User's Guide
ADS8688EVM-PDK Evaluation Module

TEXAS INSTRUMENTS

Data Acquisition Products

ABSTRACT

ADS8688EVM-PDK

This user's guide describes the operation and use of the ADS8688 evaluation module (EVM). The ADS8688 is a 16-bit, 500ksps, 8 channel multiplexed, single-supply, SAR ADC with bipolar input ranges. Operating on a single 5V the integrated analog front end can support ±10.24V input ranges with a ±20V over-voltage protection. The performance demonstration kit (PDK) eases EVM evaluation with additional hardware and software for computer connectivity through a universal serial bus (USB). The ADS8688EVM-PDK includes the ADS8688EVM as a daughter card, Precision Host Adaptor (PHI) digital controller, and a A-to-B USB cable. This user's guide covers circuit description, schematic diagram, and bill of materials for the ADS8688EVM daughter card.

Table 1-1. Related Documentation

Device	Literature Number
ADS8688	SBAS582
OPA320	SBOS513
TPS7A4700	SBVS204

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1 Trademarks
All trademarks are the property of their respective owners.

2 ADS8688EVM-PDK Overview

Table 1-1 lists the related documents that are available for download from Texas Instruments at

ADS8688EVM Features

- Hardware and software required for diagnostic testing as well as accurate performance evaluation of the ADS8688 ADC
- USB powered—no external power supply is required
- The PHI controller that provides a convenient communication interface to the ADS8688 ADC over USB 2.0 (or higher) for power delivery as well as digital input and output
- Easy-to-use evaluation software for 64-bit Microsoft Windows™7, Windows 8, and Windows 10 operating systems
- The software suite includes graphical tools for data capture, histogram analysis, and spectral analysis. This suite also has a provision for exporting data to a text file for post-processing. Fig
- Integrated 4.096-V voltage reference.
- Bipolar (±10.24 V, ±5,12 V, ±2.56 V) or unipolar (0 V to 10.24 V, 0 V to 5.12 V) input ranges for each channel.
- Onboard, second-order, Butterworth, low-pass filters for four channels.
- Onboard regulator for generating a ±15-V bipolar supply for second-order, Butterworth, low-pass filters.
- Capable of accepting a ±100-mV signal on the negative analog inputs (AIN_xGND).
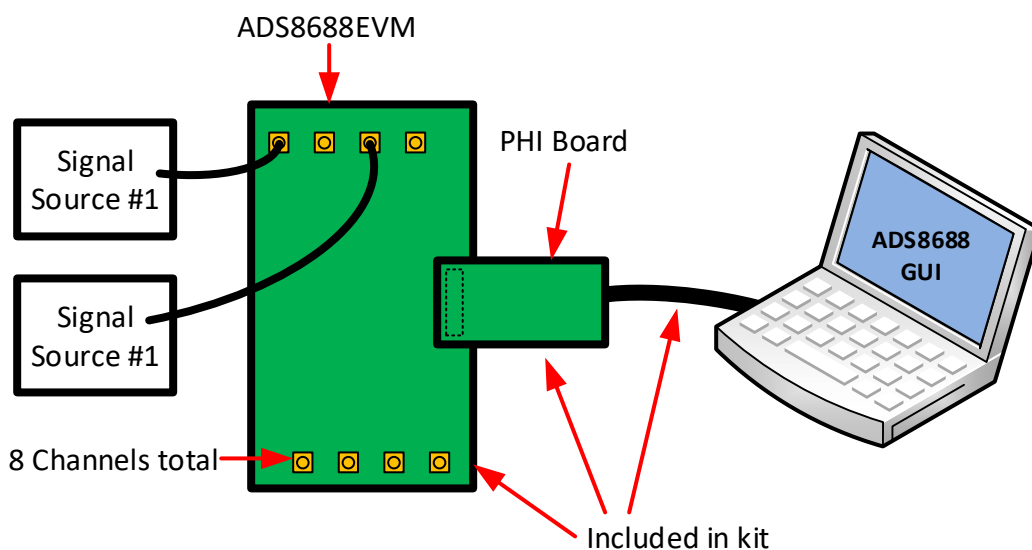
Figure 2-1. System Connection for Evaluation

ADS8688EVM Features:

- Eight input channels connected to external single ended signals source applied to SMA connectors or header
- Serial interface connects to the PHI controller via 60 pin connector (J3).
- Serial interface connects to the PHI controller via 60 pin connector (J2).
- All power for device from USB via PHI controller.
- Onboard ultra-low noise low-dropout (LDO) regulator generates 5.0V AVDD supply. Input to LDO from PHI controller.
- DVDD (3.3V) powered by PHI controller.

3 EVM Analog Interface

The ADS8688EVM is an evaluation module built to the TI Modular EVM system specifications. The EVM by itself has no microprocessor and cannot run software. Thus, the EVM is available as part of the ADS8688EVM-PDK kit that combines the ADS8688EVM as a daughter board with PHI controller using software as a graphical user interface (GUI).

3.1 ADC Analog Input Connections and Filter

The circuit shown in Figure 3-1 shows a typical analog input connection for the ADS8688 ADC. This circuit is reapeated eight times for all eight input channels. The resistor R01 can be used for input float detection but is not populated in the default configuration. The TVS diode D01, can be used for input protection, but is not populated. Refer to Video Series on Electrical Overstress. C01, R03, and R04 form the 79.5kHz low pass input the input filter for the ADC. R05 connects the negative input to ground. R05 can be removed and the negative input can be accessed in the header J6.
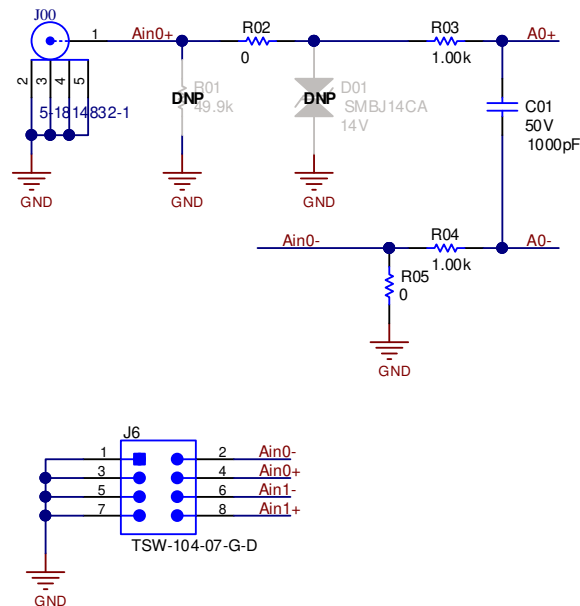
Figure 3-1. ADC Analog Input Connections and Filter

3.2 Voltage Reference, Aux Input, and Supply Decoupling

The circuit shown in Figure 3-2 illustrates the decoupling on AVDD, DVDD, and the reference IO. It is possible on the ADS8688 to use an external voltage reference, but typically the integrated internal reference is sufficient. In cases where you need to use an enthral voltage reference it can be connected via the REF test point. The capacitors for decoupling match the recomendations in the ADS8688 data sheet. The layout (see Figure 8-1) uses the shortest possible connections to the decouplign capacitors and connections the ground end to the GND plane using vias. The AUX input is a standard SAR input and does not have an analog front end. Thus, this input cannot accept high voltage input signals (Vin Full Scale = VREF = 4.096V). Furthermore, this input requires an external buffer amplifier U4 to achieve good settling.
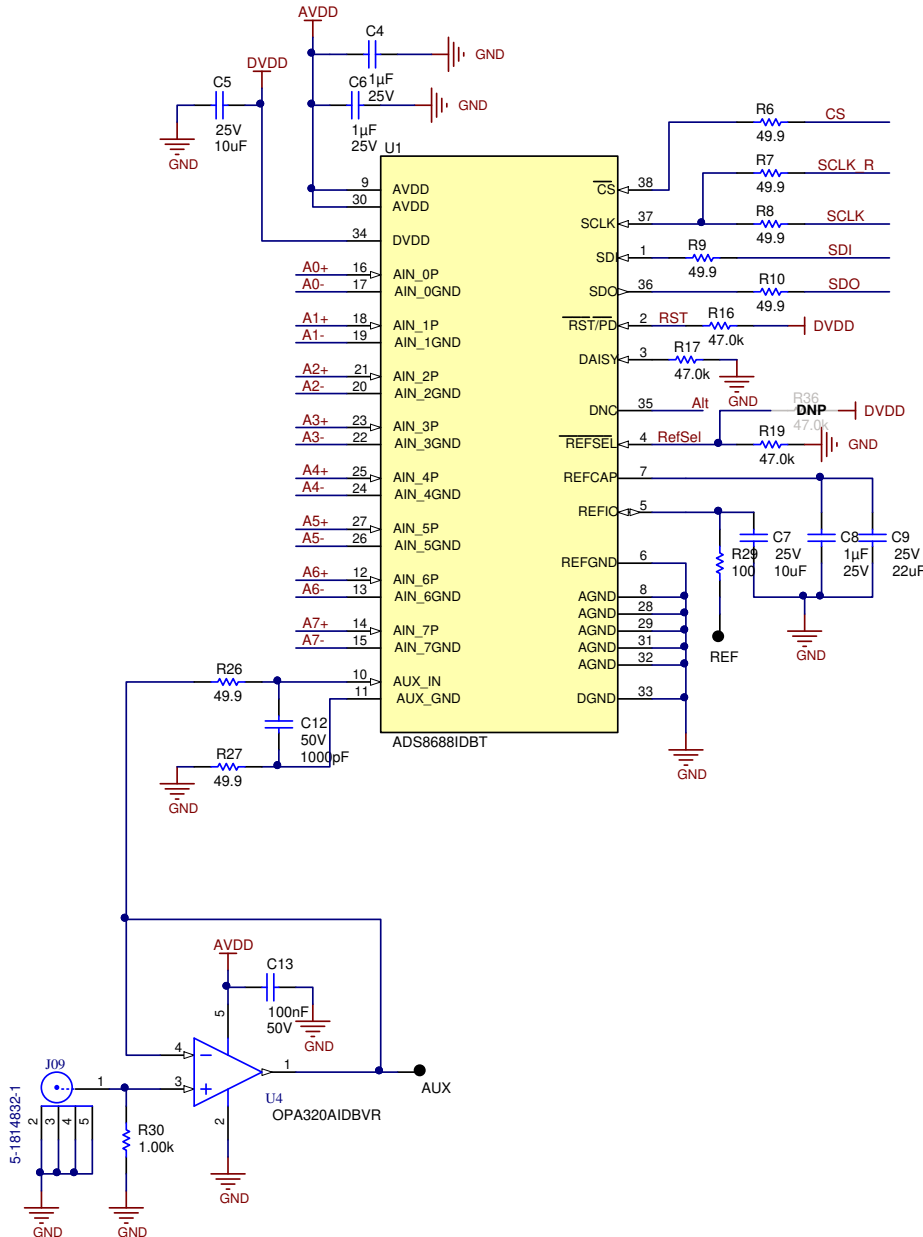
Figure 3-2. Voltage Reference, Aux Input, and Supply Decoupling

4 Digital Interface

As noted in Section 2, the EVM interfaces with the PHI and communicates with the computer over the USB. There are two devices on the EVM with which the PHI communicates: the ADS8688 ADC (over SPI) and the EEPROM (over I2C). The EEPROM comes pre-programmed with the information required to configure and initialize the ADS8688 platform. When the hardware is initialized, the EEPROM is no longer used.

