



LM5175 Synchronous 4-Switch Buck-Boost Converter

TI reference design number: PMP20042 REV A

Input: 3.5V to 20V DC

Output: Selectable 5V, 9V, 15V or 20V @ 5A

DC – DC Test Results

Table of Contents

Test Specifications.....	3
1 Circuit Description.....	3
2 Board Photos.....	3
3 Efficiency	5
3.1 15V Output Efficiency Results	5
3.2 15V Output Efficiency Data.....	5
3.3 20V Output Efficiency Results	7
3.4 20V Output Efficiency Data.....	7
3.5 5V Output Efficiency Results	9
3.6 5V Output Efficiency Data.....	9
3.7 9V Output Efficiency Results	11
3.8 5V Output Efficiency Data.....	11
4 Thermal	13
4.1 20V Input, 20V at 5A Output.....	13
4.2 12V Input, 20V at 5A Output.....	14
4.3 10V Input, 20V at 5A Output.....	15
5 Startup.....	16
5.1 Startup from Vin.....	16
6 Switching Waveform	17
7.1 8V Input.....	17
6.2 12V Input	18
6.3 20V Input.....	19
7 Output Ripple.....	20
7.1 8Vin	20
7.2 12Vin	20
7.3 20Vin	21
8 Load Transient Response.....	22
8.1 12V Input	22
8.2 20V Input.....	23
9 Output Adjustment.....	24
9.1 5Vout to 20Vout.....	24
10 Frequency Response.....	25
10.1 8V Input	25
10.2 12V Input.....	26
10.3 20V Input	27
11 Short Circuit Tests	28
11.1 Output Short Circuit.....	28
11.2 Output Short Circuit Recovery	29

PMP20042 Test Results

Test Specifications

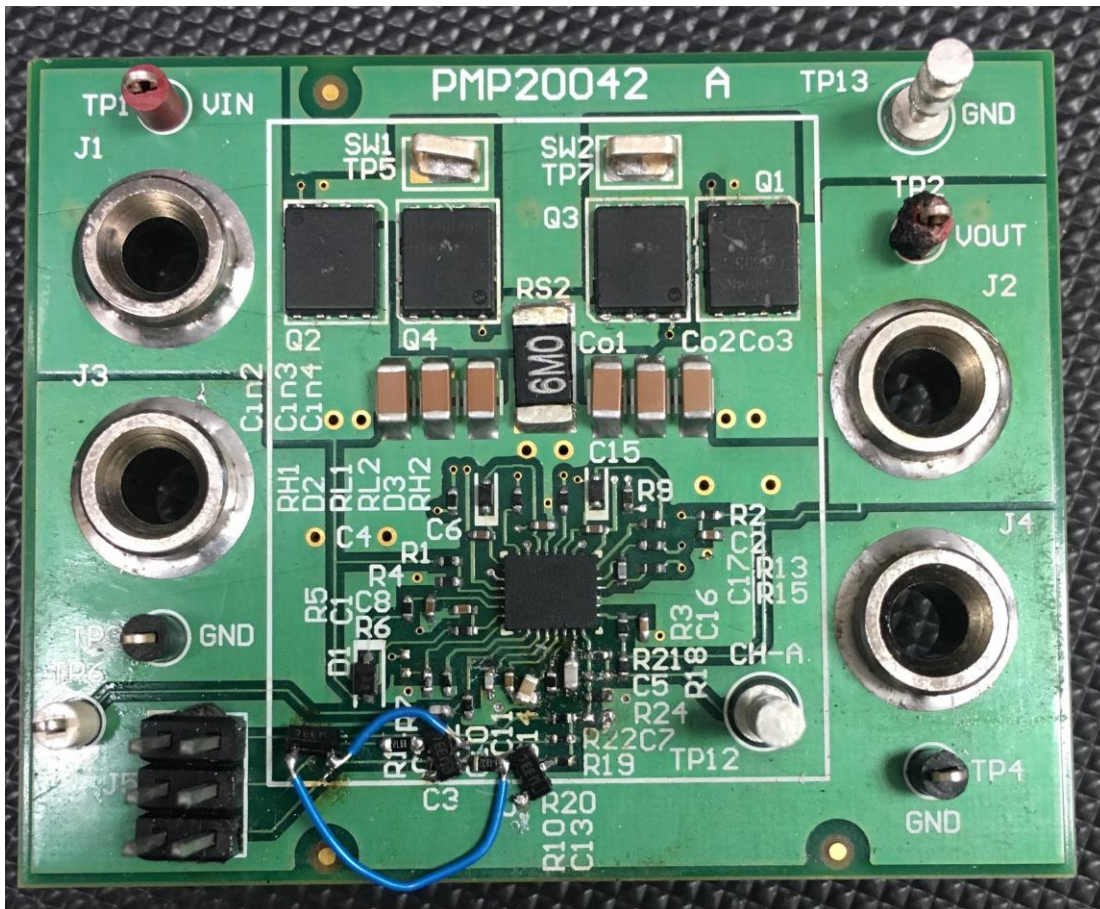
Vin min	3.8V
Vin max	20V
Vout	Selectable 5V, 9V, 15V or 20V
Iout	5A

1 Circuit Description

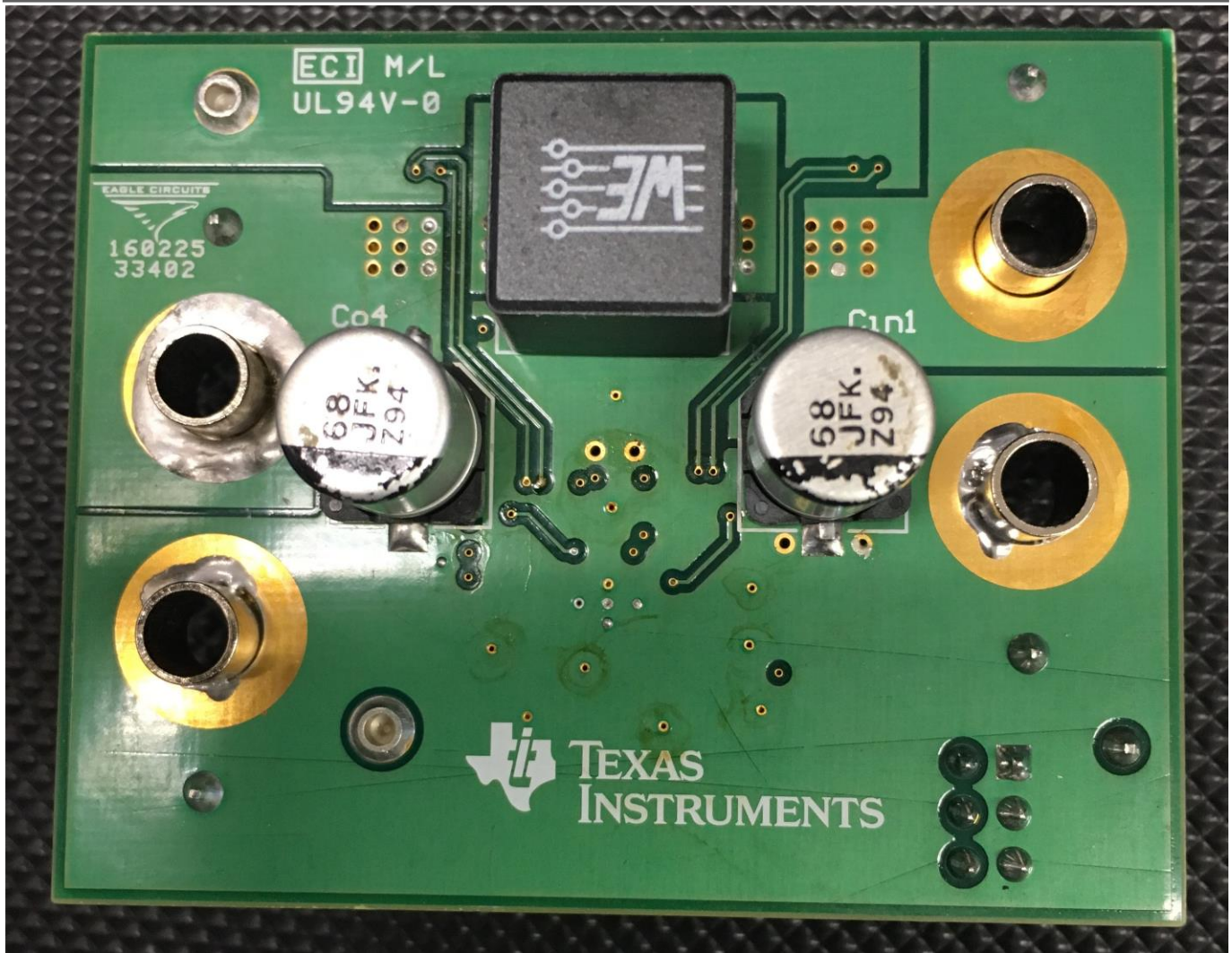
PMP20042 is a synchronous 4-switch buck-boost converter which utilizes the LM5175 controller for USB Type-C™ applications. The output voltage can be selected for 5V, 9V, 15V or 20V at 5A using jumpers or open drain control switches. Additional pulse-by-pulse current limiting is inherent in the current-mode controller. The board includes enable, synchronization and power good functions.

2 Board Photos

The design is built on PMP20042 Rev A printed circuit board. This is a 4-layer PCB with 1 oz. copper on external layers and 0.5 oz. copper on internal layers. PCB dimensions are 57.4mm x 45.7mm.

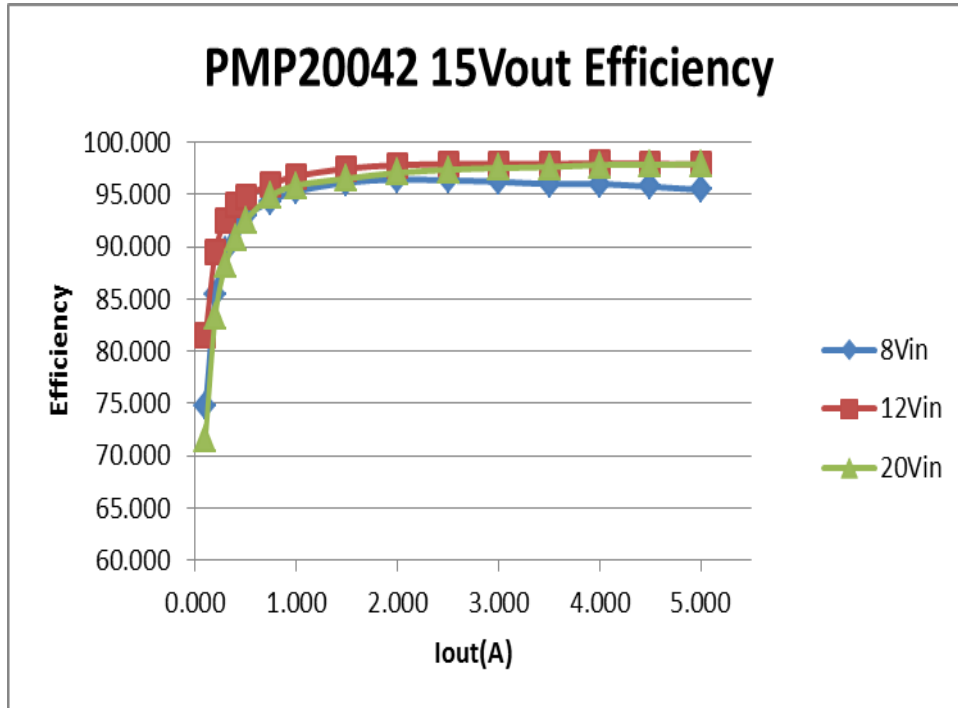


PMP20042 Test Results



3 Efficiency

3.1 15V Output Efficiency Results



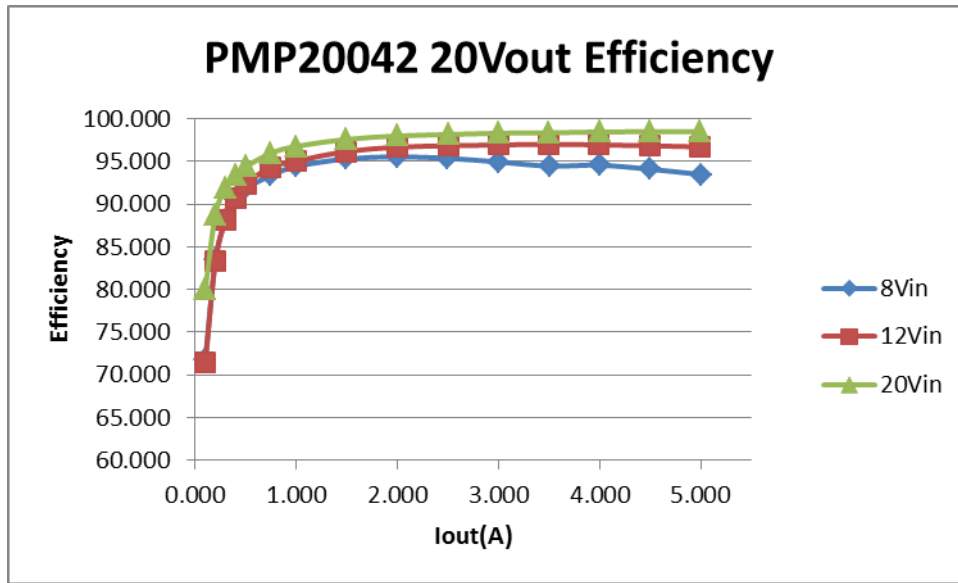
3.2 15V Output Efficiency Data

Vin(V)	Iin(A)	Vout(V)	Iout(A)	Pin(W)	Pout(W)	Loss(W)	Efficiency
7.999	0.062	14.820	0.000	0.497	0.000	0.497	0.000
8.000	0.248	14.820	0.100	1.983	1.482	0.501	74.733
7.999	0.434	14.821	0.200	3.469	2.964	0.505	85.439
7.999	0.620	14.821	0.300	4.956	4.445	0.512	89.679
7.999	0.807	14.822	0.400	6.455	5.926	0.529	91.807
7.999	0.996	14.822	0.500	7.967	7.408	0.558	92.990
7.999	1.472	14.821	0.750	11.777	11.111	0.666	94.348
7.999	1.943	14.821	1.000	15.545	14.814	0.731	95.298
7.999	2.889	14.822	1.499	23.111	22.223	0.888	96.158
7.999	3.841	14.824	1.999	30.726	29.634	1.092	96.445
7.999	4.822	14.824	2.507	38.572	37.170	1.402	96.365
7.999	5.772	14.824	2.997	46.172	44.434	1.738	96.236
7.999	6.773	14.824	3.509	54.176	52.014	2.162	96.009
7.998	7.722	14.833	3.998	61.761	59.310	2.452	96.030
7.998	8.715	14.836	4.499	69.699	66.748	2.951	95.766
7.997	9.716	14.840	4.999	77.702	74.185	3.517	95.474

