Test Report: PMP22477

Class 6 PoE PD Flyback Converter (12 V, 3.8 A) With Input Power Limiting and PSR Reference Design

Description

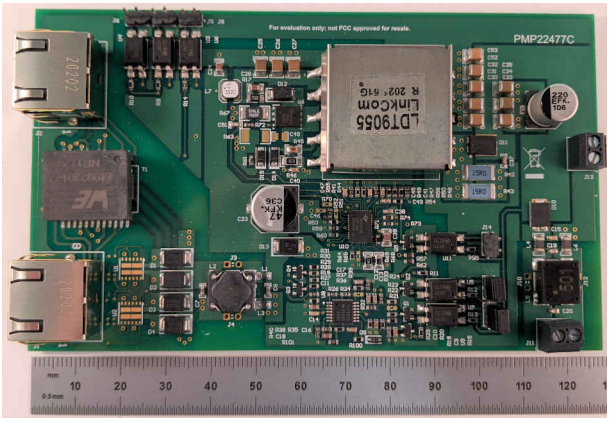
This reference design implements a Power over Ethernet (PoE) Powered Device (PD) flyback converter with a 12-V, 3.8-A output. A TPS23730 PD, pulse-width modulator (PWM) controller provides all necessary functions to implement the PoE PD control and PWM control for the flyback converter. The TPS23730 uses primary side regulation (PSR), eliminating the need for optocoupler feedback. An input power-limiting circuit enables the output to be paralleled with a second converter for increased output power capability. This reference design is ideally suited for applications such as wireless access points and security cameras.

Features

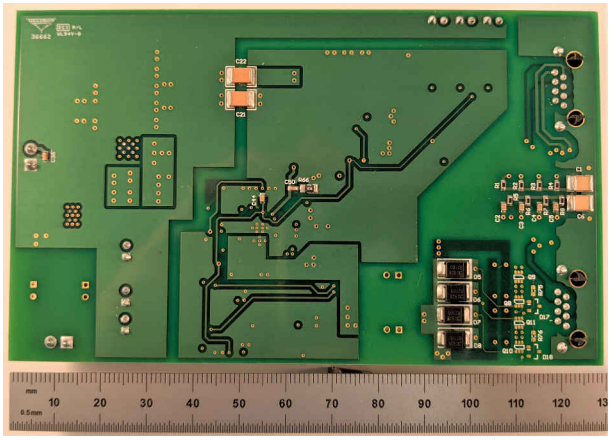
- Combined PD and PWM controller
- Primary side regulation (no optocoupler)
- Input power limiting
- Converters can be paralleled for increased power

Applications

- IP network camera
- WLAN, Wi-Fi® access point



Top Photo



Bottom Photo

1 Test Prerequisites

1.1 Voltage and Current Requirements

Table 1-1. Voltage and Current Requirements

Parameter	Specifications
Input Voltage	42.5 V–57 V
Output Voltage	12 V ±5%
Output Current	3.8 A
Nominal Switching Frequency	250 kHz
Adapter Voltage	12 V ±10%
Adapter Current	3.8 A

1.2 Required Equipment

- Isolated DC power source, 0 V–57 V, 2.0-A minimum
- IEEE802.3bt Type 3 PoE Power Source Equipment (PSE) Injector
- Isolated wall adapter, 12 V, 5 A
- 12-V, 5-A electronic load

1.3 Considerations

All measurements in this document are taken under the following conditions:

- 25°C ambient temperature
- With 48-V input at J1, unless otherwise specified
- Without power limit, unless otherwise specified

2 Testing and Results

2.1 Load Regulation

The following graph shows the load regulation curve with 48-V input.

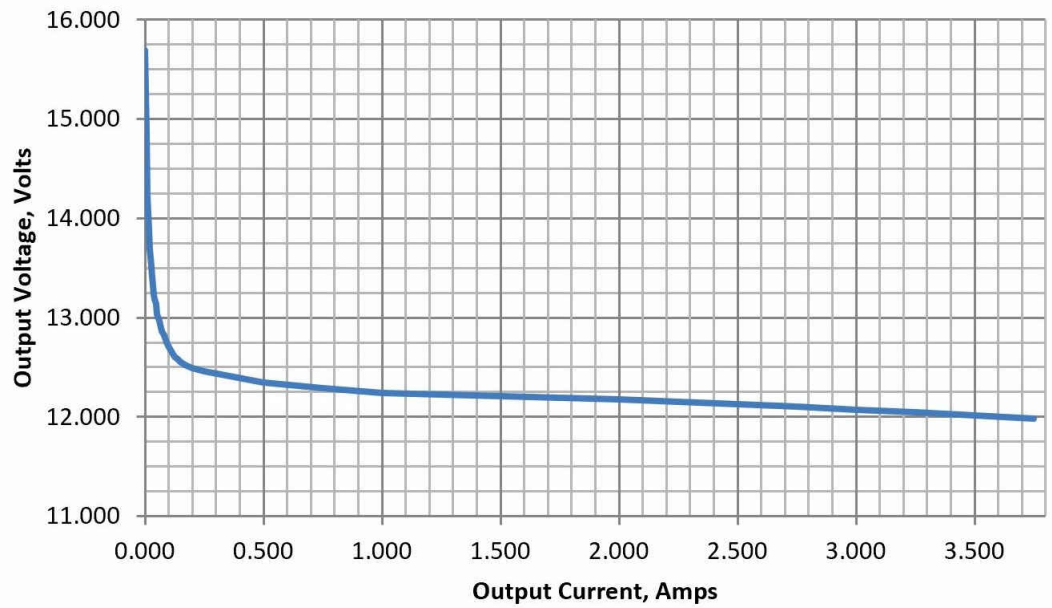


Figure 2-1. PMP22477 Rev. C Load Regulation, 48-V Input

2.2 Efficiency Graphs

Figure 2-2 shows the efficiency curves at 48-V input.

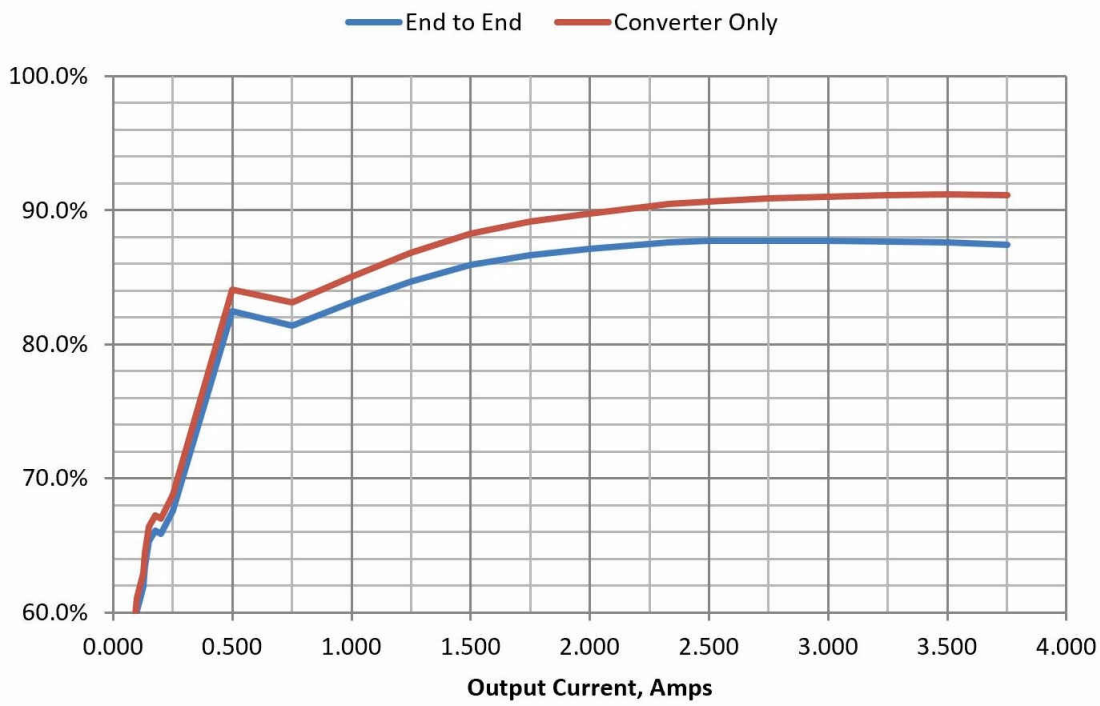


Figure 2-2. PMP22477 Rev. C Efficiency, 48-V Input

2.3 Efficiency Data

Efficiency data is shown in the following table.

