

# MAX5969A Evaluation Kit

## Evaluates: MAX5969A/MAX5974A

### General Description

The MAX5969A evaluation kit (EV kit) is a fully assembled and tested surface-mount circuit board featuring the MAX5969A IEEE 802.3af/at-compliant network powered device (PD) interface controller and the MAX5974A inductive-feedback, spread-spectrum, current-mode PWM controller. The EV kit is designed as a high-performance, compact, and cost-efficient solution for a Class 3 (scalable to Class 4) PD used in Power-over-Ethernet (PoE) applications.

The EV kit demonstrates the full functionality of the MAX5969A, such as PD detection signature, PD classification signature, inrush current control, and input undervoltage lockout (UVLO). The EV kit also features an isolated 12W, 300kHz switching-frequency, synchronous-rectified flyback DC-DC converter topology, using the MAX5974A inductive-feedback, current-mode PWM controller. The EV kit circuit is configured for an output voltage of +12V and provides up to 1A load current using primary-side regulation. The surface-mount transformer provides up to +1500V galvanic isolation for the output.

The EV kit receives power from IEEE® 802.3af/at-compliant power-sourcing equipment (PSE). The PSE provides the required -36V to -57V DC power over an unshielded twisted-pair Ethernet network cable to the EV kit's RJ45 magnetic jack. The EV kit features a 1 x 1Gb Ethernet RJ45 magnetic jack and two full-bridge diodes for separating the DC power provided by an endspan or midspan Ethernet system.

The EV kit circuit can also be powered by a +36V to +57V wall adapter power source, applied at the WAD\_IN and WAD\_GND PCB pads. When a wall adapter power source is detected, it always takes precedence over the PSE source, allowing the wall adapter to power the EV kit.

**Warning:** The EV kit is designed to operate with high voltages. Dangerous voltages are present on this EV kit and on equipment connected to it. Users who power up this EV kit or the power sources connected to it must be careful to follow safety procedures appropriately to work with high-voltage electrical equipment.

Under severe fault or failure conditions, this EV kit may dissipate large amounts of power, which could result in the mechanical ejection of a component or of component debris at high velocity. Operate this kit with care to avoid possible personal injury.

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### Features

- ◆ IEEE 802.3af/at-Compliant PD Interface Circuit
- ◆ -36V to -57V Startup Input Voltage Range
- ◆ 92% (typ) Efficiency
- ◆ Demonstrates Isolated 12W Flyback DC-DC Converter
- ◆ Isolated +12V Output at 1A
- ◆ 300kHz Switching Frequency
- ◆ Configurable for Optocoupler Feedback Operation
- ◆ Scalable to 12V Class 4 PD
- ◆ PD Detection and Configurable Classification Signatures
- ◆ 2-Event Classification or Wall Adapter Detect Output
- ◆ Inrush Current Limit of 135mA (typ)
- ◆ Internal UVLO at -35.6V (typ)
- ◆ Evaluates Endspan and Midspan Ethernet Systems
- ◆ Simplified Wall Adapter Interface
- ◆ Proven PCB Layout
- ◆ Fully Assembled and Tested

*[Ordering Information](#) appears at end of data sheet.*

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### Component List

DESIGNATION	QTY	DESCRIPTION
C1, C21	0	Not installed, ceramic capacitors (0805)
C2, C18	2	0.1 $\mu$ F $\pm$ 10%, 100V X7R ceramic capacitors (0805) TDK C2012X7R2A104K
C3	1	0.022 $\mu$ F $\pm$ 10%, 25V X7R ceramic capacitor (0603) Murata GRM188R71E223K
C4	1	10 $\mu$ F $\pm$ 10%, 25V X7R ceramic capacitor (1206) Taiyo Yuden TMK316B7106K
C5	1	10pF $\pm$ 5%, 50V C0G ceramic capacitor (0603) Murata GRM1885C1H100J
C6, C13, C30	3	1 $\mu$ F $\pm$ 10%, 100V X7R ceramic capacitors (1206) TDK C3216X7R2A105K
C7	1	22 $\mu$ F $\pm$ 20%, 63V electrolytic capacitor (6.6mm x 6.6mm) Panasonic EEEFK1J220XP
C8	1	1000pF $\pm$ 10%, 1500V X7R ceramic capacitor (1808) AVX 1808SC102KAT1A
C9	1	330pF $\pm$ 5%, 50V C0G ceramic capacitor (0603) Murata GRM1885C1H331J
C10	1	47 $\mu$ F $\pm$ 10%, 16V X5R ceramic capacitor (1210) Murata GRM32ER61C476K
C11	1	10 $\mu$ F $\pm$ 10%, 16V X5R ceramic capacitor (1206) Murata GRM31CR61C106KC31K
C12, C17	2	0.1 $\mu$ F $\pm$ 10%, 50V X7R ceramic capacitors (0603) Murata GRM188R71H104K
C14	1	0.01 $\mu$ F $\pm$ 10%, 25V X7R ceramic capacitor (0603) Murata GRM188R71E103K
C15	1	0.047 $\mu$ F, 16V X7R ceramic capacitor (0402) Murata GRM155R71E473K
C16	1	100pF, 50V X7R ceramic capacitor (0402) Murata GRM1555C1H101J

