

Precision Labs SAR ADC EVM

This user's guide describes the characteristics and use of the Precision Labs SAR ADC EVM. The evaluation module (EVM) is designed to be a companion to the [TI Precision Labs-ADCs](#) training series and is referred to as the PLABS-SAR-EVM-PDK throughout this document. This hardware allows engineers to perform experiments on general data converter topics such as ADC input drive, reference drive, amplifier selection, power consumption, and aliasing. This user's guide provides information regarding the operation and theory behind the sub-circuits on the EVM, as well as an overview of the required software.

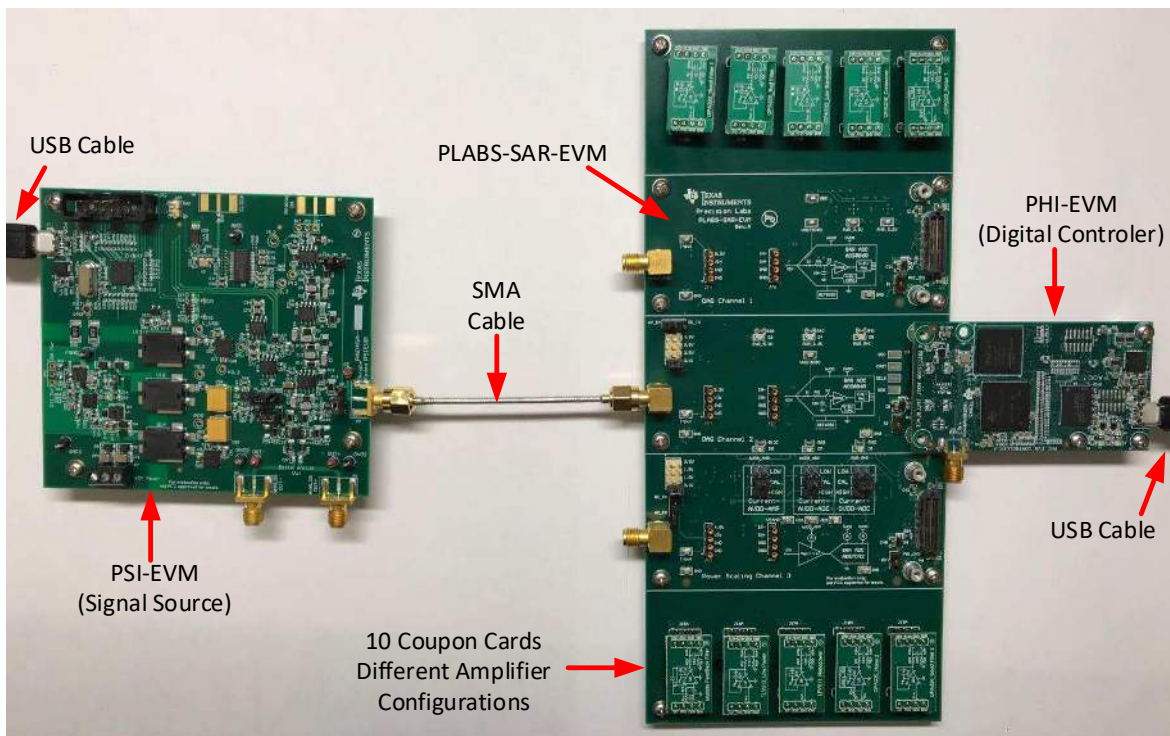


Figure 1. Typical Connections for the PLABS-SAR-EVM-PDK

The following related documents are available through the [Texas Instruments](http://Texas Instruments website) website.

Table 1. Related Documentation

| Device | Literature Number |
|-------------------------|-------------------------|
| ADS1220 | SBAS501 |
| ADS7042 | SBAS608 |
| ADS8860 | SBAS569 |
| INA326 | SBOS222 |
| LPV811 | SNOSD33 |
| OPA316 | SBOS703 |
| OPA320 | SBOS513 |
| OPA333 | SBOS351 |
| REF5050 | SBOS410 |
| REF6050 | SBOS708 |
| TLV313 | SBOS753 |

Contents

| | | |
|---|--|----|
| 1 | Introduction | 4 |
| 2 | EVM Initial Setup | 4 |
| 3 | Plug-In Amplifier Coupon Boards | 15 |
| 4 | EVM Graphical User Interface (GUI) Software Installation | 17 |
| 5 | Board Layout..... | 29 |
| 6 | Schematic and Bill of Materials..... | 33 |

List of Figures

| | | |
|----|--|----|
| 1 | Typical Connections for the PLABS-SAR-EVM-PDK | 1 |
| 2 | Overview of Features on CH1 and CH2 | 5 |
| 3 | Amplifier and ADC Input (CH1 and CH2)..... | 6 |
| 4 | Voltage Reference and Jumper-Selected Voltage Divider (CH1 and CH2)..... | 6 |
| 5 | Jumper Position for a DC Input of 0.1 V on CH1 and CH2 | 7 |
| 6 | Jumper Position for an AC Input on CH1 and CH2 | 7 |
| 7 | Power Subsection (CH1 and CH2)..... | 8 |
| 8 | Connection to the PHI Controller and EEPROM | 9 |
| 9 | Overview of Features on CH3..... | 10 |
| 10 | Amplifier and ADC Input (CH3)..... | 11 |
| 11 | INA Current Monitor (CH3)..... | 12 |
| 12 | Power, Shunt Resistors, and Range Selection for CH3 | 13 |
| 13 | DC or AC Input (CH3) | 14 |
| 14 | Coupon Card Layout..... | 15 |
| 15 | Installing a Coupon Card | 15 |
| 16 | PLABS Toolkit Link | 17 |
| 17 | Applications Agreement | 18 |
| 18 | Plabs Toolkit Dialog Box | 19 |
| 19 | Software Installation | 20 |
| 20 | Plabs Toolkit Prompt | 21 |
| 21 | Default PLABS-SAR-EVM GUI Display | 21 |
| 22 | PSI Controls: Unconnected PSI Hardware | 22 |
| 23 | PSI Controls: Ready to Generate an Input Signal | 23 |
| 24 | Time Domain Display | 24 |
| 25 | Spectral Analysis Display | 25 |

| | | |
|----|--|----|
| 26 | Histogram Analysis..... | 26 |
| 27 | Register Map Configuration | 27 |
| 28 | Power Scaling Results..... | 28 |
| 29 | PCB Top Layer | 29 |
| 30 | Bottom Layer..... | 30 |
| 31 | Ground Layer | 31 |
| 32 | Power Layer | 32 |
| 33 | Page 1: Channel 1 | 33 |
| 34 | Page 2: Channel 2 | 34 |
| 35 | Page 3: Channel 1 and 2 Power | 35 |
| 36 | Page 4: Channel 3 | 36 |
| 37 | Page 5: Channel 3 Current-Shunt Amplifiers and ADC | 37 |
| 38 | Page 6: Channel 3 LDO and Shunt Resistors | 38 |
| 39 | Page 7: Hardware | 39 |
| 40 | OPA320 Good Filter 1 | 40 |
| 41 | OPA320 Bad Filter | 40 |
| 42 | OPA333 Low Bandwidth | 40 |
| 43 | OPA316 Crossover | 41 |
| 44 | OPA320 Noise 1 | 41 |
| 45 | Sallen-Key Filter..... | 41 |
| 46 | TLV313 Low Power | 42 |
| 47 | LPV811 Nanopower | 42 |
| 48 | OPA320 Noise 2 | 42 |
| 49 | OPA320 Good Filter 2 | 43 |

List of Tables

| | | |
|---|--|----|
| 1 | Related Documentation | 2 |
| 2 | Hardware Included in the PLABS-SAR-EVM-PDK | 4 |
| 3 | Coupon Card Descriptions | 16 |
| 4 | Bill of Materials for the SAR-ADC-EVM Motherboard | 44 |
| 5 | Bill of Materials for the SAR-ADC-EVM Coupon Boards..... | 47 |

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1 Introduction

The PLABS-SAR-EVM-PDK is an evaluation module (EVM) kit containing a signal generator, an analog-to-digital converter (ADC) board, plug-in amplifier cards, and a digital controller. This kit is intended to be used in conjunction with the TI Precision Labs-ADCs training series.

1.1 Features

The PLABS-SAR-EVM-PDK includes the following features:

- Three successive-approximation register (SAR) ADC sub-circuits comprised of the [ADS8860](#) and [REF5050](#), the [ADS8860](#) and [REF6050](#), and the [ADS7042](#).
- Ten plug-in DIP adapter boards containing different amplifier configurations.
- Jumper-selectable DC input voltages (0.1 V, 1 V, 2 V, and 5 V).
- Jumper-selectable input (DC or AC).
- Jumper-selectable current measurement ranges for the op amp and ADC.
- Powered over a single USB cable.

2 EVM Initial Setup

Typical connection for the PLABS-SAR-EVM-PDK are given in [Figure 1](#). The included hardware for this EVM kit is given in [Table 2](#).

2.1 Included Hardware

[Table 2](#) lists the included hardware with this EVM.

Table 2. Hardware Included in the PLABS-SAR-EVM-PDK

| Item | Quantity | Description |
|--------------------------------------|----------|--|
| PLABS-SAR-EVM | 1 | This PCB contains three different ADC configurations and allows different amplifier drivers to be tested using plug-in amplifier coupon boards. The PCB is intended as a companion to TI Precision Labs-ADCs training series for hands-on experiments. |
| PHI-EVM | 1 | This PCB is the digital controller used to communicate with the ADCs on the PLABS-SAR-EVM-PDK. |
| PSI-EVM | 1 | This PCB is the precision signal source used to generate test signals for precision labs experiments. |
| USB cable | 2 | Used to communicate with the PHI-EVM and the PSI-EVM. |
| SMA cable | 1 | Used to connect the signal generator (PHI-EVM) to the PLABS-SAR-EVM-PDK. |
| OPA320 good filter | 1 | Demonstrates performance on the ADS8860 . |
| OPA320 bad filter | 1 | Demonstrates poor component selection. |
| OPA333 low bandwidth | 1 | Demonstrates poor component selection. |
| OPA316 crossover | 1 | Demonstrates crossover distortion. |
| OPA320 noise 1 | 1 | Demonstrates noise measurement. |
| Sallen key filter | 1 | Demonstrates an antialiasing filter. |
| TLV313 low power | 1 | Demonstrates low power amplifier driver performance. |
| LPV811 nanopower | 1 | Demonstrates low power amplifier driver performance. |
| OPA320 noise 2 | 1 | Demonstrates noise measurement. |
| OPA320 good filter 2 | 1 | Demonstrates performance on the ADS7042 . |

2.2 Channel 1 and 2 Operation

Figure 2 shows the features on channel 1 and channel 2 (CH1 and CH2, respectively) of the PLABS-SAR-EVM. The design of these two channels is very similar. The only difference is that channel 1 uses the REF5050 and channel 2 uses the REF6050. The REF6050 contains a wide bandwidth buffer and thus shows better performance than the REF5050. The goal is to show the impact that reference buffering has on performance. Both channels have an SubMiniature version A (SMA) input connector for the AC input and both channels share a precision DC source. The three LED indicators are shared between the two channels and are a good quick check to determine if the board is powered. Each channel has its own connector to the PHI digital controller, and the software used for each channel is identical.

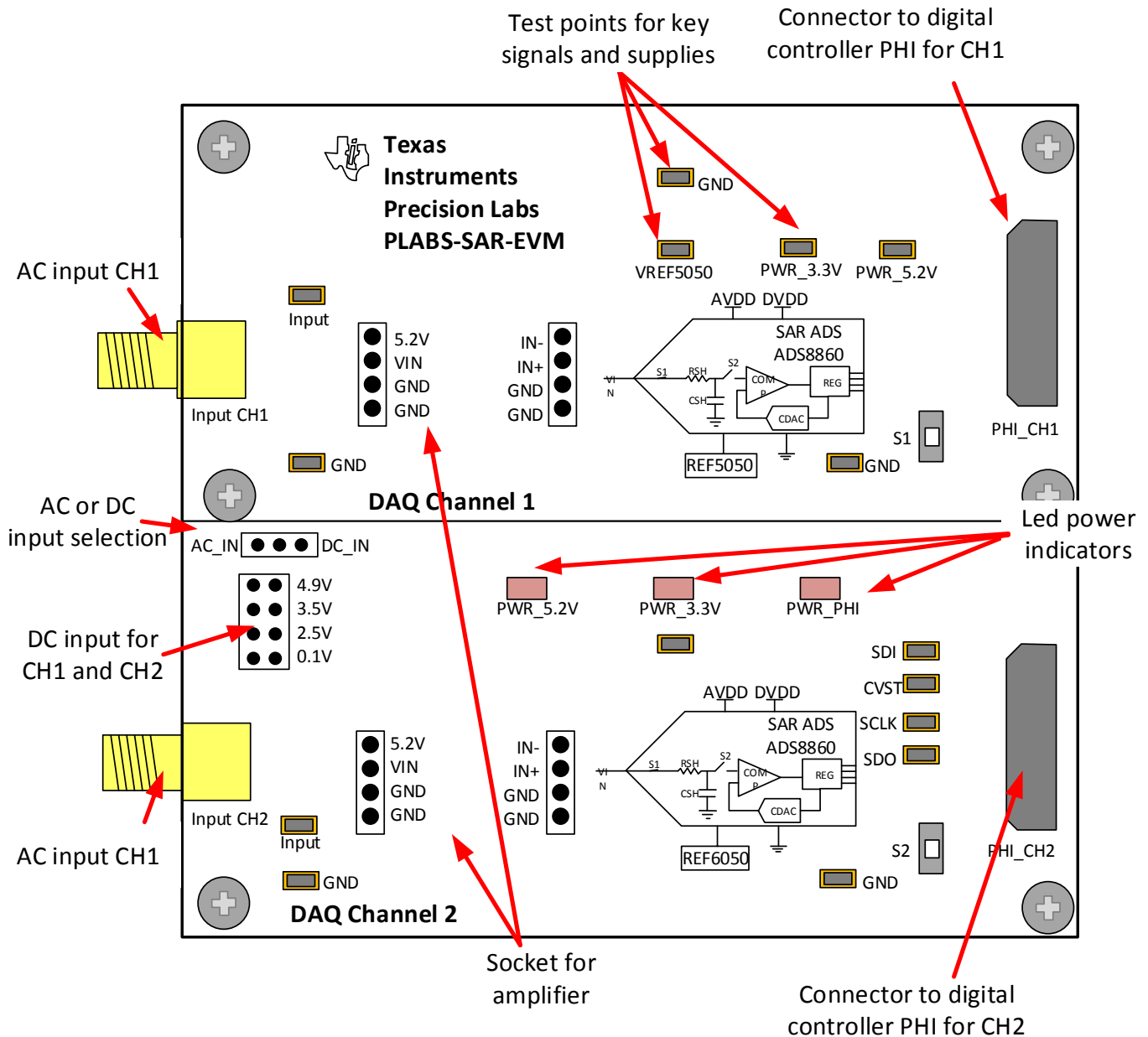


Figure 2. Overview of Features on CH1 and CH2

2.2.1 Amplifier and ADC Input (CH1 and CH2)

Figure 3 shows the AC input (input CH1) connected to the amplifier input on the coupon board. The output of the coupon board connects to the ADS8860 input. Both channel 1 and 2 have this same configuration. The DC input signal is generated by a reference and voltage divider.

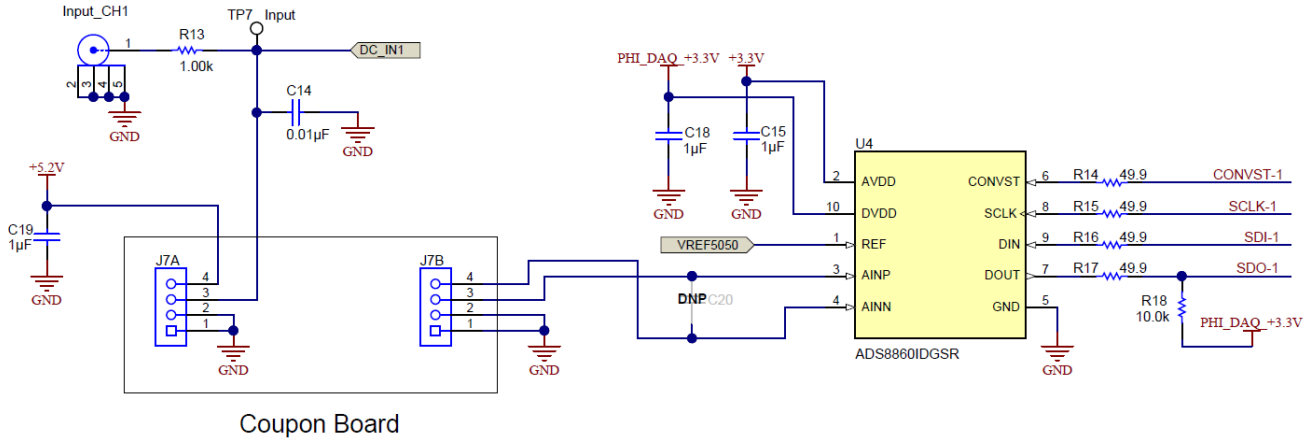


Figure 3. Amplifier and ADC Input (CH1 and CH2)

2.2.2 Jumpers and Reference (CH1 and CH2)

Figure 4 shows how the precision DC input signals are generated using a reference with a jumper-selected voltage divider. Depending on the position of the jumper in the DC options the divider output is 0.1 V, 2.5 V, 3.5 V, or 4.9 V. If the jumper is in the position shown, the output voltage is 0.1 V. The amplifier U6 buffers the precision DC signal. U8 is the reference for channel 1.

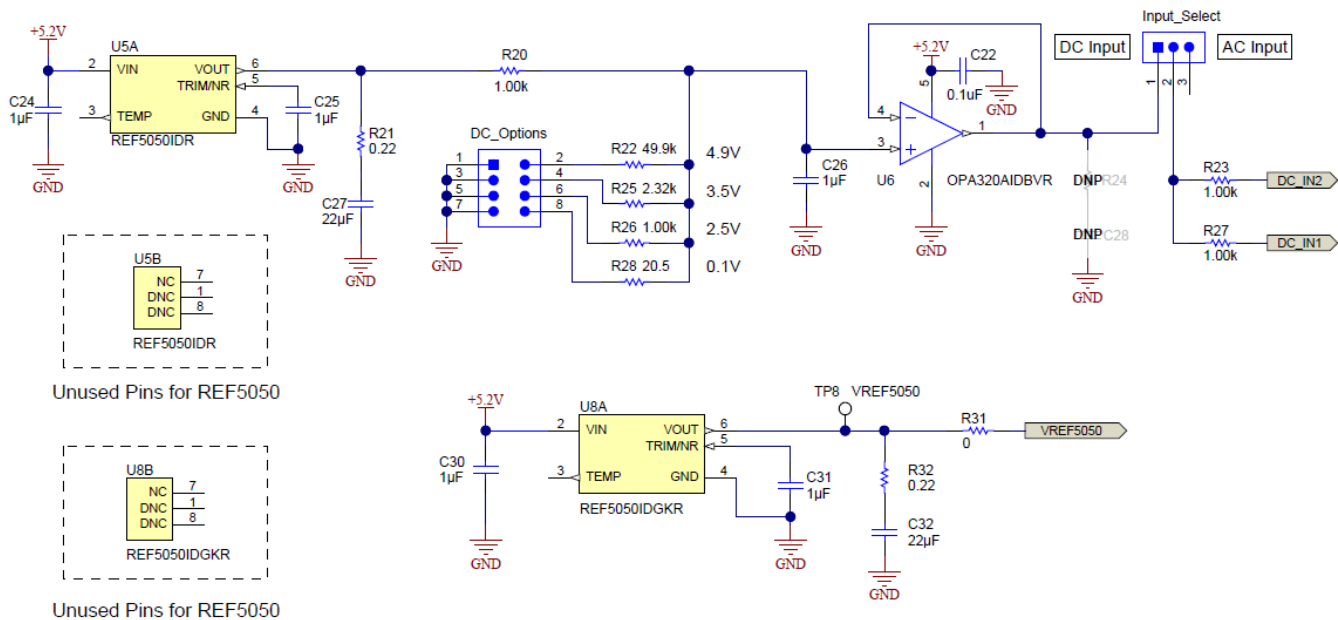


Figure 4. Voltage Reference and Jumper-Selected Voltage Divider (CH1 and CH2)

Figure 5 shows the jumper settings for a 0.1-V DC input. When using DC input mode, disconnect the input signal from the SMA connector (input CH2).