I_{OUT} (J13 - A)	V_{OUT} (J13 - V)	I_{IN} (J1 - A)	V_{IN} (J1 - V)	Efficiency (End to End - %)	V_{IN} (C23 - V)	Efficiency (%)	P_{OUT} (W)
0.000	15.690	0.011	48.02	0.0%	47.38	0.0%	0.00
0.005	14.880	0.012	48.02	12.9%	47.37	13.1%	0.07
0.010	14.226	0.014	48.02	21.2%	47.37	21.5%	0.14
0.015	13.897	0.016	48.02	27.1%	47.36	27.5%	0.21
0.020	13.696	0.017	48.02	33.6%	47.35	34.0%	0.27
0.025	13.521	0.019	48.01	37.1%	47.34	37.6%	0.34
0.030	13.413	0.021	48.01	39.9%	47.34	40.5%	0.40
0.035	13.239	0.022	48.01	43.9%	47.33	44.5%	0.46
0.040	13.185	0.024	48.01	45.8%	47.32	46.4%	0.53
0.045	13.139	0.026	48.01	47.4%	47.32	48.1%	0.59
0.050	13.035	0.028	48.01	48.5%	47.31	49.2%	0.65
0.060	12.970	0.031	48.01	52.3%	47.30	53.1%	0.78
0.070	12.865	0.034	48.01	55.2%	47.30	56.0%	0.90
0.080	12.826	0.038	48.01	56.2%	47.29	57.1%	1.03
0.090	12.746	0.041	48.01	58.3%	47.28	59.2%	1.15
0.100	12.700	0.044	48.01	60.1%	47.27	61.1%	1.27
0.125	12.604	0.053	48.01	61.9%	47.25	62.9%	1.58
0.133	12.588	0.055	48.01	63.4%	47.24	64.4%	1.67
0.150	12.545	0.060	48.01	65.3%	47.22	66.4%	1.88
0.175	12.517	0.069	48.01	66.1%	47.23	67.2%	2.19
0.200	12.493	0.079	48.01	65.9%	47.20	67.0%	2.50
0.250	12.455	0.096	48.00	67.6%	47.16	68.8%	3.11
0.500	12.349	0.156	48.00	82.5%	47.08	84.1%	6.17
0.750	12.293	0.236	48.00	81.4%	46.99	83.1%	9.22
1.000	12.244	0.307	48.00	83.1%	46.90	85.0%	12.24
1.250	12.228	0.376	48.00	84.7%	46.82	86.8%	15.29
1.500	12.211	0.444	48.01	85.9%	46.76	88.2%	18.32
1.750	12.193	0.513	48.00	86.7%	46.67	89.1%	21.34
2.000	12.173	0.582	48.01	87.1%	46.61	89.7%	24.35
2.250	12.151	0.651	48.02	87.5%	46.51	90.3%	27.34
2.330	12.143	0.673	48.01	87.6%	46.48	90.4%	28.29
2.500	12.126	0.720	48.01	87.7%	46.45	90.6%	30.32
2.750	12.100	0.790	48.01	87.7%	46.36	90.9%	33.28
3.000	12.074	0.860	48.01	87.7%	46.29	91.0%	36.22
3.250	12.046	0.930	48.01	87.7%	46.20	91.1%	39.15
3.500	12.016	1.000	48.01	87.6%	46.12	91.2%	42.06
3.750	11.984	1.071	48.01	87.4%	46.05	91.1%	44.94

2.4 Input Power Limit

Table 2-1 and Figure 2-3 show the input power limit type 1 results.

Table 2-1. Type 1 Results

V_{IN1} (J1 - V)	I_{IN1} (J1 - A)	Pin1 (J1 - W)	I_{OUT} (J12 - A)	V_{OUT} (J12 - V)	P_{OUT} (J12 - W)	Efficiency (%)
37.00	0.320	11.84	0.861	11.506	9.91	83.7%
38.00	0.315	11.97	0.869	11.502	10.00	83.5%
39.00	0.309	12.05	0.876	11.496	10.07	83.6%
40.00	0.304	12.16	0.882	11.496	10.14	83.4%
41.00	0.298	12.22	0.886	11.502	10.19	83.4%
42.00	0.292	12.26	0.889	11.505	10.23	83.4%
43.00	0.287	12.34	0.892	11.504	10.26	83.2%
44.00	0.281	12.36	0.894	11.500	10.28	83.2%
45.00	0.276	12.42	0.895	11.503	10.30	82.9%
46.00	0.270	12.42	0.894	11.507	10.29	82.8%
47.00	0.264	12.41	0.893	11.505	10.27	82.8%
48.00	0.259	12.43	0.892	11.501	10.26	82.5%
49.00	0.253	12.40	0.889	11.505	10.23	82.5%
50.00	0.248	12.40	0.885	11.503	10.18	82.1%
51.00	0.243	12.39	0.881	11.501	10.13	81.8%
52.00	0.237	12.32	0.875	11.505	10.07	81.7%
53.00	0.231	12.24	0.869	11.503	10.00	81.6%
54.00	0.225	12.15	0.863	11.502	9.93	81.7%
55.00	0.220	12.10	0.856	11.499	9.84	81.3%
56.00	0.214	11.98	0.849	11.493	9.76	81.4%
57.00	0.209	11.91	0.841	11.504	9.67	81.2%

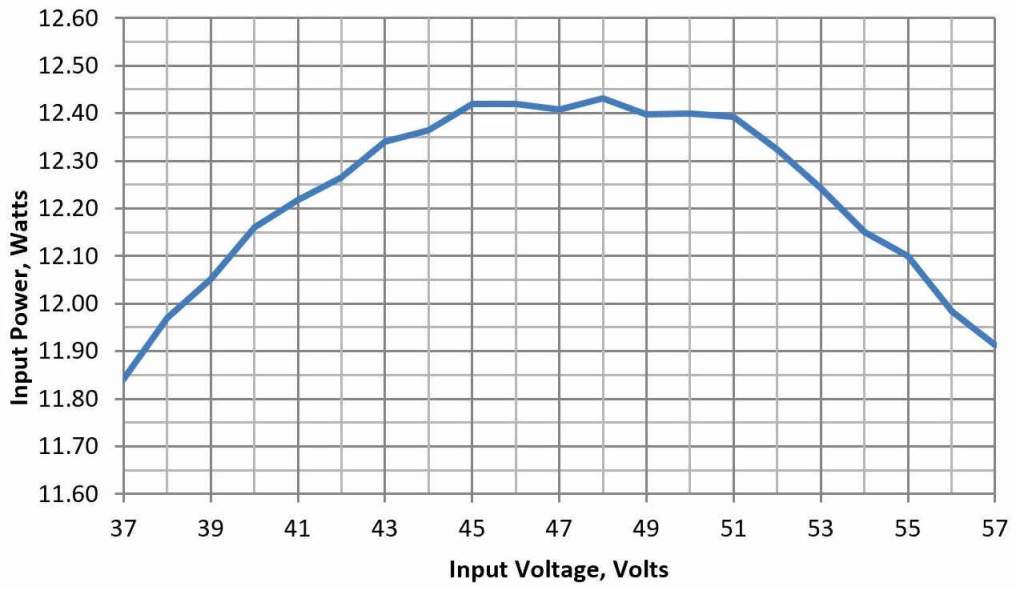


Figure 2-3. PMP22477 Rev. C Input Power Limit, Type 1

Table 2-2 and Figure 2-4 show the input power limit type 2 results.

Table 2-2. Type 2 Results

V_{IN1} (J1 - V)	I_{IN1} (J1 - A)	Pin1 (J1 - W)	I_{OUT} (J12 - A)	V_{OUT} (J12 - V)	P_{OUT} (J12 - W)	Efficiency (%)
42.00	0.556	23.35	1.764	11.503	20.29	86.9%
43.00	0.547	23.52	1.778	11.500	20.45	86.9%
44.00	0.538	23.67	1.788	11.505	20.57	86.9%
45.00	0.529	23.81	1.798	11.502	20.68	86.9%
46.00	0.519	23.87	1.806	11.502	20.77	87.0%
47.00	0.510	23.97	1.813	11.500	20.85	87.0%
48.00	0.501	24.05	1.817	11.499	20.89	86.9%
49.00	0.491	24.06	1.819	11.500	20.92	86.9%
50.00	0.482	24.10	1.819	11.501	20.92	86.8%
51.00	0.472	24.07	1.819	11.499	20.92	86.9%
52.00	0.463	24.08	1.815	11.505	20.88	86.7%
53.00	0.453	24.01	1.811	11.502	20.83	86.8%
54.00	0.444	23.98	1.805	11.503	20.76	86.6%
55.00	0.434	23.87	1.797	11.504	20.67	86.6%
56.00	0.425	23.80	1.788	11.503	20.57	86.4%
57.00	0.415	23.66	1.778	11.500	20.45	86.4%

