

AMC4330R and AMC0302R Isolated Voltage and Current Sensing Amplifiers Evaluation Module



Description

The AMC-AMP-VI-EVM is an isolated current and voltage sensing evaluation module (EVM) designed for $\pm 50\text{A}$ shunt-based current sensing and AC or DC bus voltage measurements up to $\pm 1000\text{V}$. A RES60A precision resistive divider is used in conjunction with the AMC4330R for bus voltage monitoring. The AMC4330R powers an AMC0302R for use with the current shunt. This EVM features via stitching to facilitate heat dissipation and can perform both current and voltage within $\pm 0.3\%$ accuracy without calibration.

Get Started

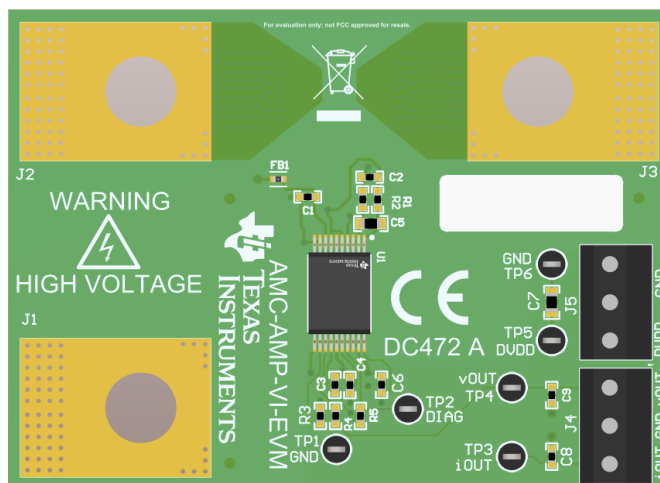
1. Order the AMC-AMP-VI-EVM from ti.com.
2. Evaluate the performance of the AMC4330 and the AMC0302R with user supplied voltage and current sources.
3. Be safe! Read through this EVM user's guide before getting started with your evaluation.

Features

- $\pm 50\text{A}$ isolated current measurements
- $1\text{m}\Omega$ current shunt
- $\pm 1000\text{V}$ isolated voltage measurements
- Heat dissipation designed for 40°C rise with 50A pulses with 50% duty cycle at 10Hz

Applications

- [Motor drives](#)
- [Server power-supply units \(PDU\)](#)
- [EV charging](#)
- [Building automation](#)

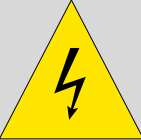


1 Evaluation Module Overview

1.1 Introduction

Throughout this document, the abbreviation *EVM* and the term *evaluation module* are synonymous with the AMC-AMP-VI-EVM. This document includes details on how to set up and evaluate the EVM, the printed circuit board (PCB) layout, schematics, and bill of materials (BOM).

CAUTION

Do not leave EVM powered when unattended.

HIGH VOLTAGE: Electric shock is possible when connecting the board to live wire. The board must be handled with care by a professional. For safety, use of isolated test equipment with overvoltage and overcurrent protection is highly recommended.

1.2 Kit Contents

The EVM kit contains a printed circuit board (PCB) with all required components mounted to evaluate the RES60A with the AMC4330R for voltage measurements along with a 1mΩ shunt and the AMC0302R for current measurements. Screw terminals are provided to allow the EVM user to power the PCB from a single 5V bench supply as well as to monitor the voltage and current measurements.

1.3 Specification

The AMC-AMP-VI-EVM provides the ability to evaluate high currents up to $\pm 50\text{A}$ continuous or pulsed current. The EVM also provides a precision resistive divider allowing voltage measurements up to $\pm 1000\text{V}$. Refer to the [RES60A](#), [AMC4330R](#), and [AMC0302R](#) datasheets for detailed device specifications.

1.4 Device Information

The AMC-AMP-VI-EVM provides a functional evaluation platform for the RES60A, the AMC4330R, and the AMC0302R. The AMC0302R is powered from the high-side supply of the AMC4330R. The EVM uses a single 5V bench supply to power the entire PCB.

1.5 General Texas Instruments High Voltage Evaluation (TI HV EVM) Guidelines



Always follow TI's setup and application instructions, including use of all interface components within the recommended electrical rated voltage and power limits. Always use electrical safety precautions to help verify your personal safety and those working around you. Contact TI's Product Information Center for further information.

Save all warnings and instructions for future reference.

WARNING

Failure to follow warnings and instructions can result in personal injury, property damage or death due to electrical shock and burn hazards.

The term "TI HV EVM" refers to an electronic device typically provided as an open-framed, unenclosed printed circuit board assembly. The device is intended strictly for use in development laboratory environments, solely for

qualified professional users having training, expertise and knowledge of electrical safety risks in development and application of high voltage electrical circuits. Any other use, application, or both are strictly prohibited by Texas Instruments. If you are not properly qualified, you must immediately stop from further use of the HV EVM.

1. Work Area Safety:

- Keep work area clean and orderly.
- Qualified observers must be present anytime circuits are energized.
- Effective barriers and signage must be present in the area where the TI HV EVM and the interface electronics are energized, indicating operation of accessible high voltages can be present, for the purpose of protecting inadvertent access.
- All interface circuits, power supplies, evaluation modules, instruments, meters, scopes, and other related apparatus used in a development environment exceeding 50Vrms/75VDC must be electrically located within a protected Emergency Power Off EPO protected power strip.
- Use stable and non-conductive work surface.
- Use adequately insulated clamps and wires to attach measurement probes and instruments

2. Electrical Safety:

- As a precautionary measure, good engineering practice is to assume that the entire EVM can have fully accessible and active high voltages.
- De-energize the TI HV EVM and all the inputs, outputs and electrical loads before performing any electrical or other diagnostic measurements. Revalidate that TI HV EVM power has been safely de-energized.
- With the EVM confirmed de-energized, proceed with required electrical circuit configurations, wiring, measurement equipment hook-ups and other application needs, while still assuming the EVM circuit and measuring instruments are electrically live.
- Once EVM readiness is complete, energize the EVM as intended.

WARNING

While the EVM is energized, never touch the EVM or the electrical circuits, as the EVM or electrical circuits can be at high voltages capable of causing electrical shock hazard.

3. Personal Safety:

- Wear personal protective equipment, such as latex gloves or safety glasses with side shields, or protect the EVM in an adequate translucent plastic box with interlocks from accidental touch.

