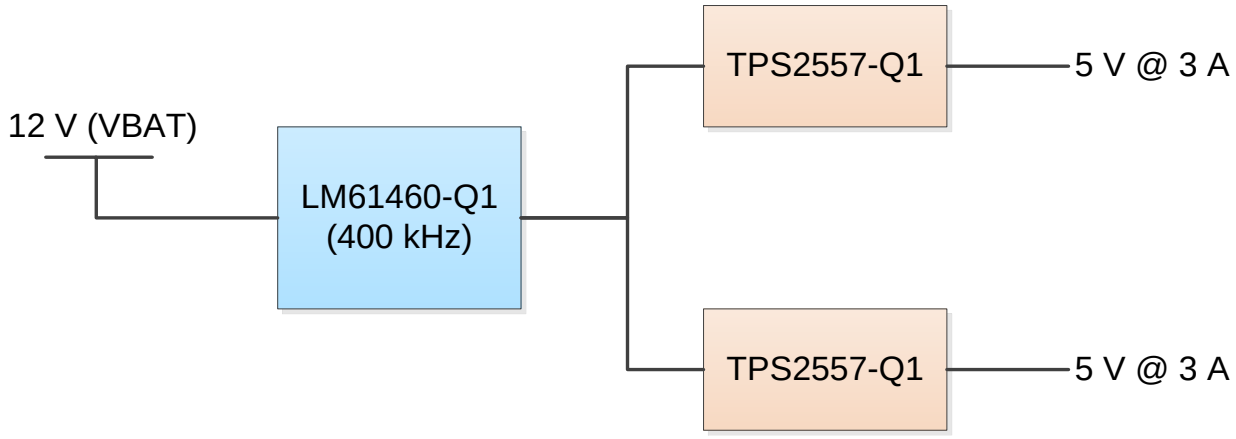
Test Report: PMP21771
30 W Power for Automotive Dual USB Type-C Charge Port Reference Design

Description

This reference design employs an LM61460-Q1 synchronous buck regulator that provides a total of 6 A of current to two TPS2557-Q1 load switch channels. The system is designed for high power efficiency and thermal performance and comes in a small solution size. The design has a switching frequency of 400 kHz and is intended for use in automotive infotainment applications.



1 Test Prerequisites

1.1 Voltage and Current Requirements

Table 1. Voltage and Current Requirements

PARAMETER	SPECIFICATIONS
Input Voltage	12 V
Output Voltage	5 V
Maximum Output Current	6 A
Switching Frequency	400 kHz

1.2 Required Equipment

- Power supply
- Electronic or resistive load
- Oscilloscope

1.3 Considerations

All testing was performed with a 12 V input, unless mentioned otherwise.

