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## General Description

The MAX17559 EV kit is a proven design to evaluate the dual synchronous step-down regulator that provides independent 3.3V and 5V outputs capable of driving 8A and 15A loads from the 6V to 60V input-voltage range. Operating the two regulators 180° out-of-phase significantly reduces the peak input ripple current, allowing the use of smaller, less expensive components, while minimizing parts count. The EV kit features adjustable input undervoltage lockout, soft-start/stop time, and current-limit threshold, as well as selectable PWM/DCM modes, foldback/latchoff current limit, and independent open-drain PGOOD signals. By disabling channel 2, the evaluation kit is capable of operating from a lower input supply (4.5V to 60V), providing a single 3.3V output driving up to 15A.

## Benefits and Features

- 6V to 60V Input Range
- Output Rails: VOUT1: 3.3V/15A, VOUT2: 5V/8A
- 150kHz Switching Frequency
- Independent Enable Inputs
- Independent Adjustable Soft-Start Time
- Configurable Tracking Operation
- Selectable PWM/DCM Modes of Operation
- Fixed 180° Out-of-Phase Operation
- Selectable Foldback/Latchoff Current Limit
- Programmable Current-Limit Threshold
- Independent PGOOD Outputs
- Overcurrent, Overvoltage, and Overtemperature Protection
- Proven PCB Layout
- Fully Assembled and Tested

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

## Quick Start

### Required Equipment

- MAX17559 EV kit
- 4.5V to 60V, 15A DC power supply
- Loads capable of sinking 8A and 15A
- Two digital voltmeters (DVM)

### 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 voltage to 24V and ensure that the DC power supply is disabled.
2) Set one load to 8A and the other load to 15A. Disable the loads in the case of electronic loads (leave the loads unconnected in case of resistor loads. Ensure that the resistor power ratings are high enough to dissipate the output voltages).
3) Connect the positive terminal of the power supply to the VIN connector and the negative terminal to the PGND connector, which is nearest to VIN connector.
4) Connect one digital voltmeter across the VOUT1 connector and the nearest PGND connector, with the positive terminal of the DVM connected to the VOUT1 connector.
5) Connect the other digital voltmeter across the VOUT2 connector and the nearest PGND connector, with the positive terminal of the DVM connected to the VOUT2 connector.
6) Verify that the shunts are connected between pins 1-2 of the JU1 and JU2 jumpers to select default settings of the EV kit
7) Turn on the DC power supply.
8) Verify that the digital voltmeters display the expected voltages (3.3V±1% on VOUT1 and 5V±1% on VOUT2).
9) Enable the electronic load (connect the load in the case of resistor load).
10) Verify that the voltmeters display the expected voltages (3.3V±1% on VOUT1 and 5V±1% on VOUT2).

## Detailed Description of Hardware

The MAX17559 EV Kit provides dual 3.3V/15A and 5V/8A outputs from a 6V to 60V input supply. By disabling channel 2, the EV kit provides a 3.3V output to drive up to 15A from a low 4.5V to 60V input voltage. The EV Kit is preset to 150kHz and operates 180° out-of-phase for optimum efficiency and component size.

The EV kit implements an optional sub-circuit, R13–R18, R28, D7, and JU1, JU2 to enable/disable the output at a desired input UVLO, as well as soft-start/stop power sequence. Resistors R35 and R36 are selected different values to configure the EV kit operating in DCM/PWM mode and foldback/latchoff, current-limit mode, respectively.

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

The device output voltages ($V_{OUT1}$ and $V_{OUT2}$) can be adjusted between 0.8V to 24V through sets of feedback resistor-dividers R19,R20 and R23,R24 by the following formula:

$$R20 = \frac{R19}{(\frac{V_{OUT1}}{0.8} - 1)} \text{ and } R24 = \frac{R23}{(\frac{V_{OUT2}}{0.8} - 1)}$$

Please refer to MAX17559 IC data sheet to select the R19 and R23 values, changing compensation components, as well as output capacitors for setting new output voltages.

### Soft-Start/Stop (SS_)

The device offers an SS_ pin to connect a capacitor to GND to adjust the soft-start/stop time during startup and shutdown. An internal 5μA current source charges/discharges the capacitor at the SS_ pin, providing a linear ramping voltage for output voltage reference. The soft-start/stop time of $V_{OUT1}$ and $V_{OUT2}$ are calculated based on the following equation:

$$t_{SS\_} = C_{SS\_} \times \frac{0.8V}{5\mu A}$$

The default soft-start/stop time of $V_{OUT1}$ or $V_{OUT2}$ is approximately 10.8ms at 68nF soft-start/stop capacitor.

