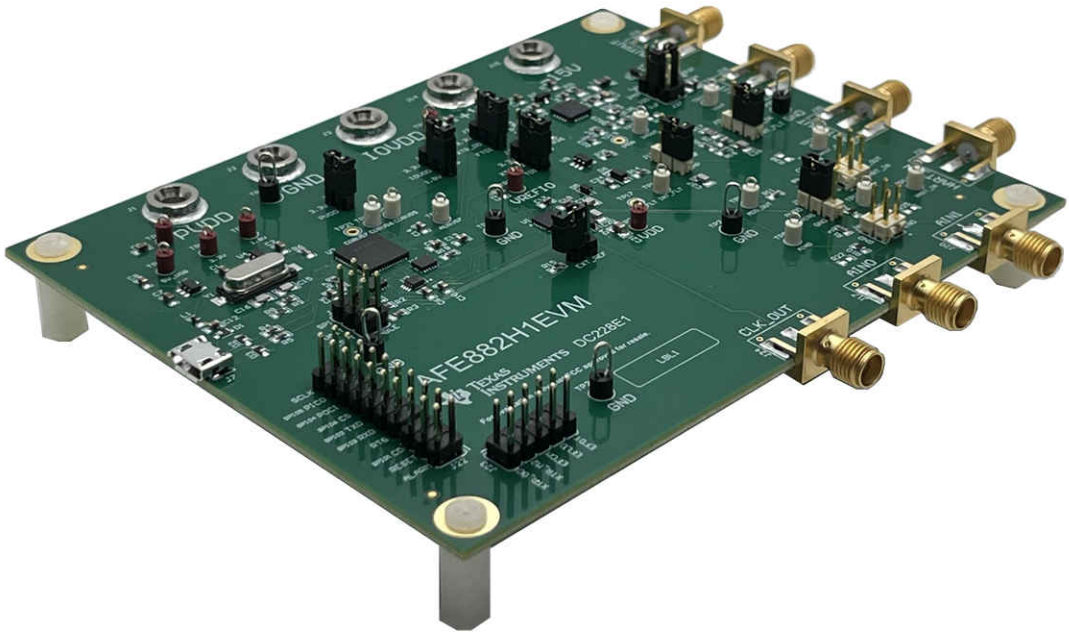
User's Guide

AFE882H1 Evaluation Module

ABSTRACT



This user's guide describes the characteristics, operation, and recommended use cases of the AFE882H1EVM. This document provides examples and instructions on how to use the AFE882H1EVM board and included software. Throughout this document, the terms evaluation board, evaluation module, and EVM are synonymous with the AFE882H1EVM. This document also includes a schematic, reference printed circuit board (PCB) layouts, and a complete bill of materials (BOM).

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1 Overview

The AFE882H1 16-bit digital-to-analog converter (DAC) is a highly-integrated, high-accuracy, and extremely low-power device with voltage-outputs designed for HART® enabled factory automation and control applications. The AFE882H1 includes most of the components required to construct an analog output module with voltage and current outputs. These components include a 16-bit highly accurate DAC, a HART FSK modem, an internal 10-ppm/°C voltage reference, and an internal diagnostic ADC. An XTR305 converts the AFE882H1 output to output voltage driver for ±11 V and an output current driver for –25 mA to +25 mA.

1.1 Kit Contents

Table 1-1 details the contents of the EVM kit. Contact the TI Product Information Center at (972) 644-5580 if any component is missing. Download the latest versions of the related software on the TI website, www.ti.com.

Table 1-1. AFE882H1EVM Kit Contents

Item	Quantity
AFE882H1EVM	1
USB-A to Micro-USB Cable	1

1.2 Related Documentation From Texas Instruments

The documents in Table 1-2 provides information regarding Texas Instruments integrated circuits used in the assembly of the AFE882H1EVM. This user's guide is available from the TI web site under literature number SLAU888. Any letter appended to the literature number corresponds to the document revision that is current at the time of the writing of this document. Newer revisions may be available from the TI web site at www.ti.com, or call the Texas Instruments Literature Response Center at (800) 477-8924 or the Product Information Center at (972) 644-5580. When ordering, identify the document by both title and literature number.

Table 1-2. Related Documentation

Document	Literature Number
AFE882H1 product data sheet	SLASF43
TLV333 product data sheet	SBOS751
TPS72118 product data sheet	SLVS352
TPS73433 product data sheet	SBVS089
TXU0202 product data sheet	SCES942
TXU0204 product data sheet	SCES936
TXU0304 product data sheet	SCES935
XTR305 product data sheet	SBOS913

2 System Setup

2.1 Software Setup

This section provides the procedure for EVM software installation.

The EVM software is compatible with the Windows® 10 operating system. Before installing the software, make sure that the AFE882H1EVM is not connected to the local machine.

Download the latest version of the EVM graphical user interface (GUI) installer from the *Order and start development* subsection of the AFE882H1EVM web folder on TI.com. Run the GUI installer to install the EVM GUI software on your local machine.

When the AFE882H1EVM software is launched, an installation dialog window opens and prompts the user to select an installation directory. If left unchanged, Figure 2-1 shows that the software location defaults to *C:\Program Files (x86)\Texas Instruments\AFE882H1EVM.*

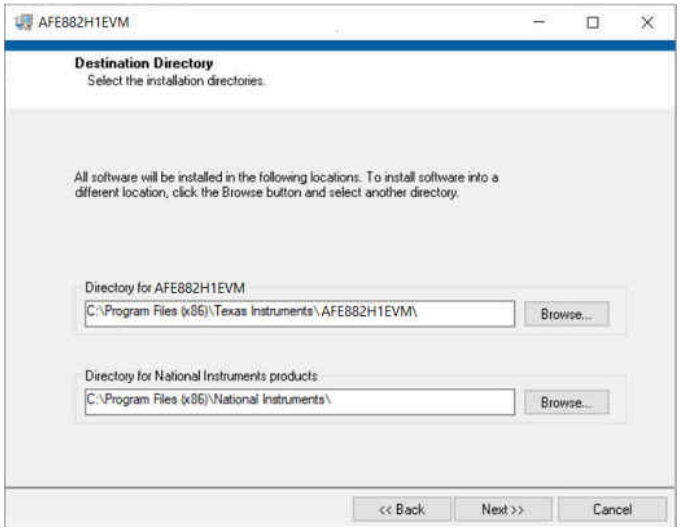

Figure 2-1. Software Installation Path

The EVM software also installs the Future Technology Devices International Limited (FTDI) USB drivers using a separate executable file, and automatically copies the required LabVIEW™ software files and drivers to the local machine. Figure 2-2 shows the FTDI USB drivers installation window that is automatically launched after the AFE882H1EVM software installation is complete.

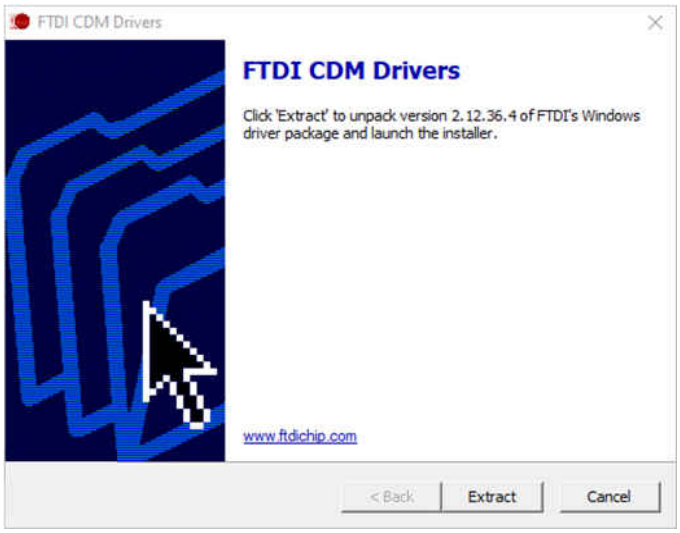

Figure 2-2. FTDI USB Drivers

2.2 Hardware Setup

This section describes the overall system setup for the EVM. A local machine runs the software that provides an interface to the AFE882H1EVM through the onboard FTDI controller. The USB connection provides 5 V of power to the EVM. Low-dropout regulators (LDOs) generate the 3.3-V and 1.8-V supplies used for PVDD and IOVDD for use as the supply voltage across the EVM board. Optional external PVDD and IOVDD connections are available through banana jack terminals after the 3.3-V and the 1.8-V LDO supplies are disconnected. The XTR305 on the board requires +15-V and –15-V supplies for operation also through banana jack terminals.

