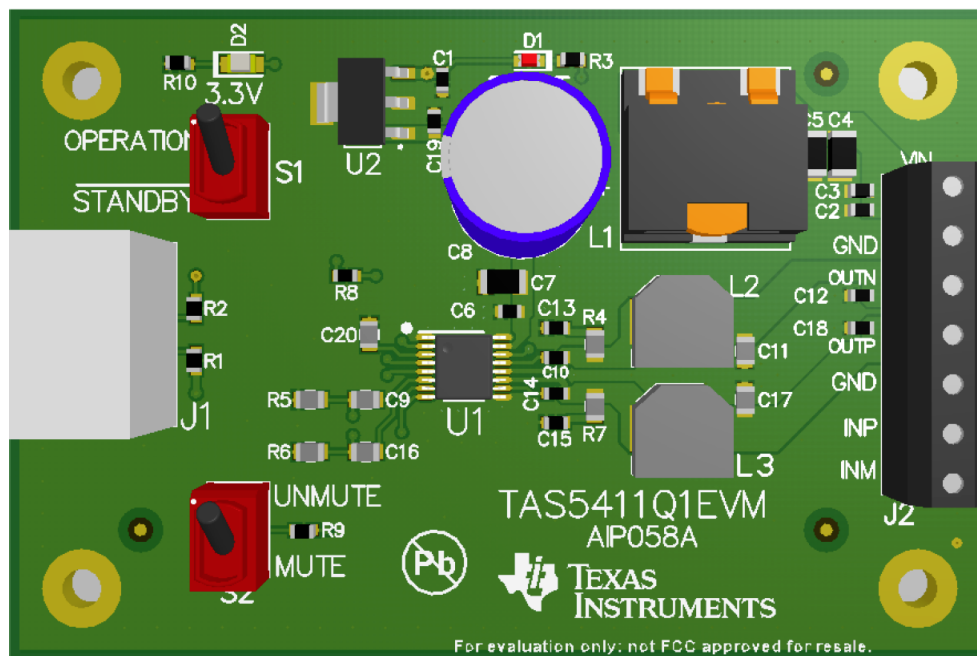


## TAS5411EVM User's Guide

The TAS5411-Q1 evaluation module (EVM) is intended to demonstrate the capabilities of the TAS5411-Q1 device. All the device features can be accessed through the hardware and the software graphical user interface (GUI) which is supplied. This user's guide contains a description of the EVM and the GUI. The schematic, bill of materials (BOM), and board layout are included.

### 1 Hardware Overview

The TAS5411EVM showcases TI's TAS5411-Q1 analog input class-D closed-loop mono amplifier. The EVM is usable as stand-alone platform with default I<sup>2</sup>C register settings. The EVM runs in default I<sup>2</sup>C register settings. The EVM can also work with a USB2IIC-2 board and TAS5421-Q1 GUI for programming the I<sup>2</sup>C register settings.



**Figure 1. TAS5411EVM**

### 1.1 TAS5411EVM Features

- Runs without I<sup>2</sup>C initialization
- Has GUI control via USB port
- Passes EMC CISPR 25, class 5

### 1.2 TAS5411EVM Gain

The gain setting for TAS5411-Q1 device is I<sup>2</sup>C programmable. The four gain options are 20 dB, 26 dB, 32 dB, and 36 dB. Set the gain by modifying I<sup>2</sup>C control register 0x03. By default, the gain is 26 dB.

### 1.3 TAS5411EVM PWM Switching Frequencies

The PWM switching frequency is I<sup>2</sup>C programmable. The two  $f_{(SW)}$  options are 400 kHz and 500 kHz. Programming the frequency in control register 0x03 is via the GUI and IIC2USB-2 board. By default,  $f_{(SW)}$  is 400 kHz.

### 1.4 TAS5411EVM SpeakerGuard™ Protection Circuitry

The SpeakerGuard protection circuitry is programmable for different voltage levels. Programming the levels in control register 0x03 via the GUI and IIC2USB-2 board. The control register shows the default value for the SpeakerGuard protection-circuitry voltage level.

**Table 1. Control Register**

D7	D6	D5	D4	D3	D2	D1	D0	FUNCTION
0	1	1	1	1	0	0	0	26-dB gain, $f_{(SW)}$ set to 400 kHz, SpeakerGuard protection circuitry is set to maximum voltage.
—	—	—	—	—	—	—	1	$f_{(SW)}$ set to 500 khz
—	—	—	—	—	1	1	—	RESERVED
—	—	1	1	0	—	—	—	SpeakerGuard protection circuitry is set to 14-V peak output.
—	—	1	0	1	—	—	—	SpeakerGuard protection circuitry is set to 11.8-V peak output.
—	—	1	0	0	—	—	—	SpeakerGuard protection circuitry is set to 9.8-V peak output.
—	—	0	1	1	—	—	—	SpeakerGuard protection circuitry is set to 8.4-V peak output.
—	—	0	1	0	—	—	—	SpeakerGuard protection circuitry is set to 7-V peak output.
—	—	0	0	1	—	—	—	SpeakerGuard protection circuitry is set to 5.9-V peak output.
—	—	0	0	0	—	—	—	SpeakerGuard protection circuitry is set to 5-V peak output.
0	0	—	—	—	—	—	—	Set gain to 20 dB.
0	1	—	—	—	—	—	—	Set gain to 32 dB.
1	1	—	—	—	—	—	—	Set gain to 36 dB.