### Enable/Undervoltage-Lockout Level (EN_)

The device can be independently started up or shut down by manipulating the EN1 and EN2 pins. Leave EN_ unconnected for a default enable controller. Place shunts across pins 1-2 of JU1 and JU2 to enable each controller through the input UVLO formed by resistor-dividers. Connect a resistor-divider from $V_{IN}$ to EN_ and EN_ to GND to program the UVLO threshold for the corresponding controller. The EN_ pin can be programmed to 1.25V (typ) to detect UVLO at a desired input voltage to enable/disable the corresponding controller with 50mV (typ) hysteresis. Place jumpers across pins 2-3 of JU1 and JU2 to disable the controllers. Table 1 shows all configurations of jumpers to enable/disable each of controllers.

Select R14 (R18 for OUT2) below 10K and calculate R13 (R17) based on the following equation:

$$R13 = \frac{R14 \times (V_{INUVLO} - 1.25)}{1.25}$$

where $V_{INUVLO}$ is the input voltage at which the controller is required to turn on.

## Table 1. Enable Control (JU1, JU2)

| JUMPER | SHUNT POSITION | EN | MAX17558 OUTPUT |
|---|---|---|---|
| JU1 | Not installed | Unconnected | Enabled |
| | 1-2 | Connected to the midpoint of input UVLO divider | Enabled, UVLO level is set by the resistor divider from VIN to GND. |
| | 2-3 | Connected to GND | Disabled |
| JU2 | Not installed | Unconnected | Enabled |
| | 1-2 | Connected to the mid-point of input UVLO divider | Enabled, UVLO level is set by the resistor divider from VIN to GND. |
| | 2-3 | Connected to GND | Disabled |

## Mode Selection (SKIP)

The SKIP pin allows the user to select between the PWM and DCM modes of operation. Set R36 = 0Ω to select constant-frequency PWM mode operation. Choose 100kΩ to operate in DCM mode.

### Fixed Phase-Shift Between Controllers

The two controllers of the dual switching regulator operate at a fixed 180° out-of-phase that interleaves the current pulses from the switches and reduces overlap time where they combine. The result is a significant reduction in total RMS input current, allowing for less expensive input capacitors to be used, reducing shielding requirements for EMI, and improving operating efficiency.

## Current-Limit Threshold Selection

The EV kit includes current-limit resistors (R12 and R22) that can be modified to program current-limit thresholds for controllers 1 and 2. The peak current limit of each controller can be programmed independently by selecting different values for R12 and R22. Note that changing R12 and R22 affect the stability and current-sense signal across the current sense pins. Refer to the *Current Limit Programming (ILIM_)* and *Current Sensing* sections of MAX17559 IC data sheet for calculating R12, R22 and the current sense resistor values.

## Switching Frequency

The EV kit is set to a 150kHz switching frequency by R14. Change the value of R14 to set a different switching frequency between 100kHz to 2200kHz. Use the following equation to calculate R14 when reconfiguring the switching frequency:

$$R_{RT} = \frac{(f_{SW} + 133)}{8.8}$$

where $f_{SW}$ is in kHz and R14 is in kΩ.

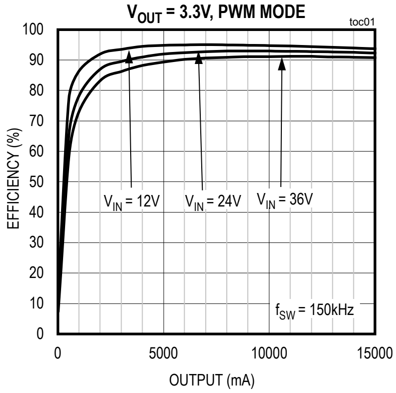
When reconfiguring the EV kit switching frequency, it might be necessary to change the values of the loop-compensation-network components. Refer to the *Loop Compensation* section of the MAX17559 IC data sheet for computing new compensation component values.

## Power-Good Outputs

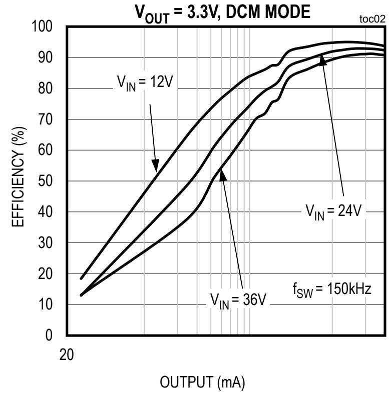
The EV kit provides power-good output test points PGOOD1 and PGOOD2 to monitor the PGOOD1 and PGOOD2 signals. The PGOOD signals are pulled-up to $V_{CCINT}$ by R26 and R27. PGOOD1 and PGOOD2 are high when $V_{OUT1}$ and $V_{OUT2}$, respectively, are above 90% and below 110% of their programmed output voltages. When $V_{OUT1}$ and $V_{OUT2}$ are below 90% or above 110% of their programmed output voltages, PGOOD1 and PGOOD2 are low.

