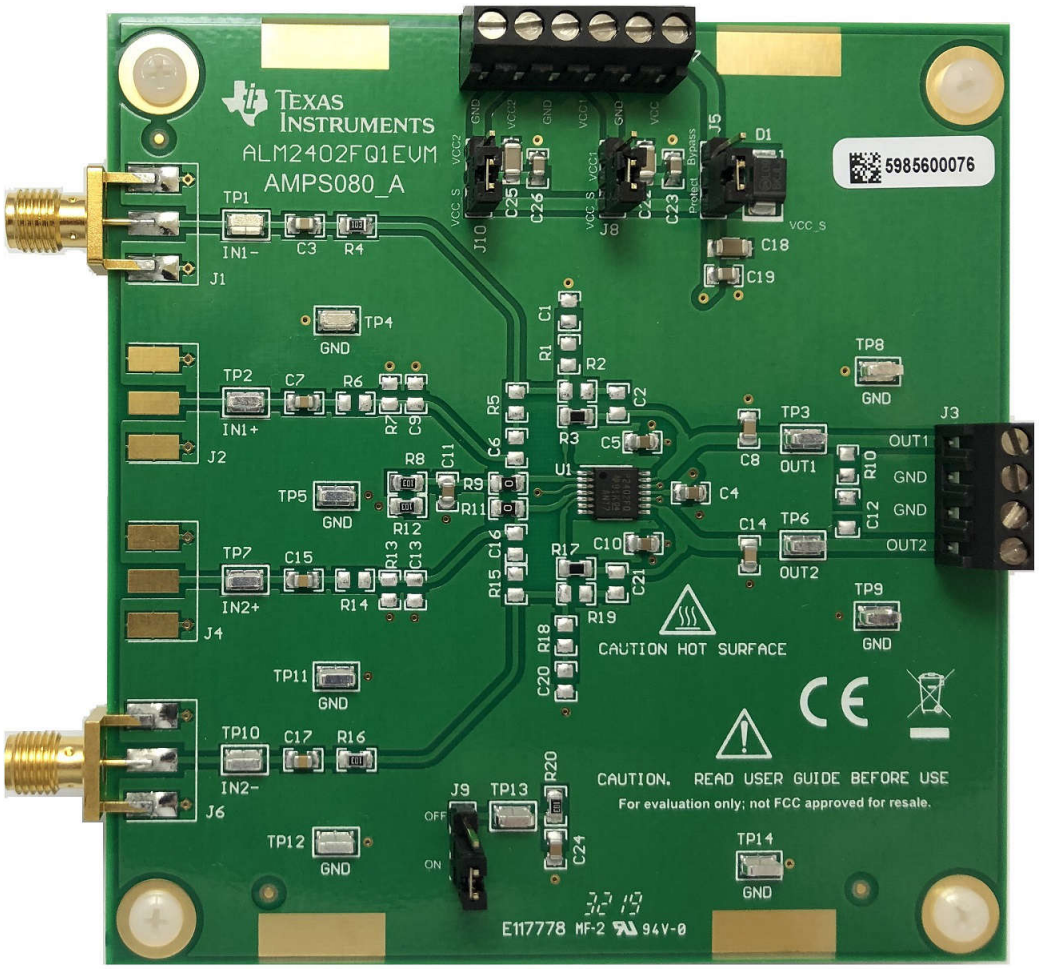
User's Guide

ALM2402F-Q1 Evaluation Module

ABSTRACT



This user's guide contains information and support documentation for the ALM2402F-Q1 evaluation module (EVM). Included are the circuit description, jumper settings, required connections, printed circuit board (PCB) layout, schematic, and bill of materials of the ALM2402FQ1EVM. Throughout this document, the terms evaluation board, evaluation module, and EVM are synonymous with the ALM2402FQ1EVM.

Table of Contents

Trademarks

1 Introduction

The ALM2402F-Q1 is an automotive-grade, dual high-voltage, high-current operational amplifier (op amp) with protection features from Texas Instruments. For a full list of electrical characteristics for the ALM2402F-Q1, see the *ALM2402F-Q1 Automotive, Dual Operational Amplifier With High Current Output* data sheet.

2 EVM Circuit Description

This EVM is designed to provide access to the features, and measure the performance, of the ALM2402F-Q1. By default, the ALM2402FQ1EVM has both amplifiers configured in the inverting configuration with a gain of –2.5 V/V. A simplified schematic of the ALM2402FQ1EVM is displayed in Figure 2-1. For a full schematic of the ALM2402FQ1EVM, see Section 7.1.

