EVM User's Guide: AFE88XH1-FELC-EVM

AFE88XH1-FELC Evaluation Module

Description

The AFE88XH1-FELC evaluation module (EVM) implements a 4–20mA interface for 2-wire loop-powered sensors. The EVM enables evaluation of the AFE881H1 and AFE882H1 in a lower power, application-like environment with a 1.8V signal chain. The AFE881H1 and AFE882H1 integrates a high precision 16-bit DAC and a HART® modem.

Get Started

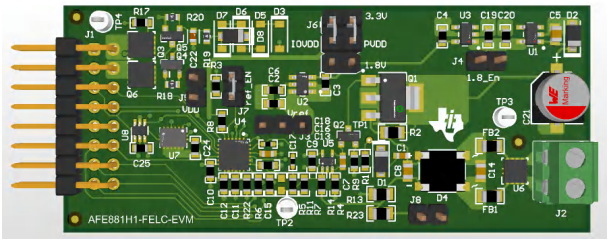
1. Order the AFE88XH1-FELC-EVM
2. Order the SNSR-DUAL-ADC-EVM (comes with an A-to-Micro-B USB Cable)
   a. For more information about installing the necessary software and using serial communication, see the SNSR-DUAL-ADC-EVM Evaluation Module User's Guide
3. Download the AFE881H1 datasheet or AFE882H1 datasheet
4. Download the TIDA-010982 reference design guide

Features

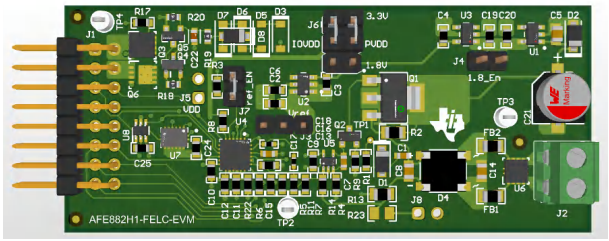
- Implementation of 4–20mA loop interface for 2-wire loop-powered sensor.
- Complete 1.8V signal chain allows for low power consumption.
- AFE88xH1 16-bit DAC with integrated reference and HART modem.
- MCU interface providing power output (1.8V, 3.3V, 1.25V reference voltage), SPI and UART interface.

Applications

- Flow transmitter
- Level transmitter
- Pressure transmitter
- Temperature transmitter
- Analog output module



AFE881H1-FELC-EVM Top View



AFE882H1-FELC-EVM Top View

1 Evaluation Module Overview

The AFE88XH1-FELC-EVM implements a 4-20mA, 2-wire loop-powered field transmitter. The design enables evaluation of the AFE881H1 and AFE882H1 in a lower power application-like environment with a 3.3V or 1.8V signal chain. The AFE881H1 and AFE882H1 integrate a high-precision 16-bit digital-to-analog converter (DAC) and a HART® modem. The EVM includes a serial peripheral interface (SPI) and universal asynchronous receiver-transmitter (UART) interface on a pin header to connect to a microcontroller (MCU). This pin header provides 3.3V and 1.8V to power a MCU and a 1.25V reference voltage to be used for an analog-to-digital converter (ADC).

1.1 Introduction

The EVM design incorporates a 16-bit DAC, either the AFE881H1 or AFE882H1. The DAC output voltage drives an OPA391 op amp, converting the voltage to current to create the 4-20mA loop control.

Power supplies with 1.8V or 3.3V output options are integrated into this design. Configuration settings dictate whether 1.8V or 3.3V is used for powering the analog circuit on the board and the connected MCU. Low dropout (LDO) regulators (TPS7A0333 and TPS7A0318) with low IQ provide stable and efficient power output.

The design incorporates a discrete P-channel Metal-Oxide-Semiconductor field-effect transistor (PMOSFET) CSD25404 power switch for an MCU. This power switch controls the 1.8V and 3.3V rails which connect to the MCU through the J1 header pins. A bulk capacitor is added at the loop input to provide the inrush current at power-up. The capacitor powers MCU initialization prior to entering low-power mode.

1.2 Kit Contents

The kit contains the AFE88XH1-FELC-EVM PCB.

Contact the Texas Instruments Product Information Center nearest you if any component is missing. Download the latest versions of the related software from ti.com.

1.3 Specification

Table 1-1 provides the AFE88XH1-FELC-EVM board specifications.

Table 1-1. AFE88XH1-FELC-EVM Specifications

PARAMETER		VALUE
Recommended operating free-air temperature range, TA		–40°C to +125°C
Loop supply voltage		8V to 30V
Resolution		16-bit
Power supply Input	AFE881H1	3.3V, 1.8V
	AFE882H1	3.3V
Reference voltage output		1.25V
Communication Interface		SPI, UART

1.4 Device Information

The AFE881H1 or AFE882H1 is a voltage DAC with an integrated HART modem. The DAC output voltage is converted to a current using OPA391 as a transimpedance amplifier (TIA).

The AFE88XH1-FELC-EVM receives SPI communication from the MCU on the SNSR-DUAL-ADC-EVM through the 16-pin header (J1). At power up, the MCU reads the EVM board ID, which the SN74LV8T165BQBR shift register provides. The ID is determined by the voltages applied to the shift register A:H pins and allows the MCU to initialize the correct configuration settings and target address. After start-up, the MCU pulls ID0 to GND to switch the TMUX1219 on the EVM from the shift register output to the SDO signal received from the DAC for register readback.

Discrete LDOs on the EVM provide 1.8V and 3.3V supply voltages. Both supplies are available on the J1 header with a silicon-controlled rectifier circuit. The AFE88XH1 uses an internal reference voltage by default when jumper J7 is shorted. The 1.8V LDO supplies the REF35125 to create a 1.25V output for use as an external

voltage reference on the VREFIO input for the AFE88XH1. The J3 header provides a selection between the 1.25V external reference or a reference voltage from the SNSR-DUAL-ADC-EVM.

The loop is protected against reverse polarity by the bridge rectifier (D4) and against transient voltages using a TVS3301 diode (U6). Ferrite beads at the J2 loop terminals create a low pass filter to remove high frequency noise.

