LM5141-Q1 Synchronous Buck Converter

TI reference design number: PMP20682 Rev B

Input: 5V to 40V
Output: 3.3V @ 10A

DC – DC Test Results

Table of Contents

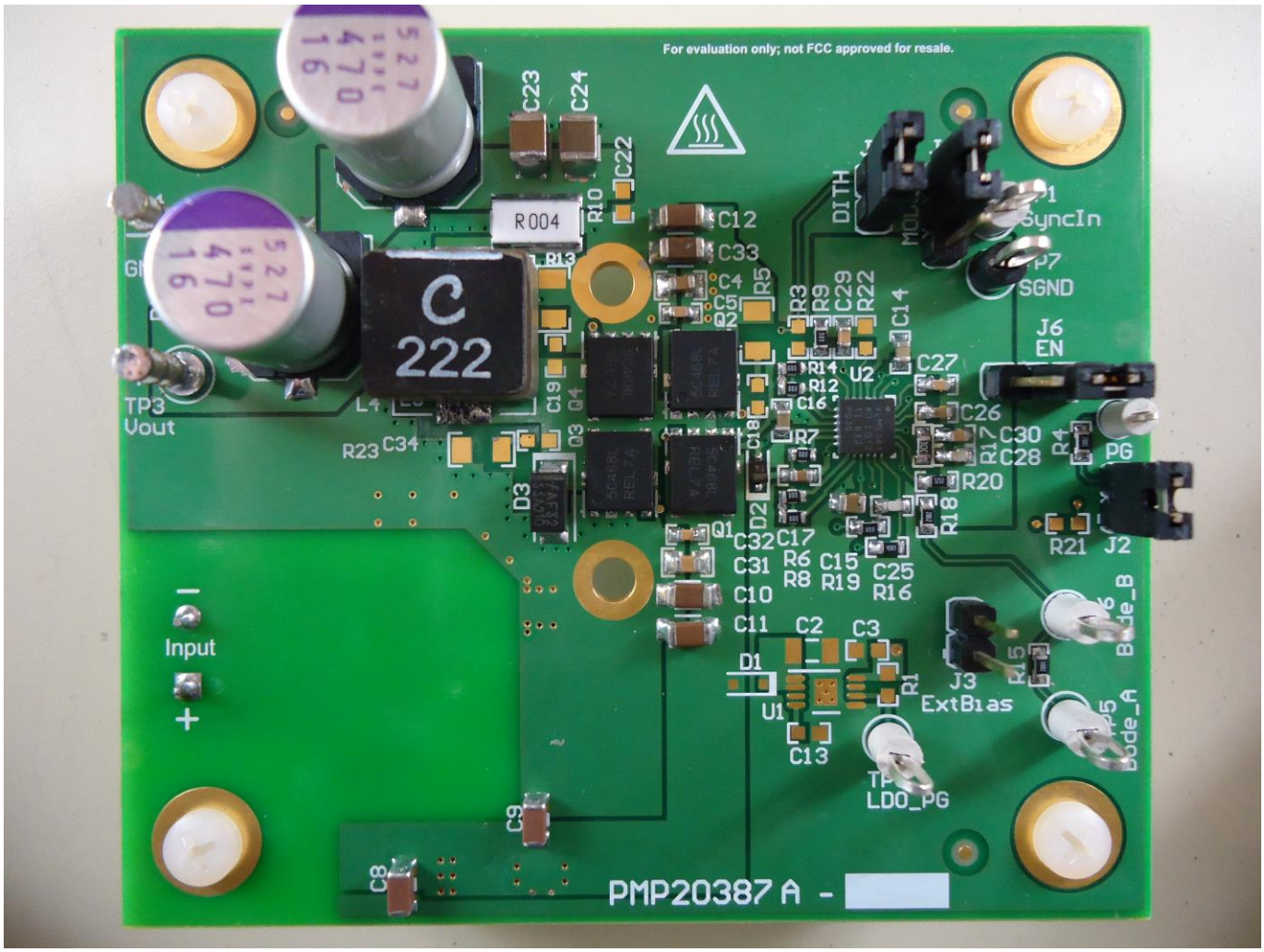
1 Circuit Description

PMP20682 is a synchronous buck converter utilizing the LM5141-Q1 synchronous buck controller I.C. The design accepts an input voltage of 5V to 40V and provides a 3.3V output capable of supplying 10A of current to the load. An EMI filter is incorporated on the input. Optional frequency dithering and slew rate control are available for additional EMI control. Mounting holes are provided for a bottom-side MOSFET heat sink.

At tests were performed at room temperature on an open bench. A 220uF 63V aluminum electrolytic capacitor was used for damping at the input.

2 Photos

The photographs below show the PMP20682 Rev B assembly as built on the PMP20387 Rev A printed circuit board. This is a 4-layer PCB with 2 oz. copper on all layers. Board dimensions are 3.0 in. x 2.3 in.



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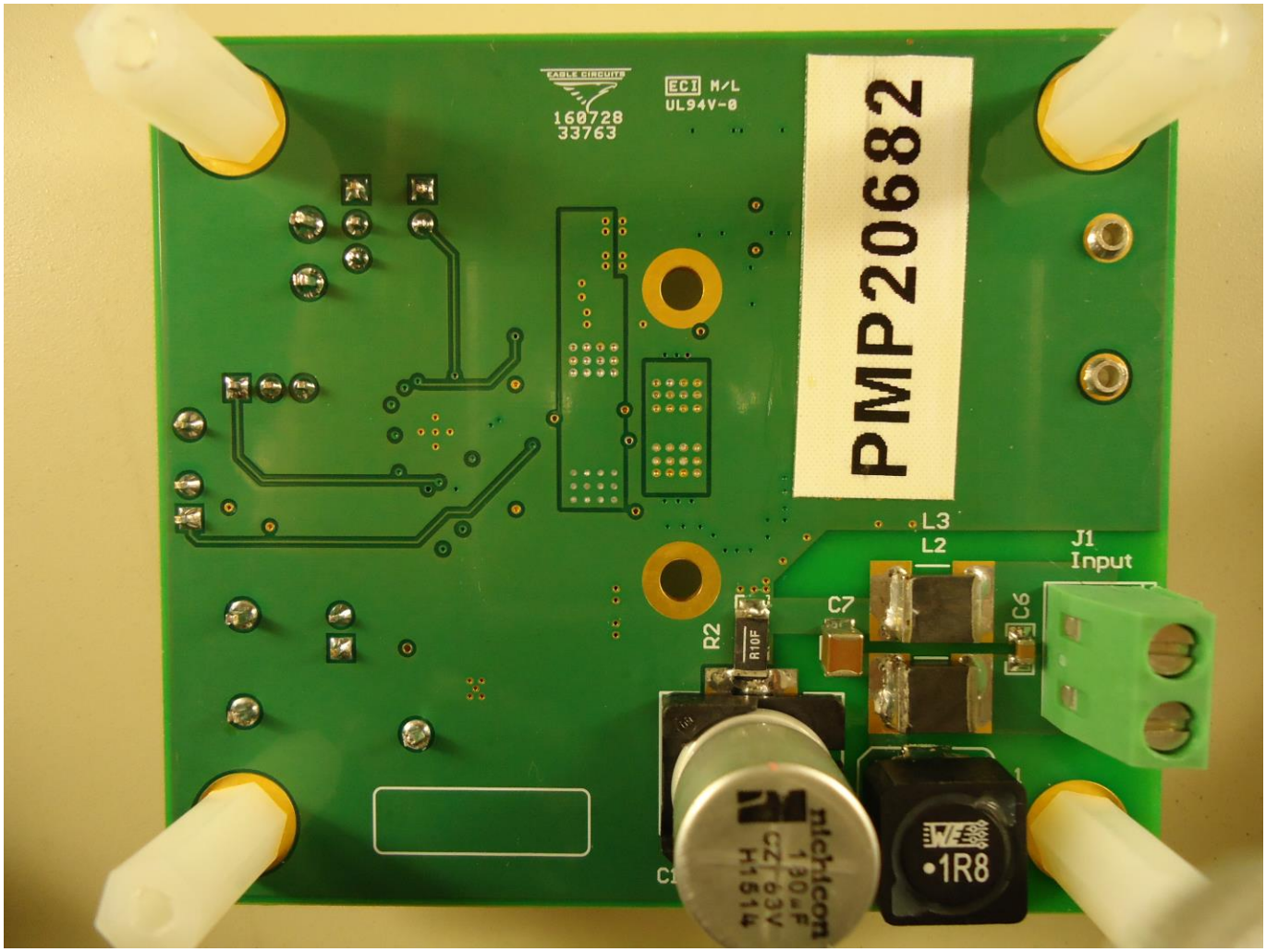
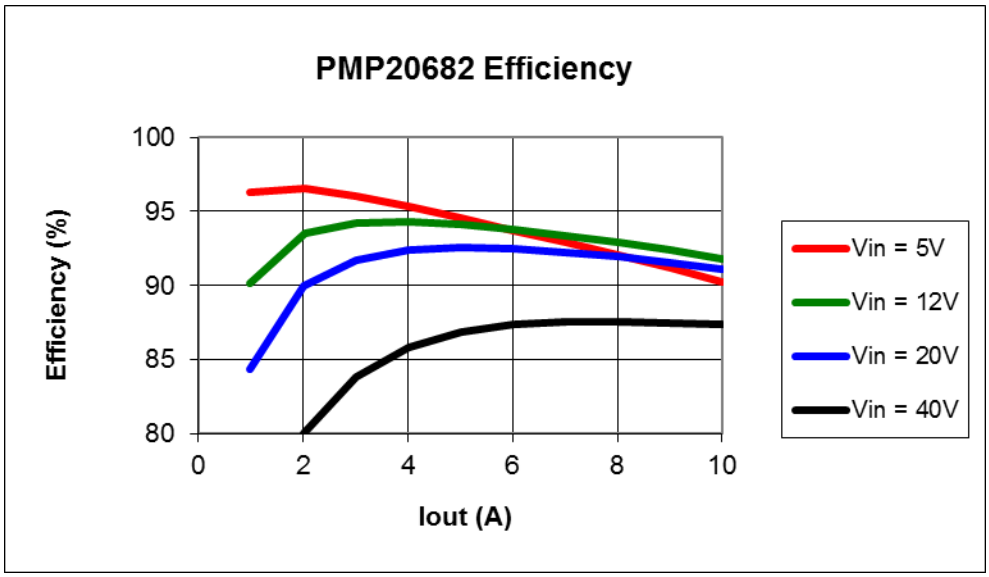


3 Efficiency

The efficiency data is shown in the tables and graphs below.

