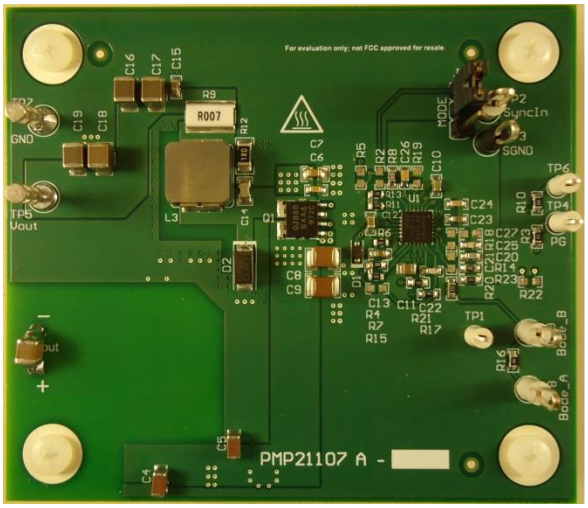
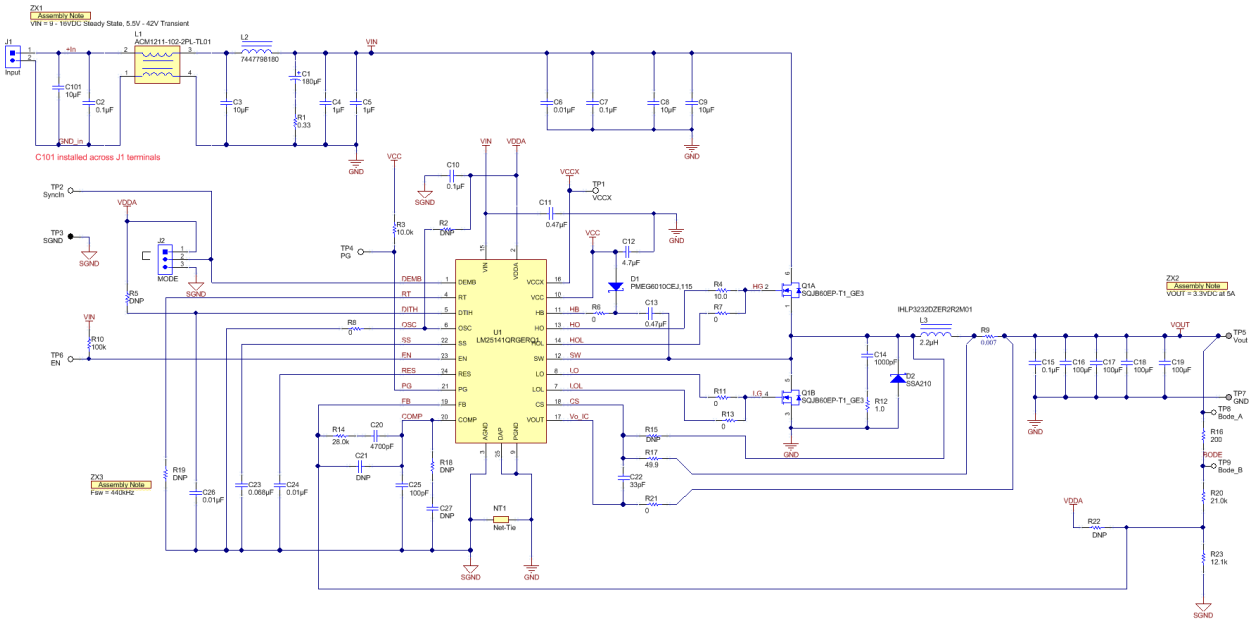
Test Report: PMP21107

Wide input synchronous buck converter reference design with frequency spread spectrum

Description

This reference design is a synchronous buck converter for automotive applications utilizing a synchronous buck controller with frequency spread spectrum. The design uses a dual MOSFET in power SO-8 package. Forced pulse width modulation (FPWM) or diode emulation mode (DEMB) is jumper selectable. Features include an enable input and power good flag. The switching frequency is set to 440 kHz. Frequency dithering and input filtering help improve EMI performance. Modified frequency compensation supports the use of all ceramic output capacitors.





1 Test Prerequisites

1.1 Voltage and Current Requirements

Table 1. Voltage and Current Requirements

PARAMETER	SPECIFICATIONS
Input Voltage	5.5 V – 42 V
Output Voltage	3.3 V
Output Current	5 A

1.2 Required Equipment

- DC power supply
- Electronic load
- Oscilloscope

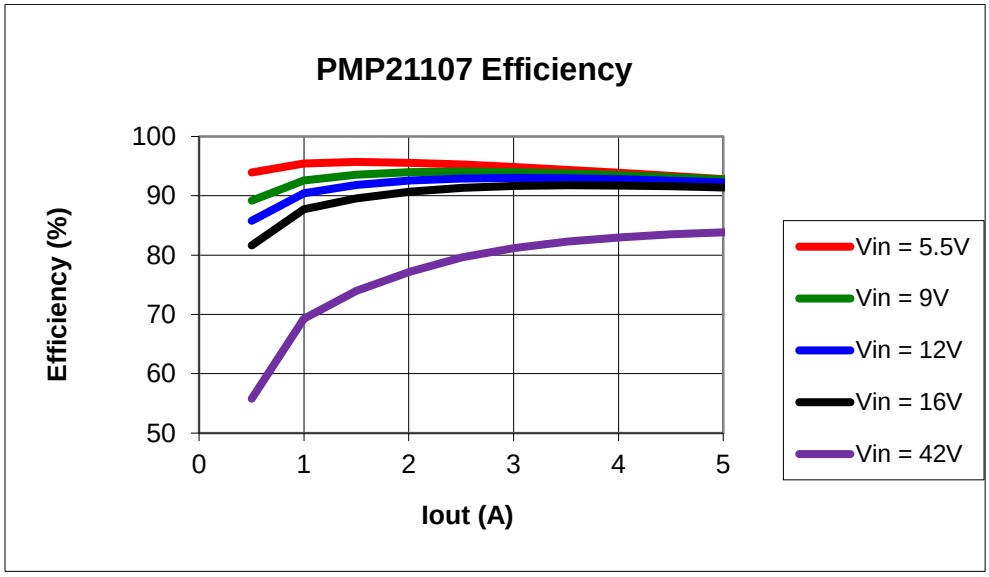
1.3 Considerations

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

2 Testing and Results

2.1 Efficiency Graphs

Figure shows the converter efficiency with 5.5-V, 9-V, 12-V, 16-V and 42-V inputs.



2.2 Efficiency Data

Table 2, Table 3, Table 4, Table 5, and Table 6 shows the efficiency data with 5.5-V, 9-V, 12-V, 16-V, and 42-V inputs.

Table 2. Efficiency Data 5.5-V Input

V_{IN}	I_{IN}	V_{OUT}	I_{OUT}	P_{IN}	P_{OUT}	Losses	Efficiency
5.5008	0.0154	3.3069	0.0000	0.085	0.000	0.085	0.00
5.5007	0.3199	3.3066	0.5000	1.760	1.653	0.106	93.96
5.5007	0.6295	3.3066	0.9995	3.463	3.305	0.158	95.44
5.5007	0.9413	3.3068	1.4988	5.178	4.956	0.222	95.72
5.5006	1.2669	3.3067	2.0141	6.969	6.660	0.309	95.57
5.5003	1.5859	3.3064	2.5134	8.723	8.310	0.413	95.27
5.5005	1.9090	3.3062	3.0125	10.501	9.960	0.541	94.85
5.5003	2.2365	3.3060	3.5121	12.301	11.611	0.690	94.39
5.5004	2.5688	3.3058	4.0123	14.129	13.264	0.866	93.87
5.5003	2.9049	3.3056	4.5120	15.978	14.915	1.063	93.35
5.5003	3.2452	3.3054	5.0114	17.849	16.565	1.285	92.80

Table 3. Efficiency Data 9-V Input

V_{IN}	I_{IN}	V_{OUT}	I_{OUT}	P_{IN}	P_{OUT}	Losses	Efficiency
9.0053	0.0196	3.3071	0.0000	0.177	0.000	0.177	0.00
9.0054	0.2058	3.3068	0.5000	1.853	1.653	0.200	89.21
9.0053	0.3964	3.3068	0.9995	3.570	3.305	0.265	92.59
9.0053	0.5884	3.3069	1.4989	5.299	4.957	0.342	93.55
9.0053	0.7863	3.3068	2.0131	7.081	6.657	0.424	94.01
9.0052	0.9803	3.3065	2.5121	8.828	8.306	0.521	94.09
9.0051	1.1763	3.3063	3.0114	10.593	9.957	0.636	93.99
9.0051	1.3745	3.3060	3.5108	12.378	11.607	0.771	93.77
9.0050	1.5752	3.3057	4.0113	14.185	13.260	0.924	93.48
9.0052	1.7778	3.3055	4.5112	16.009	14.912	1.098	93.14
9.0051	1.9825	3.3054	5.0104	17.853	16.561	1.291	92.77

Table 4. Efficiency Data 12-V Input

V_{IN}	I_{IN}	V_{OUT}	I_{OUT}	P_{IN}	P_{OUT}	Losses	Efficiency
12.0056	0.0203	3.3075	0.0001	0.244	0.000	0.243	0.14
12.0054	0.1605	3.3072	0.5000	1.927	1.654	0.273	85.82
12.0050	0.3044	3.3069	0.9996	3.654	3.306	0.349	90.46
12.0050	0.4497	3.3072	1.4989	5.399	4.957	0.441	91.82
12.0052	0.5986	3.3071	2.0125	7.186	6.655	0.531	92.61
12.0053	0.7444	3.3068	2.5115	8.937	8.305	0.632	92.93
12.0048	0.8914	3.3065	3.0108	10.701	9.955	0.746	93.03
12.0053	1.0401	3.3061	3.5104	12.487	11.606	0.881	92.95
12.0050	1.1905	3.3058	4.0111	14.292	13.260	1.032	92.78
12.0049	1.3422	3.3056	4.5109	16.113	14.911	1.202	92.54
12.0049	1.4954	3.3052	5.0104	17.952	16.560	1.392	92.25

