ADS9212 Evaluation Module

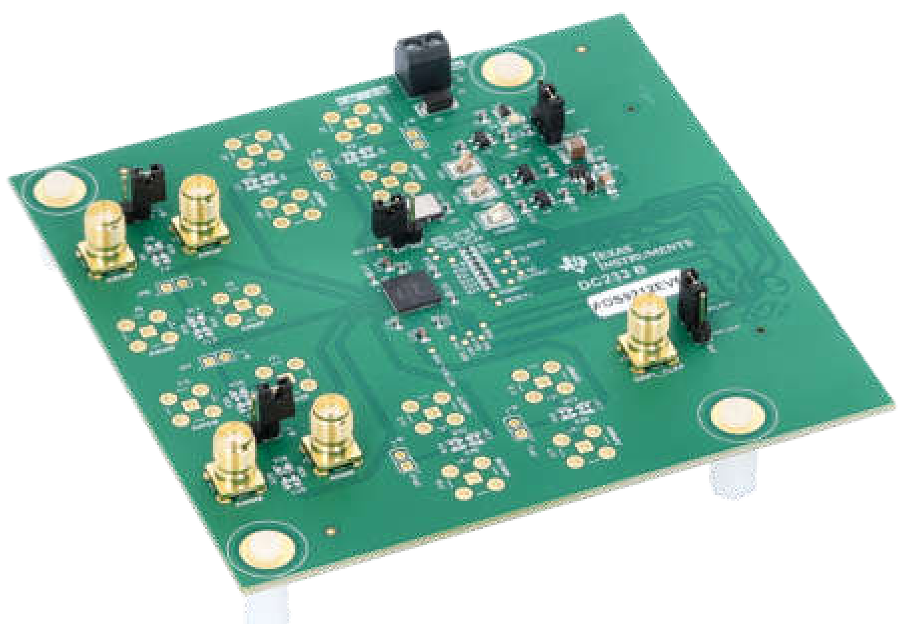
Description

The ADS9212EVM is a platform for evaluating the performance of the ADS9212 dual channel, simultaneous-sampling SAR ADC, which includes a PGA front-end to support input voltages of ±12 V, ±10 V, ±7 V, ±5 V, ±3.5 V, and ±2.5 V, in single-ended and differential configurations. The ADC core supports 18-bit resolution at 8-MSPS/channel.

The ADS9212EVM includes a standard FMC connector on the back of the PCB. The FMC connector can be used to mate with standard FPGA kits, including the TSWDC155EVM (sold separately). The TSWDC155EVM is a digital controller board that is necessary for the included EVM software GUI to communicate with the device and commute and graph measured results.

Features

- ADS9212EVM has the hardware required for diagnostic testing and accurate performance evaluation of the ADS9212 ADC.
- The TSWDC155EVM controller (sold separately) provides all necessary digital I/O signals and power rails required for operating the ADS9212EVM.
- Easy-to-use evaluation GUI for Microsoft® Windows® 10, 64-bit operating systems requires the TSWDC155EVM (sold separately) for operation.
- The included software suite features graphical tools for data capture, histogram analysis, spectral analysis, and linearity measurements.



ADS9212EVM

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1 Evaluation Module Overview

1.1 Introduction

This is an evaluation module (EVM) for the ADS9212, a 2-channel, 18-bit, 8-MSPS per channel, successive approximation register (SAR) analog-to-digital converters (ADC). The EVMs ease the evaluation of the ADS9212 device with hardware, software, and computer connectivity through the universal serial bus (USB) interface. This user's guide includes complete circuit descriptions, schematic diagrams, and a bill of materials (BOM).

1.2 Kit Contents

This kit consists of the ADS9212EVM and the ADS9212EVM-GUI software. The ADS9212EVM includes a standard FMC connector on the bottom of the PCB, which can be used to mate with standard FPGA kits. However, to use the GUI (graphical user interface) software, the ADS9212EVM must be used in conjunction with the TSWDC155EVM controller (sold separately).

1.3 Specification

The connections and basic subsystems of the ADS9212EVM are shown in Figure 1-2.

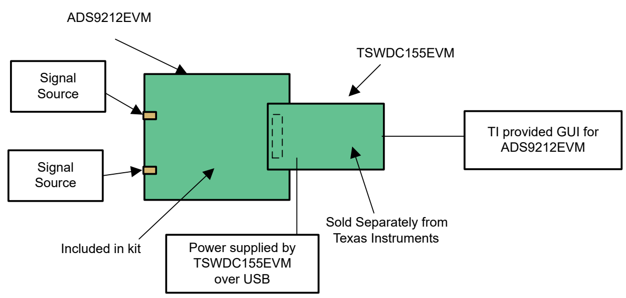

Figure 1-1. System Using GUI and TSWDC155EVM

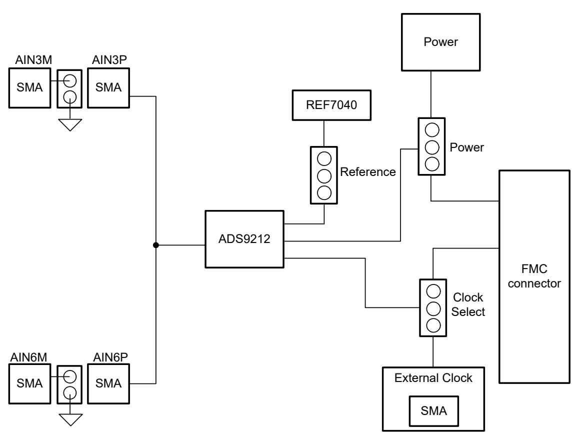

Figure 1-2. ADS9212EVM Block Diagram

1.4 Device Information

The ADS9212 SAR dual simultaneous-sampling ADC has an 18-bit resolution and samples at 8MSPS per channel. The ADS9212 features a complete analog front-end for each channel with an input clamp, 1MΩ input impedance, independently programmable gain amplifier (PGA), programmable low-pass filter, and an ADC input driver. The device also features a low-drift, precision reference with a buffer to drive the ADCs. A high-speed digital interface supporting 1.2V to 1.8V operation enables the ADS9212 to be used with high-speed interfaces. The device can be configured to accept ±12V, ±10V, ±7V, ±5V, ±3.5V, and ±2.5V bipolar inputs. The high input impedance allows direct connection with sensors and transformers, thus eliminating the need for external driver circuits. The high performance and accuracy, along with zero-latency conversions offered by this device make the ADS9212 an excellent choice for multiple industrial applications.

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2 Hardware

2.1 ADS9212EVM Quick Start Guide

The following instructions are a step-by-step guide to connecting the ADS9212EVM to the computer and evaluating the performance of the ADS9212.

1. Review the default jumper settings in Figure 2-1 below and the power guidelines in Section 2.2.1.
2. Physically connect J1 of the TSWDC155EVM to J19 of the ADS9212EVM. This component is the digital communications and power signal connection in default configuration.
3. Set jumper JP4 to the FMC_PWR position so the TSWDC155EVM provides power. Otherwise, set JP4 to EXT_PWR and connect an external 5.2V to 5.5V supply on screw terminal connection J1.
4. Bypass any external USB hub and connect the USB on the TSWDC155EVM directly to the computer.

