19-4101; Rev 0; 5/08

MAX15022 Evaluation Kit

Evaluates: MAX15022

General Description

The MAX15022 evaluation kit (EV kit) circuit demonstrates the MAX15022 IC, which integrates two high-performance PWM switching step-down regulators and two low-dropout (LDO) controllers. Each controller and regulator features independent enable controls for power-up sequence operation. The EV kit is designed to operate from a single 4.5V to 5.5V DC power supply.

The synchronous step-down outputs provide 3.3V/4A and 1.5V/2A, and can be configured for power-up sequencing or tracking operation. The converter switching frequency is set to 2MHz and operates 180° out-of-phase, reducing input voltage ripple and total RMS input ripple current. The LDO outputs provide 2.5V and 1.2V, at up to 500mA each. Each LDO controller is powered from either the input power source or one of the regulator outputs.

Ordering Information

PART	TYPE
MAX15022EVKIT+	EV Kit

+Denotes lead-free and RoHS-compliant.

Features

- **4.5V to 5.5V Input Range**
- **Regulator Outputs**
  - **3.3V at 4A**
  - **1.5V at 2A**
- **2MHz Switching Frequency**
- **LDO Outputs**
  - **2.5V (Up to 500mA)**
  - **1.2V (Up to 500mA)**
- **Independent Enable Inputs for All Outputs**
- **Configurable Power-Up Sequencing for Outputs**
- **Configurable Power-Up Tracking for Regulators (VOUT1, VOUT2)**
- **Thermal Shutdown and Hiccup-Mode Short-Circuit Protection**
- **Fully Assembled and Tested**

Component List

DESIGNATION	QTY	DESCRIPTION
C1	1	150µF ±20%, 10V aluminum electrolytic capacitor (6.6mm x 6.6mm) Panasonic EEEFK1A151P
C2, C4, C9, C10, C14, C18	6	0.1µF ±10%, 16V X7R ceramic capacitors (0603) Murata GRM188R71C104K
C3, C8, C11, C12, C19, C21	6	10µF ±10%, 6.3V X7R ceramic capacitors (0805) Murata GRM21BR70J106K
C5	1	180pF ±5%, 50V C0G ceramic capacitor (0603) Murata GRM1885C1H181J
C6	1	390pF ±5%, 50V C0G ceramic capacitor (0603) Murata GRM1885C1H391J
C7, C16	2	10pF ±5%, 50V C0G ceramic capacitors (0603) Murata GRM1885C1H100J
C13, C23, C24	0	Not installed, capacitors (0805)

DESIGNATION	QTY	DESCRIPTION
C15	1	68pF ±5%, 50V C0G ceramic capacitor (0603) Murata GRM1885C1H680J
C17	1	270pF ±5%, 50V C0G ceramic capacitor (0603) Murata GRM1885C1H271J
C20, C22	2	1µF ±10%, 10V X7R ceramic capacitors (0805) TDK C2012X7R1A105K
C25, C26	0	Not installed, ceramic capacitors (0603)
C27, C28	2	2200pF ±10%, 16V X7R ceramic capacitors (0603) Murata GRM188R71C222K
JU1–JU4	4	3-pin headers
L1	1	0.47µH, 5A inductor Vishay IHLP-1616BZ-ER-R47-M-01
L2	1	1µH, 4A inductor Vishay IHLP-1616BZ-ER-1R0-M-01

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

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Component List (continued)

DESIGNATION	QTY	DESCRIPTION
Q1, Q2	2	-20V, 1.5A pnp transistors (SOT223-4) Fairchild Semiconductor BCP69
R1, R7	2	120Ω ±5% resistors (0603)
R2	1	100Ω ±1% resistor (0603)
R3	1	23.7kΩ ±1% resistor (0603)
R4	1	7.5kΩ ±1% resistor (0603)
R5	1	15.8kΩ ±1% resistor (0603)
R6, R9, R10	3	11.5kΩ ±1% resistors (0603)
R11	1	1.5kΩ ±1% resistor (0603)
R12	1	18.7kΩ ±1% resistor (0603)
R13	1	15Ω ±1% resistor (0603)
R14, R18	2	24.9kΩ ±1% resistors (0603)
R15, R19, R24	3	16.5kΩ ±1% resistors (0603)
R16	1	1kΩ ±1% resistor (0603)
R17, R21	2	15kΩ ±1% resistors (0603)
R20	1	2.55kΩ ±1% resistor (0603)
R22	1	47.5kΩ ±1% resistor (0603)
R23	1	10.5kΩ ±1% resistor (0603)
R25	1	18.2kΩ ±1% resistor (0603)
R26	1	10kΩ ±1% resistor (0603)
R27, R28	0	Not installed, resistors (1206)
U1	1	Dual regulator/LDO controller (28 TQFN-EP*) Maxim MAX15022ATI+
—	4	Shunts (JU1–JU4)
—	1	PCB: MAX15022 Evaluation Kit+

