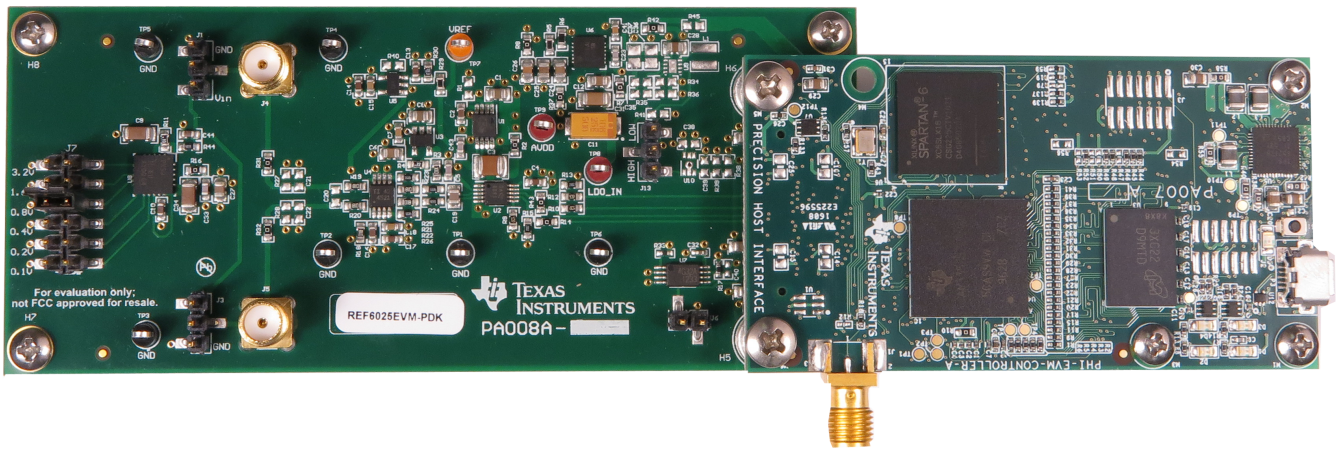
REF6025EVM-PDK



This user's guide describes the characteristics, operation, and use of the REF6025EVM performance demonstration kit (PDK). This kit is an evaluation platform for the REF6025,which is a high-precision voltage reference with an integrated high-bandwidth buffer designed specifically to drive the REF pin of the successive approximation register (SAR), analog-to-digital converter (ADC). On the REF6025EVM, the REF6025 drives the reference of TI's ADS8881 18-bit, 1-Msps true-differential input SAR ADC. This user's guide includes complete circuit descriptions, schematic diagrams, and a bill of materials.

The REF6025EVM-PDK consists of two components, the REF6025EVM and the TI Precision Host Interface (PHI) Controller. The PHI provides the hardware and the software for computer connectivity through the universal serial bus (USB) interface.

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

Related Documentation

Device	Literature Number
REF6025	SBOS708
ADS8881	SBAS547
THS4521	SBOS458
OPA333	SBOS351
LP38798	SNOSCT6
TPS7A4700	SLVU741
TPS78833	SLVU059

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1 Overview

The REF6025EVM-PDK is a platform for evaluating the performance of the REF6025. The evaluation kit includes the REF6025EVM board, the precision host interface (PHI) controller board, and a USB cable to connect to computer to capture and analyze the data.

The REF6025EVM board includes the REF6025 and all the peripheral circuits and components necessary to demonstrate the performance of the voltage reference.

The PHI board primarily serves three functions:

- Provides a communication interface from the EVM to the computer through a USB port
- Provides the digital input and output signals necessary to communicate with the REF6025EVM
- Supplies power to all active circuitry on the REF6025EVM board

Along with the REF6025EVM and the PHI controller boards, this demonstration kit includes an A-to-micro-B USB cable and the *Quick Start* guide to aid with the system setup.

1.1 REF6025EVM-PDK Features

The REF6025EVM-PDK includes the following features:

- Hardware and software required for diagnostic testing as well as accurate performance evaluation of the REF6025 Voltage Reference
- USB powered - no external power supply is required
- PHI controller that provides a convenient interface to the EVM over a USB 2.0 (or higher) for power delivery as well as digital input and output
- Easy-to-use evaluation software for Microsoft® Windows® 7, Windows 8, 64-bit operating systems
- The software suite includes graphical tools for data capture, histogram analysis, and spectral analysis. It also has a provision for exporting data to a text file for post-processing.

1.2 REF6025EVM Features

The REF6025EVM includes the following features:

- Onboard 18-bit, 1-Msps, serial interface, true-differential input, SAR ADC
- Low-noise and low distortion ADC input drivers optimized to meet ADC performance
- Input common mode of 1.32 V generated onboard to allow uni-polar and bi-polar inputs
- Ultra-low noise low-dropout (LDO) regulator for jumper-selectable DC test signal generation
- Includes LDO to provide supply voltages to the ADC and drive circuits

2 EVM Analog Interface

Most SAR ADCs, and a few delta-sigma ADCs, switch binary-weighted capacitors onto the REF pin during the conversion process. The magnitude of the capacitance switched onto the REF pin during each conversion depends on the input signal to the ADC. In order to support this dynamic load and preserve the ADC linearity, distortion, and noise performance, the output of the voltage reference must be buffered with a low-output impedance (high-bandwidth) buffer.

The REF60xx family of voltage references have integrated low-output impedance buffers that enable the user to directly drive the REF pin of a successive approximation register (SAR) analog-to-digital converter (ADC), while preserving ADC linearity, distortion, and noise performance. In addition, the output voltage of the REF60xx does not droop below 1 LSB (18-bit), even during the first conversion while driving the REF pin of the ADS8881. This feature is extremely useful in burst-mode, event-triggered, equivalent-time sampling, and variable-sampling-rate data-acquisition systems.

2.1 Onboard ADC Reference

The REF6025 generates the 2.5-V reference for the ADS8881. Unlike typical ADC reference configurations, this EVM does not require any additional active circuitry to drive the ADC reference, since the reference input signal path is entirely self-contained on the REF6025. Figure 1 illustrates the schematic.

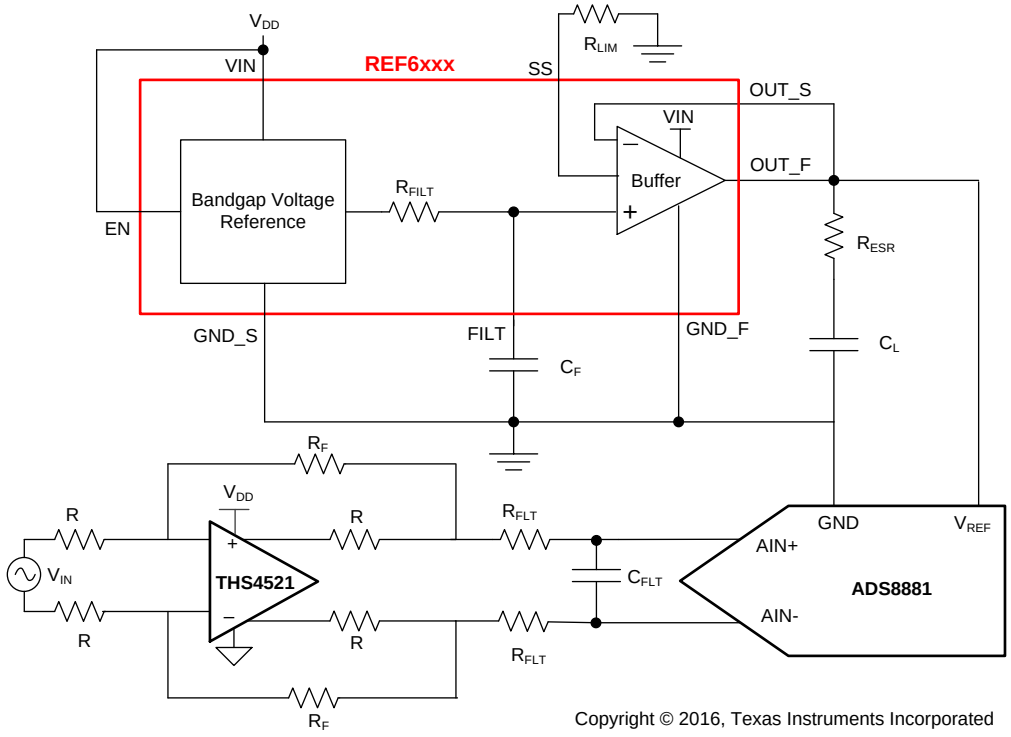

Figure 1. REF6025EVM Schematic Block Diagram

2.2 ADC Analog Input Signal Path

Figure 1 shows the signal path for the differential signal applied at the board inputs. The board input impedance is 1-kΩ with 10-nF differential filtering that keeps noise in external cabling common. The overall signal path bandwidth is limited to 1.6 MHz by the charge kickback filter formed from 4.99-Ω resistors and a 10-nF capacitor between the amplifier output and ADC input.

The REF6025EVM uses THS4521 fully-differential amplifier to drive the ADC input. The THS4521 is a very low power, fully-differential op amp with rail-to-rail output and an input common-mode range that includes the negative rail. The amplifier is designed for low-power data acquisition systems where power dissipation is a critical requirement. The amplifier provides exceptional AC performance that meets the very low distortion and high slew rate required from the input driver.

The THD performance of this design can be further enhanced by replacing the THS4521 with the pin-compatible THS4551, for a small current consumption penalty. Table 1 compares the performance with these two amplifiers.

