



# MAX13487E Evaluation Kit

## General Description

The MAX13487E evaluation kit (EV kit) is a fully assembled and tested PCB that contains a half-duplex RS-485/RS-422 AutoDirection-controlled transceiver with ESD protection. The EV kit circuit features a differential driver and receiver. The circuit's receiver is a 1/4-unit load for the RS-485 bus and can communicate up to 500kbps. The MAX13487E AutoDirection and reduced-driver slew-rate features are demonstrated on the EV kit circuit. The EV kit can also be used to evaluate the MAX13488E IC, which can communicate up to 16Mbps.

Power for the transceiver circuit is provided by a MAX256 H-bridge DC/DC converter, which powers the isolated section of the MAX13487E RS-485/RS-422 circuit. Input-ripple current and radiated noise are minimized by using an H-bridge design. The isolated H-bridge DC-DC converter operates at 420kHz. Input power to the EV kit circuit can be supplied by a +5V DC source.

The DC-DC converter circuit uses a surface-mount transformer to provide galvanic isolation and a full-wave rectifier, and provides a regulated +5V to the MAX13487E. A MAX1659 linear low dropout (LDO) regulator provides the regulated output and up to 300mA of current. The output current limit and thermal shutdown provide for a robust isolated RS-485/RS-422 transceiver circuit and power supply. The transceiver and power circuits and PCB are designed for 2500V<sub>RMS</sub> isolation.

## Features

- ◆ Demonstrates MAX13487E AutoDirection Feature
- ◆ Designed for 2500V<sub>RMS</sub> Isolation
- ◆ 1/4 RS-485 Unit Loading
- ◆ 500kbps Half-Duplex RS-485/RS-422 Communication
- ◆ +5V DC Input Range
- ◆ Isolated +5V Output
- ◆ Center-Tapped Full-Wave Rectifier Output
- ◆ 420kHz Switching Frequency
- ◆ Output Current Limit and Thermal Shutdown
- ◆ Low-Cost Integrated-FET H-Bridge Design
- ◆ Also Evaluates MAX13488E (After IC Replacement)
- ◆ Fully Assembled and Tested

## Ordering Information

PART	TYPE
MAX13487EEVKIT#	EV Kit

#Denotes RoHS compliant.

## Component List

DESIGNATION	QTY	DESCRIPTION
C1	1	10 $\mu$ F $\pm$ 10%, 10V X7R ceramic capacitor (1206) Murata GRM31CR71A106K
C2	1	0.47 $\mu$ F $\pm$ 10%, 16V X7R ceramic capacitor (0805) Murata GRM219R71C474K
C3, C5, C6, C7	4	0.1 $\mu$ F $\pm$ 10%, 16V X7R ceramic capacitors (0603) Murata GRM188R71C104K
C4	1	1 $\mu$ F $\pm$ 10%, 16V X7R ceramic capacitor (0805) Murata GRM21BR71C105K
D1, D2	2	30V, 1A Schottky diodes (SOD123) Diodes Inc. B130LAW
D3	1	15V, 350mW $\pm$ 5% zener diode (SOT-23) Central Semiconductor CMPZ5245B+

DESIGNATION	QTY	DESCRIPTION
JU1, JU3, JU4, JU5, JU6	5	2-pin headers
JU2	1	3-pin header
R1	1	39.2k $\Omega$ $\pm$ 1% resistor (0603)
R2, R9	2	100k $\Omega$ $\pm$ 5% resistors (0603)
R4, R5	2	270 $\Omega$ $\pm$ 5% resistors (0805)
R6, R8	2	220 $\Omega$ $\pm$ 5% resistors (0805)
R7	1	120 $\Omega$ $\pm$ 5% resistor (0805)
T1	1	500 $\mu$ H, 1.5W, 3:8-turn, 400kHz transformer (6-pin Gull Wing) HALO Electronics TGM-380NARL
U1	1	Half-duplex, high-speed transceiver (8 SO) Maxim MAX13487EESA+



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## Component List (continued)

DESIGNATION	QTY	DESCRIPTION
U2	1	Integrated primary-side controller and H-bridge driver (8 SO-EP*) Maxim MAX256ASA+
U3	1	Linear regulator (8 SO) Maxim MAX1659ESA+
U4, U5	2	15Mbps CMOS photocouplers (5 SO) CEL/NEC PS9151-A
—	6	Shunts (JU1–JU6)
—	4	Rubber bumpers
—	1	PCB: MAX13487E Evaluation Kit#

\*EP = Exposed pad.

