User's Guide
AFE881H1 Evaluation Module

TEXAS INSTRUMENTS

ABSTRACT
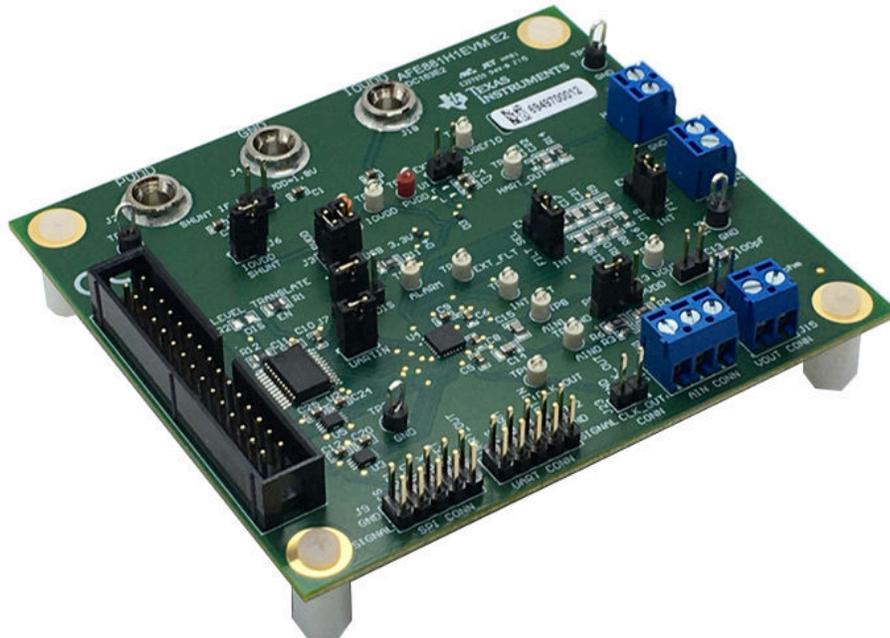
This user's guide describes the characteristics, operation, and recommended use cases of the AFE881H1EVM. This document provides examples and instructions on how to use the AFE881H1EVM board and included software. Throughout this document, the terms evaluation board, evaluation module, and EVM are synonymous with the AFE881H1EVM. 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 AFE881H1 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 sensor transmitter applications. The AFE881H1 includes most of the components required to construct a transmitter for 2-wire (loop-powered), 4-mA to 20-mA sensor transmitter applications. 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. To accommodate intrinsic and functional safety concerns, external voltage-to-current conversion and power-regulation are required.

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. AFE881H1EVM Kit Contents

Item	Quantity
AFE881H1EVM	1

Note

The EVM requires the USB2ANY digital controller. This controller is not included, and must be purchased separately.

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 AFE881H1EVM. This user's guide is available from the TI web site under literature number SLAU858. Any letter appended to the literature number corresponds to the document revision that is current at the time of the writing of this document. When released, newer revisions are 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
AFE881H1 product data sheet	SLASEU7
USB2ANY interface adapter user's guide	SNAU228
REF3312 product data sheet	SBOS392
SN74LVC8T245 product data sheet	SCES584
SN74LVC2T45 product data sheet	SCES516

Download the latest version of the EVM graphical user interface (GUI) installer from the *Order and start development* subsection of the AFE881H1EVM web folder on TI.com. Run the GUI installer to install the EVM GUI software on your personal computer (PC).

2 USB2ANY Interface Adapter

The AFE881H1EVM is controlled by a USB2ANY Interface Adapter. A PC runs the software that communicates with the USB2ANY, which provides the power and digital signals used to communicate with the EVM board. Connectors on the EVM board are used to connect the required external power supply. Figure 2-1 shows a diagram of the connections from the PC to the AFE881H1EVM.
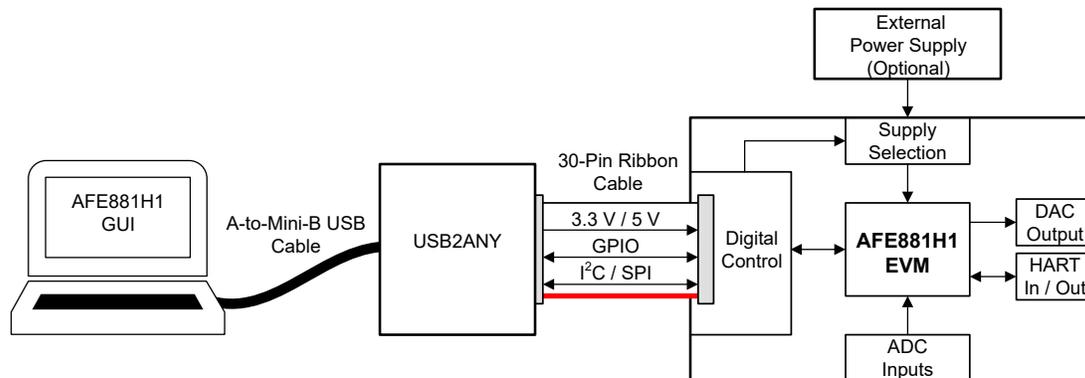
Figure 2-1. AFE881H1EVM Hardware Setup

2.1 Signal Definitions for J10

Table 2-1 shows the pinout for the 30-pin connector socket used to communicate between the EVM and the USB2ANY. Be aware that the I^{2}C communications lines (I2C_SCL and I2C_SDA1) are not used. Both the connectors and cables from the USB2ANY to the AFE881H1EVM are keyed to make sure the cable is correctly connected.

Table 2-1. USB2ANY Connector AFE881H1EVM (J10) Pinout

Pin on J10	Signal	Definition
4, 6, 8, 16, 27, 28	GND	Ground
11	$\overline{\text{ALARM}}$	Alarm notification; open drain. When an alarm occurs, this pin is held low. Otherwise, this pin goes to Hi-Z.
12	$\overline{\text{CS}}$	SPI communication for AFE881H1 chip select
13	MISO	SPI communication for AFE881H1 digital output
14	MOSI	SPI communication for AFE881H1 digital input
15	3p3V	3.3-V supply voltage
17	CD	Carrier detect. A logic high on this pin indicates a valid carrier is present.
18	SCLK	SPI communication for AFE881H1 digital clock
19	GPIO1	GPIO1 (unused)
20	GPIO2	GPIO2 (unused)
25	$\overline{\text{RTS}}$	Request to send. A logic high on this pin enables the demodulator and disables the modulator. A logic low on this pin enables the modulator and disables the demodulator. Do not leave any digital input pins floating.
26	UARTOUT	UART data output.
29	$\overline{\text{RESET}}$	Reset. A logic low on this pin places the device into power-down mode and resets the device. Logic high returns the device to normal operation. Do not leave any digital input pins floating.
30	UARTIN	UART data input. Do not leave any digital input pins floating.
1, 2, 3, 5, 7, 9, 10, 21, 22, 23, 24	NC	Not connected

2.2 USB2ANY Theory of Operation

Figure 2-2 shows the block diagram for the USB2ANY platform. This platform is a general-purpose data-acquisition system that is used on several different Texas Instruments evaluation modules. The details of operation are included in the USB2ANY Interface Adapter User's Guide.
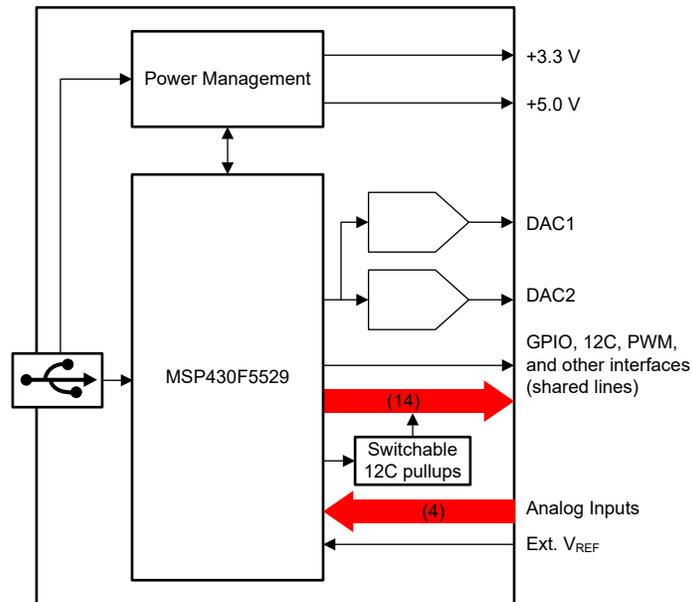
Figure 2-2. USB2ANY Interface Adapter Block Diagram

3 EVM Hardware Overview

To use the EVM hardware, set the jumpers, connect the USB2ANY to the EVM together with the 30-pin ribbon cable, apply external power (optional), and connect the USB cable from the USB2ANY to the PC. This section presents the details of these procedures.