Table 1. THS4521 vs THS4551 Comparison

Parameter	THS4521	THS4551
HD2 at 100 KHz	–110 dB	–128 dB
HD3 at 100 KHz	–125 dB	–139 dB
Voltage noise density	4.6 nV/rtHz	3.2 nV/rtHz
Current consumption	1.14 mA	1.35 mA

2.3 EVM Analog Input Options

The REF6025EVM is designed to provide easy interface options to multiple analog sources. SMA connectors allow input signals to be connected to the EVM through coaxial cables. In addition, 100-mil headers provide a convenient option to either connect an external analog source or the configurable onboard DC source. All analog inputs are buffered by the THS4521 high-speed fully-differential amplifier in order to drive the ADS8881 ADC inputs. Use appropriate caution when handling these pins.

Table 2 lists the analog inputs:

Table 2. Analog Input Options on the REF6025EVM

Pin Number	100-mil Header	Signal	Description
J4	J1.2	A0(-)	Negative differential input. Ground this pin for single-ended signals.
J5	J3.2	A0(+)	Positive differential input or input for single-ended signals

2.4 Differential Input Signal Configuration

The ADS8881 can convert differential signals with a common mode between 0 V and V_{REF}, and the THS4521 can condition a bipolar signal by changing its common mode. This REF6025EVM sets the THS4521 output common mode to 1.35 V, which corresponds to V_{REF} / 2 + 0.1 V. Thus, when a bipolar differential signal with a common mode of 0 V is applied at the EVM inputs A0(–) and A0(+), the THS4521 shifts the common mode to 1.35 V. Figure 2 illustrates an input signal of 2.5-V differential with 0-V common mode whose common mode is changed from 0 V to 1.35 V, to present a 5-V differential signal while maintaining a 100-mV headroom from the amplifier power rails to ensure linear operation.

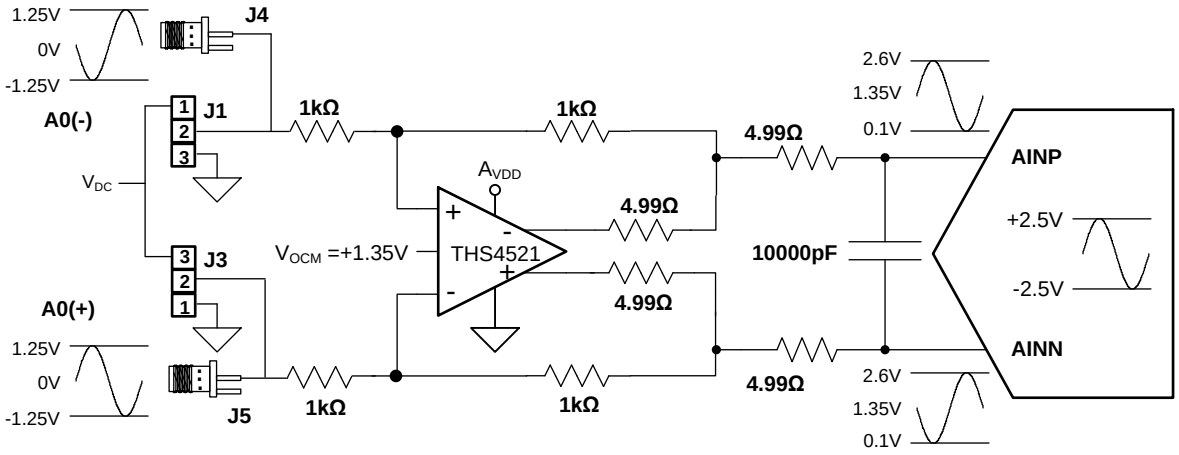

Figure 2. Differential Input Example

2.5 ADC Differential Input Signal Driver

The THS4521 can condition a single-ended input signal to a differential signal allowing a 0 V to 5 V or –2.5 V to 2.5 V input voltage range at the EVM input A0(+), as illustrated in Figure 3. Ground the EVM A0(–) input for single-ended signals by inserting a shunt from J1.2 to J1.3.

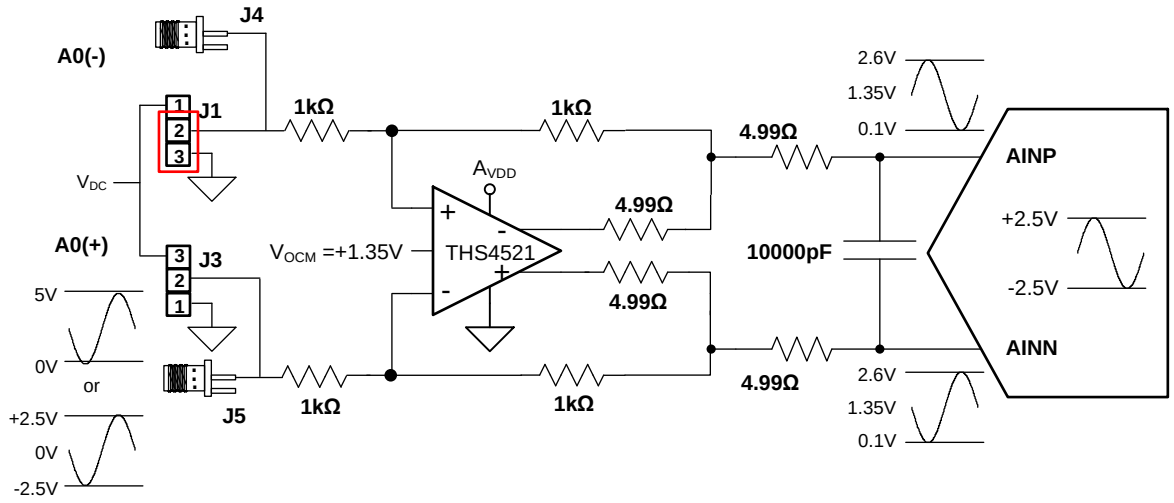

Figure 3. Single-Ended Signal Example

2.6 Onboard DC Input Configuration

The REF6025EVM includes the low-noise, user-configurable TPS7A4700 LDO voltage regulator that can be used to generate DC voltages at the inputs of the THS4521 without the need for an external source.

The TPS7A4700 includes an ANY-OUT mode, which starts with a base voltage of 1.4 V and control pins allow the addition of binary-weighted voltages to generate the required voltage in steps of 100 mV, simply by inserting shunts on the J7 header, as shown in Table 3.

Table 3. DC Input Configuration

V_{DC} (in Volts)	J7.1-J7.2 (+100 mV)	J7.3-J7.4 (+200 mV)	J7.4-J7.5 (+400 mV)	J7.1-J7.2 (+800 mV)
1.4	Open	Open	Open	Open
1.5	Close	Open	Open	Open
1.6	Open	Close	Open	Open
1.7	Close	Close	Open	Open
1.8	Open	Open	Close	Open
1.9	Close	Open	Close	Open
2.0	Open	Close	Close	Open
2.1	Close	Close	Close	Open
2.2	Open	Open	Open	Close
2.3	Close	Open	Open	Close
2.4	Open	Close	Open	Close
2.5	Close	Close	Open	Close

CAUTION

Ensure that the DC voltage provided at the input of the THS4521 never exceeds the 2.5 V V_{REF} set by REF6025. To avoid damaging the ADS8881, strictly use the jumper combinations listed in Table 3.

3 Power Supplies

The PHI provides multiple power supplies to the EVM, derived from the USB supply of the computer.

The EEPROM and the digital section of the ADC are powered by two separate 3.3-V supplies generated directly by the PHI. The REF6025 and analog input drive circuits are powered by the 5 V generated by the LP38798 onboard the EVM, which is a low-noise linear regulator that uses the 5.5-V supply out of a switching regulator on the PHI to generate a much cleaner 5-V output. The 3.3-V supply for the ADC is generated by the TPS78833 on the EVM.

The power supply for each active component on the EVM is bypassed with a ceramic capacitor placed close to that component. Additionally, the EVM layout uses thick traces or large copper fill areas, where possible, between bypass capacitors and their loads to minimize inductance along the load current path.

4 REF6025EVM-PDK Initial Setup

This section explains the initial hardware and software setup procedure that must be completed for the proper operation the REF6025EVM-PDK.

4.1 Default Jumper Settings

Upon unpacking, the EVM should have no jumper shunts installed. This is the correct setting for the standard DC and AC tests to be conducted on the EVM.

4.2 EVM Graphical User Interface (GUI) Software Installation

The EVM GUI required to power up and evaluate the performance of the EVM must be installed on the user's computer. Download the latest version of the installer from the *Tools and Software* folder of the REF6025.

The workstation used for the installation needs to be a Windows 7 or Windows 8, 64-bit computer with USB 2.0 (or higher) ports and 1GB available of hard disk space. Login with an administrator account and ensure the installation is "Run as administrator". Read and accept the license agreements and follow the on-screen instructions to complete the installation as shown in Figure 4.

CAUTION

Manually disable any anti-virus software running on the computer before running the EVM GUI installer. Depending on the anti-virus settings, an error message may appear or the installer .exe file may be deleted.

