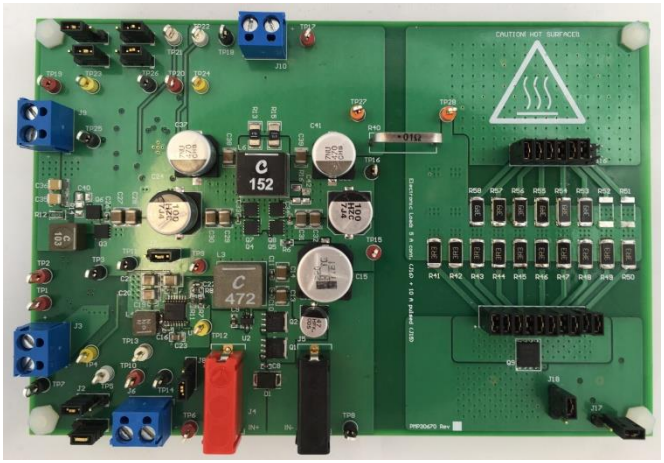
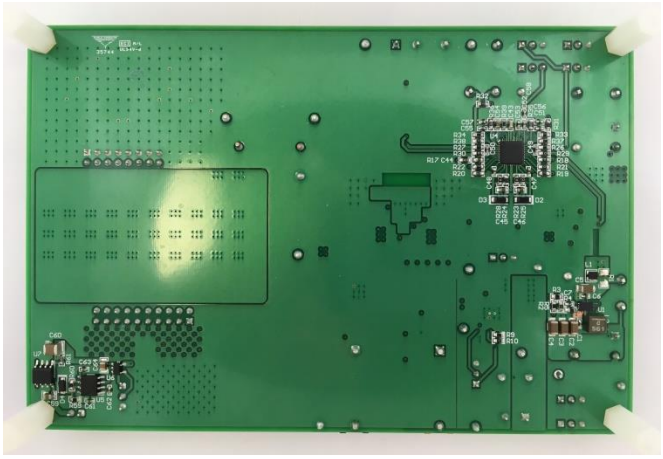
Test Report: PMP30670

Automotive Wide VIN Front-End Reference Design for Digital Cockpit Processing Unit

Description

This reference design shows a complete power tree for automotive digital cockpit applications. The LM74700-Q1 provides low-loss reverse polarity protection to the system, followed by an input filter. The LM5143-Q1 dual-synchronous buck converter provides a 3.3 V rail, which can support up to 15 A for a processor module, and a 5 V rail with 3 A from KL30. The TPS62810 synchronous buck converter provides a 1.1 V/3 A rail from the 5 V output. Another independent 3.3 V rail with 3 A from KL30 is provided by the LM63635-Q1 synchronous buck converter.





1 Test Prerequisites

1.1 Voltage and Current Requirements

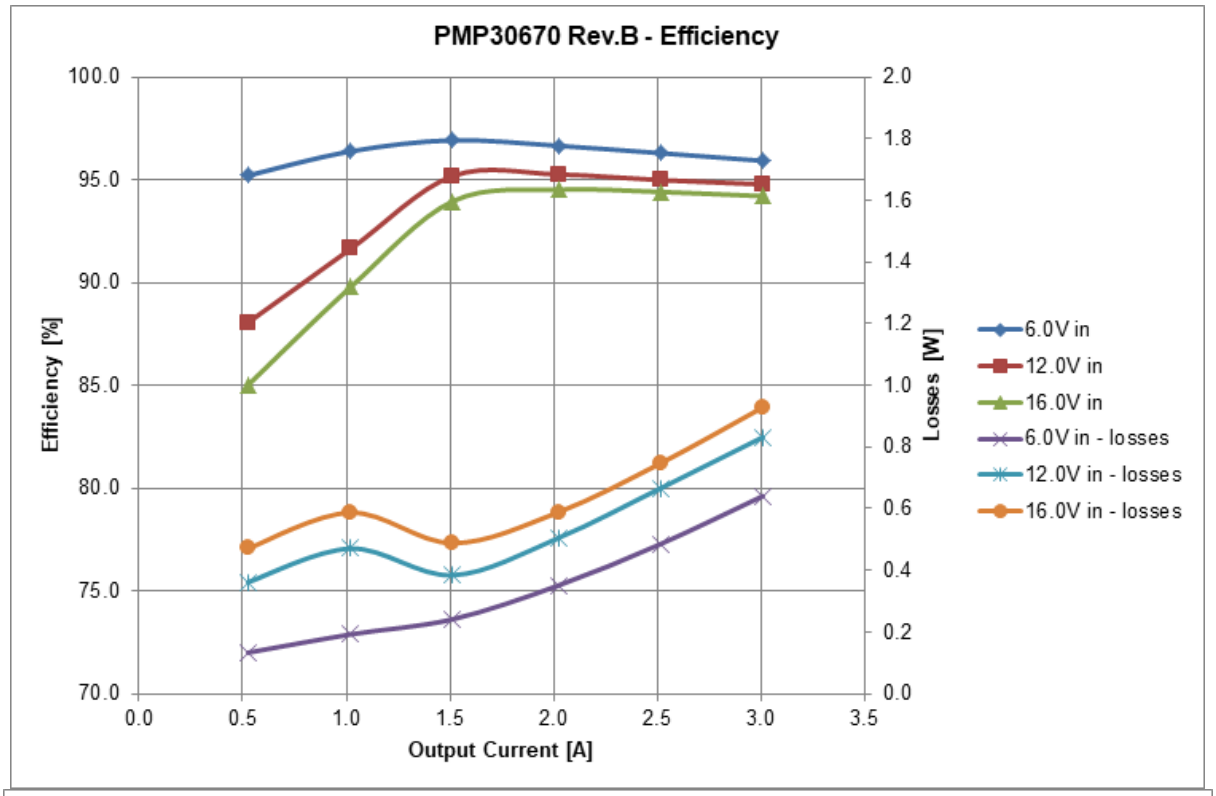
Table 1. Voltage and Current Requirements

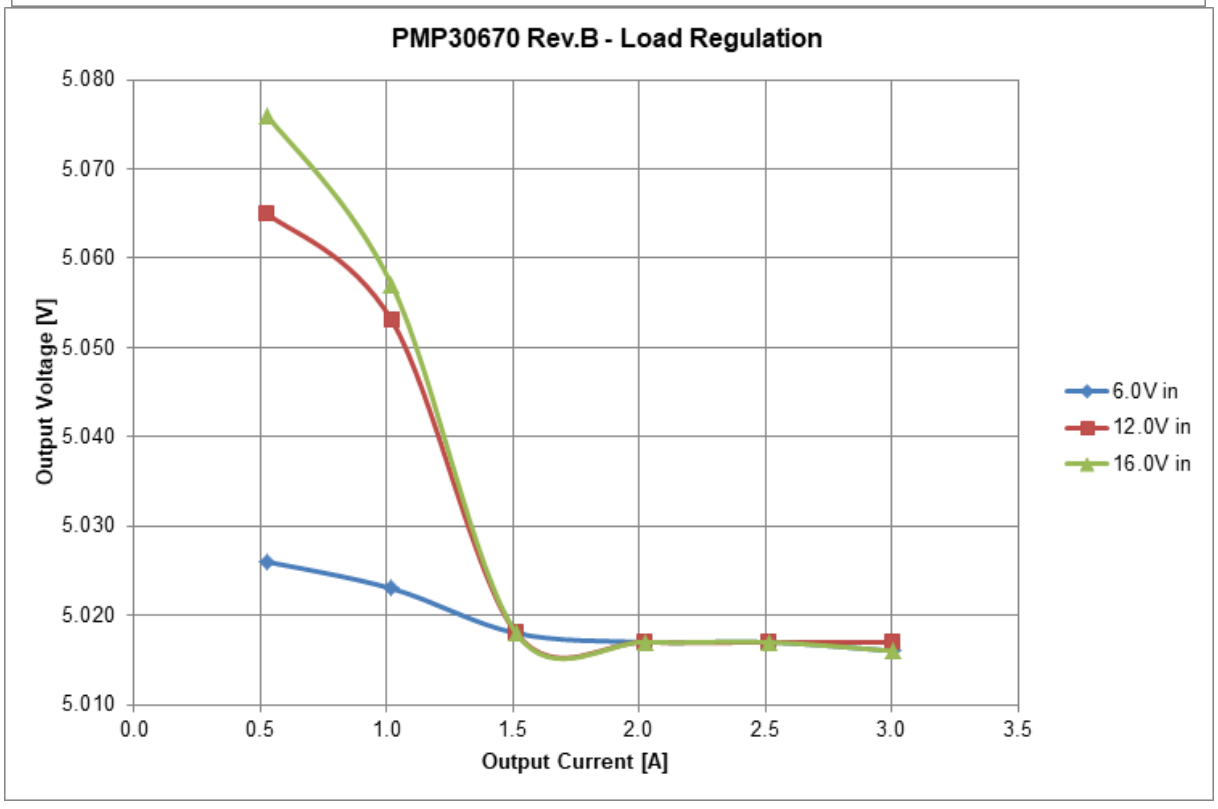
PARAMETER	SPECIFICATIONS
V_{IN}	6.0 V -16.0 V, 12.0 V nom., 36.0V peak
V_{OUT} LM5143-Q1 Buck1	5.0 V @ 3.0 A
V_{OUT} LM5143-Q1 Buck2	3.3 V @ 15.0 A
V_{OUT} LM63635-Q1	3.3 V @ 3.0 A
V_{IN} TPS62810-Q1	LM5143-Q1 Buck1 Output
TPS62810-Q1	1.1 V @ 3.0 A

2 Testing and Results

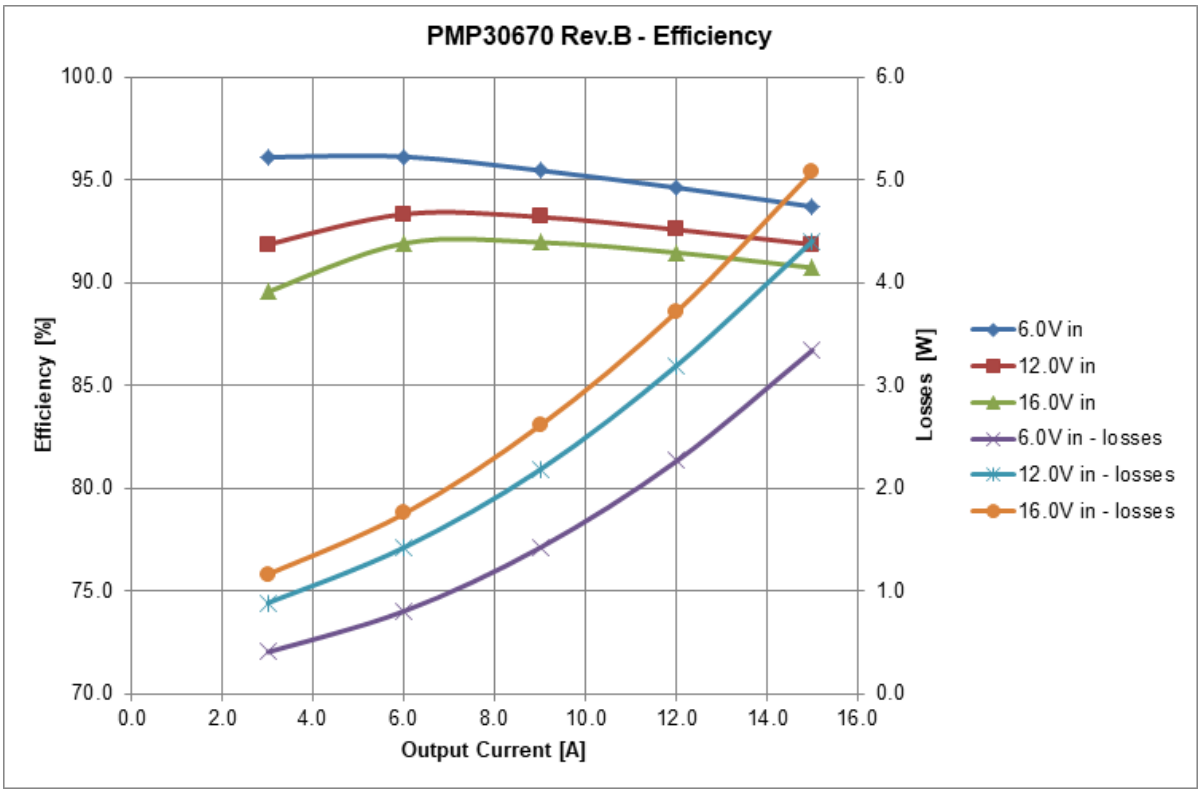
2.1 Efficiency and Load Regulation Graphs