## Quick Start

### Required Equipment

Before beginning, the following equipment is needed:

- One +5V 550mA current-limited power supply with a built-in current meter
- One voltmeter
- One logic signal generator
- One oscilloscope with a differential probe

### Procedure

The MAX13487E EV kit is fully assembled and tested. Follow the steps below to verify board operation.

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

- 1) Connect a voltmeter to the VOUT and GND PC pads.
- 2) Verify that a shunt is not installed across the pins of jumper JU1 (U2 enabled).
- 3) Verify that a shunt is installed across pins 1-2 of jumper JU2 (U1 enabled).
- 4) Verify that a shunt is installed across the pins of jumpers JU3 (AutoDirection enabled), JU4 (pull-down), JU6 (pullup), and JU5 (bus terminated).
- 5) Connect the +5V power supply to the VIN pad. Connect the power supply's ground to the PGND pad.
- 6) Turn on the power supply and verify that the voltmeter at VOUT reads +5V.
- 7) Using the logic signal generator, apply a +5V logic signal to the TXD PCB pad and PGND.
- 8) Using the oscilloscope and differential probes, verify the signal at the A-B pads (isolated side).

## Component Suppliers

SUPPLIER	PHONE	WEBSITE
CEL/NEC (California Eastern Laboratories/NEC)	408-588-2247	www.cel.com
Central Semiconductor Corp.	631-435-1110	www.centalsemi.com
Diodes, Inc.	805-446-4800	www.diodes.com
HALO Electronics, Inc.	650-903-3800	www.haloellectronics.com
Murata Electronics North America, Inc.	770-436-1300	www.murata-northamerica.com

**Note:** Indicate that you are using the MAX13487E or MAX13488E when contacting these component suppliers.

**Note:** The +5V supply powering the MAX13487E EV kit must be current-limited at 550mA and the output load current for the output should be limited to less than 300mA.

## Detailed Description of Hardware

The EV kit features a MAX13487E IC in an 8-pin SO surface-mount package and demonstrates the ESD-protected MAX13487E RS-485/RS-422 AutoDirection transceiver. The differential driver and receiver are configured for half-duplex operation and communicate up to 500kbps. The transceiver circuit is a 1/4-unit load on the receiver's bus.

The EV kit features PCB pads to ease interfacing with the driver/receiver logic signals on the non-isolated side using the TXD, RXD, and PGND pads, respectively. The MAX13487E IC is powered from the isolated VOUT supply. Photocoupler U4 provides isolation for the receiver's RO signal (RXD pad) and U5 provides isolation for the data-in DI signal (TXD pad).

The EV kit demonstrates the MAX13487E slew-rate limited driver, which minimizes EMI radiation. Photocouplers U4 and U5 are rated for up to 15Mbps.

The MAX13487E receiver signal is provided at the RO pin. The RO pin will give a logic-high if A-B > +200mV. A logic-low is given if A-B < -200mV. Refer to the *Transmitting and Receiving* sections in the *Function Tables* in the MAX13487E/MAX13488E IC data sheet for additional information on the AutoDirection circuitry operation. Also see the *AutoDirection and Receiver Enable Selection* section in this document for configuring the AutoDirection and receiver operation.

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The EV kit input power is typically a +5V DC source that provides at least 450mA of current to the MAX256 integrated primary-side controller and H-bridge driver circuit. The MAX256 contains an on-board oscillator, protection circuitry, and internal H-bridge FETs to provide power to the primary of the transformer T1. The MAX256 prevents cross conduction of the H-bridge MOSFETs by implementing break-before-make switching. The MAX256 programmable oscillator is programmed to 420kHz by resistor R1. The switching-frequency duty cycle is fixed at 50% to control energy transfer to transformer T1 isolated output.

The MAX256 IC includes UVLO for controlled startup and provides controlled turn-on during power-up and during brownouts. If the input voltage at VIN falls below 1.9V (typ), the MAX256 IC will shut down.

Surface-mount transformer T1 provides galvanic isolation and the VOUT output is powered from a center-tapped full-wave rectifier circuit (D1 or D2) to reduce output-voltage ripple. It feeds a MAX1659 LDO regulator configured for +5V output. The LDO output is current limited and features thermal shutdown to provide for a robust isolated supply at VOUT, which can provide up to 300mA of current.

The two-layer PCB is designed for 2500VRMS isolation, with 300 mils spacing between the PGND and GND planes. The bottom PCB PGND plane under U2 is utilized as a thermal heat sink for power dissipation of the

MAX256 thermally enhanced SO package. Test points TP1 (PGND) and TP2 (GND) are provided on the PCB for probing the respective ground plane or to connect the PGND to GND planes for nonisolated evaluation of the circuit.

