EVM User's Guide: AFE11612EVM
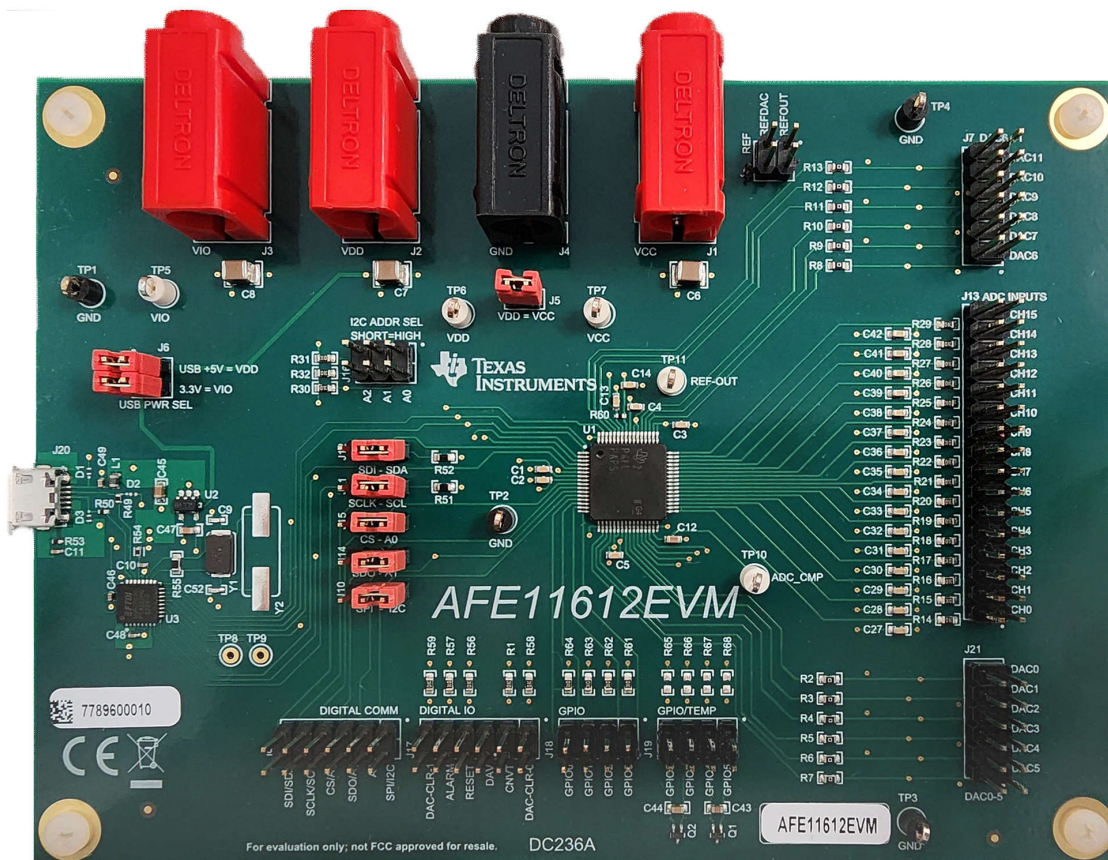# AFE11612 Evaluation Module

TEXAS INSTRUMENTS

Description

The AFE11612EVM is an easy-to-use platform that evaluates the functionality and performance of the AFE11612-SEP device. The AFE11612-SEP is a highly-integrated, low-power, complete analog monitor and controller that includes a 16-channel (12-bit) analog-to-digital converter (ADC), 12-channel (12-bit) digital-to-analog converter (DAC), eight GPIOs, two remote temperature sensor channels, and one local temperature sensor channel. The device also features

input out-of-range alarms, and a configurable serial interface supporting SPI and I2C protocols with 5V and 3V logic.

Features

- 12 monotonic, 12-bit voltage output DACs
- 16 channel, 12-bit, 500-kSPS SAR ADC
- 8 GPIO pins
- Internal 2.5V reference
- SPI and I2C interface: 2.7V to 5.5V operation

1 Evaluation Module Overview

1.1 Introduction

The AFE11612EVM is an easy-to-use platform that evaluates the functionality and performance of the AFE11612-SEP device.

The AFE11612-SEP is a highly-integrated, low-power, complete analog monitor and controller that includes a 16-channel (12-bit) analog-to-digital converter (ADC), 12-channel (12-bit) digital-to-analog converter (DAC), eight GPIOs, two remote temperature sensor channels, and one local temperature sensor channel. The device also features input out-of-range alarms, and a configurable serial interface supporting SPI and I^{2}C protocols with 5V and 3V logic.

This user's guide describes the characteristics, operation, and use of the AFE11612EVM evaluation module (EVM). This EVM is designed to evaluate the performance of the AFE11612-SEP analog front end (AFE) in a variety of configurations. Throughout this document, the terms evaluation board, evaluation module, and EVM are synonymous with the AFE11612EVM. This document includes a schematic, printed-circuit board (PCB) layouts, and a complete bill of materials.

1.2 Kit Contents

Table 1-1 details the contents of the EVM kit. Contact the nearest TI Product Information Center if any component is missing. Make sure to verify the latest versions of the related software at the Texas Instruments website, www.ti.com.

Table 1-1. Contents of AFE11612EVM Kit

Item	Quantity
AFE11612EVM evaluation board PCB	1
USB micro-B plug to USB-A plug cable	1

1.3 Specification

The EVM is intended to provide basic functional evaluation of the device. The layout is not intended to be a model for the target circuit, nor laid out for electromagnetic compatibility (EMC) testing. The EVM consists of a printed-circuit board (PCB), which has the AFE11612-SEP installed.

1.4 Device Information

The AFE11612-SEP is a highly integrated analog monitor and control device designed for high-density, general-purpose monitor and control systems. The device includes 12 12-bit digital-to-analog converters (DACs) and a 16-channel, 12-bit, analog-to-digital converter (ADC). The device also incorporates eight general-purpose inputs and outputs (GPIOs), two remote temperature sensor channels, and a local temperature sensor channel.

The device has an internal 2.5V reference that sets the DAC to an output voltage range of 0V to 5V. The device also supports operation from an external reference. The device supports communication through both SPI-compatible and I2Ccompatible interfaces.

The device high level of integration significantly reduces component count and simplifies closed-loop system design, thus making the device a great choice for high-density applications where radiation-tolerance and board space are critical.

2 Hardware

2.1 Hardware Setup

This section describes the overall system setup for the EVM. A computer runs the software that provides an interface to the AFE11612EVM through the onboard controller.

The USB connection generates 5V of power for use as the AFE supply voltage. The onboard controller generates 3.3V of power for the input/output (IO) signals generated by the controller.

2.1.1 Electrostatic Discharge Caution

CAUTION
Many of the components on the AFE11612EVM 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.

2.1.2 Power Configurations and Jumper Settings

The AFE11612EVM provides electrical connections to the device supply pins. Table 2-1 shows these connections.

Table 2-1. AFE11612EVM Power Supply Inputs

AFE11612EVM Connector	Supply Name	Voltage Range
J1	VCC	1.8V to 5.5V
J2	VDD	1.8V to 5.5V (5V available from the USB). Remove J6 if applying an external VDD to the AFE.
J3	VIO	1.8V to 5.5V
J4	GND	0V

The jumper settings on the AFE11612EVM are crucial to the proper operation of the EVM. Table 2-2 provides the details of the configurable jumper settings on the EVM.

Table 2-2. AFE11612EVM Jumper Settings

Jumper	Default Position	Available Option	Description
J6.1-2	Closed: 5V USB supply connected to EVM VDD supply	Open: 5V USB supply disconnected from EVM VDD supply	External or onboard VDD selection
J6.3-4	Closed: 3.3V USB supply connected to EVM VIO supply	Open: 3.3V USB supply disconnected from EVM VIO supply	External or onboard VIO selection
J10, J11, J12, J14, J15	2-3: I²C enabled	1-2: SPI enabled	I²C or SPI selection
J5	Closed: EVM VDD supply connected to AFE VCC	Open: EVM VDD supply disconnected from AFE VCC	AFE VCC source selection

If an external supply is applied to the EVM, then remove jumper J6.1 to disconnect the 5V USB supply from the DAC VDD pin.

2.1.3 Connecting the Hardware

After the power and jumper configurations are set up as per Section 2.1.2 , connect the USB cable from the AFE11612EVM USB port to the computer.