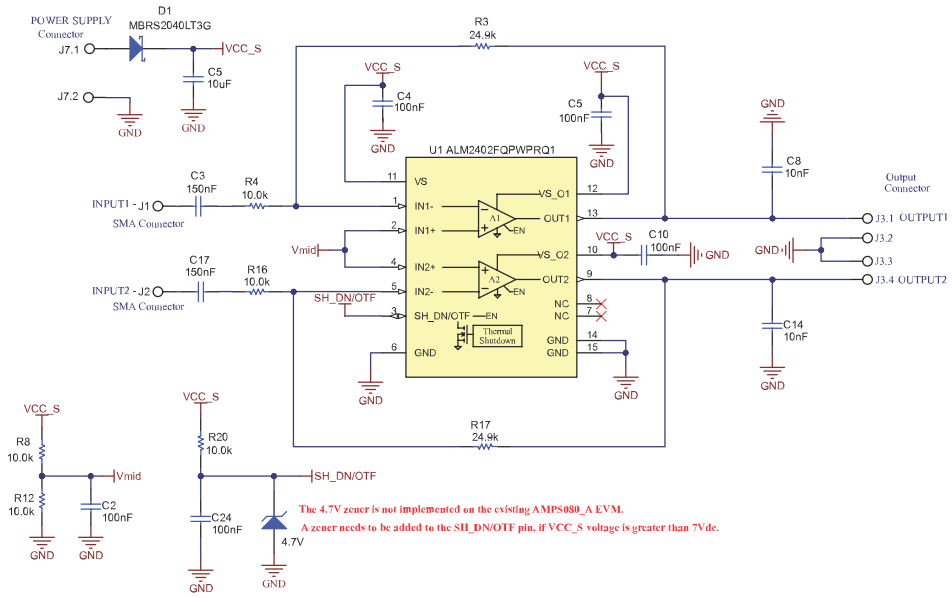


Figure 2-1. Simplified ALM2402FQ1EVM Schematic

3 Jumper Settings

Figure 3-1 details the default jumper settings of the ALM2402FQ1EVM. Figure 3-1 explains the configuration for these jumpers.

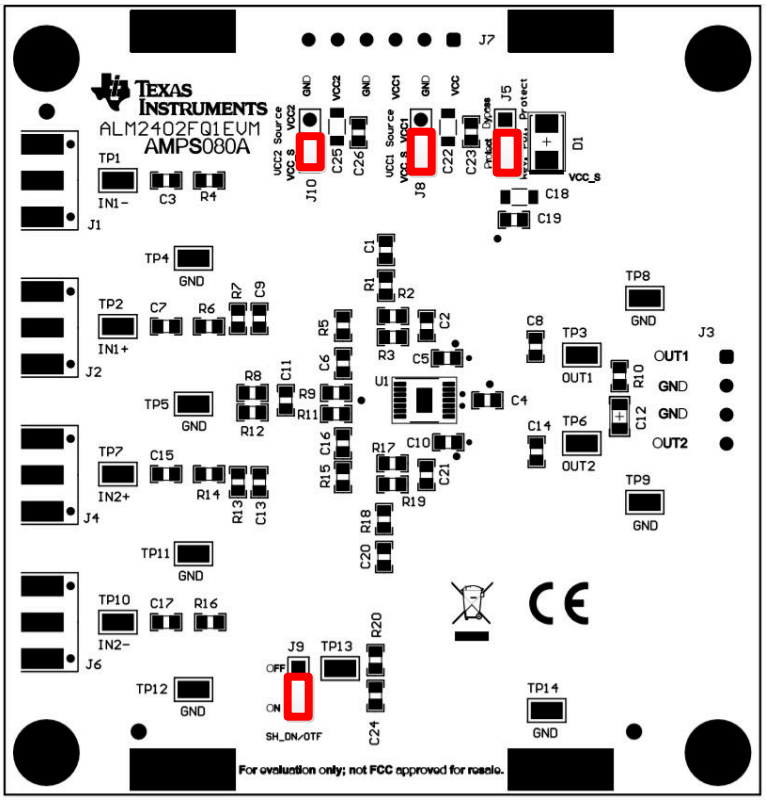


Figure 3-1. ALM2402FQ1 Evaluation Module Default Jumper Settings

Table 3-1. Default Jumper Configuration

Jumper	Function	Default Position	Description
J5	VCC_S reverse polarity protection	Shunt 2-3	Shunt 2-3: Schottky diode blocks VCC_S supply reverse current Shunt 1-2 bypasses VCC_S Schottky diode protection
J8	VCC1 source	Shunt 1-2	Shunt 1-2 selects VCC_S for op amp1 output supply Shunt 2-3 selects VCC_1 for op amp 1 output supply
J10	VCC2 source	Shunt 1-2	Shunt 1-2 selects VCC_S for op amp2 output supply Shunt 2-3 selects VCC_2 for op amp 2 output supply
J9	SH_DN / OTF	Shunt 2-3	Overtemperature flag or shutdown: Shunt 2-3 turns on amplifiers; pin works as overtemperature flag Shunt 1-2 shuts down amplifiers

CAUTION

The SH_DN/OTF's pull-up voltage larger than 7 V can permanently damage the device, see the *Absolute Maximum Ratings of ALM2402F-Q1's data sheet.*

If the supply voltage VCC_S is greater than 5 V, then the pull-up resistor R20 must be removed and the SH_DN/OTF pin must be driven from a separate voltage source, or a 4.7 V Zener needs to be added to the SH_DN/OTF pin as shown in Figure 2-1 and Figure 7-1.

Note: The 4.7 V Zener clamp has not implemented into the existing AMPS080_A EVM .

4 Power-Supply Connections

The power-supply connections for the ALM2402FQ1EVM are provided through connector J7 at the top of the EVM. Table 4-1 summarizes the pin definition for supply connector J7, and the allowed voltage range for each supply connection.

Table 4-1. ALM2402FQ1EVM Supply-Range Specifications

Pin Number	Supply Connection	Voltage Range
J7.1	Input stage supply (VCC)	4.5 V to 16 V
J7.2, J7.4, J7.6	Ground	0 V
J7.3	Op amp 1 output supply (VCC_1)	3 V to 16 V
J7.5	Op amp 2 output supply (VCC_2)	3 V to 16 V

By default, the ALM2402FQ1 is configured to use a single supply connected through J7.1 (VCC) and J7.2 (GND) with jumpers J8 and J10 set to shunt pins 1-2. Alternatively, the EVM can be configured to use three independent power-supply connections: input stage supply (VCC), op amp 1 output supply (VCC_1), and op amp 2 output supply (VCC_2). Setting jumpers J8 and J10 to shunt pins 2-3 allows the use of independent voltage supplies as indicated in Figure 4-1.

