ADS9327 Evaluation Module

Description

The ADS9327 evaluation module (EVM) is a platform for evaluating the performance of the ADS9327 and ADS93xx family of devices. The ADS9327 is a 2-channel, simultaneous-sampling, 16-bit resolution, 5-MSPS successive approximation register (SAR) analog-to-digital converter (ADC) with integrated reference. The ADS9327EVM includes an FMC connector that interfaces with standard FPGA development boards, as well as a header connector to enable compatibility in diverse development environments. The computer software paired with the ADS9327EVM works with the TWSDC155EVM (sold separately) and is provided to enable the user to communicate to the ADC over USB for data capture, configuration, and analysis.

Get Started

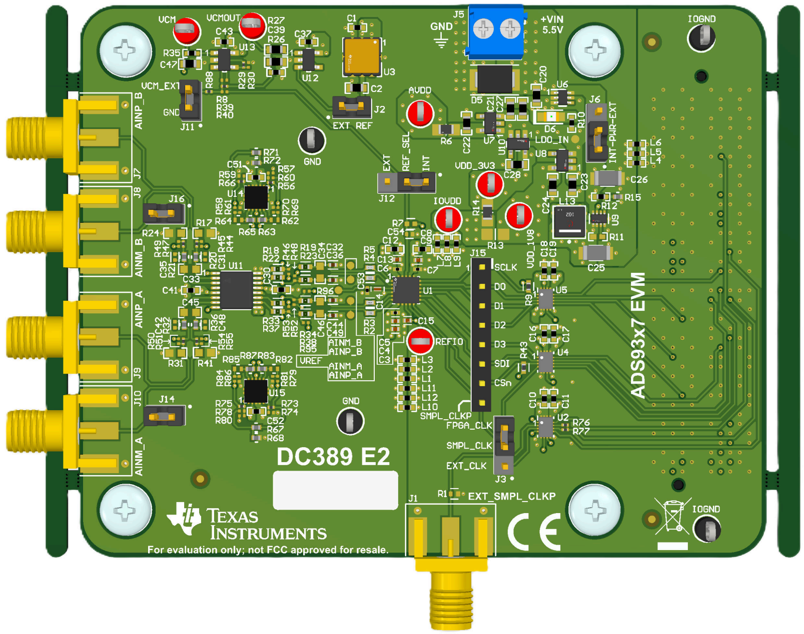
1. Order ADS9327EVM and TSWDC155EVM controller on ti.com.
2. Visit the ADS9327 Tool Folder to download the ADS9327 EVM GUI.

Features

- ADS9327EVM has the hardware required for diagnostic testing and accurate performance evaluation of the ADS9327 ADC.
- TSWDC155EVM controller (sold separately) provides all necessary digital I/O signals and power rails required for operating the ADS9327EVM.
- Easy-to-use evaluation GUI for Microsoft® Windows® 10 and 11, 64-bit operating systems requires the TSWDC155EVM (sold separately) for operation.
- The included software suite features graphical tools for data capture, spectral analysis, and linearity measurements.

Applications

- Absolute optical encoders
- Absolute magnetic encoders
- Servo drive position feedback
- Ultrasound scanners
- Programmable DC power supplies, electronic loads
- SONAR



ADS9327 Evaluation Module

1 Evaluation Module Overview

1.1 Introduction

This user's guide describes the characteristics, operation, and use of the ADS9327 evaluation module (EVM). The ADS9327 EVM is an evaluation platform for the ADS9327 device. The EVM eases the evaluation of the ADS9327 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 ADS9327EVM.

1.2 Kit Contents

The ADS9327EVM includes a standard FMC connector on the bottom of the PCB. The FMC connector can connect 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).

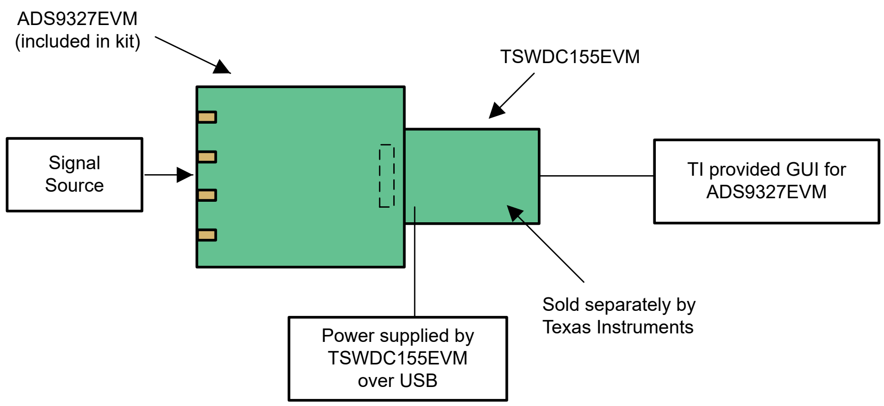


Figure 1-1. Block diagram of EVM Setup: ADS9327EVM, TSWDC155EVM, and GUI

1.3 Specification

The block diagrams in Figure 1-2 and Figure 1-2 depict the connections and basic subsystems of the ADS9327EVM.

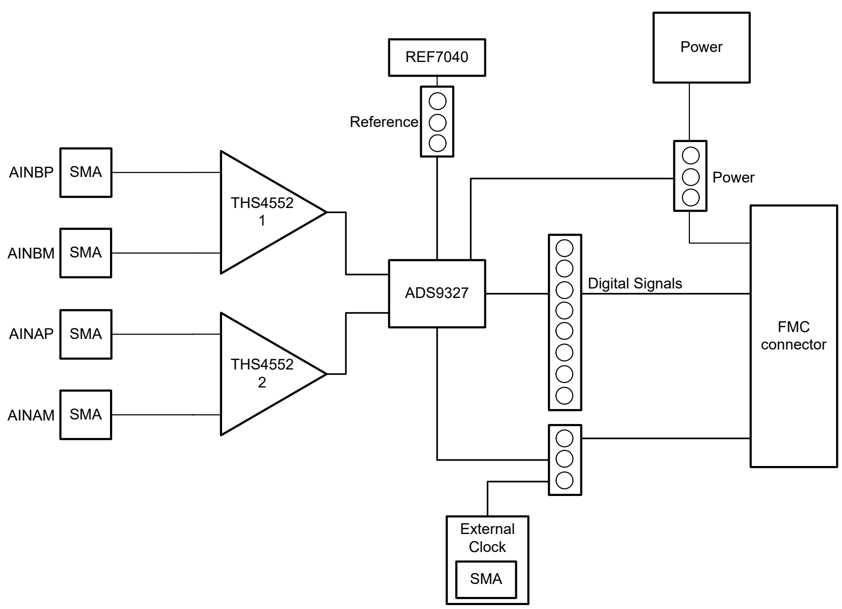


Figure 1-2. ADS9327EVM Block Diagram

1.4 Device Information

The ADS9327 is an 16-bit, 5-MSPS per channel, dual-channel, simultaneous-sampling, analog-to-digital converter (ADC). The ADS9327 has a precision voltage reference and reference buffer. Combined with low conversion latency capability, high sampling rates, minimal AC and DC errors, and low temperature drift, the ADS9327 is a high-performance design for applications requiring both precision and speed. The ADS9327 also supports data averaging that further improves AC performance.

The SPI-compatible serial interface enables and eases pairing with diverse types of digital controllers, digital signal processors (DSPs), and field-programmable arrays (FPGAs).

2 Hardware

2.1 ADS9327EVM Quick Start Guide

The following instructions are a step-by-step guide to connecting the ADS9327EVM to the computer and evaluating the performance of the ADS9327. Review the default jumper settings and power guidelines in Figure 2-1.

1. Physically connect J1 of the TSWDC155EVM to the J4 of the ADS9327EVM. The TSWDC155EVM is the digital communications and power signal connection in the default configuration in Figure 2-1.
2. Set jumper JP2 to the "INT" [1-2] position so that the TSWDC155EVM provides power to the on-board DC/DC and LDO circuits. If external power supplies are preferred, set JP2 to "EXT" [2-3] and connect an external 5.2V to 5.5V supply on screw terminal connection J5.
3. Connect connect the USB on the TSWDC155EVM directly to the computer.

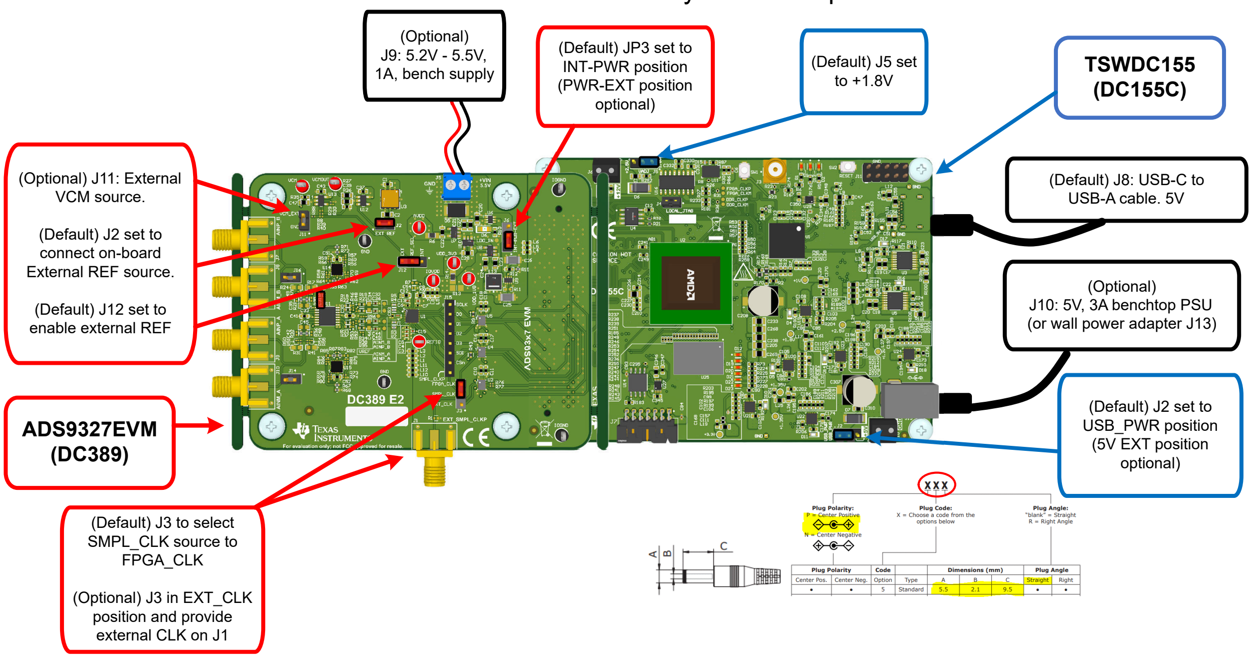


Figure 2-1. Connecting the Hardware

4. Install the GUI as described in Section 3.2.1.
5. Launch the GUI.
6. Press the *Initialize USB*, *Power Up*, *Program FPGA*, and *Initialize ADS9327* buttons, in order from top to bottom, on the *Config* tab to power up and configure the EVM. See Section 3.2.2 for details.
7. Connect an 8VPP, differential sine wave signal from a function generator to at least one pair of differential inputs of the ADC channels through the SMA input connectors:
   a. Channel A: AINP_A (J9) and AINM_A (J10)
   b. Channel B: AINP_B (J7) and AINM_B (J8)
8. Set the number of samples to a minimum of 128k points, and choose the *Hanning* window type for best frequency domain results.
9. Press the *Start Capture* button to collect and analyze the data displayed on the appropriate CHx tab; see Section 3.2.3.

