User manual for IR3887 evaluation board

30 A single-phase buck regulator with 1.0 V output

About this document

Scope and purpose

The IR3887 is a synchronous buck converter, providing a compact, high-performance and flexible solution in a small 4 mm x 5 mm power QFN package.

Key features offered by the IR3887 include internal digital soft-start, precision 0.6 V reference voltage, Power Good, thermal protection, programmable switching frequency, enable input, input undervoltage lockout for proper start-up, latched off or unlatched overvoltage protection, and pre-bias start-up.

The output overcurrent protection (OCP) function is implemented by sensing the voltage developed across the on-resistance of the synchronous MOSFET for optimum cost and performance, and the current limit is thermally compensated.

This user guide contains the schematic and Bill of materials (BOM) for the EV114-001 engineering evaluation board. The guide describes operation and use of the evaluation board itself. Detailed application information for IR3887 is available in the IR3887 data sheet.

Intended audience

This document is intended as a guide for design engineers evaluating IR3887 performance with the engineering EV114-001 demo board.

Table of contents

1 Board information

1.1 Board features

V_{in} = +12 V, V_{out} = +1 V at 0 to 30 A

F_s = 600 kHz/800 kHz/1000 kHz

L = 150 nH (12.4 mm x 8.3 mm x 8 mm, DCR = 0.15 mΩ)

C_{in} = 10 x 22 µF (25 V, ceramic 0805) + 1 x 330 µF (25 V, electrolytic, optional)

C_{out} = 9 x 47 µF (6.3 V, ceramic 0805) + 1 x 470 µF (2 V, 6 mΩ, SP-cap)

1.2 Connections and operating instructions

The IR3887 demo board requires a single +12 V for the input power and can deliver up to 30 A load current. The operation modes and OCP limits can be selected through jumpers.

Table 1 Connections

Label		Descriptions
Input	PV_{in}	Connect input power (+12 V) to this pin
	GND	Return of input power
	PV_{in}, GND	Sense pins for the input voltage
Output	V_{out}	V_{out} (+1 V), connect a load (30 A max.) to this pin
	GND	Return of V_{out}
	V_{out}, GND	Sense pins for the output voltage
Enable	Enable	Connect a scope probe to this pin to monitor enable signal Or, an external enable signal can be applied to this pin to over-drive the on-board enable signal
	GND	
Bode	A	For bode plot measurement
	B	
SS/Latch	OVP latch	Use a jumper to select one of four soft-start time selections (1 ms, 2 ms, 4 ms and 8 ms), and latched OVP or unlatched OVP
	OVP no latch	
Ton/Mode	FCCM	Use a jumper to select FCCM or DEM, and switching frequency. The available switching frequencies are: 600 kHz, 800 kHz, 1000 kHz and 1200 kHz
	DEM	
ILIM		Use a jumper to select one of four OCP limits. OCP 1 is the lowest OCP limit and OCP4 is the highest OCP limit.
P_{Good}	P_{Good}	Connect a scope probe to this pin to monitor Power Good signal
	GND	GND
	EPGb	External P_{Good} pull-up bias pin. P_{Good} pin is pulled up to V_{CC} through R4 on the standard demo board. By removing R4 and populating R42 with 49.9 kΩ, an external P_{Good} pull-up bias can be applied to the EPGb pin.
V_{CC}	V_{CC}	Standard demo board is configured to use the internal LDO. Connect a scope probe to this pin to monitor the output of the internal LDO.
	GND	

1.3 Layout

The PCB is a six-layer board (3.0 in. x 3.75 in.) using FR4 material. Top and bottom layers use 1.5 oz. copper and inner layers use 2 oz. copper. The PCB thickness is 0.062 in. The IR3887 and other major power components are mounted on the top side of the board.

