User Guide

# EVAL-AD5686RARDZ/EVAL-AD5696RARDZ

## Evaluating the AD5686R (SPI) and the AD5696R ($I^2C$) Quad Channel, 16-Bit, Voltage Output DACs

## FEATURES

- Full featured evaluation boards for the AD5686R (SPI) and the AD5696R ($I^2C$)
- On-board references
- Various link options
- PC control in conjunction with the Analog Devices, Inc., EVAL-SDP-CK1Z (SDP-K1) controller board

## EVALUATION KIT CONTENTS

- EVAL-AD5686RARDZ (SPI) evaluation board or EVAL-AD5696RARDZ ($I^2C$) evaluation board
- AD5686R (SPI) device or AD5696R ($I^2C$) device

## HARDWARE REQUIRED

- EVAL-SDP-CK1Z (SDP-K1) controller board, which must be purchased separately

## SOFTWARE REQUIRED

- ACE software available for download from the EVAL-AD5686RARDZ (SPI) product page or the EVAL-AD5696RARDZ ($I^2C$) product page

## TYPICAL EVALUATION SETUP

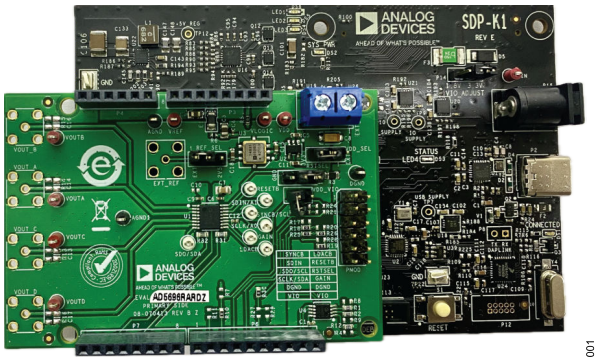


*Figure 1. Evaluation Board Connected to the SDP-K1 Controller Board (EVAL-AD5686RARDZ or EVAL-AD5696RARDZ)*

## GENERAL DESCRIPTION

This user guide details the operation of the EVAL-AD5686RARDZ (serial peripheral interface (SPI)) evaluation board and the EVAL-AD5696RARDZ ($I^2C$) evaluation board for the AD5686R (SPI) and the AD5696R ($I^2C$), respectively, which are both quad-channel, voltage output digital-to-analog converters (DACs).

The EVAL-AD5686RARDZ and the EVAL-AD5696RARDZ are designed to facilitate quick prototyping of the AD5686R circuit and the AD5696R circuit, respectively, thereby reducing design time. Both devices operate from a single 2.7 V to 5.5 V supply. Additionally, these devices also incorporate an internal 2.5 V reference. However, if required, a different reference voltage can be applied via the EXT_REF SMB connector. Although these two DACs share common features, they differ in their digital interface protocols. The AD5686R uses SPI whereas the AD5696R uses $I^2C$.

The EVAL-AD5686RARDZ and the EVAL-AD5696RARDZ interface with the USB port of a PC via a system demonstration platform (SDP) controller board. The analysis, control, evaluation (ACE) software is available for download from both the EVAL-AD5686RARDZ product page and the EVAL-AD5696RARDZ product page. The ACE software can be used with the EVAL-AD5686RARDZ or the EVAL-AD5696RARDZ to allow the user to program the AD5686R and the AD5696R, respectively. A PMOD connection can also be found on the evaluation board to allow the connection of microcontrollers without the SDP controller board. Note that when a microcontroller is used through the PMOD connection, the SDP controller board must be disconnected. Therefore, the user cannot use the ACE software.

The EVAL-AD5686RARDZ and the EVAL-AD5696RARDZ both require the EVAL-SDP-CK1Z (SDP-K1) controller board, which is available for purchase from Analog Devices.

For full details, see the AD5686R data sheet or the AD5696R data sheet, which must be consulted in conjunction with this user guide when using either the EVAL-AD5686RARDZ or the EVAL-AD5696RARDZ.

Rev. 0

DOCUMENT FEEDBACK

TECHNICAL SUPPORT

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## REVISION HISTORY

**3/2024—Revision 0: Initial Version**

## GETTING STARTED

### INSTALLING THE SOFTWARE

The EVAL-AD5686RARDZ evaluation board and the EVAL-AD5696RARDZ evaluation board use the ACE software, a desktop software application that allows the evaluation and control of multiple evaluation systems.

The ACE installer contains the necessary SDP drivers and the Microsoft® .NET Framework 4 Client Profile by default. The ACE software is available for download from the EVAL-AD5686RARDZ product page or the EVAL-AD5696RARDZ product page. This software must be installed before connecting the SDP controller board to the USB port of the PC to ensure that the PC recognizes the SDP controller board. For full instructions on how to install and use this software, see the ACE software pages on the Analog Devices website.

After the ACE software is installed, open the software, and the EVAL-AD5686RARDZ or the EVAL-AD5696RARDZ evaluation board plugin appears.