PMP20042 Test Results

7.997	10.726	14.843	5.499	85.778	81.618	4.160	95.151
12.002	0.028	14.815	0.000	0.335	0.001	0.333	0.442
12.002	0.152	14.815	0.100	1.819	1.483	0.336	81.508
12.002	0.276	14.816	0.200	3.309	2.963	0.346	89.551
12.002	0.400	14.816	0.300	4.802	4.443	0.359	92.531
12.001	0.525	14.816	0.400	6.303	5.923	0.380	93.974
12.001	0.651	14.815	0.500	7.809	7.405	0.405	94.820
12.001	0.964	14.814	0.750	11.571	11.106	0.465	95.984
12.001	1.275	14.814	1.000	15.304	14.808	0.496	96.760
12.001	1.898	14.815	1.499	22.781	22.212	0.569	97.502
12.001	2.523	14.816	1.999	30.275	29.617	0.658	97.826
12.001	3.161	14.816	2.507	37.933	37.144	0.789	97.921
12.001	3.779	14.816	2.998	45.347	44.413	0.934	97.941
12.001	4.423	14.816	3.509	53.080	51.984	1.096	97.935
12.001	5.038	14.821	3.998	60.462	59.260	1.202	98.012
12.000	5.673	14.822	4.499	68.076	66.681	1.396	97.950
12.000	6.309	14.823	4.999	75.708	74.102	1.606	97.879
12.000	6.947	14.826	5.499	83.360	81.520	1.840	97.792
20.005	0.030	14.795	0.000	0.592	0.001	0.591	0.250
20.005	0.103	14.796	0.100	2.071	1.481	0.589	71.530
20.005	0.177	14.796	0.200	3.549	2.959	0.590	83.383
20.005	0.251	14.796	0.300	5.027	4.436	0.591	88.236
20.005	0.325	14.796	0.400	6.508	5.916	0.592	90.903
20.005	0.399	14.797	0.500	7.990	7.395	0.595	92.558
20.005	0.585	14.798	0.750	11.697	11.094	0.603	94.848
20.005	0.771	14.799	1.000	15.430	14.793	0.637	95.872
20.005	1.149	14.799	1.499	22.979	22.184	0.795	96.540
20.005	1.523	14.797	1.999	30.465	29.581	0.884	97.098
20.005	1.904	14.798	2.507	38.091	37.097	0.994	97.391
20.005	2.273	14.798	2.998	45.474	44.361	1.114	97.551
20.005	2.658	14.797	3.508	53.162	51.915	1.247	97.654
20.004	3.025	14.806	3.998	60.509	59.201	1.308	97.838
20.003	3.403	14.808	4.499	68.064	66.618	1.446	97.876
20.003	3.781	14.809	4.999	75.627	74.033	1.594	97.892
20.003	4.160	14.811	5.499	83.202	81.441	1.761	97.884

3.3 20V Output Efficiency Results



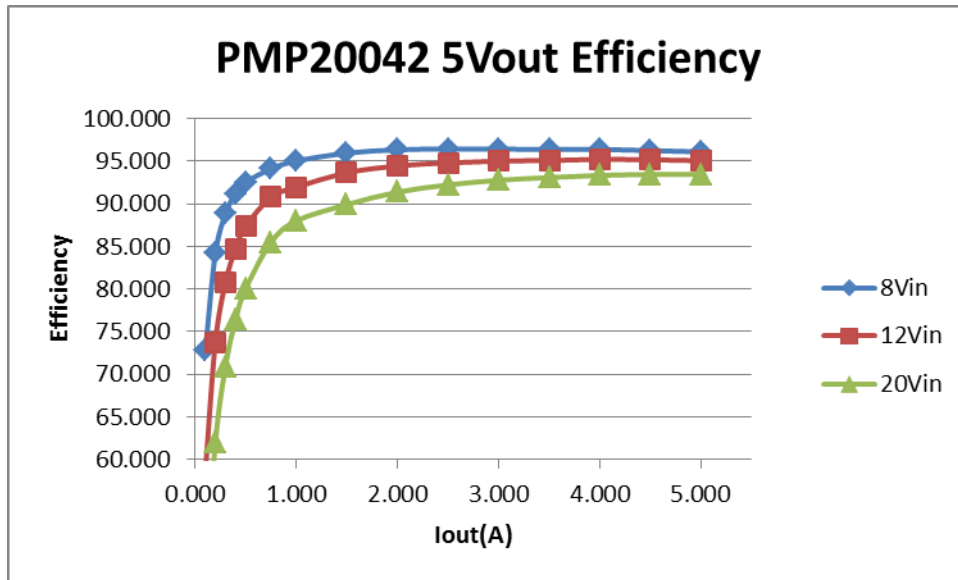
3.4 20V Output Efficiency Data

Vin(V)	Iin(A)	Vout(V)	Iout(A)	Pin(W)	Pout(W)	Loss(W)	Efficiency
8.000	0.097	19.907	0.000	0.778	0.002	0.776	0.256
8.000	0.347	19.908	0.100	2.774	1.991	0.783	71.761
8.000	0.597	19.910	0.200	4.773	3.982	0.791	83.419
8.000	0.847	19.911	0.300	6.774	5.969	0.805	88.122
7.999	1.099	19.912	0.400	8.789	7.961	0.828	90.576
7.999	1.354	19.911	0.500	10.833	9.950	0.883	91.847
7.999	1.998	19.901	0.750	15.979	14.920	1.059	93.371
7.999	2.633	19.899	1.000	21.062	19.889	1.173	94.431
7.999	3.912	19.898	1.499	31.295	29.831	1.464	95.323
7.999	5.205	19.901	1.999	41.629	39.780	1.849	95.559
7.999	6.520	19.903	2.499	52.151	49.743	2.409	95.381
7.999	7.852	19.902	2.997	62.807	59.643	3.164	94.963
7.999	9.236	19.903	3.507	73.875	69.789	4.086	94.469
7.997	10.530	19.928	3.997	84.210	79.645	4.565	94.580
7.996	11.912	19.934	4.497	95.253	89.641	5.612	94.108
7.996	13.353	19.938	5.006	106.777	99.809	6.968	93.474
12.001	0.066	19.902	0.000	0.797	0.000	0.797	0.000
12.001	0.232	19.903	0.100	2.788	1.992	0.796	71.461
12.001	0.398	19.903	0.200	4.780	3.981	0.799	83.275
12.001	0.564	19.904	0.300	6.773	5.969	0.804	88.126
12.001	0.731	19.905	0.400	8.772	7.958	0.814	90.723
12.001	0.897	19.906	0.500	10.770	9.947	0.823	92.360

PMP20042 Test Results

12.001	1.318	19.905	0.750	15.815	14.923	0.892	94.359
12.001	1.743	19.896	1.000	20.920	19.886	1.034	95.059
12.001	2.584	19.893	1.499	31.007	29.825	1.182	96.189
12.001	3.427	19.892	1.999	41.125	39.764	1.361	96.691
12.000	4.284	19.892	2.503	51.414	49.797	1.617	96.856
12.001	5.133	19.891	3.002	61.602	59.722	1.880	96.949
12.001	5.979	19.892	3.500	71.752	69.621	2.131	97.030
12.000	6.837	19.904	3.996	82.042	79.540	2.501	96.951
12.000	7.704	19.910	4.497	92.443	89.534	2.910	96.853
12.000	8.575	19.917	4.997	102.897	99.523	3.373	96.722
12.000	9.451	19.923	5.497	113.406	109.513	3.893	96.567
20.006	0.025	19.871	0.000	0.504	0.002	0.502	0.394
20.005	0.124	19.873	0.100	2.485	1.989	0.495	80.061
20.005	0.224	19.874	0.200	4.477	3.975	0.502	88.778
20.005	0.324	19.875	0.300	6.482	5.960	0.521	91.959
20.005	0.425	19.875	0.400	8.502	7.946	0.556	93.459
20.005	0.526	19.874	0.500	10.523	9.933	0.590	94.396
20.005	0.776	19.875	0.750	15.524	14.900	0.624	95.982
20.005	1.026	19.872	1.000	20.523	19.862	0.661	96.780
20.005	1.526	19.874	1.499	30.527	29.797	0.731	97.607
20.005	2.026	19.875	1.999	40.538	39.730	0.808	98.008
20.005	2.534	19.876	2.504	50.690	49.765	0.925	98.175
20.005	3.033	19.876	3.002	60.681	59.666	1.015	98.327
20.005	3.535	19.876	3.500	70.716	69.565	1.151	98.373
20.004	4.034	19.884	3.997	80.698	79.467	1.231	98.475
20.004	4.539	19.886	4.497	90.792	89.425	1.367	98.494
20.004	5.044	19.889	4.997	100.909	99.391	1.518	98.496
20.004	5.551	19.892	5.497	111.034	109.347	1.687	98.480

3.5 5V Output Efficiency Results



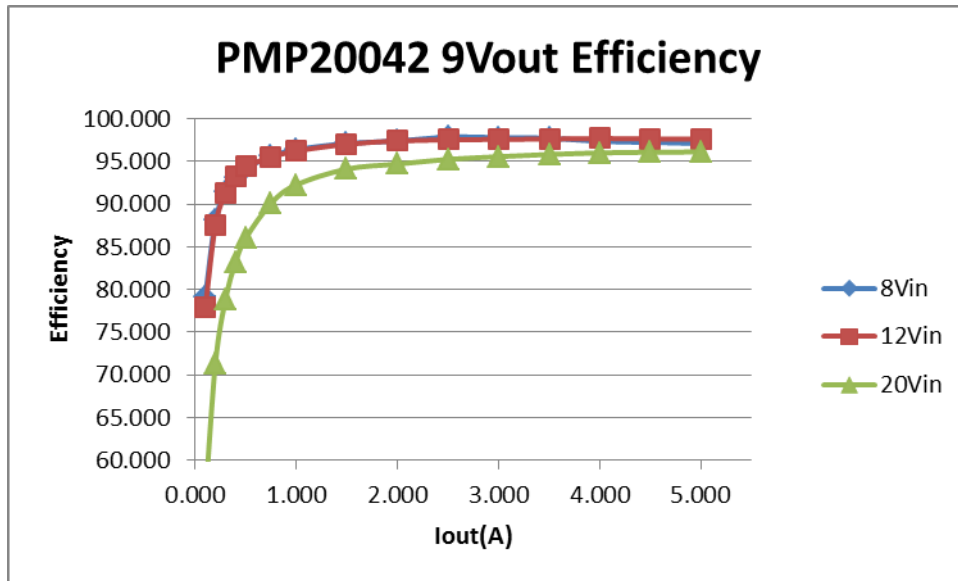
3.6 5V Output Efficiency Data

Vin(V)	Iin(A)	Vout(V)	Iout(A)	Pin(W)	Pout(W)	Loss(W)	Efficiency
7.999	0.023	4.972	0.000	0.186	0.000	0.186	0.000
8.000	0.085	4.972	0.100	0.683	0.498	0.186	72.846
7.999	0.148	4.972	0.200	1.181	0.994	0.186	84.219
7.999	0.210	4.972	0.300	1.678	1.491	0.187	88.848
7.999	0.272	4.972	0.400	2.179	1.988	0.191	91.226
7.999	0.336	4.972	0.500	2.685	2.485	0.200	92.536
7.999	0.495	4.972	0.750	3.961	3.728	0.234	94.100
7.999	0.654	4.971	1.000	5.229	4.969	0.260	95.027
7.999	0.971	4.971	1.499	7.767	7.453	0.314	95.961
7.999	1.289	4.972	1.999	10.314	9.938	0.376	96.358
7.999	1.615	4.972	2.507	12.920	12.462	0.459	96.449
7.999	1.937	4.972	3.006	15.495	14.944	0.552	96.440
7.999	2.261	4.972	3.506	18.086	17.431	0.654	96.382
7.999	2.581	4.973	4.001	20.644	19.900	0.744	96.394
7.998	2.908	4.974	4.502	23.261	22.390	0.870	96.258
7.998	3.237	4.974	5.002	25.886	24.878	1.008	96.105
7.998	3.566	4.974	5.501	28.522	27.365	1.157	95.943
12.001	0.029	4.972	0.000	0.352	0.000	0.352	0.000
12.001	0.071	4.971	0.100	0.850	0.498	0.352	58.568
12.001	0.112	4.971	0.200	1.348	0.994	0.353	73.775
12.001	0.154	4.971	0.300	1.846	1.491	0.355	80.774

PMP20042 Test Results

12.001	0.195	4.971	0.400	2.345	1.988	0.357	84.756
12.001	0.237	4.972	0.500	2.844	2.485	0.359	87.361
12.001	0.342	4.972	0.750	4.106	3.727	0.378	90.784
12.001	0.450	4.971	1.000	5.404	4.969	0.435	91.958
12.001	0.663	4.970	1.499	7.957	7.451	0.505	93.649
12.001	0.876	4.970	1.999	10.518	9.935	0.583	94.460
12.001	1.095	4.970	2.506	13.136	12.457	0.680	94.826
12.001	1.310	4.970	3.006	15.720	14.938	0.782	95.026
12.001	1.527	4.970	3.506	18.322	17.423	0.899	95.096
12.000	1.740	4.970	4.001	20.881	19.884	0.997	95.223
12.000	1.959	4.970	4.502	23.507	22.372	1.134	95.175
12.000	2.179	4.970	5.002	26.146	24.859	1.288	95.076
11.999	2.400	4.970	5.501	28.795	27.343	1.452	94.958
20.005	0.031	4.982	0.000	0.612	0.000	0.612	0.000
20.005	0.055	4.982	0.100	1.108	0.499	0.610	44.994
20.005	0.080	4.981	0.200	1.608	0.996	0.612	61.941
20.005	0.105	4.981	0.300	2.107	1.494	0.613	70.919
20.005	0.130	4.981	0.400	2.607	1.992	0.615	76.403
20.005	0.155	4.981	0.500	3.111	2.490	0.621	80.036
20.005	0.218	4.981	0.750	4.369	3.734	0.635	85.470
20.005	0.283	4.981	1.000	5.657	4.979	0.679	88.000
20.005	0.415	4.979	1.499	8.302	7.465	0.837	89.916
20.005	0.544	4.977	1.999	10.889	9.950	0.939	91.379
20.005	0.676	4.977	2.505	13.519	12.470	1.049	92.241
20.005	0.806	4.977	3.005	16.120	14.956	1.163	92.783
20.005	0.937	4.977	3.505	18.738	17.446	1.293	93.101
20.004	1.066	4.976	4.001	21.326	19.908	1.418	93.349
20.004	1.198	4.975	4.502	23.967	22.396	1.570	93.449
20.003	1.331	4.975	5.002	26.623	24.882	1.741	93.461
20.003	1.464	4.974	5.501	29.290	27.366	1.925	93.429