## 2 TAS5411EVM Setup

This section describes the TAS5411EVM setup and software installation.

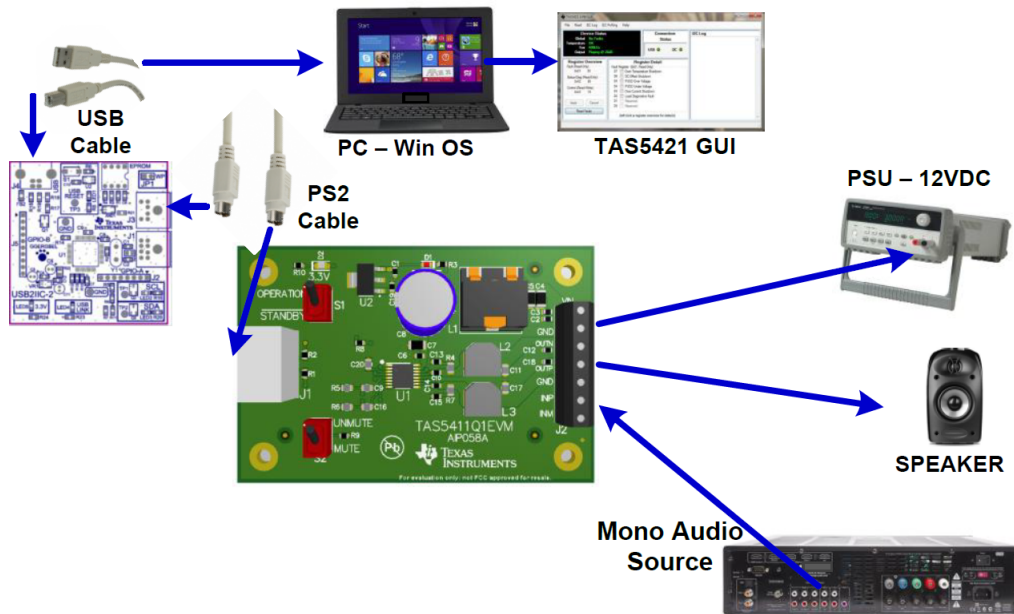


Figure 2. TAS5411EVM Connection

Hardware requirements (see [Figure 2](#)):

- Computer running Windows XP, Windows 7, or Windows 8
- Power supply unit (PSU) 5–18 VDC
- USB cable (provided)
- PS2 cable (provided)
- USB2IIC-2 board (provided)
- Audio source: analog RCA input

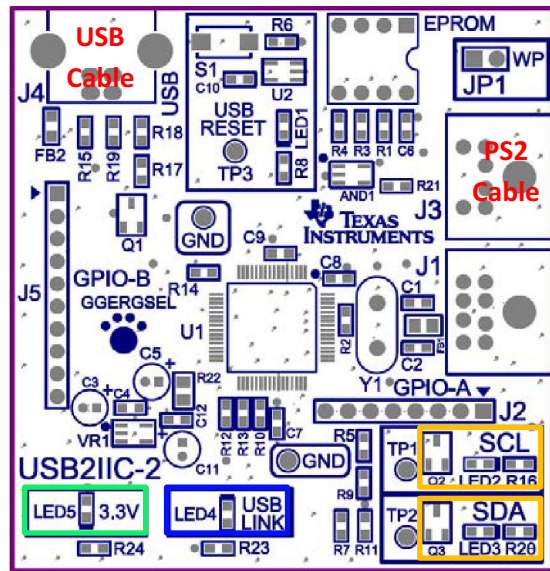
Hardware setup:

1. Connect the 6-pin (PS2) cable to the TAS5411EVM on one end and to the USB2IIC-2 board on the other (see [Figure 2](#)).
2. Plug in the USB cable from the PC to the USB2IIC-2 board (shown in [Figure 3](#)). The 3.3-V and USB LINK LEDs light. The I<sup>2</sup>C LEDs (SDA/SCL) on the USB2IIC-2 board are blinking (colored boxes in [Figure 3](#)).
3. Connect J2 (see [Figure 2](#)):
  - PSU: Pin 7 (+) and Pin 6 (-) to PSU
  - The speaker: Pin 5 (-) and Pin 4 (+) to speakers
  - The audio input: Pin 2 (+) and Pin 1 (-) to input source
  - Leave Pin 3 unconnected or connect it to ground.
4. Connect the PSU to the TAS5411EVM and turn on the power. The 3.3-V LED (D1 on the EVM board) lights (see [Figure 1](#)).
5. Set switch S1 to OPERATION and S2 to UNMUTE (see [Figure 1](#)).