DESIGNATION	QTY	DESCRIPTION
C19	1	1000pF, 50V X7R ceramic capacitor (0402) Murata GRM155R71H102K
C20, C22	2	2200pF, 100V X5R ceramic capacitors (0603) Murata GRM188R72A222K
C23	1	2200pF $\pm$ 20%, 250V AC X7R ceramic capacitor (2220) Murata GA355QR7GF222KW0IL
C24–C29	0	Not installed, ceramic capacitors (0603)
C31	0	Not installed, ceramic capacitor (1210)
D1, D2	2	100V, 0.8A bridge rectifiers (miniDIP) Diodes Inc. HD01-T
D3	1	58V transient-voltage suppressor (SMB) Diodes Inc. SMBJ58A-13-F (Top Mark: NG)
D4	1	100V, 2A Schottky diode (SMB) Diodes Inc. ES2B-13-F
D5	0	Not installed, zener diode (SOT23)
D6	1	58V transient-voltage suppressor (SMA) Diodes Inc. SMAJ58A-13-F
D7	1	100V, 1A rectifier (SMA) Diodes Inc. S1B-13-F
D8	1	60V, 500mA Schottky diode (SOD123) STMicroelectronics STPS0560
D9	0	Not installed, Schottky diode (SOD123)
D10	1	100mA, 80V switching diode (SOD323) Diodes Inc. 1N4148WS
J1	1	Modular, side-entry, 8-position jack assembly
L1	1	80V, 2A common-mode choke TDK ZJYS81R5-2P24 or Sumida CPFC74NP-4251-T11
L2	1	3.3 $\mu$ H, 2.6A inductor Cooper Bussmann SD53-3R3-R

# MAX5969A Evaluation Kit

## Evaluates: MAX5969A/MAX5974A

### Component List (continued)

DESIGNATION	QTY	DESCRIPTION
L3	1	50V, 2A common-mode choke TDK ZJYS51R5-2P-01 or Sumida CPFC74NP-PS02H2A20
N1	1	150V, 4.1A n-channel transistor (8 SO) Fairchild FDS86242
N2	1	60V, 2.7A n-channel MOSFET (3 SOT23) International Rectifier IRLML0060TRPbF
N3	0	Not installed, MOSFET (3 SOT23)
Q2	1	30V, 100mA pnp transistor (SOT23) Central Semi CMPT3906 (Top Mark: 3L)
R1	1	24.9k $\Omega$ $\pm$ 1% resistor (0603)
R2	1	68 $\Omega$ $\pm$ 5% resistor (0603)
R3	1	330 $\Omega$ $\pm$ 1% resistor (0603)
R4	1	43.2 $\Omega$ $\pm$ 1% resistor (0805)
R5	1	59k $\Omega$ $\pm$ 1% resistor (0603)
R6	1	16.9k $\Omega$ $\pm$ 1% resistor (0603)
R7	1	34k $\Omega$ $\pm$ 1% resistor (0603)
R8	1	53.6k $\Omega$ $\pm$ 1% resistor (0603)
R9, R27	2	100k $\Omega$ $\pm$ 1% resistors (0603)
R10	1	2k $\Omega$ $\pm$ 1% resistor (0603)
R11	1	30.1k $\Omega$ 1% resistor (0603)
R12, R16	2	10k $\Omega$ $\pm$ 1% resistors (0603)
R13, R14	2	10 $\Omega$ $\pm$ 5% resistors (0805)
R15	1	29.4k $\Omega$ $\pm$ 1% resistor (0603)
R17, R38, R41, R43, R44, R45, R47–R54, R56	0	Not installed, resistors (0603)
R18	1	4.02k $\Omega$ $\pm$ 1% resistor (0603)

