# MAX17595 Evaluation Kit
# Evaluates: MAX17595 as Flyback Converter

## General Description

The MAX17595 evaluation kit (EV kit) is a fully assembled and tested circuit board that contains MAX17595 peak-current-mode controller for a flyback regulator. The EV kit is configured for an isolated 15V DC output voltage that can supply up to 1.5A current. The line input voltage range is from 85V AC to 265V AC or 120V DC to 375V DC.

The EV kit demonstrates low quiescent current and efficiency up to 86%. This high efficiency is achieved by using a single-transistor (MOSFET) flyback converter topology that operates at 120kHz switching frequency. The surface-mount transformer has a tertiary winding to power the IC after startup. An optocoupler, along with the transformer, provides galvanic isolation up to 3500$V_{RMS}$.

**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 EV kit with care to avoid possible personal injury.

## Features

- **85V AC to 265V AC or 120V DC to 375V DC Input Range**
- **15V DC at 1.5A Isolated Output Voltage**
- **Galvanic Isolation Up to 3500$V_{RMS}$**
- **120kHz Switching Frequency**
- **Efficiency Up to 86%**
- **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 | 1 | 0.1µF ±20%, 275V AC X2 plastic film capacitor (17mm x 5mm) Panasonic ECQ-U2A104ML |
| C2 | 1 | 0Ω ±5% resistor (0603) |
| C3, C12, C18 | 0 | Not installed, ceramic capacitors (0603) C3 is short (PC trace); C12, C18 are open |
| C4 | 1 | 56pF ±5%, 50V C0G ceramic capacitor (0603) Murata GRM1885C1H560J |
| C5 | 1 | 100µF ±20%, 450V aluminum electrolytic capacitor (25mm diameter) Panasonic ECO-S2GP101CA |

| DESIGNATION | QTY | DESCRIPTION |
|---|---|---|
| C6, C21 | 2 | 0.47µF ±10%, 25V X7R ceramic capacitors (0603) Murata GRM188R71E474K |
| C7 | 1 | 0.1µF ±10%, 16V X7R ceramic capacitor (0603) Murata GRM188R71C104K |
| C8 | 1 | 1µF ±10%, 25V X7R ceramic capacitor (0603) Murata GRM188R71E105K |
| C9 | 1 | 4.7µF ±10%, 50V X7R ceramic capacitor (1206) Murata GRM31CR71H475K |
| C10 | 1 | 3300pF ±10%, 250V X7R ceramic capacitor (0805) Murata GRM21AR72E332K |

**For pricing, delivery, and ordering information, please contact Maxim Direct at 1-888-629-4642, or visit Maxim Integrated's website at www.maximintegrated.com.**