3.1 Electrostatic Discharge Caution

> **CAUTION**
>
> Many of the components on the AFE881H1EVM 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.

3.2 EVM Block Diagram

A block diagram of the EVM hardware setup is shown in Figure 3-1. This board provides connections and test points for the SPI and UART communication, power, reference, ground connections, ADC inputs, HART modem, and the analog output of the DAC.
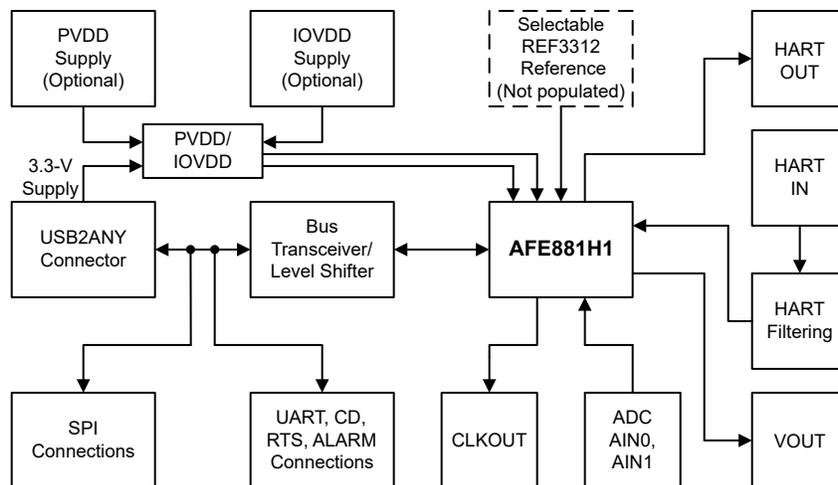
Figure 3-1. AFE881H1EVM Block Diagram

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3.3 EVM Jumper Summary

Table 3-1 summarizes all of the EVM jumper functionality.

Table 3-1. AFE881H1EVM Jumper Summary

Header	Name	Function
J2	PVDD to IOVDD	**Short 1-2** – PVDD connected to IOVDD **Open 1-2** – PVDD, IOVDD disconnected (default)
J3	USB 3.3V	**Short 1-2** – PVDD connected to USB2ANY 3p3V (default) **Open 1-2** – PVDD disconnected from USB2ANY 3p3V **Short 3-4** – IOVDD connected to USB2ANY 3p3V (default) **Open 3-4** – IOVDD disconnected from USB2ANY 3p3V
J5	Ext REF	**Short 1-2** – VREFIO connected to external reference **Open 1-2** – VREFIO disconnected from external reference (default)
J6	IOVDD Shunt	**Short 1-2** – IOVDD connected to device (default) **Open 1-2** – IOVDD disconnected from device
J7	REF EN	**Short 1-2** – REFEN connected to IOVDD (default) **Short 2-3** – REFEN connected to GND
J8	UARTIN	**Short 1-2** – UART_IN connected to bus transceiver (default) **Open 1-2** – UART_IN disconnected from bus transceiver
J13	POL SEL	**Short 1-2** – POL_SEL connected to PVDD through 100-kΩ resistor **Short 2-3** – POL_SEL connected to GND through 100-kΩ resistor (default)
J14	Resistor Load	**Short 1-2** – VOUT connected to 10-kΩ load **Open 1-2** – VOUT no resistive load (default)
J17	Cap Load	**Short 1-2** – VOUT connected to 100-pF load **Open 1-2** – VOUT no capacitive load (default)
J19, J20	FILT SEL	**Short 1-2** – HART IN pin external filter selected **Short 2-3** – HART IN pin internal filter selected
J23	Level Translator	**Short 1-2** – Bus transceiver $\overline{OE}$ connected to GND (default) **Short 2-3** – Bus transceiver $\overline{OE}$ connected to IOVDD

Figure 3-2 shows the default jumper settings with the device using USB power. The EVM can be fully operated using only the USB2ANY connector for both power and communication.
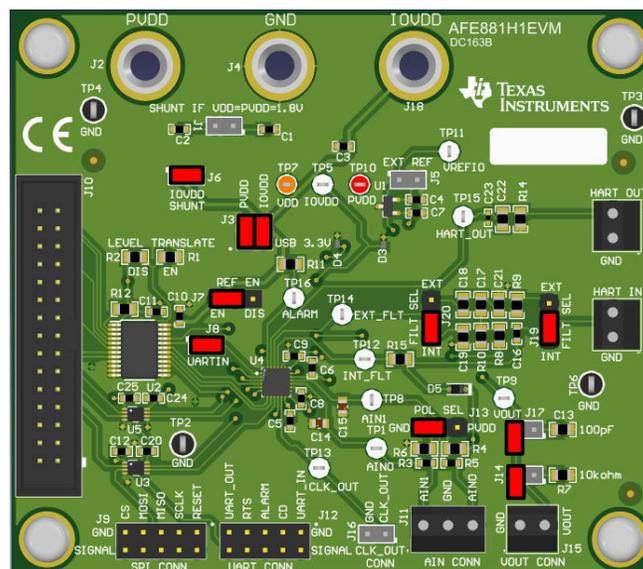
Figure 3-2. Default Header Settings for the AFE881H1EVM

3.4 Terminal and Pin Definitions

Table 3-2 shows the EVM terminal and pin definitions, allowing the user to operate and connect the device to optional power settings and other input and output signals.

Table 3-2. AFE881H1EVM Terminal and Pin Definitions

Terminal or Pin	Name	Function
J1	VDD	**Shunt 1-2:** Connect VDD to PVDD for use when VDD = PVDD = 1.8 V **Open 1-2:** Disconnects VDD when PVDD > 1.8 V
J2	PVDD	**Banana Jack:** Optional for external PVDD
J3	3p3V	**Shunt 1-2:** Connect PVDD to USB2ANY 3.3-V supply **Shunt 3-4:** Connect IOVDD to USB2ANY 3.3-V supply
J4	GND	**Banana Jack:** Optional for external GND
J5	VREFIO	**Shunt 1-2:** Connect REF3312 to VREFIO for external reference **Open 1-2:** Open for device internal reference
J6	IOVDD	**Shunt 1-2:** Connect IOVDD to power
J7	REF EN	**Shunt 1-2:** Enable device internal reference **Shunt 2-3:** Disable device internal reference
J8	UARTIN	**Shunt 1-2:** Connect UARTIN to device from USB2ANY through voltage level shifter
J9	SPI Conn	**Pin 1:** $\overline{\text{RESET}}$ **Pin 3:** SCLK **Pin 5:** SDI **Pin 7:** $\overline{\text{CS}}$ **Pin 9:** SDO **Pin 2, 4, 6, 8, 10:** GND Ground connections are on the interior side of the board. Signals are on the edge side of the board.
J10	USB2ANY	30-pin ribbon cable connection, see Table 2-1
J11	ADC	**Terminal 1:** AIN0 **Terminal 2:** GND **Terminal 3:** AIN1
J12	UART Conn	**Pin 1:** UART_IN **Pin 3:** UART_OUT **Pin 5:** $\overline{\text{RTS}}$ **Pin 7:** CD **Pin 9:** $\overline{\text{ALARM}}$ **Pin 2, 4, 6, 8, 10:** GND Ground connections are on the interior side of the board. Signals are on the edge side of the board.
J13	POL_SEL	**Shunt 1-2:** Pull up to PVDD **Shunt 2-3:** Pull down to GND **Open:** Connection to AIN1 terminal of J11
J14	RES_LOAD	**Shunt 1-2:** Connect 10-kΩ load to VOUT
J15	VOUT	**Terminal 1:** GND **Terminal 2:** VOUT
J16	CLK_OUT	**Pin 1:** CLK_OUT **Pin 2:** GND
J17	CAP_LOAD	**Shunt 1-2:** Connect 150-pF load to VOUT
J18	IOVDD	**Banana Jack:** Optional for external IOVDD
J19, J20	FILT_SEL	**Shunt 1-2:** HART IN terminal internal filter selected **Shunt 2-3:** HART IN terminal external filter selected
J21	HART_IN	**Terminal 1:** GND **Terminal 2:** HART input
J22	HART_OUT	**Terminal 1:** GND **Terminal 2:** HART output