2.2.1 Electrostatic Discharge Caution

CAUTION

Many of the components on the AFE882H1EVM are susceptible to damage by electrostatic discharge (ESD). Observe proper ESD handling precautions when unpacking and handling the EVM, including the use of a grounded wrist strap at an approved ESD workstation.

2.2.2 Power Configuration and Jumper Settings

The AFE882H1EVM provides electrical connections to the device supply pins. Table 2-1 shows the connections.

Table 2-1 summarizes all of the EVM jumper functionality.

Table 2-1. AFE882H1EVM Power Supply Inputs

Terminal	Name	Function
J7	+15V	External +15-V supply for XTR305 V+ (required for XTR305)
J8	–15V	External –15-V supply for XTR305 V– (required for XTR305)
J22	PVDD	Optional external PVDD power supply (disconnect J26 when using external supply)
J23	GND	Ground connection
J24	IOVDD	Optional external IOVDD power supply (disconnect J27 when using external supply)

The jumper settings on the AFE882H1EVM are crucial to the proper operation of the EVM. Table 2-2 provides the details of the configurable jumper settings on the EVM. Figure 2-3 defines the AFE882H1EVM show the default jumper connections on the board.

Table 2-2. AFE882H1EVM Jumper Summary

Header	Name	Function
J3	POL_SEL	**Short 1-2** – POL_SEL set alarm voltage high (default) **Short 2-3** – POL_SEL set alarm voltage low
J4	HART_IN	**Short 1-2** – HART receiver input set to internal filter (default) **Short 2-3** – HART receiver input set to external filter
J5	REF_EN	**Short 1-2** – REF_EN connected to ground, disable internal reference **Open** – REF_EN connected to IOVDD through pullup resistor, enable internal reference (default)
J6	RX_INF	**Short 1-2** – RX_IN connected to 680 pF for internal filter (default) **Short 2-3** – RX_INF set to external filter
J19	XTR_OD	**Short 1-2** – XTR output disable controlled by GUI (default) **Short 2-3** – XTR output hard enabled **Open** – XTR output disabled
J20	XTR_LOAD	**Short 1-2** – XTR output load set to 249 Ω **Short 3-4** – XTR output load set to 100 Ω **Short 5-6** – XTR output load set to 1 µF **Open** – XTR output load unconnected (default)
J21	XTR_M2	**Short 1-2** – XTR voltage or current output selection controlled by GUI (default) **Short 2-3** – XTR set to current output **Open** – XTR set to voltage output

Table 2-2. AFE882H1EVM Jumper Summary (continued)

Header	Name	Function
J25	DISABLE	**Short 1-2** – FTDI SPI level shifter disabled **Open 1-2** – FTDI SPI level shifter enabled (default) **Short 3-4** – FTDI UART level shifter disabled **Open 3-4** – FTDI UART level shifter enabled (default) **Short 5-6** – FTDI RESET level shifter disabled **Open 5-6** – FTDI RESET level shifter enabled (default)
J26	PVDD	**Short 1-2** – PVDD supplied through USB power (default) **Open** – PVDD supplied through J22
J27	IOVDD	**Short 1-2** – IOVDD supplied through 3.3-V USB power **Short 2-3** – IOVDD supplied through 1.8-V USB power (default) **Open** – IOVDD supplied through J24

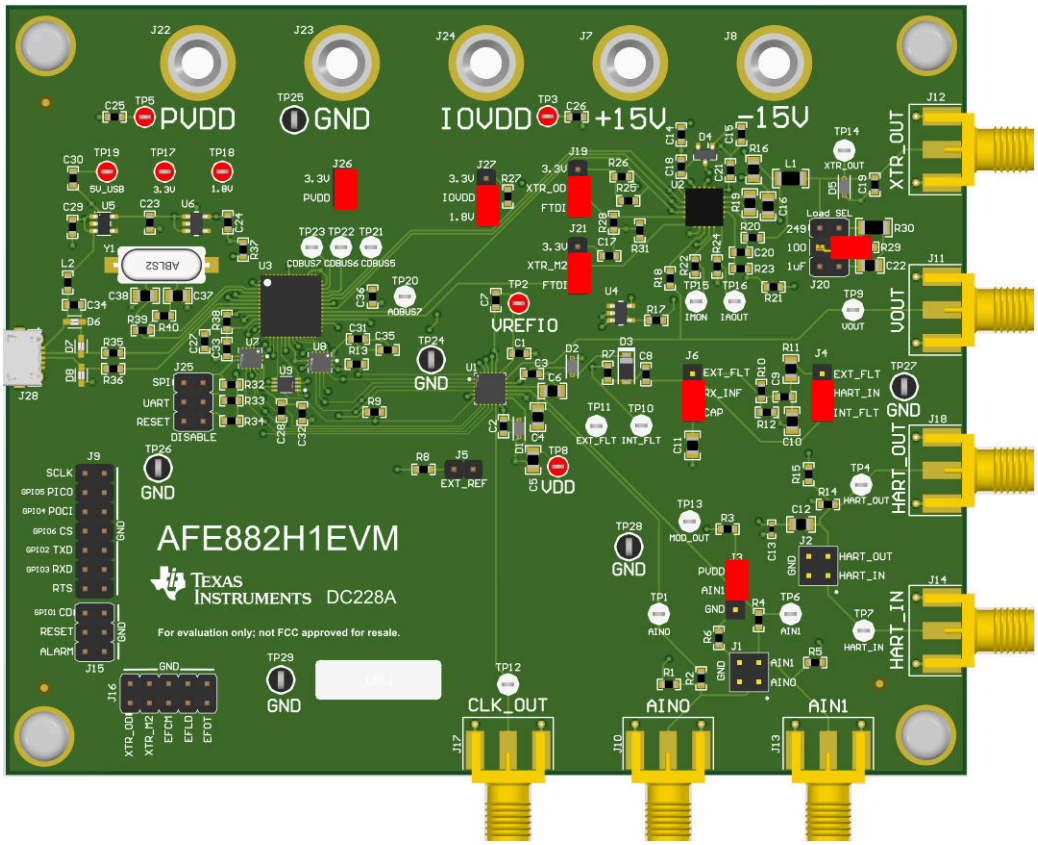

Figure 2-3. Default Header Settings for the AFE882H1EVM

2.2.3 Connecting the Hardware

After the power and jumper configurations are set up per Section 2.2.2, connect the USB cable from the AFE882H1EVM USB port to the local machine. Figure 2-4 displays the system hardware setup.

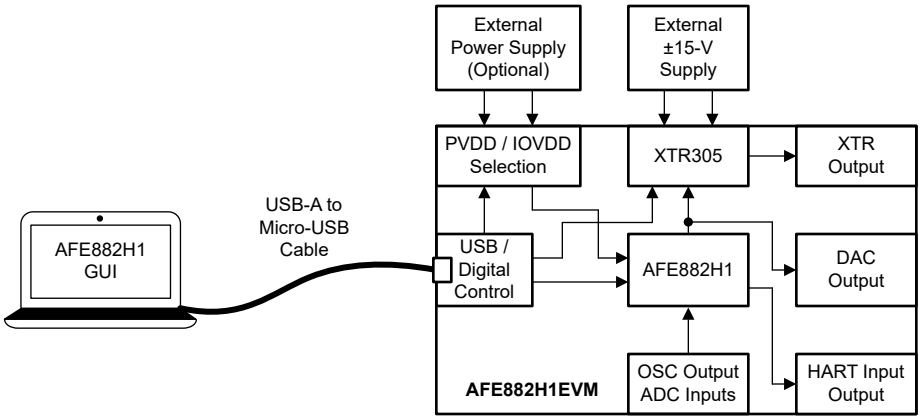

Figure 2-4. AFE882H1EVM Hardware Setup

2.2.3.1 Power Configuration

The default configuration of the AFE882H1EVM allows the board to be powered from the USB while using an external source for the ±15-V supplies. Jumper J26 connects power from the 3p3V line to the PVDD pins of the device, and jumper J27 connects power to the IOVDD pins of the device. To use external power supplies, remove the jumpers in J26 and J27 and connect the supplies to banana jacks J22 and J24 for connections to PVDD and IOVDD.

2.2.3.2 External SPI and UART Controllers

To use an external SPI or UART controller with the EVM board, disconnect the connections from the FTDI controller to the devices at the level shifters. To disable the level shifters, use the J25 header and add jumpers from SPI_EN, UART_EN, and RESET_EN to ground. After the level shifters are disabled, connect an external controller to pin headers at J9, J15, and J16 to control the AFE882H1 and XTR305.

