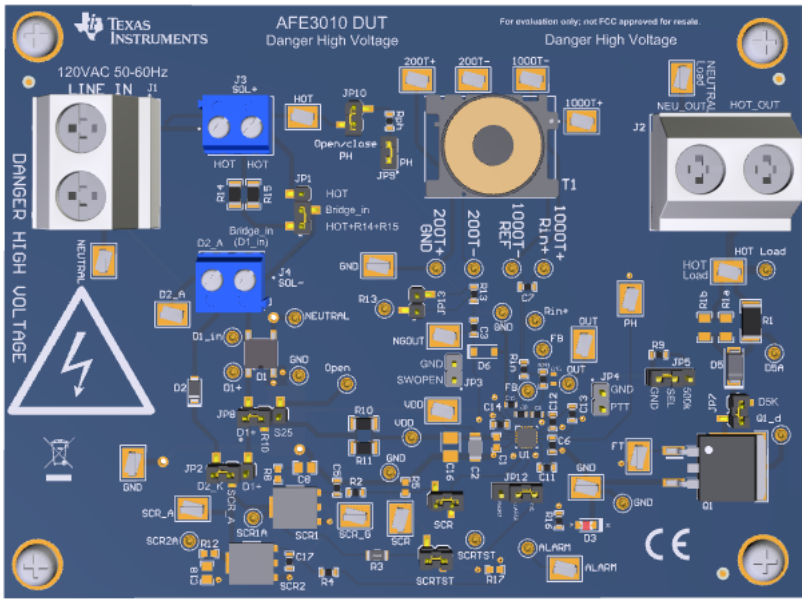
AFE3010 Evaluation Module



This user's guide describes the characteristics, operation, and use of the AFE3010 evaluation module (EVM). This EVM is designed to evaluate the performance of the AFE3010 as a ground-fault circuit interrupter IC with self-tests. Throughout this document, the terms evaluation board, evaluation module, and EVM are synonymous with the AFE3010EVM. This document also includes a schematic, reference printed-circuit board (PCB) layouts, and a complete bill of materials (BOM).

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1 Overview

The AFE3010 device is a precision, low-power, ground-fault circuit interrupter (GFCI) controller used to detect leakage currents or faults current in electrical circuits. It is a single IC solution that continuously monitors its accompanying electrical circuitry for multiple fault conditions to verify it is working properly.

1.1 EVM Kit Contents

Table 1 summarizes the contents of the AFE3010EVM kit. Contact the Texas Instruments Product Information Center nearest you if any component is missing. TI also recommends checking the AFE3010 device product folder at www.ti.com for any further information regarding this product.

Table 1. AFE3010EVM Kit Contents

Item	Item Part Number	Quantity
AFE3010EVM test board	AFE3010EVM	1
Shunt, 100-mil, gold-plated, black	SNT-100-BK-G	11

1.2 Related Documentation From Texas Instruments

This document provides information regarding Texas Instruments' integrated circuits used in the assembly of the AFE3010EVM.

Table 2. Related Documentation

Document Description	Literature Number
AFE3010 product data sheet	SBFS042

2 Hardware

The AFE3010EVM is intended to provide basic functional evaluation of the AFE3010 device. The fixture layout is not intended to be a model for the target circuit, nor is it laid out for electromagnetic compatibility (EMC) testing. The AFE3010EVM consists of one PCB with test points and sockets for external hardware connections, as well as pads to solder down optional circuitry.

It is extremely important to implement high-voltage safety precautions when using the AFE3010EVM as the board is designed to connect to a high-power AC source. The entire board is high-voltage and thus no part of it is safe to touch when it is connected to a live source. The AFE3010EVM was not designed to actually break or interrupt the source voltage if a fault current is detected.

- Never interact with the board or any of its electrical nodes when it is connected to a live source.
- Always keep the board in a high-voltage safety box when connected to a live voltage.
- Always use high-voltage differential probes when probing and measuring test points on the board.

2.1 Features

The AFE3010EVM PCB provides the following features:

- Ease of access to device pins with test points and sockets pins.
- Single sockets allows the user to experiment with different passive suited for their specific application.
- A generic, two-core current transformer with 1000-turn and 200-turn coils.
- High-power headers and components rated up to 40 A and 300 V.

See the device data sheet listed in Table 2 for comprehensive information about the AFE3010 and the available gain options.

3 Operation

3.1 Quick Start Setup

Follow these procedures to set up and ensure proper operation of the AFE3010EVM with its onboard current transformer, T1.

Step 1. Gather equipment for safe high-voltage test setup.

Step 2. Ensure the EVM is completely de-energized and not connected to any source voltage.

Step 3. Make sure the header pins are configured and shorted according to Figure 1. Note that correct EVM configuration is also reflected in Figure 3

Step 4. Insert a solenoid (not included) from HOT (line side) to the anode of D2 (D2_A). Use the J3 and J4 headers to screw in solenoid terminal to ensure secure connections. Refer to Figure 2 on how to make this connection.

- If a solenoid is not available, consider using a through-hole resistor of 10 kΩ. A lower resistance more similar to the resistance of a solenoid could be used, but the power rating needed will substantially increase. Ensure the power rating of the resistor is sufficient to withstand a couple cycles of the source voltage.

Step 5. Collect two shielded wires (not included) each of approximately 12 inches in length. Refer to these as W1 and W2. The gauge of W1 and W2 should be equal or smaller than 18 AWG. Strip the ends of both wires.

Step 6. According to Figure 2 screw W1 and W2 into J1, feed through T1, and then screw into J2. It is important that the wires start at J1 and go through the T1 hole by entering from the bottom of the board.

Step 7. Collect more wires as needed to connect source and load to the J1 and J2 headers respectively. Ensure source is off or disabled when making any connections to it.

Step 8. Place the board and all exposed metal connections into a high-voltage safety box.

Step 9. Close the box.

Step 10. Enable the source and line voltage and observe that the ALARM LED (D3) will blink once to indicate a successful first self-test. The LED will remain off during standby operation and will only blink if the device fails a self-test. This is the LED behavior when SEL = GND.