*19-6339; Rev 2; 11/14*

## Component List (continued)

| DESIGNATION | QTY | DESCRIPTION |
|---|---|---|
| C11 | 1 | 1000pF ±10%, 50V X7R ceramic capacitor (0603) Murata GRM188R71H102K |
| C13–C16 | 4 | 22µF ±10%, 25V X7R ceramic capacitors (1210) Murata GRM32ER71E226K |
| C17 | 1 | 68nF ±10%, 50V X7R ceramic capacitor (0603) TDK C1608X7R1H683K |
| C19 | 0 | Not installed, capacitor (0805) |
| C20 | 1 | 2200pF ±20%, 250V X7R ceramic capacitor (11mm diameter) TDK CD12-E2GA222MYNS |
| D1 | 1 | 600V, 1.5A bridge rectifier (DF-S) Diodes Inc. DF1506S |
| D2 | 1 | 100V, 300mA fast-switching diode (SOD123) Diodes Inc. 1N4148W-7-F |
| D3 | 1 | 800V, 1A ultra-fast rectifier (SMA) Diodes Inc. US1K-TP |
| D4 | 1 | 200V, 6A ultra-fast recovery rectifier (5 PowerDI) Diodes Inc. PDU620-13 |
| D5 | 1 | 0Ω ±5% resistor (1206) |
| L1 | 1 | 6.8mH, 0.8A line filter (13mm x 10mm) Würth Elektronik 7448640401 |
| N1 | 1 | 800V, 11A n-channel MOSFET (D2PAK) ST Micro STB11NM80T4 |
| R1 | 1 | 10Ω, 2A NTC thermistor (5mm) EPCOS B57153S0100M000 |
| R2–R4 | 3 | 549kΩ ±1% resistors (1206) |
| R5 | 1 | 19.8kΩ ±1% resistor (0603) |
| R6 | 1 | 4.99kΩ ±1% resistor (0603) |
| R7, R8, R17 | 0 | Not installed, resistors (1206) |
| R9 | 1 | 82.5kΩ ±1% resistor (0603) |
| R10, R11, R23–R25, R27 | 0 | Not installed, resistors (0603) |
| R12 | 1 | 49.9kΩ ±1% resistor (0603) |
| R13 | 1 | 22kΩ ±1% resistor (0603) |
| R14–R16 | 3 | 402kΩ ±1% resistors (1206) |
| R18 | 1 | 100kΩ ±5% resistor (1206) Panasonic ERJ-P08J104V |
| R19 | 1 | 10Ω ±1% resistor (0603) |
| R20 | 1 | 100Ω ±1% resistor (0603) |
| R21 | 1 | 0.2Ω ±1% resistor (1206) Panasonic ERJ-8BSFR20V |
| R22 | 1 | 470Ω ±1% resistor (0603) |
| R26 | 1 | 4.99kΩ ±1% resistor (0603) |
| R28 | 1 | 2.49kΩ ±1% resistor (0603) |
| R29 | 1 | 221Ω ±1% resistor (0603) |
| R30 | 0 | Not installed, resistor (0805) |
| T1 | 1 | 180µH, 0.8A, 1:0.24:0.2 transformer (EFD25) Coilcraft MA5475-AL |
| U1 | 1 | Peak-current-mode controller for flyback regulator (16 TQFN-EP*) Maxim MAX17595ATE+ |
| U2 | 1 | Phototransistor (6 DIP) Avago 4N35-300E |
| U3 | 1 | 1.24V, 0.5% shunt regulator (3 SOT23) Diodes Inc. TLV431BFTA |
| — | 1 | PCB: MAX17595 EVALUATION KIT |

**EP = Exposed pad.*

## Component Suppliers

| SUPPLIER | PHONE | WEBSITE |
|---|---|---|
| Coilcraft, Inc. | 847-639-6400 | www.coilcraft.com |
| Diodes Incorporated | 805-446-4800 | www.diodes.com |
| EPCOS AG | 732-906-4300 | www.epcos.com |
| Murata Electronics North America, Inc. | 770-436-1300 | www.murata-northamerica.com |
| Panasonic Corp. | 800-344-2112 | www.panasonic.com |
| STMicroelectronics | 408-452-8585 | www.us.st.com |
| TDK Corp. | 847-803-6100 | www.component.tdk.com |

***Note:*** *Indicate that you are using the MAX17595ATE+ when contacting these component suppliers.*

# MAX17595 Evaluation Kit
# Evaluates: MAX17595 as Flyback Converter

## Quick Start

### Required Equipment

- Isolation transformer
- Variac
- Two voltmeters

**Warnings:**

- Exercise **Caution** when connecting and measuring off-line voltages.
- Voltage at the primary side can be as high as 700V DC.
- Wear eye protective gear at all times.
- Do not touch any part of the circuit with bare hands or conductive materials when powering up.
- Make sure that all high-voltage capacitors are fully discharged before handling.