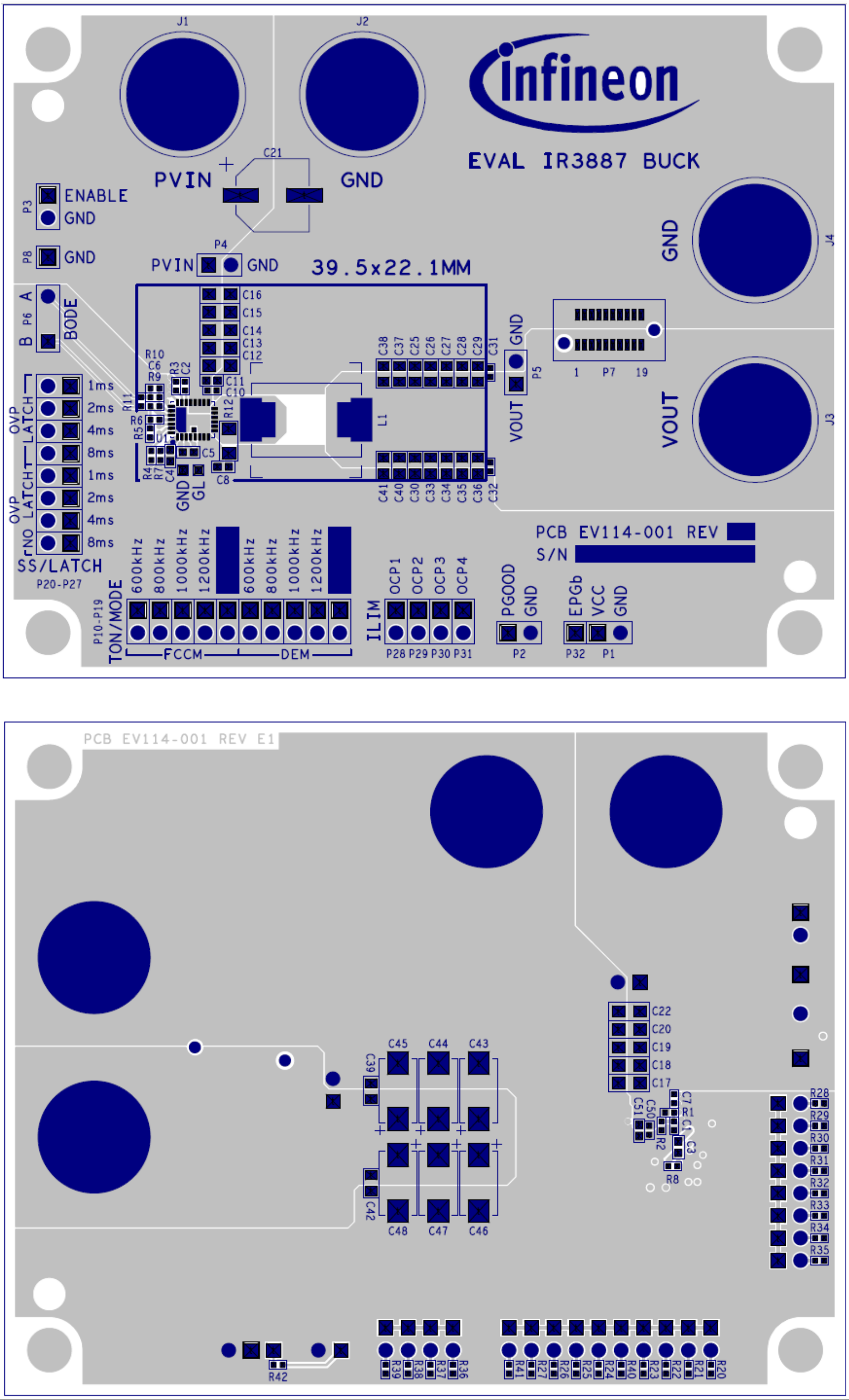

Figure 1 **Top and bottom view of IR3887 evaluation board**

1.4 PCB layout

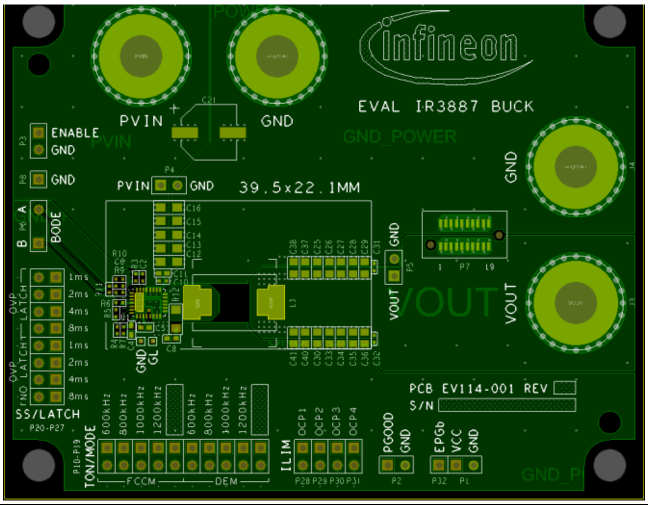

Figure 2 Top layer

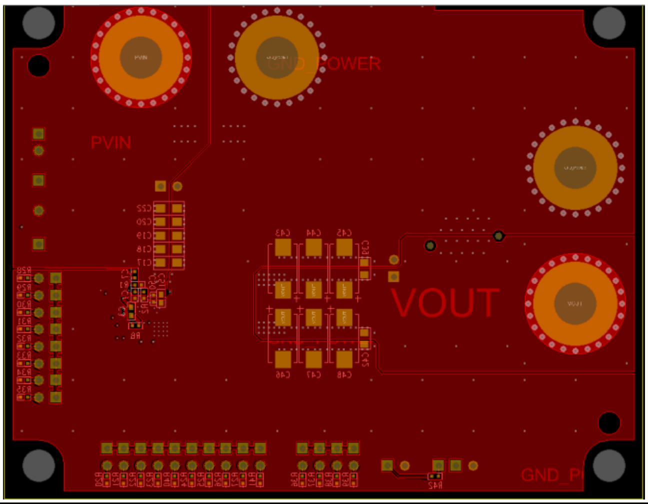

Figure 3 Bottom layer

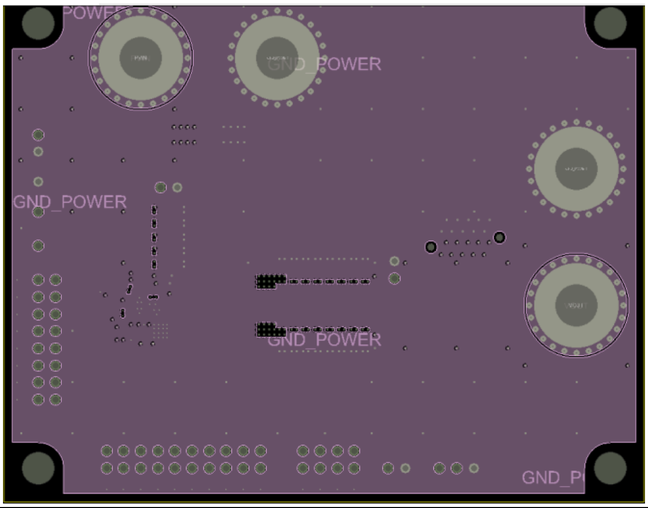

Figure 4 Mid layer 1

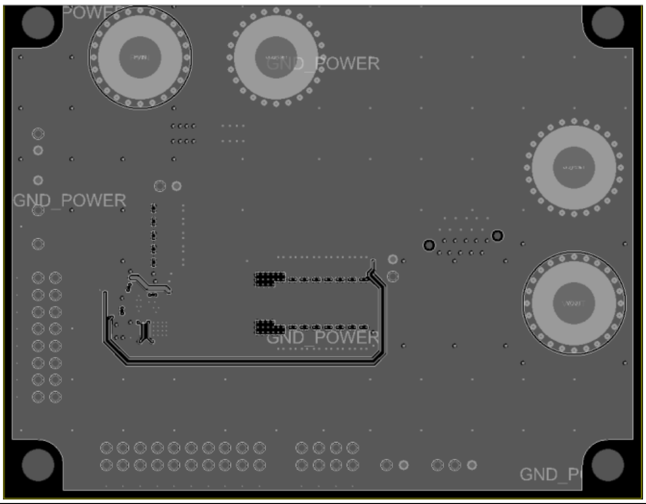

Figure 5 Mid layer 2

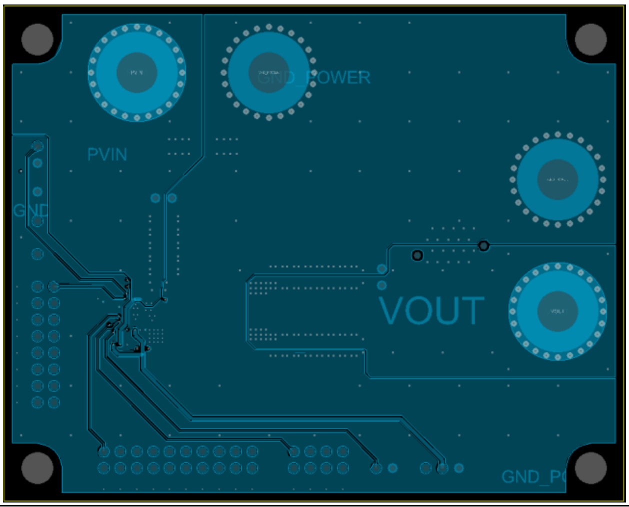

Figure 6 Mid layer 3

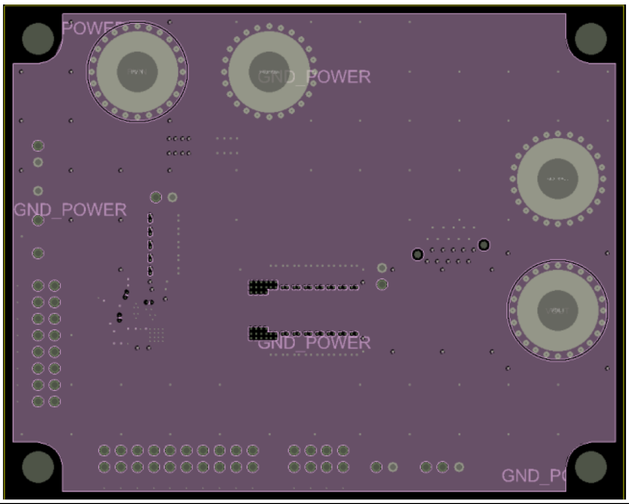

Figure 7 Mid layer 4

1.5 Schematic

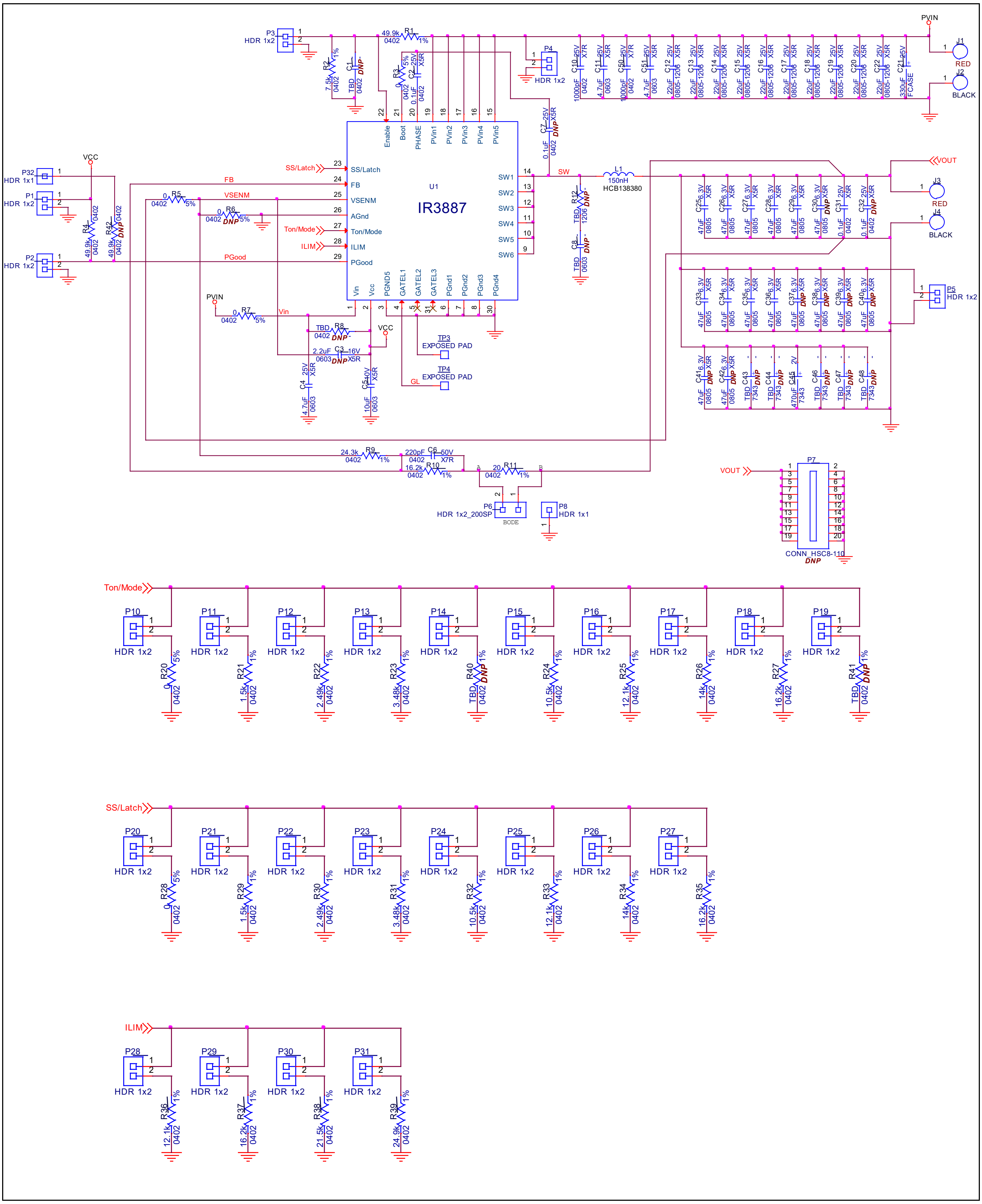

Figure 8 Schematic of the IR3887 evaluation board V_{in} = 12 V, V_{out} = 1 V, I_{outmax} = 30 A, fsw = 600 kHz/800 kHz/1000 kHz

1.6 Bill of materials

Table 2 BOM

Item	Qty.	Reference	Value	Manufacturer	Manufacturer part no.	Description
1	2	C2, C31	0.1 µF	Taiyo Yuden	TMK105BJ104KV-F	Ceramic capacitor 0.1 µF 25 V 10% X5R 0402
2	3	C4, C11, C51	4.7 µF	Murata	GRM188R61E475KE15D	Ceramic capacitor 4.7 µF 25 V 10% X5R 0603
3	1	C5	10 µF	Murata	GRM188R61A106KE69D	Ceramic capacitor 10 µF 10 V 10% X5R 0603
4	1	C6	220 pF	Kemet	C0402C221K5RACTU	Ceramic capacitor 220 pF 50 V 10% X7R 0402
5	2	C10, C50	1000 pF	Kemet	C0402C102K3RACTU	Ceramic capacitor 1000 pF 25 V 10% X7R 0402
6	10	C12, C13, C14, C15, C16, C17, C18, C19, C20, C22	22 µF	Murata	GRM21BR61E226ME44L	Ceramic capacitor 22 µF 25 V 20% X5R 0805
7	1	C21	330 µF	Panasonic	PCE3410CT-ND	Aluminum capacitor 330 µF 20% 25 V SMD
8	9	C25, C26, C27, C28, C29, C33, C34, C35, C36	47 µF	TDK	C2012X5R0J476M125AC	Ceramic capacitor 47 µF 6.3 V 20% X5R 0805
9	1	C45	470 µF	Panasonic	EEF-SX0E471XE	Aluminum capacitor poly 470 µF 20% 2.5 V SMD
10	1	L1	150 nH	Delta	HCB138380D-151	Inductor 150 nH, 75 A, 0.15 mΩ 12.4 mm x 8.3 mm, SMD
11	2	R1, R4	49.9 k	Panasonic	ERJ-2RKF4992X	Resistor 49.9 kΩ 1/10 W 1% 0402 SMD
12	1	R2	7.5 k	Panasonic	ERJ-2RKF7501X	Resistor 7.50 kΩ 1/10 W 1% 0402 SMD
13	5	R3, R5, R7, R20, R28	0	Panasonic	ERJ-2GE0R00X	Resistor 0.0 Ω 1/10 W 0402 SMD
14	1	R9	24.3 k	Panasonic	ERJ-2RKF2432X	Resistor 24.3 kΩ 1/10 W 1% 0402 SMD
15	4	R10, R27, R35, R37	16.2 k	Panasonic	ERJ-2RKF1622X	Resistor 16.2 kΩ 1/10 W 1% 0402 SMD
16	1	R11	20	Vishay Dale	CRCW040220R0FKED	Resistor 20.0 Ω 1/16 W 1% 0402 SMD
17	2	R21, R29	1.5 k	Rohm	MCR01MZPF1501	Resistor 1.50 kΩ 1/16 W 1% 0402 SMD
18	2	R22, R30	2.49 k	Vishay Dale	CRCW04022K49FKED	Resistor 2.49 kΩ 1/16 W 1% 0402 SMD
19	2	R23, R31	3.48 k	Vishay Dale	CRCW04023K48FKED	Resistor 3.48 kΩ 1/16 W 1% 0402 SMD
20	2	R24, R32	10.5 k	Panasonic	ERJ-2RKF1052X	Resistor 10.5 kΩ 1/10 W 1% 0402 SMD
21	3	R25, R33, R36	12.1 k	Panasonic	ERJ-2RKF1212X	Resistor 12.1 kΩ 1/10 W 1% 0402 SMD
22	2	R26, R34	14 k	Panasonic	ERJ-2RKF1402X	Resistor 14.0 kΩ 1/10 W 1% 0402 SMD
23	1	R38	21.5 k	Panasonic	ERJ-2RKF2152X	Resistor 21.5 kΩ 1/10 W 1% 0402 SMD
24	1	R39	24.9 k	Panasonic	ERJ-2RKF2492X	Resistor 24.9 kΩ 1/10 W 1% 0402 SMD
25	1	R42	49.9 k	Panasonic	ERJ-2RKF4992X	Resistor 49.9 kΩ 1/10 W 1% 0402 SMD
26	1	U1	IR3887	Infineon	IR3887	30 A single input voltage, synchronous buck regulator

2 Typical operating waveforms

V_{in} = 12.0 V, V_{out} = 1 V, I_{out} = 0 to 30 A, room temperature, no airflow.

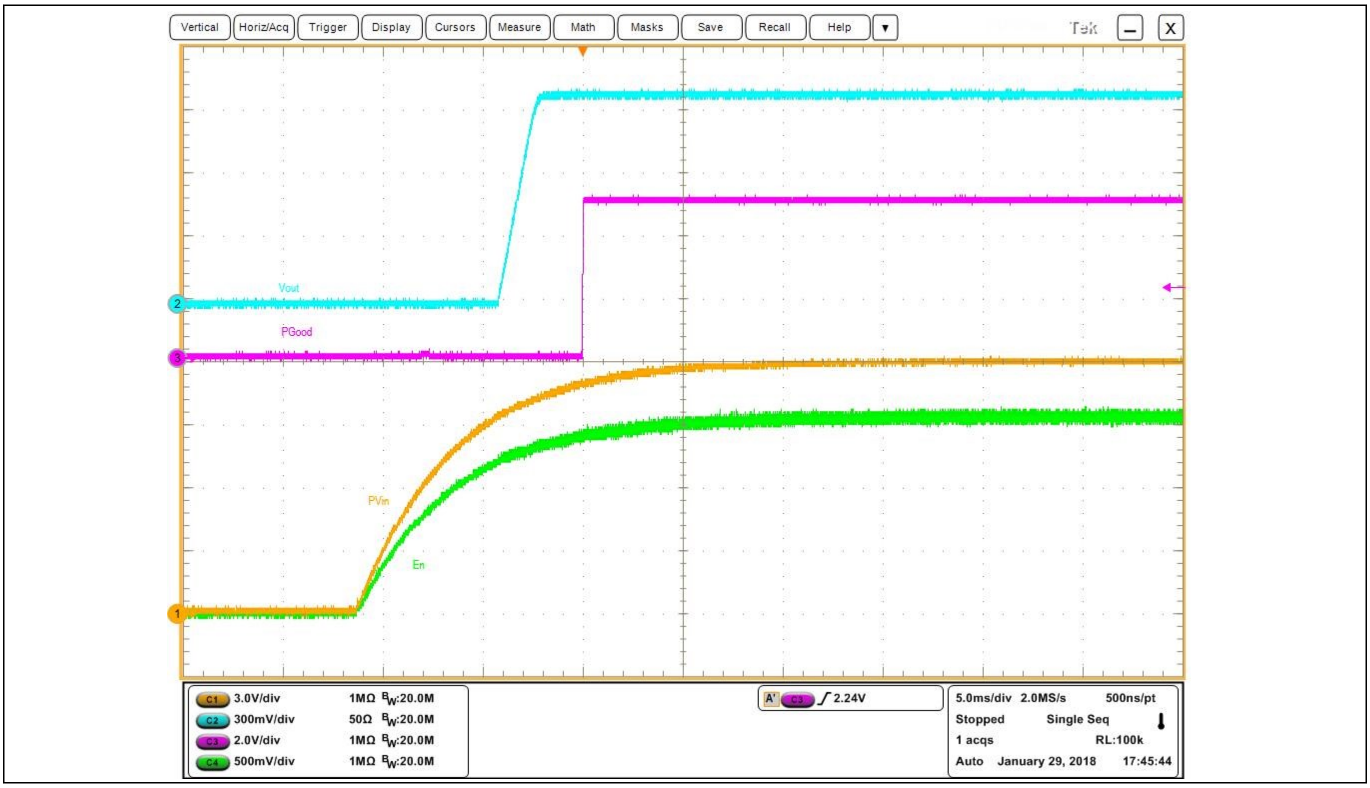

Figure 9 Start-up at 30 A load (Ch_1: PV_{in}, Ch_2: V_{out}, Ch_3: P_{Good}, Ch_4: Enable)