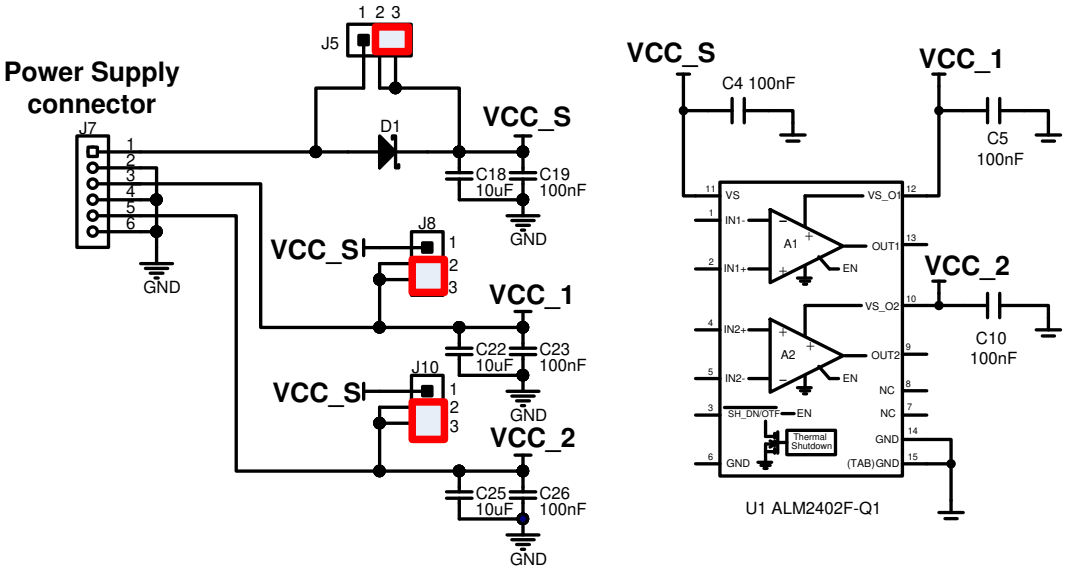
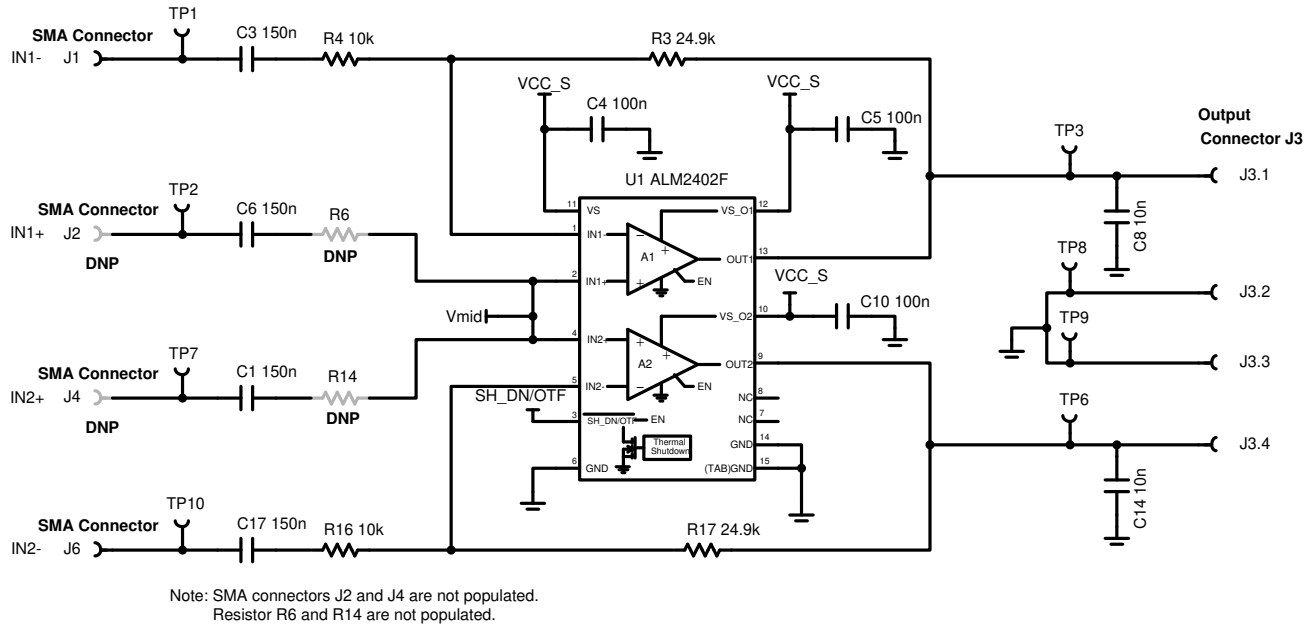


Figure 4-1. ALM2402FQ1EVM Configured With Independent Input-Stage and Output-Stage Supplies

5 Input and Output Connections

Input signal connections for the ALM2402FQ1EVM are provided through the use of the SMA connectors and test points located at the left of the EVM. The dual output-amplifier connections are provided through connector J3 and test points located at the right side of the EVM. A simplified diagram of the ALM2402FQ1EVM input and output connections is displayed in Figure 5-1.