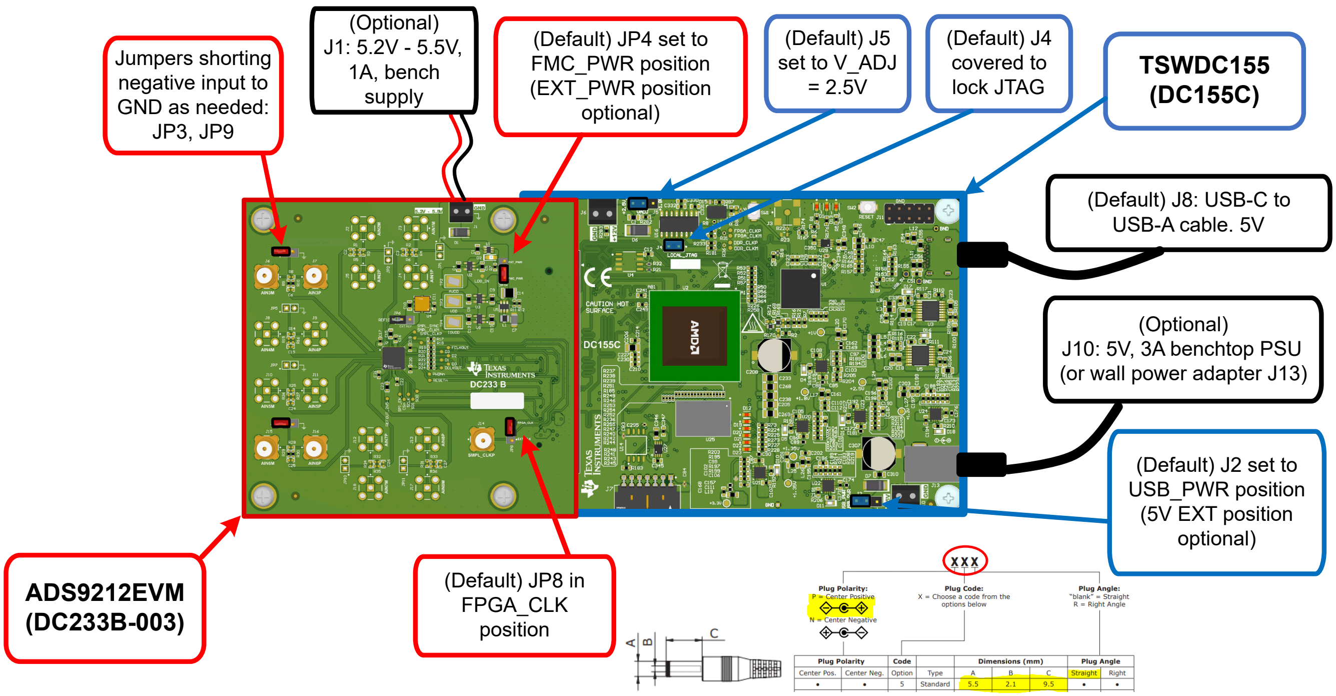

Figure 2-1. Connecting the Hardware

1. Install the GUI as described in Section 3.1.
2. Install the necessary USB drivers as described in Section 3.2.
3. Launch the GUI.
4. Press the *Initialize USB*, *Power Up*, *Program FPGA*, and *Initialize ADS92xx* buttons, in order from top to bottom, on the *CONFIG* tab to power up and configure the EVM, (see Section 3.3 for details).
5. Connect a $10V_{PP}$, single-ended sine wave signal from a function generator to any AINxP SMA input connector.
6. On the *Capture* tab, select the number of samples to be at least 32k points, and choose the Hanning window type for best frequency domain results.
7. Press the *Start Capture* button to collect and analyze the data displayed on the appropriate CHx tab; see Figure 3-6.

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2.2 Power Supplies

By default, the TSWDC155EVM provides the ADS9212EVM with a 3.3V supply (*3P3V*). The ADS9212EVM has a TPS61070 boost converter that boosts the 3.3V supply to 5.4V. By default, this voltage is applied to low-dropout regulators (LDOs) to derive the AVDD_5V, VDD_1V8, and IOVDD supplies when JP4 is in the [1-2] position. U2 (TPS7A2050) provides the 5V AVDD supply and U3 and U6 (TPS7A2018) provide the 1.8V DVDD and IOVDD supplies, respectively. The LDO input voltage (TP1) can be changed to an external source (5.2V to 5.5V) applied to terminal block J1 by placing a shunt on JP4 in the [2-3] position. In this case U1 (LM66100), provides reverse polarity protection if the connection is wired incorrectly. The power tree schematic for the ADS9212EVM is shown in Figure 2-2.

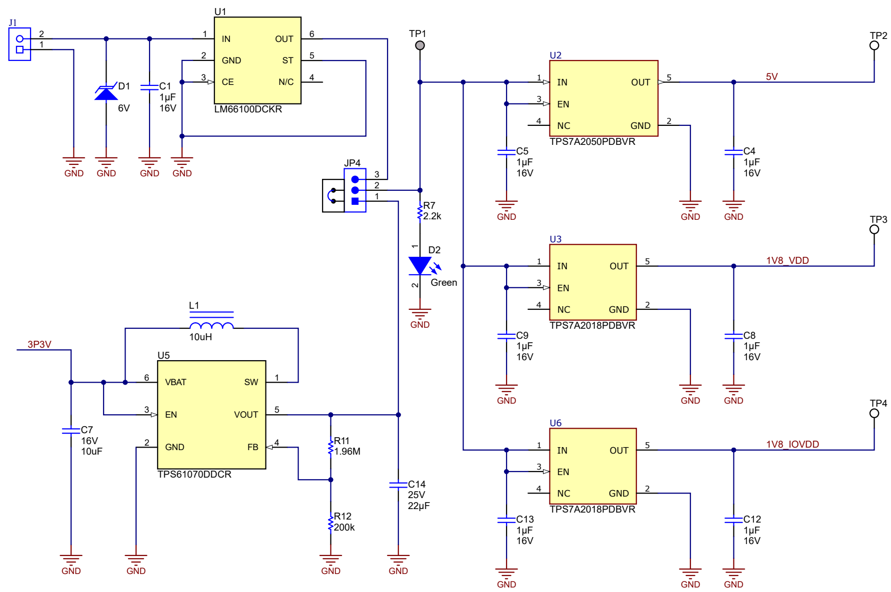

Figure 2-2. Power Entry and Regulators

2.2.1 USB Power and When to Power the Board Externally

The USB-C® connector is able to provide power to the TSWDC155EVM and ADS9212EVM using the default configuration, as discussed in Section 2.1. The combined peak current consumption reaches 600mA (typical) during the ADC conversion process and 520mA RMS (typical) after the ADS9212EVM is initialized in the GUI, as described in Section 3.3.

The TWDC155EVM is a high-power SuperSpeed (USB 3.0) device. This means a PC supplies up to 900mA from a compliant USB 3.0 port. However, many PC USB port configurations allow much less than this limit depending on the unit load handshake process, usually resulting from other devices on the bus. Tripping the current limit on a USB can result in cutting power to the USB port, excessive power dissipation or heating, depending on the PC port configuration. As a result, TI highly recommends to consider switching to an externally powered ADS9212EVM or TSWDC155EVM if:

- Only USB 1.0 or USB 2.0 ports are available.
- There are multiple devices connected to the PC by USB at the same time.
- The USB 3.0 port configuration for the PC is unknown.

To switch to the external power configuration on the ADS9212EVM, move the jumper on JP4 to the EXT_PWR position and use the J1 terminal block to provide the required 5.2V to 5.5V supply. To switch to the external power configuration on TSWDC155EVM, move the jumper on J2 to the 5V (external) position and use the J10 terminal block or barrel jack connector to provide the required 5V supply.

USB hubs can cause possible device enumeration issues and are not recommended when communicating through the TSWDC155EVM.

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2.3 Analog Interface

This section details the analog input connections to the ADS9212EVM.

2.3.1 ADC Input SMA Connections

Each ADC channel is connected to two SMA input connectors. The AIN3P and AIN3M SMA connecters (J7 and J6) correspond to CHA on the GUI software. The AIN6P and AIN6M SMA connecters (J16 and J15) correspond to CHB on the GUI software.

0402 footprints are provided to add a first-order, low-pass filter network on all ADC channels. By default, the filter capacitors are uninstalled and the filter resistors are populated with 0 ohms. Use NP0/C0G type capacitors and low-tolerance resistors to maintain AC performance when choosing to populate these footprints with a low-pass filter circuit.

Additionally, the ADC negative input connectors (for example, AIN3M) have the option to be shorted to GND with a jumper to allow for single-ended input signals. The input connections are shown in Figure 2-3.

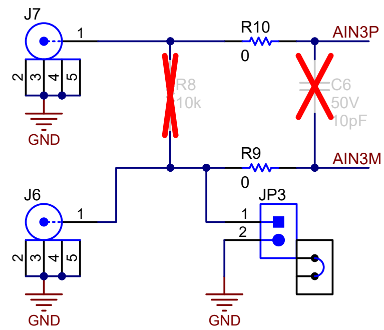

Figure 2-3. Input SMA Connections

2.3.2 Voltage Reference

The ADS9212 uses an internal 4.096V reference voltage, which can be measured on the REFIO pin when configured as an output (default). For applications which require improved drift performance, configure the REFIO pin as an input and apply an external reference voltage to the pin.

The ADS9212EVM includes a provision for evaluating the REF7040 reference IC. The REF70xx family of high precision series voltage references offers the industry's lowest noise (0.23ppm_{p-p}), very low temperature drift coefficient (2ppm/°C), and high accuracy (±0.025%). In addition, these precision reference devices feature high PSRR, low drop-out voltage and excellent load and line regulation to help meet strict transient requirements. The REF7040 on the EVM is the 4.096V output voltage option. To connect the REF7040 (U4) to the ADS9212, configure the REFIO pin as an input via the GUI and then install a shunt on jumper JP6.

