19-4282; Rev 0; 9/08

# MAX15023 Evaluation Kit

Evaluates: MAX15023

## General Description

The MAX15023 evaluation kit (EV kit) is a fully assembled and tested PCB that contains all the components necessary to evaluate the performance of the MAX15023 dual, synchronous step-down controller.

The MAX15023 EV kit requires a 9V to 16V DC power supply, which provides up to 5A for normal operation. The EV kit provides 1.2V/10A and 3.3V/5A at the outputs. Each step-down controller operates 180° out-of-phase to reduce input-voltage ripple and total RMS input ripple current.

The converters' switching frequency is programmed to 500kHz. The EV kit includes individual enable control PCB pads for each converter and power-good outputs for both converters that can be configured for power-supply sequencing of the outputs.

## Features

- **9V to 16V Input Range**
- **Optional 4.5V to 5.5V Input Range for MAX15023**
- **1.2V/10A (VOUT1)**
- **3.3V/5A (VOUT2)**
- **500kHz Switching Frequency**
- **Independent Enable Inputs**
- **Independent Power-Good Outputs**
- **Configurable for Power-Supply Sequencing Operation**
- **Lead-Free and RoHS Compliant**
- **Fully Assembled and Tested**

## Ordering Information

| PART | TYPE |
|---|---|
| MAX15023EVKIT+ | EV Kit |

*+Denotes lead-free and RoHS compliant.*

## Component List

| DESIGNATION | QTY | DESCRIPTION |
|---|---|---|
| C1 | 1 | 330µF ±20%, 25V electrolytic capacitor (10mm x 10.2mm) Panasonic EEEFC1E331P |
| C2–C5, C13, C29 | 0 | Not installed, ceramic capacitors (0603) |
| C6 | 1 | 22pF ±5%, 50V C0G ceramic capacitor (0603) Murata GRM1885C1H220J |
| C7, C9 | 2 | 3300pF ± 5%, 50V C0G ceramic capacitors (0805) Murata GRM2165C1H332J |
| C8 | 1 | 1µF ±10%, 25V X5R ceramic capacitor (0603) Murata GRM188R61E105K |
| C10 | 1 | 390pF ±5%, 50V C0G ceramic capacitor (0603) Murata GRM1885C1H391J |
| C11 | 1 | 33pF ±5%, 50V C0G ceramic capacitor (0603) Murata GRM1885C1H330J |
| C12 | 1 | 4.7µF ±10%, 6.3V X5R ceramic capacitor (0603) Murata GRM188R60J475K |

| DESIGNATION | QTY | DESCRIPTION |
|---|---|---|
| C14, C25, C26 | 3 | 10µF ±10%, 25V X5R ceramic capacitors (1206) Murata GRM31CR6E106K |
| C15, C23 | 0 | Not installed, ceramic capacitors (0805) |
| C16, C17, C18, C22 | 4 | 22µF ±20%, 6.3V X5R ceramic capacitors (1206) Murata GRM31CR0J226M |
| C19, C20 | 2 | 0.22µF ±10%, 16V X7R ceramic capacitors (0603) Murata GRM188R71C224K |
| C21 | 1 | 1500µF ±20%, 2.5V aluminum electrolytic capacitor (10.3mm x 10.3mm) Nichicon PCF0E152MCL1GS |
| C24, C27 | 2 | 2200pF ±5%, 50V C0G ceramic capacitors (0805) Murata GRM2165C1H222JA |
| C28 | 0 | Not installed, capacitor (1206) |
| JU1, JU2, JU3 | 3 | 3-pin headers |
| L1 | 1 | 0.8µH, 12A inductor Coilcraft MSS1048-801NL |

# MAX15023 Evaluation Kit

## Component List (continued)

| DESIGNATION | QTY | DESCRIPTION |
|---|---|---|
| L2 | 1 | 3.3µH, 6.3A inductor<br>Coilcraft MSS1048-332NL |
| N1, N2, N3 | 3 | 30V, 11.6A n-channel MOSFETs (8 SO)<br>Fairchild FDS8880 |
| N4 | 1 | 30V, 8.6A/6.3A n-channel MOSFET (8 SO)<br>Fairchild FDS6982AS |
| PGND (x3), VIN, VOUT1, VOUT2 | 6 | Uninsulated banana jacks |
| R1, R6 | 2 | 10Ω ±5% resistors (0603) |
| R2, R7, R11 | 0 | Not installed, resistors (0603) |
| R3, R8 | 2 | 200kΩ ±1% resistors (0603) |
| R4, R5 | 2 | 47kΩ ±5% resistors (0603) |
| R9, R10 | 2 | 12.1kΩ ±1% resistors (0603) |
| R13 | 1 | 30.1kΩ ±1% resistor (0603) |
| R14 | 1 | 16.2kΩ ±1% resistor (0603) |
| R15 | 1 | 22.1kΩ ±1% resistor (0603) |
| R17 | 1 | 33kΩ ±1% resistor (0603) |
| R18 | 1 | 1.62kΩ ±1% resistor (0603) |
| R19 | 1 | 20kΩ ±1% resistor (0603) |
| R20 | 1 | 45.3kΩ ±1% resistor (0603) |
| R21 | 1 | 10kΩ ±1% resistor (0603) |
| R24, R25 | 2 | 1.5Ω 5% resistors (1210)<br>Panasonic ERJ-P14J1R5U |
| R28, R29 | 2 | 49.9Ω ±1% resistors (0805) |
| TP1–TP6 | 6 | PC mini red test points |
| U1 | 1 | Dual, synchronous step-down controller (24 TQFN-EP*)<br>Maxim MAX15023ETG+ |
| — | 3 | Shunts (JU1, JU2, JU3) |
| — | 1 | PCB: MAX15023 Evaluation Kit+ |