Note: SMA connectors J2 and J4 are not populated.
Resistor R6 and R14 are not populated.

Figure 5-1. ALM2402FQ1EVM Input and Output Connections

Table 5-1 summarizes the input and output connectors and corresponding test points.

Table 5-1. ALM2402FQ1EVM Input and Output Connections

Connector Designator	Signal	Comment	Test Point
J1	IN1–	SMA	TP1
J2	IN1+	SMA (not populated)	TP2
J4	IN2+	SMA (not populated)	TP7
J6	IN2–	SMA	TP10
J3.1	OUT1	Screw terminal	TP3
J3.2	GND	Screw terminal	TP8
J3.3	GND	Screw terminal	TP9
J3.4	OUT2	Screw terminal	TP6

6 Modifications

By default, the ALM2402FQ1EVM is populated with both amplifiers set to the inverting configuration. However, for flexibility, the PCB layout has additional unpopulated passive component footprints, and additional input connections. These additional component footprints in the layout allow the user to change the ALM2402FQ1 circuit to other common configurations, such as the buffer and noninverting amplifier configurations. For a full schematic of the ALM2402FQ1EVM, see Figure 7-1.

7 Schematic, PCB Layout, and Bill of Materials

This section contains the schematic, bill of materials, and references for the ALM2402FQ1EVM.

7.1 Schematic

Figure 7-1 illustrates the EVM schematic.

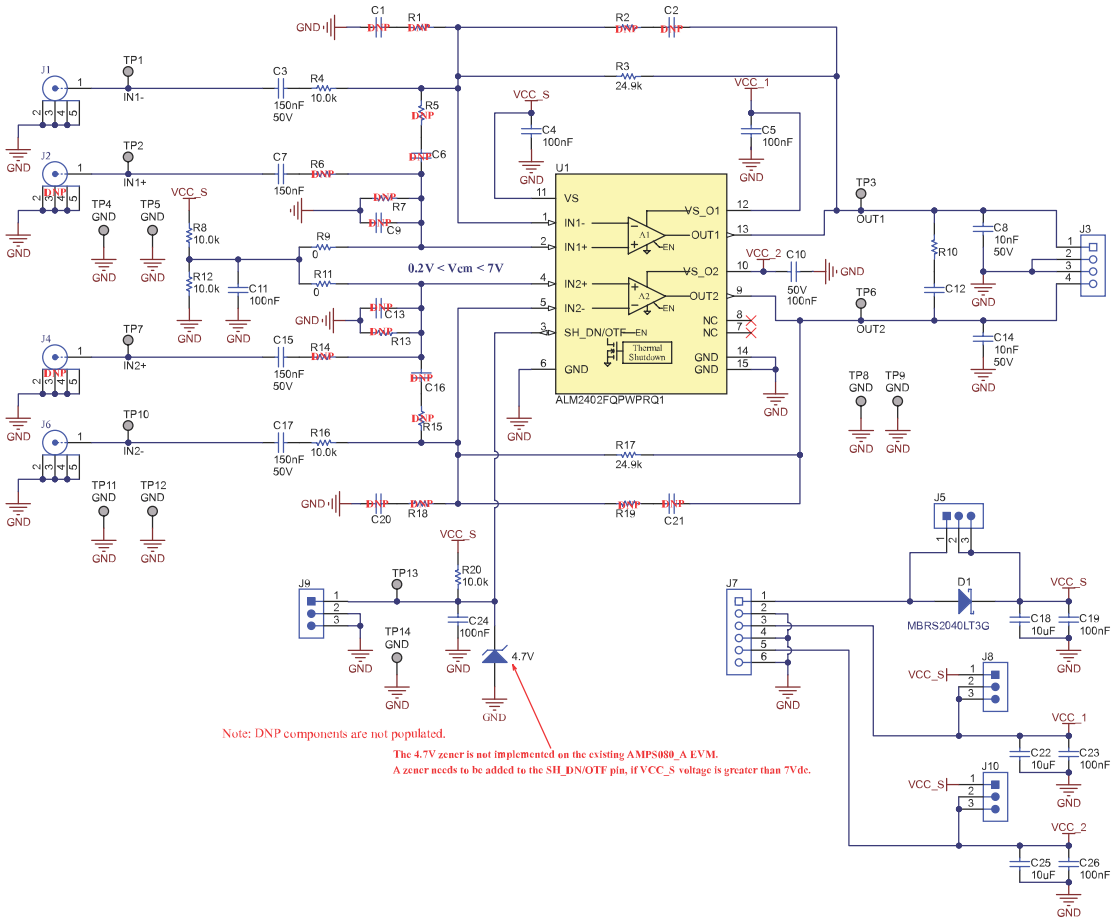


Figure 7-1. ALM2402FQ1EVM Schematic

7.2 PCB Layout

The ALM2402FQ1EVM is a four-layer PCB design. Figure 7-2 to Figure 7-5 show the PCB layer illustrations. The top layer consists of all signal path traces, and is poured with a solid ground plane. A symmetrical board layout is used on amplifier 1 and amplifier 2 to keep good performance matching. Decoupling capacitors C4, C5, and C10 are positioned on the top layer as close as possible to the power supply pins of the device. The second internal layer is a dedicated solid GND plane. Independent vias are placed at the ground connection of every component to provide a low-impedance path to ground. The third internal layer and the bottom layer route the power-supply connections.

