

EVM User's Guide: ADS9227EVM

ADS9227 Evaluation Module



Description

The ADS9227EVM is a platform for evaluating the performance of the ADS9227. The ADS9227 is a 2-channel, 16-bit resolution, 5-MSPS per channel successive approximation register (SAR) analog-to-digital converters (ADC). An integrated ADC driver simplifies external signal-chain that can be optimized for low-power and high-precision.

Get Started

1. Order [ADS9227EVM](#) and [TSWDC155EVM controller](#) on [ti.com](#).
2. Visit the [ADS9227EVM tool folder](#) to download the ADS92xx EVM GUI.

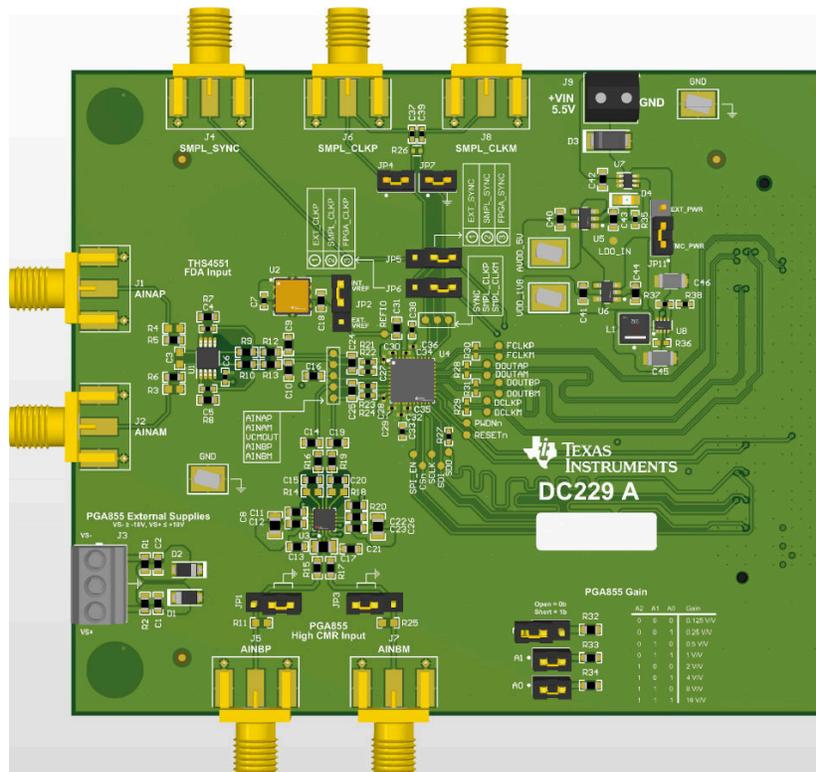
Features

- ADS9227EVM has the hardware required for diagnostic testing and accurate performance evaluation of the ADS9227 ADC.

- The TSWDC155EVM controller (sold separately) provides all necessary digital I/O signals and power rails required for operating the ADS9227EVM.
- 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.

Applications

- [Power analyzers](#)
- [Source measurement units \(SMU\)](#)
- [Marine equipment](#)
- [Servo drive position feedback](#)
- [DC power supplies, AC sources, electronic loads](#)



ADS9227 Evaluation Module

1 Evaluation Module Overview

1.1 Introduction

This user's guide describes the characteristics, operation, and use of the ADS9227 evaluation module (EVM). This is an evaluation platform for the ADS9227 device. The EVM eases the evaluation of the ADS9227 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). Throughout this document, the terms *evaluation module and EVM* are synonymous with the ADS9227EVM.

1.2 Kit Contents

The ADS9227EVM includes a standard FMC connector on the bottom 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, graph measured results, and compute common figures of merit (for example, SNR and THD).

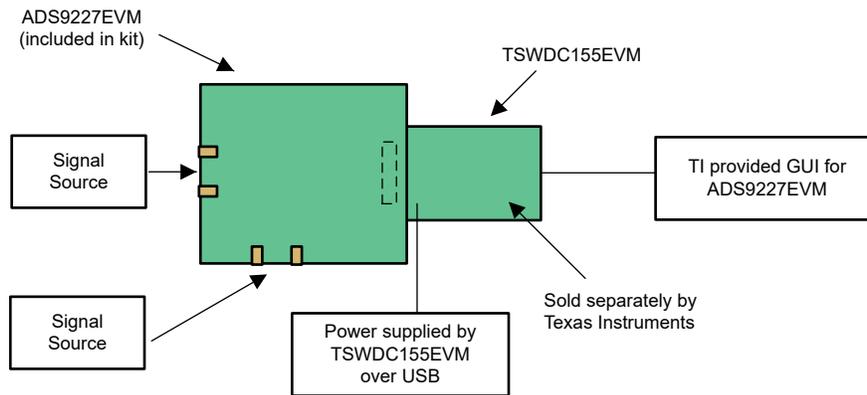


Figure 1-1. System Using GUI and TSWDC155EVM

1.3 Specification

The block diagram in [Figure 1-2](#) depicts the connections and basic subsystems of the ADS9227EVM.

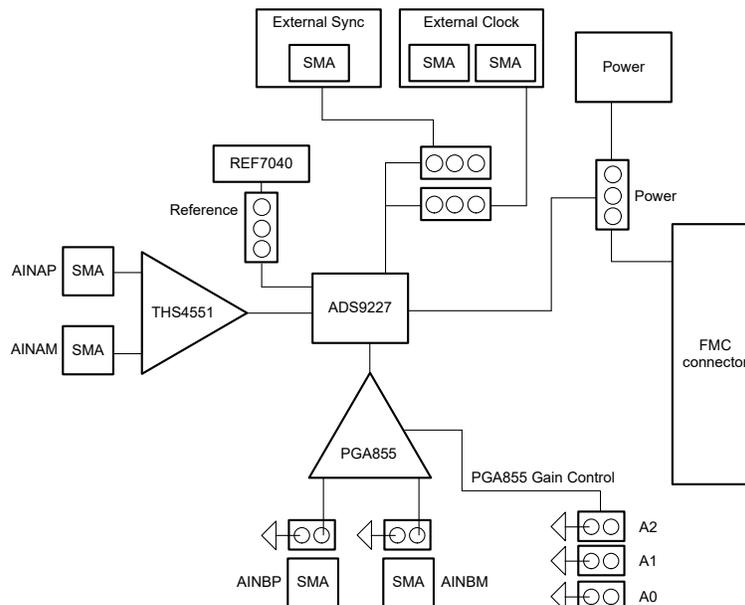


Figure 1-2. ADS9227EVM Block Diagram

1.4 Device Information

The ADS9227 is a 16-bit, 5-MSPS per channel, dual-channel, simultaneous-sampling, analog-to-digital converter (ADC). The ADS9227 integrates an ADC driver, precision voltage reference, reference buffer, and common-mode voltage output buffer. Combined with low conversion latency, high sampling rates, minimal AC and DC errors, and low temperature drift, the ADS9227 is a high-performance design for applications requiring both precision and speed.

The serial LVDS (SLVDS) digital interface reduces board layout complexities, relaxes FPGA timing closures, simplifies firmware, and supports full throughput at lower clock speeds.

2 Hardware

2.1 Analog Interface

This section details the analog input connections to the ADS9227EVM.

2.1.1 ADC Channel Inputs

Each ADC channel in the ADS9227 features an integrated, high-speed ADC driver amplifier. This internal driver circuit is specifically designed to charge the internal sample-and-hold capacitor in each ADC channel such that the sampled voltage is fully settled during the minimum acquisition period. In addition, the driver amplifiers present a high input impedance to the external signal chain. This allows systems engineers to design an analog input circuit that meets the requirements of the application without also being concerned with performance degradation due to charge-kickback during sampling.

The ADS9227EVM presents two unique signal chain proposals for the user to evaluate: a high-bandwidth, fully-differential circuit that supports input frequencies up to 1MHz and a low-bandwidth, high-CMRR circuit with programmable gain that supports input frequencies up to 300kHz. Either circuit can be used to drive ADC A and ADC B since the channels are identical by design in the ADS9227.

2.1.1.1 High-bandwidth, Fully-Differential Circuit: THS4551

[Figure 2-1](#) shows the schematic for the THS4551 input circuit connected to ADC A. The THS4551 is a precision, low-noise, fully differential amplifier with a gain-bandwidth product of 150MHz. This circuit is configured for a gain of 1V/V and can accept both single-ended and differential inputs. Install R3 and R4 as needed to support signal sources with 50-Ω output impedance.

The output common-mode voltage on the THS4551 is set by the voltage connected to the VOCM pin. When used with the ADS9227, TI recommends to buffer the VCMOUT voltage of the ADC before connecting to the VOCM pin of the THS4551. This makes sure that both amplifier outputs stay within the expected ADC input common-mode voltage range. The OPA320, shown in [Figure 2-2](#), is used as the VCMOUT buffer to drive the output common-mode voltage on both ADC A and ADC B input circuits.