2 Testing and Results

2.1 Efficiency Graphs

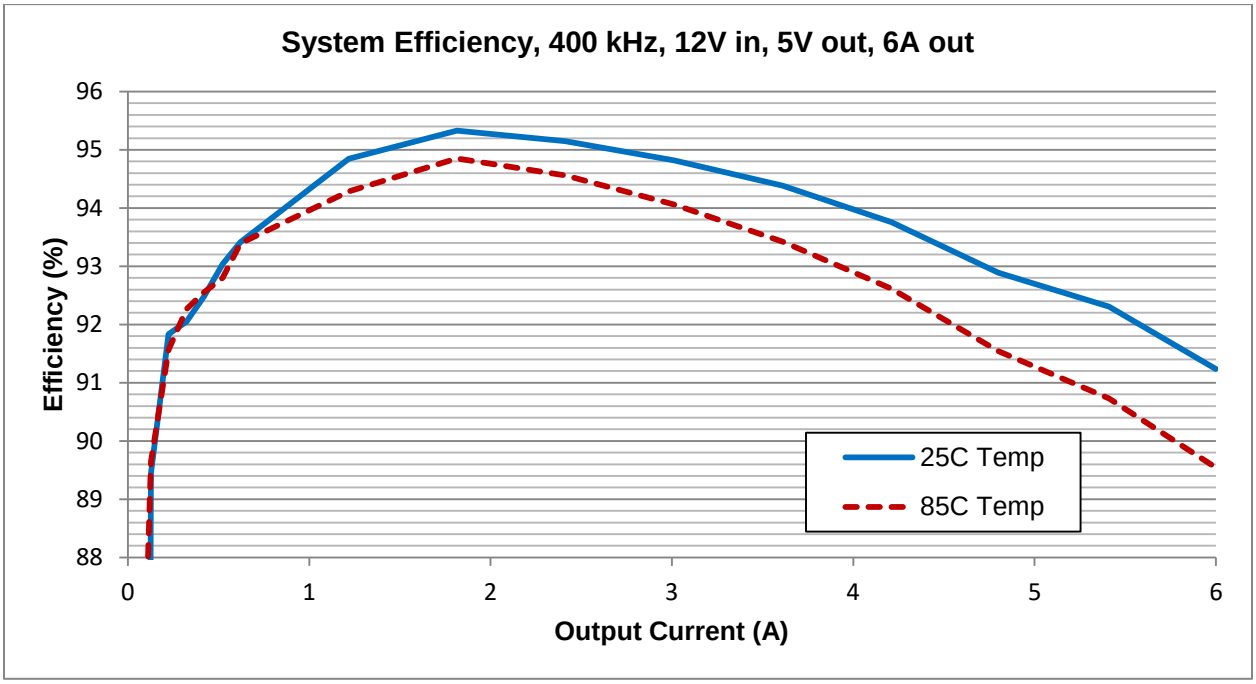


Figure 1. Efficiency vs. I_{OUT}

2.2 Power Loss

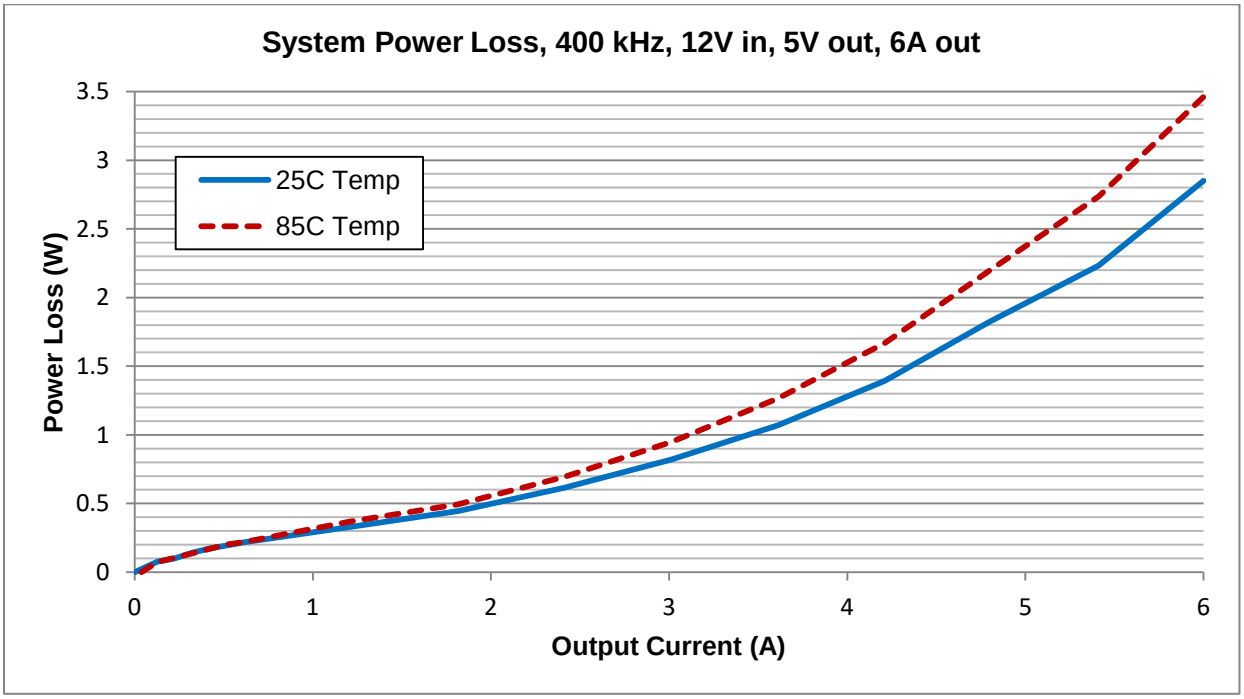


Figure 2. Power Loss vs. I_{OUT}

2.3 Load Regulation

The output voltage is regulated to within 1.4% of the nominal 5 V.

