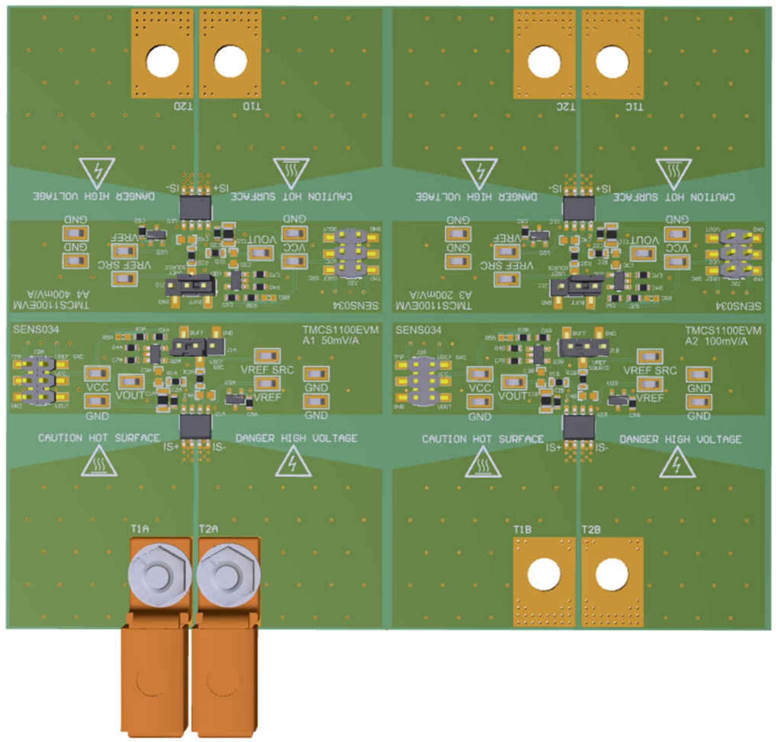
User's Guide

TMCS1100EVM



This user's guide describes the characteristics, operation, and use of the TMCS1100 evaluation module (EVM). This EVM is designed to evaluate the performance of the TMCS1100 voltage output isolated bidirectional 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 TMCS1100EVM. This document includes a schematic, reference printed-circuit board (PCB) layouts, and a complete bill of materials (BOM).

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Trademarks

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

WARNING

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 TMCS1100 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 600 V_{DC}, independent of the supply voltage. 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 TMCS1100 is currently available in an 8-pin, SOIC, surface-mount package. Table 2-1 lists the available gain options.

Table 2-1. TMCS1100Ax Device Summary

Product	Gain
TMCS1100A1	50 mV/A
TMCS1100A2	100 mV/A
TMCS1100A3	200 mV/A
TMCS1100A4	400 mV/A

2.1 Kit Contents

Table 2-2 lists the contents of the TMCS1100EVM kit. Contact the nearest Texas Instruments Customer Support Center if any component is missing. TI highly recommends checking the TMCS1100 family product folder on the TI website at www.ti.com for further information regarding this product.

Table 2-2. TMCS1100EVM Kit Contents

Item	Quantity
TMCS1100EVM 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 TMCS1100EVM. This user's guide is available from the TI website under literature number SBOU209. 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
TMCS1100 product data sheet	SBOS820

3 Hardware

The TMCS1100 is an isolated, current-sense op amp that provides ease-of-use and high performance.
The TMCS1100EVM is intended to provide basic functional evaluation of all TMCS1100 gain variants. The TMCS1100EVM is not laid out for electromagnetic compatibility (EMC) testing. The TMCS1100EVM consists of one PCB that can be snapped apart into four individual segments; one for each of the four gain variants:

- TMCS1100A1
- TMCS1100A2
- TMCS1100A3
- TMCS1100A4

3.1 Features

The layout of the TMCS1100EVM PCB is designed to provide the following features:

- Evaluation of all gain variants for the TMCS1100
- Ease-of-access to device pins with test points
- Evaluation of high-side and low-side configurations
- Buffered reference with a user-defined voltage divider
- On-board temperature sensor

See the TMCS1100 data sheet for comprehensive information about the TMCS1100.

3.2 Circuitry

This section summarizes the TMCS1100EVM components. For the following circuits, x = A to D for the A1 to A4 gain variants, respectively.

