

User's Guide

TMCS1123xEVM



ABSTRACT

NOTICE: This EVM comes without the TCMS1123 devices populated. To evaluate, order up to five devices of any gain or version and solder onto the EVM.

This user's guide describes the characteristics, operation, and use of the **TMCS1123** evaluation module (EVM). This EVM is designed to evaluate the performance of the **TMCS1123** 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 TMCS1123xEVM. This document includes a schematic, reference printed circuit board (PCB) layouts, and a complete bill of materials (BOM).

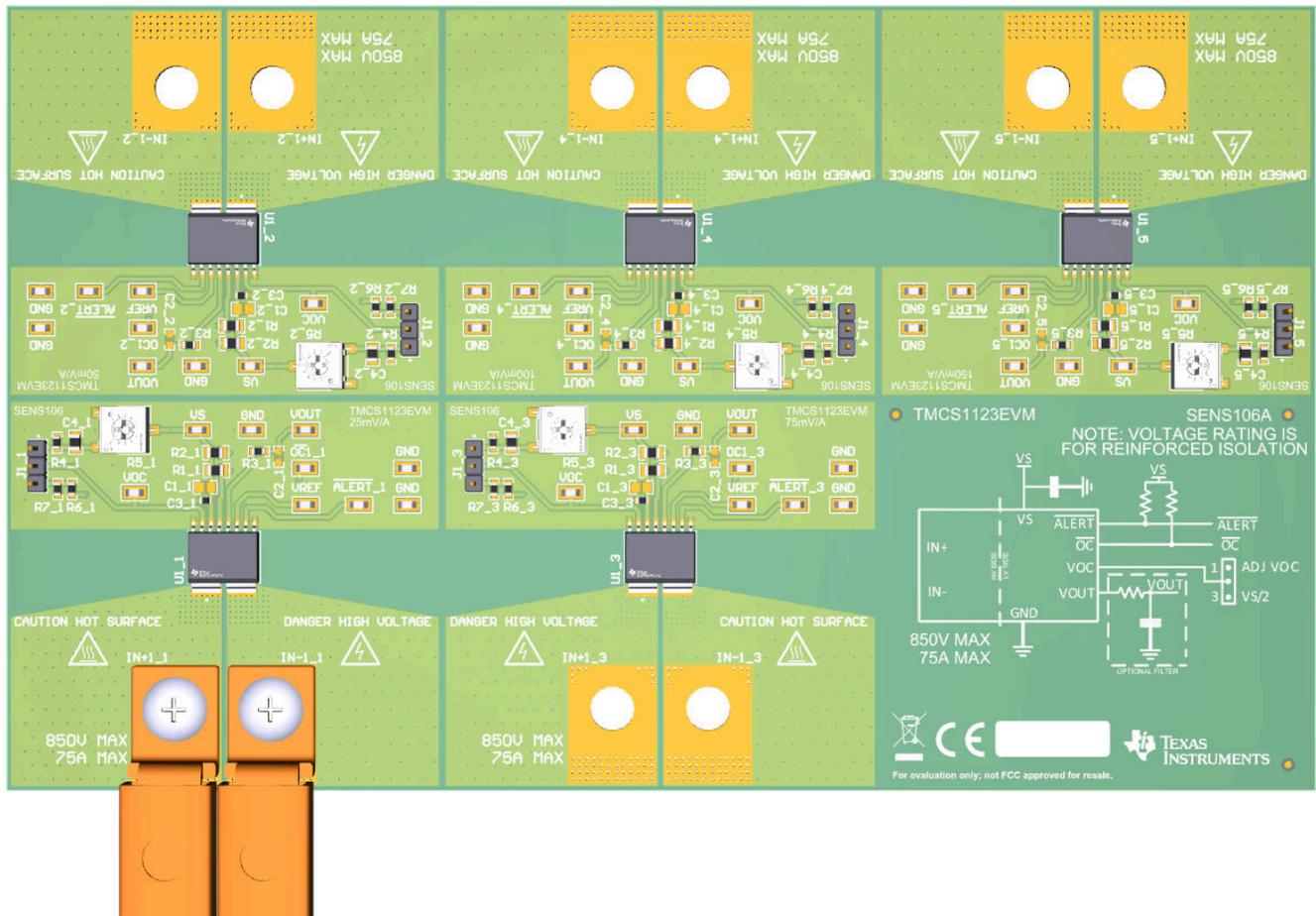


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Trademarks

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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://ti.com/support> for further information.

Save all warnings and instructions for future reference.

WARNING

Failure to follow warnings and instructions can 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 suitably qualified, then immediately stop from further use of the HV EVM.

1. Work Area Safety

- a. Keep work area clean and orderly.
- b. Qualified observers must be present anytime circuits are energized.
- c. Effective barriers and signage must be present in the area where the TI HV EVM and the interface electronics are energized, indicating operation of accessible high voltages can 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 can have fully accessible and active high voltages.

- a. De-energize the TI HV EVM and all the 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 the electrical circuits, as the EVM or the electrical circuits can 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 [TMCS1123](#) 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 ±1100 V_{DC}, independent of the supply voltage. The device is available with zero-input reference point configurations of 0.5 × V_S (A), 0.33 × V_S (B), and 0.1 × V_S (C), with five fixed sensitivities available: 25 mV/A, 50 mV/A, 75 mV/A, 100 mV/A, and 150 mV/A. These devices operate from a single 3-V to 5.5-V power supply, drawing a maximum of 9.2 mA of supply current. The [TMCS1123](#) is currently available in a 10-pin, SOIC, fused lead, surface-mount package. [Table 2-1](#) lists the available sensitivity options.

Table 2-1. TMCS1123Ax Device Summary

PRODUCT	REFERENCE POINT	SENSITIVITY
TMCS1123A1	2.5 V	25 mV/A
TMCS1123A2	2.5 V	50 mV/A
TMCS1123A3	2.5 V	75 mV/A
TMCS1123A4	2.5 V	100 mV/A
TMCS1123A5	2.5 V	150 mV/A
TMCS1123B1	1.65 V	25 mV/A
TMCS1123B2	1.65 V	50 mV/A
TMCS1123B3	1.65 V	75 mV/A
TMCS1123B4	1.65 V	100 mV/A
TMCS1123B5	1.65 V	150 mV/A
TMCS1123C1	0.33 V	25 mV/A
TMCS1123C2	0.33 V	50 mV/A
TMCS1123C3	0.33 V	75 mV/A
TMCS1123C4	0.33 V	100 mV/A
TMCS1123C5	0.33 V	150 mV/A

2.1 Kit Contents

[Table 2-2](#) lists the contents of the TMCS1123xEVM kit. Contact the [Texas Instruments Customer Support Center](#) if any component is missing. TI highly recommends checking the [TMCS1123](#) family product folder on the TI website at [www.ti.com](#) for further information regarding this product.

Table 2-2. TMCS1123xEVM Kit Contents

ITEM	QUANTITY
TMCS1123xEVM 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 TMCS1123xEVM. This user's guide is available from the TI website under literature number SBAU421. 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
TMCS1123 product data sheet	SBOSA24

3 Hardware

The [TMCS1123](#) is an isolated, Hall-effect based, current-sense amplifier that provides ease-of-use and high performance. The TMCS1123xEVM is a family of EVMs intended to provide basic, functional evaluation of all [TMCS1123](#) sensitivity variants.