2.2 Analog Interface

This section details the analog input connections to the ADS9327EVM.

2.2.1 Fully-Differential Circuit: THS4552

Figure 2-2 shows the schematic for the THS4552 input circuit connected to each ADC channel. The THS4552 is a dual-channel, low-noise, precision, 150MHz, fully differential amplifier. The THS4552 is configured for a gain of 1V/V and receives single-ended and differential inputs. By default, the THS4552 circuit is tuned for a fully-differential input signal with a 50Ω output impedance. For other input source impedances or differential inputs, remove or adjust the termination resistors from the FDA inputs accordingly. Additionaly the termination resistors can be shorted by using the jumper provided.

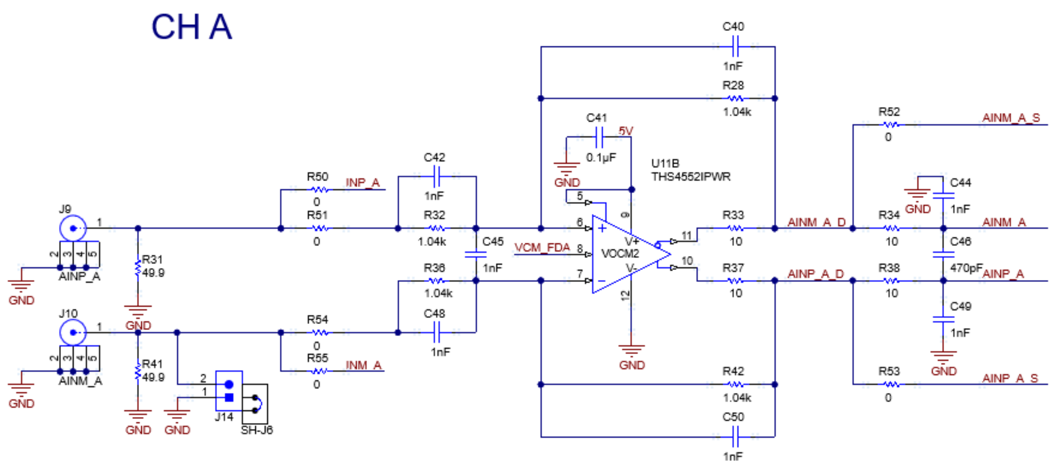


Figure 2-2. THS4541 Fully-Differential Circuit for ADC A

The OPA320, shown in Figure 2-3, is used as the "VCMOUT" buffer to drive the output common-mode voltage on both ADC A and ADC B input circuits. Additional options for sourcing the common-mode voltage are available by populating R39 (default), R40, or R88.

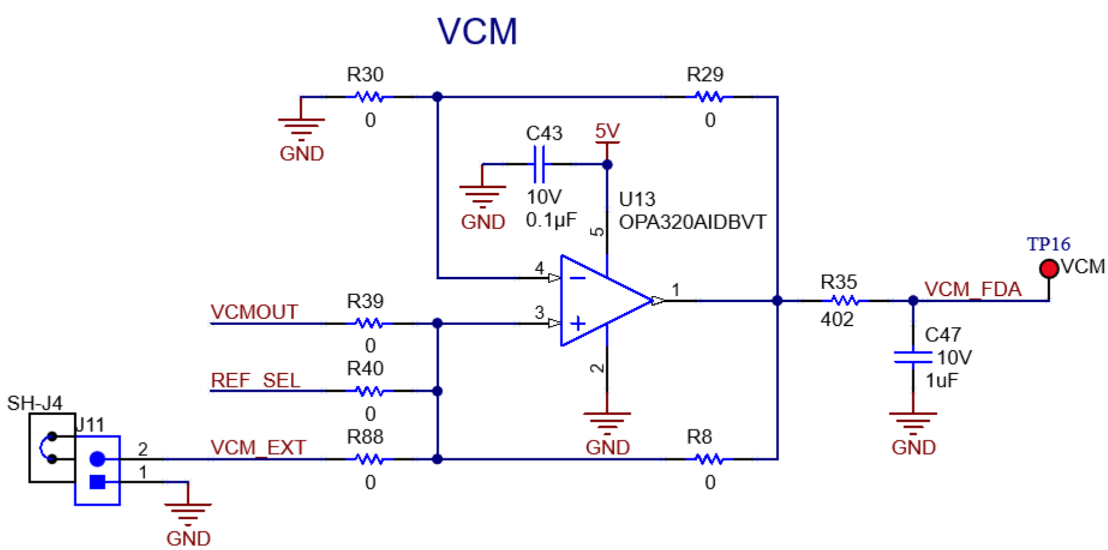


Figure 2-3. OPA320 Circuit to Buffer the ADS9327 VCMOUT Voltage

2.2.2 Voltage Reference

The ADS9327 uses an internal 4.096V reference voltage when AVDD = 5V and an internal reference voltage of 2.5V when AVDD = 3.3V, which is measurable 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 ADS9327EVM 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$_{p\text{-}p}$), 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 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 ADS9327, configure the REFIO pin as an input through the GUI and then install a shunt on jumper J2 in the [1-2] position.

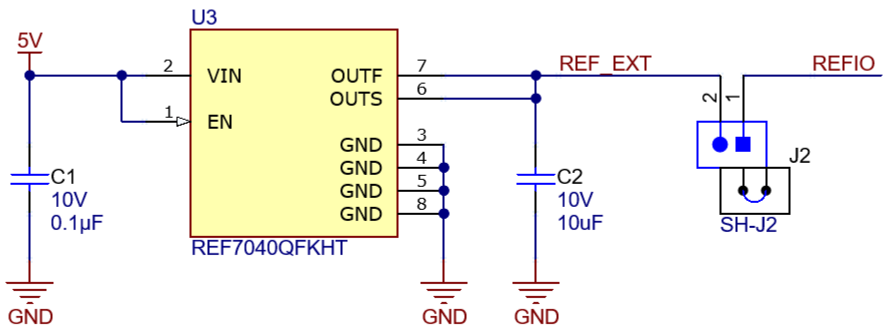


Figure 2-4. External Reference Voltage Using REF7040

2.3 Power Supplies

By default, the TSWDC155EVM provides the ADS9327EVM with a 3.3V supply (*SPRW_SUP_3P3*). The ADS9327EVM has a TPS61033 boost converter which increases the supply from 3.3V to 5.5V. The 5.5V supply applies to the input of three independent low-dropout regulators (LDOs) to provide the required analog and digital supplies for the ADS9327 when J6 is in the [1-2] position. The 5V output from the TPS7A2050 (U7) powers the AVDD 5V supply rail. U8 (TPS7A2018) outputs 1.8V for VDD_1V8 and IOVDD when R13 is populated (default). U10 (TPS7A2033) outputs 3.3V which is an optional source for the IOVDD supply, for this depopulate R13 and populate R14.

Configure the shunt on J6 in the [2-3] position and connect the external supply to terminal block J5 to change the LDO input voltage (LDO_IN) to an external source ranging from 5.2V to 5.5V. In this setup, U6 (LM66100) provides reverse polarity protection in the event that the connection is wired incorrectly.

Figure 2-5 shows the power tree schematic for the ADS9327EVM.

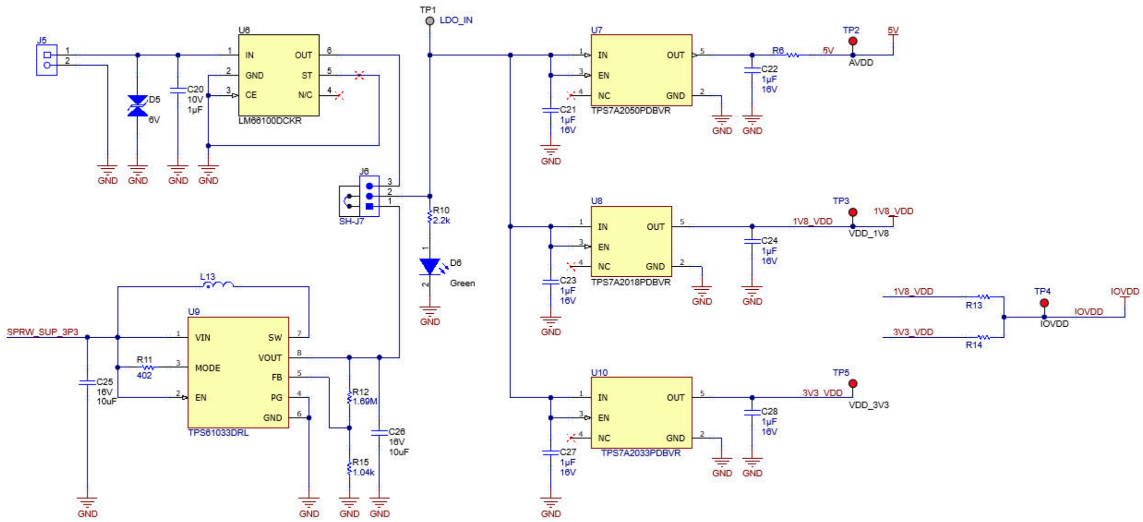


Figure 2-5. Power Entry and Regulators

2.3.1 USB Power and When to Power the Board Externally

As discussed in Section 2.1, the USB-C® connector provides power to the TSWDC155EVM and ADS9327EVM using the default configuration. Section 3.2.2 lists the ADS9327EVM GUI initialization instructions.

