User's Guide

AMC1304EVM User's Guide

ABSTRACT

This user's guide describes the characteristics, operation, and use of the AMC1304EVM. The AMC1304EVM is designed for prototyping and evaluation. A complete circuit description, schematic diagram, and bill of materials are included.

Throughout this document, the abbreviation *EVM* and the term *evaluation module* are synonymous with the AMC1304EVM.

The following related documents are available through the Texas Instruments web site at www.ti.com.

Table 1-1. Related Documentation

Device	Literature Number
AMC1304	SBAS655
AMC1210	SBAS372
SN6501	SLLSEA0
TMS320F28377D	SPRS880

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1 Trademarks

All trademarks are the property of their respective owners.

2 Overview

2.1 Features

- Full-featured evaluation module for the AMC1304 single-channel, isolated, delta-sigma (ΔΣ) modulator
- Screw terminals for easy access to analog inputs, clock input, and modulator data output
- Optional isolated power to the AMC1304 low-dropout regulator (LDO) input derived from the controller-side power supply

2.2 Introduction

The AMC1304 is a single-channel, second-order, switched-capacitor, ΔΣ modulator with an output separated from the input interface circuitry by a SiO_2 isolation barrier. The isolation barrier provides galvanic isolation of up to 7000 V_{PEAK}. The AMC1304 can be used to achieve 16 bits of resolution when paired with a digital filter (such as the ΔΣ filter module in the TMS320F28377D or the AMC1210).

3 Analog Interface

The analog input to the AMC1304 is routed from the two-wire screw terminal at J2. This screw terminal gives the user access to the inverting and noninverting inputs of the AMC1304 device installed at U1.

3.1 Analog Inputs

The analog input to the AMC1304EVM printed circuit board (PCB) consists of a simple RC filter circuit. The input circuitry for the AMC1304 is shown in Figure 3-1.

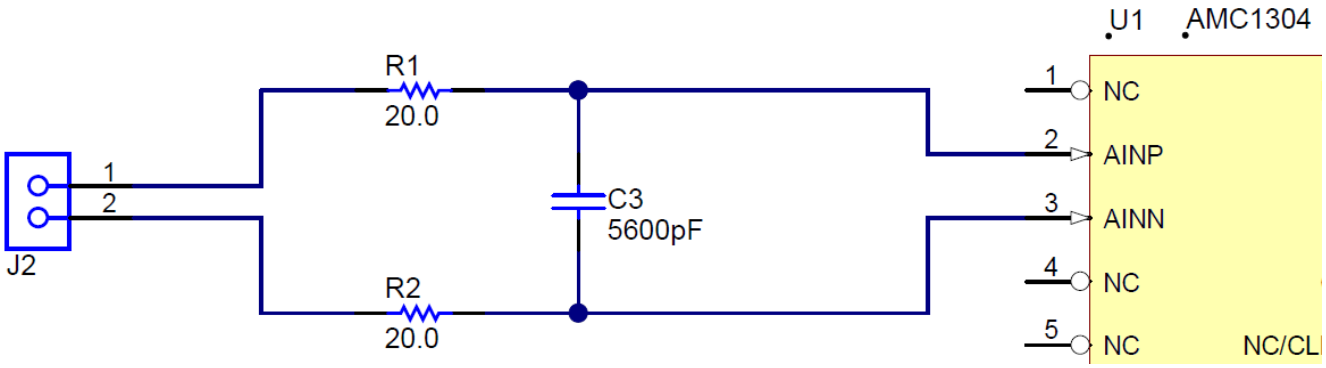

Figure 3-1. AMC1304EVM Schematic: Analog Input Section

Note that the RC filter circuit is not required in every application; the input amplifier of the AMC1304 already provides a limited input bandwidth. See Table 6-1 for additional details about the analog input bandwidth for each component in the AMC1304 family.

Note that the RC filter circuit is not required in every application; the input amplifier of the AMC1305 already provides a limited input bandwidth. Refer to Table 6-1 for additional details about the analog input bandwidth for each component in the AMC1305 family.

4 Digital Interface

The AMC1304EVM is designed for use with digital filters, such as the ΔΣ filter module in the TMS320F28377D or the AMC1210. The power, clock input, and modulator data output of the AMC1304 device are routed to the two-wire screw terminals at J1, J3, and J4, as Figure 4-1 shows.

