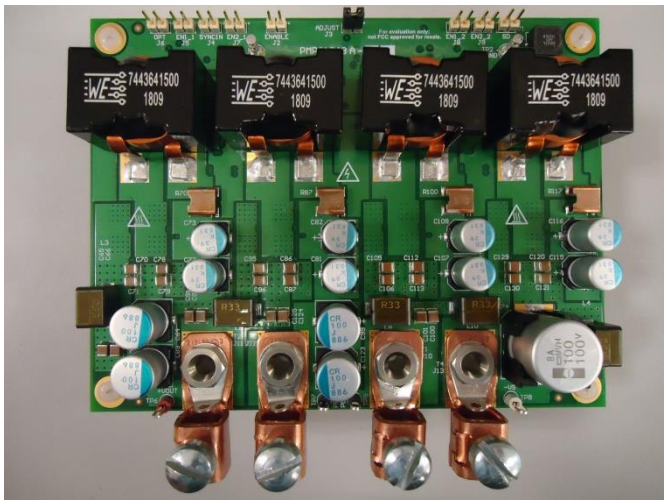
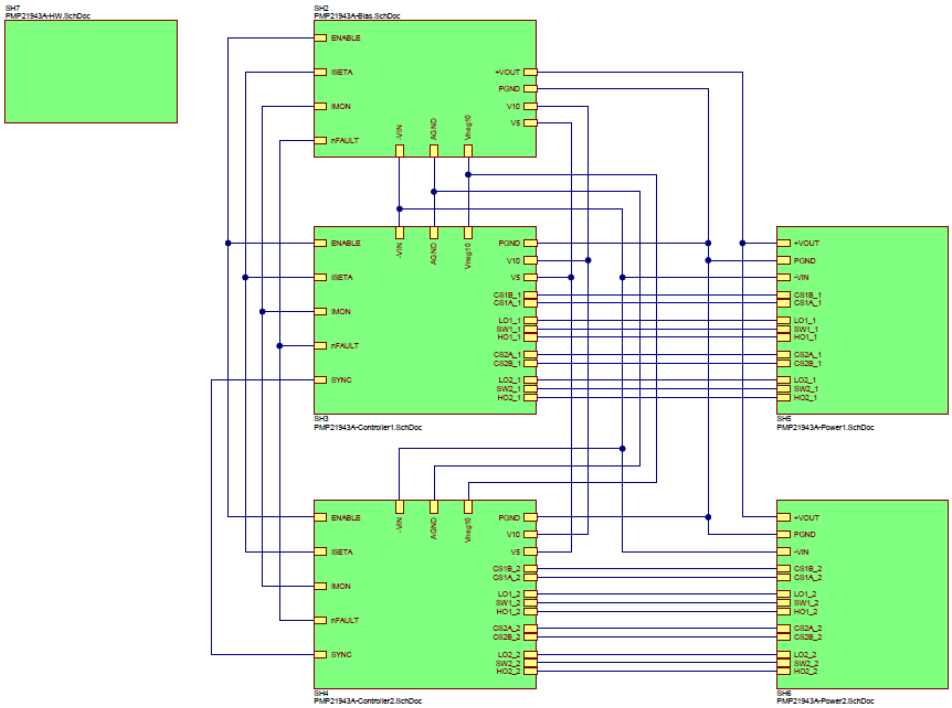
Test Report: PMP21943

48-V / 25-A Negative-to-Positive Synchronous Buck-Boost Reference Design for Power Amplifiers

Description

This reference design is a negative-to-positive synchronous buck-boost converter for power amplifier applications. The circuit is powered from the nominal -48-V system source to provide an output voltage of +48 V at 25 A. The design uses two dual synchronous boost controllers for 4-phase operation at a switching frequency of 150 kHz. Output voltage adjustment to +30 V is jumper selectable. 1 through 4 phase operation is also jumper selectable.





1 Test Prerequisites

1.1 Voltage and Current Requirements

Table 1. Voltage and Current Requirements

PARAMETER	SPECIFICATIONS
Input Voltage	-36 V to -60 V
Output Voltage	+48 V
Output Current	25 A

1.2 Required Equipment

- DC power supply
- Electronic load
- Oscilloscope

1.3 Considerations

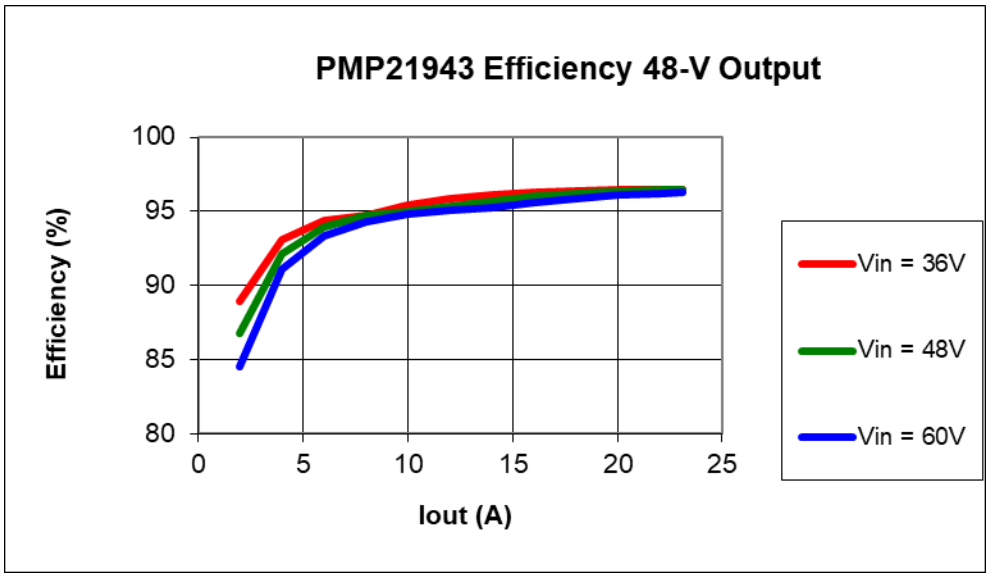
All tests were performed at room temperature on an open bench.

Heat sink and/or air flow is required for sustained operation above 50% load.

2 Testing and Results

2.1 Efficiency Graphs

Figures show the converter efficiency with 36-V, 48-V, and 60-V inputs.



2.2 Efficiency Data

Table 2, Table 3, and Table 4 shows the efficiency data with 36-V, 48-V, and 60-V inputs.