The TMCS1123xEVMs are not laid out for electromagnetic compatibility (EMC) testing. The TMCS1123xEVM family consists of three separate orderable PCBs that can be snapped apart into five individual segments, with each segment populated with a separate sensitivity. Each PCB allows testability of all sensitivity variants across one of the three orderable reference points of $0.5 \times V_S$ (TMCS1123AEVM), $0.33 \times V_S$ (TMCS1123BEVM), or $0.1 \times V_S$ (TMCS1123CEVM).

Across all EVM variants, the parts that can be examined with the EVM are:

- TMCS1123A1
- TMCS1123A2
- TMCS1123A3
- TMCS1123A4
- TMCS1123A5
- TMCS1123B1
- TMCS1123B2
- TMCS1123B3
- TMCS1123B4
- TMCS1123B5
- TMCS1123C1
- TMCS1123C2
- TMCS1123C3
- TMCS1123C4
- TMCS1123C5

3.1 Features

The layout of the TMCS1123xEVM PCB is designed to provide the following features:

- Evaluation of all sensitivity options for the [TMCS1123](#)
- Ease-of-access to device pins with test points
- Evaluation of high-side and low-side configurations

See the [TMCS1123](#) data sheet for comprehensive information about the [TMCS1123](#).

3.2 Circuitry

This section summarizes the TMCS1123xEVM components. For each panel, the number marked as 'x' designates the variant of the TMCS1123 under test. For example, C1_3 is a bypass capacitor found on the A3, B3, or C3 variant of the EVM.

3.2.1 Bypass Capacitors

C1_x and C3_x are 10- μ F and 0.1- μ F supply bypass capacitors, respectively, for the [TMCS1123](#). These devices are present to help smooth the supply voltage of the [TMCS1123](#). By default, the 10- μ F is depopulated, but can be populated to evaluate potentially extremely noisy supplies.

3.2.2 Output Filter

C2_x and R2_x are footprints for the optional output filter. Default values are 10 pF and 0 Ω , but no capacitors are installed.

3.2.3 Overcurrent Set Point and Overcurrent Circuitry

J1_x is a 1x3 header that allows the user to customize the input voltage reference of the overcurrent set point in a number of ways. Configuration options available include:

Option 1: Short J1_x pins 1 and 2 with the supplied shorting plug

This option provides the reference point with a voltage set through the potentiometer R5_x. R4_x is a 5.6-k Ω resistor that forms a voltage divider with the potentiometer that provides an output voltage. Use the following equations to calculate the overcurrent reference voltage presented to the VOC pin:

$$V_{OC} = \frac{R_4}{R_{POT} + R_4} \times V_S \quad (1)$$

$$\text{for } R_{POT, \max}, V_S = 5.5V, V_{OC} = \frac{R_4}{R_{POT} + R_4} \times V_S = \frac{5.60k\Omega}{100k\Omega + 5.60k\Omega} \times 5.5V = 0.291V \approx 0.3V \quad (2)$$

$$\text{for } R_{POT, \min}, V_S = 5.5V, V_{OC} = \frac{5.60k\Omega}{1k\Omega + 5.60k\Omega} \times V_S = 0.85 \times V_S \quad (3)$$

Note that the presence of the 5.6-k Ω resistor keeps the minimum output voltage available at approximately 0.3 V for the maximum device supply voltage of 5.5 V. This provides a quick method on board for analyzing nearly the entire voltage range of VOC. Check VOC with a digital multimeter (DMM) for the desired voltage, adjusting R_{POT} higher or lower until the desired voltage is achieved. See the [TMCS1123](#) data sheet for information on how to calculate VOC for a given overcurrent set point.

Option 2: Short J1_x pins 2 and 3 with the supplied shorting plug

This option provides the reference point with the voltage produced by a resistor divider formed between R6_x and R7_x. This resistor divider is set to approximately 90% of V_S by default (see [Equation 4](#)), but can be customized for evaluation between any resistor pair in 0805 package within data sheet specifications.

$$V_{OC} = \frac{R_7}{R_6 + R_7} \times V_S = \frac{88.7k\Omega}{98.7k\Omega} \times V_S = 0.9 \times V_S \quad (4)$$

Option 3: Do not populate the shorting plug

By not populating the shorting plug, the reference input VOC remains floating from any hardwired PCB input. This node can then be driven directly by the "VOC" test point on the board to directly drive specific external voltage the user considers in their application.

The point set by any of the above methods are presented to an internal comparator, which is constantly monitored against the output voltage VOUT. In the event that VOUT > VOC, the active low nOC pin activates,

pulling low to indicate that the system has reached the overcurrent point. Resistor R1_x acts as the pullup resistor for the active low nOC node.

3.2.4 Load Connectors

The input connectors labeled IN+_x and IN-_x correspond to the high-current rated load connectors supplied with the EVM. By default, the EVM is only populated with two of these connectors on the lowest sensitivity variant (A1, B1, or C1). These components are screwed to the board to make contact, and can be easily moved to the desired sensitivity option for test purposes. The fused lead frame inputs (pins 1 and 2 of the unit under test) 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 sensitivity and is presented at the VOUT test point. The acceptable load input maximum for the included connectors is 90 A for DC measurements. However, the continuous allowable load is bounded by the safe operating area (SOA) described in the [TMCS1123 data sheet](#).

3.2.5 TMCS1123 Isolated Current-Sense Amplifier

U1_x is the [TMCS1123](#) isolated current-sense amplifier. The TMCS1123xEVM board is divided into five detachable segments. Each segment is populated with one of the available device sensitivities for the chosen operating point A, B, or C. This configuration enables users to test all possible variants of the devices to determine the best sensitivity setting for a given application.

- A magnetic field is generated based on the load current that is connected across the inputs IN+_x and IN-_x, and flows through the TMCS1123 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 sensitivity. The maximum output voltage must remain within the range of 10 mV above ground to 100 mV below the supply voltage.
- Choose an appropriate sensitivity to create the largest appropriate output swing and to minimize error.

4 Operation

The following are instructions to set up and use the TMCS1123xEVM. [Figure 4-1](#) shows an example of a simple, low-side setup on the A1 (25 mV/A) sensitivity variant. This device has isolation, and external supplies are distinguished by "high voltage" (HV) for load and "low voltage" (LV) for DUT supply. The HV supply can be isolated and at a different potential than the LV supply.