2.2 Hardware Description

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

2.2.1 Theory of Operation

Figure 2-1 shows a simplified schematic of the AFE11612EVM board. All of the AFE pins are accessible through pin headers. There are two 12-pin connectors that provide access to all of the DAC pins, while a single 32-pin header is used to access the ADC channels. Two 12-pin connectors are used for the digital input and output (I/O) pins and the serial interface signal lines. For access to the eight GPIO pins, there are two 8-pin connectors located near the bottom of the board. Four of these pins (connected to the J19 header) are used as remote temperature sensor inputs D1+, D1−, D2+ and D2−. The AFE11612EVM board features two bipolar junction transistors (BJTs); one BJT is connected across D1+ and D1−, and the other BJT is connected across D2+ and D2−.
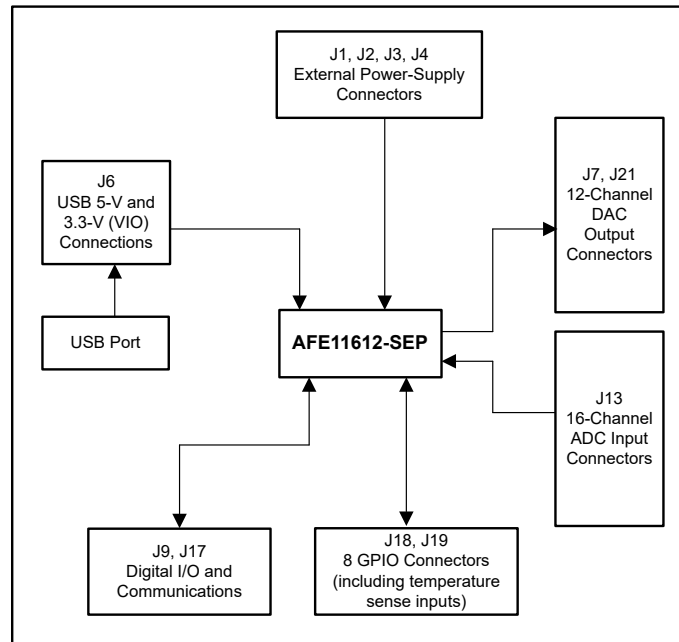

Figure 2-1. AFE11612EVM Hardware Simplified Schematic

2.2.1.1 Signal Definitions

The AFE11612EVM provides access to all pins on the device through seven pin connectors. Table 2-3 and Table 2-4 list the pin definitions for connectors J7 and J21, respectively, which contain the DAC output pins connections for the AFE11612-SEP.

Table 2-3. AFE11612EVM J7 Pin Definitions

Pin#	Signal	Description
1	DAC6	Output pin for DAC6
2	GND	Ground
3	DAC7	Output pin for DAC7
4	GND	Ground
5	DAC8	Output pin for DAC8
6	GND	Ground
7	DAC9	Output pin for DAC9
8	GND	Ground
9	DAC10	Output pin for DAC10
10	GND	Ground
11	DAC11	Output pin for DAC11
12	GND	Ground

Table 2-4. AFE11612EVM J21 Pin Definitions

Pin#	Signal	Description
1	DAC5	Output pin for DAC5
2	GND	Ground
3	DAC4	Output pin for DAC4
4	GND	Ground
5	DAC3	Output pin for DAC3
6	GND	Ground
7	DAC2	Output pin for DAC2
8	GND	Ground
9	DAC1	Output pin for DAC1
10	GND	Ground
11	DAC0	Output pin for DAC0
12	GND	Ground

The AFE11612-SEP device contains 16 analog inputs, 12 of which are single-ended (ADC4 through ADC15) and have an input range of 0V to 5V. The other four inputs (ADC0 through ADC3) can be configured as four single-ended inputs for two fully differential channels, depending on the setup of the ADC channel registers. These signal pins are connected to J13. Table 2-5 lists the pin definitions.

Table 2-5. AFE11612EVM J13 Pin Definitions

Pin#	Signal	Description
1	ADC0	ADC channel 0 input
2	GND	Ground
3	ADC1	ADC channel 1 input
4	GND	Ground
5	ADC2	ADC channel 2 input
6	GND	Ground
7	ADC3	ADC channel 3 input
8	GND	Ground
9	ADC4	ADC channel 4 input
10	GND	Ground
11	ADC5	ADC channel 5 input
12	GND	Ground
13	ADC6	ADC channel 6 input
14	GND	Ground
15	ADC7	ADC channel 7 input
16	GND	Ground
17	ADC8	ADC channel 8 input
18	GND	Ground
19	ADC9	ADC channel 9 input
20	GND	Ground
21	ADC10	ADC channel 10 input
22	GND	Ground
23	ADC11	ADC channel 11 input
24	GND	Ground
25	ADC12	ADC channel 12 input
26	GND	Ground
27	ADC13	ADC channel 13 input
28	GND	Ground
29	ADC14	ADC channel 14 input
30	GND	Ground
31	ADC15	ADC channel 15 input
32	GND	Ground

Table 2-6 and Table 2-7 list the pin definitions for connectors J9 and J17, respectively, which contain all digital input and output signals for the device

Table 2-6. AFE11612EVM J9 Pin Definitions

Pin#	Signal	Description
1	GND	Ground
2	I²C/SPI	Communication mode indicator bit: 0 = I²C, 1 = SPI
3	GND	Ground
4	A2	I²C address bit 2 (MSB)
5	GND	Ground
6	SDO/A1	SPI output or I²C address bit 1
7	GND	Ground
8	$\overline{CS}$/A0	SPI chip select or I²C address bit 0 (LSB)
9	GND	Ground
10	SCLK/SCL	Clock signal for SPI or I²C serial interface
11	GND	Ground
12	SDI/SDA	SPI input or I²C data line

Table 2-7. AFE11612EVM J17 Pin Definitions

Pin#	Signal	Description
1	GND	Ground
2	$\overline{DAC\text{-}CLR\text{-}0}$	DAC clear control signal 0 (digital input, active low).
3	GND	Ground
4	$\overline{CNVT}$	External ADC conversion trigger input, active low.
5	GND	Ground
6	$\overline{DAV}$	Data available indicator, active low output
7	GND	Ground
8	RESET	Reset input, active low.
9	GND	Ground
10	$\overline{ALARM}$	Global alarm, open-drain output
11	GND	Ground
12	$\overline{DAC\text{-}CLR\text{-}1}$	DAC clear control signal 1 (digital input, active low).

Table 2-8 and Table 2-9 list the pin definitions for the J18 and J19 headers, respectively, which contain the AFE11612-SEP GPIO signals. If remote temperature sensors are not needed, remote sensor channels D1+, D1−, D2+, and D2− can be configured as GPIOs on header J19.

Table 2-8. AFE11612EVM J18 Pin Definitions

Pin#	Signal	Description
1	GND	Ground
2	GPIO-3	General-purpose I/O (GPIO3)
3	GND	Ground
4	GPIO-2	General-purpose I/O (GPIO2)
5	GND	Ground
6	GPIO-1	General-purpose I/O (GPIO1)
7	GND	Ground
8	GPIO-0	General-purpose I/O (GPIO0)

Table 2-9. AFE11612EVM J19 Pin Definitions

Pin#	Signal	Description
1	GND	Ground
2	D1+/GPIO-4	General-purpose I/O (GPIO4) or remote temperature sensor connection
3	GND	Ground
4	D1−/GPIO-5	General-purpose I/O (GPIO5) or remote temperature sensor connection
5	GND	Ground
6	D2+/GPIO-6	General-purpose I/O (GPIO6) or remote temperature sensor connection
7	GND	Ground
8	D2−/GPIO-7	General-purpose I/O (GPIO7) or remote temperature sensor connection

3 Software

3.1 Software Setup

This section provides the procedure for EVM software installation.

3.1.1 Operating Systems

The EVM software is compatible with the Windows™ 10 operating system.

