Evaluation Kit User's Manual

DC-DC Converter PE99151/99153/99155

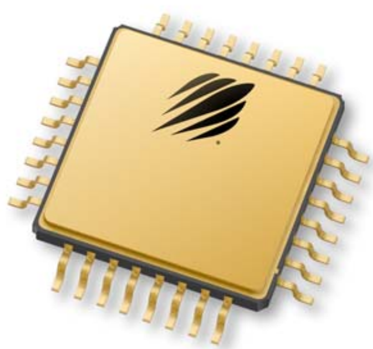

Table of Contents

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Introduction

The PE9915x evaluation kit can be used to validate the performance Peregrine's high efficiency, point-of-load (POL), synchronous buck DC-DC converters with integrated switches. The PE9915x is designed to operate from a wide 5V bus and provide an output voltage of 1.0V to 3.6V while delivering up to 2A, 6A or 10A of continuous current.

Applications Support

If you have a problem with your evaluation kit, software, or if you have applications questions, contact applications support at www.psemi.com (fastest response) or call **(858) 731-9400**.

Evaluation Kit Contents & Requirements

Kit Contents
The evaluation kit includes all of the hardware required to evaluate the PE9915x. Included in the evaluation kit are:

Quantity	Description
1	DC-DC Evaluation Board with PE99151, PE99153 or PE99155 IC
1	Set of male power/ground connectors

CAUTION: The PE9915X-00 circuit contains components that might be damaged by exposure to voltages in excess of the specified voltage, including voltages produced by electrostatic discharges. Handle the board in accordance with procedures for handling static-sensitive components. Avoid applying excessive voltages to the power supply terminals or signal inputs or outputs.

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PE9915X DC-DC Evaluation Board Assembly

The components of the PE9915x evaluation board have been optimized for an input voltage of 5V and a switching frequency of 500 kHz. For testing purposes, the input can be varied across the 4.6V to 6V operating range. The output voltage of the evaluation board is set to 2.5V nominal, but this voltage can be changed to any voltage between 1.0V and 3.6V by modifying an external resistor network.

