MAX17558 Dual-Phase Evaluation Kit

Evaluates: MAX17558

General Description

The MAX17558 dual-phase EV kit provides a proven design to evaluate the MAX17558 wide 4.5V to 60V input, dual-phase, synchronous step-down DC-DC controller. In 2-phase operation, the two channels of the MAX17558 are operated 180° out of phase. This interleaves the current pulses drawn by the 2 phases, and results in reduced total RMS input current, which allows use of lesser number of input capacitors. The EV kit provides 3.3V/20A at the outputs from a 6V to 54V input supply. The switching frequency of the EV kit is preset to 350kHz for optimal efficiency and component size. The EV kit features adjustable input undervoltage-lockout and soft-start time, selectable PWM/DCM modes, 180° out-of-phase/0° in-phase operation, current-limit threshold, and independent open-drain PGOOD signals.

Features

- 6V to 54V Input Range
- Output Rails: V_{OUT}: 3.3V/20A
- 350kHz Switching Frequency
- Independent Enable Inputs
- Independent Adjustable Soft-Start Time
- Configurable Tracking Operation
- Selectable PWM/DCM Modes of Operation
- Selectable 180° Out-of-Phase/0° In-Phase Operation
- Selectable 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

- MAX17558 EV kit 6V to 54V
- 4.5V to 54V, 15A DC power supply
- Loads capable of sinking 20A
- 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) Ensure that the DC power supply is disabled. Set the power supply voltage to 24V.
2) Set the load to 20A. Disable the load in the case of an electronic load. Leave the load unconnected in the case of a resistor load and ensure that the resistor power rating is high enough to dissipate the output power.
3) Connect the positive terminal of the power supply to the VIN connector and the negative terminal of the power supply to PGND connector, which is nearest to VIN connector.
4) Connect a digital voltmeter across VOUT connector and the nearest PGND connector with the positive terminal of the DVM connected to VOUT connector.
5) Verify the shunts on jumpers, as described in Table 1, to select default settings of the EV kit.
6) Turn on the DC power supply.
7) Verify that the digital voltmeter displays the expected voltage (3.3V±1%).
8) Enable the electronic load (connect the load in the case of resistor load).
9) Verify that the voltmeter displays the expected voltage (3.3V±1%).

19-7857; Rev 0; 5/16

Detailed Description of Hardware

The EV kit provides a proven design to evaluate the device. The EV kit provides 3.3V/20A at the outputs from 6V to 54V input supply. The EV kit is preset to operate at 350kHz for optimum efficiency and component size.

The EV kit provides set resistors R16, R17 and R18, R19 and jumpers JU4, JU5 to enable/disable the output at a desired input UVLO voltage. The DCM or PWM mode of operation can be selected using JU3. JU1 allows selection of 180°/0° phase-shift operation between the two controllers. JU2 allows the selection of three different current-limit thresholds for both controllers. Refer to Table 2 through Table 4 for additional jumper setting details.

Configuring the Output Voltage (V_{OUT})

The device's output voltages (V_{OUT}) can be adjusted between 0.8V to 24V through sets of feedback resistor-dividers (R6, R7) by the following formula:

$$R7 = \frac{R6}{\left(\frac{V_{OUT1}}{0.8} - 1\right)}$$

Please refer to the MAX17558 IC data sheet to select R6 resistor values and change compensation components, as well as output capacitors, for new output voltage settings.

Soft-Start (SS_)

The device offers an SS_ pin used to adjust the soft-start time to limit inrush current during startup. An internal 5μA current source charges the capacitor C21 at the SS_ pin, providing a linear ramping voltage for output voltage reference. The soft-start time of the output is calculated based on the following equation:

$$t_{ss\_OUT1} = C21 \times \frac{0.8V}{5\mu A}$$

The default soft-start time on the EV kit is approximately 2.4ms.

