MAX17598 Evaluation Kit

MAX17598 in Active-Clamp Forward Converter Topology

General Description

The MAX17598 evaluation kit (EV kit) is a fully assembled and tested surface-mount circuit board that contains a peak-current-mode controller for an active-clamp forward regulator. The EV kit is configured for an isolated 3.3V DC output voltage that can supply up to 8A of current. The input voltage range is from 36V DC to 72V DC.

The EV kit demonstrates low quiescent current and efficiency up to 93.6%. High efficiency is achieved by using an active-clamp forward converter topology, with self-driven synchronous secondary MOSFETs on the output side. The EV kit is configured to operate at a 350kHz switching frequency. The surface-mount transformer has a bias winding to power the IC after startup. An optocoupler along with the transformer provide galvanic isolation between input and output, up to $3000V_{RMS}$.

Warning: The EV kit is designed to operate with high voltages. Dangerous voltages are present on this EV kit and on the 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 EV kit with care to avoid possible personal injury.

Features

- 36V DC to 72V DC Input Range
- Isolated Output Voltage: 3.3V DC at 8A
- Galvanic Isolation Up to $3000V_{RMS}$
- 350kHz Switching Frequency
- Efficiency Up to 93.6%
- Active-Clamp Forward Converter Topology
- Proven PCB Layout
- Fully Assembled and Tested

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

Component List

DESIGNATION	QTY	DESCRIPTION
C1	1	100pF ±20%, 25V X7R ceramic capacitor (0603) AVX 06033C101MAT2A
C2	1	22µF ±20%, 100V aluminum electrolytic capacitor (8mm diameter) Panasonic EEEFK2A220P
C3	1	2.2µF ±10%, 100V X7R ceramic capacitor (1210) Murata GRM32ER72A225K

DESIGNATION	QTY	DESCRIPTION
C4	1	330µF ±20%, 6.3V aluminum electrolytic capacitor (7.3mm x 4.3mm x 2.8mm) SANYO 6TPF330M9L
C5, C6	2	47µF ±10%, 6.3V X7R ceramic capacitors (1210) Murata GCM32ER70J476K
C7, C20	2	4.7µF ±10%, 50V X7R ceramic capacitors (1206) Murata GRM31CR71H475K

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Component List (continued)

DESIGNATION	QTY	DESCRIPTION
C8, C18	2	0.47µF ±10%, 25V X7R ceramic capacitors (0603) Murata GRM188R71E474K
C9	1	1µF ±10%, 25V X7R ceramic capacitor (0805) Murata GRM219R71E105K
C10	1	22nF ±10%, 250V X7R ceramic capacitor (0805) TDK C2012X7R2E223K
C11	1	0.047µF ±10%, 25V X7R ceramic capacitor (0603) Murata GRM188R71E473K
C12	0	Not installed, ceramic capacitor—short (PCB trace)
C13, C17	0	Not installed, ceramic capacitors (0603)
C14	1	2.2nF ±10%, 50V X7R ceramic capacitor (0603) TDK C1608X7R1H222K
C15	1	1000pF ±10%, 25V X7R ceramic capacitor (0603) Murata GRM188R71E102K
C16	1	100nF ±10%, 16V X7R ceramic capacitor (0603) Murata GRM188R71C104K
C19	1	33nF ±10%, 25V X7R ceramic capacitor (0603) Murata GRM188R71E333K
D1–D4	4	100V, 300mA fast-switching diodes (SOD123) Diodes Inc. 1N4148W-7-F
L1	1	10mH, 20mA inductor (6.6mm x 4.45mm) API Delevan SDS680R-106M
L2	1	1.5µH, 16.8A inductor Coilcraft SER1410-152ME
N1, N2	2	25V, 58A n-channel MOSFETs (8 PG-TDSON) Infineon BSC050NE2LS
N3	1	150V, 4.1A n-channel MOSFET (8 SO) Fairchild FDS86242
P1	1	-150V, -530mA p-channel MOSFET (3 SOT23) Vishay Siliconix Si2325DS-T1-GE3
R1	1	221kΩ ±1% resistor (0805)
R2, R3	2	10Ω ±1% resistors (0603)
R9, R12	2	0Ω ±5% resistors (0603)
R4	1	24.9kΩ ±1% resistor (0603)
R5	1	1.6MΩ ±1% resistor (0805)
R6, R13	2	10kΩ ±1% resistors (0603)
R7	1	35.7kΩ ±1% resistor (0603)
R8	1	20kΩ ±1% resistor (0603)
R10	1	221Ω ±1% resistor (0603)
R11, R23	2	49.9kΩ ±1% resistors (0603)
R14	1	10kΩ ±1% resistor (0603)
R15, R16, R20	0	Not installed, resistors (0603)
R17	1	470Ω ±1% resistor (0603)
R18	1	28.7kΩ ±1% resistor (0603)
R19	1	100Ω ±1% resistor (0603)
R21	1	0.1Ω ±1% resistor (1206) Panasonic ERJ-8BWFR100V
R22	1	30kΩ ±1% resistor (0603)
R24	1	22kΩ ±1% resistor (0603)
T1	1	100µH, 1.5A, 1:0.2:0.7 transformer (EFD20) Coilcraft MA5638-BL
U1	1	Peak-current-mode, active-clamp forward PWM controller (16 TQFN-EP*) Maxim MAX17598ATE+
U2	1	Phototransistor (4PIN, SO) Avago ACPL-217-56AE
U3	1	1.24V 0.5% shunt regulator (3 SOT23) Diodes Inc. TLV431BFTA
—	1	PCB: MAX17598 EVALUATION KIT

