



LM5175 Synchronous 4-Switch Buck-Boost Converter

TI reference design number: PMP10726

Input: 6V to 30V DC

Output: 5V @ 4.5A to 20V @ 2.5A

DC – DC Test Results

PMP10726 Test Results

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1 Test Specifications

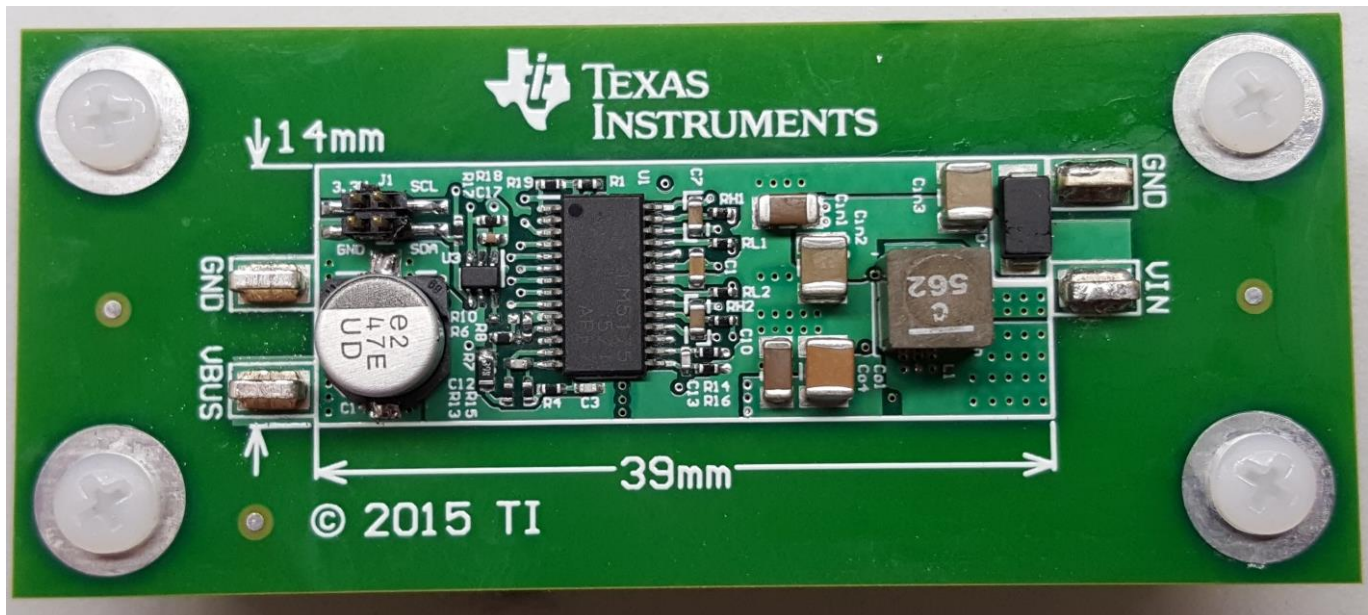
Vin min	6V
Vin max	24V
Output	5V @ 4.5A to 20V @ 2.5 A

2 Circuit Description

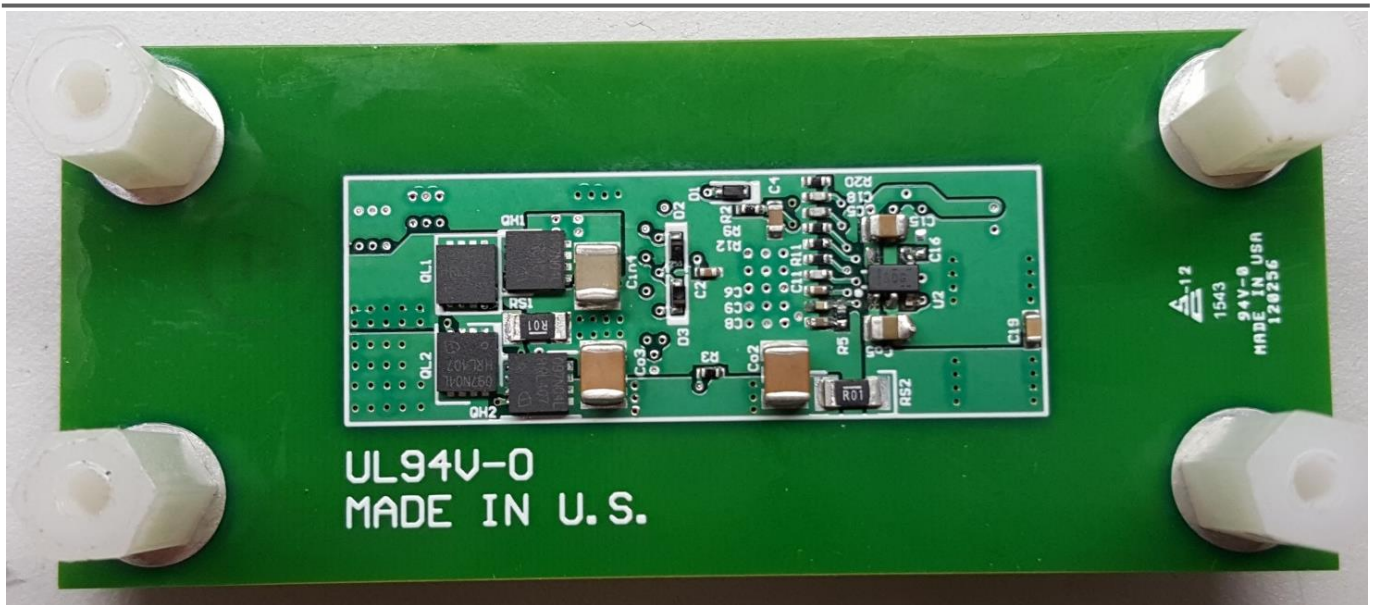
PMP10726 is a synchronous 4-switch buck-boost converter which utilizes the LM5175 controller for USB Type-C car charger applications. The output voltage is programmable from 5V to 20V by using I²C to adjust the digital potentiometer. The maximum power output is 50W. The LM5175 average current loop sets a maximum output current of 6.25A. Additional pulse-by-pulse current limiting is inherent in the current-mode controller. During testing, a 330μF electrolytic capacitor was used for damping purposes.

3 Board Photos

This is a 4-layer PCB with 2 oz. copper layers. PCB dimensions are 2.8 x 1.2 inches.

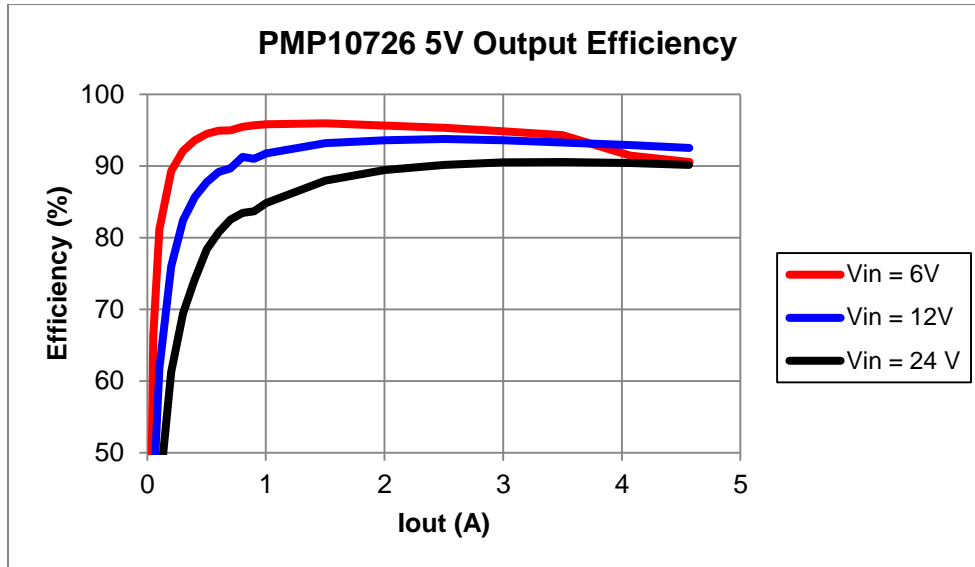


PMP10726 Test Results



4 Efficiency

4.1 5V Output Efficiency Results



4.2 5V Output Efficiency Data

Vin (V)	Iin (A)	Vout (V)	Iout (A)	Pin (W)	Pout (W)	Pdis (W)	Efficiency (%)
6.001	0.019	5.014	0.000	0.114	0.000	0.114	0.000
6.001	0.063	5.014	0.050	0.378	0.251	0.127	66.309
6.001	0.105	5.014	0.102	0.630	0.511	0.119	81.162
6.001	0.189	5.014	0.202	1.134	1.013	0.121	89.300
6.001	0.274	5.014	0.302	1.644	1.514	0.130	92.095
6.001	0.359	5.014	0.402	2.154	2.016	0.139	93.566
6.001	0.444	5.014	0.502	2.664	2.517	0.147	94.467
6.001	0.530	5.014	0.602	3.180	3.019	0.162	94.911
6.001	0.616	5.014	0.700	3.696	3.510	0.187	94.955
6.001	0.702	5.014	0.802	4.212	4.021	0.191	95.467
6.001	0.788	5.015	0.902	4.728	4.523	0.205	95.657
6.001	0.874	5.014	1.002	5.245	5.024	0.220	95.802
6.001	1.308	5.015	1.502	7.849	7.532	0.317	95.962
6.001	1.749	5.015	2.002	10.495	10.039	0.456	95.655
6.001	2.194	5.014	2.502	13.165	12.546	0.619	95.299
6.000	2.647	5.015	3.004	15.883	15.064	0.819	94.841
6.000	3.104	5.014	3.502	18.625	17.559	1.066	94.278
6.000	3.720	5.013	4.072	22.320	20.413	1.908	91.454
6.000	4.215	5.009	4.572	25.292	22.899	2.393	90.539

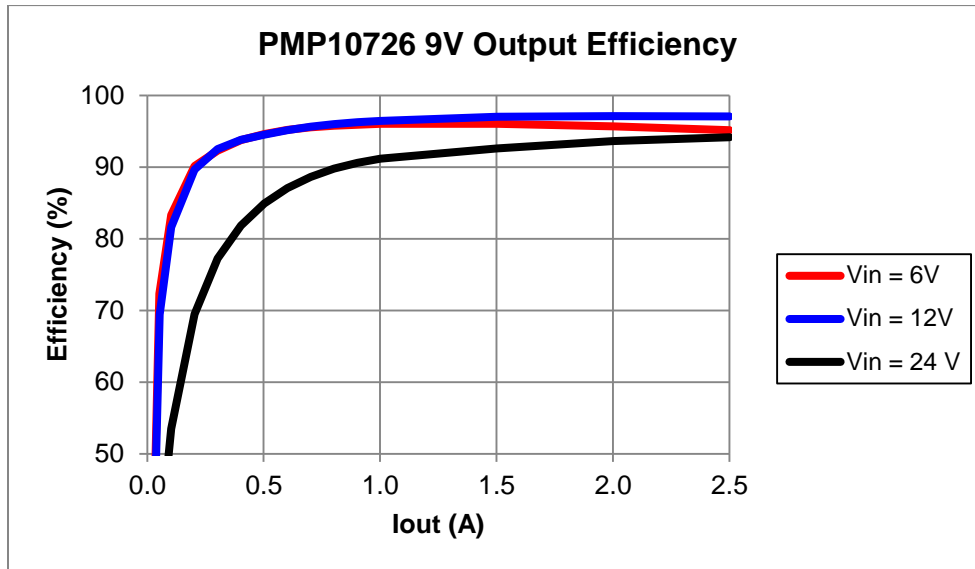
PMP10726 Test Results



Vin (V)	Iin (A)	Vout (V)	Iout (A)	Pin (W)	Pout (W)	Pdis (W)	Efficiency (%)
12.006	0.025	5.014	0.000	0.300	0.000	0.300	0.000
12.006	0.048	5.014	0.050	0.576	0.251	0.326	43.505
12.006	0.069	5.014	0.102	0.828	0.511	0.317	61.740
12.006	0.111	5.014	0.202	1.333	1.013	0.320	76.005
12.006	0.153	5.014	0.302	1.837	1.514	0.323	82.437
12.006	0.196	5.014	0.402	2.353	2.016	0.338	85.657
12.006	0.239	5.014	0.502	2.869	2.517	0.352	87.719
12.006	0.282	5.014	0.602	3.386	3.018	0.367	89.149
12.006	0.326	5.013	0.700	3.914	3.509	0.404	89.666
12.006	0.367	5.013	0.802	4.406	4.021	0.385	91.252
12.006	0.413	5.013	0.900	4.958	4.512	0.446	90.995
12.006	0.456	5.013	1.002	5.475	5.023	0.452	91.750
12.006	0.673	5.012	1.502	8.080	7.529	0.551	93.180
12.006	0.893	5.012	2.002	10.721	10.034	0.687	93.595
12.006	1.115	5.012	2.504	13.386	12.549	0.837	93.750
12.006	1.340	5.011	3.004	16.088	15.054	1.034	93.574
12.005	1.567	5.011	3.502	18.812	17.549	1.263	93.284
12.006	1.829	5.011	4.072	21.958	20.404	1.554	92.922
12.005	2.061	5.009	4.570	24.743	22.891	1.852	92.515

Vin (V)	Iin (A)	Vout (V)	Iout (A)	Pin (W)	Pout (W)	Pdis (W)	Efficiency (%)
24.013	0.026	5.025	0.000	0.624	0.000	0.624	0.000
24.013	0.038	5.025	0.052	0.912	0.261	0.651	28.635
24.013	0.048	5.025	0.102	1.153	0.513	0.640	44.466
24.013	0.069	5.025	0.202	1.657	1.015	0.642	61.257
24.013	0.091	5.024	0.302	2.185	1.517	0.668	69.438
24.013	0.112	5.024	0.396	2.689	1.989	0.700	73.974
24.013	0.134	5.024	0.502	3.218	2.522	0.696	78.376
24.013	0.156	5.023	0.602	3.746	3.024	0.722	80.728
24.013	0.178	5.023	0.702	4.274	3.526	0.748	82.497
24.013	0.201	5.023	0.802	4.827	4.028	0.798	83.461
24.013	0.225	5.022	0.900	5.403	4.520	0.883	83.661
24.013	0.247	5.022	1.002	5.931	5.032	0.899	84.839
24.013	0.357	5.020	1.502	8.573	7.541	1.032	87.964
24.013	0.468	5.019	2.002	11.238	10.049	1.189	89.416
24.013	0.580	5.018	2.502	13.927	12.555	1.372	90.150
24.013	0.693	5.017	3.002	16.641	15.061	1.580	90.505
24.013	0.808	5.016	3.502	19.402	17.565	1.837	90.534
24.013	0.940	5.015	4.070	22.572	20.410	2.162	90.421
24.012	1.057	5.012	4.566	25.381	22.885	2.496	90.164

4.3 9V Output Efficiency Results



4.4 9V Output Efficiency Data

V_{in} (V)	I_{in} (A)	V_{out} (V)	I_{out} (A)	P_{in} (W)	P_{out} (W)	P_{dis} (W)	Efficiency (%)
6.000	0.030	9.023	0.000	0.181	0.000	0.181	0.000
6.000	0.109	9.023	0.053	0.656	0.475	0.182	72.306
6.000	0.185	9.023	0.102	1.110	0.925	0.185	83.318
6.000	0.338	9.023	0.203	2.028	1.828	0.200	90.135
6.000	0.493	9.022	0.303	2.958	2.730	0.228	92.298
6.000	0.646	9.022	0.403	3.874	3.631	0.242	93.745
6.000	0.798	9.022	0.502	4.790	4.533	0.257	94.625
6.000	0.952	9.022	0.602	5.709	5.433	0.276	95.170
6.000	1.105	9.022	0.702	6.632	6.335	0.297	95.525
6.000	1.260	9.022	0.802	7.558	7.239	0.320	95.770
6.000	1.415	9.022	0.902	8.486	8.140	0.347	95.916
6.000	1.569	9.022	1.002	9.417	9.041	0.375	96.016
6.000	2.352	9.023	1.502	14.111	13.549	0.561	96.021
6.000	3.146	9.023	2.002	18.876	18.059	0.817	95.674
5.999	3.953	9.023	2.501	23.716	22.567	1.150	95.152

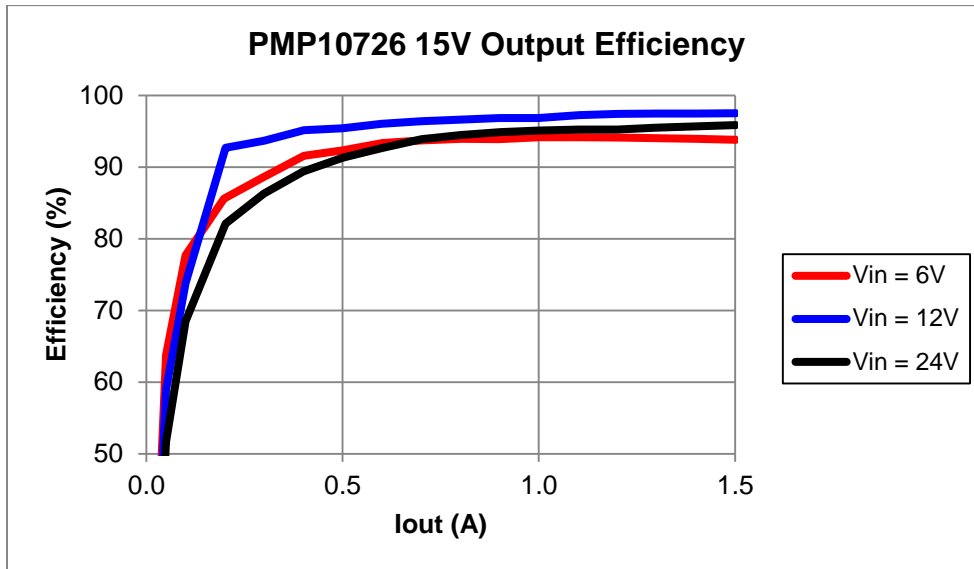
PMP10726 Test Results



Vin (V)	Iin (A)	Vout (V)	Iout (A)	Pin (W)	Pout (W)	Pdis (W)	Efficiency (%)
12.005	0.018	9.014	0.000	0.211	0.000	0.211	0.000
12.005	0.057	9.015	0.053	0.684	0.475	0.209	69.423
12.005	0.094	9.015	0.103	1.133	0.925	0.208	81.610
12.005	0.170	9.015	0.203	2.037	1.826	0.211	89.651
12.005	0.246	9.015	0.303	2.948	2.728	0.220	92.524
12.005	0.322	9.015	0.403	3.869	3.629	0.240	93.785
12.006	0.399	9.016	0.502	4.791	4.529	0.262	94.532
12.005	0.475	9.015	0.602	5.705	5.429	0.276	95.165
12.005	0.551	9.015	0.702	6.621	6.331	0.290	95.617
12.005	0.628	9.016	0.802	7.537	7.233	0.303	95.976
12.005	0.704	9.016	0.902	8.451	8.134	0.318	96.243
12.005	0.780	9.016	1.002	9.367	9.035	0.332	96.459
12.005	1.163	9.016	1.502	13.959	13.540	0.419	96.998
12.005	1.548	9.016	2.002	18.584	18.046	0.538	97.105
12.005	1.935	9.017	2.501	23.235	22.551	0.684	97.056