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**NOTE:** The TAS5411EVM can run without a USB2IIC-2 board.

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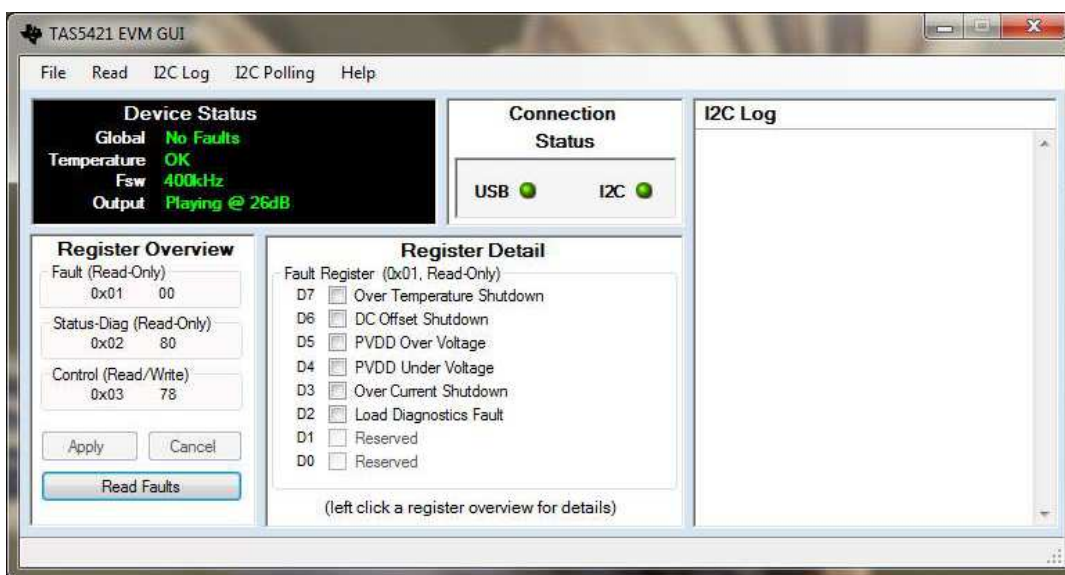
A002

Figure 3. USB2IIC-2 Board

### 3 Software Installation

The TAS5411-Q1 use the TAS5421-Q1 GUI. It is available on the [product folder](#) by clicking on *Tools and Software* tab to obtain the latest release of the GUI.

Execute the GUI installation program, TAS5421-Q1 GUI Setup.exe. After the program is installed, run the TAS5421 EVM GUI. Figure 4 shows the start-up GUI image. The GUI displays the fault register when first started. I<sup>2</sup>C data is polling by default. The I<sup>2</sup>C device address for the TAS5411-Q1 device is D8. Green USB and I<sup>2</sup>C LEDs show that USB is connected and I<sup>2</sup>C communication is valid.



A003

Figure 4. GUI Image at Start-Up

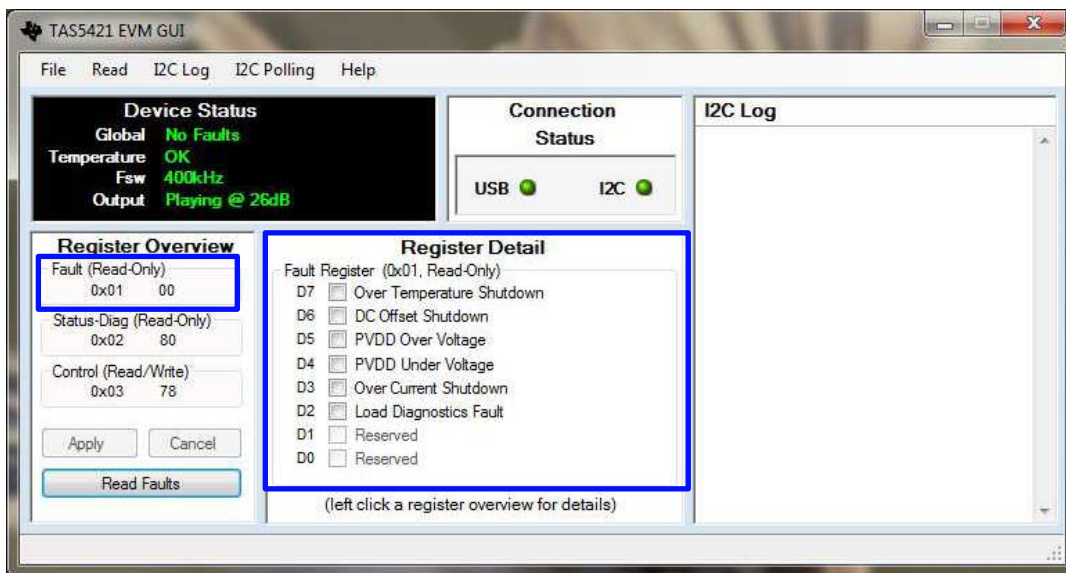
## 4 Using the GUI With the TAS5411EVM Board