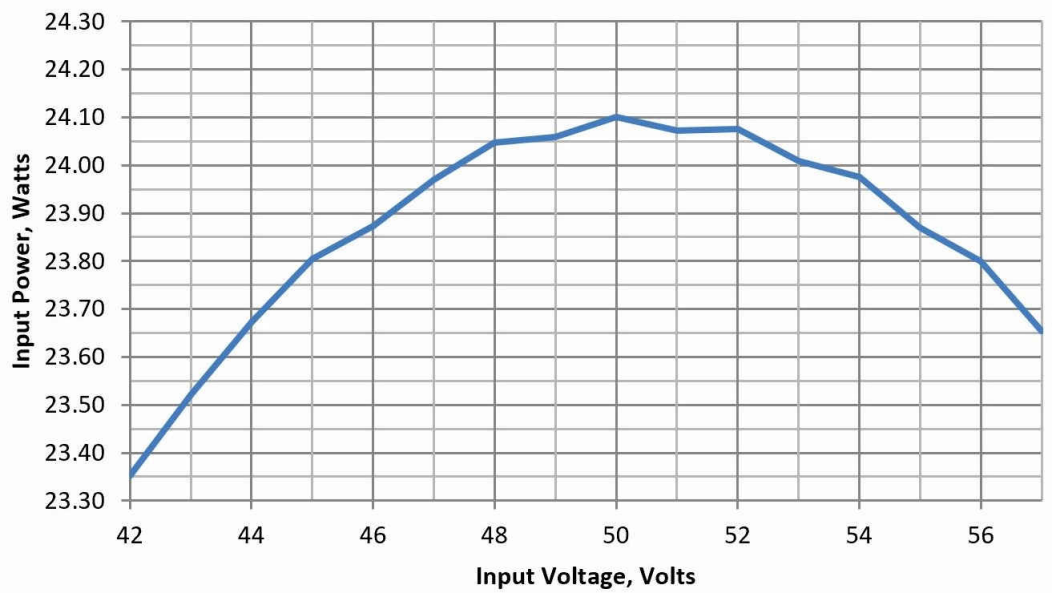


Figure 2-4. PMP22477 Rev. C Input Power Limit, Type 2

Table 2-3 and Figure 2-5 show the input power limit type 3 results

Table 2-3. Type 3 Results

V_{IN1} (J1 - V)	I_{IN1} (J1 - A)	Pin1 (J1 - W)	I_{OUT} (J12 - A)	V_{OUT} (J12 - W)	P_{OUT} (J12 - W)	Efficiency (%)
42.00	1.135	47.67	3.580	11.503	41.18	86.4%
43.00	1.117	48.03	3.610	11.501	41.52	86.4%
44.00	1.097	48.27	3.637	11.500	41.83	86.7%
45.00	1.077	48.47	3.660	11.502	42.10	86.9%
46.00	1.059	48.71	3.680	11.503	42.33	86.9%
47.00	1.040	48.88	3.698	11.501	42.53	87.0%
48.00	1.024	49.15	3.729	11.502	42.89	87.3%
49.00	1.003	49.15	3.731	11.501	42.91	87.3%
50.00	0.983	49.15	3.734	11.501	42.94	87.4%
51.00	0.962	49.06	3.734	11.503	42.95	87.5%
52.00	0.943	49.04	3.732	11.502	42.93	87.5%
53.00	0.923	48.92	3.727	11.503	42.87	87.6%
54.00	0.903	48.76	3.720	11.501	42.78	87.7%
55.00	0.883	48.57	3.708	11.502	42.65	87.8%
56.00	0.863	48.33	3.695	11.500	42.49	87.9%
57.00	0.844	48.11	3.678	11.500	42.30	87.9%

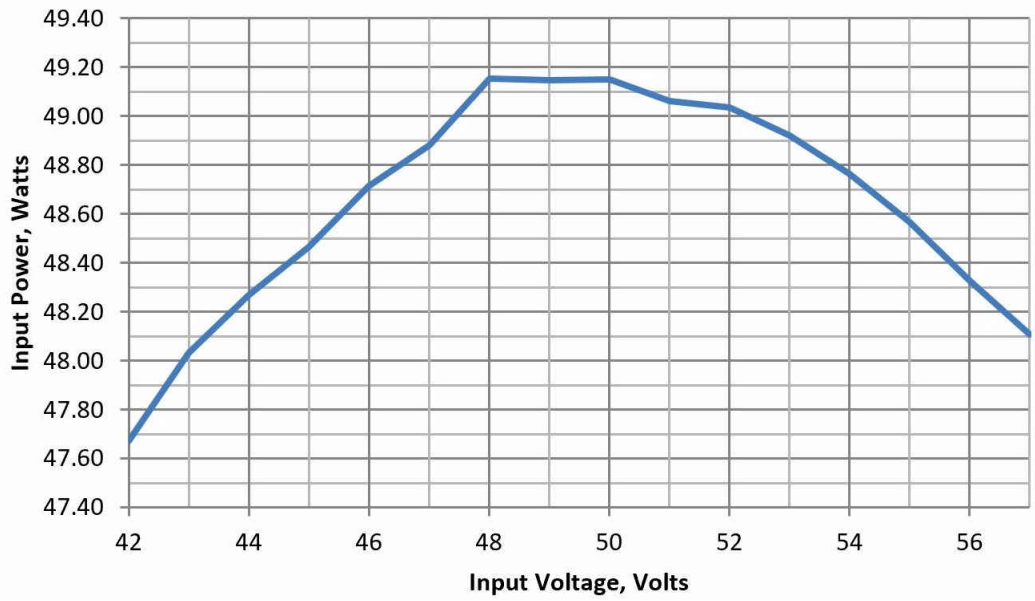


Figure 2-5. PMP22477 Rev. C Input Power Limit, Type 3

Table 2-4 and Figure 2-6 show the two port power sharing, type 3 results.

Table 2-4. Two Port Power Sharing, Type 3 Results

I_{OUT} (A)	V_{OUT} (V)	P_{OUT} (W)	$I_{IN}1$ (A)	$V_{IN}1$ (V)	Pin1 (W)	$I_{IN}2$ (A)	$V_{IN}2$ (V)	Pin2 (W)	Pin, Total (W)	Pin1%	Pin2%	Efficiency (%)
0.000	15.820	0.00	0.010	48.05	0.48	0.010	48.07	0.48	0.96	50.0%	50.0%	0.0%
0.100	13.045	1.30	0.027	48.04	1.30	0.026	48.07	1.25	2.55	50.9%	49.1%	51.2%
0.200	12.674	2.53	0.045	48.00	2.16	0.040	48.07	1.92	4.08	52.9%	47.1%	62.1%
0.300	12.511	3.75	0.059	48.00	2.83	0.056	48.06	2.69	5.52	51.3%	48.7%	68.0%
0.400	12.455	4.98	0.084	48.05	4.04	0.066	48.04	3.17	7.21	56.0%	44.0%	69.1%
0.600	12.389	7.43	0.118	48.05	5.67	0.098	48.03	4.71	10.38	54.6%	45.4%	71.6%
0.800	12.347	9.88	0.144	48.05	6.92	0.124	48.03	5.96	12.87	53.7%	46.3%	76.7%
1.000	12.315	12.32	0.168	48.06	8.07	0.144	48.02	6.91	14.99	53.9%	46.1%	82.2%
1.200	12.291	14.75	0.209	48.04	10.04	0.160	48.01	7.68	17.72	56.7%	43.3%	83.2%
1.400	12.269	17.18	0.245	48.02	11.76	0.182	48.01	8.74	20.50	57.4%	42.6%	83.8%
1.600	12.250	19.60	0.271	48.00	13.01	0.219	48.00	10.51	23.52	55.3%	44.7%	83.3%
1.800	12.237	22.03	0.303	48.00	14.54	0.246	48.03	11.82	26.36	55.2%	44.8%	83.6%
2.000	12.225	24.45	0.341	48.00	16.37	0.264	48.03	12.68	29.05	56.3%	43.7%	84.2%
2.500	12.199	30.50	0.426	48.00	20.45	0.316	48.01	15.17	35.62	57.4%	42.6%	85.6%
3.000	12.182	36.55	0.502	48.03	24.11	0.376	48.05	18.07	42.18	57.2%	42.8%	86.6%
3.500	12.165	42.58	0.577	48.04	27.72	0.438	48.03	21.04	48.76	56.9%	43.1%	87.3%
4.000	12.148	48.59	0.647	48.04	31.08	0.505	48.01	24.25	55.33	56.2%	43.8%	87.8%
4.50	12.130	54.59	0.712	48.03	34.20	0.579	48.04	27.82	62.01	55.1%	44.9%	88.0%
5.00	12.111	60.56	0.771	48.04	37.04	0.657	48.02	31.55	68.59	54.0%	46.0%	88.3%
5.50	12.092	66.51	0.832	48.03	39.96	0.735	48.04	35.31	75.27	53.1%	46.9%	88.4%
6.00	12.070	72.42	0.896	48.00	43.01	0.812	48.01	38.98	81.99	52.5%	47.5%	88.3%
6.50	12.048	78.31	0.962	48.02	46.20	0.885	48.05	42.52	88.72	52.1%	47.9%	88.3%
6.60	12.043	79.48	0.975	48.01	46.81	0.899	48.03	43.18	89.99	52.0%	48.0%	88.3%
6.70	12.038	80.65	0.990	48.00	47.52	0.914	48.03	43.90	91.42	52.0%	48.0%	88.2%
6.80	12.031	81.81	0.997	48.00	47.86	0.934	48.03	44.86	92.72	51.6%	48.4%	88.2%
6.90	12.021	82.94	0.997	48.00	47.86	0.962	48.01	46.19	94.04	50.9%	49.1%	88.2%
7.00	12.012	84.08	0.997	48.00	47.86	0.991	48.00	47.57	95.42	50.2%	49.8%	88.1%
7.10	11.898	84.48	0.997	48.00	47.86	1.001	48.00	48.05	95.90	49.9%	50.1%	88.1%
7.20	11.728	84.44	0.997	48.00	47.86	1.001	48.00	48.05	95.90	49.9%	50.1%	88.0%
7.30	11.560	84.39	0.996	48.00	47.81	1.001	48.00	48.05	95.86	49.9%	50.1%	88.0%
7.40	11.400	84.36	0.996	48.00	47.81	1.001	48.00	48.05	95.86	49.9%	50.1%	88.0%
7.50	11.245	84.34	0.996	48.00	47.81	1.001	48.00	48.05	95.86	49.9%	50.1%	88.0%
7.60	11.091	84.29	0.996	48.00	47.81	1.001	48.00	48.05	95.86	49.9%	50.1%	87.9%
7.70	10.942	84.25	0.996	48.00	47.81	1.001	48.00	48.05	95.86	49.9%	50.1%	87.9%
7.80	10.796	84.21	0.996	48.00	47.81	1.000	48.00	48.00	95.81	49.9%	50.1%	87.9%