**EP = Exposed pad.*

## Component Suppliers

| SUPPLIER | PHONE | WEBSITE |
|---|---|---|
| Coilcraft, Inc. | 847-639-6400 | www.coilcraft.com |
| Fairchild Semiconductor | 888-522-5372 | www.fairchildsemi.com |
| Murata Electronics North America, Inc. | 770-436-1300 | www.murata-northamerica.com |
| Nichicon USA | 858-824-1515 | www.nichicon-us.com |
| Panasonic Corp. | 800-344-2112 | www.panasonic.com |

***Note:*** *Indicate that you are using the MAX15023 when contacting these component suppliers.*

## Quick Start

### Required Equipment

Before beginning, the following equipment is needed:

- MAX15023 EV kit
- Adjustable 9V to 16V, 5A DC power supply
- Two electronic loads
- Two voltmeters

### Procedure

The MAX15023 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) Install shunts across pins 1-2 of jumpers JU1 (VOUT1 enabled), JU2 (VOUT2 enabled), and JU3 (VIN input source for U1).
2) Connect a voltmeter to the VOUT1 and PGND pads.
3) Connect a voltmeter to the VOUT2 and PGND pads
4) Connect a 10A electronic load to the VOUT1 and PGND banana jack connectors.
5) Connect a 5A electronic load to the VOUT2 and PGND banana jack connectors.
6) Connect a DC power supply to the VIN and PGND banana jack connectors and set the voltage to 12V.
7) Enable the power-supply output.
8) Enable the electronic loads connected at VOUT1 and VOUT2 and set to 10A and 5A, respectively.
9) Verify that voltmeters at VOUT1 and VOUT2 measure 1.2V and 3.3V, respectively.

## _Detailed Description of Hardware

The MAX15023 evaluation kit (EV kit) is a fully assembled and tested PCB that contains all the components necessary to evaluate the performance of the MAX15023 dual, synchronous step-down controller. The MAX15023 EV kit is designed to operate from a single DC power supply that provides 9V to 16V and 5A of current. The MAX15023 controller can also be operated using a separate 4.5V to 5.5V power source applied at the VCC and SGND PCB pads. **When operating the MAX15023 EV kit using separate power-supply sources at the VIN and PGND connectors and VCC PCB pads, apply power at the VIN and PGND connectors first and then at the VCC and SGND PCB pads.**

Converter 1 (VOUT1) is configured for 1.2V and provides up to 10A of output current. VOUT1's source and sink current limits are set to 14A (typ) and 7A (typ), respectively, with resistor R14. Converter 2 (VOUT2) is configured for 3.3V and provides up to 5A of output current. VOUT2's source and sink current limits are set to 7A (typ) and 3.5A (typ), respectively, with resistor R15.

The switching frequency for both converters is set to 500kHz by resistor R17 and each converter operates 180° out-of-phase to reduce input-voltage ripple and total RMS input ripple current.

The EV kit includes individual PCB pads for enable control of each converter and test points to monitor the converters' power-good status. Jumpers JU1 and JU2 are also available to configure the outputs for power-supply sequencing.

### Converters' Input Source

The power source is connected to the VIN and PGND banana jack connectors for the dual converters. The MAX15023 EV kit converters' performance is optimized over the 9V to 16V input-voltage range. The MAX15023 EV kit could operate below the 9V minimum input-voltage range and at higher output currents; however, performance might be degraded due to the limitation of the components used in the EV kit circuit.

### MAX15023 IC Bias Input

The MAX15023 EV kit features an option to select the bias input for the MAX15023 IC controller when configuring the EV kit to operate with an input source less than 6V. Jumper JU3 selects the input-voltage source for the MAX15023 IC controller. Place a shunt across pins 1-2 to power the MAX15023 IC using the power source applied at the VIN and PGND PCB pads. Place a shunt across pins 2-3 to power the MAX15023 IC input using the power source applied at the VCC and SGND PCB pads. Note that the power source applied to the VCC PCB pad has a 4.5V to 5.5V input-voltage range. **When operating the MAX15023 EV kit using a separate power source at the VCC PCB pad, apply power to the VIN and PGND connectors PCB pad first and then the VCC and SGND PCB pads.** See Table 1 for the MAX15023 bias input configuration

