

AMC1304EVM User's Guide

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. Related Documentation

Device	Literature Number
AMC1304	SBAS655
AMC1210	SBAS372
SN6501	SLLSEA0
TMS320F28377D	SPRS880

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1 Overview

1.1 Features

- Full-featured evaluation module for the [AMC1304](#) single-channel, isolated, delta-sigma ($\Delta\Sigma$) 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

1.2 Introduction

The AMC1304 is a single-channel, second-order, switched-capacitor, $\Delta\Sigma$ modulator with an output separated from the input interface circuitry by a capacitive 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 $\Delta\Sigma$ filter module in the [TMS320F28377D](#) or the [AMC1210](#)).

2 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.

2.1 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 1](#).

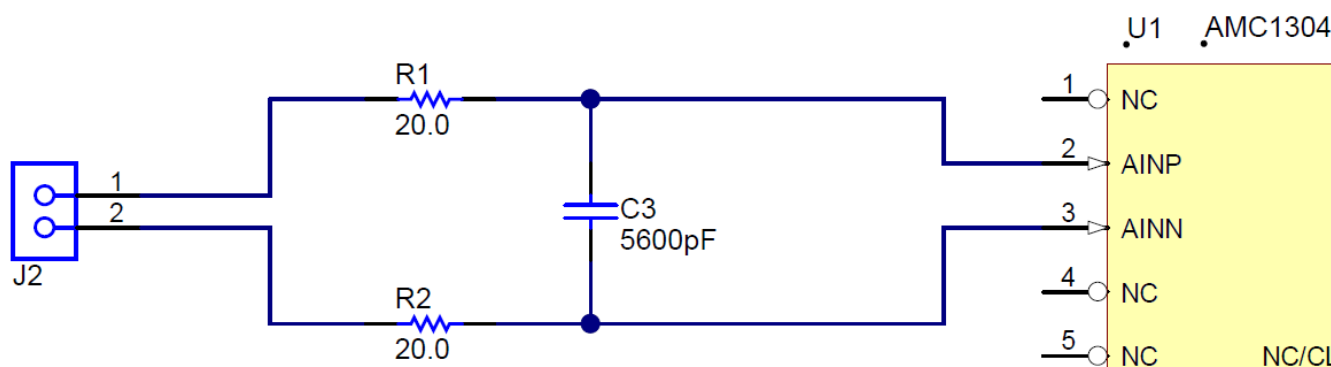


Figure 1. AMC1304EVM Schematic: Analog Input Section

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 2](#) 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 2](#) for additional details about the analog input bandwidth for each component in the AMC1305 family.

3 Digital Interface

The AMC1304EVM is designed for use with digital filters, such as the $\Delta\Sigma$ 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 2 shows.