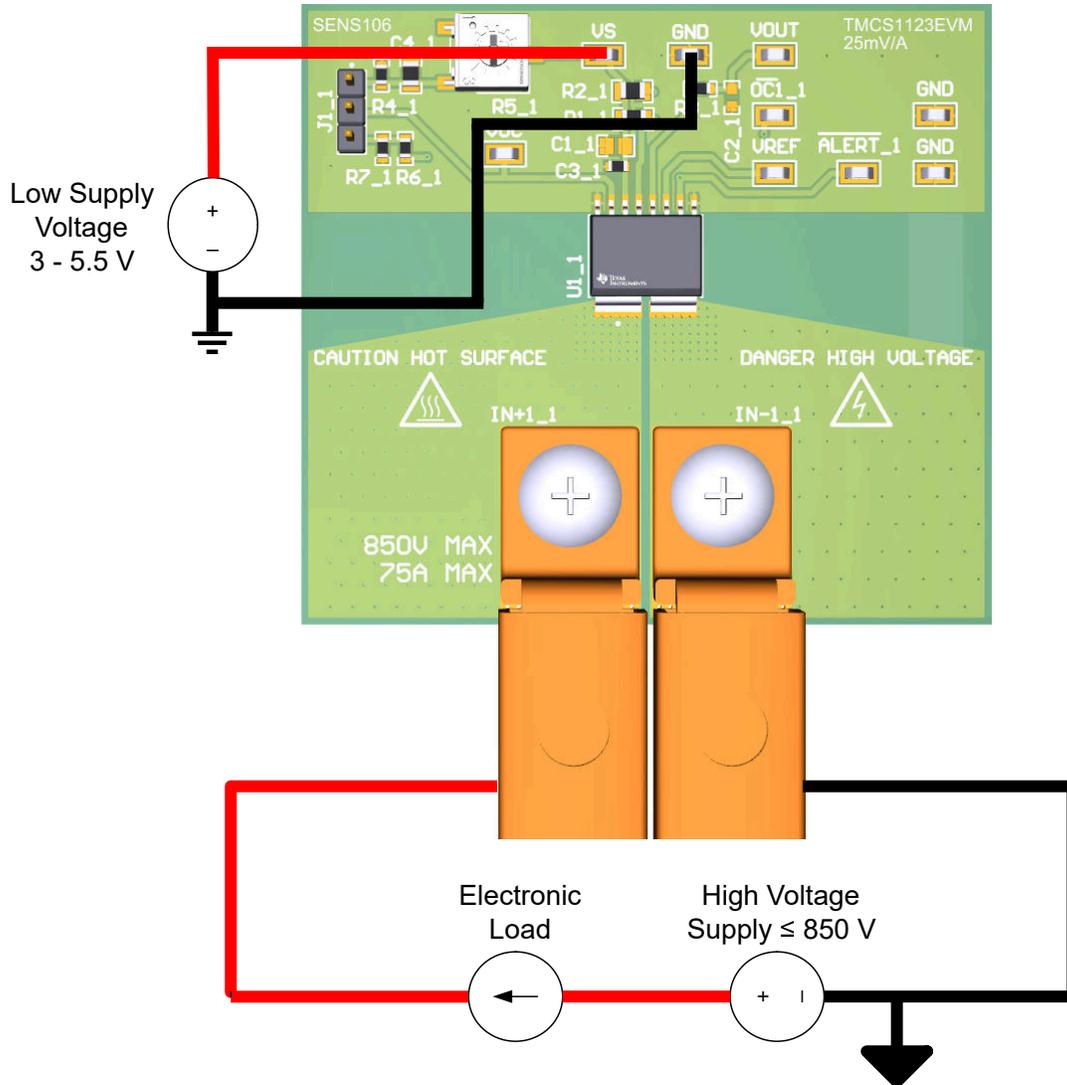


Figure 4-1. Low-Side Forward Current Setup for Reinforced Isolation

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 sensitivity version to be tested.
3. Connect the terminals of an external LV supply to the GND and VCC test points on the EVM sensitivity variant of choice. Be sure to connect GND first and make sure that the external LV supply is between 3 V and 5.5 V.
4. Connect the input per [Section 4.1](#).

WARNING

When measuring current, first make sure that equipment (wires, connectors, and so forth) can support the amperage and power dissipation. Secondly, make sure that current flowing through the inputs of the device is kept within the safe operating area limits of the device found in the [TMCS1123 data sheet](#). Failure to do so can result in damage to the EVM, or personal injury.

Do not touch the HV terminals.

Hot surface. Contact can cause burns. Do not touch!

4.1 Measurements

The following procedures are used to configure a measurement evaluation with an electronic load.

For low-side measurements:

1. Connect the electronic load positive input terminal to the positive terminal of a supply capable of sourcing the desired amount of maximum load current (see [Figure 4-1](#))
2. Connect the electronic load negative output terminal to the load sinking terminal of the EVM
3. 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 or actual system load
6. Measure the output voltage at the VOUT test point

For high-side measurements:

1. 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 supply GND terminal
3. Connect the external supply to the load sinking terminal of the EVM
4. Turn on all the connected supplies
5. Apply load with electronic load or actual system load
6. Measure the output voltage at the VOUT test point

Note

The output voltage is equal to the sensitivity 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 needs to have a kelvin connection where the generated sense voltage can be measured by a precision multimeter, such as the 3458a multimeter. Sensing an external shunt voltage is preferred, as a typical multimeter can have a current limit far below the needed current measurement limits in question. 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 HV-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, then be sure to use a supply with sufficient voltage headroom to accommodate the series resistance of the wires or bus bars, the board planes, and the DUT lead frame resistance. Use a large capacitor bank between the supply terminals to make sure there is an adequate charge reservoir available to prevent the supply from drooping. A large capacitor bank can also help supply the large current inrush through the device.

To assess temperature performance, use wide, thin bus bars to reduce the thermal sinking ability of the system and minimize the inductance of the system. Board temperature are not 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. See [Thermal Implementation Guide for In-Package Magnetic Current Sensors](#) for additional information and for details regarding thermal best practices.

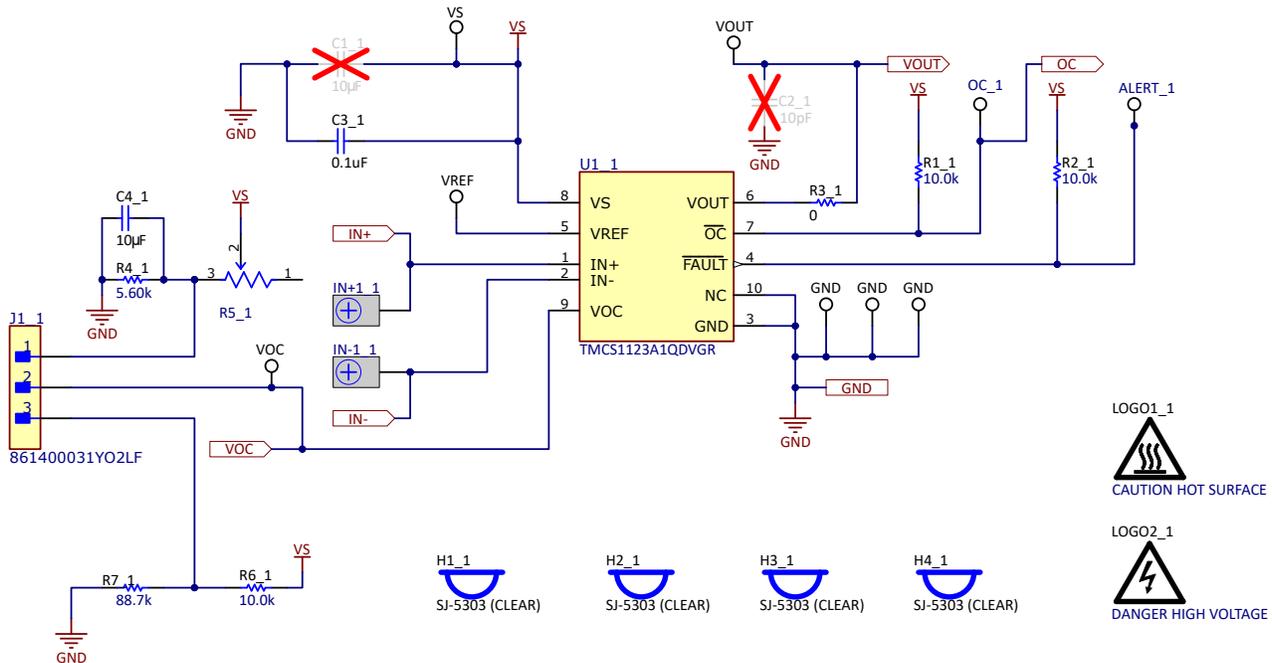
5 Schematics, PCB Layout, and Bill of Materials

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 TMCS1123xEVM PCBs.

