EVM User's Guide: AFE881H1EVM

AFE881H1 Evaluation Module

Description

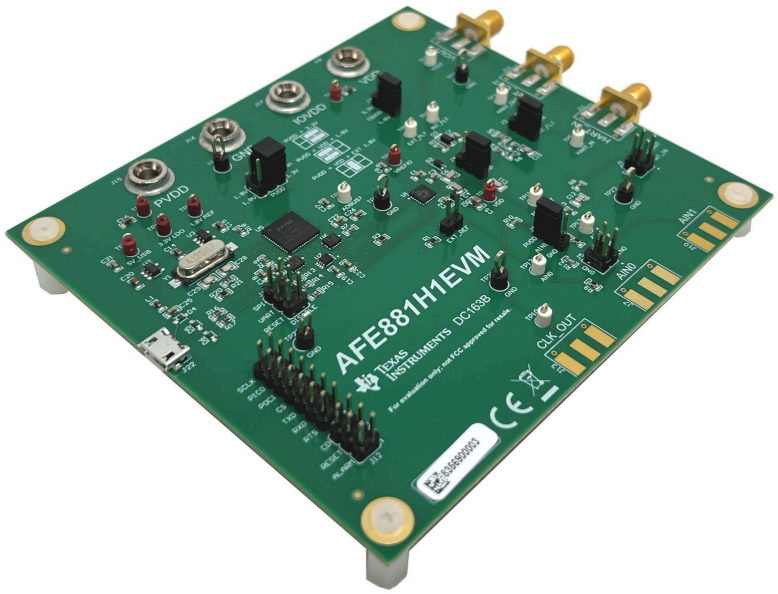
The AFE881H1 16-bit digital-to-analog converter (DAC) is a highly-integrated, high-accuracy, and extremely low-power device with voltage-outputs designed for HART® enabled factory automation and control applications. The AFE881H1 includes most of the components required to construct an analog output 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. This AFE881H1EVM provides a straightforward circuit for functional testing and verification.

Features

- Onboard or external power supply options
- USB connection for control using the *AFE88xH1EVM GUI*
- External SPI and UART connections available
- Onboard HART filter

Applications

- HART-Enabled Field Transmitter for 4-20mA Loops



1 Evaluation Module Overview

1.1 Introduction

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).

1.2 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
USB-A to Micro-USB Cable	1

2 Hardware

2.1 Hardware Description

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

2.1.1 Theory of Operation

Figure 2-1 shows the block diagram of the AFE881H1EVM board. The AFE881H1 connects to a local machine USB port through a USB-A to Micro-USB cable.

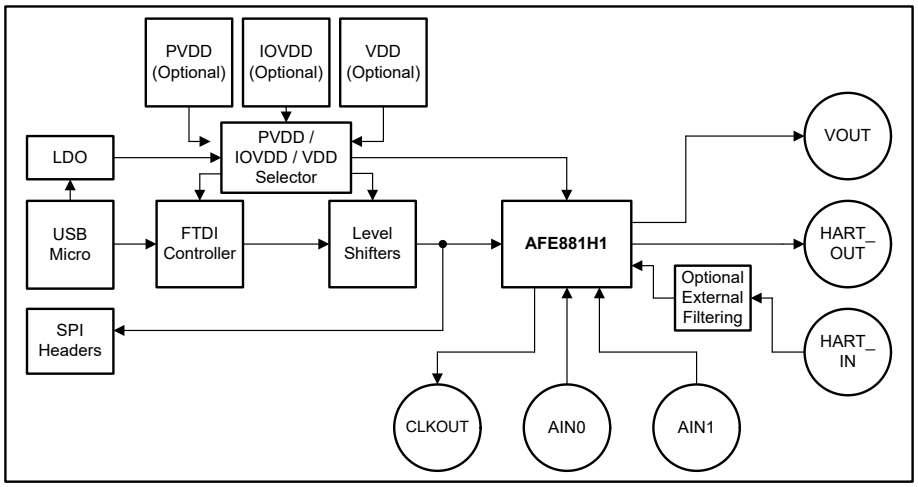


Figure 2-1. Block Diagram for the AFE881H1EVM

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 can source on-board power through J21 and J20, respectively. VDD can also be selected using J21. To use external supplies, remove the shunts connecting the jumpers and use the banana jack connectors at J15 for PVDD, J17 for IOVDD, and J18 for VDD.

SMA connector J11 is coupled to the HART input of the AFE881H1. Jumpers at J2 and J4 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 J14. SMA connectors J7 and J10 connect to the inputs of a 16-bit ADC on the AFE881H1, and SMA connector J13 connects to the device CLK_OUT output clock. Additionally, SMA connector J8 is available for the VOUT of the AFE881H1.

2.1.2 Signal Definitions

The EVM board provides access to the digital AFE881H1 pins through headers J6 and J12. Table 2-1 lists the J6 pin definitions and Table 2-2 lists the J12 pin definitions.

Table 2-1. AFE881H1 Header J6 Pin Definitions

Pin Number	Signal	Description
1	SCLK	AFE881H1 SPI serial clock input
3	PICO	AFE881H1 SDI (serial data input)
5	POCI	AFE881H1 SDO (serial data output)
7	$\overline{CS}$	AFE881H1 chip select input
9	TXD	AFE881H1 UART output
11	RXD	AFE881H1 UART input
13	$\overline{RTS}$	AFE881H1 HART request to send
2, 4, 6, 8, 10, 12, 14	GND	Ground

Table 2-2. AFE881H1 Header J12 Pin Definitions

Pin Number	Signal	Description
1	CD	AFE881H1 HART carrier detect

Table 2-2. AFE881H1 Header J12 Pin Definitions (continued)

Pin Number	Signal	Description
3	$\overline{\text{RESET}}$	AFE881H1 device reset
5	$\overline{\text{ALARM}}$	AFE881H1 alarm signal
2, 4, 6	GND	Ground

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 AFE881H1EVM through the onboard FTDI controller. The USB connection provides 5V of power to the EVM. Low-dropout regulators (LDOs) generate the 3.3V and 1.8V supplies used for PVDD, IOVDD, and VDD for use as the supply voltage across the EVM board. Optional external PVDD, IOVDD, and VDD connections are available through banana jack terminals after the 3.3V and the 1.8V LDO supplies are disconnected. An external VDD connection is only needed if PVDD is 1.8V.

2.2.1 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.

2.2.2 Power Configuration and Jumper Settings

The AFE881H1EVM provides electrical connections to the device supply pins. Table 2-3 shows the connections.

Table 2-3 summarizes all of the EVM jumper functionality.

Table 2-3. AFE881H1EVM Power Supply Inputs

Terminal	Name	Function
J15	PVDD	Optional external PVDD power supply (disconnect J21 when using external supply)
J16	GND	Ground connection
J17	IOVDD	Optional external IOVDD power supply (disconnect J20 when using external supply)
J18	VDD	Optional external VDD power supply (disconnect J21 when using external supply or set to Float)

The jumper settings on the AFE881H1EVM are crucial to the proper operation of the EVM. Table 2-4 provides the details of the configurable jumper settings on the EVM. Figure 2-2 defines the AFE881H1EVM show the default jumper connections on the board.