Enable/Undervoltage-Lockout Level (EN_)

The device's two controllers may be independently shut down/enabled using the EN1 and EN2 pins. The EN_ pin can be programmed at 1.25V (typ) to detect the input undervoltage-lockout at a desired input voltage to enable/disable the corresponding controller with 50mV (typ) hysteresis. Connect a resistor-divider to EN_ from V_{IN} to GND to program the input undervoltage-lockout threshold to turn on/off the corresponding controller.

For normal operation, the device is enabled whenever the input voltage is greater than 4.5V and JU4 and JU5 are open. Set the voltage at which each controller turns on by placing a shunt across pins 1-2 on JU4 and JU5, and adjust the resistor-divider formed by R16, R17 for controller 1 and by R18, R19 for controller 2. Table 2 shows the EV kit's jumper settings for configuring the EN_ pin.

Select R17 (R19) below 10K and calculate the R16 (R18) based on the following equation:

$$R16 = \frac{R17 \times (V_{INUVLO} - 1.25)}{1.25}$$

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

Mode Selection (SKIP)

The device's SKIP pin is used to select light-load operating mode among the PWM/DCM modes of operation. Table 3 shows the EV kit's jumper settings for configuring the desired light-load operating mode.

Phase Shift Between Controllers

JU1 can be configured to switch between 0° and 180° phase-shift of the device's two controllers. Table 4 shows the jumper configurations to select the phase-shift between the two controllers.

Current-Limit Threshold Selection (JU2)

The current-limit threshold of both of the device's controllers can be selected using the JU2. Table 5 shows the EV kit jumper settings for selecting the current-limit threshold.

Each controller's peak current limit can be adjusted independently by changing the values of R1 and R2. Note that changing R1 and R2 values affect the stability and current-sense signal across the current sense pins. Refer to the "Current Sensing" section of the MAX17558 IC data sheet for calculating the current-sense resistor value.

Switching Frequency

The device's switching frequency is set to 350kHz by resistor R14. Replace R14 with another value to set the 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's switching frequency, it may be necessary to change the loop-compensation network's components to new values. Refer to the *Loop Compensation* section of the MAX17558 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 VCCINT by R21 and R20. PGOOD1 and PGOOD2 are high when V_{OUT} is within the 90%–110% range of their programmed output voltage. When V_{OUT} is outside of the 90%–110% range of their programmed output voltage, PGOOD1 and PGOOD are pulled low.

Table 1. Default Setting of MAX17558 EV kit

JUMPER	SHUNT POSITION	FUNCTION
JU1	Unconnected	Configure controller 1 and controller 2 180° out-of-phase operation
JU2	1-2	Select 75mV current-limit threshold
JU3	1-2	Select the PWM mode of operation
JU4	Unconnected	Enable controller 1
JU5	Unconnected	Enable controller 2

Table 2. Enable Control (JU4, JU5)

JUMPER	SHUNT POSITION	EN	MAX17558 OUTPUT
JU4	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
JU5	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

Table 3. Mode Selection (JU3)

SHUNT POSITION	SKIP PIN	LIGHT-LOAD OPERATING MODE
1-2	Connected to VCCINT	PWM mode
2-3	Connected to VCCINT through a 100K resistor	DCM mode

Table 4. Phase-Shift Selection (JU1)

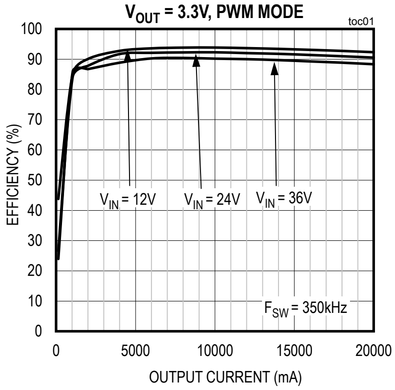
SHUNT POSITION	SEL_PH PIN	PHASE-SHIFT
1-2	Connected to VCCINT	0°
Not installed	Unconnected	180°