2 Hardware

This section summarizes the AMC-AMP-VI-EVM components, assembly instructions, interfaces, power requirements, and test point information.

2.1 Hardware Overview

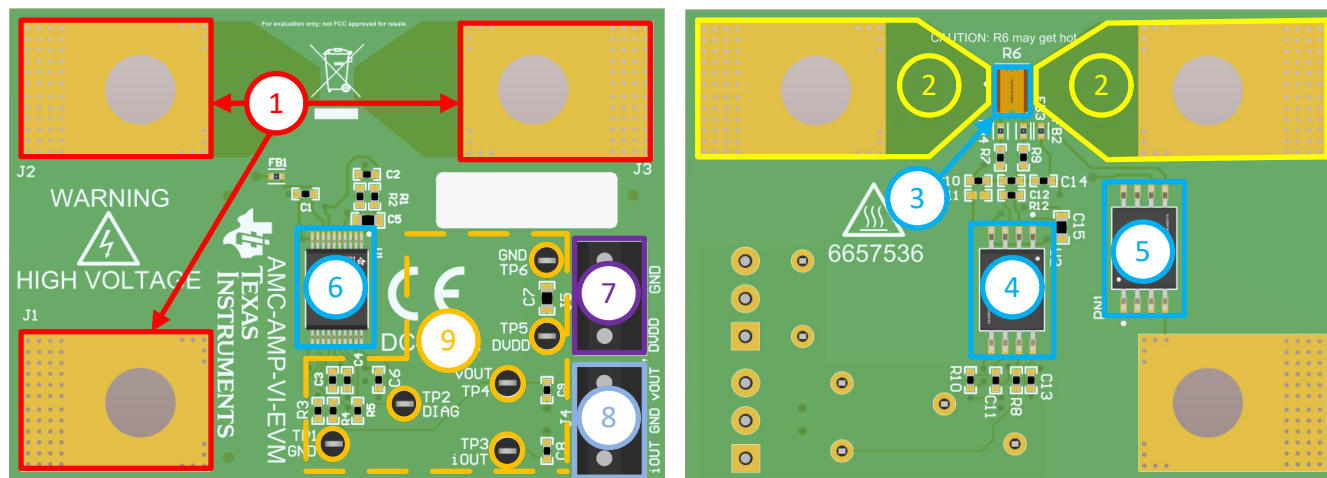


Figure 2-1. AMC-AMP-VI-EVM Hardware Labels

The AMC-AMP-VI-EVM has many hardware features, allowing the user to access and assess the EVM from many points in the signal chain. The default configuration is one 1mΩ shunt populated at R6 to sense $\pm 50\text{A}$ applications. Descriptions of the numbered sections in [Figure 2-1](#) are listed below:

1. Power Pads – J1 and J2 are for voltage monitoring. Current monitoring is done through the shunt located between J2 and J3.
2. Via Stitching – helps to distribute the heat generated by the shunt resistor.
3. Current Shunt - 1mΩ, $\pm 1\%$ tolerance shunt resistor for accurate current sensing. The AMC-AMP-VI-EVM PCB is not designed for more than $\pm 70\text{A}$.
4. AMC0302R - Precision $\pm 50\text{mV}$ -input reinforced isolated amplifier with ratiometric single-ended output
5. RES60A - Automotive 1400V matched thin-film resistor divider with 12.5MΩ fixed input
6. AMC4330R – Precision $\pm 1\text{V}$ -input reinforced isolated amplifier with ratiometric single-ended output
7. J5 EVM Power Input – apply 5V source to power the EVM
8. J4 Isolated Voltage and Current Amplifier outputs – these are the output terminals for the AMC0302R and AMC4330R
9. Various test points - refer to [Section 2.3](#) for details

2.2 Interfaces

The AMC-AMP-VI-EVM features analog input circuitry to the isolated amplifier AMC4330R and to the isolated amplifier AMC0302R. The EVM output contains two output sections: isolated amplifier (AMC4330R) analog output circuitry and isolated amplifier (AMC0302R) analog output circuitry.

2.2.1 EVM Power Supply Input

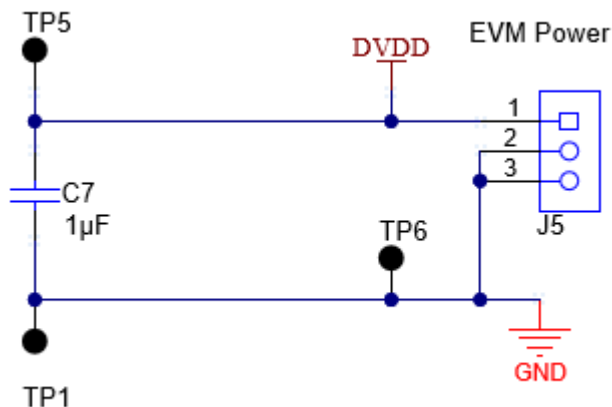


Figure 2-2. AMC-AMP-VI-EVM Input Power Connection

Power to the EVM must be applied to screw terminal J5. J5 terminal 1 is the DVDD connection from a lab power supply. The EVM needs a clean 5V source with at least 50mA current capability. J5 terminals 2 and 3 are the ground connection for the 5V source. The AMC4330R has an internal voltage regulator that is used to power the high side of the AMC0302R, so there is no need for a separate high-side power source.