Figure 3-3 shows the terminal and pin locations on the EVM.
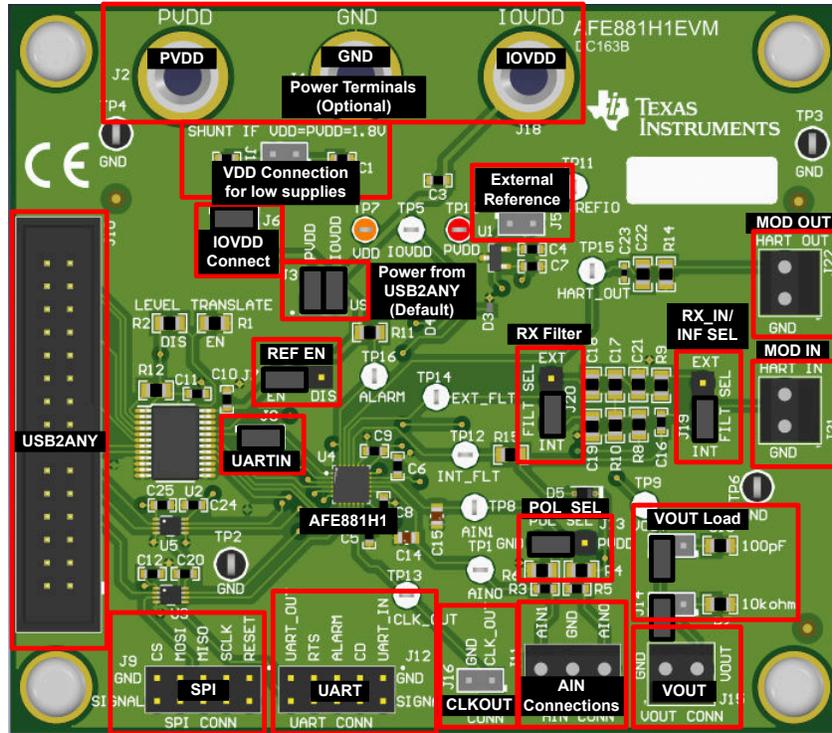
Figure 3-3. Terminal and Pin Locations for the AFE881H1EVM

3.5 Connecting the USB2ANY

To connect the EVM board and the USB2ANY Interface Adapter together, firmly slide the cable ends of the 30-pin ribbon cable into the USB2ANY Interface Adapter and the AFE881H1EVM, as shown in Figure 3-4. Make sure that the connectors are completely pushed together. Loose connections between the USB2ANY and the EVM can cause intermittent operation.
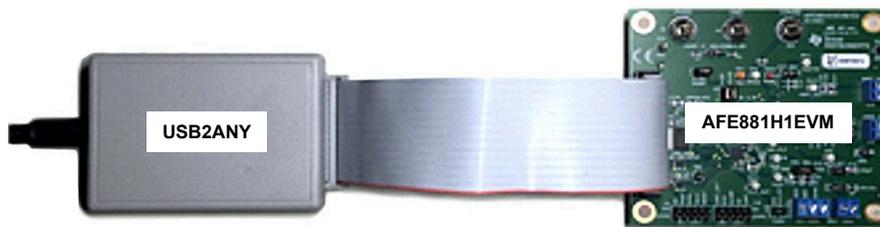
Figure 3-4. USB2ANY Connection to the AFE881H1EVM

3.6 Connecting the USB Cable to the USB2ANY Interface Adapter

Figure 3-5 shows the typical response to connecting the USB2ANY Interface Adapter board to a USB port for the first time. Typically, the PC responds with a *Found New Hardware, USB Device* pop-up dialog window. The pop-up window then changes to *Found New Hardware, USB Human Interface Device*. This pop-up indicates that the device is ready to be used. The USB2ANY Interface Adapter uses the human interface device drivers that are included in the Windows® operating system (OS).

In some cases, the *Add Hardware Wizard* appears. If this prompt occurs, allow the system device manager to install the human interface drivers by clicking *Yes* when requested to install drivers.
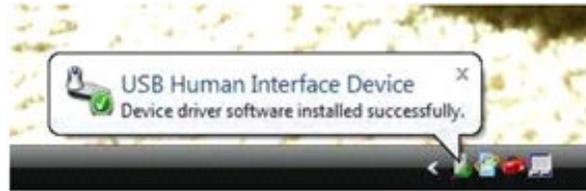
Figure 3-5. Confirmation of USB2ANY Driver Installation

CAUTION
The EVM default configuration does not require external power supplies, and power is sourced from the USB2ANY. If external supplies are used, disconnect the supply connection from the 3p3V line coming from the USB2ANY before attaching external supplies.

3.7 Optional EVM Operations

This section describes the various operational options that can be used by the EVM.

3.7.1 Power Configuration

The default configuration of the AFE881H1EVM allows the board to be powered from the 3p3V line coming from the USB2ANY. Jumper J3 connects power from the 3p3V line to the PVDD and IOVDD pins of the device. To use external power supplies, remove the jumpers in J3 to connect supplies to J1 and J4 for connections to PVDD and IOVDD. When the external supply is 1.8 V, install R1 on the board; this resistor is not installed by default. Provide the external 1.8-V supply to PVDD, VDD, and IOVDD through J1 and J4.

3.7.2 External SPI and UART Controllers

To use an external SPI or UART controller with EVM board, disconnect the USB2ANY controller, and disable the U2 level shifter by uninstalling R13 and installing R2.

4 Software Overview

This section discusses how to use the AFE881H1EVM software.

4.1 Software Installation

Before starting software installation, verify that the USB2ANY controller is not connected or else the driver may not properly install.

Download and run the latest version of the EVM GUI installer from the *Tools and Software* section of the AFE881H1EVM web folder to install the EVM GUI software on your PC. The software installation automatically copies the required LabVIEW™ software files and drivers to the local machine. The AFE881H1EVM installer installs all the driver files necessary to operate the USB2ANY controller.

Choose the destination directory for the GUI software, accept the license agreements, and follow the on-screen instructions shown in Figure 4-1 to complete the installation.
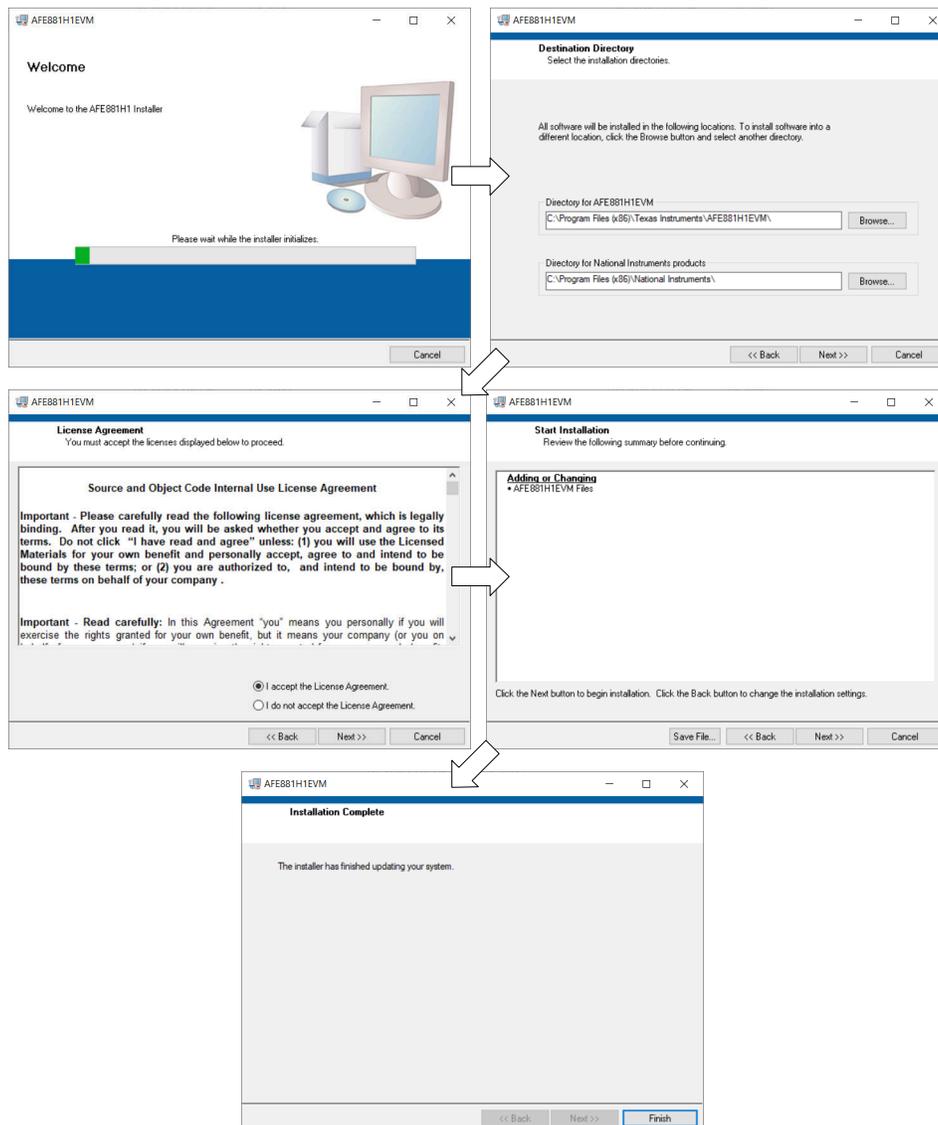
Figure 4-1. AFE881H1EVM Software Installation Prompts

To use the scripting tool, the Python™ programming environment must also be installed. Download the latest x86 version of Python 2.7 at https://www.python.org/downloads/.

