EVM User's Guide: AFE539A4EVM
AFE539A4 Evaluation Module

TEXAS INSTRUMENTS

Description

The AFE539A4EVM is a development board designed to evaluate the performance of the AFE539A4. The AFE539A4 is a device with integrated state machine configured as proportional-integral (PI) controller and ADC for real-time closed-loop control of applications such as thermoelectric cooling (TEC). The device contains advanced features such as Hi-Z output mode at power down, overcurrent sensing and protection and a non-volatile memory (NVM) to store configurations. This device allows for processor-less applications and design reuse of real-time closed loop systems.

Get Started

1. Order the AFE539A4EVM on ti.com

2. Download and install the AFE539A4EVM software at ti.com
3. Configure the hardware jumper setting
4. Connect the USB and external AFE539A4EVM supplies

Features

- On-board FTDI module for serial communication
- Headers for power selection

Applications

- Laser pointer
- Chemistry and gas analyzer
- Mechanically scanning LIDAR
- Robot sensing module
- Seeker front end
- TEC control
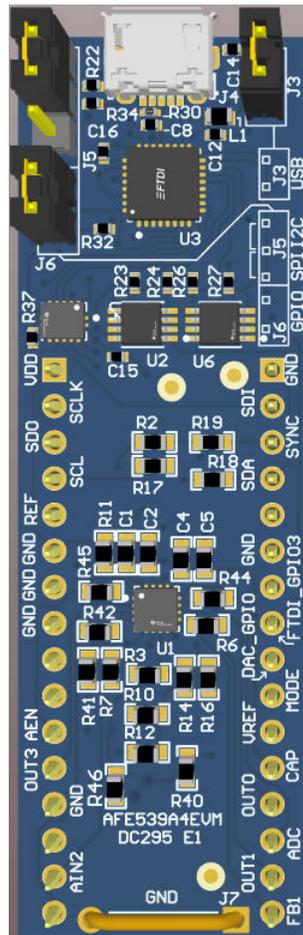
1 Evaluation Module Overview

1.1 Introduction

This user's guide describes the characteristics, operation, and use of the AFE539A4 evaluation module (EVM). This EVM is designed to evaluate the performance of the AFE539A4, a smart analog front-end (AFE) device with an integrated PI controller and ADC. Throughout this document, the terms evaluation board, evaluation module, and EVM are synonymous with the AFE539A4EVM. This document includes a schematic, printed-circuit board (PCB) layouts, and a complete bill of materials.

1.2 Kit Contents

The table below details the contents of the EVM kit. Contact the nearest TI Product Information Center if any component is missing. Verify the latest versions of the related software at the Texas Instruments website, www.ti.com.

Table 1-1. Contents of AFE539A4EVM Kit

Item	Quantity
AFE539A4EVM PCB	1
USB micro-B plug to USB-A plug cable	1

Table 1-2. Optional Components Not Included With Kit

Item	Quantity
SmartDAC-DIY-EVM - breakout board for AFE539A4EVM	1

These optional components are available for purchase from the Texas Instruments website at www.ti.com.

1.3 Specification

The evaluation board default set up is configured for TEC control. TEC control is normally used for localized and precise temperature control which is a requirement for applications such as laser biasing or in-vitro diagnostics (IVD). The hardware on AFE539A4EVM is set up for such control. AFE539A4EVM is used to control the TEC through a DC/DC driver. The output of the device (pin OUT1 on the EVM) needs to be connected to the feedback pin of a buck-boost converter through a resister ladder.

The device software is not preconfigured, so registers need to be configured by using the GUI.

1.4 Device Information

The AFE539A4 is a 10-bit, 4-channel DAC device where one of the channels can be configured as a 10-bit ADC input for analog sensing. The device contains an integrated state machine that is configured as a PI controller. The user has access to all PI parameters including set point which are then stored in the NVM. The NVM updates all of the device registers on device power-up which removes the need for any run-time software. In addition, the device has current sensing capability to clamp the output in case of a fault.

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 a simplified schematic of the AFE539A4EVM board. Two 16-pin connectors provide access to all of the DAC pins. The GPIO, I^{2}C, and SPI signals from the on-board controller are connected to the AFE through three level translators. Each level translator can be independently disabled to disconnect the on-board controller GPIO, I^{2}C, and SPI signals from the AFE signals while the AFE is running in stand-alone mode.

The default hardware is set up per AFE539A4 recommended configuration guidelines. The AEN pin is connected to VDD with a pull-up resistor to hardware enable the ADC.

AIN2 pin which is a comparator input is connected by default to VDD. With a pull-up resistor.

FB1 and OUT1 pins are connected together through R6 resistor to enable closed loop amplifier output. Disconnect R6 resistor if this feature is undesirable.

AIN0 pin is the ADC input pin.

For more details please refer to AFE539A4 data sheet or to AFE539A4EVM schematic.
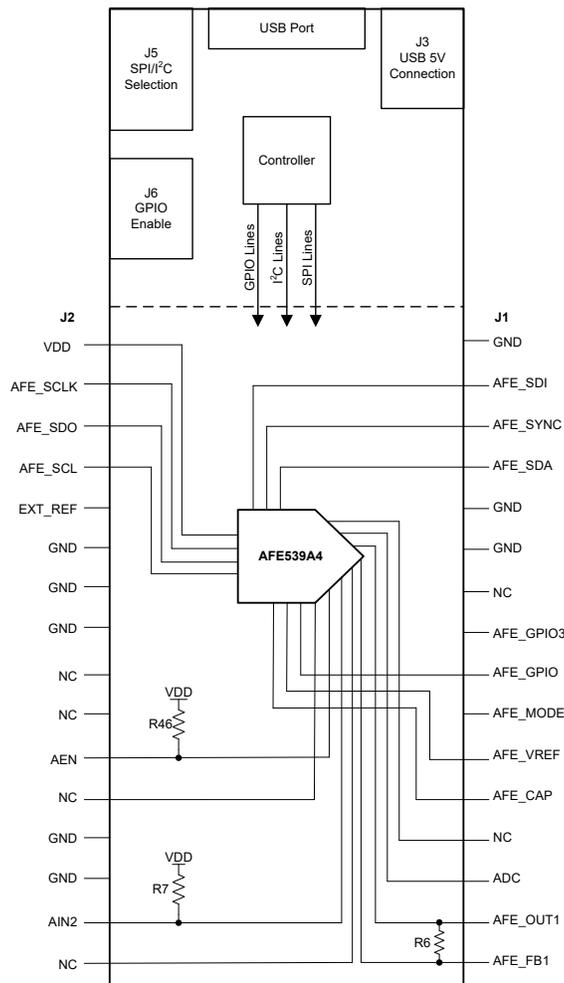
Figure 2-1. AFE539A4EVM Hardware Simplified Schematic