### VOUT Setup Procedure

The MAX17595 EV kit is fully assembled and tested. Follow these steps to verify board operation. **Caution: Do not turn on the power supply until all connections are completed.**

1) Connect the positive lead of a DC voltmeter to the VOUT PCB pad.
2) Connect the negative lead of a DC voltmeter to the GNDO PCB pad.
3) Make sure that the isolation transformer is not powered up. Connect the variac to the output of the isolation transformer.
4) Connect one lead of an AC voltmeter to the wiper terminal of the variac.
5) Connect the other lead of the AC voltmeter to one of the fixed terminals of the variac.
6) Set the output voltage of the variac to 0V AC.
7) Connect the wiper terminal of the isolated variac to the AC1 PCB pad on the EV kit.
8) Connect the fixed tap of the isolated variac to the AC2 PCB pad on the EV kit.
9) Power up the isolation transformer and gradually increase the voltage of the variac to 85V AC and up to 265V AC.
10) Verify that VOUT is 15V throughout the 85V AC to 265V AC input voltage range.

## Detailed Description of Hardware

The MAX17595 EV kit evaluates MAX17595 off-line flyback converter operating in discontinuous-conduction mode (DCM), configured for a 15V DC, 1.5A output.

This EV kit uses the peak current mode, pulse-width modulating (PWM) controller IC in a 16-pin TQFN package with an exposed pad. A simple RC charging circuit is used to start up the device. Bias winding feedback is used to supply power during normal operation. Input DC bus capacitor (C5) is designed based on 100Hz ripple content. The 100Hz ripple is chosen to be 25% at 85V AC and 1.5A load current. This PWM controller varies the duty cycle to compensate for the variation in $V_{IN}$ and the output load to maintain a constant output voltage. The duty cycle determines the on/off duration of the MOSFET (N1). The n-channel MOSFET is used as a switch to control the current through the primary winding of transformer T1.

The duty cycle is controlled by the feedback loop consisting of voltage-divider resistors (R28, R29), a shunt regulator (U3), an optocoupler (U2), and the PWM comparator inside the IC. This network provides isolated-voltage-mode feedback, regulating the output voltage to 15V ±2% with up to 3500$V_{RMS}$ galvanic isolation. A thermistor (R1) prevents high inrush currents present due to charging the input capacitor at startup. A snubber circuit (D3, C10, and R18) is used to prevent excessive drain voltages due to leakage inductance of the transformer.

### Current Limit

The IC features current limiting for the transformer's primary side by monitoring the peak current through the sense resistor (R21). Resistor R21 sets the EV kit circuit peak current ($I_{PEAK}$) to 1.52A. The IC turns off the N1 MOSFET when the peak current reaches the current limit. To reconfigure the peak current limit to a different value, use the following equation to choose a new R21 resistor:

$$R21 = \frac{305}{I_{PEAK}} m\Omega$$

where $I_{PEAK}$ is in amps and R21 is in mΩ.

### Undervoltage Lockout and Overvoltage Protection

The EV kit features a UVLO and OVI circuit that prevents operation below the programmed input supply startup voltage and above the overvoltage threshold. Resistors R2–R6 set the undervoltage and overvoltage thresholds. The circuit undervoltage and overvoltage thresholds are set at 60V AC (85V DC) and 274V AC (387V DC), respectively. To reconfigure the UVLO and OVI voltages, refer to the *Startup Voltage and Input Overvoltage Protection Setting (EN/UVLO, OVI)* section in the MAX17595/MAX17596/MAX17597 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. Capacitor C7 configures the soft-start time ($t_{SS}$) to 12ms. To reconfigure the soft-start time to a different value, use the following equation to choose a new C7 capacitor:

$$C7 = 8.2645 \times t_{SS}\ nF$$

where $t_{SS}$ is in ms and C7 is in nF.

### Switching Frequency

The EV kit switching frequency is set to 120kHz by resistor R9. To configure the IC's switching frequency to a different value, between 100kHz and 1MHz, use the following equation to choose a new R9 resistor:

$$R9 = \frac{10^{10}}{f_{SW}}\Omega$$

where $f_{SW}$ is in Hz and R9 is in Ω.

