

Test Report: PMP21783

60-W Ultra-Wide Range Power Supply Reference Design



Description

This reference design provides a 12-Vdc, 5-Vdc, and 3.3-Vdc output from an ultra-wide range of both AC and DC inputs. A universal 85 – 265-Vac input can be applied to the input of the valley-switching flyback. For DC inputs ranging from 24 – 150 Vdc, a boost is designed to create a 150-V bus voltage that is fed to the flyback. If the input is 150 – 250 Vdc the boost does not switch to improve efficiency while still powering the flyback and other down stream converters.



Figure 1. Board Top



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1 Test Prerequisites

1.1 Voltage and Current Requirements

PARAMETER	SPECIFICATIONS
Input Voltage Range (J1)	24 – 250 Vdc
Input Voltage Range (J2)	85 – 265 Vac
Output Voltage 1	12 Vdc
Output Current 1	3.25 A
Output Voltage 2	5 Vdc
Output Current 2	3 A
Output Voltage 3	3.3 Vdc
Output Current 3	3 A
UCC28742 Switching Frequency	70 kHz-80 kHz
LM5022 Switching Frequency	200 kHz +/- 15%
TPS54302 Switching Frequency	400 kHz +/- 27.5%

2 Testing and Results

2.1 Efficiency Graphs

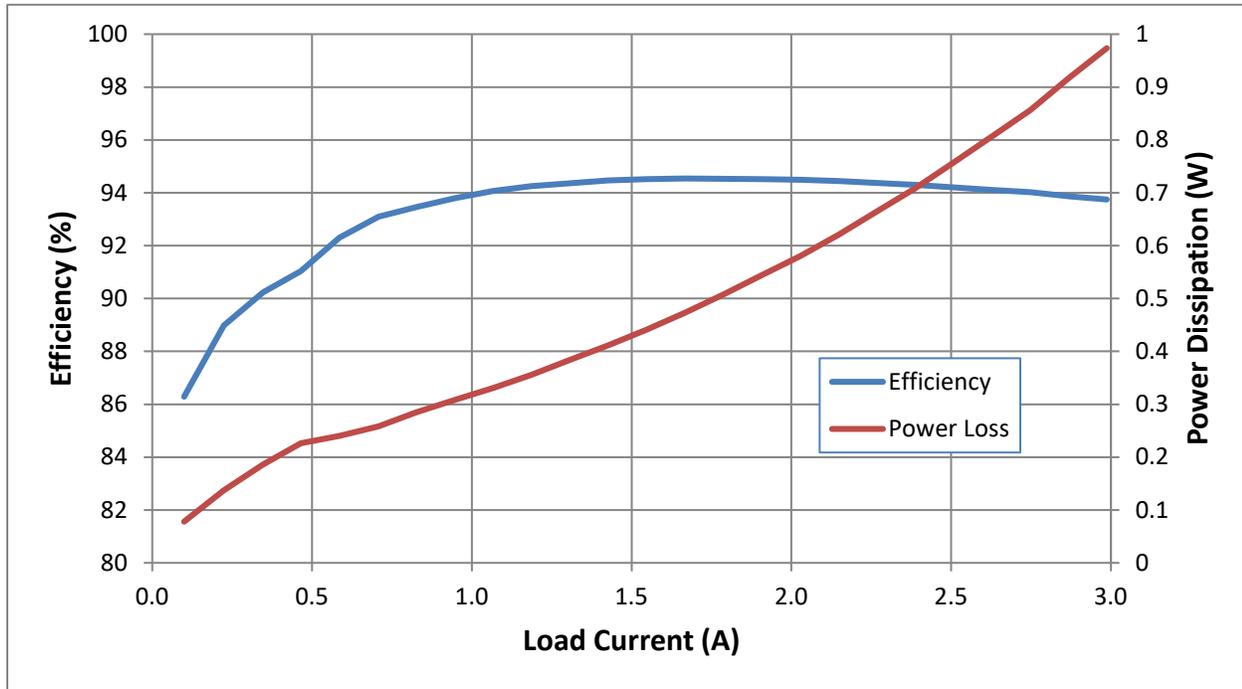


Figure 2. Efficiency for U6 buck converter with 12 Vdc input and 5 Vdc output.

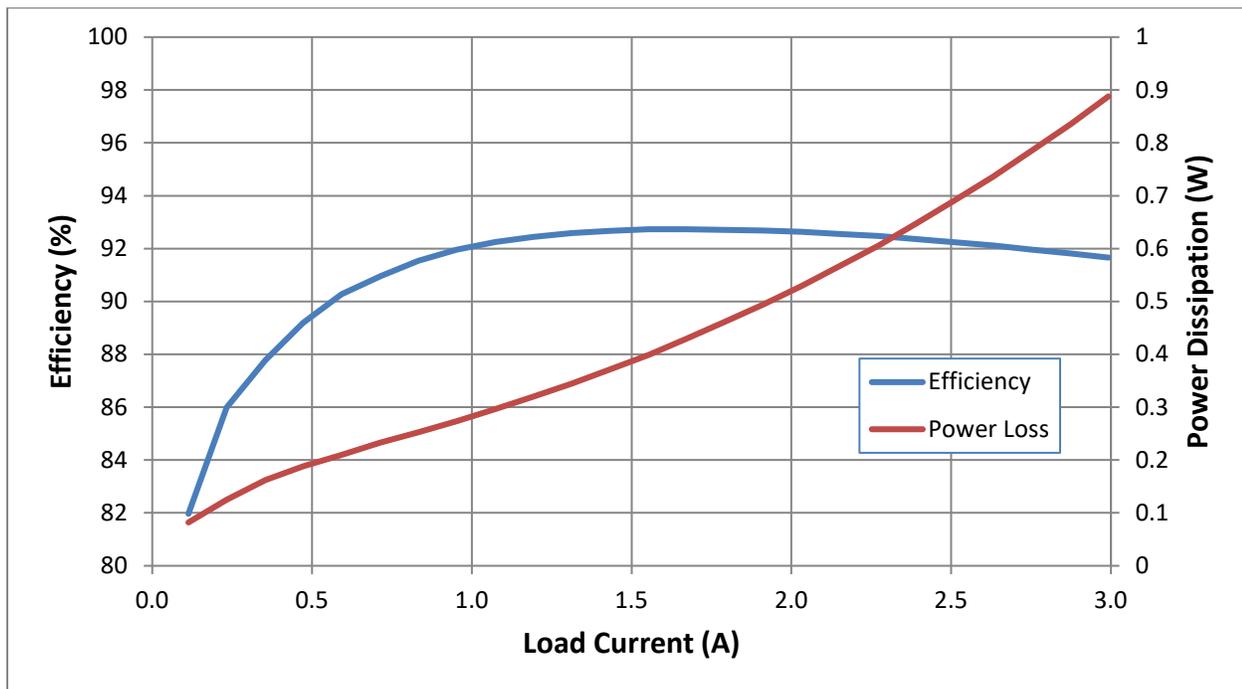


Figure 3. Efficiency for U7 buck converter with 12 Vdc input and 3.3 Vdc output.

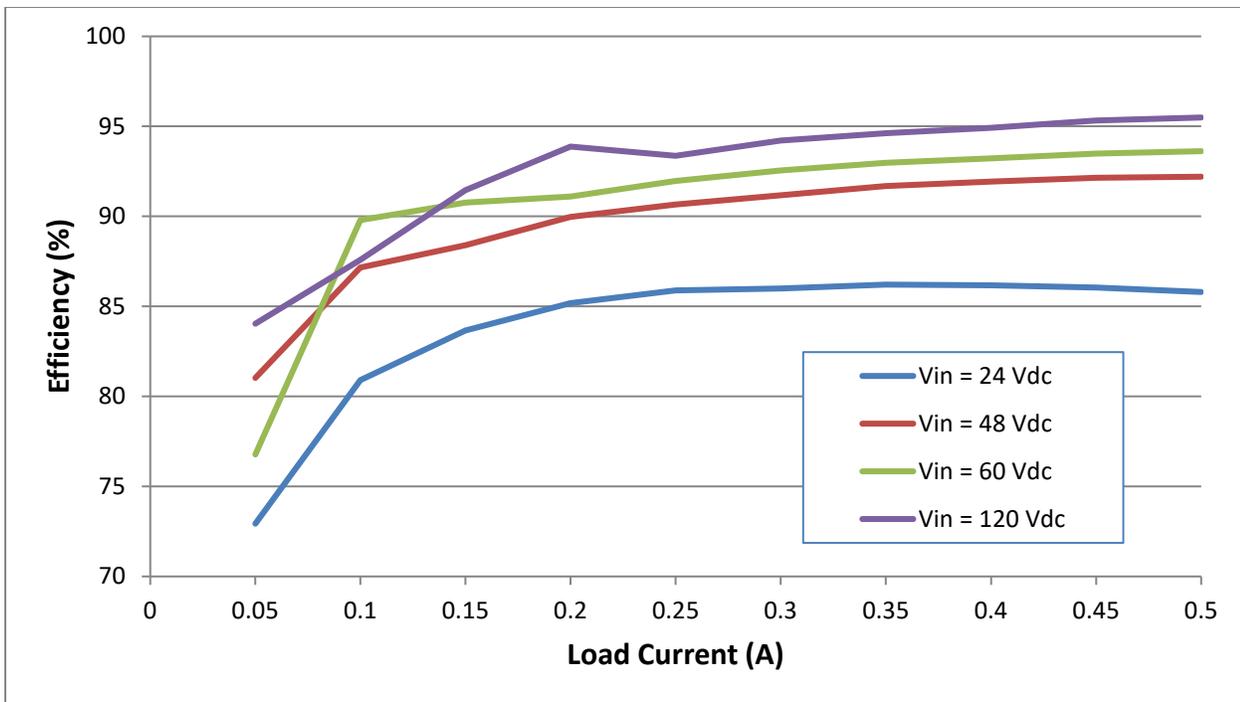


Figure 4. Efficiency for U1 boost converter with 150 Vdc output

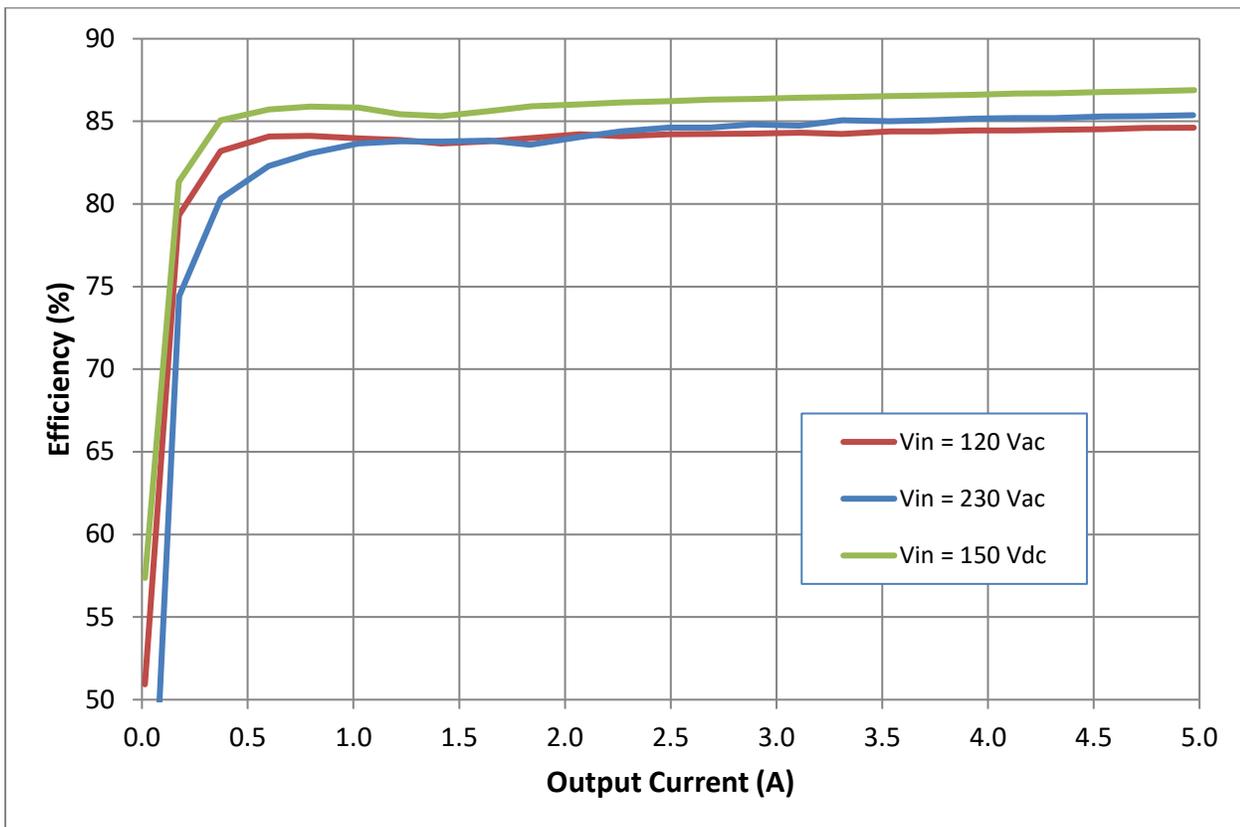


Figure 5. Efficiency for U4 flyback converter with 12 Vdc output

2.2 Efficiency Data

	Input Voltage (V)	Input Current (A)	Input Power (W)	Output Voltage (V)	Output Current (A)	Output Power (W)	Efficiency (%)	Power Loss (W)
12V	11.999	0.047	0.569	4.926	0.100	0.491	86.286	0.469
	11.999	0.362	4.350	4.922	0.826	4.065	93.458	3.524
	11.999	0.671	8.046	4.916	1.547	7.605	94.518	6.499
	11.999	0.983	11.792	4.909	2.267	11.128	94.366	9.526
	11.999	1.298	15.575	4.888	2.987	14.602	93.750	12.588