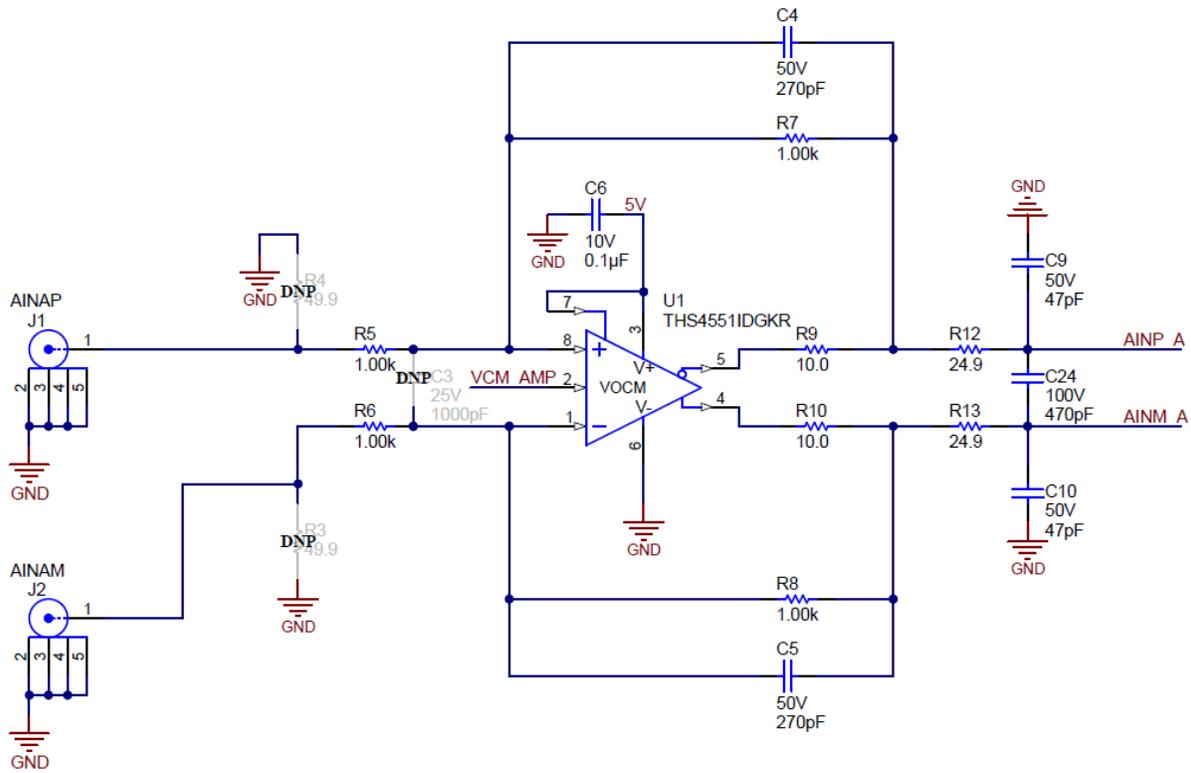


Figure 2-1. THS4551 Fully-Differential Circuit for ADC A

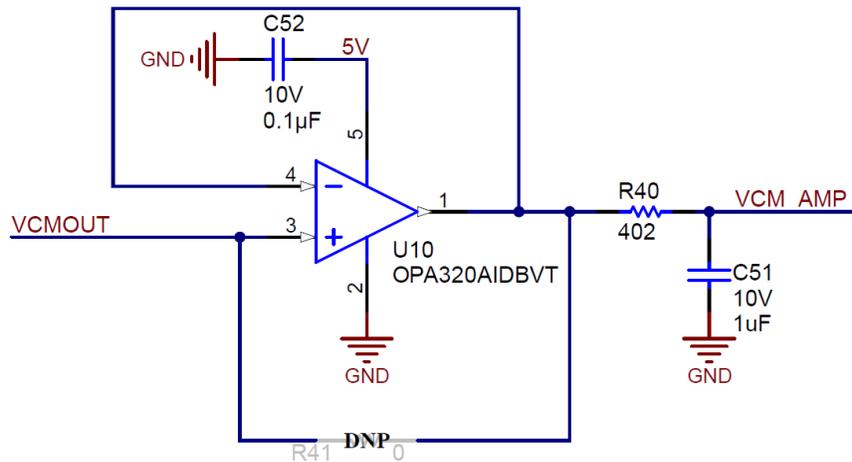


Figure 2-2. OPA320 Circuit to Buffer the ADS9227 VCMOUT Voltage

2.1.1.2 Precision, High-CMRR Circuit: PGA855

Figure 2-3 shows the schematic for the PGA855 input circuit connected to ADC B. The PGA855 is a high-bandwidth programmable gain instrumentation amplifier with fully differential outputs. This circuit is designed for input signal frequencies up to approximately 300kHz. The gain of the PGA855 is set by the combination of three binary gain pins, which are configured using the corresponding jumpers on the EVM (see Table 2-1).

The PGA855 uses separate supply voltages for the input stage and the output stage. The input stage supply rails (VS+ and VS-) can range up to ± 18 V and must be provided externally. Connect the VS+ and VS- supply voltages and a ground wire from an external power source to the J3 terminal block on the EVM. The output stage supply rails (LVDD and LVSS) are shared with the ADS9227 analog supplies (AVDD_5V and GND). This is done intentionally to limit the output swing of the PGA855 and to protect the ADS9227 inputs from overdrive.

Table 2-1. PGA855 Gain Settings

A2 (JP8)	A1 (JP9)	A0 (JP10)	Gain (V/V)
0	0	0	0.125
0	0	1	0.25
0	1	0	0.5
0	1	1	1
1	0	0	2
1	0	1	4
1	1	0	8
1	1	1	16

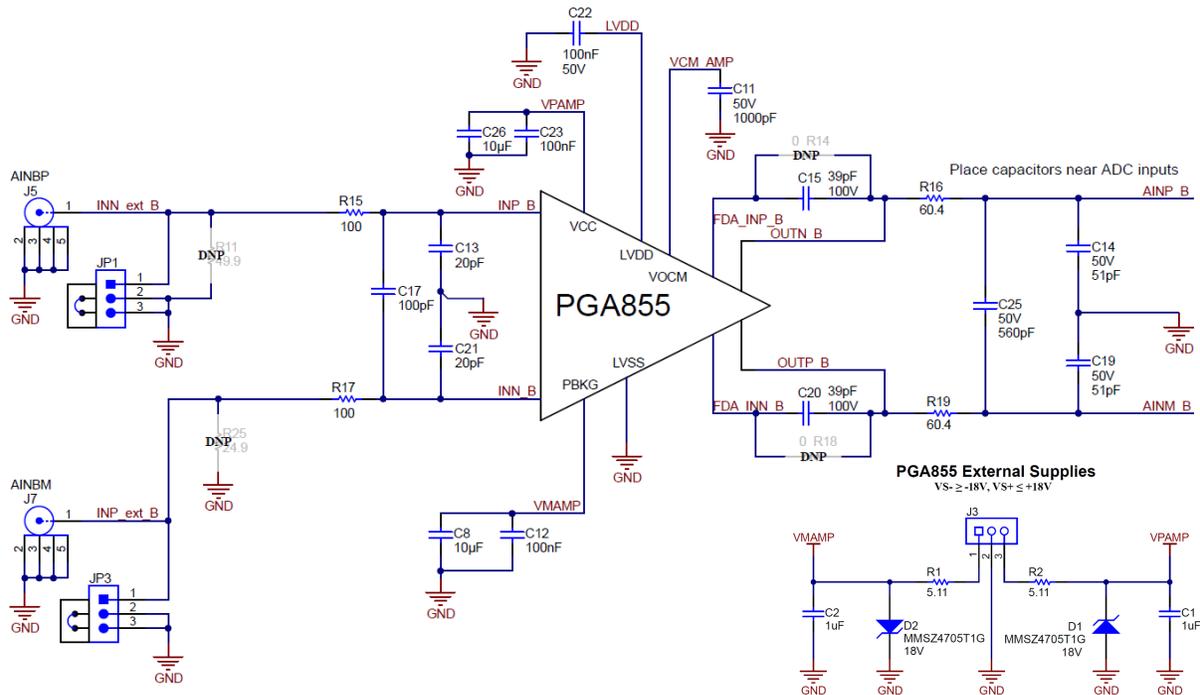


Figure 2-3. PGA855, High-CMRR Circuit for ADC B

2.1.2 Voltage Reference

The ADS9227 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 ADS9227EVM include 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 to the ADS9227, configure the REFIO pin as an input via the GUI and then install a shunt on jumper JP2 in the [1-2] position.

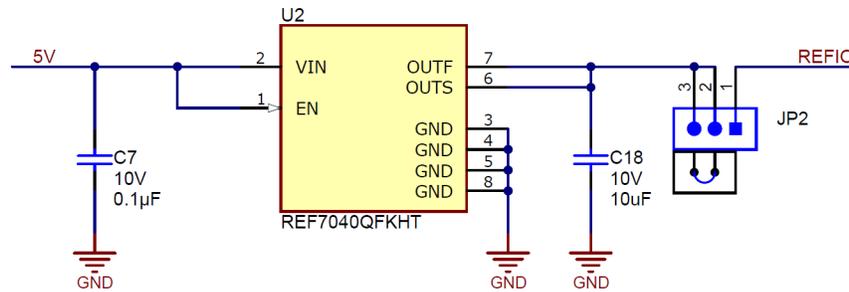


Figure 2-4. External Reference Voltage Using REF7040

2.2 Power Supplies

By default, the TSWDC155EVM provides the ADS9227EVM with a 3.3V supply ("3P3V"). The ADS9227EVM has a TPS61033 boost converter which increases the 3.3V supply to 5.5V. The 5.5V supply is applied to the input of two independent low-dropout regulators (LDOs) to derive the required analog and digital supplies for the ADS9227 when JP11 is in the [1-2] position. U5 (TPS7A2050) outputs 5V, which is used for the AVDD_5V supply. U6 (TPS7A2018) outputs 1.8V, which is shared between the AVDD_1V8 and DVDD_1V8 supplies.

The LDO input voltage (LDO_IN) can be changed to an external source ranging from 5.2V to 5.5V by configuring the shunt on JP11 in the [2-3] position and connecting the external supply to terminal block J9. In this setup, U7 (LM66100) provides reverse polarity protection in the event that the connection is wired incorrectly.

The PGA855 operates over a wide single-supply range of 8V to 36V or dual-supply range of $\pm 4V$ to $\pm 18V$. The positive and negative supply rails for the PGA855 (VS+ and VS-) must be provided from an external bench supply and connected to terminal block J3 on the ADS9227EVM.

Figure 2-5 shows the power tree schematic for the ADS9227EVM.

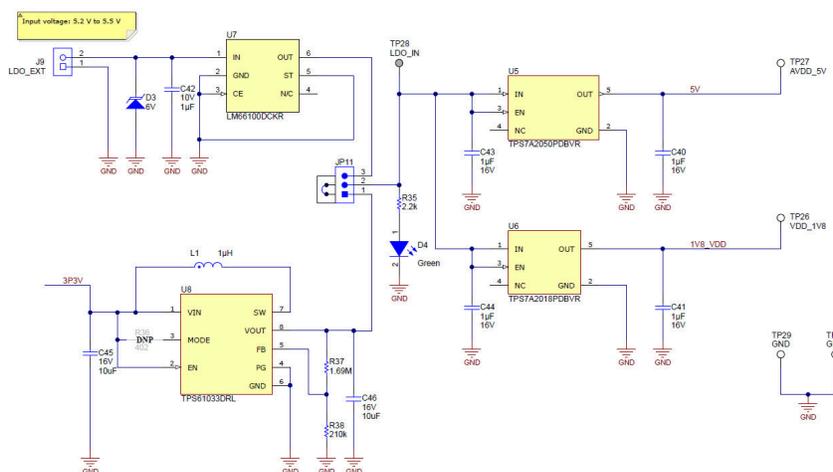


Figure 2-5. Power Entry and On-Board Regulators

2.2.1 USB Power and When to Power the Board Externally

As discussed in Section 2.4, the USB-C connector is able to provide power to the TSWDC155EVM and ADS9227EVM using the default configuration. The combined peak current consumption reaches 600 mA (typical) during the ADC conversion process and 520 mA RMS (typical) after the ADS9227EVM is initialized in the GUI, as described in Section 3.1.3.

