User's Guide
SNAU229–December 2017

BOOSTXL-ADS7841-Q1 BoosterPack™ User's Guide

The ADS7841-Q1 BoosterPack™ (BOOSTXL-ADS7841-Q1) allows users to evaluate the functionality of Texas Instruments' ADS7841-Q1 SAR ADC. The ADS7841-Q1 is a 12-bit, 4-channel, automotive qualified SAR ADC. This user's guide describes both the hardware platform with an ADS7841-Q1 device, and the graphical user interface (GUI) software used to configure the various modes of operation of this device.

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Trademarks

BoosterPack, LaunchPad, TM4C1294 LaunchPad are trademarks of Texas Instruments.

1 Introduction

The BOOSTXL-ADS7841-Q1 BoosterPack™ is a fully-assembled evaluation platform designed to highlight the ADS7841-Q1 device features and its various modes of operations.

The BOOSTXL-ADS7841-Q1 EVM interfaces to the TM4C1294 LaunchPad™ Development Kit (EK-TM4C1294XL). The Tiva C Series TM4C1294 MCU on the TM4C1294 LaunchPad™ communicates with the ADS7841-Q1 through its SPI interface and acts as a USB-to-PC GUI communication bridge.

NOTE: The BOOSTXL-ADS7841-Q1 requires an external master controller to evaluate the ADS7841-Q1.

The TM4C1294 LaunchPad™ is controlled by commands received from the BOOSTXL-ADS7841-Q1 EVM GUI, and returns data to the GUI for display and analysis. If the TM4C1294 LaunchPad™ is not used, the BoosterPack plug-in module format of the BOOSTXL-ADS7841-Q1 board allows an alternative external host to communicate with the ADS7841-Q1.

The BOOSTXL-ADS7841-Q1 EVM incorporates all required circuitry and components with the following features:

- ADS7841-Q1 12-bit, 4-channel, automotive qualified SAR ADC with SPI interface
- Optional low power voltage reference, TI's REF5045A, to generate a 4.5-V reference for the ADS7841-Q1 VREF pin when using 5.0 V from TM4C1294 LaunchPad™
- Optional precision, low noise, dual operational amplifier, TI's OPA2320, to generate buffered input for the ADS7841-Q1 AIN0 and AIN2 pins
- Optional adjustable linear regulator, TI's TPS79901, to generate stable 5V output voltage to power the ADS7841-Q1 VCC pin when using the USB power from the TM4C1294 LaunchPad™
- SPI interface for communication and configuration of modes available on the ADS7841-Q1

Figure 1 shows the BOOSTXL-ADS7841-Q1 EVM architecture, identifying the key components and blocks previously listed.

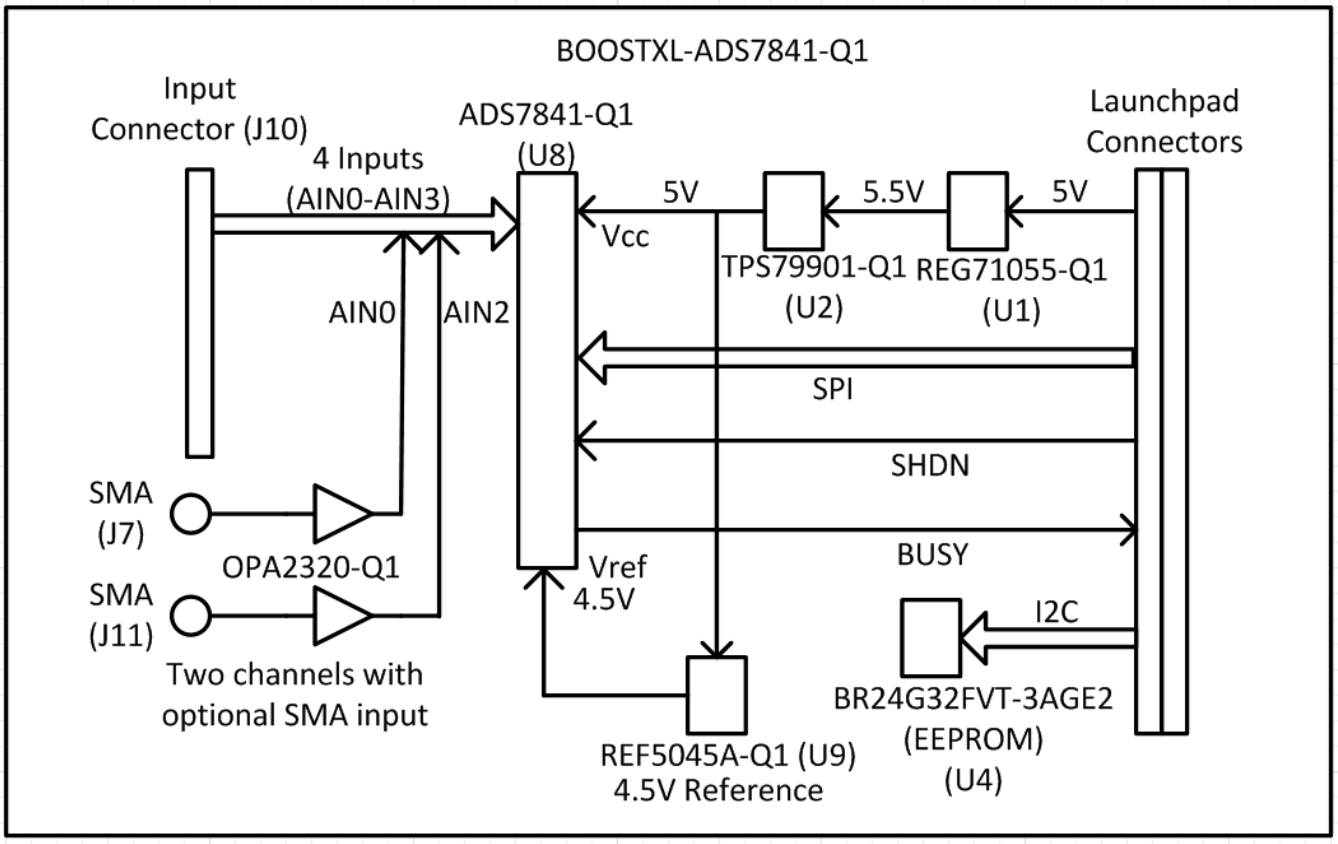

Figure 1. BOOSTXL-ADS7841-Q1 EVM Block Diagram

2 BOOSTXL-ADS7841-Q1 EVM Overview

Section 2 describes various onboard components that are used to interface analog input, digital interface, and provide power supply to BOOSTXL-ADS7841-Q1 EVM. Figure 2 shows a BOOSTXL-ADS7841-Q1 EVM overview.

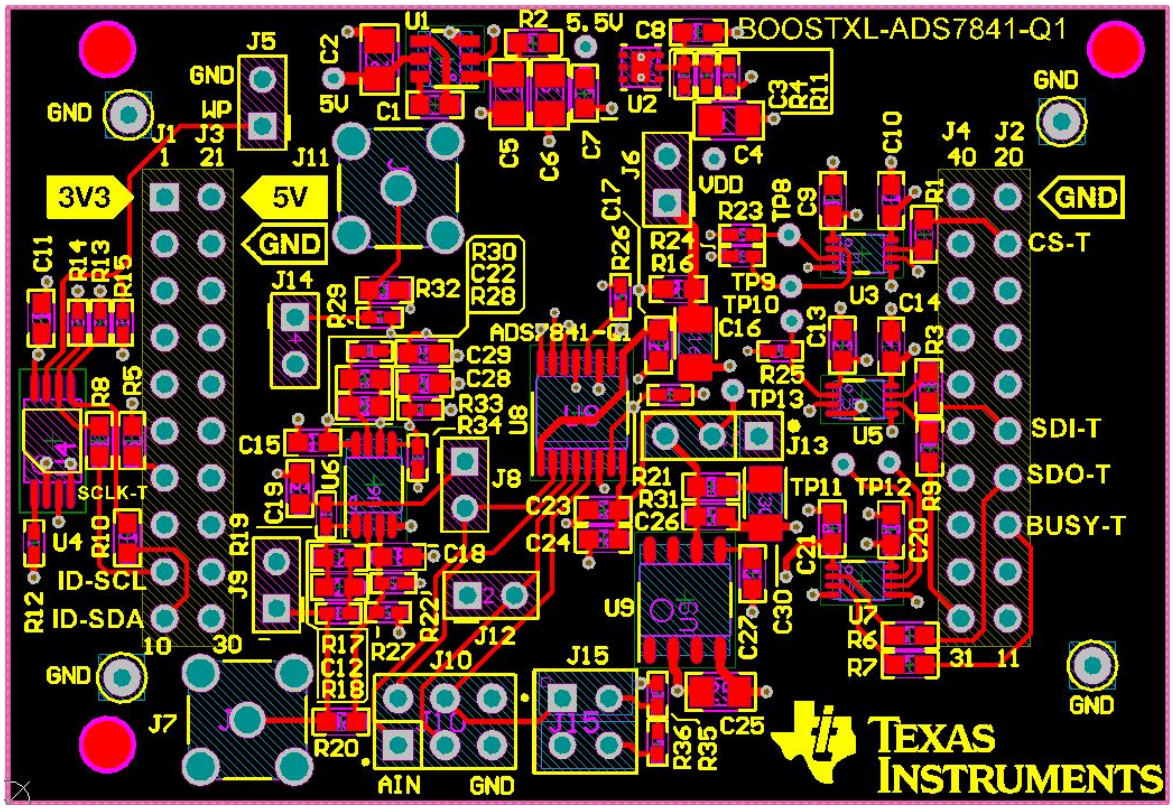

Figure 2. BOOSTXL-ADS7841-Q1EVM Top Level Overview

2.1 Connectors for Analog Input

The BOOSTXL-ADS7841-Q1 EVM is designed for easy interface to analog sources through a 100-mil header. Connector J10 allows analog source connectivity. Table 1 lists the analog input connector and input channel configuration.

Table 1. Input Connector and Channel Configuration

J10 Connector Pin	Description
J10:1	Single-ended analog input for channel 0 of ADC
J10:2	Single-ended analog input for channel 1 of ADC
J10:3	Single-ended analog input for channel 2 of ADC
J10:4	Single-ended analog input for channel 3 of ADC
J10:1 - J10:2	Pseudo-Differential analog input for channel 0 - channel 1 of ADC
J10:2 - J10:1	Pseudo-Differential analog input for channel 1 - channel 0 of ADC
J10:3 - J10:4	Pseudo-Differential analog input for channel 2 - channel 3 of ADC
J10:4 - J10:3	Pseudo-Differential analog input for channel 3 - channel 2 of ADC
J10:5 and J10:6	BoosterPack ground

The analog input range is from GND to +VREF when configured as single-ended inputs. A maximum of four single-ended inputs may be applied to J10, using pins J10:1 to J10:4. When configured for differential mode operation, the positive analog input level has a range of -0.2V to VCC + 0.2V. The voltage on the negative analog input is limited between -0.2V and 1.25V. A maximum of two pseudo-differential inputs may be applied to J10, using pins J10:1 - J10:2, and J10:3 - J10:4.