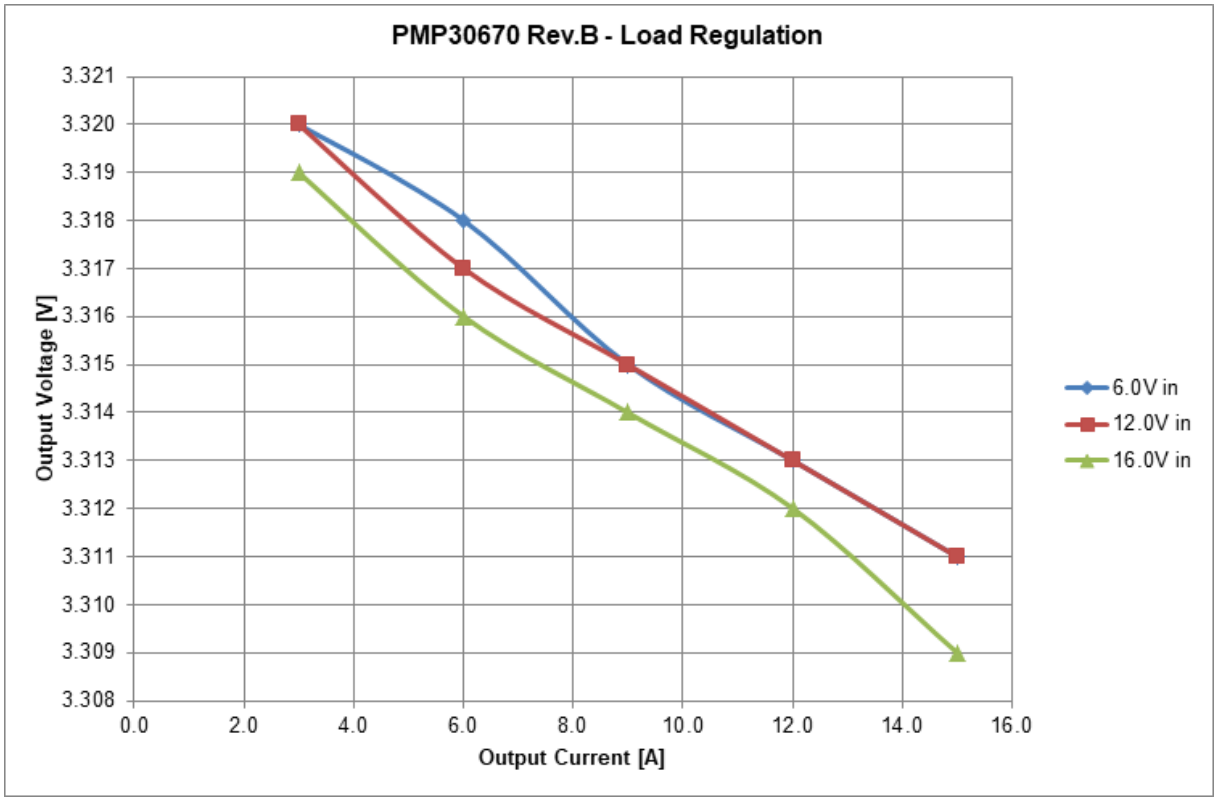
2.1.1 LM5143-Q1 - 5.0V @ 3A



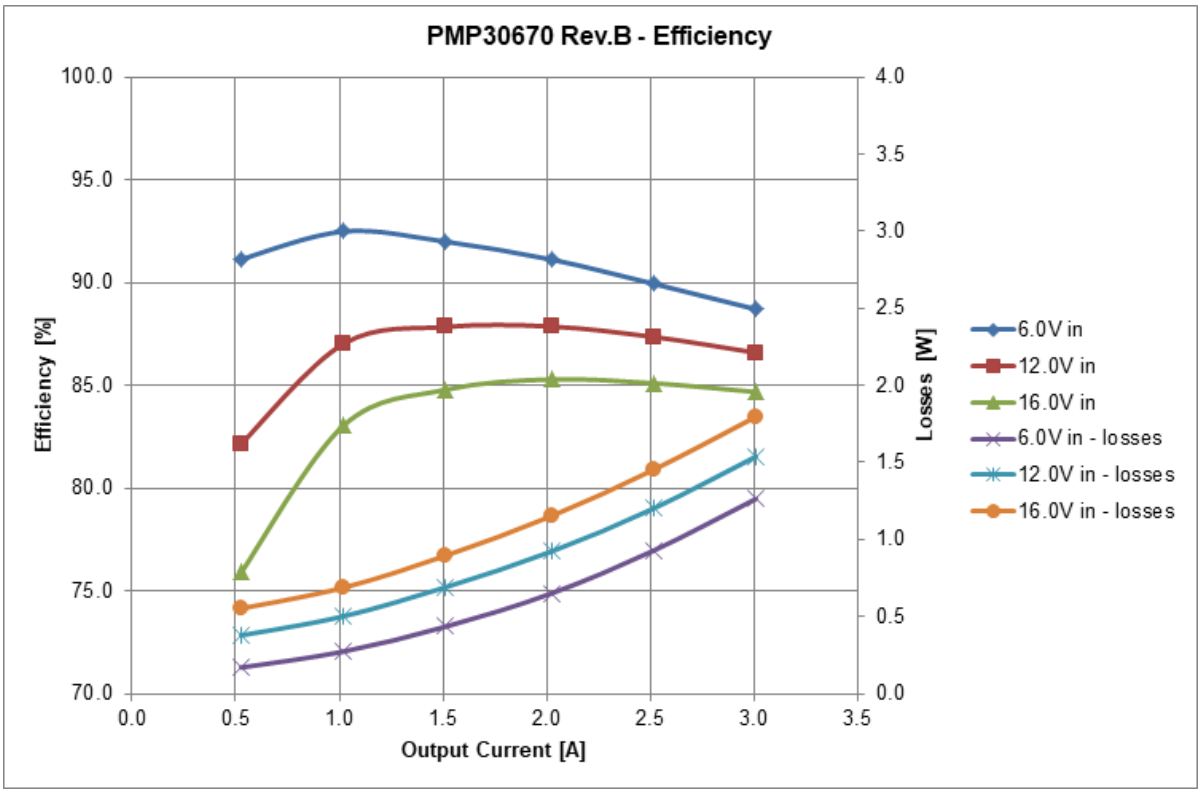


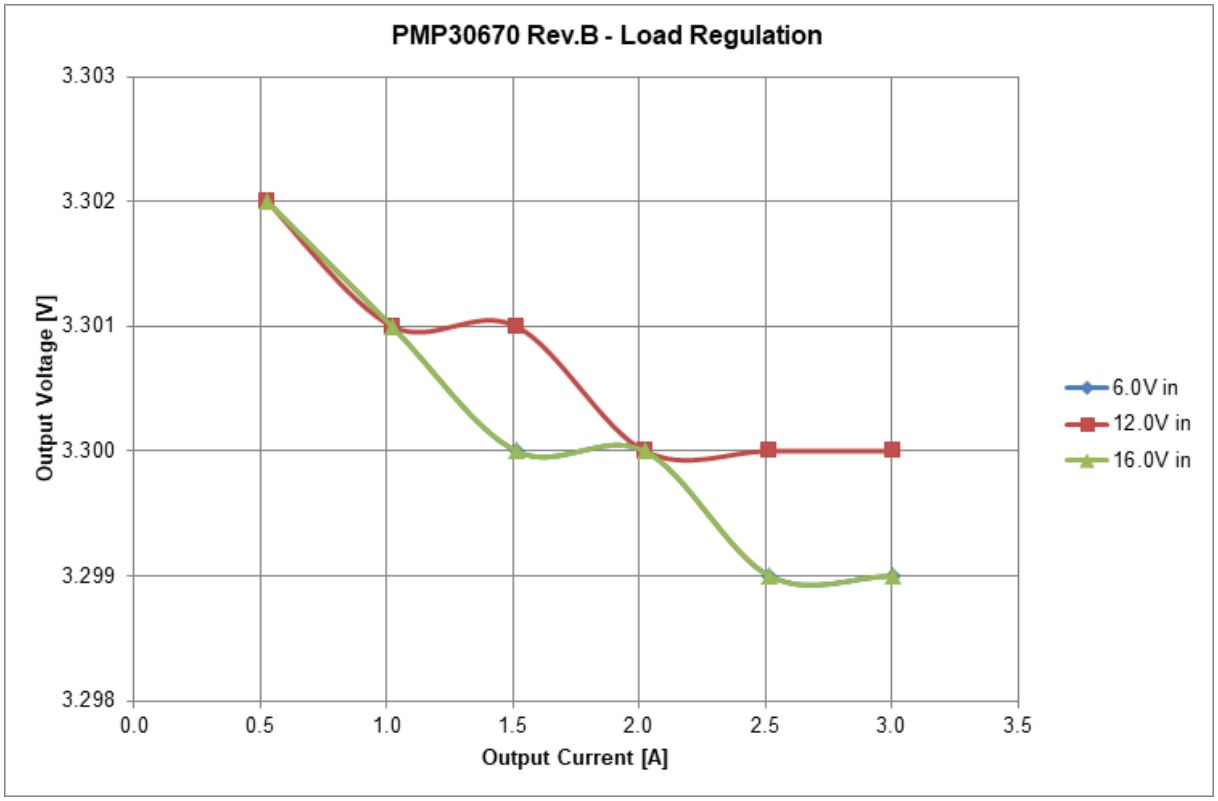
2.1.2 LM5143-Q1 - 3.3V @ 15A



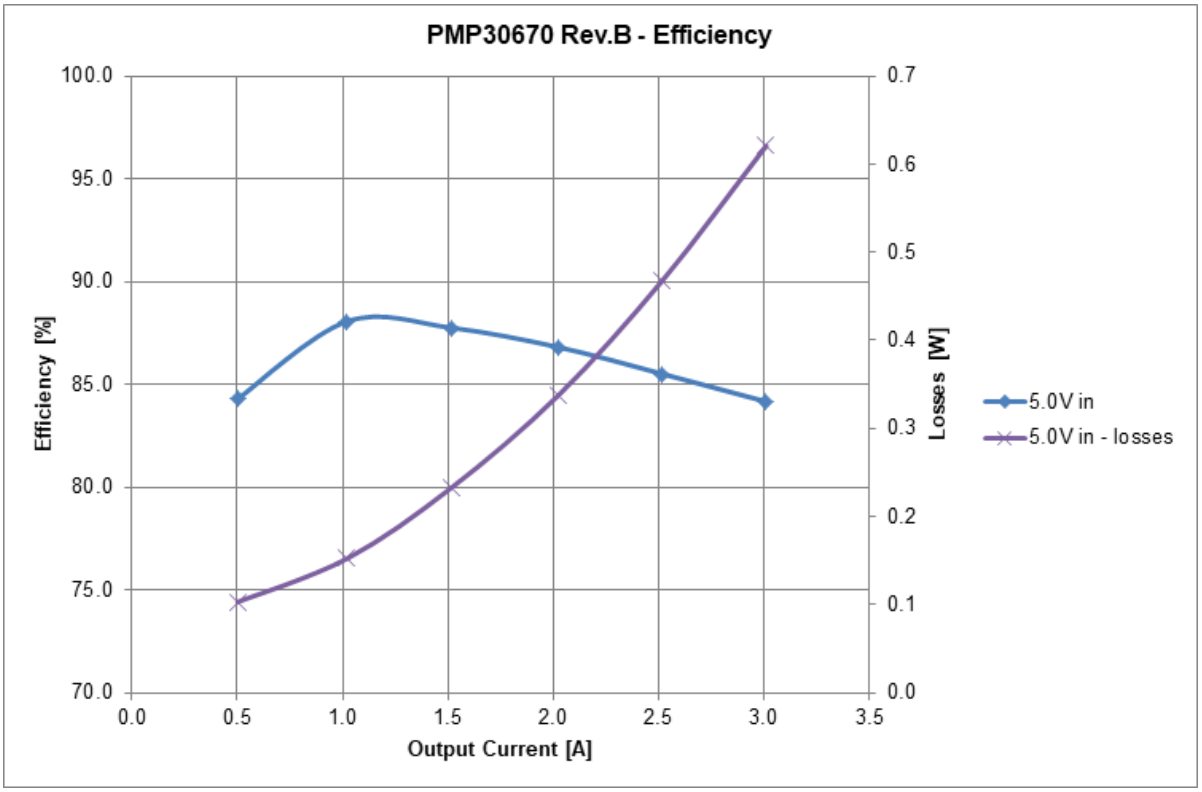


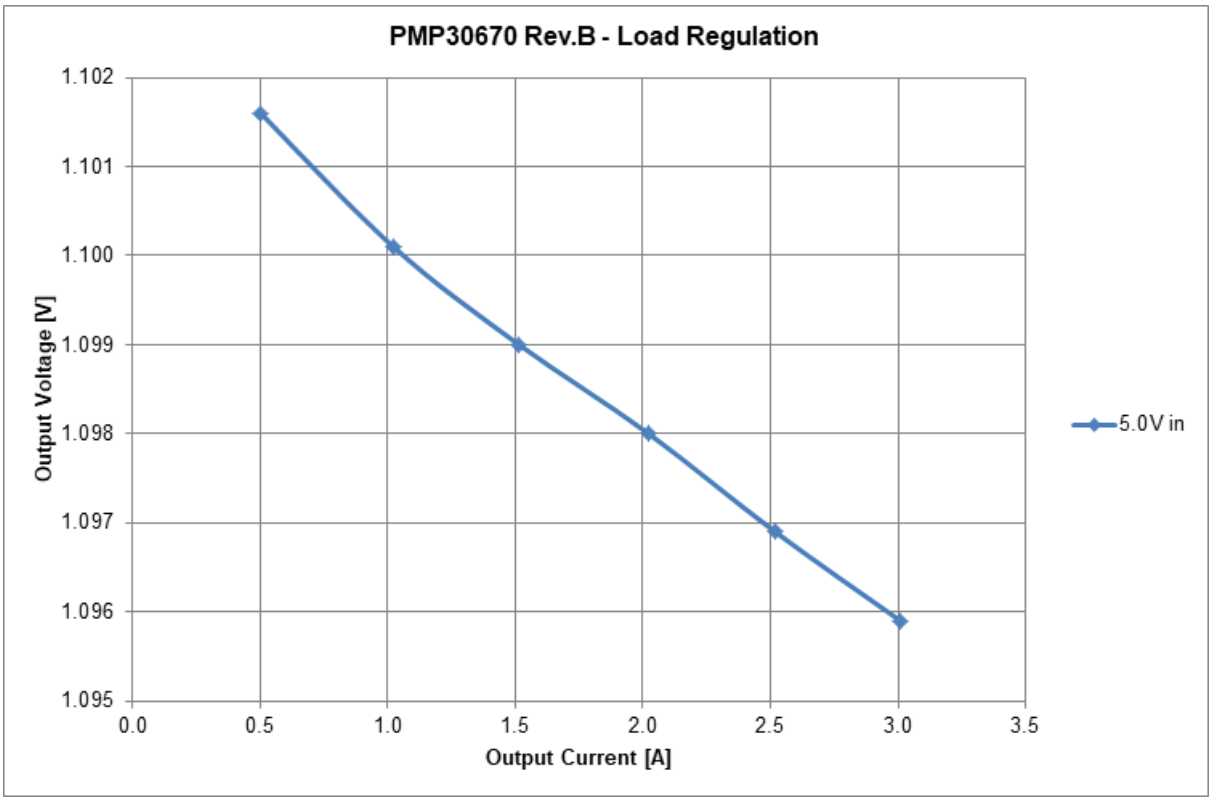
2.1.3 LM63635-Q1 – 3.3V @ 3A





2.1.4 TPS62810-Q1 – 1.1V @ 3A





2.2 Efficiency Data

2.2.1 LM5143-Q1 - 5.0V @ 3A

Voltage [V]	Current [A]	Power [W]	Voltage [V]	Current [A]	Power [W]	Losses [W]	Efficiency [%]
6.001	2.621	15.729	5.016	3.008	15.088	0.641	95.9
6.002	2.184	13.108	5.017	2.516	12.623	0.486	96.3
5.999	1.750	10.495	5.017	2.022	10.144	0.351	96.7
6.011	1.303	7.834	5.018	1.513	7.592	0.241	96.9
6.002	0.886	5.318	5.023	1.020	5.125	0.192	96.4
6.009	0.463	2.781	5.026	0.527	2.648	0.133	95.2

Voltage [V]	Current [A]	Power [W]	Voltage [V]	Current [A]	Power [W]	Losses [W]	Efficiency [%]
12.040	1.323	15.923	5.017	3.008	15.091	0.832	94.8
12.020	1.106	13.289	5.017	2.516	12.623	0.667	95.0
12.040	0.885	10.649	5.017	2.022	10.144	0.505	95.3
12.000	0.665	7.976	5.018	1.513	7.592	0.384	95.2
12.020	0.468	5.628	5.053	1.021	5.157	0.471	91.6
12.050	0.252	3.031	5.065	0.527	2.669	0.362	88.1

Voltage [V]	Current [A]	Power [W]	Voltage [V]	Current [A]	Power [W]	Losses [W]	Efficiency [%]
16.000	1.001	16.011	5.016	3.007	15.083	0.928	94.2
16.020	0.835	13.370	5.017	2.516	12.623	0.748	94.4
16.000	0.671	10.733	5.017	2.022	10.144	0.588	94.5
16.020	0.504	8.080	5.018	1.513	7.592	0.488	94.0
16.010	0.359	5.748	5.057	1.020	5.160	0.587	89.8
16.030	0.196	3.145	5.076	0.527	2.674	0.471	85.0

2.2.2 LM5143-Q1 - 3.3V @ 15A

Voltage [V]	Current [A]	Power [W]	Voltage [V]	Current [A]	Power [W]	Losses [W]	Efficiency [%]
6.018	8.808	53.007	3.311	15.000	49.665	3.342	93.7
6.000	7.009	42.054	3.313	12.010	39.789	2.265	94.6
5.998	5.211	31.256	3.315	9.000	29.835	1.421	95.5
6.001	3.457	20.745	3.318	6.010	19.941	0.804	96.1
5.998	1.728	10.365	3.320	3.000	9.960	0.405	96.1

Voltage [V]	Current [A]	Power [W]	Voltage [V]	Current [A]	Power [W]	Losses [W]	Efficiency [%]
11.970	4.517	54.068	3.311	15.000	49.665	4.403	91.9
12.030	3.573	42.983	3.313	12.010	39.789	3.194	92.6
12.000	2.668	32.016	3.315	9.000	29.835	2.181	93.2
12.020	1.777	21.360	3.317	6.010	19.935	1.424	93.3
11.980	0.905	10.843	3.320	3.000	9.960	0.883	91.9

Voltage [V]	Current [A]	Power [W]	Voltage [V]	Current [A]	Power [W]	Losses [W]	Efficiency [%]
15.970	3.426	54.713	3.309	15.000	49.635	5.078	90.7
16.020	2.715	43.494	3.312	12.010	39.777	3.717	91.5
16.010	2.026	32.436	3.314	9.000	29.826	2.610	92.0
15.990	1.356	21.682	3.316	6.010	19.929	1.753	91.9
16.030	0.694	11.118	3.319	3.000	9.957	1.161	89.6

2.2.3 LM63635-Q1 – 3.3V @ 3A

Voltage [V]	Current [A]	Power [W]	Voltage [V]	Current [A]	Power [W]	Losses [W]	Efficiency [%]
6.017	1.859	11.187	3.299	3.008	9.923	1.263	88.7
6.022	1.533	9.229	3.299	2.516	8.300	0.928	89.9
6.023	1.216	7.323	3.300	2.022	6.673	0.650	91.1
6.018	0.902	5.428	3.300	1.513	4.993	0.435	92.0
6.022	0.605	3.643	3.301	1.021	3.369	0.274	92.5
6.026	0.317	1.909	3.302	0.527	1.740	0.169	91.1

Voltage [V]	Current [A]	Power [W]	Voltage [V]	Current [A]	Power [W]	Losses [W]	Efficiency [%]
12.050	0.951	11.464	3.300	3.008	9.926	1.538	86.6
12.040	0.789	9.504	3.300	2.516	8.303	1.202	87.4
11.990	0.633	7.594	3.300	2.022	6.673	0.922	87.9
12.020	0.473	5.685	3.301	1.513	4.994	0.691	87.8
12.050	0.321	3.872	3.301	1.021	3.369	0.502	87.0
12.060	0.176	2.118	3.302	0.527	1.740	0.378	82.2

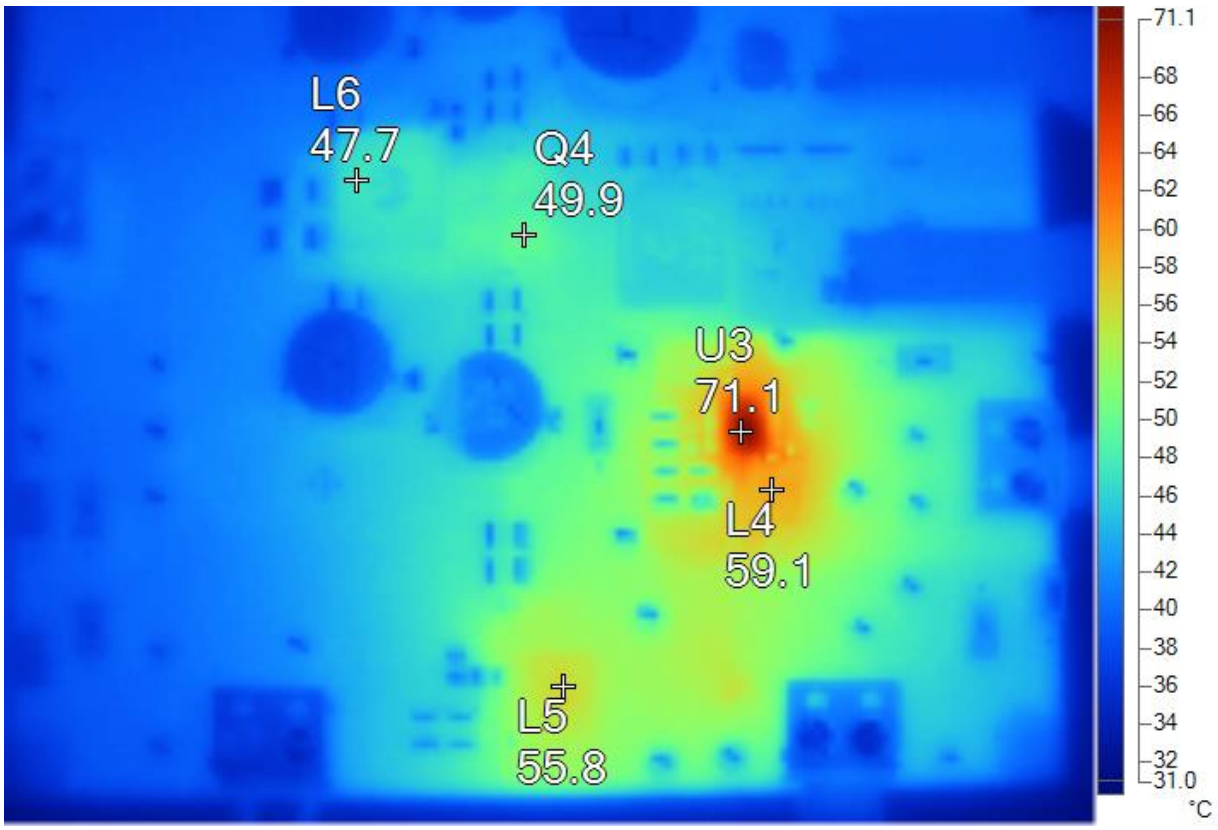
Voltage [V]	Current [A]	Power [W]	Voltage [V]	Current [A]	Power [W]	Losses [W]	Efficiency [%]
16.010	0.732	11.719	3.299	3.008	9.923	1.796	84.7
16.010	0.609	9.753	3.299	2.516	8.300	1.453	85.1
15.980	0.490	7.824	3.300	2.022	6.673	1.151	85.3
16.010	0.368	5.888	3.300	1.513	4.993	0.896	84.8
16.010	0.253	4.057	3.301	1.021	3.369	0.688	83.0
16.030	0.143	2.292	3.302	0.527	1.740	0.552	75.9