Step 11. If the LED begins blinking and there is no fault or leakage current, then the device is failing a self-test due to an incorrect connection. Consider the following debug steps:

1. If the LED begins blinking immediately after power up, then this could be a failure with an internal watchdog timer. Ensure all connections with PH and SCRTST pins are secure on the board.
2. If the LED begins blinking around 5 seconds after power up, then this indicates a self-test failure.
3. To eliminate one variable, change float the SEL pin. When SEL = GND, the device will perform its internal SCR self-test. When SEL pin is floating, it will be pulled up and this mode stops the AFE3010 from performing the SCR self-test.
4. If the device begins working (LED blinks once on power up and remains off), then there could be a problem with the SCRTST pin. Contact TI support for more assistance.
5. If the LED still blinks after 5 seconds and SEL = floating, then this means the device is failing its self-fault test.
6. Check connections with the FT pin: Q1, JP7, D5, and R1. Check that the W1 and W2 wires are set up correctly.
7. If device is still failing, then probe the OUT pin and the FT pin. See Section 3.2 for instructions on making measurements. Check that the output voltage (OUT) of the amplifier reacts to the enabling of the FT pin. The self-FT signal on OUT must be falling and thus go below the 2.5-V amplifier offset.

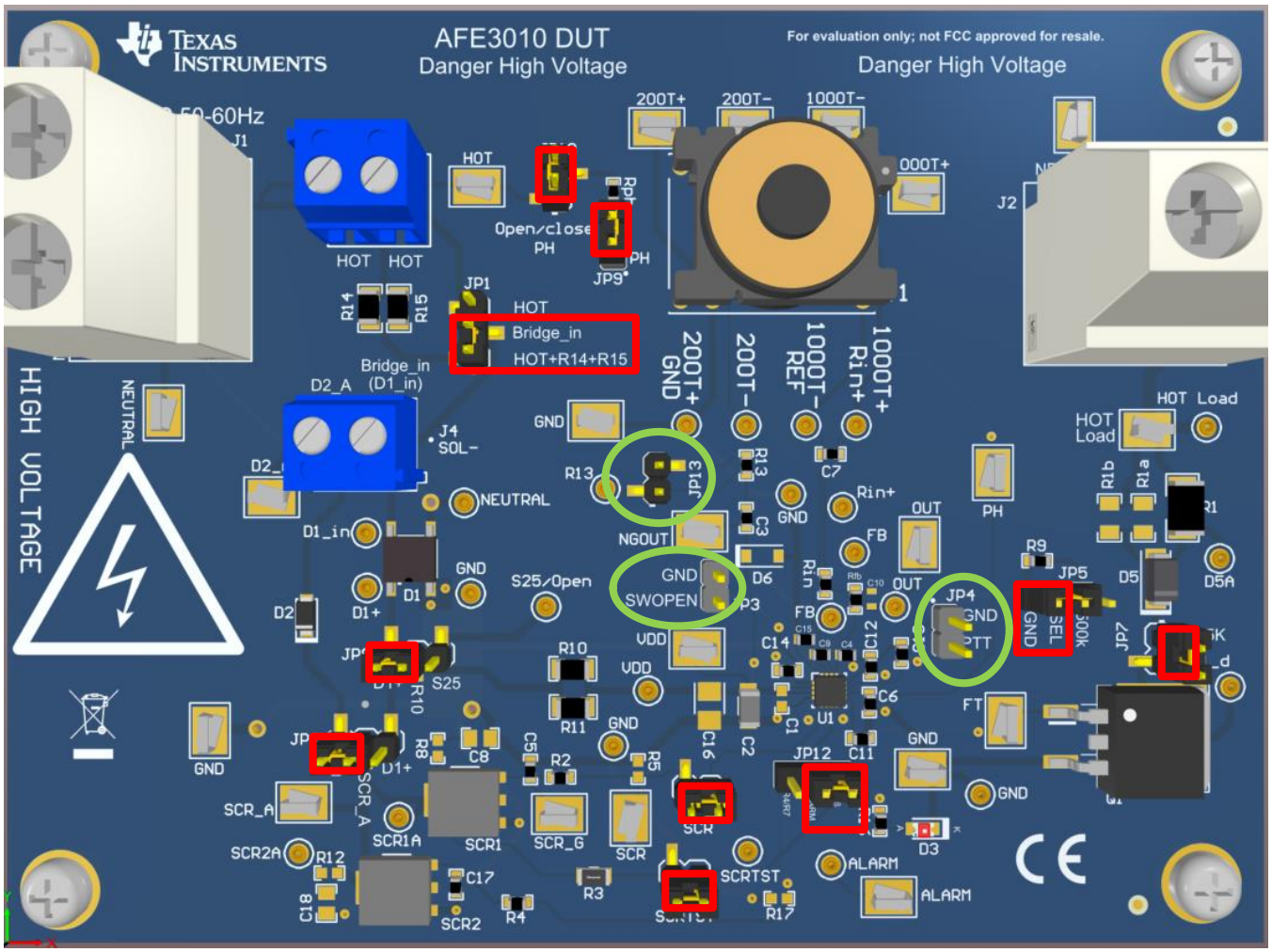

Figure 1. Shunt (H9–H19) Connector Setup: Red Squares = Shunt Position, Green Circle = Open or no shunt