3.1 Forced PWM Mode



Vin (V)	Iin (A)	Vout (V)	Iout (A)	Pin (W)	Pout (W)	Losses (W)	Efficiency (%)
5.0013	0.0160	3.3071	0.0000	0.080	0.000	0.080	0.00
5.0009	0.6858	3.3066	0.9989	3.430	3.303	0.127	96.31
5.0005	1.3885	3.3066	2.0276	6.943	6.705	0.239	96.56
5.0002	2.0824	3.3064	3.0247	10.412	10.001	0.412	96.05
5.0000	2.7905	3.3061	4.0235	13.953	13.302	0.651	95.34
4.9999	3.5112	3.3057	5.0212	17.556	16.599	0.957	94.55
4.9996	4.2454	3.3053	6.0186	21.225	19.893	1.332	93.72
4.9997	4.9947	3.3049	7.0178	24.972	23.193	1.778	92.88
4.9993	5.7582	3.3045	8.0161	28.787	26.490	2.298	92.02
4.9991	6.5360	3.3041	9.0134	32.674	29.781	2.893	91.15
4.9988	7.3309	3.3037	10.0125	36.646	33.078	3.567	90.27

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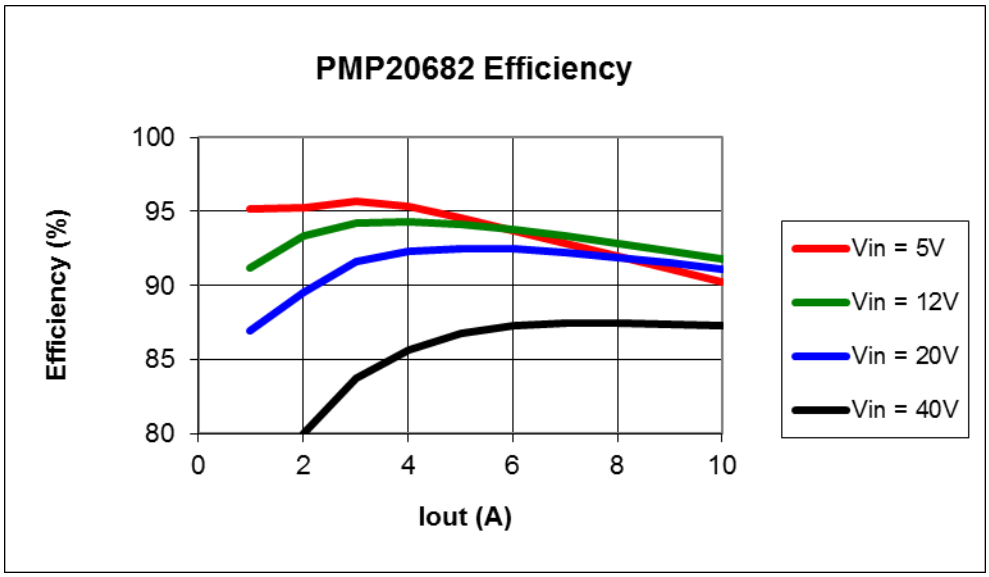
Vin (V)	Iin (A)	Vout (V)	Iout (A)	Pin (W)	Pout (W)	Losses (W)	Efficiency (%)
12.0058	0.0236	3.3072	0.0001	0.283	0.000	0.283	0.12
12.0058	0.3051	3.3064	0.9989	3.663	3.303	0.360	90.17
12.0056	0.5968	3.3061	2.0262	7.165	6.699	0.466	93.50
12.0056	0.8833	3.3058	3.0235	10.605	9.995	0.609	94.25
12.0056	1.1740	3.3057	4.0224	14.095	13.297	0.798	94.34
12.0052	1.4683	3.3054	5.0205	17.627	16.595	1.032	94.14
12.0053	1.7661	3.3050	6.0180	21.203	19.889	1.313	93.81
12.0054	2.0686	3.3044	7.0170	24.834	23.187	1.647	93.37
12.0054	2.3748	3.3039	8.0152	28.510	26.482	2.029	92.88
12.0053	2.6850	3.3035	9.0128	32.234	29.774	2.460	92.37
12.0053	3.0000	3.3032	10.0121	36.016	33.072	2.944	91.82

Vin (V)	Iin (A)	Vout (V)	Iout (A)	Pin (W)	Pout (W)	Losses (W)	Efficiency (%)
20.0064	0.0237	3.3081	0.0001	0.474	0.000	0.474	0.07
20.0066	0.1959	3.3079	0.9990	3.919	3.305	0.615	84.31
20.0068	0.3721	3.3064	2.0255	7.445	6.697	0.748	89.96
20.0066	0.5446	3.3059	3.0228	10.896	9.993	0.902	91.72
20.0062	0.7193	3.3058	4.0217	14.390	13.295	1.095	92.39
20.0063	0.8961	3.3058	5.0199	17.928	16.595	1.333	92.56
20.0064	1.0751	3.3054	6.0175	21.509	19.890	1.619	92.47
20.0061	1.2564	3.3048	7.0165	25.136	23.188	1.948	92.25
20.0061	1.4397	3.3041	8.0151	28.803	26.483	2.320	91.94
20.0066	1.6252	3.3035	9.0123	32.515	29.772	2.743	91.56
20.0061	1.8135	3.3030	10.0117	36.281	33.068	3.213	91.14

Vin (V)	Iin (A)	Vout (V)	Iout (A)	Pin (W)	Pout (W)	Losses (W)	Efficiency (%)
40.0138	0.0247	3.3103	0.0002	0.988	0.001	0.988	0.07
40.0139	0.1199	3.3095	0.9991	4.798	3.307	1.491	68.92
40.0139	0.2092	3.3078	2.0250	8.371	6.698	1.673	80.02
40.0133	0.2980	3.3074	3.0223	11.924	9.996	1.928	83.83
40.0138	0.3874	3.3077	4.0214	15.501	13.301	2.200	85.81
40.0137	0.4777	3.3076	5.0195	19.115	16.602	2.512	86.86
40.0139	0.5691	3.3073	6.0170	22.772	19.900	2.872	87.39
40.0138	0.6621	3.3068	7.0163	26.493	23.201	3.292	87.57
40.0137	0.7561	3.3062	8.0146	30.254	26.498	3.757	87.58
40.0137	0.8508	3.3055	9.0120	34.044	29.789	4.254	87.50
40.0138	0.9467	3.3049	10.0114	37.881	33.087	4.794	87.34

3.2 Diode Emulation Mode



Vin (V)	Iin (A)	Vout (V)	Iout (A)	Pin (W)	Pout (W)	Losses (W)	Efficiency (%)
5.0007	0.0002	3.3276	0.0000	0.001	0.000	0.001	0.00
5.0007	0.6946	3.3079	0.9989	3.473	3.304	0.169	95.13
5.0002	1.4075	3.3076	2.0271	7.038	6.705	0.333	95.27
4.9999	2.0897	3.3066	3.0244	10.448	10.000	0.448	95.71
4.9997	2.7909	3.3062	4.0234	13.954	13.302	0.651	95.33
5.0000	3.5119	3.3058	5.0216	17.559	16.601	0.959	94.54
4.9996	4.2462	3.3054	6.0191	21.229	19.896	1.333	93.72
4.9994	4.9957	3.3051	7.0182	24.975	23.196	1.780	92.87
4.9990	5.7596	3.3046	8.0165	28.792	26.492	2.301	92.01
4.9985	6.5379	3.3043	9.0140	32.680	29.785	2.895	91.14
4.9985	7.3327	3.3039	10.0135	36.653	33.083	3.570	90.26

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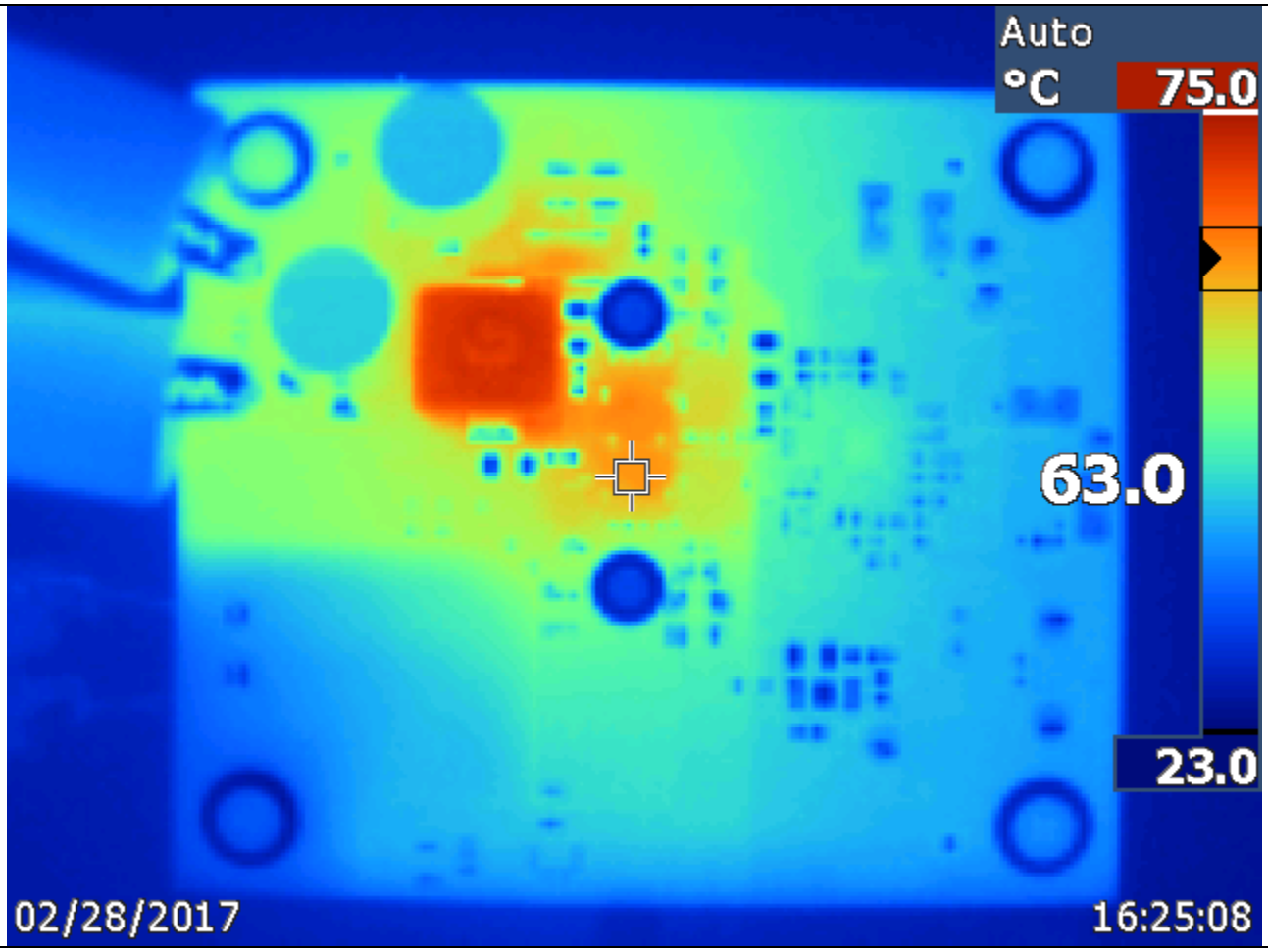
Vin (V)	Iin (A)	Vout (V)	Iout (A)	Pin (W)	Pout (W)	Losses (W)	Efficiency (%)
12.0057	0.0005	3.3138	0.0000	0.006	0.000	0.006	0.00
12.0053	0.3019	3.3093	0.9990	3.624	3.306	0.318	91.21
12.0053	0.5978	3.3067	2.0259	7.177	6.699	0.478	93.34
12.0052	0.8837	3.3059	3.0233	10.609	9.995	0.614	94.21
12.0053	1.1744	3.3057	4.0225	14.099	13.297	0.802	94.31
12.0054	1.4688	3.3055	5.0208	17.634	16.596	1.037	94.12
12.0056	1.7668	3.3051	6.0184	21.211	19.891	1.320	93.78
12.0049	2.0693	3.3045	7.0175	24.842	23.190	1.652	93.35
12.0049	2.3756	3.3040	8.0158	28.519	26.484	2.035	92.87
12.0052	2.6857	3.3036	9.0133	32.242	29.776	2.466	92.35
12.0049	3.0009	3.3032	10.0127	36.026	33.074	2.951	91.81

Vin (V)	Iin (A)	Vout (V)	Iout (A)	Pin (W)	Pout (W)	Losses (W)	Efficiency (%)
20.0064	0.0006	3.3142	0.0002	0.012	0.001	0.011	5.52
20.0061	0.1900	3.3090	0.9991	3.801	3.306	0.495	86.98
20.0062	0.3739	3.3057	2.0255	7.480	6.696	0.785	89.51
20.0061	0.5450	3.3060	3.0228	10.903	9.993	0.910	91.65
20.0061	0.7197	3.3059	4.0218	14.398	13.296	1.103	92.34
20.0062	0.8965	3.3058	5.0199	17.936	16.595	1.341	92.53
20.0057	1.0754	3.3055	6.0178	21.514	19.892	1.622	92.46
20.0061	1.2570	3.3048	7.0171	25.148	23.190	1.957	92.22
20.0057	1.4404	3.3041	8.0154	28.816	26.484	2.332	91.91
20.0058	1.6259	3.3035	9.0129	32.527	29.774	2.754	91.53
20.0058	1.8143	3.3029	10.0121	36.297	33.069	3.227	91.11

