ADS124S08 Evaluation Module

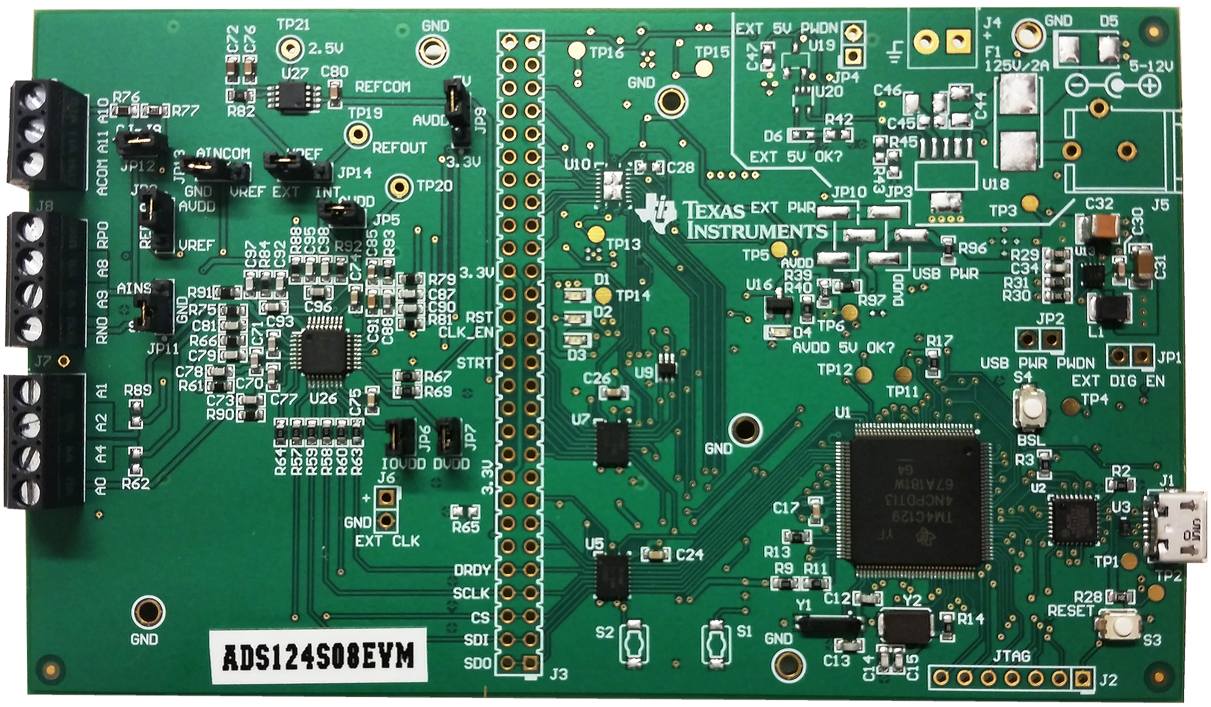

Figure 1. ADS124S08 Evaluation Module

The ADS124S08EVM is an evaluation module kit that provides hardware and software support for evaluation of the ADS124S08 delta-sigma analog-to-digital converter (ADC). The kit utilizes the TM4C1294NCPDT processor to communicate with the ADC via SPI and provide communication with a PC over USB interface. The kit also includes a software application that runs on a PC allowing for register manipulation and data collection from the ADC. The ADS124S08EVM kit includes the ADS124S08EVM, USB micro cable, and downloadable supporting software (SW).

This document includes a detailed description of the hardware (HW), software, bill of materials, and schematic for the ADS124S08EVM.

Throughout this document the term *EVM* is synonymous with the ADS124S08EVM, demonstration kit, and evaluation module. The term *GUI* is synonymous with *Delta-Sigma ADC EvaluaTIon Software*, core application, and EVM software. The use of *Tiva™* is synonymous with the TM4C1294NCPDT microcontroller.

Table 1. Related Documentation

Device	Literature Number
ADS124S08	SBAS660

Tiva is a trademark of Texas Instruments, Incorporated.
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Contents

List of Figures

1 EVM Overview

1.1 Description

This user guide describes the operation and use of the ADS124S08 evaluation module (ADS124S08EVM). The ADS124S08 is a 24-bit, 4-kSPS, 12-channel delta-sigma analog-to-digital converter (ADC) for precision sensor measurement applications. The ADS124S08EVM platform is intended for evaluating the ADS124S08 performance and functionality.

1.2 Requirements

1.2.1 Software Requirements

PC with Microsoft® Windows® 7 or higher operating system.

1.2.2 Hardware Requirements

PC with available USB 2.0 or greater connection.

1.2.2.1 Power Supply

USB powered.

1.3 Software Reference

Refer to the *Delta-Sigma ADC EvaluaTIon Software User Manual* (SBAU260) for the core software documentation or navigate to the *File -> About* option from within the GUI, then click on the *Software user guide* icon.

1.4 Supported Functionality

1.4.1 Supported Hardware Functionality

- Unipolar (3.3 V or 5 V) AVDD and AVSS (GND) supply operation
- 3.3-V IOVDD and DVDD
- Digital header for external processor or controller configuration
- Configurable for direct sensor input
- Device Start pin control
- Onboard or external ADC clock operation
- Onboard or external ADC voltage reference

1.4.2 Supported Software Functionality

- Start/Sync control
- Device software Reset
- Device Sleep/Wakeup
- Register read and write
- Conversion result readback
- Self offset and system input calibration
- Error detection through device status information
- CRC of data enable/disable (to be used for error detection of data transmission)
- External clock (Y3) enable/disable

2 Quick Start

This section provides a guide to quickly begin using the EVM.

2.1 Default Jumper and Switch Configuration

The EVM should come configured with the settings listed in Table 2 and illustrated in Figure 2.

Table 2. Default Settings

Jumper	Position	Function
JP1	Not Installed	Use onboard processor
JP2	Not Installed	USB-derived supplies ON
JP3	Not Installed	DVDD from USB supply
JP4	Not Installed	N/A
JP5	Installed	AVDD supply connected
JP6	Installed	IOVDD supply connected
JP7	Installed	DVDD supply connected
JP8	1-2	REFP0 connected to AVDD
JP9	2-3	AVDD supply sourced from 5 V
JP10	Not Installed	AVDD from USB supply
JP11	1-2	REFN0 connected to AGND
JP12	Not Installed	Thermistor (RT2) not connected to AIN10
JP13	1-2	AINCOM connected to AGND
JP14	1-2	2.5-V VREF supplied by external reference U27

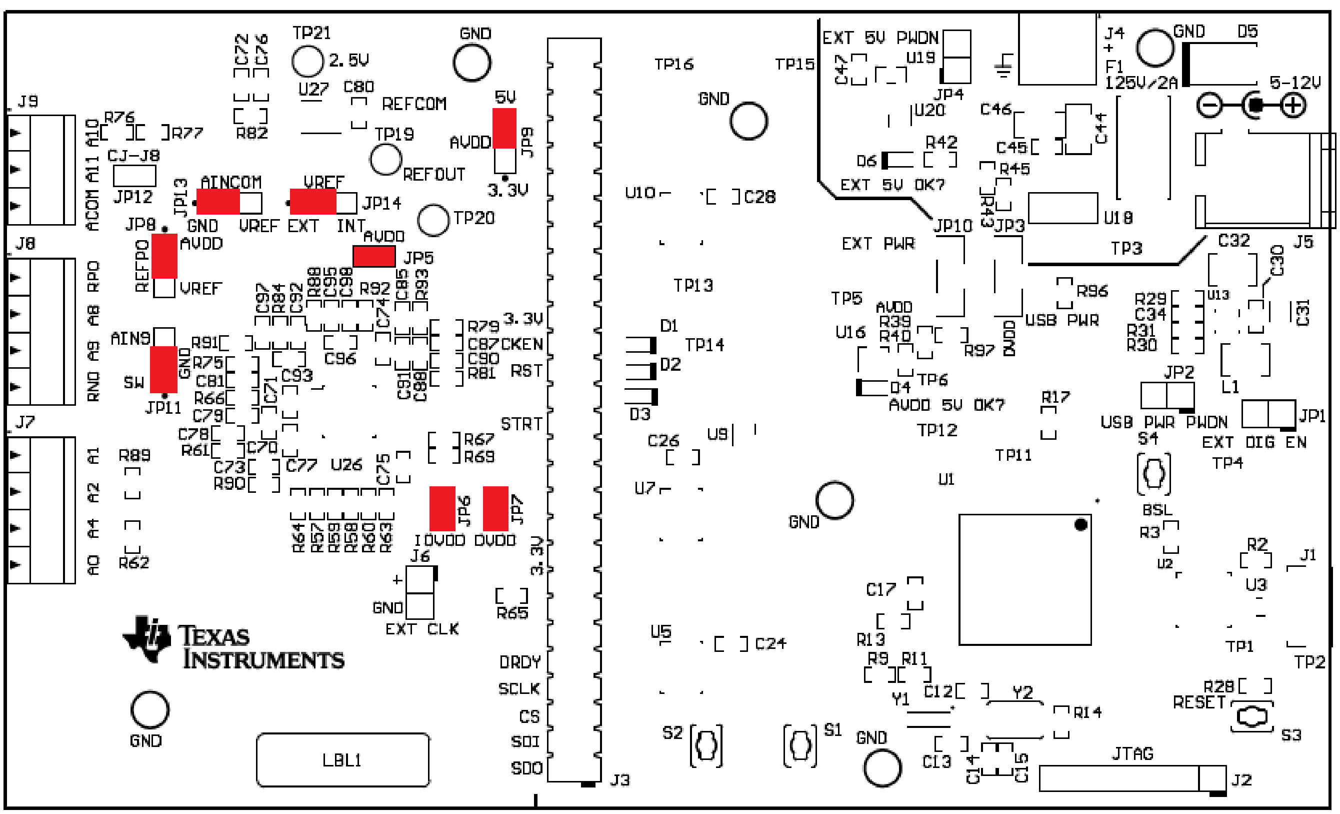


Figure 2. ADS124S08 EVM

2.2 Power Connection

The EVM is powered through the USB interface with the PC. Connect the EVM to a USB connector on the PC to power the board.

2.3 Startup

Use the following steps at startup:

1. Install the core application software on the PC.
2. Install the *ADS124S08 Device Package* software on the PC.
3. Ensure all jumpers and switches are configured in the default configuration per Table 2 and Figure 2.
4. Connect the EVM to the PC using a USB cable.
5. If prompted, install any required drivers.
6. Start the GUI software on your PC.

NOTE: The device has powered correctly if D1 and D4 are both lit green.

3 Hardware Reference

3.1 Jumper and Switch Configuration Reference

Table 3 provides all jumper and switch configuration settings for the EVM.

Table 3. Jumper and Switch Options

Jumper	Position	Description
JP1	Operation of EVM with external digital signals	
	Installed (ON)	Hold Tiva processor (U1) in reset and disable level shifters to allow external digital signals
	Uninstalled (OFF)	Normal operation with onboard Tiva processor (default)
JP2	Power down USB power supplies	
	Installed (ON)	USB-derived power supplies disabled and powered down
	Uninstalled (OFF)	USB-derived power supplies enabled and ON (default)
JP3	Digital supply source	
	1-2 shorted	Provided from USB power (default using R96 as the short)
	2-3 shorted	External supply source
	Open	No digital system power provided
JP4	External 5-V power down	
	Installed (ON)	External supply regulator (U18) disabled and powered down
	Uninstalled (OFF)	External supply regulator (U18) enabled and ON (default)
JP5	ADC AVDD supply (U26)	
	Installed (ON)	AVDD supply pin powered from selection of JP9 (3.3 V or 5 V) (default)
	Uninstalled (OFF)	No supply powering AVDD (connection is useful for direct current measurement)
JP6	ADC IOVDD supply (U26)	
	Installed (ON)	IOVDD supply pin powered from EVM 3.3-V digital supply (default)
	Uninstalled (OFF)	No supply powering IOVDD (connection is useful for direct current measurement)
JP7	ADC DVDD supply (U26)	
	Installed (ON)	DVDD supply pin powered from EVM 3.3-V digital supply (default)
	Uninstalled (OFF)	No supply powering DVDD (connection is useful for direct current measurement)

Table 3. Jumper and Switch Options (continued)

Jumper	Position	Description
JP8	REFP0 reference source (U26)	
	1-2 shorted	AVDD supplied from the selection of JP9 (3.3 V or 5 V) (default)
	2-3 shorted	VREF (2.5 V) supplied from the selection of JP14 (ADC internal reference or U27)
	Open	Externally supplied reference connected to J8 pin 1
JP9	AVDD supply connection	
	1-2 shorted	Use 3.3-V EVM source
	2-3 shorted	Use 5-V EVM source (default)
JP10	Analog supply source	
	Installed (ON)	Provided from USB power (default using R97 as the short)
	Uninstalled (OFF)	External supply source
	Open	No analog system power provided
JP11	Analog ground (AGND) connection	
	1-2 shorted	REFN0 connected to AGND (default)
	2-3 shorted	AIN9 (J8 pin 3) connected to AGND
	Open	AGND connected through low-side switch (U26)
JP12	Thermistor (RT2) cold junction sensor connection	
	Installed (ON)	Sensor connection to AIN10 for indirect measurement using R77
	Uninstalled (OFF)	Sensor not connected (default)
JP13	ADC AINCOM (U26) bias connection	
	1-2 shorted	AINCOM connected to AGND (default)
	2-3 shorted	AINCOM (J8 pin 3) connected to 2.5-V VREF source (JP14)
	Open	AINCOM connected to J9 pin 3 only
JP14	VREF voltage supply source	
	1-2 shorted	Supplied from U27 (default)
	2-3 shorted	Supplied from U26 (if U26 internal reference is powered ON)
	Open	Indirectly supplied from J8 pin 1 when JP8 is connected to 2-3
Switch	**Position**	**Description**
S3	Reset onboard controller (U1 $\overline{RST}$)	
	Closed	Tiva held in RESET
	Open	Normal operation
S4	BSL mode for *Device Firmware Update* (DFU)	
	Closed (on RESET)	Total Tiva FLASH erasure (on release Tiva enumerates as a DFU device)
	Open	Normal operation

3.2 Header, Connector and Test Point Reference

This section provides the connection information and detail for all of the connectors and test points utilized on the EVM.

3.2.1 Analog Input Terminal Blocks

Analog input to the EVM can be connected at the terminal blocks located on the left side of the board (see Figure 3) to provide external analog signal input to the EVM for evaluation purposes. The functions for these terminal blocks are listed in Table 4 through Table 6. Information and connection diagrams for direct sensor input is detailed in Section 5.1. At no time should a voltage be applied that exceeds the absolute maximum ratings for the input of the ADS124S08. The only exception is when measuring an external voltage as discussed in Section 5.1.3.

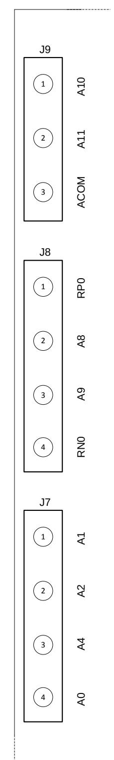


Figure 3. Input Terminal Blocks

Table 4. Analog Input Terminal Block, J7

Function	Signal Name	Pin
Analog input to ADC (excitation current source output for 2-, 3-, and 4-wire RTD)	AIN1 (AIN5)	1
Analog input to ADC (excitation current source output for 3-wire RTD)	AIN2 (AIN3)	2
Analog input to ADC	AIN4	3
Analog input to ADC (excitation return current)	AIN0	4

Table 5. Analog Input Terminal Block, J8

Function	Signal Name	Pin
Analog reference input + to ADC (excitation voltage source)	REFP0	1
Analog input + to ADC	AIN8	2
Analog input – to ADC	AIN9	3
Analog reference input – to ADC	REFPN/AVSS-SW	4

Table 6. Analog Input Terminal Block, J9

Function	Signal Name	Pin
Analog voltage input [1]	AIN10	1
Analog current input [2]	AIN11	2
Analog common	AINCOM	3

(1) The voltage drop across R77 for the voltage divider input from the terminal block should never exceed the AVDD supply. Further information is found in Section 5.1.3.

(2) The voltage drop across current shunt resistor R78 should never exceed the AVDD supply. Further information is found in Section 5.1.3

3.2.2 External Clock

By default, a clock is supplied by the internal oscillator of the ADC. An external oscillator is not installed but can be added at Y3. The EVM also provides the capability to connect an external clock directly to the ADC using the connector J6 (see Table 7). When connecting to J6, either a direct connection can be made or a 0.1-inch spaced header can be installed with the clock being applied to the header. A typical clock source of 4.096 MHz will track with all timing shown in the ADS124S08 datasheet (SBAS660).

Table 7. External Clock Connector, J6

Function	Signal Name	Pin
External clock input +	CLK	1
External clock input – (ground)	AGND	2

When using an external oscillator (Y3), the oscillator enable pin is controlled by GPIO from the Tiva microcontroller. The default state for the oscillator enable is off, or logic low. The clock can be enabled by software command in the GUI. Information regarding the software command is found in Table 10.

3.2.3 Digital Interface Header

Table 8 lists the functions and pin numbers for all signals used on the digital interface.

Table 8. Digital Interface, J3

Function	ADC Side		Processor Side	
	Signal Name	Pin Number(1)	Pin Number(2)	Signal Name
External voltage input	GND	56	55	EXT_5V
Bank2 level shifter voltage	DVDD_3.3V	36	35	DIG_VOLT2
GPIO for ADC	ADC_EXT_CLK_EN	34	33	GPIO_0
	ADC_RESET	32	31	GPIO_1
	ADC_START	28	27	GPIO_3
Bank1 level shifter voltage	DVDD_3.3V	18	17	DIG_VOLT1
SPI 0	ADC_DRDY	10	9	SPI0_OTHERB
	ADC_SCLK	8	7	SPI0_SCLK
	ADC_CS	6	5	SPI0_FS
	ADC_MOSI	4	3	SPI0_MOSI
	ADC_MISO	2	1	SPI0_MISO

(1) Even numbered pins not included are not connected.
(2) Odd numbered pins not included are connected to the Tiva microcontroller but the functionality is not used for this EVM. See Figure 32 for connection details.

3.2.4 Test Points

The test points listed in Table 9 may be used to probe onboard voltage supplies and signals.

Table 9. Useful Test Points

Function	Signal Name	Test Point	Restrictions
USB sourced supply	USB_VBUS	TP1	Probe only
USB sourced supply	USB_VBUSP	TP2	Probe only
5.5-V output (U13)	USB_IREG	TP3	Probe only
1.8 V output (U15)	1.8V	TP4	Probe only
5.0-V output (U14)	ANA_ADC	TP5	Probe only
5.0 V output	AVDD_ADC	TP6	Probe only
AGND = DGND	GND	TP7 - TP10	AGND = DGND
3.3-V output (U17)	DIG_3.3V	TP11	Probe only
3.3-V output	DVDD_3.3V	TP12	Probe only
AGND = DGND	GND	TP17 - TP18	AGND = DGND
2.5-V output (U26, if enabled)		TP19	Probe only
2.5-V output (U27)		TP21	Probe only

4 Software Details

4.1 Installing the Software

4.1.1 Delta-Sigma ADC EvaluaTIon Software

Download the *Delta-Sigma ADC EvaluaTIon Software* installer from the EVM tool page and save to a known folder. Run the installer and follow the on-screen prompts. Note that future software versions may show slightly different screens.