The TWDC155EVM is a high-power SuperSpeed (USB 3.0) device. This means a PC supplies up to 900 mA 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 ADS9227EVM and/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 ADS9227EVM, move the jumper on J18 to the EXT_PWR position and use the J17 terminal block to provide the required 5.2-V to 5.5-V supply. To switch to the external power configuration on TSWDC155EVM, move the jumper on J2 to the 5 V (external) position and use the J10 terminal block or barrel jack connector to provide the required 5-V supply.

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

2.3 Digital Interface and Clock Inputs

This section details the digital interface connections and clocking options for the ADS9227EVM.

2.3.1 Digital Interface Connections

The ADS9227 uses both SPI and LVDS type interfaces. The SPI is a CMOS interface that is used to configure the internal device registers and consists of SCLK, SDI, SDO, \overline{CS} , and SPI_EN. For data capture, the ADS9227 uses a source-synchronous LVDS interface. Data for each channel are output on a dedicated differential signal pair (DOUTP/M_A and DOUTP/M_B). In addition, the device outputs both a differential frame clock (FCLKP/M) and data clock (DCLKP/M) back to the host with the conversion data. This type of interface makes sure that propagation delays are consistent between the data output, frame clock, and data clock, improving timing closures at the host. Both the SPI and LVDS interface signals connect to the FMC connector on the EVM. [Figure 2-6](#) provides the FMC connector signal definition. 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.

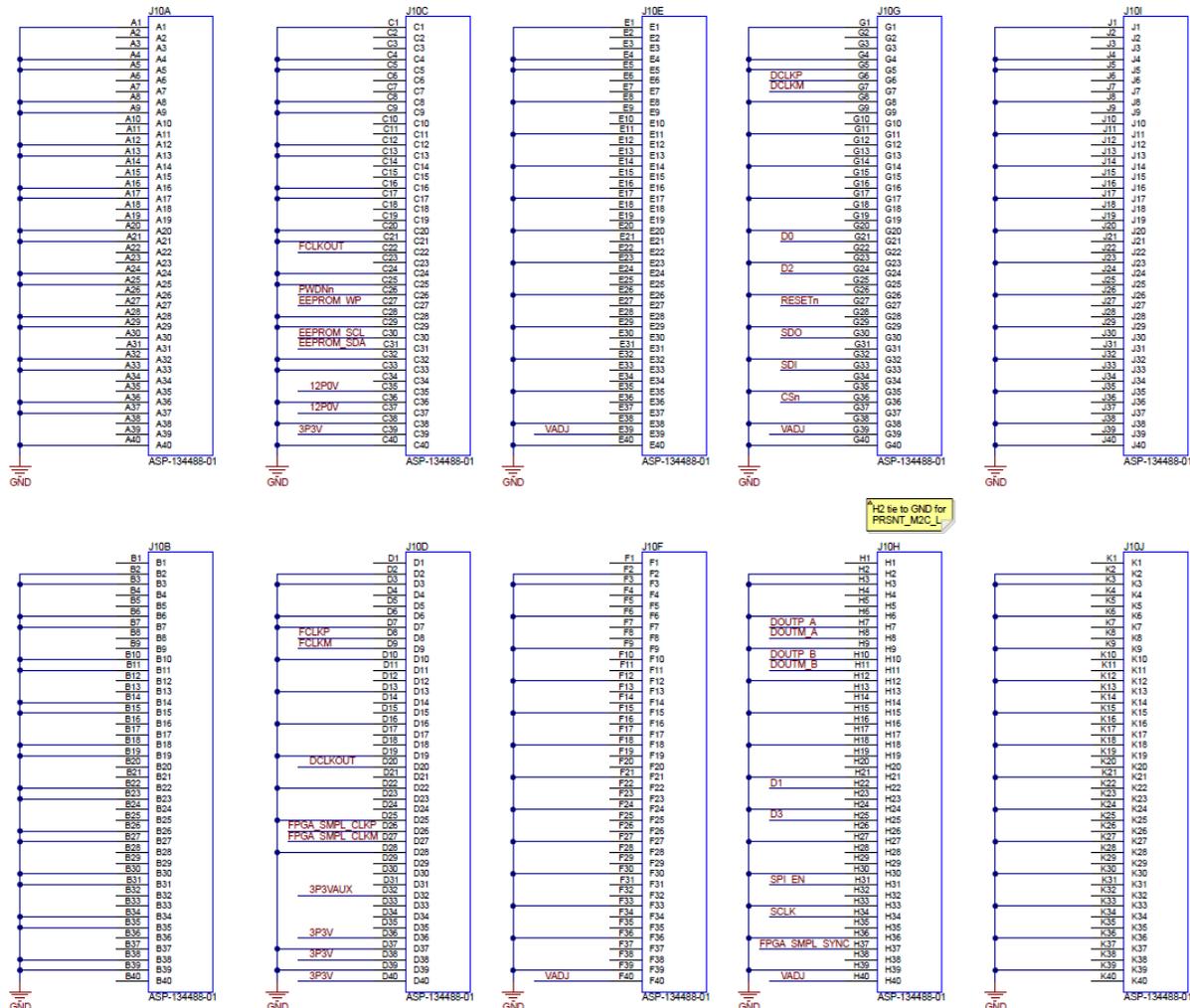


Figure 2-6. Digital I/O

2.3.2 Clock Select

The ADS9227EVM offers the following options for providing the conversion clock to the ADS9227: a CMOS clock from the TSWDC155EVM, a CMOS clock from an external source, and an LVDS clock from external source. Table 2-2 and Figure 2-7 provide an overview of the ADS9227 sample clock options available on the EVM. By default, the FPGA controller on the TSWDC155EVM (sold separately) sources a single-ended CMOS clock that can be connected directly to the SMPL_CLKP pin on the ADS9227 by configuring JP6 in the [2-3] position. Connect SMPL_CLKM to GND by installing a shunt on JP7. Lastly, install a jumper on JP5 in the [2-3] position to provide a SMPL_SYNC input from the FPGA controller, which is used to synchronize the internal averaging filter on the ADS9227 at the start of data capture. This default configuration allows the user to select the clock frequency from the options listed in the EVM GUI.

When using an external CMOS clock, move JP6 into the [1-2] position, install a shunt on JP4, and connect the external clock source to the SMA connect, J6. To use an LVDS clock, remove the jumper from JP4 and install a 100Ω resistor on the footprint for R26. Make sure that any external clock source has low jitter to maximize the performance of the ADS9227.

Table 2-2. Sample Clock Settings for ADS9227EVM

Sample Clock (SMPL_CLK)	JP4	JP6 (SMPL_CLKP)	JP7 (SMPL_CLKM)	R26
TSWDC155EVM (CMOS)	—	[2-3]	Installed	Not installed
External (CMOS - J6)	Installed	[1-2]	Installed	Not installed
External (LVDS - J6/J8)	Not installed	[1-2]	Not installed	Installed (100Ω)

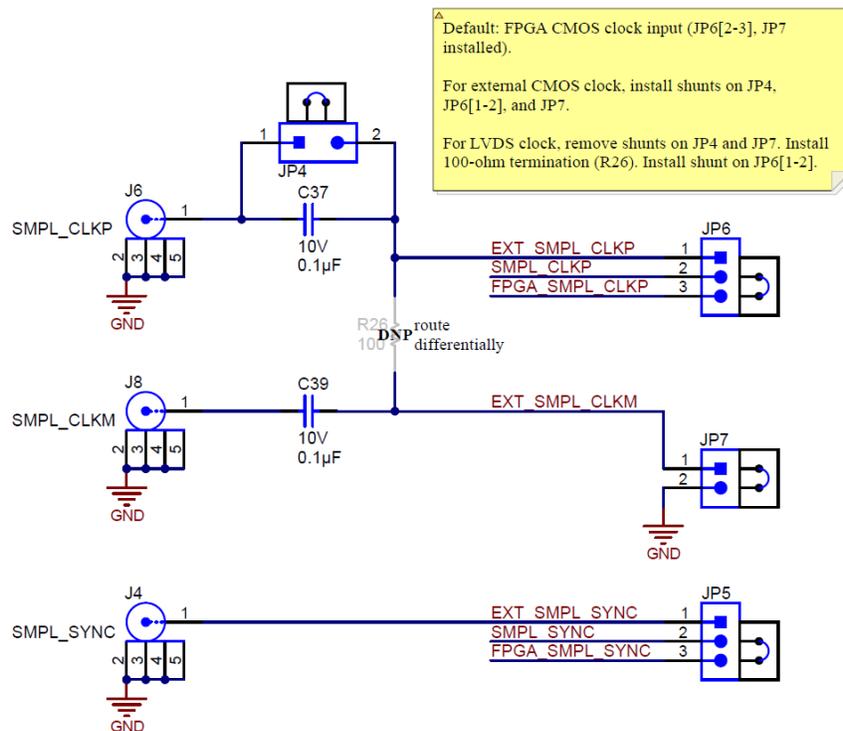


Figure 2-7. Sample Clock Selection

2.4 ADS9227EVM Quick Start Guide

The following instructions are a step-by-step guide to connecting the ADS9227EVM to the computer and evaluating the performance of the ADS9227.

1. Review the default jumper settings in [Figure 2-8](#) below as well as the power guidelines in [Section 2.2.1](#).
2. Physically connect J1 of the TSWDC155EVM to J27 of the ADS9227EVM. This component is the digital communications and power signal connection in default configuration.
3. Set jumper J18 to the FMC_PWR position so the TSWDC155EVM provides power. Otherwise, set J18 to EXT_PWR and connect an external 5.2-V to 5.5-V supply on screw terminal connection J17.
4. Bypass any external USB hub and connect the USB on the TSWDC155EVM directly to the computer.