Table 2. Efficiency Data 36-V Input, 48-V Output

V_{IN}	I_{IN}	V_{OUT}	I_{OUT}	P_{IN}	P_{OUT}	Losses	Efficiency
36.000	0.282	47.604	0.000	10.15	0.00	10.72	0.00
36.000	2.986	47.602	2.008	107.50	95.58	11.91	88.92
36.000	5.688	47.601	4.006	204.77	190.69	14.08	93.12
36.000	8.416	47.601	6.006	302.98	285.89	17.09	94.36
36.000	11.168	47.600	8.004	402.04	380.99	21.06	94.76
36.000	13.862	47.599	10.004	499.03	476.18	22.85	95.42
36.000	16.558	47.598	12.002	596.09	571.27	24.81	95.84
36.000	19.262	47.597	14.002	693.44	666.46	26.98	96.11
36.000	21.972	47.597	16.000	790.99	761.55	29.45	96.28
36.000	24.690	47.595	17.998	888.84	856.62	32.22	96.37
36.000	27.512	47.595	20.070	990.42	955.23	35.20	96.45
36.000	30.240	47.594	22.068	1088.64	1050.29	38.34	96.48
36.000	31.656	47.593	23.100	1139.61	1099.39	40.22	96.47

Table 3. Efficiency Data 48-V Input, 48-V Output

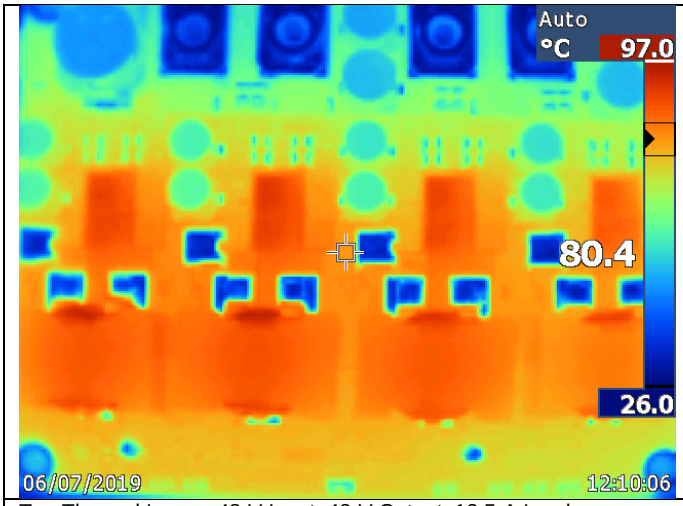
V_{IN}	I_{IN}	V_{OUT}	I_{OUT}	P_{IN}	P_{OUT}	Losses	Efficiency
48.003	0.280	47.577	0.000	13.44	0.00	13.82	0.00
48.002	2.292	47.575	2.006	110.02	95.44	14.59	86.74
48.002	4.306	47.575	4.004	206.70	190.49	16.21	92.16
48.003	6.332	47.574	6.004	303.95	285.63	18.32	93.97
48.002	8.376	47.573	8.004	402.07	380.77	21.29	94.70
48.002	10.436	47.572	10.004	500.95	475.91	25.05	95.00
48.002	12.474	47.571	12.000	598.78	570.85	27.93	95.34
48.002	14.494	47.570	14.000	695.75	665.98	29.76	95.72
48.003	16.516	47.569	16.000	792.81	761.11	31.70	96.00
48.002	18.540	47.569	17.998	889.97	856.14	33.82	96.20
48.002	20.642	47.568	20.070	990.87	954.68	36.18	96.35
48.002	22.672	47.567	22.066	1088.31	1049.61	38.70	96.44
48.002	23.740	47.566	23.114	1139.58	1099.44	40.14	96.48

Table 4. Efficiency Data 60-V Input, 48-V Output

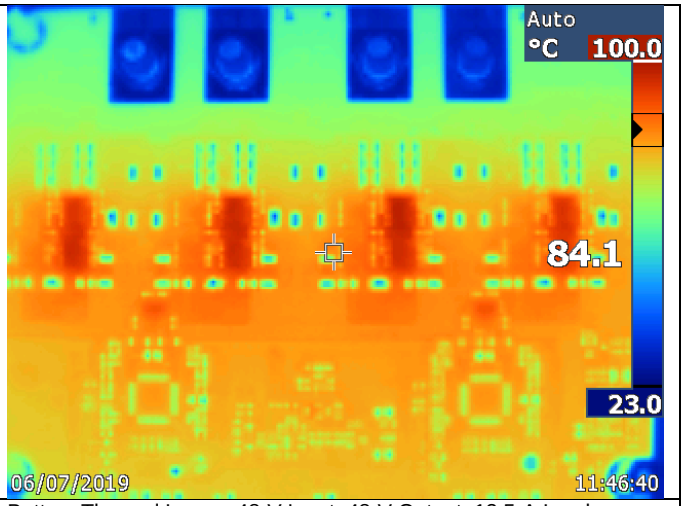
V_{IN}	I_{IN}	V_{OUT}	I_{OUT}	P_{IN}	P_{OUT}	Losses	Efficiency
60.001	0.274	47.552	0.000	16.44	0.00	16.82	0.00
60.001	1.880	47.551	2.006	112.80	95.39	17.42	84.56
60.001	3.484	47.550	4.004	209.04	190.39	18.65	91.08
60.001	5.096	47.549	6.002	305.77	285.39	20.38	93.34
60.001	6.722	47.549	8.002	403.33	380.48	22.84	94.34
60.001	8.356	47.548	10.002	501.37	475.58	25.79	94.86
60.001	10.002	47.547	12.000	600.13	570.56	29.57	95.07
60.001	11.644	47.546	13.998	698.65	665.55	33.10	95.26
60.001	13.258	47.545	16.000	795.50	760.72	34.77	95.63
60.001	14.876	47.544	17.998	892.58	855.70	36.88	95.87
60.001	16.552	47.543	20.070	993.14	954.19	38.95	96.08
60.001	18.170	47.542	22.068	1090.22	1049.16	41.06	96.23
60.001	19.030	47.542	23.126	1141.82	1099.45	42.37	96.29

Thermal Images

Figures show thermal performance for 4-phase operation at 48-V input and 48-V output at 12.5-A load with no airflow. The images were taken with the board at thermal equilibrium.