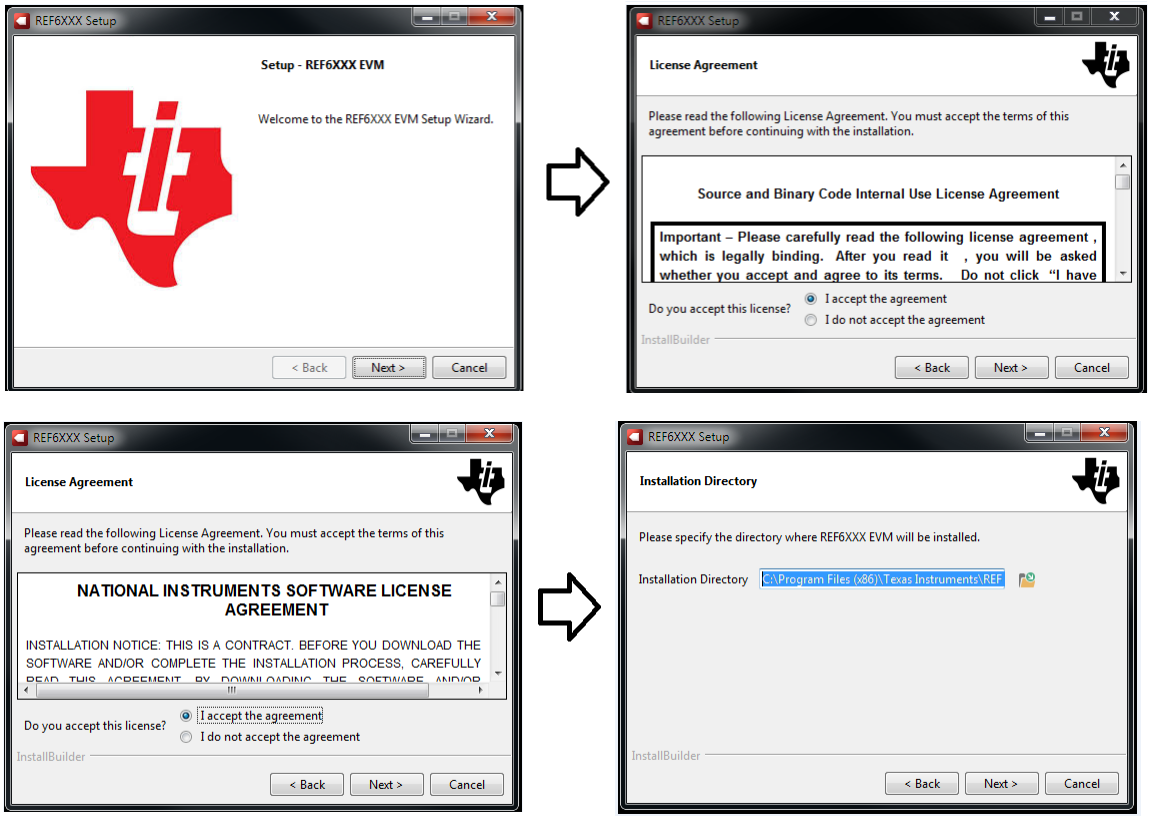

Figure 4. REF6025 Software Installation Prompts

As a part of the REF6025 EVM GUI installation, a prompt with a *Device Driver Installation* appears on the screen. Click *Next* to proceed.

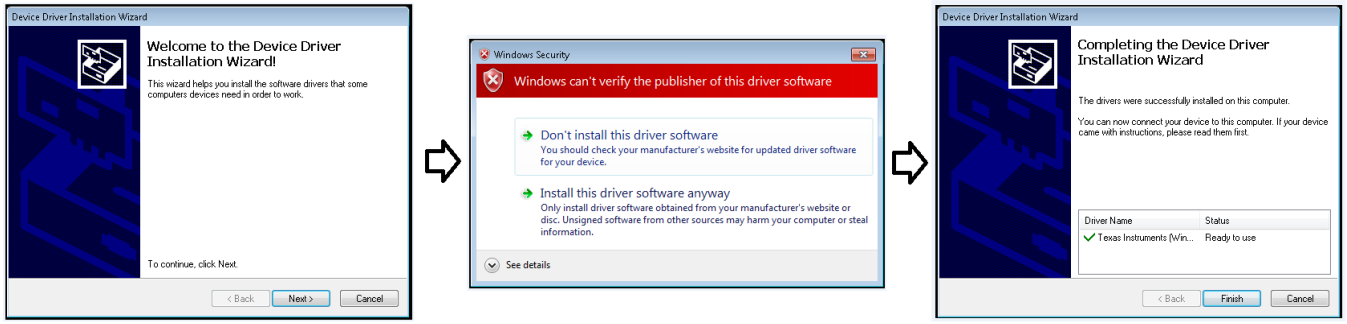

Figure 5. Device Driver Installation Wizard Prompts

NOTE: A notice may appear on the screen stating that "Widows can't verify the publisher of this driver software"; Select *Install this driver software anyway*.

This software requires NI LabVIEW™ Run-Time Engine and my prompt for the installation of this software, if it is not already installed. At the end of these installations, ensure the *Create Desktop Shortcut* and *Run REF6XXX EVM* options are selected as Figure 6 shows.

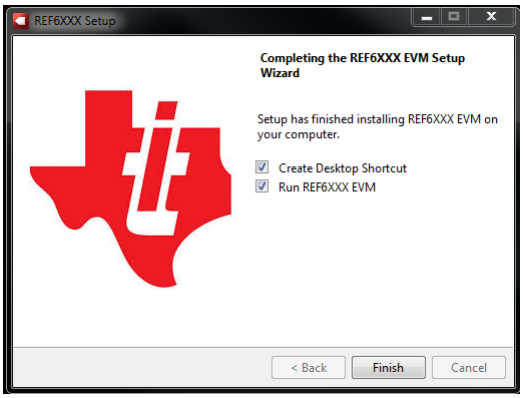

Figure 6. REF6XXX EVM GUI Installation Final Step

5 REF6025EVM-PDK Operation

The following instructions are a step-by-step guide to connecting the REF6025EVM-PDK to the computer and evaluating the performance of the REF6025:

1. Connect the REF6025EVM to the PHI. Install the two screws as indicated in Figure 7.
2. Use the provided USB cable to connect the PHI to the computer.
   - LED D5 on the PHI lights up, indicating that the PHI is powered up.
   - LEDs D1 and D2 on the PHI starts blinking to indicate that the PHI is booted up and is attempting to communicate with the PC. The resulting LED indicators are shown in Figure 7.

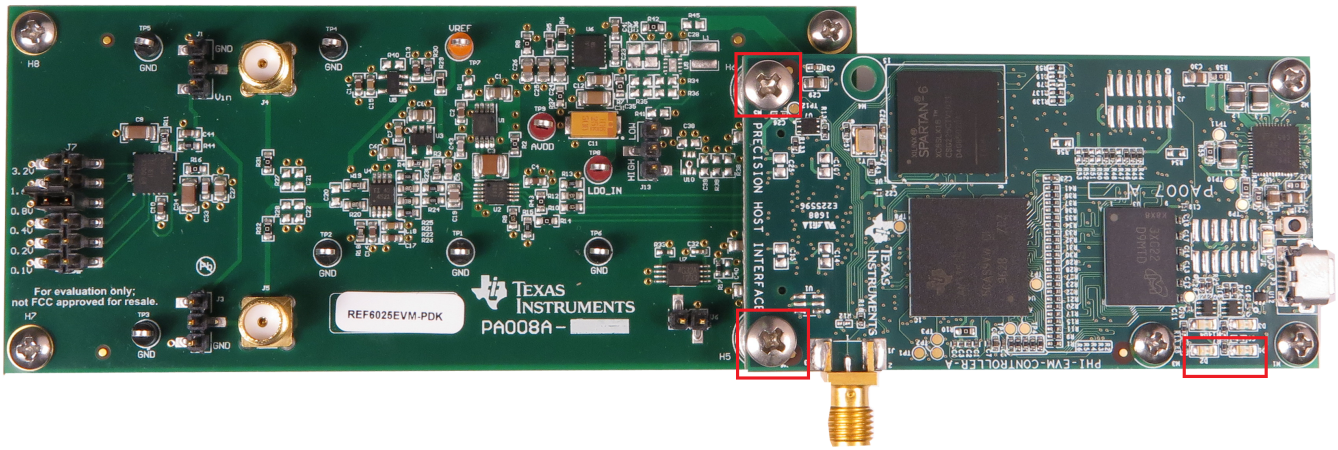

Figure 7. EVM-PDK Hardware Setup and LED Indicators

3. Launch the REF6025EVM GUI software, as shown in Figure 8. The rate at which LED D2 blinks slows down, indicating that the GUI is successfully communicating with the REF6025EVM-PDK.