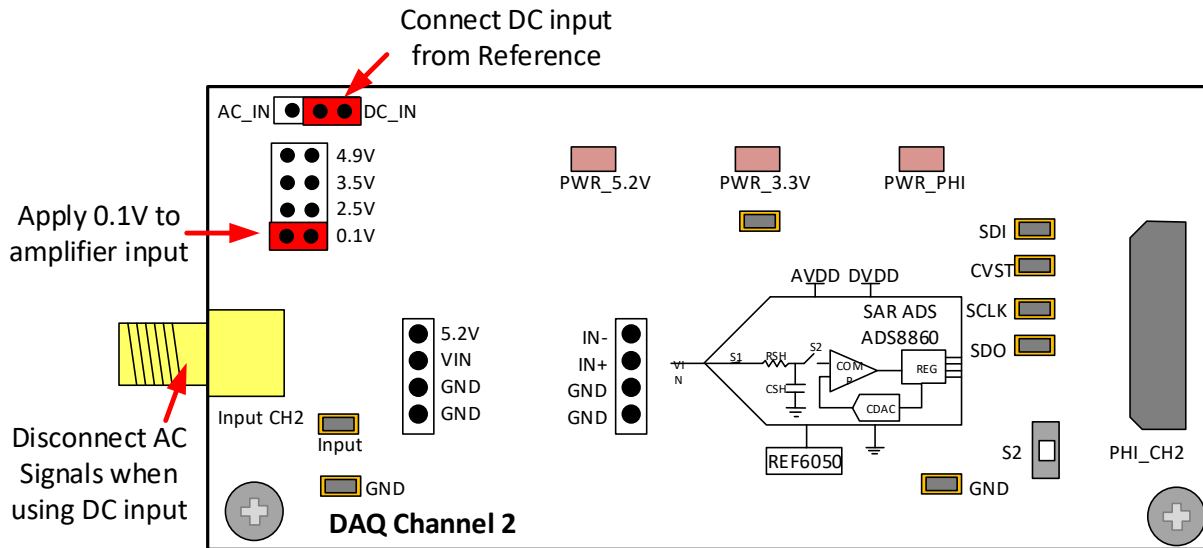


Figure 5. Jumper Position for a DC Input of 0.1 V on CH1 and CH2

Figure 6 shows the jumper settings for an AC input. When using AC input mode, the DC jumper bank is ignored.

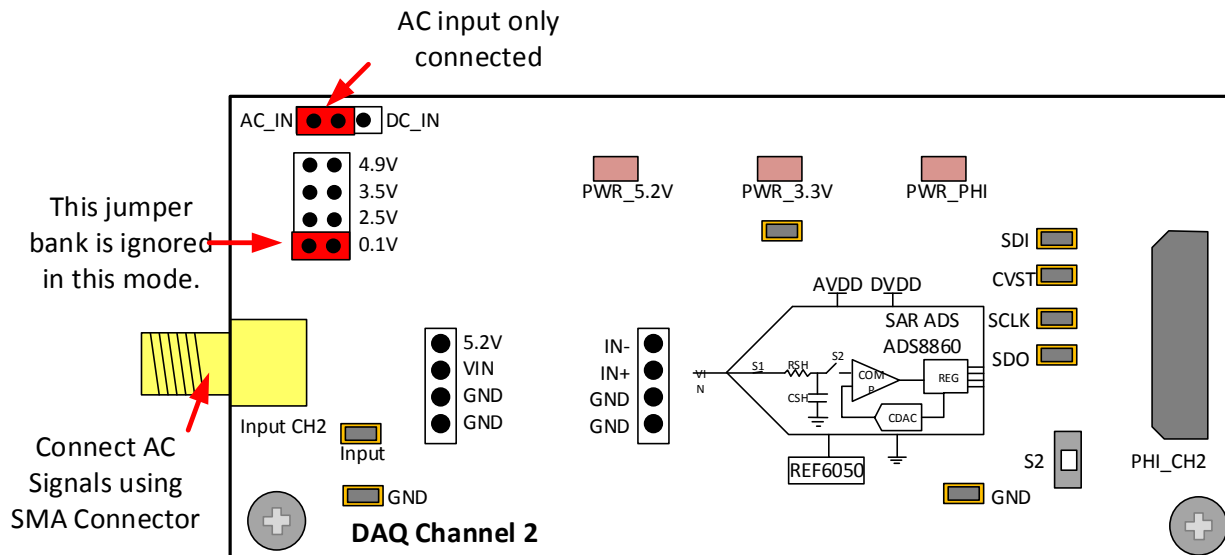


Figure 6. Jumper Position for an AC Input on CH1 and CH2

2.2.3 Power Subsection (CH1 and Ch2)

The PHI-EVM controller generates a 5.5-V supply with the USB power and a charge pump. Figure 7 shows the connection between the 5.5-V supply to two different low-noise, low dropout regulators (LDOs). U9 generates a 5.2-V supply used for the amplifier and U11 generates the 3.3-V supply used by the ADS8860.

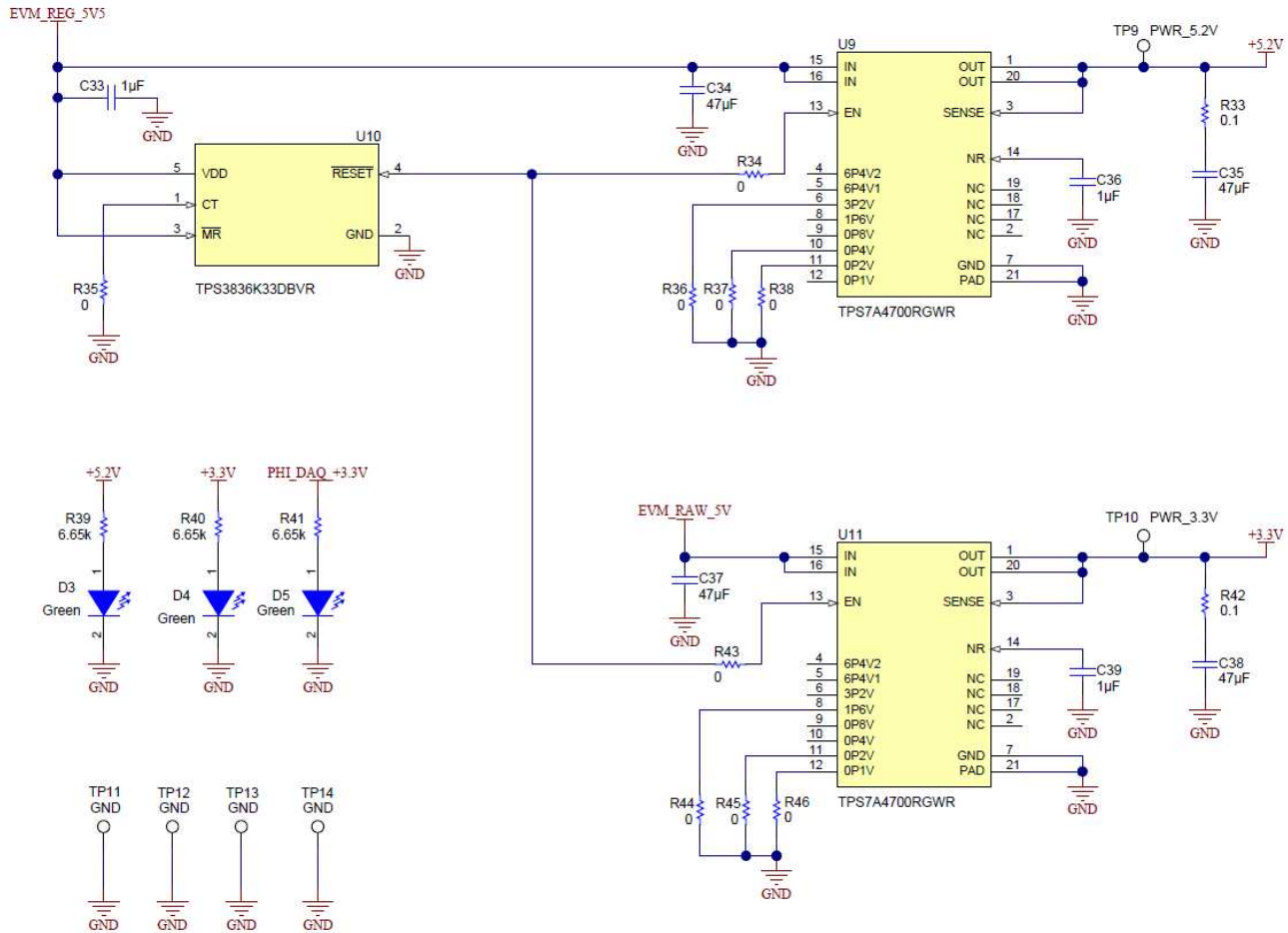


Figure 7. Power Subsection (CH1 and CH2)

2.2.4 Connection to the PHI Controller and EEPROM

Figure 8 shows the connector used to interface the digital controller (PHI-EVM) and the PLABS-SAR-EVM. The schematic also shows an EEPROM that is used for board identification.

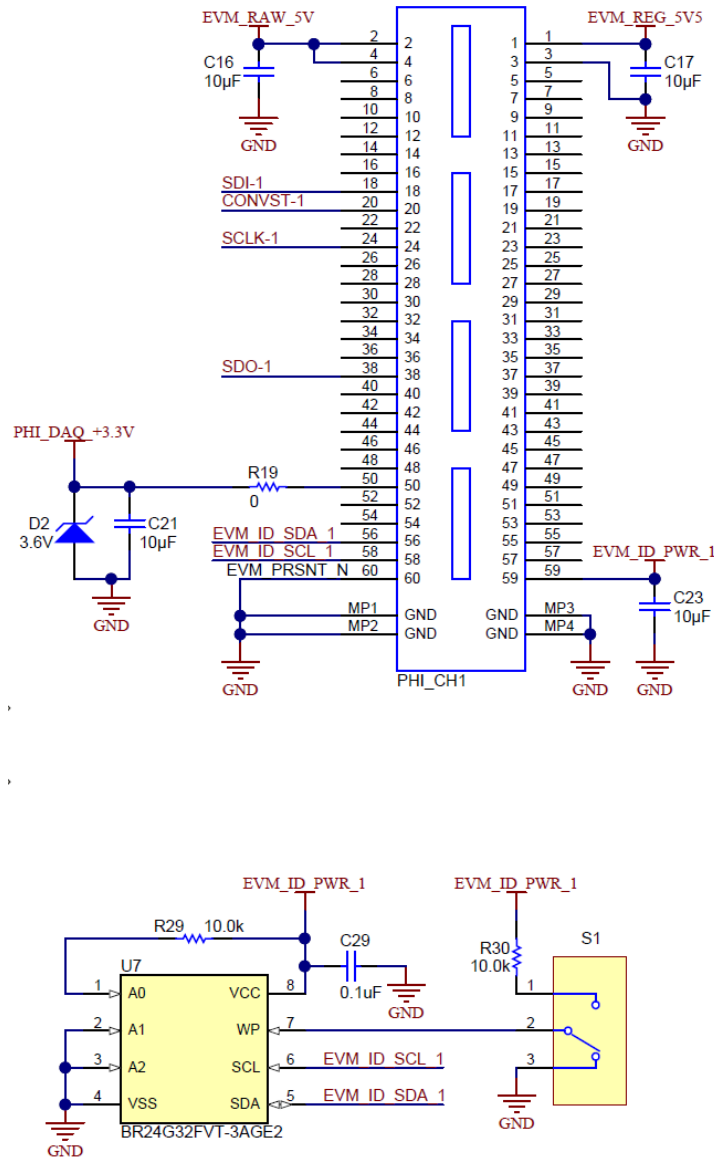


Figure 8. Connection to the PHI Controller and EEPROM

2.3 Channel 3 Operation

Figure 9 shows the features on CH3 of the PLABS-SAR-EVM. This channel allows DC or AC signals to be applied to the ADS7042. Plug-in amplifier coupon cards are used to experiment with different amplifier drive circuits. The channel also provides current measurement circuitry for measuring the analog supply current, digital supply current, and amplifier supply current. The current measurement circuit has jumper-selected ranges for high current, low current, and calibration. Current-shunt amplifiers and an ADS1220 are used to measure the currents. The three LED indicators are shared between the two channels and are a good quick check to determine if the board is powered.

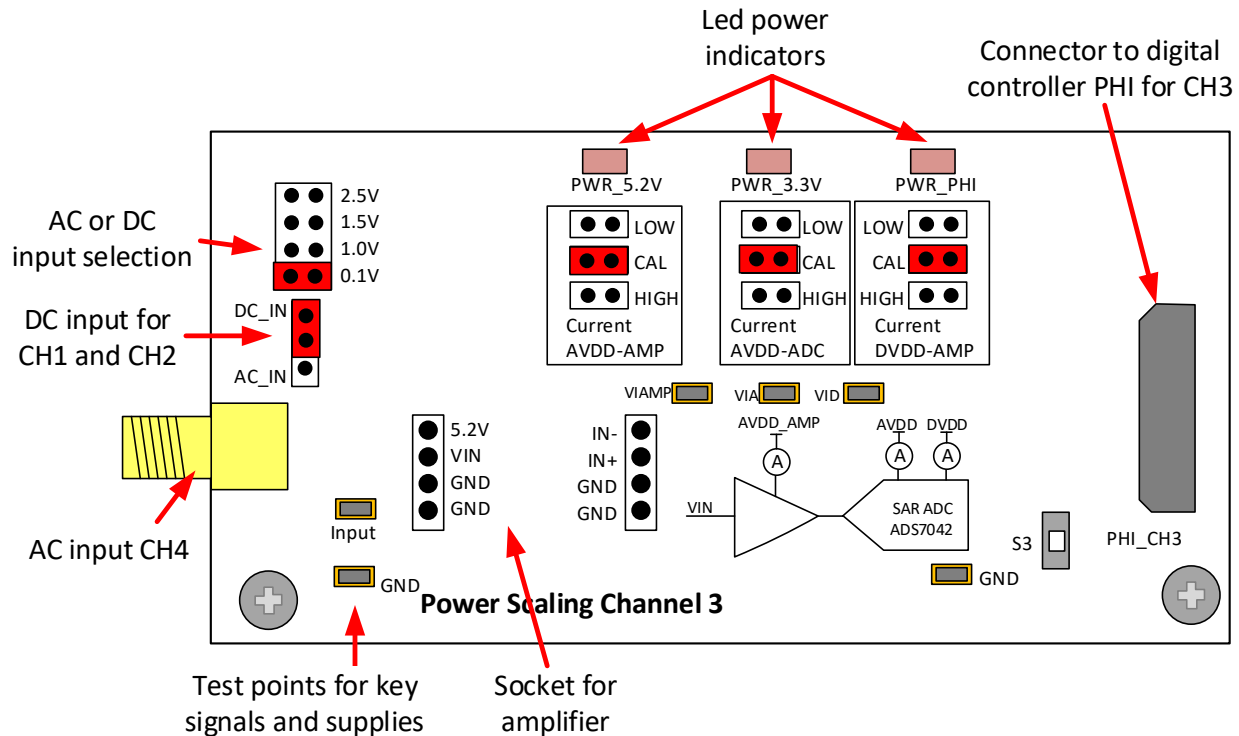


Figure 9. Overview of Features on CH3

2.3.1 Amplifier and ADC Input (CH3)

Figure 10 shows the connection between the AC input, amplifier input, and the ADS7042 data converter. The amplifiers U13A and U13B are used to shift the offset of the input signal to half of the full-scale range of the ADS7042 (when shifted by 1.5 V, the full-scale range is 3 V). The socket for the coupon board allows different amplifiers to be tested. The AC or DC jumper chooses a precision DC input or the AC input from the SMA connector (input CH3).

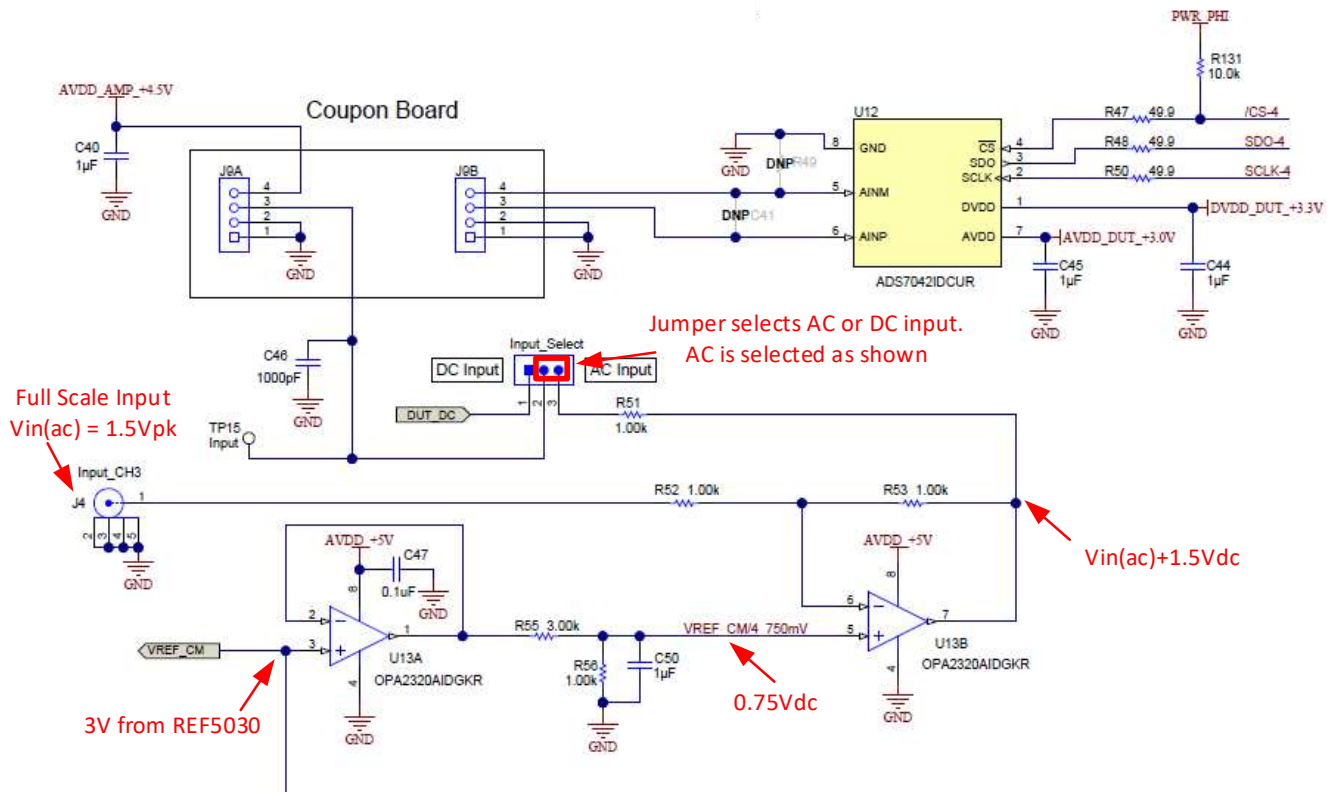


Figure 10. Amplifier and ADC Input (CH3)

2.3.2 INA Current Monitor (CH3)

Figure 11 shows the current-shunt monitor amplifiers. These components amplify the voltage developed across the shunt resistors by 823 V/V and shift the output voltage by 0.1 V. The level shift is achieved by applying 0.1 V to the reference input pin. The 0.1-V signal is developed using 0.2 V from U21 and a voltage divider. The INA326 was used because this device has rail-to-rail I/O performance. The output of the amplifier is connected to a voltage divider (divide by 2.5). The voltage divider is used to adjust the signal to the input range of the ADS1220 (full scale = 2.5 V).