**Table 1. MAX15023 Bias Input Configuration**

| SHUNT POSITION | IN PIN | MAX15023 IC INPUT RANGE (V) |
|---|---|---|
| 1-2 | Connected to VIN | 9 to 16 |
| 2-3 | Connected to VCC | 4.5 to 5.5 |

### Configuring the Output Voltages (VOUT1, VOUT2)

VOUT1 and VOUT2 output voltages can be reconfigured between 0.6V to 0.85 x VIN. Resistors R9 and R10 set VOUT1 output voltage and resistors R20 and R21 set VOUT2 output voltage. To configure the EV kit's output voltages, refer to the *Setting the Output Voltage* section in the MAX15023 IC data sheet for instructions on selecting new resistor values.

Capacitors C5, C6, and C7 and resistors R11 and R13 provide a compensation network for VOUT1 on the MAX15023 EV kit. Capacitors C9, C10, and C11 and resistors R18 and R19 provide a compensation network for VOUT2 on the MAX15023 EV kit.

Refer to the *Inductor Selection*, *Input Capacitor* and *Compensation* sections in the MAX15023 IC data sheet to verify whether other components need replacement for proper operation after reconfiguring the output voltages.

### Cycle-by-Cycle Peak Current-Limit Thresholds

The MAX15023 IC employs a current-sensing algorithm using the on-resistance of the low-side MOSFET as a current-sensing element to limit the inductor current. The inductor current is sensed in each converter by sensing the voltage drop across the on-resistance ($R_{(DSON)}$) of the respective low-side MOSFETs (N2, N3, and N4-A). VOUT1 source and sink current limits are 14A (typ) and 7A (typ), respectively. VOUT2 source and sink current limits are 7A (typ) and 3.5A (typ), respectively.

Resistors R14 and R15 set VOUT1 and VOUT2 source current-limit voltage thresholds ($V_{ITH\_}$) to 80mV and 110mV, respectively. The sink current-limit voltage threshold is approximately half the source current-limit voltage threshold. Use the following equation to reconfigure the source current-limit voltage threshold:

$$R_{ILIM\_}(\Omega) = \frac{V_{ITH\_} \times 10}{50 \times 10^{-6}}$$

where $V_{ITH\_}$ is the source current-limit voltage threshold in volts and $R_{ILIM\_}$ is R14 or R15 in ohms.

Refer to the *Current-Limit Circuit (LIM_)* and *Setting the Cycle-by-Cycle, Low-Side Source Peak Current Limit* sections in the MAX15023 IC data sheet for further instructions on computing the MAX15023 EV kit source and sink current limits.

### Switching Frequency

The MAX15023 controller's switching frequency is set to 500kHz by resistor R17. Replace resistor R17 with a new resistor value to program the switching frequency between 200kHz and 1MHz. Use the following equation to calculate R17 when reconfiguring the switching frequency:

$$R17 = \frac{24806}{(f_{SW})^{1.0663}}$$

where $f_{SW}$ is in kilohertz and R17 is in kilohms.

When reconfiguring the EV kit controller switching frequency, it might be necessary to change compensation network components to new values. Refer to the *Compensation* section in the MAX15023 IC data sheet for computing new compensation component values.

### Power-Good Outputs (PGOOD1, PGOOD2)

The MAX15023 EV kit provides power-good output test points (TP1 and TP2) to monitor the PGOOD1 and PGOOD2 signals. PGOOD1 and PGOOD2 are high when VOUT1 and VOUT2, respectively, rise 92.5% above their programmed output voltages. The PGOOD_ signals are pulled up to VCC by resistors R4 and R5. When VOUT1 and VOUT2 drop below 89.5% of their nominal regulated voltages, PGOOD1 and PGOOD2 are pulled low, respectively.

### Enable/Power-Supply Sequencing (JU1, JU2)

Jumpers JU1 and JU2 configure the MAX15023 EV kit's VOUT1and VOUT2 outputs, respectively, for independent turn-on/off control or power-supply sequencing. Install shunts across pins 1-2 of jumpers JU1 and JU2 to enable VOUT1 and VOUT2 using the MAX15023 VCC linear regulator output or the DC voltage source supplied at the VCC PCB pad.

The outputs can also be externally controlled, by placing independent voltage sources greater than 1.3V at the EN1 and EN2 PCB pads, when shunts are not installed at jumpers JU1 and JU2. Additional PCB resistor pads R2 and R7 are included to set the individual channel to a desired turn-on voltage. See Tables 2 and 3 for jumpers JU1 and JU2 settings.

## Table 2. JU1 Jumper Selection (EN1)

| SHUNT POSITION | EN1 PIN | VOUT1 OUTPUT |
|---|---|---|
| 1-2 | Connected to VCC | Enabled |
| 2-3* | Connected to PGOOD2 | Enabled (power-supply sequencing) |
| Not installed | Pulled down to GND through R8 | Disabled |

*See the *Power-Supply Sequencing* section.