Figure 1. Evaluation Board Assembly for the PE9915X

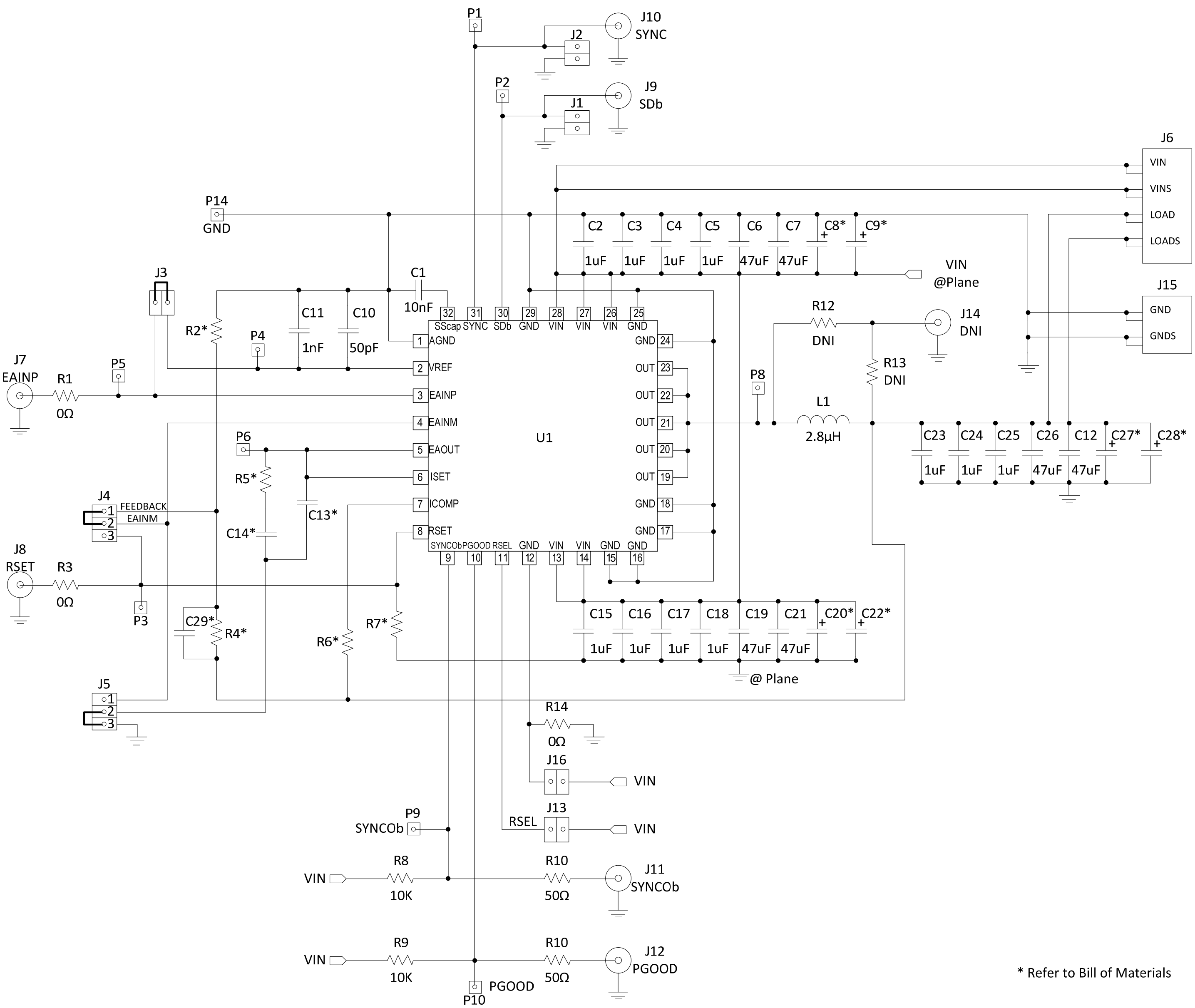

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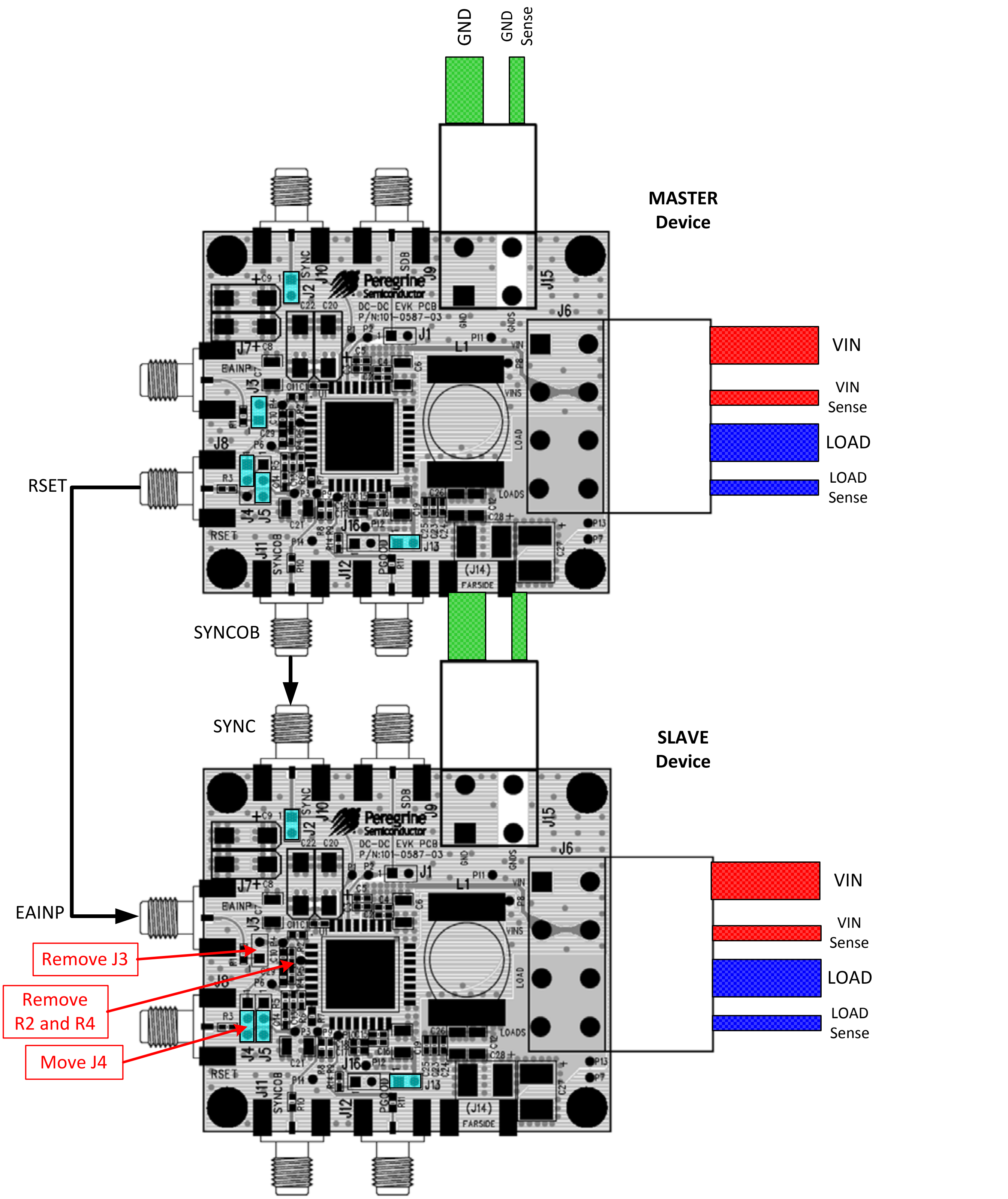
Figure 2. Current Sharing Configuration



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Hardware Operation

1. Disable the input voltage source. (Note: The input voltage source V_{IN} should be able to source between 0V and 6 Vdc and be capable of supplying up to 10 Adc for the PE99155). Set the input voltage to supply 0V and set the input source current limit accordingly (2A for PE99151, 6A for PE99153 and 10A for PE99155). Connect the positive output and the +sense of the input voltage source to the corresponding V_{IN} terminals of header **J6**. Connect the negative output and the –sense of the input voltage source to the corresponding GND terminals of header **J15**.

2. A load may be connected to header **J6** or it may be left floating for no-load operation. An electronic load with constant resistance mode capable of between 0A and 30 Adc at 2V is recommended. Connect the positive input and the +sense of the electronic load to the corresponding LOAD terminals of header **J6**. Connect the negative input and the –sense of the electronic load to the corresponding GND terminals of header **J15**.

3. V_{IN}, I_{IN} and V_{OUT} may be monitored using multi-meters having sufficient range and resolution. It is recommended to keep all lead lengths short (< 4 feet) to avoid unnecessary loss and pickup.

4. Increase V_{IN} from 0V to 5V. **J1** should be removed for normal operation. To disable the device, install jumper **J1**. The Shutdown pin (SDb) may also be controlled through SMA connector **J9**.

5. The internal oscillator defaults to 1 MHz when the board is powered up. To change the switching frequency to 500 kHz, ground the SYNC pin by placing a jumper on **J2**. If a different frequency is desired, a function generator may be connected to **J10**. A frequency between 100 kHz and 5 MHz may be used. (Note: A frequency other than 500 kHz may require re-optimization of inductor and loop compensation components).

6. SMA connector **J7** is connected to the Error Amp (+) input pin. For normal operation, EAINP must be tied to VREF through jumper **J3**. In current sharing configuration, remove **J3** on the Slave device.

7. SMA connector **J8** is connected to the RSET pin. When an external RSET resistor (R7) is installed, the RSEL pin must be pulled high by installing jumper **J13**. When the RSEL pin is grounded (**J13** removed), an internal current limiting resistor will limit the output current to the ILIMXINT listed in Table 2 of the datasheet. Connect RSET to EAINM through jumper **J4** on Slave device in current sharing configuration. RSET of Master device drives EAINP of Slave device.

8. SMA connector **J12** is the power-good inductor. Once the output voltage is within ±10% of the target value, an external pull-up resistor connected to the open-drain output will pull this output to +5V. Outside of the ±10% of the target value, the PGOOD output will be at ground.

9. The PE9915x can be configured to output a DC voltage from +1.0V to +3.6V. To set the output voltage, a resistor divider must be selected that will produce a 1.000 volt dc voltage at the EAINM pin when the V_{OUT} voltage has reached the target output voltage. Fixing R2, R4 is then calculated to be

$$R4 = R2\,(V_{OUT} - 1)$$

The PE9915x reference design uses a value of 10K for R2. In the case where the desired output voltage is 1.000V, R2 can be removed (open) and R4 can be set to 0 ohms. This is equivalent to directly connecting V_{OUT} to EAINM.

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Hardware Operation (cont.)

10. Soft-start may be implemented to limit the in-rush current as well as the output voltage ramp rate. The output voltage ramp rate of the PE9915x can be increased by tying the SScap pin to the 5V input rail through an external resistor. The ramp rate can also be decreased by connecting the SScap pin to ground through an external capacitor (C1). An initial current is set by an internal regulator, Vldo (3.2V) and an internal pull -up resistor R (1.2 MΩ) to charge C1. The desired soft-start time can be calculated from:

    *SS time (seconds) = -R*C1*ln [1-(Vref/Vldo)],*

    where Vref is the internal reference voltage of 1V.

11. When the RSEL pin is grounded, the PE9915x uses an internal current limiting resistor that will limit the output current to a value of ILIMXINT listed in Table 2 of the datasheet. The part can be adjusted to use an alternate current limit by tying the RSEL pin to V_{IN}. In this mode, the PE9915x can be programmed to various output current limits through the selection of a resistor connected from the RSET pin to ground.

12. Loop compensation is externally adjustable via C13, C14 and R5 for type II compensation and adding C29 for type III compensation to optimize transient response while still maintaining stability requirements. A design tool for the PE9915x is available.

13. The PE9915x provides adjustable slope compensation through an external resistor (R6) to allow the designer to optimize transient response and stability requirements across output voltage and switching frequency ranges. A compensation ramp is created at the ICOMP pin by R6 and an internal capacitor. A compensation slope of 1 is recommended. Refer to the data sheet and the PE9915x design tool.