2.2.2 Voltage Monitor Input

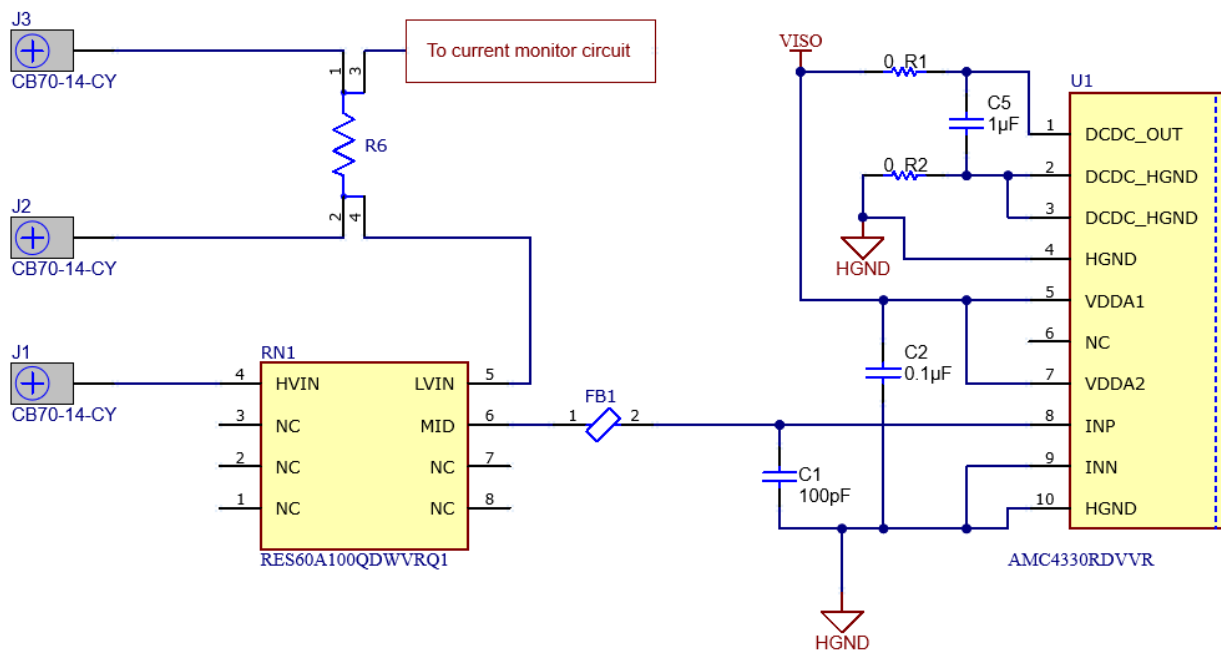


Figure 2-3. AMC-AMP-VI-EVM Voltage Monitor Circuit

The voltage monitoring input is applied between 0.25-inch lug mounting pads J1 and J2. High voltage up to $\pm 1000\text{V}$ can be fed to the precision resistive divider RES60A. A $\pm 1000\text{V}$ input between J1 and J2 produces a $\pm 1\text{V}$ signal at the input of the AMC4330 isolated amplifier.

2.2.3 Current Monitor Input

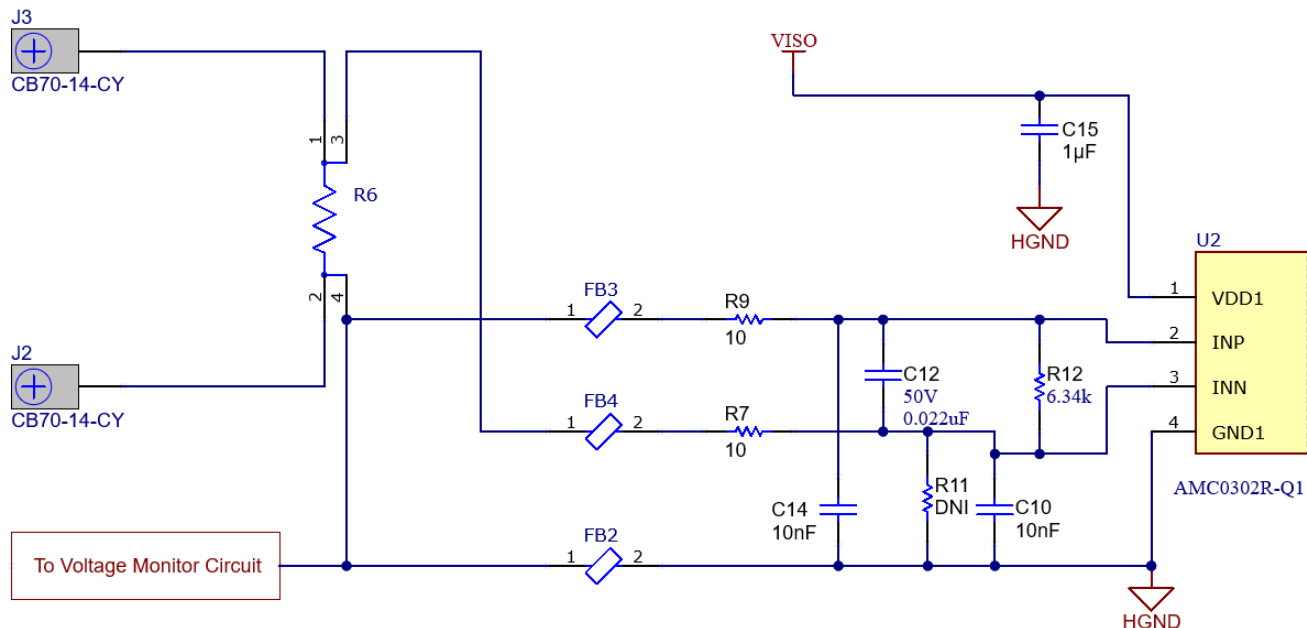


Figure 2-4. AMC-AMP-VI-EVM Current Monitor Circuit

To monitor current, connect a source which can provide $\pm 50\text{A}$ between J2 and J3. The current that flows across the $1\text{m}\Omega$ shunt resistor R6 applies $\pm 50\text{mV}$ to the INP pin of the AMC0302R.

