ANALOG DEVICES

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ADAU1401A, ADAU1401, ADAU1701, and ADAU1702 SigmaDSP Evaluation Board

GENERAL DESCRIPTION

The EVAL-ADAU1401AEBZ is a platform that operates all of the ADAU1401A's functions with a full range of analog and digital inputs and outputs. Digital I/O connections are available in both S/PDIF and 3-wire serial data formats. The DSP is controlled by the SigmaStudio™ software, which interfaces to the board through a USB connection. This evaluation board is powered by a single supply, which is regulated to the proper voltages on the board. The PCB is in a 6" × 6" 4-layer design, with a single ground plane and a single power plane on the inner layers.

The ADAU1401A can be controlled via the USBi interface control board connected to the I²C/SPI communications interface. On-board self-boot EEPROM is included for operating the board independently of the SigmaStudio software. Push-buttons, LEDs, potentiometers, and other interface options on the included GPIO board can be connected to the evaluation board to enable GPIO control.

The EVAL-ADAU1401AEBZ can also be used for evaluation of the pin-compatible ADAU1701 and ADAU1702 SigmaDSP®s. The differences between the ADAU1401A, ADAU1401, ADAU1701, and ADAU1702 are:

- The ADAU1701, ADAU1401A, and ADAU1401 have 1024 program RAM locations, while the ADAU1702 has 512 program RAM locations.
- The ADAU1701 has 2k words of data memory, while the ADAU1702 has 0.5k words of data memory.

- The ADAU1401A is qualified over the automotive temperature range (−40°C to +105°C), while the ADAU1701 and ADAU1702 are qualified over the consumer temperature range (0°C to 70°C).
- The ADAU1401 is an older revision of the ADAU1401A. The ADAU1401A is recommended for new designs.

PACKAGE CONTENTS

EVAL-ADAU1401AEBZ evaluation board
GPIO control board
USBi board
Universal power supply
Mini-USB cable
**Evaluation board/software quick-start guide, including a
    download link for the SigmaStudio tools**

OTHER SUPPORTING DOCUMENTATION

When using this evaluation board, refer also to the following documentation available at www.analog.com:

- ADAU1401A, ADAU1401, ADAU1701, ADAU1702 data sheets
- AN-923 Application Note, *Designing a System Using the ADAU1701/ ADAU1702 in Self-Boot Mode*
- AN-951 Application Note, *Using Hardware Controls with SigmaDSP GPIO Pins*
- AN-1006 Application Note, *Using the EVAL-ADUSB2EBZ*
- SigmaStudio help file (included with the software)
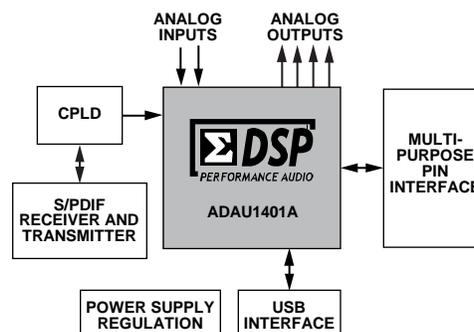
EVALUATION BOARD BLOCK DIAGRAM

Figure 1.

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REVISION HISTORY

2/12—Rev. 0 to Rev. A

Added ADAU1401A ....Universal
Changed EVAL-ADAU1401EBZ to
EVAL-ADAU1401AEBZ.....................................Universal

2/10—Revision 0: Initial Version

QUICK START SETUP

PREPARING FOR THE FIRST USE

To get started, use the following steps:

1. Install the SigmaStudio software.
2. Plug in the USBi.
3. Power up the board.
4. Connect the audio cables.
5. Set the switches and jumpers.

SIGMASTUDIO SOFTWARE INSTALLATION

1. Download the **SigmaStudio.zip** file from http://www.analog.com/sigmastudiodownload and extract the files to your PC. The key for the download is provided in the box with the evaluation board.
2. Install Microsoft® .net Framework V 3.5. If you do not already have it installed, this can be downloaded from the Microsoft website.
3. Install SigmaStudio by double-clicking **setup.exe** and following the prompts. A computer restart is not required.

POWERING UP THE BOARD

The board is powered from the included 6 V dc power supply connected to J14. The power indicator LED, D11, should be lit.

HARDWARE SETUP—USBi

1. Plug in a power supply to the power jack, J14, of the EVAL-ADAU1401AEBZ evaluation board.
2. Plug the USBi into the USB port of the PC using the mini-USB cable.
3. Plug the USBi into the control port on the evaluation board (marked yellow in Figure 2).

4. Connect the USB cable to the computer and to the USBi.
5. When prompted for drivers, use the following options:

   - Choose **Install from a list or a specific location**.
   - Choose **Search for the best driver in these locations**.
   - Check the box for **Include this location** in the search.
   - The USBi driver is located in **C:\Program Files\ Analog Devices Inc\Sigma Studio\USB drivers**, click **Next**.
   - If prompted to choose a driver, select **CyUSB.sys**.
   - In XP only, click **Continue Anyway** if a prompt appears indicating the software has not passed Windows Logo testing.

6. Make sure that Switch S4 and Switch S5 of the EVAL-ADAU1401AEBZ are set to the I2C position.

CONNECTING THE AUDIO CABLES

For this example, set up the board to have stereo analog inputs and stereo analog outputs. To do so, use the following steps:

1. Connect the audio source to the IN 0/IN 1 jacks on the top of the board (marked blue in Figure 2), using 3.5 mm (⅛") cables.
2. Connect the OUT 0/OUT 1 jacks on the top of the board (marked green in Figure 2) to your speakers or headphones.

SWITCH AND JUMPER SETTINGS

To configure the board for stereo analog input and output, make sure the switches and jumpers are set as indicated in Figure 2.
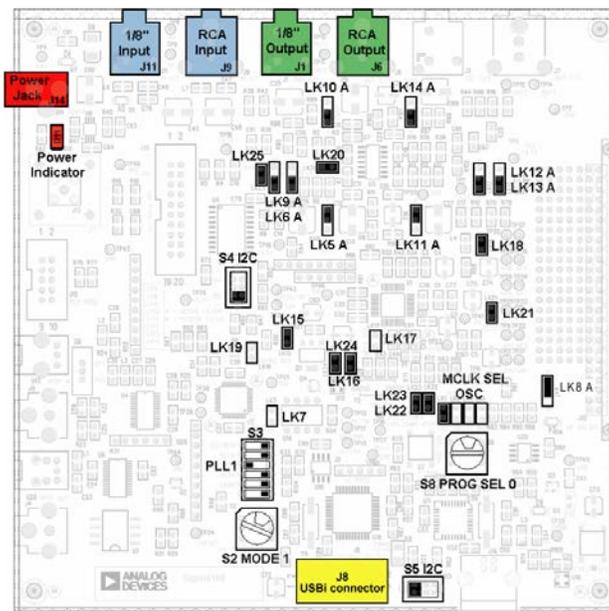

Figure 2. Evaluation Board Setup and Configuration

YOUR FIRST SIGMASTUDIO PROJECT—EQ AND VOLUME CONTROL

The following is a procedure for building your first project in SigmaStudio and running it on the evaluation board. This procedure creates a simple design that creates a volume control and five-band EQ on a stereo input signal.

