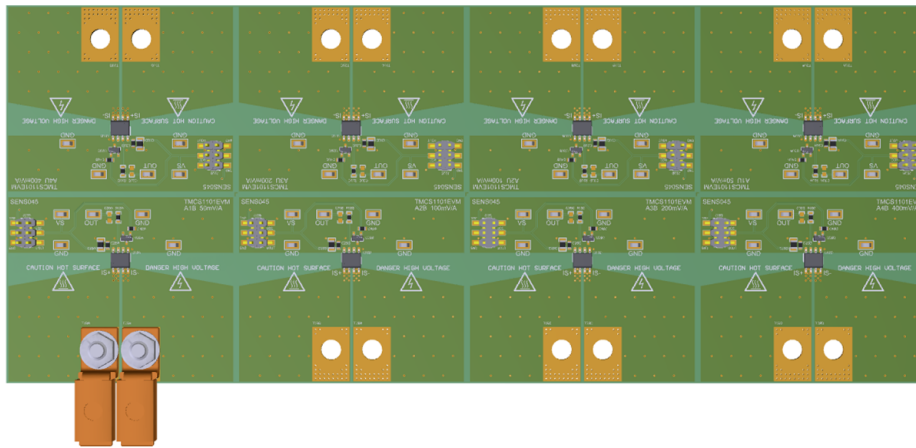


# TMCS1101EVM



This user's guide describes the characteristics, operation, and use of the TMCS1101 evaluation module (EVM). This EVM is designed to evaluate the performance of the [TMCS1101](#) 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 TMCS1101EVM. 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



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 TMCS1101 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. 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 TMCS1101 is currently available in an 8-pin, SOIC, surface-mount package. [Table 1](#) lists the available gain options.

**Table 1. TMCS1101Ax Device Summary**

Product	Direction	Gain
TMCS1101A1B	Bidirectional	50 mV/A
TMCS1101A2B	Bidirectional	100 mV/A
TMCS1101A3B	Bidirectional	200 mV/A
TMCS1101A4B	Bidirectional	400 mV/A
TMCS1101A1U	Unidirectional	50 mV/A
TMCS1101A2U	Unidirectional	100 mV/A
TMCS1101A3U	Unidirectional	200 mV/A
TMCS1101A4U	Unidirectional	400 mV/A

### 2.1 Kit Contents

[Table 2](#) lists the contents of the TMCS1101EVM kit. Contact the nearest [Texas Instruments Customer Support Center](#) if any component is missing. TI highly recommends checking the TMCS1101 family product folder on the TI website at [www.ti.com](http://www.ti.com) for further information regarding this product.

**Table 2. TMCS1101EVM Kit Contents**

Item	Quantity
TMCS1101EVM Test Board	1

### 2.2 Related Documentation From Texas Instruments

[Table 3](#) provides literature references for TI's integrated circuits used in the assembly of the TMCS1101EVM. This user's guide is available from the TI website under literature number SLYU051. 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](http://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 3. Related Documentation**

document	Literature Number
<a href="#">TMCS1101</a> product data sheet	<a href="#">SBOS825</a>

### 3 Hardware

The TMCS1101 is an isolated, current-sense op amp that provides ease-of-use and high performance. The TMCS1101EVM is intended to provide basic functional evaluation of all TMCS1101 gain variants. The TMCS1101EVM is not laid out for electromagnetic compatibility (EMC) testing. The TMCS1101EVM 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:

- TMCS1101A1B
- TMCS1101A2B
- TMCS1101A3B
- TMCS1101A4B
- TMCS1101A1U
- TMCS1101A2U
- TMCS1101A3U
- TMCS1101A4U

#### 3.1 Features

The layout of the TMCS1101EVM PCB is designed to provide the following features:

- Evaluation of all gain options for the TMCS1101
- Ease-of-access to device pins with test points
- Evaluation of high-side and low-side configurations
- On-board temperature sensor

See the [TMCS1101](#) data sheet for comprehensive information about the TMCS1101.

