19-1914; Rev 1; 3/02

MAX5003-50W Evaluation Kit

General Description

The MAX5003 50W forward converter evaluation kit (EV kit) provides a regulated +5V output voltage at currents up to 10A, when operated from a +36V to +72V input voltage range.

This EV kit is fully assembled and tested. The output voltage is preset to +5V. A single-transistor forward-converter topology with a reset winding is used for high output power and high efficiency. The use of an opto-coupler in the feedback circuit provides full 1500V primary to secondary galvanic isolation. A bottom-mounted heatsink plate safely dissipates the heat generated by the power MOSFET and the output diode. The power supply is designed to fit into a small footprint.

WARNING: 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 EV kit with care to avoid possible personal injury.

Features

- ♦ **+5V at 10A Output**
- ♦ **±36V to ±72V Input Voltage Range**
- ♦ **250kHz Switching Frequency**
- ♦ **Fully Isolated Design with 1500V Isolation Built into the Transformer**
- ♦ **Fully Assembled and Tested Board with Minimum PC Board Footprint**
- ♦ **0.3% typical Line and Load Regulation**
- ♦ **85% typical Efficiency at 25W**

Ordering Information

PART	TEMP RANGE	IC PACKAGE
MAX5003EVKIT50W	0°C to +50°C*	16 SO

**With air flow.*

Component List

DESIGNATOR	QTY	DESCRIPTION
C1, C3, C10, C15	4	0.1µF ceramic caps (0805)
C2	1	470pF ceramic cap (0805)
C4, C5, C6	3	0.47µF, 100V ceramic caps (2220)
C7, C13, C14	3	560µF, 6.3V electrolytic capacitors Nichicon UPW0J561MPH
C8, C9	2	47nF ceramic capacitors (0805)
C11	1	22nF ceramic capacitor (0805)
C12	1	1nF, 100V ceramic capacitor (0805)
C16	1	4.7nF, 1500V ceramic capacitor
D3	1	200mA, 100V diode Panasonic MA111CT
D4	1	20A, 40V low forward voltage Schottky diode General Semi SBL2040CT
D5	1	200mA, 200V, diode Panasonic MA115CT
Q1	1	200V MOSFET, Rds = 0.18Ω International Rectifier IRF640N
Q2	1	NPN transistor, FMMT3904

DESIGNATOR	QTY	DESCRIPTION
R1	1	1MΩ ±1% resistor (0805)
R2	1	39.2kΩ ±1% resistor (0805)
R3	1	80.6kΩ ±1% resistor (0805)
R4	1	1.24kΩ ±1% resistor (0805)
R5	1	56kΩ ±1% resistor (0805)
R6	1	0.02Ω resistor Dale-Vishay WSL1206 0.02Ω ±1.0% R86
R8	1	100Ω ±5% resistor (0805)
R9	1	470Ω ±5% resistor (0805)
R11, R12	2	10kΩ ±1% resistors (0805)
R13	1	20Ω ±5% resistor (1206)
R14	1	10kΩ ±5% resistor (0805)
R15	1	240kΩ ±5% resistor (0805)
R16	1	1Ω ±5% resistor (0805)
L1	1	4.7µH inductor Coiltronics HC2-4R7
T1	1	Transformer (12-pin gull wing) Coiltronics CTX03-14856

Component List (continued)

DESIGNATOR	QTY	DESCRIPTION
U2	1	Optocoupler QT Optoelectronics MOC217
U3	1	Shunt regulator TL431AID
U1	1	MAX5003ESE, 16-pin narrow SO
Z1	1	15V Zener diode Panasonic MA8150

Component Suppliers

SUPPLIER	PHONE	FAX
Coiltronics	561-241-7876	561-241-9339
Dale-Vishay	402-564-3131	402-563-6418
General Semiconductor	631-847-3000	631-847-3236
International Rectifier	310-322-3331	310-322-3332
Nichicon	847-843-7500	847-843-2798
Panasonic	201-392-7522	201-392-4441
QT Optoelectronics	408-720-1440	408-720-0848

Quick Start

The MAX5003 50W EV kit is fully assembled and tested. The power supply has full isolation between the primary and secondary circuit. A heatsink is included at the non-component side for heatsinking the power MOSFET and the output dual diode D4. During normal operation at full output current, this heatsink becomes hot. A small fan with direct airflow towards this heatsink is recommended to keep the temperature rise to acceptable levels.