Vin (V)	Iin (A)	Vout (V)	Iout (A)	Pin (W)	Pout (W)	Pdis (W)	Efficiency (%)
24.013	0.034	9.016	0.000	0.807	0.001	0.806	0.112
24.013	0.053	9.016	0.053	1.277	0.475	0.802	37.193
24.013	0.072	9.016	0.103	1.729	0.925	0.804	53.503
24.013	0.110	9.016	0.203	2.629	1.827	0.803	69.468
24.013	0.147	9.015	0.303	3.532	2.728	0.804	77.233
24.013	0.185	9.015	0.403	4.433	3.629	0.804	81.859
24.013	0.222	9.015	0.502	5.333	4.529	0.804	84.923
24.013	0.260	9.015	0.602	6.236	5.429	0.807	87.053
24.013	0.297	9.015	0.702	7.141	6.329	0.812	88.626
24.013	0.335	9.015	0.802	8.054	7.232	0.822	89.799
24.013	0.374	9.014	0.902	8.976	8.132	0.844	90.602
24.013	0.413	9.014	1.002	9.908	9.033	0.875	91.168
24.012	0.609	9.011	1.502	14.612	13.532	1.079	92.615
24.012	0.802	9.010	2.002	19.258	18.033	1.225	93.640
24.013	0.997	9.009	2.501	23.933	22.532	1.401	94.145

4.5 15V Output Efficiency Results



4.6 15V Output Efficiency Data

Vin (V)	Iin (A)	Vout (V)	Iout (A)	Pin (W)	Pout (W)	Pdis (W)	Efficiency (%)
6.000	0.065	15.149	0.000	0.390	0.000	0.390	0.000
6.000	0.198	15.150	0.050	1.188	0.758	0.430	63.764
6.000	0.325	15.150	0.100	1.950	1.515	0.435	77.696
6.000	0.584	15.150	0.198	3.504	3.000	0.504	85.609
6.000	0.849	15.145	0.298	5.094	4.513	0.581	88.598
6.000	1.108	15.145	0.402	6.648	6.088	0.560	91.583
6.000	1.367	15.145	0.500	8.202	7.573	0.629	92.331
6.000	1.628	15.145	0.602	9.768	9.118	0.650	93.343
6.000	1.891	15.146	0.702	11.346	10.632	0.713	93.712
6.000	2.155	15.146	0.802	12.930	12.147	0.783	93.944
6.000	2.420	15.146	0.900	14.520	13.632	0.888	93.881
6.000	2.686	15.146	1.002	16.115	15.177	0.939	94.175
6.000	2.954	15.147	1.102	17.723	16.692	1.031	94.180
6.000	3.224	15.147	1.202	19.343	18.207	1.137	94.123
6.000	3.496	15.148	1.302	20.974	19.723	1.252	94.031
6.000	3.769	15.148	1.402	22.612	21.238	1.374	93.923
6.000	4.043	15.149	1.502	24.256	22.754	1.502	93.809

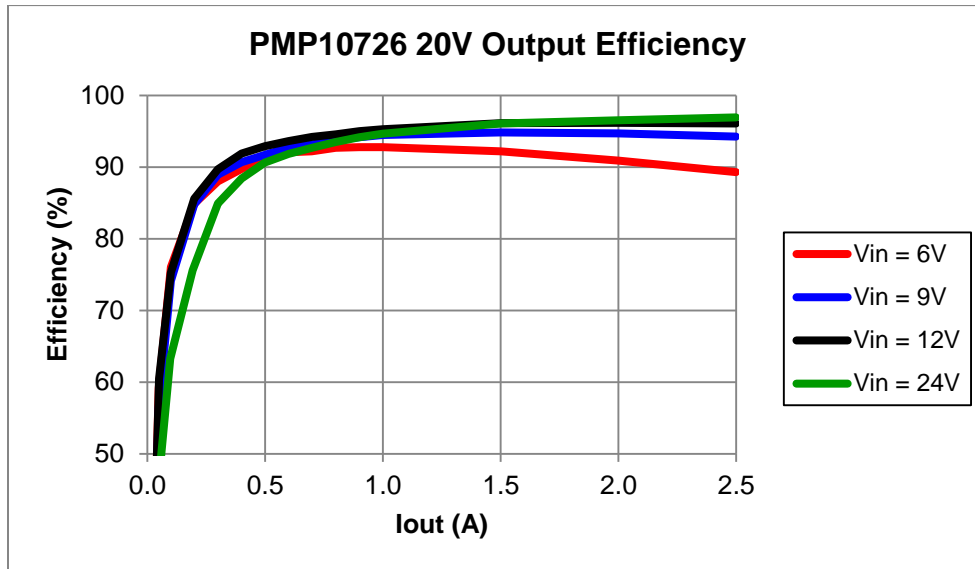
PMP10726 Test Results



Vin (V)	Iin (A)	Vout (V)	Iout (A)	Pin (W)	Pout (W)	Pdis (W)	Efficiency (%)
12.005	0.041	15.142	0.000	0.492	0.000	0.492	0.000
12.005	0.107	15.143	0.050	1.285	0.757	0.527	58.941
12.005	0.171	15.147	0.100	2.053	1.515	0.538	73.782
12.005	0.275	15.146	0.202	3.301	3.059	0.242	92.670
12.005	0.404	15.144	0.300	4.850	4.543	0.307	93.674
12.005	0.533	15.141	0.402	6.399	6.087	0.312	95.126
12.005	0.661	15.140	0.500	7.935	7.570	0.365	95.396
12.006	0.788	15.140	0.600	9.460	9.084	0.377	96.019
12.005	0.916	15.140	0.700	10.997	10.598	0.399	96.372
12.005	1.044	15.140	0.800	12.534	12.112	0.421	96.638
12.005	1.172	15.140	0.900	14.070	13.626	0.443	96.848
12.005	1.300	15.140	0.998	15.606	15.110	0.496	96.821
12.005	1.429	15.140	1.102	17.155	16.685	0.471	97.256
12.005	1.556	15.140	1.202	18.680	18.199	0.481	97.425
12.005	1.685	15.140	1.302	20.229	19.712	0.517	97.445
12.005	1.814	15.141	1.402	21.778	21.227	0.551	97.471
12.005	1.943	15.140	1.502	23.326	22.741	0.585	97.492

Vin (V)	Iin (A)	Vout (V)	Iout (A)	Pin (W)	Pout (W)	Pdis (W)	Efficiency (%)
24.013	0.028	15.129	0.000	0.672	0.000	0.672	0.000
24.013	0.061	15.129	0.050	1.465	0.756	0.708	51.642
24.013	0.092	15.129	0.100	2.209	1.513	0.696	68.482
24.013	0.155	15.129	0.202	3.722	3.056	0.666	82.107
24.013	0.219	15.130	0.300	5.259	4.539	0.720	86.311
24.013	0.282	15.130	0.400	6.772	6.052	0.720	89.371
24.013	0.345	15.130	0.500	8.284	7.565	0.719	91.317
24.013	0.408	15.130	0.600	9.797	9.078	0.719	92.660
24.013	0.471	15.131	0.702	11.310	10.622	0.688	93.915
24.013	0.535	15.131	0.802	12.847	12.135	0.712	94.460
24.013	0.599	15.131	0.902	14.384	13.648	0.736	94.885
24.013	0.664	15.131	1.002	15.944	15.161	0.783	95.089
24.013	0.729	15.130	1.102	17.505	16.674	0.831	95.251
24.013	0.794	15.130	1.200	19.066	18.155	0.910	95.225
24.012	0.859	15.129	1.302	20.627	19.698	0.929	95.496
24.012	0.923	15.129	1.402	22.163	21.210	0.953	95.699
24.012	0.987	15.129	1.502	23.700	22.723	0.977	95.879

4.7 20V Output Efficiency Results



4.8 20V Output Efficiency Data

Vin (V)	Iin (A)	Vout (V)	Iout (A)	Pin (W)	Pout (W)	Pdis (W)	Efficiency (%)
6.001	0.094	19.889	0.000	0.564	0.000	0.564	0.000
6.001	0.269	19.890	0.048	1.614	0.955	0.659	59.146
6.000	0.436	19.890	0.100	2.616	1.989	0.627	76.026
6.001	0.781	19.885	0.200	4.686	3.977	0.709	84.861
6.000	1.129	19.876	0.300	6.774	5.963	0.812	88.021
6.000	1.470	19.875	0.398	8.821	7.910	0.910	89.679
6.000	1.814	19.875	0.500	10.885	9.937	0.947	91.298
6.000	2.159	19.874	0.600	12.955	11.925	1.030	92.046
6.000	2.508	19.874	0.698	15.049	13.872	1.177	92.180
6.000	2.859	19.873	0.800	17.155	15.899	1.256	92.677
6.000	3.213	19.872	0.900	19.279	17.885	1.394	92.768
6.000	3.569	19.872	1.000	21.415	19.872	1.543	92.795
6.000	5.388	19.868	1.500	32.327	29.802	2.525	92.190
6.000	7.281	19.852	2.000	43.684	39.705	3.979	90.890
5.999	9.180	19.674	2.500	55.075	49.184	5.891	89.304

PMP10726 Test Results



Vin (V)	Iin (A)	Vout (V)	Iout (A)	Pin (W)	Pout (W)	Pdis (W)	Efficiency (%)
9.006	0.072	19.887	0.000	0.648	0.000	0.648	0.000
9.006	0.188	19.887	0.048	1.693	0.955	0.738	56.381
9.006	0.298	19.888	0.100	2.684	1.989	0.695	74.107
9.005	0.521	19.888	0.200	4.692	3.978	0.714	84.779
9.006	0.745	19.887	0.300	6.709	5.966	0.743	88.927
9.005	0.974	19.882	0.400	8.771	7.953	0.818	90.670
9.006	1.203	19.875	0.500	10.834	9.937	0.896	91.726
9.006	1.428	19.874	0.600	12.860	11.924	0.936	92.724
9.006	1.654	19.874	0.698	14.895	13.872	1.023	93.132
9.006	1.881	19.874	0.800	16.940	15.899	1.040	93.858
9.005	2.109	19.874	0.900	18.993	17.887	1.106	94.177
9.005	2.336	19.874	1.000	21.037	19.874	1.163	94.472
9.005	3.491	19.875	1.500	31.438	29.813	1.625	94.832
9.005	4.663	19.877	2.000	41.991	39.755	2.236	94.675
9.005	5.854	19.878	2.500	52.716	49.696	3.020	94.271

Vin (V)	Iin (A)	Vout (V)	Iout (A)	Pin (W)	Pout (W)	Pdis (W)	Efficiency (%)
12.005	0.051	19.884	0.000	0.612	0.000	0.612	0.000
12.006	0.137	19.884	0.050	1.645	0.994	0.651	60.447
12.006	0.220	19.884	0.100	2.641	1.988	0.653	75.283
12.006	0.387	19.885	0.200	4.646	3.977	0.669	85.599
12.006	0.554	19.885	0.300	6.651	5.966	0.685	89.694
12.006	0.721	19.883	0.400	8.656	7.953	0.703	91.882
12.006	0.891	19.881	0.500	10.697	9.940	0.757	92.927
12.006	1.061	19.873	0.600	12.738	11.924	0.814	93.610
12.005	1.230	19.871	0.700	14.766	13.909	0.857	94.196
12.006	1.400	19.870	0.800	16.808	15.896	0.911	94.577
12.006	1.568	19.870	0.900	18.825	17.883	0.942	94.997
12.005	1.737	19.870	1.000	20.853	19.870	0.983	95.284
12.005	2.586	19.871	1.502	31.046	29.846	1.200	96.134
12.005	3.443	19.872	2.000	41.334	39.743	1.591	96.151
12.005	4.308	19.874	2.500	51.719	49.685	2.034	96.067

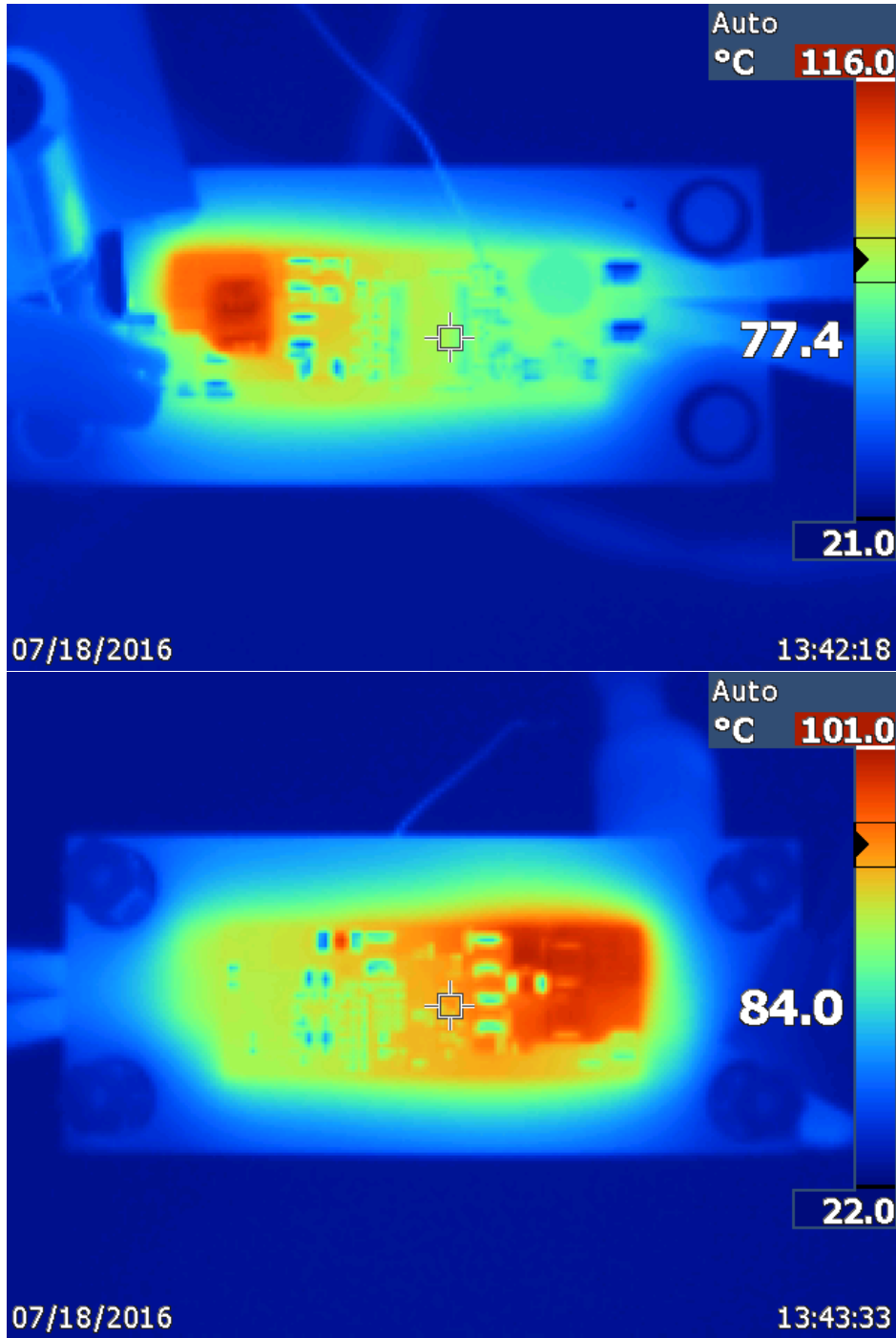
PMP10726 Test Results



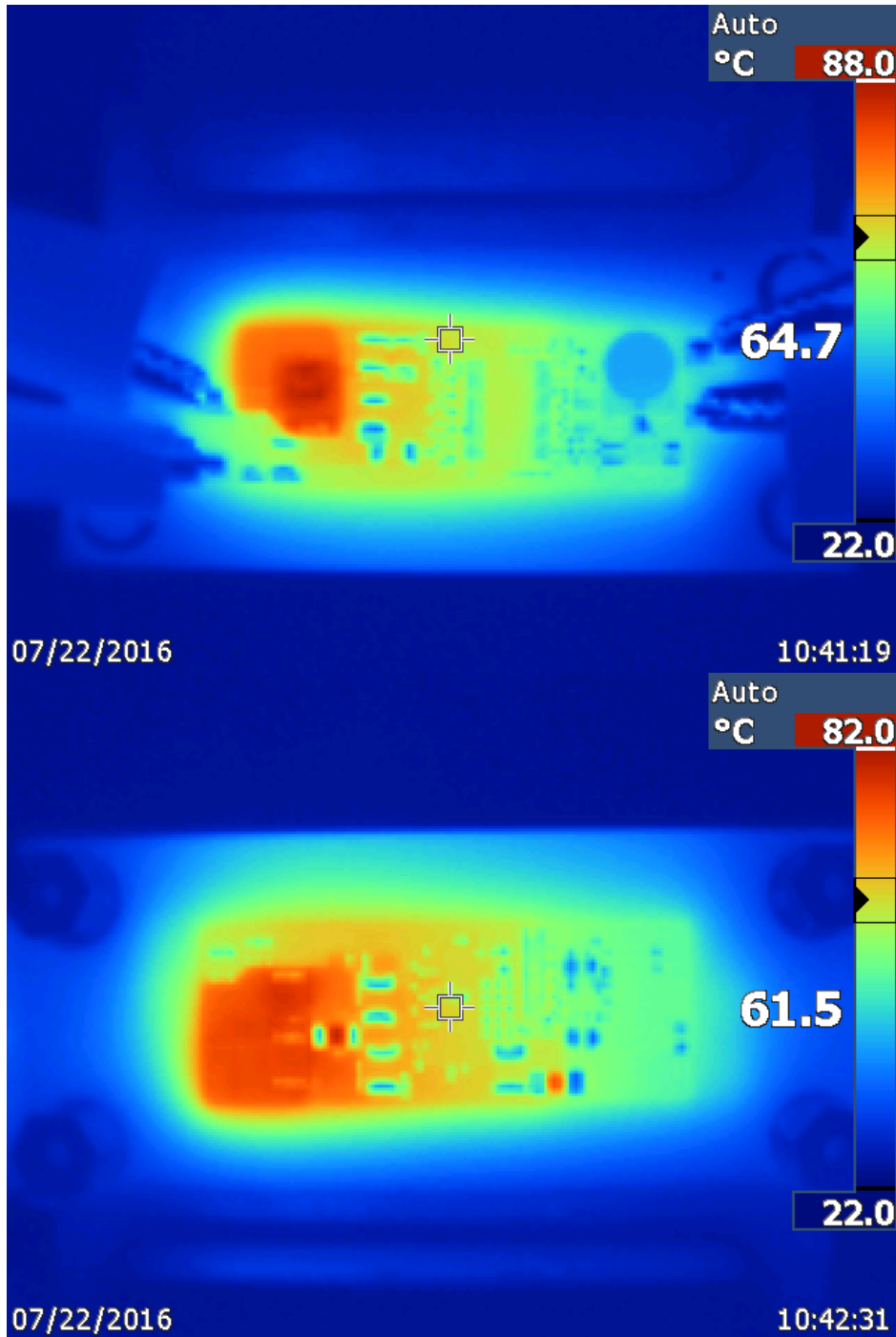
Vin (V)	Iin (A)	Vout (V)	Iout (A)	Pin (W)	Pout (W)	Pdis (W)	Efficiency (%)
24.013	0.044	19.846	0.000	1.057	0.000	1.057	0.000
24.013	0.086	19.846	0.048	2.065	0.953	1.112	46.129
24.013	0.128	19.846	0.098	3.074	1.945	1.129	63.278
24.013	0.210	19.848	0.192	5.043	3.811	1.232	75.569
24.013	0.292	19.848	0.300	7.012	5.954	1.057	84.920
24.013	0.374	19.848	0.400	8.981	7.939	1.041	88.403
24.013	0.456	19.847	0.500	10.950	9.924	1.026	90.630
24.013	0.540	19.847	0.600	12.967	11.908	1.059	91.834
24.012	0.624	19.845	0.700	14.984	13.891	1.093	92.708
24.013	0.707	19.843	0.800	16.977	15.875	1.102	93.507
24.012	0.790	19.844	0.900	18.970	17.859	1.111	94.146
24.012	0.873	19.844	1.000	20.963	19.844	1.119	94.661
24.012	1.290	19.845	1.500	30.976	29.767	1.209	96.097
24.012	1.712	19.844	2.000	41.109	39.688	1.421	96.543
24.012	2.132	19.847	2.500	51.194	49.616	1.577	96.919