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Typical Performance

V_{IN} = 5V, V_{OUT} = 2.5V, F_{SW} = 500 kHz, T_C = +25 °C (except where noted)

Figure 3. PE99151 Efficiency vs Output Current

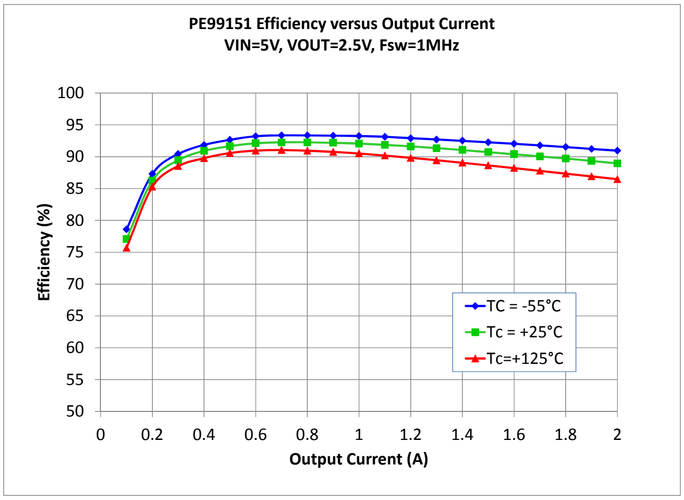


Figure 4. PE99151 Efficiency vs Output Current

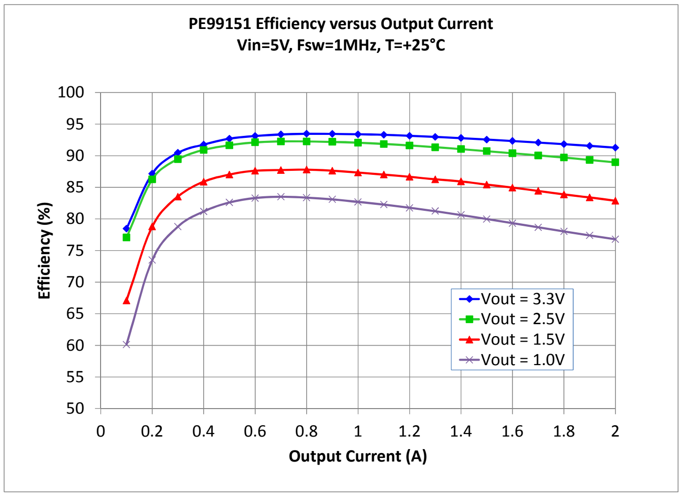


Figure 5. PE99151 Output Ripple

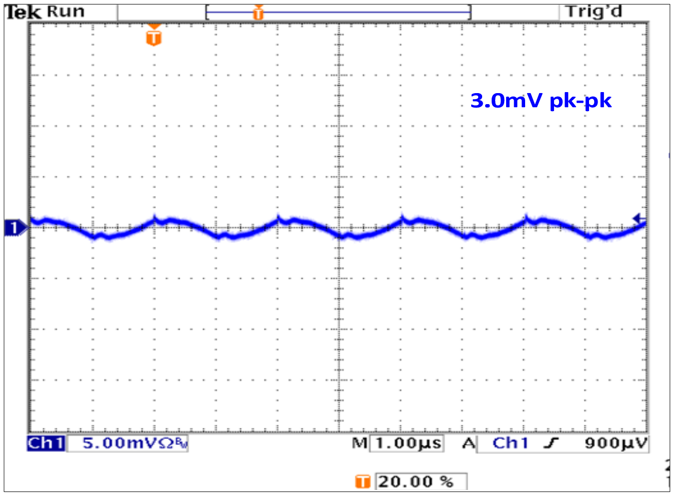
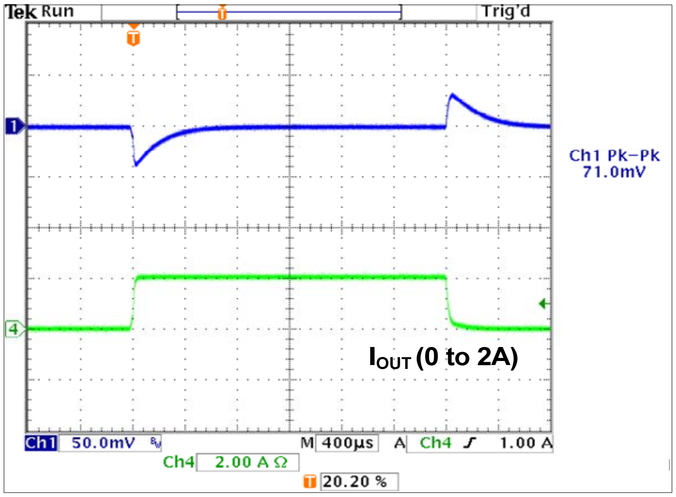


Figure 6. PE99151 Load Transient Response



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Typical Performance

V_{IN} = 5V, V_{OUT} = 2.5V, F_{SW} = 500 kHz, T_C = +25 °C (except where noted)

Figure 7. PE99153 Efficiency vs Output Current

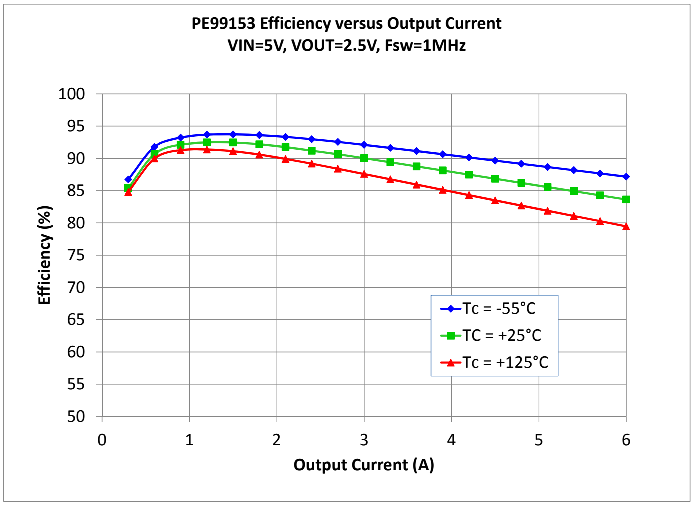


Figure 8. PE99153 Efficiency vs Output Current

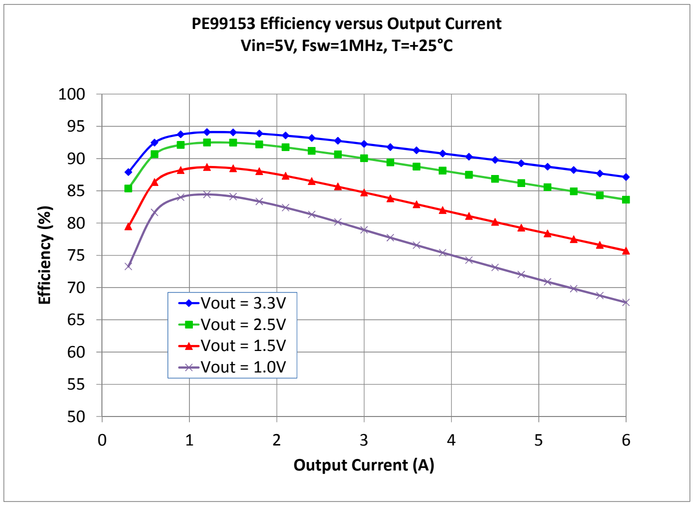


Figure 9. PE99153 Output Ripple

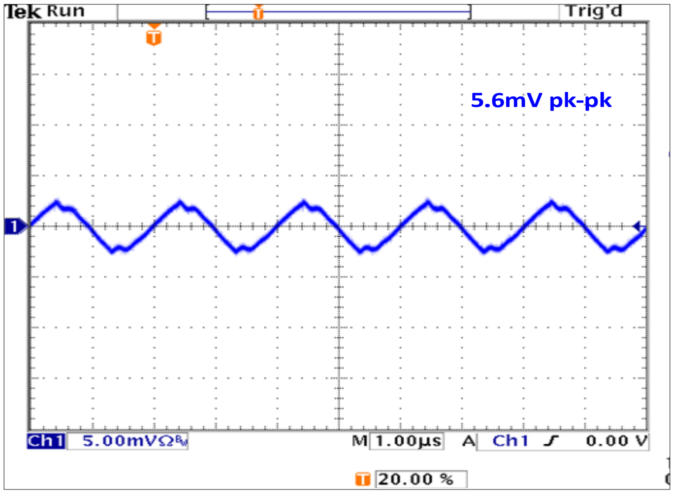
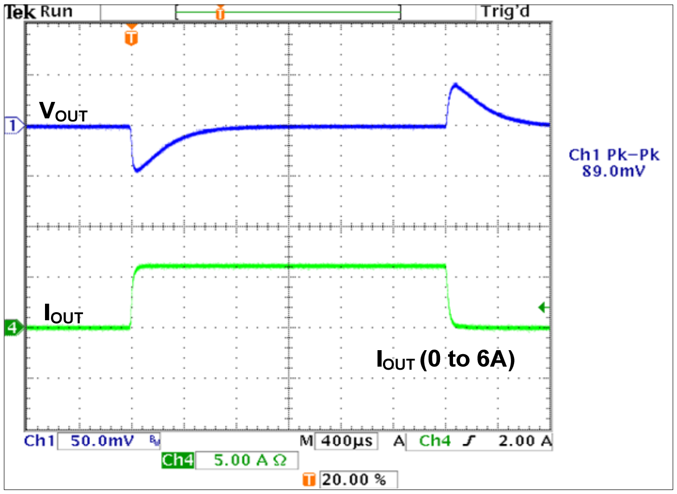


