19-5764; Rev 0; 2/11

MAX17500A Evaluation Kit
Evaluates: MAX17500A

General Description

The MAX17500A evaluation kit (EV kit) is a fully assembled and tested circuit board that contains a 9W flyback DC-DC converter. The circuit is configured for +5V and +15V output voltages and provides up to 1.5A and 100mA of current at each respective output. Power for the circuit can be provided from either a +36V to +72V or -36V to -72V DC source.

High efficiency up to 81% is achieved using a flyback DC-DC converter topology. The surface-mount transformer provides up to +1500V galvanic isolation for both outputs. Low cost is achieved through the use of primary-side regulation, while undervoltage lockout (UVLO) and digital soft-start provide for a robust 9W isolated power supply.

Operation at 350kHz allows the use of small magnetics and output capacitors.

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 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

- **+36V to +72V or -36V to -72V DC Input Range**
- **Isolated Outputs**
  - **V_{OUT1}: +5V Provides Up to 1.5A**
  - **V_{OUT2}: +15V Provides Up to 100mA**
- **±5% (typ) Load Regulation for the +5V Output Set Point (150mA to 1.5A)**
- **81% Efficiency at +48V Input and Full Load**
- **Cycle-by-Cycle Current Limit**
- **350kHz Switching Frequency**
- **Digital Soft-Start**
- **High-Accuracy UVLO**
- **UVLO Open-Drain Flag Output**
- **Designed for +1500V Isolation with Primary-Side Regulation**
- **Low-Cost Flyback Design**
- **Proven PCB Layout**
- **Fully Assembled and Tested**

***Ordering Information* appears at end of data sheet.**

Component List

DESIGNATION	QTY	DESCRIPTION
C1, C2	2	1µF ±10%, 100V X7R ceramic capacitors (1812) TDK C4532X7R2A105K
C3	1	68µF, 6.3V electrolytic capacitor (V) KEMET A700V686M006ATE028
C4	1	22µF ±20%, 6.3V X5R ceramic capacitor (1206) TDK C3216X5R0J226M
C5	1	47µF, 25V electrolytic capacitor (6.3mm x 5.8mm) Panasonic EEVFK1E470P
C6	1	0.0047µF ±10%, 250V AC X7R ceramic capacitor (1825) Murata GA355DR7GC472KY02L

DESIGNATION	QTY	DESCRIPTION
C7, C11	2	0.22µF ±10%, 50V X7R ceramic capacitors (0805) Murata GRM21BR71H224KA01B
C8, C10, C19	0	Not installed, ceramic capacitors (0603)
C9	1	100pF ±2%, 50V C0G ceramic capacitor (0603) Murata GRM1885C1H101G
C12	1	15µF ±10%, 35V tantalum capacitor (D) KEMET T491D156K035AS
C13	1	1µF ±10%, 16V X7R ceramic capacitor (0805) TDK C2012X7R1C105KT

Component List (continued)

DESIGNATION	QTY	DESCRIPTION
C14	1	3900pF ±10%, 50V X7R ceramic capacitor (0603) Murata GRM188R71H392K
C15	1	1µF ±10%, 25V X7R ceramic capacitor (0805) TDK C2012X7R1E105KT
C16	1	1µF ±10%, 50V X7R ceramic capacitor (1206) Murata GRM31MR71H105K
C17	0	Not installed, ceramic capacitor (0805)
C18	1	0.1µF ±10%, 25V X7R ceramic capacitor (0603) Murata GRM188R71E104K
D1	1	40V, 10A Schottky diode (PowerDI® 5) Diodes Inc. PDS1040-13
D2	1	200V, 1.5A super-fast diode (SMD) Vishay BYG20D
D3	0	Not installed, 250V, 250mA high-voltage switching diode (SOD123) Central Semi CMHD2003 recommended
D4	1	5.6V, 0.5W zener diode (SOD123) Diodes Inc. BZT52C5V6
D5	1	18V, 0.5W zener diode (SOD123) Diodes Inc. BZT52C18
D6	1	75V, 250mA high-speed diode (SOT23) Central Semi CMPD914
D7	0	Not installed, 14V, 250mW zener diode (SOD323) Central Semi CMDZ5244B recommended