Figure 6. Efficiency data for U6 buck converter at light load, one quarter load, half load, third quarter load, and full load

	Input Voltage (V)	Input Current (A)	Input Power (W)	Output Voltage (V)	Output Current (A)	Output Power (W)	Efficiency (%)	Power Loss (W)
12V	11.999	0.038	0.455	3.291	0.113	0.373	86.286	0.341
	11.999	0.249	2.988	3.285	0.833	2.735	93.458	2.155
	11.999	0.458	5.490	3.278	1.553	5.091	94.518	3.937
	11.999	0.670	8.037	3.271	2.272	7.432	94.366	5.765
	11.999	0.887	10.639	3.259	2.992	9.752	93.750	7.647

Figure 7. Efficiency data for U7 buck converter at light load, one quarter load, half load, third quarter load, and full load

	Input Voltage (V)	Input Current (A)	Input Power (W)	Output Voltage (V)	Output Current (A)	Output Power (W)	Efficiency (%)	Power Loss (W)
24 Vin	24.189	0.423	10.232	149.246	0.050	7.462	72.931	2.770
	24.090	1.111	26.764	149.282	0.150	22.392	83.666	4.372
	24.090	1.804	43.458	149.296	0.250	37.324	85.885	6.134
	24.090	2.517	60.635	149.352	0.350	52.273	86.210	8.361
	24.090	3.614	87.061	149.388	0.500	74.694	85.795	12.367
48 Vin	48.000	0.192	9.216	149.350	0.050	7.468	81.028	1.749
	48.000	0.528	25.344	149.361	0.150	22.404	88.400	2.940
	48.000	0.858	41.184	149.360	0.250	37.340	90.666	3.844
	48.000	1.188	57.024	149.371	0.350	52.280	91.680	4.744
	48.000	1.688	81.024	149.413	0.500	74.707	92.203	6.318
60 Vin	60.029	0.162	9.725	149.323	0.050	7.466	76.775	2.259
	60.029	0.411	24.672	149.295	0.150	22.394	90.768	2.278
	60.029	0.676	40.580	149.279	0.250	37.320	91.967	3.260
	60.029	0.936	56.187	149.269	0.350	52.244	92.982	3.943
	60.029	1.328	79.719	149.266	0.500	74.633	93.621	5.086
120 Vin	120.020	0.074	8.881	149.277	0.050	7.464	84.038	1.418
	120.020	0.204	24.484	149.278	0.150	22.392	91.454	2.092
	120.020	0.333	39.967	149.270	0.250	37.318	93.372	2.649
	120.020	0.460	55.209	149.252	0.350	52.238	94.619	2.971
	120.020	0.651	78.133	149.220	0.500	74.610	95.491	3.523

Figure 8. Efficiency data for U1 boost converter at light load, one quarter load, half load, third quarter load, and full load for different input ranges

	Input Voltage (V)	Input Current (A)	Input Power (W)	Output Voltage (V)	Output Current (A)	Output Power (W)	Efficiency (%)	Power Loss (W)
150 VDCin	150.049	0.002	0.304	12.016	0.015	0.175	57.366	0.130
	149.999	0.114	17.142	12.007	1.220	14.645	85.436	2.496
	149.939	0.232	34.712	12.001	2.494	29.931	86.228	4.781
	149.883	0.345	51.756	11.999	3.734	44.804	86.567	6.952
	149.828	0.458	68.689	11.997	4.975	59.683	86.888	9.006
	Input Voltage (Vrms)	Input Current (Arms)	Input Power (W)	Output Voltage (V)	Output Current (A)	Output Power (W)	Efficiency (%)	Power Loss (W)
230 VACin	230.120	0.016	0.510	12.026	0.013	0.161	31.559	0.349
	230.100	0.216	17.500	12.017	1.220	14.665	83.802	2.835
	230.060	0.414	35.360	12.009	2.492	29.925	84.628	5.435
	230.060	0.596	52.662	12.007	3.731	44.796	85.063	7.866
	230.010	0.756	69.896	12.007	4.970	59.672	85.373	10.224
120 VACin	120.180	0.012	0.328	12.020	0.014	0.167	50.928	0.161
	120.130	0.363	17.472	12.010	1.220	14.655	83.878	2.817
	120.080	0.647	35.542	12.004	2.494	29.933	84.218	5.609
	120.040	0.882	53.091	12.001	3.733	44.802	84.387	8.289
	119.980	1.106	70.517	11.999	4.973	59.669	84.617	10.848

Figure 9. Efficiency data for U4 flyback converter at light load, one quarter load, half load, third quarter load, and full load for different input ranges

2.3 Bode Plot

All Bode Measurements were made with full load conditions, unless noted otherwise

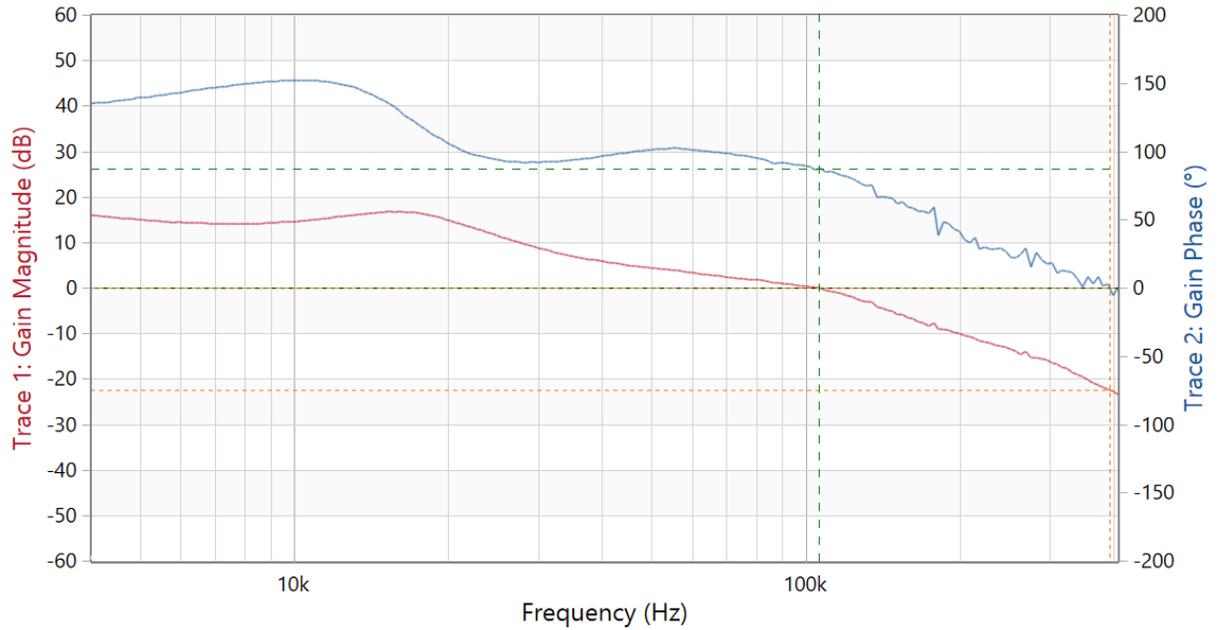


Figure 10. Bode plot for U6 buck converter

Vout (V)	Load (A)	Bandwidth (kHz)	Phase Margin (°)
5	3	106.232	87.394

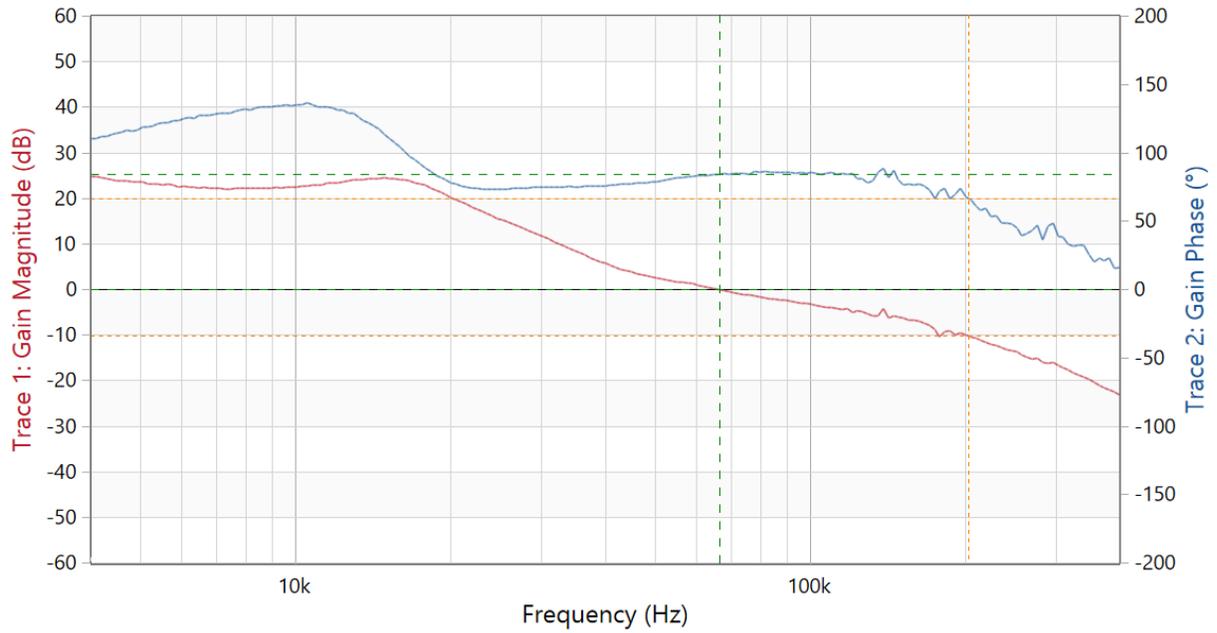


Figure 11. Bode plot for U7 buck converter

Vout (V)	Load (A)	Bandwidth (kHz)	Phase Margin (°)
3.3	3	66.66	84.312

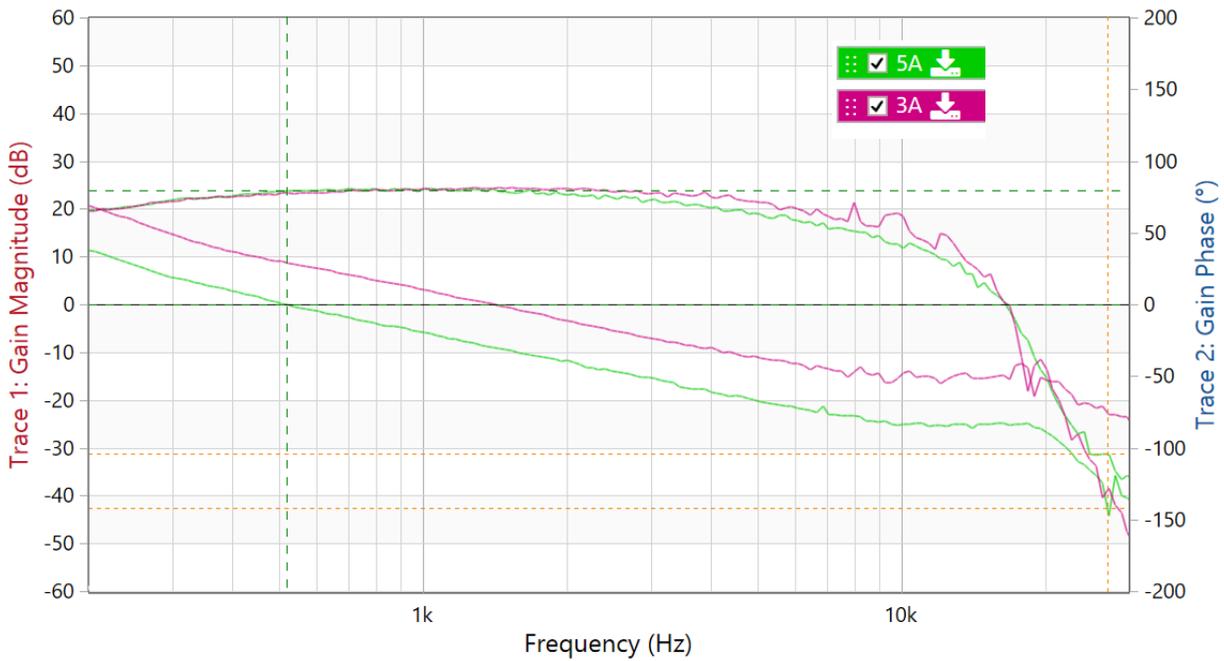


Figure 12. Bode plot for U4 flyback converter. 3 A is typical load condition, 5 A is peak load condition

Vout (V)	Load (A)	Bandwidth (kHz)	Phase Margin (°)
12	3	1.423	81.356
12	5	0.519	79.285

2.4 Thermal Image

All thermal images are taken after a 10 minute soak with no airflow.