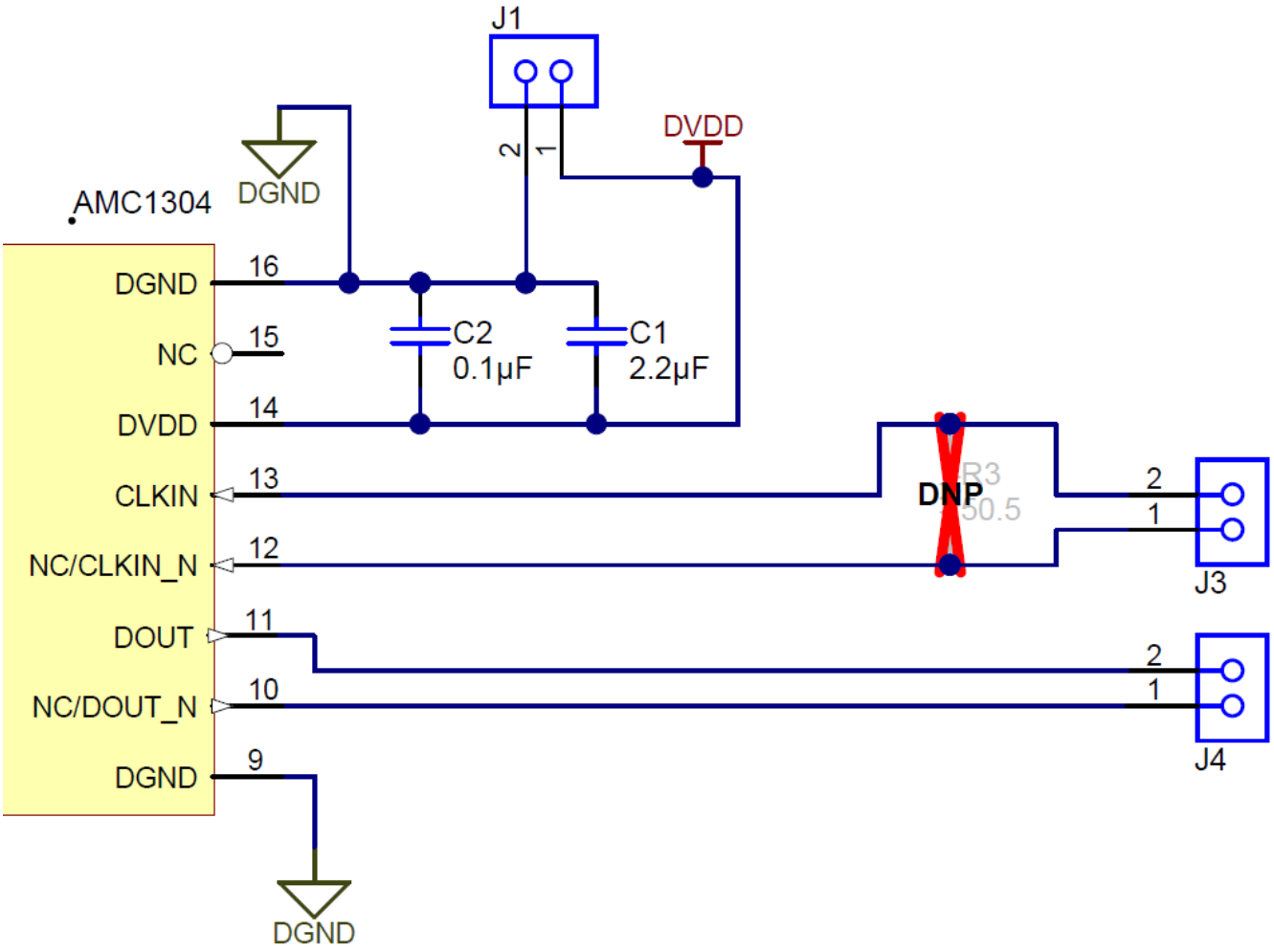

Figure 4-1. Power, Clock Input, and Digital Data Output

Note that component R3 in Figure 4-1 is marked as DNP (do not populate) because Figure 4-1 corresponds to an AMC1304EVM populated with a CMOS variant of the AMC1304. Refer to Table 6-1 for additional details about the analog input ranges and interfaces available in the AMC1304 family.

5 Power Supplies

Power for the controller side of the AMC1304 device is supplied through the two-wire screw terminal at J1.

The user has two options to provide power for the high side of the AMC1304 device (note that in both options, power is provided to the LDO input on pin 6 of the AMC1304). One option is to supply the high side of the AMC1304 through the two-wire screw terminal at J5; to accomplish that, the user must set jumper JP1 to the position labeled *Ext*; see Figure 5-1.