2 Hardware

2.1 Power Requirements

The AFE88XH1-FELC-EVM is loop-powered through the J2 terminal. The power source must provide from 8V to 30V across the LOOP+ and LOOP- connections, with a current capability of at least 50mA.

The loop power feeds two LDOs (3.3V and 1.8V) and a voltage reference (1.25V) which can power both the AFE88XH1-FELC-EVM and SNSR-DUAL-ADC-EVM. The loop power is also used for the OPA391 transimpedance amplifier which controls the loop current using an NPN bipolar junction transistor.

The AFE881H1 supports both 3.3V and 1.8V input to PVDD while the AFE882H1 only supports 3.3V input to PVDD. For detailed jumper information about the power input setup, see Section 2.4.

SPI or UART communication to the AFE88XH1 comes from the SNSR-DUAL-ADC-EVM, which interfaces with the host computer through a USB A-to-Micro-B cable connection.

2.2 Setup

The AFE88XH1-FELC-EVM is combined with a SNSR-DUAL-ADC-EVM, which uses a MSPM0G1507 and two ADS122S14 ADCs to measure voltages on the J6 input terminal. The 16-pin header (J1) of the AFE88XH1-FELC-EVM connects to J2 on the SNSR-DUAL-ADC-EVM for power and SPI communication.

Figure 2-1 shows how to set up the EVM to receive loop power and connect to the sensor board. For a detailed view of the board connections, see Section 4.1.

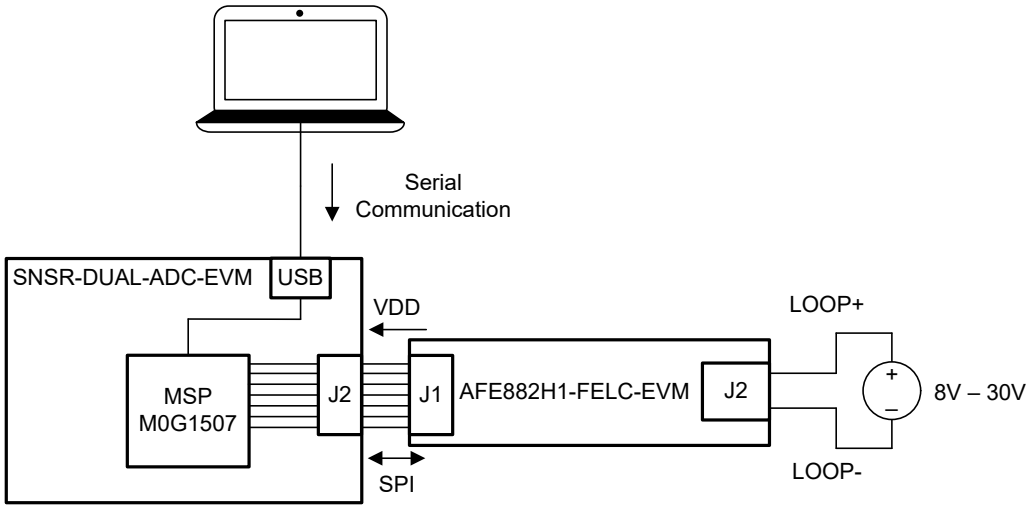


Figure 2-1. Field Transmitter Block Diagram

2.3 Header Information

The AFE88XH1-FELC-EVM has one header: J1. The J1 header connects to the SNSR-DUAL-ADC-EVM board for communication and power transfer between the AFE88XH1 and MCU. For a description of the pins, see Table 2-1.

Table 2-1. J1 Header Description

Pin Number	Description
1	GND
2	3.3V LDO output connection for VDD supply voltage
3	External VREF output connection from J3
4	1.8V LDO output connection for VDD supply voltage
5	MCU signal input to control shift register at power up
6	SCLK (SPI clock)
7	Not Used
8	SDI (SPI serial data input)
9	Not Used
10	SDO (SPI serial data output)
11	ALARM output from AFE88XH1
12	CS (SPI chip select)
13	Carrier Detect input
14	HART signal transmission output from AFE88XH1
15	AFE88XH1 Request to send input
16	HART signal receiver input to AFE88XH1

2.4 Jumper Information

Table 2-2 describes the six jumpers present on the AFE88XH1-FELC-EVM evaluation module.

Table 2-2. Jumper Description

Jumper Designator	Description
J3	AFE88XH1 VREF voltage selection **Open (Default):** Leave the jumper open when AFE88XH1 internal reference is used. **Pins 1-2:** 1.25V from REF35125 for external reference **Pins 2-3:** External reference from MCU board
J4	1.8V LDO power supply enable **Open:** Disabled **Short:** Enabled
J5	External 1.8V LDO input for AFE881H1 internal bias when PVDD < 2.7V. **Leave open when 2.7V < PVDD < 5.5V**
J6	Voltage selection for silicon-controlled rectifier (SCR) circuit to supply IOVDD. **Pins 1-3:** IOVDD supplied by 3.3V transistor connection. **Pins 3-5:** IOVDD supplied by 1.8V transistor connection. **Pins 2-4:** 3.3V input power to SCR transistor Q3 **Pins 4-6:** 1.8V input power to SCR transistor Q6
J7	AFE88XH1 internal reference enable. **Open:** Internal reference disabled **Short:** Internal reference enabled
J8	Transmission loop impedance adjustment **Open:** AFE882H1 default **Short:** AFE881H1 default

2.5 Test Points

Table 2-3 shows the available test points.

Table 2-3. Test Point Description

Test Point	Pin
TP1	MOD_IN
TP2	VOUT (AFE88XH1)
TP3	GND
TP4	GND

3 Software

The SNSR-DUAL-ADC-EVM controls the host communication with the AFE88XH1-FELC-EVM. Serial data instructions are sent from a desktop PC to the MCU on the SNSR-DUAL-ADC-EVM. The MCU then translates these commands into SPI protocol before passing the necessary instructions to the EVM through the J1 header pins.

For more information on the MCU command structure used to communicate with the EVM, see the SNSR-DUAL-ADC-EVM Evaluation Module User's Guide.