5.1 Schematics

Figure 5-1 shows the schematic of the A1 sub board on the TMCS1123AEVM PCB. Only the schematic for the A1 (25 mV/A) sensitivity variant is demonstrated in this document, as all variants use the same circuit and same PCB layout. Only U1 changes from board to board. All components associated with the 25-mV/A sensitivity variants have the nomenclature "_1" appended at the end. The 50-mV/A sensitivity variants have "_2" appended, the 75-mV/A sensitivity variants have "_3" appended, the 100-mV/A sensitivity variants have "_4" appended, and the 150-mV/A sensitivity variants have "_5" appended.



Variant/Label Table

LBL1_1
PCB Label
THT-14-423-10
Size: 0.65" x 0.20 "

Variant	LBL2_1	LBL2_2	LBL2_3	LBL2_4	LBL2_5
001	TMCS1123A1	TMCS1123A2	TMCS1123A3	TMCS1123A4	TMCS1123A5
002	TMCS1123B1	TMCS1123B2	TMCS1123B3	TMCS1123B4	TMCS1123B5
003	TMCS1123C1	TMCS1123C2	TMCS1123C3	TMCS1123C4	TMCS1123C5

Figure 5-1. Schematic for A1 Device

5.2 PCB Layout

Figure 5-2 through Figure 5-5 illustrate the PCB layers of the TMCS1123xEVM.