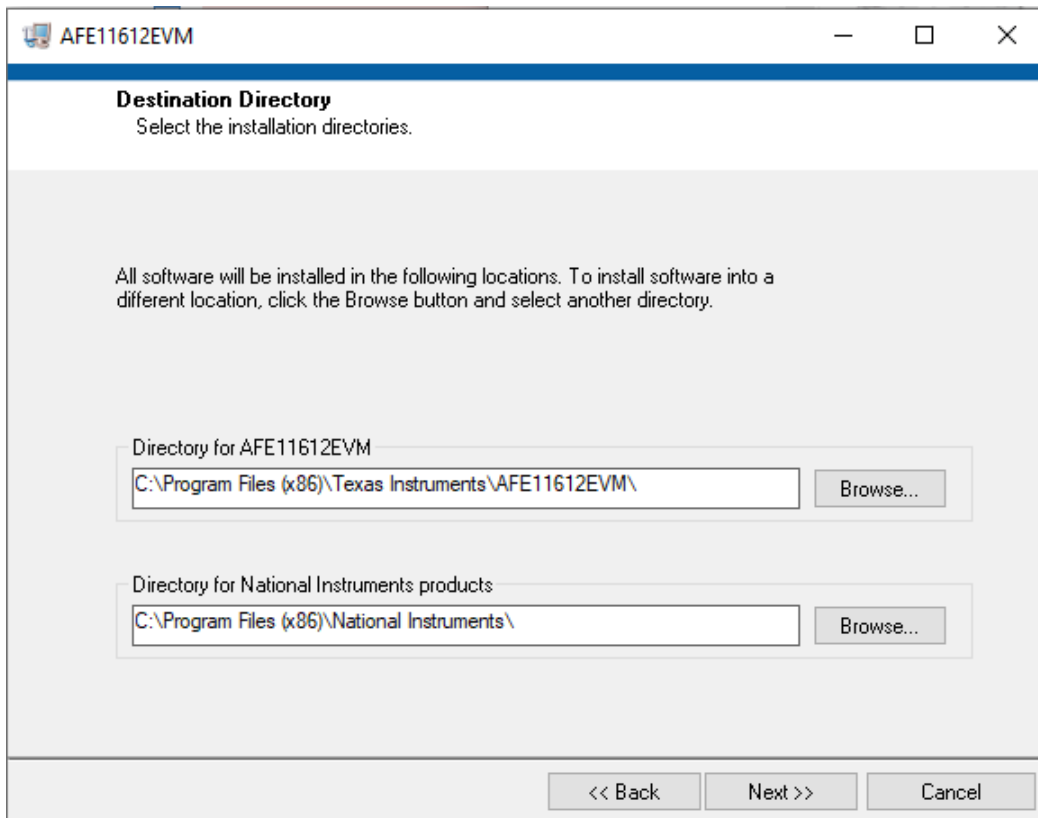### 3.1.2 Software Installation

Before software installation, make sure that the AFE11612EVM is not connected to the computer.

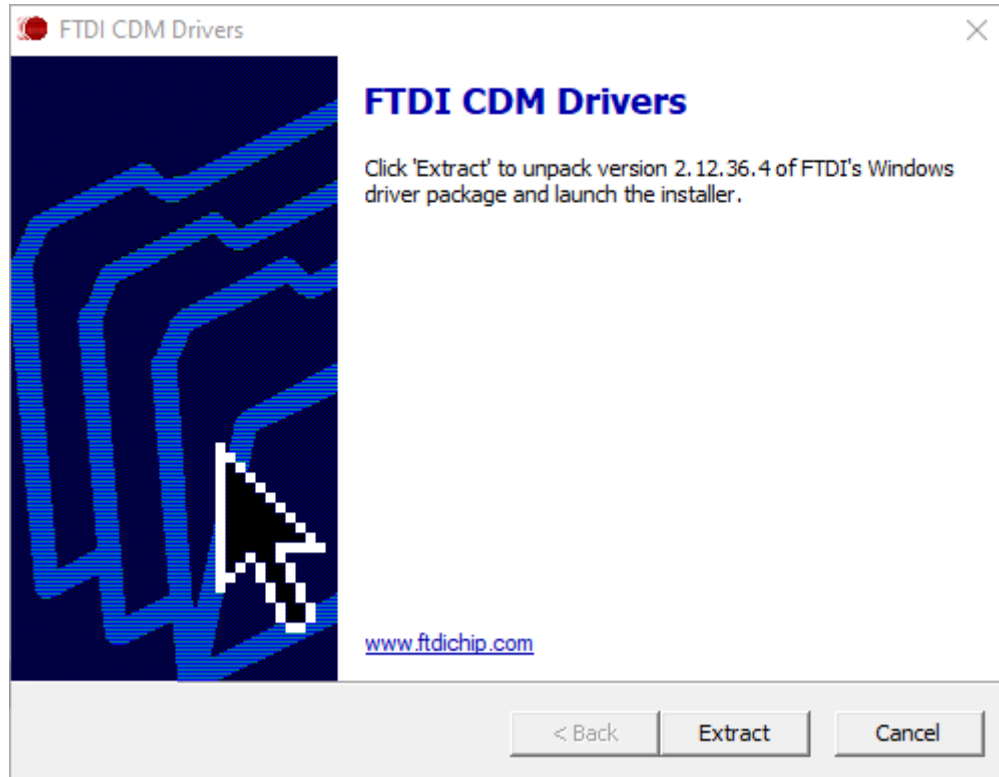The software can be downloaded from the EVM tool folder. After the software is downloaded, navigate to the download folder, and run the AFE11612EVM software installer executable.

When the AFE11612EVM software is launched, an installation dialog window opens and prompts the user to select an installation directory.

Figure 3-1 shows the *Destination Directory* window. The default software path is: *C:\Program Files (x86)\Texas Instruments\AFE11612EVM*.

Figure 3-1. Software Installation Path

The software installation also installs the FTDI USB drivers, and automatically copies the required LabVIEW™ software files and drivers to the computer. The FTDI USB drivers install in a second executable that is automatically run by the AFE11612EVM software installer. Figure 3-2 shows the window that is automatically launched after the AFE11612EVM software installation is complete.
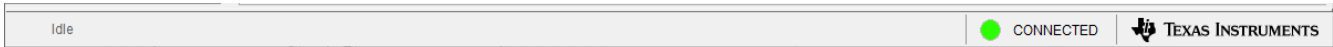

Figure 3-2. FTDI USB Drivers

3.2 Software Description

This section describes the features of the AFE11612EVM software, and discusses how to use these features. The software provides basic control of all the AFE11612-SEP registers and functions.

3.2.1 Starting the Software

To launch the software, navigate to the Texas Instruments folder in the *Start* menu, and select the *AFE11612EVM* icon.

Figure 3-3 shows that if the onboard 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 GUI is not displaying the *CONNECTED* status while the EVM is connected, unplug and reconnect the EVM, and then relaunch the GUI software. If the display continues to display DEMO, uncheck the *Demo Mode* checkbox (see Section 3.2.2.1, upper-right corner).

Figure 3-3. AFE11612EVM GUI Connection Detection

When the GUI starts, the *Interface Settings* window pops up. Figure 3-4 shows the *Interface Settings* window. This window contains drop-down menus that select protocol (SPI or I2C), and if I2C protocol is selected, the I^{2}C device address. The menu does not pop up if the GUI starts in Demo mode. In this case, uncheck the *Demo Mode* checkbox. If the interface must be updated again, toggle the *Demo Mode* checkbox for the menu to reappear.

Figure 3-4. Interface Settings

3.2.2 Software Features

The AFE11612EVM GUI incorporates interactive functions that help configure an individual AFE11612-SEP device using I^{2}C or SPI communication. These functions are built into several GUI pages, as shown in the following subsections. The menu bar on the far left of the GUI allows the user to switch between pages. The menu bar displays the *High Level Configuration* page with *DACs*, *ADCs*, *Alarms* and *GPIO + Temp* subpages, as well as the *Low Level Configuration* page.

Before using the GUI, see the AFE11612-SEP device data sheet for detailed programming instructions.

3.2.2.1 High Level Configuration Page

Figure 3-5 shows the *High Level Configuration* page that provides an interface to quickly configure the parameters and relevant register settings for the respective AFE11612-SEP device. The *High Level Configuration* page consists of the *DACs*, *ADCs*, *Alarms* and *GPIO + Temp* subpages.
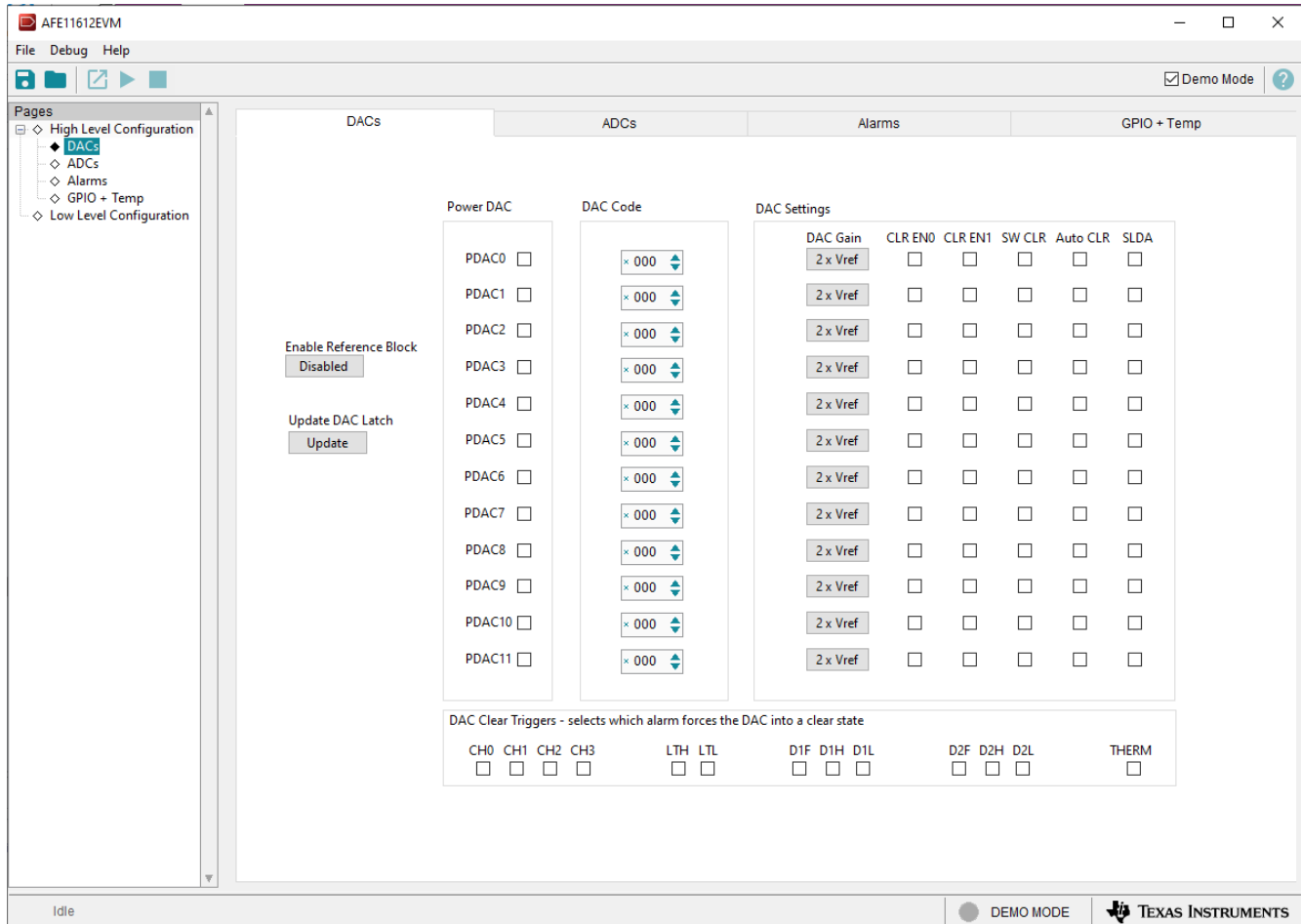

