19-3513; Rev 0; 11/04

MAX5069A Evaluation Kit

Evaluates: MAX5069A

General Description

The MAX5069A evaluation kit (EV kit) is a fully assembled and tested circuit board that contains a high-efficiency, 120W isolated push-pull DC-DC converter. The circuit is configured for a +12V output voltage and provides up to 10A of output current. The circuit can be powered from either a +36V to +72V or -36V to -72V DC source, as used in the telecom/datacom markets, industrial environments, or in automotive 42V power systems.

High efficiency up to 91% is achieved at 10A while using two n-channel primary-side MOSFETs switching at up to 90% combined duty cycle. On the secondary-side, reduced output-voltage ripple and high efficiency is achieved through full-wave rectification from a center-tapped planar transformer. Galvanic isolation up to 500V is achieved by an optocoupler and the planar surface-mount transformer. The optocoupler helps in providing isolated secondary-side regulation.

Operation at 500kHz allows the use of small magnetics and output capacitors. A SYNC input is featured to ease synchronization to an external clock. The EV kit provides cycle-by-cycle current-limit protection. Additional steady-state fault protection is provided by the integrating fault protection that reduces average dissipated power during continuous overload conditions. The MAX5069A also has a programmable input undervoltage lockout (UVLO) for protection during brownout conditions. The EV kit may be used to evaluate other versions of the MAX5069.

Warning: The MAX5069A 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 power the sources connected to it must be careful to follow safety procedures appropriate to working 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.

Features

- **120W High-Efficiency, Isolated, Push-Pull DC-DC Converter**
- **±36V to ±72V Input Range**
- **+12V Output at 10A**
- **V_{OUT} Regulation Better than 0.1% Over Line and Load**
- **91% Efficiency at 48V and 10A**
- **Programmable Input UVLO**
- **Cycle-by-Cycle Current-Limit Protection**
- **Programmable Integrating Fault Protection**
- **500kHz Oscillator Frequency**
- **External Clock SYNC Input**
- **Fully Assembled and Tested**

Ordering Information

PART	TEMP RANGE	IC PACKAGE
MAX5069AEVKIT	0°C to +50°C*	16 TSSOP

**With 200LFM airflow.*

Component List

DESIGNATION	QTY	DESCRIPTION
C1	1	0.1µF ±10%, 16V X7R ceramic capacitor (0603) Murata GRM39X7R104K016AD
C2, C3, C4	3	1µF ±10%, 100V X7R ceramic capacitors (1210) AVX 1210C105KAT9A
C5, C6, C7, C18, C19, C20	6	47µF ±10%, 16V X5R ceramic capacitors (1210) Murata GRM32ER61C476K
C8	1	0.1µF ±10%, 50V X7R ceramic capacitor (0603) Murata GRM188R71H104K
C9	1	10µF ±20%, 35V, low-impedance electrolytic capacitor (5mm x 6mm) Sanyo 35CV10KX
C10	1	12pF ±5%, 50V C0G ceramic capacitor (0603) Murata GRM1885C1H120J

Component List (continued)