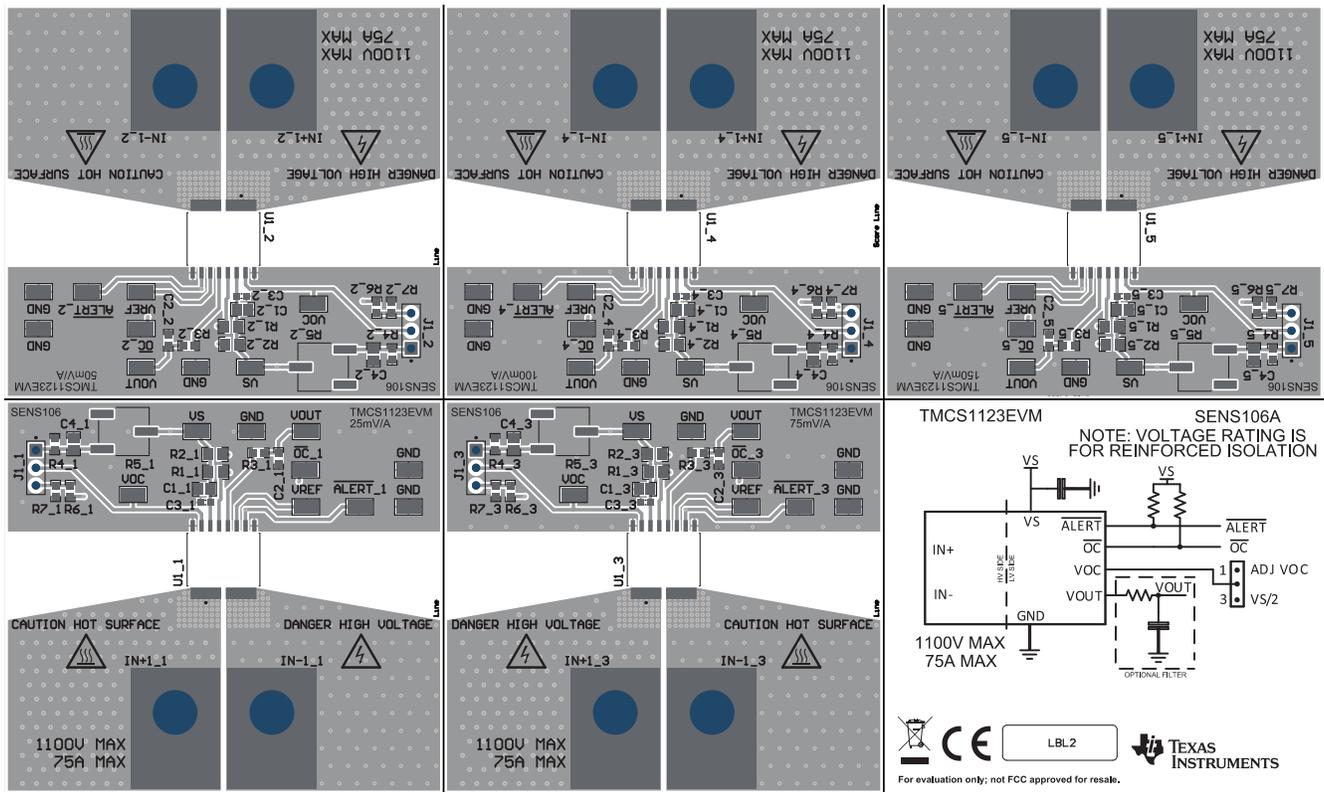


Figure 5-2. Top Overlay

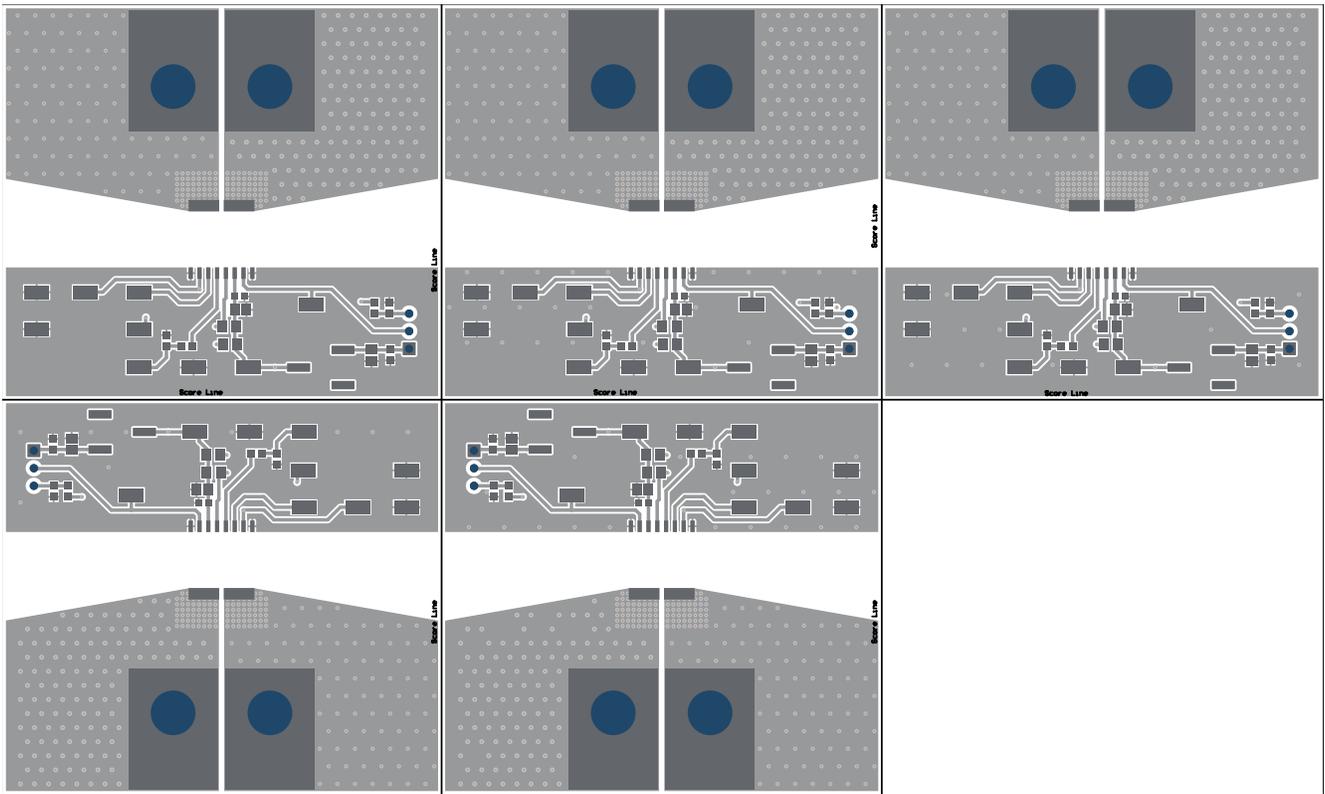


Figure 5-3. Top Layer

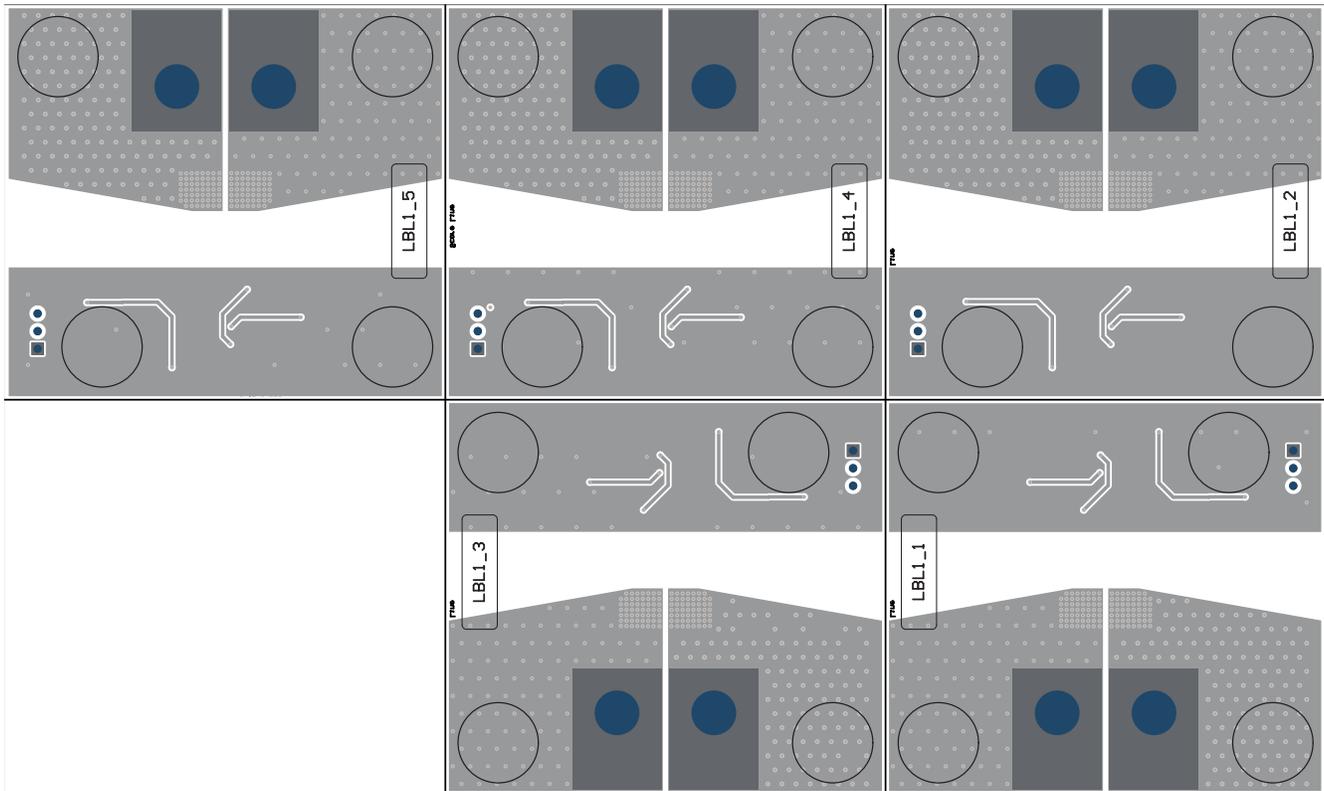


Figure 5-4. Bottom Overlay

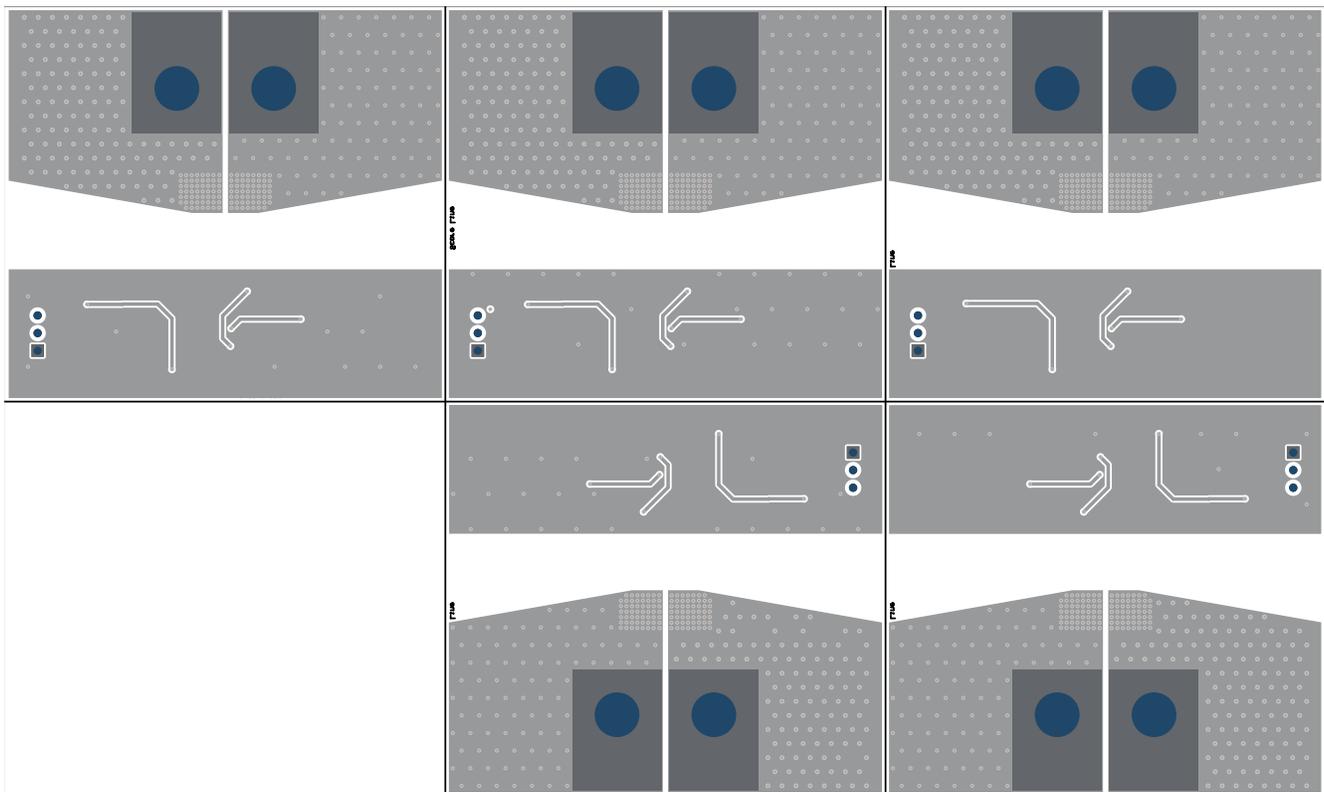


Figure 5-5. Bottom Layer

5.3 Bill of Materials

Table 5-1. Bill of Materials for TMCS1123AEVM

Designator	Quantity	Value	Description	PackageReference	PartNumber	Manufacturer
C3_1, C3_2, C3_3, C3_4, C3_5	5	0.1uF	CAP, CERM, 0.1 uF, 50 V, +/- 10%, X7R, 0603	0603	06035C104KAT2A	AVX
C4_1, C4_2, C4_3, C4_4, C4_5	5	10uF	CAP, CERM, 10 uF, 10 V, +/- 10%, X7R, 0805	0805	C2012X7R1A106K125AC	TDK
ALERT_1, ALERT_2, ALERT_3, ALERT_4, ALERT_5, OC_1, OC_2, OC_3, OC_4, OC_5, TP1_1, TP1_2, TP1_3, TP1_4, TP1_5, TP2_1, TP2_2, TP2_3, TP2_4, TP2_5, TP3_1, TP3_2, TP3_3, TP3_4, TP3_5, TP4_1, TP4_2, TP4_3, TP4_4, TP4_5, TP5_1, TP5_2, TP5_3, TP5_4, TP5_5, TP6_1, TP6_2, TP6_3, TP6_4, TP6_5, TP7_1, TP7_2, TP7_3, TP7_4, TP7_5	45		Test Point, Miniature, SMT	Testpoint_Keystone_Minature	5015	Keystone, Keystone Electronics
H1_1, H1_2, H1_3, H1_4, H1_5, H2_1, H2_2, H2_3, H2_4, H2_5, H3_1, H3_2, H3_3, H3_4, H3_5, H4_1, H4_2, H4_3, H4_4, H4_5	20		Bumpon, Hemisphere, 0.44 X 0.20, Clear	Transparent Bumpon	SJ-5303 (CLEAR)	3M
H5, H6, H7, H8, H9	5		JUMPER W/TEST PNT 1X2PINS 2.54MM		60900213421	Würth Elektronik
IN-1_1, IN+1_1	2		Terminal 90 A Lug	CB70-14-CY	CB70-14-CY	Panduit
J1_1, J1_2, J1_3, J1_4, J1_5	5		Connector Header Through Hole 3 position 0.100" (2.54mm)	HDR3	861400031YO2LF	Amphenol ICC
LBL1, LBL2_1, LBL2_2, LBL2_3, LBL2_4, LBL2_5	6		Thermal Transfer Printable Labels, 0.650" W x 0.200" H - 10,000 per roll	PCB Label 0.650 x 0.200 inch	THT-14-423-10	Brady
MP1, MP2	2		Medium-Strength Steel Hex Nut	NUT_1-4-20	95462A029	McMaster-Carr

