

EVM User's Guide: AMC-AMP-200APK-EVM

AMC-AMP-200APK-EVM



1 Description

The AMC-AMP-200A-EVM is an isolated current-sensing evaluation module designed for $\pm 200\text{A}$ shunt-based current sensing. This EVM allows users to sense up to $\pm 500\text{A}$ peak current through an external shunt resistor while measuring the isolated output through the isolation barrier of the AMC3302. The AMC3302 is a precision, isolated amplifier optimized for shunt-based current measurements and is paired with a $100\mu\Omega$ shunt resistor. This EVM features via stitching to facilitate heat dissipation at large currents and can perform within $\pm 1\%$ (typical) accuracy.

Get Started

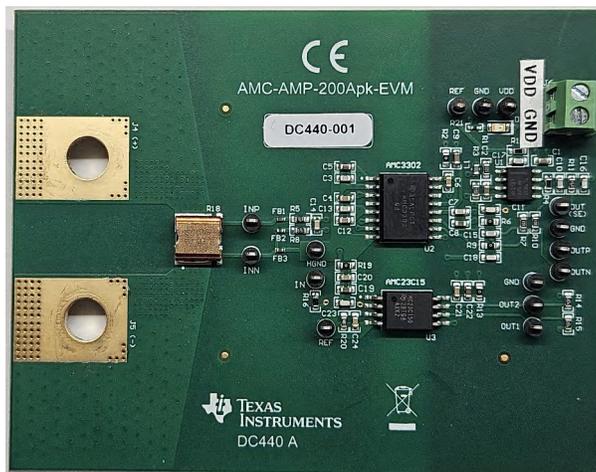
1. Order the AMC-AMP-200APK-EVM from ti.com
2. Evaluate the AMC3302 performance on the bench.

2 Features

- $\pm 200\text{A}$ isolated current sensing
- $100\mu\Omega$ shunt resistor
- Lug connection compatibility
- Heat dissipation designed for up to 120°C at 20 minutes in free air
- Test points for easy evaluation
- Differential to single-ended signal chain

3 Applications

- [Motor drives](#)
- [Power delivery](#)
- [Onboard chargers \(OBCs\)](#)
- [Traction inverters](#)
- [DC/DC converters](#)
- [Energy storage systems \(ESS\)](#)
- [EV charging](#)
- [Solar inverters](#)



4 Evaluation Module Overview

4.1 Introduction

Throughout this document, the abbreviation EVM and the term evaluation module are synonymous with the AMC-AMP-200APK-EVM. This document includes how to set up and evaluate the EVM, the printed circuit board (PCB) layout, schematics, and bill of materials (BOM).

4.2 Kit Contents

The EVM kit contains a printed circuit board with all required components mounted to evaluate the AMC3302 and AMC23C15.

4.3 Specification

The AMC-AMP-200APK-EVM provides the ability to evaluate high currents up to $\pm 200\text{A}$ continuous or $\pm 500\text{A}$ pulsed current. Refer to the data sheets of the AMC3302, AMC23C15 and the TLV9002IDR for detailed device specifications.

4.4 Device Information

The AMC-AMP-200APK-EVM is designed to provide ease-of-use and high accuracy in large current applications. The current-sensing device, AMC3302, is an isolated amplifier intended for shunt-based current sensing with reinforced isolation and an integrated DC/DC converter. Overcurrent detection is configurable using the AMC23C15, a reinforced, adjustable threshold isolated comparator. Both isolated current-sensing products sense across two $200\mu\Omega$ shunt resistors mounted in parallel.

5 Hardware

This section summarizes the AMC-AMP-200APK-EVM components, assembly instructions, interfaces, power requirements, and test point information.

5.1 Power Requirements

The AMC-AMP-200APK-EVM requires a single 3.3V to 5V power supply. J6 is provided to allow the user to connect an external bench source to the EVM to power the low side of both the AMC3302 and AMC23C15. The AMC3302 has a high side LDO output that is used to power the high side of the AMC23C15 dual window comparator.

5.2 Setup

Initial setup for the EVM is straight forward, simply provide power for the EVM by connecting a 3.3V to 5V bench supply to J6. There are two large pads, J4 and J5, for connecting the user provided current source to the EVM. The EVM has 6 layers of 4-ounce copper which helps to dissipate the power generated by the parallel shunt resistors without the use of heatsinks.