2.1.1.1 Signal Definitions

The AFE539A4EVM provides access to all AFE pins through connection J1 and J2. Figure 2-1 shows the J1 and J2 pin definitions.

Table 2-1. AFE539A4EVM J1 Pin Definitions

Pin#	Signal	Description
1	GND	Ground
2	AFE_SDI	SPI SDI signal for AFE
3	AFE_SYNC	SPI SYNC signal for AFE
4	AFE_SDA	I^{2}C SDA
5	GND	Ground
6	GND	Ground
7	NC	Not Connected
8	FTDI_GPIO3	GPIO3 output of the on-board controller
9	AFE_GPIO	GPIO input for AFE539A4
10	AFE_MODE	Stand alone or programming mode selection pin
11	AFE_VREF	VREF input to the AFE
12	AFE_CAP	LDO bypass capacitor
13	AFE_OUT0	Output pin for AFE
14	AFE_ADC	ADC input
15	AFE_OUT1	Output pin for AFE VOUT1
16	AFE_FB1	Feedback pin for AFE VOUT1

Table 2-2. AFE539A4EVM J2 Pin Definitions

Pin#	Signal	Description
1	AFE_VDD	VDD power supply for DAC
2	AFE_SCLK	SPI SCLK
3	AFE_SDO	SPI SDO
4	AFE_SCL	I^{2}C SCL
5	EXT_REF	External reference input for DAC
6	GND	Ground
7	GND	Ground
8	GND	Ground
9	NC	Not connected
10	NC	Not connected
11	AFE_AEN	ADC enable pin
12	AFE_OUT3	Output pin for AFE VOUT3
13	GND	Ground
14	GND	Ground
15	AFE_AIN2	AFE comparator input
16	AFE_FB2	Feedback pin for AFE VOUT2

2.2 Hardware Setup

This section describes the overall system setup for the EVM. A computer runs the software that provides an interface to the AFE539A4EVM through the on-board controller.

The USB connection generates 5-V of power for use as the DAC supply voltage (VDD). The on-board controller supplies 3.3-V of power for the input/output (IO) signals from the controller. These IO signals are level translated to the VDD voltage of the DAC. Figure 2-2 displays the system hardware setup.
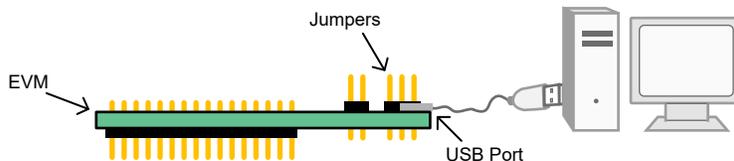

Figure 2-2. Hardware Setup

2.2.1 Electrostatic Discharge Caution

CAUTION

Many of the components on the AFE539A4EVM 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 Configurations and Jumper Settings

The AFE539A4EVM provides electrical connections to the device supply pins. The connections are shown in Table 2-3.

Table 2-3. AFE539A4EVM Power Supply Inputs

AFE539A4EVM Connector	Supply Name	Voltage Range
J2.1	VDD	1.8 V to 5.5 V (5 V available from the USB); remove J3 if applying an external VDD to the AFE.
J1.1	GND	0 V

The jumper settings on the AFE539A4EVM are crucial to the proper operation of the EVM. Table provides the details of the configurable jumper settings on the EVM. The AFE539A4EVM pin numbers are defined in Table 2-4.

Table 2-4. AFE539A4EVM Jumper Settings

Jumper	Default Position	Available Option	Description
J3	Closed: 5-V USB supply connected to DAC VDD	Open: 5-V USB supply disconnected from DAC VDD	External or on-board VDD selection
J5	2-3: I^{2}C enabled	1-2: SPI enabled	I^{2}C or SPI selection
J6	Closed: GPIOs enabled	Open: GPIOs disabled	Controller GPIO enable

If an external supply is applied to the AFE VDD pin, then remove jumper J3 to disconnect the 5-V USB supply from the DAC VDD pin.

GPIO2 from the on-board controller is connected to the AFE GPIO pin of the AFE539A4EVM. This input can be controlled through the graphical user interface (GUI). If the AFE GPIO is configured as an output, remove J6 to disable the GPIOs from the on-board controller.

GPIO3 from the onboard controller is broken out to J1, pin 8 and is controlled through the GUI using the controls for GPIO3.

To enable the GPIO pins, close jumper J6. To disable the GPIO pins, remove jumper J6.

2.2.3 Connecting the Hardware

After the power and jumper configurations are set up, connect the USB cable from the AFE539A4EVM USB port to the computer.

3 Software

3.1 Software Setup

This section provides the procedure for EVM software installation.

3.1.1 Operating Systems

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

3.1.2 Software Installation

Before software installation, make sure that the AFE539A4EVM is not connected to the computer.

The software can be downloaded from the device product folders. After the software is downloaded, navigate to the download folder, and run the installer executable.