Table 5. Efficiency Data 16-V Input

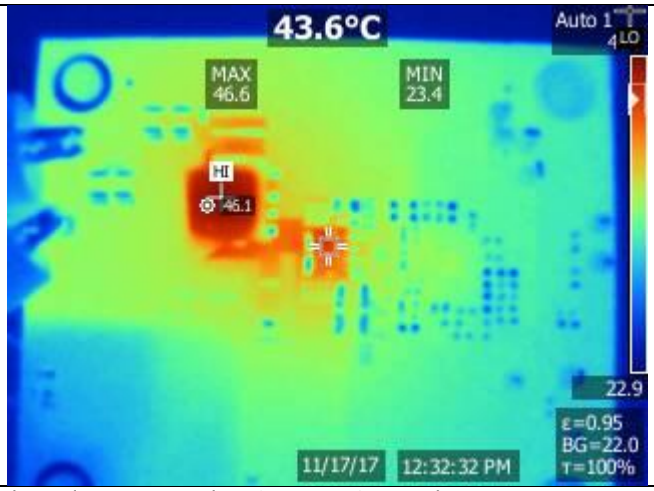
V_{IN}	I_{IN}	V_{OUT}	I_{OUT}	P_{IN}	P_{OUT}	Losses	Efficiency
16.0045	0.0206	3.3080	0.0001	0.330	0.000	0.329	0.10
16.0042	0.1266	3.3076	0.5001	2.026	1.654	0.372	81.64
16.0042	0.2355	3.3073	0.9996	3.769	3.306	0.463	87.71
16.0042	0.3459	3.3074	1.4990	5.536	4.958	0.578	89.56
16.0041	0.4584	3.3076	2.0122	7.336	6.655	0.681	90.72
16.0041	0.5681	3.3074	2.5113	9.092	8.306	0.786	91.35
16.0042	0.6787	3.3070	3.0107	10.862	9.957	0.906	91.66
16.0042	0.7904	3.3067	3.5105	12.650	11.608	1.041	91.77
16.0040	0.9033	3.3064	4.0109	14.456	13.262	1.195	91.73
16.0040	1.0172	3.3061	4.5108	16.279	14.913	1.366	91.61
16.0040	1.1321	3.3058	5.0101	18.118	16.562	1.556	91.41

Table 6. Efficiency Data 42-V Input

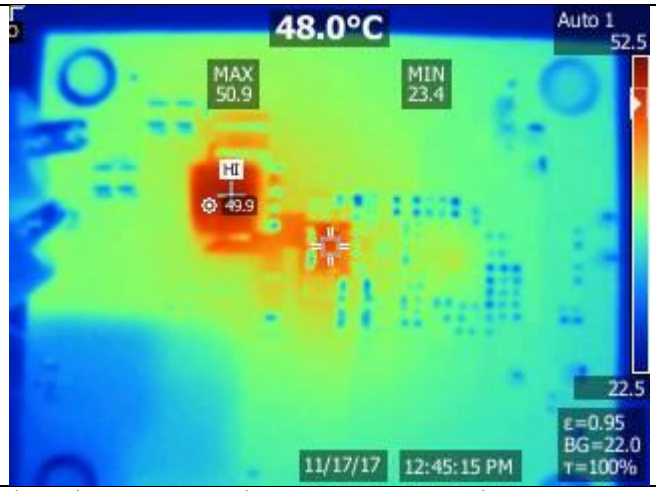
V_{IN}	I_{IN}	V_{OUT}	I_{OUT}	P_{IN}	P_{OUT}	Losses	Efficiency
42.0098	0.0318	3.3095	0.0002	1.336	0.001	1.335	0.05
42.0094	0.0706	3.3100	0.5001	2.966	1.655	1.311	55.81
42.0096	0.1137	3.3098	0.9996	4.776	3.309	1.468	69.27
42.0096	0.1597	3.3096	1.4990	6.709	4.961	1.748	73.95
42.0097	0.2052	3.3091	2.0120	8.620	6.658	1.962	77.23
42.0097	0.2484	3.3090	2.5113	10.435	8.310	2.125	79.63
42.0097	0.2920	3.3095	3.0107	12.267	9.964	2.303	81.23
42.0098	0.3360	3.3094	3.5104	14.115	11.617	2.498	82.30
42.0100	0.3808	3.3093	4.0108	15.997	13.273	2.725	82.97
42.0100	0.4255	3.3090	4.5105	17.875	14.925	2.950	83.50
42.0097	0.4706	3.3088	5.0096	19.770	16.576	3.194	83.84

2.3 Thermal Images

Figures show thermal performance at 9-V input and 16-V input with 3-A load and no airflow. The images were taken with the board at thermal equilibrium.



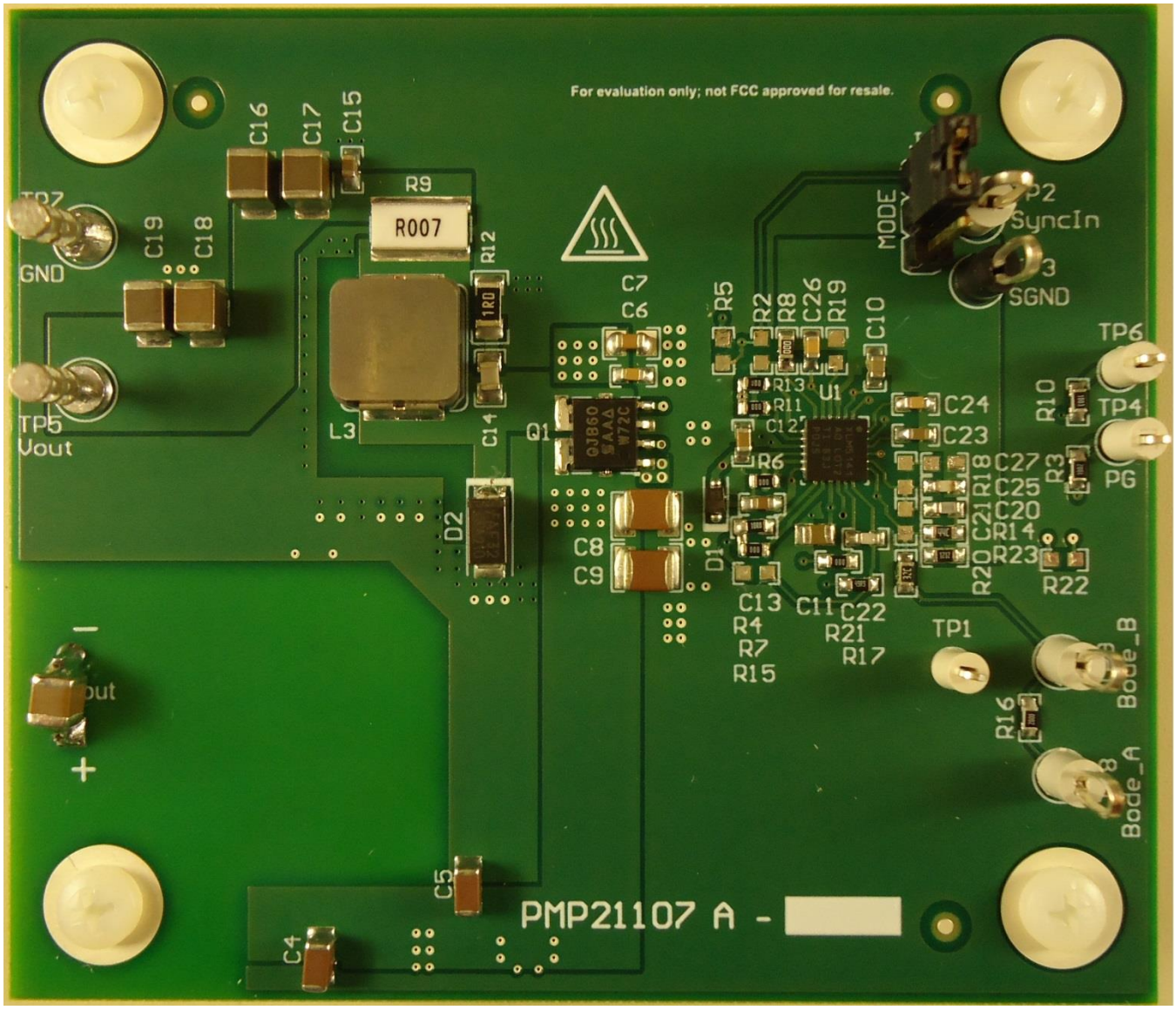
Thermal Image, Top View, 9-V Input, 3-A Load