## 3.2 Circuitry

This section summarizes the TMCS1101EVM 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- $\mu$ F and 0.1- $\mu$ F supply bypass capacitors, respectively, for the TMCS1101.  $C4_{xy}$  is the 0.1- $\mu$ F bypass capacitor for the optional temperature sensor.

### 3.2.2 Output Filter

$C3_{xy}$  and  $R1_{xy}$  are footprints for the optional output filter. Default values are 10 pF and 0  $\Omega$ , but no capacitors are installed.  $TP2_{xy}$  is the test point for the TMCS1101 output.

### 3.2.3 Measurement Connector

$J2_x$  is an additional connector for measuring  $VCC$  and  $VOUT$ .  $J2_x$  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  $y = A$ ).  $TP3_x$  and  $TP6_x$  are Kelvin connections to probe the EVM inputs. The  $IS+$  ( $T1_{xy}$ ) and  $IS-$  ( $T2_{xy}$ ) 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 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 TMCS1101 data sheet.

### 3.2.5 Ground Test Points

$TP3_x$ ,  $TP4_x$ , and  $TP5_x$  correspond to ground connections of the TMCS1100 device.

### 3.2.6 TMCS1101 Isolated Current-Sense Amplifier

$U1_{xy}$  is the TMCS1101 isolated current-sense amplifier. Eight segments are supplied within the TMCS1101EVM 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.

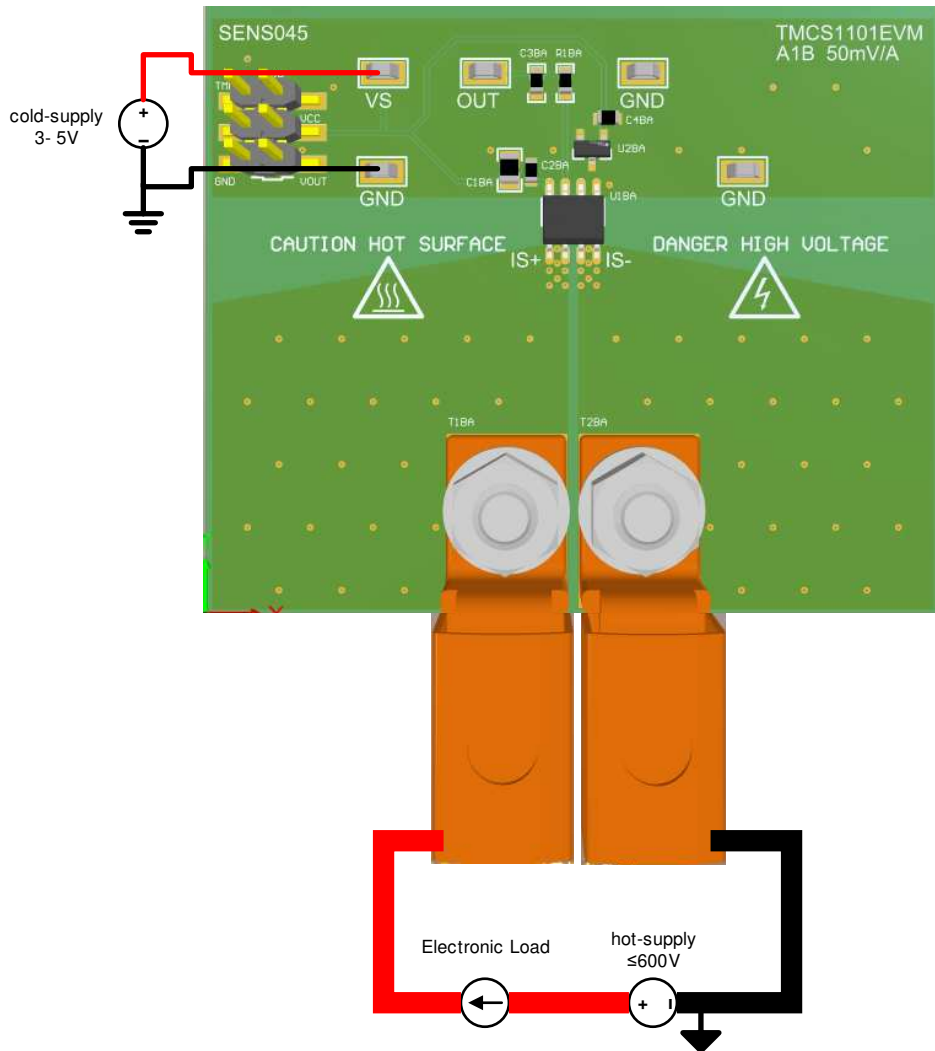
- The TMCS1101AnB is used for bidirectional applications, while TMCS1101AnU is used for unidirectional applications (where  $n = 1$  to 4 for the A1 to A4 gain variants, respectively).
- A magnetic field is generated based on the load current that is connected across the inputs  $IS+$  and  $IS-$ , and flows through the TMCS1101 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.

