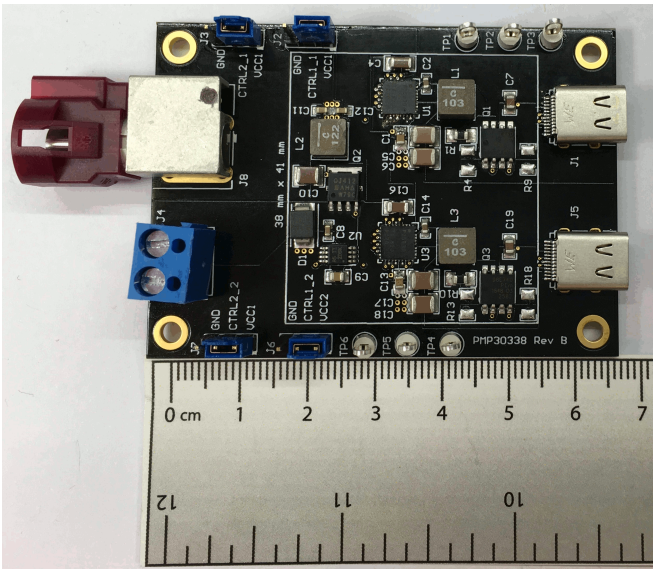
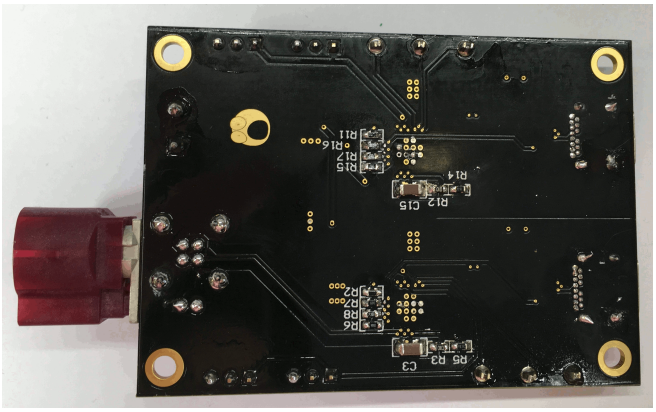
Test Report: PMP30338
Automotive dual port USB Type-C reference design (2x 15 W)

Description

This reference design showcases a system implementation of a dual port USB Type-C charger. The design includes input reverse polarity protection, input filtering and two individual USB Type-C charger circuits, which can supply up to 3.0 A each. The circuit has been space optimized to fit into a PCB area of 38 mm x 41 mm (without connectors) to meet current automotive requirements. Very good efficiency ensures that the maximum temperature rise is only 45.5 K.





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1 Test Prerequisites

1.1 Voltage and Current Requirements

Table 1. Voltage and Current Requirements

PARAMETER	SPECIFICATIONS
V_{IN}	6 V..16 V, 13 V nom., 36 V peak
V_{OUT}	2x 5 V at 3.0 A max.
Nominal switching frequency	400 kHz (spread spectrum)

1.2 Required Equipment

- PMP30338
- USB Type-C to Type-C plug 3.1 cable
- PMP20413 USB Type-C load board

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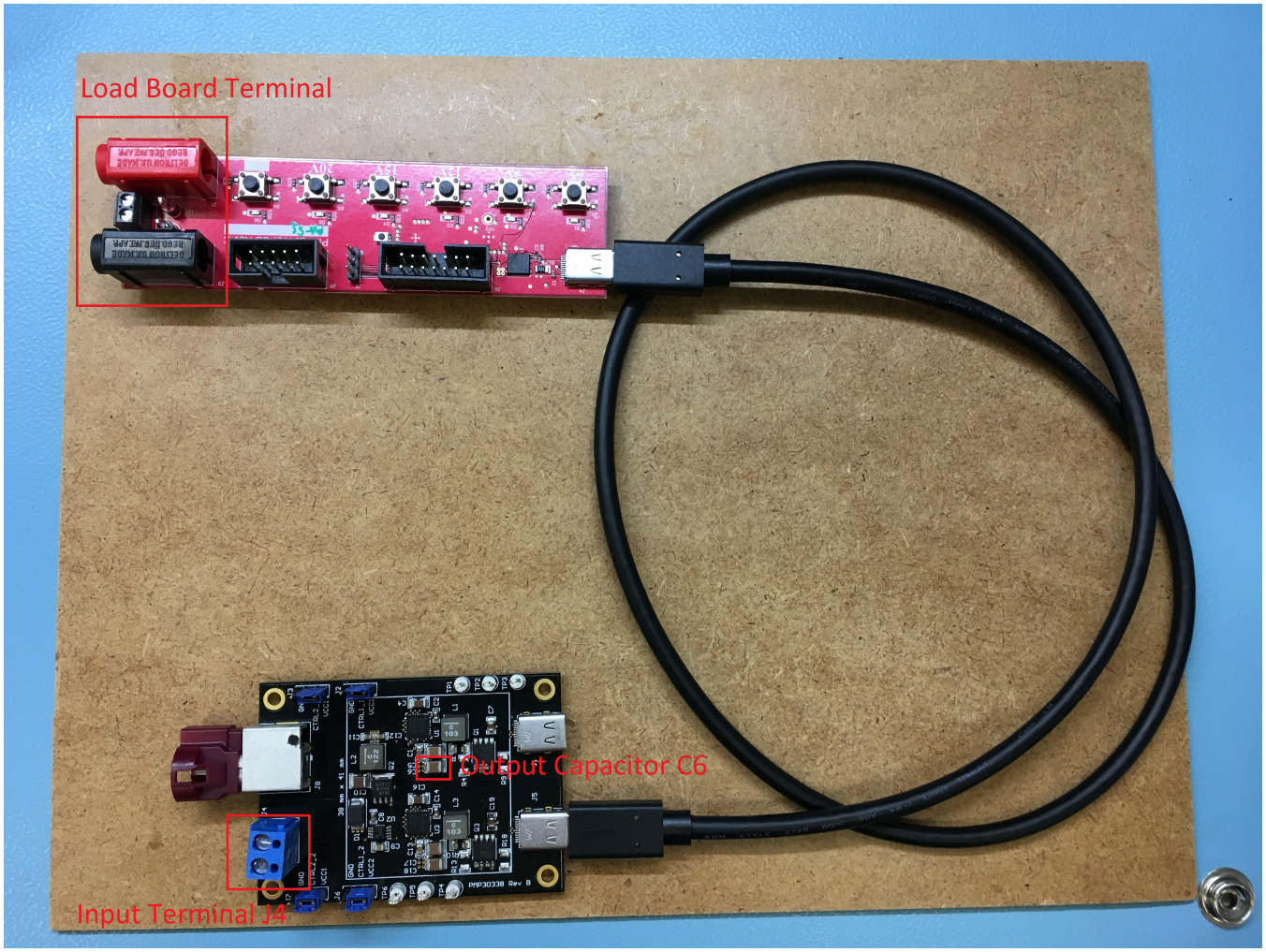
2 Testing and Results

The efficiency and load regulation measurements were made with the USB Type-C to Type-C plug cable attached to the PMP30338 and the PMP20413 load board. The input voltage was measured at J4. The output voltage was measured at C6 for the true converter efficiency and at the test points of the load board to showcase the effect of the output droop compensation of the TPS25830-Q1.