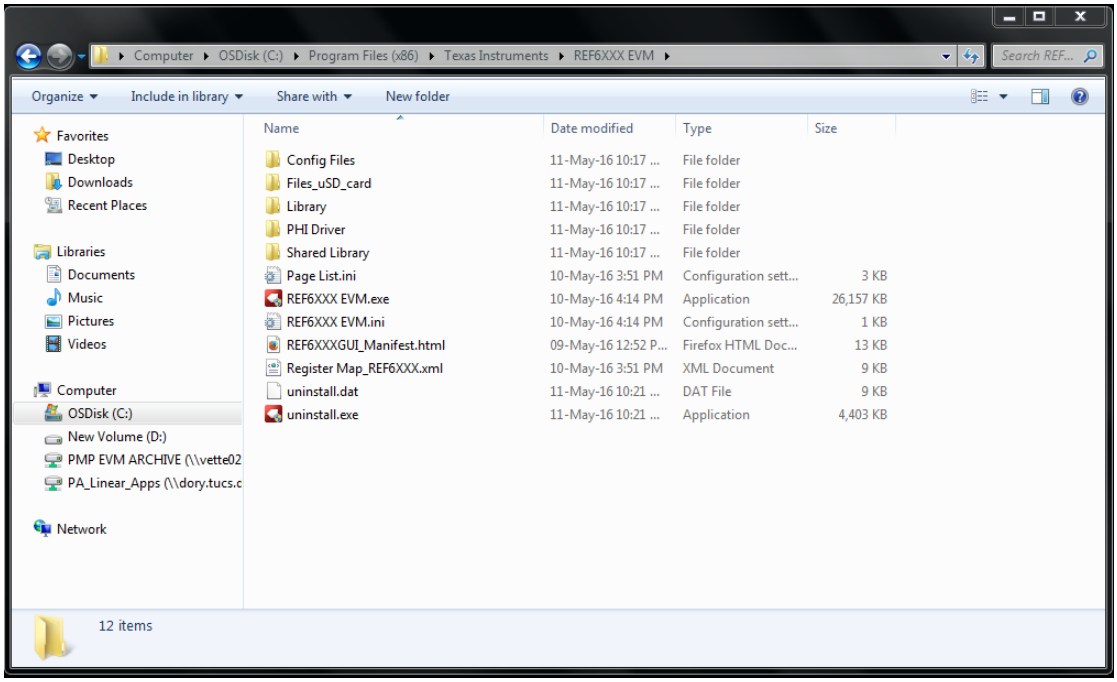

Figure 8. Launch the EVM GUI Software

5.1 EVM GUI Global Settings for ADC Configuration and Data Capture

The REF6025EVM GUI provides high-level control over the ADS8881 functions, including interface modes, sampling rate, and number of samples to be captured. With the REF6025EVM GUI, the performance of the REF6025 under different ADC operating conditions can be evaluated.

Figure 9 identifies the input parameters of the GUI (as well as their default values) through which the functionality of REF6025 can be exercised. These are global settings as they persist across the GUI tools listed in the top left pane (or from one page to another).

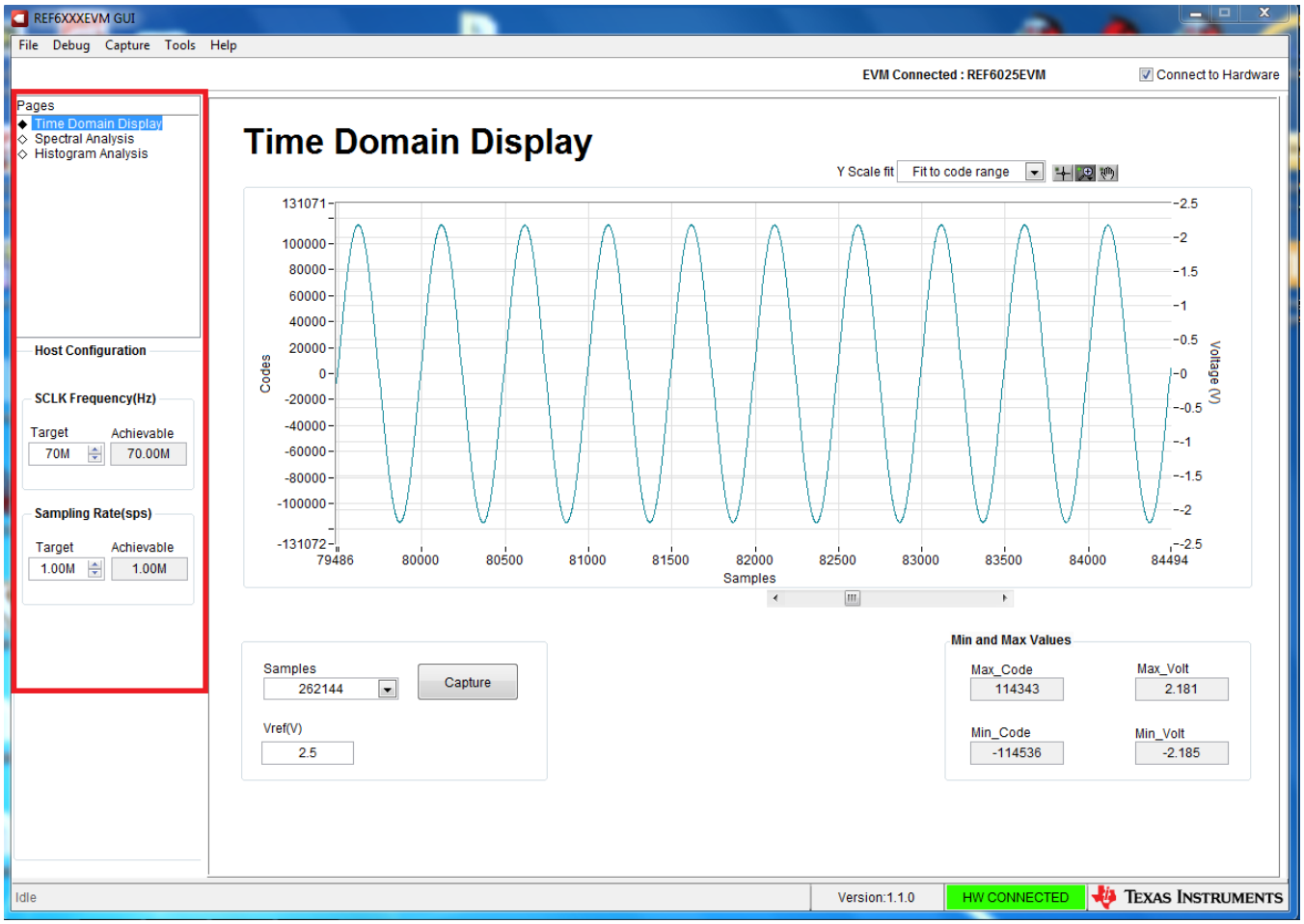

Figure 9. EVM GUI Global Input Parameters

The host configuration options in this pane allow user-configuration of the host interface of the ADS8881. In this pane, *SCLK Frequency(Hz)* and *Sampling Rate(sps)* can be selected. Using either of these two parameters, the GUI computes the best achievable values for the other, considering the timing constraints of the selected device mode.

A target SCLK frequency (in Hz) can be specified and the GUI will try to match this, as closely as possible, by changing the PHI PLL settings. The achievable frequency may differ slightly from the selected target value. Similarly, the sampling rate of the ADC can be adjusted by modifying the target sampling rate argument (also in Hz). The achievable ADC sampling rate may differ from the target value, depending on the applied SCLK frequency and the closest match achievable is displayed.

5.2 Time Domain Display Tool

The *Time Domain Display* tool allows visualization of the ADC response to a given input signal. This tool is useful for both studying the behavior and debugging any gross problems with the ADC, input drive, or reference circuits.

The user can trigger a capture of the data of the selected number of samples from the ADS8881, as per the host configuration settings using the capture button as indicated on Figure 10 . The sample indices are on the x-axis and there are two y-axes showing the corresponding output codes as well as the equivalent analog voltages based on the reference voltage driven by the REF6025. Switching pages to any of the analysis tool described in Section 5.3 and Section 5.4, triggers calculations to be performed on the same set of data.

