

# User manual for TDA38820 evaluation board

## 20 A single-phase buck regulator with 1.0 V output

### About this document

#### Scope and purpose

The TDA38820 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 TDA38820 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 manual contains the schematic and bill of materials (BOM) for the EV119-001 engineering evaluation board. The manual describes operation and use of the evaluation board itself. Detailed application information for TDA38820 is available in the TDA38820 datasheet.

#### Intended audience

This document is intended as a guide for design engineers who are evaluating TDA38820 performance with the engineering of EV119-001 demo board.

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## 1 Board information

### 1.1 Board features

$V_{in} = +12\text{ V}$ ,  $V_{out} = +1\text{ V}$  at 0 to 20 A

$F_s = 600\text{ kHz}/800\text{ kHz}/1000\text{ kHz}$

$L = 215\text{ nH}$  (10.4 mm x 8.0 mm x 7.5 mm, DCR = 0.29 mΩ)

$C_{in} = 10 \times 22\text{ }\mu\text{F}$  (25 V, ceramic 0805) + 1 x 330  $\mu\text{F}$  (25 V, electrolytic, optional)

$C_{out} = 9 \times 47\text{ }\mu\text{F}$  (6.3 V, ceramic 0805) + 1 x 470  $\mu\text{F}$  (2 V, 6 mΩ, SP-cap)

### 1.2 Connections and operating instructions

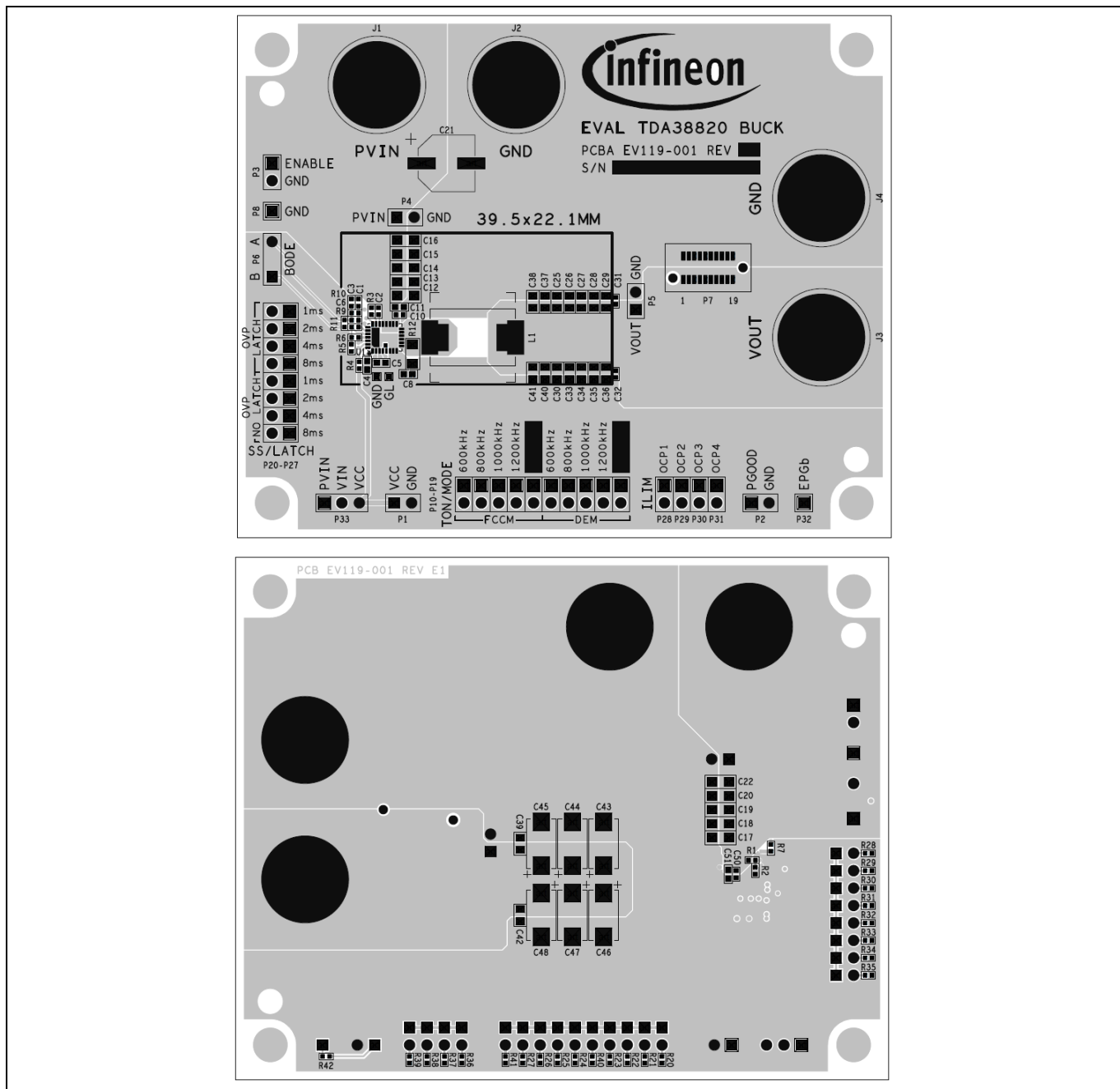
The TDA38820 demo board requires a single +12 V for the input power and can deliver up to 20 A load current. The operation modes and OCP limits can be selected through jumpers.

**Table 1 Connections**

Label		Descriptions
Input	PV <sub>in</sub>	Connect input power (+12 V) to this pin
	GND	Return of input power
	PV <sub>in</sub> , GND	Sense pins for the input voltage
Output	V <sub>out</sub>	V <sub>out</sub> (+1 V), connect a load (20 A max.) to this pin
	GND	Return of V <sub>out</sub>
	V <sub>out</sub> , GND	Sense pins for the output voltage
Enable	Enable, GND	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
Bode	A, B	For bode plot measurement
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	
Internal LDO or External VCC	PV <sub>in</sub> , V <sub>in</sub> , VCC	To use the internal LDO, connect PV <sub>in</sub> and V <sub>in</sub> with a jumper. To use an external VCC voltage, connect V <sub>in</sub> and VCC with a jumper.
	VCC, GND	When using the internal LDO, connect a scope probe to this pin to monitor the output of the internal LDO. When using using an external VCC voltage, apply +5 V between VCC and GND.
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 <sub>Good</sub>	P <sub>Good</sub> , GND	Connect a scope probe to this pin to monitor power good signal
	EPGb	External P <sub>Good</sub> pull-up bias pin. P <sub>Good</sub> pin is pulled up to V <sub>CC</sub> through R4 on the standard demo board. By removing R4 and populating R42 with 49.9 kΩ, an external P <sub>Good</sub> pull-up bias can be applied to the EPGb pin.

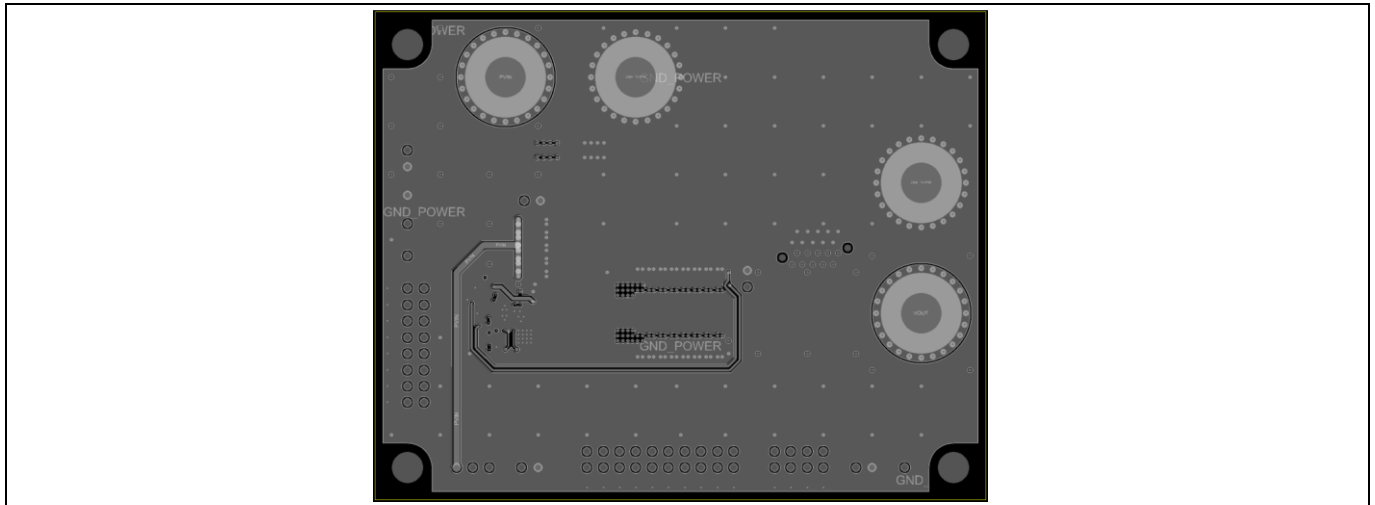
## 1.3 Layout

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 TDA38820 and other major power components are mounted on the top side of the board.