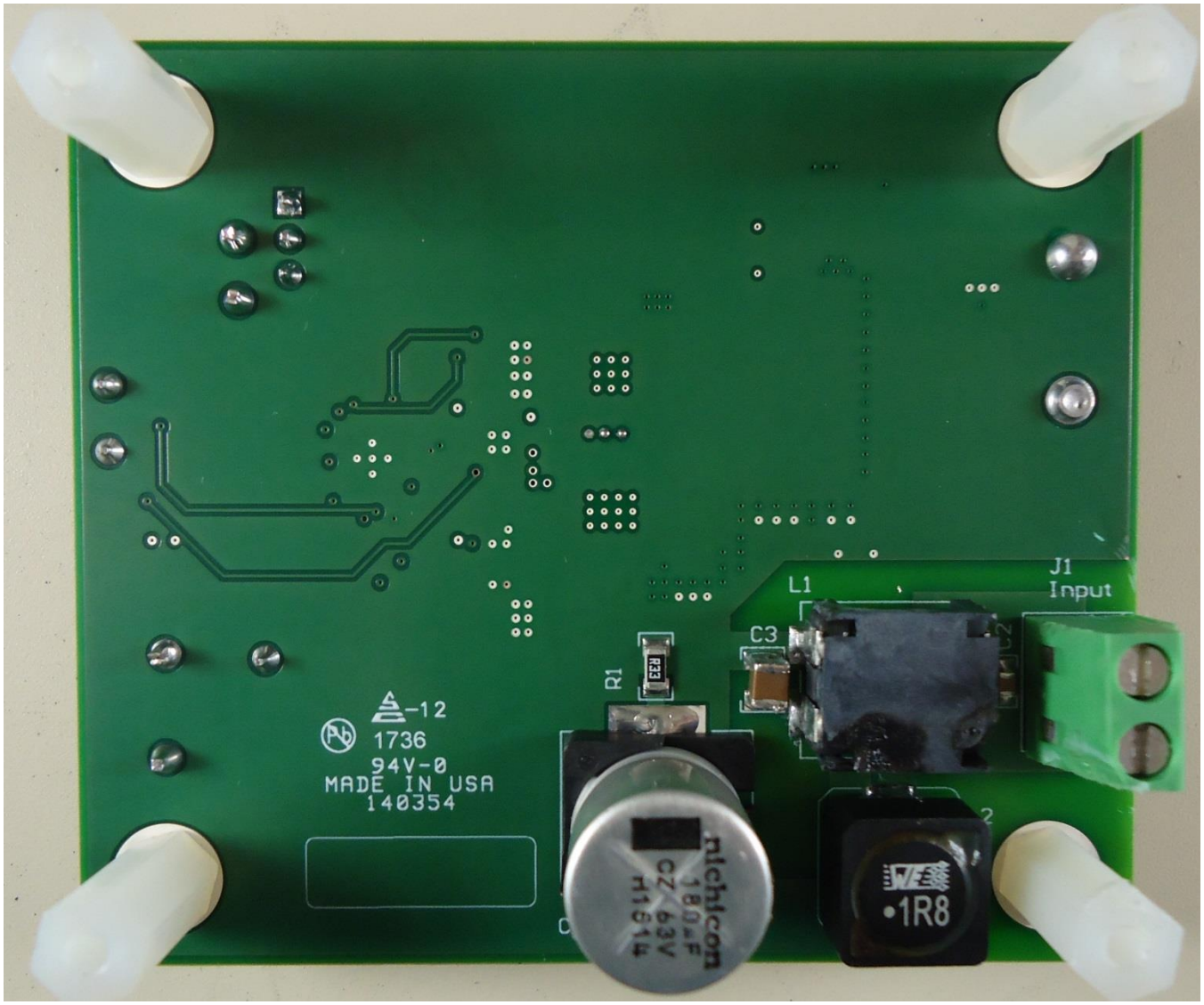
Thermal Image, Bottom View, 16-V Input, 3-A Load

2.4 Dimensions

The photographs below show the PMP21107 Rev A printed circuit board assembly. This is a 4-layer PCB with 2 oz. copper on external layers, 1 oz. copper on internal layers. Board dimensions are 3.0 in. x 2.3 in.



Top of PMP21107 Board

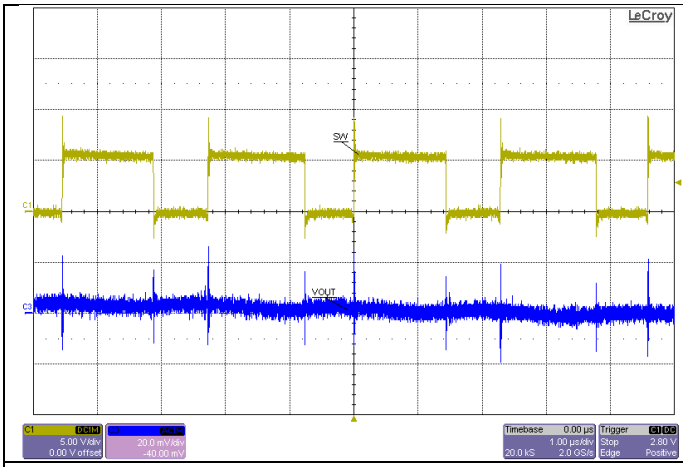


Bottom of PMP21107 Board

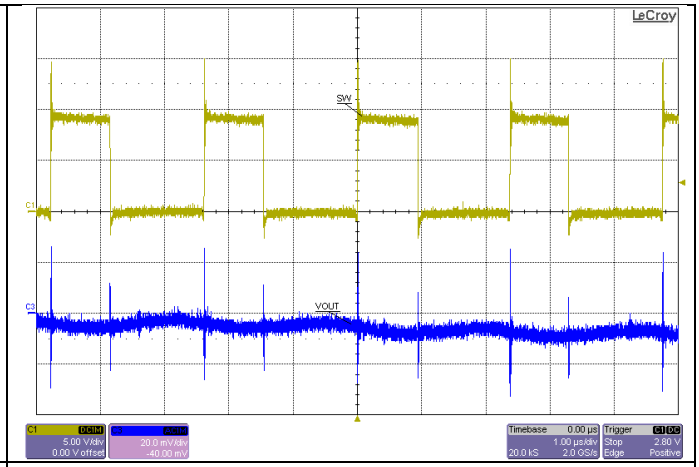
3 Waveforms

3.1 Switching and Output Voltage Ripple

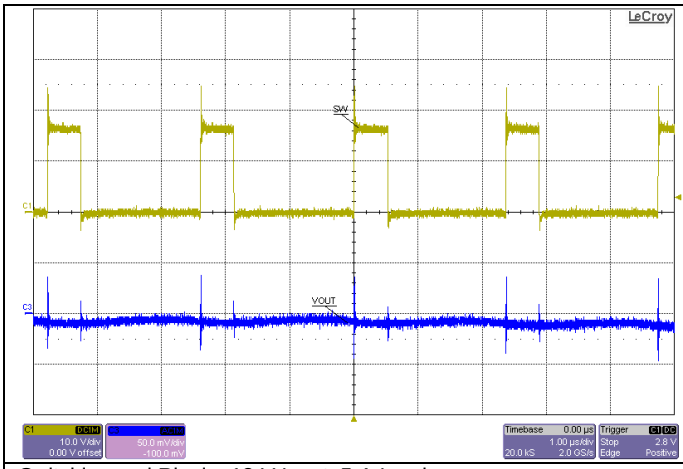
Figures show the switch node voltage and output voltage ripple of the converter. Switching was measured at full bandwidth using 500 MHz probes and 350 MHz oscilloscope.



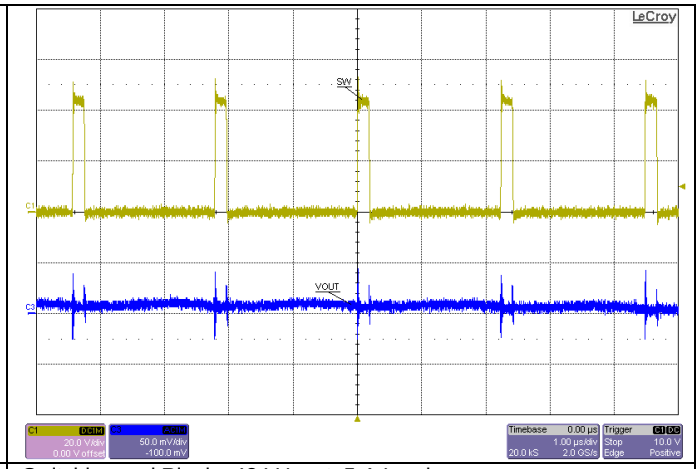
Switching and Ripple, 5.5-V Input, 5-A Load



Switching and Ripple, 9-V Input, 5-A Load



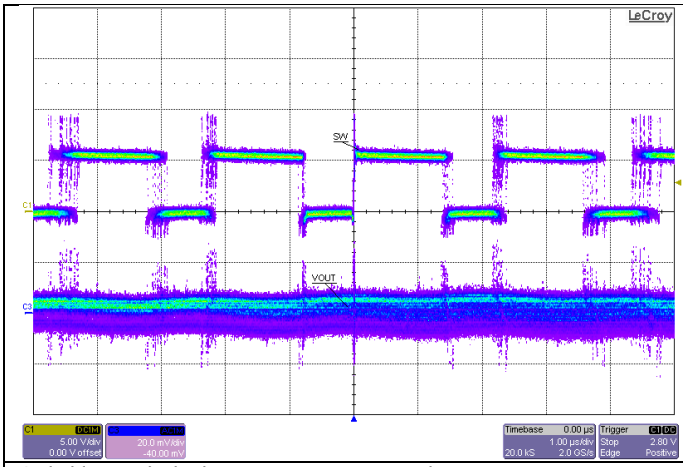
Switching and Ripple, 12-V Input, 5-A Load



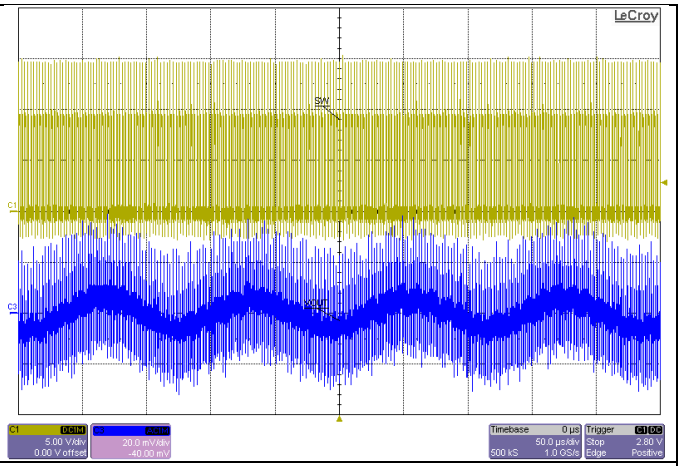
Switching and Ripple, 42-V Input, 5-A Load

3.2 Switching and Output Voltage Ripple with Dither

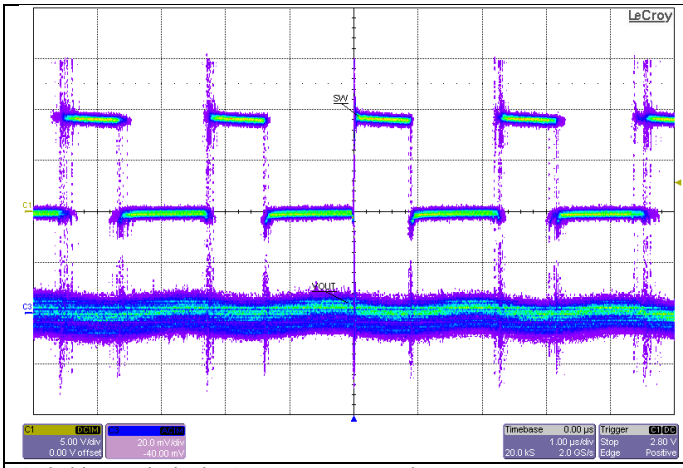
Figures show the switch node voltage and output voltage ripple of the converter. Switching was measured at full bandwidth using 500 MHz probes and 350 MHz oscilloscope.