4.1 Serial Interface (SPI)

As noted in Section 2, the EVM interfaces with the PHI and communicates with the computer over the USB. There are two devices on the EVM with which the PHI communicates: the ADS8688 ADC (over SPI) and the EEPROM (over I2C). The EEPROM comes pre-programmed with the information required to configure and initialize the ADS8688 platform. When the hardware is initialized, the EEPROM is no longer used.

4.2 I2C Bus for Onboard EEPROM

The circuit shown in Figure 4-1 is used with our EVM controller (PHI), for EVM identification. This circuit is not required by the ADS8688 for operation. The switch (S2) is a write protect and does not need to be changed for EVM operation.
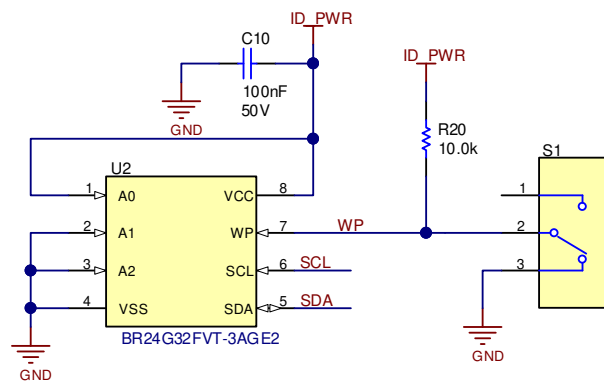
Figure 4-1. EEPROM for EVM ID

5 Power Supplies

The PHI provides multiple power-supply options for the EVM, derived from the USB supply of the computer. The EEPROM on the ADS8688EVM uses a 3.3-V power supply generated directly by the PHI. The EVM_REG_5V5 is a 5.5V supply from the PHI and is applied to the input of a low dropout regulator (LDO) to generate AVDD on the EVM. The analog supply of the ADC (AVDD = 5.0V) is powered by the TPS7A4700RGWR (U3). The ADC Digital supply (DVDD = 3.3V), is generated by the PHI. Two LEDs are connected to the AVDD, and DVDD supplies. These LEDs will illuminate after the software GUI loads and the PHI turns on its output power supplies.
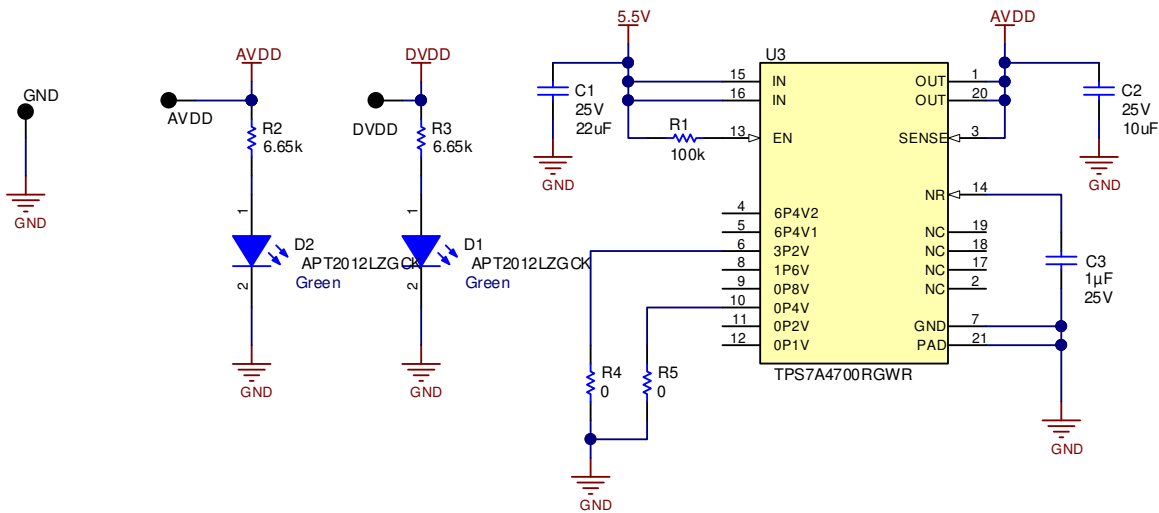
Figure 5-1. Power Supplies, Regulators, and Indicators

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6 ADS8688 Initial Setup

This section explains the initial hardware and software setup procedure that must be completed for properly operating the ADS8688EVM.

6.1 Software Installation

Download the latest version of the EVM GUI installer from the Tools and Software folder of the ADS8688EVM and run the GUI installer to install the EVM GUI software on your computer.

CAUTION

Manually disable any antivirus software running on the computer before downloading the EVM GUI installer onto the local hard disk. Depending on the antivirus settings, an error message may appear or the installer. The exe file can be deleted.

Accept the license agreements and follow the on-screen instructions shown in Figure 6-1 to complete the installation.
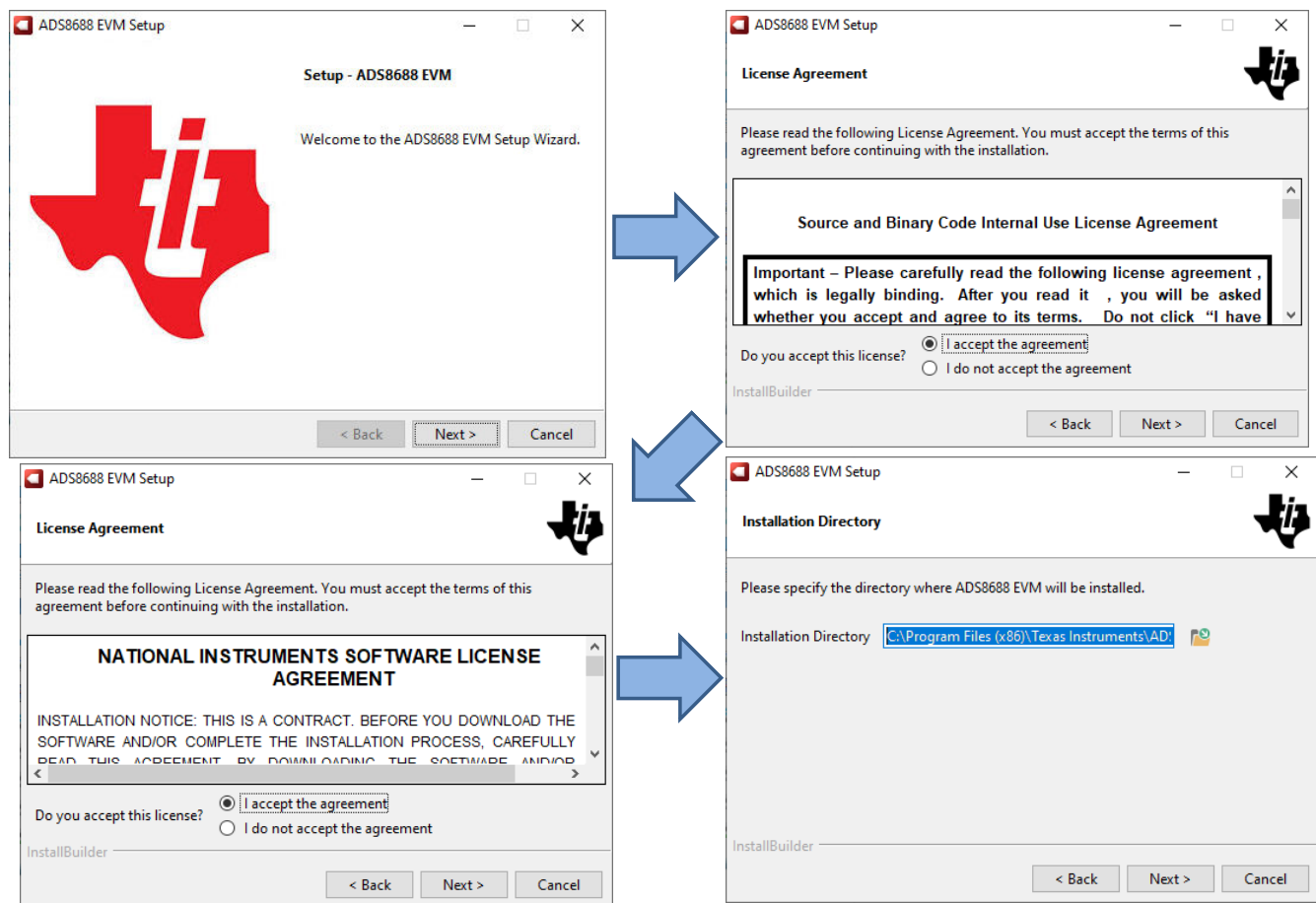
Figure 6-1. ADS8688 Software Installation Prompts

As a part of the ADS8688EVM GUI installation, a prompt with a Device Driver Installation (as shown in Figure 6-2) appears on the screen. Click Next to proceed.
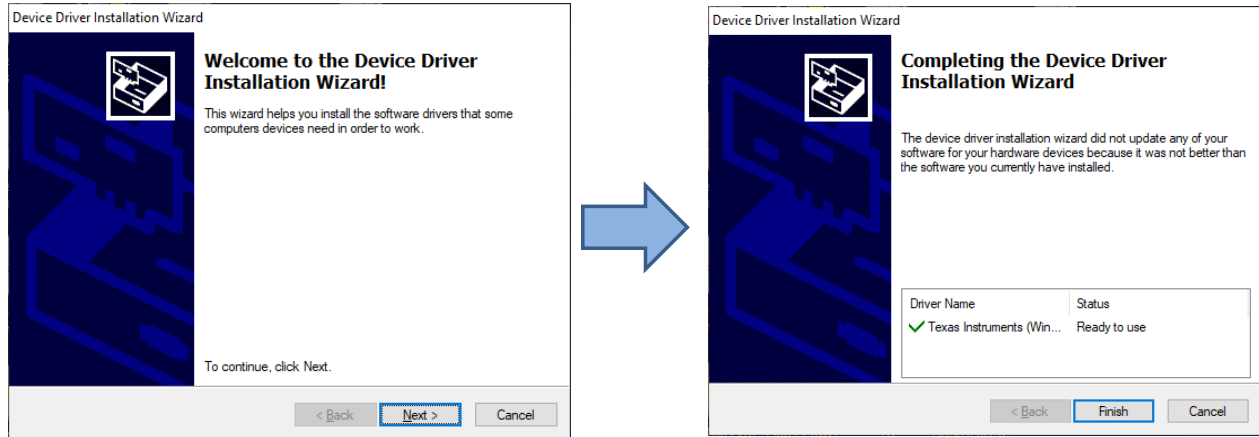
Figure 6-2. Device Driver Installation Wizard Prompts