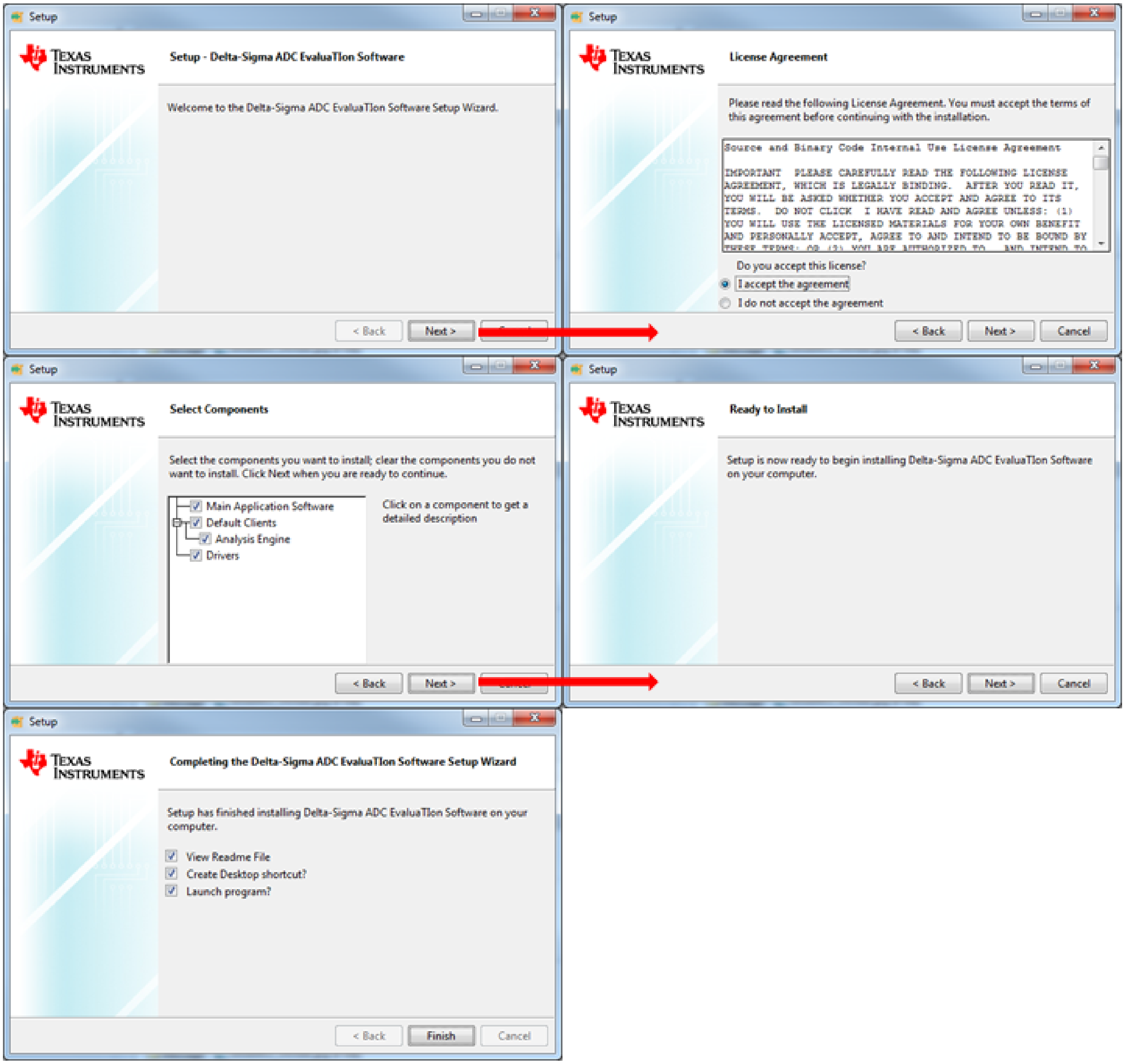


Figure 4. Delta-Sigma Evaluation Engine Installation Instructions

4.1.2 ADS124S08 Device Package

Download the *ADS124S08 Device Package* installer from the EVM tool page and save to a known folder. Run the *ADS124S08 Device Package* installer and follow the on-screen prompts. Note that future software versions may show slightly different screens.

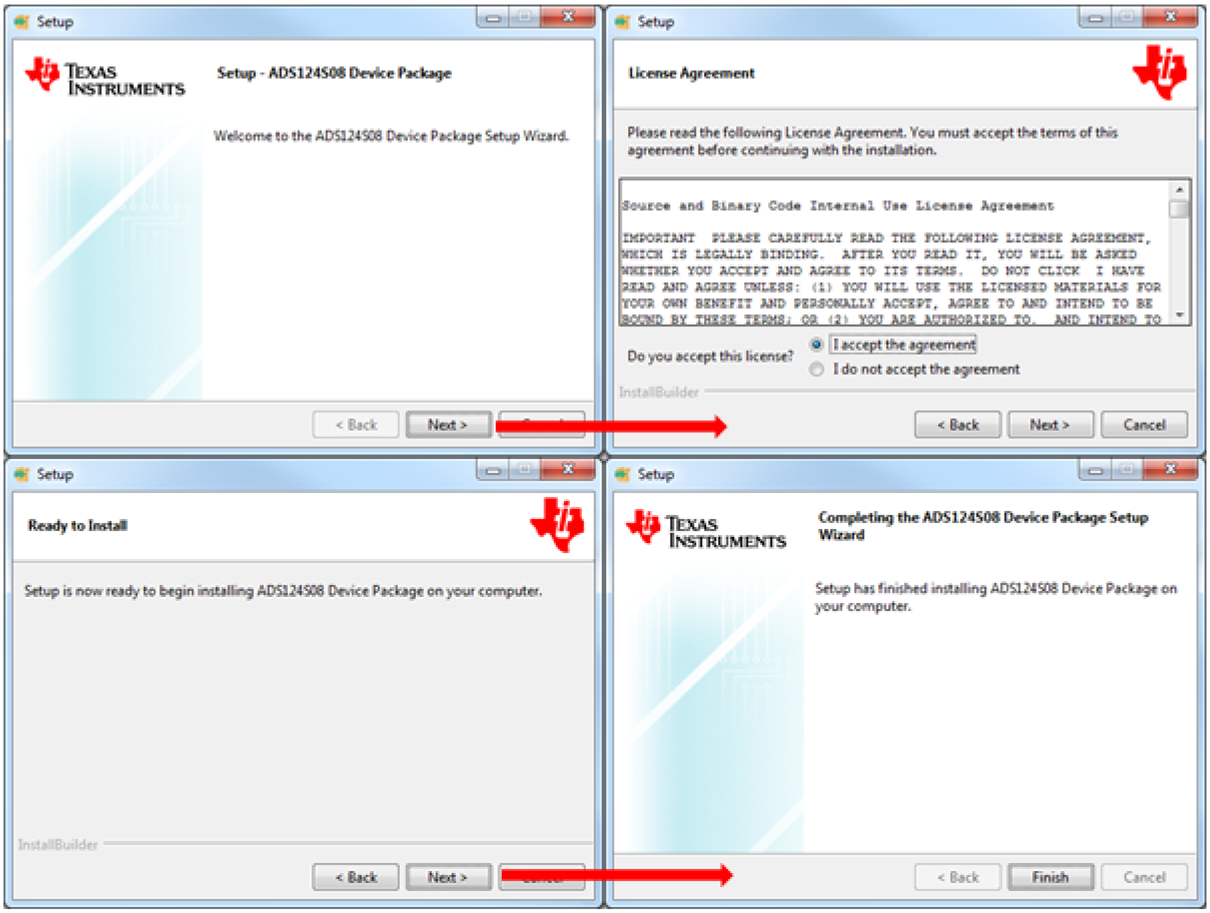


Figure 5. ADS124S08 Device Package Installation Instructions

4.2 Connecting to the EVM Hardware

After the *Delta-Sigma ADC EvaluaTIon Software* and the *ADS124S08 Device Package* are installed, ensure that all jumpers and switches are in their default positions per Table 2, and then connect the hardware with the provided USB micro cable. Start the *Delta-Sigma ADC EvaluaTIon Software*. The GUI automatically detects the connected hardware and displays the device register map under the *Device* tab as shown in Figure 6.

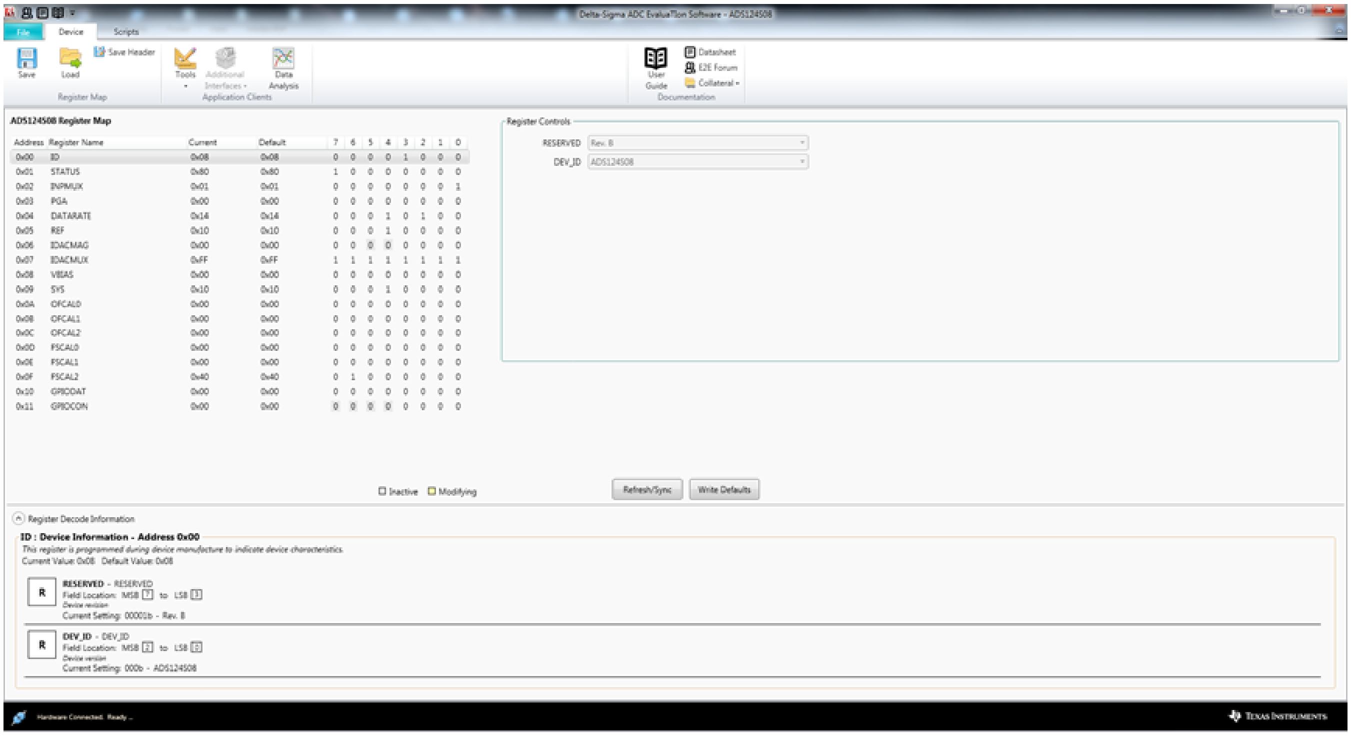


Figure 6. ADS124S08 Device Tab

4.3 *Using the Software With the ADS124S08EVM*

This section covers the functionality of the *ADS124S08 Device Package* only. For more information about the GUI operation and functionality, refer to the *Delta-Sigma ADC EvaluaTIon Software User Manual* (SBAU260) for the core software documentation. A link to the documentation is also available by navigating to *File -> Options* from within the GUI.

Upon startup, the GUI scans for the connected hardware. Once the ADS124S08EVM is plugged into the USB, the *Device* tab refreshes to display the ADS124S08 *Register Map* as shown in Figure 6. The *Device* tab also grants user control over register settings with a detailed description for the current values in each register. Click the *Refresh/Sync* button to read back the value in all registers and update the register map. Selecting a single register will provide a detailed description for the current values in the *Register Decode Information* panel below the register map (see the lower half of Figure 7).

As an example for register configuration, Figure 7 and Figure 8 show specific details for the input MUX (INPMUX) register. In the figures are two columns showing the *Current* and *Default* values represented in hex for the ADS124S08 registers. There is also a column of the binary representation of the current register settings.

In the *Register Control* section are drop-down menu options for each available setting for the register. Using the INPMUX register as an example, the upper 4 bits correspond to the MUXP selection and the lower 4 bits correspond to the MUXN selection. The drop-down menu items are shown for the MUXN selection in Figure 8 with the lower 4 bits highlighted. If the MUXP menu is selected, the upper 4 bits will be highlighted. A similar action occurs for each of the registers resulting in the binary column having the affected bits highlighted by each selected menu drop down. In this way, the bit segments of the register can be identified for the menu items affecting the changes.

It should be noted that some of the bits or register contents cannot be changed; such as the ID register and the calibration registers.

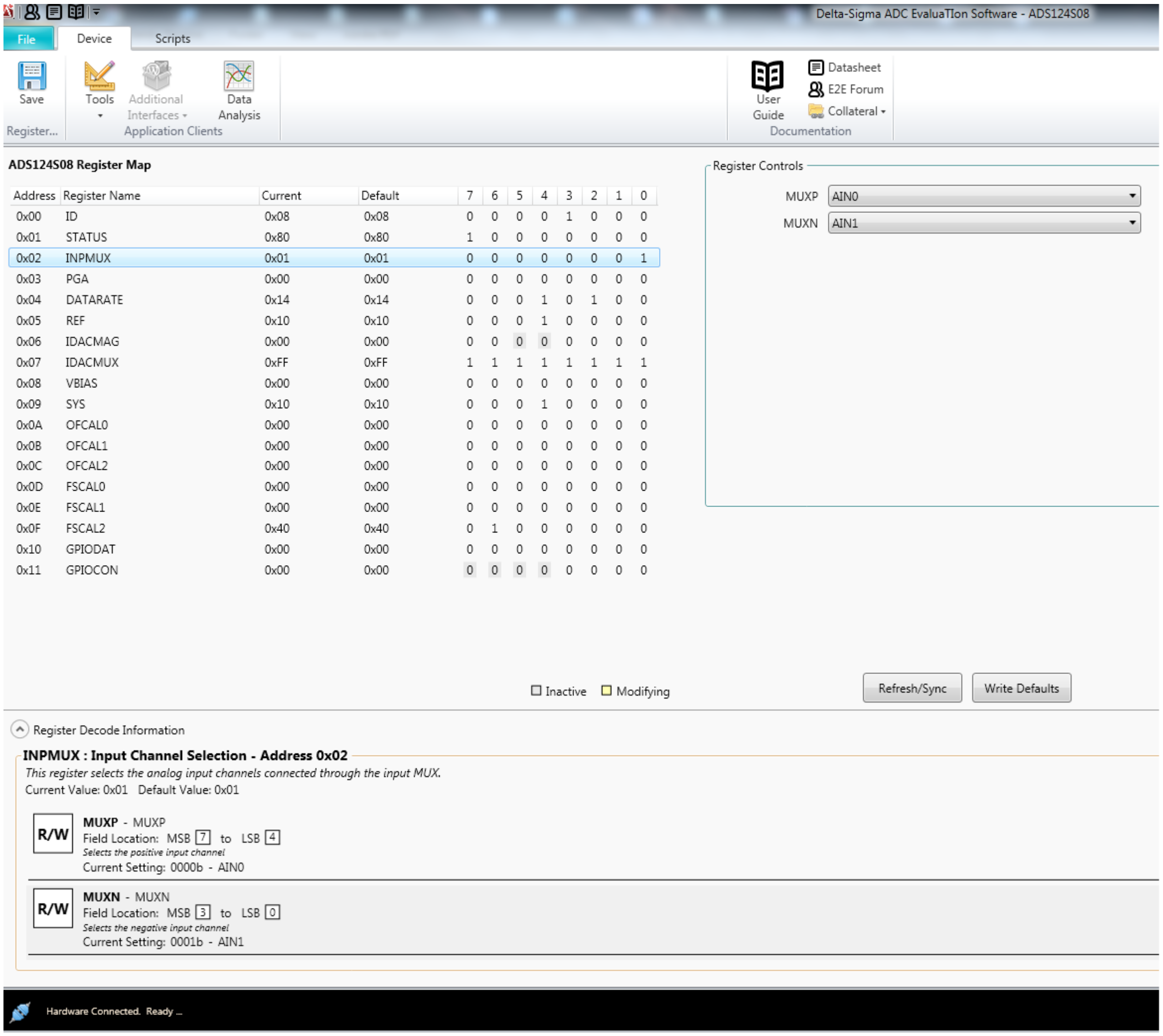


Figure 7. ADS124S08 Input Mux Register

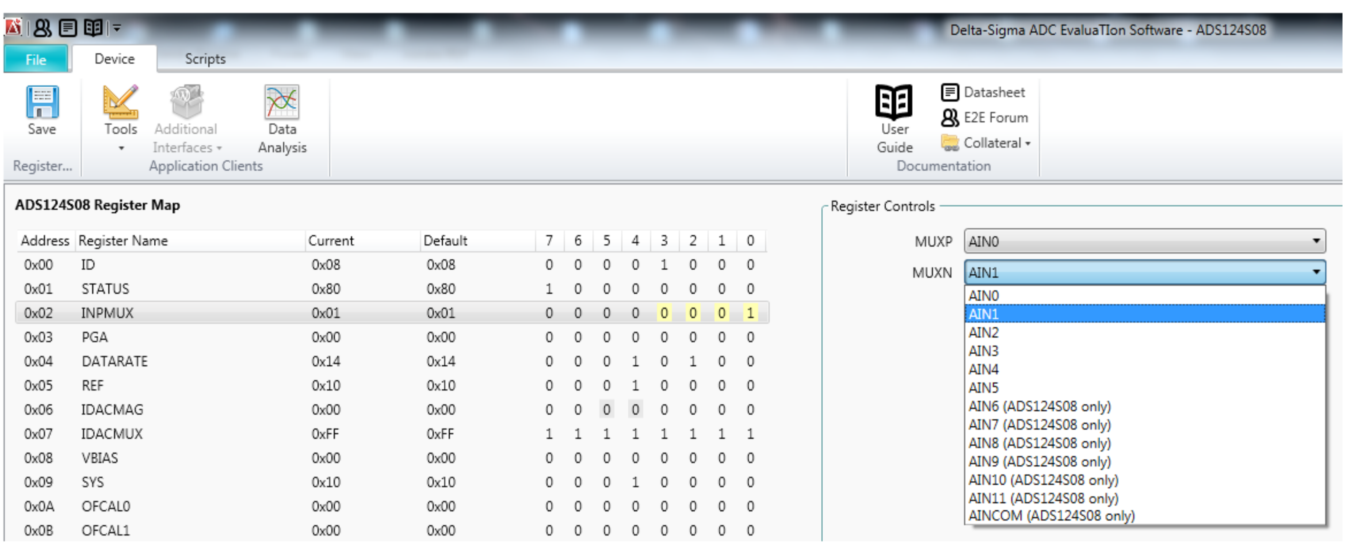


Figure 8. ADS124S08 Input Mux Selection

4.3.1 Data Collection

Data is collected through the GUI using the *Data Analysis* client which is accessed by clicking the corresponding *Data Analysis* icon in the upper left area in either the *Device* or *Scripts* tab. Details about data collection and saving collected data to a file are given in the *Delta-Sigma ADC EvaluaTIon Software User Manual* (SBAU260). In the lower right portion of the *Data Analysis* client window is a voltage reference setting (*VRef*) that defaults to the value of the internal reference of the ADS124S08. The correct *VRef* value is important when displaying the *Time Domain* plot. There is also an input selection for the number of samples to collect. The default value is 2048 samples. When ready to collect the data and display the results in the window, press the *Collect Data* button. The desired number of samples will be collected and displayed. The EVM will flash the D2 LED approximately once a second during the data collection as an indicator that conversion data are being collected.