### INITIAL SETUP

To set up the EVAL-AD5686RARDZ evaluation board or the EVAL-AD5696RARDZ evaluation board, follow these steps (GUI shown in Figure 2 to Figure 4 for the EVAL-AD5686RARDZ but functionality is the same for the EVAL-AD5696RARDZ):

1. Connect the EVAL-AD5686RARDZ or the EVAL-AD5696RARDZ to the SDP controller board and then connect a USB cable between the SDP controller board and the PC.
2. Run the ACE application, and the main window appears as shown in Figure 2. The EVAL-AD5686RARDZ or the EVAL-AD5696RARDZ evaluation board plugin appears in the **Attached Hardware** section of the **Start** tab.
3. Double-click the **EVAL-AD5686RARDZ** plugin or the **EVAL-AD5696RARDZ** plugin as shown in Figure 2 to open the board view as shown in Figure 3.
4. Double-click the **AD5686R** chip or **AD5696R** chip shown in Figure 3 to access the chip view as shown in Figure 4. This view provides a basic representation of the EVAL-AD5686RARDZ or the EVAL-AD5696RARDZ functionality. The main function blocks of these evaluation boards are labeled in Figure 5.

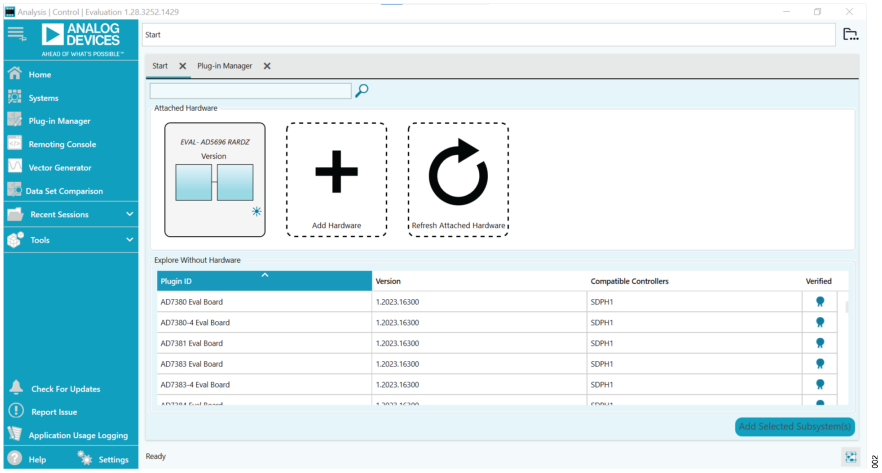


*Figure 2. ACE Software Main Window*

## GETTING STARTED

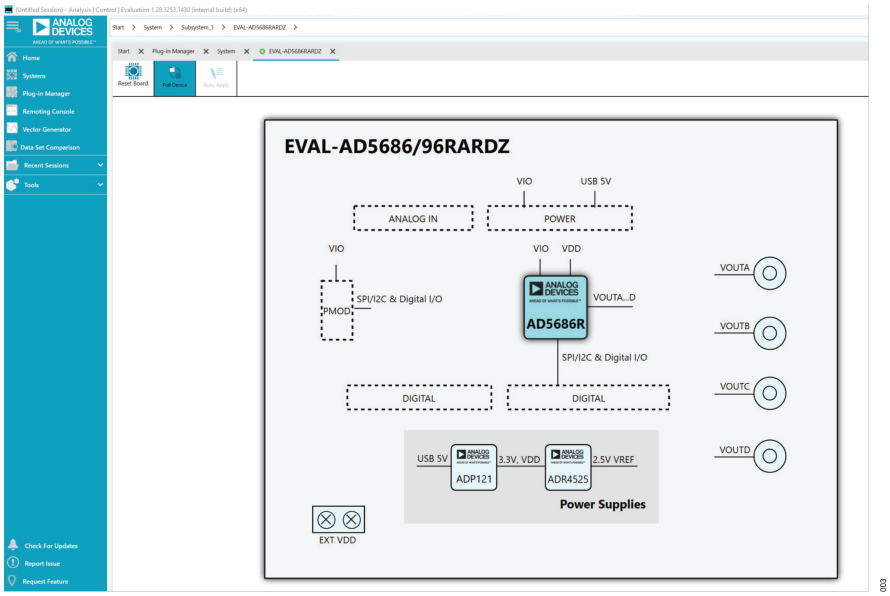


*Figure 3. Board View of the EVAL-AD5686RARDZ or the EVAL-AD5696RARDZ*

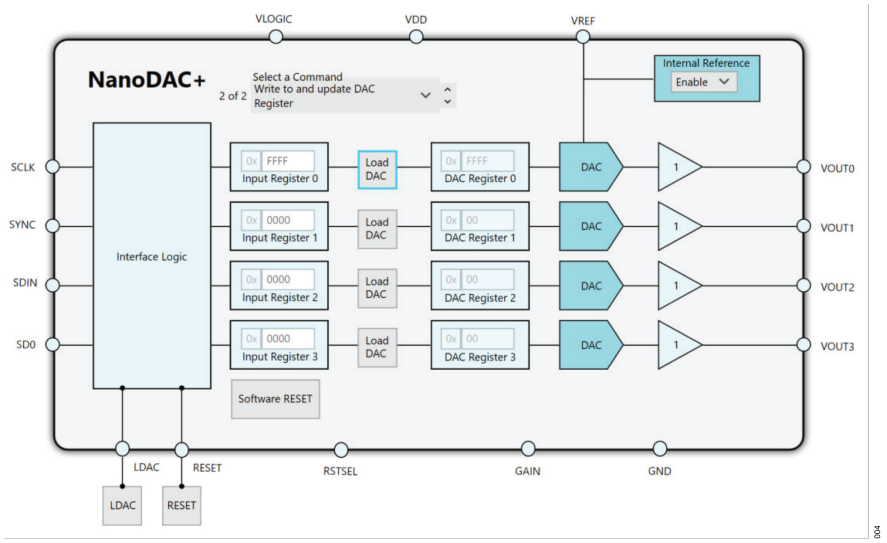


*Figure 4. Chip Block Diagram View of the AD5686R or the AD5696R*

## BLOCK DIAGRAM AND DESCRIPTION

The EVAL-AD5686RARDZ software and the EVAL-AD5696RARDZ software are organized to appear similar to the functional block diagram shown in the AD5686R data sheet and AD5696R data sheet, respectively. In this way, it is easy to correlate the functions on these evaluation boards with the descriptions in the data sheets. A full description of each block, register, and their settings is given in the AD5686R data sheet or the AD5696R data sheet.

Some of the blocks and their functions are described in this section as they pertain to the EVAL-AD5686RARDZ or the EVAL-AD5696RARDZ. The block diagram is shown in Figure 5, and Table 1 describes the functionality of each block.

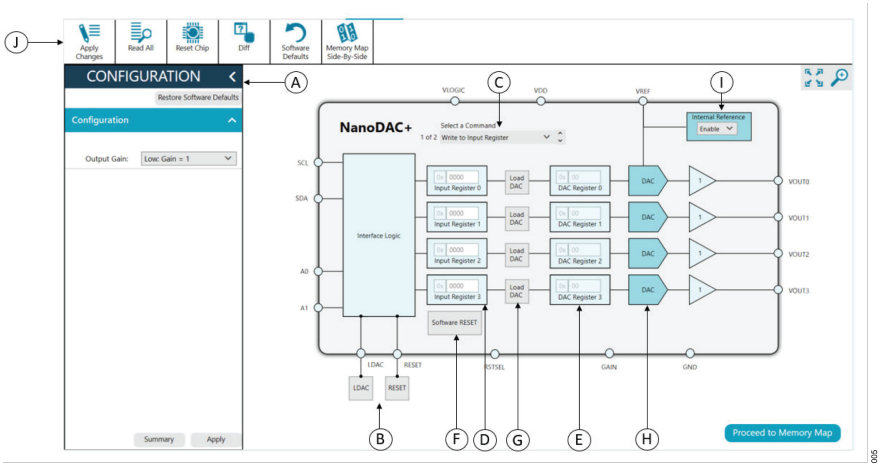


*Figure 5. Block Diagram with Labels*

*Table 1. Block Diagram Functions*

| Label | Button Name | Function |
|---|---|---|
| A | **CONFIGURATION** wizard | This button is used to set the initial configuration for the evaluation board by clicking the reference gain case from the **Output Gain** drop-down box. A gain of 1 is the default. For a gain of 2, an external supply is needed ($V_{DD}$ = $V_{REF}$ + 1.5 V). After setting up the initial configuration, click **Apply Changes** (Label J) to apply the values. These settings can be modified at any stage while evaluating the evaluation board. |