5 Thermal

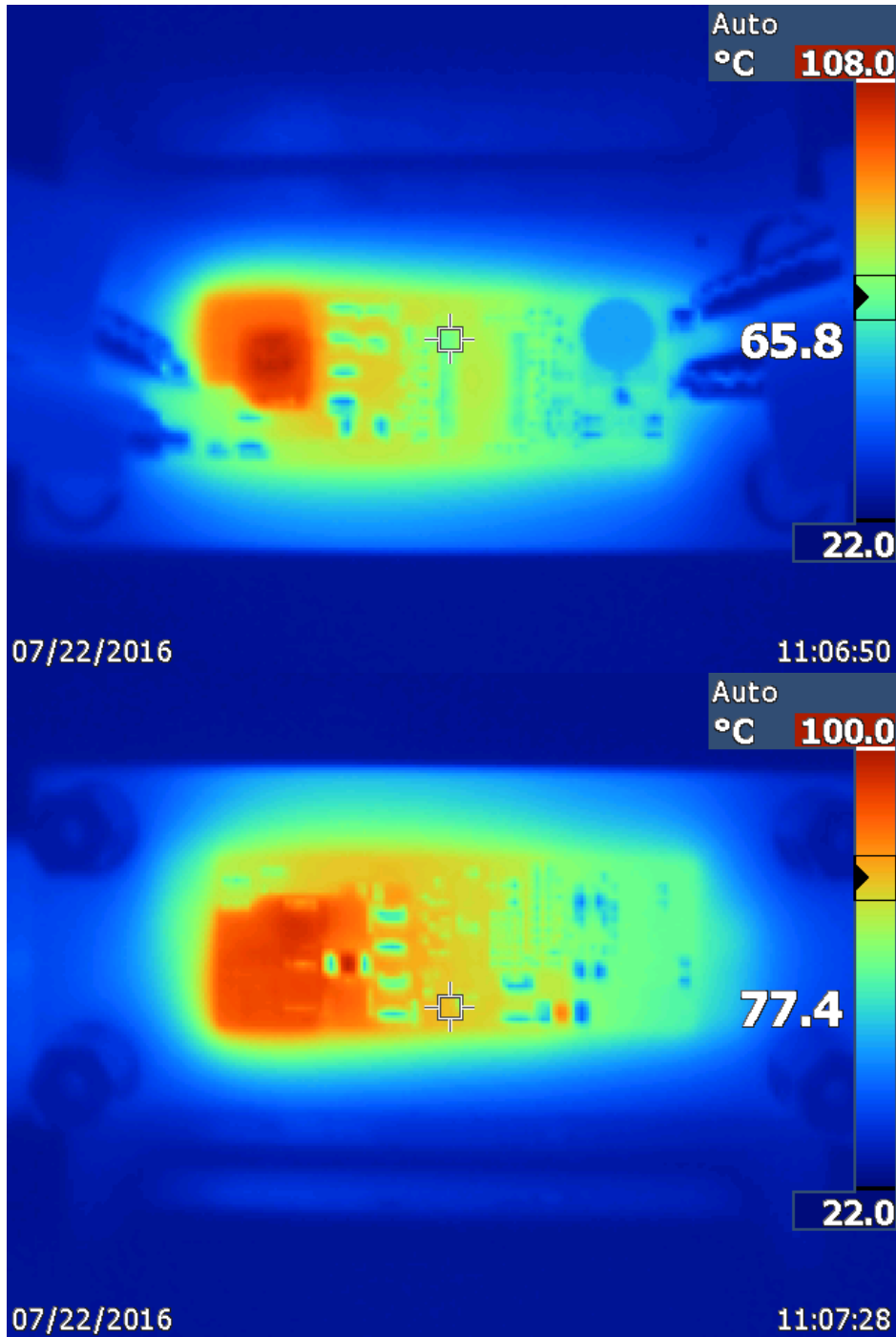
5.1 6V Input, 5V at 4.5A Output



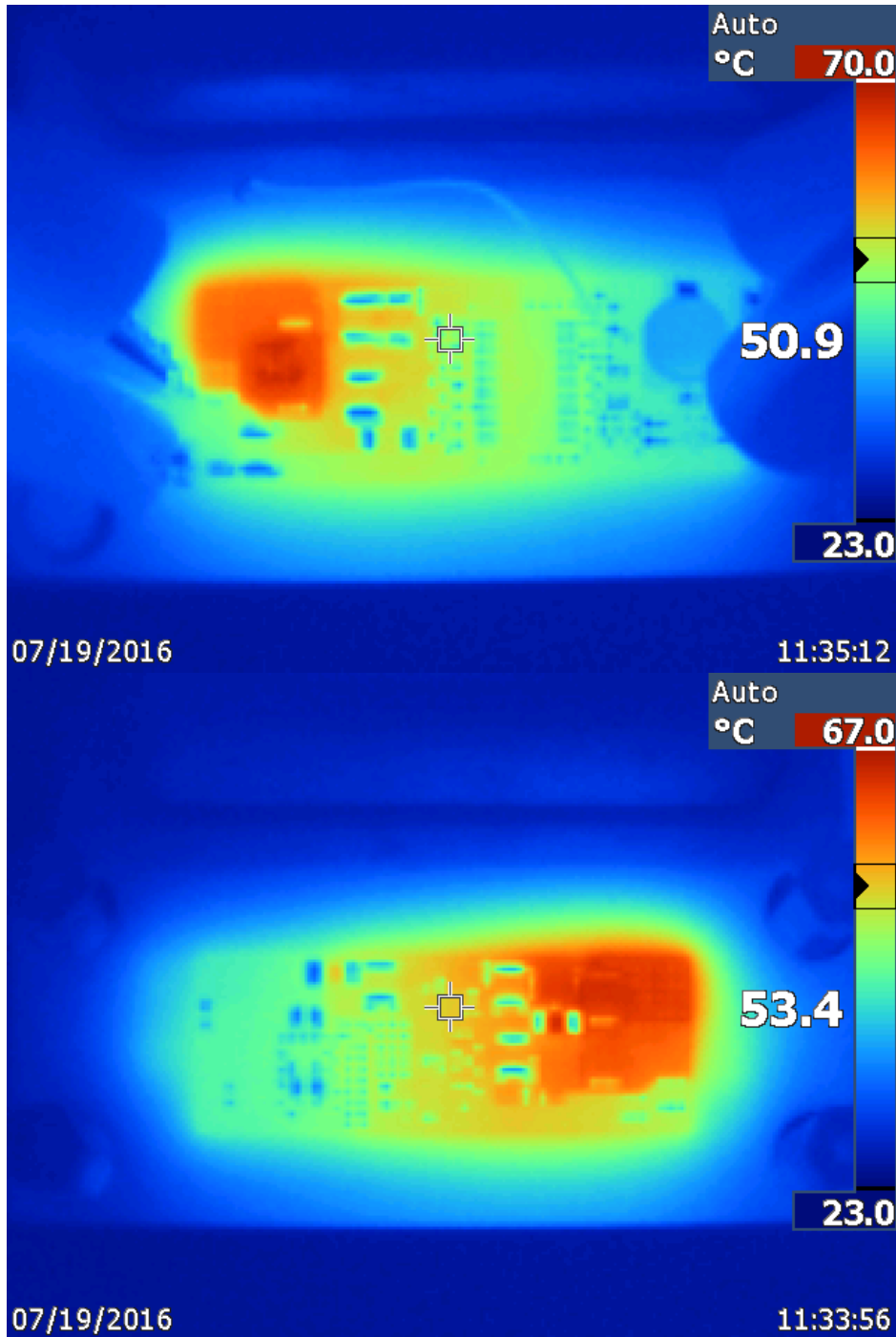
5.2 12V Input, 5V at 4.5A Output



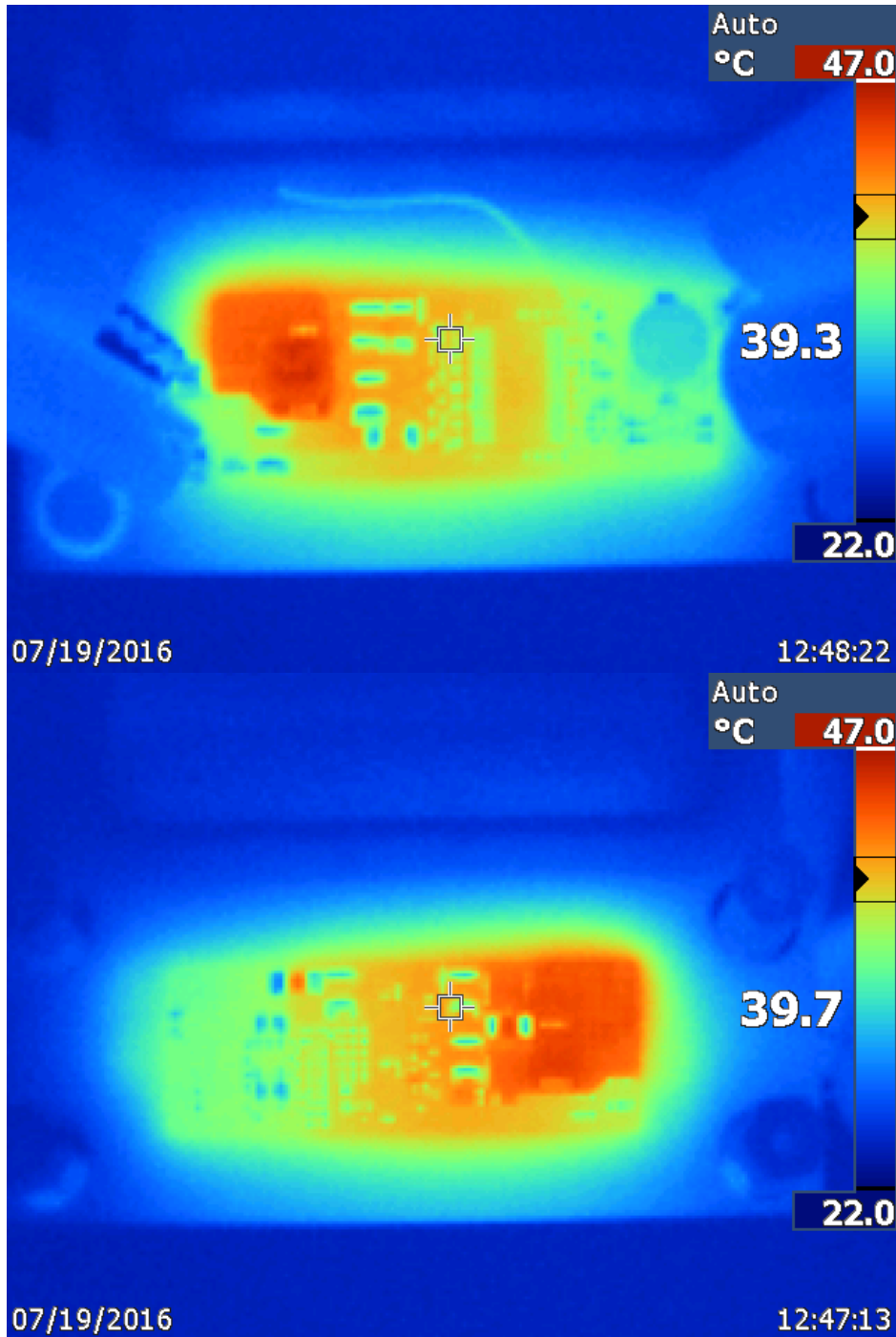
5.3 24V Input, 5V at 4.5A Output



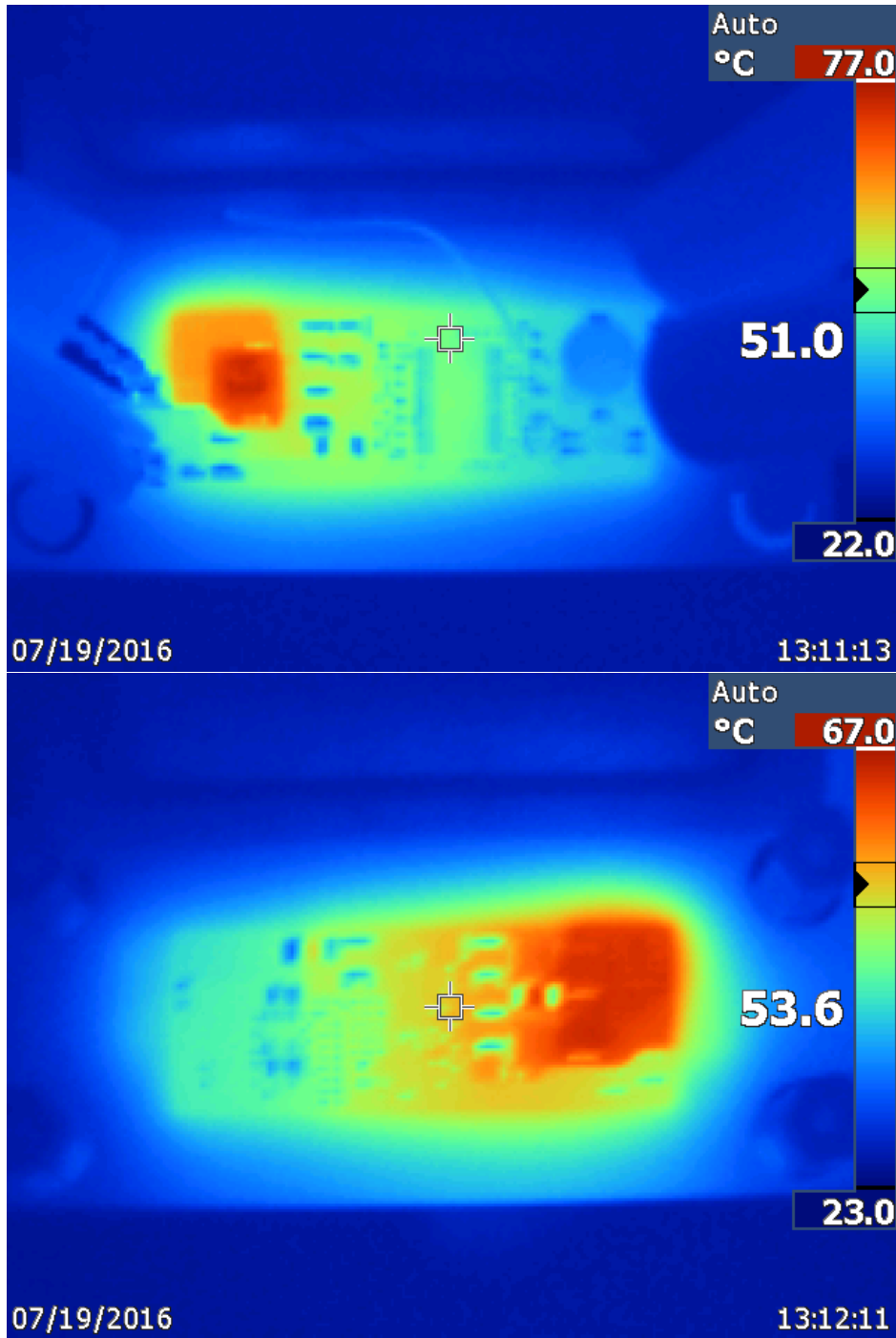
5.4 6V Input, 9V at 2.5A Output



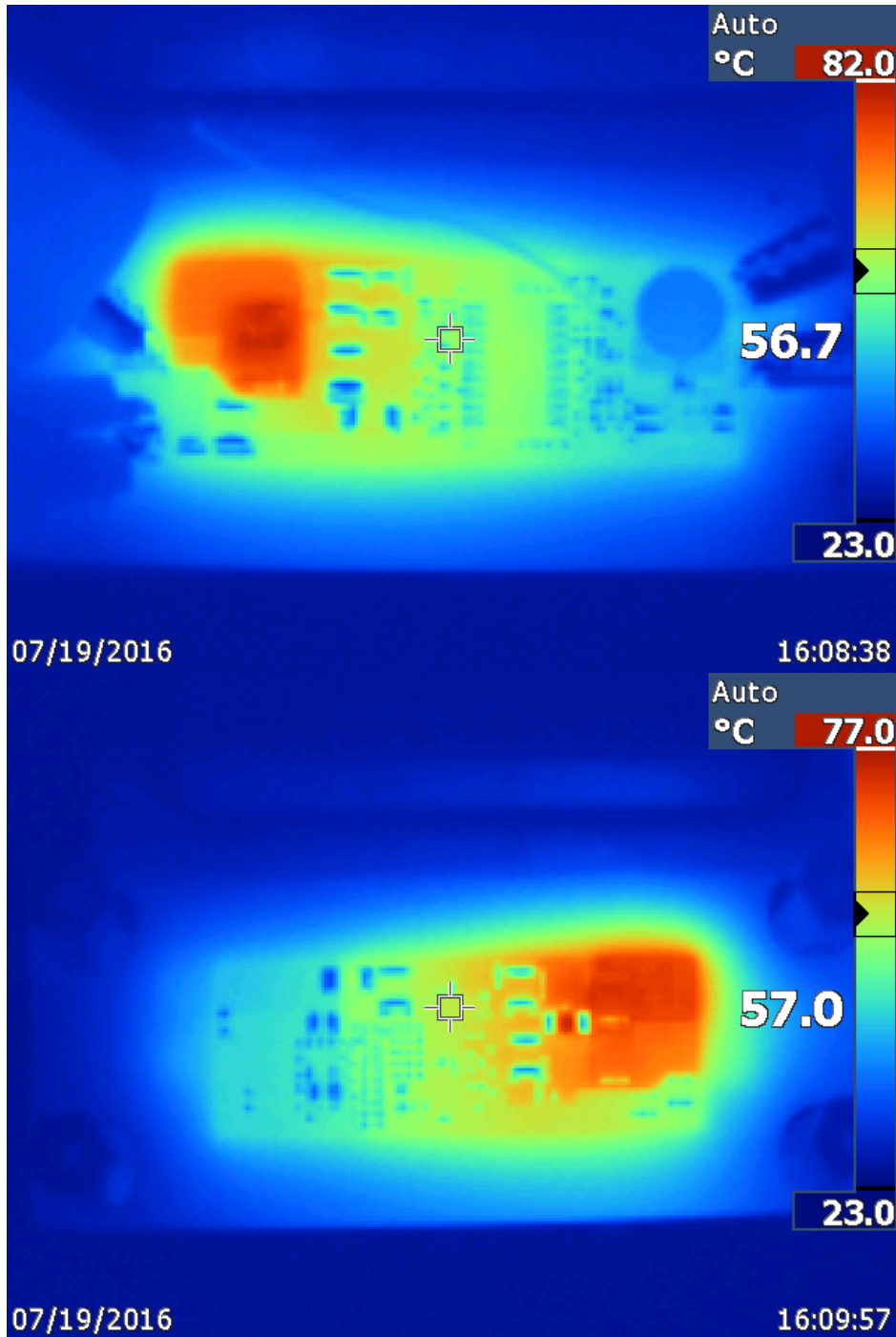
5.5 12V Input, 9V at 2.5A Output