Table 2-4. AFE881H1EVM Jumper Summary

Header	Name	Function
J2	HART_IN	**Short 1-2** – HART receiver input set to internal filter (default) **Short 2-3** – HART receiver input set to external filter
J3	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)
J4	RX_INF	**Short 1-2** – RX_IN connected to 680 pF for internal filter (default) **Short 2-3** – RX_INF set to external filter
J9	POL_SEL	**Short 1-2** – POL_SEL set alarm voltage high (default) **Short 2-3** – POL_SEL set alarm voltage low

Table 2-4. AFE881H1EVM Jumper Summary (continued)

Header	Name	Function
J19	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)
J20	IOVDD	**Short 1-2** – IOVDD supplied through 3.3V USB power **Short 2-3** – IOVDD supplied through 1.8V USB power (default) **Open** – IOVDD supplied through J17
J21	PVDD_VDD	**Short 1-3** – PVDD supplied through 1.8V USB power **Short 2-4** – VDD supplied through 1.8V USB power (only if PVDD = 1.8V) **Short 3-4** – PVDD and VDD shorted for single external 1.8V connection to either J15 or J18 **Short 3-5** – PVDD supplied through 3.3V USB power (default) **Short 4-6** – VDD supplied internally from AFE881H1(default) **Open** – PVDD and VDD supplied externally through J15 and J18

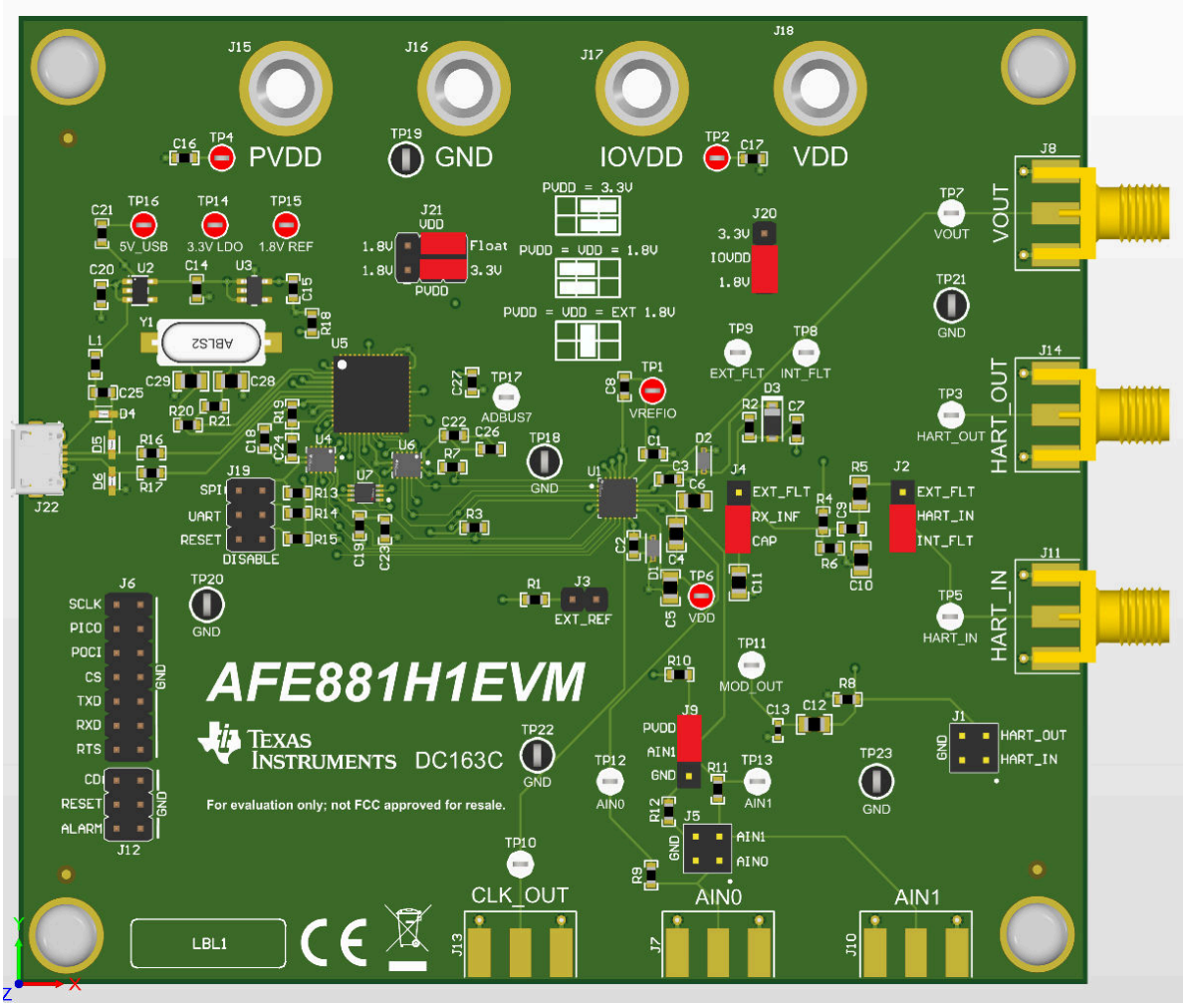


Figure 2-2. Default Header Settings for the AFE881H1EVM

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 AFE881H1EVM USB port to the local machine. Figure 2-3 displays the system hardware setup.

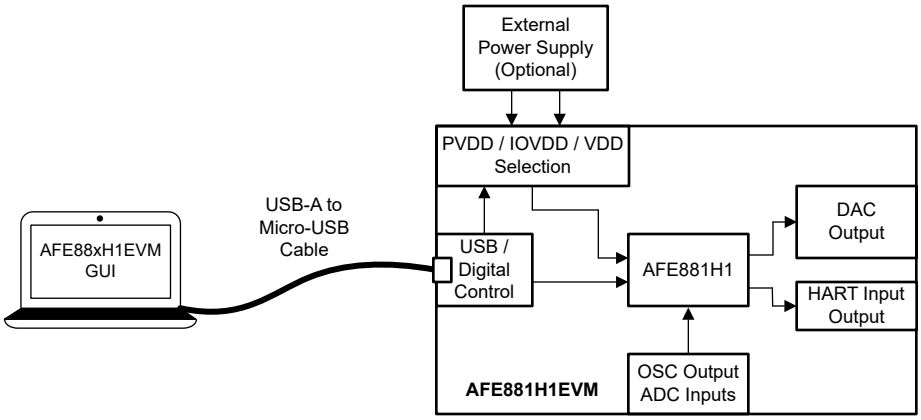


Figure 2-3. AFE881H1EVM Hardware Setup

2.2.3.1 Power Configuration

The default configuration of the AFE881H1EVM allows the board to be powered from the USB. Jumper J21 provides connection options for the USB-powered 1.8V and 3.3V supplies to the PVDD pin and 1.8 V for VDD pin of the device, and jumper J20 provides options for the IOVDD pin of the device. To use external power supplies, remove the jumpers in J20 and J21 and connect the supplies to banana jacks J15, J17 and J18 for connections to PVDD, IOVDD, and VDD.

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 J19 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 J6 and J12 to control the AFE881H1.

3 Software

3.1 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 AFE881H1EVM 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 AFE881H1EVM web folder on TI.com. Run the GUI installer to install the EVM GUI software on your local machine.

When the AFE88xH1EVM software is launched, an installation dialog window opens and prompts the user to select an installation directory. If left unchanged, Figure 3-1 shows that the software location defaults to *C:\Program Files (x86)\Texas Instruments\AFE88xH1EVM.*

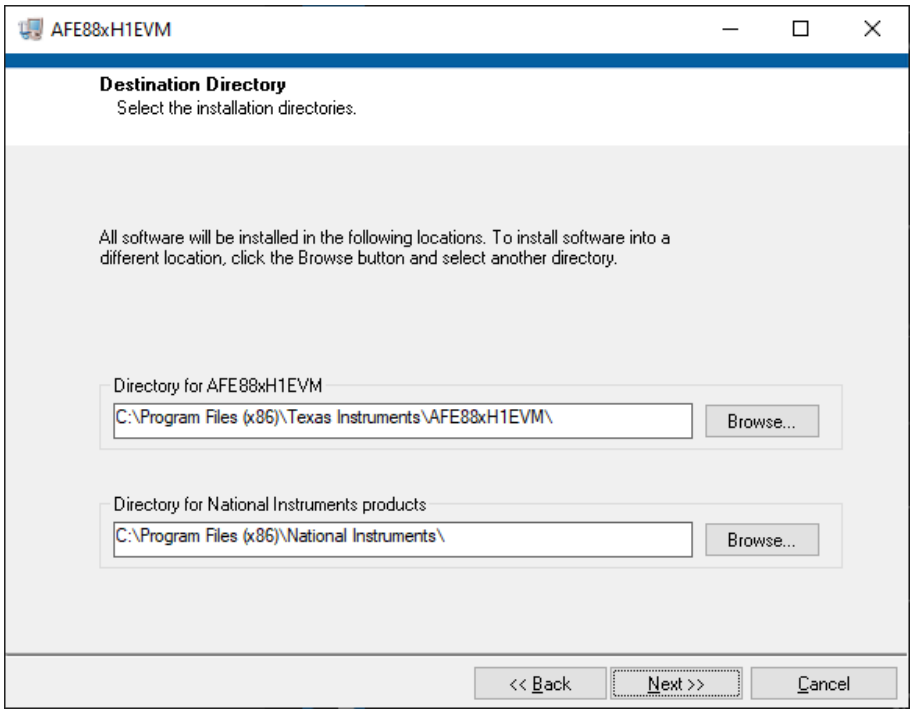


Figure 3-1. Software Installation Path

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 3-2 shows the FTDI USB drivers installation window that is automatically launched after the AFE88xH1EVM software installation is complete.