The ADS8688EVM requires the LabVIEW™ run-time engine and may prompt for the installation of this software, as shown in Figure 6-3, if not already installed.
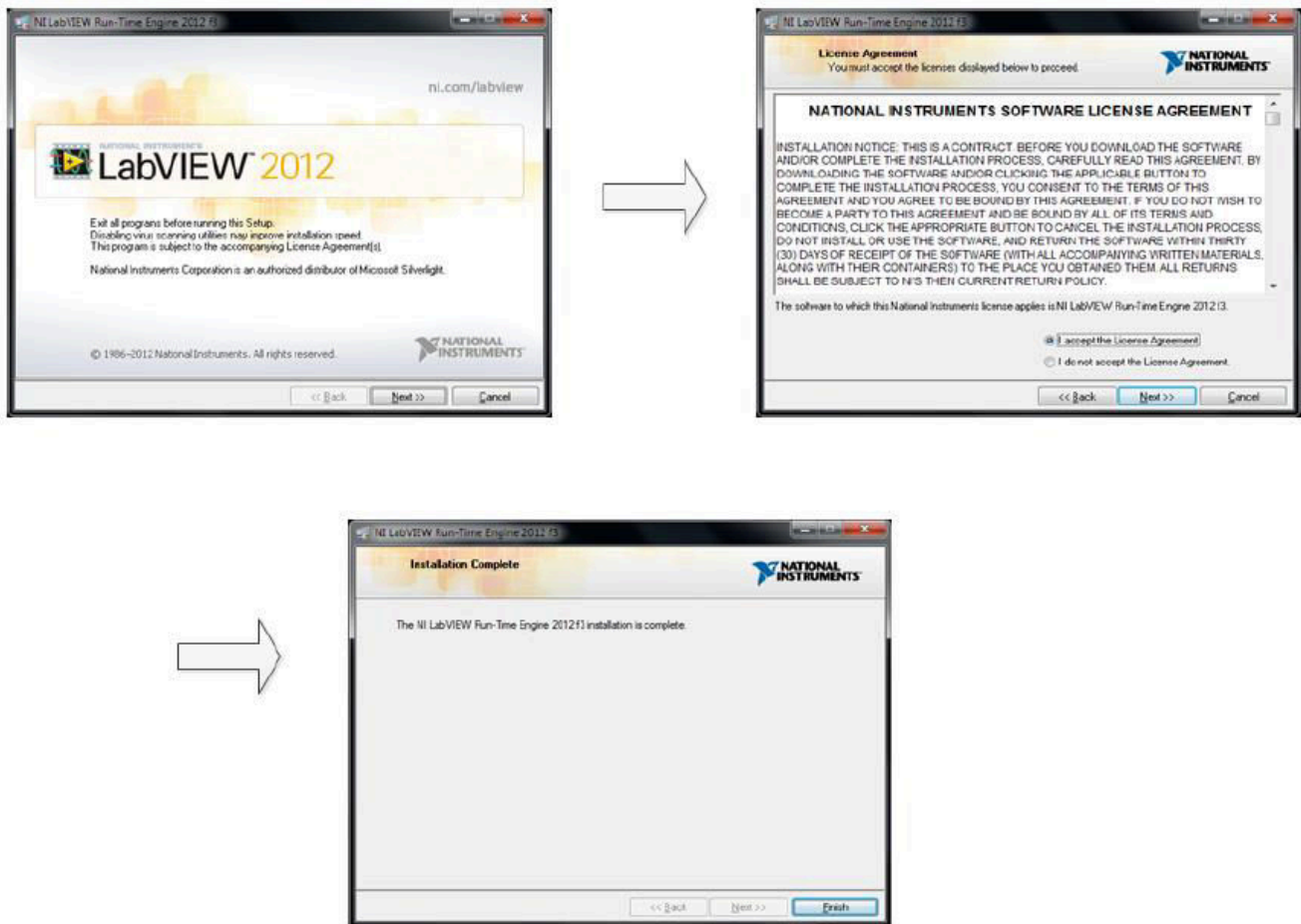
Figure 6-3. LabVIEW Run-Time Engine Installation

Verify that C:\Program Files (x86)\Texas Instruments\ADS8688EVM is as shown in Figure 6-4 after these installations.
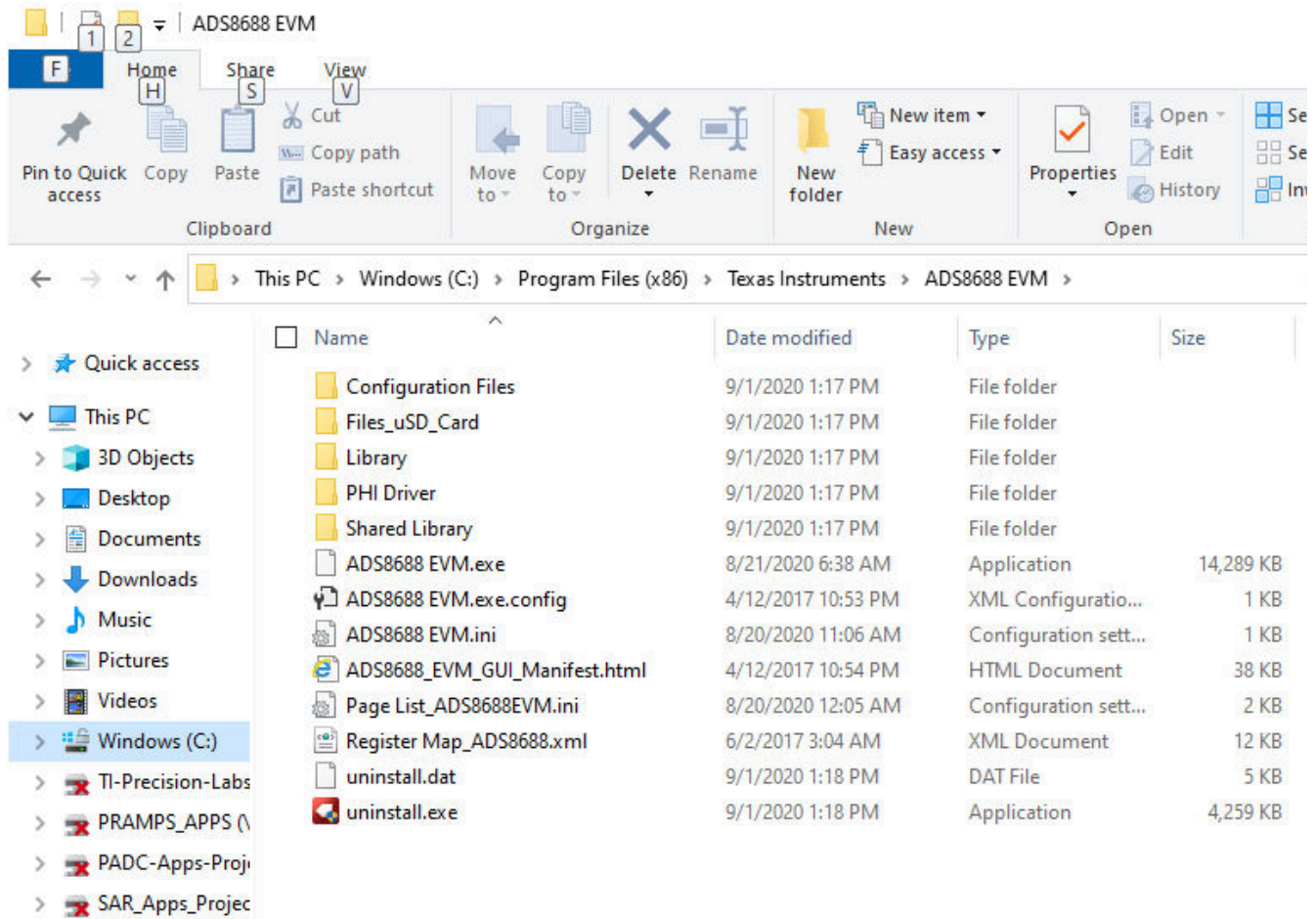
Figure 6-4. ADS8688EVM GUI Folder Post-Installation

7 EVM Operation

The following instructions are a step-by-step guide to connecting the ADS8688EVM to the computer and evaluating the performance of the ADS8688:

7.1 Connecting the Hardware

After installing the software connect the EVM as shown in Figure 7-1

1. Physically connect P2 of the PHI to J2 of the ADS8688EVM. Install the screws to assure a robust connection
2. Connect USB on PHI to the computer first
   - LED D5 on the PHI lights up, indicating that the PHI is powered up
   - LEDs D1 and D2 on the PHI start blinking to indicate that the PHI is booted up and communicating with the PC; Figure 7-1 shows the resulting LED indicators
3. Start the software GUI as shown in Figure 7-2. You will notice that the LEDs blink slowly as the FPGA firmware is loaded on the PHI. This will take a few seconds then the AVDD and DVDD power supplies will turn on.
4. Connect the signal generators to SMA inputs or headers (8 channels available). The input range is ±10.25V.
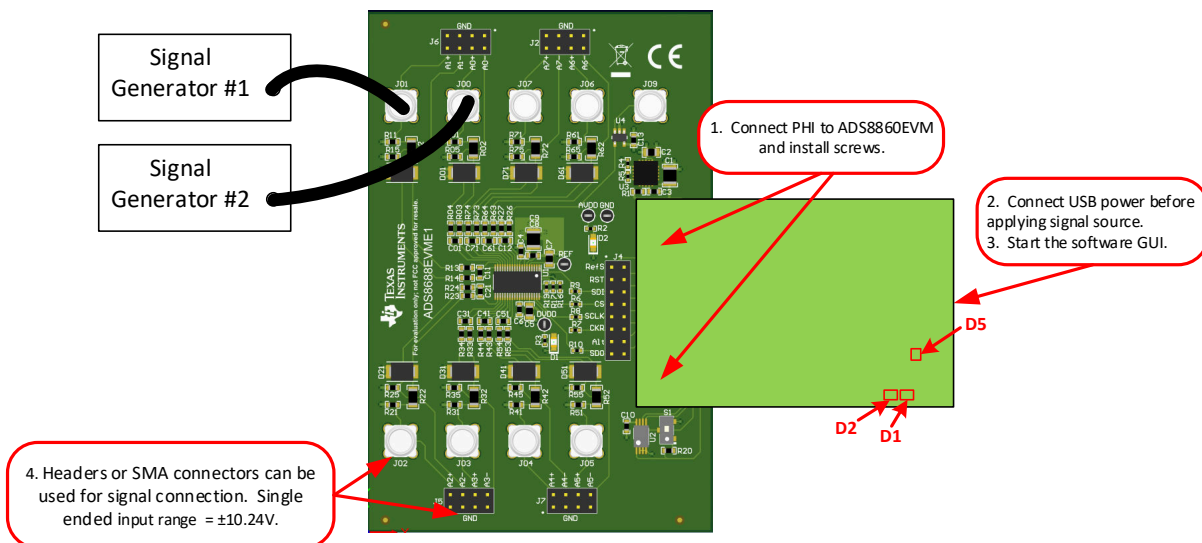
Figure 7-1. ADS8688EVM Hardware Setup and LED Indicators
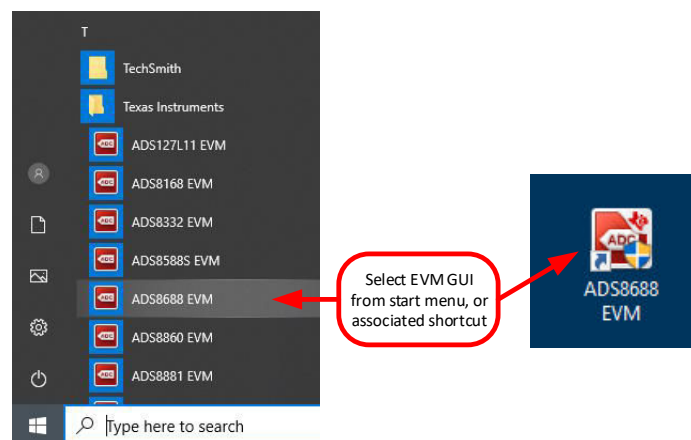
Figure 7-2. Launch the EVM GUI Software

7.2 Modifying Hardware and Using Software to Evaluate Other Devices in the Family

The ADS8688 is part of a family of related devices. This EVM hardware and software support the entire family because all the devices are pin-for-pin compatable. Table 7-1 lists other compatible devices in the family. The following procedure shows how to modify the hardware and software to evaluate the other devices in this family.