## EV Kit Performance Report

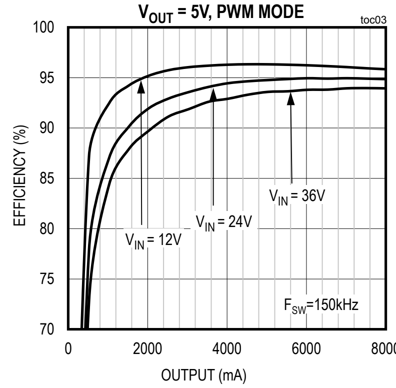
EFFICIENCY vs. OUTPUT CURRENT
$V_{OUT}$ = 3.3V, PWM MODE



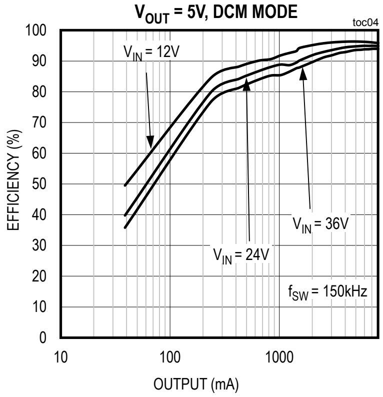

EFFICIENCY vs. OUTPUT CURRENT
$V_{OUT}$ = 3.3V, DCM MODE



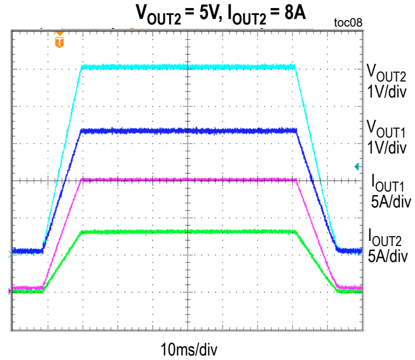

EFFICIENCY vs. OUTPUT CURRENT
$V_{OUT}$ = 5V, PWM MODE



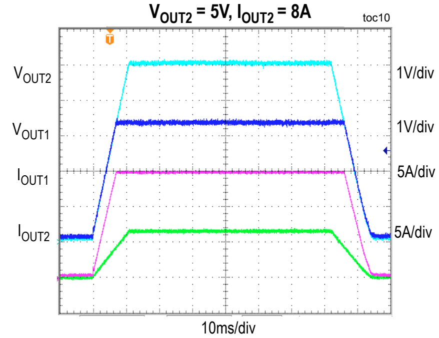

EFFICIENCY vs. OUTPUT CURRENT
$V_{OUT}$ = 5V, DCM MODE



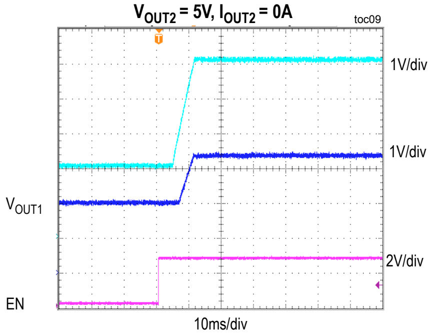

STARTUP FROM ENABLE
$V_{IN}$ = 24V, $V_{OUT1}$ = 3.3V, $I_{OUT1}$ = 15A,
$V_{OUT2}$ = 5V, $I_{OUT2}$ = 8A



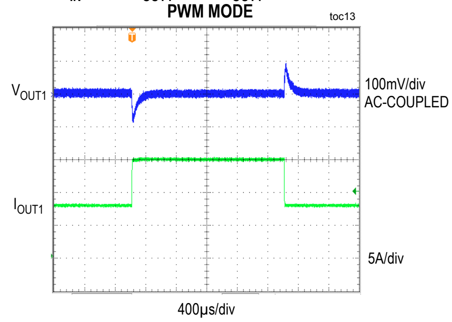

COINCIDENT TRACKING AT STARTUP
$V_{IN}$ = 24V, $V_{OUT1}$ = 3.3V, $I_{OUT1}$ = 15A,
$V_{OUT2}$ = 5V, $I_{OUT2}$ = 8A



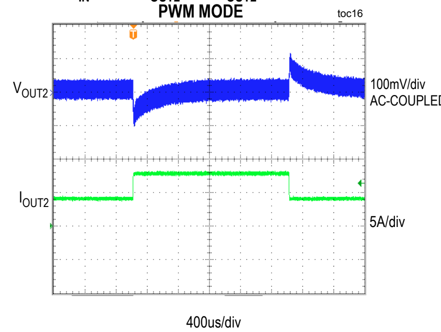

STARTUP INTO PREBIASED OUTPUT
$V_{IN}$ = 24V, $V_{OUT1}$ = 3.3V, $I_{OUT1}$ = 0A,
$V_{OUT2}$ = 5V, $I_{OUT2}$ = 0A



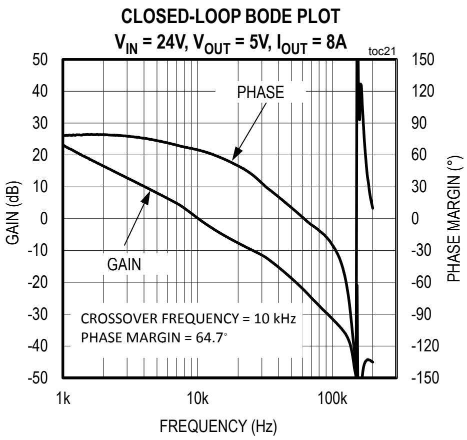

LOAD TRANSIENT RESPONSE
$V_{IN}$ = 24V, $V_{OUT1}$ = 3.3V, $I_{OUT1}$ = 7.5A to 15A
PWM MODE

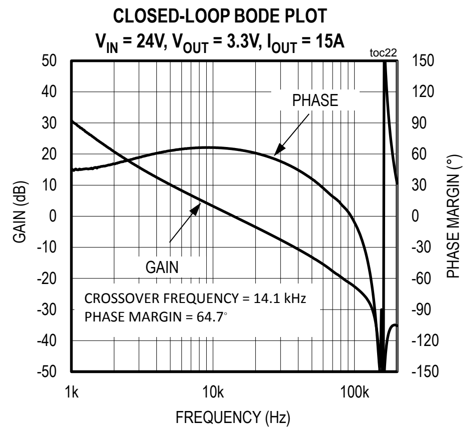



LOAD TRANSIENT RESPONSE
