



## MAX9928 Evaluation Kit

### General Description

The MAX9928 evaluation kit (EV kit) provides a proven design to evaluate the MAX9928 uni-/bidirectional, high-side, current-sense amplifier, which offers precision accuracy specifications of  $V_{OS} < 400\mu V$  and gain error  $< 1.0\%$ . This EV kit demonstrates the MAX9928 in an ultra-small, 1mm x 1.5mm x 0.6mm, 6-bump UCSP™ package. The MAX9928 is also available in an 8-pin  $\mu$ MAX®, but that package is not compatible with this EV kit.

The MAX9928 EV kit PCB comes with a MAX9928FABT+ installed, which is the  $5\mu A/mV$  gain version. The MAX9928 EV kit can also be used to evaluate the MAX9928T, MAX9929F, and MAX9929T ( $2\mu A/mV$ ,  $50V/V$ , and  $20V/V$ , respectively). This EV kit can also evaluate the MAX4372 in a footprint-compatible UCSP package. Contact the factory for free samples of the pin-compatible MAX9928TABT+, MAX9929FABT+, or MAX9929TABT+ devices.

### Features

- ◆ Precision Real-Time Current Monitoring
- ◆ -0.1V to +28V Input Common-Mode Range
- ◆ Evaluates MAX9928, MAX9929, and MAX4372
- ◆  $V_{OS} < 0.4mV$ ; Gain Error  $< 1\%$
- ◆ SIGN Bit to Show Charge/Discharge Current Flow
- ◆ Lead(Pb)-Free and RoHS Compliant
- ◆ Proven PCB Layout
- ◆ Fully Assembled and Tested

### Ordering Information

PART	TYPE
MAX9928EVKIT+	EV Kit

+Denotes lead(Pb)-free and RoHS compliant.

### Component List

DESIGNATION	QTY	DESCRIPTION
CIN, COUT	0	Not installed, capacitors (0603)
C3	1	0.1 $\mu F$ $\pm 10\%$ , 50V X7R ceramic capacitor (0603) Murata GRM188R71H104K
C4	1	1 $\mu F$ $\pm 10\%$ , 50V X5S ceramic capacitor (0603) Taiyo Yuden UMK107C5105KA

DESIGNATION	QTY	DESCRIPTION
RSENSE	1	0.1 $\Omega$ $\pm 1\%$ , 1/2W sensing resistor (1206) Vishay/Dale WSL1206R1000FEB18
RIN1, RIN2	0	Not installed, resistors—short
ROUT	1	10k $\Omega$ $\pm 1\%$ resistor (0603)
U1	1	Precision current-sense amplifier (6 UCSP) Maxim MAX9928FABT+
—	1	PCB: MAX9928 Evaluation Kit+

### Component Suppliers

SUPPLIER	PHONE	WEBSITE
Murata Electronics North America, Inc.	770-436-1300	www.murata-northamerica.com
Taiyo Yuden	800-348-2496	www.t-yuden.com
Vishay	402-563-6866	www.vishay.com

**Note:** Indicate that you are using the MAX9928 when contacting these component suppliers.

UCSP is a trademark and  $\mu$ MAX is a registered trademark of Maxim Integrated Products, Inc.



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For pricing, delivery, and ordering information, please contact Maxim Direct at 1-888-629-4642, or visit Maxim's website at [www.maxim-ic.com](http://www.maxim-ic.com).

Evaluates: MAX9928/MAX9929/MAX4372

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## Quick Start

### Recommended Equipment

Before beginning, the following equipment is needed:

- MAX9928 EV kit
- 5V/10mA DC power supply
- 12V/1A DC power supply
- An electronic load capable of sinking 800mA (e.g., HP 6060B)
- Two digital voltmeters

### Procedure

The MAX9928 EV kit is fully assembled and tested. Follow the steps below to verify board operation.

**Caution: Do not turn on the power supply or the electronic load until all connections are completed.**

- 1) Connect the positive terminal of the 5V supply to the VCC pad. Connect the negative terminal of the 5V supply to the GND pad.
- 2) Connect the positive terminal of the 12V supply to the RS+ pad. Connect the negative terminal of the 12V supply to the GND pad.
- 3) Set the electronic load to sink 500mA.
- 4) Connect the electronic load's positive terminal to the RS- pad and the negative terminal to the GND pad.
- 5) Connect the first voltmeter across the OUT and the GND pads.
- 6) Connect the second voltmeter across the SIGN and the GND pads.
- 7) Turn on the power supplies.
- 8) Turn on the electronic load.
- 9) Verify that the OUT voltmeter reading is approximately 2.5V and the SIGN voltmeter is approximately 5V. Take care not to load the internal 1M $\Omega$  pullup resistor on the SIGN pin when measuring this voltage.