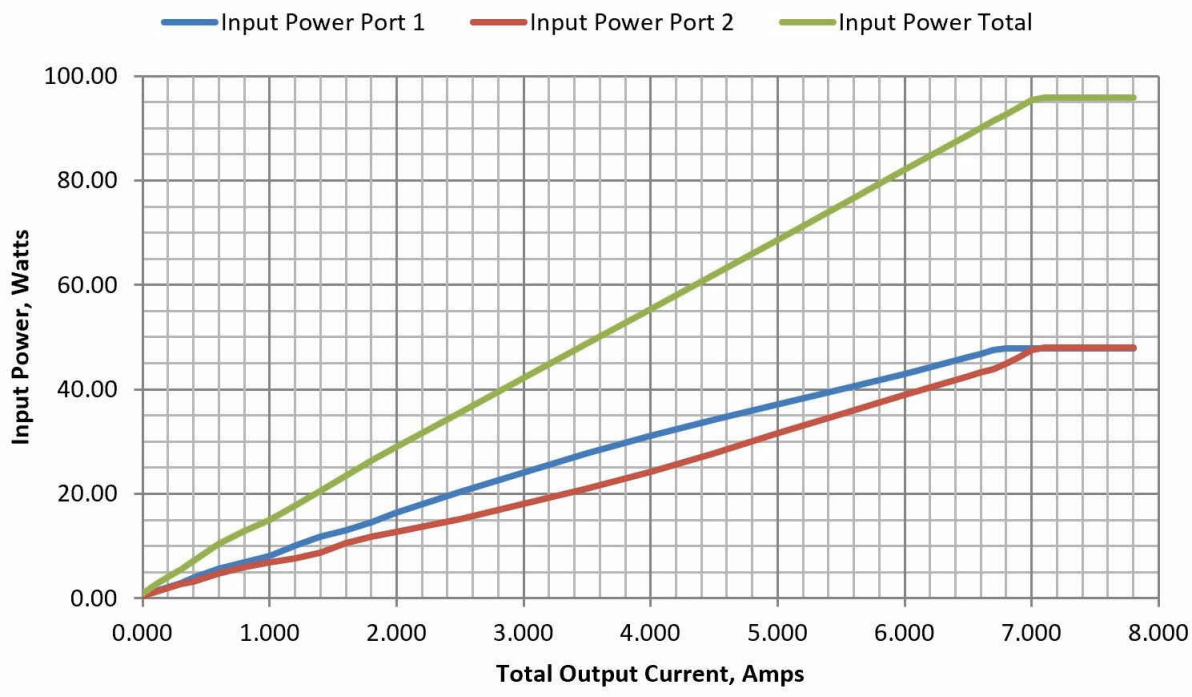


Figure 2-6. PMP22477 Rev. C Two Port Power Sharing, Type 3

2.5 Thermal Images

Figure 2-7 and Figure 2-8 show the thermal images.

Measurements	
Sp1	67.3 °C
Sp2	68.9 °C
Parameters	
Emissivity	0.95
Refl. temp.	20 °C

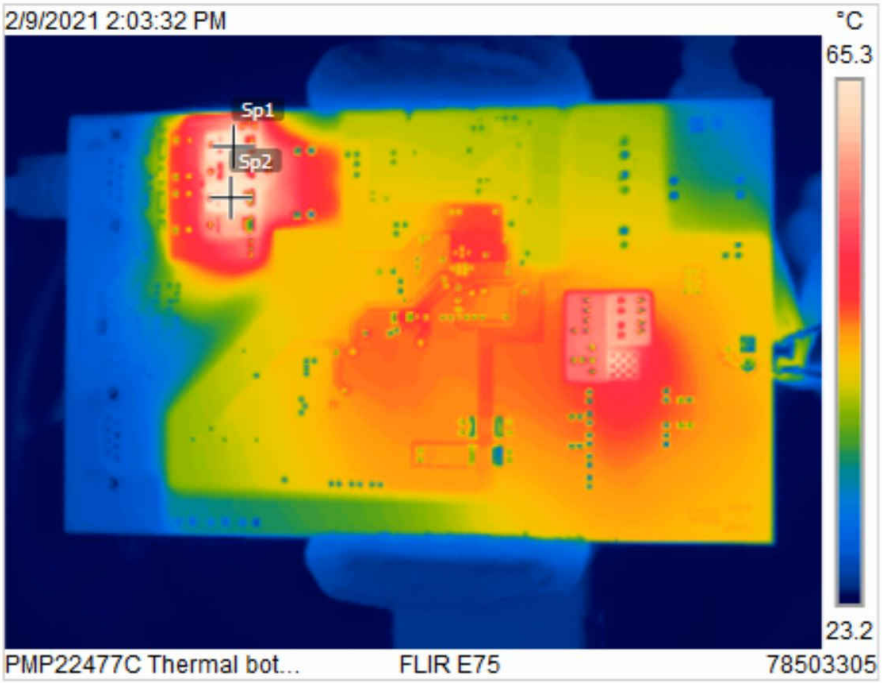


Figure 2-7. Bottom

Measurements	
Sp1	65.8 °C
Sp2	52.2 °C
Sp3	44.0 °C
Sp4	68.5 °C
Sp5	67.9 °C
Sp6	57.3 °C
Sp7	63.8 °C
Sp8	67.9 °C
Parameters	
Emissivity	0.95
Refl. temp.	20 °C

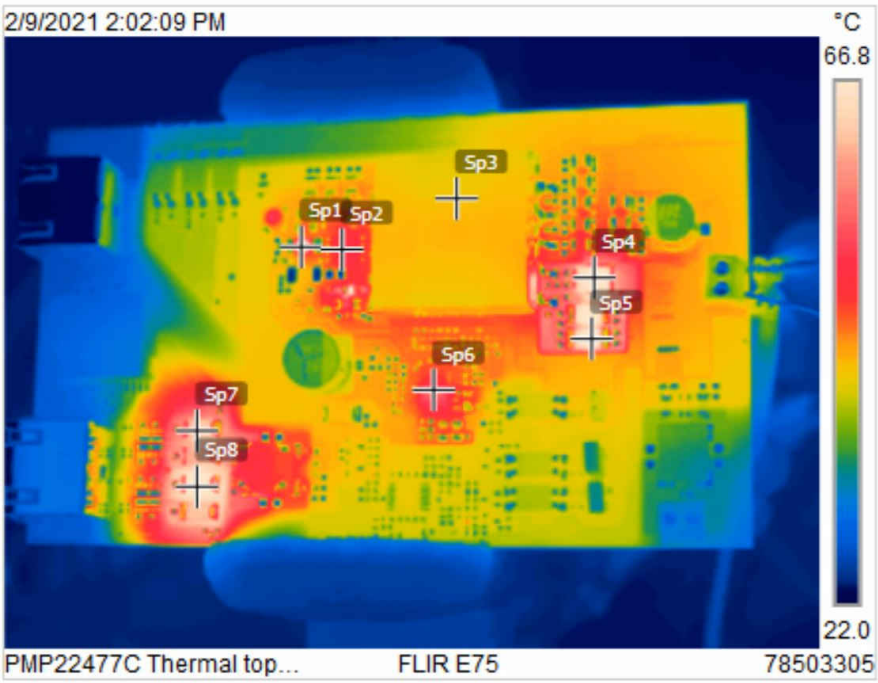


Figure 2-8. Top

3 Waveforms

3.1 Switching

The following images show the switching waveforms.

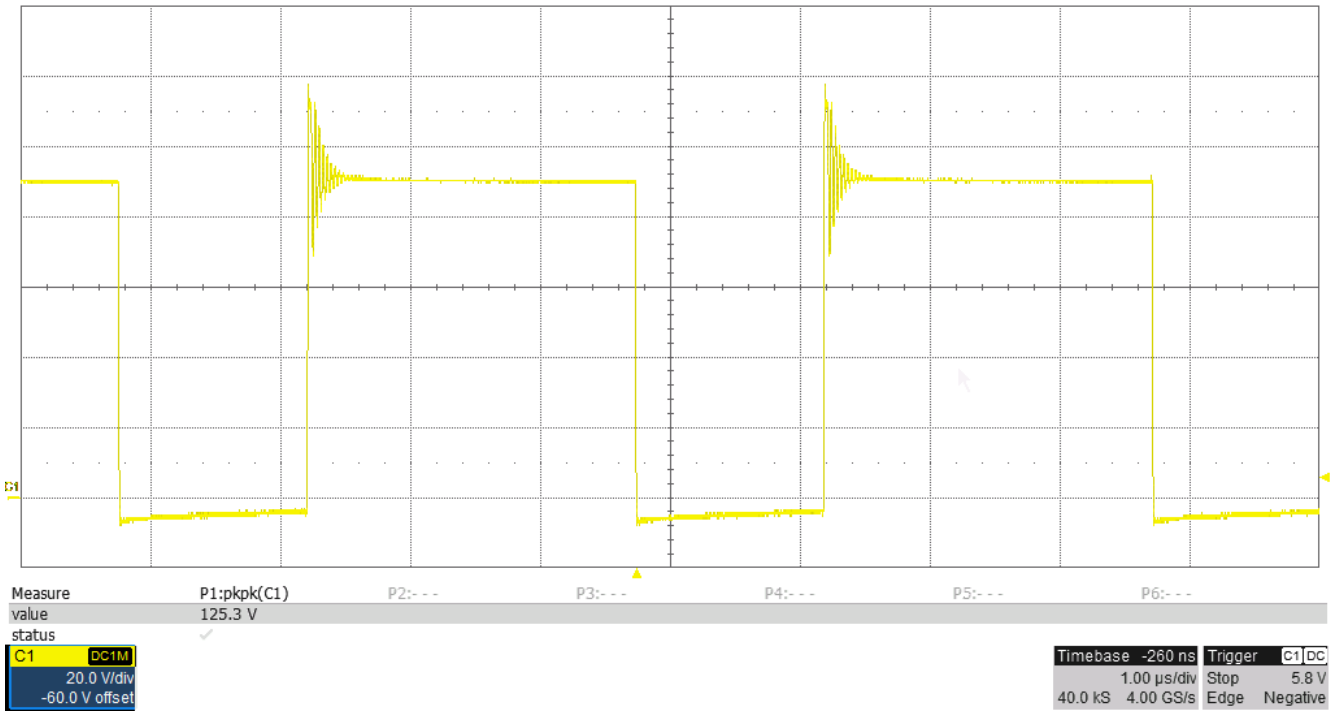


Figure 3-1. VDS, Q6, 57-V Input, 3.8-A Load, 20 V/div, 1 µs/div, Measured 125.3 V