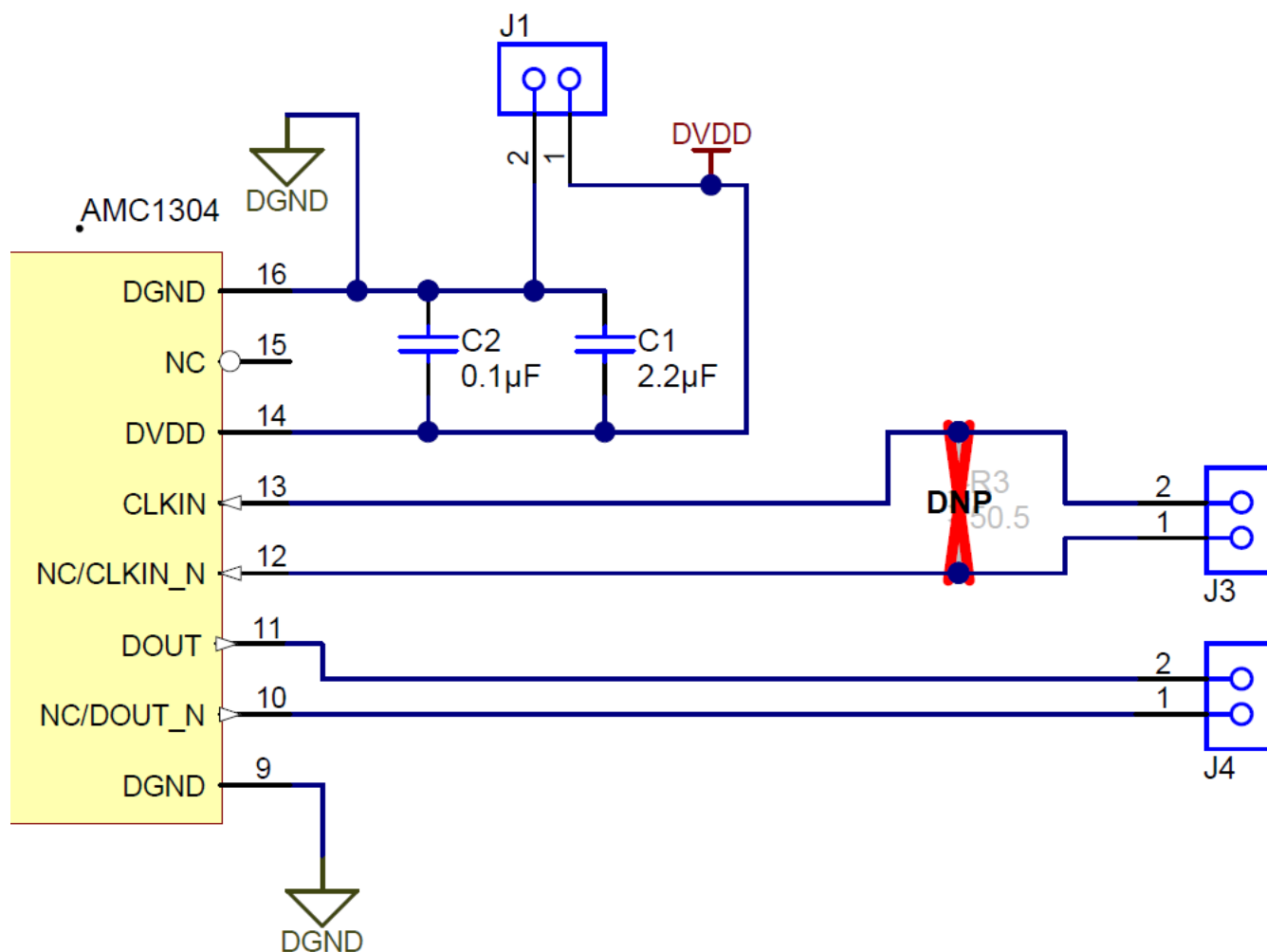


Figure 2. Power, Clock Input, and Digital Data Output

Note that component R3 in Figure 2 is marked as DNP (do not populate) because Figure 2 corresponds to an AMC1304EVM populated with a CMOS variant of the AMC1304. Refer to Table 2 for additional details about the analog input ranges and interfaces available in the AMC1304 family.

4 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 3.

