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Evaluating the ADAU1452 SigmaDSP Audio Processor

FEATURES

4 analog inputs
8 analog outputs
Stereo S/PDIF input and output
Self-boot EEPROM memory

EVALUATION KIT CONTENTS

EVAL-ADAU1452MINIZ evaluation board
EVAL-ADUSB2EBZ (USBi) communications adapter
USB cable with Mini-B plug
6 V ac-to-dc power supply

ADDITIONAL EQUIPMENT NEEDED

2 audio cables
2 optical cables
PC running Windows XP, Windows Vista, or Windows 7

DOCUMENTS NEEDED

ADAU1452 data sheet
AD1938 data sheet
AN-1006 Applications Note, *Using the EVAL-ADUSB2EBZ*

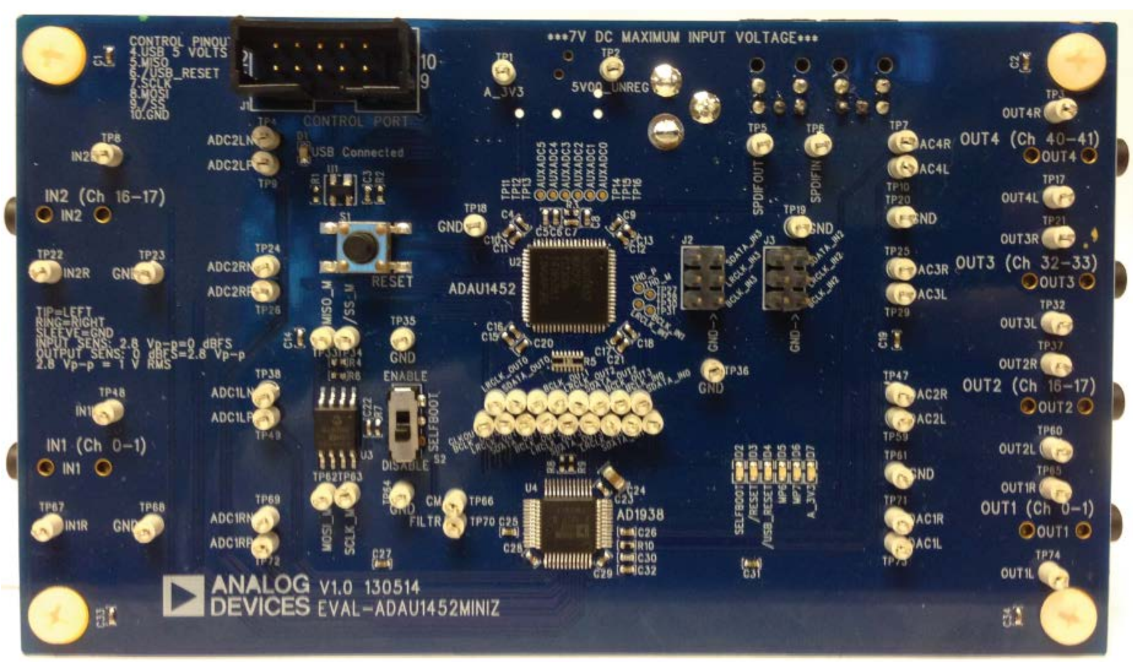
GENERAL DESCRIPTION

This user guide explains the design, setup, and operation of the EVAL-ADAU1452MINIZ evaluation board.

This evaluation board provides access to the digital serial audio ports of the ADAU1452, as well as some of its general-purpose I/Os. An analog I/O is provided by the included AD1938 codec. The ADAU1452 core is controlled by Analog Devices, Inc., SigmaStudio™ software, which interfaces to the board via a USB connection. The board is powered by a 6 V dc supply, which is regulated to the voltages required on the board. The printed circuit board (PCB) is a 4-layer design, with a single ground plane and a single power plane on the inner layers. The board contains connectors for external analog inputs and outputs and optical S/PDIF interfaces. The master clock is provided by the integrated oscillator circuit and the on-board 12.288 MHz passive crystal.

For more information about the ADAU1452 device, see the ADAU1452 data sheet, which should be used in conjunction with this user guide.

PHOTOGRAPH OF THE EVAL-ADAU1452MINIZ EVALUATION BOARD



11926-001

Figure 1. Evaluation Board Top Side Photograph

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REVISION HISTORY

1/14—Revision 0: Initial Version

EVALUATION BOARD BLOCK DIAGRAMS

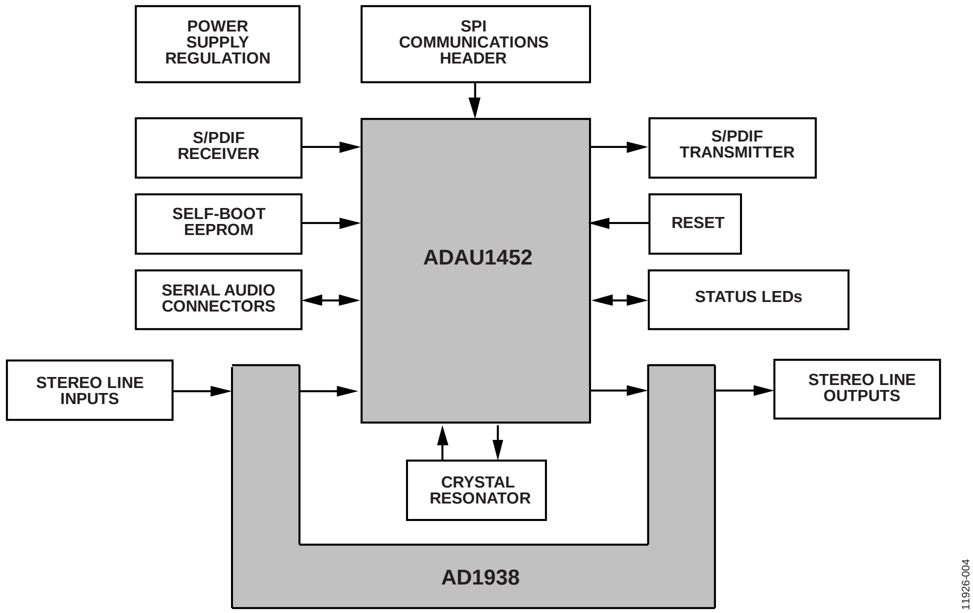


Figure 2. Functional Block Diagram

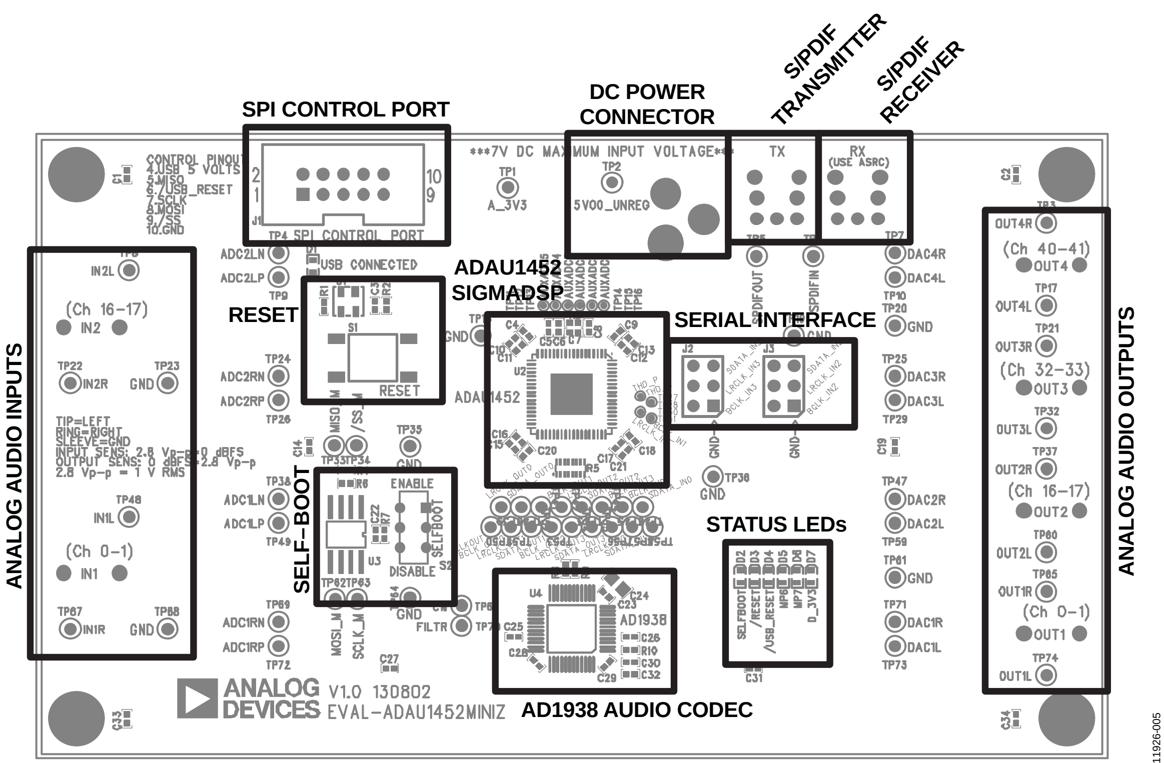


Figure 3. Board Layout Block Diagram

SETTING UP THE EVALUATION BOARD

INSTALLING THE SigmaStudio SOFTWARE

You can download the latest version of SigmaStudio by completing the following steps:

1. Install the latest version of Microsoft .NET Framework if you do not already have it installed. It can be downloaded from the Microsoft website.
2. Go to www.analog.com/SigmaStudio and select the latest version of SigmaStudio from the **Download Products** section.
3. Log into your myAnalog account. (If you do not have an account, point to **myAnalog**, click **Log In,** and then click **Register** to create a new account.)
4. Fill in the download form and choose SigmaDSP as the target hardware.
5. Download the installer and execute the executable. Follow the prompts, including accepting the license agreement, to install the software.

INSTALLING THE USBi (EVAL-ADUSB2EBZ) DRIVERS

SigmaStudio must be installed to use the USB interface (USBi). After the SigmaStudio installation is complete,

1. Connect the USBi to an available USB 2.0 port using the USB cable included in the evaluation board kit. (The USBi will not function properly with a USB 3.0 port.)
2. Install the driver software (see the Using Windows XP section or the Using Windows 7 or Windows Vista section for more information).

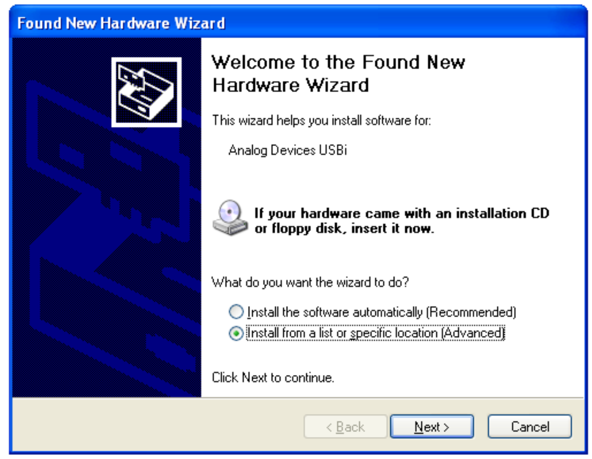
Using Windows XP

After connecting the USBi to the USB 2.0 port, Windows® XP recognizes the device (see Figure 4) and prompts you to install the drivers.

11926-006

Figure 4. Found New Hardware Notification

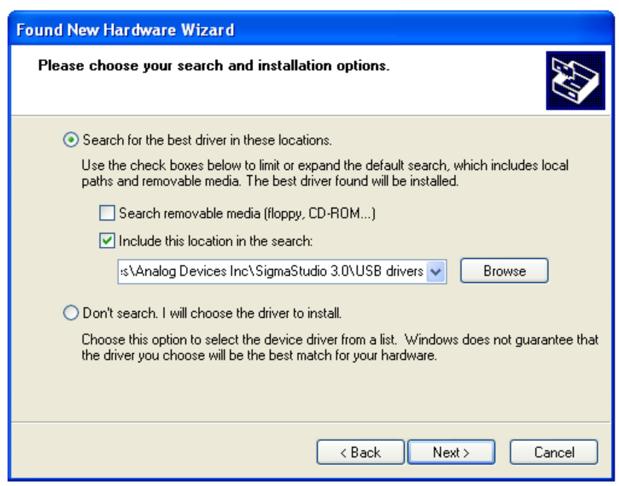
1. From the **Found New Hardware Wizard** window, select the **Install from a list or specific location (Advanced)** option and click **Next** > (see Figure 5).



11926-007

Figure 5. Found New Hardware Wizard—Installation

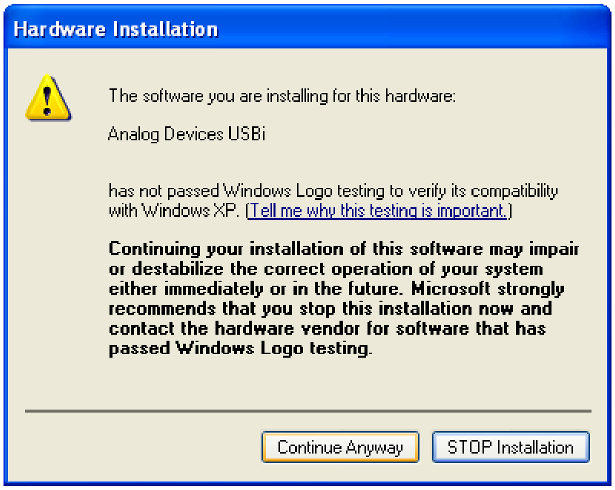
2. Click **Search for the best driver in these locations**, select **Include this location in the search**, and click **Browse** to find the USB drivers subdirectory within the SigmaStudio directory (see Figure 6).



11926-008

Figure 6. Found New Hardware Wizard—Search and Installation Options

3. When the warning about Windows logo testing appears, click **Continue Anyway** (see Figure 7).



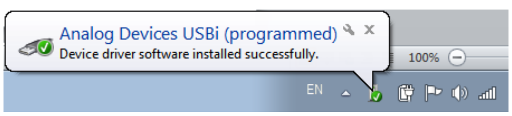
11926-009

Figure 7. Windows Logo Testing Warning

The USBi drivers should now be installed successfully. Leave the USBi connected to the PC.

Using Windows 7 or Windows Vista

After connecting the USBi to the USB 2.0 port, Windows® 7 or Windows Vista recognizes the device and installs the drivers automatically (see Figure 8). After the installation is complete, leave the USBi connected to the PC.



11926-010

Figure 8. USBi Driver Installed Correctly

Confirming Proper Installation of the USBi Drivers

To confirm that the USBi drivers have been installed properly,

1. With the USBi still connected to the USB 2.0 port of the computer, check that both the yellow I2C LED and the red power indicator LED are illuminated (see Figure 9).

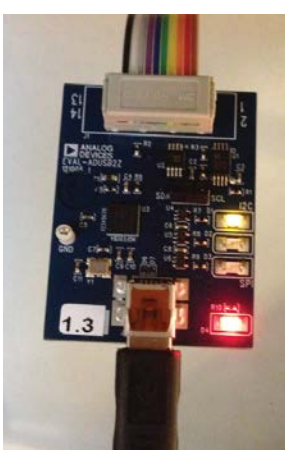
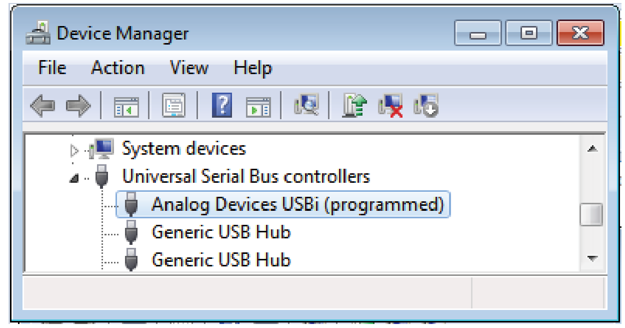

11926-111

Figure 9. State of USBi Status LEDs After Successful Driver Installation

2. In Windows **Device Manager** under the **Universal Serial Bus controllers** section (see Figure 10), check that **Analog Devices USBi (programmed)** is displayed.



11926-112

Figure 10. Confirming Successful Driver Installation Using the Device Manager

SETTING THE S2 SWITCH

When setting up the evaluation board,

1. Ensure that the S2 switch is in the DISABLED position.

The default position of this switch is the ENABLED position, which causes the ADAU1452 to execute a self-boot operation at power-up. When the switch is in the DISABLED position, no self-boot operation is executed, and the ADAU1452 powers up into its default state.

POWERING UP THE BOARD

To power up the evaluation board,

1. Connect the included power supply to the wall outlet (100 V to 240 V, ac 50 Hz to 60 Hz).
2. Connect the female plug of the power supply to the J4 male connector on the EVAL-ADAU1452MINIZ, as shown in Figure 11.

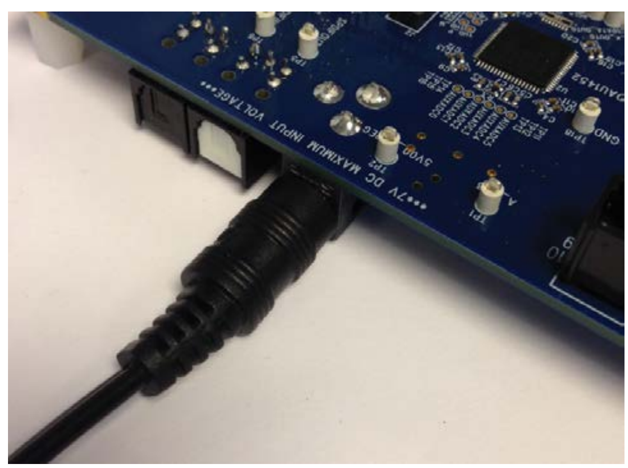

11926-013

Figure 11. Connecting the Power Supply

3. After the power supply is connected, the status LED D7 (A_3V3) illuminates.
4. Connect the ribbon cable of the USBi to the control port of the EVAL-ADAU1452MINIZ. (The USBi should already be connected to the USB 2.0 port of the computer.)