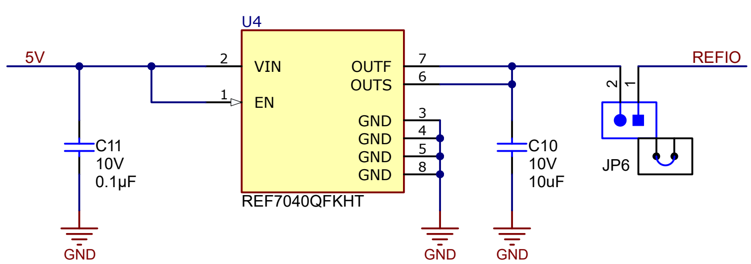

Figure 2-4. REF7040

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2.4 Digital Interface Connections

The ADS9212 uses SPI to configure the internal device registers (SCLK, SDI, SDO, CSn, and SPI_EN). A separate CMOS interface is used for capturing conversion data for each ADC channel using up to four output data lanes (D0, D1, D2, and D3). The SPI and CMOS interface signals connect to the FMC connector (J19). The FMC connector signal definition is shown in Figure 2-5. These signals are also available via test points for scope measurements as indicated in PCB silkscreen.

The FMC connector pinout below can also be interfaced with standard FPGA development kits. Note that the TI-provided software GUI is only compatible with the TSWDC155EVM and third-party software development is not supported.

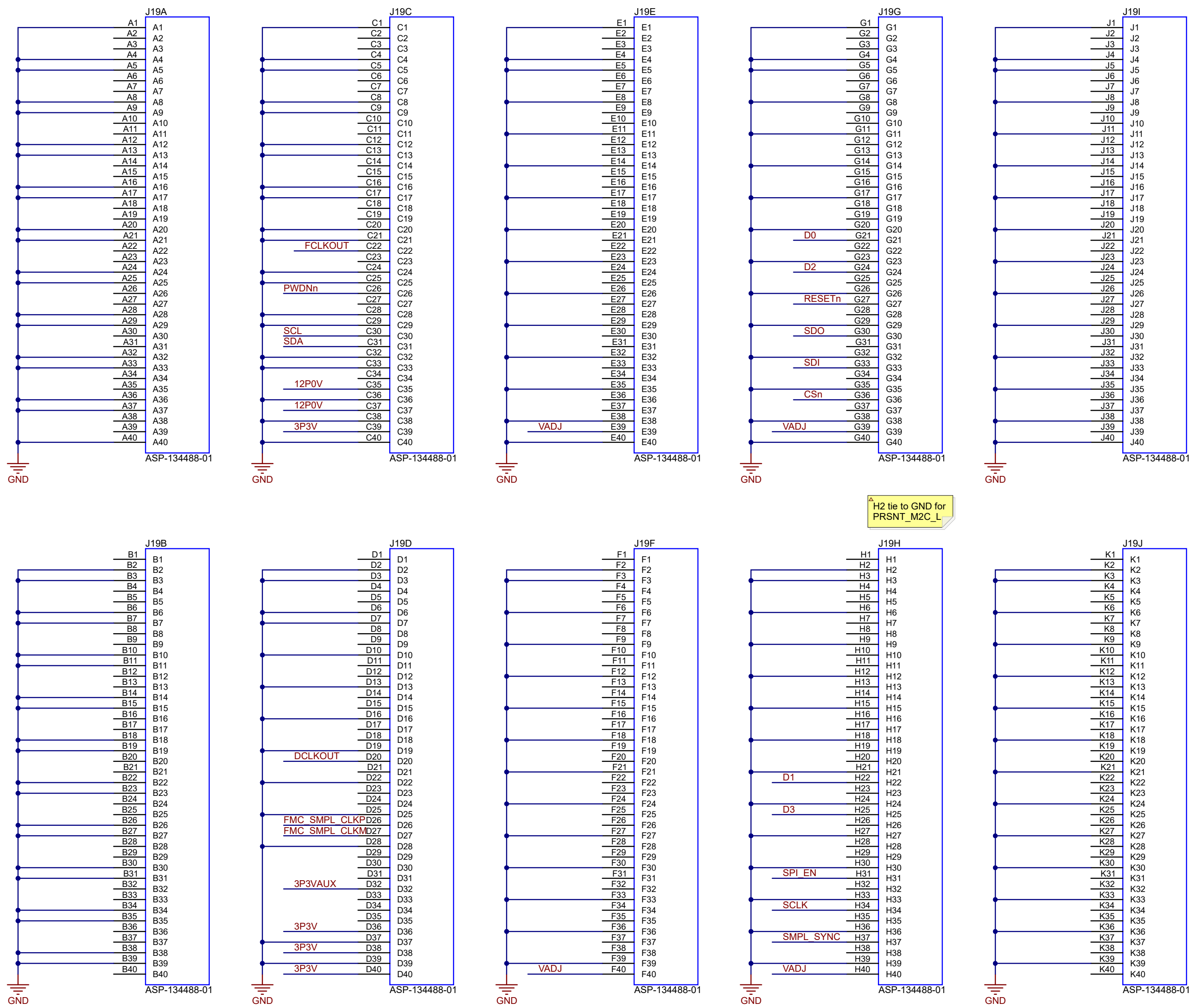

Figure 2-5. Digital I/O

The digital communication lines for the ADS9212 ADC are CMOS interface and are connected with optional termination resistors, as shown in Figure 2-6. A digital serial peripheral interface (SPI) port is used to configure registers in the device. The necessary decoupling capacitors for analog supplies, digital supplies, and ADC reference voltages are shown in Figure 2-6.

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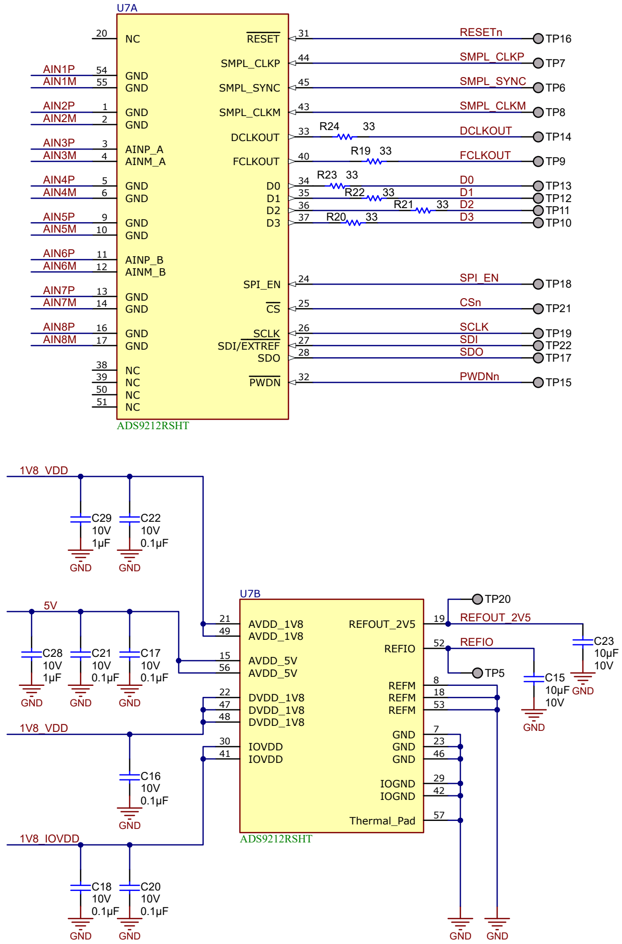

Figure 2-6. Connections to ADS9212

2.5 Digital Interface and Clock Inputs

The ADS9212EVM uses single-ended sampling clock for ADC conversions. The positive sampling clock input (SMPL_CLKP) is selected using jumper JP8. Install a shunt in the [2-3] position (default) to source the clock signal from the TSWDC155EVM through the FMC connector. This allows the user to select the clock frequency from the options listed in the EVM GUI.

An external clock source can also be used to control ADC conversions. Connect a low-jitter clock source to SMA connector J14 and install a shunt in the [1-2] position on JP8.

The negative source of the sample clock (SMPL_CLKM) can be sourced from either the FMC connector (FMC_SMPL_CLKM) through R18 or GND through R17, respectively. By default, R17 is populated and R18 is uninstalled.