When the installer is launched, an installation dialog window opens and prompts the user to select an installation directory. If left unchanged, the software location defaults to *C:\Program Files (x86)\Texas Instruments\SMART-DAC-EVM-GUI* as shown in Figure 3-1.
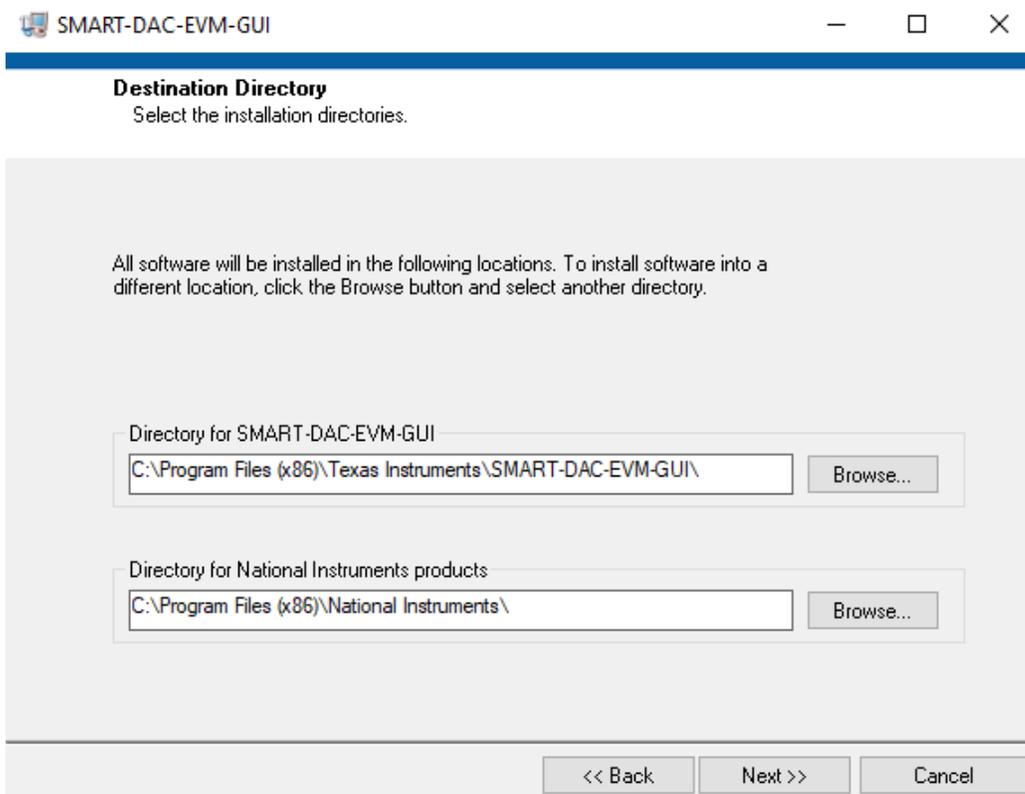

Figure 3-1. Software Installation Path

The software installation also installs the FTDI USB drivers, and automatically copies the required LabVIEW™ software files and drivers to the local machine. The FTDI USB drivers install in a second executable, shown in Figure 3-2, that is automatically launched after the AFE539A4EVM software installation is complete.
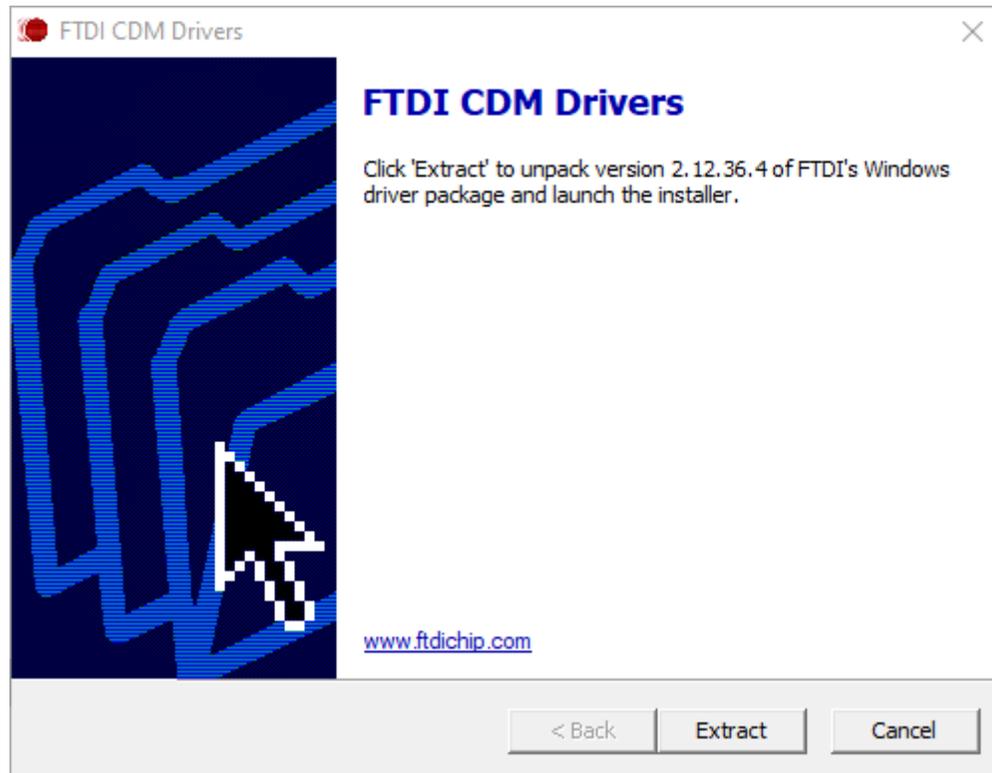
Figure 3-2. FTDI USB Drivers

3.2 Software Description

This section describes the features of the AFE539A4EVM software, and discusses how to use these features. The software provides basic control of the AFE539A4EVM 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 *SMART-DAC-EVM-GUI* icon.