4 Hardware Design Files

4.1 Schematics

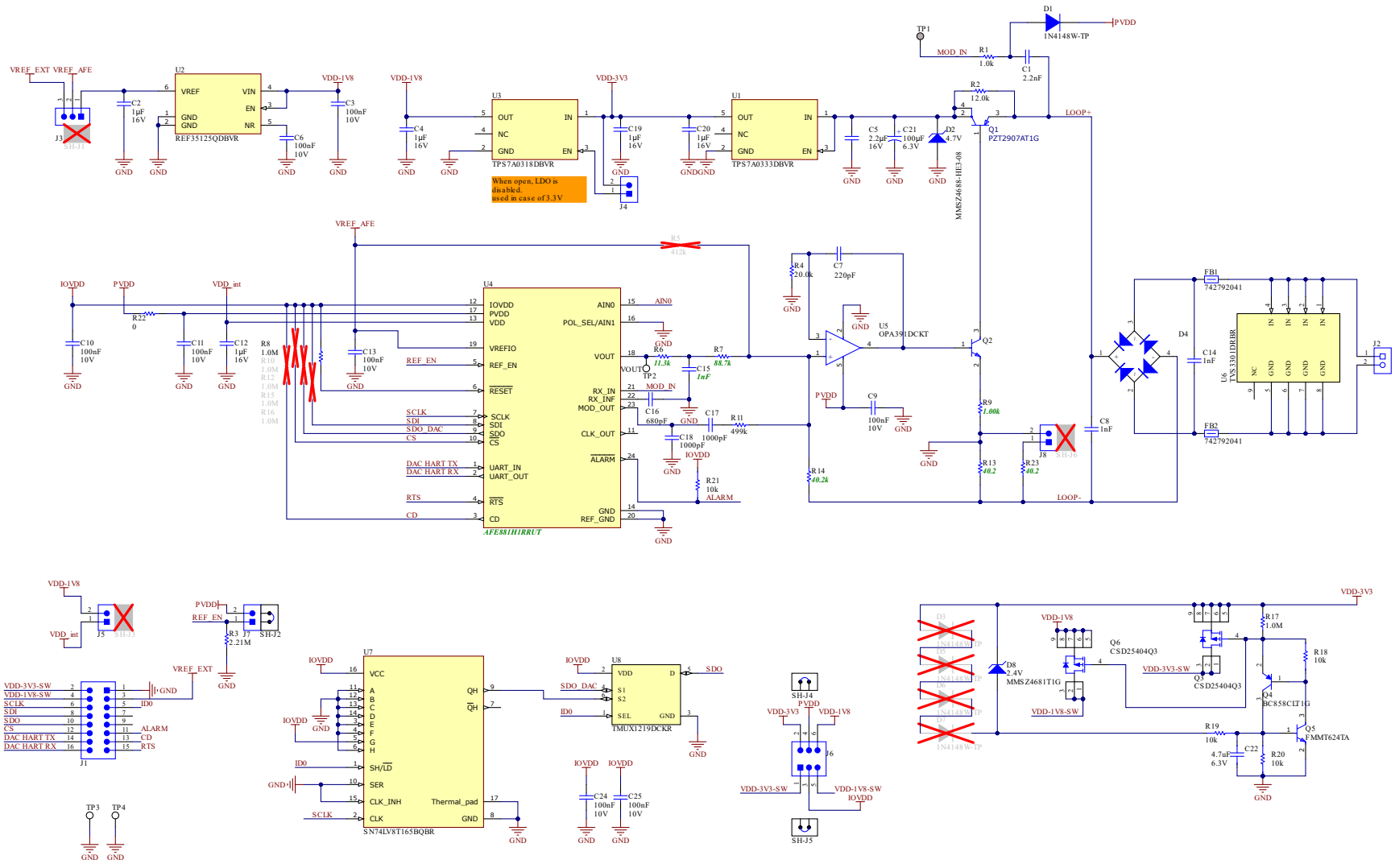


Figure 4-1. AFE881H1-FELC-EVM Schematic

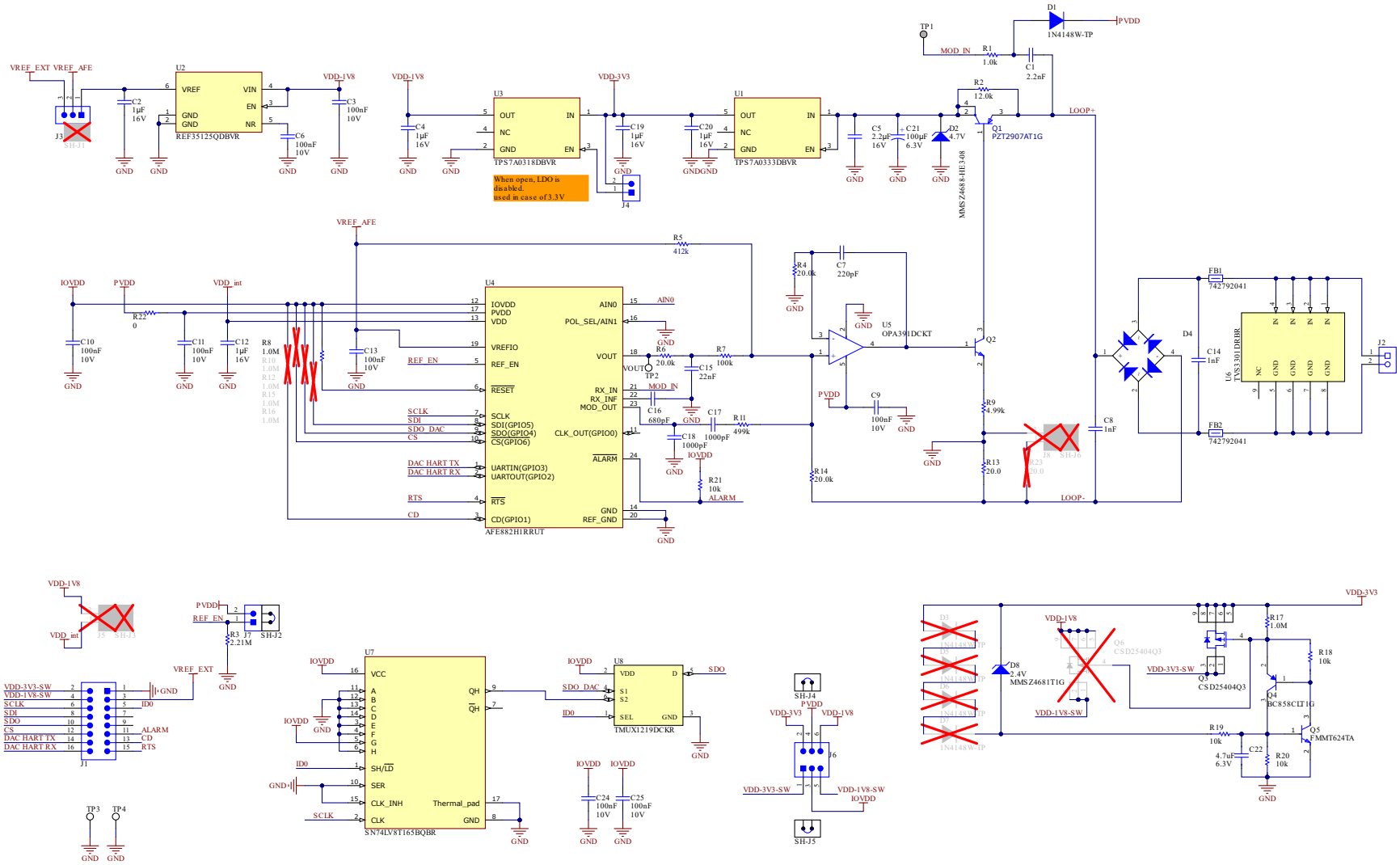


Figure 4-2. AFE882H1-FELC-EVM Schematic

4.2 PCB Layouts

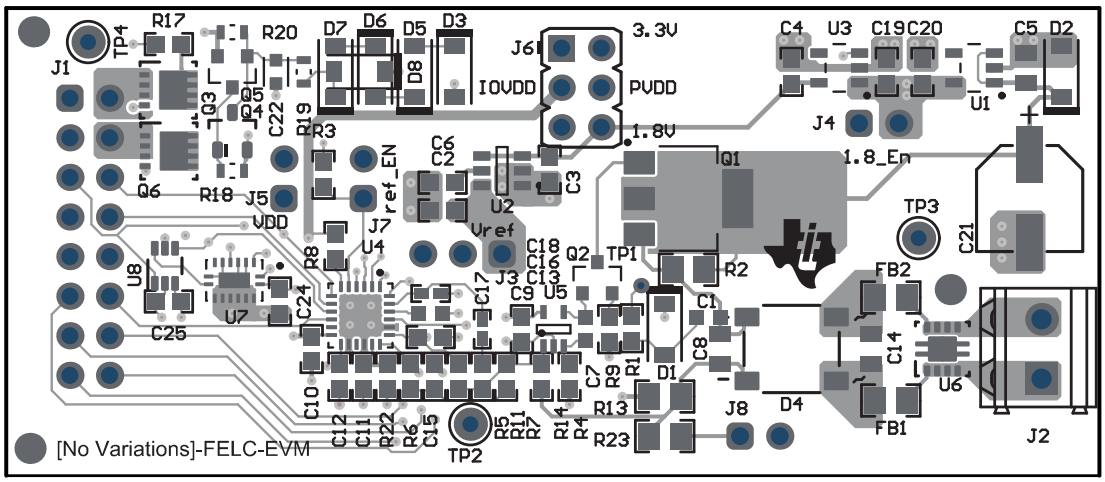


Figure 4-3. AFE88XH1-FELC-EVM Top Composite View

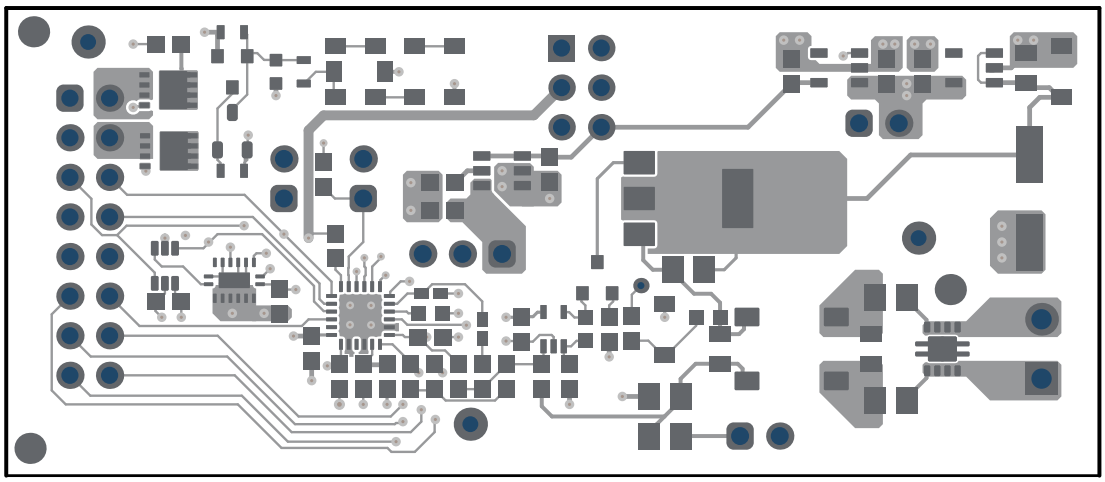


Figure 4-4. AFE88XH1-FELC-EVM Top Layer

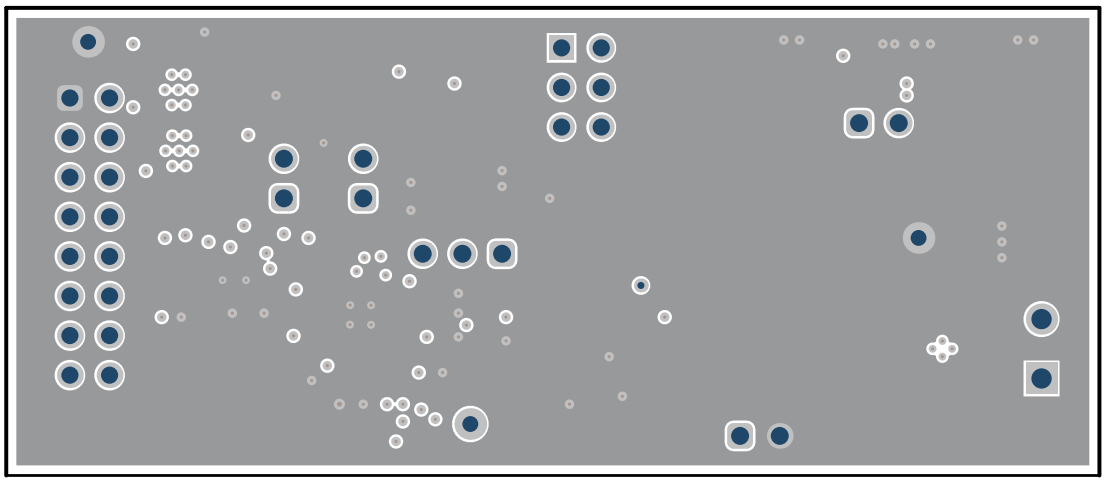


Figure 4-5. AFE88XH1-FELC-EVM Ground Plane

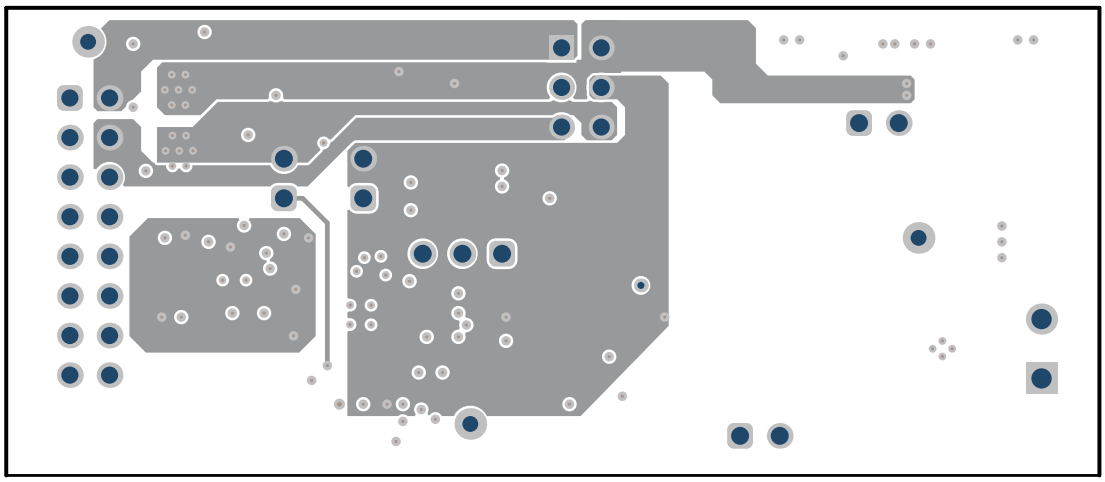


Figure 4-6. AFE88XH1-FELC-EVM Power Layer

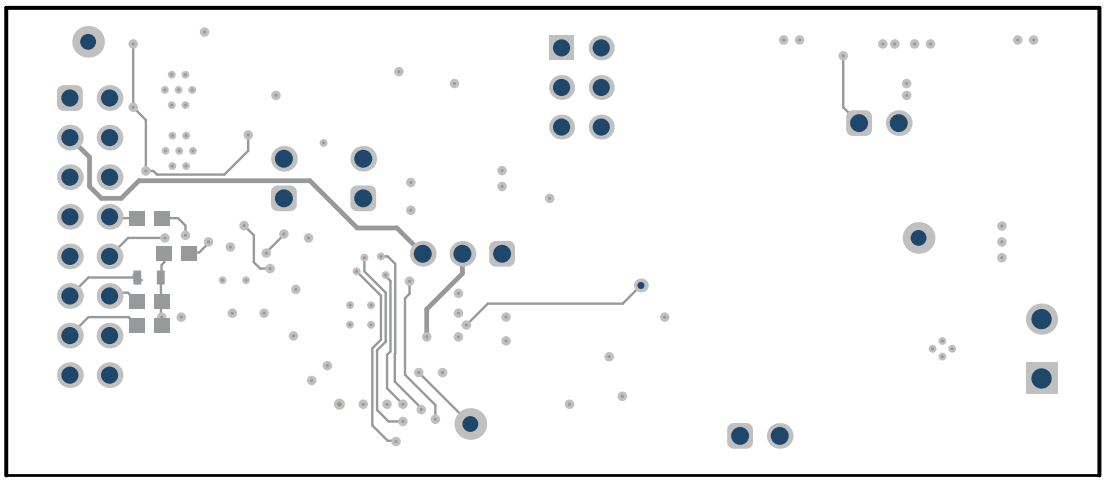


Figure 4-7. AFE88XH1-FELC-EVM Bottom Layer

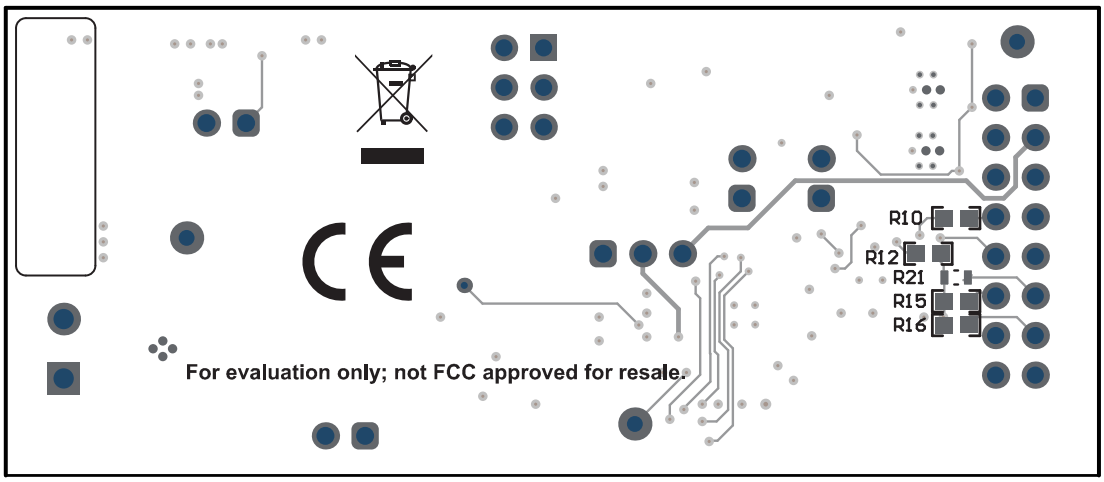


Figure 4-8. AFE88XH1-FELC-EVM Bottom Layer Composite

4.3 Bill of Materials (BOM)