This power supply is not fused at the input. For added protection, a 3A to 5A fuse should be used at the input.

Appropriately sized heavy-gauge wires should be used to connect the power supply to the EV kit and load.

Follow these steps to verify board operation. **Do not turn on the power supply until all connections are made.**

1) Connect a 220µF bulk storage capacitor at the input terminals of the EV kit. This capacitor should be rated for 100V and be able to handle 1.5A of ripple current.
2) Connect a +36V to +72V power supply to the pads labeled VIN. The positive power-supply terminal should connect to $+V_{IN}$ and the negative power-supply terminal should connect to $-V_{IN}$. The power supply must be rated to at least 3A. The input voltage to the MAX5003 EV kit should not exceed 80V at any time.
3) Connect a variable load capable of sinking at least 10A at 5V and a voltmeter to the pads labeled $+V_O$ and $-V_O$.
4) Set the load current to approximately 5A.
5) Turn on the input power and verify that the output voltage is +5V.
6) To evaluate the load regulation of the EV kit, vary the load from 0 to 10A and record the output voltage variation as needed. For best measurement accuracy, the voltmeter must be connected right to the output pads of the EV kit.
7) To evaluate the line regulation of the EV kit, vary the input voltage from +36V to +72V and record the output voltage.

Note: The MAX5003 EV kit undervoltage lockout circuitry has been designed to shut down when the input supply voltage is under 32V.

Power Supply Typical Specifications

Table 1 summarizes the typical performance of the 50W power supply.

Table 1. Typical Specifications

Output Power	50W
Input Voltage (V_{IN})	±36V to ±72V
Output Voltage (V_{OUT})	+5V
Output Current (I_{OUT})	10A
Initial Output Accuracy	±3%*
Output Voltage Regulation	0.3%, over line and load
Efficiency	85% at 48V and 25W
Input Output Isolation	1500V for 1s
Switching Topology	Feedforward Compensated Forward Converter
Dimensions	4.05in x 1.3in

**Initial setpoint accuracy can be improved by using tighter tolerance resistor divider (R11 and R12).*

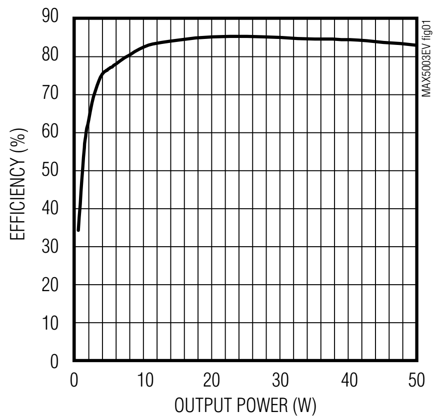

Figure 1. Efficiency vs. Output Power

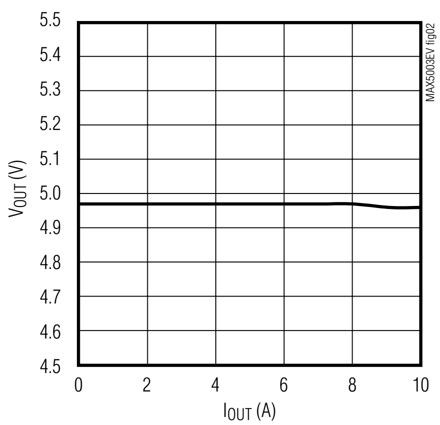

Figure 2. Output Voltage Regulation vs. Output Current

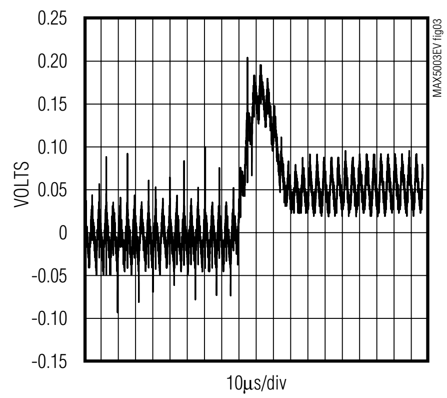

Figure 3. Output Transient Response (I_{OUT}: 10A to 0.8A)