## Table 3. JU2 Jumper Selection (EN2)

| SHUNT POSITION | EN2 PIN | VOUT2 OUTPUT |
|---|---|---|
| 1-2 | Connected to VCC | Enabled |
| 2-3* | Connected to PGOOD1 | Enabled (power-supply sequencing) |
| Not installed | Pulled down to GND through R3 | Disabled |

*See the *Power-Supply Sequencing* section.

### Power-Supply Sequencing

The MAX15023 EV kit outputs can be configured for power-supply sequencing by utilizing the PGOOD_ outputs and configuring jumpers JU1 and JU2 appropriately. Place shunts across pins 1-2 of jumper JU1 and pins 2-3 of jumper JU2 for power sequencing VOUT1, and then VOUT2. Place shunts across pins 1-2 of jumper JU2 and pins 2-3 of jumper JU1 for sequencing VOUT2, and then VOUT1. See Table 4 for configuring the outputs for power-supply sequencing operation.

## Table 4. Power-Supply Sequencing (JU1, JU2)

| SHUNT POSITION | | OUTPUT SEQUENCE OPERATION |
|---|---|---|
| JU1 | JU2 | |
| 1-2 | 2-3 | VOUT1, VOUT2 |
| 2-3 | 1-2 | VOUT2, VOUT1 |