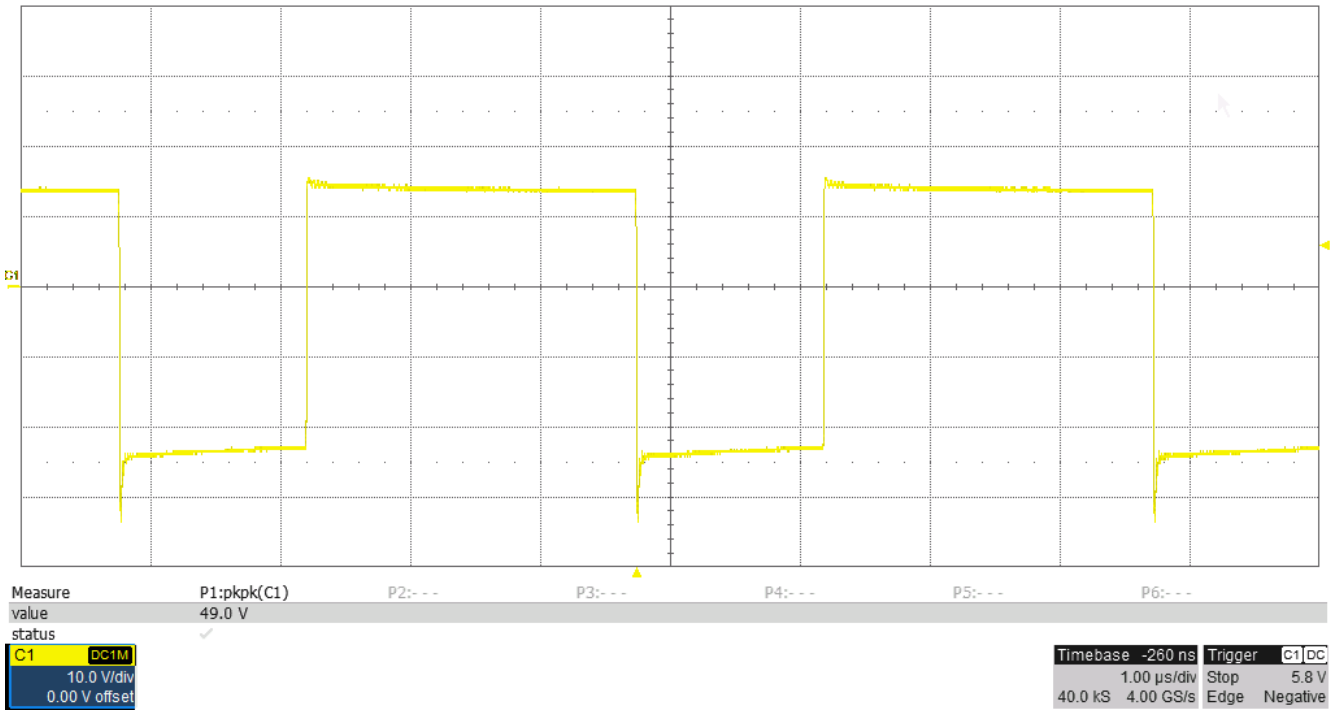


Figure 3-2. Anode-to-Cathode Voltage, D11, 57-V Input, 3.8-A Load, 10 V/div, 1 µs/div, Measured 49.0 V

3.2 Voltage Ripple

The following images show the input and output ripple waveforms.

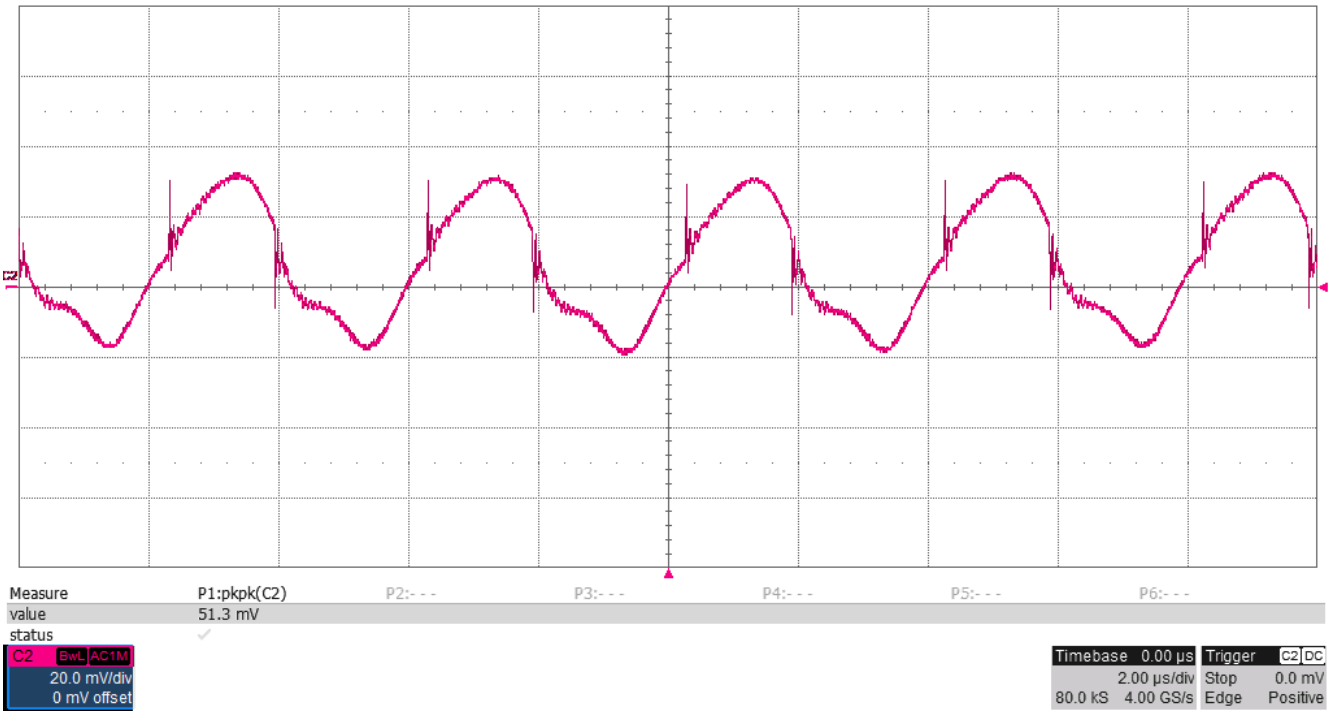


Figure 3-3. Input Ripple (C24), 20 mV/div, 2 µs/div, Measured 51.3 mVpp

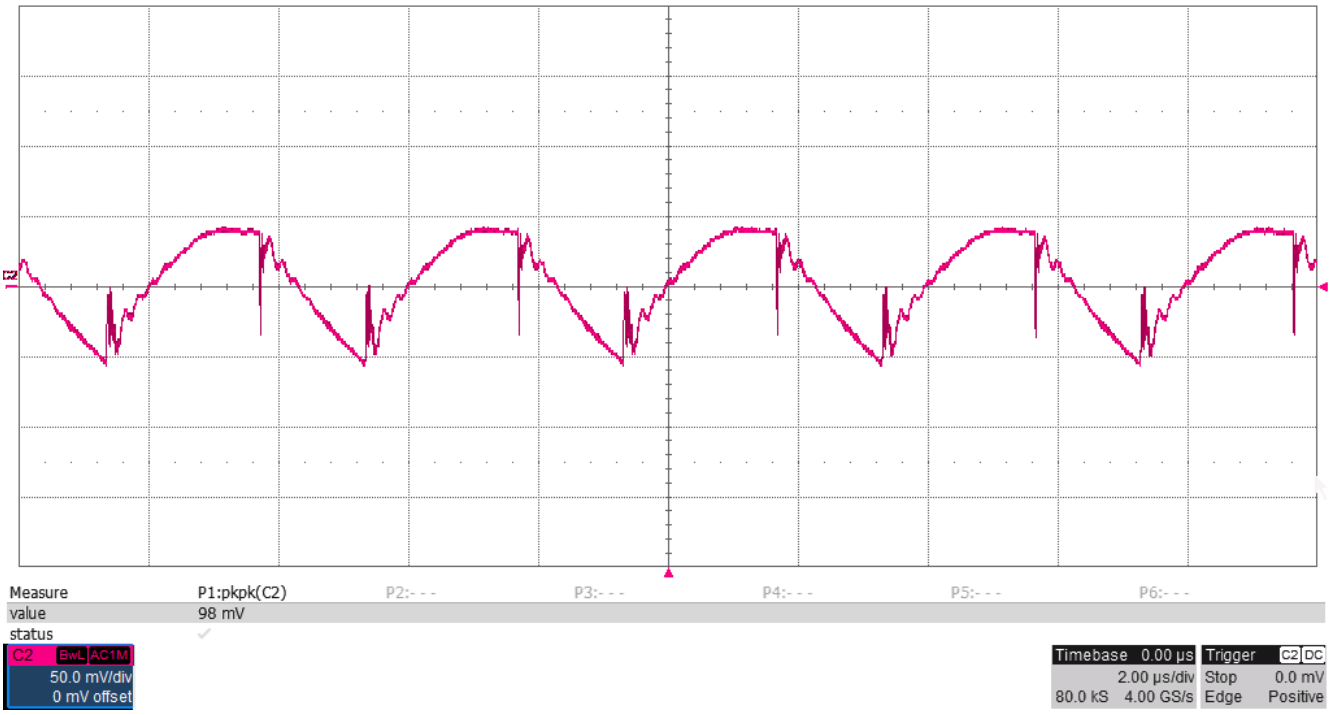


Figure 3-4. Output Ripple, 50 mV/div, 2 µs/div, Measured 98 mVpp

3.3 Bode Plots

The following images show the bode plot waveforms.