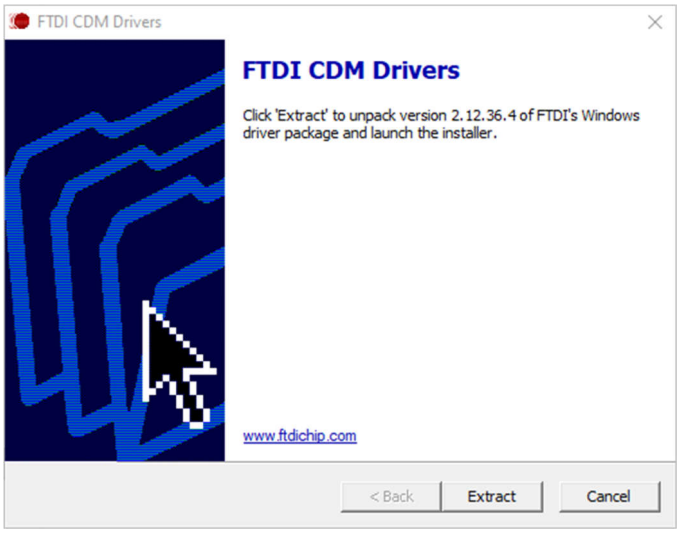


Figure 3-2. FTDI USB Drivers

3.2 Software Description

This section describes the features of the AFE88xH1EVM software, and discusses how to use these features. The software provides basic control of all the AFE881H1 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 *AFE88xH1EVM* icon.

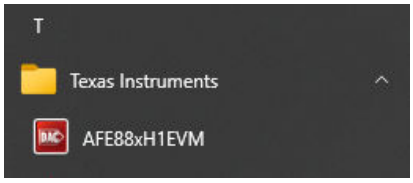


Figure 3-3. AFE88xH1EVM Software Installation Prompts

Once the software has launched, it will ask the user to select what EVM is being used. If using the AFE881H1EVM, select the *AFE881H1EVM* option.

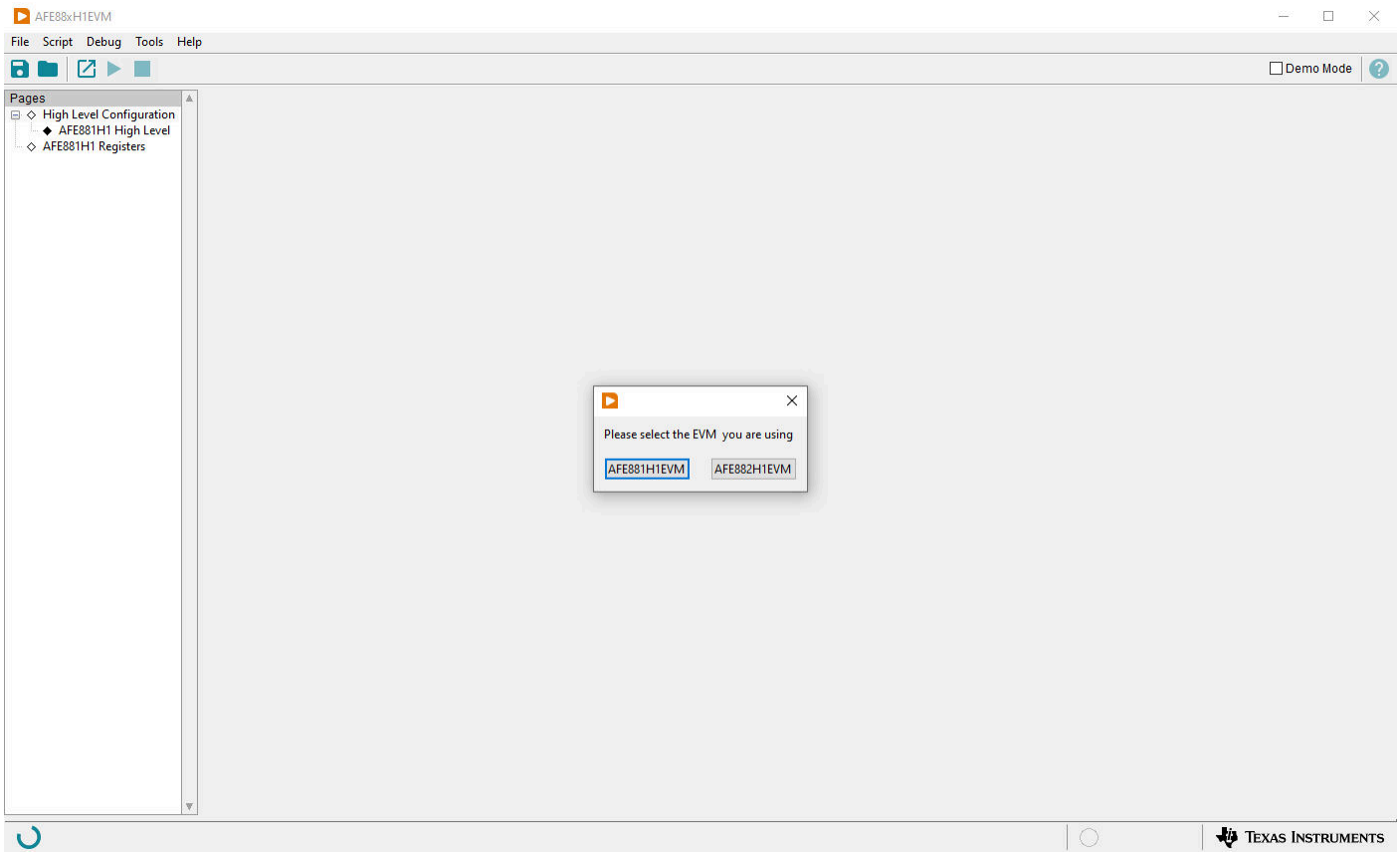


Figure 3-4. AFE88xH1EVM GUI Device Selection

Next, shown in Figure 3-5, the user can select between the 3 different communication modes the AFE881H1 supports. Specific requirements and functionality for the different modes are detailed in the AFE881H1 datasheet.

- **SPI** - used for both register and HART write/read
- **SPI+UART** - uses SPI for register write/read and 1200 baud UART for HART write/read
- **UBM** (UART Break Mode) - uses 9600 baud UART with break commands for both register and HART write/read

When the user selects a mode, the SDO, CONFIG, and UBM registers are updated to support immediate communication.