DESIGNATION	QTY	DESCRIPTION
D8	1	40V, 0.5A Schottky diode (SOT23) Zetex ZHCS500
JU1	1	2-pin header
L1	1	3A ferrite-bead inductor (1806) Fair-Rite 2518066007Y3
L2	1	100mA ferrite-bead inductor (0805) Fair-Rite 2508051027Y0
N1	1	200V, 1.2A n-channel MOSFET (8 SO) IR IRF7464PBF
R1	1	22.6kΩ ±1% resistor (0603)
R2	1	2.49kΩ ±1% resistor (0603)
R3	1	1.37MΩ ±1% resistor (0805)
R4	1	51.1kΩ ±1% resistor (0805)
R5	1	0.600Ω ±1% power resistor (1206) IRC LRC-LR1206LF-01-R600-F
R6	1	33kΩ ±5% resistor (1206)
R7, R12	2	1.2kΩ ±5% resistors (1206)
R8	0	Not installed, resistor (1206)
R9	1	75kΩ ±1% resistor (0603)
R10	1	4.7Ω ±5% resistor (0805)
R11	1	100Ω ±5% resistor (0603)
R13	1	10kΩ ±5% resistor (0805)
R14	1	14.3kΩ ±1% resistor (0805)
R15	1	750Ω ±5% resistor (0603)
T1	1	35µH, 10W, 1:0.536:0.214:0.429 turn 350kHz transformer (10 gull wing) Cooper Bussmann CTX03-17492-R
U1	1	Current-mode PWM controller (10 µMAX®) Maxim MAX17500AEUB+
—	4	Rubber bumpers
—	1	Shunt (JU1)
—	1	PCB: MAX17500A EVALUATION KIT

PowerDI is a registered trademark of Diodes Incorporated.
µMAX is a registered trademark of Maxim Integrated Products, Inc.

Componets Suppliers

SUPPLIER	PHONE	WEBSITE
Central Semiconductor Corp.	631-435-1110	www.centralsemi.com
Cooper Bussmann	916-941-1117	www.cooperet.com
Diodes Incorporated	805-446-4800	www.diodes.com
Fair-Rite Products Corp.	845-895-2055	www.fair-rite.com
International Rectifier	310-322-3331	www.irf.com
IRC, Inc.	361-992-7900	www.irctt.com
KEMET Corp.	864-963-6300	www.kemet.com
Murata Electronics North America, Inc.	770-436-1300	www.murata-northamerica.com
Panasonic Corp.	800-344-2112	www.panasonic.com
TDK Corp.	847-803-6100	www.component.tdk.com
Vishay	402-563-6866	www.vishay.com
Zetex Semiconductor (now a Division of Diodes Incorporated)	805-446-4800	www.diodes.com

Note: *Indicate that you are using the MAX17500A when contacting these component suppliers.*

Quick Start

Required Equipment

- MAX17500A EV kit
- +36V to +72V power supply capable of providing up to 1A
- Two voltmeters
- 22µF, +100V bulk-storage capacitor to be connected to the input terminals on the EV kit

Procedure

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) Connect the first voltmeter to the VOUT1 and SGND PCB pads.
2) Connect the second voltmeter to the VOUT2 and SGND PCB pads.
3) Connect a 750mA load to VOUT1 and a 50mA load to VOUT2.
4) Verify that a shunt is not installed on jumper JU1 ($\overline{SHDN}$).
5) Connect the power supply's positive terminal to the +VIN PCB pad. Connect the power supply's ground to the -VIN PCB pad.
6) Turn on the power supply above +36V and verify that the voltmeter at VOUT1 reads approximately +5V.
7) Verify that the voltmeter at VOUT2 reads approximately +15V.

The maximum current for each output should be limited to less than 1.5A for VOUT1 and 100mA for VOUT2.

For instructions on selecting the feedback resistors for other output voltages, see the *Evaluating Other Output Voltages, Current Limits, and Undervoltage Lockouts* section.