1. Create a new project. SigmaStudio opens to the **Hardware Configuration** Tab.
2. Drag a SigmaDSP IC (**ADAU1401A, ADAU1701, ADAU1702, or ADAU1401**), **E2Prom**, and a **USBi** cell into the blank white space.
   Note: If you are using a processor other than the ADAU1401A, (for example, ADAU1701 or ADAU1702), drag that processor out instead.
3. Connect the **USBi** cell to the **ADAU1401A** (or other SigmaDSP) cell by clicking and dragging from the top blue output pin to the green input pin.
4. Connect the second **USBi** blue output pin to the green input pin on the **E2Prom** cell.

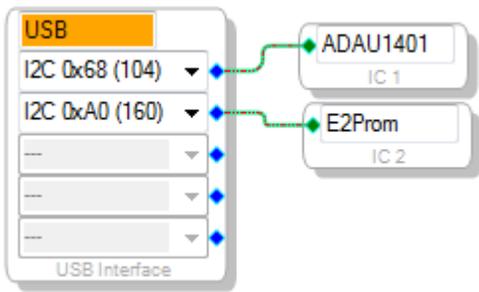   The screen should appear as it does in Figure 3.

Figure 3. Hardware Configuration Tab

5. Click the **Schematic** tab at the top of the screen.
6. In the **Tree ToolBox** section, expand the **IO** > **Input**. Click and drag an **Input** cell to the work area.
7. Similarly, expand **Filters** > **Second Order** > **Double Precision** > **2 Ch** and click and drag **Medium Size Eq** to the work area.
8. Right-click the general (second-order) cell labeled **Gen Filter1**.
9. Click **Grow Algorithm** > **1**. **2 Channel – Double Precision** > **4.** This creates a five-band equalizer (EQ). Each band's general filter settings can be modified by clicking the blue boxes on the cell.
10. Expand **Volume Controls** > **Adjustable Gain** > **Shared Slider** > **Clickless SW Slew** and click and drag **Single slew**
11. Expand the **IO** > **Output**. Click and drag two **Output** cells
12. For each of the outputs, select a DAC output by clicking the pull-down box. **DAC0** and **DAC1** are left and right outputs, 0 and 1, from the ADAU1401A (output on J1 as marked in green in Figure 2), respectively. **DAC2** and **DAC3** are left and right channel, respectively for the second stereo line output (J3 on the board).
13. Connect all the cells as depicted in Figure 4.
14. Make sure the board is powered and connected to the PC. Click the **Link-Compile-Download** button in the SigmaStudio toolbar, or select **Link-Compile-Download** from the **Action** menu.
15. If the project compiled without error, you will be in Ready-Download mode.

   Your screen should now appear as it does in Figure 4.

16. Play your audio source; audio should now be available. Move the volume control and filter sliders and hear the effect on the output audio in real time.
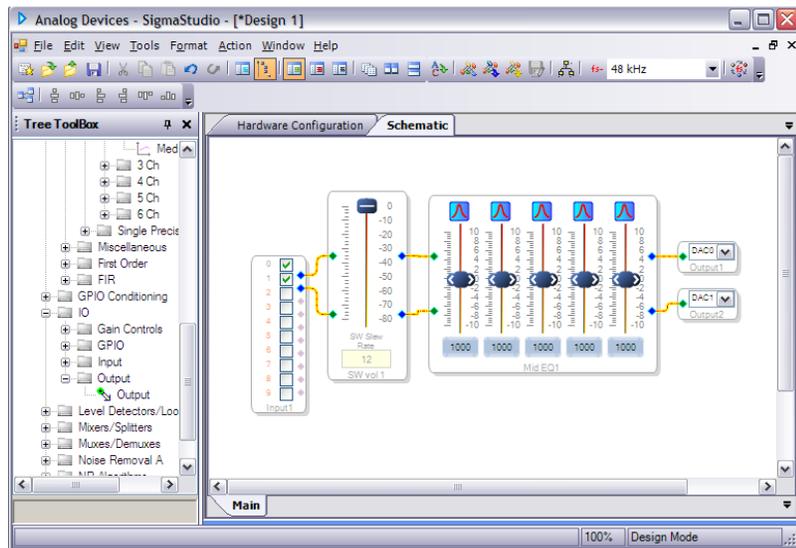

Figure 4. Schematic Tab, Full Design

EXTENDED SETUP

POWER SUPPLY

The evaluation board is powered by a single supply through Connector J14. The voltage on J14 should be 6 V dc to 9 V dc with the ability to source at least 200 mA. The tip of the power supply connector should be the positive voltage. This single supply is regulated to 3.3 V for both the analog and digital planes. The ADAU1401A generates 1.8 V from the 3.3 V supply using its integrated regulator.

DIGITAL AUDIO INPUTS AND OUTPUTS

Digital signals can be connected to the board in two different formats. The evaluation board can input or output a standard 2-channel S/PDIF stream. These I/Os can be either electrical (J5 and J4) or optical (U13 and U29). The S/PDIF I/O streams are connected to the SDATA_IN0 and SDATA_OUT0 serial data ports and are active according to specific switch settings on S2. The copy protection bit on the S/PDIF transmitter is set; therefore, audio devices, such as digital recorders, may ignore the data output from the evaluation board.

PCM digital audio data can also be interfaced to the ADAU1401A. This data is connected to the ADAU1401A through the GPIO interface board that is connected to J12. Input Header J3 and Output Header J2 can connect to external ADCs, DACs, and codecs with an I²S, left-justified, right-justified, or TDM data stream. Master clock, left/right clock, and bit clock connections are also on these headers.

Up to four stereo audio signals can be input or output on each of these headers. These signals, when selected by the rotary mode switches, interface directly to the serial data ports of the ADAU1401A. These headers also serve as the I/Os for the multi-channel TDM streams.

ANALOG AUDIO INPUTS AND OUTPUTS

The evaluation board can input two analog audio signals and can output four signals using the converters of the ADAU1401A. The full-scale input voltage is 2.0 V rms and the full-scale output voltage is 0.9 V rms.

Mini-jack J11 is the input to the ADCs. Mini-jack J1 and Mini-jack J3 are the DAC output connectors. The output is low-pass filtered with either an active anti-image filter using a U3 op amp or a passive RC filter. The active filters' −3 dB cutoff frequency is 100 kHz and has an approximate third-order Bessel (linear phase) response.