Use common-sense when connecting the current source terminals to the J4 and J5 pads. Crimped or mechanical lugs can be used with evaluation board. The PCB uses a ¼ inch through hole which is designed for use with ¼"-20 bolts and hex nut. Typical 200A connections use 2/0 AWG wire and require 16 to 23 foot-pounds of torque. Monitor the PCB temperature when using the EVM, do not allow the temperature to exceed 170° C for extended periods.

5.3 Test Points

The following section provides detail on the various test points located on the AMC-AMP-200APK-EVM.

5.3.1 Analog Inputs

The analog inputs to the AMC3302 can be monitored on the high side of the EVM through test points labeled "INP" and "INN". These two test points are directly connected to the Kelvin sense lines coming from the shunt resistors R17 and R18. The analog input then goes through a differential low-pass filter formed by R5, R8 and C14 before feeding to pins 6 and 7 of the AMC3302.

The analog input to the AMC23C15 dual-window comparator can be monitored at test point "IN" referenced to test point "REF" located just below R16, which is the resistor used for setting the variable input current.

The input supply voltage can be monitored at test points "VDD" and "GND" located to the left of J6.

5.3.2 Analog Outputs

The analog outputs of the AMC3302 can be directly monitored using the test points labeled "OUTP" and "OUTN" which are connected directly to pins 11 and 10 of the AMC3302 through zero-ohm resistors R6 and R9. Resistors R6 and R9 along with optional capacitor C15 form a low-pass differential filter on the output of the AMC3302 before doing a differential to single-ended transformation using U1 – a TLV9002 dual channel amplifier.

The outputs of the AMC23C15 comparator can be monitored directly at test points labeled "OUT1" and "OUT2" when referenced to the "GND" test point.

5.4 Cautions and Warnings

If the AMC-AMP-200APK-EVM is connected to AC Mains, there is a risk of exposure to high voltages. The use of Personal Protective Equipment (PPE) such as rubber insulating gloves, electrical hazard rated footwear and goggles is recommended when performing energized testing. TI recommends using the EVM in a protective safety enclosure that disables high-voltage potential when the enclosure is opened.

WARNING



Hot Surface! Contact can cause burns. Do not touch. Take the proper precautions when operating.

CAUTION



High Voltage! Electric shocks are possible when connecting the board to live wires. The board must be handled with care by a professional. For safety, use of isolated test equipment with overvoltage or overcurrent protection is highly recommended.

6 Implementation Results

6.1 Evaluation Setup

The AMC-AMP-200APK-EVM is designed to handle 200A continuously for extended periods of time without exceeding the temperature rating of the shunt resistors mounted to the PCB. Figure 6-1 shows a peak temperature of 115°C after 20 minutes of operation with continuous 200A current flowing through the shunts.



Figure 6-1. Thermal Image of the AMC-AMP-200APK-EVM

6.2 Performance Data and Results

The following figure represents the percentage error from 0A to 200A. The red trace represents the non-calibrated results. The yellow trace represents the offset calibrated results. The green trace represents the results after gain and offset calibration.