The input to channel 0 can be optionally configured to use the OPA2320 buffer through 100ohm resistor with an 560pF capacitor to GND. Jumper J8 can be placed on pins 1-2 to select this unity gain buffer configuration of the OPA2320 and in this case channel 0 input is provided via SMA connector J7. A similar configuration is available for channel 2 input as well by using Jumper J12 pins 1-2 and via SMA connector J11.

By default, AIN3 is factory configured by Jumper J15 pins 1-2 and J15 pins 3-4 on the BOOSTXL-ADS7841-Q1 EVM to measure a fraction of the 5V supply voltage using simple resistor divider circuit formed by R35/R36 (see schematic in Figure 19). Please ensure Jumper J15 shunts are disconnected when using J10.3 as AIN3 input.

2.2 Voltage Reference

The BOOSTXL-ADS7841-Q1 EVM has two sources for the reference voltage. Jumper J13 can select the VREF voltage from either the REF5045A (U9) or from 5V VCC. The EVM is factory configured for use with the REF5045A 4.5V reference (J13 pins 2-3).

2.3 Digital Interface

As noted in Section 1, the BOOSTXL-ADS7841-Q1 EVM interfaces with the TM4C1294 LaunchPad™, which in turn communicates with the computer over USB. The two devices on the booster pack that the TM4C1294 communicates with are the ADS7841-Q1 ADC (over SPI) and the EEPROM (over I^2C). The EEPROM comes preprogrammed with the information required to configure and initialize the BOOSTXL-ADS7841-Q1 EVM platform every time on power up.

2.4 ADS7841-Q1EVM Digital I/O Interface

The BOOSTXL-ADS7841-Q1 EVM supports the SPI digital interface and functional modes as detailed in the ADS7841-Q1EVM device data sheet (SBAS469). The TM4C1294 LaunchPad™ is operating at a 3.3-V logic level and is connected to the 5.0-V digital I/O lines of the ADC through level shifter (SN74LVC2T45QDCURQ1).

2.5 Power Supplies

The device supports a single supply with a wide range of operation. The VCC can operate from 2.7 V to 5.0 V. TI's TPS79901 adjustable voltage regulator available onboard is configured to supply 5.0 V to ADS7841-Q1 VCC pin on the BOOSTXL-ADS7841-Q1 EVM.

3 BOOSTXL-ADS7841-Q1EVM EVM Setup

3.1 BOOSTXL-ADS7841-Q1 EVM Graphical User Interface Software Installation

The following steps describe the BOOSTXL-ADS7841-Q1 EVM GUI software installation:

1. Download the latest version of the EVM graphical user interface (GUI) installer from the *Tools and Software* folder of the device, and run the GUI installer to install the EVM GUI software on your windows PC.
2. Accept the *License Agreements* and follow the on-screen instructions to complete the installation (see Figure 3).

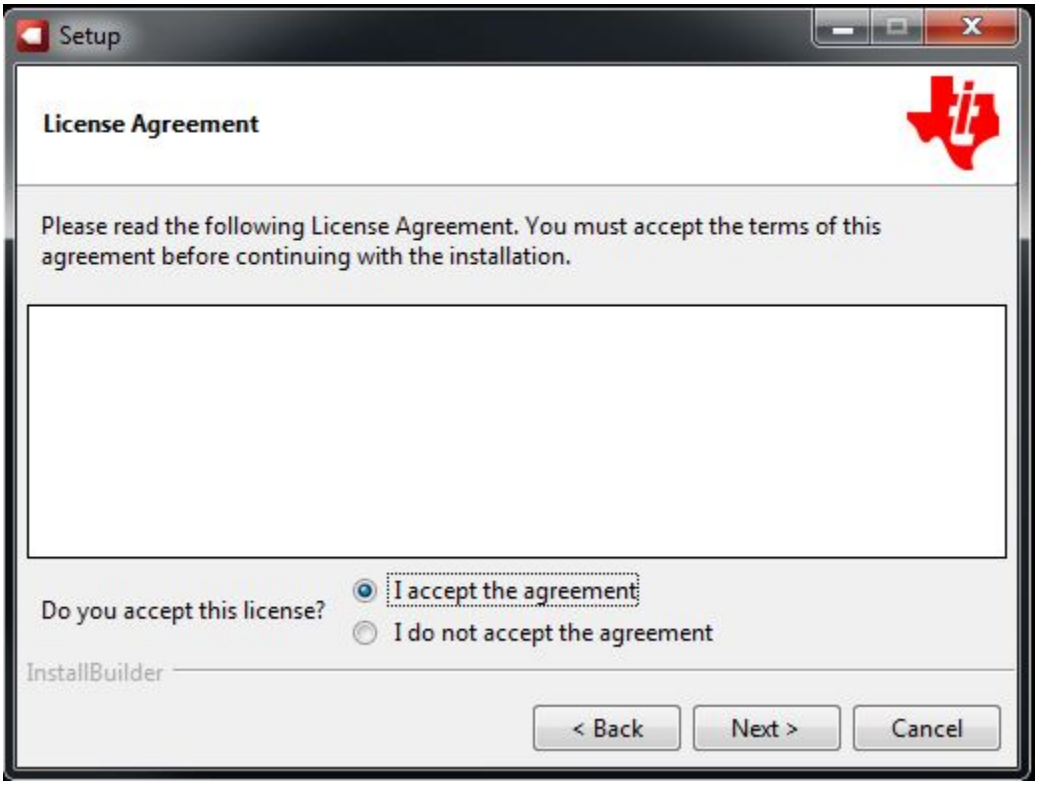

Figure 3. BOOSTXL-ADS7841-Q1 EVM GUI Installation

3. As a part of the BOOSTXL-ADS7841-Q1 EVM GUI installation, a prompt with a *Device Driver Installation Wizard* appears on the screen (see Figure 4). Click the *Next* button to proceed, then click the *Finish* button when the installation is complete.

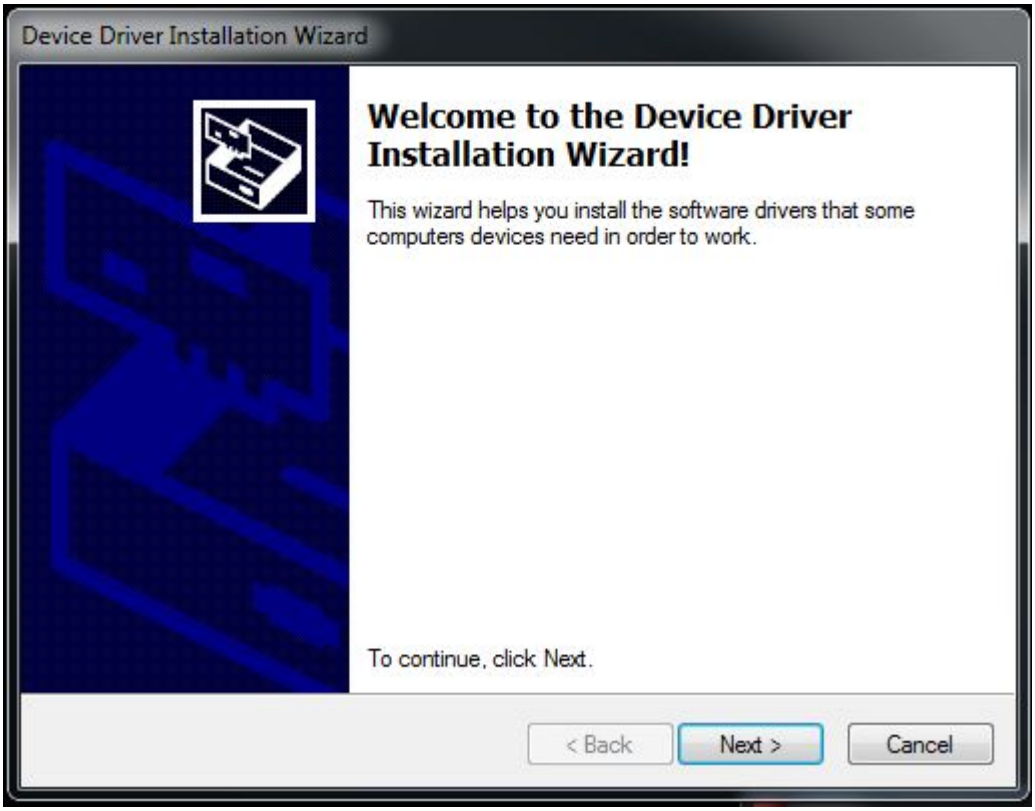

Figure 4. BOOSTXL-ADS7841-Q1 EVM Driver Installation

4. Open the computer's "Device Manager". You must be able to see the "Stellaris Virtual Serial Port" and "Stellaris In-Circuit Debug Interface" as shown in Figure 5.