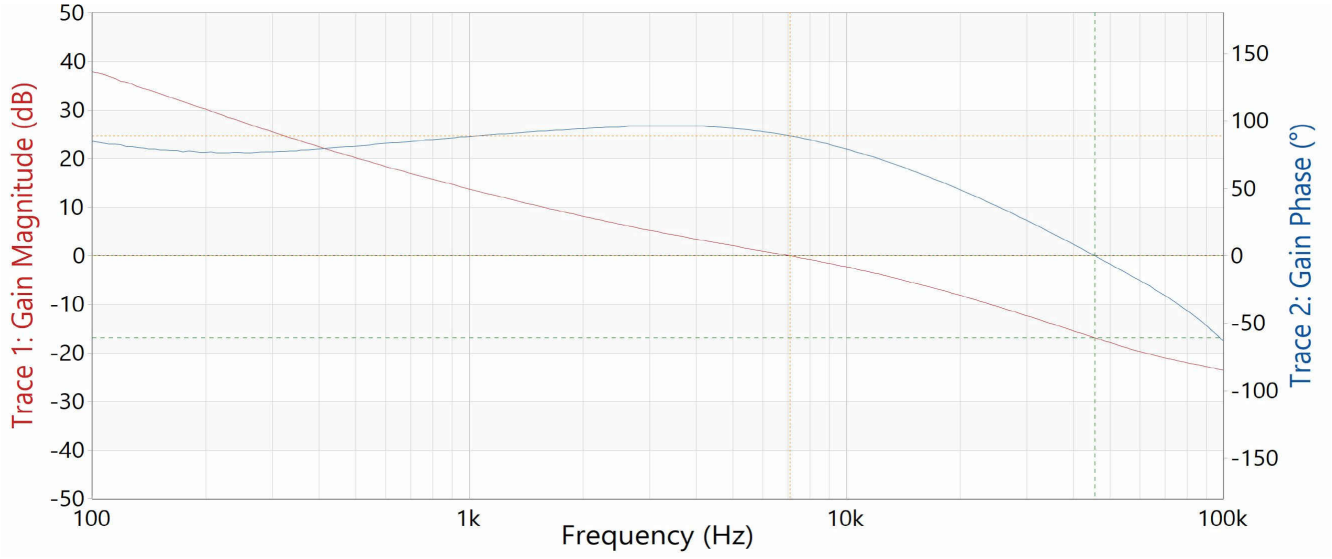


Figure 3-5. Voltage Regulation, 3.8-A Load, Bandwidth = 7.0 kHz, Phase Margin = 89.0 degrees, Gain Margin = 16.8 dB

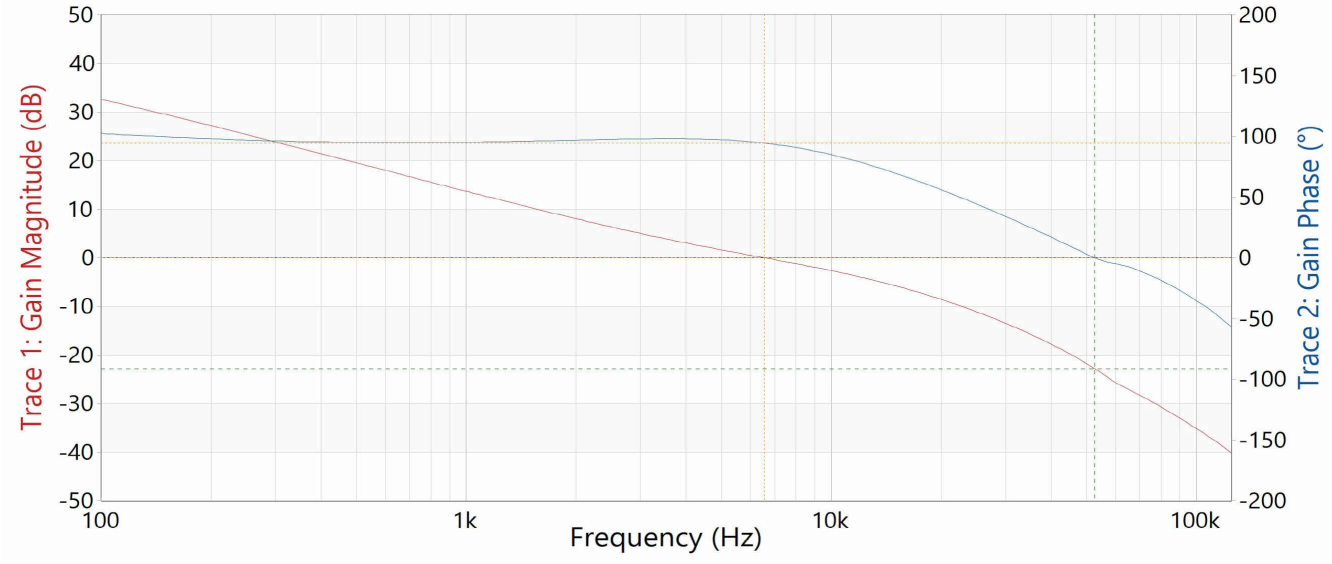


Figure 3-6. Power Limit, Type 1, Bandwidth = 6.5 kHz, Phase Margin = 94.5 degrees, Gain Margin = 22.8 dB

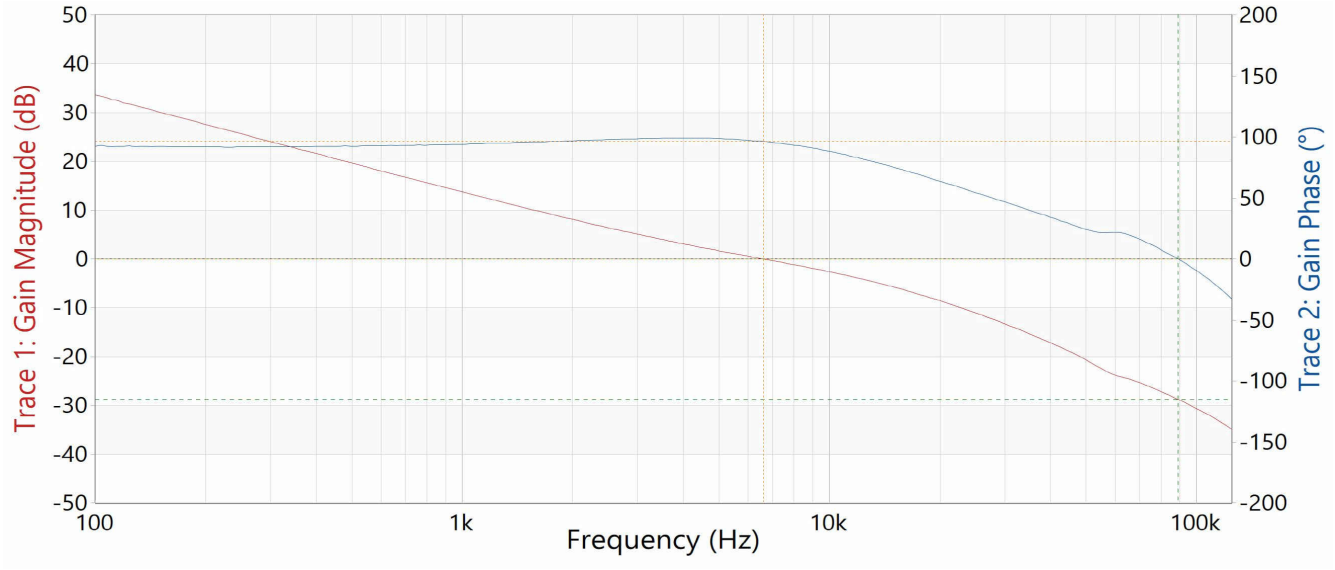


Figure 3-7. Power Limit, Type 2, Bandwidth = 6.6 kHz, Phase Margin = 96.4 degrees, Gain Margin = 28.7 dB