Detailed Description of Hardware

The MAX17500A EV kit is a fully assembled and tested circuit board that contains a 9W isolated flyback DC-DC converter that provides a +5V and +15V output. The +5V output (V_{OUT1}) provides up to 1.5A and the +15V output (V_{OUT2}) provides up to 100mA. The circuit can be powered from either a +36V to +72V or -36V to -72V DC source. **The user must supply at least 22µF of bulk-storage capacitance at the input terminals (+VIN, -VIN).** The capacitor should be rated for +100V and be able to carry approximately 200mA of ripple current.

The flyback DC-DC converter achieves up to 81% efficiency. The single-transistor topology and primary-side regulation provide for a low-cost design by eliminating the need for an optocoupler and shunt reference on the secondary side. The EV kit provides cycle-by-cycle, primary-side current-limit protection. Current-sense resistor R5 senses the current through the transformer's (T1) primary winding, switching transistor (N1), and turns off the transistor when the trip level of +1V is reached. The surface-mount transformer provides galvanic isolation up to +1500V for both outputs. The EV kit features PCB pads for an RCD snubber network (R8, C10, D3) to minimize leakage energy ringing and clamp the voltage at the drain of MOSFET N1 during switching (with most MOSFETs this snubber circuit can be eliminated).

Primary-side regulation through feedback resistors R1 and R2, rectifier D6, and transformer T1 tertiary

windings provide ±5% regulation for the +5V output set point. Resistors R7 and R12 are adjusted to preload the tertiary winding for the desired +5V output set point and regulation. UVLO provides controlled turn-on and shutdown during brownouts, power-up, or power-down. The UVLO settings can be changed by replacing resistor R3. Startup resistor R6 and reservoir capacitor C16 enable the device to start up within approximately 37ms. The digital soft-start allows the output voltage to slowly ramp up in a controlled manner within 6ms.

The device controller switches at a fixed 350kHz frequency and is set by resistor-capacitor networks R14, R15/C18, and C19. The switching duty cycle is varied to control energy transfer to the isolated outputs. The maximum duty cycle is 50% for the EV kit's discontinuous current-mode flyback design.

Shutdown Mode (Jumper and Remote-Control Methods)

The EV kit features two methods to shut down the flyback DC-DC converter. Jumper JU1 can be used to shut down the flyback DC-DC converter. An alternate method, remote-control shutdown, can be done with a user-supplied open-collector/drain transistor or relay contact connected to the $\overline{SHDN}$ and -VIN PCB pads on the EV kit. Table 1 lists the shutdown mode.

Evaluating Other Voltages, Current Limits, and Undervoltage Lockouts

V_{OUT1} and V_{OUT2} Output Voltages

The EV kit's outputs (V_{OUT1} and V_{OUT2}) are set to +5V and +15V, respectively, by the T1 transformer tertiary windings, the transformer's respective secondary output windings, and the resistor-divider R1 and R2. To generate scaled output voltages other than +5V (+4.2V to +6.8V) and +15V (+12.3V to +20.2V), select different voltage-divider resistors (R1, R2). Resistor R2 is typically chosen to be less than 5kΩ. **When evaluating other output voltages, verify that the secondary outputs' components affected by increased voltage are rated for the appropriate voltage. Components C3, C4, C13, and D4 of V_{OUT1} and components C5, C15, and D5 should have their respective voltage rating evaluated.** Using the desired scaled output voltages, resistor R1 is then found by the following equation:

$$R1 = [[\{(V_{OUT1} - V_{VD1}) \times N_T/N_1\} - V_{VD6}]/V_{FB} - 1] \times R2$$

where:

V_{OUT1} is the +5V output.

N_T = 15 is the transformer's tertiary turns.

N_1 = 6 is the transformer's secondary V_{OUT1}, +5V output turns.

V_{FB} = +1.23V is the device reference voltage.

V_{VD6} = +1V is the circuit's tertiary winding, high-speed diode D6 forward-voltage drop.

V_{VD1} = +0.45V (typ) is the circuit's secondary-side Schottky diode D1 forward-voltage drop at 1.5A.

Both output voltages are scaled up or down since the respective transformer's secondary output turns set the actual voltage. Additionally, the maximum current for each output should be limited to less than 1.5A for V_{OUT1} and 100mA for V_{OUT2}.