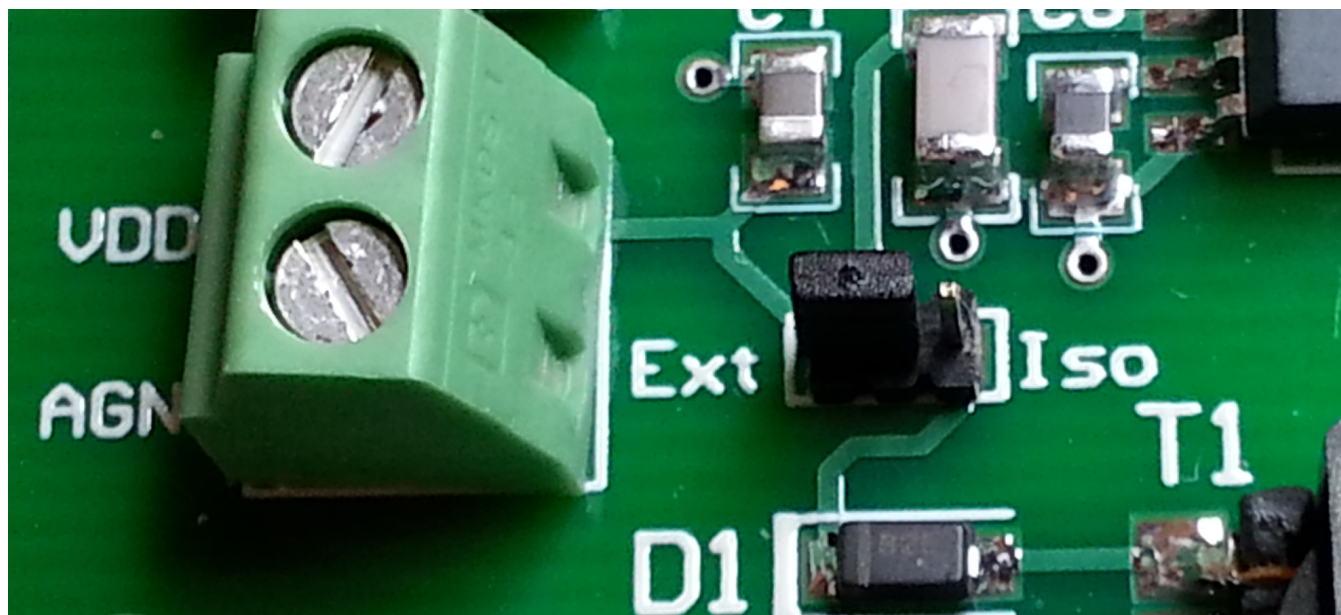


Figure 3. JP1 in Ext Position

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 4](#).

