MAX17509 Evaluation Kit

Evaluates: MAX17509 4.5V–16V, Dual 3A Synchronous Buck Converter

General Description

The MAX17509 evaluation kit (EV kit) is a fully assembled and tested circuit board to demonstrate the performance of the MAX17509, a dual 3A, high-efficiency, synchronous step-down DC-DC converter. The EV kit operates from a 4.5V to 16V input voltage to generate two, independent 3.3V and 1.2V outputs, with each regulator delivering up to 3A continuous output current. The EV kit is preset to the default 1MHz switching frequency for optimum efficiency and component sizes, and each regulator operates 180° out-of-phase to reduce input-voltage ripple and total RMS input ripple current. The EV kit also features adjustable input undervoltage-lockout (UVLO), programmable frequency, external frequency synchronization input, adjustable output voltage ranging from 0.904V to 3.782V and 4.756V to 5.048V with 20mV resolution, selectable switching slew rate, adjustable soft-start time with soft-stop option, power-good outputs, and selectable overcurrent (OC) fault response to promote design flexibility and system reliability.

Features

- Wide Input-Voltage Range (4.5V to 16V)
- 3.3V and 1.2V Output Voltages
- Up to 3A Output Current per Regulator
- Two Independent Outputs Operating 180° Out-of-Phase
- 1MHz Switching Frequency
- External Frequency Synchronization Input
- Brickwall and Latchoff Overcurrent Response (Selectable to Hiccup Response)
- Autoconfigured Internal Compensation
- Power-Good Output Indicator
- Independent Adjustable EN/UVLO Input
- Independent Adjustable Soft-Start Time with Soft-Stop Option
- Selectable Switching Slew Rate for EMC Compliant
- Low-Profile and Small-Size, Surface-Mount Components
- Fully Assembled and Tested

Quick Start

Recommended Equipment

- MAX17509 EV kit
- 4.5V to 16V, 4A DC input power supply
- Two loads capable of sinking 3A
- Digital voltmeters (DVM)
- 100MHz dual-trace oscilloscope

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) Set the power supply at a voltage between 4.5V and 16V. Disable the power supply.
2) Connect the positive and negative terminals of the power supply to IN and PGND PCB pads, respectively.
3) Connect the positive and negative terminals of the first 3A load to OUT1 and PGND PCB pads, respectively, and the second 3A load to OUT2 and PGND PCB pads, respectively. Set both loads to 0A.
4) Connect the first DVM across the OUT1 and PGND PCB pads, and the second across OUT2 and PGND, respectively.
5) Change the position of SW1 and SW2 to position 1-2 (or 2-3) to enable the respective regulator. SW1 and SW2 in the middle position will disable the device.
6) Enable the input power supply.
7) Verify that DVM1 displays 3.3V and DVM2 displays 1.2V.
8) Increase the load up to 3A to verify that DVM continues displaying 3.3V and 1.2V, respectively. Note that the EV kit is designed to demonstrate compact solution-size so that the output voltage-sensing is performed near C2 for VOUT1 and C3 for VOUT2. Therefore, the output voltage is accurate across those respective components.

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

19-7670; Rev 1; 9/16

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Detailed Description of Hardware

The EV kit is a proven circuit to demonstrate the high-efficiency and compact solution-size of the synchronous step-down DC-DC regulators. The EV kit operates from a 4.5V to 16V input voltage to generate two independent 3.3V and 1.2V outputs, with each regulator delivering up to 3A continuous output current. The switching frequency is set to 1MHz to balance efficiency and component size. The EV kit includes switches SW1,2 to enable/disable the device, test point TP1 to optionally synchronize to an external clock source (SYNC), and LED1,2 connected to PGOOD1,2 to indicate the status of the outputs. Additional footprints of optional components are included to ease board modification for different input/output configurations. Table 1 displays the resistor programming options. When the output voltage is changed, refer to the MAX17509 IC data sheet's recommendation on the inductance and capacitance selection criteria.

