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 as 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.

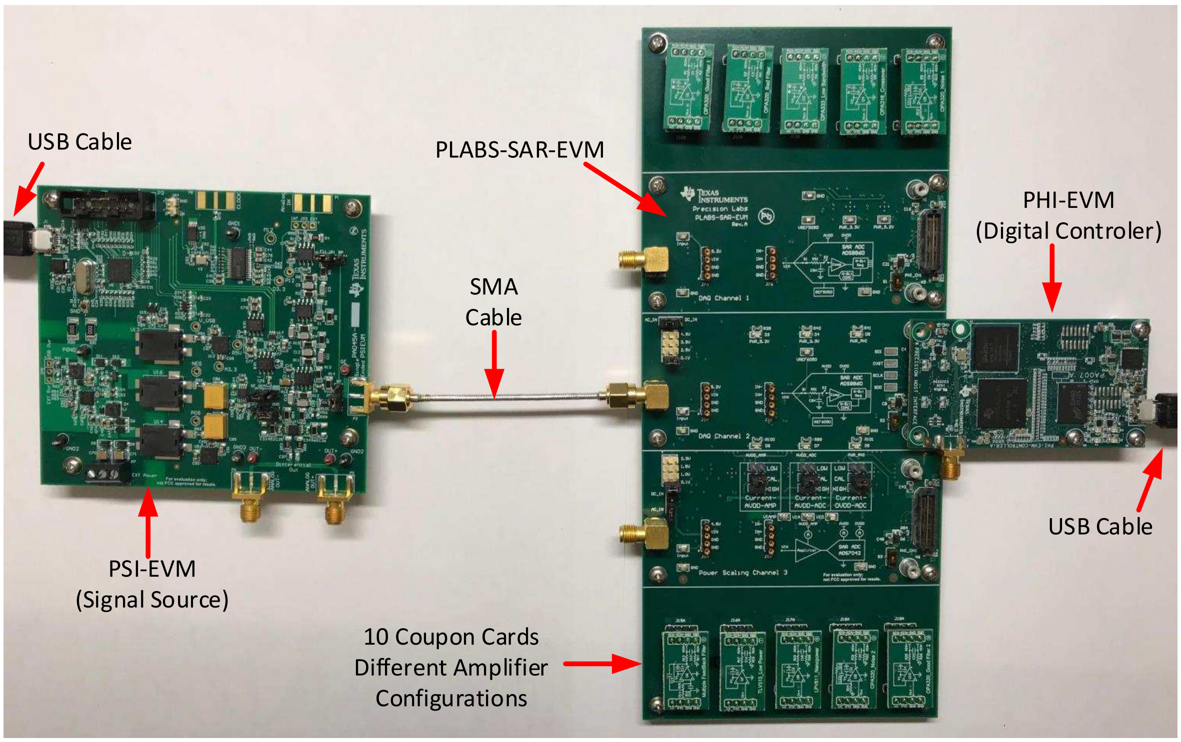

Figure 1. Typical Connections for the PLABS-SAR-EVM-PDK

The following related documents are available through the Texas Instruments 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

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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 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 it's own connector to the PHI digital controller, and the software used for each channel is identical.

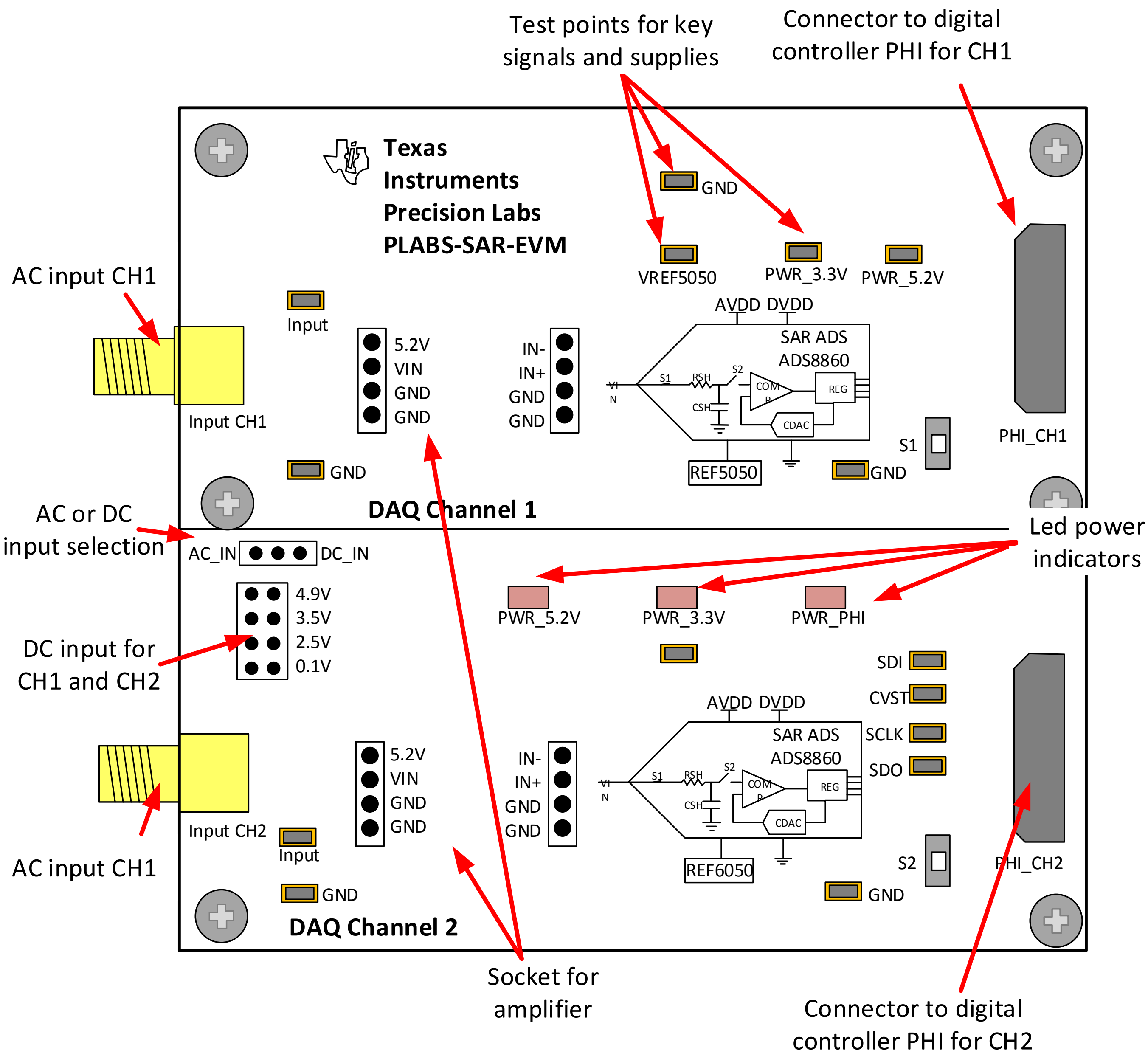


Figure 2. Overview of Features on CH1 and CH2

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.

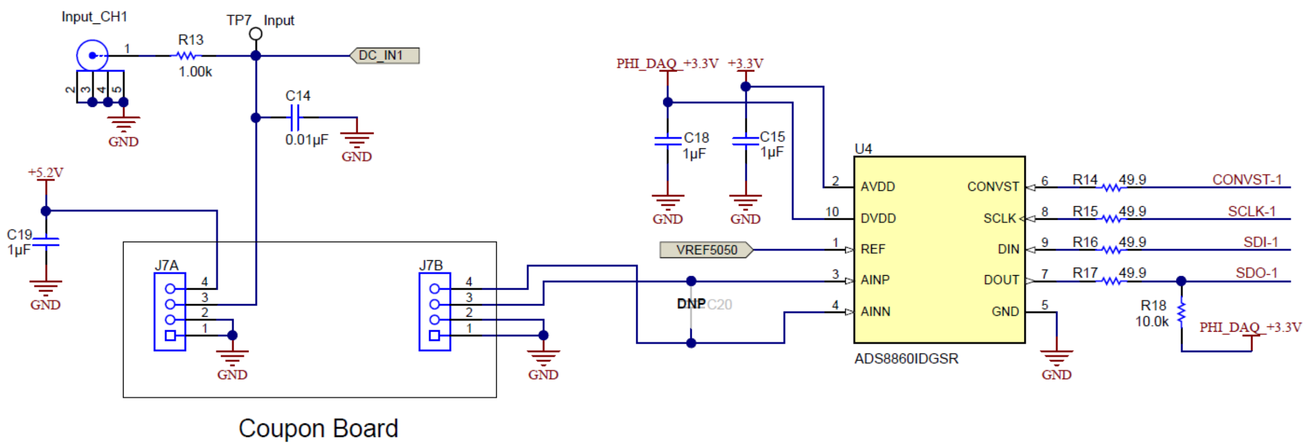


Figure 3. Amplifier and ADC Input (CH1 and CH2)

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.

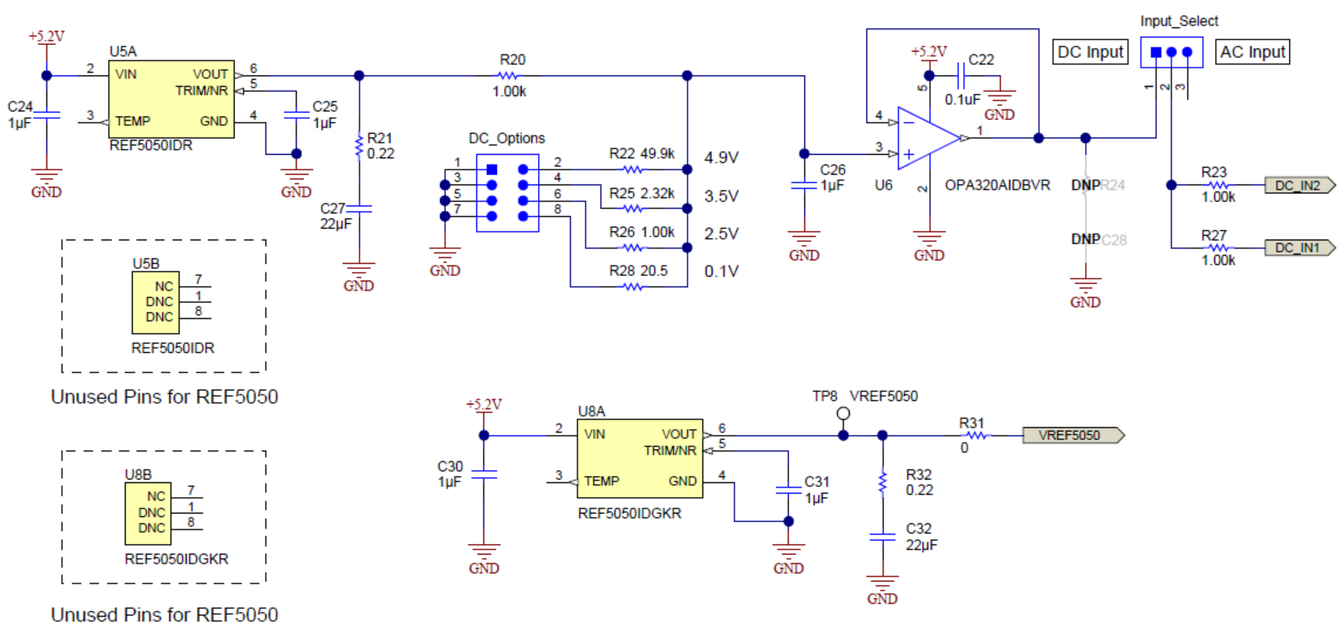


Figure 4. Voltage Reference and Jumper-Selected Voltage Divider (CH1 and CH2)

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).

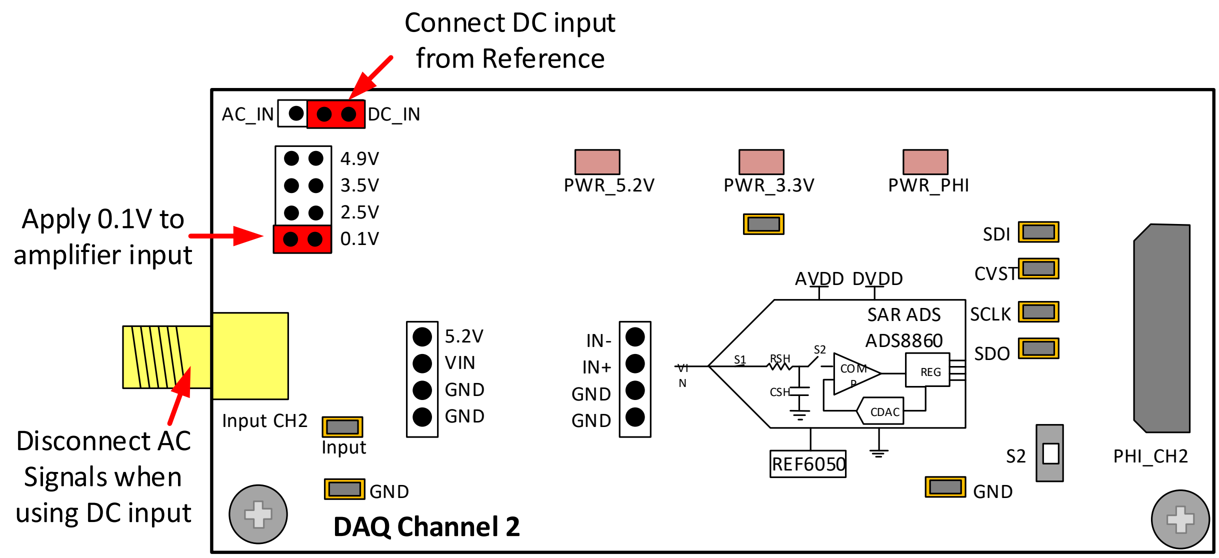


Figure 5. Jumper Position for a DC Input of 0.1 V on CH1 and CH2

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

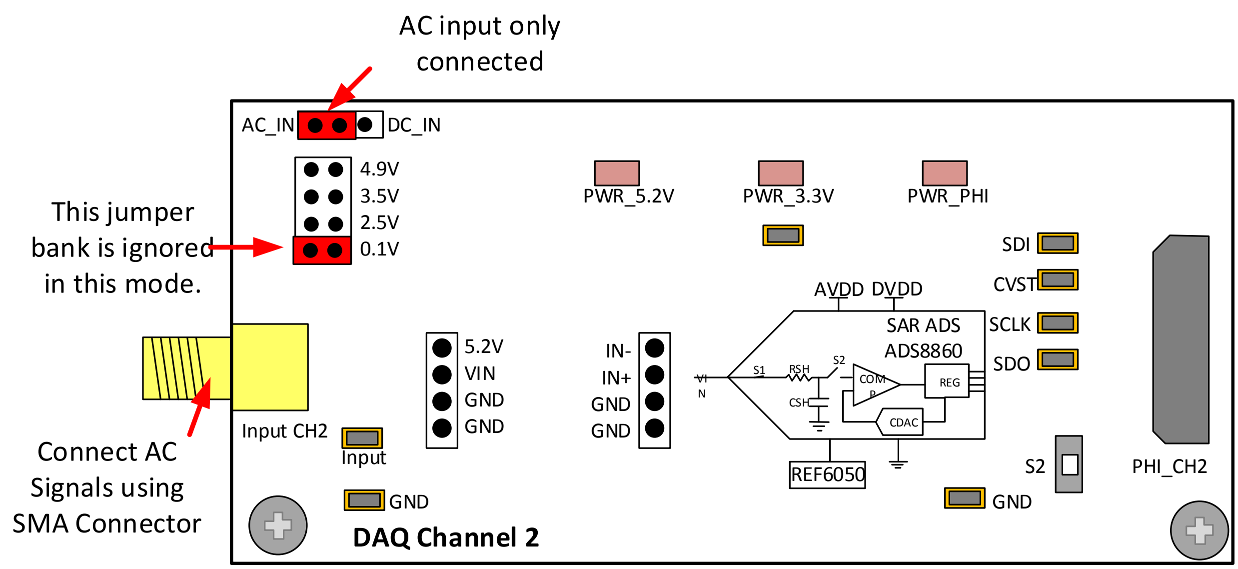


Figure 6. Jumper Position for an AC Input on CH1 and CH2

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.