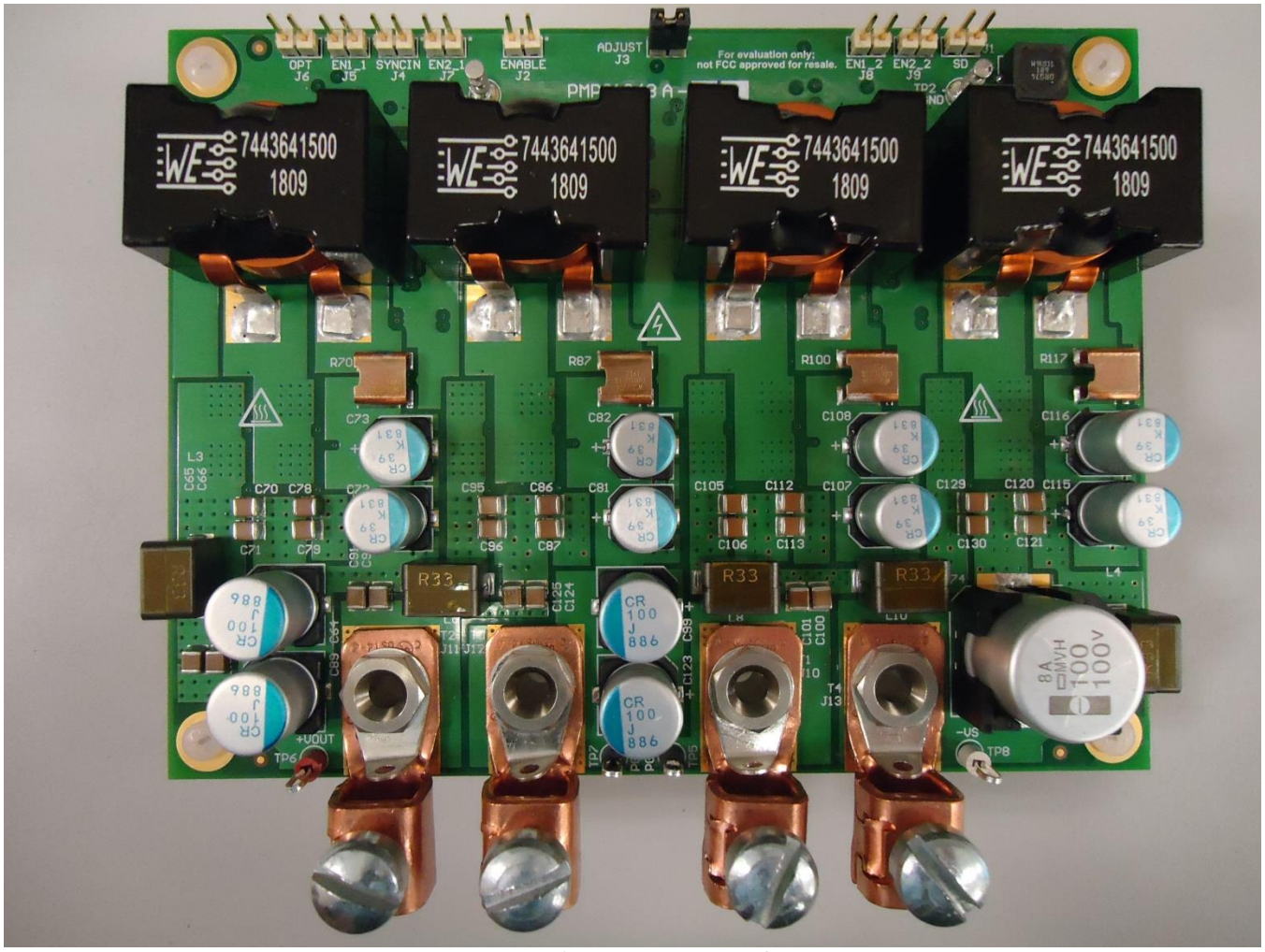
Top Thermal Image, 48-V Input, 48-V Output, 12.5-A Load



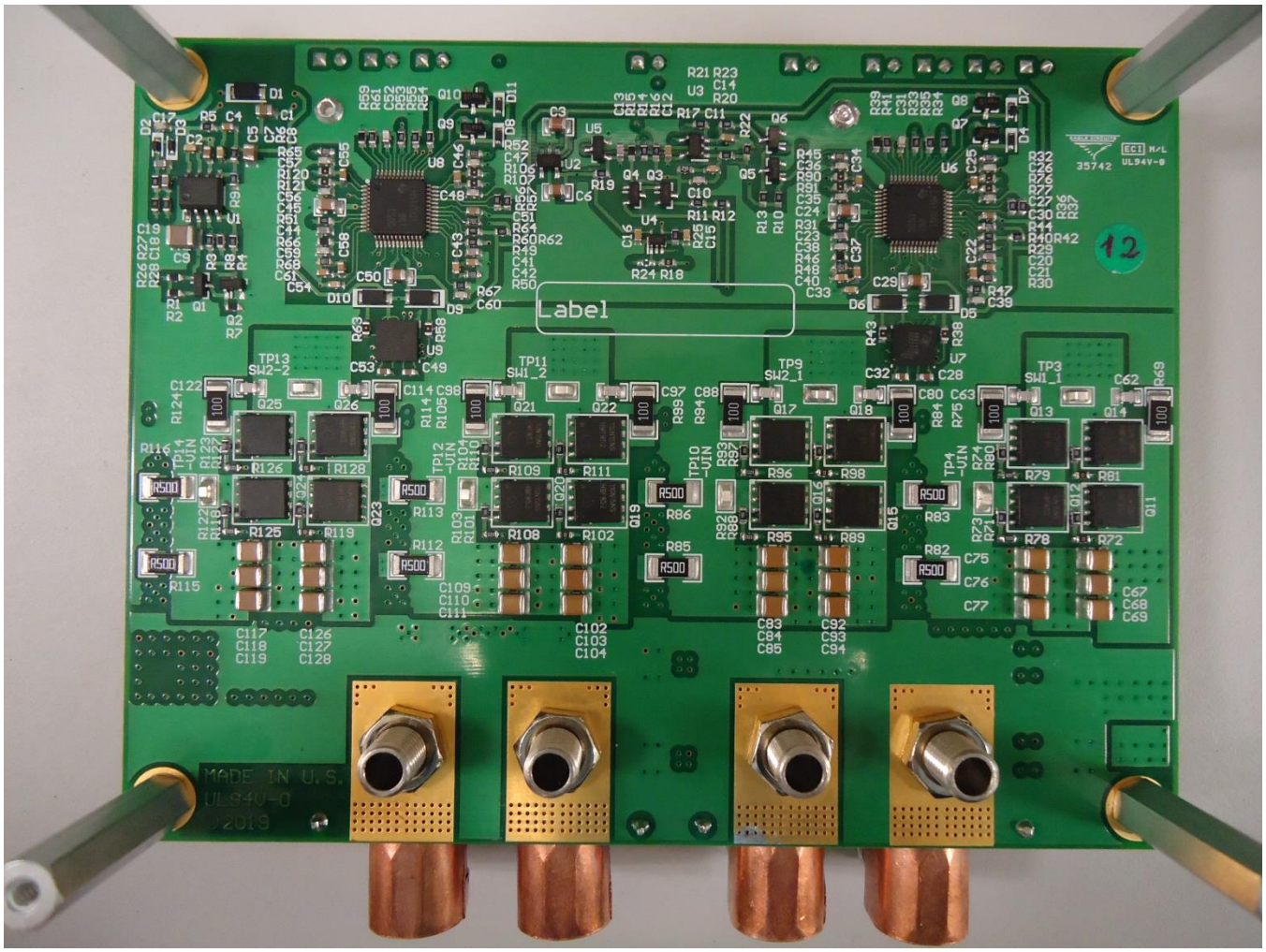
Bottom Thermal Image, 48-V Input, 48-V Output, 12.5-A Load

2.3 Dimensions

The design was built on PMP21943 Rev A printed circuit board. This is an 8-layer PCB with 2 oz. copper on all layers. Board dimensions are 5.1 in. x 3.9 in.