DESIGNATION	QTY	DESCRIPTION
R19	1	10 $\Omega$ $\pm$ 5% resistor (0603)
R20, R22, R23, R24, R40, R55	0	Not installed, resistors (0805)
R21, R25	2	0.43 $\Omega$ $\pm$ 1%, 1/4W resistors (1206)
R26	1	499 $\Omega$ $\pm$ 5% resistor (0603)
R28	1	49.9k $\Omega$ $\pm$ 1% resistor (0603)
R29	1	1M $\Omega$ $\pm$ 5% resistor (0603)
R30–R33	4	75 $\Omega$ $\pm$ 5% resistors (0805)
R35	1	1.5M $\Omega$ $\pm$ 1% resistor (0603)
R46	1	0 $\Omega$ $\pm$ 5% resistor (0603)
RJ45	1	RJ45 MagJack® 1G Ethernet, 802.3af/at standard Bel Fuse Inc. 0826-1X1T-GH-F
T1	1	4.0:8.0:3.2:1 flyback transformer (8 EP10) Pulse Engineering PA3342NL or Sumida CEP1311-04367-T204
TP1, VDD	2	Small red test points
TP2, VSS	2	Small black test points
U1	1	IEEE 802.3af/at-compliant PD interface (10 TDFN-EP) Maxim MAX5969AETB+
U2	1	Current-mode PWM controller (16 TQFN-EP) Maxim MAX5974AETE+
U3	0	Not installed, phototransistor (4 DIP)
U4	0	Not installed, shunt regulator (5 SOT23)
—	1	PCB: MAX5969A EVALUATION KIT

MagJack is a registered trademark of Bel Fuse Inc.

# MAX5969A Evaluation Kit

## Evaluates: MAX5969A/MAX5974A

### Component Suppliers

SUPPLIER	PHONE	WEBSITE
AVX Corporation	843-946-0238	www.avxcorp.com
Bel Fuse Inc.	201-432-0463	www.belfuse.com
Central Semiconductor Corp.	631-435-1110	www.centalsemi.com
Cooper Bussmann	916-941-1117	www.cooperet.com
Diodes Incorporated	805-446-4800	www.diodes.com
Fairchild Semiconductor	888-522-5372	www.fairchildsemi.com
International Rectifier	310-322-3331	www.irf.com
Murata Electronics North America, Inc.	770-436-1300	www.murata-northamerica.com
Panasonic Corp.	800-344-2112	www.panasonic.com
Pulse Engineering	858-674-8100	www.pulseeng.com
STMicroelectronics	408-452-8585	www.us.st.com
Sumida Corp.	847-545-6700	www.sumida.com
Taiyo Yuden	800-348-2496	www.t-yuden.com
TDK Corp.	847-803-6100	www.component.tdk.com

**Note:** Indicate that you are using the MAX5969A when contacting these component suppliers.

### Quick Start

#### Required Equipment

- MAX5969A EV kit
- IEEE 802.3af/at-compliant PSE and Category 5e Ethernet network cable
- -48V, 1A-capable DC power supply
- Voltmeter

#### Hardware Connections

The 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) Use one of the following methods to power the EV kit:
  - **If network connectivity is required:** Connect a Category 5e Ethernet network cable from the EV kit input port RJ45 connector to the corresponding PSE Ethernet LAN connection, which provides power to the EV kit. A modular Ethernet jack (J1) provides an interface with the Ethernet data signals only.
  - **If network connectivity is not required:** Connect a -48V DC power supply between the V+ and V- PCB pads on the EV kit. Connect the power-supply positive terminal to the V+ PCB pad and the negative terminal to the V- PCB pad.
- 2) Activate the PSE power supply or turn on the external DC power supply.
- 3) Using a voltmeter, verify that the EV kit provides +12V across the VOUT and PGND PCB pads. PGND is galvanically isolated from the EV kit's input V+ and WAD\_IN PCB pads.

### Detailed Description of Hardware

The MAX5969A EV kit features an Ethernet port network PD interface-controller circuit for -57V supply rail systems. The EV kit circuit contains a MAX5969A IEEE 802.3af/at-compliant network PD interface controller and the MAX5974A inductive-feedback, spread-spectrum, current-mode PWM controller. The EV kit circuit is used in PoE applications for powering PDs from an unshielded twisted-pair (UTP) Category 5e Ethernet network cable and PSE port using endspan or midspan Ethernet systems.

The EV kit demonstrates the full functionality of the MAX5969A, such as PD detection, PD classification, inrush current control, and UVLO. Resistors R1 and R4 set the PD detection signature and the PD classification signatures, respectively.