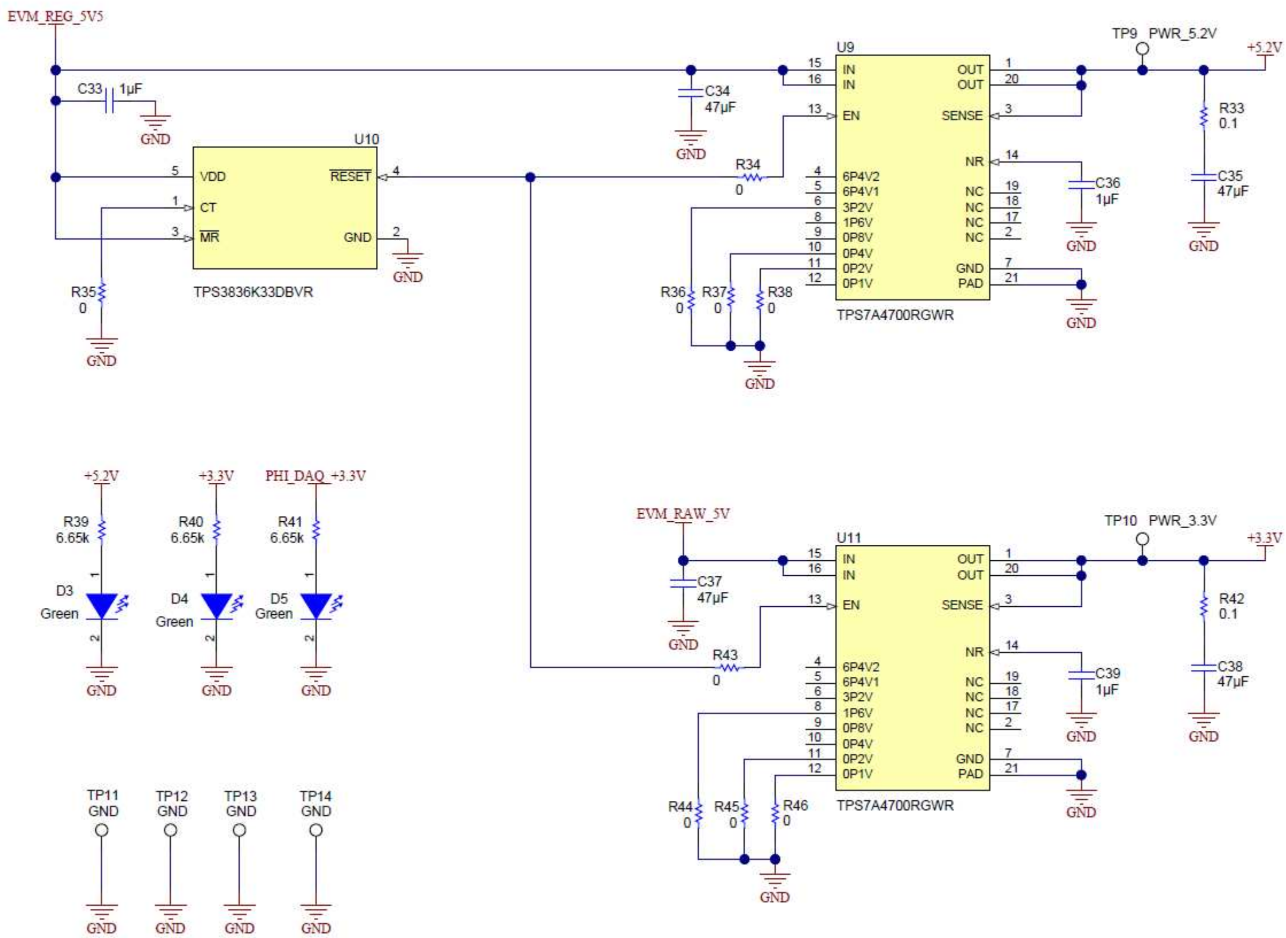


Figure 7. Power Subsection (CH1 and CH2)

2.2.4 Connection to the PHI Controler 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.

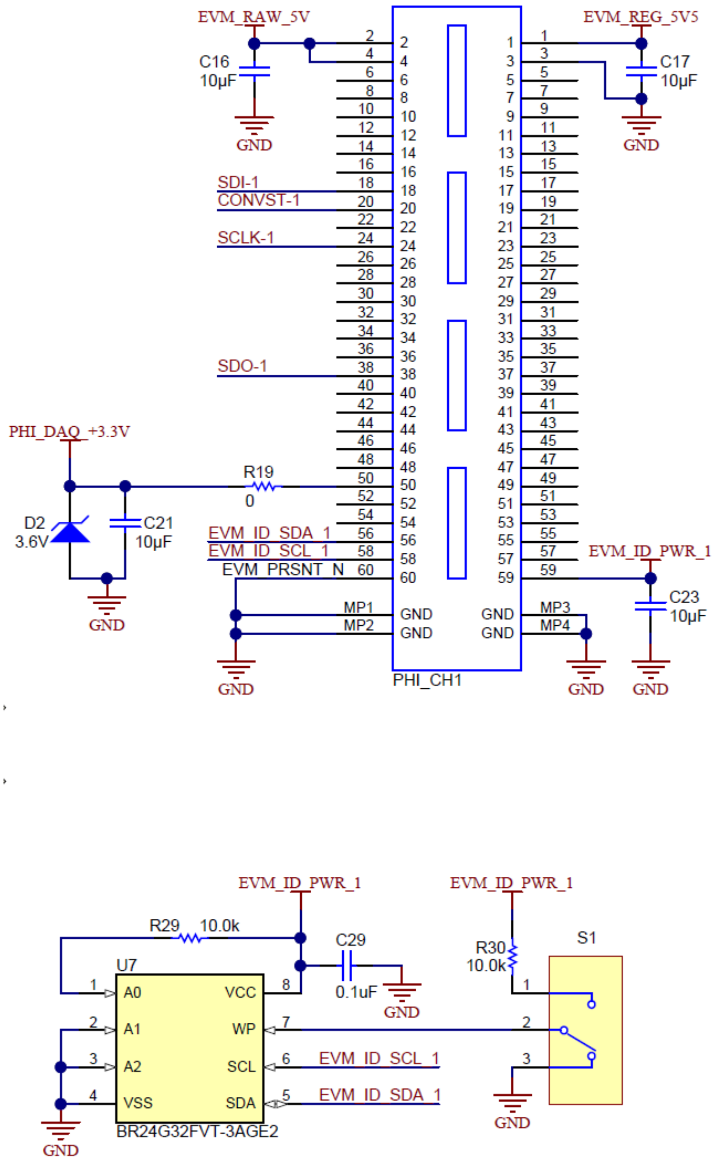


Figure 8. Connection to the PHI Controller and EEPROM

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.

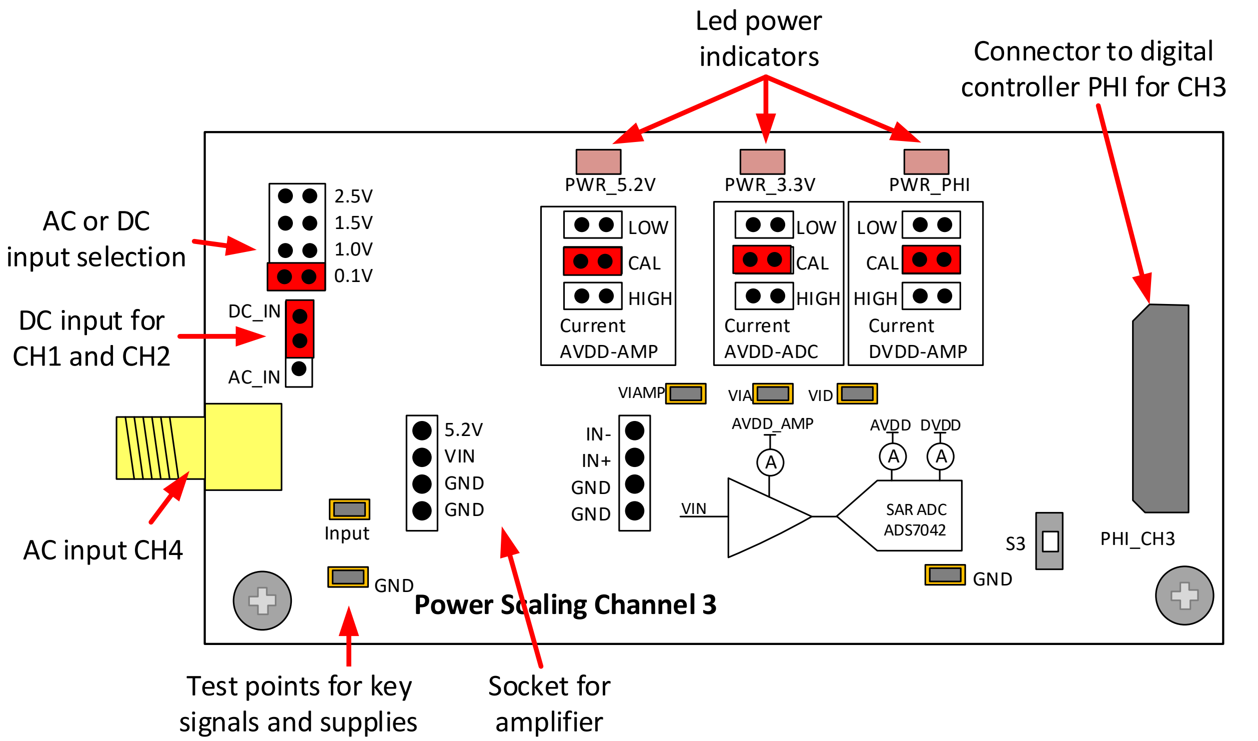


Figure 9. Overview of Features on CH3

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).

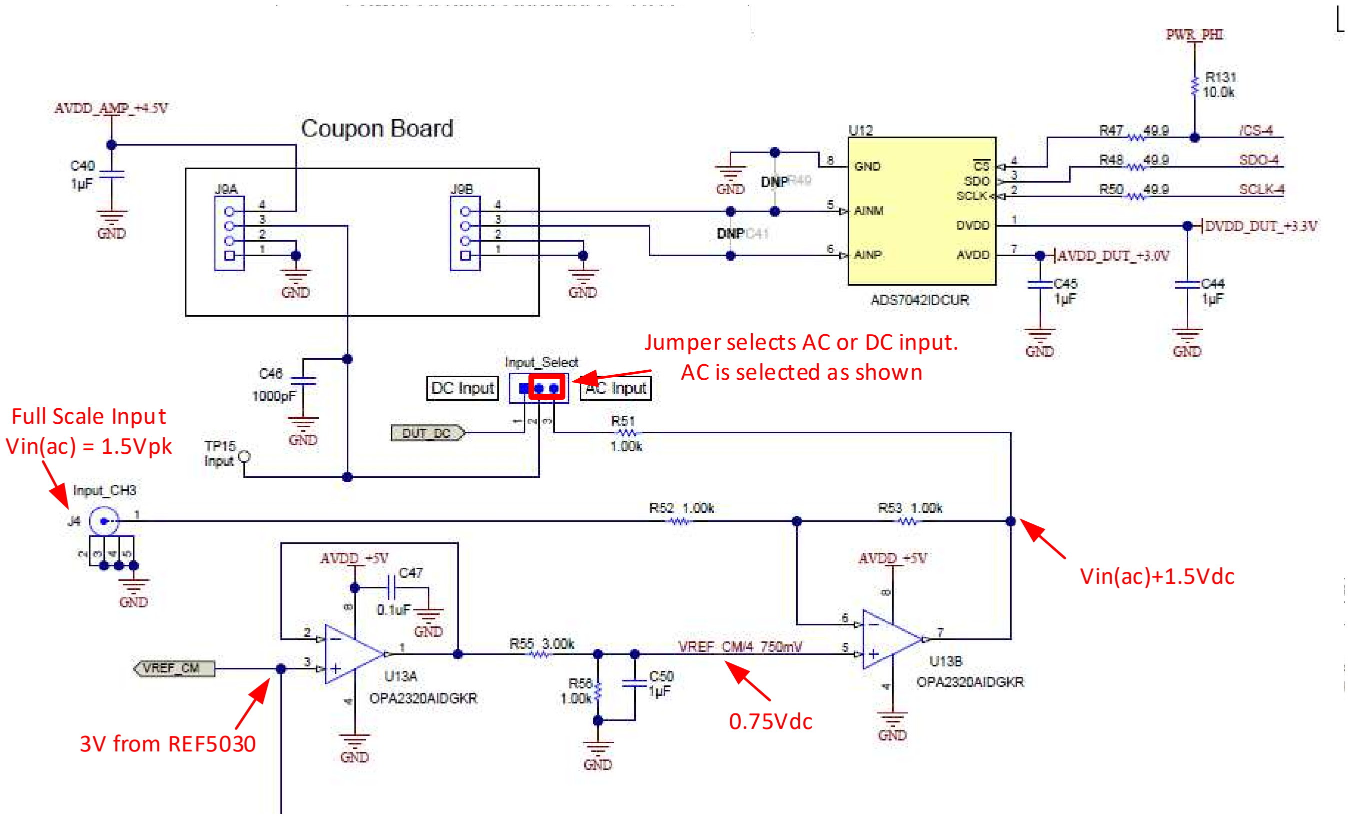


Figure 10. Amplifier and ADC Input (CH3)

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).

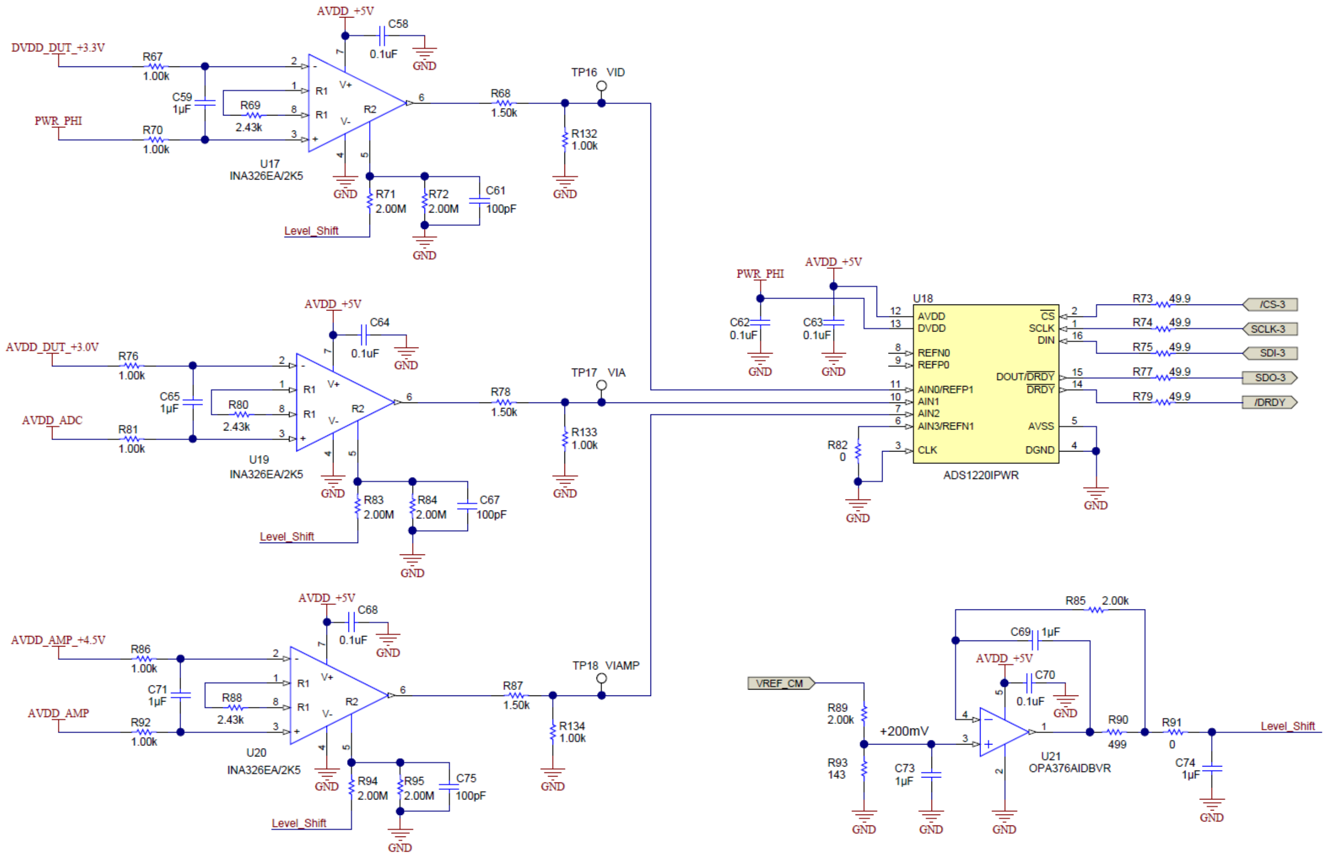


Figure 11. INA Current Monitor (CH3)

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.

