Test Report: PMP22819

450-W Dual-Phase Boost Converter Reference Design for Automotive Applications

Description

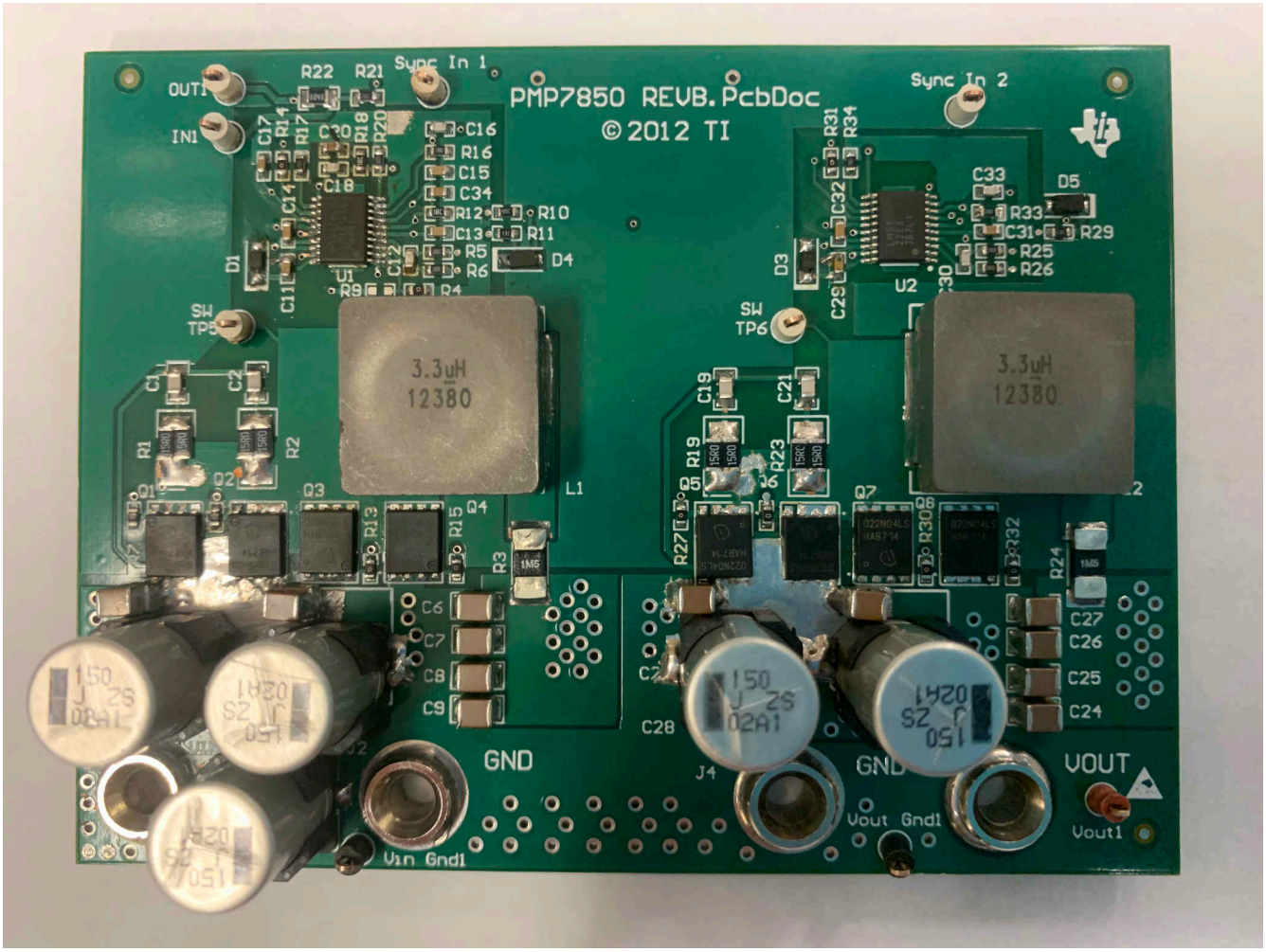
This reference design is a 450-W dual-phase boost converter for automotive applications. The circuit accepts an input voltage of 6 V to 35 V, and boosts to a nominal 12-V output rail that is capable of sourcing 37.5 A of current. The design uses two synchronous boost controllers operating at a switching frequency of 450 kHz per phase. Each controller has an internal current source to keep the high-side MOSFETs on at 100% duty cycle. This ability allows for bypass operation when the input voltage is greater than the regulated output voltage.