3.7 9V Output Efficiency Results



3.8 5V Output Efficiency Data

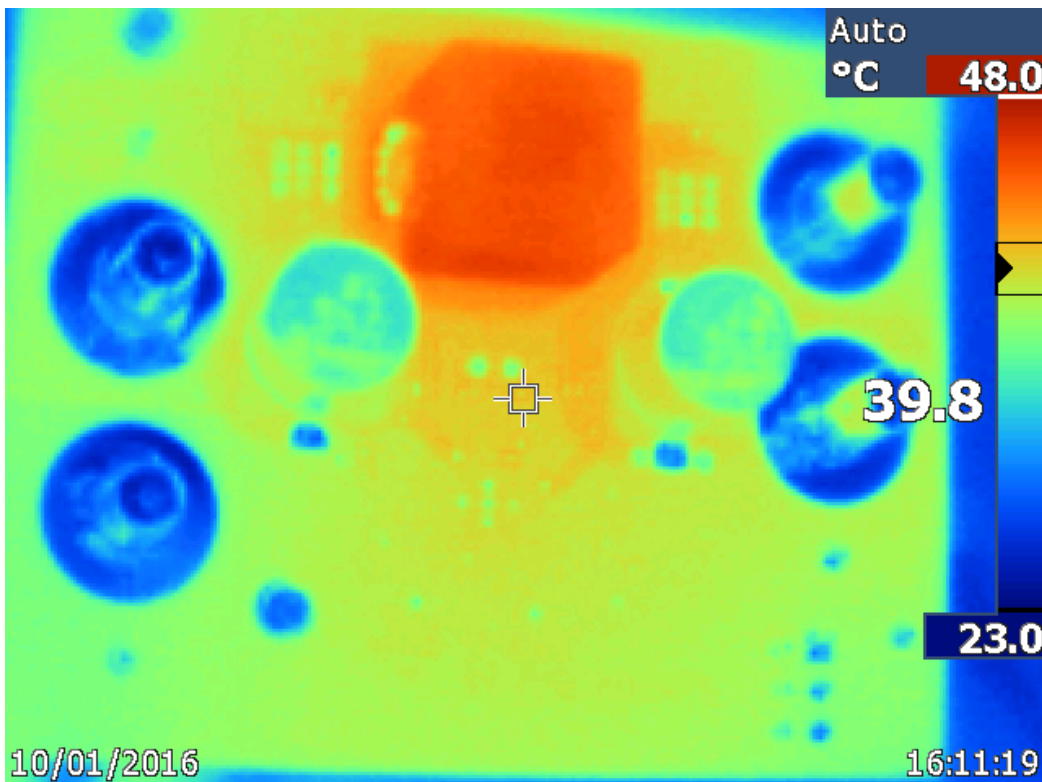
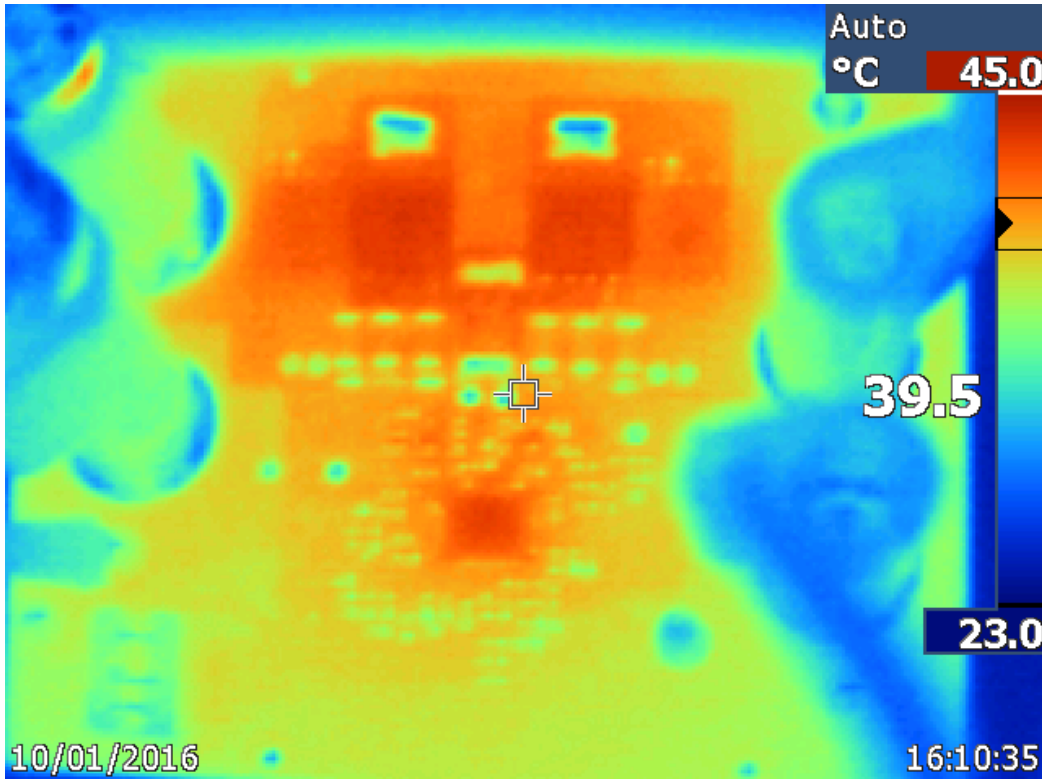
Vin(V)	Iin(A)	Vout(V)	Iout(A)	Pin(W)	Pout(W)	Loss(W)	Efficiency
8.000	0.029	8.961	0.000	0.229	0.000	0.229	0.000
7.999	0.142	8.961	0.100	1.133	0.897	0.236	79.192
7.999	0.254	8.961	0.200	2.035	1.792	0.243	88.071
7.999	0.367	8.961	0.300	2.939	2.687	0.252	91.441
7.999	0.481	8.960	0.399	3.846	3.579	0.267	93.051
7.999	0.594	8.961	0.500	4.755	4.479	0.276	94.190
7.999	0.878	8.961	0.750	7.027	6.718	0.309	95.609
7.999	1.162	8.962	1.000	9.292	8.957	0.335	96.398
7.999	1.730	8.962	1.499	13.835	13.437	0.398	97.123
7.999	2.300	8.964	1.999	18.395	17.918	0.476	97.410
7.999	2.867	8.963	2.505	22.936	22.449	0.487	97.876
7.999	3.441	8.963	3.004	27.525	26.923	0.602	97.813
7.999	4.020	8.963	3.506	32.151	31.426	0.725	97.744
7.999	4.606	8.967	4.001	36.841	35.871	0.970	97.367
7.999	5.189	8.968	4.501	41.504	40.364	1.141	97.252
7.998	5.774	8.968	5.001	46.185	44.852	1.333	97.114
7.998	6.362	8.970	5.501	50.888	49.339	1.549	96.956
12.001	0.021	8.954	0.000	0.254	0.001	0.254	0.352
12.001	0.096	8.954	0.100	1.150	0.896	0.253	77.955
12.001	0.170	8.954	0.200	2.045	1.791	0.254	87.571
12.001	0.245	8.955	0.300	2.940	2.686	0.255	91.334
12.001	0.320	8.955	0.400	3.838	3.580	0.258	93.278

PMP20042 Test Results

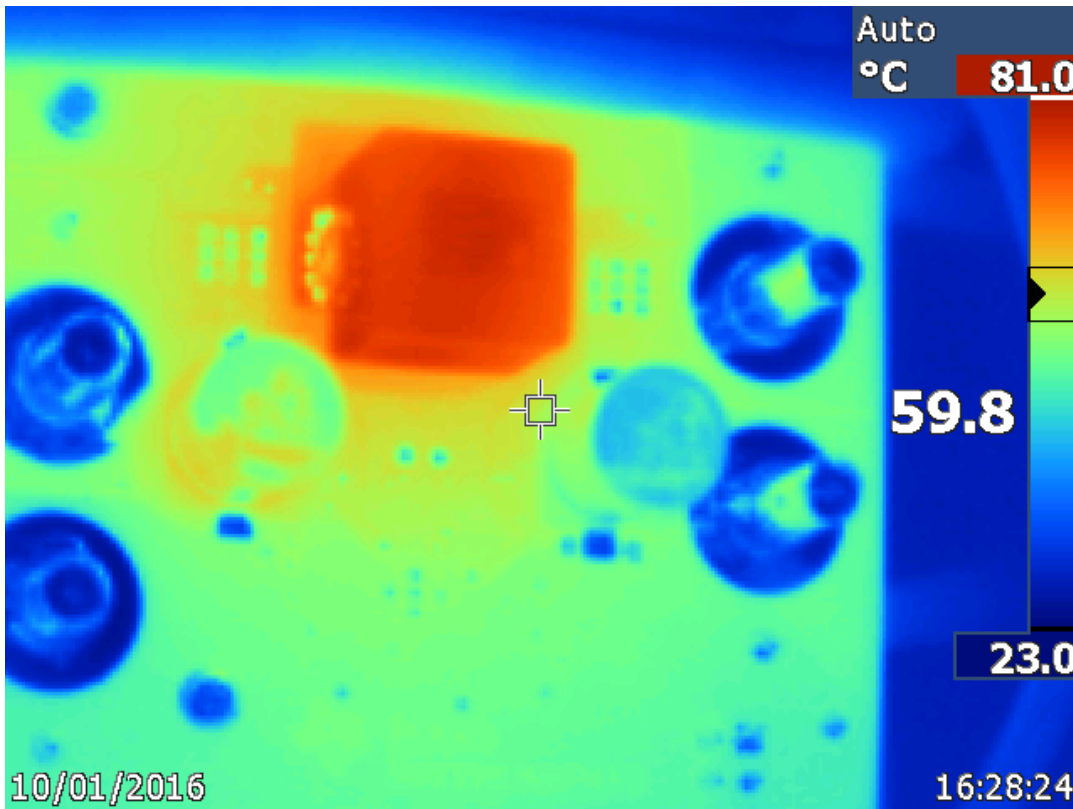
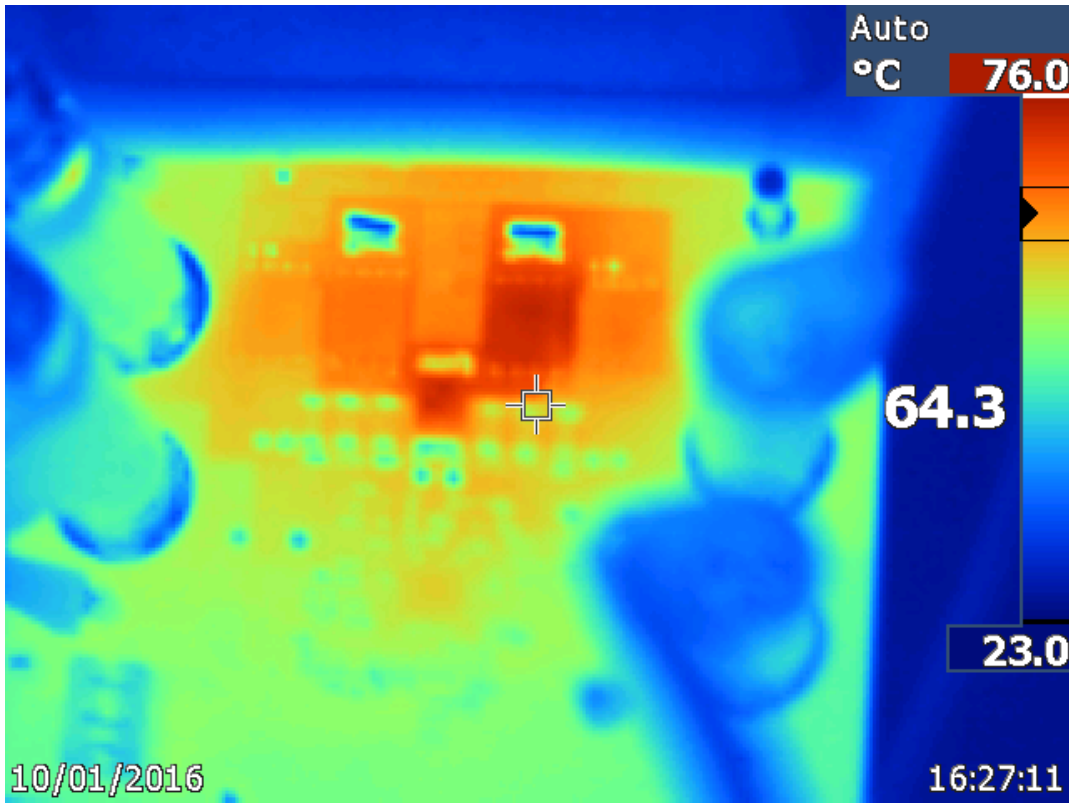
12.002	0.395	8.955	0.500	4.742	4.476	0.266	94.389
12.001	0.586	8.956	0.750	7.030	6.714	0.316	95.506
12.001	0.775	8.955	1.000	9.300	8.950	0.349	96.242
12.001	1.153	8.955	1.499	13.836	13.426	0.411	97.033
12.001	1.531	8.956	1.999	18.378	17.903	0.474	97.418
12.001	1.916	8.956	2.505	22.995	22.432	0.563	97.552
12.001	2.297	8.956	3.004	27.560	26.901	0.660	97.607
12.001	2.679	8.957	3.505	32.147	31.389	0.758	97.642
12.000	3.057	8.960	4.000	36.684	35.843	0.841	97.707
12.000	3.441	8.961	4.501	41.296	40.333	0.963	97.669
12.000	3.826	8.962	5.001	45.916	44.819	1.097	97.611
12.000	4.212	8.963	5.501	50.542	49.300	1.241	97.544
20.005	0.036	8.954	0.000	0.720	0.000	0.720	0.000
20.005	0.081	8.954	0.100	1.616	0.896	0.720	55.450
20.005	0.126	8.954	0.200	2.511	1.791	0.720	71.329
20.005	0.170	8.954	0.300	3.407	2.685	0.722	78.820
20.005	0.215	8.954	0.400	4.303	3.581	0.722	83.214
20.005	0.260	8.954	0.500	5.203	4.475	0.728	86.006
20.005	0.372	8.954	0.750	7.450	6.713	0.737	90.106
20.005	0.485	8.954	1.000	9.700	8.950	0.750	92.267
20.005	0.713	8.953	1.499	14.261	13.424	0.838	94.127
20.004	0.944	8.951	1.999	18.892	17.892	1.000	94.708
20.004	1.176	8.950	2.505	23.533	22.420	1.113	95.271
20.004	1.406	8.950	3.003	28.118	26.877	1.241	95.585
20.005	1.636	8.950	3.504	32.722	31.363	1.359	95.848
20.003	1.864	8.950	4.001	37.286	35.804	1.482	96.026
20.002	2.096	8.949	4.501	41.915	40.280	1.635	96.100
20.002	2.328	8.950	5.001	46.563	44.760	1.803	96.127
20.002	2.561	8.950	5.501	51.218	49.230	1.988	96.118