MASTER CLOCK SETTINGS

The master clock connection of the ADAU1401A is set with Jumper LK1 to Jumper LK4. These allow the user to select as a source either the on-board oscillator connected to an external crystal (OSC), the S/PDIF receiver's master clock output (DIR), an external clock from J12 (EXT), or a dedicated clock connection on a BNC connector, J13 (BNC). If any setting other than OSC is chosen, then disconnect Jumper LK16, which couples the oscillator circuit of the ADAU1401A to the crystal. If this jumper is not removed, there could be two clocks on the PCB running at very close frequencies. These clocks could easily cause serious performance degradation on the converters of the ADAU1401A.

CONTROL INTERFACE

J16 is the connection for the USBi. The USBi is used to send I²C and SPI control data to the ADAU1401A on the evaluation board. This provides a real-time programming and tuning connection to SigmaStudio.

Note that the evaluation board also includes footprints for an obsolete USB interface using Connector J16. This section of the board has been replaced by the USBi's functionality.

SWITCH AND JUMPER FUNCTIONS

This evaluation board has many switches and jumpers; however, for most applications, many of these need to be set only once and can be ignored after that. Table 1 shows the function of each jumper and switch on the evaluation board. For the S3 switch package, logic high (1) is left and logic low (0) is right, assuming analog connectors are the top of the board.

Table 1. Switches and Jumpers

Reference Designator	Function
S1	Resets evaluation board.
S2	Signal routing mode select.
S3-1	Sets SELFBOOT.
S3-2	Sets PLL_MODE0.
S3-3	Sets PLL_MODE1.
S3-4	Sets ADDR0.
S3-5	Sets ADDR1.
S3-6	Reserved—set low.
S4	Sets I^2C or SPI connection to the ADAU1401A.
S5	USBi control connector—I^2C (left) or SPI (right).
S6	Selects between RCA and optical S/PDIF input.
S7	Unused.
S8	Unused.
LK1 to LK4	Selects which master clock signal is sent to the PLL of the ADAU1401A.
LK5 to LK6, LK9 to LK14	Connects the DAC outputs to active (A) or passive (B) filters.
LK7	Sets the EEPROM write protect pin.
LK8	Selects 3.3 V or 5 V power connected to GPIO control board.
LK15	Connects the 1.8 V output of the regulator transistor to DVDD of the ADAU1401A.
LK16	Connects/disconnects 12.288 MHz crystal from oscillator circuit of the ADAU1401A.
LK17	Connects/disconnects MCLK output to external circuits. Connecting this may degrade the analog audio performance of the board.
LK18	Connects 3.3 V to AVDD of the ADAU1401A.
LK19	Writeback trigger input.
LK20	Connects 3.3 V to the AD8608 op amp.
LK21	Connects 3.3 V to the IOVDD of the ADAU1401A.
LK25	Connects 3.3 V power to serial data buffer.

ROTARY SWITCH SETTINGS

S2 is a hex rotary switch that controls the input and output signal routing on the evaluation board. The position of this switch controls which serial data signals and clocks will be routed to and from the ADAU1401A. Table 3 shows the settings of Rotary Switch S2. This switch controls the routing of digital signals to and from the ADAU1701/ADAU1702 (U1) serial input and output ports. Table 3 indicates which serial data signals and clocks are sent to each of the four serial data inputs, as well as to where the output signals of the serial port are routed. An x in the table indicates that no signal is sent to that input pin on the ADAU1701/ ADAU1702 in that mode. Switch Position 4 to Switch Position F are unused.

The functions in Table 2 are available for each of the modes in Table 3.

Table 2. S2 Settings

Mode	Function
0	Inputs: S/PDIF, analog Outputs: S/PDIF, analog, serial data (slave)
1	Inputs: analog, serial data Outputs: analog, serial data (master or slave)
2	Inputs: analog, serial data Outputs: S/PDIF, analog, serial data (master)
3	Inputs: S/PDIF, analog Outputs: analog

The multipurpose pins of the ADAU1401A must be set into serial data I/O modes to use the board's digital I/O.

Table 3. S2 Settings[1]

SW2 Position	SDATA_IN0	SDATA_IN1 to SDATA_IN3	SDATA_OUT0 to SDATA_OUT3	SPDIF Tx	Clock Master
0	S/PDIF Rx	x	External Output 0 to External Output 3	SDATA_OUT0	S/PDIF Rx
1	x	x	x	x	ADAU1401A crystal oscillator
2	External Input 0	External Input 1 to External Input 3	External Output 0 to External Output 3	SDATA_OUT0	ADAU1401A output
3	S/PDIF Rx	x	x	x	S/PDIF Rx
4 to F	x	x	x	x	x

[1] x = no signal is sent to the input pin.

IC FUNCTIONS

Table 4 explains the function of each IC on the evaluation board. The Lattice CPLD (U2) is only used for routing signals on the board and performs no decoding or signal conditioning.

Table 4. IC Functions

Reference Designator	Function
U1	ADAU1401A SigmaDSP audio processor
U2	Lattice M4A3-64/32 CPLD for signal routing
U3	AD8608 quad op amp for analog audio output buffering
U4	CS8416 S/PDIF receiver
U5	74LVC541 for buffering serial output signals
U6	CS8406 S/PDIF transmitter
U8	ADP3336-3 regulator—3.3 V analog supply
U10	ADM811RART reset generator
U11	Unused
U12	74LVC1G240 inverter
U14	Self-boot EEPROM: 32 kB × 8 (256 kB)
U18	Unused
U19	Unused
U20	Unused

LED FUNCTIONS

D11 indicates that the 3.3 V supply is present through an external supply.

RESET

The evaluation board can be reset with a push-button switch, S1. This active-low reset signal is debounced by the ADM811 (U10). This reset signal affects the ADAU1401A and S/PDIF receiver and transmitter. The board may also be reset by disconnecting the power. After reset, the ADAU1401A does not pass audio, and a control port write has to be performed so that signals are output again.

SELF-BOOT

The self-boot function of the ADAU1401A can be set up on the evaluation board. This allows the ADAU1401A to boot itself from EEPROM U14 when it is brought out of reset. The ADAU1401A is the master on the I²C bus during the self-boot operation; however, another bus master device may take control afterwards.

The first step in setting up self-boot mode is to load a program from SigmaStudio into the EEPROM. This is done by using the **Load latest compilation to EEPROM** function found by right-clicking on the IC in the **Hardware Configuration** window. This should be done while the S3-1 self-boot switch is set low (right). Note that the jumper should not be on LK7 for this operation because the EEPROM cannot be write-protected. After the program is saved, Switch S3-1 can be set high (left), which sets the ADAU1401A into self-boot mode the next time it is powered on or reset.

