PMP-11208 900 mV 220A 6 phases off 12Vin Test Report (TPS53661 / CSD95372B)
Texas Instruments

Why separate report for 900mV output:

PMP9738 has same physical design and was tested at 1.0 Vout where off 12Vin there is "fixed frequency" of about 300kHz and variable on time. PMP10393 is the 600mV version running always with fixed on time per phase of about 260 nsec (plus up to 30 nsec switch delay) and variable frequency down to the 220-250 kHz range for 600mV off 12Vin . See its report showing satisfactory performance with this mode. Efficiency is actually improved with the reduced switching frequency. Even though there is no active current sharing, the fixed pulse width per phase actually improves thermal sharing for variations in on resistance of the power stages.

With the 900 mV application at 220 A, it was decided to test up to 240 A vs. the 200 A max previously.

At each load interval of 20A from zero to 120 A and at 139A, 180A, 220A and 240A, Vin was varied from below 11V to over 13V monitoring main switching pulses to verify no instabilities during transition between quasi constant frequency and fixed pulse width modes.

In most 12Vin applications, extensive testing is not done at 11 & 13 Vin as operation and results are very similar. Here with 11 Vin having operation in quasi fixed frequency over almost the entire load range and 13 Vin having operation in fixed on time over the entire load range and 12 Vin having fixed on time at light loads and quasi fixed frequency at heavy loads, it was decided to look in more detail at all 3 inputs.

With the large load step & dump test, 11 Vin would have quasi fixed frequency throughout the change, 13 Vin would have fixed on time throughout the change and 12 Vin would switch between the two modes. However, peak overshoots and undershoots were very similar for all 3 cases.

Efficiency at light loads was about 1% higher at 11 Vin than at 13 Vin. However, about 100 A loading the 3 curves (11V, 12V, 13V) converged with efficiency differences becoming less than 0.1% for loads above 195 A. Here, lower frequency at higher Vin cancelled higher switching losses per cycle at higher Vin.

Frequency and on time vs. Vin and load: scope with 8 nsec low pass filter
Fluke 87 meter used for measuring Vout for loads under 160A
Agilent 34401A voltage meter used for measuring Vout at loads 160A and above

Vin in Volts	Vout	Iout	frequency	On time	Max temperature
12.04	0.9003	0	262k	285n	
12.01	0.9002	20	271k	278n	
12.05	0.9001	40	283k	269n	
12.00	0.9000	60	288k	268n	
12.00	0.8999	80	289k	268n	
12.02	0.8998	100	291k	268n	
12.04	0.8997	120	294k	268n	
12.01	0.8996	138.6	298k	268n	
12.00	0.8999	160	302k	267n	46/ir1072
12.01	0.8998	180	305k	267n	50
12.01	0.8996	200	307k	269n	56/ir1073
12.01	0.8995	220	310k	270n	63/ir1074
12.01	0.8994	240	310k	272n	72/ir1075
11.00	0.9003	0	286k	285n	
11.04	0.9002	20	294k	280n	
11.00	0.9001	40	298k	280n	
11.01	0.9000	60	300k	281n	
11.02	0.9000	80	301k	283n	
11.00	0.8998	100	302k	285n	
11.00	0.8997	120	304k	286n	
11.05	0.8996	138.6	304k	287n	
10.99	0.8996	180	307k	291n	52
10.99	0.8994	220	308k	295n	67/1r1080
10.99	0.8993	240	309k	298k	74/ir1077
13.01	0.9003	0	242k	285n	
13.03	0.9002	20	250k	279n	
13.01	0.9001	40	260k	269n	
13.02	0.9000	60	266k	268n	
13.01	0.8999	80	267k	268n	
13.02	0.8999	100	269k	268n	
13.01	0.8997	120	272k	268n	
13.00	0.8996	138.6	276k	268n	
13.00	0.8997	180	280k	268n	52
13.01	0.8994	220	287k	268n	66/ir1079
13.00	0.8993	240	289k	268n	75/ir1078

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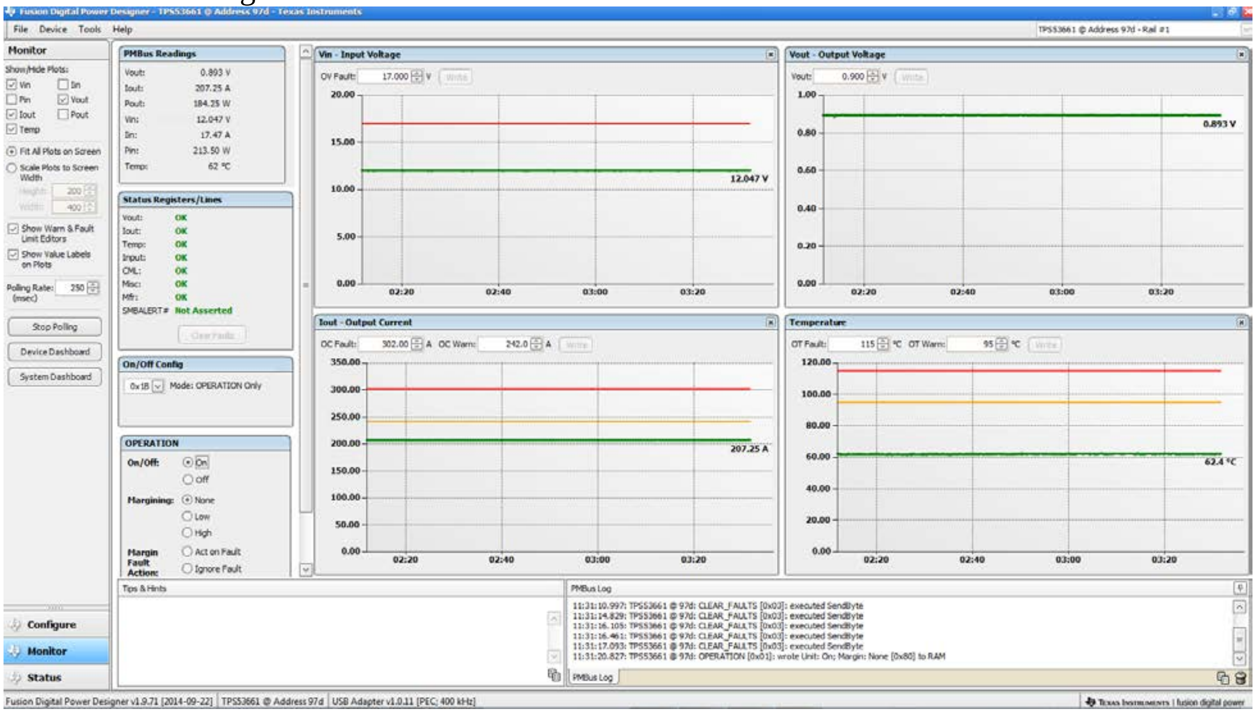
Target “quasi fixed frequency” is 300 kHz.
Even at “constant on time mode”, actual on time at zero and 20 A loads increased due to slower turn off of power stages than turn on at light loads.
Hence, at 13 Vin always in “constant on time mode” with varying frequency;
At 11 Vin at “quasi fixed frequency” except to zero and 20 A loads;
At 12 Vin in “constant on time mode” at light to moderate loads.

Full load GUI image:



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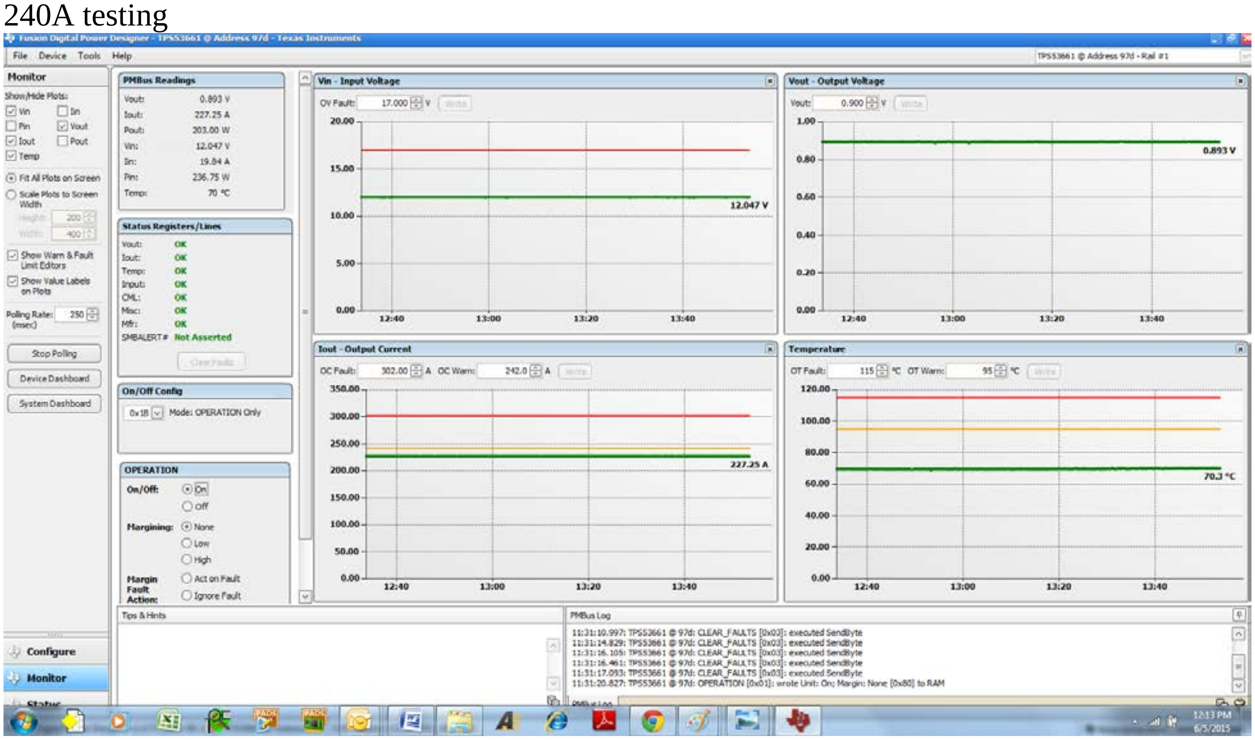
240A testing



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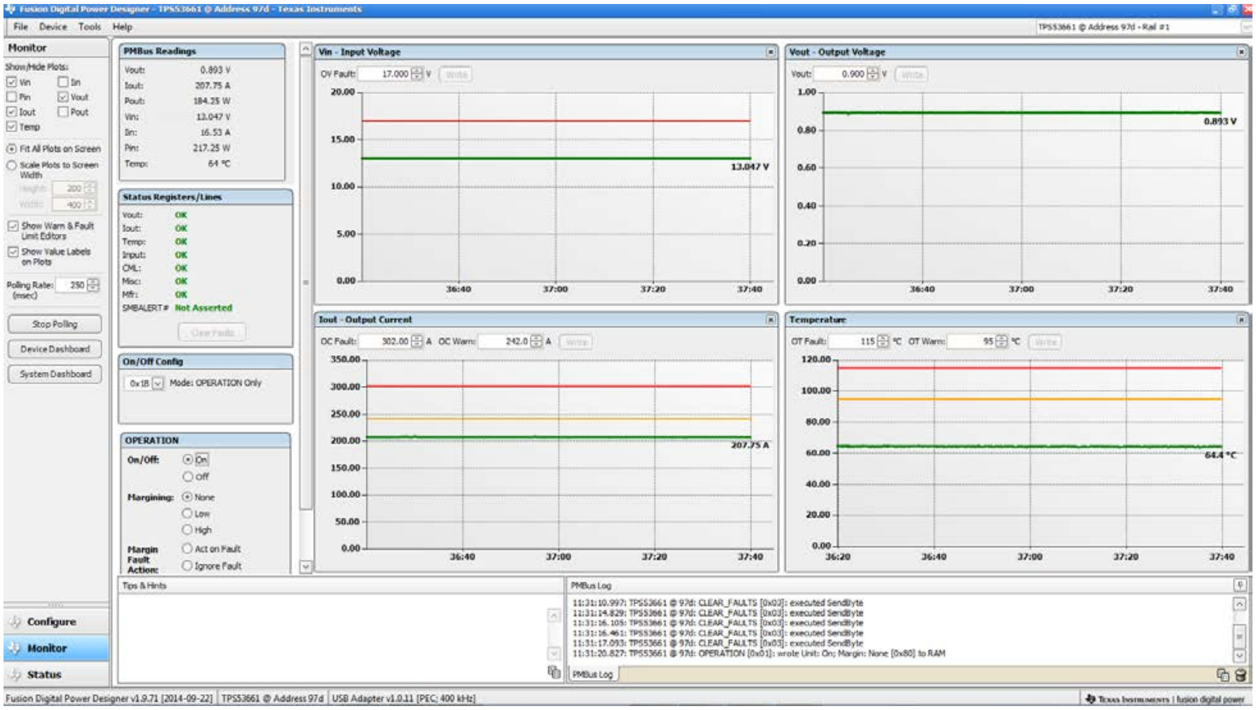
Full load 13Vin



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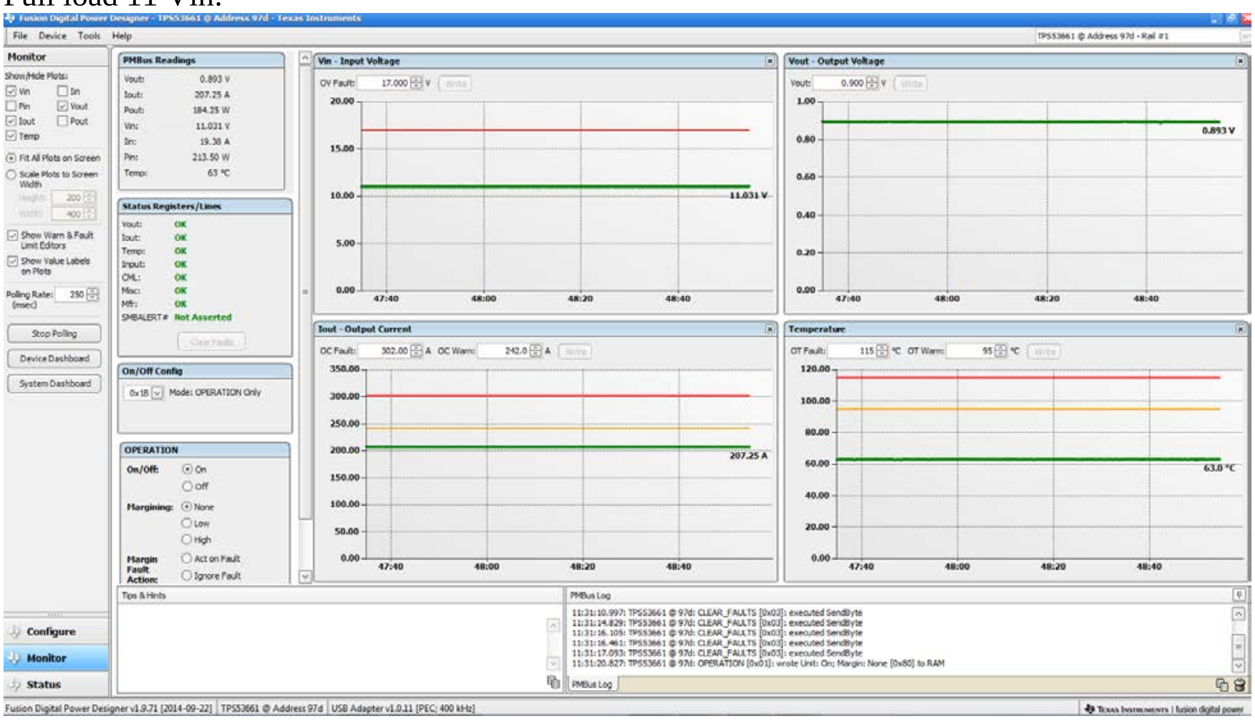
Full load 11 Vin:



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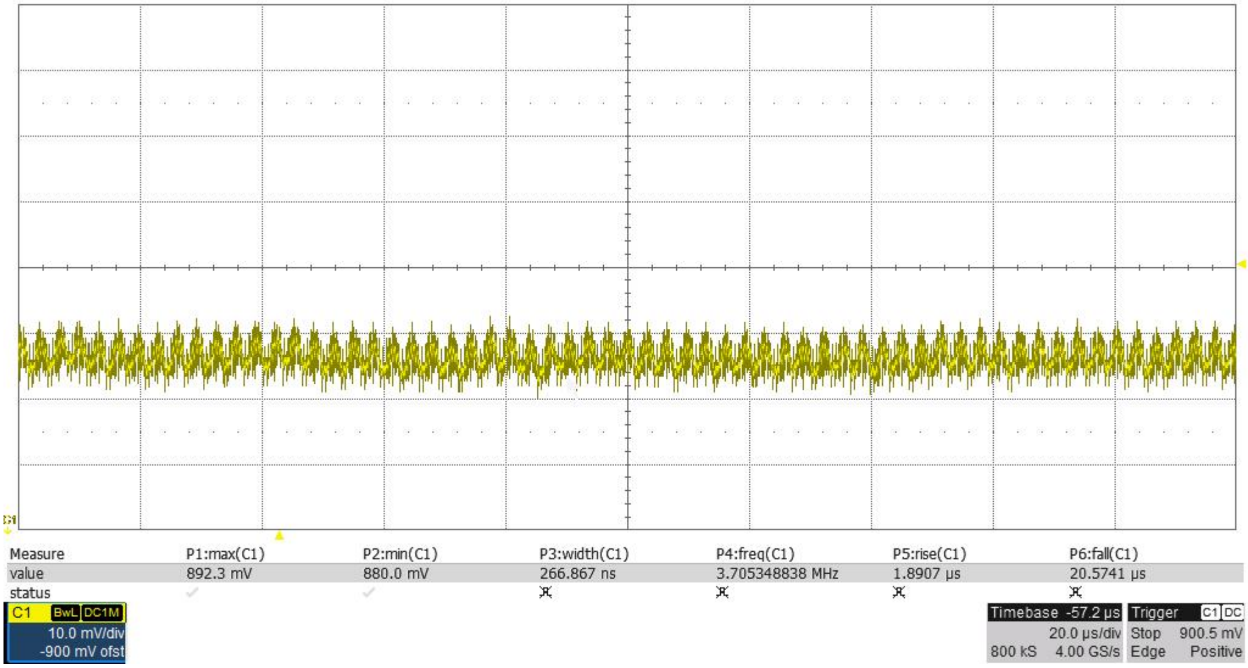
Max 240A load output ripple on C19:
12 Vin (11 Vin very similar)



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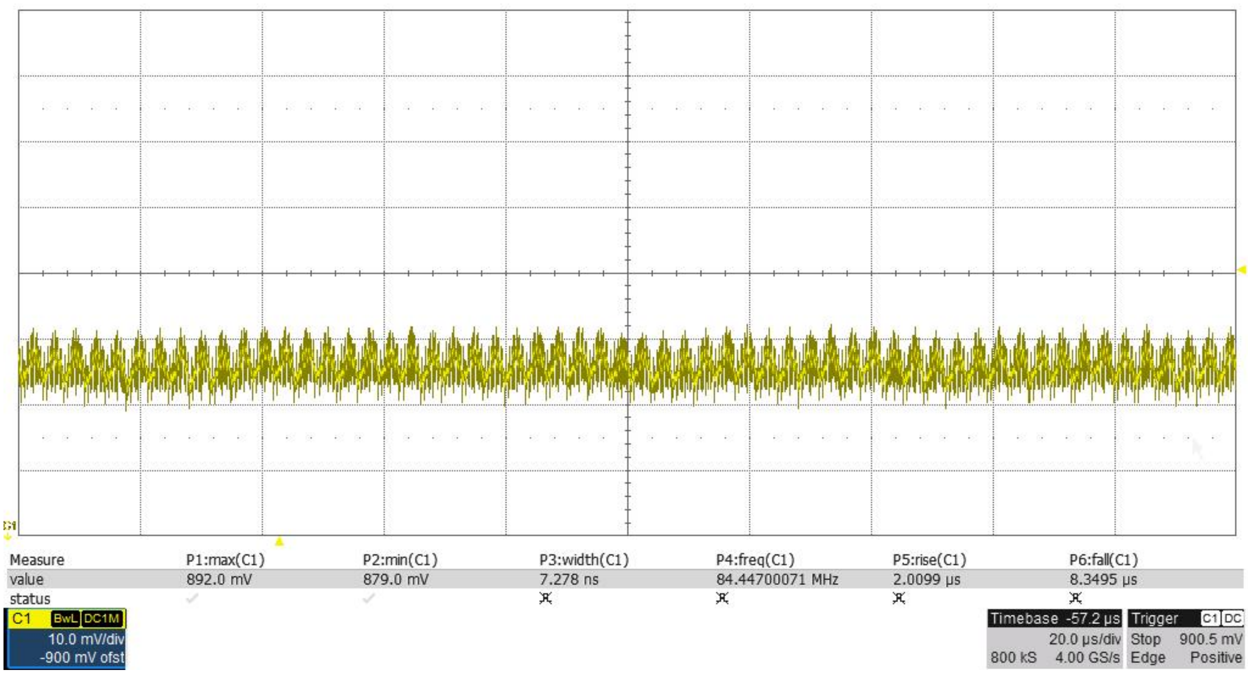
And now 13 Vin:



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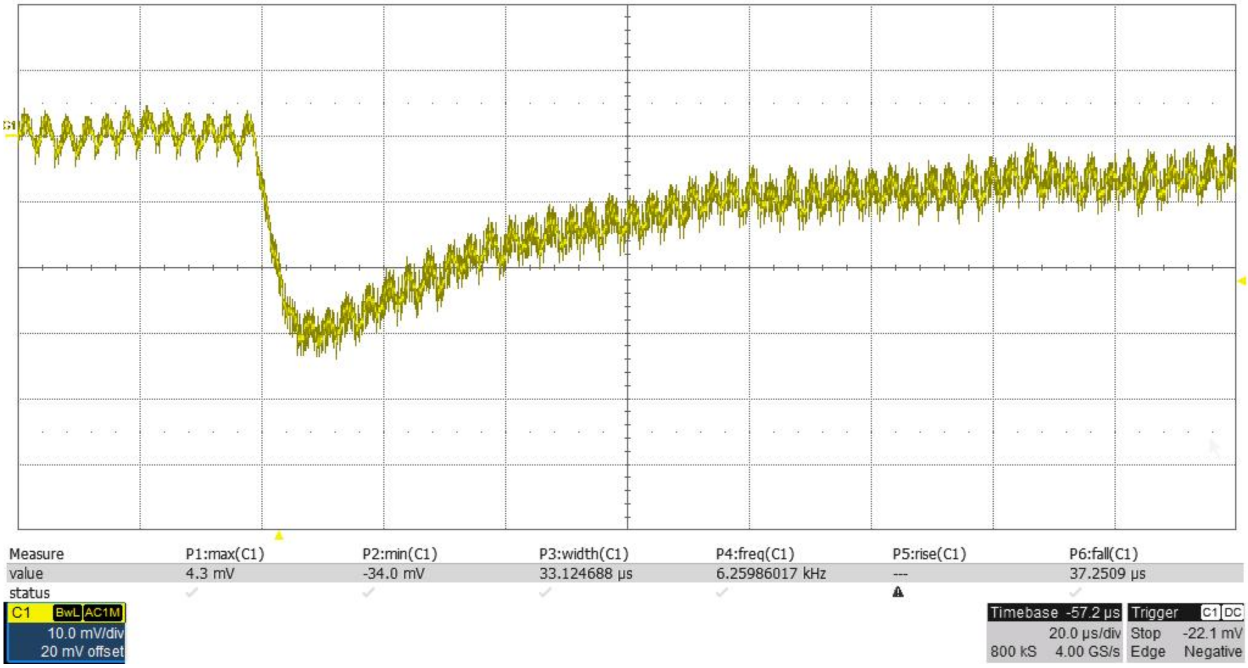
900 mV 300kHz settings: 11.0 VIN
quasi constant frequency mode: frequency range 300-308 kHz
Vout measured at C19: All 6 phases on