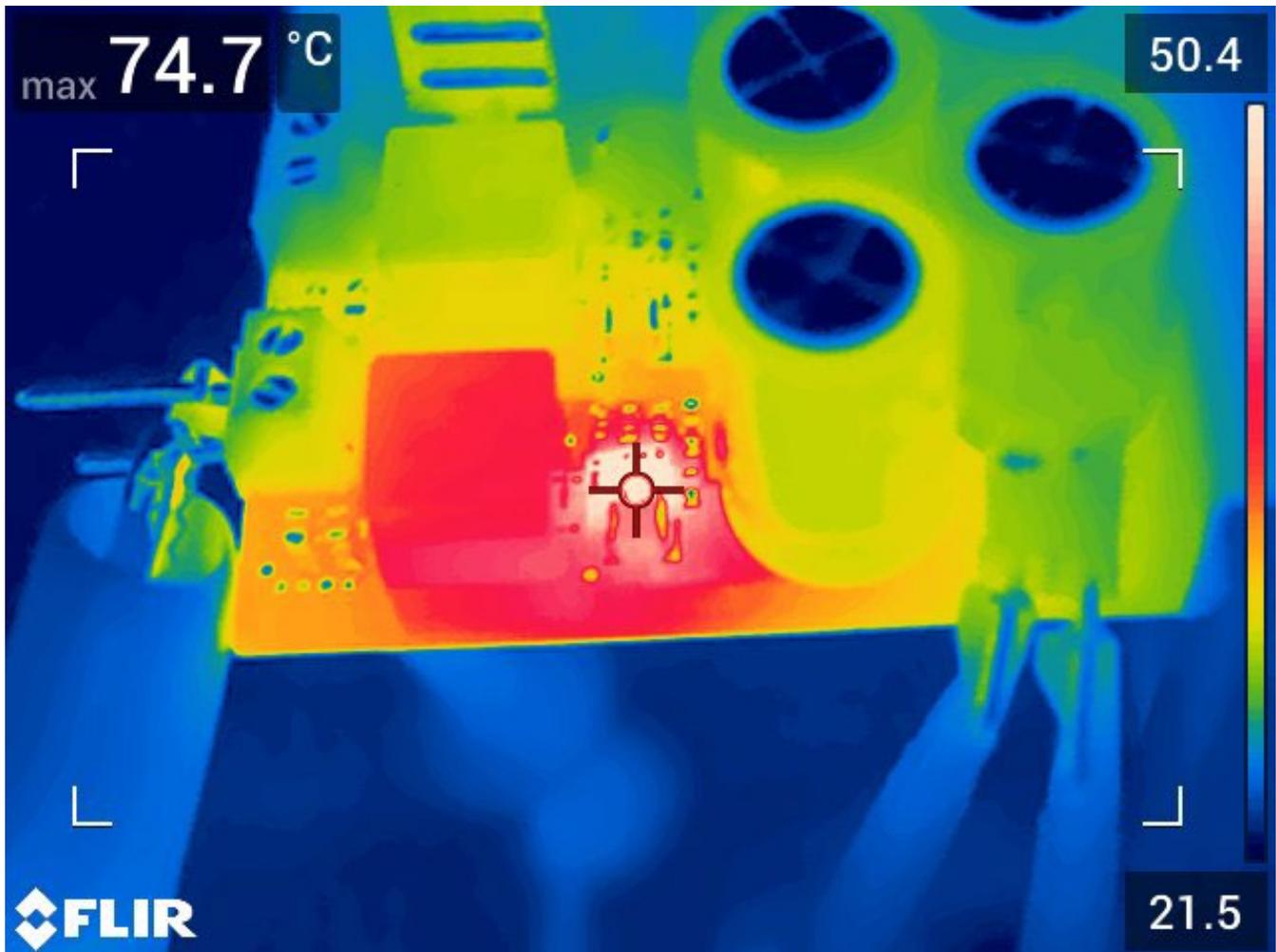


Figure 13. U6 converter after 10 minute thermal soak at 3 A load, 12 Vdc input and 5 Vdc output.

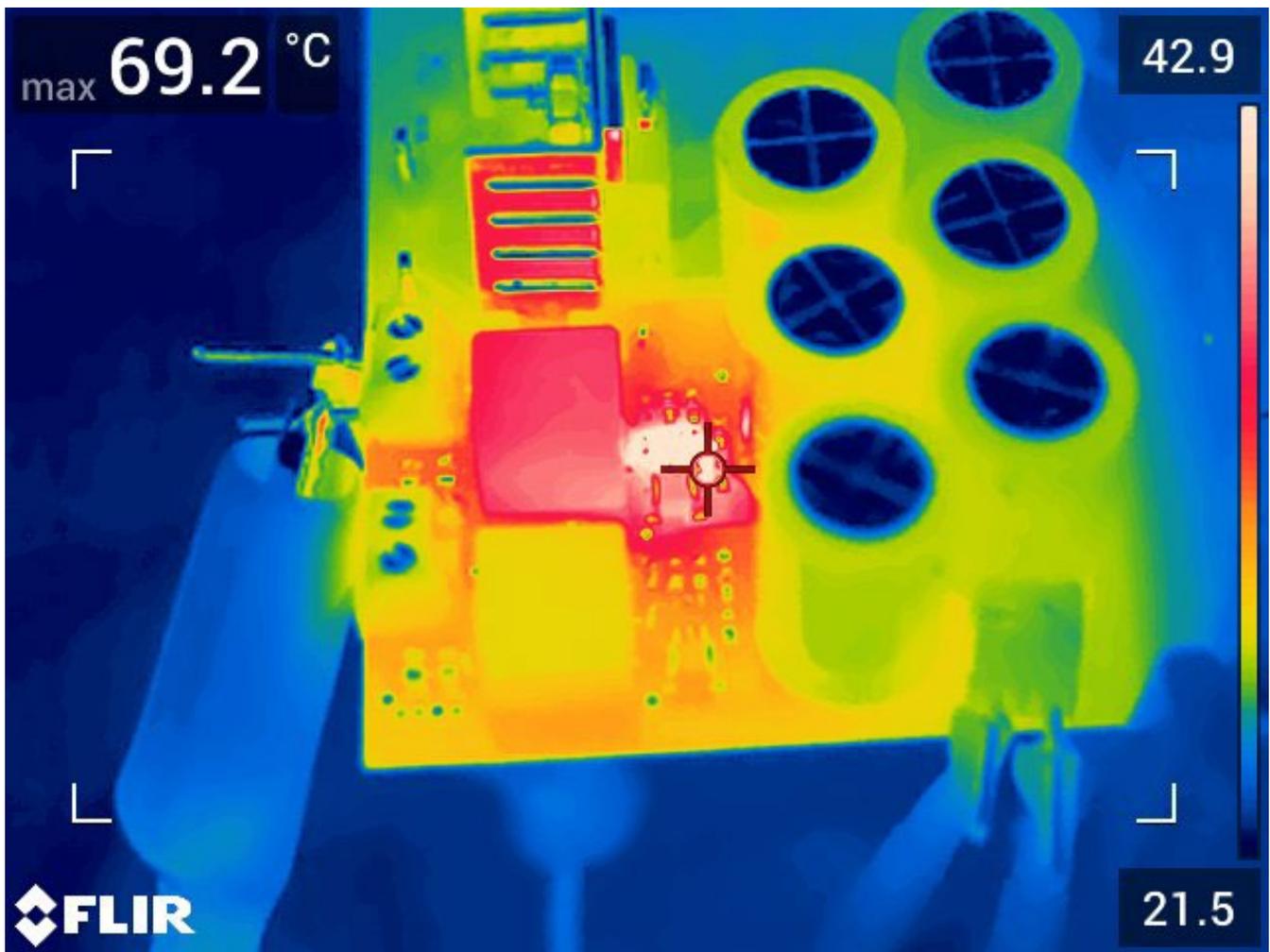


Figure 14. U7 converter after 10 minute thermal soak at 3 A load, 12 Vdc input and 3.3 Vdc output

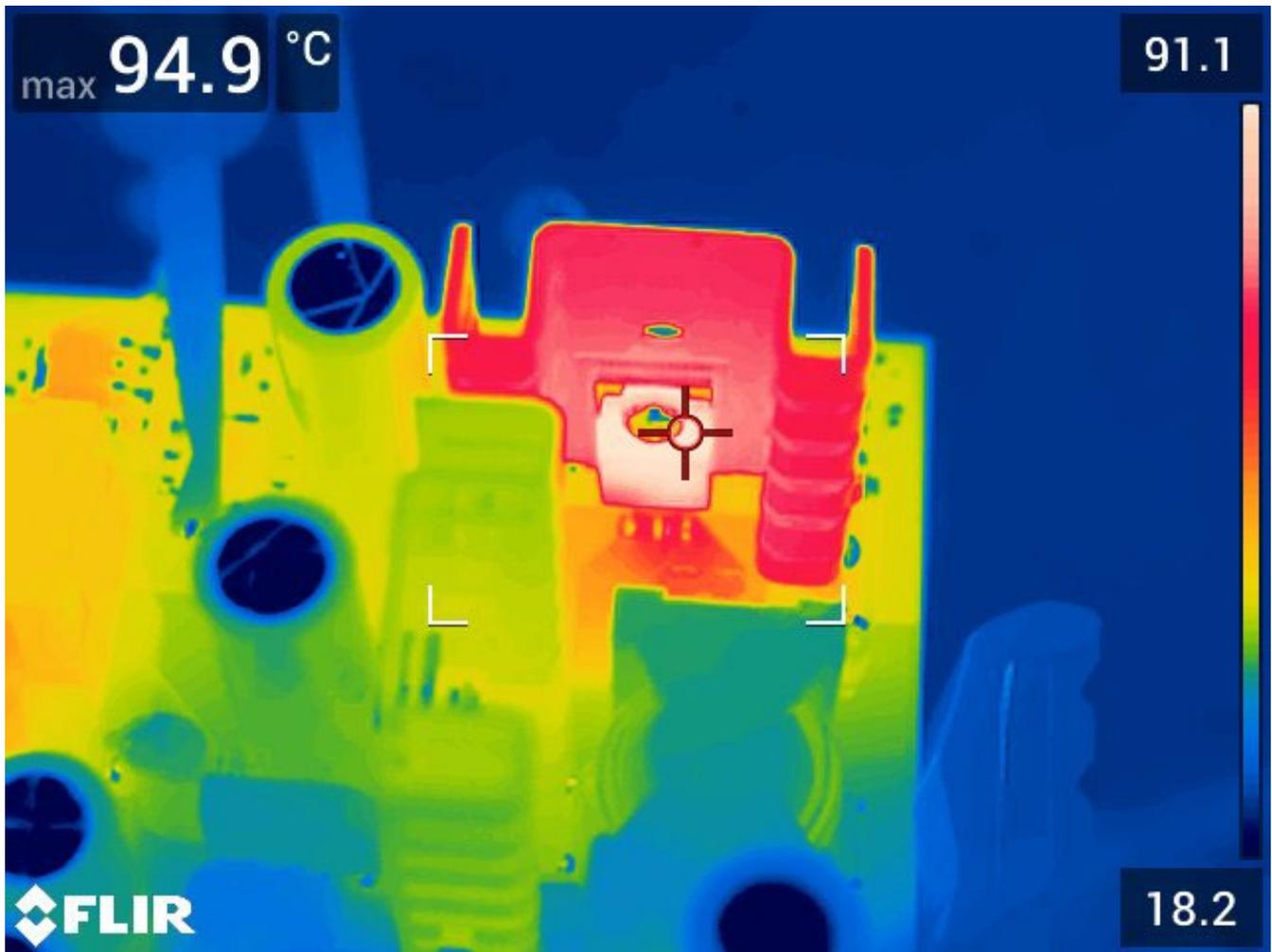


Figure 15. Q2 for LM5022 boost converter after 10 minute thermal soak at 24 Vdc input, loaded with 3.25 A on 12 Vdc rail