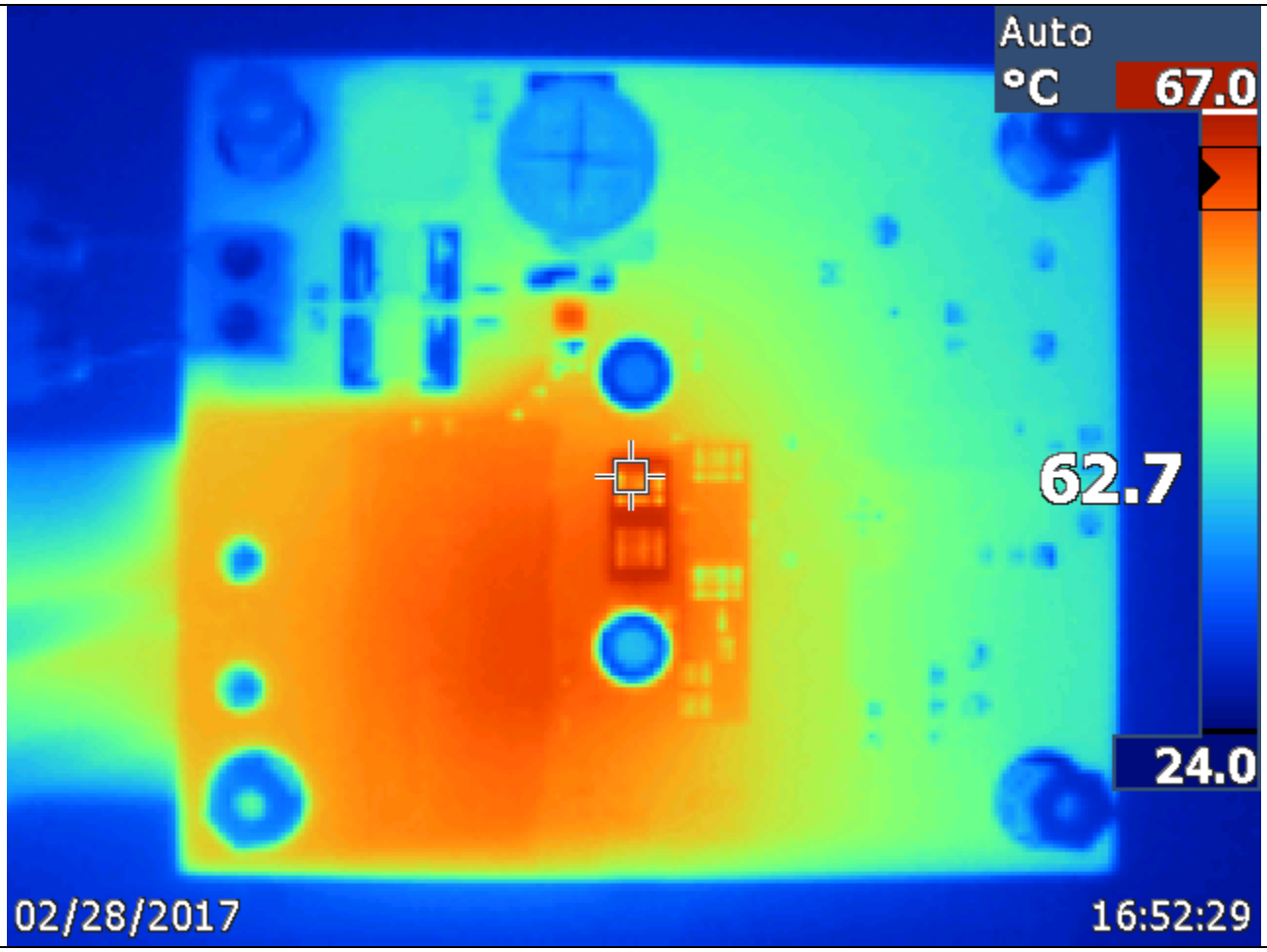
Vin (V)	Iin (A)	Vout (V)	Iout (A)	Pin (W)	Pout (W)	Losses (W)	Efficiency (%)
40.0137	0.0009	3.3154	0.0002	0.036	0.001	0.035	1.84
40.0138	0.1163	3.3091	0.9991	4.654	3.306	1.347	71.04
40.0134	0.2092	3.3070	2.0250	8.371	6.697	1.674	80.00
40.0137	0.2984	3.3072	3.0226	11.940	9.996	1.944	83.72
40.0133	0.3881	3.3076	4.0216	15.529	13.302	2.227	85.66
40.0136	0.4783	3.3075	5.0200	19.138	16.604	2.535	86.76
40.0137	0.5697	3.3072	6.0176	22.796	19.902	2.894	87.30
40.0136	0.6628	3.3067	7.0167	26.521	23.202	3.319	87.49
40.0134	0.7568	3.3061	8.0151	30.282	26.499	3.784	87.51
40.0134	0.8516	3.3053	9.0126	34.075	29.790	4.286	87.42
40.0133	0.9474	3.3047	10.0118	37.909	33.086	4.822	87.28

4 Thermal

4.1 Thermal at 12V in 10A load, no airflow



Thermal 12Vin 10A Load Top

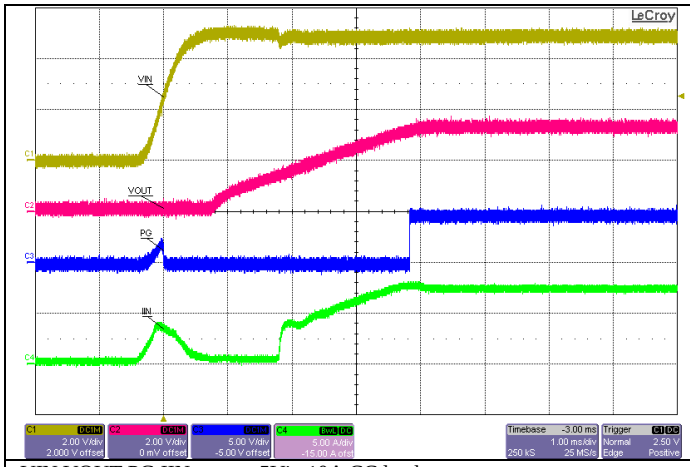


Thermal 12Vin 10A Load Bottom

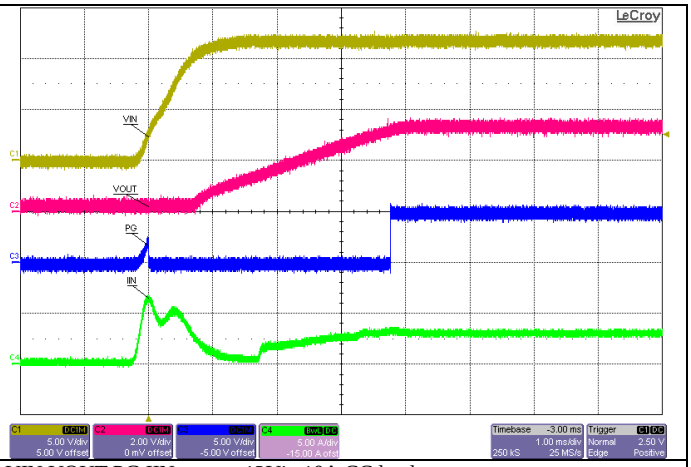
5 Startup

5.1 Startup from Vin

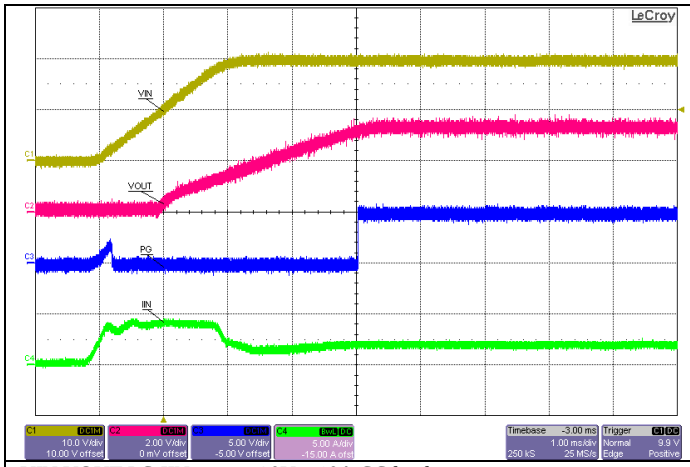
Startup was tested using a constant current electronic load.



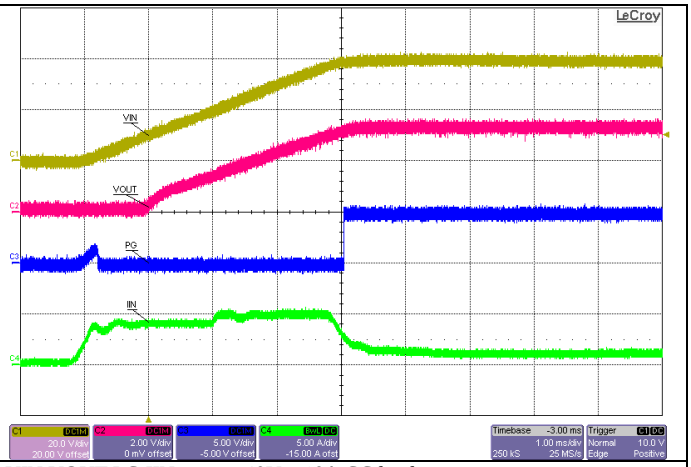
VIN VOUT PG IIN startup 5Vin 10A CC load



VIN VOUT PG IIN startup 12Vin 10A CC load

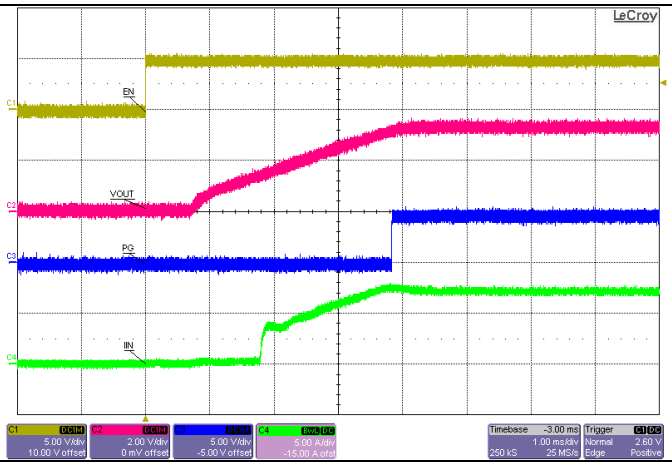


VIN VOUT PG IIN startup 20Vin 10A CC load

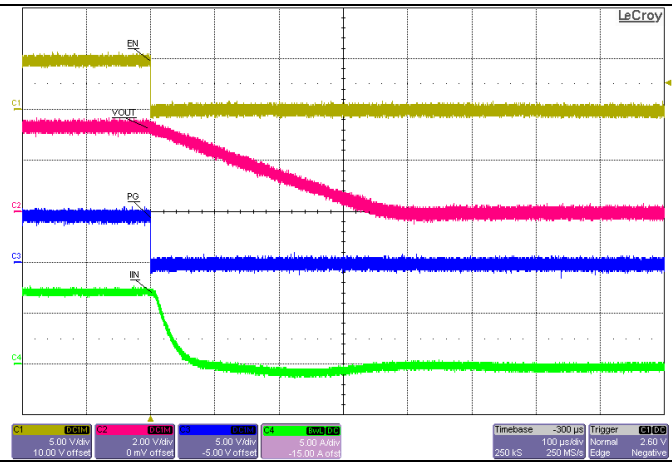


VIN VOUT PG IIN startup 40Vin 10A CC load

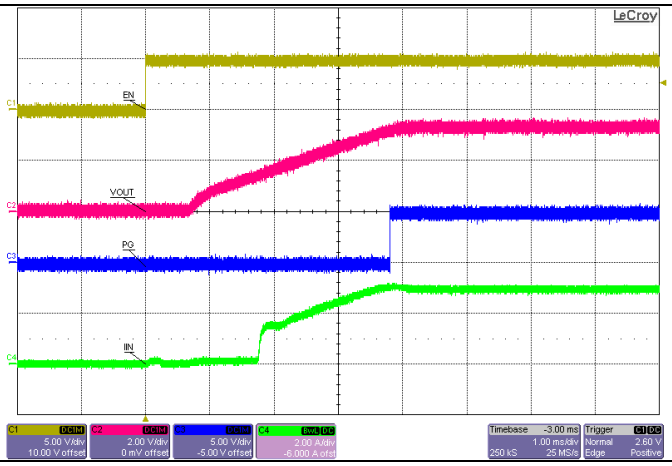
5.2 Startup and Shutdown from EN



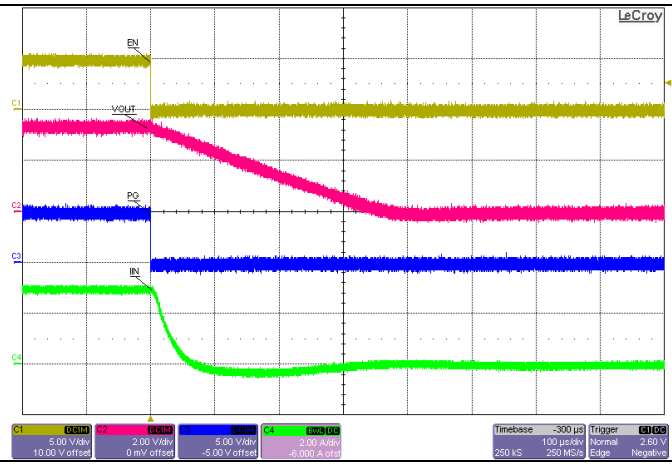
EN VOUT PG IIN startup 5Vin 10A CC load



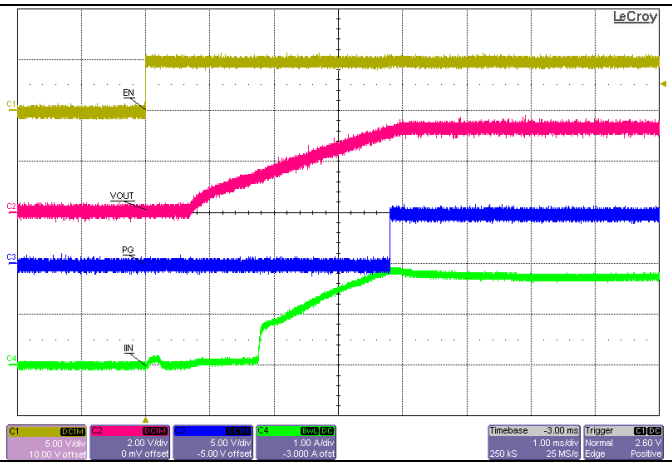
EN VOUT PG IIN shutdown 5Vin 10A CC load