3.2.1 Bypass Capacitors

C1x and C2x are 10-µF and 0.1-µF supply bypass capacitors, respectively, for the TMCS1100. C5x is the 0.1-µF bypass capacitor for the optional temperature sensor. C6x is the 0.1-µF bypass capacitor for the optional buffer amplifier.

3.2.2 Output Filter

C3x and R1x are footprints for the optional output filter. Default values are 0 Ω and 10 pF. However, no capacitors are installed. TP2x is the test point for the TMCS1100 output.

3.2.3 VREF Input Filter

C4x and R2x are footprints for the optional VREF input filter. Default values are 0 Ω and 10 pF. However, no capacitors are installed. TP3x serves as a test-point for the filtered input to the TMCS1100 VREF pin while TP7x serves as a test point for the prefiltered input to the TMCS1100 VREF pin. J1x is a jumper that conveniently allows the TMCS1100 reference to be shorted to ground, connected directly to an external power supply, or shorted to a voltage set by a buffered voltage divider.

3.2.4 Buffer Amplifier Filter and Divider

C7x and R3x serve as a low-pass filter to the buffer amplifier. R3x and R4x serve as a voltage divider to set the buffered voltage input to the TMCS1100 VREF pin. R5x serves as short that connects the voltage divider directly to VREF SOURCE. R5x is left open and unpopulated by default.

3.2.5 Measurement Connector

J2x is an additional connector for measuring VREF Source, VCC, and VOUT. J2x also provides a connection for measuring board temperature (TMP).

3.2.6 Load Connectors

T1x and T2x correspond to the high-current rated load connectors. By default, the EVM is only populated with two of these connectors on the lowest gain variant A1, x = A. The IS+ (T1x) and IS– (T2x) 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 (TP2x). The acceptable load input maximum is 20 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 TMCS1100 data sheet.

3.2.7 Ground Test Points

TP4x, TP5x, and TP6x correspond to ground connections of the TMCS1100 device.

3.2.8 TMCS1100 Isolated Current-Sense Amplifier

U1x is the TMCS1100 isolated current-sense amplifier. Four gain-option segments are supplied within the TMCS1100EVM board. Each segment is populated with one of the available device gains. This configuration enables users to test the devices and determine the best gain setting for a given application. For x = A to D, the gain is 50 mV/A, 100 mV/A, 200 mV/A, and 400 mV/A, respectively.

- The TMCS1100 can be used for both unidirectional and bidirectional applications.
- A magnetic field is generated based on the load current that is connected across the inputs IS+ and IS–, and flows through the TMCS1100 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 maximum 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.

3.2.9 Temperature Sensor

U2x is a temperature sensor that is not required for TMCS1100 operation. However, U2x provides the option of measuring board temperature for determining ambient conditions.

3.2.10 Reference Divider Buffer

U3x is the TLV376IDBVR. U3X is configured as a buffer that sets the TMCS1100 at mid-supply according to the voltage divider composed of R3x and R4x by default. The user has the option to either short out this buffer with a 0-Ω resistor at R5x or replace the amplifier with another amplifier that has a common-mode range and output-swing range that allows for a divided voltage of interest.

4 Operation

The following are instructions to set up and use the TMCS1100EVM. For the following instructions, x = A to D for the A1 to A4 gain variants, respectively. Figure 4-1 shows an example of a simple, low-side, unidirectional setup on the A1 (50 mV/A) gain variant (x = A). For bidirectional measurements, the user can either connect jumper J1x to the buffer with a custom voltage divider set by the user, or connect an additional external supply to the *VREF SOURCE* and *GND* test points, as shown in Figure 4-2. This device has isolation; external supplies are distinguished by hot for load, cold for DUT supply, and REF for VREF supply. Short the GND terminals for the cold and REF supplies together. The hot supply can be isolated and at a different potential.