Table 4-1. AFE881H1-FELC-EVM Bill of Materials

REFERENCE DESIGNATOR	QUANTITY	VALUE	DESCRIPTION	PACKAGE REFERENCE	PART NUMBER	MANUFACTURER
C1	1	2.2nF	WCAP-CSGP Multilayer Ceramic Chip Capacitor, General Purpose, size 0603, NP0, 2.2nF, 10VDC		885012006015	Würth Elektronik™
C2, C4, C12, C19, C20	5	1uF	CAP, CERM, 1uF, 16V, ±10%, X7R, 0603	0603	885012206052	Würth Elektronik
C3, C6, C9, C10, C11, C13, C24, C25	8	0.1uF	CAP, CERM, 0.1uF, 10V,±10%, X7R, 0603	0603	885012206020	Würth Elektronik
C5	1	2.2µF	WCAP-CSGP Multilayer Ceramic Chip Capacitor, General Purpose, size 0805, X7R, 2.2µF, 16VDC		885012207052	Würth Elektronik
C7	1	220pF	WCAP-CSGP Multilayer Ceramic Chip Capacitor, General Purpose, size 0603, NP0, 220pF, 10VDC		885012006010	Würth Elektronik
C8, C14	2	1nF	WCAP-CSGP Multilayer Ceramic Chip Capacitor, General Purpose, size 0805, X7R, 1nF, 50VDC		885012207086	Würth Elektronik
C15	1	1000pF	CAP, CERM, 1000pF, 50V,±10%, X7R, 0603	0603	885012206083	Würth Elektronik
C16	1	680pF	WCAP-CSGP Multilayer Ceramic Chip Capacitor, General Purpose, size 0603, NP0, 680pF, 10VDC		885012006013	Würth Elektronik
C17, C18	2	1000pF	CAP, CERM, 1000pF, 50V, ±10%, X7R, 0402	0402	885012205061	Würth Elektronik
C21	1	100µF	WCAP-AS5H Aluminum Electrolytic Capacitor, V-Chip, D6.3x H5.5mm, 100µF, 6.3V		865230143004	Würth Elektronik
C22	1	4.7µF	4.7µF ±20% 6.3V Ceramic Capacitor X5R 0603 (1608 Metric)	0603	885012106005	Würth Electronics
D1	1	100V	Diode, Switching, 100V, 0.15A, SOD-123	SOD-123	1N4148W-TP	Micro Commercial Components
D2	1	4.7V	Diode, Zener, 4.7V, 500mW, SOD-123	SOD-123	MMSZ4688T1G	onsemi®