| B | **LDAC** and **RESET** (GPIO buttons) | These buttons act as external GPIO pulses to the $\overline{\text{LDAC}}$ pin and the $\overline{\text{RESET}}$ pin. The **LDAC** button transfers data from the input registers (Label D) to the DAC registers (Label E). The **RESET** button clears all data from the input registers and DAC registers. These buttons are live. Therefore, there is no need to click **Apply Changes** (Label J). |
| C | **Select a Command** | The drop-down box under **Select a Command** controls how the data transfer to the device affects the input registers and DAC registers. When a data value is entered in an input register (Label D), it can be transferred to one or both of the internal DAC registers. The data transfer can be either to the DAC input register only, or to both the DAC input register and the DAC register at the same time. If both registers are updated, the channel DAC register (Label E) shows the new value. |
| D | **Input Register 0** to **Input Register 3** | The input registers serve as a way to select the 16-bit data word to transfer to the device. Once the desired data word is selected, click **Apply Changes** (Label J) to transfer it to the device. |
| E | **DAC Register 0** to **DAC Register 3** | The DAC registers display the value that is currently present in the DAC register on the device. The user can update the DAC registers by clicking the appropriate command option or by clicking **LDAC** (Label B). |
| F | **Software RESET** | The **Software RESET** button returns the evaluation board and software to default values. This button is live. Therefore, there is no need to click **Apply Changes** (Label J). |
| G | **Load DAC** | This button allows the user to individually control which channel loads the values from the input registers to the DAC registers. |
| H | **DAC** | The DAC configuration options provide access to individual channel configuration options such as power-down options, and hardware $\overline{\text{LDAC}}$ mask enable or disable. |
| I | **Internal Reference** | In the **Internal Reference** setting, click **Enable** to enable the on-chip reference for the evaluation board. If **Disable** is clicked, an external reference must be applied. This control is only available on the AD5686R and the AD5696R. |
| J | **Apply Changes** | This button updates the device with all the modified values. However, if there is no evaluation board connected, the input register values cannot be transferred to the DAC registers. |