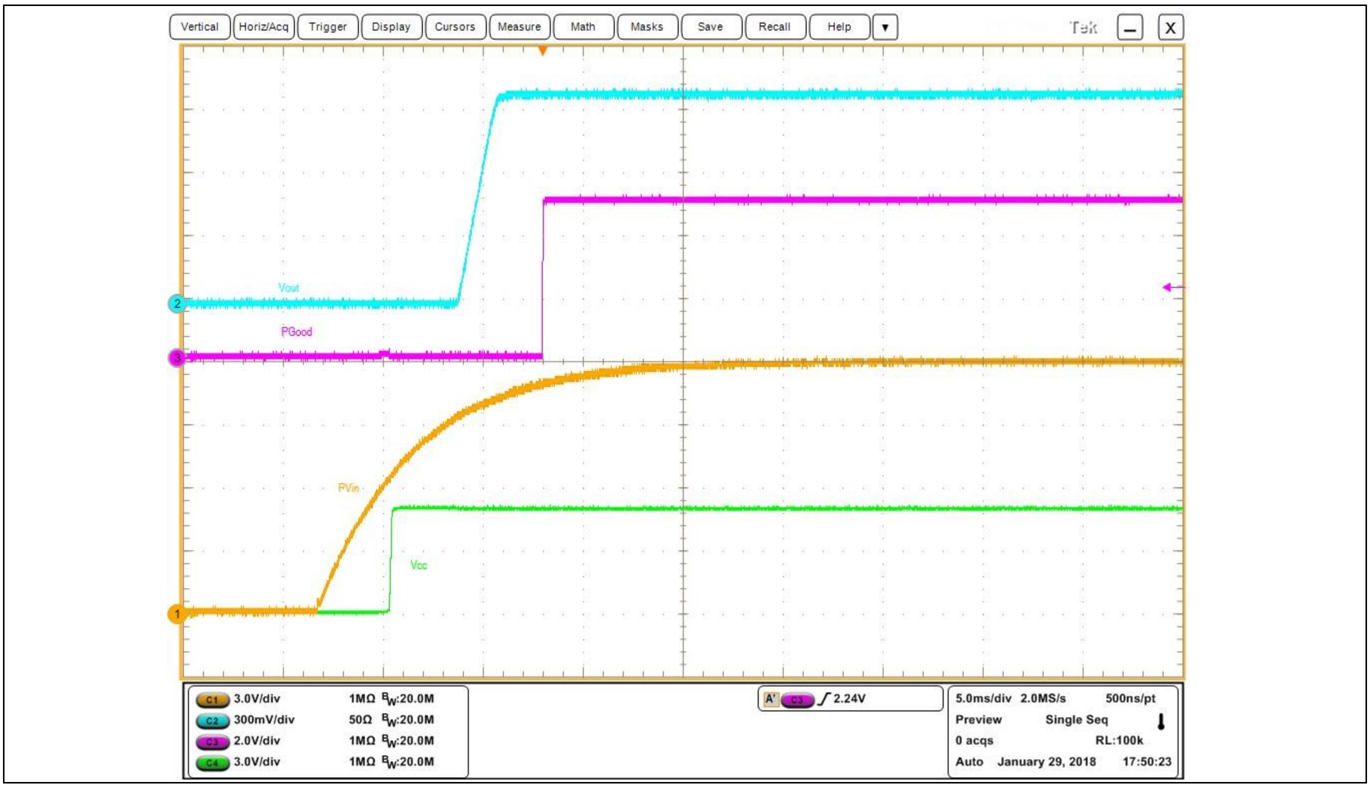

Figure 10 Start-up at 30 A load (Ch_1: PV_{in}, Ch_2: V_{out}, Ch_3: P_{Good}, Ch_4: V_{cc})

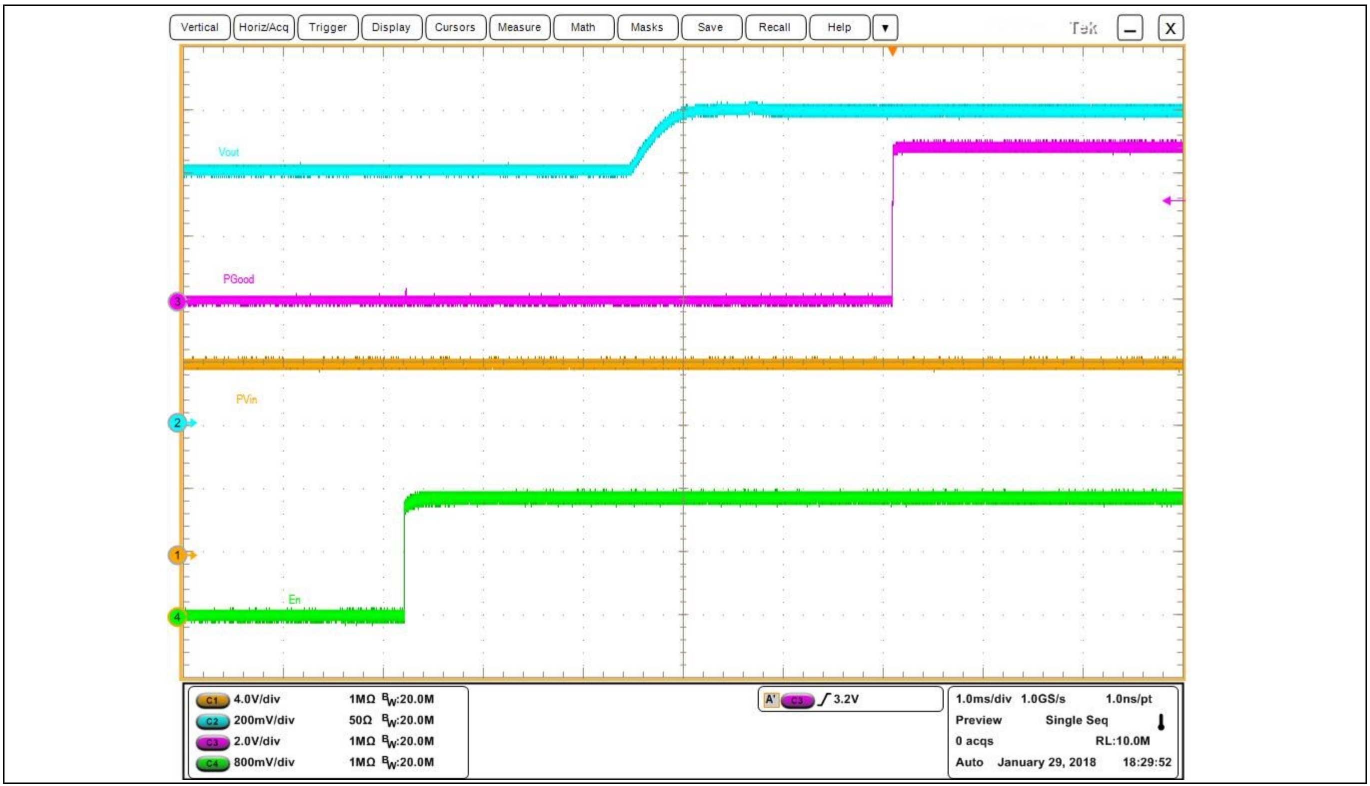

Figure 11 Pre-bias start-up at 0 A load (Ch_1: PV_{in}, Ch_2: V_{out}, Ch_3: P_{Good}, Ch_4: Enable)

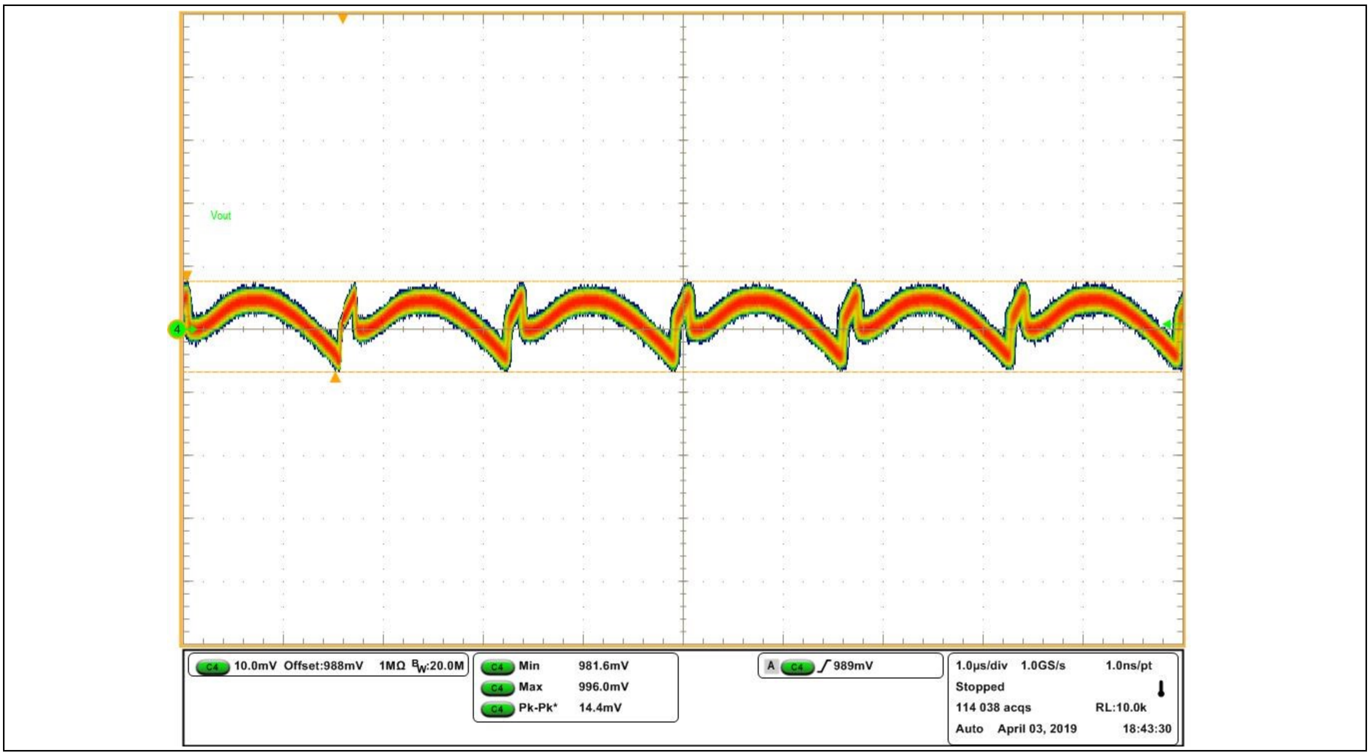

Figure 12 V_{out} ripple at 30 A load, fsw = 600 kHz (Ch_4: V_{out})