**EP = Exposed pad.*

Component Suppliers

SUPPLIER	PHONE	WEBSITE
Fairchild Semiconductor	888-522-5372	www.fairchildsemi.com
Murata Electronics North America, Inc.	770-436-1300	www.murata-northamerica.com
Panasonic Corp.	714-373-7366	www.panasonic.com
TDK Corp.	847-803-6100	www.component.tdk.com
Vishay	203-268-6261	www.vishay.com

Note: *Indicate that you are using the MAX15022 when contacting these component suppliers.*

Quick Start

Required Equipment

Before beginning, the following equipment is needed:

- Adjustable 4.5V to 5.5V, 5A DC power supply
- Four voltmeters

Procedure

The MAX15022 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 2-3 of jumpers JU1 (VOUT1 input source for VOUT3) and JU2 (VOUT2 input source for VOUT4).
2) Install shunts across pins 1-2 of jumpers JU3 (VOUT2 sequences after VOUT1) and JU4 (sequencing mode for outputs VOUT1, VOUT2).
3) Connect the voltmeter positive-terminal inputs to the VOUT1–VOUT4 PCB pads.
4) Connect the voltmeter negative-terminal inputs to the respective output's PGND PCB pads.
5) Connect a DC power supply to the VIN and PGND pads and set the voltage to 5V.
6) Enable the power-supply output.
7) Verify that the voltmeters at VOUT1–VOUT4 measure 3.3V, 1.5V, 2.5V, and 1.2V, respectively.

_Detailed Description of Hardware

The MAX15022 EV kit circuit demonstrates the MAX15022 IC, which integrates two high-performance PWM switching synchronous step-down regulators and two LDO controllers. The EV kit regulator outputs can be configured for sequencing, ratiometric-tracking, or coincident-tracking mode. The MAX15022 IC operates with either step-down regulator outputs as the master; however, the EV kit is designed with VOUT1 as the master during tracking operation. Each controller and regulator features independent enable controls for power-up sequencing operation. The EV kit is designed to operate from a single DC power supply that provides 4.5V to 5.5V and 5A of current.

The EV kit's dual step-down regulator's outputs (VOUT1 and VOUT2) are configured for 3.3V and 1.5V, providing up to 4A and 2A, respectively. The regulator's tracking sequencing operation modes are selectable through jumpers JU3 and JU4. The switching frequency is set to 2MHz by resistor R24 and can be programmed from 500kHz to 4MHz. The outputs operate 180° out-of-phase to reduce input voltage ripple and total RMS input ripple current.

The LDO outputs (VOUT3 and VOUT4) are configured for 2.5V and 1.2V, respectively, and provide up to 500mA each. Jumpers JU1 and JU2 select the LDO's input power source or configure VOUT3 and VOUT4 for power-supply sequencing to the regulator outputs, VOUT1 and VOUT2, respectively.

Input Power Source

The MAX15022 EV kit regulator outputs (VOUT1 and VOUT2) are optimized to provide up to 4A and 2A, respectively, when operating with an input-voltage source of 4.5V to 5.5V. The EV kit accommodates input voltages down to 2.35V; however, each output rail's passive filtering, enabling, and compensation circuitry needs to be revisited to confirm optimal performance. Additionally, VOUT1's 3.3V rail likely needs to be readjusted to a lower-than-VIN potential. Refer to the MAX15022 IC data sheet for additional information on the minimum voltage requirements, as well as the *PWM Controllers Design Procedure* and *LDO Controllers Design Procedure* sections.

Regulator's Power Tracking/Sequencing

The MAX15022 EV kit can be configured to power up and power down the VOUT1 and VOUT2 outputs in sequencing, ratiometric-tracking, or coincident-tracking mode by configuring jumpers JU3 and JU4. The MAX15022 IC operates with either regulator output as the master or slave during tracking mode. However, the MAX15022 EV kit is designed with VOUT1 as the master and VOUT2 as the slave during tracking operation. See Table 1 for jumpers JU3 and JU4 configuration for operating the EV kit step-down regulators in tracking or sequencing mode.