## Jumper Selection

The MAX13487E EV kit features several jumpers to reconfigure the receiver/driver enable circuits, and shutdown for the MAX256 and MAX13487E ICs. Additionally, PCB pads are provided for connecting an external load to the isolated +5V output at VOUT and GND.

## Shutdown Control

The MAX13487E EV kit features two jumpers that configure the shutdown mode of the circuit. Jumper JU1 configures the MAX256 DC-DC converter and JU2 configures the MAX13487E IC for shutdown mode. See Table 1 for placing the EV kit circuit or the desired IC in shutdown mode.

## AutoDirection and Receiver Enable Selection

The MAX13487E EV kit features a 2-pin jumper (JU3) to set the MAX13487E receiver mode of operation, AutoDirection, or receiver output enabled. Refer to the *AutoDirection Circuitry* section in the MAX13487E/MAX13488E IC data sheet for more information on the MAX13487E  $\overline{\text{RE}}$  pin modes of operation. See Table 2 for configuring the receiver mode of operation using jumper JU3.

**Table 1. JU1 and JU2 Shutdown Mode Control**

JU1 SHUNT POSITION	MAX256 MODE PIN	JU2 SHUNT POSITION	MAX13487E $\overline{\text{SHDN}}$ PIN	EV KIT OPERATION MODE
Not installed	Connected to VIN through R2	1-2	Connected to VOUT	All ICs operational
Installed	Connected to PGND	2-3	Connected to GND	Shutdown
Not installed	Connected to VIN through R2	2-3	Connected to GND	MAX13487E shutdown, all other ICs operational

**Table 2. Driver and Receiver JU3 Functions**

SHUNT POSITION	$\overline{\text{RE}}$ PIN	MAX13487E AUTODIRECTION OR RECEIVER MODE
Installed	Connected to VOUT	AutoDirection enabled*
Not installed	Connected to GND through R9	Receiver RO output enabled

\*To avoid bus contention, ensure that only one driver has control of the bus at a time.

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## RS-485 Bus Pullup/Pulldown and Termination Resistors Configuration

Jumpers JU6 and JU4 are provided for connecting the mandatory pullup and pulldown resistors onto the RS-485 bus A and B lines, respectively. Pullup resistor R8 and pulldown resistor R6 define the voltage on the A and B lines in conjunction with R7 when the driver input (DI) is high. See Table 3 for configuring the pullup and pulldown resistors. R6 and R8 can be higher valued if the differential terminal resistor (R7) is not used.

Jumper JU5 is provided for terminating the A and B bus lines when the MAX13487E EV kit is connected at the end of an RS-485 bus. Resistor R7 provides 120Ω of termination when jumper JU5 is used. See Table 4 for configuring the termination mode.

**Table 3. JU6, JU4 Functions, Pullup, Pulldown Resistors**

SHUNT POSITION	A AND B LINE SIGNAL
None	Not pulled up or down
Installed	A signal pulled up, connected to VOUT B signal pulled down to GND

**Table 4. JU5 Functions, Bus Termination**

SHUNT POSITION	A-B PINS AND RS-485 BUS TERMINATION	EV KIT BUS CONNECTION
None	Not terminated	Mid point
Installed	Terminated	End of bus line

## Evaluating the MAX13488E IC and Other Transformer Configurations/Designs

### MAX13488E Evaluation

The MAX13487E EV kit can also evaluate the MAX13488E IC. To evaluate the MAX13488E, replace IC U1 with the MAX13488E. Note that the MAX13488E driver slew rate is not limited and allows transmission speeds of up to 16Mbps. Refer to the MAX13487E/MAX13488E IC data sheet for additional information.

## Smaller Transformer and 2000VRMS Isolation Design

The EV kit's two-layer PCB is designed for 2500VRMS isolation, with 300 mils spacing between the PGND and GND planes. Additionally, transformer T1 is rated for 3000VRMS and is an integral part of the dielectric withstand voltage of the EV kit circuit. Photocouplers U4 and U5 are guaranteed to withstand 3750VRMS. However, the circuit uses the isolated transformer to transfer power from the primary side to the secondary side and the withstand voltage of the transformer, as well as photocouplers U4 and U5, so the PCB must be considered when designing and testing the EV kit circuit. For example, if less than 2500VRMS isolation is needed, a smaller 2000VRMS transformer may be used to save board area, but then the entire circuit will have only 2000VRMS of isolation.