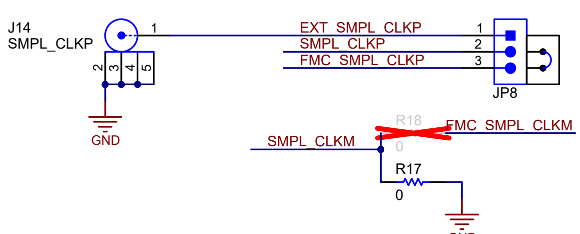

Figure 2-7. Sample Clock Selection

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3 Software

3.1 ADS9212EVM-GUI Software Installation

This section details the installation and operation of the ADS9212EVM software graphical user interface (GUI). This software requires the TSWDC155EVM (sold separately) controller to operate. The first step to installing the software is to download the latest version of the EVM GUI installer as per Table 3-1. See Figure 3-1.

Table 3-1. EVM GUI Installers

EVM	Software Download Link
ADS9212EVM	ADS9212EVM-GUI

Accept all the license agreements and choose the destination location, project directory, and start menu. Typically, the default values work, but these values can be customized as needed based on the user's requirements.

Note

The GUI installer and GUI buttons can differ slightly depending on which specific GUI is being installed.

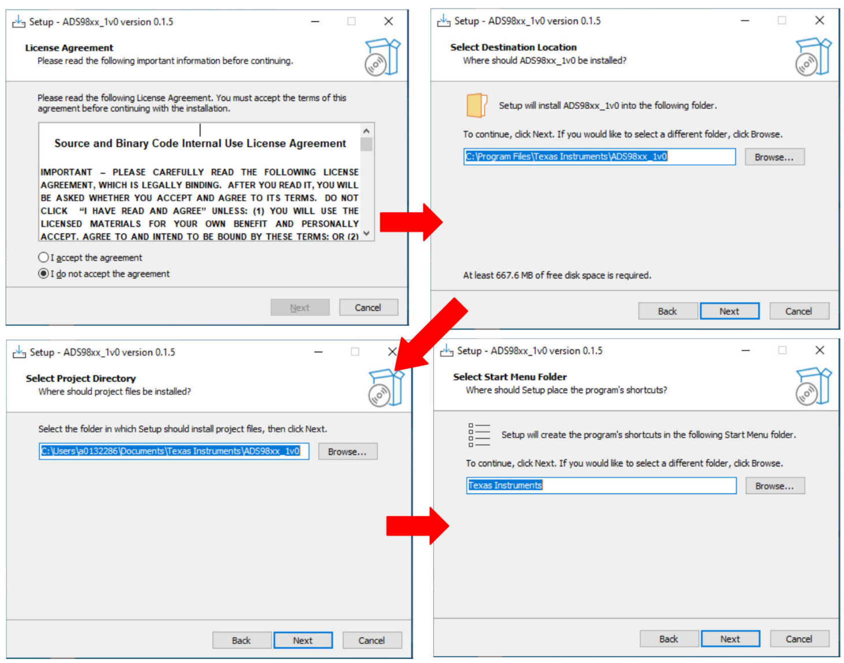

Figure 3-1. Initial Software Installation

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Next, the installer prompts the user to create a desktop icon and summarize the installation plan. Clicking *Install* begins copying software onto the computer. This process takes a few minutes. At completion, the user can launch a readme text file and the application. These steps are shown in Figure 3-2.

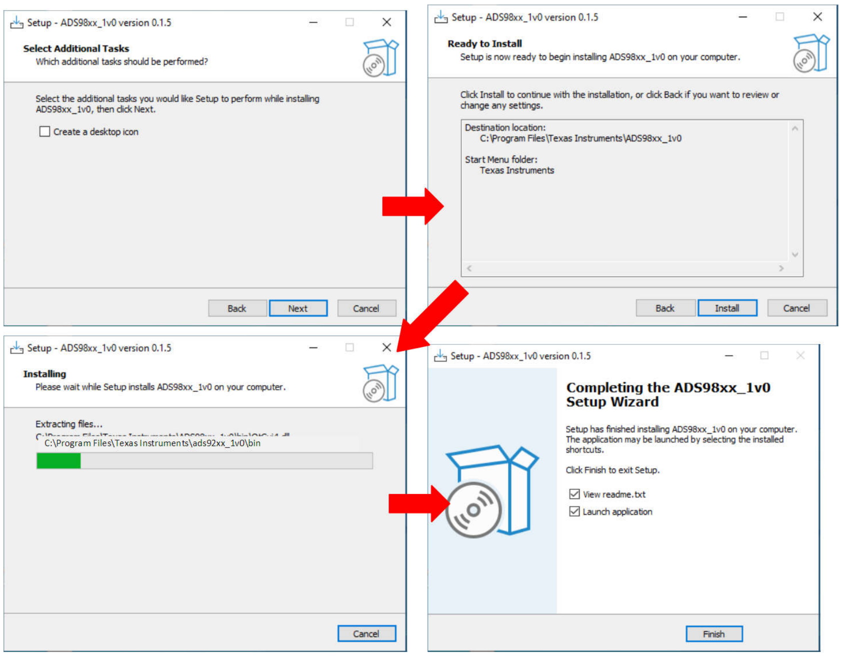

Figure 3-2. Installation Process

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3.2 USB Driver Installation

This section describes the steps for installing the USB driver.

1. For the TSWDC155EVM, connect J8 to the workstation using a USB-C to USB-A cable.
2. Bypass any USB hub and connect directly to the computer.
3. Open the Windows® Device Manager, right-click on the *WestBridge* folder in the Device Manager window, and select the *Update Driver* button as shown in Figure 3-3. See Figure 3-4.
4. In the next window that appears, select *Browse my computer for driver software*.
5. Then select *Let me pick from a list of available drivers on my computer* in the next pop-up window.
6. Click on *Have Disk* in the pop-up window and navigate to:
    a. For ADS9212EVM: *C:\Program Files\Texas Instruments\ADS9212_EVM_GUI\bin\proj_lib\Sparrow\Bootloader*

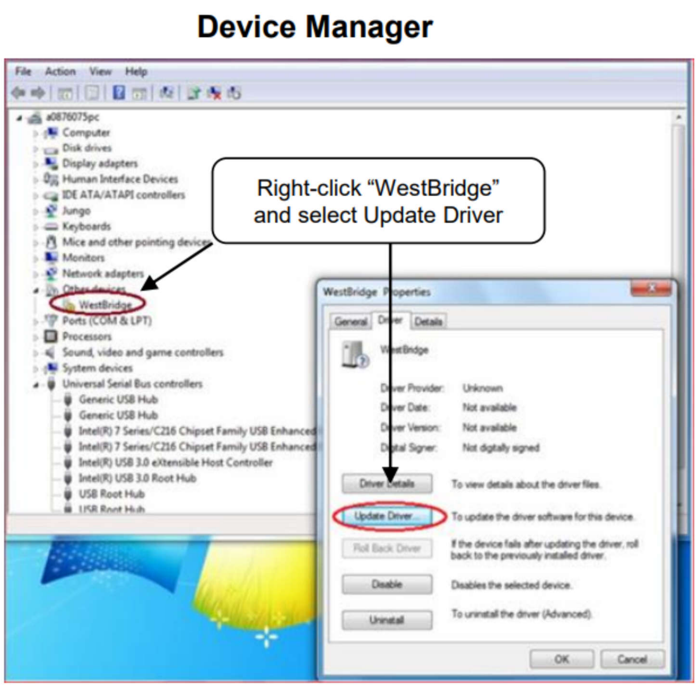

Figure 3-3. Open Device Manager

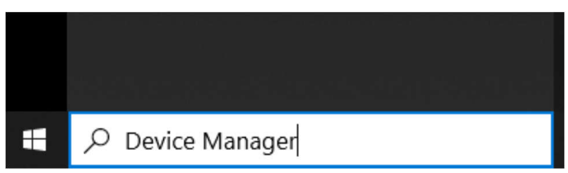

Figure 3-4. Update Driver With Device Manager

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3.3 Using the CONFIG Tab

After the EVM GUI is started, press the following buttons in the order shown in Figure 3-5 below. Confirm that each step is completed before proceeding by monitoring the Status message. For the Power Up and Program FPGA buttons, some status LEDs on the hardware illuminate. After all four buttons are pressed, the power on the ADS9212EVM is on and the ADS9212 device registers are configured.