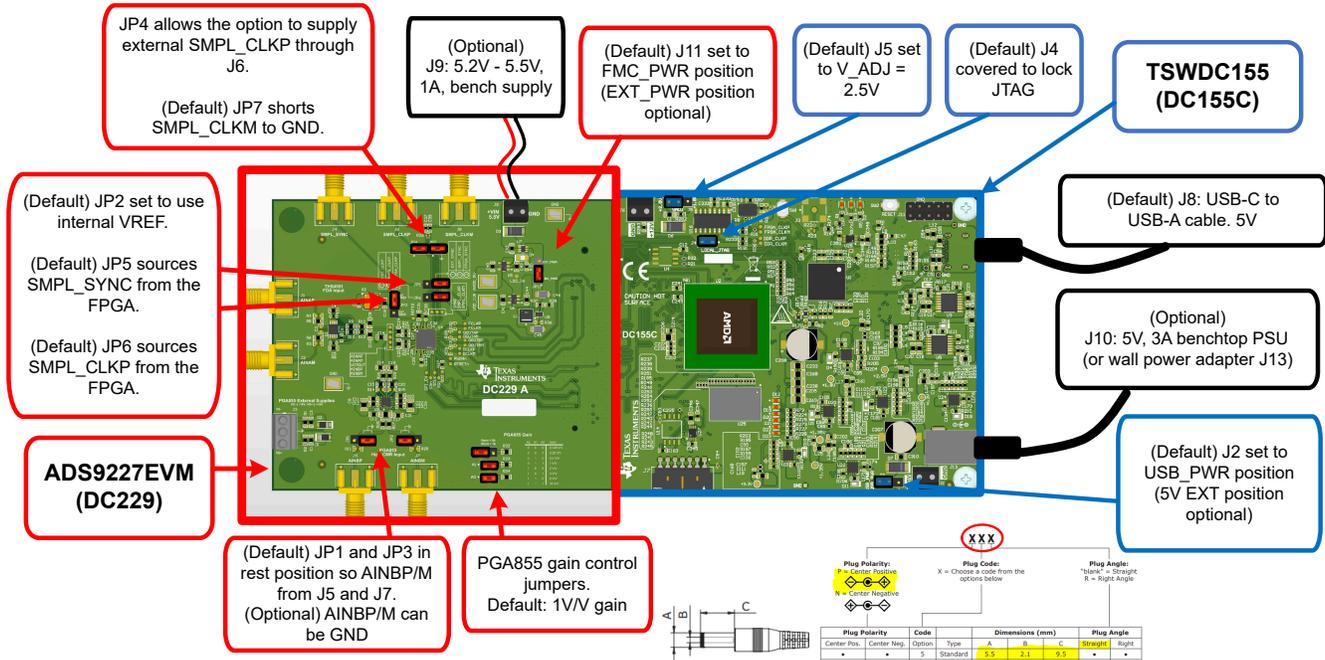


Figure 2-8. Connecting the Hardware

1. Install the GUI as described in [Section 3.1.1](#).
2. Install the necessary USB drivers as described in [Section 3.1.2](#).
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 3.1.3](#) for details).
5. Connect a 10 V_{PP}, single-ended sine wave signal from a function generator to any AINxP SMA input connector.
6. Press the *EN SYNC* button on the *Capture* tab.
7. Select the number of samples to be at least 32k points, and choose the Hanning window type for best frequency domain results.
8. Press the *Start Capture* button to collect and analyze the data displayed on the appropriate CHx tab; see [Figure 3-6](#).

3 Software

3.1 ADS9227EVM Software Reference

3.1.1 ADS9227EVM-GUI Software Installation

This section details the installation and operation of the ADS9227EVM software graphical user interfaces (GUI). These software require the TSWDC155EVM (sold separately) controller to operate. The first step to installing the software (as shown in [Figure 3-1](#)) is to download the latest version of the EVM GUI installer as per [Table 3-1](#).

Table 3-1. EVM GUI Installer

EVM	Software Download Link
ADS9227EVM	ADS9227EVM-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. 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. [Figure 3-1](#) and [Figure 3-2](#) show these steps.

Note

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

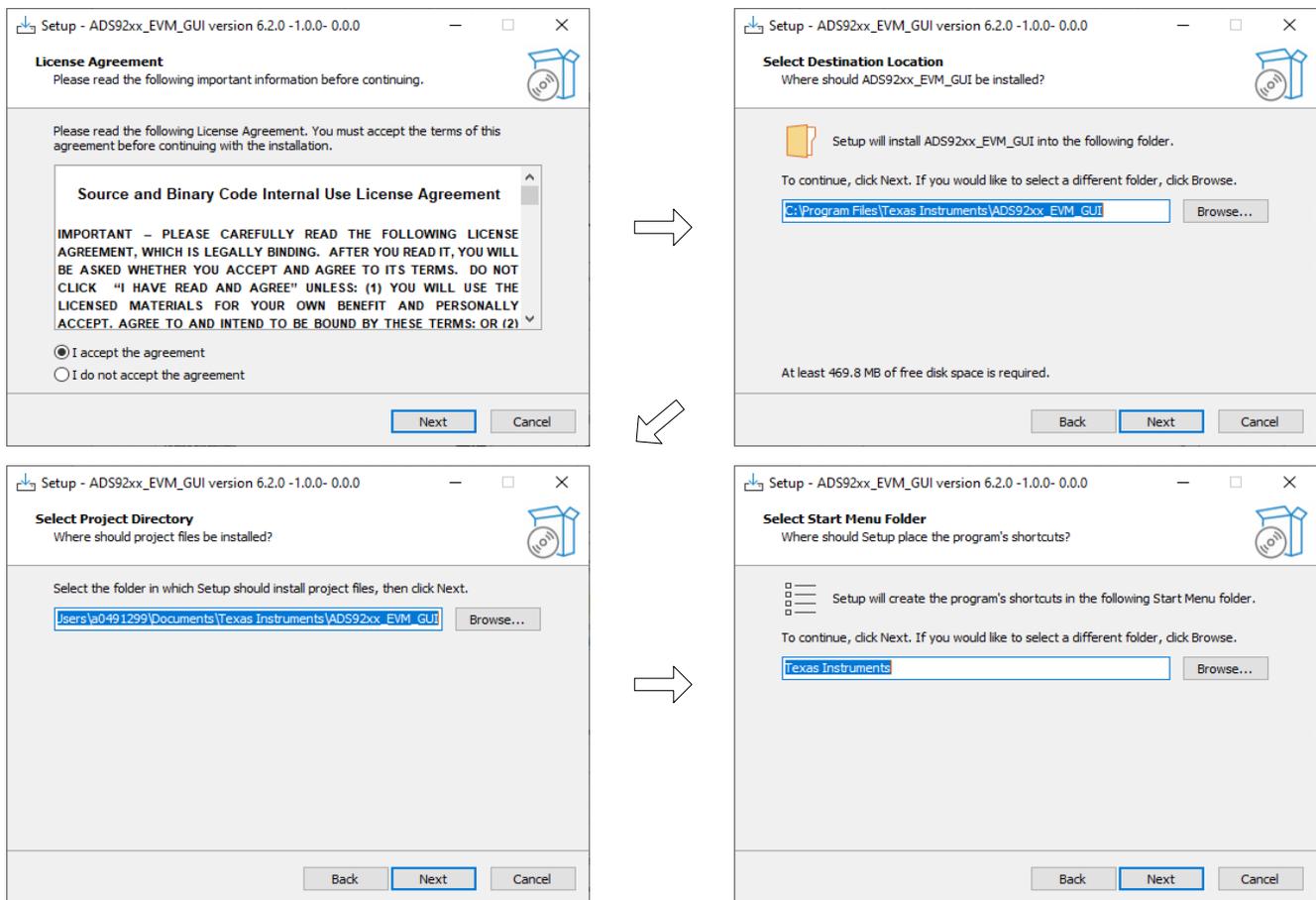


Figure 3-1. Software Installation - Part 1

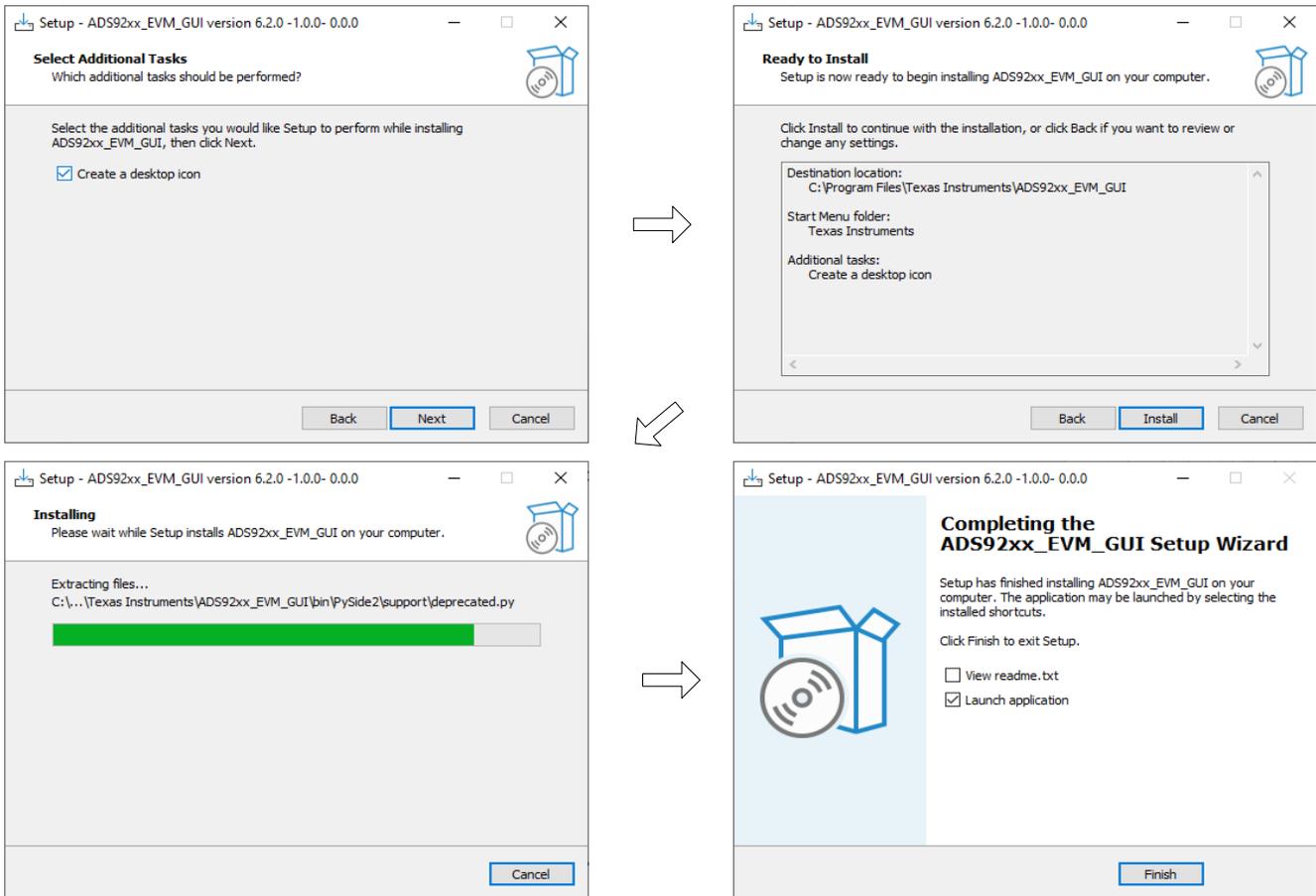


Figure 3-2. Software Installation - Part 2

3.1.2 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, as shown in [Figure 3-3](#), and right-click on the *WestBridge* folder in the Device Manager window and select the *Update Driver* button (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. `C:\Program Files\Texas Instruments\ADS92xx\bin\proj_lib\Sparrow\Bootloader`