3 Detailed Description

3.1 Hardware Description

The following sections provide detailed information on the EVM hardware and jumper configuration settings.

3.1.1 Theory of Operation

Figure 3-1 shows the block diagram of the AFE882H1EVM board. The AFE882H1 connects to a local machine USB port through a USB-A to Micro-USB cable.

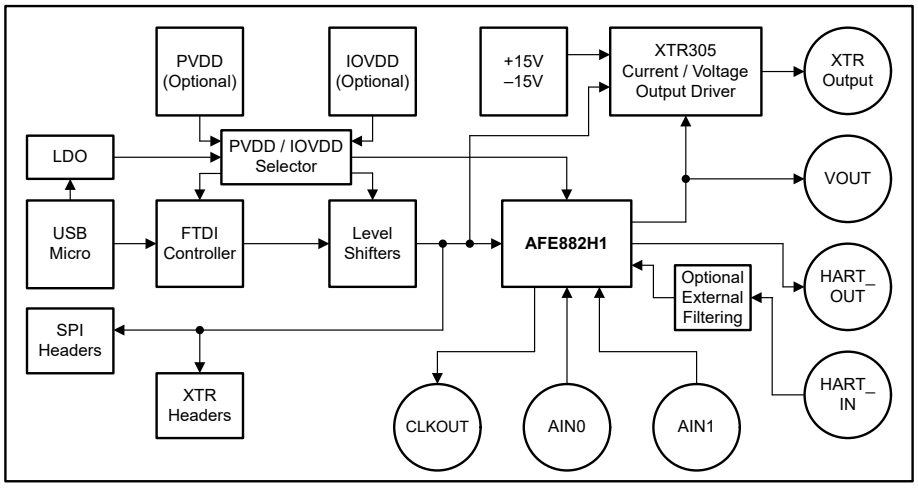

Figure 3-1. Block Diagram for the AFE882H1EVM

With the default jumper settings, the USB sources a 3.3-V supply for PVDD and a 1.8-V supply for IOVDD. The PVDD and IOVDD supplies source power through J26 and J27, respectively. To use external supplies, remove the shunts connecting the jumpers and use the banana jack connectors at J22 for PVDD and J24 for IOVDD.

The output of the AFE882H1 sets the input voltage of an XTR305 current or voltage output driver. The XTR305 requires ±15-V supplies that are applied to banana jack connectors J7 and J8. With the resistor settings of the XTR305, the output can be set to a voltage range of ±11 V or a current range of –25-mA to +25-mA. Access the AFE882H1 output and XTR305 output at SMA connectors J11 and J12, respectively.

SMA connector J14 is coupled to the HART input of the AFE882H1. Jumpers at J4 and J6 determine if the HART signal is capacitively coupled to the device, or if the HART signal connects to the device through an external filter. Access the HART output at SMA connector J18. SMA connectors J10 and J13 connect to the inputs of a 16-bit ADC on the AFE882H1, and SMA connector J17 connects to the device CLK_OUT output clock.

3.1.2 Signal Definitions

The EVM board provides access to the digital AFE882H1 pins through headers J9 and J15. Table 3-1 lists the J9 pin definitions and Table 3-2 lists the J15 pin definitions.

Table 3-1. AFE882H1 Header J9 Pin Definitions

Pin Number	Signal	Description
1	SCLK	AFE882H1 SPI serial clock input
3	PICO	AFE882H1 SDI (serial data input), optional GPIO5
5	POCI	AFE882H1 SDO (serial data output), optional GPIO4
7	$\overline{CS}$	AFE882H1 chip select input, optional GPIO6
9	TXD	AFE882H1 UART output, optional GPIO2
11	RXD	AFE882H1 UART input, optional GPIO3
13	$\overline{RTS}$	AFE882H1 HART request to send
2, 4, 6, 8, 10, 12, 14	GND	Ground

Table 3-2. AFE882H1 Header J15 Pin Definitions

Pin Number	Signal	Description
1	CD	AFE882H1 HART carrier detect, optional GPIO1
3	$\overline{\text{RESET}}$	AFE882H1 device reset
5	$\overline{\text{ALARM}}$	AFE882H1 alarm signal
2, 4, 6	GND	Ground

The EVM board also provides access to the digital XTR305 pins through headers J16. Table 3-3 lists the pin definitions for J16.

Table 3-3. XTR305 Header J16 Pin Definitions

Pin Number	Signal	Description
1	XTR_OD	XTR305 output disable
3	XTR_M2	XTR305 voltage and current select
5	XTR_EFCM	Error flag for common mode over range, active low
7	XTR_EFLD	Error flag for load error, active low
9	XTR_EFOT	Error flag for overtemperature, active low
2, 4, 6, 8, 10	GND	Ground

3.1.3 XTR305 Configuration

Following the output of the AFE882H1 output, the EVM board uses an XTR305 as an output for either voltage or current conversion. The XTR305 is set up to an output voltage of –11 V to +11 V or an output current of –25 mA to +25 mA. Figure 3-2 shows the XTR305 circuit on the AFE882H1EVM.

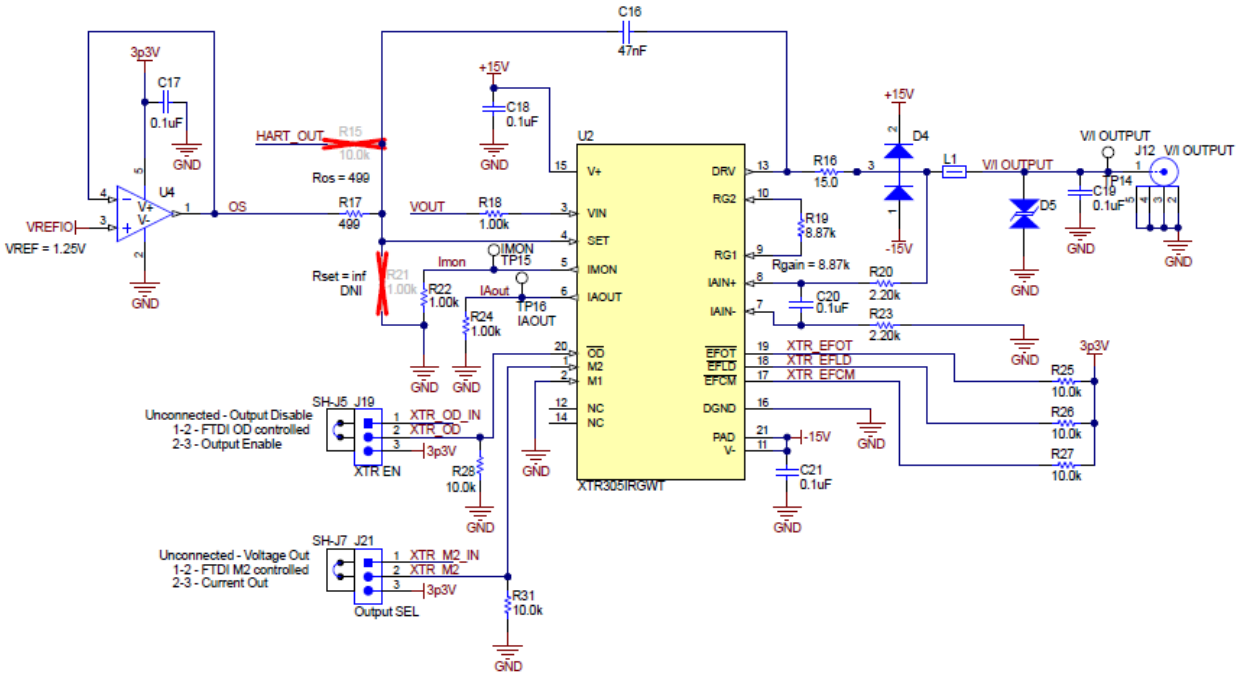

Figure 3-2. XTR305 Circuit on the AFE882H1EVM

3.2 Software Description

This section describes the features of the AFE882H1EVM software, and discusses how to use these features. The software provides basic control of all the AFE882H1 registers and functions.

3.2.1 Starting the Software

To launch the software, locate the *Texas Instruments* folder in the *All Programs* menu, and select the *AFE882H1EVM* icon.