Table 1. Summary of Resistor Programming

Index	1% RES.	R13 MODE			R1 SS1			R2 SS2			R5, R8 COARSE_	R6, R7 FINE_
	(kΩ)	MODE	PHASE SHIFT	F_{SW}	OC	SSTOP1	TSS1 (ms)	LX-SLEW	SSTOP2	TSS2 (ms)	COARSE V_{OUT} (V)	FINE V_{OUT} (V)
0	475 (OPEN or VCC)	TWO SINGLE-PHASE INDEPENDENT OUTPUTS	180°	500kHz	BRICKWALL AND LATCHOFF	DISABLE	1	MAXIMUM	DISABLE	1	0.650	0.000
1	200			1.0MHz			4			4		0.019
2	115			1.5MHz			8			8		0.037
3	75			2.0MHz			16			16	0.966	0.057
4	53.6		0°	500kHz		ENABLE	1		ENABLE	1	1.281	0.078
5	40.2			1.0MHz			4			4	1.597	0.097
6	30.9			1.5MHz			8			8	1.912	0.115
7	24.3			2.0MHz			16			16	2.228	0.135
8	19.1	DUAL-PHASE, SINGLE OUTPUT	180°	500kHz	HICCUP	DISABLE	1	MINIMUM	DISABLE	1	2.543	0.157
9	15			1.0MHz			4			4	2.859	0.176
10	11.8			1.5MHz			8			8	3.174	0.194
11	9.09			2.0MHz			16			16	3.490	0.213
12	6.81			500kHz		ENABLE	1		ENABLE	1	4.756 (7V VIN)	0.235
13	4.75			1.0MHz			4			4	4.756 (9V VIN)	0.254
14	3.01			1.5MHz			8			8	4.756 (12V VIN)	0.272
15	GND			2.0MHz			16			16	4.756 (16V VIN)	0.291

Regulator Enable and Adjustable UVLO

The device can be self-enabled by connecting EN_ to AVCC, and can optionally be programmed to turn on at the input-voltage threshold by connecting EN_ to the resistor-divider between IN_ to GND. The EV kit has SW1 and SW2 to enable regulator 1 and 2, respectively, through the input supply or AVCC. Moving the switches to position 1 enables the device at a 4.1V input UVLO threshold, while moving to position 3 connects EN_ to AVCC. Moving a switch to position 2 will disable the respective regulator. The adjustable-input UVLO threshold of a regulator can be programmed with top feedback resistor RU connected between IN_ and EN_, and bottom feedback resistor RB connected between EN_ and GND. The adjustable-input UVLO threshold of regulator 1 can be programmed with the resistor-dividers R15 (RU1) and R3 (RB1), and regulator 2 with R16 (RU2) and R10 (RB2).

Choose RU_ and then calculate RB_ with the following equation:

$$R_{B\_} = R_{U\_} \times \left[\frac{1.262}{V_{INU} - 1.262}\right]$$

Where VINU is the input threshold voltage at which the device is required to turn on. Ensure that VINU is higher than 0.93 x V_{OUT}.

Mode/Phase Shift/ Switching Frequency (MODE)

The MODE pin sets the device as a single-phase, dual-output/dual-phase, or single-output, while also setting the phase-shift and switching frequency. The EV kit operates in a single-phase, dual-output configuration, each with up to 3A output current. Each regulator operates with 180° out-of-phase and 1MHz switching frequency. The phase-shift mode can be selected to be either 0° or 180° out-of-phase in the dual-output mode only. The device is also capable of configuring different switching frequency options: 0.5MHz, 1MHz, 1.5MHz, and 2MHz for input voltage up to 6V.

Soft-Start/Soft-Stop Options and Over-Current Response (SS1)

The SS1 pin sets regulator 1's soft-start timing among 1, 4, 8, and 16ms, as well as its soft-stop option. The SS1 pin also sets options to attempt regulation following an under and overcurrent event. The two options for fault response due to UC/OC protection are: (1) hiccup and (2) Brickwall and latchoff. The EV kit is set to 8ms soft-start timing, with soft-stop enabled for regulator 1, and Brickwall-and-latchoff overcurrent response for both regulators.

Soft-Start/Soft-Stop Options and Switching Slew rate (SS2)

The SS2 pin sets regulator 2's soft-start timing among 1, 4, 8, and 16ms, as well as its soft-stop option. The SS2 pin also sets the switching slew rate of both regulators to either maximum or minimum. The EV kit is set to 8ms soft-start timing, with soft-stop enabled, for regulator 2, and maximum switching slew rate for both regulators.