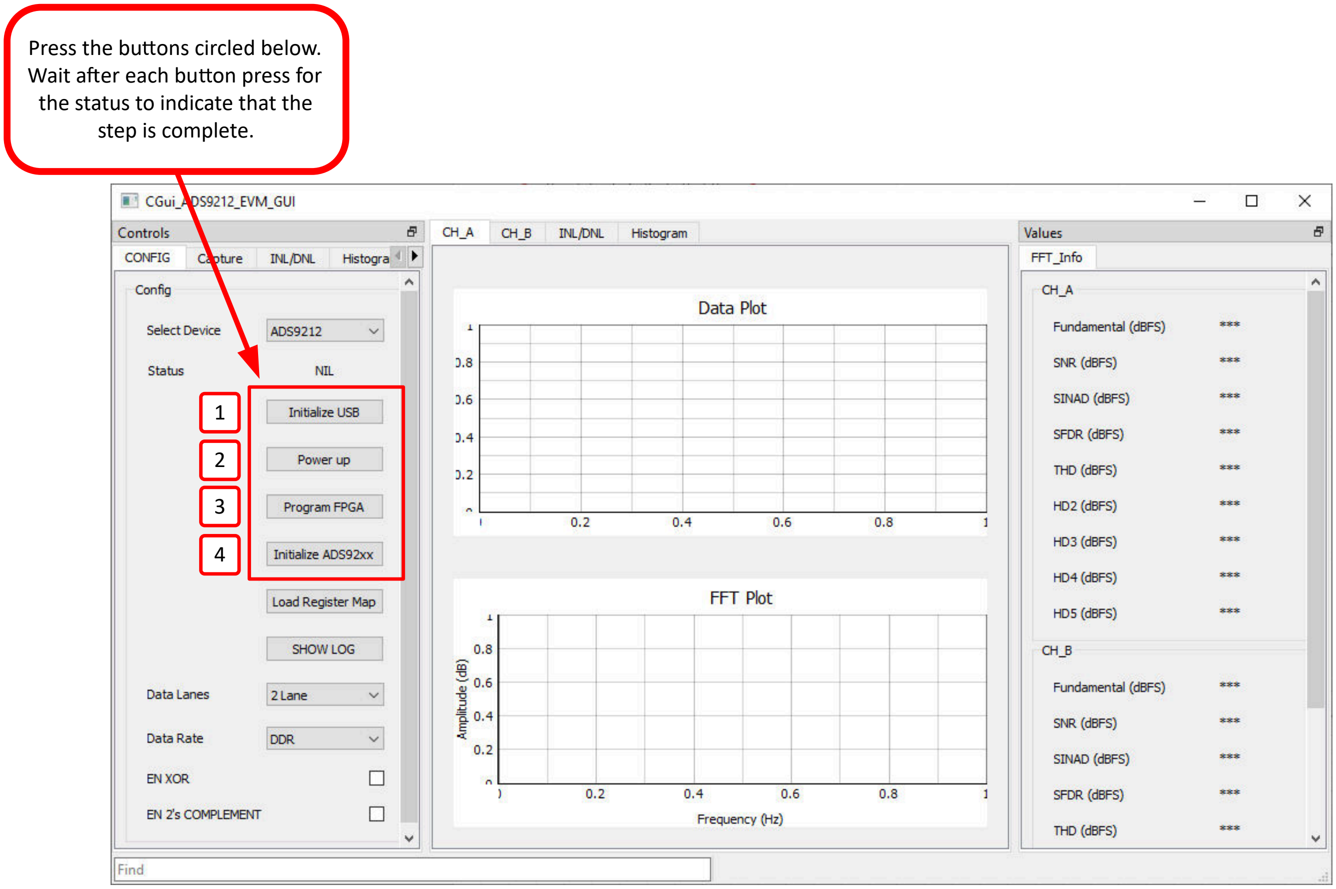

Figure 3-5. Initial Required Setup on the CONFIG Tab

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3.4 Using the Capture Tab

An example data capture display is shown in Figure 3-6. In this step, the necessary updates to the *Capture* settings are made to capture the time domain data and to get a good frequency domain result. First, update the number of samples to at least 32k to get good frequency domain results (for example, accurate FFT display, SNR data, and THD data). Next, select the Hanning type window to eliminate spectral leakage in the FFT result.

When these changes are made, press the *Start Capture* button to collect time domain and frequency domain data. Select the appropriate tab to view data for channel A or channel B.

Figure 3-6. Initial Required Setup on the Capture Tab

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3.5 Using the INL/DNL Tool

The INL/DNL tool measures the linearity of the of the ADS9212EVM by applying a full-scale, low-distortion sinusoidal input signal. The accuracy improves if the number of *hits per code* is increased at the cost of extra test time. Select the channel to measure and the *hits per code*. An input signal greater than full-scale is required to verify that all ADC codes are tested. An input signal of +0.1 dBFS is sufficient. Then press the GET INL/DNL button to run this tool as shown in Figure 3-7.

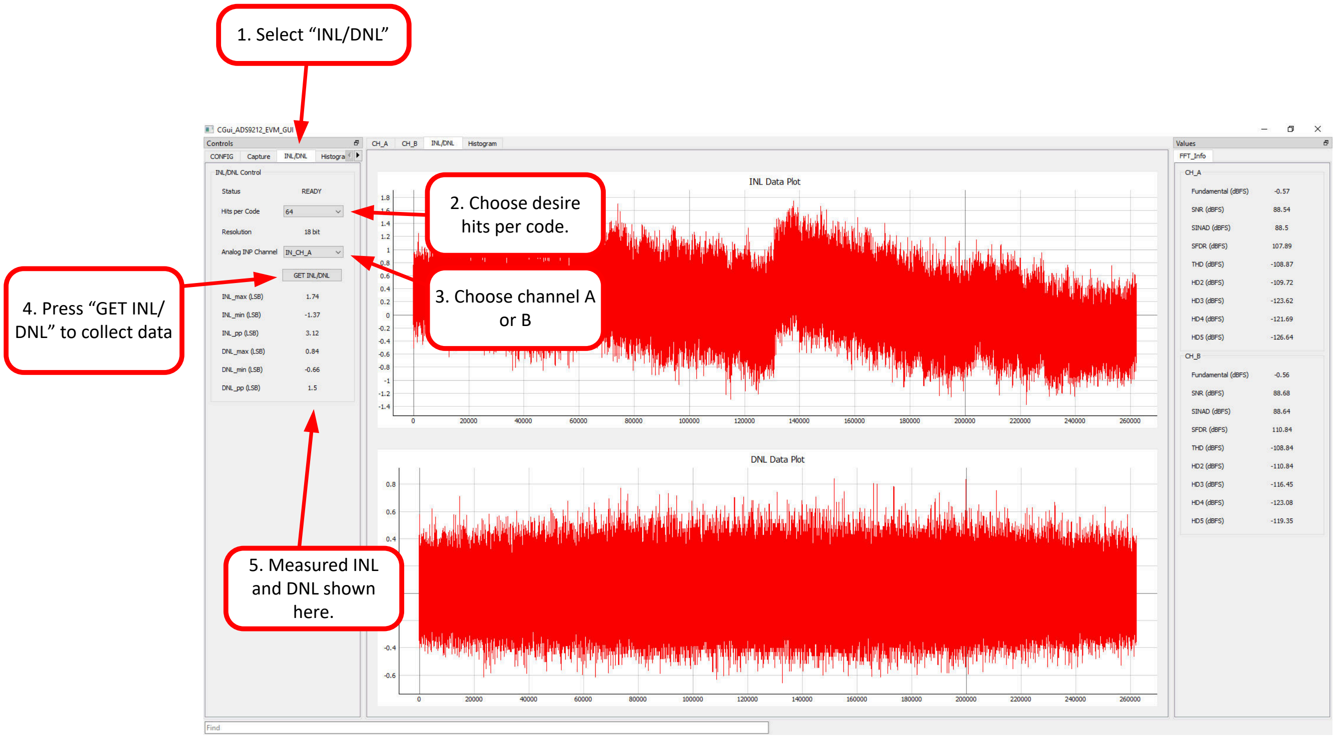

Figure 3-7. Using the INL/DNL Tool

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3.6 Using the Histogram Tab

The Histogram tool represents the distribution of ADC output codes for a given sample set. The accuracy of the statistical summary can be improved by increasing *hits per code*, which increases the sample size at the cost of extra test time. Select the channel to measure and configure the *hits per code*, *channel*, *resolution*, and enter the reference voltage value. Then, press the *GET HISTOGRAM* button as shown in Figure 3-8.

The cumulative effect of noise coupling to the ADC output comes from sources such as the input drive circuits, the reference drive circuit, the ADC power supply, and the ADC. The total noise 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. Selecting the correct reference voltage gives the result in units of voltage instead of codes.

Note that any data collected the histogram tab is not saved or stored on the *Capture Tab*. As a result, switching between the tabs results in lost data. Saving data on this screen does not provide the raw ADC codes but instead saves the histogram data presented on this tab in codes per bin. To save the raw ADC output values, use the *Capture* tab.