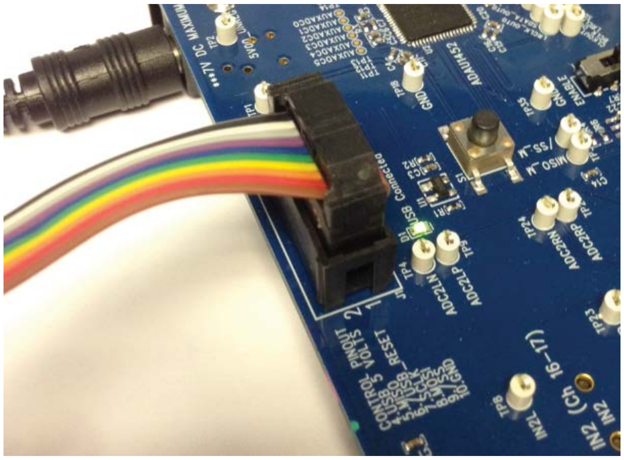

11926-014

Figure 12. Connecting the USBi to the SPI Control Port Header

CONNECTING THE AUDIO CABLES

To connect the audio cables,

1. Connect a stereo audio source to J11 (IN1) with a standard 1/8" stereo TRS audio cable. (The audio signals should be single-ended and line level, with a maximum peak-to-peak voltage of 2.828 V. The tip of the plug is the left channel of audio, the ring is the right channel of audio, and the sleeve is the common or ground.)
2. Connect headphones or powered speakers to J12 (OUT1).

Figure 13 shows the input source connection. Figure 14 shows the output connection. Figure 15 shows the location of the connectors on the board.

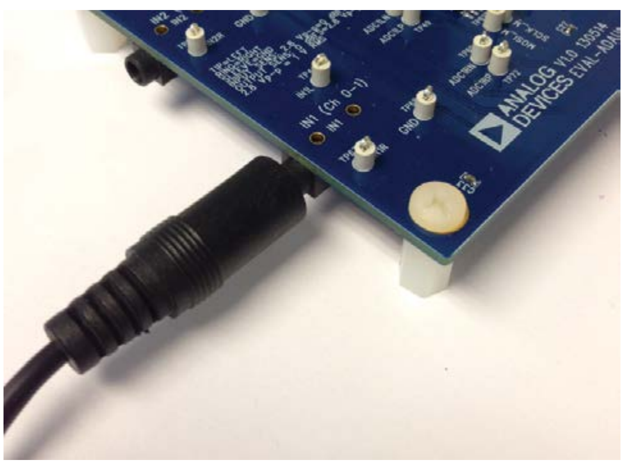

11926-016

Figure 13. Analog Stereo Input Source Connection

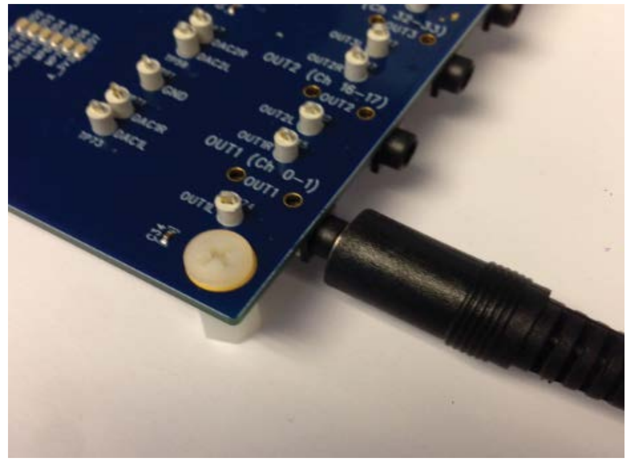
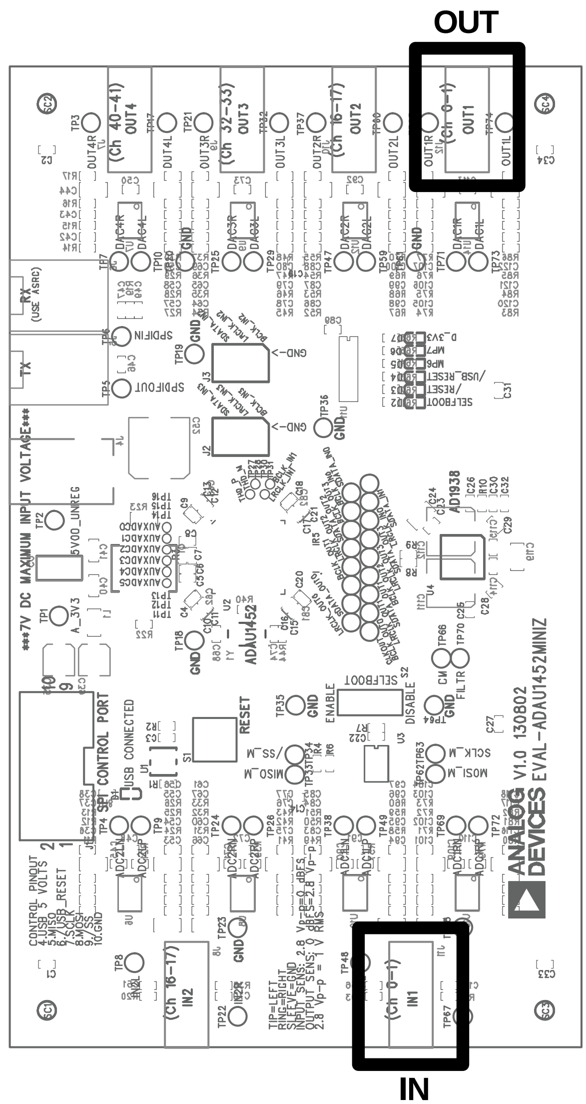

11926-017

Figure 14. Analog Stereo Output Connection



11926-015

Figure 15. Location of Stereo Output OUT1 (J12) and Stereo Input IN1 (J11), Rotated 90°

SETTING UP COMMUNICATIONS IN SigmaStudio

To set up communications in SigmaStudio,

1. Start SigmaStudio by double-clicking the shortcut on the desktop or by finding and executing the executable in Windows Explorer.
2. Create a new project by selecting **New Project** from the **File** menu or by pressing CTRL+N. (The default view of the new project is the **Hardware Configuration** tab.)
3. In the **Hardware Configuration** tab, add the appropriate components to the project space by clicking and dragging them from the **Tree ToolBox** on the left of the window to the empty white space located on the right of the window.
   a. Add a **USBi** component from the **Communication Channels** subsection of the toolbox (see Figure 16).

Figure 16. Adding the USBi Communication Channel

   b. Add an **ADAU1452** component from the **Processors (ICs/DSPs)** subsection of the toolbox (see Figure 17).

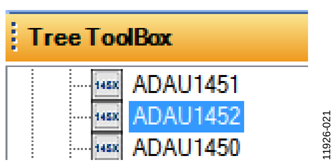


Figure 17. Adding an ADAU1452

4. Ensure that SigmaStudio can detect the USBi on the USB port of the PC as follows:
   a. If SigmaStudio detects the USBi, the background of the **USB** label is green in the **USB Interface** box (see Figure 18).

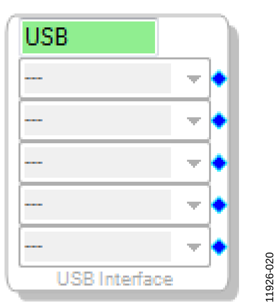


Figure 18. USBi Detected by SigmaStudio

   b. If SigmaStudio cannot detect the USBi on the USB port of the PC, the background of the **USB** label is red (see Figure 19). This may occur when the USBi is not connected or when the drivers have been installed incorrectly.

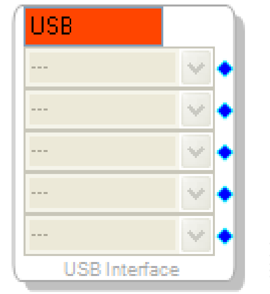


Figure 19. USBi Not Detected by SigmaStudio

5. Connect the USB interface to the target integrated circuit (IC), the ADAU1452, by clicking and dragging a line, representing a wire, between the blue pin of the USBi and the green pin of the IC (see Figure 20). This allows the USBi to communicate with the ADAU1452. The corresponding drop-down box of the USBi automatically fills with the default mode and channel for that IC. In the case of the ADAU1452, the default communications mode is SPI, the default slave select line is 1, and the default address is 0.

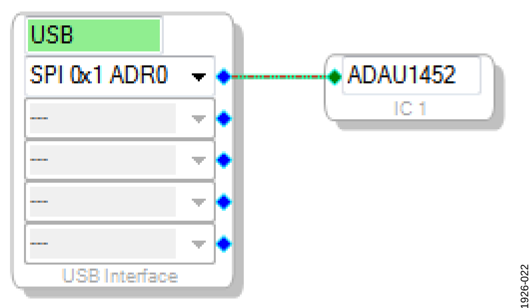


Figure 20. Connecting the USBi to an ADAU1452 in the Hardware Configuration Tab

CREATING A BASIC SIGNAL FLOW

To create a signal processing flow,

1. Click the **Schematic** tab near the top of the window (see Figure 21).

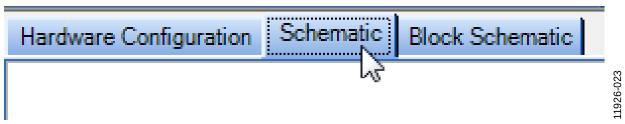


Figure 21. Schematic Tab

2. Add the appropriate elements to the project space by clicking and dragging them from the **Tree ToolBox** on the left of the window to the empty white space located on the right of the window. (The toolbox contains all of the algorithms that can run in SigmaDSP.)

    i. To add an **Input** block, from the **ADAU1452** > **IO** > **Input** > **sdata 0-15** folder, click **Input** (see Figure 22) and drag it into the project space to the right of the toolbox (see Figure 23). (By default, Channel 0 and Channel 1 are selected. This matches the analog audio source hardware connections shown in Figure 13 and Figure 14; therefore, no modifications are needed.)

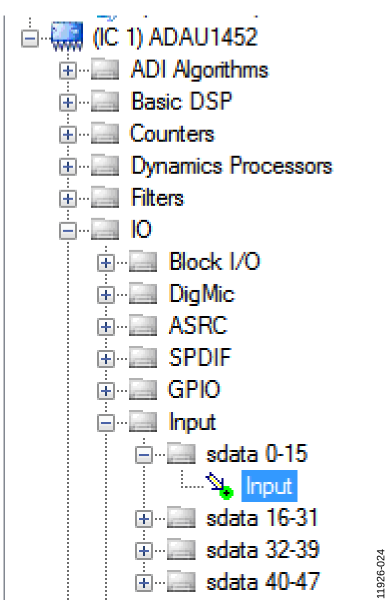


Figure 22. Input Block Selection

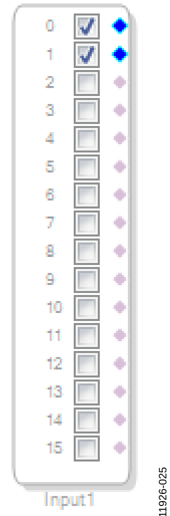


Figure 23. Input Block

b. Add two **Output** blocks as follows, making sure that these blocks are assigned to Channel 0 and Channel 1:

    i. From the **ADAU1452** > **IO** > **Output** folder, click **Output** (see Figure 24) and drag it into the project space to the right of the toolbox.

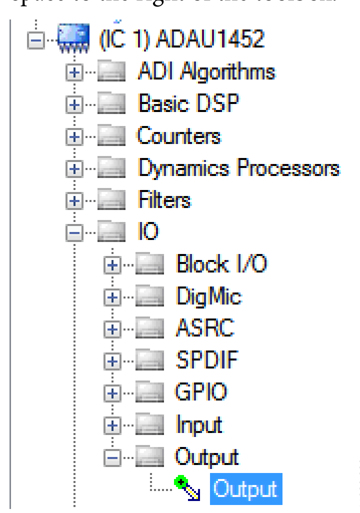


Figure 24. Output Block Selection

    ii. Repeat the previous step to add another output (see Figure 25).

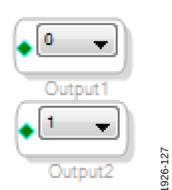


Figure 25. Output Blocks

3. Connect each **Input** channel to its corresponding **Output** channel by clicking and dragging a line, representing a wire, between the blue pin of the **Input** channel and the green pin of the **Output** channel (see Figure 26). (Input Channel 0 connects to Output Channel 0, and Input Channel 1 connects to Output Channel 1.)

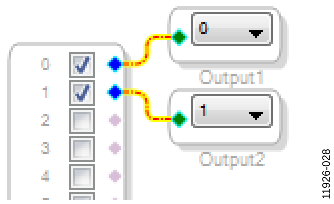


Figure 26. Connected Signal Flow with Stereo Input and Stereo Output

The default register settings in SigmaStudio are configured to match the hardware of the EVAL-ADAU1452MINIZ, including the signal routing between the ADAU1452 and the AD1938 codec.

After completing these steps, the basic signal flow is complete, with the stereo analog input source passing directly through the SigmaDSP and connecting to the stereo analog output.

Add Volume Control

1. To add a **Volume Control** block, from the **Volume Controls** > **Adjustable Gain** > **Clickless HW Slew** folder, click **Single Volume** and drag it into the project space to the right of the toolbox.

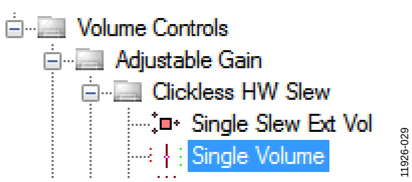


Figure 27. Single Volume Block Selection

2. Delete the existing yellow connection wires (that is, the connections added in Step 3 of the previous section) by clicking on them and then pressing the DELETE key.
3. Connect the blocks as shown in Figure 28.

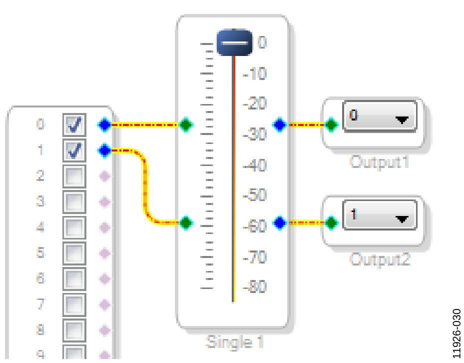


Figure 28. Completed Signal Flow with Volume Control

The schematic is ready to be compiled and downloaded to the evaluation board.

DOWNLOADING THE PROGRAM TO THE DSP

To compile and download the code to the DSP,

1. Click the **Link-Compile-Download** button once in the main toolbar of SigmaStudio (see Figure 29). Alternatively, press F7.

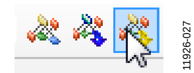


Figure 29. Link-Compile-Download Button

After the code has been downloaded to the DSP,

- If the compiler is successful in compiling the project, the compiled data downloads from SigmaStudio via the USBi to the ADAU1452, and the SigmaDSP starts running.
- The status bar turns from blue to green and the mode displayed changes from **Design Mode** to **Active: Downloaded** in the lower right corner of the window (see Figure 30 and Figure 31). (Until this point, SigmaStudio has been in design mode, as denoted by the blue bar at the bottom of the screen and the words **Design Mode** displayed in the lower right corner of the SigmaStudio window (see Figure 30).)

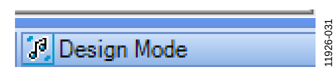


Figure 30. Design Mode and Blue Status Bar

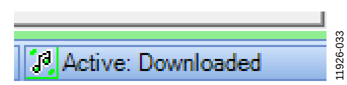


Figure 31. Active Downloaded Mode and Green Status Bar

- The signal flow begins running on the evaluation board, and the audio passes from the analog input to the analog output. (The volume can be changed in real time by clicking and dragging the volume control slider in the **Schematic** tab.)
- If the **Output** window was open at the time of compilation, a compiler output log is displayed, as shown in Figure 32. The **Output** window can be opened or closed by using the keyboard shortcut CTRL+4. The **Output** window shows the compiler output log only if it was open when the **Link-Compile-Download** button was clicked.

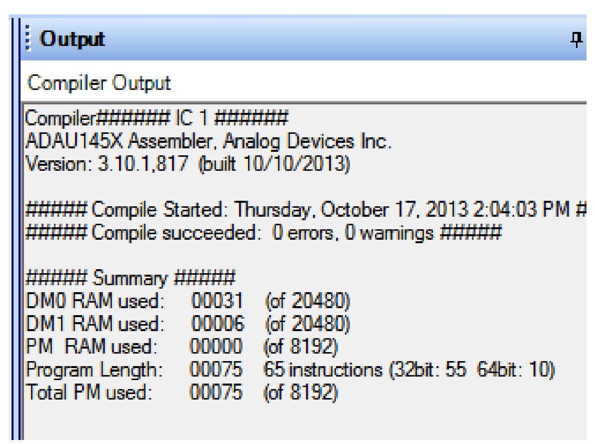


Figure 32. Compiler Output Window

ADDING S/PDIF INPUT AND OUTPUT TO THE PROJECT

The EVAL-ADAU1452MINIZ board has two optical S/PDIF interfaces. One interface is an input that converts the optical signal to an electrical signal, which goes to the ADAU1452 S/PDIF receiver (the SPDIFIN pin). The other interface is an optical output that takes the electrical output from the ADAU1452 S/PDIF transmitter (the SPDIFOUT pin) and converts it to an optical signal.

Figure 33 shows the locations of the optical input connector and the optical output connector. The connectors are located on the underside of the PCB.

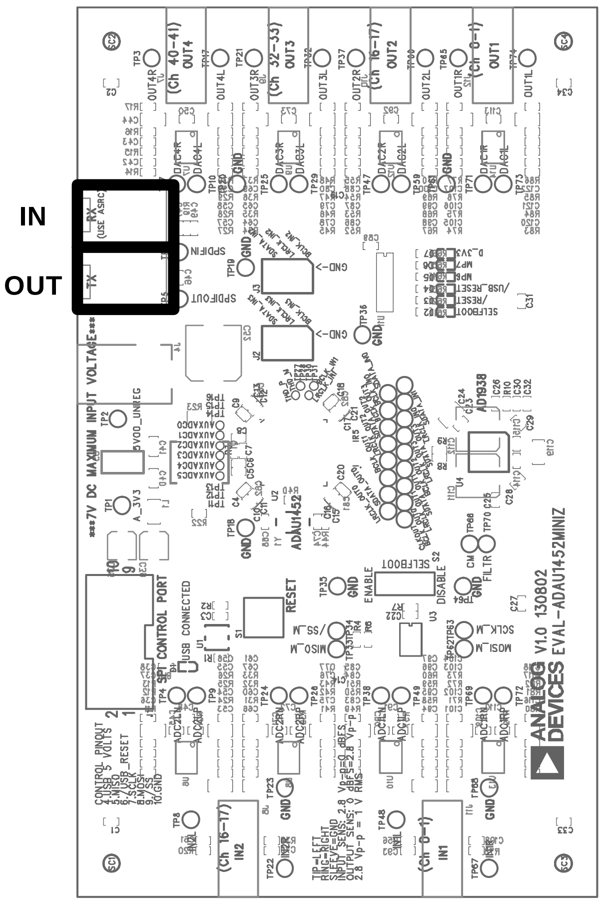


Figure 33. Location of S/PDIF Optical Input (J5) and Output (J6), Rotated 90°

To add an S/PDIF input and output to the project in SigmaStudio,

1. Connect an S/PDIF source to the EVAL-ADAU1452MINIZ by using a standard TOSLINK optical cable and connecting it to J8, the S/PDIF receiver connector (see Figure 34).