2.2.4 TPS62810-Q1 – 1.1V @ 3A

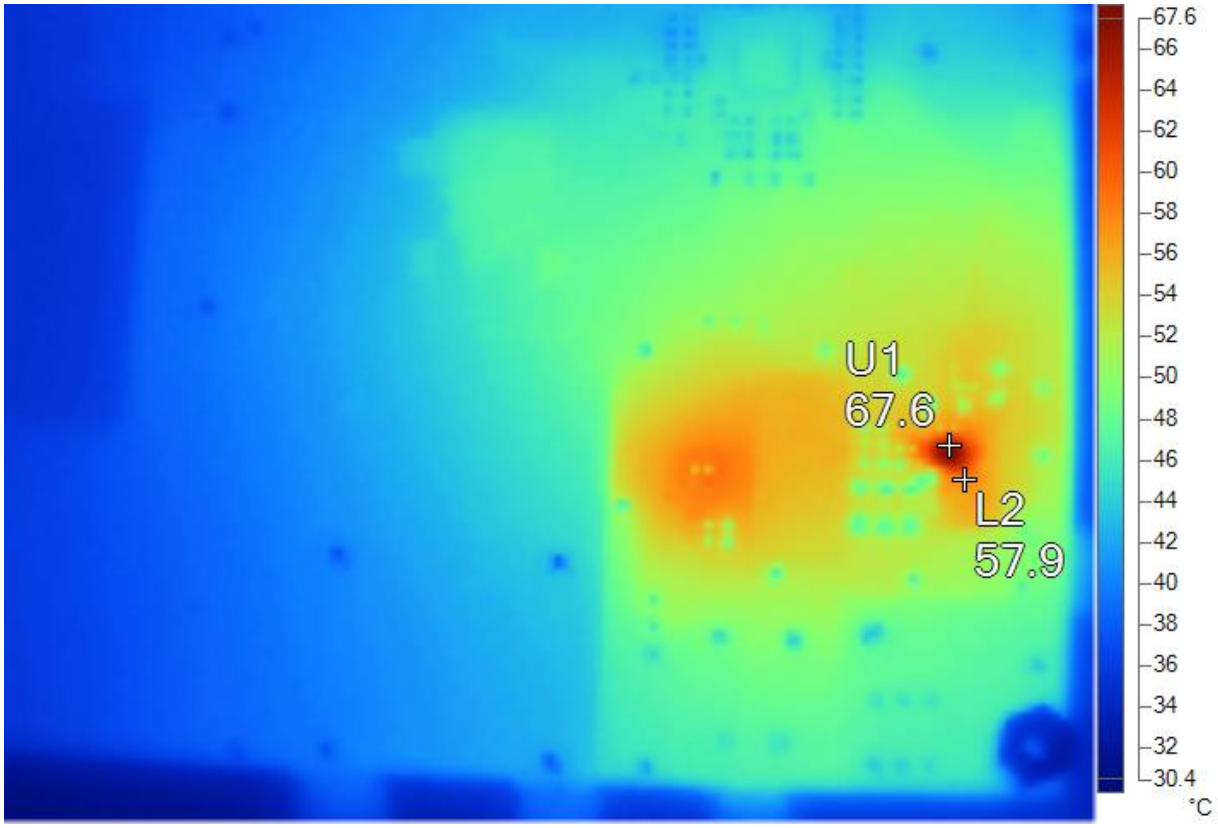
Voltage [V]	Current [A]	Power [W]	Voltage [V]	Current [A]	Power [W]	Losses [W]	Efficiency [%]
4.933	0.794	3.918	1.096	3.009	3.298	0.621	84.2
4.959	0.651	3.229	1.097	2.517	2.761	0.468	85.5
4.982	0.514	2.559	1.098	2.023	2.221	0.338	86.8
4.999	0.379	1.896	1.099	1.514	1.664	0.232	87.8
5.008	0.255	1.276	1.100	1.021	1.123	0.152	88.1
5.012	0.131	0.655	1.102	0.501	0.552	0.103	84.3

2.3 Thermal Images

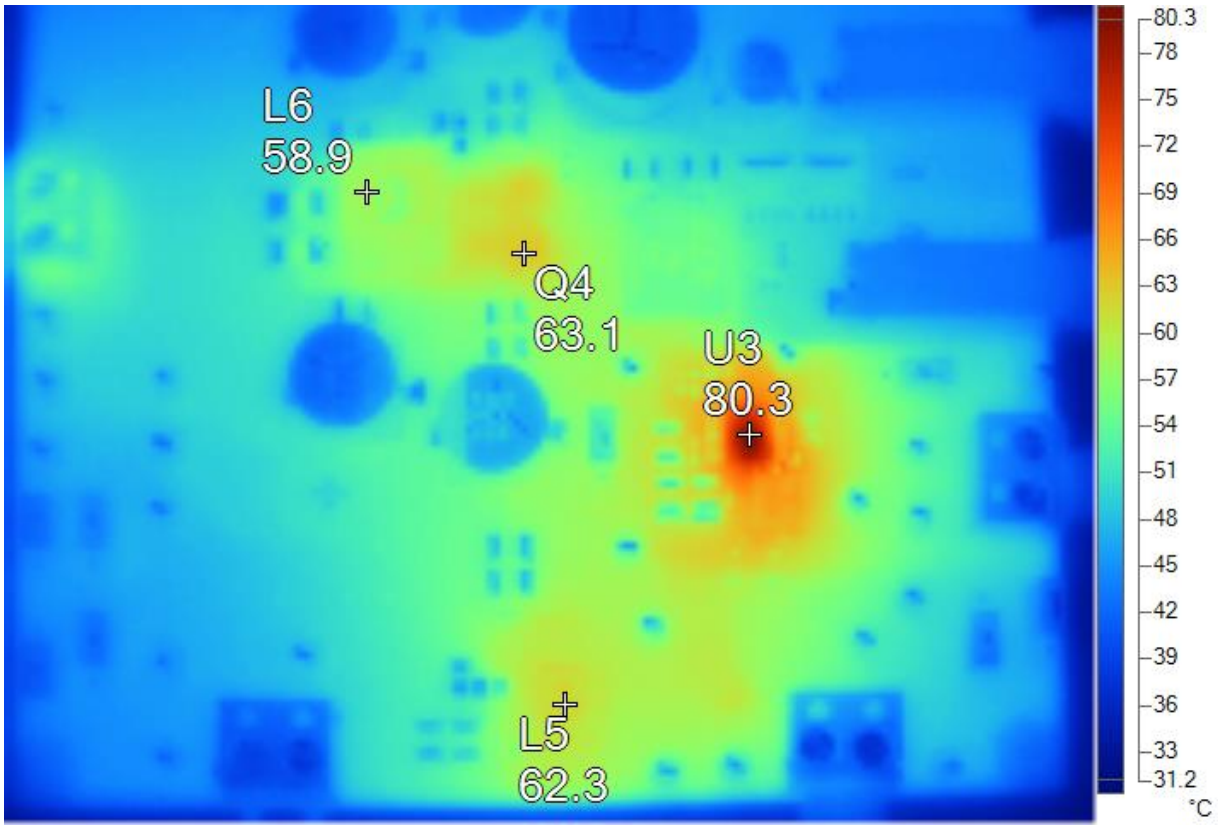
2.3.1 PCB top side with LM5143-Q1: 5.0V@3.0A, 3.3V@5.0A, LM63635-Q1: 3.3V@3.0A, TPS62810-Q1: 1.1V@3.0A



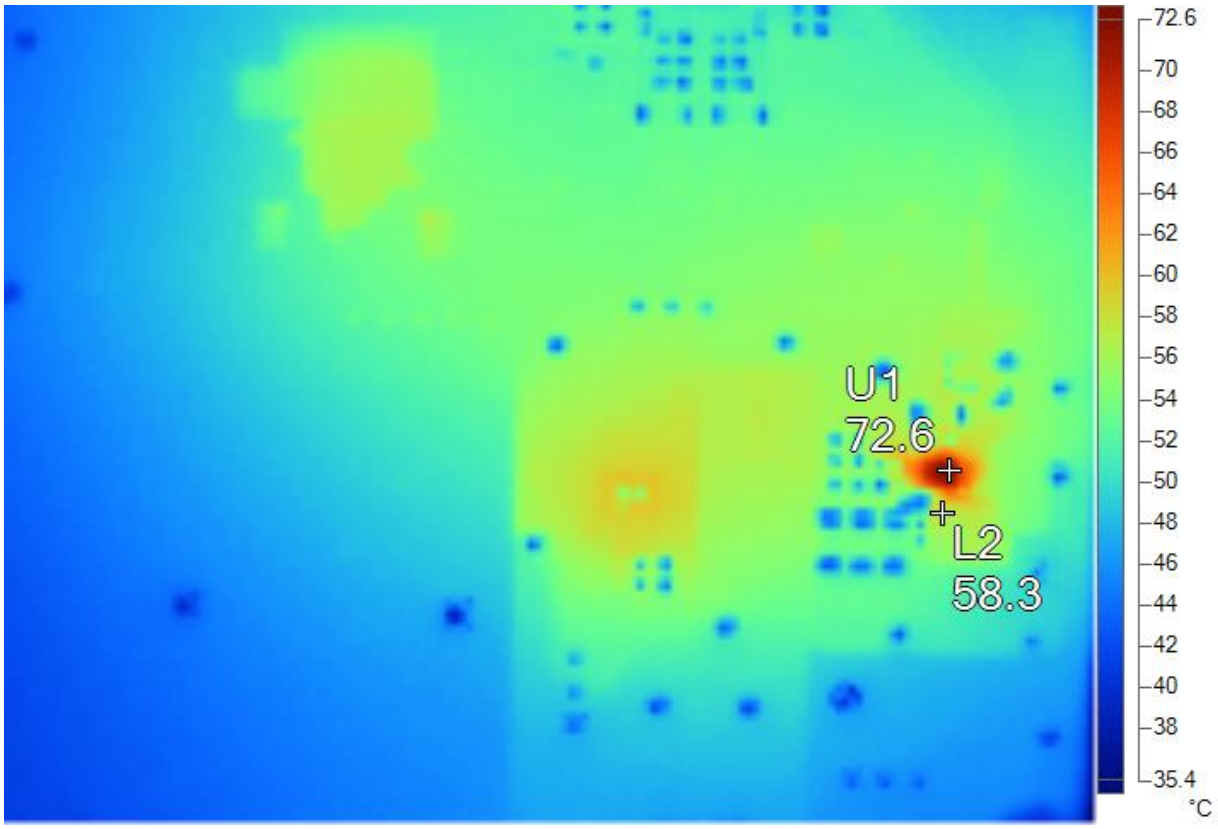
2.3.2 PCB bottom side with LM5143-Q1: 5.0V@3.0A, 3.3V@5.0A, LM63635-Q1: 3.3V@3.0A, TPS62810-Q1: 1.1V@3.0A



2.3.3 PCB top side with LM5143-Q1: 5.0V@3.0A, 3.3V@10.0A, LM63635-Q1: 3.3V@3.0A, TPS62810-Q1: 1.1V@3.0A



2.3.4 PCB bottom side with LM5143-Q1: 5.0V@3.0A, 3.3V@10.0A, LM63635-Q1: 3.3V@3.0A, TPS62810-Q1: 1.1V@3.0A

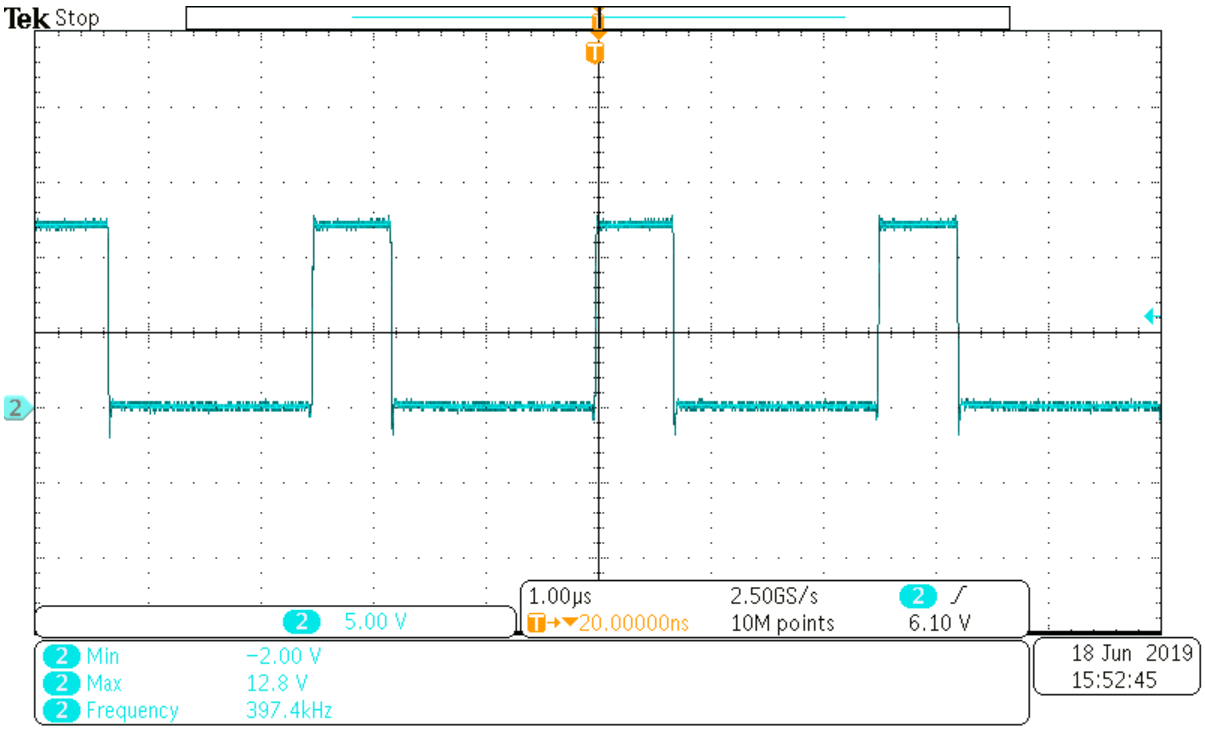


2.4 Dimensions

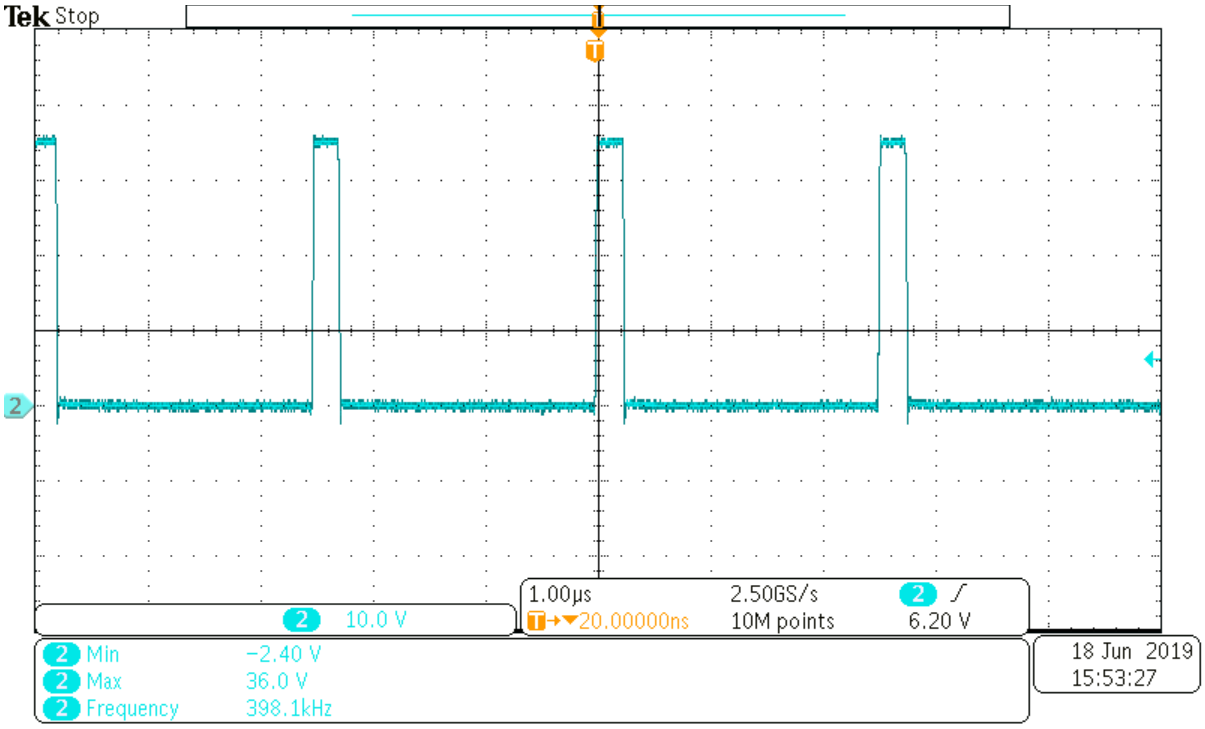
PCB:	150 mm x 100 mm
w/o onboard load:	83 mm x 100 mm