The TAS5411EVM does not need initialization. On powering up, the device performs load diagnostics. If there is no problem, the device transitions to play mode with the following default values are set:

- Gain: 26 dB
- $f_{(sw)}$ : 400 kHz
- SpeakerGuard protection circuitry: Maximum voltage level

### 4.1 Checking the Fault Register

When the GUI first runs, the Register Detail box displays the fault register. The GUI runs with I<sup>2</sup>C data polling as the default setting, clearing any previous faults after the first poll. If any fault condition is still active after device goes into play mode, with the exception of open load, the device enters the load-diagnostics mode.

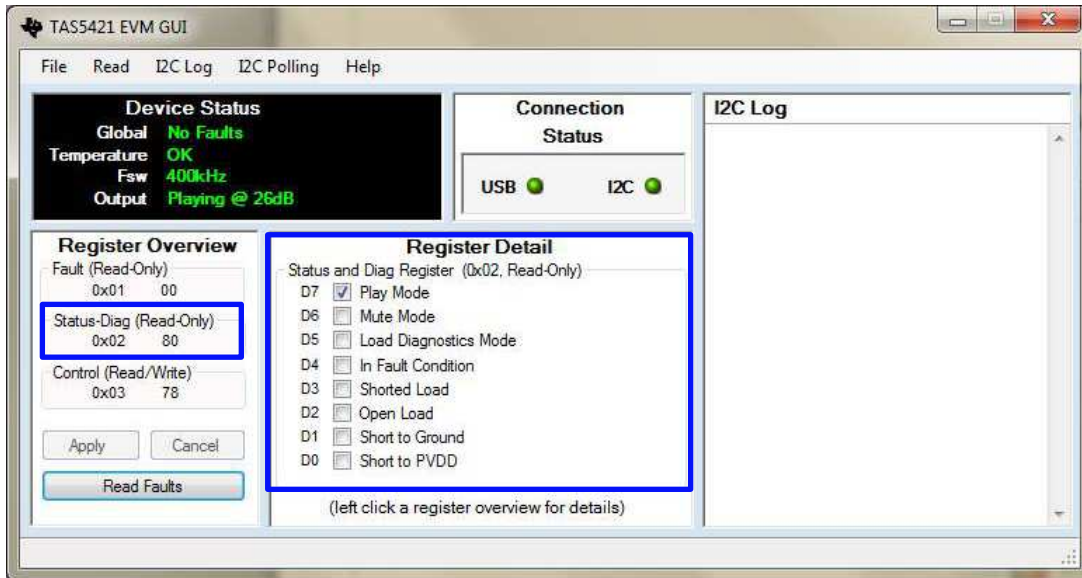


A004

Figure 5. Fault Register

### 4.2 Checking the Status Register

Figure 6 shows the status register. Click on *Status-Diag (Read-Only)* (0x02), shown in Figure 6 (blue boxes for illustration only, not shown on GUI) and the register detail appears in the middle box.

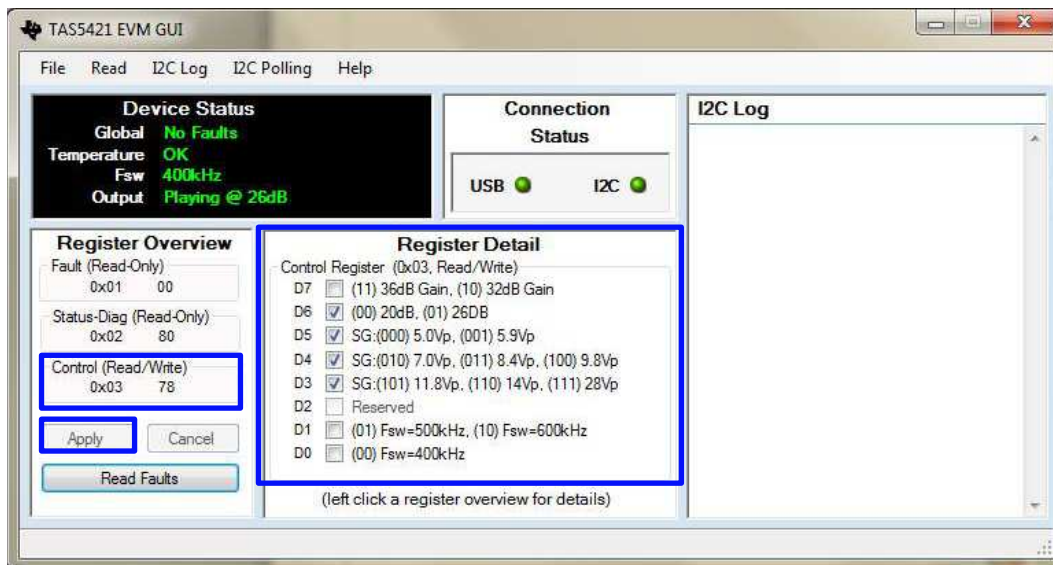


A005

Figure 6. Status Register

### 4.3 Checking and Changing the Control Register

Figure 7 shows the control register. In this register, one can change the default values for  $f_{(SW)}$ , SpeakerGuard protection circuitry, and gain. Select the desired check boxes; then click apply to update the device status box.



