User manual for IR3888 evaluation board

25 A single-phase buck regulator with 1.0 V output

About this document

Scope and purpose

The IR3888 is a synchronous buck converter, providing a compact, high-performance and flexible solution in a small 6 mm x 5 mm power QFN package.

Key features offered by the IR3888 include internal digital soft-start, precision 0.6 V reference voltage, Power Good (PGood), thermal protection, programmable switching frequency in the range of 600 kHz to 2 MHz, enable input, input undervoltage lockout (UVLO) for proper start-up, latched off or unlatched overvoltage protection (OVP) and pre-bias start-up.

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 manual contains the schematic and bill of materials for the EVAL_3888_1Vout engineering evaluation board. The manual describes operation and use of the evaluation board itself. Detailed application information for IR3888 is available in the IR3888 data sheet.

Intended audience

This document is intended as a guide for design engineers evaluating IR3888 performance with the engineering EVAL_3888_1Vout demo board.

Table of contents

1 Board information

1.1 Board features

V_{in} = +12 V, V_{out} = +1.0 V at 0 to 25 A

F_s = 600 kHz/800 kHz/1000 kHz

L= 150 nH (9.6 mm x 6.4 mm x 10 mm, DCR = 0.145 mΩ)

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

C_{out} = 10 x 47 µF (6.3 V, ceramic 0805) + 1 x 470 µF (2 V, 6 mΩ, SP-cap)

1.2 Connections and operating instructions

IR3888 demo board requires a single +12 V for the input power and can deliver up to 25 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}	Connect a load (25 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
	GND	Or, an external enable signal can be applied to this pin to over-drive the onboard enable signal
Bode	A	For bode plot measurement
	B	
SS/Latch	OVP latch	Use a jumper to make 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. Four preset switching frequencies are 600 kHz, 800 kHz, 1000 kHz and 1200 kHz. One additional jumper is a placeholder for user-selected switching frequency.
	DEM	
ILIM		Use a jumper to select one of four OCP limits. OCP4 is the highest OCP limit and OCP1 is the lowest OCP limit.
PGood	PGood	Connect a scope probe to this pin to monitor Power Good signal
	GND	GND
	EPGb	External PGood pull-up bias pin. The PGood 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 PGood pull-up bias can be applied to the EPGb pin.
V_{CC}	V_{CC}	The standard demo board is configured to use the internal LDO. Connect a scope probe to this pin to minitor the output of the internal LDO.
	GND	

1.3 Layout

The PCB is a six-layer board (3.75 in. x 3.0 in.) using FR4 material. The top and bottom layers use 1.5 oz. copper and the inner layers use 2 oz. copper. The PCB thickness is 0.062 in. The IR3888 and other major power components are mounted on the top side of the board.