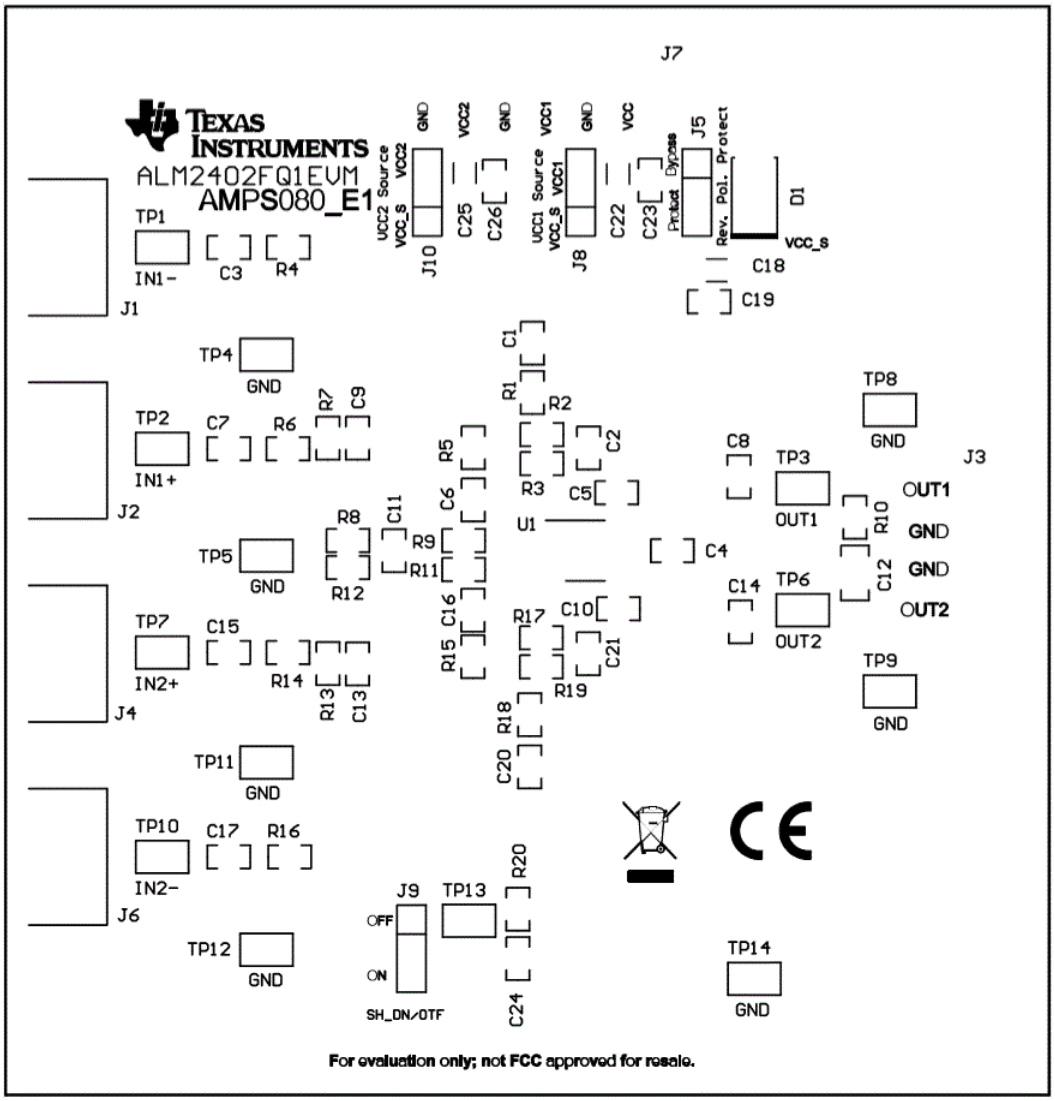


Figure 7-2. Top Overlay PCB Layout

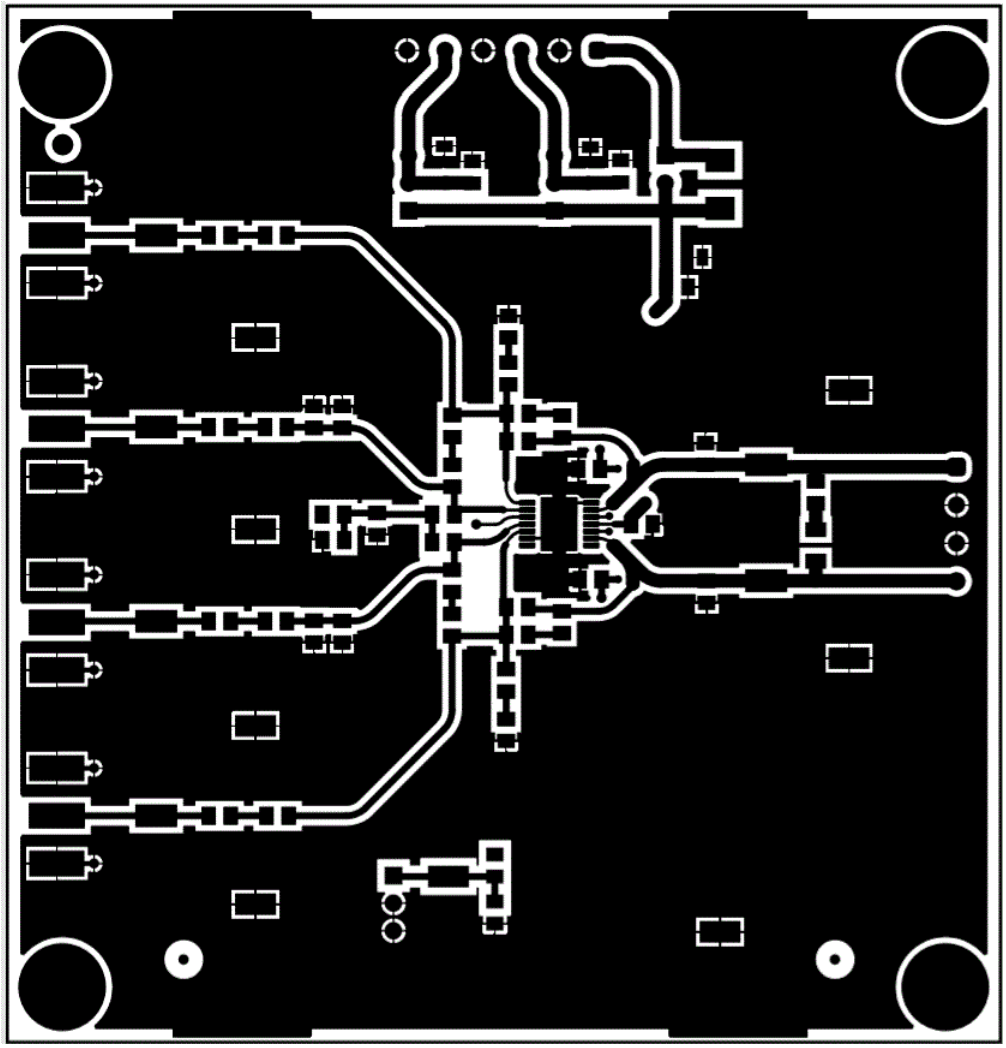


Figure 7-3. Top Layer PCB Layout

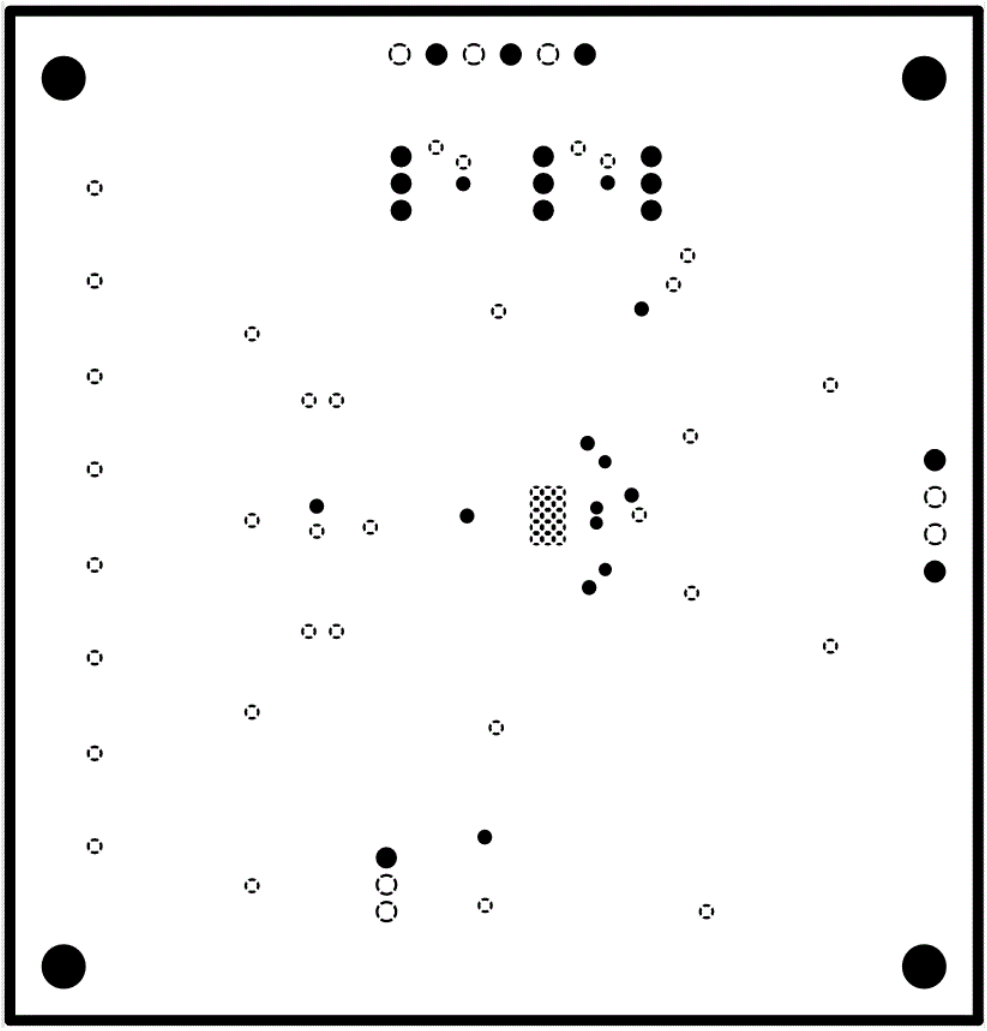


Figure 7-4. Ground Layer PCB Layout

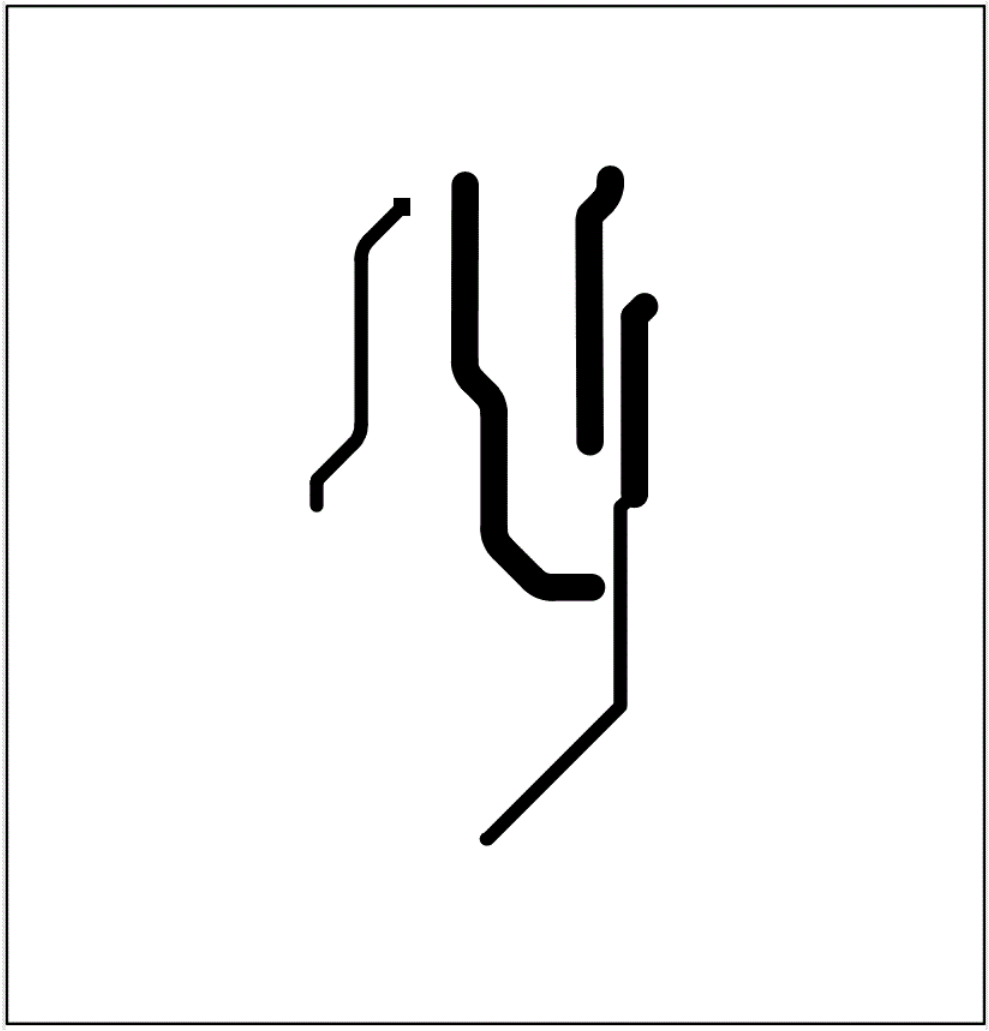


Figure 7-5. Power Layer PCB Layout

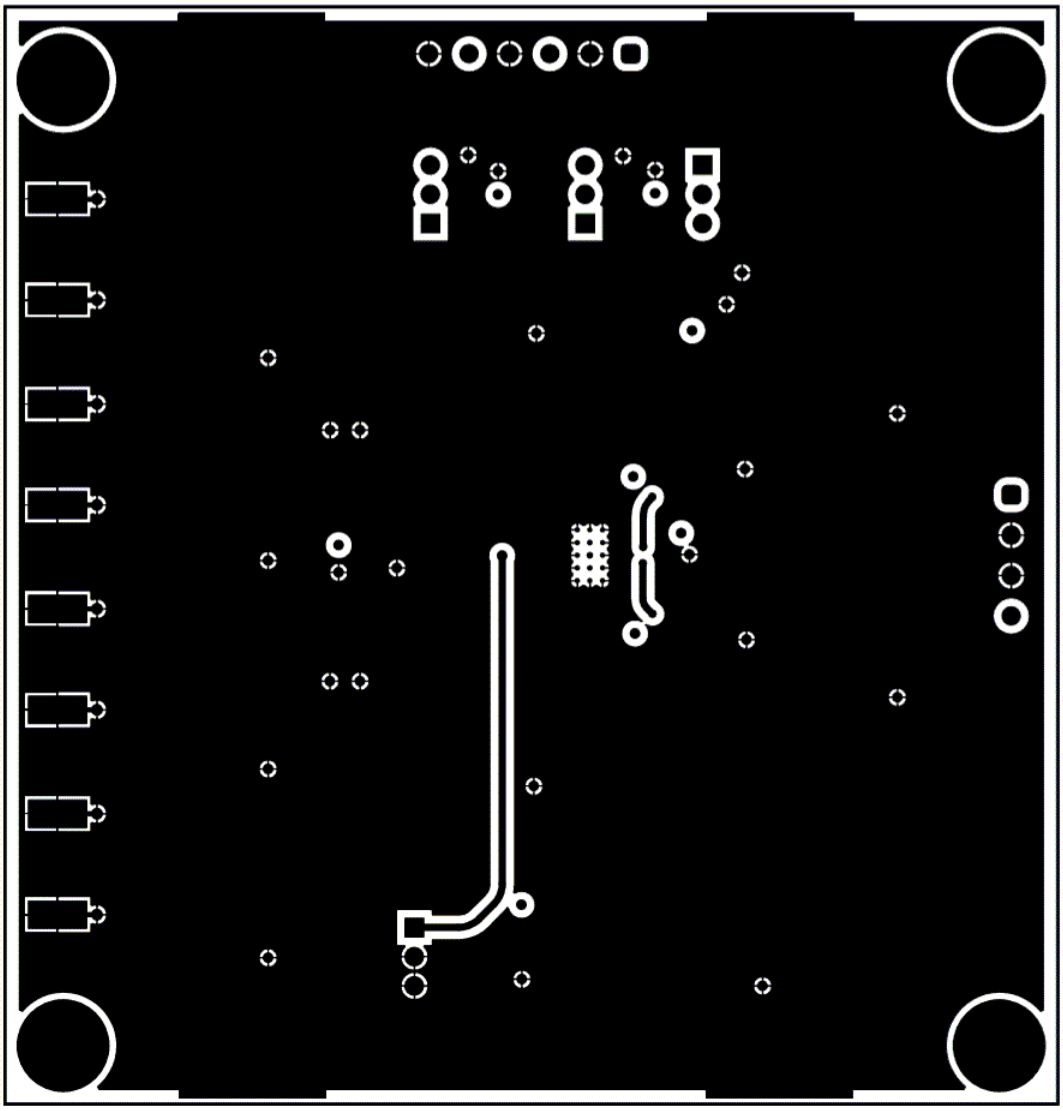


Figure 7-6. Bottom Layer PCB Layout

7.3 Bill of Materials

Table 7-1 lists the ALM2402FQ1EVM bill of materials (BOM).

Table 7-1. ALM2402FQ1EVM Bill of Materials

Designator	Qty	Value	Description	Package Reference	Part Number	Manufacturer
!PCB1	1		Printed Circuit Board		AMPS080	Any
C3, C7, C15, C17	4	0.15uF	CAP, CERM, 0.15 uF, 50 V, +/- 10%, X7R, 0805	0805	C0805C154K5RACTU	Kemet
C4, C5, C10, C11, C19, C23, C26	7	0.1uF	CAP, CERM, 0.1 uF, 50 V, +/- 10%, X7R, 0805	0805	08055C104KAT2A	AVX