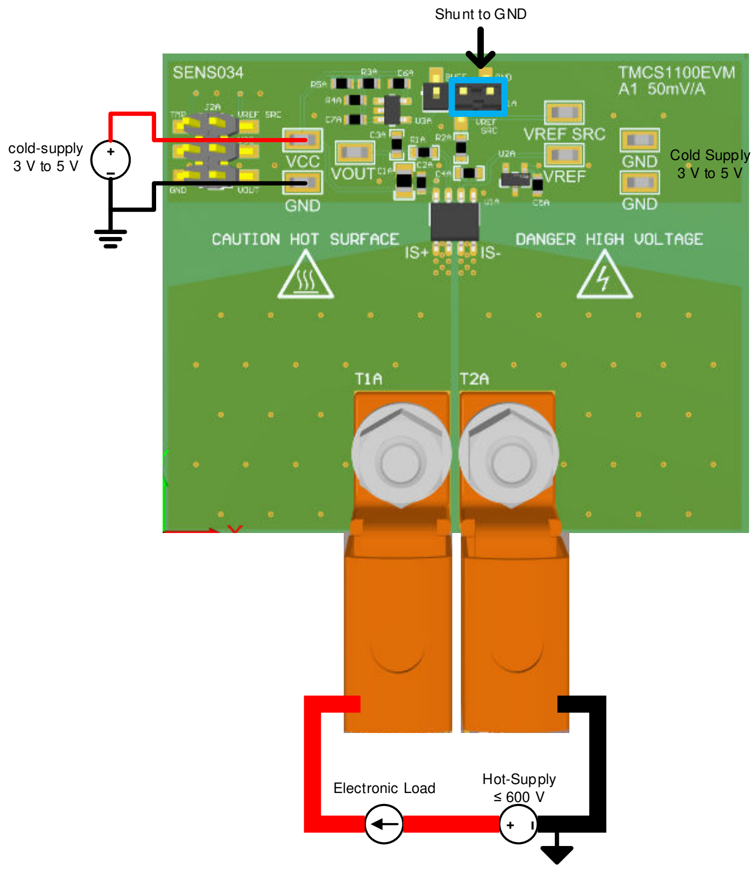

Figure 4-1. Low-Side Unidirectional Setup

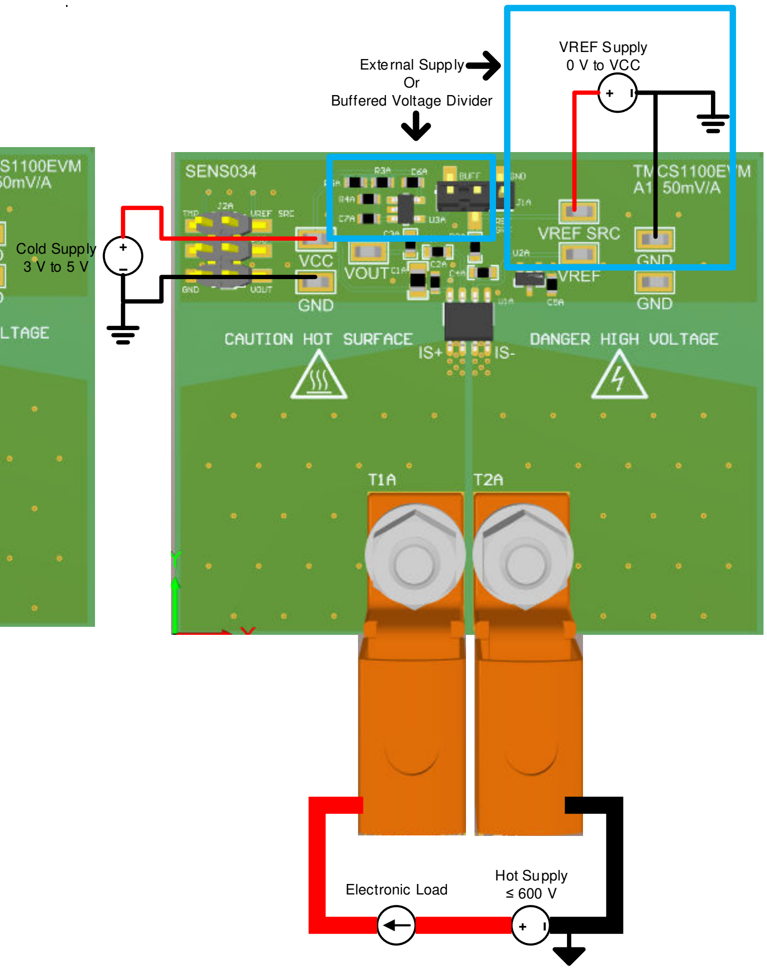

Figure 4-2. Low-Side Bidirectional Setup

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 IS+ and IS– 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. To set the VREF voltage, use an external REF supply, use a buffered voltage divider, or short VREF to GND. When VREF is supplied by the buffered voltage divider, set the jumper to short VREF to the buffer pin on connector J1x. When the VREF voltage is supplied by an external REF supply, remove the jumper short from J1x, and apply a supply to the VREF SOURCE and GND test points with a voltage set between GND and VCC.
5. 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, x = 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 ≥ 20-A capable hot-supply. For a high-side measurement, connect the electronic load positive input terminal to the load sourcing terminal (IS+ or IS–) of the EVM. For high-side measurement of forward current, IS– sources to the electronic load; for reverse current, IS+ sources to the load. Reverse current can only be measured if VREF is set to a potential higher than GND.