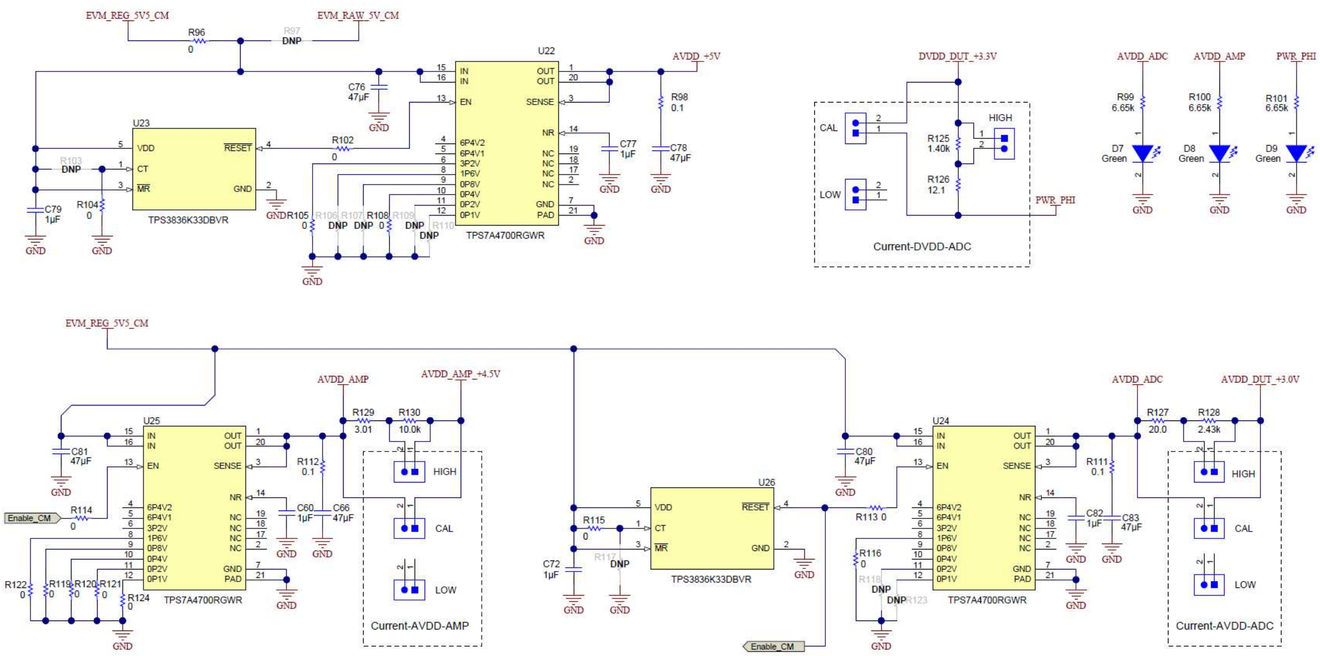


Figure 12. Power, Shunt Resistors, and Range Selection for CH3

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.

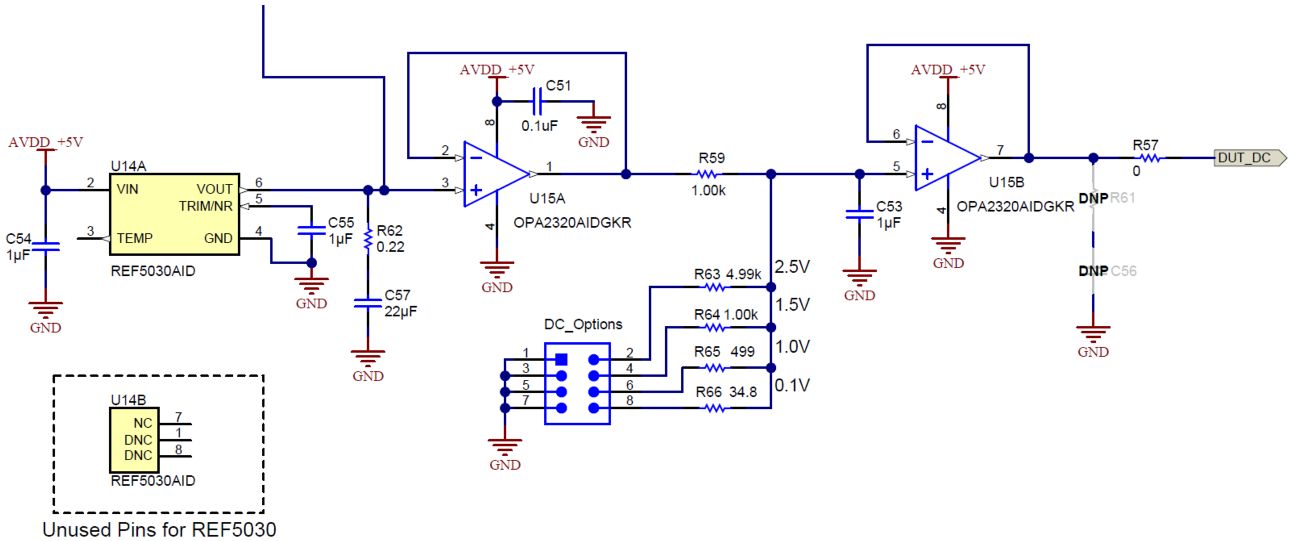


Figure 13. DC or AC Input (CH3)

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.

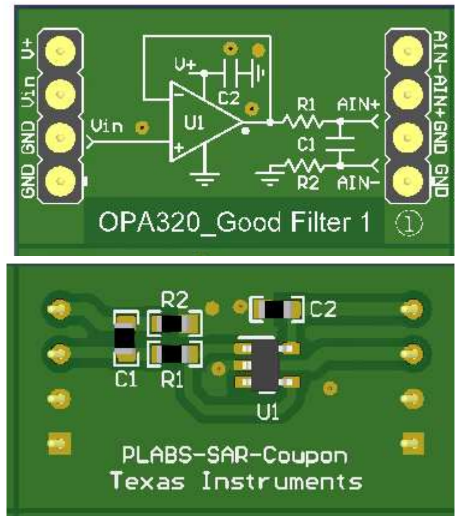


Figure 14. Coupon Card Layout

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.

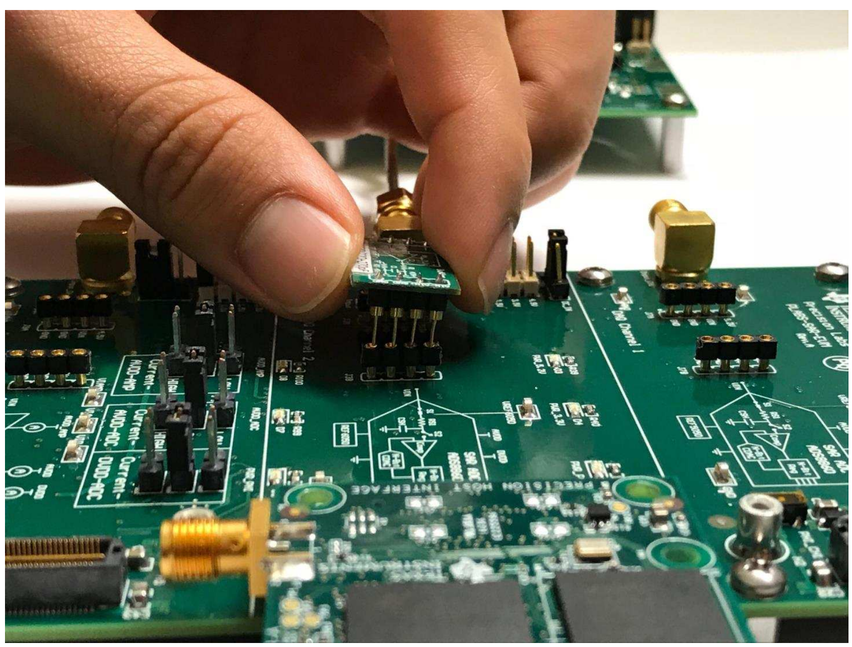


Figure 15. Installing a Coupon Card

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-µA 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.

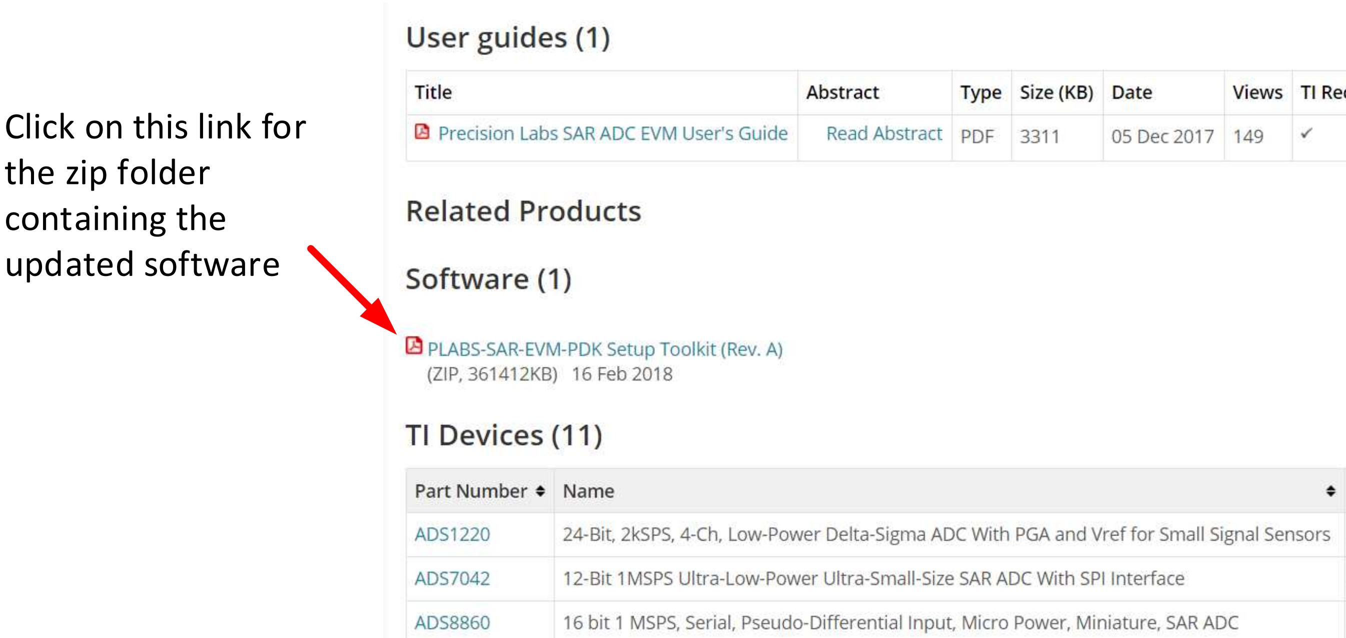
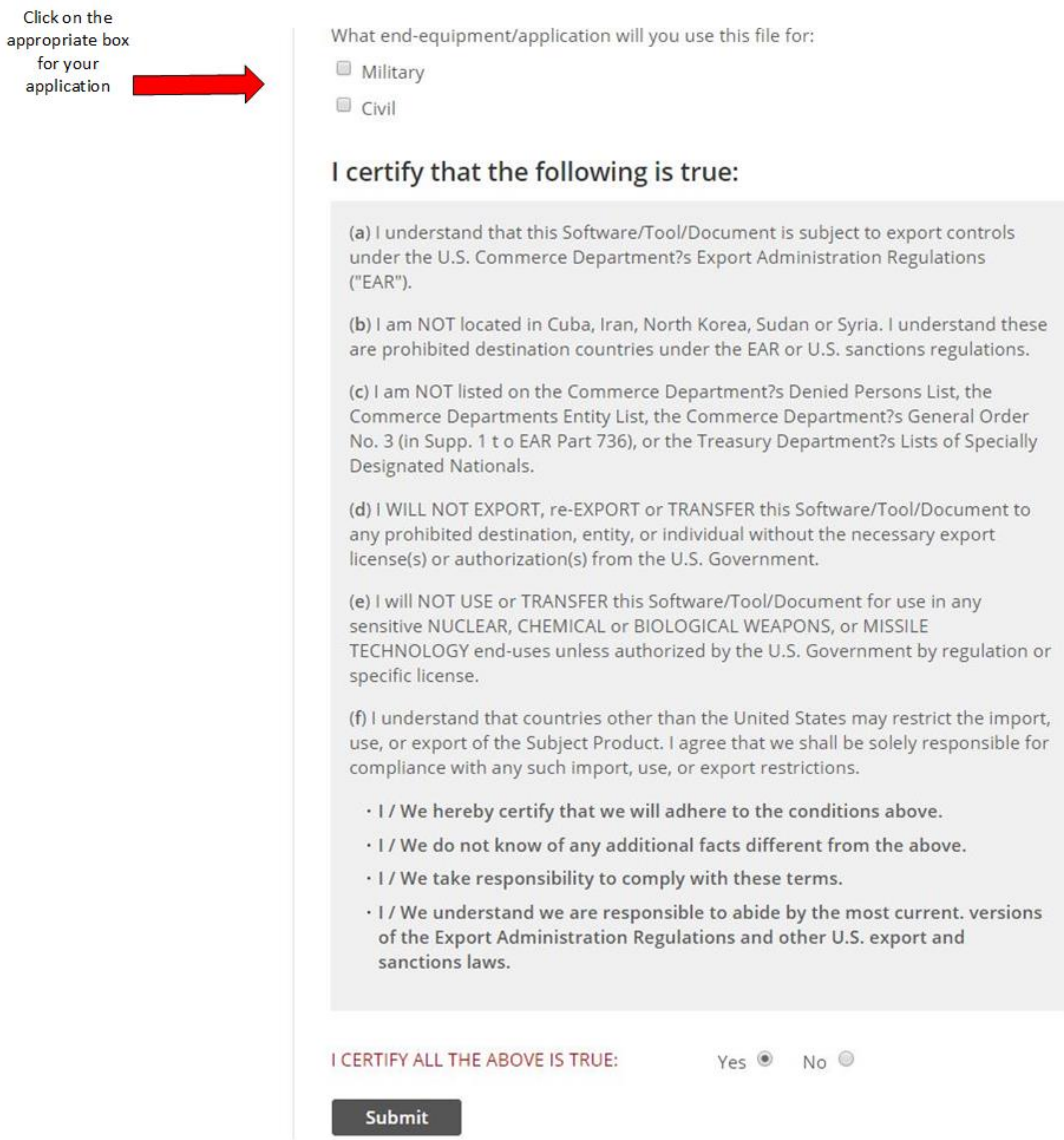


Figure 16. PLABS Toolkit Link

Upon clicking the *Setup Toolkit* link in Figure 16, the page in Figure 17 opens:



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- **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:

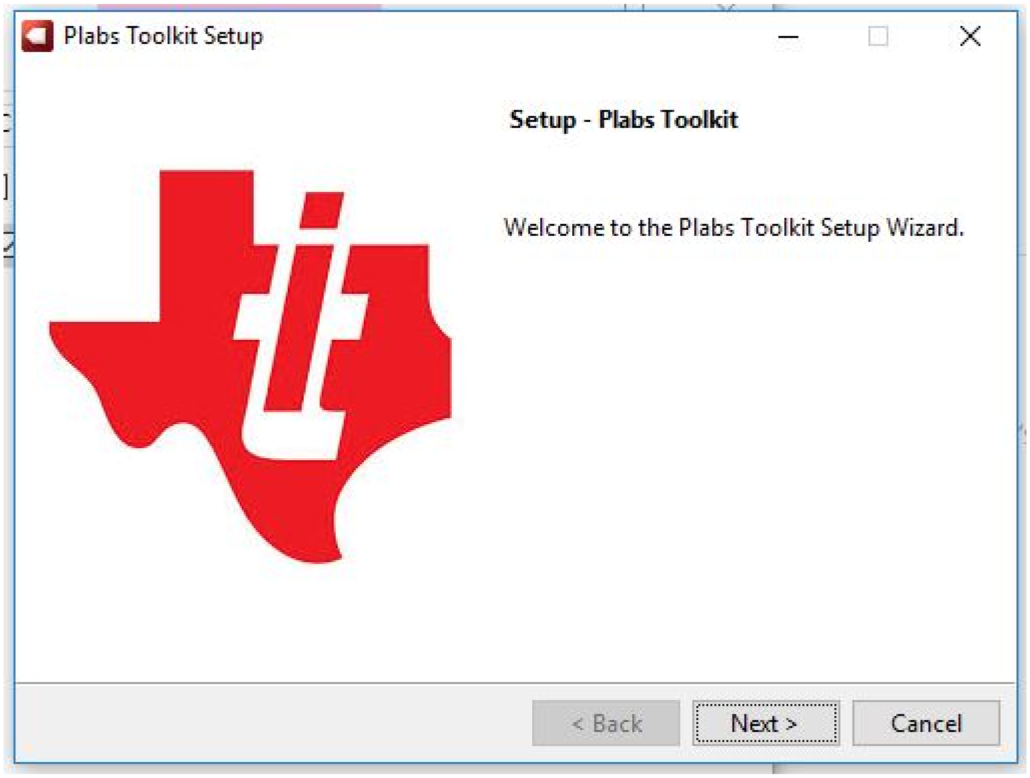

Figure 18. Plabs Toolkit Dialog Box

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

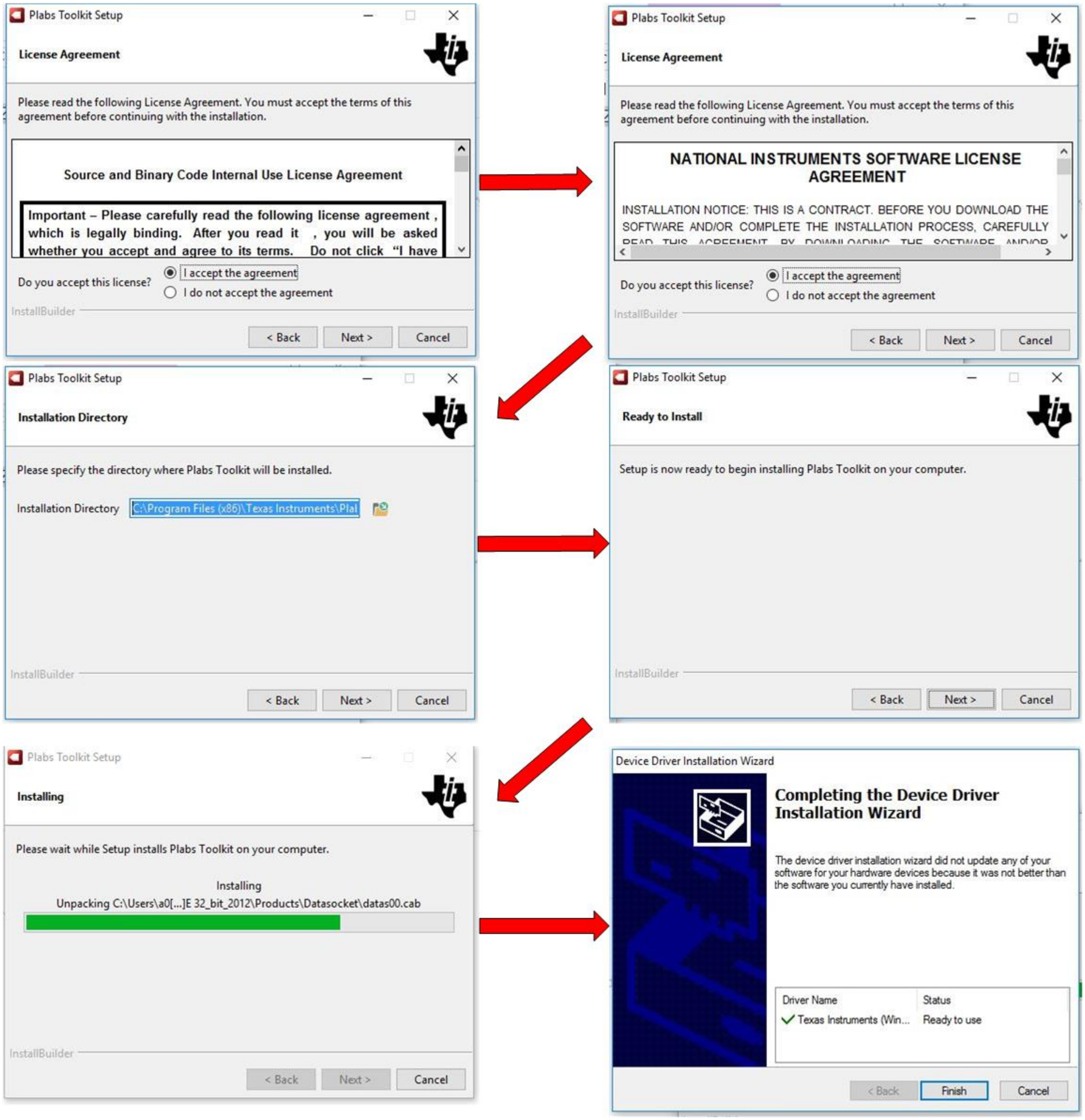

Figure 19. Software Installation

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:

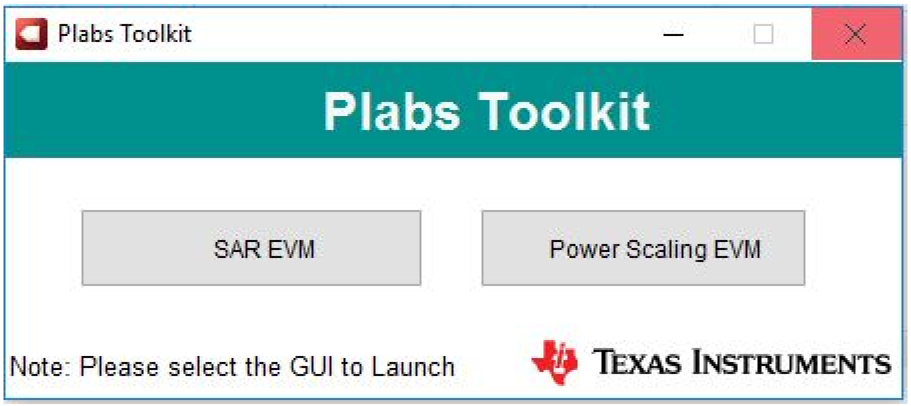

Figure 20. Plabs Toolkit Prompt

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.

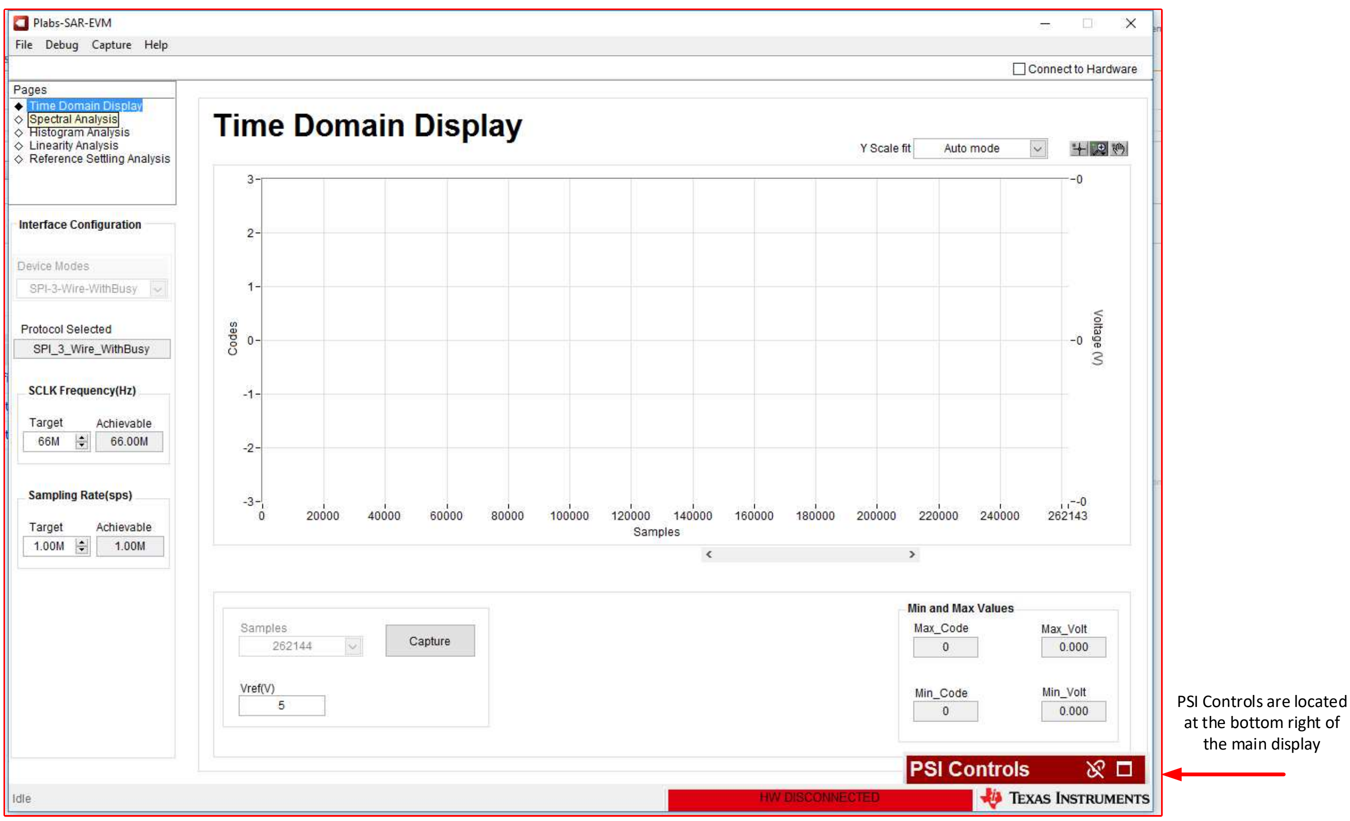

Figure 21. Default PLABS-SAR-EVM GUI Display

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.

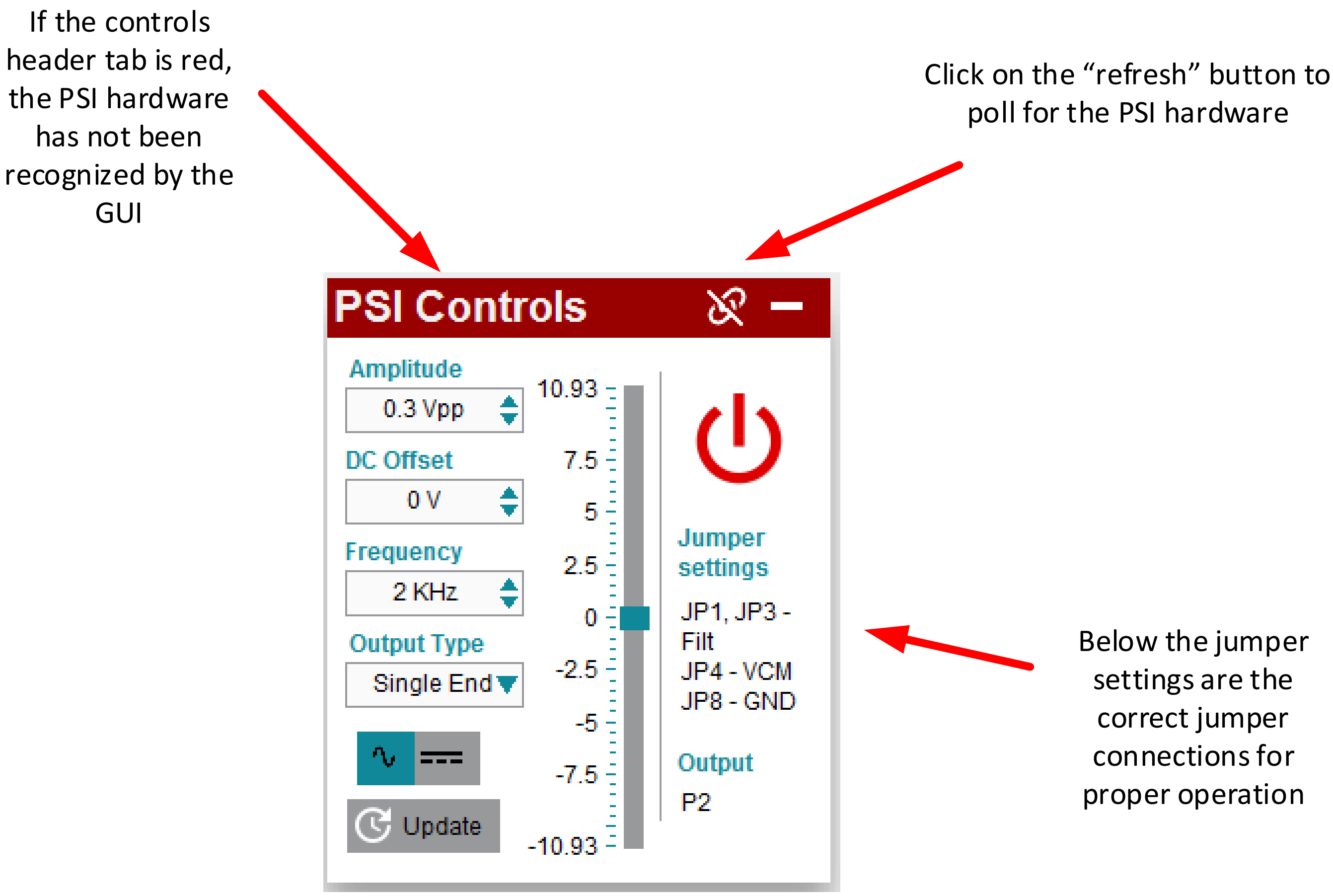

Figure 22. PSI Controls: Unconnected PSI Hardware

When the PSI hardware is recognized, the controls tab should look like Figure 23:

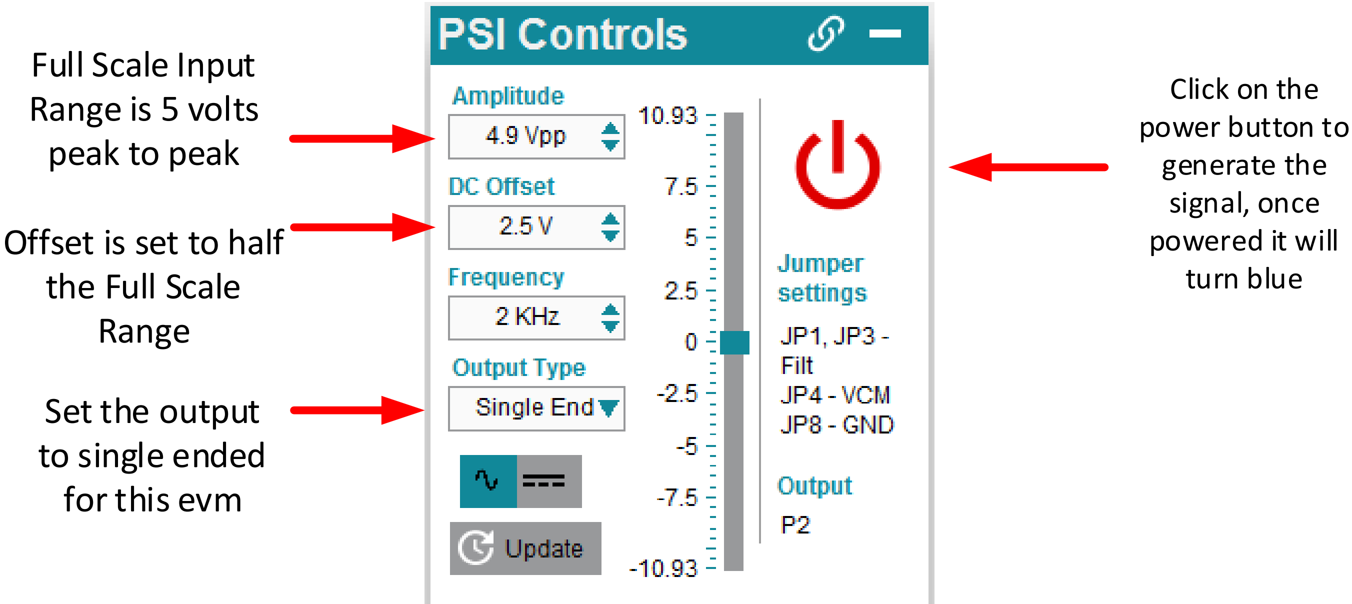

Figure 23. PSI Controls: Ready to Generate an Input Signal

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.

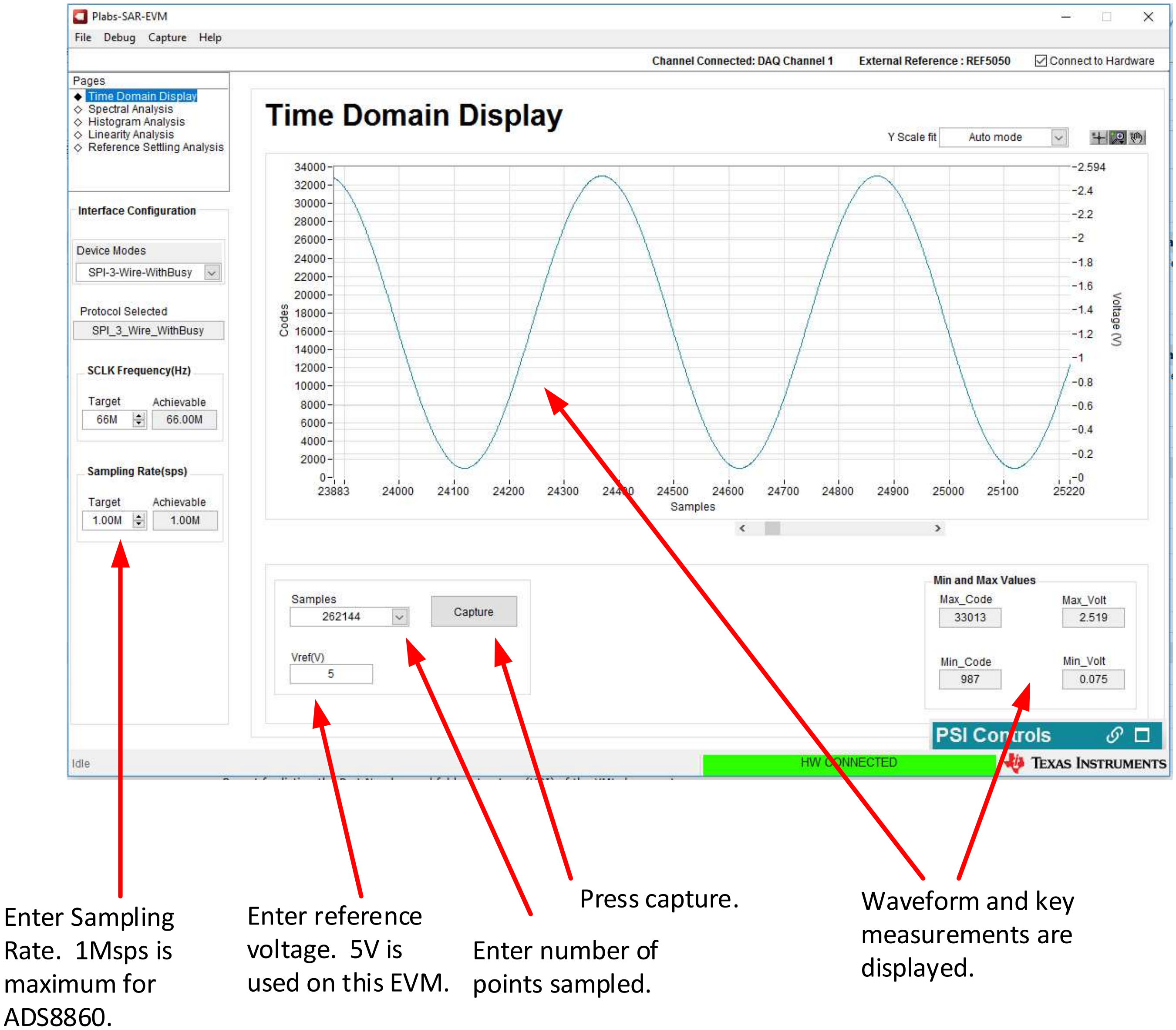

Figure 24. Time Domain Display

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.