DESIGNATION	QTY	DESCRIPTION
C11	1	0.22µF ±10%, 10V X7R ceramic capacitor (0603) TDK C1608X7R1C224K
C12	1	560pF ±5%, 50V C0G ceramic capacitor (0603) Murata GRM1885C1H561J
C13	1	1µF ±10%, 16V X5R ceramic capacitor (0603) TDK C1608X5R1C105K
C14	1	0.033µF ±10%, 16V X7R ceramic capacitor (0603) Murata GRM188R71E333K
C15	1	4700pF ±10%, 250VAC X7R ceramic capacitor (2220) Murata GA355DR7GC472K
C16	0	Not installed, ceramic capacitor (0603)
C17	1	0.015µF ±10%, 50V X7R ceramic capacitor (0603) Murata GRM188R71H153K
C21, C22	0	Not installed, ceramic capacitors (1210) 47µF ±10%, 16V X5R ceramic capacitors (1210) Murata GRM32ER61C476K recommended
C23	1	0.047µF ±10%, 25V X7R ceramic capacitor (0603) Murata GRM188R71E473K
C24	1	470pF ±10%, 100V C0G ceramic capacitor (0805) Murata GRM2165C2A471K
D1	1	60V, 30A Schottky diode (TO-220AB) International Rectifier 30CTQ060 or Vishay MBR30H60CT
D2	1	200mA, 75V, ultra-high-speed diode (SOT323) Central Semiconductor CMSD2836
D3	1	200mA, 75V ultra-high-speed diode (SOT323) Central Semiconductor CMSD2838
D4, D5	2	100mA, 80V switching diodes (SOD-323) Diodes Inc. 1N4148WS
L1	1	4.7µH, 17A inductor Cooper HC2LP-4R7 or Coilcraft D05010P-472HCB
L2	1	1000µH, 0.045A inductor Coilcraft DS1608C-105
N1, N2	2	200V, 3.2A n-channel MOSFETs (SO-8) Vishay Si7450DP or International Rectifier IRF7492
R1	1	20.0kΩ ±1% resistor (0603)
R2	1	1.05kΩ ±1% resistor (0603)
R3	1	200kΩ ±1% resistor (0603)
R4	1	24.3kΩ ±1% resistor (0603)
R5	1	499kΩ ±1% resistor (0805)
R6	1	20.0kΩ ±1% resistor (0805)
R7	1	10kΩ ±5% resistor (0805)
R8	2	10kΩ ±1% resistor (0603)
R9	1	1MΩ ±5% resistor (0603)
R10	1	27kΩ ±5% resistor (1206)
R11, R12	2	3Ω ±5% resistors (1206)
R13	1	220Ω ±5% resistor (0603)
R14	0	Not installed, resistor (2010)
R15	1	0.060Ω ±1% resistor (2010) IRC LRC-LR2010-01-R060-F
R16	0	Not installed, resistor (0603)
R17	1	15kΩ ±5% resistor (0603)
R18	1	1kΩ ±1% resistor (0603)
R19	0	2.2kΩ ±5% resistor (0603)
R20	1	5.1kΩ ±5% resistor (0603)
R21	1	10Ω ±5% resistor (1206)

Component List (continued)

DESIGNATION	QTY	DESCRIPTION
R22	0	Not installed, resistor (1206)
TB1	1	2 points terminal block (0.2in center)
T1	1	180W planar transformer Coilcraft B0860-C
U1	1	MAX5069AAUE (16-pin TSSOP-EP)
U2	1	High CTR optocoupler (ultra-small flat-lead) NEC PS2911-1-M
U3	1	0.6V ±0.5% shunt regulator (SOT23-5) Maxim MAX8515AEZK-T

DESIGNATION	QTY	DESCRIPTION
VOUT, SGND	2	Uninsulated banana jacks
None	4	Rubber bumpers
None	2	Zinc-plated metal screws, 4-40 x 1/4
None	1	Nylon hex nut 4-40
None	1	Nylon screw 4-40 x 3/8
None	1	TO-220 thermally conductive insulating pad
None	1	TO-220AB aluminum heatsink (10.4°C/W)
None	1	MAX5069 PC board

Component Suppliers

SUPPLIER	PHONE	FAX	WEBSITE
AVX	843-946-0238	843-626-3123	www.avxcorp.com
CEL/NEC; California Eastern Laboratories	408-588-2247	408-588-2213	www.cel.com
Central Semiconductor	631-435-1110	631-435-1824	www.centralsemi.com
Coilcraft	847-639-6400	847-639-1469	www.coilcraft.com
Cooper-Coiltronics	561-752-5000	561-742-1178	www.cooperet.com
International Rectifier	310-322-3331	310-726-8721	www.irf.com
IRC	361-992-7900	361-992-3377	www.irctt.com
Murata	770-436-1300	770-436-3030	www.murata.com
Sanyo Electronic Device	619-661-6835	619-661-1055	www.sanyodevice.com
TDK	847-803-6100	847-390-4405	www.component.tdk.com
Vishay	—	—	www.vishay.com