Features

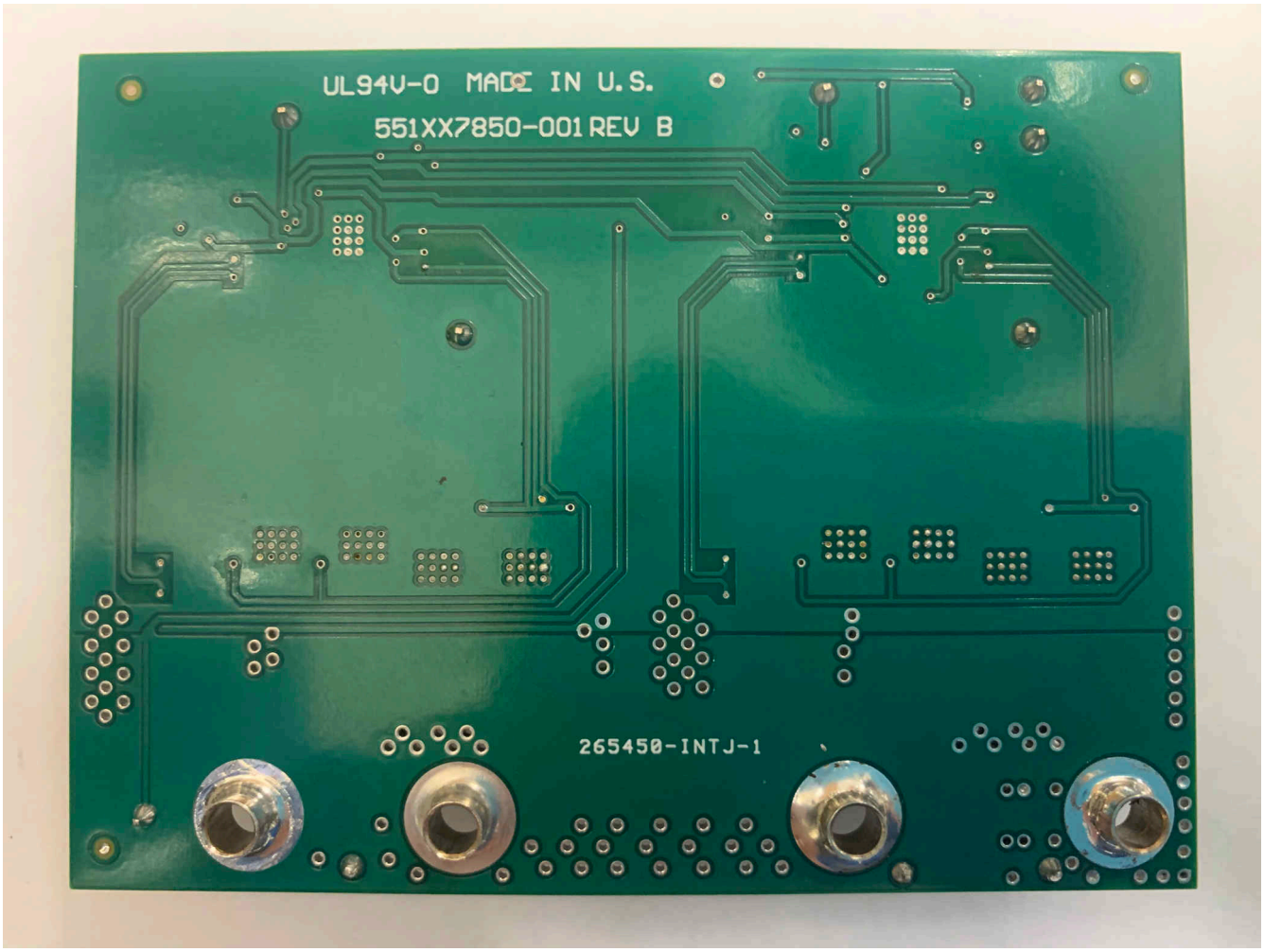
- High-side MOSFETs have 100% duty cycle capability
- All components are on the top layer
- Excellent phase current sharing for balanced thermal performance
- Rapid start-up
- High-power boost solution