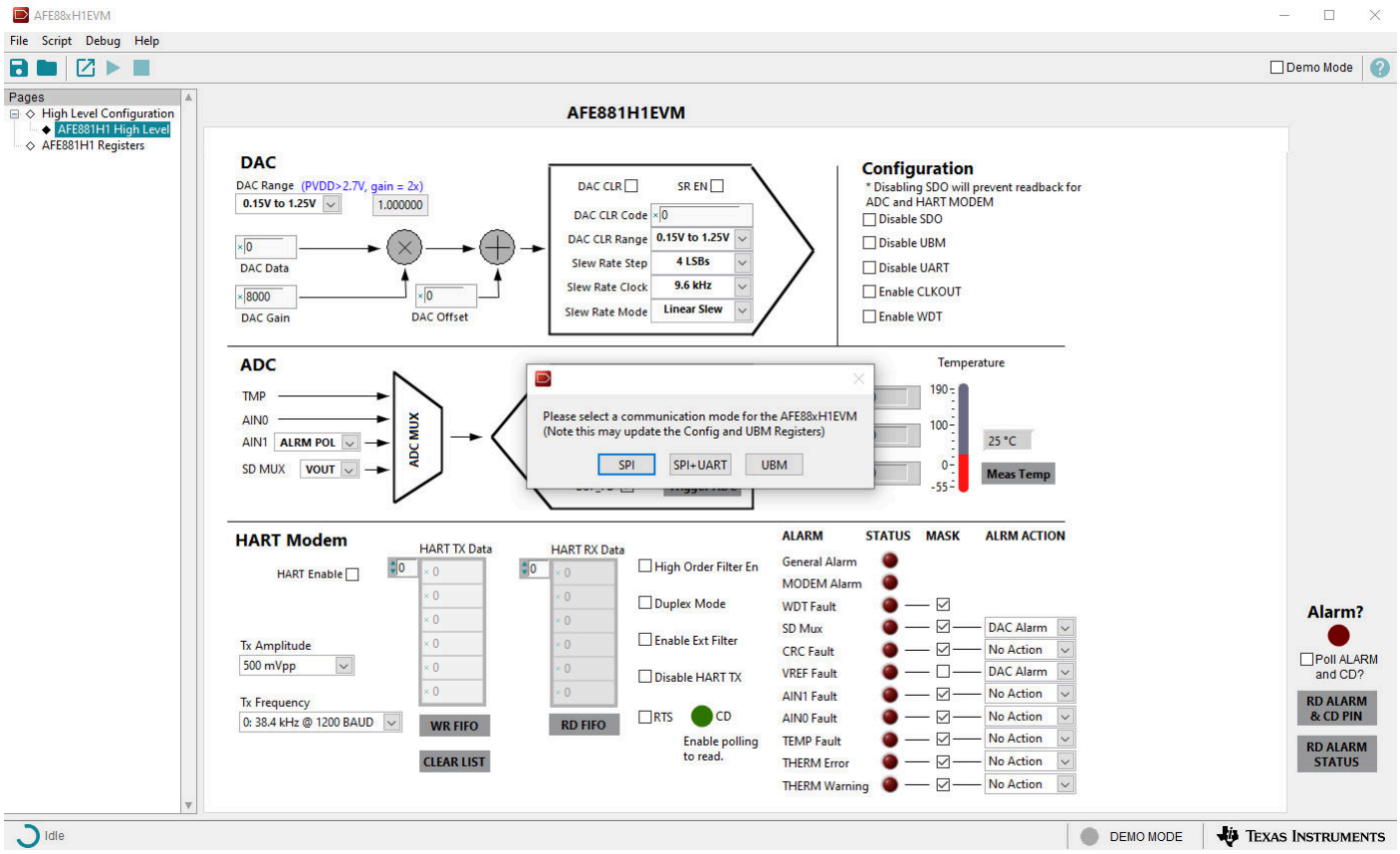


Figure 3-5. AFE88xH1EVM GUI Communication Selection

Figure 3-6 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.

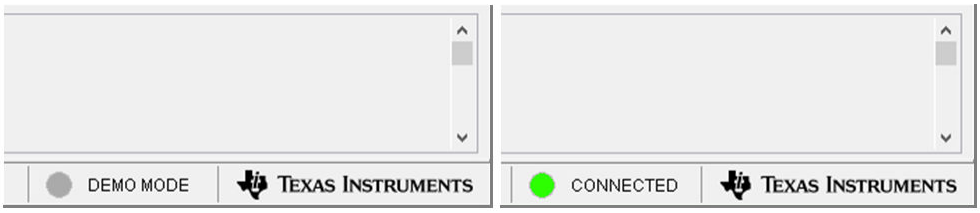


Figure 3-6. AFE88xH1EVM GUI Connection Detection

3.2.2 Software Features

The AFE88xH1EVM GUI allows for easy access to the registers that help configure an individual AFE881H1 device using SPI or UBM communication.

Before using the GUI, see the AFE881H1 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 AFE88xH1EVM GUI. Figure 3-7 shows the *AFE881H1 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, and HART modem functions for the device. Alarms and status information are also displayed on this tab.

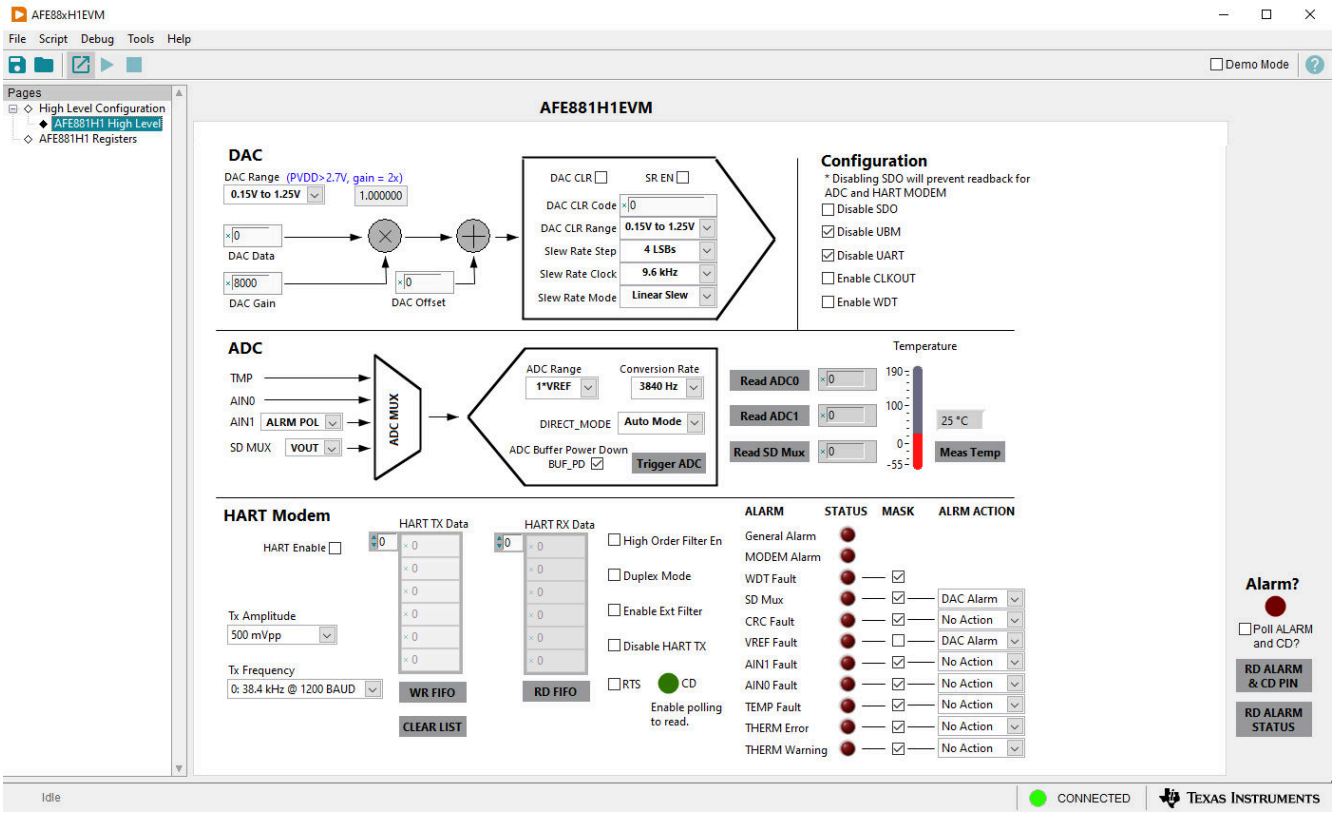


Figure 3-7. AFE881H1 High Level Tab

3.2.2.2 AFE881H1 Register Page

Figure 3-8 shows the *AFE881H1 Register* page of the AFE88xH1EVM 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.