D4	1	600V	Diode, P-N-Bridge, 600V, 2A, 5.8mm × 5.3mm	5.8mm × 5.3mm	CD-MBL206SL	Bourns™
D8	1	2.4V	Diode, Zener, 2.4V, 500mW, SOD-123	SOD-123	MMSZ4681T1G	onsemi
FB1, FB2	2	600Ω	Ferrite Bead, 600Ω at 100MHz, 0.2A, 0805	0805	742792041	Würth Elektronik
J1	1		Header, 2.54mm, 8 × 2, Gold, R/A, TH	Header, 2.54mm, 8 × 2, R/A, TH	61301621021	Würth Elektronik
J2	1		Terminal Block, 2x1, 3.81mm, 24-16 AWG, 10A, 300VAC, TH	2 × 1 Terminal Block	691214310002	Würth Elektronik
J3	1		Header, 2.54mm, 3 × 1, Gold, TH	Header, 2.54mm, 3 × 1, TH	61300311121	Würth Elektronik
J4, J5, J7, J8	4		Header, 2.54mm, 2 × 1, Gold, TH	Header, 2.54mm, 2 × 1, TH	61300211121	Würth Elektronik
J6	1		Header, 2.54mm, 3x2, Gold, TH	Header, 2.54mm, 3 × 2, TH	61300621121	Würth Elektronik

Table 4-1. AFE881H1-FELC-EVM Bill of Materials (continued)