Figure 3-5. High Level Configuration Page

3.2.2.1.1 DACs Subpage

Figure 3-6 shows the DACs subpage. The DAC page gives the user an interface to observe and control the different data registers, modes, and configurations available for each individual DAC channel. The AFE11612-SEP contains 12 DACs with 12 bits of resolution. The DACs can be used with an internal or external reference. To enable each DAC channel, select the respective checkbox in the *Power DAC* column.
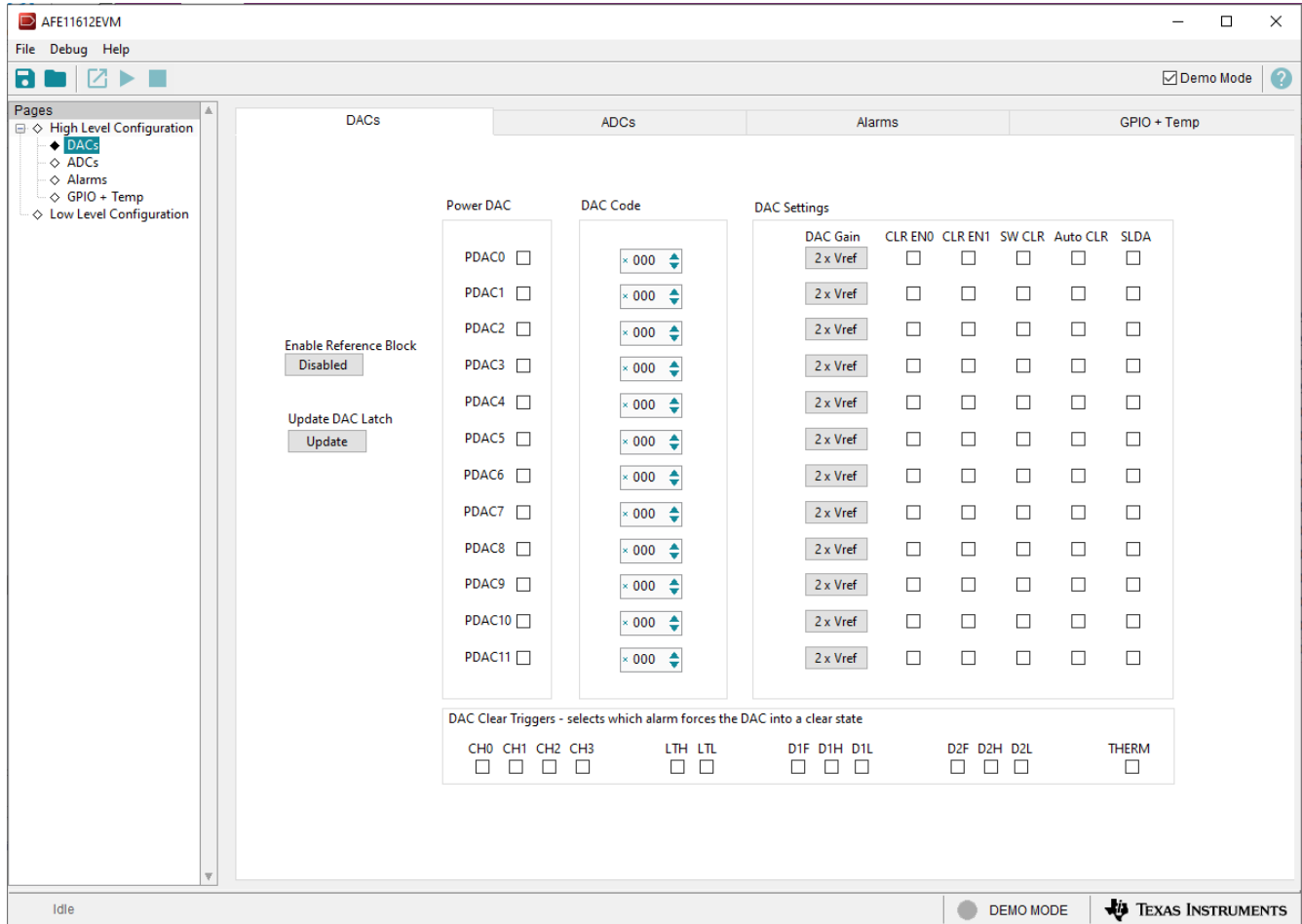