Note: *Indicate that you are using the MAX5069A when contacting these component suppliers.*

Quick Start

Required Equipment

- 36V to 72V power supply capable of providing up to 6A
- 20A electronic load e.g., HP 6060B
- Voltmeter
- 330µF, 100V bulk storage capacitor to be connected to the input terminals of the EV kit
- A fan to provide at least 200LFM airflow for extended operation at 10A

The MAX5069A EV kit is fully assembled and tested. Follow these steps to verify board operation. **Do not turn on the power supply until all connections are completed.**

DC-DC Converter Output

1) Connect the electronic load (+) terminal to the VOUT banana jack. Connect the electronic load (-) terminal to the SGND banana jack.
2) Connect a voltmeter to the VOUT and SGND terminals to measure the output voltage.
3) Connect the positive terminal of a 36V to 72V power supply to the +VIN terminal (TB1-1). Connect the power supply's ground to the -VIN terminal (TB1-2).
4) Turn on the electronic load and set it for "current mode" and up to 5A of current.
5) Turn on the power supply above 36V and verify that the voltmeter reads +12V normally.
6) Verify that the electronic load is drawing the appropriate current.

Detailed Description

The MAX5069A EV kit is a 120W, isolated, push-pull DC-DC converter that provides +12V at up to 10A output. The circuit can be powered from a 36V to 72V DC source. **The user should supply an additional 330µF bulk storage capacitor between the input terminals (+VIN, -VIN).** This capacitor should be rated for 100V and be able to carry approximately 2A of ripple current. Lower ripple-current-rated capacitors should be acceptable for short-term operation

The push-pull converter achieves high efficiency by using two external n-channel MOSFETs on the primary side that can switch up to 90% combined duty cycle that results in lower primary RMS currents through the MOSFET switches resulting in improved efficiency.

Cycle-by-cycle current limiting prevents the primary current from reaching destructive levels, whereas the fault integration feature provides hiccup fault protection. For a continuous short circuit at the output, the MAX5069's fault integration feature provides hiccup fault protection. This greatly minimizes destructive temperature rise during persistent overload conditions. Pin 8 of the MAX5069A, capacitor C11, and resistor R9 form the fault integration circuit. Current-sense resistors R14 and R15 sense the current through the primary of transformer T1 and turn off the respective MOSFET (N1 or N2) that is switching when the trip level of 314mV (typ) is reached.

The planar surface-mount transformer features a bias winding that, along with diode-pair D2, D3, and inductor L2, provide full-wave rectification for the bias voltage powering the MAX5069A once the input voltage is stable. Upon initial input-voltage application, bootstrap resistor R10 and reservoir capacitor C9 enable the MAX5069A to startup within approximately 200ms. The transformer uses a secondary-side center tap and dual Schottky diode D1 to provide full-wave rectification for reduced output-voltage ripple. When either MOSFET is turned off and the alternate turned on, both D1 diodes are conducting. The transformer provides galvanic isolation up to 500V. Resistor R21 and capacitor C24 form a snubber network that suppresses transient overvoltage ringing at diode D1 caused by transformer T1 leakage inductance and diode D1 junction capacitance.

On the transformer's secondary side, a 0.6V shunt regulator (MAX8515, U3) along with feedback resistors R1 and R2 provide secondary-side voltage feedback through optocoupler U2 to the primary side. The MAX5069A receives the voltage feedback signal on the primary side from biasing resistors R16, R17, R18, and optocoupler U2.

The MAX5069A controller's internal oscillator clock switches at 500kHz and the frequency is programmed by resistor R3. The duty cycle of both MOSFETs is varied to control energy transfer to the output. The MAX5069A EV kit's maximum duty cycle is 90% as configured. Resistor R4 sets the dead time for both switches and has an impact on the maximum duty cycle.

The MAX5069A brownout and input-supply startup UVLO threshold voltage is set by resistors R5 and R6. This prevents the power supply from starting up or operating below the programmed input supply voltage. Test point TP1 is provided to connect an external clock to the SYNC pin on the MAX5069A.