## BLOCK DIAGRAM AND DESCRIPTION

### MEMORY MAP

All registers are fully accessible from the **Memory Map** tab as shown in Figure 6. The **Memory Map** tab allows registers to be edited at a bit level. The bits shaded in dark gray (see Figure 7) are read only bits and cannot be accessed from the ACE software. All other bits can be edited. The **Apply Changes** button is used to transfer data to the device. All changes in the **Memory Map** tab correspond to the block diagram. For example, if the internal register bit is enabled, it shows as enabled on the block diagram. Any bits or registers that are in bold are modified values that have not been transferred to the evaluation board. After **Apply Changes** is clicked, the data is transferred to the evaluation board.

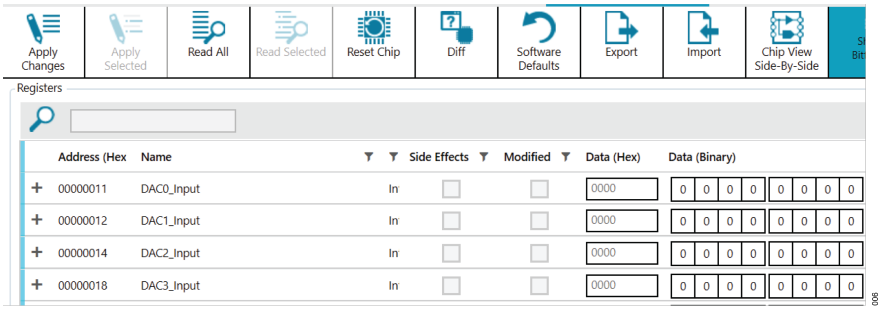


*Figure 6. AD5686R or AD5696R Memory Map Tab*

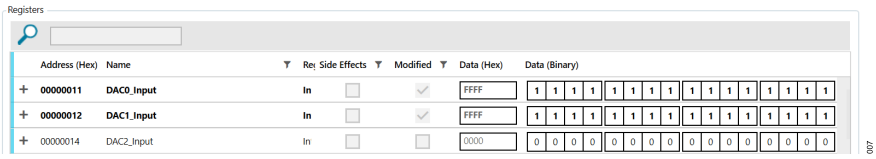


*Figure 7. Memory Map of the AD5686R or the AD5696R with Pending Changes in the DAC0_Input Register*

## EVALUATION BOARD HARDWARE

Before applying power and signals to the EVAL-AD5686RARDZ or the EVAL-AD5696RARDZ, ensure that all link positions are as required by the operating mode. There are two modes in which to operate the EVAL-AD5686RARDZ or the EVAL-AD5696RARDZ. First is the SDP controlled mode to be used with the EVAL-SDP-CK1Z (SDP-K1). Second is the standalone mode in which an external supply must be provided.

### POWER SUPPLIES

The EVAL-AD5686RARDZ evaluation board and the EVAL-AD5696RARDZ evaluation board provide an on-board, 3.3 V regulator powered through the USB supply. If the evaluation board is controlled through the PMOD connection or a gain of 2 is required, an external supply must be provided via the EXT_VDD connector. See Table 2, and the power requirements stated in the AD5686R data sheet and the AD5696R data sheet for more details.

Both AGND input and DGND input are provided on the evaluation board. The AGND plane and DGND plane are connected at one location close to the AD5686R or the AD5696R. To avoid ground loop problems, it is recommended that the AGND input and the DGND input must not be connected elsewhere in the system.

***Table 2. Power Supply Connectors***

| Connector | Label | External Voltage Supplies Description |
|---|---|---|
| EXT_VDD, Pin 1 | EXT_VDD | External analog power supply from 2.7 V to 5.5 V, $V_{DD}$ |
| EXT_VDD, Pin 2 | EXT_VDD | Analog ground |
| EXT_REF, SMB Connector | EXT_REF | External voltage reference supply |

## EVALUATION BOARD HARDWARE

### LINK OPTIONS

Various link options are incorporated in the EVAL-AD5686RARDZ evaluation board and the EVAL-AD5696RARDZ evaluation board, and must be set for the required operating conditions before using these evaluation boards. The functions of these link options are described in Table 4.

Table 3 lists the positions of the different links controlled by the PC via the USB port. An SDP controller board operating in single-supply mode is required.