1. Desolder the ADS8688 and replace this device with the device you want to evaluate.
2. Enable the EEPROM for writing. This process is done by changing switch S2 to the top position using tweezers.Figure 7-3 details this process.
3. Connect the EVM and start the GUI as described in Section 7.1.
4. Use the *Tools* menu to *Load EEPROM* according to the device that is currently installed. When this procedure is successfully completed, you will see the status bar at the top of the software update according to the device installed on the hardware. For details, see Figure 7-4.

Table 7-1. Compatible Devices in the Family

Number of Channels	Resolution				
	12-Bit	14-Bit	16-Bit		18-Bit
4	ADS8664	ADS8674	ADS8684	ADS8684A	ADS8694
8	ADS8668	ADS8678	ADS8688	ADS8688A	ADS8698

Use tweezers to change position of switch S1 up as shown to allow the EEPROM write operation.
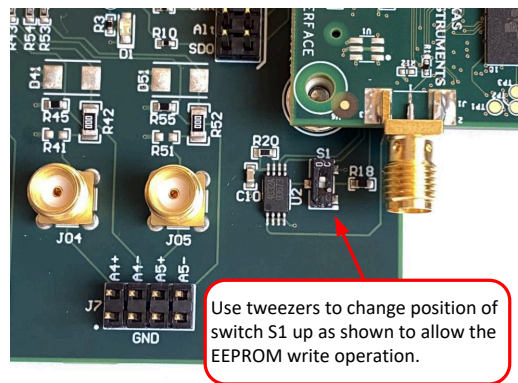
Figure 7-3. Enable EEPROM for Writing

1. On the "tools" menu select "Load EEPROM"

2. Under "Supported Devices" select the desired devices and press "Load EEPROM".

3. After pressing "load EEPROM" it will take a few minutes to load the EEPROM.

4. The top of the status bar on the software will indicate what the EVM connected has been updated to.
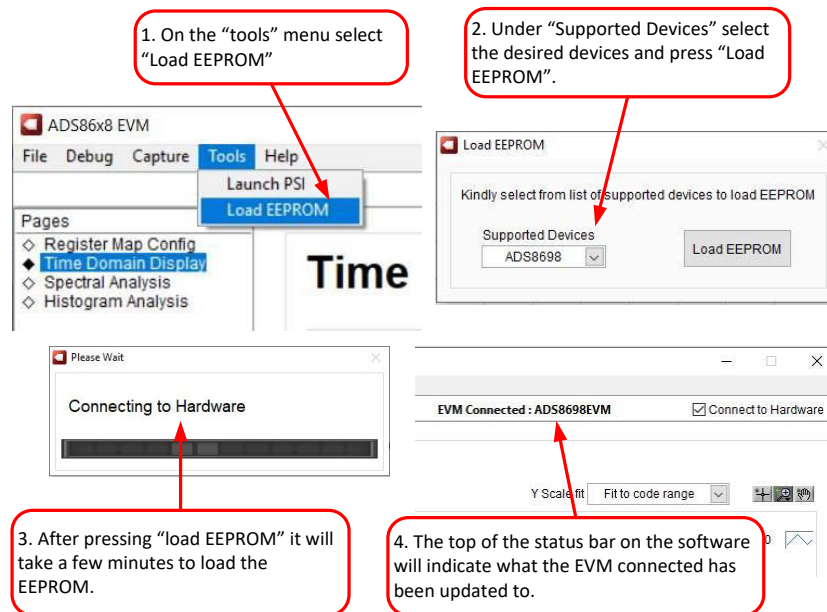
Figure 7-4. Configure EEPROM and Software for the New Device

7.3 EVM GUI Global Settings for ADC Control

Figure 7-5 shows that the EVM Global controls are located on the right hand side of the GUI. These controls choose the page display, SPI Mode, SCLK frequency, and sampling frequency.
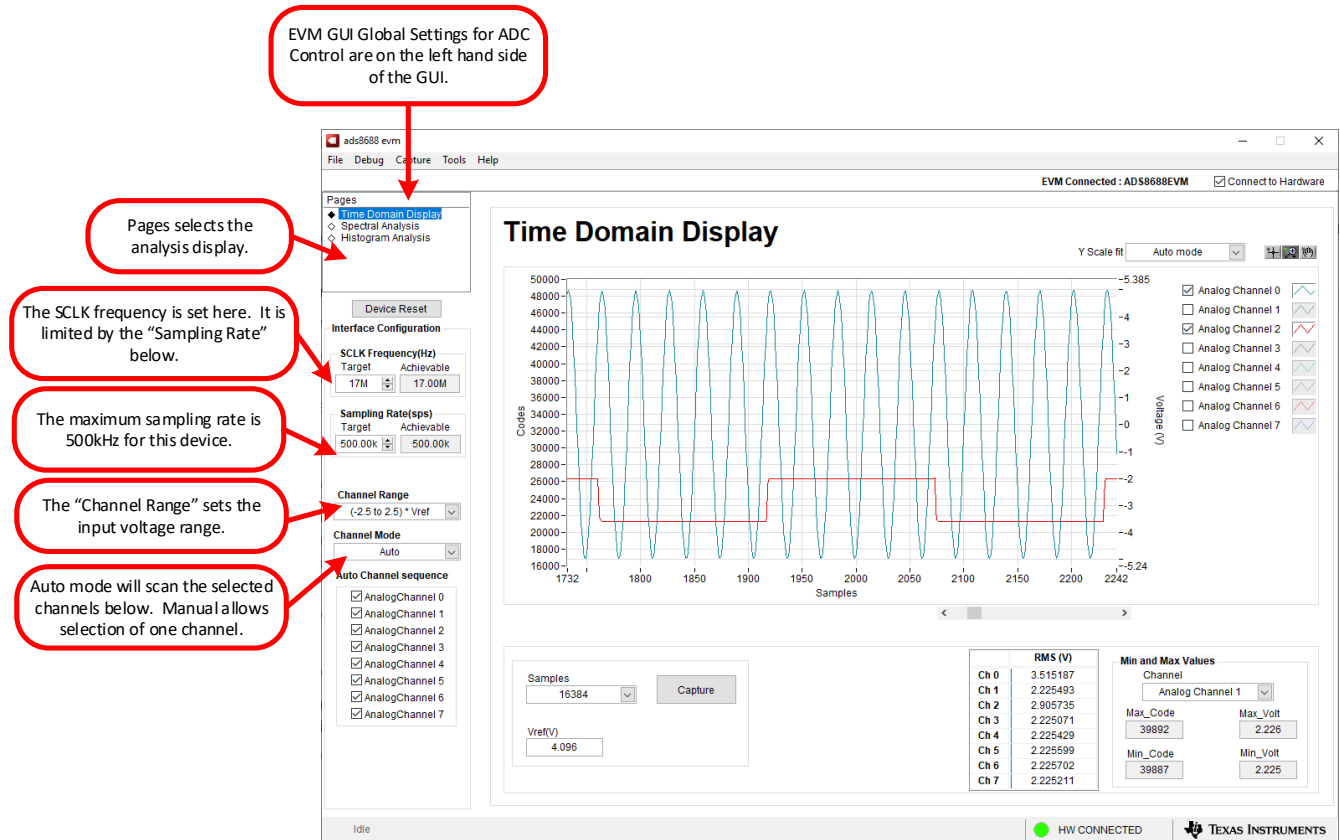
Figure 7-5. EVM GUI Global Input Controls

7.4 Time Domain Display

The time domain display tool allows visualization of the ADC response to a given input signal. This tool is useful for both studying the behavior and debugging any gross problems with the ADC or drive circuits. The user can trigger a capture of the data of the selected number of samples from the ADS8688EVM, as per the current interface mode settings indicated in Figure 7-6 by using the Capture button. The sample indices are on the x-axis and there are two y-axes showing the corresponding output codes as well as the equivalent analog voltages based on the specified reference voltage. Switching pages to any of the Analysis tools described in the subsequent sections causes calculations to be performed on the same set of data.
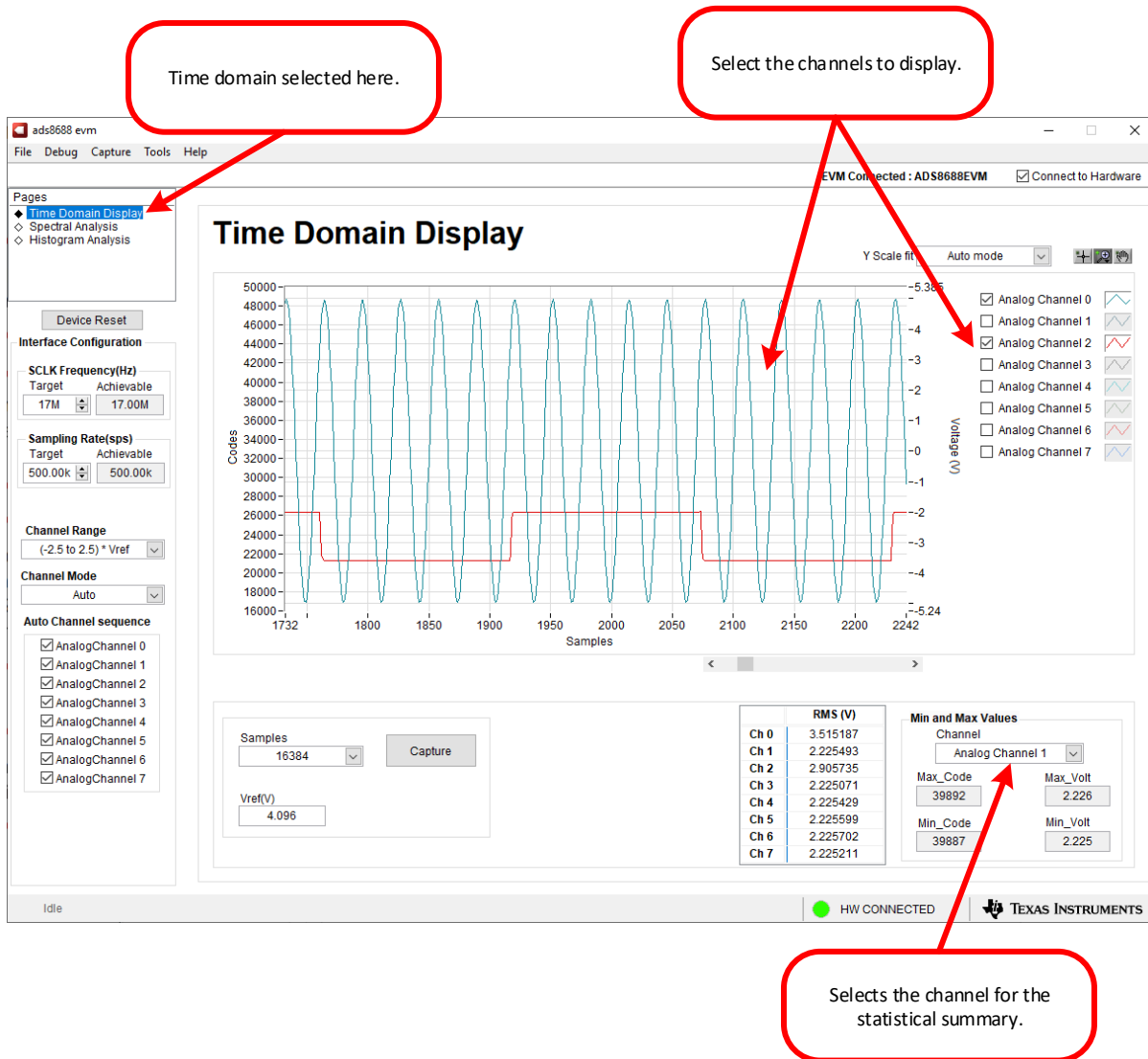
Figure 7-6. Time Domain Display Tool Options