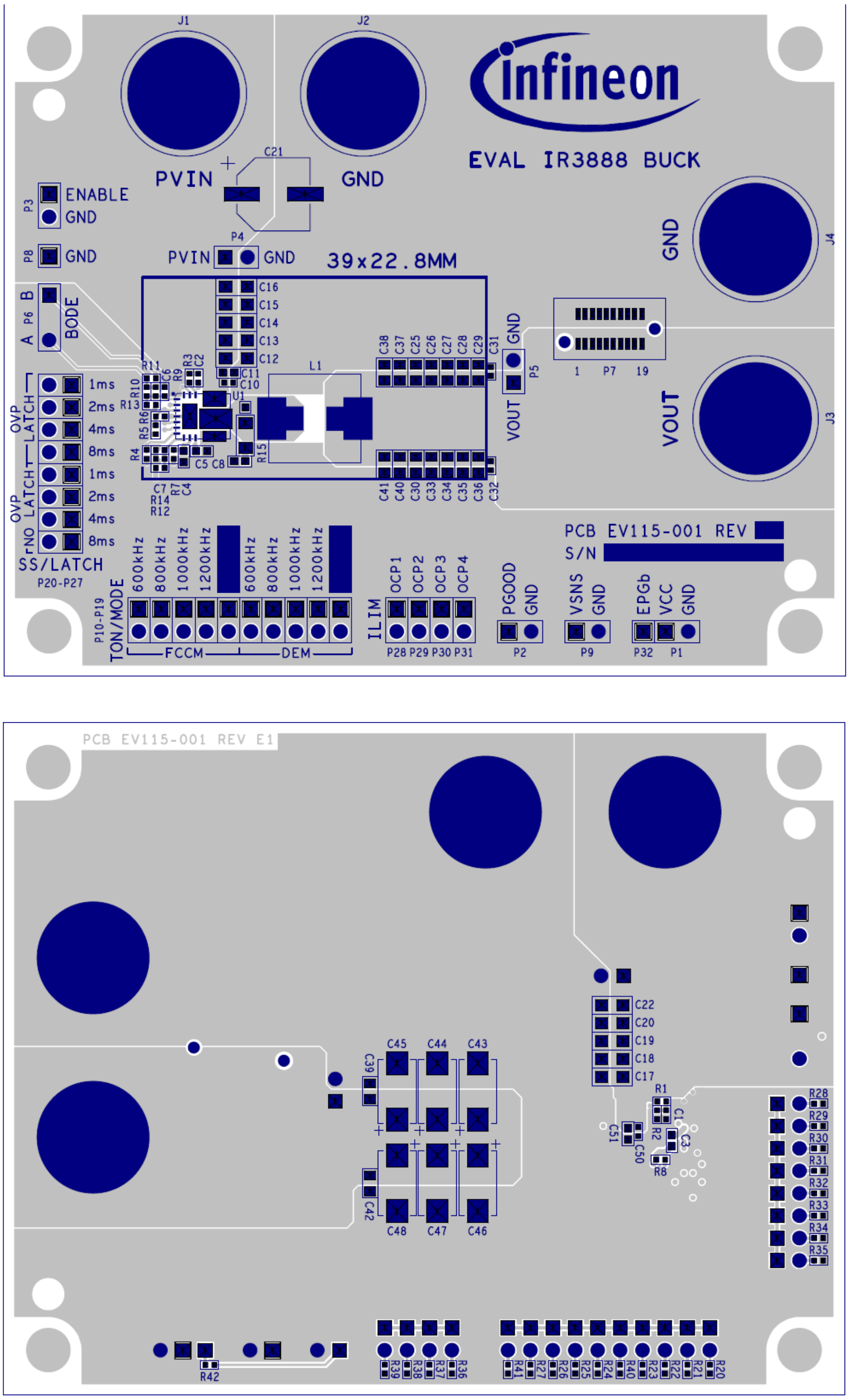


Figure 1 Top and bottom view of IR3888 evaluation board

1.4 PCB layout

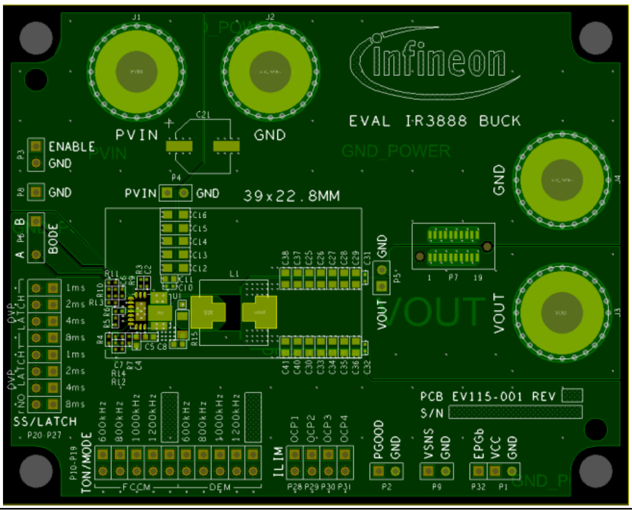


Figure 2 **Top layer**

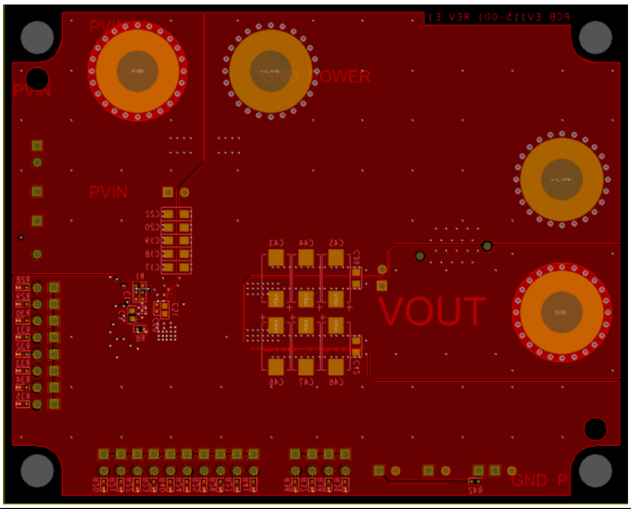


Figure 3 **Bottom layer**

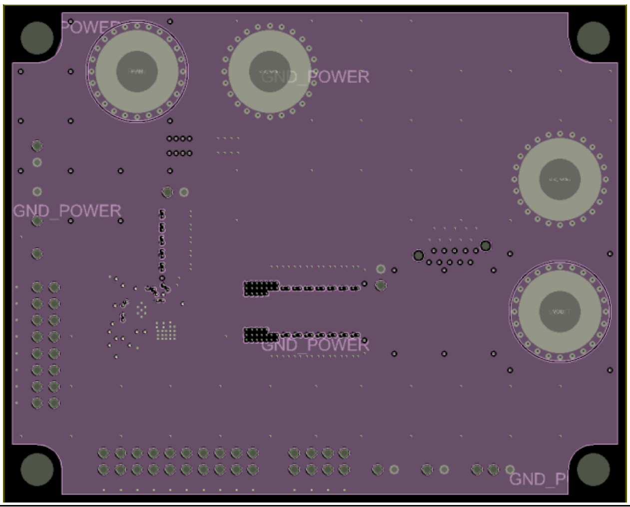


Figure 4 **Mid layer 1**

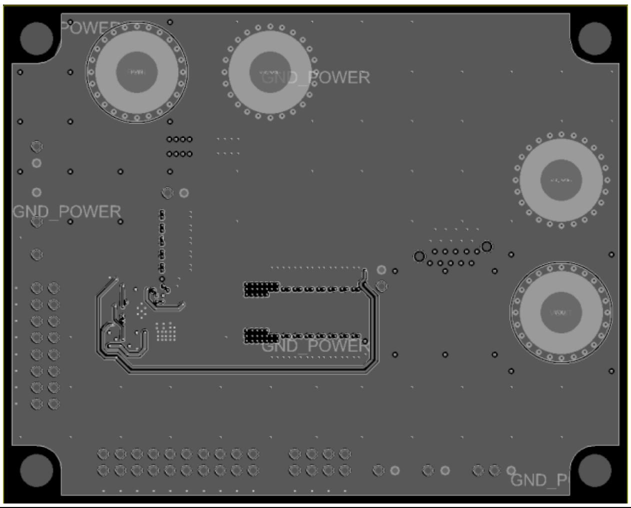


Figure 5 Mid layer 2

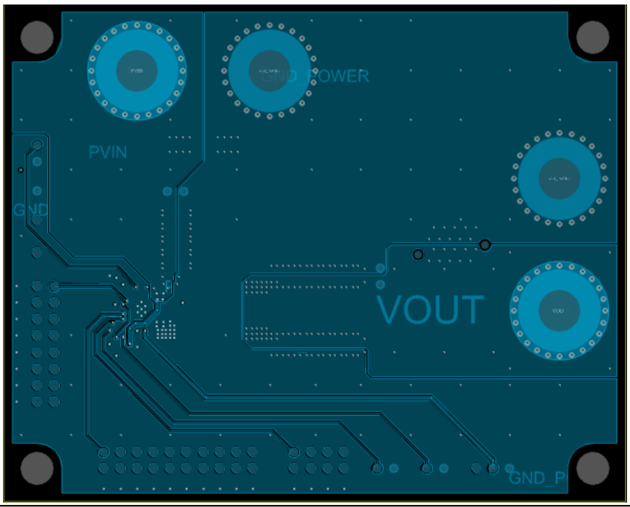


Figure 6 Mid layer 3

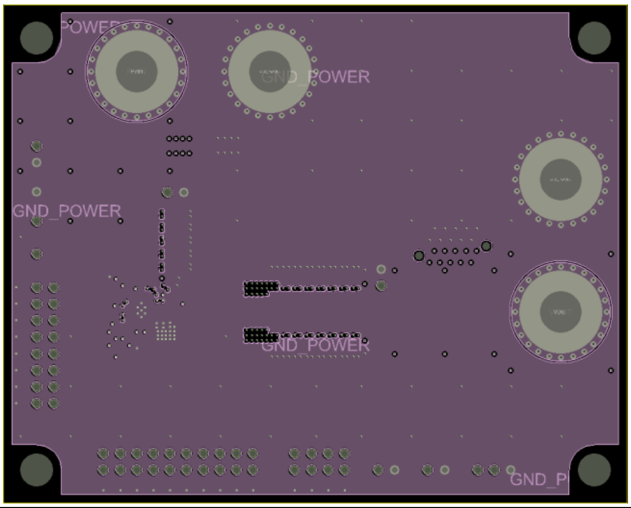


Figure 7 Mid layer 4

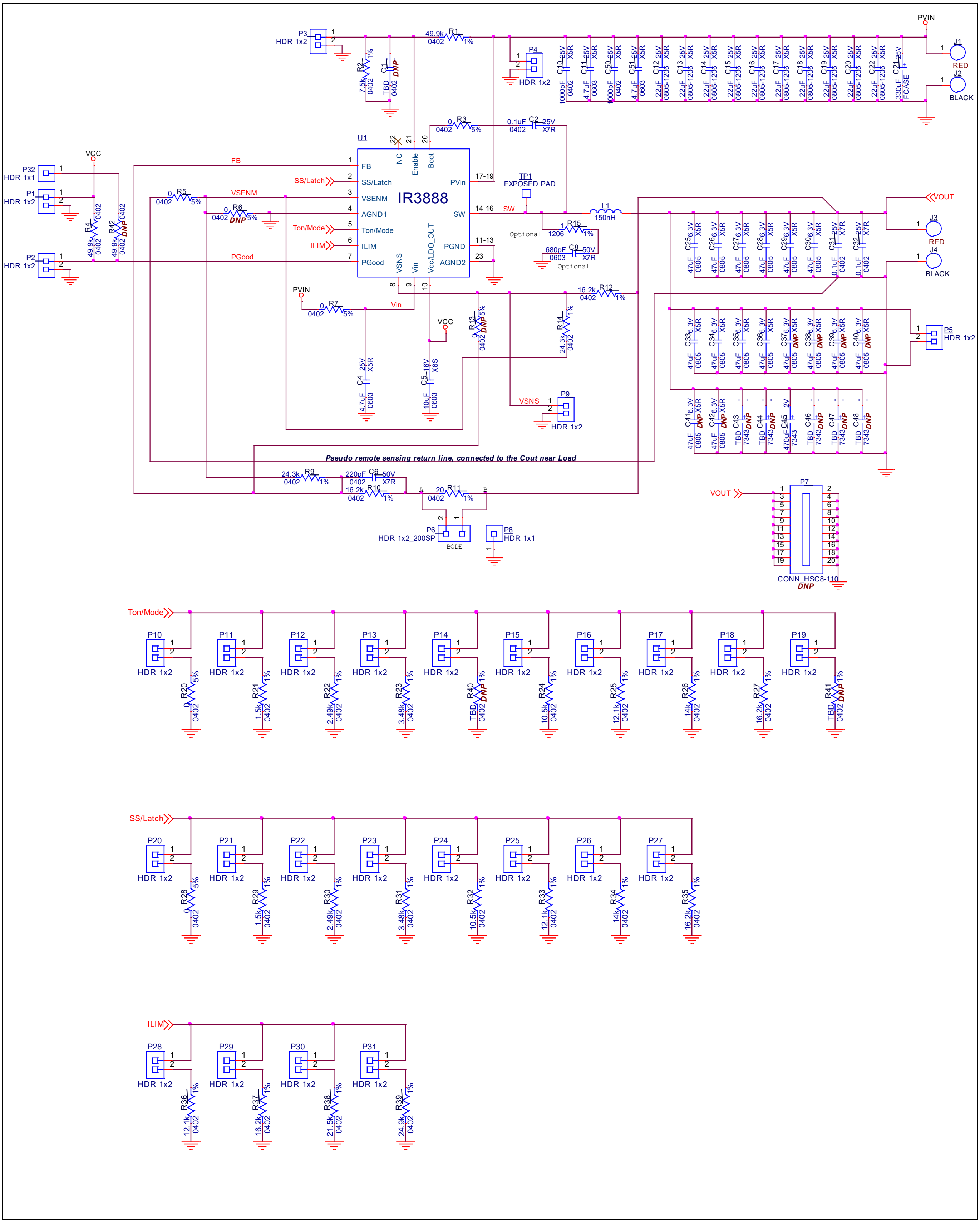


Figure 8 **Schematic of the EVAL_3888_1Vout board V_{in} = 12 V, V_{out} = 1.0 V, I_{outmax} = 25 A**

1.5 Bill of materials

Table 2 BOM

Item	Qty.	Reference	Value	Manufacturer	Part number	Description
1	3	C2, C31, C32	0.1 µF	Murata	GRM155R71E104KE14J	Ceramic capacitor, 0.1 µF, 25 V, 10%, X7R, 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	GRM188C81C106MA73D	Ceramic capacitor, 10 µF, 16 V, X6S, 0603
4	1	C6	220 pF	Murata	GRM155R71H221KA01D	Ceramic capacitor, 220 pF, 50 V, 10%, X7R, 0402
5	1	C8	680 pF	Murata	GRM188R71H681KA01D	Ceramic capacitor, 680 pF, 50 V, X7R, 0603
6	2	C10, C50	1000 pF	Murata	GRM155R61E102KA01D	Ceramic capacitor, 1000 pF, 25 V, 10%, X5R, 0402
7	10	C12, C13, C14, C15, C16, C17, C18, C19, C20, C22	22 µF	Murata	GRM21BR61E226ME44L	Ceramic capacitor, 22 µF, 25 V, 20%, X5R, 0805
8	1	C21	330 µF	Panasonic	PCE3410CT-ND	Aluminum capacitor, 330 µF, 20%, 25 V, SMD
9	10	C25, C26, C27, C28, C29, C36, C30, C33, C34, C35	47 µF	TDK	C2012X5R0J476M125AC	Ceramic capacitor, 47 µF, 6.3 V, 20%, X5R, 0805
10	1	C45	470 µF	Panasonic	EEF-SX0D471XE	Polymer aluminum capacitor, 470 µF, 20%, 2 V, SMD
11	1	L1	150 nH	ITG	AH3740-150k	Inductor, 150 nH, I_{sat} = 60 A, 9.6 mm x 6.4 mm x 10 mm, DCR = 0.145 mΩ, SMD
12	2	R1, R4	49.9 k	Panasonic	ERJ-2RKF4992X	Resistor, 49.9 kΩ, 1/10 W, 1%, 0402, SMD
13	1	R2	7.5 k	Panasonic	ERJ-2RKF7501X	Resistor, 7.50 kΩ, 1/10 W, 1%, 0402, SMD

14	1	R3	0	Panasonic	ERJ-2GE0R00X	Resistor 0.0 Ω, 1/10W, 0402, SMD
15	5	R5, R7, R20, R28, R36	0	Panasonic	ERJ-2GE0R00X	Resistor, 0.0 Ω, 1/10 W, 0402, SMD
16	2	R27, R35	16.2 k	Panasonic	ERJ-2RKF1622X	Resistor, 16.2 kΩ, 1/10 W, 1%, 0402, SMD
17	2	R9, R14	24.3 k	Panasonic	ERJ-2RKF2432X	Resistor, 24.3 kΩ, 1%, 1/10 W, 0402, SMD
18	2	R10, R12	16.4 k	Panasonic	ERJ-2RKF1622X	Resistor, 16.2 kΩ, 1/10 W, 1%, 0402, SMD
19	1	R11	20	Vishay Dale	CRCW040220R0FKED	Resistor, 20.0 Ω, 1/16 W, 1%, 0402, SMD
20	1	R15	1	Susumu	RL1632R-1R00-F	Resistor, 1 Ω, 1%, 1/2 W, 1206, SMD
21	3	R21, R29, R37	1.5 k	Panasonic	ERJ-2GEJ152X	Resistor, 1.5 kΩ, 5%, 1/10 W, 0402, SMD
22	3	R22, R30, R38	2.49 k	Vishay Dale	CRCW04022K49FKED	Resistor, 2.49 kΩ, 1/16 W, 1%, 0402, SMD
23	2	R23, R31	3.48 k	Vishay Dale	CRCW04023K48FKED	Resistor, 3.48 kΩ, 1/16 W, 1%, 0402, SMD
24	2	R24, R32	10.5 k	Panasonic	ERJ-2RKF1052X	Resistor, 10.5 kΩ, 1/10 W, 1%, 0402, SMD
25	2	R25,R33	12.1 k	Panasonic	ERJ-2RKF1212X	Resistor, 12.1 kΩ, 1/10 W, 1%, 0402, SMD
26	2	R26, R34	14 k	Panasonic	ERJ-2RKF1402X	Resistor, 14.0 kΩ, 1/10 W, 1%, 0402, SMD
27	1	U1	IR3888	Infineon	IR3888	25 A single input voltage, synchronous buck regulator

2 Typical operating waveforms

V_{in} = 12.0 V, V_{out} = 1.0 V, I_{out} = 0 to 25 A, room temperature, no airflow