The EV kit's power circuit is a galvanically isolated 12W power supply using the MAX5974A DC-DC current-mode PWM controller in a synchronous-rectified flyback DC-DC converter topology. The EV kit receives power from an IEEE 802.3af/at-compliant PSE and a Category 5e Ethernet network cable connected to the EV kit's RJ45 MagJack. The EV kit uses a 1 x 1Gb Ethernet RJ45 MagJack and two full-bridge power rectifiers (D1, D2) to separate the -57V DC power sent by the PSE. The EV kit accepts power from an endspan or midspan PSE network configuration. The EV kit also provides an Ethernet jack (J1) for interfacing to the Ethernet data signals. PCB pads V+ and V- are available for powering the EV kit if network connectivity is not required. Common-mode chokes L1 and L3 are provided for EMI filtering at the EV kit power supply (V+, V-) and wall adapter (WAD\_IN, WAD\_GND) inputs, respectively.

# MAX5969A Evaluation Kit

## Evaluates: MAX5969A/MAX5974A

The EV kit's 12W, 300kHz flyback DC-DC converter uses a MAX5974A inductive-feedback current-mode PWM controller. The MAX5969A's VDD and RTN pins provide power for the DC-DC converter input circuit. The DC-DC converter is configured for an output voltage of +12V and provides up to 1A of output load current. The EV kit circuit achieves up to 92% efficiency using MOSFET N2 for synchronous rectification on the secondary side. An additional MOSFET N3 (SOT23) PCB pad is available for increasing the output current load up to 2A with a switching frequency of 400kHz. Transistor Q2 is provided to limit the output overshoot at startup. Surface-mount transformer T1 provides up to 1500V galvanic isolation for the isolated output. Current-sense resistors R21 and R25 limit the peak current through transistor N1 and the primary of transformer T1. Primary-side feedback regulation is achieved using T1 auxiliary winding and voltage feedback resistors R3, R8, and R12 to set the isolated output voltage. Diodes D6 and D7 are provided for limiting the voltage spikes across transformer T1 during N1 turn-off time. The EV kit also includes additional circuitry with uninstalled PCB pads to reconfigure the EV kit using optocoupler feedback. See the *Reconfiguring the EV Kit for Optocoupler Feedback* section for additional information.

### PD Classification Signature

The EV kit is configured for a Class 3 (6.49W to 12.95W) PD classification by resistor R4. To reconfigure the PD classification, replace surface-mount (0805) resistor R4. Table 1 lists the PD classification options.

### Wall Adapter Power Source (WAD\_IN, WAD\_GND)

The EV kit can also accept power from a wall adapter power source. Use the WAD\_IN and WAD\_GND (+30V to +57V) PCB pads to connect the wall adapter power source. The wall adapter power-source operating-voltage range must be within +36V to +57V for the EV kit.

When the wall adapter power source is above +36V, it takes precedence over the PSE source. Once the wall adapter power source is detected, The MAX5969A (U1) internal isolation switch disconnects VSS from RTN. The wall adapter power is supplied to VDD (through diode D4 and RTN). Once it takes over, the PD internal switch is turned off. Resistors R27 and R28 are available for adjusting the EV kit wall adapter voltage for disabling the PSE source.

If the wall adapter power source is below +27V, the PSE provides power through the device's RTN after a successful detection and classification. Diode D4 prevents the PSE from backdriving the wall adapter power source.

### Ethernet Data-Signal Interfacing

The EV kit features Ethernet jack J1 to interface with the Ethernet data signals. J1 is provided for interfacing the EV kit with the Ethernet data signals only. Refer to the RJ45 MagJack data sheet on the Bel Fuse website prior to interfacing the EV kit's J1 jack with the Ethernet data signals.

### Reconfiguring the EV Kit for Optocoupler Feedback

The EV kit also supports an isolated DC-DC converter design using optocoupler feedback. On the transformer's secondary side, PCB footprint pads are available for shunt regulator U4, along with additional resistors and capacitor components, providing secondary-side voltage feedback to the primary side through optocoupler U3. The MAX5974A receives the voltage feedback signal on the primary side from biasing resistors R51, R53, and R54. When reconfiguring the EV kit for optocoupler feedback, the following modifications must be made:

- Remove components R3, R8, and R12 (primary-side feedback regulation components)
- Install optocoupler U3 (4-pin DIP footprint)
- Install shunt regulator U4 (5-pin SOT23 footprint)
- Install required surface-mount (0402/0603) resistor and capacitor components for feedback regulation.