REFERENCE DESIGNATOR	QUANTITY	VALUE	DESCRIPTION	PACKAGE REFERENCE	PART NUMBER	MANUFACTURER
LBL1	1		Thermal Transfer Printable Labels Width: 0.650in Height: 0.200in 10,000 per roll	PCB Label 0.650in × 0.200in	THT-14-423-10	Brady™
Q1	1	–60V	Trans GP BJT PNP 60V 0.6A 1500mW 4-Pin(3+Tab) SOT-223T/R	SOT-223	PZT2907AT1G	onsemi™
Q2	1	40V	Bipolar (BJT) Transistor NPN 40V 200mA 300MHz 300mW Surface Mount SOT-23-3 (TO-236)	SOT23	SMMBT3904LT3G	onsemi
Q3, Q6	2	–20V	MOSFET, P-CH, –20V, –60A, DQG0008A (VSON-CLIP-8)	DQG0008A	CSD25404Q3	Texas Instruments
Q4	1	30V	Transistor, PNP, 30V, 0.1A, SOT-23	SOT-23	BC858CLT1G	onsemi
Q5	1	125V	Bipolar (BJT) Transistor NPN 125V 1A 155MHz 625mW Surface Mount SOT-23-3	SOT23	FMMT624TA	Diodes Incorporated
R1	1	1.0k	RES, 1.0k, 5%, 0.1W, 0603	0603	RC0603JR-071KL	Yageo™
R2	1	12.0k	RES, 12.0k, 0.1%, 0.125W, 0805	0805	RG2012P-123-B-T5	Susum™
R3	1	2.21Meg	RES, 2.21M, 1%, 0.1W, 0603	0603	RC0603FR-072M21L	Yageo
R4	1	20.0k	RES, 20.0k, 0.1%, 0.1W, 0603	0603	RG1608P-203-B-T5	Susum
R6	1	11.3k	RES, 11.3k, 0.1%, 0.1W, 0603	0603	RG1608P-1132-B-T5	Susum
R7	1	88.7k	RES, 88.7k, 0.1%, 0.1W, 0603	0603	RT0603BRD0788K7L	Yageo America
R8, R17	2	1.0Meg	RES, 1.0M, 5%, 0.1W, AEC-Q200 Grade 0, 0603	0603	CRCW06031M00JNEA	Vishay-Dale
R9	1	1.00k	RES, 1.00k, 0.5%, 0.1W, 0603	0603	RT0603DRE071KL	Yageo America
R11	1	499k	RES, 499k, 0.5%, 0.1W, 0603	0603	RT0603DRE07499KL	Yageo America
R13, R23	2	40.2000000 00000003	RES, 40.2, 0.1%, 0.125W, 0805	0805	RT0805BRD0740R2L	Yageo America
R14	1	40.2k	RES, 40.2k, 0.1%, 0.1W, 0603	0603	RG1608P-4022-B-T5	Susumu
R18, R19, R20, R21	4	10k	10kΩ ±1% 0.1W, 1/10W Chip Resistor 0603 (1608 Metric) Thick Film	0603	CRCW060310K0FKEAC	Vishay™ Semiconductor
R22	1	0	RES, 0, 0%, 0.25W, AEC-Q200 Grade 0, 0603	0603	RCS06030000Z0EA	Vishay-Dale™
SH-J2, SH-J4, SH-J5	3		Shunt, 2.54mm, Gold, Black	Shunt, 2.54mm, Black	60900213421	Würth Elektronik
TP2, TP3, TP4	3		Test Point, Miniature, White, TH	White Miniature Testpoint	5002	Keystone Electronics™
U1	1		Nanopower-IQ 200nA 200mA low-dropout (LDO) voltage regulator with fast transient response	SOT-23-5	TPS7A0333DBVR	Texas Instruments
U2	1		Ultra Low-Power, High-Precision Voltage Reference	SOT23-6	REF35125QDBVR	Texas Instruments
U3	1		Nanopower-IQ 200nA 200mA low-dropout (LDO) voltage regulator with fast transient response 5-SOT-23 –40 to 125	SOT23-5	TPS7A0318DBVR	Texas Instruments

Table 4-1. AFE881H1-FELC-EVM Bill of Materials (continued)

REFERENCE DESIGNATOR	QUANTITY	VALUE	DESCRIPTION	PACKAGE REFERENCE	PART NUMBER	MANUFACTURER
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
U5	1		General Purpose Amplifier 1 Circuit Rail-to-Rail SC-70-5	SC70-5	OPA391DCKT	Texas Instruments
U6	1		33V Bidirectional Flat-Clamp Surge Protection Device, DRB0008A (VSON-8)	DRB0008A	TVS3301DRBR	Texas Instruments
U7	1		1.65V to 5.5V 8-bit parallel-load shift register with voltage translation	WQFN16	SN74LV8T165BQBR	Texas Instruments
U8	1		1ch, 2:1 general-purpose analog multiplexer with 1.8V logic control, DCK0006A (SOT-SC70-6)	DCK0006A	TMUX1219DCKR	Texas Instruments

Table 4-2. AFE882H1-FELC-EVM Bill of Materials

REFERENCE DESIGNATOR	QUANTITY	VALUE	DESCRIPTION	PACKAGE REFERENCE	PART NUMBER	MANUFACTURER
C1	1	2.2nF	WCAP-CSGP Multilayer Ceramic Chip Capacitor, General Purpose, size 0603, NP0, 2.2nF, 10VDC		885012006015	Würth Elektronik
C2, C4, C12, C19, C20	5	1uF	CAP, CERM, 1uF, 16V, ±10%, X7R, 0603	0603	885012206052	Würth Elektronik
C3, C6, C9, C10, C11, C13, C24, C25	8	0.1uF	CAP, CERM, 0.1uF, 10V, ±10%, X7R, 0603	0603	885012206020	Würth Elektronik
C5	1	2.2µF	WCAP-CSGP Multilayer Ceramic Chip Capacitor, General Purpose, size 0805, X7R, 2.2µF, 16VDC		885012207052	Würth Elektronik
C7	1	220pF	WCAP-CSGP Multilayer Ceramic Chip Capacitor, General Purpose, size 0603, NP0, 220pF, 10VDC		885012006010	Würth Elektronik
C8, C14	2	1nF	WCAP-CSGP Multilayer Ceramic Chip Capacitor, General Purpose, size 0805, X7R, 1nF, 50VDC		885012207086	Würth Elektronik
C15	1	0.022uF	CAP, CERM, 0.022uF, 50V, ±10%, X7R, 0603	0603	885012206091	Würth Elektronik
C16	1	680pF	WCAP-CSGP Multilayer Ceramic Chip Capacitor, General Purpose, size 0603, NP0, 680pF, 10VDC		885012006013	Würth Elektronik
C17, C18	2	1000pF	CAP, CERM, 1000pF, 50V, ±10%, X7R, 0402	0402	885012205061	Würth Elektronik
C21	1	100µF	WCAP-AS5H Aluminum Electrolytic Capacitor, V-Chip, 6.3mm × 5.5mm, 100µF, 6.3V		865230143004	Würth Elektronik
C22	1	4.7µF	4.7µF ±20% 6.3V Ceramic Capacitor X5R 0603 (1608 Metric)	0603	885012106005	Würth Electronics
D1	1	100V	Diode, Switching, 100V, 0.15A, SOD-123	SOD-123	1N4148W-TP	Micro Commercial Components™
D2	1	4.7V	Diode, Zener, 4.7V, 500mW, SOD-123	SOD-123	MMSZ4688T1G	onsemi
D4	1	600V	Diode, P-N-Bridge, 600V, 2A, 5.8x5.3mm	5.8x5.3mm	CD-MBL206SL	Bourns
D8	1	2.4V	Diode, Zener, 2.4V, 500mW, SOD-123	SOD-123	MMSZ4681T1G	onsemi
FB1, FB2	2	600Ω	Ferrite Bead, 600Ω at 100MHz, 0.2A, 0805	0805	742792041	Würth Elektronik
J1	1		Header, 2.54mm, 8 × 2, Gold, R/A, TH	Header, 2.54mm, 8 × 2, R/A, TH	61301621021	Würth Elektronik
J2	1		Terminal Block, 2 × 1, 3.81mm, 24-16 AWG, 10A, 300VAC, TH	2 × 1 Terminal Block	691214310002	Würth Elektronik
J3	1		Header, 2.54mm, 3 × 1, Gold, TH	Header, 2.54mm, 3 × 1, TH	61300311121	Würth Elektronik
J4, J7	2		Header, 2.54mm, 2 × 1, Gold, TH	Header, 2.54mm, 2 × 1, TH	61300211121	Würth Elektronik
J6	1		Header, 2.54mm, 3 × 2, Gold, TH	Header, 2.54mm, 3 × 2, TH	61300621121	Würth Elektronik
LBL1	1		Thermal Transfer Printable Labels, 0.650in	PCB Label 0.650in × 0.200in	THT-14-423-10	Brady