Figure 1. PMP30338 Measurement Setup



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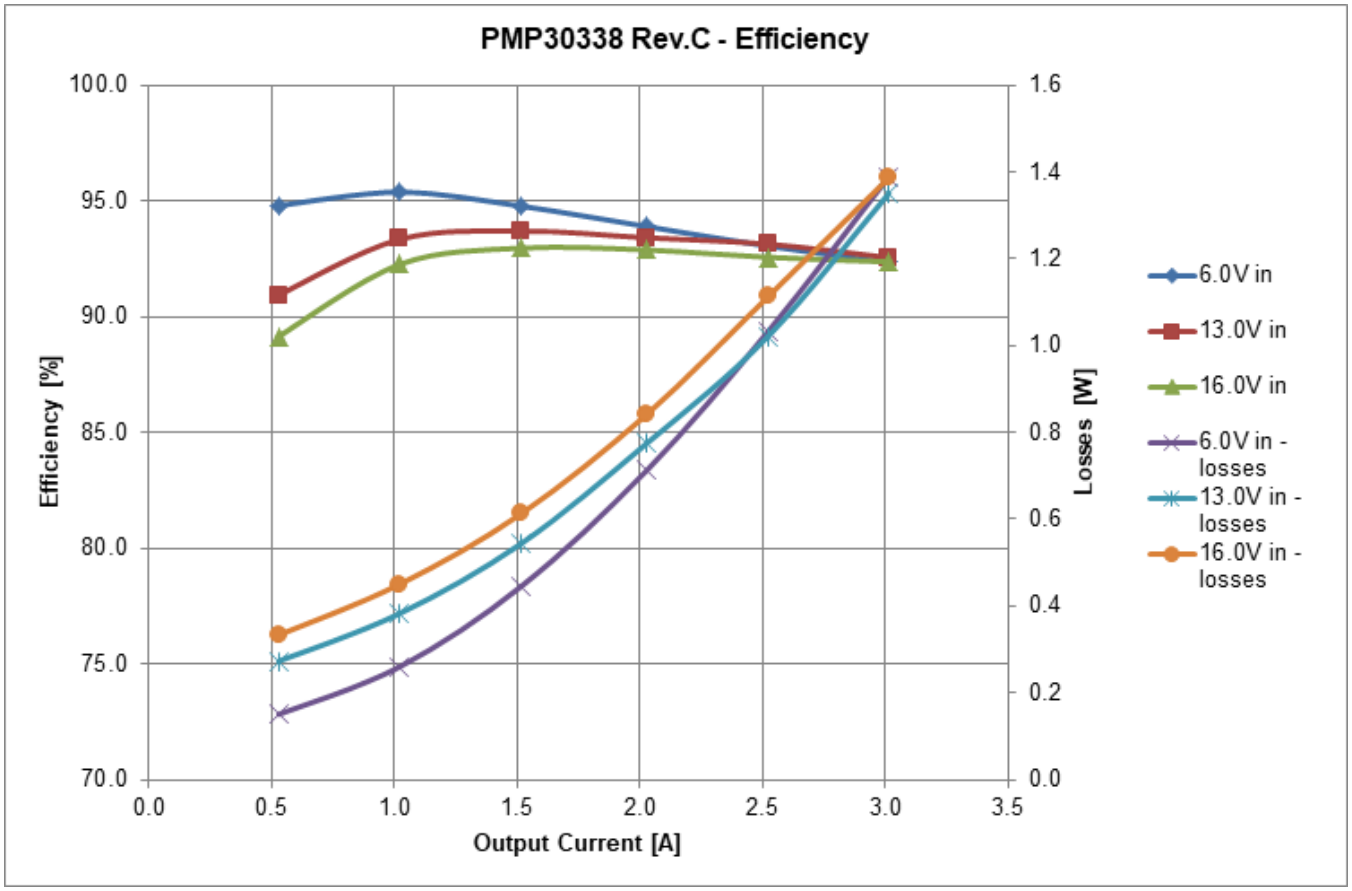
2.1 Efficiency Graphs



2.2 Efficiency Data

Voltage [V]	Current [A]	Power [W]	Voltage [V]	Current [A]	Power [W]	Losses [W]	Efficiency [%]
6.022	3.011	18.132	5.557	3.013	16.743	1.389	92.3
6.025	2.463	14.840	5.477	2.521	13.808	1.032	93.0
6.027	1.934	11.656	5.402	2.026	10.944	0.712	93.9
6.042	1.411	8.525	5.326	1.517	8.080	0.446	94.8
6.045	0.931	5.628	5.252	1.022	5.368	0.260	95.4
6.058	0.476	2.884	5.177	0.528	2.733	0.150	94.8

Voltage [V]	Current [A]	Power [W]	Voltage [V]	Current [A]	Power [W]	Losses [W]	Efficiency [%]
13.020	1.392	18.124	5.567	3.013	16.773	1.350	92.5
13.027	1.141	14.864	5.491	2.521	13.843	1.021	93.1
13.031	0.901	11.741	5.413	2.026	10.967	0.774	93.4
13.043	0.662	8.634	5.333	1.517	8.090	0.544	93.7
13.047	0.441	5.754	5.255	1.022	5.371	0.383	93.3
13.072	0.230	3.007	5.178	0.528	2.734	0.273	90.9

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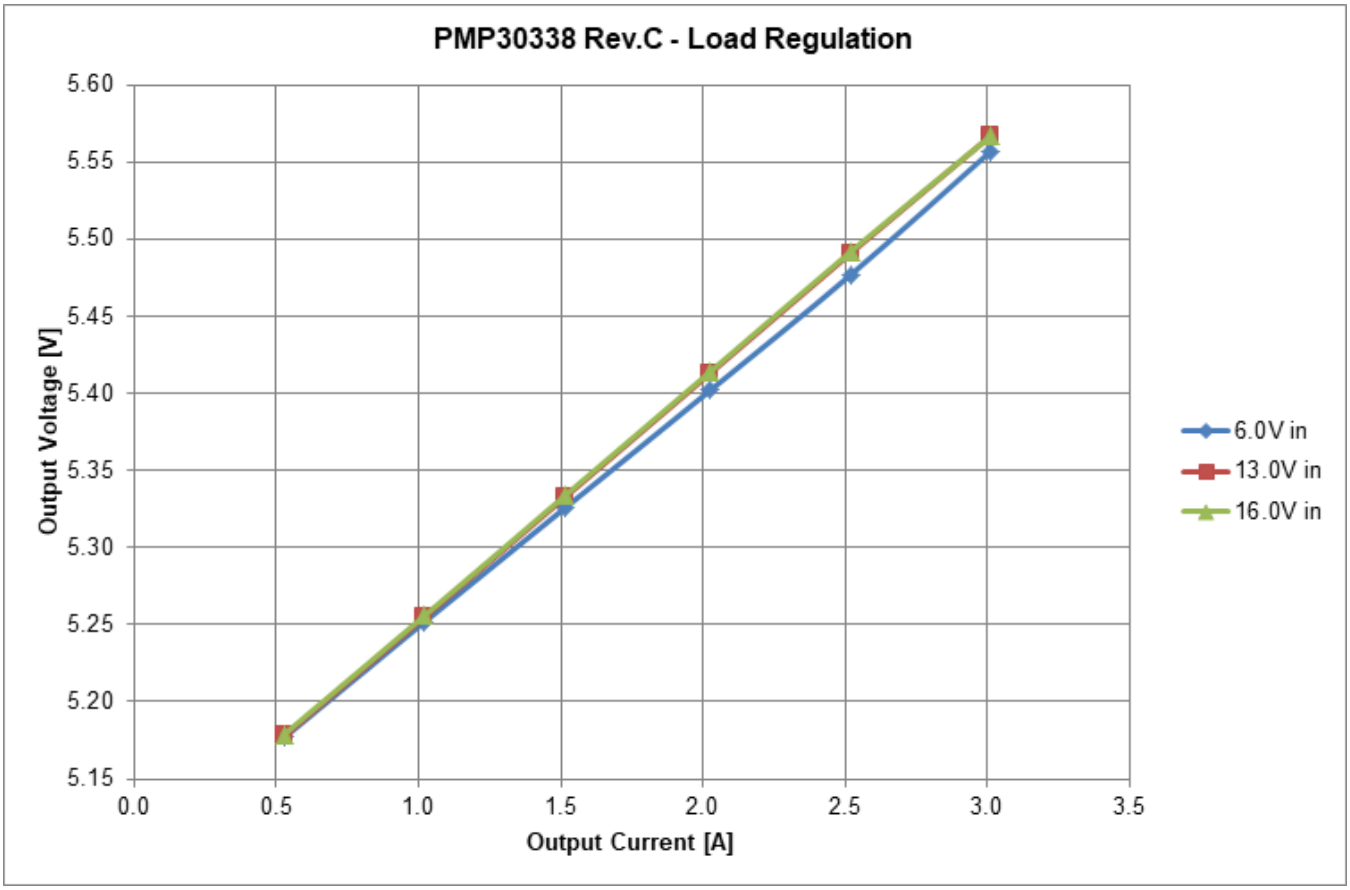
Voltage [V]	Current [A]	Power [W]	Voltage [V]	Current [A]	Power [W]	Losses [W]	Efficiency [%]
16.014	1.134	18.160	5.567	3.013	16.773	1.387	92.4
16.015	0.934	14.958	5.492	2.521	13.845	1.113	92.6
16.024	0.737	11.810	5.414	2.026	10.969	0.841	92.9
16.031	0.543	8.705	5.334	1.517	8.092	0.613	93.0
16.039	0.363	5.822	5.256	1.022	5.372	0.451	92.3
16.060	0.191	3.067	5.179	0.528	2.735	0.333	89.1