**EP = Exposed pad.*

Component Suppliers

SUPPLIER	PHONE	WEBSITE
API Delevan	408-865-0344	www.delevan.com
AVX Corporation	843-946-0238	www.avx.com
Coilcraft, Inc.	847-639-6400	www.coilcraft.com
Diodes Incorporated	805-446-4800	www.diodes.com
Fairchild Semiconductor	888-522-5372	www.fairchildsemi.com
Infineon Technologies AG	919-998-5334	www.infineon.com
Murata Electronics North America, Inc.	770-436-1300	www.murata-northamerica.com
Panasonic Corp.	800-344-2112	www.panasonic.com
SANYO Electric Co., Ltd.	619-661-6835	www.sanyo.com
TDK Corp.	847-803-6100	www.component.tdk.com
Vishay	402-563-6866	www.vishay.com

Note: *Indicate that you are using the MAX17598ATE when contacting these component suppliers.*

Quick Start

Required Equipment

- MAX17598 EV kit
- 36V to 72V DC power supply
- Electronic load
- Voltmeter

Warning:

- Do not turn on the power supply until all connections are completed.
- Wear protective eye gear at all times.
- Do not touch any part of the circuit with bare hands or conductive materials when powered up.
- Make sure all high-voltage capacitors are fully discharged before handling. Allow 5 minutes after disconnecting input power source before touching circuit parts.

Setup and Test Procedure

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

1) Connect the positive lead of the DC voltmeter to the VOUT PCB pad.
2) Connect the negative lead of the DC voltmeter to the PGND0 PCB pad.
3) Set the DC power-supply output to 36V. Disable the power supply.
4) Set the electronic load in constant-current (CC) mode. Disable the electronic load.
5) Connect the power-supply positive terminal to the INPUT PCB pad.
6) Connect the power-supply negative terminal to the PGND PCB pad.
7) Connect the electronic load across the VOUT and PGND0 PCB pads.
8) Enable the power supply.
9) Verify that VOUT is 3.3V throughout the input voltage range of 36V DC to 72V DC.
10) Enable the electronic load.
11) Verify that VOUT is 3.3V throughout the output current range of 0 to 8A.

Detailed Description of Hardware

The MAX17598 EV kit is a wide input voltage range, isolated, 26.4W output power, active-clamp forward converter, configured for a 3.3V DC, 8A output. A bias winding in the transformer is used to power the MAX17598 during normal operation. The secondary winding provides 3.3V DC output that can supply up to 8A.