4 Thermal

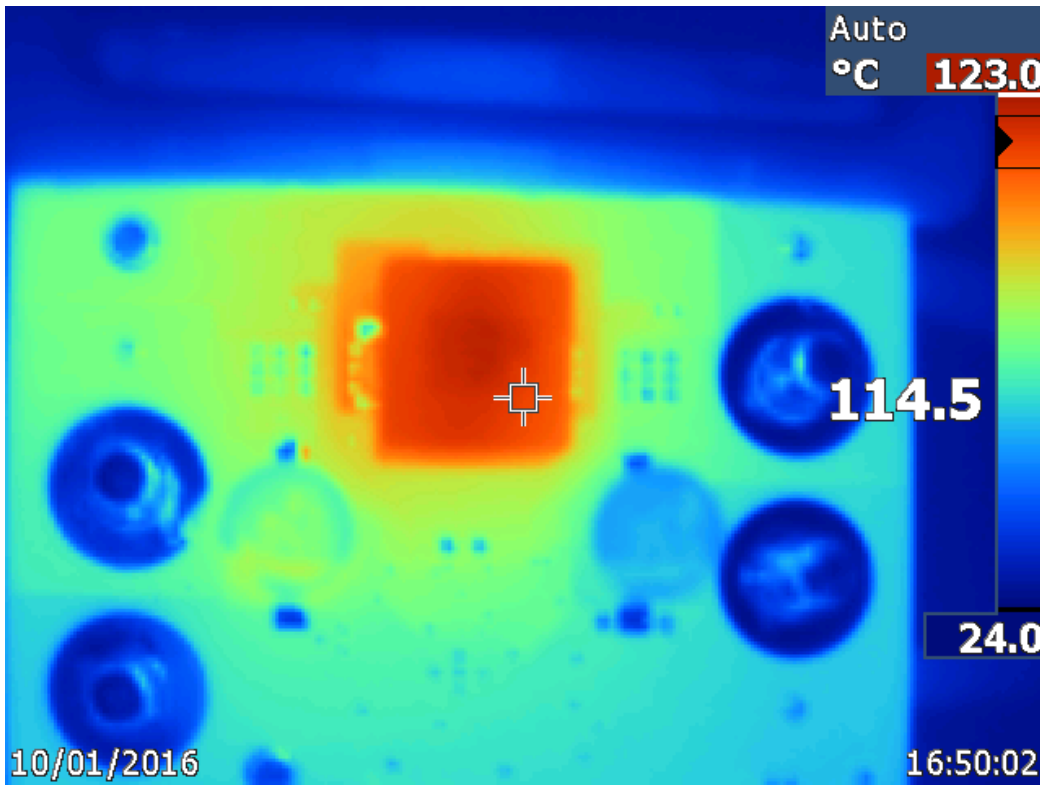
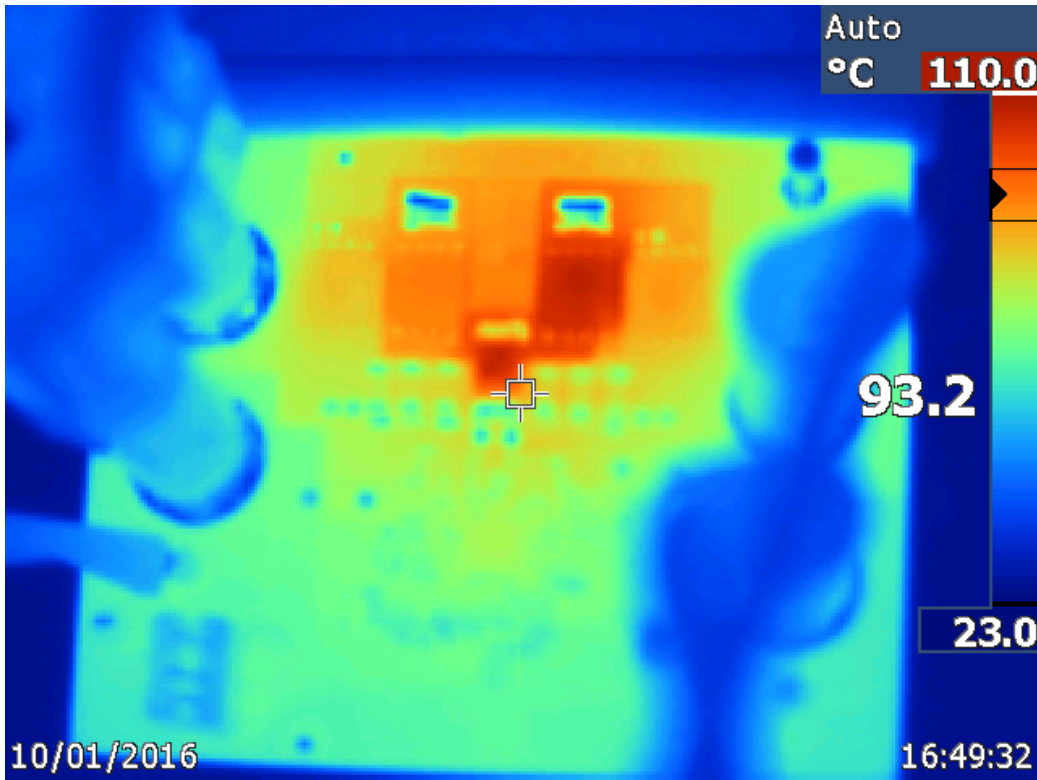
4.1 20V Input, 20V at 5A Output



4.2 12V Input, 20V at 5A Output

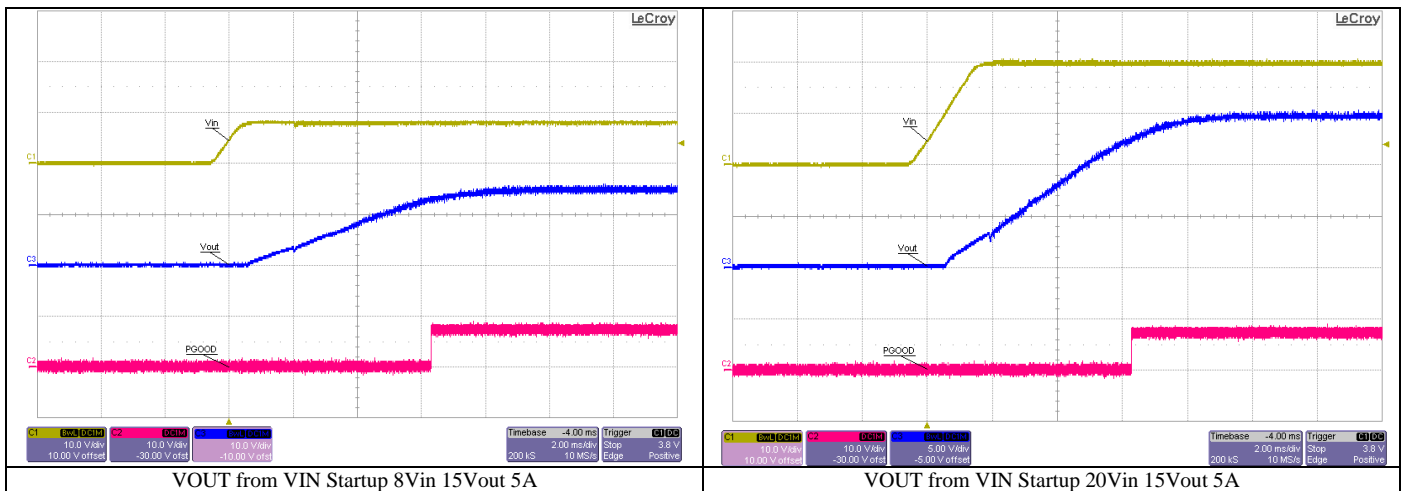
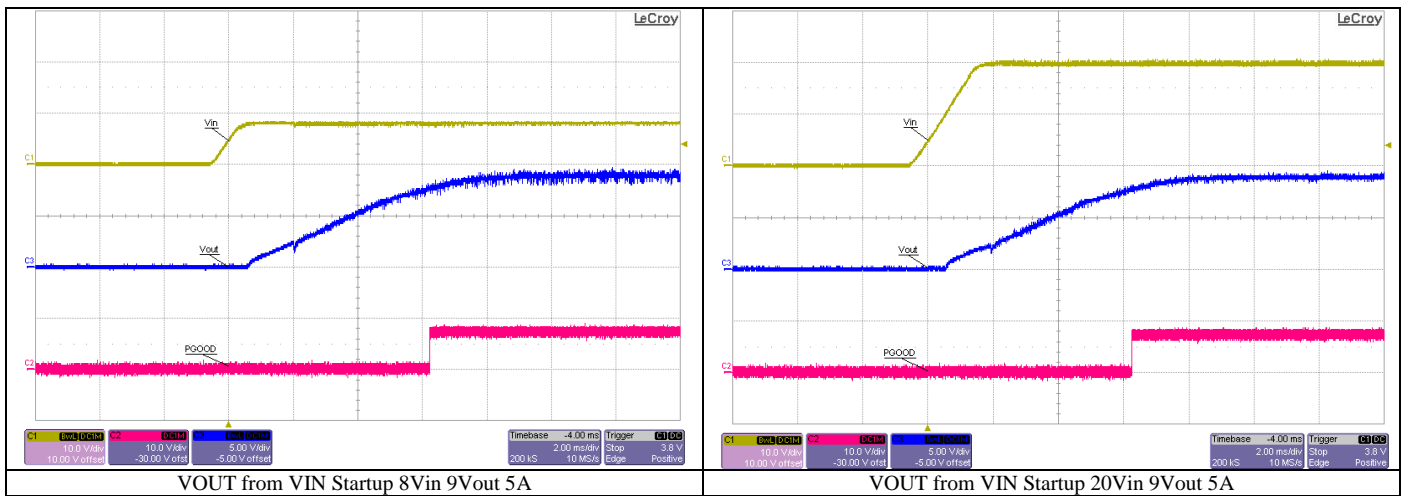
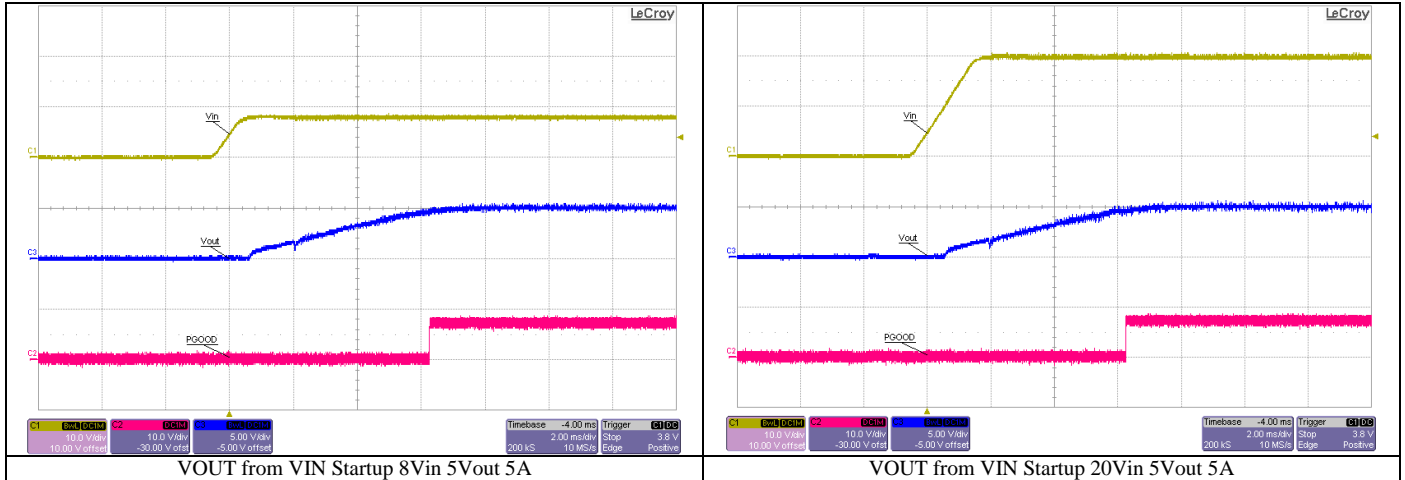