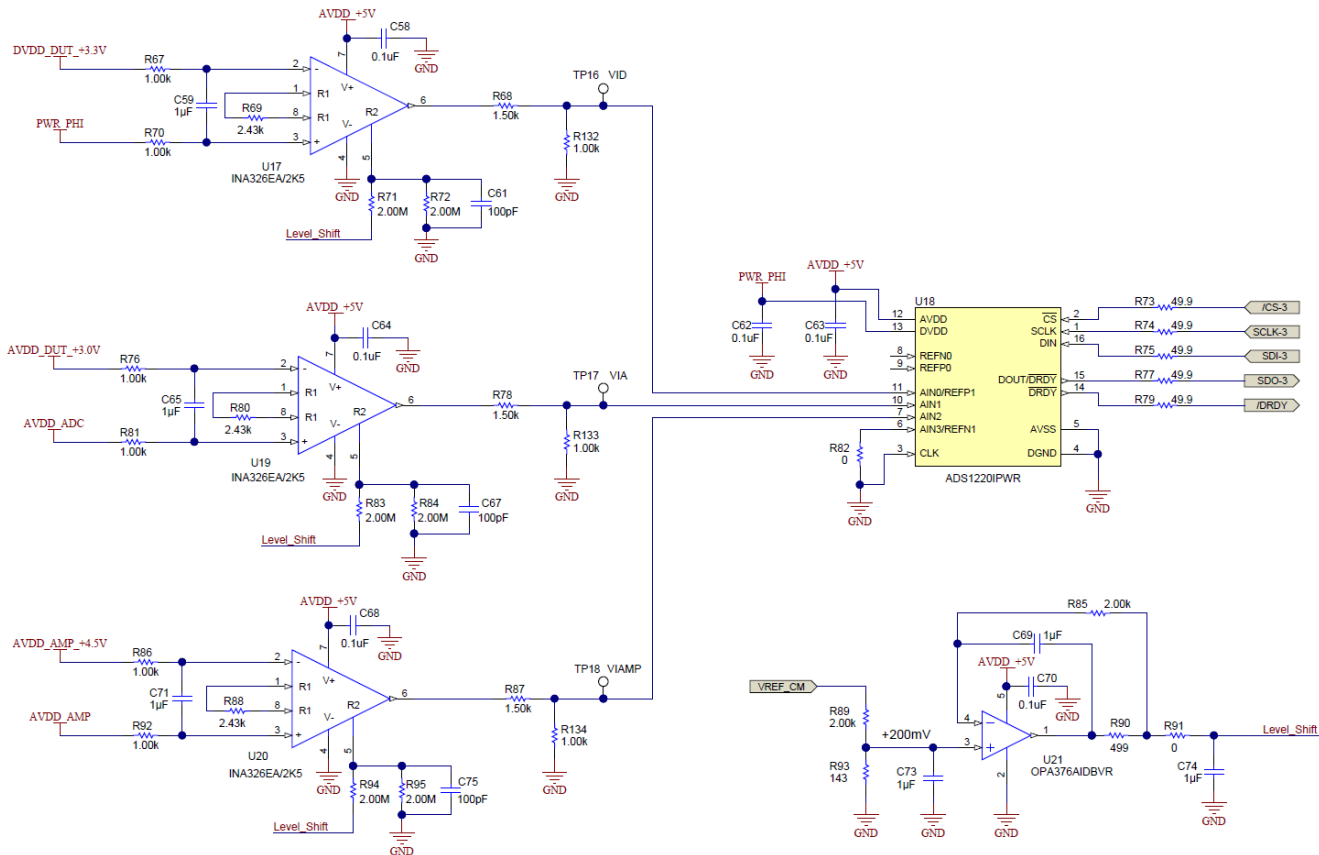


Figure 11. INA Current Monitor (CH3)

2.3.3 Power, Shunt Resistors, and Range Selection for CH3

Figure 12 shows how the LDOs are used to generate the amplifier 4.5-V supply, the ADC digital 3.3-V supply, and the ADC analog 3-V supply. A shunt resistor is connected between each supply output and the device being monitored. Also, notice that the shunt resistor value can be adjusted by changing the jumper position. When the jumper is in the CAL position, the shunt resistor is shorted out so that the offset of the measurement amplifiers can be measured.

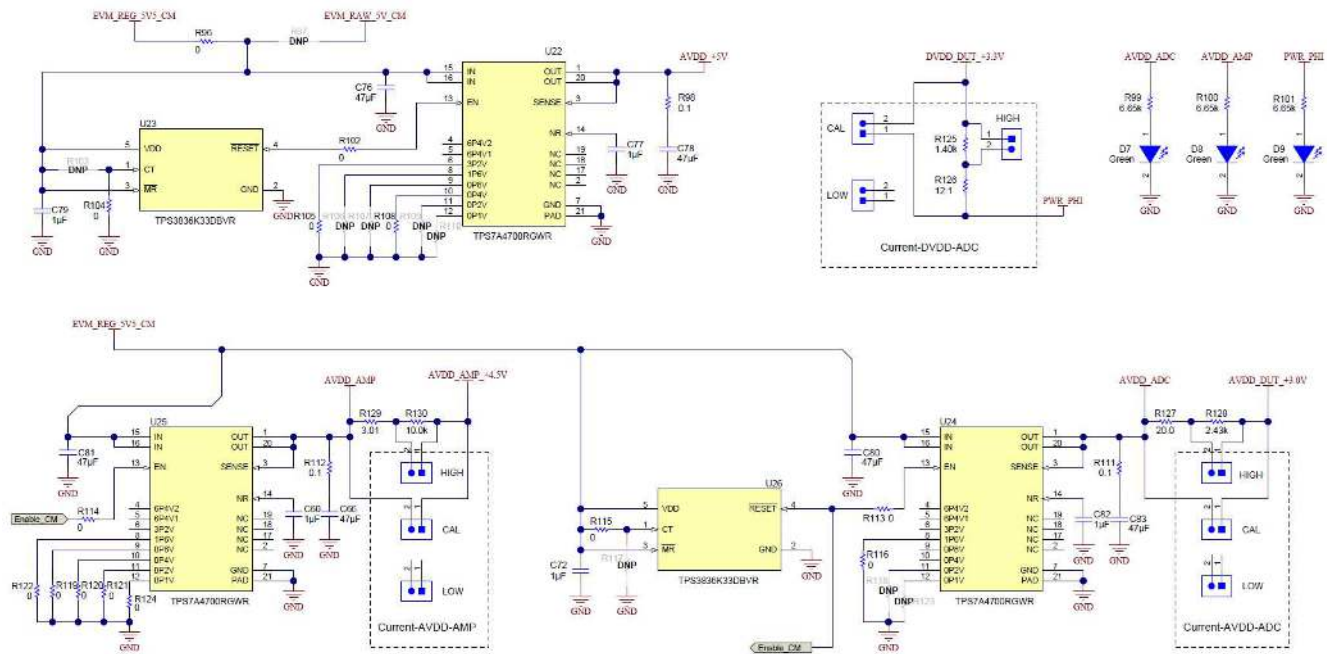


Figure 12. Power, Shunt Resistors, and Range Selection for CH3

2.3.4 DC or AC Input (CH3)

Figure 13 shows how the precision DC input signals are generated using a reference with a jumper-selected voltage divider. Depending on the position of the jumper in the DC options the divider output is 0.1 V, 1.0 V, 1.5 V, or 2.5 V. If the jumper is in the position shown, the output voltage is 0.1 V. The amplifier U15 buffers the precision DC signal.

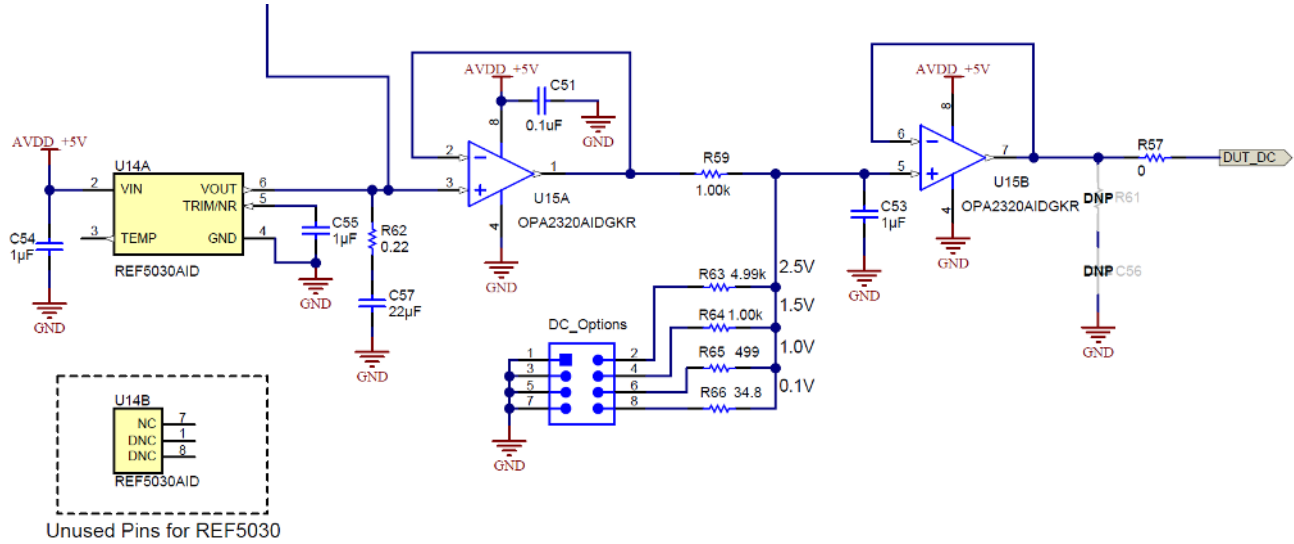


Figure 13. DC or AC Input (CH3)

3 Plug-In Amplifier Coupon Boards

Figure 14 shows a typical coupon board. The top of the board shows the full schematic of the design. The components are soldered to the bottom of the board. The label at the bottom of the coupon board describes the design. This example uses the OPA320 and *good filter* indicates that the filter was properly designed.

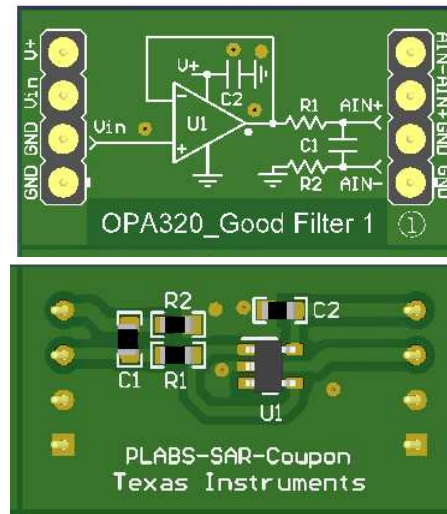


Figure 14. Coupon Card Layout

Be careful when installing the coupon board to properly align the pins. Also, make sure that the board is not upside-down. The label must be at the bottom of the card so that the amplifier output connects to the ADC. Plunging the coupon card in incorrectly can damage the device. Figure 15 shows the proper method of installing a coupon card.

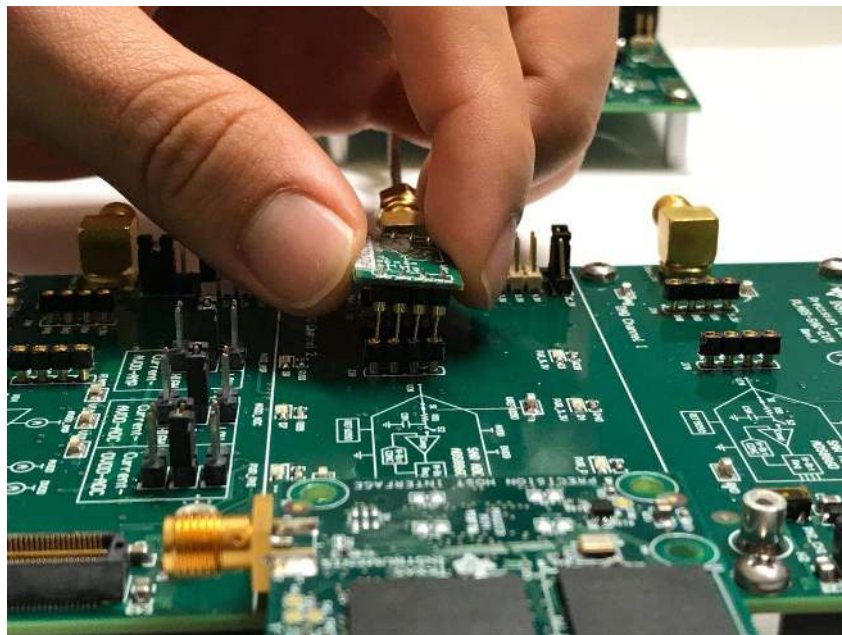


Figure 15. Installing a Coupon Card

Table 3 outlines the function of each coupon card and highlights the key device in the system:

Table 3. Coupon Card Descriptions

| Coupon Card Designation | Key Device | System Description |
|-------------------------|------------|--|
| OPA320_Good Filter 1 | OPA320 | Good Filter 1 does not act as an antialiasing filter, but rather helps with noise. The op amp is chosen with appropriate bandwidth and charge bucket values to achieve the required acquisition settling time of 290 ns for the ADS8860. |
| OPA320_Bad Filter | OPA320 | This filter uses the same drive amp as Good Filter 1, but includes an improper RC charge bucket combination. The settling time is now too long, so acquisition of the input does not occur quick enough to reflect an accurate result. |
| OPA333_Low Bandwidth | OPA333 | As opposed to the OPA320 bandwidth of 20 MHz, the OPA333 has a bandwidth of 350 kHz so settling time is also negatively affected. |
| OPA316_Crossover | OPA316 | This circuit is used for checking the effect of crossover distortion on the output. The system is intentionally in a noninverting topology with a non zero-crossover distortion device (additional offset is summed with the input signal and causes further distortion). |
| OPA320_Noise 1 | OPA320 | This circuit is designed to measure the effect of resistor noise on an output response to a DC input: note the gain and resistance values in the feedback path. |
| Sallen_Key Filter | OPA320 | This Sallen-Key filter is a low-pass antialiasing filter. Aliasing is also known as foldover distortion. Because the ADS8860 has a sample rate of 1 MHz, aliasing occurs at any input frequency over 500 kHz. If aliasing occurs, the filter significantly attenuates the foldover at the ADC input to some desired level (for example, 100 mV or less). |
| TLV313_Low Power | TLV313 | The TLV313 consumes a 65- μ A quiescent current. Power consumption by the ADC scales with two concepts: drive amp bandwidth and ADC sampling rate. |
| LPV811_Nanopower | LPV811 | The LPV811 consumes 425 nA per channel. |
| OPA320_Noise 2 | OPA320 | This circuit is also designed to measure the effect of resistor noise on an output response to a DC input: note that the gain is the same as Noise 1 but the resistance values are divided by 100 so resistor noise is much less. |
| OPA320_Good Filter 2 | OPA320 | Good Filter 2 uses the same op amp as Good Filter 1 but the charge bucket filter has a different time constant. |


4 EVM Graphical User Interface (GUI) Software Installation

This section outlines the step-by-step GUI installation procedure. First, uninstall the separate PLABS-SAR-EVM and Power Scaling GUIs by opening your control panel and accessing *Programs and Features*. Scroll down your programs to find any instances of PLABS-SAR-EVM or Power Scaling GUI executable files. Upon uninstalling, you might have to reboot your computer. The two programs are merged into one toolkit named *PLABS-SAR-EVM toolkit*. Go to the [PLABS-SAR-EVM-PDK link](#) on ti.com for the updated software. [Figure 16](#) shows the first step in acquiring the toolkit software.

Click on this link for the zip folder containing the updated software




User guides (1)

| Title | Abstract | Type | Size (KB) | Date | Views | TI Rec |
|---|-------------------------------|------|-----------|-------------|-------|--------|
|  Precision Labs SAR ADC EVM User's Guide | Read Abstract | PDF | 3311 | 05 Dec 2017 | 149 | ✓ |

Related Products

Software (1)

 [PLABS-SAR-EVM-PDK Setup Toolkit \(Rev. A\)](#)
(ZIP, 361412KB) 16 Feb 2018

TI Devices (11)

| Part Number | Name |
|-------------------------|---|
| ADS1220 | 24-Bit, 2kSPS, 4-Ch, Low-Power Delta-Sigma ADC With PGA and Vref for Small Signal Sensors |
| ADS7042 | 12-Bit 1MSPS Ultra-Low-Power Ultra-Small-Size SAR ADC With SPI Interface |
| ADS8860 | 16 bit 1 MSPS, Serial, Pseudo-Differential Input, Micro Power, Miniature, SAR ADC |

Figure 16. PLABS Toolkit Link

Upon clicking the *Setup Toolkit* link in [Figure 16](#), the page in [Figure 17](#) opens:

Click on the appropriate box for your application



What end-equipment/application will you use this file for:

- Military
- Civil

I certify that the following is true:

- (a) I understand that this Software/Tool/Document is subject to export controls under the U.S. Commerce Department’s Export Administration Regulations (“EAR”).
 - (b) I am NOT located in Cuba, Iran, North Korea, Sudan or Syria. I understand these are prohibited destination countries under the EAR or U.S. sanctions regulations.
 - (c) I am NOT listed on the Commerce Department’s Denied Persons List, the Commerce Department’s Entity List, the Commerce Department’s General Order No. 3 (in Supp. 1 to EAR Part 736), or the Treasury Department’s Lists of Specially Designated Nationals.
 - (d) I WILL NOT EXPORT, re-EXPORT or TRANSFER this Software/Tool/Document to any prohibited destination, entity, or individual without the necessary export license(s) or authorization(s) from the U.S. Government.
 - (e) I will NOT USE or TRANSFER this Software/Tool/Document for use in any sensitive NUCLEAR, CHEMICAL or BIOLOGICAL WEAPONS, or MISSILE TECHNOLOGY end-uses unless authorized by the U.S. Government by regulation or specific license.
 - (f) I understand that countries other than the United States may restrict the import, use, or export of the Subject Product. I agree that we shall be solely responsible for compliance with any such import, use, or export restrictions.
- I / We hereby certify that we will adhere to the conditions above.
 - I / We do not know of any additional facts different from the above.
 - I / We take responsibility to comply with these terms.
 - I / We understand we are responsible to abide by the most current versions of the Export Administration Regulations and other U.S. export and sanctions laws.