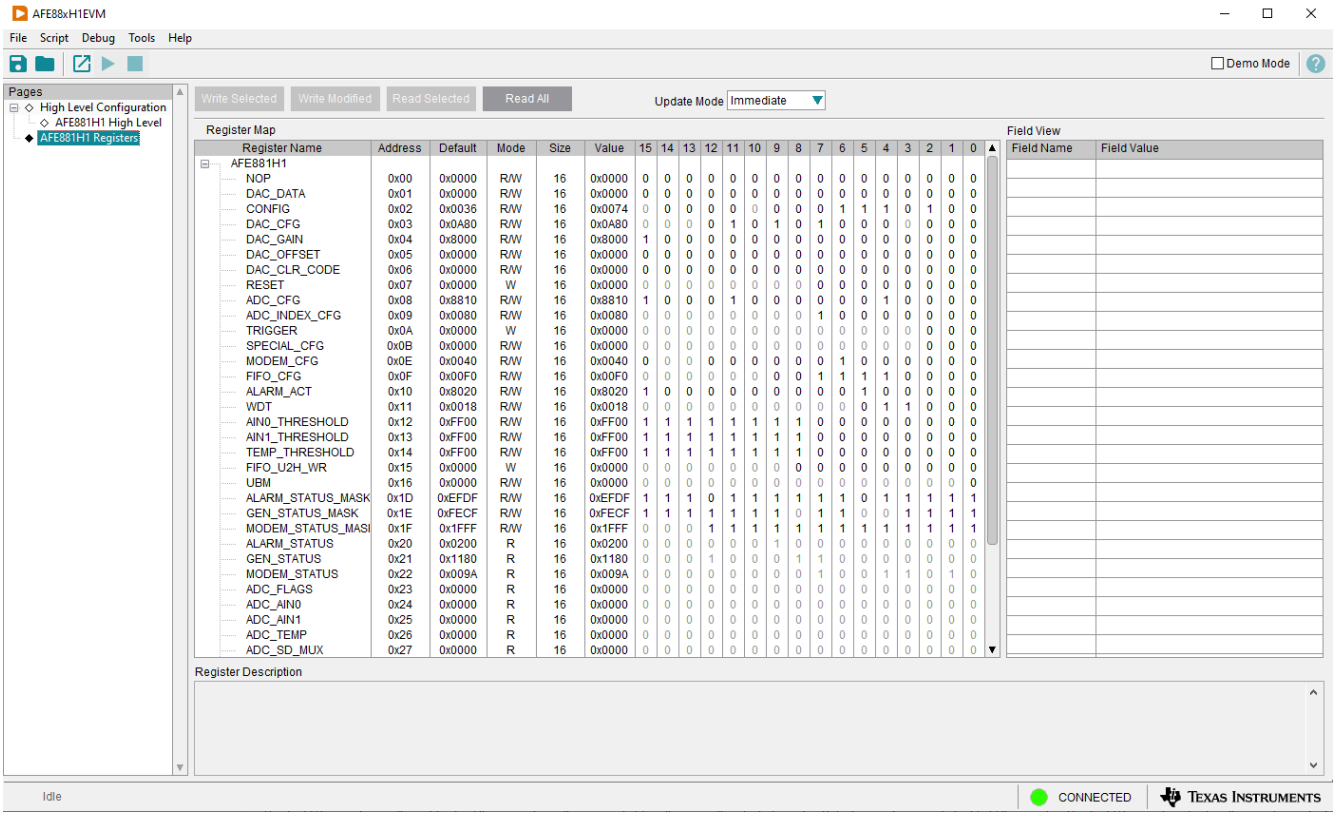


Figure 3-8. AFE881H1 Register Page

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 3-9 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**

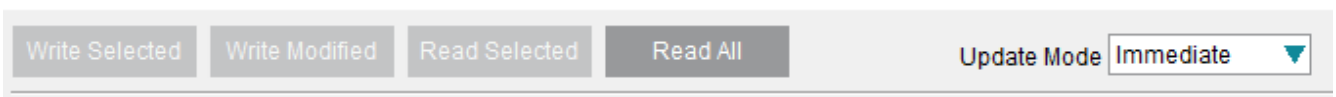


Figure 3-9. AFE881H1 Register Page Options

4 Hardware Design Files

4.1 Board Schematic

The AFE881H1EVM schematic is shown in Figure 4-1 and Figure 4-2.