Figure 3-6. DACs Subpage

3.2.2.1.2 ADCs Subpage

Figure 3-7 shows the *ADCs* subpage. This page provides insight into the functionality of the AFE11612-SEP, a 16-channel, 12-bit ADC. The ADC block can be configured as 16 single-ended inputs (ADC0 to ADC15) or as 2 differential inputs (ADC0 to ADC3) plus 12 single-ended (ADC4 to ADC15). With V_{REF} defined as the reference voltage input to the ADC, the analog input range for the device can be selected as 0 V to V_{REF} (2.5 V) or 0 V to 2 × V_{REF} (5 V).
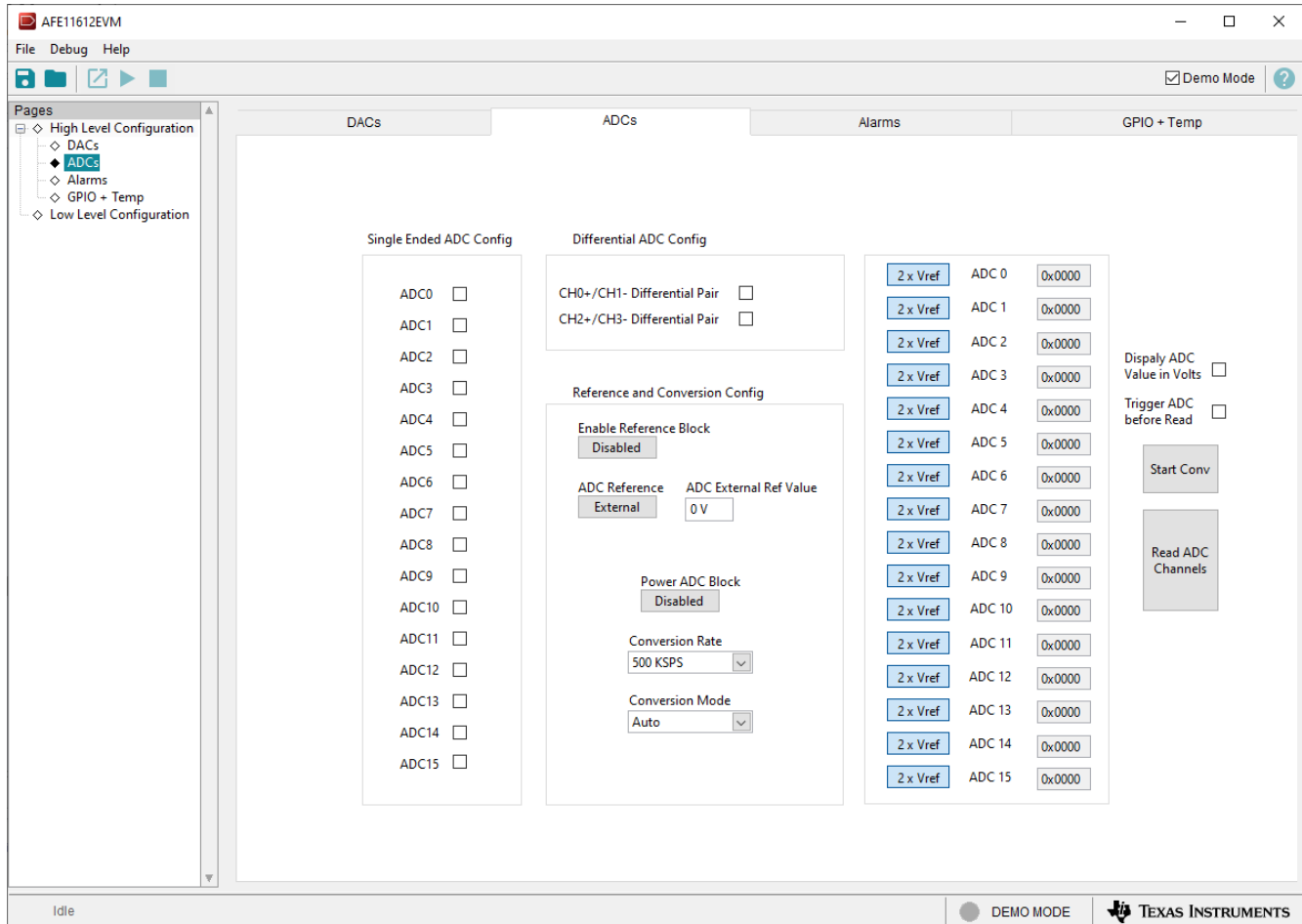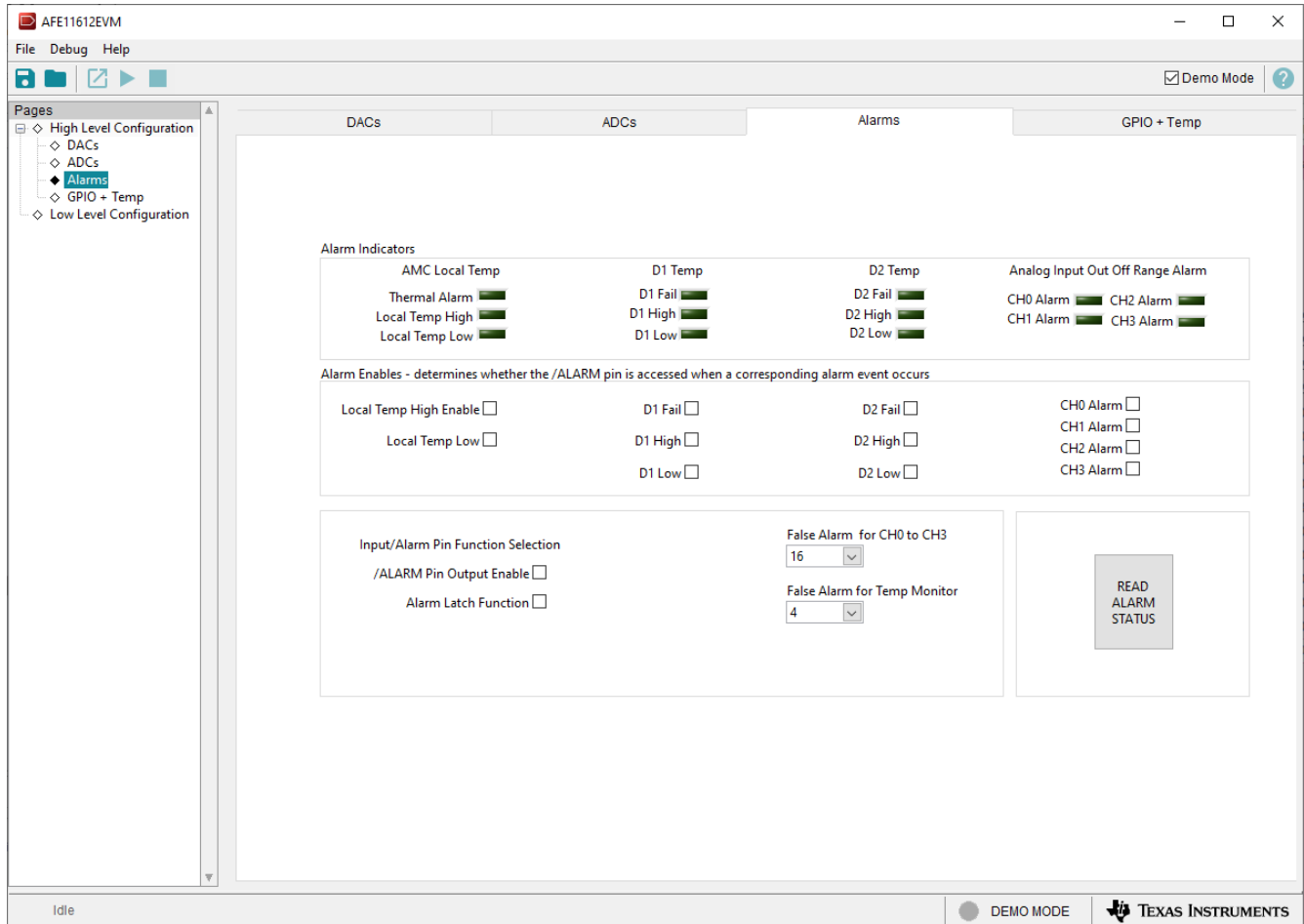

Figure 3-7. ADCs Subpage

Most of the controls listed within the ADC subpage are used to set up the ADC configuration register. These controls include the conversion-rate and conversion-mode parameters, which are selectable through the respective drop-down menu. The conversion mode can be either *Auto* or *Direct*. In Direct mode, the analog inputs specified in the ADC channel registers are converted sequentially one time. In Auto mode, the analog inputs are converted sequentially and repeatedly. After a conversion is completed, the ADC multiplexer returns to the first channel and repeats the process.

The ADCs also have the option to use an external or internal reference. To enable the external reference, press the **External** button located under *ADC Reference*. If the button is not selected, the internal reference is enabled. When the external reference is selected, the *ADC External Ref Value* field is used to enter a value. This value is used to calculate the ADC conversion in volts when the *Display ADC Value in Volts* checkbox is selected.

3.2.2.1.3 Alarms Subpage

Figure 3-8 shows the *Alarms* subpage. The *Alarms* page allows the user to view and access the AFE11612-SEP register bits related to common programmable settings and alarms.

Figure 3-8. Alarms Subpage

The false-alarm protection settings for each alarm are also displayed. These settings allow the user to choose how many consecutive triggers must occur before the alarm is activated. Additionally, the bottom left of the GUI includes a checkbox that enables or disables the alarm pin and alarm latch functions.