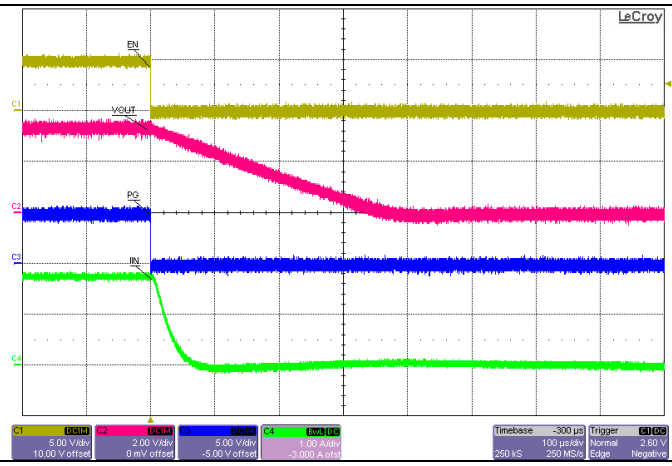
EN VOUT PG IIN startup 12Vin 10A CC load



EN VOUT PG IIN shutdown 12Vin 10A CC load



EN VOUT PG IIN startup 20Vin 10A CC load



EN VOUT PG IIN shutdown 20Vin 10A CC load

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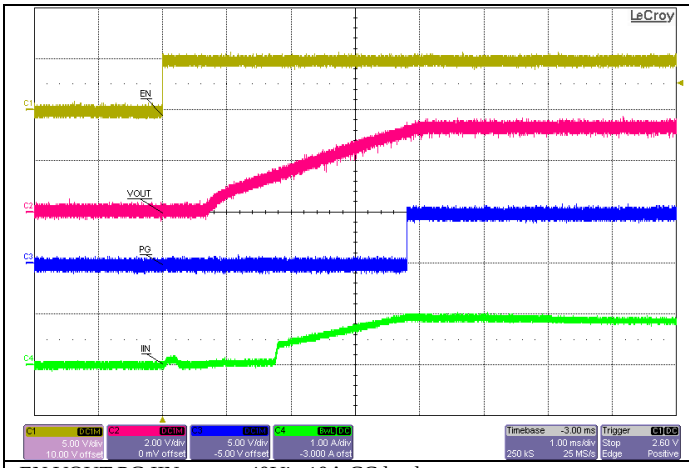
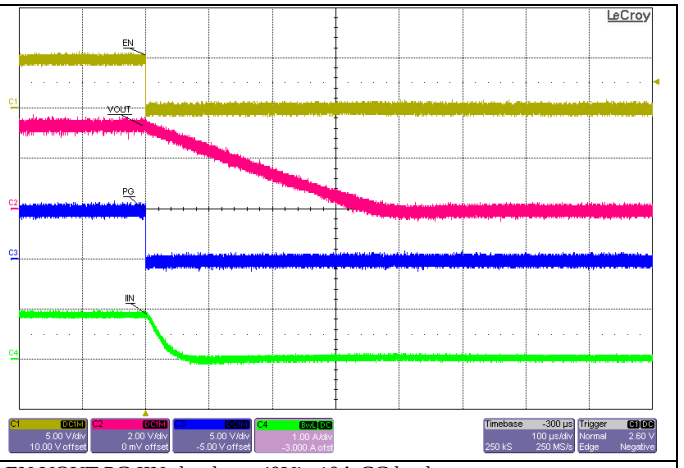


EN VOUT PG IIN startup 40Vin 10A CC load

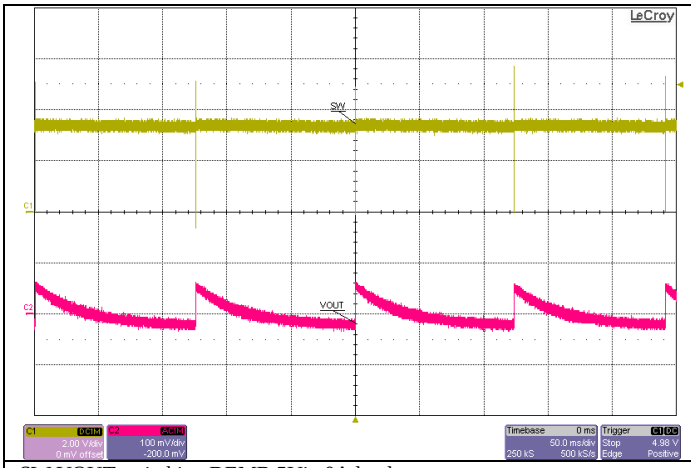


EN VOUT PG IIN shutdown 40Vin 10A CC load

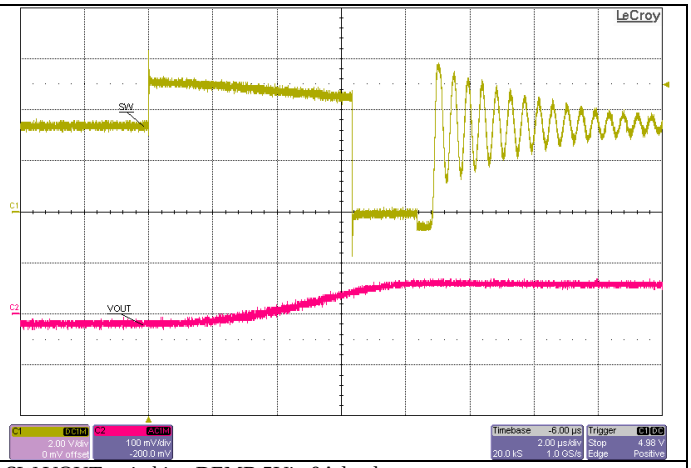
6 Switching and Ripple

6.1 Switching and Ripple

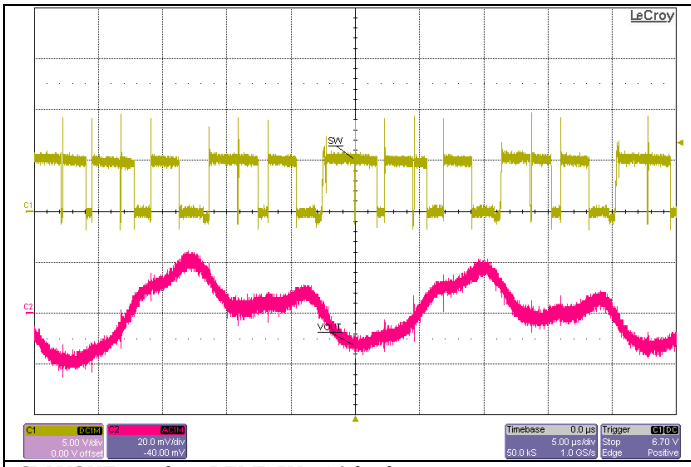
Switching and ripple were measured in diode emulation mode at full bandwidth using 500 MHz probes and 350 MHz oscilloscope.



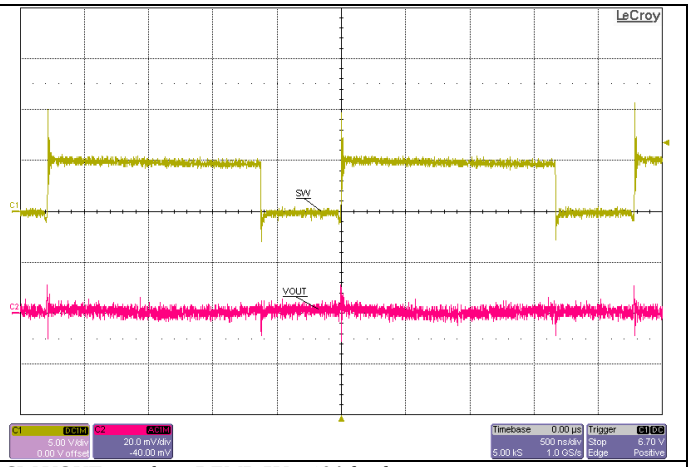
SW VOUT switching DEMB 5Vin 0A load



SW VOUT switching DEMB 5Vin 0A load



SW VOUT switching DEMB 5Vin 2A load



SW VOUT switching DEMB 5Vin 10A load

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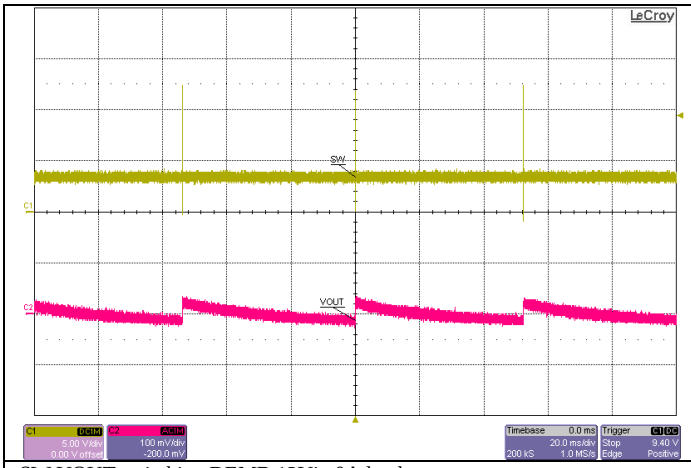
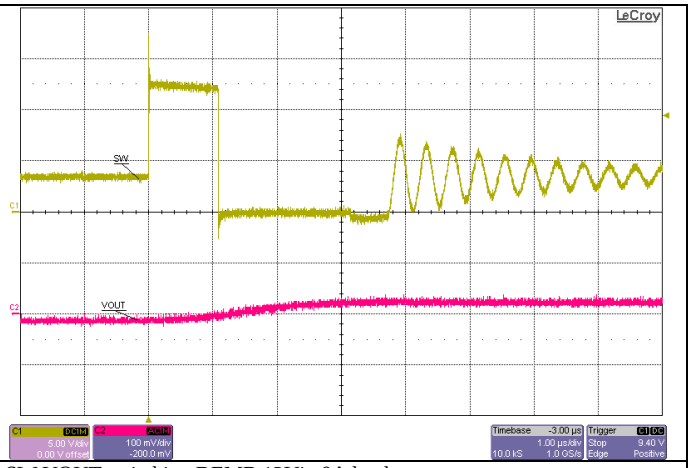
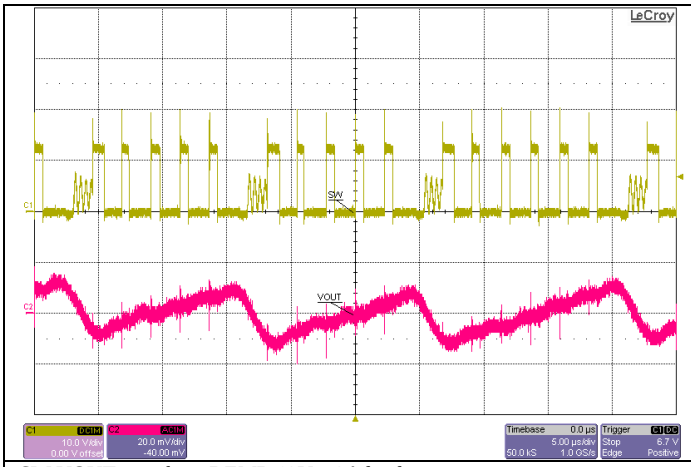