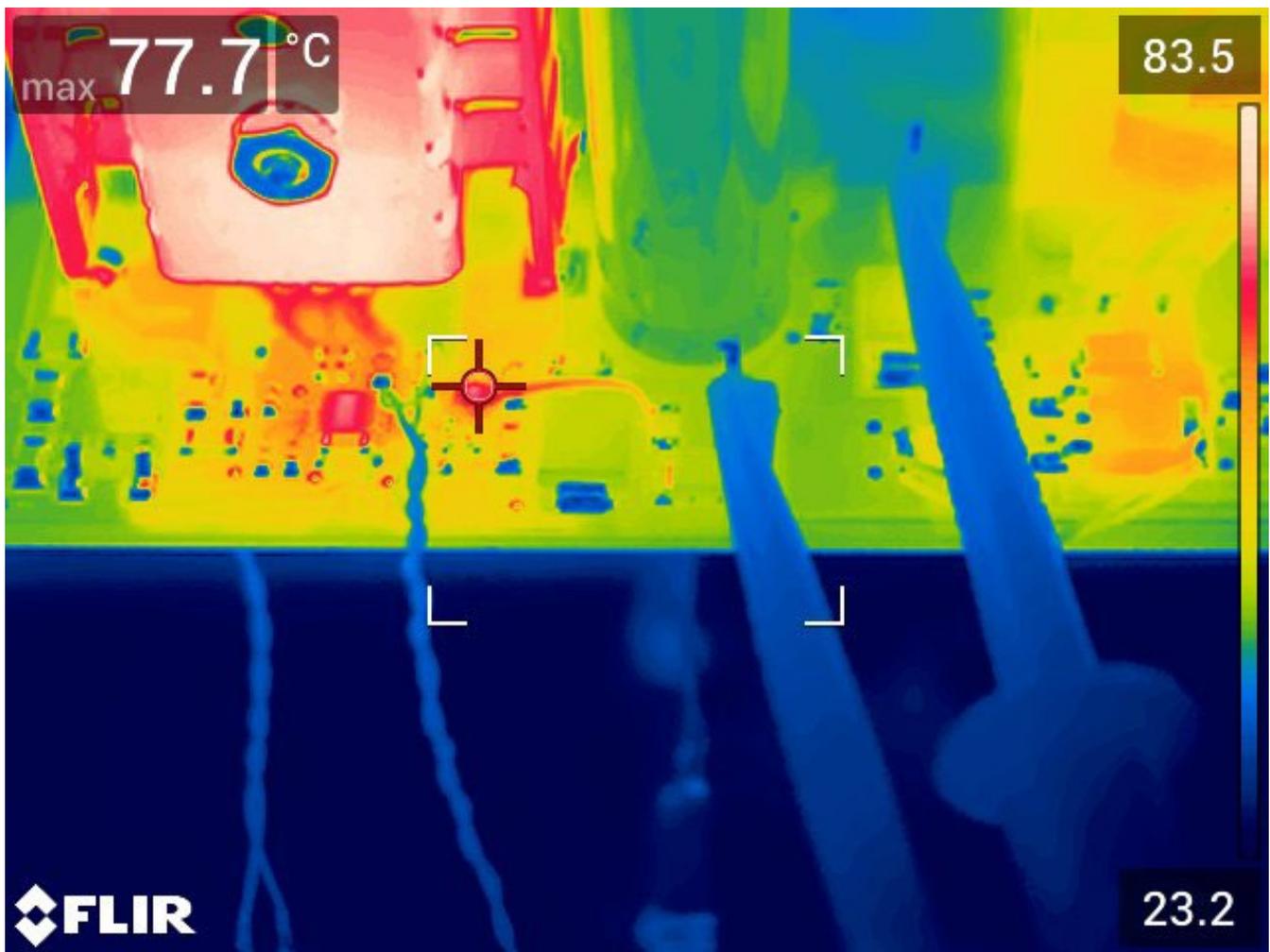


Figure 16. Regulator for VCC of LM5022 after 10 minute thermal soak at 24 Vdc input, loaded with 3.25 A on 12 Vdc rail

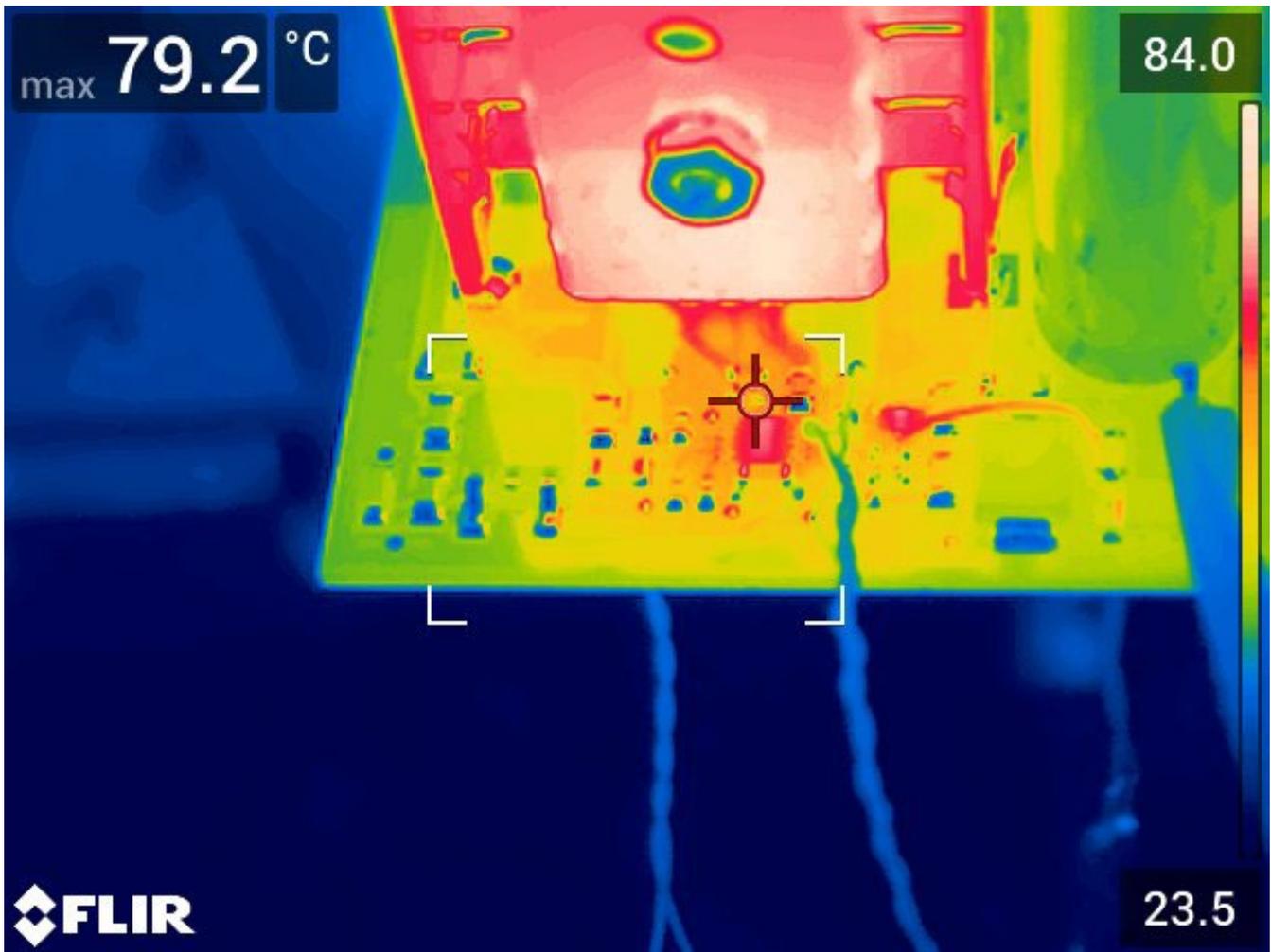


Figure 17. U1 LM5022 after 10 minute thermal soak at 24 Vdc input, loaded with 3.25 A on 12 Vdc rail

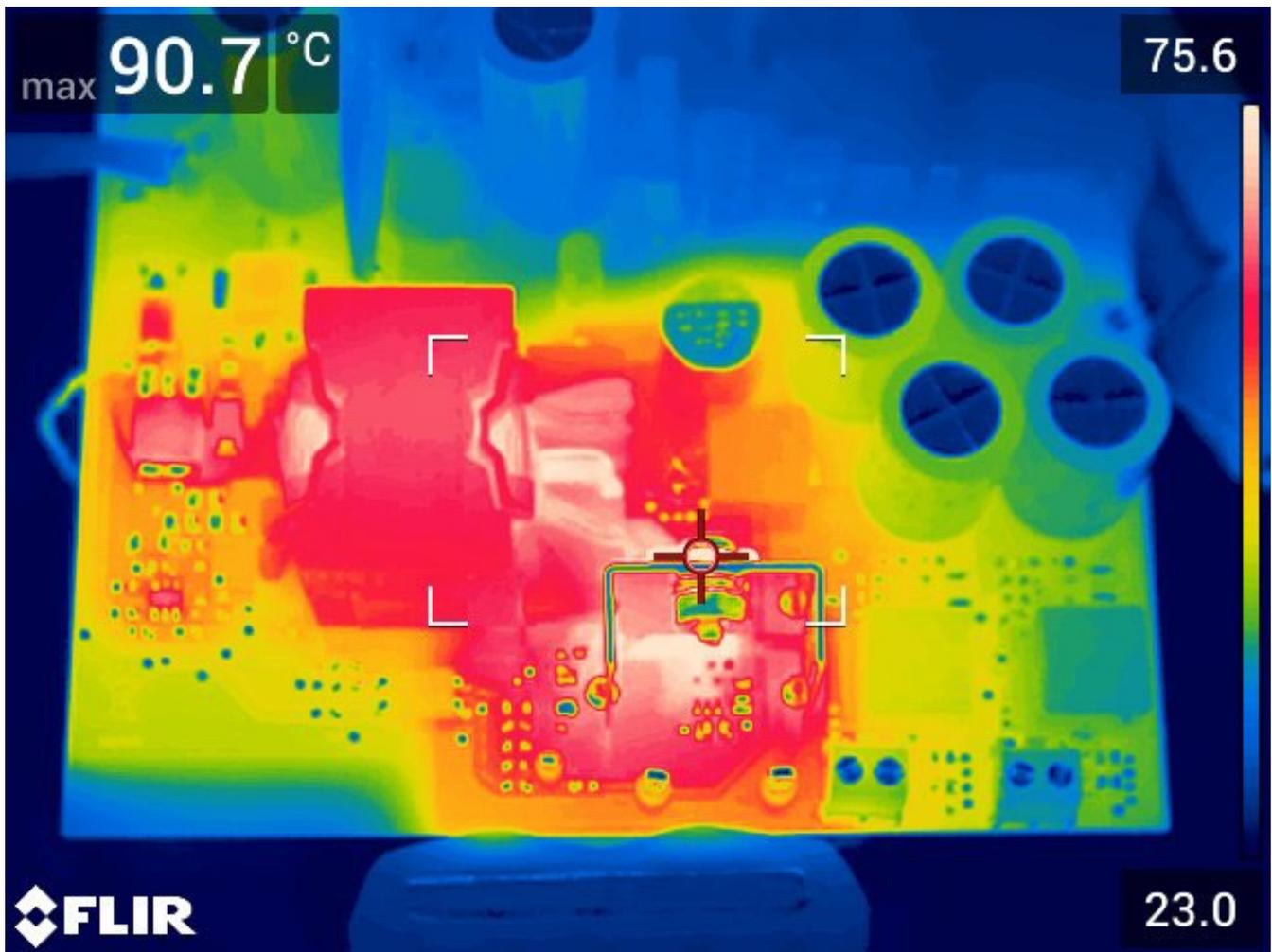


Figure 18. Top of board, only U4 flyback is on, after 10 minute thermal soak at 150 Vdc input, loaded with 5 A on 12 Vdc rail

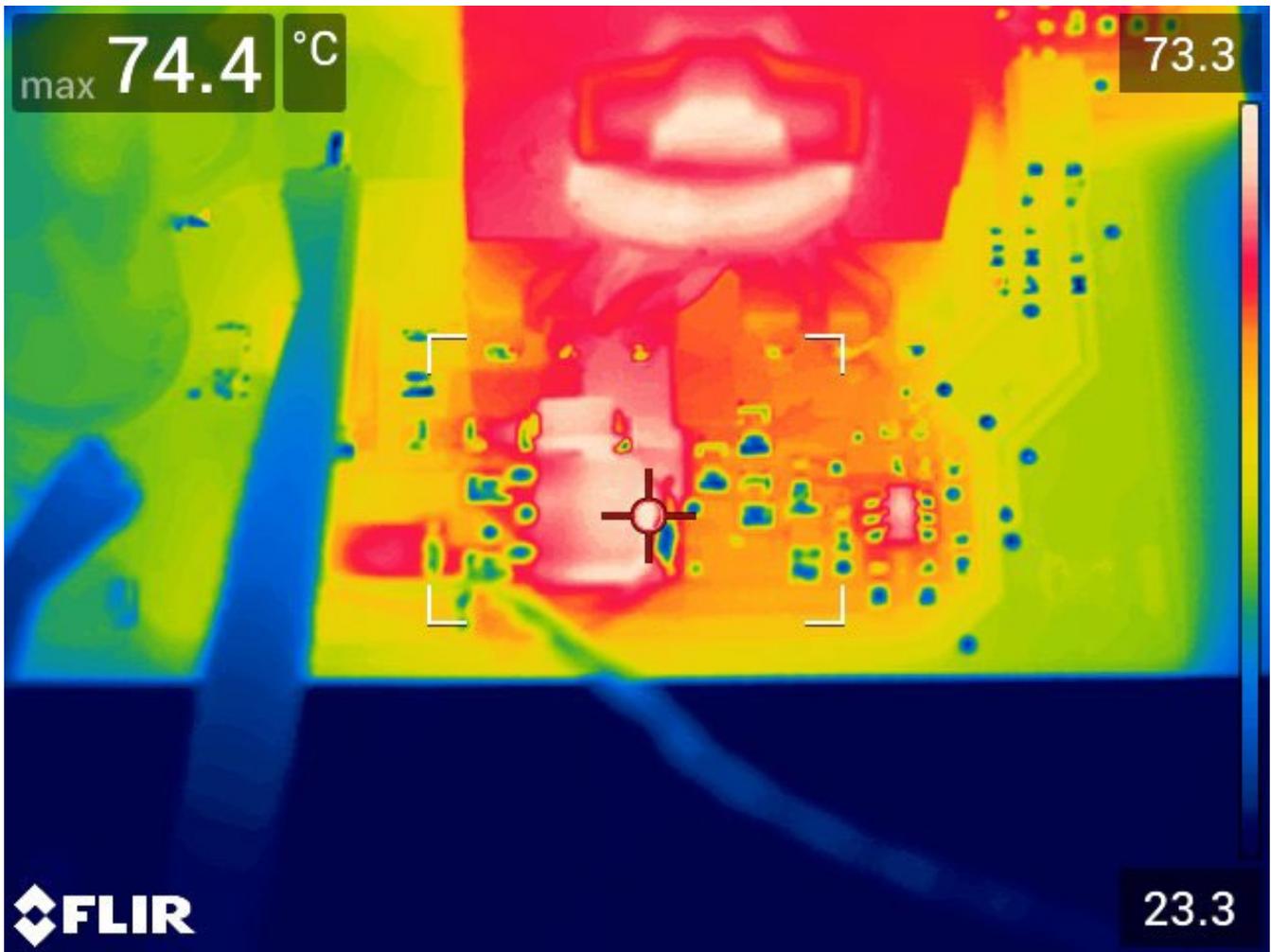


Figure 19. Q4 for UCC28742 flyback after 10 minute thermal soak at 150 Vdc input, loaded with 5 A on 12 Vdc rail