## Detailed Description of Hardware

The MAX9928 evaluation kit (EV kit) provides a proven design to evaluate the MAX9928 uni-/bidirectional, high-side, current-sense amplifier, which offers precision accuracy specifications of  $V_{OS} < 400\mu\text{V}$  and gain error  $< 1.0\%$ .

### Output Voltage Calculation

The MAX9928 EV kit is installed with a MAX9928FABT+, which has a gain of 5 $\mu\text{A}/\text{mV}$ . The current-sense resistor ( $R_{SENSE}$ ) value is 0.1 $\Omega$  with  $\pm 1\%$  tolerance. The  $V_{OUT}$  is given by:

$$V_{OUT} = I_{LOAD} \times R_{SENSE} \times G_m \times R_{OUT}$$

where  $G_m$  is the gain and  $I_{LOAD}$  is the current load applied to the device. Vary  $R_{OUT}$  to change the effective voltage gain.

### Applying VCC and VRS+ Supply Voltages

The normal operating range for  $V_{CC}$  is 2.5V to 5.5V for MAX9928/MAX9929. The normal operating range for  $V_{CC}$  is 2.7V to 28V for MAX4372.

The normal input common-mode range at  $V_{RS+}$  and  $V_{RS-}$  is -0.1V to +28V for MAX9928/MAX9929. The MAX4372 operates with an input range of 0V to 28V, but the total OUT error at 0V can be up to 28%.

### Measuring the Load Current

The load current is measured as a voltage drop ( $V_{SENSE}$ ) across an external sense resistor. This voltage is then amplified by the current-sense amplifier and presented as a current at its output pin and converted to a voltage by  $R_{OUT}$ . Like all differential amplifiers, the output voltage has two components of error: an offset error and a gain error. The offset error affects accuracy at small  $V_{SENSE}$  and a gain error affects accuracy at large  $V_{SENSE}$ . By minimizing both offset and gain errors, accuracy can be optimized over a wide dynamic range.

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## Evaluating SIGN Output for MAX9928/MAX9929

The MAX9928 and MAX9929 have a digital SIGN output to indicate the direction of the load current flow (charge vs. discharge current for a battery).

To evaluate current flowing in the opposite direction, swap the position of the 12V supply and the electronic load (connect the 12V supply to RS- and connect the electronic load to RS+). Verify that the OUT voltmeter still reads approximately 2.5V and the SIGN voltmeter has changed to 0V.

## Evaluating MAX9929 or MAX4372

The MAX9929 and MAX4372 are voltage output devices with an internal  $10k\Omega$   $R_{OUT}$  resistor. When evaluating these devices, leave the MAX9928 EV kit  $R_{OUT}$  open.

Refer to the MAX9928/MAX9929 IC data sheet and/or the MAX4372 IC data sheet for more information.