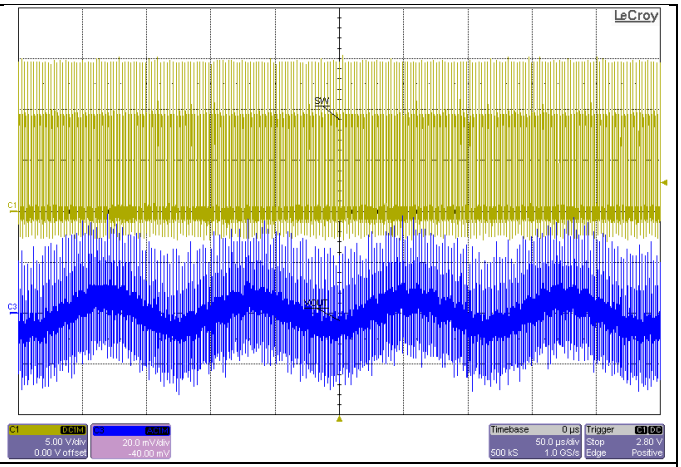
Switching and Ripple, 5.5-V Input, 5-A Load



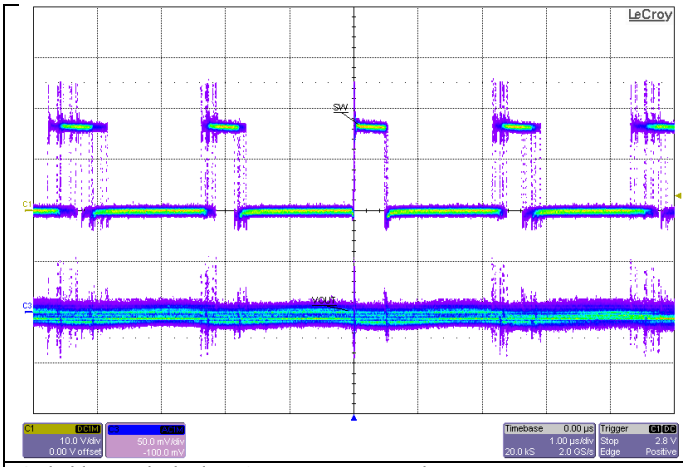
Switching and Ripple, 5.5-V Input, 5-A Load



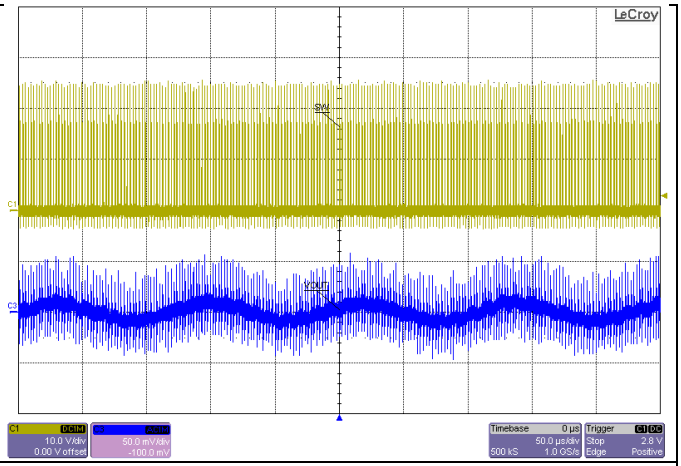
Switching and Ripple, 9-V Input, 5-A Load



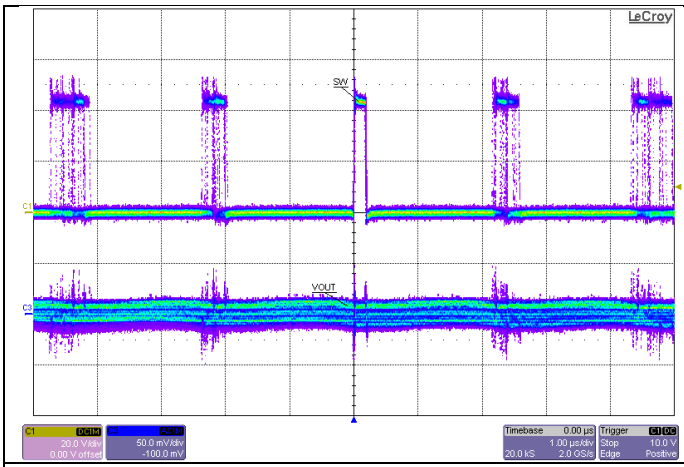
Switching and Ripple, 9-V Input, 5-A Load



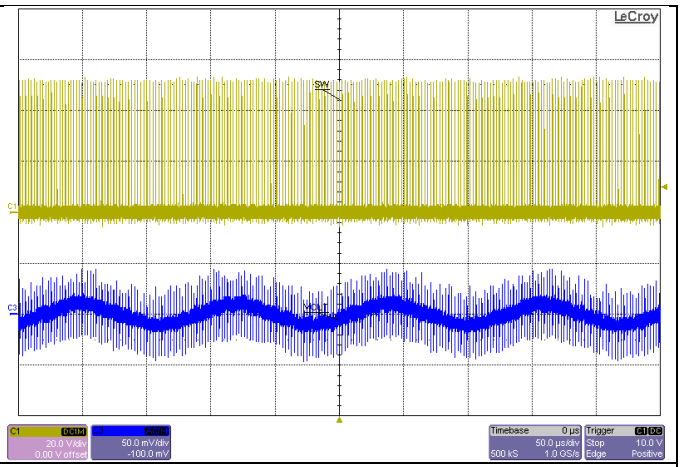
Switching and Ripple, 16-V Input, 5-A Load



Switching and Ripple, 16-V Input, 5-A Load



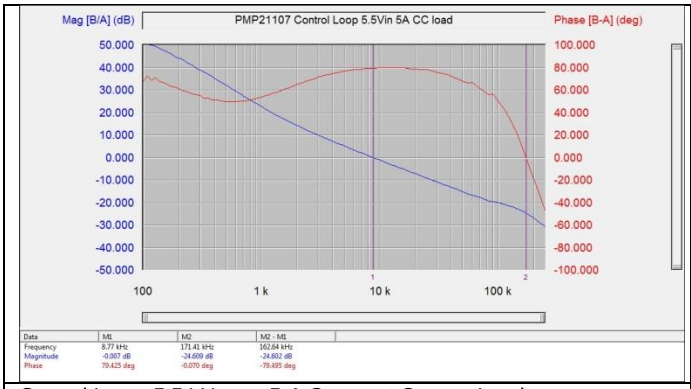
Switching and Ripple, 42-V Input, 5-A Load



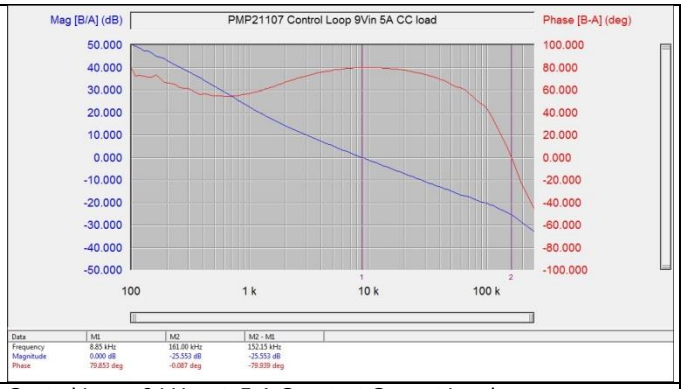
Switching and Ripple, 42-V Input, 5-A Load

3.3 Bode Plots

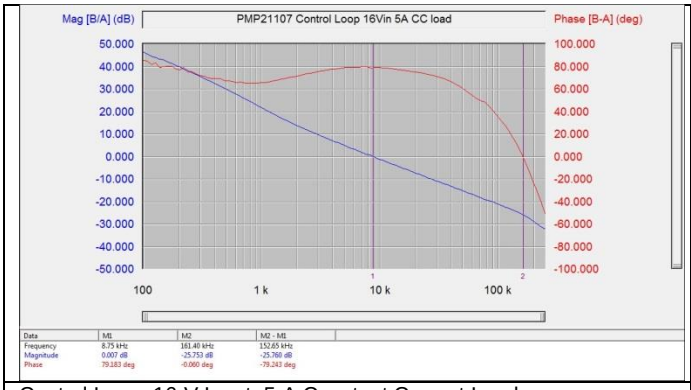
Figures show Bode plots of the control loop at 5-A constant current load.