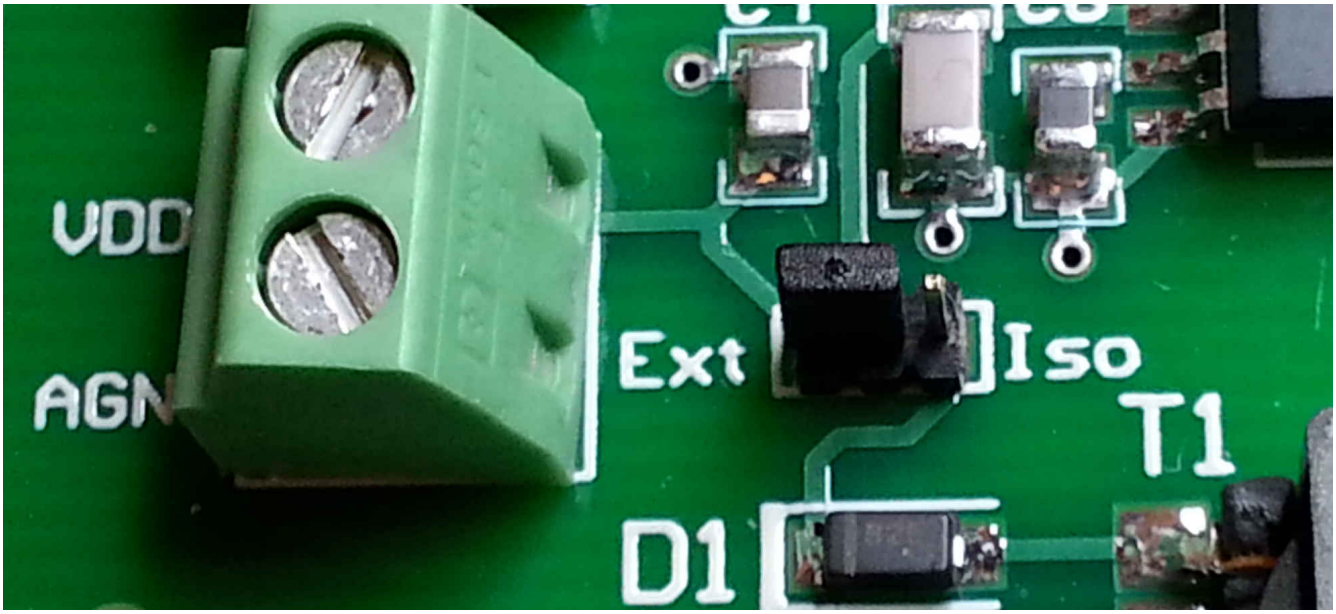

Figure 5-1. JP1 in *Ext* Position

The second option is to supply the high side of the AMC1304 with the filtered signal coming from the isolated side of the onboard transformer T1. Note that the filtered signal on the isolated side of T1 is generated from the power supplied to the controller side of the AMC1304 device by using the SN6501 transformer driver located at U2. To take advantage of this isolated, onboard supply, the user must set jumper JP1 to the position labeled *Iso*, as shown in Figure 5-2.