4.2 Launching the Software

After installation, a shortcut to launch the GUI can be found in the *Start* menu. If installed in the default directory, the AFE881H1EVM software can also be launched by navigating to the *Texas Instruments* folder in the *Program Files (x86)* directory, as Figure 4-2 shows.
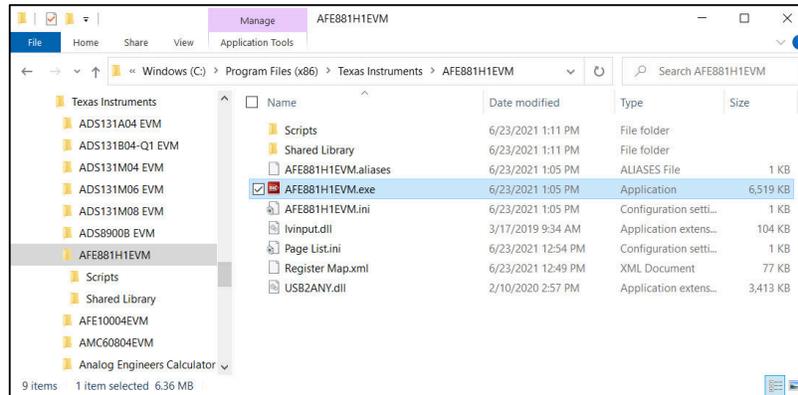
Figure 4-2. Launching the AFE881H1EVM GUI

Figure 4-3 shows the GUI after launch. If the USB2ANY controller is not connected to the PC when the software is launched, the GUI defaults to *demo* mode. Figure 4-4 illustrates the bottom-left corner of the GUI showing the hardware connection status: DEMO MODE or CONNECTED. After the USB2ANY controller is properly connected to the PC, close and reopen the AFE881H1EVM software to detect the device.
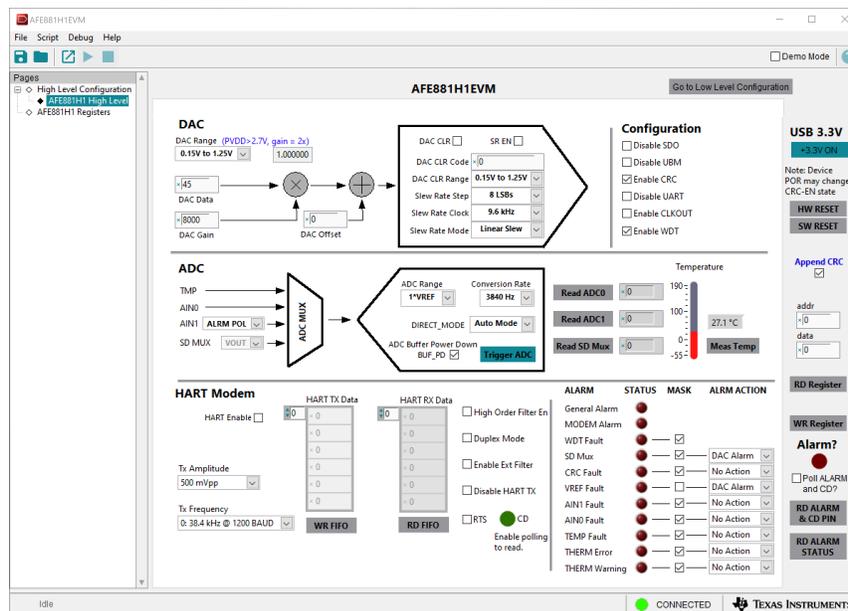
Figure 4-3. AFE881H1EVM GUI at Launch
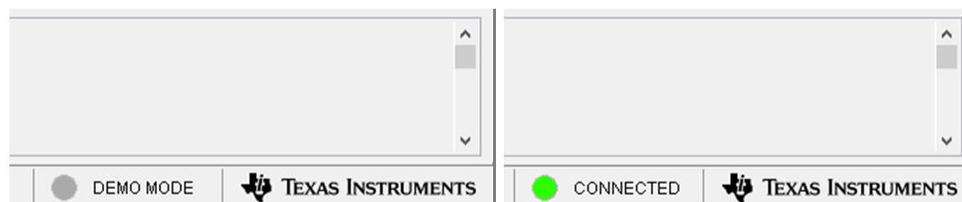
Figure 4-4. USB2ANY Digital Controller Connection Status

4.3 Software Features

The AFE881H1EVM GUI allows for SPI communication with the AFE881H1 and control of the device. While the entire register map is available to the user, some features have been integrated into user controls for easy operation.

4.3.1 AFE881H1 Register Page

Figure 4-5 shows the *AFE881H1 Register* page of the AFE881H1EVM GUI. This page allows direct access to all registers on the AFE881H1. 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.
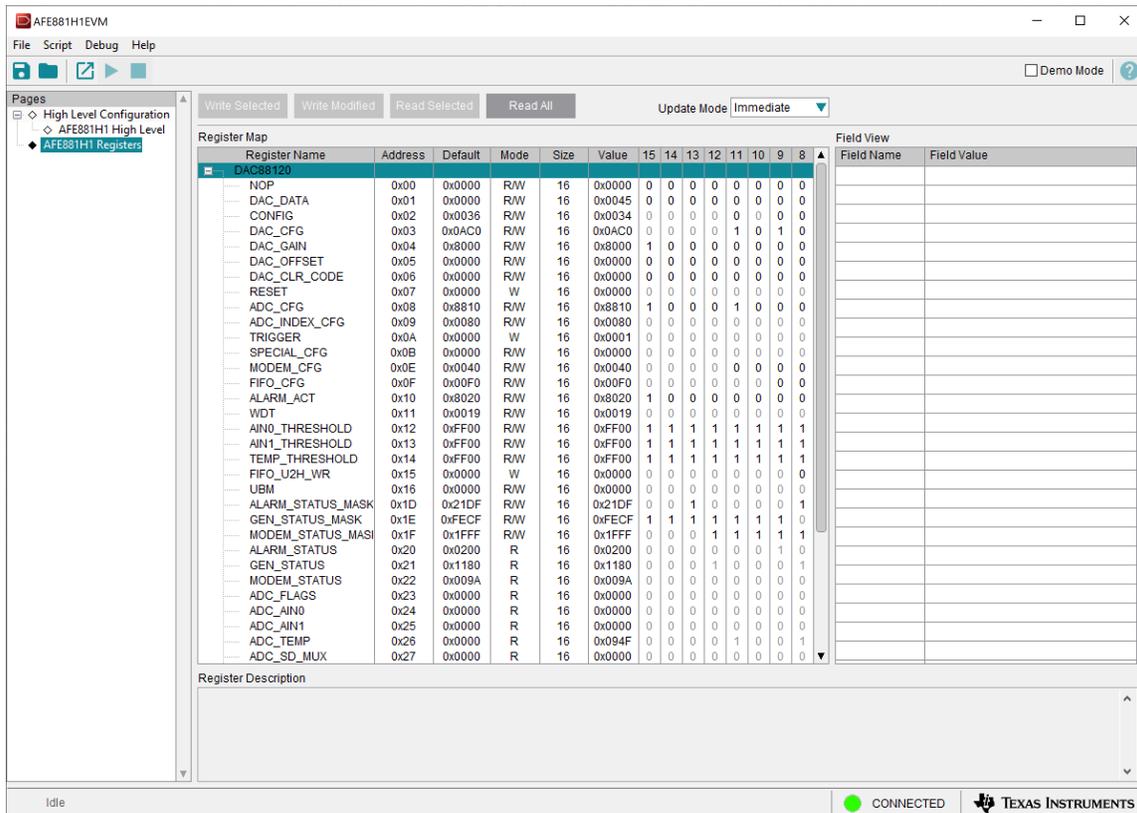
Figure 4-5. AFE881H1 Register Page