2.2.4 Voltage and Current Monitor Outputs

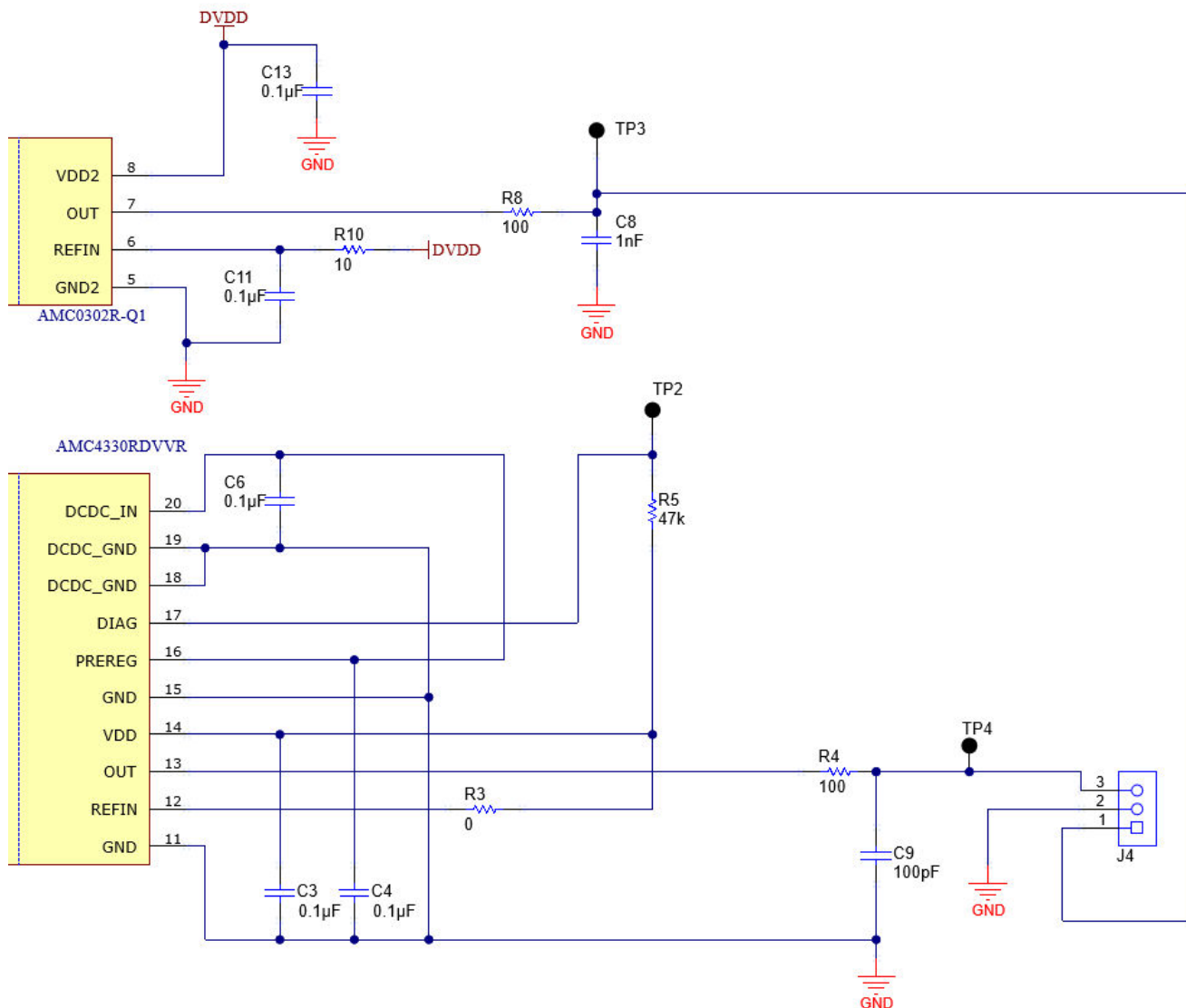


Figure 2-5. AMC-AMP-VI-EVM Voltage and Current Monitor Outputs

As shown in [Figure 2-5](#), screw terminal J4 allows the EVM user to monitor the outputs of both the AMC4330R and AMC0302R. J4.1 is the output of the AMC0302R (U2 mounted on the bottom side of the PCB). Current passed through shunt resistor R6 develops a voltage which is amplified by the AMC0302R and provided on TP3 labeled iOUT.

J4.3 is the output of the voltage monitoring circuit implemented with the RES60A and AMC4330R. High voltage applied between terminals J1 and J2 is divided down by the RES60A and presented to the AMC4330R. The AMC4330 output is also available on TP4 labeled vOUT.

2.3 Test Points

There are six test points available on the EVM. TP1 and TP6 are both user-side ground. TP2 is provided to monitor the DIAG pin of the AMC4330R. TP3 and TP4 are the current and voltage monitoring points. TP5 is provided to monitor DVDD applied to the EVM. Each test point is labeled with the function of the test point.

3 Implementation Results

The following sections provide details on how the AMC-AMP-VI-EVM was tested and provides performance results.

3.1 Evaluation Procedure

To evaluate the function of the board, TI recommends running a test procedure – see [Section 3.1.2](#) and [Section 3.1.3](#) for more detail.

3.1.1 Minimum Equipment Required for Full Scale testing

1. One 5V source limited to 100mA
2. High voltage power supply or SMU capable of providing $\pm 1000\text{V}$
3. Current source capable of delivering $\pm 50\text{A}$
4. Cables and Lugs rated for 50A (6AWG or larger cable)
5. Electronic load capable of sinking 50A
6. Digital multimeter (DMM) with at least 6.5 digits of resolution
7. Safety box with automatic cutoff switch for high voltage testing

3.1.2 Voltage Test Procedure

Note

Verify that the outputs of the connected supplies are disabled before connecting or disconnecting equipment.

1. Set the 5V source and limit the current to 100mA as noted in [Section 3.1.1](#). Connect the EVM voltage source to the DVDD pin of J5, referenced to GND.
2. Verify the high voltage source is disabled before connecting leads to J1 and J2.
3. Place the EVM into the safety box and close the lid.
4. Enable the 5V power supply, current draw must be less than 60mA.
5. Enable the high voltage source and sweep from -1000V to $+1000\text{V}$.
6. Monitor the output of the AMC4330R through TP4 or J4.3.

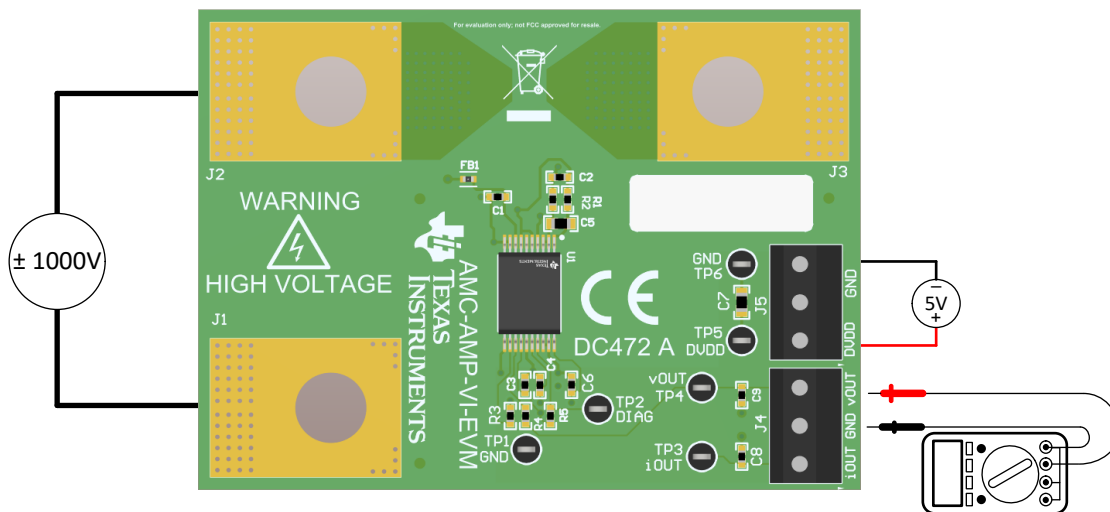


Figure 3-1. AMC-AMP-VI-EVM High Voltage Input

3.1.3 Current Test Procedure

Note

Verify that the outputs of the connected supplies are disabled before connecting or disconnecting equipment.