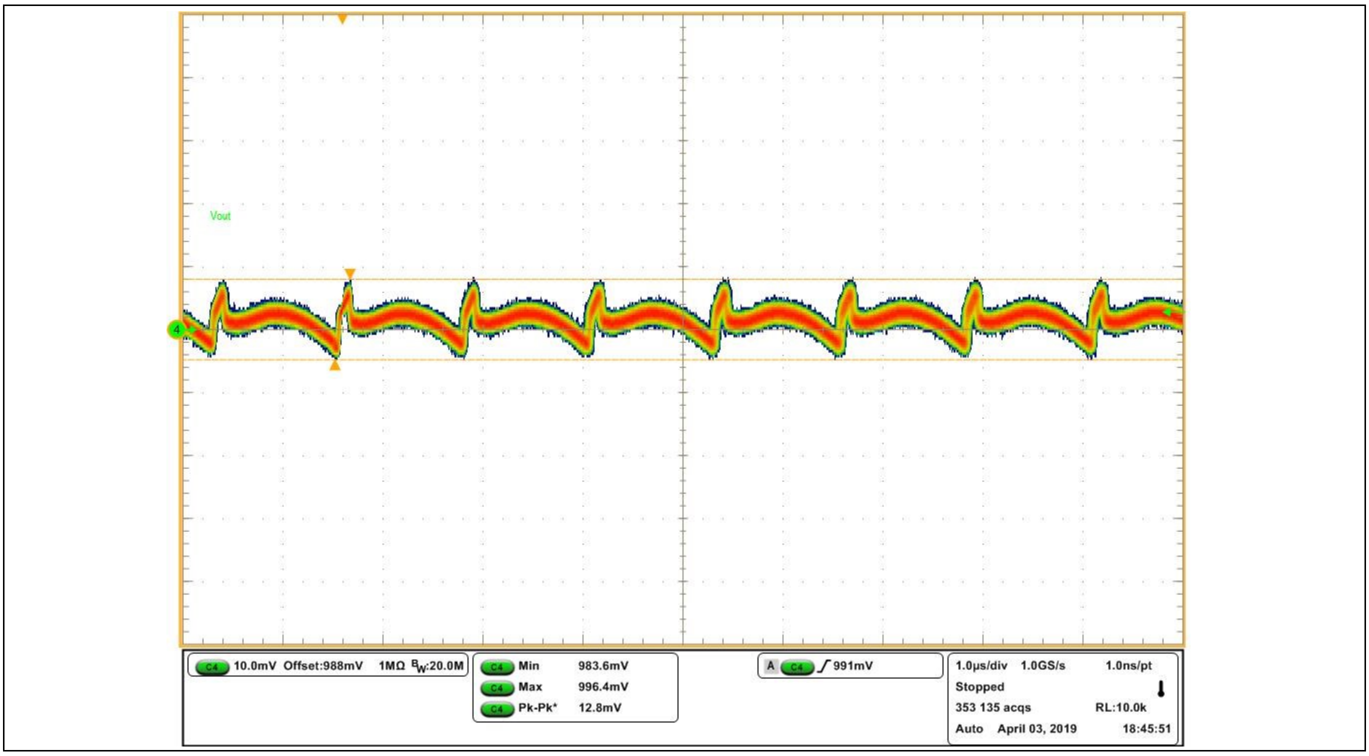

Figure 13 V_{out} ripple at 30 A load, fsw = 800 kHz (Ch_4: V_{out})

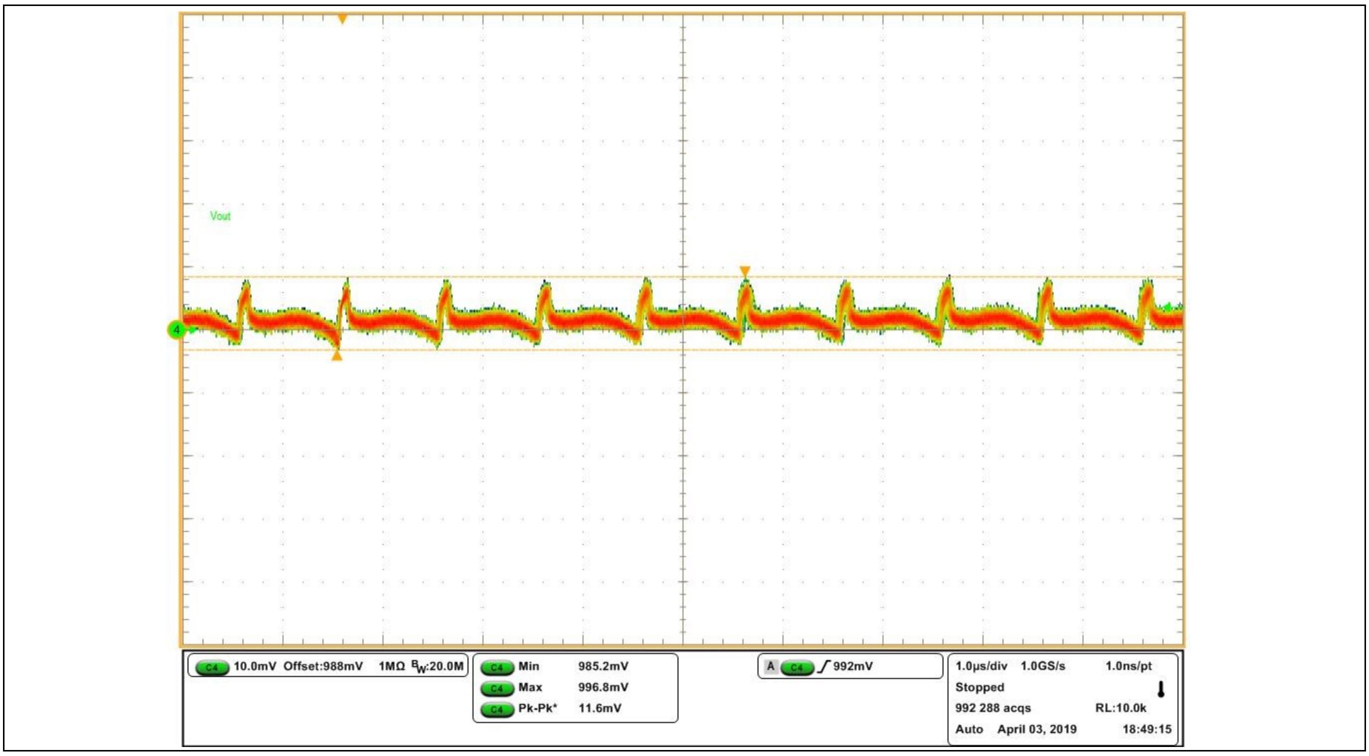

Figure 14 V_{out} ripple at 30 A load, fsw = 1000 kHz (Ch_4: V_{out})