Table 1. VOUT1/VOUT2 Tracking/ Sequencing Operation (JU3, JU4)

SHUNT POSITION		EV KIT CIRCUIT MODIFICATION	EV KIT VOUT1/VOUT2 OPERATION
JU3	JU4		
1-2	1-2	—	Sequence mode
2-3	2-3	—	Coincident-tracking mode (VOUT1 master, VOUT2 slave)
2-3	2-3	Resistor R14 must be removed	Ratiometric-tracking mode (VOUT1 master, VOUT2 slave)

The EV kit's VOUT1 and VOUT2 outputs are configured for coincident-tracking operation by default. VOUT2 output voltage ramps up, tracking the VOUT1 voltage using resistor pairs R14/R15 and R18/R19, which sets the resistor-divider ratios. Place shunts across pins 2-3 of jumpers JU3 and JU4 to operate VOUT1 and VOUT2 in coincident tracking mode.

In ratiometric-tracking mode, VOUT1 and VOUT2 soft-start controllers are synchonized, and hence, their respective output voltages track ratiometrically. For ratiometric-tracking operation, the EV kit PCB requires a minor modification. Place shunts across pins 2-3 of jumpers JU3 and JU4 and remove resistor R14 for ratiometric-tracking mode.

When operating the EV kit in sequencing mode, each regulator operates independently with its own enable input. To operate regulator outputs VOUT1 and VOUT2 in sequencing mode, install shunts across pins 1-2 of jumpers JU3 and JU4. The VOUT2 output does not turn on until VOUT1 rises above the EN2 1.22V threshold.

Refer to the *Tracking/Sequencing* section in the MAX15022 IC data sheet for additional information on operating in coincident/ratiometric-tracking and sequencing modes, and to calculate the proper values for resistor pairs R14/R15 and R18/R19.

Step-Down Regulator Output Voltages (VOUT1, VOUT2)

Regulator output VOUT1 is set to 3.3V with resistors R22 and R23 and provides up to 4A at 90% efficiency. Capacitors C15, C16, and C17, and resistors R18 and R19 provide a compensation network for VOUT1 on the EV kit.

Regulator output VOUT2 is set to 1.5V with resistors R18 and R19 and provides up to 2A at 84% efficiency. Capacitors C5, C6, and C7, and resistors R16 and R17 provide a compensation network for VOUT2 on the EV kit.

VOUT1 and VOUT2 output voltages can be reconfigured between 0.6V to VIN by replacing the respective feedback resistors. To reconfigure the regulator outputs, refer to the *Compensation Design Guidelines* section in the MAX15022 IC data sheet for instructions on selecting new resistor values. Also refer to the *Effective Input-Voltage Range* section in the MAX15022 IC data sheet for the minimum and maximum input-voltage range when reconfiguring the regulator outputs.

Component changes are necessary for proper operation after reconfiguring the output voltage. Refer to the *Inductor Selection*, *Input-Capacitor Selection*, and the *Compensation Design Guidelines* sections in the MAX15022 IC data sheet to select the proper values.

2.5V LDO Output (VOUT3)

The VOUT3 LDO output is set to 2.5V by feedback resistors R3 and R4 and provide up to 500mA of output current. Jumper JU1 selects the input power source for VOUT3 or configures VOUT3 for power-supply sequencing with VOUT1. Install a shunt across pins 1-2 to select VIN as the input power source. Install a shunt across pins 2-3 to select VOUT1 as the LDO input power source. Resistors R5 and R6 set VOUT3 turn-on threshold to 3V. See Table 2 for proper jumper configuration of VOUT3 input power source.

Table 2. VOUT3 Input Power Source (JU1)

SHUNT POSITION	VOUT3 INPUT POWER SOURCE	EV KIT OPERATION
1-2	VIN	VOUT3 enabled
2-3	VOUT1	VOUT3 enabled
Not installed	—	VOUT3 disabled

To reconfigure VOUT3 to different output voltages, refer to the *Output 3 and Output 4 Voltage Selection* section in the MAX15022 IC data sheet for additional information.

VOUT3 current capability is restricted by the regulator's input power source, the output voltage setting, and transistor Q1. Verify that Q1 power dissipation rating is not exceeded when operating the LDO regulator at high input-to-output voltage differentials and full load.

1.2V Regulator Output (VOUT4)

VOUT4 LDO output is set to 1.2V by feedback resistors R9 and R10 and provides up to 500mA of output current. Jumper JU2 selects the input power source for VOUT4 or configures VOUT4 for power-supply sequencing with VOUT2. Install a shunt across pins 1-2 to select VIN as the input power source. Install a shunt across pins 2-3 to select VOUT2 as the LDO input power source. Resistors R11 and R12 set the VOUT4 turn-on threshold to 1.3V. See Table 3 for proper jumper configuration of VOUT4 input power source.