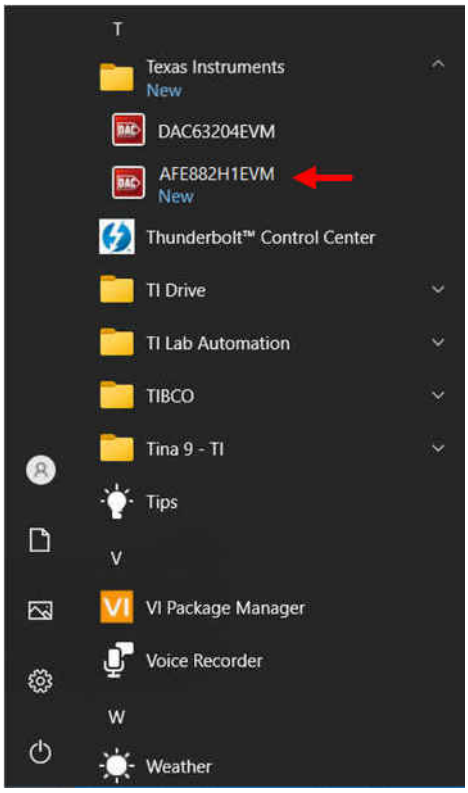

Figure 3-3. AFE882H1EVM Software Installation Prompts

Figure 3-4 shows that if the onboard FTDI controller is connected correctly, the status bar at the bottom of the screen displays *CONNECTED*. If the controller is not properly connected or not connected at all, the status displays *DEMO*. If the graphical user interface (GUI) is not displaying the *CONNECTED* status while the EVM is connected, unplug and reconnect the EVM, and then relaunch the GUI software.

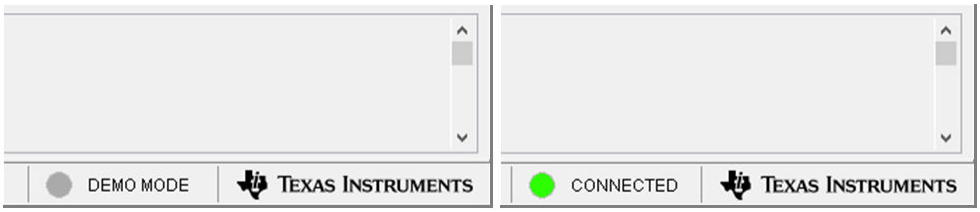

Figure 3-4. AFE882H1EVM GUI Connection Detection

3.2.2 Software Features

The AFE882H1EVM GUI allows for easy access to the registers that help configure an individual AFE882H1 device using SPI communication.

Before using the GUI, see the AFE882H1 device data sheet for detailed programming instructions.

3.2.2.1 High Level Configuration Page

The *High Level Configuration* page is used to set the configuration of the AFE882H1EVM GUI. Figure 3-5 shows the *AFE882H1 High Level* tab of the *High Level Configuration* Page. This tab is used to set the DAC controls and calibration, ADC and custom channel sequencer, XTR configurations, and HART modem functions for the device. Alarms and status information are also displayed on this tab.

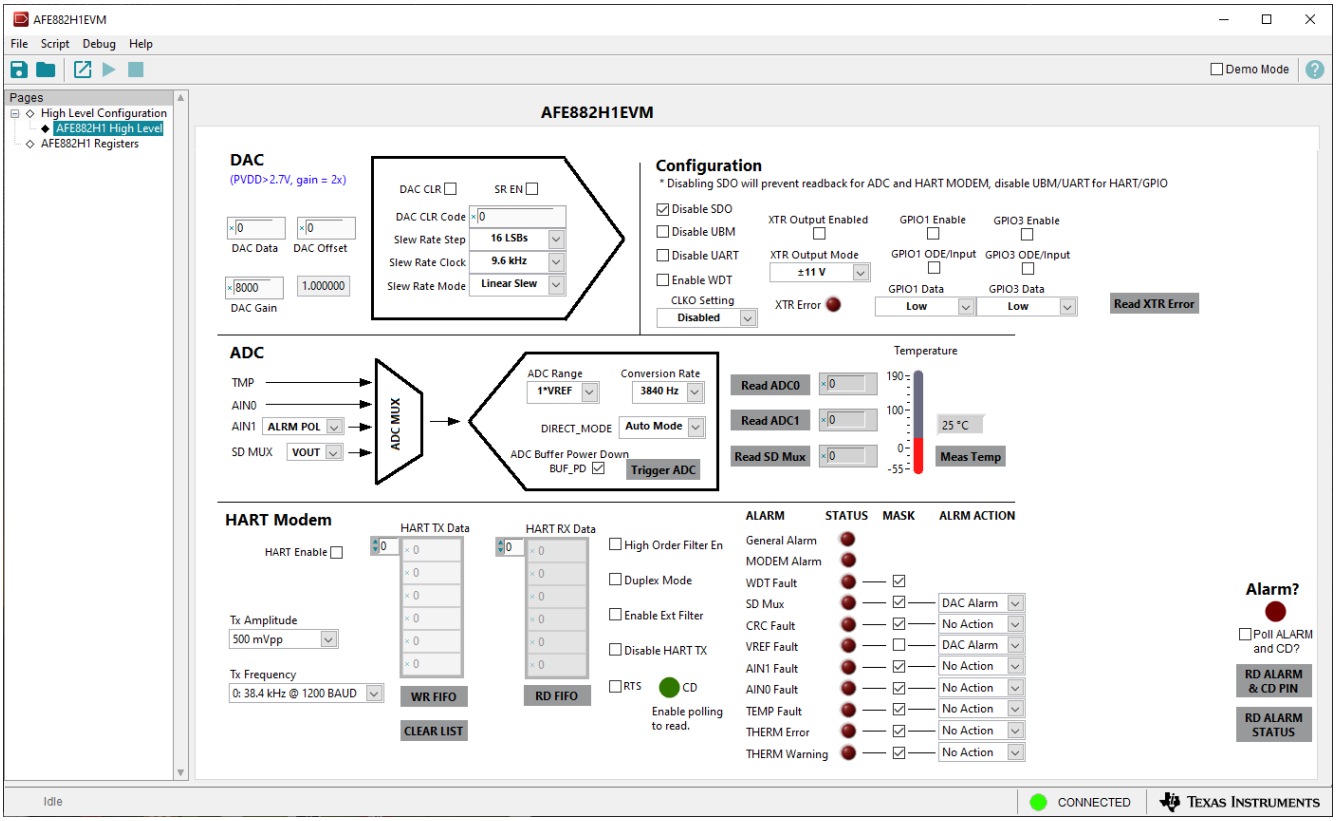

Figure 3-5. AFE882H1 High Level Tab

3.2.2.2 AFE882H1 Register Page

Figure 3-6 shows the *AFE882H1 Register* page of the AFE882H1EVM GUI. This page allows direct access to all registers on the AFE882H1. The GUI handles page address management, allowing seamless access to registers.

The *Register Map* section in the center of the page lists all the registers, grouped by the pages in the device. Directly above the *Register Map* section are four buttons that allow read and write access to all registers.

The *Field View* section on the right side of the page shows the various fields in the currently selected register. Select a register name to highlight the register. The *Field View* section displays the register contents as described in the data sheet.