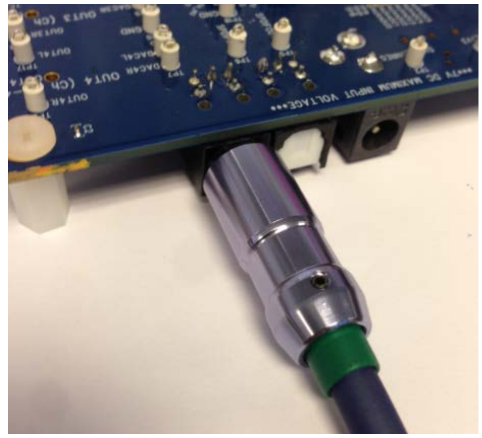


Figure 34. Photograph of the Optical S/PDIF Input Connection

2. Configure the S/PDIF input and output by modifying the ADAU1452 registers as follows:
   a. Click the **Hardware Configuration** tab, and then click the **IC 1 – ADAU145x Register Controls** tab at the bottom of the window (see Figure 35).

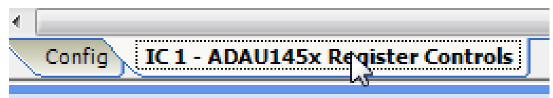


Figure 35. ADAU145x Register Controls Tab

   b. Click the **SPDIF** tab (see Figure 37). (There are several register control tabs listed across the top of the window. To access the **SPDIF** tab, scroll to the right by clicking the right arrow (see Figure 36).)

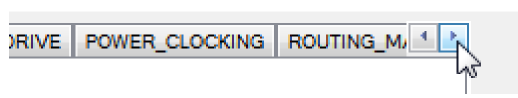


Figure 36. Using the Register Tab Scroll Button

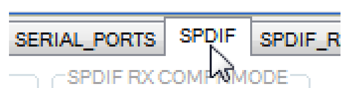


Figure 37. Selecting the SPDIF Tab

   c. Enable the SPDIF_RESTART register by clicking **Do not restart the audio once a re-lock has occurred** in the **SPDIF RESTART** box. (Upon clicking this button, the text displayed on the button changes to **Restarts the audio once a re-lock has occurred** and the button color changes from red to green (see Figure 38).)

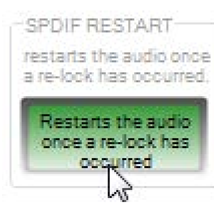


Figure 38. Activating the SPDIF_RESTART Register

d. Activate the SPDIF_TX_ENABLE register by clicking **Disabled** in the **SPDIF TX EN** box. (Upon clicking this button, the text displayed on the button changes to **Enabled** and the button color changes from red to green (see Figure 39).)

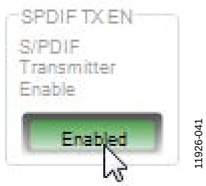


Figure 39. Activating the SPDIF_TX_EN Register

3. Click the **ROUTING_MATRIX** tab (see Figure 40) to allow configuring the routing matrix.

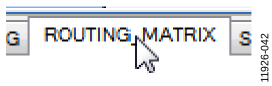


Figure 40. Selecting the ROUTING_MATRIX Tab

4. Configure the S/PDIF receiver signal routing by clicking **ASRC 0** (see Figure 41) and then configuring ASRC 0 using the drop-down menus until it matches Figure 42. (This routes the S/PDIF receiver signal through an asynchronous sample rate converter (ASRC) before it is accessed in the DSP core. Routing the signal in this way is necessary because the S/PDIF source is not synchronous to the ADAU1452.)

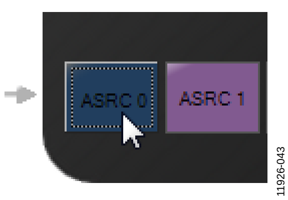


Figure 41. ASRC 0 Control Button

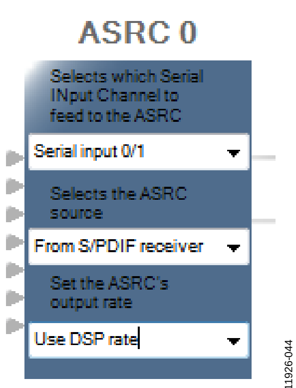


Figure 42. Configuring the ASRC 0 Routing Matrix Registers

5. Configure the S/PDIF transmitter signal routing as follows:

a. Click the **S/PDIF TX** box (see Figure 43).

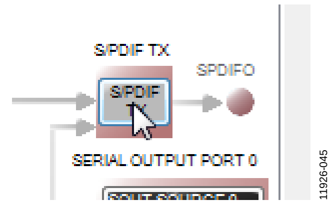


Figure 43. Configuring the S/PDIF Transmitter Routing Matrix Register

b. From the drop-down menu that appears, select **From DSP** to choose the signal coming from the DSP core (see Figure 44).

Figure 44. Routing the DSP Core Outputs to the S/PDIF Transmitter

c. Close the pop-up window.

d. Confirm that the setting has taken effect by verifying that the color of the **S/PDIF TX** box has changed from gray to black (see Figure 45). (If the color of the box has changed to black, the DSP core has been routed to the S/PDIF transmitter and the S/PDIF receiver signal has been routed to ASRC 0; therefore, the output of ASRC 0 can be used in the DSP program.)

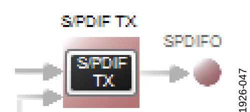


Figure 45. Confirming that the DSP Core Outputs are Routed to the S/PDIF Transmitter

6. Click the **Schematic** tab at the top of the window to return to the schematic design view.

7. Add an S/PDIF input to the project as follows.

a. From the **IO** > **ASRC** > **Input** folder, click **Asrc Input** (see Figure 46) and drag it into the project space to the right of the toolbox (see Figure 47).

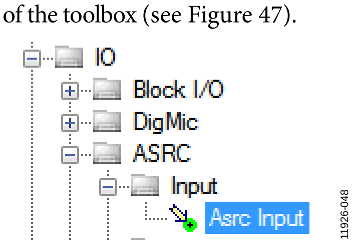


Figure 46. ASRC Input Block Selection

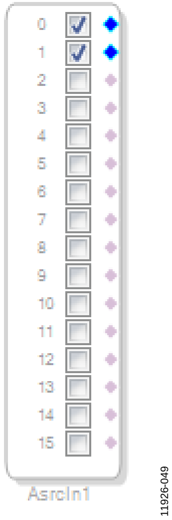


Figure 47. ASRC Input Block

Because the left and right signals of the S/PDIF receiver are passing through ASRC 0, the input to the DSP program is the **Asrc Input** block in SigmaStudio. This naming convention is such that all blocks in SigmaStudio are named from the perspective of the DSP core. Therefore, the **Asrc Input** block in SigmaStudio represents the input to the DSP from the ASRC outputs. The inputs to the ASRCs themselves are defined in the register map (see Figure 42).

By default, Channel 0 and Channel 1 are active when their corresponding checkboxes are selected. Because the ASRC 0 outputs correspond to Channel 0 and Channel 1, this default configuration can be used (see Figure 47). For reference, a mapping of the ASRC outputs to the corresponding channels on the **Asrc Input** block in the DSP schematic is provided in Table 1.

Table 1. ASRC Output to SigmaStudio Input Channel Mapping

ASRC Output	Corresponding Channels on ASRC Input Block in SigmaStudio
ASRC 0	Channel 0 and Channel 1
ASRC 1	Channel 2 and Channel 3
ASRC 2	Channel 4 and Channel 5
ASRC 3	Channel 6 and Channel 7
ASRC 4	Channel 8 and Channel 9
ASRC 5	Channel 10 and Channel 11
ASRC 6	Channel 12 and Channel 13
ASRC 7	Channel 14 and Channel 15

8. Add two S/PDIF outputs to the project as follows:
   a. From the **IO** > **SPDIF** > **Output** folder, click **Spdif Output** (see Figure 48) and drag it into the project space to the right of the toolbox.

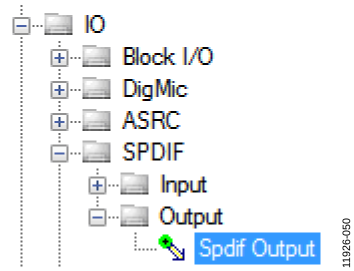


Figure 48. S/PDIF Output Block Selection

   b. Repeat the previous step to add another **Spdif Output** block.
9. Connect the signals from the **Asrc Input** block to the **Spdif Output** blocks so that the resulting signal flow resembles Figure 49.
10. Click the **Link-Compile-Download** button (see Figure 29) or press F7. (The signal flow is then compiled and downloaded to the hardware.)
11. Confirm proper operation by checking that any signal input to the S/PDIF optical receiver is copied and output on the S/PDIF optical transmitter.

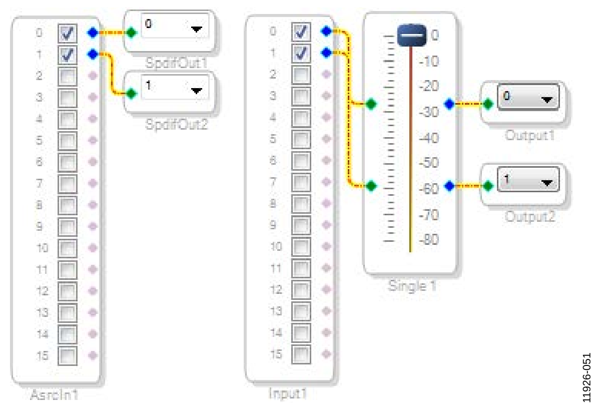


Figure 49. Signal Flow Including S/PDIF Input (via ASRC) and S/PDIF Output

Add a Filter

To add a filter,

1. Add a **Medium-Size Eq** block to the project space as follows:
   a. From the **Filters** > **Second Order** > **Double Precision** folder, click **Medium-Size Eq** (see Figure 50) and drag it into the project space to the right of the toolbox.

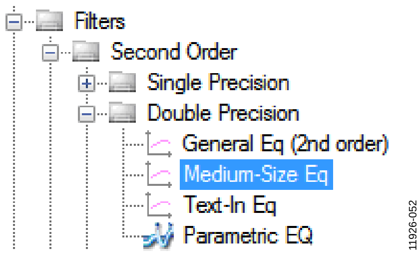


Figure 50. Medium-Size Eq Block Selection

2. By default, the block has one input and one output. In other words, it is a single channel. To add another channel, right-click in the empty white space of the **Medium-Size Eq** block, and then from the drop-down menu that appears, select **Grow Algorithm** > **1. Multi-Channel – Double Precision: Grow Channels** > **1** (see Figure 52).

3. Connect the filter in series between the **Asrc Input** block and the **Spdif Output** blocks so that the filter can be applied to the signals passing through the DSP. The completed signal flow should resemble Figure 51.

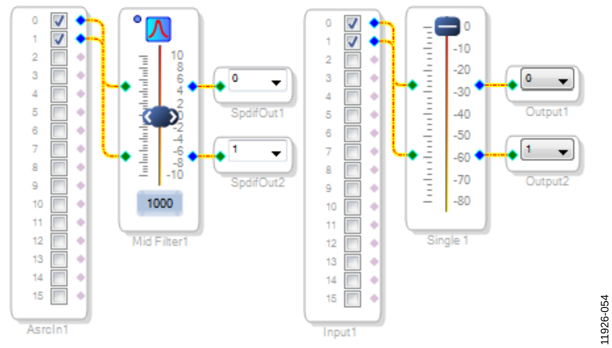


Figure 51. Completed Signal Flow

4. Click the **Link-Compile-Download** button (see Figure 29) or press F7 to compile the signal flow and download it to the hardware. The audio signal passes from the S/PDIF receiver through the ASRCs into the DSP and the EQ filter, and then out on the S/PDIF transmitter. Change the settings of the EQ filter by clicking and dragging the control slider in SigmaStudio when the project is running.

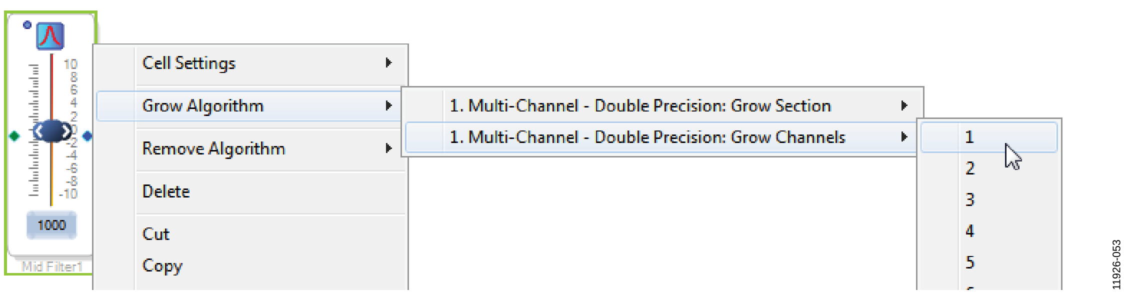


Figure 52. Adding a Channel to the Filter

USING THE EVALUATION BOARD

POWER SUPPLY

Power is supplied to the board using a dc power supply with a female positive center plug. The plug should have a 2.1 mm inner diameter, a 5.5 mm outer diameter, and a 9.5 mm length. The output should range between 5 V and 7 V and should be able to source at least 1.5 A of current. Connect the power supply to Connector J4. The unregulated supply is used to power the operational amplifiers used in the active audio filters for the analog audio inputs and outputs. An on-board linear regulator (U5) generates the 3.3 V dc supply required for the ADAU1452 and AD1938, as well as other supporting ICs. When the power supply is connected properly, LED D7 (A_3V3) illuminates.

11926-055

Figure 53. DC Power Supply Plug and Cable

INPUTS AND OUTPUTS

The EVAL-ADAU1452MINIZ provides access to the serial ports, S/PDIF interfaces, multipurpose pins, and auxiliary ADCs of the ADAU1452.

AD1938 Codec

Two of the four serial input ports are connected to the AD1938 ADCs, and all four of the serial output ports are connected to the AD1938 DACs. This provides a total of four channels of analog audio input and eight channels of analog audio output.

The AD1938 is hardwired in standalone mode, and its serial ports are configured as slaves. Therefore, the corresponding serial ports on the ADAU1452 must be set as clock masters. By default, all serial ports on the ADAU1452 are set as clock masters when a new project is created in SigmaStudio.

The AD1938 is configured to run at a sample rate of 44.1 kHz or 48 kHz. It is not possible to change this setting. Even though the ADAU1452 is very flexible and can run at any sample rate up to 192 kHz, the analog audio inputs and outputs on the EVAL-ADAU1452MINIZ may be distorted or silent if a sample rate other than 44.1 kHz or 48 kHz is used for the ADAU1452 serial ports.

Stereo Line Inputs

Two stereo input jacks allow for four single-ended line-level analog input signals. The AD1938 ADC inputs are configured such that the full scale is 2.8 V peak-to-peak, which is approximately 1 V rms for a sine wave. Any signal that exceeds 2.8 V peak-to-peak at the audio jack is clipped, creating distortion. The signals are fed to active low-pass filters and then are converted to differential pairs before reaching the AD1938 ADCs. The filters are designed for a system sample rate of 44.1 kHz or 48 kHz.

The stereo input jacks accept standard stereo TRS 1/8" mini plugs (tip = left, ring = right, sleeve = ground) with two channels of audio (see Figure 54).

11926-056

Figure 54. Standard Stereo TRS 1/8" Mini Audio Plug and Cable

The signals pass through the AD1938 ADCs and then are sent to the ADAU1452 serial input ports in I²S format. The mapping of input signals to input channels in SigmaDSP and SigmaStudio is shown in Table 2.

Table 2. Mapping of Stereo Analog Input Signals to SigmaStudio Channels

Input Jack	Plug Contact	AD1938 ADC Pins	ADAU1452 Serial Input Pin	Input Channel in SigmaStudio
J11	Left (tip)	ADC1LN, ADC1LP	SDATA_IN0	0
J11	Right (ring)	ADC1RN, ADC1RP	SDATA_IN0	1
J8	Left (tip)	ADC2LN, ADC2LP	SDATA_IN1	16
J8	Right (ring)	ADC2RN, ADC2RP	SDATA_IN1	17

Stereo Line Outputs

Four stereo output jacks allow eight line-level analog output signals. The AD1938 DAC outputs are configured such that a full-scale signal is 2.8 V peak-to-peak at the jack, which is approximately 1 V rms for a sine wave. The signals output from the DACs are fed to active low-pass filters and then ac-coupled before reaching the output jacks. The filters are designed for a system sample rate of 44.1 kHz or 48 kHz.

The output filters are designed to drive high impedance loads, like loads from active speakers. Some low impedance loads, like loads from headphones, can also be driven by these outputs, but very low impedance loads, like loads from passive speakers, cannot be driven by these outputs.

The stereo output jacks accept standard stereo TRS 1/8" mini plugs (tip = left, ring = right, sleeve = ground) with two channels of audio (see Figure 54).

The signals pass from the ADAU1452 serial outputs in I^2S format to the AD1938 DACs, where they are then converted to analog signals and sent through the output filters to the output jacks. The mapping among the SigmaStudio output channels, output serial ports, and output jacks is shown in Table 3.

Table 3. Mapping of SigmaStudio Channels to Output Jacks

Output Jack	Plug Contact	AD1938 DAC Pin	ADAU1452 Serial Output Pin	Output Channel in SigmaStudio
J12	Left (tip)	OL1	SDATA_OUT0	0
J12	Right (ring)	OR1	SDATA_OUT0	1
J10	Left (tip)	OL2	SDATA_OUT1	16
J10	Right (ring)	OR2	SDATA_OUT1	17
J9	Left (tip)	OL3	SDATA_OUT2	32
J9	Right (ring)	OR3	SDATA_OUT2	33
J7	Left (tip)	OL4	SDATA_OUT3	40
J7	Right (ring)	OR4	SDATA_OUT3	41

S/PDIF Optical Transmitter and Receiver

The ADAU1452 S/PDIF interfaces are connected directly to optical transmitter and receiver connectors, which convert the electrical signals to and from optical signals, respectively. The connectors accept standard TOSLINK connectors and optical fiber cables (see Figure 55).

11926-057

Figure 55. TOSLINK Connector and Optical Fiber Cable for S/PDIF Input and Output

The ADAU1452 S/PDIF receiver accepts signals with sample rates between 18 kHz and 96 kHz. Because the incoming signal is asynchronous to the system sample rate, an ASRC should be used to convert the sample rate of the incoming signal. Optionally, the SigmaDSP core can be configured to start processing audio samples based on the sample rate of the incoming S/PDIF receiver signal, meaning that no ASRC is required. However, using an ASRC is strongly recommended for performance and reliability reasons.