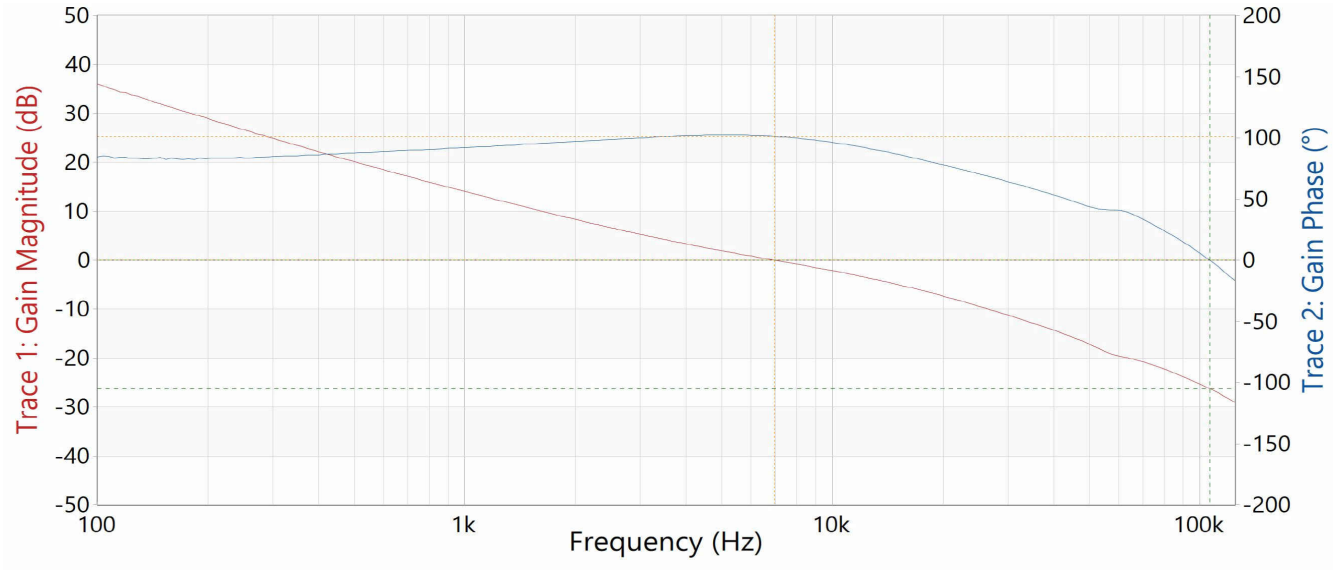


Figure 3-8. Power Limit, Type 3, Bandwidth = 6.9 kHz, Phase Margin = 101.1 degrees, Gain Margin = 26.2 dB

3.4 Load Transients

Load transient response is shown in the following figures.

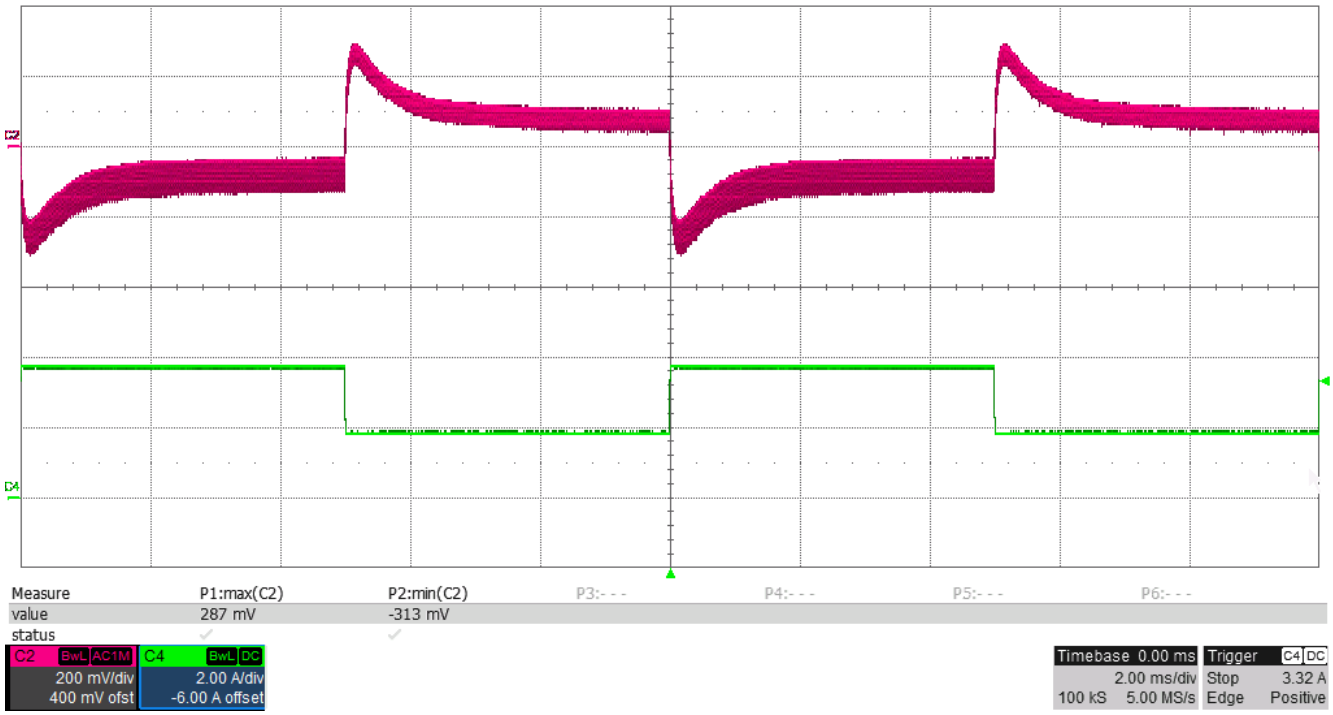


Figure 3-9. Output Load Step Response, 1.9-A to 3.8-A Load Step (50 to 100%), 200 mV/div, 2 A/div, 2 ms/div, Slew Rate = 250 mA/µs, Measured –313 mV, +287 mV

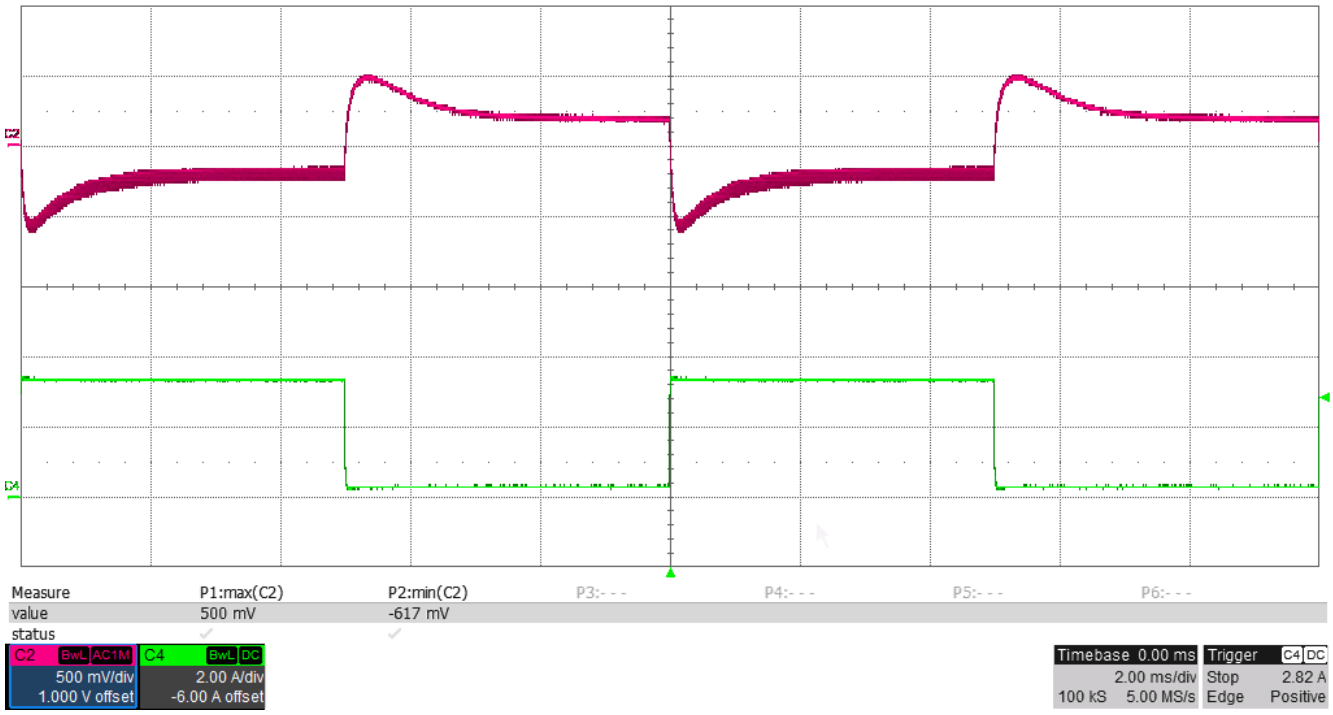


Figure 3-10. Output Load Step Response, 380-mA to 3.4-A Load Step (10 to 90%), 500 mV/div, 2 A/div, 2 ms/div, Slew Rate = 250 mA/µs, Measured –617 mV, +500 mV