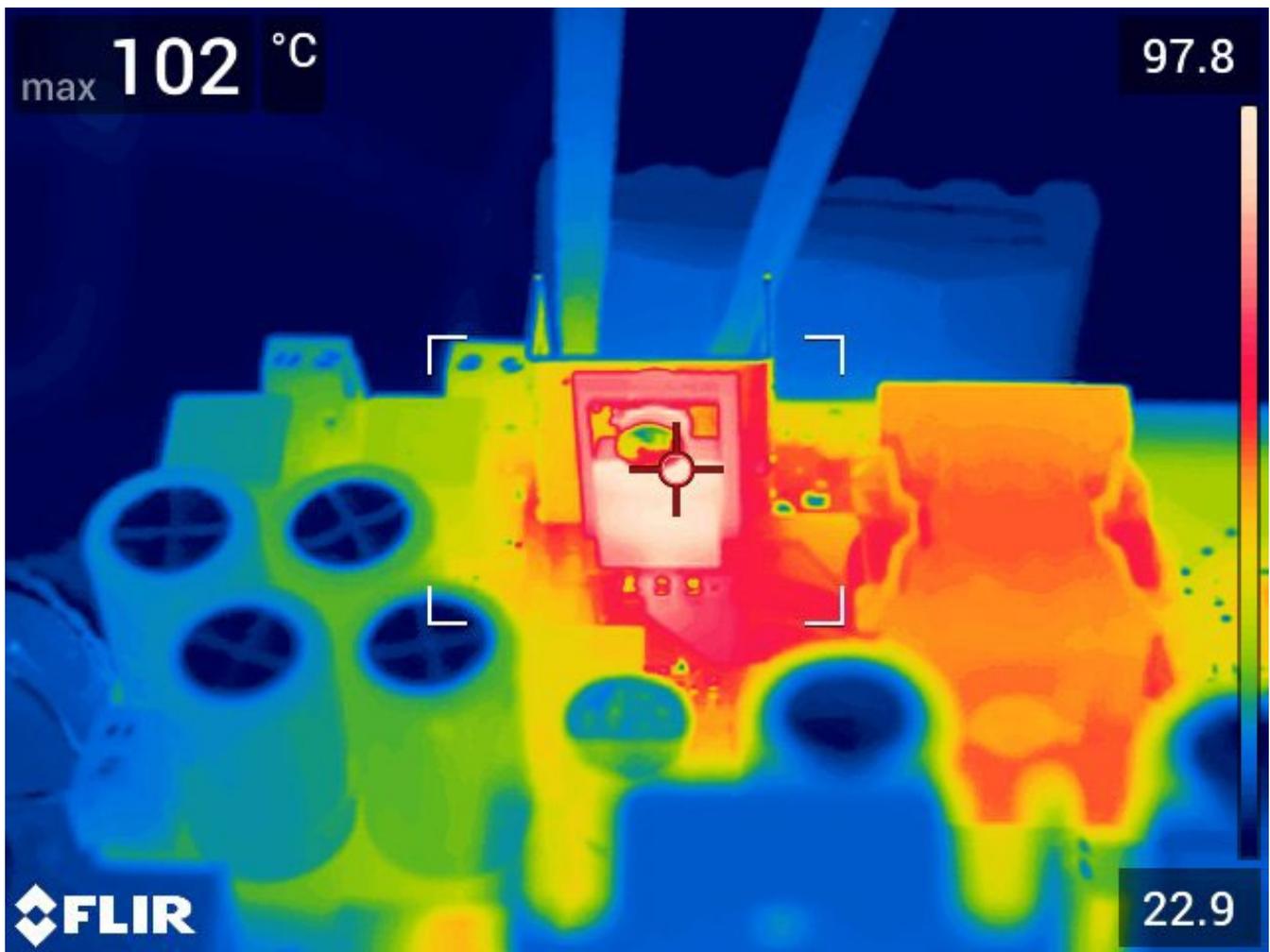


Figure 20. Q3 for flyback after 10 minute thermal soak at 150 Vdc input, loaded with 5 A on 12 Vdc rail

3 Waveforms

3.1 Switching

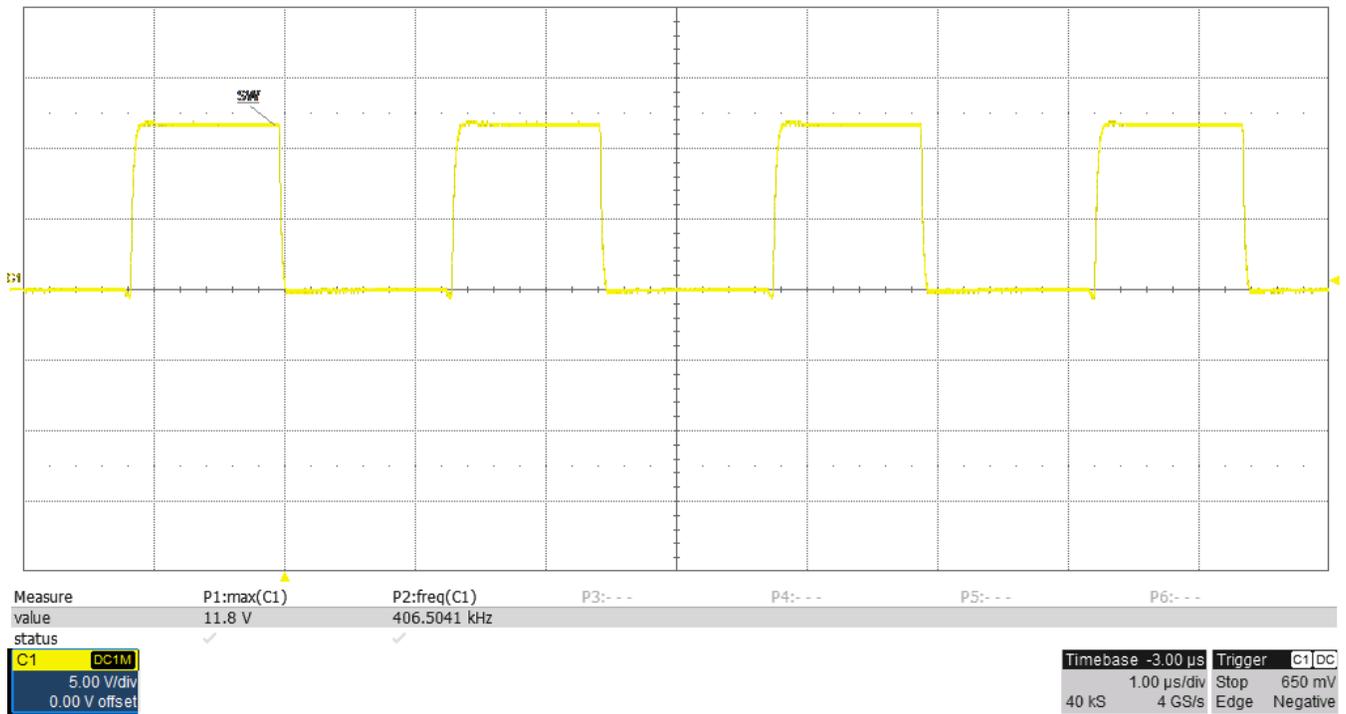


Figure 21. Switch node for U6 buck converter at 3 A load, 12 Vdc input and 5 Vdc output

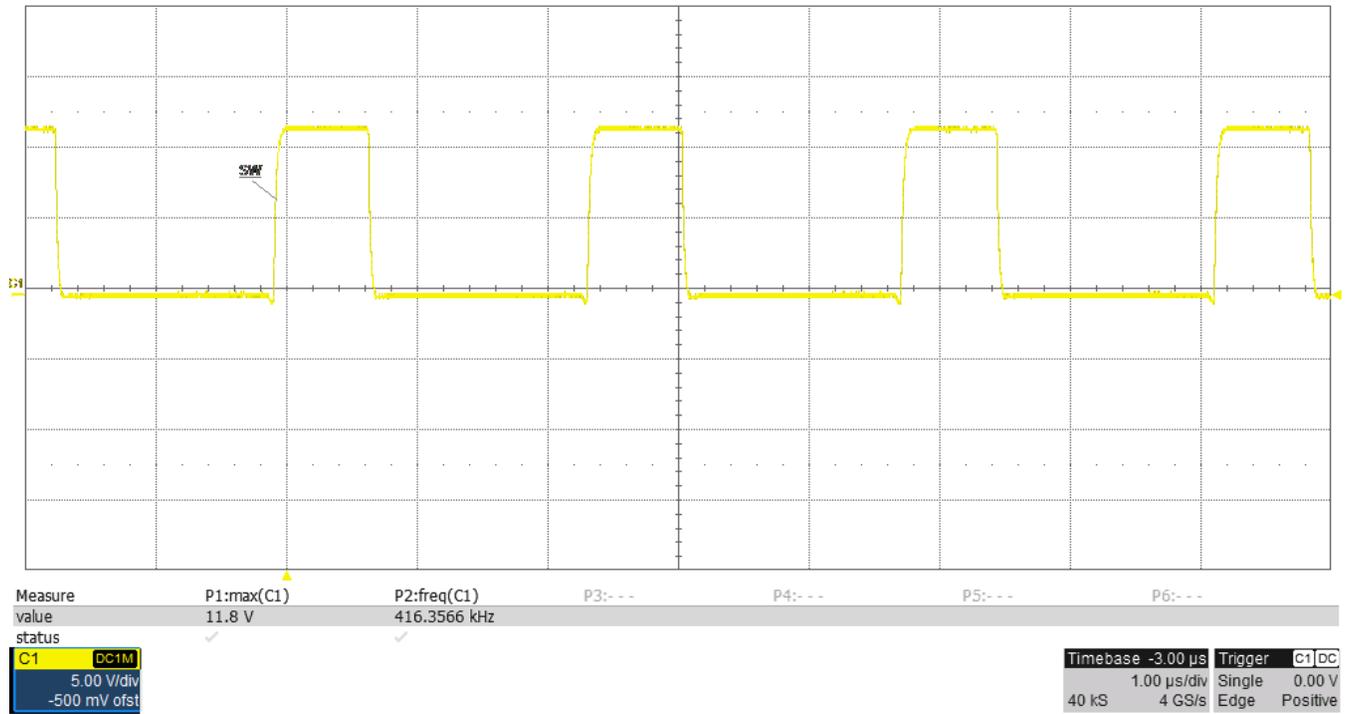


Figure 22. Switch node for U7 buck converter at 3 A load, 12 Vdc input and 3.3 Vdc output

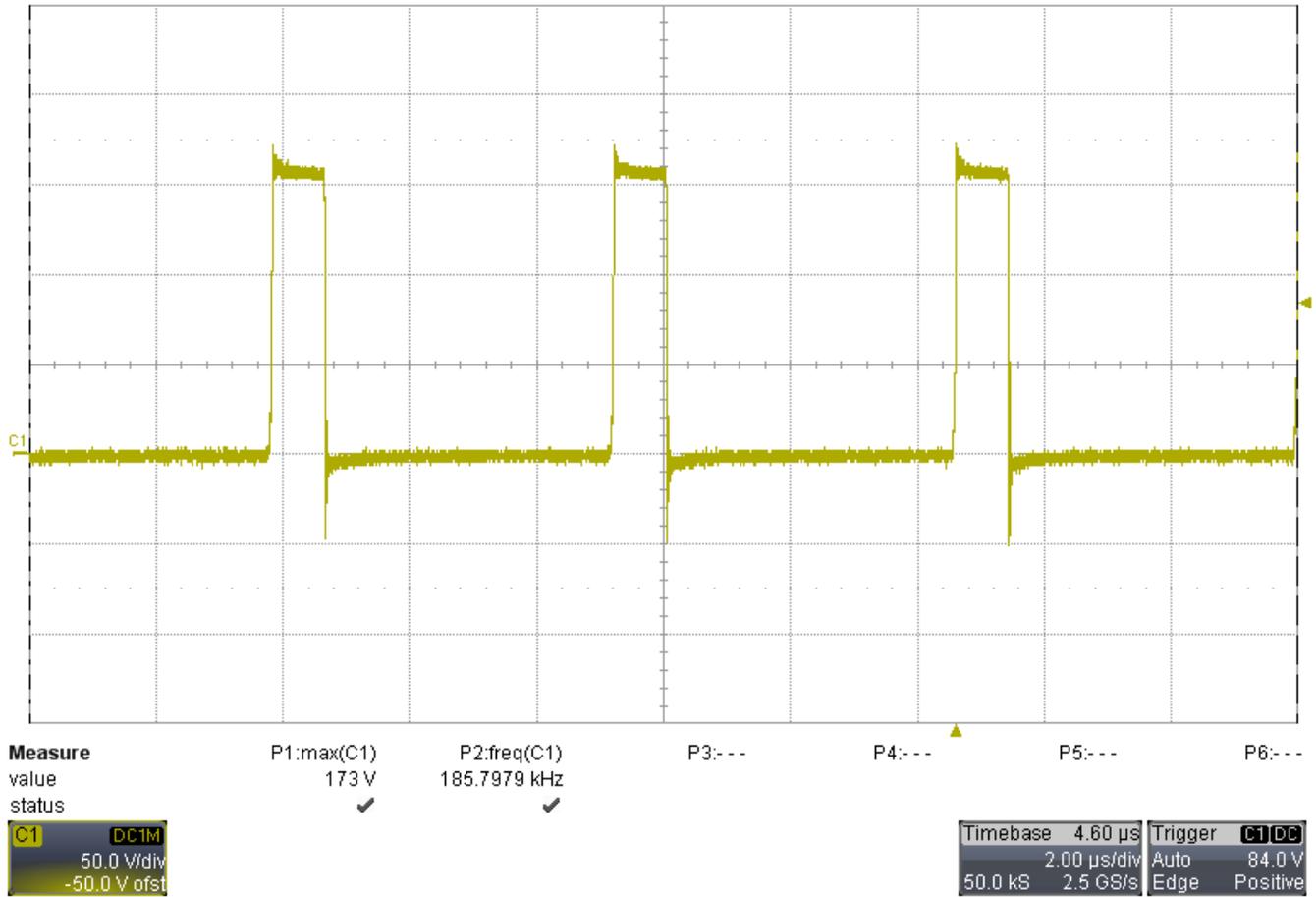


Figure 23. Switch Node for the LM5022 boost converter at full load on the 12 Vdc rail with 24 Vdc input