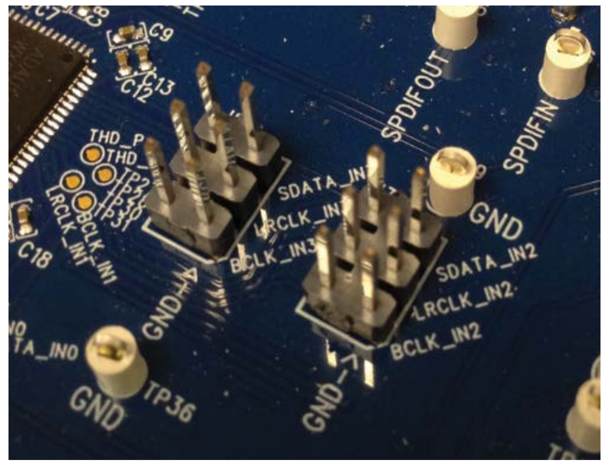
The ADAU1452 S/PDIF transmitter typically transmits signals from the DSP core, meaning that the sample rate of the audio coming out of the S/PDIF transmitter on the EVAL-ADAU1452MINIZ is typically 44.1 kHz or 48 kHz. Optionally, the S/PDIF transmitter can be configured in a pass through mode, where it simply transmits a copy of the signal directly from the receiver.

Both the S/PDIF receiver and transmitter carry two channels of uncompressed audio.

Serial Audio Interface

Two of the four ADAU1452 serial input ports are connected to the AD1938. Because the AD1938 is in standalone mode, it always drives the SDATA_IN0 and SDATA_IN1 pins of the ADAU1452. As a result, external data signals cannot be input to SDATA_IN0 or SDATA_IN1.

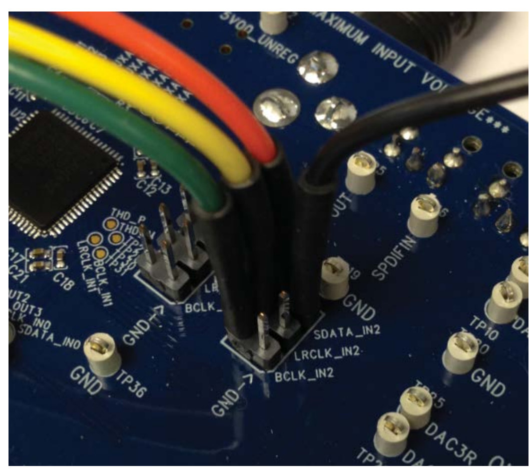
However, the remaining two serial input ports (SDATA_IN2 and SDATA_IN3, along with their corresponding clock pins—BCLK_IN2, LRCLK_IN2, BCLK_IN3, and LRCLK_IN3), are accessible directly via the J2 and J3 headers (see Figure 56).



11926-058

Figure 56. Serial Input Port 2 and Serial Input Port 3 Signal Access Headers

Using jumper wires with a square socket that is 0.025" (0.64 mm) wide, signals can be connected to these headers from external sources. The J2 and J3 headers each comprise two columns and three rows of pins. There is one signal column and one ground column. Always connect at least one ground wire between the header and the external signal source to maintain proper signal integrity.



11926-059

Figure 57. Connecting External I^2S Signals to Serial Input Port 2

The signals passing between the ADAU1452 serial output ports and the AD1938 DAC are also accessible via the test points that are situated between the two ICs. Signals can be tapped from these test points and connected to external digital audio sinks, if desired (see Figure 58). When connecting these signals to external devices, at least one ground signal should be connected as well to maintain signal integrity.

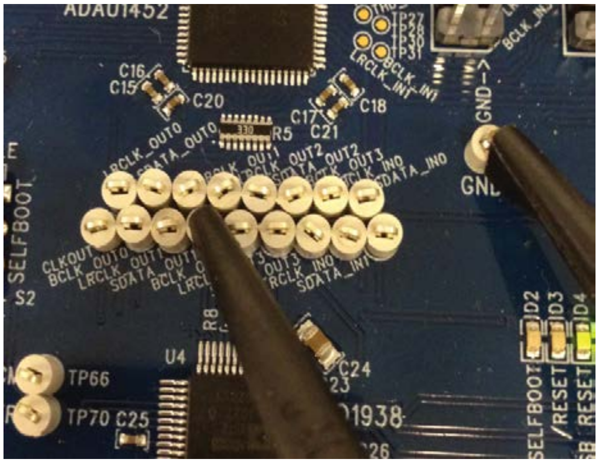


Figure 58. Monitoring Digital Audio Signals from the Test Points

MULTIPURPOSE (MP) PINS

The multipurpose pins on the ADAU1452 can be used for general-purpose input or output when configured as such using the ADAU1452 control registers. Of the 14 multipurpose pins, two are connected to LED drivers, and six are available on test points or headers. The remaining six pins are used for other functionality and are, therefore, unavailable for use as multipurpose pins.

The signal from MP6 is fed to an inverter that drives LED D5. The signal from MP7 is fed to an inverter that drives LED D6.

The six multipurpose pins available for use as general-purpose inputs or outputs, along with their access points on the evaluation board, are described in Table 4.

Table 4. Multipurpose Pins and Hardware Access Points

MP Pin	Access Point
MP5	TP38
MP8	TP34
MP9	TP32
MP11	TP29
MP12	Header J3, Pin 4
MP13	Header J2, Pin 4

To configure the operation of the multipurpose pins, navigate to the **MULTIPURPOSE** tab in the **Hardware Configuration** tab in SigmaStudio (see Figure 59).

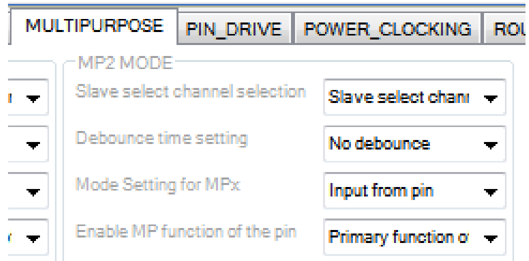


Figure 59. Multipurpose Pin Configuration in SigmaStudio

AUXILIARY ADC PINS

The ADAU1452 has an auxiliary ADC with six channels, each of which has an independent input pin. These six input pins, AUXADC0 to AUXADC5, are accessible via bare copper pads located next to the ADAU1452. External signals between 0 V and 3.3 V can be connected to these pads and then used in the SigmaStudio signal flow.

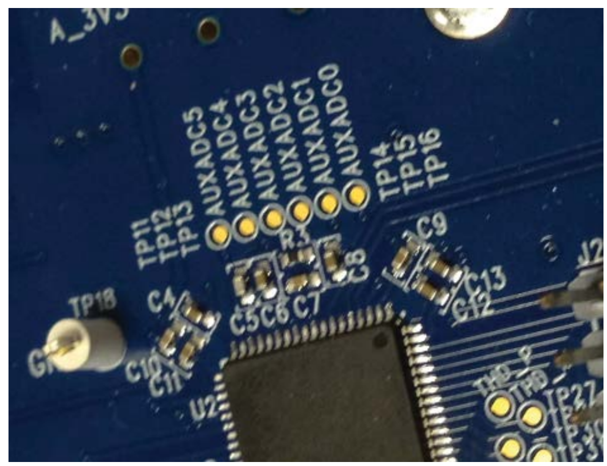


Figure 60. Copper Pads for Inputting Signals to the Auxiliary ADC

COMMUNICATIONS HEADER

The communications header is a 10-pin header designed to work with the EVAL-ADUSB2EBZ, or USBi. The SPI signals are wired from the communications header to the corresponding SPI slave port pins on the ADAU1452. The I^2C pins are not used in this design. A reset line is also included, which allows the user to reset the devices on the board via a command in SigmaStudio. When the USBi is connected and powered and the computer has successfully recognized the USBi on its USB 2.0 port, LED D1 illuminates.

SELF-BOOT

A 1-Mbit, 20 MHz SPI serial EEPROM memory is included on the EVAL-ADAU1452MINIZ for the purpose of self-booting the ADAU1452. Slide Switch S2 (see Figure 61) sets the state of the SELFBOOT pin of the ADAU1452, which determines whether a self-boot operation is executed when the ADAU1452 powers up or on a rising edge of the $\overline{\text{RESET}}$ pin.

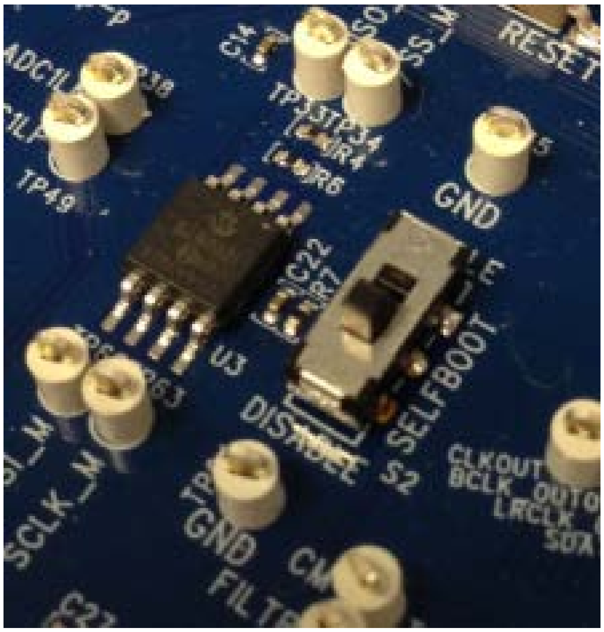


Figure 61. Self-Boot EEPROM and Slide Switch

To use the self-boot functionality,

1. Add an **E2Prom** block to the project space of the **Hardware Configuration** tab. From the **Processors (ICs / DSPs)** folder, click **E2Prom** (see Figure 62) and drag it into the project space to the right of the toolbox.

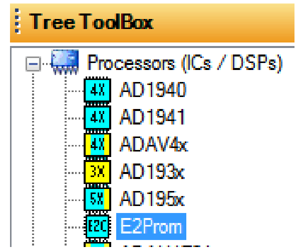


Figure 62. E2Prom IC Selection in SigmaStudio

2. Connect the green input pin of the **E2Prom** IC to one of the available blue output pins of the **USB Interface** block.
3. Set the communication mode to SPI 0x1 ADR0 (see Figure 63). (There is no physical connection between the USBi connector and the EEPROM on the EVAL-ADAU1452MINIZ. SigmaStudio writes a small program to the ADAU1452, which then writes the self-boot data from its master SPI port to the EEPROM.)

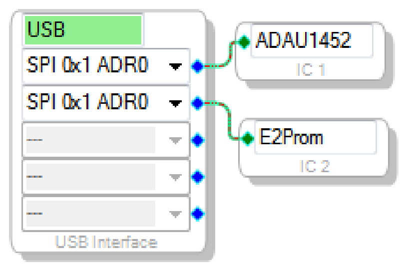


Figure 63. E2Prom Setup in Hardware Configuration Tab

4. Before downloading the self-boot data to the EEPROM, click the **Link-Compile-Download** button (see Figure 29) or press F7 to compile the SigmaStudio project file.
5. When writing to the EEPROM, set the self-boot switch, S2, to the DISABLED position.
6. Right-click on the empty white space in the **ADAU1452 IC** block in the **Hardware Configuration** tab of SigmaStudio. From the menu that appears, choose **Self-boot Memory** > **Write Latest Compilation through DSP** (see Figure 64).

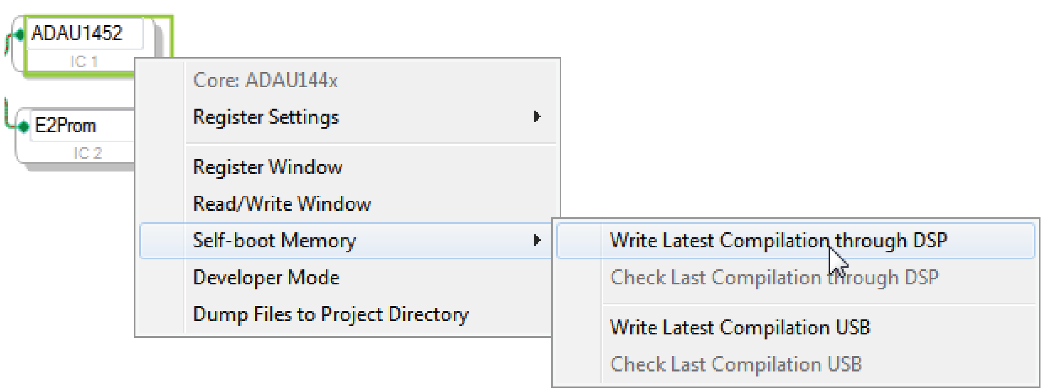


Figure 64. Writing to the EEPROM Through the ADAU1452 Master SPI Port

7. An **EEPROM Properties** dialog box appears. Type the appropriate information into the boxes as shown in Figure 65, and then click **OK**.

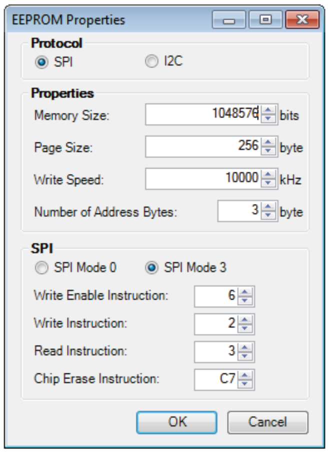


Figure 65. EEPROM Properties Window and Required Settings

8. A warning window appears to remind you that executing this action erases and overwrites any data currently stored on the EEPROM (see Figure 67). Click **OK** to proceed.

9. SigmaStudio begins the EEPROM write operation. This may take several minutes to complete (see Figure 66). When the status window disappears, the operation is complete.

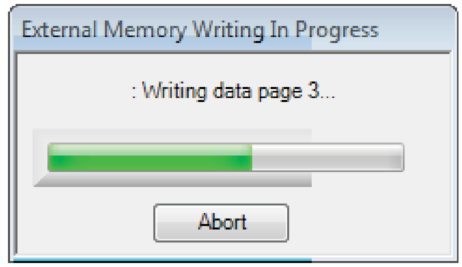


Figure 66. External Memory Write Operation Status Window

To execute a self-boot operation,

1. Set the self-boot switch, S2, to the ENABLED position.
2. Press and release the RESET push-button, S1.

A self-boot operation is then performed, and the ADAU1452 starts running a program.

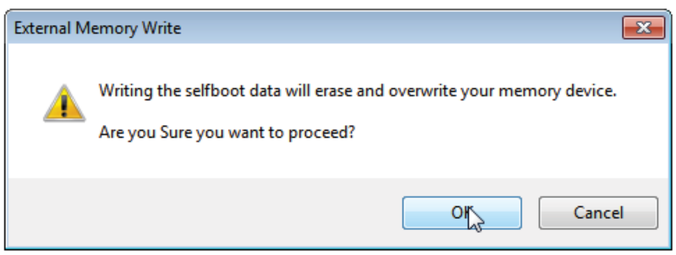


Figure 67. External Memory Erase and Overwrite Warning Window

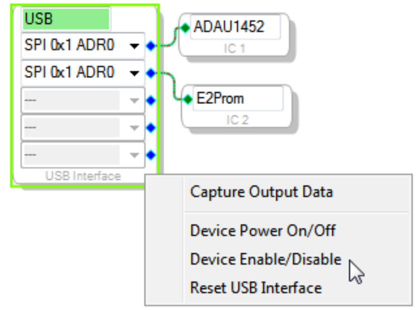
RESET

To manually reset the ADAU1452 and AD1938, press and release the RESET push-button, S1 (see Figure 68). A reset generator circuit toggles the reset pins on the ADAU1452 and AD1938 to perform a full hardware reset of those devices.

11926-070

Figure 68. Manual Reset Push-Button and Reset Generator IC

To generate a reset in software, right-click in the empty white border of the **USB Interface** block in the **Hardware Configuration** tab, and then choose **Device Enable/Disable** from the menu that appears (see Figure 69). Doing this once sets the system reset signal to logic low. Both the /RESET and /USB_RESET status LEDs (D3 and D4) should be illuminated. To bring the devices out of a reset, click **Device Enable/Disable** a second time. Doing so brings the system reset signal back to logic high, and the D3 and D4 status LEDs turn off.

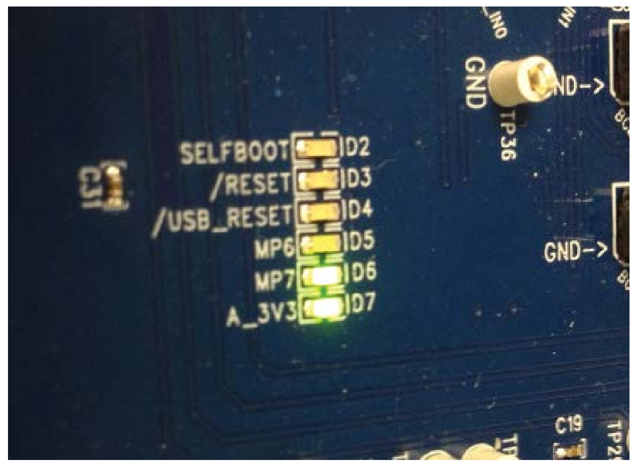


11926-071

Figure 69. Toggling the Reset Signal in SigmaStudio

STATUS LEDS

Six status LEDs provide information about the state of the EVAL-ADAU1452MINIZ (see Figure 70). More information pertaining to the status LEDs is available in Table 6.



11926-072

Figure 70. Status LEDs

HARDWARE DESCRIPTION

INTEGRATED CIRCUITS (IC)

Table 5. IC Descriptions

Reference	Functional Name	Description
U1	ADM811TARTZ reset supervisor	Generates a master reset signal for the ADAU1452 and AD1938 if the RESET push-button, S1, is pressed or SigmaStudio sends a reset command via the USBi.
U2	ADAU1452 SigmaDSP audio processor	Acts as an audio hub for all audio inputs and outputs in the system and performs digital signal processing on those signals.
U3	Microchip 25AA1024 serial EEPROM	Stores data, allowing the ADAU1452 to perform a self-boot operation.
U4	AD1938 audio codec	Converts analog audio inputs to digital data for the ADAU1452 processor and takes digital data back from the ADAU1452 to convert to analog audio outputs.
U5	ADP3338AKCZ-3.3 LDO voltage regulator	Accepts the unregulated dc supply voltage between 5 V and 7 V that is provided on Connector J4 and regulates it down to 3.3 V.
U6, U7, U8, U9, U10, U12, U13, U14	ADA4841 dual low power low noise and distortion rail-to-rail output amplifier	Implements the analog audio filtering required for the stereo line inputs and outputs.
U11	74ACT04SC hexadecimal inverter	Buffers logic signals and drives status LEDs.