C8, C14, C24	3	0.01uF	CAP, CERM, 0.01 uF, 50 V, +/- 10%, X7R, 0805	0805	08055C103KAT2A	AVX
C18, C22, C25	3	10uF	CAP, CERM, 10 uF, 35 V, +/- 10%, X7R, 1206	1206	'C3216X7R1V106K160AC	TDK
D1	1	40 V	Diode, Schottky, 40 V, 2 A, SMB	SMB	MBRS2040LT3G	ON 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
J1, J2, J4, J6	4		Connector, End launch SMA, 50 ohm, SMT	End Launch SMA	142-0701-801	Cinch Connectivity
J3	1		Terminal Block, 3.5mm, 4x1, Tin, TH	Terminal Block, 3.5mm, 4x1, TH	0393570004	Molex
J5, J8, J9, J10	4		Header, 100mil, 3x1, Gold, TH	PBC03SAAN	PBC03SAAN	Sullins Connector Solutions
J7	1		Terminal Block, 3.5mm, 6x1, Tin, TH	Terminal Block, 3.5mm, 6x1, TH	0393570006	Molex
R3, R17	2	24.9k	RES, 24.9 k, 0.5%, 0.1 W, 0805	0805	RR1220P-2492-D-M	Susumu Co Ltd
R4, R8, R12, R16, R20	5	10.0k	RES, 10.0 k, 0.5%, 0.125 W, 0805	0805	RT0805DRE0710KL	Yageo America
R9, R11	2	0	RES, 0, 5%, 0.125 W, AEC-Q200 Grade 0, 0805	0805	ERJ-6GEY0R00V	Panasonic