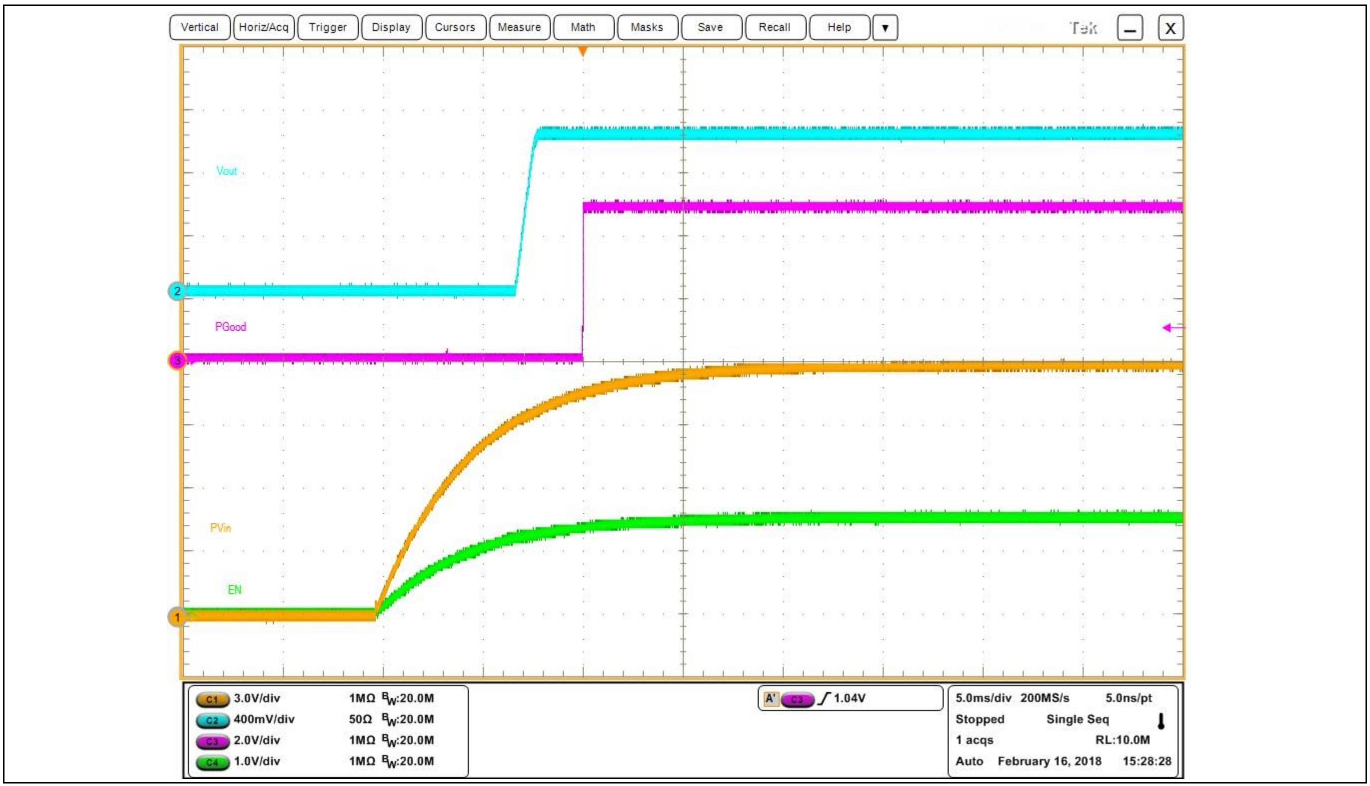


Figure 9 Start-up at 25 A load (Ch₁: PV$_{in}$, Ch₂: V$_{out}$, Ch₃: P$_{Good}$, Ch₄: enable)

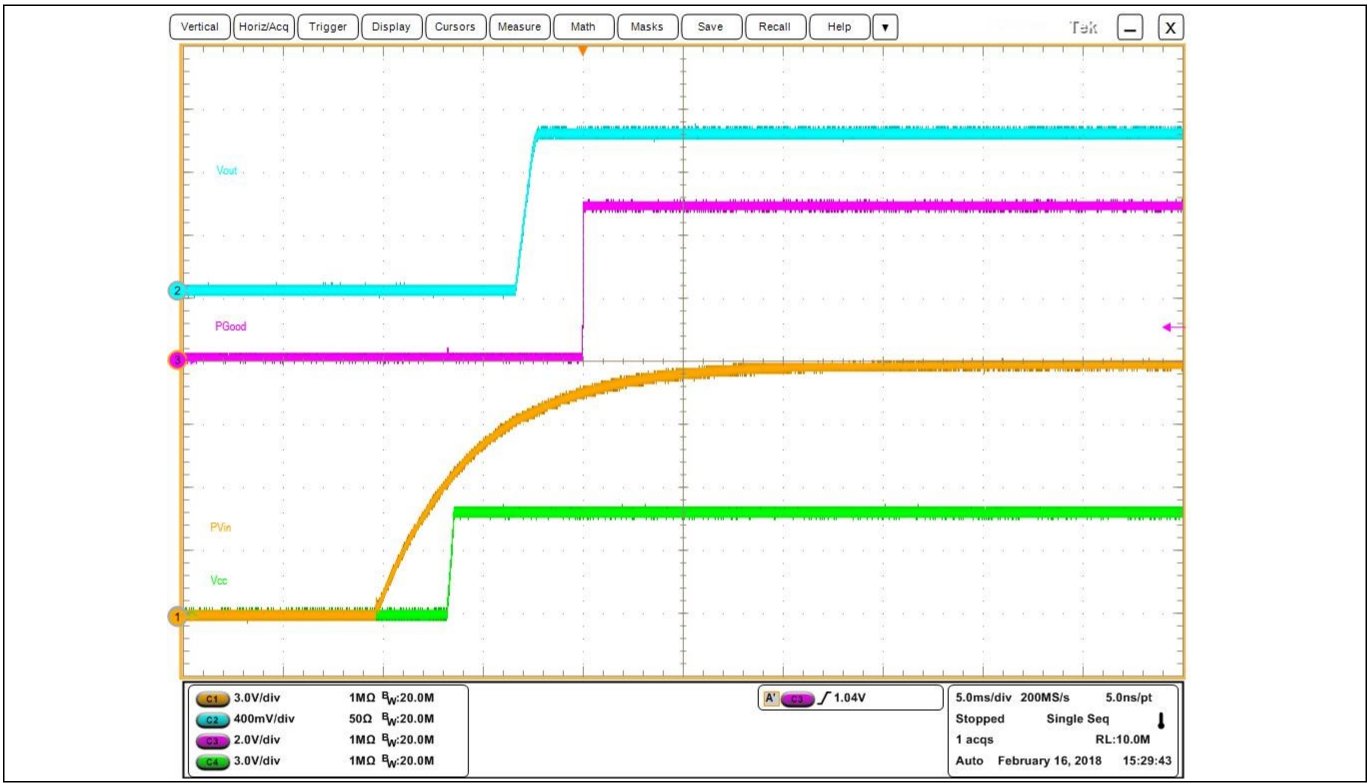


Figure 10 Start-up at 25 A load (Ch_1: PV_{in}, Ch_2: V_{out}, Ch_3: P_{Good}, Ch_4: V_{CC})

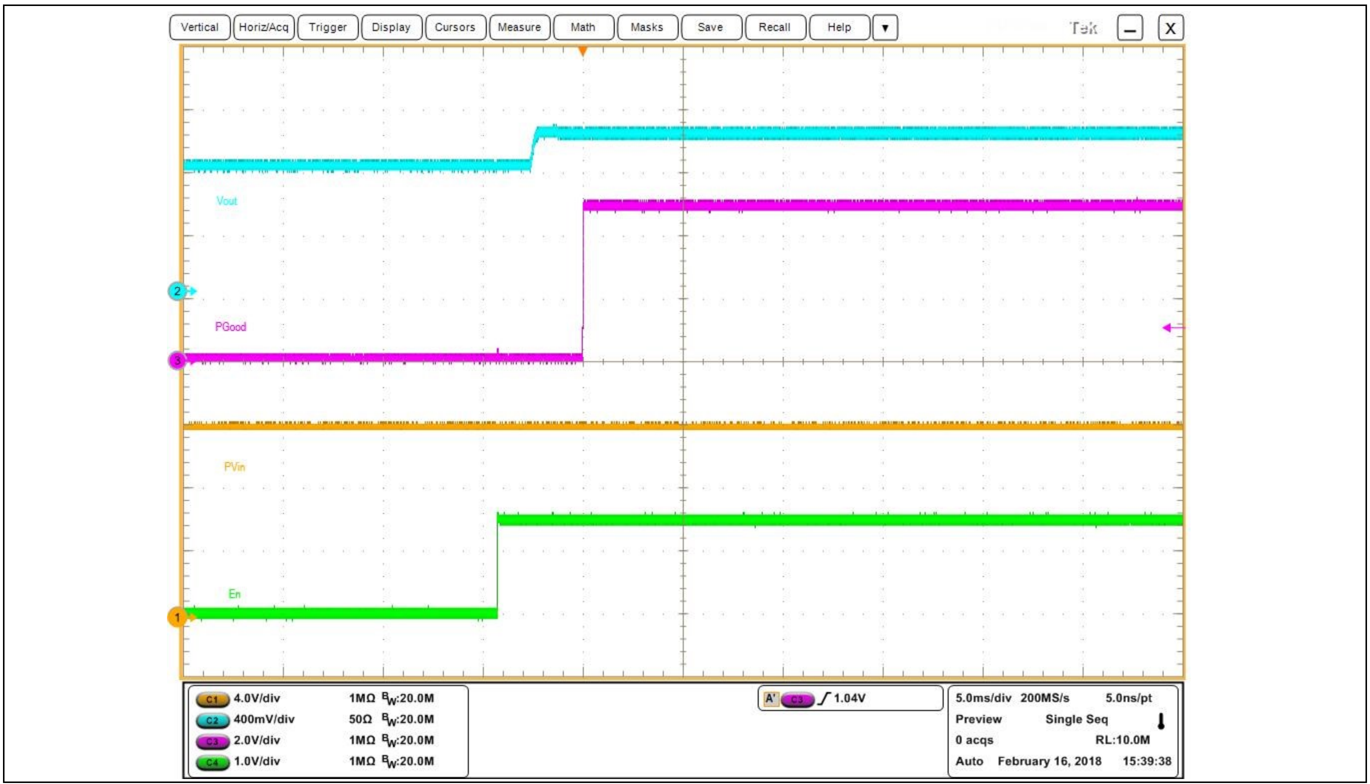
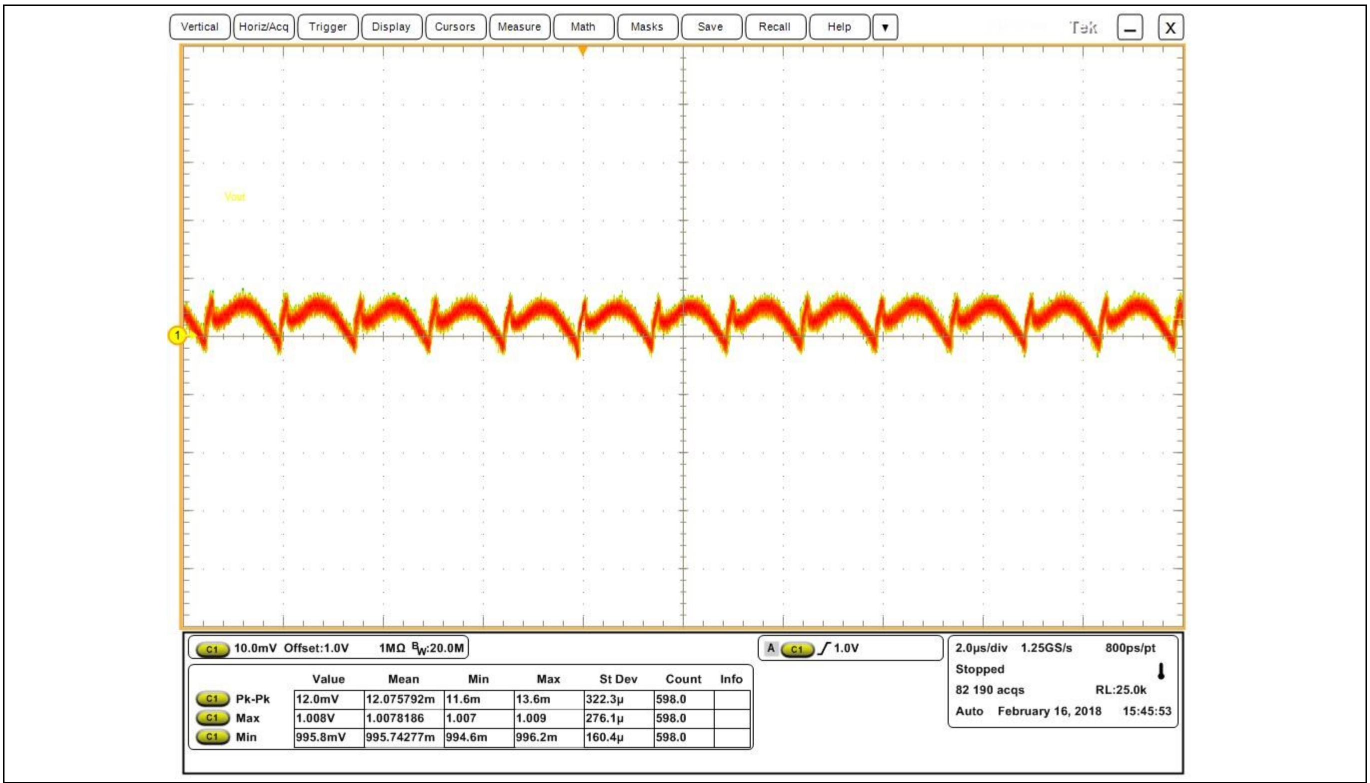