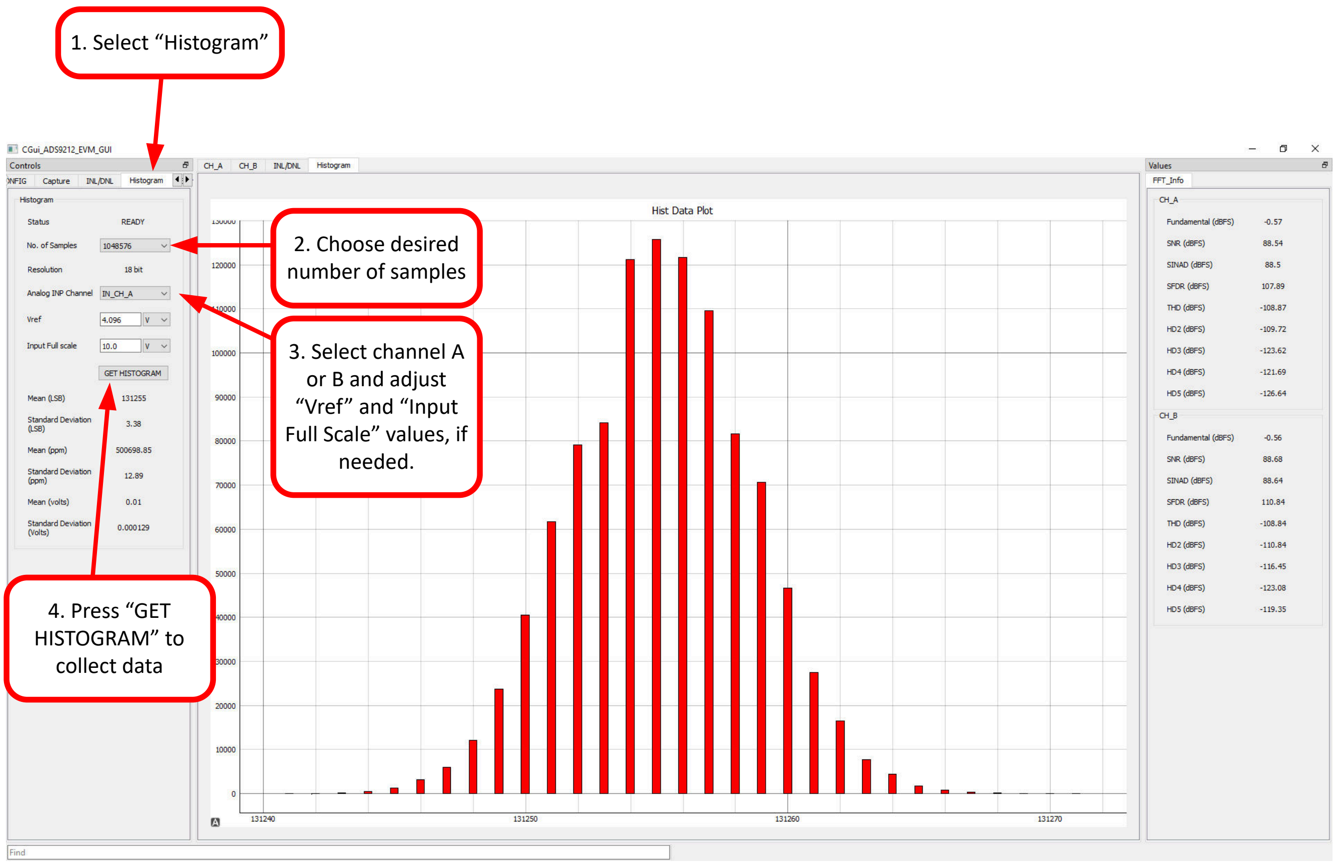

Figure 3-8. Using the Histogram Tab

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4 Hardware Design Files

4.1 Schematics

4.1.1 ADS9212EVM Schematics

The schematics below show the various connections to the ADS9212 device. The digital signals connect to J19, as shown in Figure 4-3. The analog signals connect to SMA connectors and input filtering. The decoupling for the device is shown in Figure 4-1.