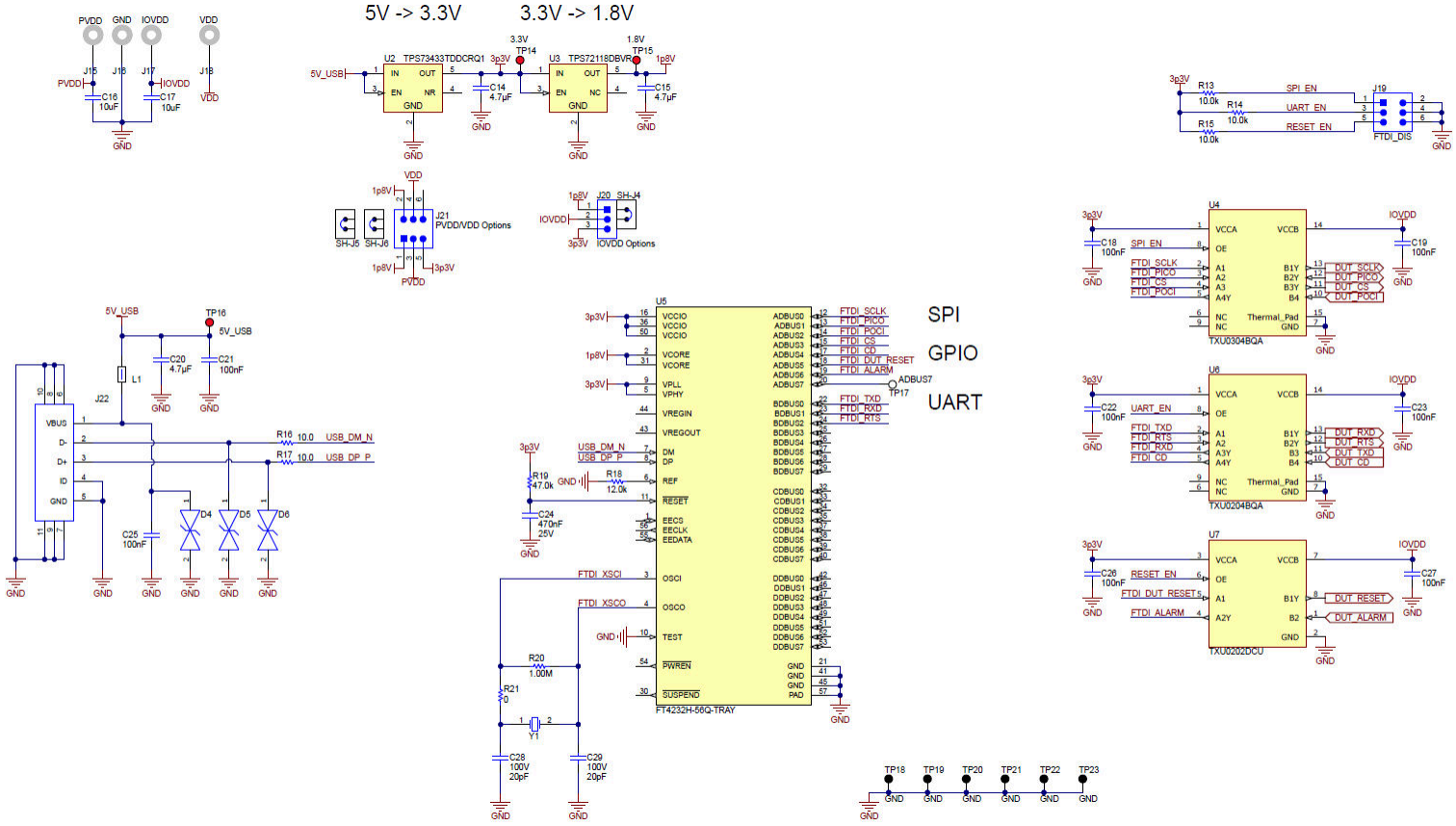


Figure 4-1. AFE881H1EVM Schematic: FTDI Controller

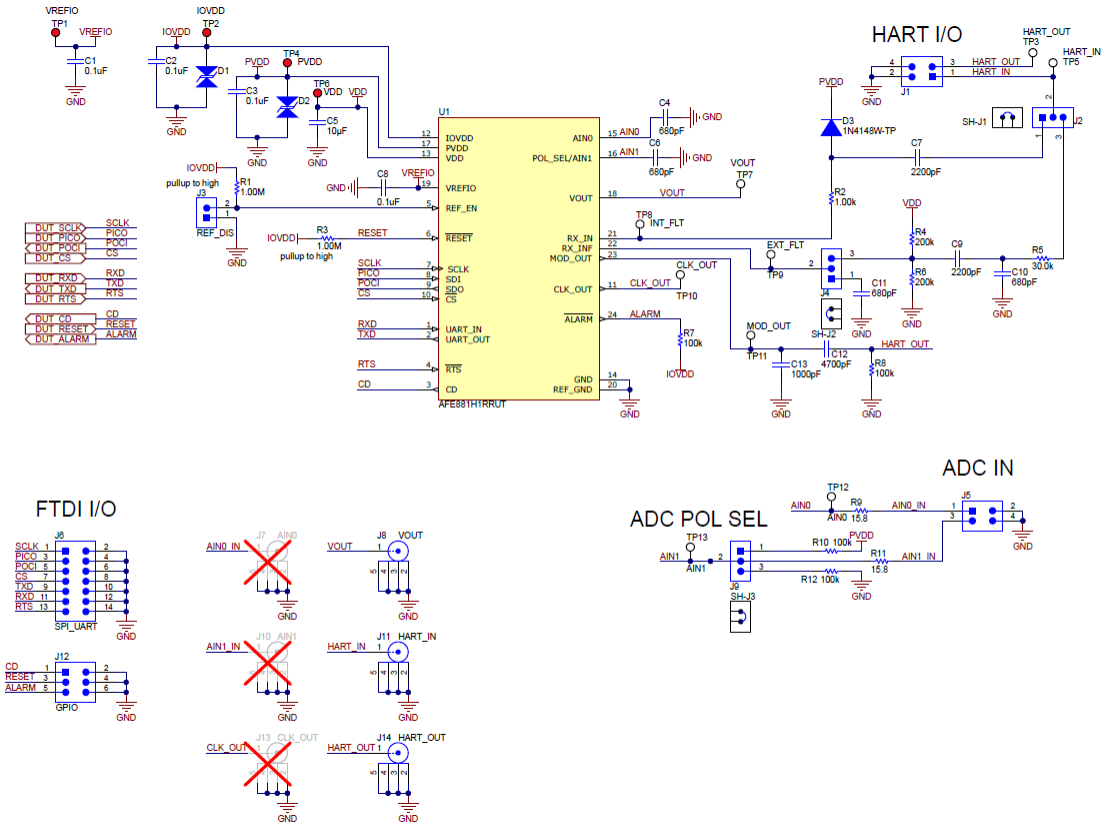


Figure 4-2. AFE881H1EVM Schematic: AFE881H1 I/O

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4.2 PCB Layout

Figure 4-3 through Figure 4-6 show the board layout for the AFE881H1EVM.