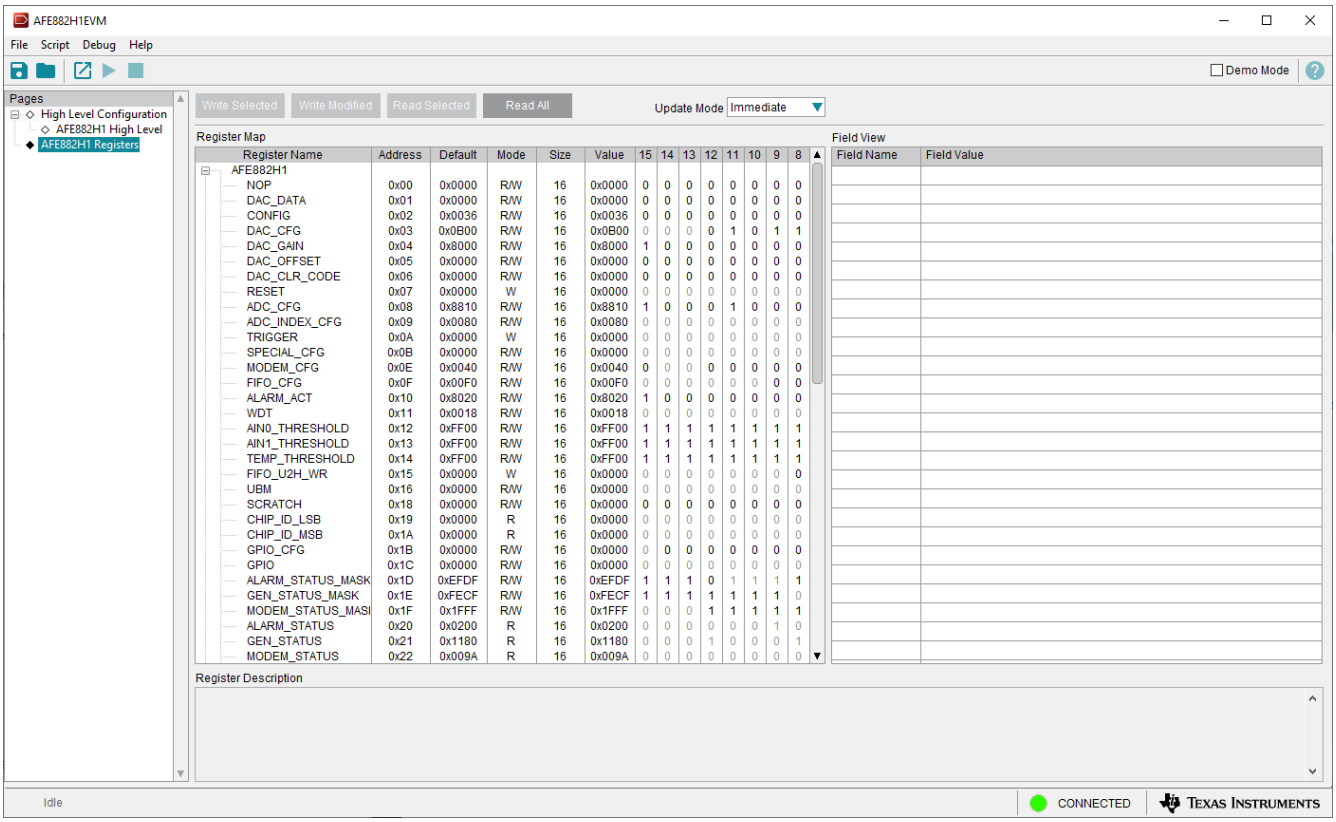

Figure 3-6. AFE882H1 Register Page

To store the values of the register map locally, select *Save Configuration* under the *File* menu option. The stored configuration files can be recalled and loaded by selecting *Open Configuration*.

Figure 3-7 shows the four configuration buttons provided on the *Register* page above the *Register Map* that allow the user to interact with the device registers:

- **Write Selected**
- **Write Modified**
- **Read Selected**
- **Read All**

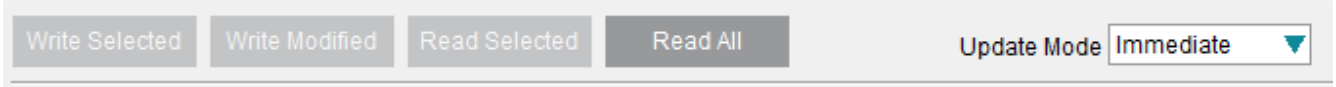

Figure 3-7. AFE882H1 Register Page Options

4 Schematics, PCB Layout, and Bill of Materials

4.1 Board Schematic

The AFE882H1EVM schematic is shown in Figure 4-1 and Figure 4-2.