7.5 Frequency Domain Display

The spectral analysis tool, shown in Figure 7-7, is intended to evaluate the dynamic performance (SNR, THD, SFDR, SINAD, and ENOB) of the ADS8688 ADC through single-tone sinusoidal signal FFT analysis using the 7-term Blackman-Harris window setting. The FFT tool includes windowing options that are required to mitigate the effects of non-coherent sampling (this discussion is beyond the scope of this document). The 7-Term Blackman Harris window is the default option and has sufficient dynamic range to resolve the frequency components of up to a 24-bit ADC. The None option corresponds to not using a window (or using a rectangular window) and is not recommended.
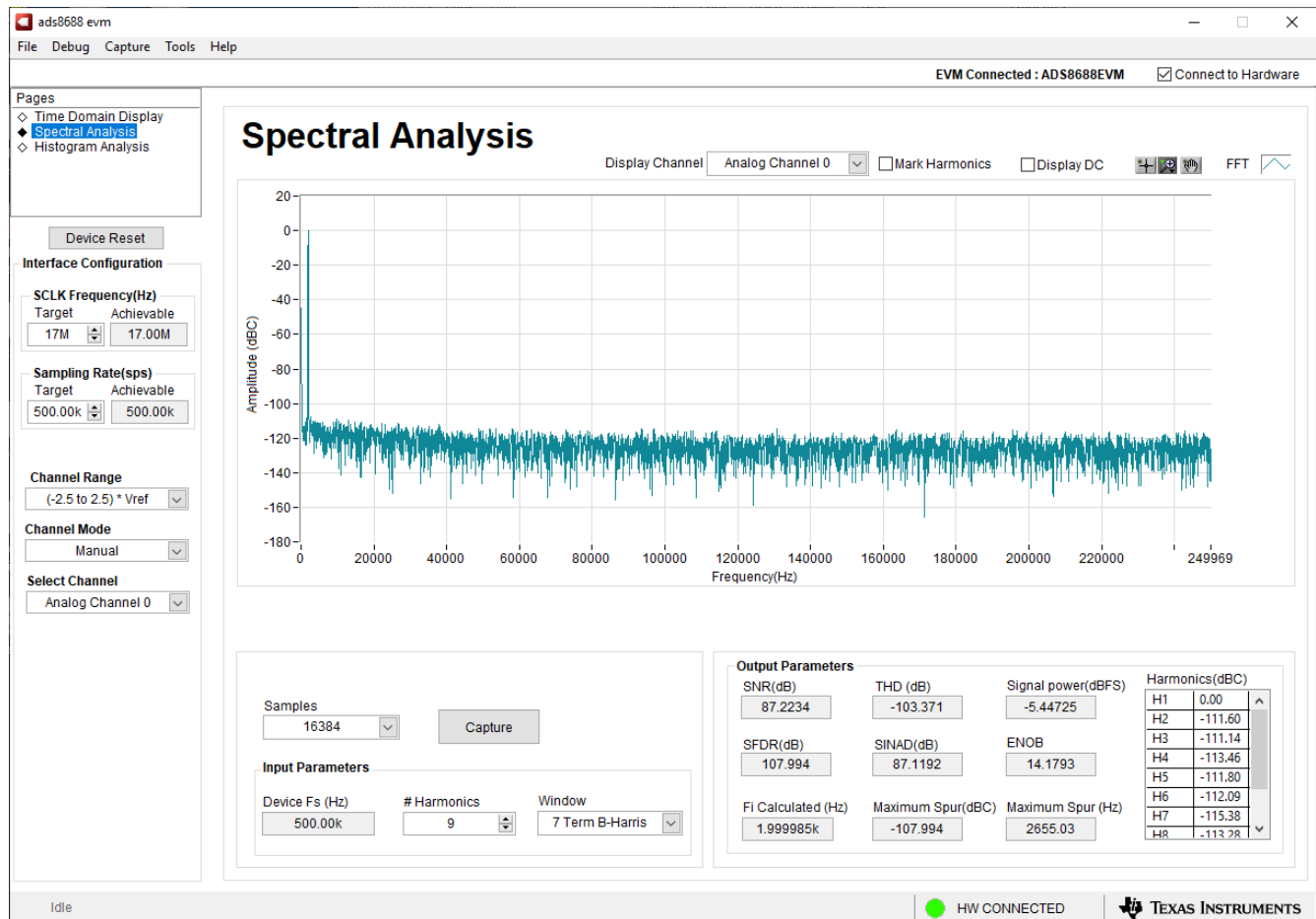
Figure 7-7. Spectral Analysis Tool

7.6 Histogram Display

Noise degrades ADC resolution and the histogram tool can be used to estimate effective resolution, which is an indicator of the number of bits of ADC resolution losses resulting from noise generated by the various sources connected to the ADC when measuring a DC signal. The cumulative effect of noise coupling to the ADC output from sources such as the input drive circuits, the reference drive circuit, the ADC power supply, and the ADC itself is reflected in the standard deviation of the ADC output code histogram that is obtained by performing multiple conversions of a DC input applied to a given channel. As shown in Figure 7-8, the histogram corresponding to a DC input is displayed on clicking the Capture button.
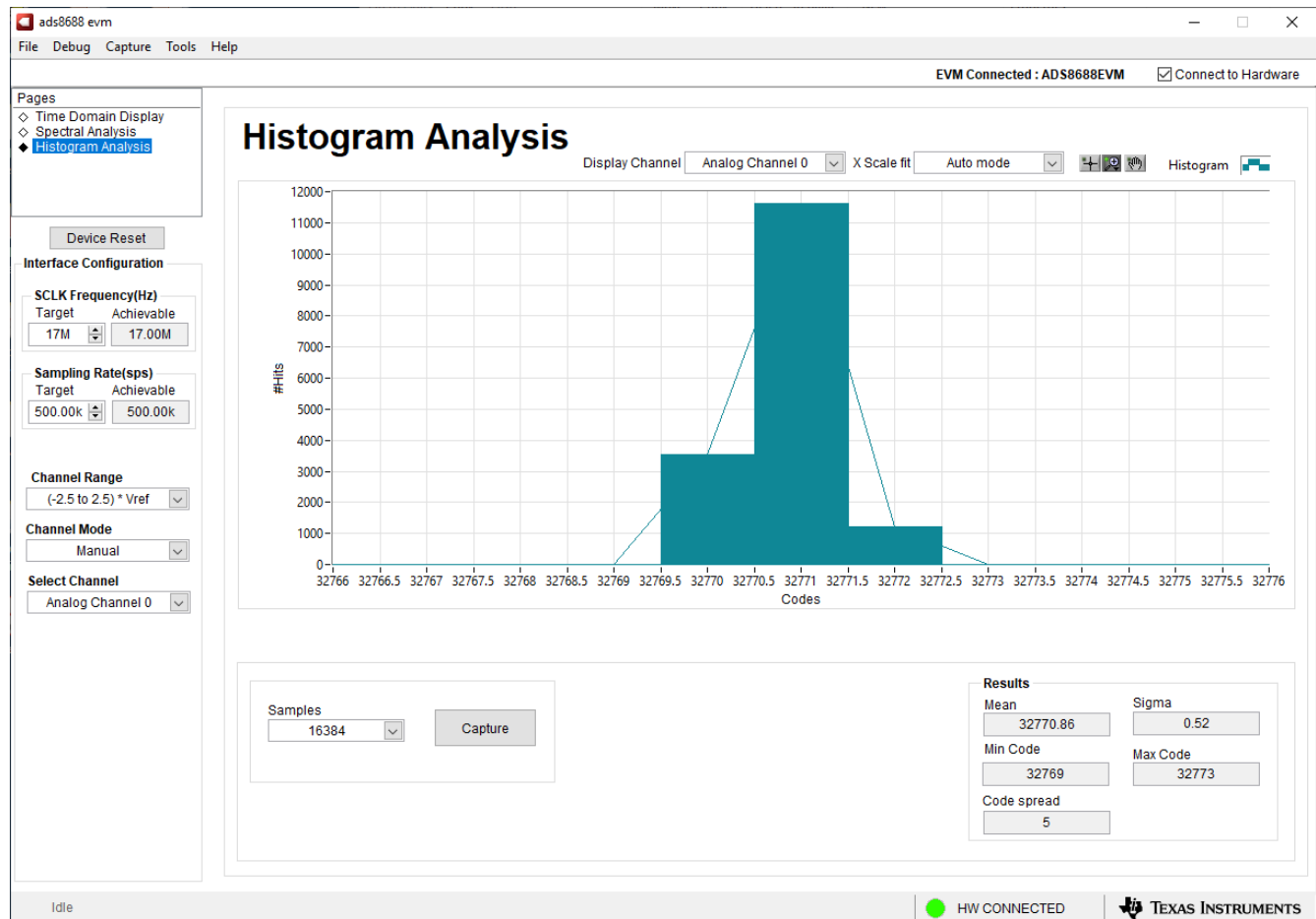
Figure 7-8. Histogram Analysis Tool

8 Bill of Materials, Schematics, and Layout

Schematics for the ADS8688EVM are appended to this user's guide. The bill of materials is provided in Table 8-1. Section 8.2 shows the PCB layouts for the ADS8688EVM.

