

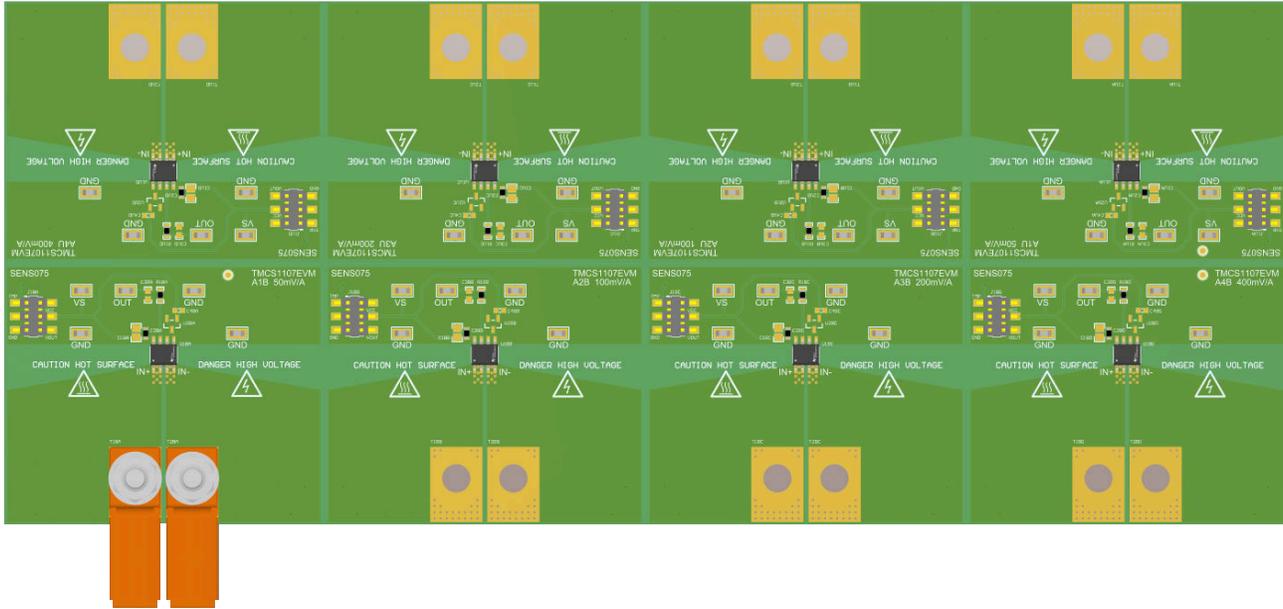
User's Guide

TMCS1107EVM



Patrick Simmons

ABSTRACT



This user's guide describes the characteristics, operation, and use of the TMCS1107 evaluation module (EVM). This EVM is designed to evaluate the performance of the [TMCS1107](#) voltage output isolated Hall-effect current sense amplifiers in a variety of configurations. Throughout this document, the terms evaluation board, evaluation module, and EVM are synonymous with the TMCS1107EVM. This document includes a schematic, reference printed-circuit board (PCB) layouts, and a complete bill of materials (BOM).

Table of Contents

1 General Texas Instruments High Voltage Evaluation (TI HV EVM) User Safety Guidelines	3
2 Overview	4
2.1 Kit Contents.....	4
2.2 Related Documentation From Texas Instruments.....	4
3 Hardware	5
3.1 Features.....	5
3.2 Circuitry.....	6
4 Operation	7
4.1 Measurements.....	7
4.2 Advanced Measurement Tips.....	8
5 Schematics, PCB Layout, and Bill of Materials	9
5.1 Schematics.....	9
5.2 PCB Layout.....	10
5.3 Bill of Materials.....	12

List of Figures

Figure 4-1. Low-Side Forward Current Setup.....	7
Figure 5-1. Schematic for A1 Device.....	9
Figure 5-2. Top Overlay.....	10
Figure 5-3. Top Layer.....	10
Figure 5-4. Bottom Overlay.....	11
Figure 5-5. Bottom Layer.....	11

List of Tables

Table 2-1. TMCS1107Ax Device Summary.....	4
Table 2-2. TMCS1107EVM Kit Contents.....	4
Table 2-3. Related Documentation.....	4
Table 5-1. Bill of Materials.....	12

Trademarks

All trademarks are the property of their respective owners.

1 General Texas Instruments High Voltage Evaluation (TI HV EVM) User Safety Guidelines



Always follow TI's setup and application instructions, including use of all interface components within their recommended electrical rated voltage and power limits. Always use electrical safety precautions to help ensure your personal safety and those working around you. Contact TI's Product Information Center <http://support/ti.com> for further information.

Save all warnings and instructions for future reference.

WARNING

Failure to follow warnings and instructions may 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. It 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 and/or application are strictly prohibited by Texas Instruments.* If you are not suitable qualified, you should immediately stop from further use of the HV EVM.