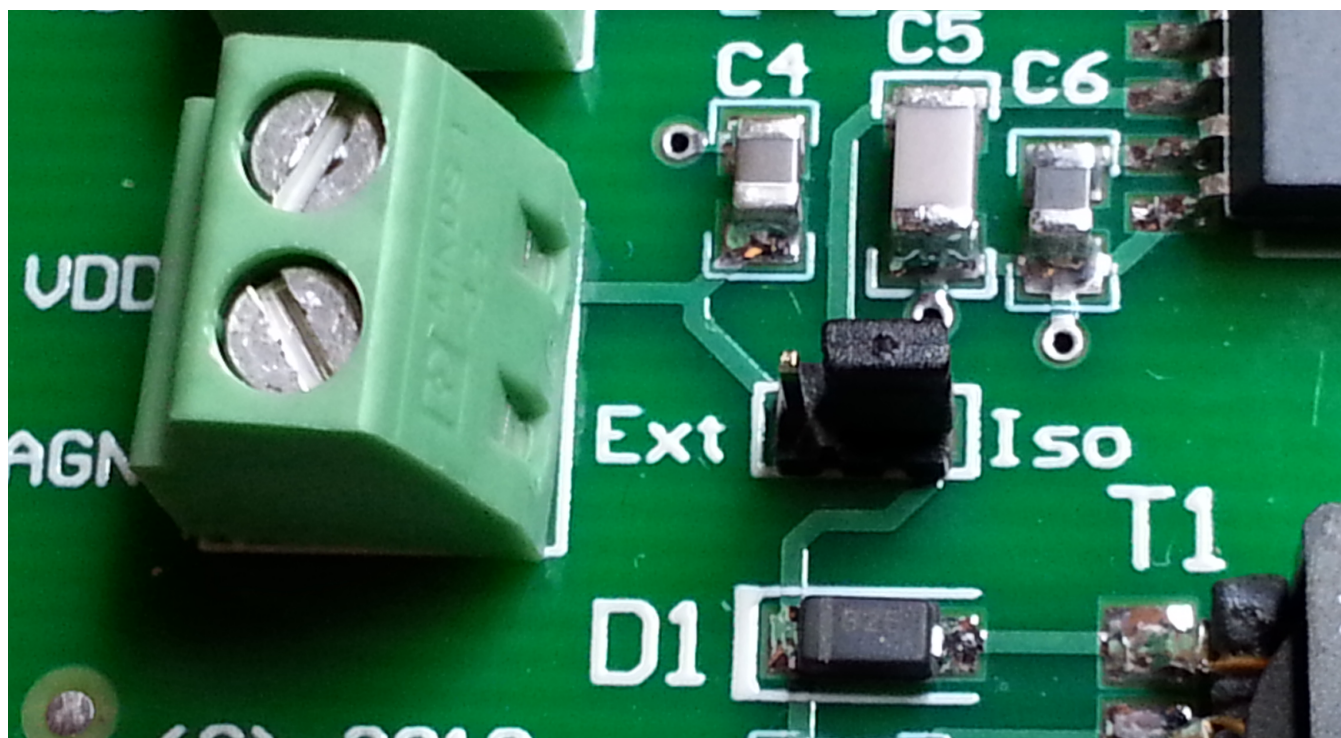


Figure 4. JP1 in Iso Position

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.

4.1 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 V μ s. The specified V-t product of the isolation transformer selected (DA2304) is well above this 9.1-V μ s 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.

4.2 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](#) illustrates the forward voltage versus forward current characteristics of the MBR0520L diode.