Applications

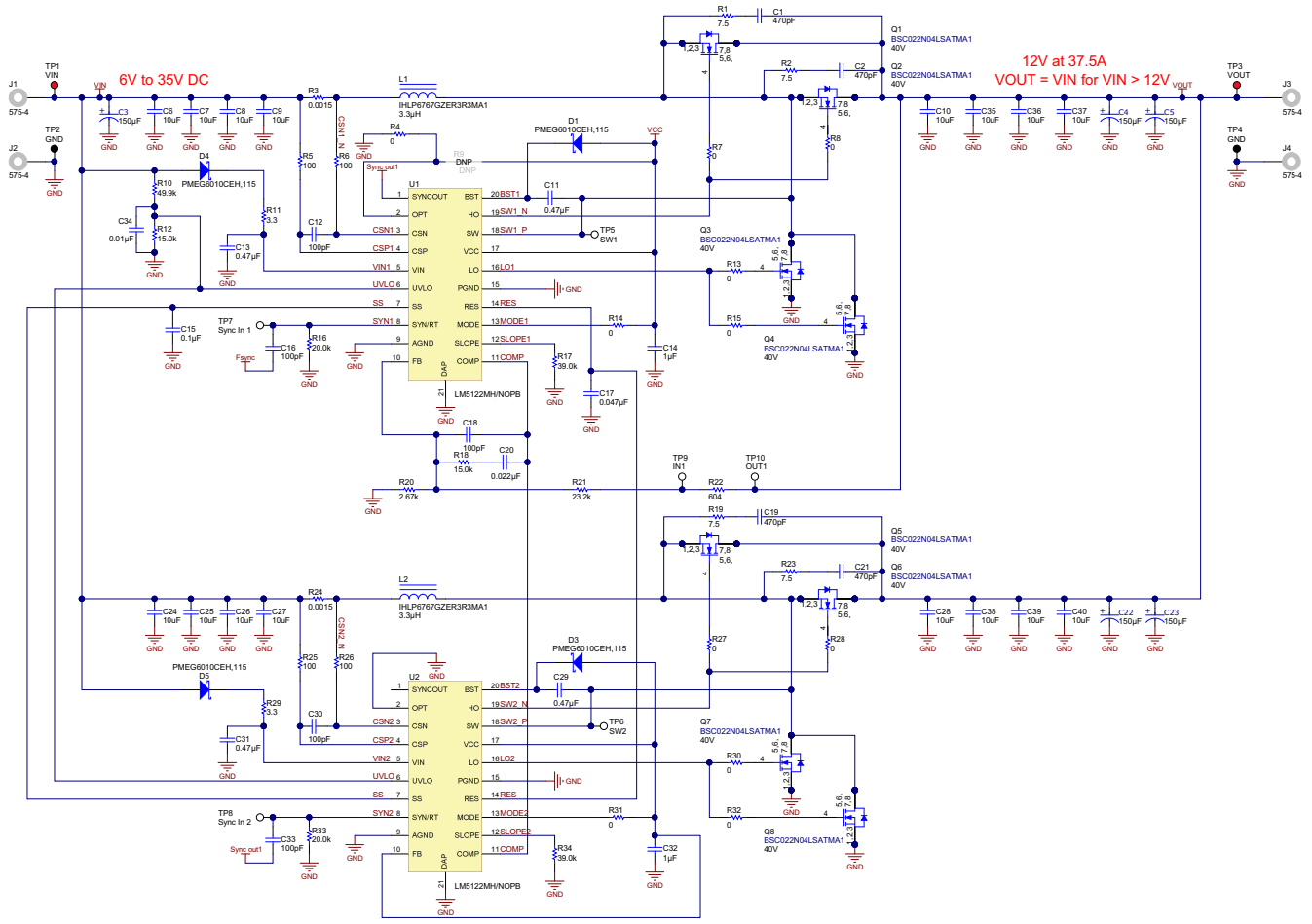
- Mid Power DC/DC Converter



Top Photo



Bottom Photo



Schematic

1 Test Prerequisites

1.1 Design Requirements

Table 1-1. Design Requirements

Parameter	Specifications
Input Voltage	6 V to 35 V DC
Output Voltage	12 V
Load Current	37.5 A

1.2 Required Equipment

- DC power supply
- Electronic load
- Oscilloscope

1.3 Considerations

All tests were performed at room temperature on an open bench.

Use additional bulk input capacitors at low input voltage if there are long wires to the power source. Otherwise, input filter oscillation may occur due to the wiring inductance.

At sustained load, airflow or a heat sink attached to the bottom of the board is required, especially at low input voltage.

1.4 Dimensions

The design was built on PMP7850 Rev. B printed circuit board. This is a 4-layer PCB with 1-oz copper on all layers. Board dimensions are 4.0 in × 3.0 in.

2 Testing and Results

2.1 Efficiency Graphs

The following figure shows the converter efficiency.

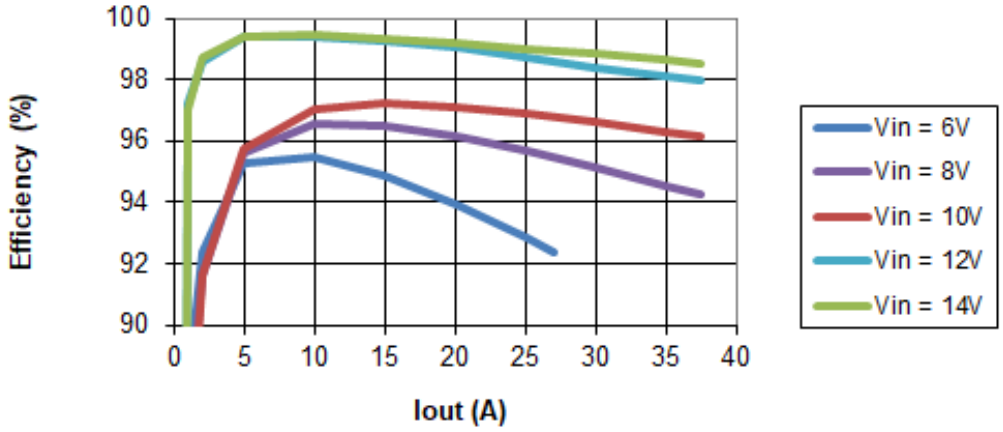


Figure 2-1. Efficiency

2.2 Efficiency Data

Efficiency data is shown in the following tables.

Table 2-1. 6-V Input

V_{IN} (V)	I_{IN} (A)	V_{OUT} (V)	I_{OUT} (A)	P_{IN} (W)	P_{OUT} (W)	P_{LOSS} (W)	Efficiency (%)
5.996	0.154	11.882	0.000	0.923	0.000	0.923	0.00
5.996	2.080	11.882	0.924	12.471	10.979	1.492	88.04
5.995	4.132	11.882	1.926	24.773	22.884	1.889	92.38
5.995	10.244	11.881	4.926	61.416	58.524	2.892	95.29
5.995	20.596	11.879	9.926	123.471	117.913	5.558	95.50
5.994	42.164	11.876	19.986	252.727	237.356	15.370	93.92
5.993	53.306	11.875	24.980	319.452	292.626	22.826	92.85
5.992	57.858	11.874	26.976	346.702	320.310	26.392	92.39