Evaluates: MAX9928/MAX9929/MAX4372

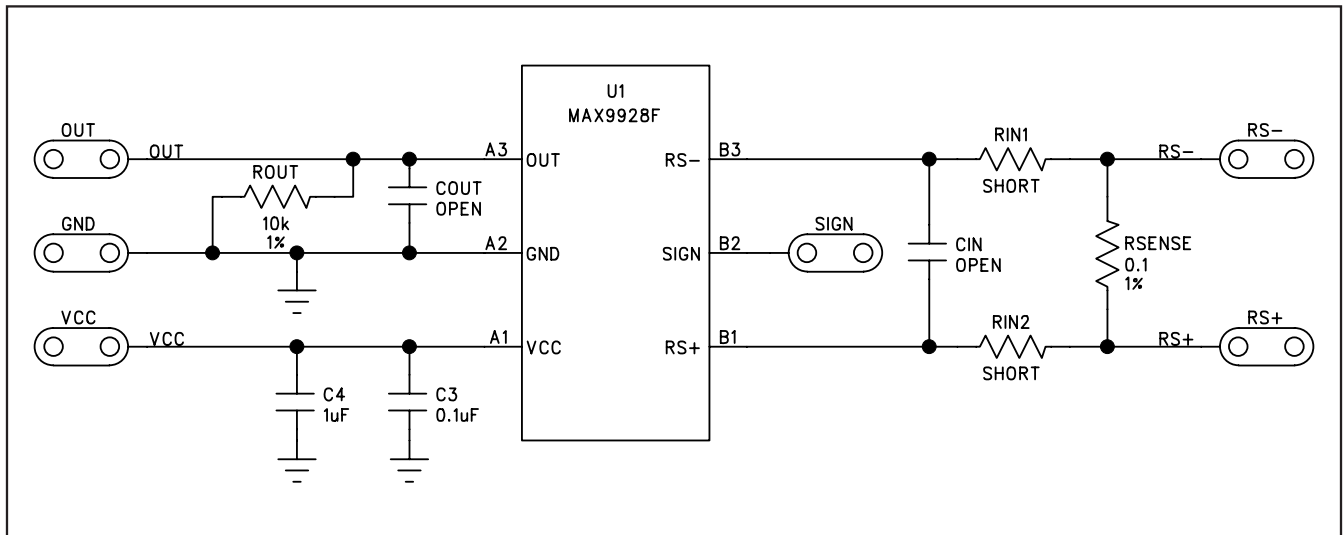


Figure 1. MAX9928F EV Kit Schematic

# MAX9928 Evaluation Kit

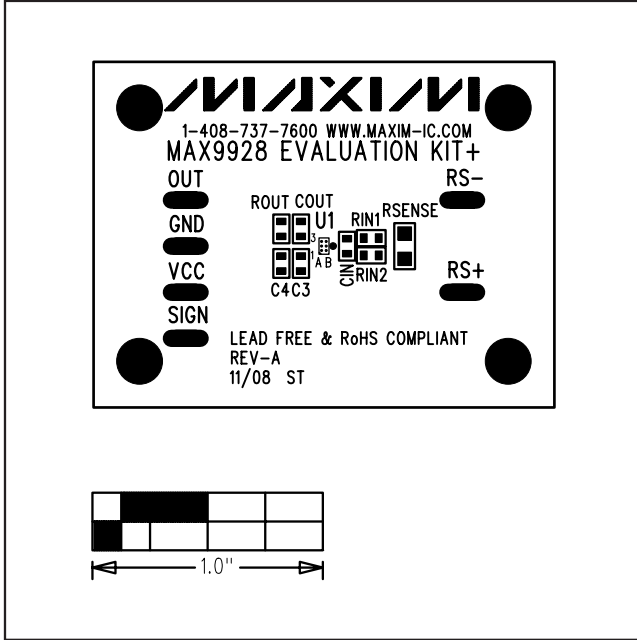


Figure 2. MAX9928 EV Kit Component Placement Guide—Component Side

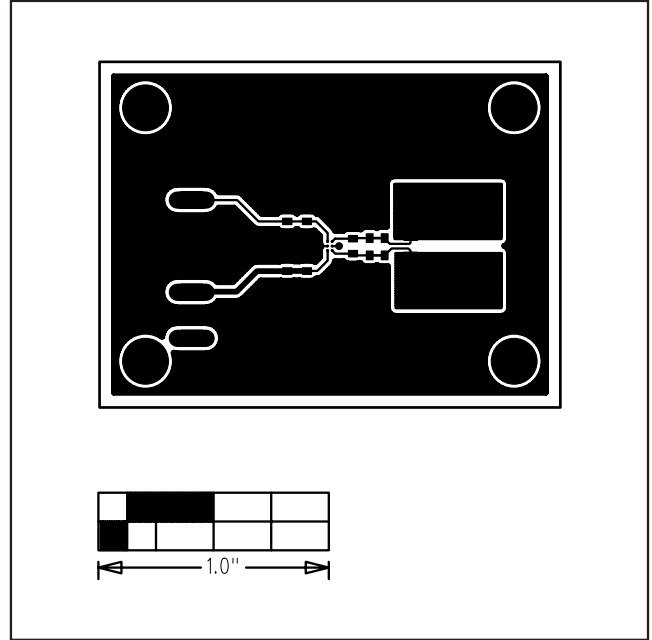


Figure 3. MAX9928 EV Kit PCB Layout—Component Side

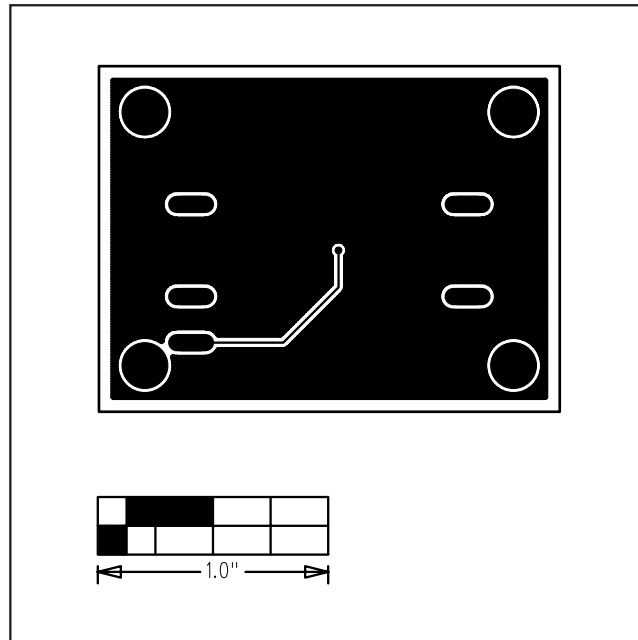


Figure 4. MAX9928 EV Kit PCB Layout—Solder Side

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