1. Work Area Safety

- a. Keep work area clean and orderly.
- b. Qualified observer(s) must be present anytime circuits are energized.
- c. Effective barriers and signage must be present in the area where the TI HV EVM and its interface electronics are energized, indicating operation of accessible high voltages may be present, for the purpose of protecting inadvertent access.
- d. 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.
- e. Use stable and nonconductive work surface.
- f. Use adequately insulated clamps and wires to attach measurement probes and instruments. No freehand testing whenever possible.

2. Electrical Safety

As a precautionary measure, it is always a good engineering practice to assume that the entire EVM may have fully accessible and active high voltages.

- a. De-energize the TI HV EVM and all its inputs, outputs and electrical loads before performing any electrical or other diagnostic measurements. Revalidate that TI HV EVM power has been safely de-energized.
- b. With the EVM confirmed de-energized, proceed with required electrical circuit configurations, wiring, measurement equipment connection, and other application needs, while still assuming the EVM circuit and measuring instruments are electrically live.
- c. After EVM readiness is complete, energize the EVM as intended.

WARNING

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

3. Personal Safety

- a. Wear personal protective equipment (for example, latex gloves or safety glasses with side shields) or protect EVM in an adequate lucent plastic box with interlocks to protect from accidental touch.

Limitation for safe use:

EVMs are not to be used as all or part of a production unit.

2 Overview

The TMCS1107 Hall-effect current sense amplifier (also called an isolated current-sense amplifier) senses magnetic flux generated from current passing through the lead frame at common-mode voltages from 0 V_{DC} to 420 V_{DC}, independent of the supply voltage. In both bidirectional (B) and unidirectional (U) configurations, four fixed gains are available: 50 mV/A, 100 mV/A, 200 mV/A, and 400 mV/A. These devices operate from a single 3-V to 5.5-V power supply, drawing a maximum of 5 mA of supply current per amplifier channel. The TMCS1107 is currently available in an 8-pin, SOIC, surface-mount package. [Table 2-1](#) lists the available gain options.

Table 2-1. TMCS1107Ax Device Summary

Product	Direction	Gain
TMCS1107A1B	Bidirectional	50 mV/A
TMCS1107A2B	Bidirectional	100 mV/A
TMCS1107A3B	Bidirectional	200 mV/A
TMCS1107A4B	Bidirectional	400 mV/A
TMCS1107A1U	Unidirectional	50 mV/A
TMCS1107A2U	Unidirectional	100 mV/A
TMCS1107A3U	Unidirectional	200 mV/A
TMCS1107A4U	Unidirectional	400 mV/A

2.1 Kit Contents

[Table 2-2](#) lists the contents of the TMCS1107EVM kit. Contact the nearest [Texas Instruments Customer Support Center](#) if any component is missing. TI highly recommends checking the TMCS1107 family product folder on the TI website at www.ti.com for further information regarding this product.

Table 2-2. TMCS1107EVM Kit Contents

Item	Quantity
TMCS1107EVM Test Board	1

2.2 Related Documentation From Texas Instruments

[Table 2-3](#) provides literature references for TI's integrated circuits used in the assembly of the TMCS1107EVM. This user's guide is available from the TI website under literature number SBOU248. Any letter appended to the literature number corresponds to the document revision that is current at the time of the writing of this document. Newer revisions are available from www.ti.com or the Texas Instruments' Literature Response Center at (800) 477-8924 or the Product Information Center at (972) 644-5580. When ordering, identify the document by both title and literature number.

Table 2-3. Related Documentation

document	Literature Number
TMCS1107 product data sheet	SBOSA35

3 Hardware

The TMCS1107 is an isolated, current-sense op amp that provides ease-of-use and high performance. The TMCS1107EVM is intended to provide basic functional evaluation of all TMCS1107 gain variants. The TMCS1107EVM is not laid out for electromagnetic compatibility (EMC) testing. The TMCS1107EVM consists of one PCB that can be snapped apart into eight individual segments; one for each of the four gain variants in both the bidirectional (B) and unidirectional (U) configurations:

- TMCS1107A1B
- TMCS1107A2B
- TMCS1107A3B
- TMCS1107A4B
- TMCS1107A1U
- TMCS1107A2U
- TMCS1107A3U
- TMCS1107A4U

3.1 Features

The layout of the TMCS1107EVM PCB is designed to provide the following features:

- Evaluation of all gain options for the TMCS1107
- Ease-of-access to device pins with test points
- Evaluation of high-side and low-side configurations
- On-board temperature sensor

See the [TMCS1107](#) data sheet for comprehensive information about the TMCS1107.

3.2 Circuitry

This section summarizes the TMCS1107EVM components.

For the following circuits:

- $x = B$ for bidirectional, or U for unidirectional
- $y = A$ to D for the A1 to A4 gain variants, respectively.

3.2.1 Bypass Capacitors

$C1_{xy}$ and $C2_{xy}$ are 10- μF and 0.1- μF supply bypass capacitors, respectively, for the TMCS1107. By default $C1_{xy}$ is not populated as it may only be necessary for very noisy power supplies. $C4_{xy}$ is the 0.1- μF bypass capacitor for the optional temperature sensor. By default $C4_{xy}$ is also not populated.