The TWDC155EVM is a high-power SuperSpeed (USB 3.0) device, which means a PC can supply up to 900mA from a compliant USB 3.0 port. However, the actual power available from a PC's USB port is often lower than 900mA, due to the unit load handshake process and the presence of 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, switch to an externally powered ADS9327EVM 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 ADS9327EVM, move the jumper on J6 to the [2:3] position and use the J5 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 device enumeration issues and are not recommended when communicating through the TSWDC155EVM.

3 Software

3.1 Digital Interface and Clock Inputs

This section details the digital interface connections and clocking options for the ADS9327EVM.

3.1.1 Digital Interface Connections

The ADS9327 uses an SPI that configures internal device registers and consists of SCLK, SDI, D[3:0], and CSn. Configure the SPI to 1-lane, 2-lane, and 4-lane options to capture data. All of the SPI signals connect to the FMC connector on the EVM. Figure 3-1 provides the FMC connector signal definition. These signals are also available through test points for scope measurements, as indicated in the PCB silkscreen.

The FMC connector pin-out in Figure 3-1 interfaces with standard FPGA development kits.

Note

The TI-provided software GUI is only compatible with the TSWDC155EVM. Third-party software development is not supported.

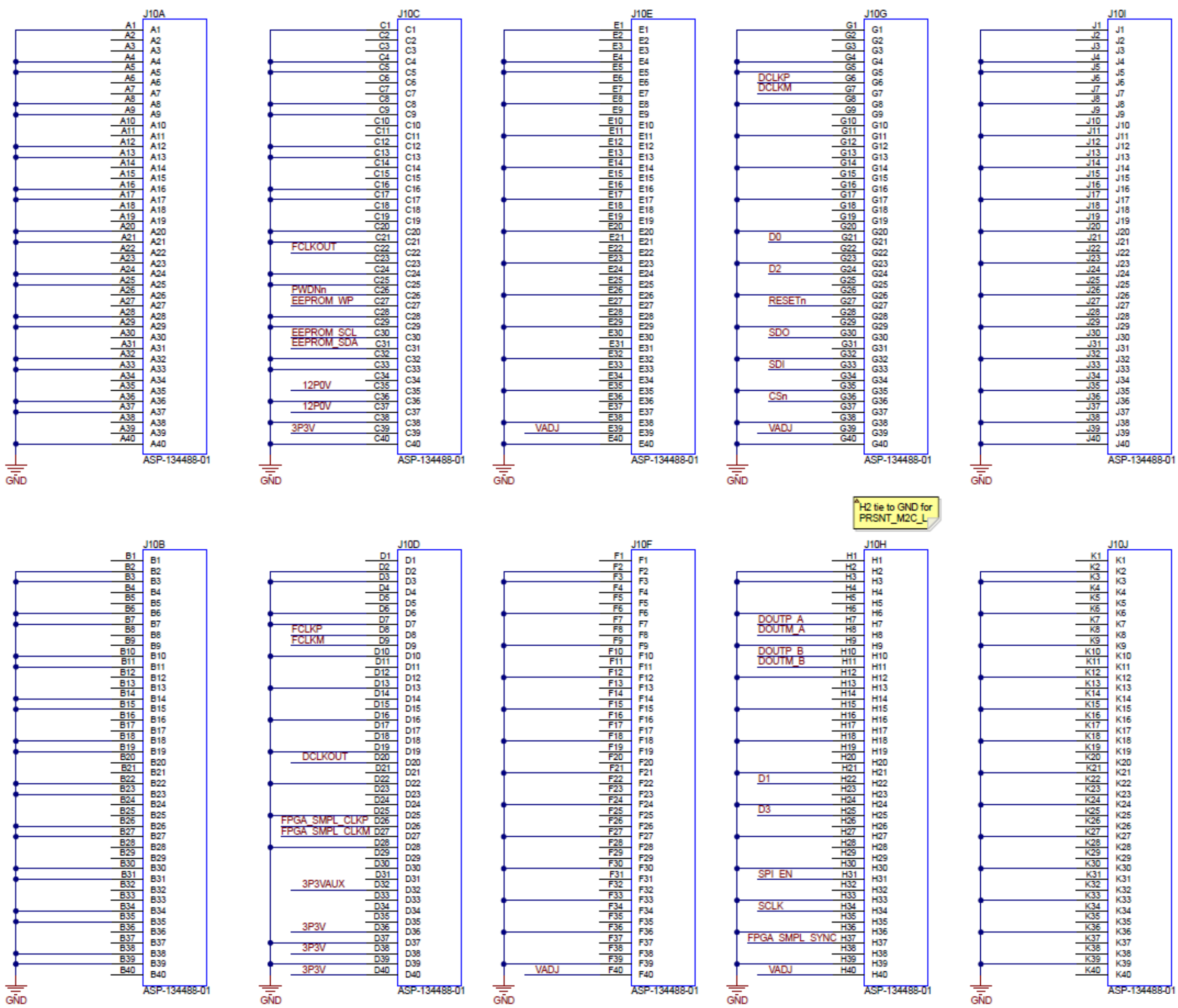


Figure 3-1. Digital I/O

3.1.2 Clock Select

The ADS9327EVM provides two options for supplying the conversion clock to the ADS9327: either a clock signal from the TSWDC155EVM or an external clock source. Table 3-1 and Figure 3-2 provide an overview of the ADS9327 sample clock options available on the EVM. By default, the FPGA controller on the TSWDC155EVM (sold separately) sources a clock that connects directly to the SMPL_CLKP pin on the ADS9327 by configuring J3 in the [2-3] position. The default configuration allows users to select the clock frequency from the options listed in the EVM GUI.

When using an external clock, move J3 into the [1-2] position and connect the external clock source to the SMA connector, J1. To maximize the performance of the ADS9327, establish that any external clock source has low jitter.

Table 3-1. Sample Clock Settings for ADS9327EVM

Sample Clock Source (SMPL_CLK)	J1	J3 (SMPL_CLKP)	R1
TSWDC155EVM	—	[2-3]	Not installed
External	Installed	[1-2]	Not installed

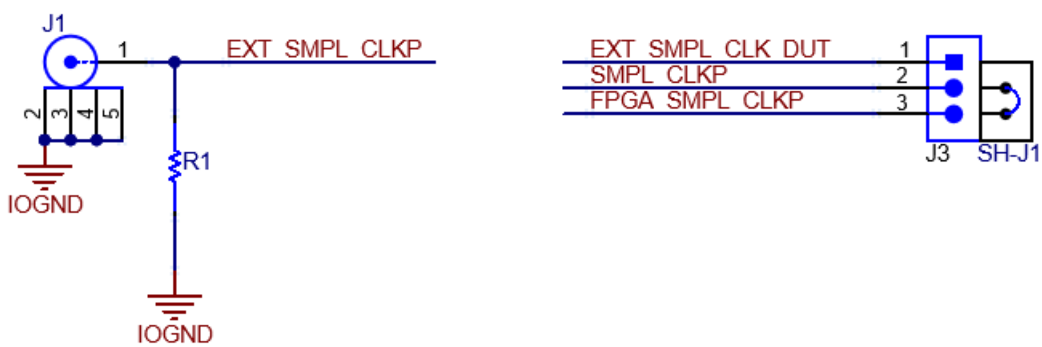


Figure 3-2. Sample Clock Selection

3.2 ADS9327EVM Software Reference

3.2.1 ADS9327EVM-GUI Software Installation

This section details the installation and operation of the ADS9327EVM software graphical user interfaces (GUI). These software require the TSWDC155EVM (sold separately) controller to operate. To install the software (as shown in Figure 3-3):

1. Download the latest version of the EVM GUI installer as per Table 3-2.

Table 3-2. EVM GUI Installer

EVM	Software Download Link
ADS9327EVM	ADS9327EVM-GUI

2. Accept all the license agreements and choose the destination location, project directory, and start menu. Use the default values or customize the values to the user's requirements.
3. The installer prompts the user to create a desktop icon and summarize the installation plan. Click *Install* to copy software onto the computer. The installation process takes a few minutes.
4. At completion, the user launches a readme text file and the application. Figure 3-3 and Figure 3-4 show these steps.