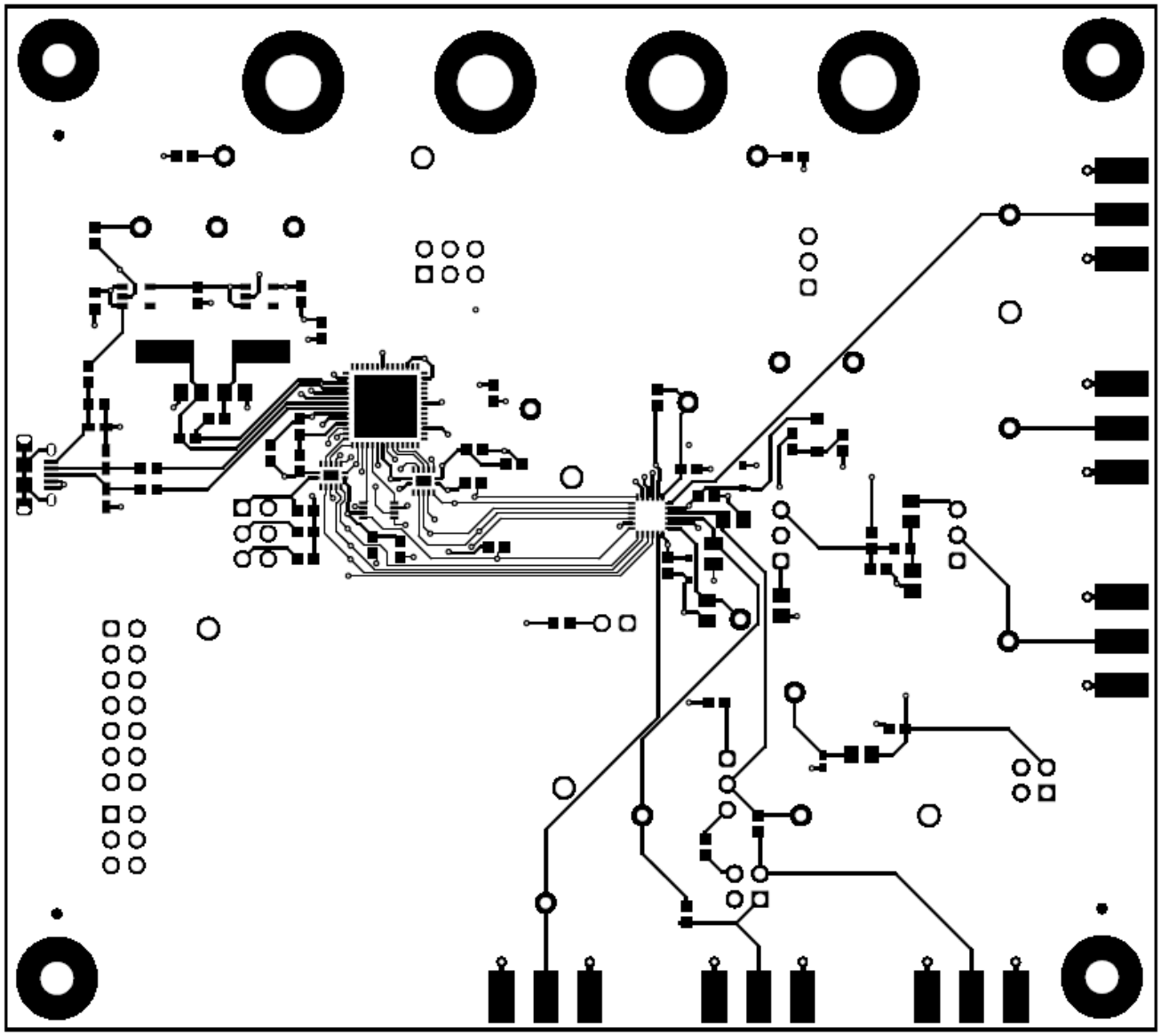

Figure 4-3. AFE881H1EVM PCB Top Layer Layout

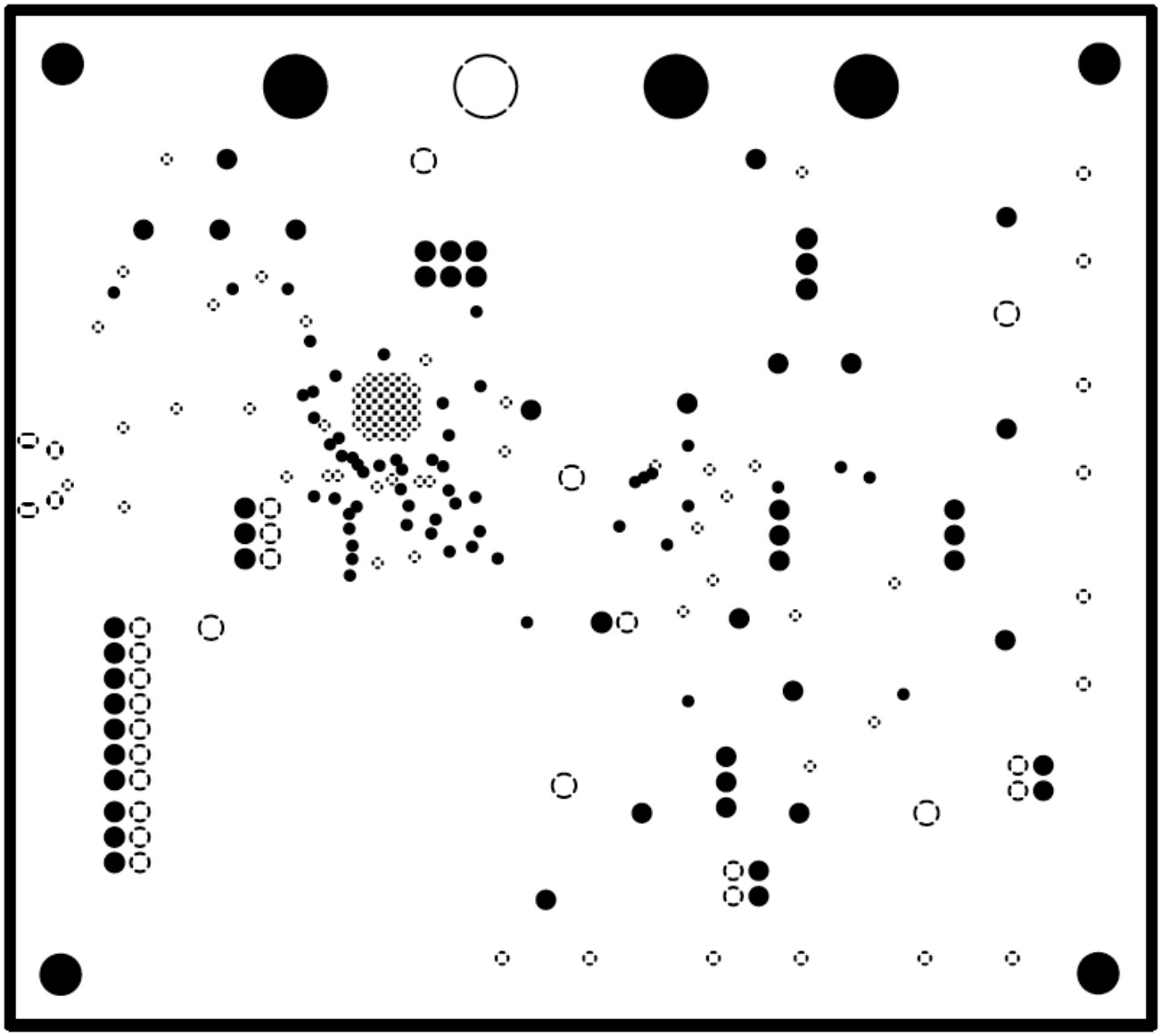

Figure 4-4. AFE881H1EVM PCB Mid Layer 1 Layout

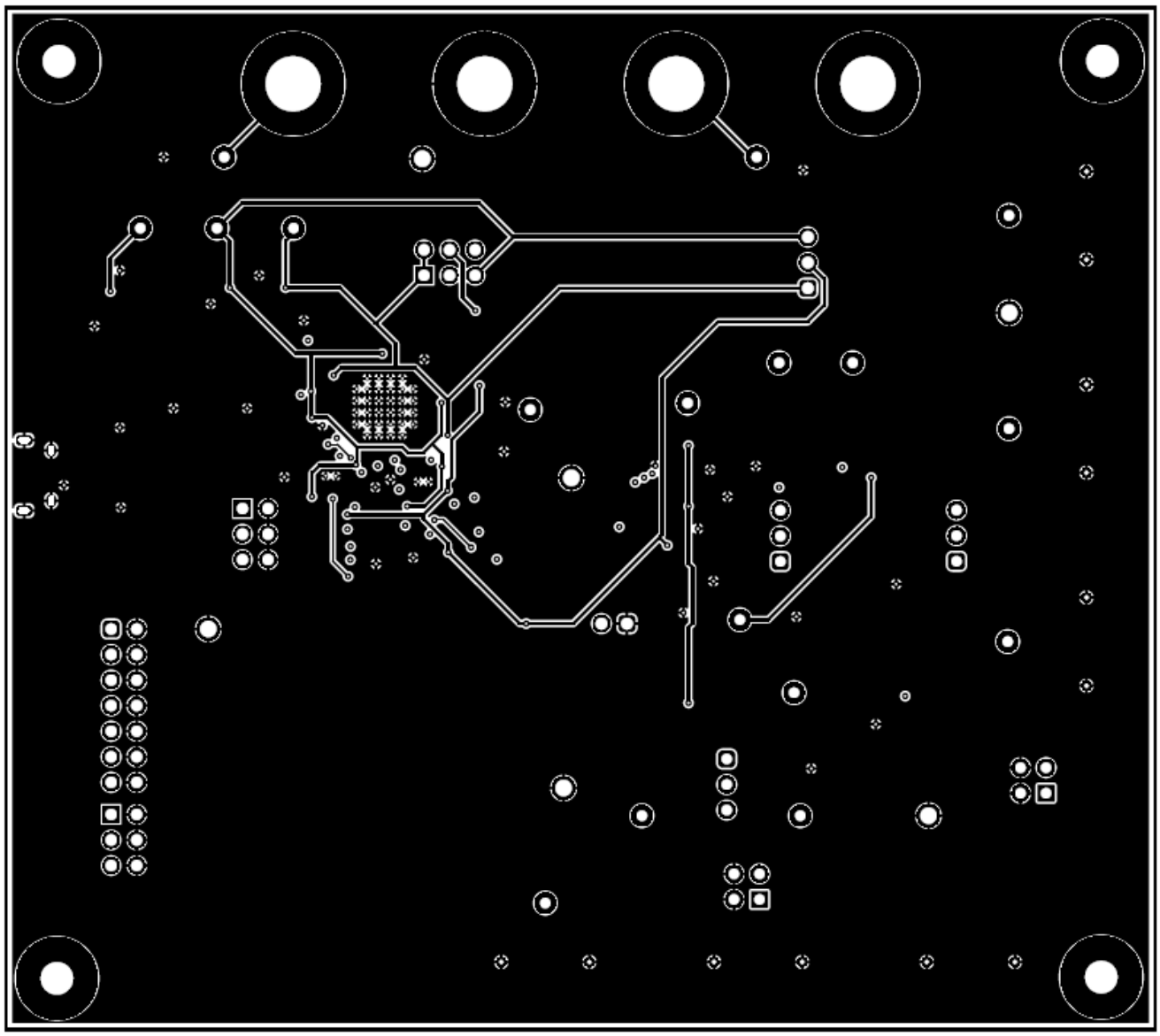

Figure 4-5. AFE881H1EVM PCB Mid Layer 2 Layout

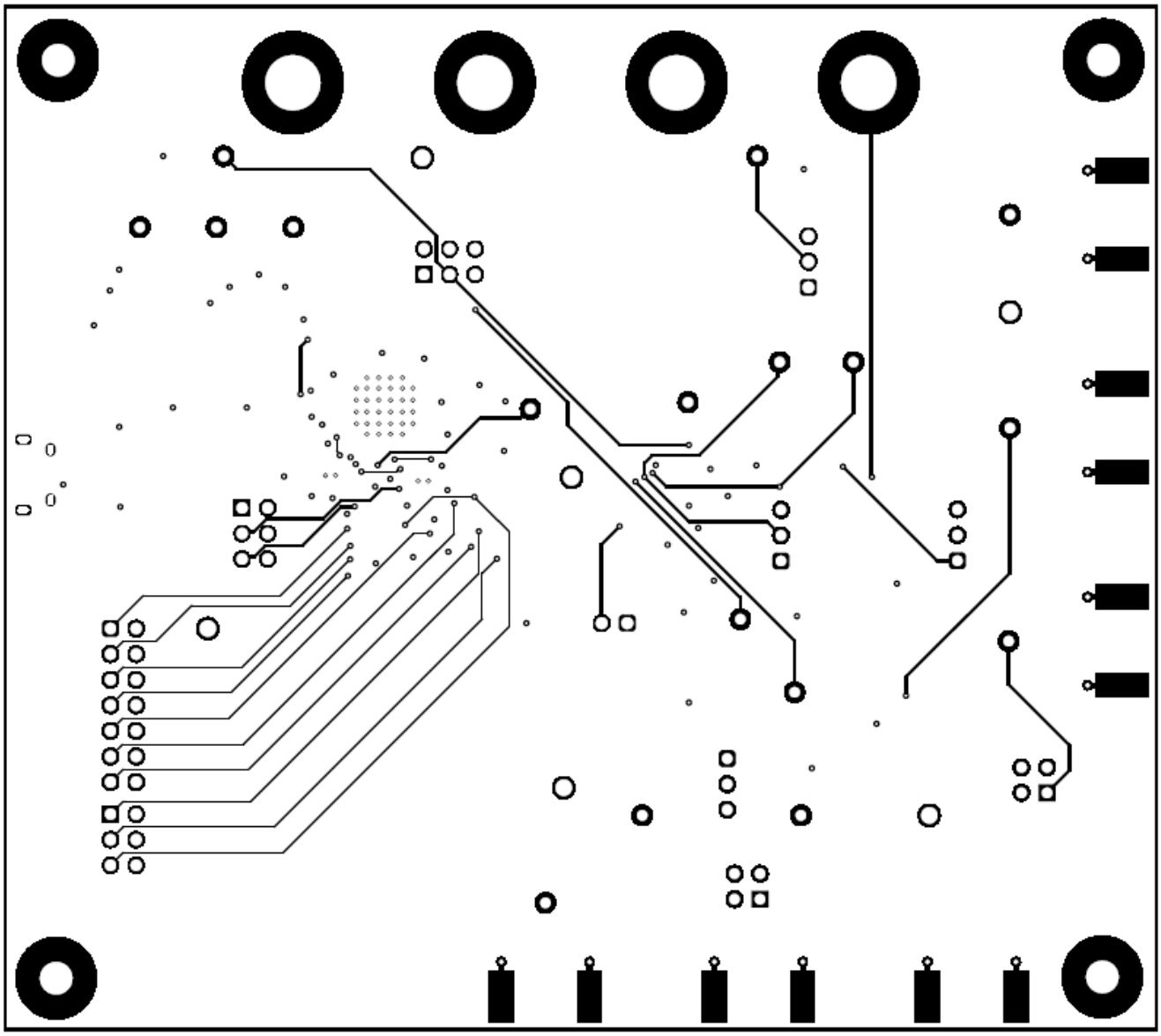

Figure 4-6. AFE881H1EVM PCB Bottom Layer Layout

4.3 Bill of Materials

Table 4-1 lists the AFE881H1EVM bill of materials (BOM).

Table 4-1. Bill of Materials for the AFE881H1EVM

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
C1, C2, C3, C8	4	0.1uF	CAP, CERM, 0.1 uF, 25 V, +/- 5%, X7R, 0603	0603	06033C104JAT2A	AVX
C4, C6	2	680pF	CAP, CERM, 680 pF, 50 V, +/- 10%, X7R, 0805	0805	08055C681KAT2A	AVX
C5	1	10uF	CAP, CERM, 10 µF, 16 V,+/- 10%, X7R, 0805	0805	CL21B106KOQNNNG	Samsung
C7, C9	2	2200pF	CAP, CERM, 2200 pF, 50 V, +/- 5%, C0G/NP0, 0603	0603	GRM1885C1H222JA01D	MuRata
C10	1	680pF	CAP, CERM, 680 pF, 100 V, +/- 5%, C0G/NP0, 0805	0805	08051A681JAT2A	AVX
C11	1	680pF	CAP, CERM, 680 pF, 100 V, +/- 5%, C0G/NP0, 0805	0805	08051A681JAT2A	AVX
C12	1	4700pF	CAP, CERM, 4700 pF, 25 V, +/- 5%, C0G/NP0, 0805	0805	08053A472JAT2A	AVX
C13	1	1000pF	CAP, CERM, 1000 pF, 50 V, +/- 5%, C0G/NP0, AEC-Q200 Grade 1, 0402	0402	CGA2B2C0G1H102J050BA	TDK
C14, C15, C20	3	4.7uF	CAP, CERM, 4.7 uF, 16 V,+/- 10%, X7R, 0603	0603	GRM188Z71C475KE21D	MuRata
C16, C17	2	10uF	CAP, CERM, 10 uF, 25 V, +/- 20%, X5R, 0603	0603	GRT188R61E106ME13D	MuRata
C18, C19, C21, C22, C23, C25, C26, C27	8	0.1uF	CAP, CERM, 0.1 µF, 50 V,+/- 10%, X7R, AEC-Q200 Grade 0, 0603	0603	06035C104K4Z4A	AVX
C24	1	0.47uF	CAP, CERM, 0.47 uF, 25 V, +/- 10%, X7R, 0603	0603	GRM188R71E474KA12D	MuRata
C28, C29	2	20pF	CAP, CERM, 20 pF, 100 V, +/- 5%, C0G/NP0, 0805	0805	08051A200JAT2A	AVX
D1, D2	2	5V	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	100V	Diode, Switching, 100 V, 0.15 A, SOD-123	SOD-123	1N4148W-TP	Micro Commercial Components
D4, D5, D6	3		150V (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, J5	2		Header, 100mil, 2x2, Gold, TH	2x2 Header	TSW-102-07-G-D	Samtec
J2, J4, J9	3		Header, 100mil, 3x1, Gold, TH	3x1 Header	TSW-103-07-G-S	Samtec
J3	1		Header, 2.54 mm, 2x1, Gold, TH	Header, 2.54mm, 2x1, TH	61300211121	Wurth Elektronik
J6	1		Header, 2.54mm, 7x2, Gold, TH	Header, 2.54mm, 7x2, TH	61301421121	Wurth Elektronik
J8, J11, J14	3		Connector, End launch SMA, 50 ohm, SMT	End Launch SMA	142-0701-801	Cinch Connectivity

Table 4-1. Bill of Materials for the AFE881H1EVM (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
J12, J19, J21	3		Header, 2.54mm, 3x2, Gold, TH	Header, 2.54mm, 3x2, TH	61300621121	Wurth Elektronik
J15, J16, J17, J18	4		Standard Banana Jack, Uninsulated, 5.5mm	Keystone_575-4	575-4	Keystone