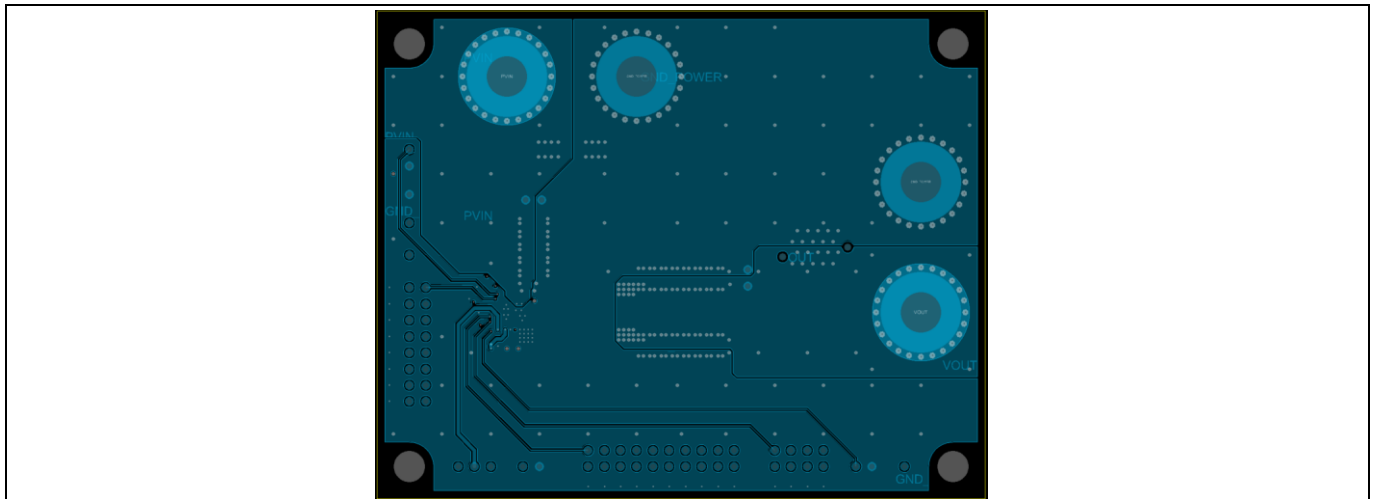


**Figure 1** Top and bottom view of TDA38820 evaluation board

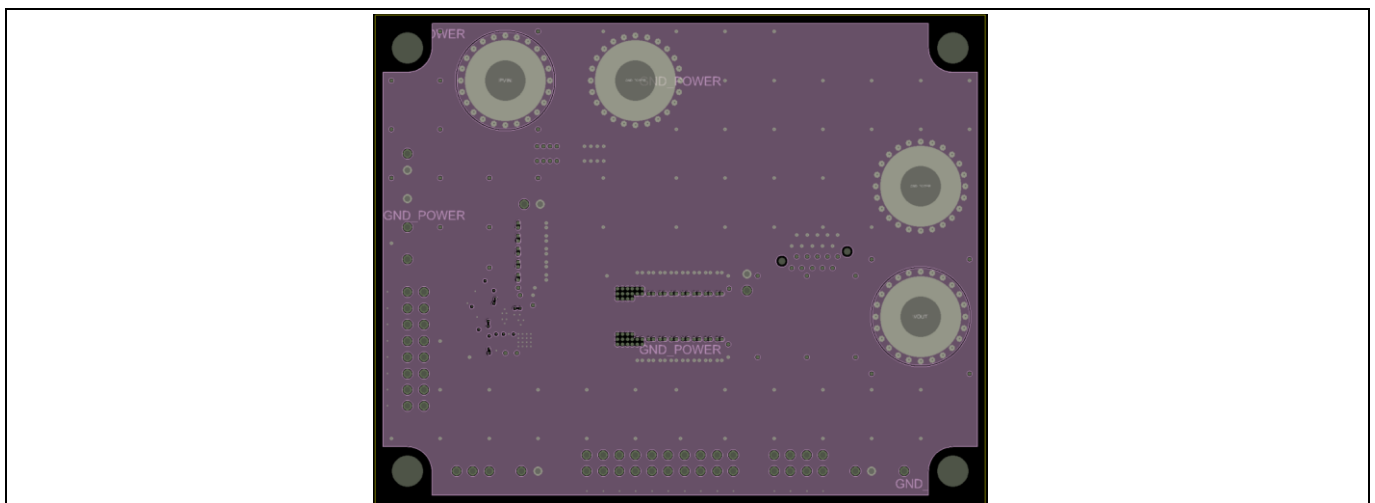




**Figure 5** Mid layer 2

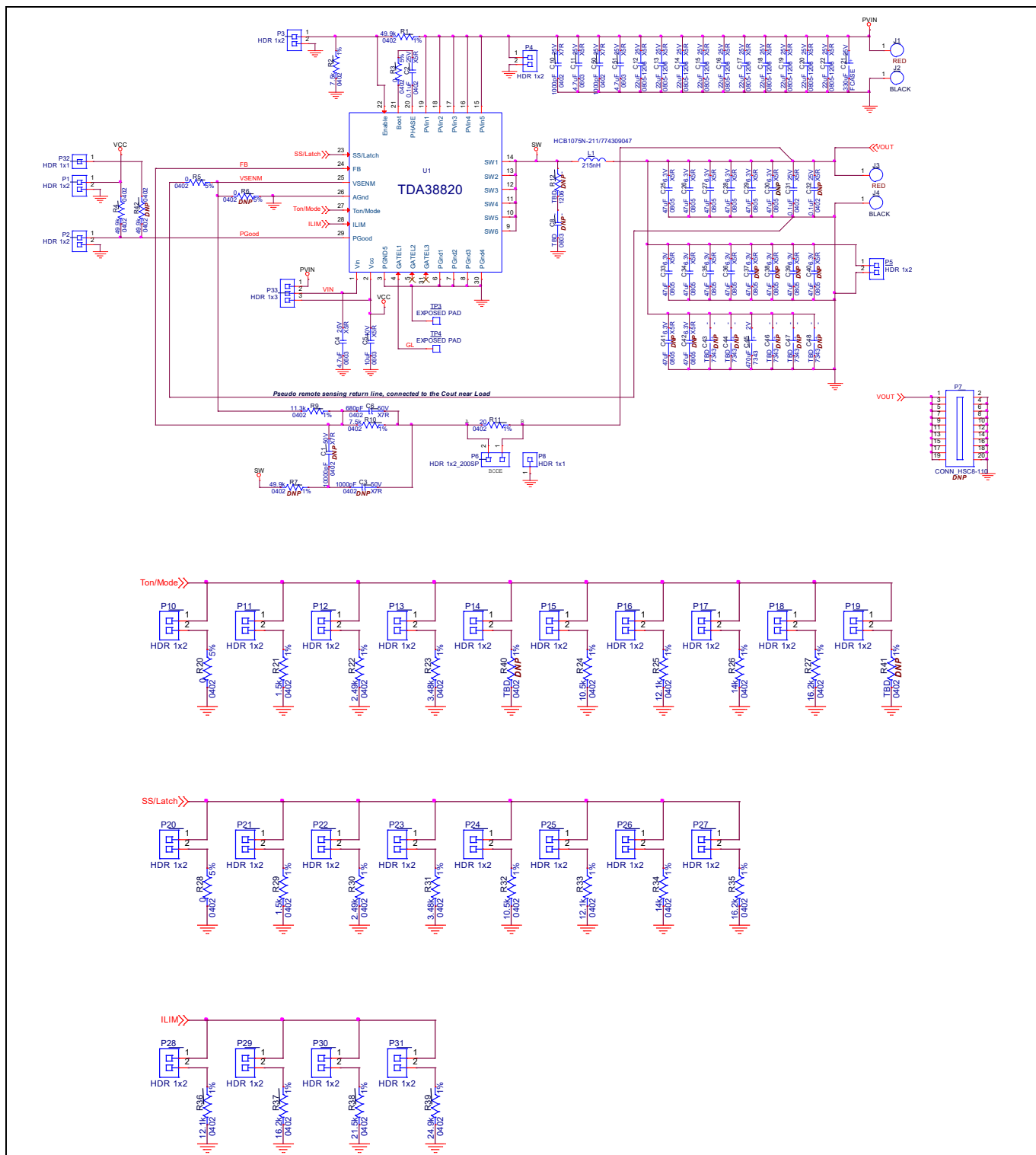


**Figure 6** Mid layer 3



**Figure 7** Mid layer 4

## 1.5 Schematic



**Figure 8** Schematic of the TDA38820 evaluation board  $V_{in} = 12\text{ V}$ ,  $V_{out} = 1\text{ V}$ ,  $I_{out,max} = 20\text{ A}$ ,  $f_{sw} = 600\text{ kHz}/800\text{ kHz}/1000\text{ kHz}$ . See [Note 1](#)

**Note 1:** The inductor selection here does not consider overcurrent protection (OCP) limit requirement. Please refer to the sections 9.8 and 10.4 in the [TDA38820 datasheet](#) for the guideline of inductor selection for a desired OCP limit.

## 1.6 Bill of Materials (BOM)

**Table 2 Bill of materials**

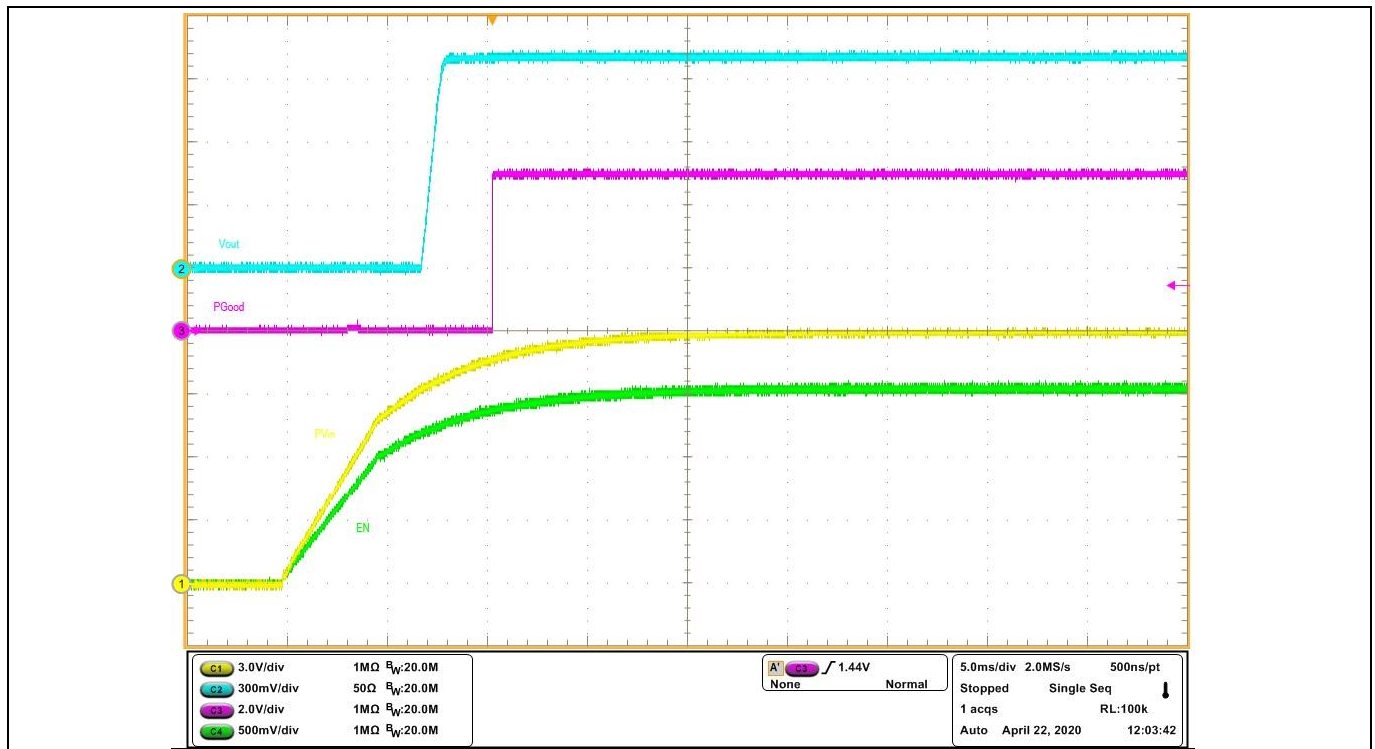
Item	Qty.	Reference	Value	Manufacturer	Manufacturer part no.	Description
1	2	C10,C50	1000 pF	Kemet	C0402C102K3RAC TU	Ceramic capacitor 1000 pF 25V 10% X7R 0402
2	10	C12,C13,C14,C15 C16,C17,C18,C19 C20,C22	22 $\mu$ F	Murata	GRM21BR61E226 ME44L	Ceramic capacitor 22 $\mu$ F 25V 20% X5R 0805
3	2	C2,C31	0.1 $\mu$ F	Taiyo Yuden	TMK105BJ104KV-F	Ceramic capacitor 0.1 $\mu$ F 25V 10% X5R 0402
4	1	C21	330 $\mu$ F	Panasonic	EEE-FK1E331P	CAP ALUM 330 $\mu$ F 20% 25V SMD
5	9	C25,C26,C27,C28 C29,C33,C34,C35 C36	47 $\mu$ F	Murata	GRM21BR60J476M E11	Ceramic capacitor 47 $\mu$ F 6.3V 20% X5R 0805
6	3	C4,C11,C51	4.7 $\mu$ F	Murata	GRM188R61E475K E15D	Ceramic capacitor 4.7 $\mu$ F 25V 10% X5R 0603
7	1	C5	10 $\mu$ F	Murata	GRM188R61A106K E69D	Ceramic capacitor 10 $\mu$ F 10V 10% X5R 0603
8	1	C45	470 $\mu$ F	Panasonic	EEF-SX0D471XE	CAP ALUM POLY 470 $\mu$ F 20% 2V SM
9	1	C6	680 pF	Yageo	CC0402KRX7R9BB 681	Ceramic capacitor 680 pF 50V 10% X7R 0402
10	1	L1	215 nH	Delta	HCB1075N-211	Inductor 215 nH, 48 A, 0.29 m $\Omega$ 10.4 x 8.0 x 7.5 mm, SMD
11	2	R1,R4	49.9 k	Panasonic	ERJ-2RKF4992X	Resistor 49.9 k $\Omega$ 1/10W 1% 0402 SMD
12	1	R11	20	Vishay Dale	CRCW040220R0FK ED	Resistor 20.0 $\Omega$ 1/16W 1% 0402 SMD
13	2	R2,R10	7.5 k	Panasonic	ERJ-2RKF7501X	Resistor 7.50 k $\Omega$ 1/10W 1% 0402 SMD
14	2	R21,R29	1.5 k	Rohm	MCR01MZPF1501	Resistor 1.50 k $\Omega$ 1/16W 1% 0402 SMD
15	2	R22,R30	2.49 k	Vishay Dale	CRCW04022K49FK ED	Resistor 2.49 k $\Omega$ 1/16W 1% 0402 SMD
16	2	R23,R31	3.48 k	Vishay Dale	CRCW04023K48FK ED	Resistor 3.48 k $\Omega$ 1/16W 1% 0402 SMD
17	2	R24,R32	10.5 k	Panasonic	ERJ-2RKF1052X	Resistor 10.5 k $\Omega$ 1/10W 1% 0402 SMD
18	3	R25,R33,R36	12.1 k	Panasonic	ERJ-2RKF1212X	Resistor 12.1 k $\Omega$ 1/10W 1% 0402 SMD
19	2	R26,R34	14 k	Panasonic	ERJ-2RKF1402X	Resistor 14.0 k $\Omega$ 1/10W