1. Set the 5V source and limit the current to 100mA as noted in Section 3.1.1. Connect the EVM voltage source to the DVDD pin of J5, referenced to GND.
2. Verify the high voltage source is disabled before connecting leads to J2 and J3.
3. Place the EVM into the safety box and close the lid.
4. Enable the 5V power supply, current draw must be less than 60mA.
5. Enable the 50A current source and sweep from 0A to 50A
6. Monitor the output of the AMC0302R through TP3 or J4.1

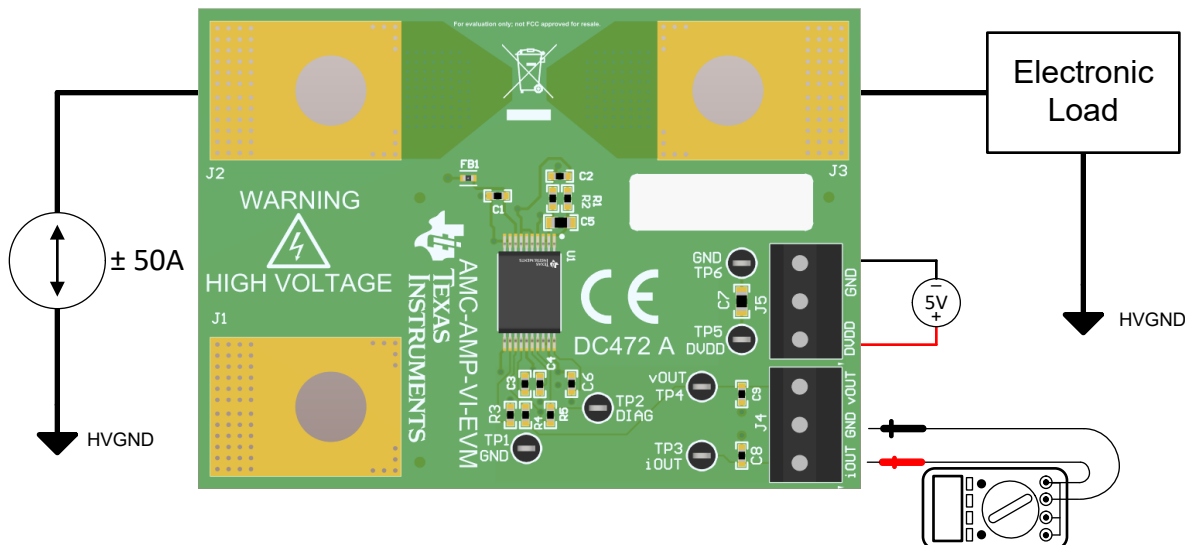


Figure 3-2. AMC-AMP-VI-EVM Current Input

3.1.4 Notes on Voltage and Current Measurements

The AMC4330R used for voltage measurements has a full-scale input range of $\pm 1V$. Under normal operating conditions, the AMC4330 outputs 2.5V when 0V is applied to the input when 5V is applied to the REFIN pin (see AMC4330R pin 12, Figure X). Positive voltage on J1 relative to J2 causes the AMC4330R output to rise towards 4.5V at +1000V. Positive voltage on J2 relative to J1 causes the AMC4330R output to fall towards 0.5V at -1000V.

The same is true for current measurements via R6 and the AMC0302R. The full-scale input to the AMC0302R is $\pm 50mV$. Under normal operating conditions, the output of the AMC0302R is $V_{REF}/2$ when no input current is flowing through R6. With the reference voltage set to 5V (see AMC0302R pin 6, Figure X), the output is 2.5V. Current flowing from J2 to J3 will cause the output to rise from 2.5V to 4.5V at +50A. Current flowing in the opposite direction from J3 to J2 causes the output voltage of the AMC0302R to fall from 2.5 to 0.5V at -50A.

3.1.5 Calculations

The AMC4330R and AMC0302R both have a single-ended ratiometric output voltage that depends on a stable reference voltage. The full-scale output voltage is set by the REFIN pin. For any input voltage within the specified linear input range, the device outputs a voltage equal to:

$$V_{out} = \frac{V_{in}}{V_{clipping}} \times \frac{V_{refin}}{2} = \frac{V_{inp} - V_{inn}}{V_{clipping}} \times \frac{V_{refin}}{2} + V_{refin} / 2 \quad (1)$$

The associated errors in both the voltage and current measurements follows [Equation 2](#):

$$\% \text{ Error} = \left(\frac{\text{expected output} - \text{actual output}}{\text{output range}} \right) \times 100 \quad (2)$$

The only difference is the analog input voltage range of the two devices used on the EVM. The AMC4330R V_{in} range is $\pm 1V$ with clipping at $\pm 1.28V$ and the AMC0302R input range is $\pm 50mV$ with clipping at $\pm 64mV$. The following section describes the test results associated with the AMC-AMP-VI-EVM.

3.1.6 Voltage and Current Test Results

The AMC-AMP-VI-EVM was tested from -40°C to 85°C with a $\pm 1000\text{V}$ source between J1 and J2 and a $\pm 50\text{-amp}$ current source between J2 and J3. The uncalibrated current and voltage errors were less than 0.3% over the full-scale range of $\pm 50\text{A}$ and $\pm 1000\text{V}$ as shown in Figure 3-3.