4.3 10V Input, 20V at 5A Output

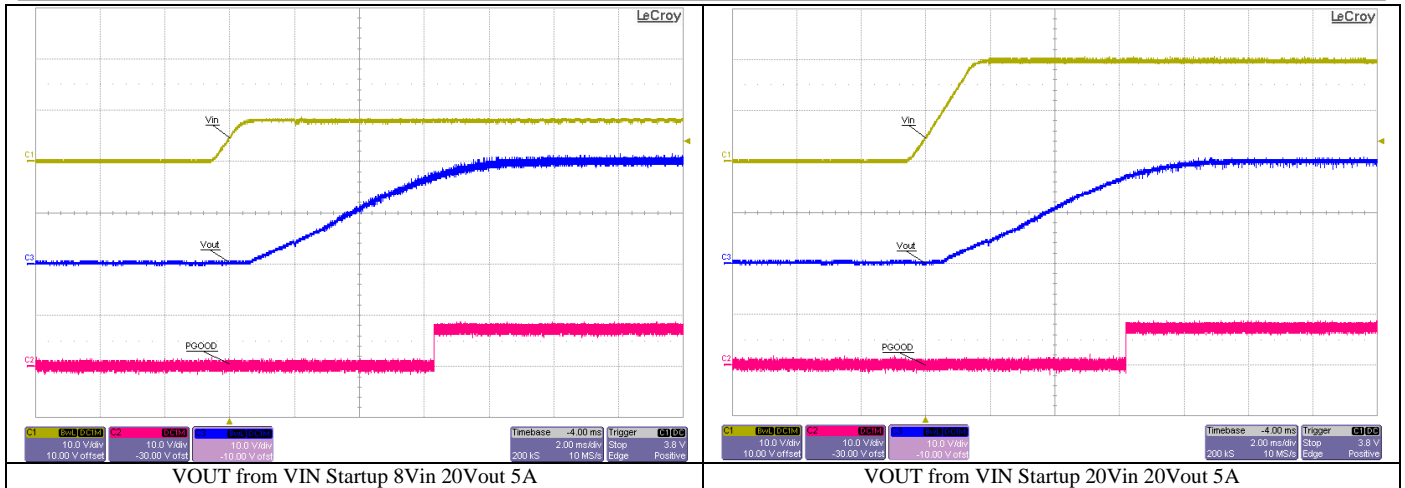


5 Startup

5.1 Startup from Vin

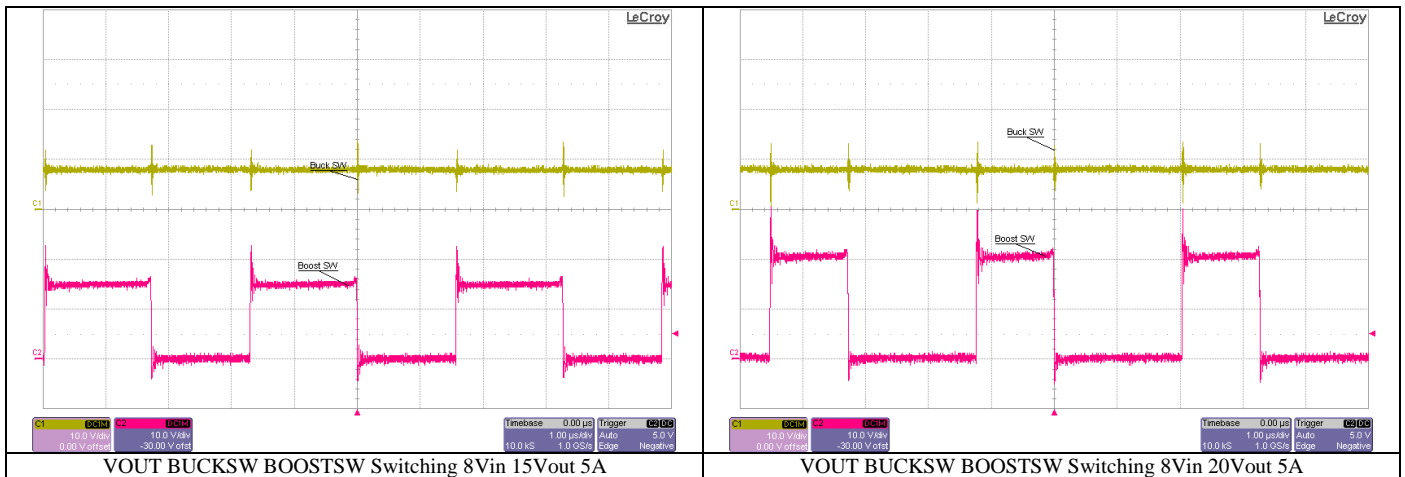
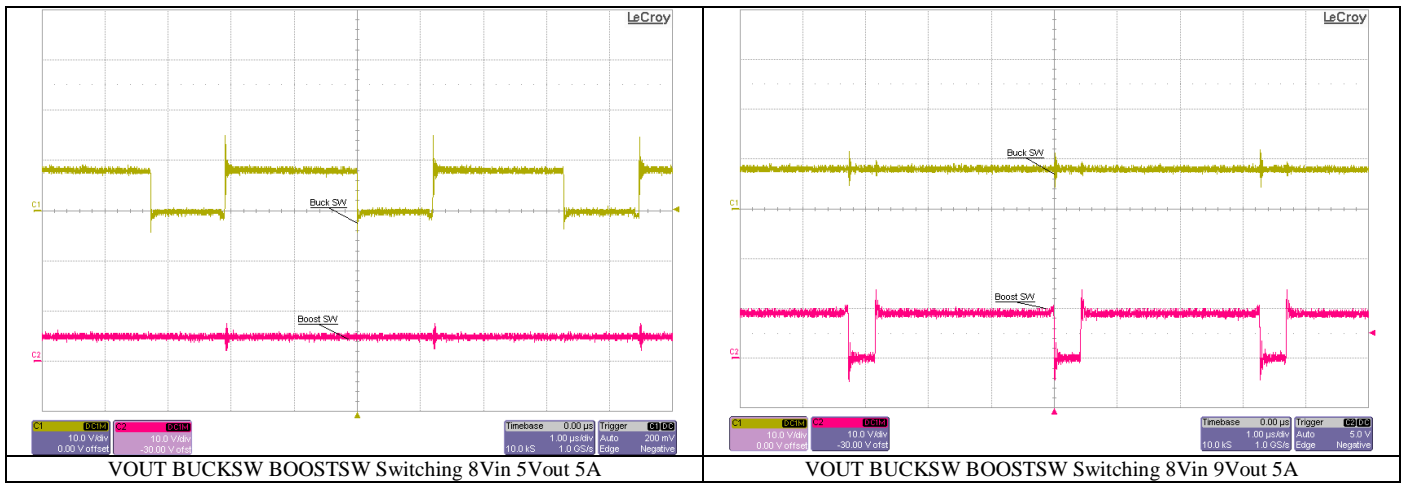


PMP20042 Test Results

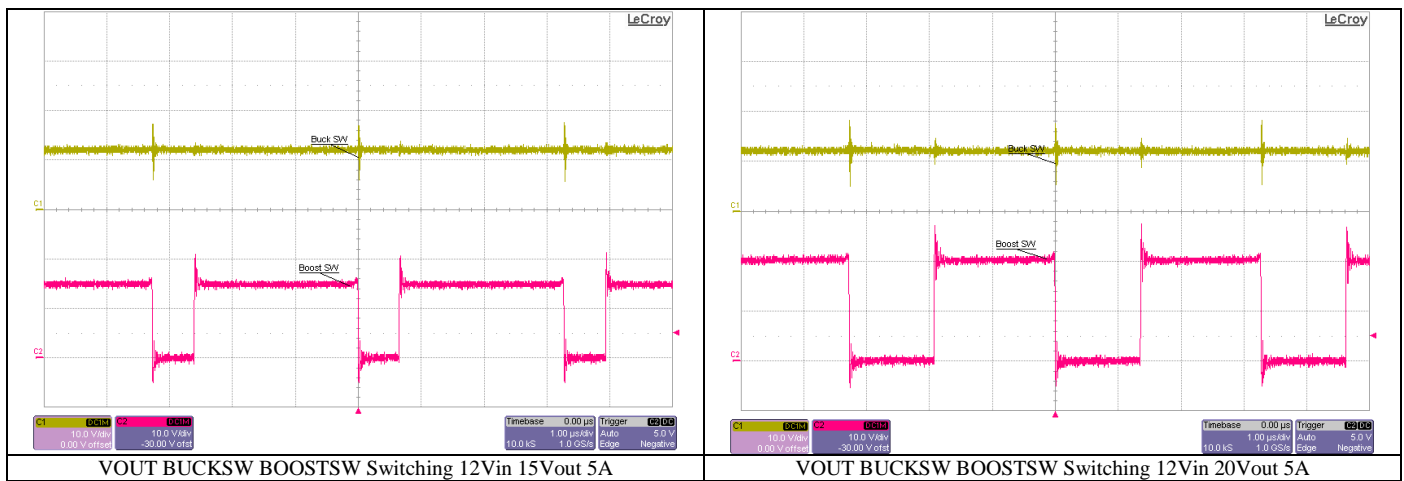
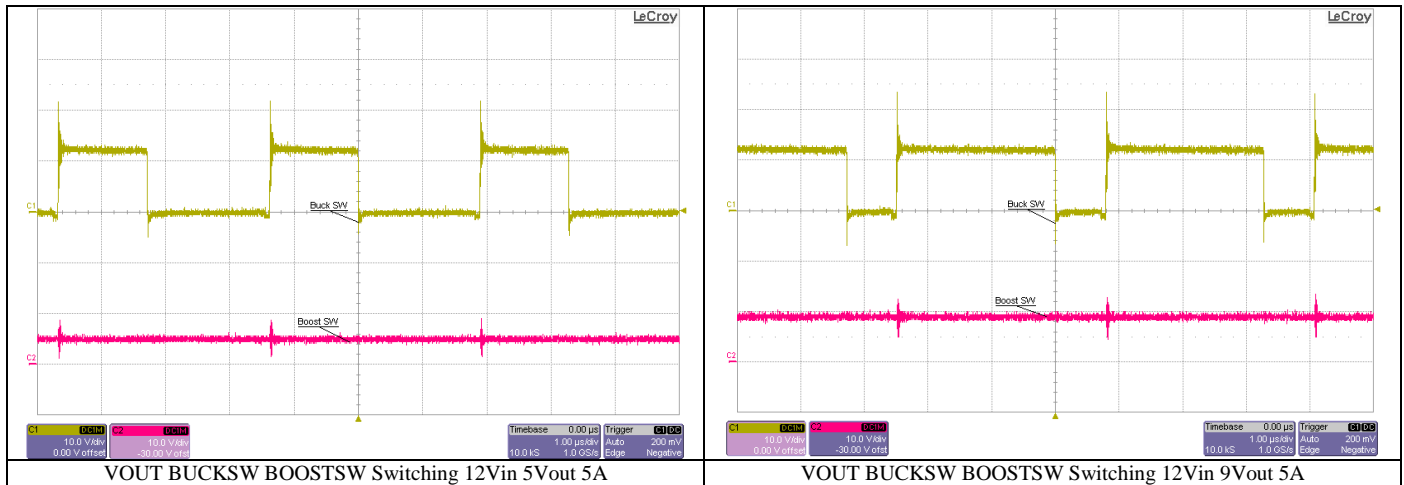


6 Switching Waveform

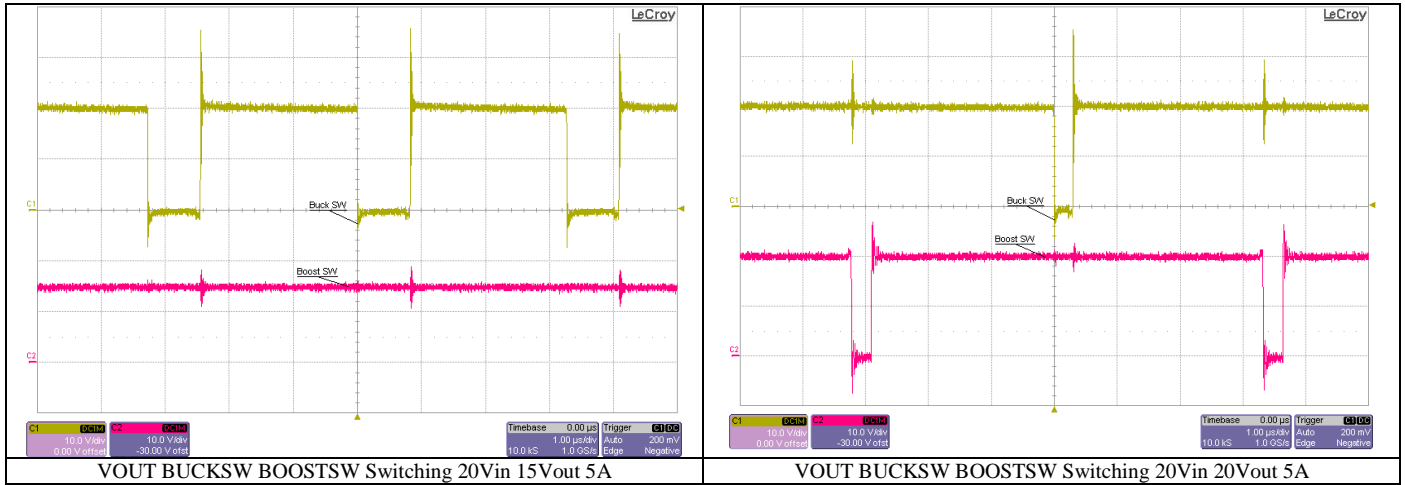
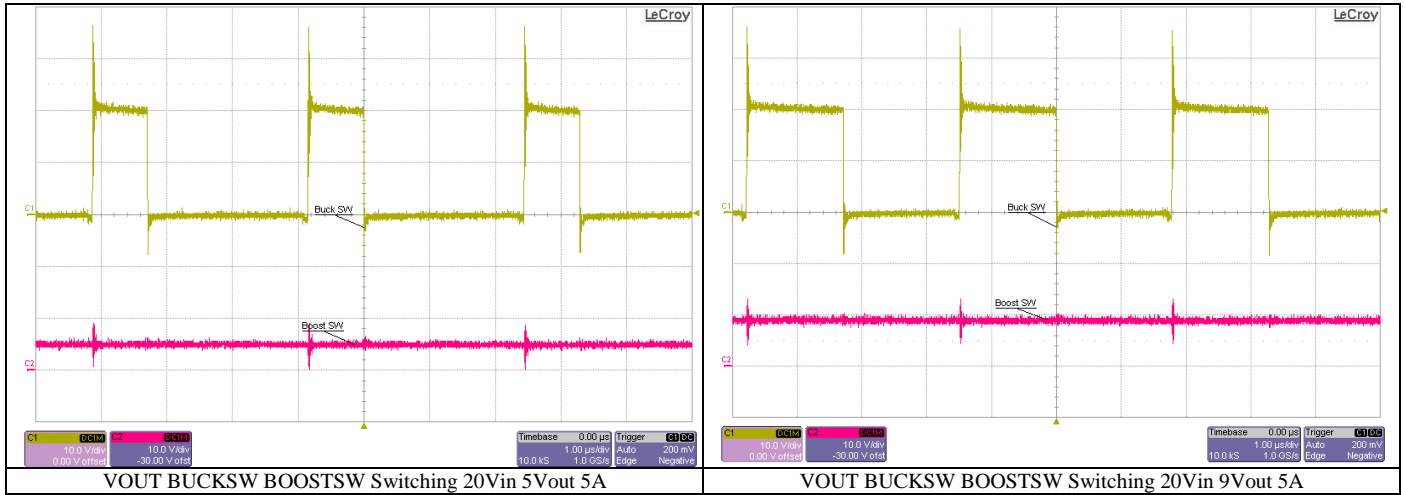
7.1 8V Input



6.2 12V Input

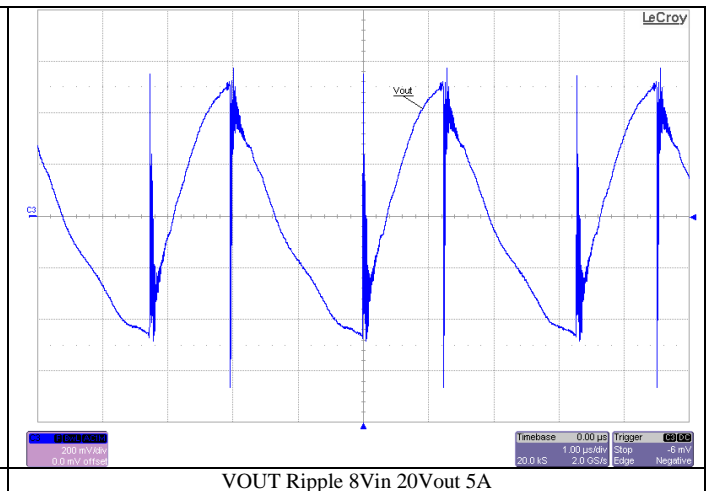
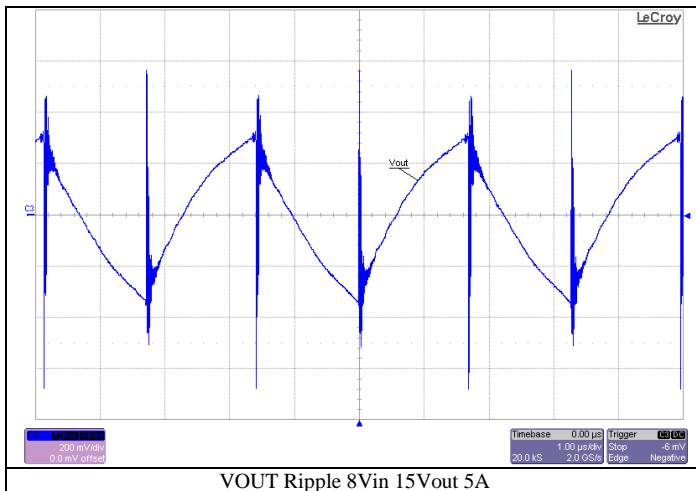
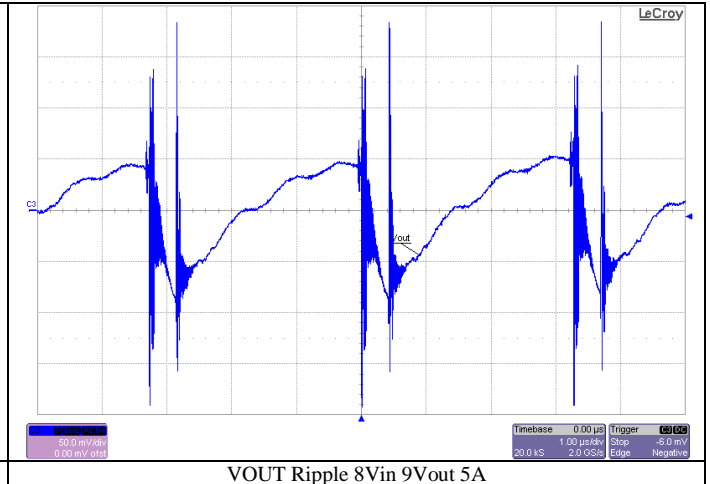
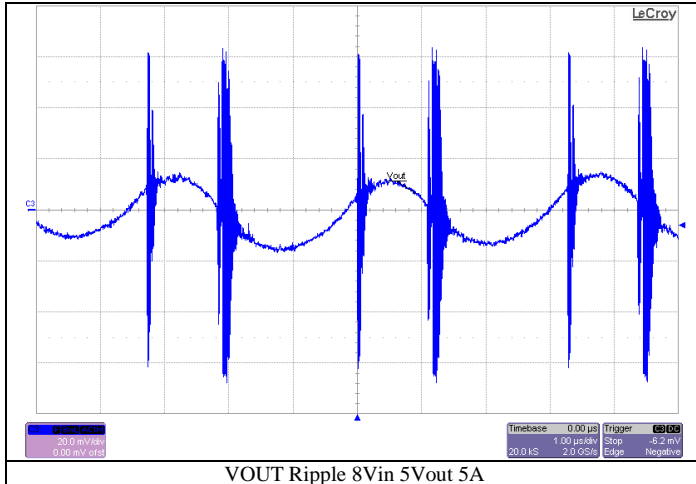