Table 2-2. 8-V Input

V_{IN} (V)	I_{IN} (A)	V_{OUT} (V)	I_{OUT} (A)	P_{IN} (W)	P_{OUT} (W)	P_{LOSS} (W)	Efficiency (%)
7.999	0.174	11.886	0.000	1.392	0.000	1.392	0.00
7.999	1.598	11.886	0.928	12.782	11.030	1.751	86.30
7.998	3.126	11.886	1.928	25.003	22.916	2.087	91.65
7.998	7.660	11.885	4.928	61.267	58.569	2.698	95.60
7.998	15.280	11.883	9.928	122.211	117.979	4.232	96.54
7.998	22.986	11.882	14.926	183.835	177.352	6.483	96.47
7.997	30.878	11.881	19.984	246.943	237.423	9.520	96.14
7.997	38.780	11.879	24.978	310.115	296.722	13.393	95.68
7.996	46.876	11.878	29.970	374.116	355.980	18.137	95.15
7.996	54.926	11.876	34.968	439.188	415.293	23.896	94.56
7.996	59.058	11.876	37.472	472.208	445.005	27.203	94.24

Table 2-3. 10-V Input

V_{IN} (V)	I_{IN} (A)	V_{OUT} (V)	I_{OUT} (A)	P_{IN} (W)	P_{OUT} (W)	P_{LOSS} (W)	Efficiency (%)
10.001	0.182	11.887	0.000	1.820	0.000	1.820	0.00
10.002	1.304	11.886	0.924	13.042	10.983	2.059	84.21
10.001	2.498	11.886	1.926	24.983	22.892	2.091	91.63
10.001	6.112	11.885	4.926	61.129	58.546	2.583	95.77
10.001	12.156	11.884	9.926	121.573	117.958	3.615	97.03
10.001	18.242	11.882	14.924	182.441	177.333	5.108	97.20
10.001	24.446	11.881	19.986	244.486	237.455	7.030	97.12
10.001	30.618	11.880	24.980	306.196	296.757	9.439	96.92
10.000	36.838	11.878	29.968	368.389	355.974	12.415	96.63
10.000	43.122	11.877	34.968	431.226	415.318	15.908	96.31
10.000	46.290	11.876	37.472	462.906	445.033	17.874	96.14

Table 2-4. 12-V Input

V_{IN} (V)	I_{IN} (A)	V_{OUT} (V)	I_{OUT} (A)	P_{IN} (W)	P_{OUT} (W)	P_{LOSS} (W)	Efficiency (%)
11.998	0.016	11.999	0.000	0.192	0.000	0.192	0.00
11.999	0.950	11.993	0.924	11.399	11.082	0.317	97.22
11.999	1.950	11.988	1.924	23.397	23.064	0.333	98.57
11.999	4.944	11.970	4.924	59.321	58.941	0.380	99.36
11.998	9.938	11.942	9.924	119.240	118.510	0.731	99.39
11.998	14.930	11.913	14.924	179.138	177.791	1.346	99.25
11.999	19.984	11.884	18.986	239.779	237.515	2.264	99.06
11.998	25.062	11.880	24.978	300.701	296.751	3.950	98.69
11.998	30.160	11.879	29,970	361.863	356.021	5.842	98.39
11.998	35.296	11.878	34.968	423.478	415.349	8.128	98.08
11.998	37.870	11.877	37.472	454.358	445.066	9.292	97.95

Table 2-5. 14-V Input

V_{IN} (V)	I_{IN} (A)	V_{OUT} (V)	I_{OUT} (A)	P_{IN} (W)	P_{OUT} (W)	P_{LOSS} (W)	Efficiency (%)
13.998	0.014	13.998	0.000	0.196	0.000	0.196	0.00
13.998	0.950	13.992	0.922	13.298	12.901	0.397	97.02
13.998	1.948	13.987	1.924	27.268	26.911	0.357	98.69
13.998	4.944	13.970	4.924	69.204	68.787	0.417	99.40
13.998	9.938	13.941	9.924	139.108	138.353	0.755	99.46
13.998	14.930	13.913	14.924	208.984	207.633	1.351	99.35
13.998	19.982	13.884	19.984	279.700	277.453	2.247	99.20
13.997	24.970	13.955	24.976	349.507	346.038	3.469	99.01
13.997	29.954	13.826	29.970	419.272	414.377	4.895	98.83
13.997	34.946	13.798	34.970	489.146	482.502	6.644	98.64
13.997	37.444	13.783	37.472	524.116	516.470	7.646	98.54

2.3 Thermal Images

The following figure shows thermal performance for operation at 10-V input, 30-A load with no airflow. The image was taken with the board at thermal equilibrium.