## 3.3 Temperature Sensor

$U2_x$  is a temperature sensor that is not required for TMCS1100 operation. However,  $U2_x$  provides the option of measuring board temperature for determining ambient conditions.

## 4 Operation

The following are instructions to set up and use the TMCS1101EVM. For the following instructions,  $y = A$  to  $D$  for the A1 to A4 gain variants, respectively. [Figure 1](#) shows an example of a simple, low-side setup on the A1B (50 mV/A) gain variant. This device 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 1. Low-Side Forward Current Setup**

- Step 1. For greater maneuverable flexibility, break apart the EVM sub boards along the score lines. Otherwise, the board can be left intact.
- Step 2. Attach the high-current lug connectors to IS+ and IS- of the gain version to be tested.
- Step 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.
- Step 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.

- Step 1. According to [Figure 1](#), for a low-side measurement, connect the electronic load positive input terminal to the positive terminal of a  $\geq 20$ -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.
- Step 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.
- Step 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.
- Step 4. Turn on all the connected supplies.
- Step 5. Apply load with electronic load.
- Step 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 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 TMCS1101EVM PCBs.

### 5.1 Schematics

Figure 2 shows the schematic of the A1B sub board on the TMCS1101EVM 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 TMCS1101 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 D appended. All components labeled with a B after the number correspond to the bidirectional TMCS1101 devices, while all components labeled with a U after the number correspond to unidirectional TMCS1101 devices.