6.3 20V Input

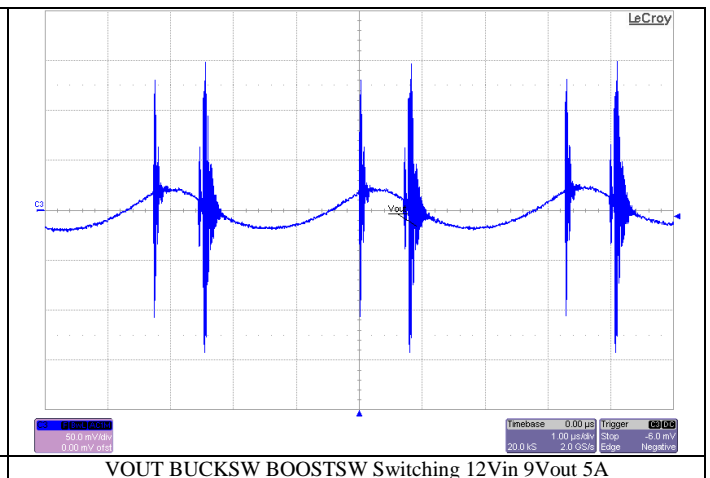
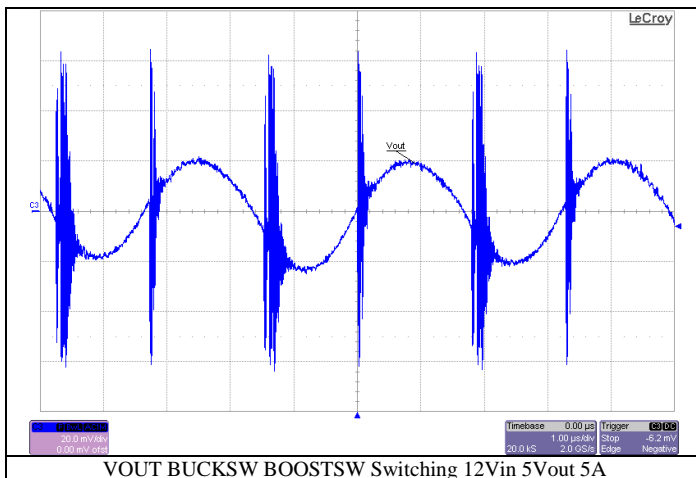


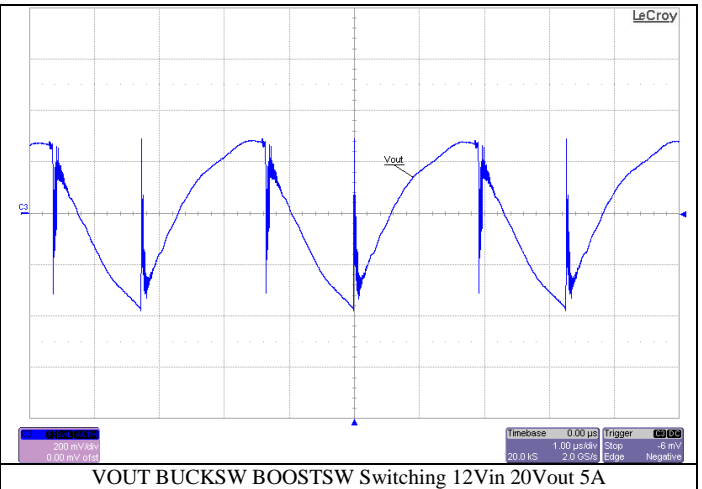
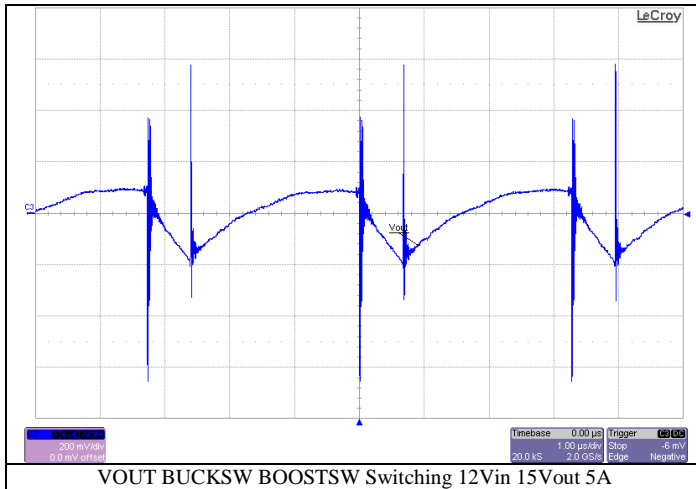
7 Output Ripple

7.1 8Vin

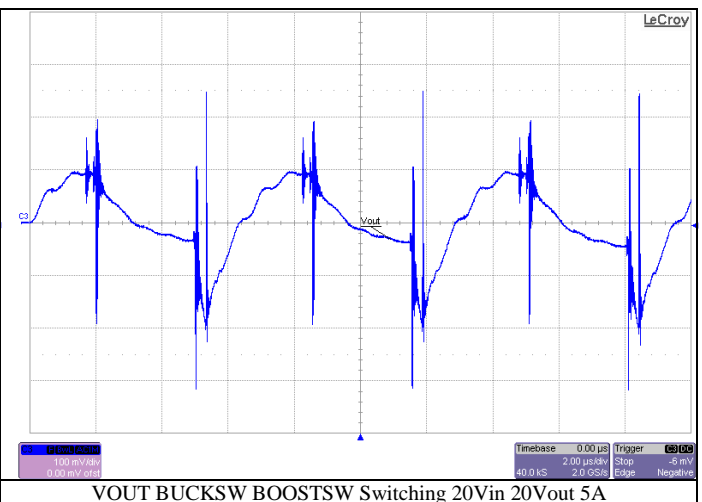
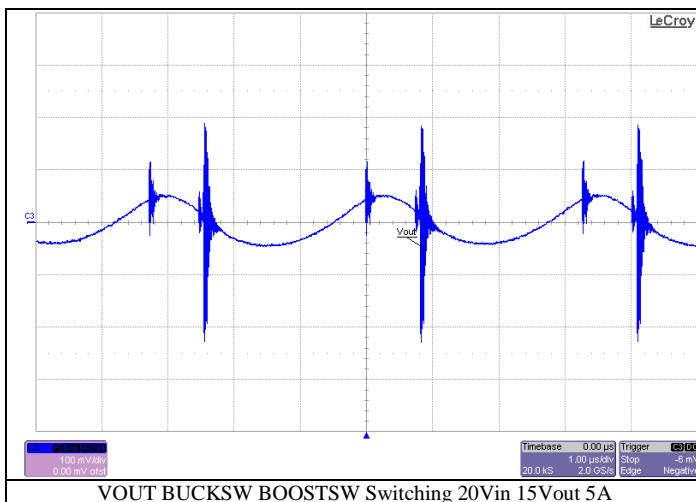
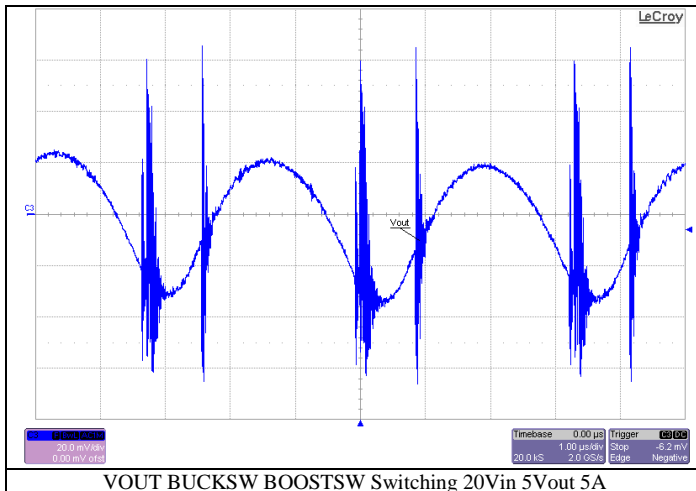


7.2 12Vin



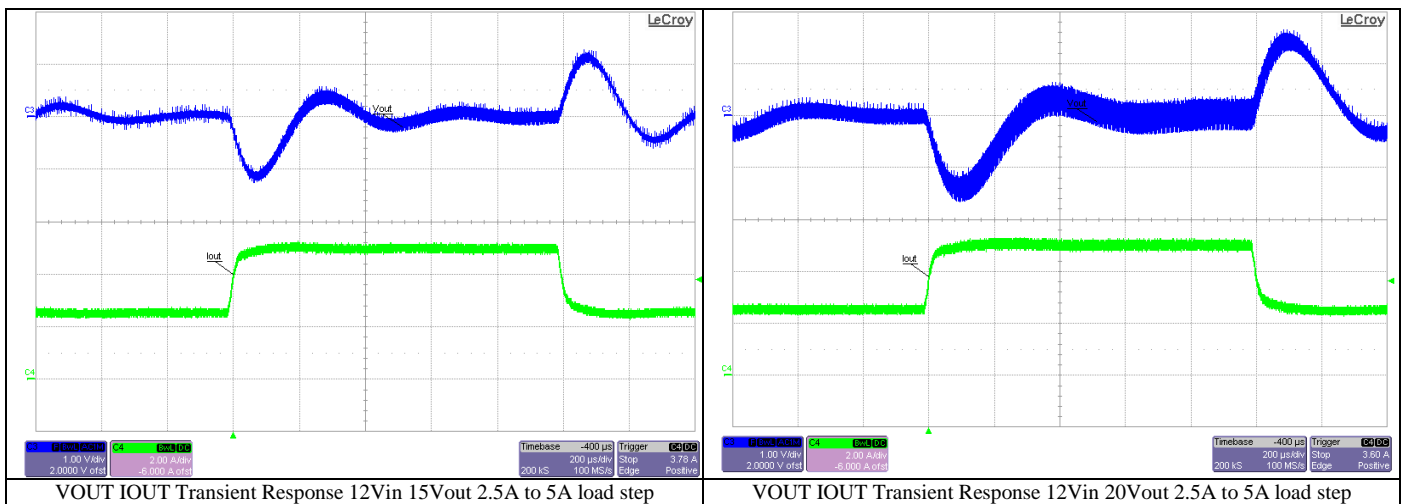
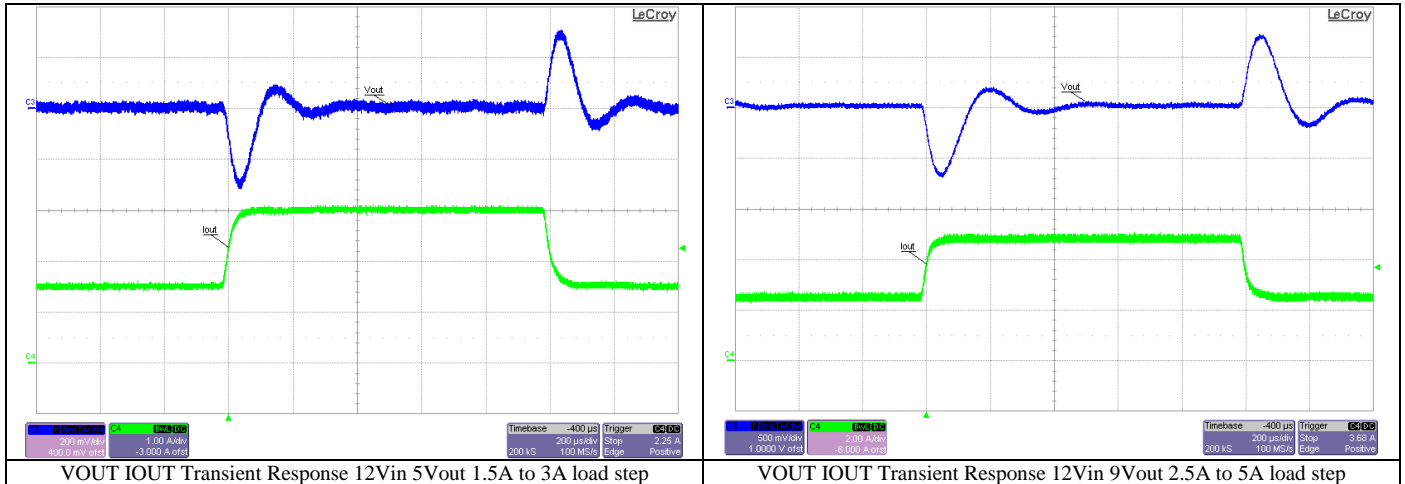