J20	1		Header, 2.54 mm, 3x1, Gold, TH	Header, 2.54mm, 3x1, TH	61300311121	Wurth Elektronik
J22	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	600 ohm	Ferrite Bead, 600 ohm @ 100 MHz, 1 A, 0603	0603	782633601	Wurth Elektronik
R1, R3, R20	3	1.00Meg	RES, 1.00 M, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	RMCF0603FG1M00	Stackpole Electronics Inc
R2	1	1.00k	RES, 1.00 k, 1%, 0.1 W, 0603	0603	RC0603FR-071KL	Yageo
R4, R6	2	200k	RES, 200 k, 1%, 0.1 W, 0603	0603	RC0603FR-07200KL	Yageo
R5	1	30.0k	RES, 30.0 k, 0.1%, 0.125 W, 0805	0805	RG2012P-303-B-T5	Susumu Co Ltd
R7, R8, R10, R12	4	100k	RES, 100 k, 1%, 0.1 W, 0603	0603	RC0603FR-07100KL	Yageo
R9, R11	2	15.8	RES, 15.8, 1%, 0.1 W, 0603	0603	RC0603FR-0715R8L	Yageo
R13, R14, R15	3	10.0k	RES, 10.0 k, 1%, 0.1 W, 0603	0603	RC0603FR-0710KL	Yageo
R16, R17	2	10.0	RES, 10.0, 1%, 0.1 W, 0603	0603	RC0603FR-0710RL	Yageo
R18	1	12.0k	RES, 12.0 k, 1%, 0.1 W, 0603	0603	RC0603FR-0712KL	Yageo
R19	1	47.0k	RES, 47.0 k, 1%, 0.1 W, 0603	0603	RC0603FR-0747KL	Yageo
R21	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	6	1x2	Shunt, 100mil, Gold plated, Black	Shunt	SNT-100-BK-G	Samtec
TP1, TP2, TP4, TP6, TP14, TP15, TP16	7		Test Point, Miniature, Red, TH	Red Miniature Testpoint	5000	Keystone
TP3, TP5, TP7, TP8, TP9, TP10, TP11, TP12, TP13, TP17	10		Test Point, Miniature, White, TH	White Miniature Testpoint	5002	Keystone
TP18, TP19, TP20, TP21, TP22, TP23	6		Test Point, Multipurpose, Black, TH	Black Multipurpose Testpoint	5011	Keystone Electronics
U1	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
U2	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

Table 4-1. Bill of Materials for the AFE881H1EVM (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
U3	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
U4	1		4-Bit Fixed Direction Voltage-Level Translator with Schmitt- Trigger Inputs, and Tri-State Outputs, WQFN14	WQFN14	TXU0304BQA	Texas Instruments
U5	1		Future Technology Devices International Ltd FT4232H Quad High Speed USB to Multipurpose UART/MPSSE IC, VQFN-56	VQFN-56	FT4232H-56Q-TRAY	FTDI
U6	1		Automotive 4-Bit Fixed Direction Voltage-Level Translator with SchmittTrigger Inputs, and Tri-State Outputs	WQFN14	TXU0204BQA	Texas Instruments
U7	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

5 Additional Information

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6 Related Documentation

The documents in Table 6-1 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. 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 6-1. Related Documentation

Document	Literature Number
AFE881H1 product data sheet	SLASEU7
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

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Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265