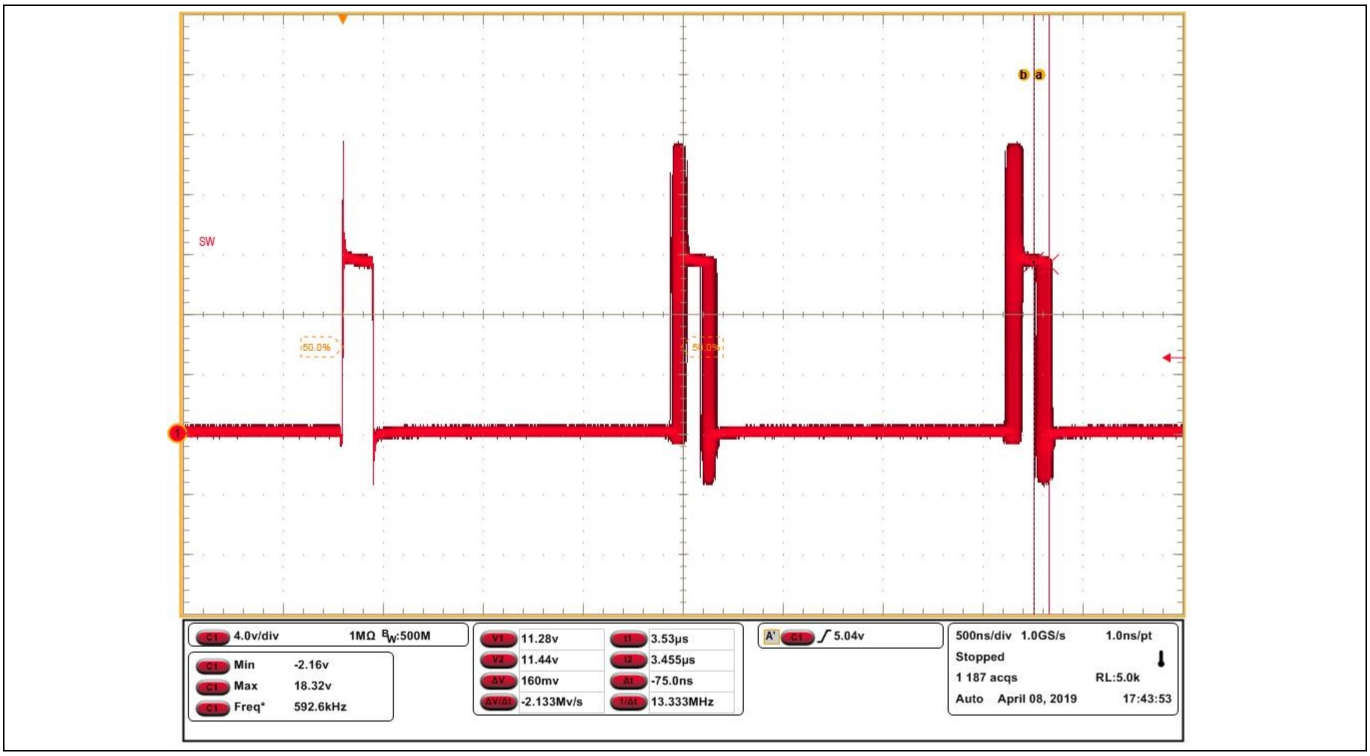

Figure 15 SW node, 30 A load, fsw = 600 kHz

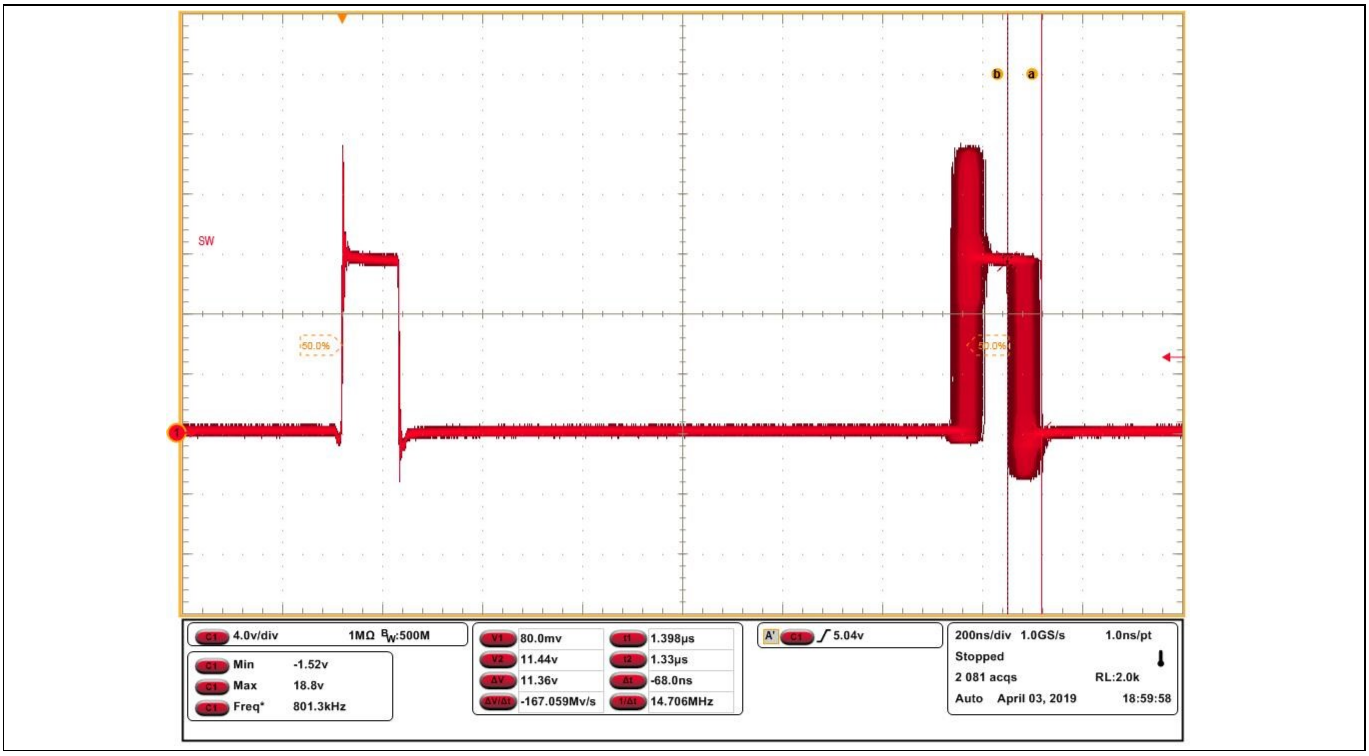

Figure 16 SW node, 30 A load, fsw = 800 kHz

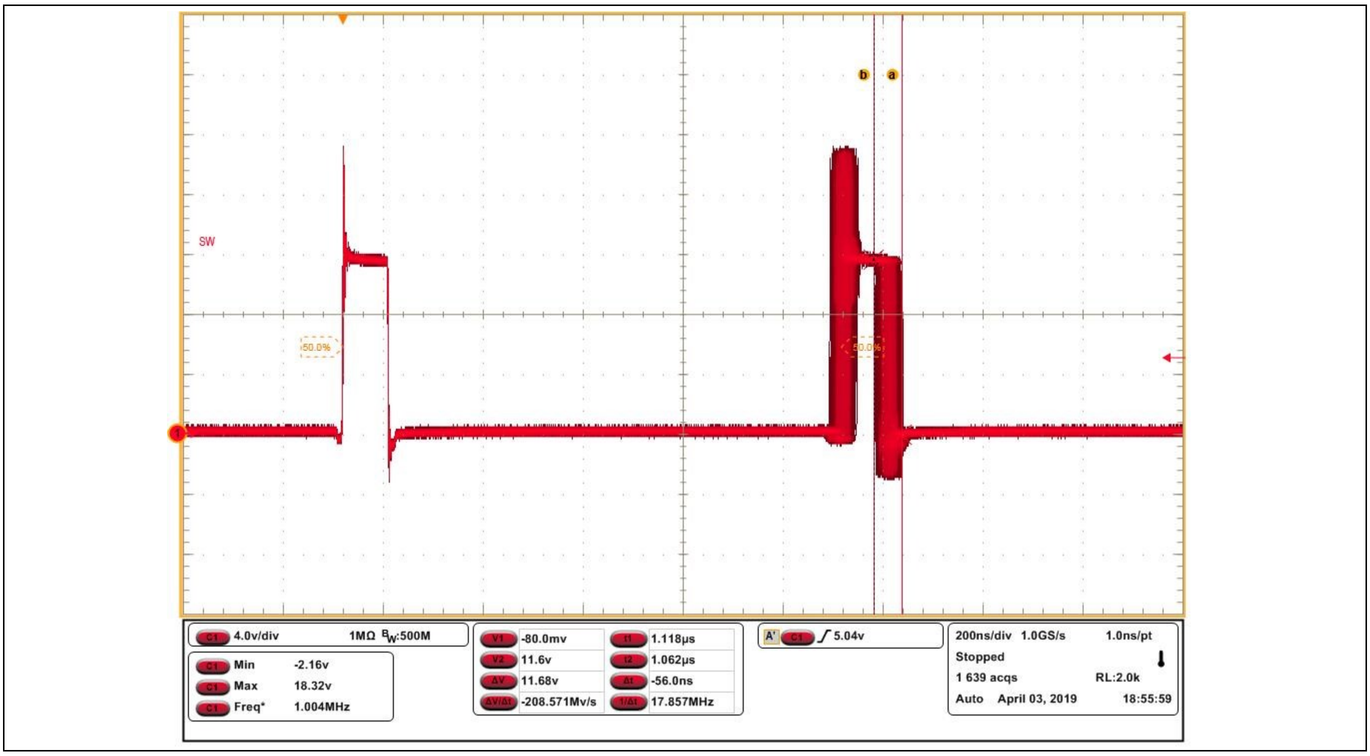

Figure 17 SW node, 30 A load, fsw = 1000 kHz

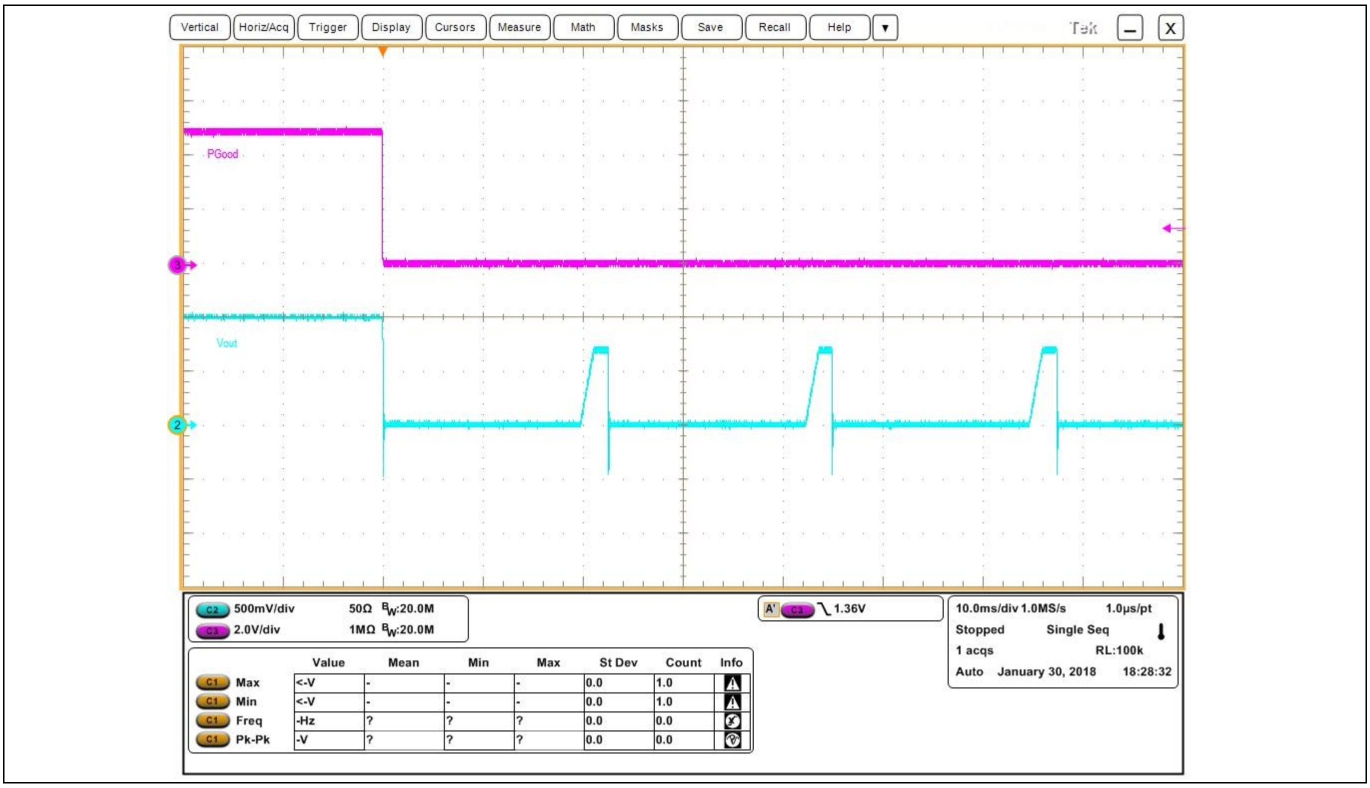

Figure 18 Short-circuit and UVP (hiccup), (Ch_2: V_o, Ch_3: P_{Good})

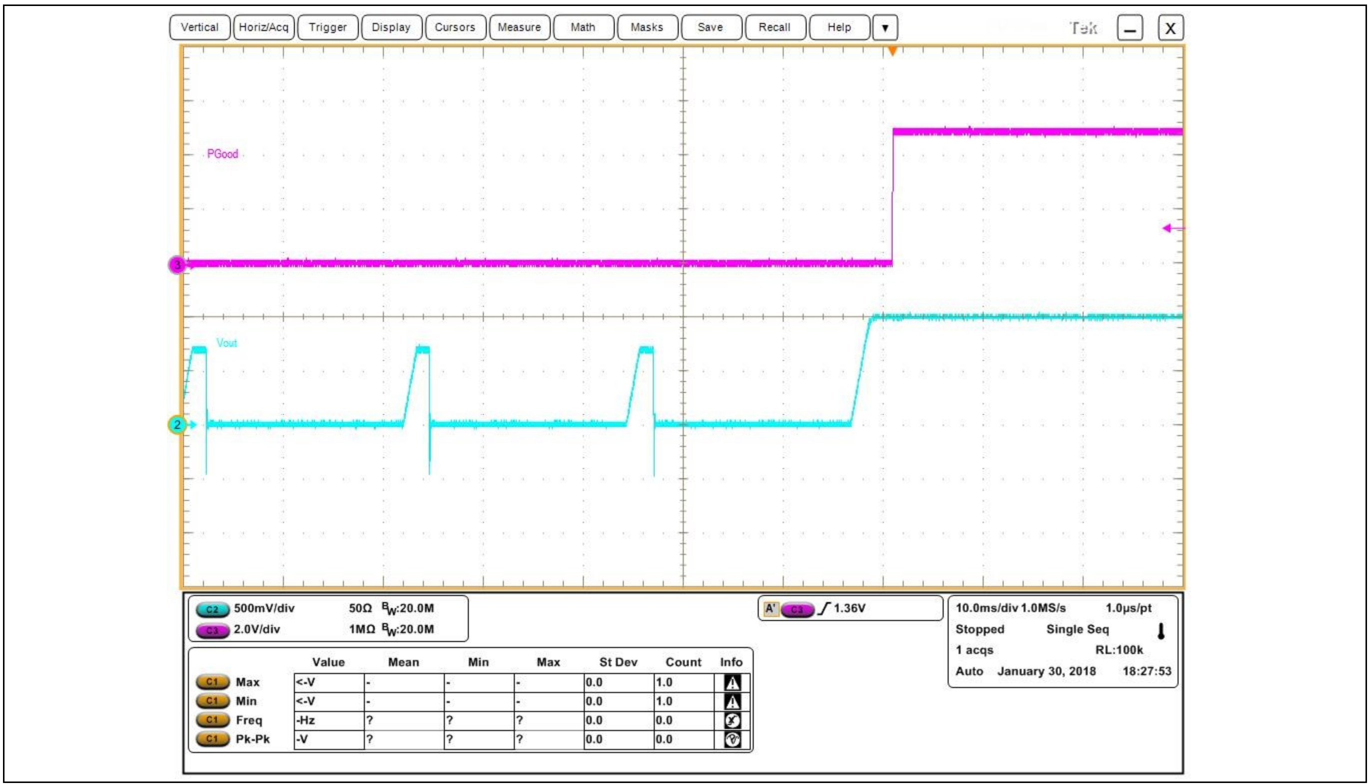

Figure 19 Short-circuit and UVP (hiccup) recover (Ch_2: V_{out}, Ch_3: P_{Good})

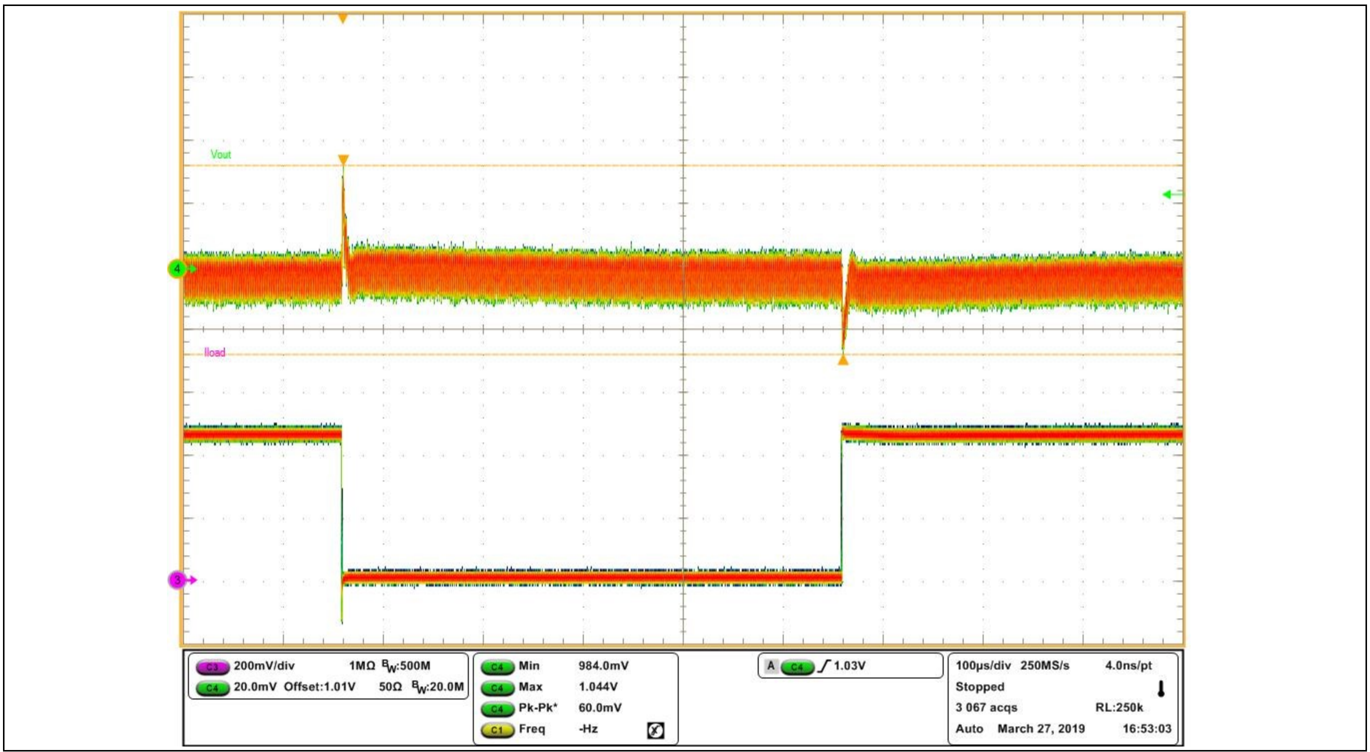

Figure 20 Transient response at 9 A step load current at 30 A/µs slew rate: I_{out} = 0 to 9 A (Ch_4: V_{out}, Ch_3: I_{out}, 50 mV/A) pk-pk: 60 mV, fsw = 600 kHz