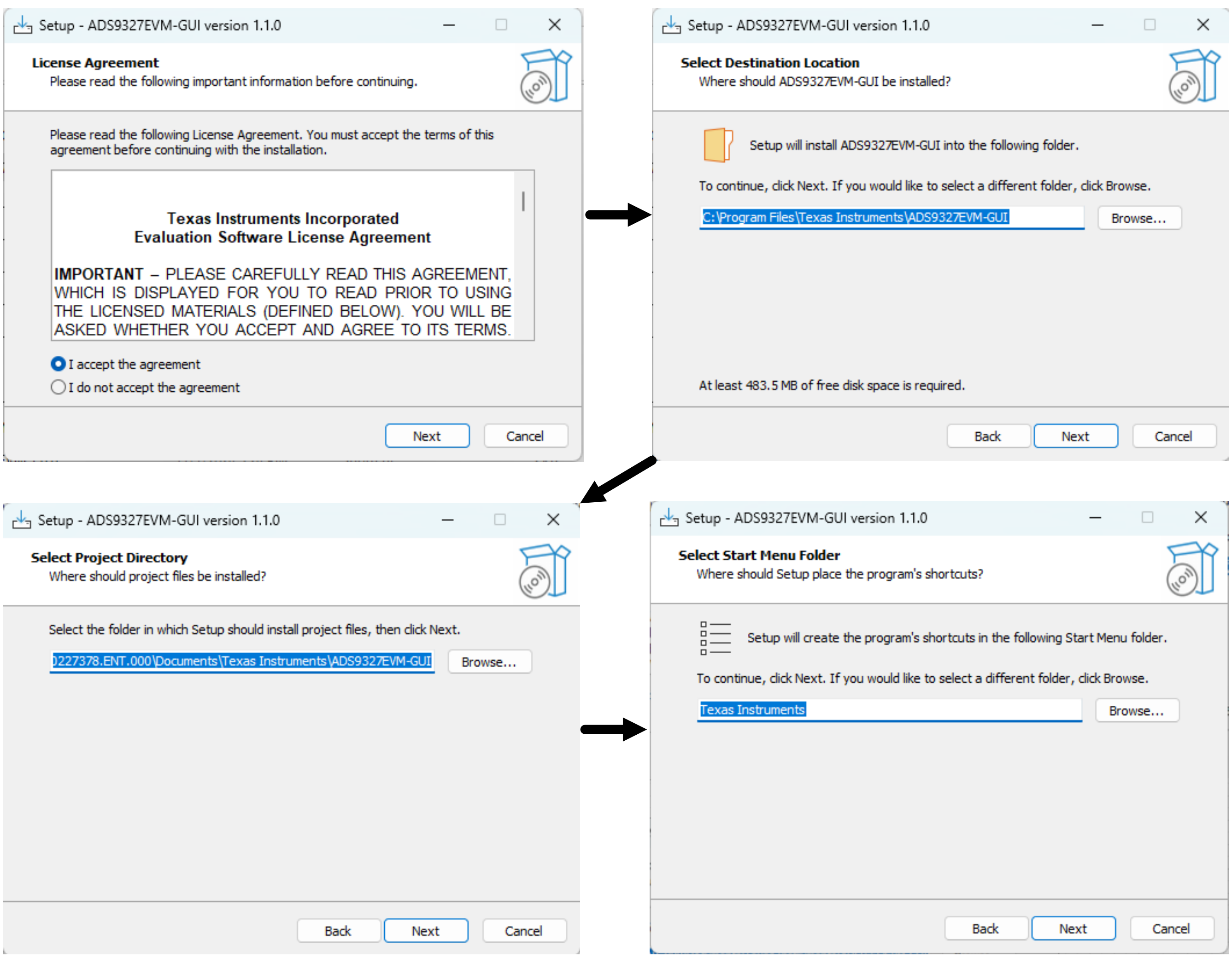


Figure 3-3. Software Installation - Part 1

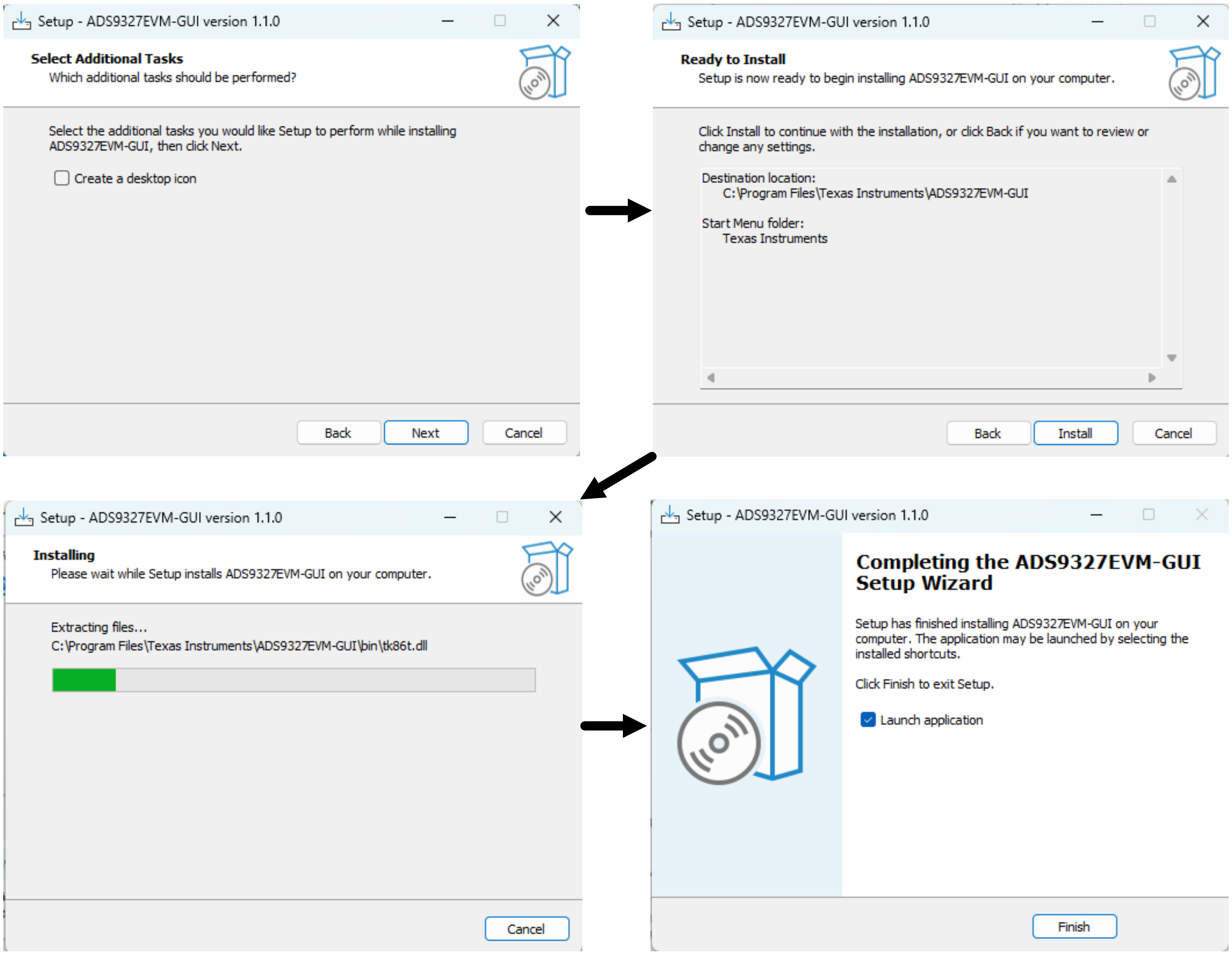


Figure 3-4. Software Installation - Part 2

3.2.2 Using the CONFIG Tab

After the EVM GUI starts, press the following buttons in the order shown in Figure 3-5 below. Monitor the Status message to confirm that each step is completed before proceeding to the next step. 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 ADS9327EVM is on and the ADS9327 device registers are configured.

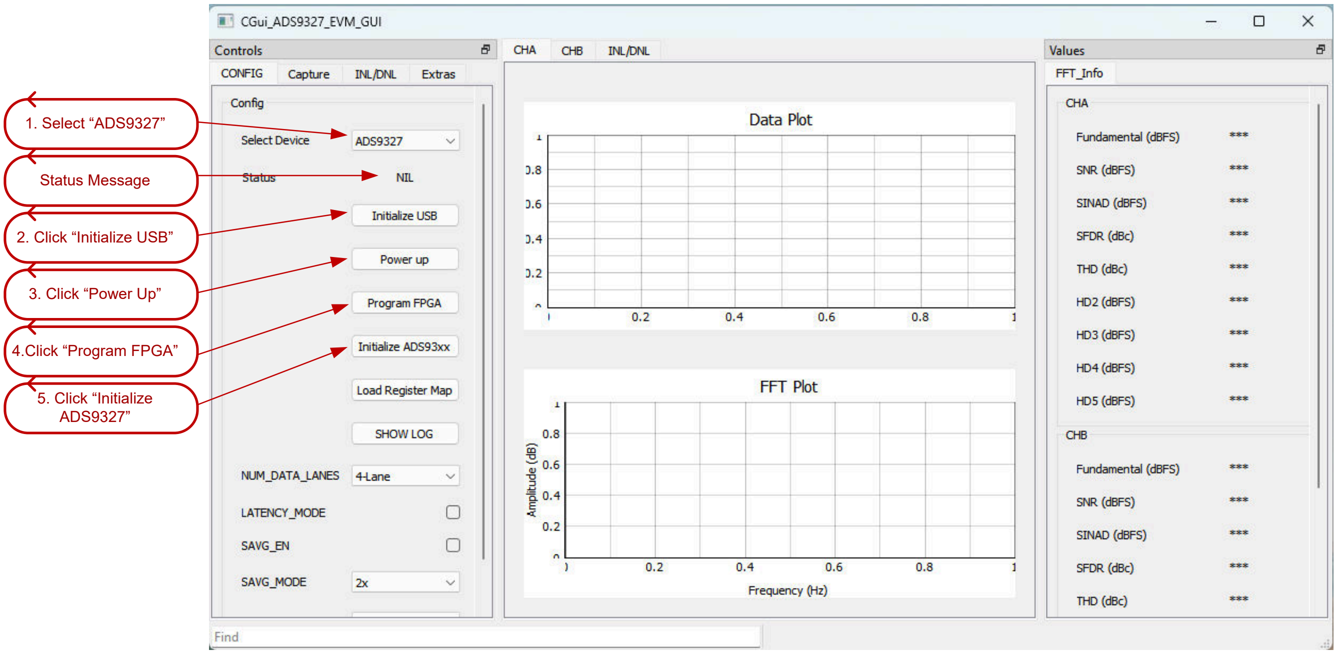


Figure 3-5. Initial Required Setup on the Config Tab

3.2.3 Using the Capture Tab

Figure 3-6 shows the initial required setup for the data capture display.

1. Select the *Capture* settings to record time domain data and achieve a good frequency domain result. Update the settings.
2. Update the number of samples to at least 32k for allow for sufficinet samples for accurate alaysis and frequency domain results (for example, accurate FFT display, SNR data, and THD data).
3. Select the Hanning type window to eliminate spectral leakage in the FFT result.
4. Press the *Start Capture* button to collect time domain and frequency domain data.
5. Select the appropriate tab to view data for channel 1 or channel 2.