I CERTIFY ALL THE ABOVE IS TRUE: Yes No

Submit

Figure 17. Applications Agreement

When the required agreements are accepted you will be prompted to the download page. When the download is finished, open the downloaded zip folder and run the executable file within. Upon successful completion of this step, [Figure 18](#) opens:

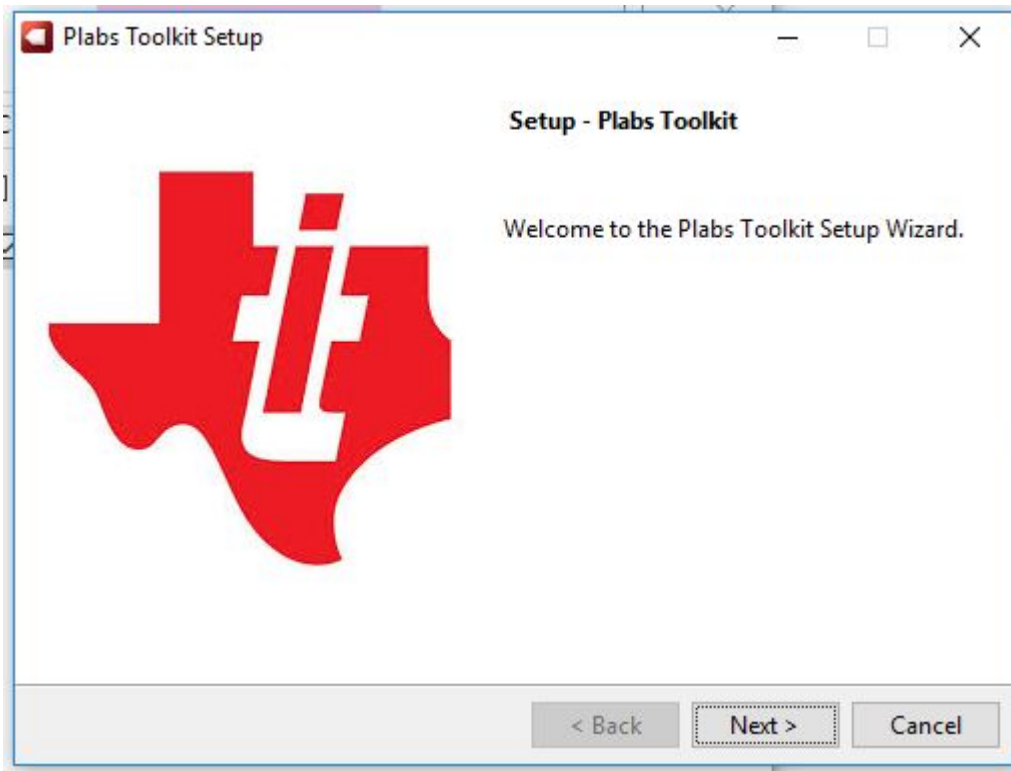


Figure 18. Plabs Toolkit Dialog Box

Click *Next* and follow the dialog box prompts to install the Plabs toolkit. [Figure 19](#) shows the PLABS toolkit setup steps:

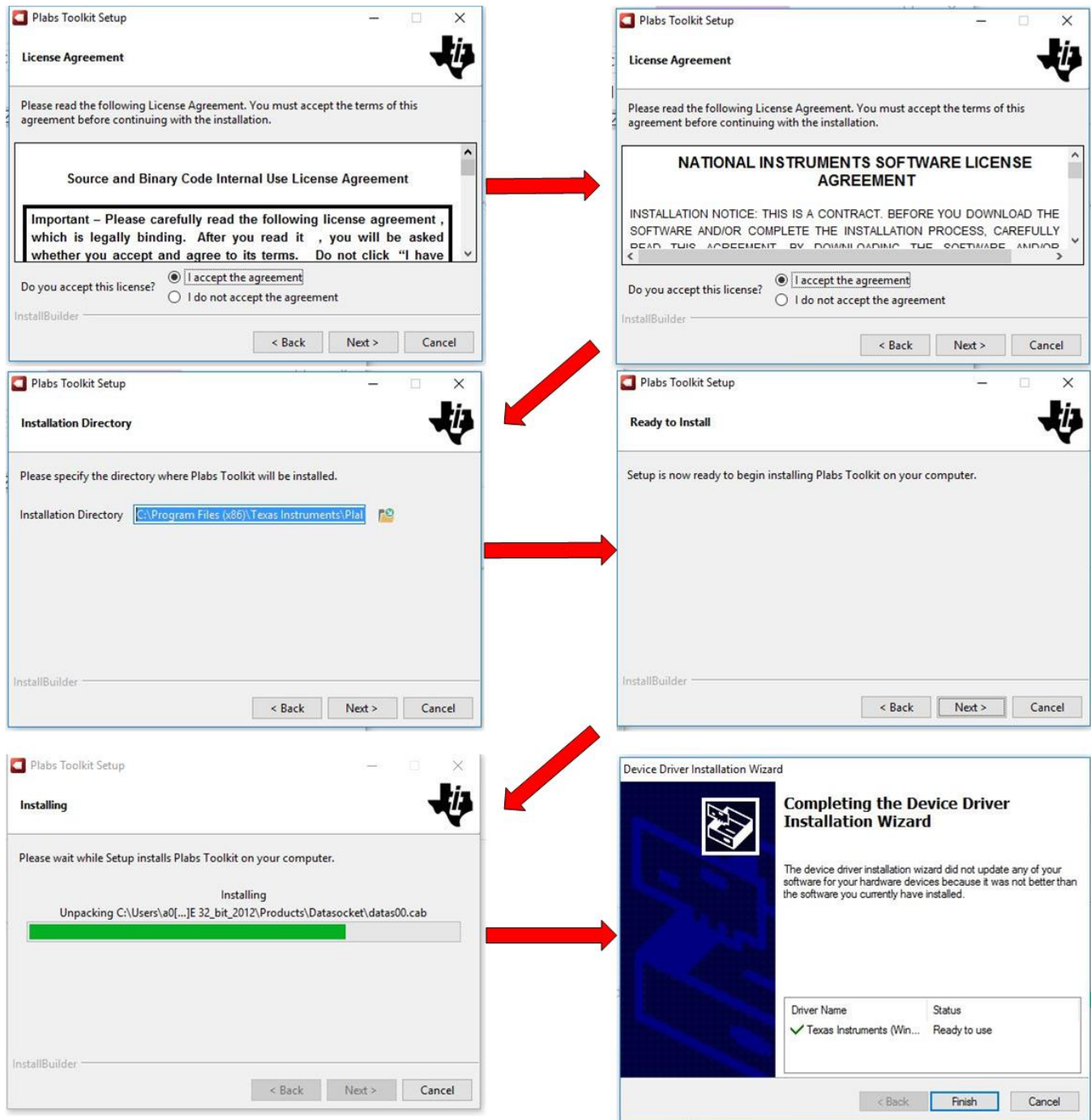


Figure 19. Software Installation

4.1 Overview of PLABS-SAR-EVM GUI

When the download is finished, you should have the option to run the toolkit. If not, search for the program using the start menu and open the toolkit. The prompt in [Figure 20](#) should appear:

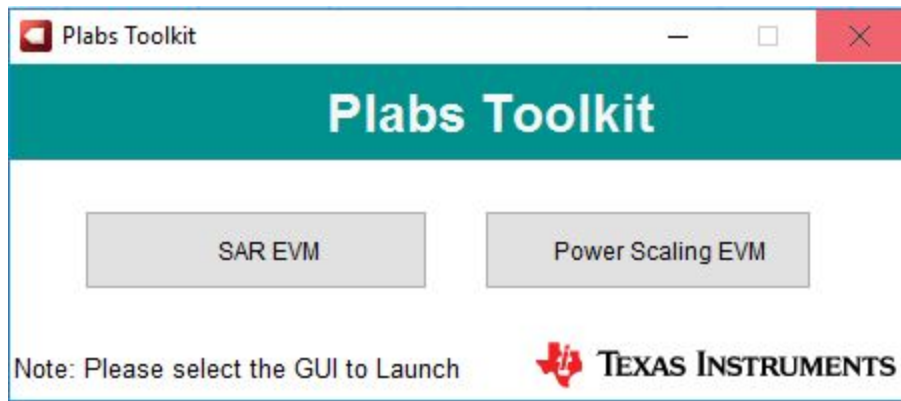


Figure 20. Plabs Toolkit Prompt

Click on the **SAR EVM** button to open the SAR EVM GUI, the default display that opens should look like the page in [Figure 21](#). The PSI controls are located at the bottom right of the main display and the red tab indicates if the PSI hardware is not connected.

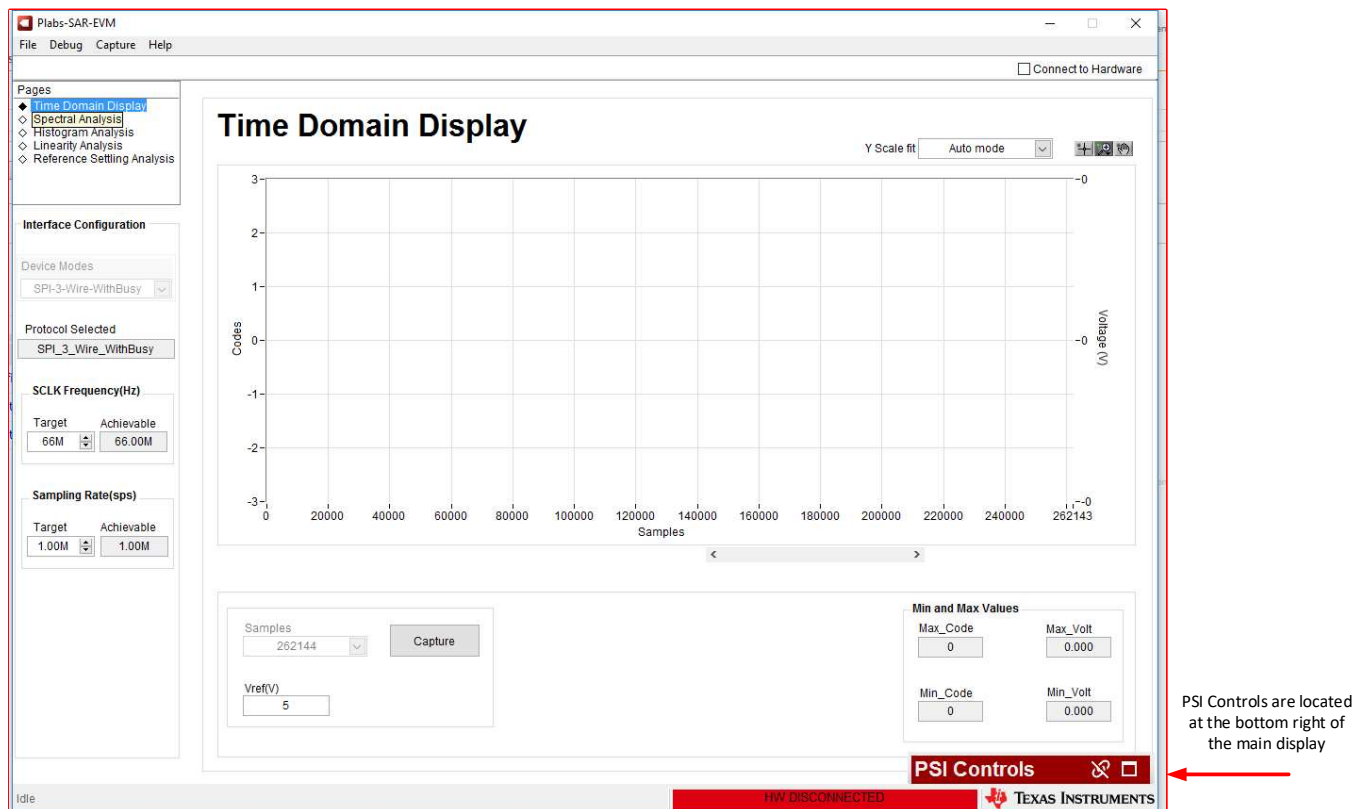
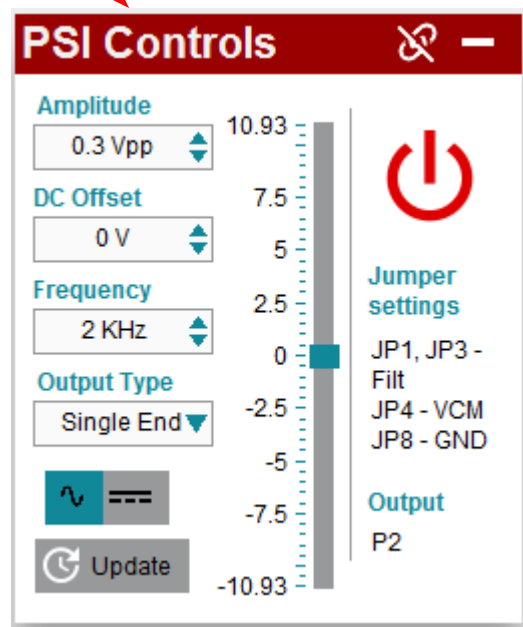


Figure 21. Default PLABS-SAR-EVM GUI Display

The PSI software interface within the SAR EVM GUI allows the user to enter the peak-to-peak amplitude of the output signal, the offset voltage, and the frequency. The output enable switches the output signal on and off. Single-ended and differential options are also available but the SAR-PLABS-EVM only uses the single-ended mode. Click on the *PSI Controls* tab to expand this screen, which then shows the controls in Figure 22.

If the controls header tab is red, the PSI hardware has not been recognized by the GUI

Click on the “refresh” button to poll for the PSI hardware



Below the jumper settings are the correct jumper connections for proper operation

Figure 22. PSI Controls: Unconnected PSI Hardware

When the PSI hardware is recognized, the controls tab should look like [Figure 23](#):

Full Scale Input Range is 5 volts peak to peak

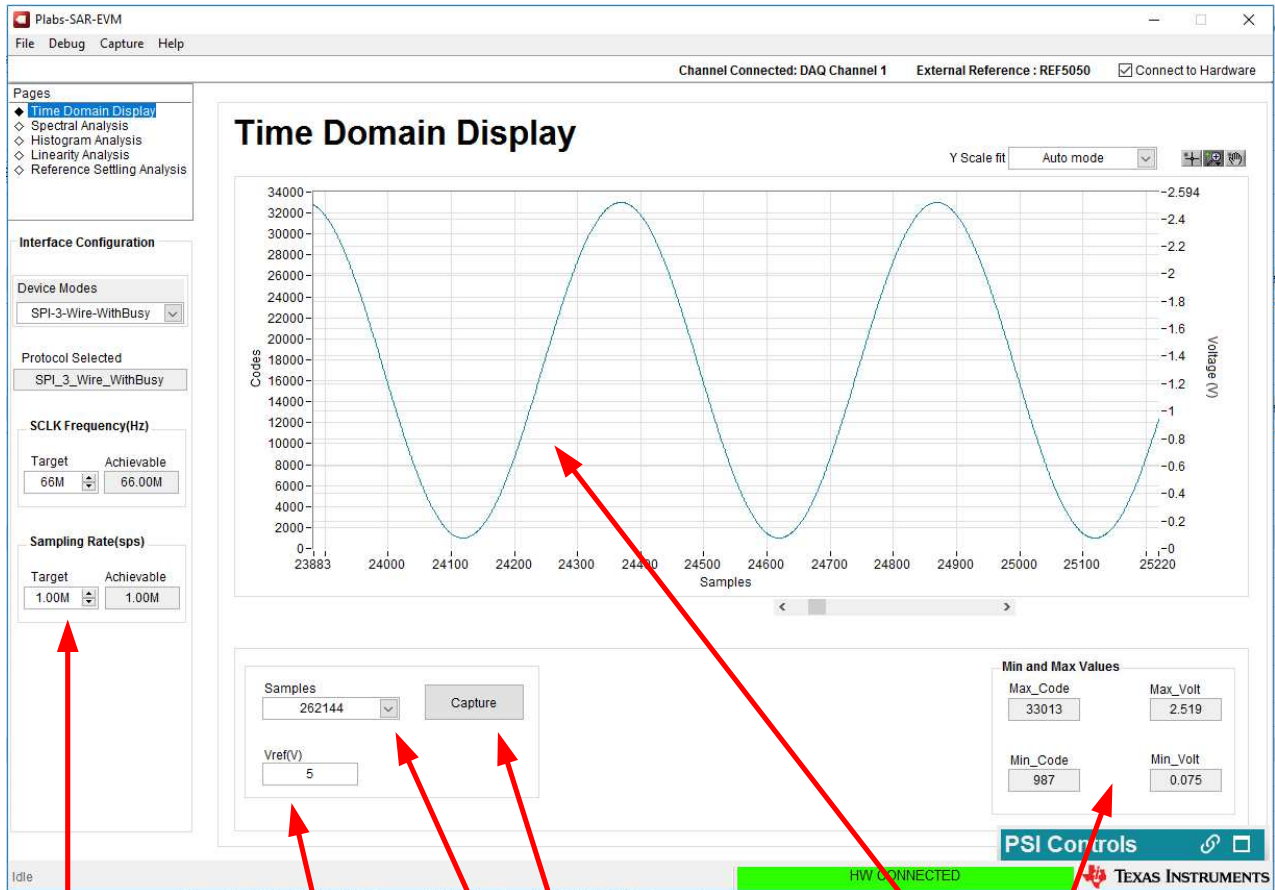
Offset is set to half the Full Scale Range

Set the output to single ended for this evm

Click on the power button to generate the signal, once powered it will turn blue

Figure 23. PSI Controls: Ready to Generate an Input Signal

The time domain display allows the user to view the input signal in a pre-defined window when captured by the ADS8860. Figure 24 shows some key features of the display.



Enter Sampling Rate. 1Mps is maximum for ADS8860.

Enter reference voltage. 5V is used on this EVM.

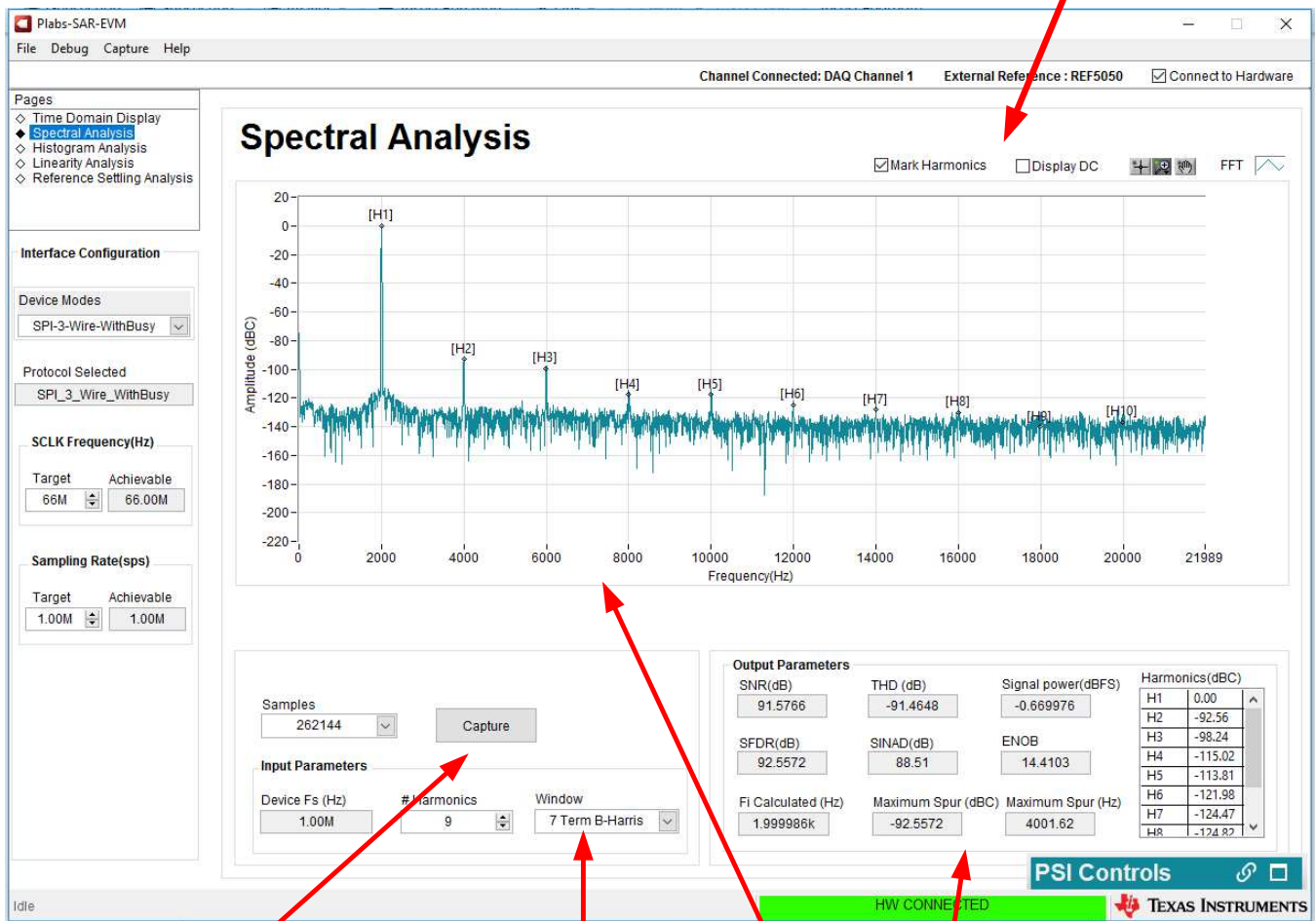
Enter number of points sampled. Press capture.