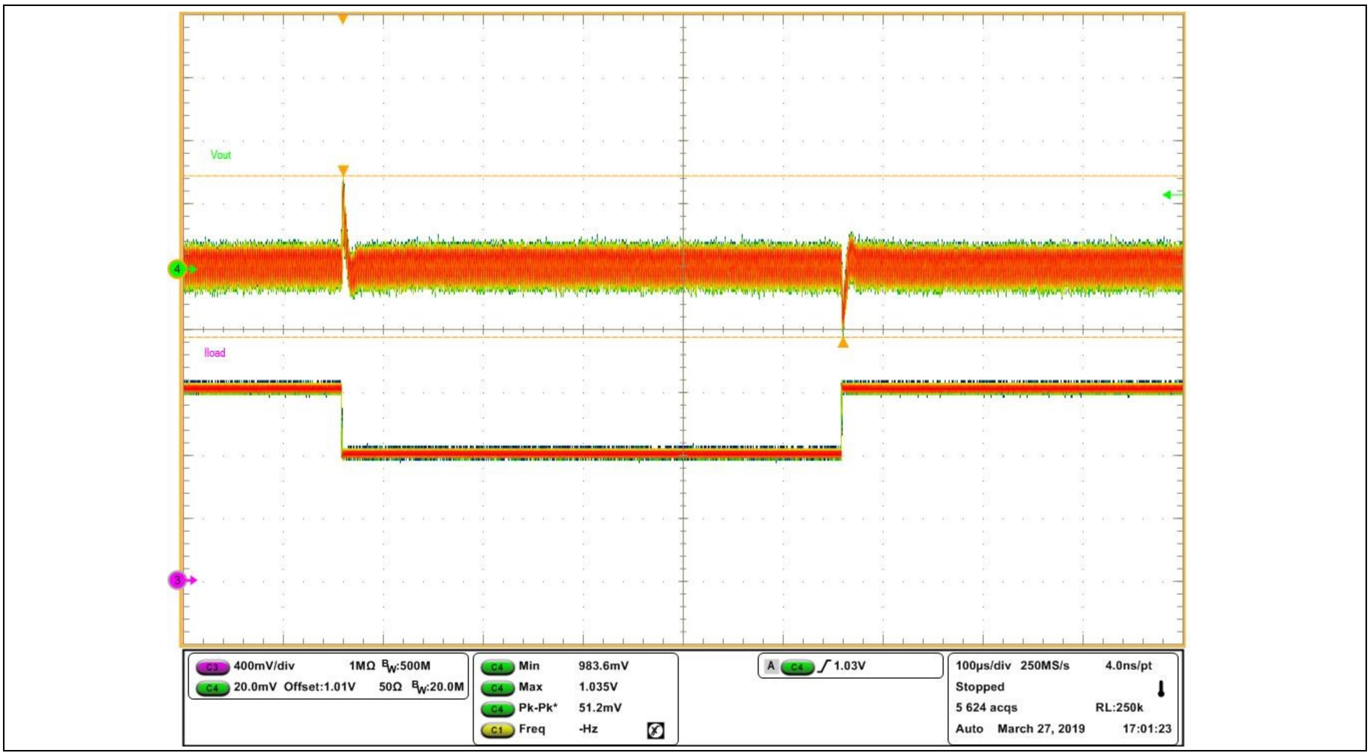

Figure 21 Transient response at 9 A step load current at 30 A/µs slew rate: I_{out} = 16 to 25 A (Ch_4: V_{out}, Ch_3: I_{out}, 50 mV/A), pk-pk: 51.2 mV, fsw = 600 kHz

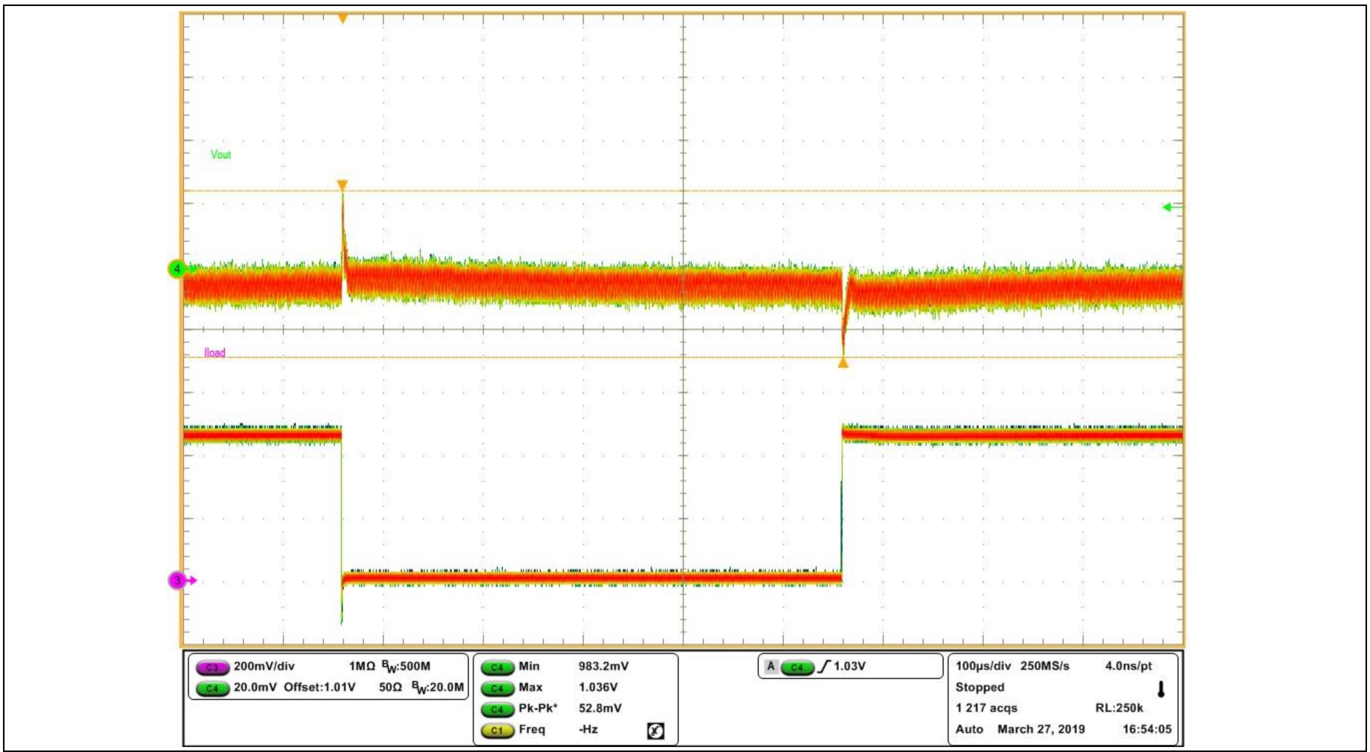

Figure 22 Transient response at 9 A step load current at 30 A/µs slew rate: I_{out} = 0 to 9 A (Ch_4: V_{out}, Ch_3: I_{out}, 50 mV/A) pk-pk: 53 mV, fsw = 800 kHz

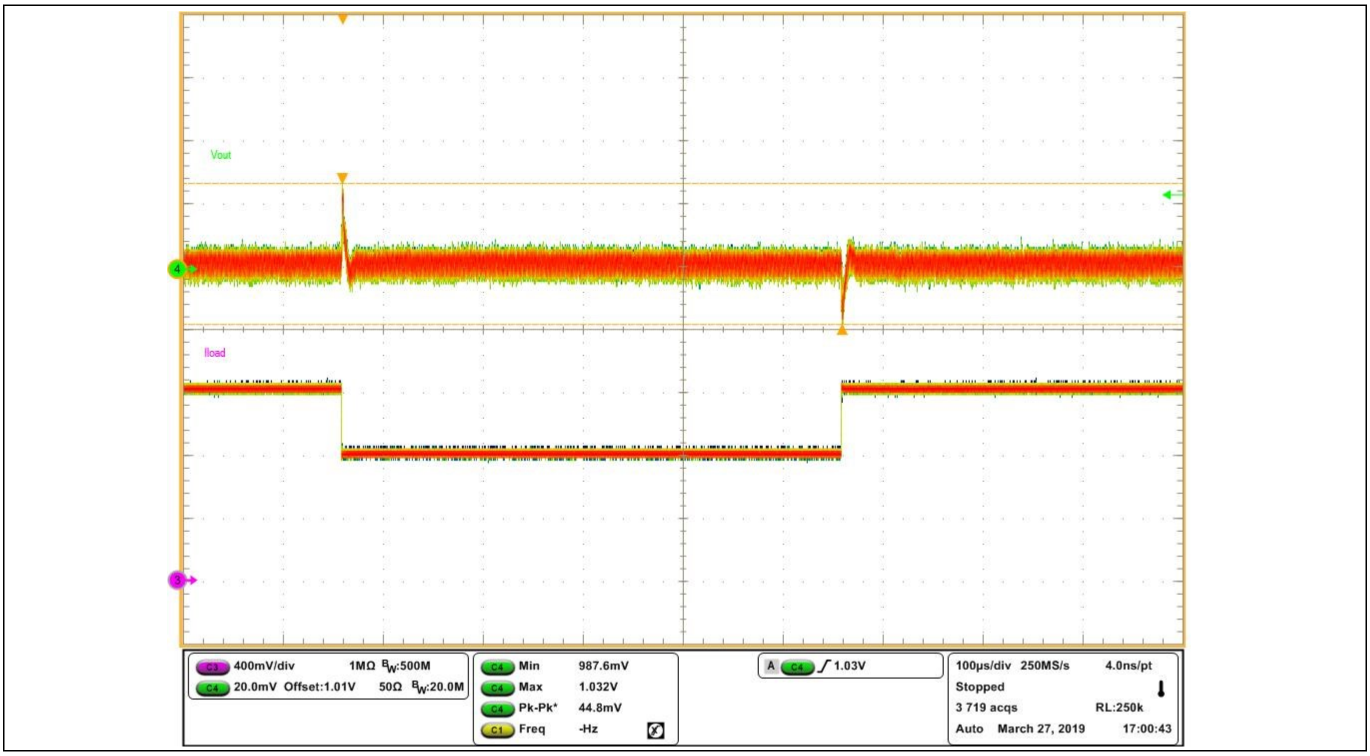

Figure 23 Transient response at 9 A step load current at 30 A/µs slew rate: I_{out} = 16 to 25 A (Ch_4: V_{out}, Ch_3: I_{out}, 50 mV/A), pk-pk: 45 mV, fsw = 800 kHz