***Table 3. Link Options Setup for SDP Control (Default)***

| Link | Option |
|---|---|
| VDD_SEL | Position B (2-3) |
| REF_SEL | Position A (1-2) |
| VDD_VIO | Disconnected |
| RSTSEL | Position A (1-2) |

***Table 4. Link Functions***

| Link | Description |
|---|---|
| VDD_SEL | This link selects the DAC analog voltage source. There are two options as follows:<br>Position A (1-2): the EXT_VDD option selects an external supply voltage (the EXT_VDD connector).<br>Position B (2-3): the 3V3 option selects the on-board voltage source (the SDP-K1, the ADP121). |
| REF_SEL | This link selects the DAC voltage reference source. There are two options as follows:<br>Position A (1-2): the EXT_REF option selects an external reference source (the EXT_REF connector). If no external supply is present, the internal on-chip reference is the default.<br>Position B (2-3): the 2V5 option selects the on-board reference from the ADR4525. |
| VDD_VIO | The VDD_VIO link selects the DAC digital voltage source. There are two options as follows:<br>Connected option: shorts $V_{DD}$ and $V_{LOGIC}$. Use this option only when the SDP controller board is not connected.<br>Disconnected option: opens the connection of $V_{DD}$ and $V_{LOGIC}$. Use this option when using the SDP controller board. |
| RSTSEL | The reset select (RSTSEL) link selects the power-on reset state of the device. There are two options as follows:<br>Position A (1-2): this position ties the RSTSEL pin to VLOGIC and powers up all DACs to midscale.<br>Position B (2-3): this position ties the RSTSEL pin to GND and powers up all DACs to zero scale. |

## EVALUATION BOARD SCHEMATICS AND ARTWORK

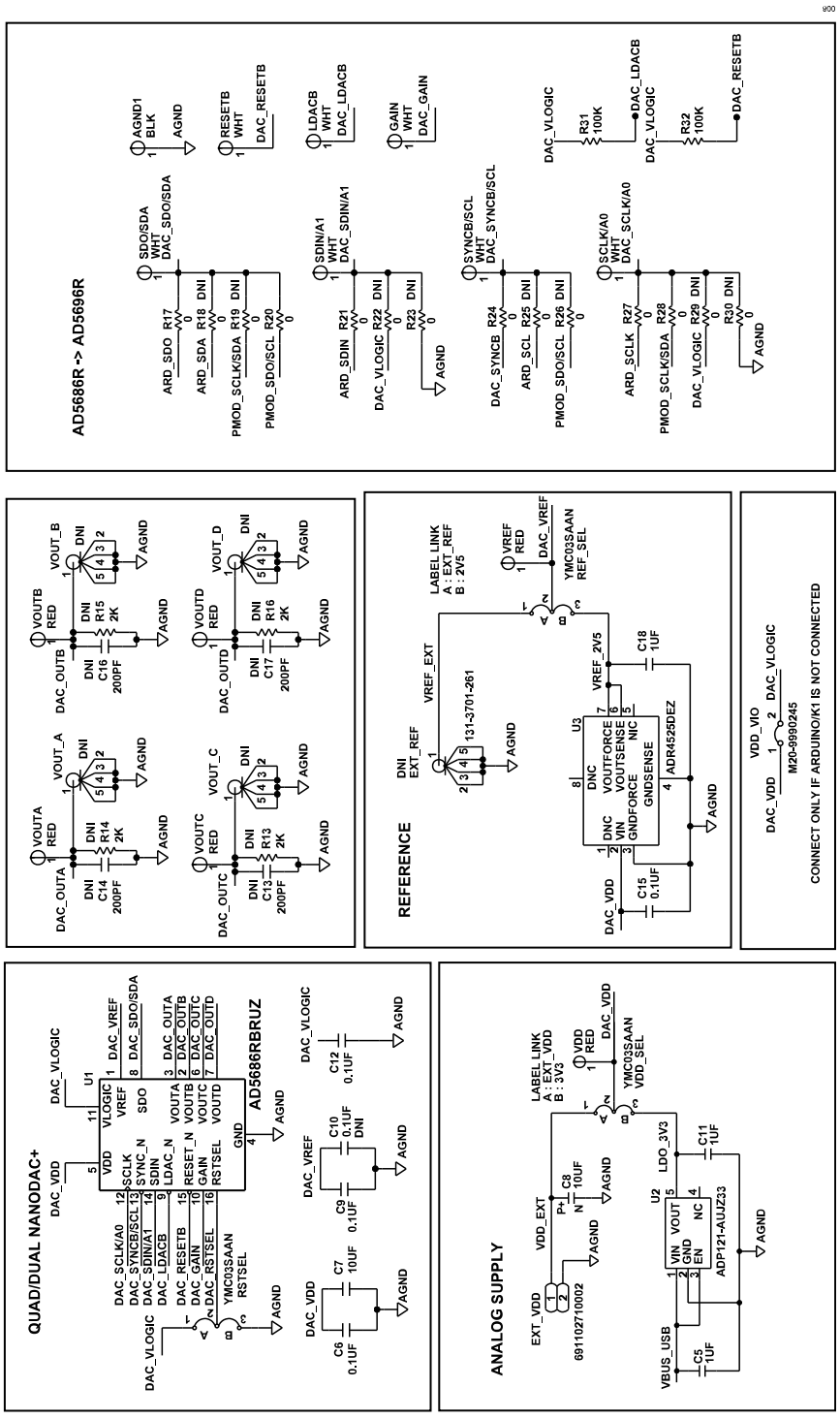


*Figure 8. NanoDAC+ Evaluation Board Schematic Diagram—Power Supply and Signal Route*