3.2.2 Output Filter

$C3_{xy}$ and $R1_{xy}$ are footprints for the optional output filter. Default values are 10 pF and 0 Ω , but no capacitors are installed. TP2 $_{xy}$ is the test point for the TMCS1107 output.

3.2.3 Measurement Connector

J1 $_{xy}$ is an additional connector for measuring VCC and VOUT. J1 $_{xy}$ also provides a connection for measuring board temperature (TMP).

3.2.4 Load Connectors

T1 $_{xy}$ and T2 $_{xy}$ correspond to the high-current rated load connectors. By default, the EVM is only populated with two of these connectors on the bidirectional, lowest gain variant ($x = B$ and $y = A$). The IN+ (T1 $_{xy}$) and IN- (T2 $_{xy}$) inputs accept a load that is converted to a magnetic field sensed by a Hall element that produces a voltage. This voltage is amplified by the selected device gain and is presented at the VOUT test point (TP2 $_{xy}$). The acceptable load input maximum is 30 A for DC measurements. However, the load can be significantly higher for AC signals, and the load is bound by the safe operating area (SOA) described in the TMCS1107 data sheet.

3.2.5 Ground Test Points

TP3 $_{xy}$, TP4 $_{xy}$, and TP5 $_{xy}$ correspond to ground connections of the TMCS1107 device.

3.2.6 TMCS1107 Isolated Current-Sense Amplifier

U1 $_{xy}$ is the TMCS1107 isolated current-sense amplifier. Eight segments are supplied within the TMCS1107EVM board. Each segment is populated with one of the available device gains for bidirectional or unidirectional sensing. This configuration enables users to test the devices and determine the best gain setting for a given application. For $y = A$ to D , the gain is 50 mV/A, 100 mV/A, 200 mV/A, and 400 mV/A, respectively.

- The TMCS1107AnB is used for bidirectional applications, while TMCS1107AnU is used for unidirectional applications (where $n = 1$ to 4 for the A1 to A4 gain variants, respectively).
- A magnetic field is generated based on the load current that is connected across the inputs IN+ and IN-, and flows through the TMCS1107 leadframe.
- The output voltage swing limitation and required load current sensing range are the key factors when determining device selection.
- The selected device must allow the output voltage to remain within the acceptable range after the load current is transduced and amplified by the respective device gain. The max output voltage must remain within the range of 25 mV above ground to 100 mV below the supply voltage.
- Choose an appropriate gain to create the largest appropriate output swing, and to minimize error.

3.2.7 Temperature Sensor

U2 $_{xy}$ is a temperature sensor that is not required for TMCS1107 operation. However, U2 $_{xy}$ provides the option of measuring board temperature for determining ambient conditions. By default U2 $_{xy}$ is not populated.

4 Operation

The following are instructions to set up and use the TMCS1107EVM. For the following instructions, $y = A$ to D for the A1 to A4 gain variants, respectively. Figure 4-1 shows an example of a simple, low-side setup on the A1B (50 mV/A) gain variant. Reverse current can be measured on the TMCS1107nB devices by switching the placement of the hot-supply and electronic load along with reversing their polarities. The EVM has isolation, and external supplies are distinguished by hot for load and cold for DUT supply. The hot supply can be isolated and at a different potential than the cold supply.