Table 5-1. Bill of Materials for TMCS1123AEVM (continued)

Designator	Quantity	Value	Description	PackageReference	PartNumber	Manufacturer
MP3, MP4	2		Passivated 18-8 Stainless Steel Pan Head Socket Head Screw 1/4"-20 Thread Size, 3/8" Long	NPTH_SCREW_M5x0.8 mm	92196A535	McMaster-Carr
R1_1, R1_2, R1_3, R1_4, R1_5, R2_1, R2_2, R2_3, R2_4, R2_5	10	10.0k	RES, 10.0 k, 1%, 0.125 W, AEC-Q200 Grade 0, 0805	0805	CRCW080510K0FKEA	Vishay-Dale
R3_1, R3_2, R3_3, R3_4, R3_5	5	0	RES, 0, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	RMCF0603ZT0R00	Stackpole Electronics Inc
R4_1, R4_2, R4_3, R4_4, R4_5	5	5.60k	RES, 5.60 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	ERJ3EKF5601V	Panasonic
R5_1, R5_2, R5_3, R5_4, R5_5	5	100k	100 kOhms 0.5W, 1/2W Gull Wing Surface Mount Trimmer Potentiometer Cermet 1.0 Turn Top Adjustment	SMT3_6MM71_7MM04	3361P-1-104GLF	Bourns
R6_1, R6_2, R6_3, R6_4, R6_5	5	10.0k	RES, 10.0 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	RMCF0603FT10K0	Stackpole Electronics Inc
R7_1, R7_2, R7_3, R7_4, R7_5	5	87.7k	RES, 88.7 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060388K7FKEA	Vishay-Dale
U1_1	1		TMCS1123A1QDVGR	SOIC10	TMCS1123A1QDVGR	Texas Instruments
U1_2	1		TMCS1123A2QDVGR	SOIC10	TMCS1123A2QDVGR	Texas Instruments
U1_3	1		TMCS1123A3QDVGR	SOIC10	TMCS1123A3QDVGR	Texas Instruments
U1_4	1		TMCS1123A4QDVGR	SOIC10	TMCS1123A4QDVGR	Texas Instruments
U1_5	1		TMCS1123A5QDVGR	SOIC10	TMCS1123A5QDVGR	AVX
C1_1, C1_2, C1_3, C1_4, C1_5	0	10uF	CAP, CERM, 10 uF, 10 V, +/- 10%, X7R, 0805	0805	C2012X7R1A106K125AC	TDK
C2_1, C2_2, C2_3, C2_4, C2_5	0	10 pF	CAP, CERM, 10 pF, 10 V, +/- 10%, X7R, 0603	0603	0603ZC100KAT2A	AVX
IN-1_2, IN-1_3, IN-1_4, IN-1_5, IN+1_2, IN+1_3, IN+1_4, IN+1_5	0		Terminal 90 A Lug	CB70-14-CY	CB70-14-CY	Panduit