7.3 20Vin

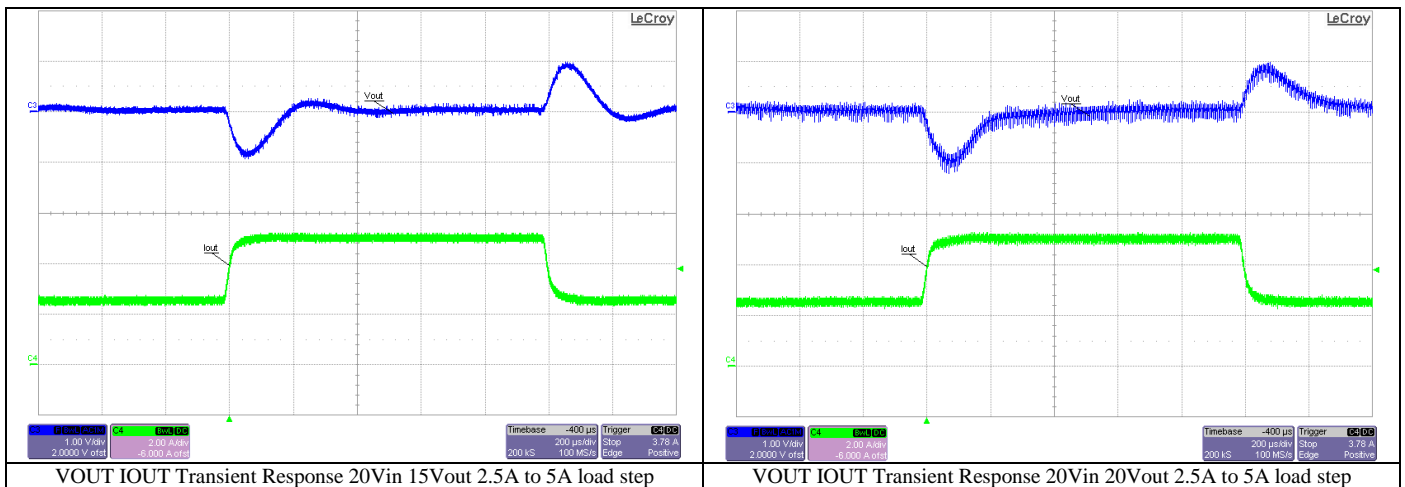
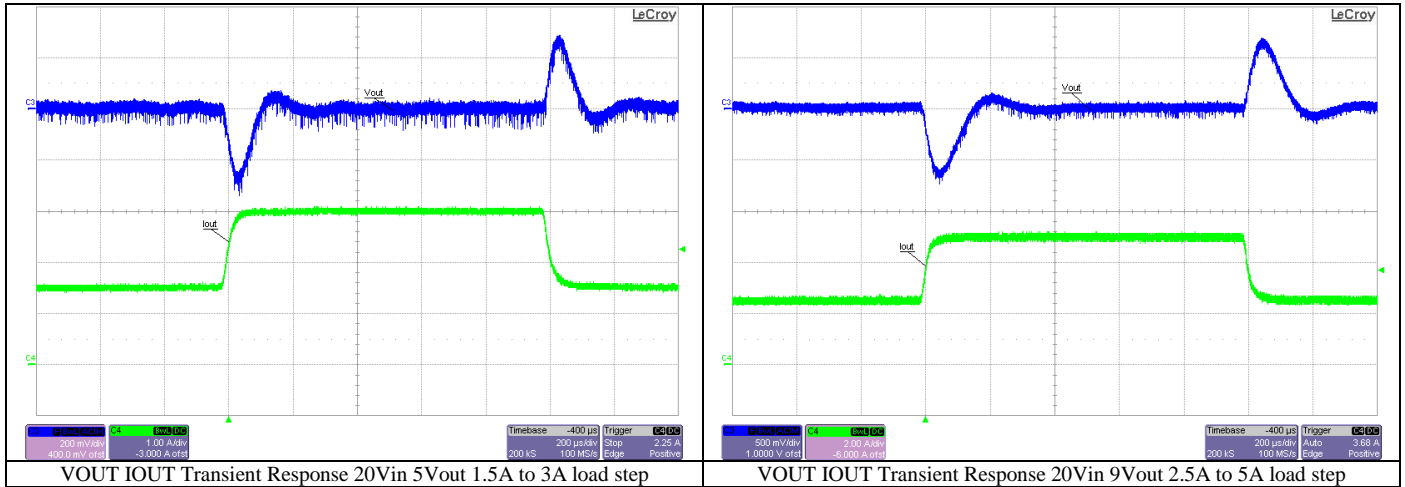


8 Load Transient Response

8.1 12V Input

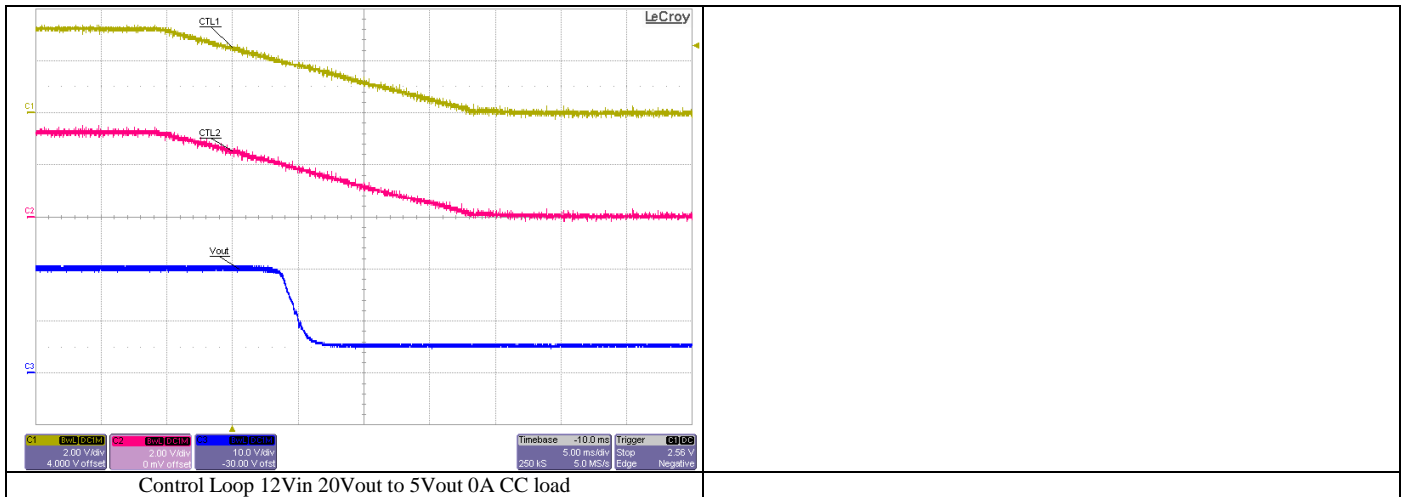
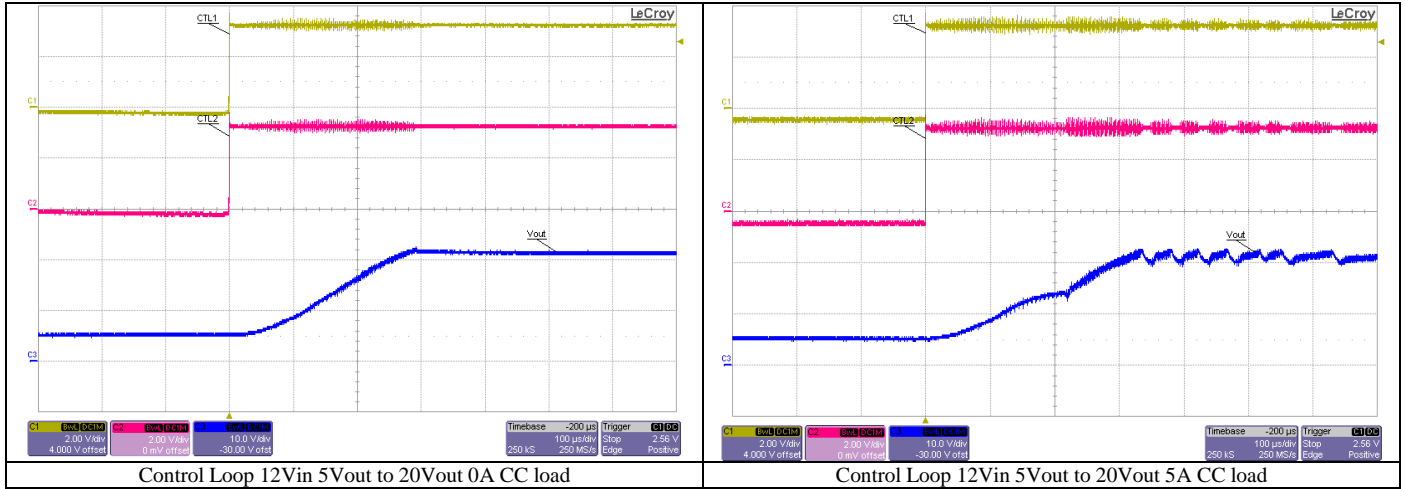