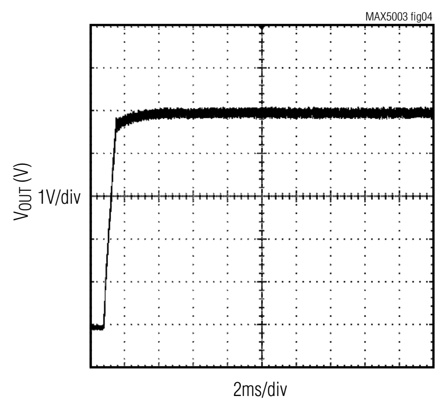

Figure 4. Output Voltage Transient At Power-Up (V_{IN} = 48V, I_{OUT} = 5A)

Power-Supply Performance

Key performance characteristics of the power supply include efficiency and output voltage regulation. Figure 1 shows the efficiency vs. output power. The efficiency reaches 85% at about 25W of output power and stays relatively flat up to 50W. Even though the efficiency is very high, heatsinking is required for the power MOSFET and output diode. The diode will dissipate about 6W with a 10A output current and the MOSFET can be expected to dissipate about 3W to 4W at full 50W load. Sufficient airflow over the power supply is recommended to cool down the power transformer and output inductor.

Figure 2 shows the output voltage regulation of the power supply from 0 to 10A of output current. Voltage measurement was done across the output voltage sense points $+V_O$ and $-V_O$.

Another interesting performance waveform for power supplies is the output voltage transient response to a step change in output current. Figure 3 shows load transient response when the load is stepped from 10A to 0.8A.

As can be seen from Figure 3, the initial transient response time is less than 30µs. This is a side benefit of using an optocoupler in conjunction with a TL431 shunt regulator for isolation.

Figure 4 shows the well-behaved startup characteristics of this power supply, which are characterized by the monotonic rise of the output voltage as well as the absence of any overshoots at the end of the rise period.

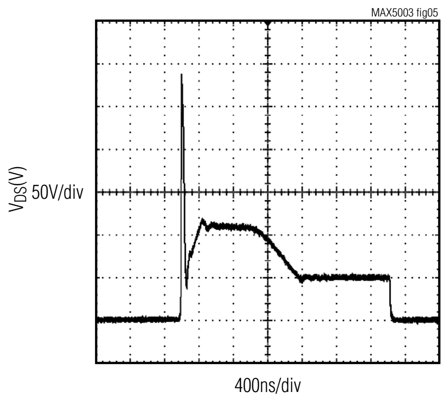

Figure 5. Drain-Source Voltage Waveform

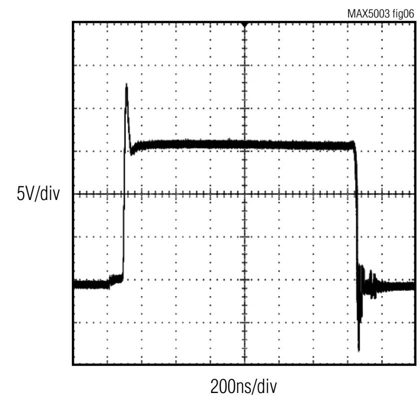

Figure 6. Waveform at Cathode of D4

The Power Circuit Topology

Among the several power topologies available, the single-transistor forward topology offers a simple and low-cost solution and provides very good efficiency throughout the operating power range. However, this topology requires a transformer reset winding connected to pins T1–3 and T1–4 (Figure 7). The forward converter was chosen because it offers higher power density and higher efficiency than a flyback converter at these power levels. Transformer T1 provides 1500V isolation between primary and secondary. Efficiency is further improved by powering the control circuit from a primary bias winding (T1–5, T1–6, Figure 7) after initial startup. A 250kHz switching frequency was selected to allow small form-factor transformer, inductor, and output capacitors.