The EV kit's PC board layout is a 4-layer 2oz copper PC board.

Evaluating Other Output Voltages, Current Limits, UVLOs

V_{OUT} Output Voltage

The MAX5069A EV kit's output (V_{OUT}) is set to +12V by feedback resistors R1 and R2. To generate other output voltages in the vicinity of +12V (from +8V to +15V, limited by the output capacitor and diode D1 voltage rating), select different voltage-divider resistors (R1, R2). Resistor R2 is typically chosen to be less than 2kΩ. Using the desired output voltage, resistor R1 is then found by the following equation:

$$R1 = R2 \left(\left(\frac{V_{OUT}}{V_{REF}} \right) - 1 \right)$$

where V_{REF} = 0.6V

The maximum output current should be limited to less than 10A. The usable output voltage range for the EV kit is +8V to +15V. Additionally, ICs U3, U2, and resistor R19 limit the minimum output voltage (V_{OUT}) to +2.6V. For voltages outside the above range, a different turns ratio transformer may be required.

Current Limiting

The EV kit features cycle-by-cycle current limiting of the transformer primary current. Current-sense resistors R14 and R15 sense the current through the primary of transformer T1 and turn off MOSFET N1 or N2 when the trip level of 314mV (typ) is reached. Current-sense resistors R14 and R15 limit the peak primary current to approximately 5.3A (314mV / 0.060Ω ≈ 5.3A). This will limit short-circuit current on the secondary output (VOUT) to 20A typically. To evaluate lower current limits, current-sense resistors R14 and R15 must be replaced with different value surface-mount resistors (2010 size) as determined by the following equation:

$$R_{CS} = \frac{V_{SENSE}}{\left(\frac{N_S}{N_P}\right) \times \left(1.2 \times I_{OUTMAX}\right)}$$

where R_{CS} = parallel combination of R14 and R15, V_{SENSE} = 0.314V, N_S = 2, N_P = 5, and I_{OUTMAX} = maximum DC output current (10A or less). Note that some fine-tuning may be required when selecting the current-limit resistors. Errors are introduced as a result of the MAX5069A IC current-limit propagation delays.

Input Undervoltage Lockout (UVLO)

The MAX5069A EV kit features a brownout and input-supply startup UVLO circuit that prevents operation below the programmed input-supply start voltage. Resistors R5 and R6 set the input undervoltage lockout threshold of the EV kit. To evaluate other input UVLO voltages, replace resistor R5 with another surface-mount resistor (0805 size). Using the desired startup voltage, resistor R5 is then found by the following equation:

$$R5 = \left(\frac{VIN_{STARTUP}}{1.231V} - 1\right) \times R6$$

where $VIN_{STARTUP}$ is the desired startup voltage at which the EV kit starts and resistor R6 is typically in the 20kΩ range. Refer to the *MAX5069A/D UVLO Adjustment* and *Bootstrap Undervoltage Lockout* sections of the MAX5069 data sheet for additional information on the UVLO/EN pin of the MAX5069A IC.

Push-Pull DC-DC Converter

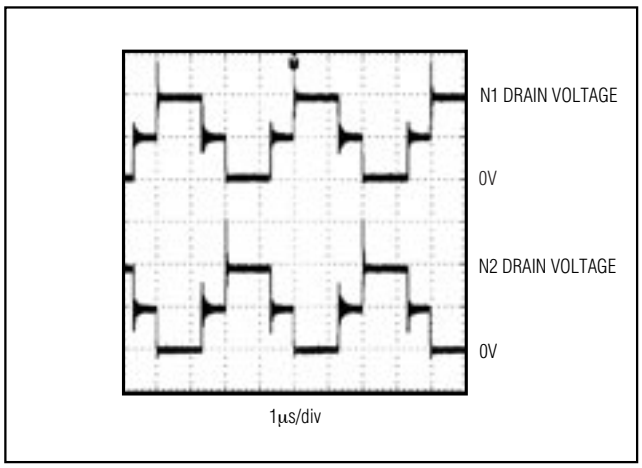

Figure 1. MOSFETs N1 and N2 Drain-Source Voltage Waveforms (50V per Division, 1µs per Division)