Table 5. Peak Current-Limit Threshold Selection (JU2)

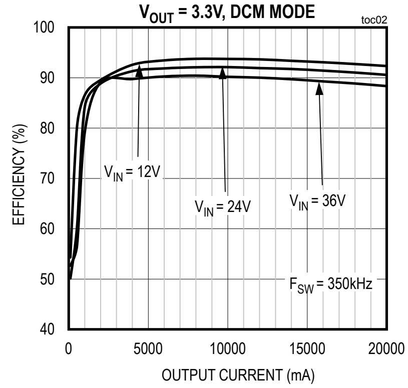
SHUT POSITION	ILIM Pin	PEAK CURRENT LIMIT THRESHOLD
1-2	Connected to VCCINT	75mV
Not installed	Unconnected	50mV
2-3	Connected to GND	30mV

EV Kit Performance Report

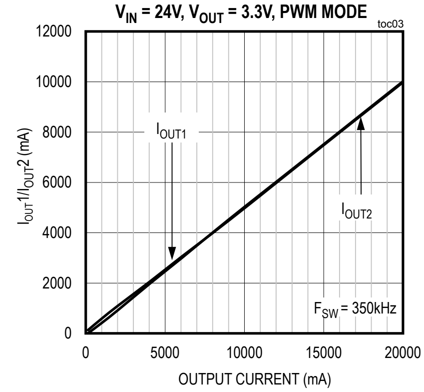
EFFICIENCY vs. OUTPUT CURRENT
V_{OUT} = 3.3V, PWM MODE



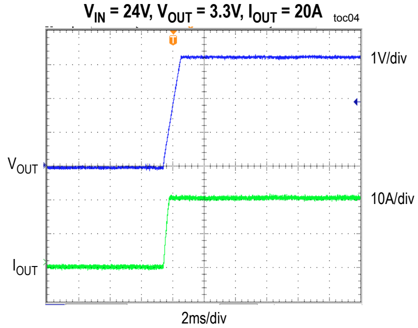
EFFICIENCY vs. OUTPUT CURRENT
V_{OUT} = 3.3V, DCM MODE



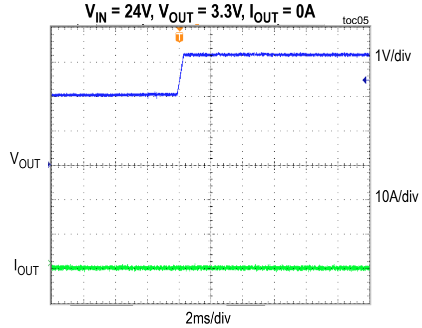
CURRENT SHARING
V_{IN} = 24V, V_{OUT} = 3.3V, PWM MODE



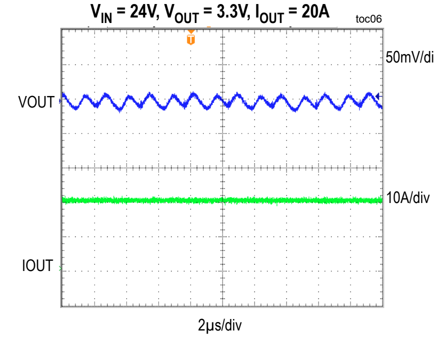
STARTUP FROM INPUT SUPPLY
V_{IN} = 24V, V_{OUT} = 3.3V, I_{OUT} = 20A



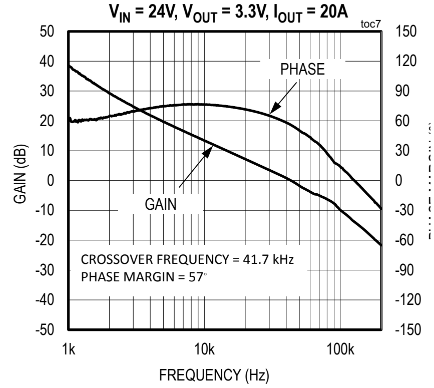
STARTUP INTO PREBIASED OUTPUT
V_{IN} = 24V, V_{OUT} = 3.3V, I_{OUT} = 0A



OUTPUT RIPPLE
V_{IN} = 24V, V_{OUT} = 3.3V, I_{OUT} = 20A



CLOSED-LOOP BODE PLOT
V_{IN} = 24V, V_{OUT} = 3.3V, I_{OUT} = 20A



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 MAX17558 when contacting these component suppliers.*

Component Information, PCB Layout, and Schematic

See the following links for component information, PCB layout diagrams, and schematic.