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Evaluates: MAX13487E/MAX13488E

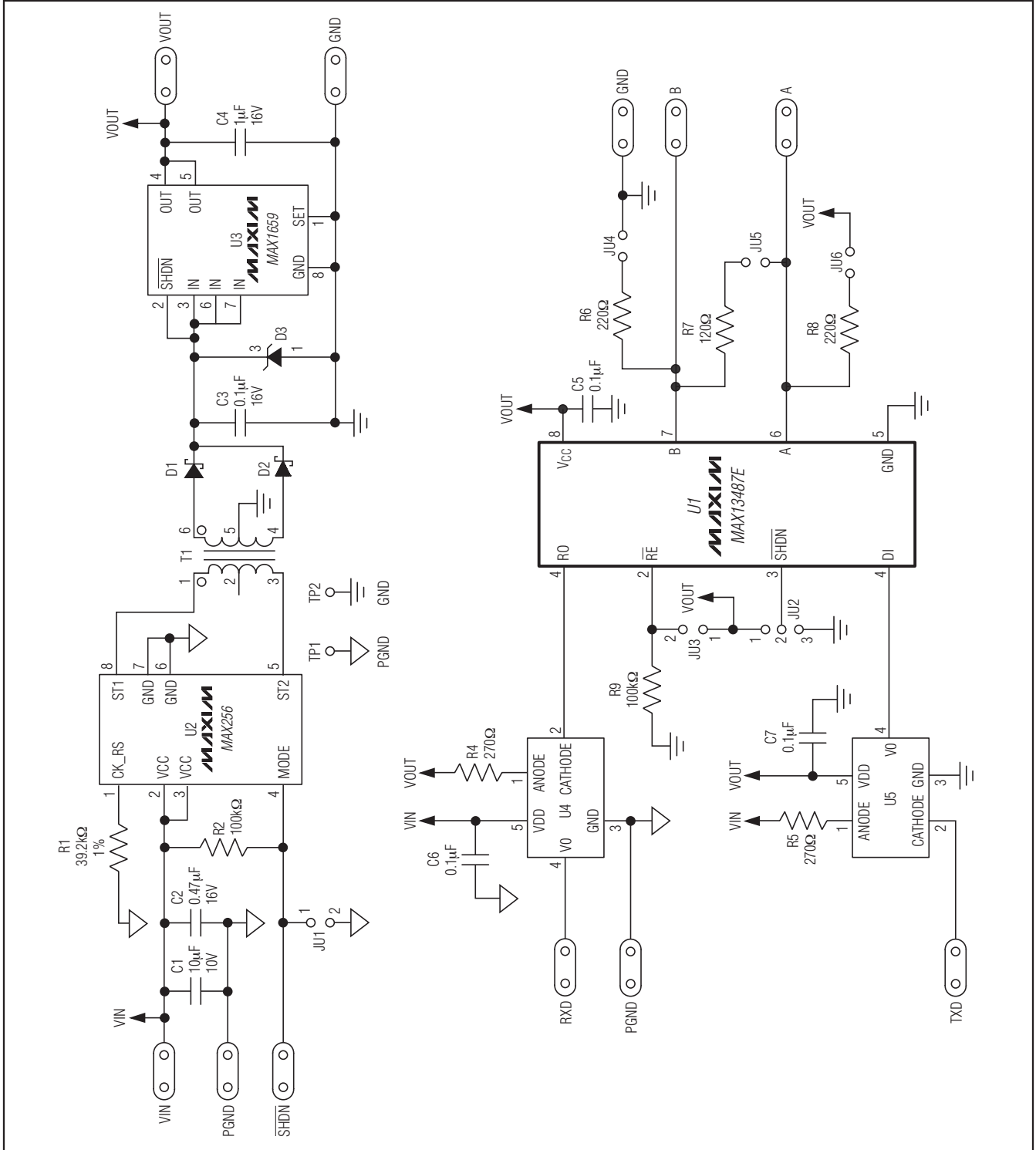


Figure 1. MAX13487E EV Kit Schematic

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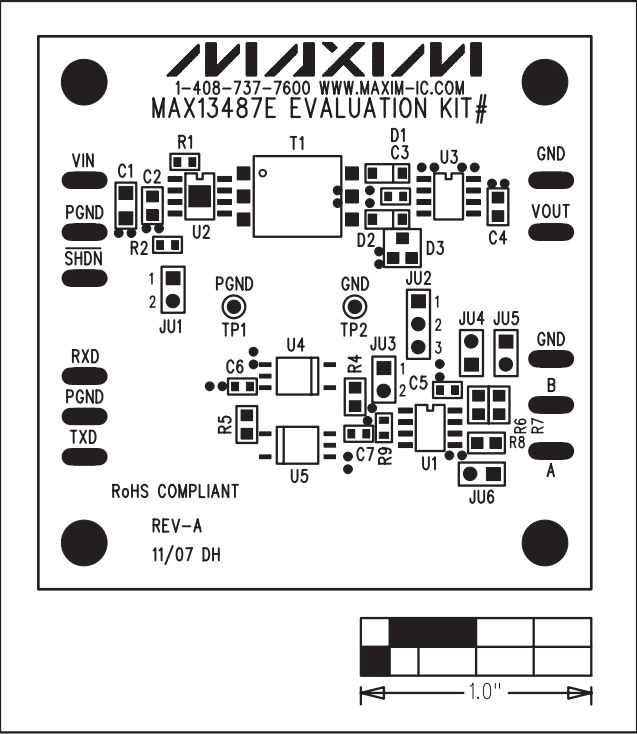


Figure 2. MAX13487E EV Kit Component Placement Guide—Component Side

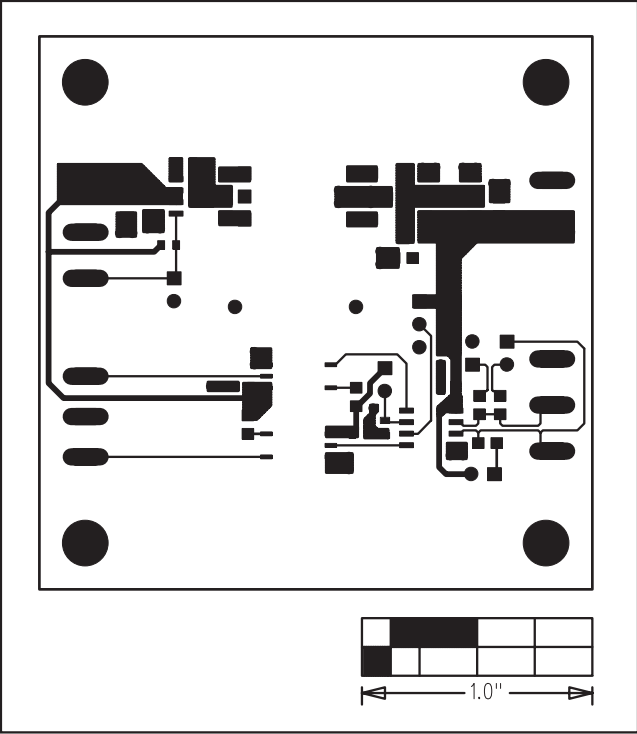


Figure 3. MAX13487E EV Kit PCB Layout—Component Side