TYPICAL SETUPS

ALL SETUPS

The switch and jumper settings in Table 5 are common for all typical setups described in this user guide.

Table 5. Standard Switch and Jumper Settings

Component	Setting
LK15, LK18, LK20 to LK25	Jumper on
LK7, LK19	Jumper off
S3-4	0 (right)
S3-5	0 (right)
S4	Down (for default I²C communication)
S5	Left (for default I²C communication)

ANALOG INPUT AND ANALOG OUTPUT

Input comes from the stereo analog inputs to Pin ADC0 and Pin ADC1 of the ADAU1401A and outputs on the DACs. Default outputs for the ADC inputs are DAC outputs, VOUT2 and VOUT3.

In this setup, the master clock is generated by the ADAU1401A's oscillator connected to a 12.288 MHz crystal. Table 6 explains how the switches and jumpers need to be set up for this mode. Any component setting not mentioned in Table 6 or in Table 5 can be considered don't care.

The settings in Table 5 and Table 6 are also appropriate for using the serial data I/Os.

Table 6. Evaluation Board Settings for Analog I/O

Component	Setting
S2	Position 1
S3-2	0 (right)
S3-3	1 (left)
LK1	Connected
LK2 to LK4	Disconnected
LK5 to LK6, LK9 to LK14	A for active filter, and B for passive filter on DAC outputs
LK16	Connected
LK17	Disconnected

S/PDIF INPUT AND S/PDIF OUTPUT

Input comes from the stereo S/PDIF receiver to SDATA_IN0 (Pin 10) of the ADAU1401A and outputs on whichever outputs (SDATA_OUTx) are designated in the SigmaStudio software. The default output for the input is SDATA_OUT0 (Pin 15).

In this setup, the master clock and serial data clocks are generated by the CS8416. Table 7 explains how the switches and jumpers need to be set up for this mode. Any component setting not mentioned in Table 7 can be considered don't care.

Table 7. Evaluation Board Settings for S/PDIF Input, Analog and S/PDIF Output

Component	Setting
S2	Position 0
S3-2	0 (right)
S3-3	1 (left)
LK1, LK3 to LK4	Disconnected
LK2	Connected
LK5 to LK6, LK9 to LK14	A for active filter, and B for passive filter on DAC outputs
LK16	Disconnected
LK17	Connected

USING THE GPIO BOARD

The GPIO board is provided with the EVAL-ADAU1401AEBZ to connect control and data interfaces to the multipurpose pins of the ADAU1401A. These controls are broken out on a separate board from the main evaluation board so that different configurations beyond what is supplied can be easily connected. The functions on this board include potentiometers, LEDs, push buttons, switches, and a rotary encoder.

Table 8 shows how the jumpers should be set to properly route the controls to the ADAU1401A's MPx pins. The settings in

Table 8 assume that the board is oriented with a 50-pin connector, J1, on the left of the board.

The 12 jumpers, J3 to J14, should be left on the pins to connect the MPx pins to the control interfaces. These jumpers should be removed if the GPIO board is being used to interface serial audio data to the ADAU1401A through Header J2 and Header J3. JP1 and JP2 are used to route the serial data ports' master clock signals.

The GPIO board uses a Hirose PCN10C-50S-2.54DS connector to interface to the ADAU1401A evaluation board. Using this connector and the pinout in Figure 10, any set of controls can be connected to the multipurpose pins of the ADAU1401A. The GPIO board is powered through Pin 1 of J12 on the evaluation board. The voltage supplied to the GPIO board is set with LK8—3.3 V in Position A or 5.0 V in Position B.

Table 8. GPIO Board Jumper Settings and Functions

ADAU1401A **Pin**	**Jumper**	**Control Routed to MPx Pin**	**Jumper Setting**	**Notes**
MP0	JP9	LED D20	Left	
		Push Button S10	Right	Use debounce, signal low on button press
MP1	JP10	LED D21	Left	
		Push Button S11	Right	Use debounce, signal low on button press
MP2	JP11	Rotary encoder	Left	Must be set to input GPIO, no debounce
		Potentiometer R28	Right	Read ADC value from Register 0x080A
MP3	JP12	Rotary encoder	Left	Must be set to input GPIO, no debounce
		Potentiometer R30	Right	Read ADC value from Register 0x080B
MP4	JP13	Switch S12	Left	
		Push Button S13	Right	Use debounce, signal low on button press
MP5	JP14	Switch S14	Left	
		Push Button S14	Right	Use debounce, signal low on button press
MP6	JP8	Push Button S7	Left	Use debounce, signal low on button press
		Switch S8	Right	
MP7	JP7	Push Button S5	Left	Use debounce, signal low on button press
		Switch S6	Right	
MP8	JP6	Potentiometer R4	Left	Read ADC value from Register 0x080C
		LED D2	Right	
MP9	JP5	Potentiometer R3	Left	Read ADC value from Register 0x0809
		LED D1	Right	
MP10	JP4	Push-button S3	Left	Use debounce, signal low on button press
		Switch S4	Right	
MP11	JP3	Push Button S1	Left	Use debounce, signal low on button press
		Switch S2	Right	