						1% 0402 SMD
20	3	R27,R35,R37	16.2 k	Panasonic	ERJ-2RKF1622X	Resistor 16.2 kΩ 1/10W 1% 0402 SMD
21	4	R3,R5,R20,R28	0	Panasonic	ERJ-2GE0R00X	Resistor 0.0 Ω 1/10W 0402 SMD
22	1	R38	21.5 k	Panasonic	ERJ-2RKF2152X	Resistor 21.5 kΩ 1/10W 1% 0402 SMD
23	1	R39	24.9 k	Panasonic	ERJ-2RKF2492X	Resistor 24.9 kΩ 1/10W 1% 0402 SMD
24	1	R9	11.3 k	Panasonic	ERJ-2RKF1132X	Resistor 11.3 kΩ 1/10W 1% 0402 SMD
25	1	U1	TDA38820	Infineon	TDA38820	20 A Single input voltage, synchronous buck regulator

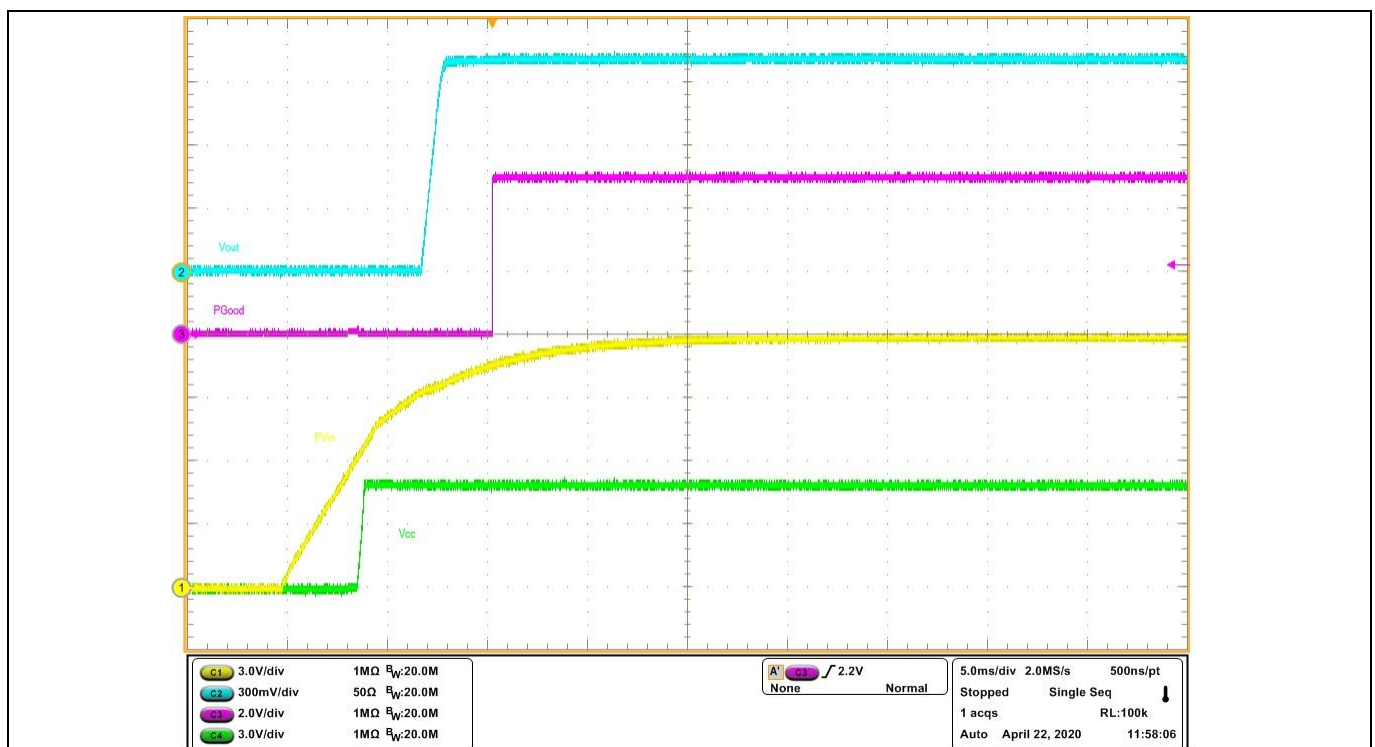


## 2 Typical operating waveforms

$V_{in} = 12.0\text{ V}$ ,  $V_{out} = 1\text{ V}$ ,  $I_{out} = 0\text{ to }20\text{ A}$ , room temperature, no airflow.



**Figure 9 Start-up at 20 A load (Ch<sub>1</sub>:  $PV_{in}$ , Ch<sub>2</sub>:  $V_{out}$ , Ch<sub>3</sub>:  $P_{Good}$ , Ch<sub>4</sub>: Enable)**

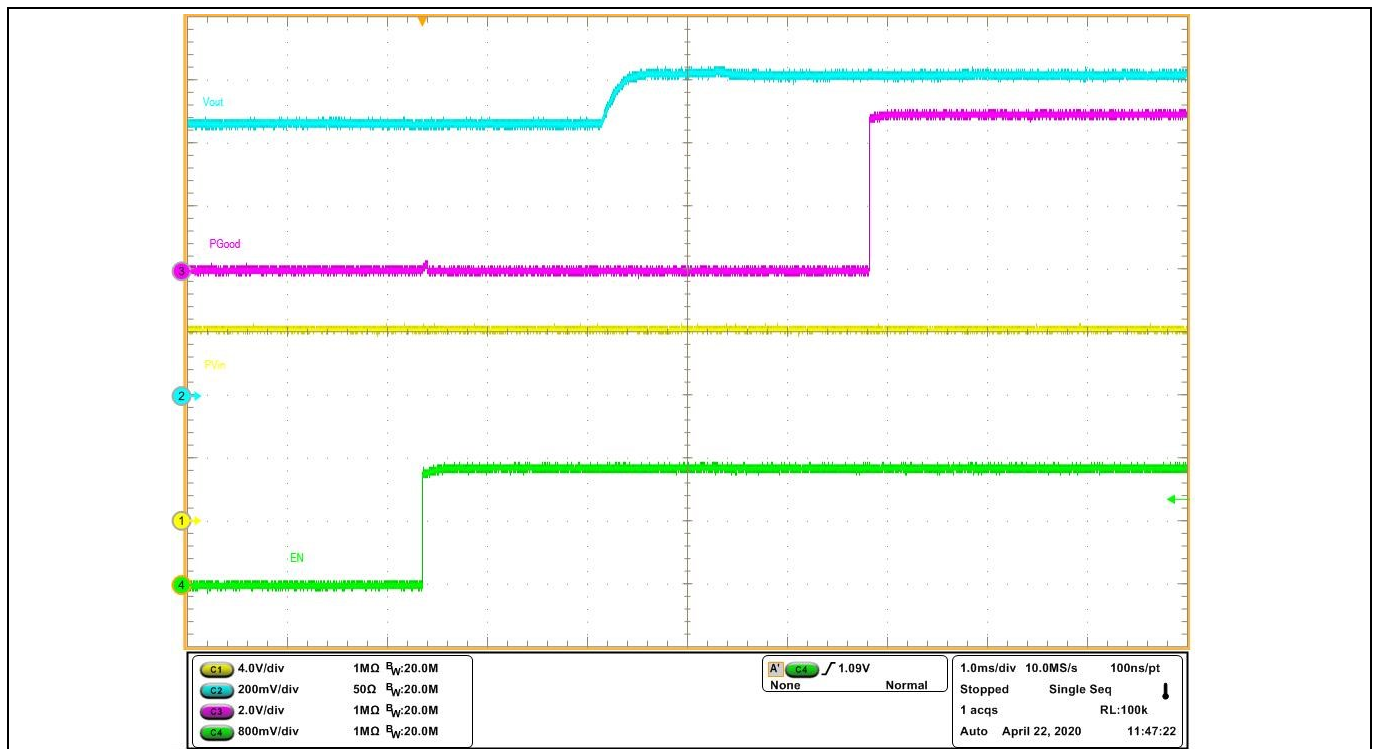


**Figure 10 Start-up at 20 A load (Ch<sub>1</sub>:  $PV_{in}$ , Ch<sub>2</sub>:  $V_{out}$ , Ch<sub>3</sub>:  $P_{Good}$ , Ch<sub>4</sub>:  $V_{cc}$ )**

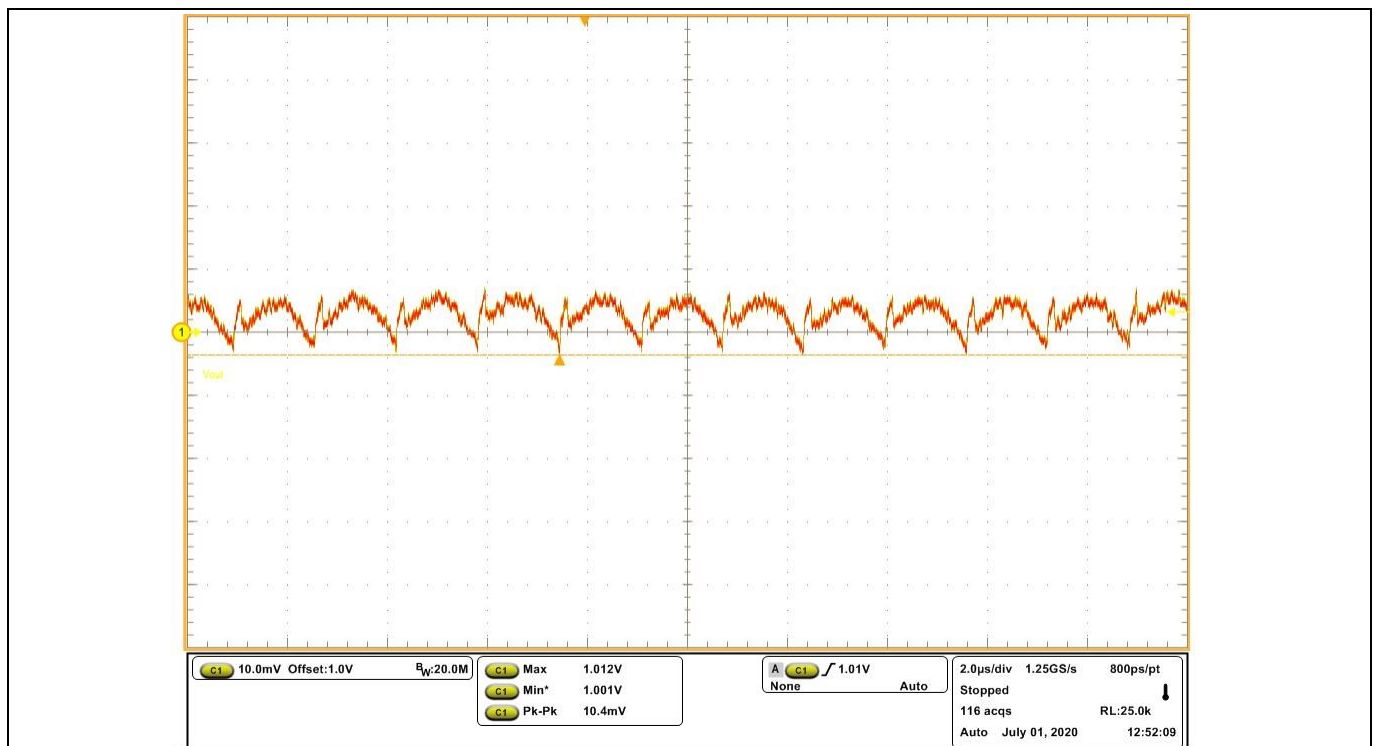
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## 20 A single-phase buck regulator with 1.0 V output