8.1 Bill of Materials

Note

All components are 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 www.ti.com.)

Table 8-1. ADS8688EVM Bill of Materials

| Item #	Designator	Quantity	Value	Part Number	Manufacturer	Description	Package Reference
1	!PCB1	1		ADS8688EVM	Any	Printed Circuit Board	
2	C1, C9	2	22uF	GRM32ER71E226KE15L	MuRata	CAP, CERM, 22 uF, 25 V, +/- 10%, X7R, 1210	1210
3	C01, C11, C12, C21, C31, C41, C51, C61, C71	9	1000pF	GRM1885C1H102FA01J	MuRata	CAP, CERM, 1000 pF, 50 V, +/- 1%, C0G/NP0, 0603	0603
4	C2, C5, C7	3	10uF	CL21A106KAFN3NE	Samsung Electro-Mechanics	CAP, CERM, 10 uF, 25 V, +/- 10%, X5R, 0805	0805
5	C3, C4, C6, C8	4	1uF	C0603C105K3RACTU	Kemet	CAP, CERM, 1 uF, 25 V, +/- 10%, X7R, 0603	0603
6	C10, C13	2	0.1uF	GRM188R71H104KA93D	MuRata	CAP, CERM, 0.1 uF, 50 V, +/- 10%, X7R, 0603	0603
7	D1, D2	2	Green	APT2012LZGCK	Kingbright	LED, Green, SMD	LED_0805
8	H1, H2	2		RM3X4MM 2701	APM HEXSEAL	Machine Screw Pan PHILLIPS M3	
9	H3, H4, H5, H6	4		SJ-5303 (CLEAR)	3M	Bumpon, Hemisphere, 0.44 X 0.20, Clear	Transparent Bumpon
10	H7, H8	2		9774050360R	Wurth Elektronik	ROUND STANDOFF M3 STEEL 5MM	ROUND STANDOFF M3 STEEL 5MM
11	J00, J01, J02, J03, J04, J05, J06, J07, J09	9		5-1814832-1	TE Connectivity	SMA Straight PCB Socket Die Cast, 50 Ohm, TH	SMA Straight PCB Socket Die Cast, TH
12	J2, J5, J6, J7	4		TSW-104-07-G-D	Samtec	Header, 100mil, 4x2, Gold, TH	4x2 Header
13	J3	1		QTH-030-01-L-D-A-K-TR	Samtec	Header(Shrouded), 19.7mil, 30x2, Gold, SMT	Header (Shrouded), 19.7mil, 30x2, SMT
14	J4	1		TSW-108-07-G-D	Samtec	Header, 100mil, 8x2, Gold, TH	8x2 Header
15	R1	1	100k	CRCW0603100KFKEA	Vishay-Dale	RES, 100 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603
16	R2, R3	2	6.65k	CRCW04026K65FKED	Vishay-Dale	RES, 6.65 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402

Table 8-1. ADS8688EVM Bill of Materials (continued)

Item #	Designator	Quantity	Value	Part Number	Manufacturer	Description	Package Reference
17	R02, R12, R22, R32, R42, R52, R62, R72	8	0	ERJ-8GEY0R00V	Panasonic	RES, 0, 5%, 0.25 W, AEC-Q200 Grade 0, 1206	1206
18	R03, R04, R13, R14, R23, R24, R33, R34, R43, R44, R53, R54, R63, R64, R73, R74	16	1.00k	RG1608P-102-B-T5	Susumu Co Ltd	RES, 1.00 k, 0.1%, 0.1 W, 0603	0603
19	R4, R5	2	0	RC0402JR-070RL	Yageo America	RES, 0, 5%, 0.063 W, 0402	0402
20	R05, R15, R18, R25, R35, R45, R55, R65, R75	9	0	CRCW06030000Z0EA	Vishay-Dale	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603
21	R6, R7, R8, R9, R10	5	49.9	CRCW040249R9FKED	Vishay-Dale	RES, 49.9, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402
22	R16, R17, R19	3	47.0k	RC0402FR-0747KL	Yageo America	RES, 47.0 k, 1%, 0.0625 W, 0402	0402
23	R20	1	10.0k	RC0603FR-0710KL	Yageo	RES, 10.0 k, 1%, 0.1 W, 0603	0603
24	R26, R27	2	49.9	RC0603FR-0749R9L	Yageo	RES, 49.9, 1%, 0.1 W, 0603	0603
25	S1	1		CAS-120TA	Copal Electronics	Switch, Slide, SPDT 100mA, SMT	Switch, 5.4x2.5x2.5mm
26	TP1, TP2, TP3, TP4	4		5001	Keystone	Test Point, Miniature, Black, TH	Black Miniature Testpoint
27	U1	1		ADS8688IDBT	Texas Instruments	16-Bit, 500-kSPS, 8-Channel, Single-Supply, SAR ADCs with Bipolar Input Ranges, DBT0038A (TSSOP-38)	DBT0038A
28	U2	1		BR24G32FVT-3AGE2	Rohm	I2C BUS EEPROM (2-Wire), TSSOP-B8	TSSOP-8
29	U3	1		TPS7A4700RGWR	Texas Instruments	36V, 1A, 4.17µVRMS, RF Low-Dropout (LDO) Voltage Regulator, RGW0020A (VQFN-20)	RGW0020A
30	U4	1		OPA320AIDBVR	Texas Instruments	Precision, 20 MHz, 0.9 pA Ib, RRIO, CMOS Operational Amplifier, 1.8 to 5.5 V, -40 to 125 degC, 5-pin SOT23 (DBV5), Green (RoHS & no Sb/Br)	DBV0005A
31	D01, D11, D21, D31, D41, D51, D61, D71	0	14V	SMBJ14CA	Littelfuse	Diode, TVS, Bi, 14 V, SMB	SMB
32	FID1, FID2, FID3	0		N/A	N/A	Fiducial mark. There is nothing to buy or mount.	N/A
33	R01, R11, R21, R31, R41, R51, R61, R71	0	49.9k	CRCW060349K9FKEA	Vishay-Dale	RES, 49.9 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603

8.2 Board Layout

Figure 8-1 shows the PCB layout for the ADS8688EVM.

Note

The board layouts is not to scale. This figure is intended to show how the board is laid out and is not intended to be used for manufacturing ADS8688EVM PCBs.
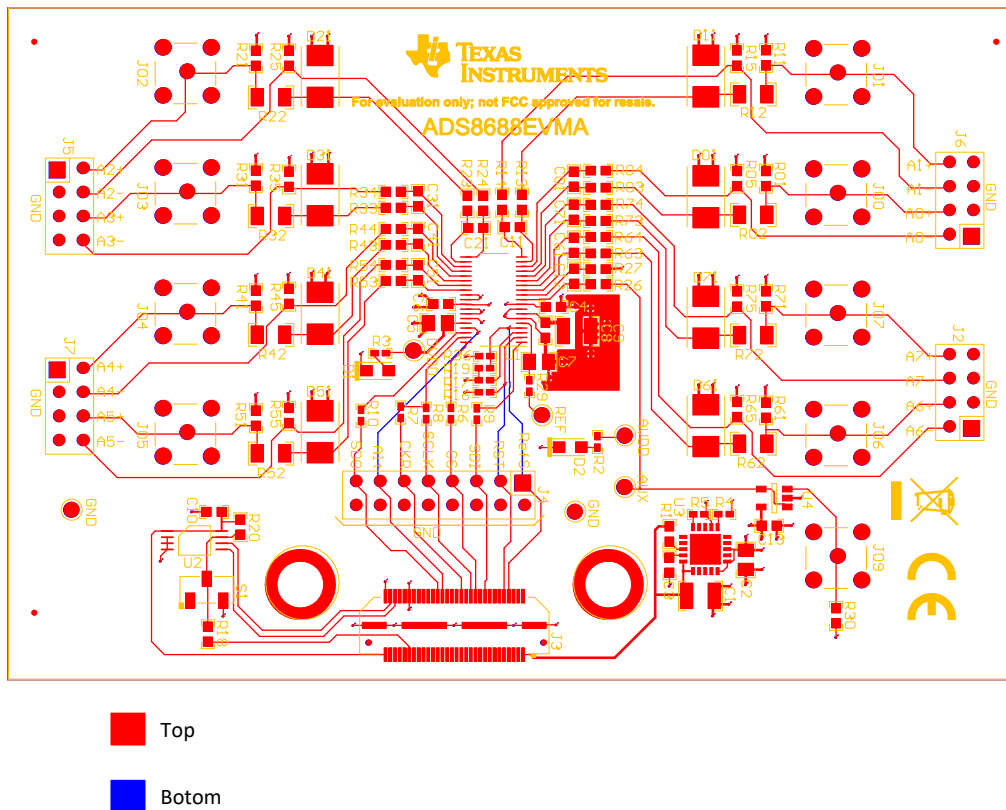

🟥 Top

🟦 Botom

Figure 8-1. ADS8688EVM PCB

8.3 Schematic

Figure 8-2 shows the input filter, terminal block, and SMA connections.