Step load response from 60 A to 180 A (120 A step) in 7 usec: ~30 mV undeshoot



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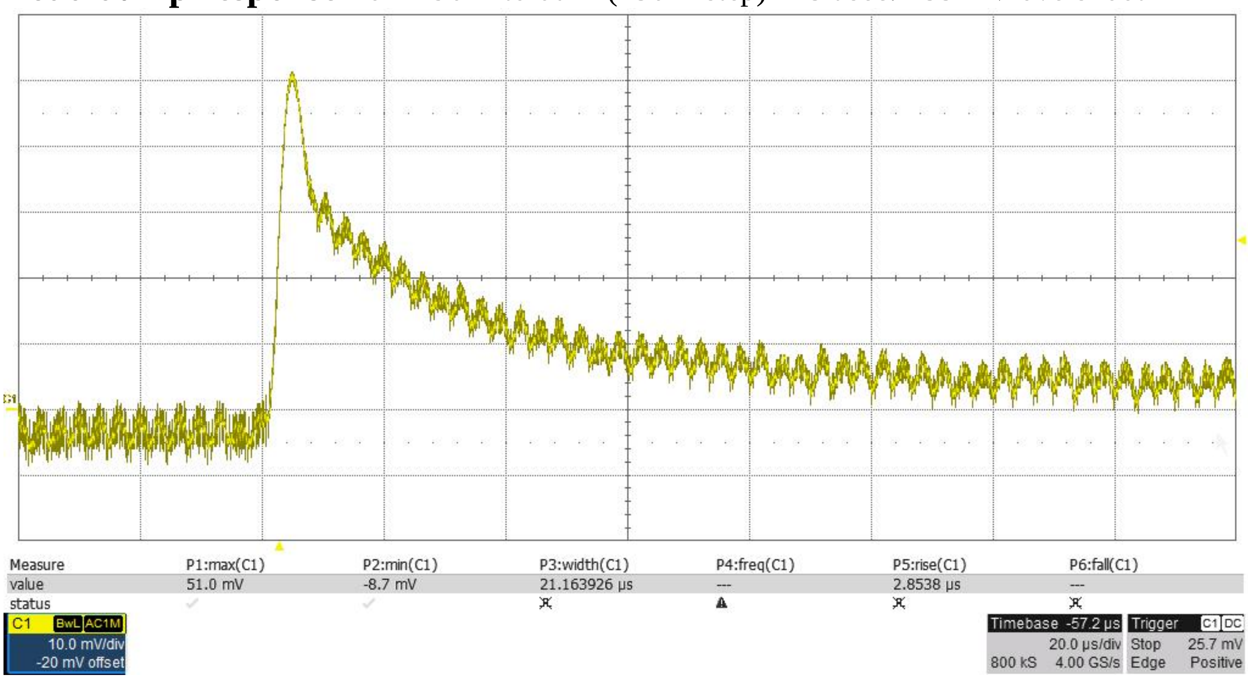
Load dump response from 196 A to 60 A (136 A step) in 5 usec: ~55 mV overshoot



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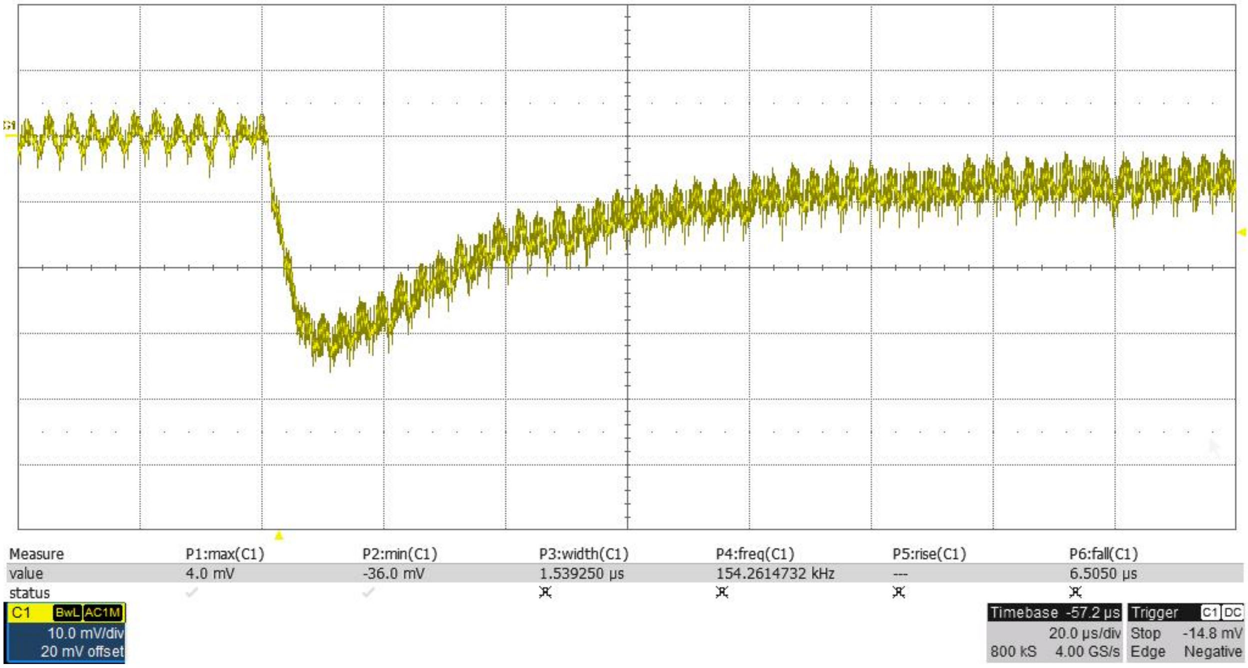
900 mV 300kHz settings: 12.0 VIN
Constant on time mode at 60A & quasi constant frequency at 180A:
frequency range 288-308 kHz Vout measured at C19: All 6 phases on

Step load response from 60 A to 180 A (120 A step) in 7 usec: ~31 mV undeshoot



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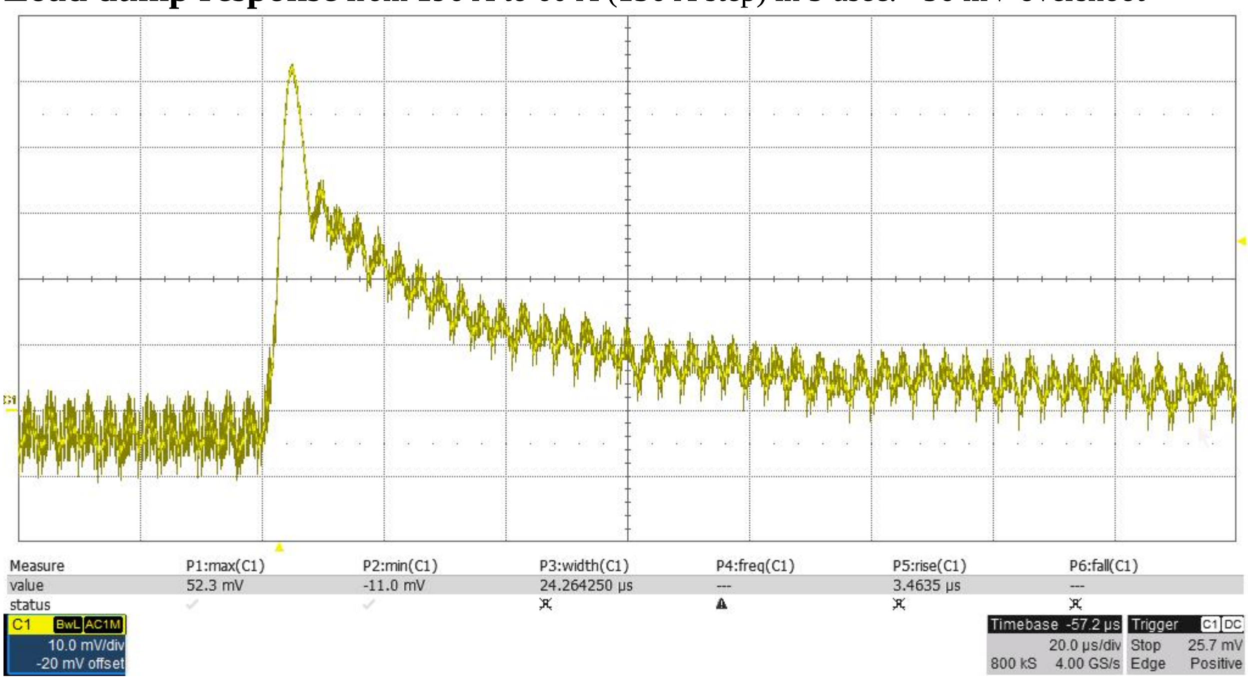
Load dump response from 196 A to 60 A (136 A step) in 5 usec: ~56 mV overshoot