- MAX17558DP EV BOM
- MAX17558DP EV PCB Layout
- MAX17558DP EV Schematic

Ordering Information

PART	TYPE
MAX17558DPEVKIT#	EV kit

#Denotes RoHS compliant.

Revision History

REVISION NUMBER	REVISION DATE	DESCRIPTION	PAGES CHANGED
0	5/16	Initial release	—

Designation	Qty	Description
C1	1	150uF,80V Panasonic Electronic EEV-FK1K151Q
C2-C9,	8	CAP CER 4.7UF 80V 10% X7R 1210 Murata GRM32ER71K475ME14
C10, C11, C14, C15	4	180uF,6.3V RUBYCON 6SW180M
C12, C13, C16, C17	4	10uF,10V,X7R,1210,10% Murata GRM32DR71A106KA01
C18	1	1uF,100V,X7R,0805,10% TDK C2012X7S2A105K125
C19, C31, C32	3	CAP CER 1UF 16V 10% X7R 0603 KEMET C0603C105K4RAC /MURATA GRM188R71C105KA12/TDK C1608X7R1C105K/TAIYO YUDEN EMK107B7105KA
C20	1	10uF,10V,X7R,0805,10% Murata GRM188R71C153KA01
C21	1	0.015uF,10V(16V),10%,X7R, 0603 Murata GRM188R71C153KA01
C22	1	0.012uF,10V(16V),10%,X7R, 0603 Murata GRM188R71C123KA01
C23	1	120pF,50V,COG,10%,0603 KEMET C0603C121K5GAC
C24-C27	4	1nF,16V,X7R,0603,10% Murata GRM188R71C102KA01
C28	1	1uF,100V,X7R,1206,10% MURATA GRM31CR72A105KA01L/TDK C3216X7R2A105K160
C29	1	0.22uF,25V,X7R,0603,10% KEMET C0603C224K3RAC/ MURATA GRM188R71E224KA88/
C30	1	10UF,10V,X7R,10%,1206 Murata GRM31CR71A106KA01L
R1,R2	2	5mΩ, 1.5W,1%,2010 TT Electronics LRMAT2010-R005F
R3, R5, R10,R11	4	0Ω ±1% resistor (0603)
R6,R15	2	100KΩ ±1% resistor (0603)