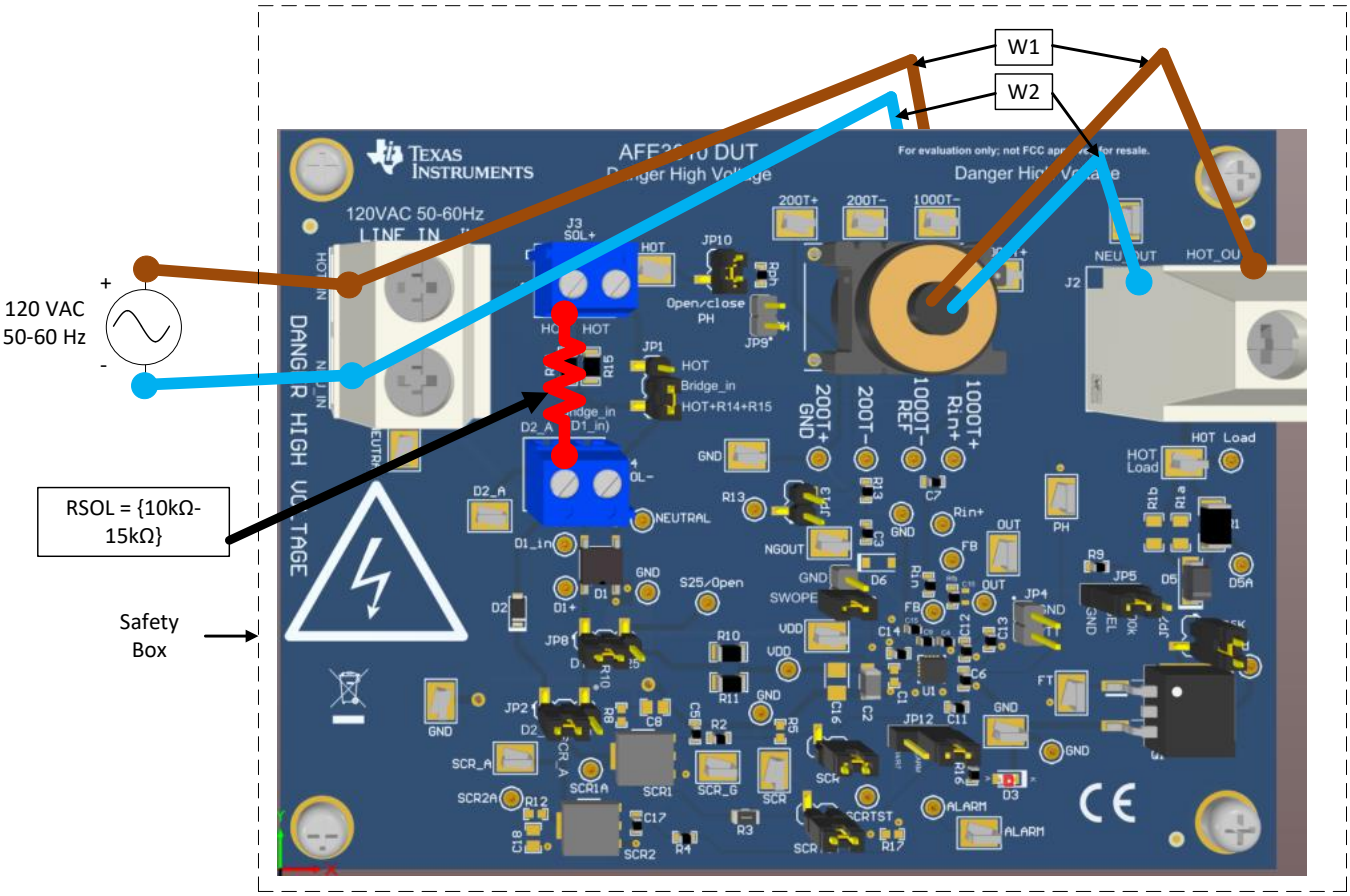

Figure 2. AFE3010EVM and Hardware Setup

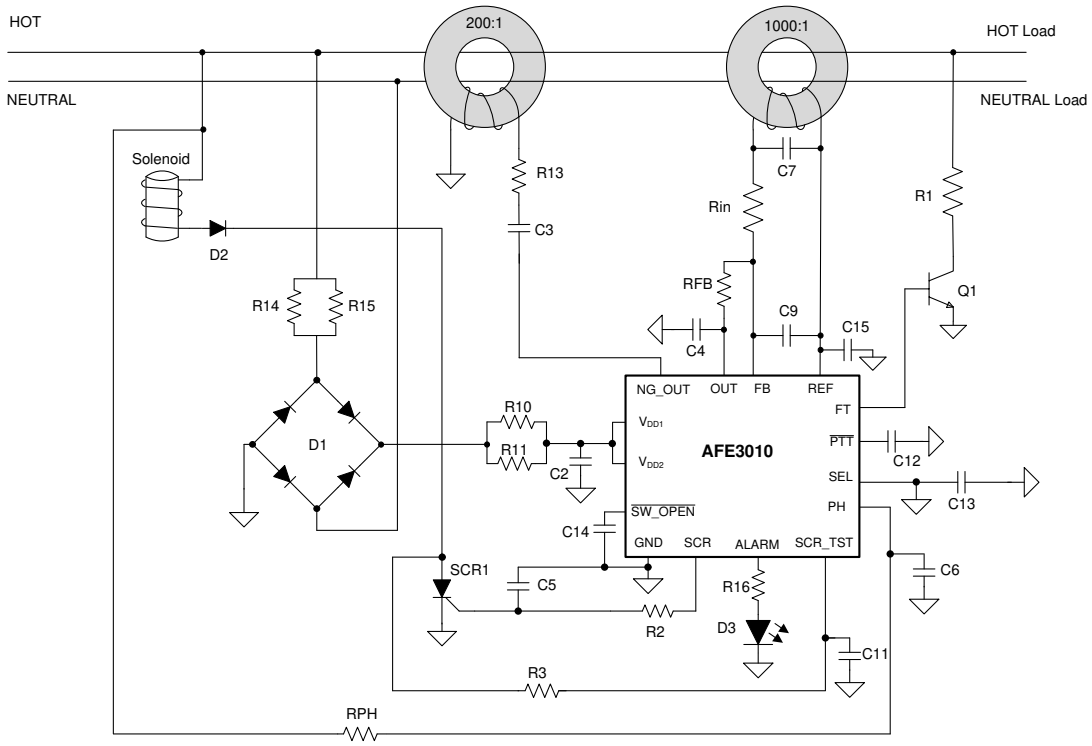

Figure 3. Simplified AFE3010EVM Schematic and Hardware for Quick Setup

3.1.1 Quick Start Setup - Testing the Trip Current

Follow these procedures to test at what fault current the AFE3010EVM trips to interrupt the fault current. Note that the EVM was not mechanically constructed to break the circuit.

Step 1. Power off the source voltage.

Step 2. Connect a resistor array along with a rheostat or potentiometer to create an adjustable leakage current from load HOT to Earth Ground or from load HOT to line NEUTRAL.

Step 3. Connect an ammeter in series with the fault resistors to measure fault current.

Step 4. Adjust total fault resistance so that fault current will approximately equal 3 mA RMS.

Step 5. Place the EVM and all exposed metal and components into a high-voltage safety box.

Step 6. Close the box.