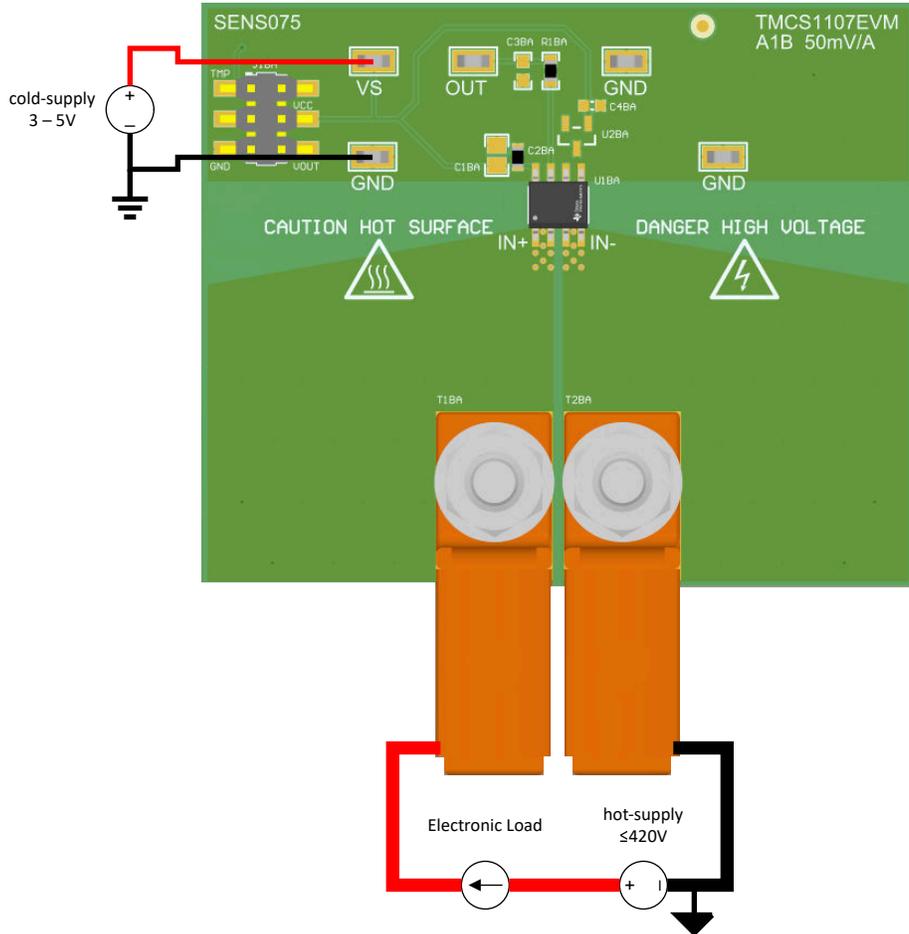


Figure 4-1. Low-Side Forward Current Setup

1. For greater maneuverable flexibility, break apart the EVM sub boards along the score lines. Otherwise, the board can be left intact.
2. Attach the high-current lug connectors to IN+ and IN- of the gain version to be tested.
3. Connect the terminals of an external cold supply to the GND and VCC test points on the EVM gain variant of choice. Be sure to connect GND first and make sure that the external cold supply is between 3 V and 5.5 V.
4. Connect the input per Section 4.1.

WARNING

Do not leave EVM powered when unattended.
Hot surface. Contact may cause burns. Do not touch!

4.1 Measurements

The following procedures are used to configure a measurement evaluation with an electronic load. For the following instructions, $y = A$ to D for the A1 to A4 gain variants, respectively.

1. According to [Figure 4-1](#), for a low-side measurement, connect the electronic load positive input terminal to the positive terminal of a 30-A capable hot-supply. For a high-side measurement, connect the electronic load positive input terminal to the load sourcing terminal (IN+ or IN-) of the EVM. For high-side measurement of forward current, IN- sources to the electronic load; for reverse current, IN+ sources to the load.
2. Connect the electronic load negative output terminal to the external hot supply GND terminal for high-side measurements, or to the load sinking terminal of the EVM for low-side measurements.
3. For high-side measurements, connect the external supply to the load sinking terminal of the EVM. Otherwise, for low-side measurements, connect the load sourcing terminal of the EVM (IN+ or IN-) to the external supply gnd.
4. Turn on all the connected supplies.
5. Apply load with electronic load.
6. Measure the output voltage at the VOUT test point.

Note

The output voltage is equal to an offset plus the gain of the device multiplied by the load current passing through the leadframe of the DUT. For bidirectional devices, the offset is the product of the device supply voltage and 0.5. For unidirectional devices, the offset is the product of the device supply voltage and 0.1.

4.2 Advanced Measurement Tips

To assess whether the expected load matches the measured load, use a precision shunt resistor rated for the maximum intended current in series with the DUT. The precision shunt should have a kelvin connection where the generated sense voltage can be measured by a precision multimeter, such as the 3458a multimeter. Sensing the shunt voltage is preferred as a typical multimeter may have a current limit far below 30 A. Additionally some meters have better voltage measurement precision than current measurement precision.

For evaluating performance when the DUT is subjected to quick current pulses, use short, large-diameter wire, or short bus bars, to reduce the inductance and resistance between the hot-supply, load, and EVM. By minimizing the inductance, the rate of load slew can be increased. If assessing the performance over large transient current spikes (>30 A) is desired, be sure to use a supply with sufficient voltage headroom to accommodate the series resistance of the wires/bus bars, board planes, and DUT lead frame resistance. A large capacitor bank between the supply terminals should be used to ensure there is an adequate charge reservoir available to prevent the supply from drooping and helping supply the large current inrush through the device.

If assessing temperature performance is desired, use wide, thin bus bars to reduce the thermal sinking ability of the system and minimize the inductance of the system. While the board provides an onboard temperature sensor, board temperature may not be an exact indicator of DUT temperature. More precise measurements can be obtained by placing a layer of thermally conductive grease on top of the DUT package and placing a thermal sensor directly on the thermal grease.

5 Schematics, PCB Layout, and Bill of Materials

Note

Board layouts are not to scale. These figures are intended to show how the board is laid out. The figures are not intended to be used for manufacturing TMCS1107EVM PCBs.

5.1 Schematics

Figure 5-1 shows the schematic of the A1B sub board on the TMCS1107EVM PCB. Only the schematic for the bidirectional A1 (50 mV/A) gain variant is included as all variants use the same circuit and same PCB layout. All components associated with the 50-mV/A TMCS1107 A1 gain variant have the letter A appended at the end. The 100-mV/A A2 gain variant has B appended, the 200-mV/A A3 gain variant has C appended, and the 400-mV/A A4 gain variant has a D appended. All components labeled with a B after the number correspond to the bidirectional TMCS1107 devices, while all components labeled with a U after the number correspond to unidirectional TMCS1107 devices.