3.2.2.1.4 GPIO + Temp Subpage

Figure 3-9 shows the *GPIO + Temp* subpage. The *GPIO + Temp* page allows the user to view and access the AFE11612-SEP registers related to the three temperature monitoring functions. Press the **READ TEMP** button to enable a temperature conversion and update the temperature value for all temperature functions in degrees Celsius (°C) and hexadecimal. Additionally, these functions can be modified by adjusting the corresponding *Hysteresis* and *nFactor* values.
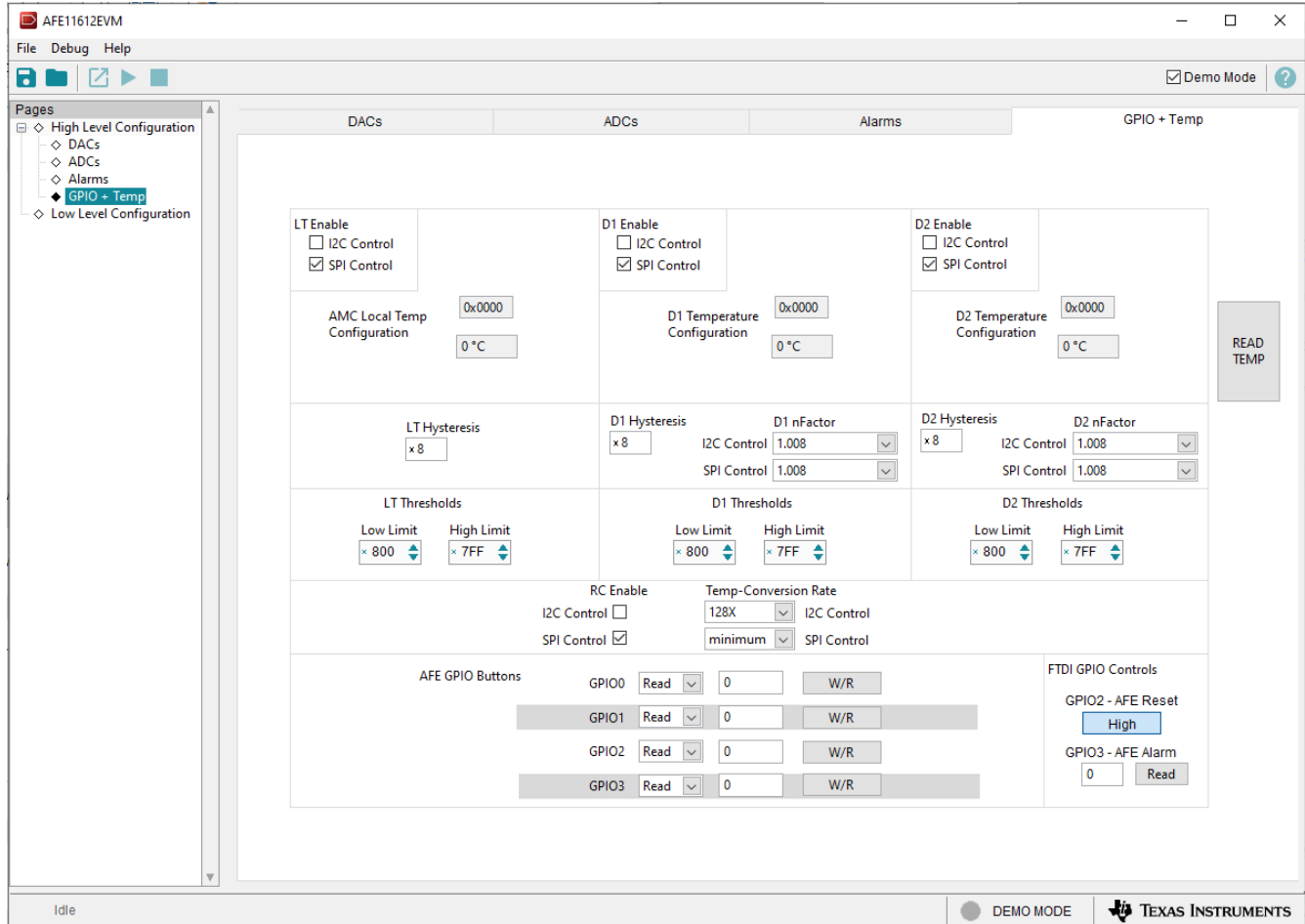

Figure 3-9. GPIO + Temp Subpage

3.2.2.2 Low Level Configuration Page

Figure 3-10 shows the *Low Level Configuration* page. This page allows access to low-level communication directly with the respective device registers. Select a register on the *Register Map* list to show a description of the values in that register, as well as information on the register address, default value, size, and current value. Data are written to the registers by entering a value in the value column of the GUI.
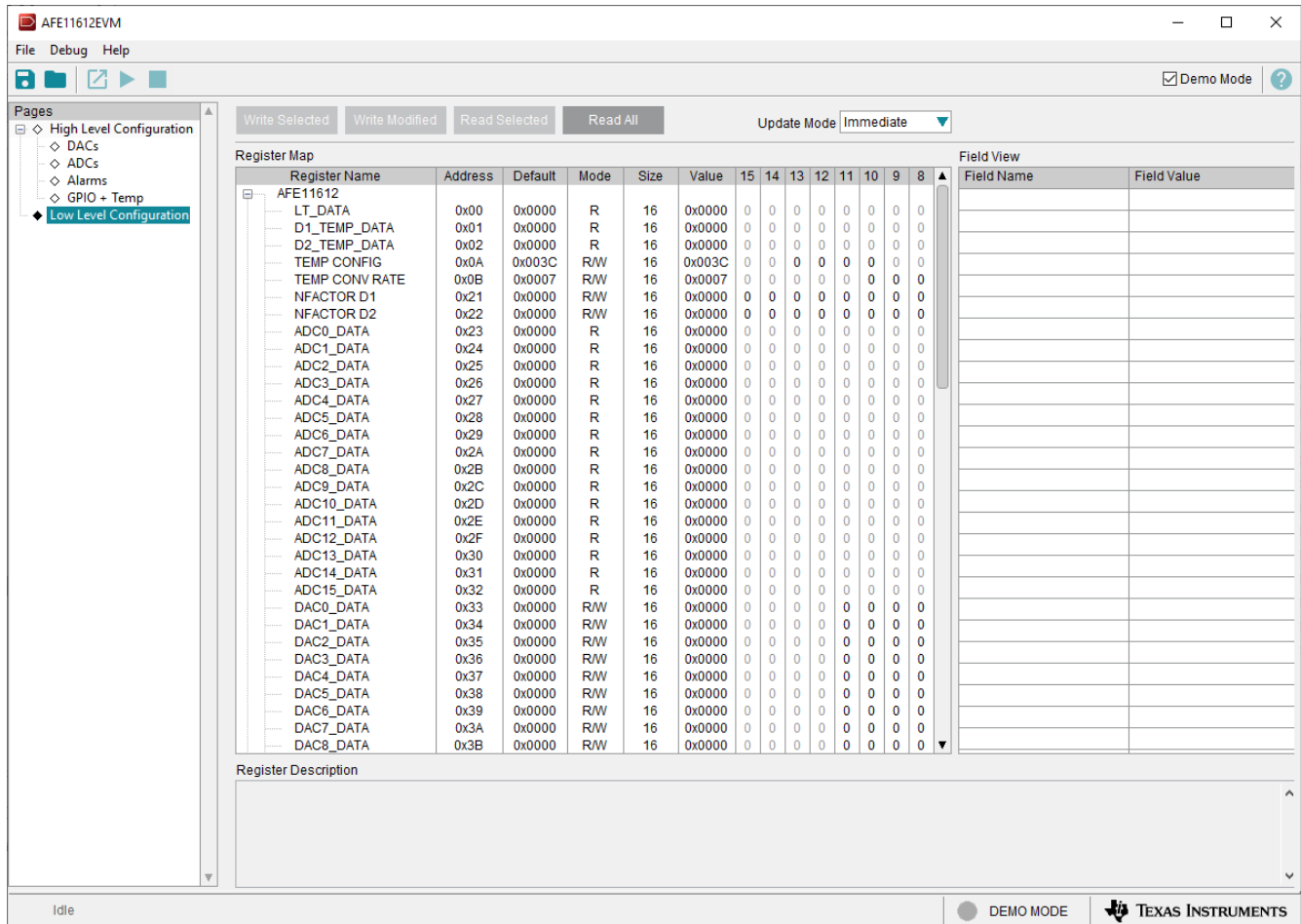

Figure 3-10. Low Level Configuration Page

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

Figure 3-11 shows the four configuration buttons provided on the *Low Level Configuration* page that allow the user to read from and write to the device registers:

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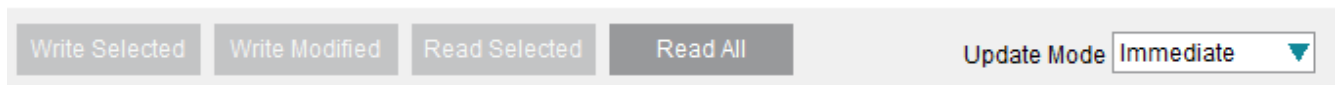- **Read Selected**
- **Read All**

Figure 3-11. Low Level Configuration Page Options

By default, *Immediate Update Mode* is selected for the *Low Level Configuration* page write operations. The **Write Modified** button is enabled only when the *Update Mode* is set to *Deferred*. In this mode, a write operation is initiated only when the **Write Selected** or **Write Modified** buttons are pressed.