This EV kit uses the MAX17598ATE in a 16-pin TQFN package with exposed pad, peak-current-mode, and pulse-width modulating (PWM) controller. This PWM controller varies the duty cycle to compensate for the variation in input voltage and the output load current to maintain constant output voltage. The duty cycle determines the on/off duration of the main (N3) and auxiliary (P1) MOSFETs. The P1 MOSFET functions as an active-clamp switch that implements the active-clamp transformer reset topology in forward converters. The two MOSFETs are used as switches to control the current through the primary winding of the transformer (T1).

The duty cycle is controlled by the feedback loop consisting of voltage-divider resistors (R11, R22), shunt regulator (U3), optocoupler (U2), and the error amplifier and current-mode PWM comparator inside the IC. This network chain provides isolated voltage mode feedback, regulating the output voltage to 3.3V ±3% with up to $3000V_{RMS}$ galvanic isolation.

Current Limit

The IC features current limiting in the transformer's primary side by monitoring peak current through the sense resistor (R21). R21 programs the maximum peak-current-limit setting. The IC turns off its internal switch when the peak current reaches the current limit. Use the following equation to calculate the value of R21:

$$R21 = \frac{305}{1.2 \times I_{PRI\_PEAK}} m\Omega,$$

where I_{PRI_PEAK} is the maximum operational peak current in the primary side of the transformer in amps, and R21 is in mΩ.

Undervoltage Lockout and Overvoltage Protection

The EV kit features an input UVLO and OVI circuit that prevents operation below the programmed input supply startup voltage and above the overvoltage threshold. Resistors R5, R7, and R4 set the undervoltage and overvoltage thresholds. The circuit undervoltage and overvoltage thresholds are set at 33V DC (typ) and 80.7V DC (typ), respectively. To reconfigure the UVLO and OVI voltages, refer to the *Startup Voltage and Input Overvoltage Protection Setting (EN/UVLO, OVI)* section in the MAX17598/MAX17599 IC data sheet.

EN/UVLO and OVI PCB pads are available for monitoring the voltages present at the respective inputs.

Soft-Start

The EV kit provides an option to configure the circuit soft-start period. Capacitor C16 configures the soft-start time (t_{SS}) to 5ms. To reconfigure the soft-start time to a different value, use the following equation to choose a new C16 capacitor:

$$C16 = \frac{10 \times t_{ss}}{V_{COMP} - 1.81} nF$$

where t_{SS} is in ms, V_{COMP} is the steady-state COMP voltage ($V_{COMP,MAX}$ = 2.6V), and C16 is in nF.

Slope Compensation

The EV kit operates at a maximum duty cycle of 46%. A minimum amount of slope signal is added to the sensed current signal, even if the operating duty cycle is below 50%, to provide stable, jitter-free operation. The EV kit is configured for default minimum slope with the SLOPE pin left unconnected. To reconfigure the slope compensation to a different value, use the following equation to choose a new R20 resistor:

$$R_{SLOPE} = \left(\frac{S_E - 8}{1.55}\right) k\Omega,$$

where R_{SLOPE} is in kΩ and S_E is in mV/µs.

Switching Frequency

The EV kit switching frequency is set to 350kHz by resistor R18. To configure the IC's switching frequency to a different value, between 100kHz and 1MHz, use the following equation to choose a new R18 resistor:

$$R18 = \frac{10^{10}}{f_{SW}} \Omega,$$

where f_{SW} is in Hz and R18 is in Ω.

Frequency Dithering

The EV kit switching frequency can be dithered in a range of ±10% to enable spread-spectrum operation. There are two specifications for the frequency dithering: frequency (how often) of dithering, and amount (how much) of dithering. Capacitor C12 configures the dither frequency using the following equation:

$$C12 = \frac{15.625}{f_{DITHER}} nF,$$

where f_{DITHER} is in kHz and C12 is in nF. A dither frequency f_{DITHER} = 1kHz is recommended.