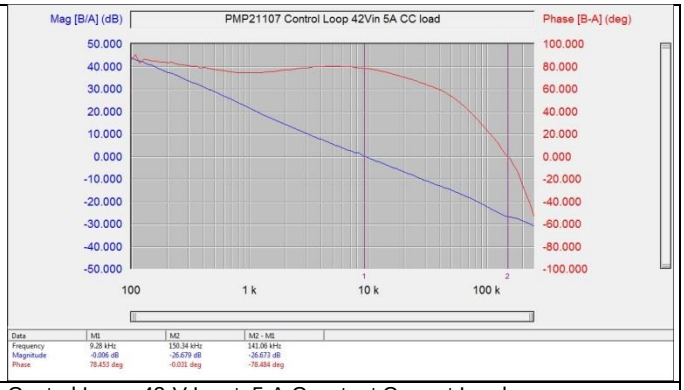
Control Loop, 5.5-V Input, 5-A Constant Current Load



Control Loop, 9-V Input, 5-A Constant Current Load



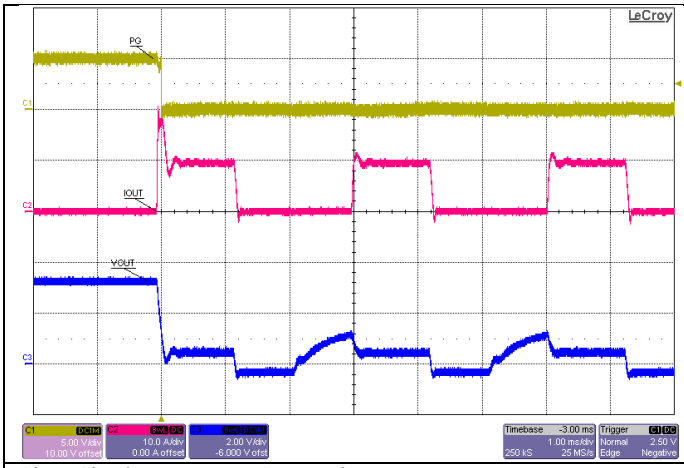
Control Loop, 16-V Input, 5-A Constant Current Load



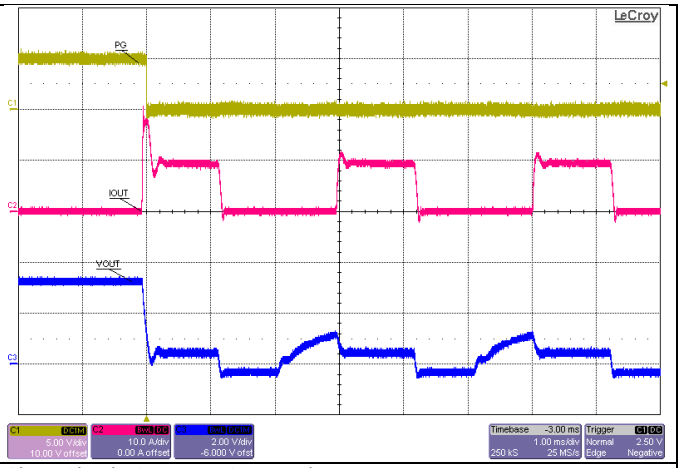
Control Loop, 42-V Input, 5-A Constant Current Load

3.4 Output Short Circuit

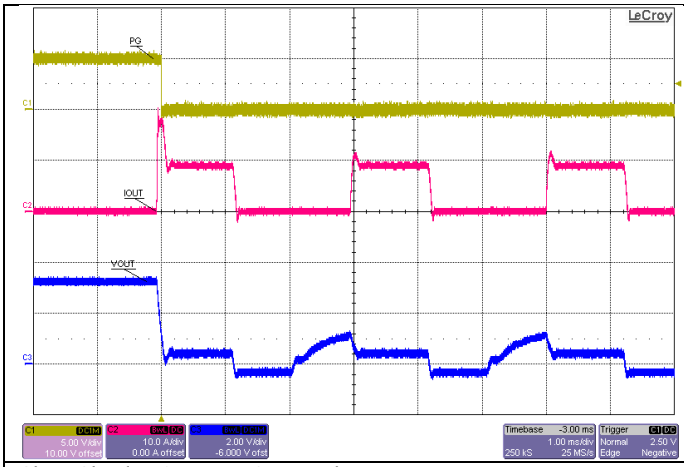
Figures show short circuit cycling of the converter.



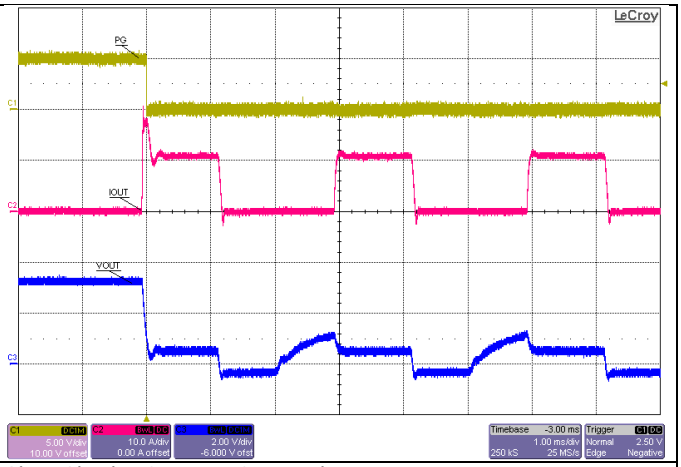
Short Circuit, 5.5-V Input 0-A Load



Short Circuit, 9-V Input 0-A Load



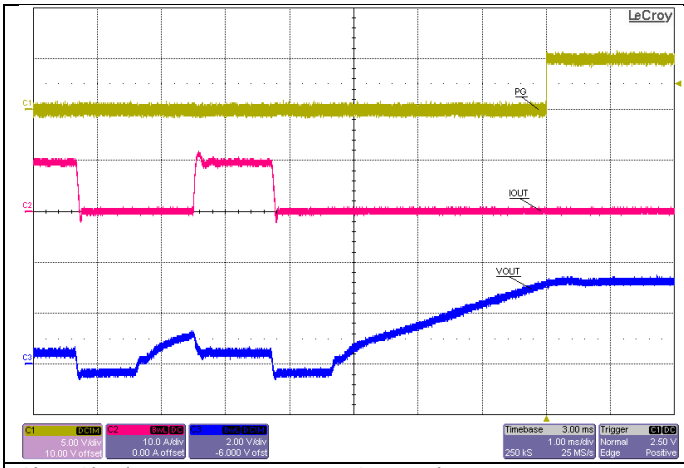
Short Circuit, 16-V Input 0-A Load



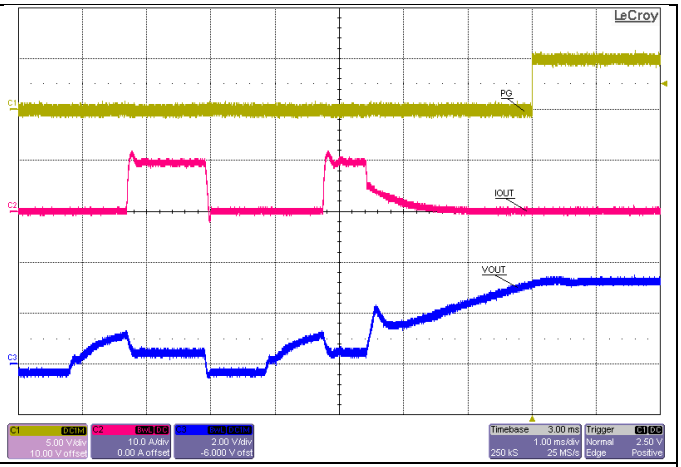
Short Circuit, 42-V Input 0-A Load

3.5 Short Circuit Recovery

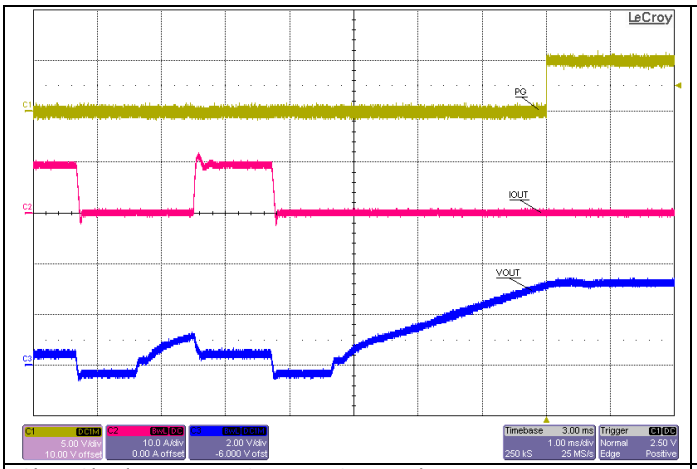
Figures show short circuit recovery of the converter.