4 Hardware Design Files

This section contains the schematics, printed circuit board (PCB) layout diagrams, and a complete bill of materials for the AFE11612EVM. Optional components are shown as do not populate (DNP) on the schematic, and have quantities of zero in the BOM.
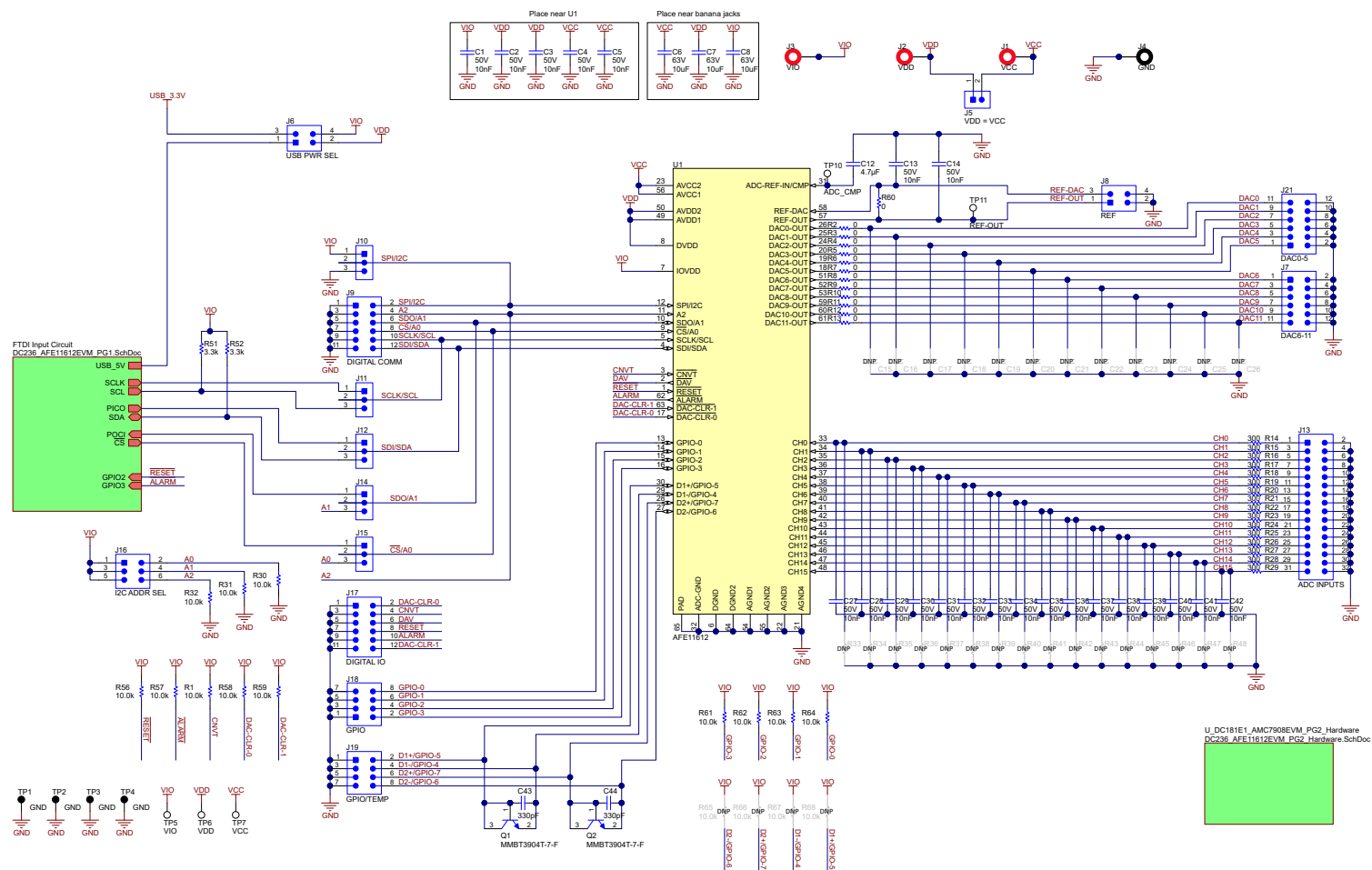
4.1 Schematics

Figure 4-1. AFE11612EVM Schematic Page 1

Figure 4-2. AFE11612EVM Schematic Page 2

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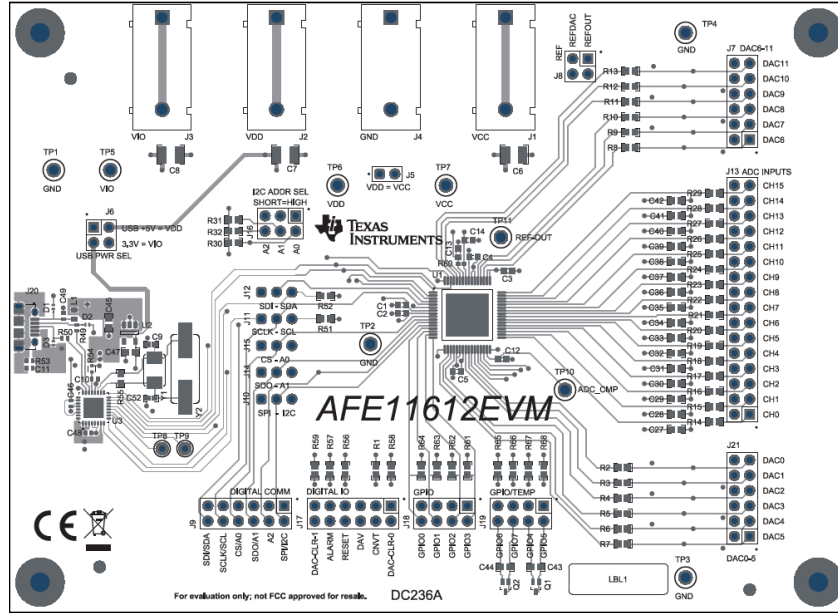
4.2 PCB Layout

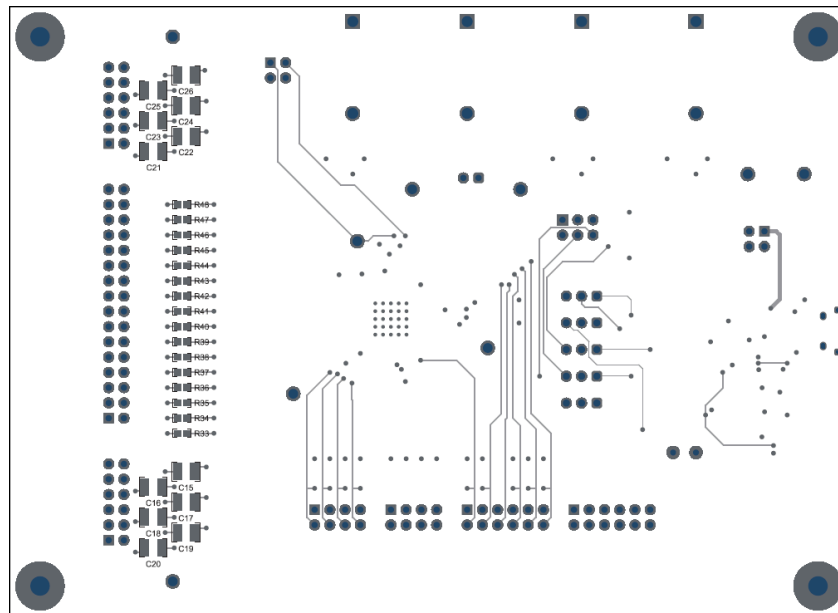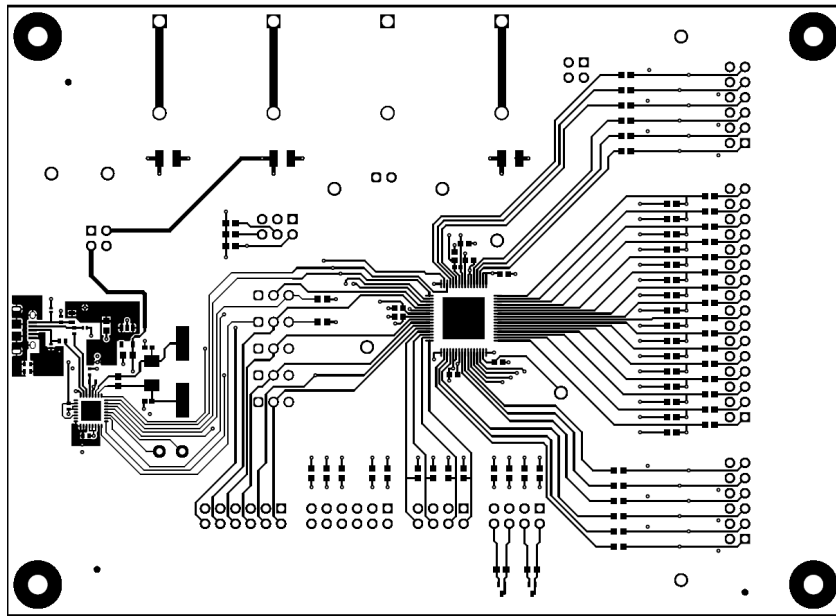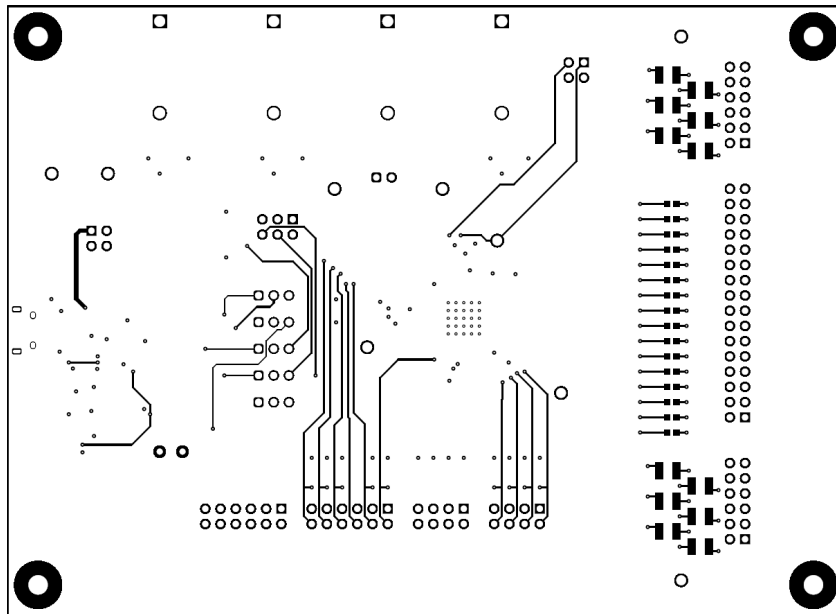**Figure 4-3. AFE11612EVM PCB Components Layout - Top Layer**