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Evaluates: MAX13487E/MAX13488E

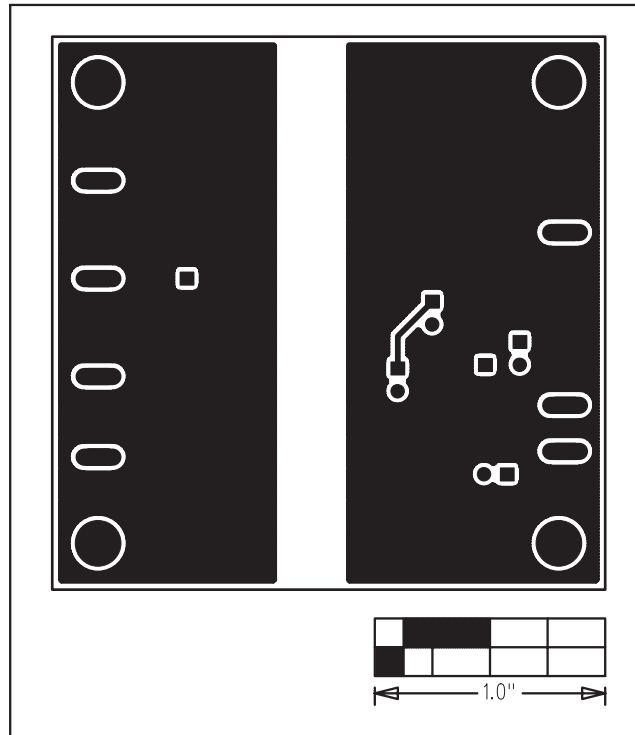


Figure 4. MAX13487E EV Kit PCB Layout—Solder Side

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## Revision History

REVISION NUMBER	REVISION DATE	DESCRIPTION	PAGES CHANGED
0	1/08	Initial release	—
1	11/08	Revised data sheet in several places with changes to resistors R6 and R8.	1, 2, 4, 5

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