Figure 11 Pre-bias start-up at 0 A load (Ch_1: PV_{in}, Ch_2: V_{out}, Ch_3: P_{Good}, Ch_4: enable)



	Value	Mean	Min	Max	St Dev	Count	Info
C1 Pk-Pk	12.0mV	12.075792m	11.6m	13.6m	322.3µ	598.0	
C1 Max	1.008V	1.0078186	1.007	1.009	276.1µ	598.0	
C1 Min	995.8mV	995.74277m	994.6m	996.2m	160.4µ	598.0	

Figure 12 V_{out} ripple at 25 A load, f_{sw} = 600 kHz (Ch_1: V_{out})

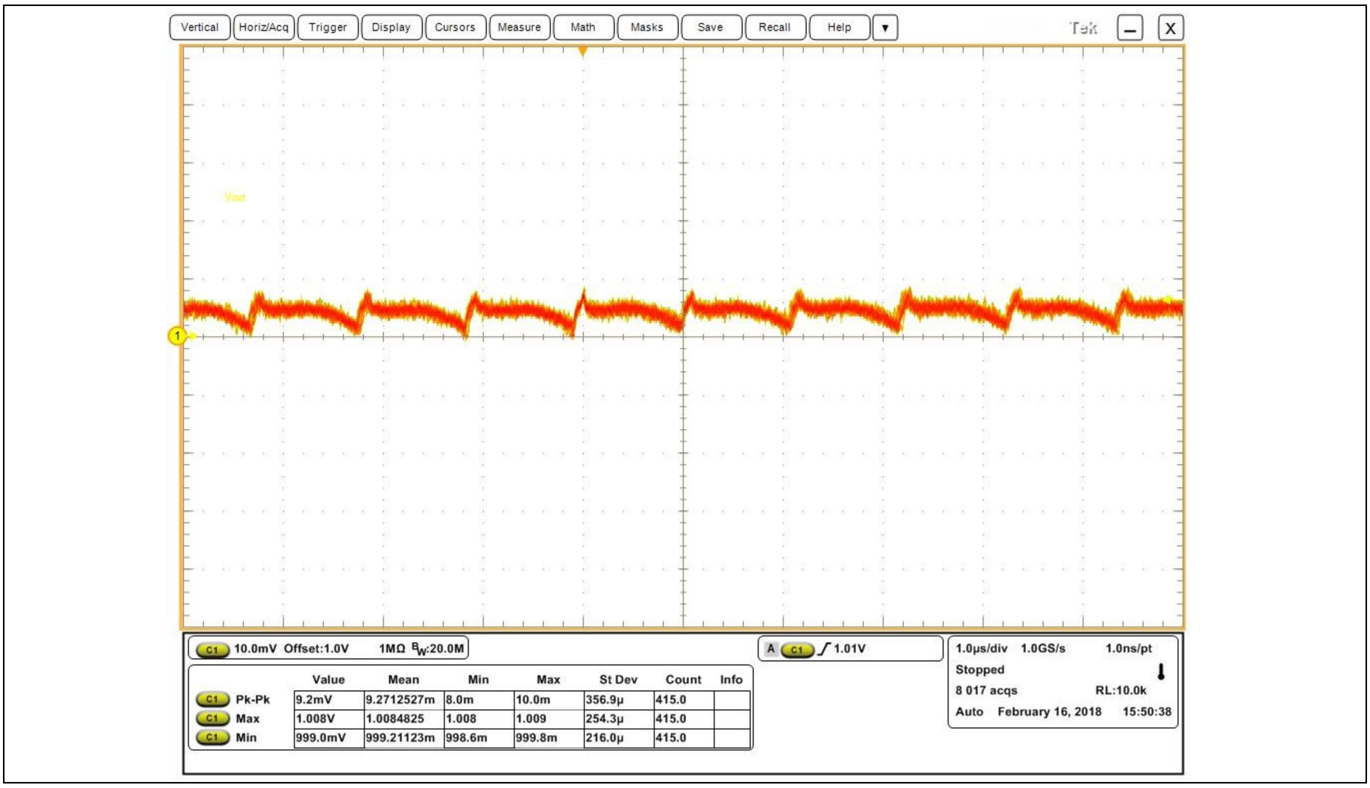


Figure 13 V_{out} ripple at 25 A load, f_{sw} = 800 kHz (Ch_1: V_{out})