2.3 Load Regulation



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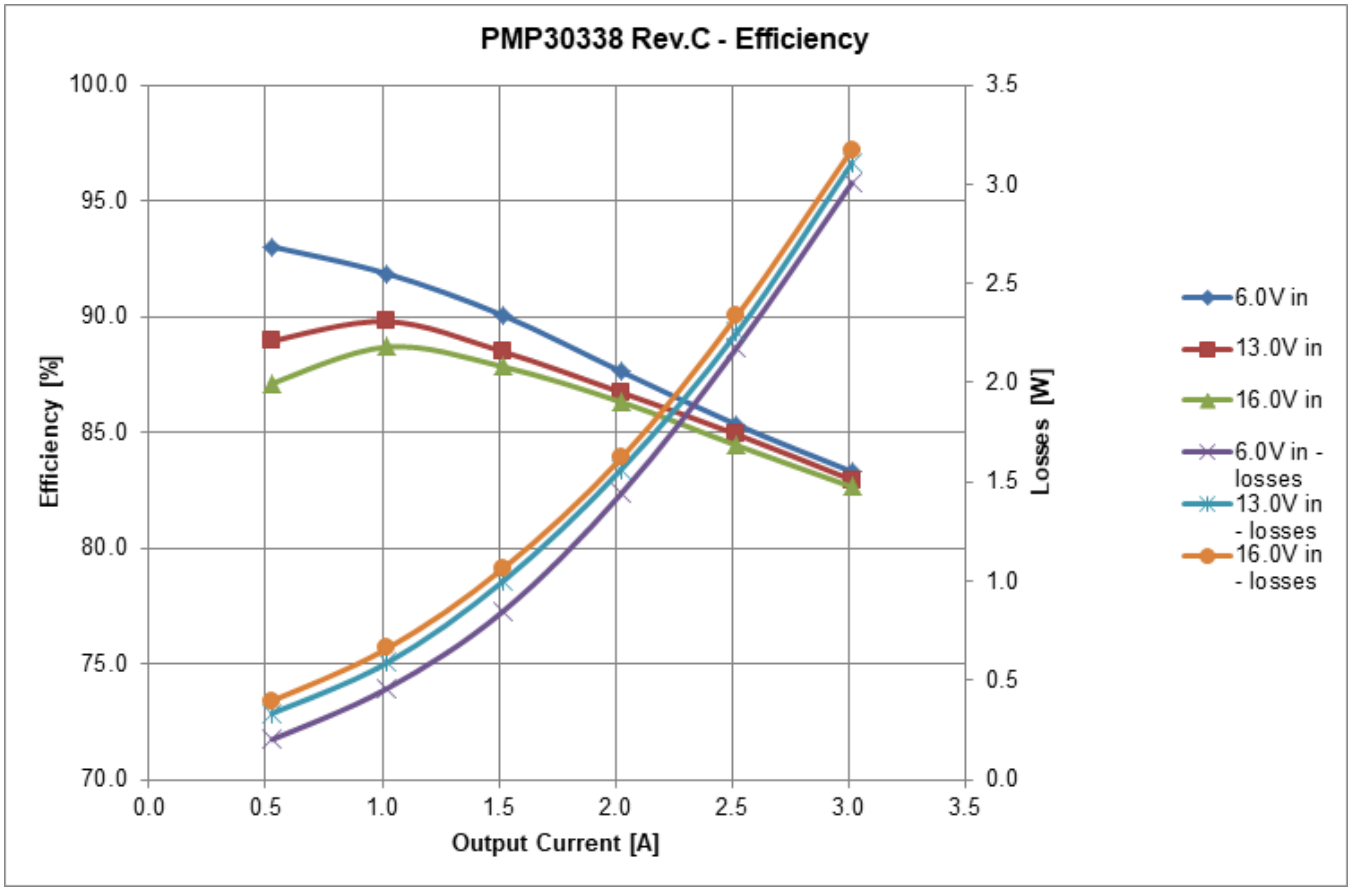
2.4 Efficiency Graphs Including USB Cable and Load Board



2.5 Efficiency Data Including USB Cable and Load Board

Voltage [V]	Current [A]	Power [W]	Voltage [V]	Current [A]	Power [W]	Losses [W]	Efficiency [%]
6.044	2.980	18.011	4.980	3.013	15.005	3.006	83.3
6.048	2.453	14.836	5.021	2.521	12.658	2.178	85.3
6.154	1.893	11.650	5.038	2.026	10.207	1.443	87.6
6.157	1.383	8.515	5.055	1.517	7.668	0.847	90.1
6.152	0.917	5.641	5.070	1.022	5.182	0.460	91.8
6.140	0.470	2.886	5.084	0.528	2.684	0.201	93.0

Voltage [V]	Current [A]	Power [W]	Voltage [V]	Current [A]	Power [W]	Losses [W]	Efficiency [%]
13.000	1.401	18.213	5.014	3.013	15.107	3.106	82.9
13.050	1.144	14.929	5.028	2.521	12.676	2.254	84.9
13.100	0.899	11.782	5.043	2.026	10.217	1.565	86.7
13.150	0.659	8.670	5.057	1.517	7.671	0.998	88.5
13.190	0.438	5.772	5.071	1.022	5.183	0.589	89.8
13.230	0.228	3.018	5.084	0.528	2.684	0.333	89.0

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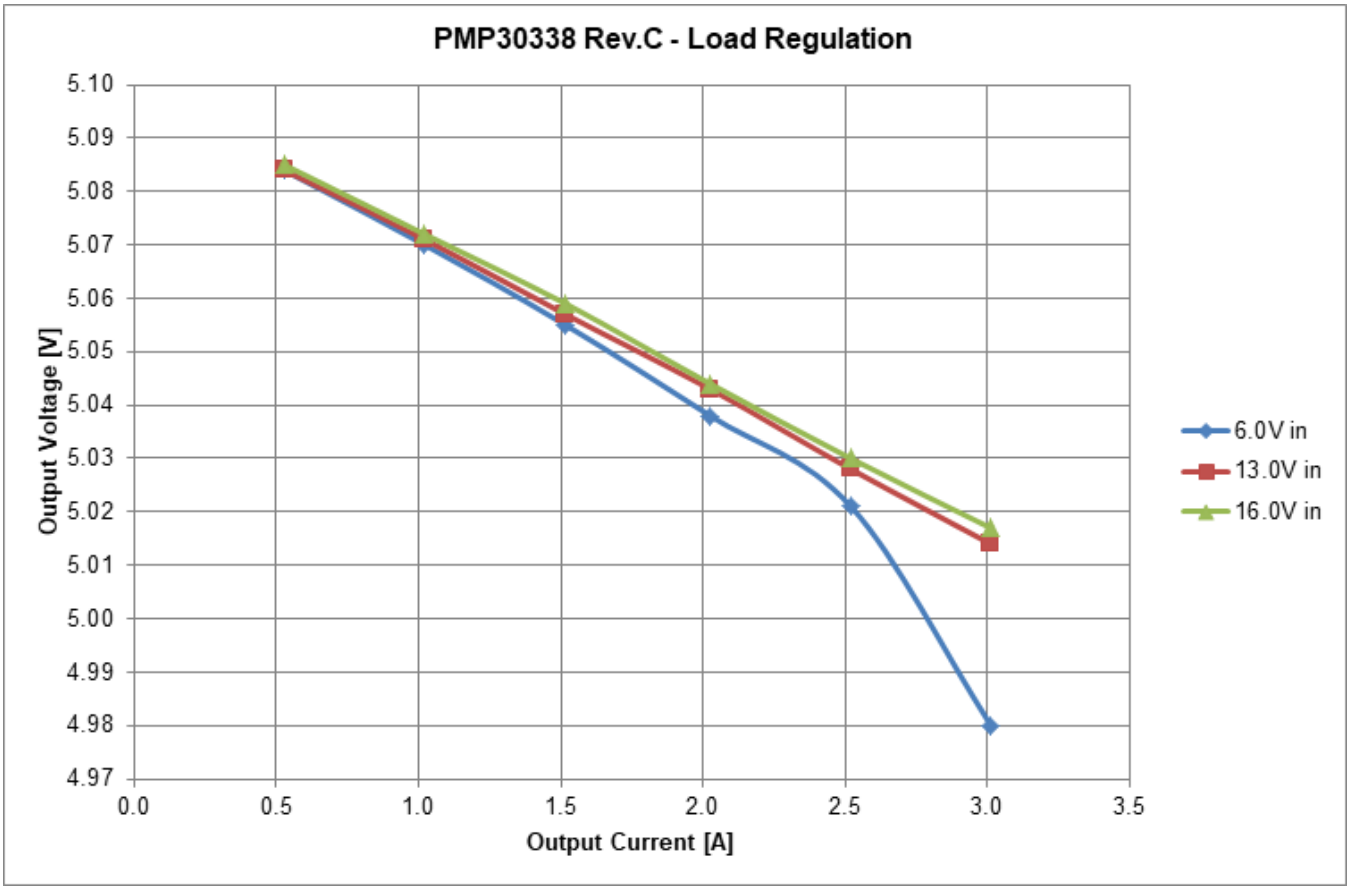
Voltage [V]	Current [A]	Power [W]	Voltage [V]	Current [A]	Power [W]	Losses [W]	Efficiency [%]
16.030	1.141	18.290	5.017	3.013	15.116	3.174	82.6
16.080	0.934	15.019	5.030	2.521	12.681	2.338	84.4
16.110	0.735	11.841	5.044	2.026	10.219	1.622	86.3
16.150	0.541	8.737	5.059	1.517	7.675	1.063	87.8
16.190	0.361	5.845	5.072	1.022	5.184	0.661	88.7
16.220	0.190	3.082	5.085	0.528	2.685	0.397	87.1