Step 7. Turn on the source voltage and check for the device to enter its standby mode (the ALARM blinks once on power up when SEL is grounded).

Step 8. Check the ammeter to make sure fault current is at 3 mA RMS.

Step 9. Gradually increase fault current until the system trips and note the trip current. It should be from 4 mA RMS to 6 mA RMS.

- The user can determine if system trips by hearing the solenoid pop or measuring a pulse on the SCR pin. See Section 3.2 for more information on making measurements). Note that if a fault current is detected and no subsequent disconnection of the fault from the EVM is made, then this will be detected by the AFE3010EVM as a self-test failure in which case the ALARM LED will begin blinking.

3.2 Measurements (Optional)

The AFE3010EVM allows the user to test the AFE3010 with different values for certain passive components. Follow these procedures to probe and measure the EVM signals.

1. Power off the source voltage or EVM.
2. Make sure to use high-voltage rated differential probes whenever probing the AFE3010EVM.
3. Before making probe connections to the EVM, ensure it is not connected to a live source.
4. Connect the positive lead to the signal of consideration. The most likely places to probe are:
    1. OUT - The internal output voltage of the amplifier.
    2. SCR - The gate driver for the onboard SCR. This is enabled high when the device detects a ground fault current.
    3. FT - The fault test pin, which is enabled high periodically for the internal self-test of the AFE3010 device.
    4. VDD - The supply voltage for the AFE3010 device.
5. Connect the negative lead of the differential probe to any GND pin on the board. Note that the ground of the board is not Earth ground. The ground of the board is floating and a high-voltage node just as is every node on the AFE3010EVM that is never safe to have exposed.

4 EVM Components

This section summarizes the AFE3010EVM components.

4.1 U1 - AFE3010

GFCI controller IC with self test.

4.2 T1

Dual core, insulated, GFCI current transformer.

4.3 J1 and J2

High-power headers. J1 is where the line or source voltage should connect. J2 is where the load should connect. Shielded wires (not included) are needed to connect the HOT input of J1 (Line HOT) to HOT of J2 (Load HOT) and NEUTRAL of J1 (Line Neutral) to NEUTRAL of J2 (Load Neutral). These wires must feed through T1.

4.4 J3 (SOL+), J4 (SOL-)

These headers provide secure connections from Line-HOT (J3) to the input of D1 or anode of D2 (J4). A solenoid is needed to connect from HOT to D2 anode (D2_A). If a solenoid is not available, a resistor could be used instead.

4.5 D1

Full-bridge rectifier to supply a fully-rectified voltage signal to be conditioned for the power supply of the AFE3010 device.

4.6 R10, R11, R14, R15, C2, C16, and C1

These components serve to filter down the rectified source voltage from D1 for the internal 20-V regulator. C2 also provides decoupling capacitance for VDD pin of the AFE3010 device. C1 and C16 are not populated, but allow for the user to experiment with decoupling capacitors if needed.

4.7 D2, SCR1, SCR2

D2 is high-voltage diode rectifier that allows for forward conduction current when SCR is turned on and current flows from HOT through a solenoid, through D2, and then through SCR1. SCR2 is a redundant SCR that can be driven by the ALARM pin when the AFE3010 is configured to do so.

4.8 R2, C5, R5, R4, C17, R8, C8, R12, and C18

These components allow the user to experiment with conditioning circuitry for the onboard SCR devices. R8, C8, R12, C18 are not populated.

4.9 R3, C11

R3 has a specific value for the SCRTST pin to work properly and C11 serves are simple filtering capacitor for the SCRTST pin.

4.10 C6, C12, C13, and C14

These capacitors serve to filter any noise that could be coupled to their respective pins.

4.11 C4, C9, C7, C10, C15, Rin, and RFB

All of these components serve to condition the 1000-turn coil current signal with the internal amplifier of the AFE3010 device. The gain (and thus trip point) is determined by the ratio of RFB and Rin. C7 helps to stabilize the coil current based upon the inductance of the coil so that the OUT voltage is approximately 180° out of phase with the line voltage. C9, C10, and C15 help to filter any noise injected or coupled into the amplifier.

4.12 RPH

This is a 1-MΩ resistor to help limit the current into the PH pin which is responsible for determining the phase of the LINE.

4.13 R13, C3, and D6

These components serve the operation of our N-G detection capability. The NGOUT pin drives the C3 capacitor to generate a current into the 200-turn coil. The R13 resistor helps limit current going into the NGOUT pin during inductive kickback, which protects the NGOUT pin from breaking due to an analog voltage violation. D6 is not populated, but can be populated if more protection is needed for the NGOUT pin.

4.14 R9

This is a pulldown resistor to pulldown the SEL pin to 2.5 V for the redundant SCR mode.

4.15 R16, D3

D3 is the LED driven by the ALARM pin when SEL is either grounded or floating. R16 provides additional current limiting.

4.16 R1, R1a, R1b, D5, and Q1

These components constitute the self-fault test circuitry. Q1 is turned on by the FT pin periodically to test that they system can detect fault currents. The fault current that is tested is determined by the source voltage divided by R1. R1a and R1b are not populated, but can be populated if user wants to test with lower power rated resistors in parallel.

D5 prevents any current flowing in the opposite direction, which can occur under certain bias conditions of Q1.

4.17 JP1–JP13

These 100-mil headers allow for easy access to pins, allow for quick ways to test the device in different modes, and also allow the user to quickly test AFE3010 response to single-point failures. For example, the JP7 header can be opened up to test what the AFE3010 device will do if it cannot successfully run its self-fault test.

JP13 allows the user to see the difference in the N-G detection when the current-limiting resistor, R13, is shorted. Although it is not recommended to short R13 when the T1 current transformer is being used.

4.18 S1–S25

These are single sockets located in critical positions on the board to allow the user to quickly insert and test the EVM with different through-hole passive components. They can also serve as test points or ways to short out components to test single-point failures.

For example, sockets S8, S9, S10, and S11 can be used to connect a completely different current transformer to the board; however, the user will want to remove or de-solder T1 from the board to ensure realistic system data.

4.19 TP1–TP25

These test points allow for the user to probe various pins and nodes on the EVM with secure hook connections.