Three views of the data are possible. The first view, Figure 9, is the *Data Inspector*. This view shows the result codes collected as either decimal or hex values. The result data can be saved to a file for later review or as import into another application.

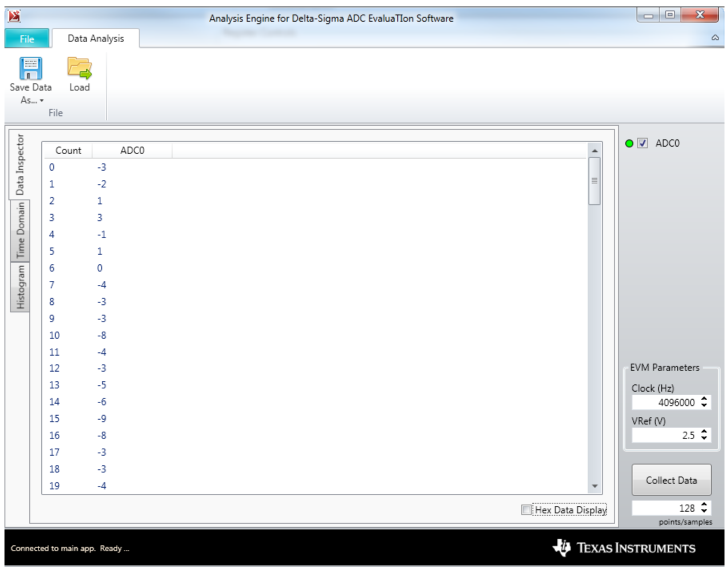


Figure 9. Data Inspector

The second view is shown in Figure 10 and is the *Time Domain* plot of the data. The data will display in the window based on the selection from the drop-down menu. The options are *Volts (Input Referred)*, *Volts*, and *Codes*. At the bottom of the display are statistic calculations of the collected data.

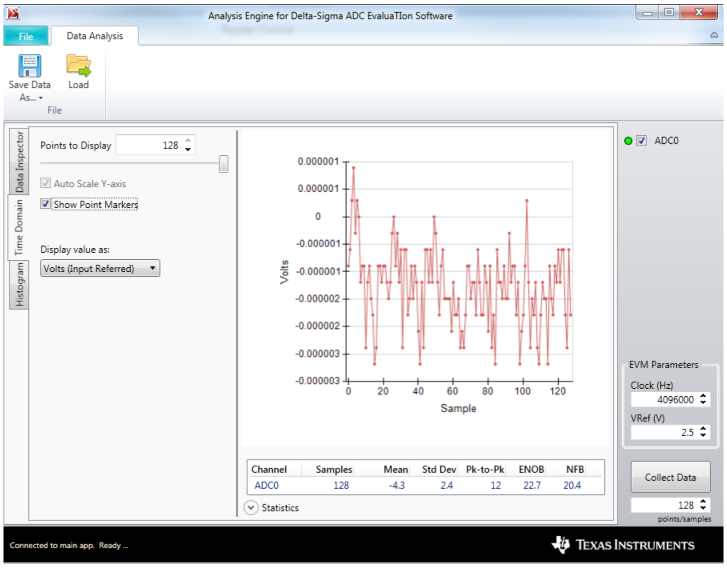


Figure 10. Time Domain

Along with the statistics information is the third view; the *Histogram* plot (Figure 11). The *Histogram* shows the distribution of the collected data based on the desired number of bins (# *Bins*) and the number of codes per bin (# *Codes/Bin*).

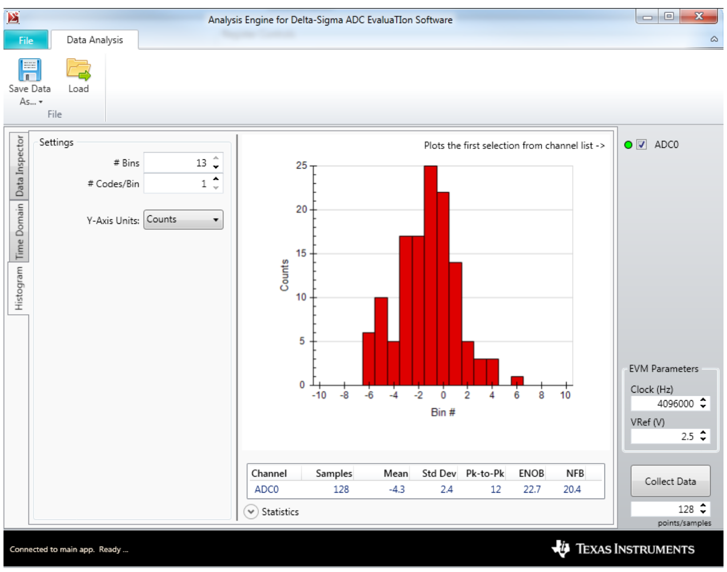


Figure 11. Histogram

The previous discussion pertains specifically to the ADC result data. In addition to the ADC data, *Status* or *CRC* data may be returned for *Data Analysis* depending on the settings in the *SYS* register. The result of *Status* and *CRC* data must be manually determined from the *Data Inspector* view. The data for *Status* and *CRC* will be meaningless for the *Time Domain* and *Histogram* views. It is suggested to uncheck *DSTATUS0* and *CRC0* boxes when viewing the *Time Domain* or *Histogram* plots.

4.3.2 ADS124S08 Commands

The ADS124S08EVM commands are given in Table 10. These commands are available for use within the *Scripts* tab. For more information about using scripts, refer to the *Delta-Sigma ADC EvaluaTIon Software User Manual* (SBAU260). Script usage as it applies to the ADS124S08EVM is further explained in Section 4.3.3.

Table 10. ADS124S08 EVM Software Commands

Command	Description	Format
NULL	Null command	NULL
WAKE	Wakeup from power-down mode	WAKE
SLEEP	Enter a low power state	SLEEP
RESET	Software reset - forces device into a POR state	RESET
START	Start or restart (synchronize) conversions	START
STOP	Stop conversions	STOP
SFOCAL	Self offset calibration	SFOCAL
SYOCAL	System offset calibration	SYOCAL
SYGCAL	System gain calibration	SYGCAL
RREG	Read <number> registers beginning at <address>	RREG <address> <number>
WREG	Write register <address> with <data>	WREG <address> <data>
READDATA	Read conversion result	READDATA
EVM GPIO Commands		
HOLDSTART	Hardware START pin control with <number>	HOLDSTART <number>
		Hold START pin low = 0
		Hold START pin high = 1
HOLDCLOCK	Hardware oscillator enable pin control with <number>	HOLDCLOCK <number>
		Oscillator (Y3) disable = 0
		Oscillator (Y3) enable = 1
Standard EVM Commands		
COLLECT	Collect data by collecting a <number> of samples	COLLECT <number>
COLLECTSTOP	End any data collection in progress	COLLECTSTOP
COMMANDLIST	Return the complete list of all available commands	COMMANDLIST
ID	Send EVM identification	ID
REGMAP	Return the current contents of the ADC register map	REGMAP

4.3.3 Using Scripts

There are a number of *Predefined* scripts found under the *Scripts* tab. Scripts are available for each of the sensor input configurations listed in Section 5.1. These *Predefined* scripts are meant to be a type of pseudo code describing the setup of registers and sequence of events for the various configurations.

Figure 12 demonstrates one of the *Predefined* scripts within the script window. Once loaded, the script will highlight the top entry. The script can *Run* through the entire script all at once, or can run *Step by step*. The same script can be run again by first clicking *Reset* to highlight the first step in the script. The *Predefined* scripts contain a description of the purpose of the script, and each element of the script describes the action contained in each step. A more detailed view of the script is shown in Figure 13. Each script element acts as pseudo code for showing the register configuration and program flow that can be used in an end-application.

The scripts can be edited and saved as *User*-defined scripts. Other scripting commands are given in Table 11 in addition to the commands for the EVM in Table 10.

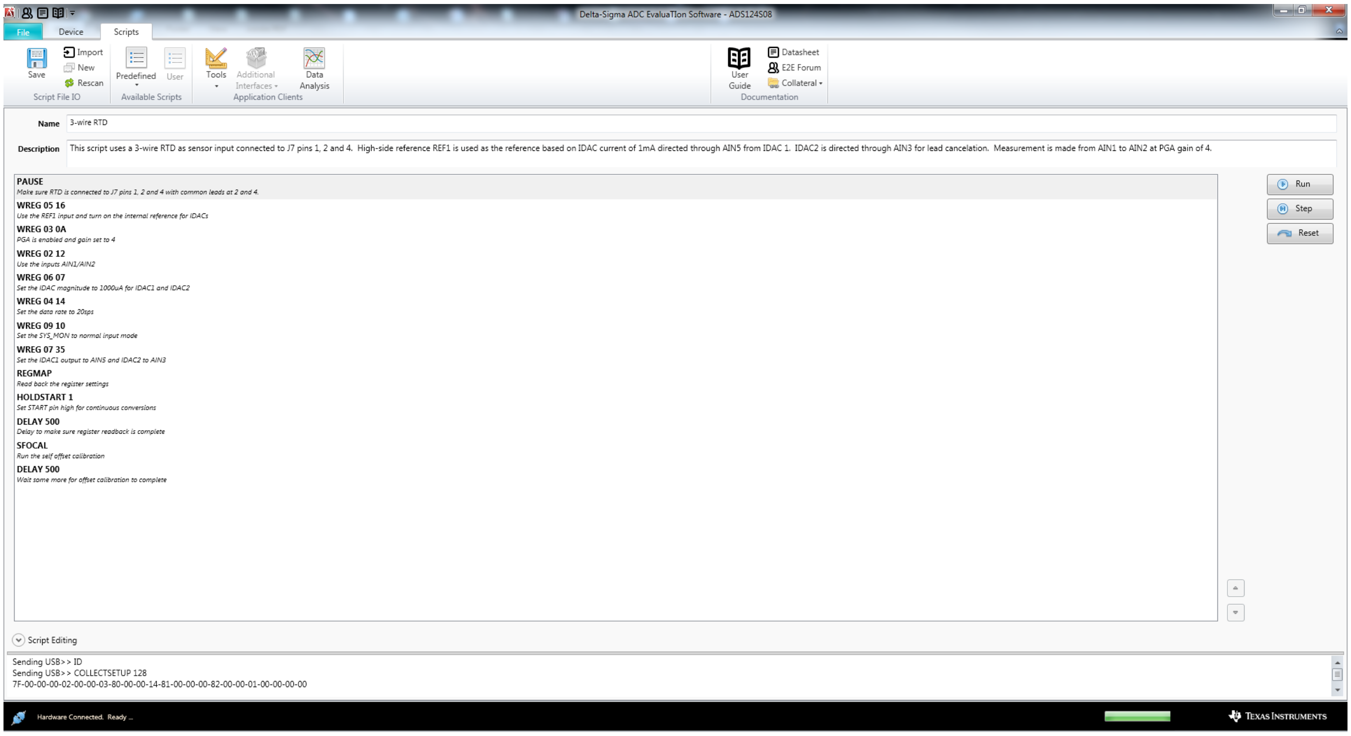


Figure 12. 3-Wire RTD Predefined Script

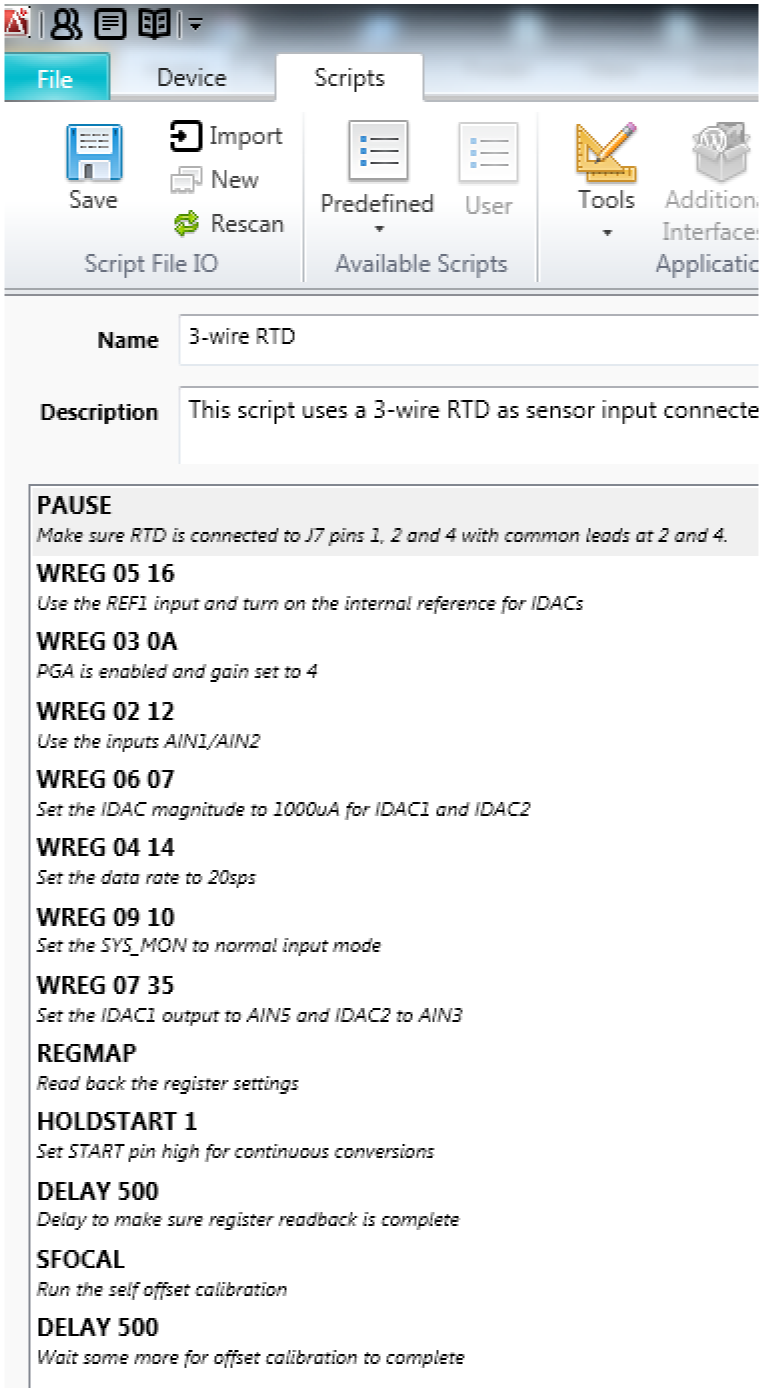


Figure 13. 3-Wire RTD Script Detail

Table 11. Special Scripting Commands

Command	Description	Format
DELAY	Delay <number> of milliseconds	DELAY <number>
PAUSE	Pause execution of running script	PAUSE
COLLECT	Collect <number> samples of data	COLLECT <number>
ANALYSIS	Open *Data Analysis* client to display data	ANALYSIS

5 EVM Hardware Details

5.1 Analog Inputs

The analog inputs to the EVM can be connected at the terminal blocks located on the left side of the board (J7, J8, and J9). At no time should an input voltage be applied that will exceed the absolute maximum input ratings of the ADS124S08 for the AVDD supply voltage being. The only exception is when measuring an external voltage as discussed in Section 5.1.3. Various combinations for direct sensor input are provided for common sensor types used with the ADS124S08. However, sensor connections are not limited to the devices mentioned and many additional sensor types and combinations can also be connected to the ADS124S08.

In the following discussion, the various sensor connections are meant to show how those sensors can be connected and used with the ADS124S08. J7 allows for RTD or thermocouple sensor input. For bridge, thermistor, or thermocouple sensors, J8 can be used. J9 is designated for voltage or current measurement.

5.1.1 RTD and Thermocouple Measurements Using J7

Two different sensor types can be connected to J7. Table 12 demonstrates the various connections for each sensor type, the excitation source and ADC measurement channels used. Thermocouple and RTDs are the primary sensor types.

Table 12. J7 Sensor Connector Options

Sensor	J7 Connection				Excitation (mA)	Current Source		ADC Inputs	
	TB-1	TB-2	TB-3	TB-4		AIN5	AIN3	AINP	AINN
2-wire RTD	A			B	1	Y		AIN1	AIN0
3-wire RTD	A	B		B	1	Y	Y	AIN1	AIN2
4-wire RTD	A	A	B	B	1	Y		AIN2	AIN4
Thermocouple[(1)]		+	–					AIN2	AIN4

(1) Thermocouple cold-junction can be measured by installing temperature sensor RT1 and using the 2-wire RTD configuration. See BOM Table 15 for sensor part information. Bias for proper common-mode can be provided from internal VBIAS connected to AIN4 or by installing equal value pullup and pulldown resistors at R62 and R89.

5.1.1.1 RTD Configurations

For RTD measurements the EVM circuit is designed for PT100 sensors. The sensor circuit uses a high-side ratiometric reference with a current source for excitation sourced from AIN5. The excitation current creates a voltage across R68 that is used for the REF1 inputs. The same reference current also excites the RTD for any RTD sensor type. To maintain a proper common-mode voltage when using PGA gain, return current from the RTD passes through R70. Resistor values for R68 and R70 can be changed as required, such as when using a PT1000 RTD. A connection diagram for a 3-wire RTD is shown in Figure 14. The same J7 terminal block is also used for 2-wire and 4-wire RTDs, but the input configuration is different for each RTD type. See Figure 15 for 2-wire connections and Figure 16 for 4-wire connections.

Using the high-side reference as a single current source allows for a ratiometric measurement for all RTD sensor types. This is not the case for a low-side reference and a 3-wire RTD using two current sources. The second current source cancels lead resistance from the measurement, but also adds the noise of the current source to the low-side reference. For the 3-wire case, the RTD and low-side reference are not truly ratiometric. This differs from the high-side reference which still allows the cancellation of the lead resistance for 3-wire RTDs by using an additional current source through AIN3 that is not a part of the reference circuit.