Top of PMP21943 Board

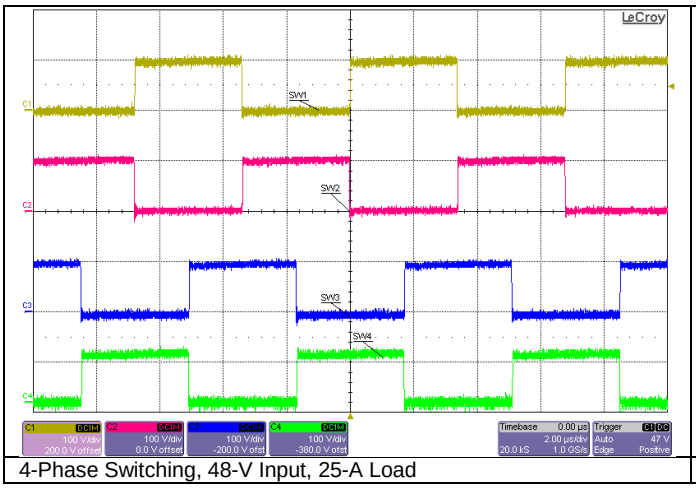


Bottom of PMP21943 Board

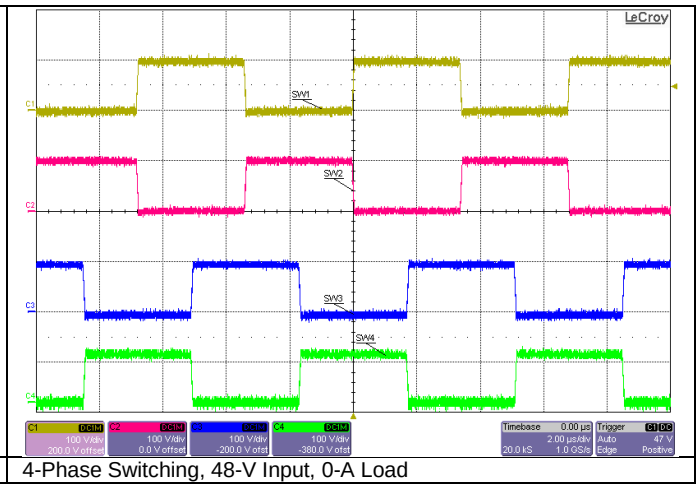
3 Waveforms

3.1 Switching

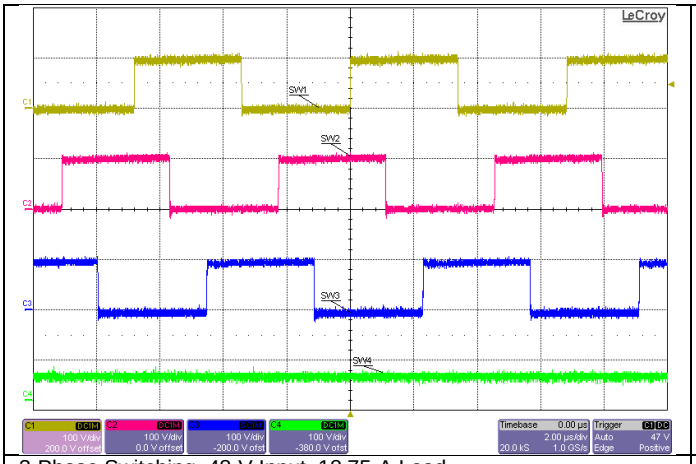
Figures show the switch node voltages of the converter.



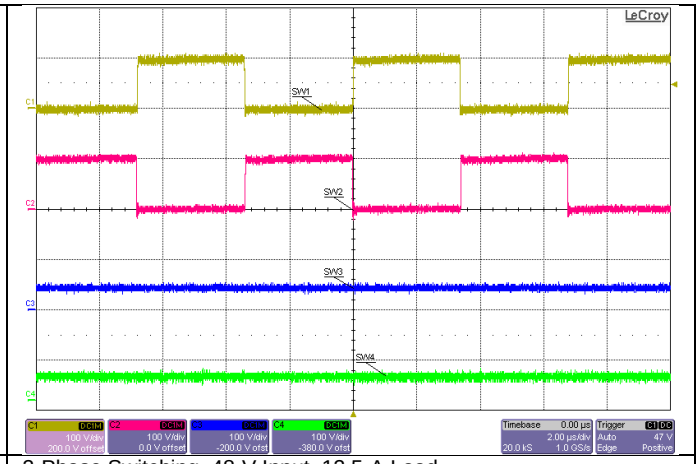
4-Phase Switching, 48-V Input, 25-A Load



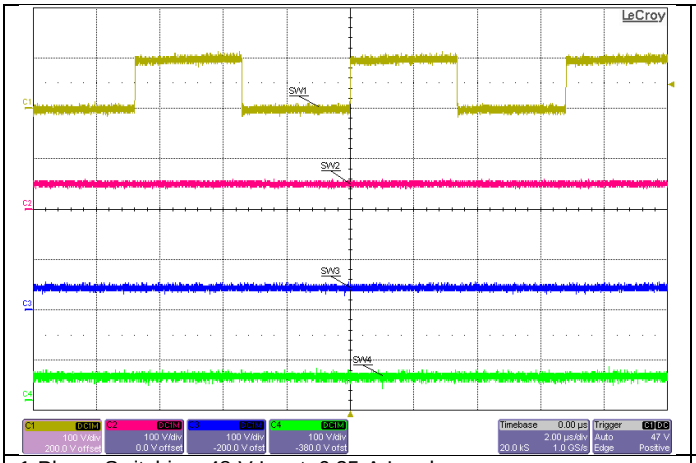
4-Phase Switching, 48-V Input, 0-A Load



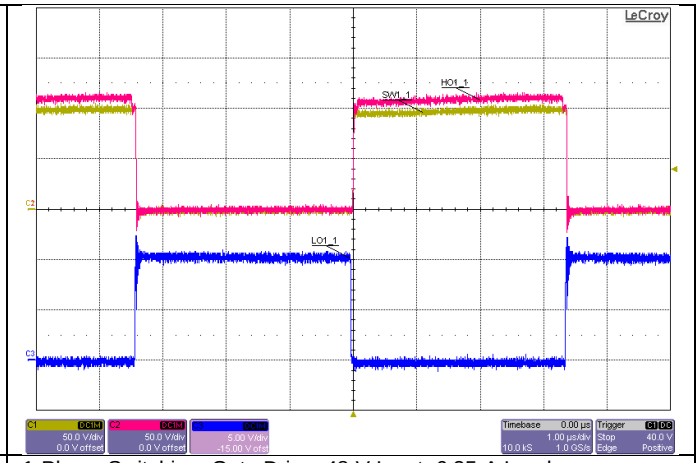
3-Phase Switching, 48-V Input, 18.75-A Load