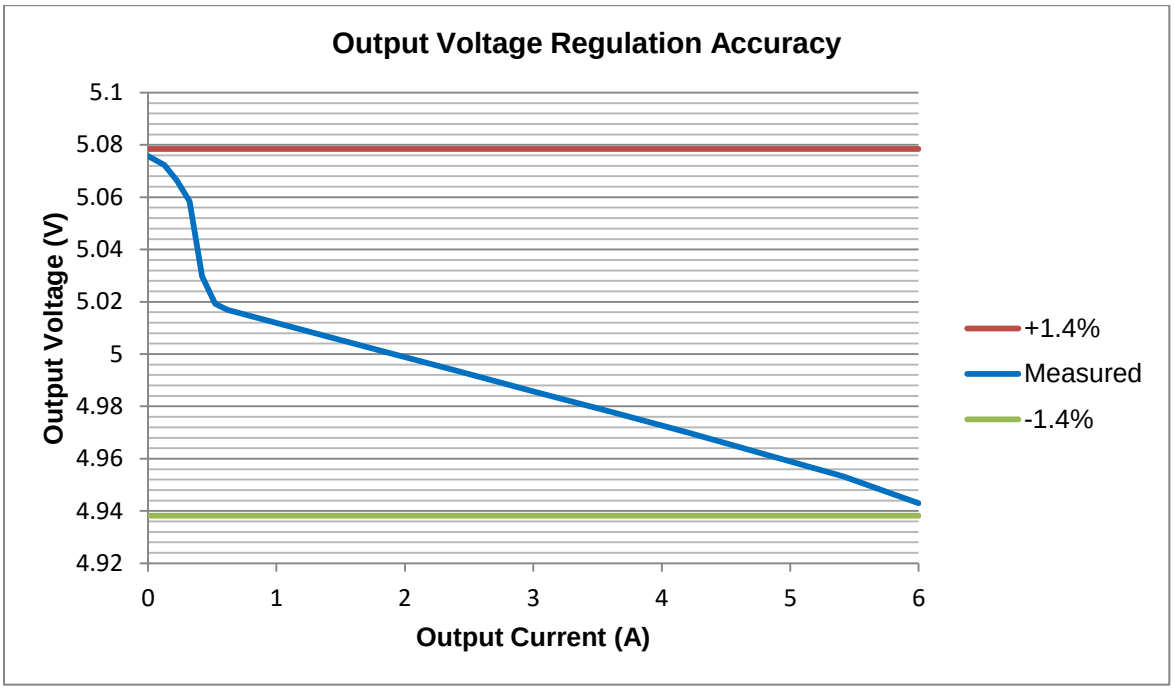


Figure 3. Load Regulation Graph

2.4 Efficiency Data

Table 2. Efficiency Raw Data (V_{IN} = 12 V) at 25C

V_{IN} (V)	I_{IN} (A)	V_{OUT} (V)	I_{OUT} (A)	Efficiency (%)	P_{LOSS} (W)
12.008	0.019	5.0758	0	0	0
12.003	0.060	5.0723	0.127	89.4473743	0.075998
11.998	0.103	5.0665	0.224	91.8353706	0.100898
11.993	0.148	5.0584	0.323	92.0504979	0.141101
11.988	0.191	5.0298	0.421	92.4810413	0.172162
11.983	0.235	5.0192	0.522	93.040403	0.195983
11.978	0.278	5.0169	0.620	93.4110017	0.219406
11.947	0.538	5.0091	1.217	94.8438425	0.331411
11.917	0.799	5.0012	1.815	95.3316551	0.444505
11.886	1.065	4.9935	2.412	95.1474216	0.614268
11.854	1.336	4.9856	3.012	94.820233	0.820317
11.822	1.611	4.9779	3.611	94.3815621	1.070045
11.789	1.893	4.9699	4.210	93.756668	1.393298
11.756	2.181	4.9617	4.800	92.8873336	1.823676
11.720	2.477	4.9533	5.410	92.3077742	2.233087
11.685	2.782	4.9430	6.000	91.2338534	2.849670

Table 3. Efficiency Raw Data (V_{IN} = 12 V) at 85C

V_{IN} (V)	I_{IN} (A)	V_{OUT} (V)	I_{OUT} (A)	Efficiency (%)	P_{LOSS} (W)
12.008	0.020	5.0879	0.038	80.5047468	0
12.004	0.060	5.0838	0.127	89.6427024	0.074597
11.998	0.104	5.0781	0.225	91.5675449	0.105220
11.993	0.148	5.0700	0.323	92.2615895	0.137354
11.988	0.191	5.0337	0.421	92.5527491	0.170520
11.983	0.236	5.0276	0.522	92.8012141	0.203581
11.978	0.279	5.0259	0.621	93.3935602	0.220778
11.947	0.542	5.0165	1.217	94.2829678	0.370194
11.917	0.804	5.0071	1.815	94.8505615	0.493382
11.886	1.073	4.9978	2.413	94.5585375	0.693987
11.854	1.348	4.9885	3.013	94.0620183	0.948841
11.821	1.628	4.9789	3.611	93.4226698	1.265780
11.789	1.916	4.9690	4.210	92.6144219	1.668234
11.755	2.212	4.9591	4.800	91.5453622	2.198380
11.719	2.518	4.9488	5.410	90.7299952	2.735434
11.682	2.838	4.9384	6.010	89.5222817	3.473732

2.5 Thermal Image

Figure 4 shows the board temperature after the system was left on for 10 minutes at full load. The inductor and LM61460-Q1 IC get the hottest on the board.