4.3.2 High Level Configuration Page

The *High Level Configuration* page is used to set the configuration of the AFE881H1EVM GUI. Figure 4-6 shows the *AFE881H1 High Level* tab of the *High Level Configuration* Page. This tab is used to set the DAC range and outputs, ADCs controls and settings, and HART modem functions for the device. Alarms and status information are also displayed on this tab.
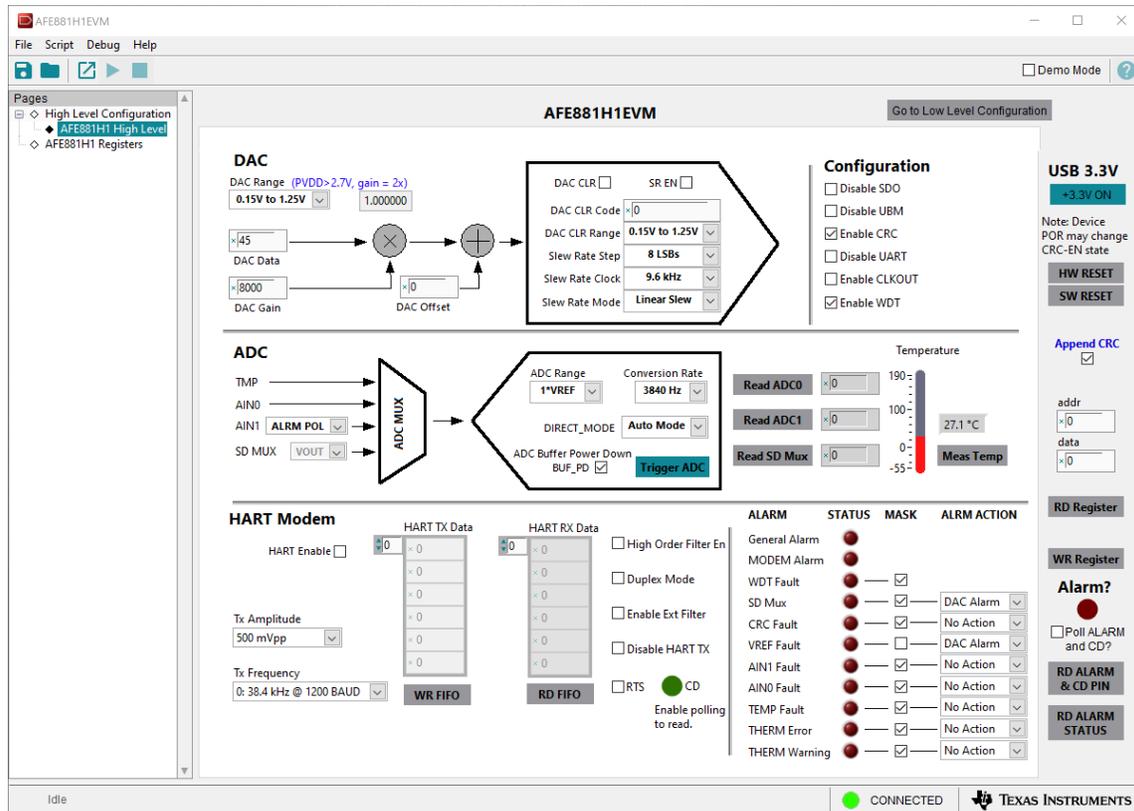
Figure 4-6. AFE881H1 High Level Tab

4.3.3 Using the Python Scripting Tool

The AFE881H1EVM software provides a scripting tool to automate register reads and writes for reuse. To use the scripting tool, the Python™ programming environment must be installed. Download the latest x86 version of Python 2.7 at https://www.python.org/downloads/. To launch the scripting tool, click *Script > Launch Window*, as shown in Figure 4-7.
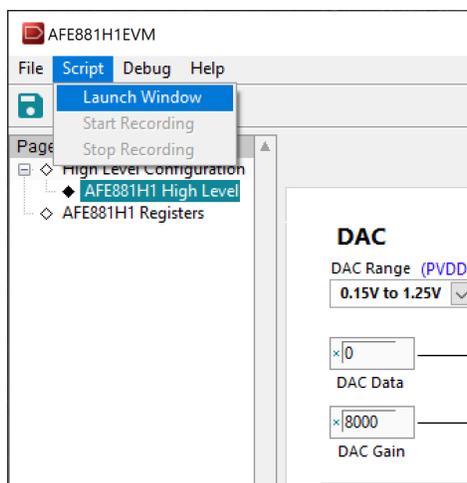
Figure 4-7. Launch Script Window

The scripting tool launches a Python IDLE window. This window lists any register interaction when recording a macro. To record a macro, find the *Launch Window* function in the *Scripting* tab. Figure 4-8 shows the scripting tool recording a macro. After the actions are recorded, use the **Stop** button to end the script. This script can be saved and reused as desired.
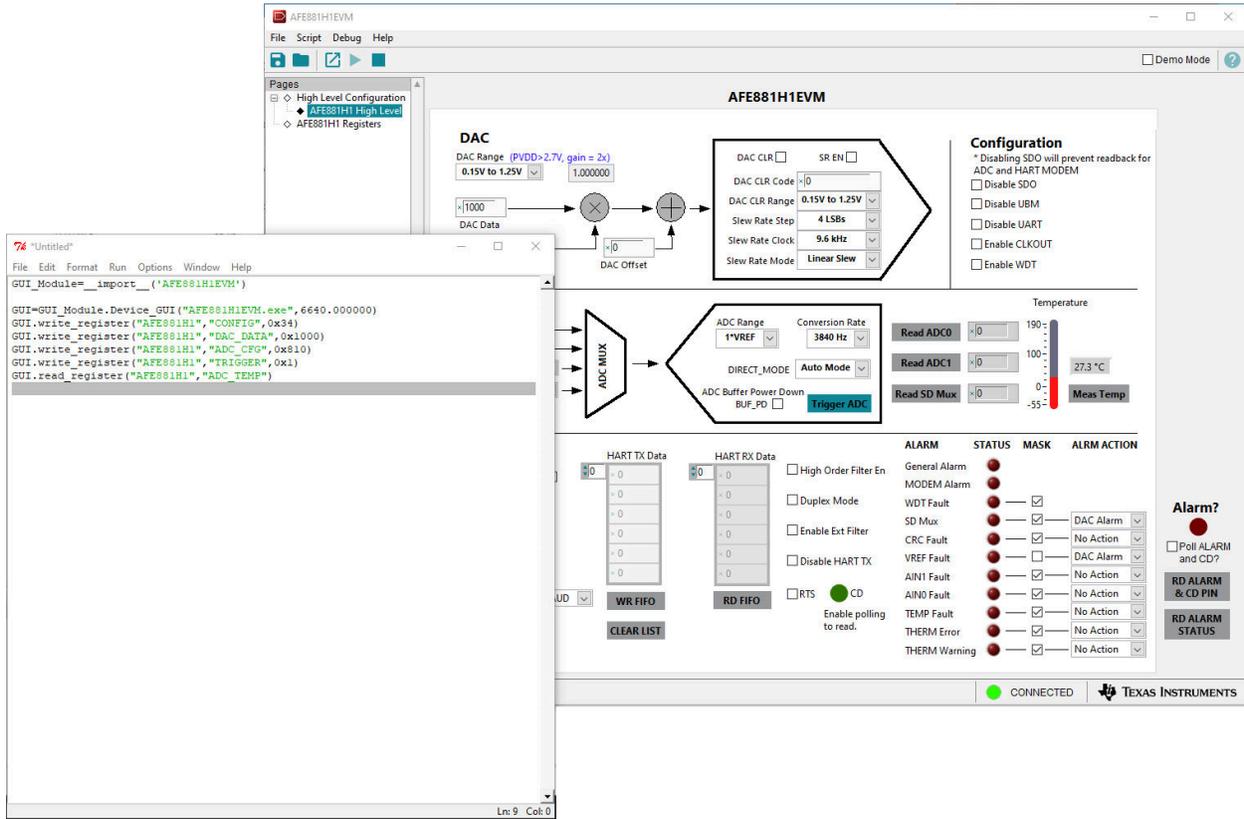
Figure 4-8. Scripting Tool Recording a Macro