## EVALUATION BOARD SCHEMATICS AND ARTWORK

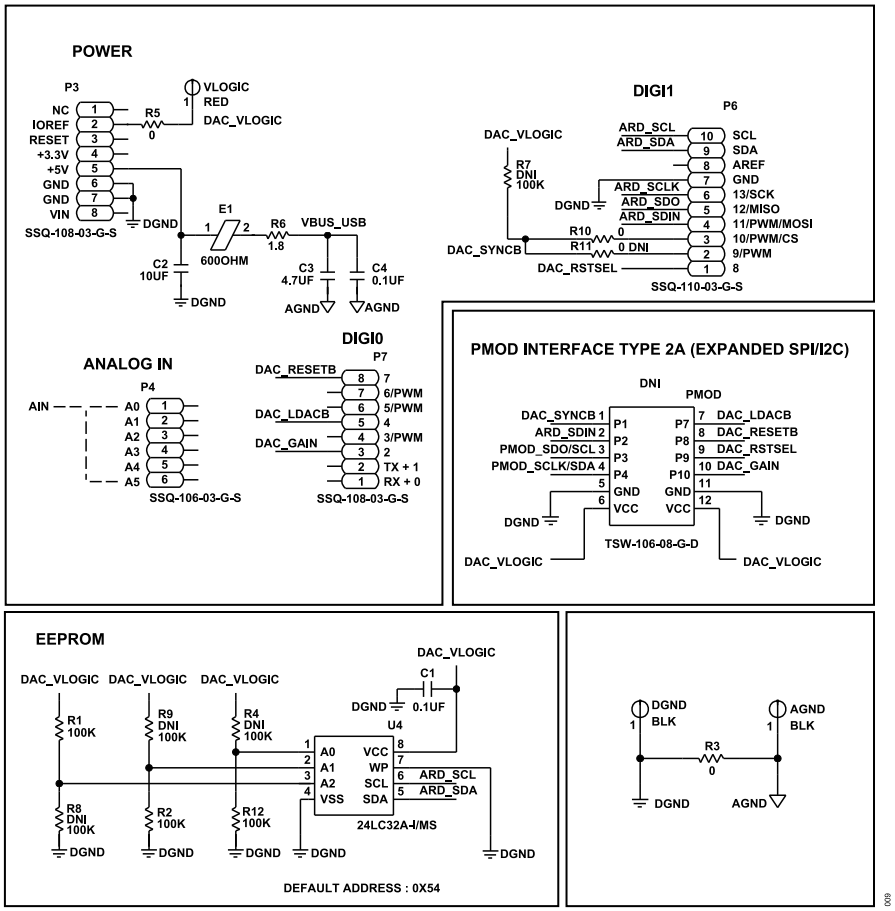


*Figure 9. NanoDAC+ Evaluation Board Schematic Diagram—SDP Connector, PMOD, and EEPROM*