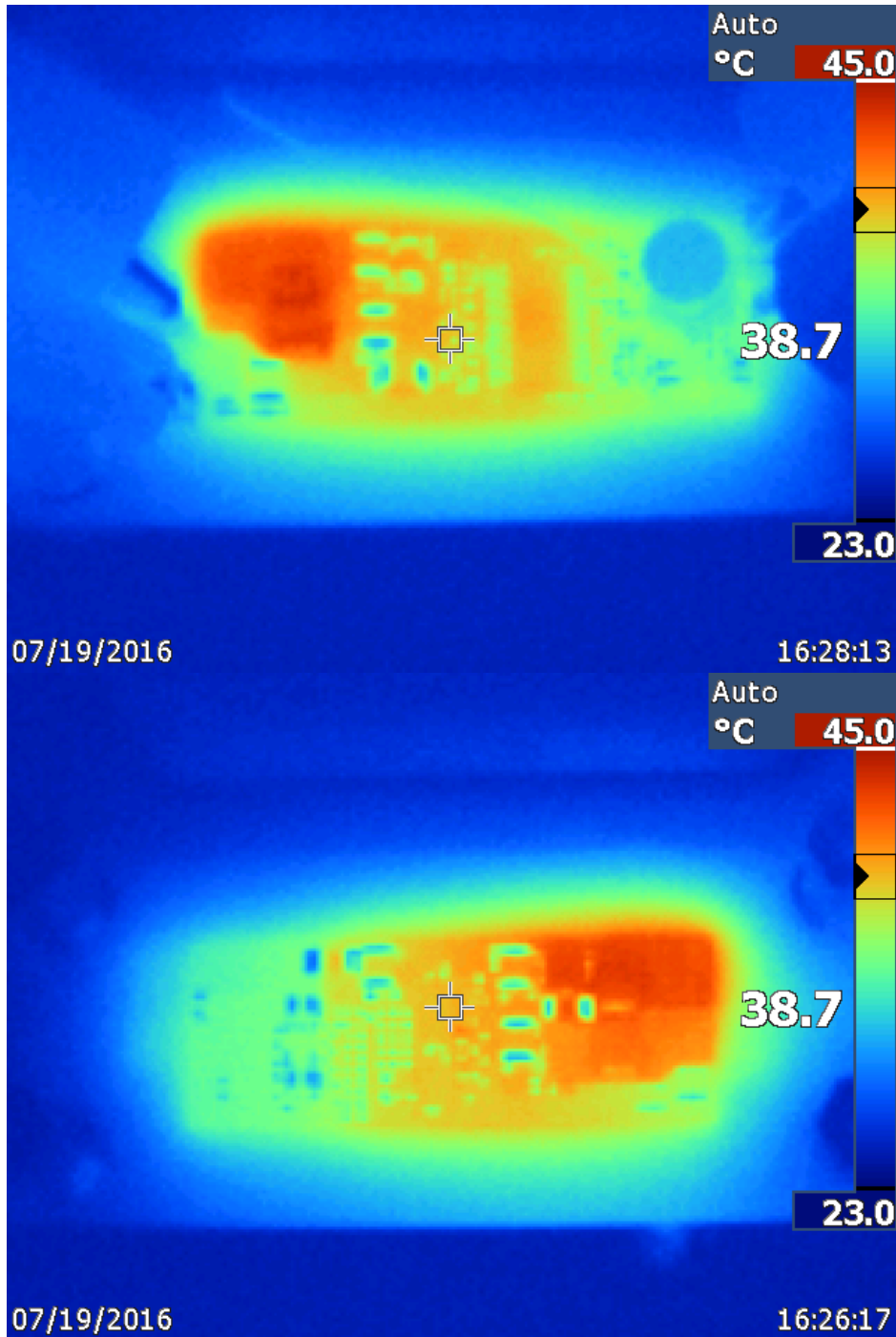
5.6 24V Input, 9V at 2.5A Output



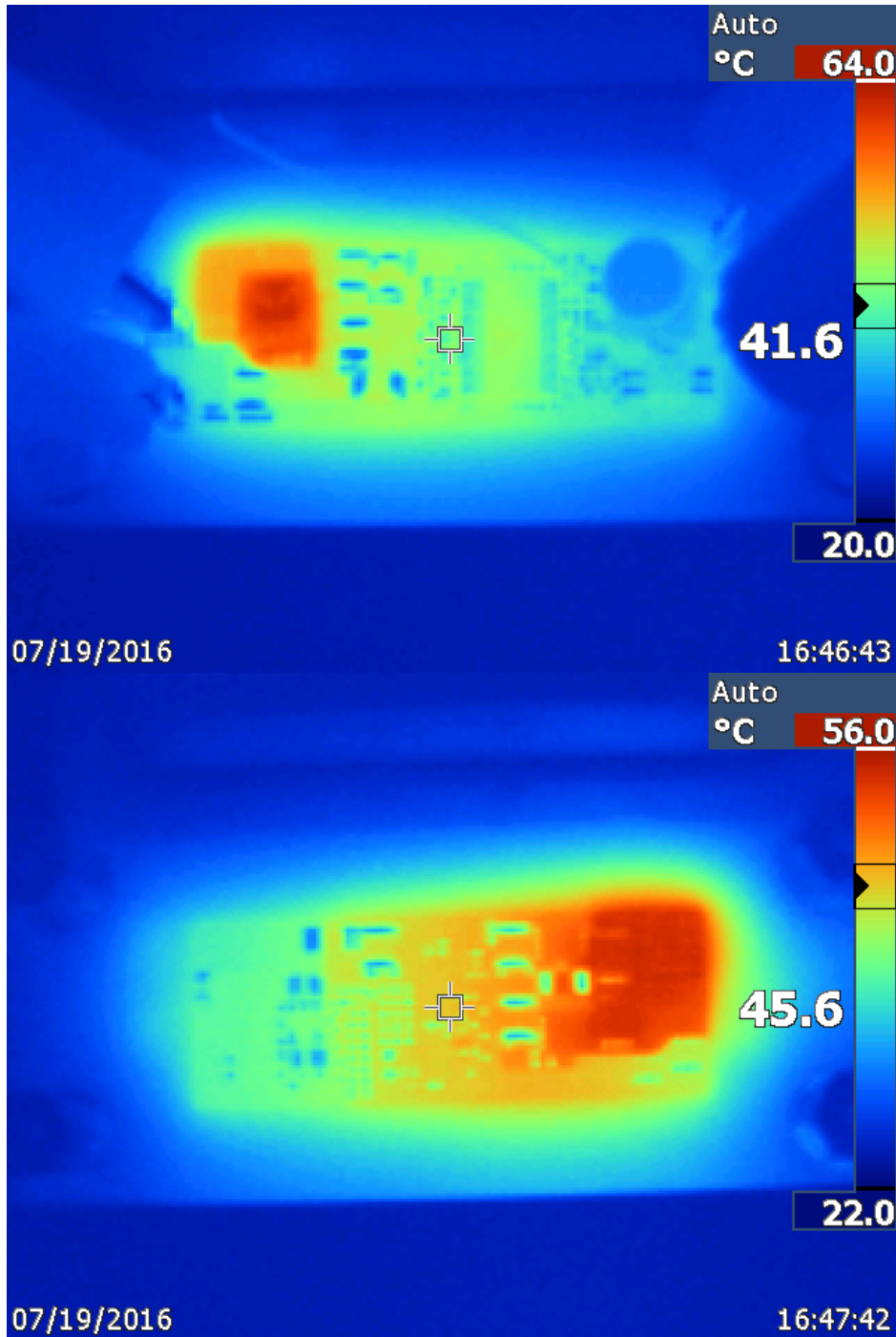
5.7 6V Input, 15V at 1.5A Output



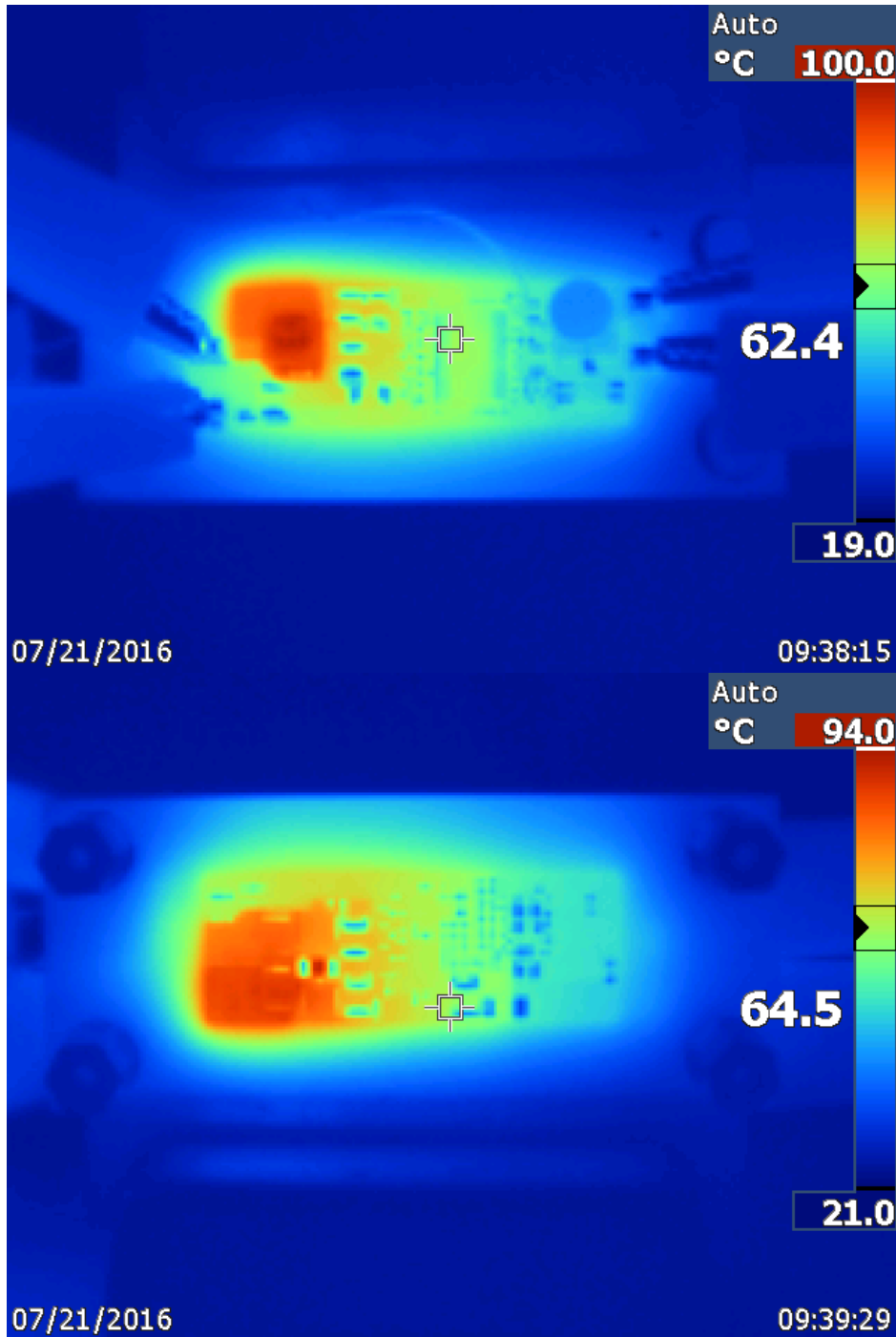
5.8 12V Input, 15V at 1.5A Output



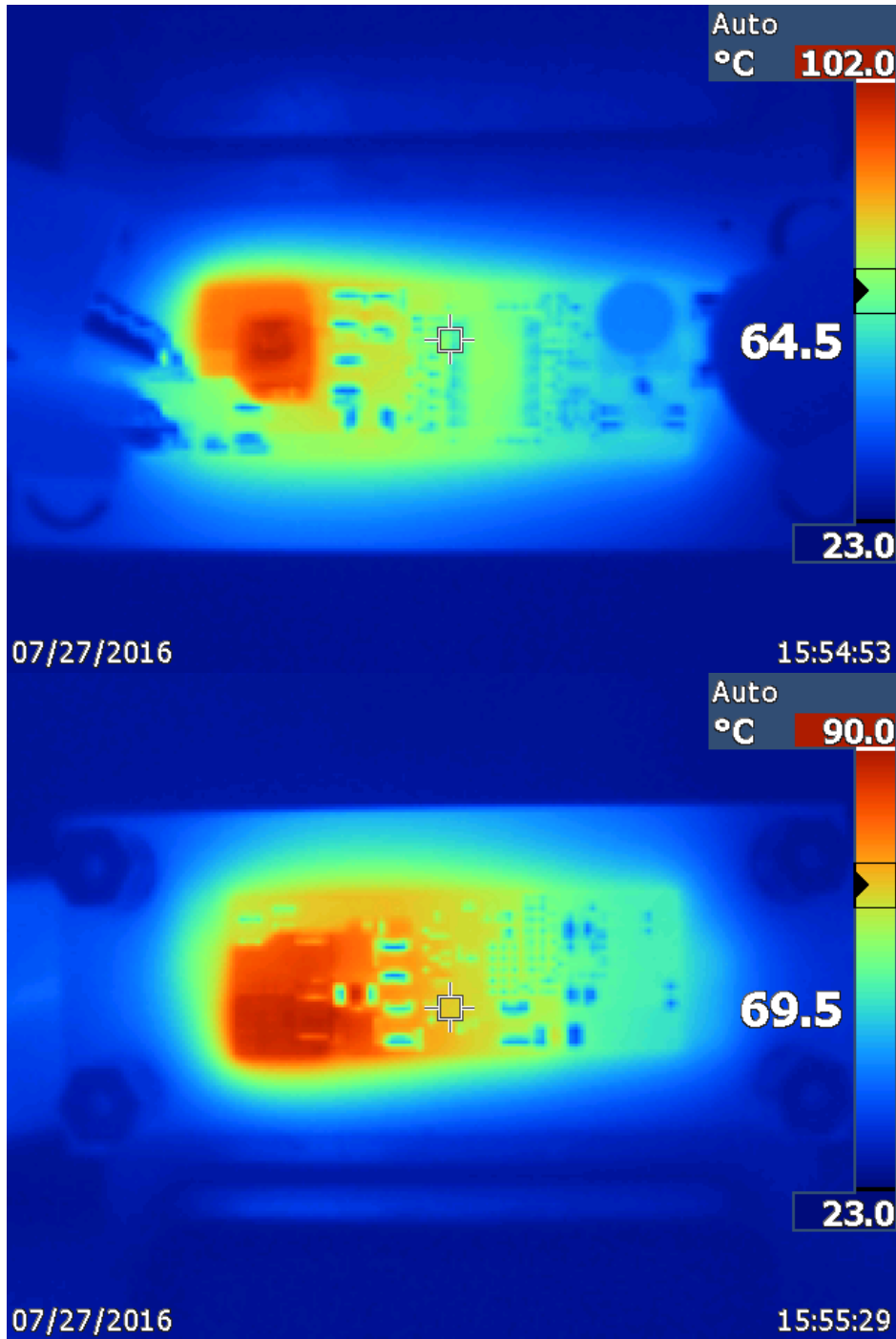
5.9 24V Input, 15V at 1.5A Output



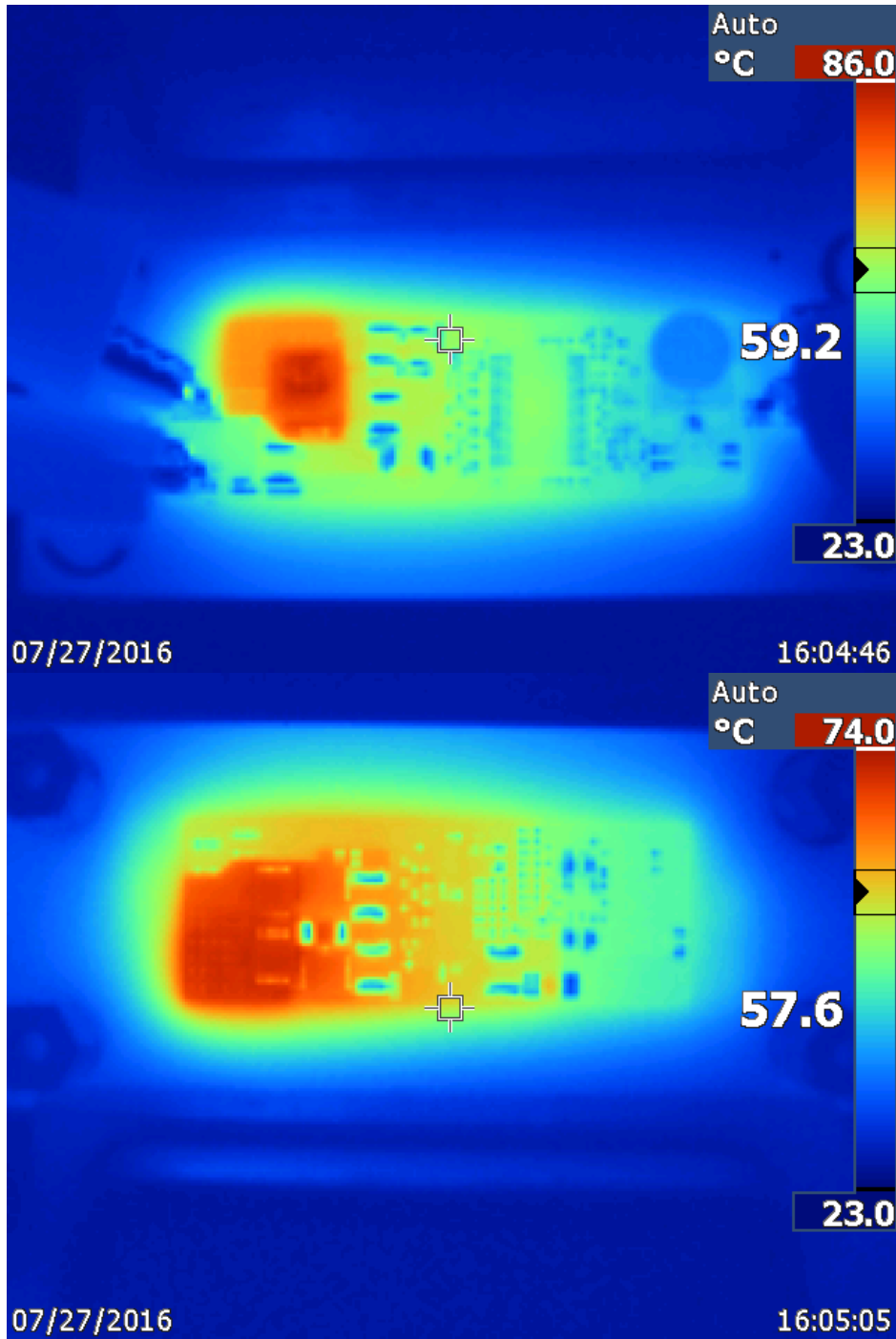
5.10 6V Input, 20V at 1.25A Output