5 Schematic, PCB Layout, and Bill of Materials

NOTE: Board layouts are not to scale. These figures are intended to show how the board is laid out; they are not intended to be used for manufacturing AFE3010EVM PCBs.

5.1 Schematics

Figure 4 shows the schematics for the AFE3010EVM PCB.

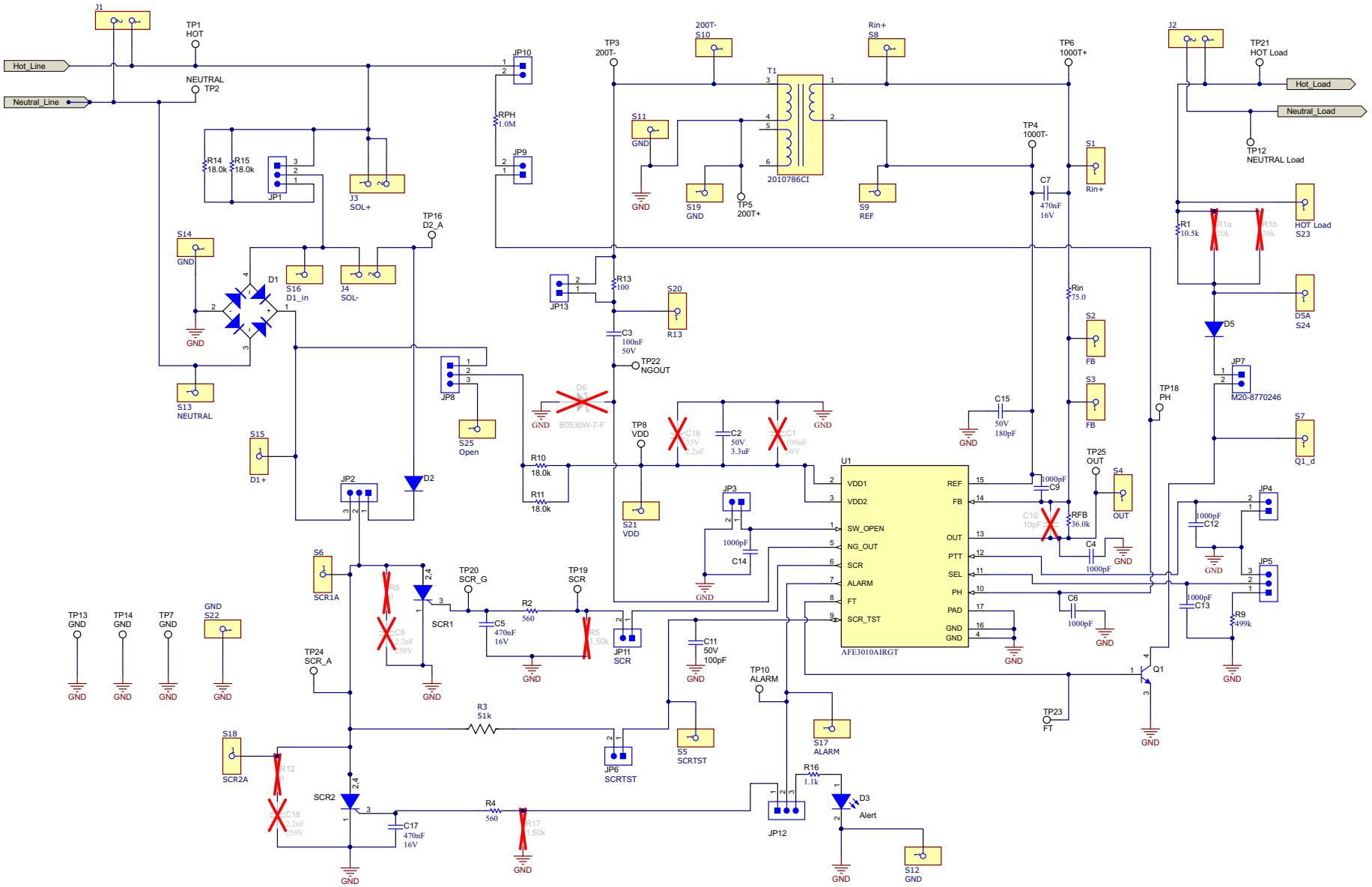

Figure 4. AFE3010EVM Schematic

5.2 PCB Layout

Figure 5 through Figure 11 illustrate the PCB layout for the AFE3010EVM.