Upon launching the executable, device selection window pops up. Select the correct device in the drop down menu as shown in Figure 3-3.
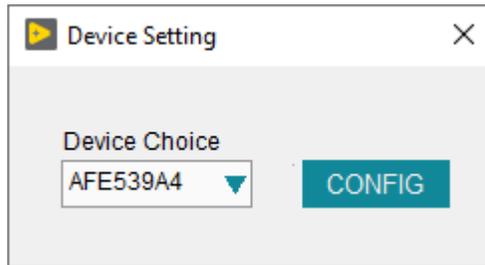

Figure 3-3. AFE539A4EVM GUI Device Setting

Upon selecting the device, a digital interface selection window pops up. This window contains a drop-down menu list that selects the protocol (SPI or I^{2}C) used to communicate with the device and a figure of the corresponding jumper setting. Select the mode and make sure that jumpers are positioned accordingly.
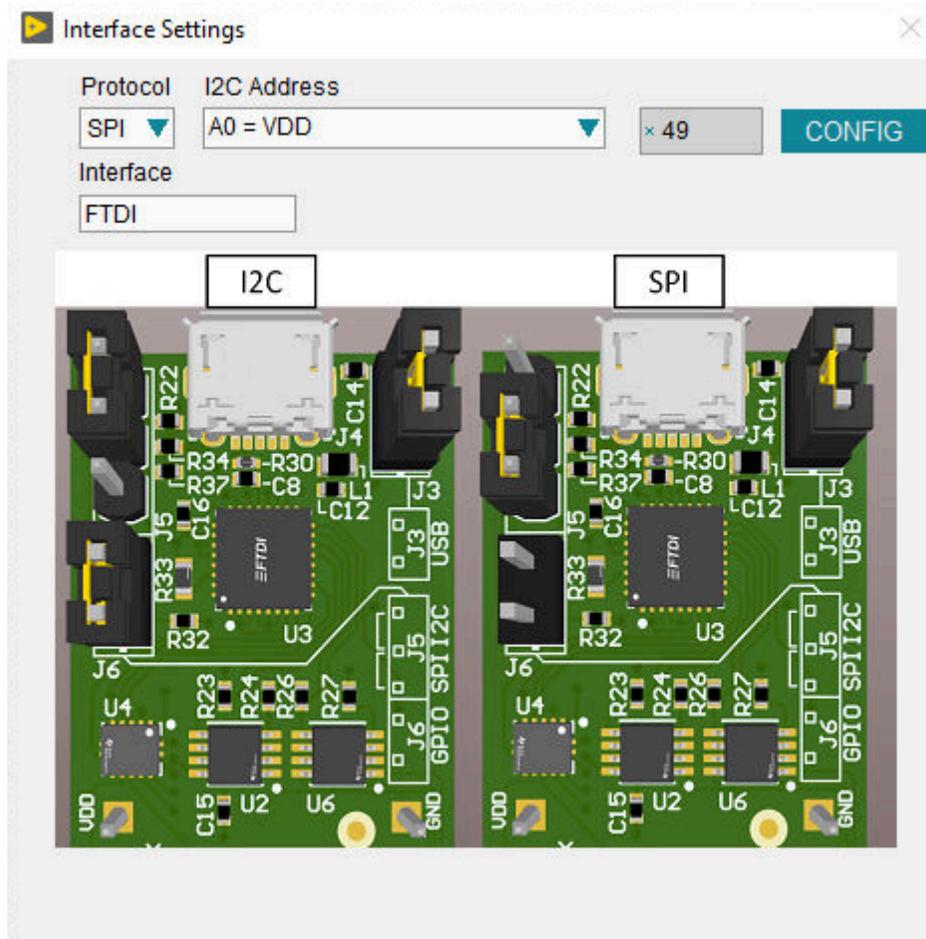

Figure 3-4. AFE539A4EVM GUI Interface Settings

If the on-board controller is connected correctly, then the status bar at the bottom of the screen displays *CONNECTED* as shown in the Figure 3-5. 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.
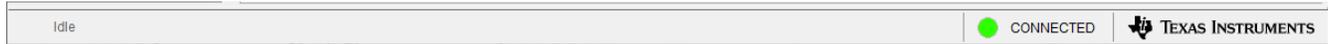
Figure 3-5. SMART-DAC-EVM-GUI Connection Detection

3.2.2 Software Features

The SMART-DAC-EVM-GUI incorporates interactive functions that configure an individual AFE539A4EVM 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 *AFE539A4* sub page, and the *Low Level Configuration* page.

Before using the GUI, see the device data sheet for detailed AFE539A4EVM programming instructions.

3.2.2.1 High Level Configuration Page

The *High Level Configuration* page, shown in Figure 3-6, provides an interface to quickly configure the parameters and relevant register settings for the respective AFE539A4EVM device. The *High Level Configuration* page consists of the AFE539A4 sub-page.

The AFE539A4 sub-page provides an interface to quickly power up, and configure all of the parameters and settings of the device