EVALUATION BOARD SCHEMATICS

Figure 5. ADAU1401A Evaluation Board Schematic
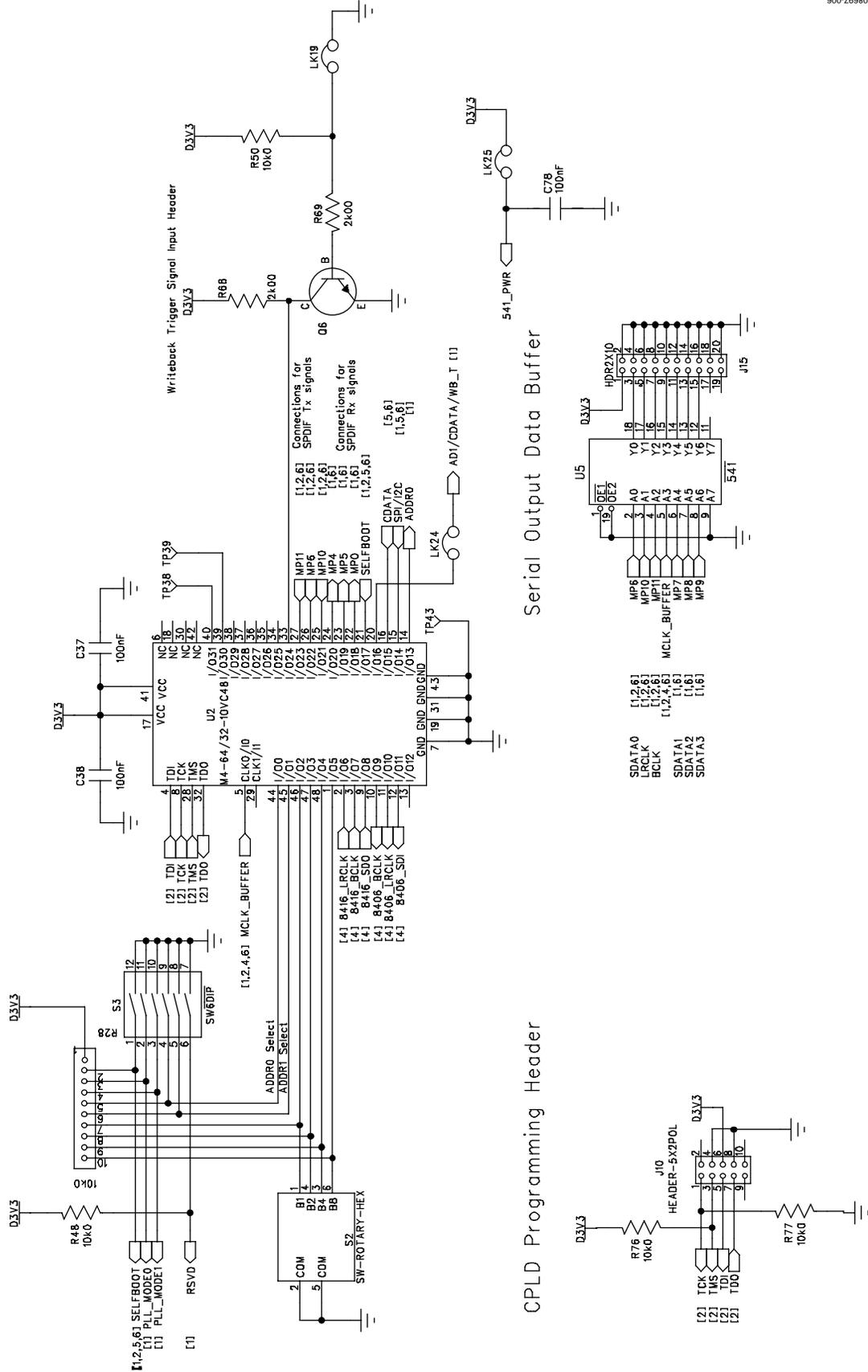
Figure 6. CPLD
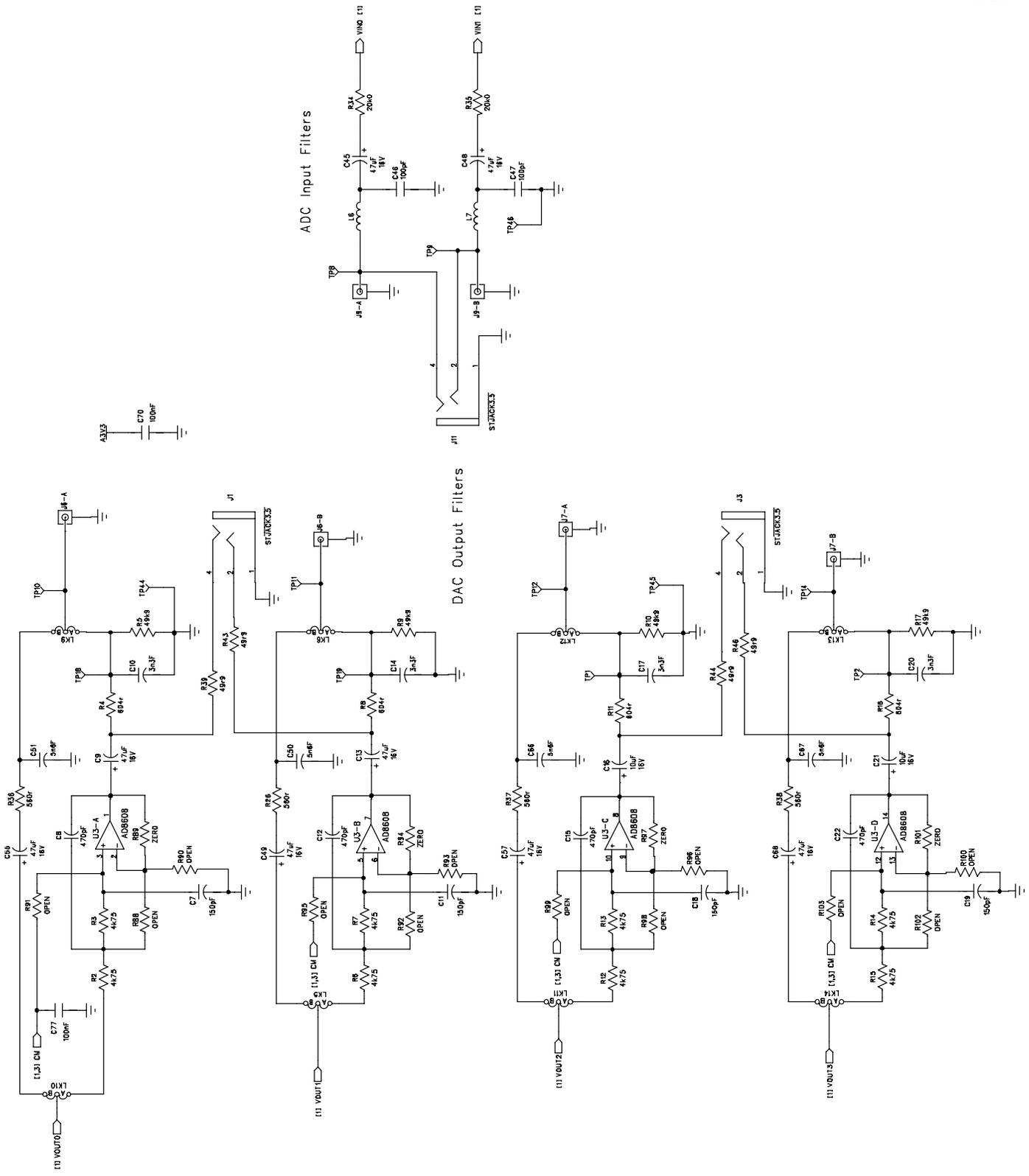
Figure 7. Analog Input and Output Filters
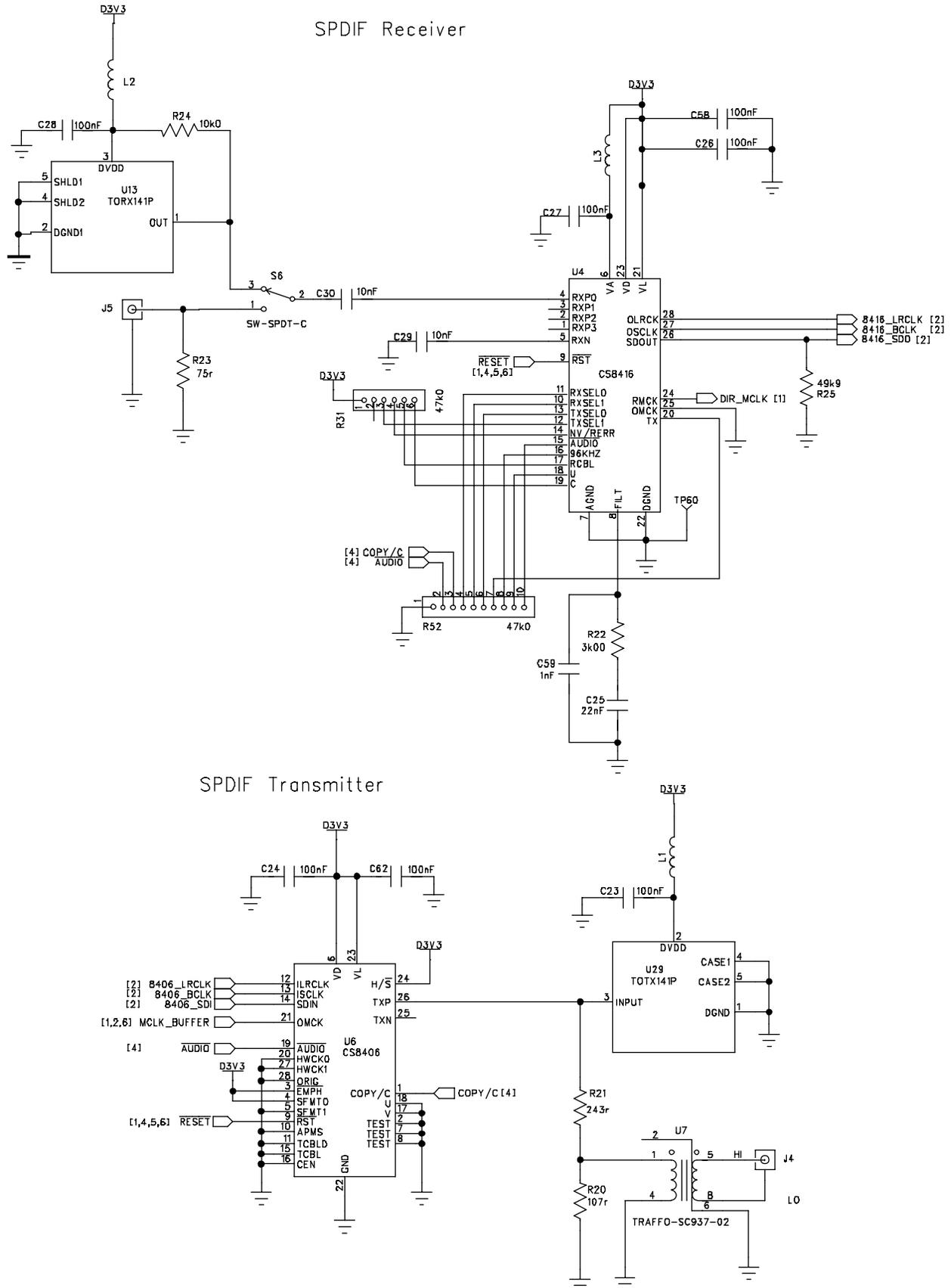
Figure 8. S/PDIF Receiver and Transmitter