3 Waveforms LM5143-Q1 Buck 1 (5.0 V @ 3.0 A)

3.1 Switching

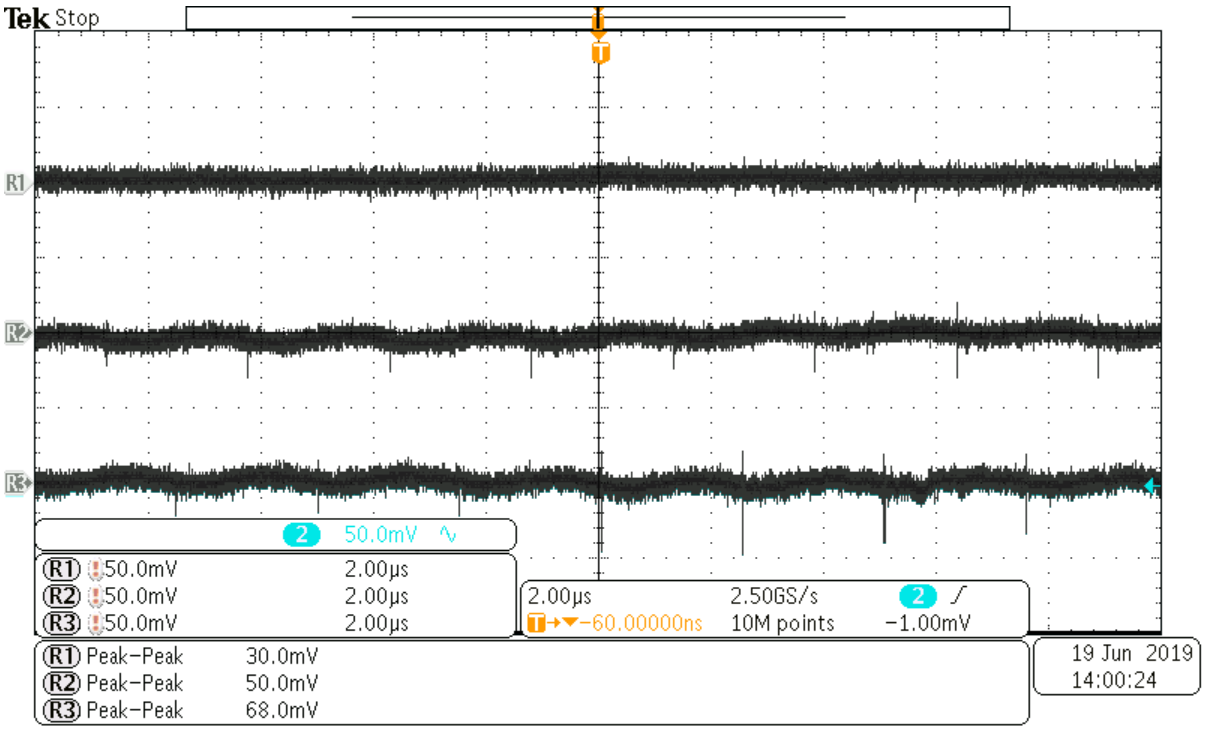


- Ch2: Switching node at 12.0V in and 3.0A load current [scale: 5.0V/div, 1.0us/div]



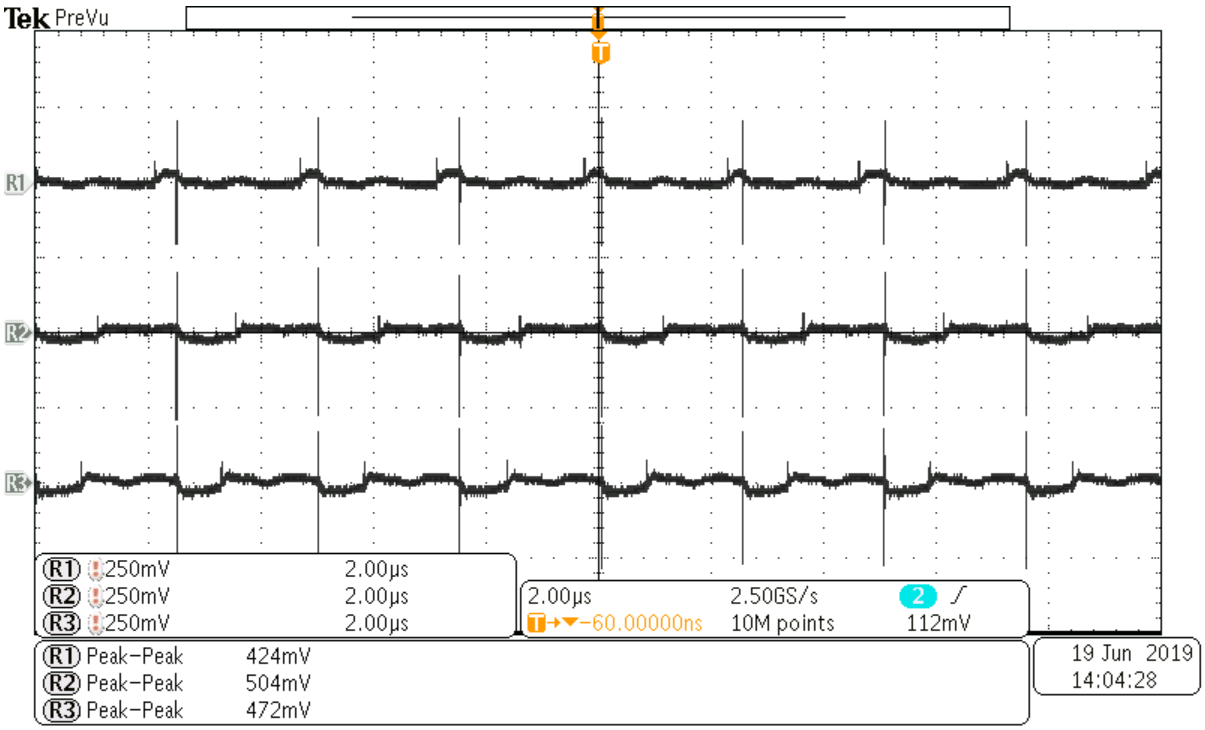
- Ch2: Switching node at 36.0V in and 3.0A load current [scale: 10.0V/div, 1.0us/div]

3.2 Output Voltage Ripple & Noise



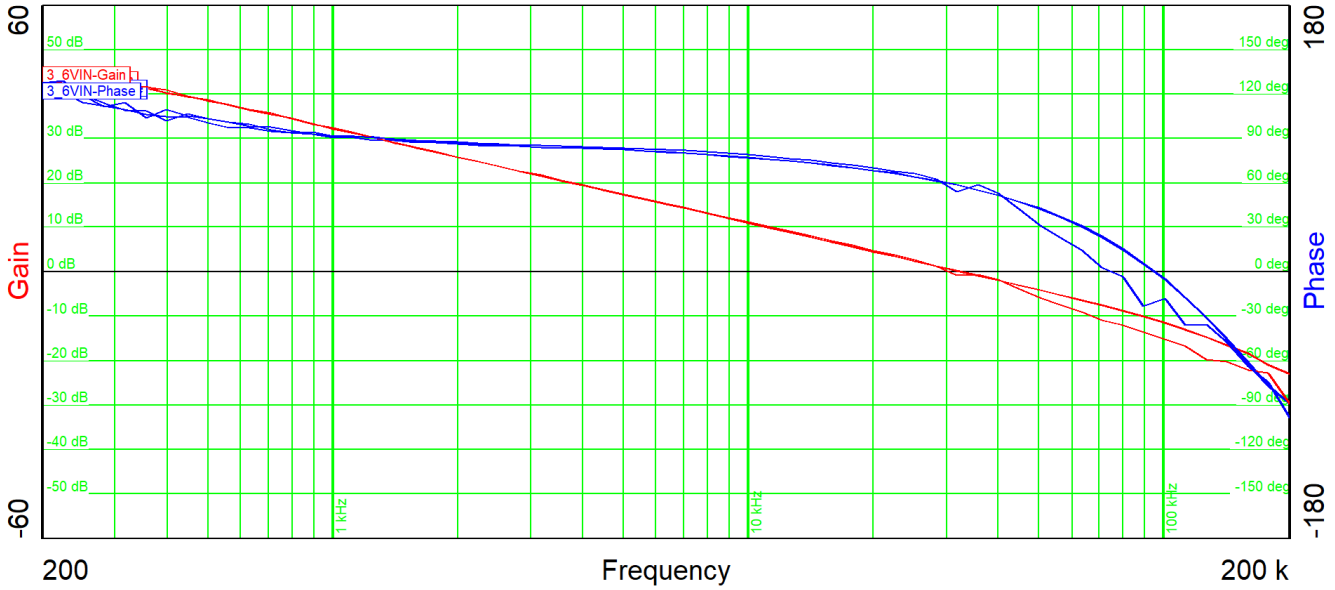
- R1: Output voltage ripple and noise, 30.0mV peak-peak [scale: 50.0mV/div, 2.0us/div]
- R2: Output voltage ripple and noise, 50.0mV peak-peak [scale: 50.0mV/div, 2.0us/div]
- R3: Output voltage ripple and noise, 68.0mV peak-peak [scale: 50.0mV/div, 2.0us/div]

3.3 Input Voltage Ripple & Noise



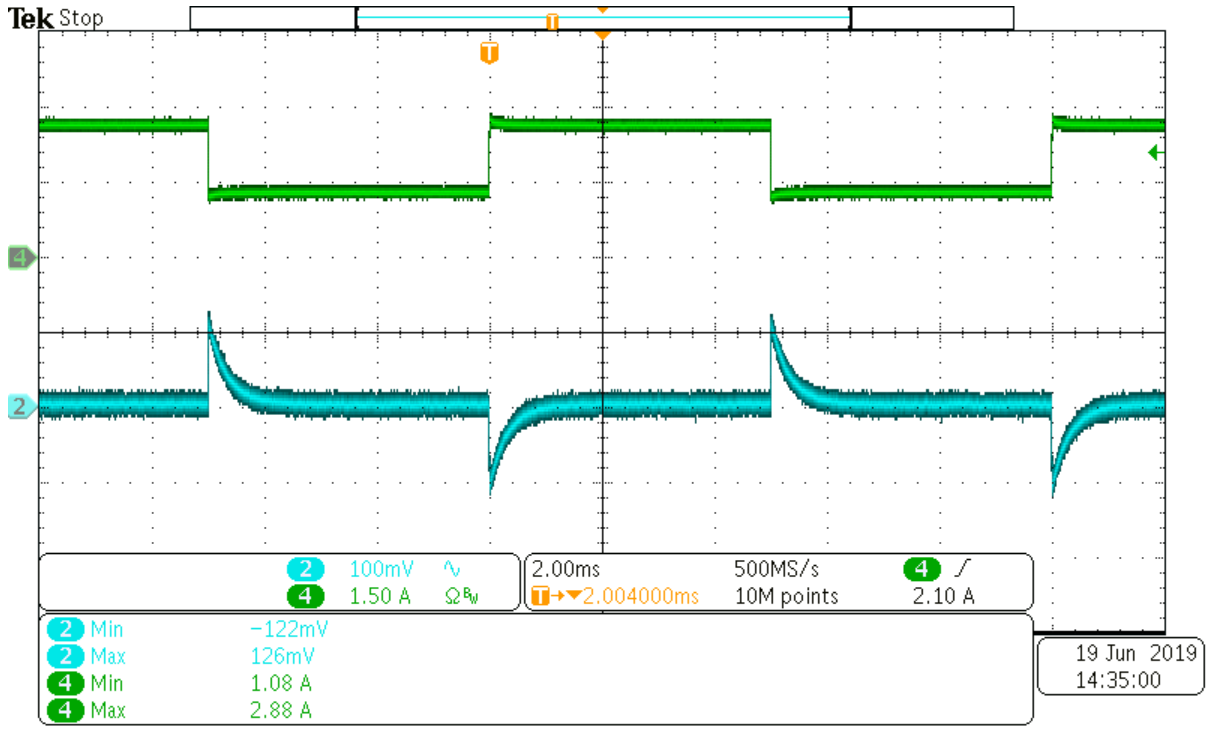
- R1: Input voltage ripple and noise, 424mV peak-peak [scale: 250mV/div, 2.0us/div]
- R2: Input voltage ripple and noise, 504mV peak-peak [scale: 250mV/div, 2.0us/div]
- R3: Input voltage ripple and noise, 472mV peak-peak [scale: 250mV/div, 2.0us/div]

3.4 Bode Plot



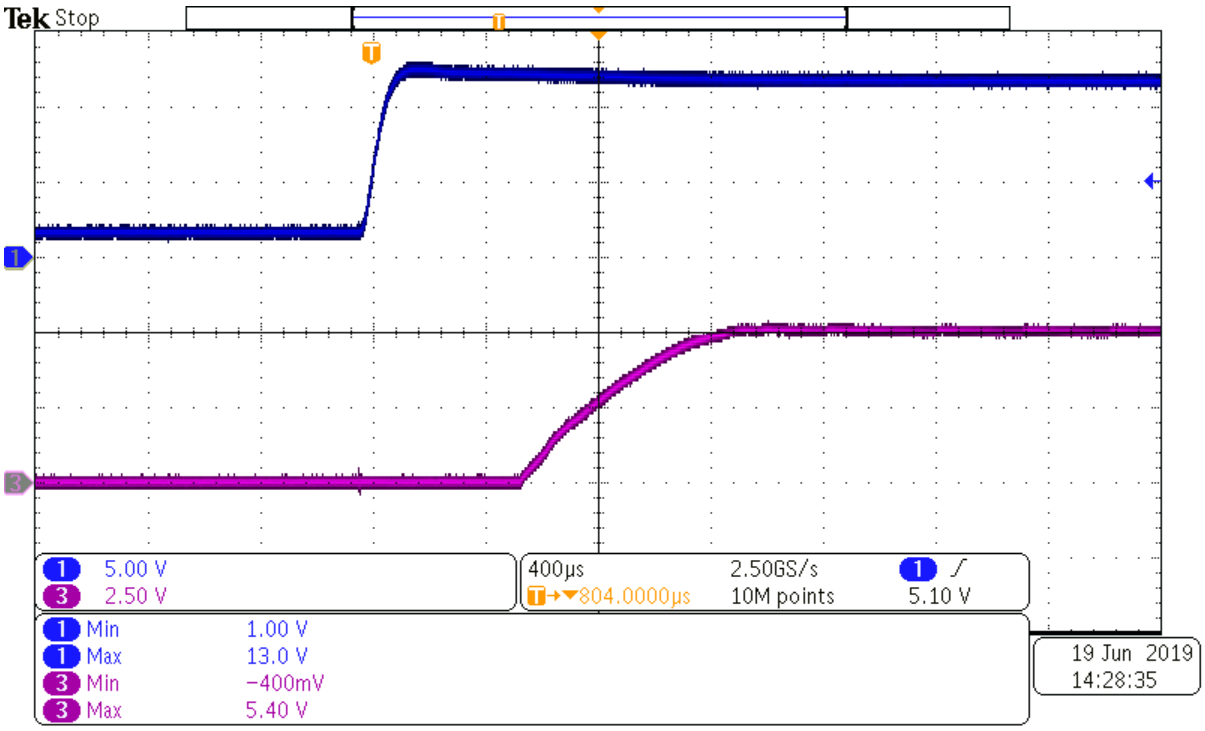
- 6.0V in, 3.0A load current: fco 30.4kHz, 57deg phase margin, -11dB gain margin
- 12.0V in, 3.0A load current: fco 32.5kHz, 58deg phase margin, -11dB gain margin
- 16.0V in, 3.0A load current: fco 32.2kHz, 58deg phase margin, -11dB gain margin

3.5 Load Transients



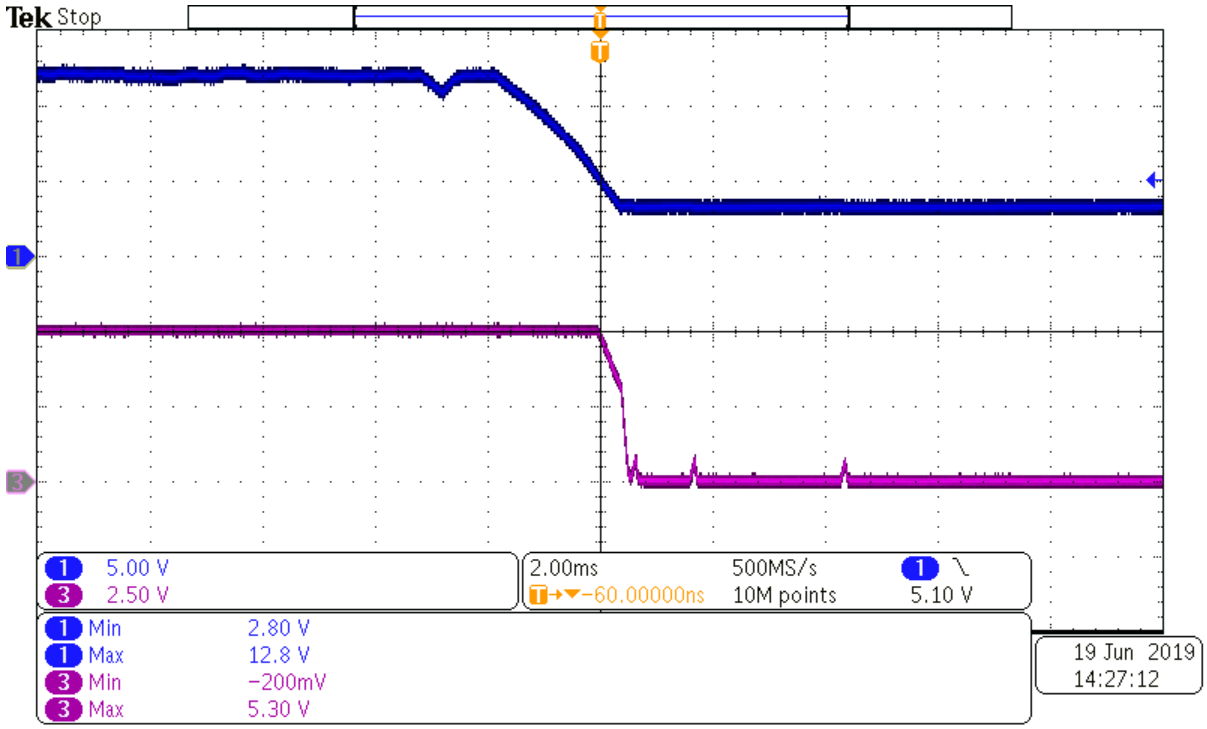
- Ch2: AC-coupled output voltage at 12.0V in [scale: 100mV/div, 2.0ms/div]
- Ch4: Load current, 50% to 100% load step (20MHz bw limited) [scale: 1.5A/div, 2.0ms/div]