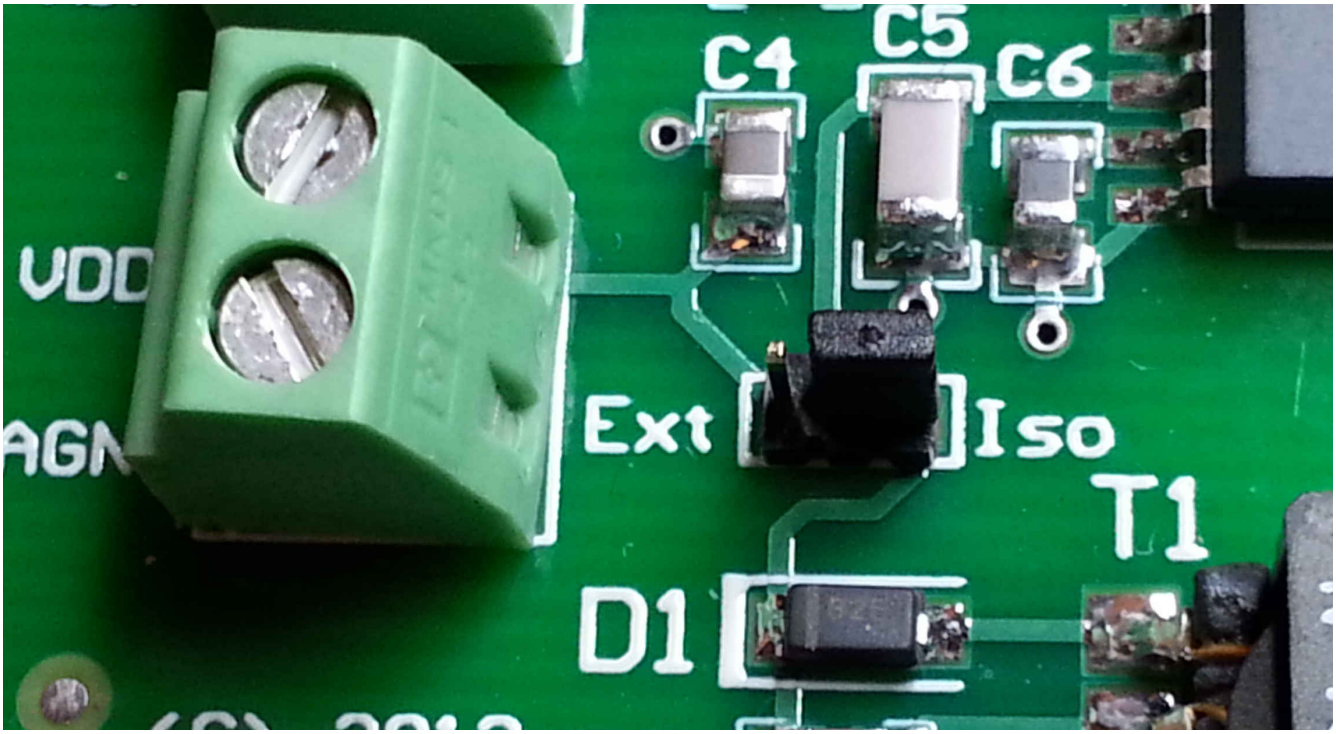

Figure 5-2. JP1 in *Iso* Position

The design of the isolated, unregulated power source to the AMC1304 LDO input closely follows the TIPD121 Design Reference Guide, *0-5 A, Single-Supply, 2 kV Isolated Current Sensing Solution* (SLAU521).

The SN6501 transformer driver is used because it is designed for low-power, push-pull converters with input voltages in the range of 3 V to 5.5 V; such voltage range fits well within the AMC1304 controller-side supply range. Two important components in the dc-dc converter are the isolation transformer and the rectifier diode.

5.1 Transformer Selection

To prevent the isolation transformer from saturating, its volt-seconds (V-t) product must be greater than the maximum volt-seconds product applied by the SN6501. The maximum voltage delivered by the SN6501 is the nominal converter input plus a 10% margin. The maximum time this voltage is applied to the primary is half the period of the lowest frequency at the specified input voltage. The minimum switching frequency of the SN6501 at 5-V operation is 300 kHz. Therefore, the transformer minimum V-t product under these conditions, as determined by equations (1) and (2) in the SN6501 data sheet data sheet, is 9.1 Vμs. The specified V-t product of the isolation transformer selected (DA2304) is well above this 9.1-Vμs requirement.

When searching for a suitable transformer, the minimum turns ratio required must be determined; such a ratio allows the push-pull converter to operate over the specified current and temperature range. The minimum turns ratio required can be expressed through the ratio of secondary to primary voltage multiplied by a correction factor that takes into account the transformer typical efficiency. Equations (3) through (8) in the SN6501 data sheet show the specific requirements for determining the minimum turns ratio for a given application. The DA2304 has a 1:2.2 turns ratio; such a ratio produces an unregulated, open-circuit voltage output well within the AMC1304 low-dropout regulator input range.

5.2 Rectifier Diode Selection

The chosen rectifier diode must possess low forward voltage to provide as much voltage to the converter output as possible. When used in high-frequency switching applications, the rectifier must also possess a short recovery time. Schottky diodes meet both of these requirements. The MBR0520L with a typical forward voltage of approximately 100 mV at 8-mA forward current is used in this low-voltage design. Figure 5-3 illustrates the forward voltage versus forward current characteristics of the MBR0520L diode.