Table 5-2. Bill of Materials for TMCS1123BEVM

Designator	Quantity	Value	Description	PackageReference	PartNumber	Manufacturer
C3_1, C3_2, C3_3, C3_4, C3_5	5	0.1uF	CAP, CERM, 0.1 uF, 50 V, +/- 10%, X7R, 0603	0603	06035C104KAT2A	AVX
C4_1, C4_2, C4_3, C4_4, C4_5	5	10uF	CAP, CERM, 10 uF, 10 V, +/- 10%, X7R, 0805	0805	C2012X7R1A106K125AC	TDK
ALERT_1, ALERT_2, ALERT_3, ALERT_4, ALERT_5, OC_1, OC_2, OC_3, OC_4, OC_5, TP1_1, TP1_2, TP1_3, TP1_4, TP1_5, TP2_1, TP2_2, TP2_3, TP2_4, TP2_5, TP3_1, TP3_2, TP3_3, TP3_4, TP3_5, TP4_1, TP4_2, TP4_3, TP4_4, TP4_5, TP5_1, TP5_2, TP5_3, TP5_4, TP5_5, TP6_1, TP6_2, TP6_3, TP6_4, TP6_5, TP7_1, TP7_2, TP7_3, TP7_4, TP7_5	45		Test Point, Miniature, SMT	Testpoint_Keystone_Minature	5015	Keystone, Keystone Electronics
H1_1, H1_2, H1_3, H1_4, H1_5, H2_1, H2_2, H2_3, H2_4, H2_5, H3_1, H3_2, H3_3, H3_4, H3_5, H4_1, H4_2, H4_3, H4_4, H4_5	20		Bumpon, Hemisphere, 0.44 X 0.20, Clear	Transparent Bumpon	SJ-5303 (CLEAR)	3M
H5, H6, H7, H8, H9	5		JUMPER W/TEST PNT 1X2PINS 2.54MM		60900213421	Würth Elektronik
IN-1_1, IN+1_1	2		Terminal 90 A Lug	CB70-14-CY	CB70-14-CY	Panduit
J1_1, J1_2, J1_3, J1_4, J1_5	5		Connector Header Through Hole 3 position 0.100" (2.54mm)	HDR3	861400031YO2LF	Amphenol ICC
LBL1, LBL2_1, LBL2_2, LBL2_3, LBL2_4, LBL2_5	6		Thermal Transfer Printable Labels, 0.650" W x 0.200" H - 10,000 per roll	PCB Label 0.650 x 0.200 inch	THT-14-423-10	Brady
MP1, MP2	2		Medium-Strength Steel Hex Nut	NUT_1-4-20	95462A029	McMaster-Carr
MP3, MP4	2		Medium-Strength Steel Hex NutPassivated 18-8 Stainless Steel Pan Head Socket Head Screw 1/4"-20 Thread Size, 3/8" Long	NPTH_SCREW_M5x0.8 mm	92196A535	McMaster-Carr

Table 5-2. Bill of Materials for TMCS1123BEVM (continued)

Designator	Quantity	Value	Description	PackageReference	PartNumber	Manufacturer
R1_1, R1_2, R1_3, R1_4, R1_5, R2_1, R2_2, R2_3, R2_4, R2_5	10	10.0k	RES, 10.0 k, 1%, 0.125 W, AEC-Q200 Grade 0, 0805	0805	CRCW080510K0FKEA	Vishay-Dale
R3_1, R3_2, R3_3, R3_4, R3_5	5	0	RES, 0, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	RMCF0603ZT0R00	Stackpole Electronics Inc
R4_1, R4_2, R4_3, R4_4, R4_5	5	5.60k	RES, 5.60 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	ERJ3EKF5601V	Panasonic
R5_1, R5_2, R5_3, R5_4, R5_5	5	100k	100 kOhms 0.5W, 1/2W Gull Wing Surface Mount Trimmer Potentiometer Cermet 1.0 Turn Top Adjustment	SMT3_6MM71_7MM04	3361P-1-104GLF	Bourns
R6_1, R6_2, R6_3, R6_4, R6_5	5	10.0k	RES, 10.0 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	RMCF0603FT10K0	Stackpole Electronics Inc
R7_1, R7_2, R7_3, R7_4, R7_5	5	87.7k	RES, 88.7 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060388K7FKEA	Vishay-Dale
U1_1	1		TMCS1123B1QDVGR	SOIC10	TMCS1123B1QDVGR	Texas Instruments
U1_2	1		TMCS1123B2QDVGR	SOIC10	TMCS1123B2QDVGR	Texas Instruments
U1_3	1		TMCS1123B3QDVGR	SOIC10	TMCS1123B3QDVGR	Texas Instruments
U1_4	1		TMCS1123B4QDVGR	SOIC10	TMCS1123B4QDVGR	Texas Instruments
U1_5	1		TMCS1123B5QDVGR	SOIC10	TMCS1123B5QDVGR	AVX
C1_1, C1_2, C1_3, C1_4, C1_5	0	10uF	CAP, CERM, 10 uF, 10 V, +/- 10%, X7R, 0805	0805	C2012X7R1A106K125AC	TDK
C2_1, C2_2, C2_3, C2_4, C2_5	0	10 pF	CAP, CERM, 10 pF, 10 V, +/- 10%, X7R, 0603	0603	0603ZC100KAT2A	AVX
IN-1_2, IN-1_3, IN-1_4, IN-1_5, IN+1_2, IN+1_3, IN+1_4, IN+1_5	0		Terminal 90 A Lug	CB70-14-CY	CB70-14-CY	Panduit

Table 5-3. Bill of Materials for TMCS1123CEVM

Designator	Quantity	Value	Description	PackageReference	PartNumber	Manufacturer
C3_1, C3_2, C3_3, C3_4, C3_5	5	0.1uF	CAP, CERM, 0.1 uF, 50 V, +/- 10%, X7R, 0603	0603	06035C104KAT2A	AVX
C4_1, C4_2, C4_3, C4_4, C4_5	5	10uF	CAP, CERM, 10 uF, 10 V, +/- 10%, X7R, 0805	0805	C2012X7R1A106K125AC	TDK
ALERT_1, ALERT_2, ALERT_3, ALERT_4, ALERT_5, OC_1, OC_2, OC_3, OC_4, OC_5, TP1_1, TP1_2, TP1_3, TP1_4, TP1_5, TP2_1, TP2_2, TP2_3, TP2_4, TP2_5, TP3_1, TP3_2, TP3_3, TP3_4, TP3_5, TP4_1, TP4_2, TP4_3, TP4_4, TP4_5, TP5_1, TP5_2, TP5_3, TP5_4, TP5_5, TP6_1, TP6_2, TP6_3, TP6_4, TP6_5, TP7_1, TP7_2, TP7_3, TP7_4, TP7_5	45		Test Point, Miniature, SMT	Testpoint_Keystone_Minature	5015	Keystone, Keystone Electronics
H1_1, H1_2, H1_3, H1_4, H1_5, H2_1, H2_2, H2_3, H2_4, H2_5, H3_1, H3_2, H3_3, H3_4, H3_5, H4_1, H4_2, H4_3, H4_4, H4_5	20		Bumpon, Hemisphere, 0.44 X 0.20, Clear	Transparent Bumpon	SJ-5303 (CLEAR)	3M
H5, H6, H7, H8, H9	5		JUMPER W/TEST PNT 1X2PINS 2.54MM		60900213421	Würth Elektronik
IN-1_1, IN+1_1	2		Terminal 90 A Lug	CB70-14-CY	CB70-14-CY	Panduit
J1_1, J1_2, J1_3, J1_4, J1_5	5		Connector Header Through Hole 3 position 0.100" (2.54mm)	HDR3	861400031YO2LF	Amphenol ICC
LBL1, LBL2_1, LBL2_2, LBL2_3, LBL2_4, LBL2_5	6		Thermal Transfer Printable Labels, 0.650" W x 0.200" H - 10,000 per roll	PCB Label 0.650 x 0.200 inch	THT-14-423-10	Brady
MP1, MP2	2		Medium-Strength Steel Hex Nut	NUT_1-4-20	95462A029	McMaster-Carr
MP3, MP4	2		Passivated 18-8 Stainless Steel Pan Head Socket Head Screw 1/4"-20 Thread Size, 3/8" Long	NPTH_SCREW_M5x0.8 mm	92196A535	McMaster-Carr