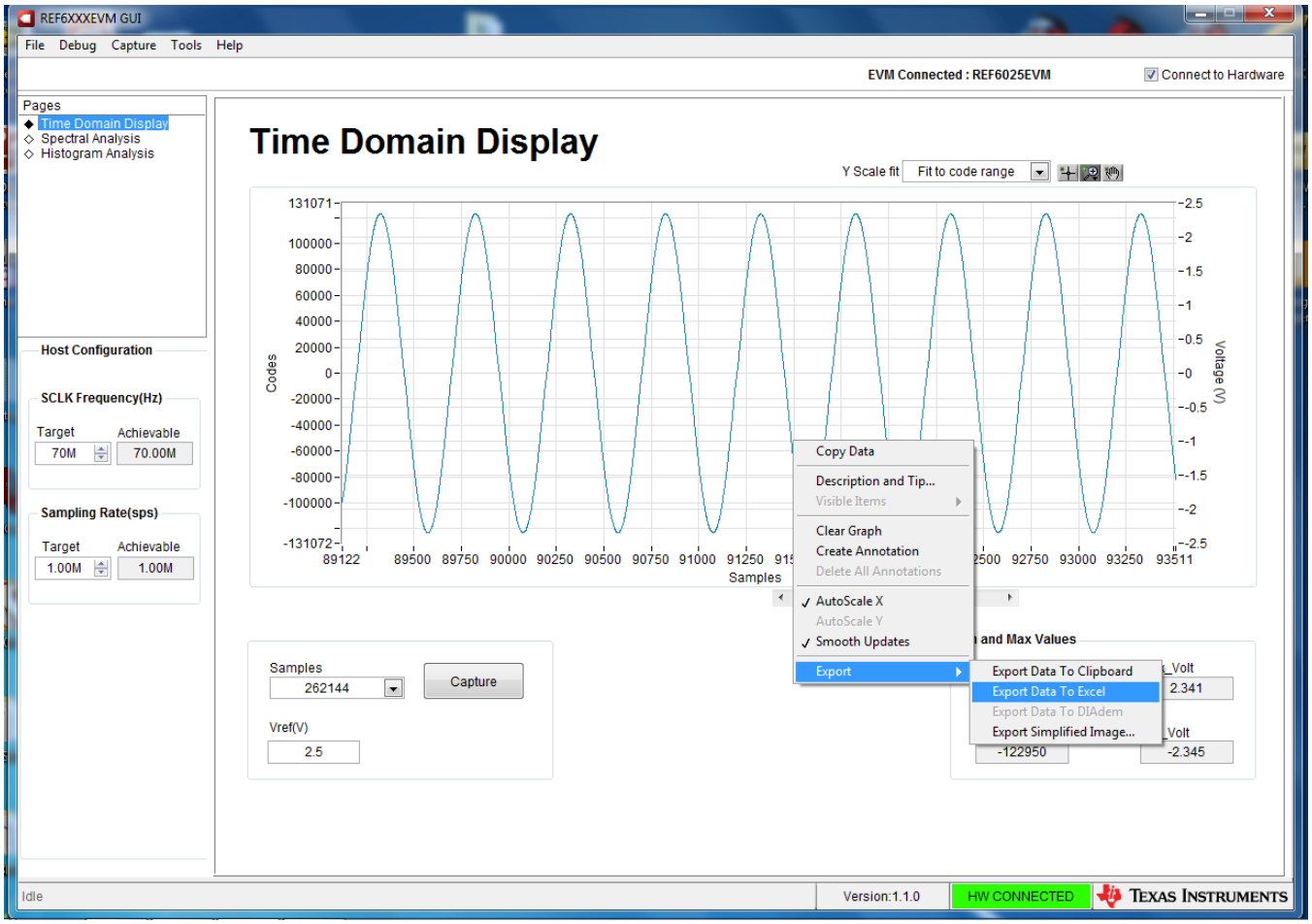

Figure 10. Time Domain Data Capture with Data Export Option

5.3 Spectral Analysis Tool

This tool helps with the evaluation the dynamic performance of the REF6025EVM through FFT analysis of the ADC output for time-varying inputs and computation of key dynamic range metrics (such as SNR, THD, SFDR, SINAD, and ENOB).

The expected ADC input is a sinusoidal signal of peak-to-peak amplitude close to the ADC full-scale input range (FSR). The RMS power of the input signal normalized to FSR is shown in the Signal Power (dB) field and must be approximately –0.5 dBFS (or approximately 95% × FSR) to avoid input clipping.

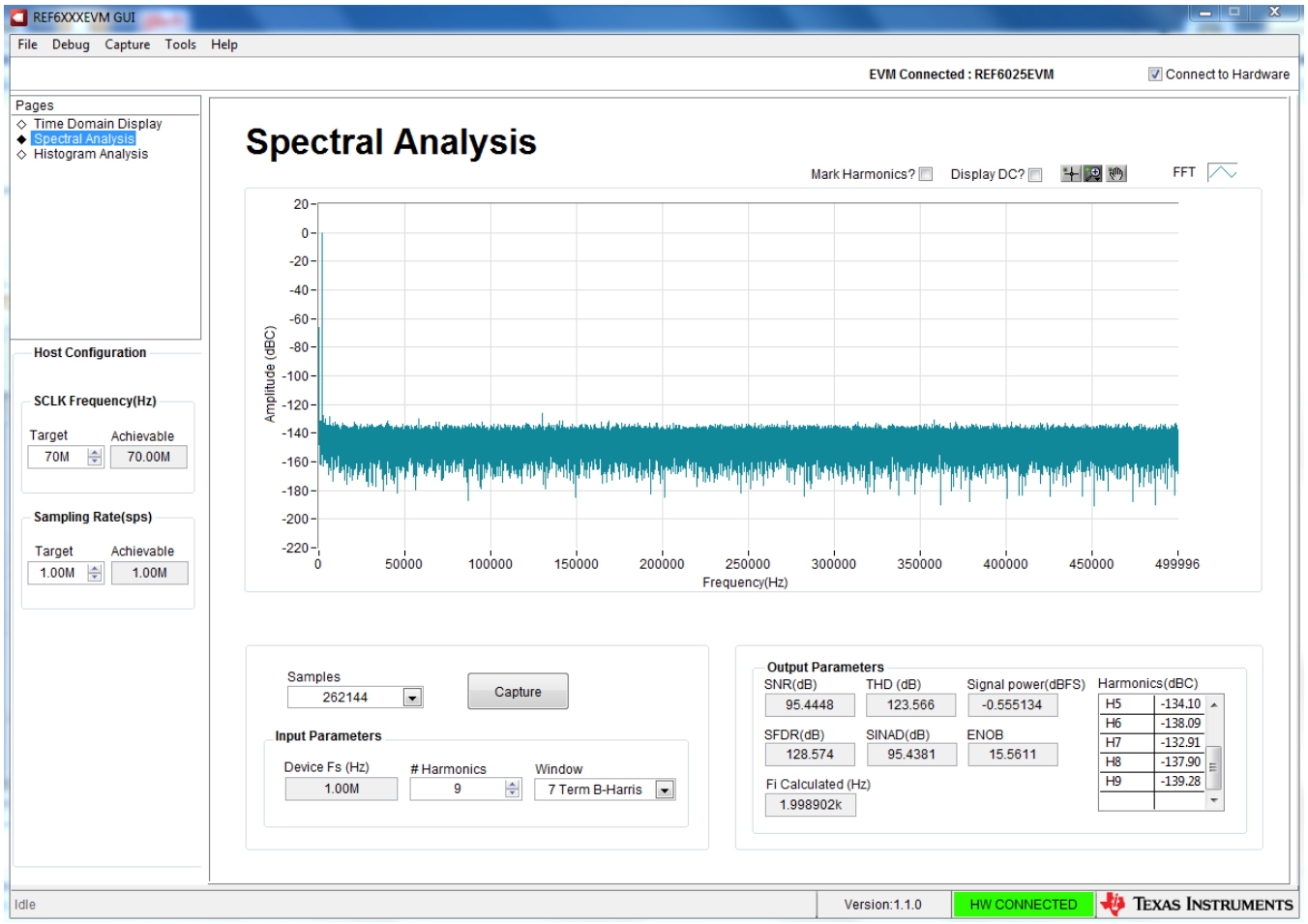

Figure 11. Spectral Analysis Tool

Finally, the FFT tool includes windowing options that are required to mitigate the effects of non-coherent sampling (this discussion is beyond the scope of this document). The *7-Term Blackman Harris* window is the default option and has sufficient dynamic range to resolve the frequency components of up to a 24-bit ADC. Note that the *None* option corresponds to not using a windowing function (or using a rectangular window) and is not recommended.

5.4 Histogram Tool

Noise degrades ADC resolution and the histogram tool can be used to estimate *effective resolution*, which is an indicator of the number of bits of ADC resolution losses resulting from noise generated by the various sources connected to the ADC when measuring a DC signal. The cumulative effect of noise coupling to the ADC output from sources such as the input drive circuits, the reference drive circuit, the ADC power supply, and the ADC itself is reflected in the standard deviation of the ADC output code histogram that is obtained by performing multiple conversions of a dc input applied to a given channel.

The histogram corresponding to a dc input is displayed on clicking on the **Capture** button as Figure 12 shows:

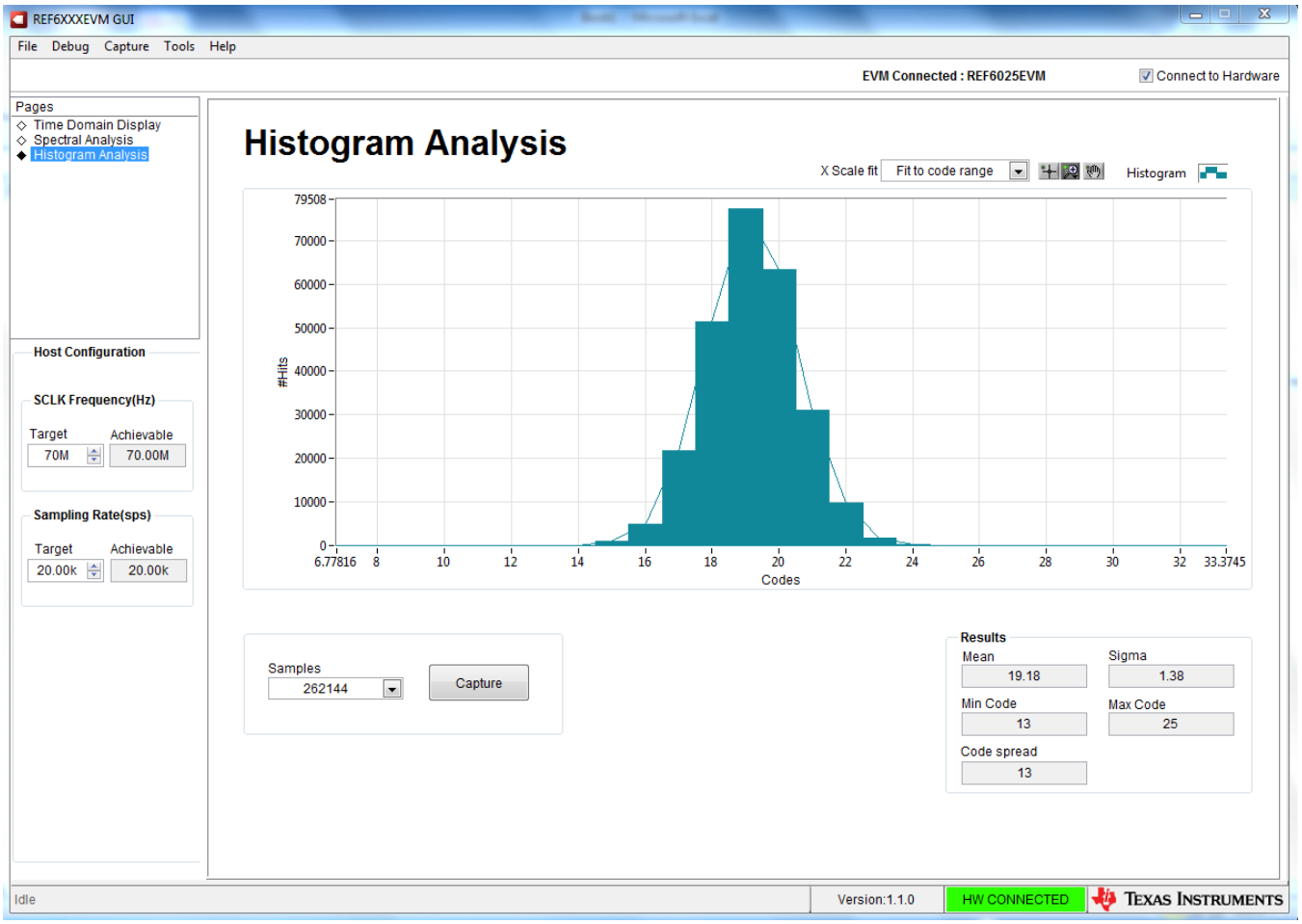

Figure 12. Histogram Analysis Tool

6 Bill of Materials, PCB Layout, and Schematics

This section contains the REF6025EVM bill of materials, PCB layout, and the EVM schematics.