External Clock Synchronization (SYNC)

The SYNC pin allows frequency-synchronization to external clock. The EV kit provides a SYNC test point (TP1) that allows connecting an external clock for frequency synchronization with frequency within the 900kHz to 1.3MHz range before regulation starts for stable operation of 1MHz internal switching frequency at the $12V_{IN}$ range, and within 0.7–2.75 of the internal switching frequency, with a limit of 450kHz to 2.2MHz for the $5V_{IN}$ range. The minimum external clock high pulse width should be greater than 30ns. The minimum voltage should be below 0.6V, with the maximum level being above 1.8V (e.g., 0 to 5V).

Programmable Output Voltage

The device generates an independently adjustable output voltage in the ranges of 0.904V to 3.782V and 4.756V to 5.048V in 20mV steps. The EV kit provides 3.3V on regulator 1 and 1.2V on regulator 2. The target output voltage (V_{OUT}) is determined by the sum of COARSE voltage (COARSE_) and FINE voltage (FINE_), which can be programmed by connecting resistors from COARSE and FINE pins to GND. The COARSE-resistor value is selected according to the closest COARSE_ voltage less than or equal to the target output voltage from Table 1. The FINE resistor value is chosen by the index number, calculated by the following equation:

$$Index = \left(\frac{\left[V_{OUT} - V_{OUTCOARSE} \right]}{0.02} \right)$$

Where $V_{OUTCOARSE}$ is the COARSE_ closest to the value of V_{OUT}; Index is the index number selected for the FINE resistor value from Table 1. Table 2 summarizes the resistor setting and the optimal inductor and output capacitor selection for typical output voltages for typical $12V_{IN}$ range. Consult the MAX17509 IC data sheet's recommendation on the inductance and capacitance value, as well as the guideline for the $5V_{IN}$ range.

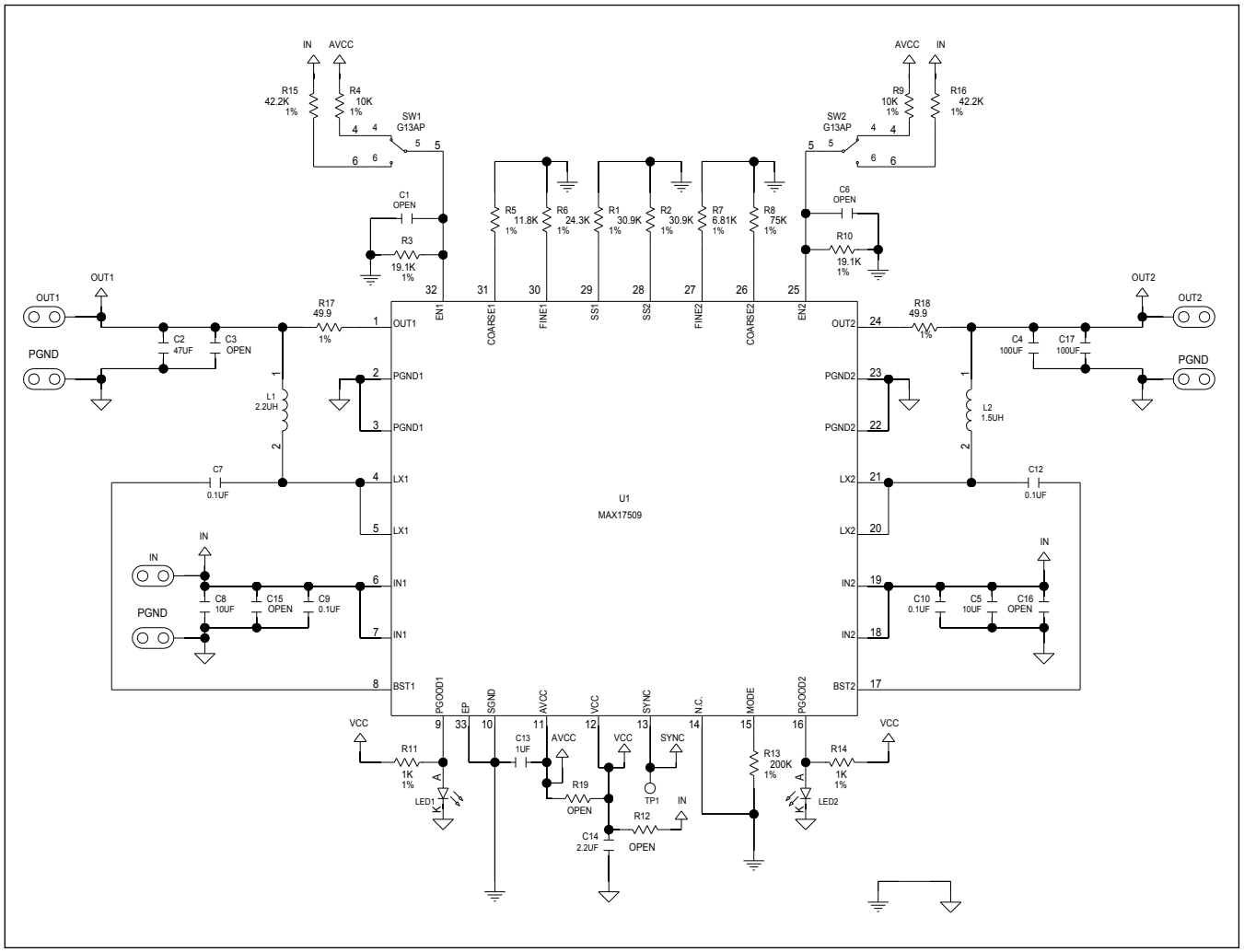
Table 2. Summary of Resistor Setting and the Optimal Inductor and Output Capacitor Selection for Typical Output Voltages