3.6 Start-up



- Ch1: Input voltage [scale: 5.0V/div, 400us/div]
- Ch3: Output voltage [scale: 2.5V/div, 400us/div]

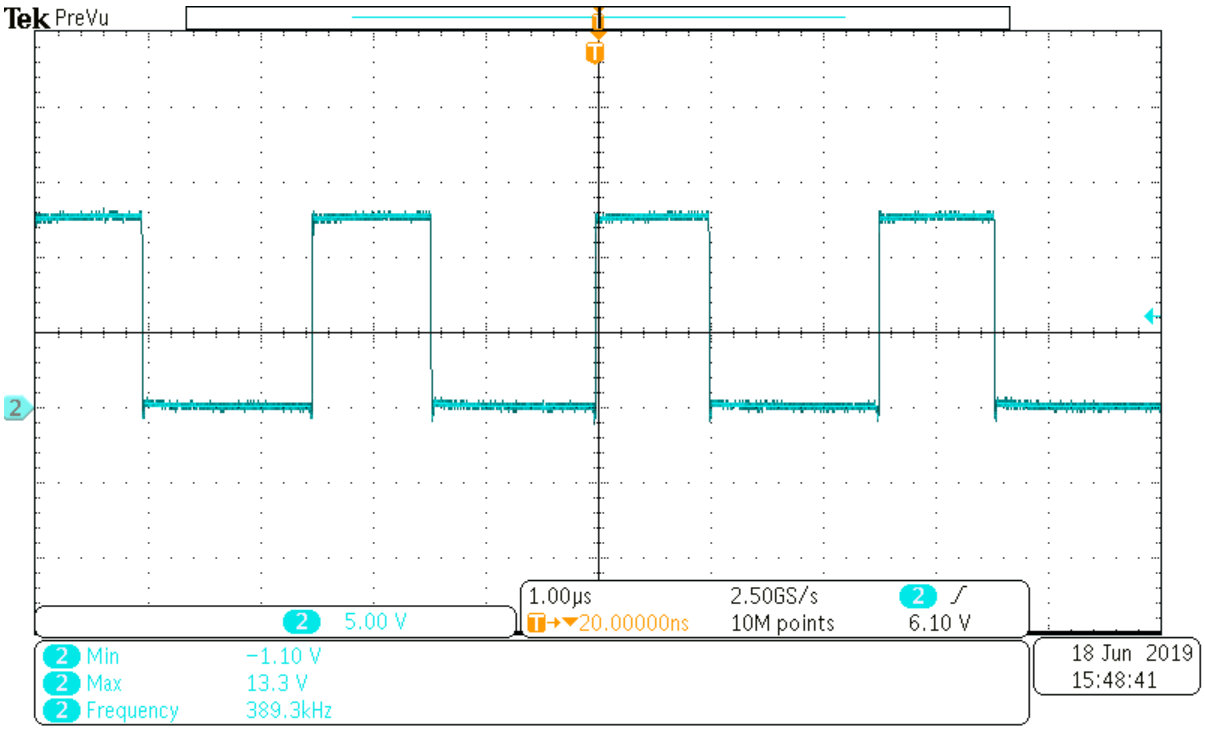
3.7 Shut down



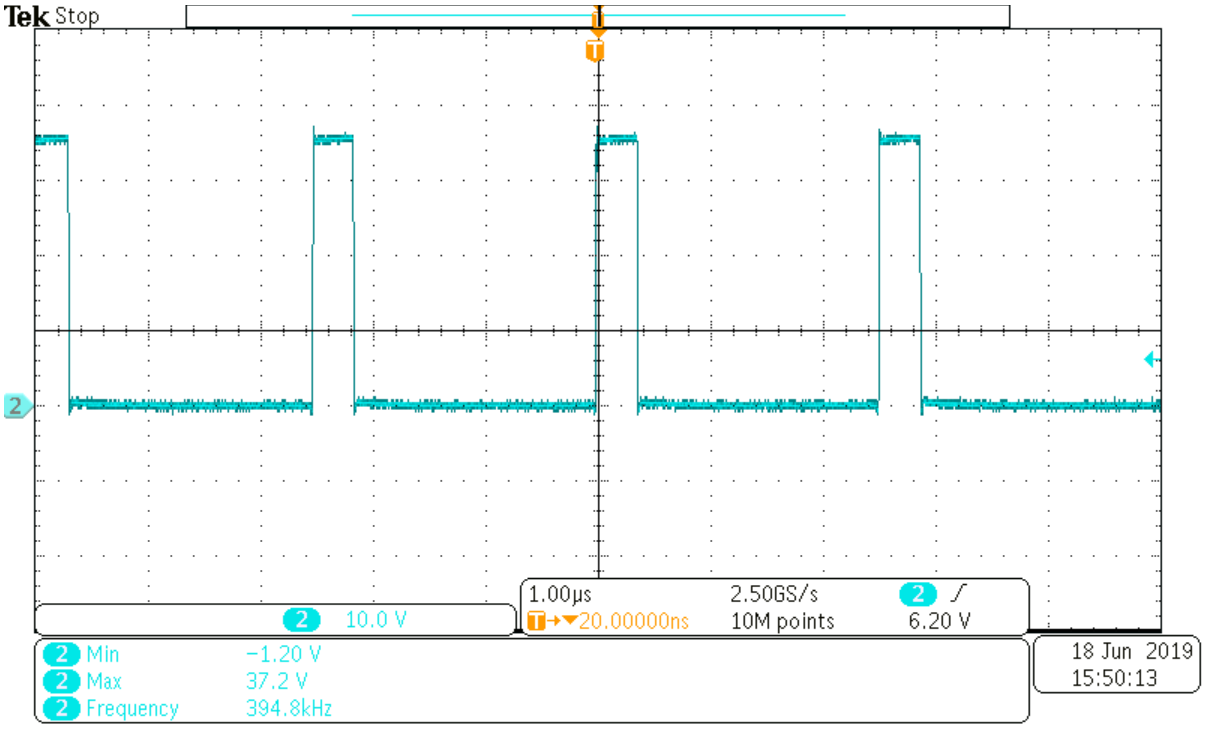
- Ch1: Input voltage [scale: 5.0V/div, 2.0ms/div]
- Ch3: Output voltage [scale: 2.5V/div, 2.0ms/div]

4 Waveforms LM5143-Q1 Buck 2 (3.3 V @ 15.0 A)

4.1 Switching

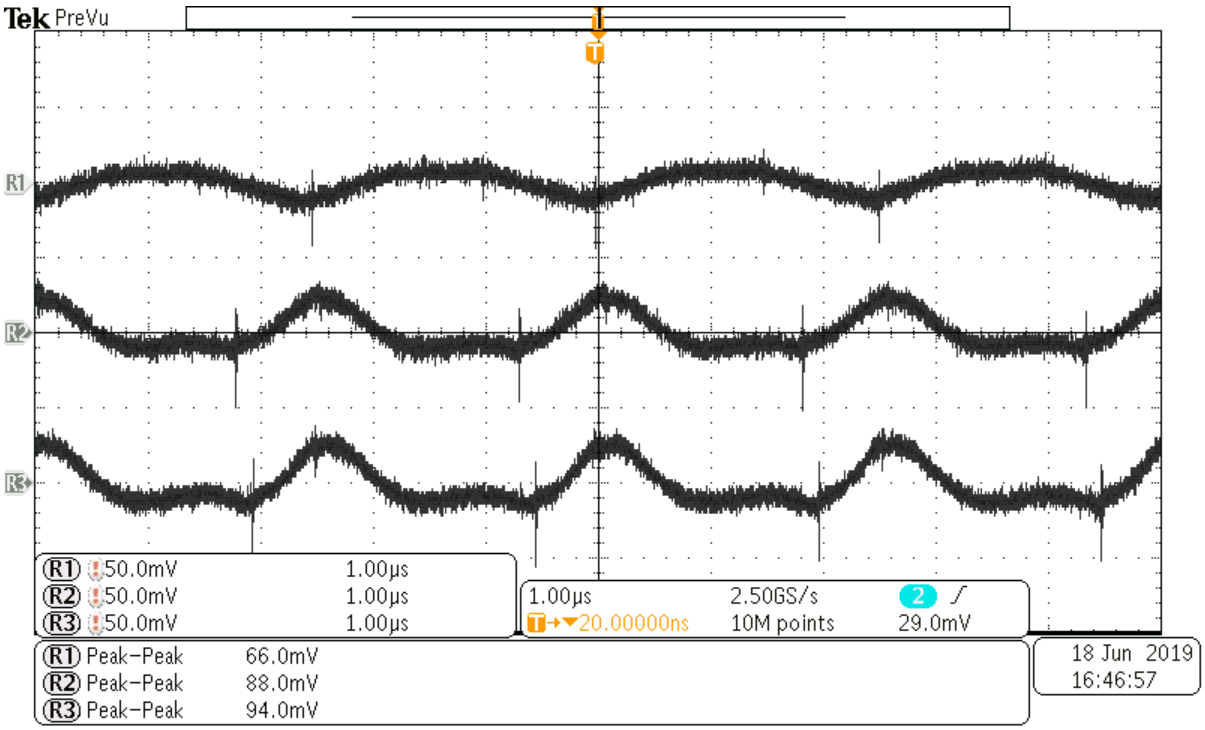


- Ch2: Switching node at 12.0V in and 15.0A load current [scale: 5.0V/div, 1.0us/div]



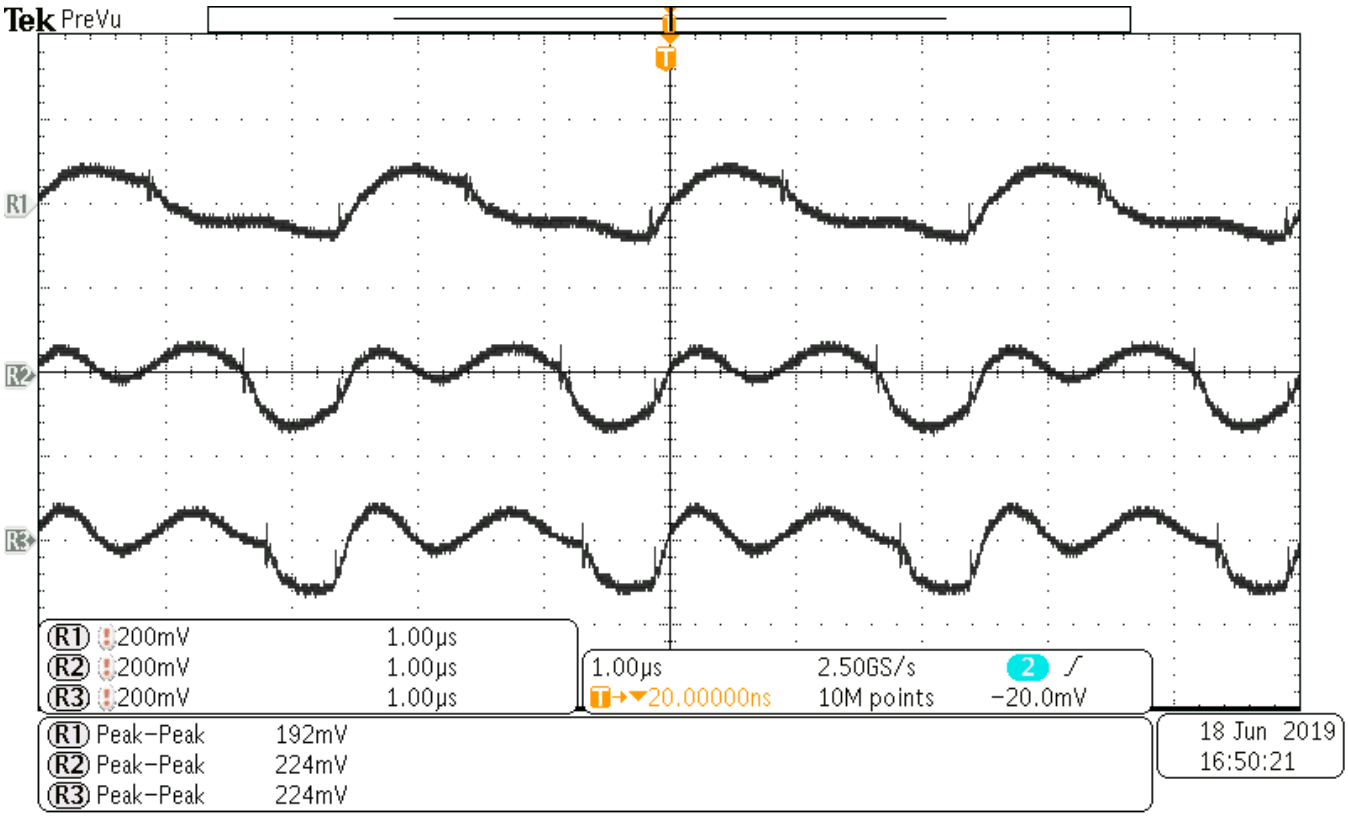
- Ch2: Switching node at 36.0V in and 15.0A load current [scale: 10.0V/div, 1.0us/div]

4.2 Output Voltage Ripple & Noise



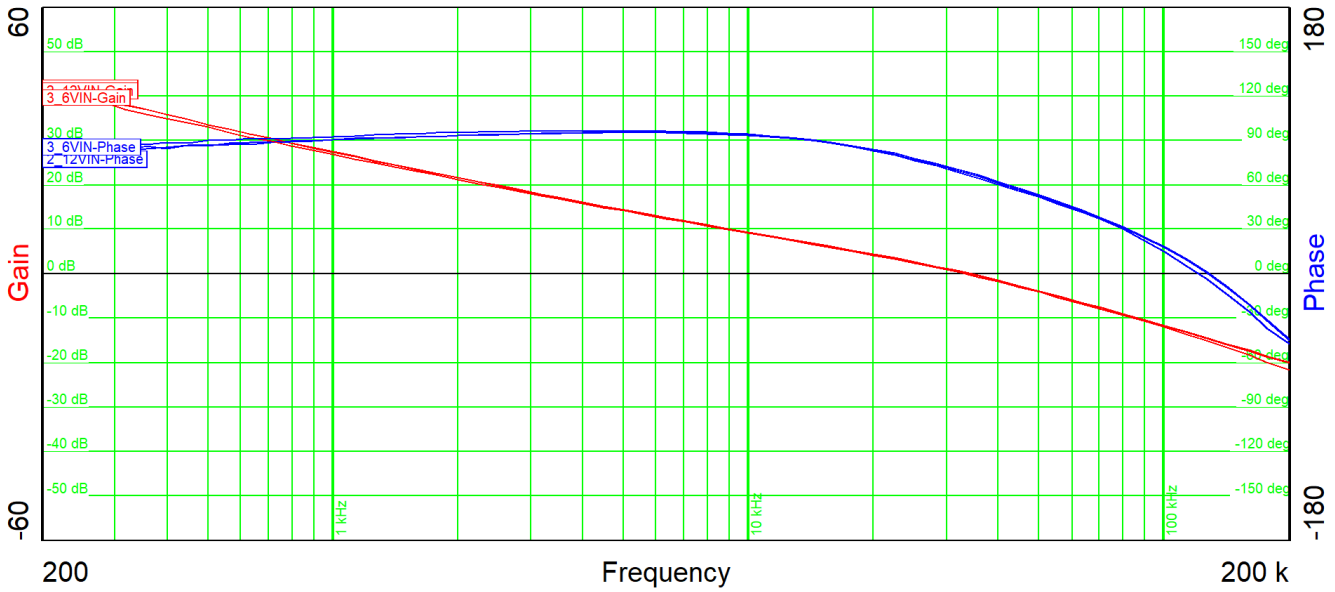
- R1: Output voltage ripple and noise, 66.0mV peak-peak [scale: 50.0mV/div, 1.0us/div]
- R2: Output voltage ripple and noise, 88.0mV peak-peak [scale: 50.0mV/div, 1.0us/div]
- R3: Output voltage ripple and noise, 94.0mV peak-peak [scale: 50.0mV/div, 1.0us/div]