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 (IS+ or IS–) 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 the gain of the device multiplied by the load current passing through the leadframe of the DUT.

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 20 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-gauge 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 (>20 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 help 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 TMCS1100EVM PCBs.

5.1 Schematics

Figure 5-1 shows the schematic of the A1 sub board on the TMCS1100EVM PCB. Only the schematic for the 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 TMCS1100 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.

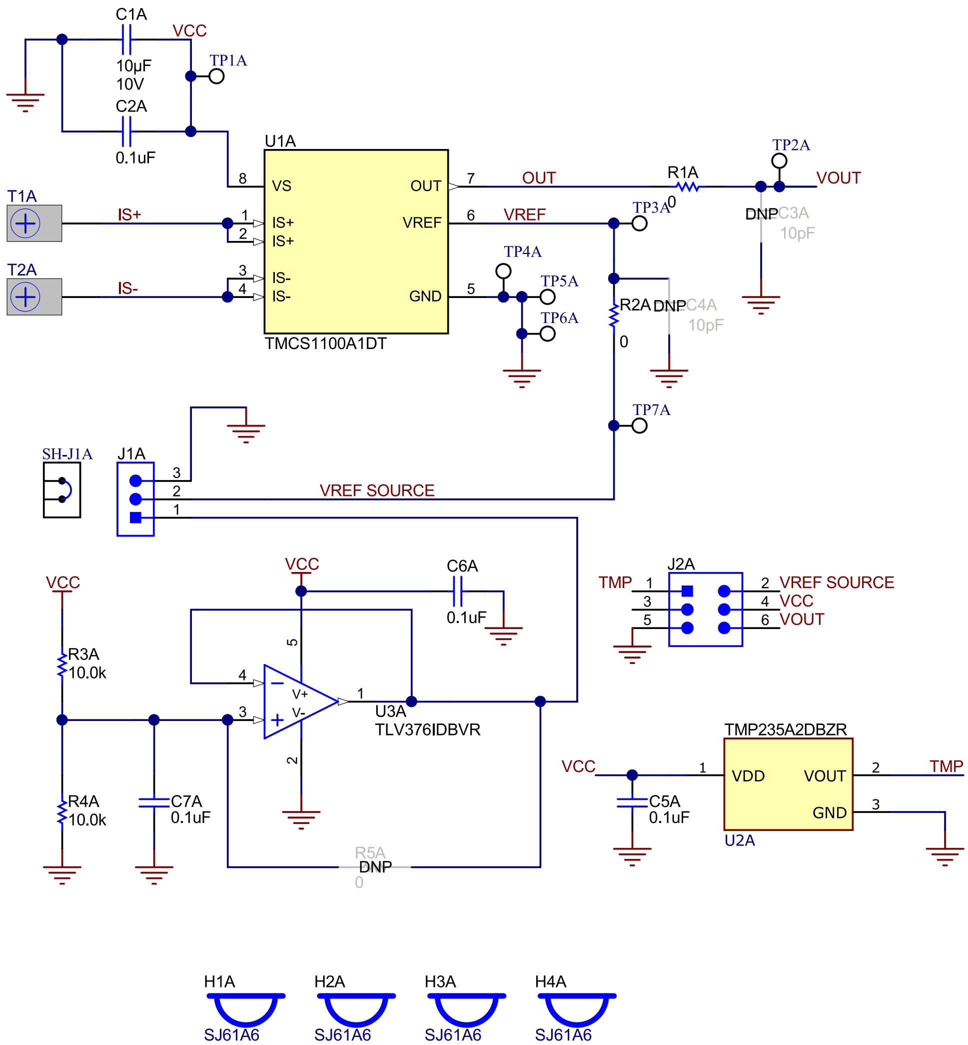

Figure 5-1. Schematic for A1 Device

5.2 PCB Layout

Figure 5-2 through Figure 5-5 illustrate the PCB layers of the TMCS1100EVM.