Resistors R18 and R15 configure the amount of dithering in percentage (%) of the switching frequency using the following equation:

$$\%DITHER = \frac{R18}{R15},$$

The EV kit is shipped with the frequency dithering disabled, with the DITHER/SYNC pin shorted to SGND through PCB trace. To set the desired frequency dither, cut the PCB trace to place capacitor C12 and install resistor R15 with the appropriate values. The DITHER/SYNC PCB pad is available for monitoring the signal at the DITHER/SYNC pin.

Dead Time

The EV kit provides an option to configure the dead time between the main and AUX output pulses. Resistor R8 configures the dead time (t_{DT}) to 50ns. To reconfigure the dead time to a different value, use the following equation to choose a new R8 resistor:

$$R_8 = 0.4 \times t_{DT}\ k\Omega,$$

where t_{DT} is in ns and R8 is in kΩ.

EV Kit Performance Results

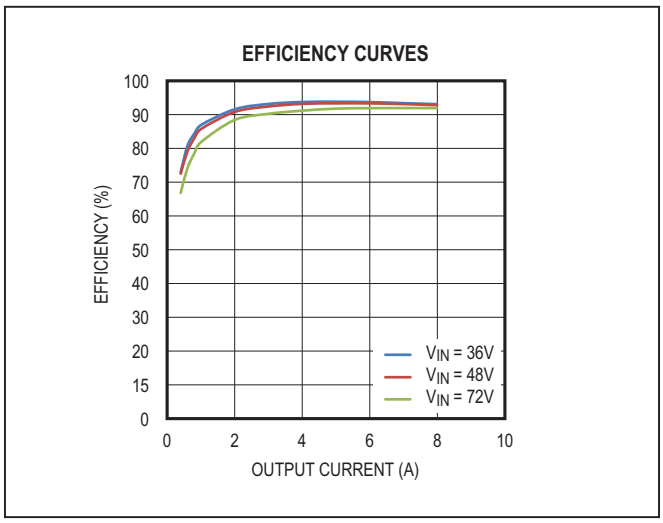