If the python IDLE window does not appear, check the settings for application execution aliases. To do so, open the Windows *Settings*, and then select *Apps*. In the resulting *Apps* window, select *Apps & features*, and then click on the *Manage app execution aliases* link. The next page loads a list of apps. Deselect both application installers for python.exe and python3.exe. Figure 4-9 shows the windows settings for managing application execution aliases.
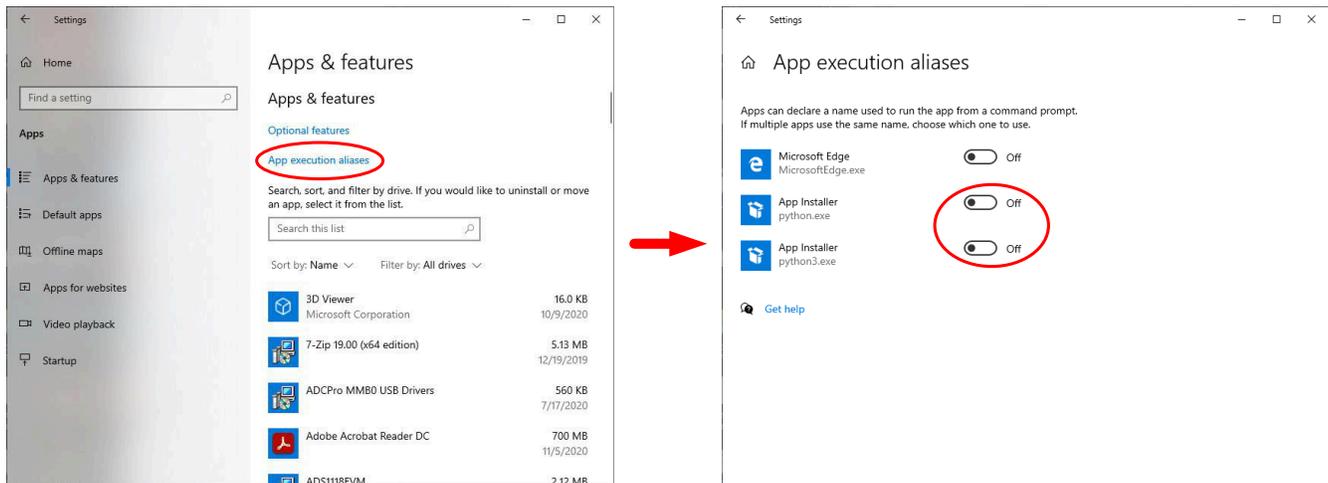
Figure 4-9. Deselecting App Execution Aliases

5 Schematics, PCB Layout, and Bill of Materials

5.1 Board Schematic

The AFE881H1EVM schematic is shown in Figure 5-1.
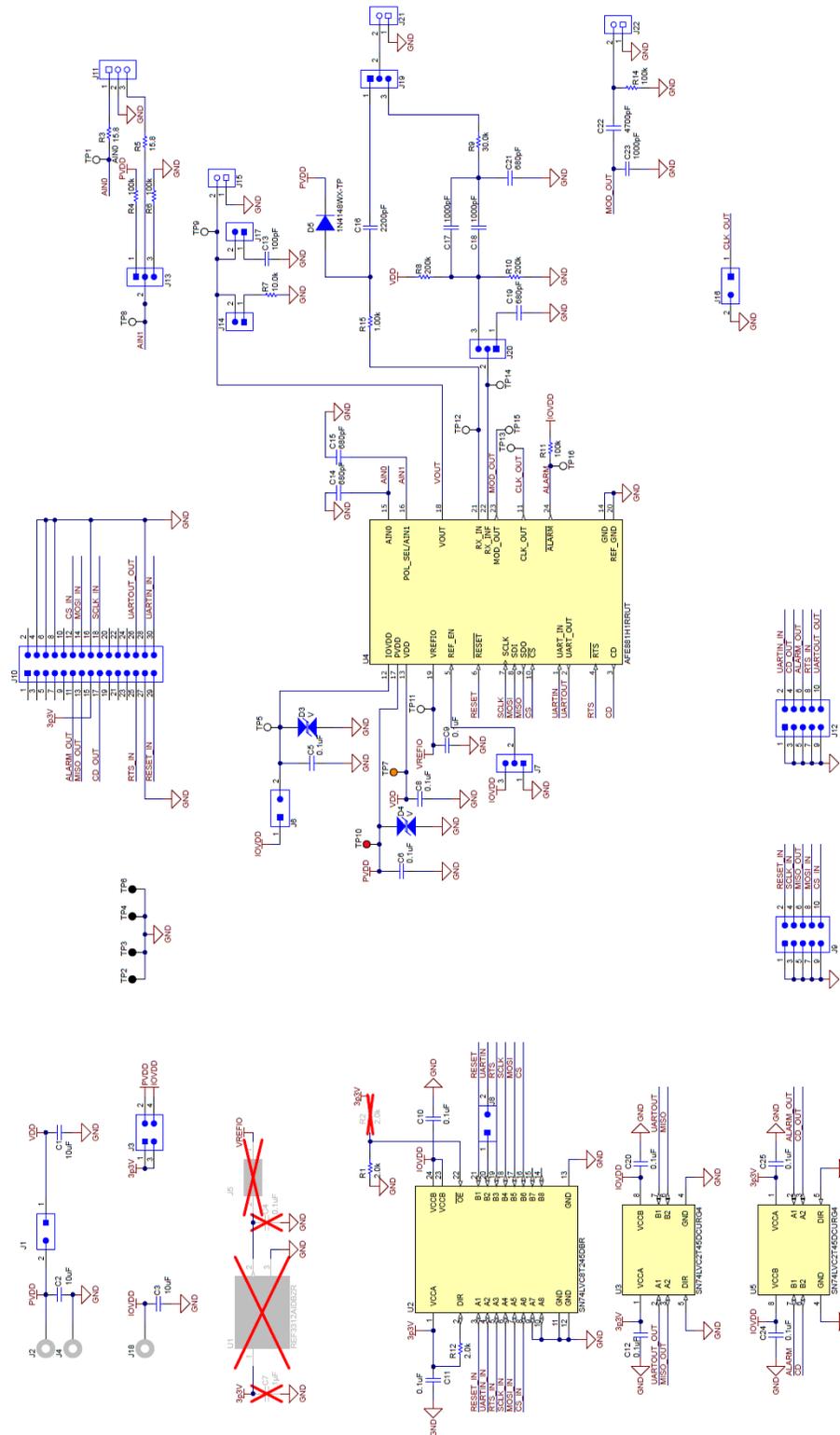
Figure 5-1. AFE881H1EVM Schematic