2.6 Load Regulation Including USB Cable and Load Board



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2.7 Thermal Images

Figure 2. Thermal Image of the PCB's Top Side at 13.0-V in and 3.0-A Load Current at Both USB Type-C Charger Outputs (Top/Bottom Layers are 2 oz)

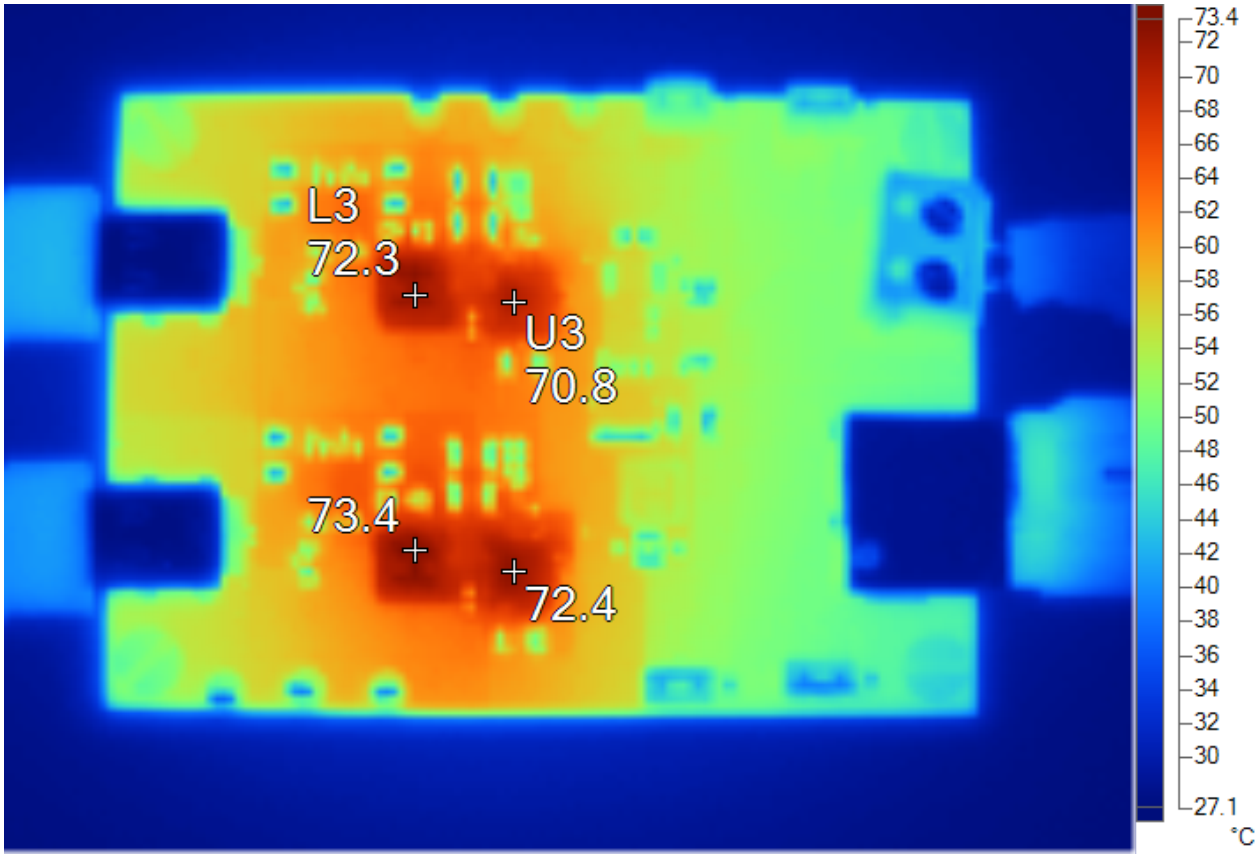

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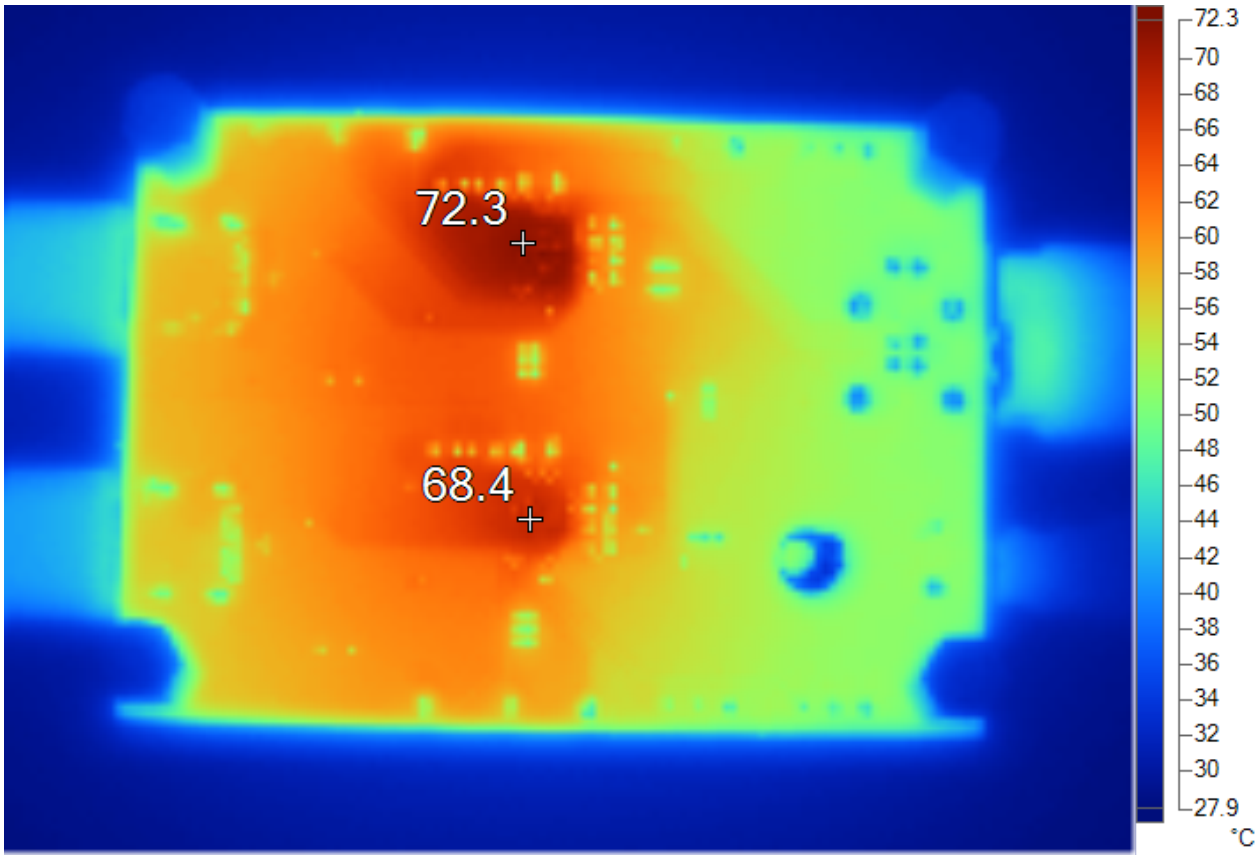
Figure 3. Thermal Image of the PCB's Bottom Side at 13.0-V in and 3.0-A Load Current at Both USB Type-C Charger Outputs (Top/Bottom Layers are 2 oz)