6.1 Bill of Materials

Table 4 lists the REF6025EVM BOM.

Table 4. REF6025EVM Bill of Materials

Manufacturer Part Number	Qty	Reference Designators	Manufacturer	Description
PA008	3	!PCB	Any	Printed Circuit Board
GRM21BR71A106KE51L	10	C1, C6, C8, C12, C24, C27, C29, C30, C42, C45	Murata	CAP, CERM, 10uF, 10V, +/-10%, X7R, 0805
GRM188R71A105KA61D	8	C2, C4, C10, C13, C14, C16, C17, C44	Murata	CAP, CERM, 1uF, 10V, +/-10%, X7R, 0603
GRM32ER71A476KE15L	1	C3	Murata	CAP, CERM, 47 µF, 10V, +/- 10%, X7R, 1210
06031C102JAT2A	1	C5	AVX	CAP, CERM, 1000 pF, 100V, +/- 5%, X7R, 0603
C0603X104K3RACTU	3	C7, C15, C18	Kemet	CAP, CERM, 0.1uF, 25V, +/-10%, X7R, 0603
C3216X5R1E476M160AC	2	C9, C34	TDK	CAP, CERM, 47 µF, 25 V, +/- 20%, X5R, 1206
593D106X9025C2TE3	1	C11	Vishay-Sprague	CAP, TA, 10 µF, 25 V, +/- 10%, 0.45 ohm, SMD
C0805C103F1GACTU	1	C19	Kemet	CAP, CERM, 0.01 µF, 100 V, +/- 1%, C0G/NP0, 0805
C1608C0G1E103J	2	C23, C43	TDK	CAP, CERM, 0.01 µF, 25 V, +/- 5%, C0G/NP0, 0603
GRM21BR71C475KA73L	1	C25	Murata	CAP, CERM, 4.7 µF, 16 V, +/- 10%, X7R, 0805
0805ZC105KAT2A	1	C26	AVX	CAP, CERM, 1 µF, 10 V, +/- 10%, X7R, 0805
GRM21BR71A475KA73L	1	C28	Murata	CAP, CERM, 4.7 µF, 10 V, +/- 10%, X7R, 0805
GMK316AB7106KL	1	C31	Taiyo Yuden	CAP, CERM, 10 µF, 35 V, +/- 10%, X7R, 1206
C1005X7R1H104K	1	C32	TDK	CAP, CERM, 0.1uF, 50V, +/-10%, C0G/NP0, 0402
GRM1885C1H102FA01J	1	C33	Murata	CAP, CERM, 1000 pF, 50 V, +/- 1%, C0G/NP0, 0603
06035A102KAT2A	1	C41	AVX	CAP, CERM, 1000 pF, 50 V, +/- 10%, C0G/NP0, 0603
1891	4	H1, H2, H3, H4	Keystone	3/16 Hex Female Standoff
9774050360R	2	H5, H6	Wurth Elektronik	ROUND STANDOFF M3 STEEL 5MM
PMSSS 440 0025 PH	4	H7, H8, H9, H10	B&F Fastener Supply	MACHINE SCREW PAN PHILLIPS 4-40
RM3X4MM 2701	2	H11, H12	APM HEXSEAL	Machine Screw Pan PHILLIPS M3
TSM-103-01-L-SV	3	J1, J3, J13	Samtec	Header, 100mil, 3x1, Gold, SMT
QTH-030-01-L-D-A	1	J2	Samtec	Header(Shrouded), 19.7mil, 30x2, Gold, SMT
5-1814832-1	2	J4, J5	TE Connectivity	SMA Straight PCB Socket Die Cast, 50 Ohm, TH
TSM-102-03-T-SV	1	J6	Samtec	Header, 2.54mm, 2x1, Tin, SMT
TSM-106-01-L-DV	1	J7	Samtec	Header, 2.54mm, 6x2, Gold, SMT
THT-14-423-10	1	LBL1	Brady	Thermal Transfer Printable Labels, 0.650" W x 0.200" H - 10,000 per roll
CRCW06030000Z0EA	9	R2, R7, R8, R14, R16, R31, R32, R37, R43	Vishay-Dale	RES, 0, 5%, 0.1 W, 0603

Table 4. REF6025EVM Bill of Materials (continued)

Manufacturer Part Number	Qty	Reference Designators	Manufacturer	Description
CRCW060310R0FKEA	1	R3	Vishay-Dale	RES, 10.0, 1%, 0.1 W, 0603
ERJ-3RQFR22V	1	R4	Panasonic	RES, 0.22 ohm, 1%, 0.1W, 0603
CRCW060347K5FKEA	1	R5	Vishay-Dale	RES, 47.5 k, 1%, 0.1 W, 0603
CRCW060315K0FKEA	1	R6	Vishay-Dale	RES, 15.0 k, 1%, 0.1 W, 0603
RC0603FR-0747RL	3	R9, R10, R12	Yageo America	RES, 47.0, 1%, 0.1 W, 0603
ERJ-3RSFR10V	1	R11	Panasonic	RES, 0.1, 1%, 0.1 W, 0603
CRCW060320K0FKEA	2	R13, R15	Vishay-Dale	RES, 20.0 k, 1%, 0.1 W, 0603
CRCW040210K0FKED	2	R17, R33	Vishay-Dale	RES, 10.0k ohm, 1%, 0.063W, 0402
CRCW06031K00FKEA	5	R18, R19, R20, R21, R22	Vishay-Dale	RES, 1.00k ohm, 1%, 0.1W, 0603
CRCW06034R99FKEA	5	R23, R24, R25, R26, R44	Vishay-Dale	RES, 4.99, 1%, 0.1 W, 0603
RC0603FR-0716KL	1	R29	Yageo America	RES, 16.0 k, 1%, 0.1 W, 0603
RC0603FR-0718KL	1	R30	Yageo America	RES, 18.0 k, 1%, 0.1 W, 0603
CRCW06030000Z0EA	1	R42	Vishay-Dale	RES, 0, 5%, 0.1 W, 0603
5006	6	TP1, TP2, TP3, TP4, TP5, TP6	Keystone	Test Point, Compact, Black, TH
5008	1	TP7	Keystone	Test Point, Compact, Orange, TH
5005	2	TP8, TP9	Keystone	Test Point, Compact, Red, TH
REF6025AIDGK	1	U1	Texas Instruments	High-Precision Voltage Reference with Integrated High-Bandwidth Buffer, DGK0008A
ADS8881IDGSR	1	U2	Texas Instruments	18-Bit, 1-MSPS, Serial Interface, microPower, Miniature, True-Differential Input, SAR Analog-to-Digital Converter, DGS0010A
TPS78833DBVR	1	U3	Texas Instruments	Single Output Low Noise LDO, 150 mA, Fixed 3.3 V Output, 2.7 to 10 V Input, with Low IQ, 5-pin SOT-23 (DBV), 0 to 70 degC
THS4521IDGKR	1	U4	Texas Instruments	VERY LOW POWER, NEGATIVE RAIL INPUT, RAIL-TO-RAIL OUTPUT, FULLY DIFFERENTIAL AMPLIFIER, DGK0008A
OPA333AIDBVR	1	U5	Texas Instruments	17 uA, MicroPower, Precision, Zero Drift CMOS Operational Amplifier, 1.8 to 5.5 V, -40 to 125 degC, 5-pin SOT23 (DBV0005A)
LP38798SD-ADJ/NOPB	1	U6	Texas Instruments	Ultra Low Noise, 800 mA Linear Voltage Regulator for RF/Analog Circuits, DNT0012B
BR24G32FVT-3AGE2	1	U7	Rohm	I2C BUS EEPROM (2-Wire), TSSOP-B8
TPS7A4700RGWR	1	U8	Texas Instruments	36V, 1-A, 4.17-µVRMS, RF LDO Voltage Regulator, RGW0020A

6.2 PCB Layout

Figure 13 through Figure 16 illustrate the EVM PCB layout.