4.3 Input Voltage Ripple & Noise



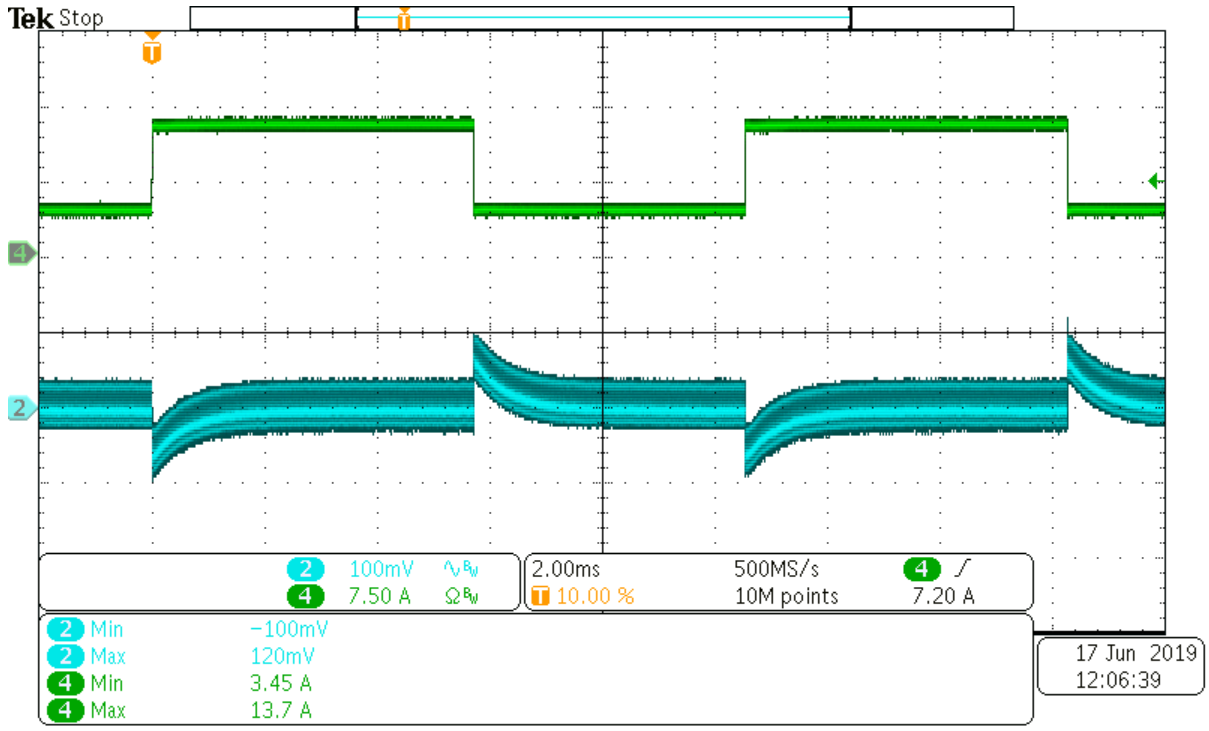
- R1: Input voltage ripple and noise, 192mV peak-peak [scale: 200mV/div, 1.0us/div]
- R2: Input voltage ripple and noise, 224mV peak-peak [scale: 200mV/div, 1.0us/div]
- R3: Input voltage ripple and noise, 224mV peak-peak [scale: 200mV/div, 1.0us/div]

4.4 Bode Plot



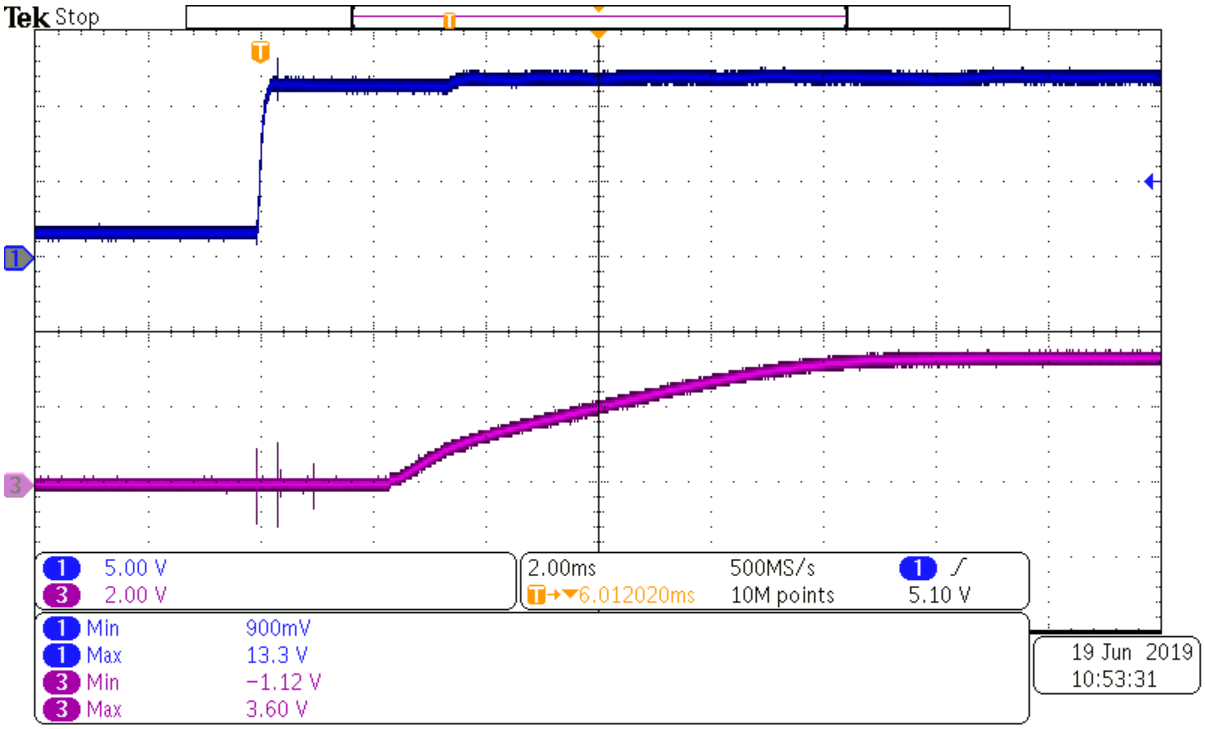
- 6.0V in, 15.0A load current: fco 32.9kHz, 67deg phase margin, -15dB gain margin
- 12.0V in, 15.0A load current: fco 34.0kHz, 68deg phase margin, -15dB gain margin
- 16.0V in, 15.0A load current: fco 33.7kHz, 67deg phase margin, -15dB gain margin

4.5 Load Transients



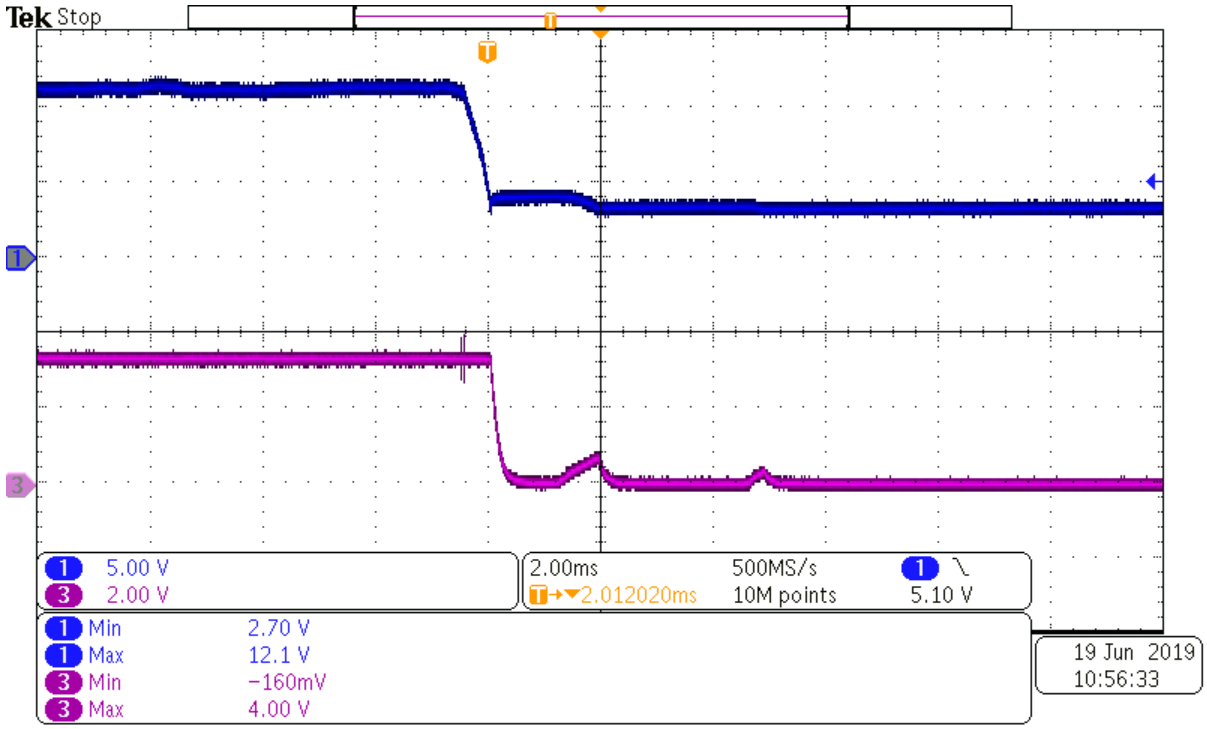
- Ch2: AC-coupled output voltage at 12.0V in, 100mV undershoot, 120mV overshoot (20MHz bw limited) [scale: 100mV/div, 2.0ms/div]
- Ch4: Load current, 25% to 75% load step using the onboard load (20MHz bw limited) [scale: 7.5A/div, 2.0ms/div]

4.6 Start-up



- Ch1: Input voltage [scale: 5.0V/div, 2.0ms/div]
- Ch3: Output voltage [scale: 2.0V/div, 2.0ms/div]

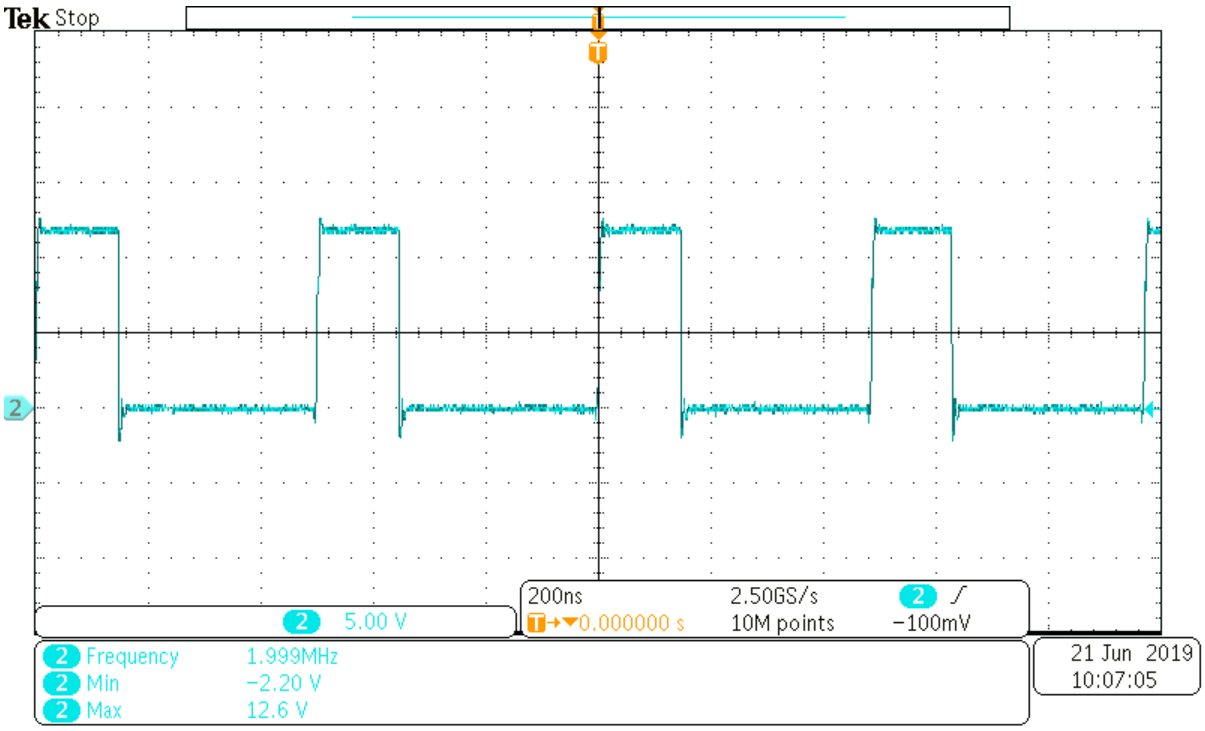
4.7 Shut down



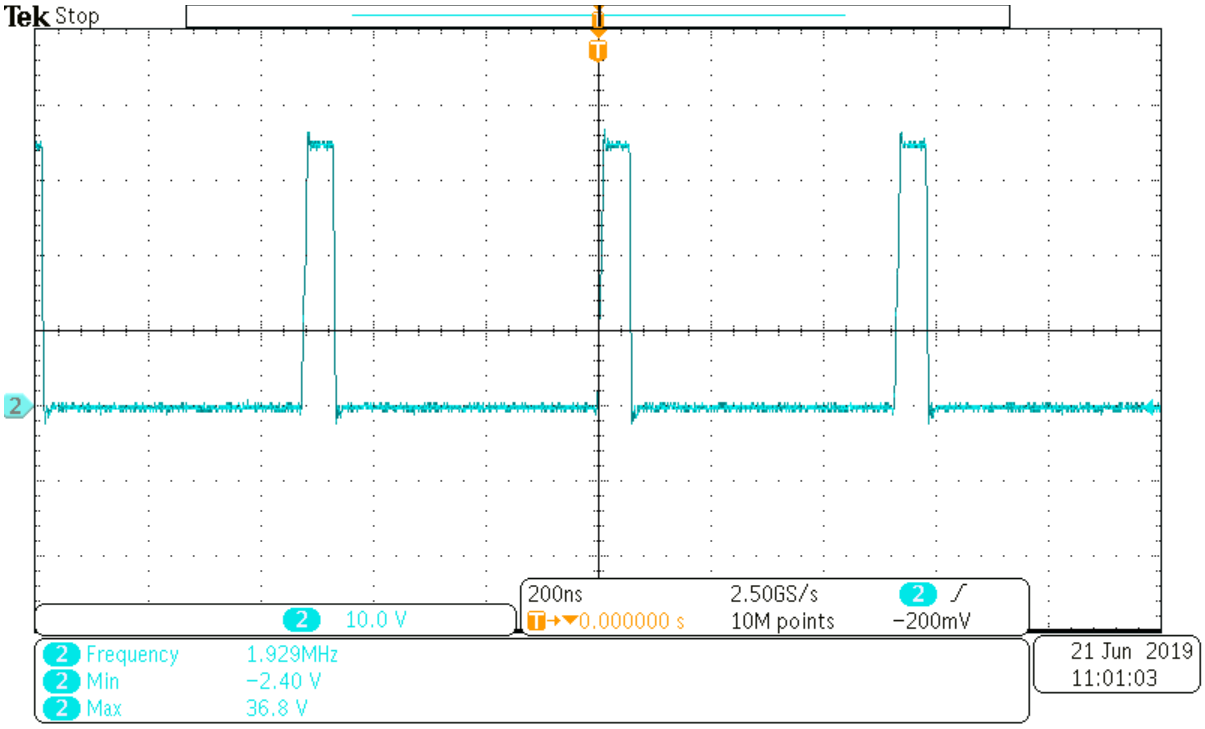
- Ch1: Input voltage [scale: 5.0V/div, 2.0ms/div]
- Ch3: Output voltage [scale: 2.0V/div, 2.0ms/div]

5 Waveforms LM63635-Q1 (3.3 V @ 3.0 A)

5.1 Switching

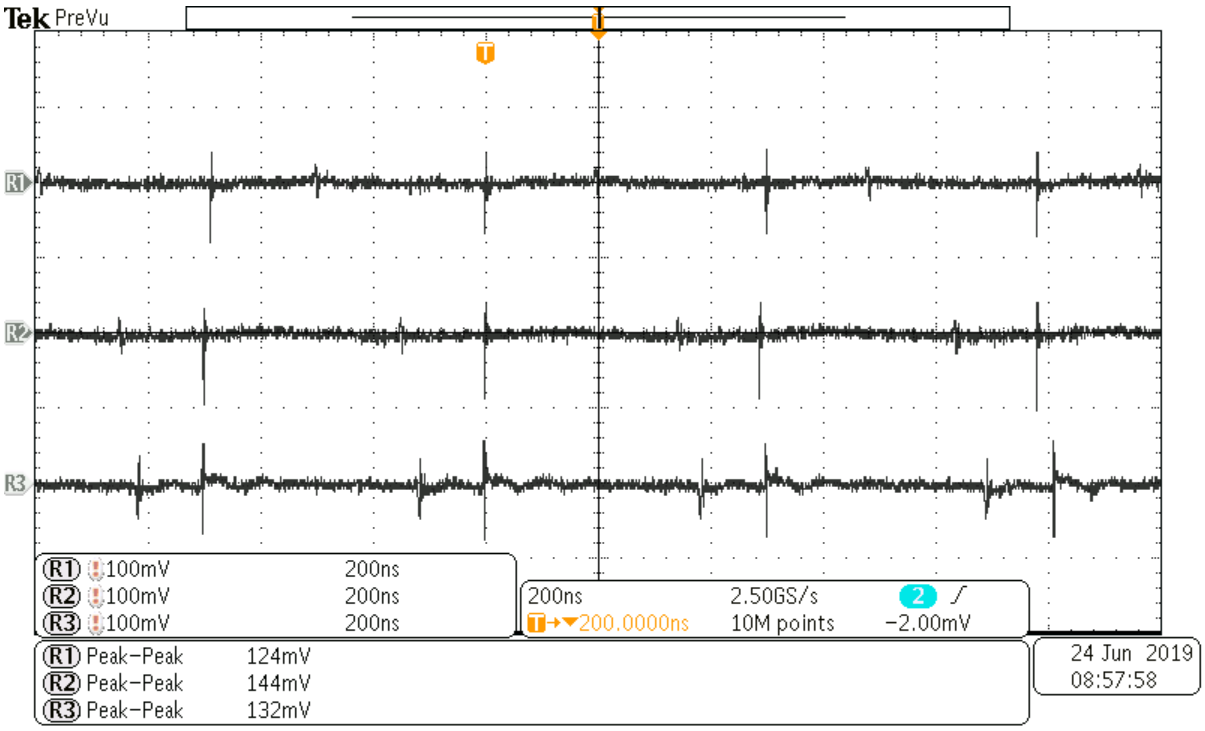


- Ch2: Switching node at 12.0V in and 3.0A load current [scale: 5.0V/div, 200ns/div]