Table 4-2. AFE882H1-FELC-EVM Bill of Materials (continued)

REFERENCE DESIGNATOR	QUANTITY	VALUE	DESCRIPTION	PACKAGE REFERENCE	PART NUMBER	MANUFACTURER
Q1	1	-60V	Trans GP BJT PNP 60V 0.6A 1500mW 4-Pin(3+Tab) SOT-223T/R	SOT-223	PZT2907AT1G	onsemi
Q2	1	40V	Bipolar (BJT) Transistor NPN 40V 200mA 300MHz 300mW Surface Mount SOT-23-3 (TO-236)	SOT23	SMMBT3904LT3G	onsemi
Q3	1	–20V	MOSFET, P-CH, –20V, –60A, DQG0008A (VSON-CLIP-8)	DQG0008A	CSD25404Q3	Texas Instruments
Q4	1	30V	Transistor, PNP, 30V, 0.1A, SOT-23	SOT-23	BC858CLT1G	onsemi
Q5	1	125V	Bipolar (BJT) Transistor NPN 125V 1A 155MHz 625mW Surface Mount SOT-23-3	SOT23	FMMT624TA	Diodes Incorporated™
R1	1	1.0k	RES, 1.0k, 5%, 0.1W, 0603	0603	RC0603JR-071KL	Yageo
R2	1	12.0k	RES, 12.0k, 0.1%, 0.125W, 0805	0805	RG2012P-123-B-T5	Susumu
R3	1	2.21Meg	RES, 2.21M, 1%, 0.1W, 0603	0603	RC0603FR-072M21L	Yageo
R4, R6, R14	3	20.0k	RES, 20.0k, 0.1%, 0.1W, 0603	0603	RG1608P-203-B-T5	Susumu
R5	1	412k	RES, 412k, 0.1%, 0.1W, 0603	0603	RT0603BRD07412KL	Yageo America
R7	1	100k	RES, 100k, 0.1%, 0.1W, 0603	0603	RG1608P-104-B-T5	Susumu
R8, R17	2	1.0Meg	RES, 1.0M, 5%, 0.1W, AEC-Q200 Grade 0, 0603	0603	CRCW06031M00JNEA	Vishay-Dale
R9	1	4.99k	RES, 4.99k, 0.1%, 0.1W, 0603	0603	RT0603BRD074K99L	Yageo America
R11	1	499k	RES, 499k, 0.5%, 0.1W, 0603	0603	RT0603DRE07499KL	Yageo America
R13	1	20	RES, 20.0, 0.1%, 0.125W, 0805	0805	RT0805BRD0720RL	Yageo America
R18, R19, R20, R21	4	10k	10kΩ ±1% 0.1W, 1/10W Chip Resistor 0603 (1608 Metric) Thick Film	0603	CRCW060310K0FKEAC	Vishay-Dale
R22	1	0	RES, 0, 0%, 0.25W, AEC-Q200 Grade 0, 0603	0603	RCS06030000Z0EA	Vishay-Dale
SH-J2, SH-J4, SH-J5	3		Shunt, 2.54mm, Gold, Black	Shunt, 2.54mm, Black	60900213421	Würth Elektronik
TP2, TP3, TP4	3		Test Point, Miniature, White, TH	White Miniature Testpoint	5002	Keystone Electronics
U1	1		Nanopower-IQ 200nA 200mA low-dropout (LDO) voltage regulator with fast transient response	SOT-23-5	TPS7A0333DBVR	Texas Instruments
U2	1		Ultra Low-Power, High-Precision Voltage Reference	SOT23-6	REF35125QDBVR	Texas Instruments
U3	1		Nanopower-IQ 200nA 200mA low-dropout (LDO) voltage regulator with fast transient response 5-SOT-23 –40 to 125	SOT23-5	TPS7A0318DBVR	Texas Instruments
U4	1		AFE882H1RRUT	UQFN24	AFE882H1RRUT	Texas Instruments
U5	1		General Purpose Amplifier 1 Circuit Rail-to-Rail SC-70-5	SC70-5	OPA391DCKT	Texas Instruments
U6	1		33V Bidirectional Flat-Clamp Surge Protection Device, DRB0008A (VSON-8)	DRB0008A	TVS3301DRBR	Texas Instruments

Table 4-2. AFE882H1-FELC-EVM Bill of Materials (continued)

REFERENCE DESIGNATOR	QUANTITY	VALUE	DESCRIPTION	PACKAGE REFERENCE	PART NUMBER	MANUFACTURER
U7	1		1.65V to 5.5V 8-bit parallel-load shift register with voltage translation	WQFN16	SN74LV8T165BQBR	Texas Instruments
U8	1		1ch, 2:1 general-purpose analog multiplexer with 1.8V logic control, DCK0006A (SOT-SC70-6)	DCK0006A	TMUX1219DCKR	Texas Instruments

5 Additional Information

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6 Related Documentation

1. Texas Instruments, *SNSR-DUAL-ADC-EVM product page*
2. Texas Instruments, *SNSR-DUAL-ADC-EVM Evaluation Module User's Guide*
3. Texas Instruments, *AFE881H1 product page*
4. Texas Instruments, *AFE882H1 product page*
5. Texas Instruments, *TIDA-010982 design guide*

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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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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