$V_{IN}$ = 24V, $V_{OUT2}$ = 5V, $I_{OUT2}$ = 4A to 8A
PWM MODE



## EV Kit Performance Report (continued)



## Component Suppliers

| SUPPLIER | WEBSITE |
|---|---|
| Wurth Elektronik | www.we-online.com |
| Renesas Electronics | am.renesas.com |
| Murata Americas | www.murata.com |
| Panasonic Electronic Components | www.panasonic.com/industrial |
| Vishay Dale | www.vishay.com |
| TDK Corp. | www.tdk.com |
| Rubycon Corp. | www.rubycon.com |
| TT Electronics/Welwyn | www.welwyn-tt.com |

***Note:*** *Indicate that you are using the MAX17559 when contacting these component suppliers.*

## Component List, PCB Files and Schematic

See the following links for component information, PCB files, and schematics:

- **MAX17559 EV BOM**
- **MAX17559 EV PCB Files**
- **MAX17559 EV Schematics**

## Ordering Information

| PART | TYPE |
|---|---|
| MAX17559EVKIT# | EV kit |

*#Denotes RoHS compliant.*

## Revision History

| REVISION NUMBER | REVISION DATE | DESCRIPTION | PAGES CHANGED |
|---|---|---|---|
| 0 | 6/15 | Initial release | — |

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.