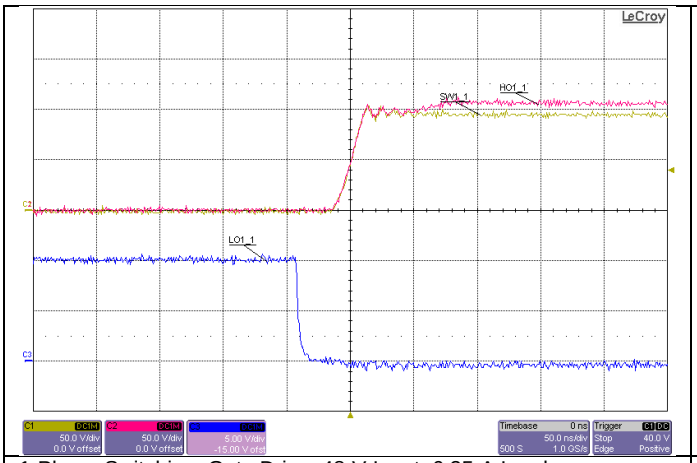
2-Phase Switching, 48-V Input, 12.5-A Load



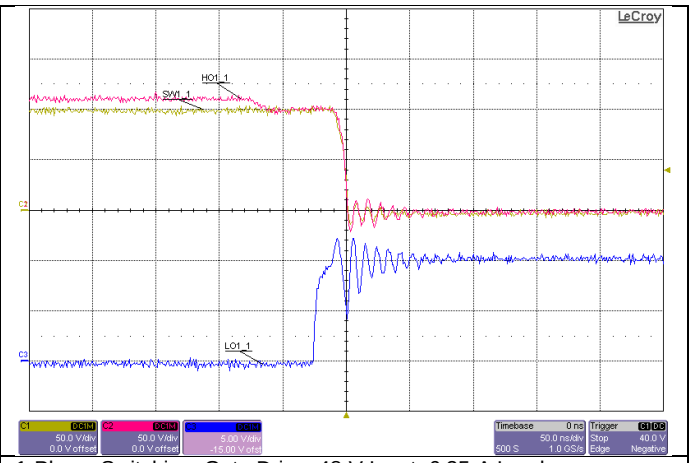
1-Phase Switching, 48-V Input, 6.25-A Load



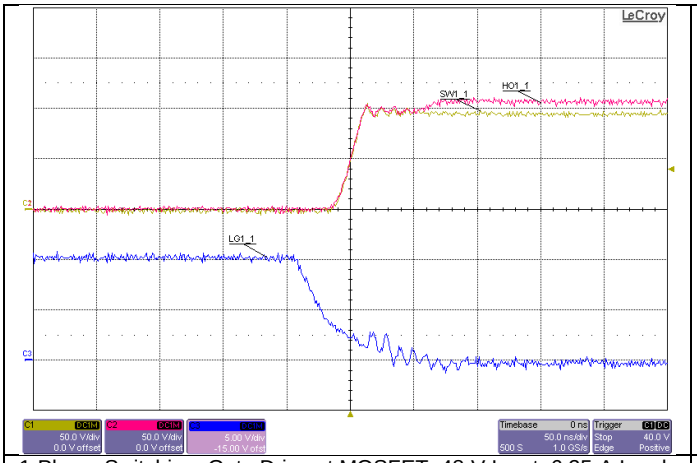
1-Phase Switching, Gate Drive, 48-V Input, 6.25-A Load



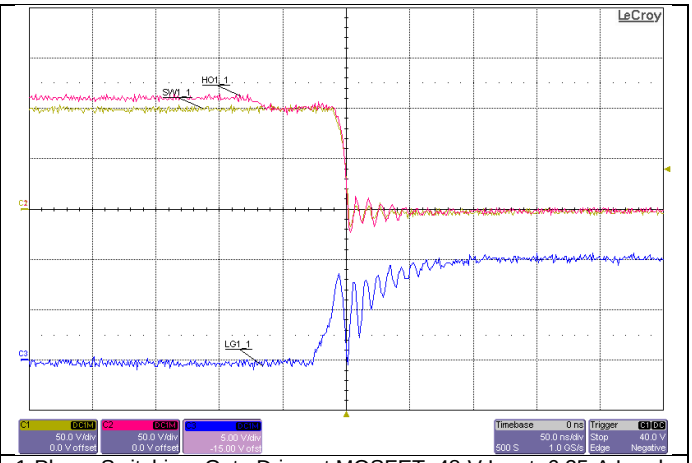
1-Phase Switching, Gate Drive, 48-V Input, 6.25-A Load



1-Phase Switching, Gate Drive, 48-V Input, 6.25-A Load



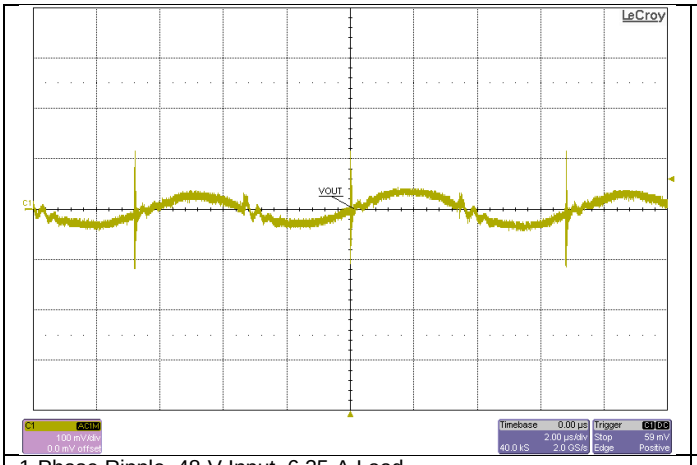
1-Phase Switching, Gate Drive at MOSFET, 48-V Input, 6.25-A Load



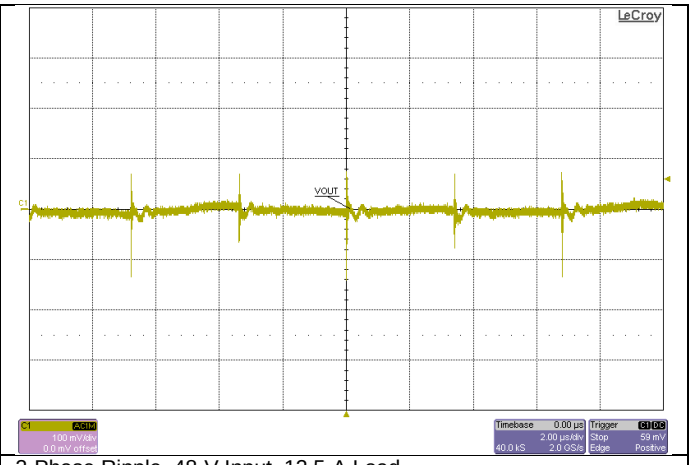
1-Phase Switching, Gate Drive at MOSFET, 48-V Input, 6.25-A Load