MAX5069A Evaluation Kit

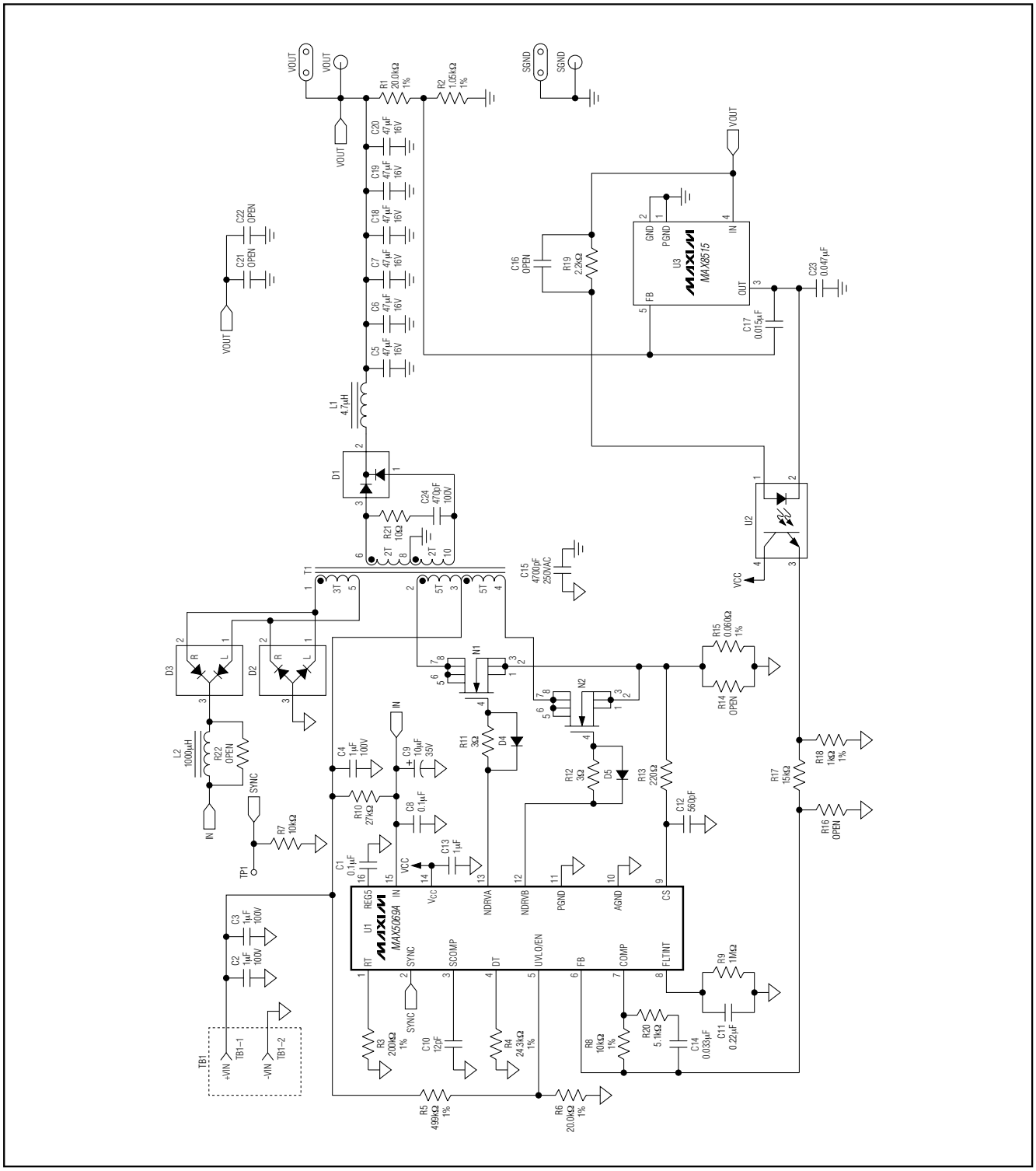

Figure 2. MAX5069A EV Kit Schematic

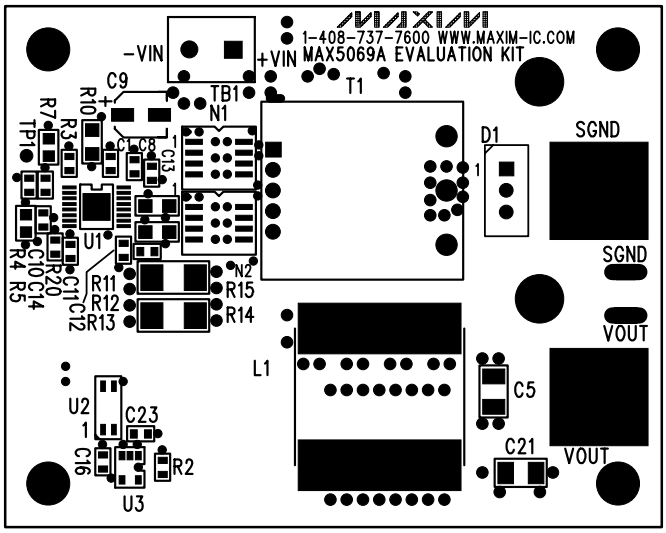

Figure 3. MAX5069A EV Kit Component