Disable the state machine using the State Machine Enable drop down menu before updating any SRAM parameters. Re-enable the state machine after configuring these settings.
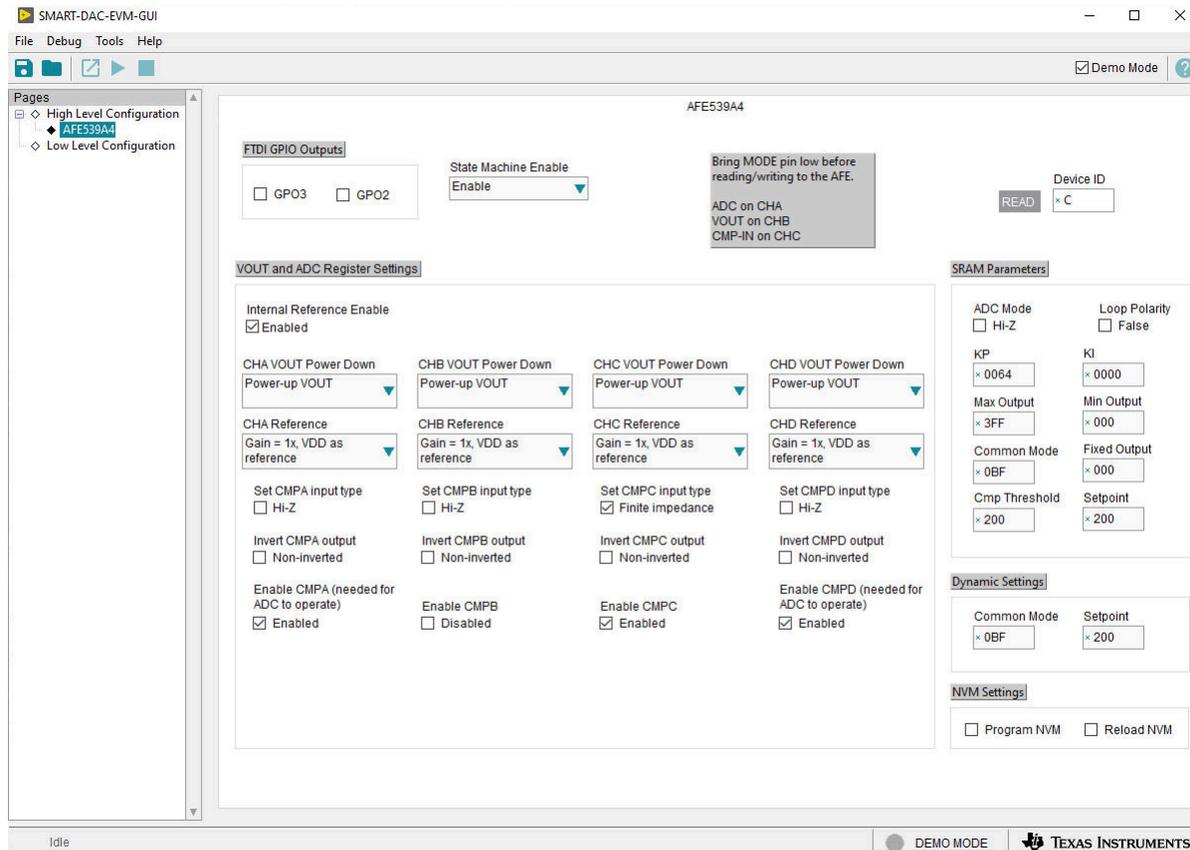

Figure 3-6. High Level Configuration Page

3.2.2.2 Low Level Configuration Page

The *Low Level Configuration* page, shown in Figure 3-7, allows access to low-level communication directly with the respective AFE539A4 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.
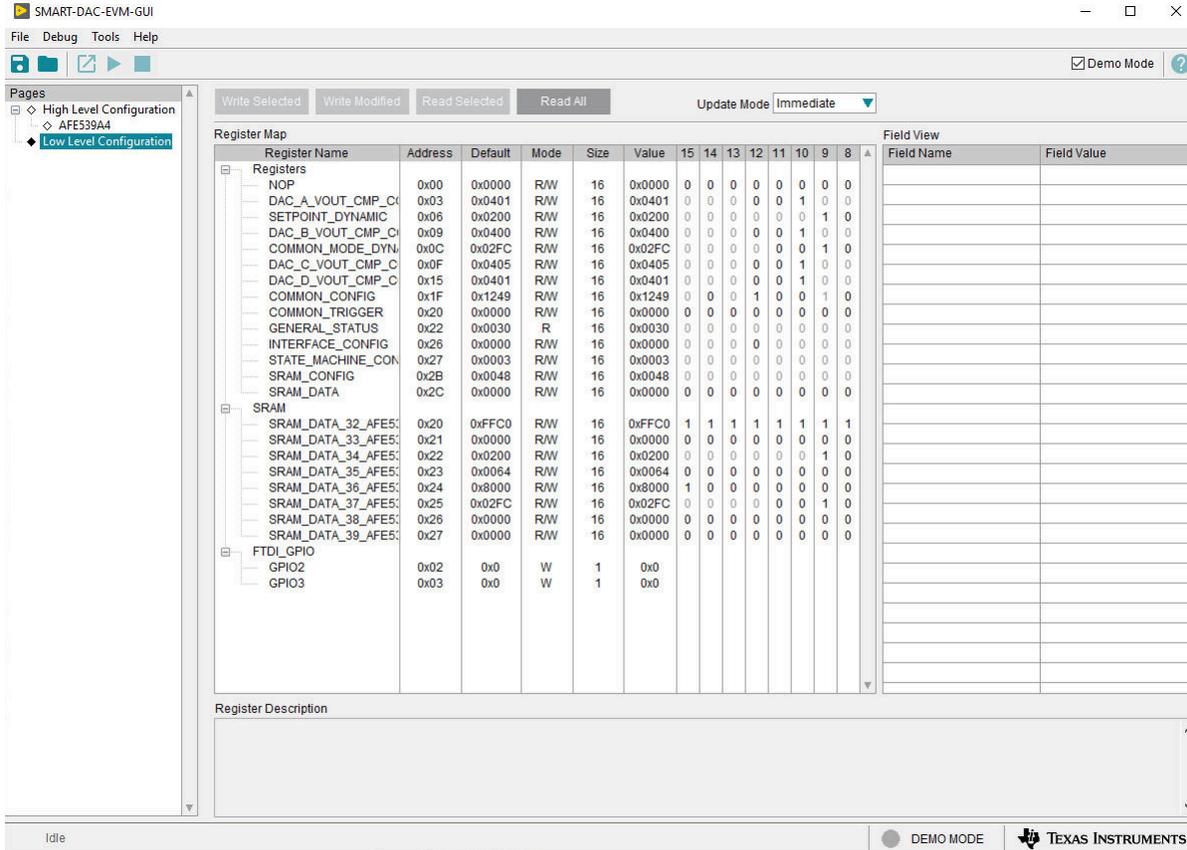