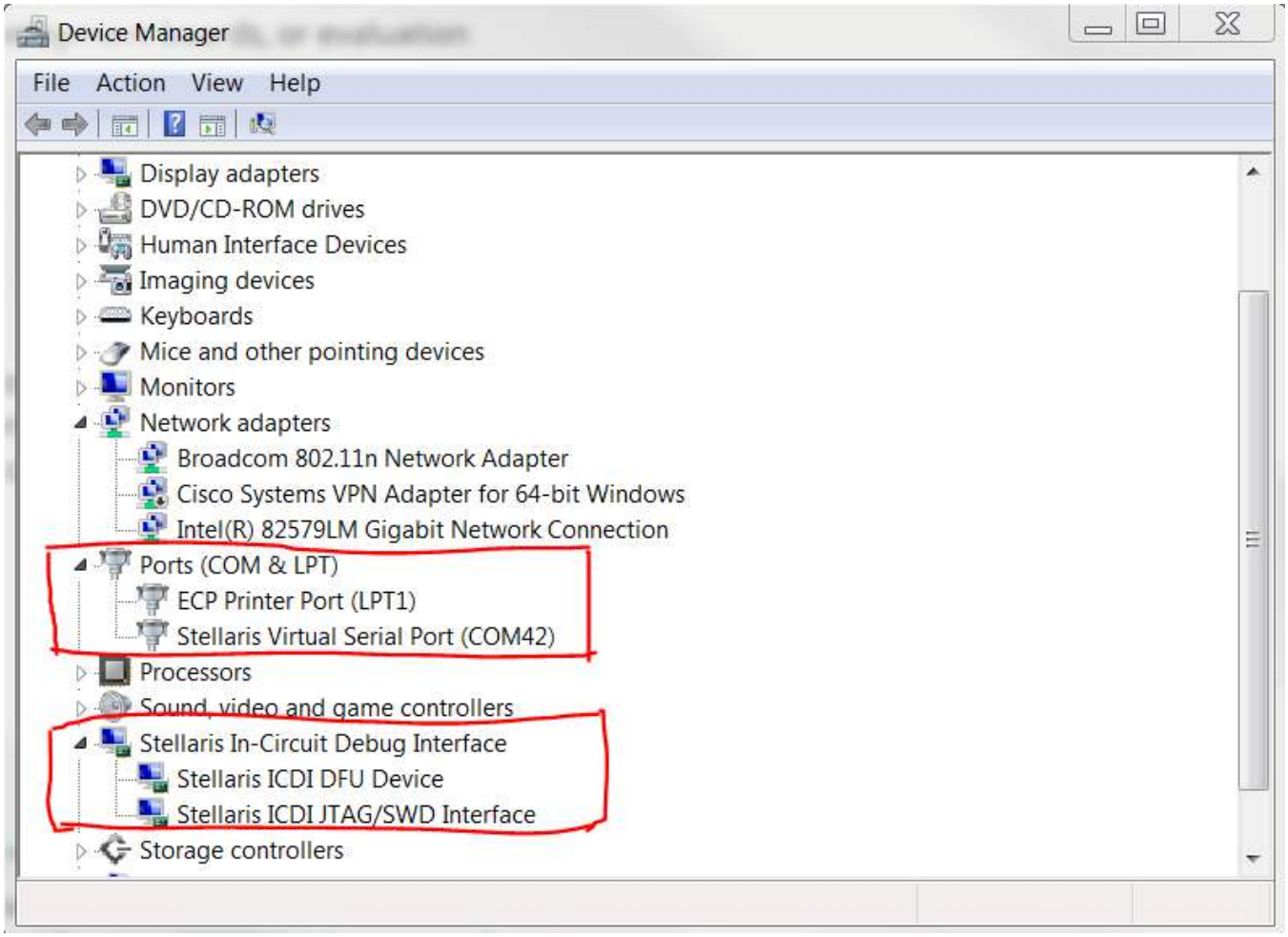

Figure 5. TM4C1294 LaunchPad™ Stellaris Virtual Serial Port and ICDI Driver

3.2 LM Flash Programmer for TM4C1294 LaunchPad™ Software Programming

The TM4C1294 LaunchPad™ ships with a default firmware program flashed on its memory. When a TM4C1294 LaunchPad™ is connected to the PC for the first time, its firmware needs to be updated for communications with the BOOSTXL-ADS7841-Q1 EVM. The following steps describe the programming of this firmware on the flash memory:

1. Download the latest version of *LM Flash Programmer*. The LM Flash Programmer is also included as part of the BOOSTXL-ADS7841-Q1 EVM GUI installation in the following folder: C:\Program Files (x86)\Texas Instruments\ADS7841\Firmware
2. Make sure the power select JP1 jumper on the TM4C1294 LaunchPad™ is on ICDI. Connect the *Debug USB port* on the TM4C1294 LaunchPad™ to the PC with a micro USB cable as shown in Figure 6. This must light the green power LED D0 on the TM4C1294 LaunchPad™.

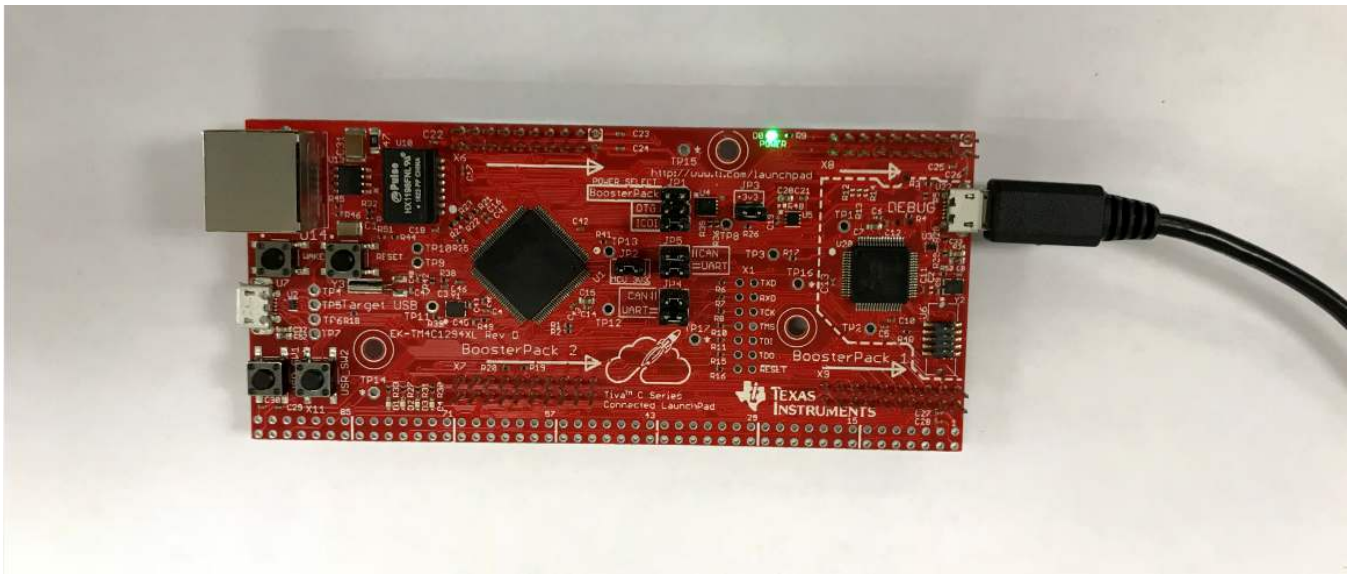

Figure 6. TM4C1294 LaunchPad™ Software Programming Setup

3. Launch the LM Flash Programmer. In the Configuration tab select *TM4C1294XL LaunchPad* from the drop-down menu as shown in Figure 7.