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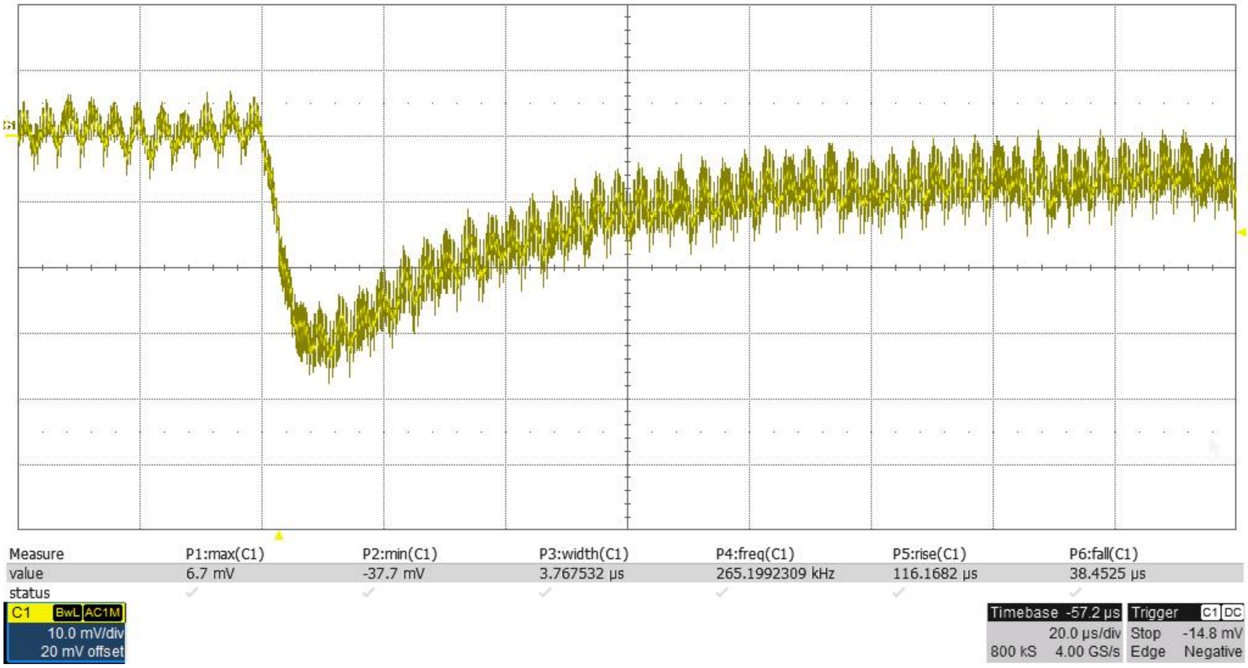
900 mV 300kHz settings: 13.0 VIN
Constant on time mode at ~268-270nsec on times: frequency range 266-280 kHz
Vout measured at C19: All 6 phases on

Step load response from 60 A to 180 A (120 A step) in 7 usec: ~32 mV undeshoot



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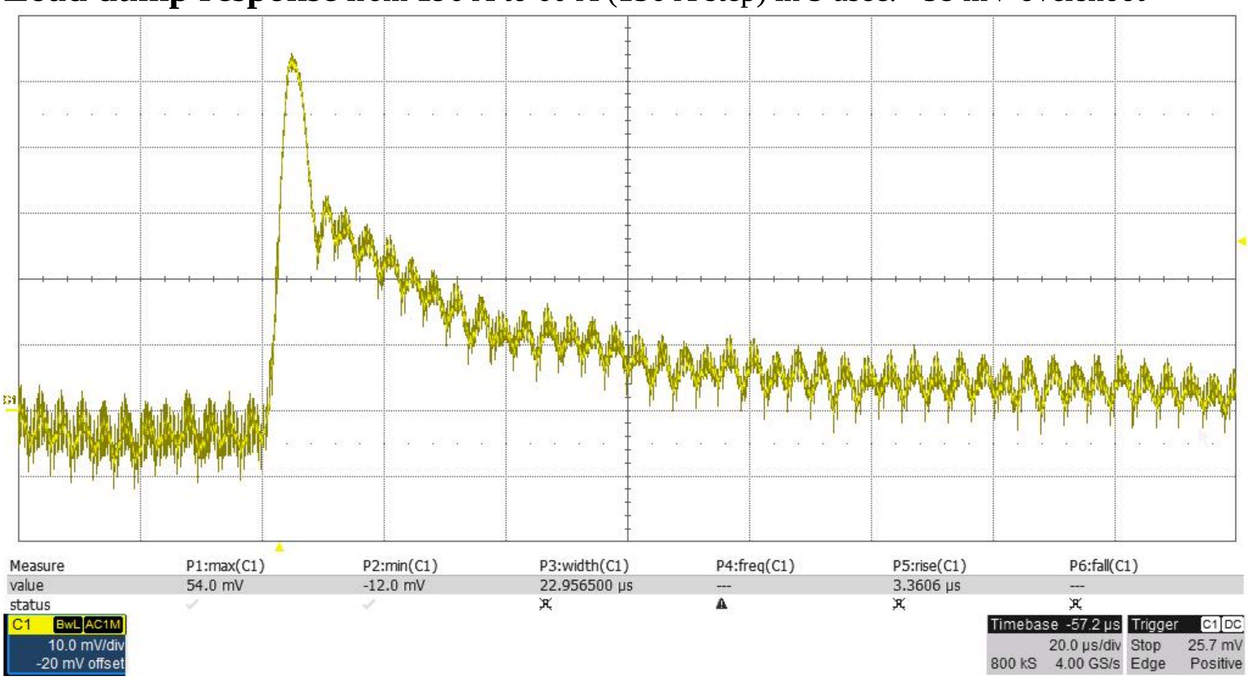
Load dump response from 196 A to 60 A (136 A step) in 5 usec: ~58 mV overshoot



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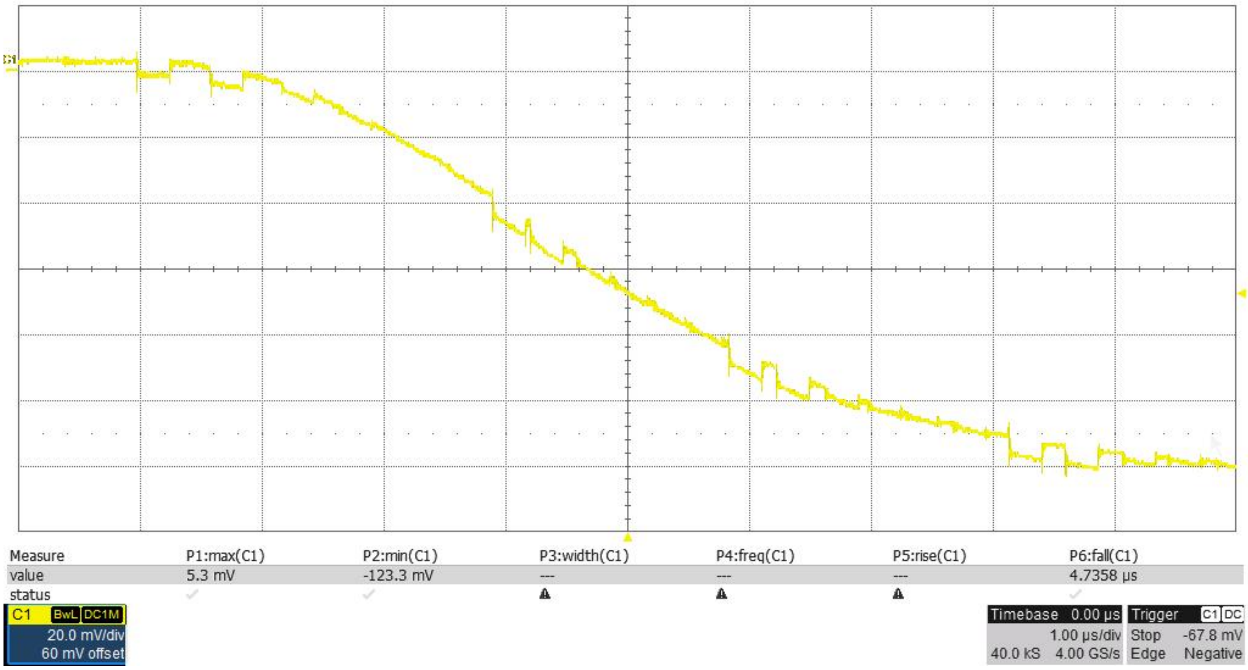
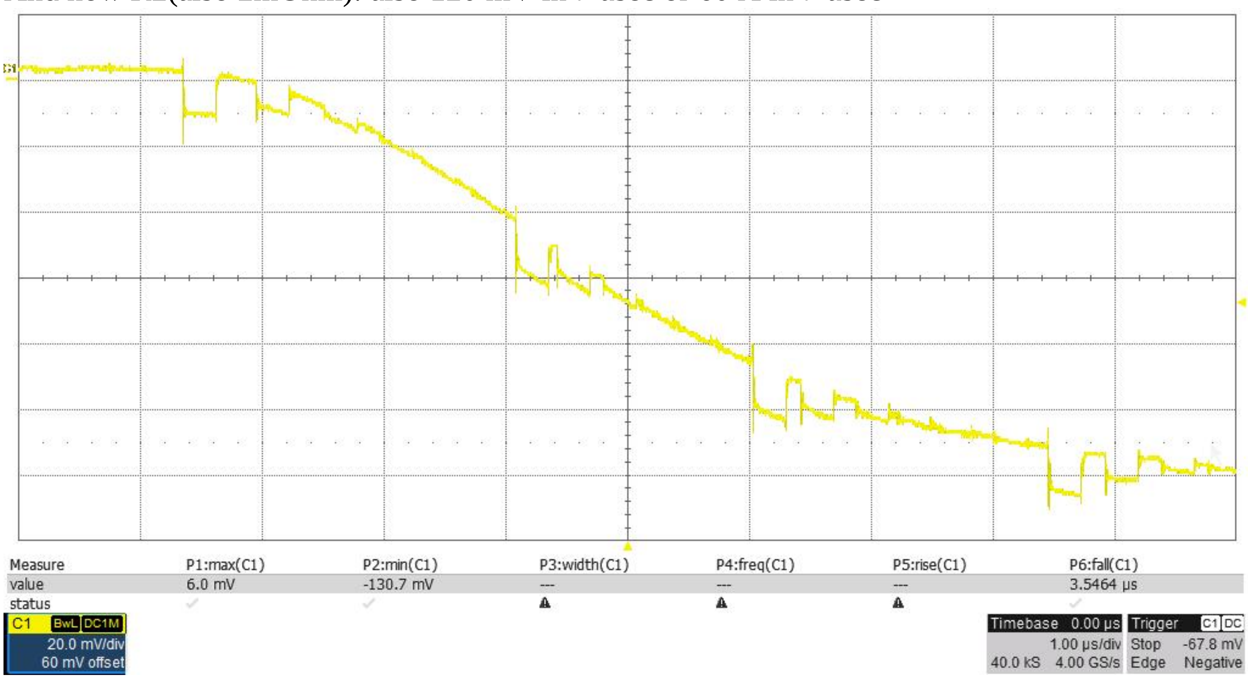
Waveforms across resistors in dynamic load bank used to calculate step load current and speed: There are two resistor paths from Vout; R1 and R2 each 2mOhm and tied to Vout. Hence, the total load step is the sum of both. Here scope ground on Vout side of resistor.