### Typical operating waveforms



**Figure 11** Pre-bias start-up at 0 A load (Ch1: PV<sub>in</sub>, Ch2: V<sub>out</sub>, Ch3: P<sub>Good</sub>, Ch4: Enable)

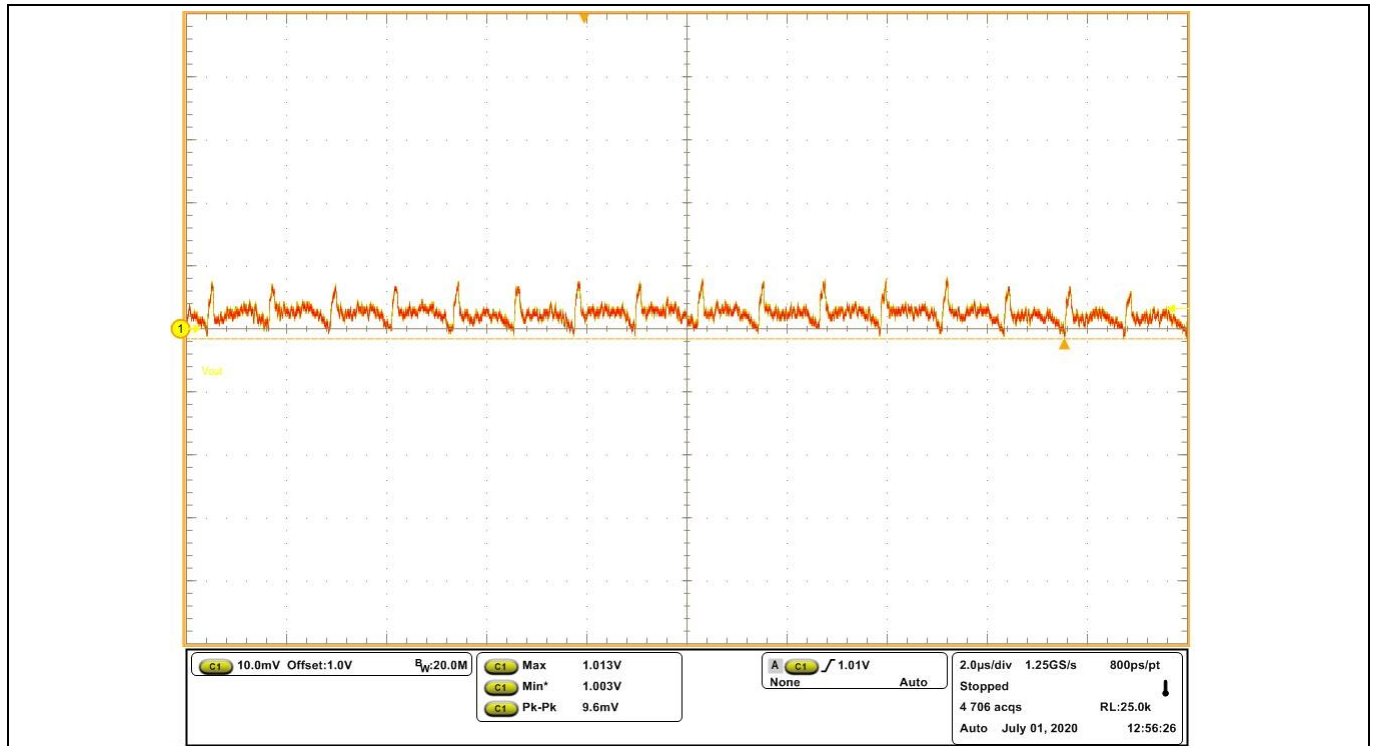


**Figure 12** V<sub>out</sub> ripple at 20 A load, f<sub>sw</sub> = 600 kHz (Ch1: V<sub>out</sub>)

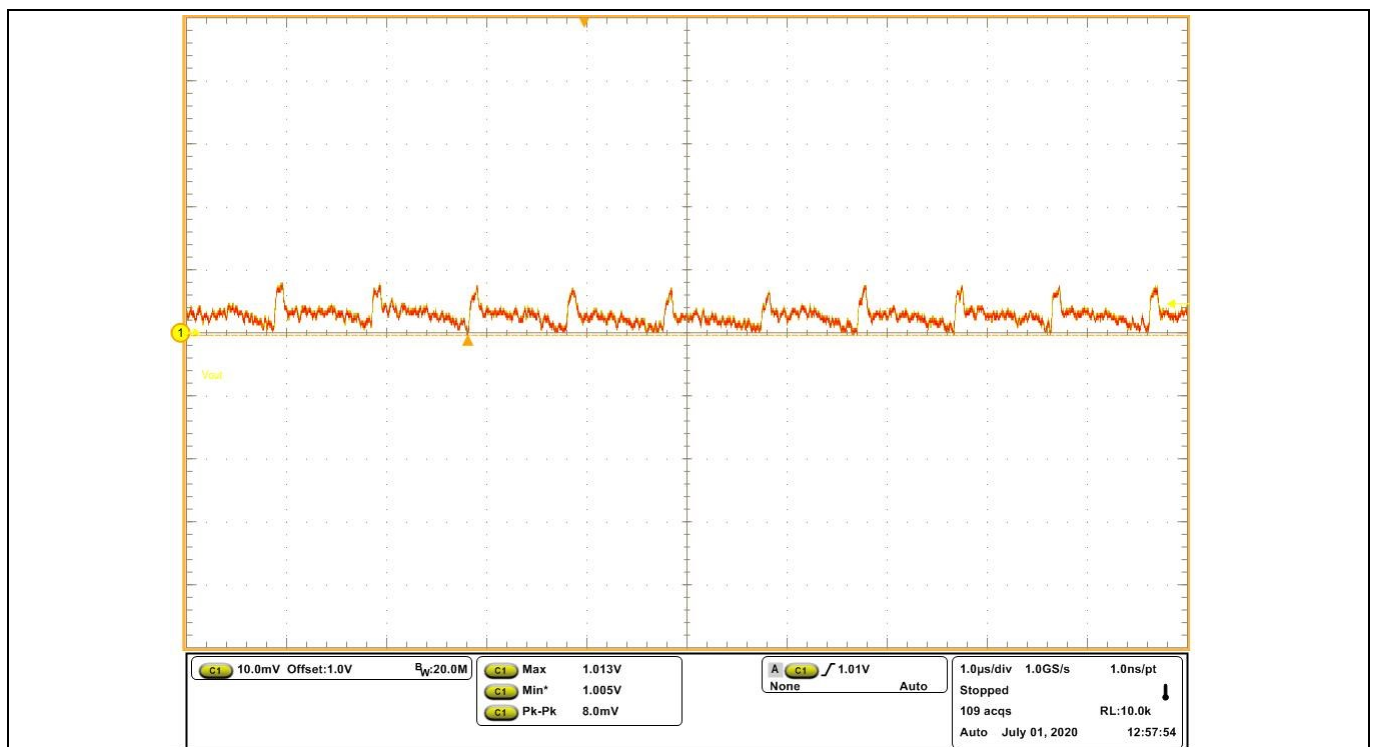
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## 20 A single-phase buck regulator with 1.0 V output