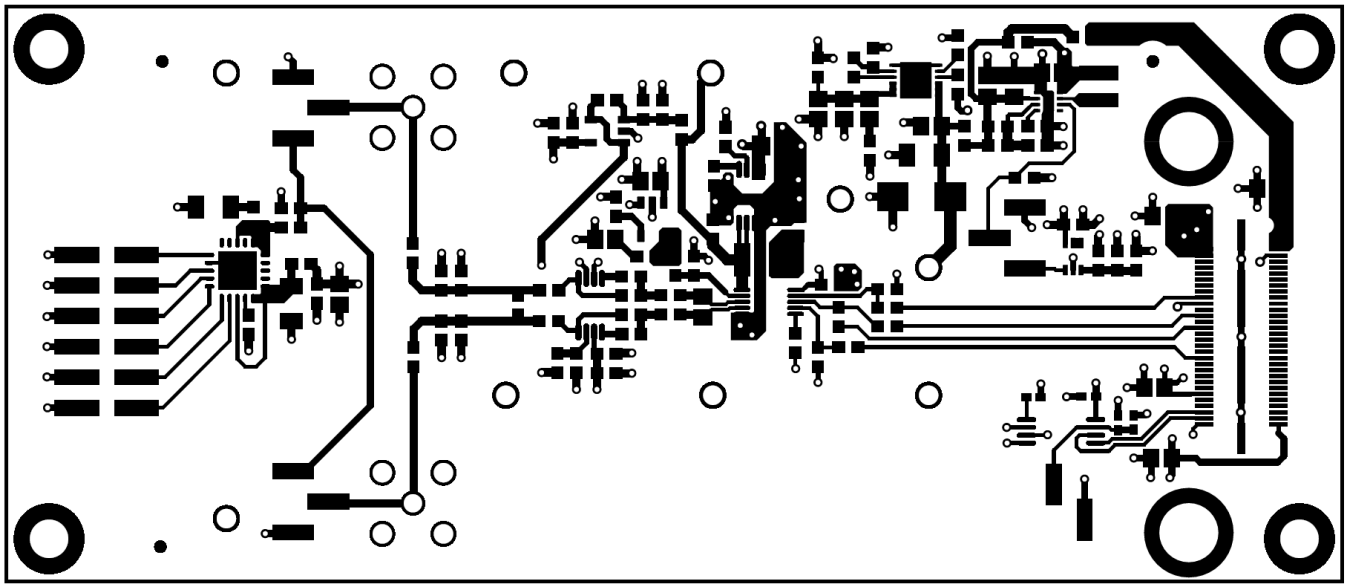

Figure 13. REF6025EVM PCB Layer 1: Top Layer

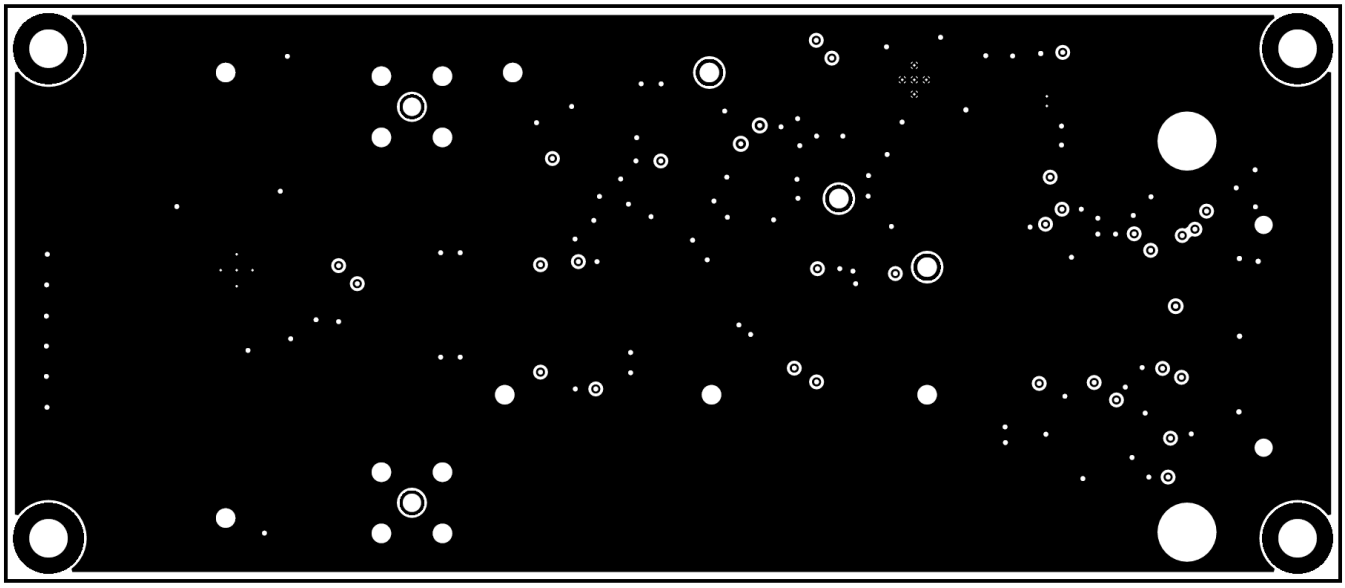

Figure 14. REF6025EVM PCB Layer 2: GND Plane

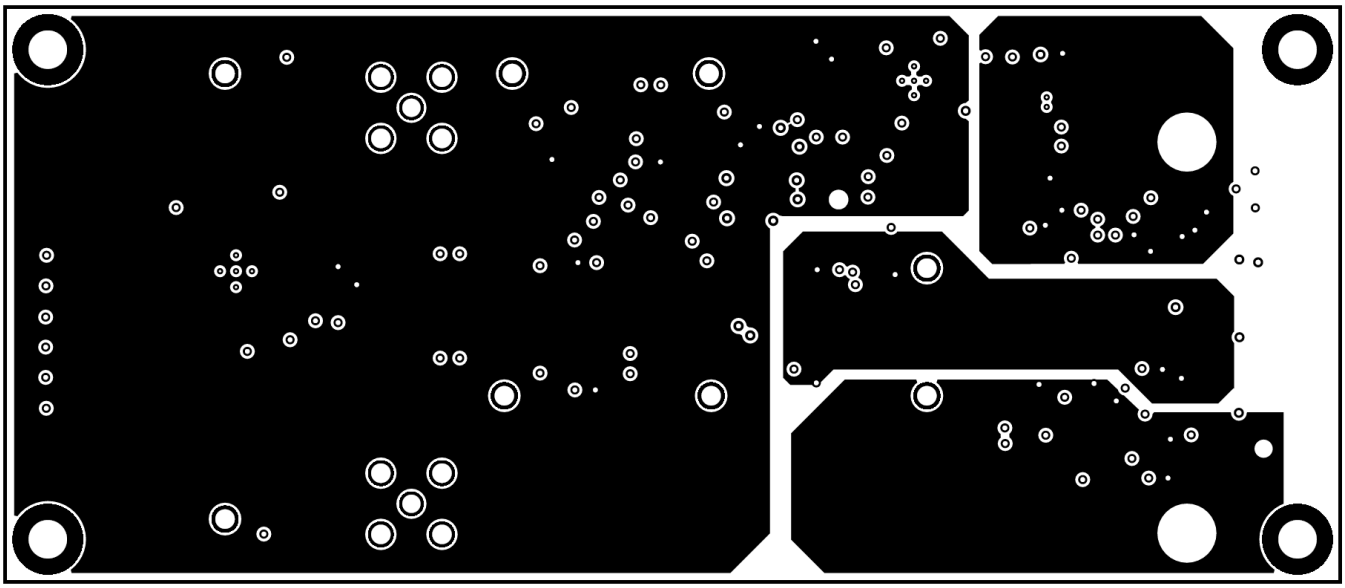

Figure 15. REF6025EVM PCB Layer 3: Power Planes

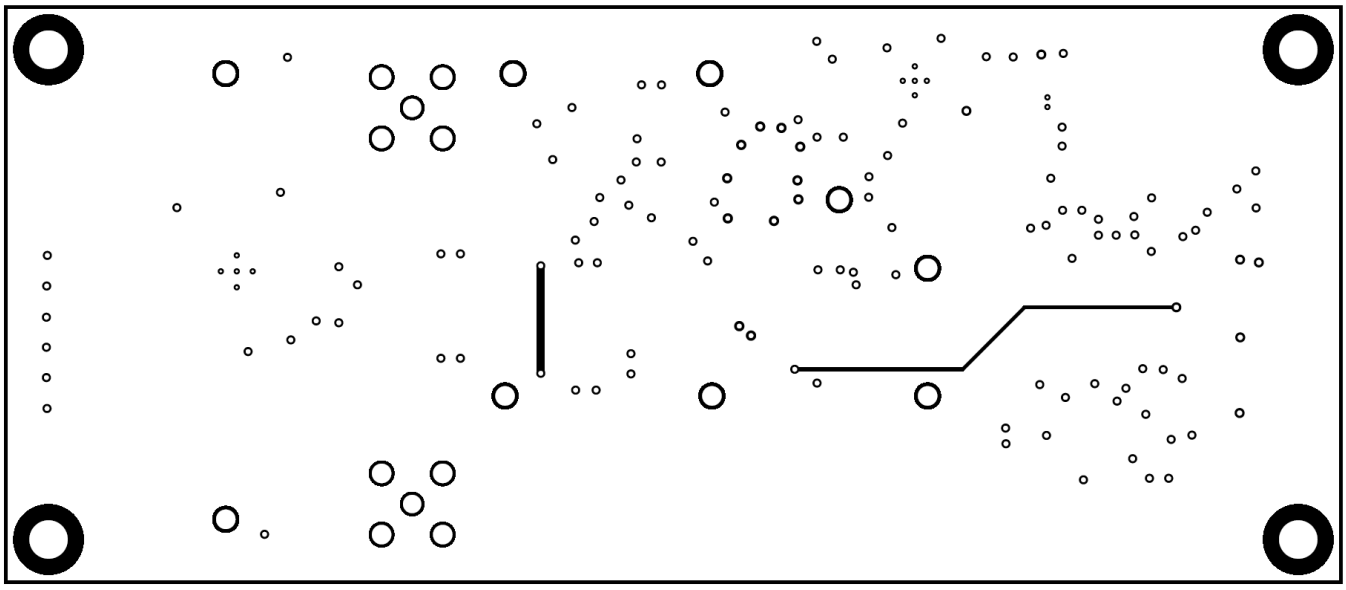

Figure 16. REF6025EVM PCB Layer 4: Bottom Layer

6.3 Schematic

Figure 17 and Figure 18 illustrate the EVM schematics.