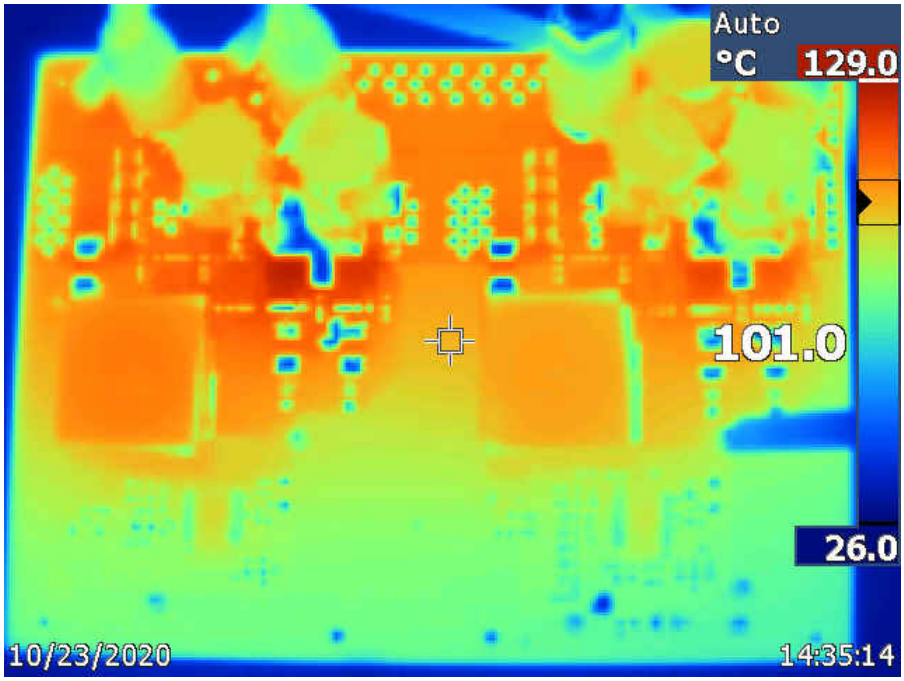


Figure 2-2. 10-V Input, 30-A Load, No Airflow

2.4 Thermal Efficiency Data

Table 2-6. Thermal Efficiency Data

V_{IN} (V)	I_{IN} (A)	V_{OUT} (V)	I_{OUT} (A)	P_{IN} (W)	P_{OUT} (W)	P_{LOSS} (W)	Efficiency (%)
10.000	37.244	11.877	30.167	372.44	358.44	14.04	96.23

2.5 Frequency Response

The frequency response is shown in the following figures.

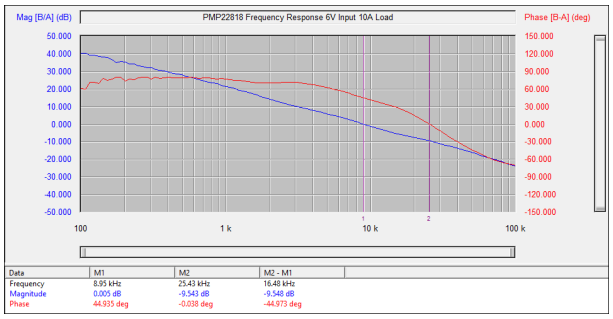


Figure 2-3. 6-V Input, 10-A Load

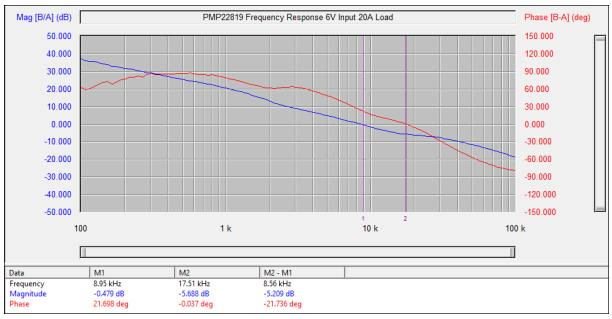


Figure 2-4. 6-V Input, 20-A Load

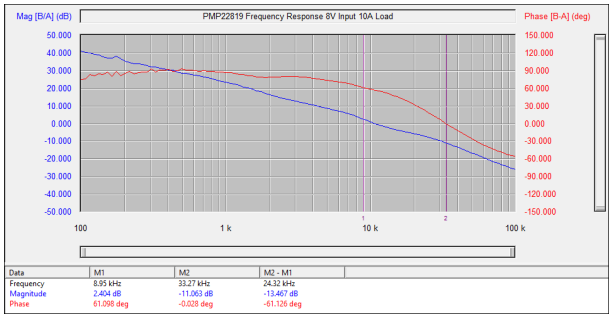


Figure 2-5. 8-V Input, 10-A Load

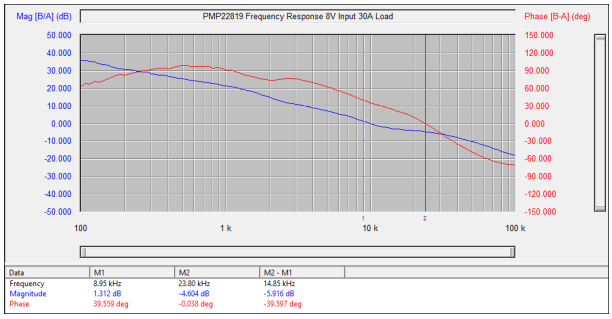


Figure 2-6. 8-V Input, 30-A Load

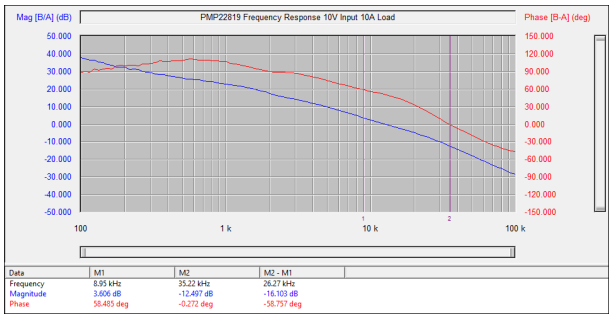


Figure 2-7. 10-V Input, 10-A Load

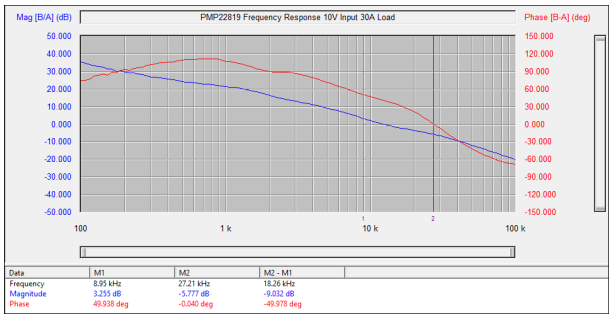


Figure 2-8. 10-V Input, 30-A Load

3 Waveforms

3.1 Switching

The switching behavior is shown in the following figures.