Current Limiting

The EV kit features current limiting for the transformer's primary current. The device turns off switching MOSFET N1 when the voltage at the device's CS pin reaches +1V. Current-sense resistor R5 (0.6Ω) limits the transformer peak primary current to 1.67A (+1V/0.6Ω = 1.67A). This limits the average short-circuit current on the secondary outputs typically to 1.42A (average with I_{OUT2} = 100mA) and 0.52A (average with I_{OUT1} = 1.5A) for V_{OUT1} and V_{OUT2}, respectively. To evaluate a lower current limit, current-sense resistor R5 must be replaced with a different surface-mount resistor (1206 size), as determined by the following equation.

When considering the transformer's primary input current:

$$R5 = (V_{SENSE}/I_{PRIMARY})$$

where V_{SENSE} = +1V and $I_{PRIMARY}$ is the transformer's maximum primary current.

Undervoltage Lockout (UVLO)

The EV kit features an accurate UVLO circuit that prevents operation below the programmed input-supply start voltage. Resistors R3 and R4 set the voltage at the device's UVLO/EN pin, which determines the UVLO wake-up and shutdown levels of +1.23V (typ) and +1.17V (typ), respectively. To evaluate other wake-up and shut-down levels, replace R3 with another surface-mount

Table 1. Jumper JU1 Shutdown Mode

SHUNT POSITION	DEVICE UVLO/EN PIN	DEVICE OUTPUT
Not installed	UVLO resistors R3 and R4 determine startup voltage	Device enabled
Installed	Pulled low to -VIN	Shutdown mode

resistor (0805 size). Refer to the *Undervoltage Lockout* section in the MAX17499/MAX17500 IC data sheet for instructions on selecting resistor R3, as determined by the following equation:

$$R3 = ((V_{IN} - V_{UVLO})/V_{UVLO}) \times R4$$

where V_{IN} is the +36V to +72V supply voltage applied between the +VIN and -VIN PCB pads on the EV kit and V_{UVLO} = +1.23V (typ).

UVLO Flag (UFLG and FLG_PULL)

The EV kit features an open-drain UVLO flag output at the UFLG PCB pad. The UFLG signal can be used to indicate that a UVLO condition has occurred. A voltage source of up to +25V can be connected to the PCB's FLG_PULL PCB pad, which, along with resistor R13, pulls up the UFLG signal. Refer to the *UVLO Flag (UFLG)* section in the MAX17499/MAX17500 IC data sheet for instructions and additional information on using the device's UFLG pin.

Flyback Converter Waveforms

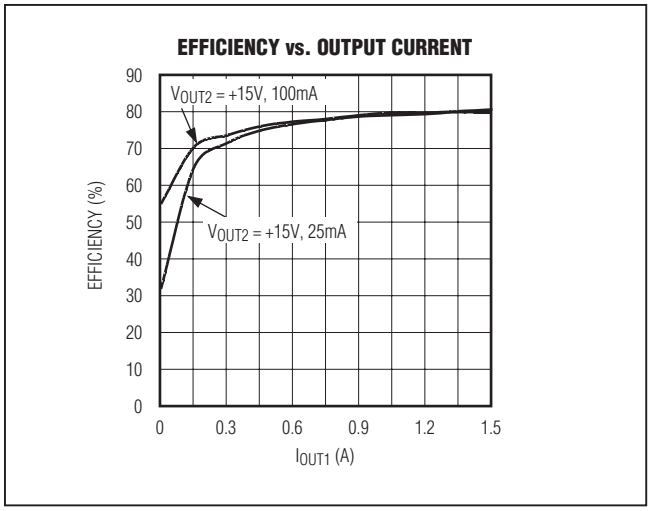

Figure 1. Efficiency vs. Output Current I_{OUT1} (+VIN = +48V)