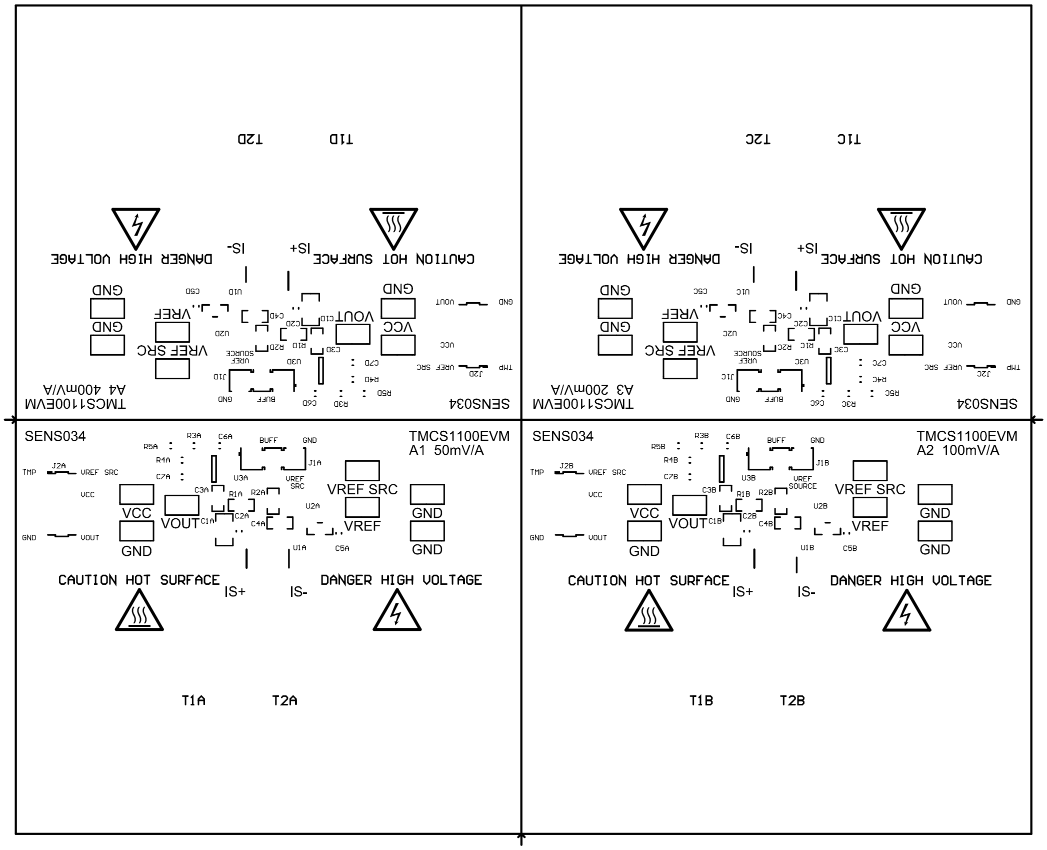

Figure 5-2. Top Overlay

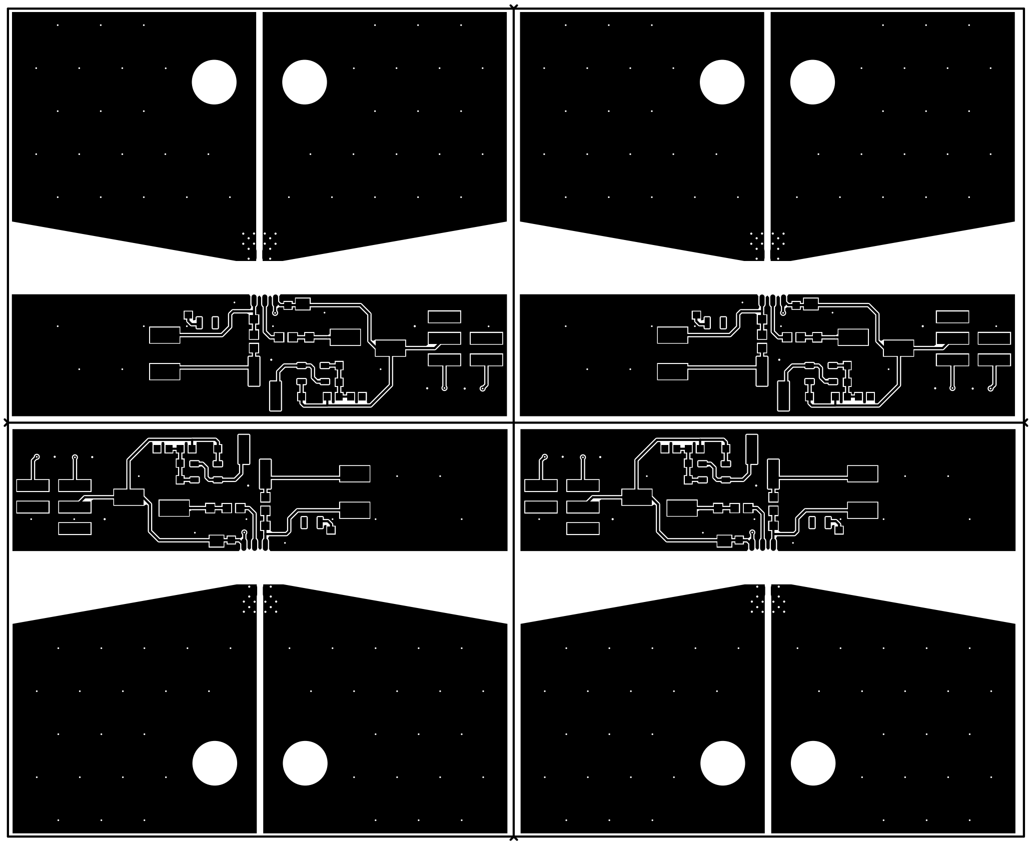