The measurement result will be the ratio of the RTD resistance to the reference resistance. The voltage drop across the RTD (V_{RTD}) is equal to the value of one code (LSB) times the number of codes in the ADC result. The full-scale range is based on the reference voltage which is equal to R68 times the excitation current (I_{EXC}).

$$Code_{LSB} = \text{Full-Scale Range / Total Number of Codes} = \pm V_{REF} / PGA / (2^{24} - 1) = 2 \times V_{REF} / PGA / (2^{24} - 1) \quad (1)$$

$$V_{RTD} = Code_{LSB} \times Result_{CODES} = (2 \times R68 \times I_{EXC} / PGA) / (2^{24} - 1) \times Result_{CODES} \text{ V} \quad (2)$$

V_{RTD} is also equal to the resistance of the RTD times the excitation current.

$$V_{RTD} = R_{RTD} \times I_{EXC} \quad (3)$$

Equating Equation 2 to Equation 3 and solving for the RTD resistance (R_{RTD}), the I_{EXC} term drops out of the equation and the RTD resistance R_{RTD} is found to be directly proportional to R68.

$$R_{RTD} = (2 \times R68 \times Result_{CODES} / PGA) / (2^{24} - 1) \quad (4)$$

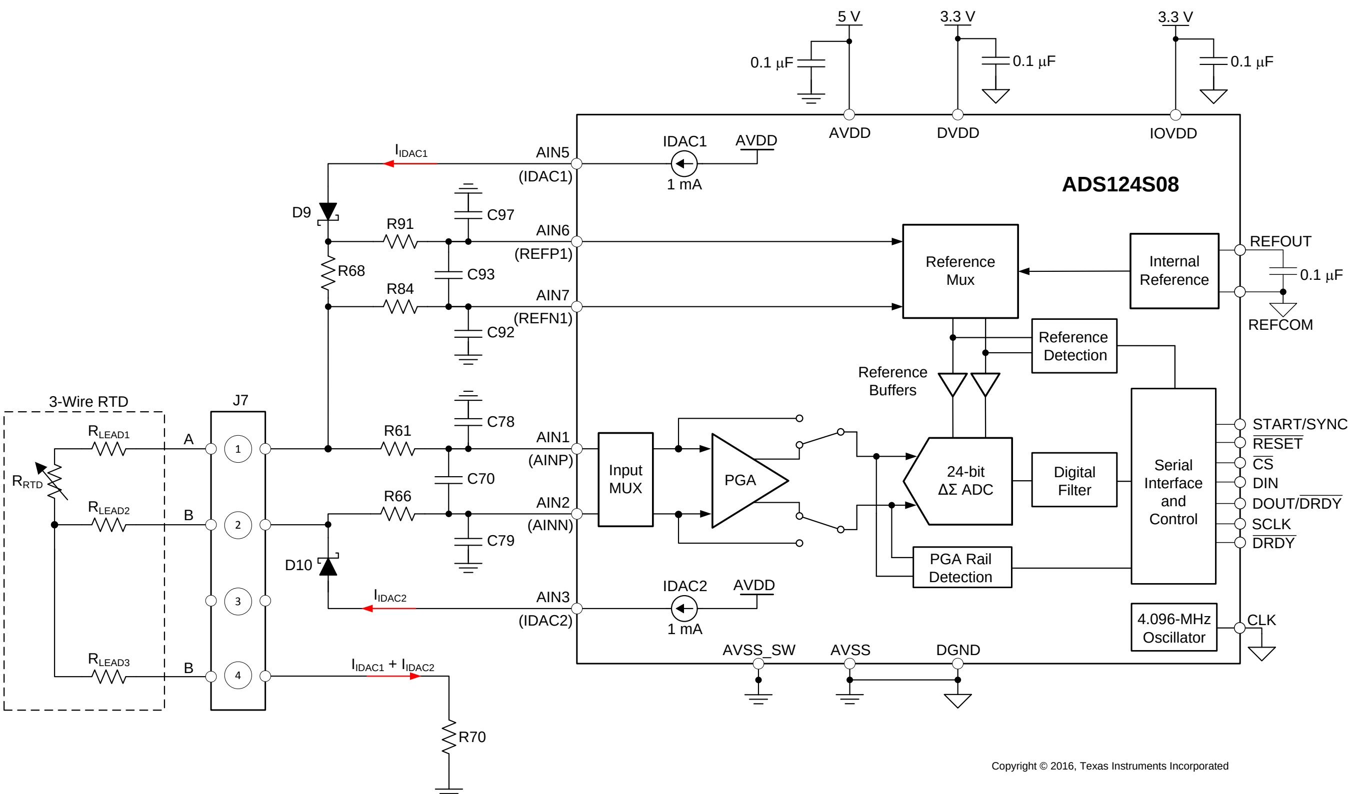


Figure 14. Simplified 3-Wire RTD Input Diagram

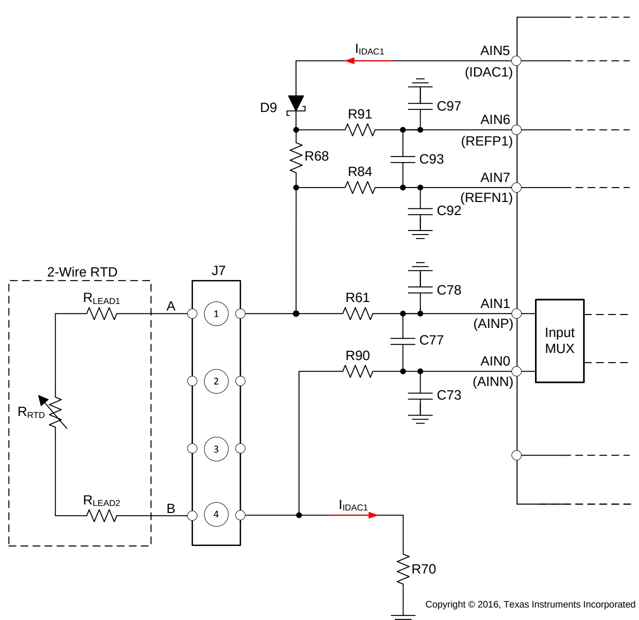


Figure 15. Simplified 2-Wire RTD Input Diagram

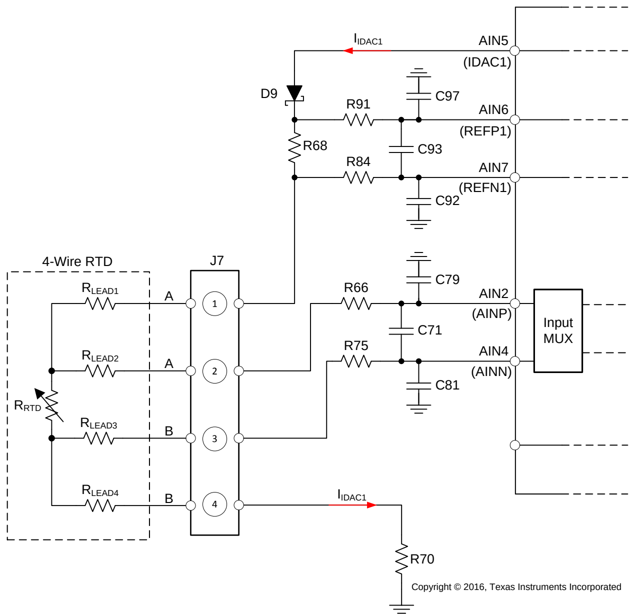


Figure 16. Simplified 4-Wire RTD Input Diagram

5.1.1.2 *Thermocouple Configuration*

When connecting a thermocouple to J7, the junction of the thermocouple and the terminal block create a second thermocouple. The temperature effect of the undesired thermocouple needs to be removed from the total temperature calculation. Typically, this calculation is described as cold-junction compensation. The cold-junction temperature can be measured by attaching an SMD chip, RTD, at RT1 (see Table 15 for device information) and calculating the cold-junction temperature from the RT1 resistance. Figure 17 is a connection diagram showing excitation of RT1 and the thermocouple input measurement channels.

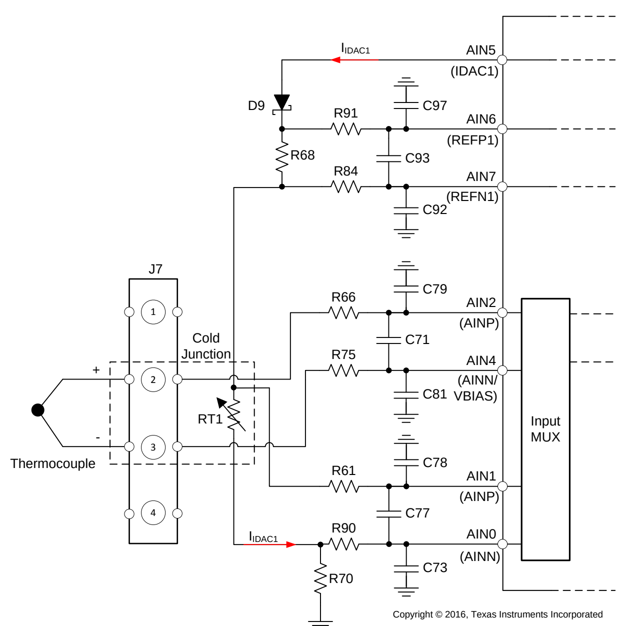


Figure 17. Simplified Thermocouple Input Diagram (J7)

The RTD resistance of RT1 can be calculated using Equation 4. Another method to calculate the resistance is to first measure the voltage drop across RT1 (V_{RT1}). V_{RT1} can be directly measured by the ADC and the resistance value of RT1 (R_{RT1}) can be calculated by dividing the measured voltage for V_{RT1} by the excitation current I_{IDAC1}.

$$R_{RT1} = V_{RT1} / I_{IDAC1}\ \Omega \quad (5)$$

If the PT100 chip RTD is used for RT1, standard PT100 lookup tables can be used to determine the cold-junction temperature. The cold-junction temperature is used to determine the cold-junction voltage (V_{CJ}) by using a reverse lookup table for the thermocouple type being used.

The temperature for the desired connected thermocouple at J7 is the addition of the voltages of the ADC measured thermocouple (V_{TC}) and the cold-junction voltage (V_{CJ}).

$$V_{ACTUAL} = V_{TC} + V_{CJ}\ V \quad (6)$$

The actual thermocouple temperature can be determined from the desired thermocouple-type lookup tables using V_{ACTUAL}. All thermocouple calculations can be accomplished using the polynomial equations for the thermocouple type being used instead of the lookup table.

5.1.2 Bridge, Thermistor, and Thermocouple Measurements Using J8

J8 allows for a variety of sensor input as detailed in Table 13.

Table 13. J8 Sensor Connector Options

Sensor	J8 Connection				Reference Inputs		ADC Inputs	
	TB-1	TB-2	TB-3	TB-4	REFP0	REFN0	AINP	AINN
Bridge	E+	S+	S–	E–	AVDD (JP8, 1-2)	AGND (JP11, 1-2)	AIN8	AIN9
Thermistor/Resistor	R1	R2/T1	T2		VREF (JP8, 2-3)	AGND (JP11, 2-3)	AIN8	AIN9
Thermocouple[(1)]		+	–				AIN8	AIN9

(1) Thermocouple cold-junction can be measured by using RT2 after installing jumper JP12. See Table 14 for more information. Bias for proper common-mode can be provided by installing equal value pullup and pulldown resistors at R71 and R72.

5.1.2.1 *Bridge Configuration*

Bridge sensors, such as a load-cell, can be connected so that the excitation of the bridge is also used as the ADC reference. This arrangement allows for a ratiometric measurement limiting the affects of noise and drift in the conversion result. The bridge connection is shown in Figure 18.

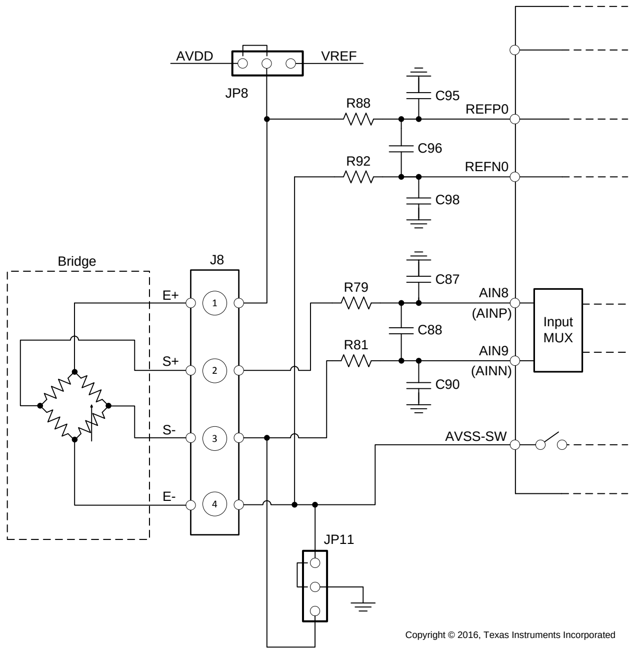


Figure 18. Simplified Bridge Input Diagram

When jumper JP8 is connected to the AVDD supply, AVDD becomes the source for excitation and is also connected to the REF0 reference input. One option for excitation return current to AGND can be accomplished by directly connecting the bridge to AGND by using JP11. Another option is to use the low-side switch internal to the ADS124S08 to complete the excitation current path (with JP11 removed).

As the measurement circuit is ratiometric, the output of the bridge will be proportional to the excitation. One type of bridge circuit is a strain gauge load-cell which is used in weight scales. A load-cell will have a sensitivity of a specific output voltage at full-rated capacity for each volt of excitation and is expressed as mV / V for full-scale output. The most common sensitivities range from 1 to 3 mV / V at the rated capacity of the load-cell. The desired result might be in resistance, weight, or pressure. However, the ADC output code result is related to a fraction of the reference voltage and because of this, bridge measurements are often confusing. A conversion to the desired result is required as the ADC does not measure any of the desired quantities directly.

As an example, the load-cell case will be used with a sensitivity of 2 mV / V and a full-scale capacity of 10 kg. The excitation and reference voltage is 5 V. The full-scale output voltage will be equal to the excitation voltage multiplied by the sensitivity.

$$V_{OUTPUT} = V_{EXC} \times V_{SENSITIVITY} = 5\text{ V} \times 2\text{ mV / V} = 10\text{ mV} \quad (7)$$

The full-scale range of the ADC is two times the reference voltage divided by the applied gain. As the output is very small, the maximum PGA gain can be applied.

$$V_{FS} = \pm(V_{REF} / PGA) = 2 \times V_{EXC} / PGA = 2 \times 5\text{ V} / 128 = 10 / 128 = 78.125\text{ mV} = \pm 39.0625\text{ mV} \quad (8)$$

For this example only about one-eighth of the total available full-scale range will be utilized. The impact of noise on the measurement must be carefully considered. Conversion noise will be a factor of the PGA setting, data rate, and digital filter setting. The conversion noise will directly impact the flicker-free scale resolution. A flicker-free or noise-free resolution occurs at the point where noise no longer affects the repeatability of the measurement. Repeatability can be calculated in a couple of different ways. One approach is to use the capacity of the load-cell times the noise (peak to peak) divided by the full-scale output at the rated capacity for the excitation being used. This approach gives a quick indication of the best case noise-free resolution of the measurement.

$$\text{Repeatability} = (\text{Capacity} \times V_{NOISEp\text{-}to\text{-}p}) / V_{OUTPUT} \quad (9)$$

Continuing the example using a PGA gain of 128, SINC3 filter and a data rate of 100 SPS, there may be typical noise of 520 nV, peak to peak. The repeatability can be calculated for the 10-kg capacity load-cell used.

$$\text{Repeatability} = (10\ \text{kg} \times 520\ \text{nV}) / 10\ \text{mV} = 520\ \text{mg} \tag{10}$$

Repeatability is also the representation of the value of a single noise-free code (count). As proof, a similar analysis approach using noise-free counts will result in the same repeatability. The ADC result has a voltage relationship that directly relates to the reference voltage and applied gain. A single count (code) is a function of the full-scale range of the ADC divided by the total available codes.

$$V_{CODE} = V_{FS} / (2^{(24)} - 1) = 78.125\ \text{mV} / 16777215 = 4.66\ \text{nV} \tag{11}$$

The number of codes representing conversion noise is the noise voltage divided by the voltage value of one code.

$$\text{Code}_{NOISE} = V_{NOISEp\text{-}to\text{-}p} / V_{CODE} = 520\ \text{nV} / 4.66\ \text{nV} = 111.7\ \text{codes} \tag{12}$$

The number of noise codes can be easily converted to number of bits which equates to 6.803 bits of noise. The total number of noise-free bits equals the total number of ADC bits (24-bit resolution for the ADS124S08) less the noise bits. For the example, the noise-free bits total 17.197 bits. The number of noise-free counts for the capacity of the load-cell is equal to the total available counts for noise-free resolution times the ratio of the maximum output of the load-cell to the full-scale range.

$$\text{Counts}_{NOISE\text{-}FREE} = 2^{(17.197)} \times V_{OUTPUT} / V_{FS} = 150249 \times 10\ \text{mV} / 78.125\ \text{mV} = 19232\ \text{codes} \tag{13}$$

Using the noise-free counts the repeatability will be equal to the capacity divided by the number of counts.

$$\text{Repeatability} = \text{Capacity} / \text{Counts}_{NOISE\text{-}FREE} = 10\ \text{kg} / 19232 = 520\ \text{mg} \tag{14}$$

As shown, the result of equation Equation 10 equates to Equation 14 and is proportional to the noise. The repeatability calculation is a best case scenario based solely on the typical converter noise with shorted input. Any system noise, such as EMI / RFI, will degrade the repeatability further.

5.1.2.2 Thermistor Configuration

Another sensor option for J8 is temperature measurement using a thermistor. Temperature is a calculation based on the resistance value of the thermistor. This measurement requires a known resistor to create a voltage divider in series with the thermistor. The thermistor connection is shown in Figure 19.

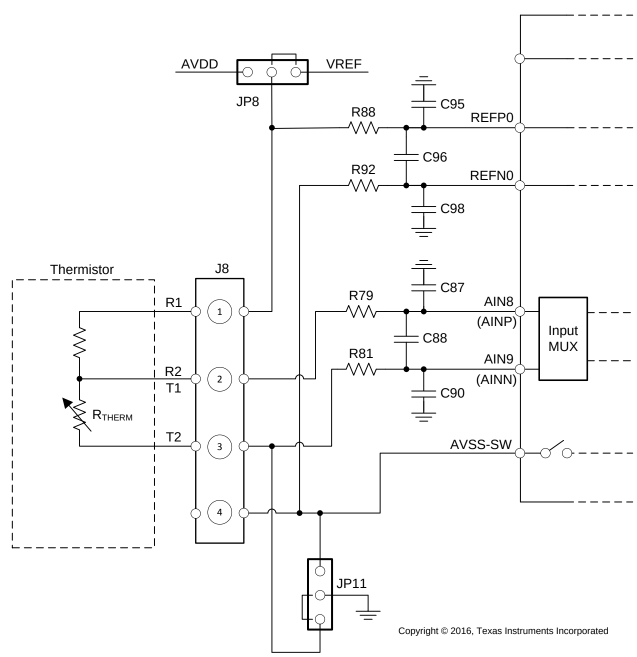


Figure 19. Simplified Thermistor Input Diagram

The series combination of the known resistance and the thermistor is excited using the VREF voltage source. The voltage drop across the thermistor is measured by the ADC and the resistance is calculated based on the current flowing in the series combination. The known resistance is used for calculating the current by dividing the known resistance voltage drop by the value of resistance.

$$R_{THERM} = V_{THERM} / I_{THERM} = V_{THERM} / [\ (VREF - V_{THERM}) / R_{KNOWN}\ ] = (V_{THERM} \times R_{KNOWN}) / (VREF - V_{THERM}) \tag{15}$$

Using the value of the calculated resistance, the temperature can be found using the lookup table for the thermistor being used.