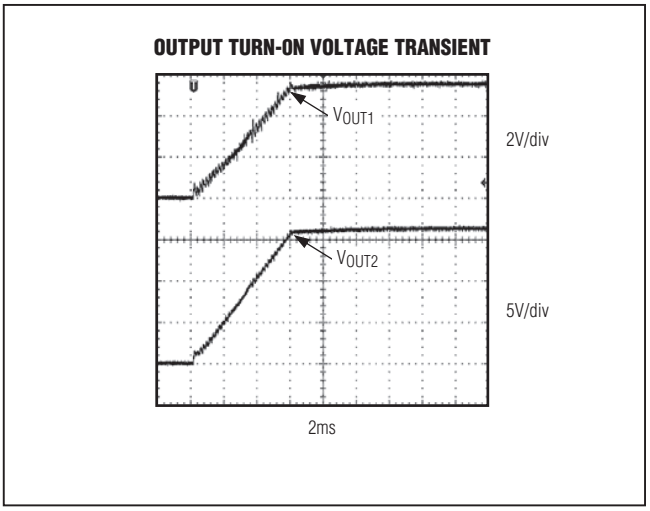

Figure 2. Output-Voltage Transient at Power-Up (+VIN = +48V, Channel 1 = V_{OUT1} (I_{OUT1} = 150mA), and Channel 2 = V_{OUT2} (I_{OUT2} = 25mA))