Key Operating Waveforms

Key operating waveforms are always useful in understanding the operation of switching power supplies. A 10× oscilloscope probe is necessary for effective probing. A digital scope is very useful in capturing startup sequences. However, extreme caution should be exercised when probing live power supplies. For example, shorting the drain-source terminals of Q1 while power is applied is sure to produce a big spark and may damage the EV kit.

Figure 5 shows the drain-to-source waveform of Q1. Notice the leading-edge voltage spike. This is a result of the energy stored in transformer T1's leakage inductance.

Figure 6 shows the voltage at the output of the secondary rectifier (cathode of D4).

PC Board Layout and Component Placement

As with any other switching power supply, component placement is very important. Because of the primary-to-secondary isolation, the primary and secondary grounds are separated. Figure 10 clearly shows the separation on both sides of the PC board. The layout of the board can be changed to accommodate different footprints. Also, the power MOSFET and output rectifier should be mounted on a heatsink for best thermal management. In this implementation, both of these components are on the noncomponent side of the board, with their tabs mounted to the heatsink plate.

The critical layout considerations are as follows:

- Distance from the secondary transformer leads to diode D4 should be kept to a minimum. This will improve EMI as well as the effective available power transfer.
- Bypass capacitors C4, C5, and C6 should be as close as possible to T1–1.
- The PC board trace connecting T1–2 to the drain of Q1 should be as short as possible.
- The current-sense resistor R6 should be as close as possible to the source of Q1 and should return with a very short trace either to the ground plane or to the negative lead of bypass capacitors C4, C5, and C6.
- The gate-drive loop, consisting of pin 14 of MAX5003, R16, Q1, R6, and pin 13 of the MAX5003, must be kept as short as possible and preferably routed over a ground plane.
- Relevant trace spacing (relating to trace creepage) must be observed according to applicable safety agency guidelines.