Figure 3-3. Open Device Manager

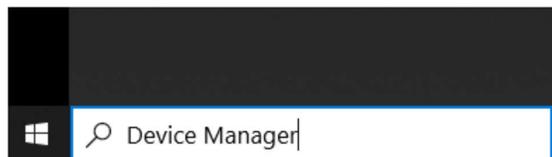
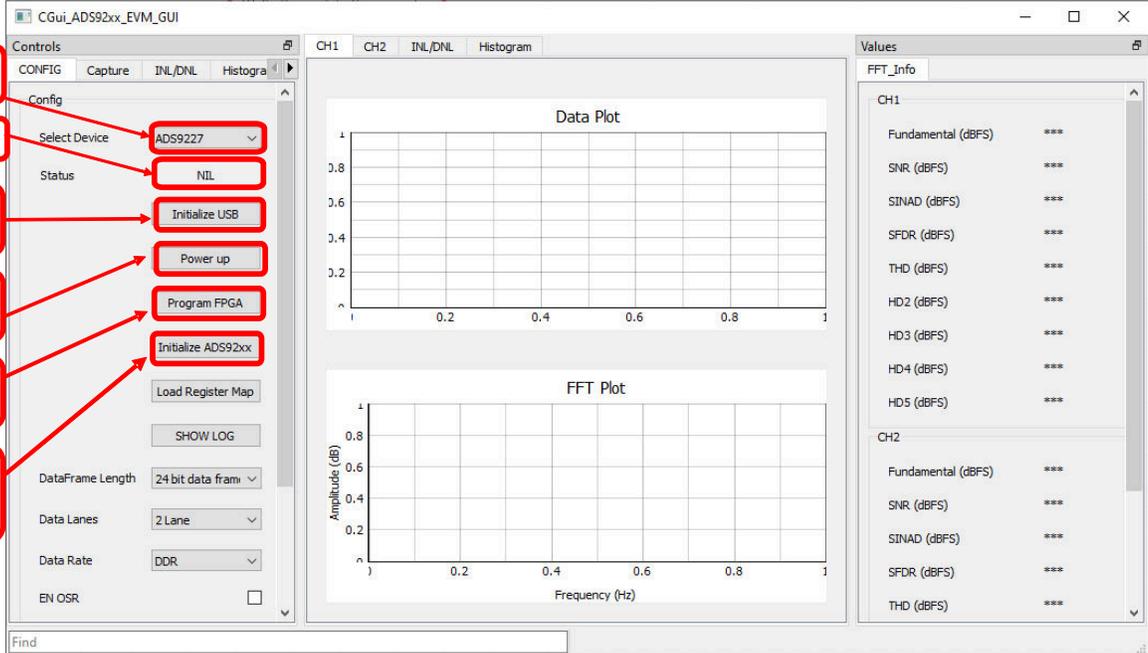


Figure 3-4. Update Driver With Device Manager

3.1.3 Using the CONFIG Tab

After the EVM GUI starts, 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 ADS9227EVM is on and the ADS9227 device registers are configured.

Press the buttons circled below. Wait after each button press for the status to indicate that the step is complete.



The screenshot shows the 'CGui_ADS92xx_EVM_GUI' window. On the left, the 'Controls' tab is active, showing a 'Config' sub-tab. The 'Select Device' dropdown is set to 'ADS9227'. The 'Status' field shows 'NIL'. Below this are four buttons: 'Initialize USB', 'Power up', 'Program FPGA', and 'Initialize ADS92xx'. To the right of the controls are two empty plots: 'Data Plot' and 'FFT Plot'. On the far right, the 'Values' panel shows 'FFT_Info' for 'CH1' and 'CH2', with various metrics like Fundamental (dBFS), SNR (dBFS), SINAD (dBFS), SFDR (dBFS), THD (dBFS), HD2 (dBFS), HD3 (dBFS), HD4 (dBFS), and HD5 (dBFS) all showing '***'.

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

3.1.4 Using the Capture Tab

In Figure 3-6, shows an example data capture display. 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). Finally, 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 1 or channel 2.



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

3.1.5 Using the INL/DNL Tool

The INL/DNL tool measures the linearity of the of the ADS9227EVM 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](#).

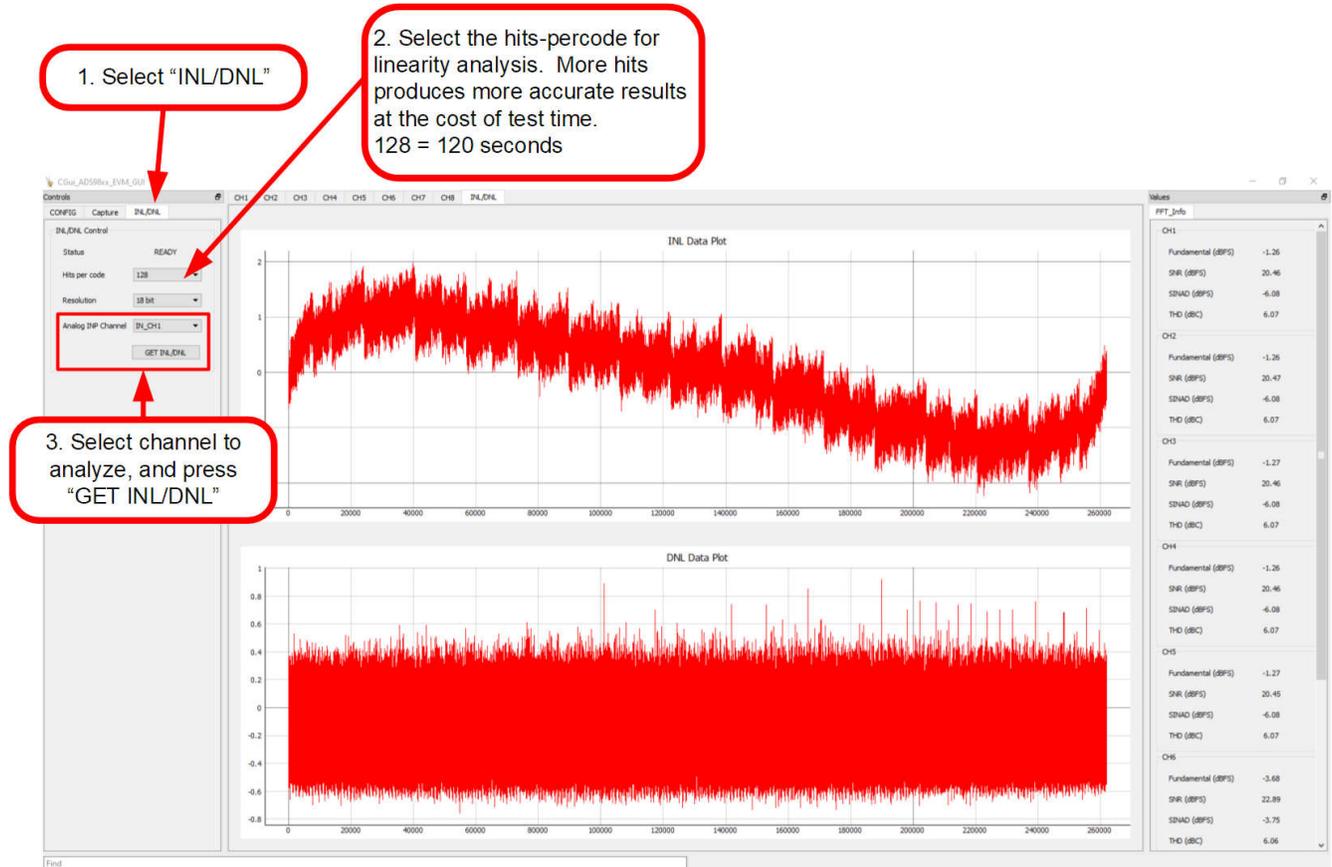


Figure 3-7. Using the INL/DNL Tool

3.1.6 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

4 Hardware Design Files

4.1 Schematics

The schematics below show the various connections to the ADS9227 device. The digital signals connect to J10, as shown in , and the analog signals connect to SMA connectors and input filtering. also shows the decoupling for the device.

Place 0.1 μ F capacitors directly between:
1. Pins 1 (AVDD_5V) and 2 (GND)
2. Pins 1 (AVDD_5V) and 40 (REFM)
3. Pins 9 (GND) and 10 (AVDD_5V)
4. Pins 10 (AVDD_5V) and 11 (REFM)

Place 0.1 μ F capacitors directly between:
1. Pins 12 (GND) and 13 (AVDD_1V8)
2. Pins 37 (AVDD_1V8) and 38 (GND)

Place 0.1 μ F capacitors directly between:
1. Pins 14 (DVDD_1V8) and 15 (GND)
2. Pins 34 (GND) and 35, 36 (DVDD_1V8)