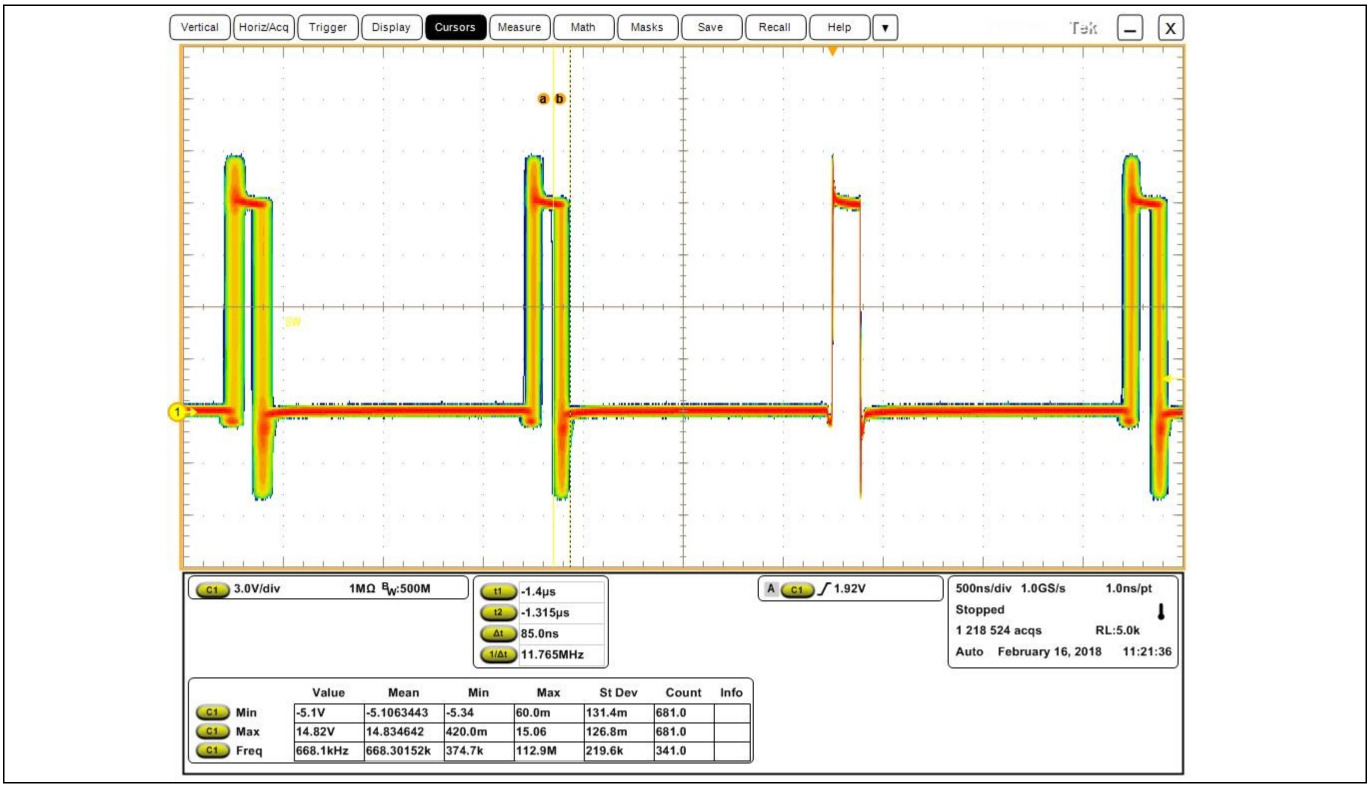


Figure 14 SW node, 25 A load, f_{sw} = 600 kHz

Typical operating waveforms

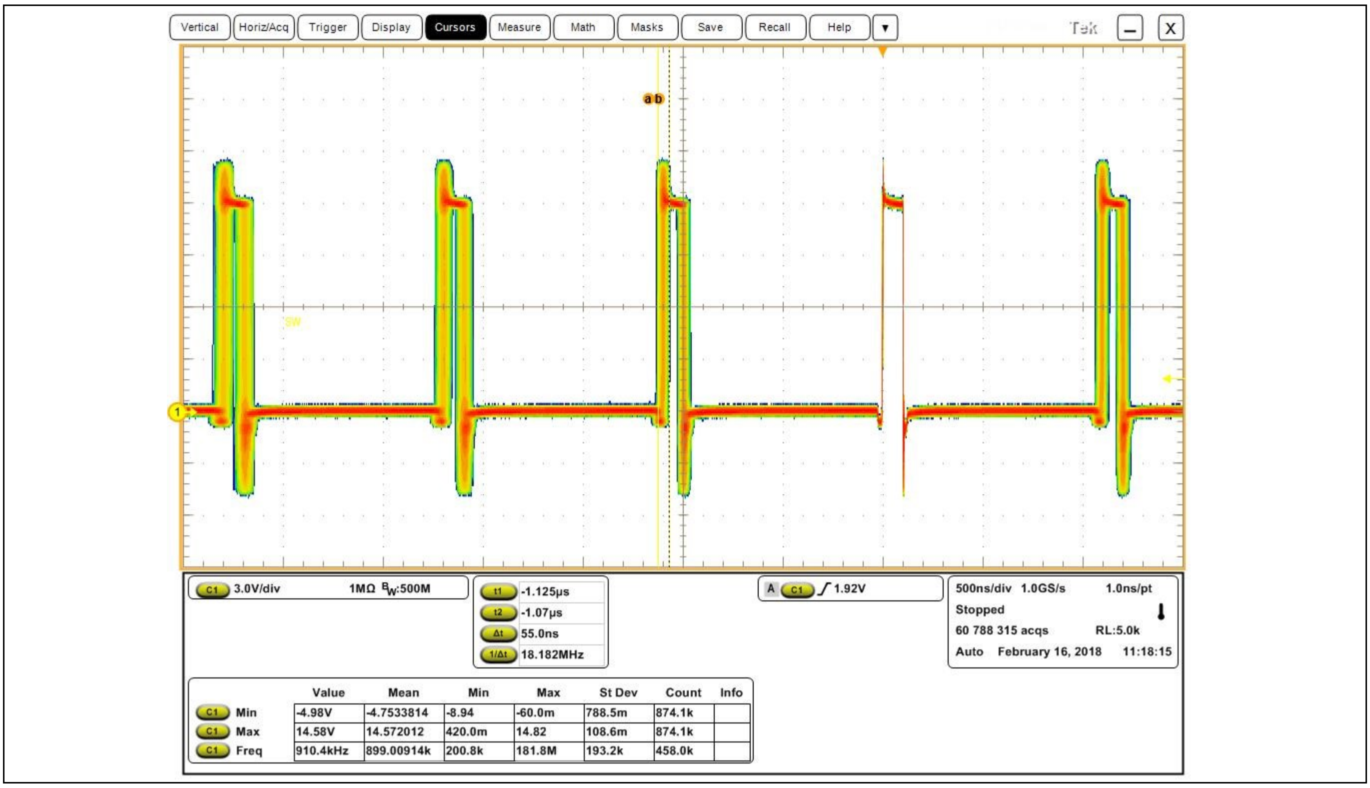


Figure 15 SW node, 25 A load, f_{sw} = 800 kHz

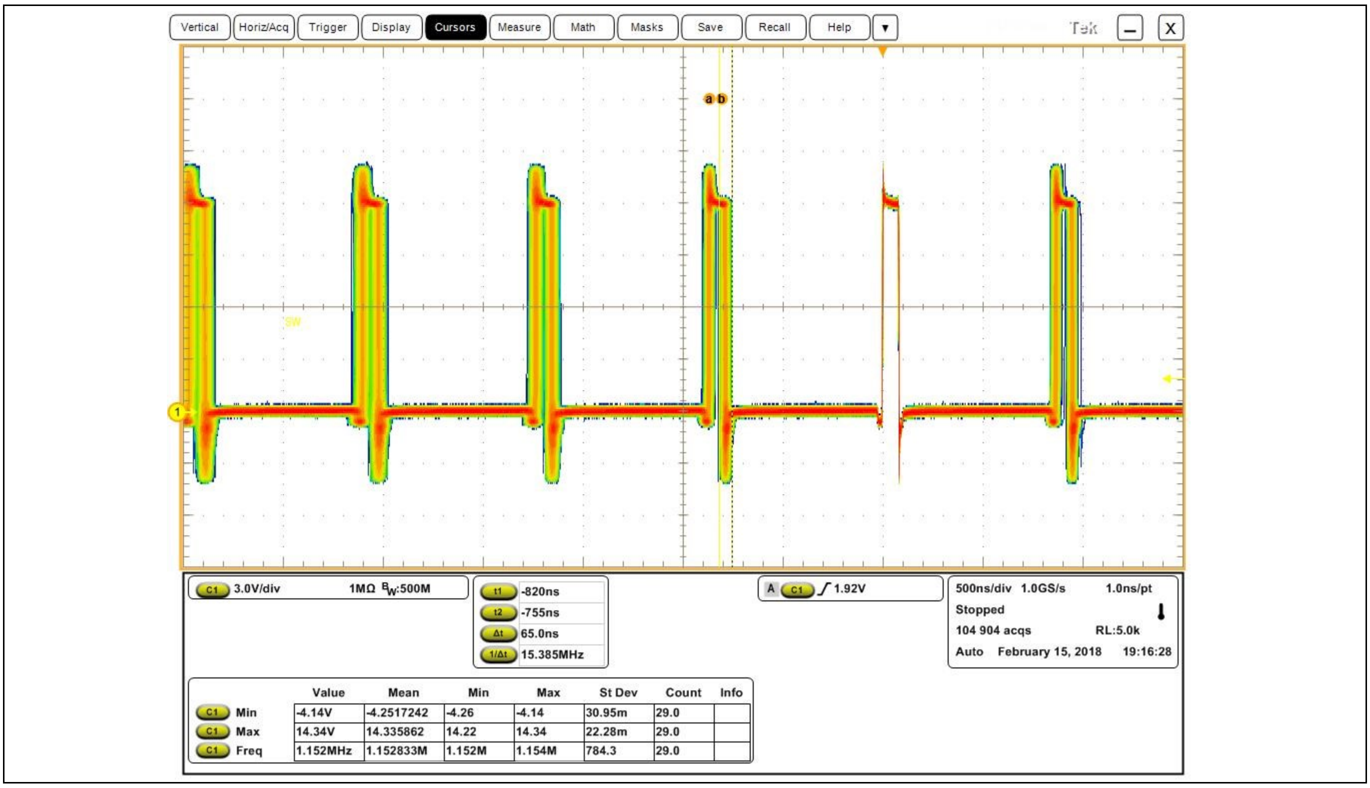


Figure 16 SW node, 25 A load, f_{sw} = 1000 kHz

Typical operating waveforms

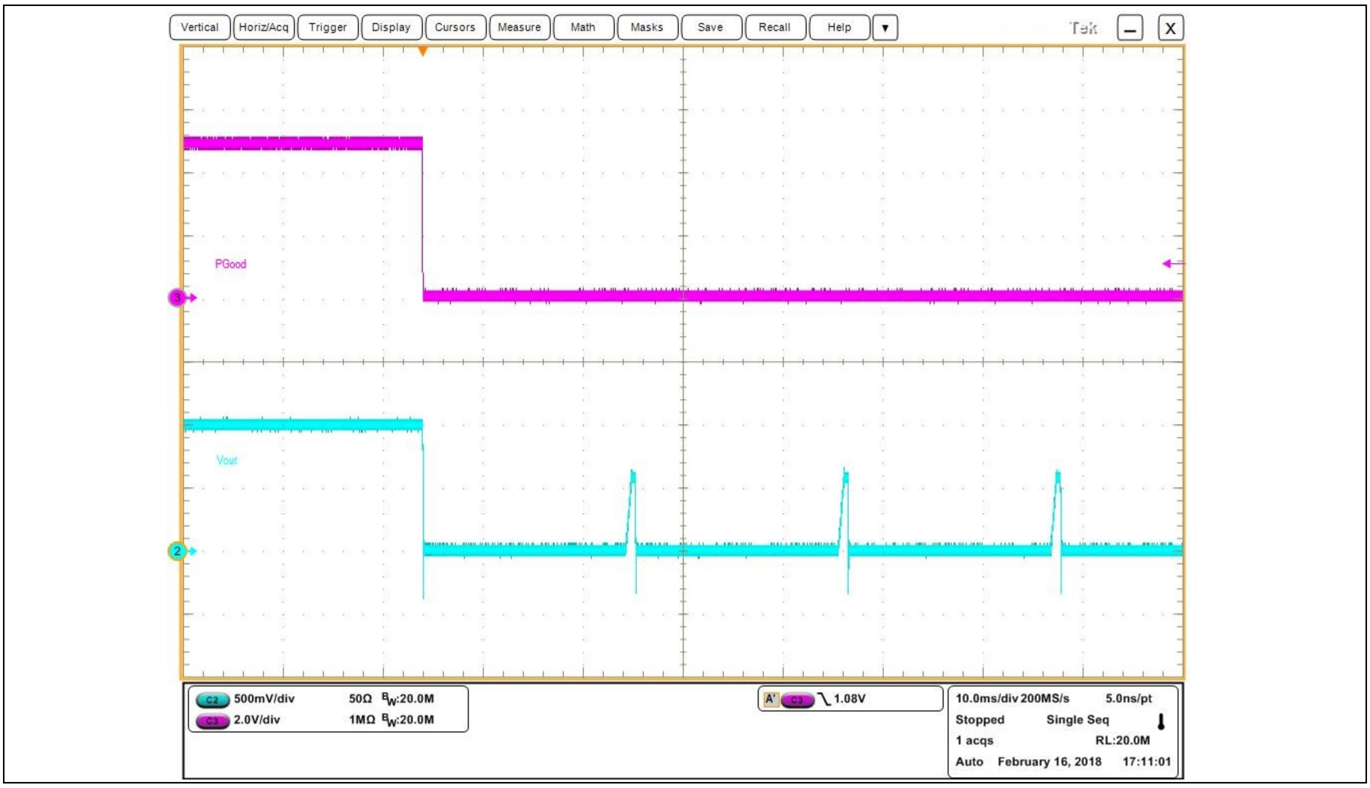


Figure 17 **Short-circuit and UVP (hiccup), (Ch_2: V_{out}, Ch_3: P_{Good})**

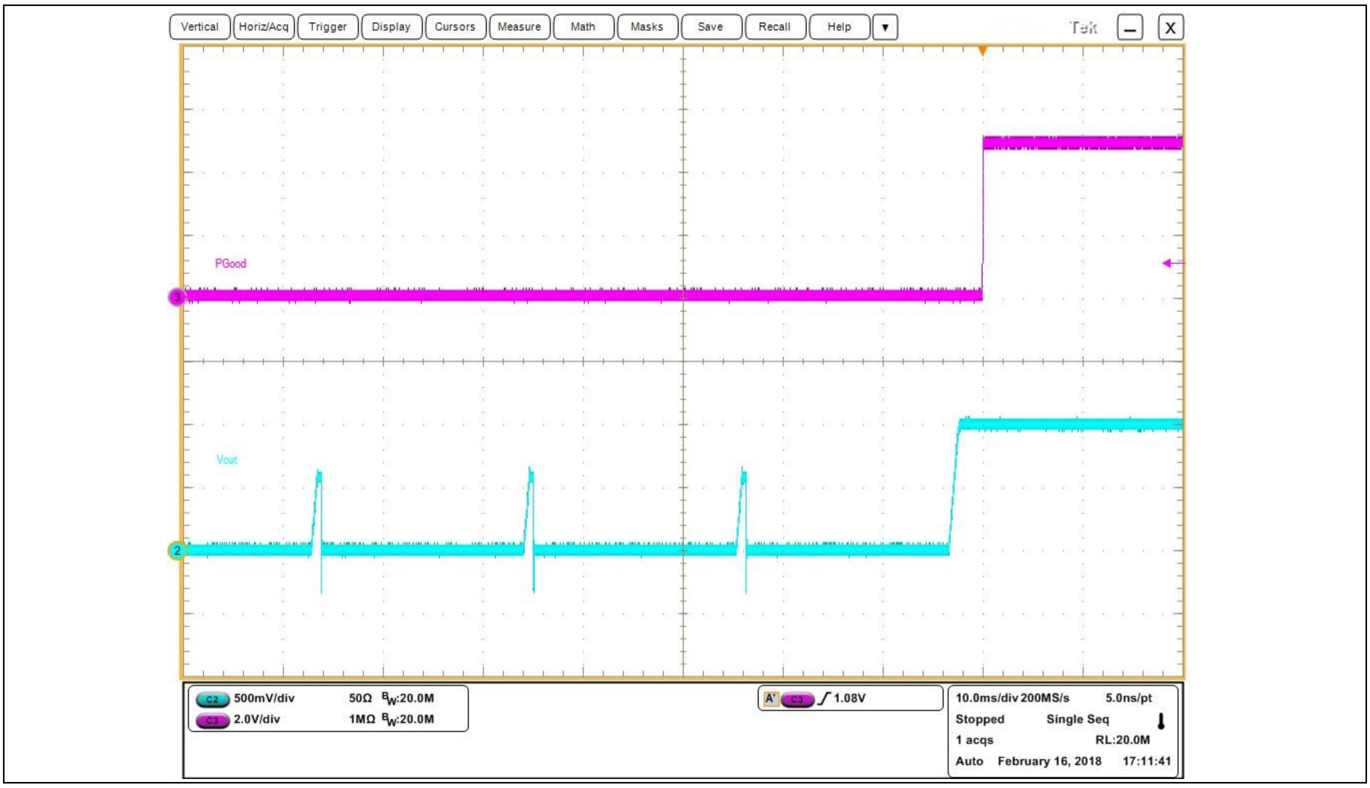