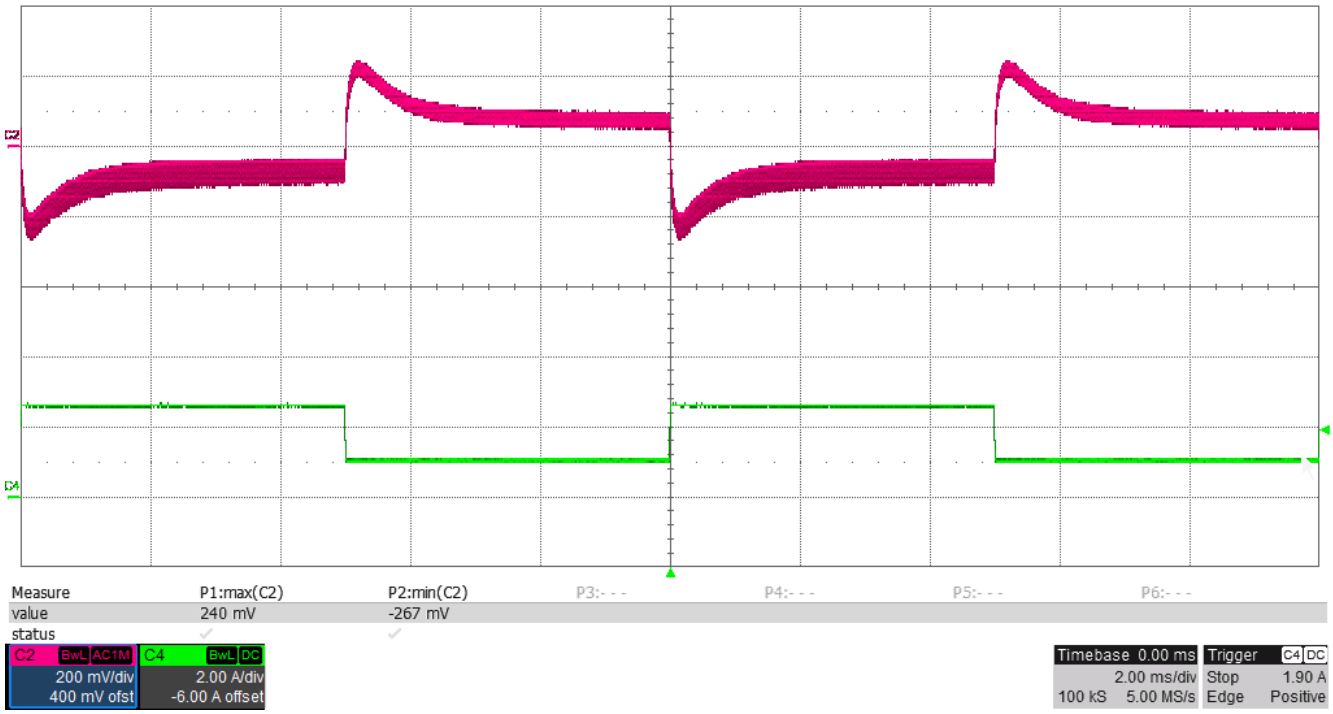


Figure 3-11. Output Load Step Response, 1.1-A to 2.6-A Load Step (30 to 70%), 200 mV/div, 2 A/div, 2 ms/div, Slew Rate = 250 mA/µs, Measured –267 mV, +240 mV

3.5 Start-Up Sequence

The following images show the start-up behavior waveforms.

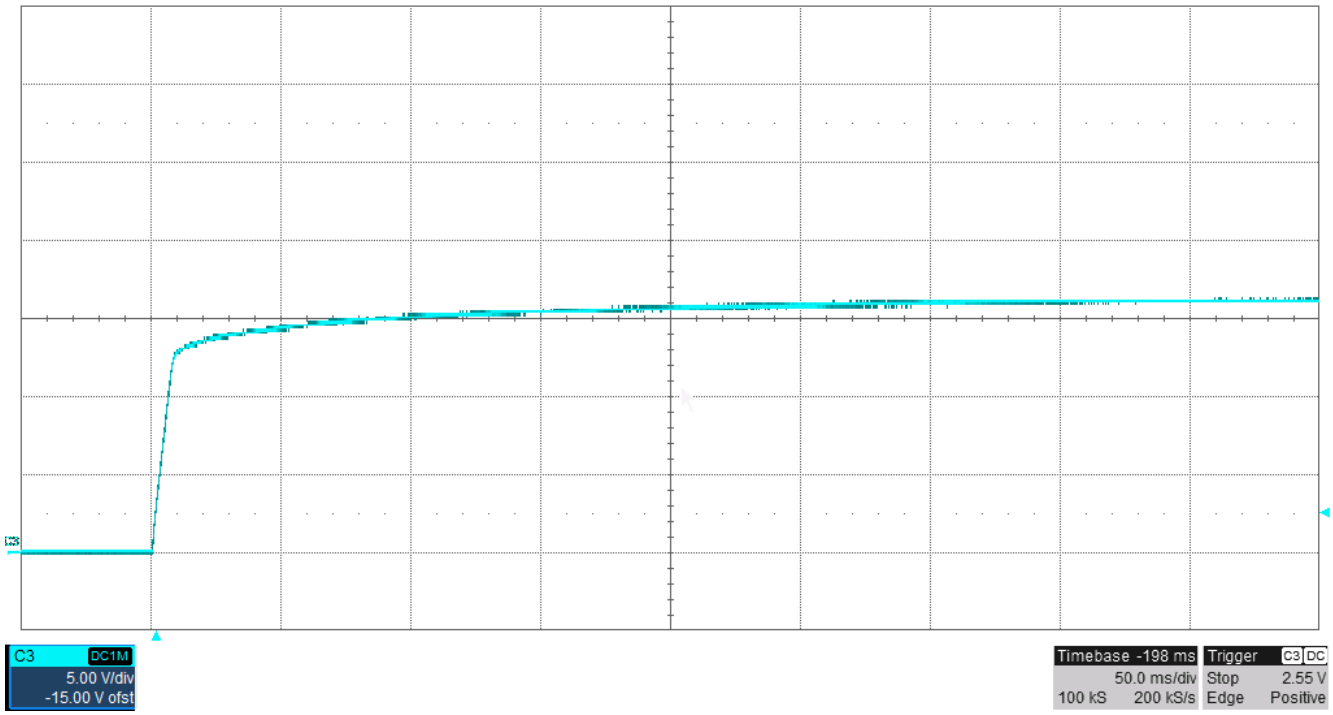


Figure 3-12. Start-Up, 0-A Load, 5 V/div, 50 ms/div

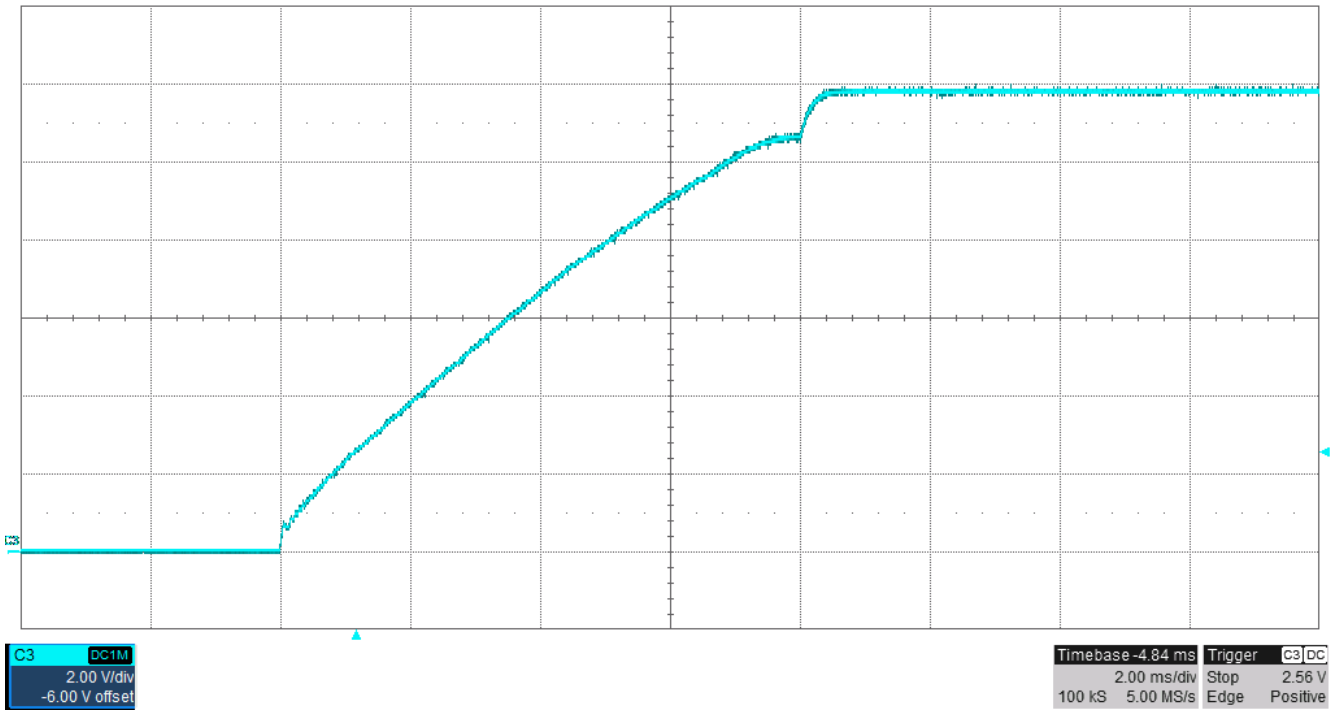


Figure 3-13. Start-Up, 3.8-A Load, 2 V/div, 2 ms/div

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