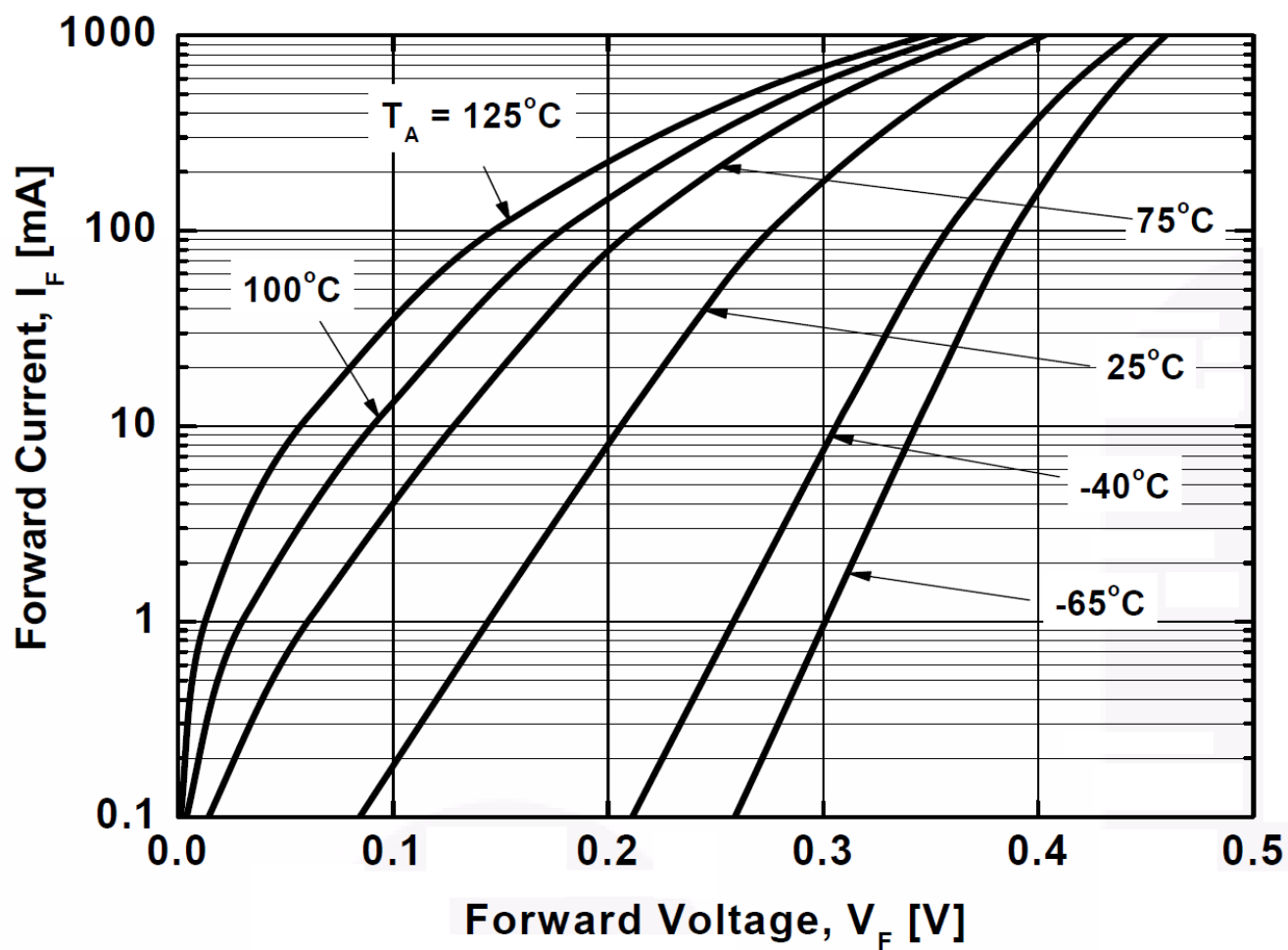


Figure 5. Forward Voltage of the Rectifier Diode

5 EVM Set-Up and Operation

This section describes the general operation of the AMC1304EVM.

5.1 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 3](#)) 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.

5.2 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 1](#) for more details. There are four products in the AMC1304 family; [Table 2](#) lists additional details about the analog input ranges and interfaces available in the family.

Table 2. 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%.

6 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.

6.1 Printed Circuit Board Layout

Figure 6 shows the PCB layout.