Figure 18 **Short-circuit and UVP (hiccup) recover (Ch_2: V_{out}, Ch_3: P_{Good})**

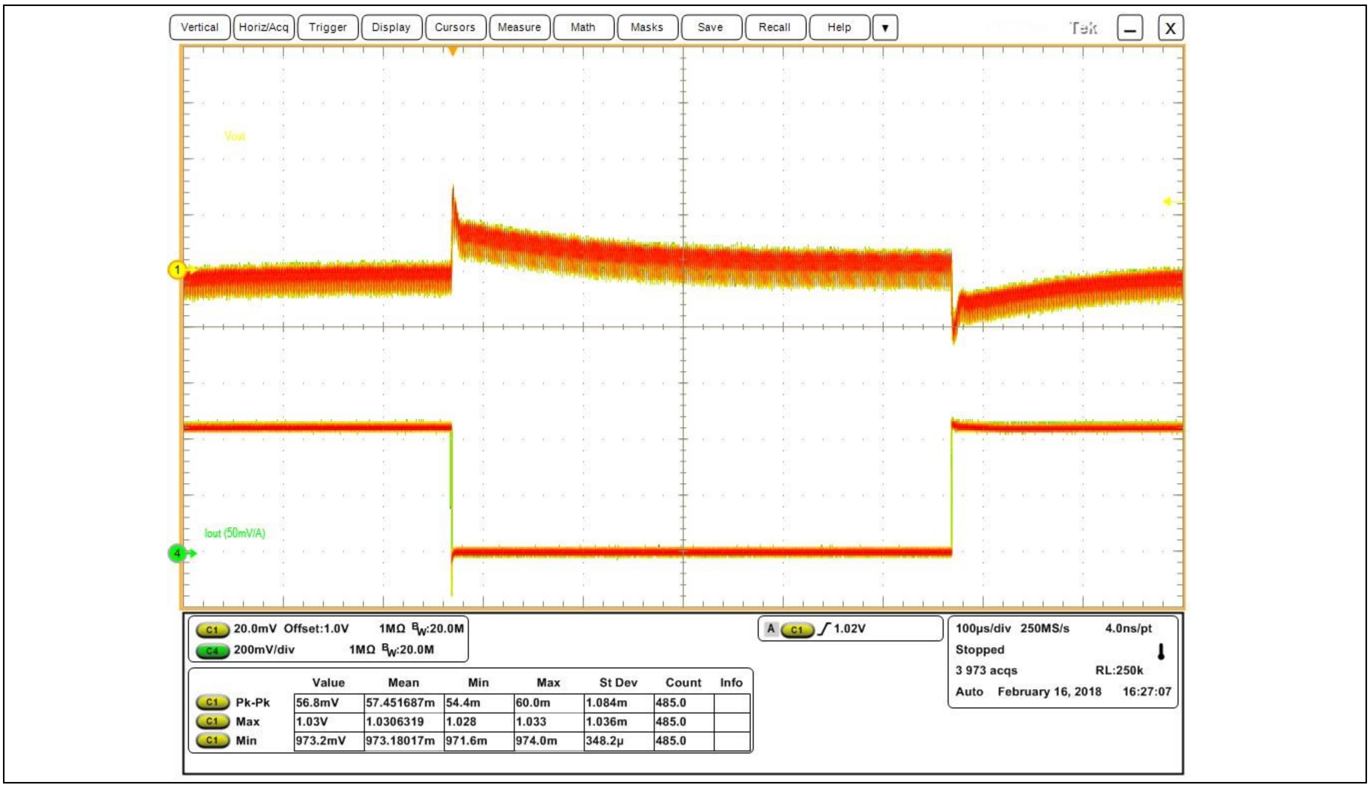


Figure 19 **Transient response at 9 A step-load current at 30 A/µs slew rate: I_{out} = 0 A to 9 A (Ch_1: V_{out}, Ch_4: I_{out}) pk-pk: 60 mV, f_{sw} = 600 kHz**

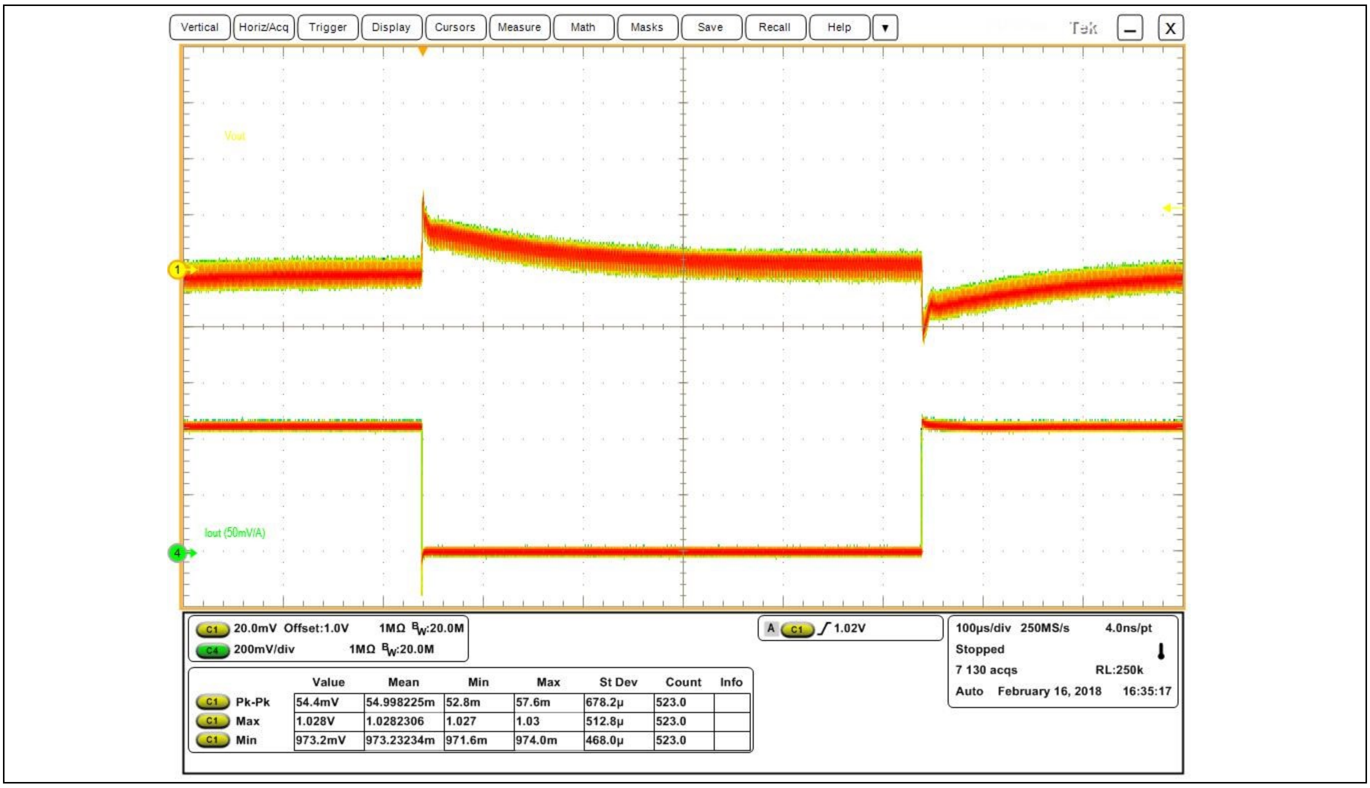


Figure 20 **Transient response at 9 A step-load current at 30 A/µs slew rate: I_{out} = 0 A to 9 A (Ch_1: V_{out}, Ch_4: I_{out}), pk-pk: 57.6 mV, f_{sw} = 800 kHz**