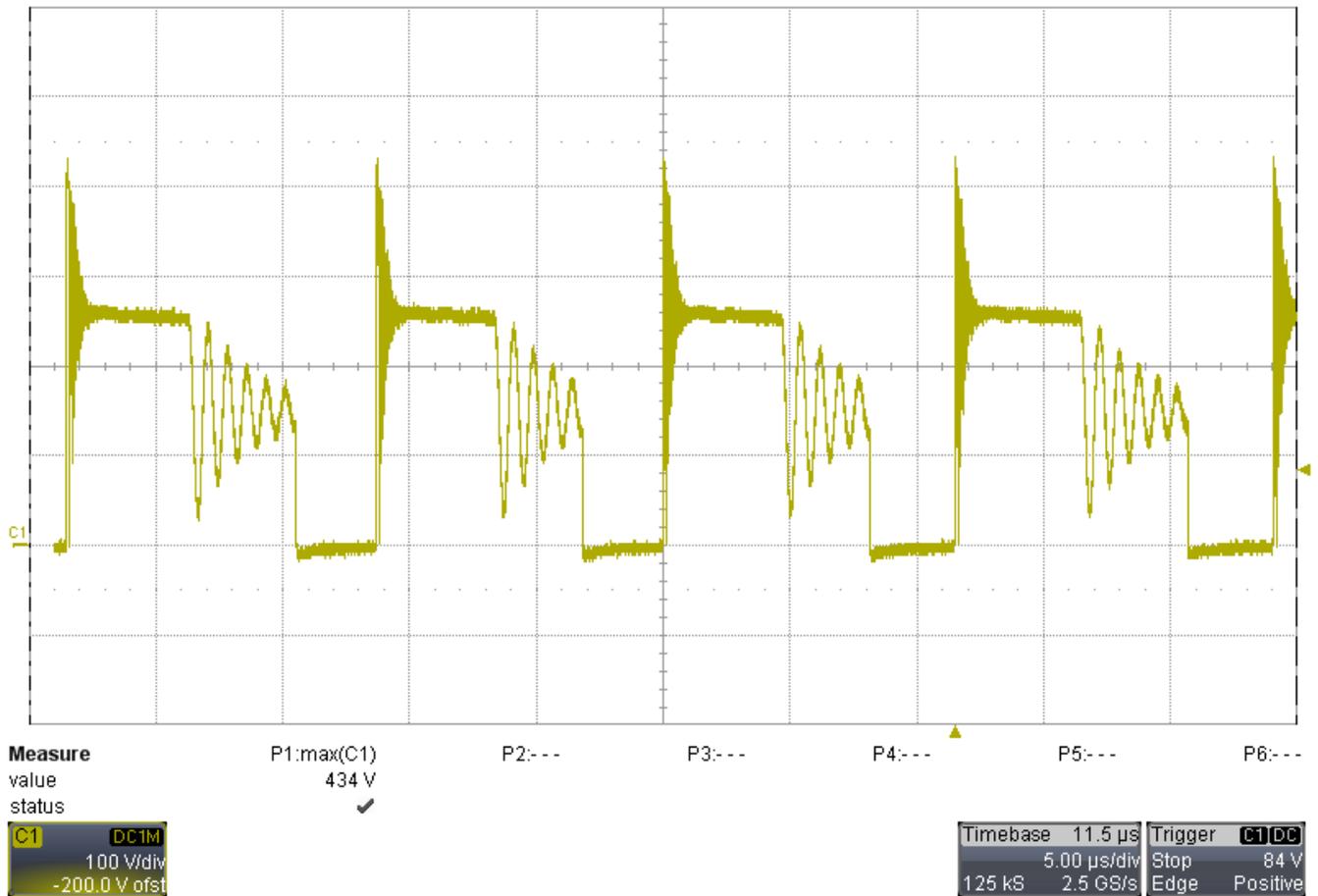


Figure 24. Switch node for the U4 flyback with 150 Vdc input, and 5 A on the 12 Vdc rail

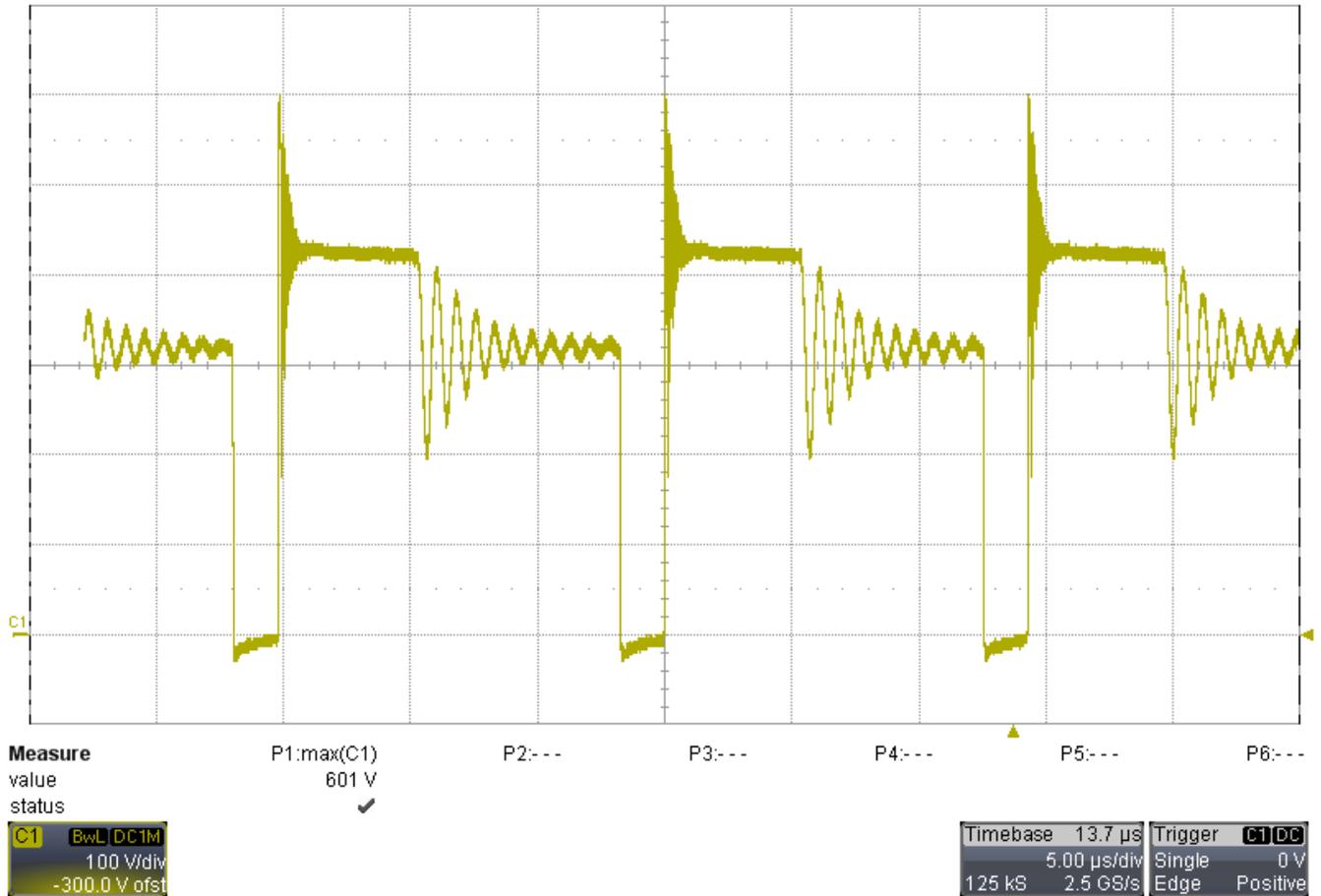


Figure 25. Switch node for the U4 flyback with 230 Vac input, and 5 A on the 12 Vdc rail

3.2 Output Voltage Ripple

Measurements were taken using the tip and barrel method across the output caps for each rail when at full load.

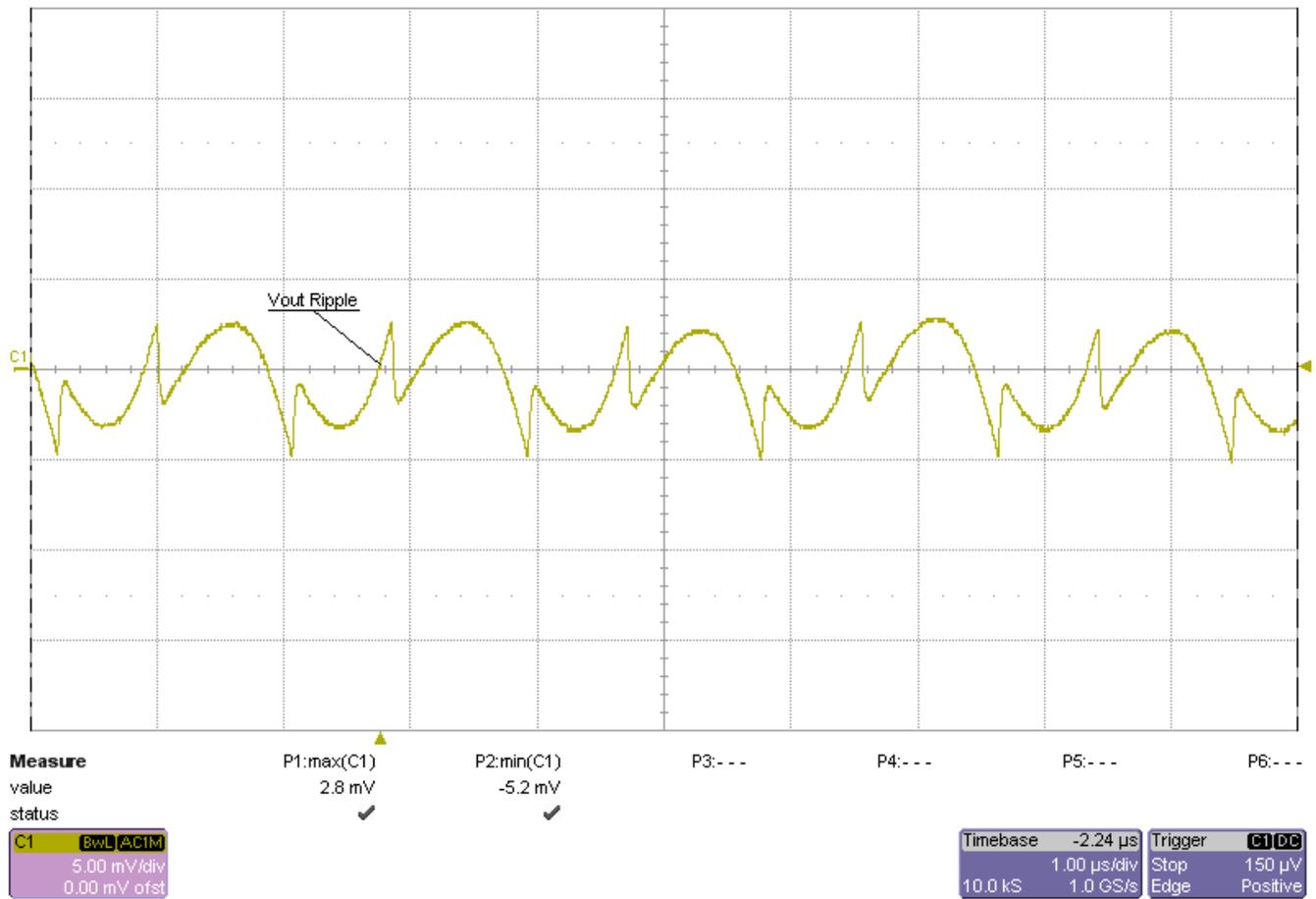


Figure 26. Output ripple of U6 converter at 3 A load, 12 Vdc input and 5 Vdc output