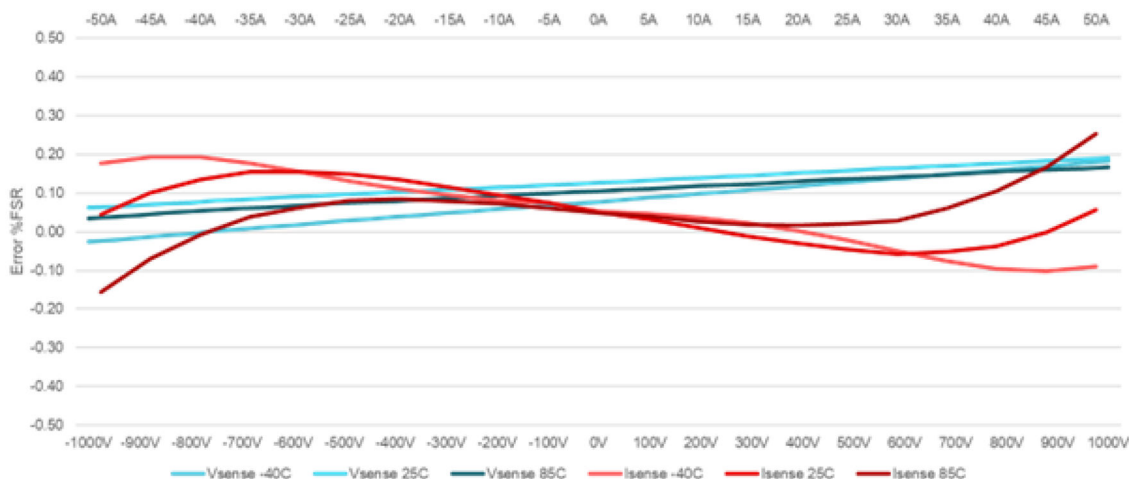


Figure 3-3. AMC-AMP-VI-EVM Voltage and Current % Full-scale Error

3.1.7 Thermal Images

Figure 3-4 and Figure 3-5 show the thermal performance of the AMC-AMP-VI-EVM.

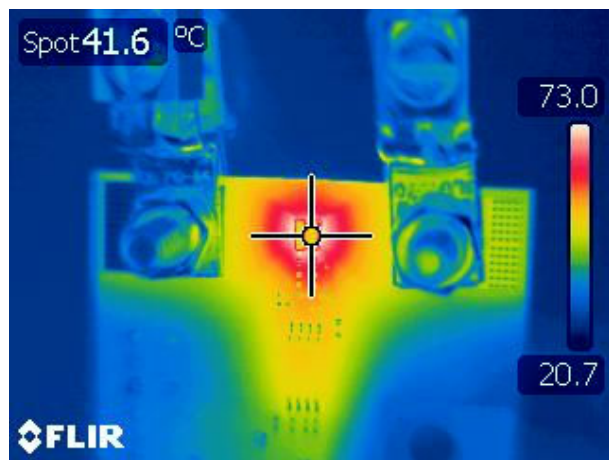


Figure 3-4. 10Hz Square Wave 50% Duty Cycle



Figure 3-5. 50A DC for Two Minutes

3.1.8 EMI Test Results

Figure 3-6 and Figure 3-7 show the radiated emission plots of the AMC-AMP-VI-EVM.