STATUS LEDs

Table 6. LED Descriptions

Reference	Functional Name	Description
D1	USB connected	Illuminates when the USBi is recognized by Windows after the USBi is connected to Control Port J1 and the USB 2.0 port of the computer.
D2	Self-boot status LED	Illuminates when the self-boot slide switch, S2, is set to the ENABLED position, signifying that a self-boot operation is to be executed on the rising edge of the ADAU1452 RESET signal or when ADAU1452 is powered up; D2 does not illuminate when the self-boot slide switch, S2, is set to the DISABLED position, signifying that no self-boot operation is to occur.
D3	Master reset status LED	Illuminates when the master reset signal being generated by the ADM811TARTZ reset supervisor IC is logic low, putting the ADAU1452 and AD1938 into hardware reset; D3 does not illuminate when the master reset signal is logic high and the ADAU1452 and AD1938 are out of reset.
D4	USBi reset status LED	Illuminates when the USBi has been connected to the USB 2.0 port of the computer with a USB cable, is recognized by Windows, and is connected via the ribbon cable to the SPI control port header, J1; otherwise, D4 does not illuminate.
D5	MP6 general-purpose LED	Illuminates when the status of the ADAU1452 MP6 pin is set to logic high by the ADAU1452.
D6	MP7 general-purpose LED	Illuminates when the status of the ADAU1452 MP7 pin is set to logic high by the ADAU1452.
D7	3.3 V supply status LED	Illuminates when the output of the ADP3338AKCZ-3.3 LDO voltage regulator has reached a level sufficient to exceed the V_{IH} logic high input level of the 74ACT04SC inverter. (When this LED is illuminated, it does not guarantee that the LDO output is 3.3 V. It only shows that the LDO output is about 2 V or greater. To perform more detailed measurements of the LDO output level, check the voltage on the A_3V3 test point, TP1.)

SWITCH AND PUSH-BUTTON

Table 7. Switch and Push-Button Descriptions

Reference	Functional Name	Description
S1	Reset push-button	When this switch is pressed and then released, a reset signal is generated, which causes the ADM811TARTZ reset supervisor to generate a master reset signal for the ADAU1452 and AD1938.
S2	Self-boot slide switch	Sets the SELFBOOT pin of the ADAU1452 to either logic high or logic low to determine whether a self-boot operation is to be performed.