Table 3. VOUT4 Input Power Source (JU2)

SHUNT POSITION	VOUT4 INPUT POWER SOURCE	EV KIT OPERATION
1-2	VIN	VOUT4 enabled
2-3	VOUT2	VOUT4 enabled
Not installed	—	VOUT4 disabled

To reconfigure VOUT4 to different output voltages, refer to the *Output 3 and Output 4 Voltage Selection* section in the MAX15022 IC data sheet for additional information.

VOUT4 current capability is restricted by the regulator's input power source, the output voltage setting, and transistor Q2. Verify that Q2 power dissipation rating is not exceeded when operating the LDO regulator at high input-to-output voltage differentials and full load.

Switching Frequency

The MAX15022 switching frequency is set to 2MHz by resistor R24. Replace resistor R24 with a new resistor value to program the switching frequency between 500kHz and 4MHz. Use the following equation to select R24 when reconfiguring the switching frequency:

$$R24 \cong (8.36 \times 10^{-3}) \times f_{SW}$$

where f_{SW} is in hertz and R24 is in ohms.

When reconfiguring the EV kit switching frequency, it is necessary to replace the compensation network and power components. Refer to the *Inductor Selection* and *Compensation Design Guidelines* sections in the MAX15022 IC data sheet for computing new compensation and power component values.