5.1.2.3 Thermocouple Configuration

A thermocouple can also be connected to J8 with the cold-junction measured by thermistor RT2. To use RT2, JP12 must be shorted (installed). The previous discussion in Section 5.1.2.2 is similar to the measurement used on the EVM, except the thermistor is not directly measured. Instead, the voltage drop across RT2 is calculated based on the known resistance. Further discussion regarding this measurement is found in Section 5.1.3. The thermocouple connection when using J8 is shown in Figure 20.

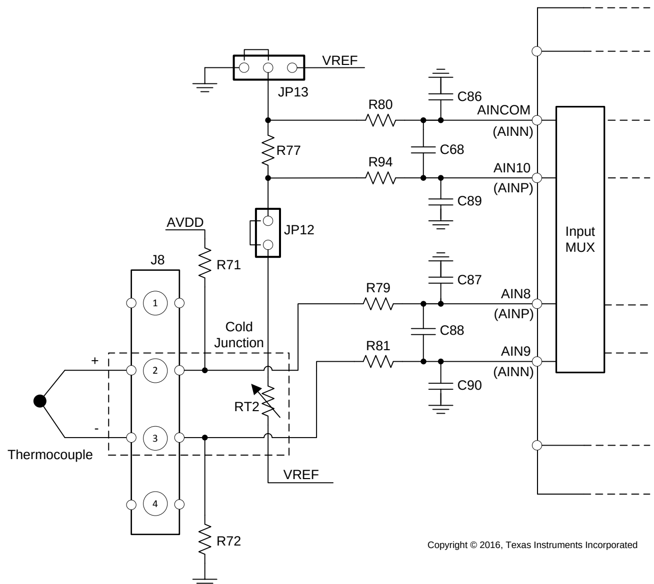


Figure 20. Simplified Thermocouple Input Diagram (J8)

5.1.3 Voltage and Current Measurements Using J9

Voltages measurements greater than AVDD and current measurements up to 24 mA can be made using J9. The possible input combinations are shown in Figure 21. Table 14 details the input range allowed for the possible configurations and analog supply voltages. The EVM uses a voltage divider (R76 and R77) so that up to 24 V can be applied when AINCOM is connected to AGND (JP13) and the reference voltage is AVDD (REF0). When AINCOM is connected to VREF (JP13), the input range changes to ±12 V to ensure the input remains within AVDD to AVSS. The measured voltage from the ADC must be converted to the proper input voltage value based on the scaling of the values of the resistor divider.

$$V_{IN} = V_{R77} \times (R76 + R77) / R77 = V_{R77} \times (93.1 + 24) / 24 = V_{R77} \times (117.1 / 24)\ V \quad (16)$$

When voltage measurements are taken, JP12 must be open, or not installed. It is not possible to measure an external voltage applied to J9 and also measure and calculate the voltage for RT2 at the same time.

Current measurement is a calculated measurement using the low-side shunt resistor R78 (100 Ω). The voltage drop across this resistor is measured by the ADC and current is calculated from the voltage result divided by the value of R78.

$$I_{IN} = V_{IN} / R78 = V_{IN} / 100\ A \quad (17)$$

Table 14. J9 Sensor Connector Options

Sensor	J9 Connection			AVDD (V)	AINCOM (JP13)	ADC Inputs	
	TB-1	TB-2	TB-3			AINP	AINN
0–24 V (REF = 5 V)	+		-	5	AGND	AIN10	AINCOM
0–15 V (REF = AVDD)	+		-	5 or 3.3	AGND	AIN10	AINCOM
±12 V (REF = 2.5 V)	±		Common	5	VREF	AIN10	AINCOM
0–24 mA		+	-	5 or 3.3	AGND	AIN11	AINCOM
±24 mA		±	Common	5	VREF	AIN11	AINCOM
±7 mA		±	Common	5 or 3.3	VREF	AIN11	AINCOM
Thermistor (RT2)	JP12-ON			5 or 3.3	AGND	AIN10	AINCOM

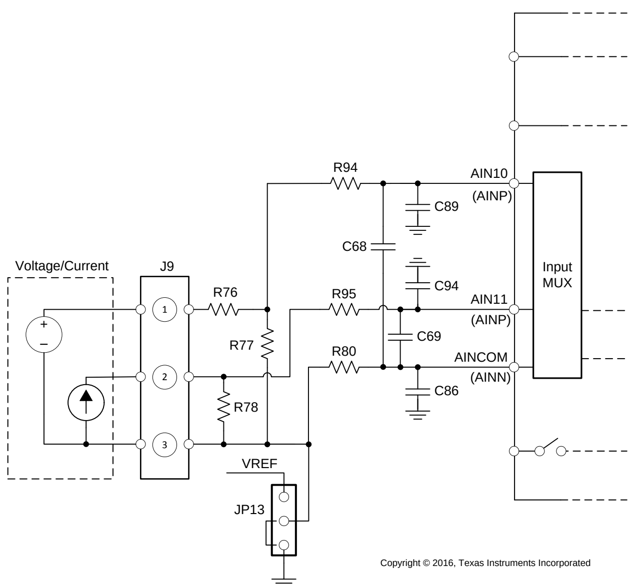


Figure 21. Simplified Voltage and Current Input Diagram

5.1.3.1 Thermistor Configuration and Measurement

The resistance of RT2 is a calculated measurement when JP12 is shorted (installed). RT2 is a part of a voltage divider circuit with R77 (Figure 20). The voltage drop across RT2 (V_{RT2}) is calculated from the value of VREF less the voltage drop across R77 (V_{R77}). V_{R77} is directly measured by the ADC. The current through RT2 is calculated from the voltage drop across R77 and the resistance value of R77. The resistance of RT2 is calculated from the voltage across RT2 divided by the current through R77. Temperature can be calculated from the resistance value of RT2 as given by the sensor manufacturer (Table 15).

$$R_{RT2} = (VREF - V_{R77}) / I_{R77} = (2.5\ V - V_{R77}) / (V_{R77} / 24\ k\Omega) = (2.5\ V \times 24\ k\Omega / V_{R77}) - 24\ k\Omega \quad (18)$$

5.2 Digital Inputs

Access the digital signals of the device using J3. The J3 header allows for the connection to a logic analyzer or when the EVM is used in a stand-alone configuration for connections to an external microprocessor or microcontroller.

If controlling the ADS124S08 with an external processor, power down the onboard TM4C1294NCPDT by placing a jumper on JP1. This can be accomplished by soldering a wire between the JP1 terminals or by installing a 2-pin, 0.1-in spaced header that has the pins shorted with a shorting block (see Table 3).

5.3 Clock

By default, a clock is supplied to the ADC using the internal oscillator of the ADS124S08. To connect an external clock to the device, follow the detailed information in Section 3.2.2.

5.4 ADC Reference

The reference of the ADC can be provided by using the internal reference of the ADS124S08, or by connecting an external reference source to either the REF0 or REF1 inputs on the EVM. External reference inputs are differential input pairs.

The REF1 input pair is dedicated for use with the high-side reference for ratiometric RTD measurements, and is excited by using the ADC current source. The REF1 current source must make a complete circuit path to AVSS (analog ground) for current to flow through resistor R68 when used to establish the reference voltage.

The REF0 input is primarily used to make ratiometric bridge measurements. The excitation voltage is also the reference voltage. The excitation voltage is supplied through JP8, and is either the AVDD supply voltage (selected at JP9), or the 2.5-V source (selected at JP14). The excitation path is completed by installing the jumper at JP11 to the analog ground (JP11, pins 1 and 2).

It is also possible to connect an independent voltage source to J8 pins 1 and 4. When connecting an external voltage, reference JP8 should be removed to prevent any voltage contention between voltage sources (Figure 22).

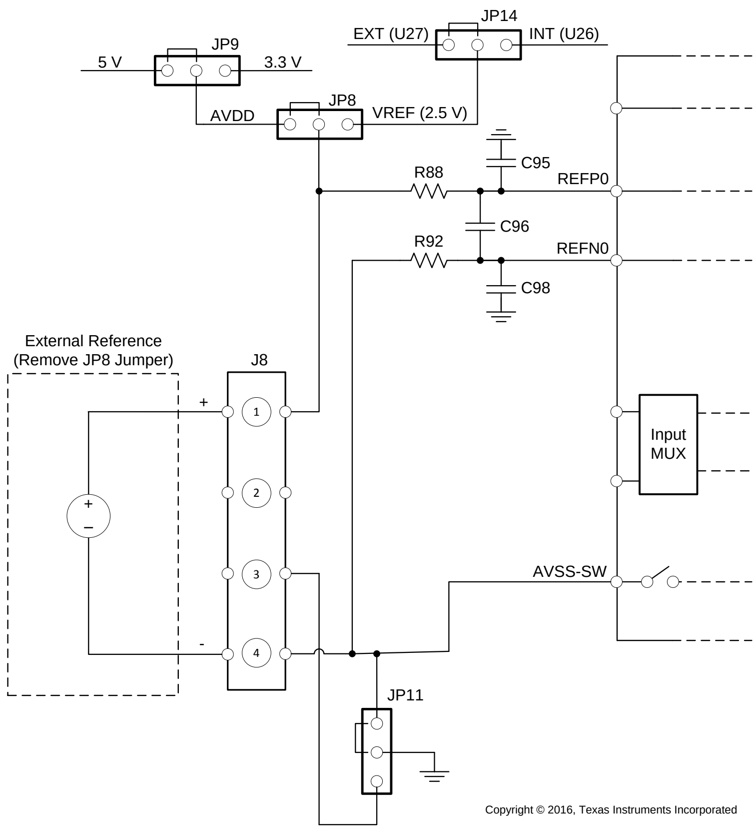


Figure 22. Simplified REF0 Input

5.5 Reset

Hardware reset the ADC by pressing S3. This is a whole system reset which resets the microcontroller and will re-enumerate the Tiva, when released. If only a reset of the ADC is required, then use the *Reset* command.

6 Power Supply Connections – EVM and ADC

6.1 Powering the EVM

The EVM is only powered by the USB connection at J1.

6.2 Powering the ADS124S08

The ADS124S08 analog supply is provided at the AVDD and AVSS connections. The digital section of the ADS124S08 requires a DVDD supply for the ADC core digital and an IOVDD supply for the digital interface.

6.2.1 Analog Supply Configuration

The EVM is designed to be operated by using a unipolar supply. This means that AVSS is tied to analog ground and bipolar supply operation is unavailable on the EVM. For AVDD, two possible voltage sources are available at jumper JP9. Achieving 3.3 V is possible when JP9 pins 1 and 2 are shorted and 5 V is possible by shorting JP9 pins 2 and 3 (default). Jumper JP5 can be used for direct current measurement of the AVDD current into the ADC by removing the jumper and connecting a DC current meter between the pins.

6.2.2 Digital Supply

The digital supply has only one voltage source option of 3.3 V for both DVDD and IOVDD. Jumper JP6 can be used for direct current measurement of the IOVDD current into the ADC by removing the jumper and connecting a DC current meter between the pins. DVDD current can be measured at JP7.

7 ADS124S08 Bill of Materials, PCB Layouts, and Schematics

7.1 Bill of Materials

NOTE: All components should be compliant with the *European Union Restriction on Use of Hazardous Substances* (RoHS) directive. Some part numbers may be either leaded or RoHS. Verify that purchased components are RoHS-compliant. (For more information about TI's position on RoHS compliance, see http://www.ti.com.)

Table 15. ADS124S08 EVM Bill of Materials

Designator	Qty	Value	Description	Package Reference	Part Number	Manufacturer	Alternate Part Number	Alternate Manufacturer
!PCB1	1		Printed Circuit Board		PA014	Any		
C1, C20	2	2.2uF	CAP, CERM, 2.2 µF, 35 V, ± 10%, X5R, 0603	0603	GRM188R6YA225KA12D	Murata		
C2, C3, C4, C5, C6, C7, C11, C16, C17, C18, C19, C22, C23, C24, C25, C26, C27, C30, C35, C74, C75	21	0.1uF	CAP, CERM, 0.1 µF, 25 V, ± 5%, X7R, 0603	0603	06033C104JAT2A	AVX		
C12, C13	2	6.8pF	CAP, CERM, 6.8 pF, 50 V, ± 4%, C0G/NP0, 0603	0603	06035A6R8CAT2A	AVX		
C14, C15	2	12pF	CAP, CERM, 12 pF, 50 V, ± 5%, C0G/NP0, 0603	0603	C0603C120J5GACTU	Kemet		
C21, C38, C39, C41, C42, C76, C80, C91	8	1uF	CAP, CERM, 1 µF, 25 V, ± 10%, X7R, 0603	0603	GRM188R71E105KA12D	Murata		
C31	1	4.7uF	CAP, CERM, 4.7 µF, 50 V, ± 10%, X7R, 1206	1206	GRM31CR71H475KA12L	Murata		
C32	1	22uF	CAP, CERM, 22 µF, 16 V, ± 20%, X7R, 1210	1210	C3225X7R1C226M	TDK		
C33	1	10uF	CAP, CERM, 10 µF, 25 V, ± 10%, X7R, 1206_190	1206_190	C1206C106K3RACTU	Kemet		
C34	1	100pF	CAP, CERM, 100 pF, 25 V, ± 10%, X7R, 0603	0603	06033C101KAT2A	AVX		
C36	1	47uF	CAP, CERM, 47 µF, 16 V, ± 15%, X5R, 1206	1206	C3216X5R1C476M160AB	TDK		
C37	1	0.01uF	CAP, CERM, 0.01 µF, 250 V, ± 10%, C0G/NP0, 0603	0603	C1608C0G1E103J	TDK		
C40, C43	2	1000pF	CAP, CERM, 1000 pF, 100 V, ± 5%, X7R, 0603	0603	06031C102JAT2A	AVX		
C68, C69, C70, C71, C77, C88, C93, C96	8	4700pF	CAP, CERM, 4700 pF, 25 V, ± 5%, C0G/NP0, 0603	0603	C1608C0G1E472J	TDK		
C72	1	10uF	CAP, CERM, 10 µF, 25 V, ± 20%, X5R, 0603	0603	GRM188R61E106MA73D	Murata		
C73, C78, C79, C81, C86, C87, C89, C90, C92, C94, C95, C97, C98	13	470pF	CAP, CERM, 470 pF, 50 V, ± 5%, C0G/NP0, 0603	0603	GRM1885C1H471JA01D	Murata		
C83, C85	2	0.33uF	CAP, CERM, 0.33 µF, 16 V, ± 10%, X7R, 0603	0603	C0603C334K4RACTU	Kemet		
D1, D2, D4	3	Green	LED, Green, SMD	LED_0603	LTST-C191TGKT	Lite-On		
D3	1	Red	LED, Red, SMD	LED_0603	LTST-C191KRKT	Lite-On		
D9, D10	2	70V	Diode, Schottky, 70 V, 0.07 A, SOT-23	SOT-23	BAS70-7-F	Diodes Inc.		
H1, H2, H3, H4	4		Bumpon, Cylindrical, 0.312 X 0.200, Black	Black Bumpon	SJ61A1	3M		
J1	1		Connector, Receptacle, Micro-USB Type B, R/A, Bottom Mount SMT	7.5x2.45x5mm	0473460001	Molex		
J7, J8	2		Terminal Block, 3.5mm Pitch, 4x1, TH	14x8.2x6.5mm	ED555/4DS	On-Shore Technology		
J9	1		Terminal Block, 3.5mm Pitch, 3x1, TH	10.5x8.2x6.5mm	ED555/3DS	On-Shore Technology		
JP5, JP6, JP7, JP12	4		Header, 2mm, 2x1, Tin, TH	Header, 2mm, 2x1	TMM-102-01-T-S	Samtec		

Table 15. ADS124S08 EVM Bill of Materials (continued)