Figure 5-3. Top Layer

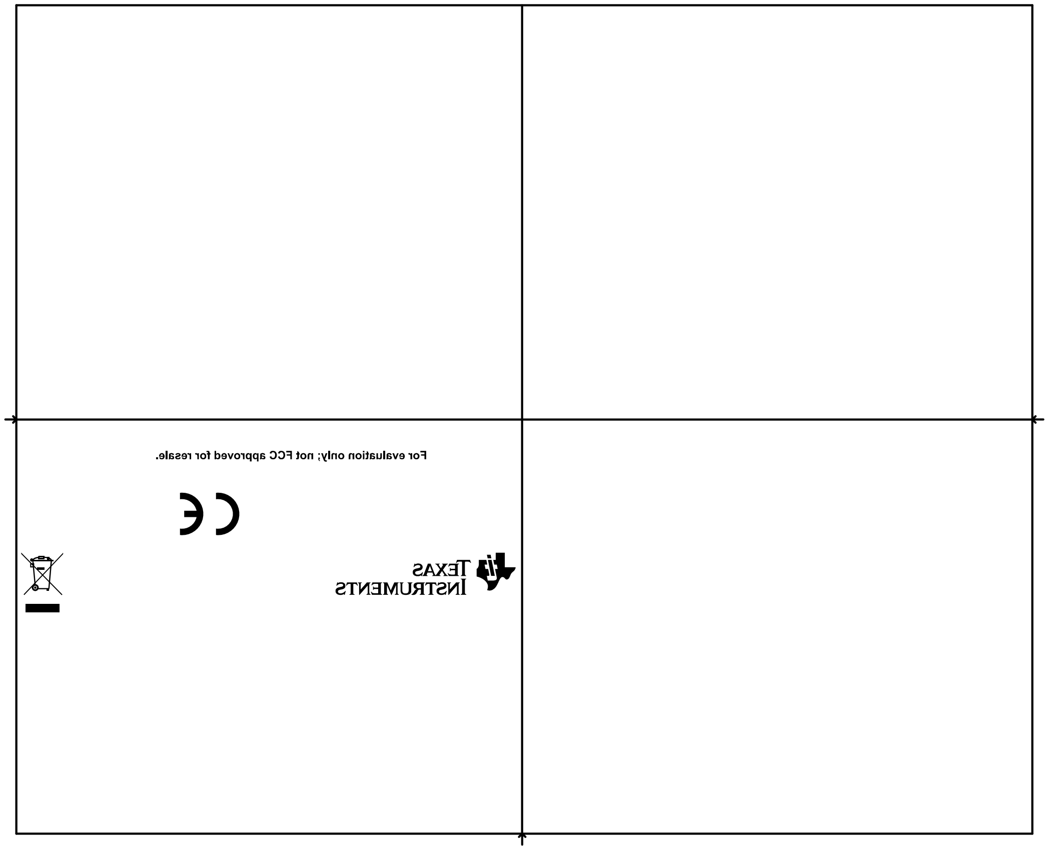

Figure 5-4. Bottom Overlay

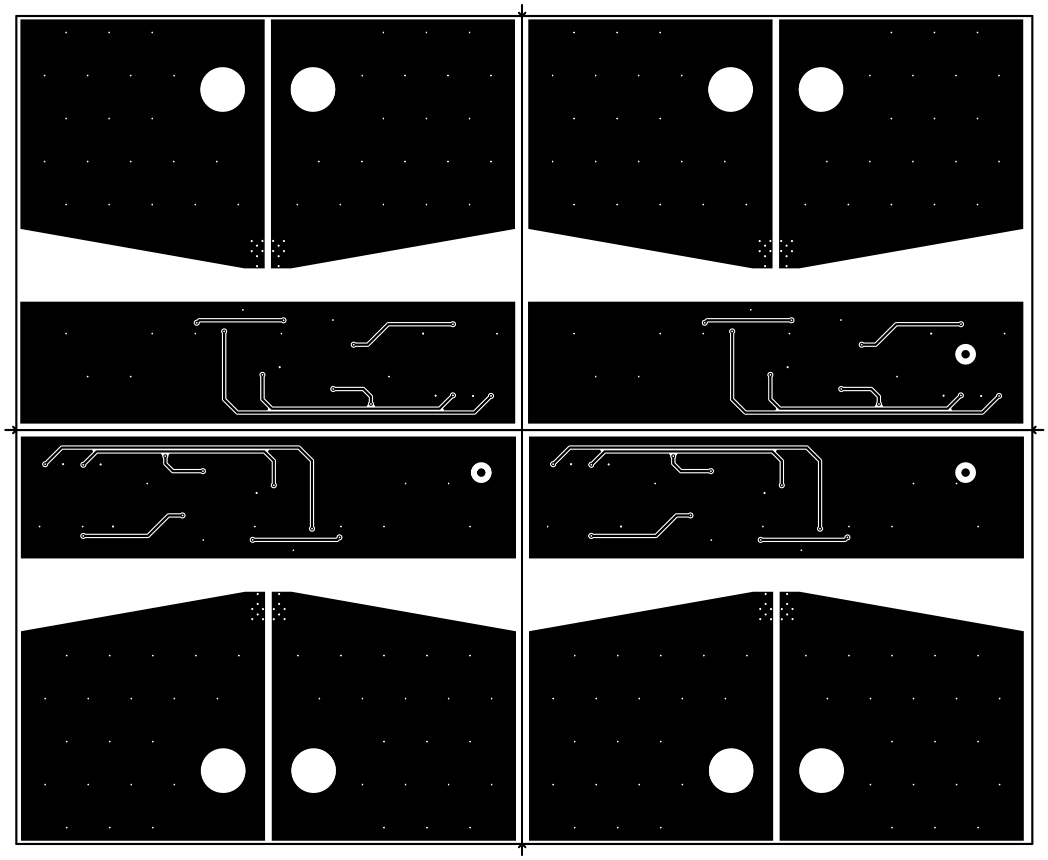

Figure 5-5. Bottom Layer

5.3 Bill of Materials

Table 5-1 provides the parts list for the TMCS1100EVM.