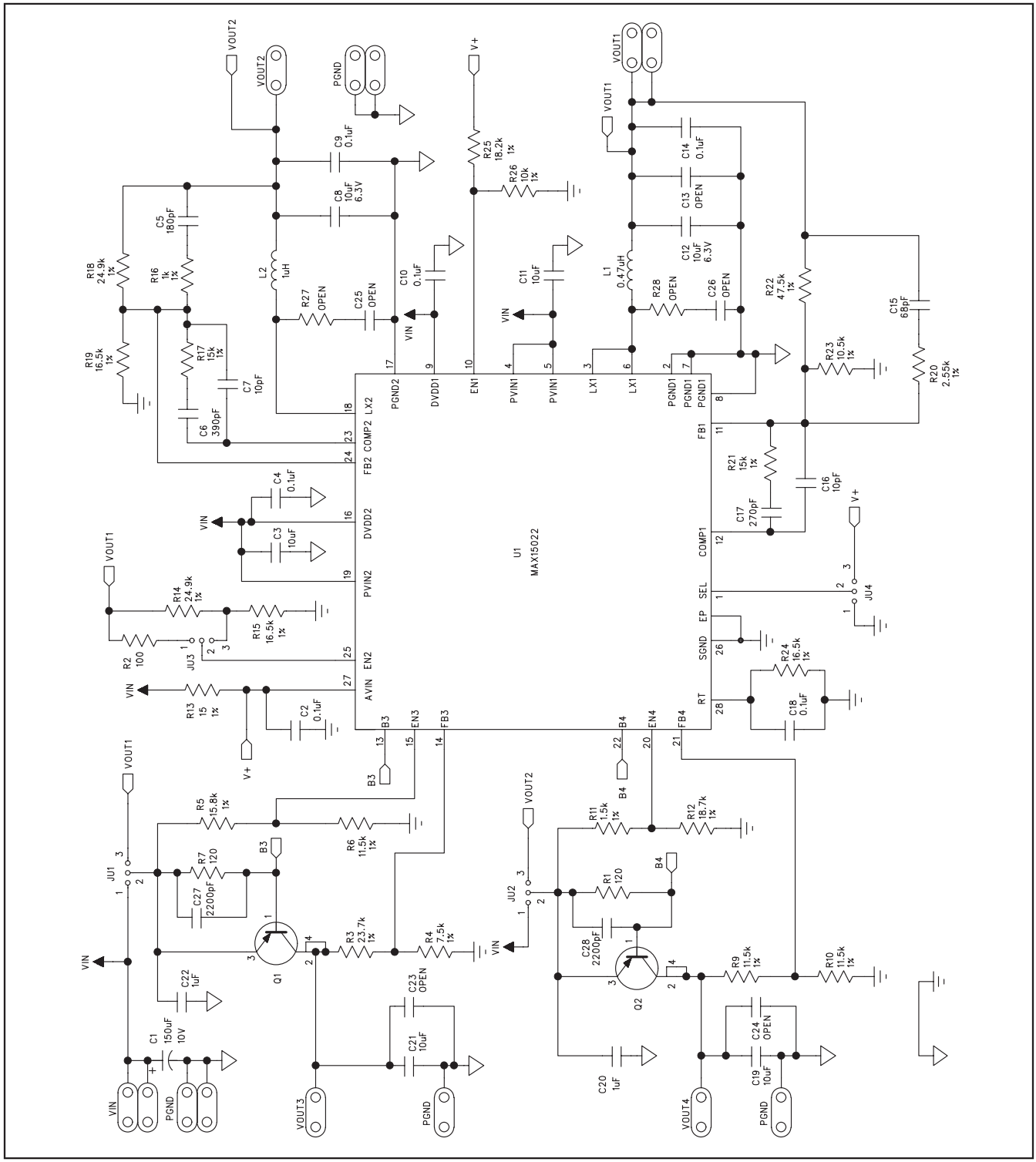


Figure 1. MAX15022 EV Kit Schematic

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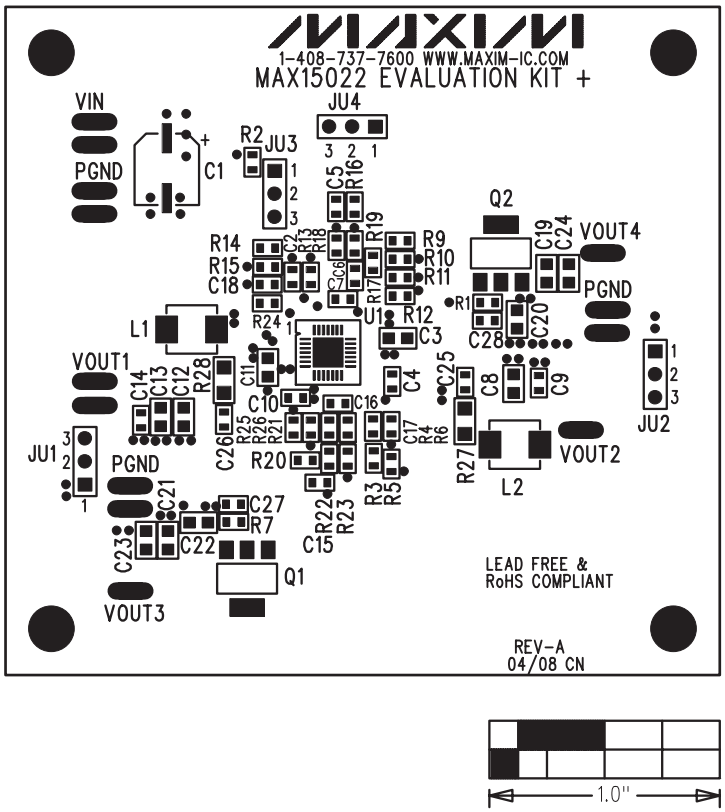