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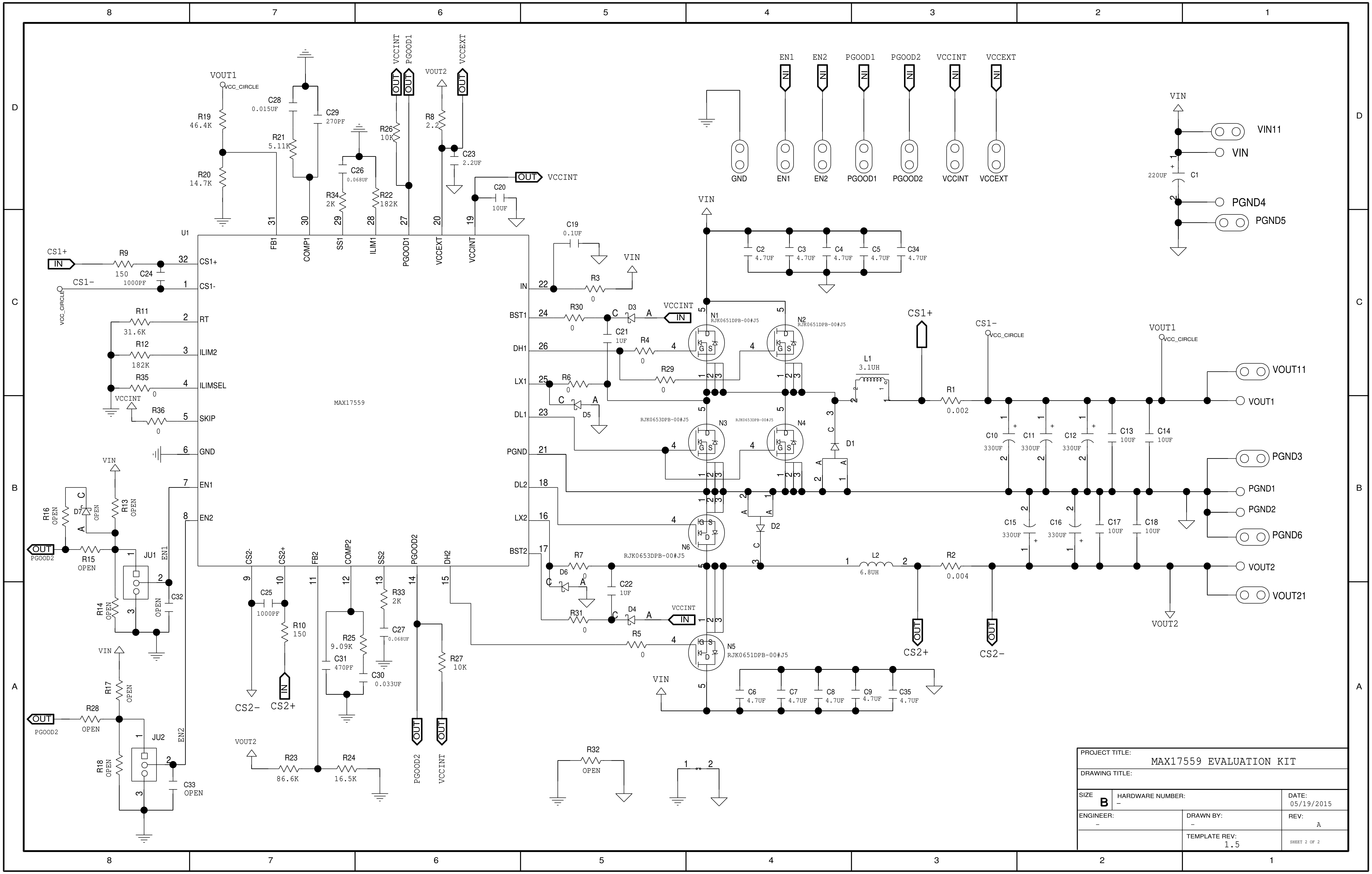
MAX17559
U1
PROJECT TITLE:
MAX17559 EVALUATION KIT
DRAWING TITLE:
SIZE
B
HARDWARE NUMBER:
-
DATE:
05/19/2015
ENGINEER:
-
DRAWN BY:
-
REV:
A
TEMPLATE REV:
1.5
SHEET 2 OF 2