### Typical operating waveforms



**Figure 13**  $V_{out}$  ripple at 20 A load,  $f_{sw} = 800$  kHz (Ch1:  $V_{out}$ )

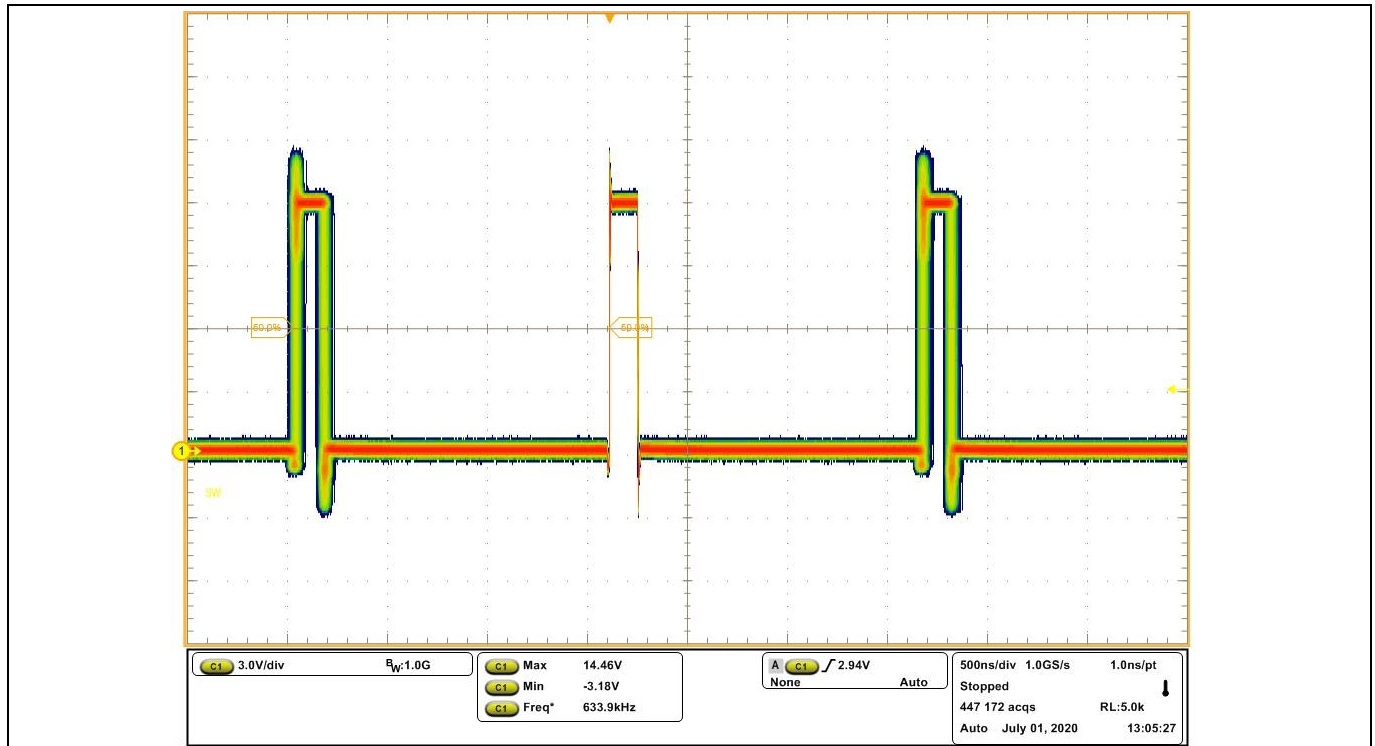


**Figure 14**  $V_{out}$  ripple at 20 A load,  $f_{sw} = 1000$  kHz (Ch1:  $V_{out}$ )

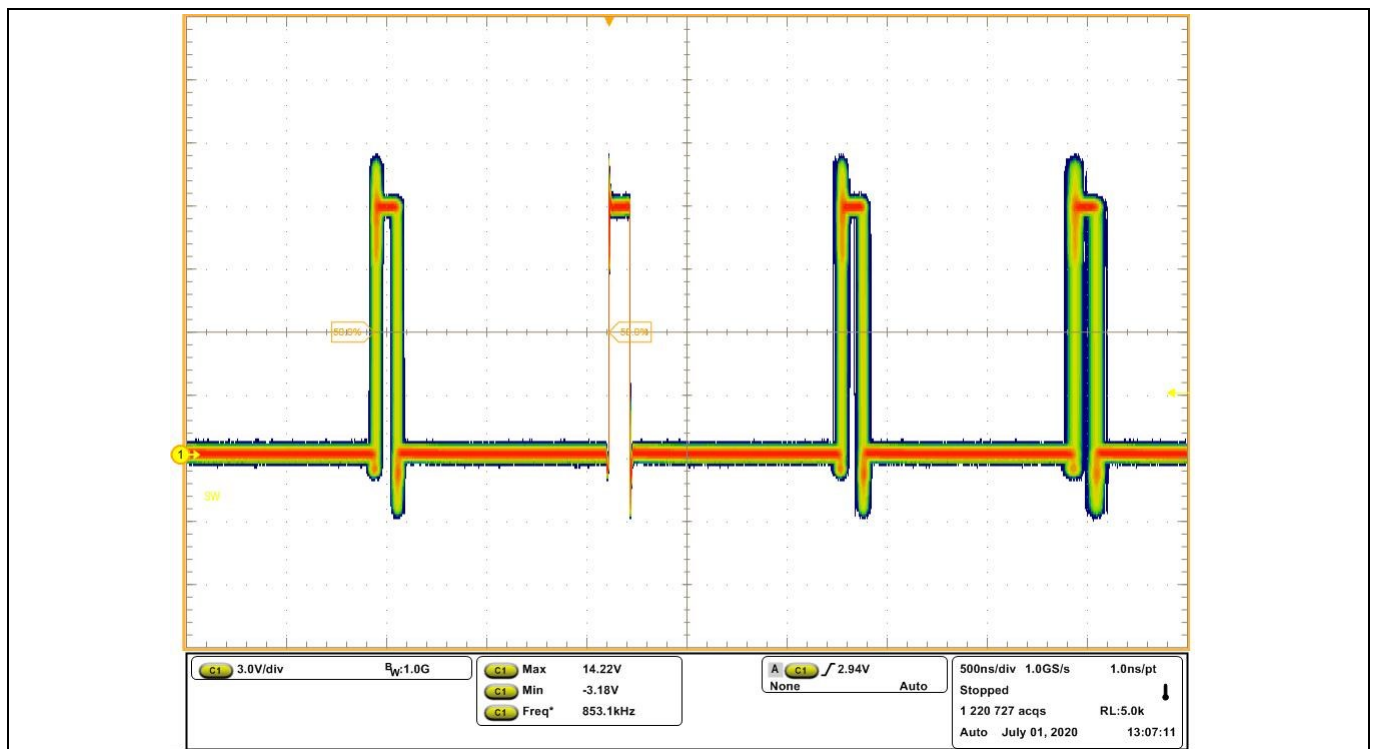
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### Typical operating waveforms



**Figure 15** SW node, 20 A load, fsw = 600 kHz



**Figure 16** SW node, 20 A load, fsw = 800 kHz

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### Typical operating waveforms

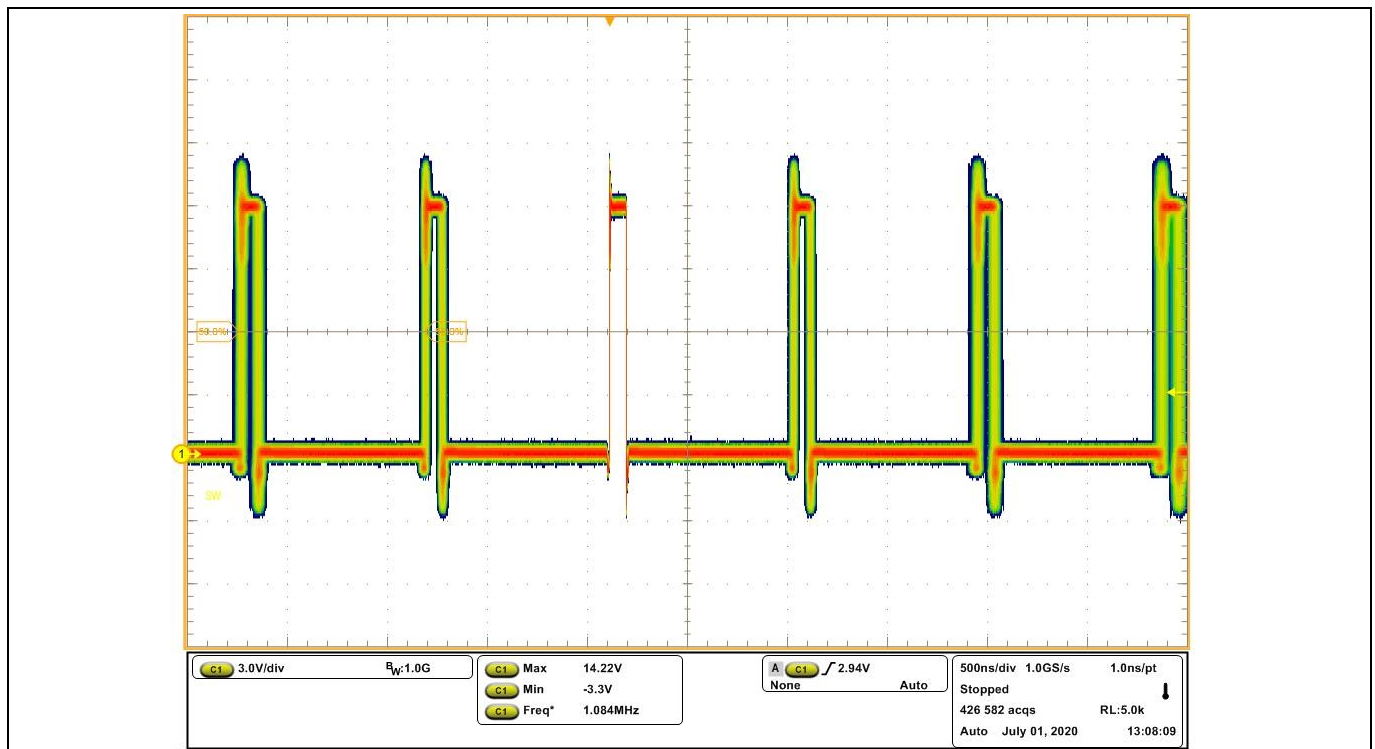


Figure 17 SW node, 20 A load, fsw = 1000 kHz

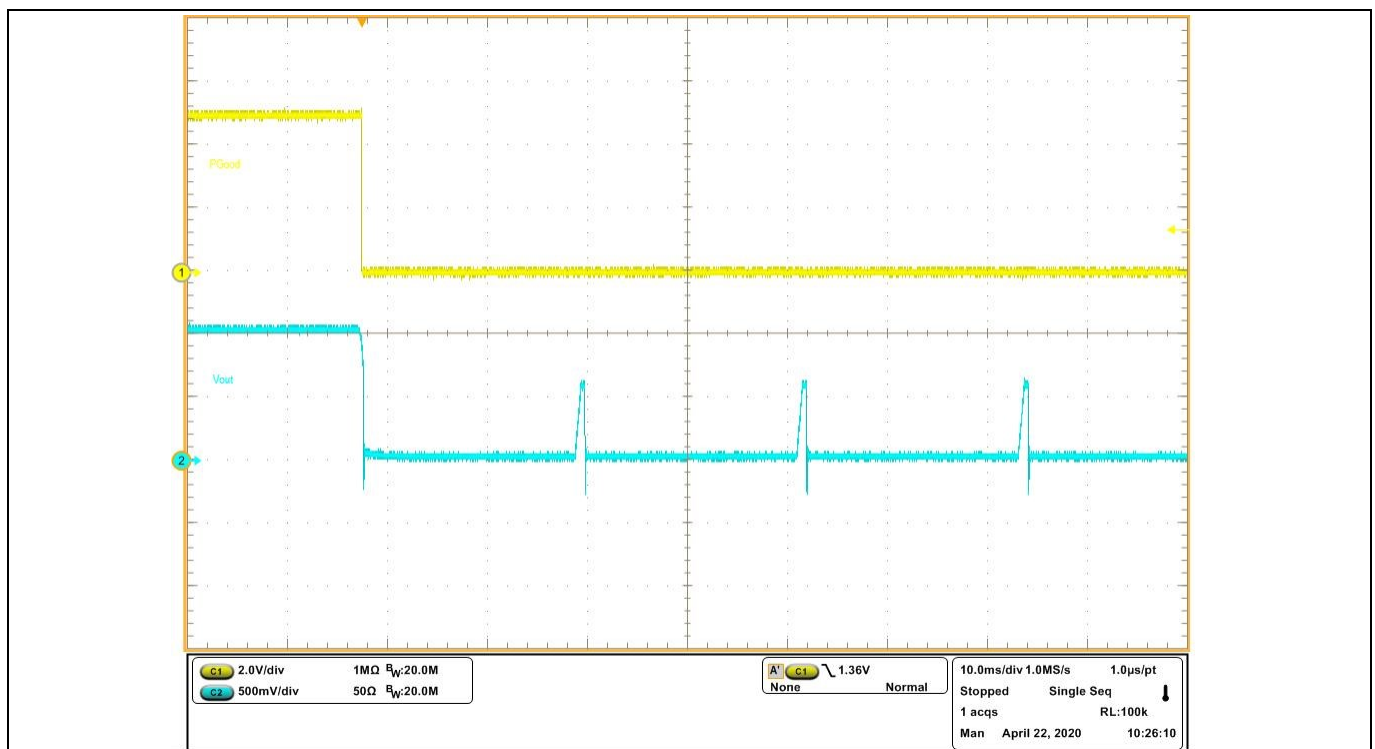
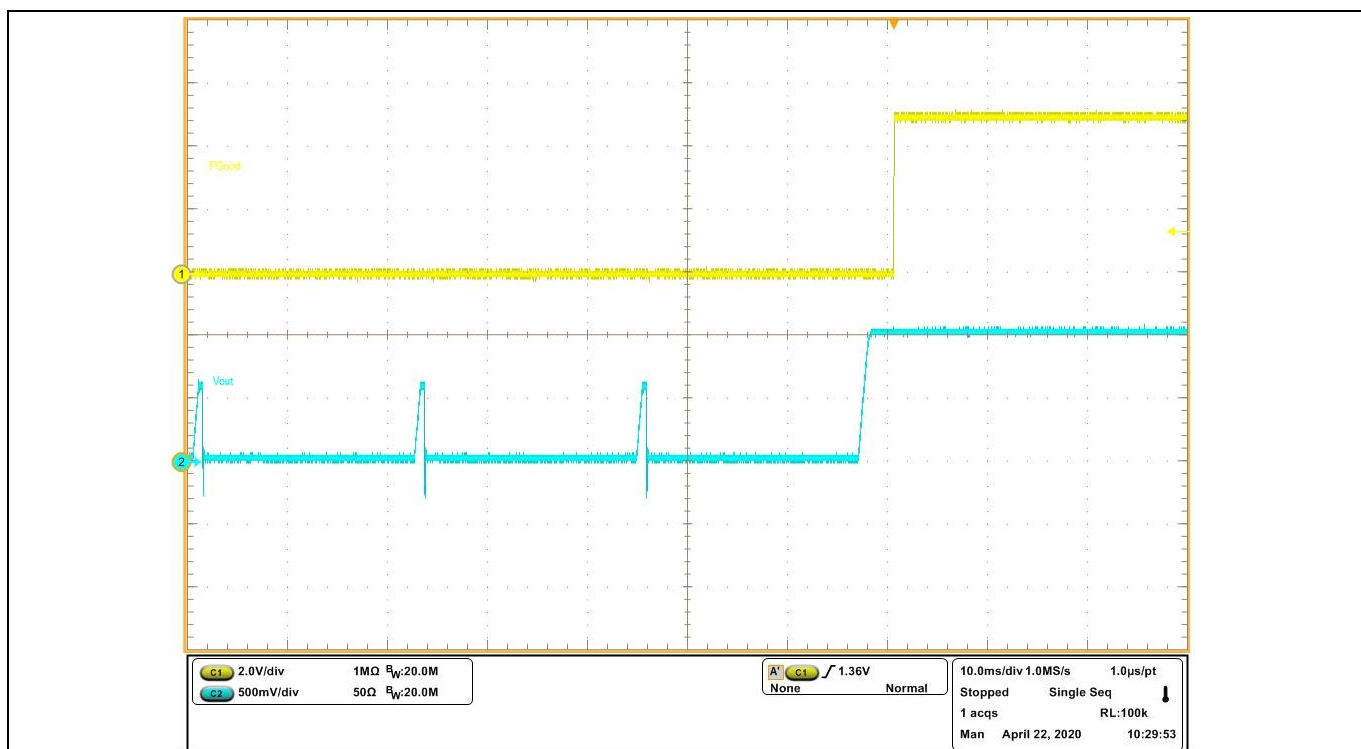
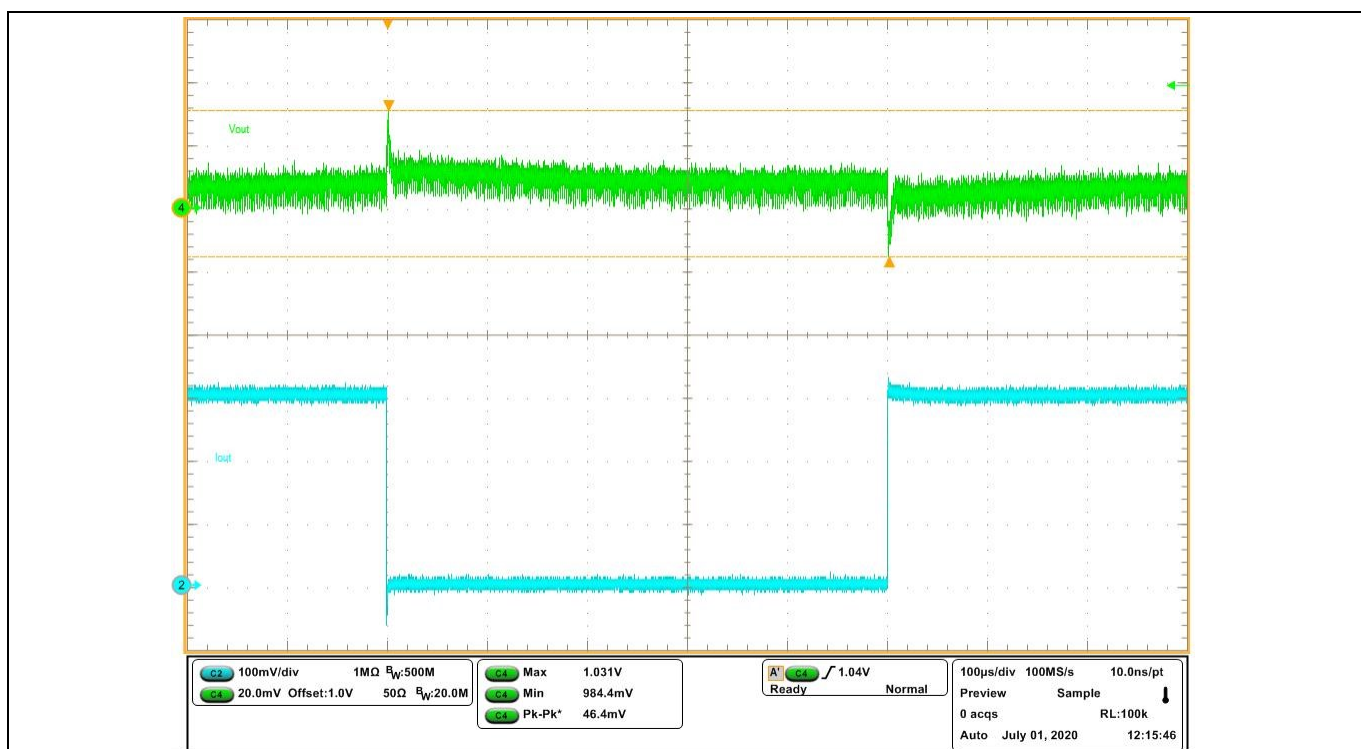