Table 5-1. Bill of Materials

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
C1A, C1B, C1C, C1D	4	10uF	CAP, CERM, 10 uF, 10 V, +/- 10%, X7R, 0805	0805	C2012X7R1A106K125AC	TDK
C2A, C2B, C2C, C2D, C5A, C5B, C5C, C5D, C6A, C6B, C6C, C6D, C7A, C7B, C7C, C7D	16	0.1uF	CAP, CERM, 0.1 uF, 50 V, +/- 10%, X7R, 0603	0603	06035C104KAT2A	AVX
H1A, H1B, H1C, H1D, H2A, H2B, H2C, H2D, H3A, H3B, H3C, H3D, H4A, H4B, H4C, H4D	16		BUMPER CYLIN 0.312" DIA BLK		SJ61A6	3M
J1A, J1B, J1C, J1D	4		Header, 2.54mm, 3x1, Gold, SMT	Header, 2.54mm, 3x1, SMT	TSM-103-01-L-SV-P-TR	Samtec
J2A, J2B, J2C, J2D	4		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
R1A, R1B, R1C, R1D, R2A, R2B, R2C, R2D	8	0	RES, 0, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	RMCF0603ZT0R00	Stackpole Electronics Inc
R3A, R3B, R3C, R3D, R4A, R4B, R4C, R4D	8	10.0k	RES, 10.0 k, 1%, 0.1 W, 0603	0603	RC0603FR-0710KL	Yageo
SH-J1A, SH-J1B, SH-J1C, SH-J1D	4		Shunt, 100mil, Gold plated, Black	Shunt 2 pos. 100 mil	881545-2	TE Connectivity
T1A, T2A	2		Terminal 50A Lug	CB35-36-CY	CB35-36-CY	Panduit

Table 5-1. Bill of Materials (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
TP1A, TP1B, TP1C, TP1D, TP2A, TP2B, TP2C, TP2D, TP3A, TP3B, TP3C, TP3D, TP4A, TP4B, TP4C, TP4D, TP5A, TP5B, TP5C, TP5D, TP6A, TP6B, TP6C, TP6D, TP7A, TP7B, TP7C, TP7D	28		Test Point, Miniature, SMT	Testpoint_Keystone_Miniature	5015	Keystone
U1A	1		TMCS1100A1DT, D0008A (SOIC-8)	D0008A	TMCS1100A1DT	Texas Instruments
U1B	1		TMCS1100A2DT, D0008A (SOIC-8)	D0008A	TMCS1100A2DT	Texas Instruments
U1C	1		TMCS1100A3DT, D0008A (SOIC-8)	D0008A	TMCS1100A3DT	Texas Instruments
U1D	1		TMCS1100A4DT, D0008A (SOIC-8)	D0008A	TMCS1100A4DT	Texas Instruments
U2A, U2B, U2C, U2D	4		Temperature Sensor Analog, Local -40°C ~ 150°C 10mV/°C SOT-23-3	SOT-23	TMP235A2DBZR	Texas Instruments
U3A, U3B, U3C, U3D	4		TLVx376, 5.5 MHz, Low-Noise, Low Quiescent Current, Precision Operational Amplifiers, DBV0005A (SOT-23-5)	DBV0005A	TLV376IDBVR	Texas Instruments
C3A, C3B, C3C, C3D, C4A, C4B, C4C, C4D	0	10pF	CAP, CERM, 10 pF, 10 V, +/- 10%, X7R, 0603	0603	0603ZC100KAT2A	AVX
R5A, R5B, R5C, R5D	0	0	RES, 0, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	RMCF0603ZT0R00	Stackpole Electronics Inc
T1B, T1C, T1D, T2B, T2C, T2D	0		Terminal 50A Lug	CB35-36-CY	CB35-36-CY	Panduit

6 Revision History

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

Changes from Revision A (March 2020) to Revision B (August 2021) **Page**

- Updated the numbering format for tables, figures and cross-references throughout the document.................. 3

Changes from Revision * (August 2019) to Revision A (March 2020) **Page**

- Added the on-board temperature sensor to the *Features* list.. 5
- Changed the *Circuitry* section.. 6
- Changed step 4 in the *Operation* setup.. 8
- Changed the *Advanced Measurement Tips* section... 9
- Changed the *Bill of Materials* table... 15

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