2.8 Dimensions

PCB: 70 mm x 50 mm

Circuit: 38 mm x 41mm

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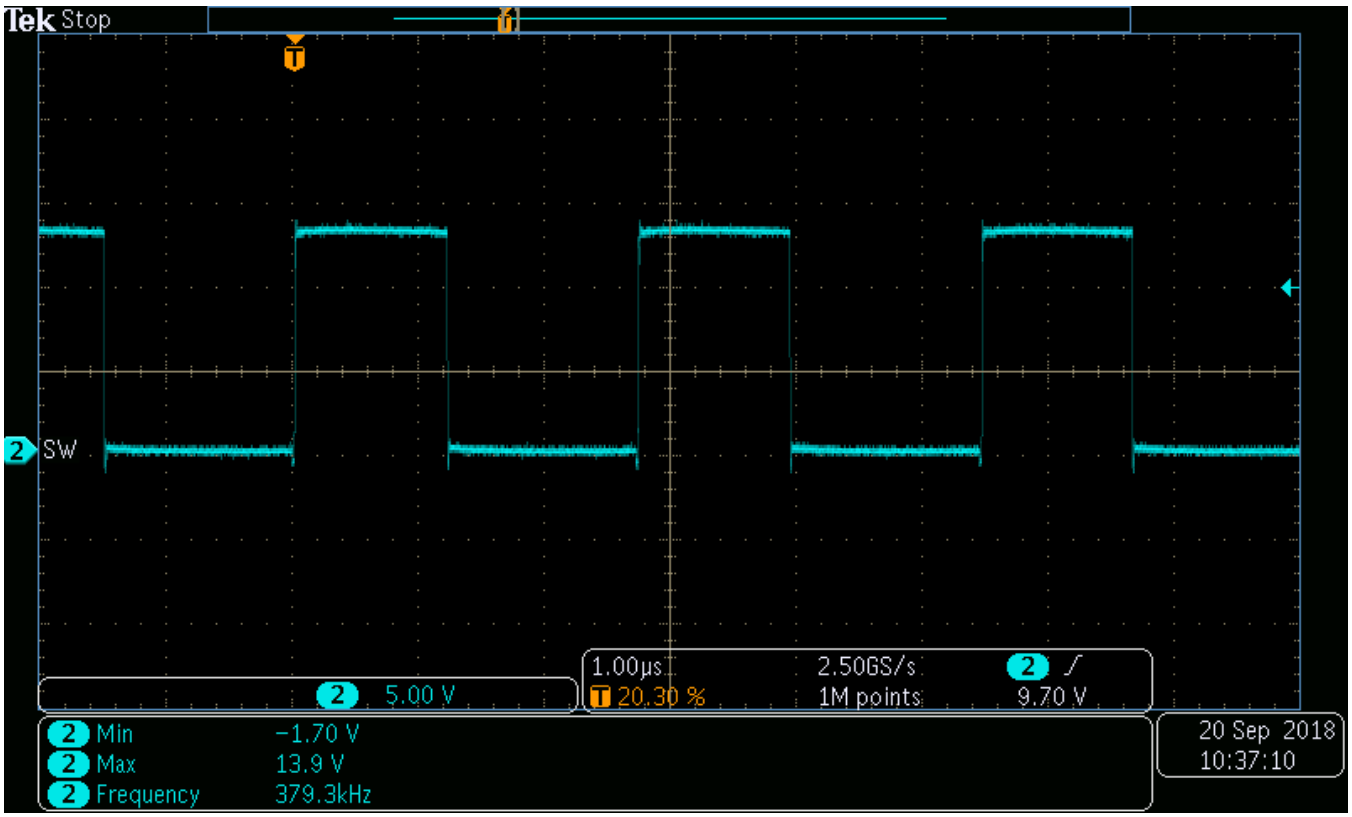
3 Waveforms

3.1 Switching

Figure 4. Switching Node of U1 at 13.0-V in and 3.0-A Load Current



- Ch2: Switching Node of U1 [scale: 5.0 V/div, 1.0 us/div]

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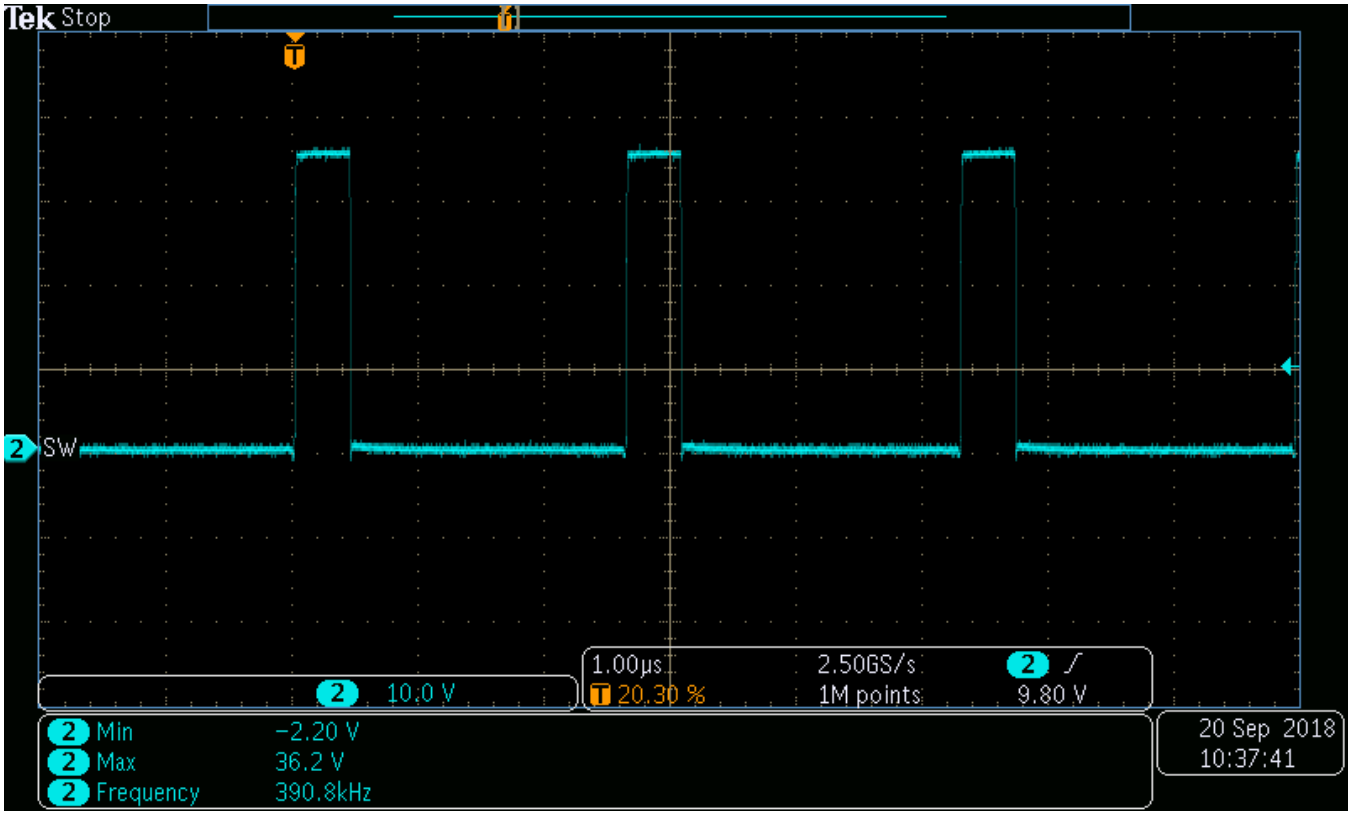
Figure 5. Switching Node of U1 at 36.0-V in and 3.0-A Load Current