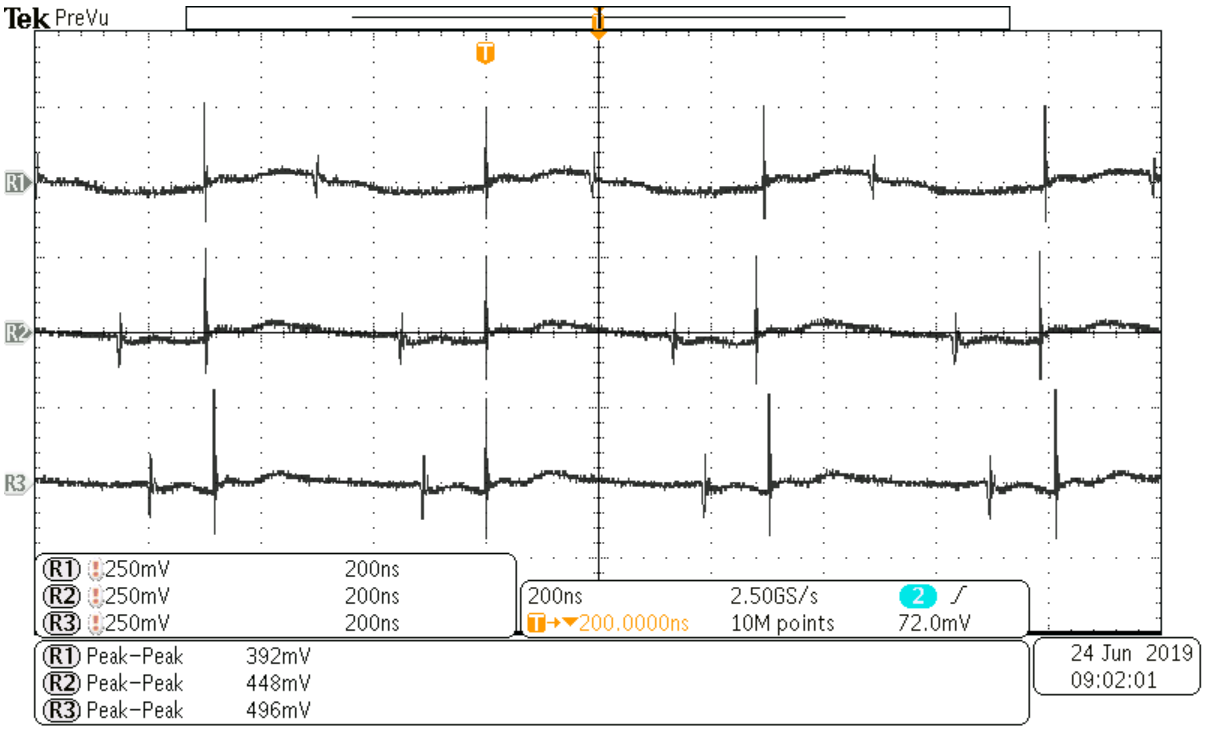
- Ch2: Switching node at 36.0V in and 3.0A load current [scale: 10.0V/div, 200ns/div]

5.2 Output Voltage Ripple



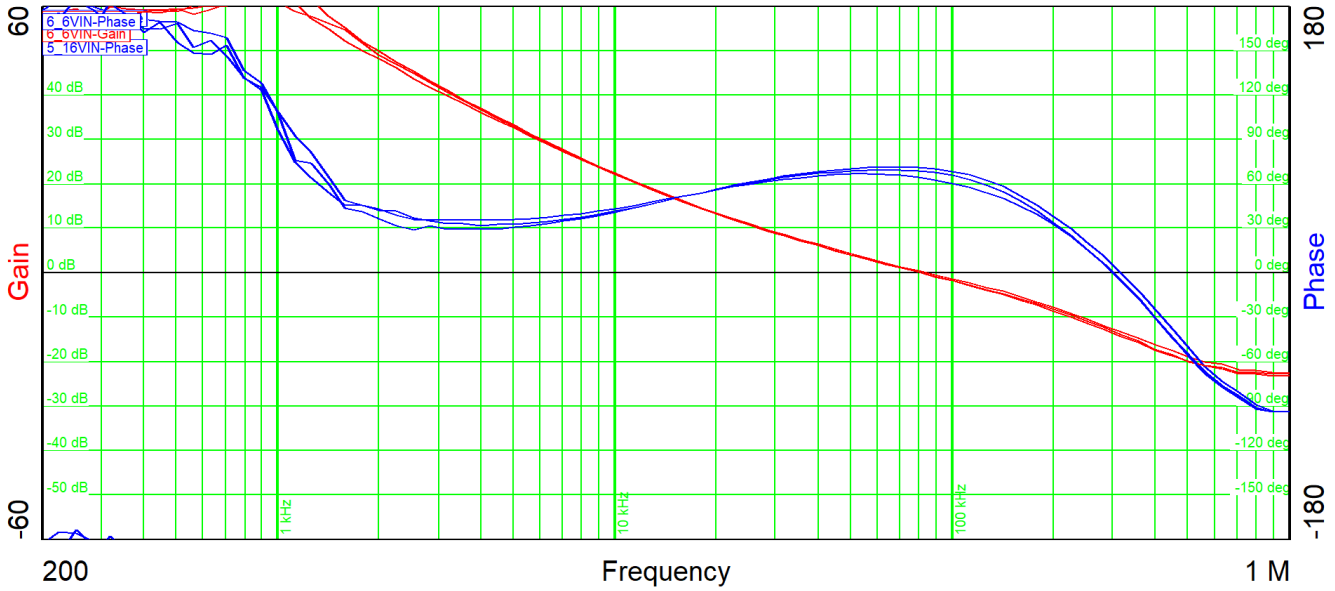
- R1: Output voltage ripple and noise, 124mV peak-peak [scale: 100mV/div, 200ns/div]
- R2: Output voltage ripple and noise, 144mV peak-peak [scale: 100mV/div, 200ns/div]
- R3: Output voltage ripple and noise, 132mV peak-peak [scale: 100mV/div, 200ns/div]

5.3 Input Voltage Ripple



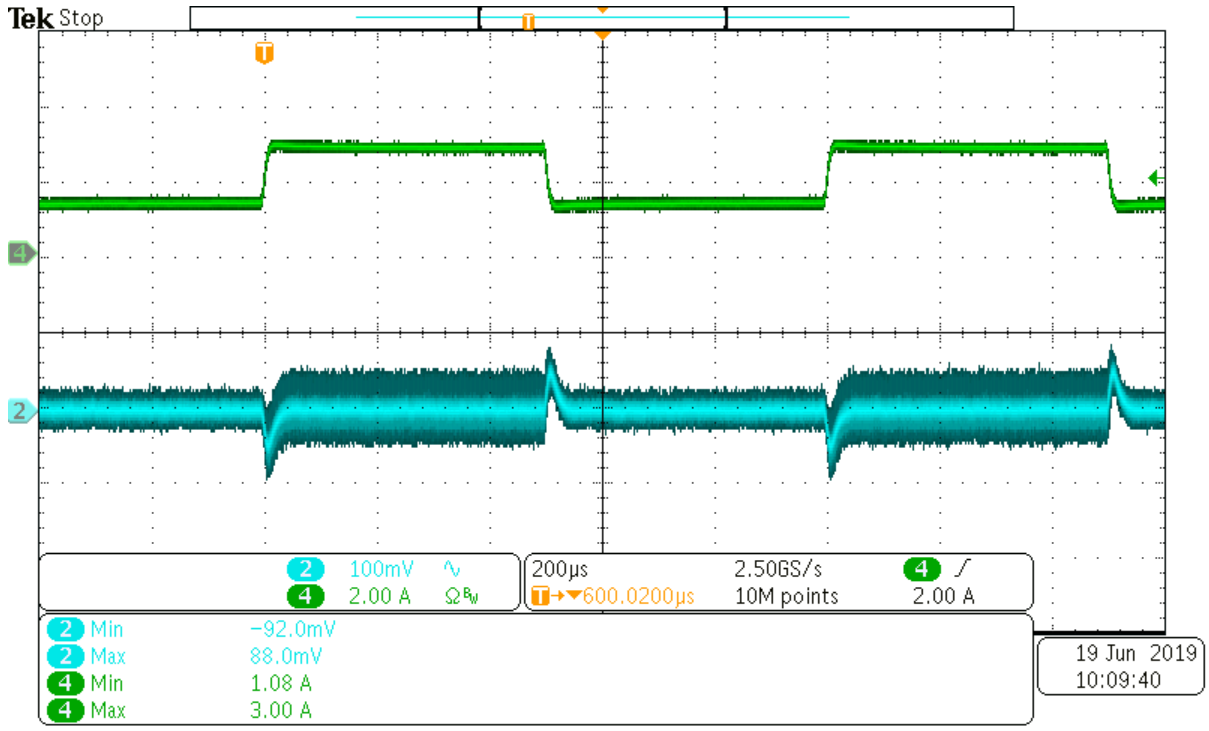
- R1: Input voltage ripple and noise, 392mV peak-peak [scale: 250mV/div, 200ns/div]
- R2: Input voltage ripple and noise, 448mV peak-peak [scale: 250mV/div, 200ns/div]
- R3: Input voltage ripple and noise, 496mV peak-peak [scale: 250mV/div, 200ns/div]

5.4 Bode Plot



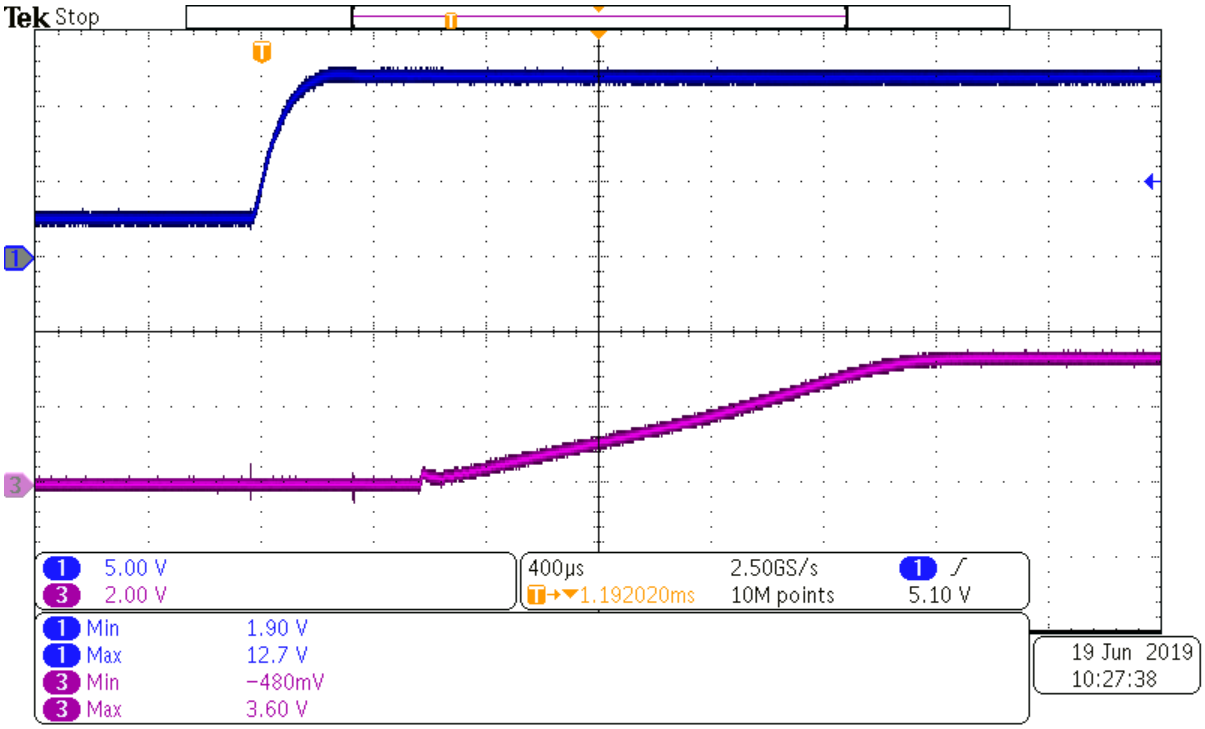
- 6.0V in, 15.0A load current: fco 80.3kHz, 64deg phase margin, -13dB gain margin
- 12.0V in, 15.0A load current: fco 83.6kHz, 71deg phase margin, -13dB gain margin
- 16.0V in, 15.0A load current: fco 79.7kHz, 67deg phase margin, -14dB gain margin

5.5 Load Transients



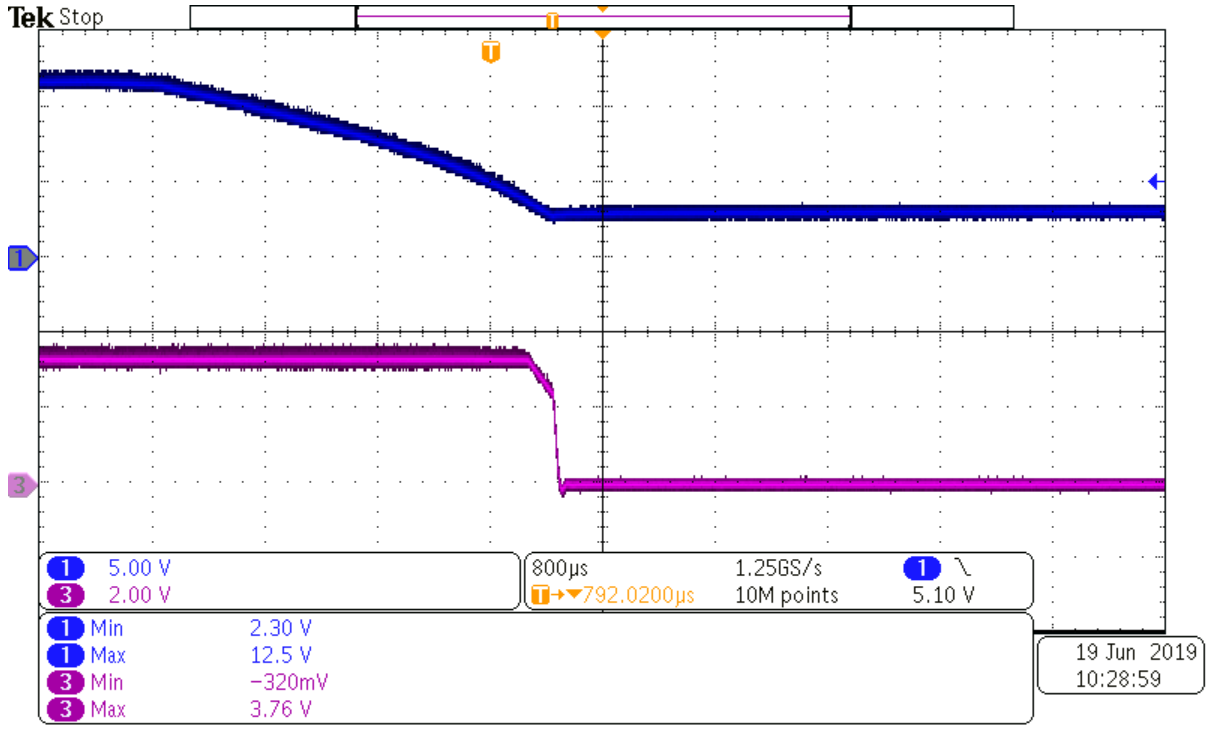
- Ch2: AC-coupled output voltage at 12.0V in [scale: 100mV/div, 200us/div]
- Ch4: Load current, 50% to 100% load step [scale: 2.0A/div, 200us/div]

5.6 Start-up



- Ch1: Input voltage [scale: 5.0V/div, 400us/div]
- Ch3: Output voltage [scale: 2.0V/div, 400us/div]