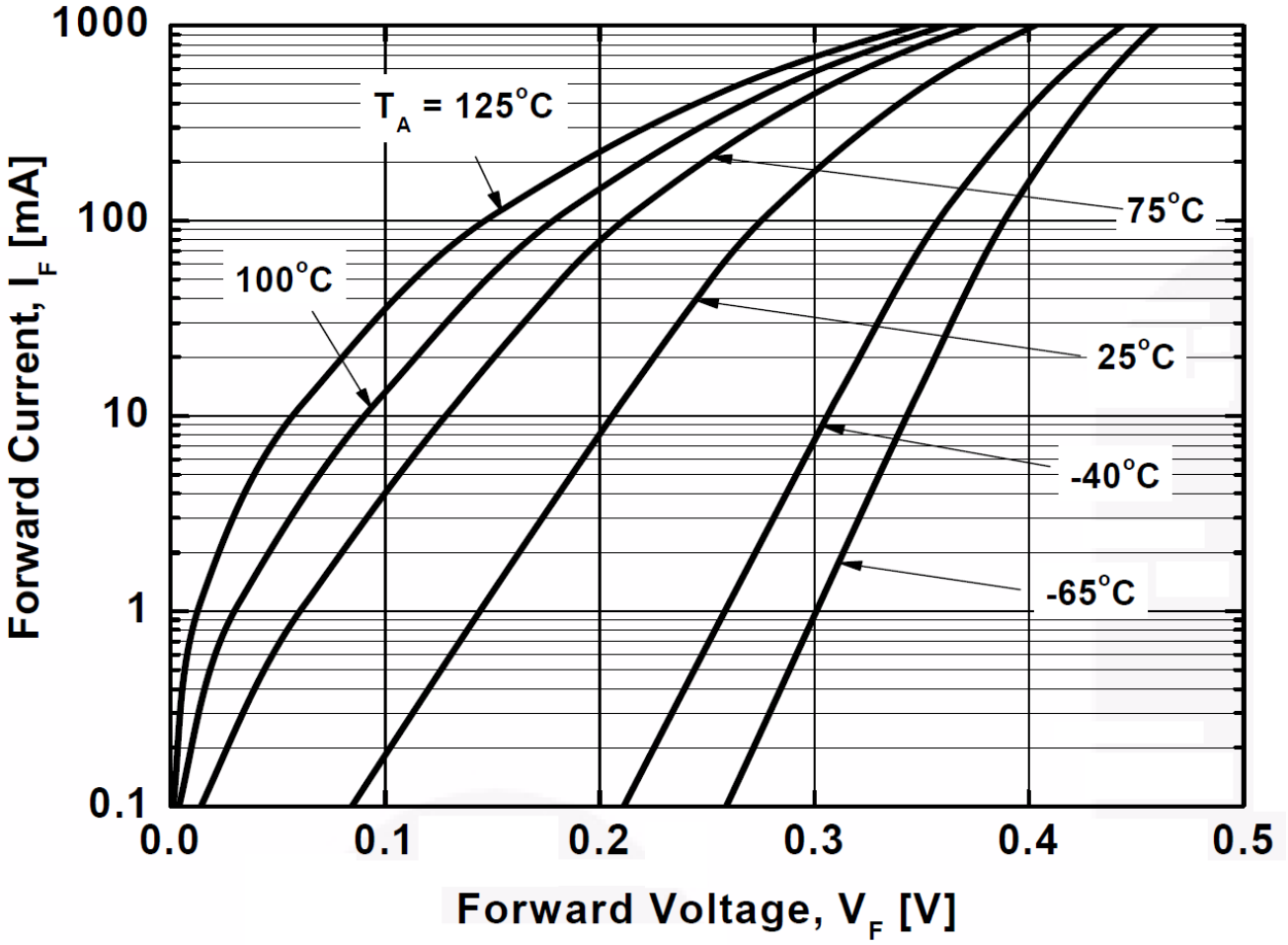

Figure 5-3. Forward Voltage of the Rectifier Diode

6 EVM Set-Up and Operation

This section describes the general operation of the AMC1304EVM.

6.1 Power and Analog Inputs: J1, J2, and J5

In the EVM default configuration the isolated onboard supply is used. In other words, power to pin 6 of the AMC1304 is provided from the supply connected to J1 by means of an isolation transformer and the SN6501 transformer driver. This configuration provides an isolated, unregulated source to the AMC1304 low-dropout regulator input. The isolated, unregulated, open-circuit voltage generated is between 7.85 V and 12.8 V when the voltage applied to J1 is between 2.7 V and 5.5 V, respectively. For power provided from high-side isolated rails (such as from a gate drive supply), move the shunt on jumper JP1 to the *Ext* position (see Figure 5-1) so that the two-wire screw terminal at J5 can be used.