Figure 3-7. Low Level Configuration Page

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 3-8 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**

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

The high level page does not get auto-updated. To get the high level page updated after low level page modifications, click *Read All* button at the top of the screen.
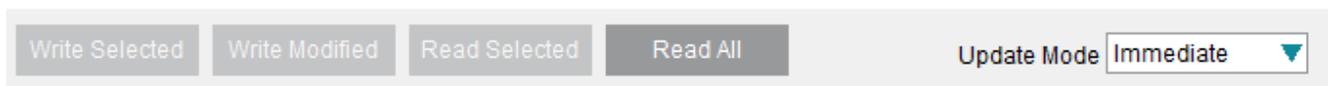
Figure 3-8. Low Level Configuration Page Options

4 Hardware Design Files

4.1 Schematic
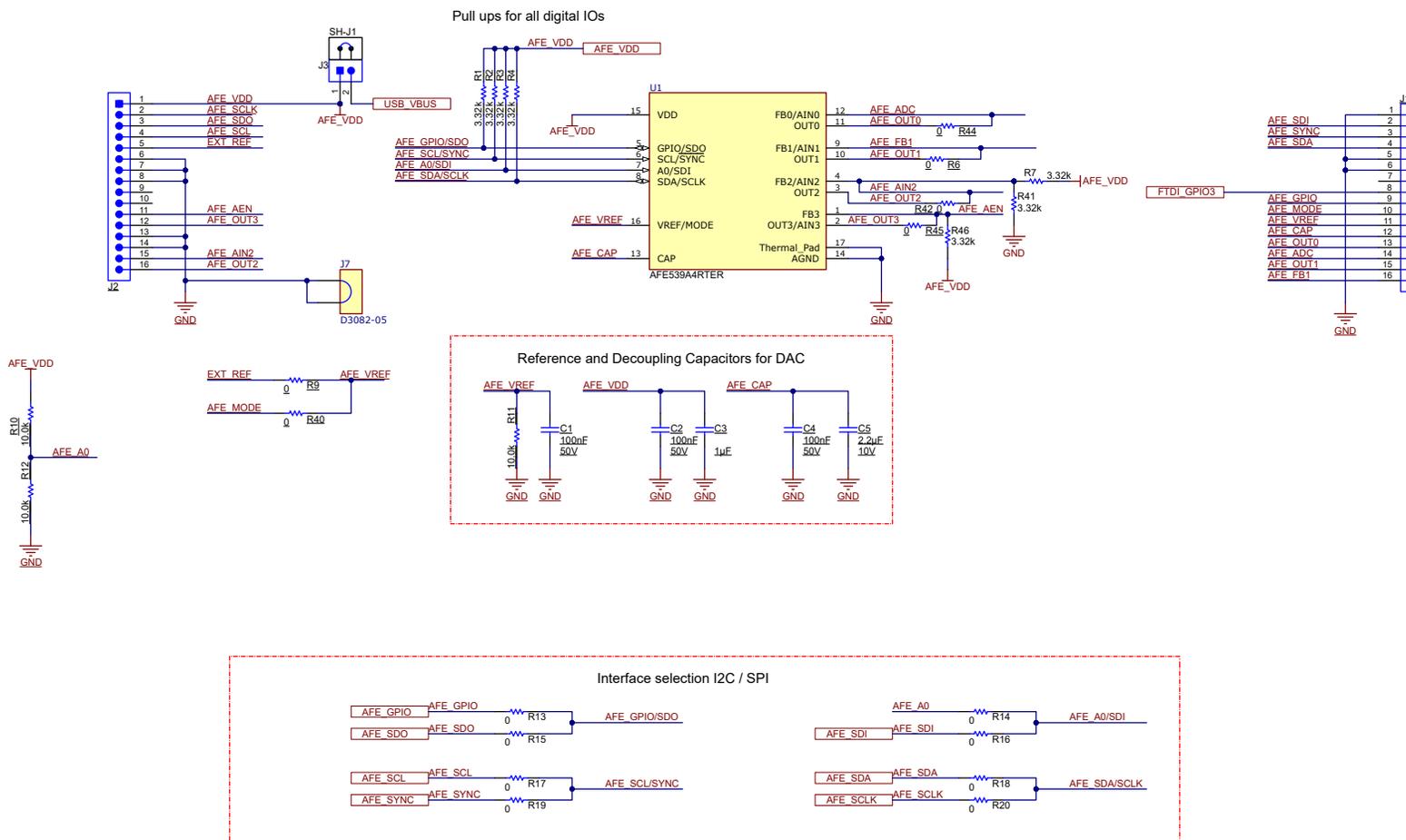

Figure 4-1. AFE539A4EVM Schematic Page 1

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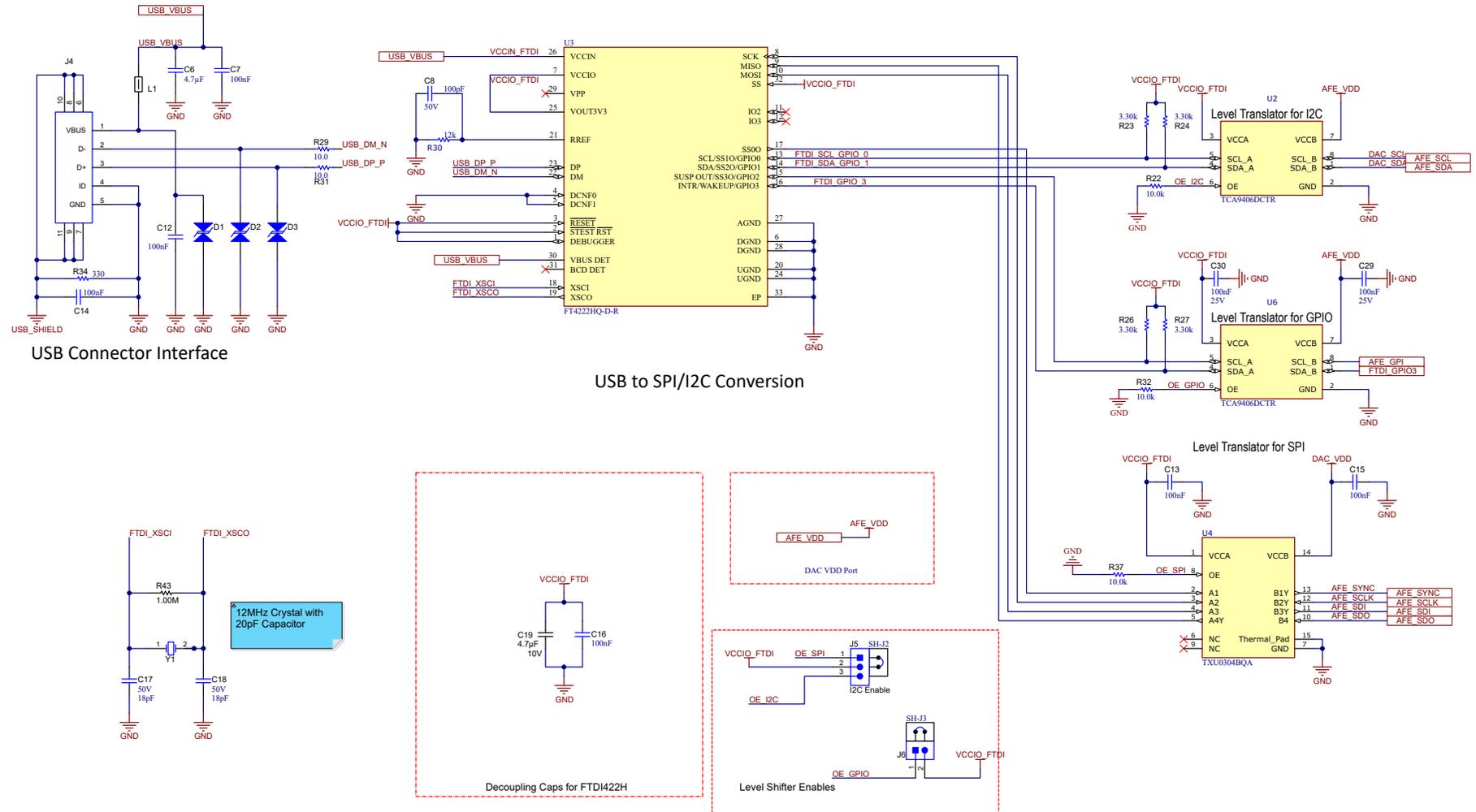
Figure 4-2. AFE539A4EVM Schematic Page 2

4.2 PCB Layout
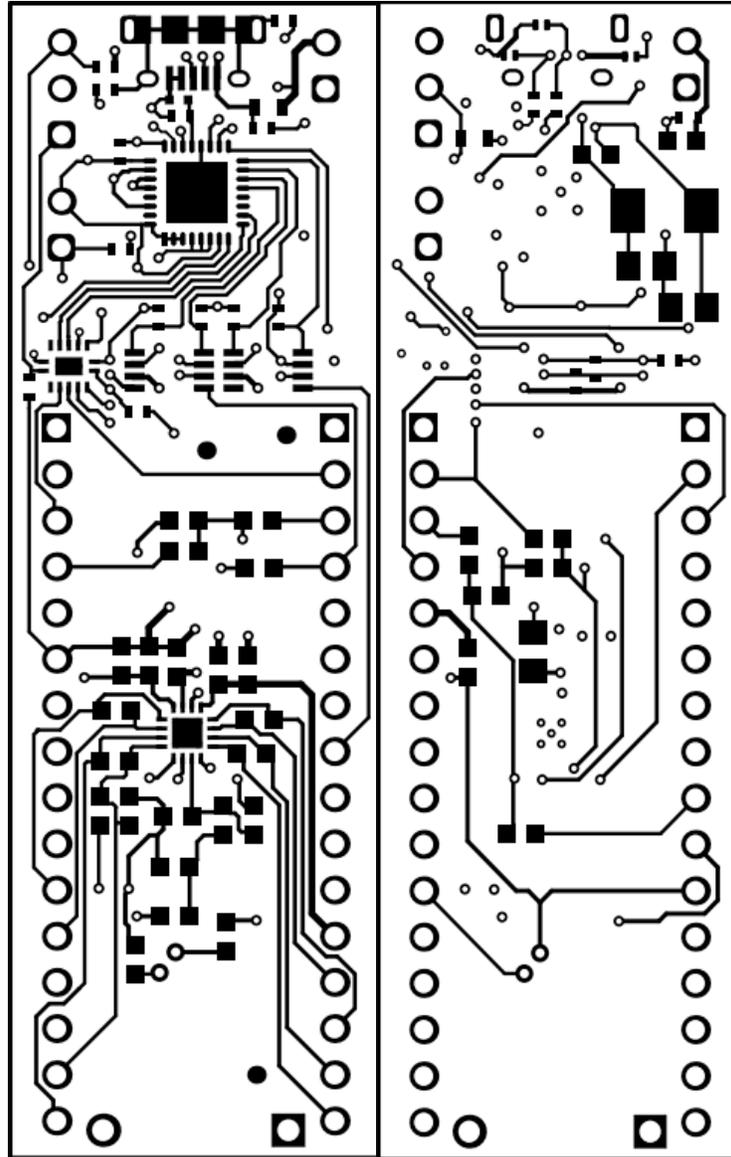
Figure 4-3. AFE539A4EVM PCB Top and Bottom Layers

4.3 Bill of Materials

lists the bill of materials for AFE539A4EVM.