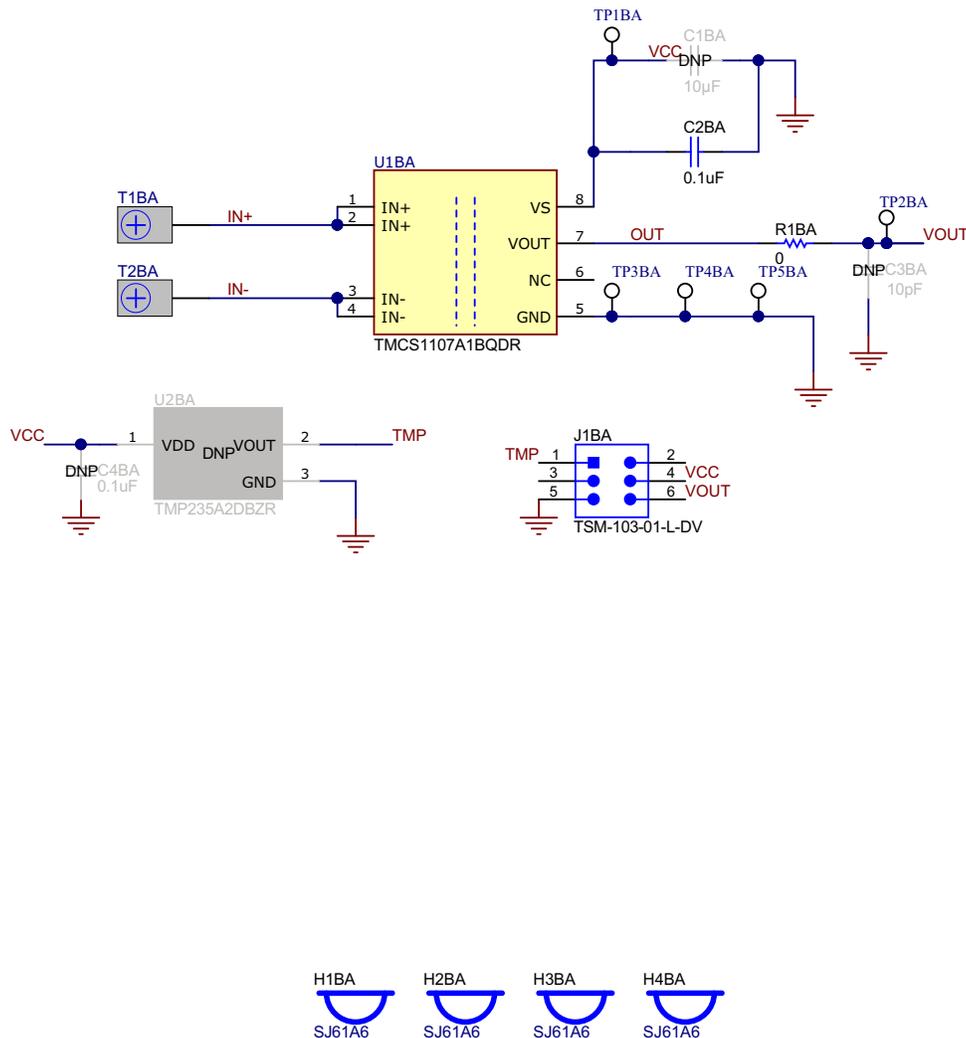


Figure 5-1. Schematic for A1 Device

5.2 PCB Layout

Figure 5-2 through Figure 5-5 illustrate the PCB layers of the TMCS1107EVM.