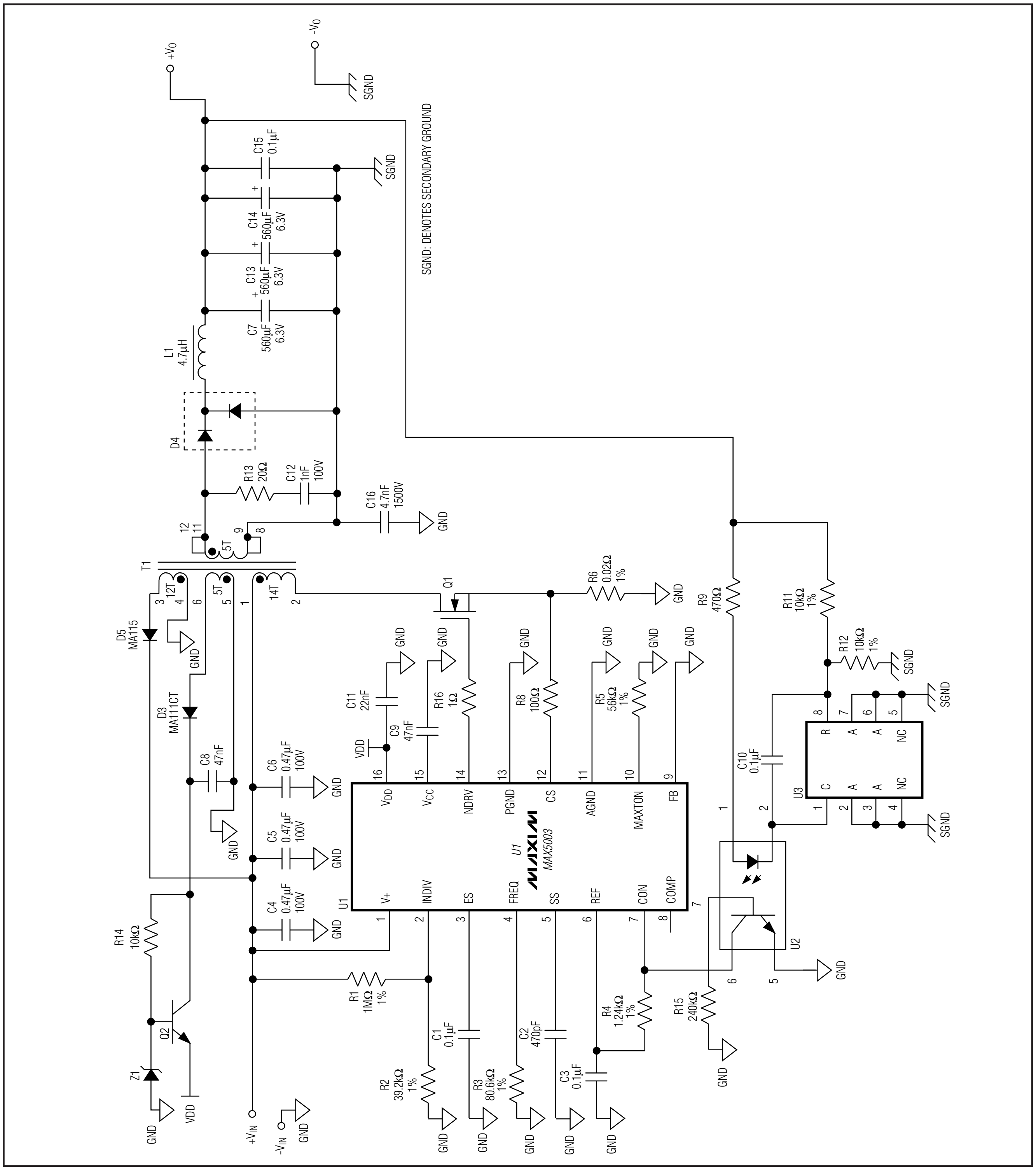

Figure 7. MAX5003 50W EV Kit Schematic

MAX5003-50W Evaluation Kit

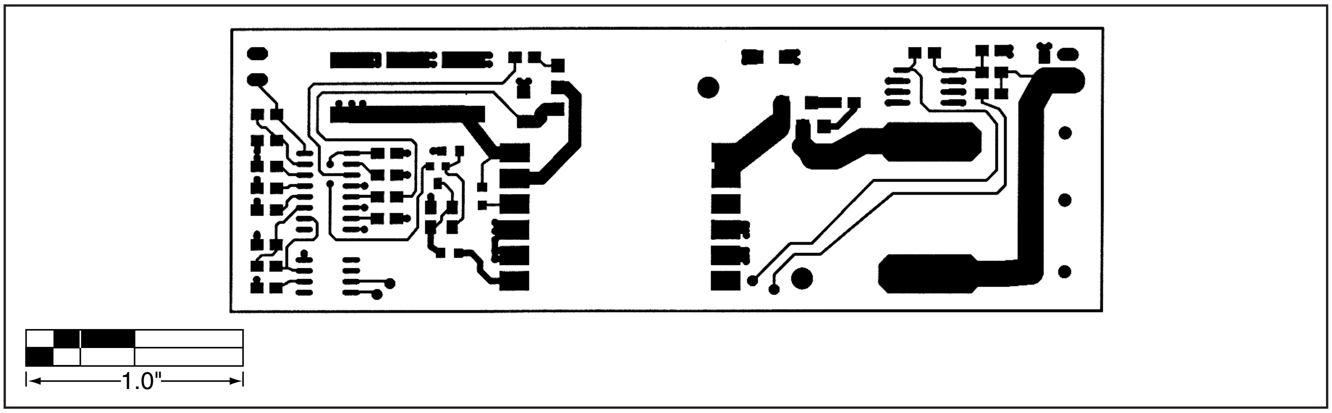

Figure 8. MAX5003-50W EV Kit PC Board Layout—Component Side

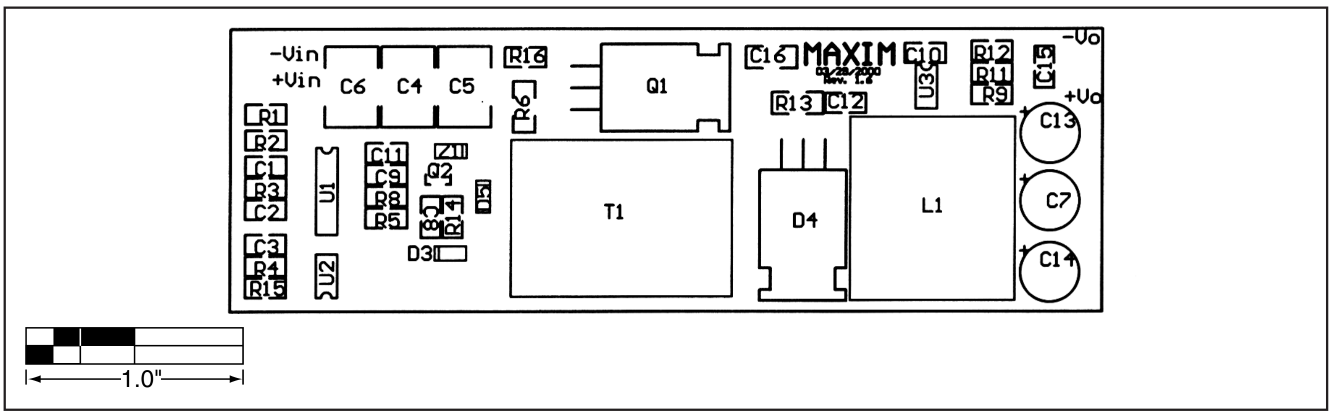

Figure 9. MAX5003-50W EV Kit Component Placement Guide—Component Side.