V_{OUT} (V)	COARSE INDEX	FINE INDEX	COARSE RESISTOR (kΩ)	FINE RESISTOR (kΩ)	$6 \le V_{IN} \le 16V$, F_{SW} = 1MHz	
					L_{MIN} (µH)	C_{OUTMIN} (µF)
0.9	2	13	115	4.75	1	100
1.0	3	2	75	115	1.2	82
1.2	3	12	75	6.81	1.2	68
1.5	4	11	53.6	9.09	1.5	55
2.0	6	5	30.9	40.2	2.2	41
2.5	7	14	24.3	3.01	2.2	33
3.0	9	7	15.0	24.3	2.2	18
3.3	10	7	11.8	24.3	2.2	18
5.0 (7V VIN)	12	13	6.81	4.75	1.8	18
5.0 (9V VIN)	13		4.75		2.7	
5.0 (12V VIN)	14		3.01		3.9	
5.0 (16V VIN)	15		GND		4.7	

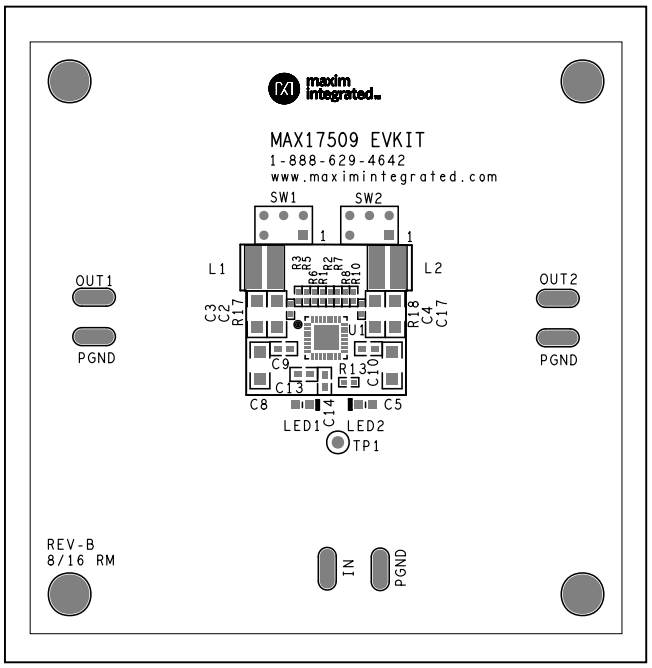
MAX17509 EV Bill of Materials

REFERENCE	QTY	DESCRIPTION
C2	1	CAPACITOR; SMT (1206); CERAMIC CHIP; 47µF; 16V; TOL = 20%; MODEL = C SERIES; TG = -55°C TO +85°C; TC = X5R
C4, C17	2	CAPACITOR; SMT (1206); CERAMIC CHIP; 100µF; 10V; TOL = 20%; MODEL = C SERIES; TG = -55°C TO +85°C; TC = X5R
C5, C8	2	CAPACITOR; SMT (1206); CERAMIC CHIP; 10µF; 25V; TOL = 10%; TG = -55°C TO +125°C; TC = X7R
C7, C12	2	CAPACITOR; SMT (0603); CERAMIC CHIP; 0.1µF; 16V; TOL = 10%; TG = -55°C TO +125°C; TC = X7R
C9, C10	2	CAPACITOR; SMT (0603); CERAMIC CHIP; 0.1µF; 25V; TOL = 10%; MODEL = C SERIES; TG = -55°C TO +125°C; TC = X7R
C13	1	CAPACITOR; SMT (0603); CERAMIC CHIP; 1µF; 16V; TOL = 10%; MODEL = ; TG = -55°C TO +125°C; TC = X7R
C14	1	CAPACITOR; SMT (0603); CERAMIC CHIP; 2.2µF; 10V; TOL = 10%; TG = -55°C TO +125°C; TC = X7R
IN, OUT1, OUT2, PGND1-PGND3	6	EVK KIT PARTS; MAXIM PAD; WIRE; NATURAL; SOLID; WEICO WIRE; SOFT DRAWN BUS TYPE-S; 20AWG