Figure 10. PE99153 Load Transient Response



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Typical Performance

V_{IN} = 5V, V_{OUT} = 2.5V, F_{SW} = 500 kHz, T_C = +25 °C (except where noted)

Figure 11. PE99155 Efficiency vs Output Current

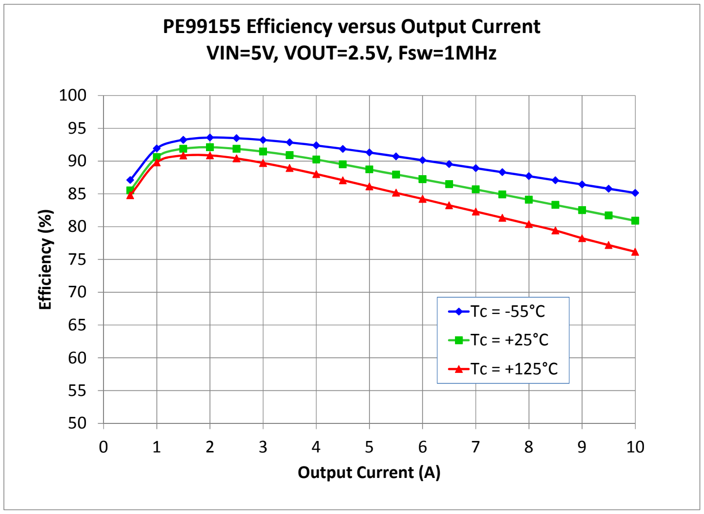


Figure 12. PE99155 Efficiency vs Output Current

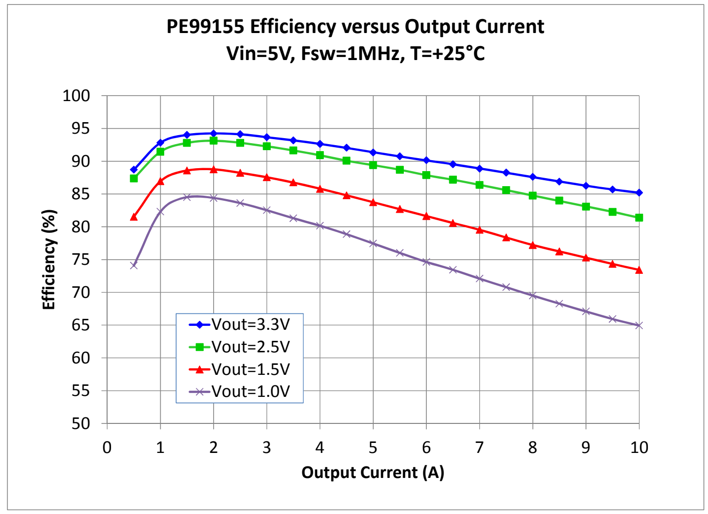


Figure 13. PE99155 Output Ripple

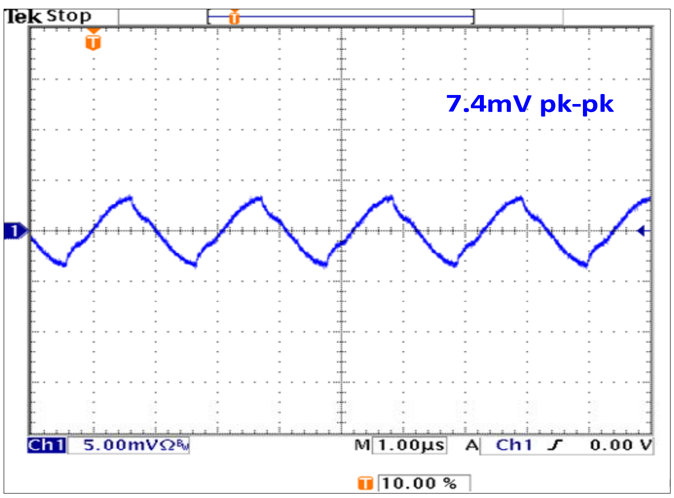
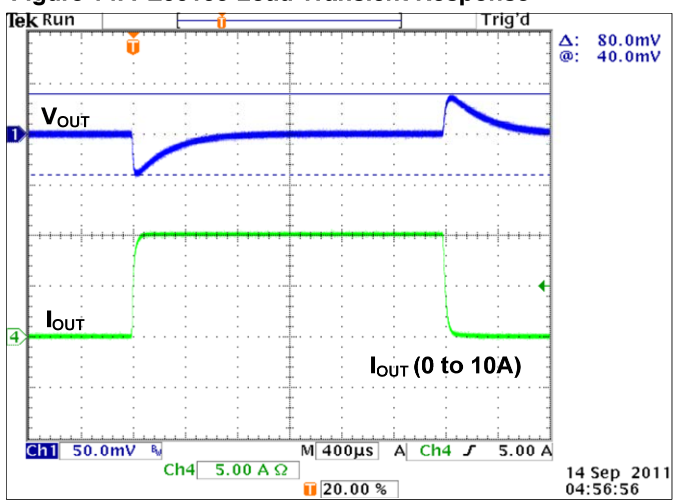


Figure 14. PE99155 Load Transient Response



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Typical Performance

V_{IN} = 5V, V_{OUT} = 2.5V, F_{SW} = 500 kHz, T_C = +25 °C (except where noted)