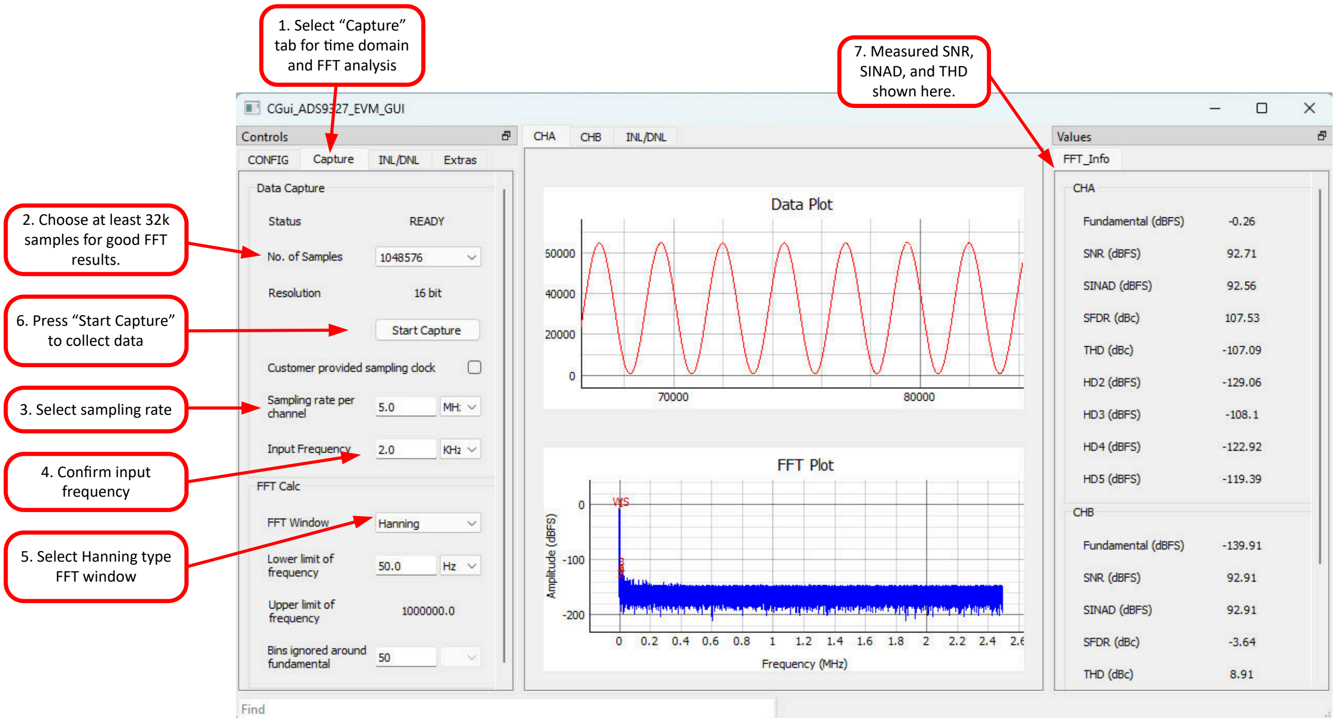


Figure 3-6. Initial Required Setup on the Capture Tab

3.2.4 Using the INL/DNL Tool

The INL/DNL tool measures the linearity of the of the ADS9327EVM by applying a full-scale, low-distortion sinusoidal input signal. The accuracy of the INL/DNL tool improves as the number of *hits per code* increases, at the cost of extra test time. Select the channel to measure the *hits per code*. An input signal greater than full-scale, like +0.1dBFS, is required to verify that all ADC codes are tested. Press the *GET INL/DNL* button to run the INL/DNL tool, as shown in Figure 3-7.

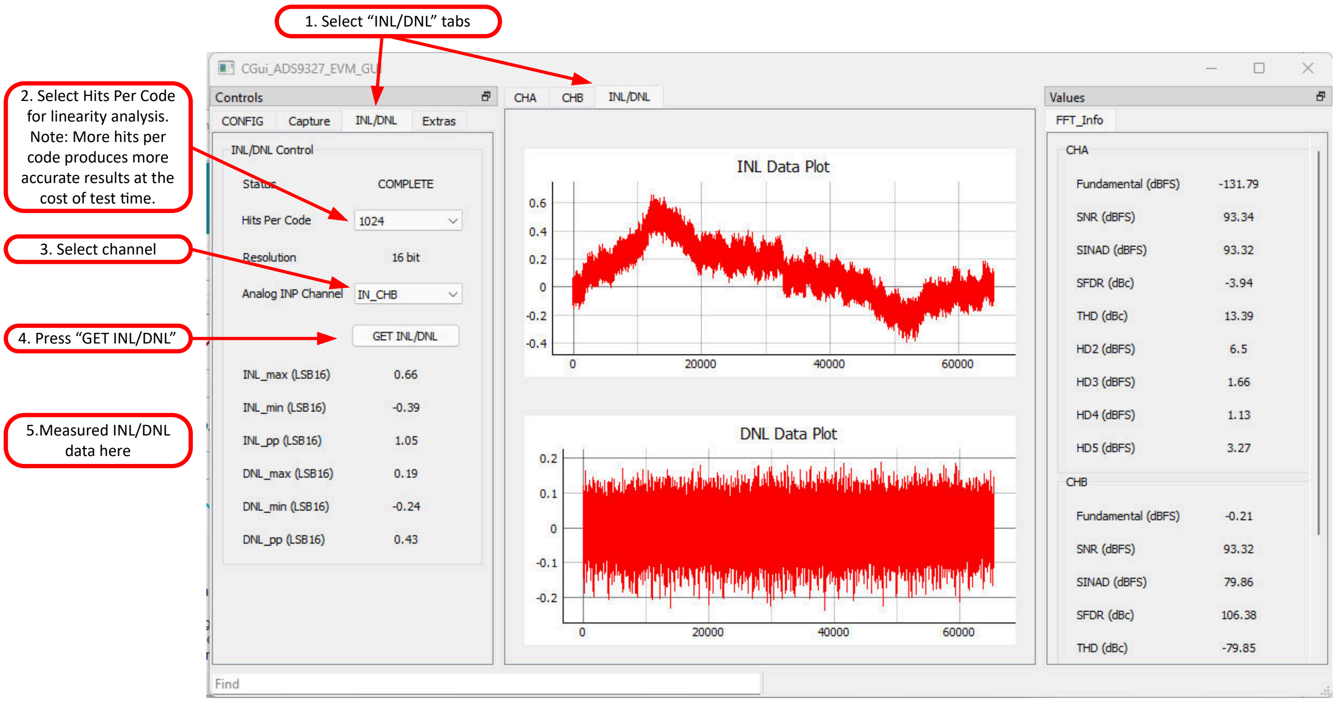
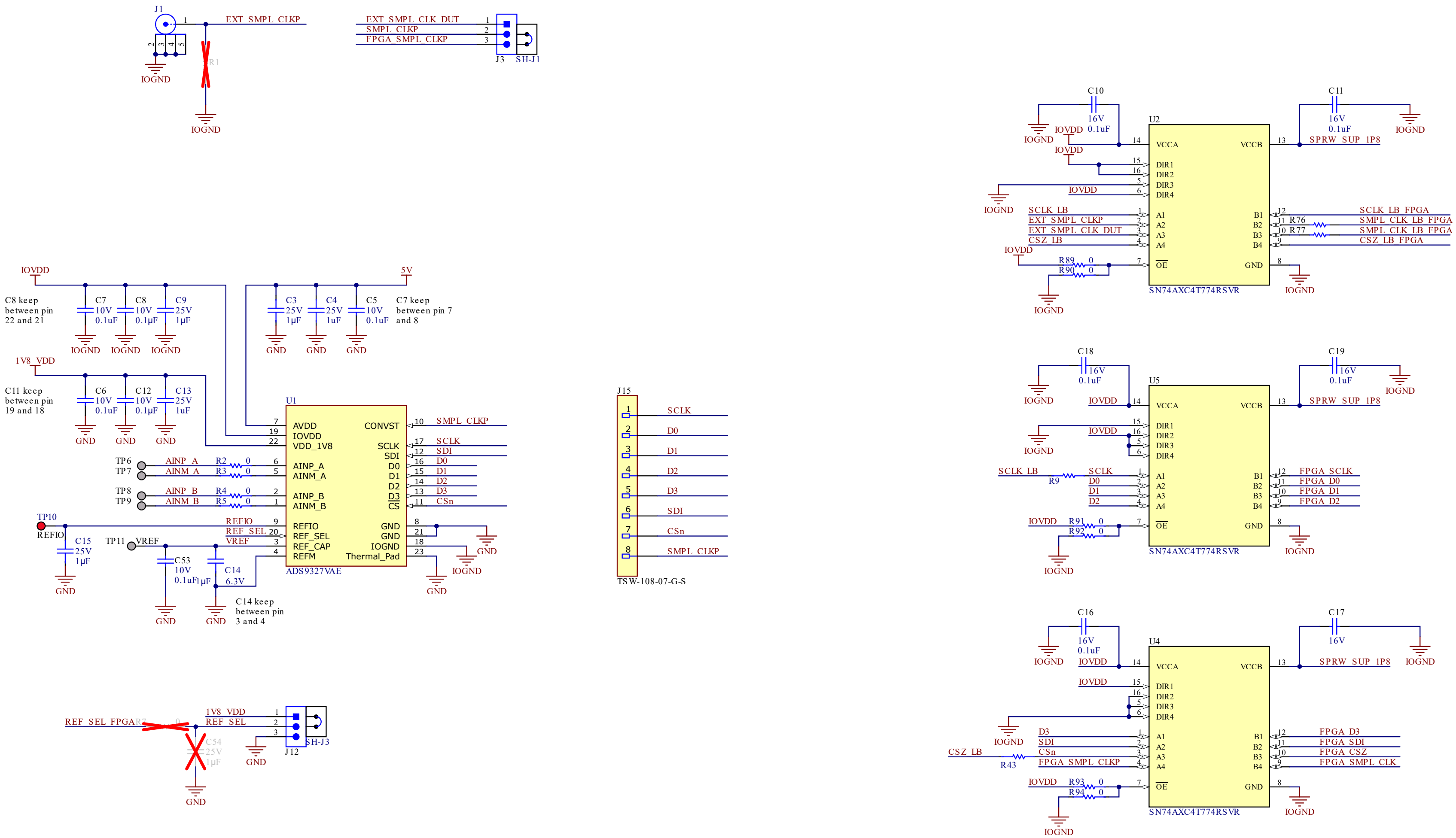


Figure 3-7. Using the INL/DNL Tool

4 Hardware Design Files

4.1 Schematics

The following figures show the ADS9327EVM schematics. Figure 4-1 shows the connections to the ADS9327 device, including the recommended decoupling capacitors, as well as optional connections for external clock and reference voltage inputs. The analog signals connect to SMA connectors and the input signal chain shown in Figure 4-2. The digital signals connect to J9, as shown in Figure 4-4.