Designator	Qty	Value	Description	Package Reference	Part Number	Manufacturer	Alternate Part Number	Alternate Manufacturer
JP8, JP9, JP11, JP13, JP14	5		Header, 2mm, 3x1, Tin, TH	Header, 2mm, 3x1	TMM-103-01-T-S	Samtec		
L1	1	1uH	Inductor, Wirewound, Ferrite, 1 µH, 2.05 A, 0.045 ohm, SMD	1210	LQH32PN1R0NN0	Murata		
LBL1	1		Thermal Transfer Printable Labels, 0.650" W x 0.200" H - 10,000 per roll	PCB Label 0.650"H x 0.200"W	THT-14-423-10	Brady		None
R1, R22, R24, R25, R40	5	1.00k	RES, 1.00 k, 1%, 0.1 W, 0603	0603	CRCW06031K00FKEA	Vishay-Dale		
R2	1	8.06k	RES, 8.06 k, 1%, 0.1 W, 0603	0603	CRCW06038K06FKEA	Vishay-Dale		
R3, R10, R19, R21, R86, R87	6	10.0k	RES, 10.0 k, 1%, 0.1 W, 0603	0603	CRCW060310K0FKEA	Vishay-Dale		
R4, R12	2	100	RES, 100, 1%, 0.1 W, 0603	0603	CRCW0603100RFKEA	Vishay-Dale		
R9, R17, R33, R36, R83, R85, R93, R96, R97	9	0	RES, 0, 5%, 0.1 W, 0603	0603	CRCW06030000Z0EA	Vishay-Dale		
R11	1	1.00Meg	RES, 1.00 M, 1%, 0.1 W, 0603	0603	CRCW06031M00FKEA	Vishay-Dale		
R13	1	4.87k	RES, 4.87 k, 1%, 0.1 W, 0603	0603	CRCW06034K87FKEA	Vishay-Dale		
R14	1	2.00k	RES, 2.00 k, 1%, 0.1 W, 0603	0603	CRCW06032K00FKEA	Vishay-Dale		
R18	1	51	RES, 51, 5%, 0.1 W, 0603	0603	CRCW060351R0JNEA	Vishay-Dale		
R20, R23, R32	3	100k	RES, 100 k, 1%, 0.1 W, 0603	0603	CRCW0603100KFKEA	Vishay-Dale		
R28, R39, R41	3	0.1	RES, 0.1, 1%, 0.1 W, 0603	0603	ERJ-L03KF10CV	Panasonic		
R29	1	768k	RES, 768 k, 1%, 0.1 W, 0603	0603	RC0603FR-07768KL	Yageo America		
R30	1	20.0k	RES, 20.0 k, 1%, 0.1 W, 0603	0603	RC0603FR-0720KL	Yageo America		
R31	1	215k	RES, 215 k, 1%, 0.1 W, 0603	0603	RC0603FR-07215KL	Yageo America		
R57, R58, R59, R60, R63, R64, R67, R69	8	47	RES, 47, 5%, 0.1 W, 0603	0603	CRCW060347R0JNEA	Vishay-Dale		
R61, R66, R75, R79, R80, R81, R84, R88, R90, R91, R92, R94, R95	13	4.12k	RES, 4.12 k, 1%, 0.1 W, 0603	0603	RC0603FR-074K12L	Yageo America		
R68, R70	2	1.00k	RES, 1.00 k, 0.1%, 0.125 W, 0805	0805	RG2012P-102-B-T5	Susumu Co Ltd		
R74	1	470k	RES, 470 k, 5%, 0.1 W, 0603	0603	CRCW0603470KJNEA	Vishay-Dale		
R76	1	93.1k	RES, 93.1 k, 0.1%, 0.1 W, 0603	0603	RG1608P-9312-B-T5	Susumu Co Ltd		
R77	1	24.0k	RES, 24.0 k, 0.1%, 0.1 W, 0603	0603	RG1608P-243-B-T5	Susumu Co Ltd		
R78	1	100	RES, 100, 0.1%, 0.1 W, 0603	0603	RG1608P-101-B-T5	Susumu Co Ltd		
R82	1	1.1	RES, 1.1, 5%, 0.1 W, 0603	0603	CRCW06031R10JNEA	Vishay-Dale		
RT2	1	15k ohm	Thermistor NTC, 15k ohm, 5%, 0805	0805	NCP21XW153J03RA	Murata		
S3, S4	2		Switch, Tactile, SPST-NO, 0.05A, 12V, SMT	Switch, 4.4x2x2.9 mm	TL1015AF160QG	E-Switch		
SH-JP5, SH-JP6, SH-JP7, SH-JP8, SH-JP9, SH-JP11, SH-JP12, SH-JP13, SH-JP14	9	1x2	Shunt, 2mm, Gold plated, Black	2mm Shunt, Closed Top	Samtec	2SN-BK-G		
TP17, TP18	2	Double	Terminal, Turret, TH, Double	Keystone1573-2	1573-2	Keystone		
U1	1		Tiva C Series Microcontroller, PDT0128A	PDT0128A	TM4C1294NCPDTI3R	Texas Instruments	TM4C1294NCPDTI3	Texas Instruments
U2	1		Highly Integrated Full Featured Hi-Speed USB 2.0 ULPI Transceiver, QFN-32	5x5 QFN-32	USB3320C-EZK	Microchip		
U3	1		USB ESD Solution with Power Clamp, 4 Channels, -40 to +85 deg C, 6-pin SON (DRY), Green (RoHS & no Sb/Br)	DRY0006A	TPD4S012DRYR	Texas Instruments	Equivalent	Texas Instruments

Table 15. ADS124S08 EVM Bill of Materials (continued)

Designator	Qty	Value	Description	Package Reference	Part Number	Manufacturer	Alternate Part Number	Alternate Manufacturer
U5, U7	2		8-BIT BIDIRECTIONAL VOLTAGE-LEVEL TRANSLATOR FOR OPEN-DRAIN AND PUSH-PULL APPLICATIONS, RGY0020A	RGY0020A	TXS0108ERGYR	Texas Instruments		Texas Instruments
U6, U8	2		SINGLE BUFFER/DRIVER WITH OPEN-DRAIN OUTPUT, DCK0005A	DCK0005A	SN74LVC1G07DCKR	Texas Instruments	SN74LVC1G07DCKT	Texas Instruments
U9	1		Dual Inverter Buffer/Driver With Open-Drain Outputs, DCK0006A	DCK0006A	SN74LVC2G06DCKR	Texas Instruments		Texas Instruments
U11	1		Single Inverter Buffer/Driver With Open-Drain Output, DCK0005A	DCK0005A	SN74LVC1G06DCKR	Texas Instruments	SN74LVC1G06DCKT	Texas Instruments
U13	1		TINY 1.5-A BOOST CONVERTER WITH ADJUSTABLE INPUT CURRENT LIMIT, DSG0008A	DSG0008A	TPS61252DSGR	Texas Instruments	TPS61252DSGT	Texas Instruments
U14	1		36-V, 1-A, 4.17-uVRMS, RF LDO Voltage Regulator, RGW0020A	RGW0020A	TPS7A4700RGWR	Texas Instruments	TPS7A4700RGWT	Texas Instruments
U15	1		Single Output High PSRR LDO, 150 mA, Fixed 1.8 V Output, 2.5 to 6.5 V Input, with Low IQ, 5-pin SC70 (DCK), -40 to 85 deg C, Green (RoHS & no Sb/Br)	DCK0005A	TPS71718DCKR	Texas Instruments	Equivalent	Texas Instruments
U16	1		3-Pin Voltage Supervisors with Active-Low, Open-Drain Reset, DBZ0003A	DBZ0003A	TLV803MDBZR	Texas Instruments	TLV803MDBZT	Texas Instruments
U17	1		1-A Low-Dropout Regulator With Reverse Current Protection, DRV0006A	DRV0006A	TPS73733DRVR	Texas Instruments	TPS73733DRVT	Texas Instruments
U25	1		High-Speed USB 2.0 (480 Mbps) 1:2 Multiplexer / Demultiplexer Switch with Single Enable, 6 ohm RON, 2.5 to 3.3V, -40 to 85 deg C, 10-Pin UQFN (RSE), Green (RoHS & no Sb/Br)	RSE0010A	TS3USB221ERSER	Texas Instruments	Equivalent	Texas Instruments
U26	1		Low-Power, Low-Noise, Highly-Integrated, 12-Channel, 24-Bit, Delta-Sigma Analog-to-Digital Converter (ADC) with Programmable Gain Amplifier (PGA) and Voltage Reference, PBS0032A	PBS0032A	ADS124S08IPBSR	Texas Instruments	ADS124S08IPBS	Texas Instruments
U27	1		Low Noise, Very Low Drift, Precision Voltage Reference, -40 to 125 deg C, 8-pin MSOP(DGK), Green (RoHS & no Sb/Br)	DGK0008A	REF5025AIDGKR	Texas Instruments	Equivalent	Texas Instruments
Y1	1		CRYSTAL, 32.768KHZ, 7PF, SMD	1.5x1.4x6.7mm	SSPT7F-7PF20-R	Seiko Instruments		
Y2	1		Crystal, 25 MHz, 18 pF, SMD	ABM3	ABM3-25.000MHZ-D2Y-T	Abracon Corporation		
C8	0	10uF	CAP, CERM, 10 µF, 25 V, ± 20%, X5R, 0603	0603	GRM188R61E106MA73D	Murata		
C9, C10, C28, C29, C45, C54, C56, C60, C65, C82	0	0.1uF	CAP, CERM, 0.1 µF, 25 V, ± 5%, X7R, 0603	0603	06033C104JAT2A	AVX		
C44, C46, C48, C51, C52, C53, C62, C63, C64	0	10uF	CAP, CERM, 10 µF, 35 V, ± 10%, X7R, 1206	1206	GMK316AB7106KL	Taiyo Yuden		
C47, C50, C55, C61, C66	0	0.01uF	CAP, CERM, 0.01 µF, 25 V, ± 10%, X7R, 0603	0603	GRM188R71E103KA01D	Murata		
C49	0	1uF	CAP, CERM, 1 µF, 25 V, ± 10%, X7R, 0603	0603	GRM188R71E105KA12D	Murata		
C57	0	1100pF	CAP, CERM, 1100 pF, 50 V, ± 5%, C0G/NP0, 0603	0603	GRM1885C1H112JA01D	Murata		
C58	0	0.22uF	CAP, CERM, 0.22 µF, 25 V, ± 10%, X5R, 0603	0603	06033D224KAT2A	AVX		
C59	0	10pF	CAP, CERM, 10 pF, 50 V, ± 5%, C0G/NP0, 0603	0603	06035A100JAT2A	AVX		
C67	0	4700pF	CAP, CERM, 4700 pF, 100 V, ± 10%, X7R, 0603	0603	06031C472KAT2A	AVX		
C84	0	0.01uF	CAP, CERM, 0.01 µF, 25 V, ± 5%, C0G/NP0, 0603	0603	C0603H103J3GACTU	Kemet		
D5	0	12V	Diode, TVS, Uni, 12 V, 600 W, SMB	SMB	SMBJ12A-13-F	Diodes Inc.		
D6	0	Green	LED, Green, SMD	LED_0603	LTST-C191TGKT	Lite-On		
D7	0	20V	Diode, Schottky, 20 V, 1 A, SOD-123F	SOD-123F	PMEG2010AEH,115	NXP Semiconductor		

Table 15. ADS124S08 EVM Bill of Materials (continued)

Designator	Qty	Value	Description	Package Reference	Part Number	Manufacturer	Alternate Part Number	Alternate Manufacturer
D8	0	20V	Diode, Schottky, 20 V, 1.1 A, DO-219AB	DO-219AB	SL02-GS08	Vishay-Semiconductor		
F1	0		Fuse, 2 A, 125 V, SMD	SMD, 2-Leads, Body 9.73x5.03mm	0154002.DRT	Littelfuse		
FID1, FID2, FID3, FID4, FID5, FID6	0		Fiducial mark. There is nothing to buy or mount.	N/A	N/A	N/A		
H5	0		CABLE USB-A TO MICRO USB-B 0.5M		102-1092-BL-00100	CNC Tech	-	-
J2	0		Header, 100mil, 7x1, Gold, TH	7x1 Header	TSW-107-07-G-S	Samtec		
J3	0		Header, 2.54 mm, 28x2, Gold, TH	Header, 2.54 mm, 28x2, TH	TSW-128-07-S-D	Samtec		
J4	0		Terminal Block, 6A, 3.5mm Pitch, 2-Pos, TH	7.0x8.2x6.5mm	ED555/2DS	On-Shore Technology		
J5	0		Connector, DC Jack 2.1X5.5 mm, TH	POWER JACK, 14.4x11x9mm	PJ-102A	CUI Inc.		
J6, JP1, JP2, JP4	0		Header, 100mil, 2x1, Gold, TH	2x1 Header	TSW-102-07-G-S	Samtec		
JP3, JP10	0		Header, 100mil, 3x1, Gold, SMT	Samtec_TSM-103-01-X-SV	TSM-103-01-L-SV	Samtec		
L2	0	3.3uH	Inductor, Shielded Drum Core, Ferrite, 3.3 µH, 1.5 A, 0.033 ohm, SMD	CDPH4D19F	CDPH4D19FNP-3R3MC	Sumida		
L3	0	10uH	Inductor, Shielded Drum Core, Ferrite, 10 µH, 1.2 A, 0.124 ohm, SMD	CDRH5D18	CDRH5D18NP-100NC	Sumida		
R5, R7, R15, R16, R26, R44, R56	0	10.0k	RES, 10.0 k, 1%, 0.1 W, 0603	0603	CRCW060310K0FKEA	Vishay-Dale		
R6, R8	0	100	RES, 100, 1%, 0.1 W, 0603	0603	CRCW0603100RFKEA	Vishay-Dale		
R27, R53	0	100k	RES, 100 k, 1%, 0.1 W, 0603	0603	CRCW0603100KFKEA	Vishay-Dale		
R34, R35, R37, R38	0	0	RES, 0, 5%, 0.1 W, 0603	0603	CRCW06030000Z0EA	Vishay-Dale		
R42	0	1k	RES, 1.00 k, 1%, 0.1 W, 0603	0603	CRCW06031K00FKEA	Vishay-Dale		
R43	0	9.31k	RES, 9.31 k, 1%, 0.1 W, 0603	0603	CRCW06039K31FKEA	Vishay-Dale		
R45	0	3.01k	RES, 3.01 k, 1%, 0.1 W, 0603	0603	CRCW06033K01FKEA	Vishay-Dale		
R46	0	158k	RES, 158 k, 1%, 0.1 W, 0603	0603	CRCW0603158KFKEA	Vishay-Dale		
R47	0	453k	RES, 453 k, 1%, 0.1 W, 0603	0603	CRCW0603453KFKEA	Vishay-Dale		
R48	0	51.1k	RES, 51.1 k, 1%, 0.1 W, 0603	0603	CRCW060351K1FKEA	Vishay-Dale		
R49	0	49.9k	RES, 49.9 k, 1%, 0.1 W, 0603	0603	CRCW060349K9FKEA	Vishay-Dale		
R50	0	15.0k	RES, 15.0 k, 1%, 0.1 W, 0603	0603	CRCW060315K0FKEA	Vishay-Dale		
R51	0	121k	RES, 121 k, 1%, 0.1 W, 0603	0603	CRCW0603121KFKEA	Vishay-Dale		
R52	0	10.0	RES, 10.0, 1%, 0.1 W, 0603	0603	CRCW060310R0FKEA	Vishay-Dale		
R54	0	1.30Meg	RES, 1.30 M, 1%, 0.1 W, 0603	0603	CRCW06031M30FKEA	Vishay-Dale		
R55	0	93.1k	RES, 93.1 k, 1%, 0.1 W, 0603	0603	CRCW060393K1FKEA	Vishay-Dale		
R62, R71, R72, R89	0	10.0Meg	RES, 10.0 M, 1%, 0.1 W, 0603	0603	CRCW060310M0FKEA	Vishay-Dale		
R65	0	47k	RES, 47 k, 5%, 0.1 W, 0603	0603	CRCW060347K0JNEA	Vishay-Dale		
R73	0	14.7k	RES, 14.7 k, 0.1%, 0.1 W, 0603	0603	RG1608P-1472-B-T5	Susumu Co Ltd		
RT1	0	100 ohm	Temperature Sensor, 100 ohm, 1%, 1206	1206	PTS120601B100RP100	Vishay/Beyschlag		
S1, S2	0		Switch, Tactile, SPST-NO, 0.05A, 12V, SMT	Switch, 4.4x2x2.9 mm	TL1015AF160QG	E-Switch		
SH-JP1, SH-JP2, SH-JP3, SH-JP4, SH-JP10	0	1x2	Shunt, 100mil, Gold plated, Black	Shunt	969102-0000-DA	3M	SNT-100-BK-G	Samtec
TP7, TP8, TP9, TP10	0	Double	Terminal, Turret, TH, Double	Keystone1573-2	1573-2	Keystone		

Table 15. ADS124S08 EVM Bill of Materials (continued)

Designator	Qty	Value	Description	Package Reference	Part Number	Manufacturer	Alternate Part Number	Alternate Manufacturer
TP19, TP20, TP21	0	Blue	Test Point, Miniature, Blue, TH	Blue Miniature Testpoint	5117	Keystone		
U4	0		256K I2C™ CMOS Serial EEPROM, TSSOP-8	TSSOP-8	24AA256-I/ST	Microchip		
U10	0		8-BIT BIDIRECTIONAL VOLTAGE-LEVEL TRANSLATOR FOR OPEN-DRAIN AND PUSH-PULL APPLICATIONS, RGY0020A	RGY0020A	TXS0108ERGYR	Texas Instruments		Texas Instruments
U12	0		SINGLE BUFFER/DRIVER WITH OPEN-DRAIN OUTPUT, DCK0005A	DCK0005A	SN74LVC1G07DCKR	Texas Instruments	SN74LVC1G07DCKT	Texas Instruments
U18	0		1.5-A LOW-NOISE FAST-TRANSIENT-RESPONSE LOW-DROPOUT REGULATOR, DCQ0006A	DCQ0006A	TL1963ADCQR	Texas Instruments	TL1963ADCQT	Texas Instruments
U19	0		3-PIN VOLTAGE SUPERVISORS, DBV0003A	DBV0003A	TPS3809I50QDBVRQ1	Texas Instruments		Texas Instruments
U20	0		Single Inverter Buffer/Driver With Open-Drain Output, DCK0005A	DCK0005A	SN74LVC1G06DCKR	Texas Instruments	SN74LVC1G06DCKT	Texas Instruments
U21	0		Step-Up DC-DC Converter with Forced PWM Mode, 2.3 to 6 V, -40 to 105 deg C, 8-pin SOP (PW8), Green (RoHS & no Sb/Br)	PW0008A	TPS61085TPWR	Texas Instruments	Equivalent	Texas Instruments
U22	0		Single Output High PSRR LDO, 150 mA, Adjustable 1.2 to 33 V Output, 3 to 36 V Input, with Ultra-Low Noise, 8-pin MSOP (DGN), -40 to 125 deg C, Green (RoHS & no Sb/Br)	DGN0008D	TPS7A4901DGNR	Texas Instruments	Equivalent	Texas Instruments
U23	0		DC-DC INVERTER, DRC0010J	DRC0010J	TPS63700DRCR	Texas Instruments	TPS63700DRCT	Texas Instruments
U24	0		Single Output High PSRR LDO, 200 mA, Adjustable -1.18 to -33 V Output, -3 to -36 V Input, with Ultra-Low Noise, 8-pin MSOP (DGN), -40 to 125 deg C, Green (RoHS & no Sb/Br)	DGN0008D	TPS7A3001DGNR	Texas Instruments	Equivalent	Texas Instruments
Y3	0		Crystal, 4.096MHz, 3.3V, SMD	7x5mm	7W-4.096MBB-T	TXC Corporation		
Notes:	Unless otherwise noted in the Alternate Part Number or Alternate Manufacturer columns, all parts may be substituted with equivalents.							

7.2 PCB Layouts

Figure 23 and Figure 28 illustrate the PCB layouts.