EVALUATION BOARD SCHEMATICS AND LAYOUT ARTWORK

SigmaDSP AUDIO PROCESSOR

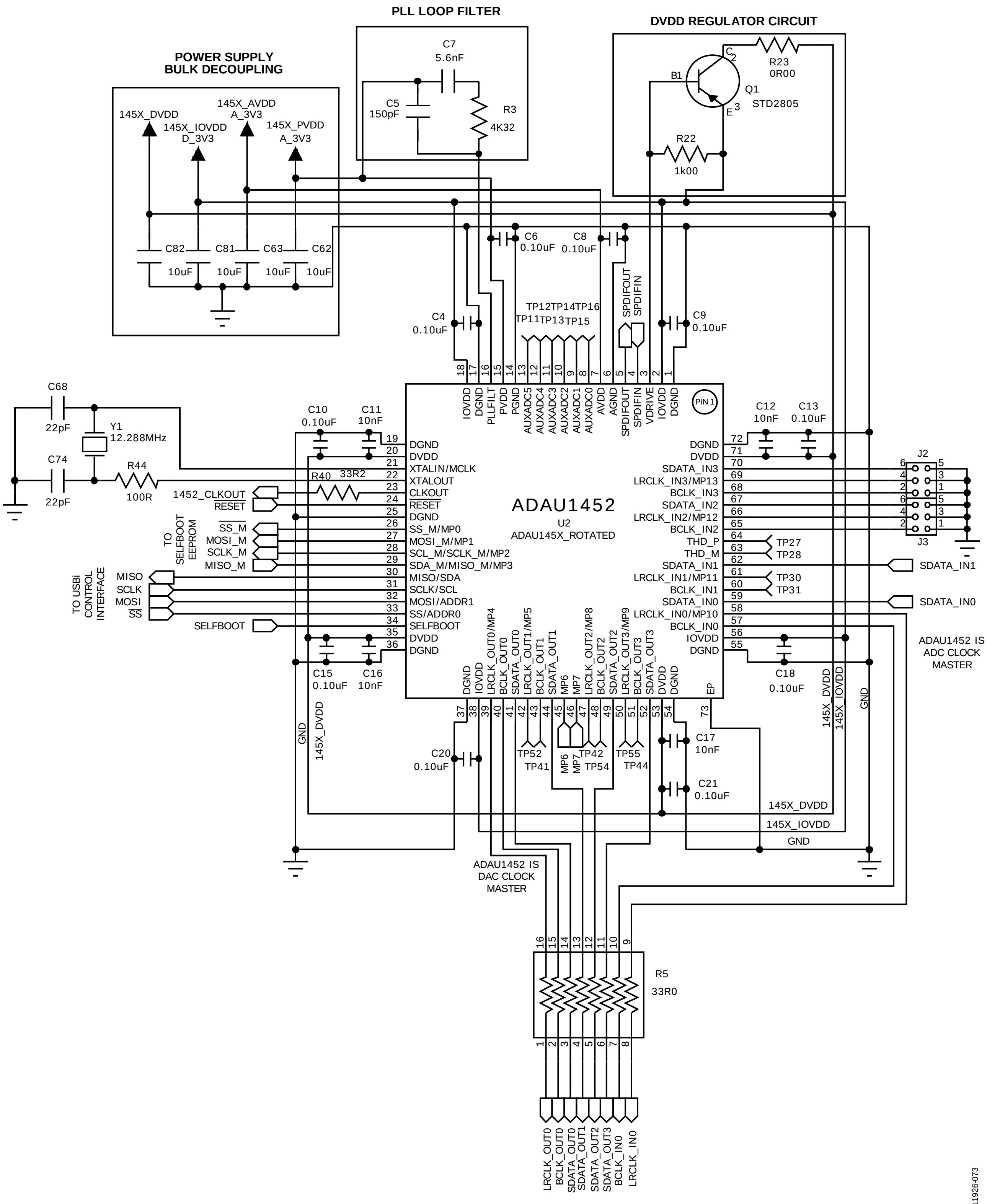


Figure 71. SigmaDSP Audio Processor

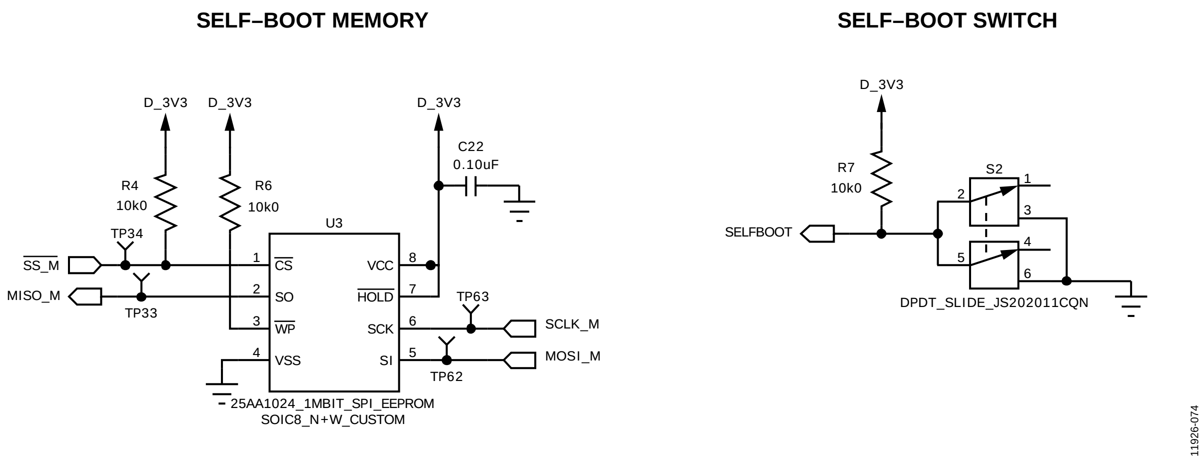


Figure 72. Self-Boot Circuit

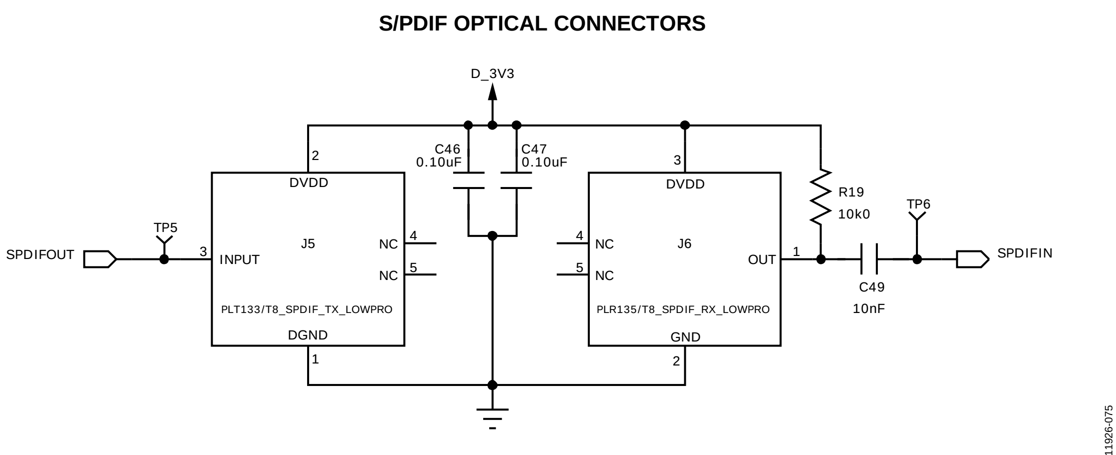


Figure 73. S/PDIF Optical Interfaces

STATUS LEDs

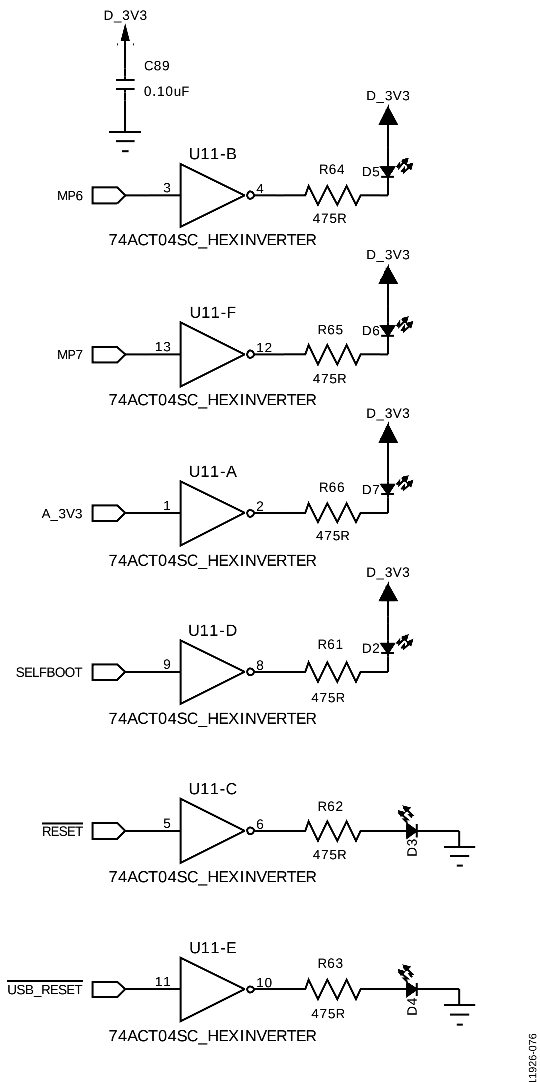


Figure 74. Status LEDs

AUDIO CODEC

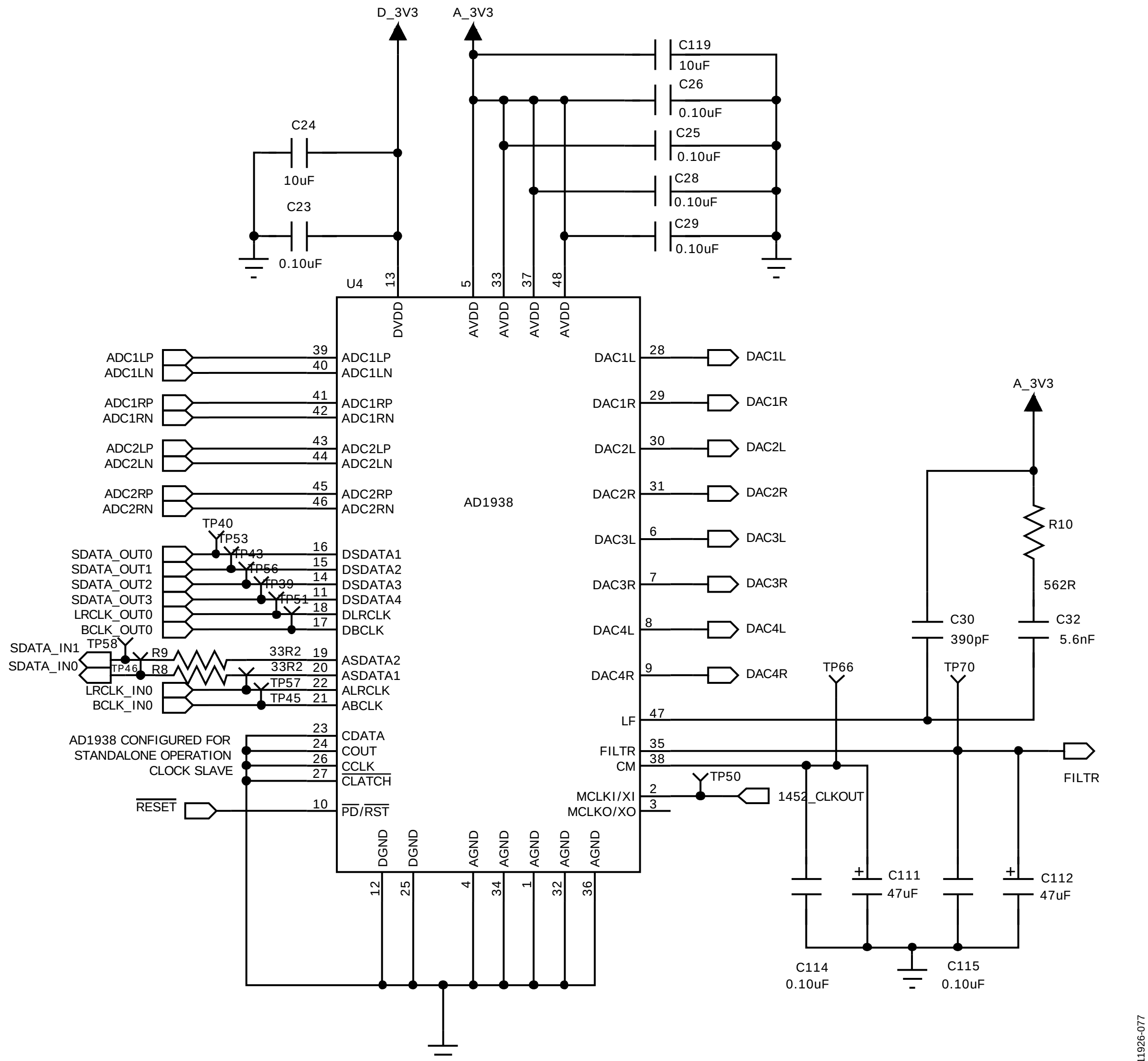


Figure 75. AD1938 Audio Codec

POWER SUPPLY

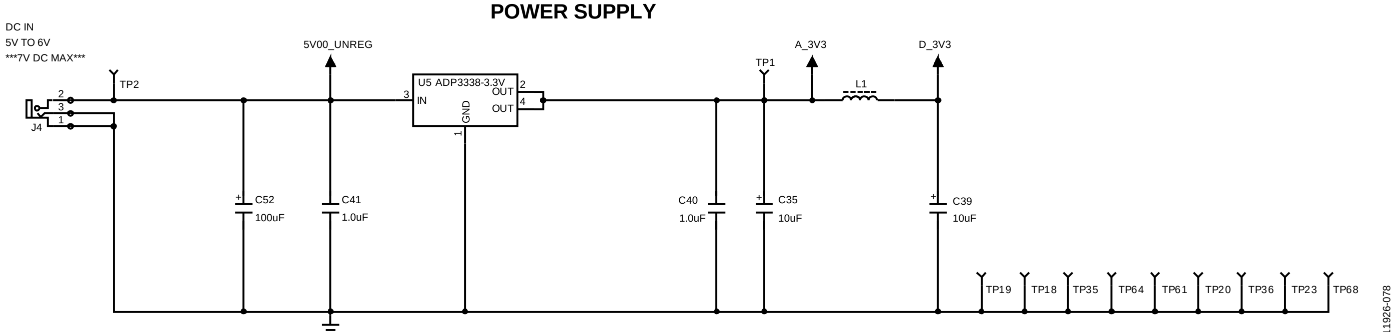


Figure 76. Power Supply

RESET GENERATOR AND CONTROL

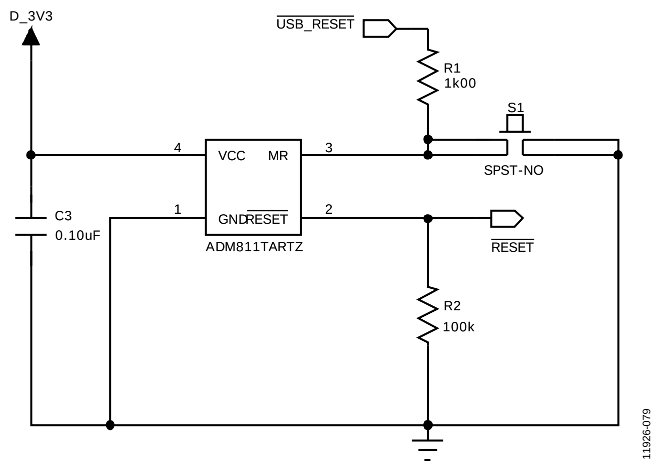


Figure 77. Reset Generator Circuit

CONTROL PORT HEADER

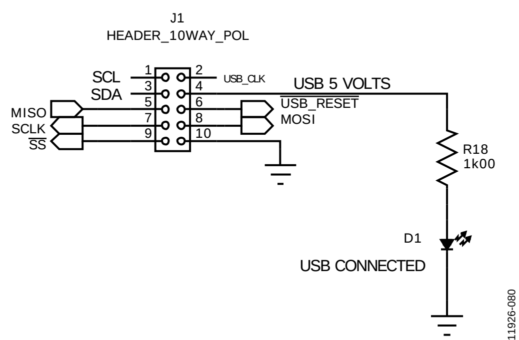


Figure 78. SPI Communication Interface Header

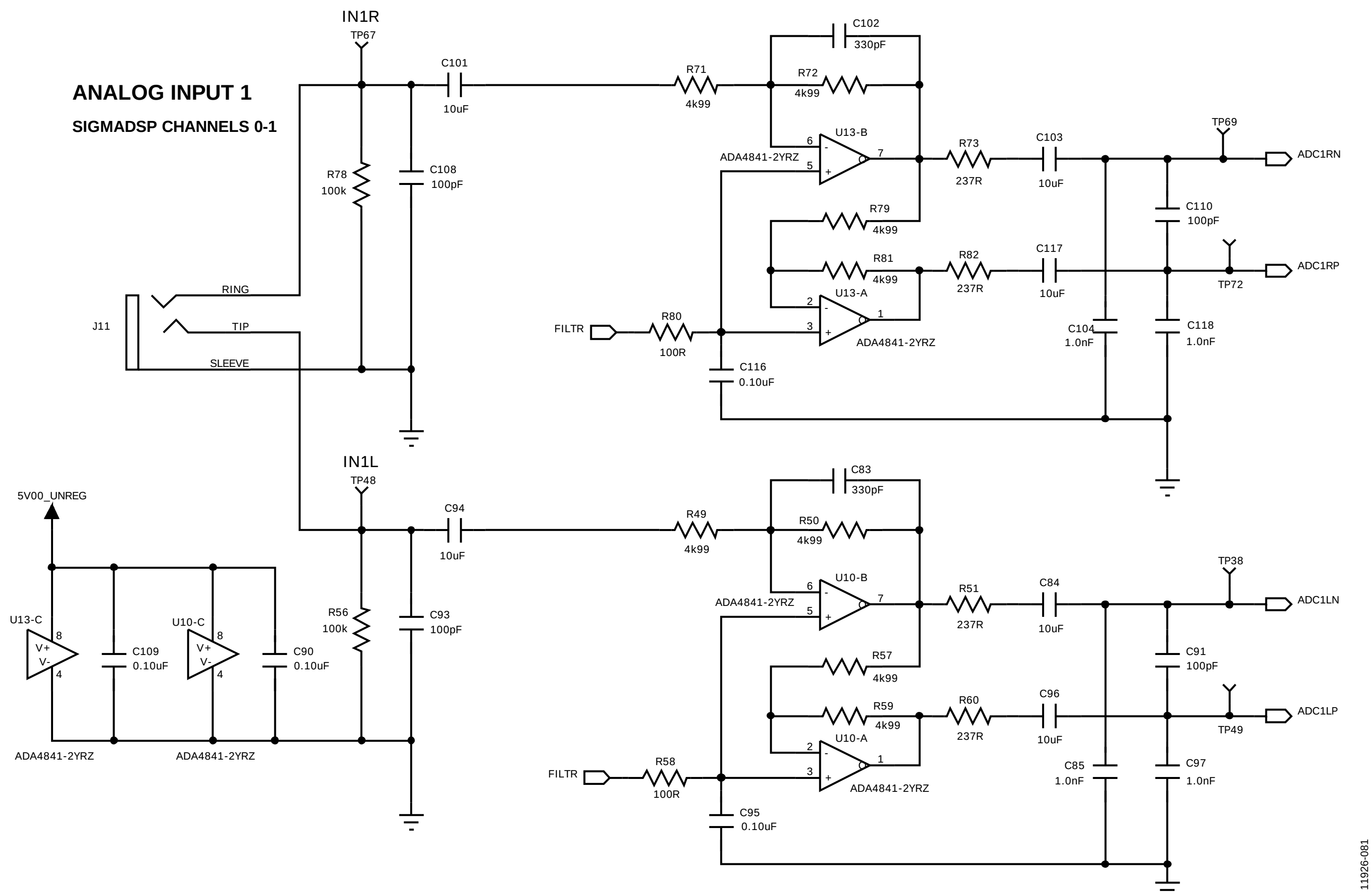


Figure 79. Analog Input Channel 0 and Channel 1

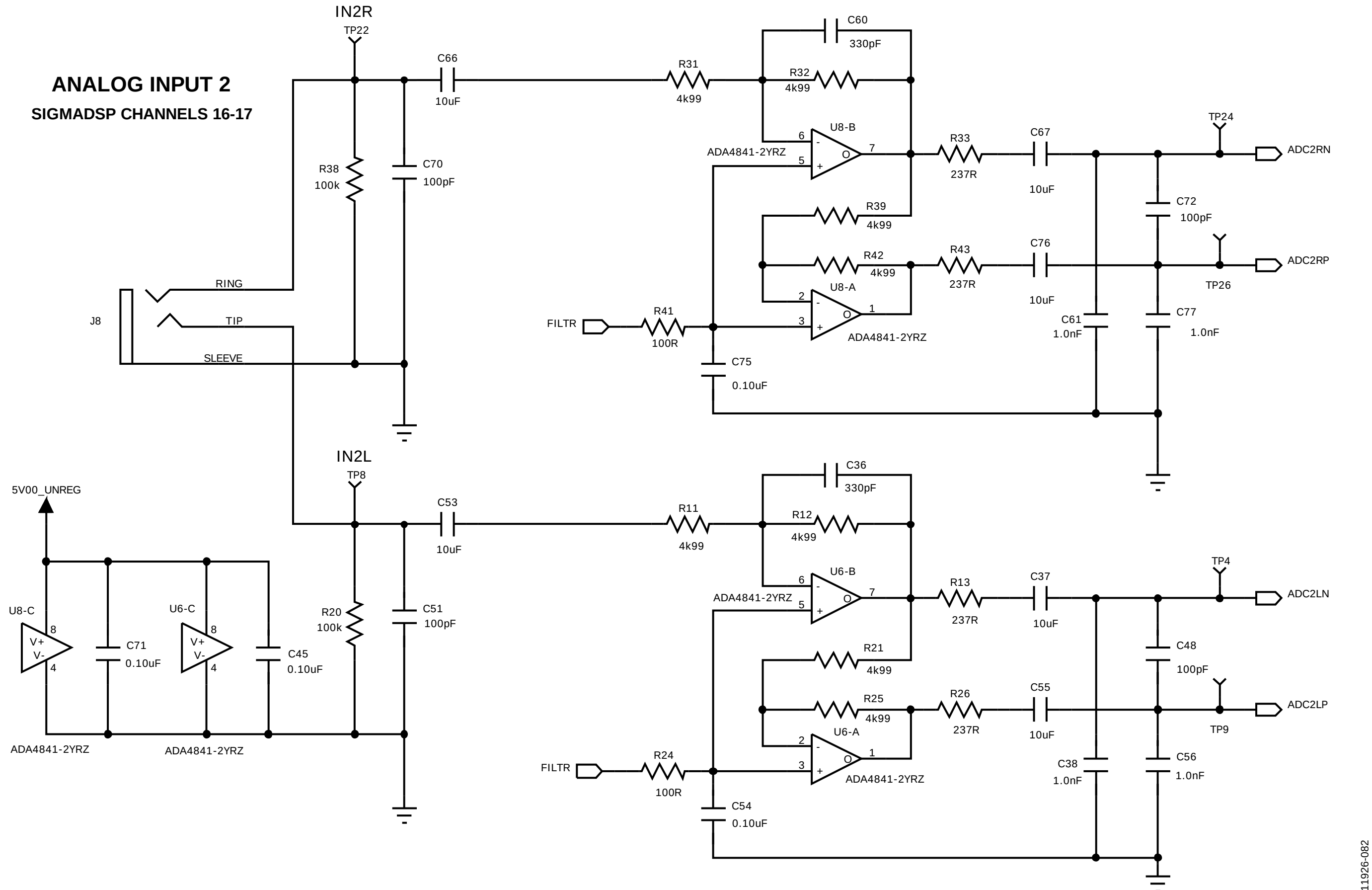