Figure 18 Short-circuit and UVP (hiccup), (Ch<sub>2</sub>: V<sub>o</sub>, Ch<sub>1</sub>: P<sub>Good</sub>)

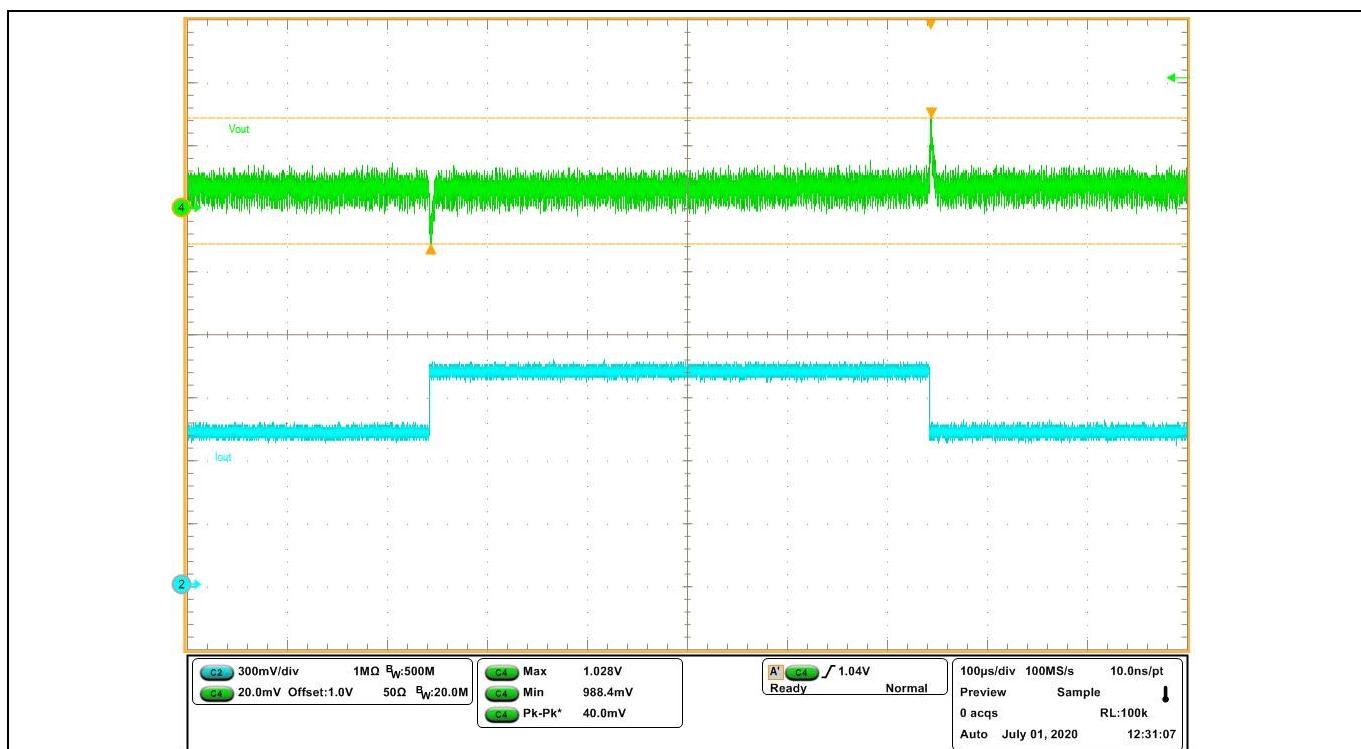




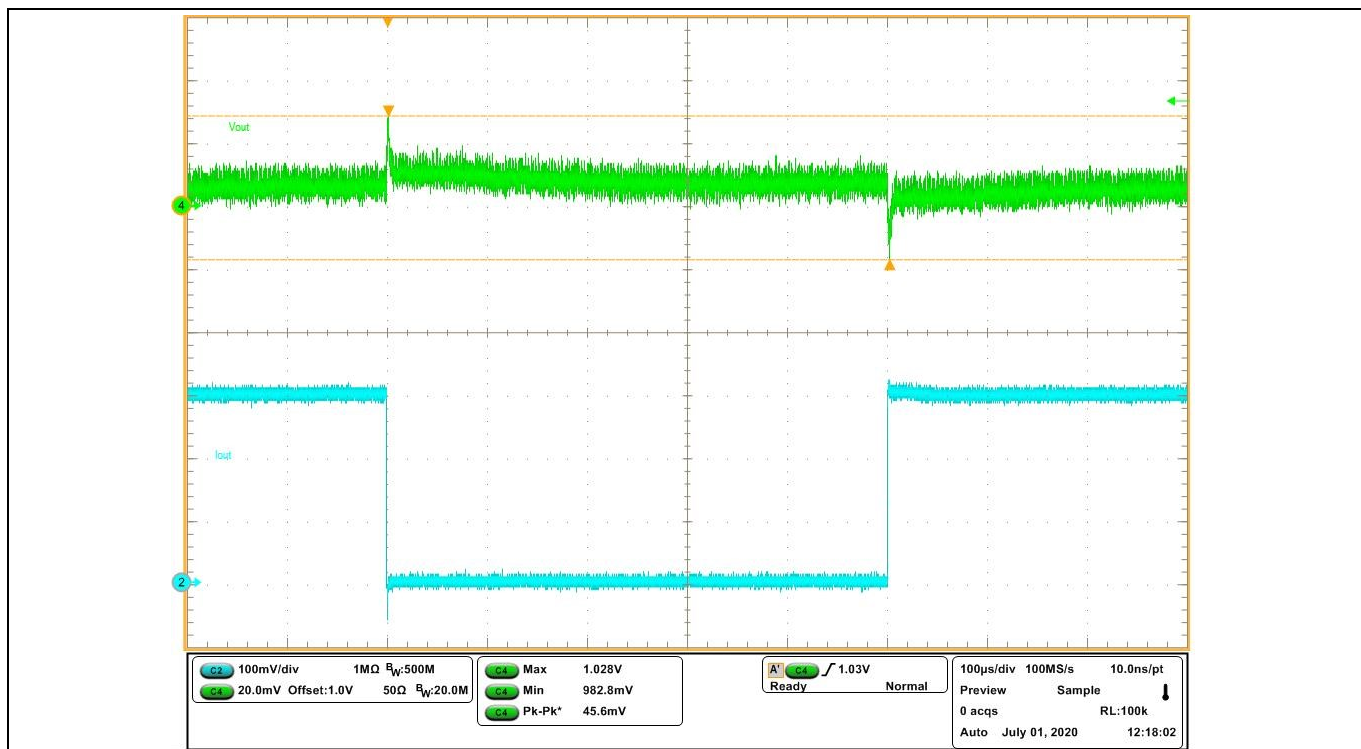
**Figure 19** Short-circuit and UVP (hiccup) recover (Ch<sub>2</sub>:  $V_{out}$ , Ch<sub>1</sub>:  $P_{Good}$ )