Placement Guide—Component Side

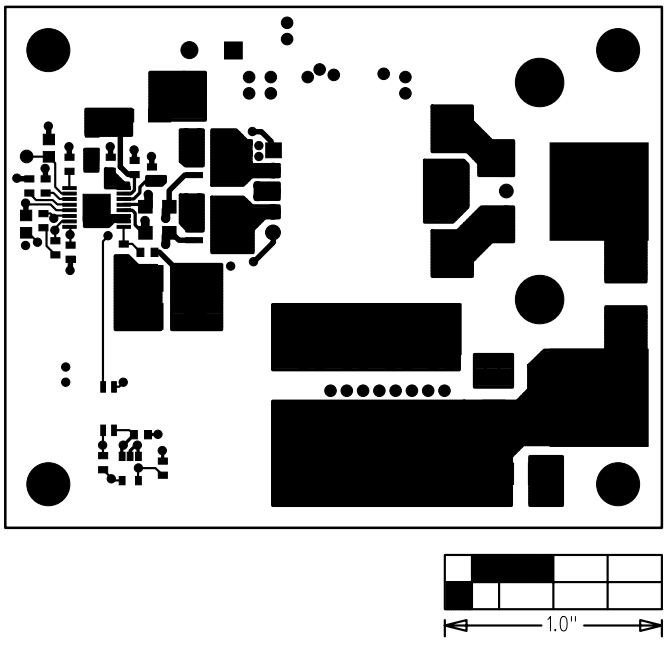

Figure 4. MAX5069A EV Kit PC Board Layout—Component Side

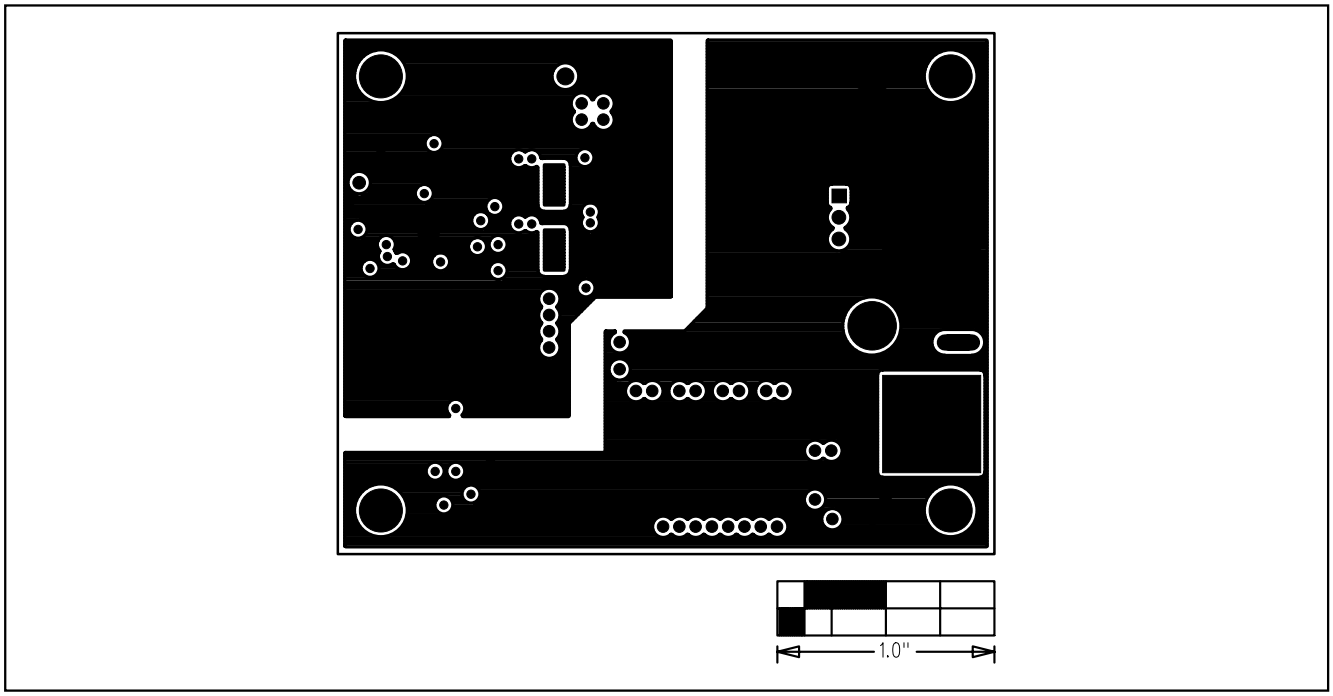