R7	1	32.4KΩ ±1% resistor (0603)
R8	1	8.06KΩ ±1% resistor (0603)
R9,R12	2	1Ω ±1% resistor (0603)
R13, R22, R24, R29, R31, R32	6	0Ω ±1% resistor (0603)
R14	1	53.6KΩ ±1% resistor (0603)
R20,R21	2	10KΩ ±1% resistor (0603)
R25	1	69.8KΩ ±1% resistor (0603)
R26	1	22.1Ω ±1% resistor (0603)
R27	1	324KΩ ±1% resistor (0603)
R28	1	49.9KΩ ±1% resistor (0603)
R33	1	2.2Ω ±1% resistor (0603)
L1,L2	2	2.2µH, 11.5A Inductor , Wurth Electronics 7447709002
L3	1	100µH, 0.19A Inductor , COIL CRAFT LPS3015-104MR
Q1, Q3, Q5, Q7	4	60V, 25A N-Channel MOSFET (LFPAK) Renesas RJK0651DPB-00#J5
Q2, Q4, Q6, Q8	4	60V, 45A MOSFET (LFPAK) Renesas RJK0653DPB-00#J5
D1,D2	2	100V Schottky Diode (POWERDI 123) Diodes Incorporated DFLS 1100-7
U1	1	Wide 4.5V to 60V Input, Dual Output, Step-Down DC-DC Controller (32 TQFN-EP) Maxim
U2	1	ULTRA-SMALL; HIGH-EFFICIENCY; SYNCHRONOUS STEP-DOWN DC-DC CONVERTER WITH 22uA NO-LOAD SUPPLY CURRENT;
EN1, EN2, GND, VIN, PGND, VOUT, PGND3, PGOOD1, PGOOD2, TRACK1, TRACK2, VCCINT	12	20G tinned copper Bus wire formed into “U” shaped loops (0.25” off the PC board)
JU1	1	2-pin header (0.1” pitch)
JU2, JU3,JU4,JU5	4	3-pin header (0.1” pitch) Sullins PREC003SAAN-RC
VIN,PGND,VOUT1,PGND,VOUT2,PGND	6	Non -Insulate Jack Keystone Electronics 575-4
C33, C34	2	OPEN
R4, R16-R19, R23, R30	7	OPEN

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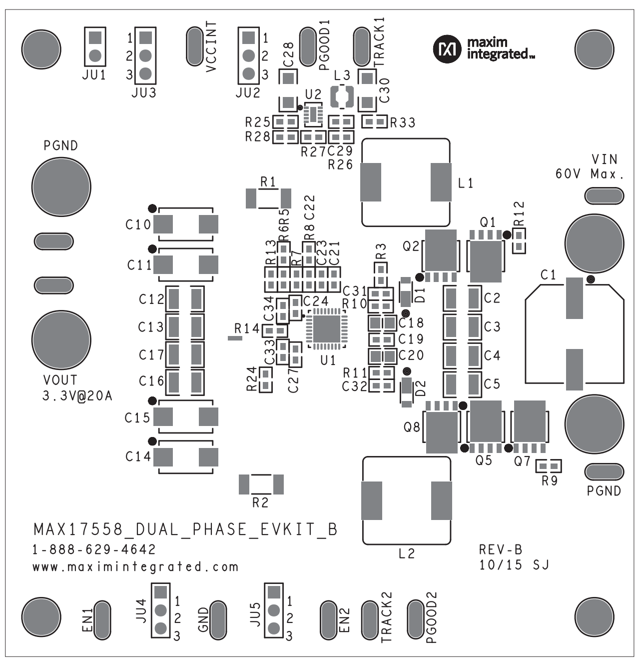
HARDWARE NAME:MAX17558_DUAL_PHASE_EVKIT_B

HARDWARE NUMBER:

ENGINEER: DESIGNER:

DATE: 10/20/2015 ODB++/GERBER: SILK_TOP



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HARDWARE NAME: MAX17558_DUAL_PHASE_EVKIT_B	
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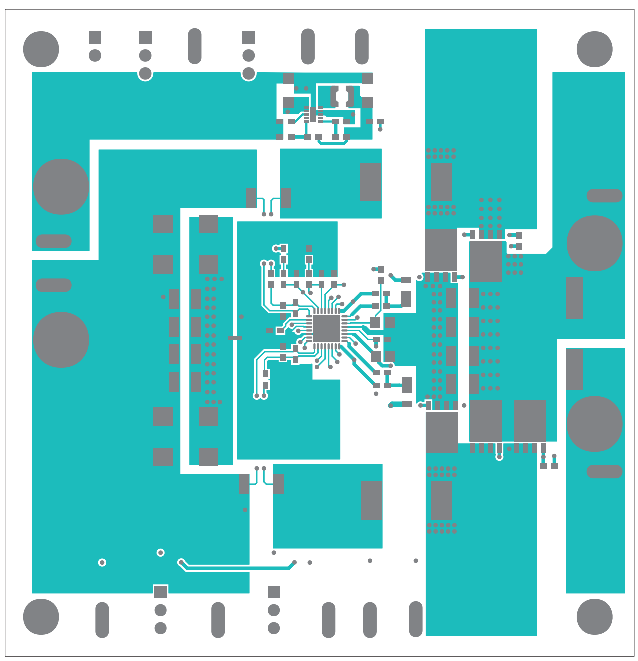
ENGINEER:	DESIGNER:
DATE: 10/20/2015	ODB++/GERBER: TOP