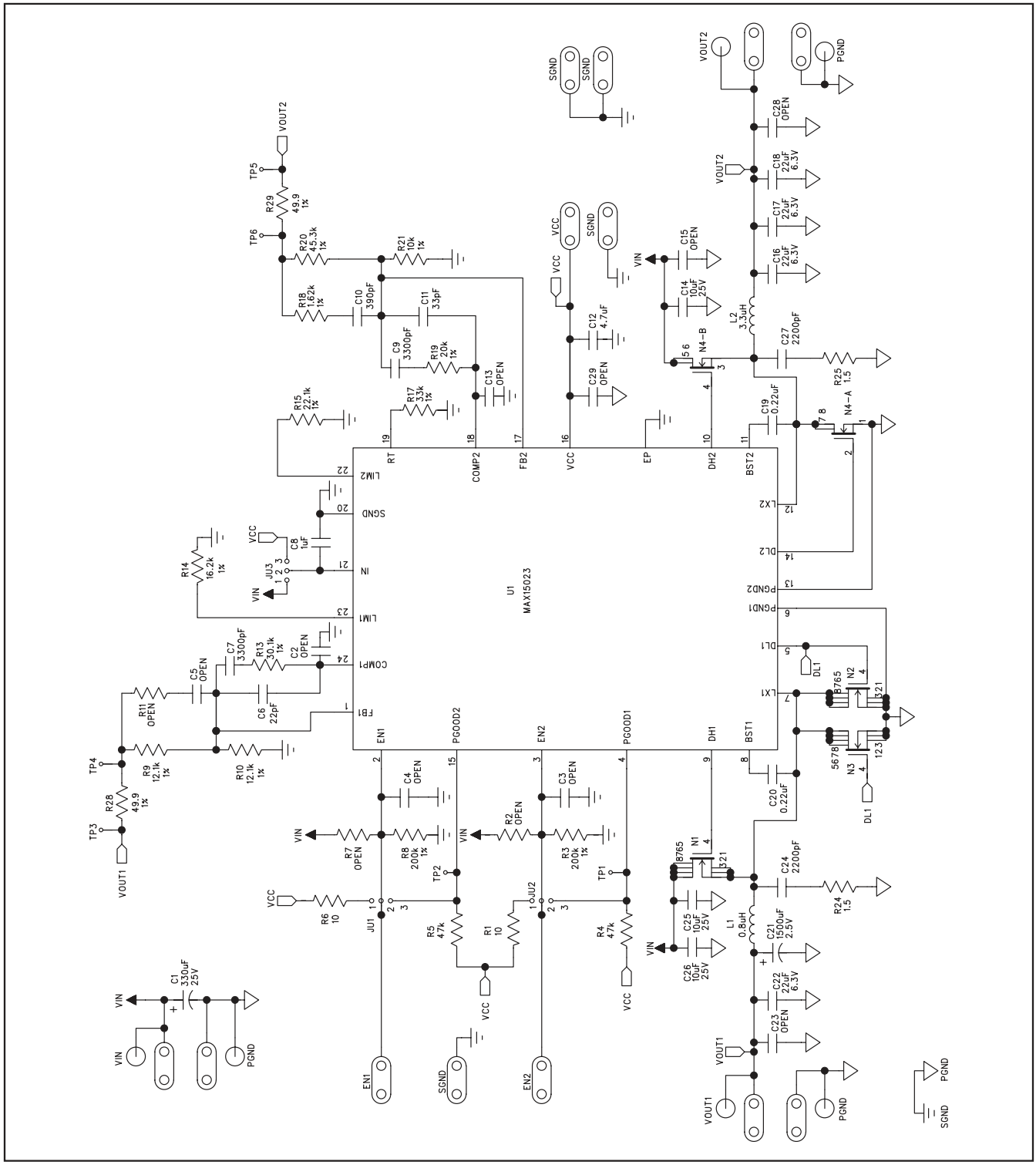


*Figure 1. MAX15023 EV Kit Schematic*

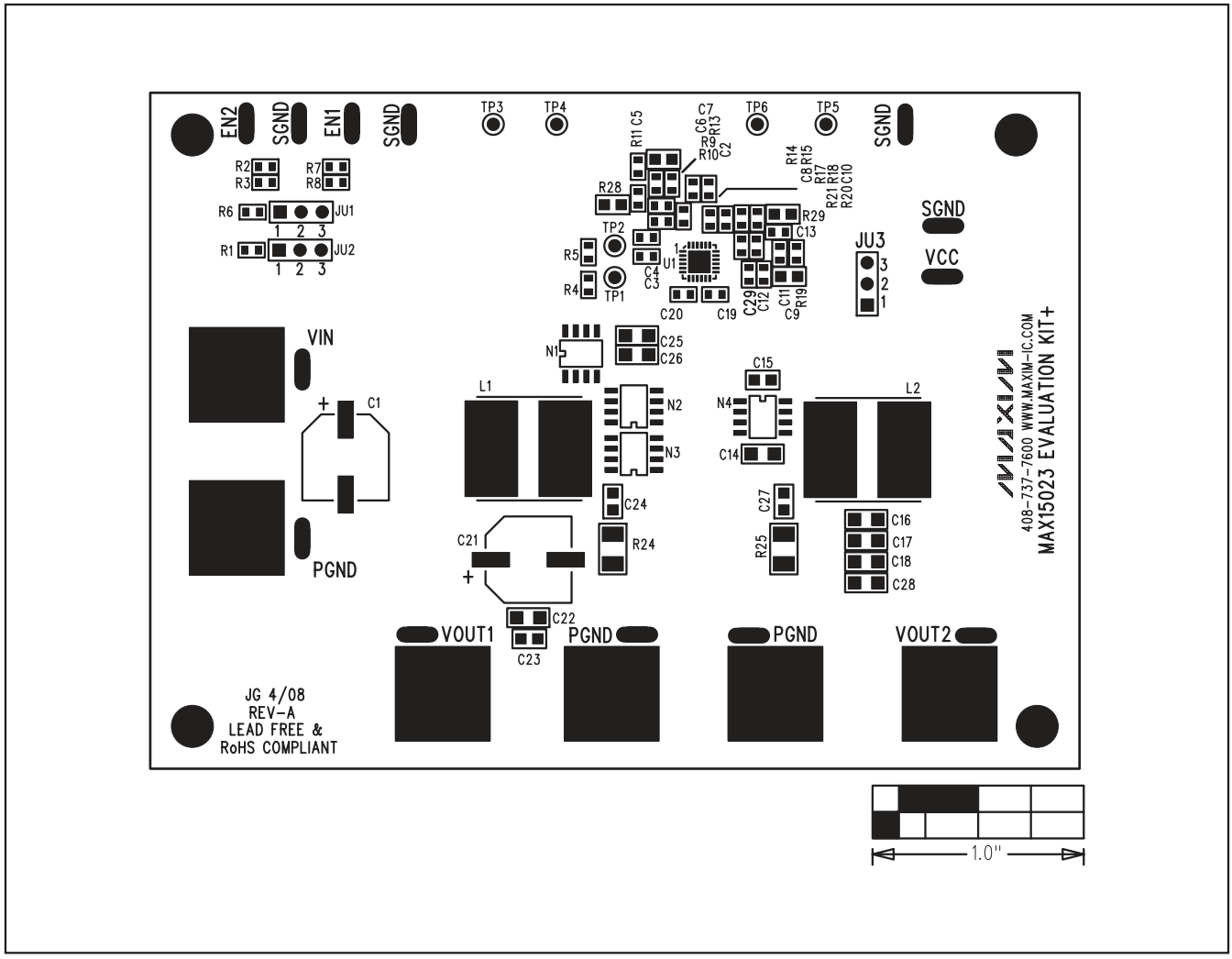