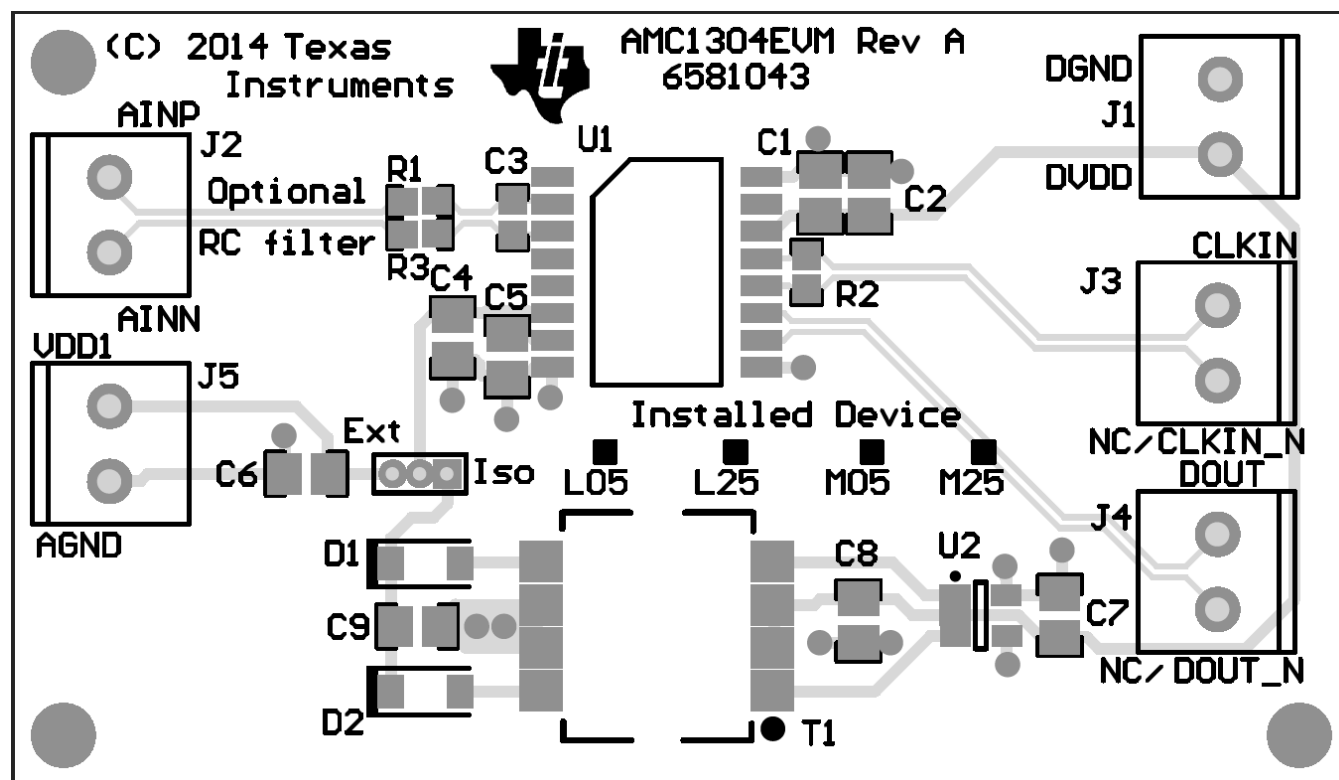


Figure 6. AMC1304EVM Silk Screen Drawing

6.2 Schematic

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

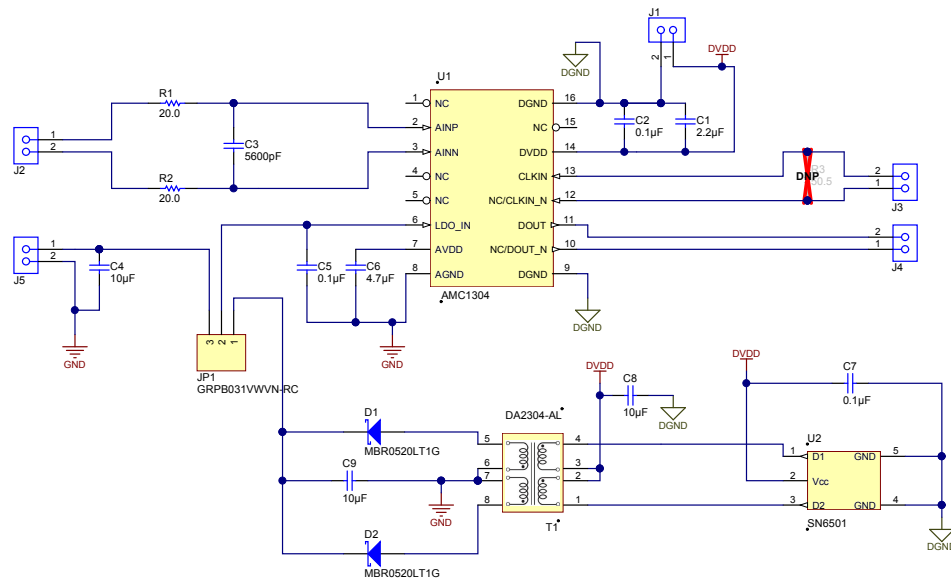
6.3 Bill of Materials

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 3. 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

Revision History	
Revision	Notes



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Number: AMC1304EVM Rev. E1	Designed for: Public Release	Mod. Date: 7/1/2014
SVN Rev.: Not in version control	Project Title: AMC1304 Evaluation Module	Sheet Title: Main Schematic
Drawn By: Jose Duenas	Assembly Variant: CMOS output	Sheet 2 of 3
Engineer: Jose Duenas	File: AMC1304_Main_Sch.Doc	Size: B
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