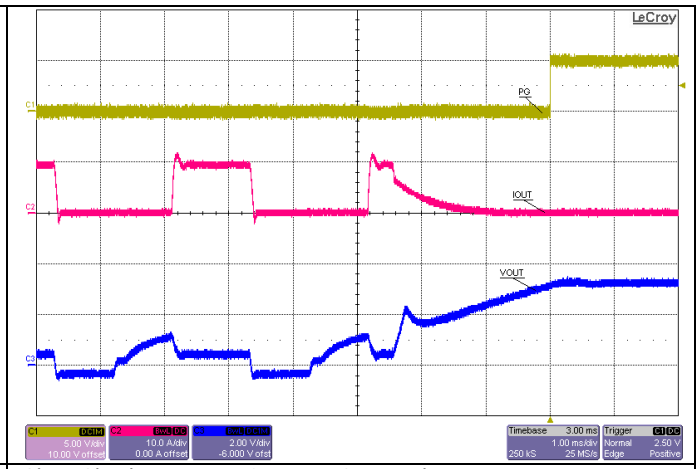
Short Circuit Recovery, 5.5-V Input 0-A Load



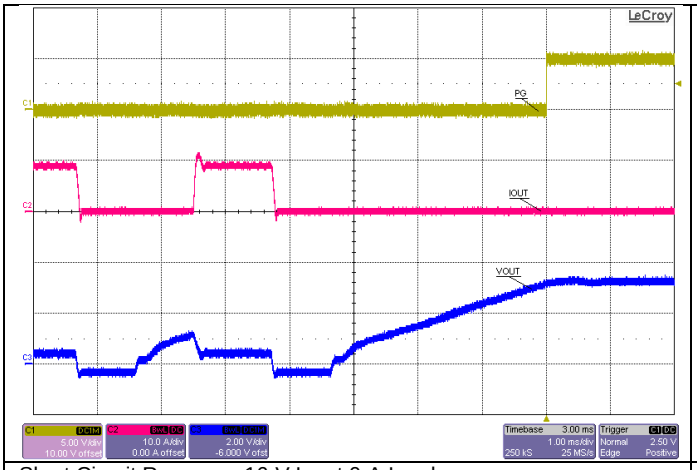
Short Circuit Recovery, 5.5-V Input 0-A Load



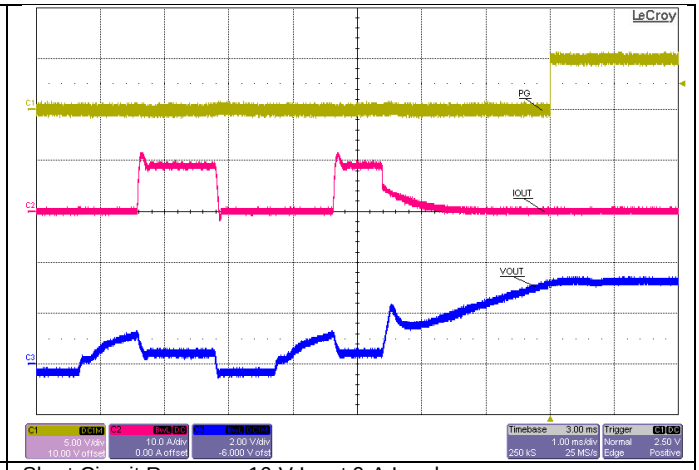
Short Circuit Recovery, 9-V Input 0-A Load



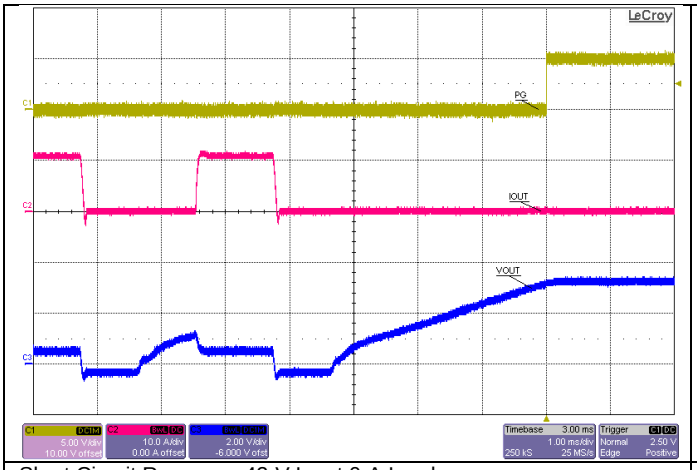
Short Circuit Recovery, 9-V Input 0-A Load



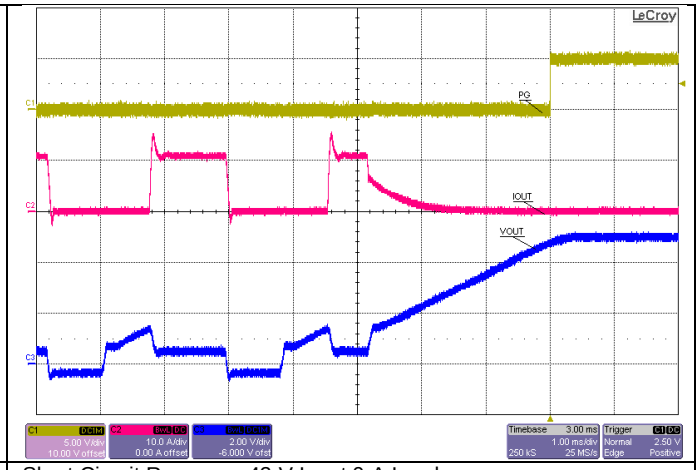
Short Circuit Recovery, 16-V Input 0-A Load



Short Circuit Recovery, 16-V Input 0-A Load



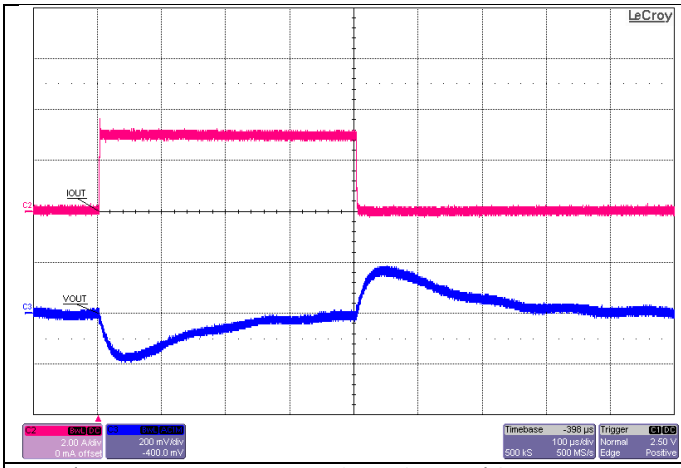
Short Circuit Recovery, 42-V Input 0-A Load



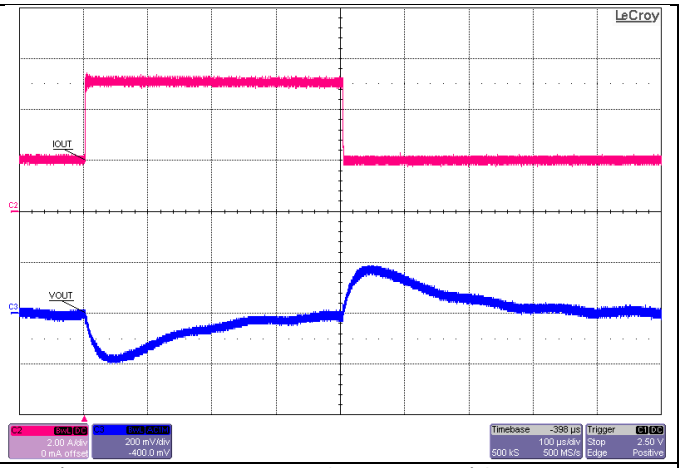
Short Circuit Recovery, 42-V Input 0-A Load

3.6 Load Transients

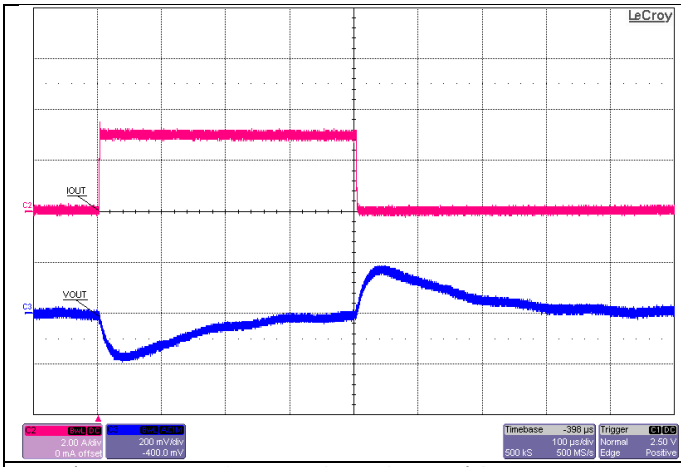
Figures show the load transient response of the converter for a 3-A load step.



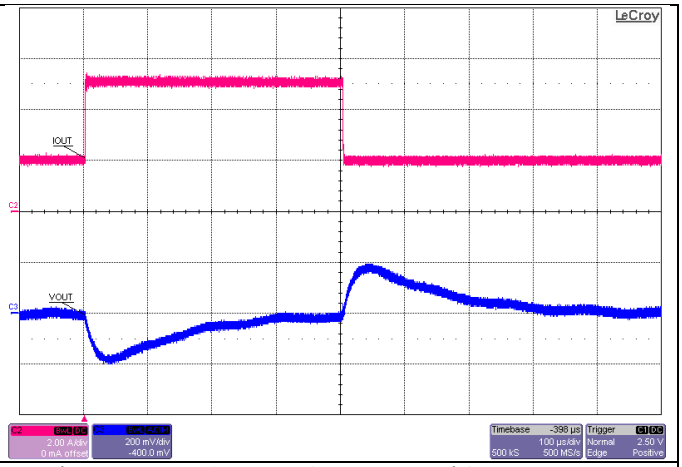
Transient Response, 5.5-V Input, 0-A to 3-A Load Step



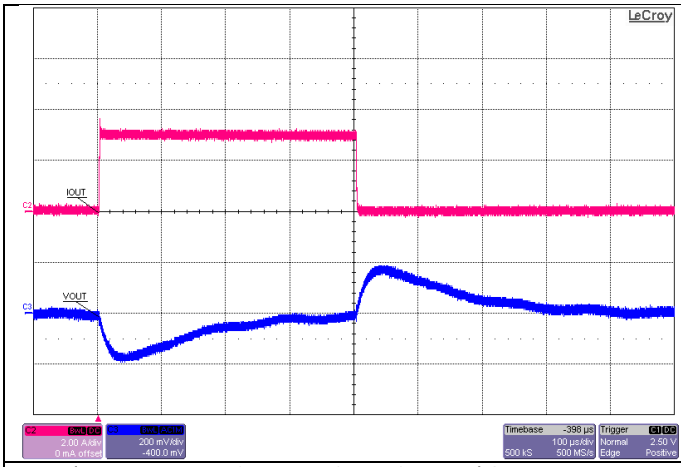
Transient Response, 5.5-V Input, 2-A to 5-A Load Step