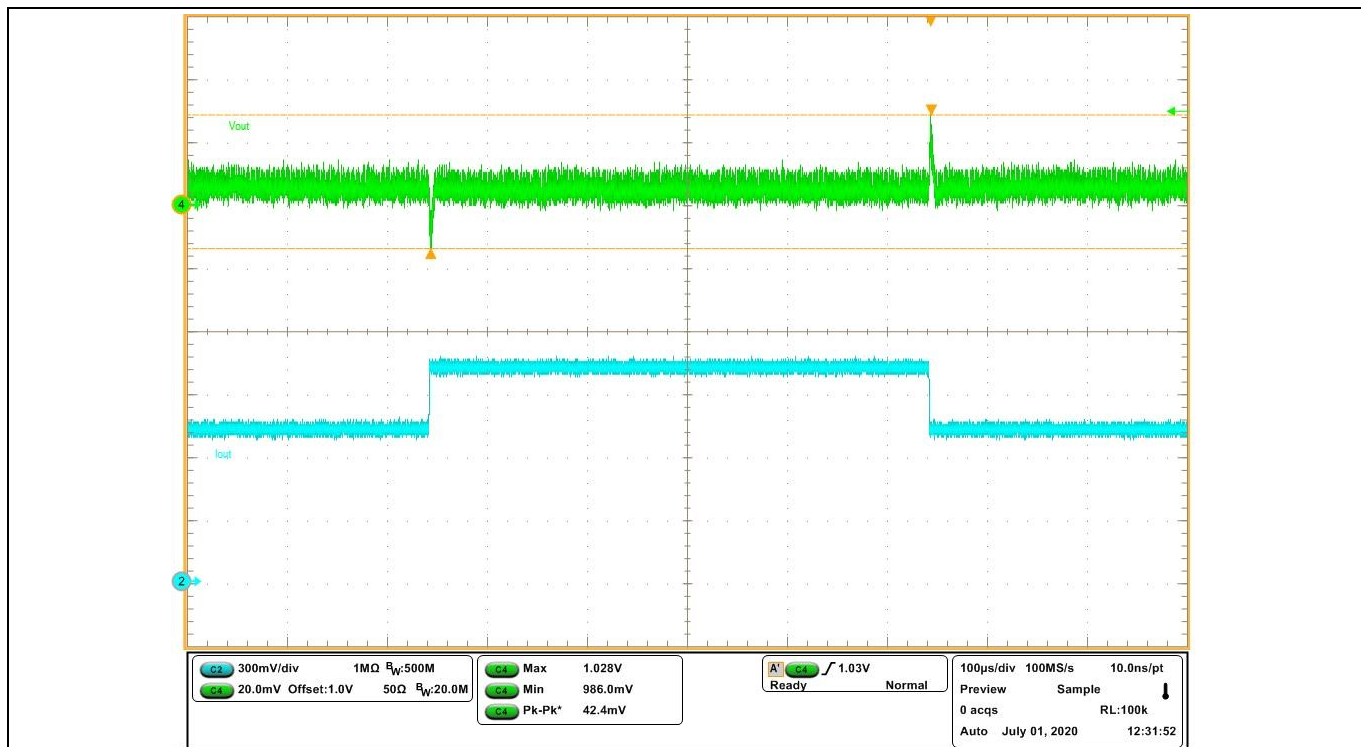
**Figure 20** Transient response at 6 A step load current at 30 A/ $\mu$ s slew rate:  $I_{out} = 0$  to 6 A (Ch<sub>4</sub>:  $V_{out}$ , Ch<sub>2</sub>:  $I_{out}$ , 50 mV/A) pk-pk: 46.4 mV, fsw = 600 kHz



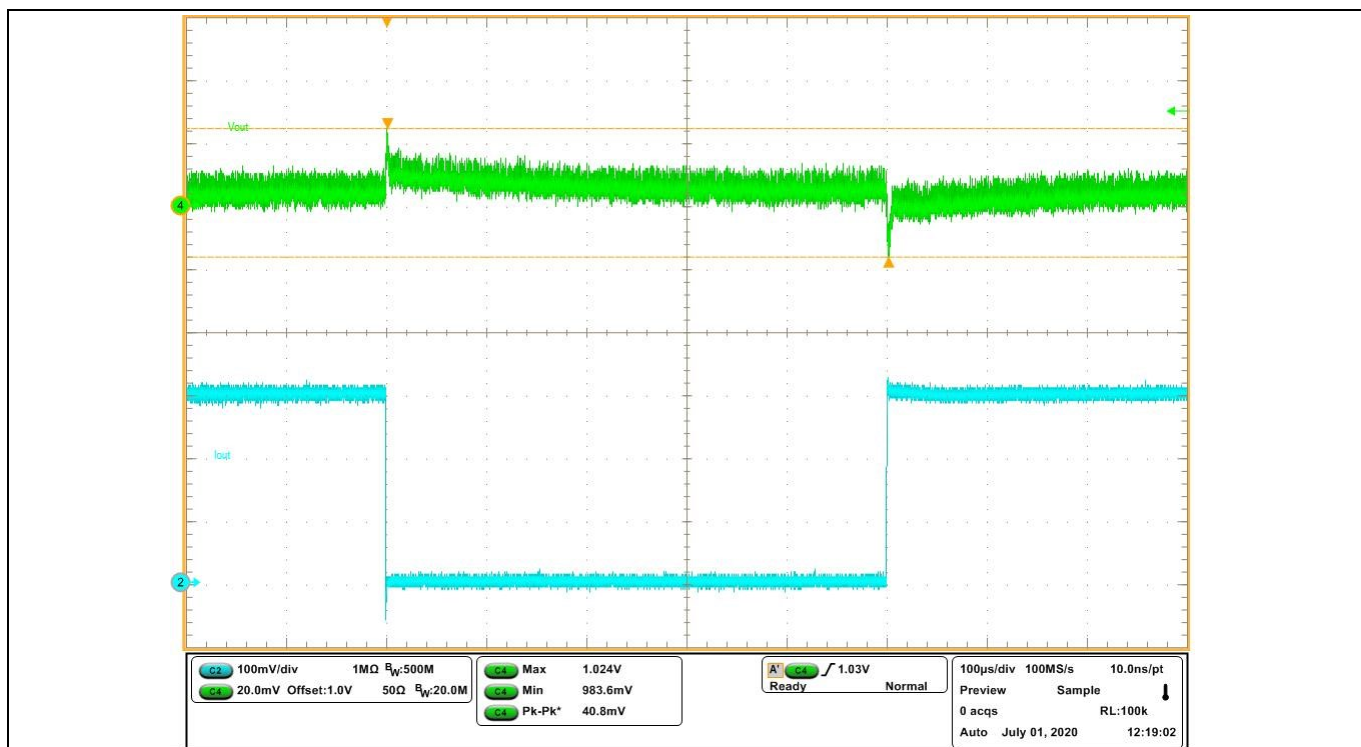
**Figure 21** Transient response at 6 A step load current at 30 A/µs slew rate:  $I_{out} = 14$  to 20 A (Ch4:  $V_{out}$ , Ch2:  $I_{out}$ , 50 mV/A), pk-pk: 40 mV, fsw = 600 kHz



**Figure 22** Transient response at 6 A step load current at 30 A/µs slew rate:  $I_{out} = 0$  to 6 A (Ch4:  $V_{out}$ , Ch2:  $I_{out}$ , 50 mV/A) pk-pk: 45.6 mV, fsw = 800 kHz

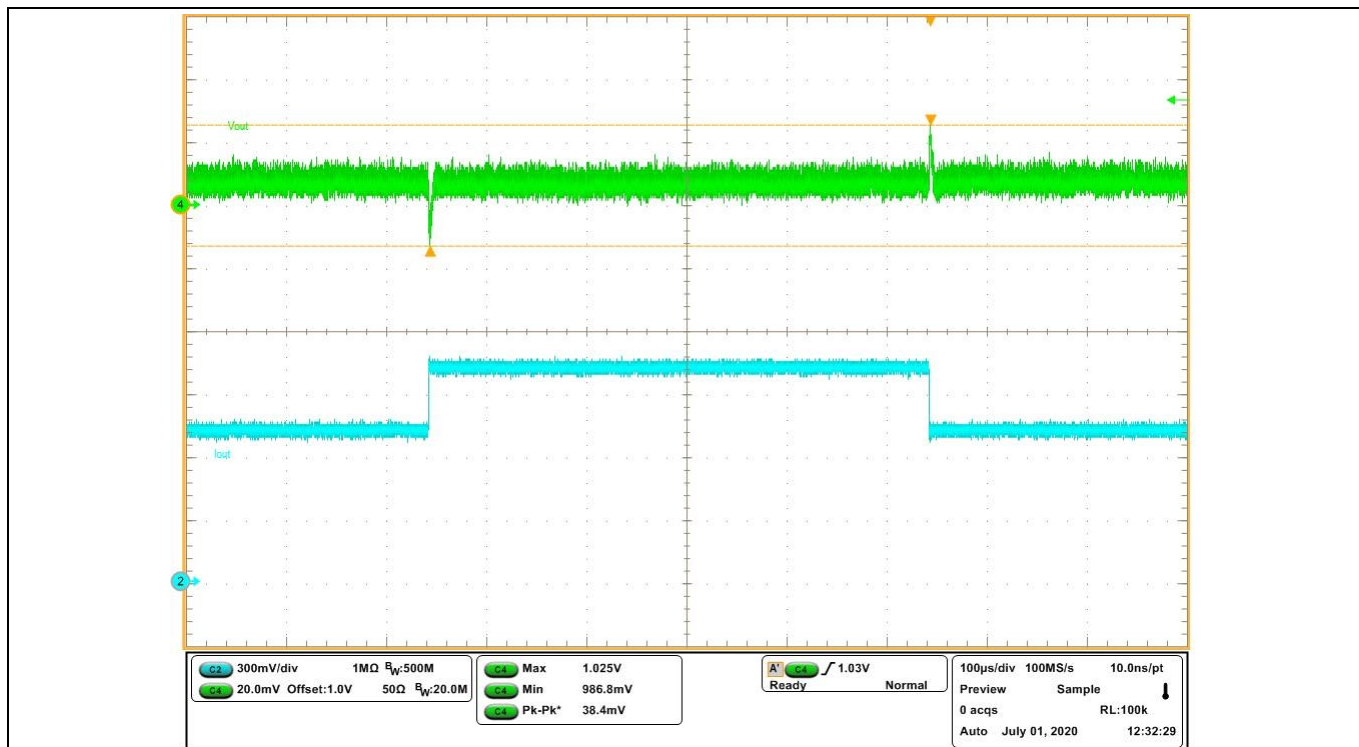


**Figure 23** Transient response at 6 A step load current at 30 A/μs slew rate:  $I_{out} = 14$  to 20 A (Ch4:  $V_{out}$ , Ch2:  $I_{out}$ , 50 mV/A), pk-pk: 42.4 mV, fsw = 800 kHz