Figure 15. PE99155 Switching Waveforms, 500 kHz

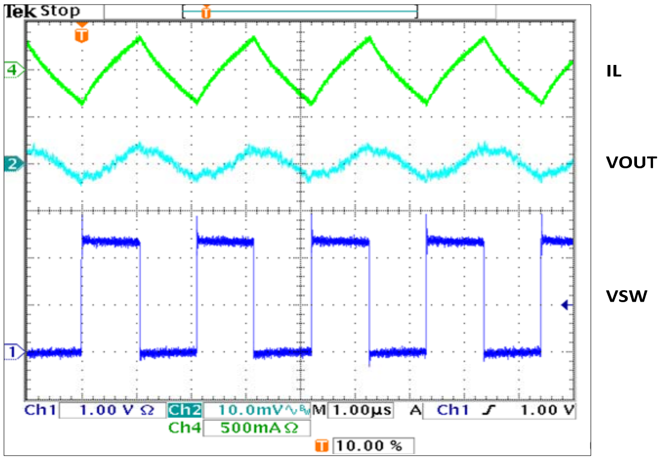


Figure 16. PE99155 Switching Waveforms,1 MHz

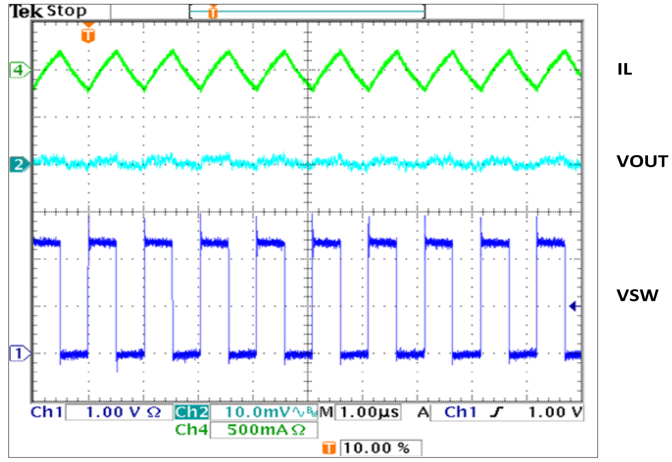


Figure 17. Start-up Waveforms

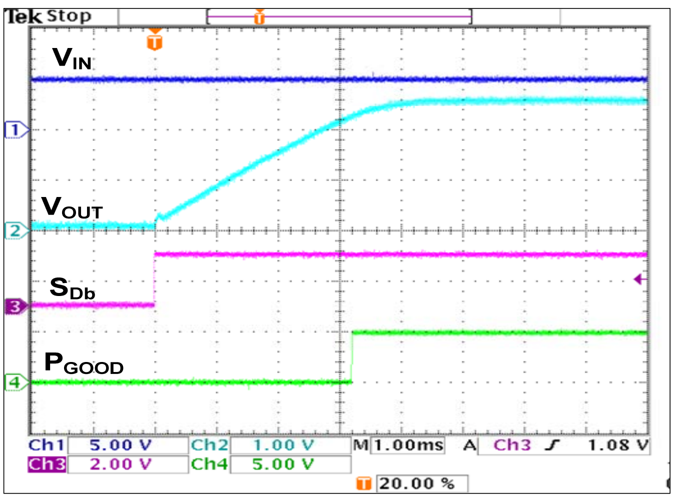


Figure 18. Shut-down Waveforms

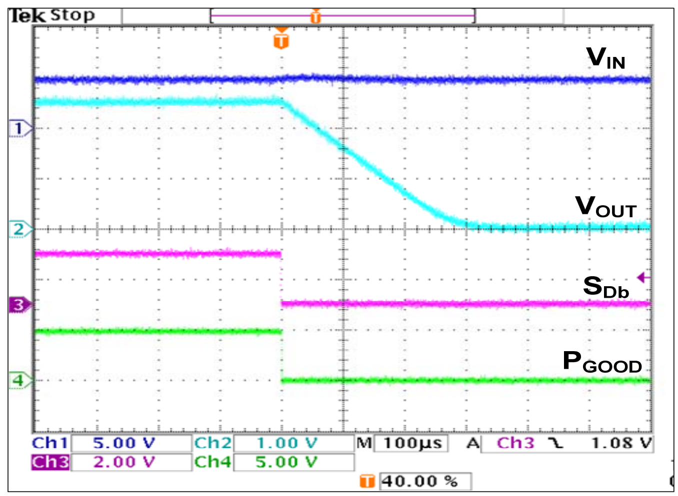


Figure 19. Soft Start C_SS$_{CAP}$ = 10 nF

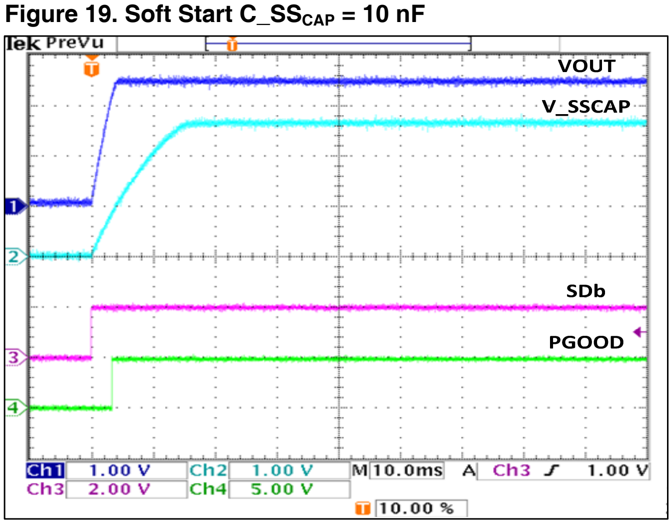
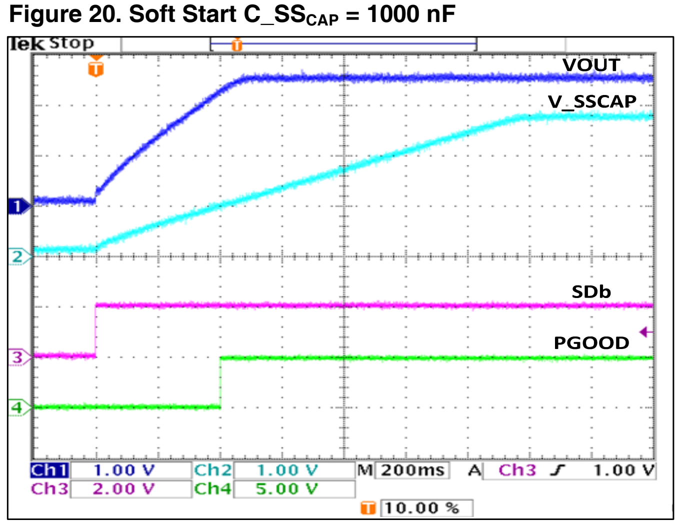


Figure 20. Soft Start C_SS$_{CAP}$ = 1000 nF



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Applications

If more output current is required, two or more regulators operating at the same frequency may be connected in a parallel configuration. This current sharing technique is illustrated in Figures 27 and 28 using the two PE99155 10A POLs. The resulting load current will be the sum of the combined regulators.

Synchronization allows the regulators to be locked together to one frequency. This eliminates any beat frequency interference that could result in the absence of synchronization. The PE9915x contains an internal oscillator capable of operating at 1 MHz when the SYNC pin is tied to V_{IN} or at 500 kHz when the SYNC pin is tied to ground. Optionally, the switching frequency can be synchronized to an external reference from 100 kHz to 5 MHz for design flexibility.

Whether operating synchronously or asynchronously, the open drain SYNCOb pin contains the inverted internal clock reference. This inverted clock signal can be used to drive additional regulators. The out-of-phase clock signal has the added benefit of reducing the RMS input ripple current and filtering requirements through peak current phase interleaving.