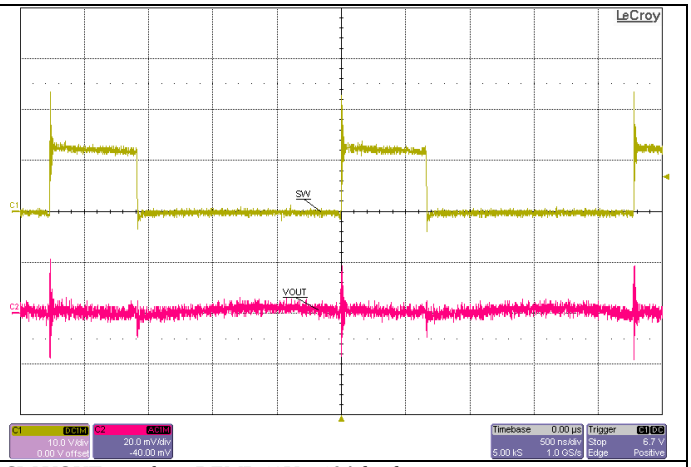
SW VOUT switching DEMB 12Vin 0A load



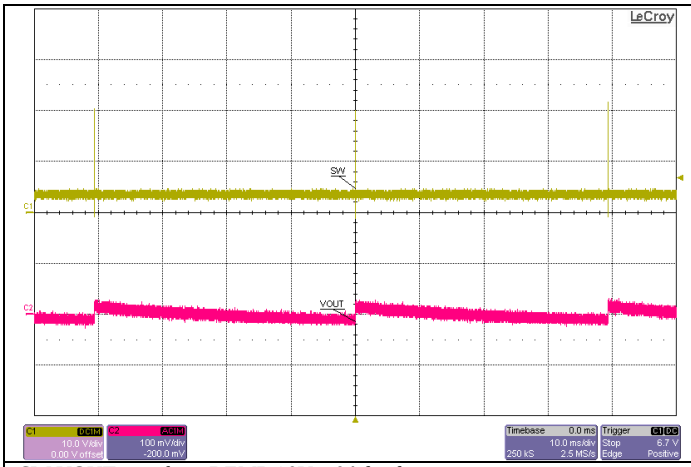
SW VOUT switching DEMB 12Vin 0A load



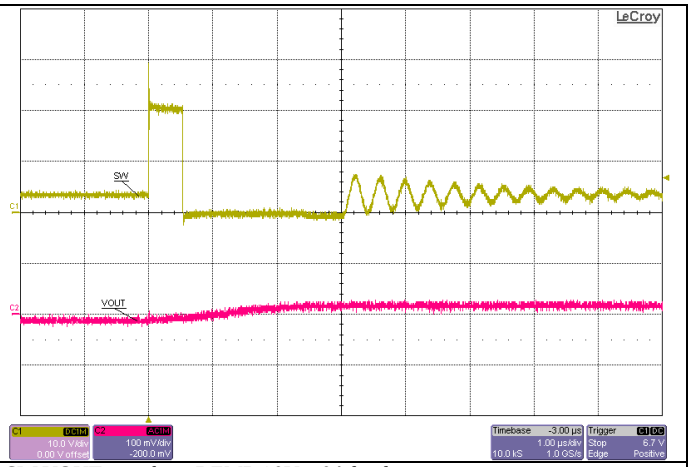
SW VOUT switching DEMB 12Vin 2A load



SW VOUT switching DEMB 12Vin 10A load

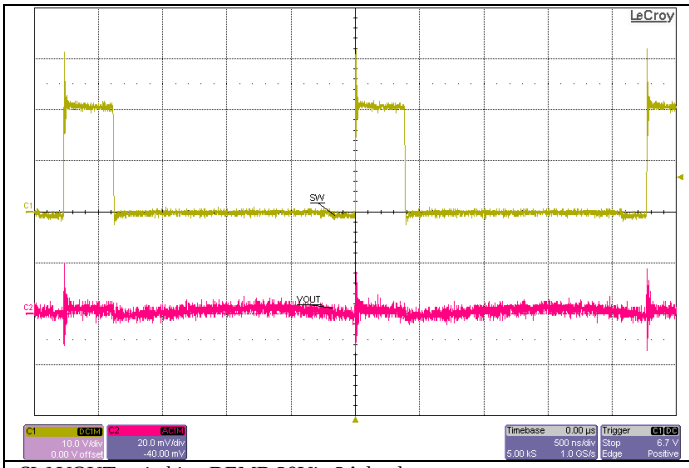


SW VOUT switching DEMB 20Vin 0A load

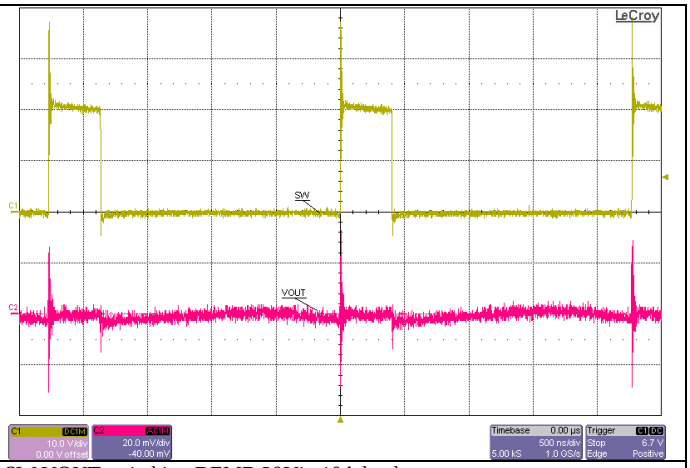


SW VOUT switching DEMB 20Vin 0A load

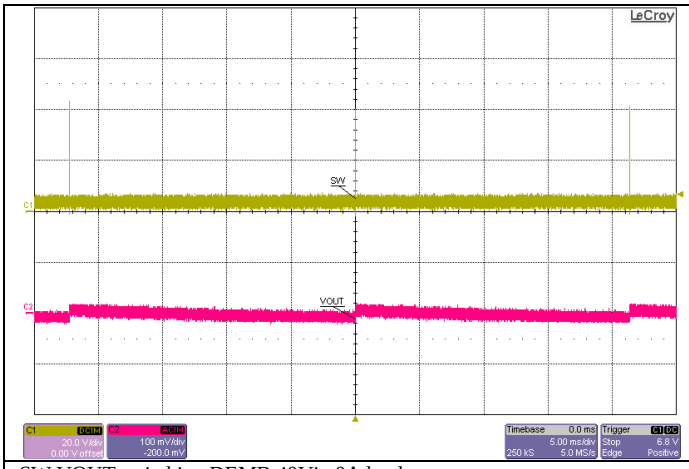
PMP20682 Rev B Test Results



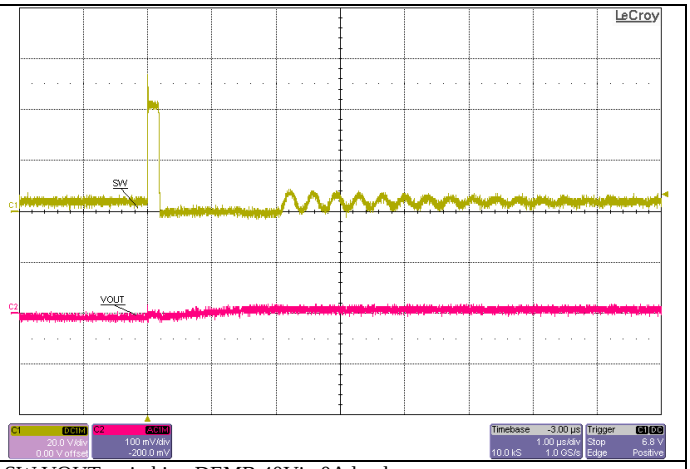
SW VOUT switching DEMB 20Vin 2A load



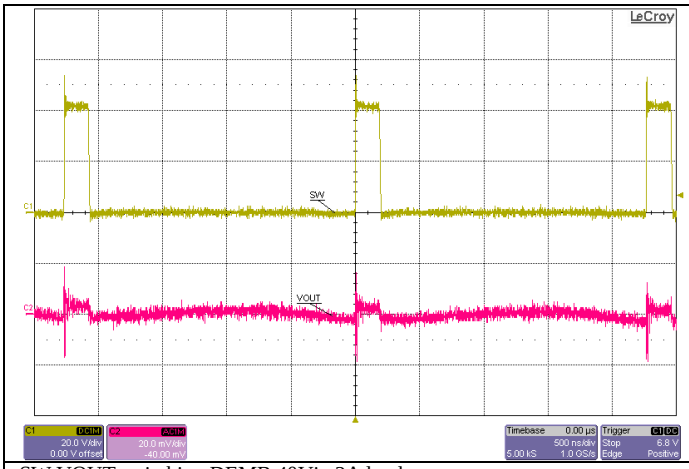
SW VOUT switching DEMB 20Vin 10A load



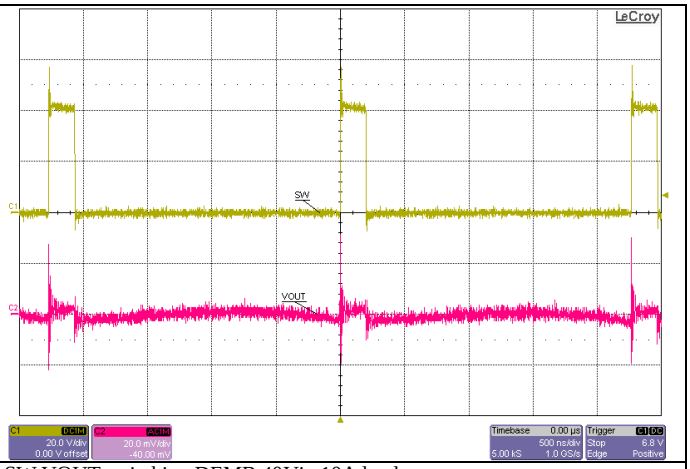
SW VOUT switching DEMB 40Vin 0A load



SW VOUT switching DEMB 40Vin 0A load



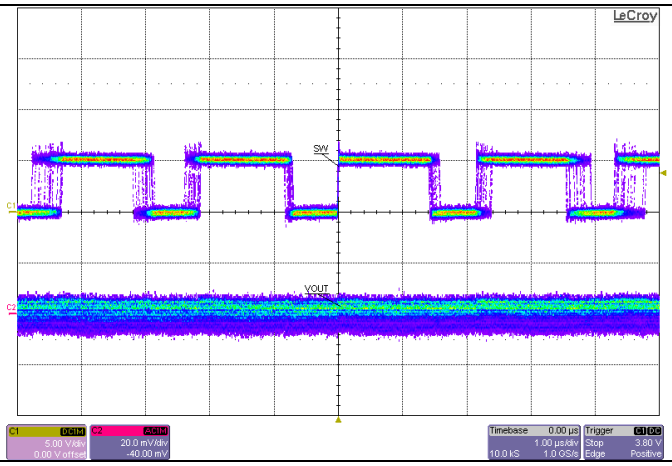
SW VOUT switching DEMB 40Vin 2A load



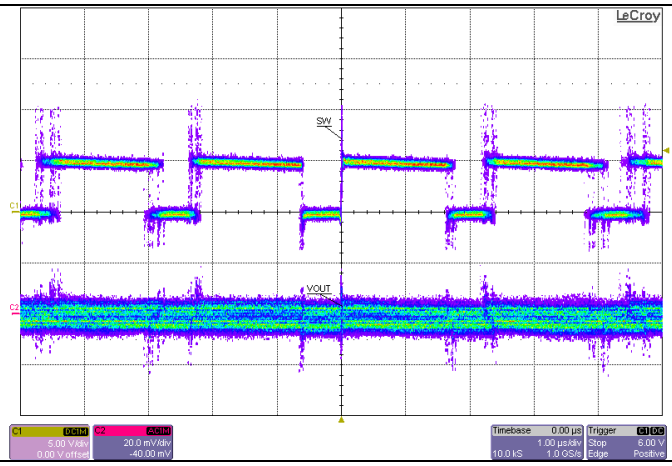
SW VOUT switching DEMB 40Vin 10A load

6.2 Frequency Dithering

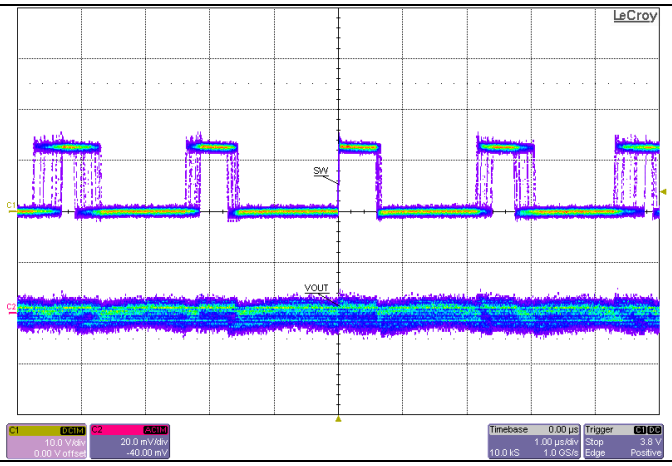
Switching and ripple with frequency dithering were measured in forced PWM mode at full bandwidth using 500 MHz probes and 350 MHz oscilloscope.