Ch2: Switching Node of U1 [scale: 10.0 V/div, 1.0 us/div]

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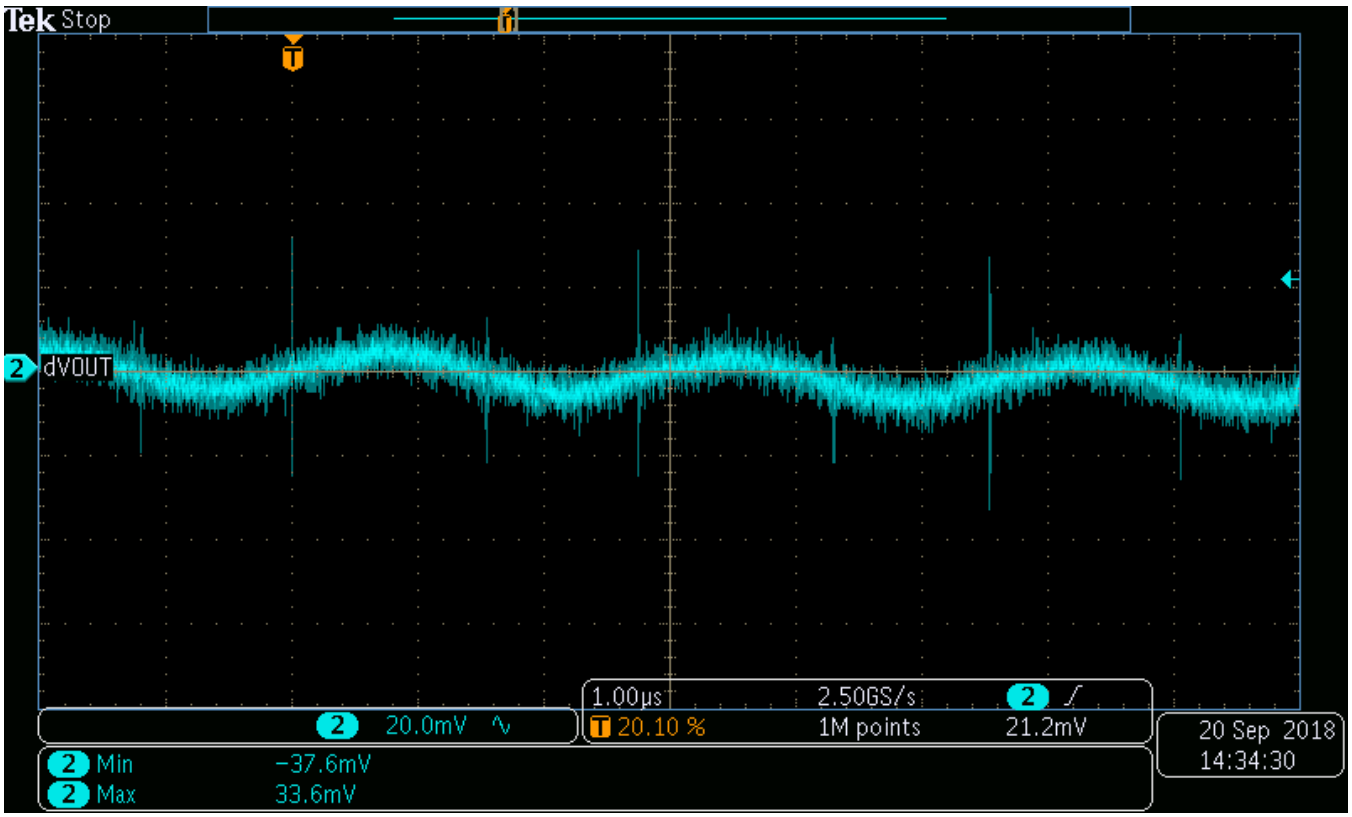
3.2 Output Voltage Ripple

Figure 6. AC-Coupled Output Voltage Signal at 13.0-V in Measured at C6



Ch2: 13.0-V in, 71.2-mV peak-peak ripple (1.4%) [scale: 20.0 mV/div, 1.0 us/div]

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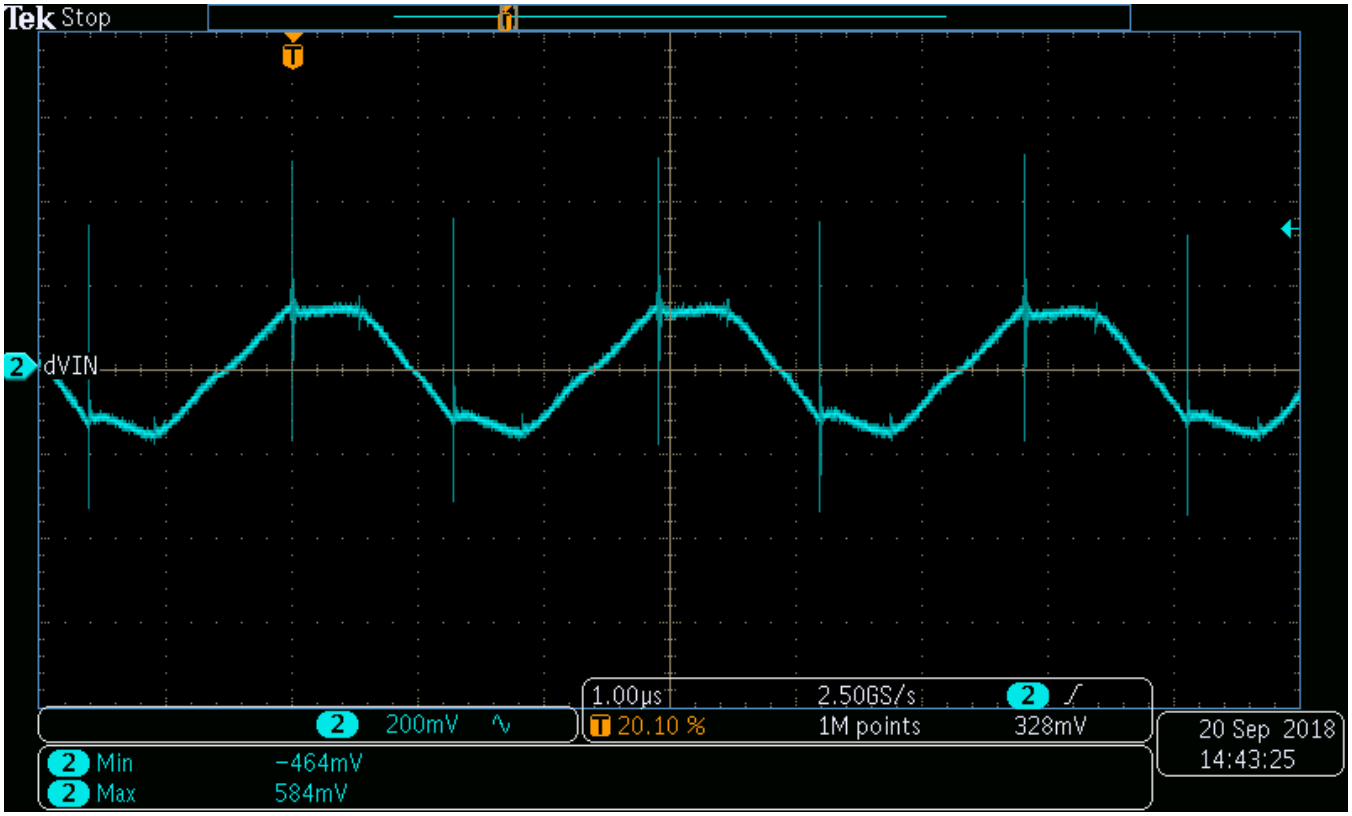
3.3 Input Voltage Ripple