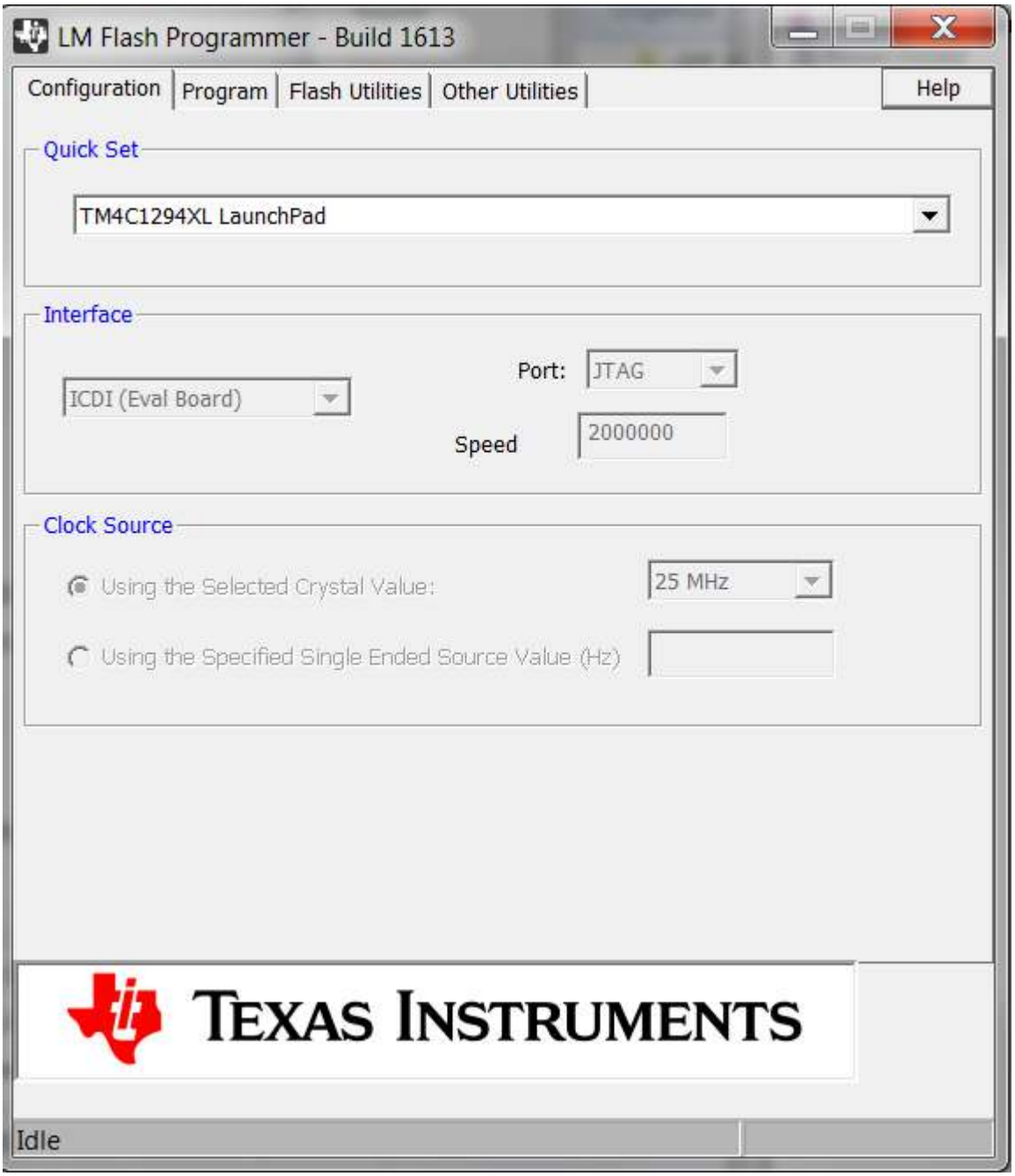

Figure 7. TM4C1294 LaunchPad™ selection in Configuration Tab

4. From the Program tab, program the TM4C1294 with the BOOSTXL-ADS7841-Q1 EVM firmware as shown in Figure 8.

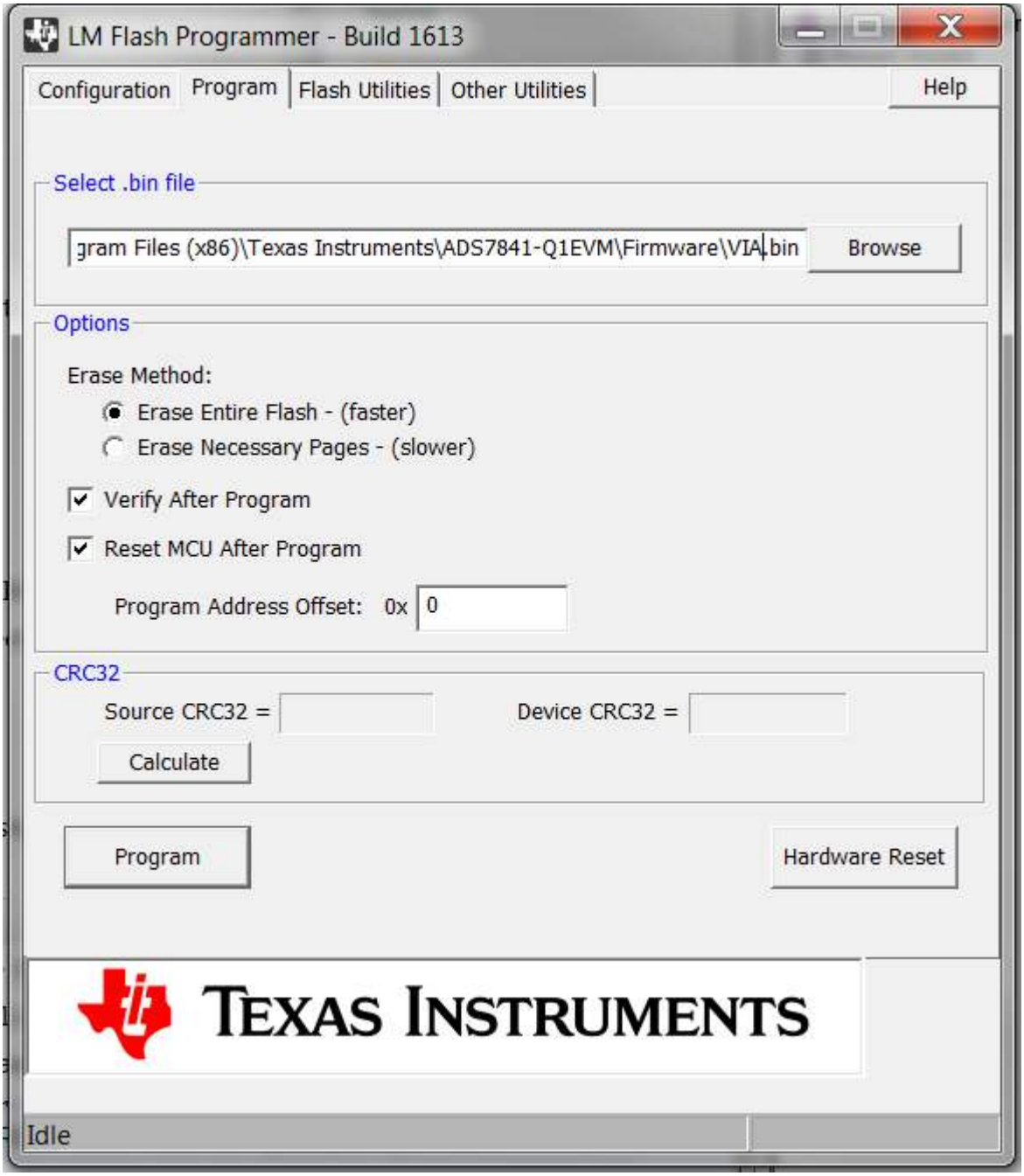

Figure 8. TM4C1294 LaunchPad™ Programming Using LM Flash Programmer

5. After programming and verification is successful, disconnect the micro USB cable from the TM4C1294 LaunchPad™ debug port. Switch the power select JP1 jumper position from ICDI to the OTG location.

3.3 BOOSTXL-ADC7841-Q1 EVM Stack Up

Following are the instructions to set up the BOOSTXL-ADS7841-Q1EVM for evaluation:

1. Stack the BOOSTXL-ADS7841-Q1 EVM on the TM4C1294 LaunchPad™. Make sure the 20-pin connector (J1, J3) on BOOSTXL-ADS7841-Q1 EVM is mapped against connector X6 and connector (J4, J2) on BOOSTXL-ADS7841-Q1EVM is mapped against connector X7 on the TM4C1294 LaunchPad™. Pin 1 of BOOSTXL-ADS7841-Q1EVM must align with pin 1 of connector X6 on the TM4C1294 LaunchPad™.
2. Position the power select JP1 jumper on the TM4C1294 LaunchPad™ on pins corresponding to OTG.
3. Connect using the micro USB cable, the TM4C1294 LaunchPad™ USB port U7 to the PC. This must light the green power LED D0 on the TM4C1294 LaunchPad™
4. Open computer's "Device Manager". You must see under ports “VIA USB BoosterPack” and “VIA USB BoosterPack Console” as shown in Figure 9

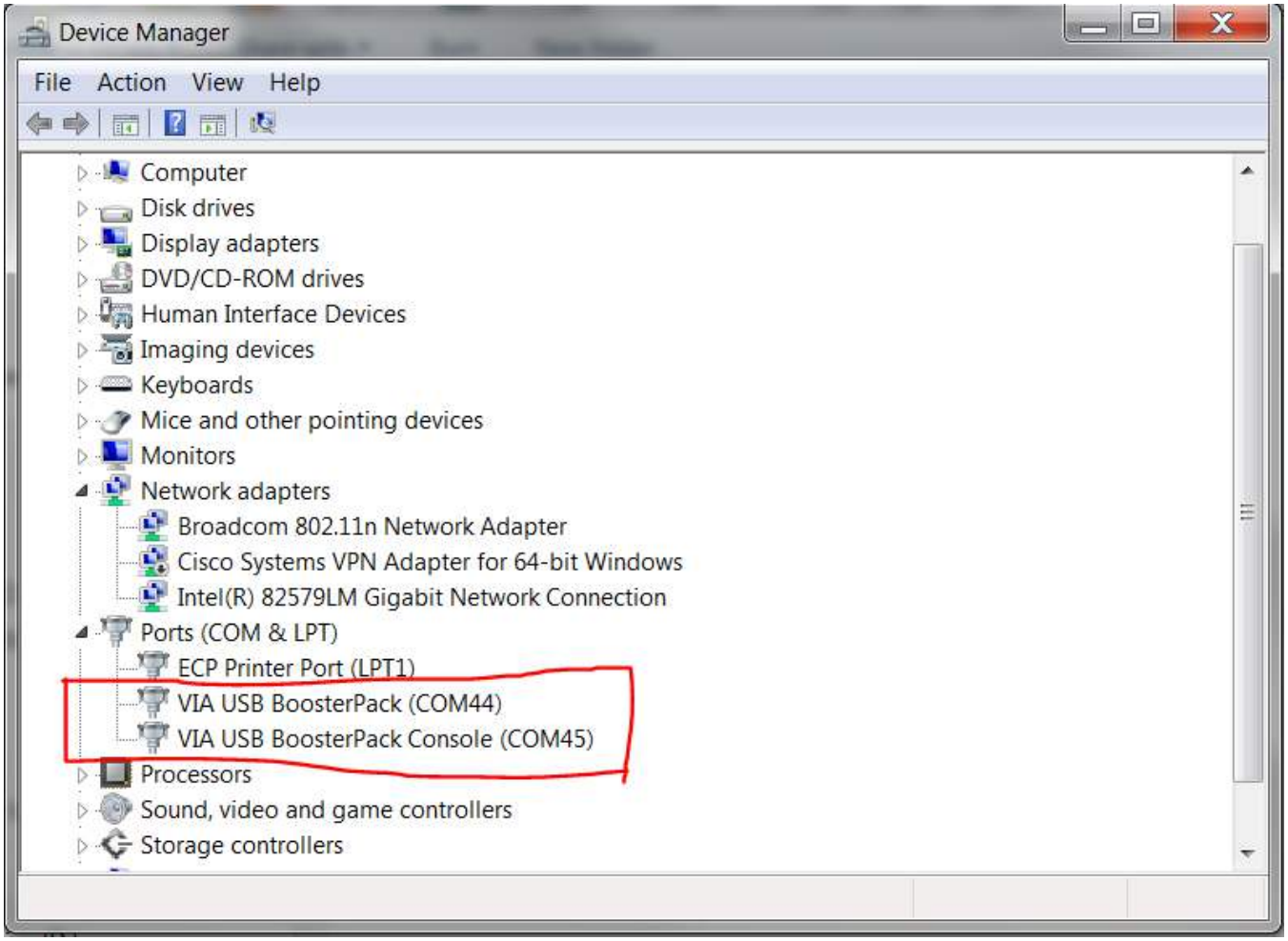

Figure 9. TMC1294 LaunchPad™ VIA BoosterPack Driver

5. Figure 10 shows the assembled BOOSTXL-ADS7841-Q1EVM and TM4C1294 LaunchPad™ configuration.

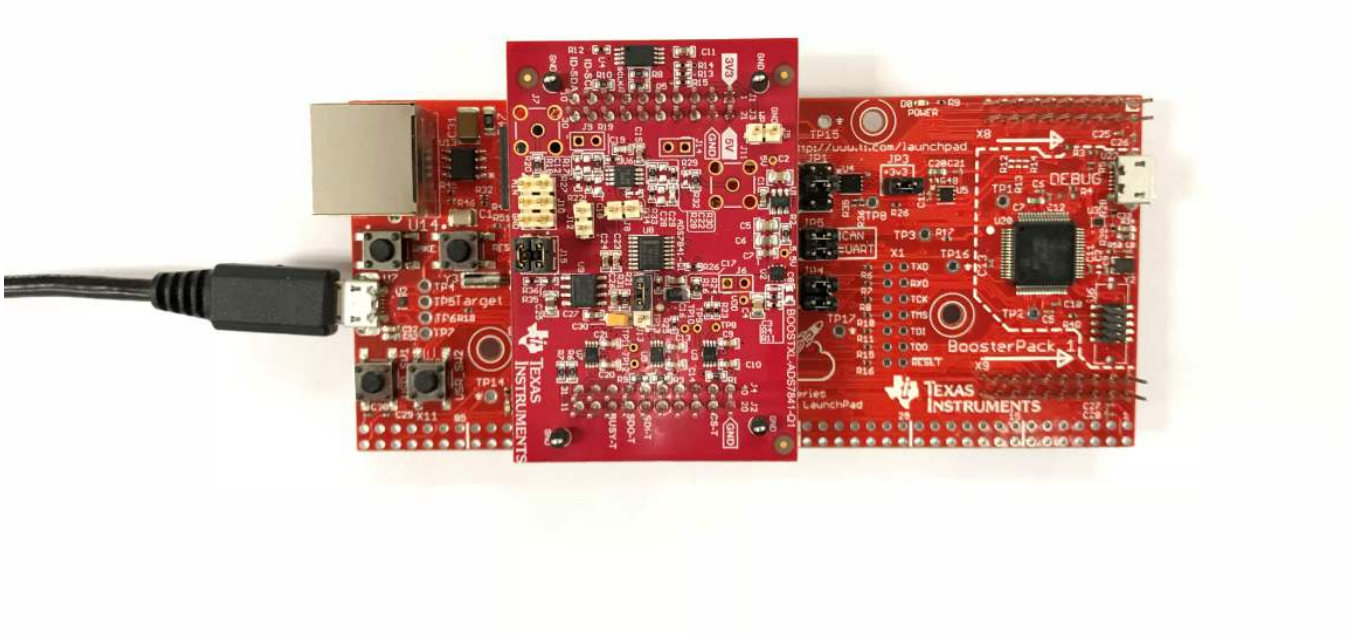

Figure 10. BOOSTXL-ADS7841-Q1EVM stacked on TM4C1294 LaunchPad™

4 BOOSTXL-ADS7841-Q1 EVM GUI Operation

4.1 Description

Figure 11 shows the landing page of the BOOSTXL-ADS7841-Q1 EVM GUI. This page provides a high-level overview of the ADS7841-Q1 device. The left corner shows the tabs required to navigate to the BOOSTXL-ADS7841-Q1 EVM GUI *Home* and *Analysis* pages. When the TM4C1294 LaunchPad™ with the BOOSTXL-ADS7841-Q1 EVM stacked is connected to the PC with the micro USB cable, the GUI detects the BoosterPack™ by reading the onboard EEPROM. Once detected and connected, the GUI indicates this status at the bottom left corner of the GUI.