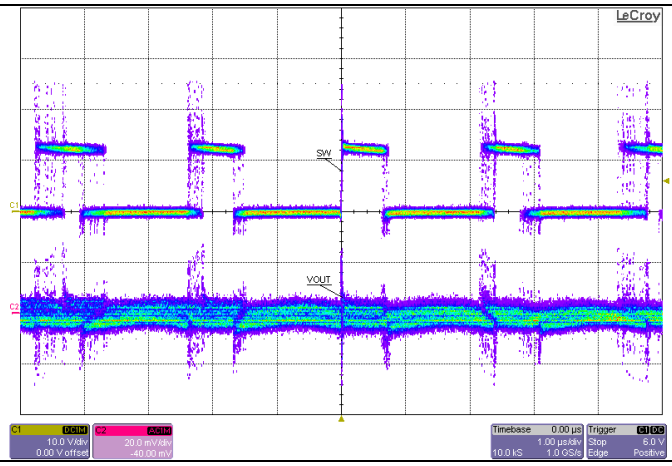
SW VOUT switching DITH 5Vin 0A load



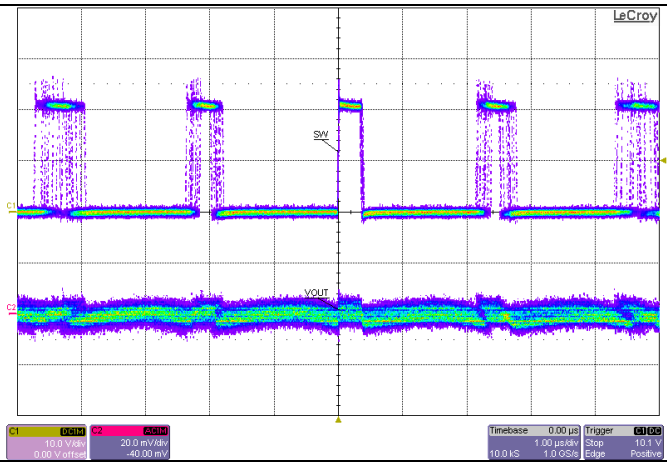
SW VOUT switching DITH 5Vin 10A CC load



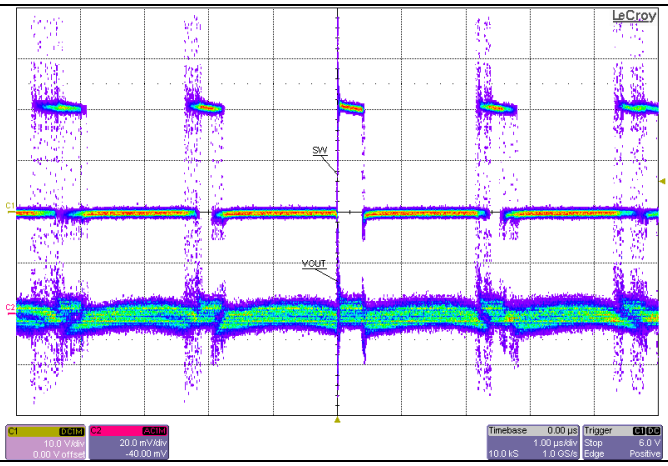
SW VOUT switching DITH 12Vin 0A load



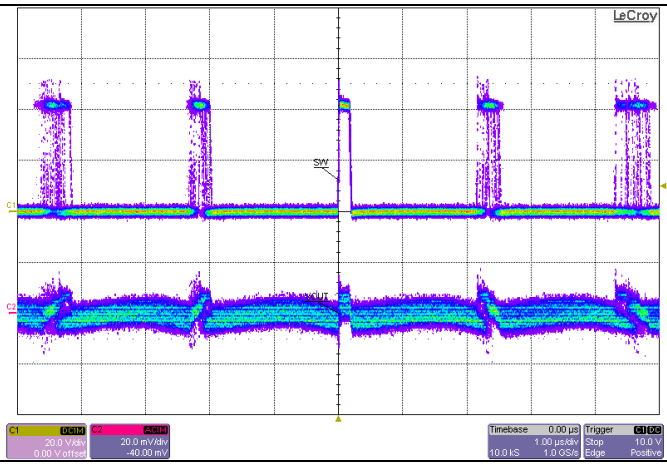
SW VOUT switching DITH 12Vin 10A CC load



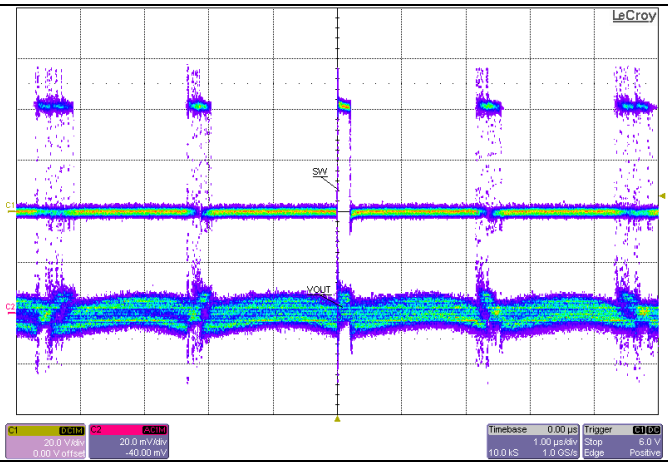
SW VOUT switching DITH 20Vin 0A load



SW VOUT switching DITH 20Vin 10A CC load



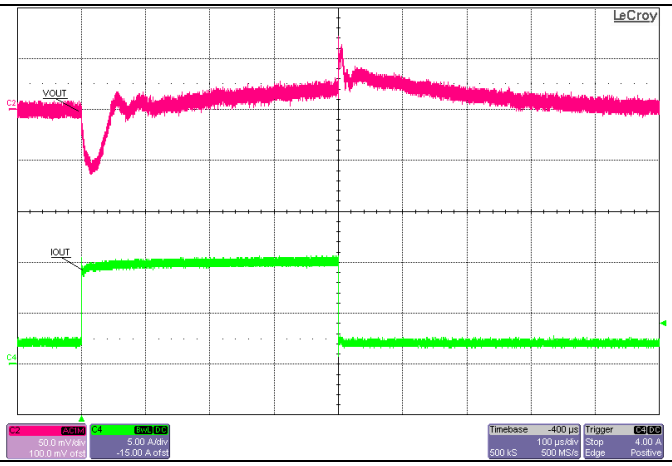
SW VOUT switching DITH 40Vin 0A load



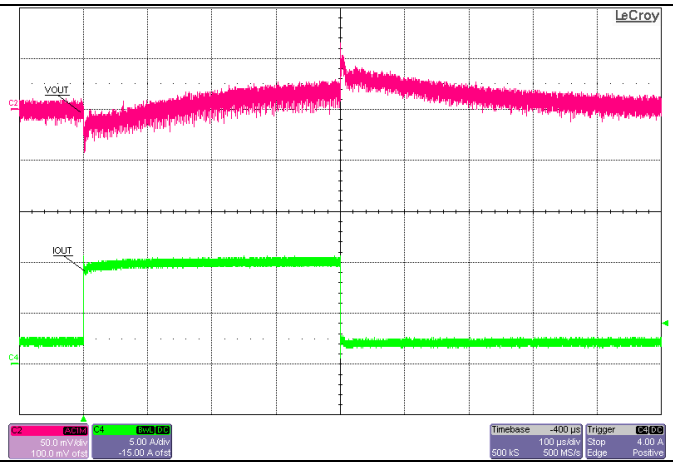
SW VOUT switching DITH 40Vin 10A CC load

7 Load Transient Response

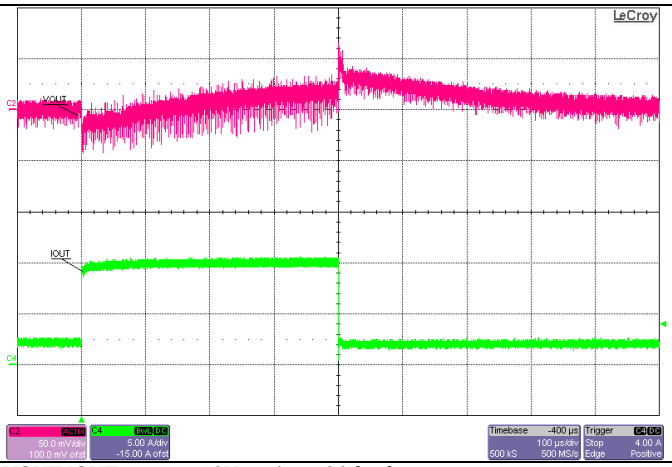
7.1 Forced PWM mode



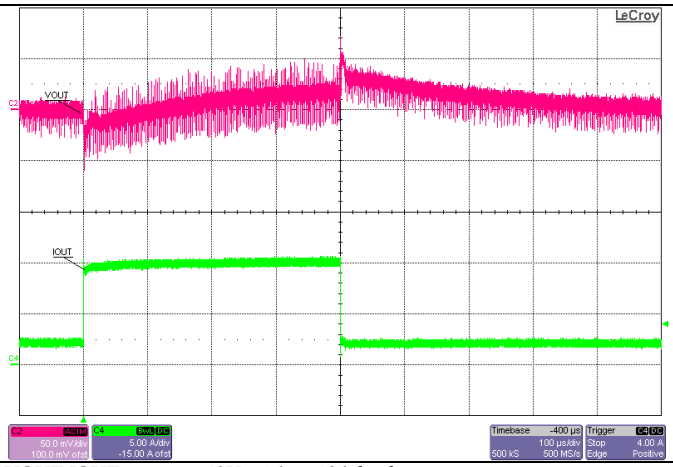
VOUT IOUT transient 5Vin 2A to 10A load step



VOUT IOUT transient 12Vin 2A to 10A load step



VOUT IOUT transient 20Vin 2A to 10A load step

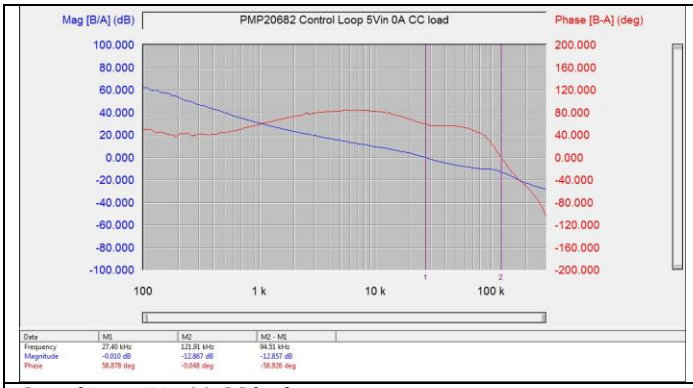


VOUT IOUT transient 40Vin 2A to 10A load step

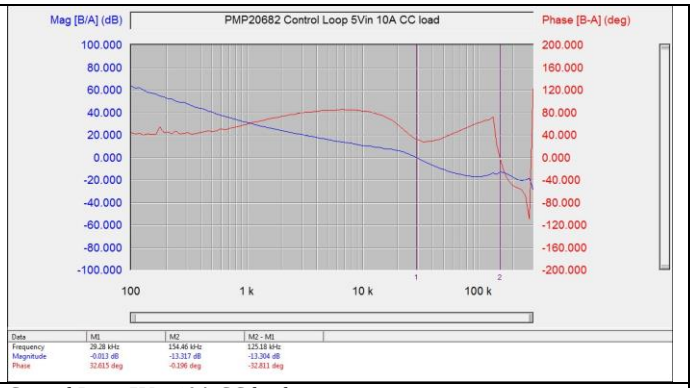
8 Frequency Response

8.1 Frequency Response

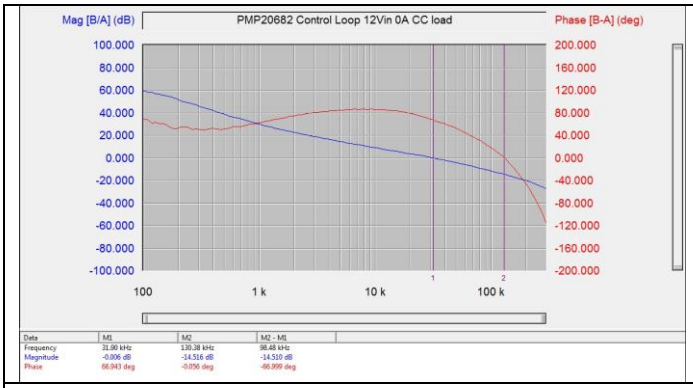
Frequency was measured in forced PWM mode. A constant current electronic load was used for the tests.