3.2 Output Voltage Ripple

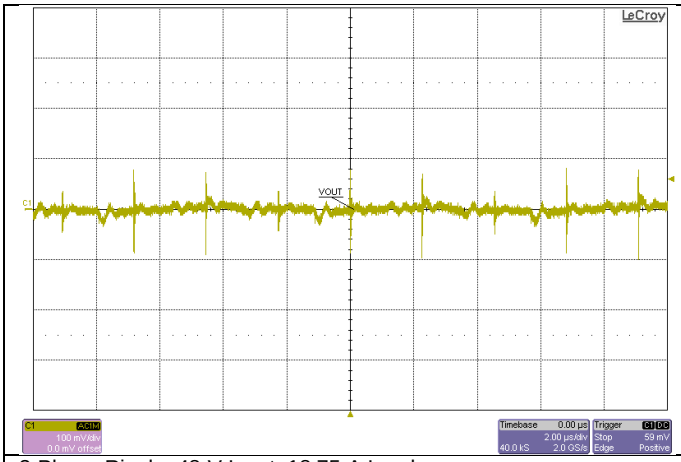
Figures show the output voltage ripple of the converter.



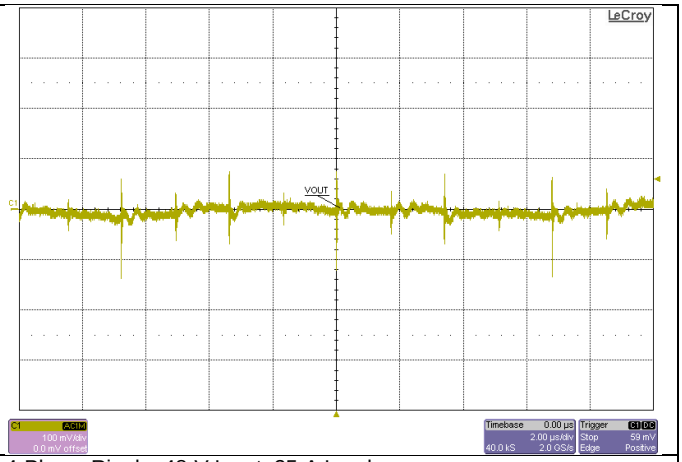
1-Phase Ripple, 48-V Input, 6.25-A Load



2-Phase Ripple, 48-V Input, 12.5-A Load



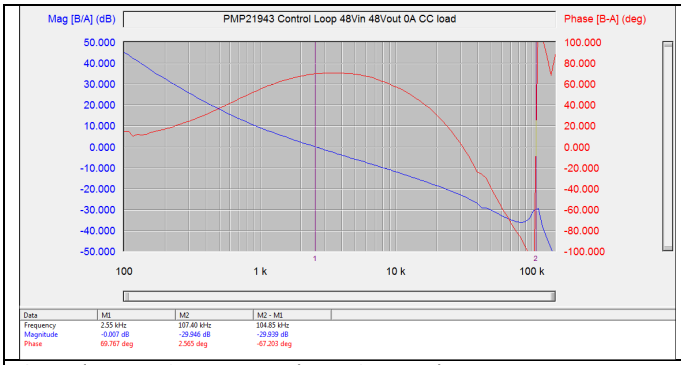
3-Phase Ripple, 48-V Input, 18.75-A Load



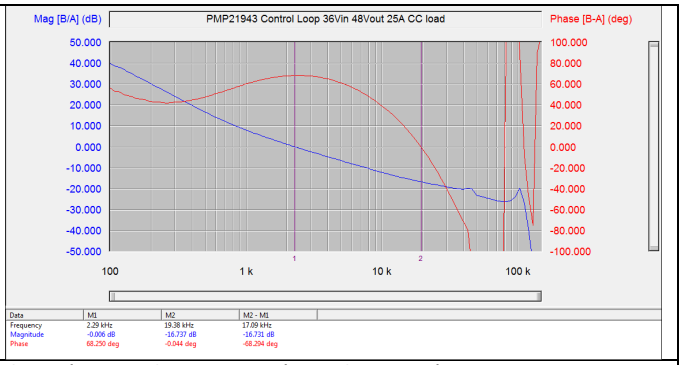
4-Phase Ripple, 48-V Input, 25-A Load

3.3 Bode Plots

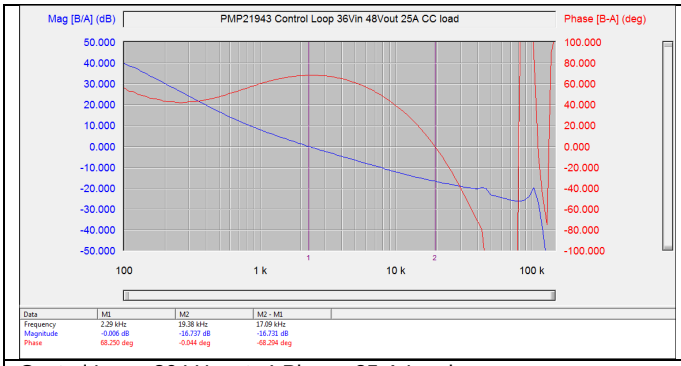
Figures show Bode plots of the control loop with a constant current load.



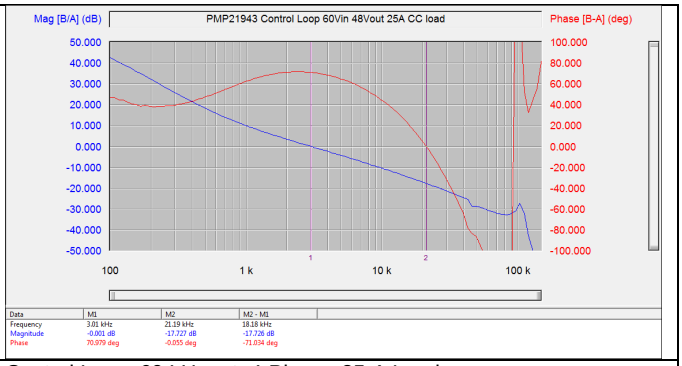
Control Loop, 48-V Input, 4-Phase, 0-A Load



Control Loop, 48-V Input, 4-Phase, 25-A Load



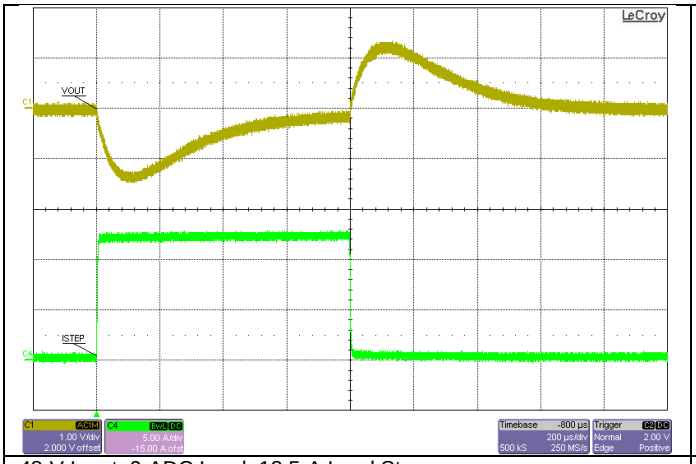
Control Loop, 36-V Input, 4-Phase, 25-A Load