Waveform and key measurements are displayed.

Figure 24. Time Domain Display

The spectral analysis page performs a fast Fourier transform (FFT) of the input signal and displays key measurements such as signal-to-noise ratio (SNR), total harmonic distortion (THD), signal power (dBFS), spurious-free dynamic range (SFDR), signal-to-noise and distortion (SINAD), and effective number of Bits (ENOB). With a 4.9-V_{PP}, 2-kHz sine wave and 2.5-V DC offset the spectral analysis should look similar to the page shown in Figure 25.

Enable the display of harmonics and DC offset in the FFT



Press capture.

Use default "7 term B-Harris for best results".

FFT and key measurements are displayed.

Figure 25. Spectral Analysis Display

The histogram analysis displays a histogram of data points clustered at sets of codes corresponding to the digital values converted by the ADS8860. **Figure 26** shows the histogram analysis with Noise Card 1 placed at channel 1 and a DC input of 0.1 V.

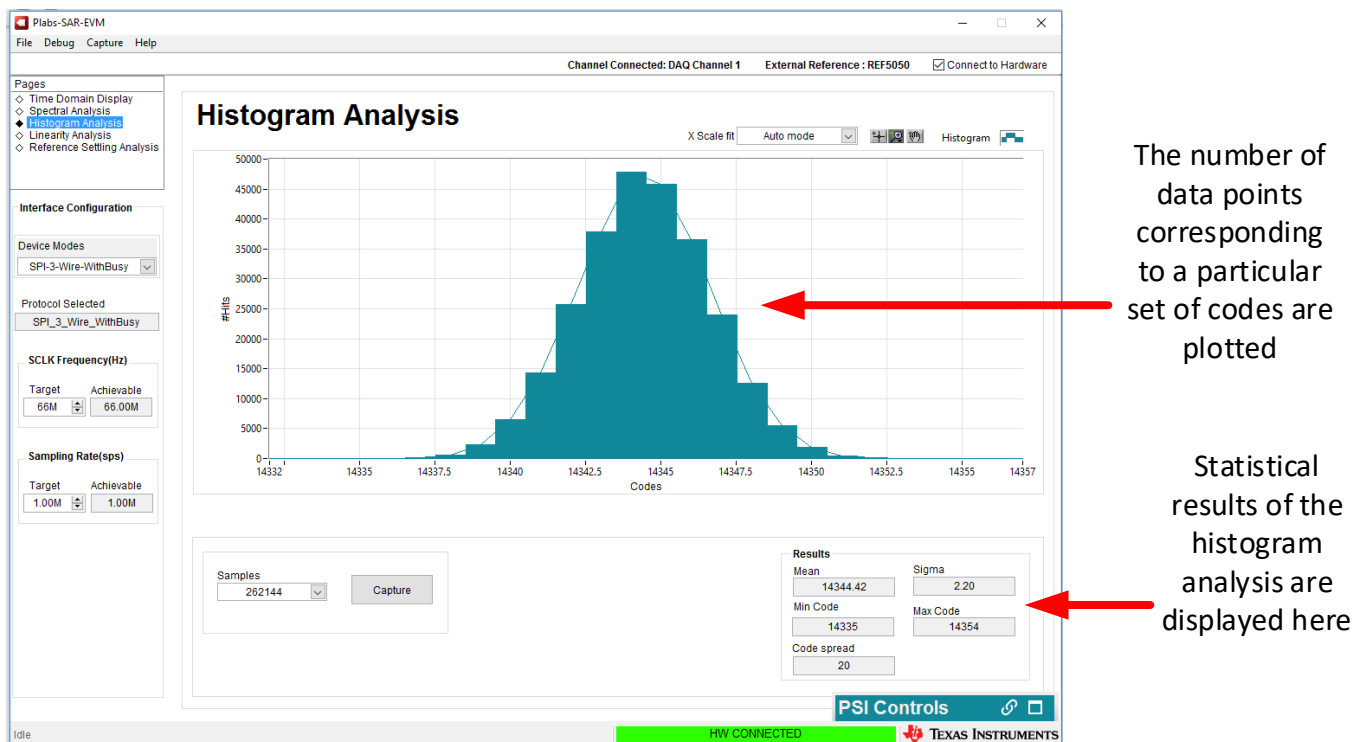


Figure 26. Histogram Analysis

4.2 Overview of PLABS Power Scaling GUI

The Power Scaling GUI allows the user to analyze how power consumption by the ADC changes. The Power Scaling GUI must recognize the PHI and PSI connected to channel 3 for proper operation. Be sure to correctly connect the hardware. [Figure 27](#) describes the register map configuration display.

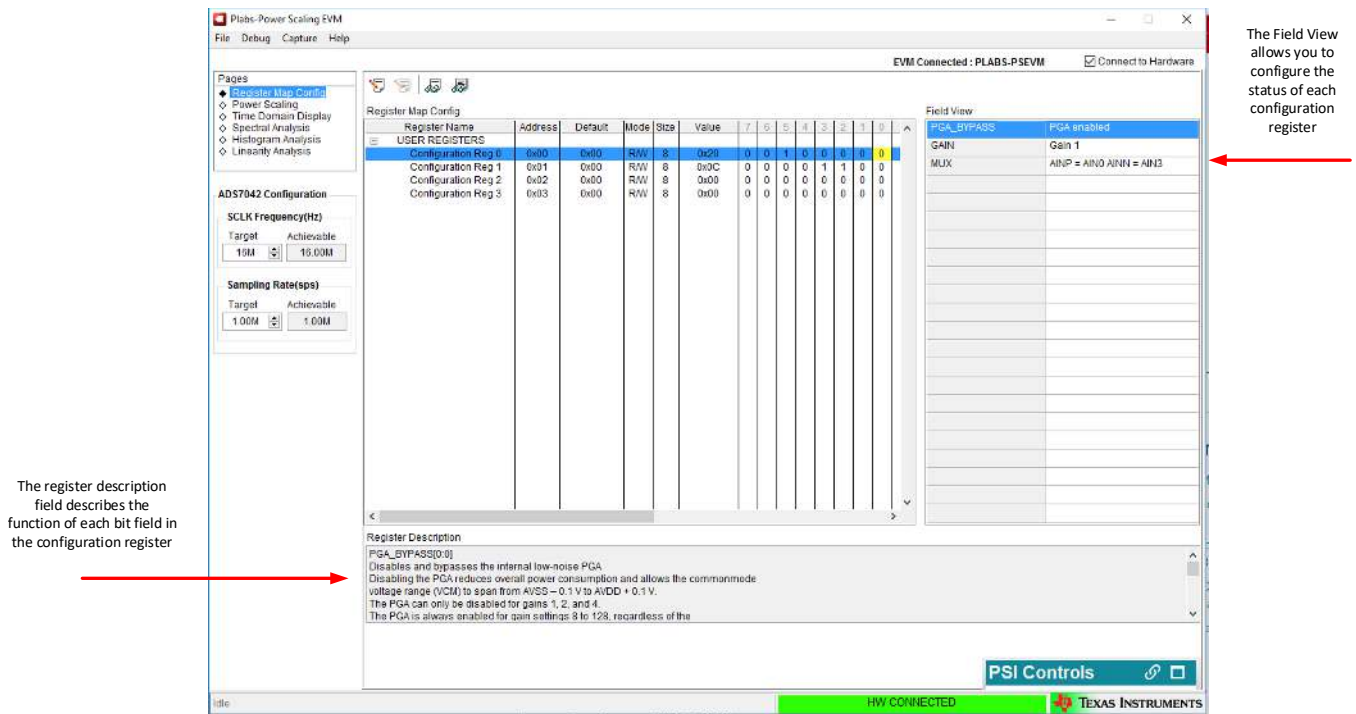


Figure 27. Register Map Configuration

The *Power Scaling* tab shows power consumption results by the ADS7042 when the sampling rate changes and bandwidth of the front-end drive op amp changes. Calibrate the system before experimenting with the power-scaling analysis tools. **Figure 28** shows power-scaling results for the ADS7042. When calibration is complete, power-scaling results are obtained by clicking on each sampling rate button and performing the appropriate coupon card and jumper connection updates on the EVM.

Click the calibrate button to remove static errors such as offset error, INL, DNL, and Gain error from the system measurement

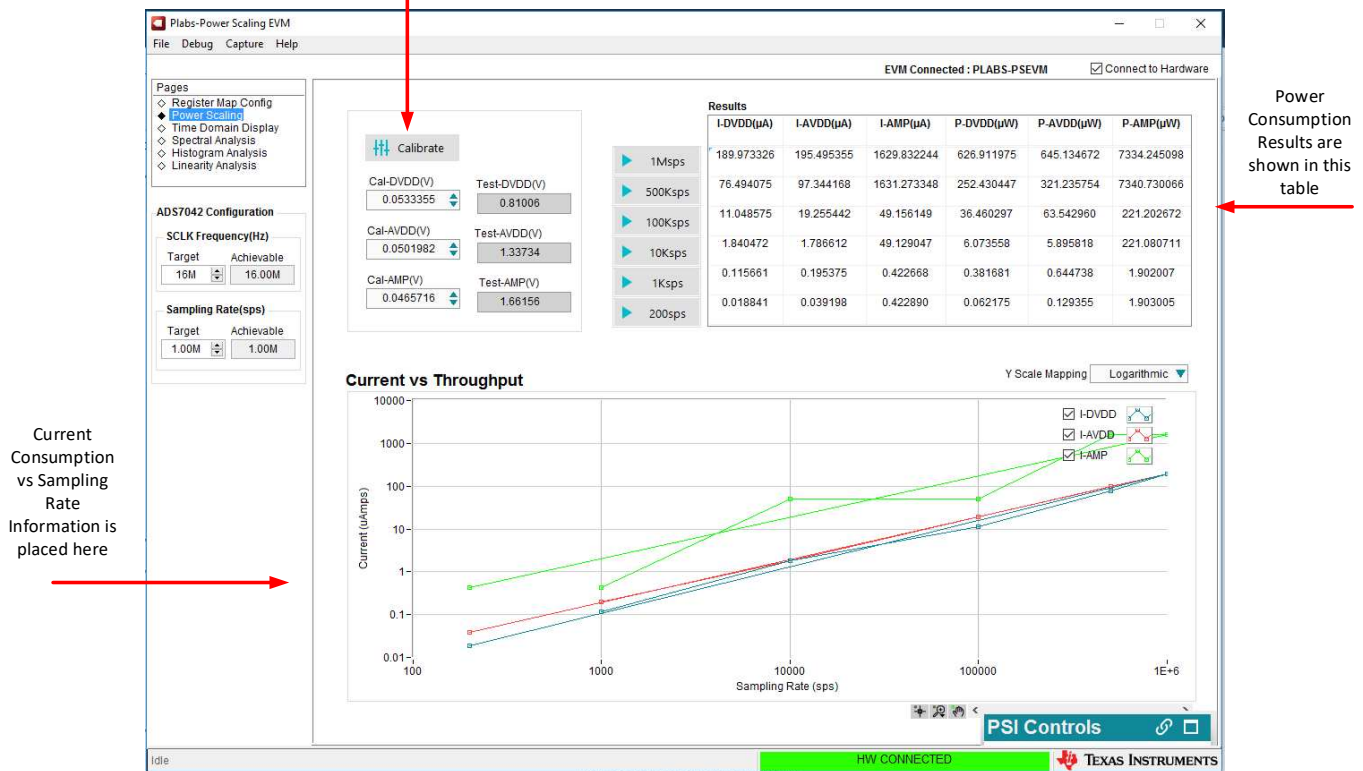


Figure 28. Power Scaling Results

Similar to the PLABS-SAR-EVM GUI, the Power Scaling GUI includes virtually identical time domain analysis, spectral analysis, and linearity analysis displays.

5 Board Layout

The SAR-ADC-EVM uses a four-layer board. Signals are on the top and bottom layer. Internal layers are used for power and ground connections. [Figure 29](#) shows the top layer of the PCB.

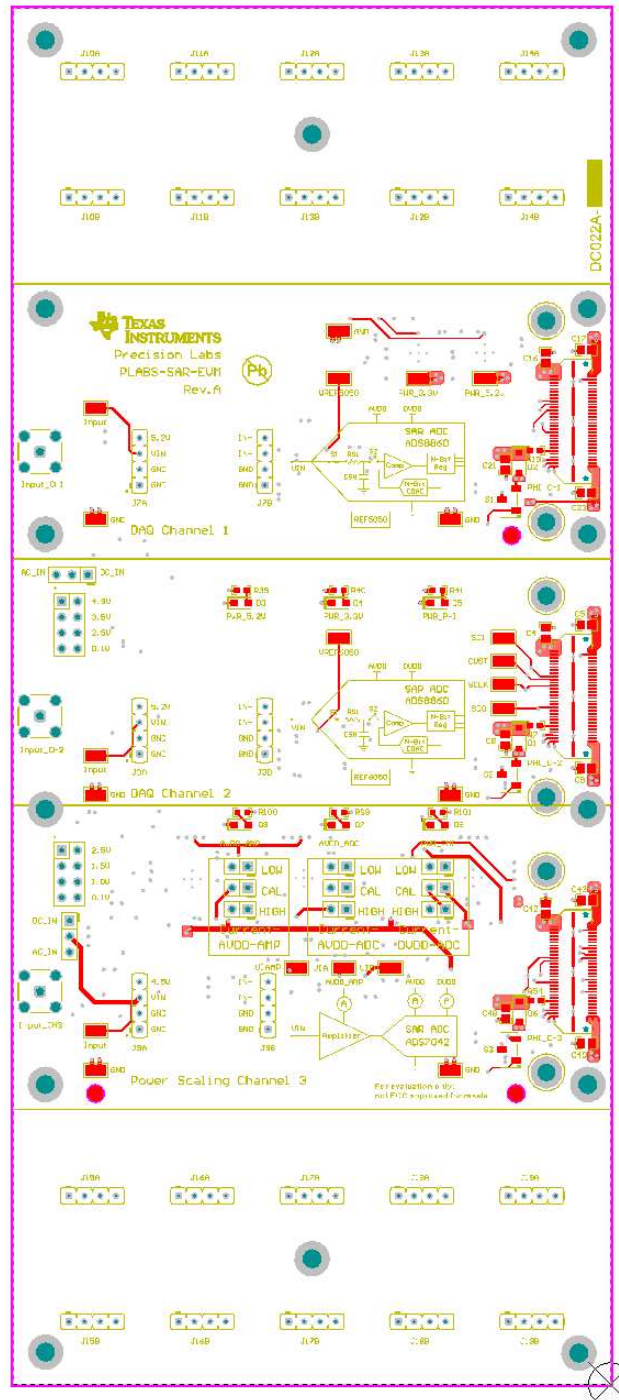


Figure 29. PCB Top Layer

Figure 30 shows that most of the components are placed on the bottom layer.

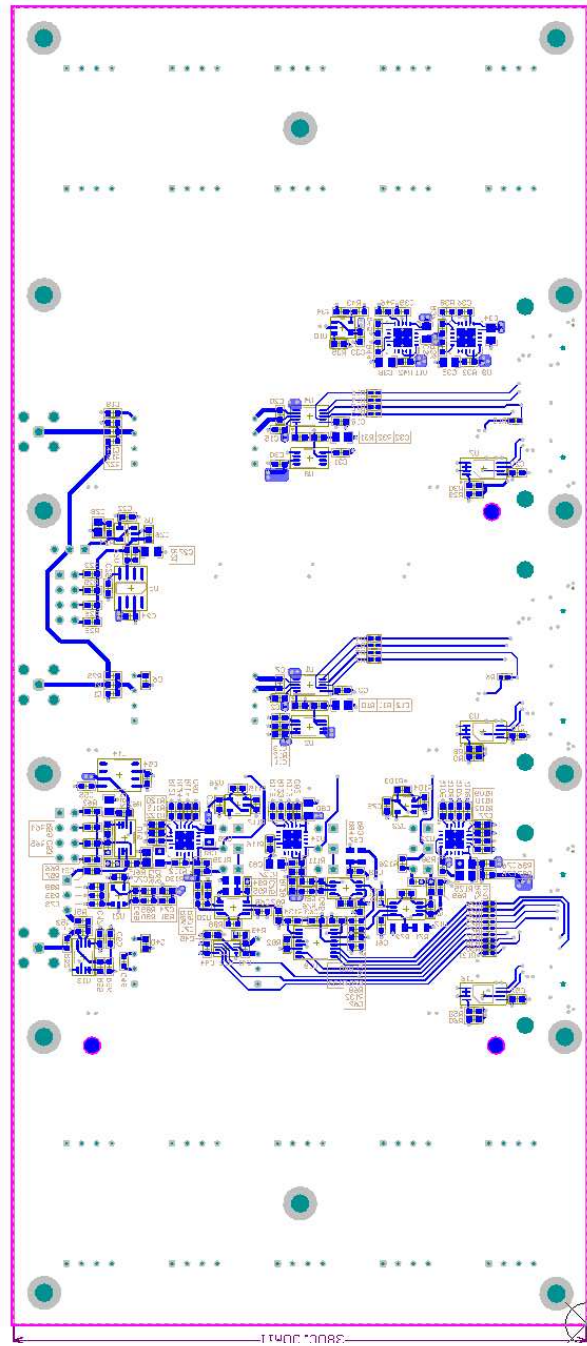


Figure 30. Bottom Layer

The ground layer, shown in [Figure 31](#), is a solid ground plane. All connections to ground are made to this layer.

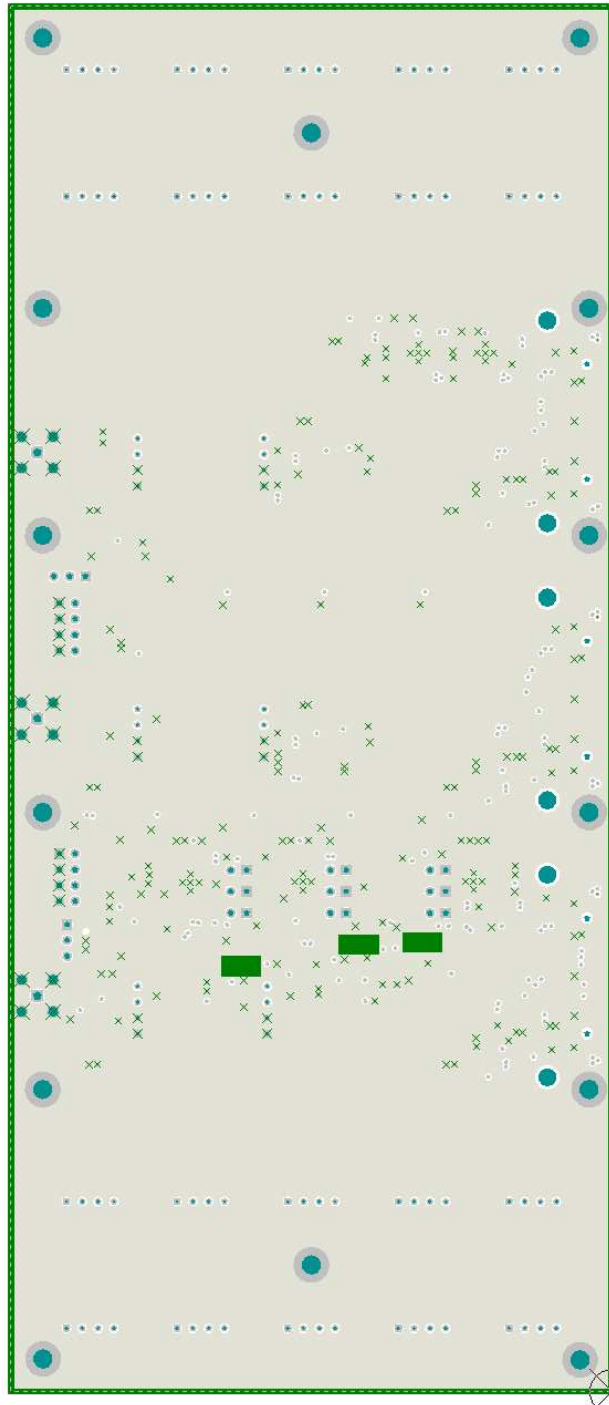


Figure 31. Ground Layer

The power layer, shown in [Figure 32](#), has several different polygon power planes.