L1	1	INDUCTOR; SMT; COMPOSITE CORE; 2.2µH; TOL = ±20%; 4A
L2	1	INDUCTOR; SMT; COMPOSITE CORE; 1.5µH; TOL = ±20%; 5.2A
LED1, LED2	2	DIODE; LED; STANDARD; YELLOW; SMT (0603); PIV = 5.0V; IF = 0.02A; -55°C TO +85°C
R1, R2	2	RESISTOR; 0402; 30.9KΩ; 1%; 100PPM; 0.063W; THICK FILM
R3, R10	2	RESISTOR; 0402; 19.1KΩ; 1%; 100PPM; 0.063W; THICK FILM
R4, R9	2	RESISTOR; 0402; 10KΩ; 1%; 100PPM; 0.10W; THICK FILM
R5	1	RESISTOR; 0402; 11.8KΩ; 1%; 100PPM; 0.063W; METAL FILM
R6	1	RESISTOR; 0402; 24.3KΩ; 1%; 50PPM; 0.063W; THIN FILM
R7	1	RESISTOR; 0402; 6.81KΩ; 1%; 100PPM; 0.063W; METAL FILM
R8	1	RESISTOR; 0402; 75KΩ; 1%; 100PPM; 0.063W; THICK FILM
R11, R14	2	RESISTOR; 0402; 1KΩ; 1%; 100PPM; 0.10W; THICK FILM
R13	1	RESISTOR; 0402; 200K; 1%; 100PPM; 0.0625W; THICK FILM
R15, R16	2	RESISTOR; 0402; 42.2K; 1%; 100PPM; 0.0625W; THICK FILM
R17, R18	2	RESISTOR; 0402; 49.9Ω; 1%; 100PPM; 0.0625W; THICK FILM
SW1, SW2	2	SWITCH; SPDT; THROUGH HOLE; 28V; 0.1A; PROCESS SEALED ULTRA-MINIATURE TOGGLE; RCOIL = Ω; RINSULATION = 1G OHM; NKK SWITCHES
TP1	1	TEST POINT; PIN DIA = 0.1IN; TOTAL LENGTH = 0.3IN; BOARD HOLE = 0.04IN; RED; PHOSPHOR BRONZE WIRE SILVER PLATE FINISH;
U1	1	EVKIT PART - IC; MAX17509; TQFN32-EP 5X5; PKG. DWG. NO.: 21-0140; PKG CODE T3255+4
C1, C6	0	PACKAGE OUTLINE 0402 NON-POLAR CAPACITOR
C3, C15, C16	0	PACKAGE OUTLINE 1206 NON-POLAR CAPACITOR
R12	0	PACKAGE OUTLINE 0402 RESISTOR
R19	0	RESISTOR; 0603 PACKAGE; GENERIC
PCB	1	PCB Board: MAX17509 EVALUATION KIT

