 11. Schematic of Test Circuits

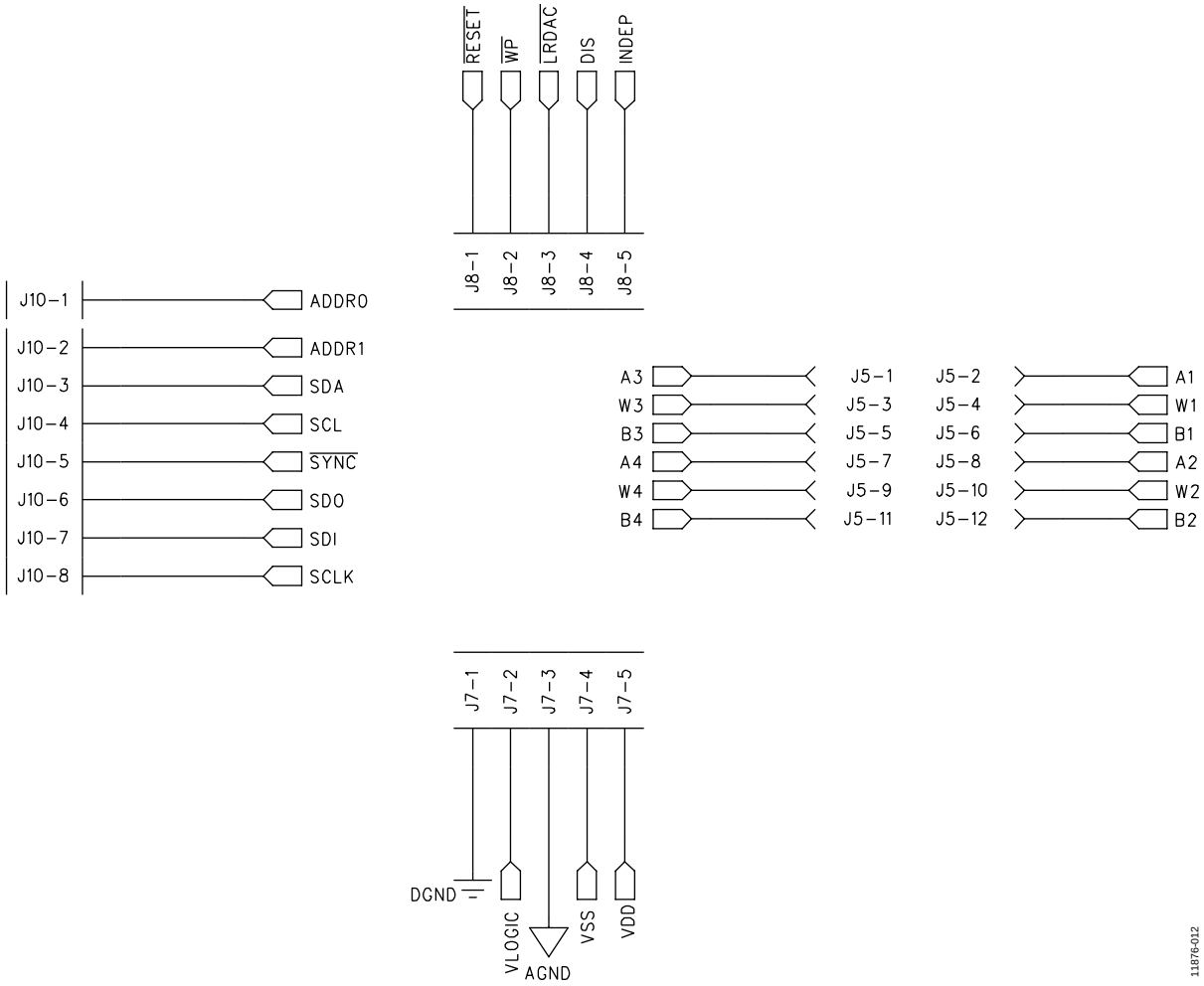

Figure 12. Schematic of Connectors to Daughter Board

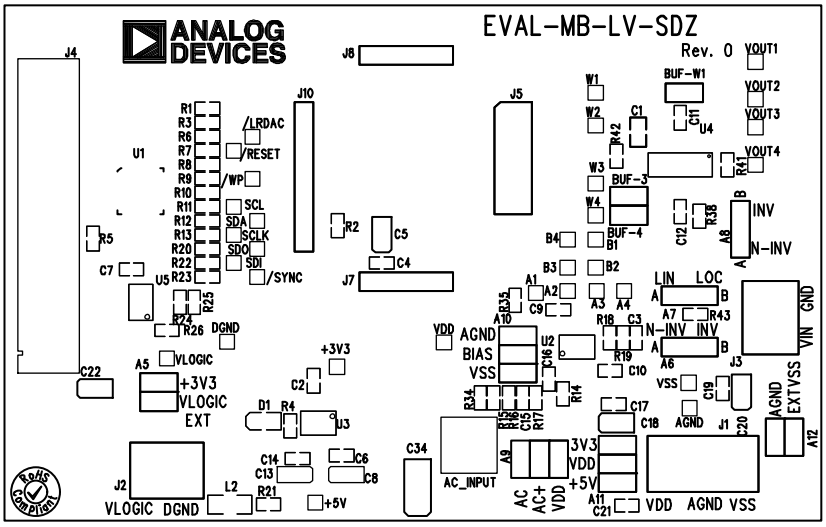

Figure 13. Component Side View

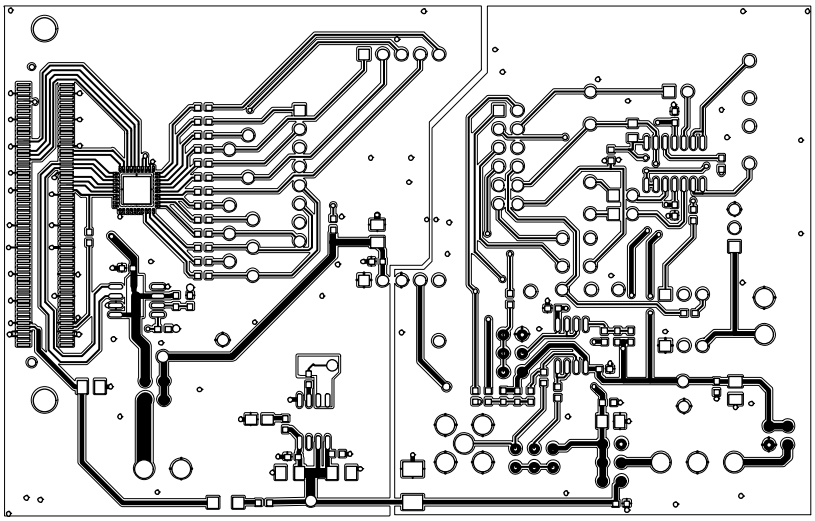

Figure 14. Component Placement Drawing

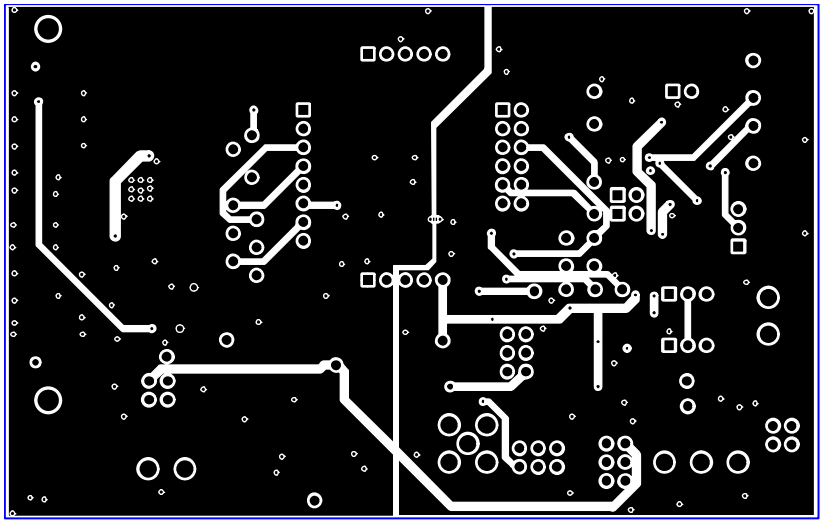

Figure 15. Layer 2 Side PCB Drawing

DAUGHTER BOARD

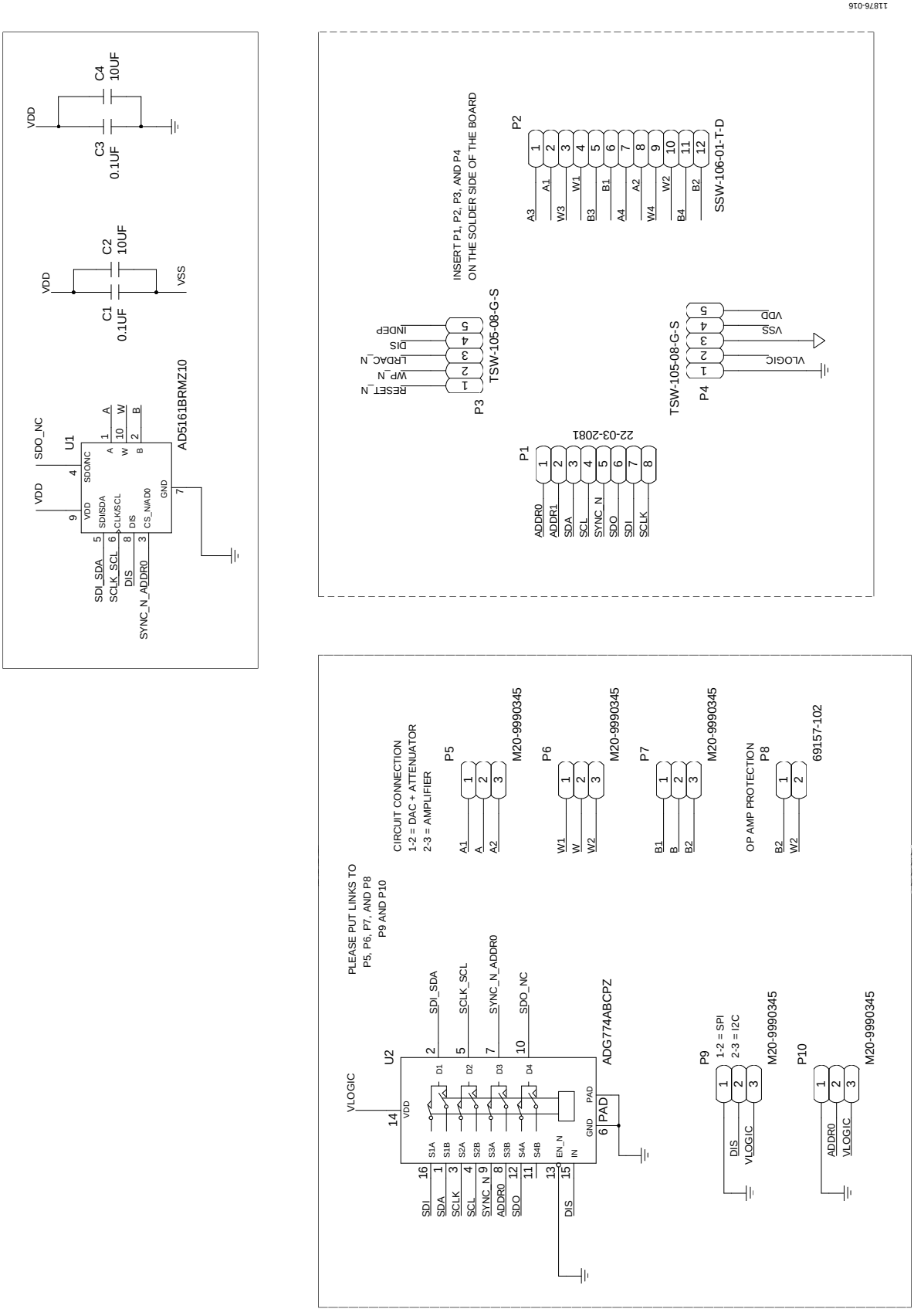

Figure 16. Schematic of Daughter Board

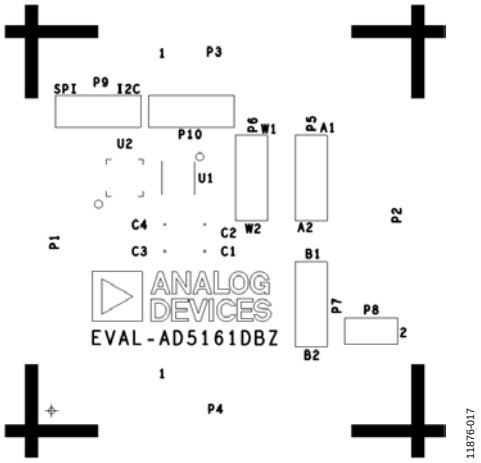

Figure 17. Component Side View

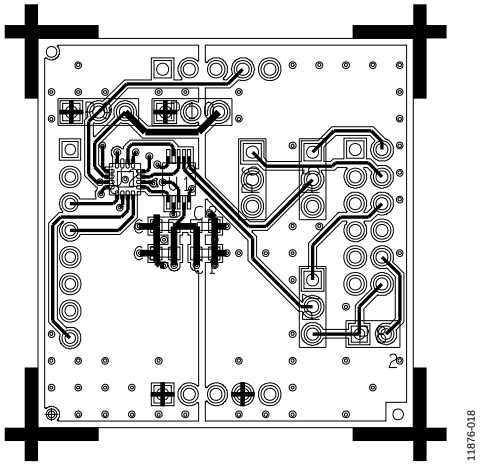

Figure 18. Component Placement Drawing

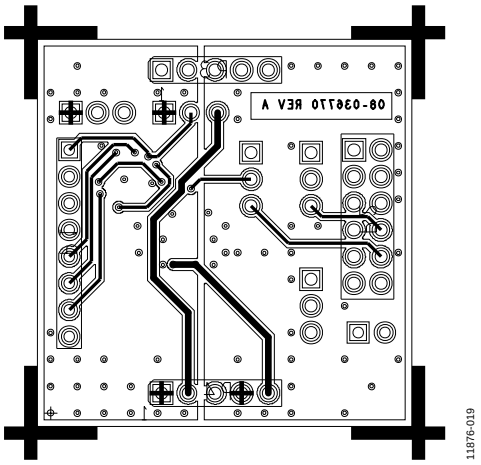