Table 5-3. Bill of Materials for TMCS1123CEVM (continued)

Designator	Quantity	Value	Description	PackageReference	PartNumber	Manufacturer
R1_1, R1_2, R1_3, R1_4, R1_5, R2_1, R2_2, R2_3, R2_4, R2_5	10	10.0k	RES, 10.0 k, 1%, 0.125 W, AEC-Q200 Grade 0, 0805	0805	CRCW080510K0FKEA	Vishay-Dale
R3_1, R3_2, R3_3, R3_4, R3_5	5	0	RES, 0, 1%, 0.1 W, AEC- Q200 Grade 0, 0603	0603	RMCF0603ZT0R00	Stackpole Electronics Inc
R4_1, R4_2, R4_3, R4_4, R4_5	5	5.60k	RES, 5.60 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	ERJ3EKF5601V	Panasonic
R5_1, R5_2, R5_3, R5_4, R5_5	5	100k	100 kOhms 0.5W, 1/2W Gull Wing Surface Mount Trimmer Potentiometer Cermet 1.0 Turn Top Adjustment	SMT3_6MM71_7MM04	3361P-1-104GLF	Bourns
R6_1, R6_2, R6_3, R6_4, R6_5	5	10.0k	RES, 10.0 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	RMCF0603FT10K0	Stackpole Electronics Inc
R7_1, R7_2, R7_3, R7_4, R7_5	5	87.7k	RES, 88.7 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060388K7FKEA	Vishay-Dale
U1_1	1		TMCS1123C1QDVGR	SOIC10	TMCS1123C1QDVGR	Texas Instruments
U1_2	1		TMCS1123C2QDVGR	SOIC10	TMCS1123C2QDVGR	Texas Instruments
U1_3	1		TMCS1123C3QDVGR	SOIC10	TMCS1123C3QDVGR	Texas Instruments
U1_4	1		TMCS1123C4QDVGR	SOIC10	TMCS1123C4QDVGR	Texas Instruments
U1_5	1		TMCS1123C5QDVGR	SOIC10	TMCS1123C5QDVGR	AVX
C1_1, C1_2, C1_3, C1_4, C1_5	0	10uF	CAP, CERM, 10 uF, 10 V, +/- 10%, X7R, 0805	0805	C2012X7R1A106K125AC	TDK
C2_1, C2_2, C2_3, C2_4, C2_5	0	10 pF	CAP, CERM, 10 pF, 10 V, +/- 10%, X7R, 0603	0603	0603ZC100KAT2A	AVX
IN-1_2, IN-1_3, IN-1_4, IN-1_5, IN+1_2, IN+1_3, IN+1_4, IN+1_5	0		Terminal 90 A Lug	CB70-14-CY	CB70-14-CY	Panduit

6 Revision History

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

Changes from Revision A (November 2023) to Revision B (December 2023)	Page
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- Added notice: This EVM comes without the TCMS1123 devices populated. To evaluate, order up to five devices of any gain or version and solder onto the EVM..... 1
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Changes from Revision * (June 2023) to Revision A (November 2023)	Page
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- Changed the *Reference Point* column in *Device Summary* table.....4
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STANDARD TERMS FOR EVALUATION MODULES

1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, and/or documentation which may be provided together or separately (collectively, an "EVM" or "EVMs") to the User ("User") in accordance with the terms set forth herein. User's acceptance of the EVM is expressly subject to the following terms.
 - 1.1 EVMs are intended solely for product or software developers for use in a research and development setting to facilitate feasibility evaluation, experimentation, or scientific analysis of TI semiconductor products. EVMs have no direct function and are not finished products. EVMs shall not be directly or indirectly assembled as a part or subassembly in any finished product. For clarification, any software or software tools provided with the EVM ("Software") shall not be subject to the terms and conditions set forth herein but rather shall be subject to the applicable terms that accompany such Software
 - 1.2 EVMs are not intended for consumer or household use. EVMs may not be sold, sublicensed, leased, rented, loaned, assigned, or otherwise distributed for commercial purposes by Users, in whole or in part, or used in any finished product or production system.
2. *Limited Warranty and Related Remedies/Disclaimers:*
 - 2.1 These terms do not apply to Software. The warranty, if any, for Software is covered in the applicable Software License Agreement.
 - 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 DEGRADATION 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/lstds/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。

<https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-delivered-in-japan.html>

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.

【無線電波を送信する製品の開発キットをお使いになる際の注意事項】 開発キットの中には技術基準適合証明を受けていないものがあります。技術適合証明を受けていないものご使用に際しては、電波法遵守のため、以下のいずれかの措置を取っていただく必要がありますのでご注意ください。

1. 電波法施行規則第6条第1項第1号に基づく平成18年3月28日総務省告示第173号で定められた電波暗室等の試験設備でご使用いただく。
2. 実験局の免許を取得後ご使用いただく。
3. 技術基準適合証明を取得後ご使用いただく。

なお、本製品は、上記の「ご使用にあたっての注意」を譲渡先、移転先に通知しない限り、譲渡、移転できないものとします。

上記を遵守頂けない場合は、電波法の罰則が適用される可能性があることをご留意ください。日本テキサス・イ

ンスツルメンツ株式会社

東京都新宿区西新宿 6 丁目 2 4 番 1 号

西新宿三井ビル

3.3.3 *Notice for EVMs for Power Line Communication:* Please see http://www.tij.co.jp/lstds/ti_ja/general/eStore/notice_02.page

電力線搬送波通信についての開発キットをお使いになる際の注意事項については、次のところをご覧ください。 <https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-for-power-line-communication.html>

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.

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- 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.
 - 4.3.2 EVMs 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 assumes all responsibility and liability for proper and safe handling and use of the EVM by User or its employees, affiliates, contractors or designees. User assumes all responsibility and liability to ensure that any interfaces (electronic and/or mechanical) between the EVM and any human body are designed with suitable isolation and means to safely limit accessible leakage currents to minimize the risk of electrical shock hazard. User assumes all responsibility and liability for any improper or unsafe handling or use of the EVM by User or its employees, affiliates, contractors or designees.
 - 4.4 User assumes all responsibility and liability to determine whether the EVM is subject to any applicable international, federal, state, or local laws and regulations related to User's handling and use of the EVM and, if applicable, User assumes all responsibility and liability for compliance in all respects with such laws and regulations. User assumes all responsibility and liability for proper disposal and recycling of the EVM consistent with all applicable international, federal, state, and local requirements.
 5. *Accuracy of Information:* To the extent TI provides information on the availability and function of EVMs, TI attempts to be as accurate as possible. However, TI does not warrant the accuracy of EVM descriptions, EVM availability or other information on its websites as accurate, complete, reliable, current, or error-free.
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