Figure 7. AC-Coupled Input Voltage Signal at 13.0-V in and Both TPS25830-Q1 Operating at 3.0-A Load Current Measured Directly at the Input Capacitor C4



- Ch2: 13.0-V in, 1.05-V peak-peak ripple [scale: 200 mV/div, 1.0 us/div]

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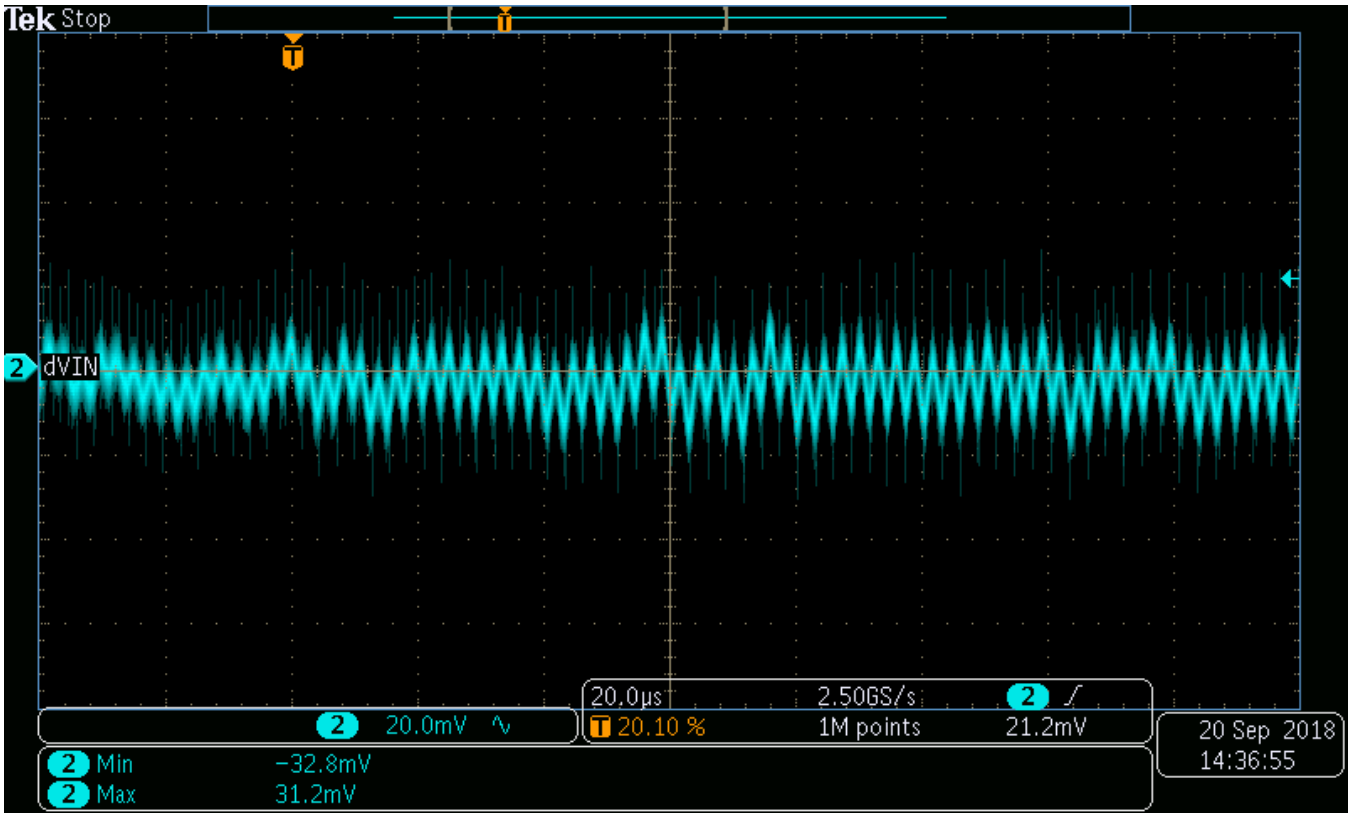
Figure 8. AC-Coupled Input Voltage Signal at 13.0-V in and Both TPS25830-Q1 Operating at 3.0-A Load Current Measured at the Input Filter Capacitor C10



- Ch2: 13.0-V in, 64-mV peak-peak ripple [scale: 20.0 mV/div, 20.0 us/div]

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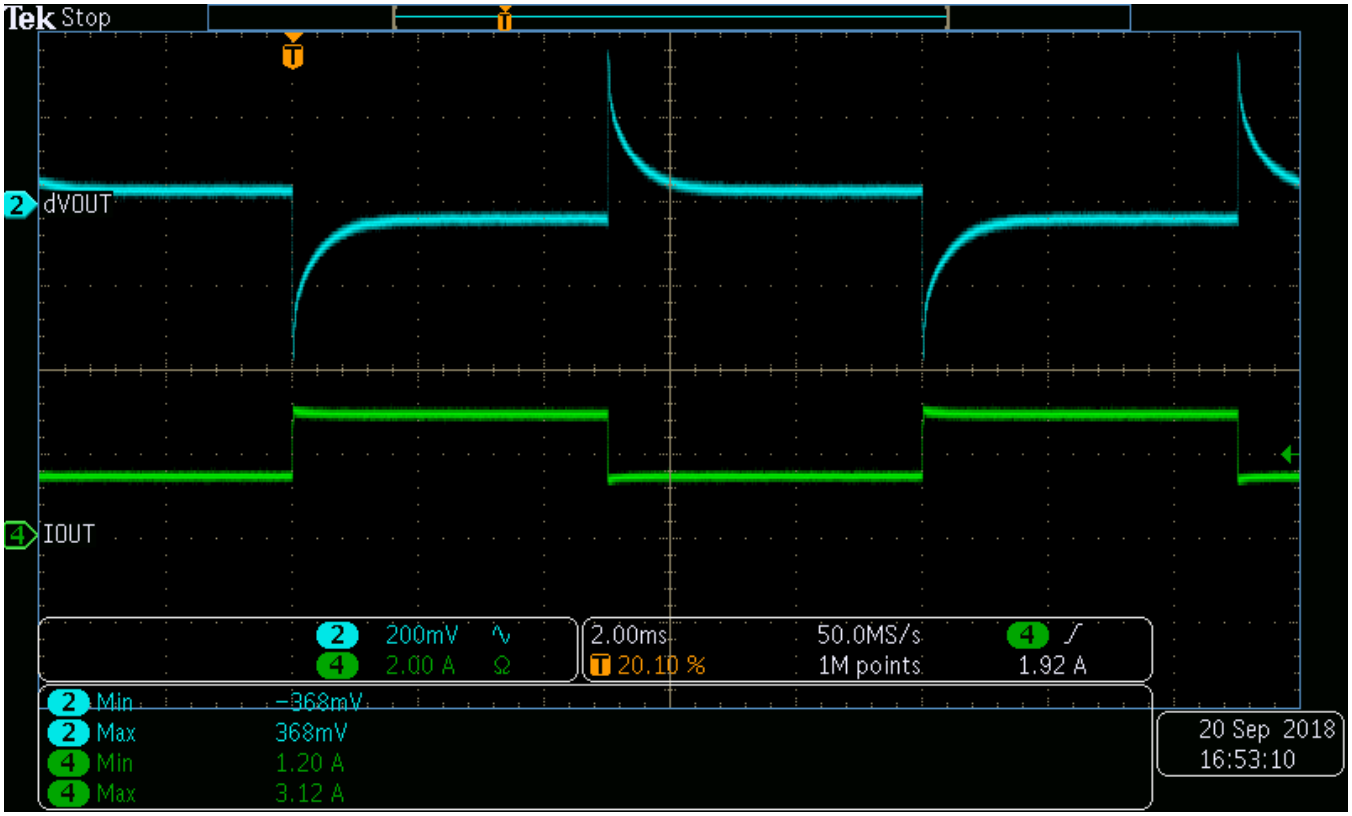
3.4 Load Transients