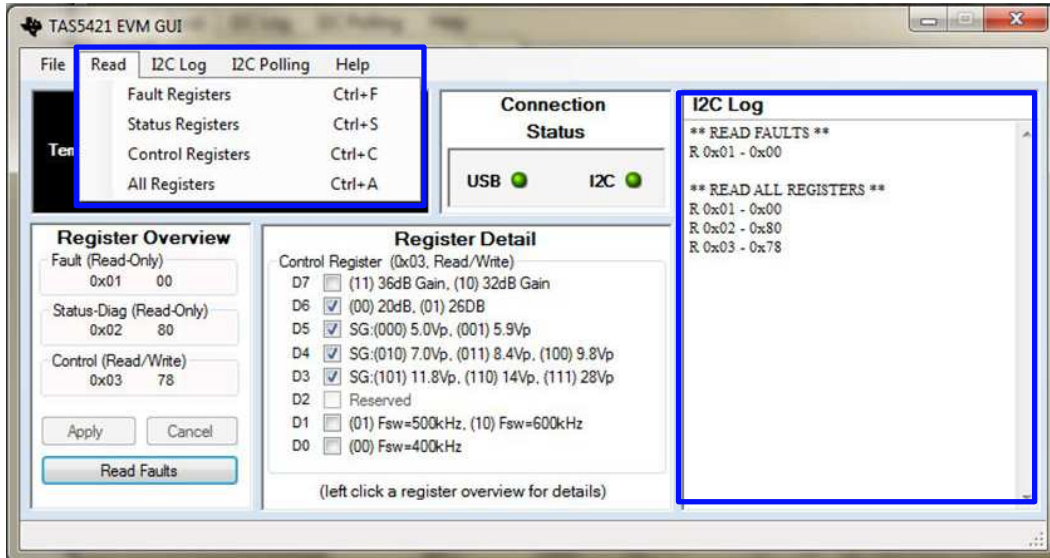
A006

Figure 7. Control Register

#### 4.4 Read and I<sup>2</sup>C Log

The I<sup>2</sup>C log displays I<sup>2</sup>C registers read data (see Figure 8). An option exists for reading the three registers all at once or individually. Pressing the Read Faults button displays the fault register value on the I<sup>2</sup>C log as well.

Starting the GUI enables the I<sup>2</sup>C log. An option is available to turn off logging on the pulldown I<sup>2</sup>C Log menu.

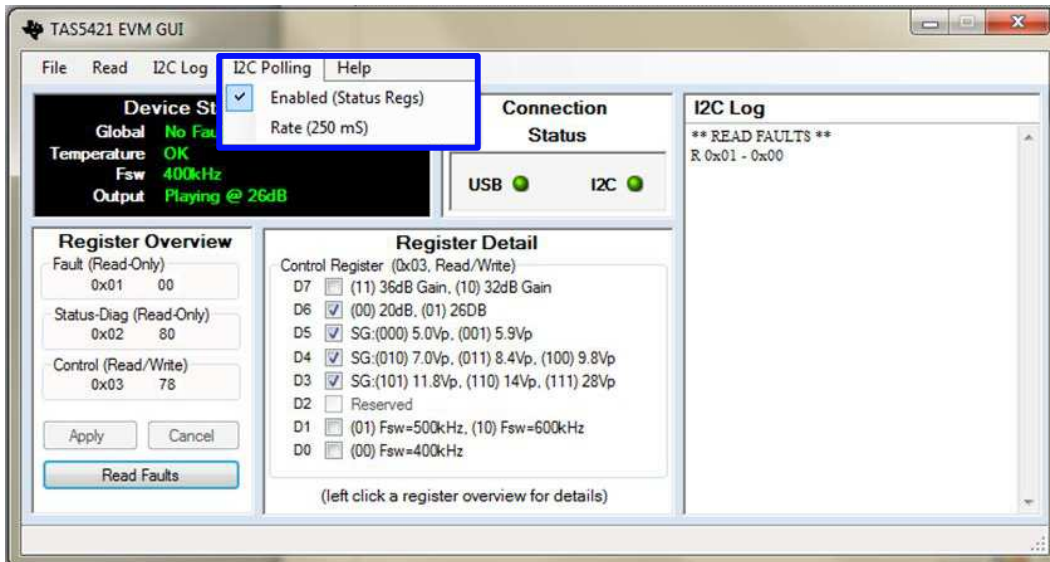


A007

Figure 8. Read and I<sup>2</sup>C Log

#### 4.5 I<sup>2</sup>C Polling

As mentioned above, the I<sup>2</sup>C polling is on when the GUI starts. To disable I<sup>2</sup>C polling, click on I<sup>2</sup>C polling pulldown tab and unselect the check box. The polling time can also be changed as shown in Figure 9.