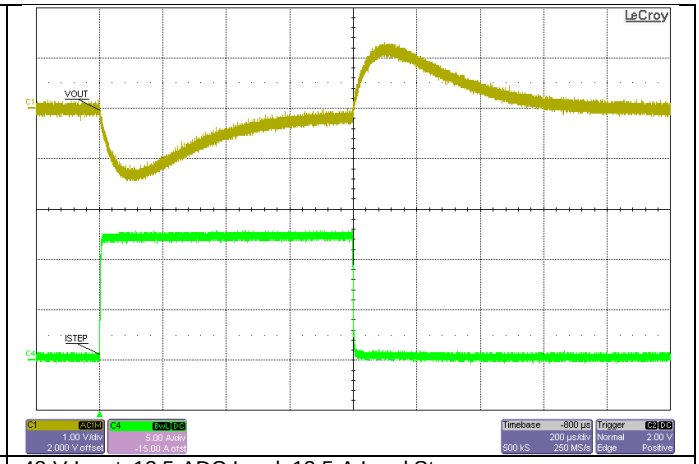
Control Loop, 60-V Input, 4-Phase, 25-A Load

Load Transients

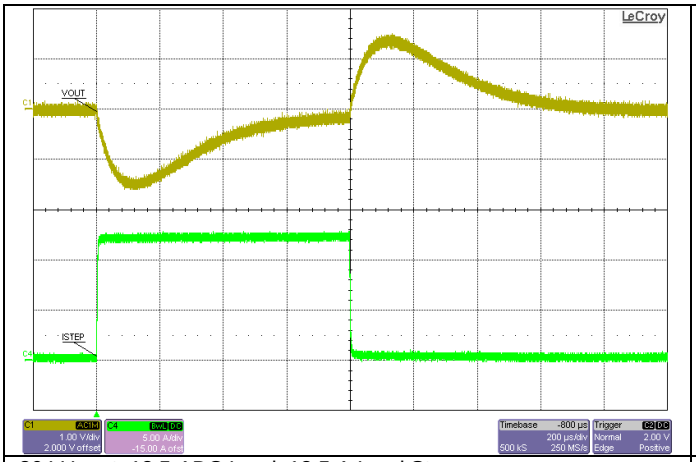
Figures show the load transient response of the converter for a 50% load step.



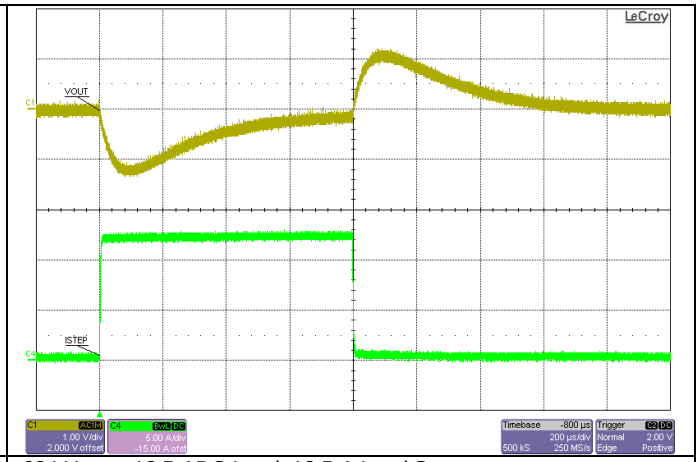
48-V Input, 0-ADC Load, 12.5-A Load Step



48-V Input, 12.5-ADC Load, 12.5-A Load Step



36-V Input, 12.5-ADC Load, 12.5-A Load Step



60-V Input, 12.5-ADC Load, 12.5-A Load Step

3.4 Current Sharing

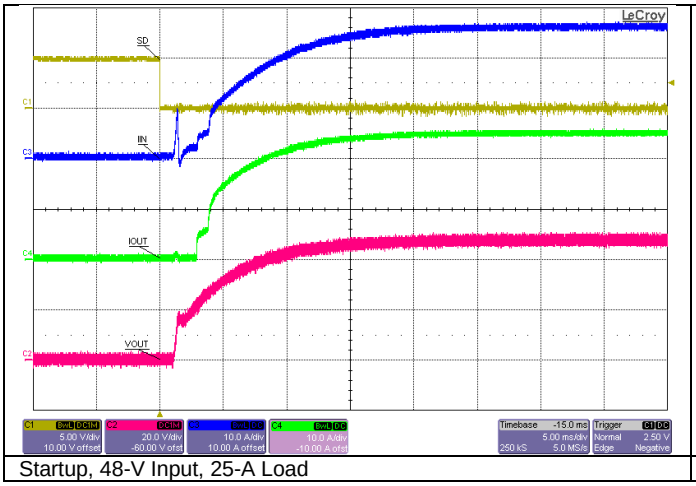
Table 5 shows the current sharing by measuring the current sense shunt voltages, where 1 mV = 1 A.

Table 5. Current Sharing at 48-V Input, 48-V Output

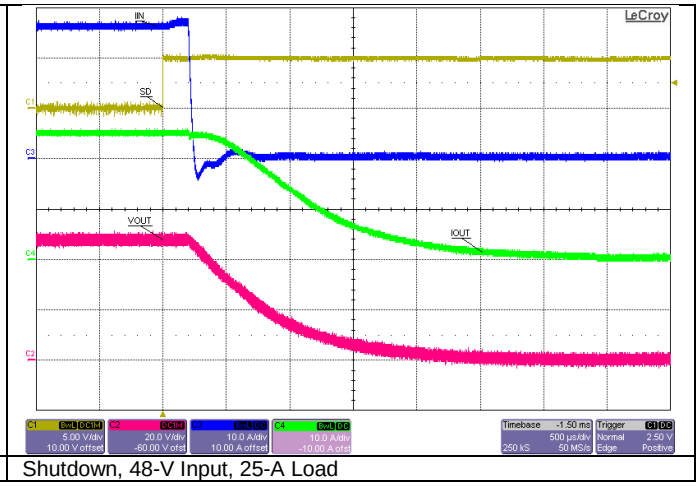
I_{LOAD}	I_{PH1}	I_{PH2}	I_{PH3}	I_{PH4}
0	0.295	0.053	-0.072	-0.067
6.25	3.743	3.450	3.569	3.427
12.5	7.176	6.967	7.175	6.870
25	14.040	14.033	14.080	13.919

3.5 Startup and Shutdown

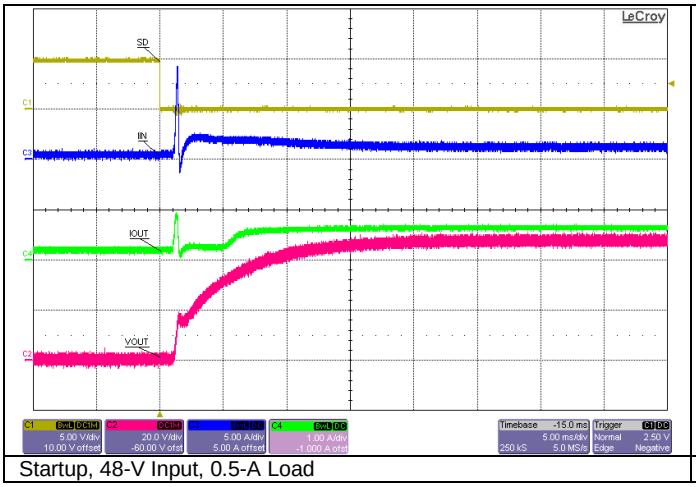
Figures show the startup and shutdown of the converter from the shutdown control.