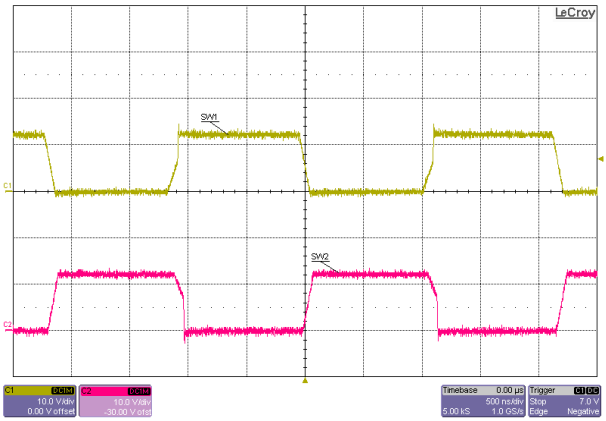


Figure 3-1. 6-V Input, 0-A Load

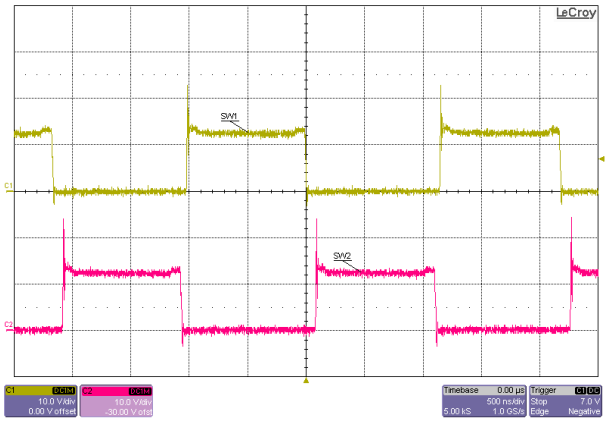


Figure 3-2. 6-V Input, 27-A Load

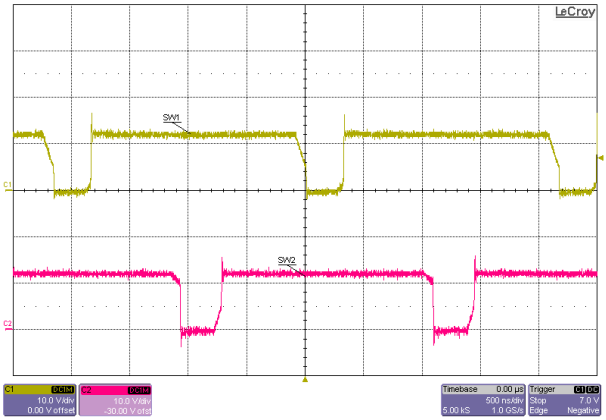


Figure 3-3. 10-V Input, 0-A Load

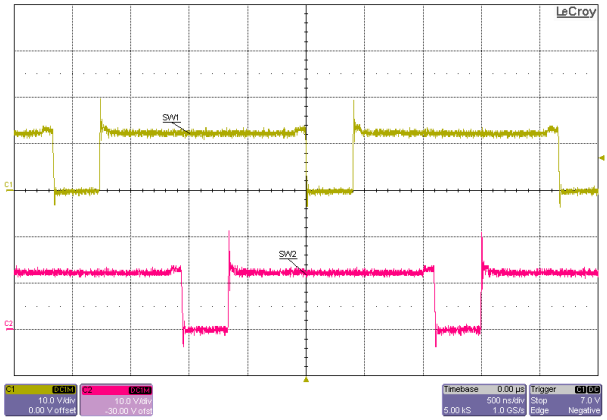


Figure 3-4. 10-V Input, 37.5-A Load

3.2 Output Voltage Ripple

Output voltage ripple is shown in the following figures.