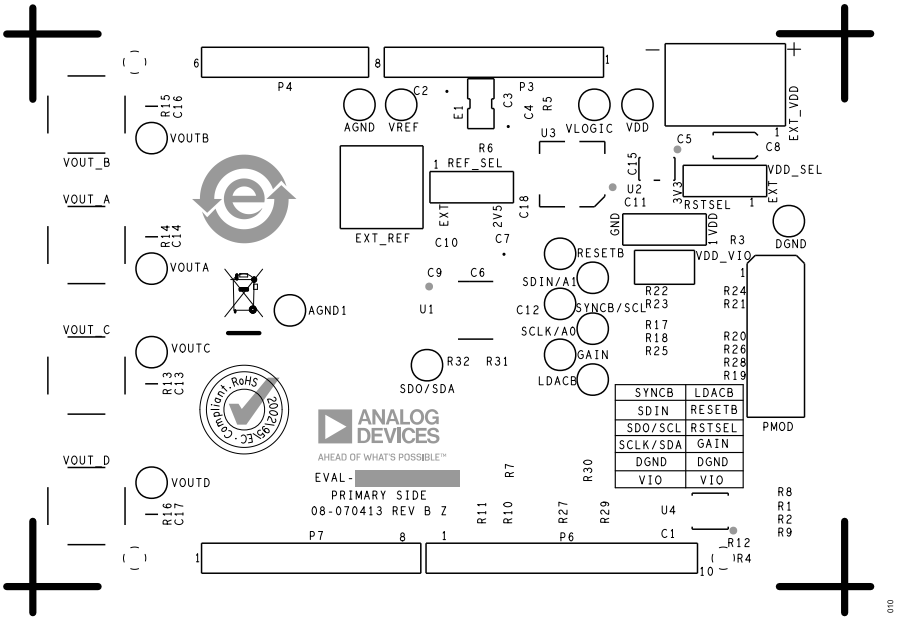


*Figure 10. NanoDAC+ Evaluation Board—Component Placement*

## EVALUATION BOARD SCHEMATICS AND ARTWORK

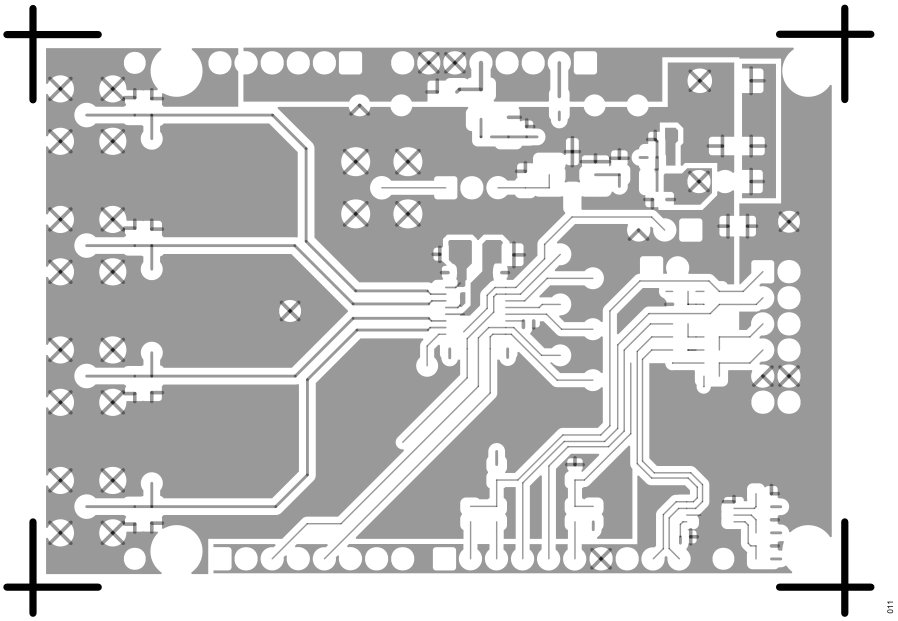

*Figure 11. NanoDAC+ Evaluation Board—Top Side Routing*

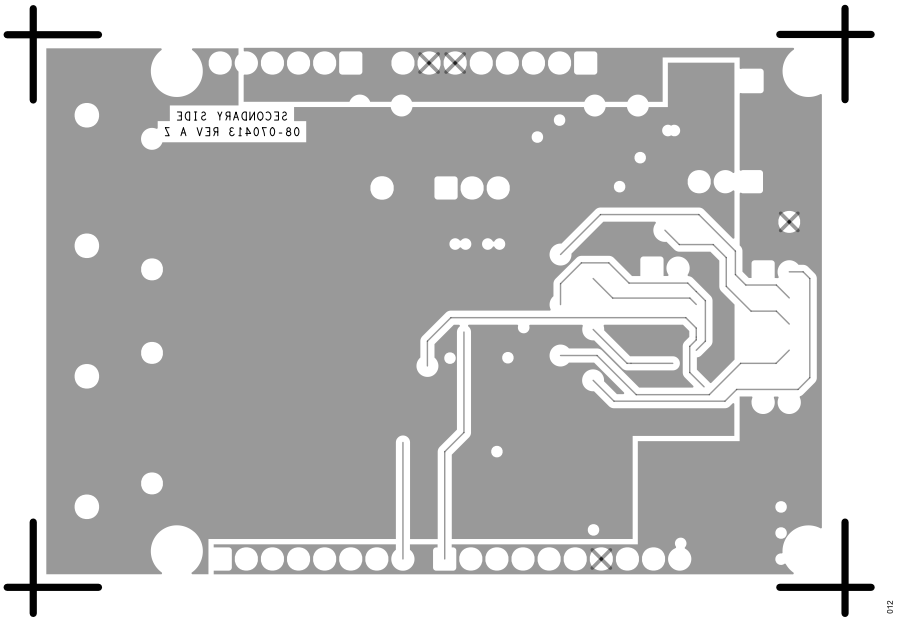


*Figure 12. NanoDAC+ Evaluation Board—Bottom Side Routing*

## ORDERING INFORMATION

## BILL OF MATERIALS

*Table 5. Bill of Materials*

| Quantity | Reference Designator | Description | Supplier, Part Number[1] |
|---|---|---|---|
| 1 | U1 | IC, Analog Devices, quad, 16-bit or 14-bit or 12-bit nanoDAC | Analog Devices, AD5686R/AD5696R |
| 1 | U2 | IC, Analog Devices, 150 mA, low quiescent current, CMOS linear regulator, 3.3 VOUT | Analog Devices, ADP121-AUJZ33R7 |
| 1 | U3 | IC, Analog Devices, ultra-low noise, high accuracy voltage references | Analog Devices, ADR4525DEZ |
| 1 | U4 | IC, 32 kb serial electronically erasable programmable read-only memory (EEPROM) | Generic |
| 2 | AGND, DGND | Connector for printed circuit board (PCB) test points, black | Generic |
| 1 | AGND1 | Connector for PCB test points, black | Generic |
| 1 | C1 | 0.1 µF ceramic capacitors, 16 V, 10%, X7R, 0402, AEC-Q200 | Generic |
| 3 | C5, C11, C18 | 1 µF ceramic capacitors, 16 V, 10%, X7R, 0603 | Generic |
| 4 | C4, C6, C9, C12 | 0.1 µF ceramic capacitors, 16 V, 10%, X7R, 0402 | Generic |
| 1 | C15 | 0.1 µF ceramic capacitors, 50 V, 10%, X7R, 0603 | Generic |
| 2 | C2, C7 | 10 µF ceramic capacitors, 25 V, 10%, X5R, 0805 | Generic |
| 1 | C3 | 4.7 µF ceramic capacitors, 25 V, 10%, X5R, 0805 | Generic |
| 1 | C8 | 10 µF tantalum capacitors, 10 V, 10%, 3216-18, low effective series resistance (ESR) | Generic |
| 1 | E1 | Inductor, ferrite bead, 600 Ω, 25%, 100 MHz, 2.9 A, 0.038 Ω, 1206, AEC-Q200 | Generic |
| 1 | EXT_VDD | Connector for PCB 2-position terminal block side entry, 5 mm pitch | Generic |
| 7 | GAIN, LDACB, RESETB, SCLK/A0, SDIN/A1, SDO/SDA, SYNCB/SCL | Connector for PCB test points, white | Generic |
| 2 | P3, P7 | Connector for PCB receptacles, 25 mil square post, 2.54 mm pitch | Generic |
| 1 | P4 | Connector for PCB receptacles, 25 mil square post, 2.54 mm pitch | Generic |
| 1 | P6 | Connector for PCB receptacles, 25 mil square post, 2.54 mm pitch | Generic |