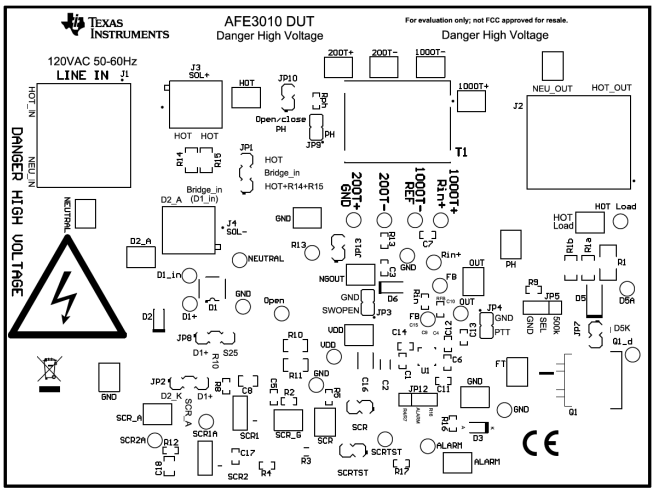

Figure 5. AFE3010EVM Top Overlay

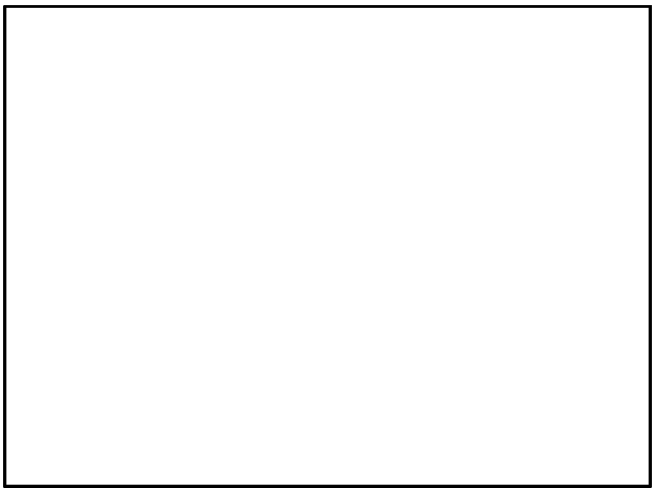

Figure 6. AFE3010EVM Bottom Overlay

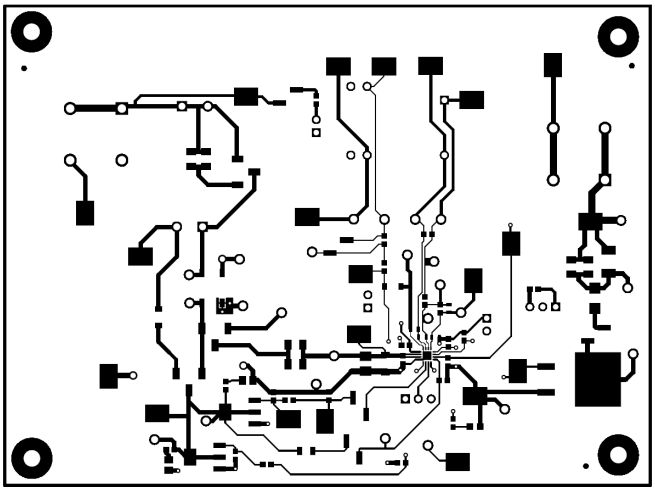

Figure 7. AFE3010EVM Top Layer

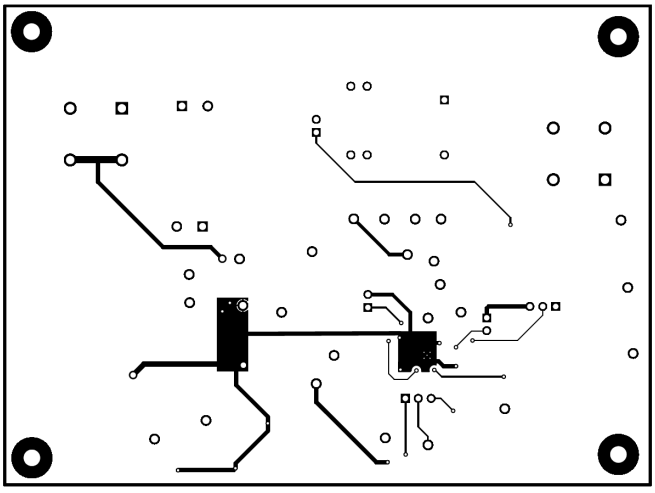

Figure 8. AFE3010EVM Bottom Layer

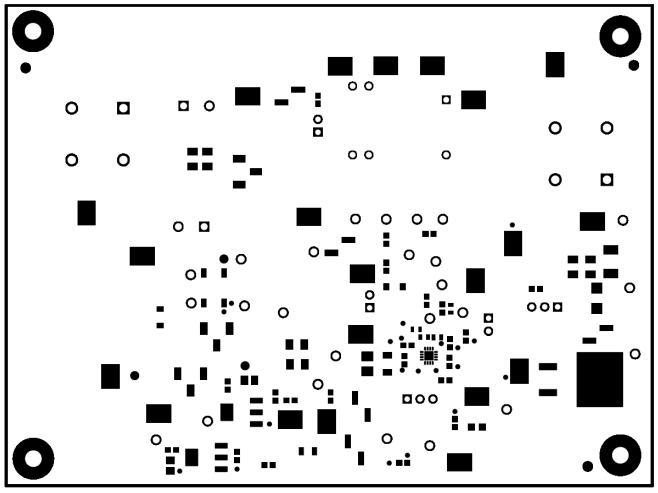

Figure 9. AFE3010EVM Top Solder

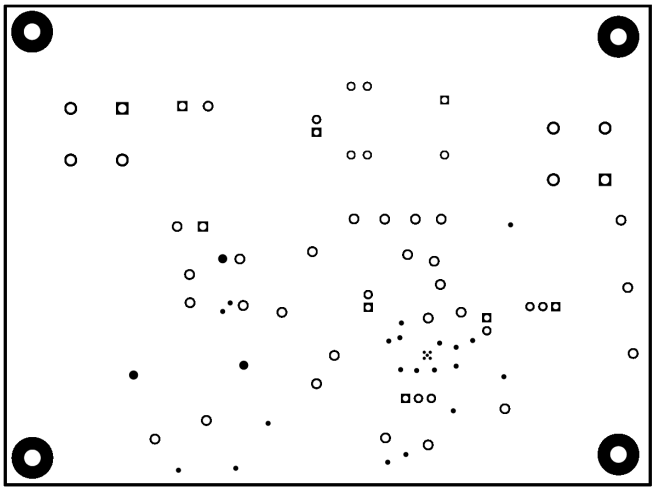

Figure 10. AFE3010EVM Bottom Solder

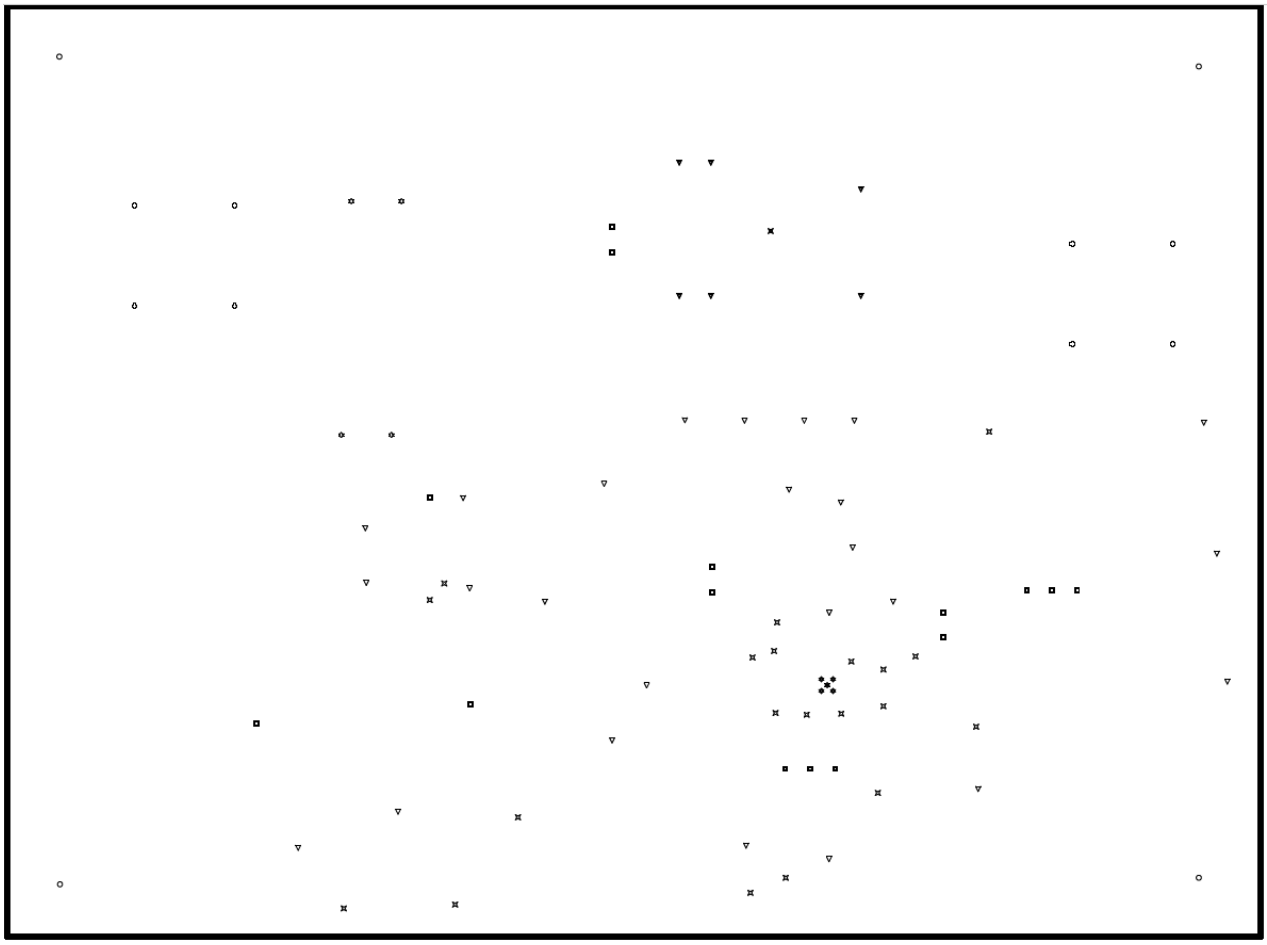

Figure 11. AFE3010EVM Drill Drawing

5.3 Bill of Materials

Table 3 provides the parts list for the AFE3010EVM.

Table 3. Bill of Materials

Designator	QTY	Value	Description	Package Reference	Part Number	Manufacturer
C2	1	3.3uF	CAP, CERM, 3.3 uF, 50 V, ±10%, X7R, 1206_190	1206_190	C3216X7R1H335K160AC	TDK
C3	1	0.1uF	CAP, CERM, 0.1 uF, 50 V, ±10%, X7R, 0603	0603	06035C104KAT2A	AVX
C4, C6, C9, C12, C13, C14	6	1000pF	CAP, CERM, 1000 pF, 25 V, ±10%, C0G/NP0, 0603	0603	C0603C102K3GACTU	Kemet
C5, C7, C17	3	0.47uF	CAP, CERM, 0.47 uF, 16 V, ±10%, X7R, AEC-Q200 Grade 1, 0603	0603	GCM188R71C474KA55D	MuRata
C11	1	100pF	CAP, CERM, 100 pF, 50 V, ±5%, C0G/NP0, 0603	0603	C1608C0G1H101J080AE	TDK
C15	1	180pF	CAP, CERM, 180 pF, 50 V, ±5%, C0G/NP0, 0603	0603	06035A181JAT2A	AVX
D1	1	600V	Diode, Switching-Bridge, 600 V, 1 A, MICRODIP_4	MICRODIP_4	MDB6S	Fairchild Semiconductor
D2	1	1000V	Diode, Standard Recovery Rectifier, 1000 V, 1 A, SOD-123FL	SOD-123FL	SM4007PL-TP	Micro Commercial Components
D3	1	Red	LED, Red, SMD	1.2x2mm	LH R974-LP-1	OSRAM
D5	1	600V	Diode, Ultrafast, 600 V, 1.5 A, SMA	SMA	BYG20J-E3/TR	Vishay-Semiconductor
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