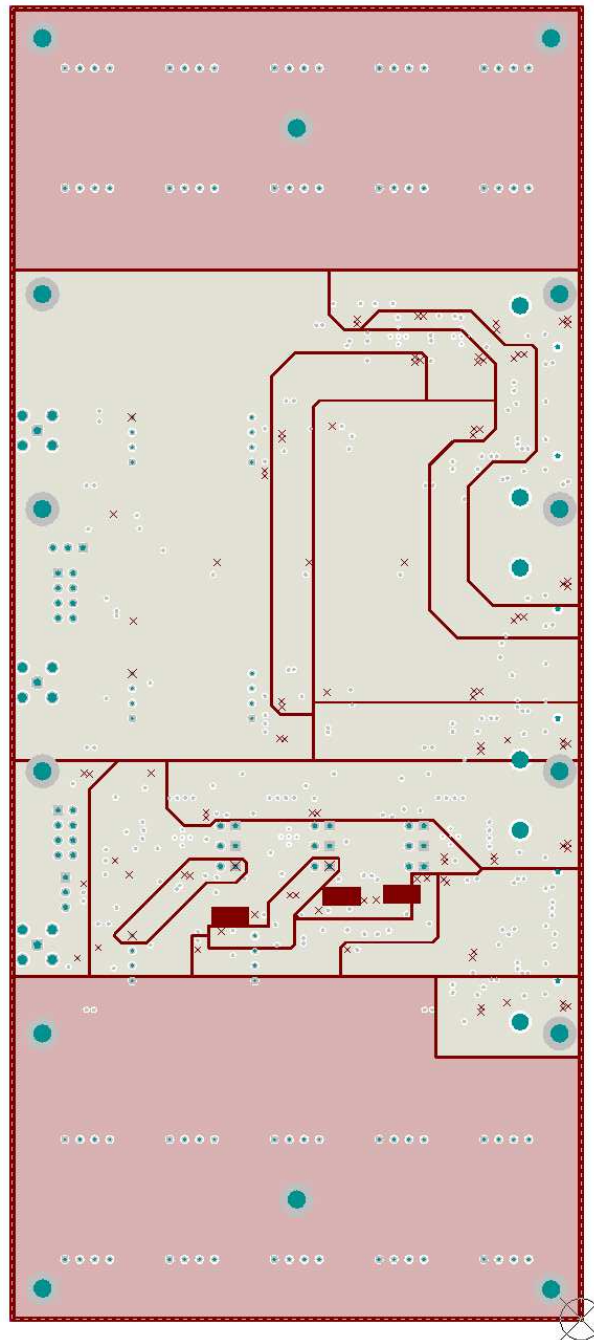


Figure 32. Power Layer

6 Schematic and Bill of Materials

Subsections of the schematic are used throughout this document. The full schematic and bill of materials is provided for reference in this section.

6.1 Schematic

The SAR-ADC-EVM seven-page schematic is provided in [Figure 33](#) through [Figure 39](#).

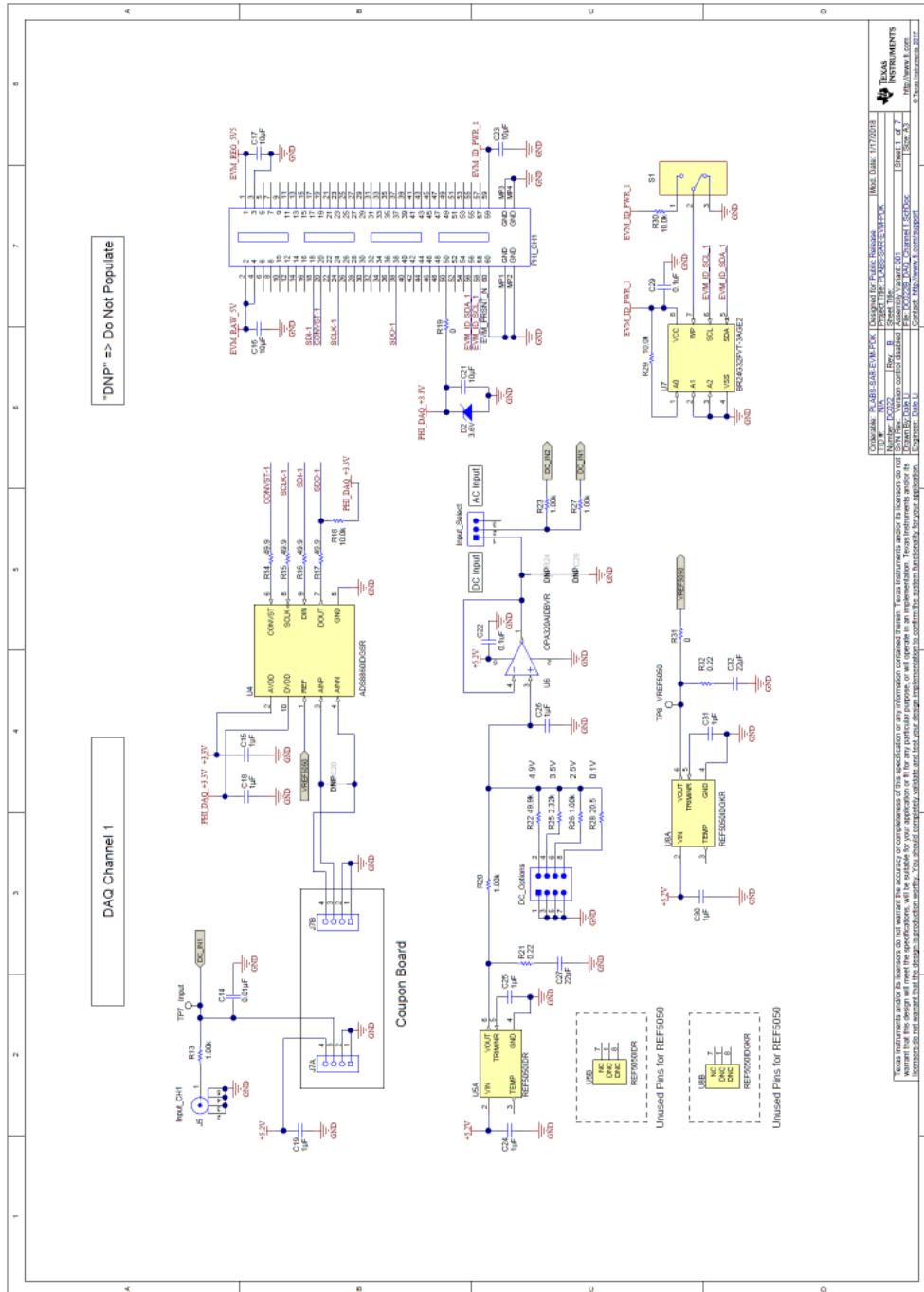


Figure 33. Page 1: Channel 1

Figure 34 shows the input configuration for channel 2.

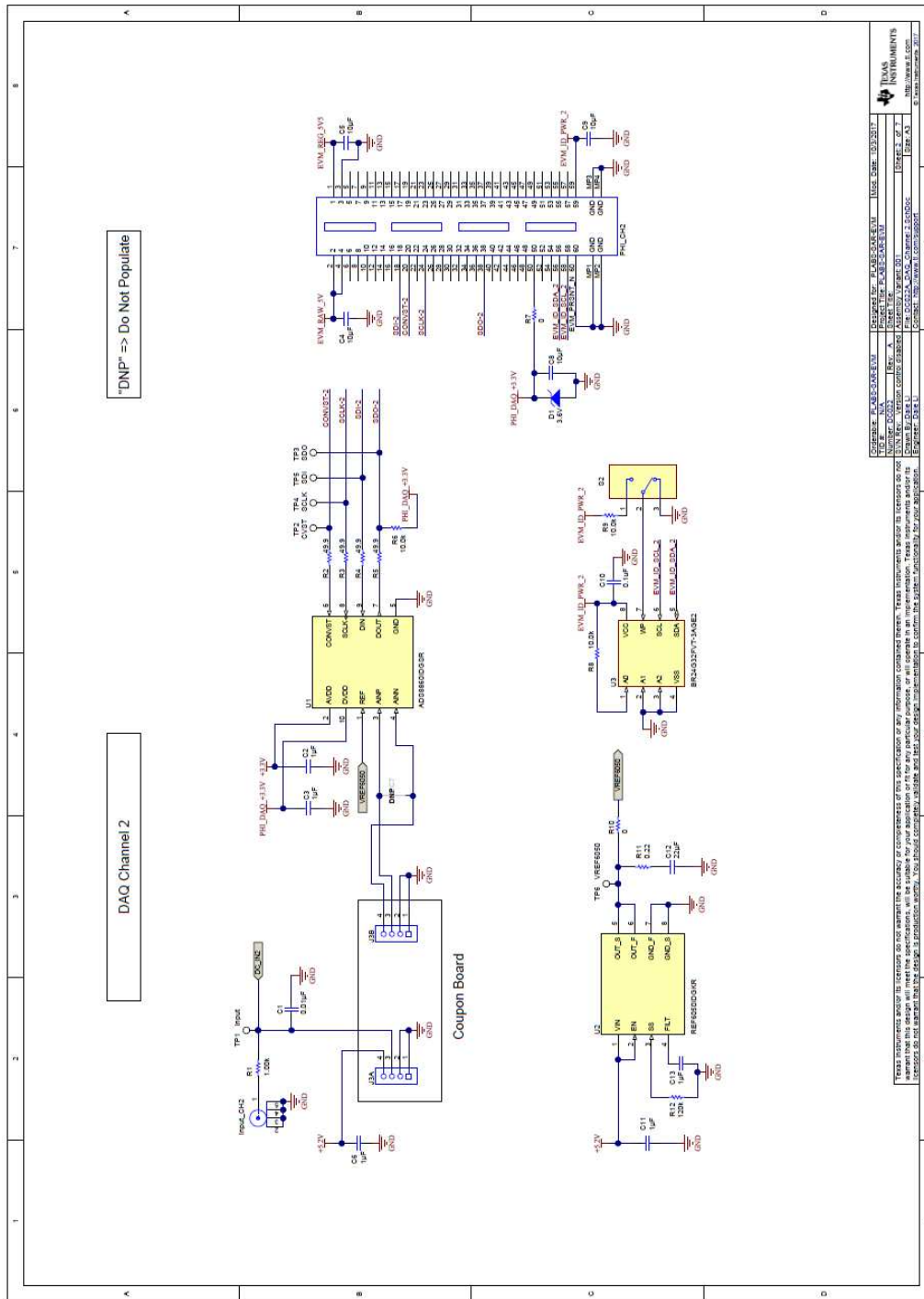


Figure 34. Page 2: Channel 2

This page (Figure 35) shows low dropout regulators for channels 1 and 2.

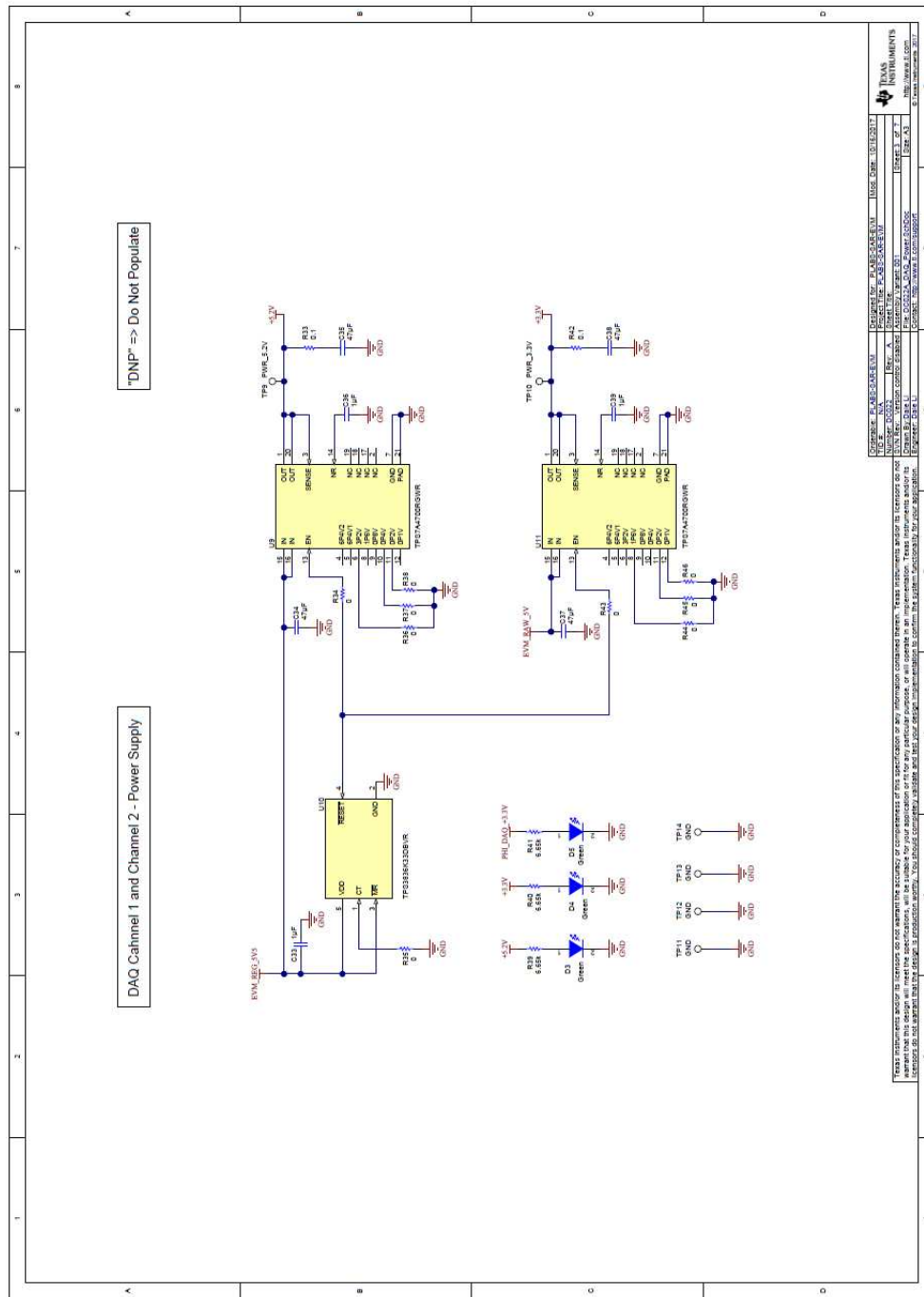


Figure 35. Page 3: Channel 1 and 2 Power

This page (Figure 36) shows the AC and DC connections to channel 3.

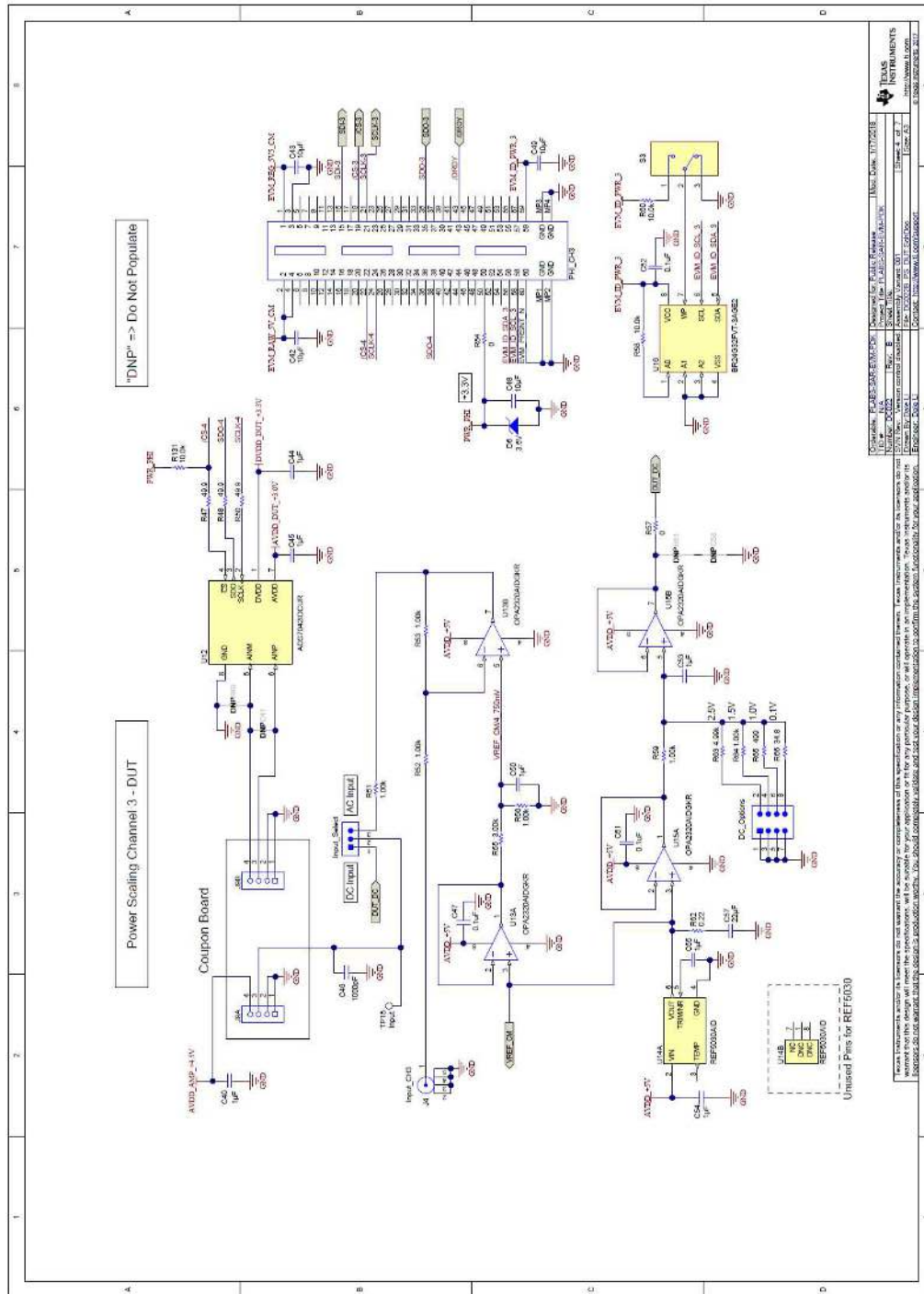


Figure 36. Page 4: Channel 3

This page (Figure 37) shows the current-shunt amplifiers.