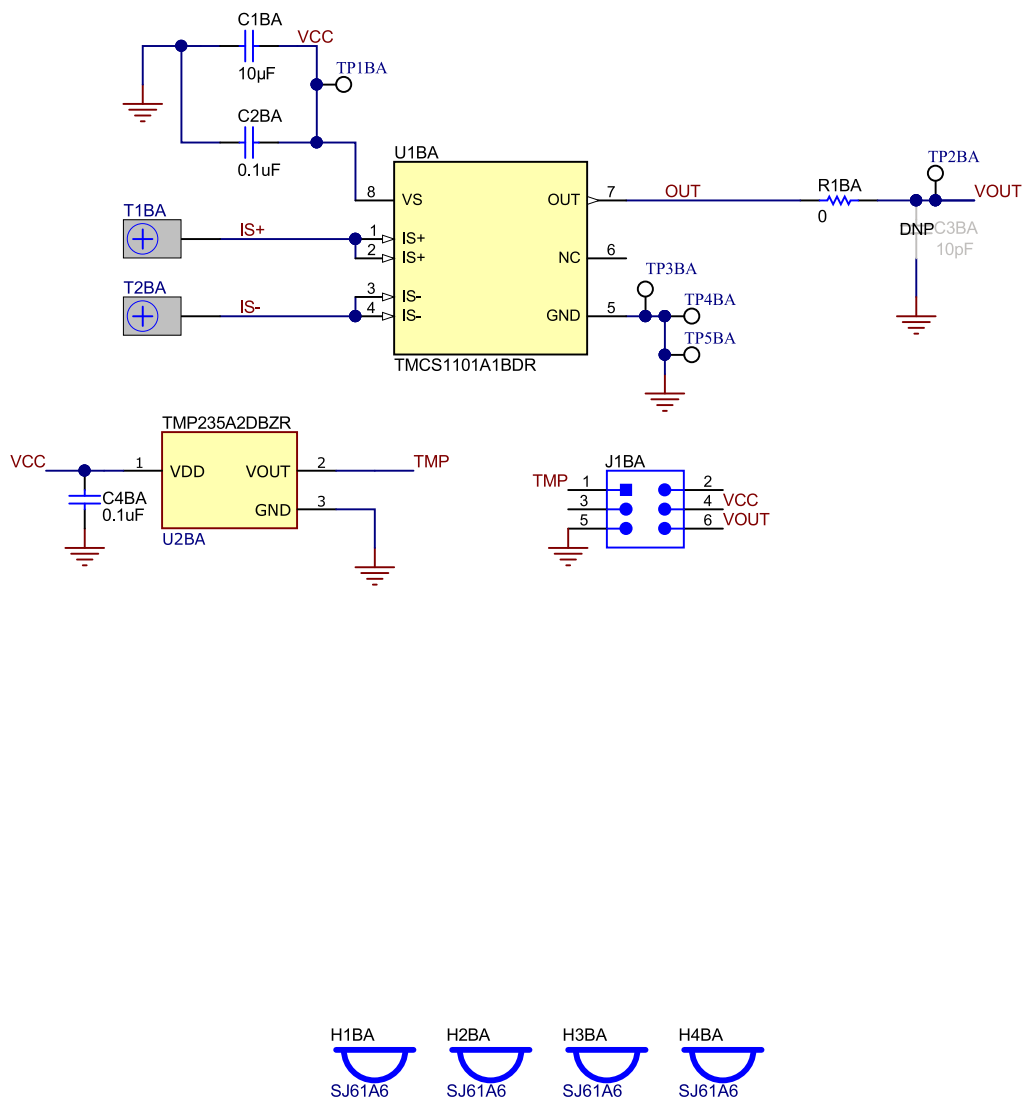


Figure 2. Schematic for A1 Device

## 5.2 PCB Layout

Figure 3 through Figure 6 illustrate the PCB layers of the TMCS1101EVM.