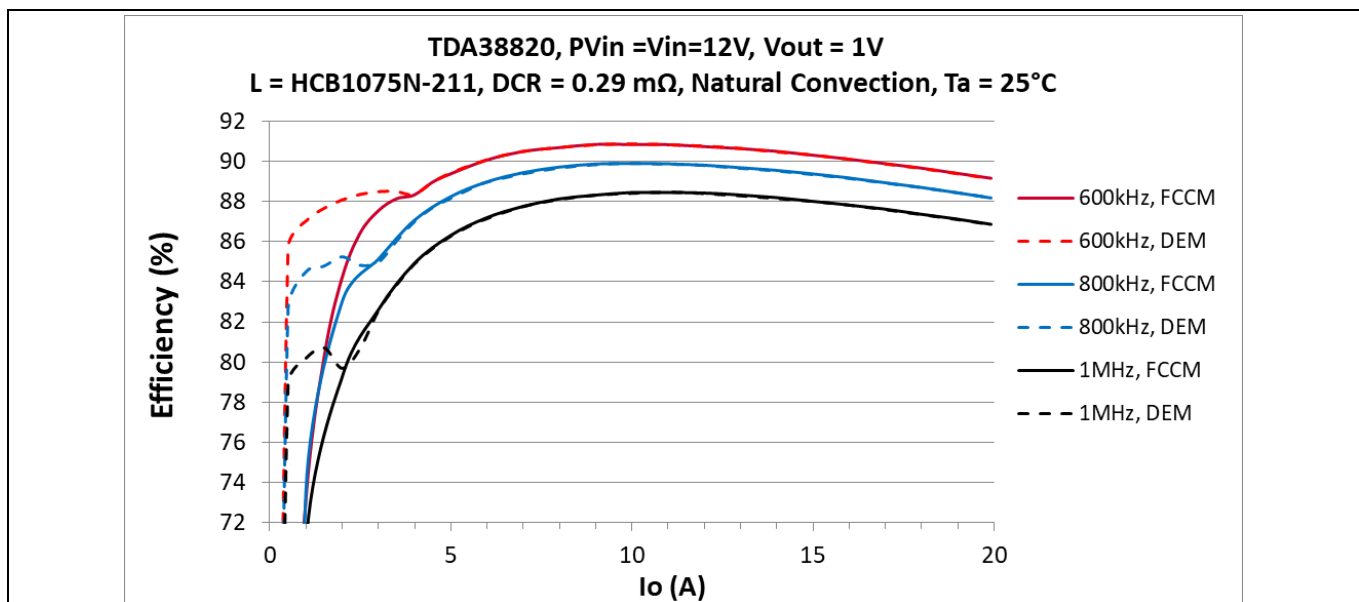


**Figure 24** Transient response at 6 A step load current at 30 A/μs slew rate:  $I_{out} = 0$  to 6 A (Ch4:  $V_{out}$ , Ch2:  $I_{out}$ , 50 mV/A) pk-pk: 40.8 mV, fsw = 1000 kHz

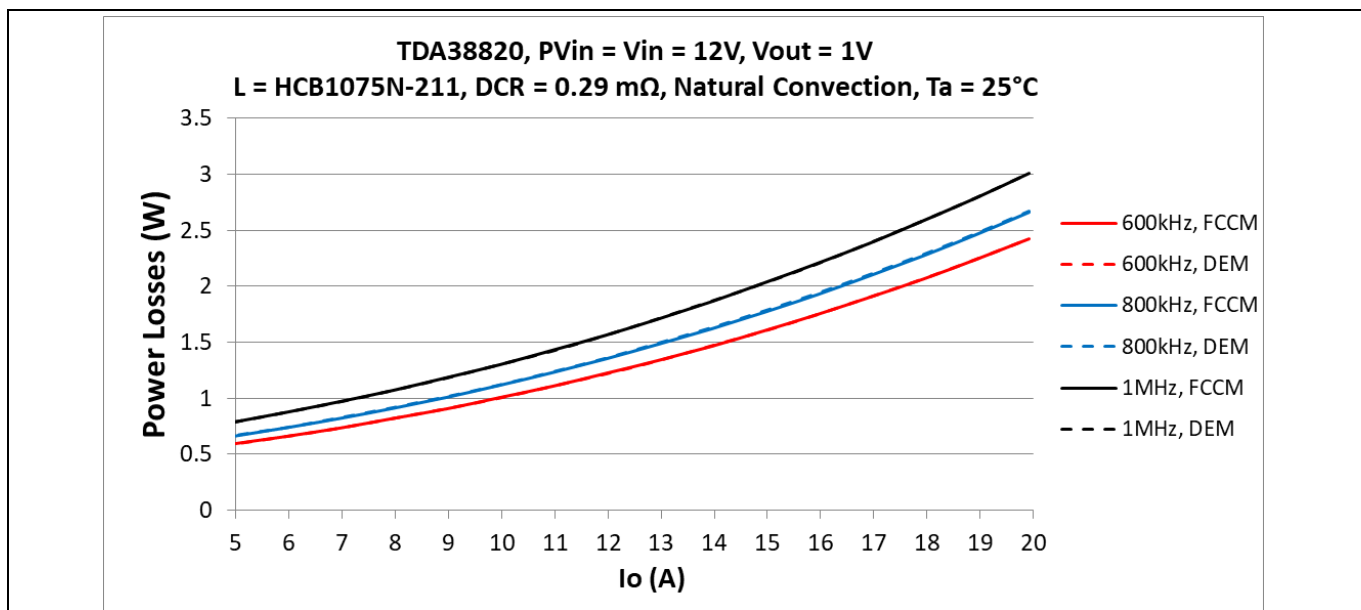




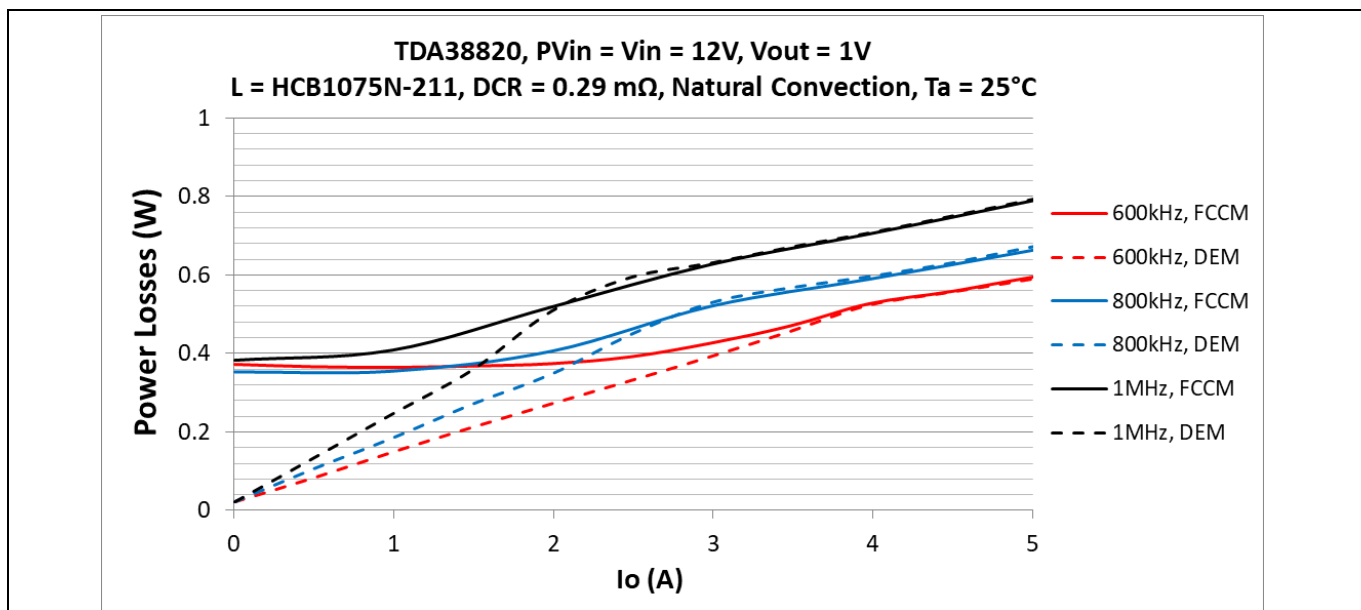
**Figure 25** Transient response at 6 A step load current at 30 A/μs slew rate:  $I_{out} = 14$  to 20 A (Ch4:  $V_{out}$ , Ch2:  $I_{out}$ , 50 mV/A) pk-pk: 38.4 mV, fsw = 1000 kHz



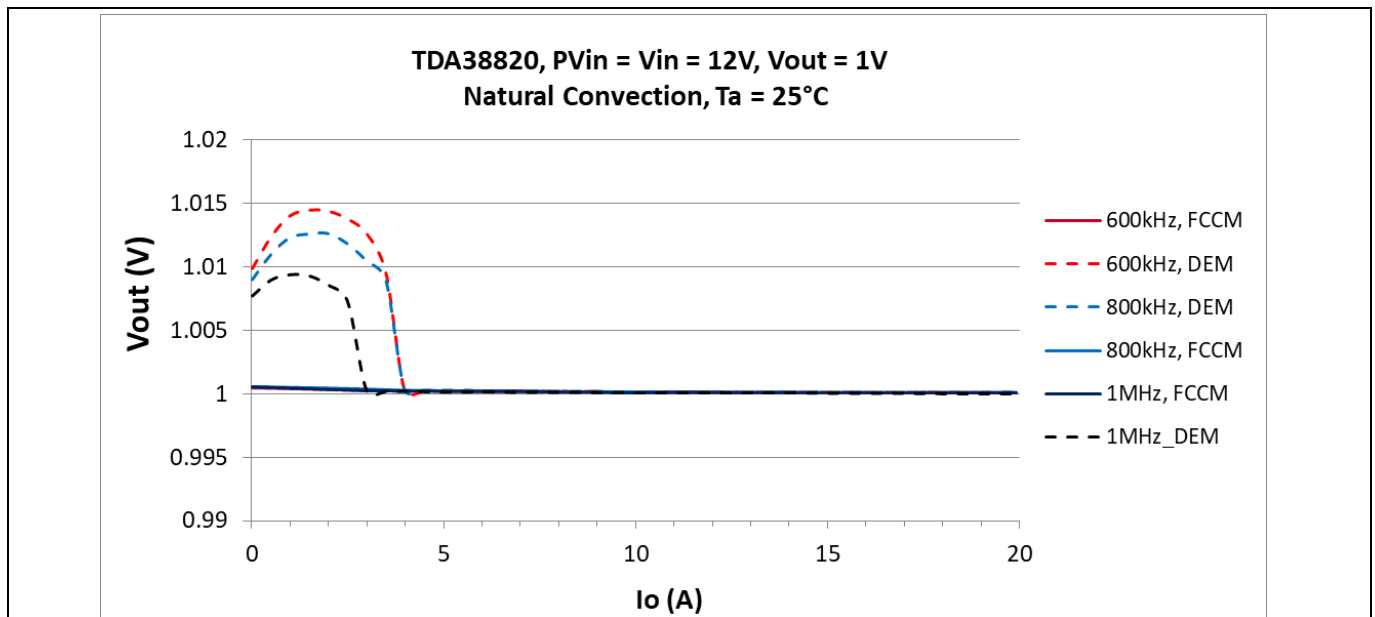
**Figure 26** Efficiency with natural convection ( 12 V<sub>in</sub>, 1 V<sub>out</sub>, 215 nH, 600 kHz, 800 kHz and 1000 kHz, T<sub>a</sub> = 25°C)



**Figure 27** Power loss with natural convection ( $12 V_{in}$ ,  $1 V_{out}$ ,  $215 \text{ nH}$ ,  $600 \text{ kHz}$ ,  $800 \text{ kHz}$  and  $1000 \text{ kHz}$ ,  $T_a = 25^\circ\text{C}$ )



**Figure 28** Power loss with natural convection ( $12 V_{in}$ ,  $1 V_{out}$ ,  $215 \text{ nH}$ ,  $600 \text{ kHz}$ ,  $800 \text{ kHz}$  and  $1000 \text{ kHz}$ ,  $T_a = 25^\circ\text{C}$ )



**Figure 29** TDA38820  $V_{out}$  regulation ( $12 V_{in}$ ,  $1 V_{out}$ ,  $215 nH$ ,  $800 kHz$  and  $1000 kHz$ ,  $T_a = 25^\circ C$ )



**Figure 30** Thermal image at 20 A load TDA38820 =  $58^\circ C$ ,  $L = 49^\circ C$ ,  $f_{sw} = 600 kHz$ ,  $T_a = 25^\circ C$ , natural convection



Figure 31 Thermal image at 20 A load TDA38820 = 63°C, L = 52°C, fsw = 800 kHz, T<sub>a</sub> = 25°C, natural convection



Figure 32 Thermal image at 20 A load TDA38820 = 68°C, L = 53.3°C, fsw = 1000 kHz, T<sub>a</sub> = 25°C, natural convection

### 3 Revision history

Document version	Date of release	Description of changes
V 1.0	11-09-2020	First release
V 1.1	01-13-2021	Added Note 1
V 1.2	04-28-2022	Title and subtitle updated

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**Document reference**

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