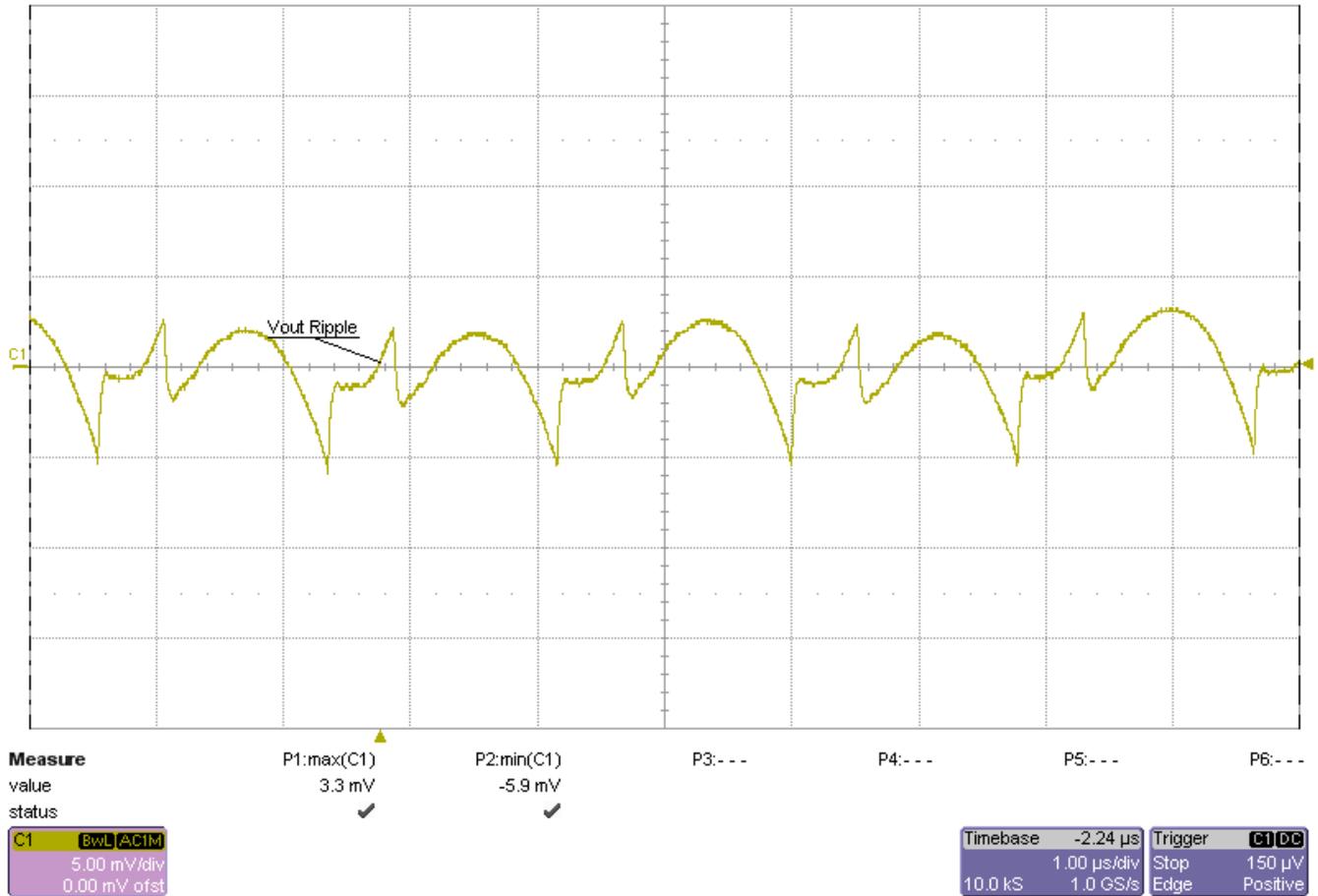


Figure 27. Output ripple of U7 converter at 3 A load, 12 Vdc input and 3.3 Vdc output

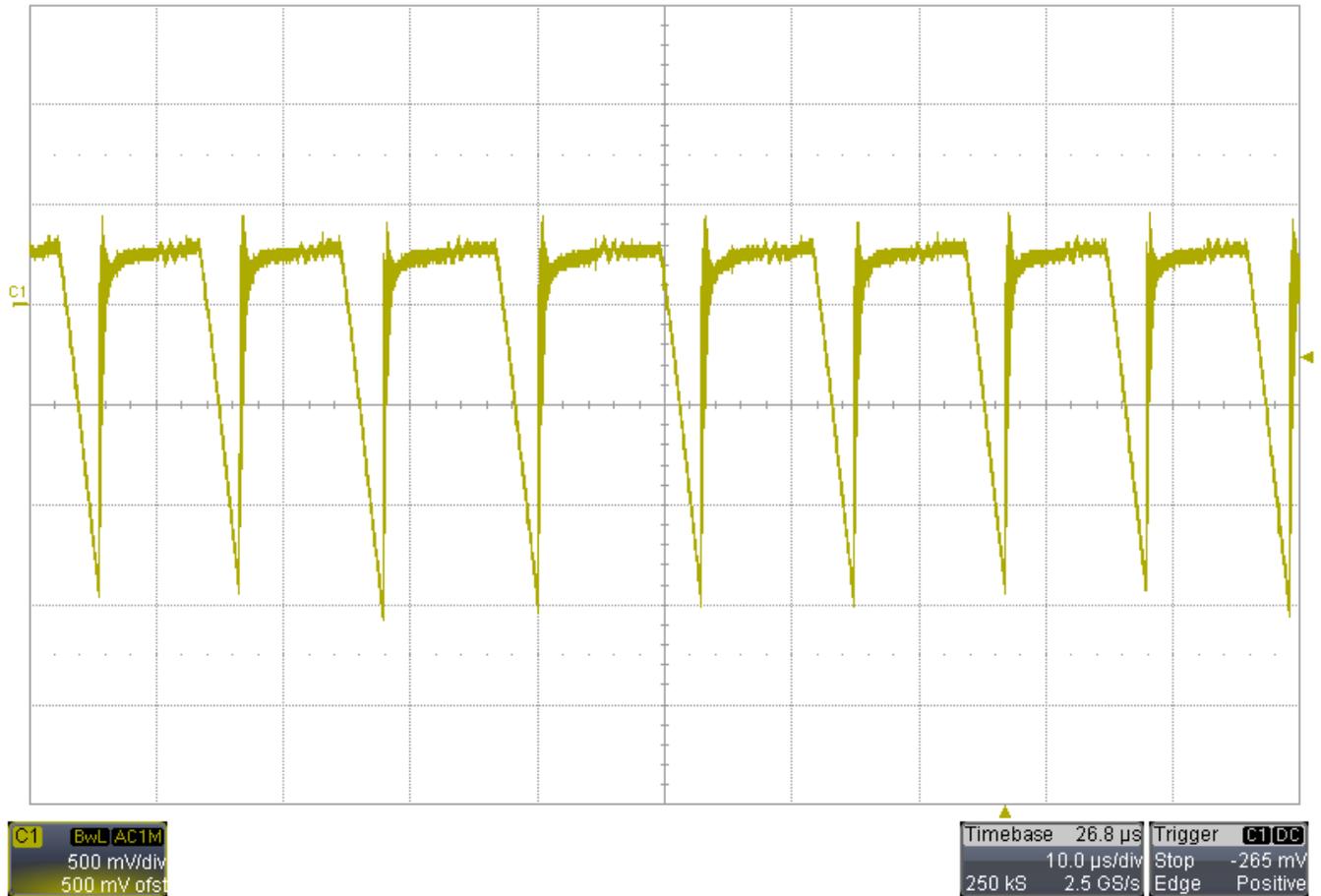


Figure 28. Output ripple for U1 boost converter with 24 Vdc input and 3.25 A load on the 12 Vdc rail

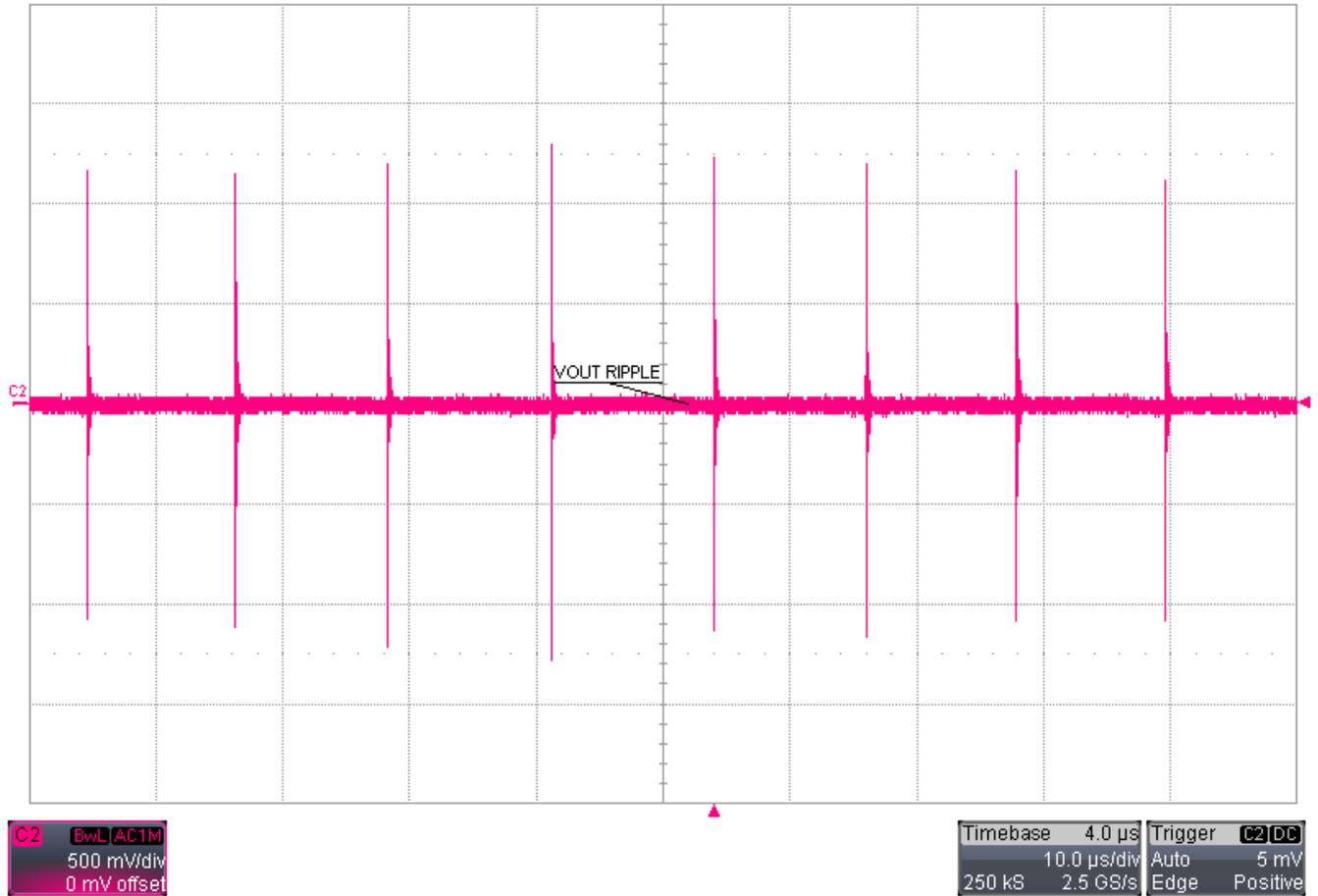


Figure 29. Output voltage for U4 flyback at 5 A load and 150 Vdc input

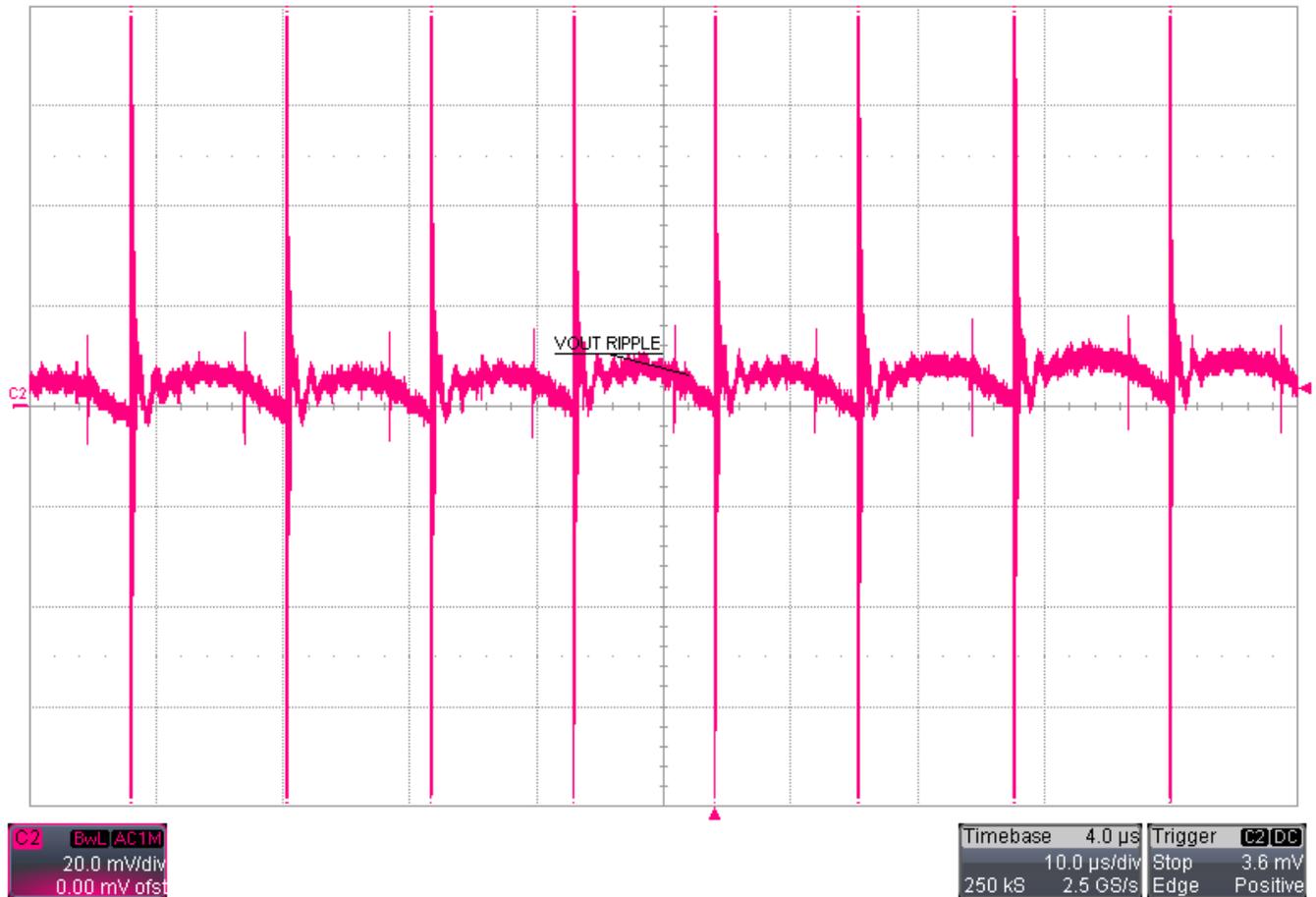


Figure 30. Output voltage for U4 flyback at 5 A load and 150 Vdc input. Voltage per division is increased for close up view of ripple