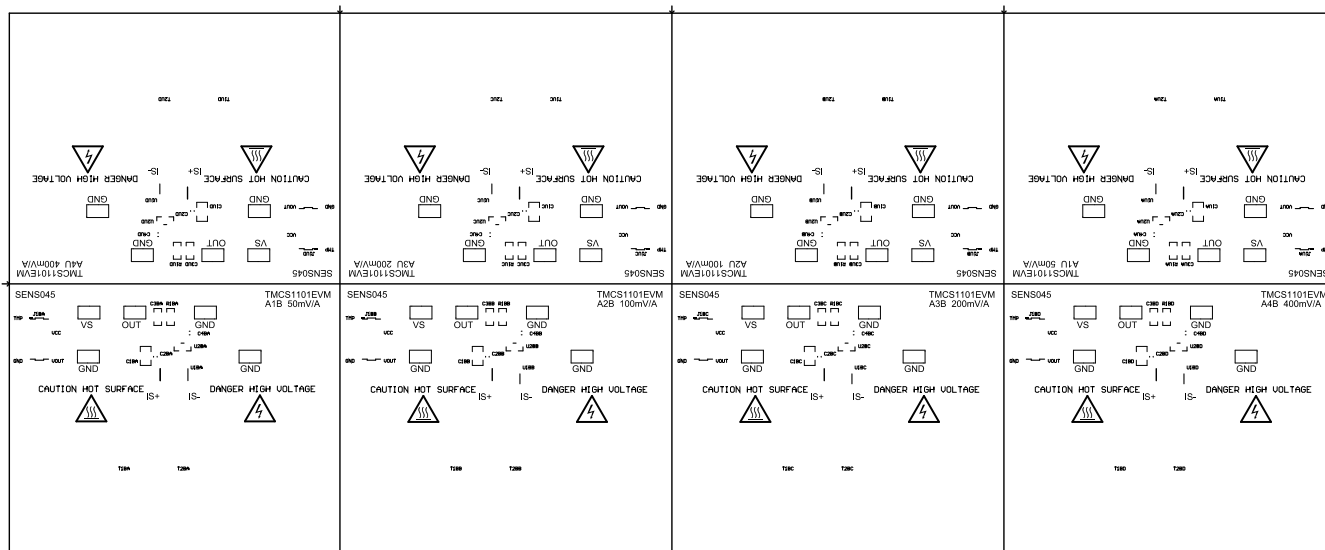


Figure 3. Top Overlay

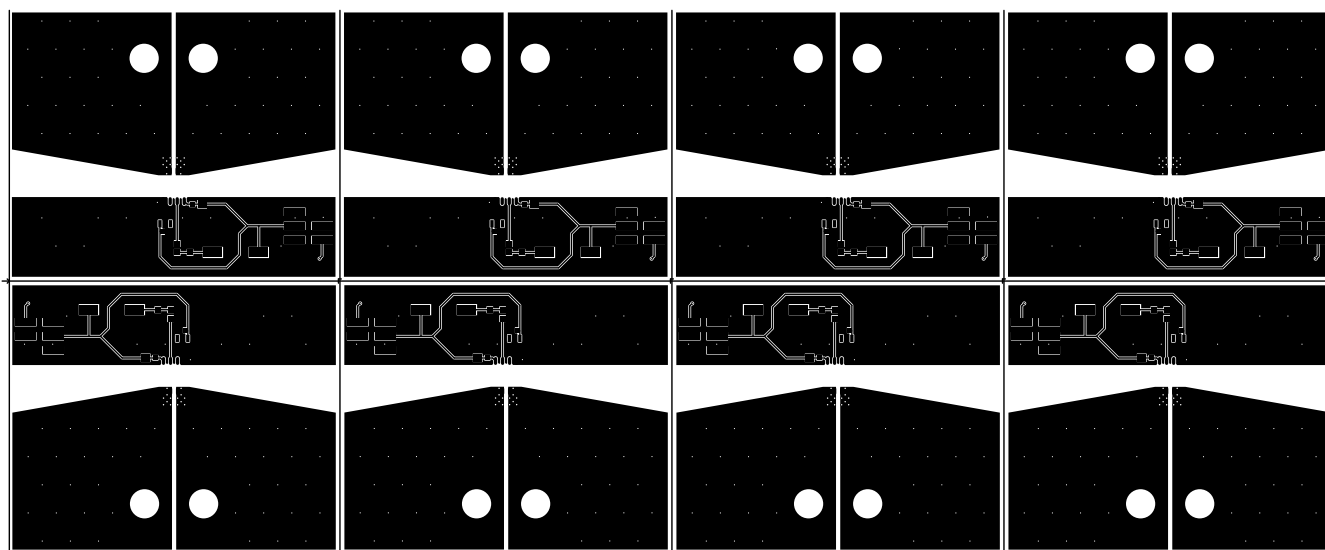