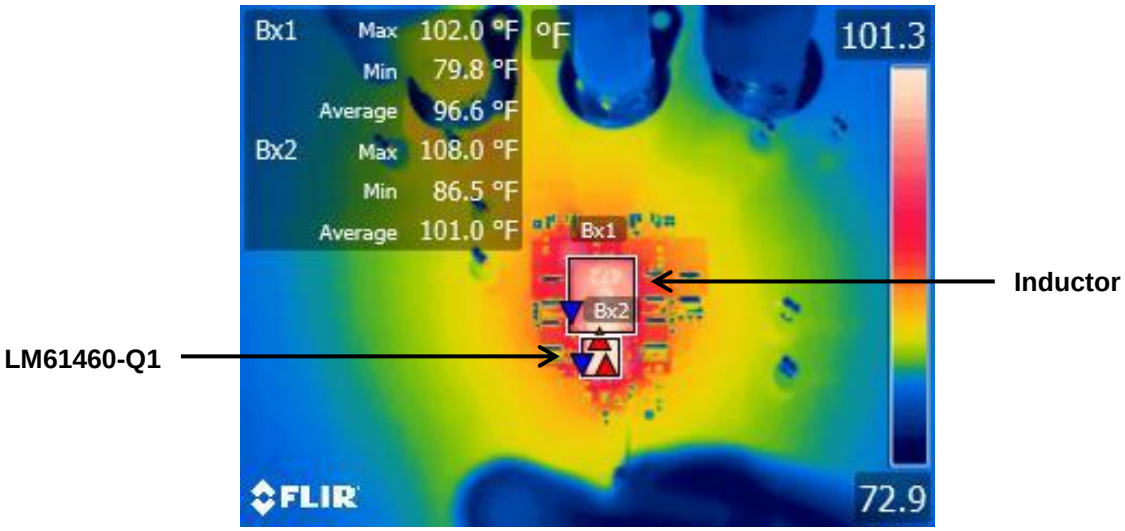


Figure 4. V_{IN} = 12 V, I_{OUT} = 6 A

2.6 Dimensions

The evaluation board dimensions are 4.95 in x 3.45 in. It is a 4-layer board with 1 oz. copper per layer.

Figure 5. PMP21771 Evaluation Board

The small solution size without testpoints and connectors measures 0.95 in x 0.78 in.

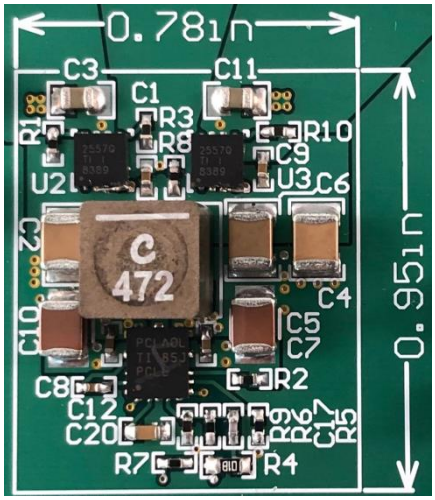


Figure 6. PMP21771 Solution Size

3 Waveforms

3.1 Switching

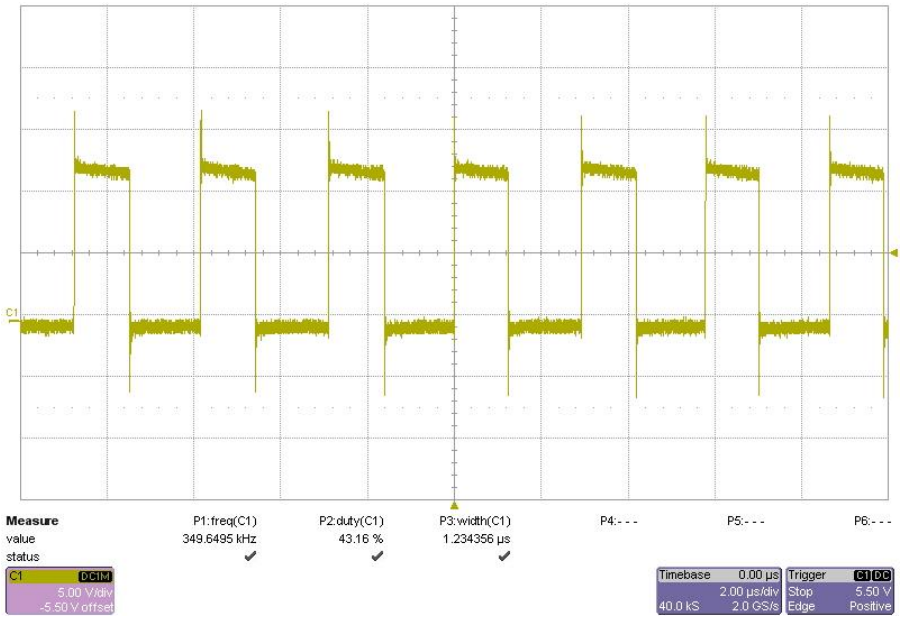


Figure 7. Switch Node Waveform (No Load)