Figure 80. Analog Input Channel 16 and Channel 17

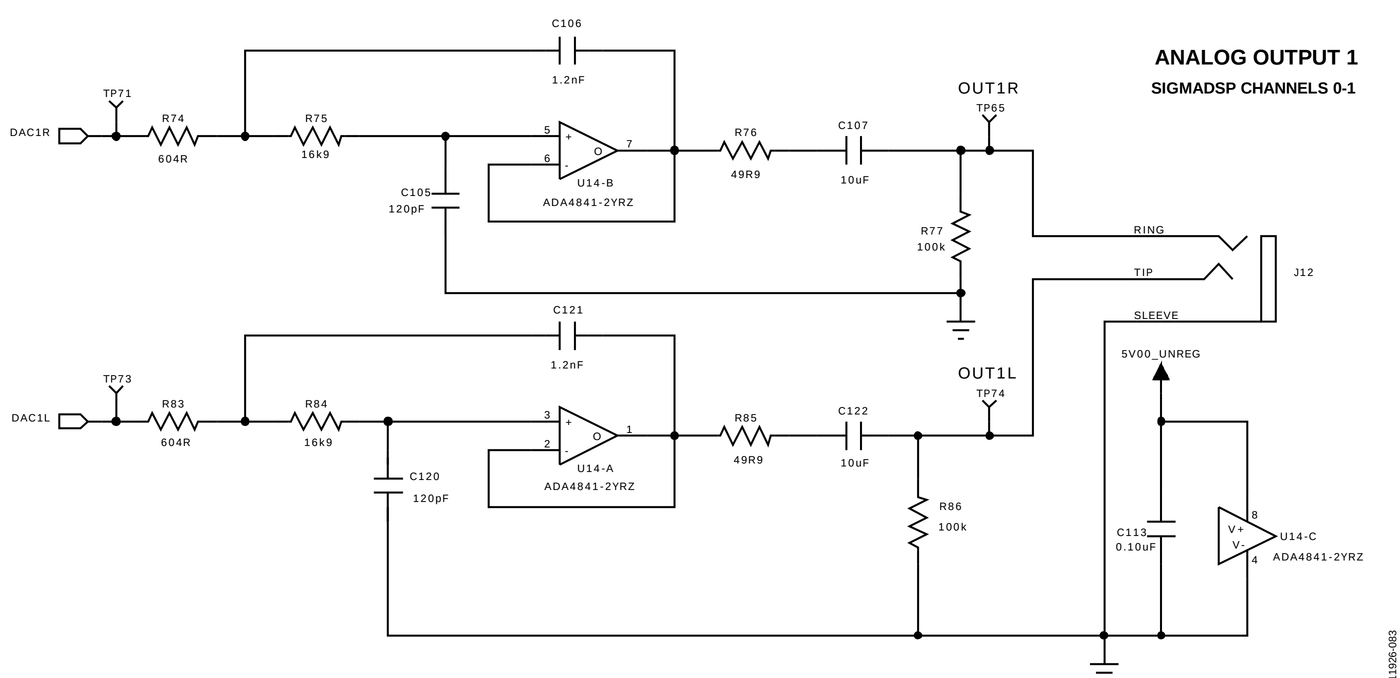


Figure 81. Analog Output Channel 0 and Channel 1

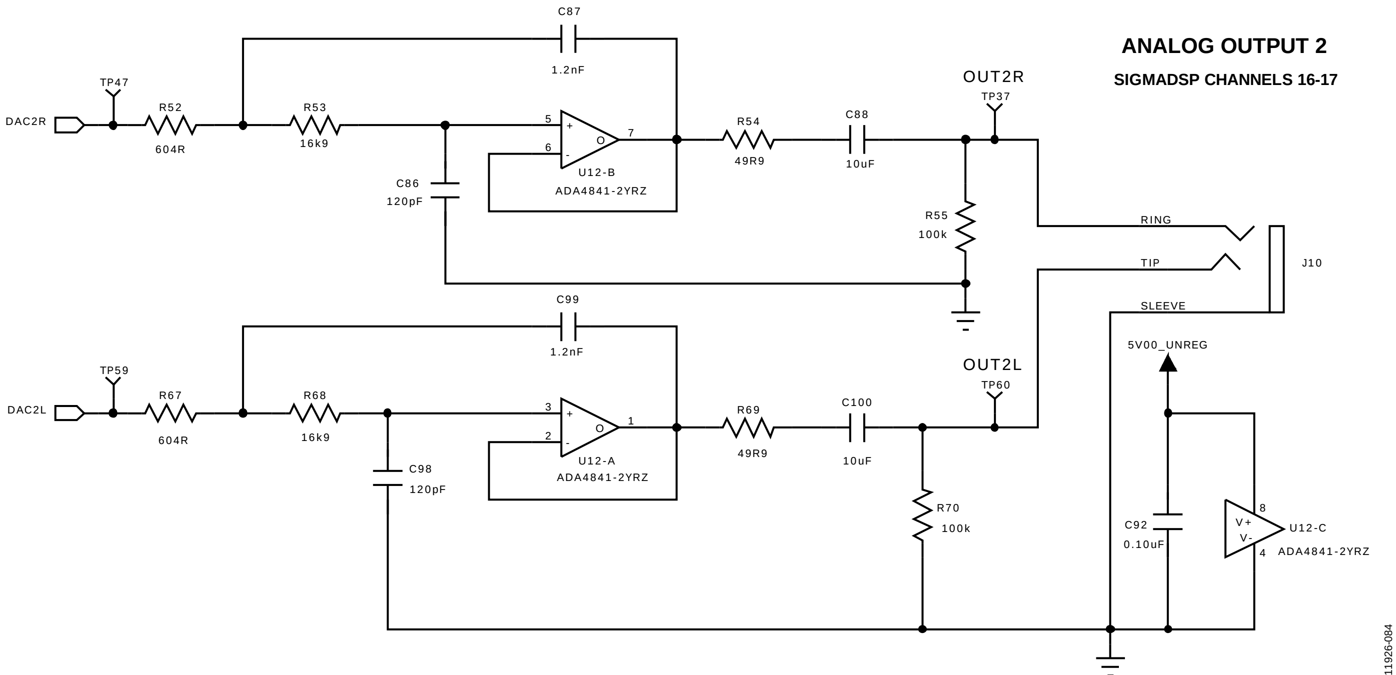


Figure 82. Analog Output Channel 16 and Channel 17

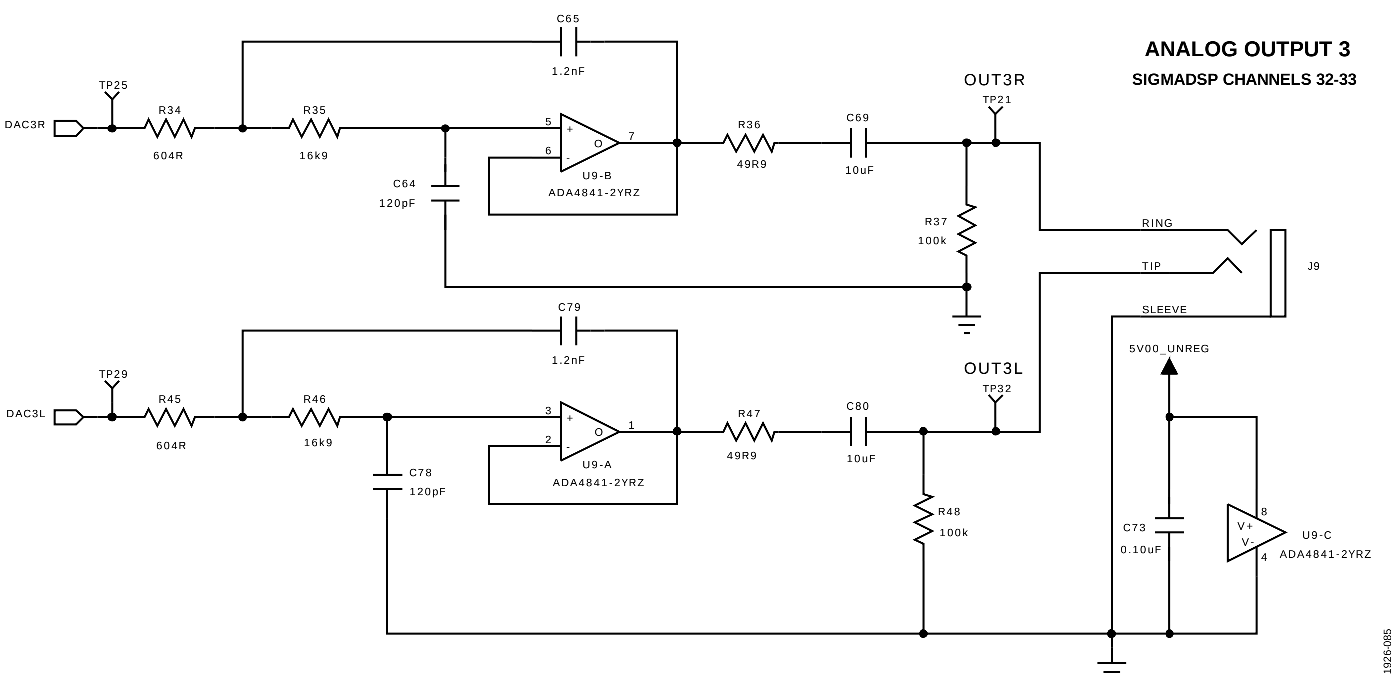


Figure 83. Analog Output Channel 32 and Channel 33

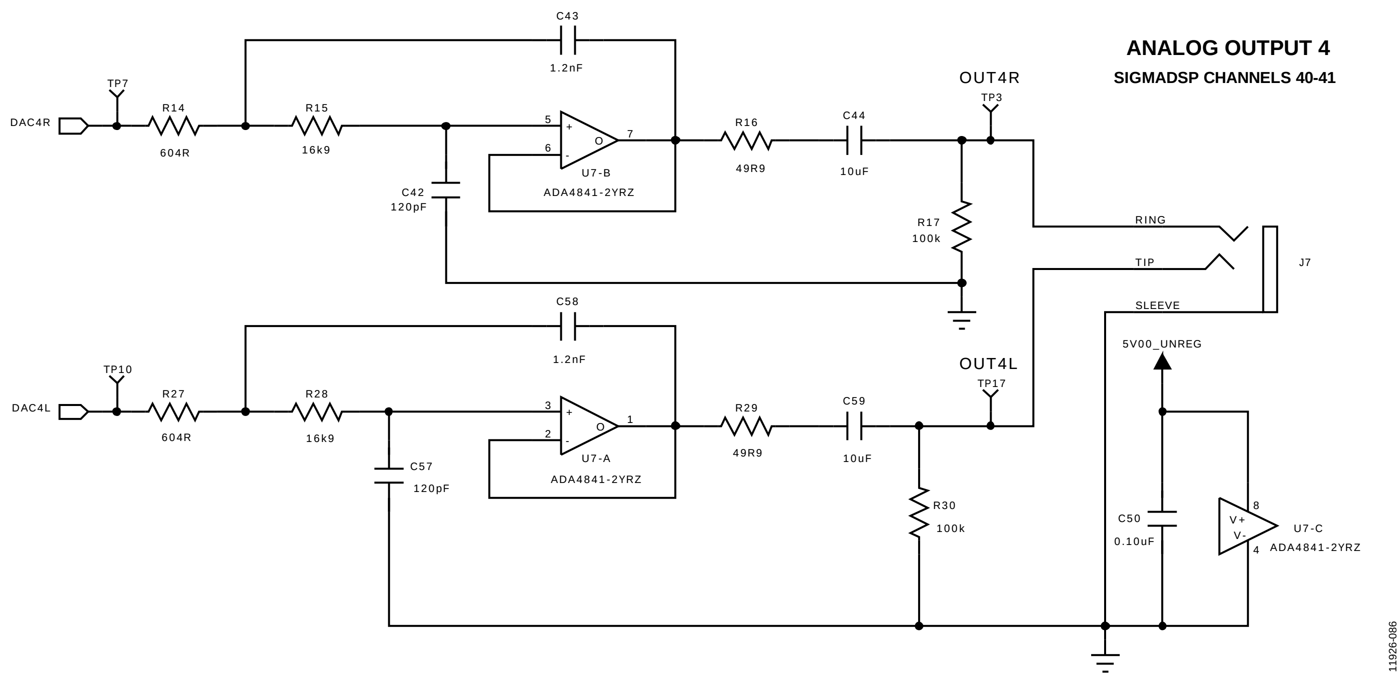


Figure 84. Analog Output Channel 40 and Channel 41

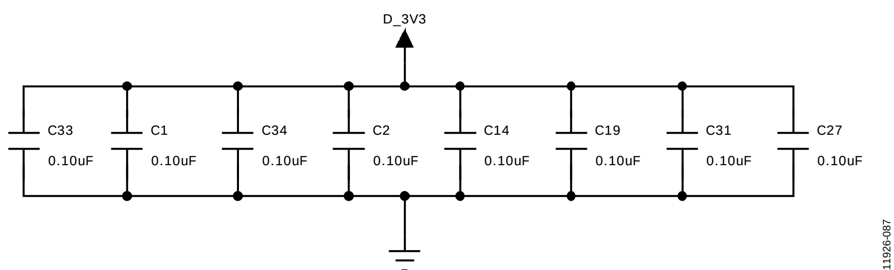
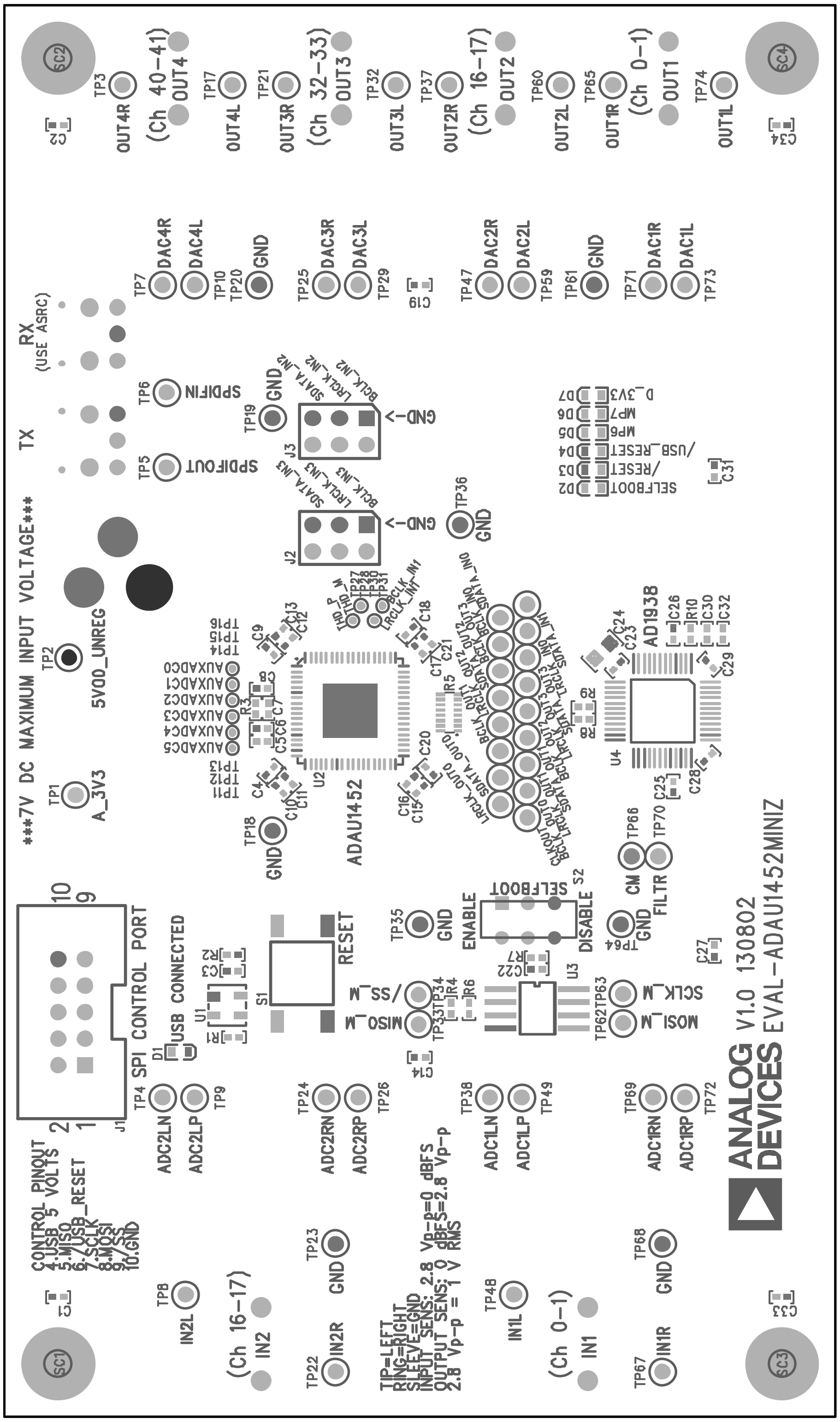


Figure 85. Plane Decoupling Capacitors



11926-088

Figure 86. EVAL-ADAU1452MINIZ Layout, Top Assembly

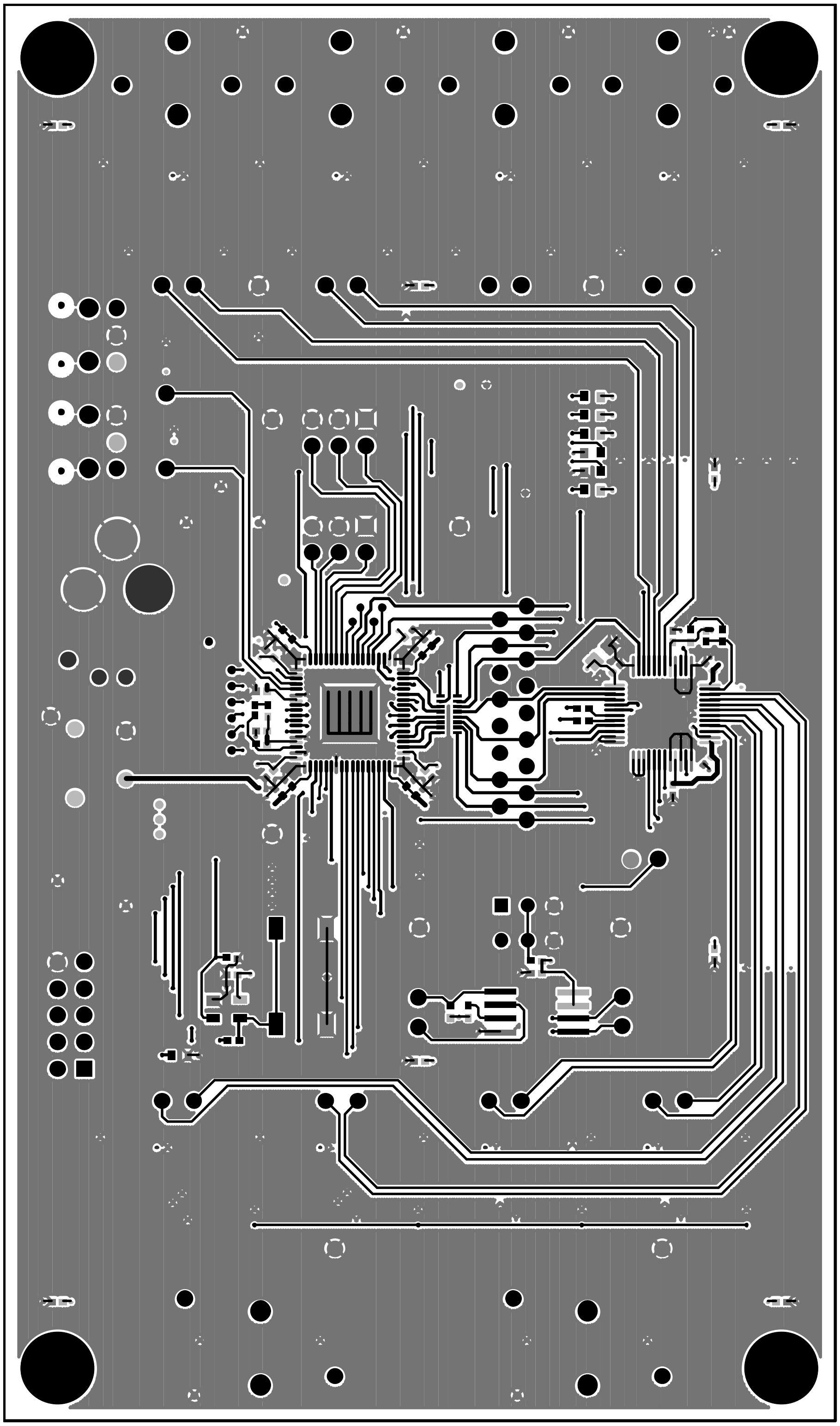


Figure 87. EVAL-ADAU1452MINIZ Layout, Top Copper

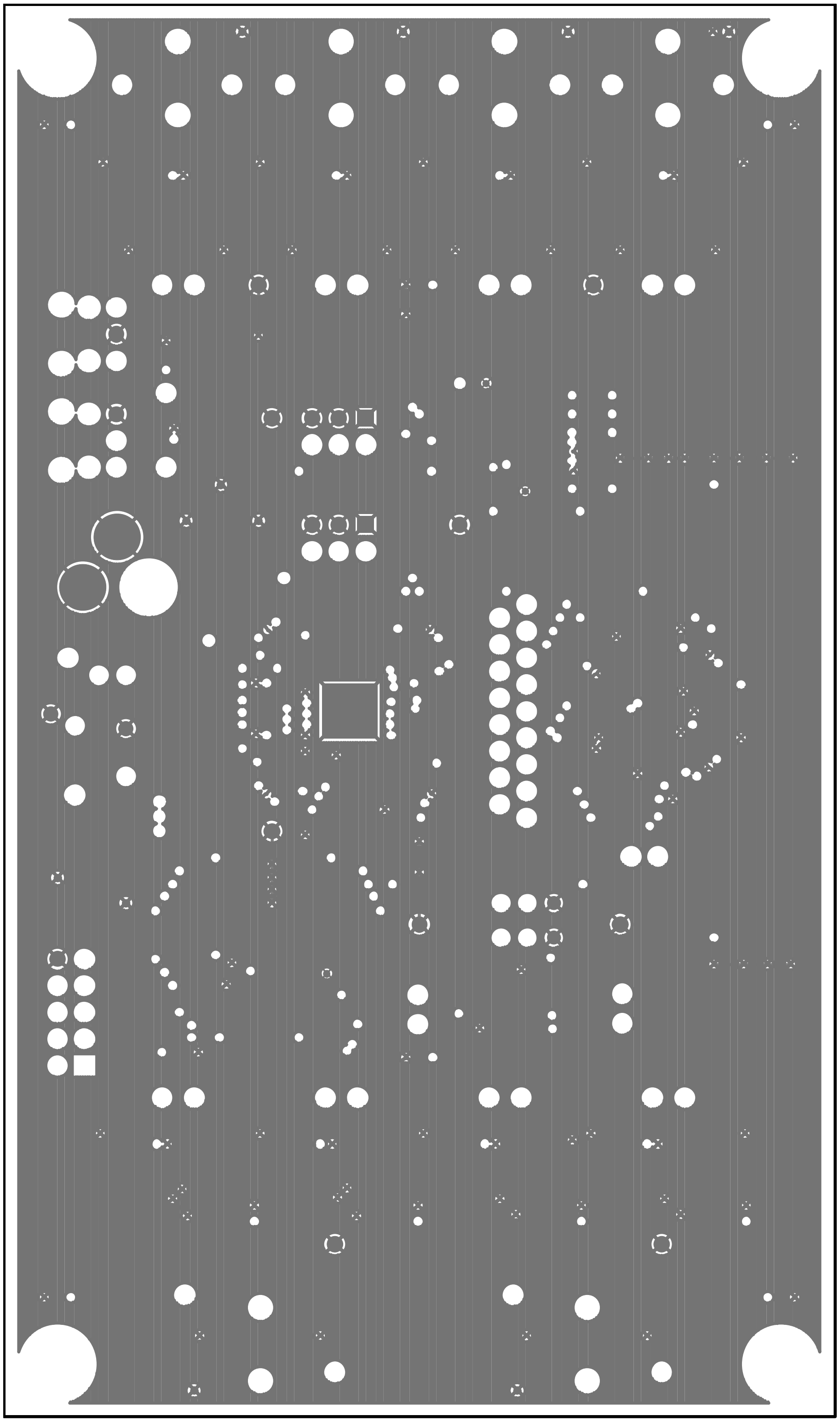


Figure 88. EVAL-ADAU1452MINIZ Layout, Ground Plane

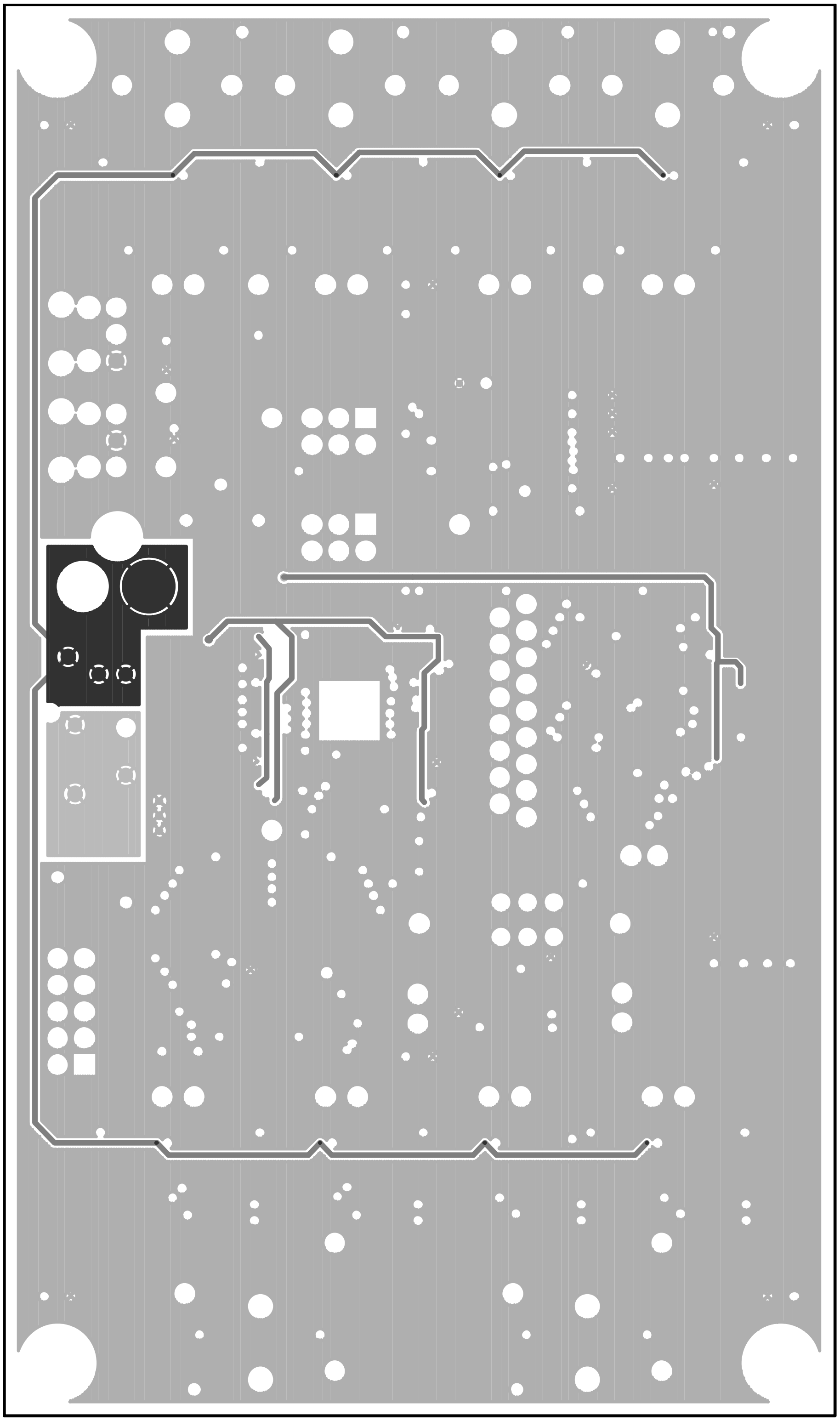
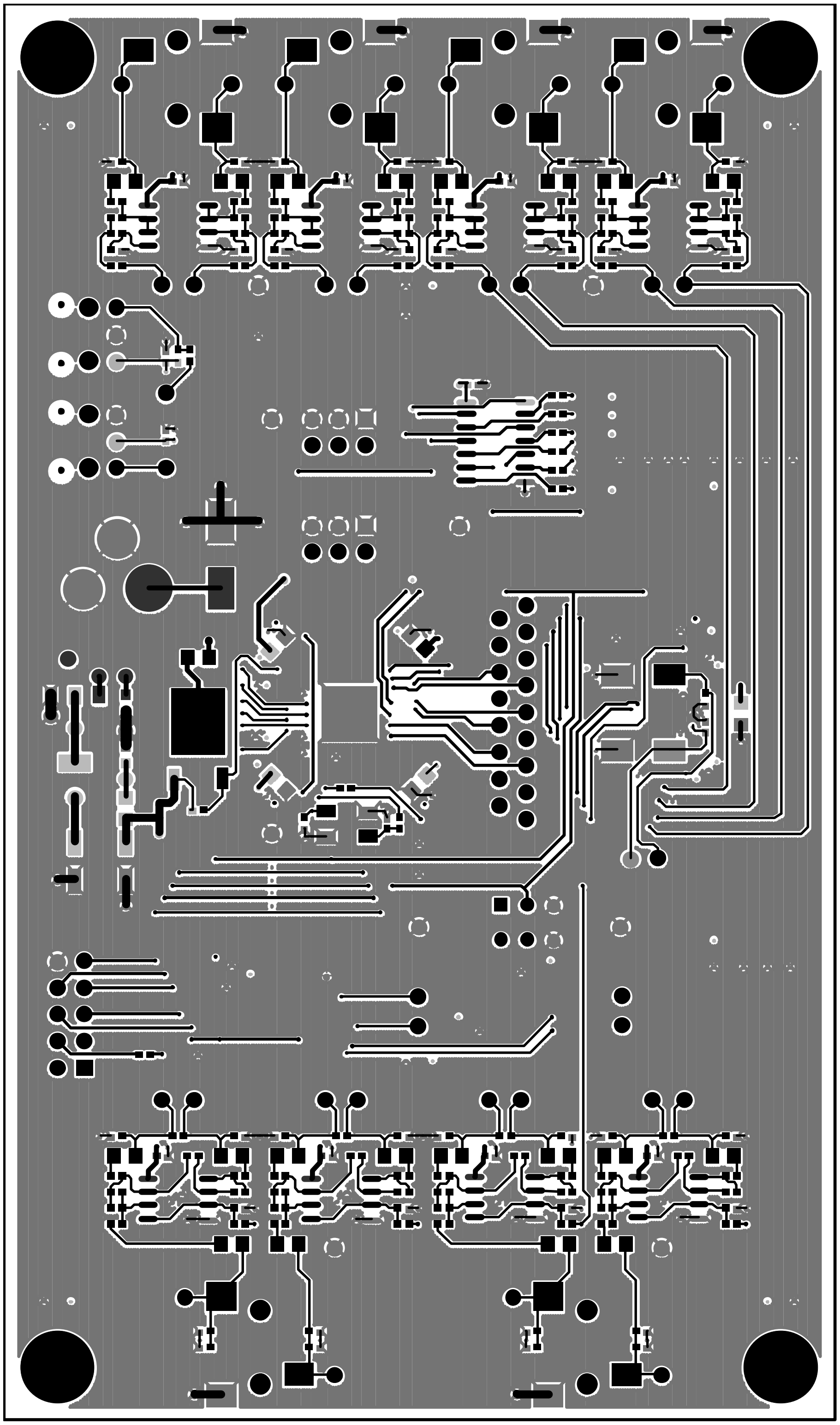