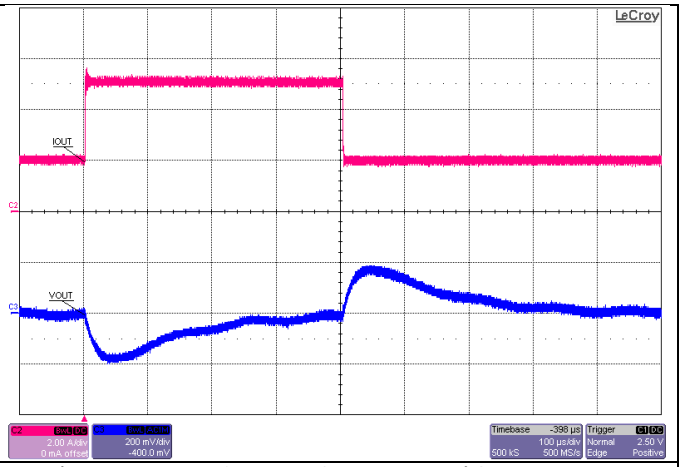
Transient Response, 9-V Input, 0-A to 3-A Load Step



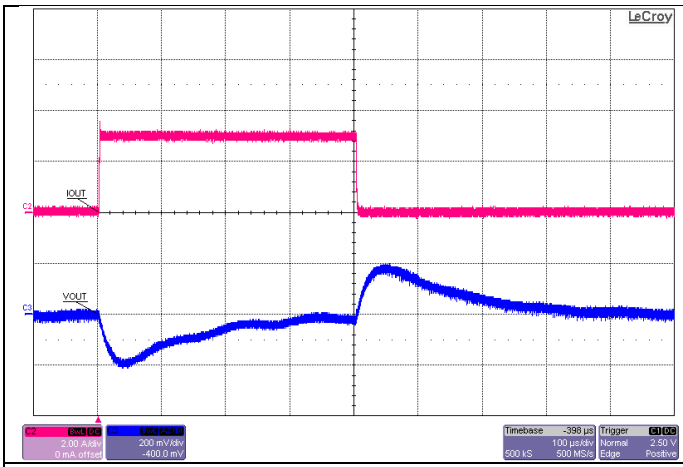
Transient Response, 9-V Input, 2-A to 5-A Load Step



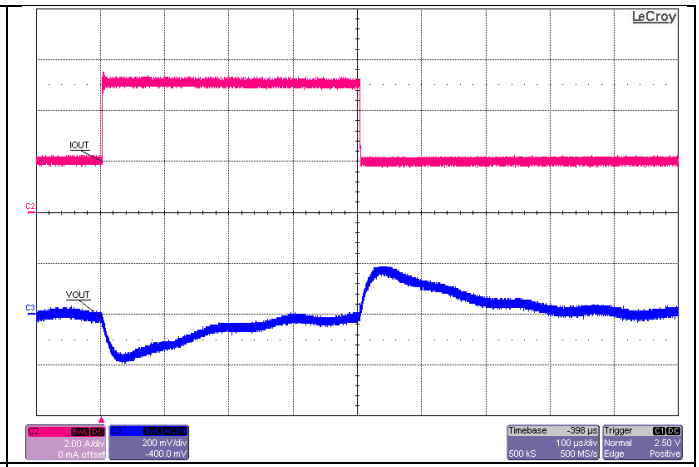
Transient Response, 16-V Input, 0-A to 3-A Load Step



Transient Response, 16-V Input, 2-A to 5-A Load Step



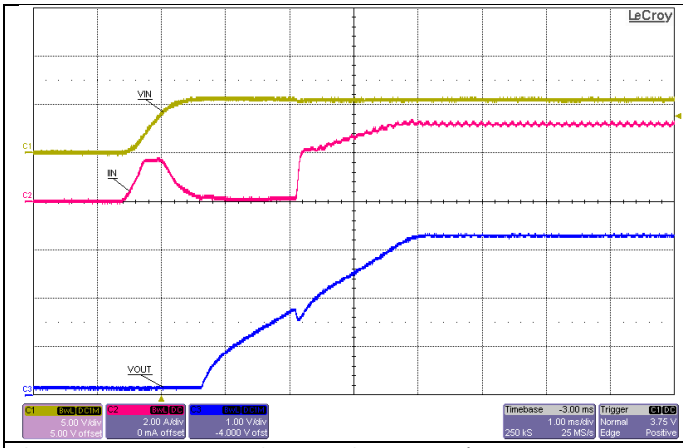
Transient Response, 42-V Input, 0-A to 3-A Load Step



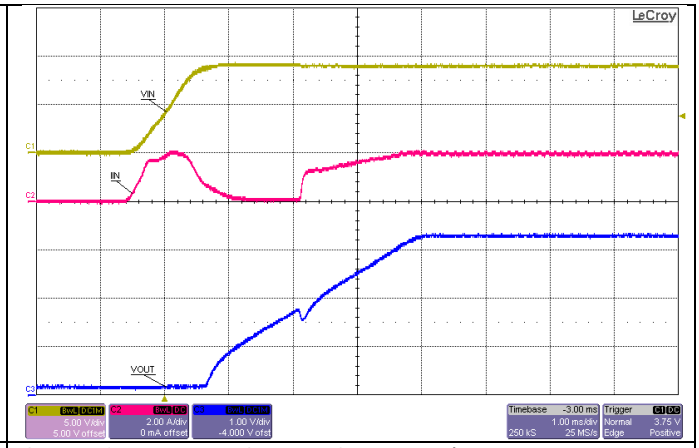
Transient Response, 42-V Input, 2-A to 5-A Load Step

3.7 Start-up

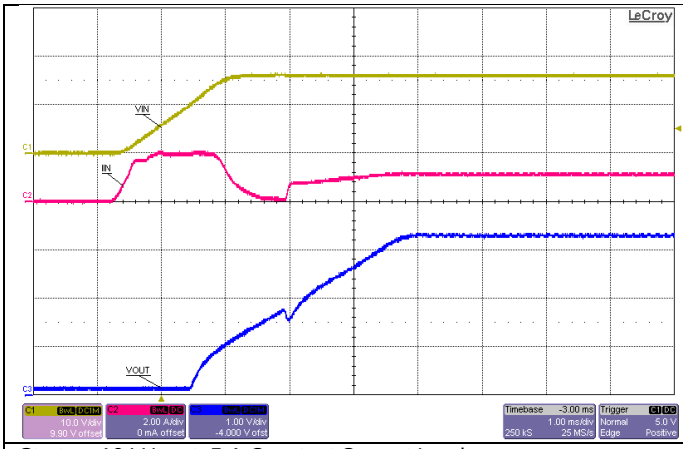
Figures show the startup performance using a 5-A constant current load.



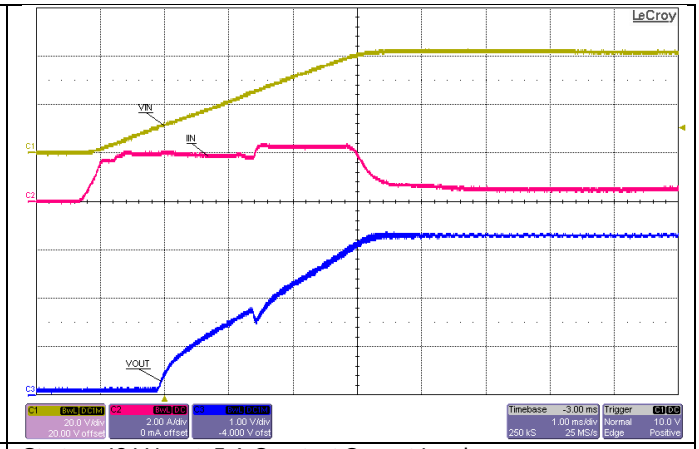
Startup, 5.5-V Input, 5-A Constant Current Load



Startup, 9-V Input, 5-A Constant Current Load



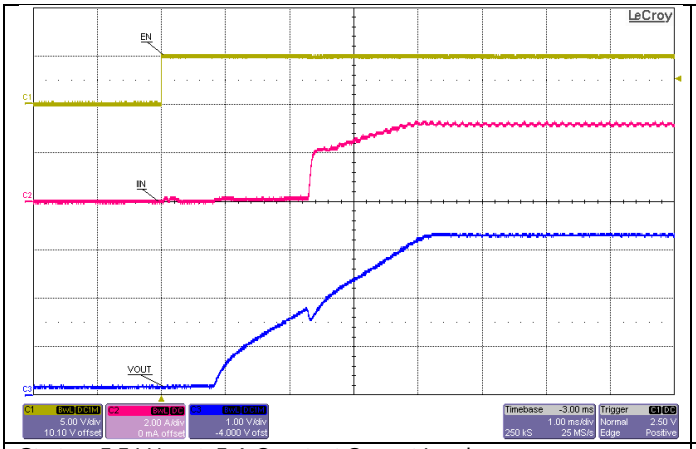
Startup, 16-V Input, 5-A Constant Current Load



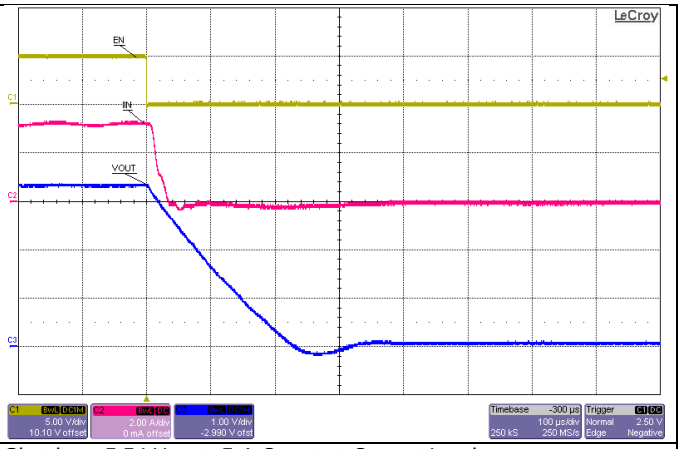
Startup, 42-V Input, 5-A Constant Current Load

3.8 Start-up and Shutdown from Enable

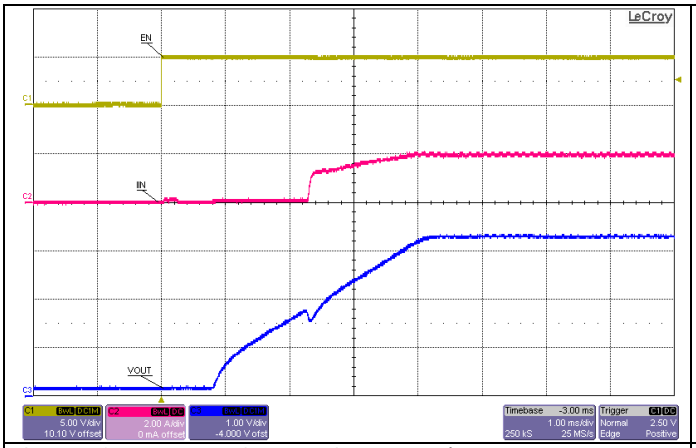
Figures show the startup and shutdown performance using a 5-A constant current load.