5.2 PCB Components Layout

through show the board layout for the AFE881H1EVM.
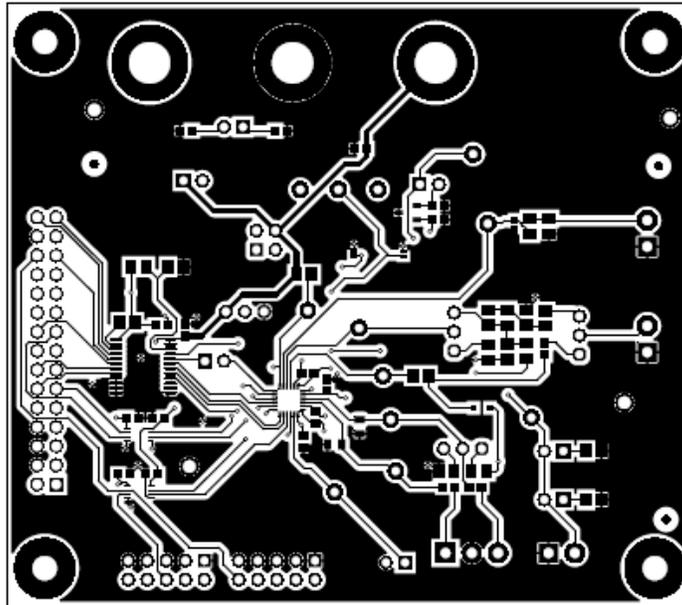
Figure 5-2. AFE881H1EVM PCB Top Layer Layout
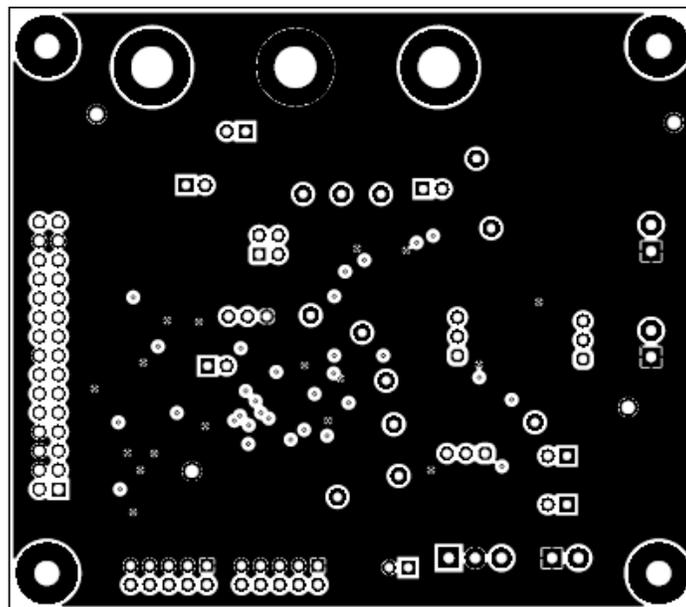
Figure 5-3. AFE881H1EVM PCB Mid Layer 1 Layout
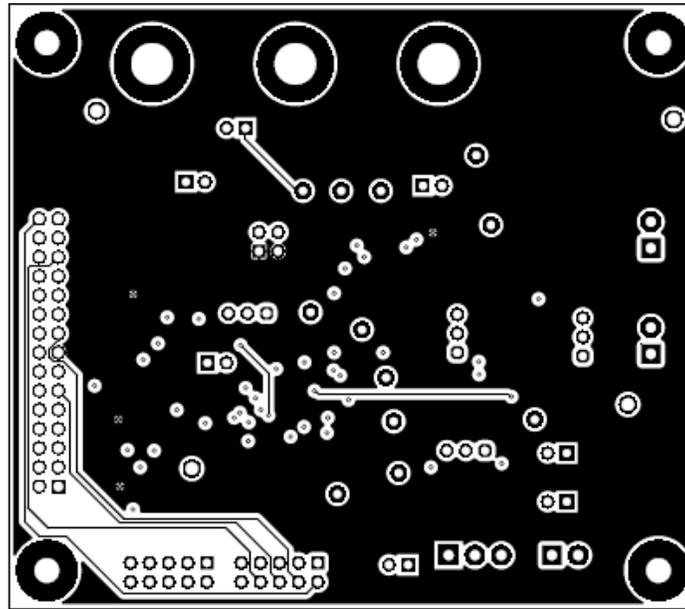
Figure 5-4. AFE881H1EVM PCB Mid Layer 2 Layout
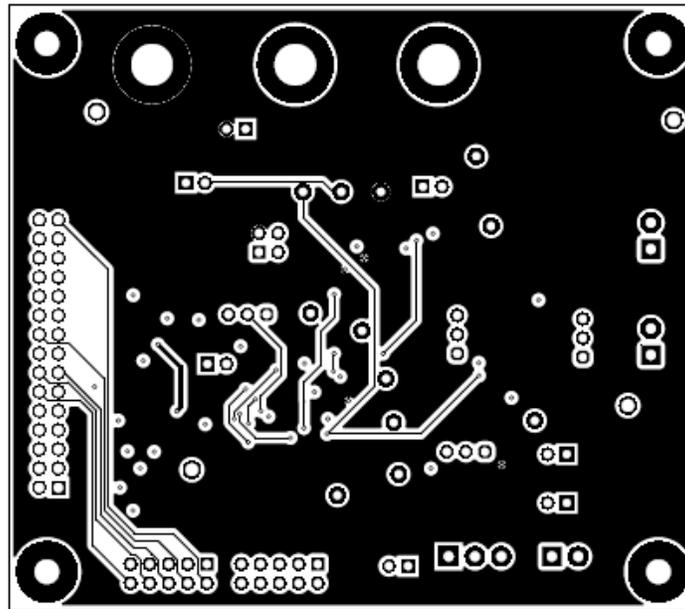
Figure 5-5. AFE881H1EVM PCB Bottom Layer Layout

5.3 Bill of Materials

Table 5-1 lists the AFE881H1EVM bill of materials (BOM).

Table 5-1. Bill of Materials for the AFE881H1EVM

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
C1, C2, C3	3	10 uF	CAP, CERM, 10 uF, 25 V, +/- 20%, X5R, 0603	0603	GRT188R61E106ME13D	MuRata
C5, C6, C8, C9, C10, C11, C12, C20, C24, C25	10	0.1 uF	CAP, CERM, 0.1 uF, 25 V, +/- 5%, X7R, 0603	0603	06033C104JAT2A	AVX
C13	1	100 pF	CAP, CERM, 100 pF, 100 V, +/- 5%, X7R, 0805	0805	C0805C101J1RACTU	Kemet
C14, C15	2	680 pF	CAP, CERM, 680 pF, 25 V, +/- 10%, X7R, 0805	0805	885012207085	Würth Elektronik
C16	1	2200 pF	CAP, CERM, 2200 pF, 50 V, +/- 5%, C0G/NP0, 0603	0603	GRM1885C1H222JA01D	MuRata
C17, C18	2	1000 pF	CAP, CERM, 1000 pF, 50 V, +/- 1%, C0G/NP0, 0805	0805	08055A102FAT2A	AVX
C19, C21	2	680 pF	CAP, CERM, 680 pF, 100 V, +/- 5%, C0G/NP0, 0805	0805	08051A681JAT2A	AVX
C22	1	4700 pF	CAP, CERM, 4700 pF, 25 V, +/- 5%, C0G/NP0, 0805	0805	08053A472JAT2A	AVX
C23	1	1000 pF	CAP, CERM, 1000 pF, 50 V, +/- 5%, C0G/NP0, AEC-Q200 Grade 1, 0402	0402	CGA2B2C0G1H102J050BA	TDK
D3, D4	2		Diode, TVS, Bi, 5.5 V, 14 Vc, 1x0.6mm	1x0.6mm	ESD105B102ELE6327XTMA1	Infineon Technologies
D5	1	75 V	Diode, Switching, 75 V, 0.15 A, SOD-323	SOD-323	1N4148WX-TP	Micro Commercial Components
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, J6, J8, J14, J16, J17	6		Header, 100mil, 2x1, Tin, TH	Header, 2x1, 100mil, TH	5-146278-2	TE Connectivity
J2, J4, J18	3		Standard Banana Jack, Uninsulated, 5.5mm	Keystone_575-4	575-4	Keystone
J3	1		Header, 100mil, 2x2, Gold, TH	2x2 Header	TSW-102-07-G-D	Samtec
J7, J13, J19, J20	4		Header, 100mil, 3x1, Gold, TH	3x1 Header	TSW-103-07-G-S	Samtec
J9, J12	2		Header, 100mil, 5x2, Gold, TH	5x2 Header	TSW-105-07-G-D	Samtec
J10	1		Header(shrouded), 2.54mm, 15x2, Gold, TH	Header(shrouded), 2.54mm, 15x2, TH	302-S301	On-Shore Technology
J11	1		Terminal Block, 3.5mm Pitch, 3x1, TH	10.5x8.2x6.5mm	ED555/3DS	On-Shore Technology
J15, J21, J22	3		Terminal Block, 3.5mm Pitch, 2x1, TH	7.0x8.2x6.5mm	ED555/2DS	On-Shore Technology
R1, R12	2	2.0 k	RES, 2.0 k, 5%, 0.125 W, AEC-Q200 Grade 0, 0805	0805	ERJ-6GEYJ202V	Panasonic

Table 5-1. Bill of Materials for the AFE881H1EVM (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
R3, R5	2	15.8	RES, 15.8, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060315R8FKEA	Vishay-Dale
R4, R6, R11, R14	4	100 k	RES, 100 k, 1%, 0.125 W, AEC-Q200 Grade 0, 0805	0805	CRCW0805100KFKEA	Vishay-Dale
R7	1	10.0 k	RES, 10.0 k, 1%, 0.125 W, AEC-Q200 Grade 0, 0805	0805	CRCW080510K0FKEA	Vishay-Dale
R8, R10	2	200 k	RES, 200 k, 1%, 0.125 W, AEC-Q200 Grade 0, 0805	0805	CRCW0805200KFKEA	Vishay-Dale
R9	1	30.0 k	RES, 30.0 k, 0.1%, 0.125 W, 0805	0805	RG2012P-303-B-T5	Susumu Co Ltd
R15	1	1k	RES, 1.00 k, 1%, 0.125 W, AEC-Q200 Grade 0, 0805	0805	ERJ-6ENF1001V	Panasonic
TP1, TP5, TP8, TP9, TP11, TP12, TP13, TP14, TP15, TP16	10		Test Point, Miniature, White, TH	White Miniature Testpoint	5002	Keystone
TP2, TP3, TP4, TP6	4		Test Point, Multipurpose, Black, TH	Black Multipurpose Testpoint	5011	Keystone
TP7	1		Test Point, Miniature, Orange, TH	Orange Miniature Testpoint	5003	Keystone
TP10	1		Test Point, Miniature, Red, TH	Red Miniature Testpoint	5000	Keystone
U2	1		8-Bit Dual-Supply Bus Transceiver with Configurable Voltage-Level Shifting and Three-State Outputs, DB0024A (SSOP-24)	DB0024A	SN74LVC8T245DBR	Texas Instruments
U4	1		16-Bit, Low-Power DACs With Internal HART Modem, Voltage Reference, and Diagnostic ADC for 4-20mA Loop-Powered Applications, UQFN24	UQFN24	AFE881H1RRUT	Texas Instruments
U3, U5	2		2-Bit Dual Supply Transceiver with Configurable Voltage-Level Shifting and 3-State Outputs, DCU0008A (VSSOP-8)	DCU0008A	SN74LVC2T45DCURG4	Texas Instruments
C4	0	0.1 uF	CAP, CERM, 0.1 uF, 25 V, +/- 5%, X7R, 0603	0603	06033C104JAT2A	AVX
C7	0	1 uF	CAP, CERM, 1 uF, 50 V, +/- 10%, X7R, 0603	0603	UMK107AB7105KA-T	Taiyo Yuden
J5	0		Header, 100mil, 2x1, Tin, TH	Header, 2x1, 100mil, TH	5-146278-2	TE Connectivity
R2	0	2.0 k	RES, 2.0 k, 5%, 0.125 W, AEC-Q200 Grade 0, 0805	0805	ERJ-6GEYJ202V	Panasonic
U1	0		30 ppm / degC Drift, 3.9 uA, Voltage Reference, -40 to 125 degC, 3-pin SOT-23 (DBZ), Green (RoHS & no Sb/Br)	DBZ0003A	REF3312AIDBZR	Texas Instruments

6 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

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.