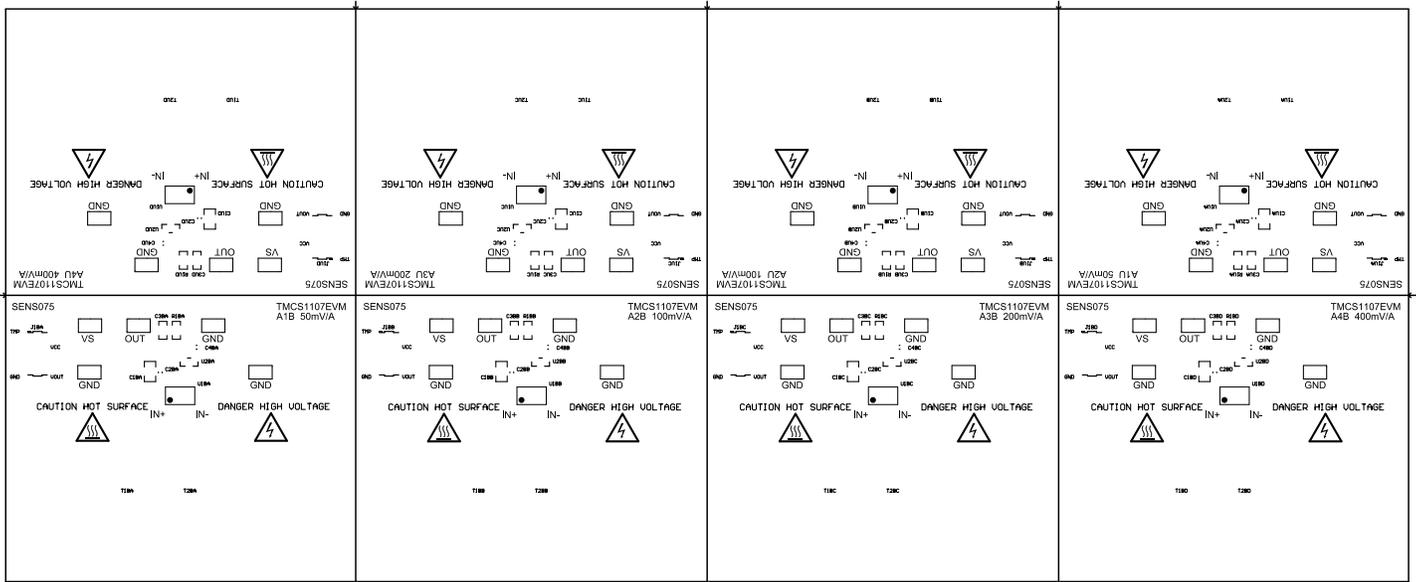


Figure 5-2. Top Overlay

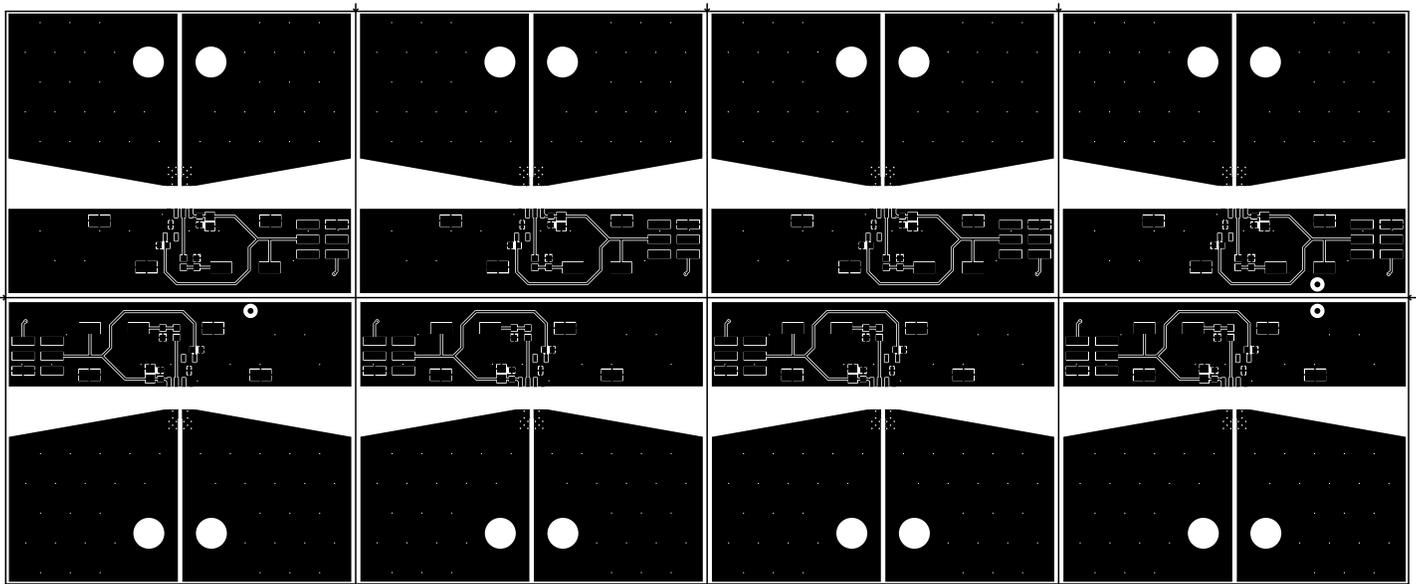


Figure 5-3. Top Layer

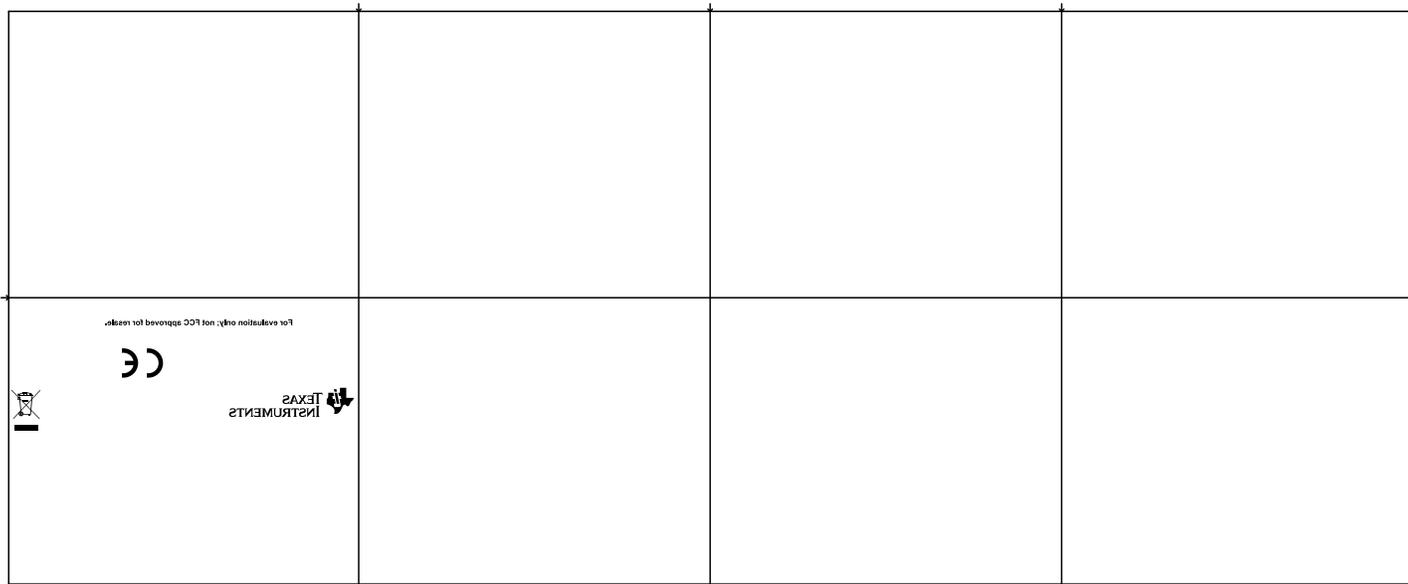


Figure 5-4. Bottom Overlay

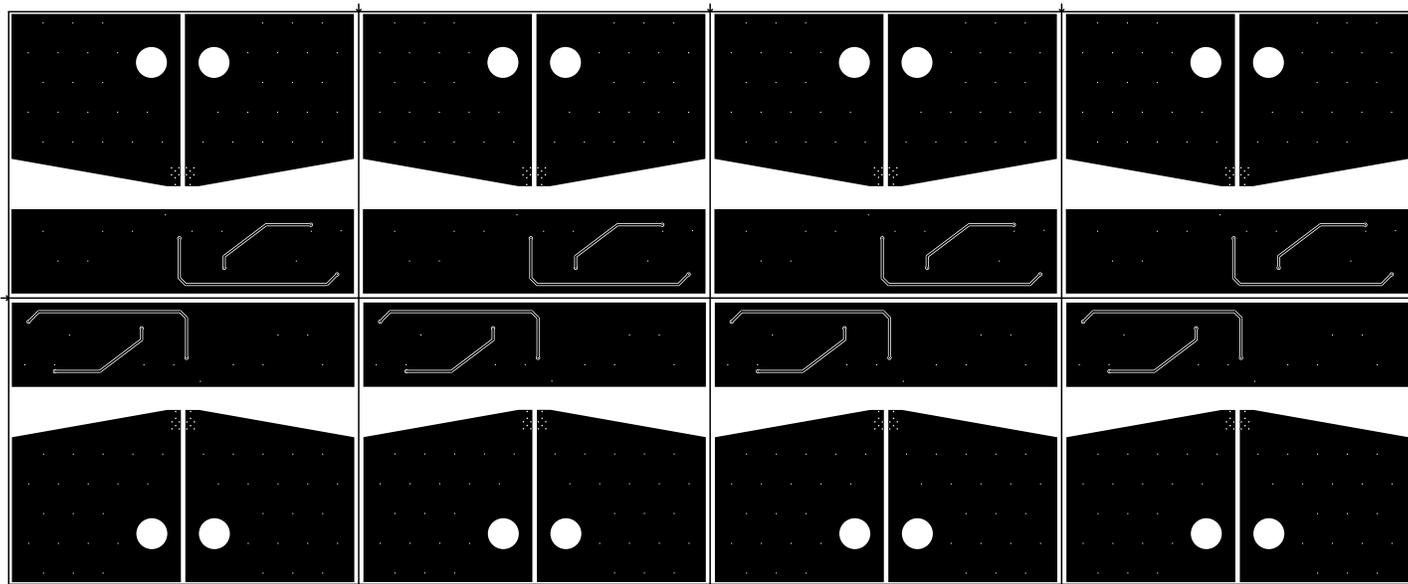


Figure 5-5. Bottom Layer

5.3 Bill of Materials

Table 5-1. Bill of Materials

Designator	Quantity	Value	Description	PackageReference	PartNumber	Manufacturer
C2BA, C2BB, C2BC, C2BD, C2UA, C2UB, C2UC, C2UD	8	0.1uF	CAP, CERM, 0.1 uF, 50 V, +/- 10%, X7R, 0603	0603	06035C104KAT2A	AVX
H1BA, H1BB, H1BC, H1BD, H1UA, H1UB, H1UC, H1UD, H2BA, H2BB, H2BC, H2BD, H2UA, H2UB, H2UC, H2UD, H3BA, H3BB, H3BC, H3BD, H3UA, H3UB, H3UC, H3UD, H4BA, H4BB, H4BC, H4BD, H4UA, H4UB, H4UC, H4UD	32		BUMPER CYLIN 0.312" DIA BLK		SJ61A6	3M
J1BA, J1BB, J1BC, J1BD, J1UA, J1UB, J1UC, J1UD	8		Header, 2.54mm, 3x2, Gold, SMT	Header, 2.54mm, 3x2, SMT	TSM-103-01-L-DV	Samtec
MP1, MP2	2		Passivated 18-8 Stainless Steel Pan Head Phillips Screws M5 x 0.8mm Thread, 10mm Long	NPTH_SCREW_M5x0.8 mm	92000A320	McMaster-Carr
MP3, MP4	2		316 Stainless Steel Washer for M5 Screw Size, 5.3 mm ID, 10 mm OD	STEEL_WASHER	90965A160	McMaster-Carr
MP5, MP6	2		JIS Hex Nut Medium- Strength Zinc-Plated Steel, Class 8, M5 x 0.8 mm Thread	HEXNUT	91028A415	McMaster-Carr
R1BA, R1BB, R1BC, R1BD, R1UA, R1UB, R1UC, R1UD	8	0	RES, 0, 1%, 0.1 W, AEC- Q200 Grade 0, 0603	0603	RMCF0603ZT0R00	Stackpole Electronics Inc