Table 4-1. Bill of Materials

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer	Alternate Part Number	Alternate Manufacturer
C1, C2, C4	3	0.1uF	CAP, CERM, 0.1 µF, 50 V,+/- 5%, X7R, 0603	0603	06035C104JAT2A	AVX		
C3	1	1uF	CAP, CERM, 1 µF, 50 V,+/- 10%, X7R, 0805	0805	GJ821BR71H105KA12L	MuRata		
C5	1	2.2uF	CAP, CERM, 2.2 uF, 10 V, +/- 10%, X7R, 0603	0603	GRM188R71A225KE15D	MuRata		
C6, C19	2	4.7uF	CAP, CERM, 4.7 uF, 10 V, +/- 20%, X7R, 0603	0603	GRM188Z71A475ME15D	MuRata		
C7, C12, C13, C14, C15, C16, C29, C30	8	0.1uF	CAP, CERM, 0.1 µF, 25 V,+/- 10%, X7R, 0402	0402	CC0402KRX7R8BB104	Yageo		
C8	1	100 pF	CAP, CERM, 100 pF, 50 V, +/- 10%, X7R, 0402	0402	8.85012E+11	Wurth Elektronik		
C17, C18	2	18 pF	CAP, CERM, 18 pF, 50 V, +/- 5%, C0G/NP0, 0805	0805	C0805C180J5GACTU	Kemet		
D1, D2, D3	3		1-Channel ESD Protection Diode for USB Type-C and Thunderbolt 3, DPY0002A (X1SON-2)	DPY0002A	TPD1E01B04DPYR	Texas Instruments	TPD1E01B04DPYT	Texas Instruments
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		
J1, J2	2		Header, 2.54mm, 16x1, TH	Header, 2.54mm, 16x1, TH	22284160	Molex		
J3, J6	2		Header, 2.54mm, 2x1, Tin, TH	Header, 2.54mm, 2x1, TH	TSW-102-23-T-S	Samtec		
J4	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		
J5	1		Header, 2.54mm, 3x1, Gold, TH	Header, 2.54mm, 3x1, TH	TSW-103-08-G-S	Samtec		

Table 4-1. Bill of Materials (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer	Alternate Part Number	Alternate Manufacturer
J7	1		2 (1 x 2) Position Shunt Connector Non-Insulated 0.400" (10.16mm) Gold	JUMPER2	D3082-05	Harwin		
L1	1	600 ohm	Ferrite Bead, 600 ohm @ 100 MHz, 1 A, 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		
R1, R2, R3, R4, R7, R46	6	3.32k	RES, 3.32 k, 1%, 0.1 W, 0603	0603	RC0603FR-073K32L	Yageo		
R6, R9, R13, R14, R15, R16, R17, R18, R19, R20, R40	11	0	RES, 0, 5%, 0.1 W, 0603	0603	RC0603JR-070RL	Yageo America		
R11	1	10.0k	RES, 10.0 k, 1%, 0.1 W, 0603	0603	RC0603FR-0710KL	Yageo		
R22, R32, R37	3	10.0k	RES, 10.0 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	RMCF0402FT10K0	Stackpole Electronics Inc		
R23, R24, R26, R27	4	3.30k	RES, 3.30 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	RK73H1ETTP3301F	KOA Speer		
R29, R31	2	10	RES, 10.0, 1%, 0.063 W, 0402	0402	RK73H1ETTP10R0F	KOA Speer		
R30	1		12 kOhms ±1% 0.1W, 1/10W Chip Resistor 0402 (1005 Metric) Automotive AEC-Q200 Thick Film	0402	ERJ-2RKF1202X	Panasonic ECG		
R34	1	330	RES, 330, 1%, 0.1 W, AEC-Q200 Grade 0, 0402	0402	ERJ-2RKF3300X	Panasonic		
R43	1	1.00Meg	RES, 1.00 M, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW06031M00FKEA	Vishay-Dale		
SH-J1, SH-J2, SH-J3	3	1x2	Shunt, 100mil, Gold plated, Black	Shunt	SNT-100-BK-G	Samtec	969102-0000-DA	3M
U1	1		Smart Analog Front End (AFE) With Quad-Channel, 10-bit DAC and ADC for Proportional-Integral (PI) Control With I2C and SPI Interface	WQFN16	AFE539A4RTER	Texas Instruments		

Table 4-1. Bill of Materials (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer	Alternate Part Number	Alternate Manufacturer
U2, U6	2		Voltage Level Translator Bidirectional 1 Circuit 2 Channel 24Mbps SM8	SSOP8	TCA9406DCTR	Texas Instruments		
U3	1		IC BRIDGE USB TO I2C/SPI 32VQFN					
U4	1		4-Bit Fixed Direction Voltage-Level Translator with Schmitt- Trigger Inputs, and Tri-State Outputs, WQFN14	WQFN14	TXU0304BQA	Texas Instruments		
Y1	1		Crystal, 12 MHz, 18 pF, SMD	ABM3	ABM3-12.000MHZ-B2-T	Abracon Corporation		
R10, R12	0	10.0k	RES, 10.0 k, 1%, 0.1 W, 0603	0603	RC0603FR-0710KL	Yageo		
R41	0	3.32k	RES, 3.32 k, 1%, 0.1 W, 0603	0603	RC0603FR-073K32L	Yageo		
R42, R44, R45	0	0	RES, 0, 5%, 0.1 W, 0603	0603	RC0603JR-070RL	Yageo America		

5 Additional Information

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 AFE539A4EVM. This user's guide is available from the TI web site under literature number SLAU913. 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 can 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
AFE539A4 product page	SBASAC1A

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.

<div style="border:2px solid black; padding:10px;">

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.

</div>

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.