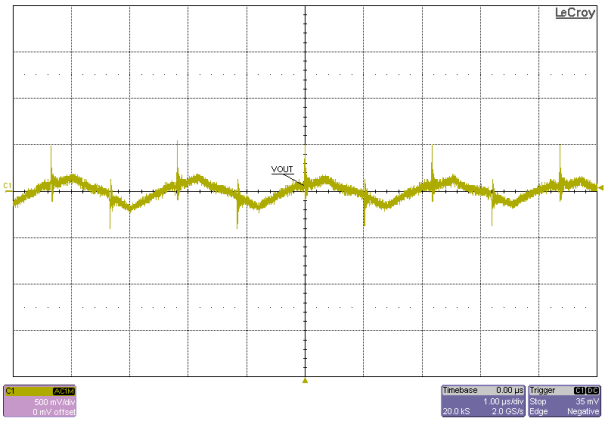


Figure 3-5. 6-V Input, 27-A Load

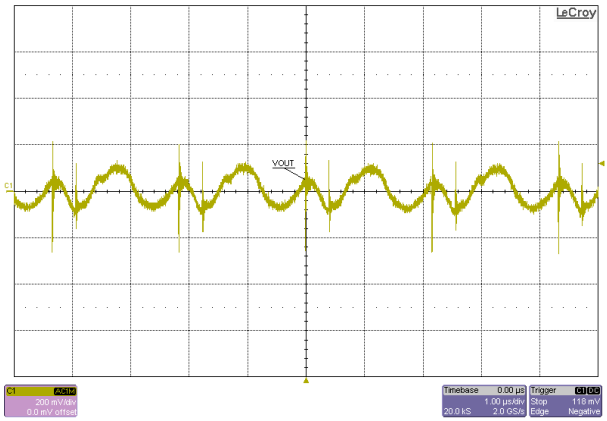


Figure 3-6. 10-V Input, 37.5-A Load

3.3 Load Transients

Load transient response is shown in the following figures.

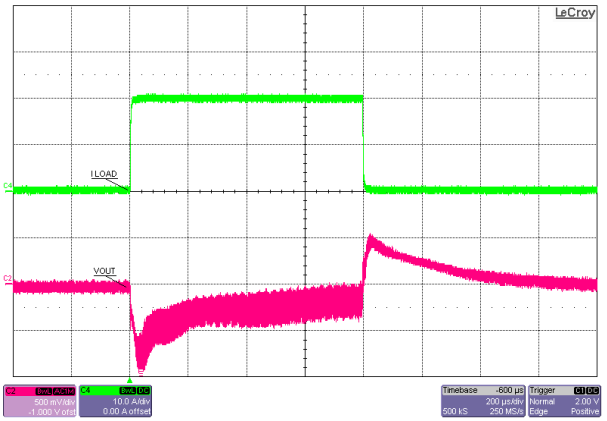


Figure 3-7. 8-V Input, 0-A to 20-A Load Step

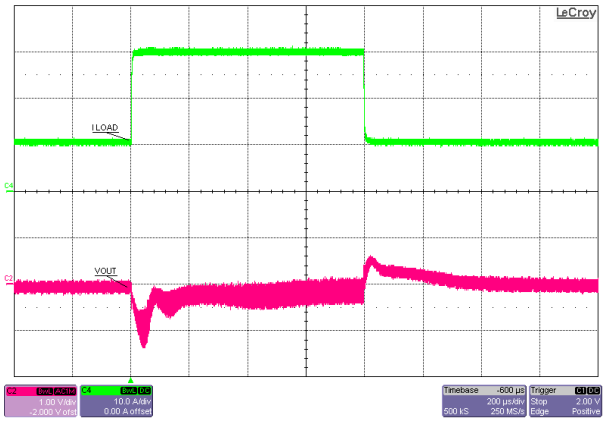


Figure 3-8. 8-V Input, 10-A to 30-A Load Step

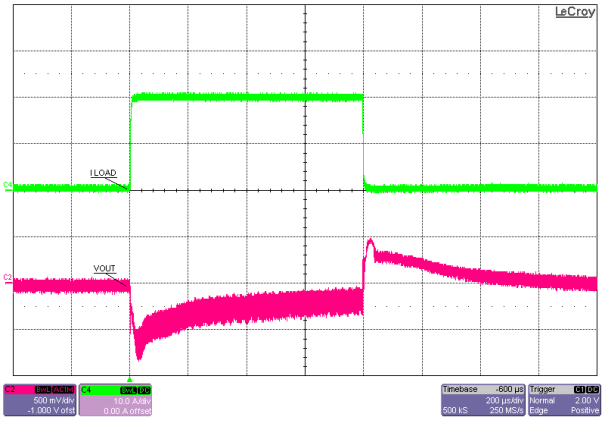


Figure 3-9. 10-V Input, 0-A to 20-A Load Step

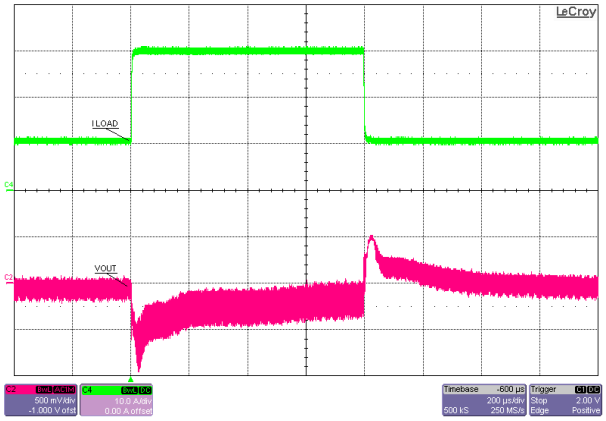


Figure 3-10. 10-V Input, 10-A to 30-A Load Step

3.4 Start-Up Sequence

Start-up behavior is shown in the following figures.