Figure 2. MAX15022 EV Kit Component Placement Guide—Component Side

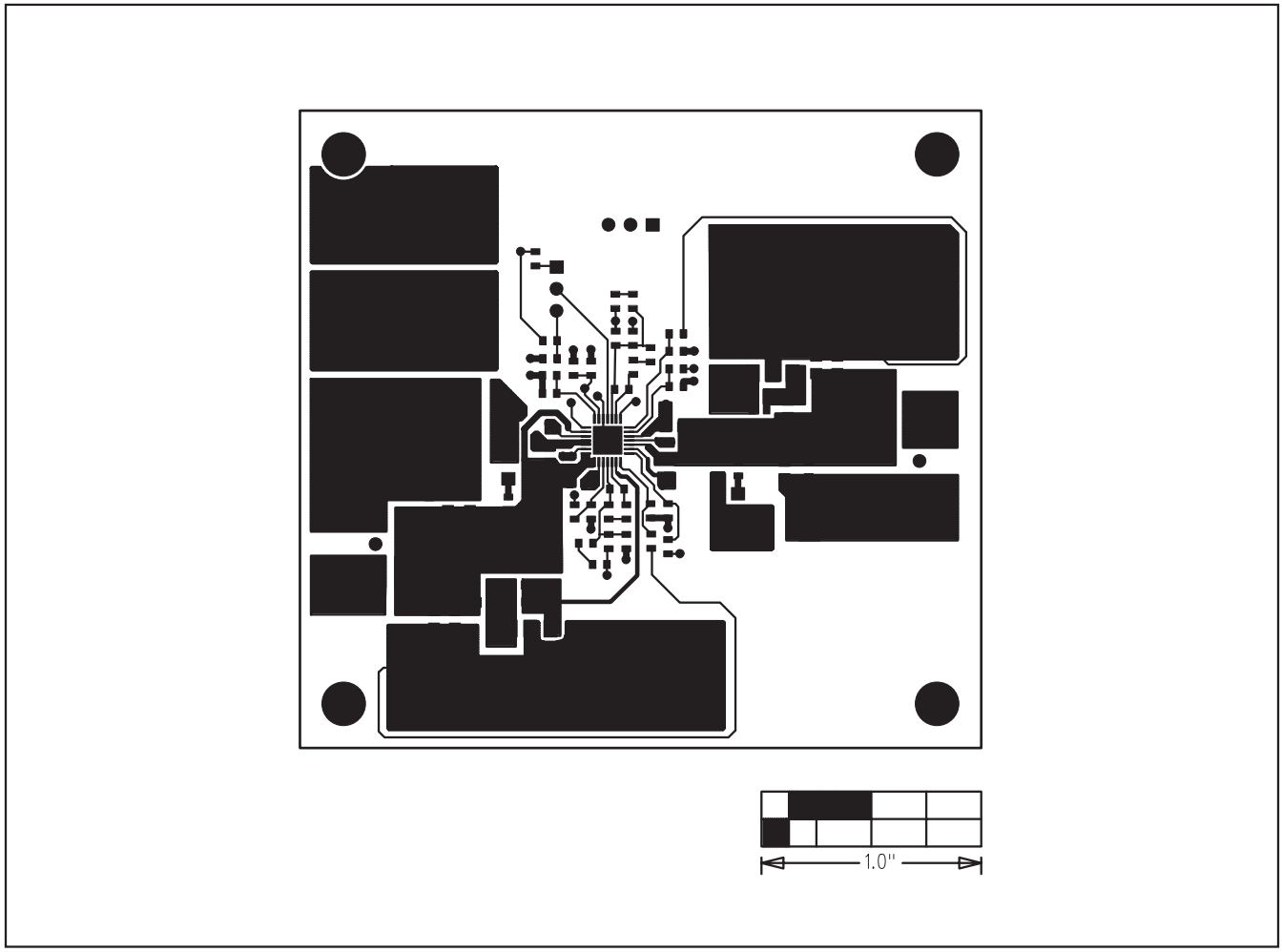


Figure 3. MAX15022 EV Kit PCB Layout—Component Side

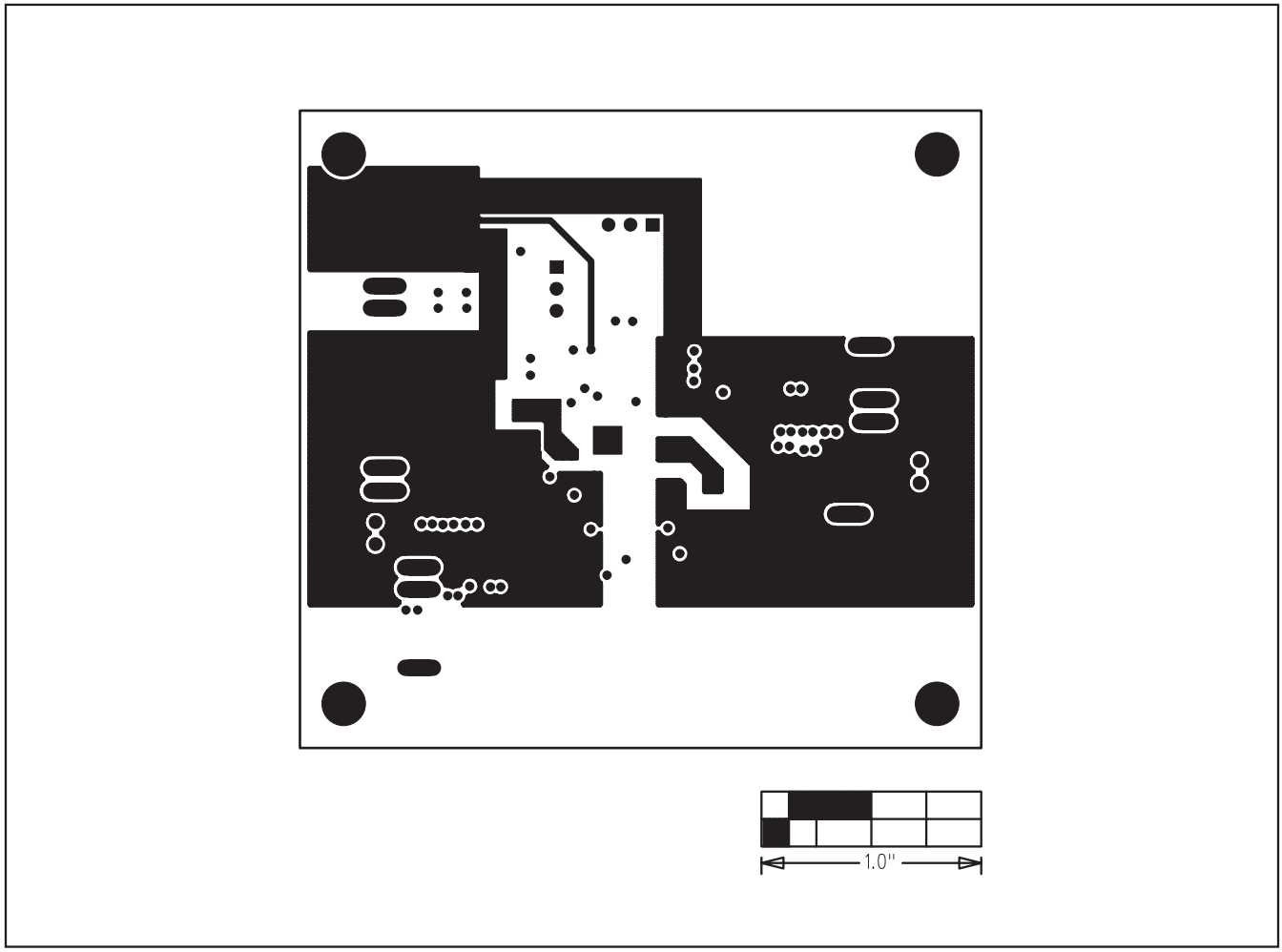