5.11 12V Input, 20V at 2.5A Output

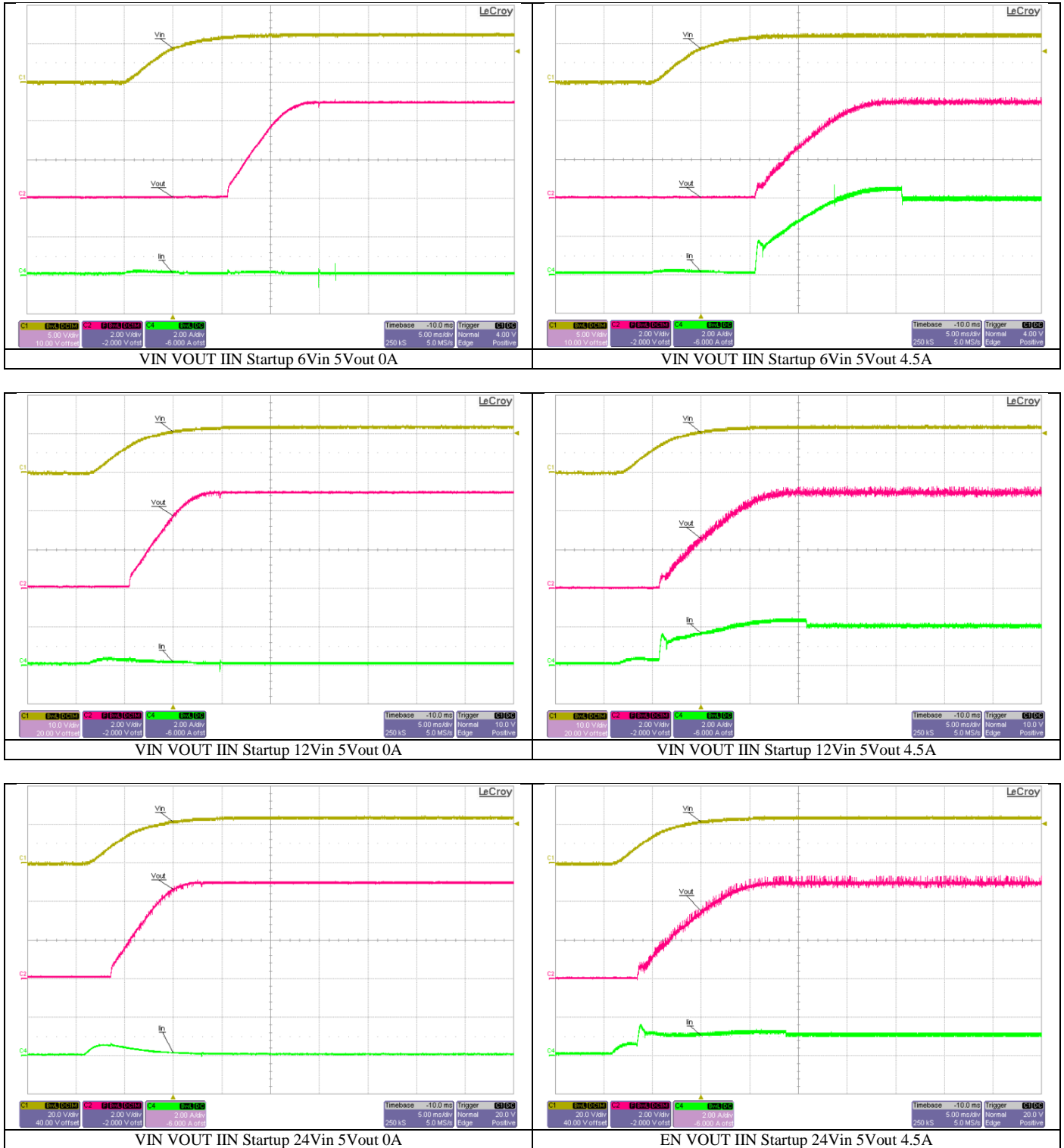


5.12 24V Input, 20V at 2.5A Output

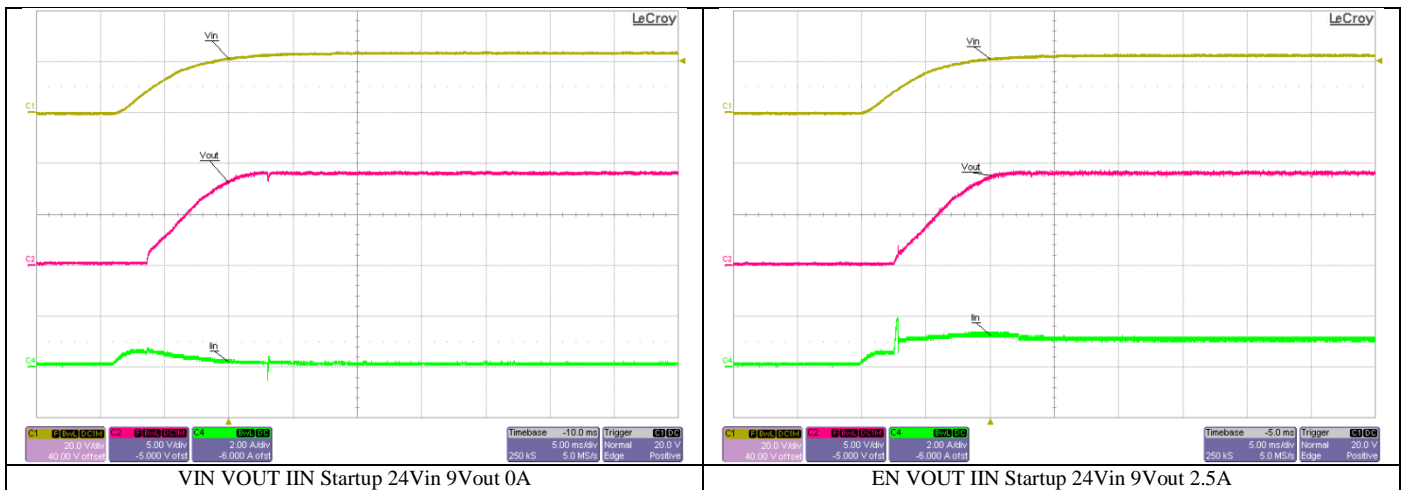
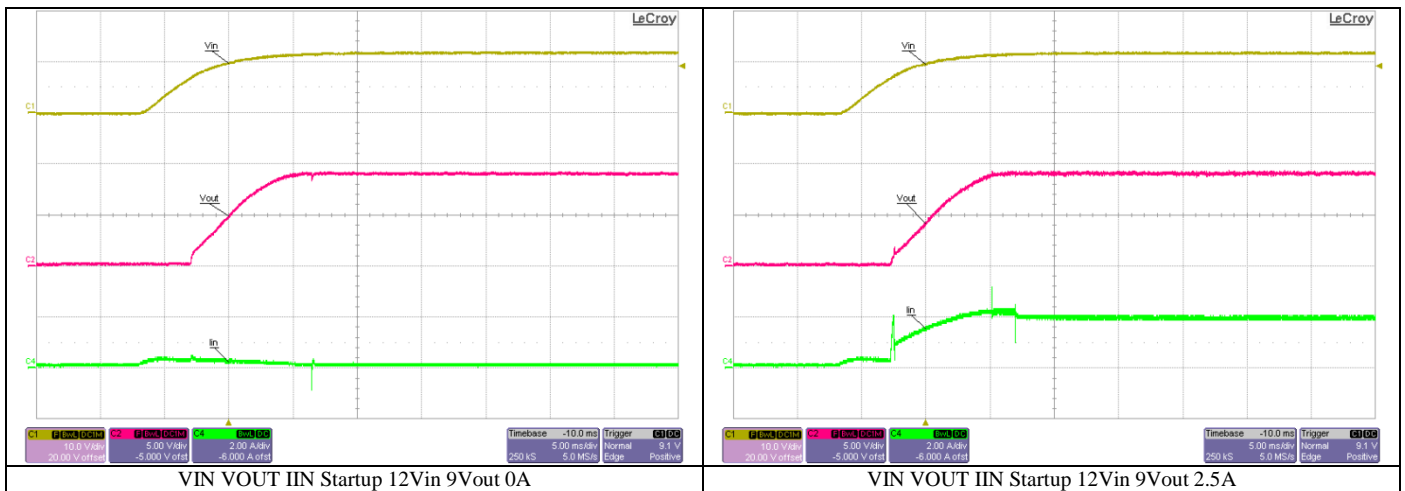
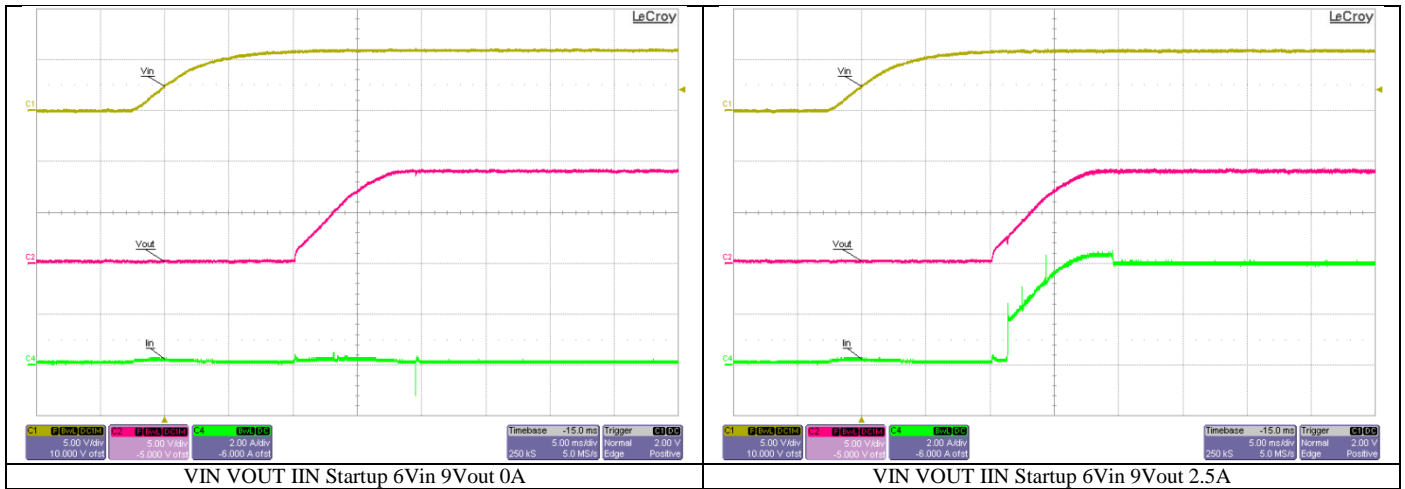


6 Startup

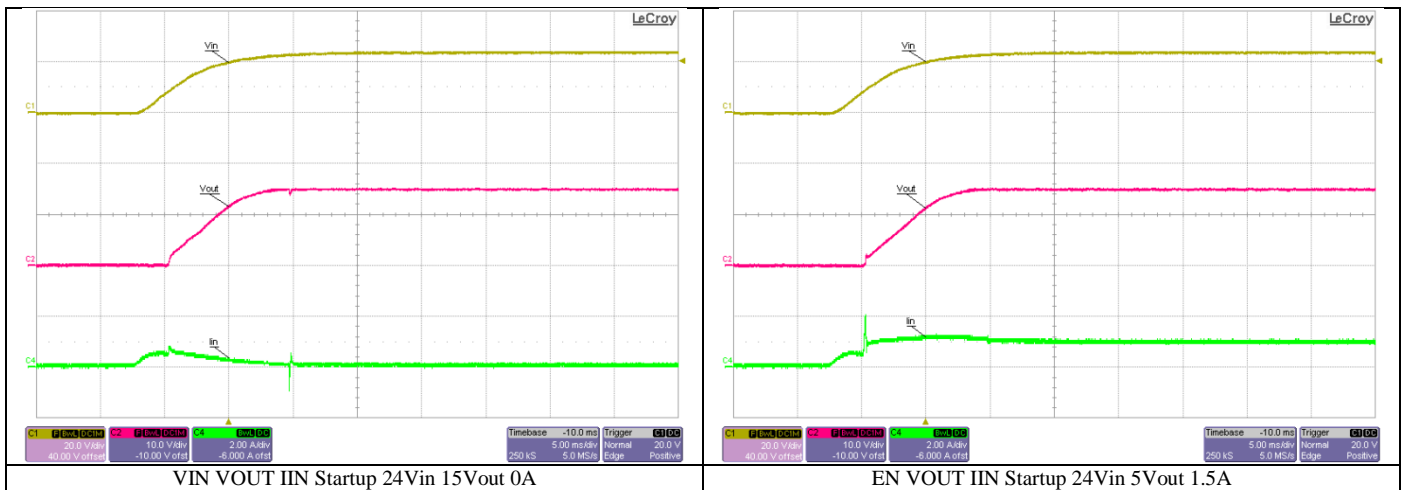
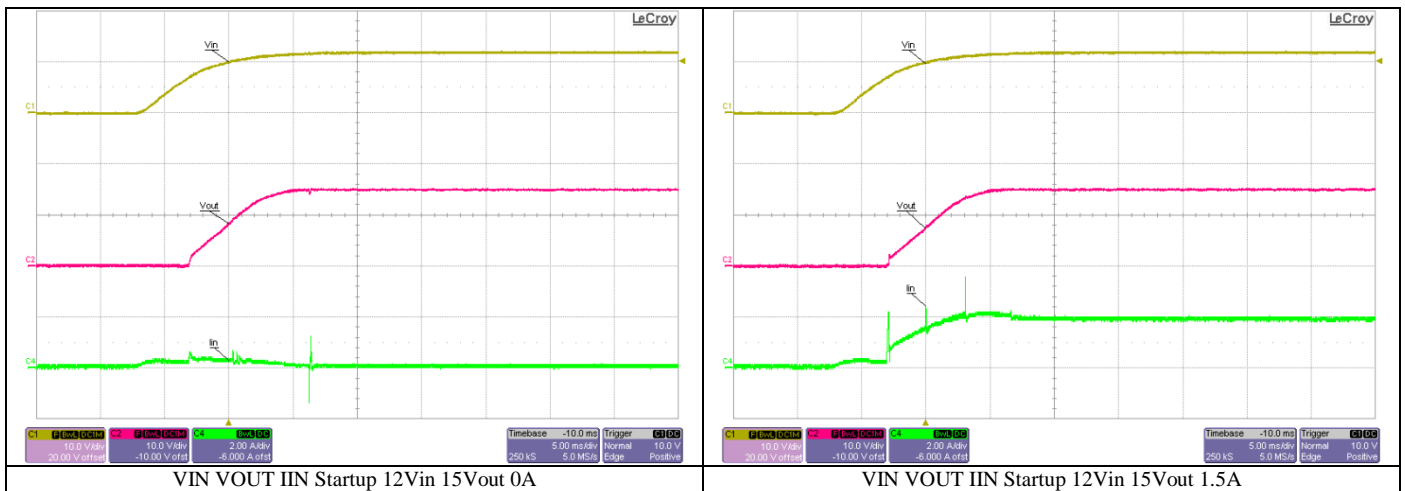
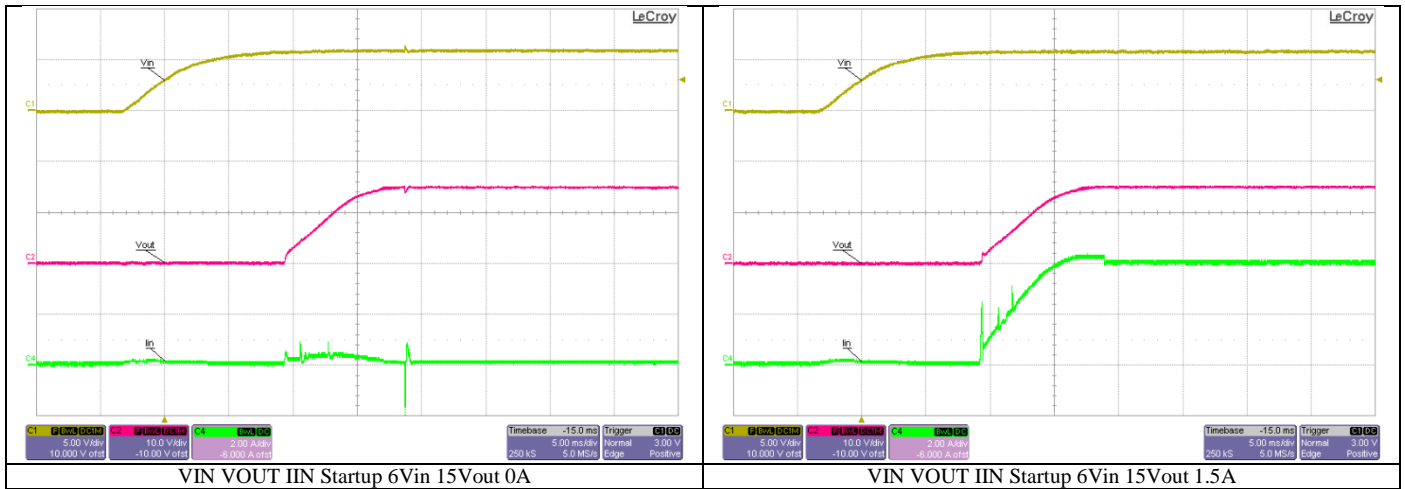
6.1 5V Output