*Figure 2. MAX15023 EV Kit Component Placement Guide—Component Side*

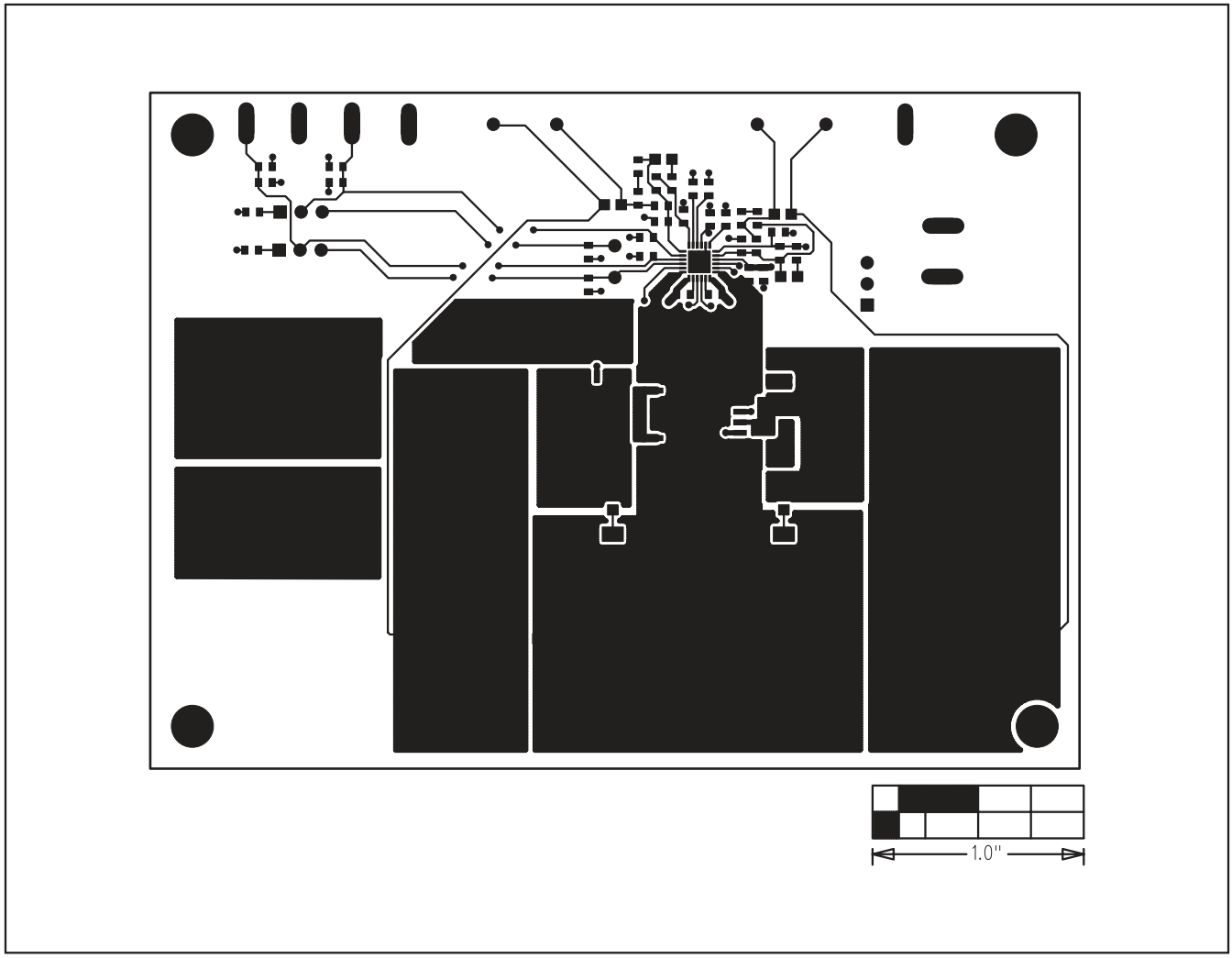


*Figure 3. MAX15023 EV Kit PCB Layout—Component Side*