Figure 4. MAX15022 EV Kit PCB Layout—GND Layer 2

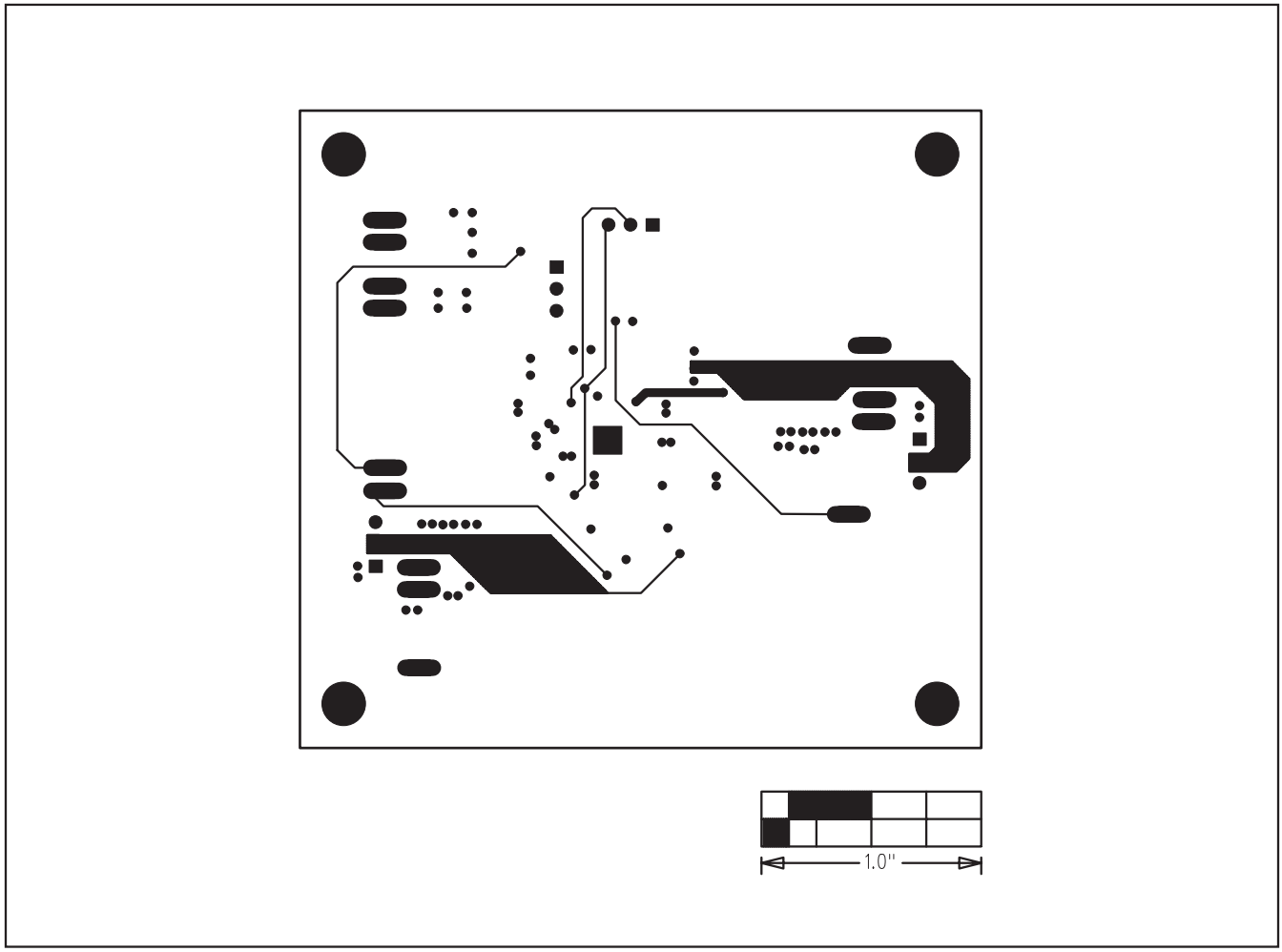


Figure 5. MAX15022 EV Kit PCB Layout—Inner Trace Layer 3