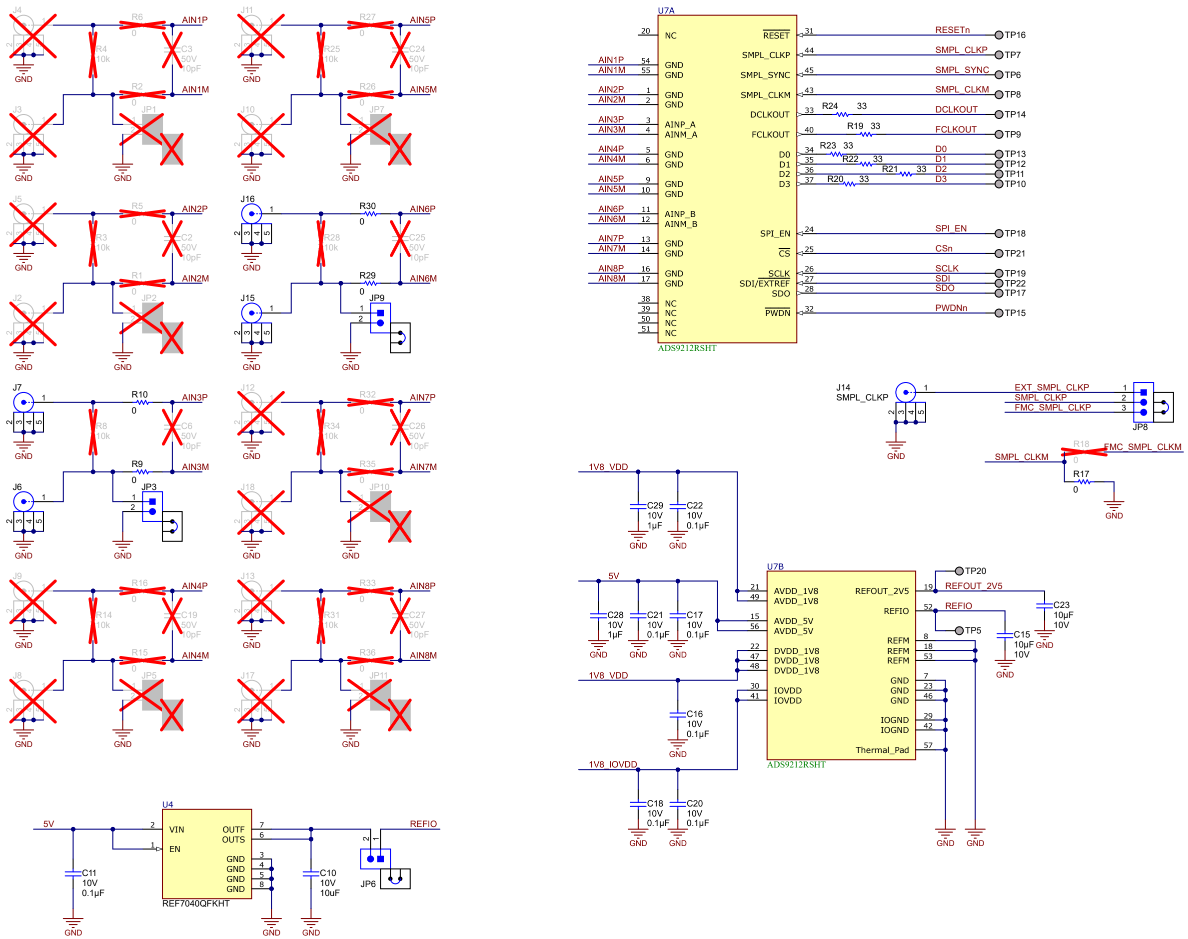

Figure 4-1. ADS9212 Device Connections Schematic

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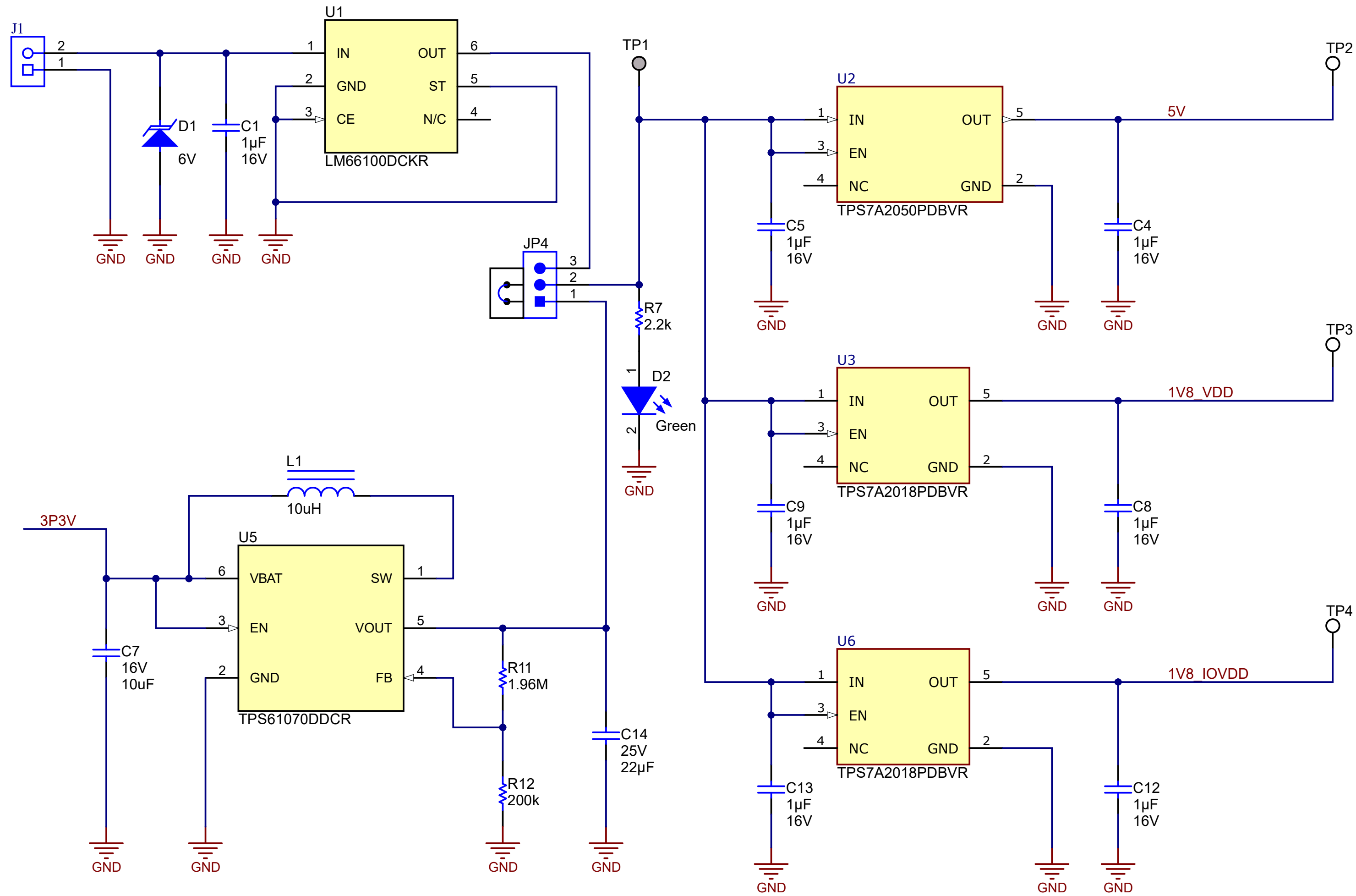

Figure 4-2. Power Connections and Regulators Schematic

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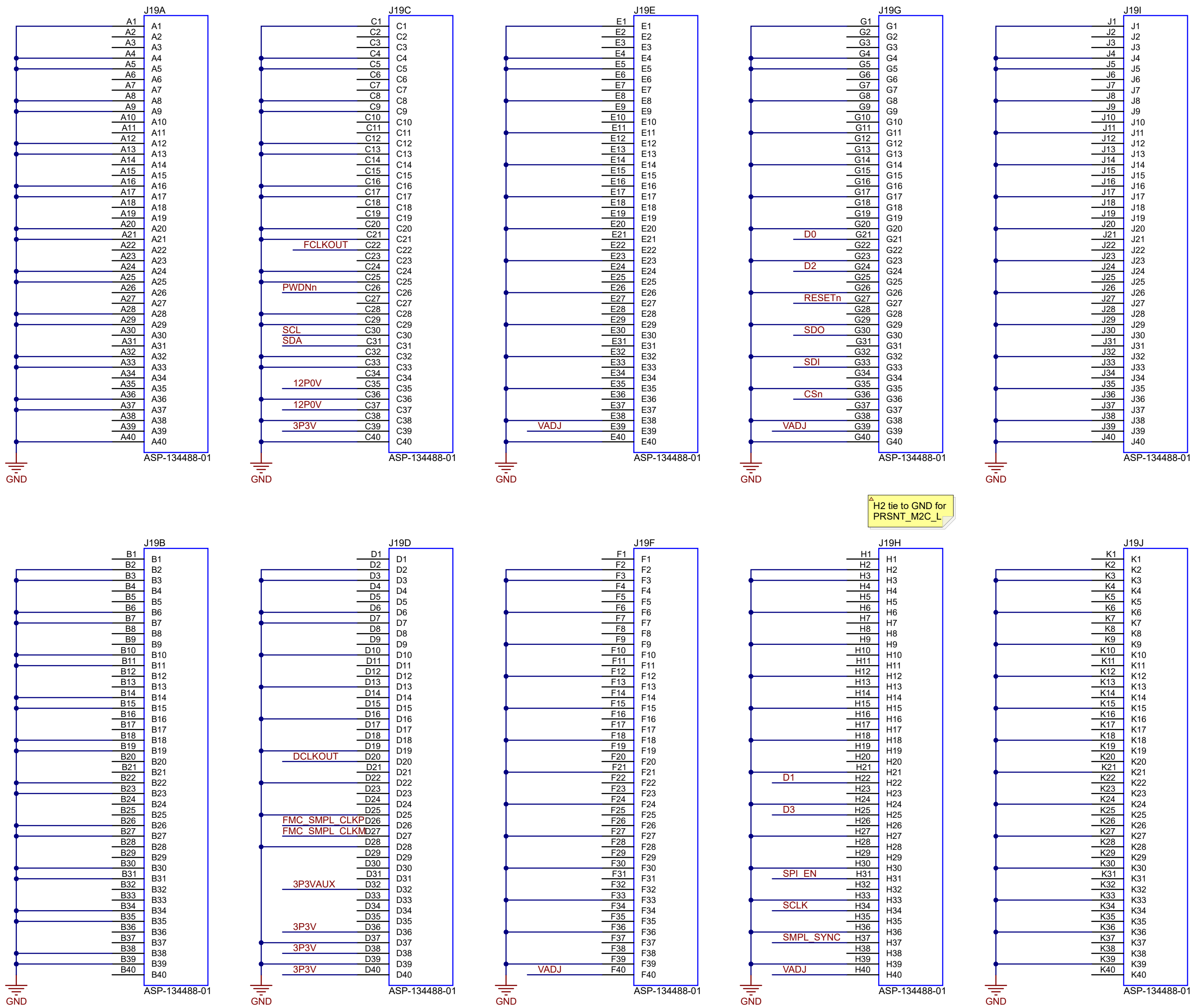

Figure 4-3. Digital Connector Schematic

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4.2 Layout

The figures below show the PCB layer plots for the ADS9212EVM.