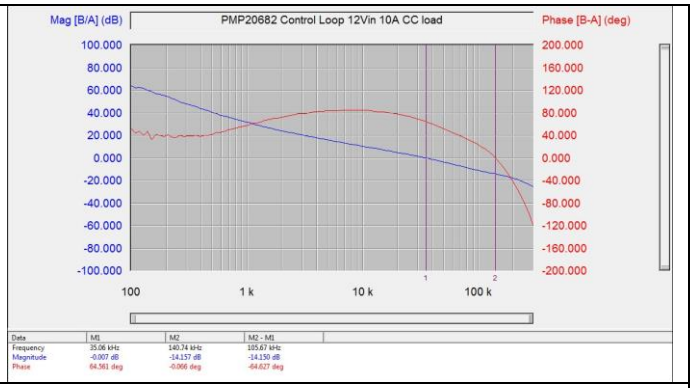
Control Loop 5Vin 0A CC load



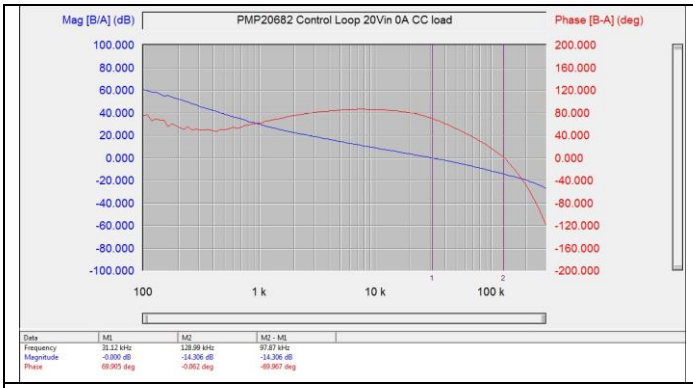
Control Loop 5Vin 10A CC load



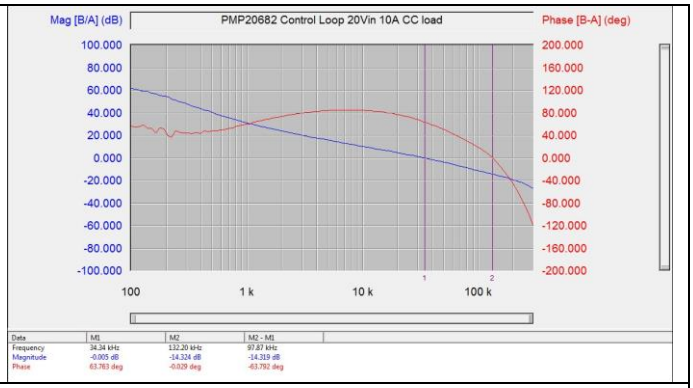
Control Loop 12Vin 0A CC load



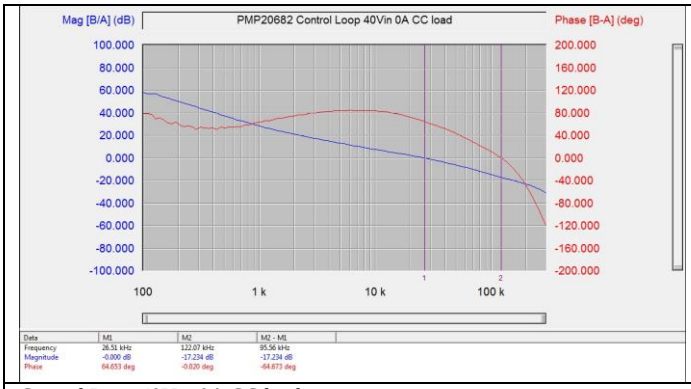
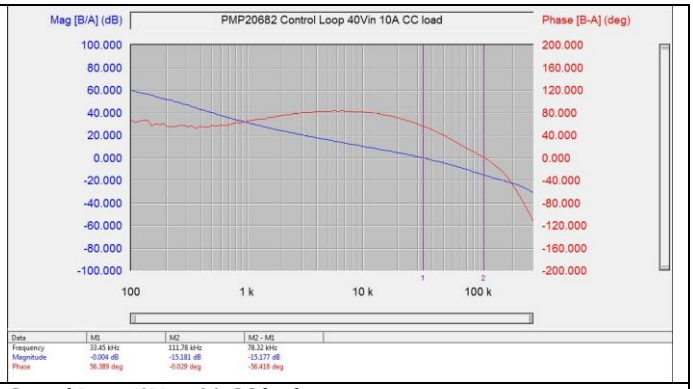
Control Loop 12Vin 10A CC load



Control Loop 20Vin 0A CC load



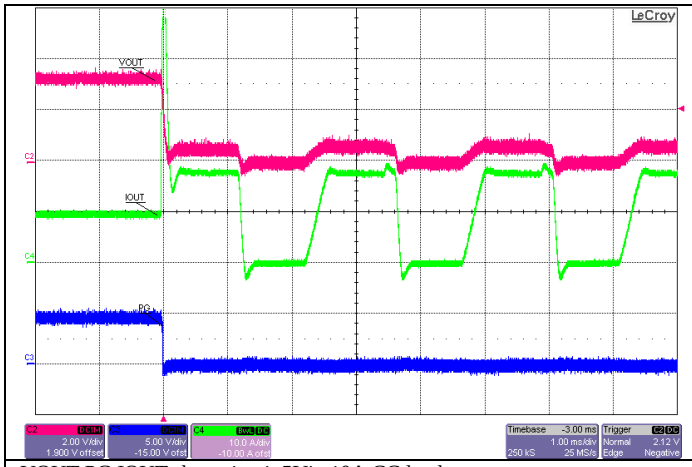
Control Loop 20Vin 10A CC load

	
Control Loop 40Vin 0A CC load	Control Loop 40Vin 10A CC load

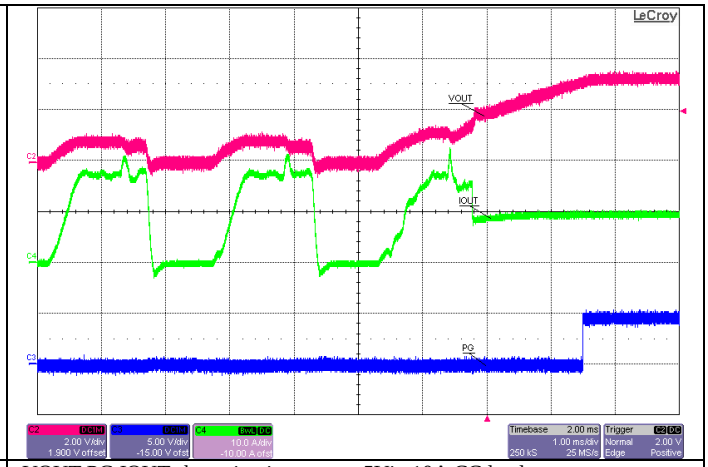
9 Short Circuit

9.1 Short Circuit at 10A Load

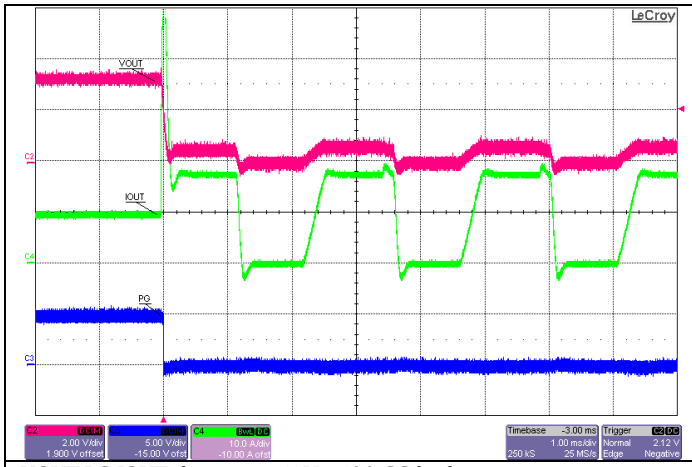
A constant current electronic load was used to test output short circuit protection.



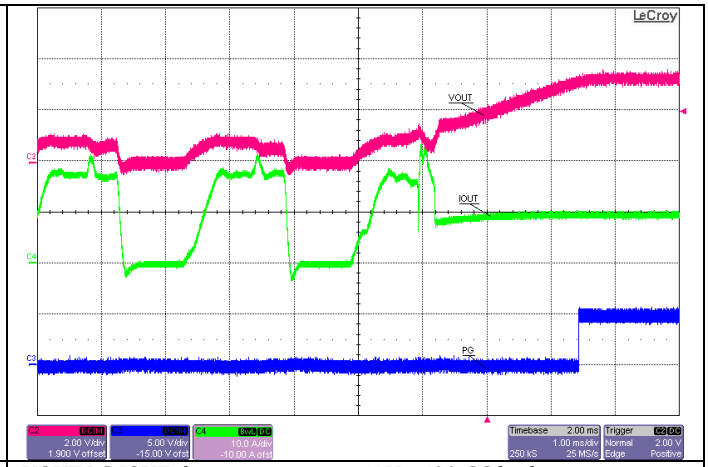
VOUT PG IOUT short circuit 5Vin 10A CC load