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HARDWARE NAME:MAX17558_DUAL_PHASE_EVKIT_B

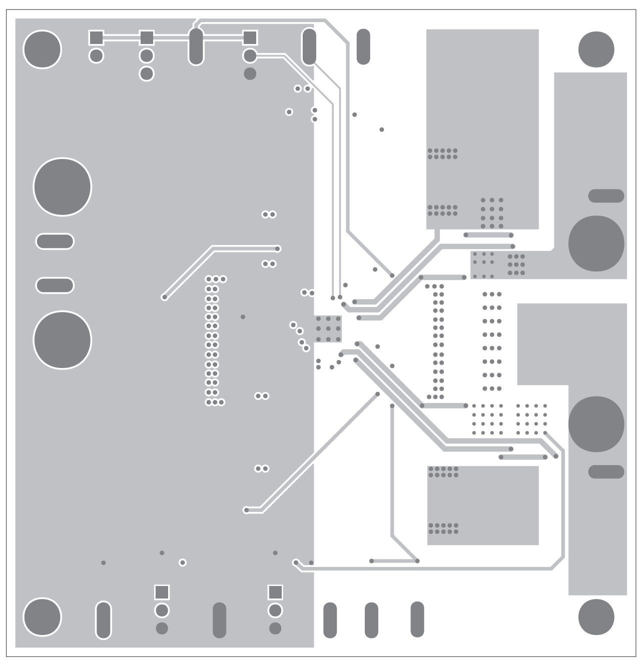
HARDWARE NUMBER:

ENGINEER:

DESIGNER:

DATE: 10/20/2015

ODB++/GERBER: SGND



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HARDWARE NAME: MAX17558_DUAL_PHASE_EVKIT_B

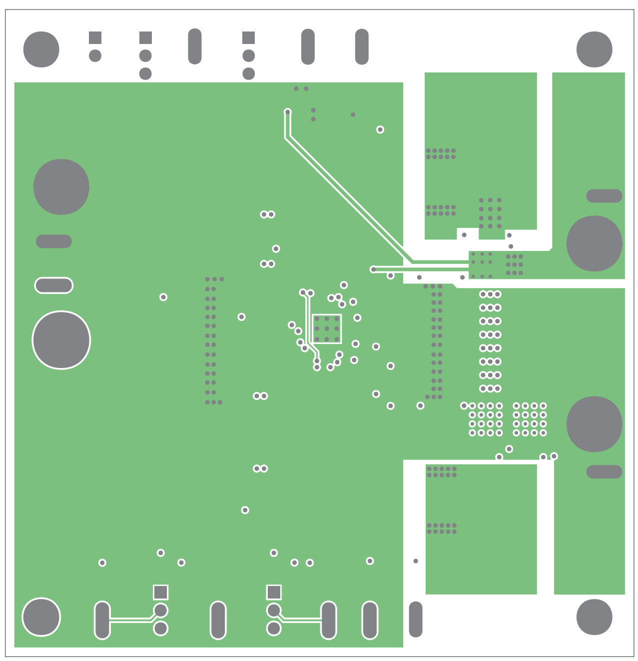
HARDWARE NUMBER:

ENGINEER:

DESIGNER:

DATE: 10/20/2015

ODB++/GERBER: PGND



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HARDWARE NAME:MAX17558_DUAL_PHASE_EVKIT_B	
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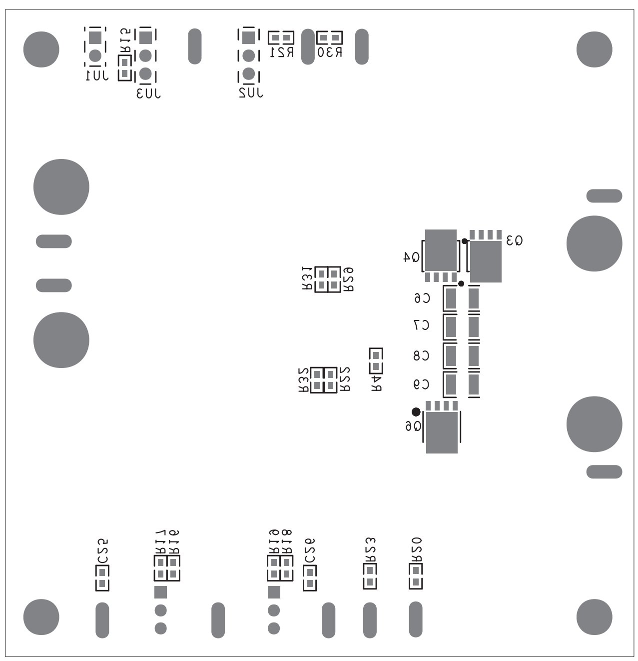
ENGINEER:	DESIGNER:
DATE: 10/20/2015	ODB++/GERBER: SILK_BOT