H9, H10, H11, H12, H13, H14, H15, H16, H17, H18, H19	11	1x2	Shunt, 100mil, Gold plated, Black	Shunt	SNT-100-BK-G	Samtec
J1, J2	2			HDR2	691256610002	Wurth
J3, J4	2			HDR2	OSTTA024163	On Shore Technology
JP1, JP2, JP8	3		Header, 2.54mm, 3x1, Gold, SMT	Header, 2.54mm, 3x1, SMT	M20-8770342	Harwin
JP3, JP4, JP9	3		Header, 100mil, 2x1, Gold, TH	Sullins 100mil, 1x2, 230 mil above insulator	PBC02SAAN	Sullins Connector Solutions
JP5, JP12	2		Header, 100mil, 3x1, Gold, TH	PBC03SAAN	PBC03SAAN	Sullins Connector Solutions
JP6, JP7, JP10, JP11, JP13	5		Header, 2.54mm, 2x1, Tin, SMT	Header, 2.54mm, 2x1, SMT	M20-8770246	Harwin
Q1	1	400 V	Transistor, NPN, 400 V, 8 A, DDPAK	DDPAK	STB13007DT4	STMicroelectronics
R1	1	10.5k	RES, 10.5 k, 1%, 0.75 W, AEC-Q200 Grade 0, 2010	2010	CRCW201010K5FKEF	Vishay-Dale
R2, R4	2	560	RES, 560, 5%, 0.1 W, 0603	0603	RC0603JR-07560RL	Yageo
R3	1		51 kOhms ±5% 0.667W, 2/3W Chip Resistor 1206 (3216 Metric) Automotive AEC-Q200, Pulse Withstanding Thick Film	1206	ERJ-P08J513V	Panasonic Electronic Components
R9	1	499k	RES, 499 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW0603499KFKEA	Vishay-Dale
R10, R11, R14, R15	4	18.0k	RES, 18.0 k, 1%, 0.5 W, 1206	1206	RC1206FR-0718KL	Yageo America
R13	1	100	RES, 100, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW0603100RFKEA	Vishay-Dale
R16	1	1.1k	RES, 1.1 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW06031K10JNEA	Vishay-Dale
RFB	1	36.0k	RES, 36.0 k, 1%, 0.1 W, 0603	0603	RC0603FR-0736KL	Yageo
Rin	1	75.0	RES, 75.0, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060375R0FKEA	Vishay-Dale
RPH	1	1.0Meg	RES, 1.0 M, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW06031M00JNEA	Vishay-Dale