VOUT PG IOUT short circuit recovery 5Vin 10A CC load

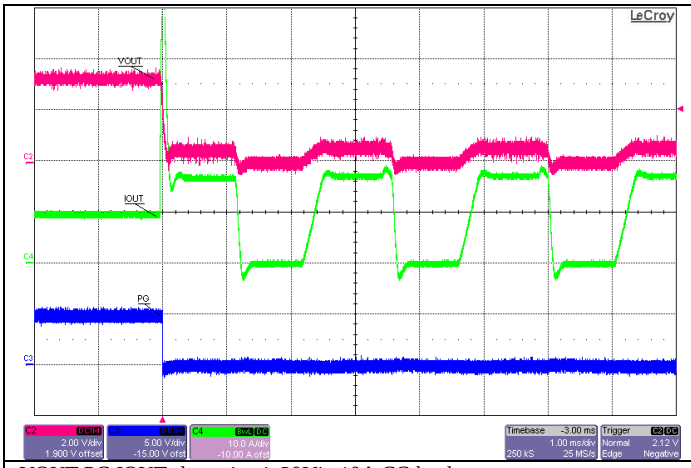


VOUT PG IOUT short circuit 12Vin 10A CC load

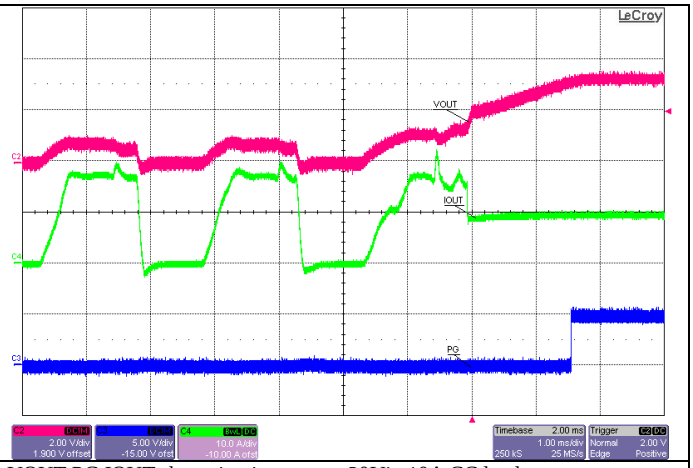


VOUT PG IOUT short circuit recovery 12Vin 10A CC load

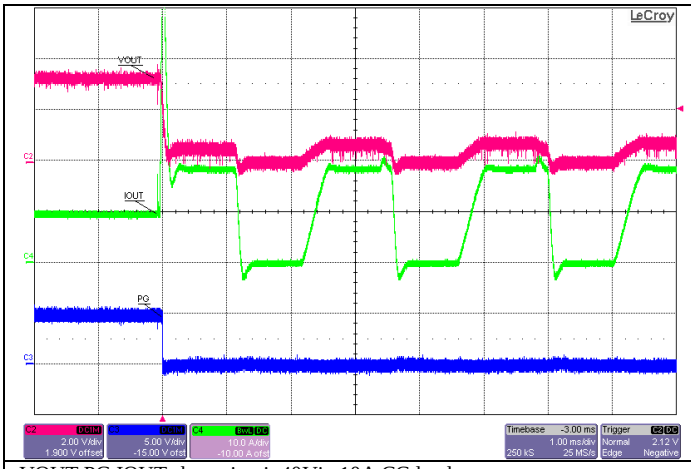
PMP20682 Rev B Test Results



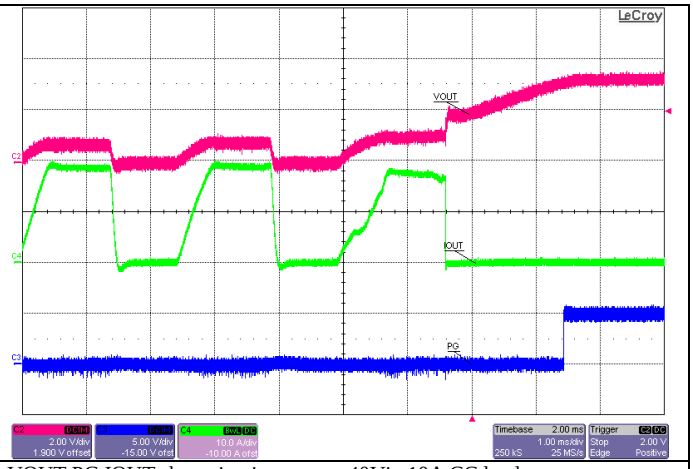
VOUT PG IOUT short circuit 20Vin 10A CC load



VOUT PG IOUT short circuit recovery 20Vin 10A CC load

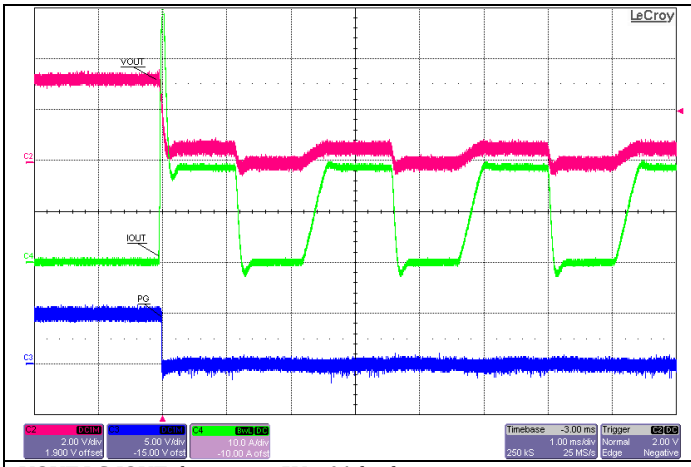


VOUT PG IOUT short circuit 40Vin 10A CC load

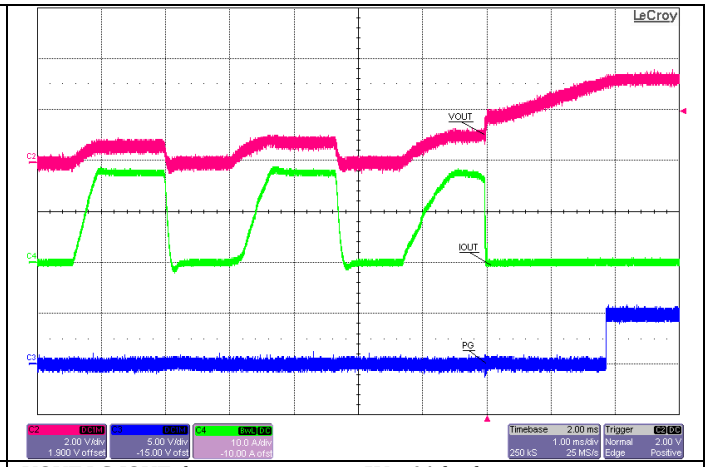


VOUT PG IOUT short circuit recovery 40Vin 10A CC load

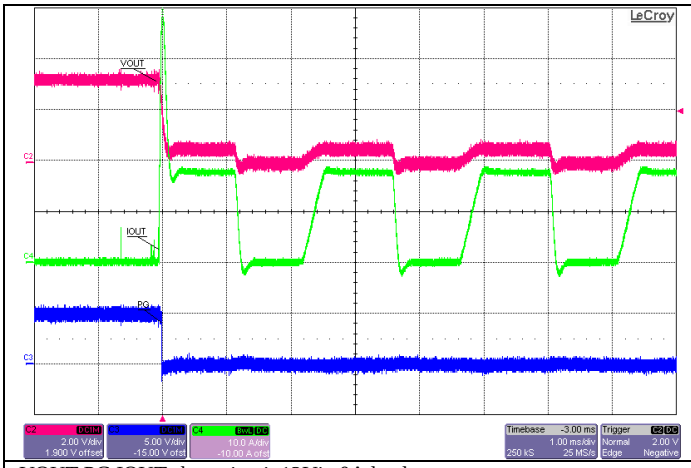
9.1 Short Circuit at 0A Load



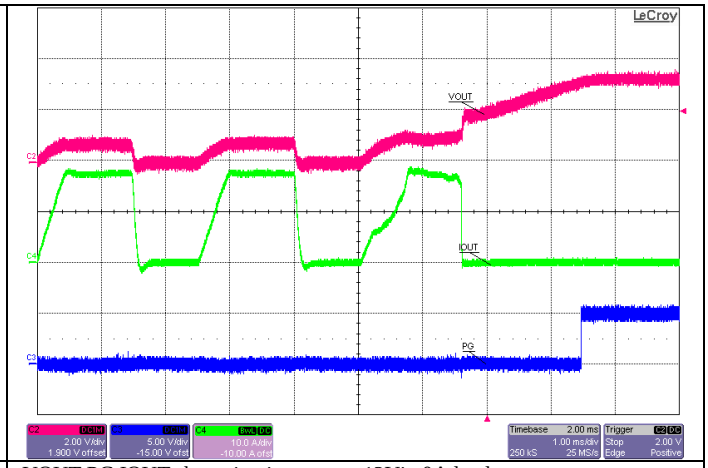
VOUT PG IOUT short circuit 5Vin 0A load



VOUT PG IOUT short circuit recovery 5Vin 0A load

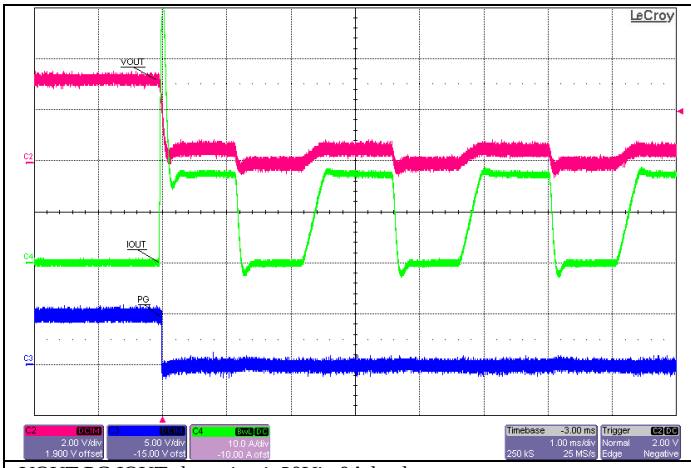


VOUT PG IOUT short circuit 12Vin 0A load

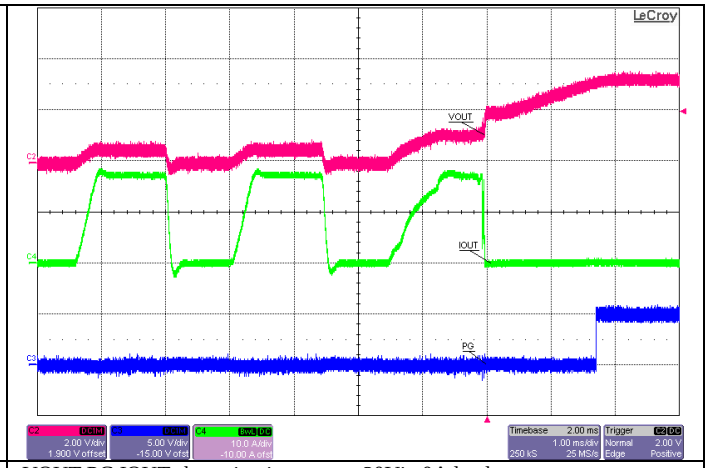


VOUT PG IOUT short circuit recovery 12Vin 0A load

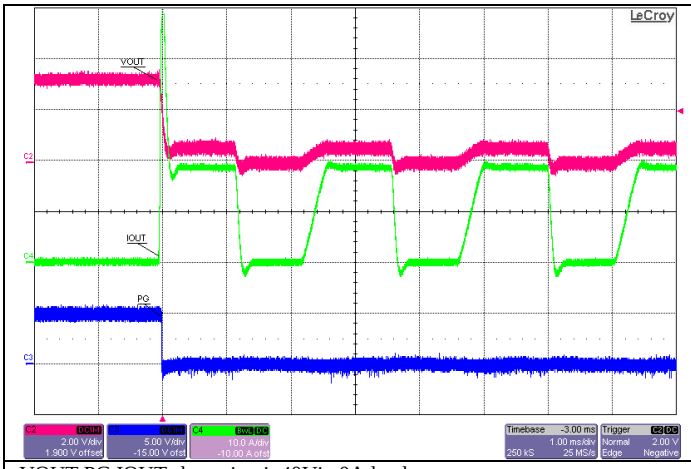
PMP20682 Rev B Test Results



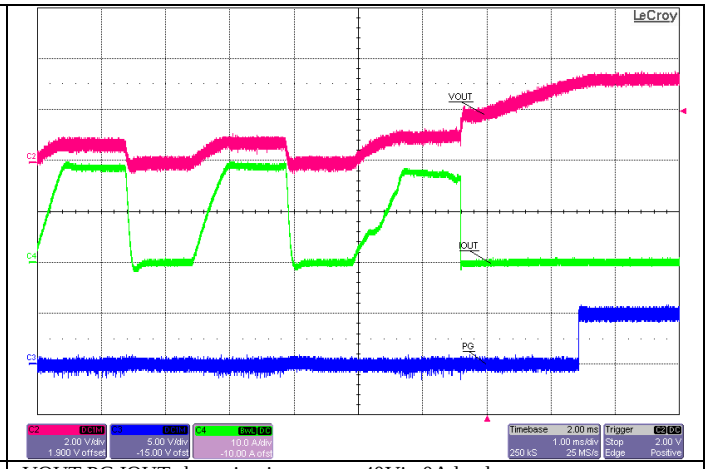
VOUT PG IOUT short circuit 20Vin 0A load



VOUT PG IOUT short circuit recovery 20Vin 0A load



VOUT PG IOUT short circuit 40Vin 0A load



VOUT PG IOUT short circuit recovery 40Vin 0A load

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