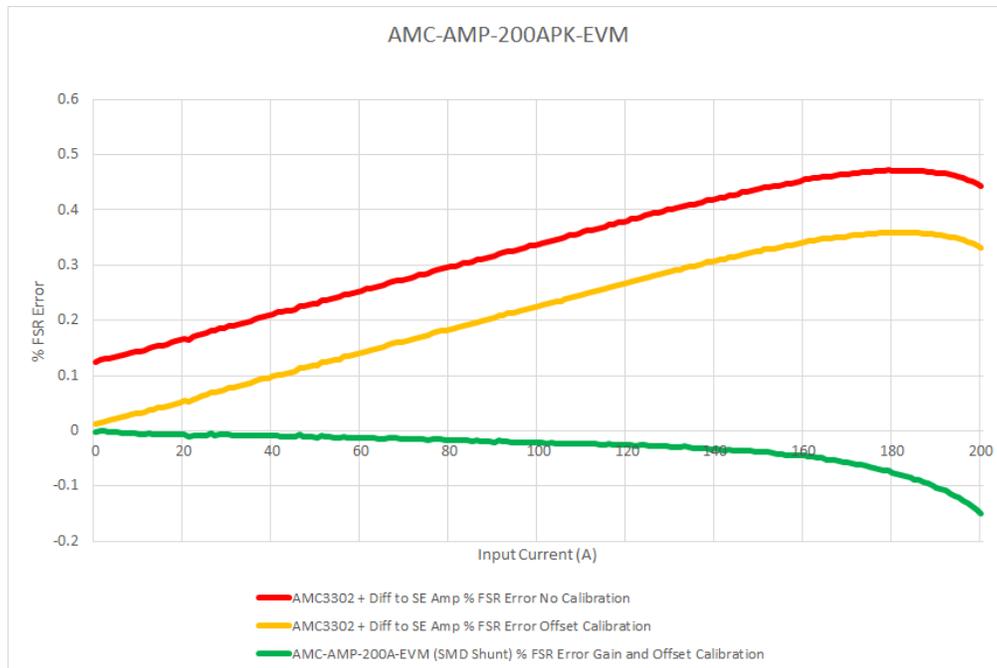
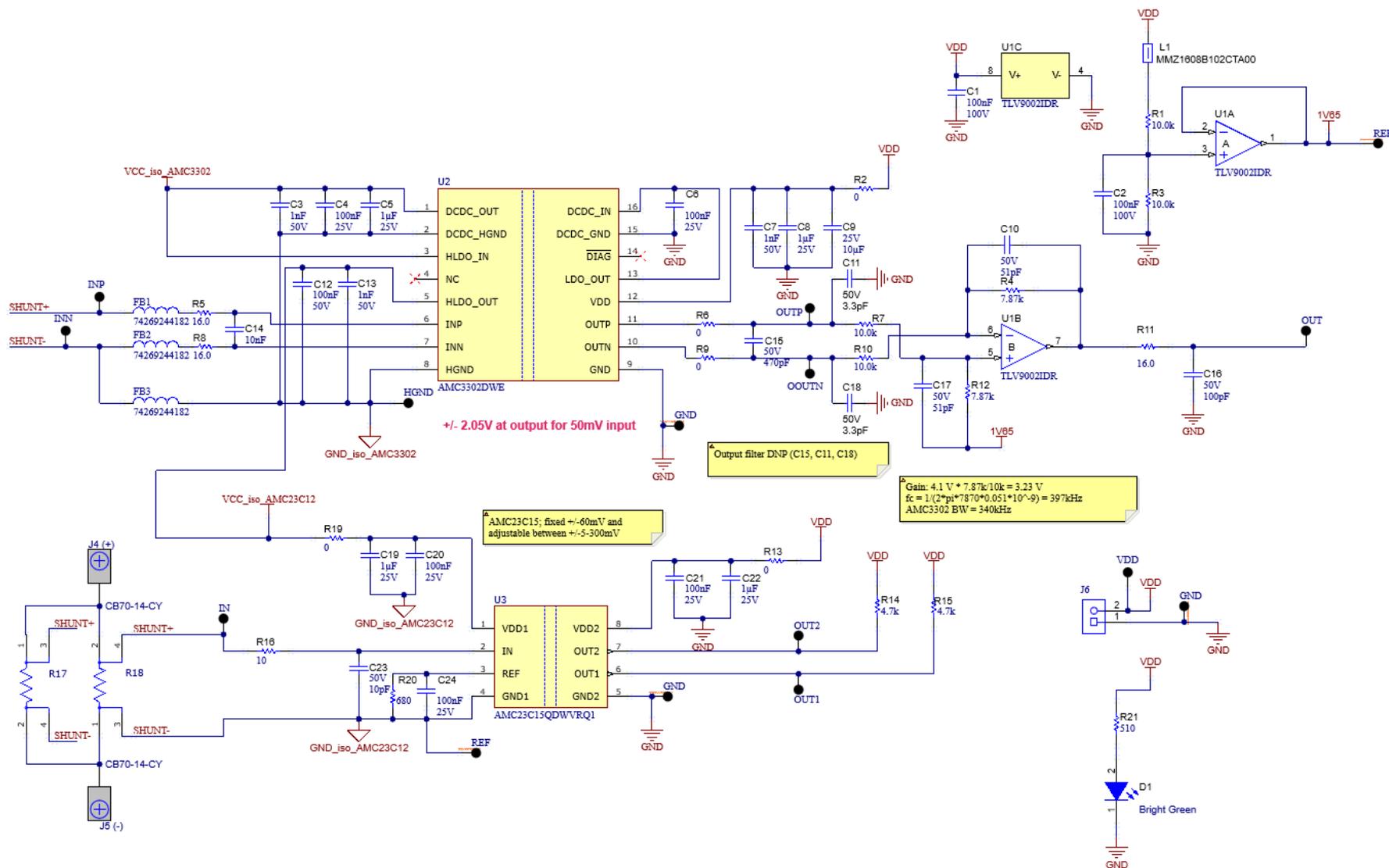


Figure 6-2. Percentage Error

7 Hardware Design Files

7.1 Schematics

The following diagram is the overall circuit schematic of the AMC-AMP-200APK-EVM.