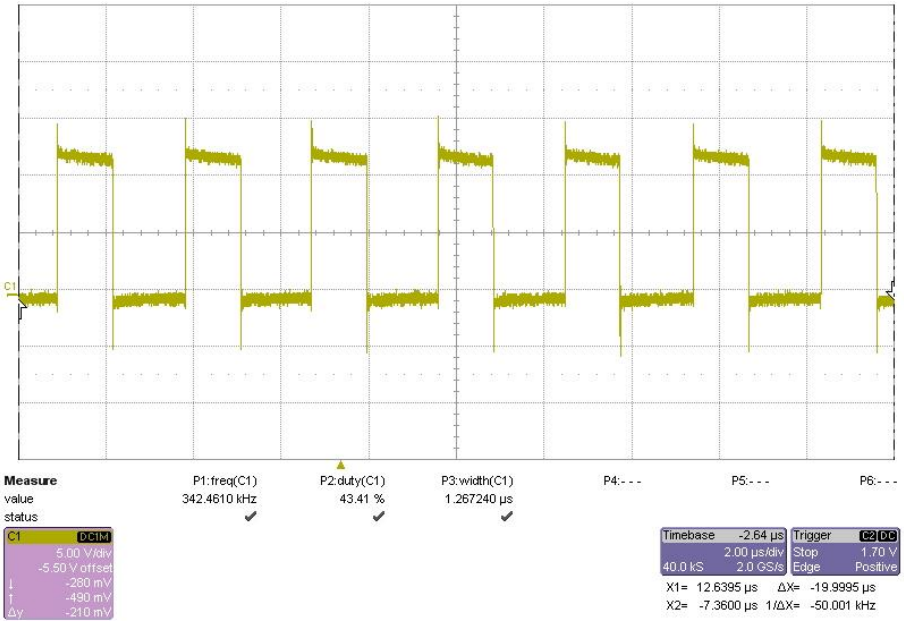


Figure 8. Switch Node Waveform (6 A Load)

3.2 Output Voltage Ripple

Figure 9 shows the output ripple measured across C3 (OUT1). The magnitude of the output ripple is 21.2 mV. This is approximately 0.42% of the output voltage.

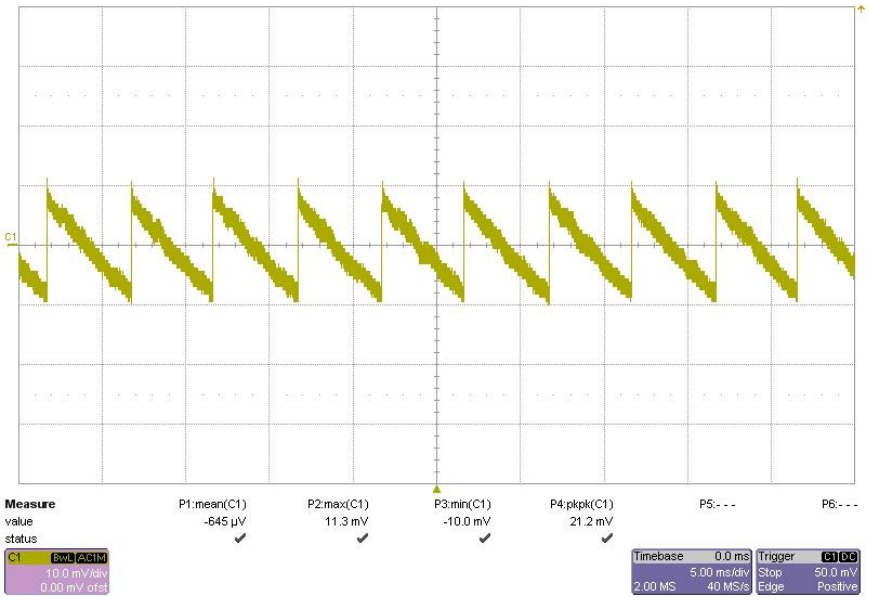


Figure 9. V_{IN} = 12 V, I_{OUT} = 0 A (OUT1)

Figure 10 shows the output ripple measured across C11 (OUT2). The magnitude of the output ripple is 21.9 mV. This is approximately 0.44% of the output voltage.