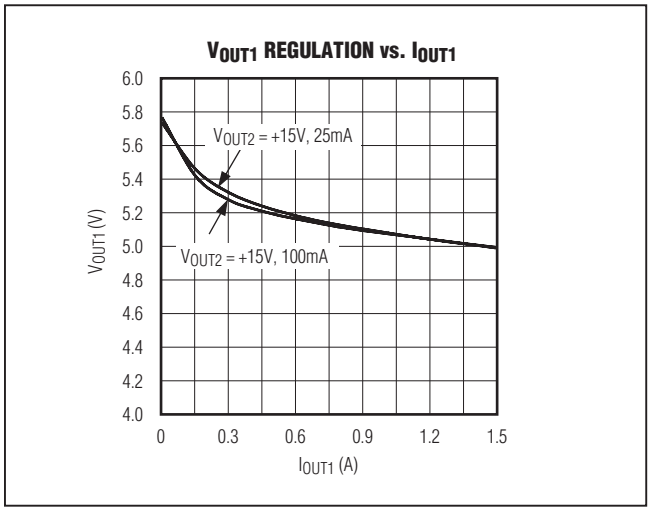

Figure 3. V_{OUT1} (+5V) Output-Voltage Regulation

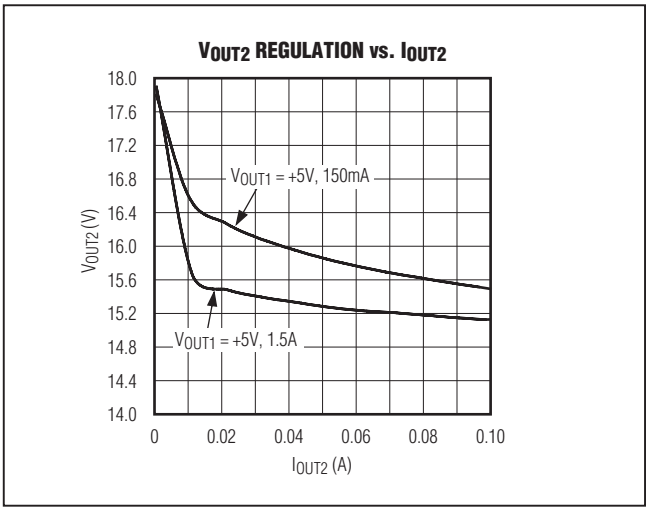

Figure 4. V_{OUT2} (+15V) Output-Voltage Regulation

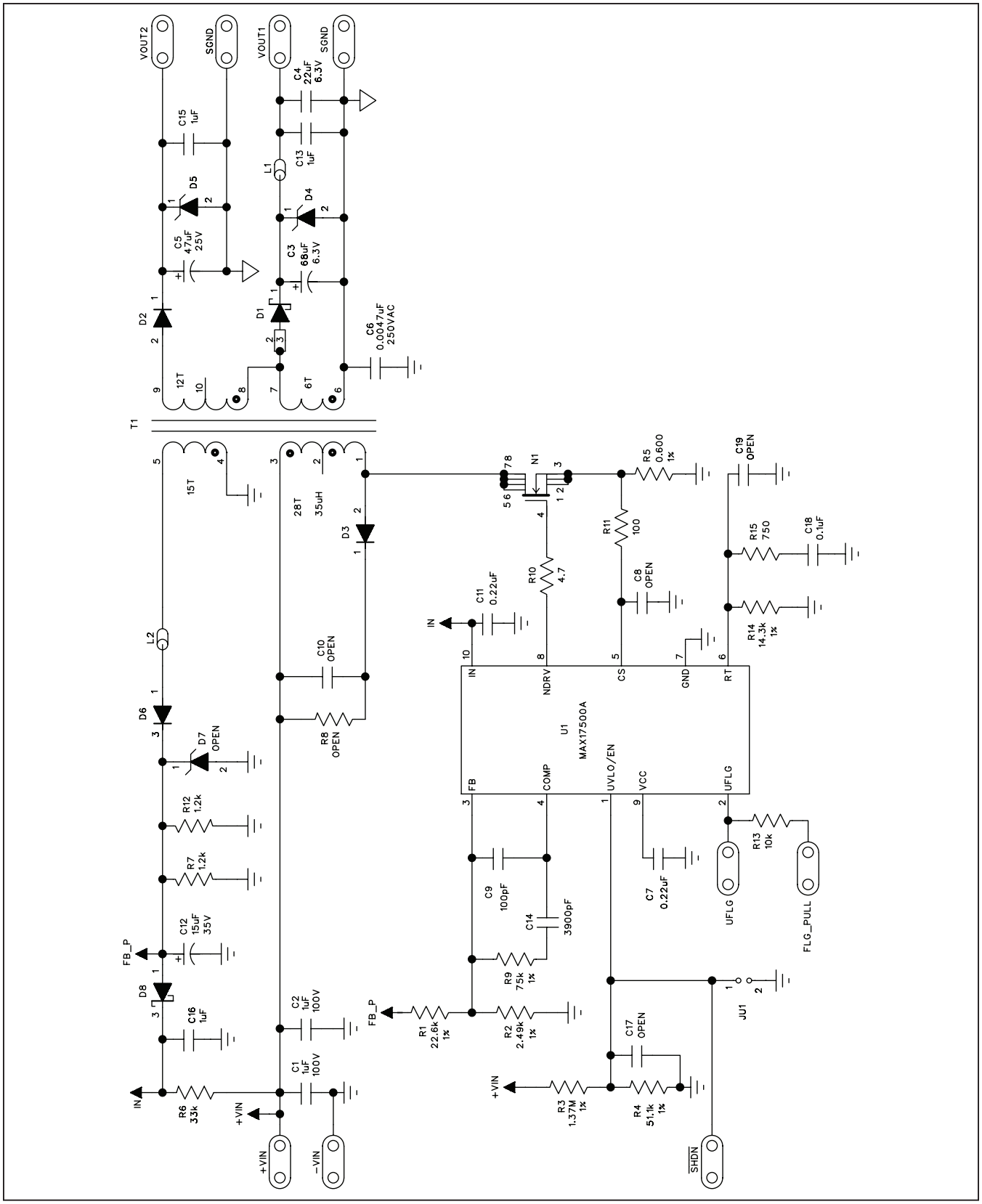

Figure 5. MAX17500A EV Kit Schematic

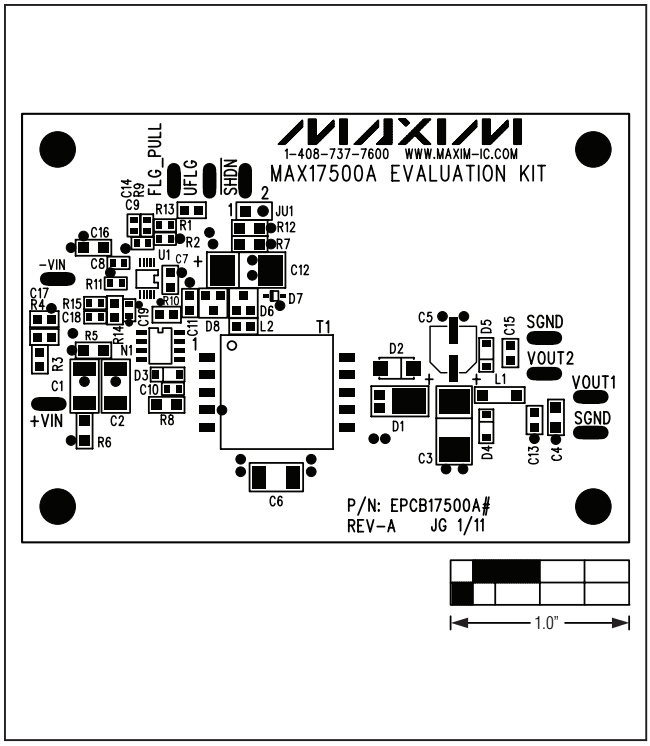

Figure 6. MAX17500A EV Kit Component Placement Guide—Component Side