TP1, TP2, TP3, TP4, TP5, TP6, TP7, TP8, TP9, TP10, TP11, TP12, TP13, TP14	14		Test Point, Miniature, SMT	Test Point, Miniature, SMT	5019	Keystone
U1	1		Automotive, Dual Operational Amplifier With High Current Output, PWP0014H (HTSSOP-14)	PWP0014H	ALM2402FQPWPRQ1	Texas Instruments
C1, C2, C6, C9, C13, C16, C20, C21, C24	0	0.01uF	CAP, CERM, 0.01 uF, 50 V, +/- 10%, X7R, 0805	0805	08055C103KAT2A	AVX
C12	0	0.22uF	CAP, CERM, 0.22 uF, 50 V, +/- 5%, X7R, 1206	1206	C1206C224J5RACTU	Kemet
R1, R2, R5, R7, R10, R13, R15, R18, R19	0	24.9k	RES, 24.9 k, 0.5%, 0.1 W, 0805	0805	RR1220P-2492-D-M	Susumu Co Ltd
R6, R14	0	10.0k	RES, 10.0 k, 0.5%, 0.125 W, 0805	0805	RT0805DRE0710KL	Yageo America

8 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Revision * (September 2019) to Revision A (November 2023)	Page
• Changed *Simplified ALM2402FQ1EVM Schematic* figure	3
• Changed *Caution* note at the end of the section	4
• Changed schematic	7

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。

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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3.3.3 *Notice for EVMs for Power Line Communication:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_02.page

電力線搬送波通信についての開発キットをお使いになる際の注意事項については、次のところをご覧ください。https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-for-power-line-communication.html

3.4 *European Union*

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

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

4 *EVM Use Restrictions and Warnings:*

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

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

4.3 *Safety-Related Warnings and Restrictions:*

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