First R1 2mOhm: 120 mV in 7 usec or 60 A in 7 usec



And now R2(also 2mOhm): also 120 mV in 7 usec or 60 A in 7 usec

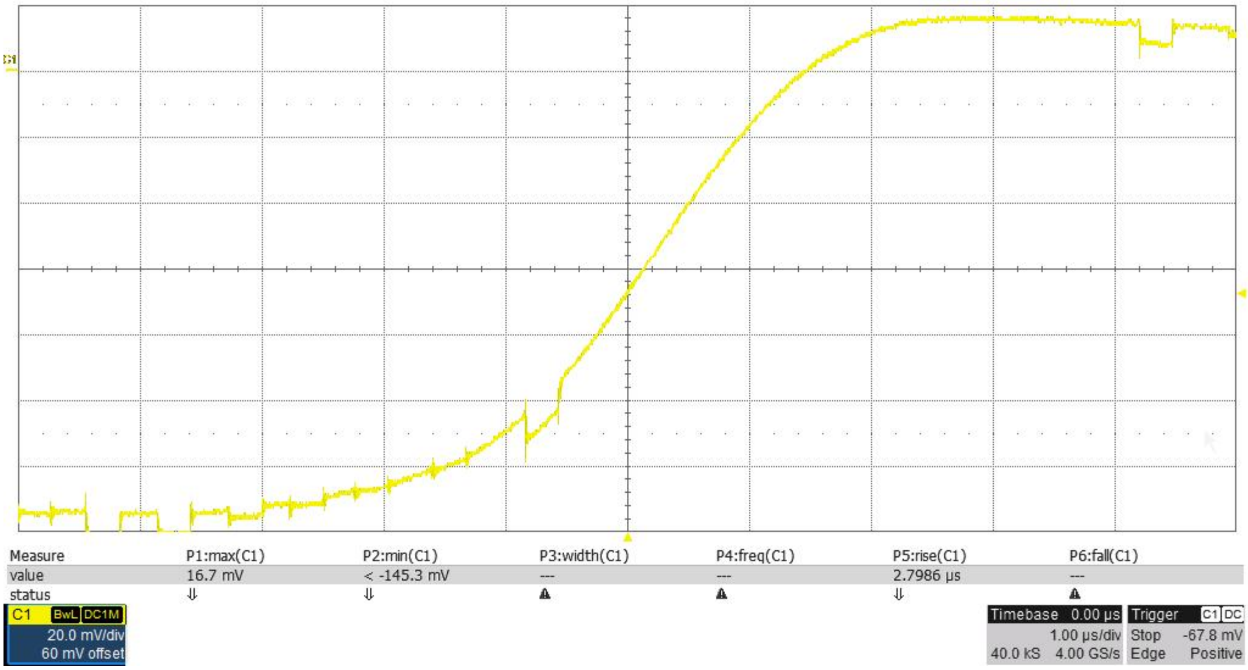


Load strings are in parallel driven by same FET Q1: Hence, combined: 120 A in 7 usec

Waveforms across resistors in dynamic load bank used to calculate load dump current and speed: There are two resistor paths from Vout; R1 and R2 each 2mOhm and tied to Vout. Hence, the total load dump is the sum of both. Here scope ground on Vout side of resistor.

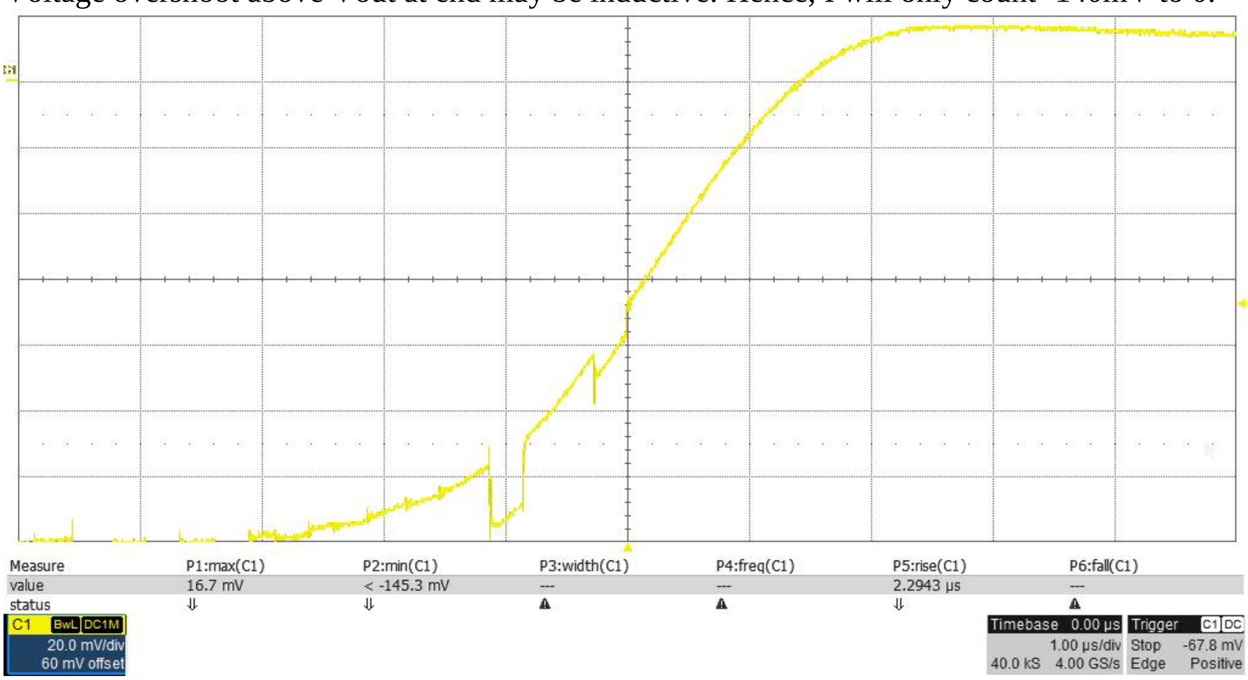
First R1 2mOhm: 132mV in 5 usec or 66 A in 5 usec

Voltage overshoot above Vout at end may be inductive: Hence, I will only count -132mV to 0