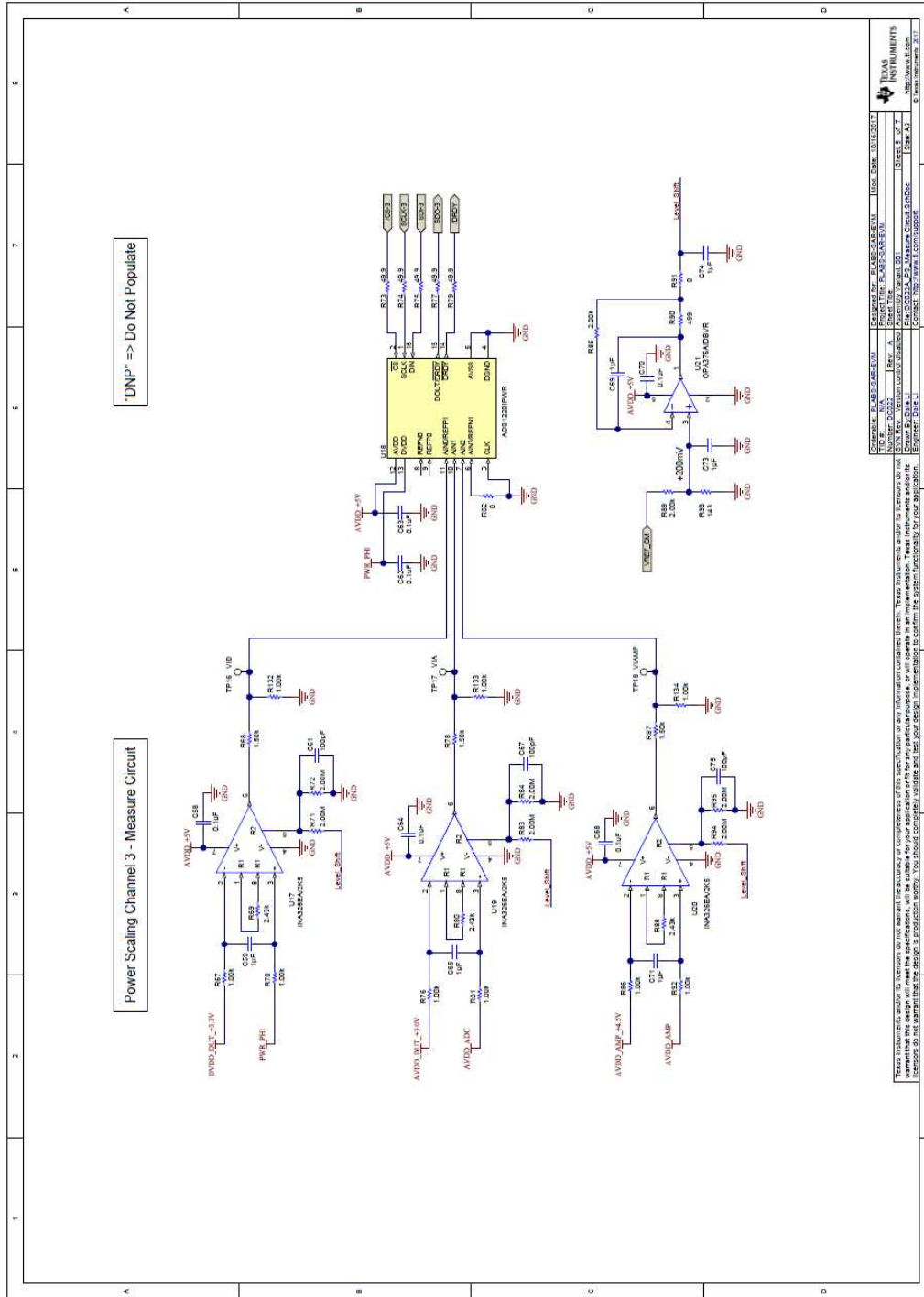


Figure 37. Page 5: Channel 3 Current-Shunt Amplifiers and ADC

Schematics for the coupon cards are presented in Figure 40 through Figure 49 for reference.

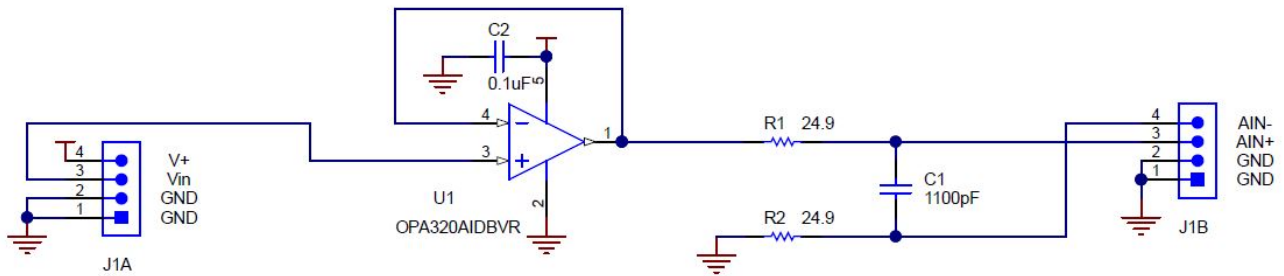


Figure 40. OPA320 Good Filter 1

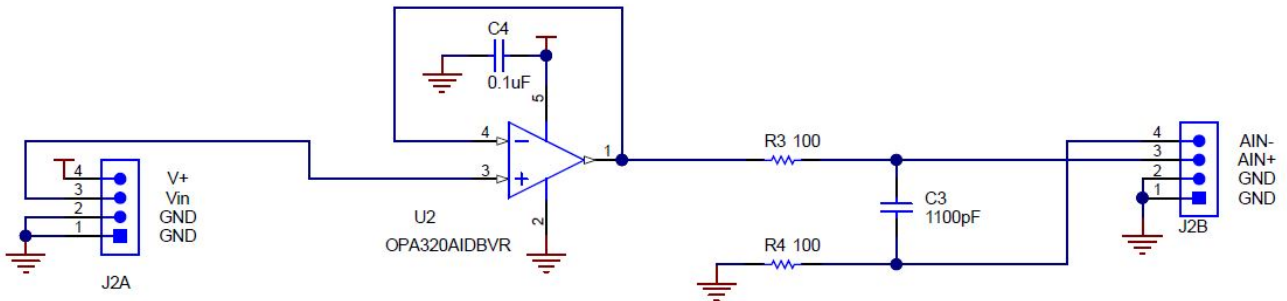


Figure 41. OPA320 Bad Filter

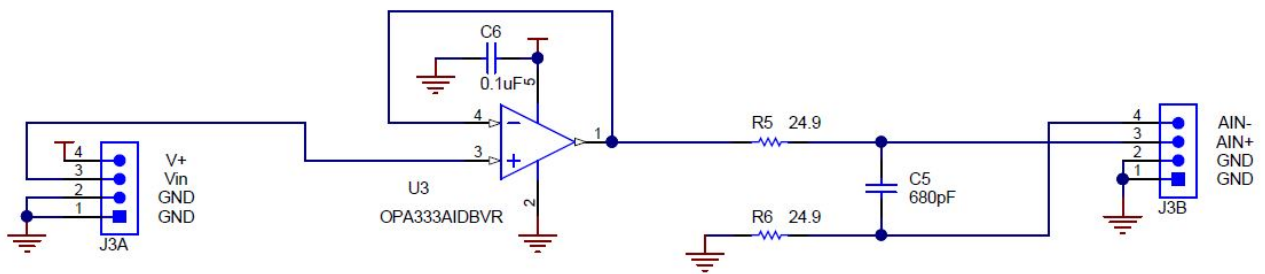


Figure 42. OPA333 Low Bandwidth

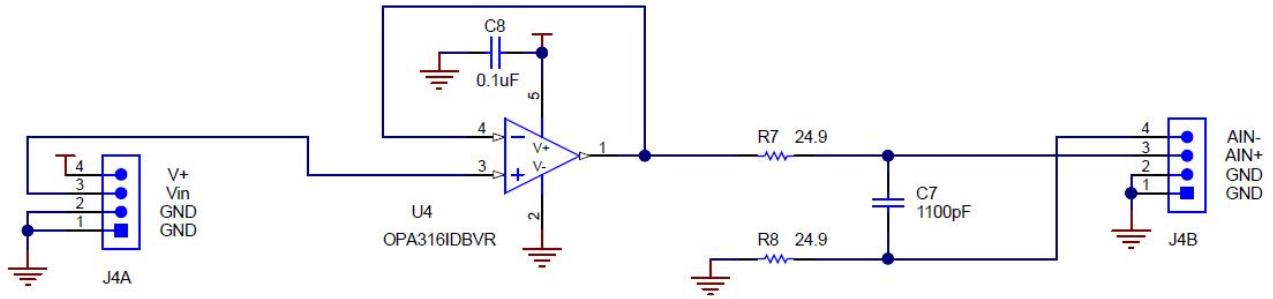


Figure 43. OPA316 Crossover

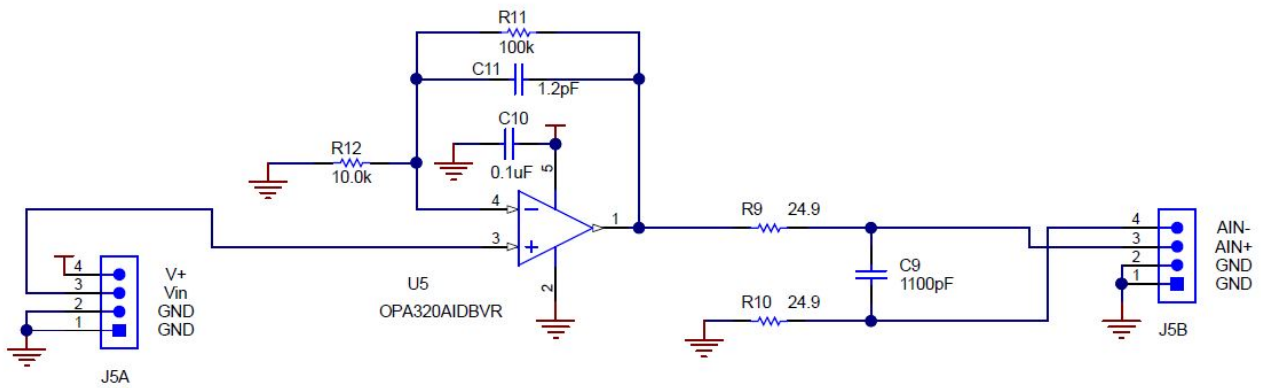


Figure 44. OPA320 Noise 1

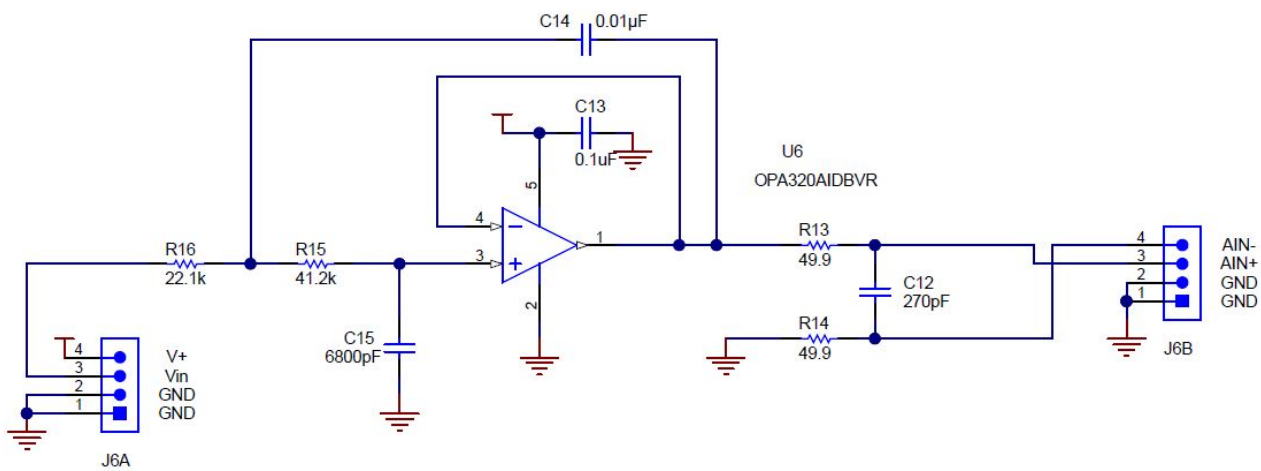


Figure 45. Sallen-Key Filter

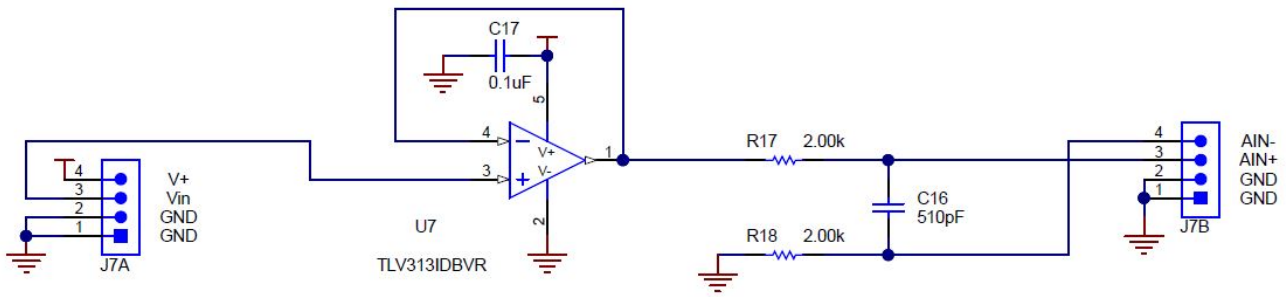


Figure 46. TLV313 Low Power

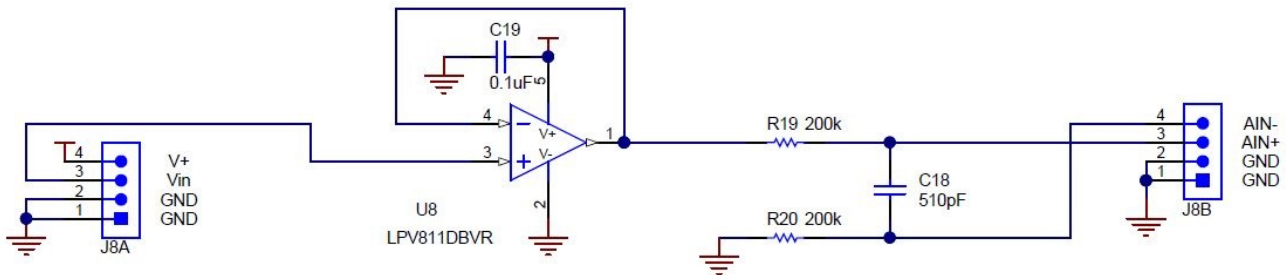


Figure 47. LPV811 Nanopower

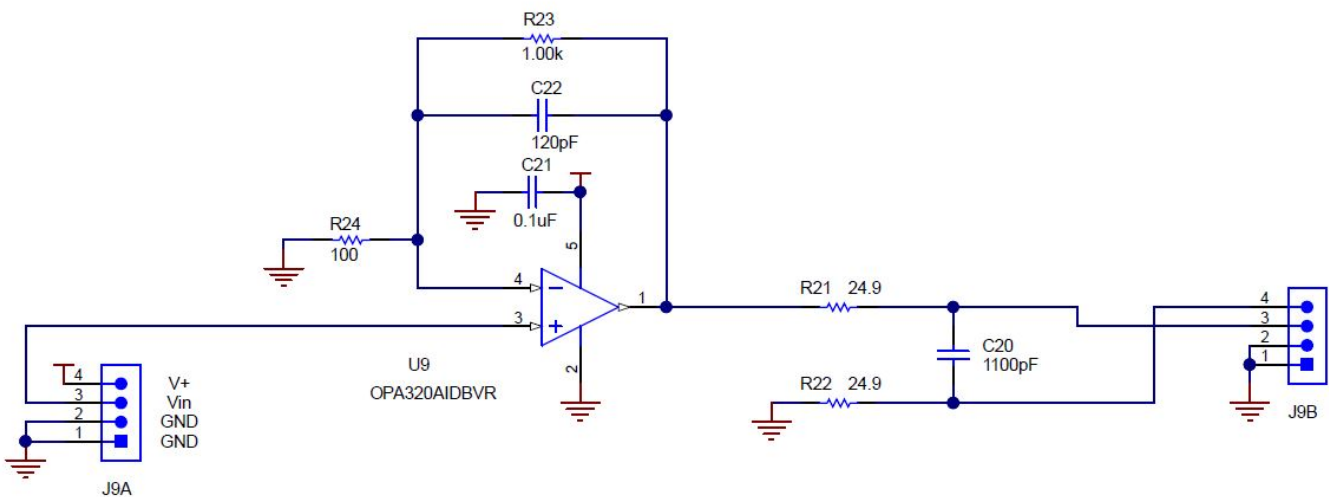


Figure 48. OPA320 Noise 2

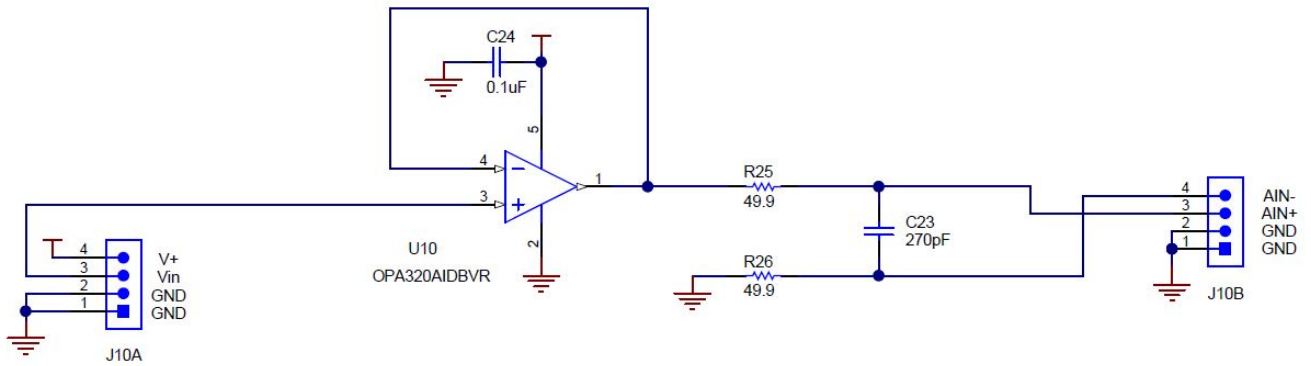


Figure 49. OPA320 Good Filter 2

6.2 Bill of Materials

Table 4 provides a bill of materials for the SAR-ADC-EVM motherboard.