Use a voltage between 2.7 V dc and 5.5 V dc for the supply provided to J1 and a voltage between 4 V dc and 18 V dc for the supply provided to J5.

The analog inputs to the AMC1304EVM PCB can be applied directly to the two-wire screw terminal at J2.

CAUTION

Carefully review the AMC1304 product data sheet for the limitations of the analog input range, and ensure that the appropriate analog and digital voltages are applied before connecting any analog input to the EVM.

Note that the AMC1304EVM is designed for evaluation of the electrical characteristics of the AMC1304 only. The EVM is not meant for isolation tests and is not designed to be used in a high-voltage environment.

The transformer used to derive the isolated, unregulated power source to the AMC1304 LDO input has isolation ratings different from those of the AMC1304. Consult the transformer manufacturer for more information on the isolation capabilities of the transformer.

6.2 Device Operation

When the analog and digital power sources are applied to the AMC1304EVM, the digital output activates when an external modulator clock source is applied. The internal reference of the AMC1304 is used as the conversion reference.

Additionally, an analog input signal can be applied directly at screw terminal J2. See Figure 3-1 for more details. There are four products in the AMC1304 family; Table 6-1 lists additional details about the analog input ranges and interfaces available in the family.

Table 6-1. AMC1304 Family Information

Product	Input Voltage Range	Interface	Input Bandwidth
AMC1304M05	±50 mV	CMOS	1 MHz
AMC1304M25	±250 mV	CMOS	1.8 MHz
AMC1304L05	±50 mV	LVDS	1 MHz
AMC1304L25	±250 mV	LVDS	1.8 MHz

When the input voltage approaches the upper end of the specified full-scale range (50 mV or 250 mV, depending on the AMC1304 device type), the ones density of the modulator output approaches 90%.

When the input voltage approaches the lower end of the specified full-scale range (–50 mV or –250 mV, depending on the AMC1304 device type), the ones density of the modulator output approaches 10%.

7 BOM, Schematic, and Layout

This section contains the complete bill of materials (BOM), schematic diagram, and PCB layout for the AMC1304EVM.

Note

Board layouts are not to scale. These layouts are intended to show how the board is laid out and are not intended to be used for manufacturing AMC1304EVM PCBs.

7.1 Printed Circuit Board Layout

Figure 7-1 shows the PCB layout.