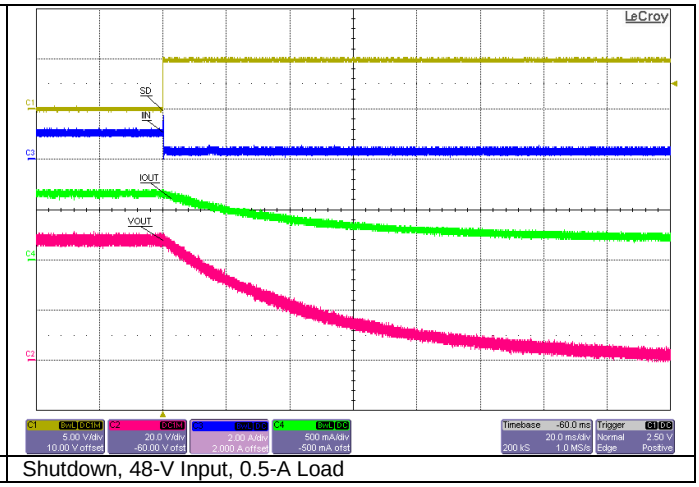
Startup, 48-V Input, 25-A Load



Shutdown, 48-V Input, 25-A Load



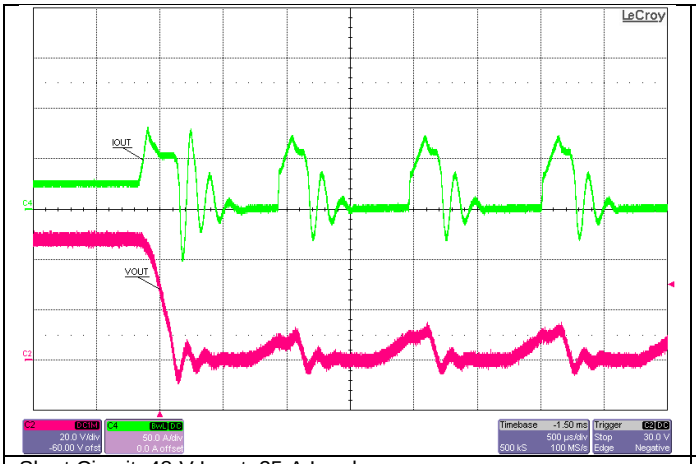
Startup, 48-V Input, 0.5-A Load



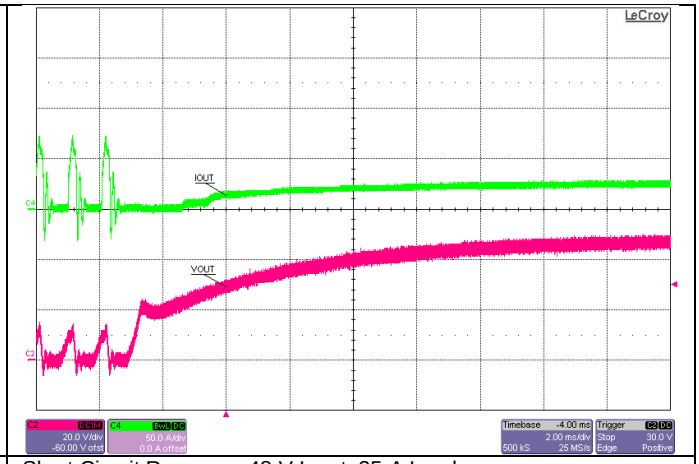
Shutdown, 48-V Input, 0.5-A Load

3.6 Short Circuit Protection

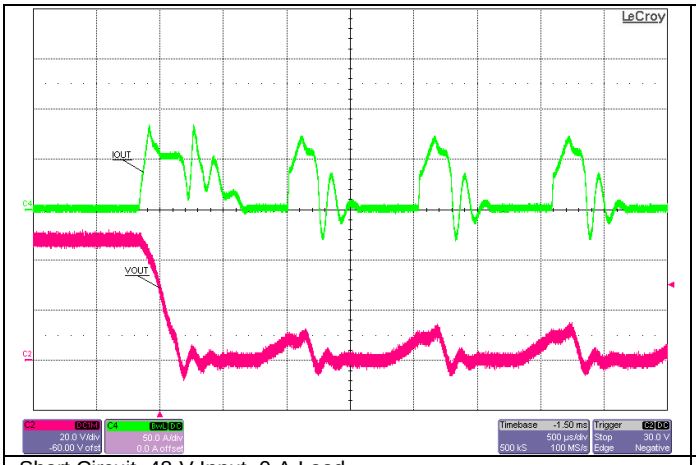
Figures show the output short circuit protection and recovery of the converter for a 48-V input.



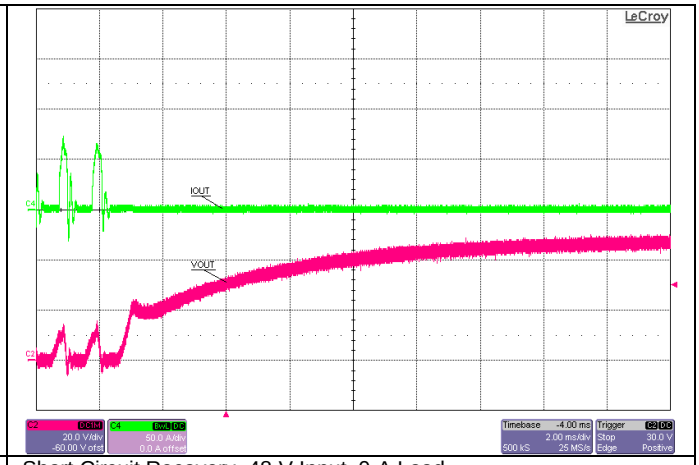
Short Circuit, 48-V Input, 25-A Load



Short Circuit Recovery, 48-V Input, 25-A Load



Short Circuit, 48-V Input, 0-A Load



Short Circuit Recovery, 48-V Input, 0-A Load

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