Note: Q1 and D4 are placed on the bottom side where their metal tabs are exposed to heatsink plate.

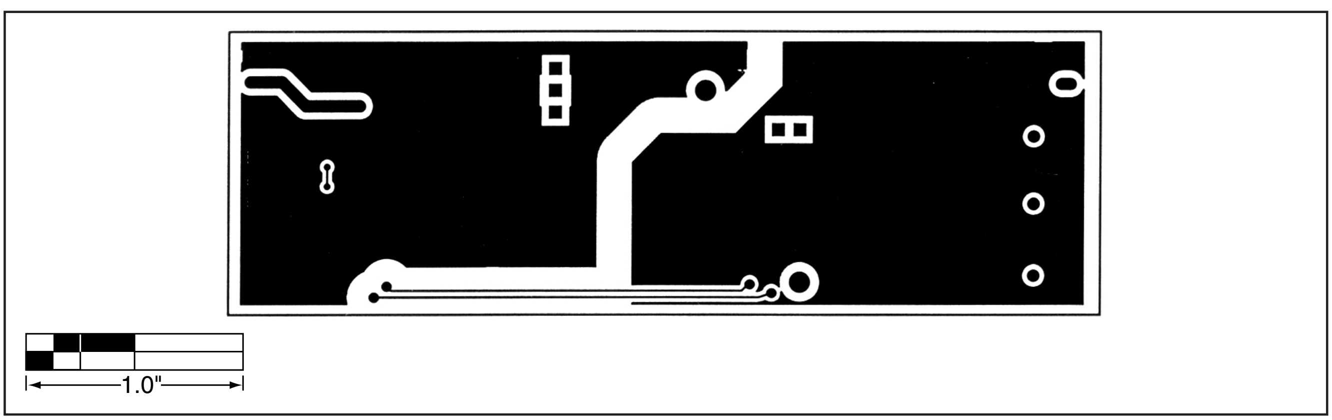

Figure 10. MAX5003-50W EV Kit PC Board Layout—Solder Side

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.