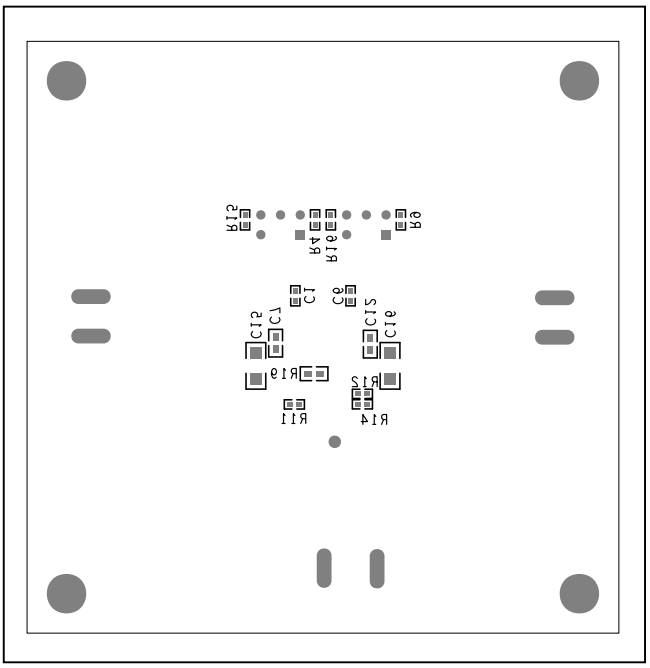
MAX17509 EV Schematic



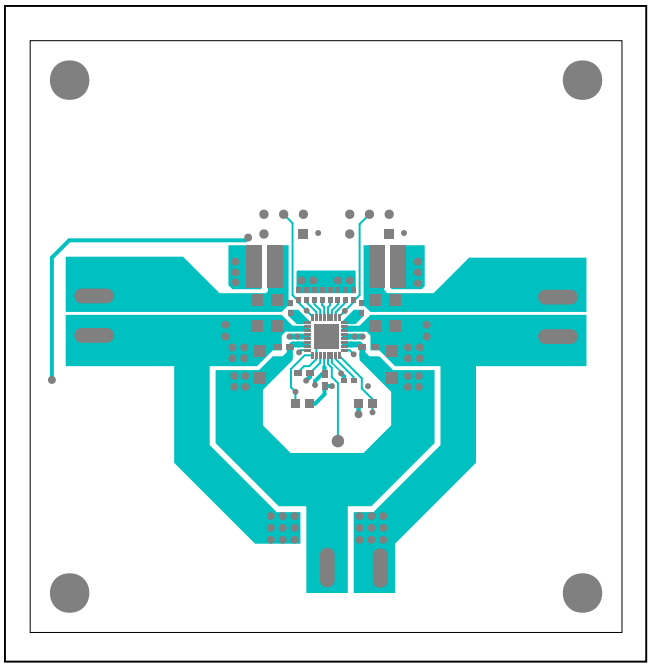
PCB Layout Diagrams



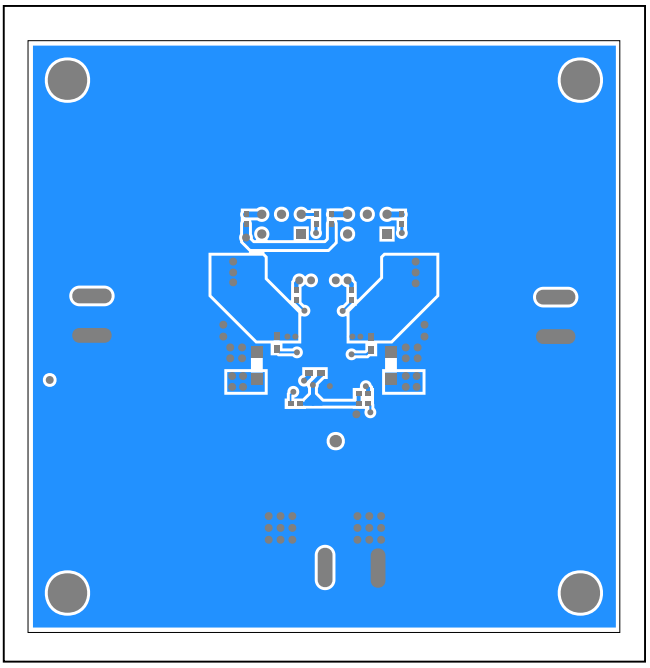
MAX17509 EV Kit—Top Silkscreen



MAX17509 EV Kit—Bottom Silkscreen

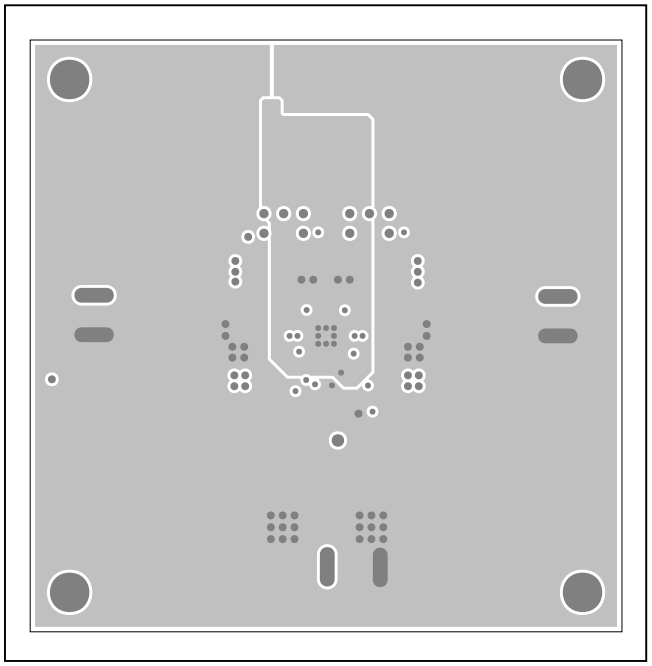


MAX17509 EV Kit—Top

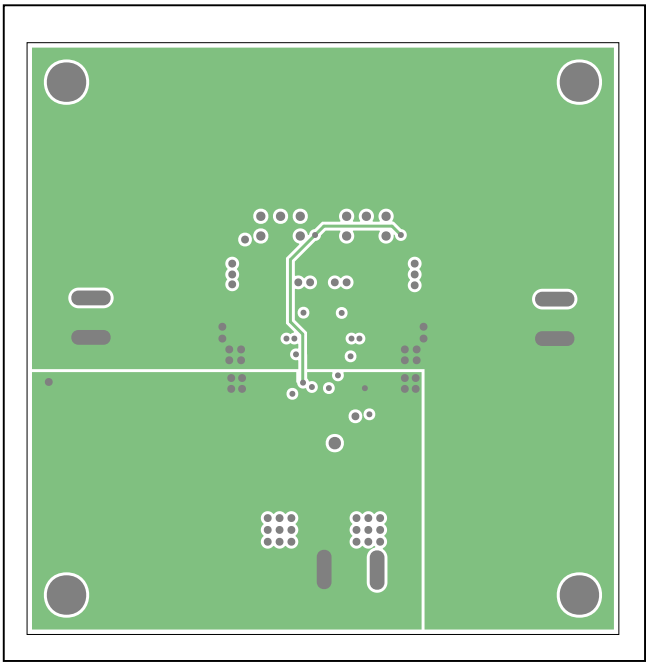


MAX17509 EV Kit—Bottom

PCB Layout Diagrams (continued)



MAX17509 EV Kit—Layer 2 GND



MAX17509 EV Kit—Layer 3 Power

Ordering Information

PART	TYPE
MAX17509EVKIT#	EV Kit

#Denotes RoHS compliant.

Revision History

REVISION NUMBER	REVISION DATE	DESCRIPTION	PAGES CHANGED
0	6/15	Initial release	—
1	9/16	Updated *Bill of Materials* and removed *Typical Operating Characteristics* section	5–8

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