Figure 21. Current Sharing Schematic

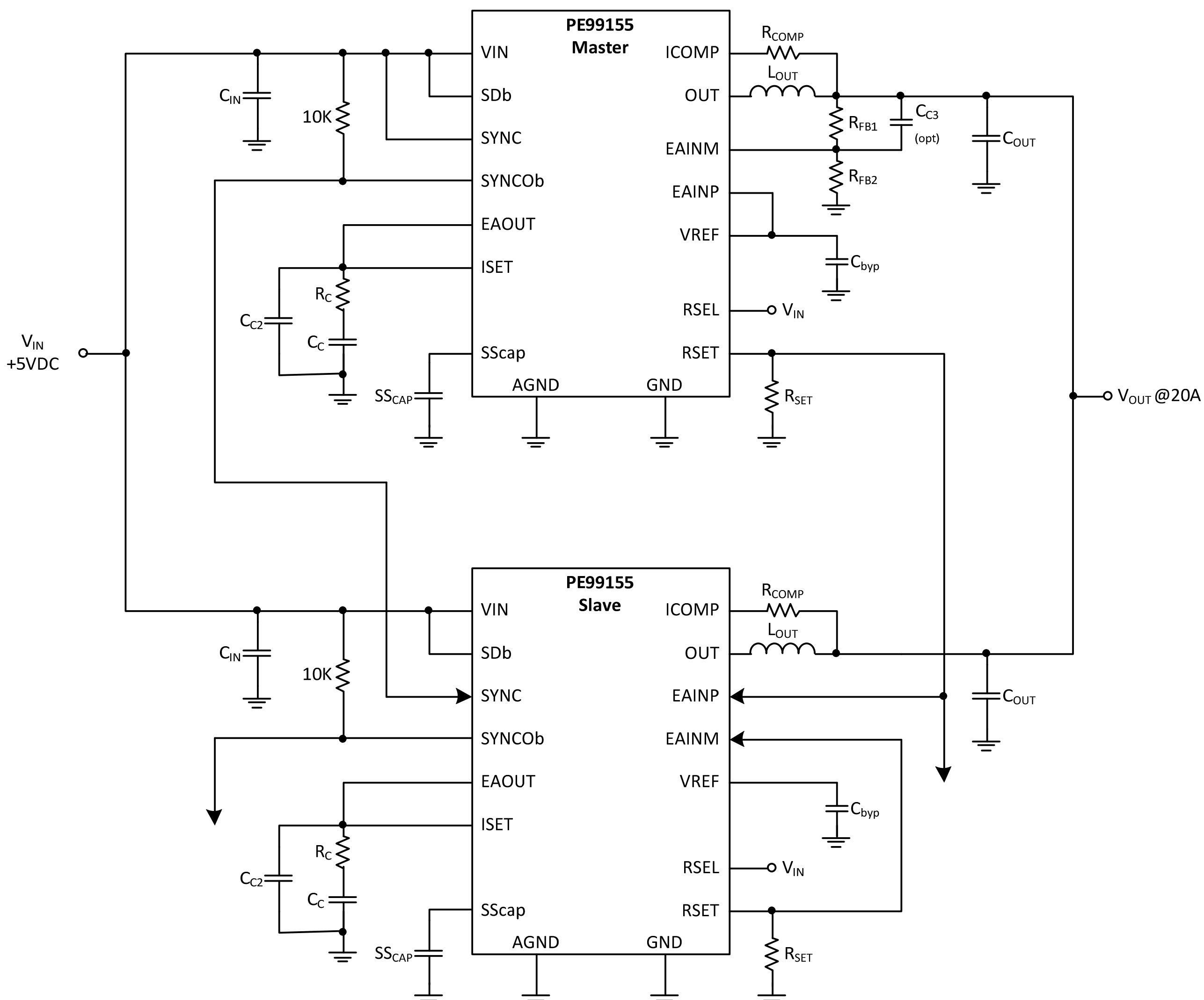

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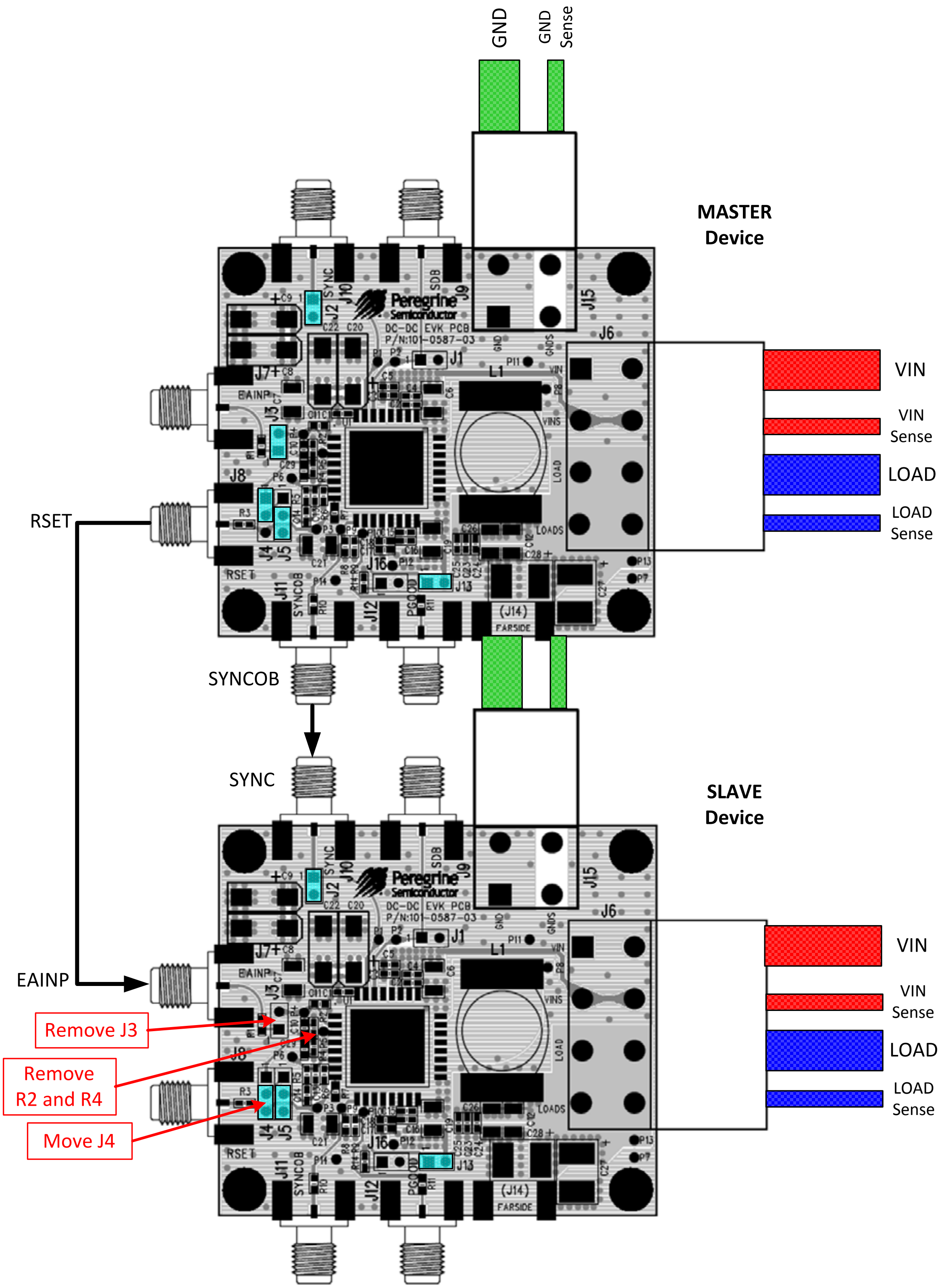
Figure 22. Current Sharing Configuration (cont.)