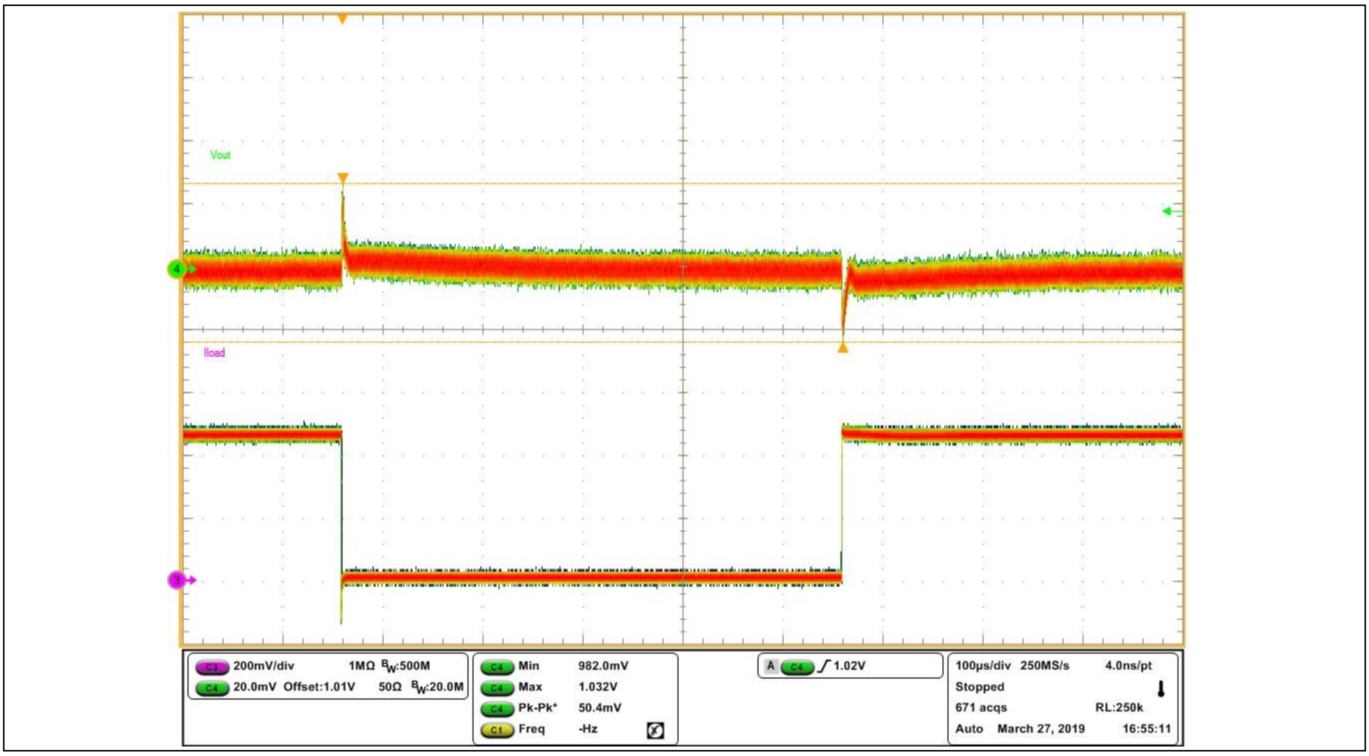

Figure 24 Transient response at 9 A step load current at 30 A/µs slew rate: I_{out} = 0 to 9 A (Ch_4: V_{out}, Ch_3: I_{out}, 50 mV/A) pk-pk: 50.4 mV, fsw = 1000 kHz

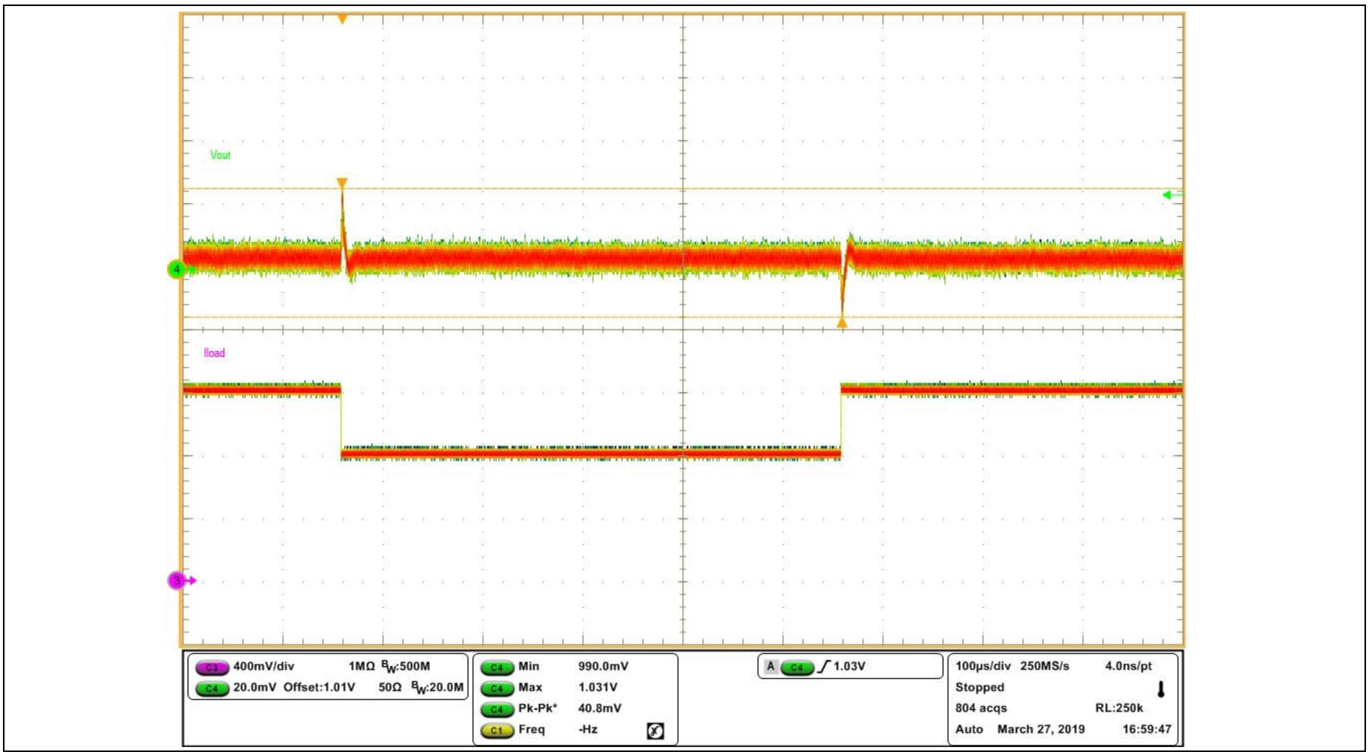

Figure 25 **Transient response at 9 A step load current at 30 A/µs slew rate: I_{out} = 16 to 25 A (Ch_4: V_{out}, Ch_3: I_{out}, 50 mV/A) pk-pk: 41 mV, fsw = 1000 kHz**

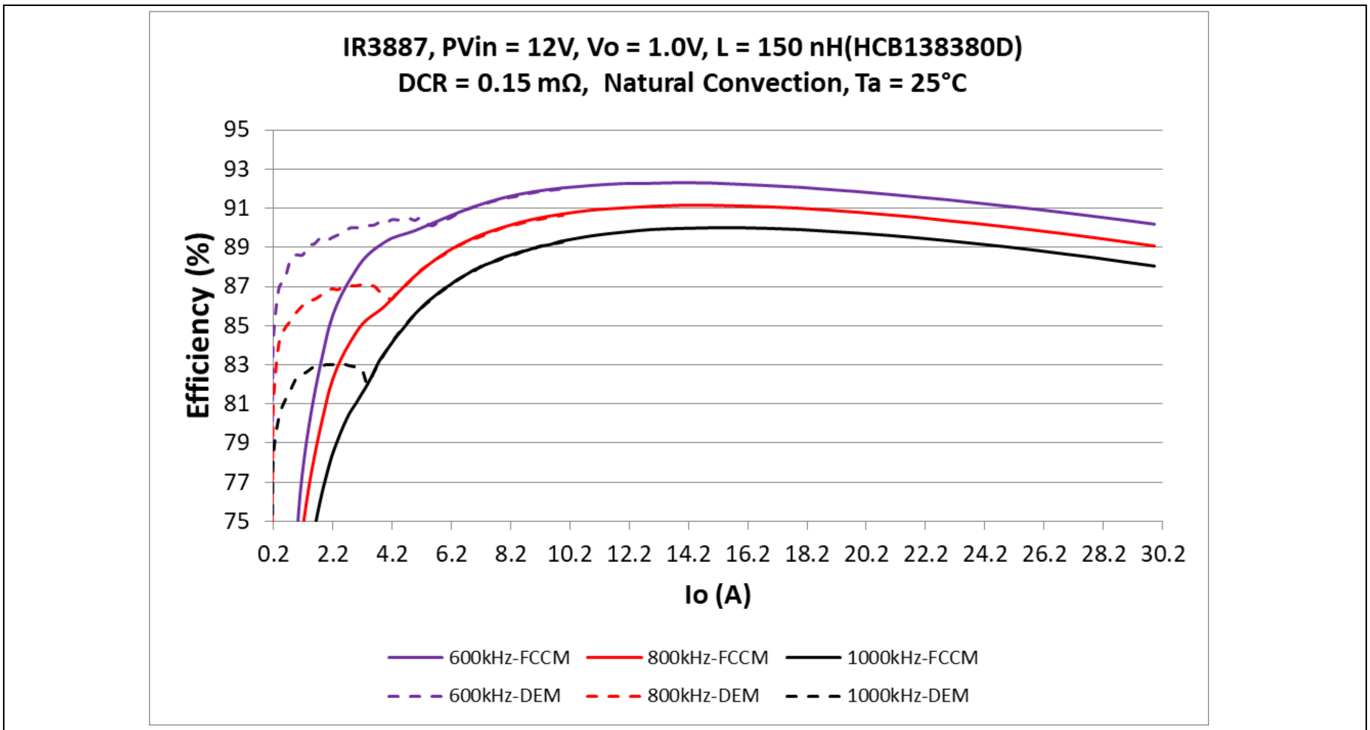

Figure 26 **Efficiency with natural convection (12 V_{in}, 1 V_{out}, 150 nH, 600 kHz, 800 kHz and 1000 kHz, T_a = 25°C)**

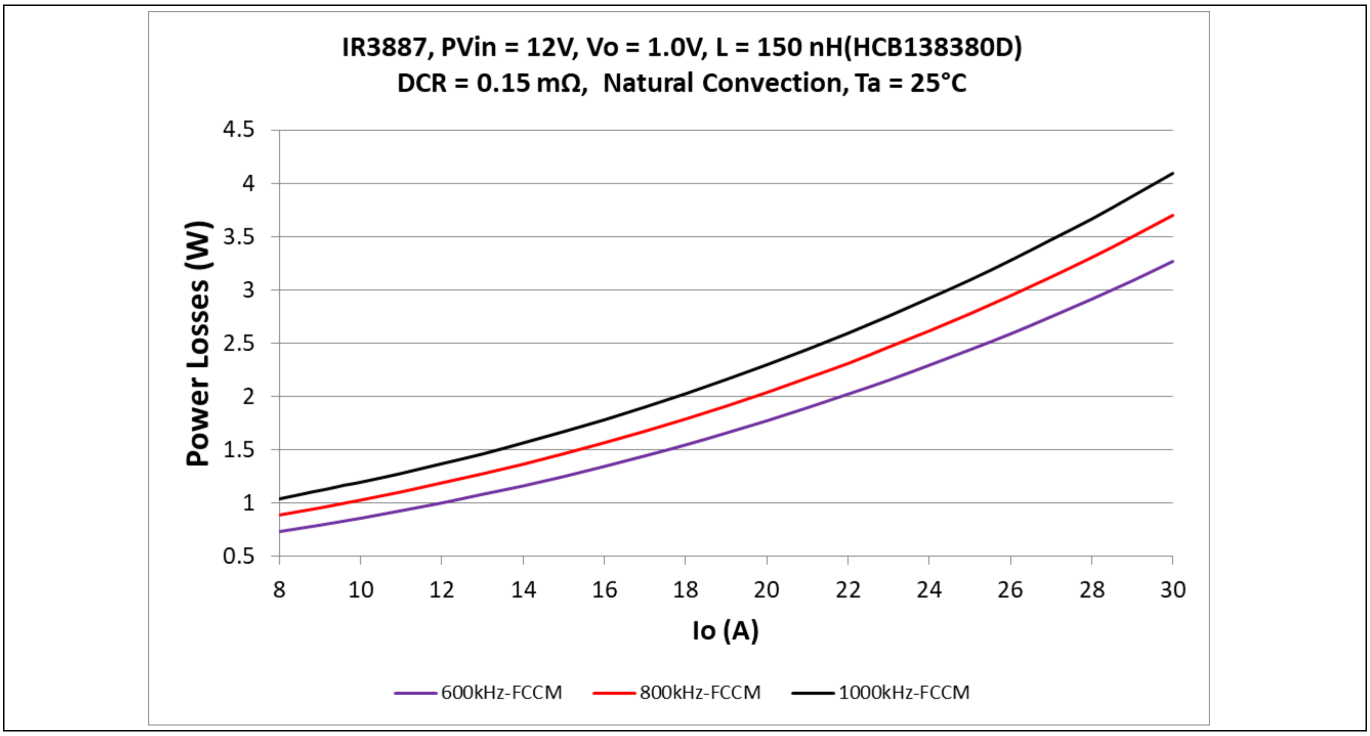

Figure 27 Power loss with natural convection (12 V_{in}, 1 V_{out}, 150 nH, 600 kHz, 800 kHz and 1000 kHz, T_a = 25°C)