7.2 PCB Layouts

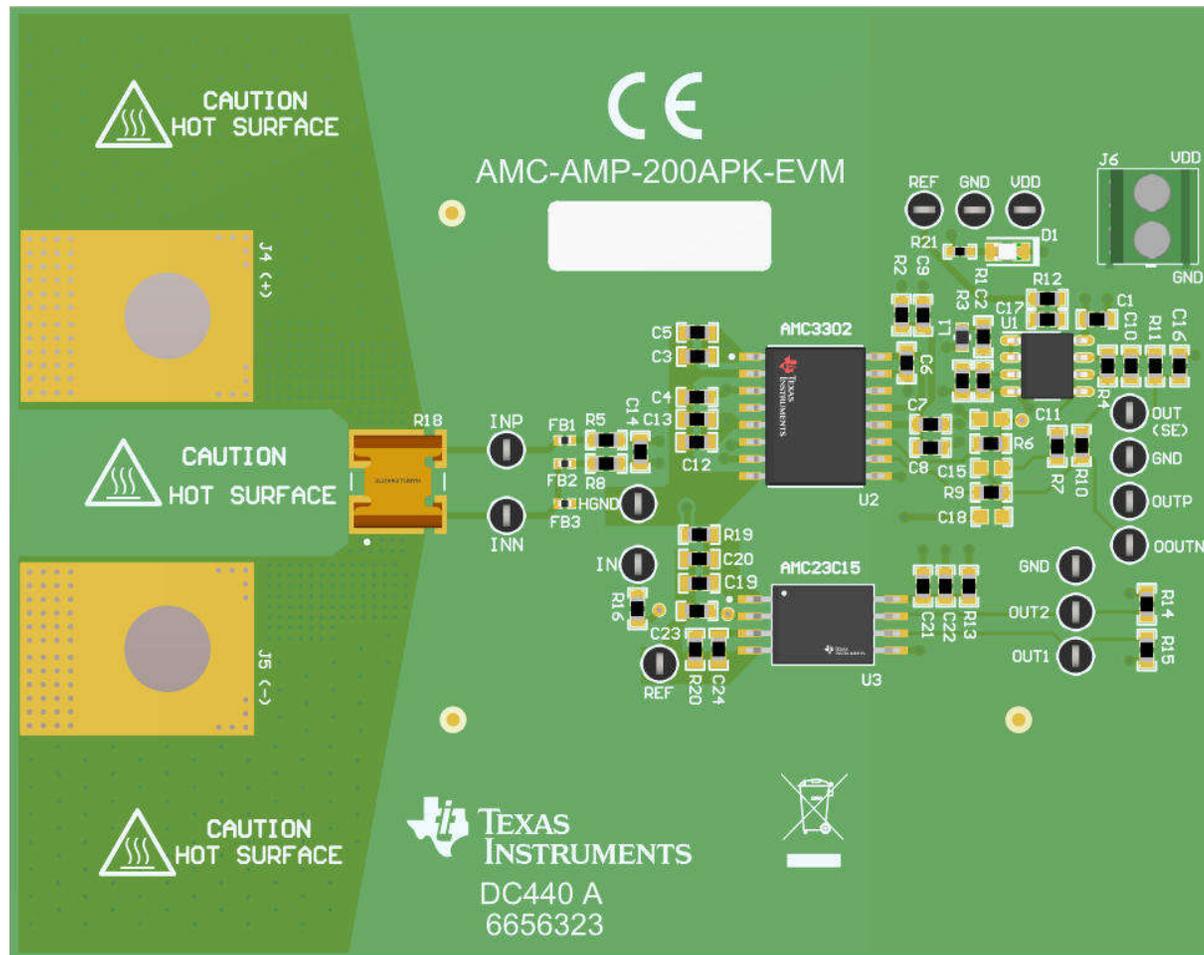


Figure 7-1. Topside EVM layout

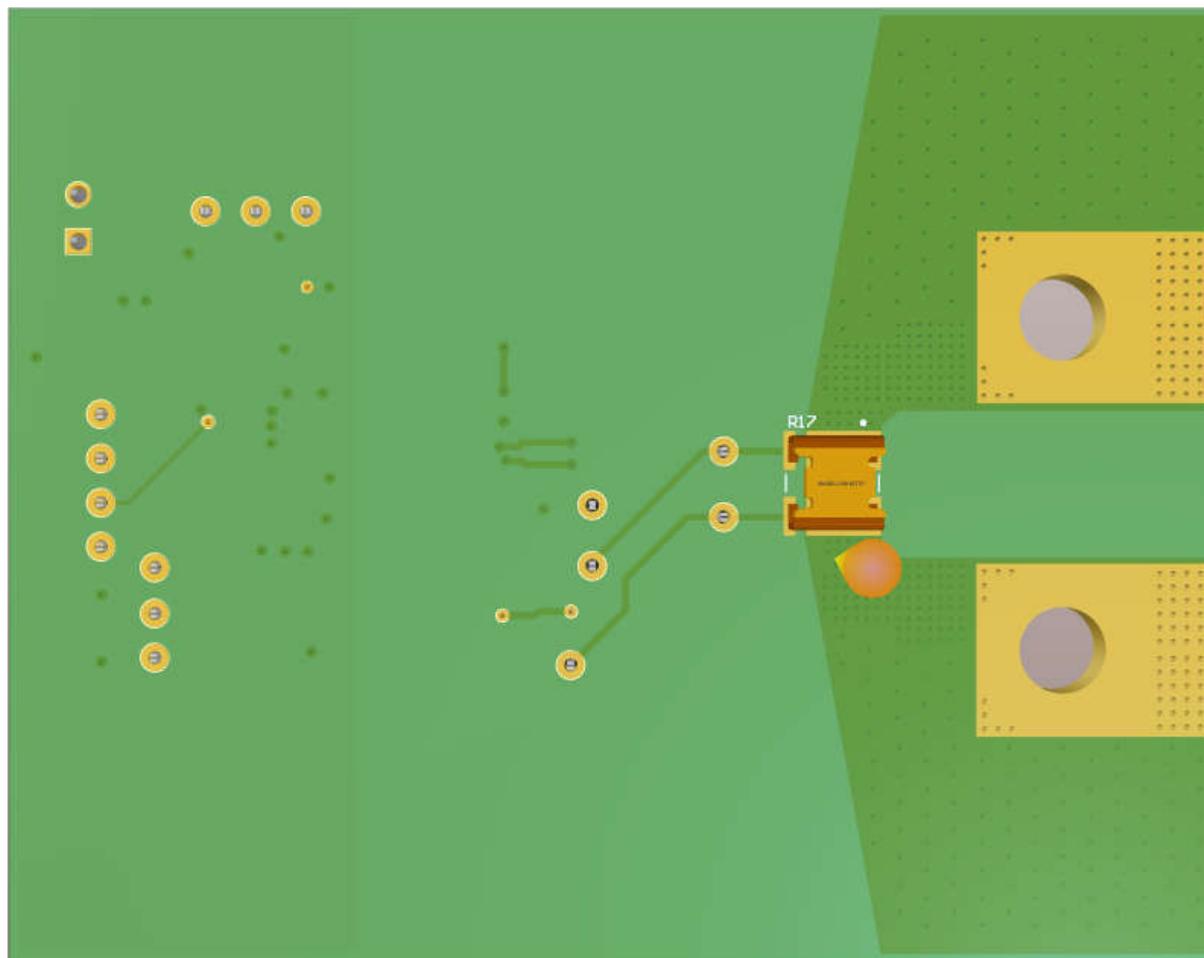


Figure 7-2. Bottom Side Layout

7.3 Bill of Materials (BOM)

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

DESIGNATOR	DESCRIPTION	MANUFACTURER	PART NUMBER
FB1, FB2, FB3	WE-TMSB Tiny Multilayer Suppression Bead, size 0402, 1800Ohm, 0.21A	Würth Elektronik	74269244182
C1, C2	CAP, CERM, 0.1uF, 100V, +/- 10%, X7R, 0603	MuRata	GRM188R72A104KA35J
C3, C7, C13	CAP, CERM, 1000pF, 50V, +/- 10%, X7R, 0603	Kemet	C0603C102K5RACTU
C4, C6, C20, C21, C24	CAP, CERM, 0.1uF, 25V, +/- 10%, X7R, 0603	AVX	06033C104KAT2A
C5, C8	CAP, CERM, 1 µF, 25V,+/- 10%, X7R, AEC-Q200 Grade 1, 0603	TDK	CGA3E1X7R1E105K080A C
C9	CAP, CERM, 10 µF, 25V,+/- 10%, X5R, 0603	MuRata	GRM188R61E106KA73D
C10, C17	CAP, CERM, 51pF, 50V, +/- 5%, C0G/NP0, AEC-Q200 Grade 1, 0603	MuRata	GCM1885C1H510JA16D
C11, C18	CAP, CERM, 3.3pF, 50V, +/- 8%, C0G/NP0, 0603	AVX	06035A3R3CAT2A
C12	CAP, CERM, 0.1 µF, 50V,+/- 10%, X7R, AEC-Q200 Grade 1, 0603	Kemet	C0603C104K5RACAUTO
C14	CAP, CERM, 0.01 µF, 16V,+/- 10%, X7R, 0603	Kemet	C0603C103K4RACTU
C15	CAP, CERM, 470pF, 50V, +/- 5%, C0G/NP0, 0603	MuRata	GRM1885C1H471JA01D
C16	CAP, CERM, 100pF, 50V,+/- 1%, C0G/NP0, 0603	Kemet	C0603C101F5GACTU