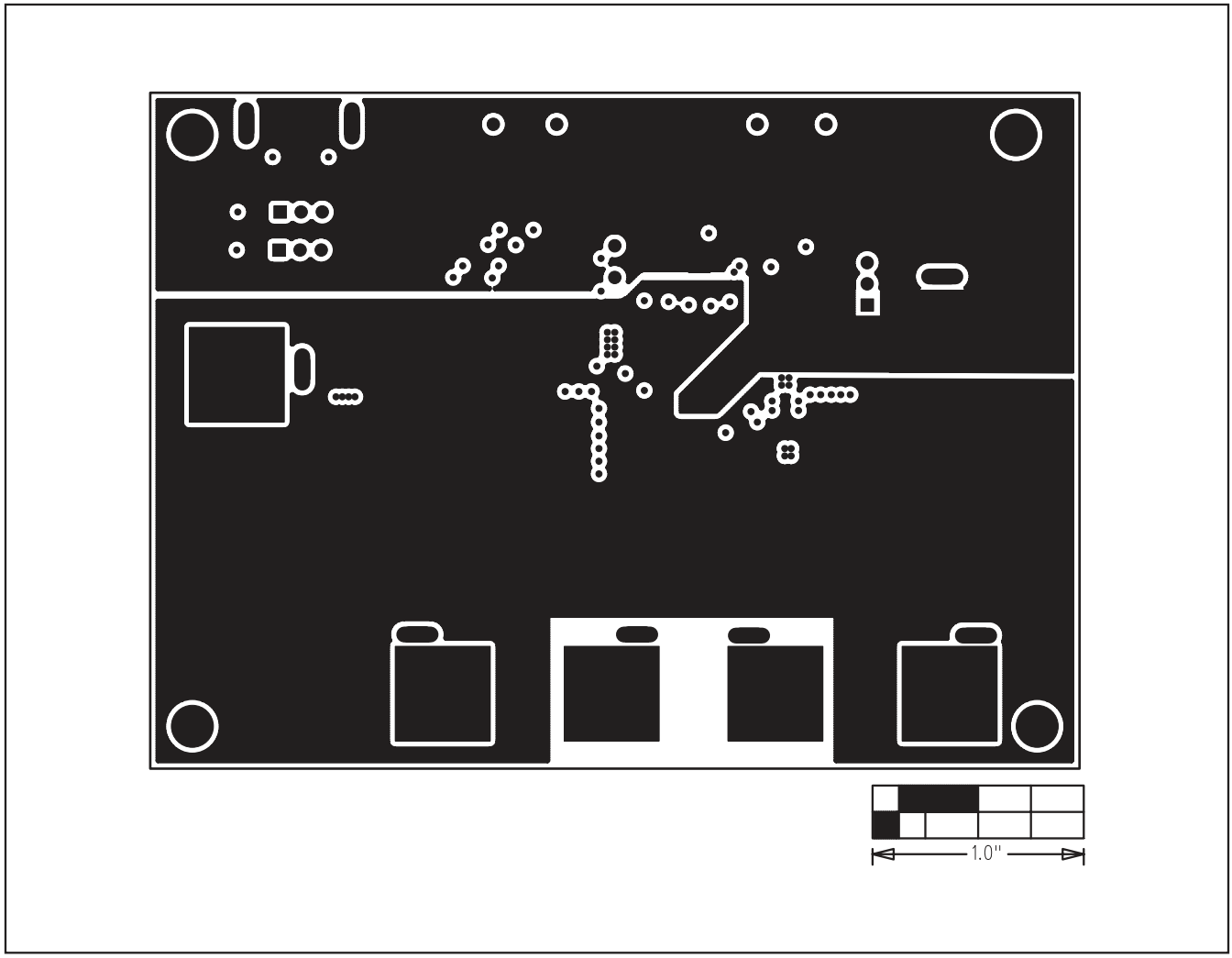


*Figure 4. MAX15023 EV Kit PCB Layout—GND Layer 2*

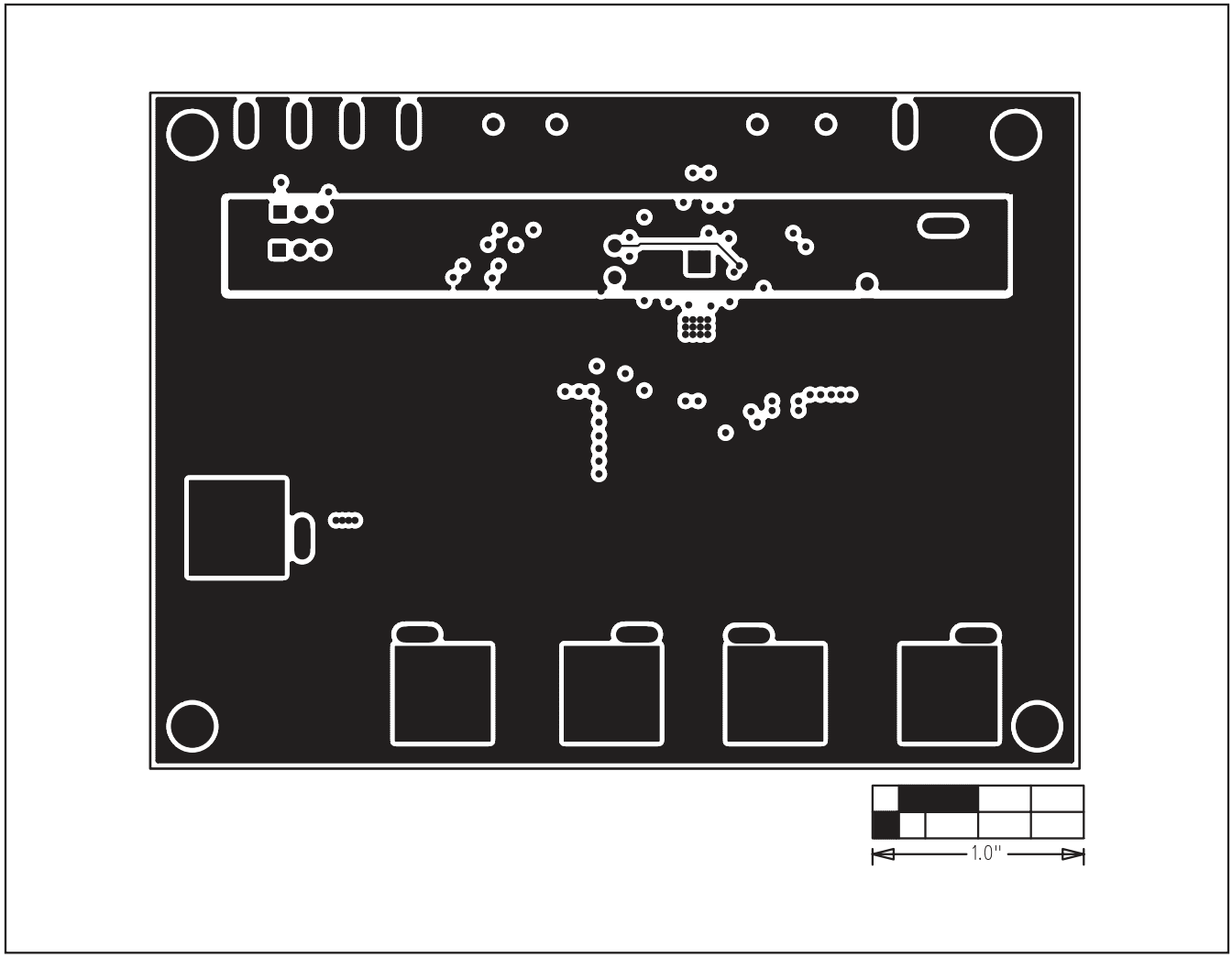