8.2 20V Input



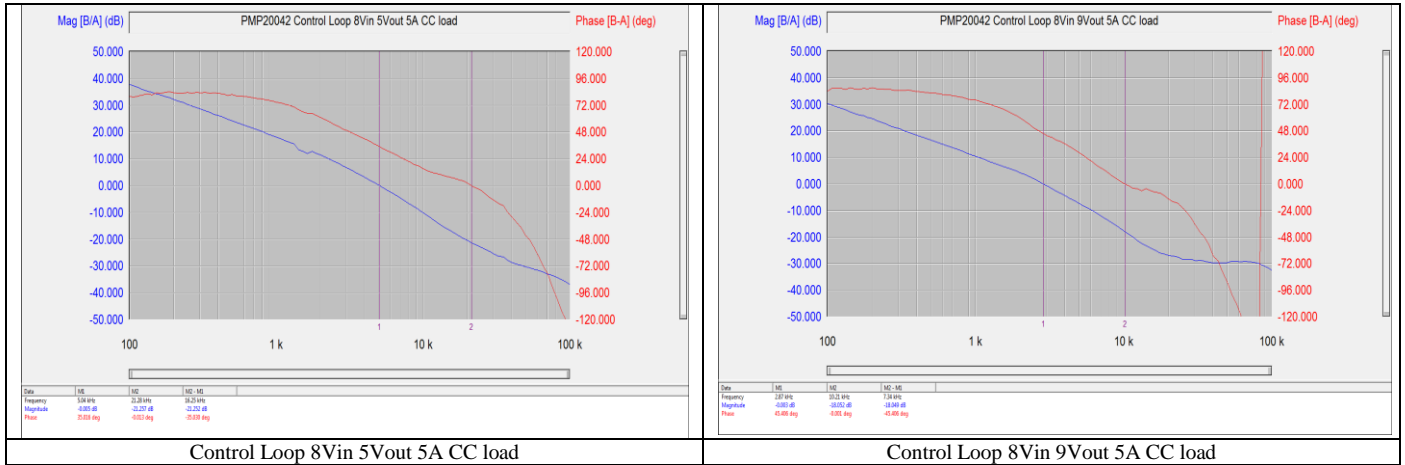
9 Output Adjustment

9.1 5Vout to 20Vout



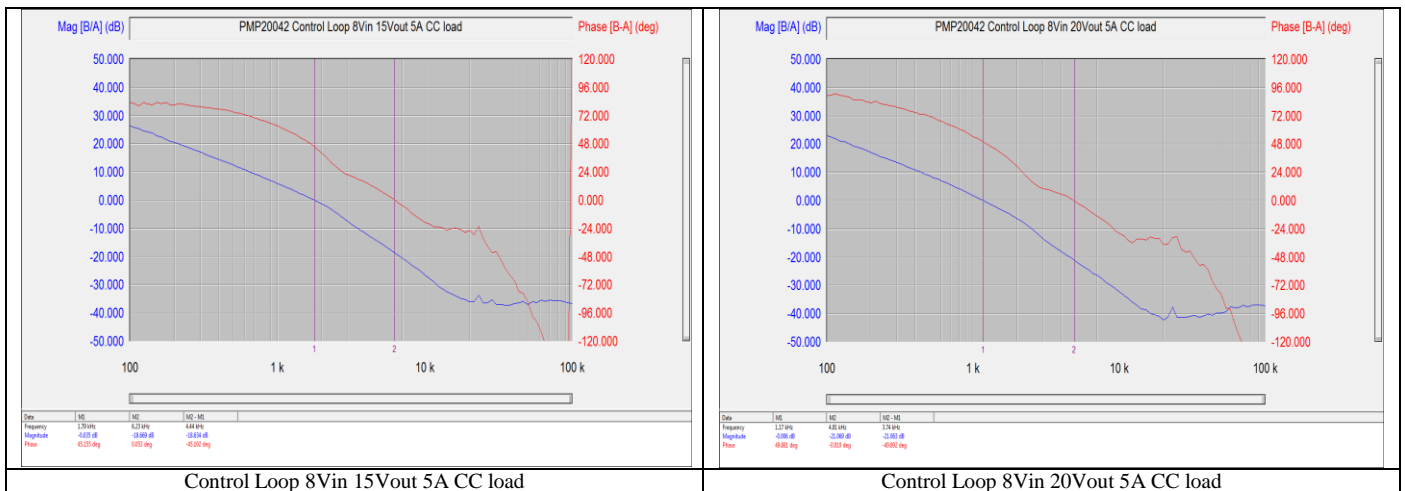
10 Frequency Response

10.1 8V Input



Control Loop 8Vin 5Vout 5A CC load

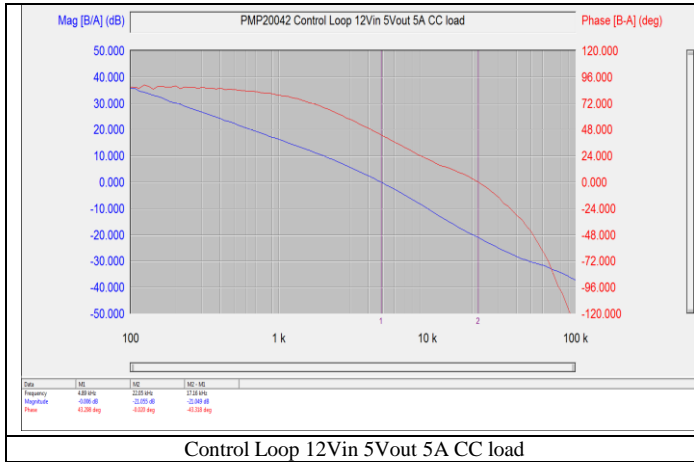
Control Loop 8Vin 9Vout 5A CC load



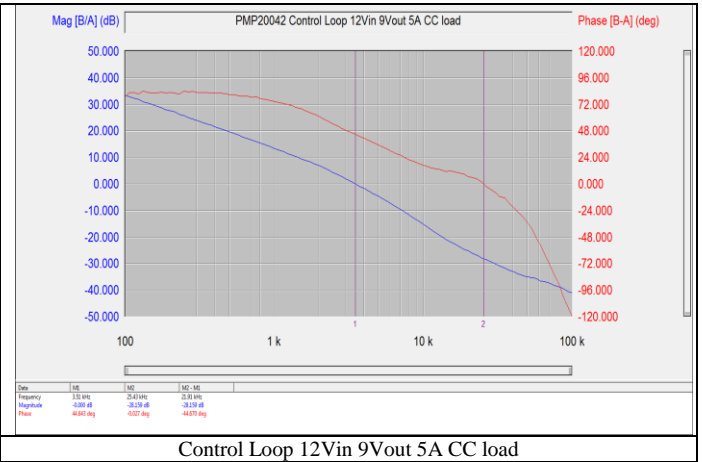
Control Loop 8Vin 15Vout 5A CC load

Control Loop 8Vin 20Vout 5A CC load

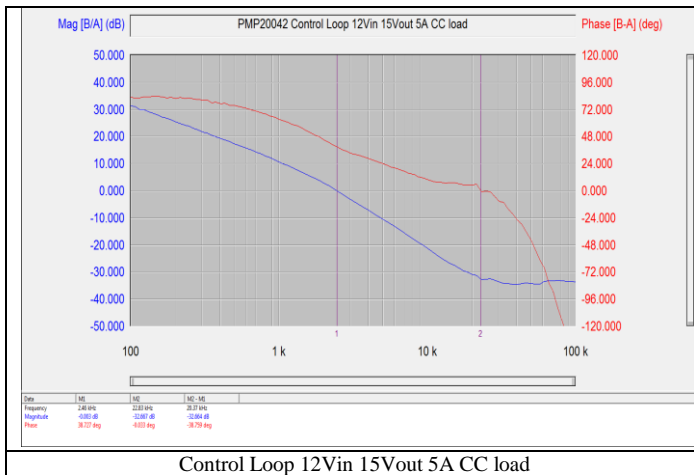
10.2 12V Input



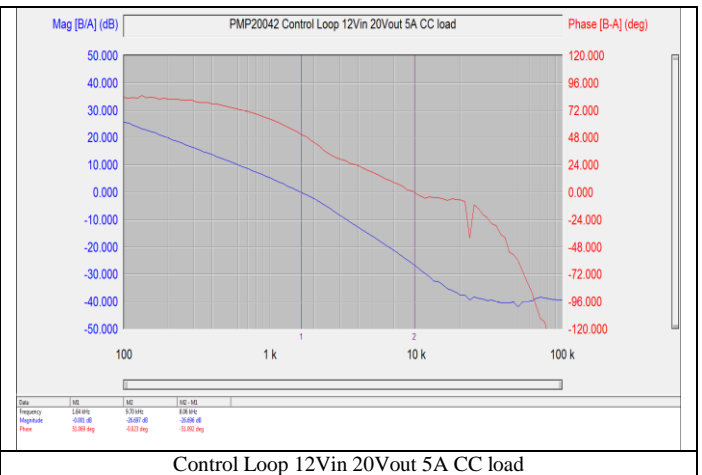
Control Loop 12Vin 5Vout 5A CC load



Control Loop 12Vin 9Vout 5A CC load

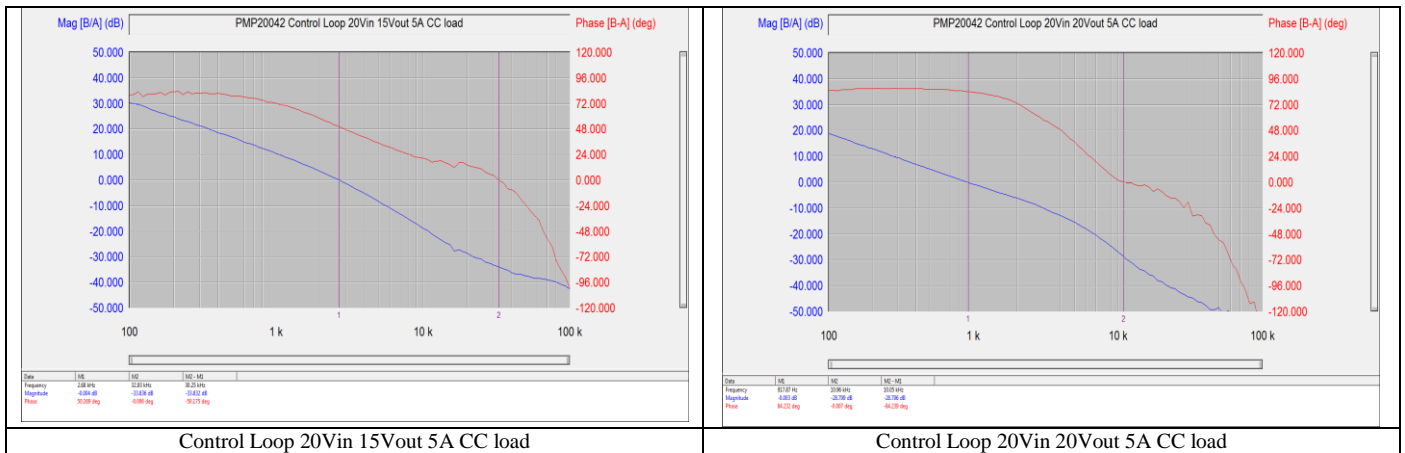
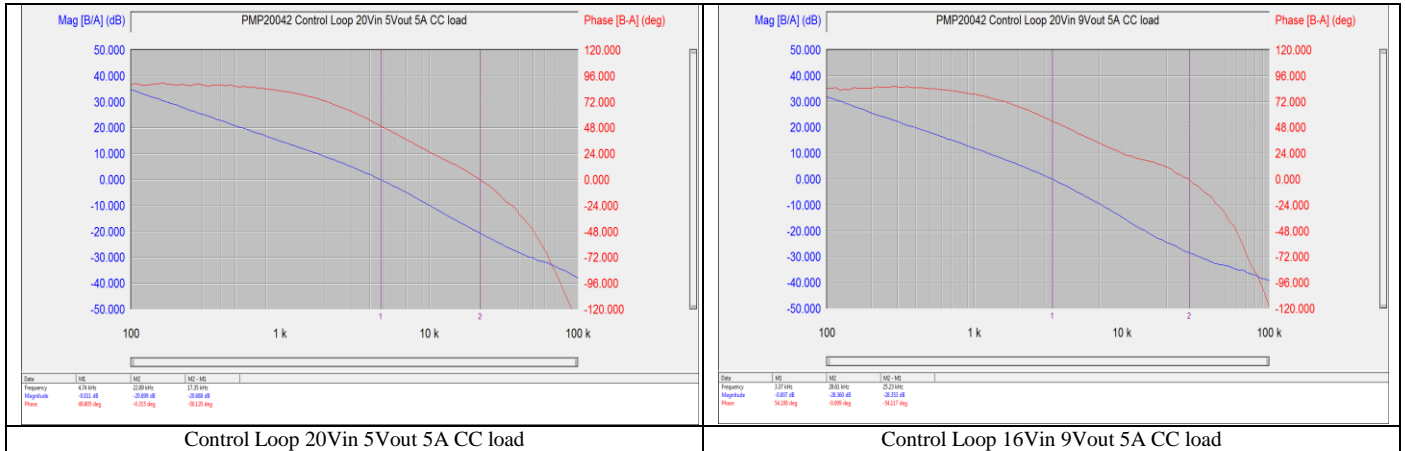


Control Loop 12Vin 15Vout 5A CC load



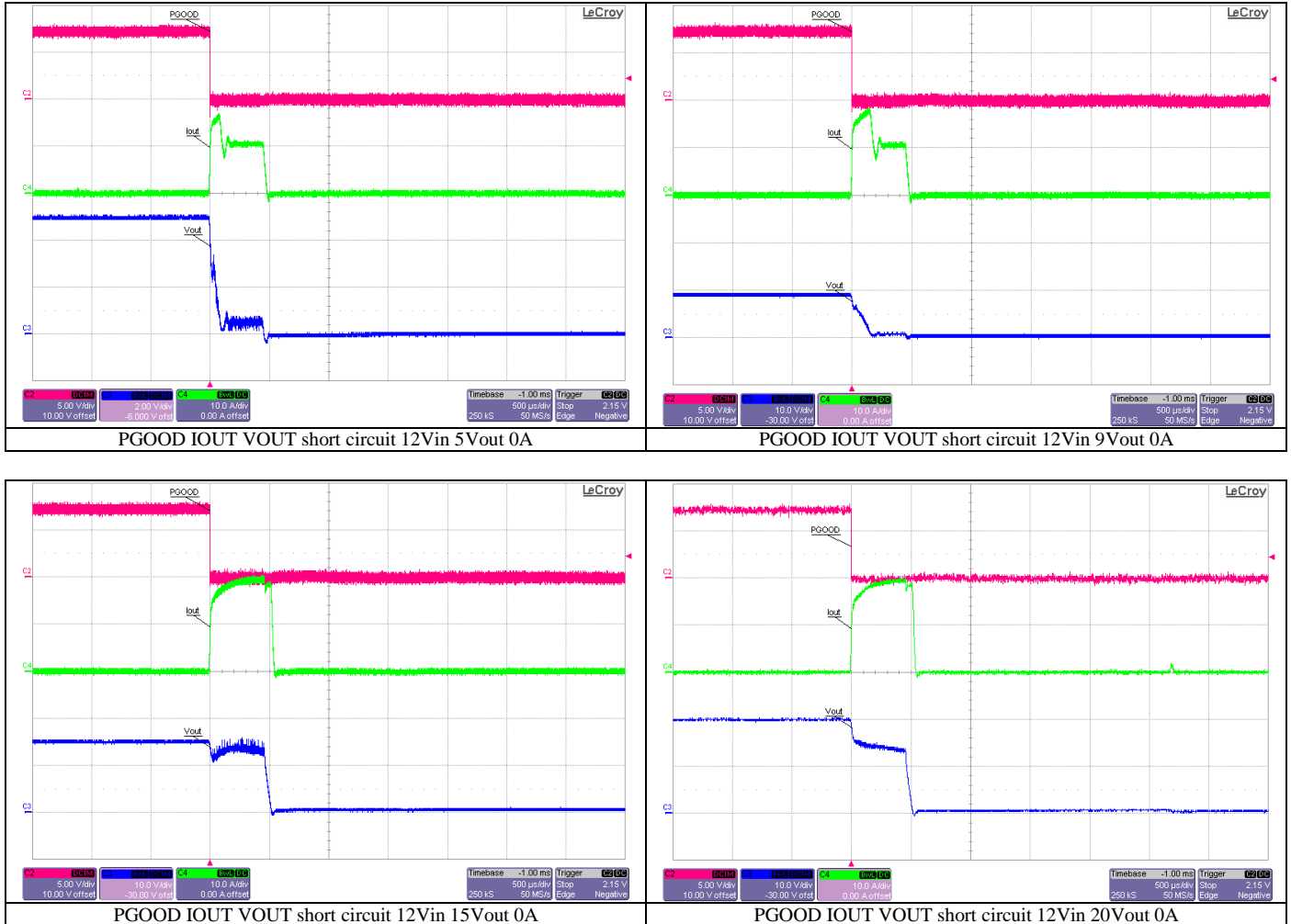
Control Loop 12Vin 20Vout 5A CC load

10.3 20V Input

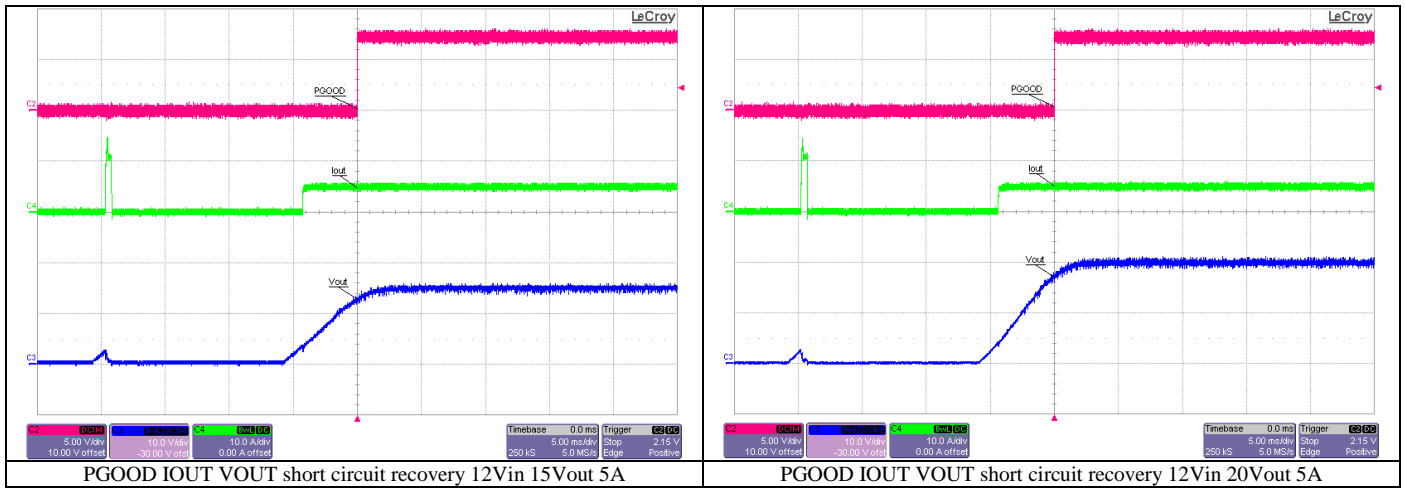
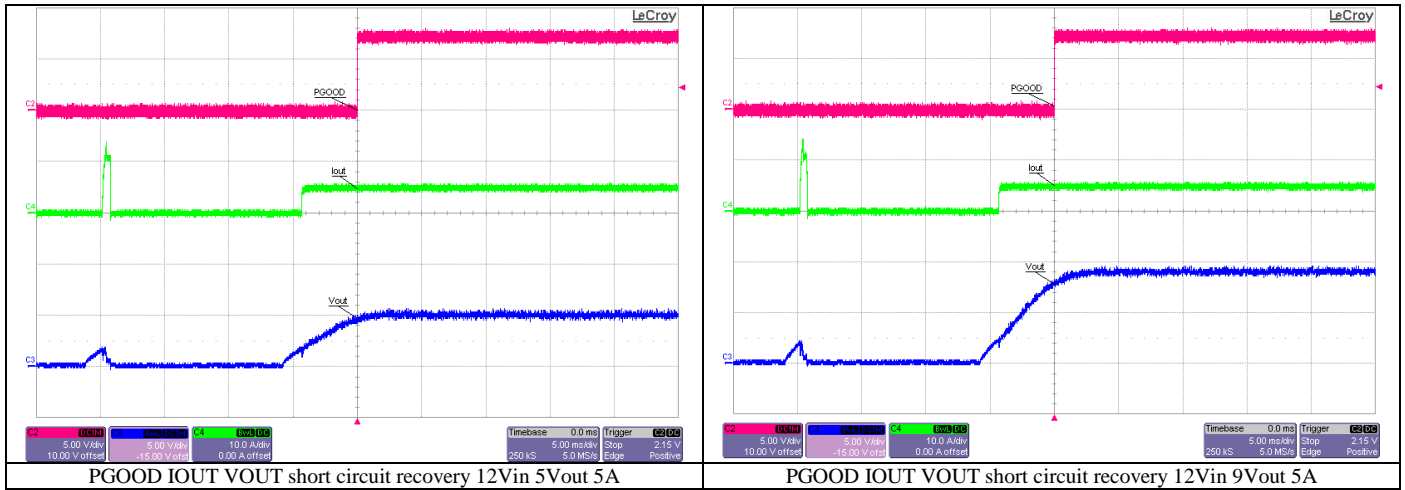


11 Short Circuit Tests

11.1 Output Short Circuit



11.2 Output Short Circuit Recovery



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