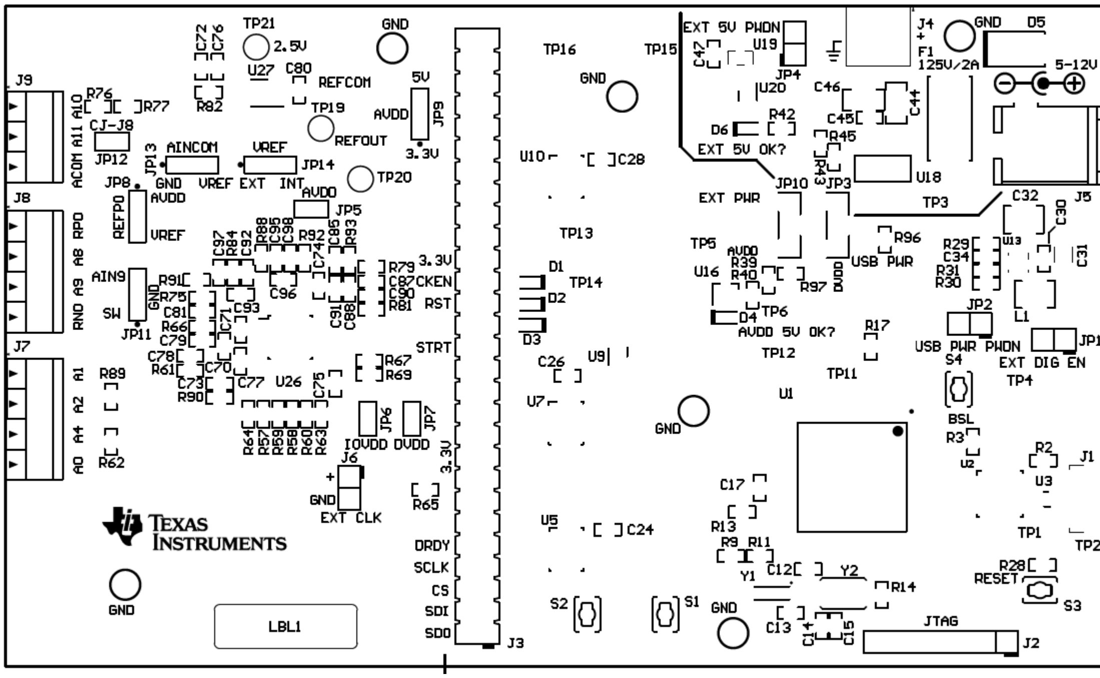


Figure 23. Top Silkscreen

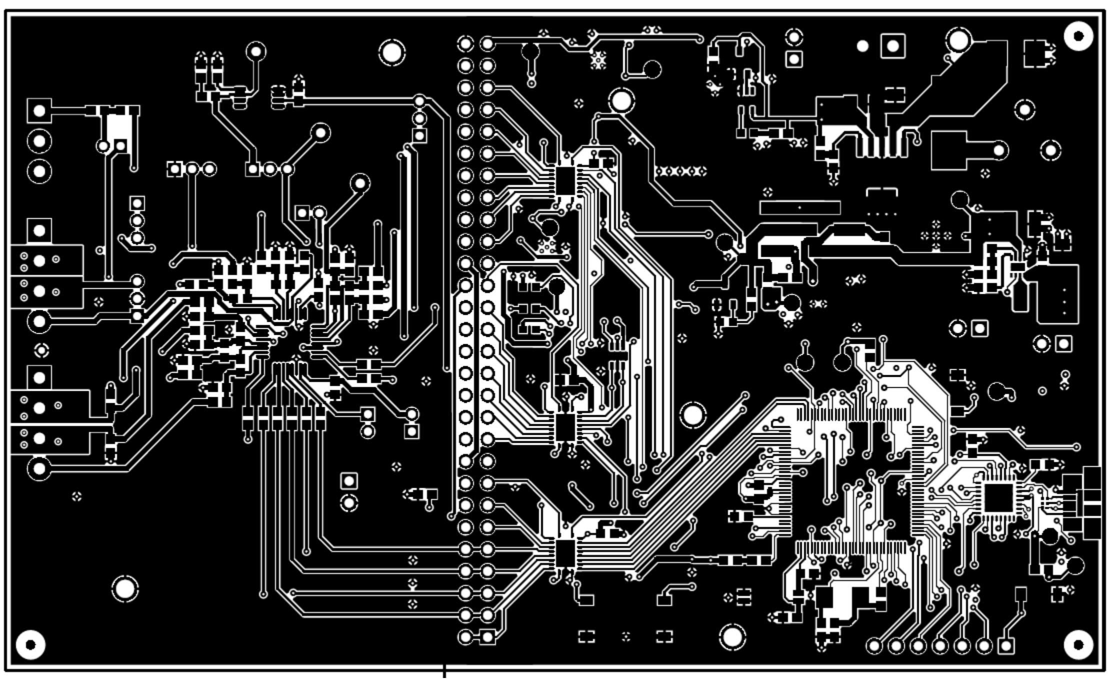


Figure 24. Top Layer (Positive)

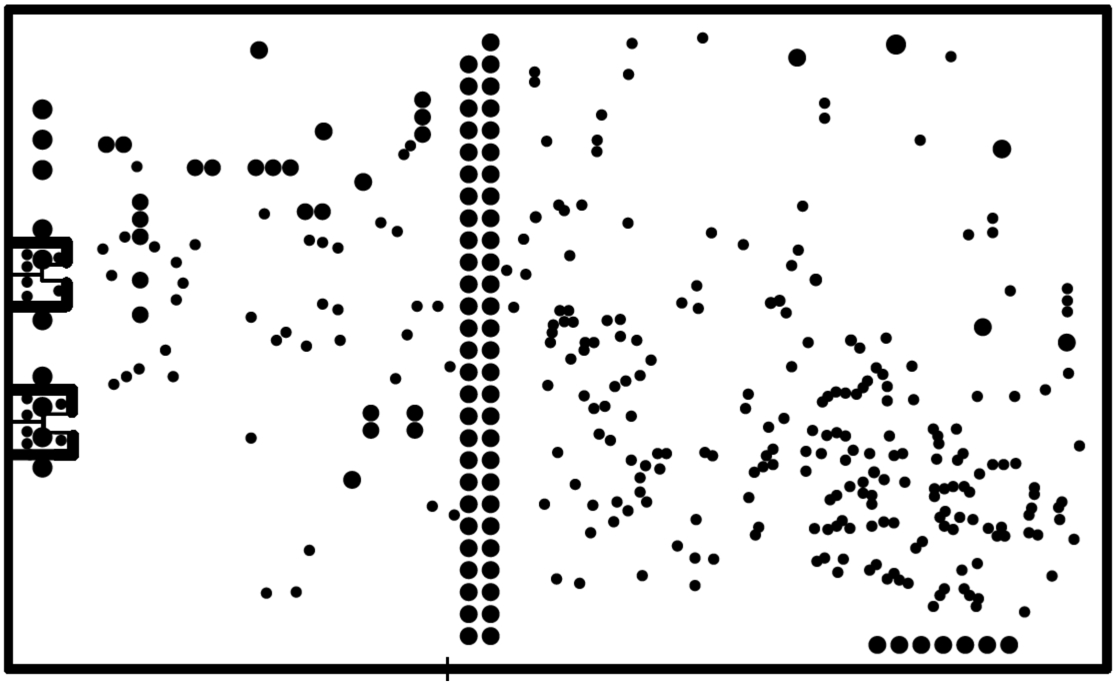


Figure 25. Ground Layer (Negative)

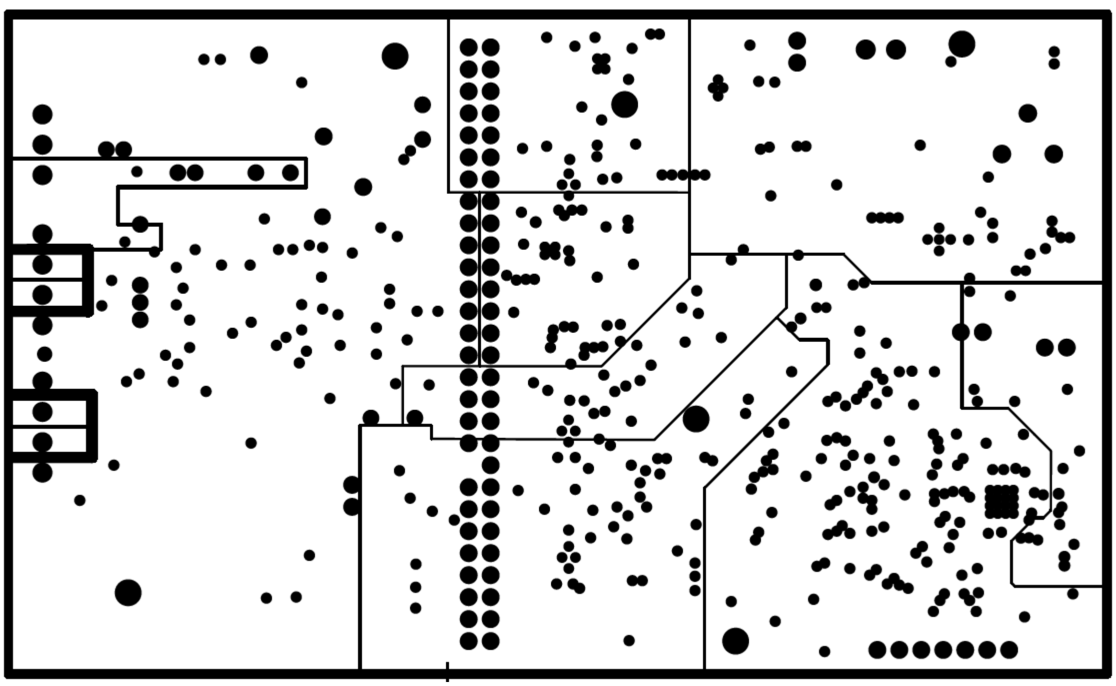


Figure 26. Power Layer (Negative)

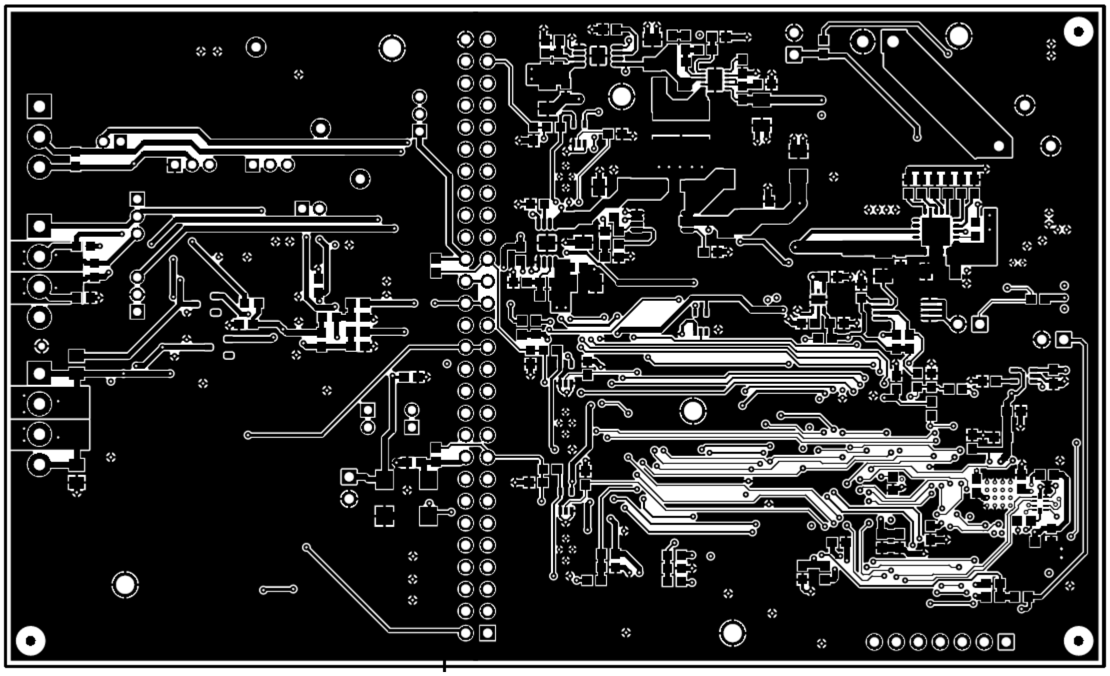


Figure 27. Bottom Layer (Positive)

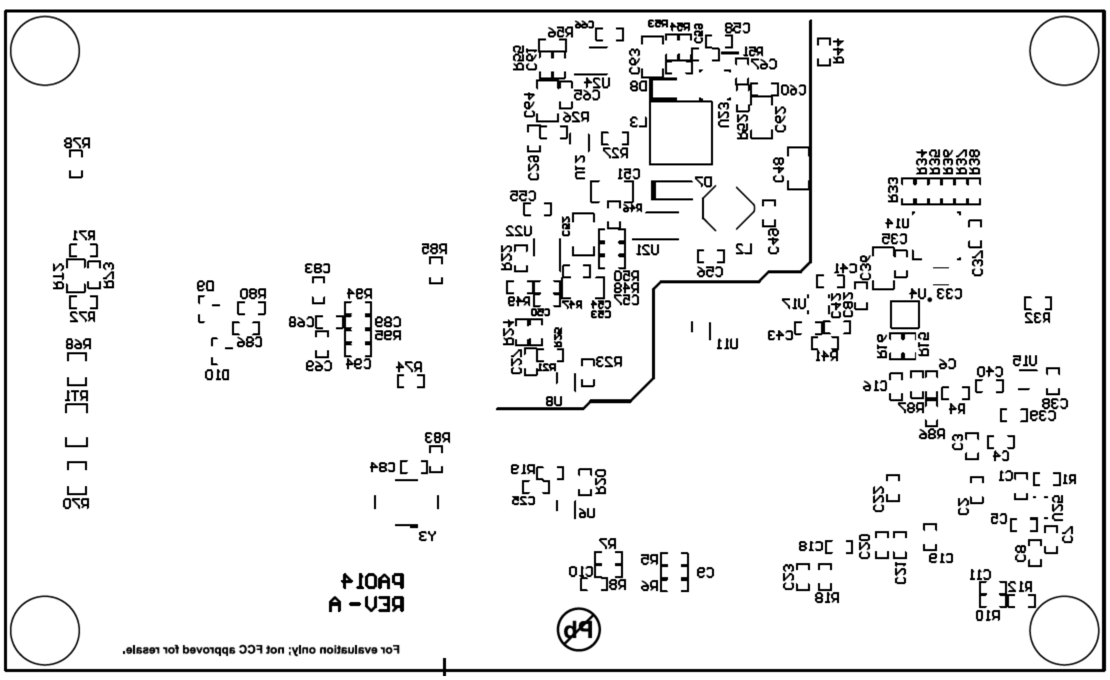


Figure 28. Bottom Silkscreen

7.3 Schematic

Figure 29 through Figure 34 illustrate the EVM schematics.