Figure 89. EVAL-ADAU1452MINIZ Layout, Power Plane



11926-092

Figure 90. EVAL-ADAU1452MINIZ Layout, Bottom Copper

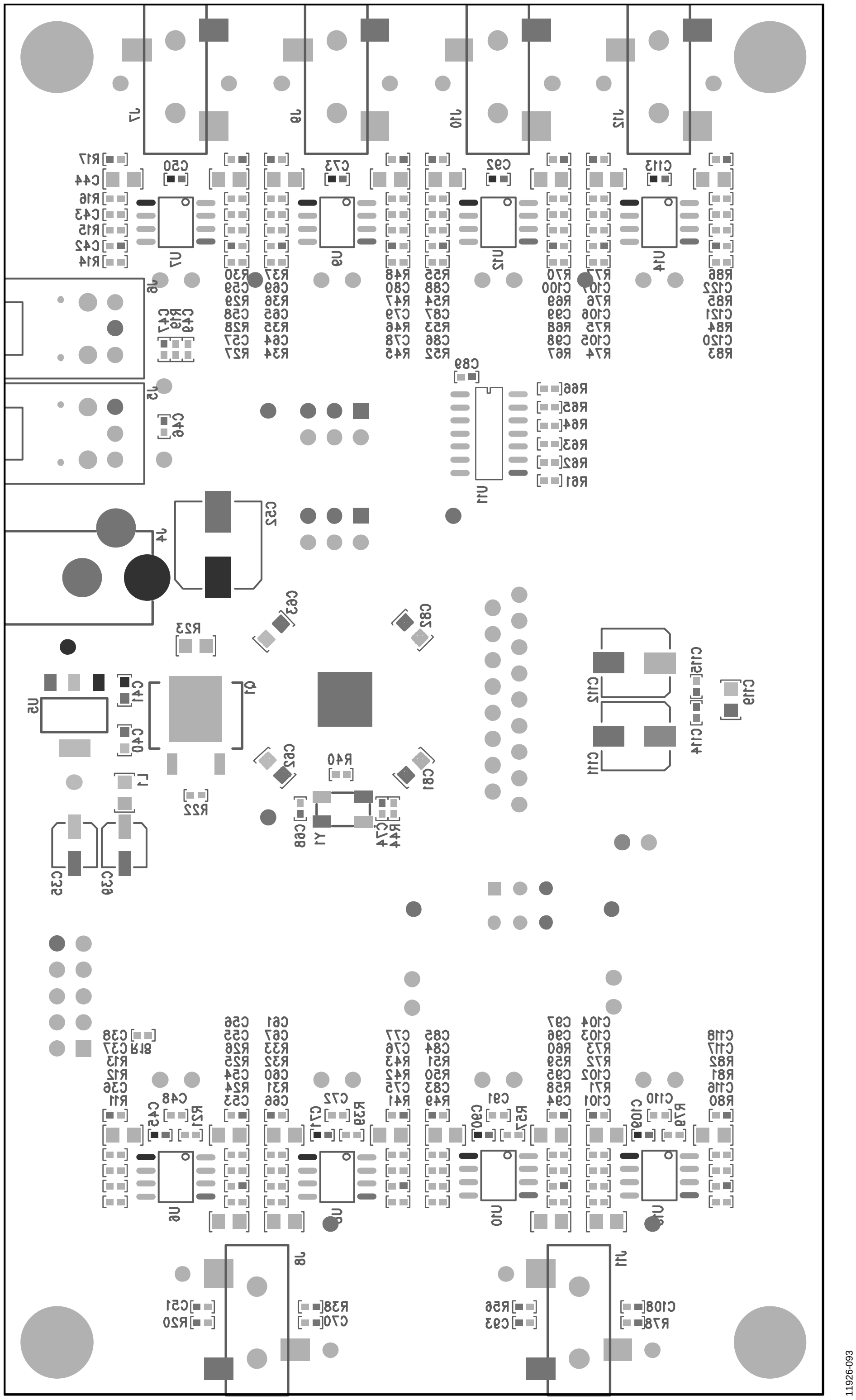
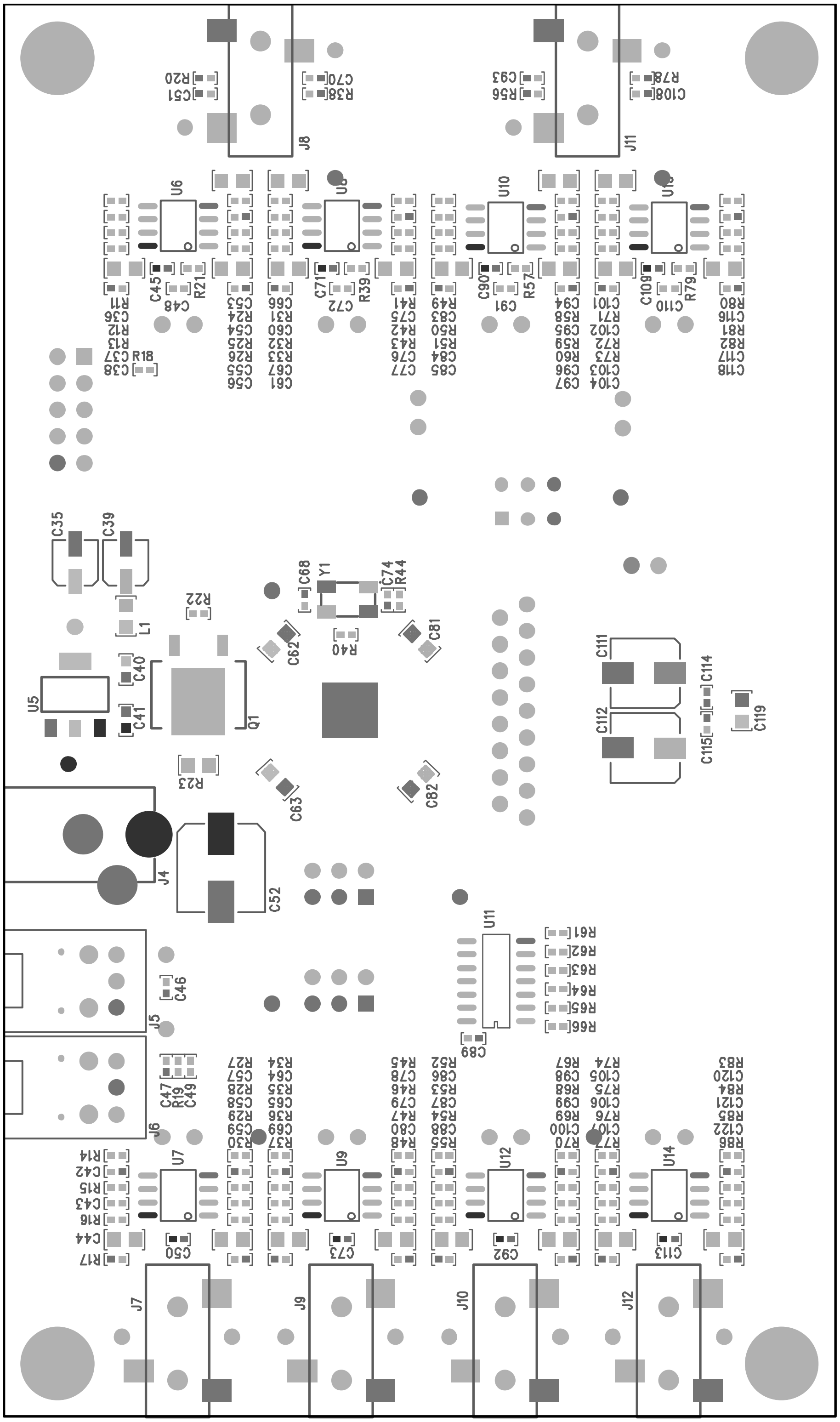


Figure 91. EVAL-ADAU1452MINIZ Layout, Bottom Assembly (Viewed from Above)



11926-094

Figure 92. EVAL-ADAU1452MINIZ Layout, Bottom Assembly (Viewed from Below)

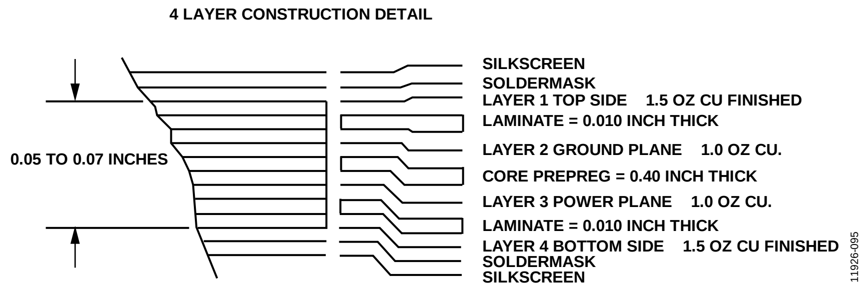


Figure 93. Cross Section of PCB Stack Up

BILL OF MATERIALS

Table 8. EVAL-ADAU1452MINIZ Bill of Materials

Qty.	Designator	Description	Part Number	Manufacturer
42	C1, C2, C3, C4, C6, C8, C9, C10, C13, C14, C15, C18, C19, C20, C21, C22, C23 C25, C26, C27, C28, C29, C31, C33, C34, C45, C46, C47, C50, C54, C71, C73, C75, C89, C90, C92, C95, C109, C113, C114, C115, 116	Multilayer ceramic capacitor, 16 V, X7R, 0402	GRM155R71C104KA88D	Murata ENA
1	R23	Chip resistor, 5%, 125 mW, thick film, 0805	ERJ-6GEY0R00V	Panasonic EC
8	C38, C56, C61, C77, C85, C97, C104, C118	Multilayer ceramic capacitor, 50 V, NP0, 0402	GRM1555C1H102JA01D	Murata ENA
2	C40, C41	Multilayer ceramic capacitor, 16 V, X7R, 0603	GRM188R71C105KA12D	Murata ENA
8	C43, C58, C65, C79, C87, C99, C106, C121	Multilayer ceramic capacitor, 50 V, NP0, 0402	C0402C122J5GACTU	Kemet
13	R2, R17, R20, R30, R37, R38, R48, R55, R56, R70, R77, R78, R86	Chip resistor, 1%, 100 mW, thick film, 0402	ERJ-2RKF1003X	Panasonic ECG
8	C48, C51, C70, C72, C91, C93, C108, C110	Multilayer ceramic capacitor, 50 V, NP0, 0402	GRM1555C1H101JZ01D	Murata ENA
5	R24, R41, R44, R58, R80	Chip resistor, 1%, 63 mW, thick film, 0402	RC0402FR-07100RL	Yageo
1	C52	Aluminum electrolytic capacitor, FC, 105°, SMD_E	EEE-FC1C101P	Panasonic EC
4	R4, R6, R7, R19	Chip resistor, 1%, 63 mW, thick film, 0402	RC0402FR-0710KL	Yageo
5	C11, C12, C16, C17, C49	Multilayer ceramic capacitor, 25 V, X7R, 0402	GRM155R71E103JA01J	Murata
26	C24, C37, C44, C53, C55, C59, C62, C63, C66, C67, C69, C76, C80, C81, C82, C84, C88, C94, C96, C100, C101, C103, C107, C117, C119, C122	Multilayer ceramic capacitor, 10 V, X7R, 0805	GRM21BR71A106KE51L	Murata ENA
2	C35, C39	Aluminum electrolytic capacitor, FC, 105°, SMD_B	EEE-FC1C100R	Panasonic EC
8	C42, C57, C64, C78, C86, C98, C105, C120	Multilayer ceramic capacitor, 50 V, NP0, 0402	GRM1555C1H121JA01D	Murata ENA
1	C5	Multilayer ceramic capacitor, 50 V, NP0, 0402	GRM1555C1H151JA01D	Murata ENA
8	R15, R28, R35, R46, R53, R68, R75, R84	Chip resistor, 1%, 63 mW, thick film, 0402	RMCF0402FT16K9	Stackpole
3	R1, R18, R22	Chip resistor, 1%, 63 mW, thick film, 0402	RC0402FR-071KL	Yageo
2	C68, C74	Multilayer ceramic capacitor, 50 V, NP0, 0402	GRM1555C1H220JZ01D	Murata ENC
8	R13, R26, R33, R43, R51, R60, R73, R82	Chip resistor, 1%, 63 mW, thick film, 0402	RMCF0402FT237R	Stackpole
1	U3	IC EEPROM, 1 Mbit, 20 MHz, 8-lead SOIC	25AA1024-I/SM	Microchip Technology
4	C36, C60, C83, C102	Multilayer ceramic capacitor, 50 V, NP0, 0402	GRM1555C1H331JA01D	Murata ENA
3	R8, R9, R40	Chip resistor, 1%, 63 mW, thick film, 0402	RMCF0402FT33R2	Stackpole
1	C30	Multilayer ceramic capacitor 50V NP0 (0402)	GRM1555C1H391JA01D	Murata ENA
6	R61, R62, R63, R64, R65, R66	Chip resistor 1% 63mW thick film 0402	RMCF0402FT475R	Stackpole
2	C111, C112	Aluminum electrolytic capacitor, FC, 105°, SMD_D	EEE-FC1C470P	Panasonic EC
8	R16, R29, R36, R47, R54, R69, R76, R85	Chip resistor, 1%, 63 mW, thick film, 0402	RC0402FR-0749R9L	Yageo
1	R3	Chip resistor, 1%, 100 mW, thick film, 0402	ERJ-2RKF4321X	Panasonic ECG

Qty.	Designator	Description	Part Number	Manufacturer
16	R11, R12, R21, R25, R31, R32, R39, R42, R49, R50, R57, R59, R71, R72, R79, R81	Chip resistor, 1%, 63 mW, thick film, 0402	RMCF0402FT4K99	Stackpole
2	C7, C32	Multilayer ceramic capacitor, 25 V, NP0, 0402	GRM155R71E562KA01D	Murata
1	R10	Chip resistor, 1%, 63 mW, thick film, 0402	RMCF0402FT562R	Stackpole
8	R14, R27, R34, R45, R52, R67, R74, R83	Chip resistor, 1%, 63 mW, thick film, 0402	CRCW0402604RFKED	Vishay/Dale
1	U11	IC inverter hexadecimal, 14-lead SOIC	74ACT04SC	Fairchild Semiconductor
1	Y1	Crystal, 12.288 MHz, SMT, 18 pF	ABM3B-12.288MHZ-10-1-U-T	Abracon Corp.
1	U4	Four ADC, Eight DAC with PLL 192 kHz, 24-bit codec	AD1938YSTZ	Analog Devices
8	U6, U7, U8, U9, U10, U12, U13, U14	Dual low power low noise and distortion rail-to-rail output amplifier	ADA4841-2YRZ	Analog Devices
1	U2	300 MHz SigmaDSP	ADAU1452	Analog Devices
1	U1	Microprocessor voltage supervisor logic low reset output	ADM811TARTZ-REEL7	Analog Devices
1	U5	High accuracy, low dropout 3.3 V dc voltage regulator	ADP3338AKCZ-3.3-R7	Analog Devices
1	S2	DPDT slide switch vertical	JS202011CQN	C&K Components
1	L1	Chip ferrite bead, 600 Ω at 100 MHz	HZ0805E601R-10	Steward
1	J1	10-way shroud polarized header	N2510-6002RB	3M
2	J2, J3	6-way unshrouded header	PBC06DAAN, or cut PBC36DAAN	3M
7	D1, D2, D3, D4, D5, D6, D7	Green 3 millicandela, 565 nm, 0603	LNJ312G8LRA	Panasonic
6	J7, J8, J9, J10, J11, J12	Stereo mini jack SMT	SJ-3523-SMT	CUI Inc.
1	R5	Resistor network isolated, eight resistors	741X163330JP	CTS Corp.
1	J6	16 Mbps optical receiver	PLR135/T8	Everlight

NOTES

I²C refers to a communications protocol originally developed by Philips Semiconductors (now NXP Semiconductors).