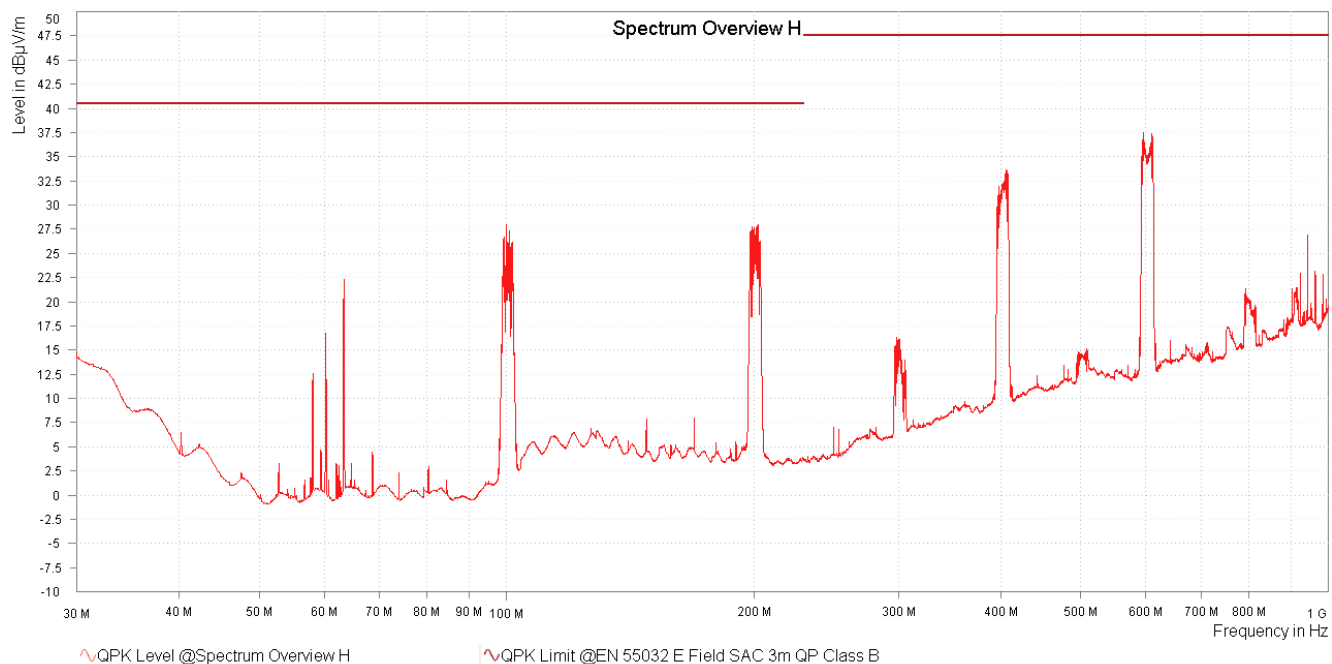


Figure 3-6. Horizontal Emissions Plot

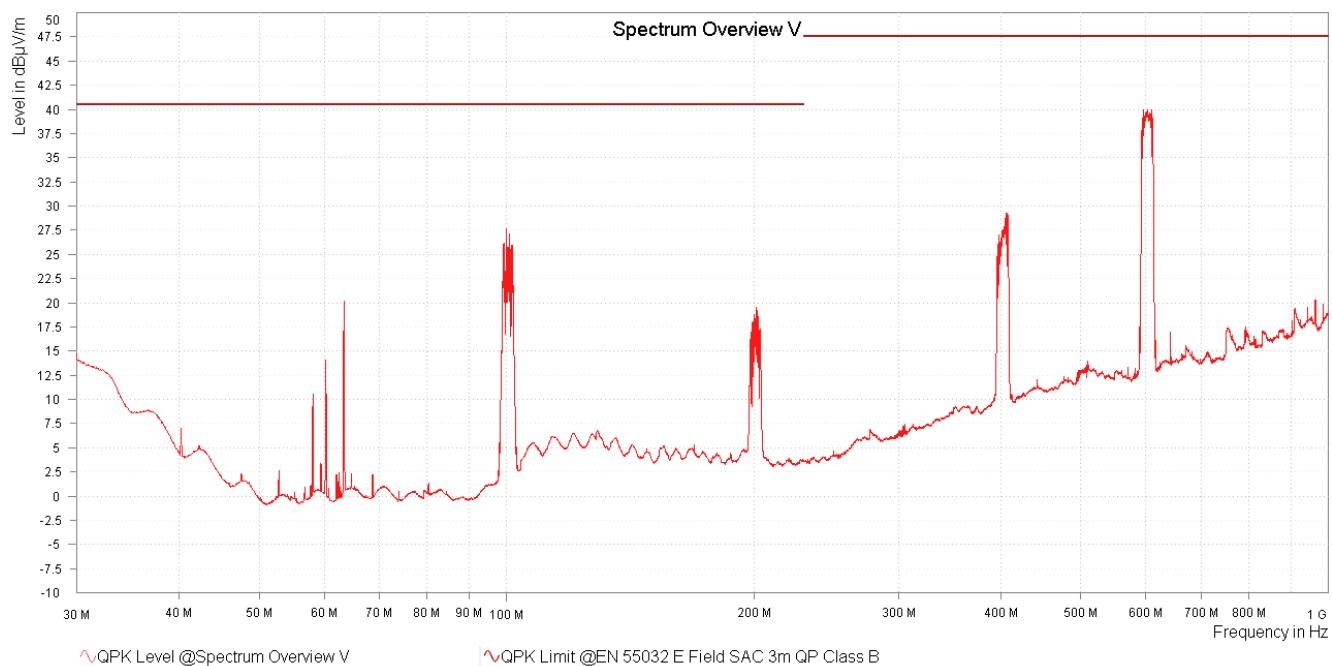


Figure 3-7. Vertical Emissions Plot

4 Hardware Design Files

4.1 Schematics

Figure 4-1 shows the complete AMC-AMP-VI-EVM Schematic.

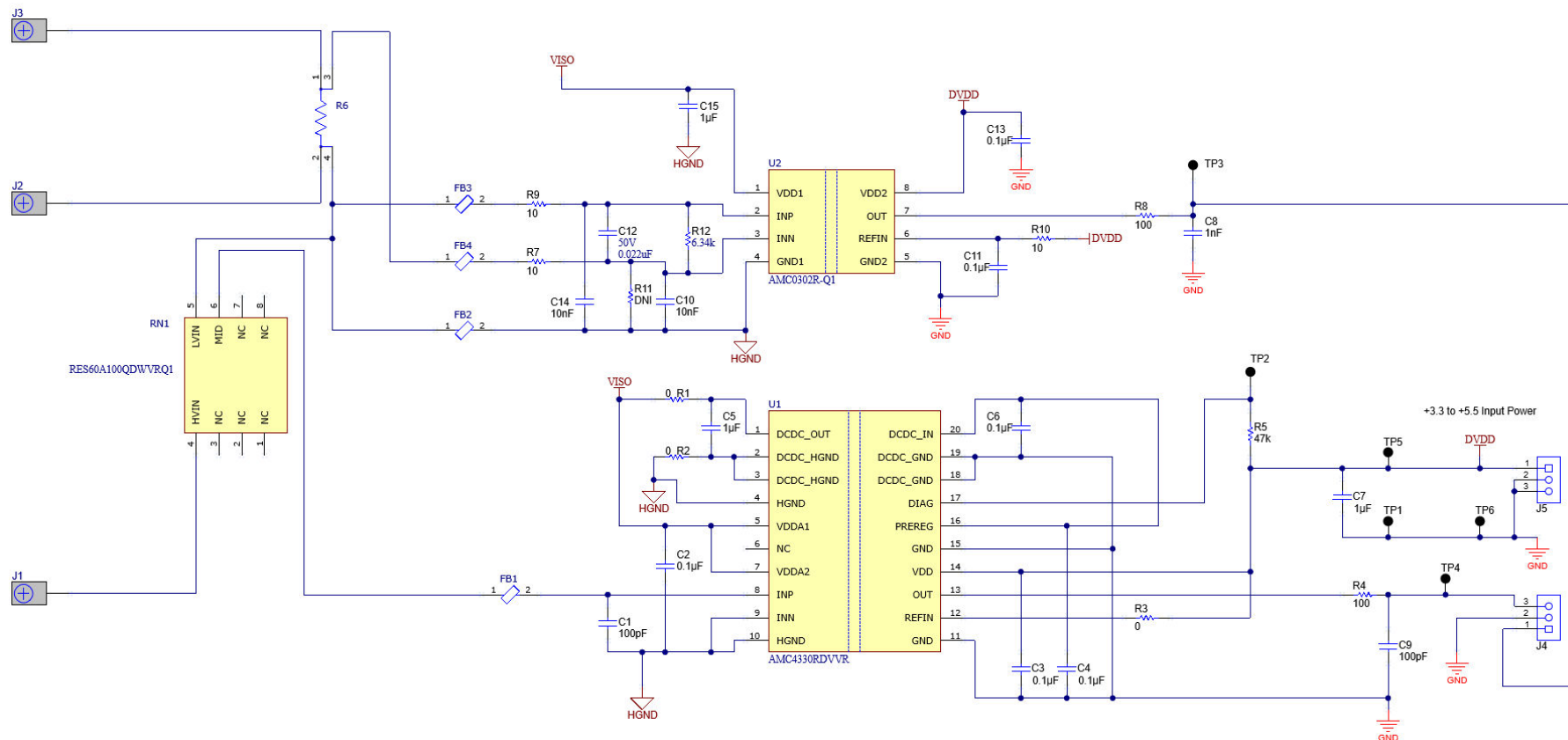


Figure 4-1. AMC-AMP-VI-EVM Schematic

4.2 PCB Layouts

Figure 4-2 and Figure 4-3 represent the layout of the AMC-AMP-VI-EVM.