| 5 | R1, R2, R12, R31, R32 | 100 kΩ resistors, surface-mount device (SMD), 1%, 1/16 W, 0603 | Generic |
| 2 | R5, R10 | 0 Ω resistors, jumper, 1/10 W, 0603 | Generic |
| 1 | R3 | 0 Ω resistors, SMD, jumper, 1/8 W, 0805, AEC-Q200 | Generic |
| 1 | R6 | 1.8 Ω resistors, SMD, 5%, 1/10 W, 0402, AEC-Q200 | Generic |
| 3 | REF_SEL, RSTSEL, VDD_SEL | Connector for PCB high temperature 3-position, male header, unshrouded, single row, straight, 2.54 mm pitch, 3.05 mm solder tail | Generic |
| 7 | VDD, VLOGIC, VOUTA, VOUTB, VOUTC, VOUTD, VREF | Connector for PCB, test point, red | Generic |
| 1 | VDD_VIO | Connector for PCB header, 1 row, 2 way | Generic |
| 6 | R17, R20, R21, R24, R27, R28 | 0 Ω resistors, jumper, 1/10 W, 0603 | Install for AD5686R |
| 6 | R18, R19, R23, R25, R26, R30 | Resistors, film, SMD, 0603 | Install for AD5696R |
| 6 | R18, R19, R23, R25, R26, R30 | 0 Ω resistors, jumper, 1/10 W, 0603 | Do not install for AD5686R |
| 6 | R17, R20, R21, R24, R27, R28 | 0 Ω resistors, jumper, 1/10 W, 0603 | Do not install for AD5696R |
| 2 | R22, R29 | 0 Ω resistors, jumper, 1/10 W, 0603 | Do not install |
| 1 | C10 | 0.1 µF ceramic capacitors, 16 V, 10%, X7R, 0402 | Do not install |
| 4 | C13, C14, C16, C17 | 200 pF ceramic capacitors, 16 V, 55%, C0G, 0805 | Do not install |
| 1 | EXT_REF | Connector for PCB, coaxial, SMB, jack | Do not install |
| 1 | PMOD | Connector for PCB, Berg, header, straight, male, 12 position, do not insert (DNI) or do not populate (DNP) for both the EVAL-AD5686RARDZ and the EVAL-AD5696RARDZ | Do not install |
| 1 | R11 | 0 Ω resistors, jumper, 1/10 W, 0603 | Do not install |
| 4 | R13, R14, R15, R16 | 2.0 kΩ resistors, SMD, 0.1%, 1/18 W, 0805, AEC-Q200, high reliability | Do not install |
| 4 | R4, R7, R8, R9 | 100 kΩ resistors, SMD, 1%, 1/16 W, 0603 | Do not install |

## ORDERING INFORMATION

*Table 5. Bill of Materials (Continued)*

| Quantity | Reference Designator | Description | Supplier, Part Number[1] |
|---|---|---|---|
| 4 | VOUT_A, VOUT_B, VOUT_C, VOUT_D | Connector for PCB, SMB, jack, straight | Do not install |

[1] Generic indicates that any part with the specified value, size, and rating can be used.

## NOTES

$I^2C$ refers to a communications protocol originally developed by Philips Semiconductors (now NXP Semiconductors).