**Table 1. PD Classification Selection**

CLASS	MAXIMUM POWER USED BY PD (W)	RESISTOR R4 ( $\Omega$ )
0	0.44 to 12.95	619
1	0.44 to 3.84	118
2	3.84 to 6.49	66.5
3	6.49 to 12.95	43.2
4	12.95 to 25.5	30.9
5	> 25.5	21.3

# MAX5969A Evaluation Kit

## Evaluates: MAX5969A/MAX5974A

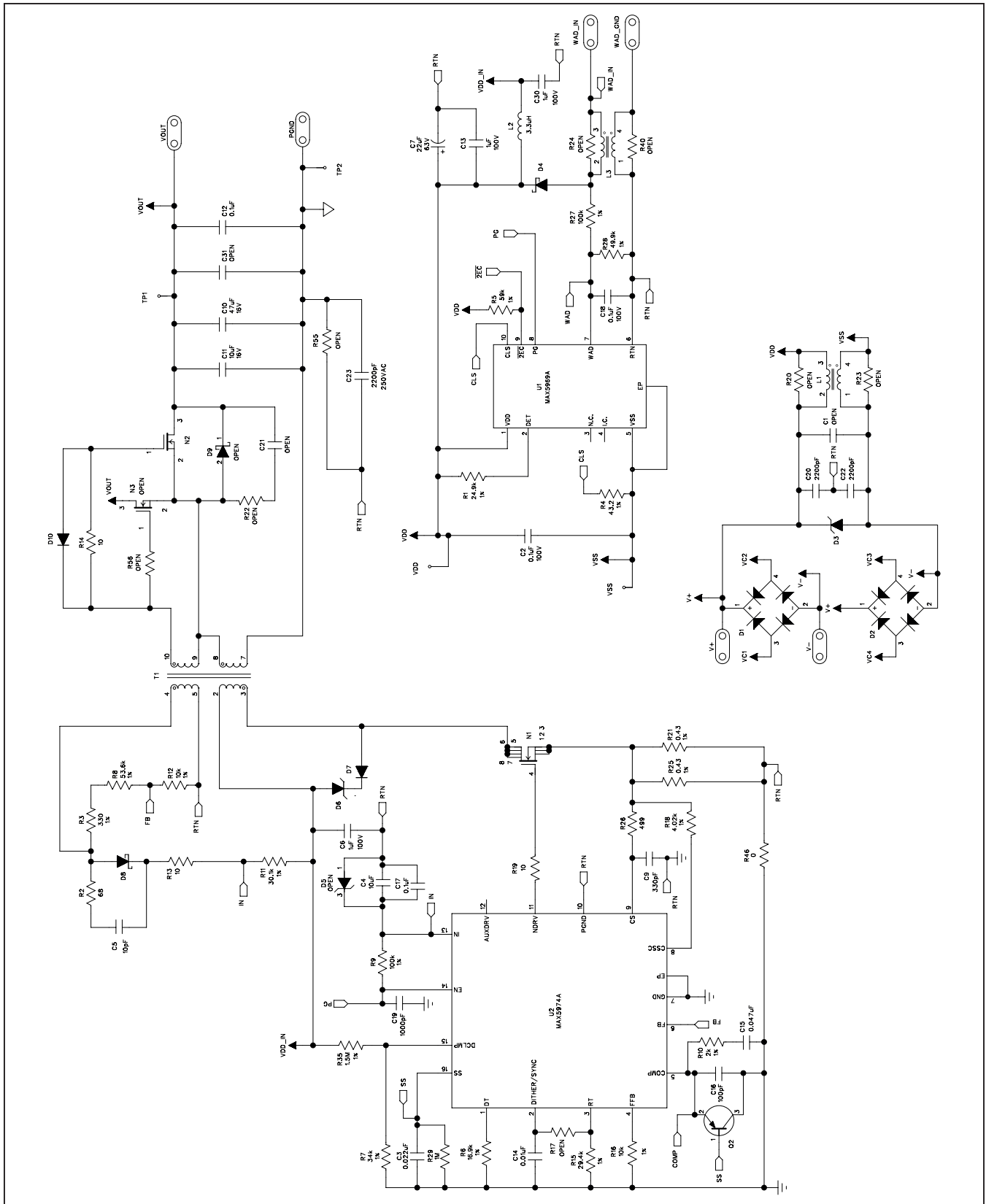


Figure 1a. MAX5969A EV Kit Schematic (Sheet 1 of 2)