Table 3. Bill of Materials (continued)

Designator	QTY	Value	Description	Package Reference	Part Number	Manufacturer
S1, S2, S3, S4, S5, S6, S7, S8, S9, S10, S11, S12, S13, S14, S15, S16, S17, S18, S19, S20, S21, S22, S23, S24, S25	25		CONN PIN RCPT .018-.021 SOLDER	PIN_RCPT	3-331272-8	TE Connectivity
SCR1, SCR2	2		SCR 400V 800mA Sensitive Gate, SOT-223	SOT-223	S4X8TS1	Littelfuse
T1	1		Transformer	PTH_20MM65_16MM0	2010786CI	GFCI
TP1, TP2, TP3, TP4, TP5, TP6, TP7, TP8, TP10, TP12, TP13, TP14, TP16, TP18, TP19, TP20, TP21, TP22, TP23, TP24, TP25	21		Test Point, Compact, SMT	Testpoint_Keystone_Compact	5016	Keystone
U1	1		Ground Fault Circuit Interrupter (GFCI) with Self Test, RGT0016C (VQFN-16)	RGT0016C	AFE3010AIRGT	Texas Instruments
C1	0	0.1uF	CAP, CERM, 0.1 uF, 50 V, ±10%, X7R, 0603	0603	06035C104KAT2A	AVX
C8, C18	0	2200pF	CAP, CERM, 2200 pF, 250 V, ±10%, X7R, 0805	0805	GRM21AR72E222KW01D	MuRata
C10	0	10pF	CAP, CERM, 10 pF, 50 V, ±5%, C0G/NP0, AEC-Q200 Grade 1, 0603	0603	CGA3E2C0G1H100D080AA	TDK
C16	0	2.2uF	CAP, TA, 2.2 uF, 35 V, ±10%, 3.8 ohm, SMD	3528-21	293D225X9035B2TE3	Vishay-Sprague
D6	0	30V	Diode, Schottky, 30 V, 0.5 A, SOD-123	SOD-123	B0530W-7-F	Diodes Inc.
FID1, FID2, FID3	0		Fiducial mark. There is nothing to buy or mount.	N/A	N/A	N/A
R1a, R1b	0	20k	RES, 20 k, 5%, 0.25 W, AEC-Q200 Grade 0, 1206	1206	CRCW120620K0JNEA	Vishay-Dale
R5, R17	0	1.50k	RES, 1.50 k, 1%, 0.1 W, 0603	0603	RC0603FR-071K5L	Yageo
R8, R12	0	0	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	ERJ-3GEY0R00V	Panasonic

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。
http://www.tij.co.jp/lsds/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 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。
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東京都新宿区西新宿 6 丁目 2 4 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
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3.4 *European Union*

3.4.1 *For EVMs subject to EU Directive 2014/30/EU (Electromagnetic Compatibility Directive)*:

This is a class A product intended for use in environments other than domestic environments that are connected to a low-voltage power-supply network that supplies buildings used for domestic purposes. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.

4 *EVM Use Restrictions and Warnings:*

4.1 EVMS ARE NOT FOR USE IN FUNCTIONAL SAFETY AND/OR SAFETY CRITICAL EVALUATIONS, INCLUDING BUT NOT LIMITED TO EVALUATIONS OF LIFE SUPPORT APPLICATIONS.

4.2 User must read and apply the user guide and other available documentation provided by TI regarding the EVM prior to handling or using the EVM, including without limitation any warning or restriction notices. The notices contain important safety information related to, for example, temperatures and voltages.

4.3 *Safety-Related Warnings and Restrictions:*

4.3.1 User shall operate the EVM within TI's recommended specifications and environmental considerations stated in the user guide, other available documentation provided by TI, and any other applicable requirements and employ reasonable and customary safeguards. Exceeding the specified performance ratings and specifications (including but not limited to input and output voltage, current, power, and environmental ranges) for the EVM may cause personal injury or death, or property damage. If there are questions concerning performance ratings and specifications, User should contact a TI field representative prior to connecting interface electronics including input power and intended loads. Any loads applied outside of the specified output range may also result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM user guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative. During normal operation, even with the inputs and outputs kept within the specified allowable ranges, some circuit components may have elevated case temperatures. These components include but are not limited to linear regulators, switching transistors, pass transistors, current sense resistors, and heat sinks, which can be identified using the information in the associated documentation. When working with the EVM, please be aware that the EVM may become very warm.

4.3.2 EVMs are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems. User assumes all responsibility and liability for proper and safe handling and use of the EVM by User or its employees, affiliates, contractors or designees. User assumes all responsibility and liability to ensure that any interfaces (electronic and/or mechanical) between the EVM and any human body are designed with suitable isolation and means to safely limit accessible leakage currents to minimize the risk of electrical shock hazard. User assumes all responsibility and liability for any improper or unsafe handling or use of the EVM by User or its employees, affiliates, contractors or designees.

4.4 User assumes all responsibility and liability to determine whether the EVM is subject to any applicable international, federal, state, or local laws and regulations related to User's handling and use of the EVM and, if applicable, User assumes all responsibility and liability for compliance in all respects with such laws and regulations. User assumes all responsibility and liability for proper disposal and recycling of the EVM consistent with all applicable international, federal, state, and local requirements.

5. *Accuracy of Information:* To the extent TI provides information on the availability and function of EVMs, TI attempts to be as accurate as possible. However, TI does not warrant the accuracy of EVM descriptions, EVM availability or other information on its websites as accurate, complete, reliable, current, or error-free.

6. *Disclaimers:*

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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