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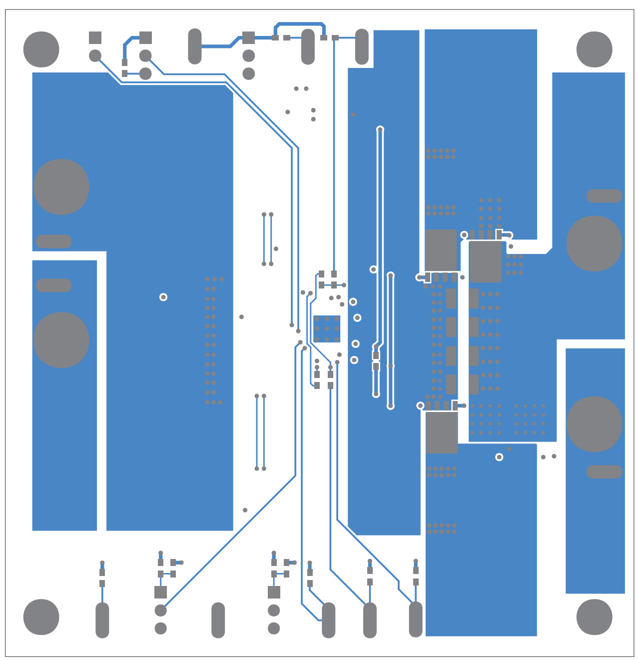
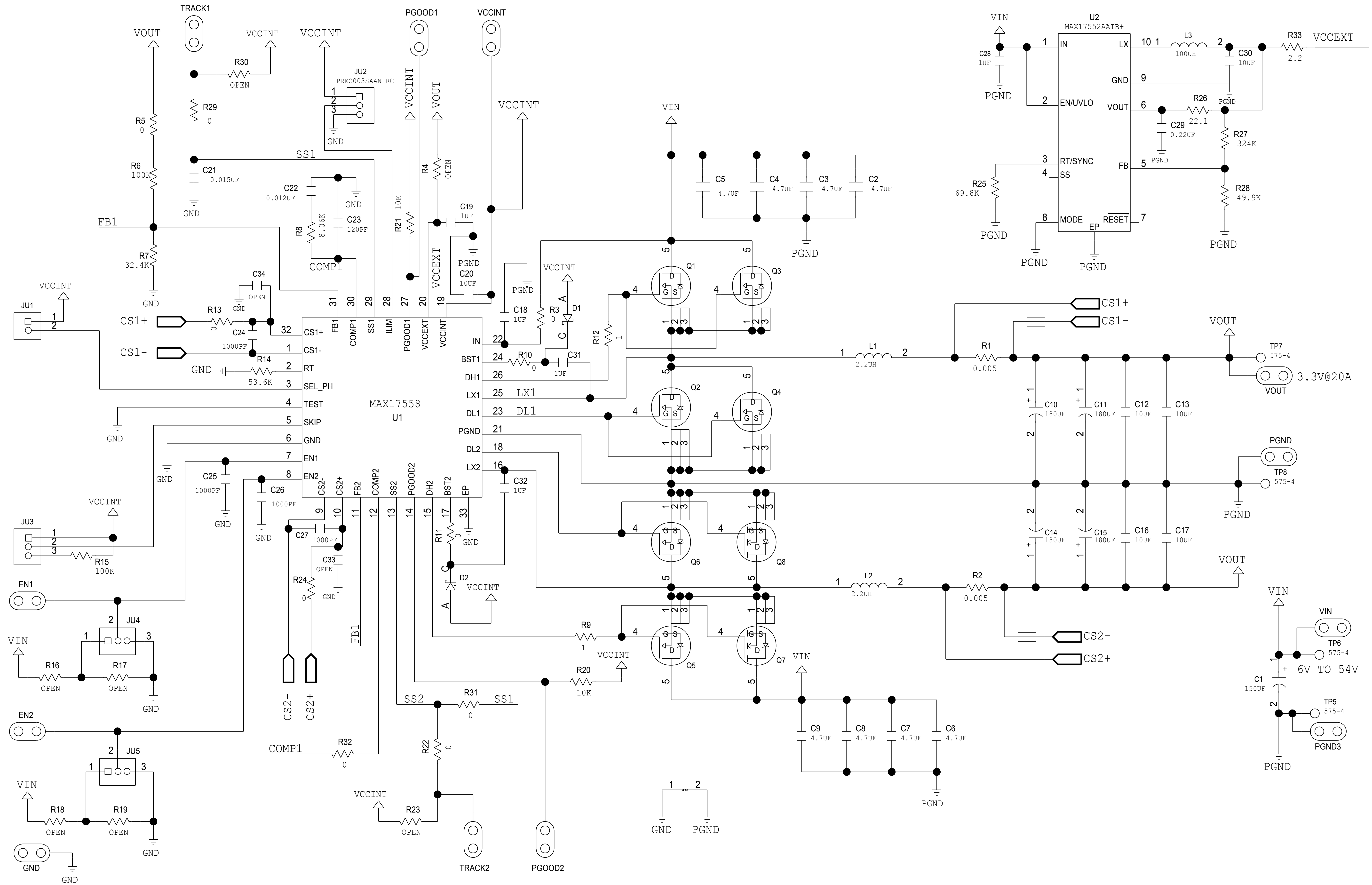
HARDWARE NAME:MAX17558_DUAL_PHASE_EVKIT_B

HARDWARE NUMBER:

ENGINEER: DESIGNER:

DATE: 10/20/2015 ODB++/GERBER: BOTTOM




MAX17558
U1
MAX17552AATB+
U2
3.3V@20A
6V TO 54V
VOUT
VIN
VCCINT
VCCEXT
PGND
GND
TRACK1
TRACK2
PGOOD1
PGOOD2
EN1
EN2
JU1
JU2
JU3
JU4
JU5
PREC003SAAN-RC
CS1+
CS1-
CS2+
CS2-
FB1
SS1
SS2
COMP1
LX1
DL1
L1
2.2UH
L2
2.2UH
L3
100UH
R1
0.005
R2
0.005
R33
2.2
R26
22.1
R27
324K
R28
49.9K
R25
69.8K
C1
150UF
C10
180UF
C11
180UF
C14
180UF
C15
180UF
TP5
TP6
TP7
TP8
575-4
PGND3