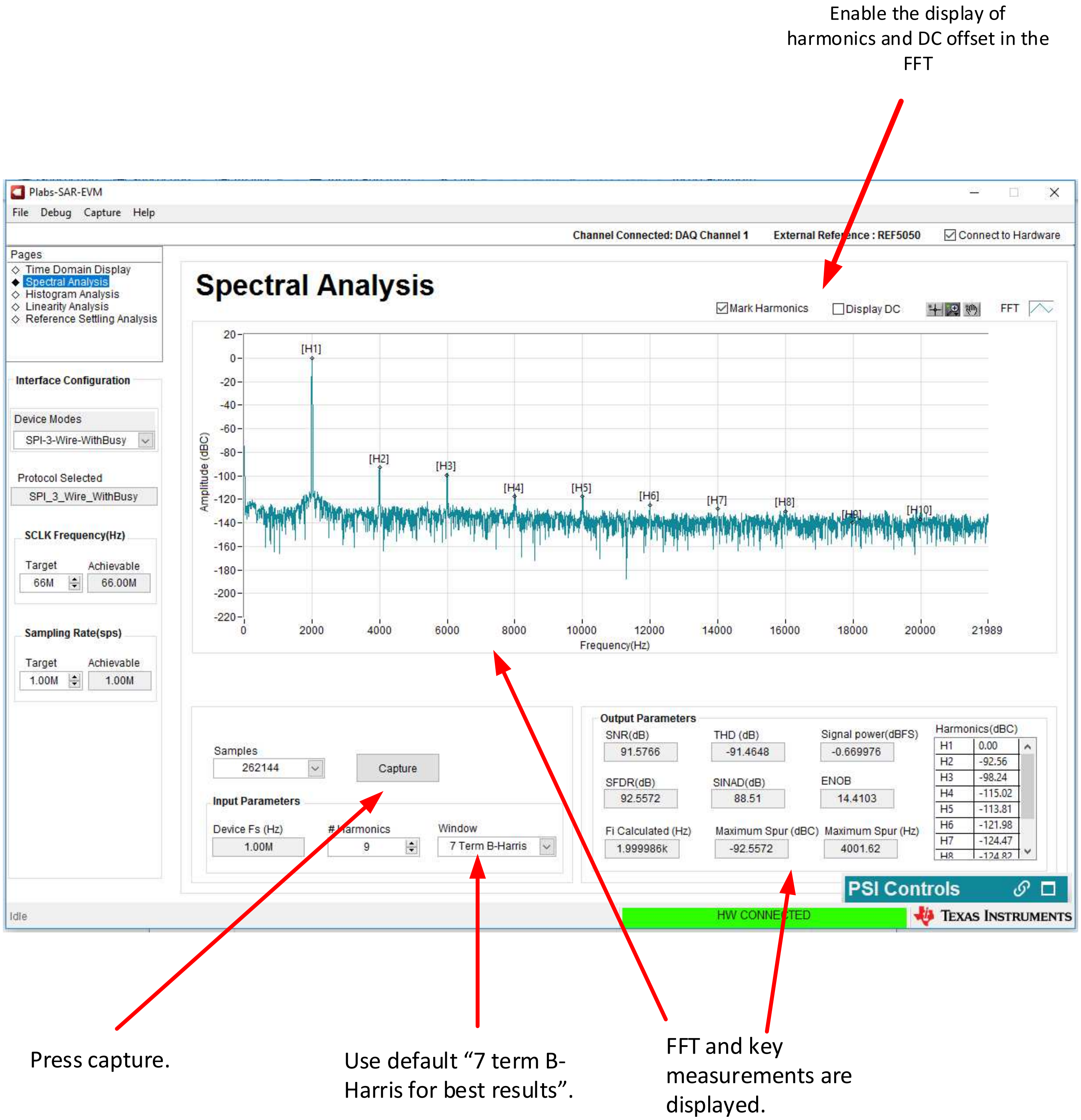

Figure 25. Spectral Analysis Display

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.

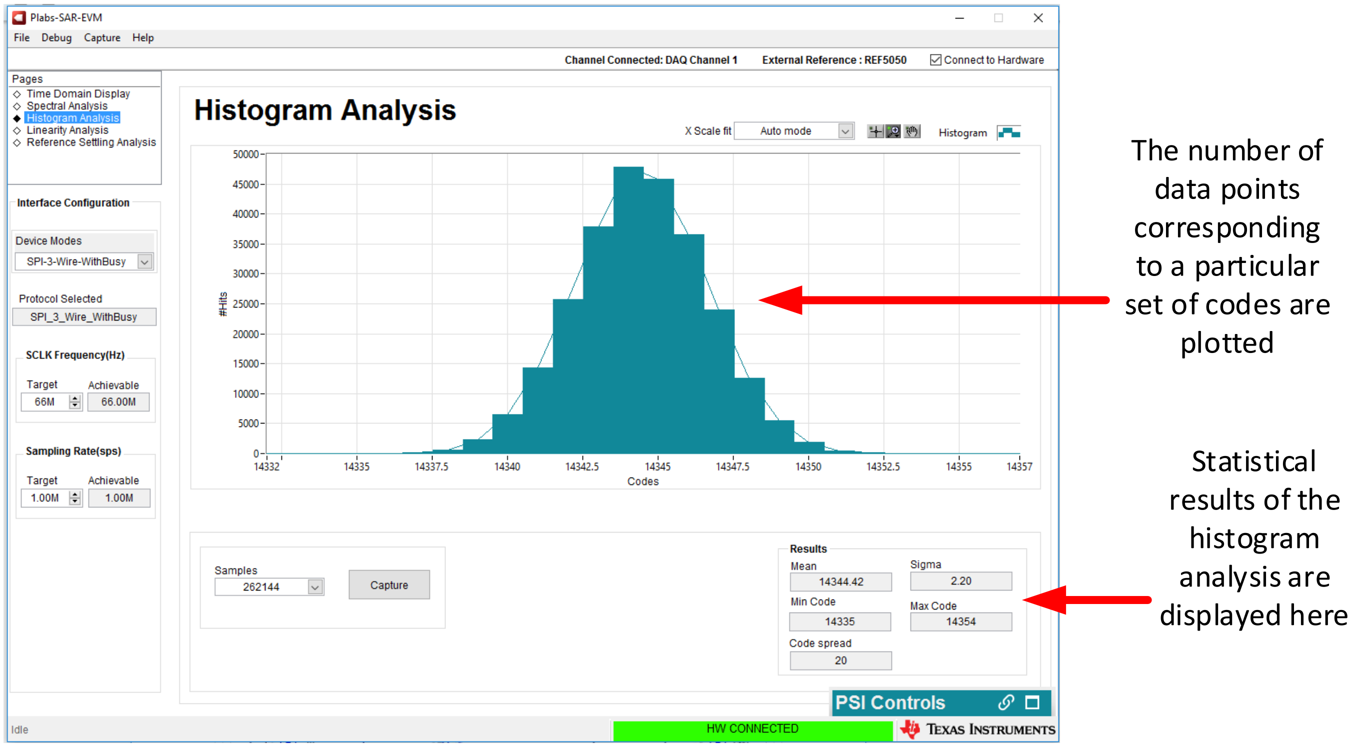

Figure 26. Histogram Analysis

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.

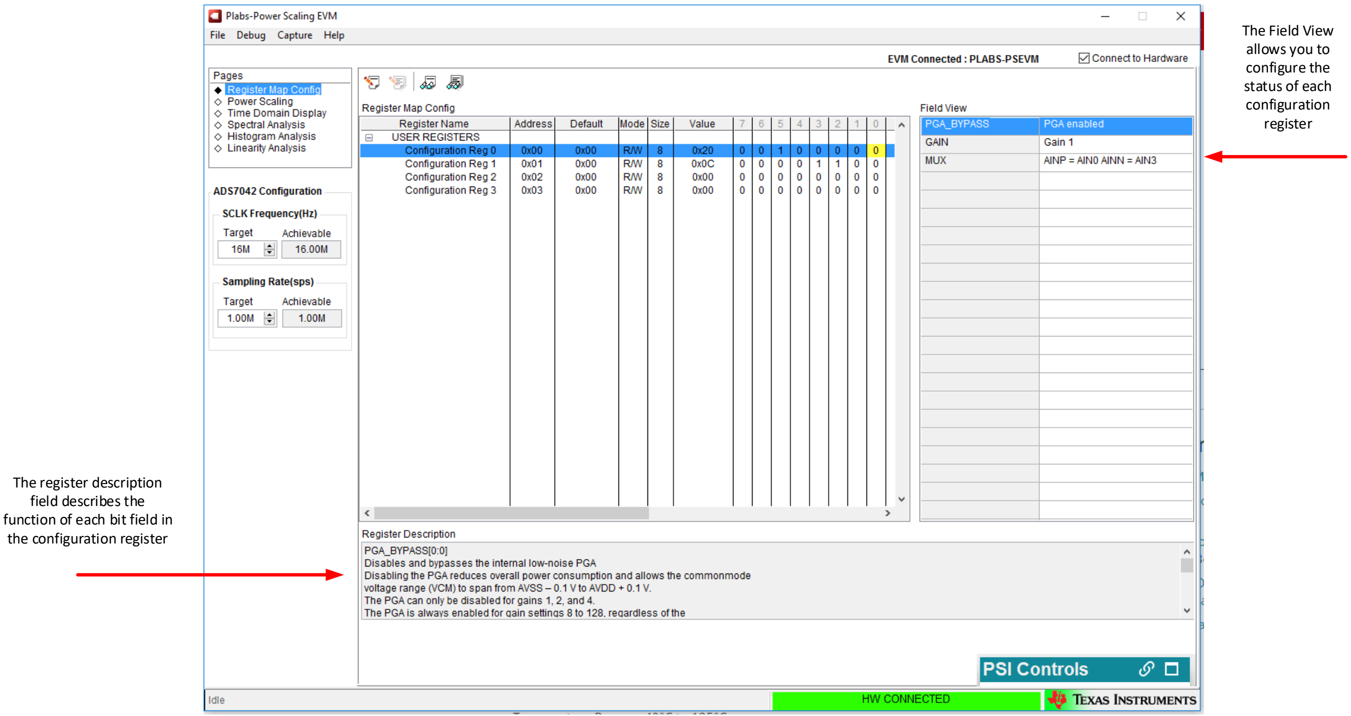

Figure 27. Register Map Configuration

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.

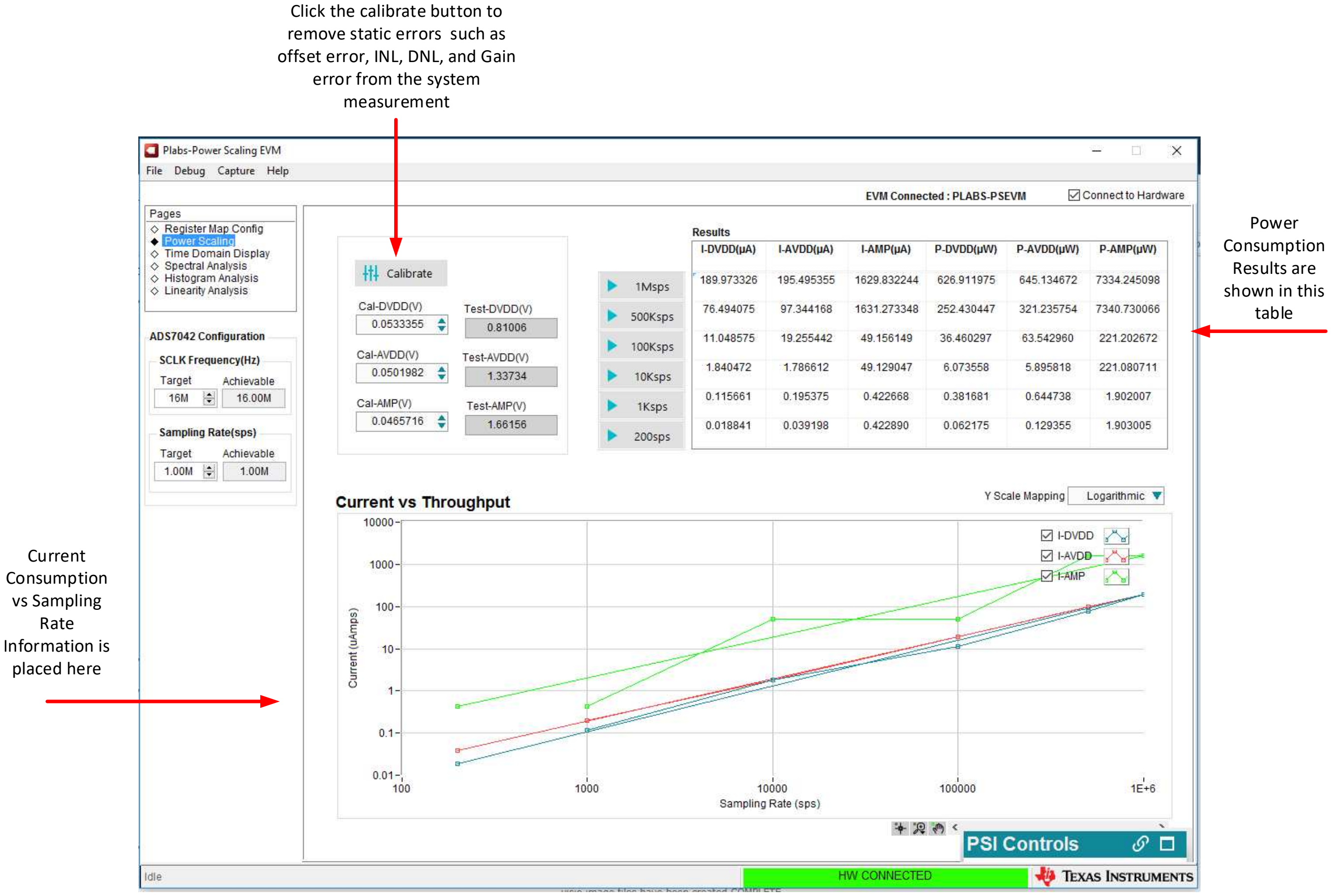

Figure 28. Power Scaling Results

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.