T1BA, T2BA	2		Terminal 50A Lug	CB35-36-CY	CB35-36-CY	Panduit

Table 5-1. Bill of Materials (continued)

Designator	Quantity	Value	Description	PackageReference	PartNumber	Manufacturer
TP1BA, TP1BB, TP1BC, TP1BD, TP1UA, TP1UB, TP1UC, TP1UD, TP2BA, TP2BB, TP2BC, TP2BD, TP2UA, TP2UB, TP2UC, TP2UD, TP3BA, TP3BB, TP3BC, TP3BD, TP3UA, TP3UB, TP3UC, TP3UD, TP4BA, TP4BB, TP4BC, TP4BD, TP4UA, TP4UB, TP4UC, TP4UD, TP5BA, TP5BB, TP5BC, TP5BD, TP5UA, TP5UB, TP5UC, TP5UD	40		Test Point, Miniature, SMT	Testpoint_Keystone_Minature	5015	Keystone
U1BA	1		Precision Isolated Current Sense Monitor With External Reference, D0008A (SOIC-8)	D0008A	TMCS1107A1BQDR	Texas Instruments
U1BB	1		Precision Isolated Current Sense Monitor With External Reference, D0008A (SOIC-8)	D0008A	TMCS1107A2BQDR	Texas Instruments
U1BC	1		Precision Isolated Current Sense Monitor With External Reference, D0008A (SOIC-8)	D0008A	TMCS1107A3BQDR	Texas Instruments
U1BD	1		Precision Isolated Current Sense Monitor With External Reference, D0008A (SOIC-8)	D0008A	TMCS1107A4BQDR	Texas Instruments
U1UA	1		Precision Isolated Current Sense Monitor With External Reference, D0008A (SOIC-8)	D0008A	TMCS1107A1UQDR	Texas Instruments
U1UB	1		Precision Isolated Current Sense Monitor With External Reference, D0008A (SOIC-8)	D0008A	TMCS1107A2UQDR	Texas Instruments