Figure 19. Layer 2 Side PCB Drawing

BILL OF MATERIALS

Table 7. Motherboard Bill of Materials

Qty	Reference Designator	Description	Supplier[1]/Part Number
3	BUF-3, BUF-4, BUF-W1	2-pin (0.1" pitch) header and shorting shunt	FEC 1022247 and FEC 150411
3	A6, A7, A8	3-pin SIL header and shorting link	FEC 1022248 and FEC 150410
5	A5, A9, A10, A11, A12	6-pin (3 × 2), 0.1" header and shorting block	FEC 148535 and FEC 150411 (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 1650863
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 3019482
2	C8, C13	SMD capacitor, 10 µF, ±10%	FEC 197130
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	ADG3247BCPZ
1	U2	Dual op amp	AD8652ARZ
1	U3	Precision low dropout voltage regulator	ADP3303ARZ-3.3
1	U4	Operational amplifier	AD8618ARZ
1	U5	I²C serial EEPROM, 64k, 2.5 V, MSOP-8	FEC 1331335
18	$\overline{\text{LRDAC}}$, $\overline{\text{RESET}}$, $\overline{\text{SYNC}}$, $\overline{\text{WP}}$, 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

[1] FEC refers to Farnell Electronic Component Distributors; Digi-Key refers to Digi-Key Corporation.

Table 8. Daughter Board Bill of Materials

Qty	Reference Designator	Description	Supplier[1]/Part Number
1	U1	256-position digital potentiometer	AD5161BRMZ10
1	U2	Quad 2:1 multiplexer	ADG774ABCPZ
1	P8	2-pin (0.1" pitch) header and shorting shunt	FEC 1022247 and FEC 150411
5	P5, P6, P7, P9, P10	3-pin SIL header and shorting link	FEC 1022248 and FEC 150410
2	C2, C4	6.3 V, X5R, ceramic capacitor, 10 µF, ±20%	GRM188R60J106ME47D
2	C1, C3	50 V, X7R, ceramic capacitor, 0.1 µF, ±10%	GRM188R71H104KA93D
1	P1	Header, 2.54 mm, PCB, 1 × 8-way	FEC 1766172
1	P2	12-pin (2 × 6), 0.1" pitch header	FEC 1804099
2	P3, P4	5-pin SIL header	FEC 1929016

[1] FEC refers to Farnell Electronic Component Distributors.

NOTES

I²C 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.

UG11876-0-12/13(0)

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