Reset Generator
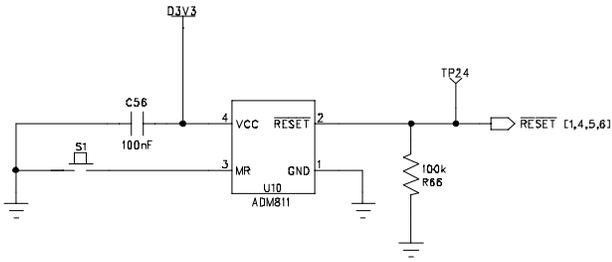
USBi Header
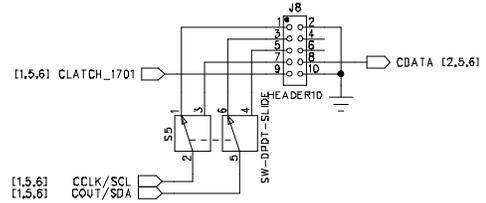
Figure 9. Reset Generator and USBi
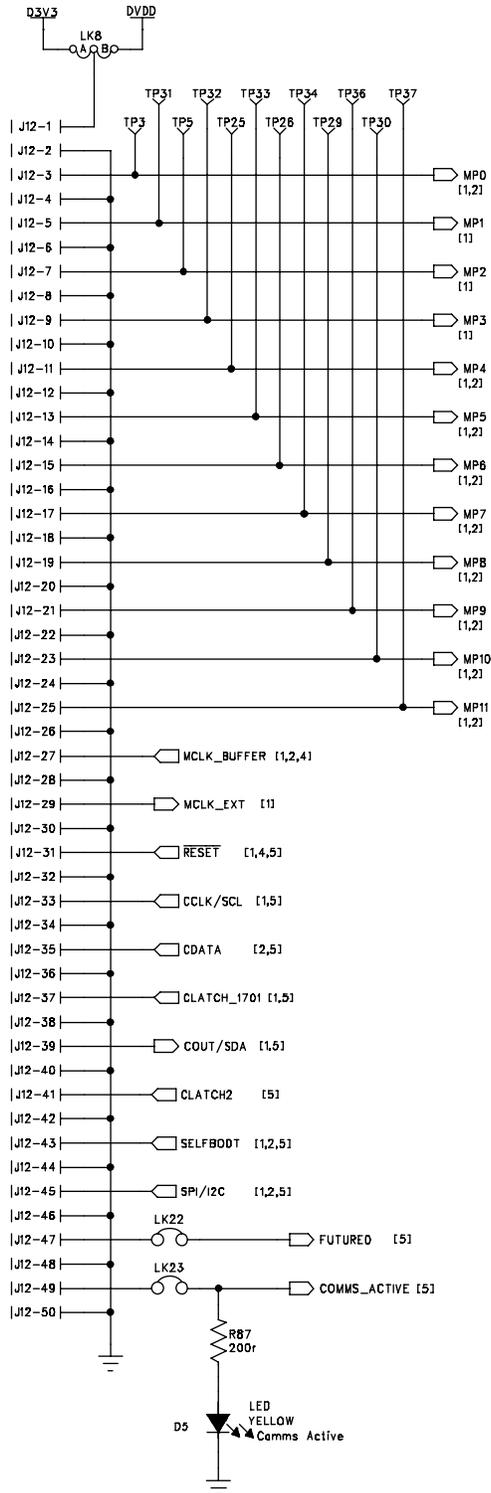
Figure 10. Multipurpose Pin Interface
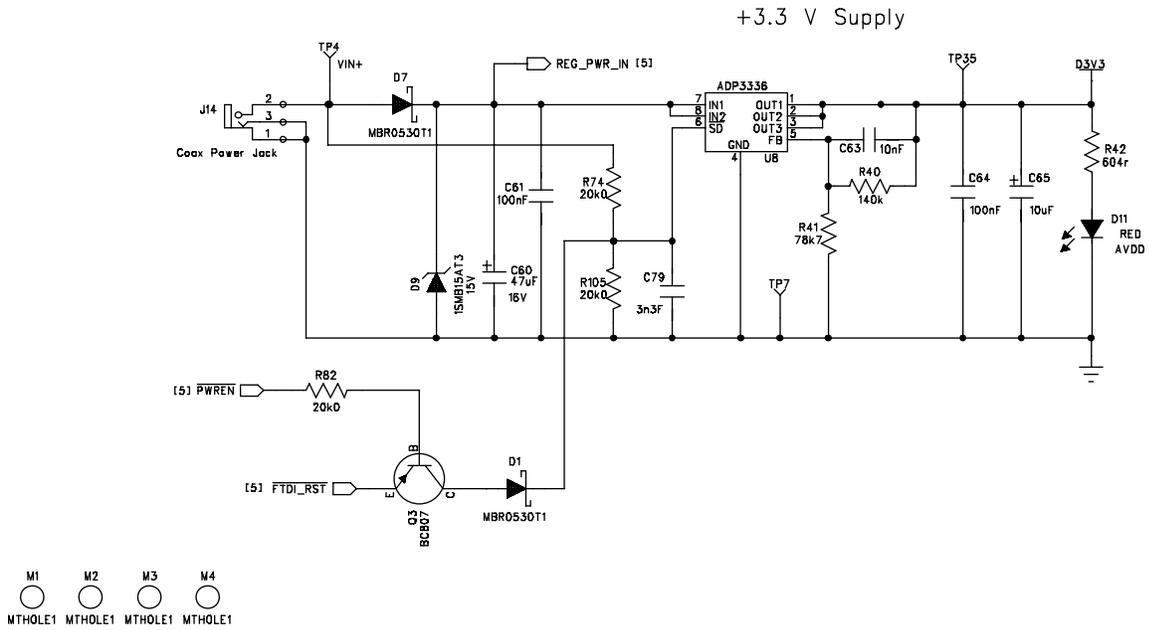
Figure 11. Power Supply