Table 4. Bill of Materials for the SAR-ADC-EVM Motherboard

| Designator | Qty | Value | Description | Package Reference | Part Number | Manufacturer |
|--|-----|--------|--|---------------------------------------|---------------------|---------------------------|
| !PCB | 1 | | Printed Circuit Board | | DC022 | Any |
| !PCB2 | 1 | | Coupon board: DC028. | N/A | DC028 | Any |
| @H1-@H6 | 6 | | MACHINE SCREW PAN PHILLIPS M2 | | MPMS 002 0005 PH | B&F Fastener Supply |
| @H7-@H18 | 12 | | Hex Standoff, #4-40, Aluminum, 1/4" | 1/4" Aluminum Hex Standoff | 1891 | Keystone |
| C1, C14 | 2 | 0.01uF | CAP, CERM, 0.01 μ F, 50 V, +/- 5%, C0G/NP0, 0603 | 0603 | C1608NP01H103J080AA | TDK |
| C2, C3, C6, C11, C13, C15, C18, C19, C24-C26, C30, C31, C33, C36, C39, C40, C44, C45, C50, C53-C55, C59, C60, C65, C69, C71-C74, C77, C79, C82 | 34 | 1uF | CAP, CERM, 1 μ F, 16 V, +/- 10%, X7R, 0603 | 0603 | C1608X7R1C105K | TDK |
| C4, C5, C8, C9, C16, C17, C21, C23, C42, C43, C48, C49 | 12 | 10uF | CAP, CERM, 10 μ F, 25 V, +/- 10%, X5R, 0805 | 0805 | CL21A106KAFN3NE | Samsung Electro-Mechanics |
| C10, C22, C29, C47, C51, C52, C58, C62-C64, C68, C70 | 12 | 0.1uF | CAP, CERM, 0.1 μ F, 50 V, +/- 10%, X7R, 0603 | 0603 | C0603C104K5RACTU | Kemet |
| C12, C27, C32, C57 | 4 | 22uF | CAP, CERM, 22 μ F, 25 V, +/- 20%, X5R, 0805 | 0805 | CL21A226MAQNNNE | Samsung Electro-Mechanics |
| C34, C35, C37, C38, C66, C76, C78, C80, C81, C83 | 10 | 47uF | CAP, CERM, 47 μ F, 10 V, +/- 20%, X5R, 0805 | 0805 | C2012X5R1A476M125AC | TDK |
| C61, C67, C75 | 3 | 100pF | CAP, CERM, 100 pF, 50 V, +/- 5%, C0G/NP0, 0603 | 0603 | C0603C101J5GACTU | Kemet |
| D1, D2, D6 | 3 | 3.6V | Diode, Zener, 3.6 V, 500 mW, SOD-123 | SOD-123 | MMSZ4685T1G | ON Semiconductor |
| D3-D5, D7-D9 | 6 | Green | LED, Green, SMD | LED_0805 | APT2012LZGCK | Kingbright |
| FID1-FID6 | 6 | | Fiducial mark. There is nothing to buy or mount. | N/A | N/A | N/A |
| H0 | 1 | | CABLE USB A MALE-B MICRO MALE 1M (Kit Item) | USB Cable | 102-1092-BL-00100 | CNC Tech |
| H1-H6 | 6 | | ROUND STANDOFF M2 STEEL 5MM | ROUND STANDOFF M2 STEEL 5MM | 9774050243R | Würth Elektronik |
| H7-H18 | 12 | | MACHINE SCREW PAN PHILLIPS 4-40 | Machine Screw, 4-40, 1/4" | PMSSS 440 0025 PH | B&F Fastener Supply |
| J1, J4, J5 | 3 | | JACK, SMA, 50 Ohm, Gold, R/A, TH | SMA Jack, 50 Ohm, R/A, TH | 901-143-6RFX | Amphenol RF |
| J2, J6, J8 | 3 | | Header(Shrouded), 19.7mil, 30x2, Gold, SMT | Header (Shrouded), 19.7mil, 30x2, SMT | QTH-030-01-L-D-A | Samtec |
| J3A, J3B, J7A, J7B, J9A, J9B, J10A, J10B, J11A, J11B, J12A, J12B, J13A, J13B, J14A, J14B, J15A, J15B, J16A, J16B, J17A, J17B, J18A, J18B, J19A, J19B | 26 | | Receptacle, 2.54mm, 4x1, Gold, TH | Socket, 2.54mm, 4x1, TH | SS-104-G-2 | Samtec |
| JP1, JP3 | 2 | | Header, 100mil, 3x1, Gold, TH | 3x1 Header | TSW-103-07-G-S | Samtec |

Table 4. Bill of Materials for the SAR-ADC-EVM Motherboard (continued)

| Designator | Qty | Value | Description | Package Reference | Part Number | Manufacturer |
|--|-----|---------|-----------------------------------|-----------------------|-------------------|-------------------|
| JP2, JP4 | 2 | | Header, 100mil, 4x2, Gold, TH | 4x2 Header | TSW-104-07-G-D | Samtec |
| JP5-JP13 | 9 | | Header, 100mil, 2x1, Gold, TH | 2x1 Header | TSW-102-07-G-S | Samtec |
| R1, R13, R20, R23, R26, R27, R51-R53, R56, R59, R64, R67, R70, R76, R81, R86, R92, R132-R134 | 21 | 1.00k | RES, 1.00 k, 0.1%, 0.1 W, 0603 | 0603 | RT0603BRB071KL | Yageo America |
| R2-R5, R14-R17, R47, R48, R50, R73-R75, R77, R79 | 16 | 49.9 | RES, 49.9, 1%, 0.063 W, 0402 | 0402 | CRCW040249R9FKED | Vishay-Dale |
| R6, R18, R131 | 3 | 10.0k | RES, 10.0 k, 0.1%, 0.0625 W, 0402 | 0402 | RT0402BRD0710KL | Yageo America |
| R7, R10, R19, R31, R34-R38, R43-R46, R54, R57, R82, R91, R96, R102, R104, R105, R108, R113-R116, R119-R122, R124 | 31 | 0 | RES, 0, 5%, 0.1 W, 0603 | 0603 | CRCW06030000Z0EA | Vishay-Dale |
| R8, R9, R29, R30, R58, R60 | 6 | 10.0k | RES, 10.0 k, 1%, 0.1 W, 0603 | 0603 | RC0603FR-0710KL | Yageo America |
| R11, R21, R32, R62 | 4 | 0.22 | RES, 0.22, 1%, 0.1 W, 0603 | 0603 | ERJ-3RQFR22V | Panasonic |
| R12 | 1 | 120k | RES, 120 k, 1%, 0.1 W, 0603 | 0603 | RC0603FR-07120KL | Yageo America |
| R22 | 1 | 49.9k | RES, 49.9 k, 0.1%, 0.1 W, 0603 | 0603 | RT0603BRD0749K9L | Yageo America |
| R25 | 1 | 2.32k | RES, 2.32 k, 0.1%, 0.1 W, 0603 | 0603 | RG1608P-2321-B-T5 | Susumu Co Ltd |
| R28 | 1 | 20.5 | RES, 20.5, 0.1%, 0.1 W, 0603 | 0603 | RT0603BRD0720R5L | Yageo America |
| R33, R42, R98, R111, R112 | 5 | 0.1 | RES, 0.1, 1%, 0.1 W, 0603 | 0603 | ERJ-3RSFR10V | Panasonic |
| R39-R41, R99-R101 | 6 | 6.65k | RES, 6.65 k, 1%, 0.1 W, 0603 | 0603 | RC0603FR-076K65L | Yageo America |
| R55 | 1 | 3.00k | RES, 3.00 k, 0.1%, 0.1 W, 0603 | 0603 | RG1608P-302-B-T5 | Susumu Co Ltd |
| R63 | 1 | 4.99k | RES, 4.99 k, 0.1%, 0.1 W, 0603 | 0603 | RG1608P-4991-B-T5 | Susumu Co Ltd |
| R65, R90 | 2 | 499 | RES, 499, 0.1%, 0.1 W, 0603 | 0603 | RT0603BRD07499RL | Yageo America |
| R66 | 1 | 34.8 | RES, 34.8, 1%, 0.1 W, 0603 | 0603 | CRCW060334R8FKEA | Vishay-Dale |
| R68, R78, R87 | 3 | 1.50k | RES, 1.50 k, 0.1%, 0.1 W, 0603 | 0603 | RT0603BRD071K5L | Yageo America |
| R69, R80, R88 | 3 | 2.43k | RES, 2.43 k, 0.1%, 0.1 W, 0603 | 0603 | RT0603BRD072K43L | Yageo America |
| R71, R72, R83, R84, R94, R95 | 6 | 2.00Meg | RES, 2.00 M, 0.1%, 0.1 W, 0805 | 0805 | CPF0805B2M0E | TE Connectivity |
| R85, R89 | 2 | 2.00k | RES, 2.00 k, 0.1%, 0.1 W, 0603 | 0603 | RT0603BRD072KL | Yageo America |
| R93 | 1 | 143 | RES, 143, 0.1%, 0.1 W, 0603 | 0603 | RT0603BRD07143RL | Yageo America |
| R125 | 1 | 1.40k | RES, 1.40 k, 0.1%, 0.1 W, 0603 | 0603 | RG1608P-1401-B-T5 | Susumu Co Ltd |
| R126 | 1 | 12.1 | RES, 12.1, 0.1%, 0.1 W, 0603 | 0603 | RT0603BRD0712R1L | Yageo America |
| R127 | 1 | 20.0 | RES, 20.0, 0.1%, 0.1 W, 0603 | 0603 | RT0603BRD0720RL | Yageo America |
| R128 | 1 | 2.43k | RES, 2.43 k, 0.1%, 0.1 W, 0603 | 0603 | RG1608P-2431-B-T5 | Susumu Co Ltd |
| R129 | 1 | 3.01 | RES, 3.01, 0.5%, 0.1 W, 0603 | 0603 | RT0603DRE073R01L | Yageo America |
| R130 | 1 | 10.0k | RES, 10.0 k, 0.1%, 0.1 W, 0603 | 0603 | RG1608P-103-B-T5 | Susumu Co Ltd |
| S1-S3 | 3 | | Switch, Slide, SPDT 100mA, SMT | Switch, 5.4x2.5x2.5mm | CAS-120TA | Copal Electronics |

Table 4. Bill of Materials for the SAR-ADC-EVM Motherboard (continued)

| Designator | Qty | Value | Description | Package Reference | Part Number | Manufacturer |
|--|-----|--------|--|------------------------------|--------------------|---------------------------|
| SH-J1, SH-J2 | 2 | 1x2 | Shunt, 100mil, Gold plated, Black | Shunt | 969102-0000-DA | 3M |
| TP1-TP21 | 21 | SMT | Test Point, Miniature, SMT | Testpoint_Keystone_Miniature | 5015 | Keystone |
| U1, U4 | 2 | | 16-Bit, 1-MSPS, Serial Interface, microPower, Miniature, Single-Ended Input, SAR Analog-to-Digital Converter, DGS0010A | DGS0010A | ADS8860IDGSR | Texas Instruments |
| U2 | 1 | | High-Precision Voltage Reference with Integrated High-Bandwidth Buffer, DGK0008A (VSSOP-8) | DGK0008A | REF6050IDGKR | Texas Instruments |
| U3, U7, U16 | 3 | | I2C BUS EEPROM (2-Wire), TSSOP-B8 | TSSOP-8 | BR24G32FVT-3AGE2 | Rohm |
| U5 | 1 | | Low Noise, Very Low Drift, Precision Voltage Reference, -40 to 125 degC, 8-pin SOIC (D), Green (RoHS & no Sb/Br) | D0008A | REF5050IDR | Texas Instruments |
| U6 | 1 | | Precision, 20 MHz, 0.9 pA Ib, RRIO, CMOS Operational Amplifier, 1.8 to 5.5 V, -40 to 125 degC, 5-pin SOT23 (DBV0005A), Green (RoHS & no Sb/Br) | DBV0005A | OPA320AIDBVR | Texas Instruments |
| U8 | 1 | | Low Noise, Very Low Drift, Precision Voltage Reference, -40 to 125 degC, 8-pin VSSOP (DGK), Green (RoHS & no Sb/Br) | DGK0008A | REF5050IDGKR | Texas Instruments |
| U9, U11, U22, U24, U25 | 5 | | 36-V, 1-A, 4.17-uVRMS, RF LDO Voltage Regulator, RGW0020A (VQFN-20) | RGW0020A | TPS7A4700RGWR | Texas Instruments |
| U10, U23, U26 | 3 | | NanoPower Supervisory Circuits, DBV0005A (SOT-5) | DBV0005A | TPS3836K33DBVR | Texas Instruments |
| U12 | 1 | | 12-Bit, 1-MSPS, Ultra-Low-Power & Ultra-Small-Size SAR ADC with SPI Interface, DCU0008A (VSSOP-8) | DCU0008A | ADS7042IDCUR | Texas Instruments |
| U13, U15 | 2 | | Precision, 20 MHz, 0.9 pA Ib, RRIO, CMOS Operational Amplifier, 1.8 to 5.5 V, -40 to 125 degC, 8-pin SOP (DGK0008A), Green (RoHS & no Sb/Br) | DGK0008A | OPA2320AIDGKR | Texas Instruments |
| U14 | 1 | | Low Noise, Very Low Drift, Precision Voltage Reference, -40 to 125 degC, 8-pin SOIC (D), Green (RoHS & no Sb/Br) | D0008A | REF5030AID | Texas Instruments |
| U17, U19, U20 | 3 | | Precision, Rail-to-Rail I/O INSTRUMENTATION AMPLIFIER, DGK0008A (VSSOP-8) | DGK0008A | INA326EA/2K5 | Texas Instruments |
| U18 | 1 | | 24-Bit, 2kSPS, 4-Ch, Low-Power, Delta-Sigma ADC with PGA and Voltage Reference, PW0016A (TSSOP-16) | PW0016A | ADS1220IPWR | Texas Instruments |
| U21 | 1 | | Precision, Low Noise, Low Iq Operational Amplifier, 2.2 to 5.5 V, -40 to 125 degC, 5-pin SOT23 (DBV0005A), Green (RoHS & no Sb/Br) | DBV0005A | OPA376AIDBVR | Texas Instruments |
| @H19, @H20 | 0 | | Hex Standoff, #4-40, Aluminum, 1/4" | 1/4" Aluminum Hex Standoff | 1891 | Keystone |
| C7 | 0 | 1000pF | CAP, CERM, 1000 pF, 50 V, +/- 5%, X7R, 0603 | 0603 | GRM188R71H102JA01D | MuRata |
| C20, C41 | 0 | 1000pF | CAP, CERM, 1000 pF, 50 V, +/- 1%, C0G/NP0, 0603 | 0603 | GRM1885C1H102FA01J | MuRata |
| C46 | 1 | 1000pF | CAP, CERM, 1000 pF, 50 V, +/- 1%, C0G/NP0, 0603 | 0603 | GRM1885C1H102FA01J | MuRata |
| C28, C56 | 0 | 10uF | CAP, CERM, 10 uF, 25 V, +/- 10%, X5R, 0805 | 0805 | CL21A106KAFN3NE | Samsung Electro-Mechanics |
| H19, H20 | 0 | | MACHINE SCREW PAN PHILLIPS 4-40 | Machine Screw, 4-40, 1/4" | PMSSS 440 0025 PH | B&F Fastener Supply |
| R24, R61 | 0 | 0.47 | RES, 0.47, 1%, 0.1 W, 0603 | 0603 | ERJ-3RQFR47V | Panasonic |
| R49, R97, R103, R106, R107, R109, R110, R117, R118, R123 | 0 | 0 | RES, 0, 5%, 0.1 W, 0603 | 0603 | CRCW06030000Z0EA | Vishay-Dale |

Table 5 provides a bill of materials for the SAR-ADC-EVM coupon boards.

Table 5. Bill of Materials for the SAR-ADC-EVM Coupon Boards

| Designator | Qty | Value | Description | Package Reference | Part Number | Manufacturer |
|--|-----|--------|---|-------------------------|---------------------|---------------------------|
| !PCB | 1 | | Printed Circuit Board | | DC028 | Any |
| C1, C3, C7, C9, C20 | 5 | 1100pF | CAP, CERM, 1100 pF, 50 V,+/- 5%, C0G/NP0, 0603 | 0603 | GRM1885C1H112JA01D | MuRata |
| C2, C4, C6, C8, C10, C13, C17, C19, C21, C24 | 10 | 0.1uF | CAP, CERM, 0.1 μF, 50 V, +/- 10%, X7R, 0603 | 0603 | C0603C104K5RACTU | Kemet |
| C5 | 1 | 680pF | CAP, CERM, 680 pF, 50 V, +/- 5%, C0G/NP0, 0603 | 0603 | GRM1885C1H681JA01D | MuRata |
| C11 | 1 | 1.2pF | CAP, CERM, 1.2 pF, 50 V,+/- 10%, C0G/NP0, 0603 | 0603 | CL10C1R2BB8NNNC | Samsung Electro-Mechanics |
| C12, C23 | 2 | 270pF | CAP, CERM, 270 pF, 50 V,+/- 5%, C0G/NP0, 0603 | 0603 | GRM1885C1H271JA01D | MuRata |
| C14 | 1 | 0.01uF | CAP, CERM, 0.01 μF, 50 V,+/- 5%, C0G/NP0, 0603 | 0603 | C1608NP01H103J080AA | TDK |
| C15 | 1 | 6800pF | CAP, CERM, 6800 pF, 50 V,+/- 5%, C0G/NP0, 0603 | 0603 | GRM1885C1H682JA01D | MuRata |
| C16, C18 | 2 | 510pF | CAP, CERM, 510 pF, 50 V,+/- 5%, C0G/NP0, 0603 | 0603 | GRM1885C1H511JA01D | MuRata |
| C22 | 1 | 120pF | CAP, CERM, 120 pF, 50 V, +/- 5%, C0G/NP0, 0603 | 0603 | C0603C121J5GACTU | Kemet |
| J1A, J1B, J2A, J2B, J3A, J3B, J4A, J4B, J5A, J5B, J6A, J6B, J7A, J7B, J8A, J8B, J9A, J9B, J10A, J10B | 20 | | Header, 2.54mm, 4x1, Gold, Black, TH | Header, 2.54mm, 4x1, TH | TS-104-G-AA | Samtec |
| R1, R2, R5-R10, R21, R22 | 10 | 24.9 | RES, 24.9, 0.1%, 0.1 W, 0603 | 0603 | RT0603BRD0724R9L | Yageo America |
| R3, R4, R24 | 3 | 100 | RES, 100, 0.1%, 0.1 W, 0603 | 0603 | RG1608P-101-B-T5 | Susumu Co Ltd |
| R11 | 1 | 100k | RES, 100 k, 0.1%, 0.1 W, 0603 | 0603 | RG1608P-104-B-T5 | Susumu Co Ltd |
| R12 | 1 | 10.0k | RES, 10.0 k, 0.1%, 0.1 W, 0603 | 0603 | RG1608P-103-B-T5 | Susumu Co Ltd |
| R13, R14, R25, R26 | 4 | 49.9 | RES, 49.9, 0.1%, 0.1 W, 0603 | 0603 | RT0603BRD0749R9L | Yageo America |
| R15 | 1 | 41.2k | RES, 41.2 k, 0.1%, 0.1 W, 0603 | 0603 | RT0603BRD0741K2L | Yageo America |
| R16 | 1 | 22.1k | RES, 22.1 k, 0.1%, 0.1 W, 0603 | 0603 | RT0603BRD0722K1L | Yageo America |
| R17, R18 | 2 | 2.00k | RES, 2.00 k, 0.5%, 0.1 W, 0603 | 0603 | RT0603DRE072KL | Yageo America |
| R19, R20 | 2 | 200k | RES, 200 k, 5%, 0.1 W, 0603 | 0603 | CRCW0603200KJNEA | Vishay-Dale |
| R23 | 1 | 1.00k | RES, 1.00 k, 0.1%, 0.1 W, 0603 | 0603 | RT0603BRD071KL | Yageo America |
| U1, U2, U5, U6, U9, U10 | 6 | | Precision, 20 MHz, 0.9 pA Ib, RRIO, CMOS Operational Amplifier, 1.8 to 5.5 V, -40 to 125 degC, 5-pin SOT23 (DBV0005A), Green (RoHS & no Sb/Br) | DBV0005A | OPA320AIDBVR | Texas Instruments |
| U3 | 1 | | 17 uA, MicroPower, Precision, Zero Drift CMOS Operational Amplifier, 1.8 to 5.5 V, -40 to 125 degC, 5-pin SOT23 (DBV0005A), Green (RoHS & no Sb/Br) | DBV0005A | OPA333AIDBVR | Texas Instruments |

Table 5. Bill of Materials for the SAR-ADC-EVM Coupon Boards (continued)

| Designator | Qty | Value | Description | Package Reference | Part Number | Manufacturer |
|-------------------|------------|--------------|--|--------------------------|--------------------|---------------------|
| U4 | 1 | | 10-MHz, Low-Power, Low-Noise, RRIO, 1.8-V CMOS Operational Amplifier, DBV0005A (SOT-5) | DBV0005A | OPA316IDBVR | Texas Instruments |
| U7 | 1 | | Low-Power, Rail-to-Rail In/Out, 500-uV Typical Offset, 1-MHz Operational Amplifier for Cost-Sensitive Systems, DBV0005A (SOT-23-5) | DBV0005A | TLV313IDBVR | Texas Instruments |
| U8 | 1 | | Single Channel 450nA Precision Nanopower Operational Amplifier, DBV0005A (SOT-23-5) | DBV0005A | LPV811DBVR | Texas Instruments |

Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

| Changes from Original (December 2017) to A Revision | Page |
|---|-------------|
| • Added title to <i>Coupon Card Descriptions</i> table | 16 |
| • Changed <i>EVM Graphical User Interface (GUI) Software Installation</i> section: changed figures, added clarification on GUI and installation procedure | 17 |
| • Changed <i>Overview of PLABS-SAR-EVM GUI</i> section: added figures and expanded description of the GUI..... | 21 |
| • Added <i>Overview of PLABS Power Scaling GUI</i> section..... | 27 |
| • Added figures <i>OPA320 Good Filter 1</i> through <i>OPA320 Good Filter 2</i> and associated text to <i>Schematic and Bill of Materials</i> section | 40 |
| • Added <i>Motherboard</i> to title of <i>Bill of Materials for the SAR-ADC-EVM Motherboard</i> table | 44 |
| • Changed first ceramic capacitor row (row 5): deleted C46 designator, changed Qty from 3 to 2 | 44 |
| • Changed first resistor row (row 24): added R23 and R27 designators and changed Qty from 19 to 21..... | 45 |
| • Changed fourth resistor row (row 27): deleted R23 and R27 designators and changed Qty from 33 to 31 | 45 |
| • Added third 1000pF ceramic capacitor row (row 71)..... | 46 |

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