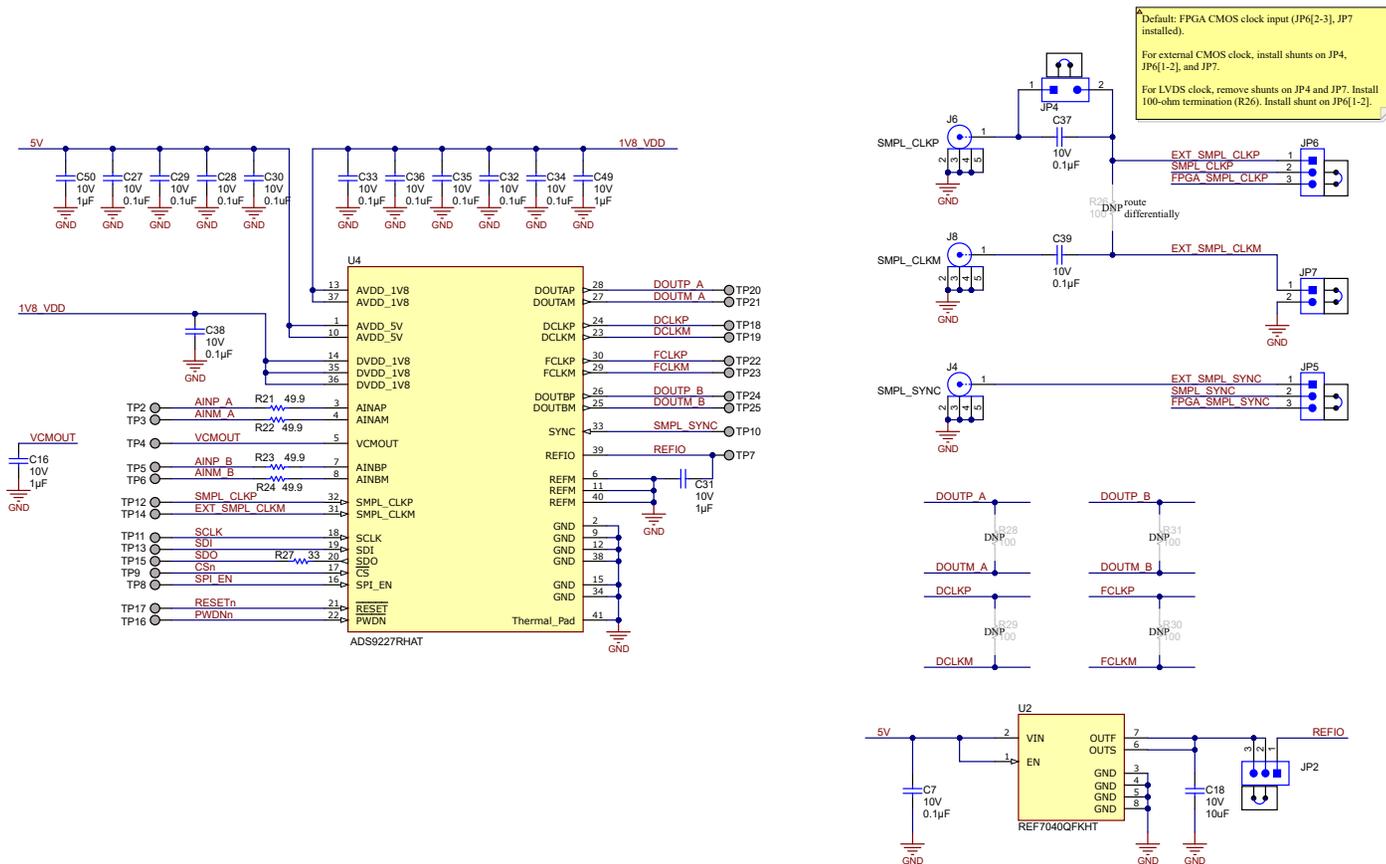


Figure 4-1. ADS9227 Device Connections Schematic

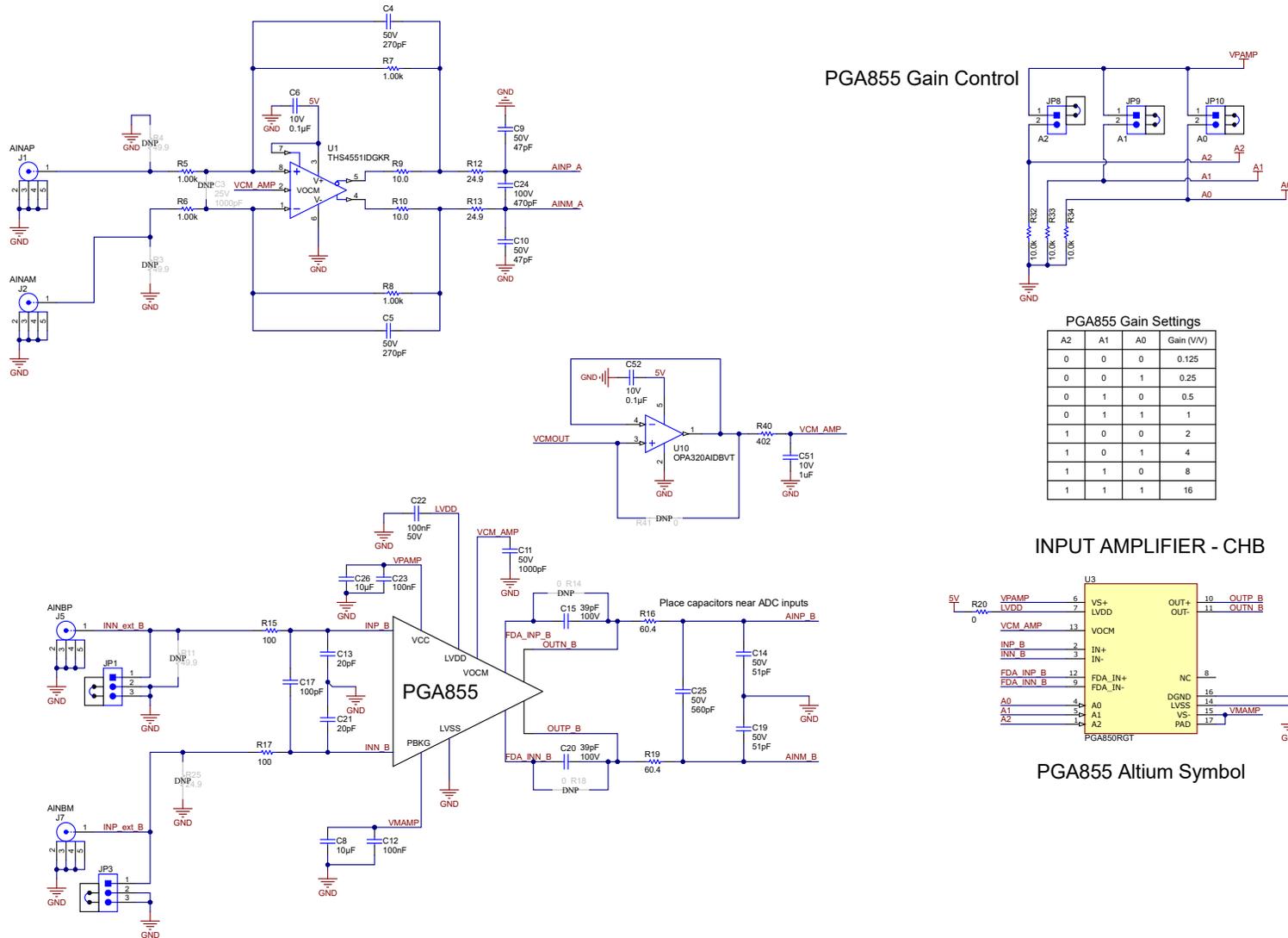


Figure 4-2. Input Connections

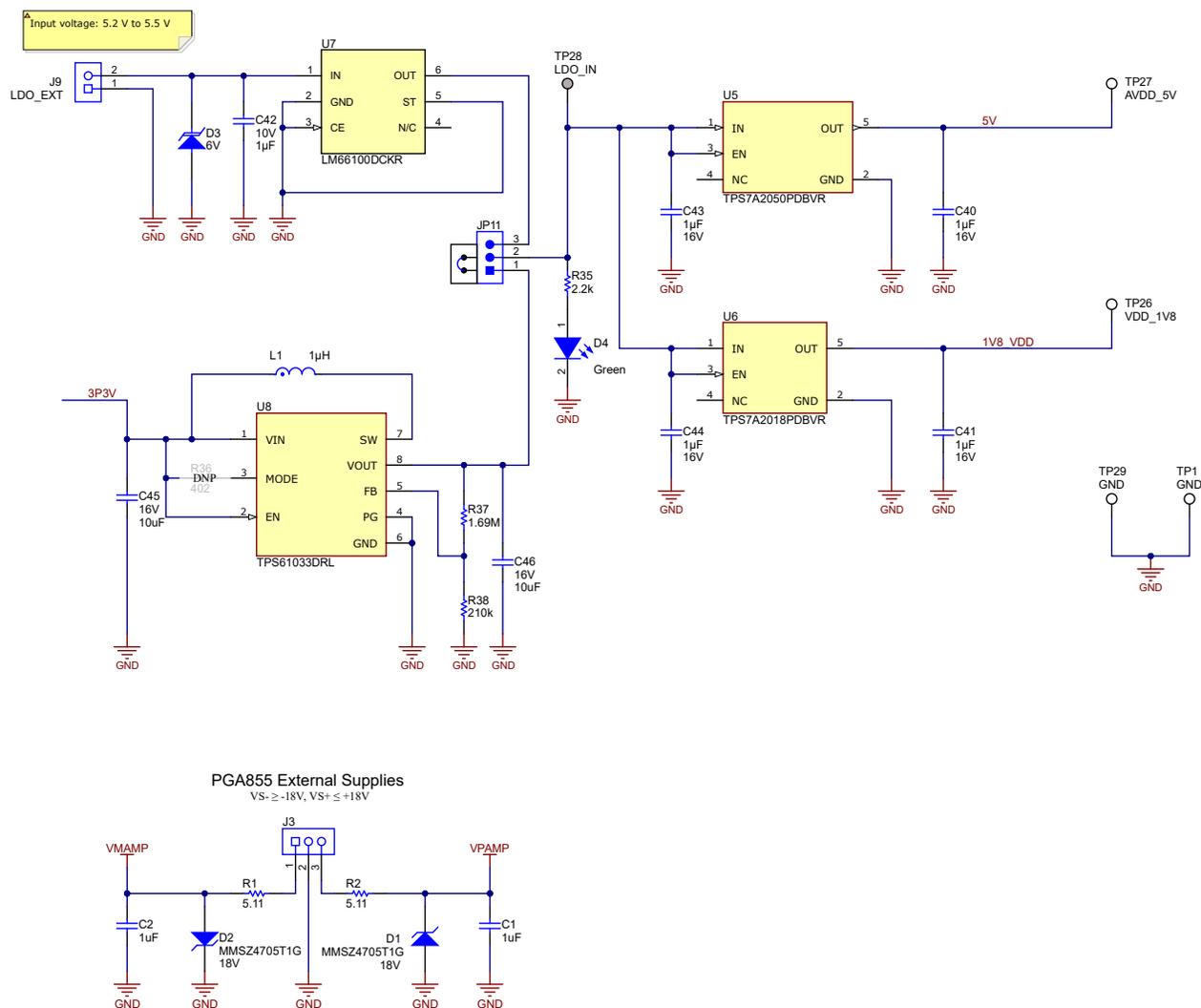


Figure 4-3. Power Connections and Regulators Schematic

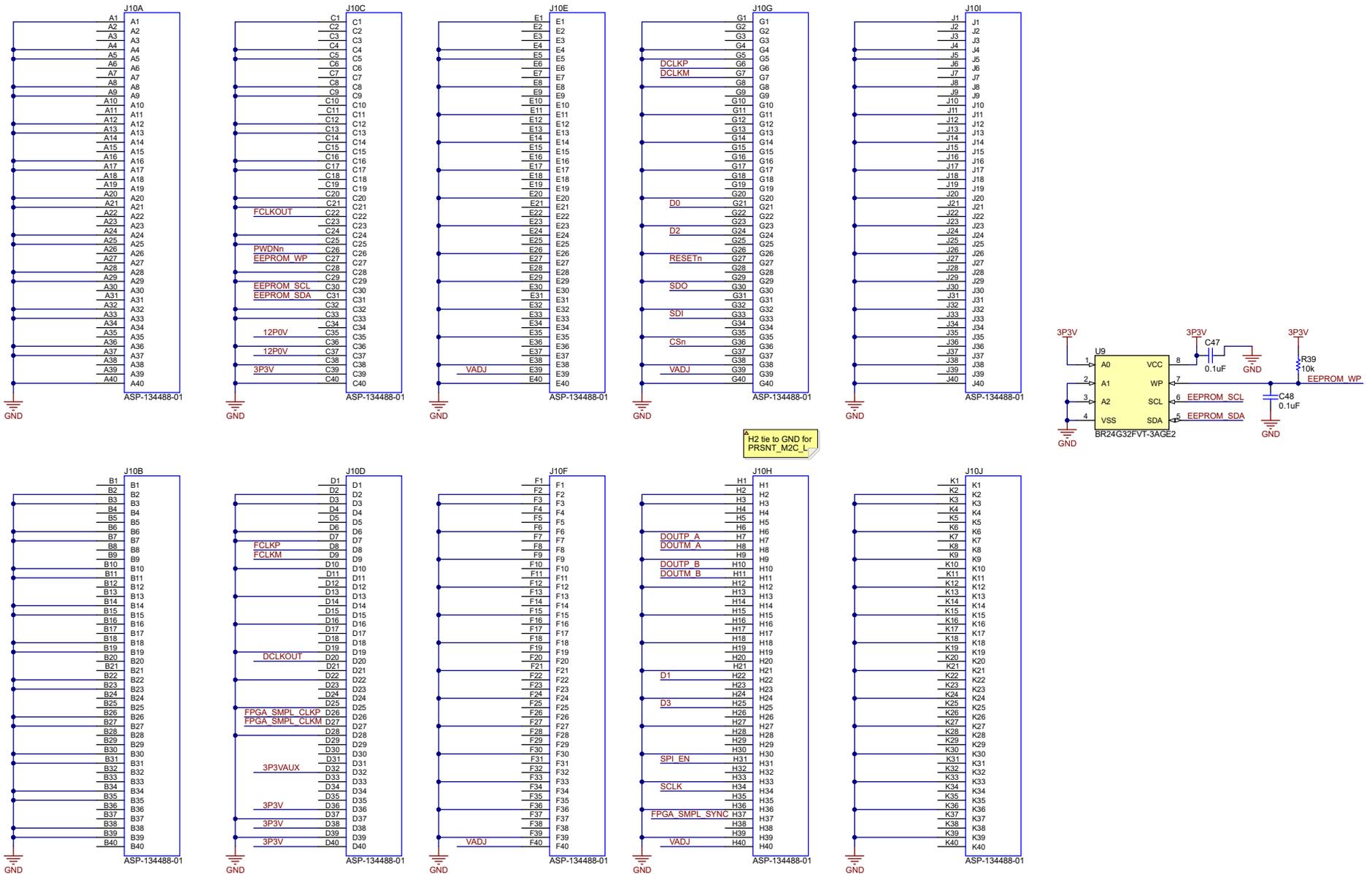


Figure 4-4. Digital Connector Schematic

4.2 PCB Layout

The figures below show the PCB layer plots for the ADS9227EVM.

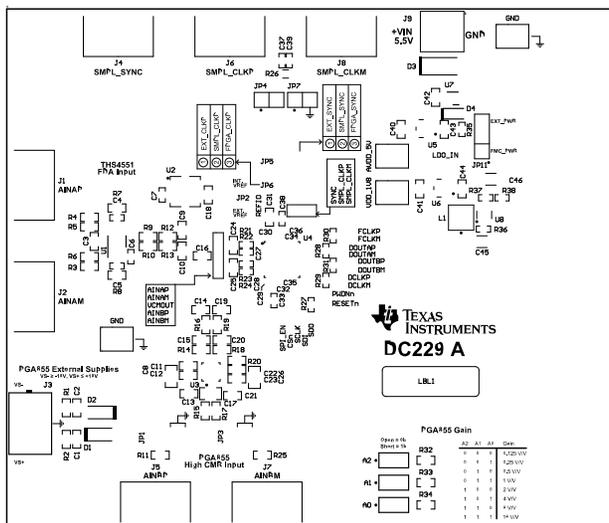