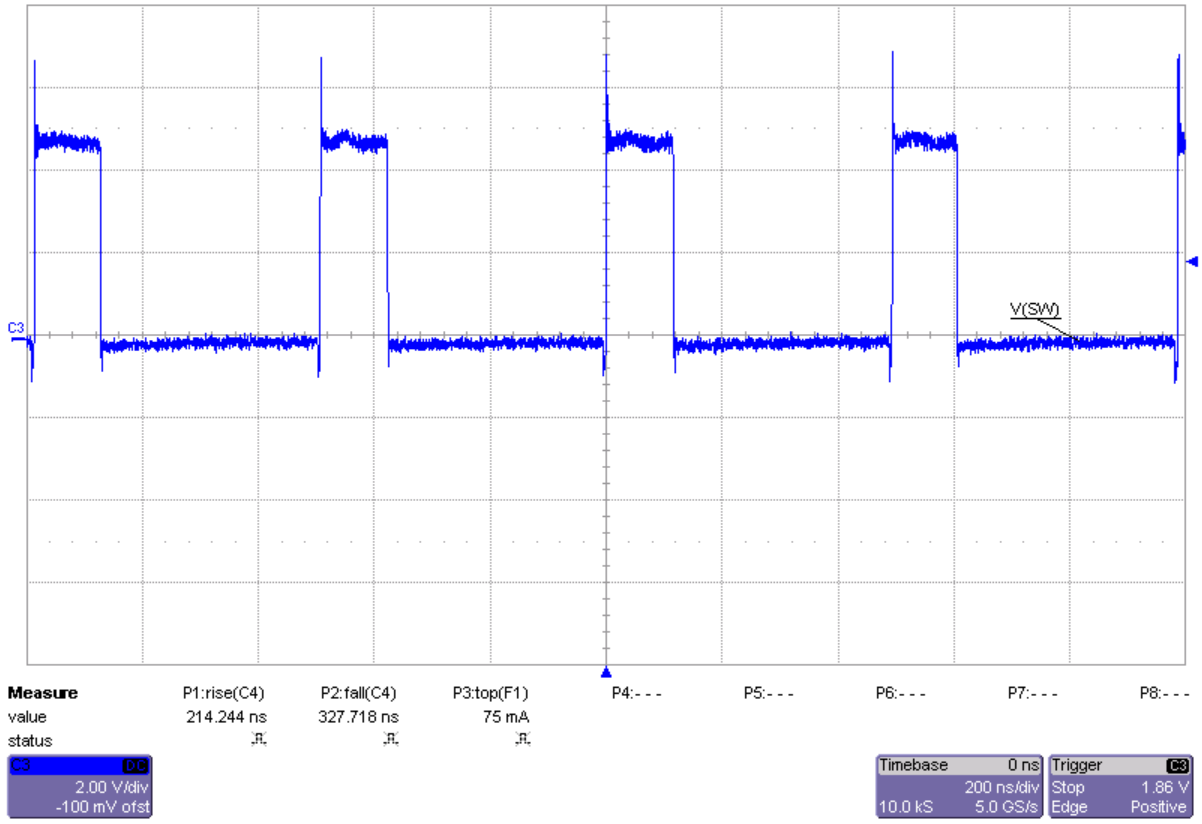
5.7 Shut down



- Ch1: Input voltage [scale: 5.0V/div, 800us/div]
- Ch3: Output voltage [scale: 2.0V/div, 800us/div]

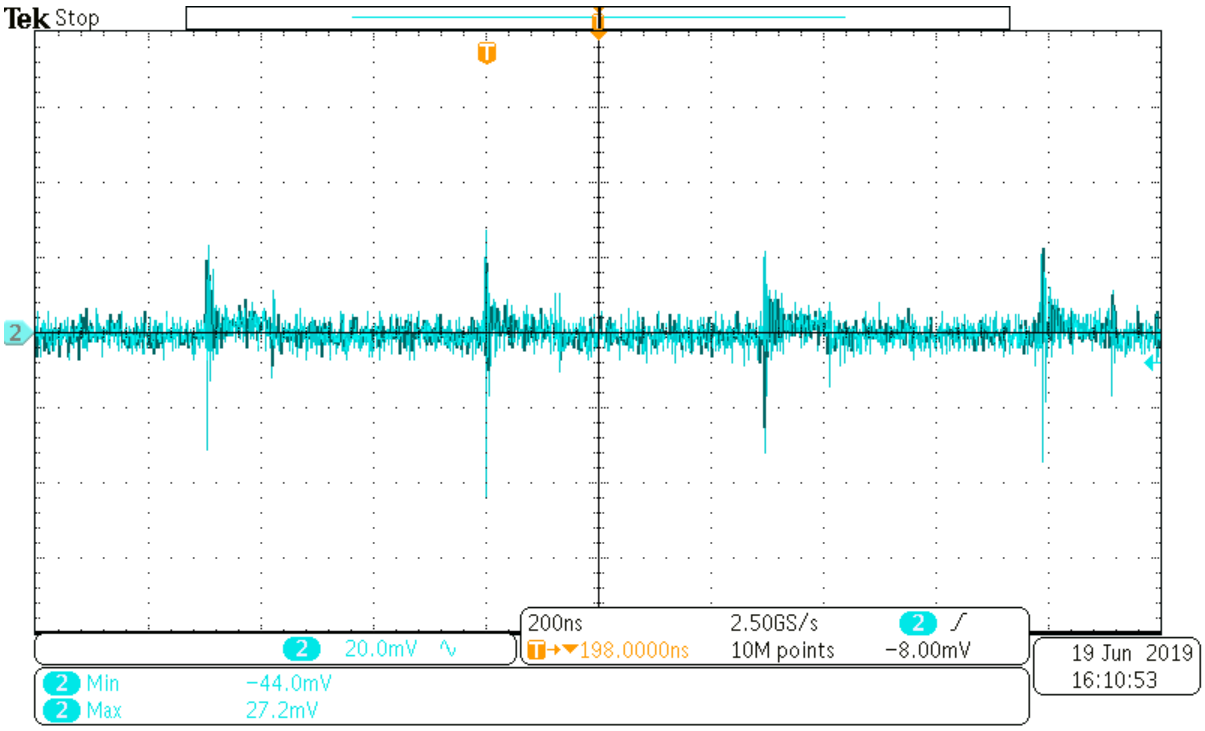
6 Waveforms TPS62810-Q1 (3.3 V @ 3.0 A)

6.1 Switching



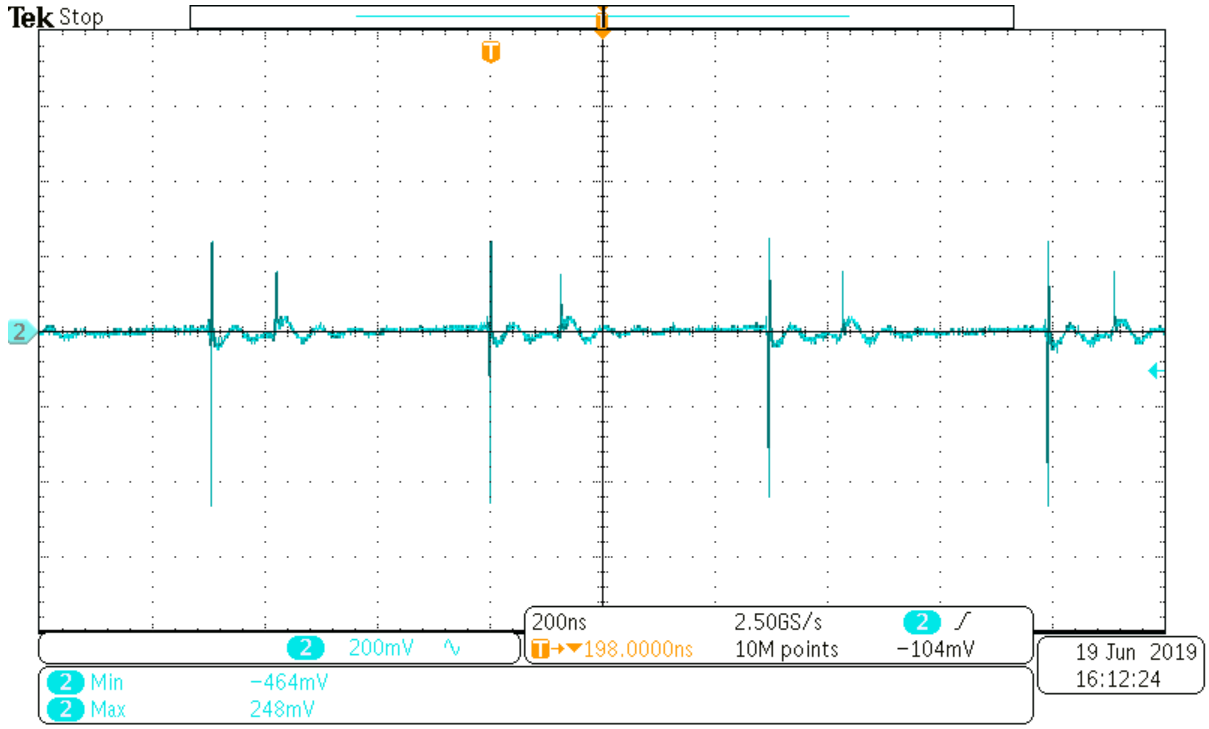
- Ch3: Switching node at 5.0V in from LM5143-Q1 Buck 1 output and 3.0A load current [scale: 2.0V/div, 200ns/div]

6.2 Output Voltage Ripple & Noise



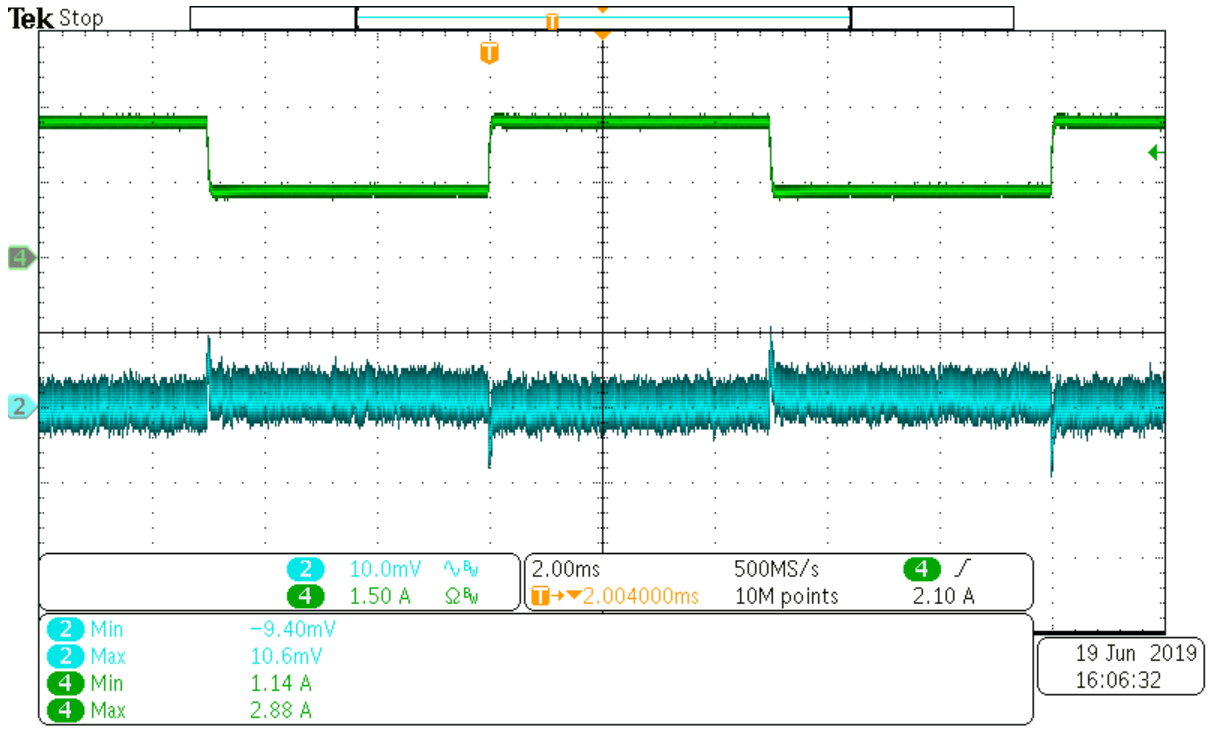
- Ch2: Output voltage ripple and noise, 71.2mV peak-peak [scale: 20.0mV/div, 200ns/div]

6.3 Input Voltage Ripple & Noise



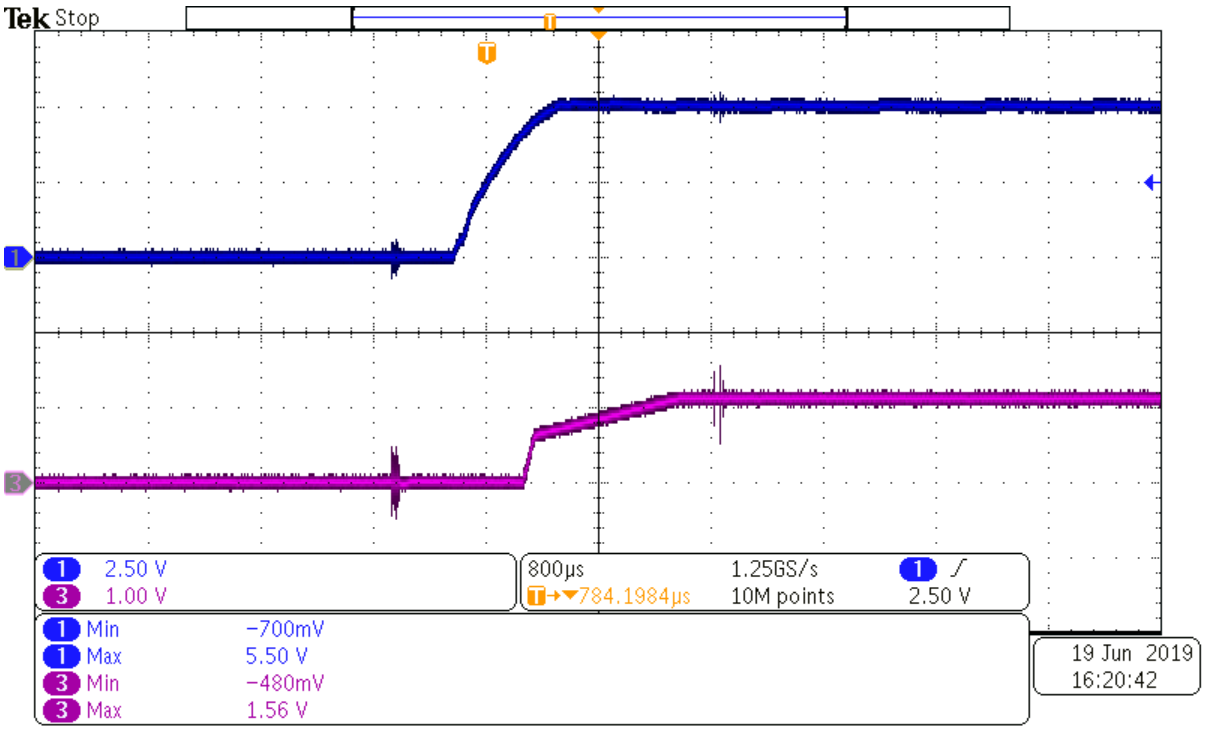
- Ch2: Input voltage ripple and noise, 712mV peak-peak [scale: 200mV/div, 200ns/div]

6.4 Load Transients



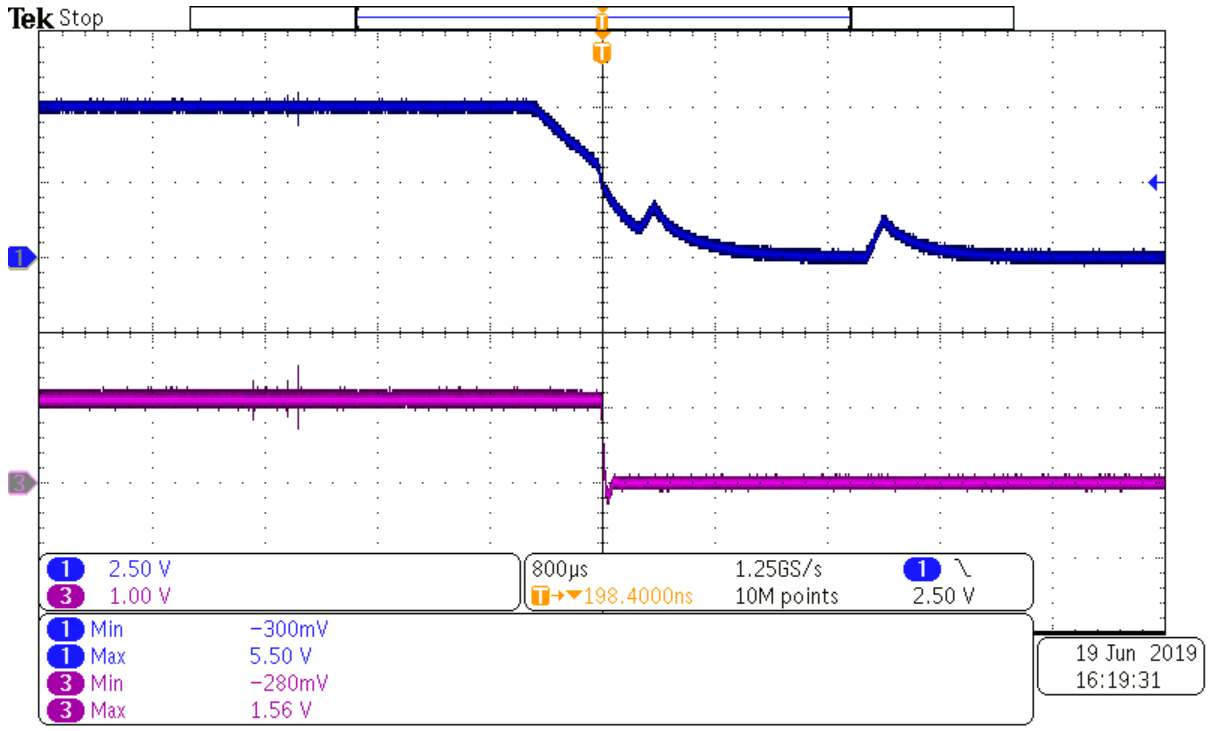
- Ch2: AC-coupled output voltage at 5.0V in, -9.4mV undershoot, 10.6mV overshoot [scale: 10.0mV/div, 2.0ms/div]
- Ch4: Load current, 50% to 100% load step [scale: 1.5A/div, 2.0ms/div]

6.5 Start-up



- Ch1: Input voltage [scale: 2.5V/div, 800us/div]
- Ch3: Output voltage [scale: 1.0V/div, 800us/div]

6.6 Shut down



- Ch1: Input voltage [scale: 2.5V/div, 800us/div]
- Ch3: Output voltage [scale: 1.0V/div, 800us/div]

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