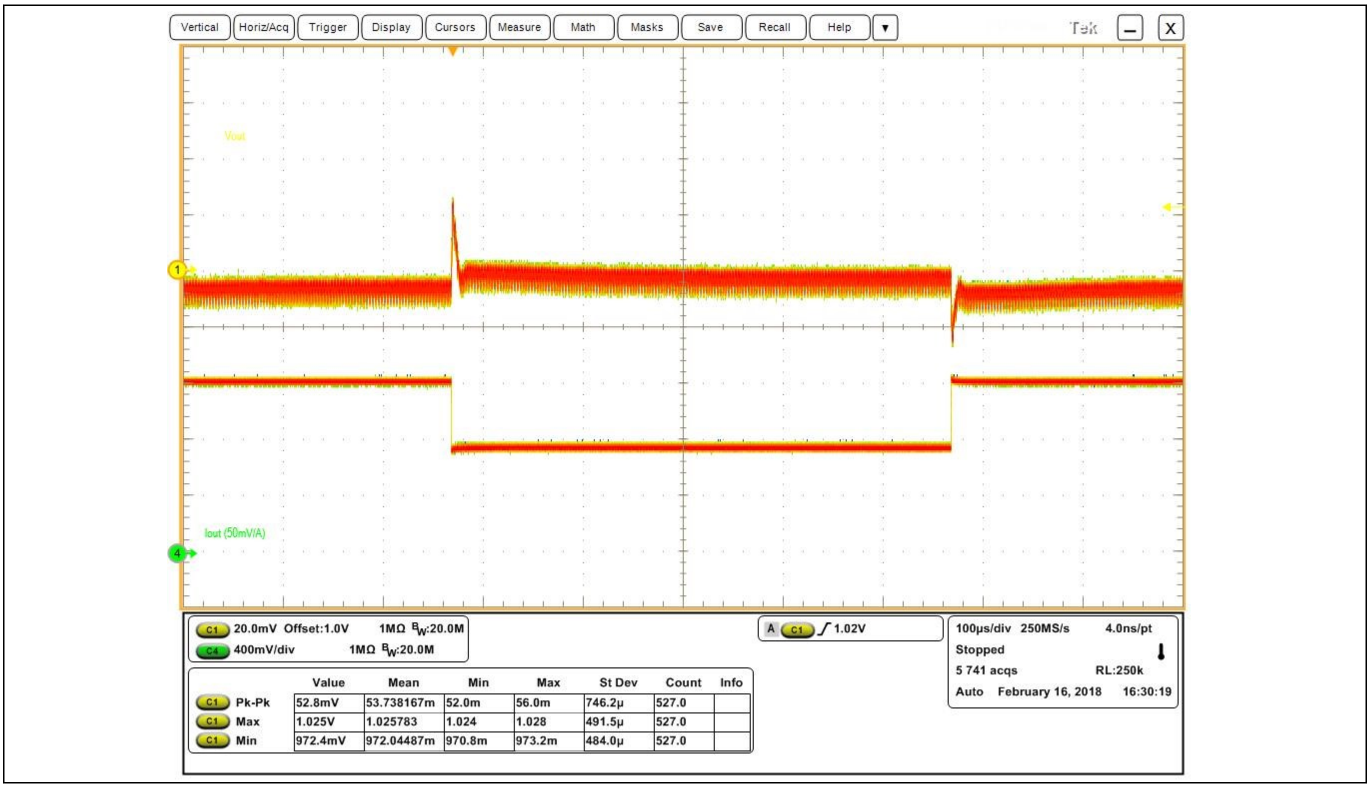


Figure 21 Transient response at 9 A step-load current at 30 A/µs slew rate: I_{out} = 16 A to 25 A (Ch_1: V_{out}, Ch_4: I_{out}) pk-pk: 56 mV, f_{sw} = 600 kHz

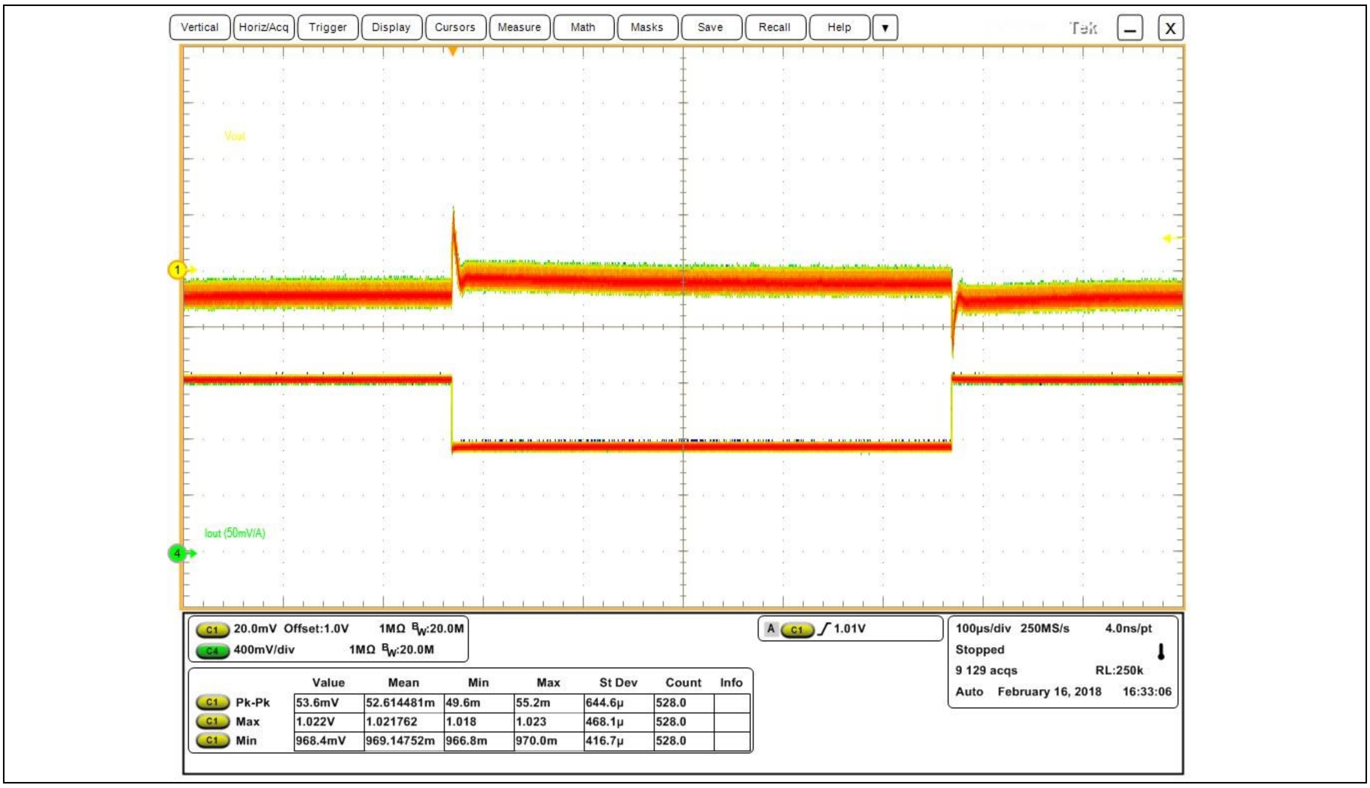


Figure 22 Transient response at 9 A step-load current at 30 A/µs slew rate: I_{out} = 16 A to 25 A (Ch_1: V_{out}, Ch_4: I_{out}) pk-pk: 55.2 mV, f_{sw} = 800 kHz

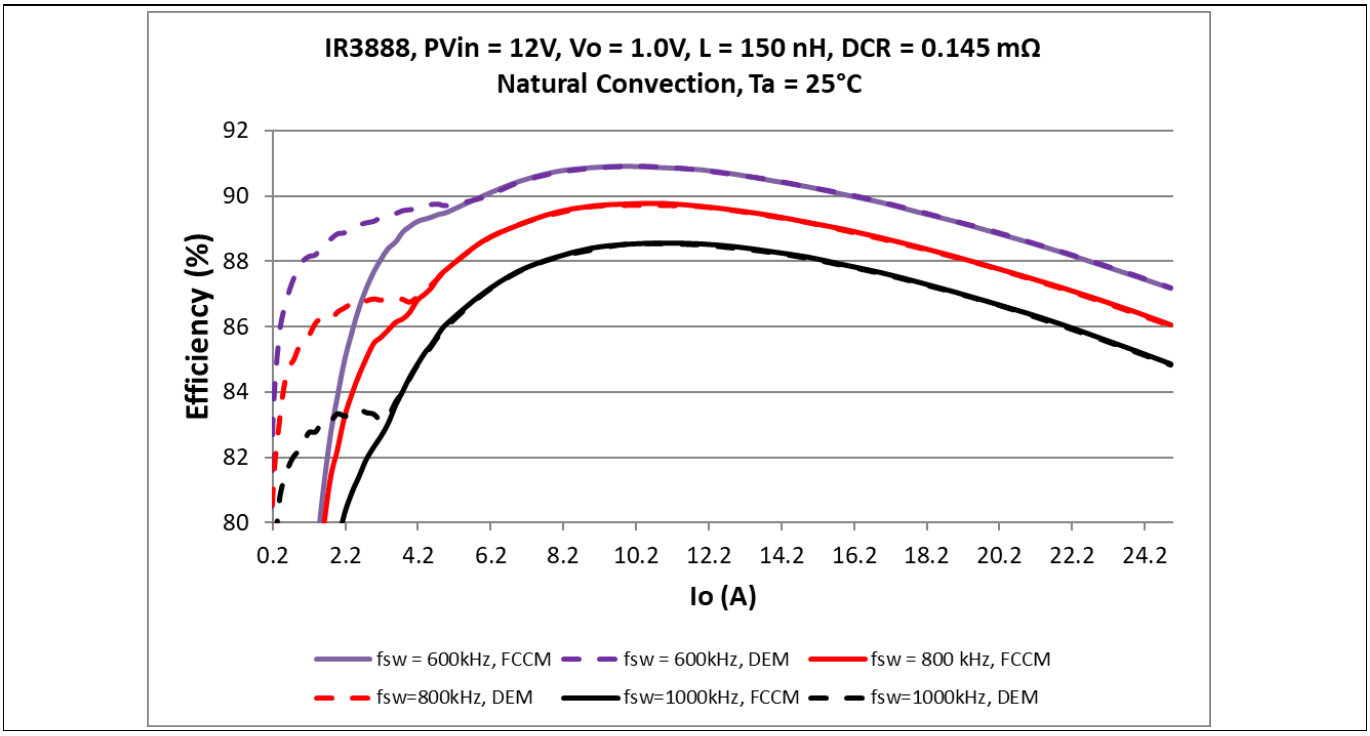


Figure 23 Efficiency vs. load current natural convection (12 V_{in}, 1 V_{out}, 150 nH, 600 kHz/800 kHz/1000 kHz, T_a = 25°C, FCCM: solid line, DEM: dashed line)

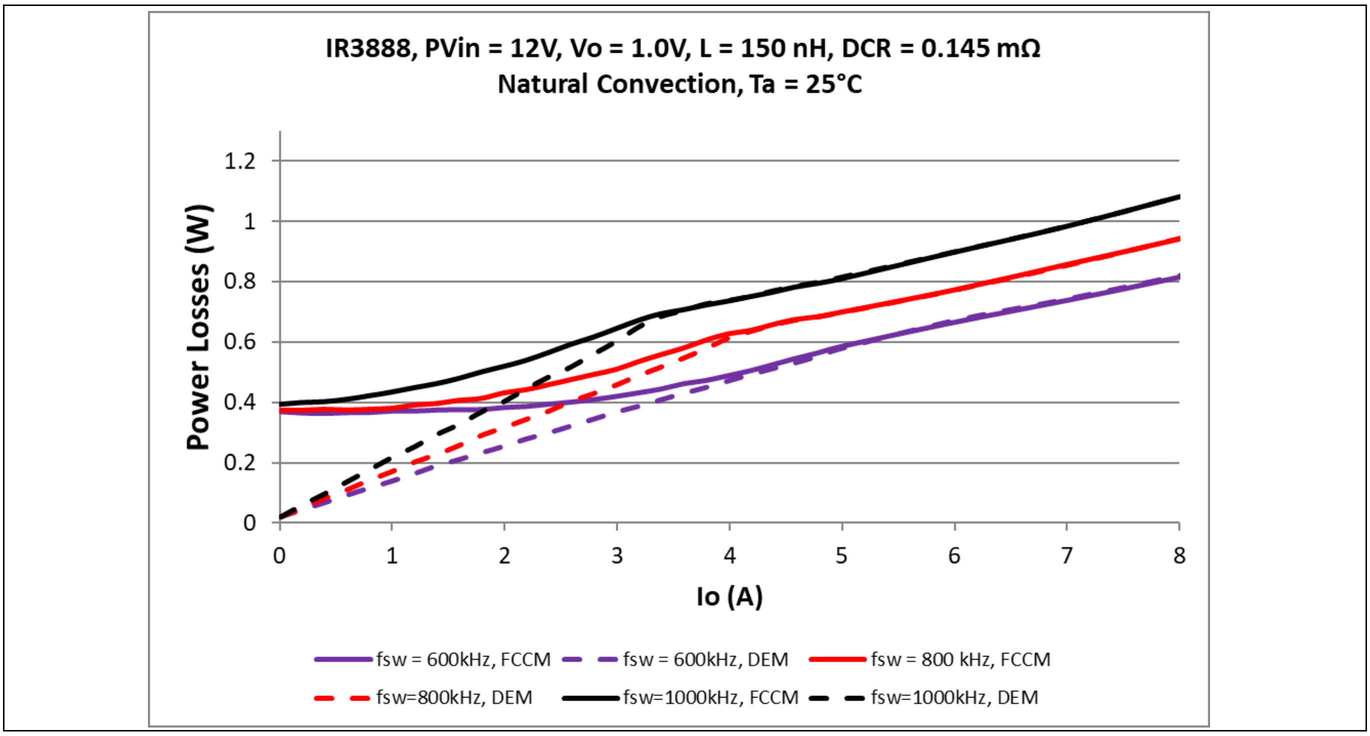


Figure 24 Power loss vs. load current natural convection (12 V_{in}, 1.0 V_{out}, 150 nH, 600 kHz/800 kHz/1000 kHz, T_a = 25°C, FCCM: solid line, DEM: dashed line)