# BILL OF MATERIALS (BOM) Revision 5/15

| Designation | Qty | Description |
|---|---|---|
| C1 | 1 | 220uF,63V<br>Panasonic Electronic EEVFK1J221Q |
| C2-C9, C34, C35 | 10 | CAP CER 4.7UF 80V 10% X7R 1210<br>Murata GRM32ER71K475KE14L |
| C10,C11,C12, C15, C16 | 5 | 330uF,9mΩ, 6.3V<br>Panasonic Electronic 6TPF330M9L |
| C13,C14,C17, C18 | 4 | 10uF,10V,X7R,1210,10%<br>Murata GRM32DR71A106KA01L |
| C18 | 0 | 10uF,10V,X7R,1210,10%<br>Murata GRM32DR71A106KA01L |
| C19 | 1 | CAP CER 0.1UF 100V 10% X7R 0603<br>Murata GRM188R72A104KA35D |
| C20 | 1 | 10uF,10V,X7R,0805,10%<br>Murata GRM21BR71A106KE51L |
| C21,C22 | 2 | 1uF,10V(16V),10%,X7R<br>Murata GRM188R71A105KA61J<br>Murata GRM188R71A225KE15 |
| C24,C25 | 2 | 1nF,50V,1%,NP0<br>Murata GRM1885C1H102FA01J |
| C26,C27 | 2 | 68nF,25V,X7R,10%<br>Murata GRM188R71E683KA01<br>Murata GRM188R71E153KA01 |
| C29 | 1 | 270pF,50V,C0G,2%(5%)<br>Murata GRM1885C1H271GA01<br>(GRM1885C1H271JA01) |
| C30 | 1 | 33nF,25V,X7R,10%<br>Murata GRM188R71E333KA01 |
| C31 | 1 | 470pF,50V,C0G,55<br>Murata GRM1885C1H471JA01 |
| C32,C33 | 0 | OPEN |
| R1 | 1 | 2mΩ, 1W,1%<br>Rohm Semiconducto PMR25HZPFV2L00 |
| R2 | 1 | 4mΩ, 1W,1%<br>Rohm Semiconducto PMR25HZPFV4L00 |
| R3,R4,R5,R6,R7, R29, R30, R31, R35, R36 | 10 | 0Ω |
| R8 | 1 | 2.2Ω |
| R11 | 1 | 31.6KΩ |
| R13,R14,R15,R16,R17,R18, R28, R32 | 0 | OPEN |
| R19 | 1 | 46.4KΩ |
| R20 | 1 | 14.7KΩ |
| R21 | 1 | 5.11KΩ |
| R23 | 1 | 86.6KΩ |
| R24 | 1 | 16.5KΩ |
| R25 | 1 | 9.09KΩ |
| R26, R27 | 2 | 10KΩ |
| R33, R34 | 2 | 2KΩ |
| L1 | 1 | 3.1uH, 15%,26A,2.09mΩ<br>Wurth Electronics 7443630310 |
| L2 | 1 | 6.8uH,20%,18.5A,4.1mΩ<br>Wurth Electronics 7443556680 |

| | | |
|---|---|---|
| N1,N2,N5 | 3 | 60V,25A,13mΩ<br>Renesas RJK0651DPB-00#J5 |
| N3, N4, N6 | 3 | 60V,45A,4.5mΩ<br>Renesas RJK0653DPB-00#J5 |
| D1,D2 | 2 | DIODE SCHOTTKY 60V 5A TO277A<br>Vishay Semiconductor SS5P6-M3/86A |
| D3,D4 | 2 | DIODE SCHOTTKY 100V 250MA<br>NXP Semiconductors BAT46WJ,115 |
| D5,D6 | 0 | Open |
| D7 | 0 | Open |
| U1 | 1 | MAX17559<br>Maxim MAX17559ACJ+ |
| VIN,PGND,VOUT1,PGND,VOUT2,EN1,EN2,PGOO | 11 | 20G tinned copper Bus wire formed into “U” shaped loops (0.25” off the PC board) |
| JU1, JU2 | 6 | 3-pin header ( 0.1” pitch)<br>Sullins PREC003SAAN-RC |
| VIN,PGND,VOUT1,PGND,VOUT2,PGND | 2 | Non -Insulate Jack<br>Keystone Electronics 575-4 |
| CONN JUMPER SHORTING TIN | 2 | Shunts, 0.1" Pitch<br>Sullins STC02SYAN |

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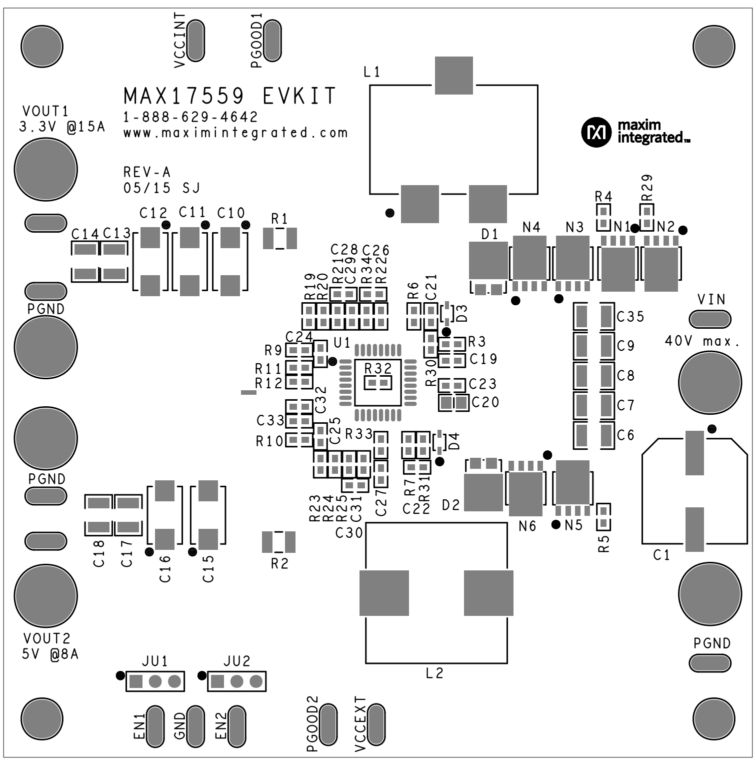
HARDWARE NAME:MAX17559_EVKIT_A