LOAD TRANSIENTS

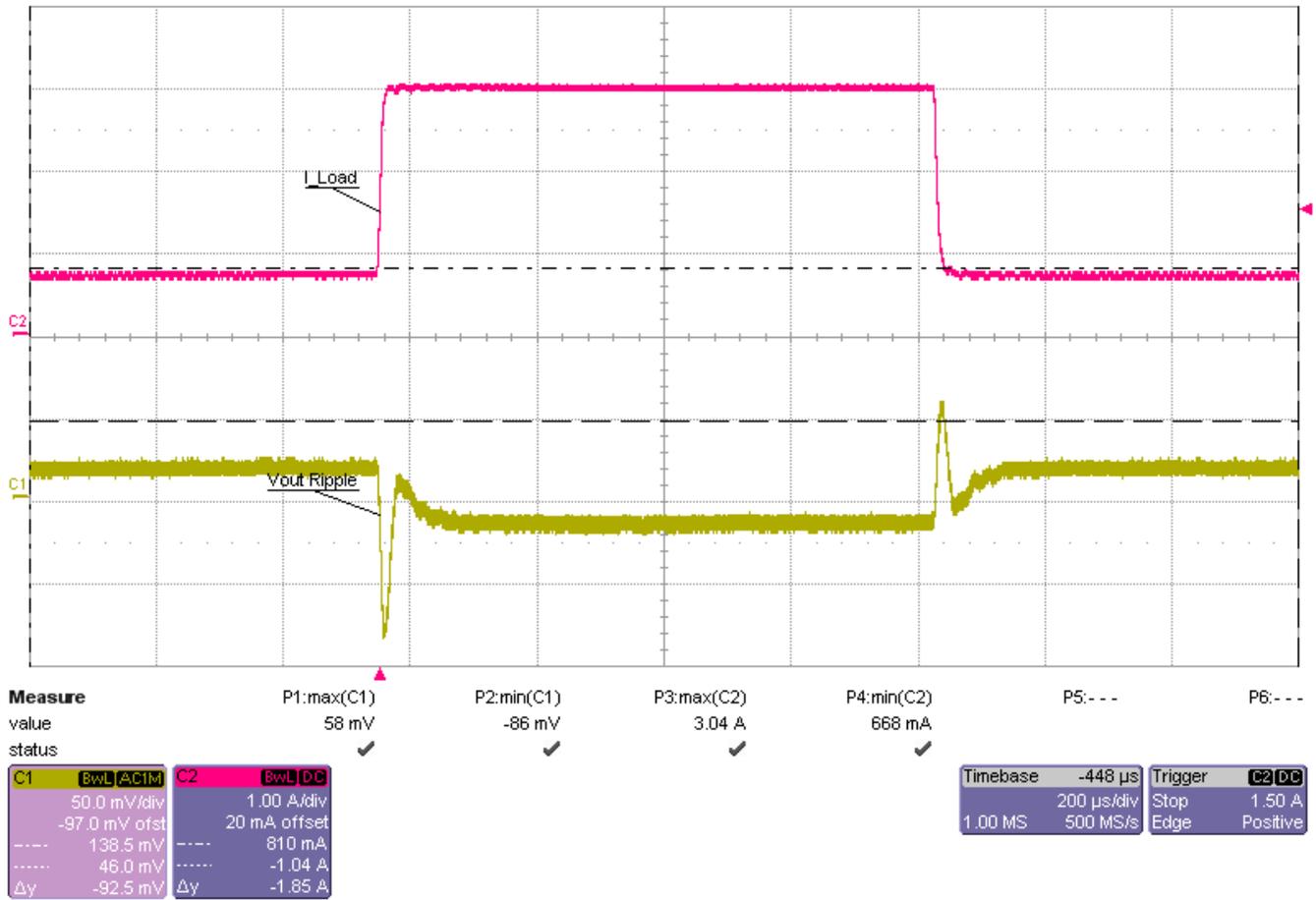


Figure 31. Load transient response for U6 buck converter at 3 A load, 12 Vdc input and 5 Vdc output

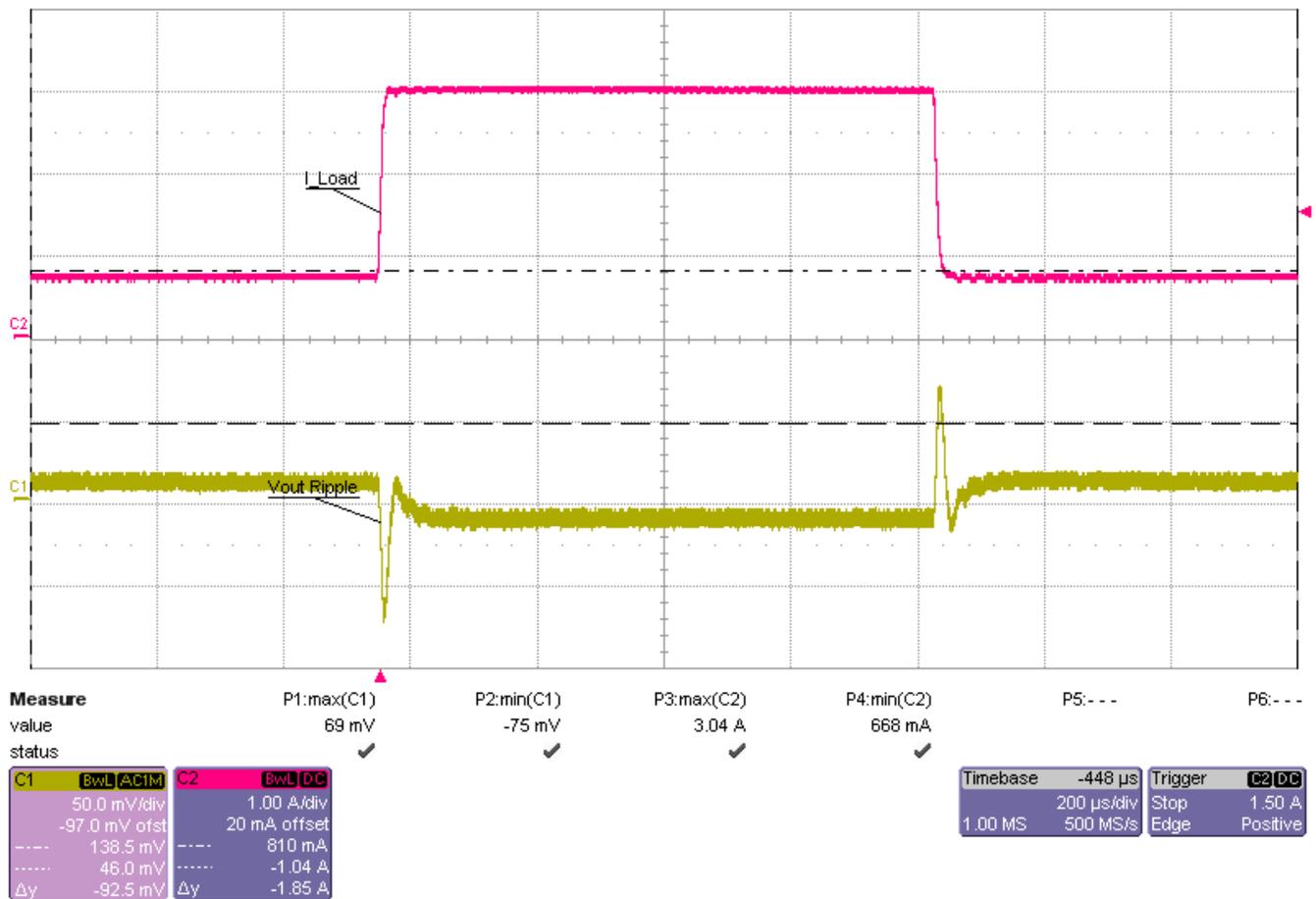


Figure 32. Load transient response for U7 buck converter at 3 A load, 12 Vdc input and 3.3 Vdc output

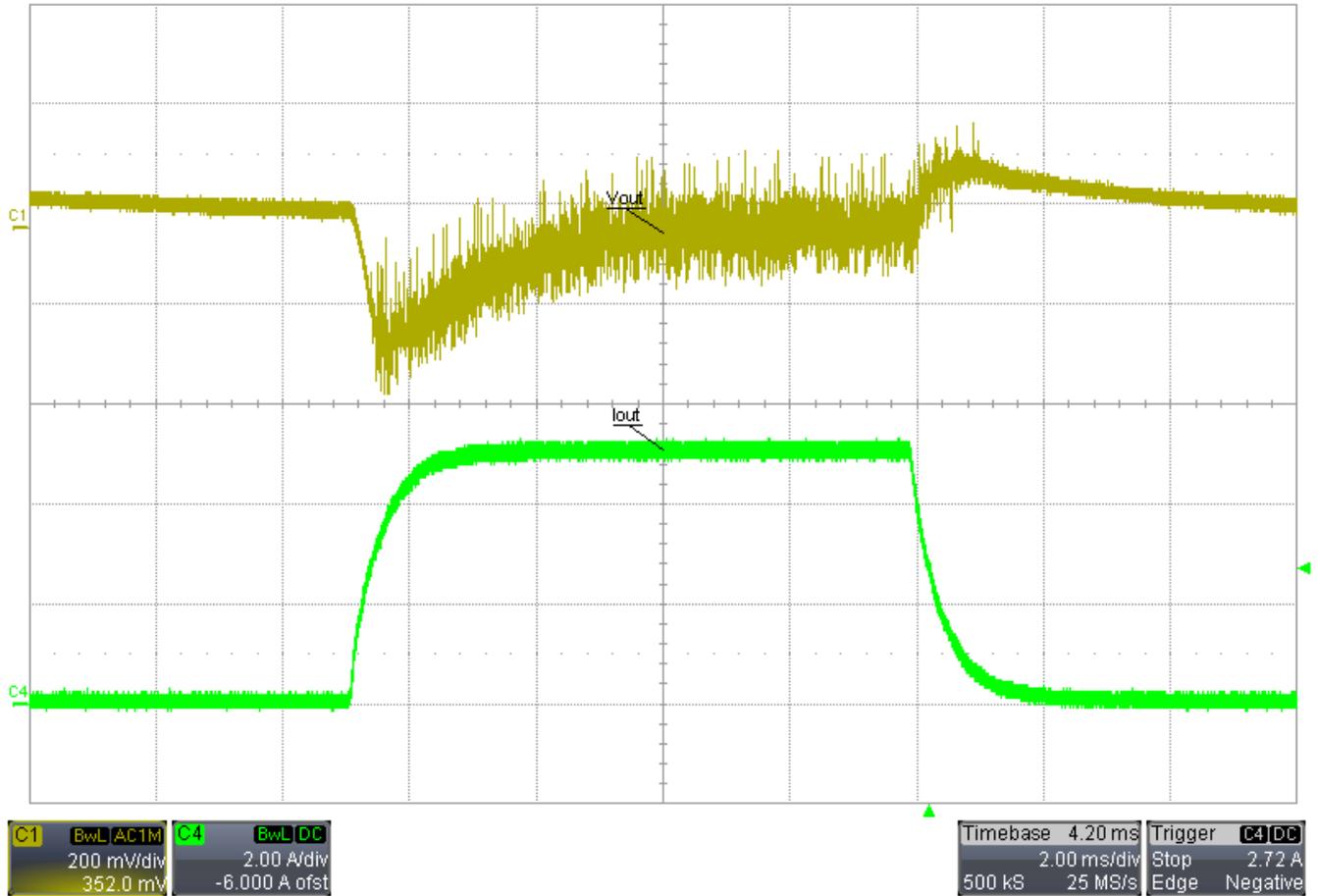


Figure 33. U4 flyback Load transient response, with load transient between 0 A and 5 A

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