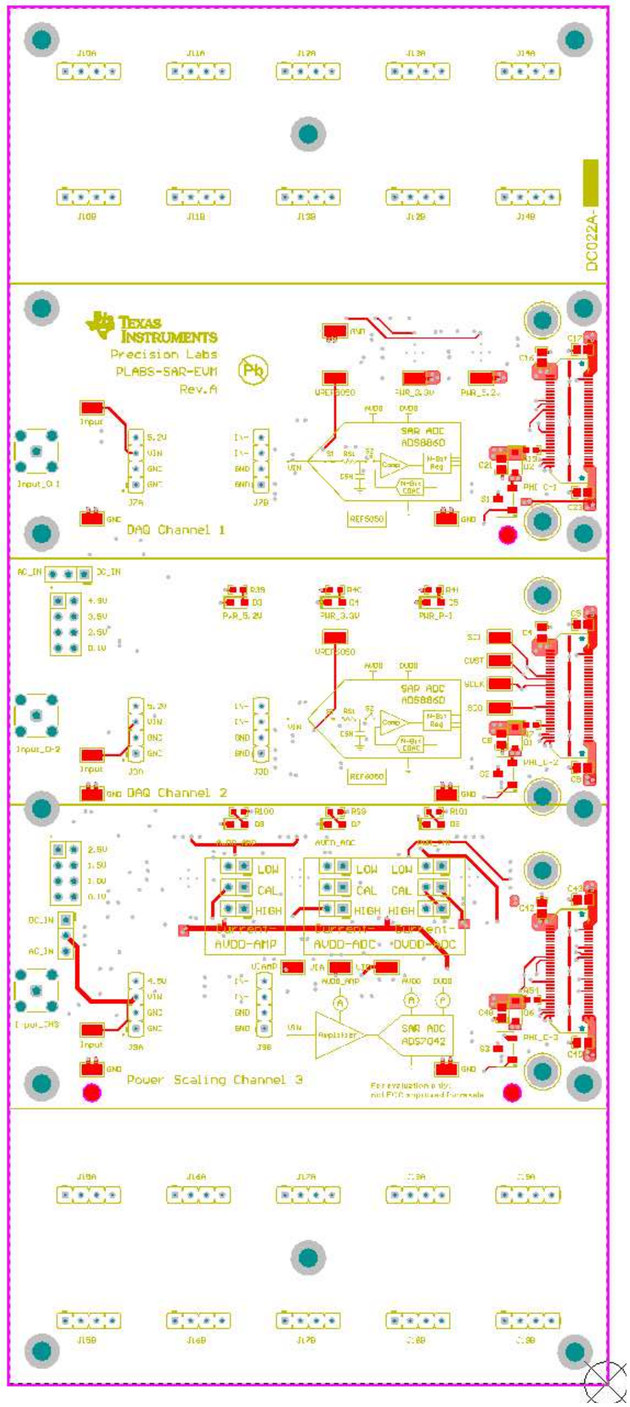

Figure 29. PCB Top Layer

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

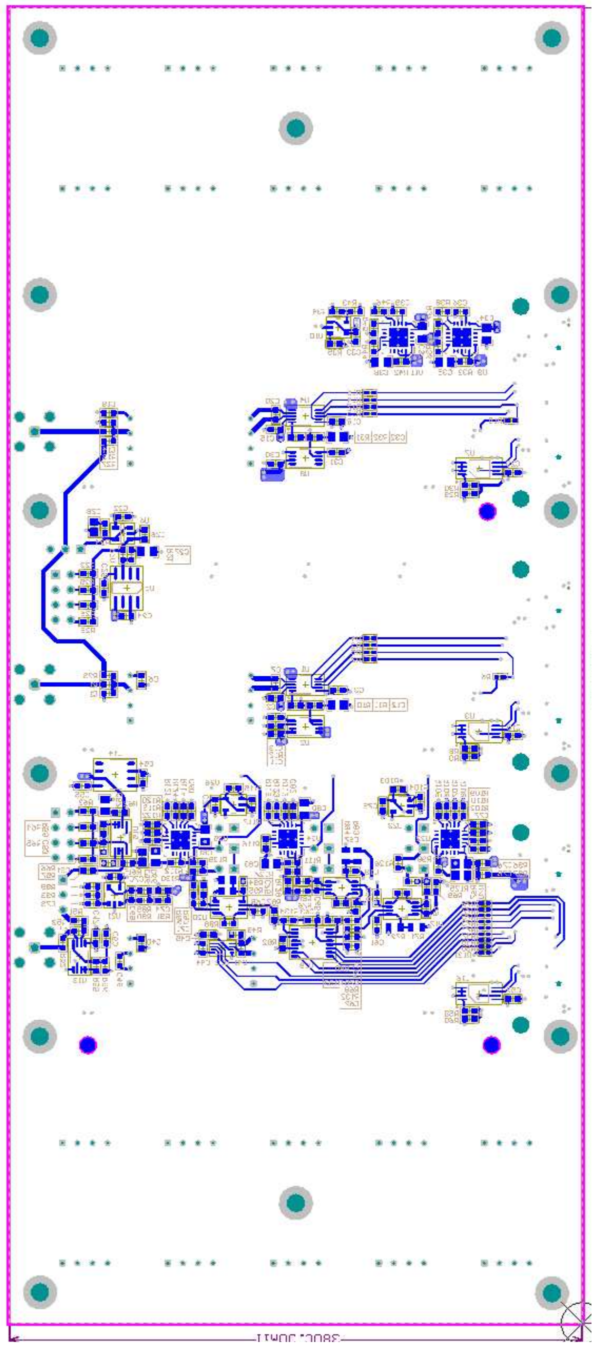

Figure 30. Bottom Layer

The ground layer, shown in Figure 31, is a solid ground plane. All connections to ground are made to this layer.

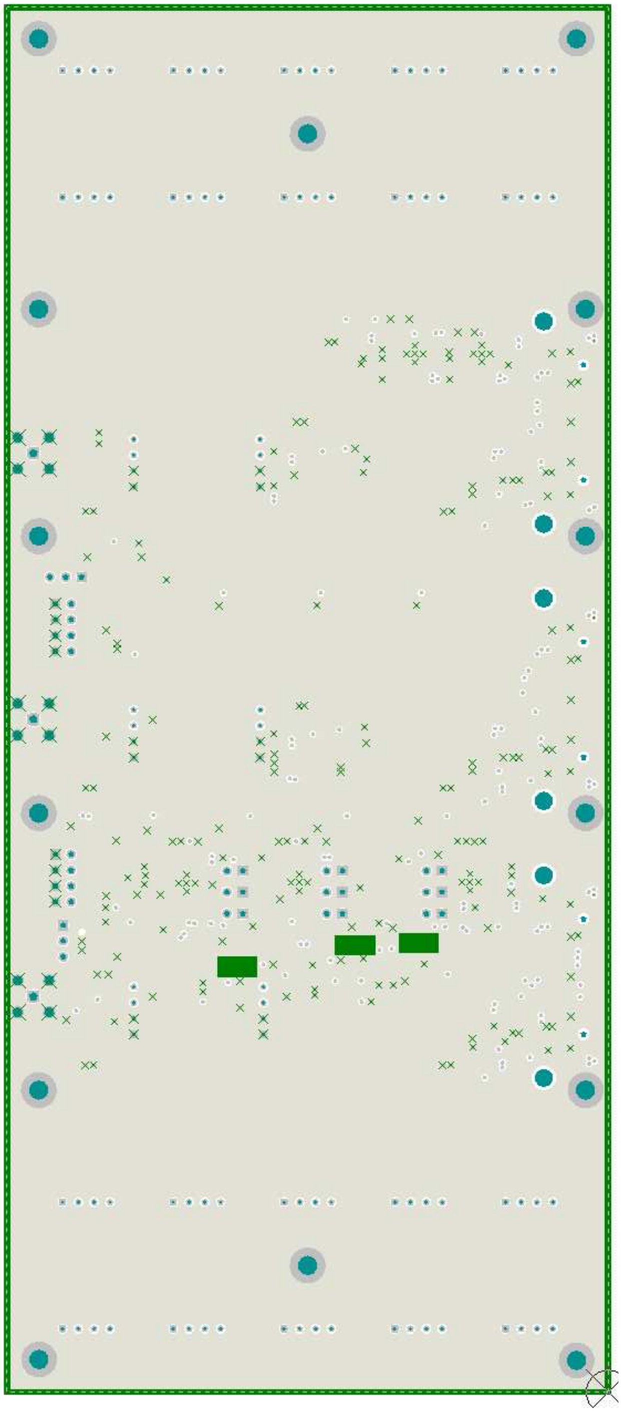

Figure 31. Ground Layer

The power layer, shown in Figure 32, has several different polygon power planes.

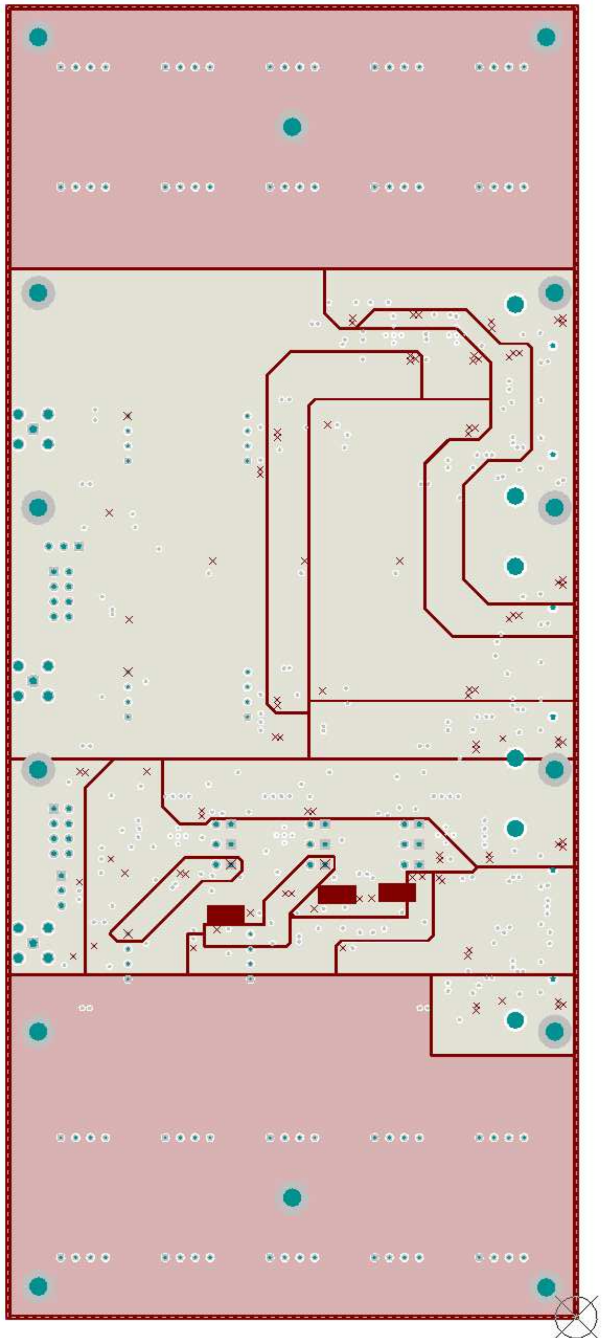

Figure 32. Power Layer

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.

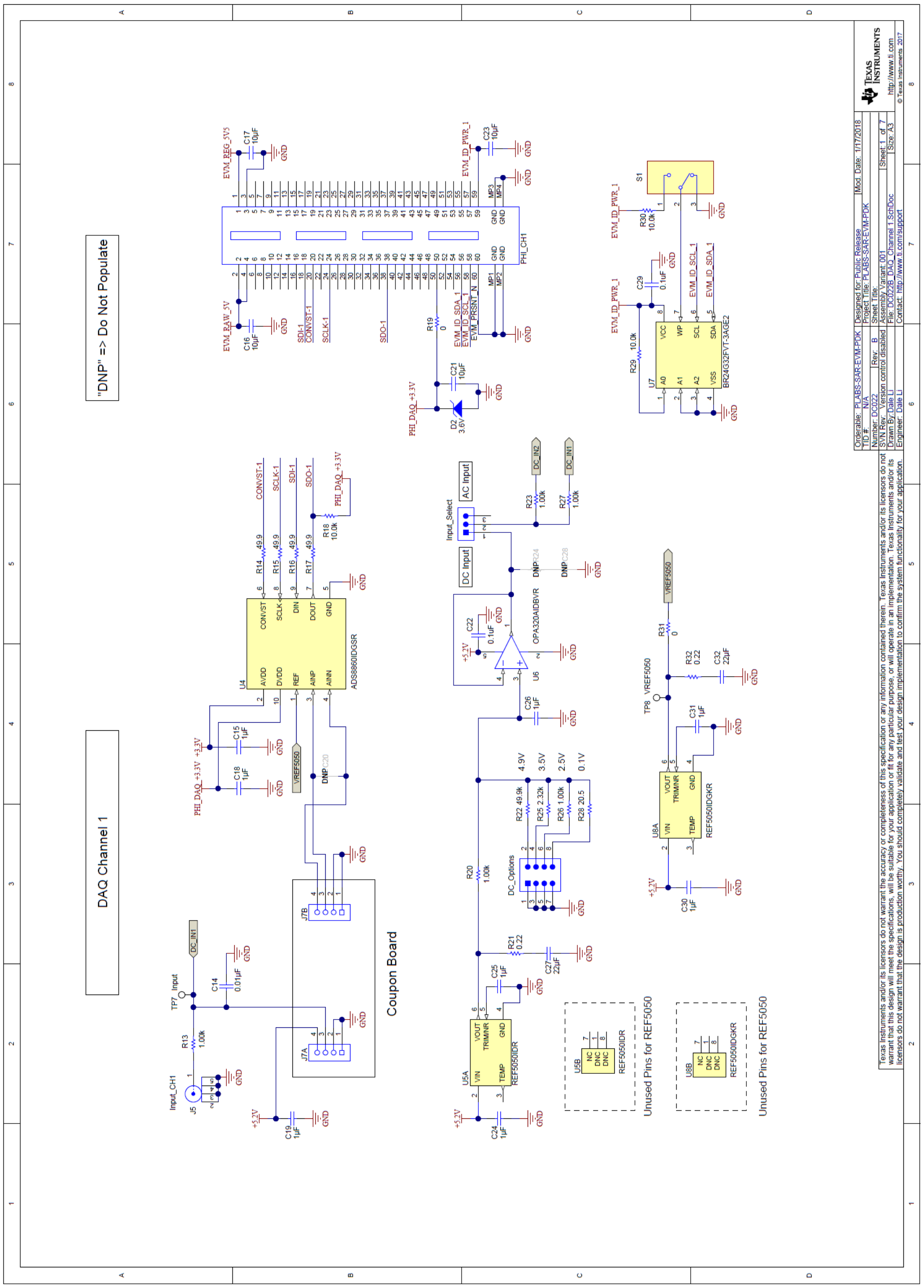

Figure 33. Page 1: Channel 1

Figure 34 shows the input configuration for channel 2.