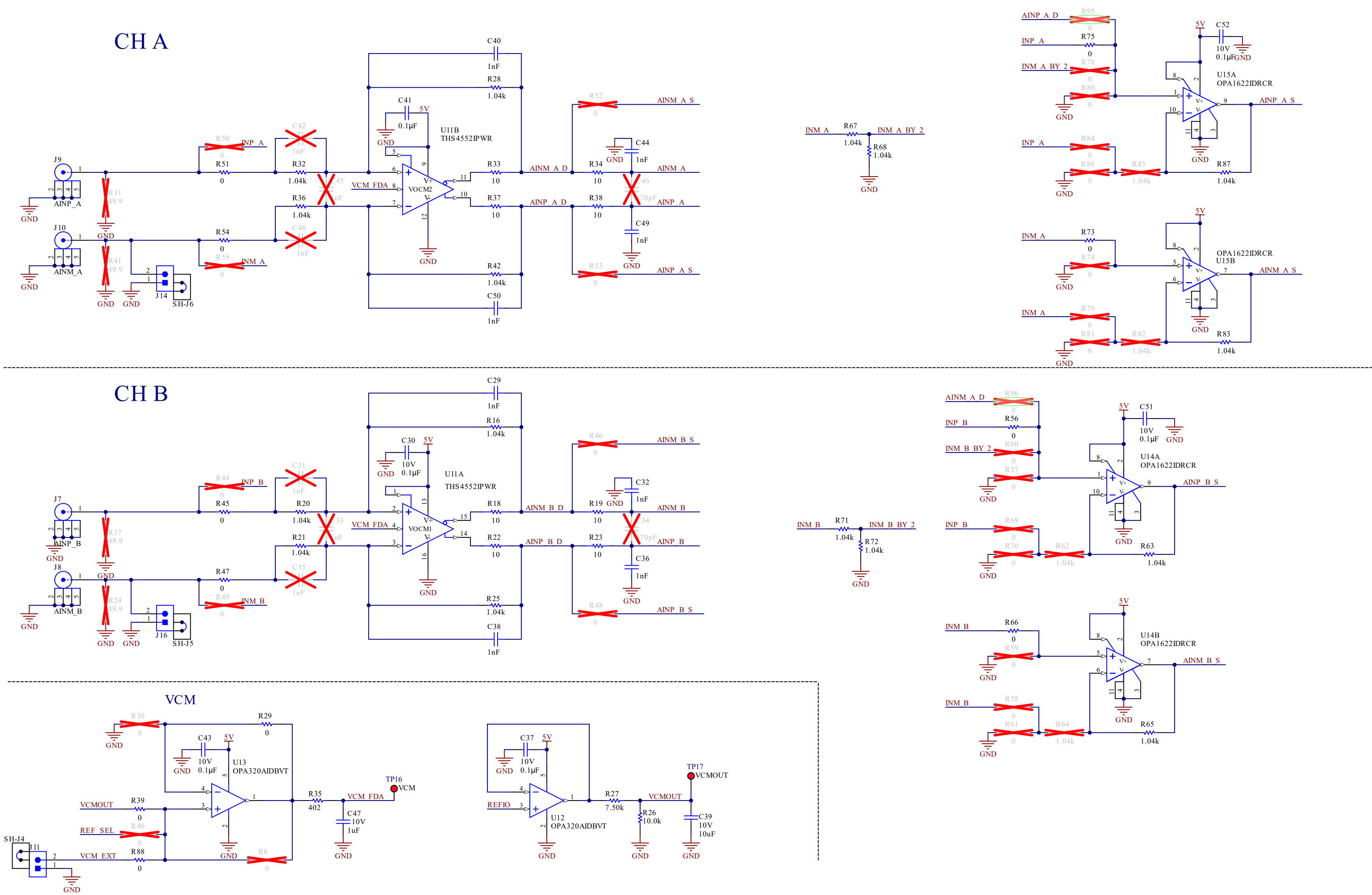


Figure 4-2. Input Connections

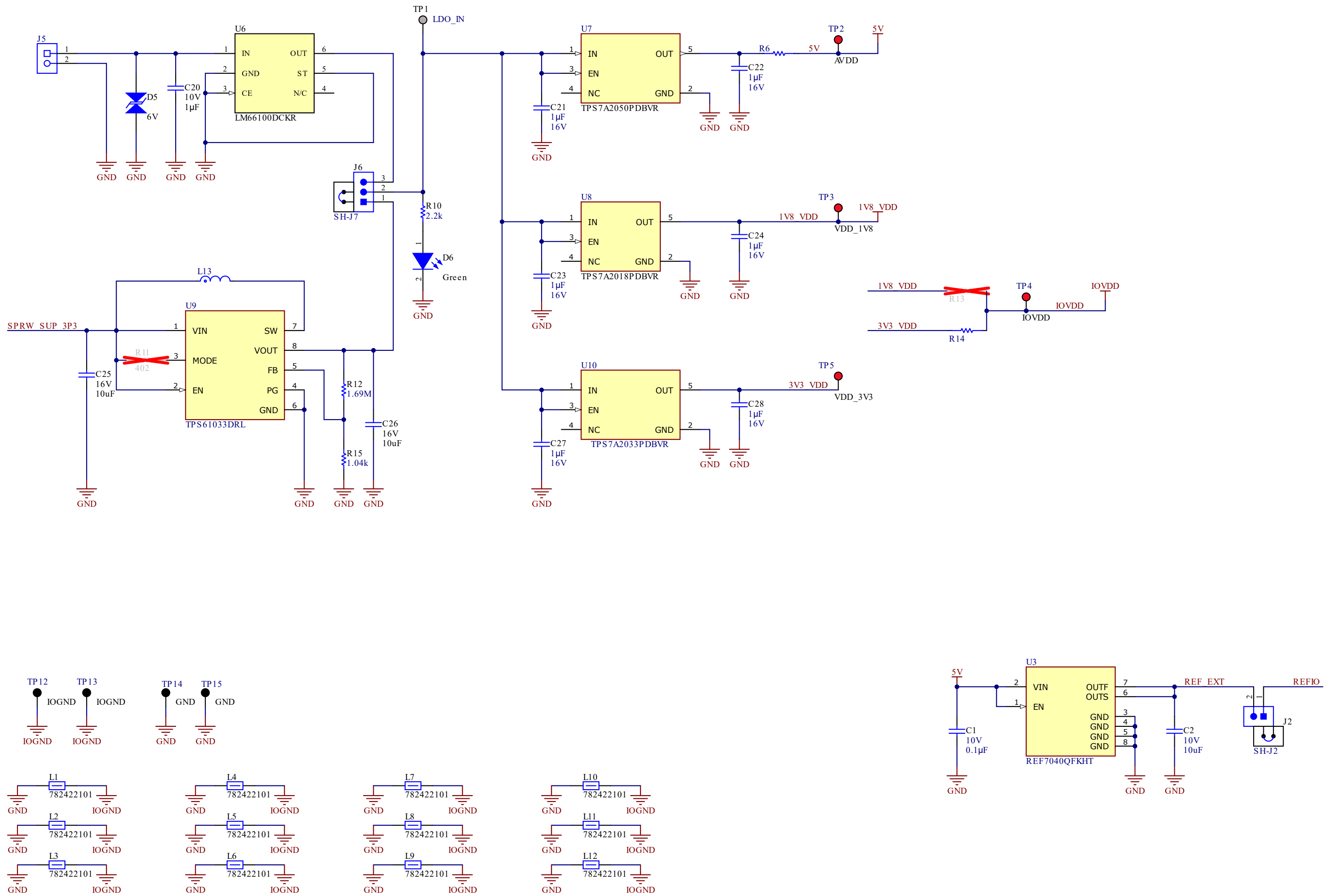


Figure 4-3. Power Connections and Regulators Schematic

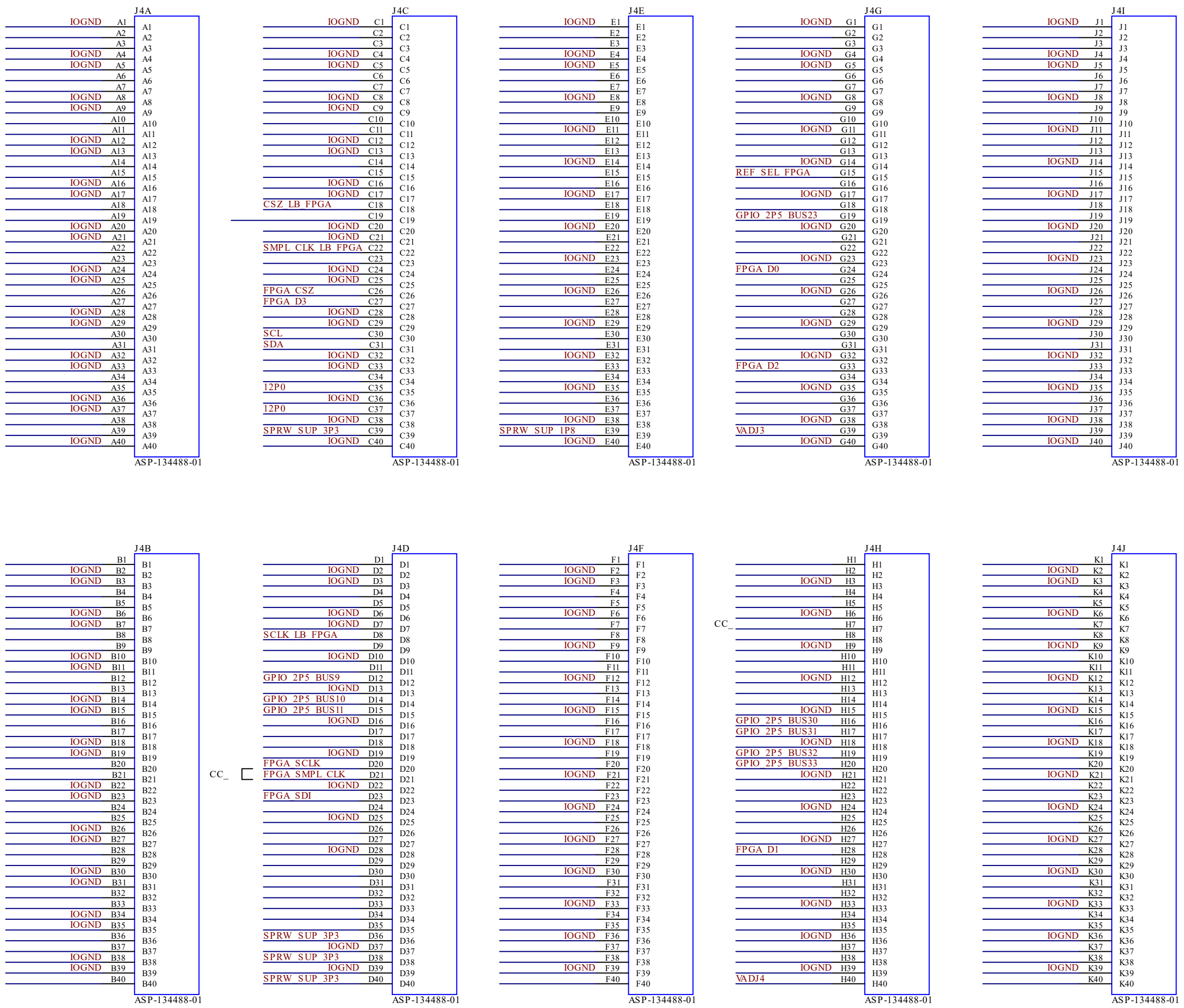


Figure 4-4. Digital Connector Schematic

4.2 PCB Layout

The following figures show the PCB layer plots for the ADS9327EVM.

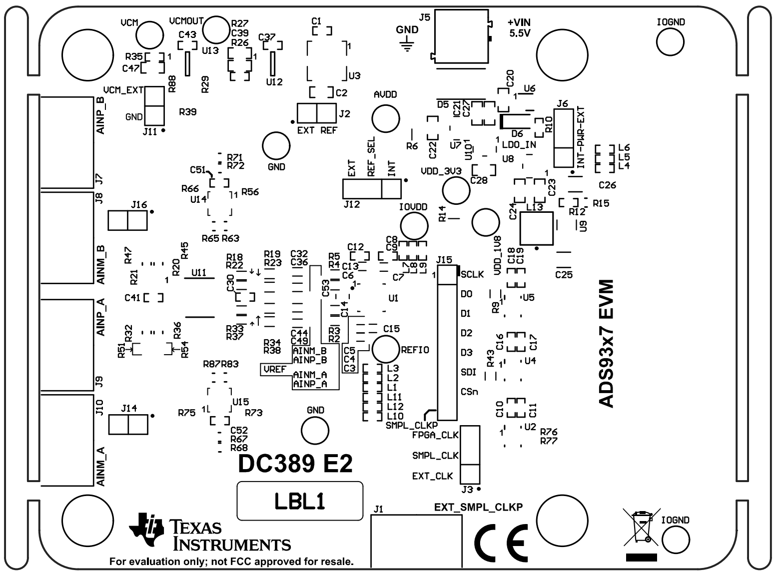


Figure 4-5. Top Overlay

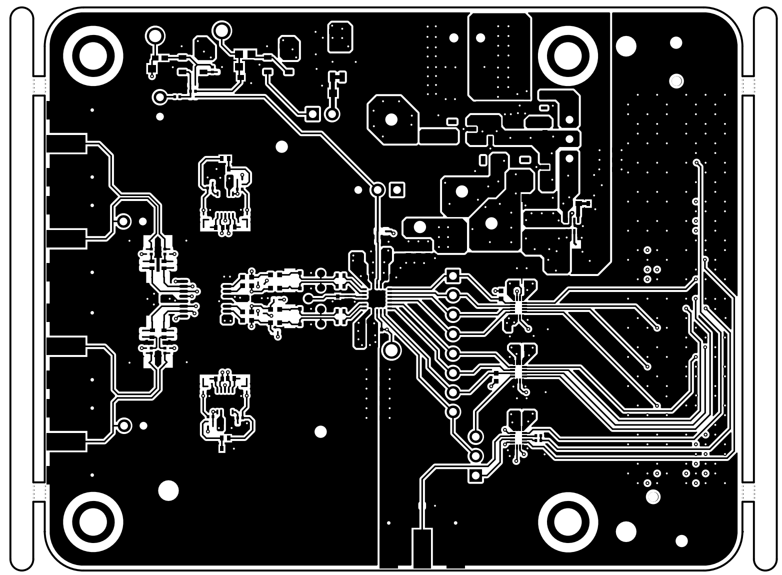