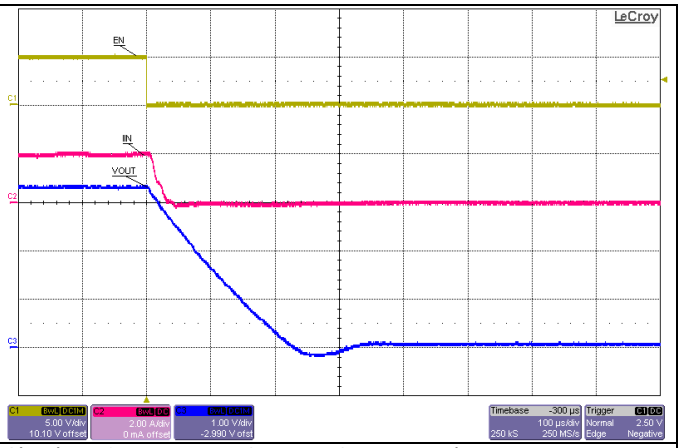
Startup, 5.5-V Input, 5-A Constant Current Load



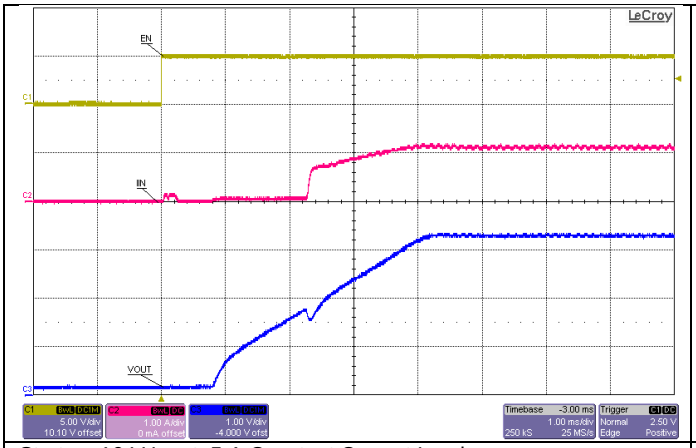
Shutdown 5.5-V Input, 5-A Constant Current Load



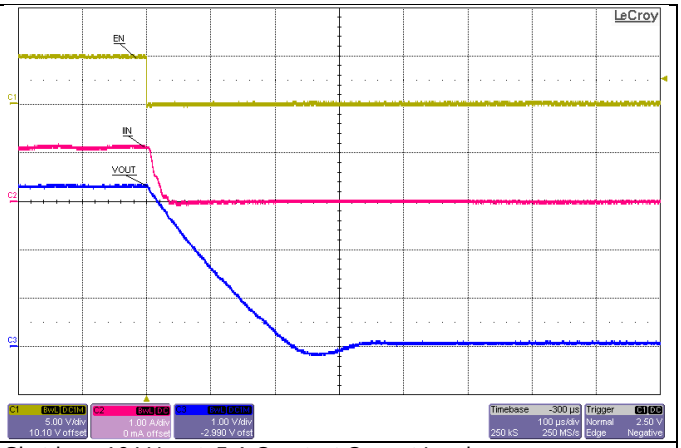
Startup, 9-V Input, 5-A Constant Current Load



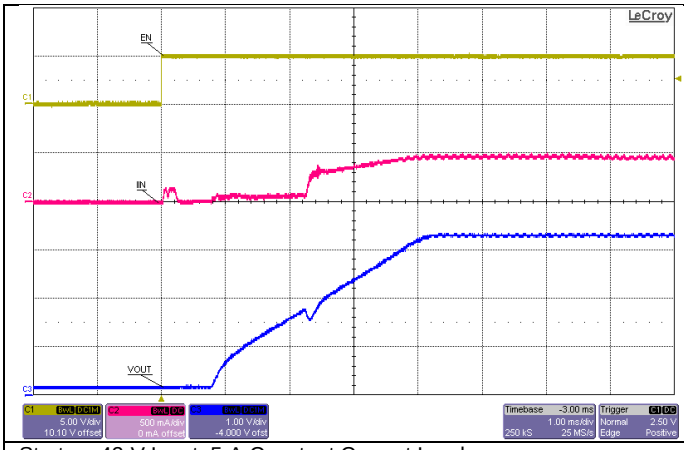
Shutdown 9-V Input, 5-A Constant Current Load



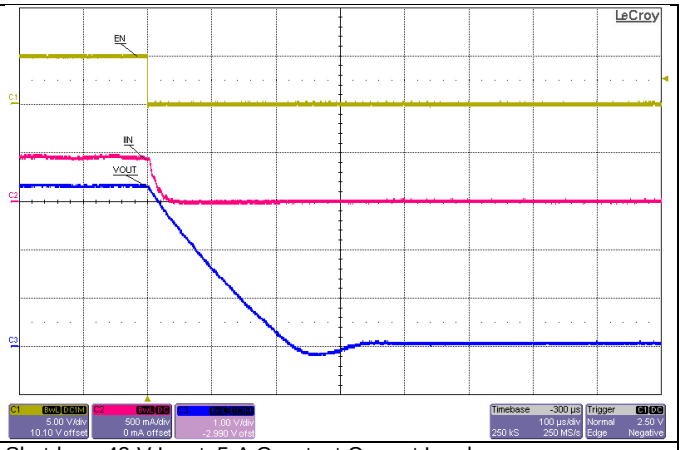
Startup, 16-V Input, 5-A Constant Current Load



Shutdown 16-V Input, 5-A Constant Current Load



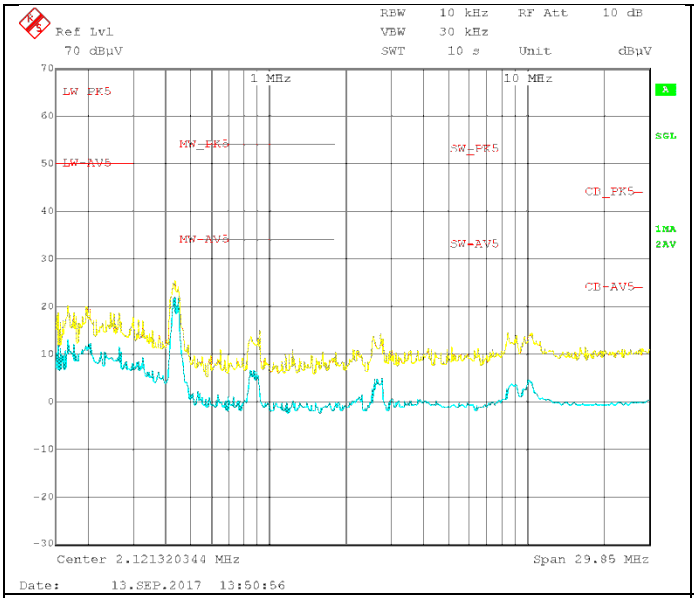
Startup, 42-V Input, 5-A Constant Current Load



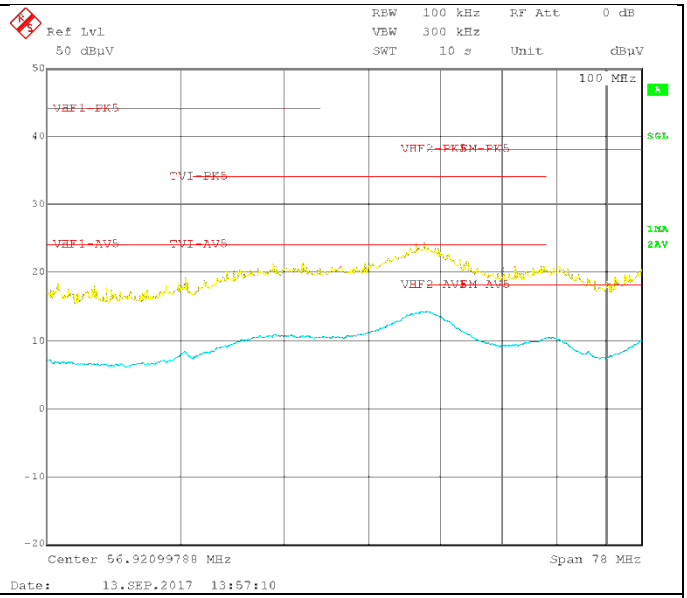
Shutdown 42-V Input, 5-A Constant Current Load

3.9 Conducted EMI

Figures show the EMI performance for conducted emissions. CISPR 25 Class 5 limit lines are used.



Conducted EMI, Low Frequency, 12-V Input, 5-A Load



Conducted EMI, High Frequency, 12-V Input, 5-A Load

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