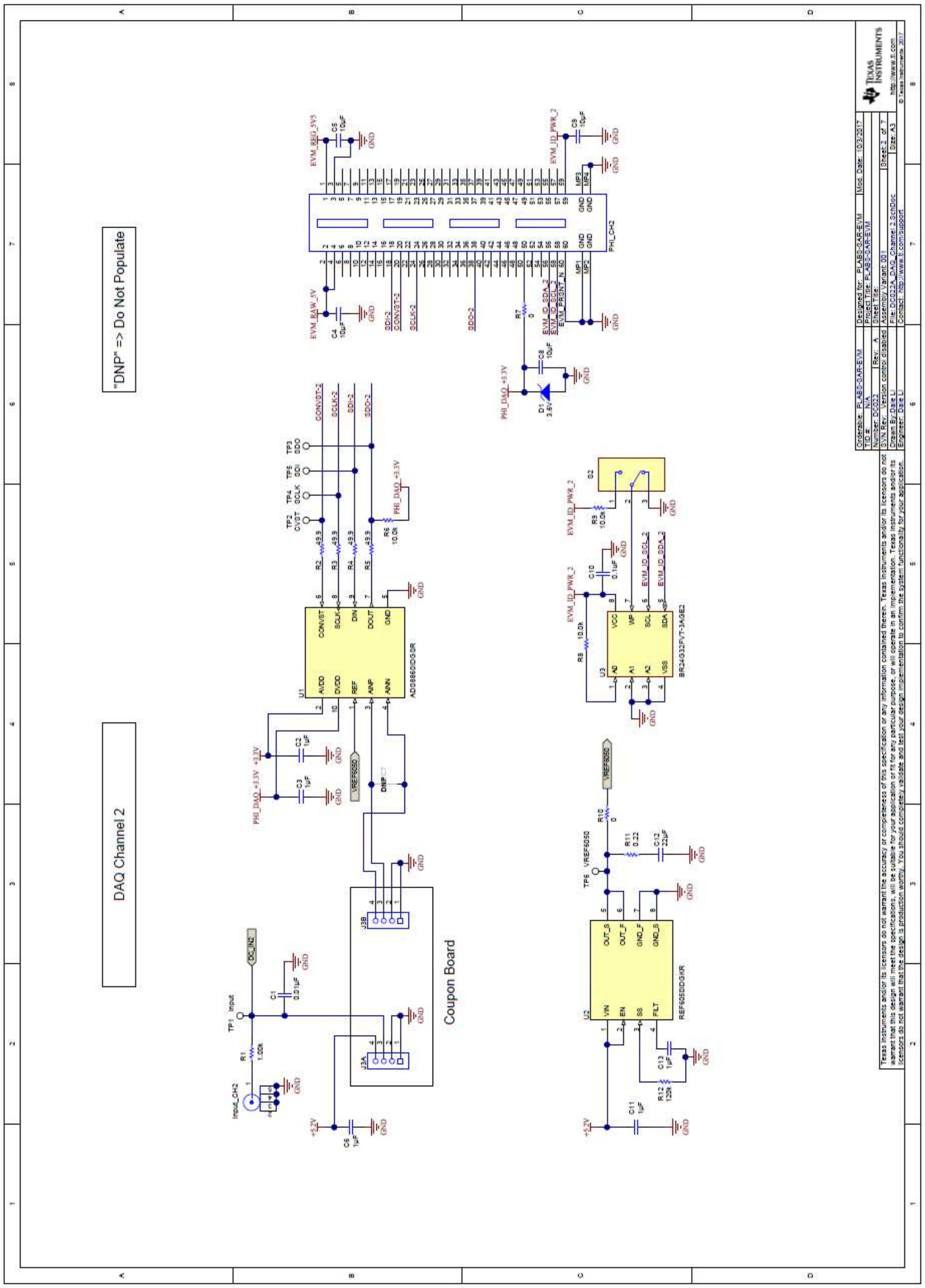

Figure 34. Page 2: Channel 2

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

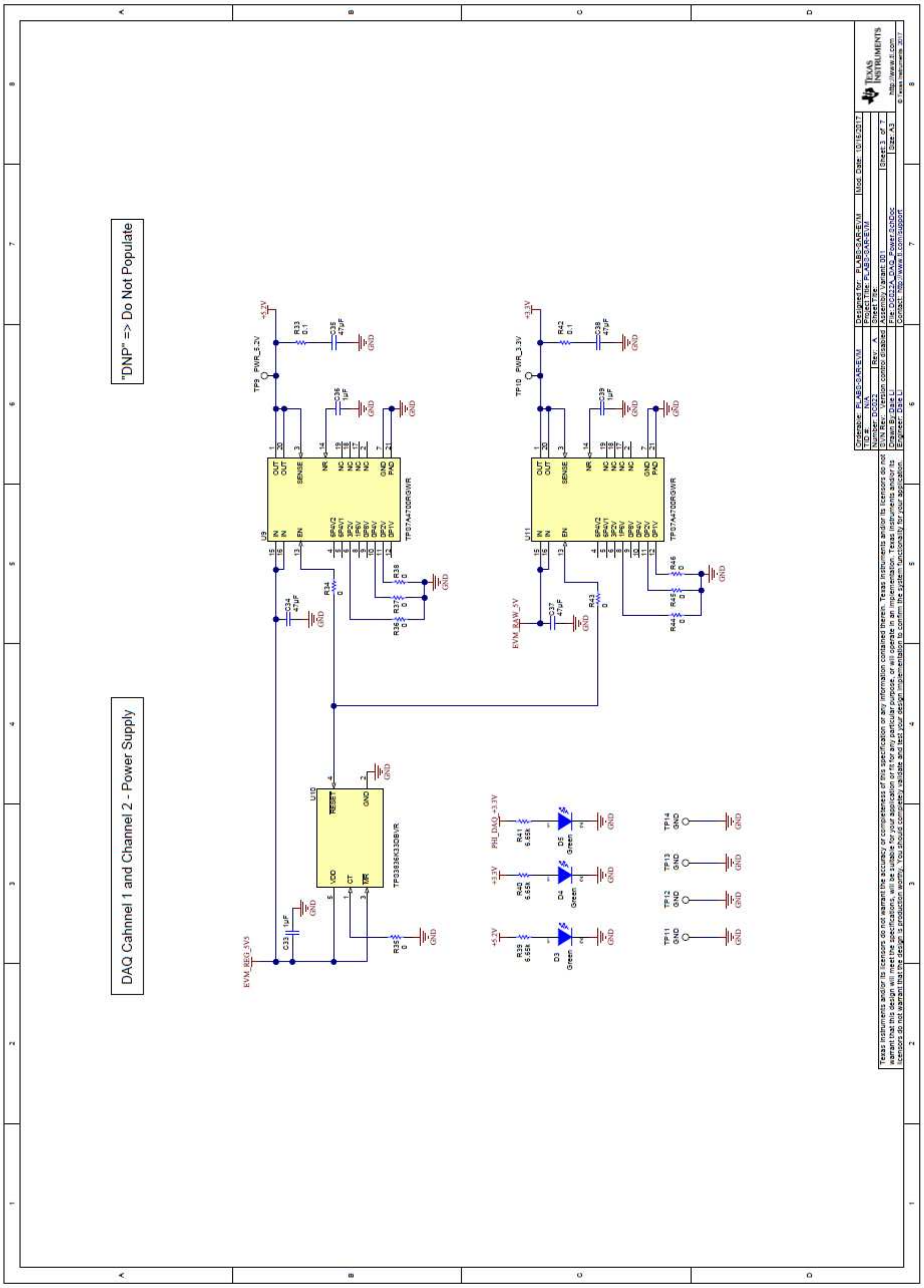

Figure 35. Page 3: Channel 1 and 2 Power

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

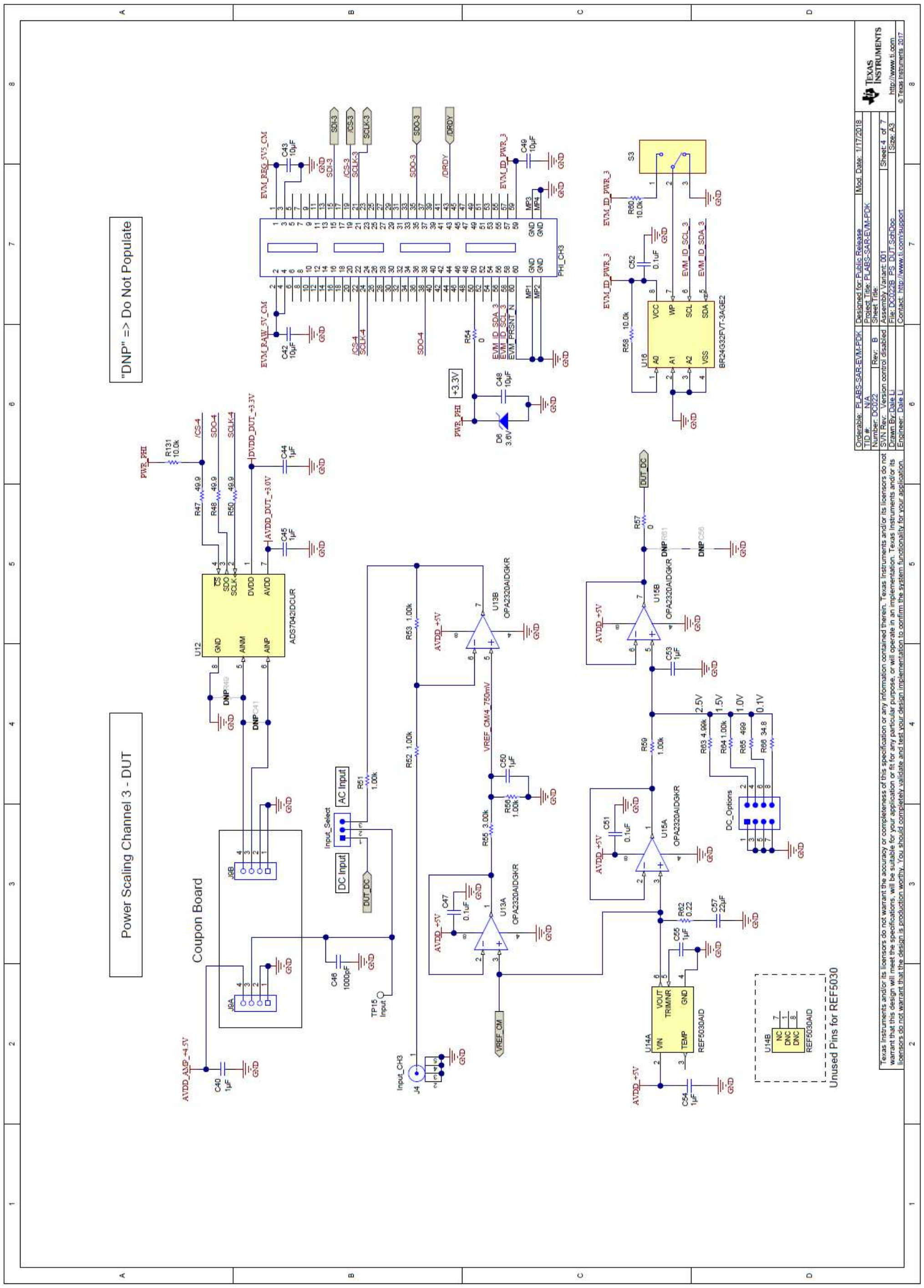

Figure 36. Page 4: Channel 3

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

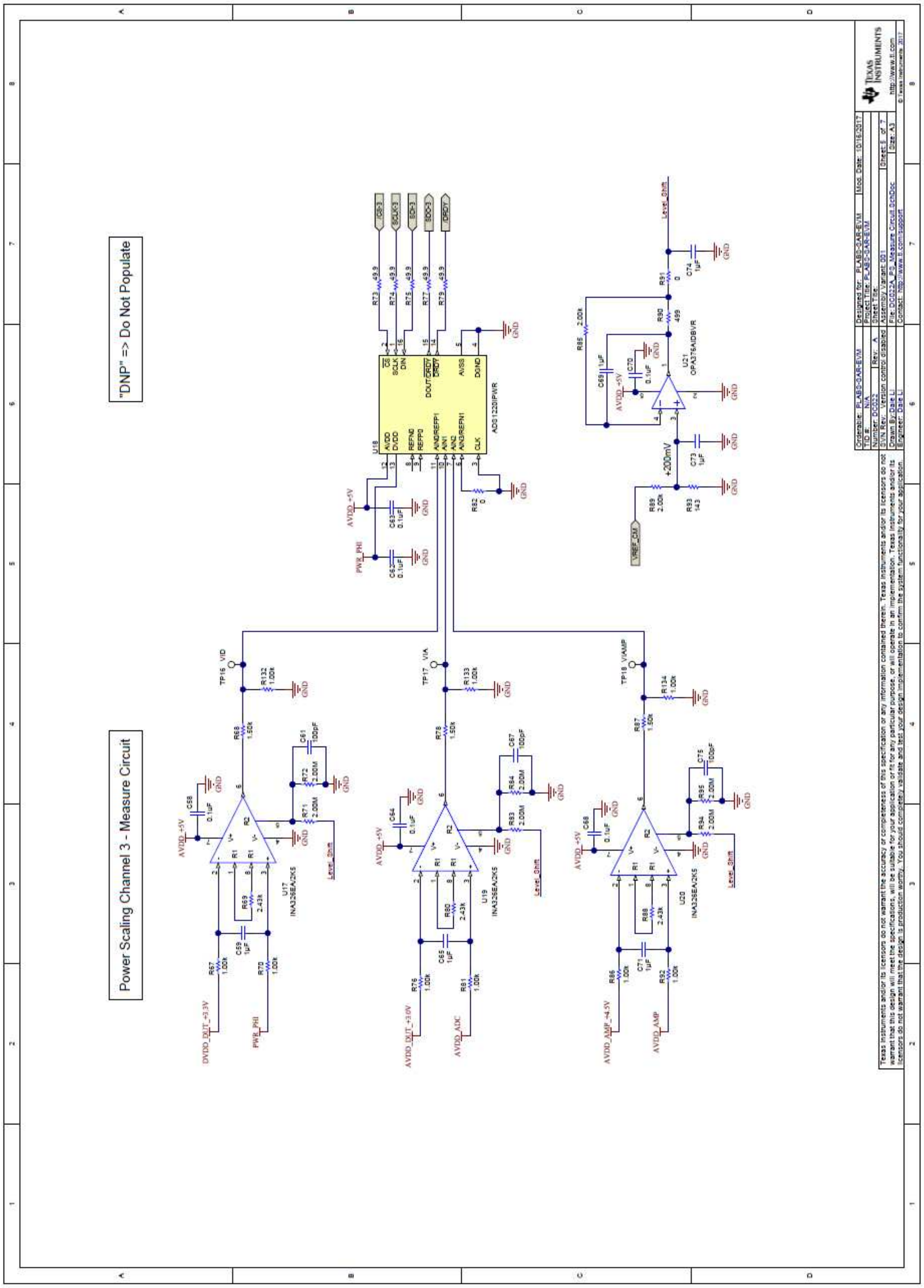

Figure 37. Page 5: Channel 3 Current-Shunt Amplifiers and ADC

This page (Figure 38) shows the range jumpers for the shunt measurement.

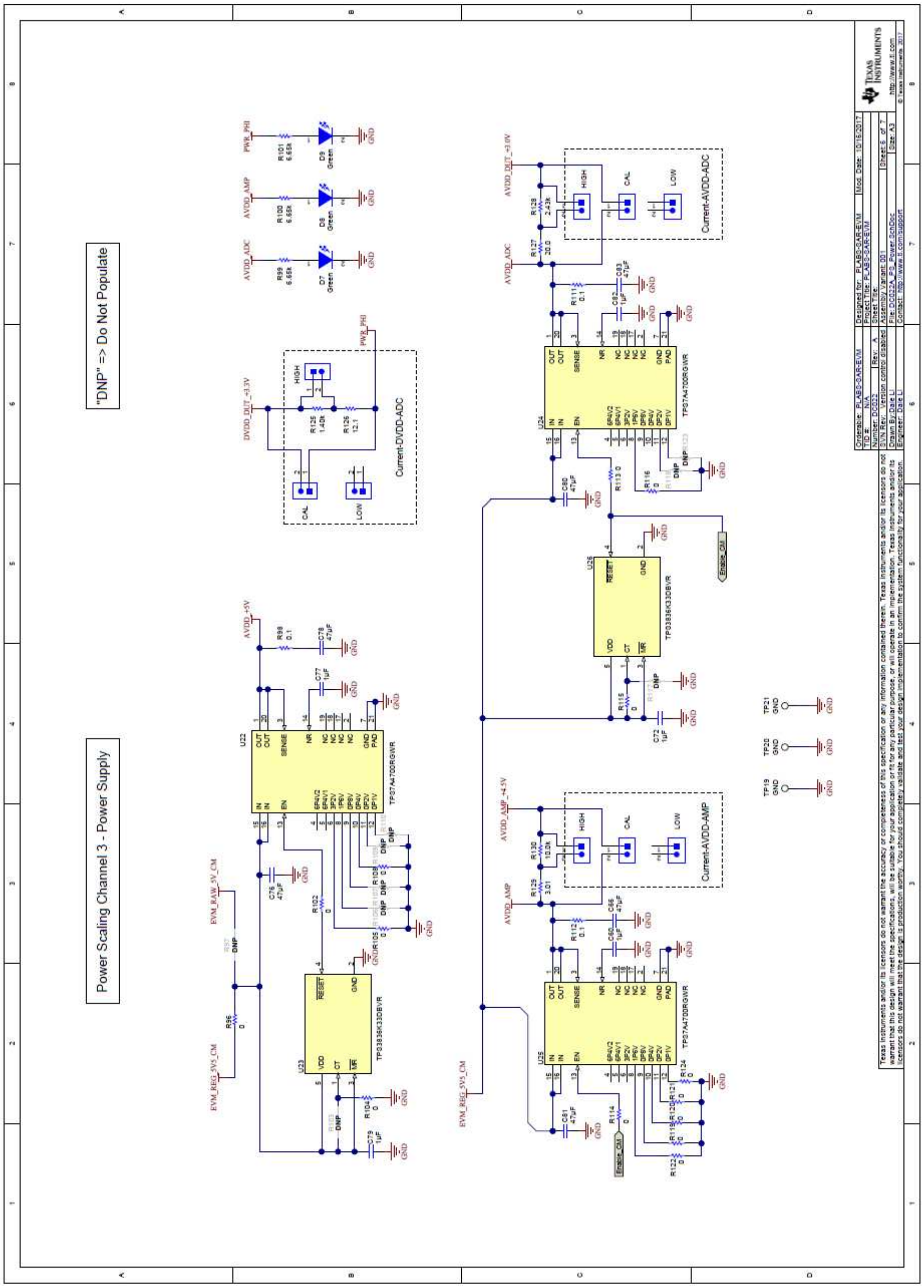

Figure 38. Page 6: Channel 3 LDO and Shunt Resistors

Mechanical hardware such as screws and standoffs are shown in this page (Figure 39).