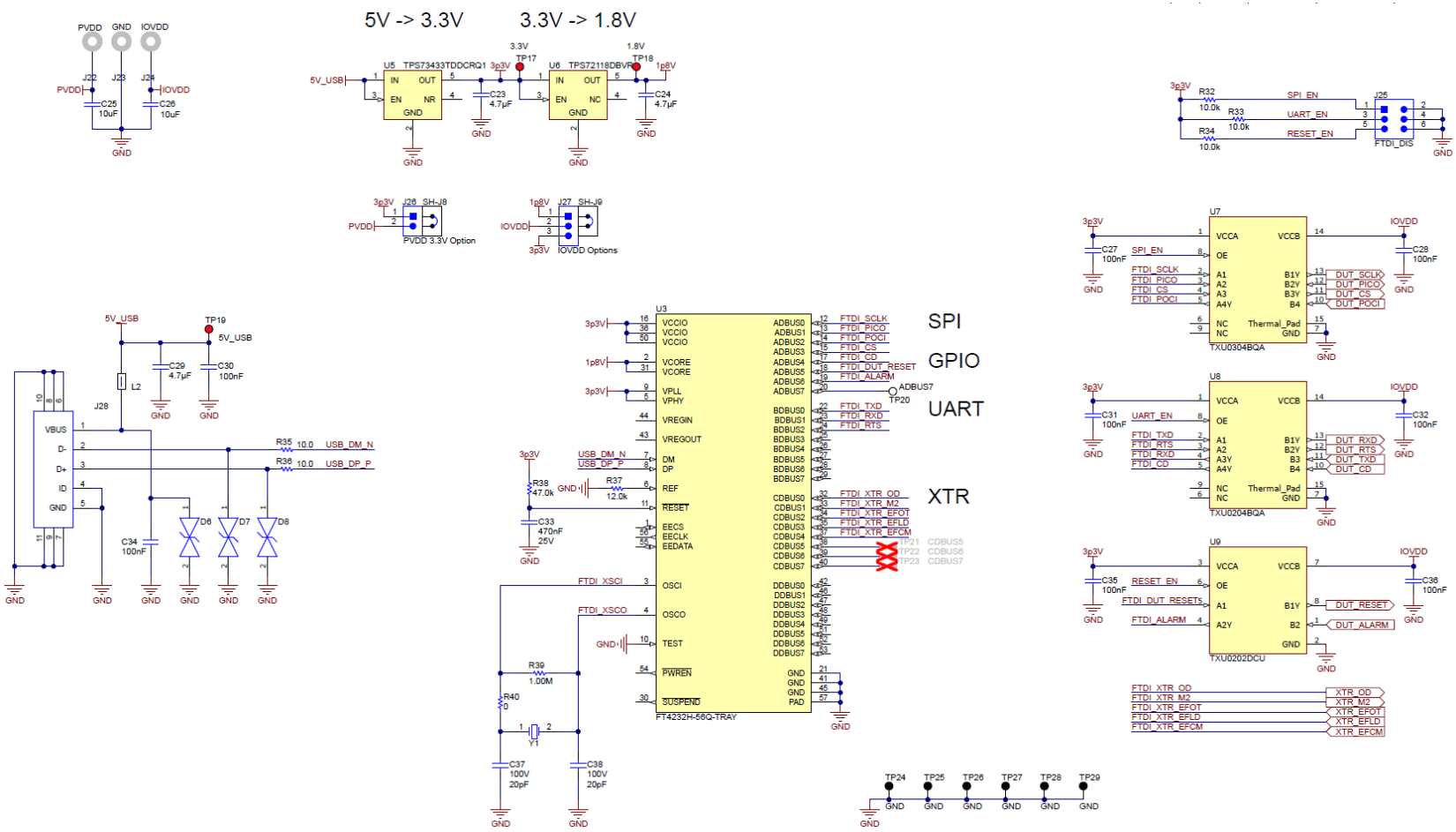

Figure 4-1. AFE882H1EVM Schematic: FTDI Controller

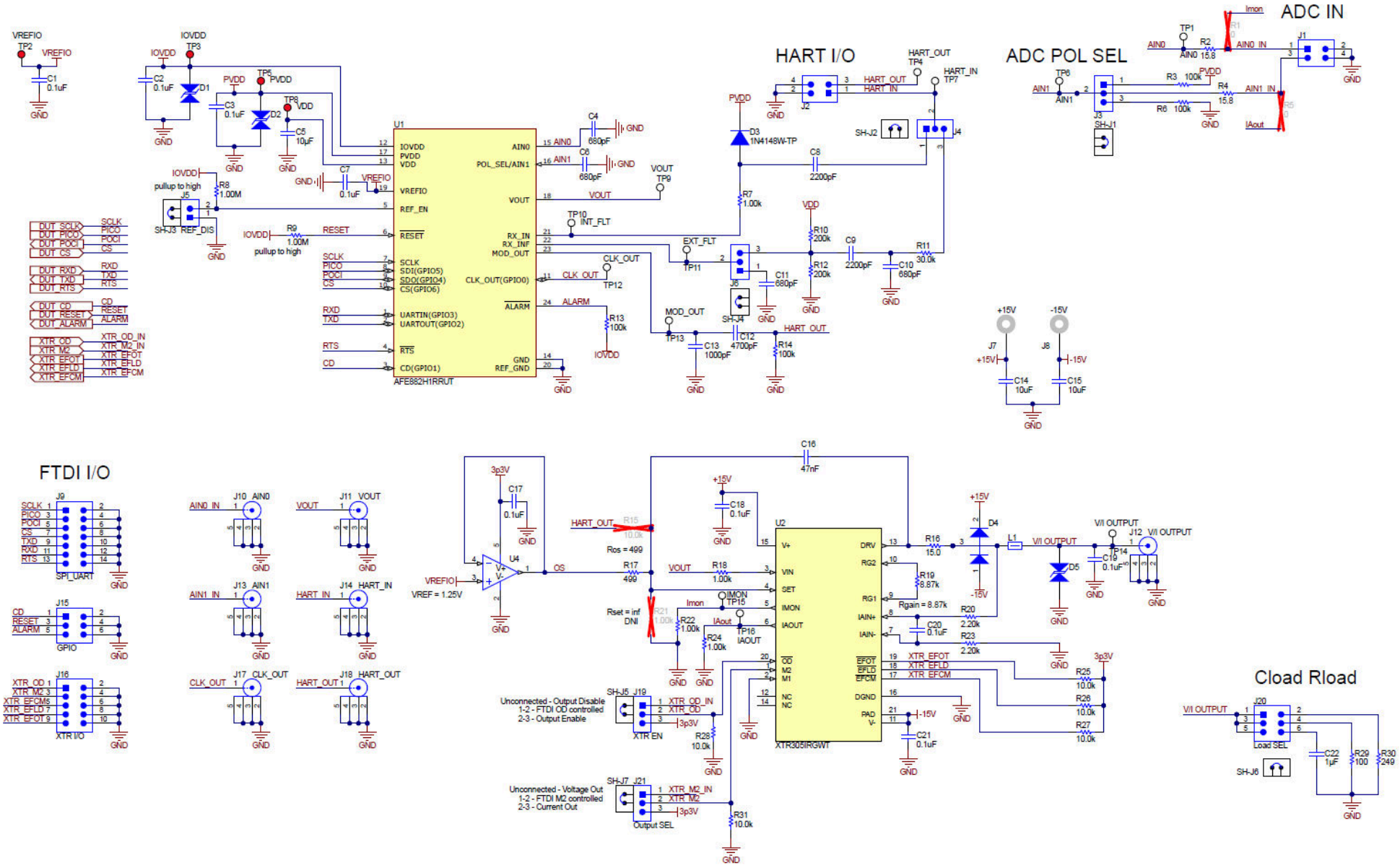

Figure 4-2. AFE882H1EVM Schematic: AFE882H1 and XTR305 Analog Output

4.2 PCB Components Layout

Figure 4-3 through Figure 4-6 show the board layout for the AFE882H1EVM.