<u>WARNING</u>

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.

【無線電波を送信する製品の開発キットをお使いになる際の注意事項】 開発キットの中には技術基準適合証明を受けて

いないものがあります。 技術適合証明を受けていないもののご使用に際しては、電波法遵守のため、以下のいずれかの

措置を取っていただく必要がありますのでご注意ください。

1. 電波法施行規則第6条第1項第1号に基づく平成18年3月28日総務省告示第173号で定められた電波暗室等の試験設備でご使用いただく。

2. 実験局の免許を取得後ご使用いただく。

3. 技術基準適合証明を取得後ご使用いただく。

なお、本製品は、上記の「ご使用にあたっての注意」を譲渡先、移転先に通知しない限り、譲渡、移転できないものとします。
　　　　上記を遵守頂けない場合は、電波法の罰則が適用される可能性があることをご留意ください。 日本テキサス・イ

ンスツルメンツ株式会社

東京都新宿区西新宿６丁目２４番１号

西新宿三井ビル

3.3.3 *Notice for EVMs for Power Line Communication:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_02.page

電力線搬送波通信についての開発キットをお使いになる際の注意事項については、次のところをご覧ください。https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-for-power-line-communication.html

3.4 *European Union*

3.4.1 *For EVMs subject to EU Directive 2014/30/EU (Electromagnetic Compatibility Directive)*:

This is a class A product intended for use in environments other than domestic environments that are connected to a low-voltage power-supply network that supplies buildings used for domestic purposes. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.

4   *EVM Use Restrictions and Warnings:*

4.1   EVMS ARE NOT FOR USE IN FUNCTIONAL SAFETY AND/OR SAFETY CRITICAL EVALUATIONS, INCLUDING BUT NOT LIMITED TO EVALUATIONS OF LIFE SUPPORT APPLICATIONS.

4.2   User must read and apply the user guide and other available documentation provided by TI regarding the EVM prior to handling or using the EVM, including without limitation any warning or restriction notices. The notices contain important safety information related to, for example, temperatures and voltages.

4.3   *Safety-Related Warnings and Restrictions:*

4.3.1   User shall operate the EVM within TI's recommended specifications and environmental considerations stated in the user guide, other available documentation provided by TI, and any other applicable requirements and employ reasonable and customary safeguards. Exceeding the specified performance ratings and specifications (including but not limited to input and output voltage, current, power, and environmental ranges) for the EVM may cause personal injury or death, or property damage. If there are questions concerning performance ratings and specifications, User should contact a TI field representative prior to connecting interface electronics including input power and intended loads. Any loads applied outside of the specified output range may also result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM user guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative. During normal operation, even with the inputs and outputs kept within the specified allowable ranges, some circuit components may have elevated case temperatures. These components include but are not limited to linear regulators, switching transistors, pass transistors, current sense resistors, and heat sinks, which can be identified using the information in the associated documentation. When working with the EVM, please be aware that the EVM may become very warm.

4.3.2   EVMs are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems. User assumes all responsibility and liability for proper and safe handling and use of the EVM by User or its employees, affiliates, contractors or designees. User assumes all responsibility and liability to ensure that any interfaces (electronic and/or mechanical) between the EVM and any human body are designed with suitable isolation and means to safely limit accessible leakage currents to minimize the risk of electrical shock hazard. User assumes all responsibility and liability for any improper or unsafe handling or use of the EVM by User or its employees, affiliates, contractors or designees.

4.4   User assumes all responsibility and liability to determine whether the EVM is subject to any applicable international, federal, state, or local laws and regulations related to User's handling and use of the EVM and, if applicable, User assumes all responsibility and liability for compliance in all respects with such laws and regulations. User assumes all responsibility and liability for proper disposal and recycling of the EVM consistent with all applicable international, federal, state, and local requirements.

5.   *Accuracy of Information:* To the extent TI provides information on the availability and function of EVMs, TI attempts to be as accurate as possible. However, TI does not warrant the accuracy of EVM descriptions, EVM availability or other information on its websites as accurate, complete, reliable, current, or error-free.

6.   *Disclaimers:*

6.1   EXCEPT AS SET FORTH ABOVE, EVMS AND ANY MATERIALS PROVIDED WITH THE EVM (INCLUDING, BUT NOT LIMITED TO, REFERENCE DESIGNS AND THE DESIGN OF THE EVM ITSELF) ARE PROVIDED "AS IS" AND "WITH ALL FAULTS." TI DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, REGARDING SUCH ITEMS, INCLUDING BUT NOT LIMITED TO ANY EPIDEMIC FAILURE WARRANTY OR IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF ANY THIRD PARTY PATENTS, COPYRIGHTS, TRADE SECRETS OR OTHER INTELLECTUAL PROPERTY RIGHTS.

6.2   EXCEPT FOR THE LIMITED RIGHT TO USE THE EVM SET FORTH HEREIN, NOTHING IN THESE TERMS SHALL BE CONSTRUED AS GRANTING OR CONFERRING ANY RIGHTS BY LICENSE, PATENT, OR ANY OTHER INDUSTRIAL OR INTELLECTUAL PROPERTY RIGHT OF TI, ITS SUPPLIERS/LICENSORS OR ANY OTHER THIRD PARTY, TO USE THE EVM IN ANY FINISHED END-USER OR READY-TO-USE FINAL PRODUCT, OR FOR ANY INVENTION, DISCOVERY OR IMPROVEMENT, REGARDLESS OF WHEN MADE, CONCEIVED OR ACQUIRED.

7.   *USER'S INDEMNITY OBLIGATIONS AND REPRESENTATIONS.* USER WILL DEFEND, INDEMNIFY AND HOLD TI, ITS LICENSORS AND THEIR REPRESENTATIVES HARMLESS FROM AND AGAINST ANY AND ALL CLAIMS, DAMAGES, LOSSES, EXPENSES, COSTS AND LIABILITIES (COLLECTIVELY, "CLAIMS") ARISING OUT OF OR IN CONNECTION WITH ANY HANDLING OR USE OF THE EVM THAT IS NOT IN ACCORDANCE WITH THESE TERMS. THIS OBLIGATION SHALL APPLY WHETHER CLAIMS ARISE UNDER STATUTE, REGULATION, OR THE LAW OF TORT, CONTRACT OR ANY OTHER LEGAL THEORY, AND EVEN IF THE EVM FAILS TO PERFORM AS DESCRIBED OR EXPECTED.

8. *Limitations on Damages and Liability:*

   8.1 *General Limitations.* IN NO EVENT SHALL TI BE LIABLE FOR ANY SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL, OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF THESE TERMS OR THE USE OF THE EVMS , REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. EXCLUDED DAMAGES INCLUDE, BUT ARE NOT LIMITED TO, COST OF REMOVAL OR REINSTALLATION, ANCILLARY COSTS TO THE PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES, RETESTING, OUTSIDE COMPUTER TIME, LABOR COSTS, LOSS OF GOODWILL, LOSS OF PROFITS, LOSS OF SAVINGS, LOSS OF USE, LOSS OF DATA, OR BUSINESS INTERRUPTION. NO CLAIM, SUIT OR ACTION SHALL BE BROUGHT AGAINST TI MORE THAN TWELVE (12) MONTHS AFTER THE EVENT THAT GAVE RISE TO THE CAUSE OF ACTION HAS OCCURRED.

   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.

IMPORTANT NOTICE AND DISCLAIMER