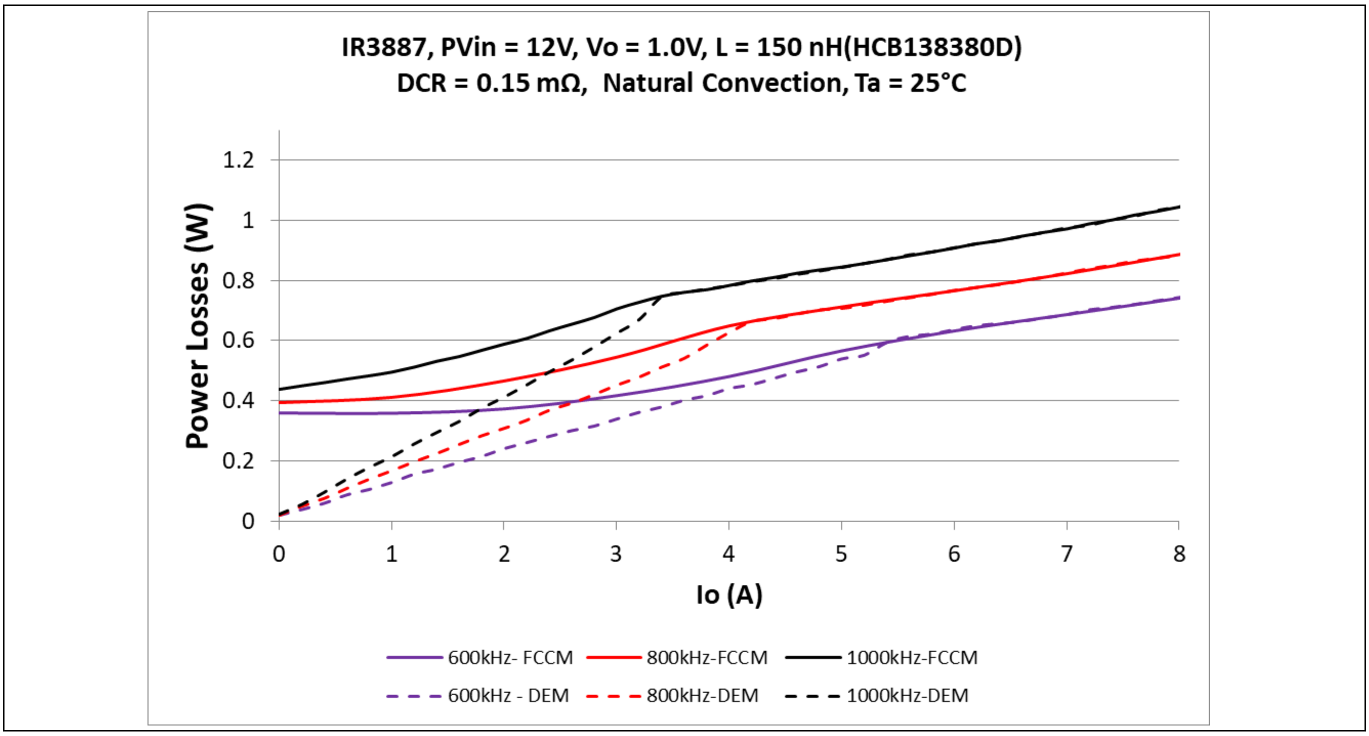

Figure 28 Power loss with natural convection (12 V_{in}, 1 V_{out}, 150 nH, 600 kHz, 800 kHz and 1000 kHz, T_a = 25°C)

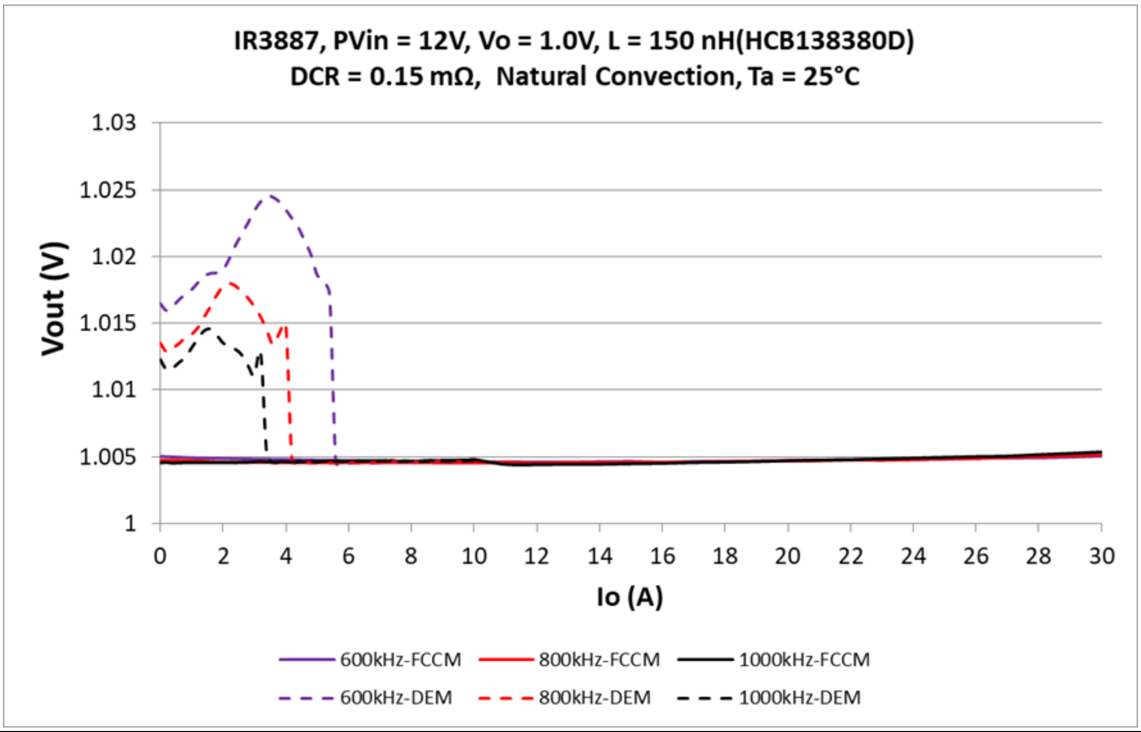

Figure 29 IR3887 V_{out} regulation (12 V_{in}, 1 V_{out}, 150 nH, 600 kHz, 800 kHz and 1000 kHz, T_a = 25°C)

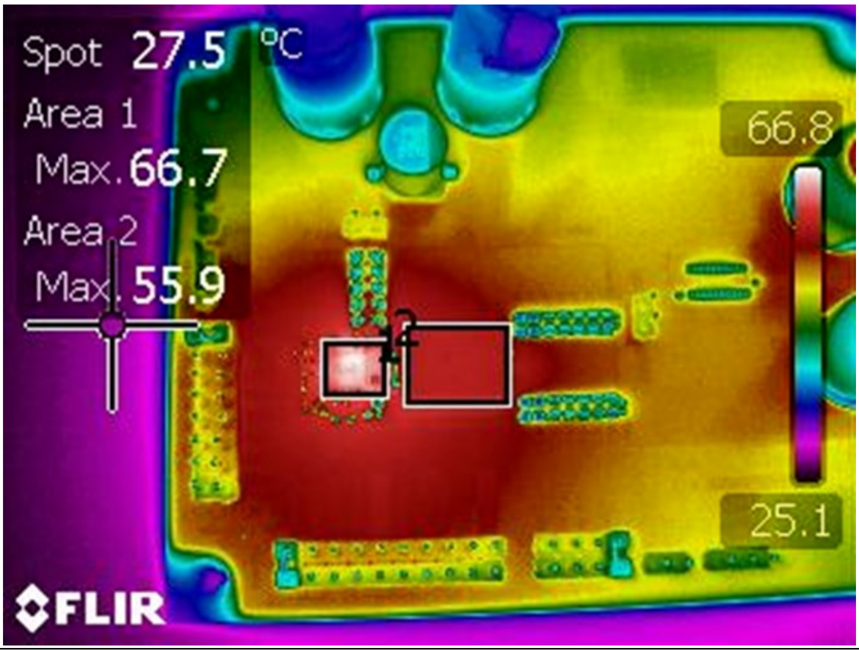

Figure 30 Thermal image at 30 A load IR3887 = 68°C, L = 56°C, fsw = 600 kHz, T_a = 25°C, natural convection

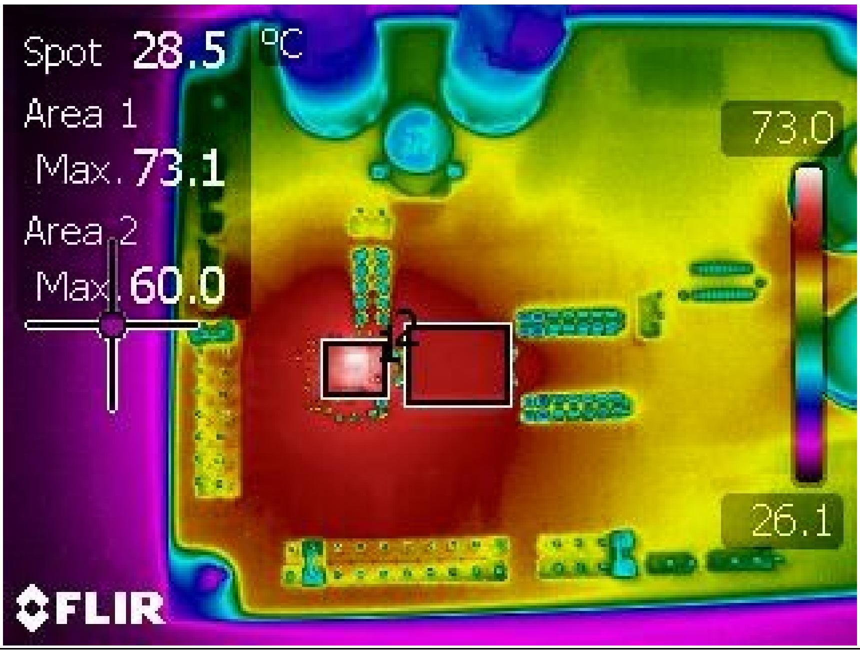

Figure 31 Thermal image at 30 A load IR3887 = 73°C, L = 60°C, fsw = 800 kHz, T_a = 25°C, natural convection

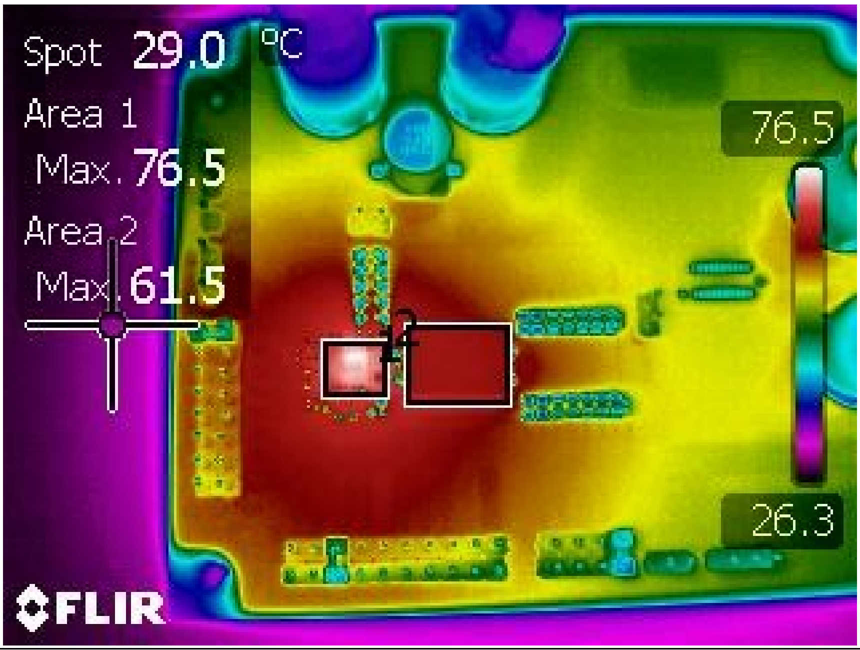

Figure 32 Thermal image at 30 A load IR3887 = 76.5°C, L = 61.5°C, fsw = 1000 kHz, T_a = 25°C, natural convection

Revision history

Document version	Date of release	Description of changes
V 1.0	2020-03-09	Initial release
V 2.0	2022-02-05	Title and subtitle updated

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