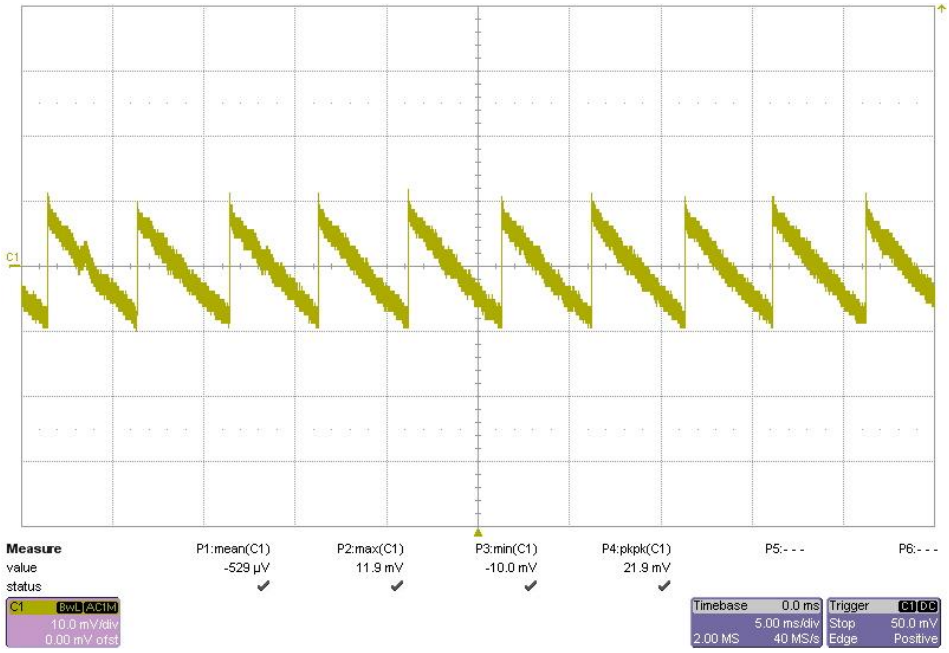


Figure 10. V_{IN} = 12 V, I_{OUT} = 0 A (OUT2)

3.3 Bode Plot

The following bode plots were taken at the output of the LM61460-Q1. With a 1 A load applied, the crossover frequency is 14.292 kHz. The gain margin is -20.025 dB, and the phase margin is 66.872°.

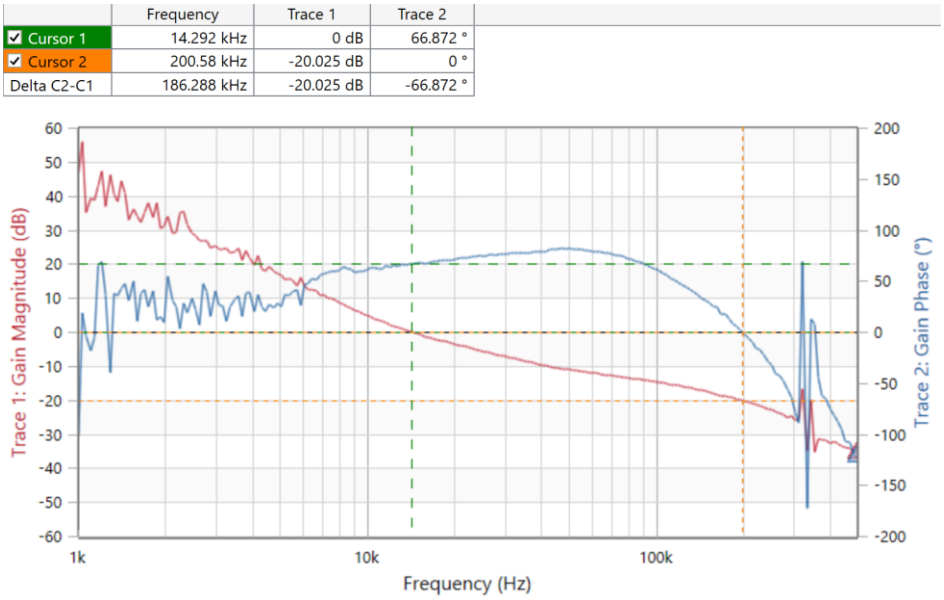


Figure 11. V_{IN} = 12 V, I_{OUT} = 1 A

With a 6 A load applied, the crossover frequency is 30.142 kHz. The gain margin is -12.981 dB, and the phase margin is 61.57°.

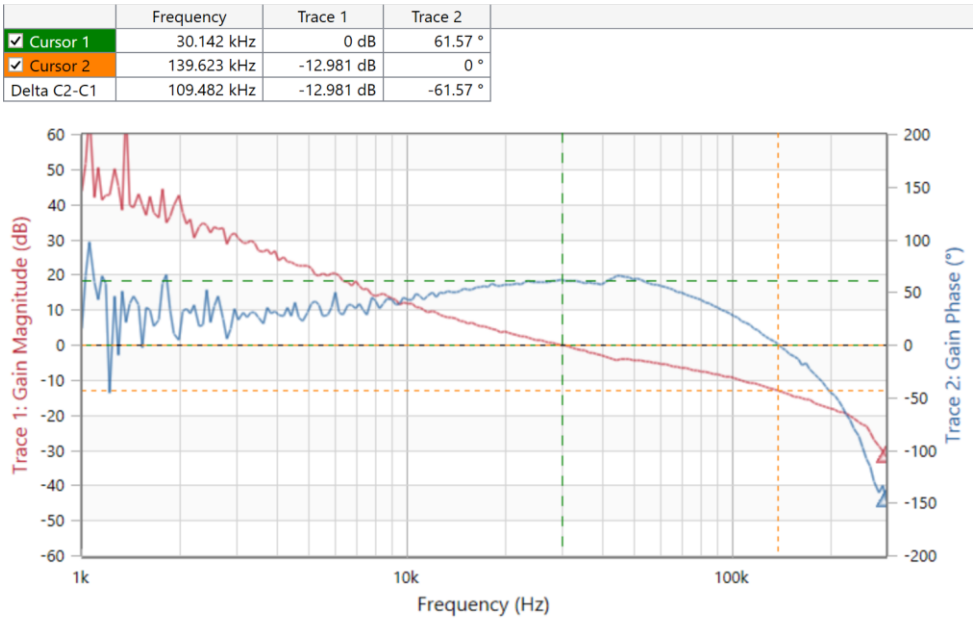


Figure 12. V_{IN} = 12 V, I_{OUT} = 6 A

3.4 Start-up Sequence

Figures 13 and 14 show the start-up waveforms at the output of the LM61460-Q1 with and without load.