### Frequency Dithering

The EV kit switching frequency can be dithered in a range of ±10% to reduce EMI. There are two specifications for the frequency dithering: the frequency (how often) of dithering and the amount (how much) of dithering. Capacitor C2 configures the dither frequency using the following equation:

$$C2 = \frac{50\mu A}{3.2V \times f_{DITHER}}F$$

where $f_{DITHER}$ is in Hz and C2 is in farads, and the dither frequency ($f_{DITHER}$) is recommended to be set close to 1kHz.

Resistors R9 and R10 configure the amount of dithering in percentage (%) of the switching frequency using the following equation:

$$\%DITHER = \frac{R9}{R11}$$

The EV kit is shipped with the frequency dithering disabled and the DITHER/SYNC pin shorted to SGND by a 0Ω resistor installed on the C2 footprint. To set the desired frequency dither, replace capacitor C2 and install resistor R11 with the appropriate values. The DITHER/SYNC PCB pad is available for monitoring the signal at the DITHER/SYNC pin.

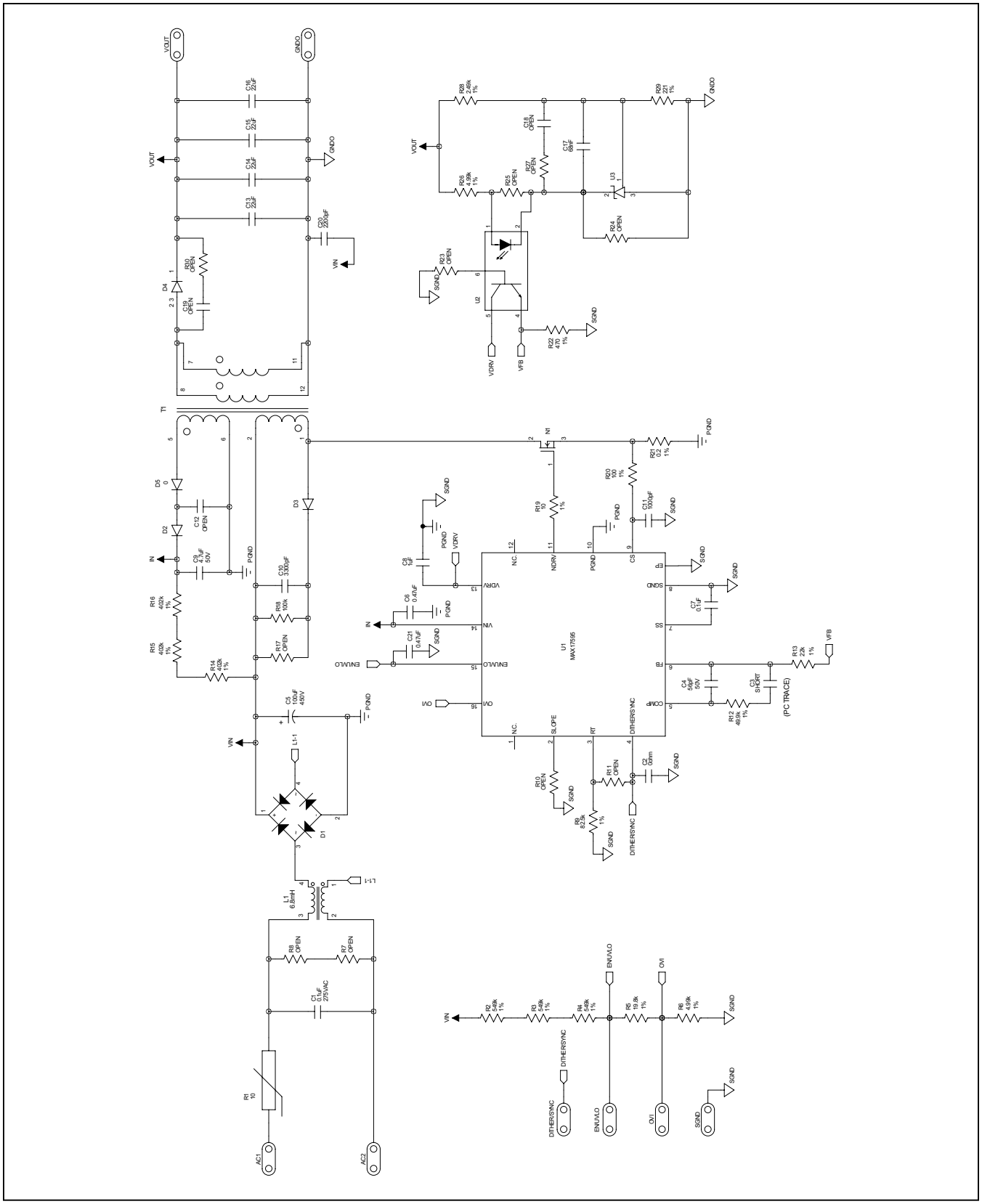



*Figure 1. MAX17595 EV Kit Schematic*

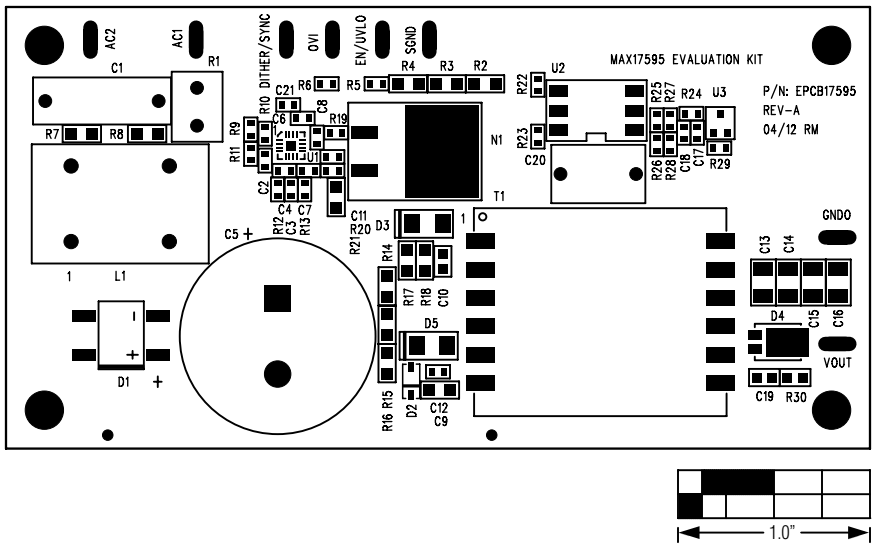



*Figure 2. MAX17595 EV Kit Component Placement Guide—Component Side*

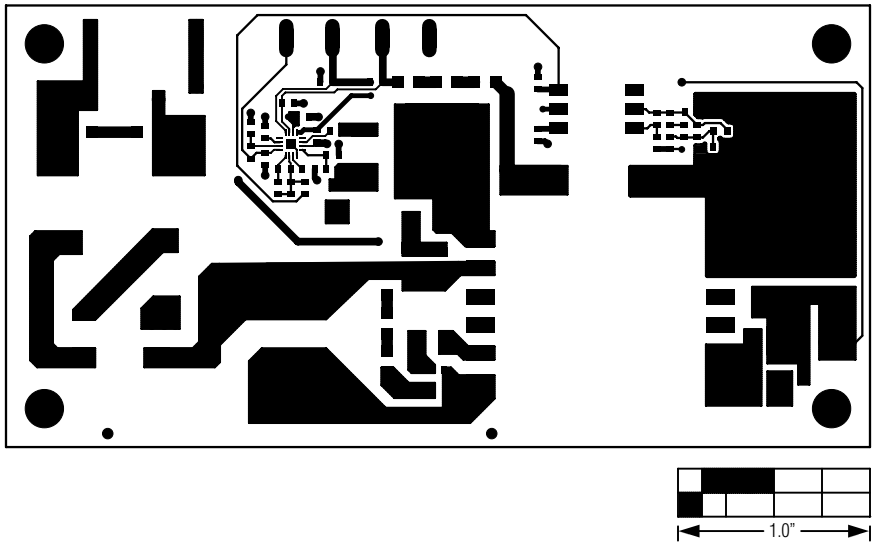



*Figure 3. MAX17595 EV Kit PCB Layout—Component Side*