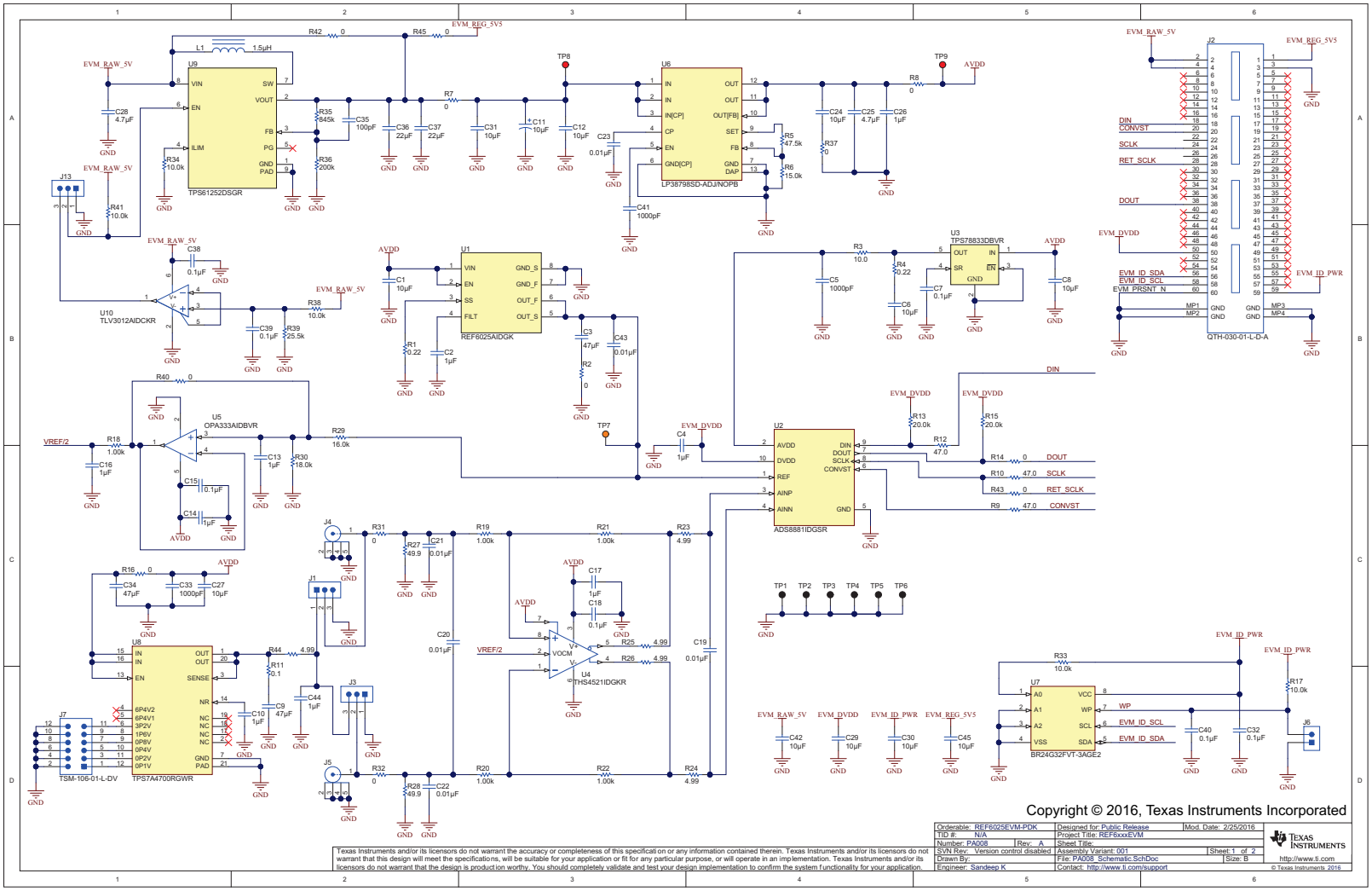

Figure 17. Schematic Diagram (Page 1) of the REF6025EVM PCB

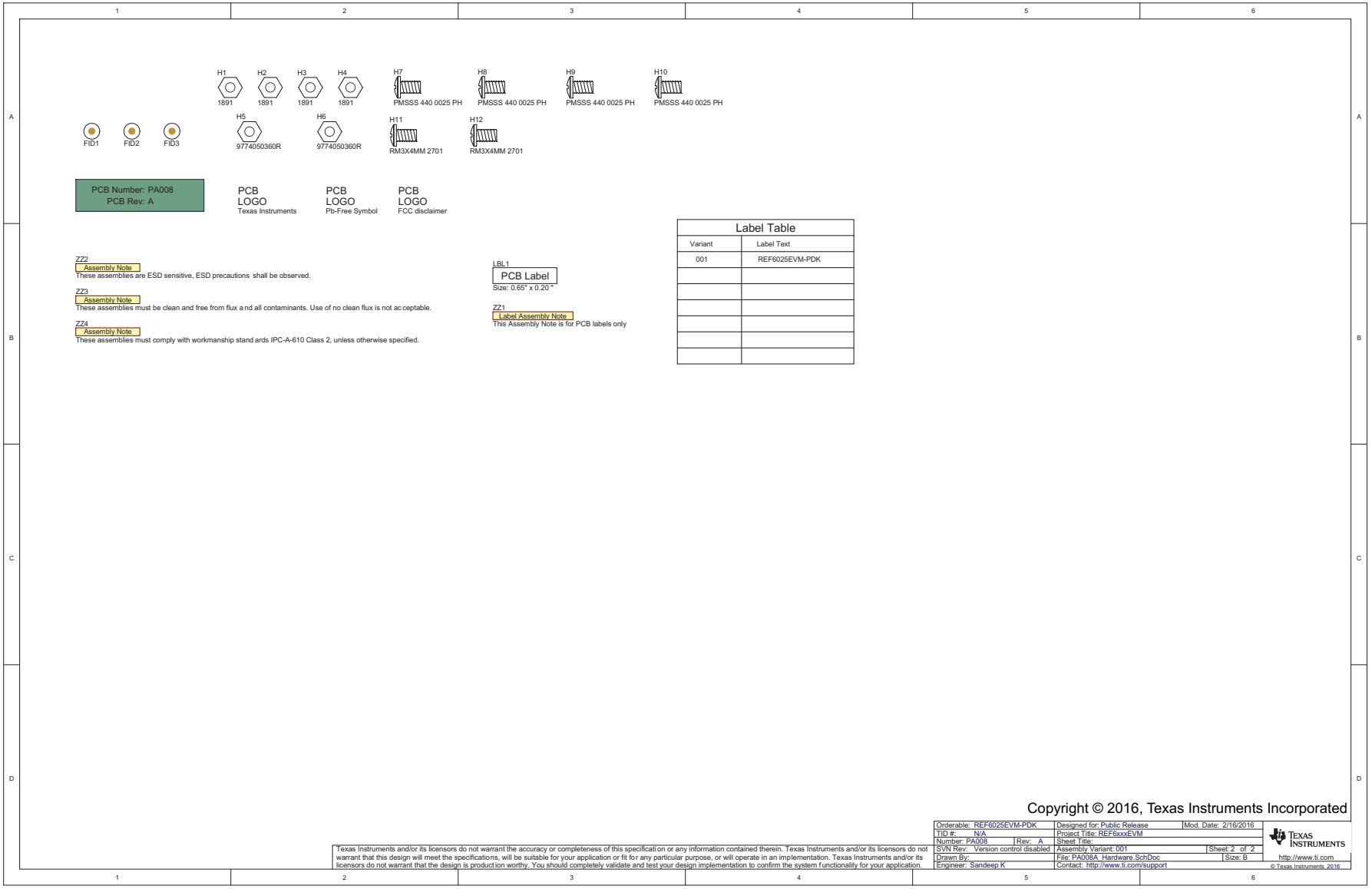

Figure 18. Schematic Diagram (Page 2) of the REF6025EVM PCB

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2 *Limited Warranty and Related Remedies/Disclaimers*:

   2.1 These terms and conditions 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 any defects that are 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. Moreover, TI shall not be liable for any defects that result from User's design, specifications or instructions for such EVMs. Testing and other quality control techniques are used to the extent TI deems necessary or as mandated by government requirements. TI does not test all parameters of each EVM.

   2.3 If any EVM fails to conform to the warranty set forth above, TI's sole liability shall be at its option to repair or replace such EVM, 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.

3 *Regulatory Notices:*

   3.1 *United States*

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

      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*

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Concernant les EVMs avec appareils radio:

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

Concerning EVMs Including Detachable Antennas:

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

Concernant les EVMs avec antennes détachables

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

3.3 *Japan*

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

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If User uses EVMs in Japan, not certified to Technical Regulations of Radio Law of Japan, User is required by Radio Law of Japan to follow the instructions below with respect to EVMs:

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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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.

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