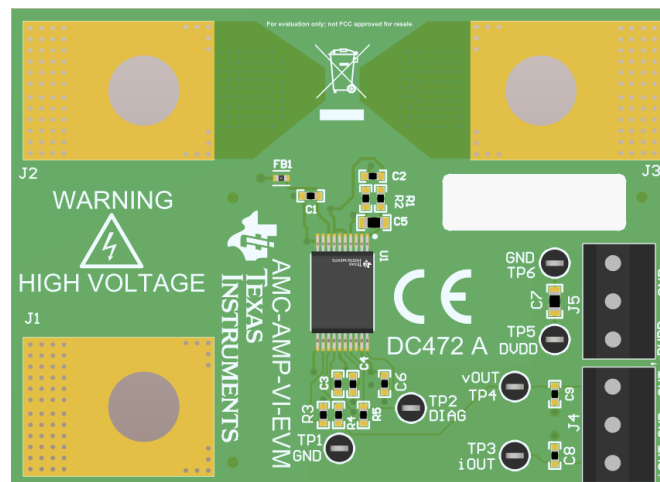


Figure 4-2. Top Side

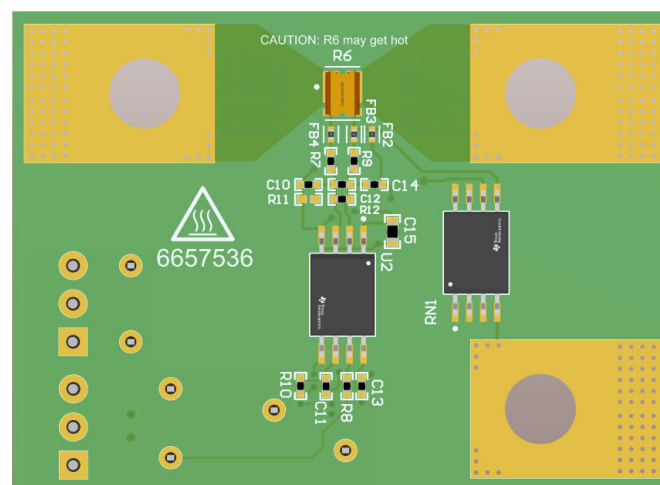


Figure 4-3. Bottom Side

Note

The AMC-AMP-VI-EVM is a 4-layer printed circuit board. Layers 2 and 3 have the same copper arrangements between J1, J2, and J3 as layers 1 and 4. Otherwise, there are no internal traces on layers 2 and 3.

4.3 Bill of Materials (BOM)

The complete Bill of Materials is provided in the following table.

Designator	Description	Manufacturer	Part Number
C1, C9	CAP, CERM, 100 pF, 16 V, +/- 10%, X7R, 0402	AVX	0402YC101KAT2A
C2, C3, C4, C6, C11, C13	CAP, CERM, 0.1 μ F, 16 V, +/- 5%, X7R, AEC-Q200 Grade 1, 0402	MuRata	GCM155R71C104JA55D
C5, C7, C15	CAP, CERM, 1 μ F, 16 V, +/- 10%, X5R, 0603	AVX	0603YD105KAT2A
C8	CAP, CERM, 1000 pF, 16 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0402	Yageo	AC0402KRX7R7BB102
C10, C14	CAP, CERM, 0.01 μ F, 16 V, +/- 10%, X7R, 0402	Würth Elektronik	885012205031
C12	CAP, CERM, 0.022 μ F, 50 V, +/- 10%, C0G/NP0, 0402	MuRata	GCM155R71H223KA55D
FB1, FB2, FB3, FB4	1.8 kOhms @ 100MHz 1 Power, Signal Line Ferrite Bead 0402 (1005 Metric) 210mA 2.1Ohm	Würth Electronics	74269244182
J4, J5	Terminal Block, 3.5mm Pitch, 3x1, TH	On-Shore Technology	ED555/3DS
R1, R2, R3	RES, 0, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	Vishay-Dale	CRCW04020000Z0ED
R4, R8	RES, 100, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	Stackpole Electronics Inc	RMCF0402JT100R
R5	RES, 47 k, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	Vishay-Dale	CRCW040247K0JNED
R6	1 mOhms $\pm$ 1% 7W Chip Resistor Wide 1612 (3831 Metric), 1216 Current Sense, Moisture Resistant	Isabellenhuette	BVN-M-R001-1.0
R7, R9, R10	RES, 10, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	Vishay-Dale	CRCW040210R0JNED
R12	RES, 6.34 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	Vishay-Dale	CRCW04026K34FKED
RN1	Automotive, 1700-V, Precision Resistive Divider	Texas Instruments	RES60A100QDWVRQ1
TP1, TP2, TP3, TP4, TP5, TP6	Test Point, Miniature, Black, TH	Keystone Electronics	5001
U1	AMC4330RDVVR	Texas Instruments	AMC4330RDVVR
U2	Automotive, Precision, $\pm$ 50-mV Input, Basic and Reinforced Isolated Amplifiers With Single-Ended, Ratiometric Output	Texas Instruments	AMC0302R-Q1

5 Compliance Information

5.1 Compliance and Certifications

[AMC4330R and AMC0302R UL Certificate of Compliance](#)

[AMC4330R and AMC0302R Verband der Elektrotechnik, Elektronik und Informationstechnik \(VDE\) Certificate of Conformity](#)

[AMC-AMP-VI-EVM EU Declaration of Conformity \(DoC\)](#)

6 Additional Information

6.1 Trademarks

All trademarks are the property of their respective owners.

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 DEGRADATION 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/sds/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 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/sds/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, INDEMNITY 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.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2023, Texas Instruments Incorporated

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATASHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES "AS IS" AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you fully indemnify TI and its representatives against any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI's products are provided subject to [TI's Terms of Sale](#), [TI's General Quality Guidelines](#), or other applicable terms available either on ti.com or provided in conjunction with such TI products. TI's provision of these resources does not expand or otherwise alter TI's applicable warranties or warranty disclaimers for TI products. Unless TI explicitly designates a product as custom or customer-specified, TI products are standard, catalog, general purpose devices.

TI objects to and rejects any additional or different terms you may propose.

Copyright © 2026, Texas Instruments Incorporated

Last updated 10/2025