C19, C22	CAP, CERM, 1uF, 25V, +/- 10%, X7R, 0603	AVX	06033C105KAT2A
C23	CAP, CERM, 10pF, 50V, +/- 5%, C0G/NP0, 0603	Kemet	C0603C100J5GACTU
D1	LED, Bright Green, SMD	Würth Elektronik	150080VS75000
GND, HGND, IN, INN, INP, OUT, OUT1, OUT2, OUTN, OUTP, REF, VDD	Test Point, Miniature, Black, TH	Keystone Electronics	5001
J6	Terminal Block, 3.5mm, 2x1, Tin, TH	Würth Elektronik	691214110002
L1	Ferrite Bead, 1000ohm @ 100MHz, 0.3A, 0603	TDK	MMZ1608B102CTA00
R1, R3, R7, R10	RES, 10.0k, 0.1%, 0.1W, 0603	Yageo America	RT0603BRD0710KL
R2, R6, R9, R13, R19	RES, 0, 5%, 0.1W, 0603	Yageo	RC0603JR-070RL
R4, R12	RES, 7.87k, 0.1%, 0.1W, 0603	Yageo America	RT0603BRD077K87L
R5, R8, R11	RES, 16.0, 0.5%, 0.1W, 0603	Yageo America	RT0603DRE0716RL
R14, R15	RES, 4.7k, 5%, 0.1W, 0603	Yageo	RC0603JR-074K7L
R16	RES, 10, 5%, 0.1W, AEC-Q200 Grade 0, 0603	Vishay-Dale	CRCW060310R0JNEA
R17, R18	ISA-WELD PRECISION RESISTORS Current sensor for power hybrid applications	Isabellenhütte	BVB-Z-R0002-1.0
R20	RES, 680, 1%, 0.1W, 0603	Yageo	RC0603FR-07680RL
R21	RES, 510, 5%, 0.1W, AEC-Q200 Grade 0, 0402	Panasonic	ERJ-2GEJ511X
U1	2-Channel, 1MHz, RRIO, 1.8V to 5.5V Operational Amplifier for Cost-Optimized Systems, D0008A (SOIC-8)	Texas Instruments	TLV9002IDR
U2	High-Precision, ±50mV Input, Reinforced Isolated Amplifier With Integrated DC/DC Converter	Texas Instruments	AMC3302DWE
U3	Dual, Fast Response, Reinforced Isolated Window Comparator with Adjustable Threshold, SOICW8	Texas Instruments	AMC23C15QDWVRQ1

8 Additional Information

8.1 Trademarks

All trademarks are the property of their respective owners.

9 References

For additional information on EMI performance, performing a differential to single-ended transformation, or learning more about the accuracy associated with TI's isolated amplifiers, please review the following application notes.

1. Texas Instruments, [Best Practices to Attenuate AMC3301 Family Radiated Emissions EMI](#)
2. Texas Instruments, [Interfacing a Differential-Output \(Isolated\) Amp to a Single-ended Input ADC](#) application brief
3. Texas Instruments, [Isolated Amplifier Voltage Sensing Excel Calculator](#) tool

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 - 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/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。

<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.

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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.
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