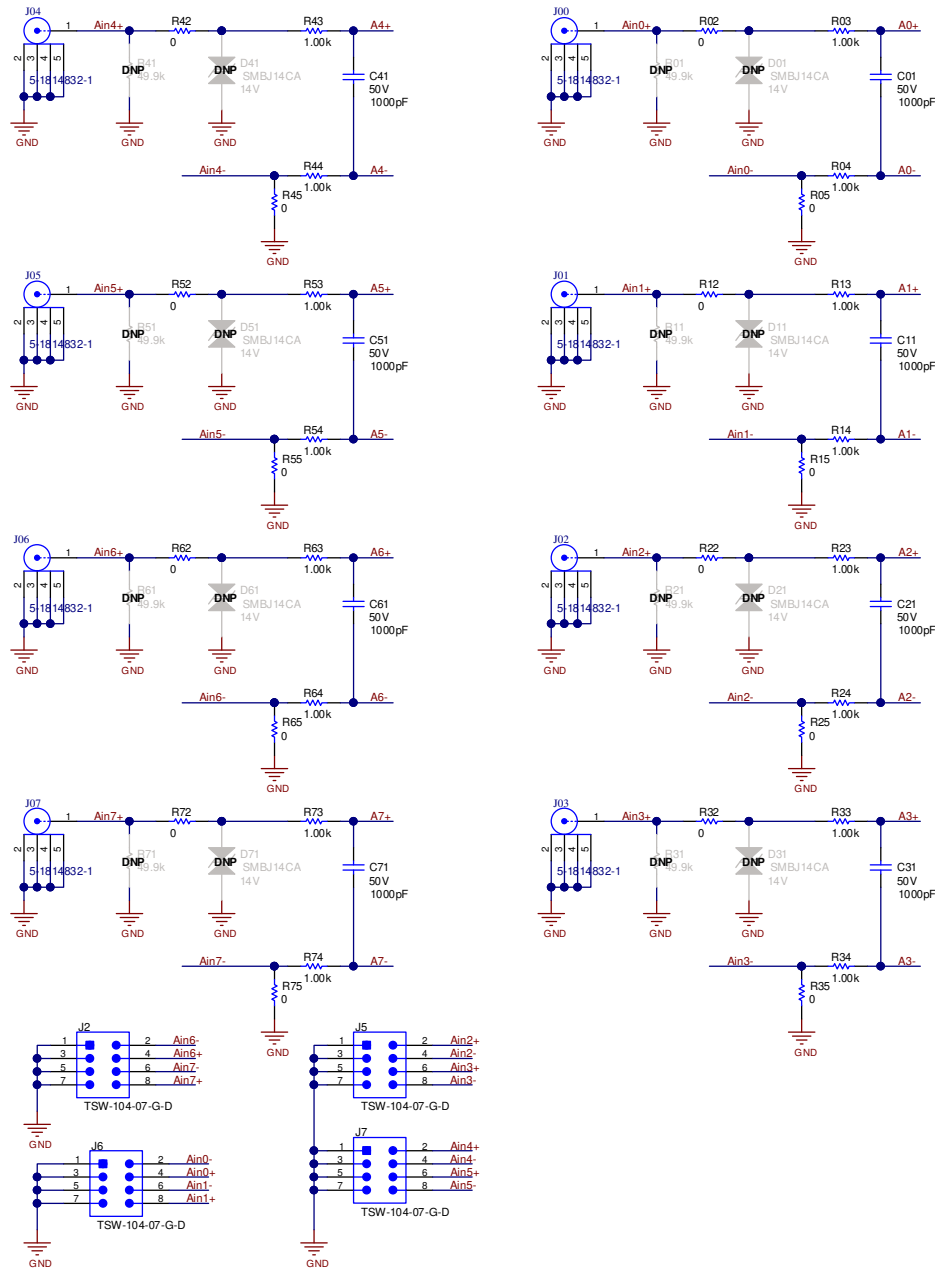

Figure 8-2. Input Filter
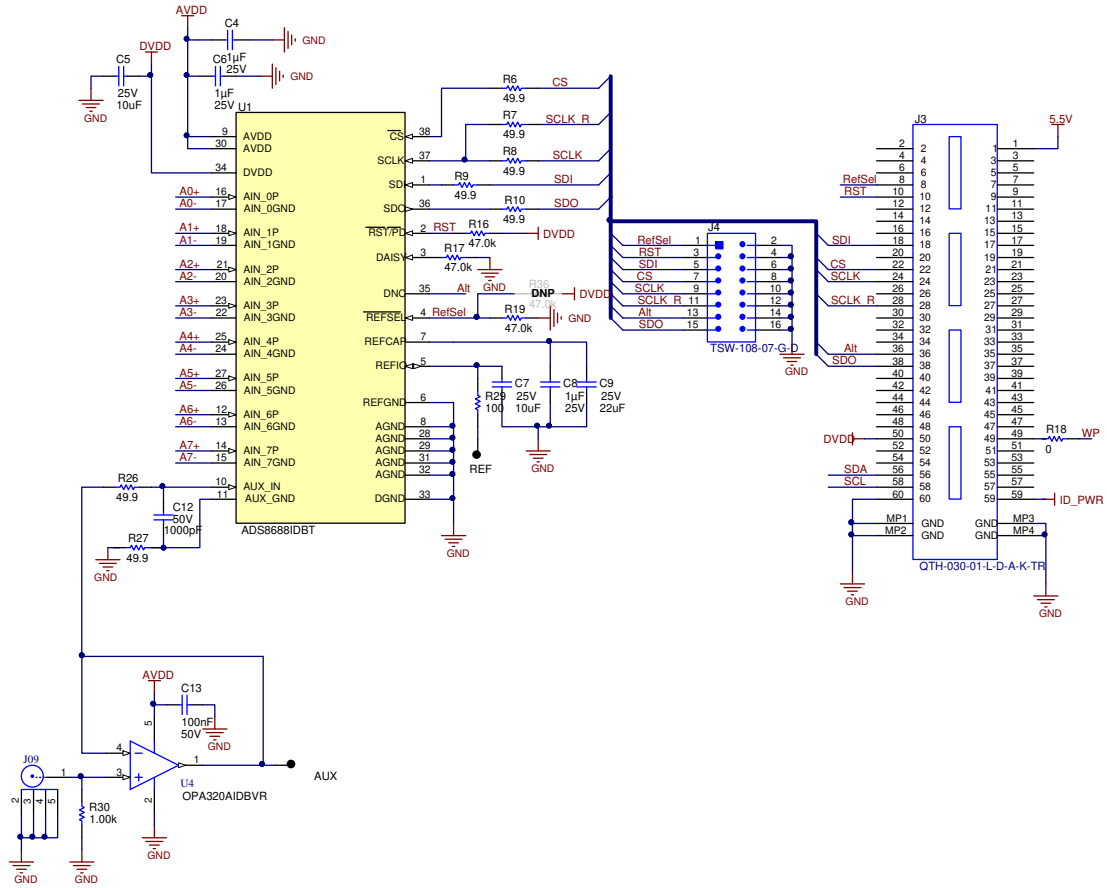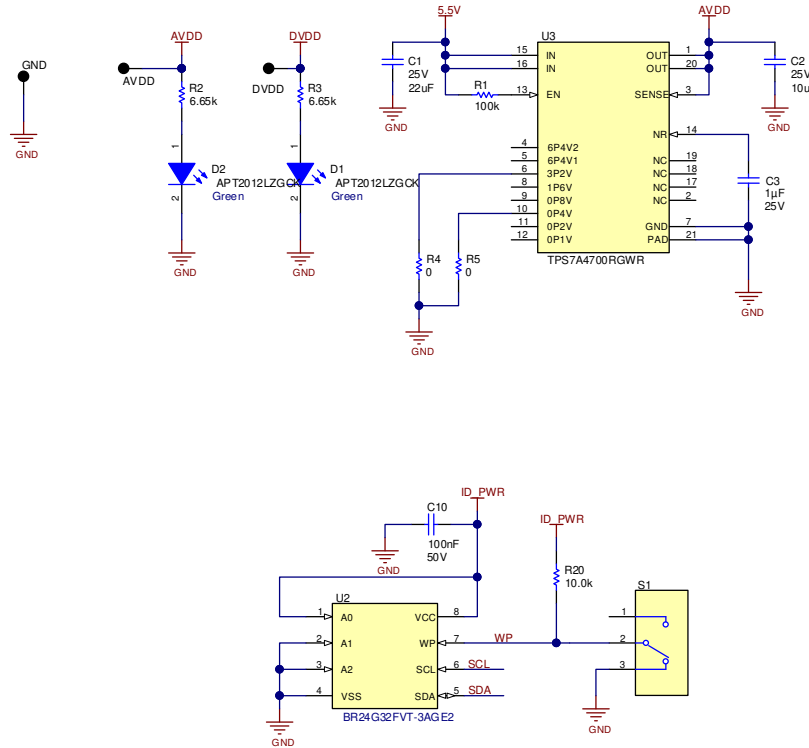
Figure 8-3 shows the input filter, terminal block, and SMA connections.

Figure 8-3. ADC and Digital Interface

Figure 8-4 shows power and EEPROM connections.

Figure 8-4. Power and EEPROM

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10 Revision History

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

STANDARD TERMS FOR EVALUATION MODULES

1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, and/or documentation which may be provided together or separately (collectively, an "EVM" or "EVMs") to the User ("User") in accordance with the terms set forth herein. User's acceptance of the EVM is expressly subject to the following terms.

    1.1 EVMs are intended solely for product or software developers for use in a research and development setting to facilitate feasibility evaluation, experimentation, or scientific analysis of TI semiconductors products. EVMs have no direct function and are not finished products. EVMs shall not be directly or indirectly assembled as a part or subassembly in any finished product. For clarification, any software or software tools provided with the EVM ("Software") shall not be subject to the terms and conditions set forth herein but rather shall be subject to the applicable terms that accompany such Software

    1.2 EVMs are not intended for consumer or household use. EVMs may not be sold, sublicensed, leased, rented, loaned, assigned, or otherwise distributed for commercial purposes by Users, in whole or in part, or used in any finished product or production system.

2 *Limited Warranty and Related Remedies/Disclaimers*:

    2.1 These terms do not apply to Software. The warranty, if any, for Software is covered in the applicable Software License Agreement.

    2.2 TI warrants that the TI EVM will conform to TI's published specifications for ninety (90) days after the date TI delivers such EVM to User. Notwithstanding the foregoing, TI shall not be liable for a nonconforming EVM if (a) the nonconformity was caused by neglect, misuse or mistreatment by an entity other than TI, including improper installation or testing, or for any EVMs that have been altered or modified in any way by an entity other than TI, (b) the nonconformity resulted from User's design, specifications or instructions for such EVMs or improper system design, or (c) User has not paid on time. Testing and other quality control techniques are used to the extent TI deems necessary. TI does not test all parameters of each EVM. User's claims against TI under this Section 2 are void if User fails to notify TI of any apparent defects in the EVMs within ten (10) business days after delivery, or of any hidden defects with ten (10) business days after the defect has been detected.

    2.3 TI's sole liability shall be at its option to repair or replace EVMs that fail to conform to the warranty set forth above, or credit User's account for such EVM. TI's liability under this warranty shall be limited to EVMs that are returned during the warranty period to the address designated by TI and that are determined by TI not to conform to such warranty. If TI elects to repair or replace such EVM, TI shall have a reasonable time to repair such EVM or provide replacements. Repaired EVMs shall be warranted for the remainder of the original warranty period. Replaced EVMs shall be warranted for a new full ninety (90) day warranty period.

WARNING

Evaluation Kits are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems.

User shall operate the Evaluation Kit within TI's recommended guidelines and any applicable legal or environmental requirements as well as reasonable and customary safeguards. Failure to set up and/or operate the Evaluation Kit within TI's recommended guidelines may result in personal injury or death or property damage. Proper set up entails following TI's instructions for electrical ratings of interface circuits such as input, output and electrical loads.

NOTE:
EXPOSURE TO ELECTROSTATIC DISCHARGE (ESD) MAY CAUSE DEGREDATION OR FAILURE OF THE EVALUATION KIT; TI RECOMMENDS STORAGE OF THE EVALUATION KIT IN A PROTECTIVE ESD BAG.

3 *Regulatory Notices:*

  3.1 *United States*

    3.1.1 *Notice applicable to EVMs not FCC-Approved:*

FCC NOTICE: This kit is designed to allow product developers to evaluate electronic components, circuitry, or software associated with the kit to determine whether to incorporate such items in a finished product and software developers to write software applications for use with the end product. This kit is not a finished product and when assembled may not be resold or otherwise marketed unless all required FCC equipment authorizations are first obtained. Operation is subject to the condition that this product not cause harmful interference to licensed radio stations and that this product accept harmful interference. Unless the assembled kit is designed to operate under part 15, part 18 or part 95 of this chapter, the operator of the kit must operate under the authority of an FCC license holder or must secure an experimental authorization under part 5 of this chapter.