Figure 4-4. AFE11612EVM PCB Components Layout - Bottom Layer

Figure 4-5. AFE11612EVM PCB Traces - Top Layer

Figure 4-6. AFE11612EVM PCB Traces - Bottom Layer

4.3 Bill of Materials

Table 4-1. AFE11612EVM Bill of Materials

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
!PCB	1		Printed Circuit Board		DC236	Any
C1, C2, C3, C4, C5, C13, C14, C27, C28, C29, C30, C31, C32, C33, C34, C35, C36, C37, C38, C39, C40, C41, C42	23	0.01μF	CAP, CERM, 0.01uF, 50V, +/- 10%, X7R, 0603	0603	885012206089	Wurth Elektronik
C6, C7, C8	3	10μF	CAP, CERM, 10uF, 63V, +/- 20%, X7R, 1210	1210	GRM32ER71J106KA12L	MuRata
C9, C52	2	18pF	CAP, CERM, 18pF, 50V, +/- 5% C0G/NP0, 0402	0402	GRM1555C1H180JA01D	MuRata
C10	1	100pF	CAP, CERM, 100pF, 50V, +/- 10%, X7R, 0402	0402	885012205055	Wurth Elektronik
C11, C46, C48, C49	4	0.1μF	CAP, CERM, 0.1μF, 25V, +/- 10%, X7R, 0402	0402	CC0402KRX7R8BB104	Yageo
C12, C45, C47	3	4.7μF	CAP, CERM, 4.7μF, 10V, +/- 20%, X7R, 0603	0603	GRM188Z71A475ME15D	MuRata
C43, C44	2	330pF	CAP, CERM, 330pF, 100V, +/- 10%, X7R, 0603	0603	GRM188R72A331KA01D	MuRata
FID1,FID2,FID3	3		Fiducial mark. There is nothing to buy or mount.	N/A	N/A	N/A
H1, H2, H3, H4	4		Machine Screw, Round, #4-40 x 1/4, Nylon, Philips panhead	Screw	NY PMS 440 0025 PH	B&F Fastener Supply
H5, H6, H7, H8	4		Standoff, Hex, 0.5"L #4-40 Nylon	Standoff	1902C	Keystone
J1, J2, J3	3		Standard Banana Jack, insulated, 10A, red	571-0500	571-0500	DEM Manufacturing
J4	1		Standard Banana Jack, insulated, 10A, black	571-0100	571-0100	DEM Manufacturing
J5	1		Header, 100mil, 2x1, Gold, TH	2x1 Header	TSW-102-07-G-S	Samtec
J6,J8	2		Header, 100mil, 2x2, Gold, TH	2x2 Header	TSW-102-07-G-D	Samtec
J7, J9, J17, J21	4		Header, 100mil, 6x2, Gold, TH	6x2 Header	TSW-106-07-G-S	Samtec
J10, J11, J12, J14, J15	5		Header, 2.54mm, 3x1, Gold, TH	Header, 2.54mm, 3x1, TH	61300311121	Wurth Elektronik
J13	1		Header, 100mil, 16x2, Gold, TH	16x2 Header	TSW-116-07-G-D	Samtec
J16	1		Header, 100mil, 3x2, Gold, TH	3x2 Header	TSW-103-07-G-D	Samtec
J18,J19	2		Header, 100mil, 4x2, Gold, TH	4x2 Header	TSW-104-07-G-D	Samtec
J20	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	600Ω	Ferrite Bead, 600 ohm at 100MHz, 1A, 0603	0603	782633601	Wurth Elektronik
LBL1	1		Thermal Transfer Printable Labels, 0.650" W x 0.200" H - 10,000 per roll	PCB Label 0.650 x 0.200 inch	THT-14-423-10	Brady
Q1,Q2	2	40V	Transistor, NPN, 40V, 0.2A, SOT-523	SOT-523	MMBT3904T-7-F	Diodes Inc.
R1, R14, R15, R16, R17, R18, R19, R20, R21, R22, R23, R24, R25, R26, R27, R28, R29, R30, R31, R32, R56, R57, R58, R59, R61, R62, R63, R64	28	10kΩ	RES, 10.0 k, 1%, 0.1 W, 0603	0603	ERJ-3EKF1002V	Panasonic
R2, R3, R4, R5, R6, R7, R8, R9, R10, R11, R12, R13	12	0Ω	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW06030000Z0EA	Vishay-Dale
R49,R50	2	10Ω	RES, 10, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	RMCF0402JT10R0	Stackpole Electronics Inc
R51,R52	2	3.3kΩ	RES, 3.3 k, 5%, 0.1 W, 0603	0603	RC0603JR-073K3L	Yageo

Table 4-1. AFE11612EVM Bill of Materials (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
R53	1	330Ω	RES, 330, 1%, 0.1 W, AEC-Q200 Grade 0, 0402	0402	ERJ-2RKF3300X	Panasonic
R54	1		12 kOhms ±1% 0.1W, 1/10W Chip Resistor 0402 (1005 Metric) Automotive AEC-Q200 Thick Film	0402	ERJ-2RKF1202X	Panasonic ECG
R55	1	1MΩ	RES, 1.00M, 0.5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW06031M00DHEAP	Vishay-Dale
R60	1	0	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0402	0402	ERJ-2GE0R00X	Panasonic
SH-J1, SH-J2, SH-J3, SH-J4, SH-J5, SH-J6	6		Shunt, 2.54mm, Gold, Red	Shunt,2.54mm, Red	60900213521	Wurth Elektronik
TP1, TP2, TP3, TP4	4		Test Point, Compact, Black, TH	Black Compact Testpoint	5006	Keystone Electronics
TP5, TP6, TP7, TP10, TP11	5		Test Point, Compact, White, TH	White Compact Testpoint	5007	Keystone Electronics
U1	1		12-bit analog monitoring and control solution with multichannel ADC, DACs and temperature sensors, RGC0064A (VQFN-64)	RGC0064A	AFE11612	Texas Instruments
U2	1		250mA Ultra-Low-Noise, Low-IQ LDO, DBV0005A (SOT-23-5)	DBV0005A	LP5907MFX-3.3/NOPB	Texas Instruments
U3	1		USB Bridge, USB to I²C/SPI USB 2.0 I²C, SPI Interface 32-VQFN (5x5)	VQFN32	FT4222HQ-D-R	FTDI
Y1	1		Crystal, 12MHz, 18pF, SMD	ABM3	ABLS2-12.000MHZ-B2-T	Abracon Corporation
C15, C16, C17, C18, C19, C20, C21, C22, C23, C24, C25, C26	0	10μF	CAP, CERM, 10uF, 63V, +/- 10%, X7R, 1210	1210	GRM32ER71J106KA12L	MuRata
D1, D2, D3	0		Single-Channel ESD Protection in 0402 Package With 10pF Capacitance and 9V Breakdown, DPY0002A (X1SON-2)	DPY002A		Texas Instruments
R33, R34, R35, R36, R37, R38, R39, R40, R41, R42, R43, R44, R45, R46, R47, R48, R65, R66, R67, R68	0	10kΩ	RES, 10.0 k, 1%, 0.1 W, 0603	0603	ERJ-3EKF1002V	Panasonic
Y2	0		Crystal, 12MHz, 30ppm, 18pF, SMD	11.4x4.7mm	ABLS2-12.000MHZ-D4Y-T	Abracon Corporation

5 Additional Information

5.1 Trademarks

Windows™ is a trademark of Microsoft Corporation.

LabVIEW™ is a trademark of National Instruments.

All trademarks are the property of their respective owners.

6 Related Documentation from Texas Instruments

The following document provides information regarding Texas Instruments integrated circuits used in the assembly of the AFE11612EVM. This user's guide is available from the TI web site under literature number SLAU892. 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 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 6-1. Related Documentation

Document	Literature Number
AFE11612-SEP product page	SLASF76

7 Revision History

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

Changes from Revision * (March 2023) to Revision A (June 2024)   **Page**

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.

【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.

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