Figure 4-6. Top Layer

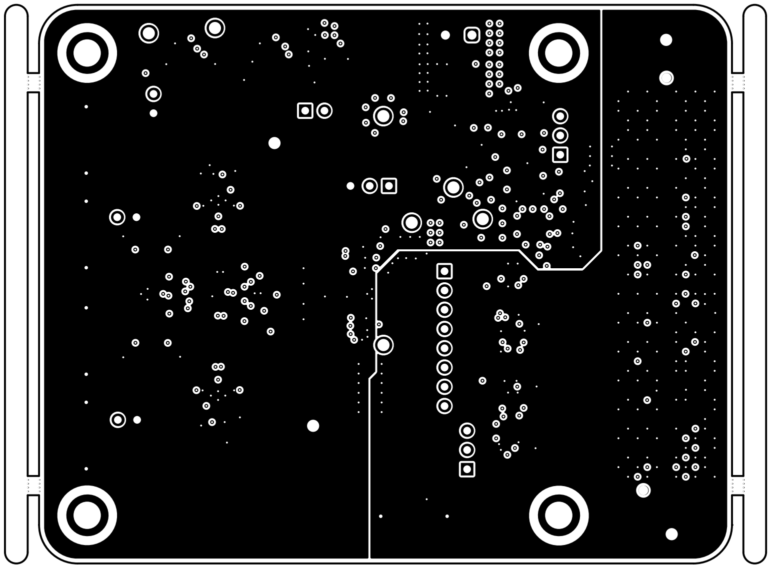


Figure 4-7. Ground Layer (Negative Plane)

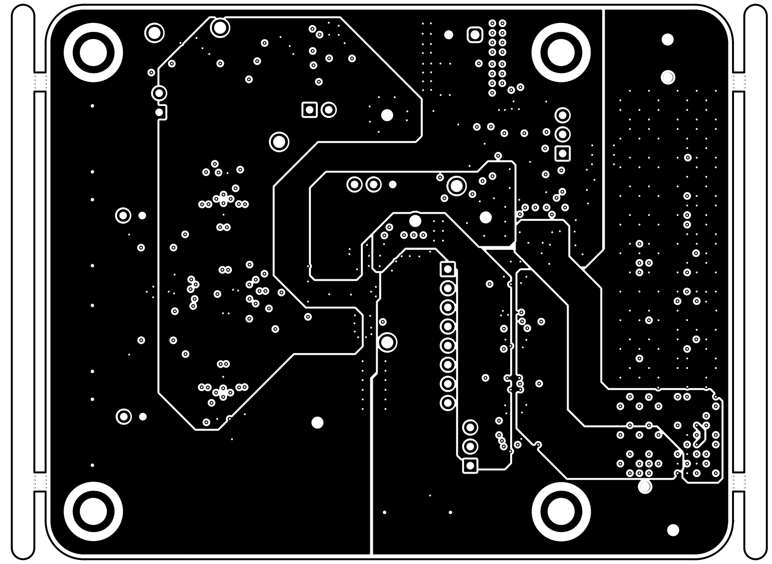


Figure 4-8. Power Layer (Negative Plane)

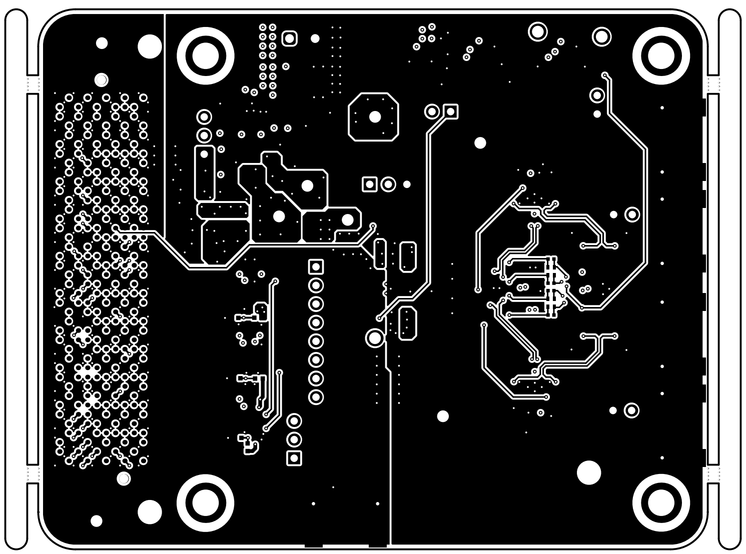


Figure 4-9. Bottom Layer

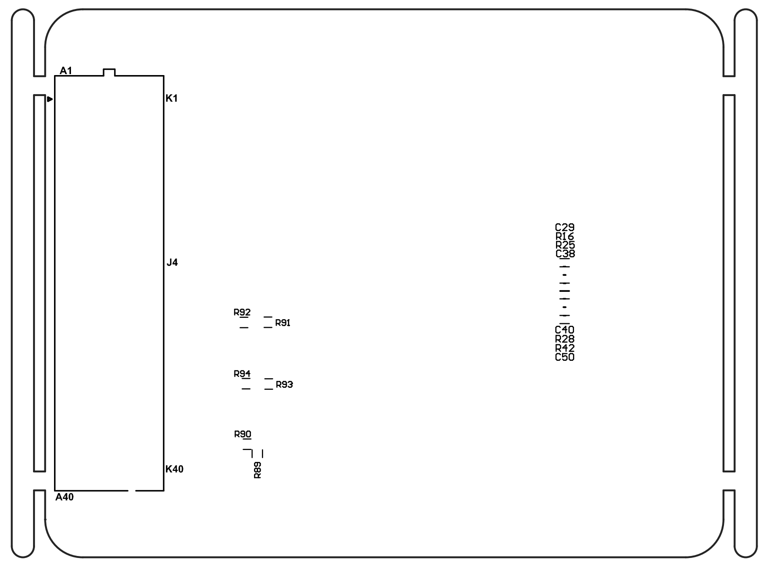


Figure 4-10. Bottom Overlay

4.3 Bill of Materials (BOM)

Table 4-1 lists the ADS9327EVM bill of materials.