# MAX5969A Evaluation Kit

## Evaluates: MAX5969A/MAX5974A

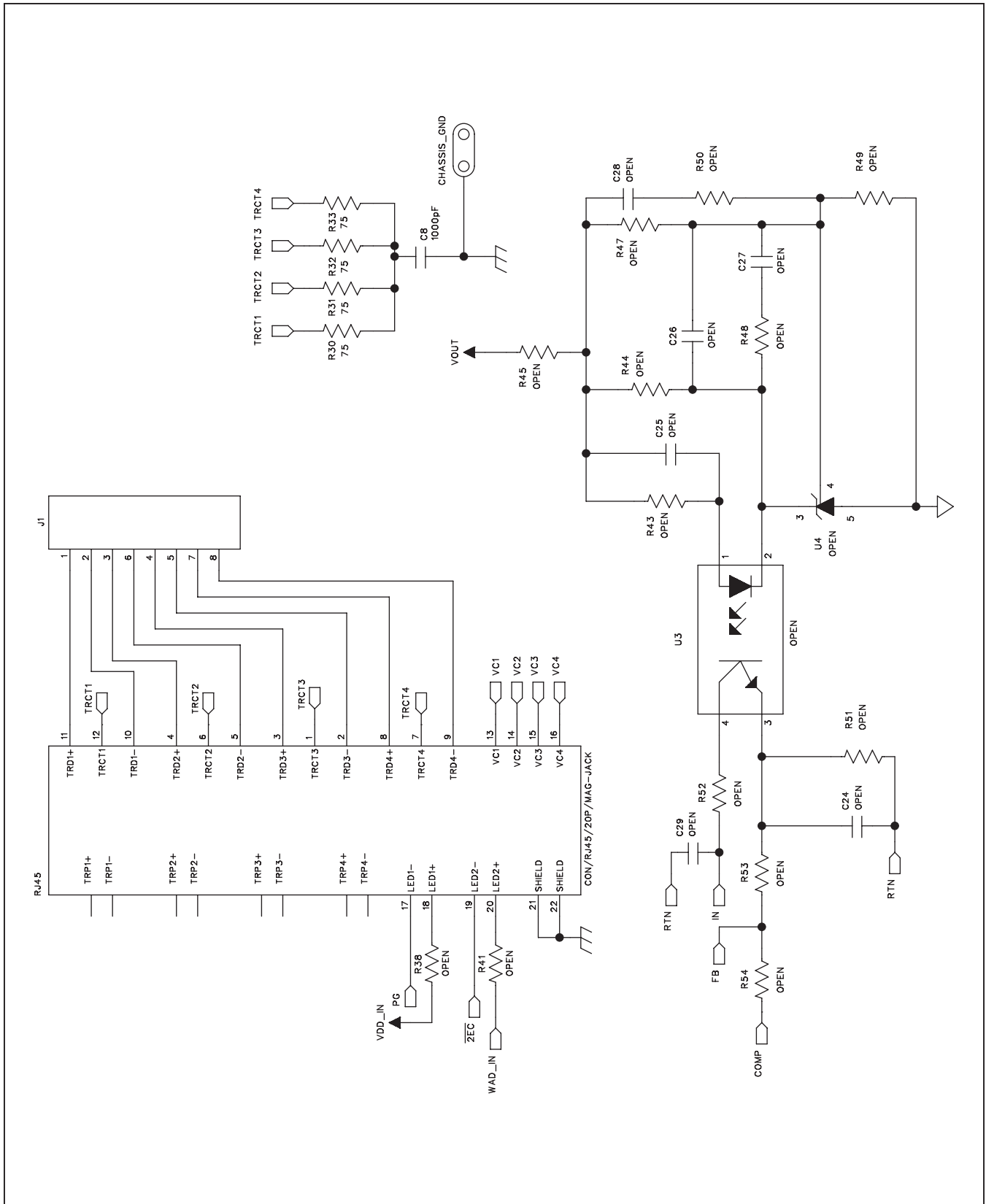


Figure 1b. MAX5969A EV Kit Schematic (Sheet 2 of 2)