A008

Figure 9. I<sup>2</sup>C Polling

## 5 Board Layouts, Bill of Materials, and Schematic

### 5.1 TAS5411EVM Board Layouts

Figure 10 and Figure 11 show the board layouts for the EVM.

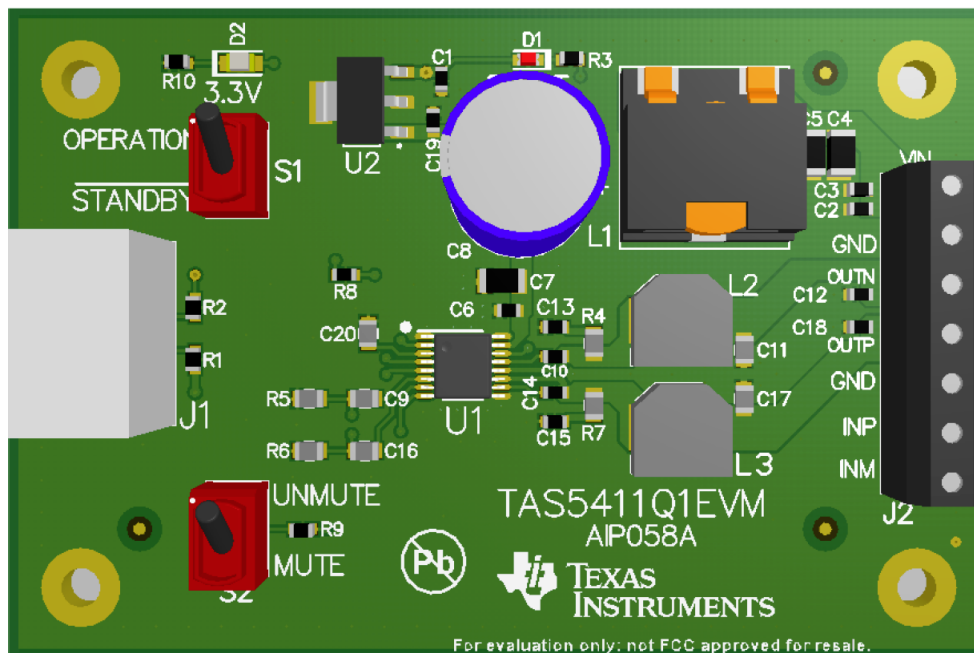


Figure 10. TAS5411EVM Top View

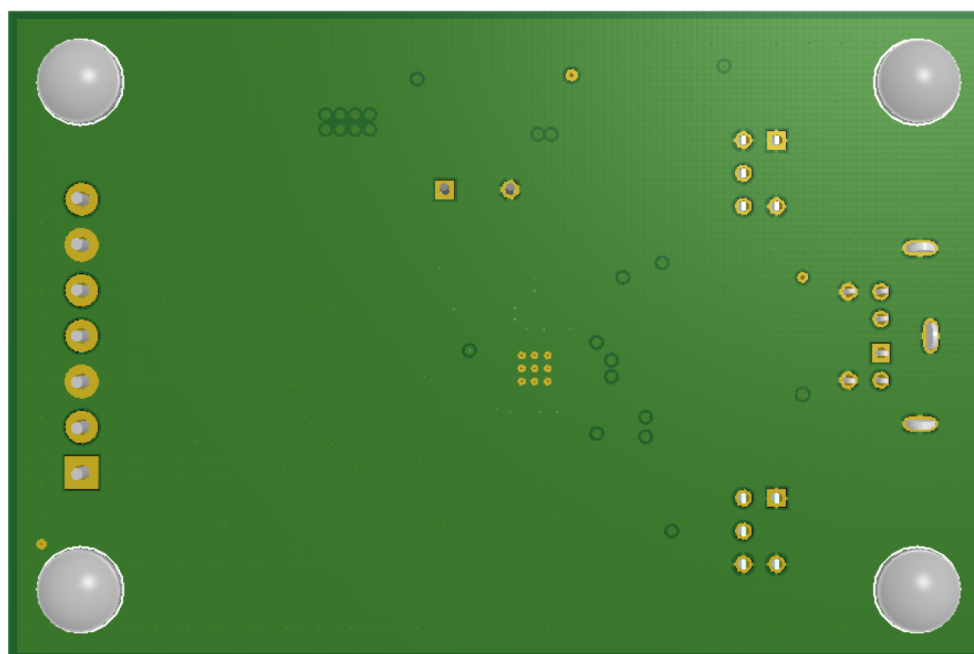


Figure 11. TAS5411EVM Bottom View



## 5.2 Bill of Materials

Table 2 lists the BOM for this EVM.