GPIO INTERFACE BOARD SCHEMATICS
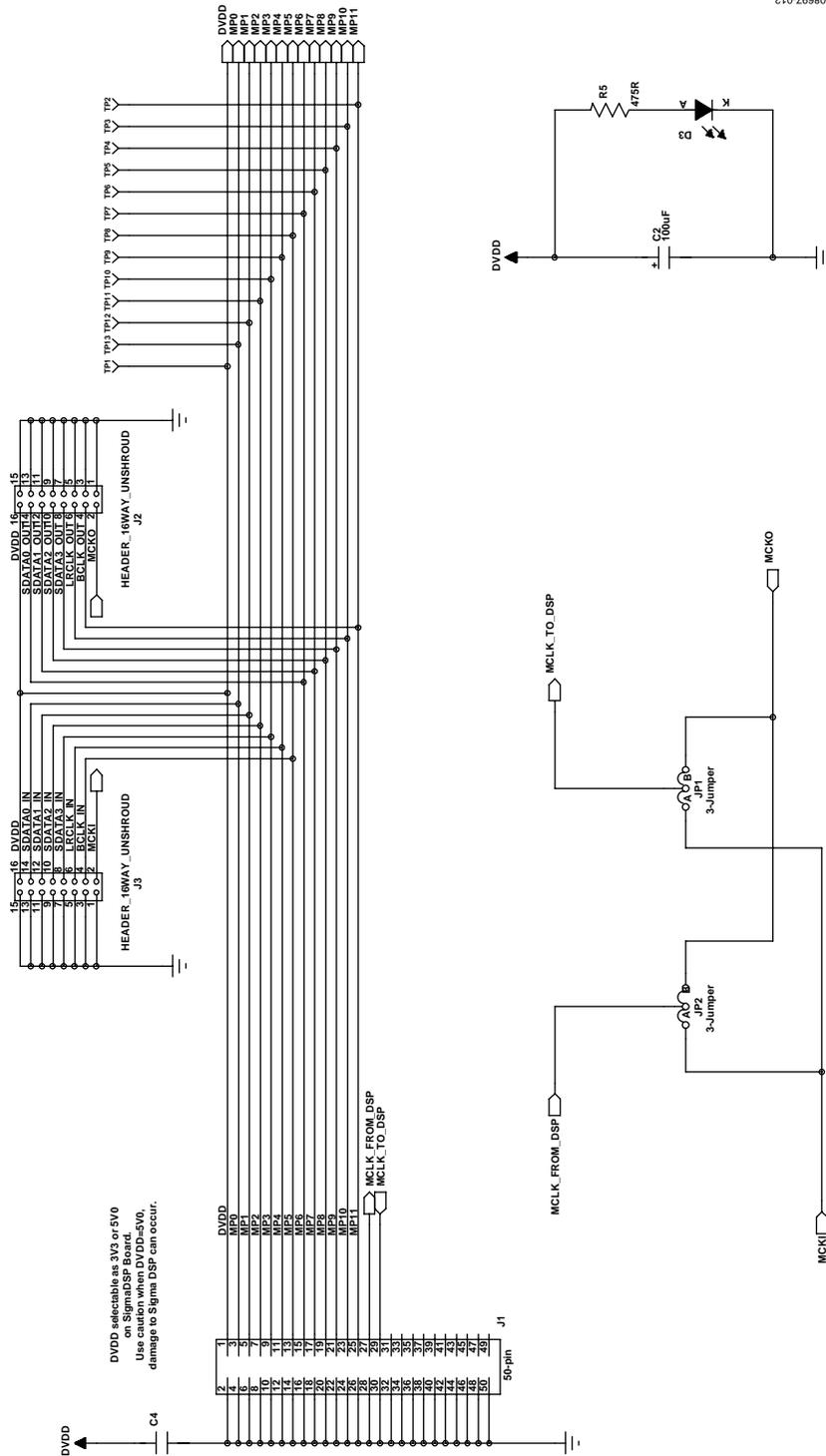
Figure 12. GPIO Board Connector