U1UC	1		Precision Isolated Current Sense Monitor With External Reference, D0008A (SOIC-8)	D0008A	TMCS1107A3UQDR	Texas Instruments

Table 5-1. Bill of Materials (continued)

Designator	Quantity	Value	Description	PackageReference	PartNumber	Manufacturer
U1UD	1		Precision Isolated Current Sense Monitor With External Reference, D0008A (SOIC-8)	D0008A	TMCS1107A4UQDR	Texas Instruments
C1BA, C1BB, C1BC, C1BD, C1UA, C1UB, C1UC, C1UD	0	10uF	CAP, CERM, 10 uF, 10 V, +/- 10%, X7R, 0805	0805	C2012X7R1A106K125AC	TDK
C3UA, C3UB, C3UC, C3UD, C3BA, C3BB, C3BC, C3BD	0	10pF	CAP, CERM, 10 pF, 10 V, +/- 10%, X7R, 0603	0603	0603ZC100KAT2A	AVX
C4BA, C4BB, C4BC, C4BD, C4UA, C4UB, C4UC, C4UD	0	0.1uF	CAP, CERM, 0.1 uF, 50 V, +/- 10%, X7R, 0603	0603	06035C104KAT2A	AVX
T1BB, T1BC, T1BD, T1UA, T1UB, T1UC, T1UD, T2BB, T2BC, T2BD, T2UA, T2UB, T2UC, T2UD	0		Terminal 50A Lug	CB35-36-CY	CB35-36-CY	Panduit
U2BA, U2BB, U2BC, U2BD, U2UA, U2UB, U2UC, U2UD	0		Temperature Sensor Analog, Local -40°C ~ 150°C 10mV/°C SOT-23-3	SOT-23	TMP235A2DBZR	Texas Instruments

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATA SHEETS), 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 will 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](#) 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.

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

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2022, Texas Instruments Incorporated