**Table 2. Bill of Materials**

ITEM	MFR PART NO.	MFR	QTY	REF DESIGNATORS	DESCRIPTION
1	GRM188R71E104KA01D	MuRata	3	C1, C6, C19	Capacitor, ceramic, 0.1- $\mu$ F, 25-V, $\pm$ 10%, X7R, 0603
2	GRM188R71H222KA01D	MuRata	1	C2	Capacitor, ceramic, 2200-pF, 50-V, $\pm$ 10%, X7R, 0603
3	GRM188R71E823KA01D	MuRata	1	C3	Capacitor, ceramic, 0.082- $\mu$ F, 25-V, $\pm$ 10%, X7R, 0603
4	GRM31CR71E475KA88L	MuRata	2	C4, C5	Capacitor, ceramic, 4.7- $\mu$ F, 25-V, $\pm$ 10%, X7R, 1206
5	GRM31CR71E106KA12L	MuRata	1	C7	Capacitor, ceramic, 10- $\mu$ F, 25-V, $\pm$ 10%, X7R, 1206
6	UBT1E331MPD1TD	Nichicon	1	C8	Capacitor, AL, 330- $\mu$ F, 25-V, $\pm$ 20%, 0.075- $\Omega$ , TH
7	GRM21BR71E105KA99L	MuRata	3	C9, C16, C21	Capacitor, ceramic, 1- $\mu$ F, 25-V, $\pm$ 10%, X7R, 0805
8	GRM188R71E224KA88D	MuRata	2	C10, C14	Capacitor, ceramic, 0.22- $\mu$ F, 25-V, $\pm$ 10%, X7R, 0603
9	GRM21BR71E335KA73L	MuRata	2	C11, C17	Capacitor, ceramic, 3.3- $\mu$ F, 25-V, $\pm$ 10%, X7R, 0805
10	GRM188R71E103KA01D	MuRata	2	C12, C18	Capacitor, ceramic, 0.01- $\mu$ F, 25-V, $\pm$ 10%, X7R, 0603
11	GRM188R72E471KW07D	MuRata	2	C13, C15	Capacitor, ceramic, 470-pF, 250-V, $\pm$ 10%, X7R, 0603
12	LTST-C190CKT	Lite-On	1	D1	LED, Red, SMD
13	LTST-C171GKT	Lite-On	1	D2	LED, Green, SMD
14	SJ5382	3M	4	H1, H2, H3, H4	Bumpon, hemisphere, 0.25 x 0.075, clear
15	MD-60SM	CUI Inc.	1	J1	Receptacle, 6x1_3MH, R/A, TH
16	ED555/7DS	On-Shore Technology	1	J2	Terminal Block, 6A, 3.5mm Pitch, 7-Pos, TH
17	SER1360-103KLB	Coilcraft	1	L1	Inductor, shielded E core, ferrite, 10- $\mu$ H, 7.2-A, 0.01- $\Omega$ , SMD
18	DFEG7030D-150M	Toko	2	L2, L3	Inductor, Shielded, Metal Composite, 15 $\mu$ H, 2.7 A, 0.179 ohm, AEC-Q200 Grade 1, SMD
19	RC0603FR-074K7L	Yageo America	4	R1, R2, R8, R9	Resistor, 4.70 k $\Omega$ , 1%, 0.1-W, 0603
20	CRCW0603499RFKEA	Vishay-Dale	2	R3, R10	Resistor, 499- $\Omega$ , 1%, 0.1-W, 0603
21	CRCW08055R60JNEA	Vishay-Dale	2	R4, R7	Resistor, 5.6- $\Omega$ , 5%, 0.125-W, 0805
22	CRCW080549K9FKEA	Vishay-Dale	2	R5, R6	Resistor, 49.9-k $\Omega$ , 1%, 0.125-W, 0805
23	200USP1T1A1M2RE	E-Switch	2	S1, S2	Switch, SPDT, On-On, 2 Pos, TH
24	TAS5411QPWPRQ1	Texas Instruments	1	U1	10-W mono automotive digital amplifier with diagnostics, PWP0016A
25	UA78M33CDCY	Texas Instruments	1	U2	Positive voltage regulator, DCY0004A

### 5.3 TAS5411EVM Schematic

Figure 12 shows the TAS5411EVM schematic.