08697-013
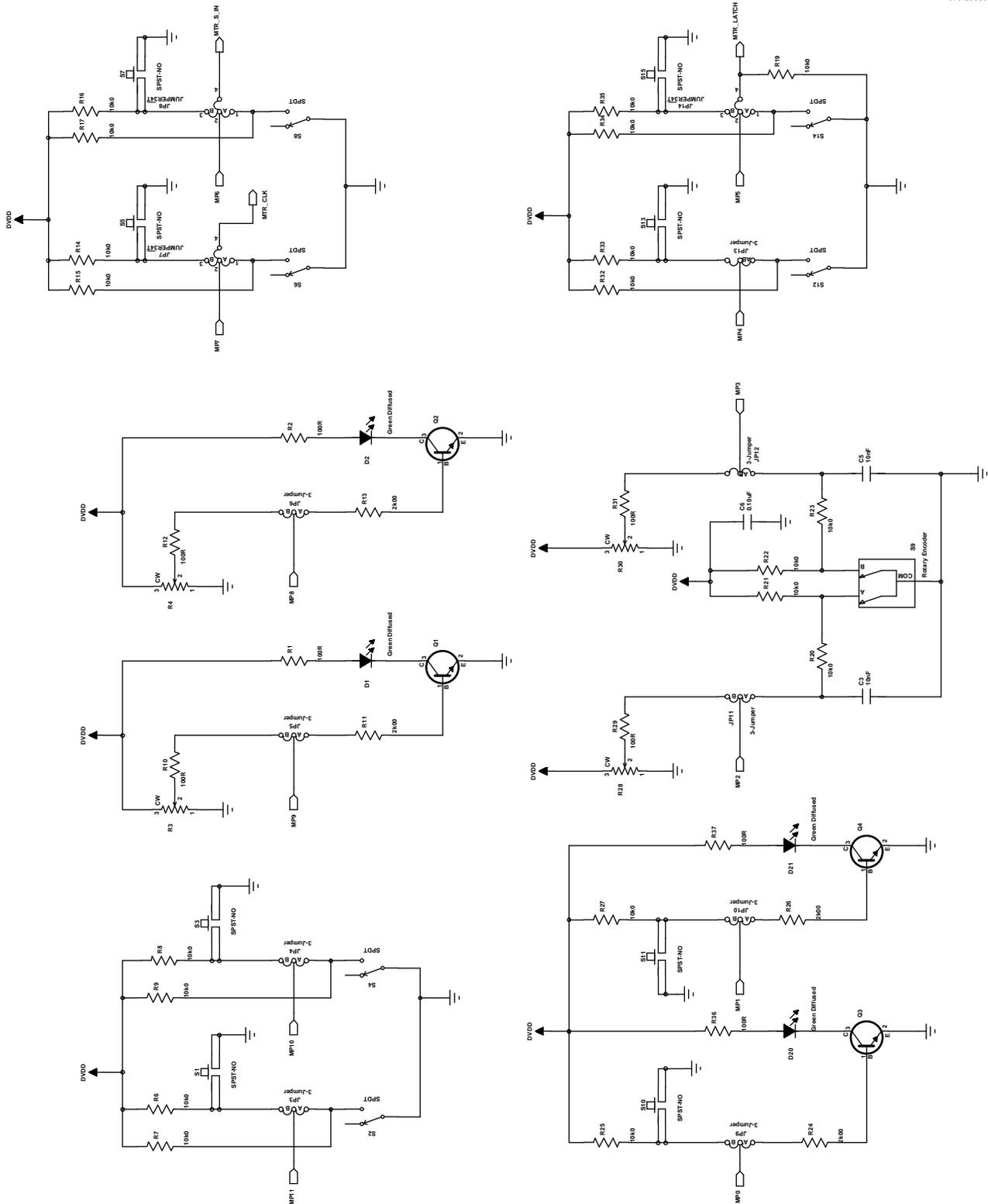
Figure 13. GPIO Board Controls

EVALUATION BOARD PCB SILKSCREEN DRAWING
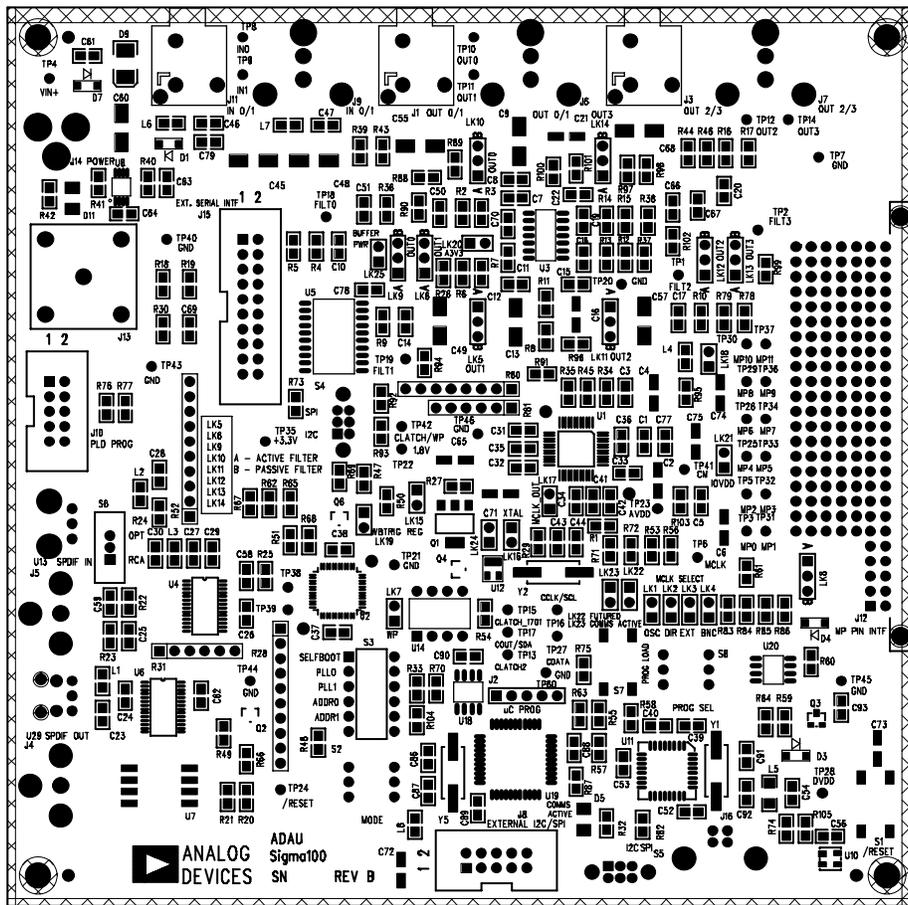
Figure 14. Top Layer Silkscreen

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.

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