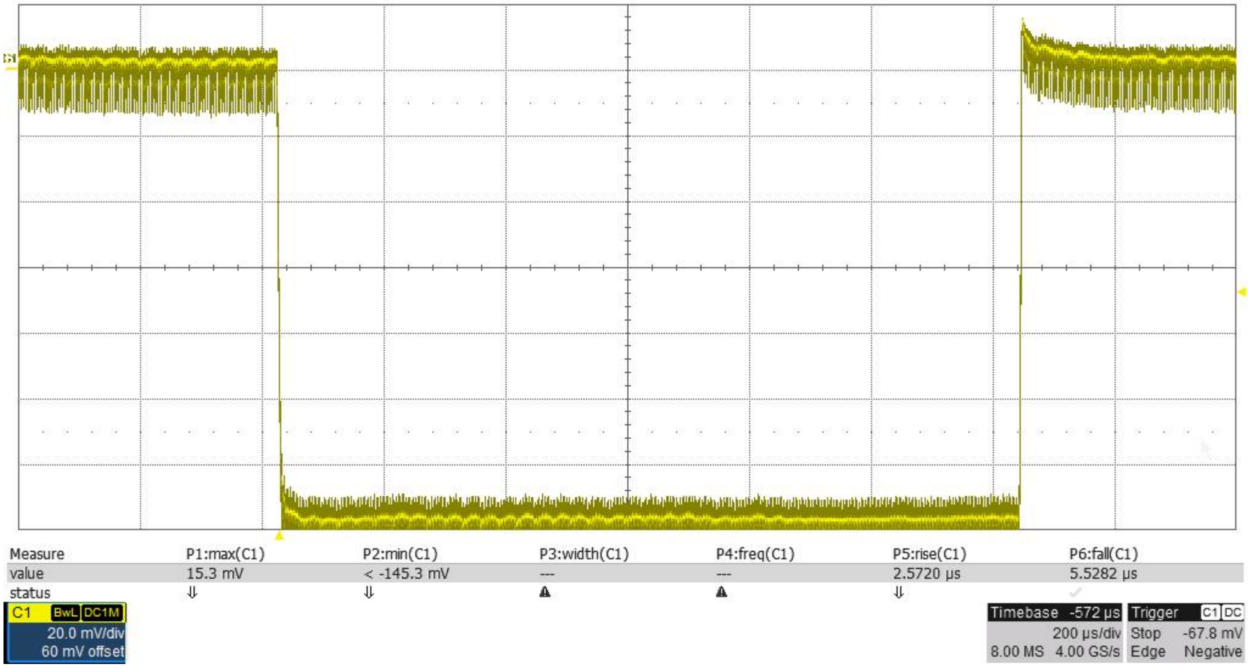
And now R2(also 2mOhm): 140mV in 5 usec or 70A in 5 usec

Voltage overshoot above Vout at end may be inductive: Hence, I will only count -140mV to 0.

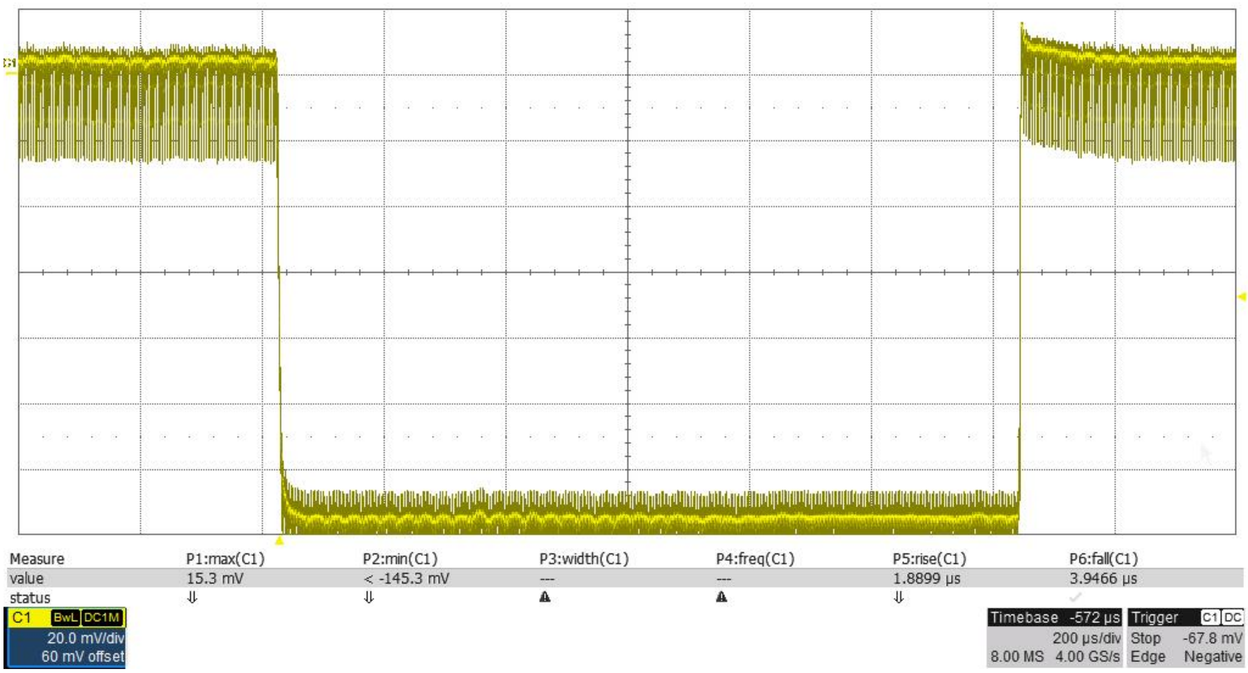


Load strings are in parallel driven by same FET Q1: Hence, combined: 136 A in 5 usec

Step load & Dump waveforms:
R1



And now R2



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Efficiency data on Model t13 at 900mV / 300kHz / 6 phases: 1-2 Meters per second airflow 21 degrees Celsius ambient: 12 Vin

Vin in Volts	Iin Amperes	Vout	Iout	Efficiency %	Losses in W
11.999	0.225	0.901	0.000	0.000	2.694
11.999	0.601	0.901	4.989	62.326	2.716
11.999	0.979	0.900	9.988	76.551	2.755
11.999	1.360	0.901	14.990	82.747	2.815
11.999	1.742	0.900	19.990	86.118	2.902
11.999	2.130	0.900	24.991	88.049	3.054
11.999	2.527	0.900	29.991	89.072	3.313
11.999	2.934	0.900	34.993	89.515	3.691
11.999	3.347	0.900	39.994	89.660	4.153
11.999	3.751	0.900	44.996	90.017	4.493
11.999	4.163	0.900	49.999	90.126	4.932
11.999	4.564	0.900	55.002	90.430	5.241
11.999	4.964	0.900	60.007	90.713	5.531
11.999	5.362	0.900	65.012	90.967	5.812
11.999	5.769	0.900	70.018	91.064	6.185
11.999	6.162	0.900	75.026	91.359	6.389
11.999	6.571	0.900	80.031	91.384	6.793
11.999	6.982	0.900	85.040	91.384	7.218
11.999	7.395	0.900	90.050	91.358	7.668
11.999	7.810	0.900	95.060	91.317	8.137
11.999	8.227	0.900	100.071	91.256	8.632
11.999	8.646	0.900	105.082	91.176	9.154
11.999	9.067	0.900	110.096	91.089	9.696
11.999	9.491	0.900	115.113	90.982	10.270
11.999	9.916	0.900	120.128	90.872	10.862
11.999	9.904	0.900	120.000	90.881	10.837
11.999	10.330	0.900	124.983	90.749	11.466
11.999	10.760	0.900	129.982	90.613	12.120
11.999	11.192	0.900	134.984	90.462	12.810
11.999	11.626	0.900	139.985	90.308	13.521
11.999	12.063	0.900	144.986	90.143	14.268
11.999	12.502	0.900	149.986	89.976	15.038
11.999	12.944	0.900	154.990	89.801	15.841
11.999	13.389	0.900	159.992	89.616	16.682
11.999	13.836	0.900	164.993	89.428	17.551
11.999	14.286	0.900	169.998	89.240	18.444
11.999	14.738	0.900	175.001	89.044	19.375
11.999	15.192	0.900	180.008	88.851	20.325
11.999	15.648	0.900	185.012	88.654	21.304
11.999	16.108	0.900	190.020	88.454	22.317
11.999	16.570	0.900	195.027	88.252	23.358
11.999	17.035	0.900	200.034	88.044	24.439
11.999	17.503	0.900	205.043	87.828	25.564
11.999	17.975	0.900	210.053	87.612	26.719
11.999	18.451	0.900	215.063	87.384	27.930
11.999	18.929	0.900	220.076	87.161	29.161
11.999	19.410	0.899	225.088	86.931	30.438
11.999	19.894	0.899	230.103	86.701	31.745
11.999	20.383	0.899	235.120	86.465	33.103
11.999	20.874	0.899	240.135	86.226	34.501