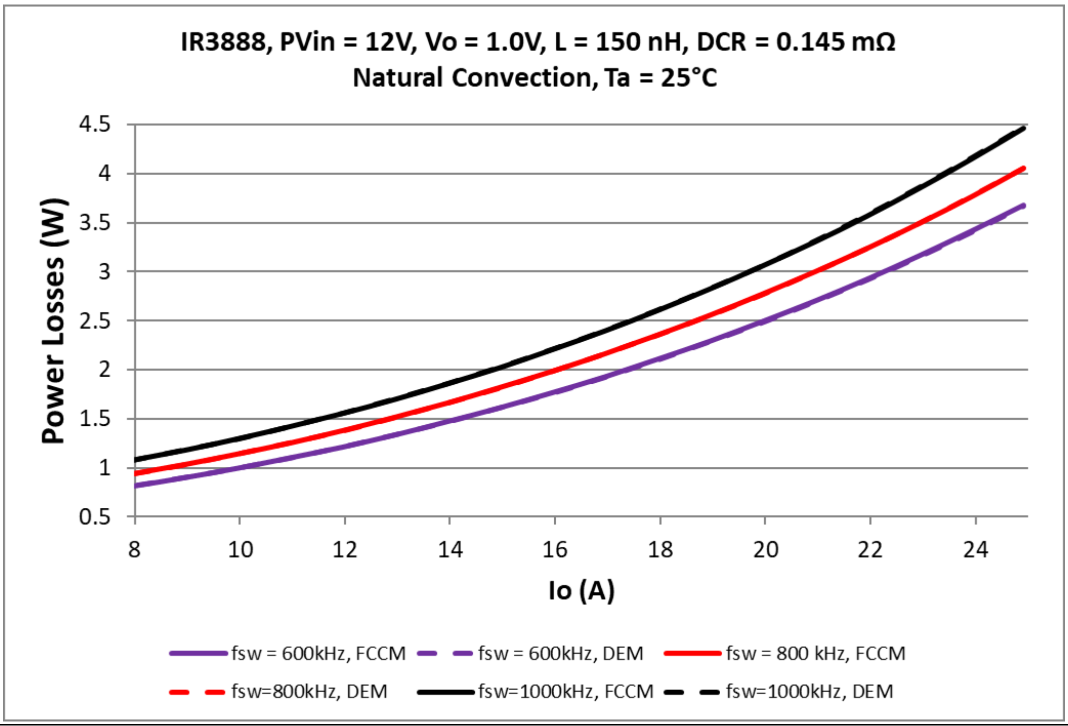


Figure 25 **Power loss vs. load current natural convection (12 V_{in}, 1.0 V_{out}, 150 nH, 600 kHz/800 kHz/1000 kHz, T_a = 25°C, FCCM: solid line, DEM: dashed line)**

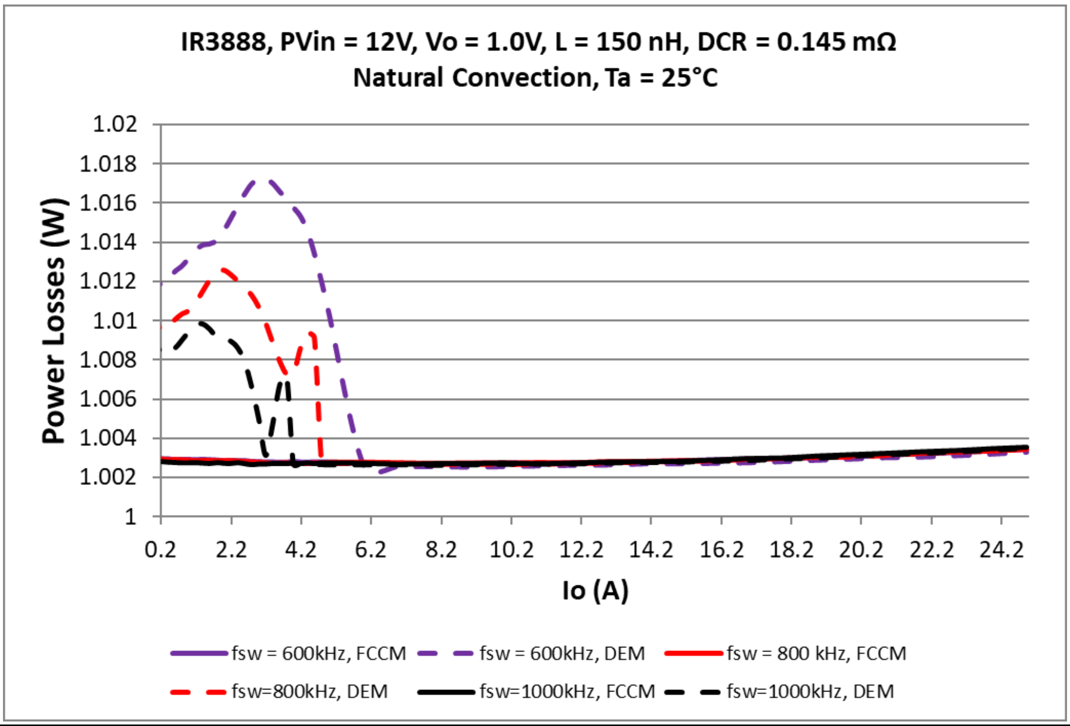


Figure 26 **IR3888 V_{out} regulation (12 V_{in}, 1.0 V_{out}, 150 nH, 600 kHz/800 kHz/1 MHz, T_a = 25°C, FCCM: solid line, DEM: dashed line)**

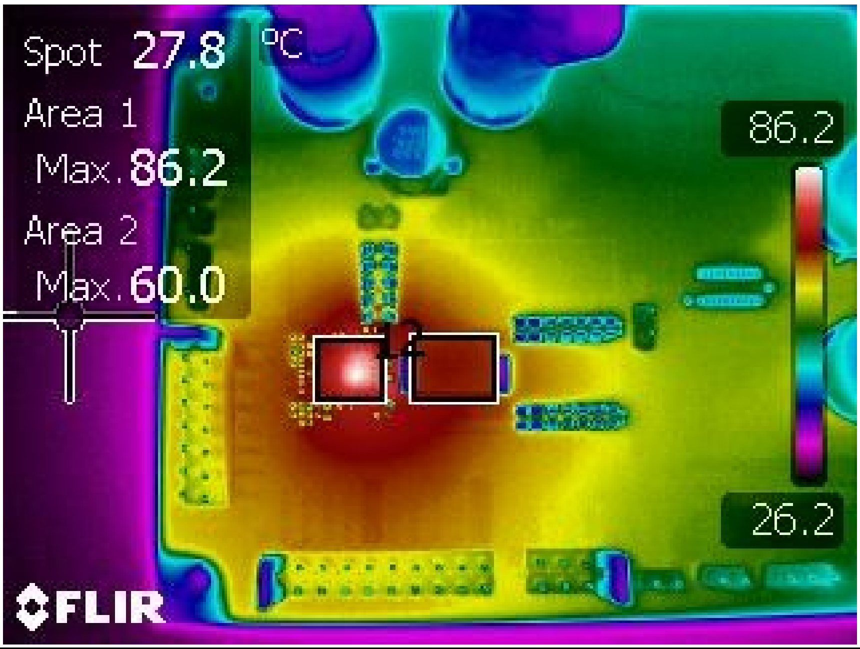


Figure 27 **Thermal image of the board at 25 A load IR3888 = 86°C, L = 6°C, f_{sw} = 600 kHz, T_a = room temperature, natural convection**

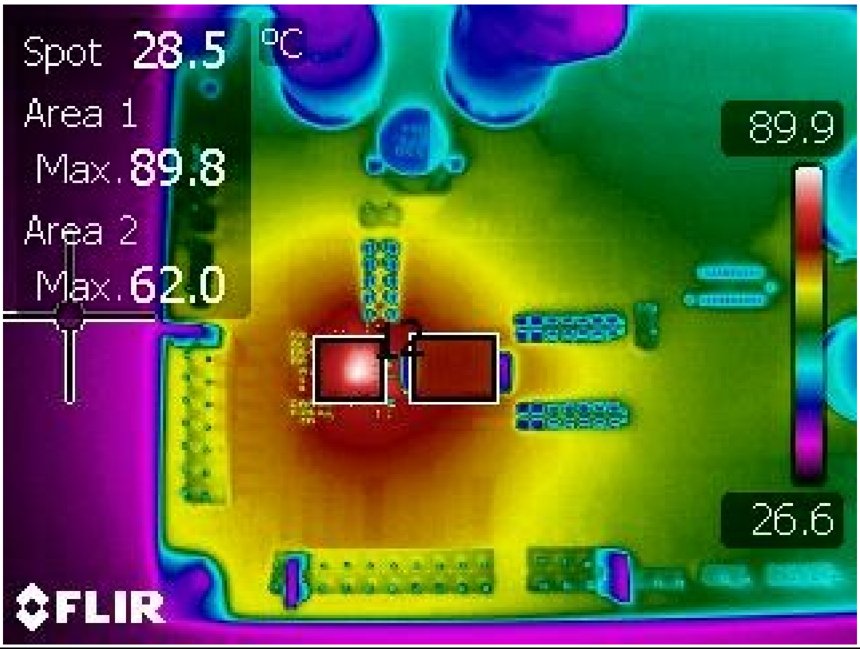


Figure 28 **Thermal image of the board at 25 A load IR3888 = 90°C, L = 62°C, f_{sw} = 800 kHz, T_a = room temperature, natural convection**

Figure 29 **Thermal Image of the board at 25 A load IR3888 = 95°C, L = 66°C, f_{sw} = 1000 kHz, T_a = room temperature, natural convection**

Revision history

Document version	Date of release	Description of changes
V 1.0	2019-11-06	First release of final user guide
V 2.0	2022-05-02	Updated title and subtitle

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