HARDWARE NUMBER:

ENGINEER: DESIGNER:

DATE: 05/28/2015 ODB++/GERBER: SILK_TOP



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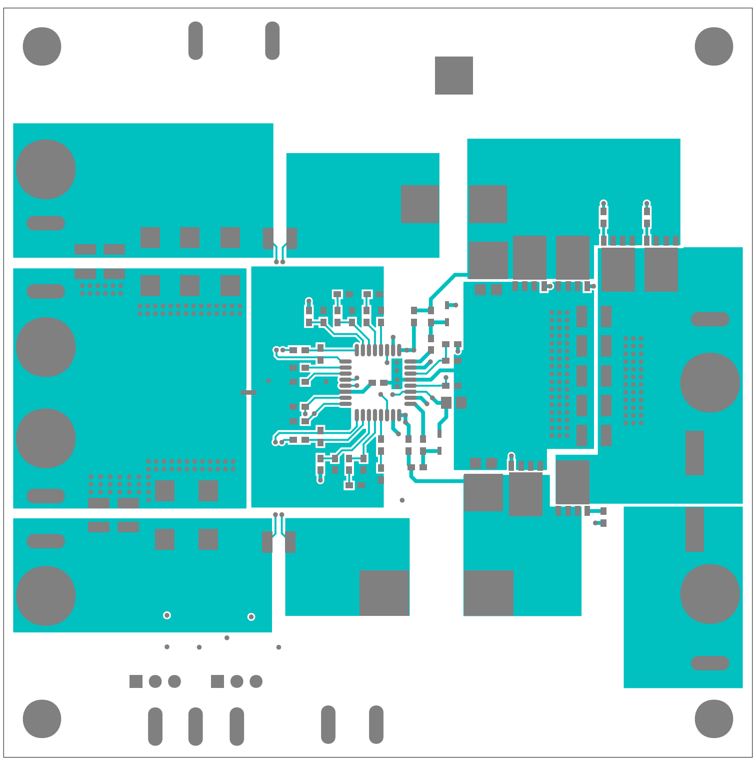
HARDWARE NUMBER:

ENGINEER: DESIGNER:

DATE: 05/28/2015 ODB++/GERBER: TOP



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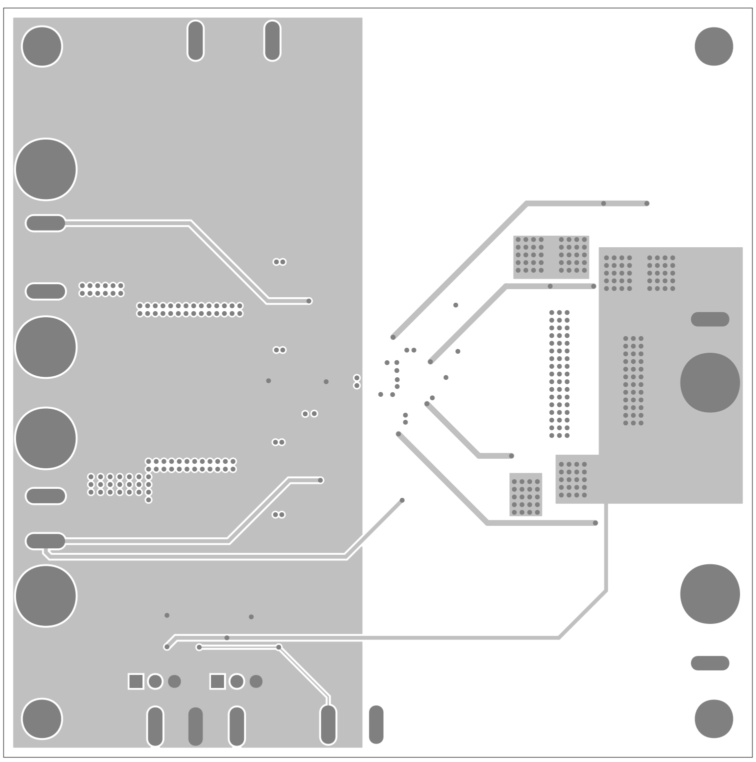
ENGINEER: DESIGNER:

DATE: 05/28/2015

ODB++/GERBER: SGND



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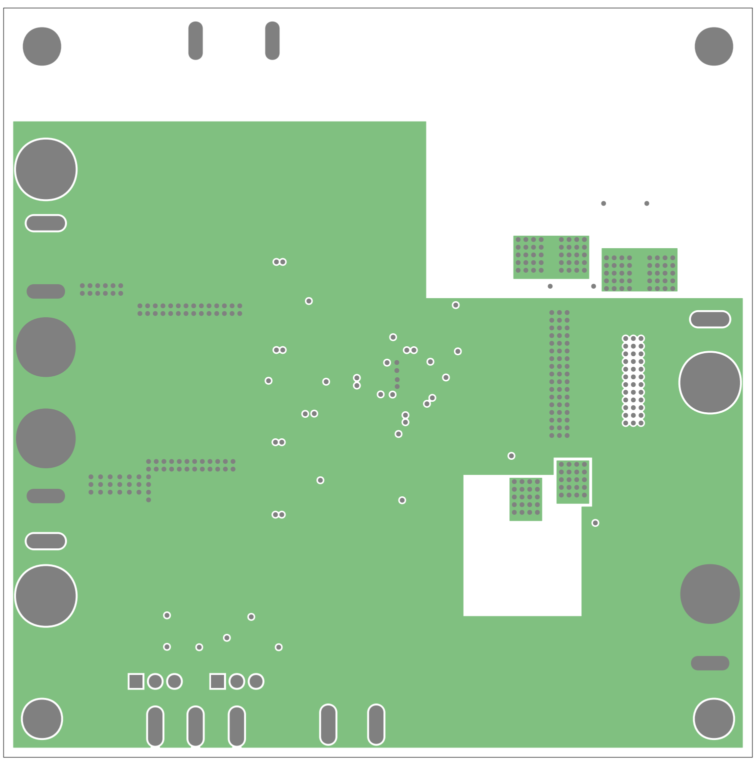
ENGINEER: DESIGNER:

DATE: 05/28/2015 ODB++/GERBER: PGND



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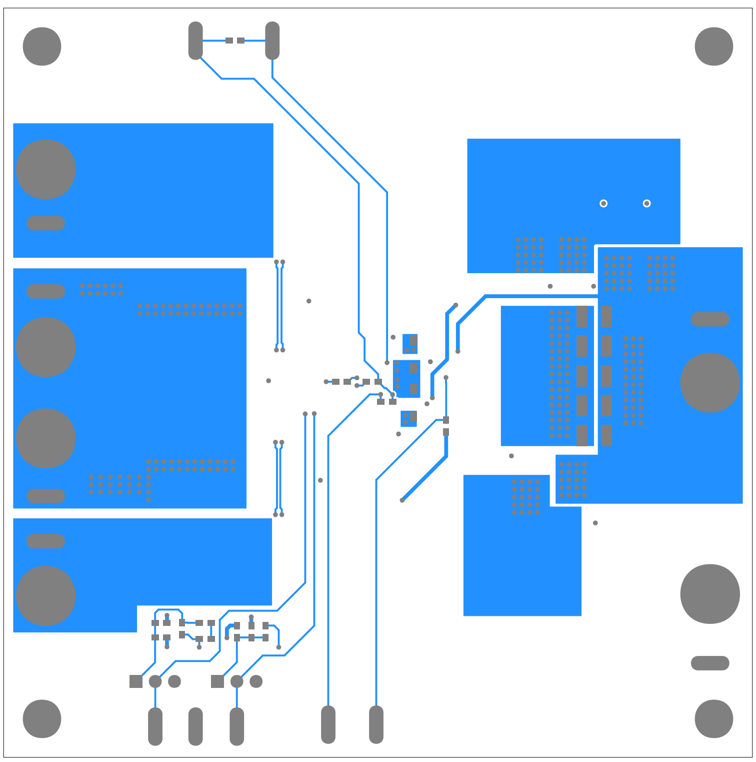
HARDWARE NUMBER:

ENGINEER: DESIGNER:

DATE: 05/28/2015 ODB++/GERBER: BOTTOM



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HARDWARE NAME: MAX17559_EVKIT_A

HARDWARE NUMBER:

ENGINEER: DESIGNER:

DATE: 05/28/2015

ODB++/GERBER: SILK_BOT