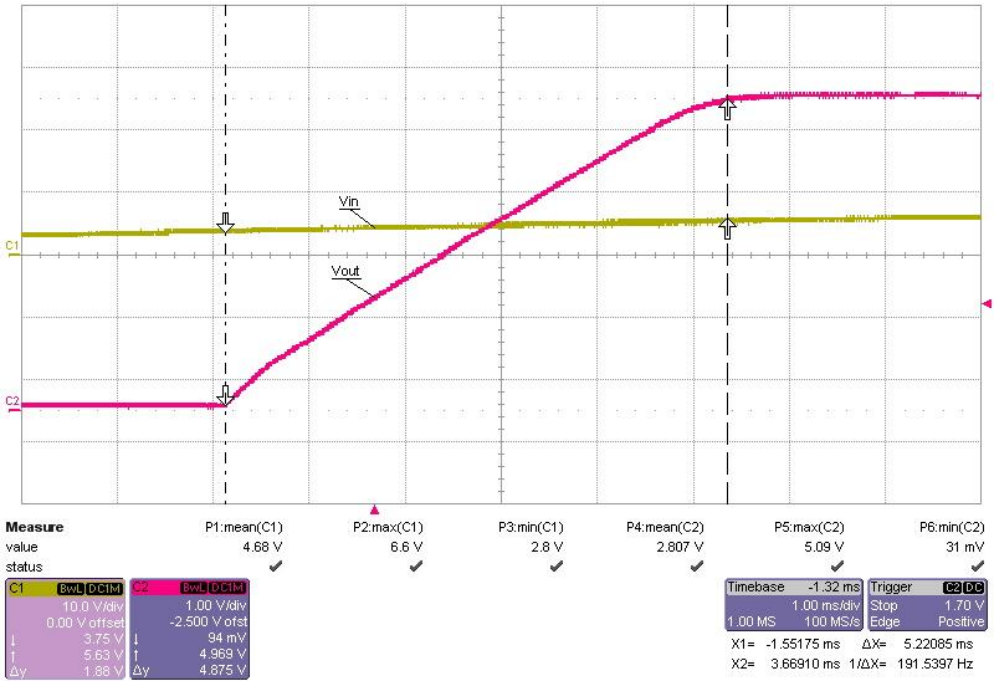


Figure 13. V_{IN} = 12 V, I_{OUT} = 0 A

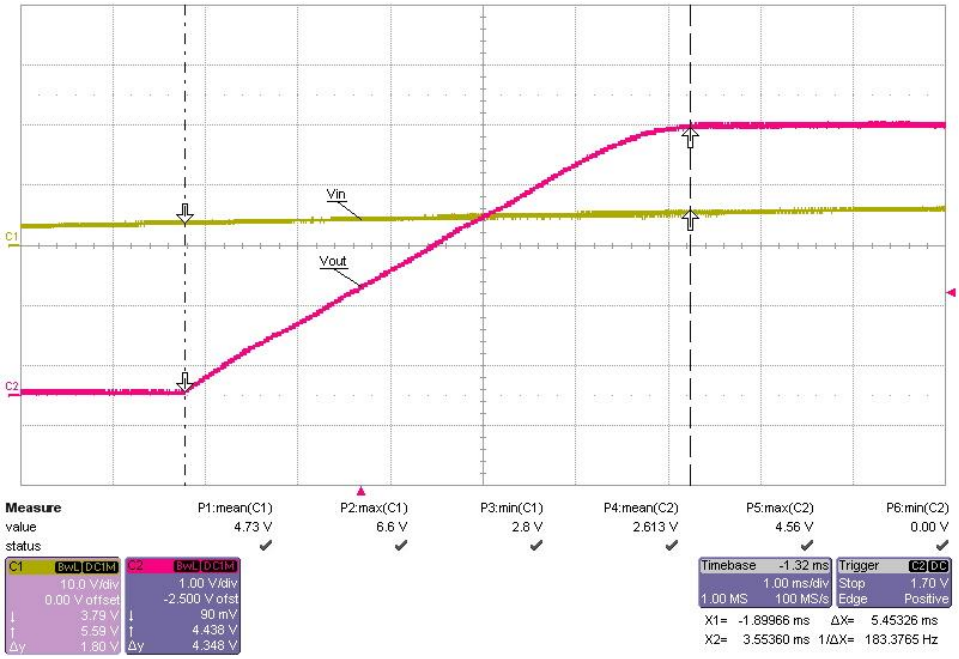


Figure 14. V_{IN} = 12 V, I_{OUT} = 6 A

Figures 15 and 16 show the start-up waveforms at each output of the TPS2557-Q1 load switches with no load applied.