Figure 9. Load Transient From 1.5 A to 3.0 A at 13.0 V in Results in 368-mV Undershoot and 368-mV Overshoot (Measured at the Terminal of the Load Board)



- Ch2: AC-coupled output voltage at the load board [scale: 200 mV/div, 2.0 ms/div]
- Ch4: output current [scale: 2.0 A/div, 2.0 ms/div]

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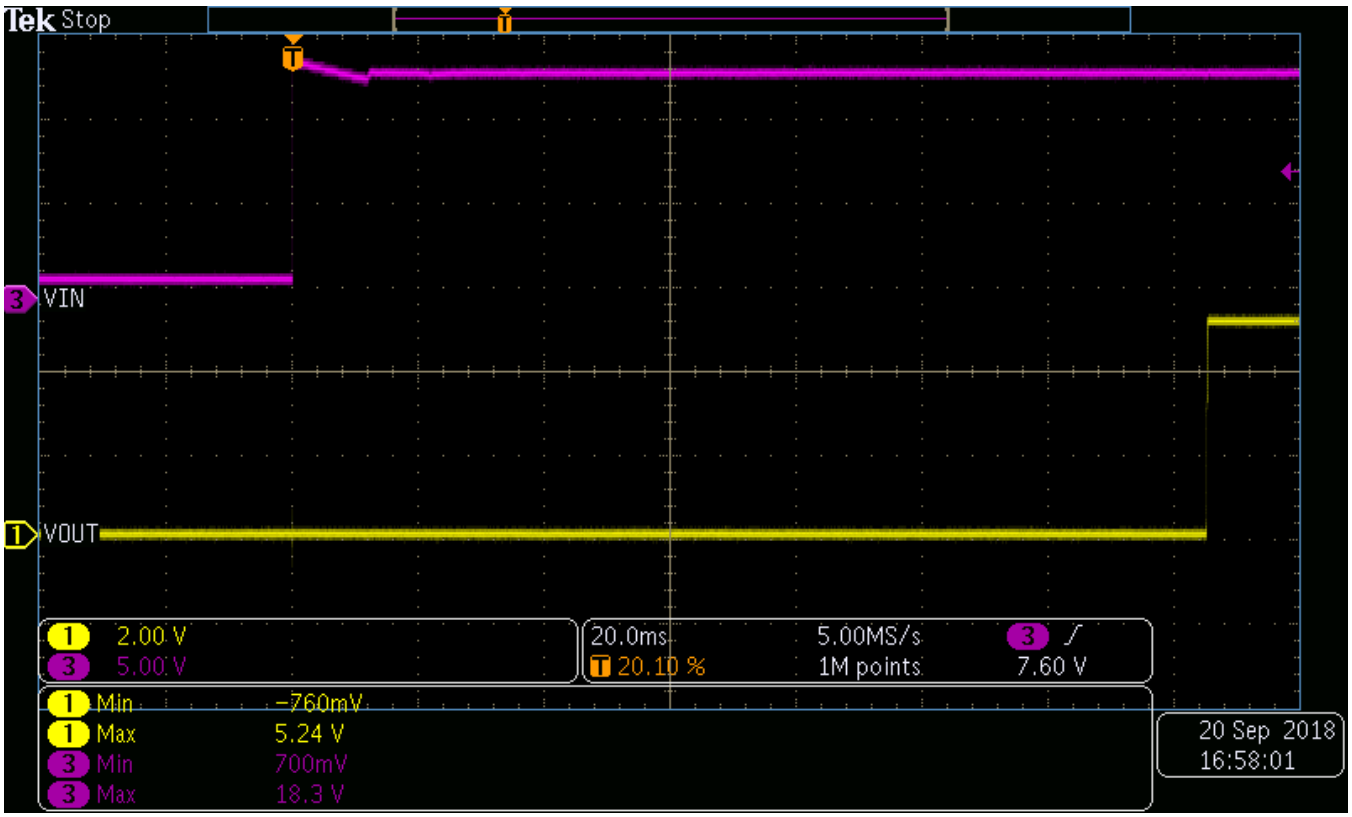
3.5 Start-up Sequence

Figure 10. Start-up Sequence at 13.0-V in With No Load Attached



- Ch1: output voltage at the load board [scale: 2.0 V/div, 20.0 ms/div]
- Ch3: input voltage [scale: 5.0 V/div, 20.0 ms/div]

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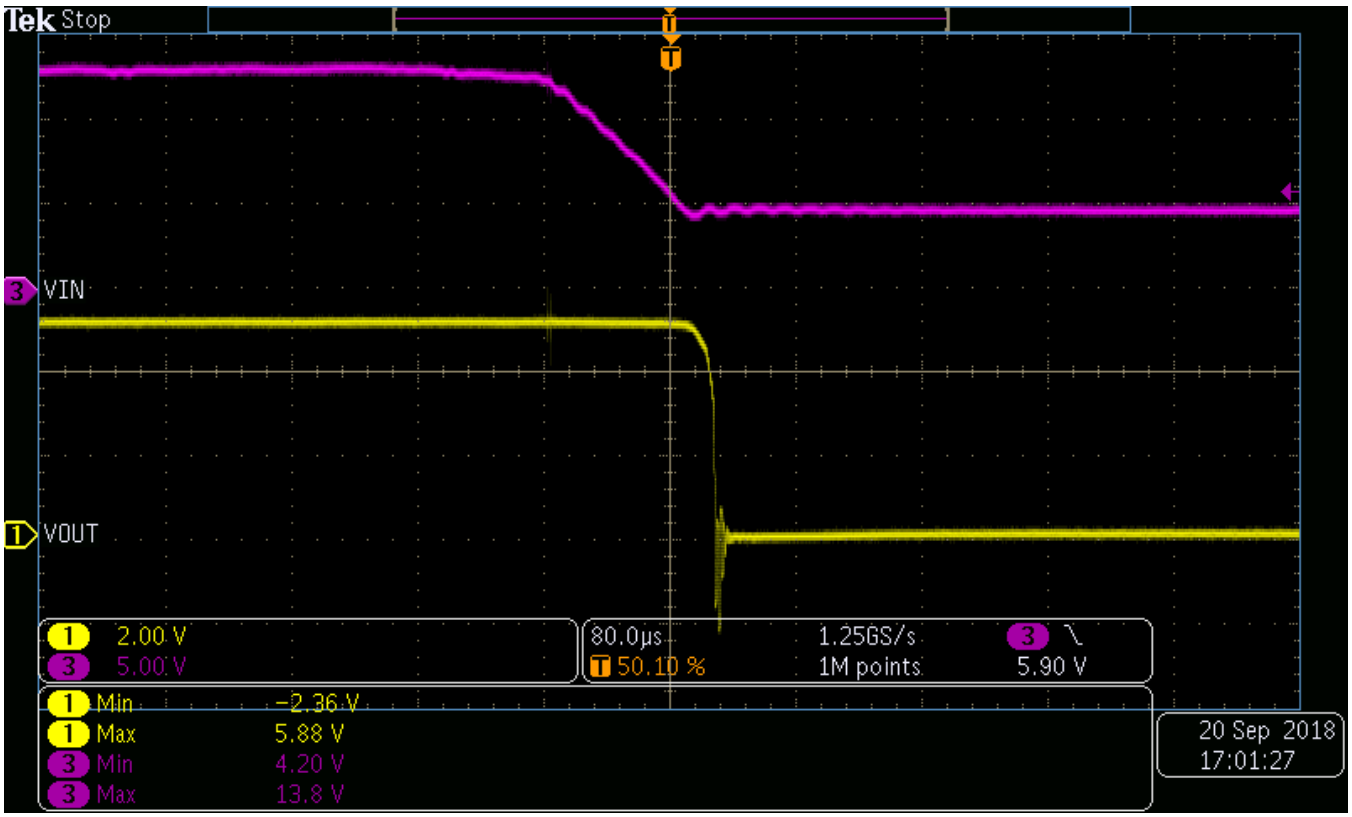
3.6 Undervoltage Protection

Figure 11. Undervoltage Protection With 3.0-A Load Attached



- Ch1: output voltage at the load board [scale: 2.0 V/div, 80.0 us/div]
- Ch3: input voltage [scale: 5.0 V/div, 80.0 us/div]

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