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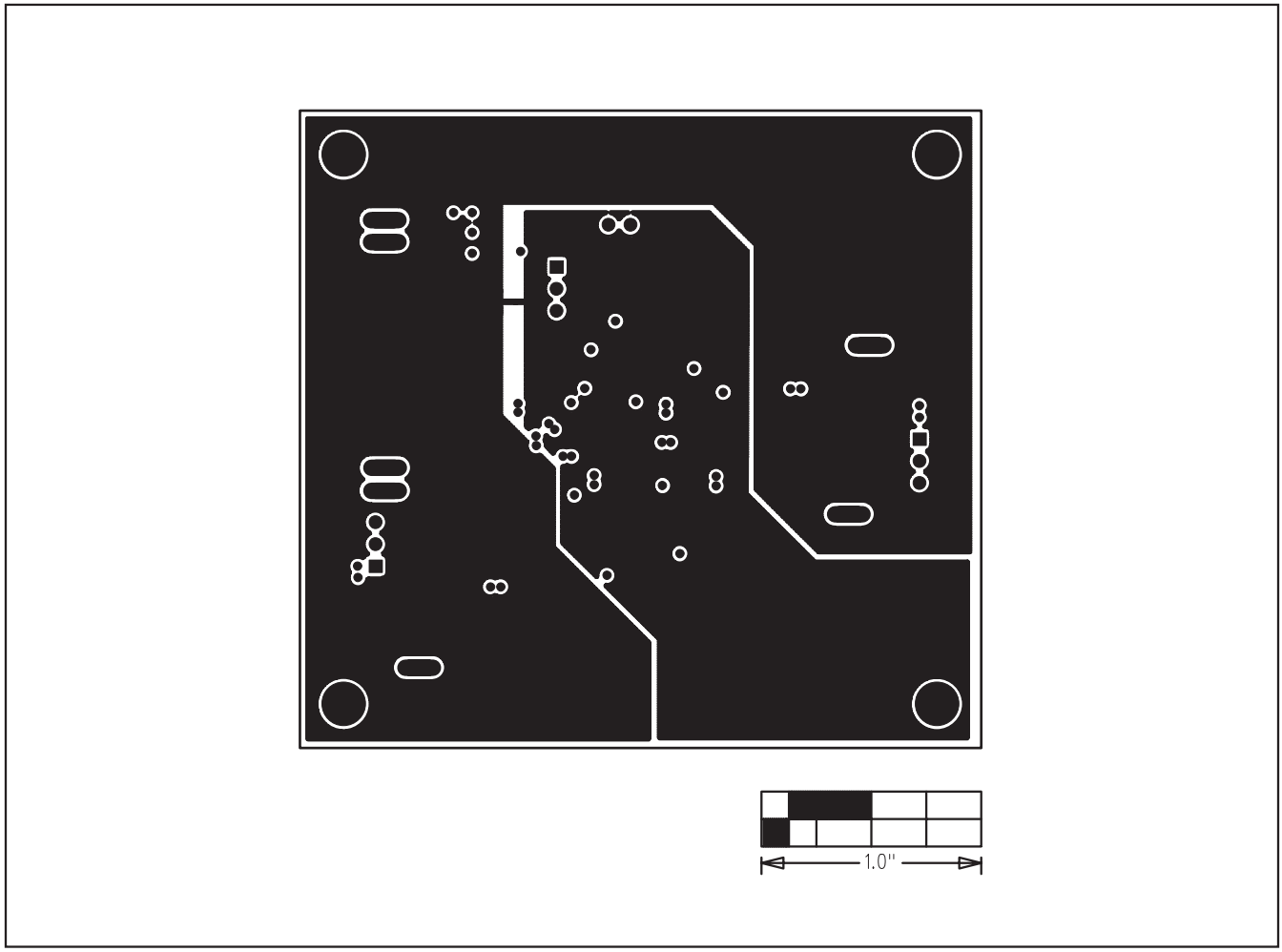


Figure 6. MAX15022 EV Kit PCB Layout—Solder Side

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