Table 4-1. ADS9327EVM Bill of Materials

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
C1, C8, C12, C30, C37, C41, C43, C51, C52	9	0.1uF	CAP, CERM, 0.1µF, 10V,±10%, X7R, AEC-Q200 Grade 1, 0402	0402	C0402C104K8RACAUTO	Kemet
C2, C39	2	10uF	CAP, CERM, 10uF, 10V, ±20%, X6S, 0603	0603	GRM188C81A106MA73D	MuRata
C3, C4, C9, C13, C15	5	1µF	Multi-Layer Ceramic Capacitor 1uF 25V X5R ±10% 0402 Paper T/R	0402	GRT155R61E105KE01D	MuRata
C5, C6, C7, C53	4	0.1uF	CAP, CERM, 0.1uF, 10V, ±10%, X5R, 0201	0201	CL03A104KP3NNNC	Samsung Electro-Mechanics
C10, C11, C16, C17, C18, C19	6	0.1uF	CAP, CERM, 0.1uF, 16V, ±5%, X7R, 0402	0402	GRM155R71C104JA88D	MuRata
C14	1	1µF	1µF ±20% 6.3V Ceramic Capacitor X5R 0204 (0510 Metric)	0204	C0510X5R0J105M030BC	TDK
C20	1	1uF	CAP, CERM, 1µF, 10V,±10%, X7R, 0603	0603	0603ZC105KAT4A	AVX
C21, C22, C23, C24, C27, C28	6	1uF	CAP, CERM, 1uF, 16V, ±10%, X7R, 0603	0603	C1608X7R1C105K080AC	TDK
C25, C26	2	10uF	CAP, CERM, 10uF, 16V, ±10%, X7R, 1206	1206	GRM31CR71C106KAC7L	MuRata
C29, C32, C36, C38, C40, C44, C49, C50	8	1nF	Cap, Ceramic, 0.001uF, 25V, C0G, 5%, Pad SMD, 0402 125C T/R	0402	0402N102J250CT	Walsin Technology
C47	1	1uF	CAP, CERM, 1uF, 10V, ±10%, X5R, 0603	0603	C0603C105K8PACTU	Kemet
D5	1	6V	Diode, TVS, Bi, 6V, SMB	SMB	SMBJ6.0CA	Littelfuse
D6	1	Green	LED, Green, SMD	LED_0805	APT2012LZGCK	Kingbright
H1, H2, H3, H4	4		MACHINE SCREW PAN PHILLIPS M3	M3 Screw	RM3X8MM 2701	APM HEXSEAL
H5, H6, H7, H8	4		Standoff, Hex, 25mm Length, M3, Aluminum	Standoff M3	24438	Keystone
J1, J7, J8, J9, J10	5		Connector, End launch SMA, 50Ω, SMT	End Launch SMA	132255	Amphenol RF
J2, J11, J14, J16	4		Header, 100mil, 2 × 1, Gold, TH	Header, 100mil, 2 × 1, TH	HTSW-102-07-G-S	Samtec
J3, J6, J12	3		Header, 100mil, 3 × 1, Gold, TH	Header, 100mil, 3 × 1, TH	HTSW-103-07-G-S	Samtec
J4	1		Connector, 1.27mm, 40 × 10, Black, SMT	Connector, 1.27mm, 40 × 10, SMT	ASP-134488-01	Samtec

Table 4-1. ADS9327EVM Bill of Materials (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
J5	1		Terminal Block, 3.5mm, 2 × 1, Tin, TH	Terminal Block, 3.5mm, 2 × 1, TH	1751248	Phoenix Contact
J15	1		Header, 100mil, 8 × 1, Gold, TH	8 × 1 Header	TSW-108-07-G-S	Samtec
L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12	12	100Ω	Ferrite Bead, 100Ω at 100MHz, 0.3A, 0402	0402	782422101	Wurth Elektronik
L13	1		Shielded Power Inductors	SMT_IND_4MM0_4MM0	XGL4020-102MEC	Coilcraft
LBL1	1		Thermal Transfer Printable Labels, 0.650	PCB Label 0.650 × 0.200 inch	THT-14-423-10	Brady
R2, R3, R4, R5	4	0	0Ω Jumper Chip Resistor 0402 (1005 Metric) Metal Element	0402	5113	Keystone Electronics
R6, R14	2	0	0Ω Jumper 0.5W, 1/2W Chip Resistor 0805 (2012 Metric) Automotive AEC-Q200 Metal Foil	0805	HCJ0805ZT0R00	Stackpole
R9, R43, R89, R90, R91, R92, R93, R94	8	0	RES Thick Film, 0?, 0.2W, 0402	0402	CRCW04020000Z0EDHP	Vishay Dale
R10	1	2.2k	RES, 2.2 k, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW04022K20JNEDC	Vishay-Dale
R12	1	1.69Meg	RES, 1.69M, 1%, 0.063W, AEC-Q200 Grade 0, 0402	0402	CRCW04021M69FKED	Vishay-Dale
R15, R16, R20, R21, R25, R28, R32, R36, R42, R63, R65, R67, R68, R71, R72, R83, R87	17	1.04k	RES, 1.04 k, 0.1%, 0.1W, AEC-Q200 Grade 0, 0402	0402	TNPW04021K04BEED	Vishay-Dale
R18, R19, R22, R23, R33, R34, R37, R38	8	10	10Ω ±0.1% 0.05W, 1/20W Chip Resistor 0402 (1005 Metric) RF, High Frequency Thin Film	0402	FC0402E10R0BST0	Vishay Dale
R26	1	10.0k	RES, 10.0 k, 0.1%, 0.063 W, 0402	0402	RNCF0402BTE10K0	Stackpole Electronics Inc
R27	1	7.50k	RES, 7.50 k, 0.1%, 0.1W, 0603	0603	RT0603BRD077K5L	Yageo America
R29, R39, R45, R47, R51, R54, R56, R66, R73, R75, R76, R77, R88	13		RES SMD 0Ω JUMPER 1/20W 0201	0201 (0603 Metric)	RC0201JR-070RL	Yageo
R35	1	402	RES, 402, 1%, 0.063W, AEC-Q200 Grade 0, 0402	0402	CRCW0402402RFKED	Vishay-Dale

Table 4-1. ADS9327EVM Bill of Materials (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
SH-J1, SH-J2, SH-J3, SH-J4, SH-J5, SH-J6, SH-J7	7		CONN JUMPER S2 (1 × 2) Position Shunt Connector Black Open Top 0.100	JUMPER	QPC02SXGN-RC	Sullins
TP2, TP3, TP4, TP5, TP10, TP16, TP17	7		Test Point, Multipurpose, Red, TH	Red Multipurpose Testpoint	5010	Keystone Electronics
TP12, TP13, TP14, TP15	4		Test Point, Multipurpose, Black, TH	Black Multipurpose Testpoint	5011	Keystone Electronics
U1	1		Dual, Simultaneous-Sampling, 16-Bit, 5MSPS SAR ADC, VQFN-HR22	VQFN-HR22	ADS9327VAE	Texas Instruments
U2, U4, U5	3		4 Bit Direction Controlled Level Translator, RSV0016A (UQFN-16)	RSV0016A	SN74AXC4T774RSVR	Texas Instruments
U3	1		2ppm/°C Maximum Drift, 0.23ppmp-p 1/f Noise, Precision Voltage Reference	LCCC8	REF7040QFKHT	Texas Instruments
U6	1		±6V, Low IQ Ideal Diode with Input Polarity Protection, DCK0006A (SOT-SC70-6)	DCK0006A	LM66100DCKR	Texas Instruments
U7	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
U8	1		Linear Voltage Regulator IC Positive Fixed 1 Output 300mA SOT-23-5	SOT23-5	TPS7A2018PDBVR	Texas Instruments
U9	1		5.0A 2.4MHz High Efficiency Boost Converter	SOT-5X3	TPS61033DRL	Texas Instruments
U10	1		300mA, Ultra-Low-Noise, Low-IQ, High PSRR LDO	SOT23-5	TPS7A2033PDBVR	Texas Instruments
U11	1		Low-Noise, Precision, 150MHz, Fully Differential Amplifier, PW0016A (TSSOP-16)	PW0016A	THS4552IPWR	Texas Instruments
U12, U13	2		Precision, 20MHz, 0.9pA Ib, RRIO, CMOS Operational Amplifier, 1.8 to 5.5V, -40 to 125°C, 5-pin SOT23 (DBV5), Green (RoHS and no Sb/Br)	DBV0005A	OPA320AIDBVT	Texas Instruments
U14, U15	2		SoundPlus(TM) Audio Operational Amplifier with High Performance, Low THD+N and Bipolar Input, DRC0010J (VSON-10)	DRC0010J	OPA1622IDRCR	Texas Instruments

5 Additional Information

5.1 Trademarks

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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 ti.com.

Table 6-1. Related Documentation

Device	Literature Number
TSWDC155EVM	SLAU870
TPS61033	SLVSGI6
TPS7A20	SBVS338
LM66100	SLVSEZ8
REF7040	SNAS781
THS4552	SBOS831B
SN74AXC4T774	SCES898C
OPA320	SBOS523F
OPA1622	SBOS727B

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。

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.

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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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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.

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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.

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