*Figure 5. MAX15023 EV Kit PCB Layout—Inner Trace Layer 3*

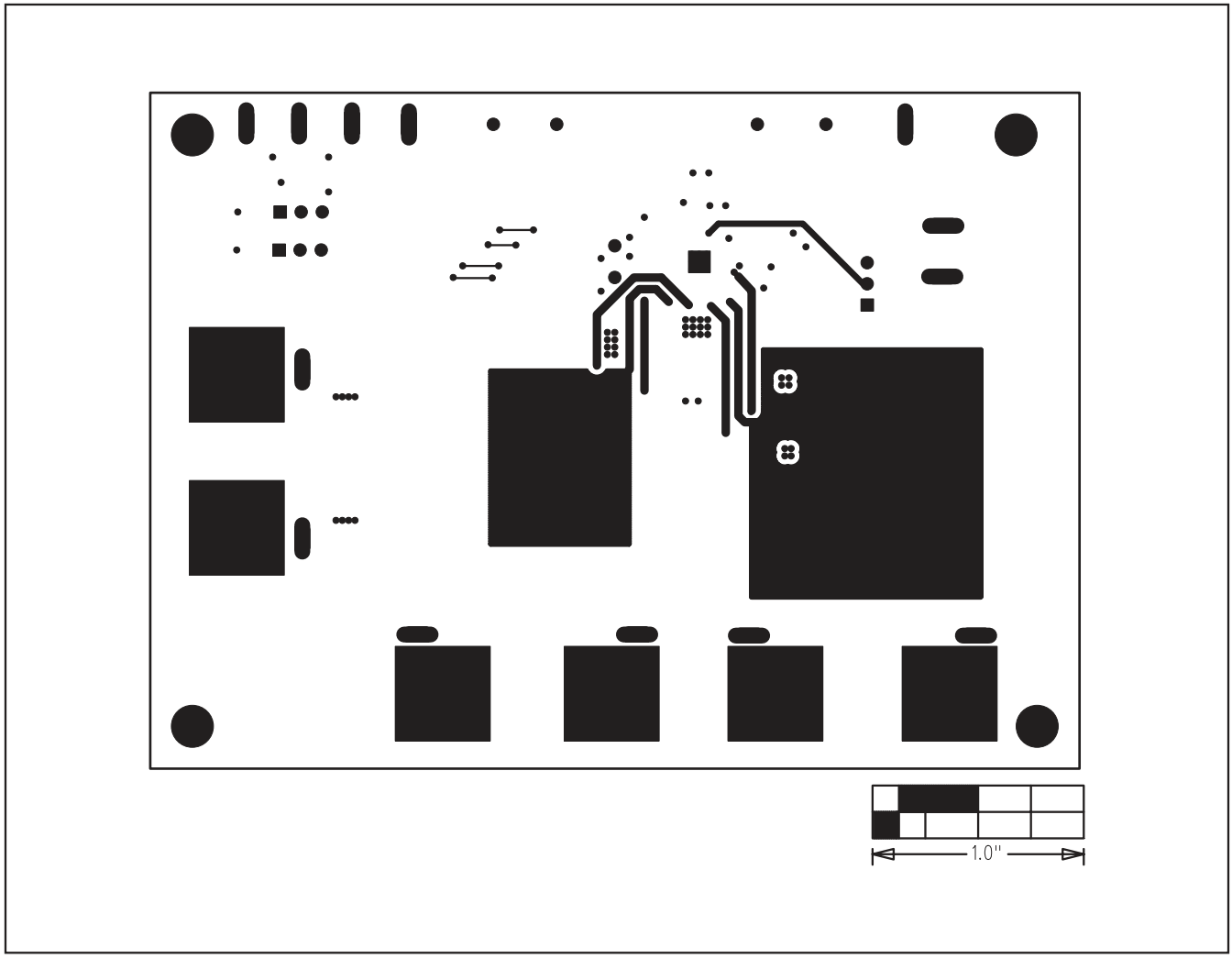


*Figure 6. MAX15023 EV Kit PCB Layout—Solder Side*