Figure 5. MAX5069A EV Kit PC Board Layout—Inner Layer, GND Plane

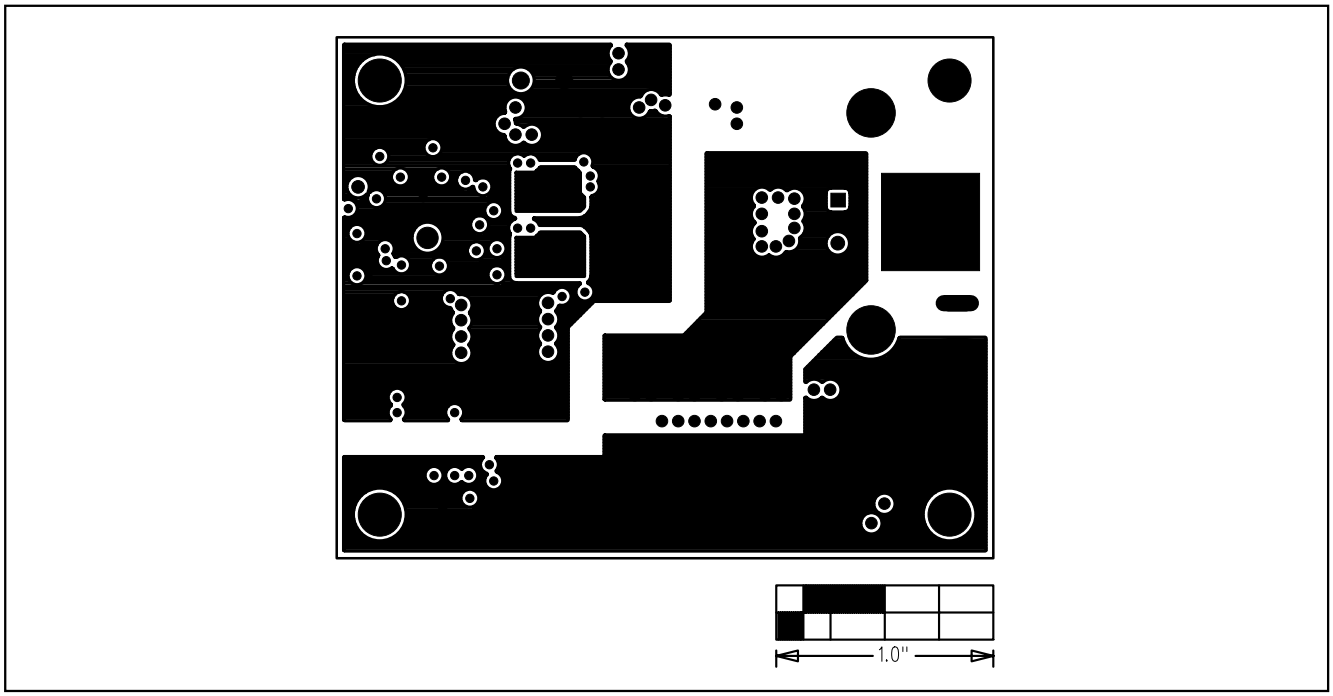

Figure 6. MAX5069A EV Kit PC Board Layout—Inner Layer, VCC Plane