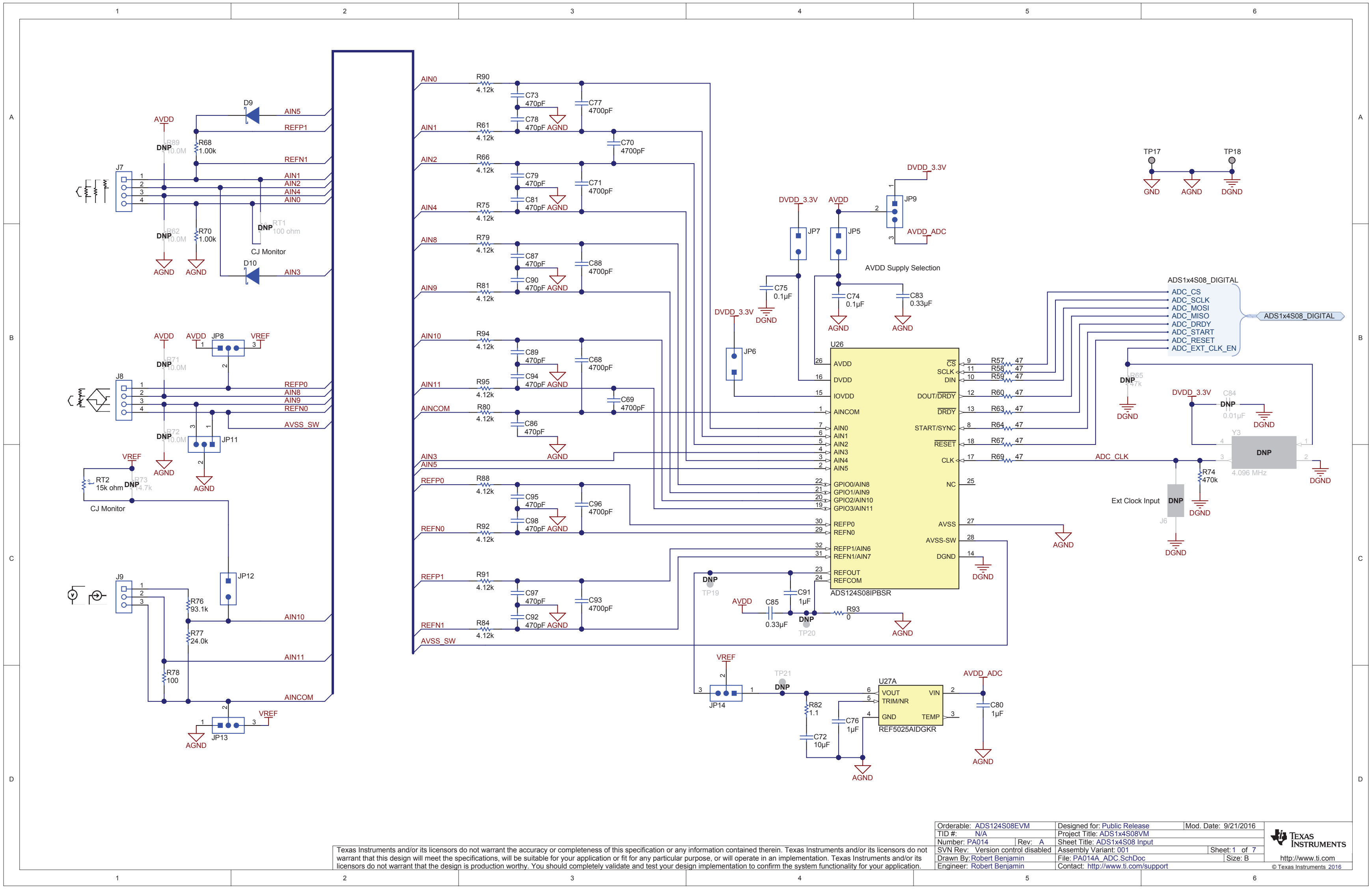


Figure 29. ADS124S08EVM ADC Schematic

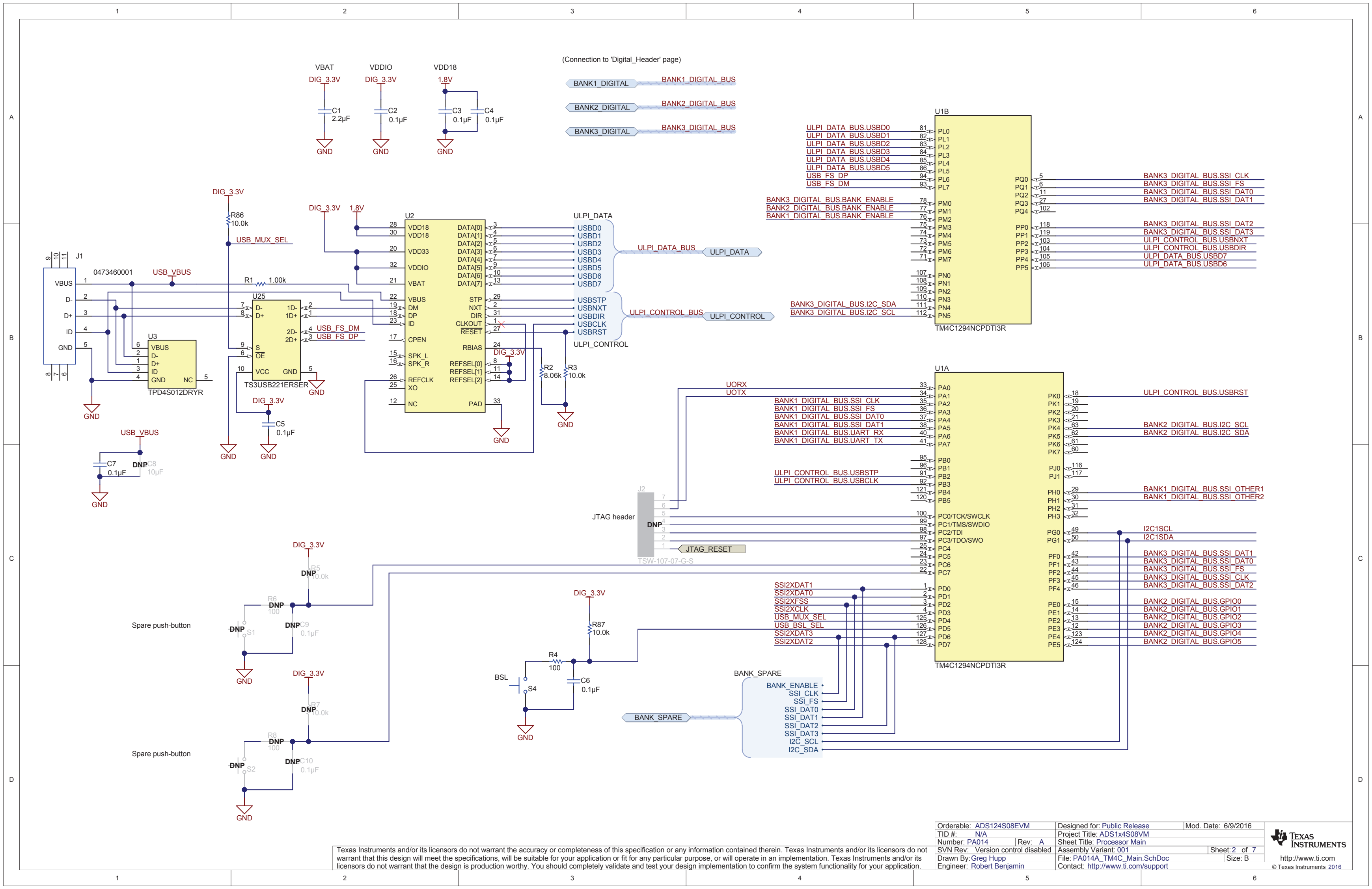


Figure 30. ADS124S08EVM Controller Schematic

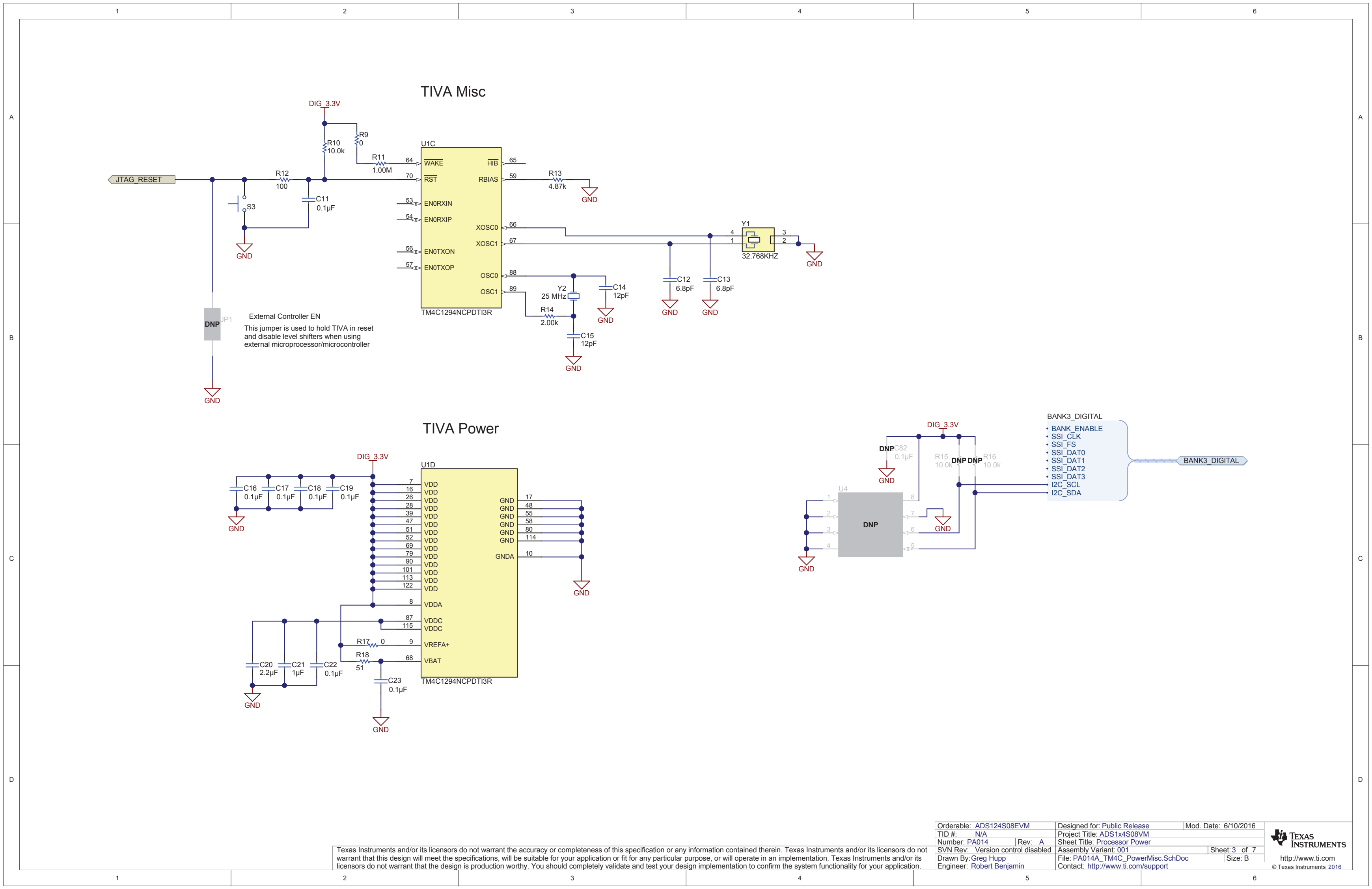


Figure 31. ADS124S08EVM Controller Power Schematic

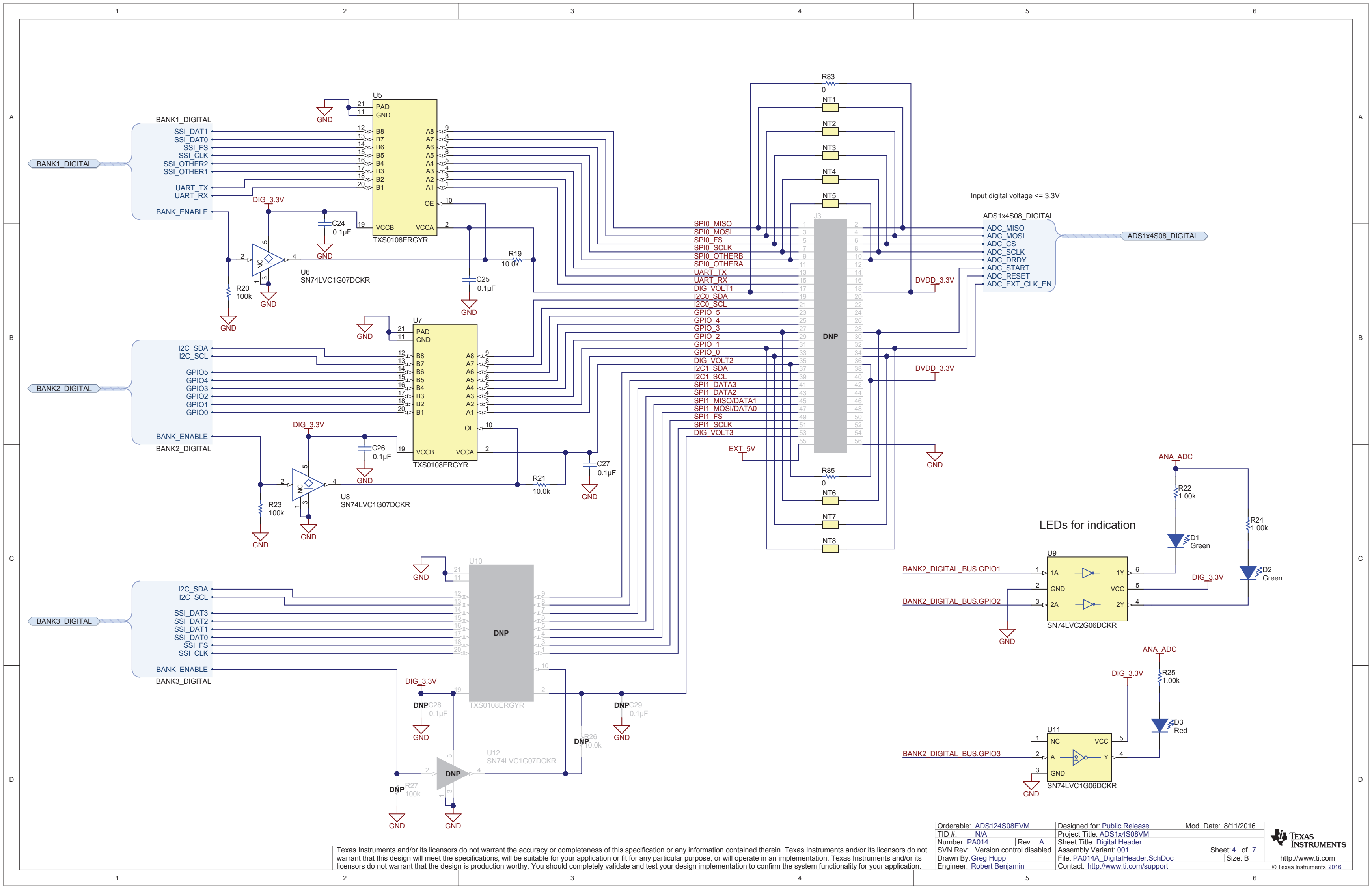
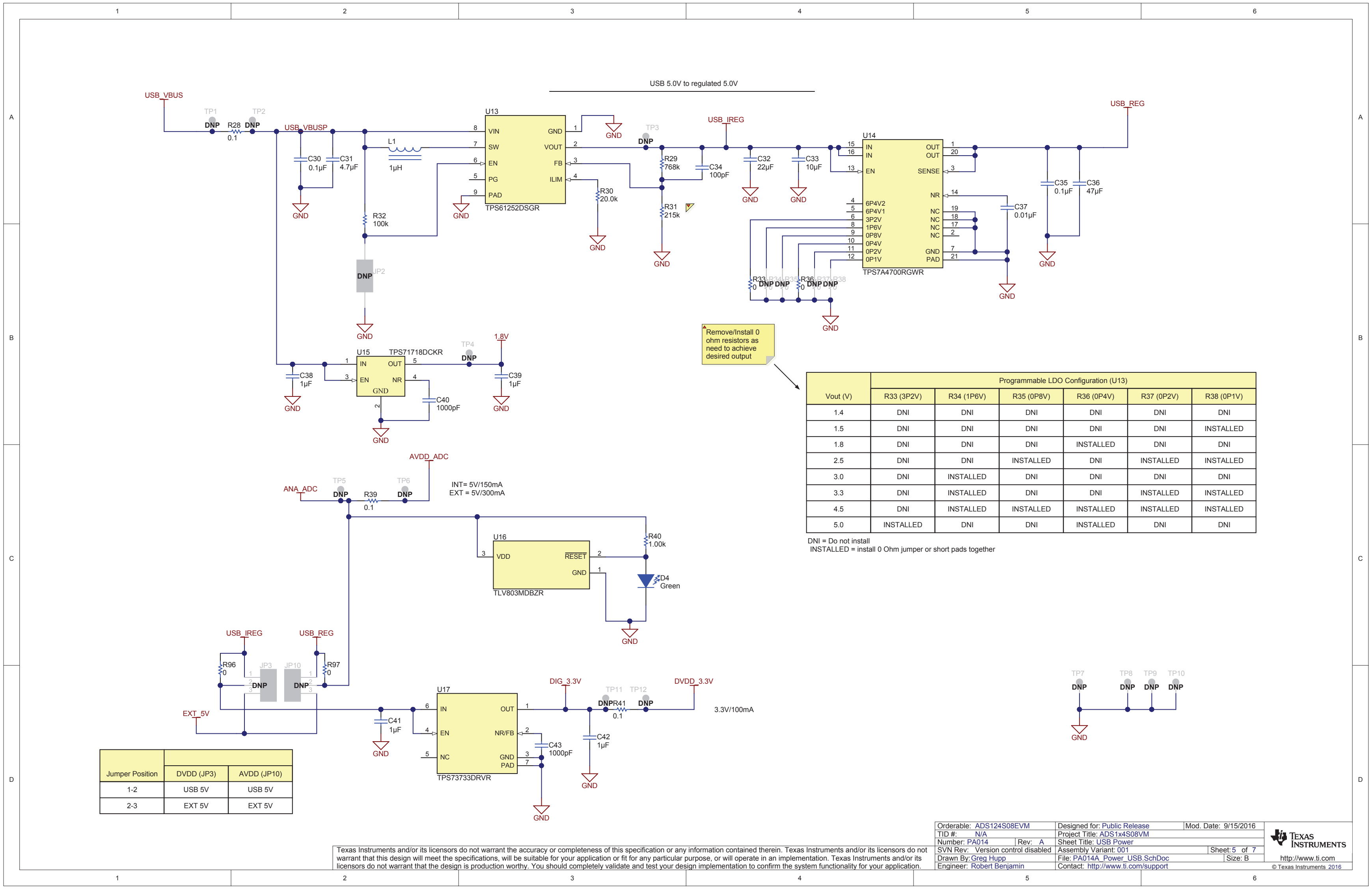


Figure 32. ADS124S08EVM Digital Header Schematic



Vout (V)	Programmable LDO Configuration (U13)					
	R33 (3P2V)	R34 (1P6V)	R35 (0P8V)	R36 (0P4V)	R37 (0P2V)	R38 (0P1V)
1.4	DNI	DNI	DNI	DNI	DNI	DNI
1.5	DNI	DNI	DNI	DNI	DNI	INSTALLED
1.8	DNI	DNI	DNI	INSTALLED	DNI	DNI
2.5	DNI	DNI	INSTALLED	DNI	INSTALLED	INSTALLED
3.0	DNI	INSTALLED	DNI	DNI	DNI	DNI
3.3	DNI	INSTALLED	DNI	DNI	INSTALLED	INSTALLED
4.5	DNI	INSTALLED	INSTALLED	INSTALLED	INSTALLED	INSTALLED
5.0	INSTALLED	DNI	DNI	INSTALLED	DNI	DNI

DNI = Do not install
INSTALLED = install 0 Ohm jumper or short pads together

Jumper Position	DVDD (JP3)	AVDD (JP10)
1-2	USB 5V	USB 5V
2-3	EXT 5V	EXT 5V

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Orderable: ADS124S08EVM | TID #: N/A | Number: PA014 | Rev: A | SVN Rev: Version control disabled | Drawn By: Greg Hupp | Engineer: Robert Benjamin | Designed for: Public Release | Mod. Date: 9/15/2016 | Project Title: ADS1x4S08VM | Sheet Title: USB Power | Assembly Variant: 001 | Sheet: 5 of 7 | File: PA014A_Power_USB.SchDoc | Size: B | Contact: http://www.ti.com/support | http://www.ti.com | © Texas Instruments 2016

Figure 33. ADS124S08EVM Power USB Schematic

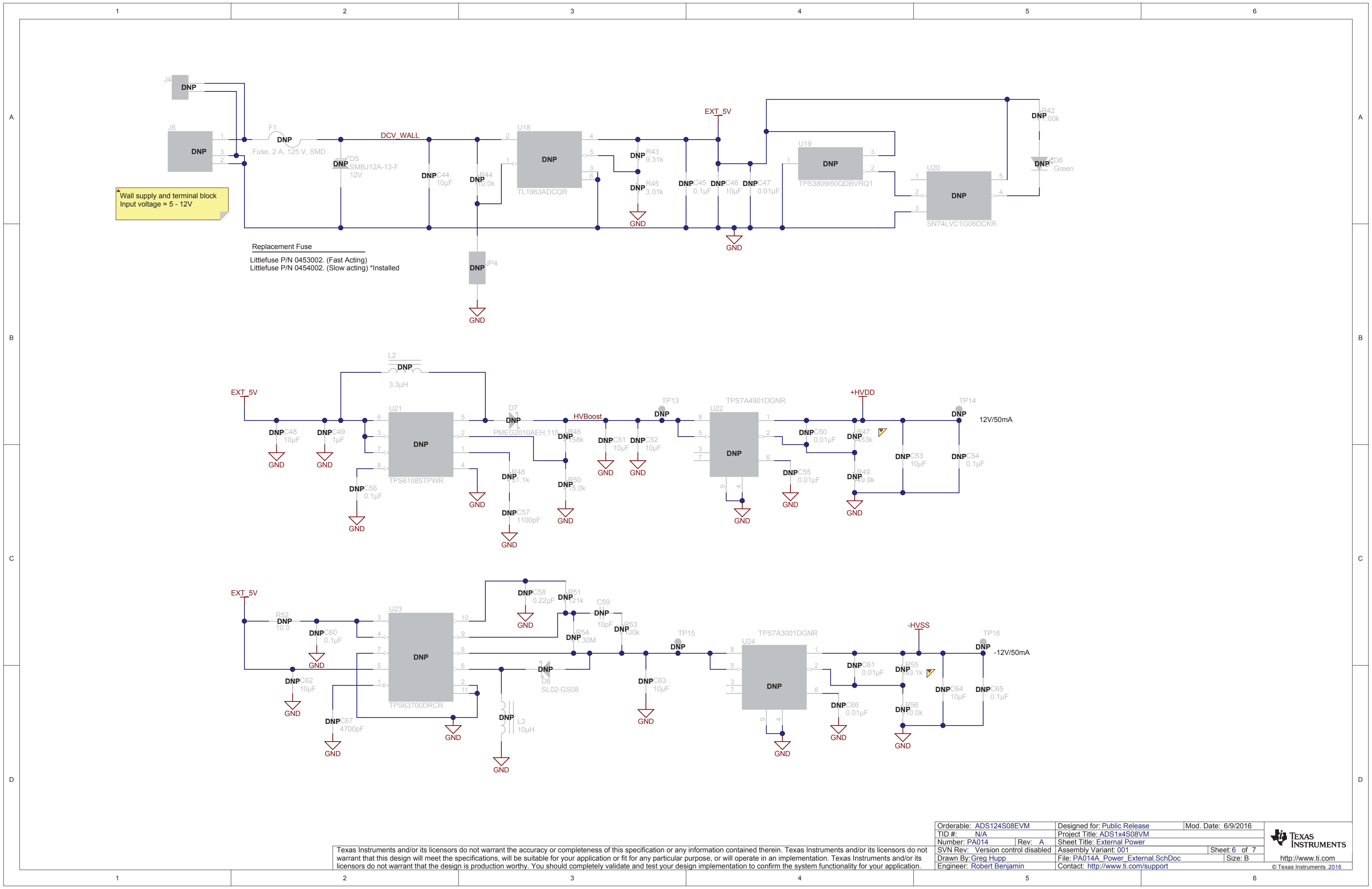

Figure 34. ADS124S08EVM Power External Schematic