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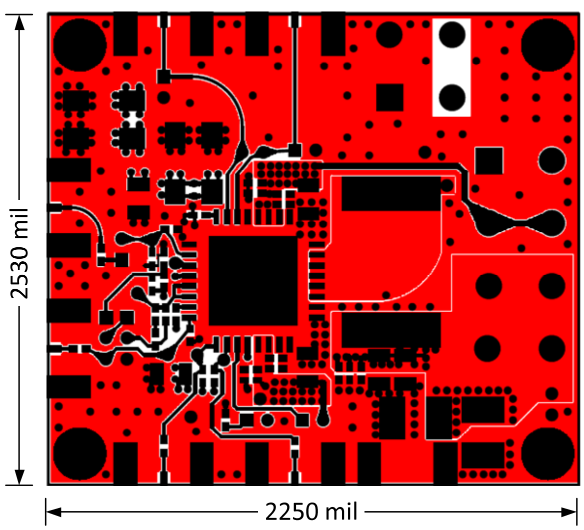
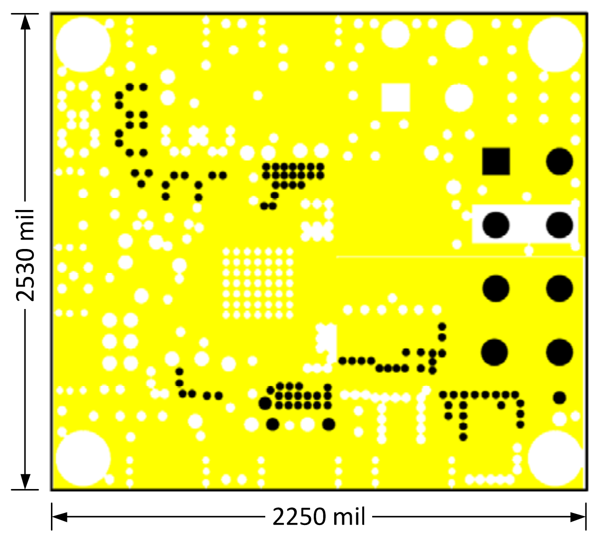
PCB Layout Guidelines

In order to suppress electric fields generated by the rapid switching rate of the regulator, proper PCB layout is essential. Critical voltage transients and noise can result if trace inductance is not minimized. Good layout practices as well as decoupling component placement and selection can minimize output noise and conducted emissions from the input. It is recommended to keep critical component traces as short and fat as possible. Traces carrying high ripple currents should be routed over ground planes to minimize radiated fields.

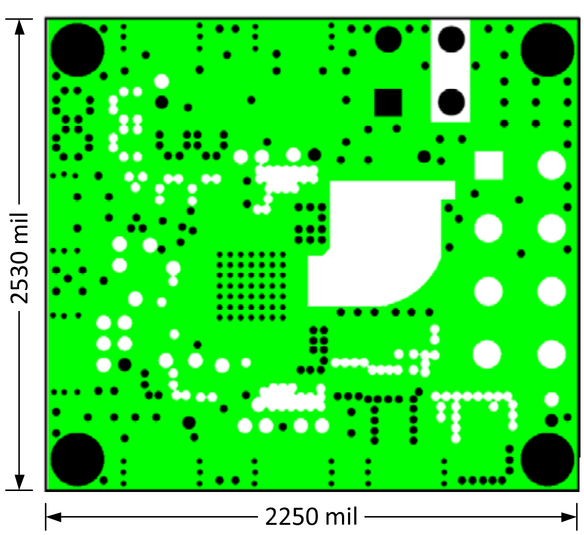
The recommended board layout is shown below. The sensitive feedback line has been routed directly to the bottom layer to avoid any coupling. The 32-lead ceramic package underside incorporates a heat slug that should be soldered to the PCB to ensure proper grounding and device performance. The EVK PCB is fabricated on FR-4 with 4 oz. copper outer layers and 1 oz. copper inner layers. 8mil diameter vias are placed under the package and overall board thickness is 0.062 ± 0.005 inches. Gerber files are available upon request.



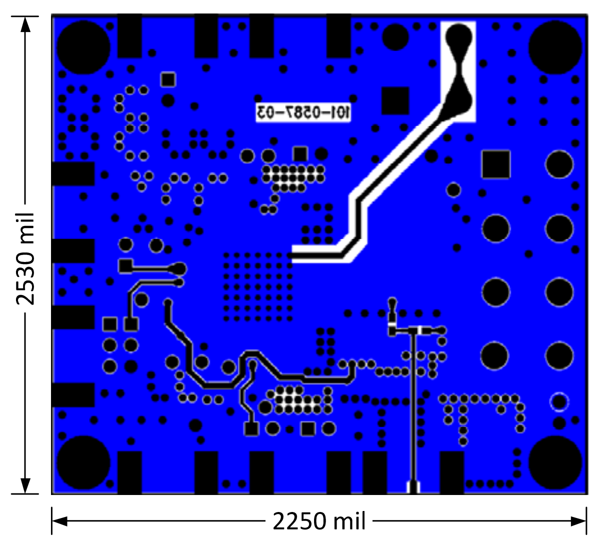
Top Layer



Mid Layer 2



Mid Layer 1



Bottom Layer

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Bill of Materials

PE99151

ITEM	QTY	REF-DES	VALUE	PART DESCRIPTION	PEREGRINE P/N	MANUFACTURER
1	1	C1	10nF	Capacitor, Ceramic, 10nF, 50V, Y5V, 0603		MURATA
2	1	C11	1nF	Capacitor, Ceramic, 1nF, 50V, X7R, ±5%, 0603		KEMET
3	11	C2-5 C15-18 C23-25	1µF	Capacitor, Ceramic, 1µF, 10V, X5R, ±10%, 0603		AVX Corporation
4	1	C13	15pF	Capacitor, Ceramic, 15pF, 50V, 5%, C0G, 0603		MURATA
5	1	C14	3.9nF	Capacitor, Ceramic, 3.9nF, 50V, 10%, X7R, 0603		MURATA
6	1	C10	50pF	Capacitor, Ceramic, 50pF, 100V, NPO, 0603		AVX Corporation
7	6	C6-7 C12 C19 C21 C26	47µF	Capacitor, Ceramic, 47µF, 10V, X7R, 10%, 1210		Murata
8	2	C27 C28	47µF	Capacitor, Ceramic, 47µF, 10V, X7R, 10%, 1210		Murata
9	1	C20	330µF	Capacitor, Tant, 330µF, 10V, 10%, 7343		Kemet
10	1	C29	150pF	Capacitor, Ceramic, 150pF, 50,V 5%, C0G, 0603		MURATA
11	1	U1	NTK 32 LEAD	IC, 32 LEAD, 0.500 SQUARE, FLATPACK	PE99151-01	
12	1	J15	2 POS. HEADER	HEADER, FCI, 4 PIN, DUAL ROW, TERMINAL BLOCK		FCI
13	1	J6	4 POS. HEADER	HEADER, FCI, 8 PIN, DUAL ROW, TERMINAL BLOCK		FCI
14	1	L1	2.8µH	INDUCTOR, 2.8 uH POWER INDUCTOR, DO5040H-282MLB		COILCRAFT
15	2	J4-5	3 PIN JUMPER	Jumper, 3 PIN, 0.100 centers		
16	4	MT1-4	Mounting Hole	PCB MTG HOLE, 0.200 OD x 0.138 Drill Hole		
17	2	R1 R3	0 ohm	RESISTOR, 0 OHM, 1/10W, 5%, 0603		Panasonic - ECG
18	1	R6	47K	RESISTOR, 47K OHM, 1/10W, 5%, 0603, SMD		Panasonic - ECG
19	3	R2 R8-9	10K	RESISTOR, 10.0K OHM, 1/10W, 0.1%, 0603		Panasonic - ECG
20	1	R4	15K	RESISTOR, 15.0K OHM, 1/10W, 0.1%, 0603		PANASONIC
21	1	R5	39K	RESISTOR, 39K OHM, 1/10W, 5%, 0603, SMD		PANASONIC
22	2	R10-11	50 ohm	RESISTOR, 50 OHM, 125MW, .1%, 0603		Vishay
23	1	R7	130 ohm	RESISTOR, 130 OHM, 1/10W, 5%, 0603, SMD		Panasonic - ECG
24	4	J1-3 J13	2 PIN JUMPER	CONN HEADER, .100 SINGLE STR, 2 POS		Sullins Electronics Corp.
25	6	J7-12	SMA CONN	SMA 50 OHM END LAUNCH JACK RECEPTACLE-ROUND CONTACT		Johnson Components Inc.
26	13	P1-11 P13-14	SINGLE PIN HEADER	SINGLE PIN HEADER		Sullins Electronics Corp.
27	1	REF		DC-DC EVK PCB	101-0587-02	