    3.1.2 *For EVMs annotated as FCC – FEDERAL COMMUNICATIONS COMMISSION Part 15 Compliant:*

CAUTION

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

FCC Interference Statement for Class A EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

FCC Interference Statement for Class B EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- *Reorient or relocate the receiving antenna.*
- *Increase the separation between the equipment and receiver.*
- *Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.*
- *Consult the dealer or an experienced radio/TV technician for help.*

  3.2 *Canada*

    3.2.1 *For EVMs issued with an Industry Canada Certificate of Conformance to RSS-210 or RSS-247*

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-exempt RSSs. Operation is subject to the following two conditions:

(1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Concernant les EVMs avec appareils radio:

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes: (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Concerning EVMs Including Detachable Antennas:

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication. This radio transmitter has been approved by Industry Canada to operate with the antenna types listed in the user guide with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Concernant les EVMs avec antennes détachables

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante. Le présent émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés dans le manuel d'usage et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur

3.3 *Japan*

3.3.1 *Notice for EVMs delivered in Japan:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page 日本国内に輸入される評価用キット、ボードについては、次のところをご覧ください。
http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page

3.3.2 *Notice for Users of EVMs Considered "Radio Frequency Products" in Japan:* EVMs entering Japan may not be certified by TI as conforming to Technical Regulations of Radio Law of Japan.

If User uses EVMs in Japan, not certified to Technical Regulations of Radio Law of Japan, User is required to follow the instructions set forth by Radio Law of Japan, which includes, but is not limited to, the instructions below with respect to EVMs (which for the avoidance of doubt are stated strictly for convenience and should be verified by User):

1. Use EVMs in a shielded room or any other test facility as defined in the notification #173 issued by Ministry of Internal Affairs and Communications on March 28, 2006, based on Sub-section 1.1 of Article 6 of the Ministry's Rule for Enforcement of Radio Law of Japan,

2. Use EVMs only after User obtains the license of Test Radio Station as provided in Radio Law of Japan with respect to EVMs, or

3. Use of EVMs only after User obtains the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to EVMs. Also, do not transfer EVMs, unless User gives the same notice above to the transferee. Please note that if User does not follow the instructions above, User will be subject to penalties of Radio Law of Japan.

【無線電波を送信する製品の開発キットをお使いになる際の注意事項】 開発キットの中には技術基準適合証明を受けて

いないものがあります。 技術適合証明を受けていないもののご使用に際しては、電波法遵守のため、以下のいずれかの

措置を取っていただく必要がありますのでご注意ください。

1. 電波法施行規則第6条第1項第1号に基づく平成18年3月28日総務省告示第173号で定められた電波暗室等の試験設備でご使用いただく。
2. 実験局の免許を取得後ご使用いただく。
3. 技術基準適合証明を取得後ご使用いただく。

なお、本製品は、上記の「ご使用にあたっての注意」を譲渡先、移転先に通知しない限り、譲渡、移転できないものとします。

上記を遵守頂けない場合は、電波法の罰則が適用される可能性があることをご留意ください。 日本テキサス・イ

ンスツルメンツ株式会社

東京都新宿区西新宿６丁目２４番１号

西新宿三井ビル

3.3.3 *Notice for EVMs for Power Line Communication:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_02.page
電力線搬送波通信についての開発キットをお使いになる際の注意事項については、次のところをご覧ください。http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_02.page

3.4 *European Union*

3.4.1 *For EVMs subject to EU Directive 2014/30/EU (Electromagnetic Compatibility Directive)*:

This is a class A product intended for use in environments other than domestic environments that are connected to a low-voltage power-supply network that supplies buildings used for domestic purposes. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.

4   *EVM Use Restrictions and Warnings:*

4.1 EVMS ARE NOT FOR USE IN FUNCTIONAL SAFETY AND/OR SAFETY CRITICAL EVALUATIONS, INCLUDING BUT NOT LIMITED TO EVALUATIONS OF LIFE SUPPORT APPLICATIONS.

4.2 User must read and apply the user guide and other available documentation provided by TI regarding the EVM prior to handling or using the EVM, including without limitation any warning or restriction notices. The notices contain important safety information related to, for example, temperatures and voltages.

4.3 *Safety-Related Warnings and Restrictions:*

4.3.1 User shall operate the EVM within TI's recommended specifications and environmental considerations stated in the user guide, other available documentation provided by TI, and any other applicable requirements and employ reasonable and customary safeguards. Exceeding the specified performance ratings and specifications (including but not limited to input and output voltage, current, power, and environmental ranges) for the EVM may cause personal injury or death, or property damage. If there are questions concerning performance ratings and specifications, User should contact a TI field representative prior to connecting interface electronics including input power and intended loads. Any loads applied outside of the specified output range may also result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM user guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative. During normal operation, even with the inputs and outputs kept within the specified allowable ranges, some circuit components may have elevated case temperatures. These components include but are not limited to linear regulators, switching transistors, pass transistors, current sense resistors, and heat sinks, which can be identified using the information in the associated documentation. When working with the EVM, please be aware that the EVM may become very warm.

4.3.2 EVMs are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems. User assumes all responsibility and liability for proper and safe handling and use of the EVM by User or its employees, affiliates, contractors or designees. User assumes all responsibility and liability to ensure that any interfaces (electronic and/or mechanical) between the EVM and any human body are designed with suitable isolation and means to safely limit accessible leakage currents to minimize the risk of electrical shock hazard. User assumes all responsibility and liability for any improper or unsafe handling or use of the EVM by User or its employees, affiliates, contractors or designees.

4.4 User assumes all responsibility and liability to determine whether the EVM is subject to any applicable international, federal, state, or local laws and regulations related to User's handling and use of the EVM and, if applicable, User assumes all responsibility and liability for compliance in all respects with such laws and regulations. User assumes all responsibility and liability for proper disposal and recycling of the EVM consistent with all applicable international, federal, state, and local requirements.

5. *Accuracy of Information:* To the extent TI provides information on the availability and function of EVMs, TI attempts to be as accurate as possible. However, TI does not warrant the accuracy of EVM descriptions, EVM availability or other information on its websites as accurate, complete, reliable, current, or error-free.

6. *Disclaimers:*

6.1 EXCEPT AS SET FORTH ABOVE, EVMS AND ANY MATERIALS PROVIDED WITH THE EVM (INCLUDING, BUT NOT LIMITED TO, REFERENCE DESIGNS AND THE DESIGN OF THE EVM ITSELF) ARE PROVIDED "AS IS" AND "WITH ALL FAULTS." TI DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, REGARDING SUCH ITEMS, INCLUDING BUT NOT LIMITED TO ANY EPIDEMIC FAILURE WARRANTY OR IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF ANY THIRD PARTY PATENTS, COPYRIGHTS, TRADE SECRETS OR OTHER INTELLECTUAL PROPERTY RIGHTS.

6.2 EXCEPT FOR THE LIMITED RIGHT TO USE THE EVM SET FORTH HEREIN, NOTHING IN THESE TERMS SHALL BE CONSTRUED AS GRANTING OR CONFERRING ANY RIGHTS BY LICENSE, PATENT, OR ANY OTHER INDUSTRIAL OR INTELLECTUAL PROPERTY RIGHT OF TI, ITS SUPPLIERS/LICENSORS OR ANY OTHER THIRD PARTY, TO USE THE EVM IN ANY FINISHED END-USER OR READY-TO-USE FINAL PRODUCT, OR FOR ANY INVENTION, DISCOVERY OR IMPROVEMENT, REGARDLESS OF WHEN MADE, CONCEIVED OR ACQUIRED.

7. *USER'S INDEMNITY OBLIGATIONS AND REPRESENTATIONS.* USER WILL DEFEND, INDEMNIFY AND HOLD TI, ITS LICENSORS AND THEIR REPRESENTATIVES HARMLESS FROM AND AGAINST ANY AND ALL CLAIMS, DAMAGES, LOSSES, EXPENSES, COSTS AND LIABILITIES (COLLECTIVELY, "CLAIMS") ARISING OUT OF OR IN CONNECTION WITH ANY HANDLING OR USE OF THE EVM THAT IS NOT IN ACCORDANCE WITH THESE TERMS. THIS OBLIGATION SHALL APPLY WHETHER CLAIMS ARISE UNDER STATUTE, REGULATION, OR THE LAW OF TORT, CONTRACT OR ANY OTHER LEGAL THEORY, AND EVEN IF THE EVM FAILS TO PERFORM AS DESCRIBED OR EXPECTED.

8. *Limitations on Damages and Liability:*

    8.1 *General Limitations.* IN NO EVENT SHALL TI BE LIABLE FOR ANY SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL, OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF THESE TERMS OR THE USE OF THE EVMS , REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. EXCLUDED DAMAGES INCLUDE, BUT ARE NOT LIMITED TO, COST OF REMOVAL OR REINSTALLATION, ANCILLARY COSTS TO THE PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES, RETESTING, OUTSIDE COMPUTER TIME, LABOR COSTS, LOSS OF GOODWILL, LOSS OF PROFITS, LOSS OF SAVINGS, LOSS OF USE, LOSS OF DATA, OR BUSINESS INTERRUPTION. NO CLAIM, SUIT OR ACTION SHALL BE BROUGHT AGAINST TI MORE THAN TWELVE (12) MONTHS AFTER THE EVENT THAT GAVE RISE TO THE CAUSE OF ACTION HAS OCCURRED.

    8.2 *Specific Limitations.* IN NO EVENT SHALL TI'S AGGREGATE LIABILITY FROM ANY USE OF AN EVM PROVIDED HEREUNDER, INCLUDING FROM ANY WARRANTY, INDEMITY OR OTHER OBLIGATION ARISING OUT OF OR IN CONNECTION WITH THESE TERMS, , EXCEED THE TOTAL AMOUNT PAID TO TI BY USER FOR THE PARTICULAR EVM(S) AT ISSUE DURING THE PRIOR TWELVE (12) MONTHS WITH RESPECT TO WHICH LOSSES OR DAMAGES ARE CLAIMED. THE EXISTENCE OF MORE THAN ONE CLAIM SHALL NOT ENLARGE OR EXTEND THIS LIMIT.

9. *Return Policy.* Except as otherwise provided, TI does not offer any refunds, returns, or exchanges. Furthermore, no return of EVM(s) will be accepted if the package has been opened and no return of the EVM(s) will be accepted if they are damaged or otherwise not in a resalable condition. If User feels it has been incorrectly charged for the EVM(s) it ordered or that delivery violates the applicable order, User should contact TI. All refunds will be made in full within thirty (30) working days from the return of the components(s), excluding any postage or packaging costs.

10. *Governing Law:* These terms and conditions shall be governed by and interpreted in accordance with the laws of the State of Texas, without reference to conflict-of-laws principles. User agrees that non-exclusive jurisdiction for any dispute arising out of or relating to these terms and conditions lies within courts located in the State of Texas and consents to venue in Dallas County, Texas. Notwithstanding the foregoing, any judgment may be enforced in any United States or foreign court, and TI may seek injunctive relief in any United States or foreign court.