Figure 4-5. Top Overlay

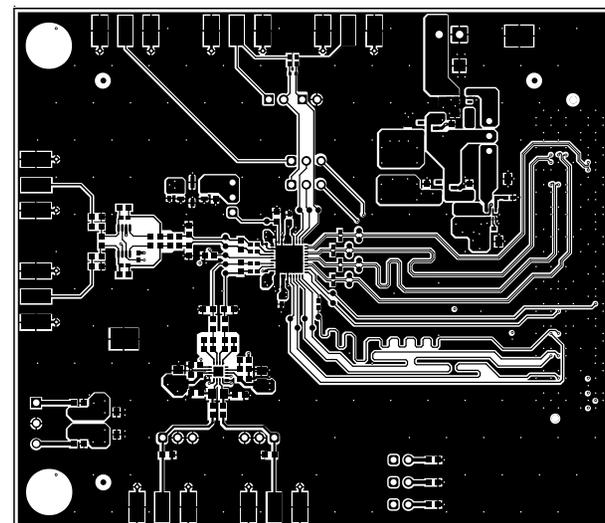


Figure 4-6. Top Layer

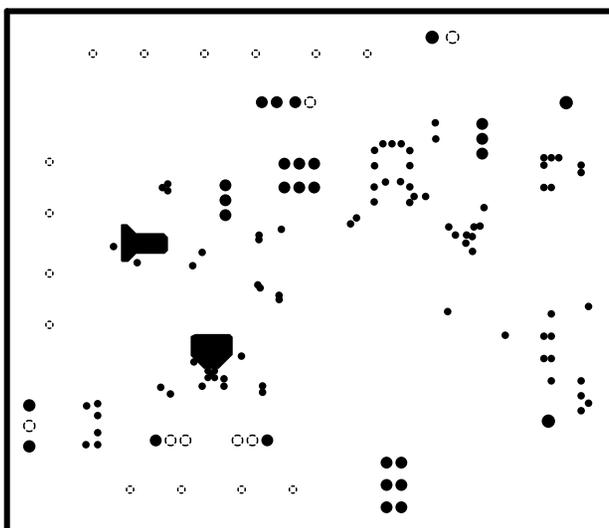


Figure 4-7. GND Layer

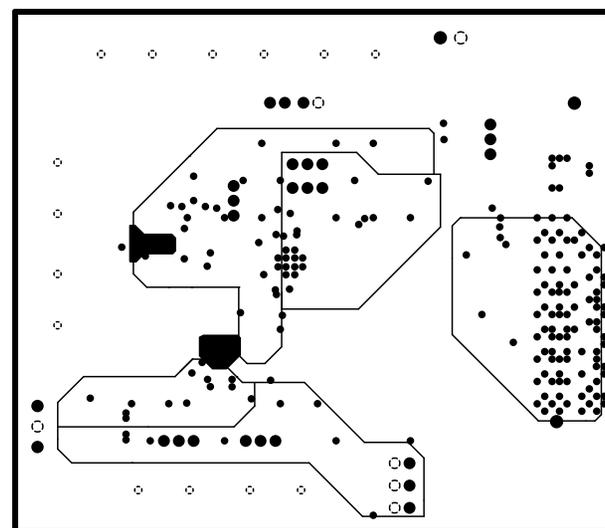


Figure 4-8. Power Layer

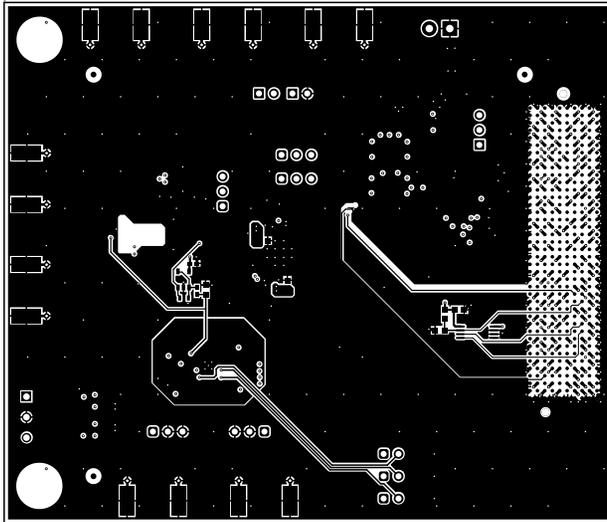


Figure 4-9. Bottom Layer

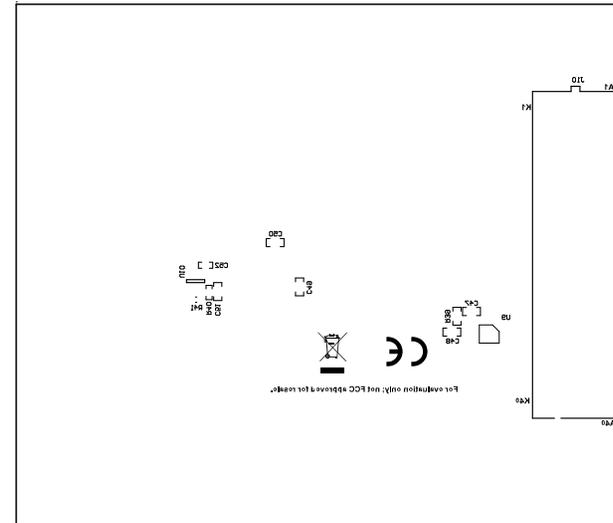


Figure 4-10. Bottom Overlay

4.3 Bill of Materials (BOM)

Table 4-1 lists the ADS9227EVM bill of materials.