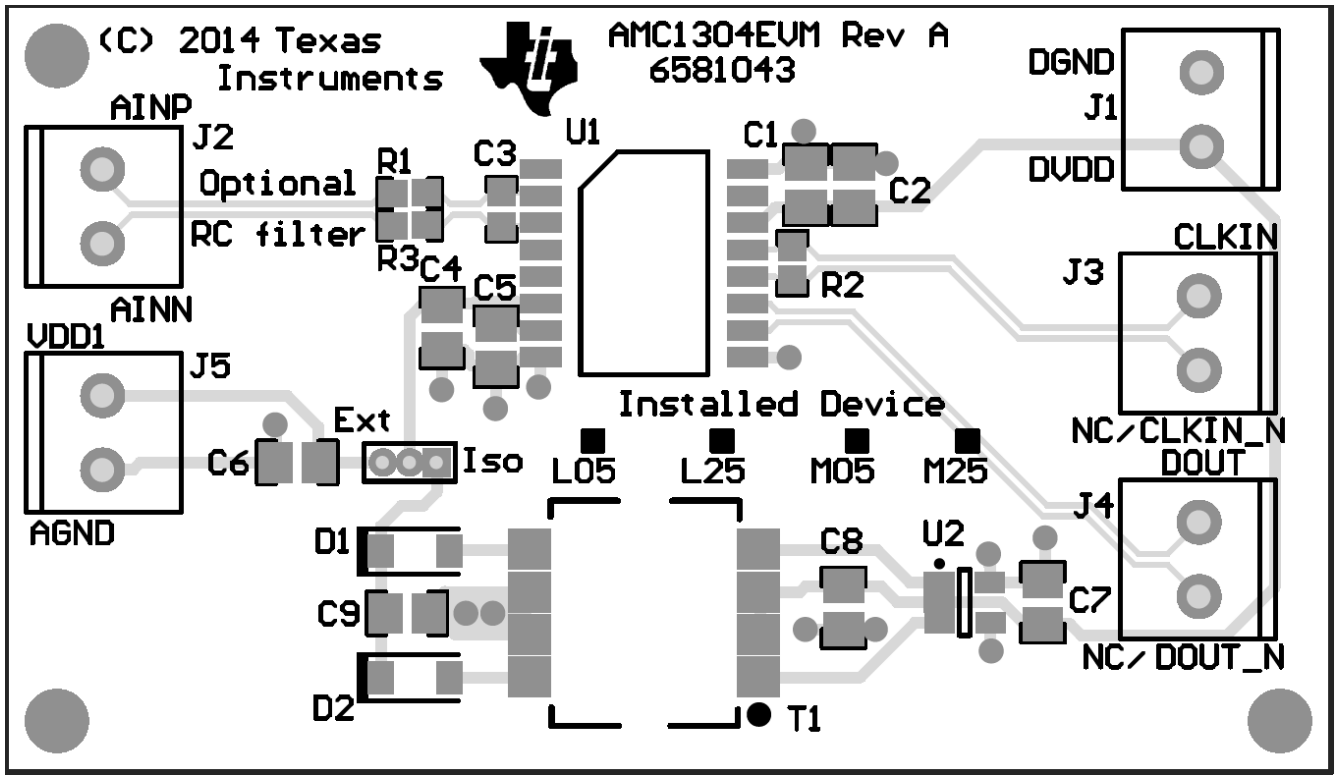

Figure 7-1. AMC1304EVM Silk Screen Drawing

7.2 Schematic

The AMC1304EVM schematic is appended to the end of this document.

7.3 Bill of Materials

Note that items 14 and 16 of the bill of materials depend on the type of AMC1304 used in the EVM. Resistor R3 is populated only when the AMC1304 used is the AMC1304L05 or the AMC1304L25. R3 is not populated for EVMs that use the AMC1304M05 or AMC1304M25.

Table 7-1. AMC1304EVM Bill of Materials

Item	Qty	Reference Designator	Description	Manufacturer	Mfr Part Number
1	1	—	Printed circuit board	Any	N/A
2	1	C1	CAP, CERM, 2.2uF, 16V, +/-10%, X7R, 0805	Taiyo Yuden	EMK212B7225KG-T
3	3	C2, C5, C7	CAP, CERM, 0.1uF, 25V, +/-5%, C0G/NP0, 1206	TDK	C3216C0G1E104J
4	1	C3	CAP, CERM, 5600pF, 25V, +/-5%, C0G/NP0, 0805	TDK	C2012C0G1E562J
5	3	C4, C8, C9	CAP, CERM, 10uF, 16V, +/-10%, X5R, 0805	Taiyo Yuden	EMK212BJ106KG-T
6	1	C6	CAP, CERM, 4.7uF, 10V, +/-10%, X5R, 0805	Kemet	C0805C475K8PACTU
7	2	D1, D2	Diode, Schottky, 20V, 0.5A, SOD-123	ON Semiconductor	MBR0520LT1G
8	3	FID1, FID2, FID3	Fiducial mark. There is nothing to buy or mount.	N/A	N/A
9	5	J1, J2, J3, J4, J5	Conn Term Block, 2POS, 3.5mm, TH	Phoenix Contact	1751248
10	1	JP1	Header, 3-Pin	Sullins Connector Solutions	GRPB031VWVN-RC
11	2	R1, R2	RES, 20.0 ohm, 0.1%, 0.1W, 0603	Yageo America	RT0603BRD0720RL
12	1	SH-J1	Shunt, 1.27 mm	Harwin Inc	M50-2000005
13	1	T1	1:2.2 Isolation Transformer	Coilcraft	DA2304-AL
14	1	U1	AMC1304 isolated delta-sigma modulator, 16-pin DW (SOIC)	Texas Instruments	AMC1304
15	1	U2	SN6501 transformer driver	Texas Instruments	SN6501
16	1	R3	RES, 50.5 ohm, 0.1%, 0.1W, 0603. Populated only on EVMs with LVDS interface.	Yageo America	RT0603BRD0750R5L

8 Revision History

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

Changes from Revision * (October 2014) to Revision A (September 2022)	Page
• Replaced Capacitive with SiO_2	1

STANDARD TERMS FOR EVALUATION MODULES

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   2.2 TI warrants that the TI EVM will conform to TI's published specifications for ninety (90) days after the date TI delivers such EVM to User. Notwithstanding the foregoing, TI shall not be liable for a nonconforming EVM if (a) the nonconformity was caused by neglect, misuse or mistreatment by an entity other than TI, including improper installation or testing, or for any EVMs that have been altered or modified in any way by an entity other than TI, (b) the nonconformity resulted from User's design, specifications or instructions for such EVMs or improper system design, or (c) User has not paid on time. Testing and other quality control techniques are used to the extent TI deems necessary. TI does not test all parameters of each EVM. User's claims against TI under this Section 2 are void if User fails to notify TI of any apparent defects in the EVMs within ten (10) business days after delivery, or of any hidden defects with ten (10) business days after the defect has been detected.