Figure 1. Efficiency Curves

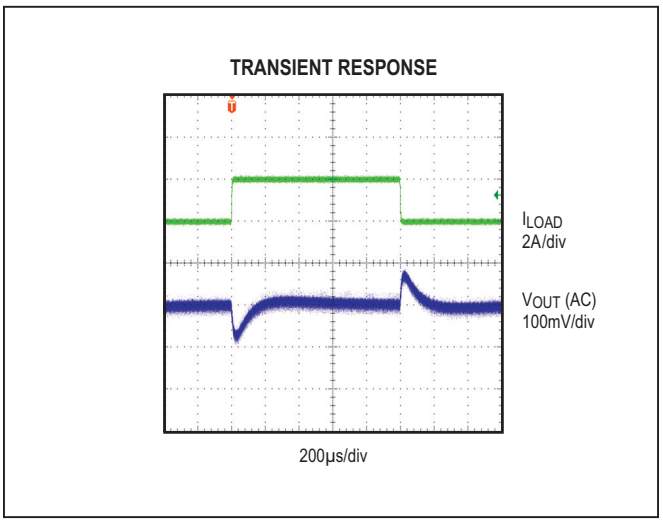

Figure 3. Transient Response

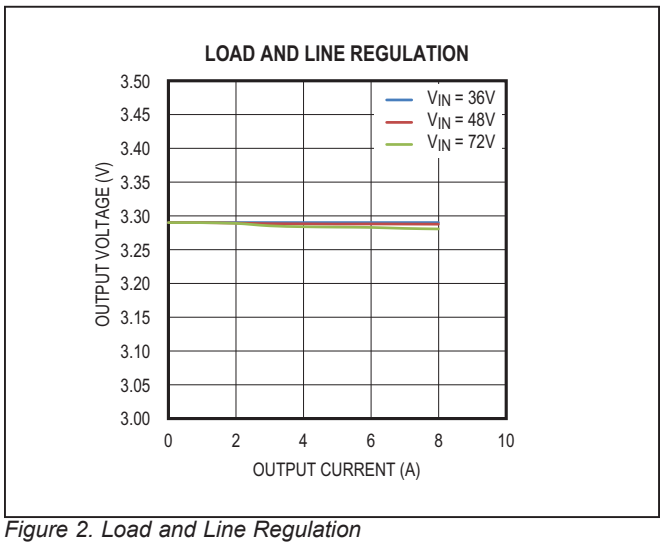

Figure 2. Load and Line Regulation

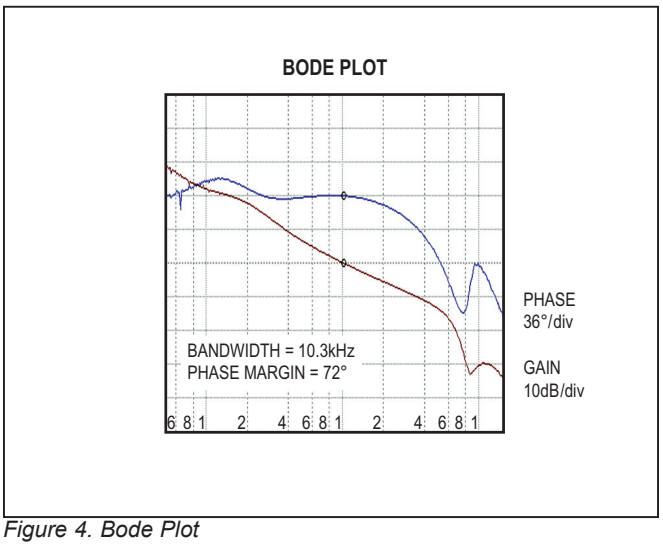

Figure 4. Bode Plot

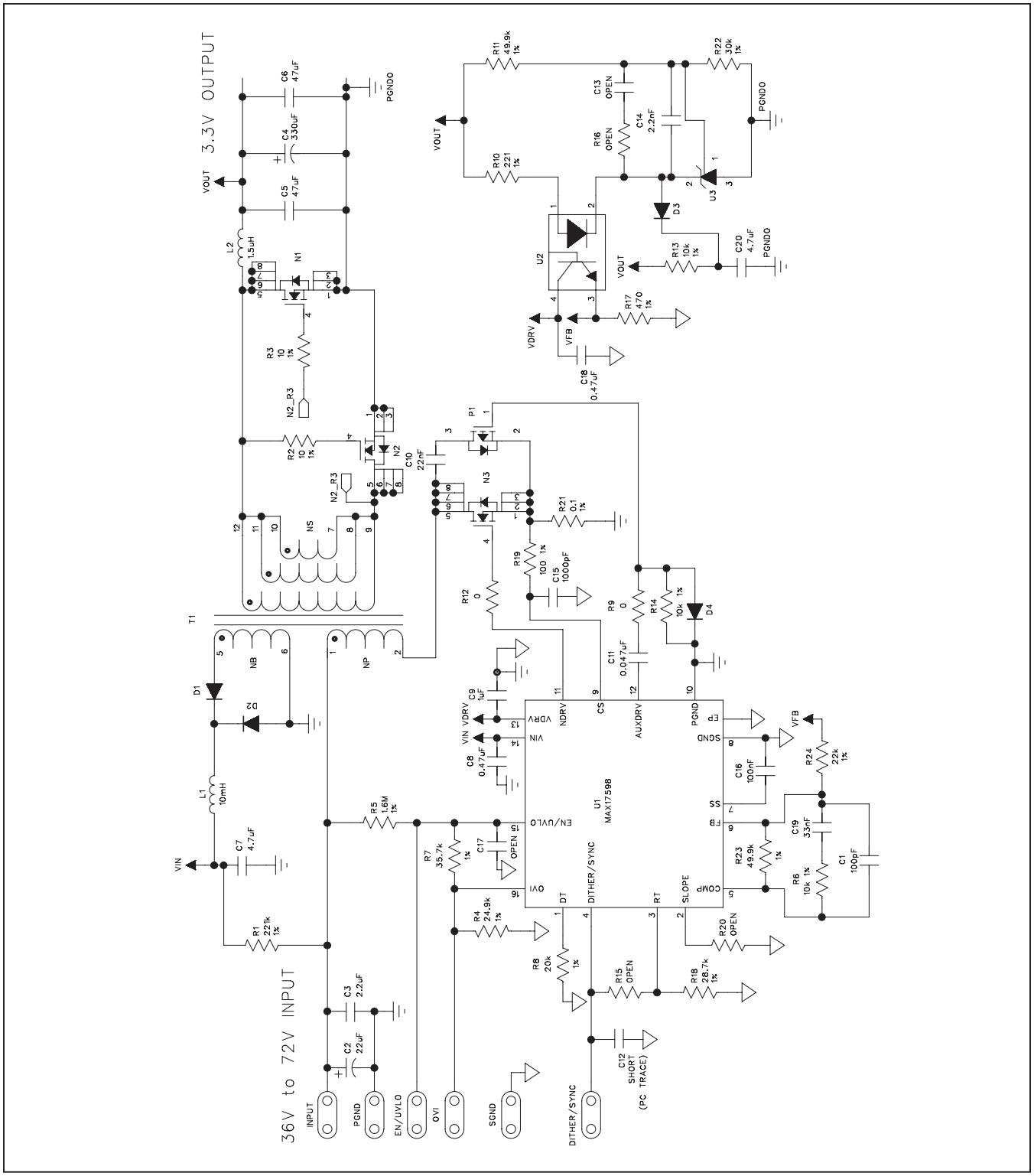

Figure 5. MAX17598 EV Kit Schematic

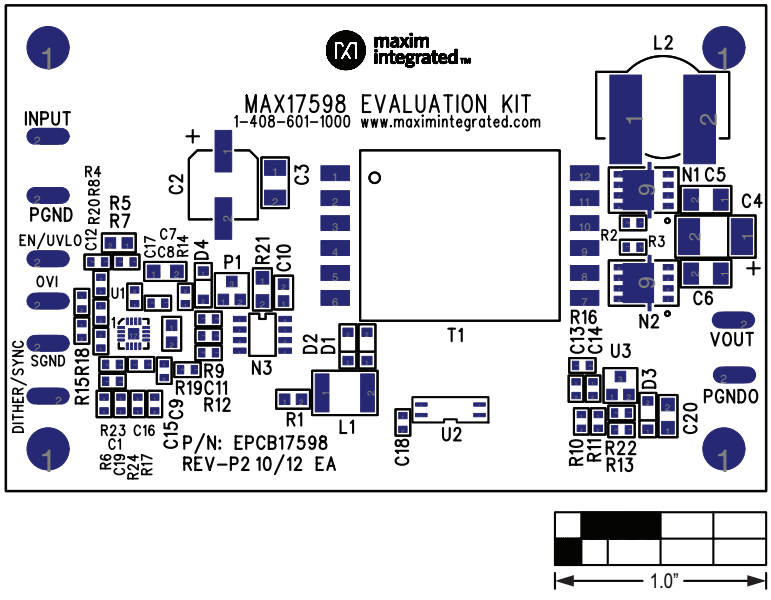

Figure 6. MAX17598 EV Kit Component Placement Guide—Component Side