Table 4-1. ADS9227EVM Bill of Materials

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
C1, C2	2	1uF	CAP, CERM, 1uF, 25V, +/- 10%, X7R, 0603	603	C0603C105K3RACTU	Kemet
C4, C5	2	270pF	CAP, CERM, 270pF, 50V, +/- 1%, C0G/NP0, 0402	402	GRM1555C1H271FA01D	MuRata
C6, C7, C33, C38, C52	5	0.1uF	CAP, CERM, 0.1uF, 10V,+/- 10%, X7R, 0402	402	C0402C104K8RACTU	Kemet
C8, C26	2	10uF	CAP, CERM, 10uF, 10V,+/- 10%, X7R, 0805	805	GRM21BR71A106KA73L	MuRata
C9, C10	2	47pF	CAP, CERM, 47pF, 50V, +/- 5%, C0G/NP0, 0603	603	GRM1885C1H470JA01D	MuRata
C11	1	1000pF	CAP, CERM, 1000pF, 50V, +/- 5%, C0G/NP0, 0603	603	C0603C102J5GAC	Kemet
C12, C23	2	0.1uF	CAP, CERM, 0.1uF, 25V, +/- 5%, X7R, 0603	603	C0603C104J3RACTU	Kemet
C13, C21	2	20pF	CAP, CERM, 20pF, 50V, +/- 5%, C0G/NP0, 0603	603	GRM1885C1H200JA01D	MuRata
C14, C19	2	51pF	CAP, CERM, 51 pF, 50 V,+/- 1%, C0G/NP0, 0603	603	C0603C510F5GAC7867	Kemet
C15, C20	2	39pF	CAP, CERM, 39 pF, 100 V, +/- 5%, C0G/NP0, 0603	603	GRM1885C2A390JA01D	MuRata
C16, C31, C42, C49, C50	5	1uF	CAP, CERM, 1 uF, 10 V,+/- 10%, X7R, 0603	603	0603ZC105KAT4A	AVX
C17	1	100pF	CAP, CERM, 100 pF, 50 V, +/- 5%, C0G/NP0, 0805	805	08055A101JAT2A	AVX
C18	1	10uF	CAP, CERM, 10 uF, 10 V, +/- 20%, X6S, 0603	603	GRM188C81A106MA73D	MuRata
C22	1	0.1uF	CAP, CERM, 0.1 uF, 50 V, +/- 10%, X7R, 0603	603	8.85012E+11	Wurth Elektronik
C24	1	470pF	CAP, CERM, 470 pF, 100 V, +/- 5%, C0G/NP0, 0603	603	GRM1885C2A471JA01D	MuRata
C25	1	560pF	CAP, CERM, 560 pF, 50 V, +/- 5%, C0G/NP0, 0603	603	C0603C561J5GACTU	Kemet
C27, C28, C29, C30, C32, C34, C35, C36	8	0.1uF	CAP, CERM, 0.1 uF, 10 V, +/- 10%, X5R, 0201	201	CL03A104KP3NUNC	Samsung Electro-Mechanics
C37, C39	2	0.1uF	CAP, CERM, 0.1 uF, 10 V,+/- 10%, X7R, AEC-Q200 Grade 1, 0402	402	C0402C104K8RACAUTO	Kemet

Table 4-1. ADS9227EVM Bill of Materials (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
C40, C41, C43, C44	4	1uF	CAP, CERM, 1 uF, 16 V, +/- 10%, X7R, 0603	603	C1608X7R1C105K080AC	TDK
C45, C46	2	10uF	CAP, CERM, 10 uF, 16 V, +/- 10%, X7R, 1206	1206	GRM31CR71C106KAC7L	MuRata
C47, C48	2	0.1uF	CAP, CERM, 0.1 uF, 25 V, +/- 5%, X7R, 0603	603	06033C104JAT2A	AVX
C51	1	1uF	CAP, CERM, 1 uF, 10 V, +/- 10%, X5R, 0603	603	C0603C105K8PACTU	Kemet
D1, D2	2	18V	Diode, Zener, 18 V, 500 mW, SOD-123	SOD-123	MMSZ4705T1G	ON Semiconductor
D3	1	6V	Diode, TVS, Uni, 6 V, 10.3 Vc, 400 W, 38.8 A, SMA	SMA	SMAJ6.0A	Littelfuse
D4	1	Green	LED, Green, SMD	LED_0805	APT2012LZGCK	Kingbright
H1, H2	2		MACHINE SCREW PAN PHILLIPS M3	M3 Screw	RM3X8MM 2701	APM HEXSEAL
H3, H4	2		Standoff, Hex,25mm Length, M3, Aluminum	Standoff M3	24438	Keystone
J1, J2, J4, J5, J6, J7, J8	7		Connector, End launch SMA, 50 ohm, SMT	End Launch SMA	142-0701-801	Cinch Connectivity
J3	1		Terminal Block, 3.5 mm, 3x1, Tin, TH	Terminal Block, 3.5 mm, 3x1, TH	393570003	Molex
J9	1		Terminal Block, 3.5mm Pitch, 2x1, TH	7.0x8.2x6.5mm	ED555/2DS	On-Shore Technology
J10	1		Connector, 1.27mm, 40x10, Black, SMT	Connector, 1.27mm, 40x10, SMT	ASP-134488-01	Samtec
JP1, JP2, JP3, JP5, JP6	5		Header, 100mil, 3x1, Gold, TH	3x1 Header	TSW-103-07-G-S	Samtec
JP4, JP7	2		Header, 100mil, 2x1, Gold, TH	Header, 100mil, 2x1, TH	HTSW-102-07-G-S	Samtec
JP8, JP9, JP10	3		Header, 100mil, 2x1, Gold, TH	2x1 Header	TSW-102-07-G-S	Samtec
JP11	1		Header, 100mil, 3x1, Gold, TH	Header, 100mil, 3x1, TH	HTSW-103-07-G-S	Samtec
L1	1		Shielded Power Inductors	SMT_IND_4MM0_4MM0	XGL4020-102MEC	Coilcraft
LBL1	1		Thermal Transfer Printable Labels, 0.650" W x 0.200" H - 10,000 per roll	PCB Label 0.650 x 0.200 inch	THT-14-423-10	Brady
R1, R2	2	5.11	RES, 5.11, 1%, 0.1 W, 0603	603	RC0603FR-075R11L	Yageo
R5, R6, R7, R8	4	1.00k	RES, 1.00 k, 0.1%, 0.1 W, 0603	603	RT0603BRD071KL	Yageo America
R9, R10	2	10	RES, 10.0, 0.1%, 0.1 W, 0603	603	CRT0603-BY-10R0ELF	Bourns
R12, R13	2	24.9	RES, 24.9, 0.1%, 0.1 W, 0603	603	RT0603BRD0724R9L	Yageo America
R15, R17	2	100	RES, 100, 0.1%, 0.1 W, 0603	603	RT0603BRD07100RL	Yageo America
R16, R19	2	47	RES, 47.0, 0.1%, 0.1 W, 0603	603	RT0603BRD0747RL	Yageo America
R20	1	0	RES, 0, 5%, 0.1 W, 0603	603	RC0603JR-070RL	Yageo

Table 4-1. ADS9227EVM Bill of Materials (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
R21, R22, R23, R24	4	49.9	RES, 49.9, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	402	CRCW040249R9FKED	Vishay-Dale
R27	1	33	RES, 33, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	402	CRCW040233R0JNED	Vishay-Dale
R32, R33, R34	3	10.0k	RES, 10.0 k, 1%, 0.1 W, 0603	603	RCG060310K0FKEA	Vishay Draloric
R35	1	2.2k	RES, 2.2 k, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	402	CRCW04022K20JNED	Vishay-Dale
R37	1	1.69Meg	RES, 1.69 M, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	402	CRCW04021M69FKED	Vishay-Dale
R38	1	210k	RES, 210 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0402	402	ERJ-2RKF2103X	Panasonic
R39	1	10k	RES, 10 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	603	CRCW060310K0JNEA	Vishay-Dale
R40	1	402	RES, 402, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	402	CRCW0402402RFKED	Vishay-Dale
SH-J1, SH-J2, SH-J3, SH-J4, SH-J5, SH-J6, SH-J7, SH-J8, SH-J9, SH-J10, SH-J11	11	1x2	Shunt, 100mil, Gold plated, Black	Shunt	SNT-100-BK-G	Samtec
TP1, TP26, TP27, TP29	4		Test Point, Compact, SMT	Testpoint_Keystone_Compact	5016	Keystone Electronics
U1	1		Low Noise, Precision, 150MHz, Fully Differential Amplifier, DGK0008A (VSSOP-8)	DGK0008A	THS4551IDGKR	Texas Instruments
U2	1		2 ppm/°C Maximum Drift, 0.23 ppm-p 1/f Noise, Precision Voltage Reference	LCCC8	REF7040QFKHT	Texas Instruments
U3	1		PGA850RGT	VQFN17	PGA850RGT	Texas Instruments
U4	1		Dual, Simultaneous Sampling, 16-bit, 5-MSPS SAR ADC with Fully Differential ADC Input Driver	VQFN40	ADS9227RHAT	Texas Instruments
U5	1		300-mA, ultra-low-noise, low-IQ, low-dropout (LDO) linear regulator with high PSRR 5-SOT-23 -40 to 125	SOT23-5	TPS7A2050PDBVR	Texas Instruments
U6	1		Linear Voltage Regulator IC Positive Fixed 1 Output 300mA SOT-23-5	SOT23-5	TPS7A2018PDBVR	Texas Instruments
U7	1		+/-6V, Low IQ Ideal Diode with Input Polarity Protection, DCK0006A (SOT-SC70-6)	DCK0006A	LM66100DCKR	Texas Instruments
U8	1		5.0-A 2.4-MHz High Efficiency Boost Converter	SOT-5X3	TPS61033DRL	Texas Instruments
U9	1		I2C BUS EEPROM (2-Wire), TSSOP-B8	TSSOP-8	BR24G32FVT-3AGE2	Rohm

Table 4-1. ADS9227EVM Bill of Materials (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
U10	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 (DBV5), Green (RoHS & no Sb/Br)	DBV0005A	OPA320AIDBVT	Texas Instruments

5 Additional Information

Trademarks

Microsoft® and Windows® are registered trademarks of Microsoft Corporation. All trademarks are the property of their respective owners.

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

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 DEGRADATION 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/lstds/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。

<https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-delivered-in-japan.html>

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。

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3.3.3 *Notice for EVMs for Power Line Communication:* Please see http://www.tij.co.jp/lstds/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。 <https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-for-power-line-communication.html>

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:*
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