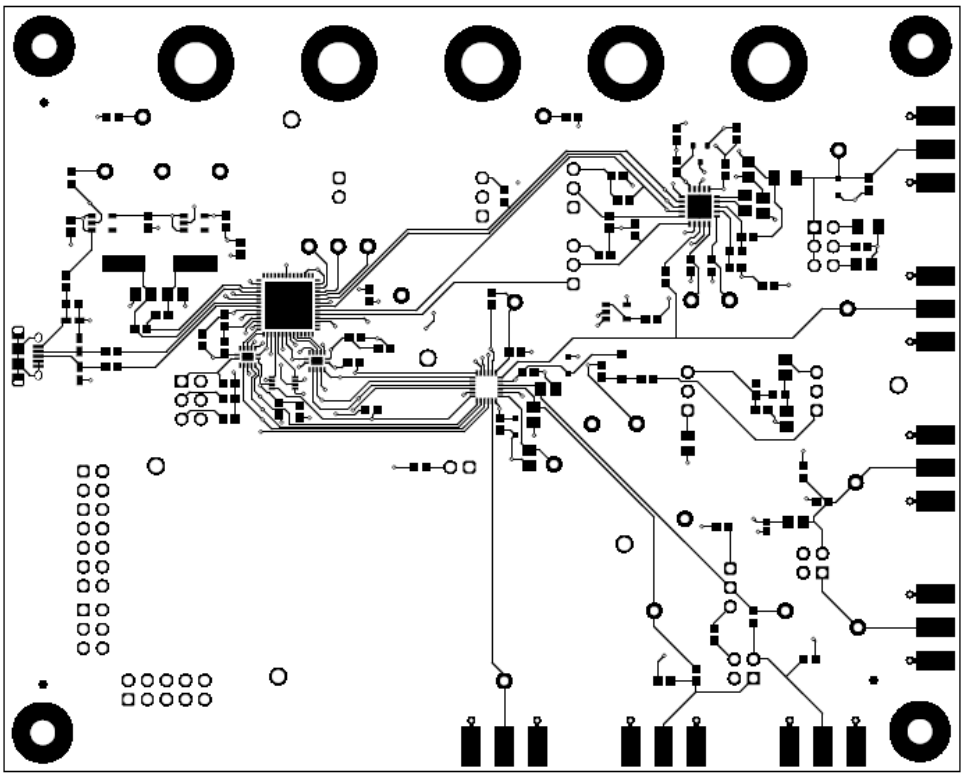

Figure 4-3. AFE882H1EVM PCB Top Layer Layout

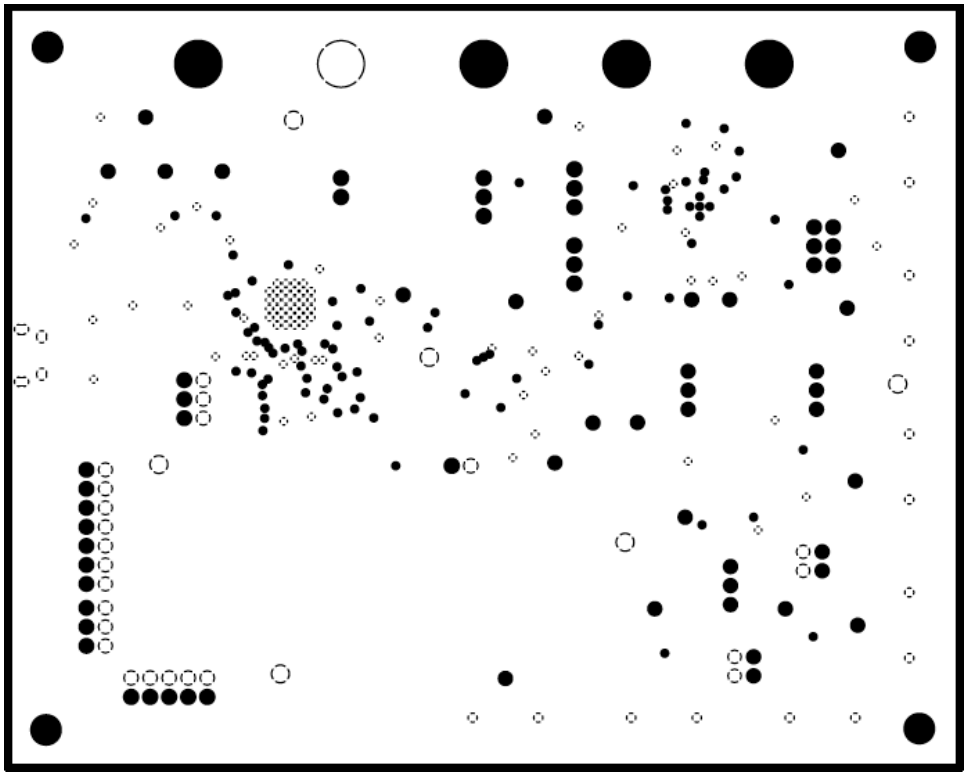

Figure 4-4. AFE882H1EVM PCB Mid Layer 1 Layout

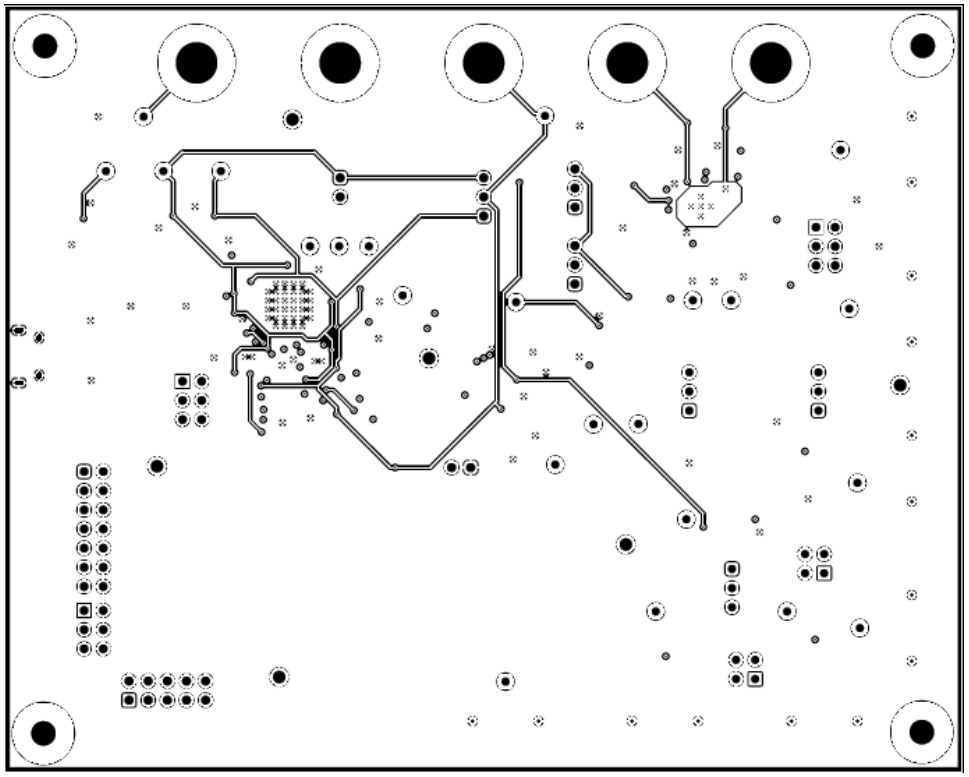

Figure 4-5. AFE882H1EVM PCB Mid Layer 2 Layout

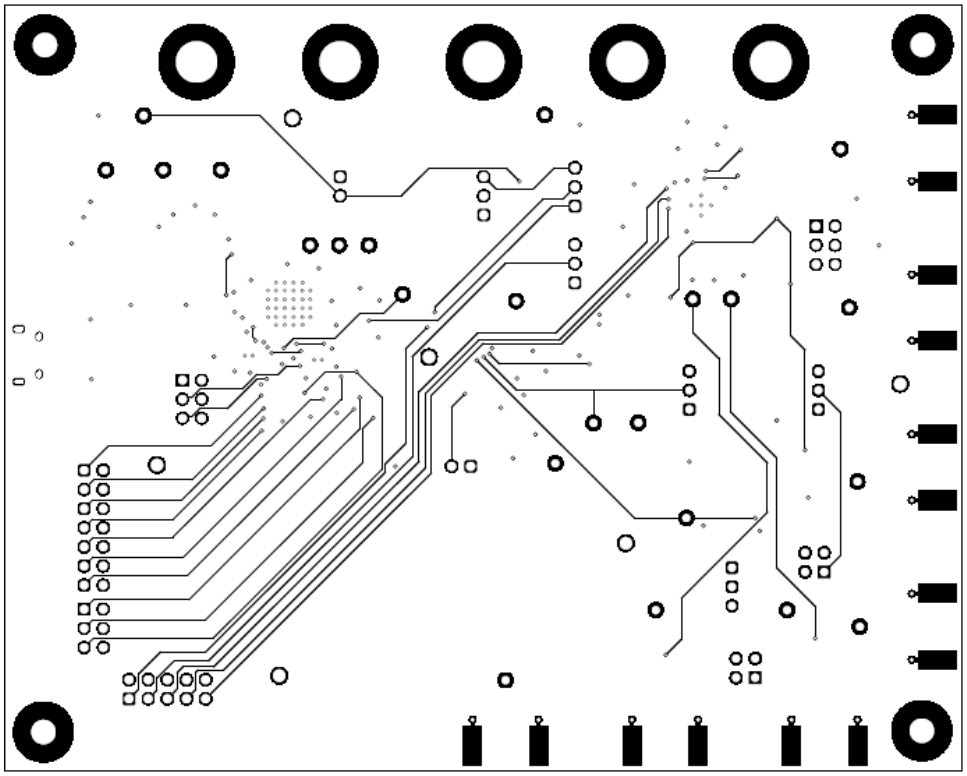

Figure 4-6. AFE882H1EVM PCB Bottom Layer Layout

4.3 Bill of Materials

Table 4-1 lists the AFE882H1EVM bill of materials (BOM).

Table 4-1. Bill of Materials for the AFE882H1EVM

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
C1, C2, C3, C7, C17, C18, C19, C20, C21	9	0.1 uF	CAP, CERM, 0.1 uF, 25 V, +/- 5%, X7R, 0603	0603	06033C104JAT2A	AVX
C4, C6	2	680 pF	CAP, CERM, 680 pF, 50 V, +/- 10%, X7R, 0805	0805	08055C681KAT2A	AVX
C5	1	10 uF	CAP, CERM, 10 µF, 16 V,+/- 10%, X7R, 0805	0805	CL21B106KOQNNNG	Samsung
C8, C9	2	2200 pF	CAP, CERM, 2200 pF, 50 V, +/- 5%, C0G/NP0, 0603	0603	GRM1885C1H222JA01D	MuRata
C10, C11	2	680 pF	CAP, CERM, 680 pF, 100 V, +/- 5%, C0G/NP0, 0805	0805	08051A681JAT2A	AVX
C12	1	4700 pF	CAP, CERM, 4700 pF, 25 V, +/- 5%, C0G/NP0, 0805	0805	08053A472JAT2A	AVX
C13	1	1000 pF	CAP, CERM, 1000 pF, 50 V, +/- 5%, C0G/NP0, AEC-Q200 Grade 1, 0402	0402	CGA2B2C0G1H102J050BA	TDK
C14, C15, C25, C26	4	10 uF	CAP, CERM, 10 uF, 25 V, +/- 20%, X5R, 0603	0603	GRT188R61E106ME13D	MuRata
C16	1	0.047 uF	CAP, CERM, 0.047 uF, 50 V, +/- 5%, X7R, 0805	0805	08055C473JAT2A	AVX
C22	1	1 uF	CAP, CERM, 1 uF, 16 V, +/- 10%, X7R, 0805	0805	B37941K9105K62	TDK
C23, C24, C29	3	4.7 uF	CAP, CERM, 4.7 uF, 16 V,+/- 10%, X7R, 0603	0603	GRM188Z71C475KE21D	MuRata
C27, C28, C30, C31, C32, C34, C35, C36	8	0.1uF	CAP, CERM, 0.1 µF, 50 V,+/- 10%, X7R, AEC-Q200 Grade 0, 0603	0603	06035C104K4Z4A	AVX
C33	1	0.47uF	CAP, CERM, 0.47 uF, 25 V, +/- 10%, X7R, 0603	0603	GRM188R71E474KA12D	MuRata
C37, C38	2	20 pF	CAP, CERM, 20 pF, 100 V, +/- 5%, C0G/NP0, 0805	0805	08051A200JAT2A	AVX
D1, D2	2	5 V	Diode, TVS, Bi, 5 V, 14.5 Vc, SOD323, 2-Leads, Body 1.9x1.45mm, No Polarity Mark	SOD323, 2-Leads, Body 1.9x1.45mm, No Polarity Mark	CDSOD323-T05SC	Bourns
D3	1	100 V	Diode, Switching, 100 V, 0.15 A, SOD-123	SOD-123	1N4148W-TP	Micro Commercial Components
D4	1	75 V	Diode, Switching, 75 V, 0.3 A, SOT-23	SOT-23	BAV99-7-F	Diodes Inc.
D5	1	15 V	Diode, TVS, Bi, 15 V, SOD323, 2-Leads, Body 1.9x1.45mm, No Polarity Mark	SOD323, 2-Leads, Body 1.9x1.45mm, No Polarity Mark	CDSOD323-T15SC	Bourns
D6, D7, D8	3		150 V (Typ) Clamp Ipp Tvs Diode Surface Mount 0603 (1608 Metric)	0603	PGB1010603MRHF	Littelfuse Inc
H1, H2, H3, H4	4		Machine Screw, Round, #4-40 x 1/4, Nylon, Philips panhead	Screw	NY PMS 440 0025 PH	B&F Fastener Supply
H5, H6, H7, H8	4		Standoff, Hex, 0.5"L #4-40 Nylon	Standoff	1902C	Keystone
J1, J2	2		Header, 100mil, 2x2, Gold, TH	2x2 Header	TSW-102-07-G-D	Samtec
J3, J4, J6	3		Header, 100mil, 3x1, Gold, TH	3x1 Header	TSW-103-07-G-S	Samtec