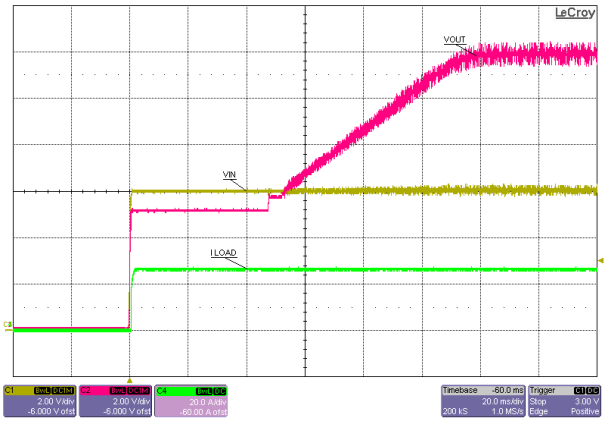


Figure 3-11. 6-V Input, 27-A Load

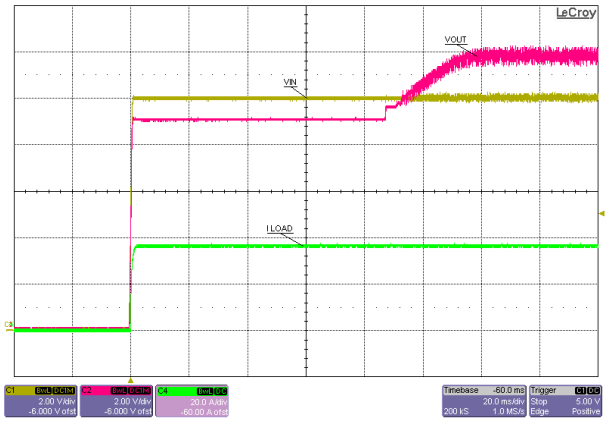


Figure 3-12. 10-V Input, 37.5-A Load

3.5 Bypass Operation

Bypass operation is shown in the following figures.

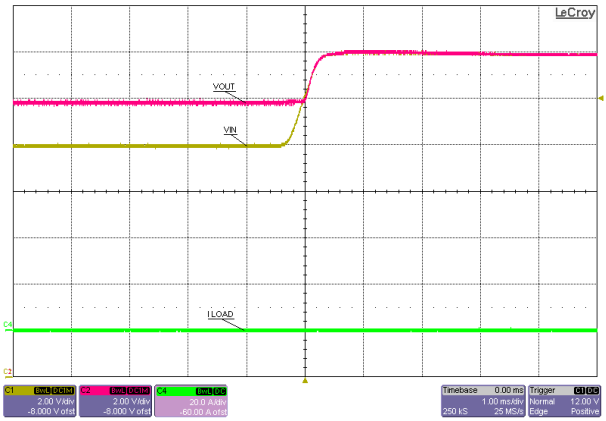


Figure 3-13. 10-V to 14-V Input, 0-A Load

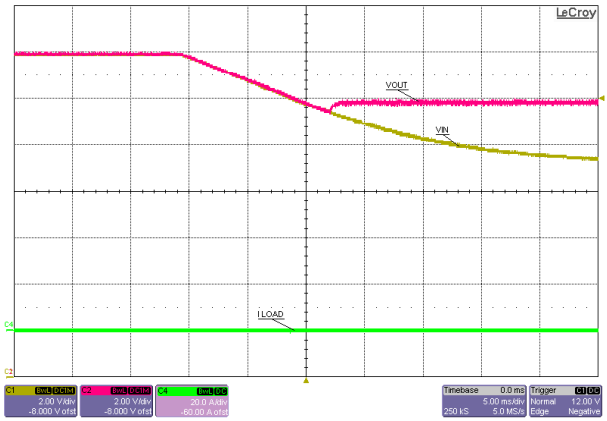


Figure 3-14. 14-V to 10-V Input, 0-A Load

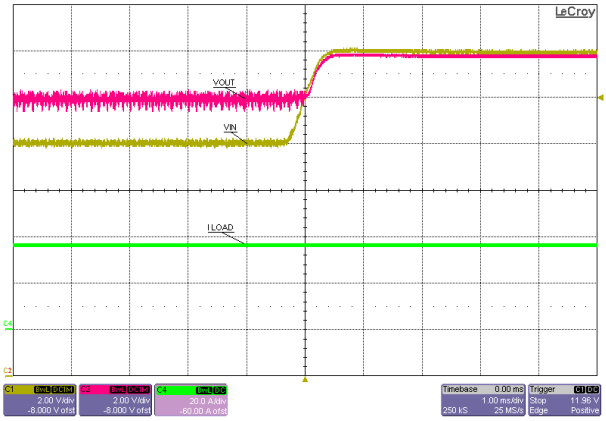


Figure 3-15. 10-V to 14-V Input, 37.5-A Load

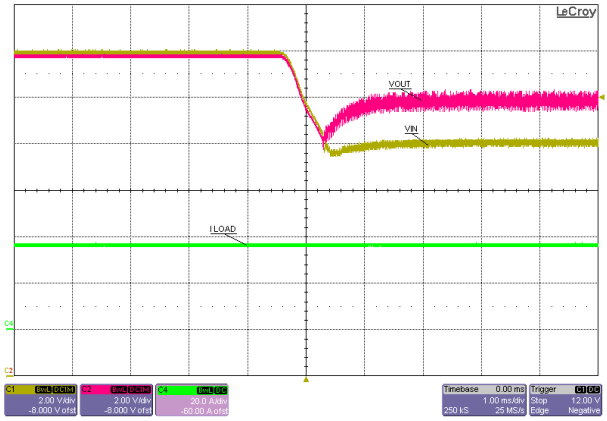


Figure 3-16. 14-V to 10-V Input, 37.5-A Load

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