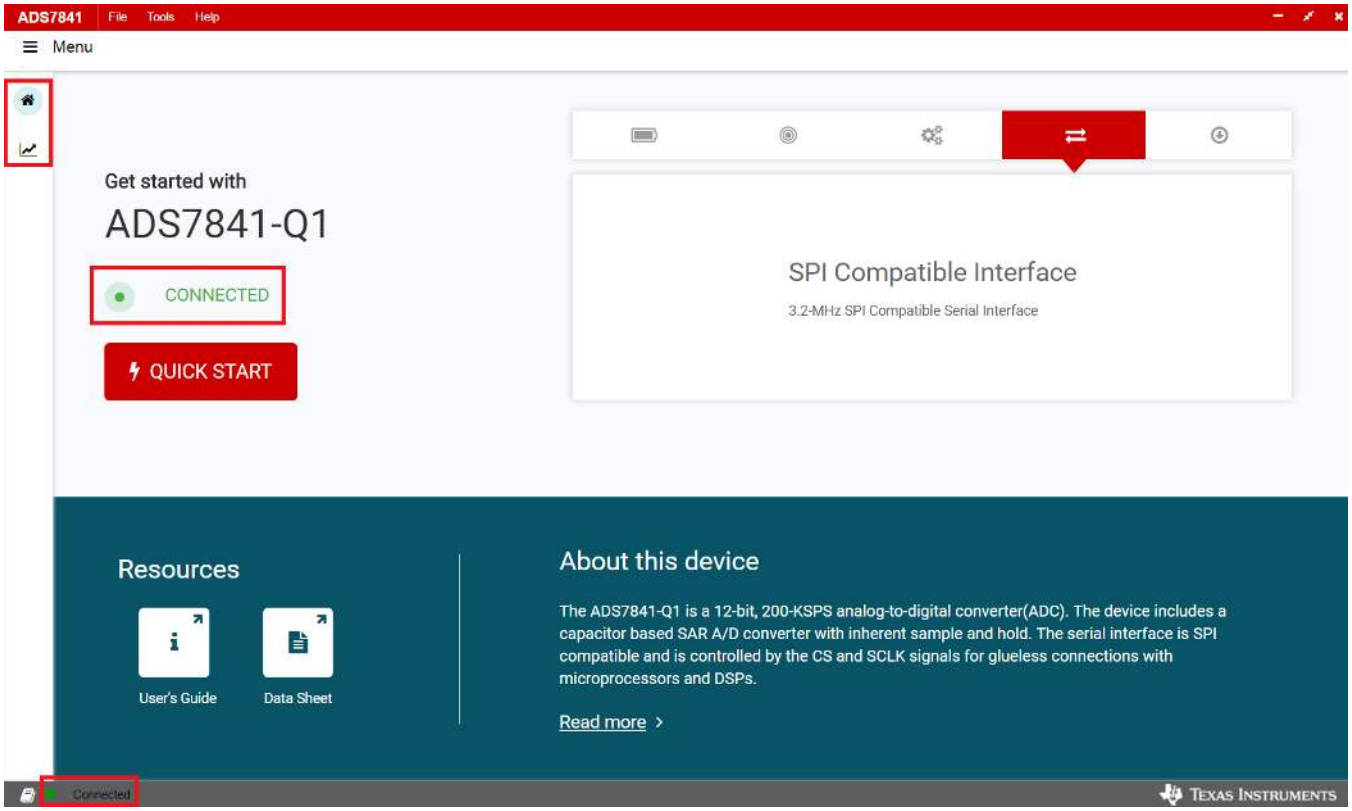

Figure 11. ADS7841-Q1EVM GUI Landing Page

4.2 Time Domain Analysis

Go to *Analysis* page, and select the *Time Domain* Analysis. Time Domain Analysis displays the acquired data versus time for the selected channel as shown in Figure 12. Note default reference voltage for ADC measurement *REF Volt (V)* is set as 4.5V.

4.2.1 Measure AIN0 (Channel0) Voltage

This section describes the steps involved in selecting and measuring AIN0 (Channel0) voltage:

1. Make sure following shunt is in place on the BOOSTXL-ADS7841-Q1 EVM: J13 between 2 and 3 (select VREF = 4.5V)
2. Connect J10.1 to J1.1 (3.3V) by a jumper wire.
3. Select "Samples" as 4096, set "SCLK" as 1000 (KHz), and set "Sample Rate" as 10 (KHz).
4. Make sure "Selected Channel" is Channel0, "Single/Diff" is selected as Single, and "Power Down" is Always On as shown in Figure 12 below.
5. Press “Collect”.
6. Min Code, Max Code, Min Volt (V), Max Volt (V) read out are displayed as shown in Figure 12.

Figure 12. AIN0 (Channel0) Voltage

4.3 Measure AIN3 (Channel3) Voltage

This section describes the steps involved in selecting and measuring AIN3 (Channel3) voltage. By default, AIN3 is configured on the BOOSTXL-ADS7841-Q1 EVM to measure a fraction of the 5V supply voltage using simple resistor divider circuit formed by R35/R36 (see schematic in Figure 19):

1. Make sure following shunts are in place on the BOOSTXL-ADS7841-Q1 EVM: J13 between 2 and 3 (select VREF = 4.5V), J15 between 1 and 2, and J15 between 3 and 4.
2. Select "Samples" as 4096, set "SCLK" as 1000 (KHz), and set "Sample Rate" as 10 (KHz).
3. Make sure "Selected Channel" is Channel3, "Single/Diff" is selected as Single, and "Power Down" is Always On as shown in Figure 13 below.
4. Press “Collect”.
5. Min Code, Max Code, Min Volt (V), Max Volt (V) read out are displayed as shown in Figure 13.

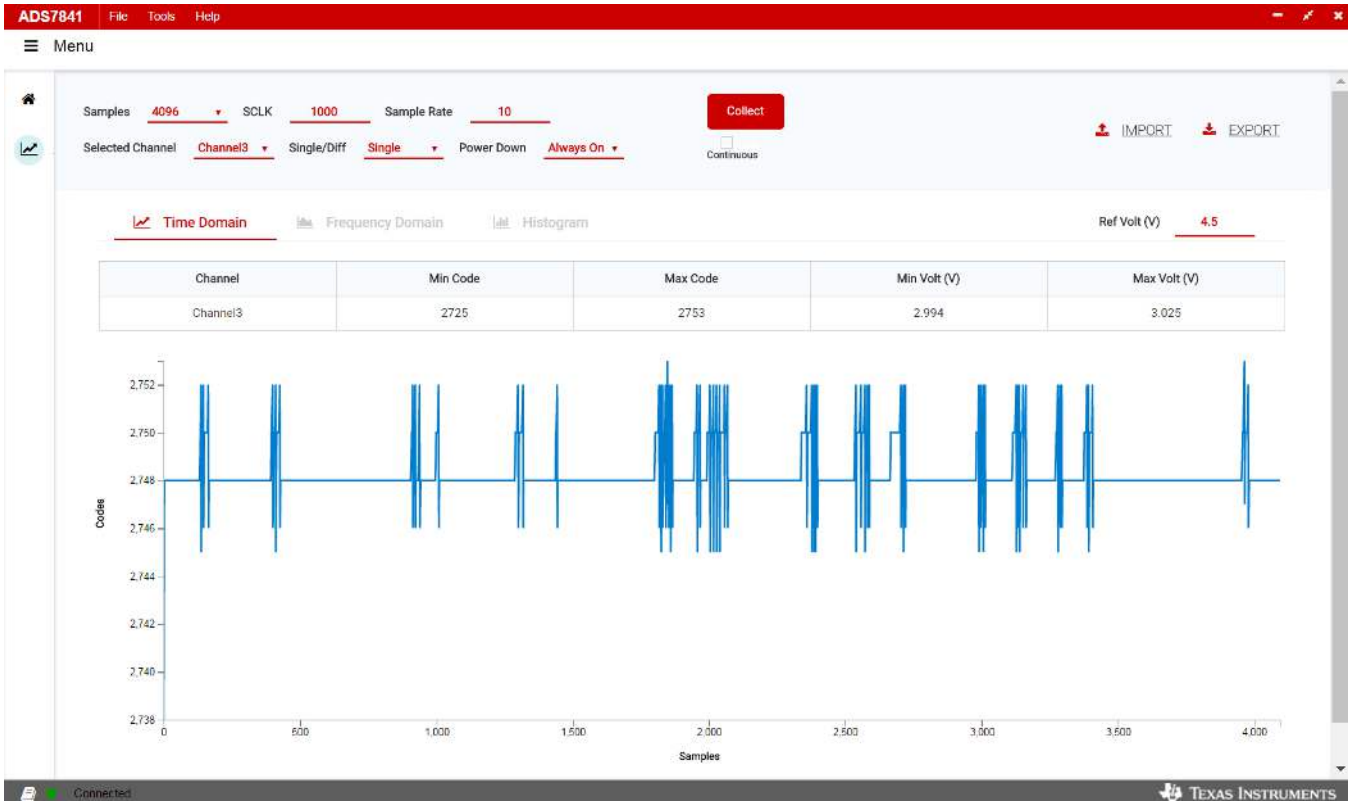

Figure 13. AIN3 (Channel3) Voltage

4.4 Frequency Domain Analysis

The *Frequency Domain* page in the GUI performs the fast fourier transform (FFT) of the captured data, and displays the resulting frequency domain plots of the selected channel of ADS7841. This page also calculates key ADC dynamic performance parameters, such as signal-to-noise ratio (SNR), total harmonic distortion (THD), signal-to-noise and distortion ratio (SINAD), spurious-free dynamic range (SFDR), and effective number of bits (ENOB). Figure 14 shows the Frequency Domain analysis display for a 2kHz sinusoidal input generated by *PSIEVM*.