Table 4-1. Bill of Materials for the AFE882H1EVM (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
J5, J26	2		Header, 2.54 mm, 2x1, Gold, TH	Header, 2.54mm, 2x1, TH	61300211121	Wurth Elektronik
J7, J8, J22, J23, J24	5		Standard Banana Jack, Uninsulated, 5.5mm	Keystone_575-4	575-4	Keystone
J9	1		Header, 2.54mm, 7x2, Gold, TH	Header, 2.54mm, 7x2, TH	61301421121	Wurth Elektronik
J10, J11, J12, J13, J14, J17, J18	7		Connector, End launch SMA, 50 ohm, SMT	End Launch SMA	142-0701-801	Cinch Connectivity
J15, J20, J25	3		Header, 2.54mm, 3x2, Gold, TH	Header, 2.54mm, 3x2, TH	61300621121	Wurth Elektronik
J16	1		Header, 2.54 mm, 5x2, Gold, TH	Header, 2.54mm, 5x2, TH	61301021121	Wurth Elektronik
J19, J21, J27	3		Header, 2.54 mm, 3x1, Gold, TH	Header, 2.54mm, 3x1, TH	61300311121	Wurth Elektronik
J28	1		Receptacle, USB 2.0, Micro-USB Type B, R/A, SMT	USB-micro B USB 2.0, 0.65mm, 5 Pos, R/A, SMT	10118194-0001LF	FCI
L1	1	500 ohm	Ferrite Bead, 500 ohm @ 100 MHz, 2.5 A, 1206	1206	742792116	Wurth Elektronik
L2	1	600 ohm	Ferrite Bead, 600 ohm @ 100 MHz, 1 A, 0603	0603	782633601	Wurth Elektronik
R2, R4	2	15.8	RES, 15.8, 1%, 0.1 W, 0603	0603	RC0603FR-0715R8L	Yageo
R3, R6, R13, R14	4	100k	RES, 100 k, 1%, 0.1 W, 0603	0603	RC0603FR-07100KL	Yageo
R7	1	1.00k	RES, 1.00 k, 1%, 0.1 W, 0603	0603	RC0603FR-071KL	Yageo
R8, R9, R39	3	1.00Meg	RES, 1.00 M, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	RMCF0603FG1M00	Stackpole Electronics Inc
R10, R12	2	200k	RES, 200 k, 1%, 0.1 W, 0603	0603	RC0603FR-07200KL	Yageo
R11	1	30.0k	RES, 30.0 k, 0.1%, 0.125 W, 0805	0805	RG2012P-303-B-T5	Susumu Co Ltd
R16	1	15.0	RES, 15.0, 0.1%, 0.125 W, 0805	0805	RT0805BRD0715RL	Yageo America
R17	1	499	RES, 499, 0.1%, 0.1 W, 0603	0603	RG1608P-4990-B-T5	Susumu Co Ltd
R18, R22, R24	3	1.00k	RES, 1.00 k, 0.1%, 0.1 W, 0603	0603	RT0603BRD071KL	Yageo America
R19	1	8.87k	RES, 8.87 k, 0.1%, 0.125 W, 0805	0805	RG2012P-8871-B-T5	Susumu Co Ltd
R20, R23	2	2.20k	RES, 2.20 k, 0.1%, 0.1 W, 0603	0603	RG1608P-222-B-T5	Susumu Co Ltd
R25, R26, R27, R28, R31, R32, R33, R34	8	10.0k	RES, 10.0 k, 1%, 0.1 W, 0603	0603	RC0603FR-0710KL	Yageo
R29	1	100	RES, 100, 0.1%, 0.1 W, 0603	0603	RT0603BRD07100RL	Yageo America
R30	1	249	RES, 249, 0.1%, 0.25 W, 1206	1206	TNPW1206249RBEEA	Vishay-Dale
R35, R36	2	10.0	RES, 10.0, 1%, 0.1 W, 0603	0603	RC0603FR-0710RL	Yageo
R37	1	12.0k	RES, 12.0 k, 1%, 0.1 W, 0603	0603	RC0603FR-0712KL	Yageo
R38	1	47.0k	RES, 47.0 k, 1%, 0.1 W, 0603	0603	RC0603FR-0747KL	Yageo

Table 4-1. Bill of Materials for the AFE882H1EVM (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
R40	1	0	RES, 0, 5%, 0.1 W, 0603	0603	RC0603JR-070RL	Yageo
SH-J1, SH-J2, SH-J3, SH-J4, SH-J5, SH-J6, SH-J7, SH-J8, SH-J9	9	1x2	Shunt, 100mil, Gold plated, Black	Shunt	SNT-100-BK-G	Samtec
TP1, TP4, TP6, TP7, TP9, TP10, TP11, TP12, TP13, TP14, TP15, TP16, TP20	13		Test Point, Miniature, White, TH	White Miniature Testpoint	5002	Keystone
TP2, TP3, TP5, TP8, TP17, TP18, TP19	7		Test Point, Miniature, Red, TH	Red Miniature Testpoint	5000	Keystone
TP24, TP25, TP26, TP27, TP28, TP29	6		Test Point, Multipurpose, Black, TH	Black Multipurpose Testpoint	5011	Keystone Electronics
U1	1		AFE882H1RRUT	UQFN24	AFE882H1RRUT	Texas Instruments
U2	1		XTR305 Industrial Analog Current/Voltage Output Driver, RGW0020A (VQFN-20)	RGW0020A	XTR305IRGWT	Texas Instruments
U3	1		Future Technology Devices International Ltd FT4232H Quad High Speed USB to Multipurpose UART/MPSSE IC, VQFN-56	VQFN-56	FT4232H-56Q-TRAY	FTDI
U4	1		350 kHz, Low-Noise, RRIO, CMOS Operational Amplifier for Cost-Sensitive Systems, DBV0005A (SOT-23-5)	DBV0005A	TLV333IDBVR	Texas Instruments
U5	1		Single Output High PSRR LDO, 250 mA, Fixed 3.3 V Output, 2.7 to 6.5 V Input, with Low IQ, 5-pin SOT (DDC), -40 to 105 degC, Green (RoHS & no Sb/Br)	DDC0005A	TPS73433TDDCRQ1	Texas Instruments
U6	1		Single Output Low Input Voltage Requirement LDO, 150 mA, Fixed 1.8 V Output, 1.8 to 5.5 V Input, with Low IQ, 5-pin SOT-23 (DBV), -40 to 125 degC, Green (RoHS & no Sb/Br)	DBV0005A	TPS72118DBVR	Texas Instruments
U7	1		4-Bit Fixed Direction Voltage-Level Translator with Schmitt- Trigger Inputs, and Tri-State Outputs, WQFN14	WQFN14	TXU0304BQA	Texas Instruments
U8	1		Automotive 4-Bit Fixed Direction Voltage-Level Translator with SchmittTrigger Inputs, and Tri-State Outputs	WQFN14	TXU0204BQA	Texas Instruments
U9	1		Single-Bit Fixed Direction Voltage-Level Translator with Schmitt-Trigger Inputs and 3-State Outputs	VSSOP8	TXU0202DCU	Texas Instruments
Y1	1		Crystal, 12 MHz, 30 ppm, 18 pF, SMD	11.4x4.7mm	ABLS2-12.000MHZ-D4Y-T	Abracon Corporation

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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   8.2 *Specific Limitations.* IN NO EVENT SHALL TI'S AGGREGATE LIABILITY FROM ANY USE OF AN EVM PROVIDED HEREUNDER, INCLUDING FROM ANY WARRANTY, INDEMITY OR OTHER OBLIGATION ARISING OUT OF OR IN CONNECTION WITH THESE TERMS, , EXCEED THE TOTAL AMOUNT PAID TO TI BY USER FOR THE PARTICULAR EVM(S) AT ISSUE DURING THE PRIOR TWELVE (12) MONTHS WITH RESPECT TO WHICH LOSSES OR DAMAGES ARE CLAIMED. THE EXISTENCE OF MORE THAN ONE CLAIM SHALL NOT ENLARGE OR EXTEND THIS LIMIT.

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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