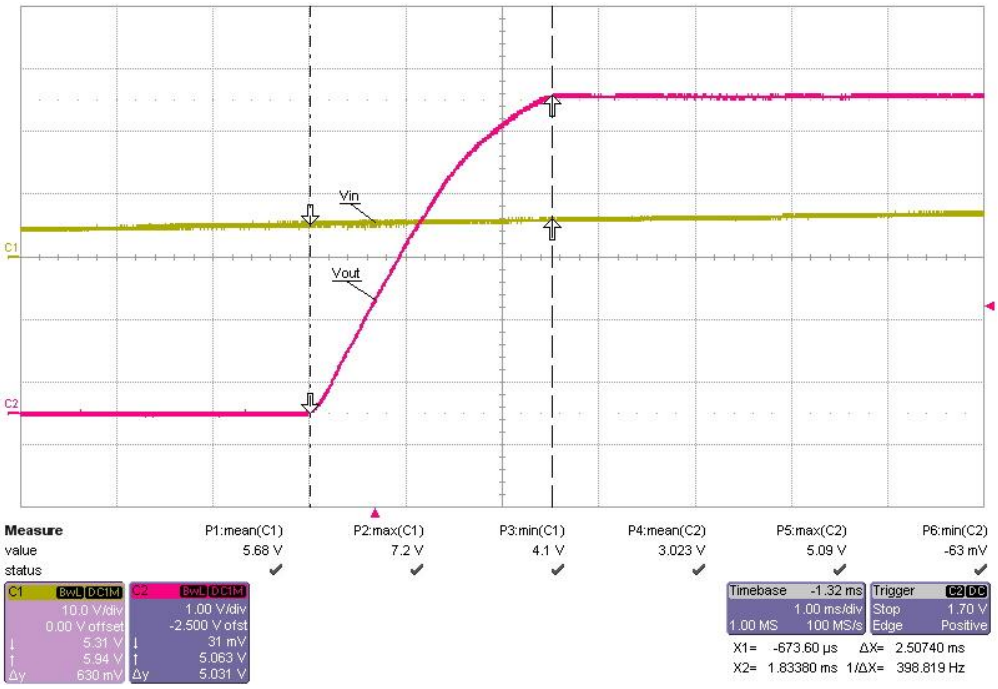


Figure 15. V_{IN} = 12 V, I_{OUT} = 0 A (OUT1)

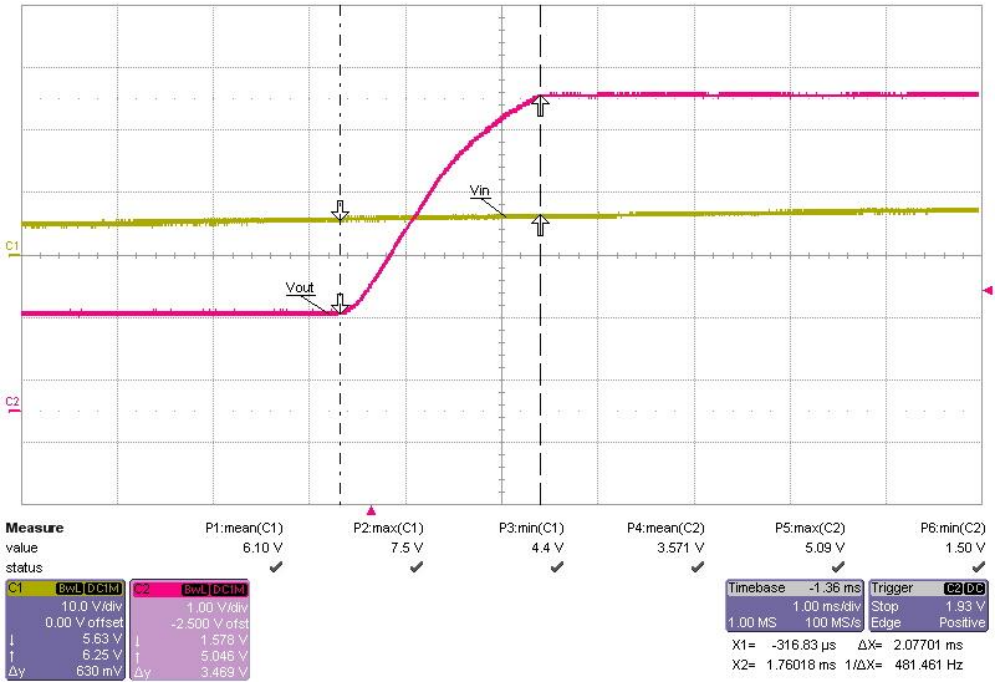


Figure 16. V_{IN} = 12 V, I_{OUT} = 0 A (OUT2)

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Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265