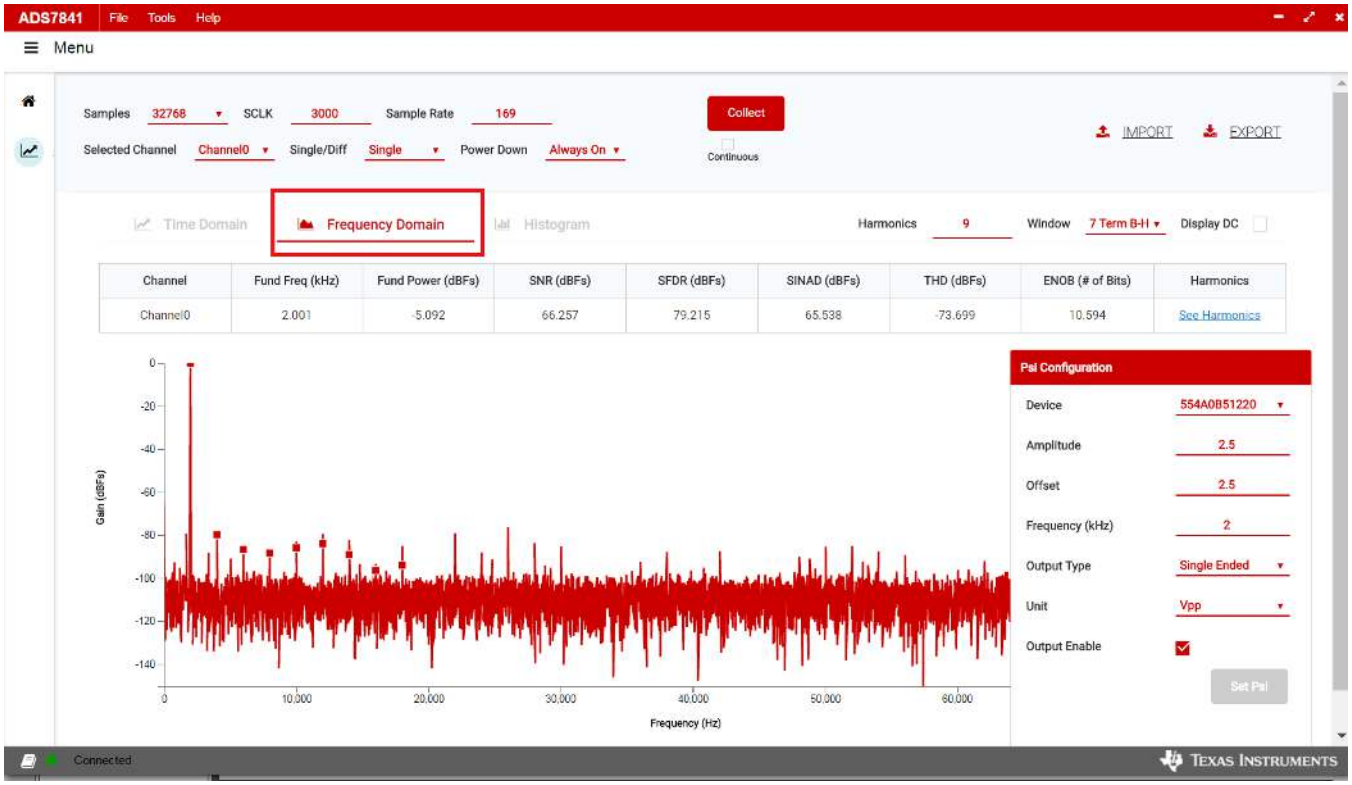

Figure 14. Frequency Domain Analysis Page

4.4.1 FFT Analysis Settings and Controls

Sample Rate - This field indicates the sampling frequency of the ADC data (kHz)

Samples - The FFT requires a time domain record with a number of samples that is a power of 2. The Samples drop-down menu provides a list of values that satisfy this requirement.

Fund Freq (kHz) - This field displays the frequency of the largest amplitude input signal computed from the FFT data, typically the fundamental frequency.

Window - The window function is a mathematical function that reduces the signal to zero at the end points of the data block.

In applications where coherent sampling cannot be achieved, a window-weighing function can be applied to the data to minimize spectral leakage. The following options are available:

- Rectangular
- Hamming
- Hann
- Blackman
- 7-Term Blackman-Harris

For a more thorough discussion of windowing, refer to IEEE1241-2000

HarmonicsThis field sets the number of harmonics that are included in the FFT performance calculations.

4.5 Histogram Analysis

The *Histogram Analysis* page creates a histogram of the captured channel data and displays it. A histogram is merely a count of the number of times a code has occurred in a particular data set. The following parameters of the captured data set are displayed:

- The **Std Dev [σ]** displays the standard deviation of the data set. This value is equivalent to the RMS noise of the signal when analyzing a dc data set.
- The **Mean** displays the average value of the data set.
- The **Median** displays the median value of the data set.
- The **Code Spread** displays the peak-to-peak spread of the codes in the data set; for a dc data set, this range would be the peak-to-peak noise.

5 Bill of Materials, Printed-Circuit Board Layout, and Schematics

This section contains the BOOSTXL-ADS7841-Q1EVM bill of materials (BOM), printed-circuit board (PCB) layout, and schematics.

5.1 Bill of Materials

Table 2 lists the bill of materials (BOM) for the BOOSTXL-ADS7841-Q1 EVM.

Table 2. Bill of Materials

Designator	Quantity	Description	Manufacturer Part Number	Manufacturer
PCB	1	Printed Circuit Board	DC013	Any
C1	1	CAP, CERM, 0.22 µF, 25 V, +/- 5%, X7R, 0603	C0603C224J3RAC7867	Kemet
C2, C4, C5	3	CAP, CERM, 2.2 µF, 16 V, +/- 10%, X7R, 0805	C0805C225K4RACTU	Kemet
C3	1	CAP, CERM, 180 pF, 50 V, +/- 1%, C0G/NP0, 0402	04025A181FAT2A	AVX
C6	1	CAP, CERM, 10 µF, 16 V, +/- 20%, X5R, 0805	0805YD106MAT2A	AVX
C7	1	CAP, CERM, 1 µF, 25 V, +/- 10%, X7R, 0603	C0603C105K3RACTU	Kemet
C9, C10, C13, C14, C20, C21	6	CAP, CERM, 0.01 µF, 16 V, +/- 10%, X7R, 0603	GRM188R71C103KA01D	MuRata
C11, C15	2	CAP, CERM, 0.1 µF, 16 V, +/- 10%, X7R, 0603	GRM188R71C104KA01D	MuRata
C16	1	CAP, TA, 4.7 µF, 10 V, +/- 10%, 4 ohm, AEC-Q200 Grade 1, SMD	F931A475KAA	AVX
C17, C23	2	CAP, CERM, 0.1 µF, 25 V, +/- 10%, X5R, 0603	06033D104KAT2A	AVX
C19, C29	2	CAP, CERM, 560 pF, 50 V, +/- 5%, C0G/NP0, 0603	C0603C561J5GACTU	Kemet
C24, C26, C27	3	CAP, CERM, 1 µF, 50 V, +/- 10%, X5R, 0603	C1608X5R1H105K080AB	TDK
C25	1	CAP, CERM, 10 µF, 25 V, +/- 10%, X5R, 0805	C2012X5R1E106K125AB	TDK
C30	1	CAP, TA, 10 µF, 10 V, +/- 20%, 3 ohm, SMD	TAJA106M010RNJ	AVX
J1/J3, J2/J4	2	Receptacle, 2.54mm, 10x2, Tin, TH	SSQ-110-03-T-D	Samtec
J5, J8, J12	3	Header, 100mil, 2x1, Tin, TH	PEC02SAAN	Sullins Connector Solutions
J10	1	Header, 100mil, 3x2, Gold, TH	TSW-103-07-G-D	Samtec
J13	1	Header, 100mil, 3x1, Tin, TH	PEC03SAAN	Sullins Connector Solutions
J15	1	Header, 100mil, 2x2, Tin, TH	PEC02DAAN	Sullins Connector Solutions
R1, R3, R5, R6, R7, R8, R9, R10, R16, R17, R20, R28, R31, R32	14	RES, 0, 5%, 0.1 W, 0603	CRCW06030000Z0EA	Vishay-Dale
R2	1	RES, 10.0, 1%, 0.1 W, 0603	CRCW060310R0FKEA	Vishay-Dale
R4	1	RES, 100 k, 0.1%, 0.063 W, 0402	RG1005P-104-B-T5	Susumu Co Ltd
R11	1	RES, 31.6 k, 1%, 0.063 W, 0402	CRCW040231K6FKED	Vishay-Dale
R12, R15, R21	3	RES, 10.0 k, 1%, 0.063 W, 0402	CRCW040210K0FKED	Vishay-Dale
R13, R14	2	RES, 1.00 k, 1%, 0.063 W, 0402	MCR01MZPF1001	Rohm
R19, R30	2	RES, 100, 1%, 0.063 W, 0402	CRCW0402100RFKED	Vishay-Dale
R22, R33	2	RES, 1.0 M, 5%, 0.063 W, 0402	CRCW04021M00JNED	Vishay-Dale
R23, R24, R25, R26	4	RES, 49.9, 1%, 0.063 W, 0402	CRCW040249R9FKED	Vishay-Dale
R35	1	RES, 68.1 k, 1%, 0.063 W, 0402	CRCW040268K1FKED	Vishay-Dale
R36	1	RES, 100 k, 1%, 0.063 W, 0402	CRCW0402100KFKED	Vishay-Dale
SH-J1, SH-J2, SH-J3	3	Shunt, 100mil, Gold plated, Black	969102-0000-DA	3M
TP4, TP5, TP6, TP7	4	Test Point, Miniature, Black, TH	5001	Keystone
U1	1	5.5 V, Buck-Boost Charge Pump Regulator, 60 mA, 3 to 5.5 V Input, -40 to 85 degC, 6-pin SOT23 (DDC6), Green (RoHS & no Sb/Br)	REG71055IDDCRQ1	Texas Instruments
U2	1	Single Output High PSRR LDO, 200 mA, Adjustable 1.2 to 6.5 V Output, 2.7 to 6.5 V Input, with Low IQ, 6-pin SON (DRV), -40 to 125 degC, Green (RoHS & no Sb/Br)	TPS79901QDRVRQ1	Texas Instruments
U3, U5, U7	3	Automotive Catalog Dual-Bit Dual Supply Transceiver with Configurable Voltage Translation, DCU0008A (VSSOP-8)	SN74LVC2T45QDCURQ1	Texas Instruments

Table 2. Bill of Materials (continued)

Designator	Quantity	Description	Manufacturer Part Number	Manufacturer
U4	1	I2C BUS EEPROM (2-Wire), TSSOP-B8	BR24G32FVT-3AGE2	Rohm
U6	1	Automotive, Precision, 20MHz, 0.9pA Ib, RRIO, CMOS Operational Amplifier, DGK0008A (VSSOP-8)	OPA2320AQDGKRQ1	Texas Instruments
U8	1	12-BIT 4-CHANNEL SERIAL-OUTPUT SAMPLING ANALOG-TO-DIGITAL CONVERTER, DBQ0016A (SSOP-16)	ADS7841ESQDBQRQ1	Texas Instruments
U9	1	Automotive Catalog, Low Noise, Very Low Drift, Precision Voltage Reference, -40 to125 degC, 8-pin SOIC (D), Green (RoHS & no Sb/Br)	REF5045AQDRQ1	Texas Instruments
C8, C12, C18, C22, C28	0	CAP, CERM, 0.01 µF, 16 V, +/- 10%, X7R, 0603	GRM188R71C103KA01D	MuRata
J6, J9, J14	0	Header, 100mil, 2x1, Tin, TH	PEC02SAAN	Sullins Connector Solutions
J7, J11	0	SMA Straight PCB Socket Die Cast, 50 Ohm, TH	5-1814832-1	TE Connectivity
R18, R29	0	RES, 1.0 k, 5%, 0.063 W, 0402	CRCW04021K00JNED	Vishay-Dale
R27, R34	0	RES, 330 k, 5%, 0.063 W, 0402	CRCW0402330KJNED	Vishay-Dale
TP1, TP2, TP3, TP8, TP9, TP10, TP11, TP12, TP13	0	TEST POINT. No entry in BOM.		