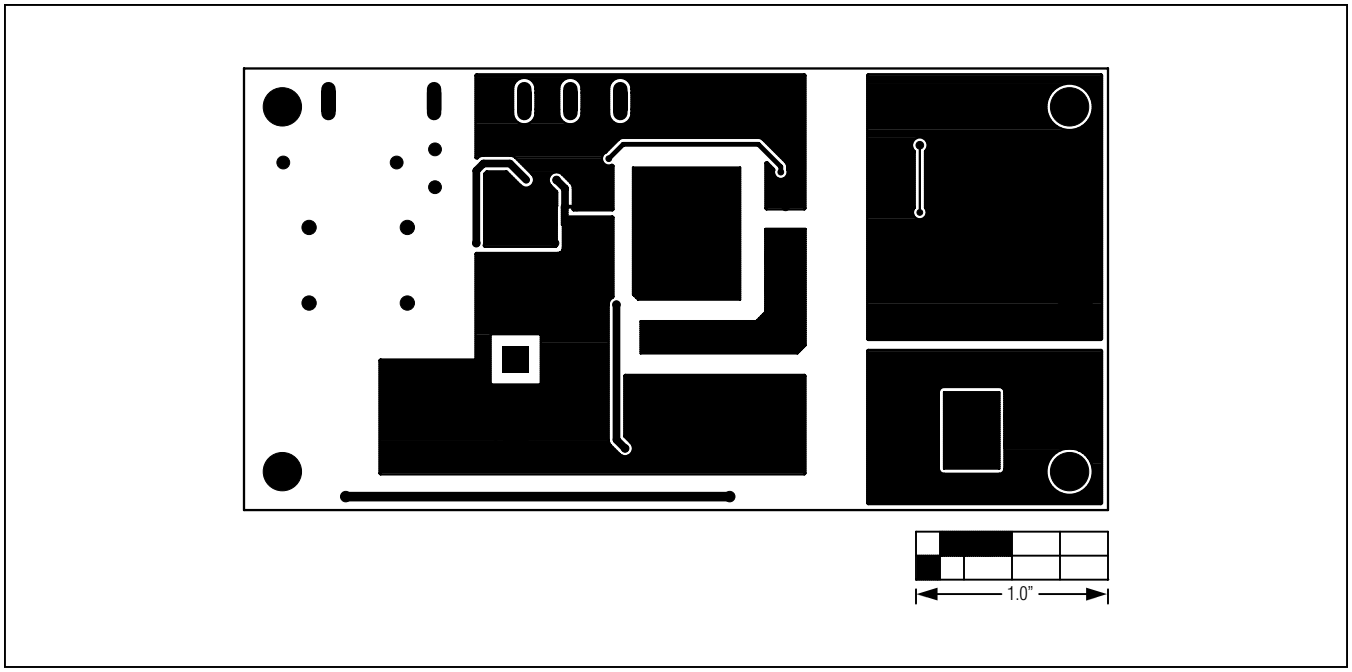



*Figure 4. MAX17595 EV Kit PCB Layout—Solder Side*

## *Ordering Information*

| PART | TYPE |
|---|---|
| MAX17595EVKIT# | EV Kit |

*#Denotes RoHS compliant.*

# MAX17595 Evaluation Kit
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## *Revision History*

| REVISION NUMBER | REVISION DATE | DESCRIPTION | PAGES CHANGED |
|---|---|---|---|
| 0 | 5/12 | Initial release | — |
| 1 | 4/13 | Updated *Component List*, EV kit specifications, and Figure 1 | 1–5 |
| 2 | 11/14 | Updated L1 supplier in *Component List* | 2 |

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