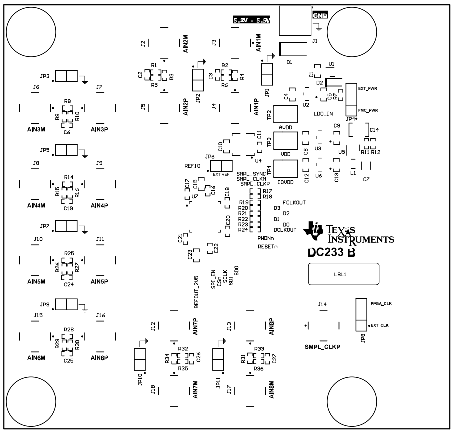

Figure 4-4. Top Overlay

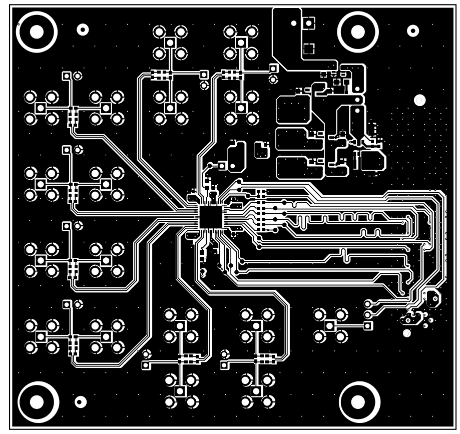

Figure 4-5. Top Layer

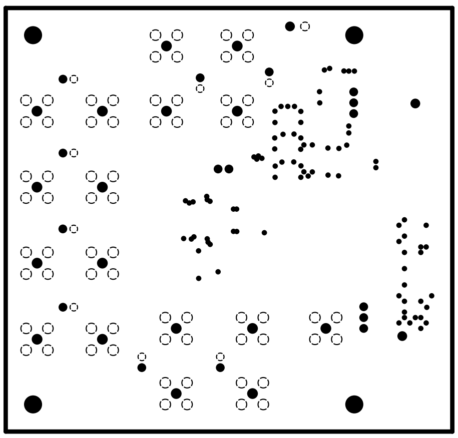

Figure 4-6. Ground Layer

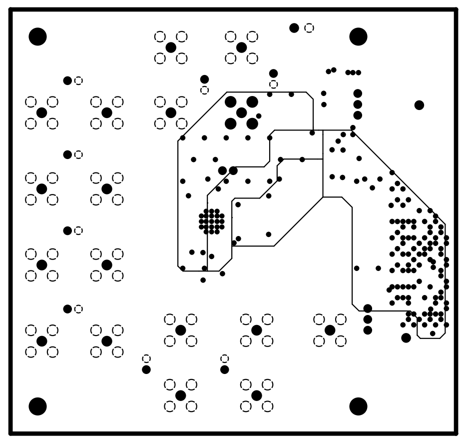

Figure 4-7. Power Layer

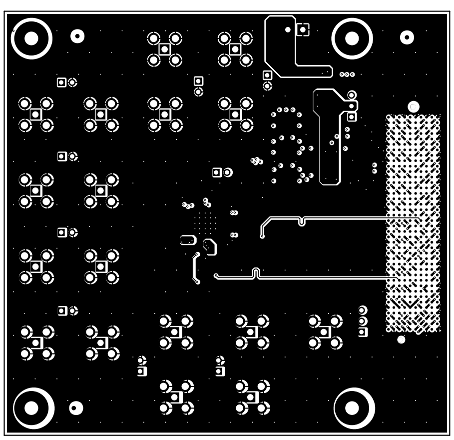

Figure 4-8. Bottom Layer

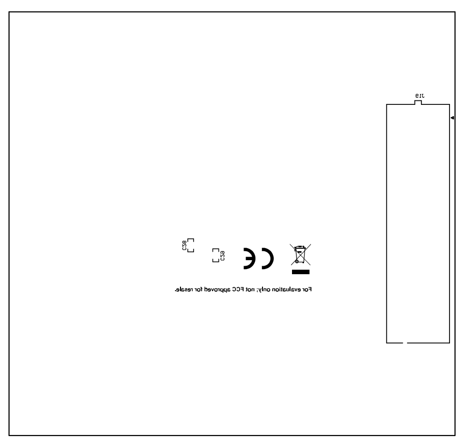

Figure 4-9. Bottom Overlay

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4.3 Bill of Materials (BOM)

The ADS9212EVM bill of materials is listed in Table 4-1.

Table 4-1. ADS9212EVM Bill of Materials

Designator	Qty	Value	Description	Package Reference	Part Number	Manufacturer
C1, C4, C5, C8, C9, C12, C13	7	1uF	CAP, CERM, 1uF, 16V, +/- 10%, X7R, 0603	0603	C1608X7R1C105K080AC	TDK
C7	1	10uF	CAP, CERM, 10uF, 16V, +/- 10%, X7R, 1206	1206	GRM31CR71C106KAC7L	MuRata
C10	1	10uF	CAP, CERM, 10uF, 10V, +/- 20%, X6S, 0603	0603	GRM188C81A106MA73D	MuRata
C11, C16, C17, C18, C20, C21, C22	7	0.1uF	CAP, CERM, 0.1µF, 10V,+/- 10%, X7R, 0402	0402	C0402C104K8RACTU	Kemet
C14	1	22uF	CAP, CERM, 22µF, 25V,+/- 10%, X7R, AEC-Q200 Grade 1, 1210	1210	TMK325B7226KMHP	Taiyo Yuden
C15, C23	2	10uF	CAP, CERM, 10uF, 10V, +/- 20%, X7R, 0603	0603	GRM188Z71A106MA73D	MuRata
C28, C29	2	1uF	CAP, CERM, 1µF, 10V,+/- 10%, X7R, 0603	0603	0603ZC105KAT4A	AVX
D1	1	6V	Diode, TVS, Uni, 6V, 10.3 Vc, 400 W, 38.8A, SMA	SMA	SMAJ6.0A	Littelfuse
D2	1	Green	LED, Green, SMD	LED_0805	APT2012LZGCK	Kingbright
H1, H2, H3, H4	4		Machine Screw, Round, #4-40 x 1/4, Nylon, Philips panhead	Screw	NY PMS 440 0025 PH	B&F Fastener Supply
H5, H6, H7, H8	4		Standoff, Hex, 0.5"L #4-40 Nylon	Standoff	1902C	Keystone
J1	1		Terminal Block, 3.5mm Pitch, 2x1, TH	7.0x8.2x6.5mm	ED555/2DS	On-Shore Technology
J6, J7, J14, J15, J16	5		SMA Connector Jack, Female Socket 50Ohm Through Hole Solder	CONN_SMA_PTH	6.0312E+13	Wurth Electronics
J19	1		Connector, 1.27mm, 40x10, Black, SMT	Connector, 1.27mm, 40x10, SMT	ASP-134488-01	Samtec
JP3, JP6, JP9	3		Header, 100mil, 2x1, Gold, TH	Header, 100mil, 2x1, TH	HTSW-102-07-G-S	Samtec
JP4, JP8	2		Header, 100mil, 3x1, Gold, TH	Header, 100mil, 3x1, TH	HTSW-103-07-G-S	Samtec
L1	1	10uH	Inductor, Wirewound, Ceramic, 10uH, 0.48A, 0.36 ohm, SMD	2.5x1.8x1.8mm	CBC2518T100M	Taiyo Yuden
R7	1	2.2k	RES, 2.2 k, 5%, 0.063 W, 0402	0402	CRCW04022K20JNED	Vishay-Dale
R9, R10, R17, R29, R30	5	0	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0402	0402	ERJ-2GE0R00X	Panasonic
R11	1	1.96Meg	RES, 1.96M, 1%, 0.063 W, 0402	0402	CRCW04021M96FKED	Vishay-Dale
R12	1	200k	RES, 200 k, 1%, 0.063 W, 0402	0402	CRCW0402200KFKED	Vishay-Dale
R19, R20, R21, R22, R23, R24	6	33	RES, 33, 5%, 0.063 W, 0402	0402	CRCW040233R0JNED	Vishay-Dale
SH-J2, SH-J3, SH-J5, SH-J6, SH-J11	5		Shunt, 2.54mm, Gold, Black	Shunt, 2.54mm, Black	60900213421	Wurth Elektronik

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Table 4-1. ADS9212EVM Bill of Materials (continued)

Designator	Qty	Value	Description	Package Reference	Part Number	Manufacturer
TP2, TP3, TP4	3		Test Point, Compact, SMT	Testpoint_Keystone_Compact	5016	Keystone Electronics
U1	1		+/-6V, Low IQ Ideal Diode with Input Polarity Protection, DCK0006A (SOT-SC70-6)	DCK0006A	LM66100DCKR	Texas Instruments
U2	1		300mA, ultra-low-noise, low-IQ, low-dropout (LDO) linear regulator with high PSRR 5-SOT-23 -40 to 125	SOT23-5	TPS7A2050PDBVR	Texas Instruments
U3, U6	2		Linear Voltage Regulator IC Positive Fixed 1 Output 300mA SOT-23-5	SOT23-5	TPS7A2018PDBVR	Texas Instruments
U4	1		2ppm/°C Maximum Drift, 0.23 ppmp-p 1/f Noise, Precision Voltage Reference	LCCC8	REF7040QFKHT	Texas Instruments
U5	1		Adjustable, 600mA Switch, 90% Efficient PFM/PWM Boost Converter in ThinSOT-23, DDC0006A (SOT-23-T-6)	DDC0006A	TPS61070DDCR	Texas Instruments
U7	1		18-Bit, 2-MSPS, Dual Simultaneous-Sampling ADC with Integrated analog Front-End	VQFN56	ADS9212RSHT	Texas Instruments

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5 Additional Information

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6 Related Documentation

The following related documents are available for download through the Texas Instruments web site at www.ti.com.

Table 6-1. Related Documentation

Device	Literature Number
TSWDC155EVM	SLAU870
TPS61070	SLVS510
TPS7A20	SBVS338
LM66100	SLVSEZ8
REF7040	SNAS781

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