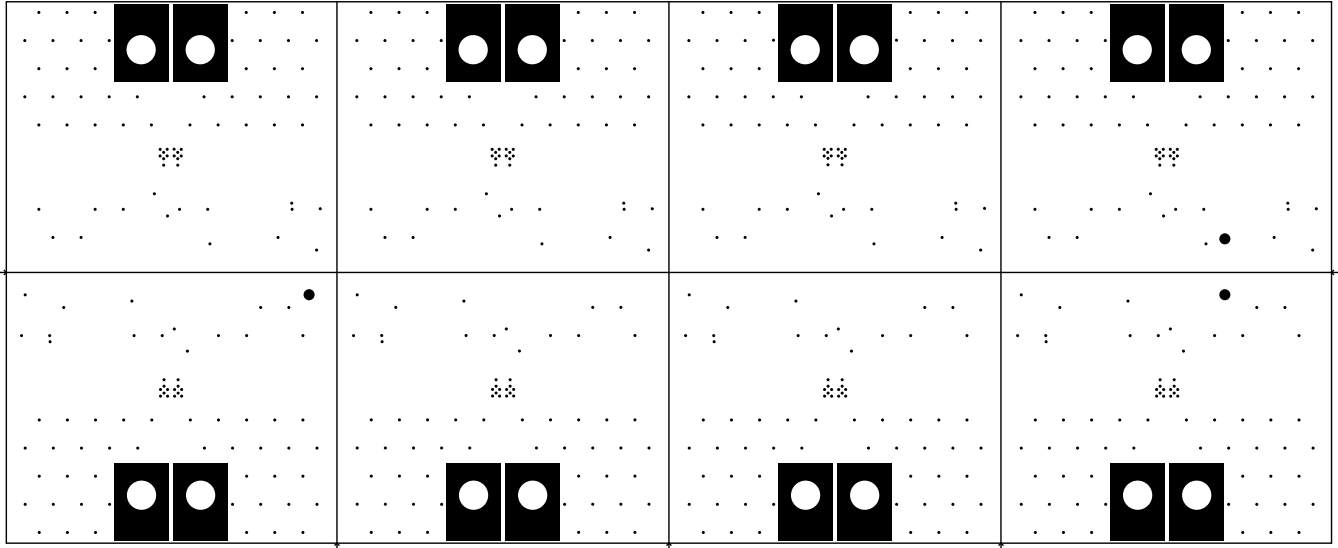
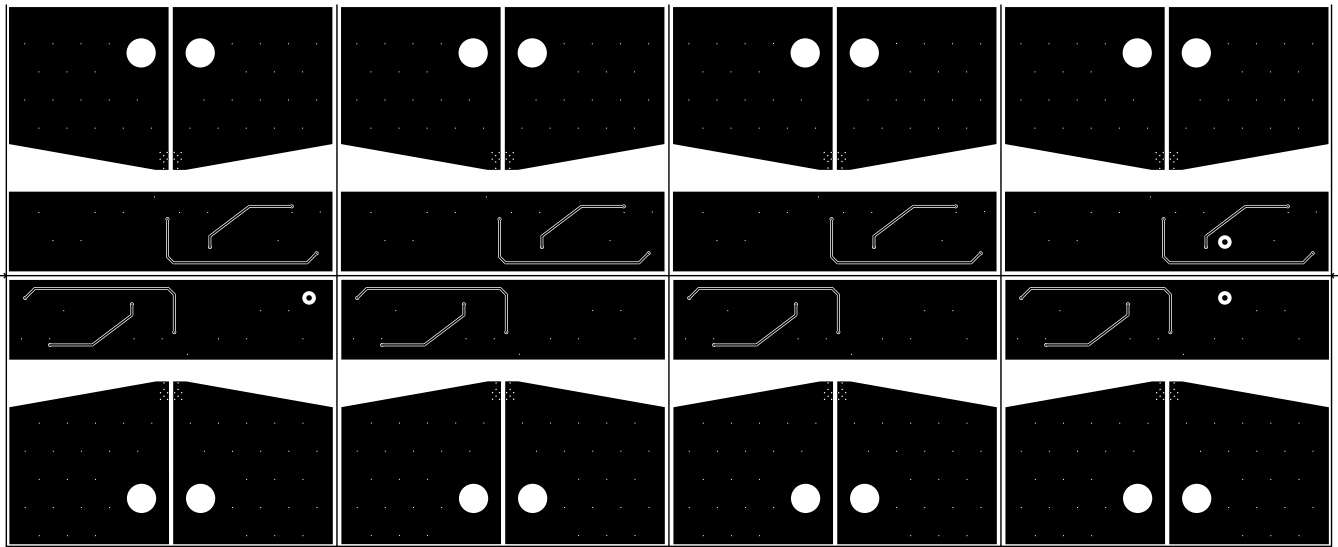