5.2 PCB Layout

Figure 15 to Figure 18 show the EVM PCB layout.

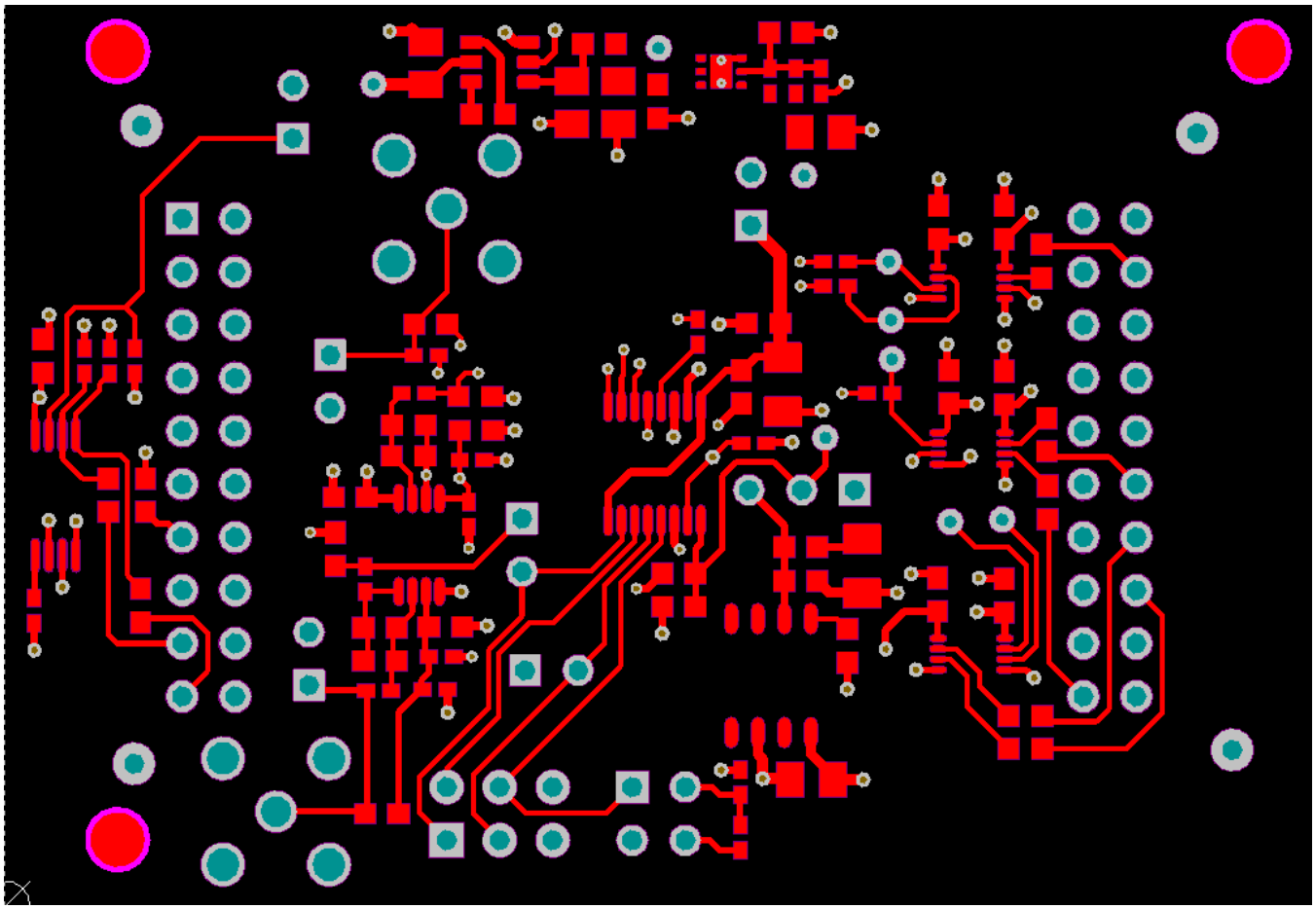

Figure 15. BOOSTXL-ADS7841-Q1 Top Layer Routing

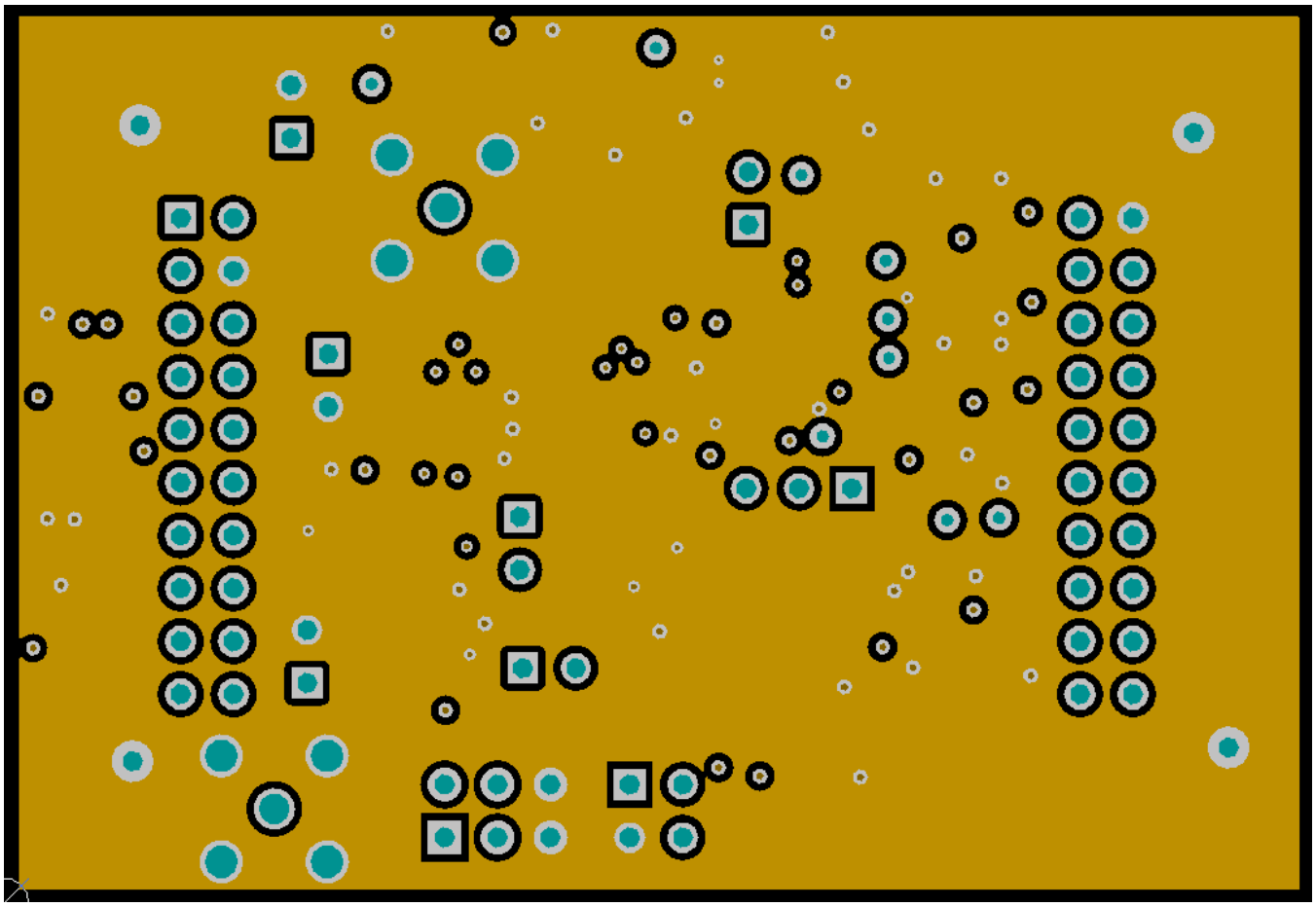

Figure 16. BOOSTXL-ADS7841-Q1 Ground Layer

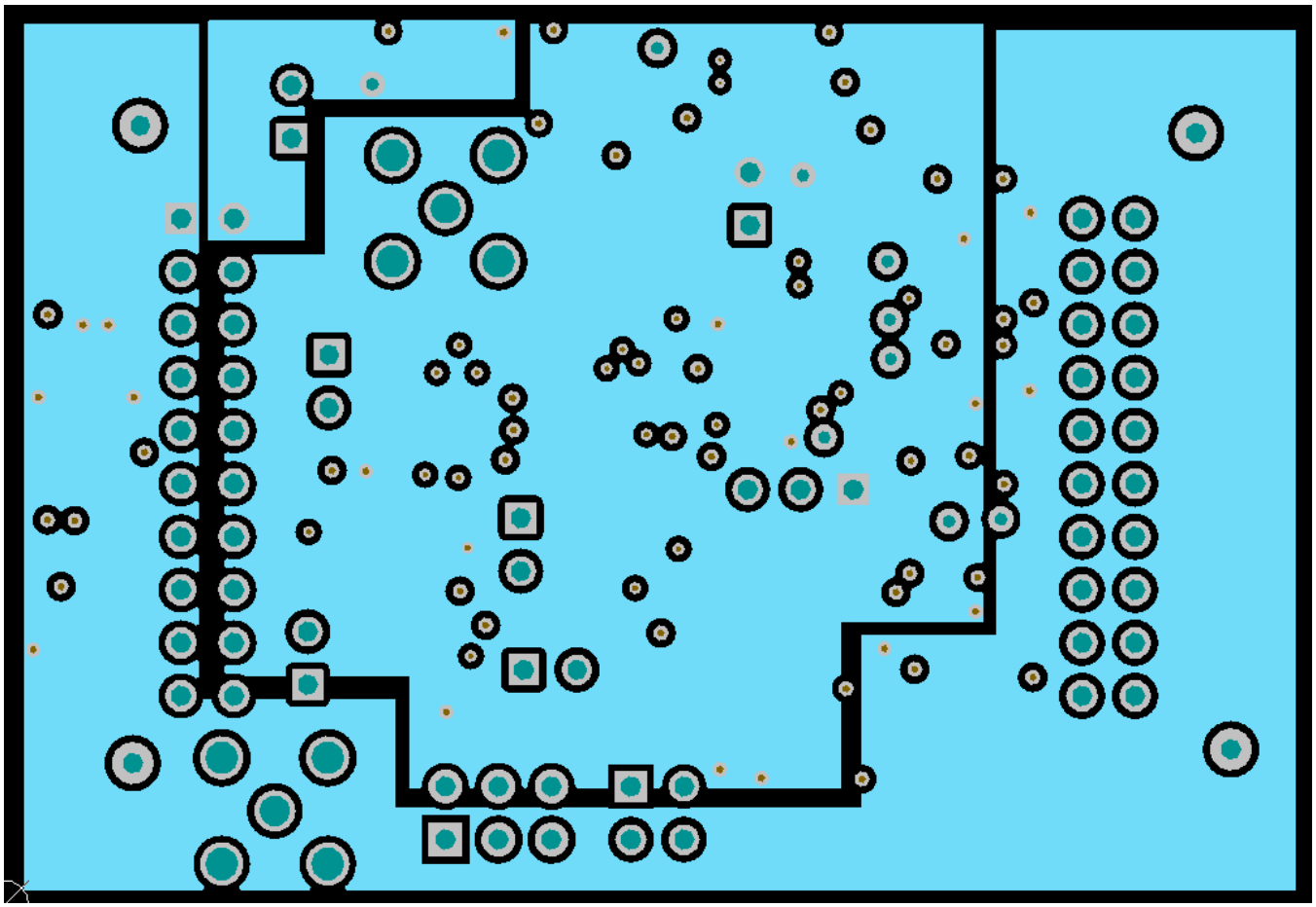

Figure 17. BOOSTXL-ADS7841-Q1 Power Layer

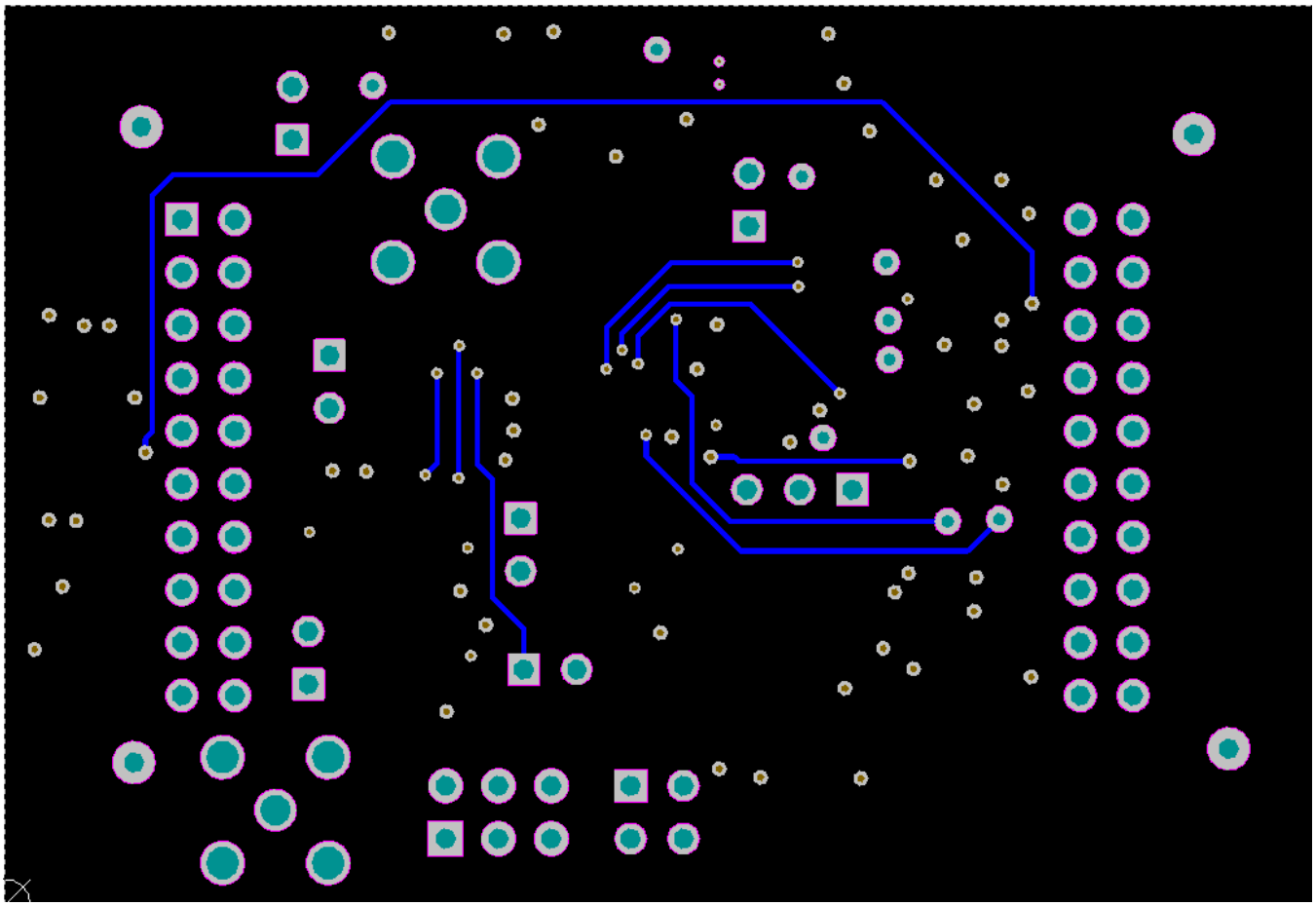

Figure 18. BOOSTXL-ADS7841-Q1 Bottom Layer Routing

5.3 Schematics

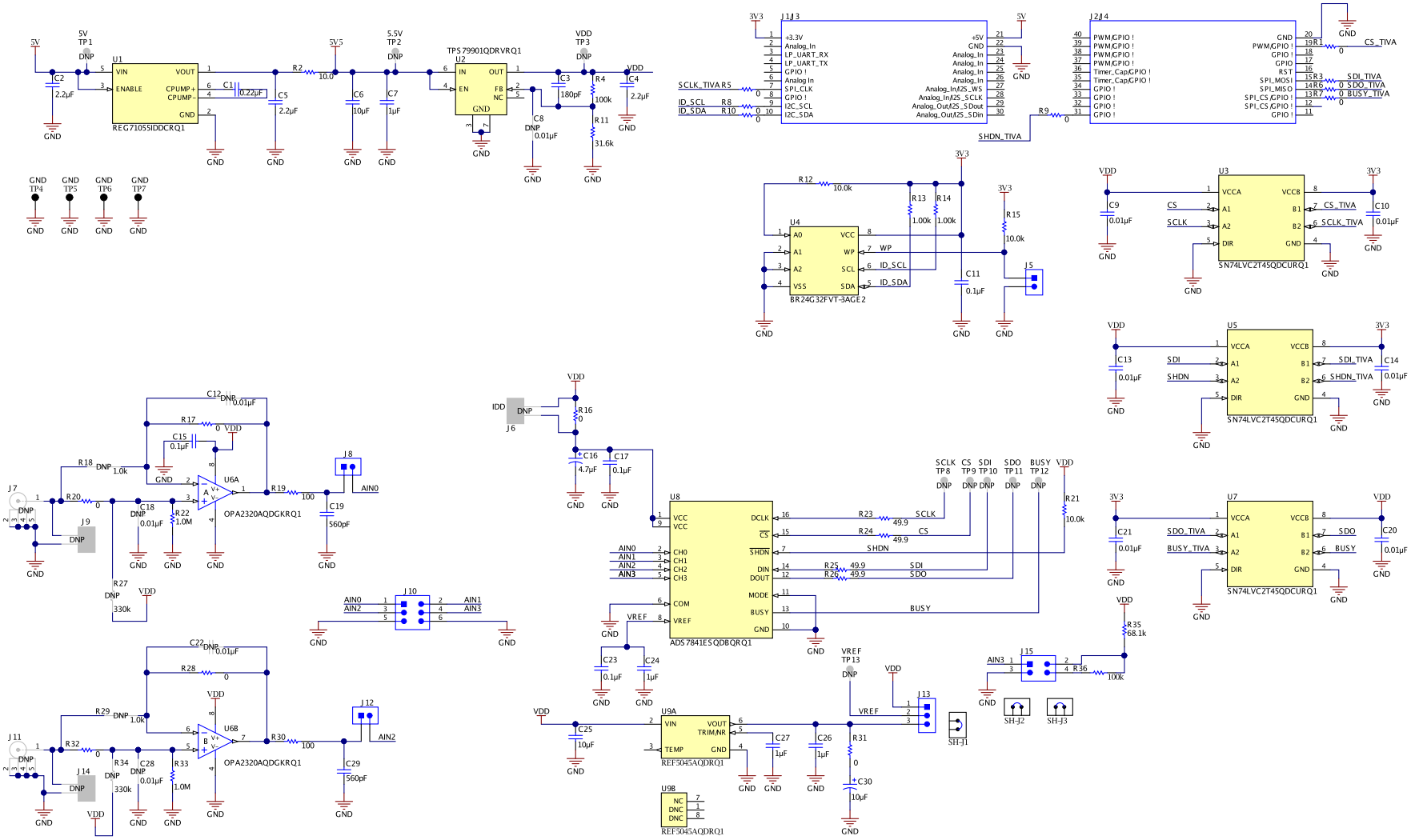

Figure 19. BOOSTXL-ADS7841-Q1 EVM Schematic Diagram

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   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.

3 *Regulatory Notices:*

   3.1 *United States*

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

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

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

      CAUTION

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

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

      FCC Interference Statement for Class A EVM devices

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

FCC Interference Statement for Class B EVM devices

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

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

3.2 *Canada*

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

Concerning EVMs Including Radio Transmitters:

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

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

Concernant les EVMs avec appareils radio:

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

Concerning EVMs Including Detachable Antennas:

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

Concernant les EVMs avec antennes détachables

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

3.3 *Japan*

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

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

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

1. Use EVMs in a shielded room or any other test facility as defined in the notification #173 issued by Ministry of Internal Affairs and Communications on March 28, 2006, based on Sub-section 1.1 of Article 6 of the Ministry's Rule for Enforcement of Radio Law of Japan,
2. Use EVMs only after User obtains the license of Test Radio Station as provided in Radio Law of Japan with respect to EVMs, or
3. Use of EVMs only after User obtains the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to EVMs. Also, do not transfer EVMs, unless User gives the same notice above to the transferee. Please note that if User does not follow the instructions above, User will be subject to penalties of Radio Law of Japan.

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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.

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