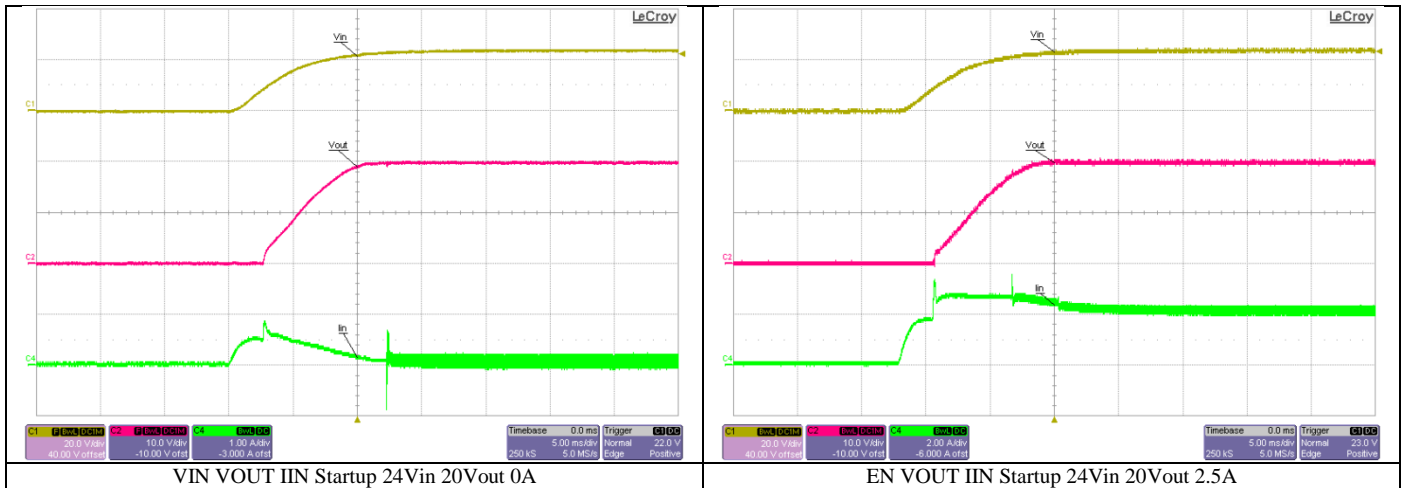
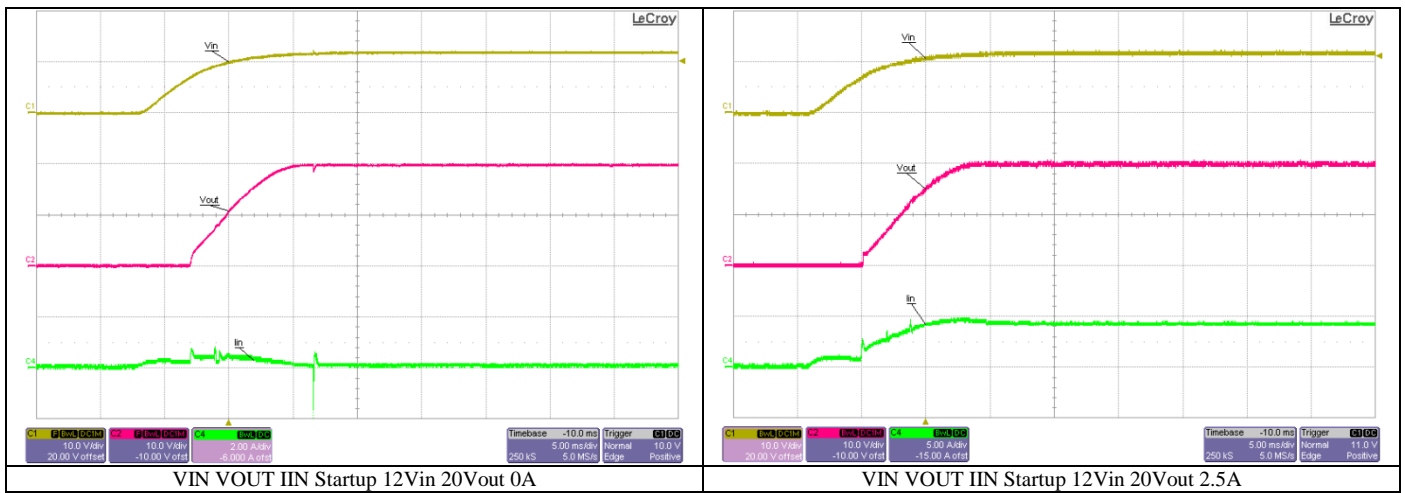
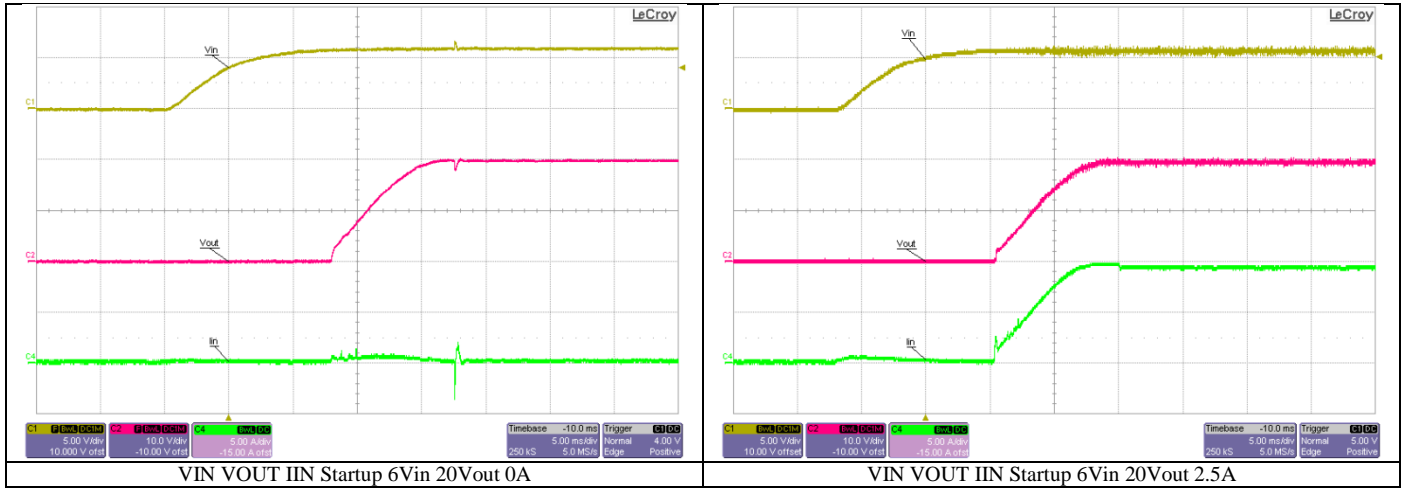
6.2 9V Output



6.3 15V Output

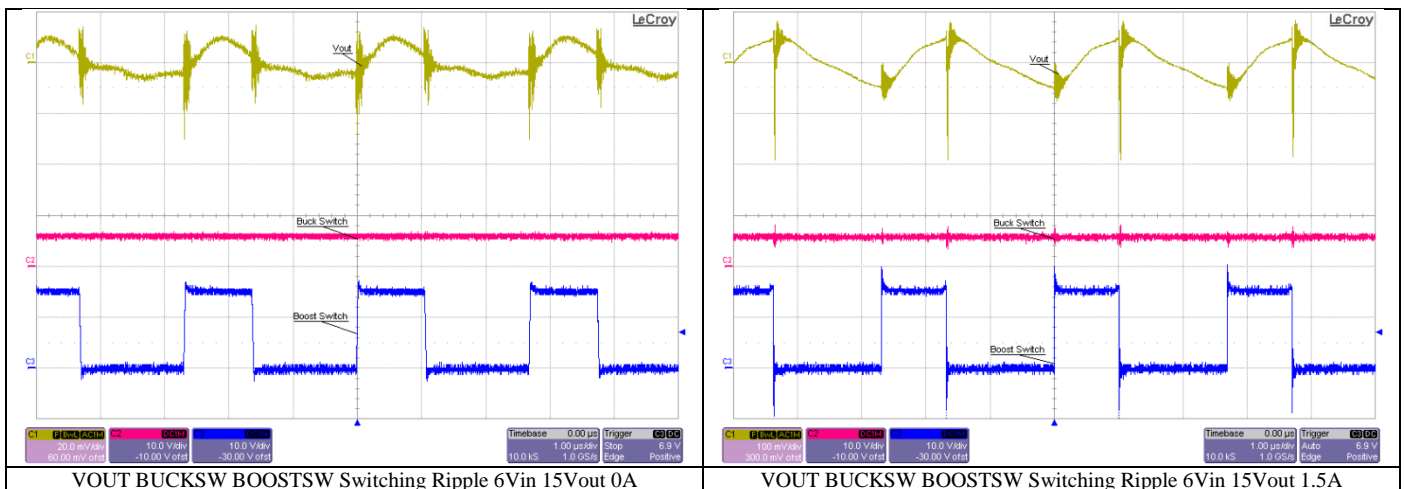
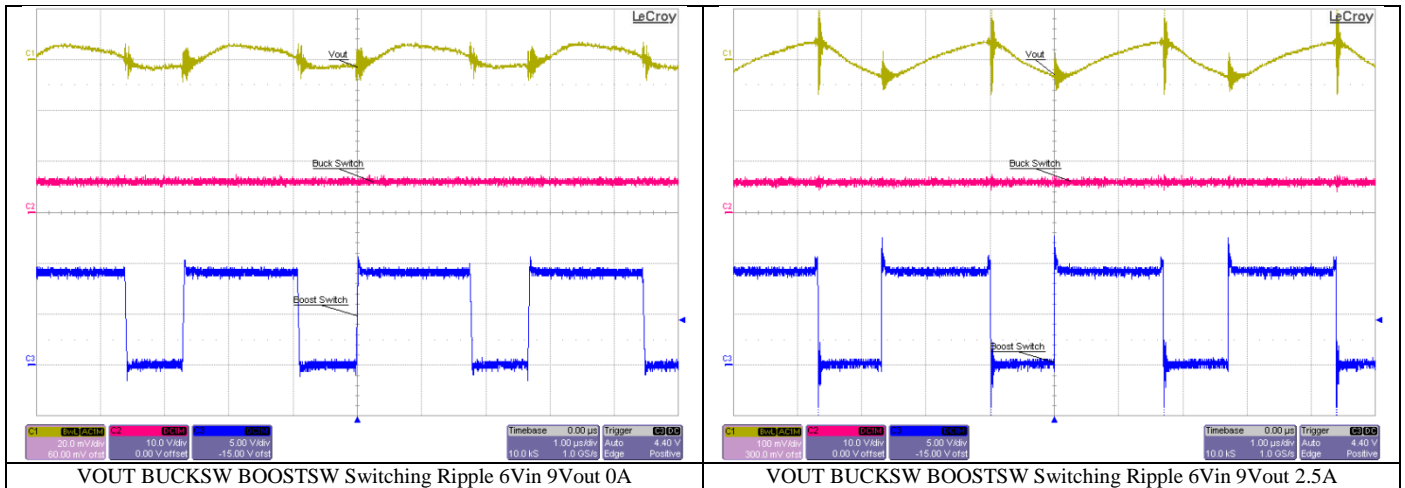
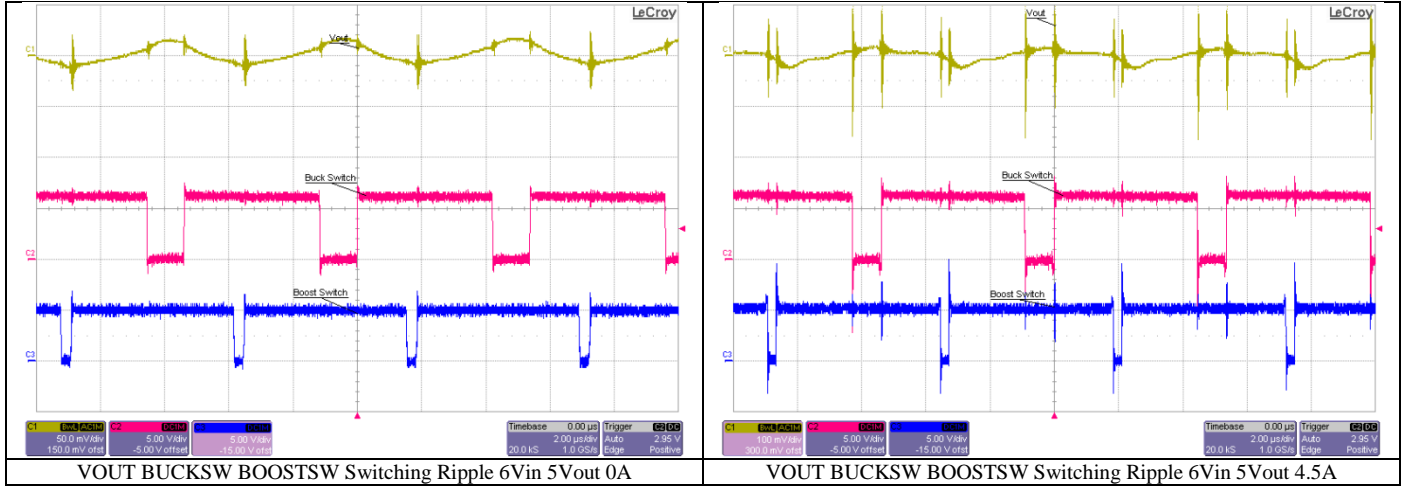


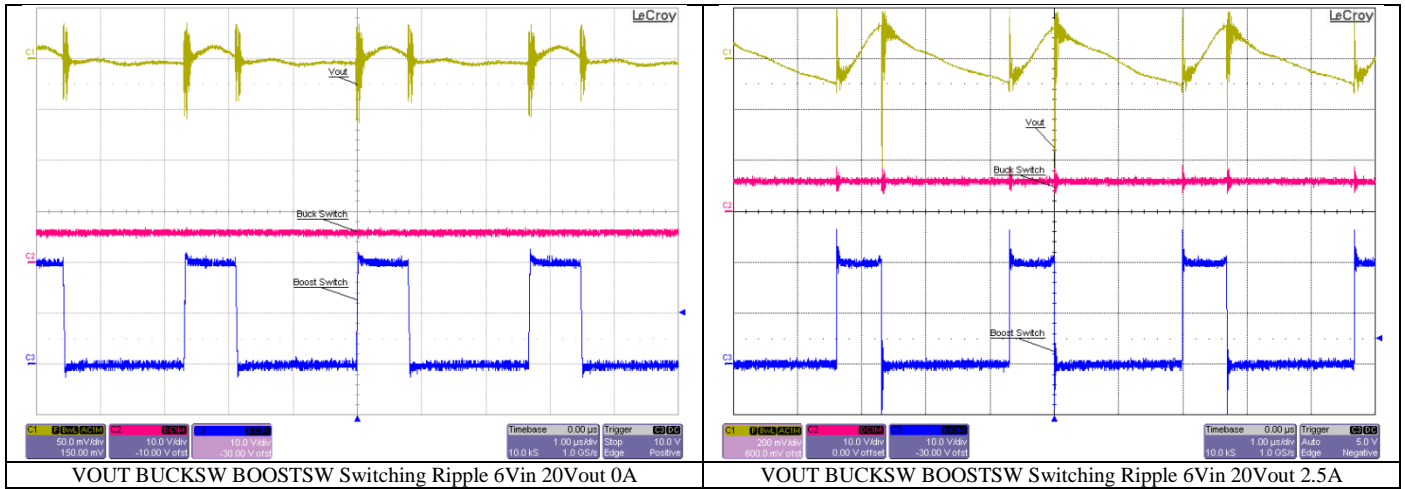
6.4 20V Output



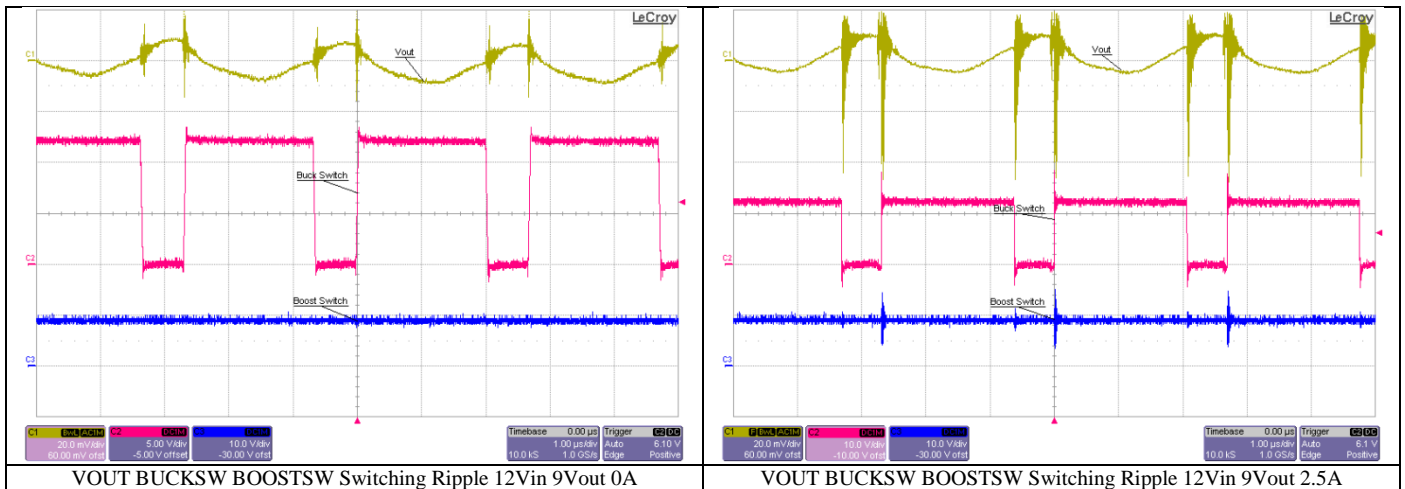
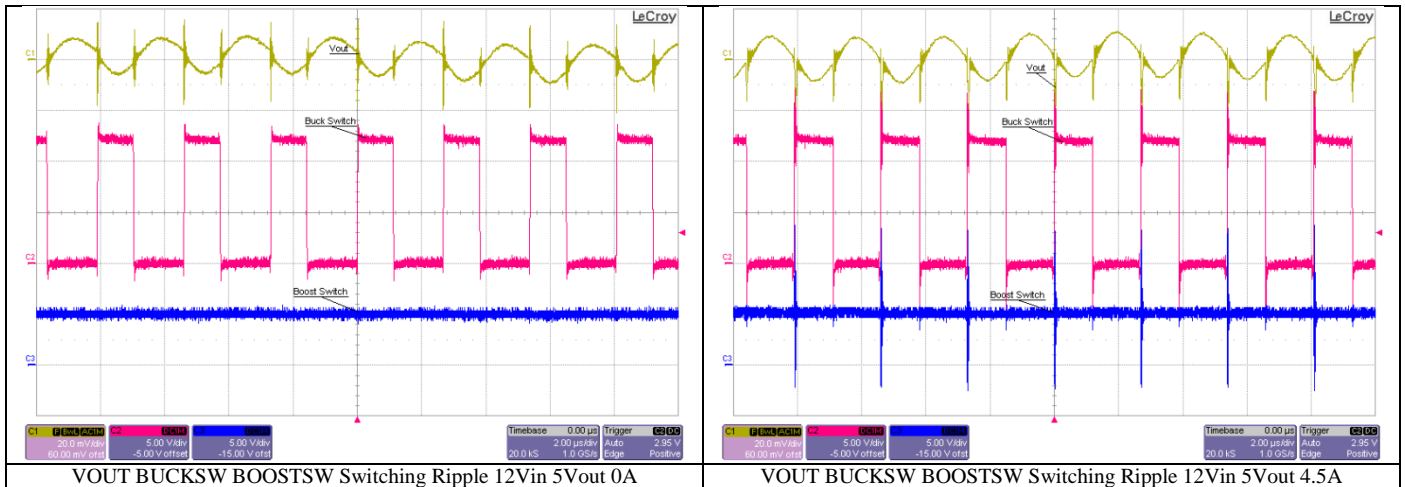
7 Switching and Ripple Voltage