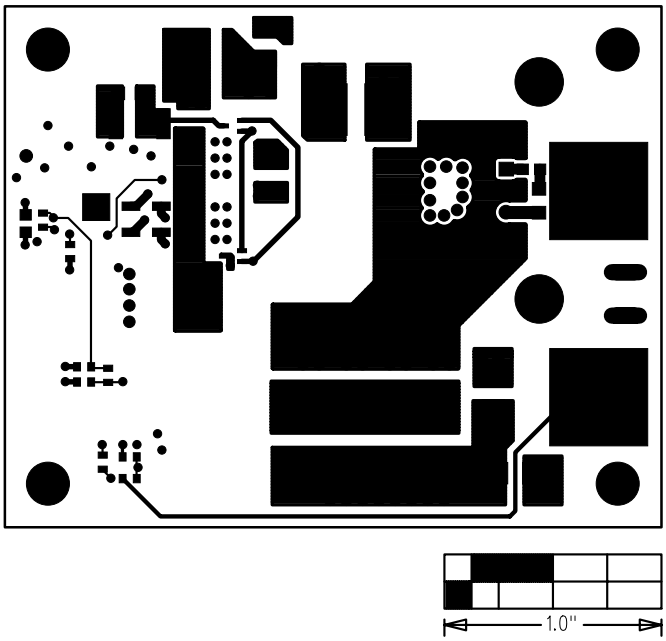

Figure 7. MAX5069A EV Kit PC Board Layout—Solder Side

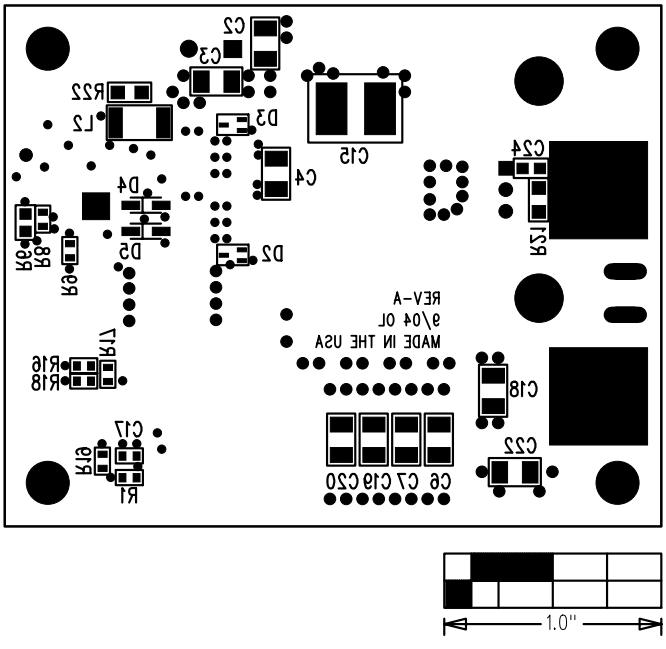

Figure 8. MAX5069A EV Kit Component Placement Guide—Solder Side