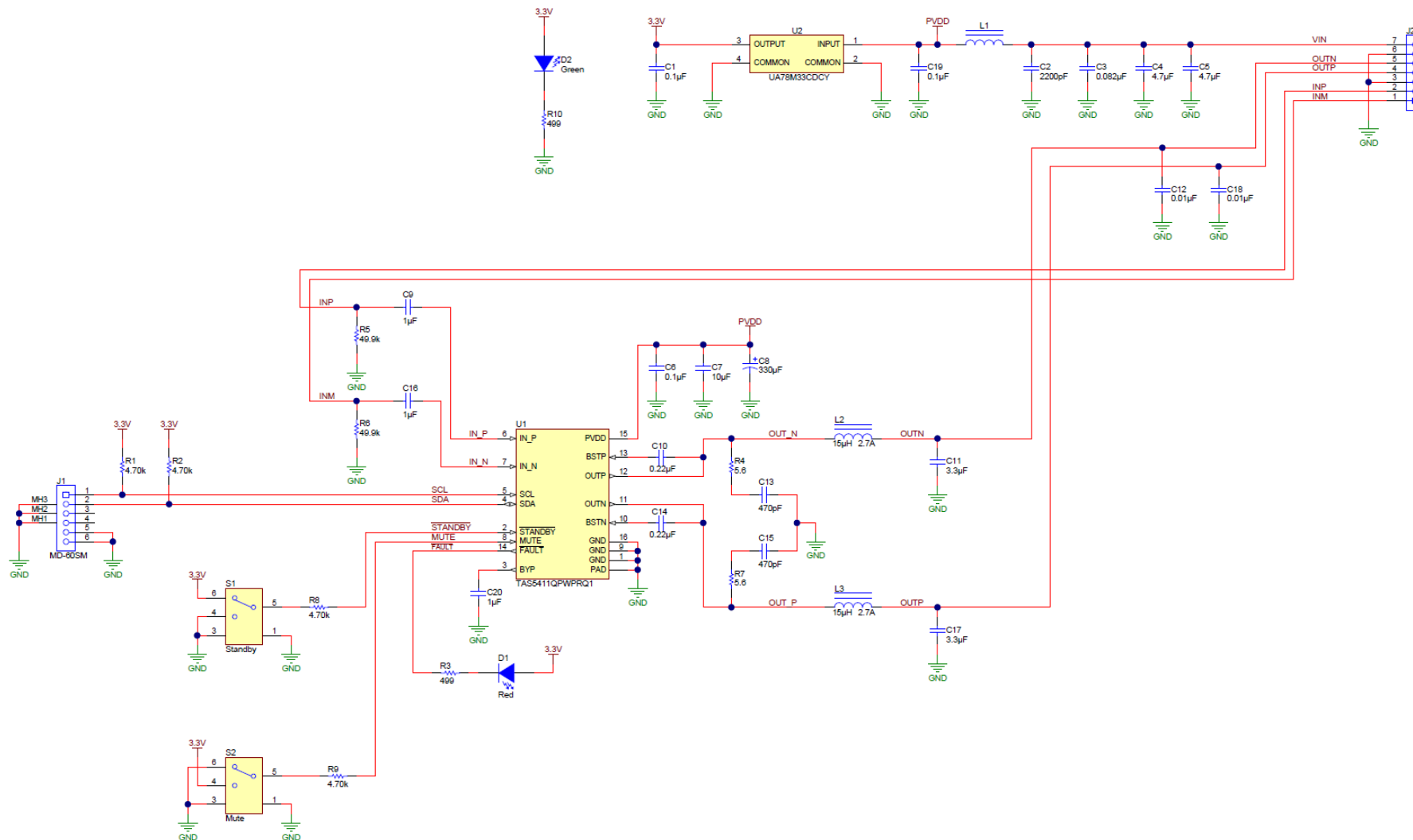


Figure 12. TAS5411EVM Schematic

## STANDARD TERMS AND CONDITIONS FOR EVALUATION MODULES

1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, or documentation (collectively, an "EVM" or "EVMs") to the User ("User") in accordance with the terms and conditions set forth herein. Acceptance of the EVM is expressly subject to the following terms and conditions.
  - 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 and conditions 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 and conditions 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 any defects that are 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. Moreover, TI shall not be liable for any defects that result from User's design, specifications or instructions for such EVMs. Testing and other quality control techniques are used to the extent TI deems necessary or as mandated by government requirements. TI does not test all parameters of each EVM.
  - 2.3 If any EVM fails to conform to the warranty set forth above, TI's sole liability shall be at its option to repair or replace such EVM, 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.
3. *Regulatory Notices:*
  - 3.1 *United States*
    - 3.1.1 *Notice applicable to EVMs not FCC-Approved:*

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

##### **Concerning EVMs Including Radio Transmitters:**

This device complies with Industry Canada license-exempt RSS standard(s). 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/lstds/ti\\_ja/general/eStore/notice\\_01.page](http://www.tij.co.jp/lstds/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。  
[http://www.tij.co.jp/lstds/ti\\_ja/general/eStore/notice\\_01.page](http://www.tij.co.jp/lstds/ti_ja/general/eStore/notice_01.page)

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 by Radio Law of Japan to follow the instructions below with respect to EVMs:

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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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。[http://www.tij.co.jp/llds/ti\\_ja/general/eStore/notice\\_02.page](http://www.tij.co.jp/llds/ti_ja/general/eStore/notice_02.page)

#### 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.

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