7.1 6V Input

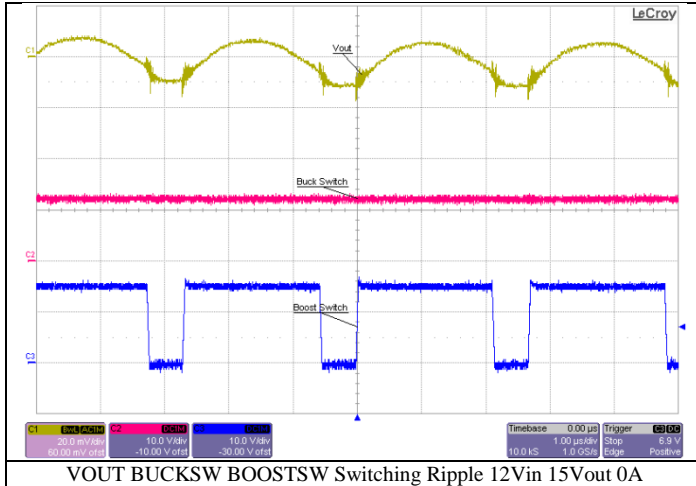




7.2 12V Input



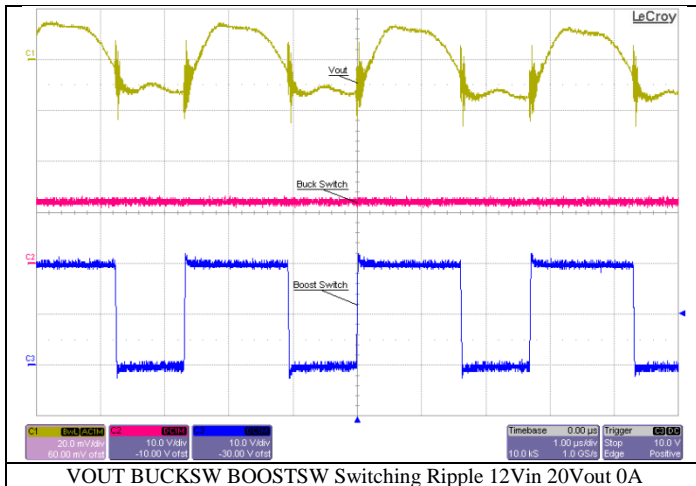
PMP10726 Test Results



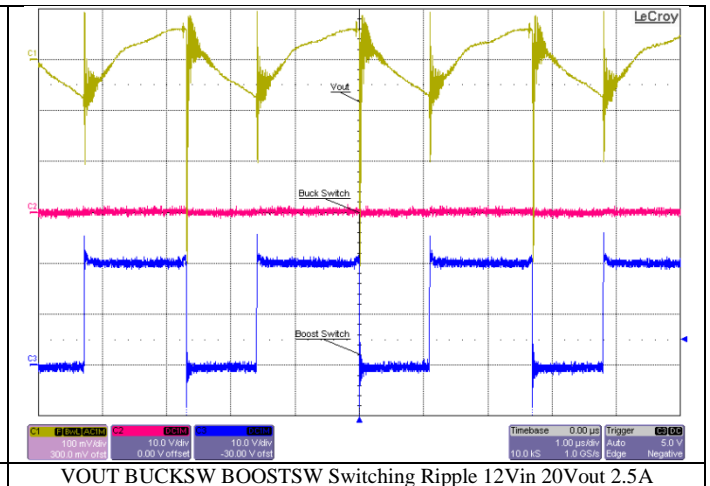
VOUT BUCKSW BOOSTSW Switching Ripple 12Vin 15Vout 0A



VOUT BUCKSW BOOSTSW Switching Ripple 12Vin 15Vout 1.5A

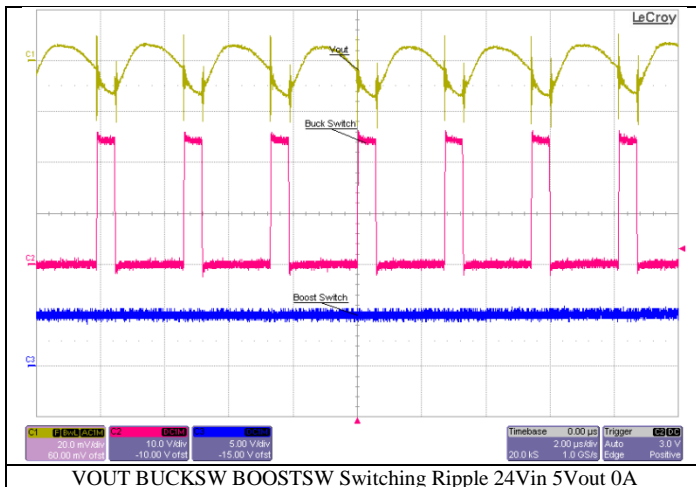


VOUT BUCKSW BOOSTSW Switching Ripple 12Vin 20Vout 0A

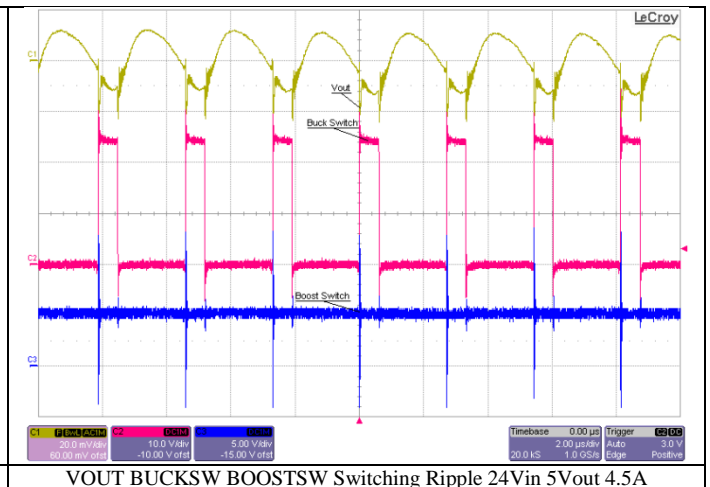


VOUT BUCKSW BOOSTSW Switching Ripple 12Vin 20Vout 2.5A

7.3 24V Input

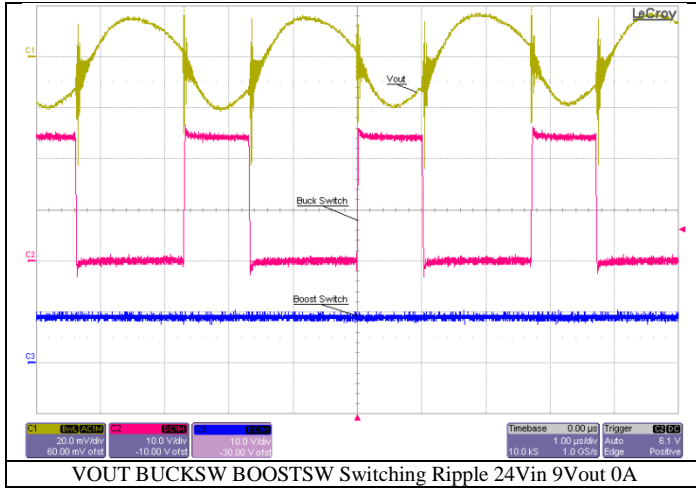


VOUT BUCKSW BOOSTSW Switching Ripple 24Vin 5Vout 0A

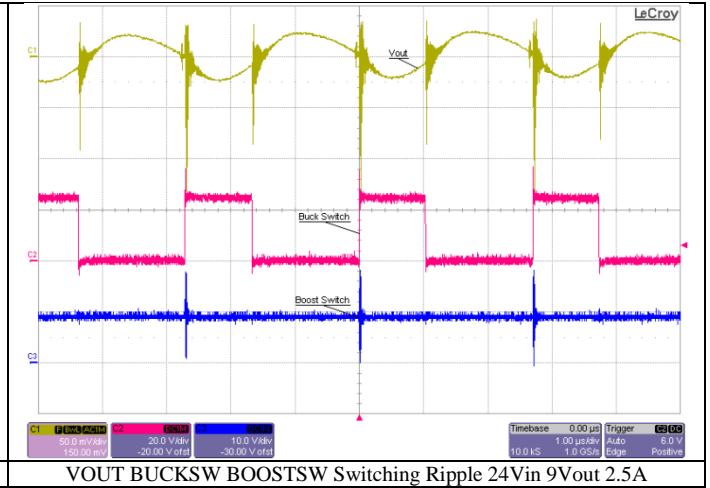


VOUT BUCKSW BOOSTSW Switching Ripple 24Vin 5Vout 4.5A

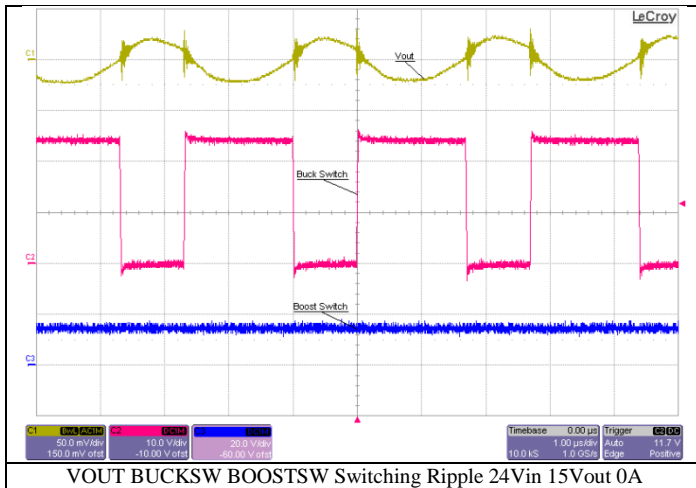
PMP10726 Test Results



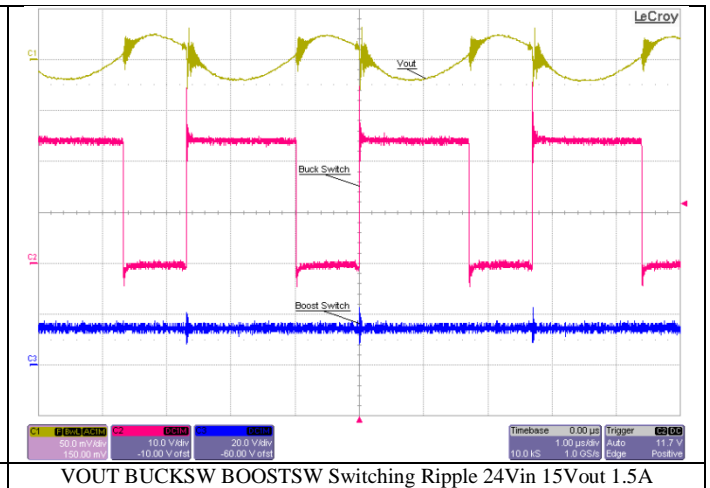
VOUT BUCKSW BOOSTSW Switching Ripple 24Vin 9Vout 0A



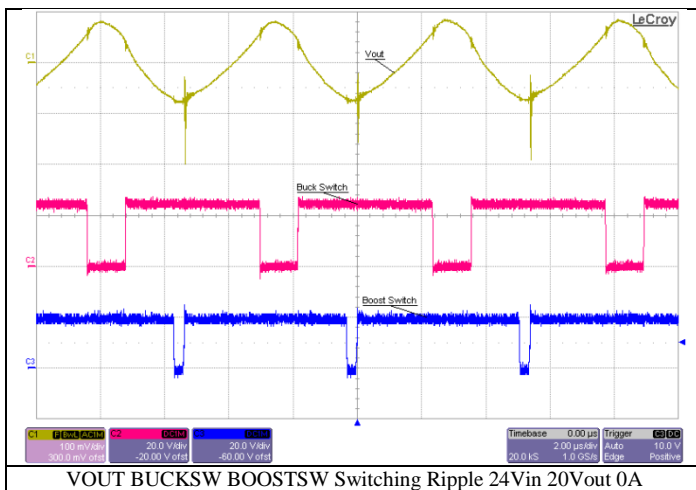
VOUT BUCKSW BOOSTSW Switching Ripple 24Vin 9Vout 2.5A



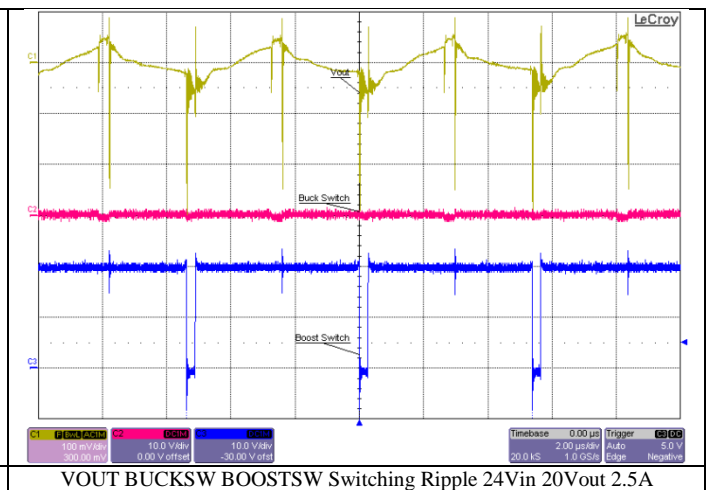
VOUT BUCKSW BOOSTSW Switching Ripple 24Vin 15Vout 0A



VOUT BUCKSW BOOSTSW Switching Ripple 24Vin 15Vout 1.5A



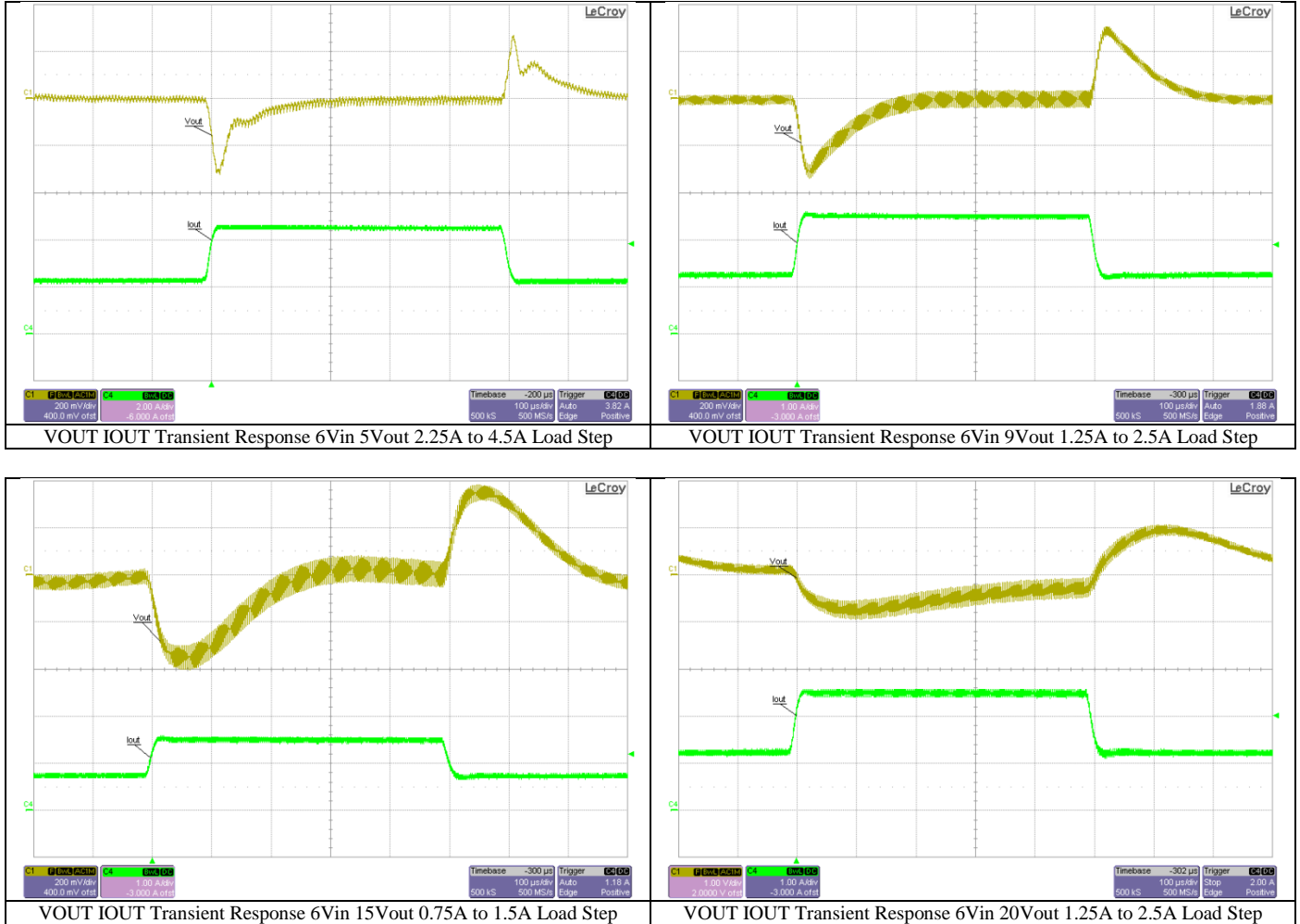
VOUT BUCKSW BOOSTSW Switching Ripple 24Vin 20Vout 0A