PE99153

ITEM	QTY	REF-DES	VALUE	PART DESCRIPTION	PEREGRINE P/N	MANUFACTURER
1	1	C1	10nF	Capacitor, Ceramic, 10nF, 50V, Y5V, 0603		MURATA
2	1	C11	1nF	Capacitor, Ceramic, 1nF, 50V, X7R, ±5%, 0603		KEMET
3	11	C2-5 C15-18 C23-25	1µF	Capacitor, Ceramic, 1µF, 10V, X5R, ±10%, 0603		AVX Corporation
4	1	C13	33pF	Capacitor, Ceramic, 33pF, 50V, 5%, C0G, 0603		MURATA
5	1	C14	3.3nF	Capacitor, Ceramic, 3.3nF, 50V, 10%, X7R, 0603		MURATA
6	1	C10	50pF	Capacitor, Ceramic, 50pF, 100V, NPO, 0603		AVX Corporation
7	6	C6-7 C12 C19 C21 C26	47µF	Capacitor, Ceramic, 47µF, 10V, X7R, 10%, 1210		Murata
8	2	C20 C22	330µF	Capacitor, Tant, 330µF, 10V, 10%, 7343		Kemet
9	1	C28	470µF	Capacitor, Tant, 470µF, 6.3V, 20%, SMD		KEMET
10	1	C29	150pF	Capacitor, Ceramic, 150pF, 50,V 5%, C0G, 0603		MURATA
11	1	U1	NTK 32 LEAD	IC, 32 LEAD, 0.500 SQUARE, FLATPACK	PE99153-01	
12	1	J15	2 POS. HEADER	HEADER, FCI, 4 PIN, DUAL ROW, TERMINAL BLOCK		FCI
13	1	J6	4 POS. HEADER	HEADER, FCI, 8 PIN, DUAL ROW, TERMINAL BLOCK		FCI
14	1	L1	2.8µH	INDUCTOR, 2.8 uH POWER INDUCTOR, DO5040H-282MLB		COILCRAFT
15	2	J4-5	3 PIN JUMPER	Jumper, 3 PIN, 0.100 centers		
16	4	MT1-4	Mounting Hole	PCB MTG HOLE, 0.200 OD x 0.138 Drill Hole		
17	2	R1 R3	0 ohm	RESISTOR, 0 OHM, 1/10W, 5%, 0603		Panasonic - ECG
18	1	R6	100K	RESISTOR, 100K OHM, 1/10W, 5%, 0603, SMD		Panasonic - ECG
19	3	R2 R8-9	10K	RESISTOR, 10.0K OHM, 1/10W, 0.1%, 0603		Panasonic - ECG
20	1	R4	15K	RESISTOR, 15.0K OHM, 1/10W, 0.1%, 0603		PANASONIC
21	1	R5	56K	RESISTOR, 56K OHM, 1/10W, 5%, 0603, SMD		Panasonic - ECG
22	2	R10-11	50 ohm	RESISTOR, 50 OHM, 125MW, .1%, 0603		Vishay
23	1	R7	82 ohm	RESISTOR, 82 OHM, 1/10W, 5%, 0603, SMD		Panasonic - ECG
24	4	J1-3 J13	2 PIN JUMPER	CONN HEADER, .100 SINGLE STR, 2 POS		Sullins Electronics Corp.
25	6	J7-12	SMA CONN	SMA 50 OHM END LAUNCH JACK RECEPTACLE-ROUND CONTACT		Johnson Components Inc.
26	13	P1-11 P13-14	SINGLE PIN HEADER	SINGLE PIN HEADER		Sullins Electronics Corp.
27	1	REF		DC-DC EVK PCB	101-0587-02	

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Bill of Materials (cont.)

PE99155

ITEM	QTY	REF-DES	VALUE	PART DESCRIPTION	PEREGRINE P/N	MANUFACTURER
1	1	C1	10nF	Capacitor, Ceramic, 10nF, 50V, Y5V, 0603		MURATA
2	1	C11	1nF	Capacitor, Ceramic, 1nF, 50V, X7R, ±5%, 0603		KEMET
3	11	C2-5 C15-18 C23-25	1µF	Capacitor, Ceramic, 1µF, 10V, X5R, ±10%, 0603		AVX Corporation
4	1	C13	39pF	Capacitor, Ceramic, 39pF, 50V, 5%, C0G, 0603		MURATA
5	1	C14	3.3nF	Capacitor, Ceramic, 3.3nF, 50V, 10%, X7R, 0603		MURATA
6	1	C10	50pF	Capacitor, Ceramic, 50pF, 100V, NPO, 0603		AVX Corporation
7	6	C6-7 C12 C19 C21 C26	47µF	Capacitor, Ceramic, 47µF, 10V, X7R, 10%, 1210		Murata
8	3	C9 C20 C22	330µF	Capacitor, Tant, 330µF, 10V, 10%, 7343		Kemet
9	2	C27 C28	470µF	Capacitor, Tant, 470µF, 6.3V, 20%, SMD		KEMET
10	1	C29	150pF	Capacitor, Ceramic, 150pF, 50,V 5%, C0G, 0603		MURATA
11	1	U1	STRATEDGE 32 LEAD	IC, 32 LEAD, 0.500 SQUARE, FLATPACK	NTK 32 LEAD	
12	1	J15	2 POS. HEADER	HEADER, FCI, 4 PIN, DUAL ROW, TERMINAL BLOCK		FCI
13	1	J6	4 POS. HEADER	HEADER, FCI, 8 PIN, DUAL ROW, TERMINAL BLOCK		FCI
14	1	L1	2.8µH	INDUCTOR, 2.8 uH POWER INDUCTOR, DO5040H-282MLB		COILCRAFT
15	2	J4-5	3 PIN JUMPER	Jumper, 3 PIN, 0.100 centers		
16	4	MT1-4	Mounting Hole	PCB MTG HOLE, 0.200 OD x 0.138 Drill Hole		
17	2	R1 R3	0 ohm	RESISTOR, 0 OHM, 1/10W, 5%, 0603		Panasonic - ECG
18	1	R6	150K	RESISTOR, 150K OHM, 1/10W, 5%, 0603, SMD		Panasonic - ECG
19	3	R2 R8-9	10K	RESISTOR, 10.0K OHM, 1/10W, 0.1%, 0603		Panasonic - ECG
20	1	R4	15K	RESISTOR, 15.0K OHM, 1/10W, 0.1%, 0603		PANASONIC
21	1	R5	68K	RESISTOR, 68K OHM, 1/10W, 5%, 0603, SMD		Panasonic - ECG
22	2	R10-11	50 ohm	RESISTOR, 50 OHM, 125MW, .1%, 0603		Vishay
23	1	R7	56 ohm	RESISTOR, 56 OHM, 1/10W, 5%, 0603, SMD		Panasonic - ECG
24	4	J1-3 J13	2 PIN JUMPER	CONN HEADER, .100 SINGLE STR, 2 POS		Sullins Electronics Corp.
25	6	J7-12	SMA CONN	SMA 50 OHM END LAUNCH JACK RECEPTACLE-ROUND CONTACT		Johnson Components Inc.
26	13	P1-11 P13-14	SINGLE PIN HEADER	SINGLE PIN HEADER		Sullins Electronics Corp.
27	1	REF		DC-DC EVK PCB	101-0587-02	

Technical Resources

Additional technical resources are available for download in the Products section at www.psemi.com. These include the Product Specification datasheet, Evaluation Kit schematic and Bill of Materials, PC-compatible software file, Evaluation Kit instruction manual, phase noise loop filter calculation spreadsheet and application notes.

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