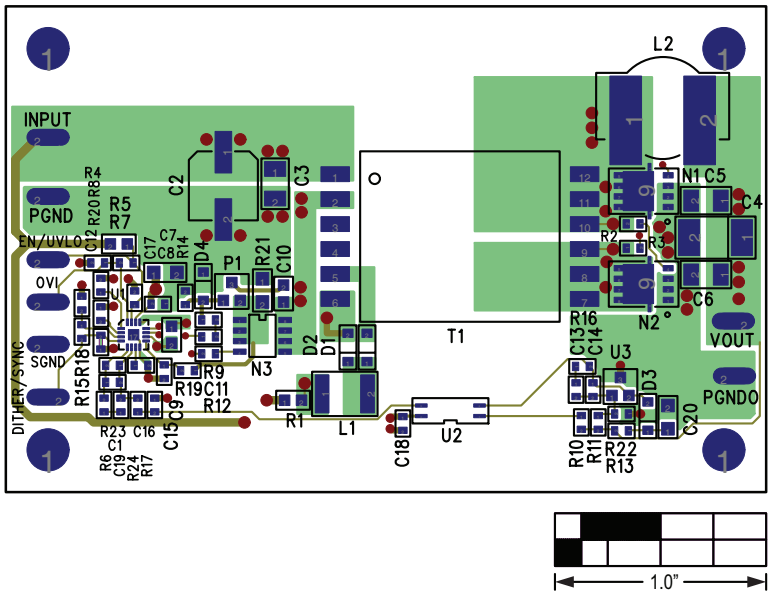

Figure 7. MAX17598 EV Kit PCB Layout—Component Side

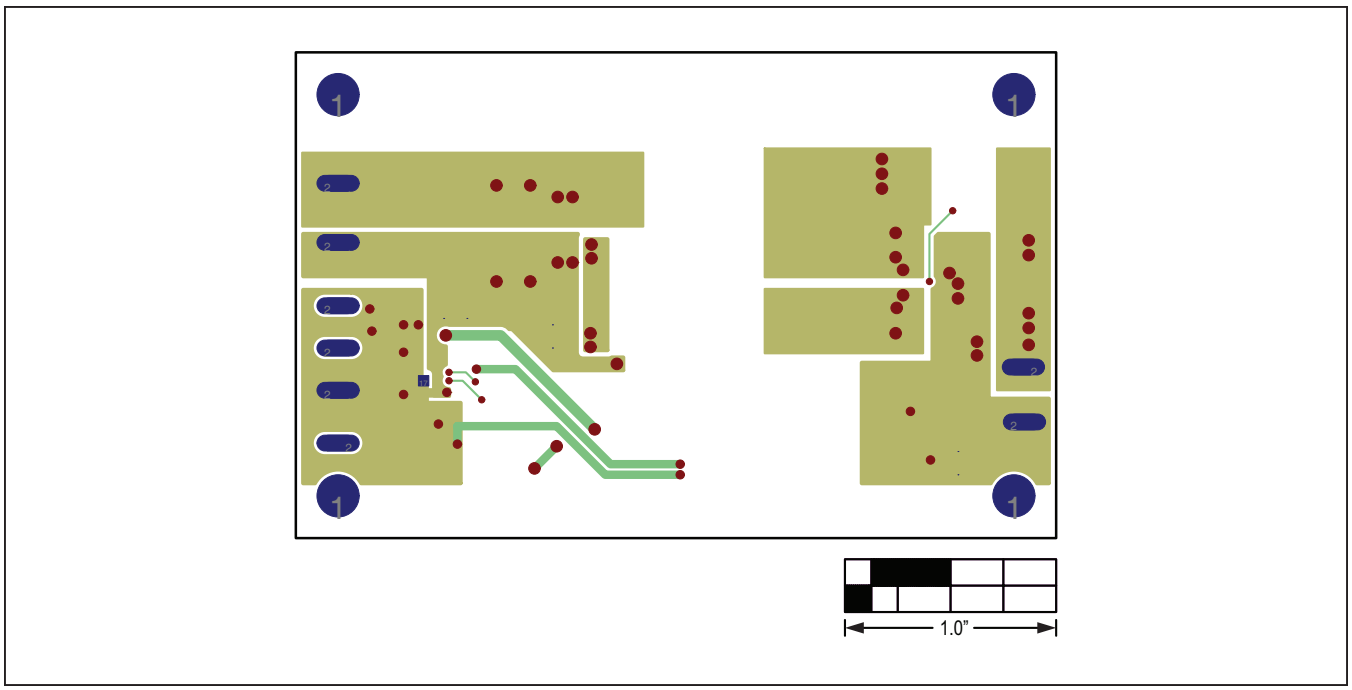

Figure 8. MAX17598 EV Kit PCB Layout—Solder Side

Ordering Information

PART	TYPE
MAX17598EVKIT#	EV Kit

#Denotes RoHS compliant.

Revision History

REVISION NUMBER	REVISION DATE	DESCRIPTION	PAGES CHANGED
0	2/13	Initial release	—
1	4/14	Updated R2, R3 component values	2, 6

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