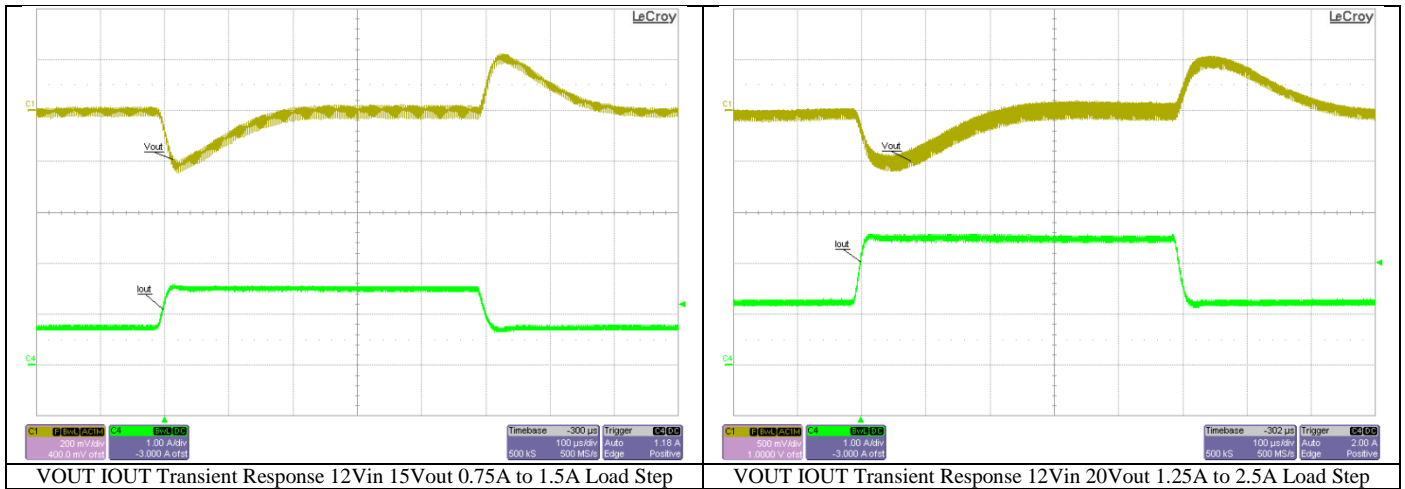
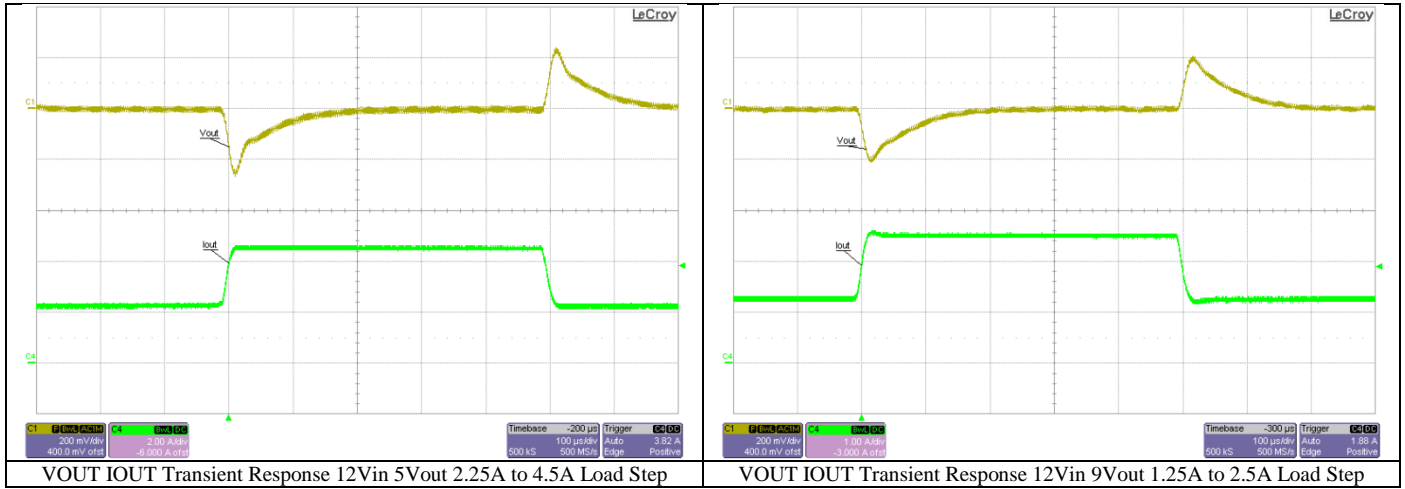
VOUT BUCKSW BOOSTSW Switching Ripple 24Vin 20Vout 2.5A

8 Load Transient Response

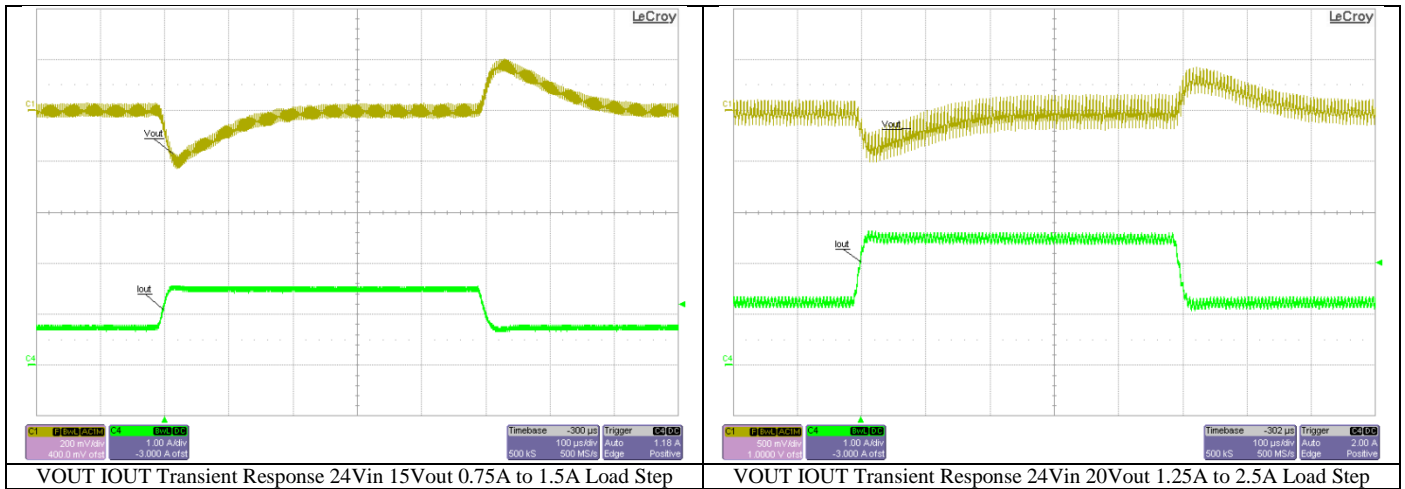
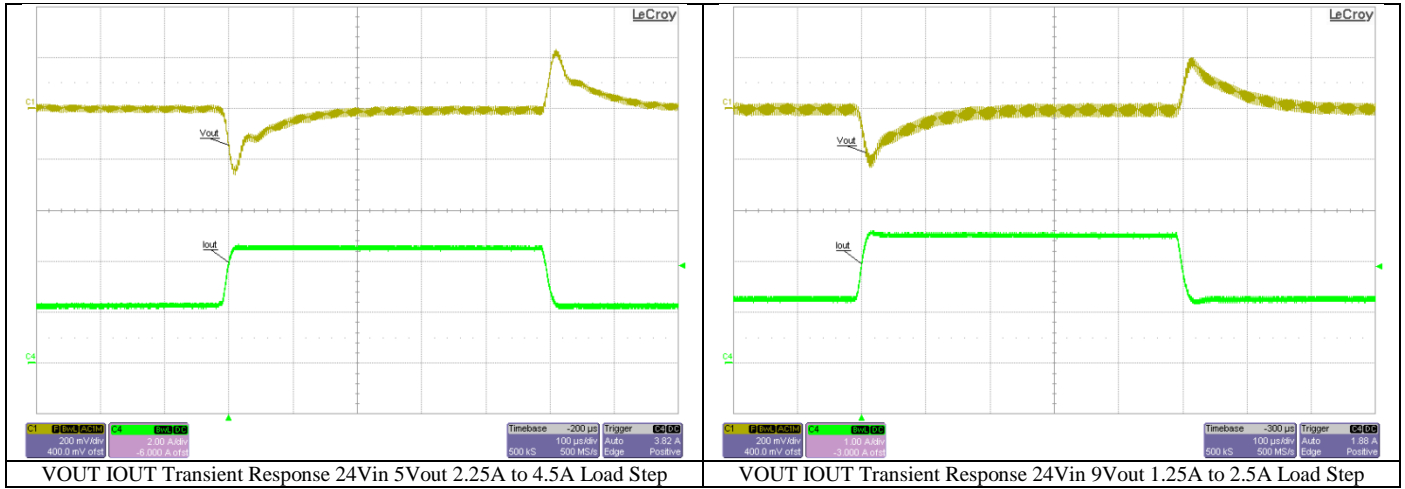
8.1 6V Input



8.2 12V Input

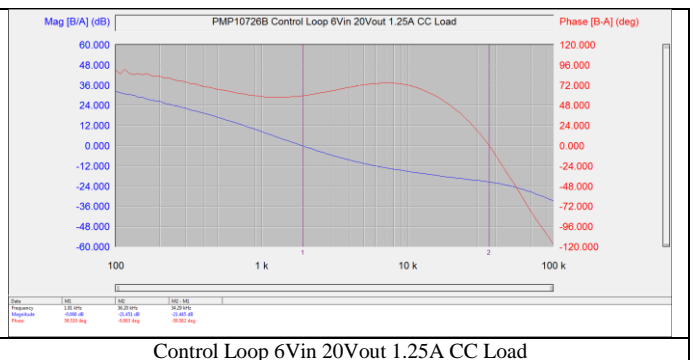
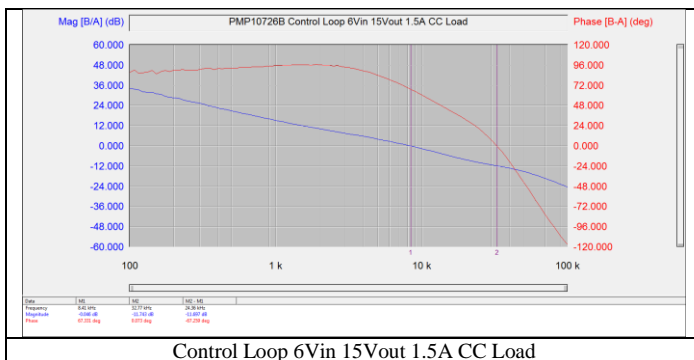
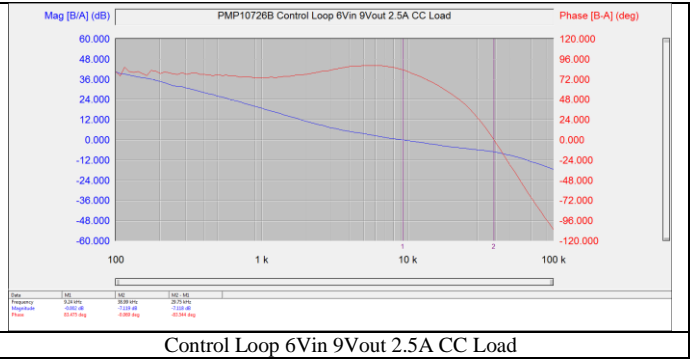
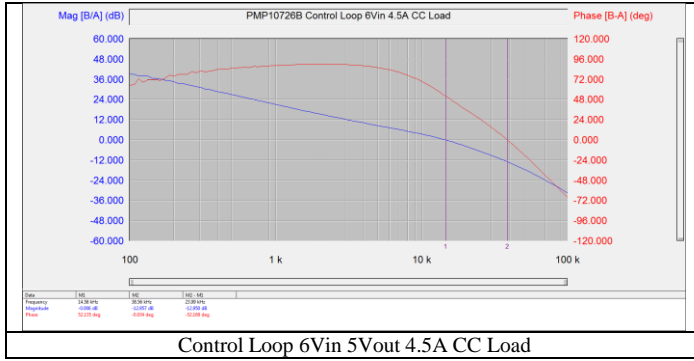


8.3 24V Input

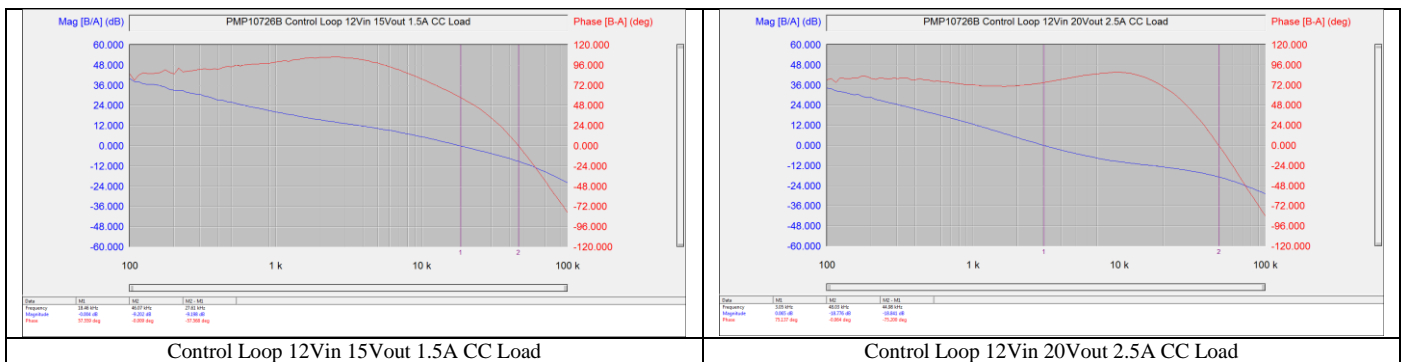
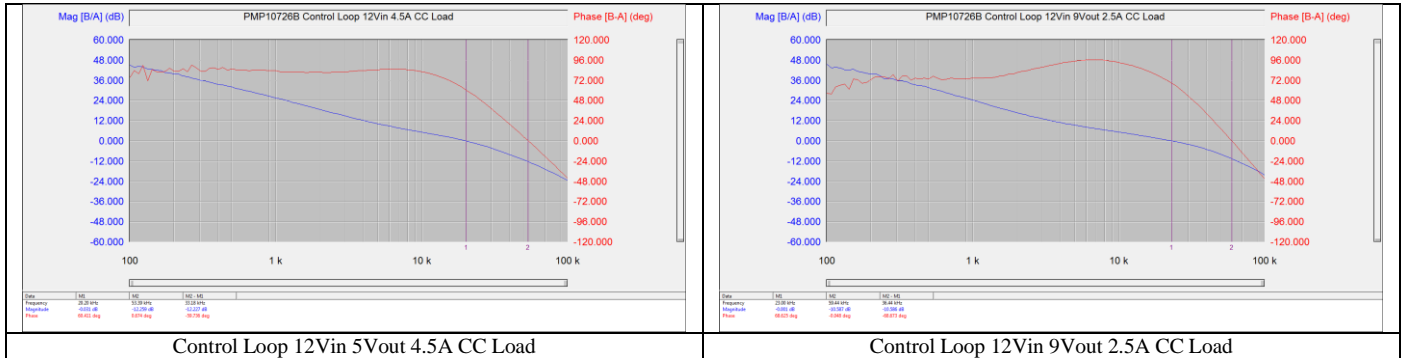


9 Frequency Response

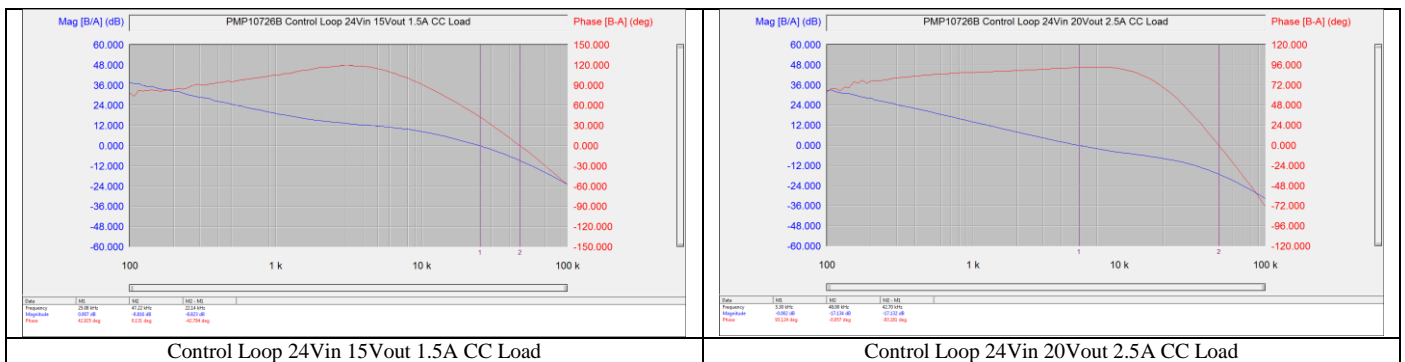
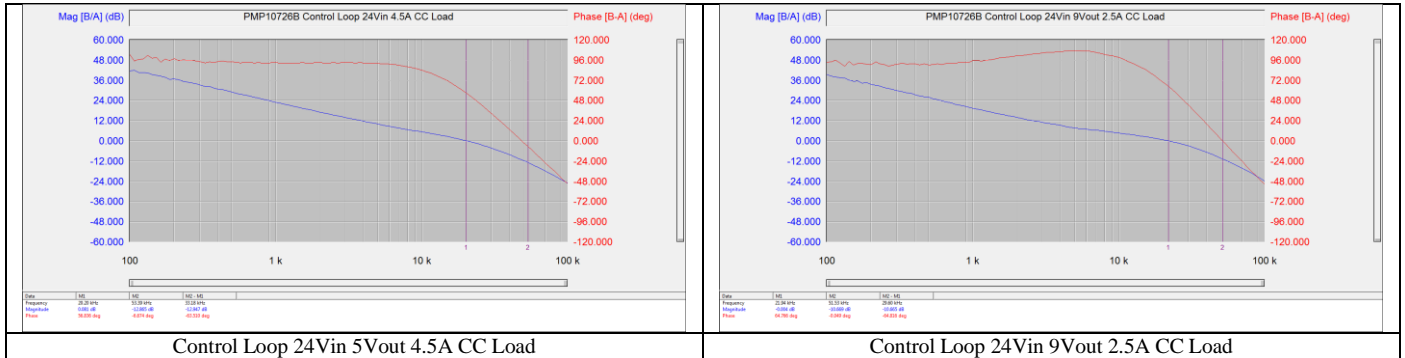
9.1 6V Input



9.2 12V Input



9.3 24V Input



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