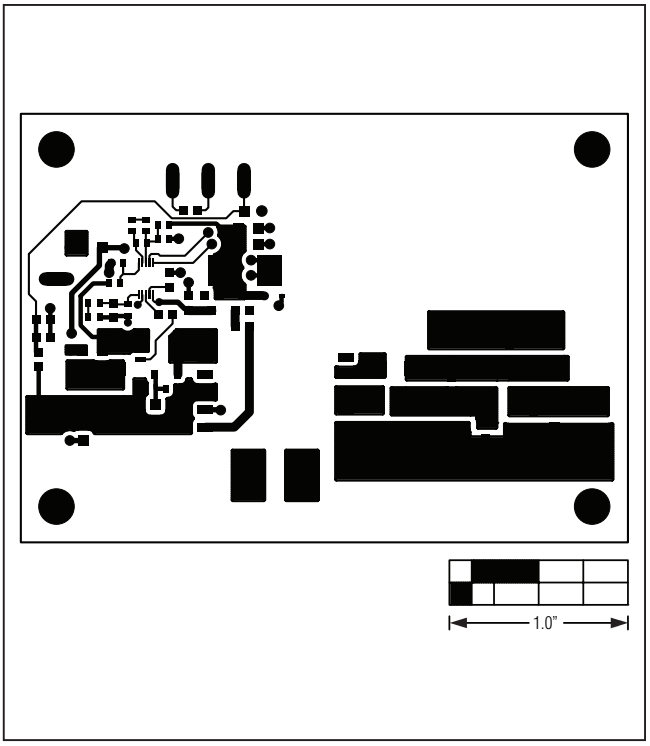

Figure 7. MAX17500A EV Kit PCB Layout—Component Side

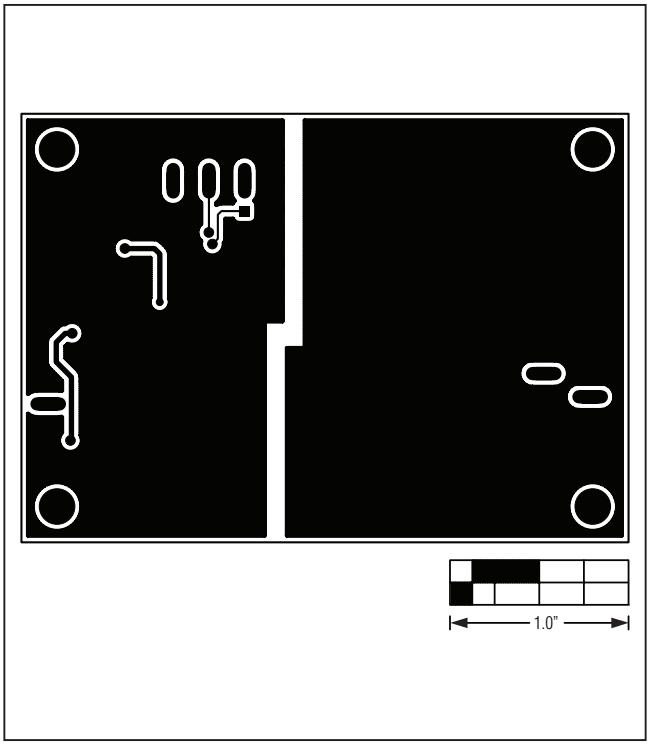

Figure 8. MAX17500A EV Kit PCB Layout—Solder Side

Ordering Information

PART	TYPE
MAX17500AEVKIT	EV Kit

Revision History

REVISION NUMBER	REVISION DATE	DESCRIPTION	PAGES CHANGED
0	2/11	Initial release	—