   2.3 TI's sole liability shall be at its option to repair or replace EVMs that fail to conform to the warranty set forth above, or credit User's account for such EVM. TI's liability under this warranty shall be limited to EVMs that are returned during the warranty period to the address designated by TI and that are determined by TI not to conform to such warranty. If TI elects to repair or replace such EVM, TI shall have a reasonable time to repair such EVM or provide replacements. Repaired EVMs shall be warranted for the remainder of the original warranty period. Replaced EVMs shall be warranted for a new full ninety (90) day warranty period.

WARNING

Evaluation Kits are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems.

User shall operate the Evaluation Kit within TI’s recommended guidelines and any applicable legal or environmental requirements as well as reasonable and customary safeguards. Failure to set up and/or operate the Evaluation Kit within TI’s recommended guidelines may result in personal injury or death or property damage. Proper set up entails following TI’s instructions for electrical ratings of interface circuits such as input, output and electrical loads.

NOTE:

EXPOSURE TO ELECTROSTATIC DISCHARGE (ESD) MAY CAUSE DEGREDATION OR FAILURE OF THE EVALUATION KIT; TI RECOMMENDS STORAGE OF THE EVALUATION KIT IN A PROTECTIVE ESD BAG.

3 *Regulatory Notices:*

3.1 *United States*

3.1.1 *Notice applicable to EVMs not FCC-Approved:*

FCC NOTICE: This kit is designed to allow product developers to evaluate electronic components, circuitry, or software associated with the kit to determine whether to incorporate such items in a finished product and software developers to write software applications for use with the end product. This kit is not a finished product and when assembled may not be resold or otherwise marketed unless all required FCC equipment authorizations are first obtained. Operation is subject to the condition that this product not cause harmful interference to licensed radio stations and that this product accept harmful interference. Unless the assembled kit is designed to operate under part 15, part 18 or part 95 of this chapter, the operator of the kit must operate under the authority of an FCC license holder or must secure an experimental authorization under part 5 of this chapter.

3.1.2 *For EVMs annotated as FCC – FEDERAL COMMUNICATIONS COMMISSION Part 15 Compliant:*

CAUTION

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

FCC Interference Statement for Class A EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

FCC Interference Statement for Class B EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- *Reorient or relocate the receiving antenna.*
- *Increase the separation between the equipment and receiver.*
- *Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.*
- *Consult the dealer or an experienced radio/TV technician for help.*

3.2 *Canada*

3.2.1 *For EVMs issued with an Industry Canada Certificate of Conformance to RSS-210 or RSS-247*

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-exempt RSSs. Operation is subject to the following two conditions:

(1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Concernant les EVMs avec appareils radio:

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes: (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Concerning EVMs Including Detachable Antennas:

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication. This radio transmitter has been approved by Industry Canada to operate with the antenna types listed in the user guide with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Concernant les EVMs avec antennes détachables

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante. Le présent émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés dans le manuel d'usage et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur

3.3 *Japan*

3.3.1 *Notice for EVMs delivered in Japan:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page 日本国内に輸入される評価用キット、ボードについては、次のところをご覧ください。
http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page

3.3.2 *Notice for Users of EVMs Considered "Radio Frequency Products" in Japan:* EVMs entering Japan may not be certified by TI as conforming to Technical Regulations of Radio Law of Japan.

If User uses EVMs in Japan, not certified to Technical Regulations of Radio Law of Japan, User is required to follow the instructions set forth by Radio Law of Japan, which includes, but is not limited to, the instructions below with respect to EVMs (which for the avoidance of doubt are stated strictly for convenience and should be verified by User):

1. Use EVMs in a shielded room or any other test facility as defined in the notification #173 issued by Ministry of Internal Affairs and Communications on March 28, 2006, based on Sub-section 1.1 of Article 6 of the Ministry's Rule for Enforcement of Radio Law of Japan,
2. Use EVMs only after User obtains the license of Test Radio Station as provided in Radio Law of Japan with respect to EVMs, or
3. Use of EVMs only after User obtains the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to EVMs. Also, do not transfer EVMs, unless User gives the same notice above to the transferee. Please note that if User does not follow the instructions above, User will be subject to penalties of Radio Law of Japan.

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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.

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