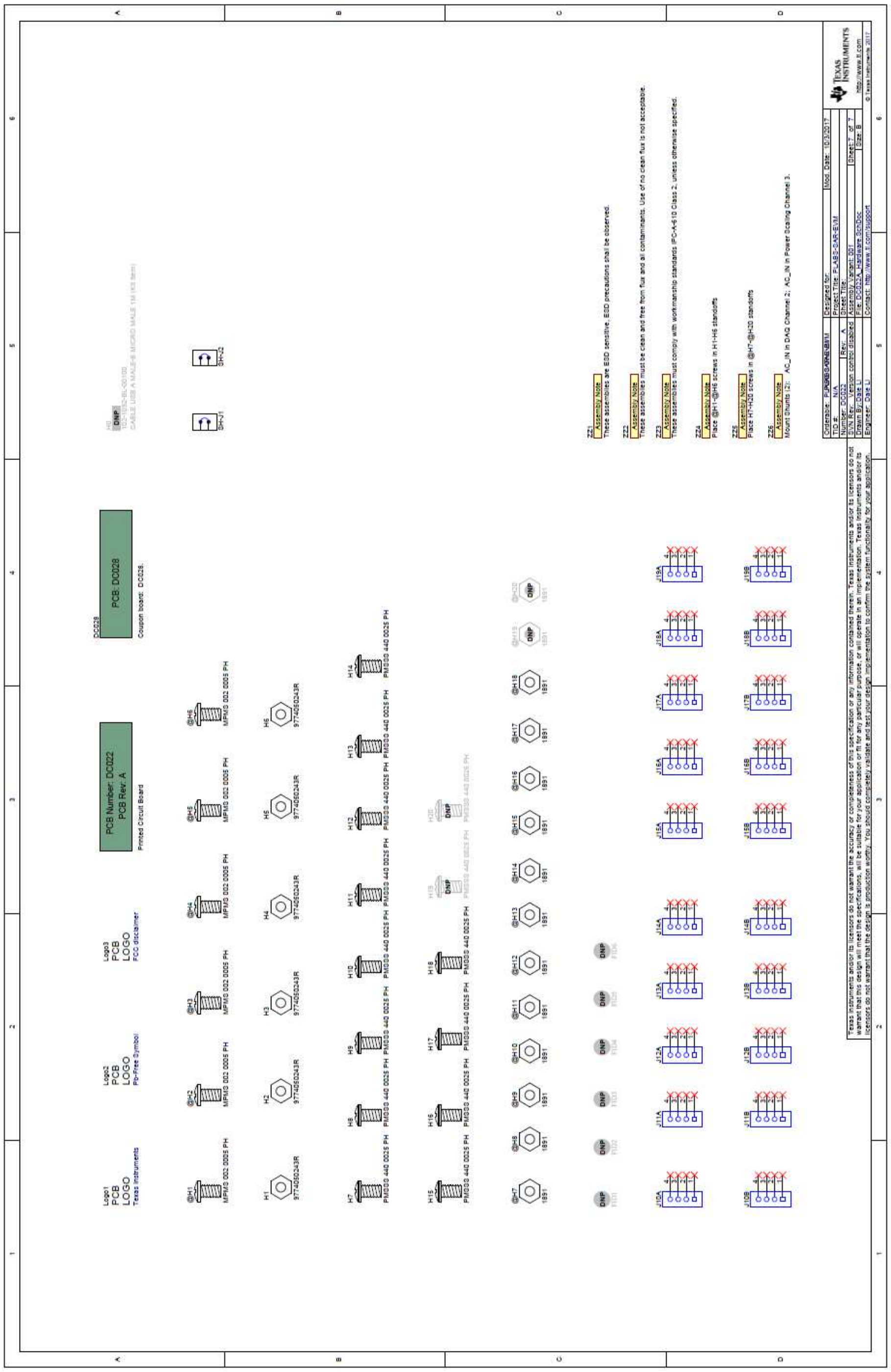

Figure 39. Page 7: Hardware

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

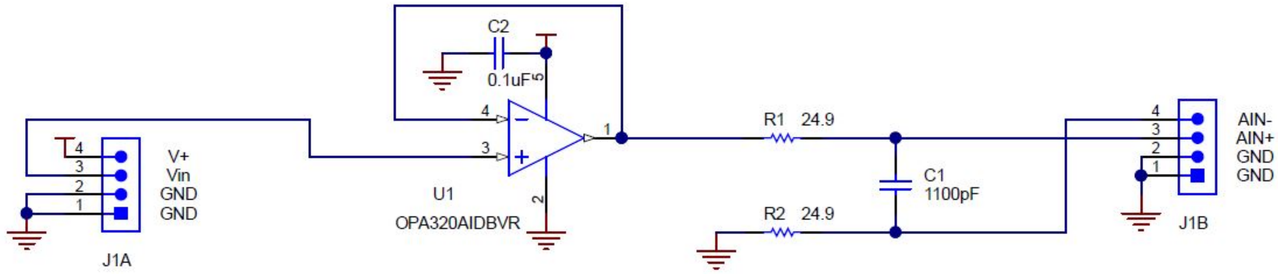

Figure 40. OPA320 Good Filter 1

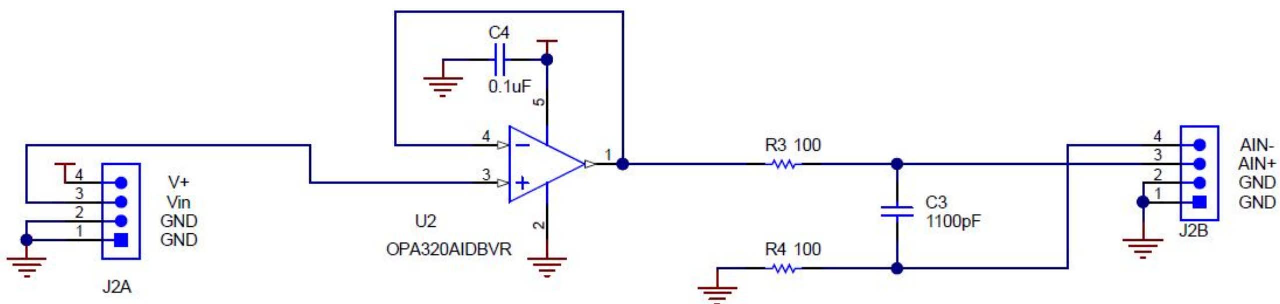

Figure 41. OPA320 Bad Filter

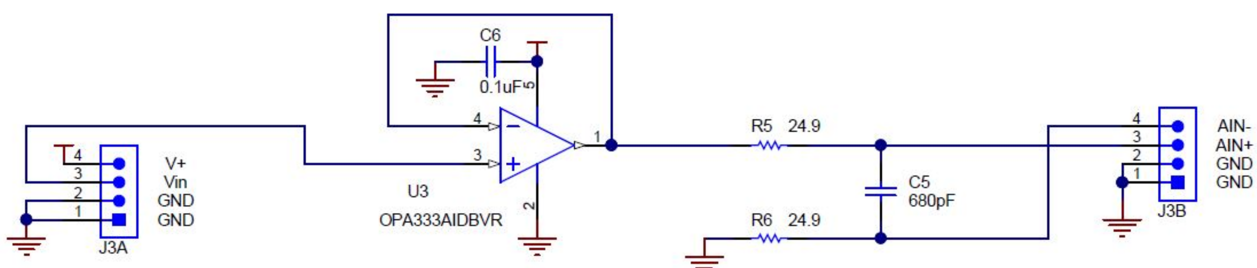

Figure 42. OPA333 Low Bandwidth

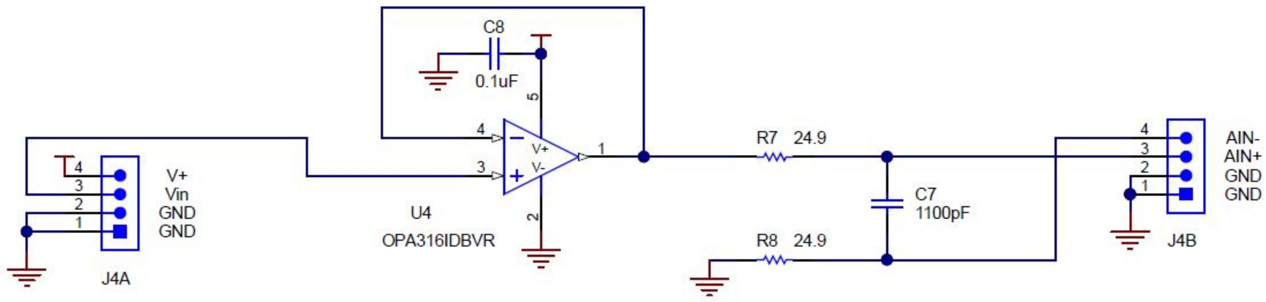

Figure 43. OPA316 Crossover

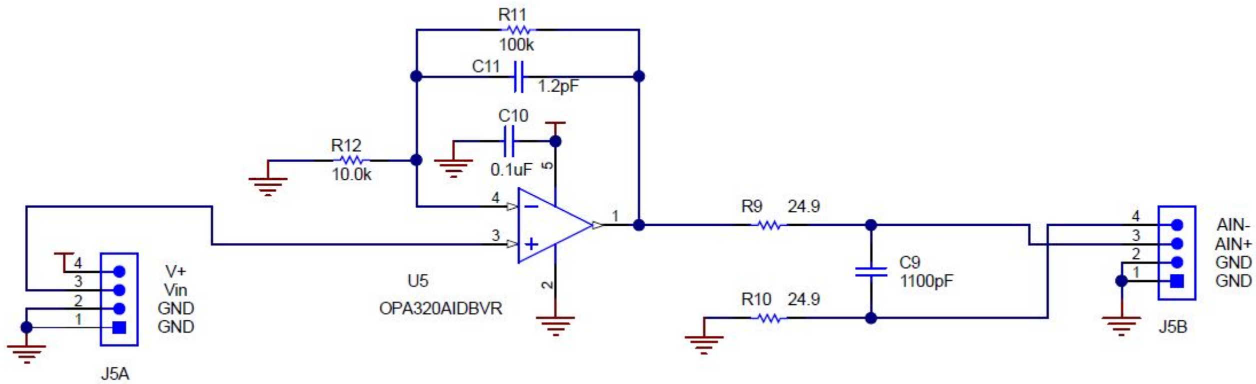

Figure 44. OPA320 Noise 1

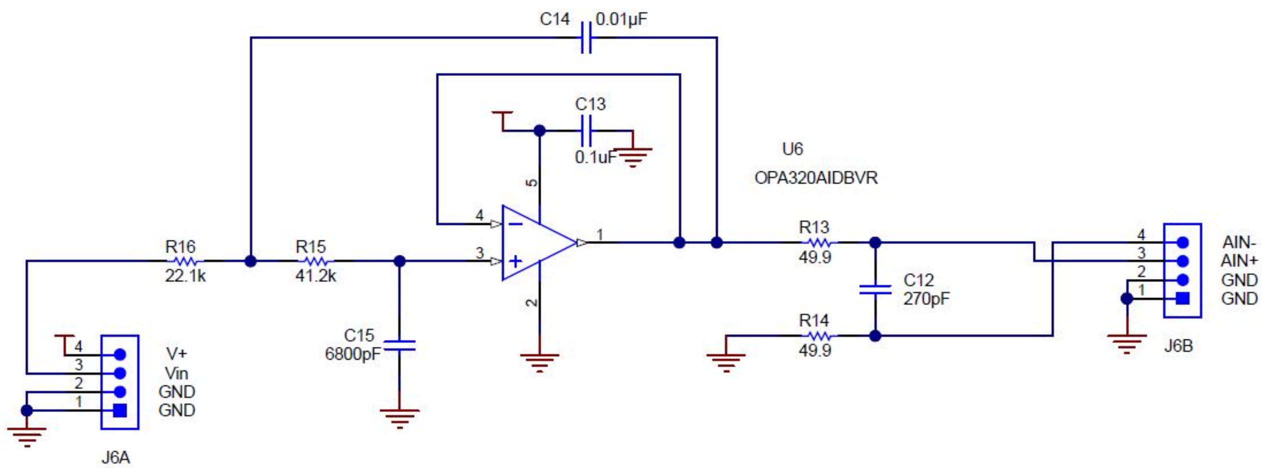

Figure 45. Sallen-Key Filter

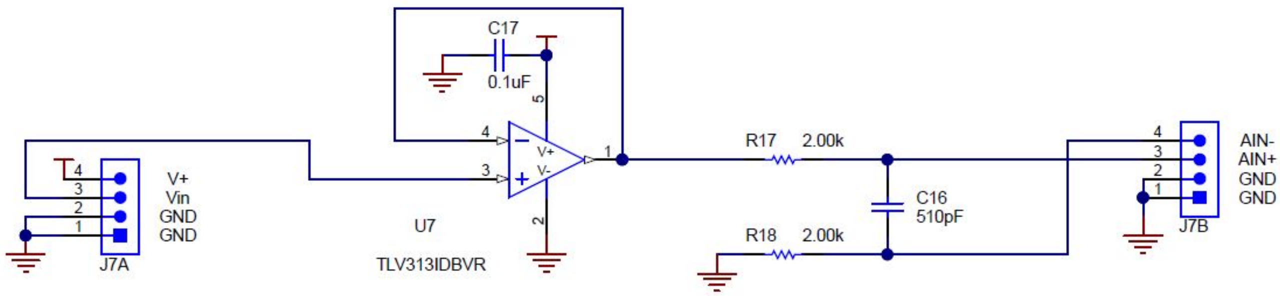

Figure 46. TLV313 Low Power

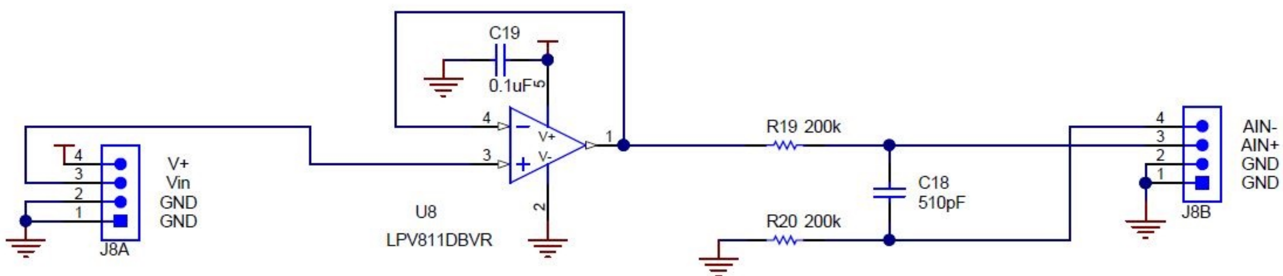

Figure 47. LPV811 Nanopower

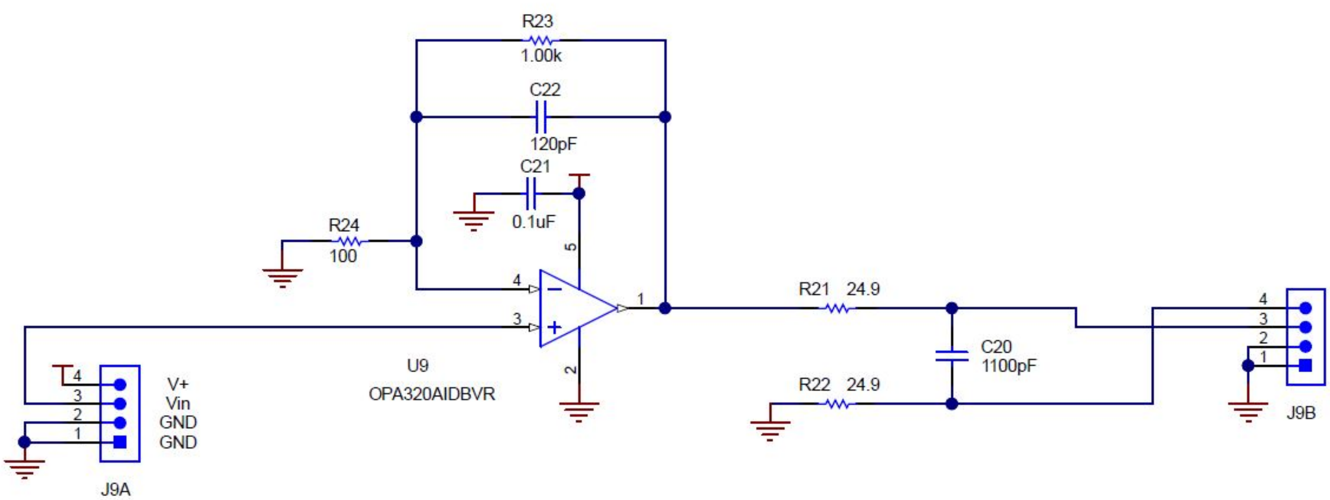

Figure 48. OPA320 Noise 2

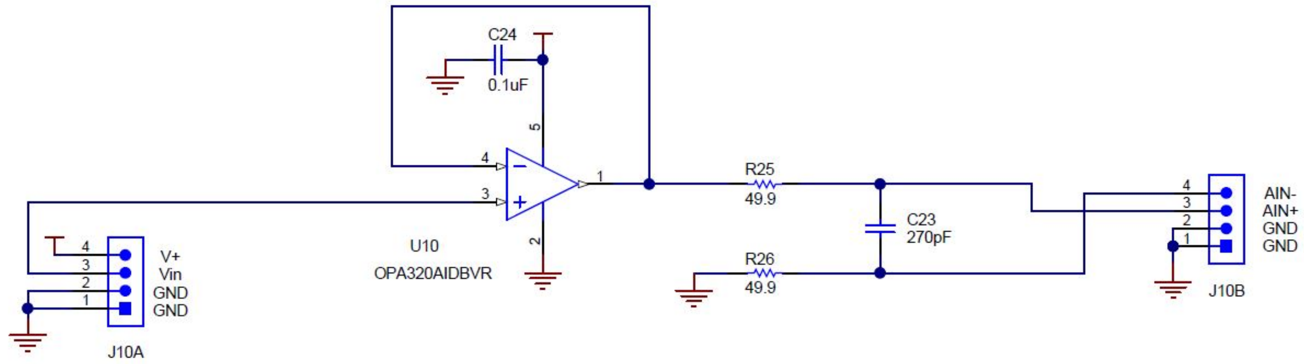

Figure 49. OPA320 Good Filter 2

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 µF, 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 µF, 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 µF, 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 µF, 50 V, +/- 10%, X7R, 0603	0603	C0603C104K5RACTU	Kemet
C12, C27, C32, C57	4	22uF	CAP, CERM, 22 µF, 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 µF, 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	Wurth 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 µF, 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 *Coupon Card Descriptions* table	16
• Changed *EVM Graphical User Interface (GUI) Software Installation* section: changed figures, added clarification on GUI and installation procedure	17
• Changed *Overview of PLABS-SAR-EVM GUI* section: added figures and expanded description of the GUI	21
• Added *Overview of PLABS Power Scaling GUI* section	27
• Added figures *OPA320 Good Filter 1* through *OPA320 Good Filter 2* and associated text to *Schematic and Bill of Materials* section	40
• Added *Motherboard* to title of *Bill of Materials for the SAR-ADC-EVM Motherboard* 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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