# MAX5969A Evaluation Kit

## Evaluates: MAX5969A/MAX5974A

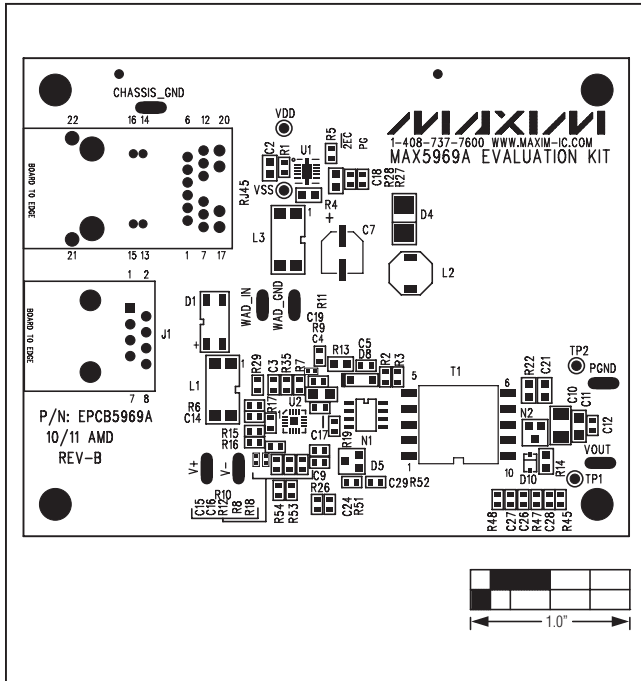


Figure 2. MAX5969A EV Kit Component Placement Guide—Component Side

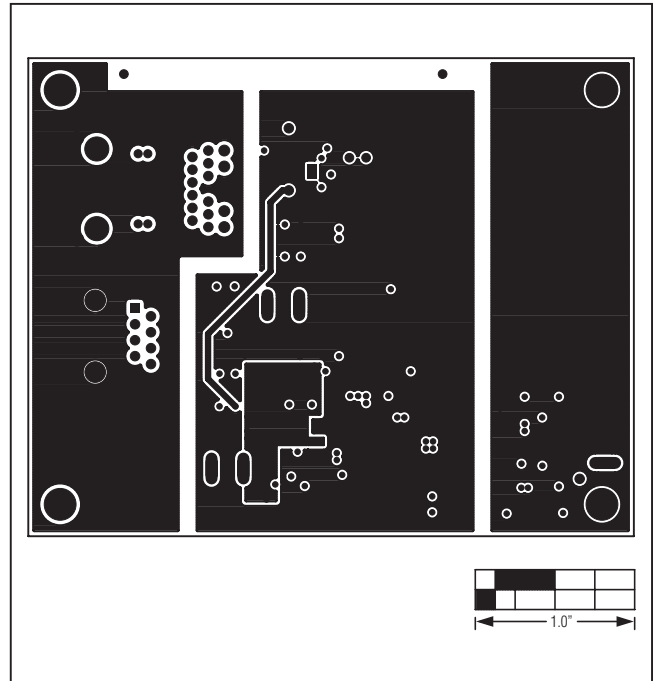


Figure 4. MAX5969A EV Kit PCB Layout—Ground Layer 2

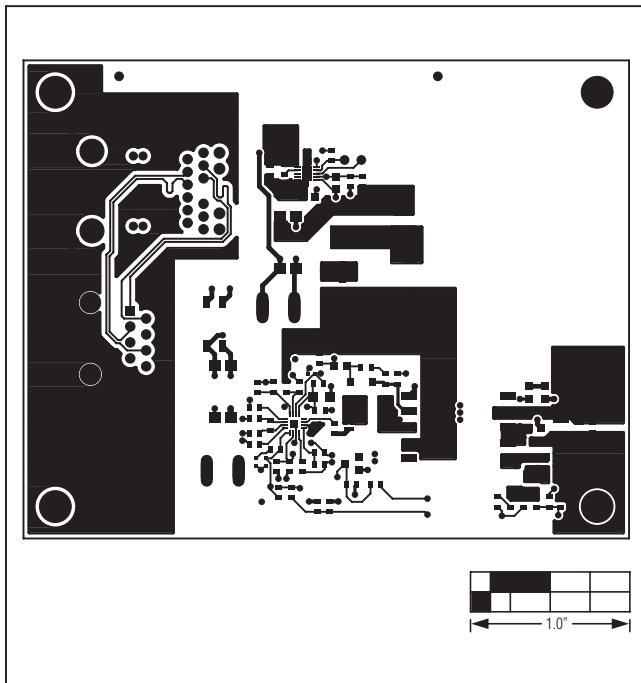


Figure 3. MAX5969A EV Kit PCB Layout—Component Side

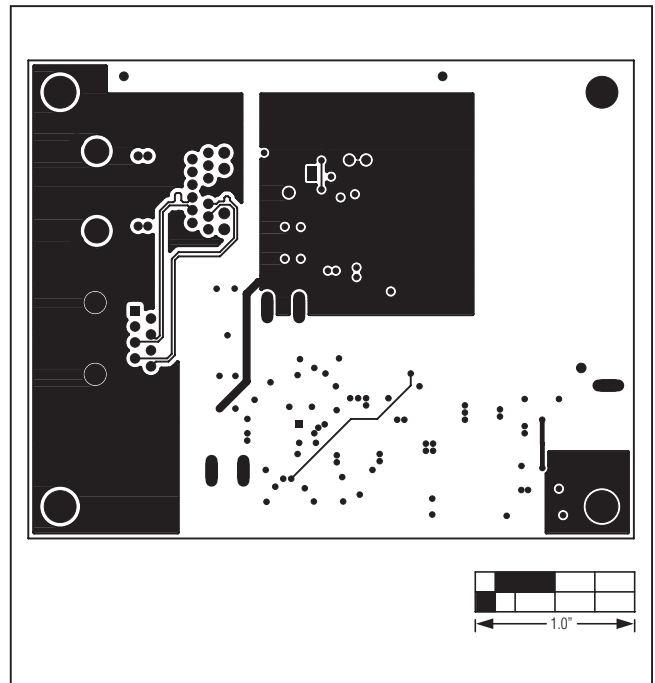


Figure 5. MAX5969A EV Kit PCB Layout—VCC Layer 3



# MAX5969A Evaluation Kit

## Evaluates: MAX5969A/MAX5974A

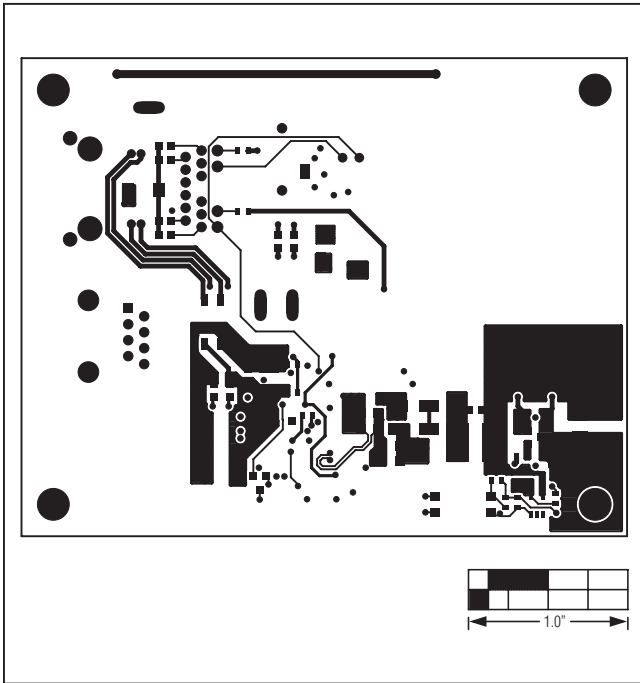


Figure 6. MAX5969A EV Kit PCB Layout—Solder Side

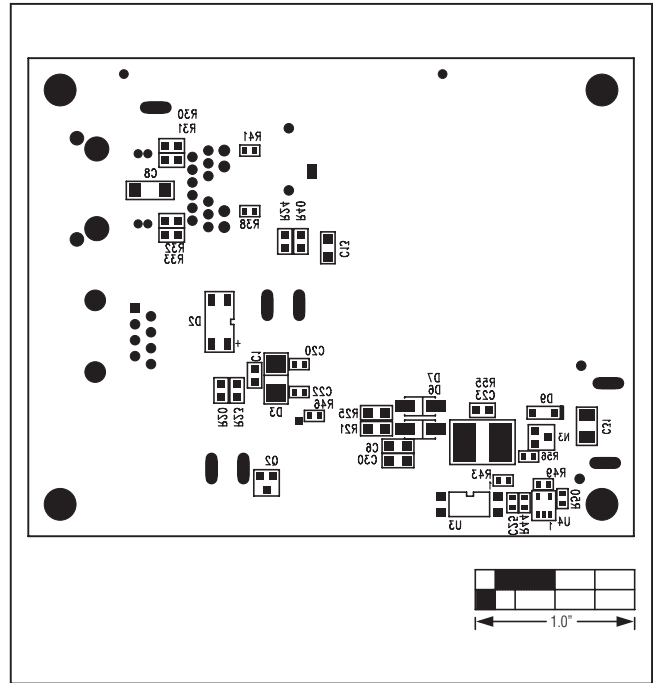


Figure 7. MAX5969A EV Kit Component Placement Guide—Solder Side

# MAX5969A Evaluation Kit

## Evaluates: MAX5969A/MAX5974A

### ***Ordering Information***

<b>PART</b>	<b>TYPE</b>
MAX5969AEVKIT#	EV Kit

#Denotes RoHS compliant.

# MAX5969A Evaluation Kit

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### Revision History

REVISION NUMBER	REVISION DATE	DESCRIPTION	PAGES CHANGED
0	10/11	Initial release	—

*Maxim cannot assume responsibility for use of any circuitry other than circuitry entirely embodied in a Maxim product. No circuit patent licenses are implied. Maxim reserves the right to change the circuitry and specifications without notice at any time.*

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