Figure 4. Top Layer



**Figure 5. Bottom Overlay**



**Figure 6. Bottom Layer**

### 5.3 Bill of Materials

**Table 4. Bill of Materials**

Designator	Quantity	Value	Description	PackageReference	PartNumber	Manufacturer
C1BA, C1BB, C1BC, C1BD, C1UA, C1UB, C1UC, C1UD	8	10uF	CAP, CERM, 10 uF, 10 V, +/- 10%, X7R, 0805	0805	C2012X7R1A106K125A C	TDK
C2BA, C2BB, C2BC, C2BD, C2UA, C2UB, C2UC, C2UD, C4BA, C4BB, C4BC, C4BD, C4UA, C4UB, C4UC, C4UD	16	0.1uF	CAP, CERM, 0.1 uF, 50 V, +/- 10%, X7R, 0603	0603	06035C104KAT2A	AVX
C3UA, C3UB, C3UC, C3UD	4	10pF	CAP, CERM, 10 pF, 10 V, +/- 10%, X7R, 0603	0603	0603ZC100KAT2A	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 4. 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	TMCS1101A1BDR	Texas Instruments
U1BB	1		Precision Isolated Current Sense Monitor With External Reference, D0008A (SOIC-8)	D0008A	TMCS1101A2BDR	Texas Instruments
U1BC	1		Precision Isolated Current Sense Monitor With External Reference, D0008A (SOIC-8)	D0008A	TMCS1101A3BDR	Texas Instruments
U1BD	1		Precision Isolated Current Sense Monitor With External Reference, D0008A (SOIC-8)	D0008A	TMCS1101A4BDR	Texas Instruments
U1UA	1		Precision Isolated Current Sense Monitor With External Reference, D0008A (SOIC-8)	D0008A	TMCS1101A1UDR	Texas Instruments
U1UB	1		Precision Isolated Current Sense Monitor With External Reference, D0008A (SOIC-8)	D0008A	TMCS1101A2UDR	Texas Instruments
U1UC	1		Precision Isolated Current Sense Monitor With External Reference, D0008A (SOIC-8)	D0008A	TMCS1101A3UDR	Texas Instruments

**Table 4. 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	TMCS1101A4UDR	Texas Instruments
U2BA, U2BB, U2BC, U2BD, U2UA, U2UB, U2UC, U2UD	8		Temperature Sensor Analog, Local -40°C ~ 150°C 10mV/°C SOT-23-3	SOT-23	TMP235A2DBZR	Texas Instruments
C3BA, C3BB, C3BC, C3BD	0	10pF	CAP, CERM, 10 pF, 10 V, +/- 10%, X7R, 0603	0603	0603ZC100KAT2A	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

## Revision History

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

Changes from Original (August 2019) to A Revision	Page
• Changed the <i>Hardware</i> section .....	5
• Added the on-board temperature sensor to the <i>Features</i> list .....	5
• Changed the <i>Circuitry</i> section .....	6
• Changed <i>Unidirectional Setup</i> to <i>Forward Current Setup</i> .....	7
• Changed the <i>Advanced Measurement Tips</i> section .....	8
• Changed the <i>Bill of Materials</i> table .....	12

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