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PMP-11208 900 mV 220A 6 phases off 12Vin Test Report (TPS53661 / CSD95372B)
Texas Instruments

Efficiency data on Model t13 at 900mV / 300kHz / 6 phases: 1-2 Meters per second airflow 21 degrees Celsius ambient: 13 Vin

Vin in Volts	Iin Amperes	Vout	Iout	Efficiency %	Losses in W
13.004	0.223	0.901	0.000	0.002	2.896
13.004	0.570	0.900	4.992	60.649	2.916
13.004	0.919	0.900	9.992	75.283	2.954
13.004	1.270	0.900	14.993	81.762	3.011
13.004	1.622	0.900	19.993	85.344	3.092
13.004	1.978	0.900	24.993	87.505	3.213
13.004	2.340	0.900	29.993	88.759	3.420
13.004	2.710	0.900	34.996	89.404	3.734
13.004	3.089	0.900	39.997	89.655	4.156
13.004	3.471	0.900	44.998	89.759	4.622
13.004	3.845	0.900	50.002	90.042	4.979
13.004	4.217	0.900	55.004	90.302	5.318
13.004	4.596	0.900	60.010	90.397	5.739
13.004	4.966	0.900	65.013	90.636	6.047
13.004	5.335	0.900	70.020	90.867	6.336
13.004	5.705	0.900	75.028	91.050	6.639
13.004	6.075	0.900	80.032	91.199	6.953
13.004	6.454	0.900	85.040	91.213	7.375
13.004	6.835	0.900	90.050	91.206	7.816
13.004	7.218	0.900	95.060	91.172	8.286
13.004	7.602	0.900	100.071	91.123	8.776
13.004	7.988	0.900	105.081	91.054	9.292
13.004	8.376	0.900	110.096	90.978	9.827
13.004	8.767	0.900	115.113	90.884	10.393
13.004	9.159	0.900	120.126	90.779	10.983
13.004	9.149	0.900	120.000	90.785	10.964
13.004	9.541	0.900	124.983	90.664	11.584
13.004	9.938	0.900	129.984	90.530	12.238
13.004	10.335	0.900	134.985	90.389	12.917
13.004	10.736	0.900	139.986	90.245	13.619
13.004	11.138	0.900	144.988	90.086	14.360
13.004	11.543	0.900	149.987	89.921	15.130
13.004	11.950	0.900	154.990	89.755	15.921
13.004	12.360	0.900	159.992	89.582	16.745
13.004	12.771	0.900	164.993	89.399	17.605
13.004	13.186	0.900	169.999	89.213	18.497
13.004	13.602	0.900	175.000	89.024	19.415
13.004	14.021	0.900	180.007	88.833	20.360
13.004	14.443	0.900	185.012	88.636	21.344
13.004	14.867	0.900	190.020	88.434	22.360
13.004	15.293	0.900	195.029	88.230	23.408
13.004	15.723	0.900	200.033	88.022	24.490
13.004	16.155	0.900	205.043	87.810	25.609
13.004	16.590	0.900	210.053	87.593	26.765
13.004	17.028	0.900	215.064	87.374	27.957
13.004	17.468	0.900	220.076	87.155	29.177
13.004	17.911	0.900	225.088	86.933	30.435
13.004	18.357	0.899	230.102	86.703	31.743
13.004	18.807	0.899	235.119	86.471	33.087
13.004	19.261	0.899	240.133	86.232	34.483

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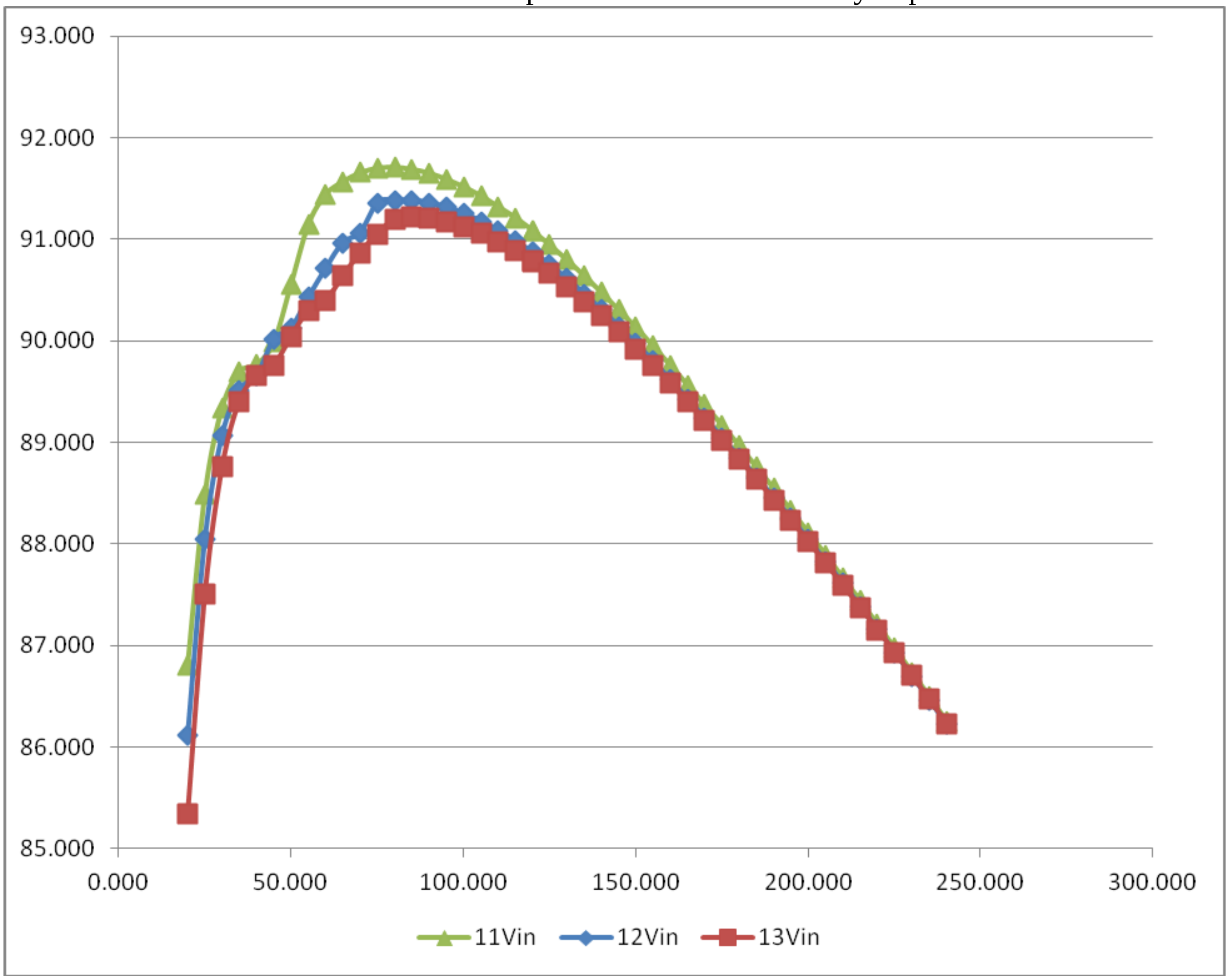
Efficiency data on Model t13 at 900mV / 300kHz / 6 phases: 1-2 Meters per second airflow 21 degrees Celsius ambient: 11 Vin

Vin in Volts	Iin Amperes	Vout	Iout	Efficiency %	Losses in W
10.995	0.228	0.901	0.000	0.000	2.511
10.995	0.639	0.900	4.986	63.921	2.534
10.995	1.052	0.900	9.986	77.733	2.576
10.995	1.467	0.900	14.987	83.646	2.638
10.995	1.886	0.900	19.989	86.809	2.735
10.995	2.313	0.900	24.990	88.491	2.926
10.995	2.749	0.900	29.989	89.343	3.221
10.995	3.195	0.900	34.992	89.698	3.619
10.995	3.649	0.900	39.994	89.767	4.105
10.995	4.095	0.900	44.995	89.989	4.507
10.995	4.521	0.900	50.000	90.561	4.692
10.995	4.941	0.900	55.003	91.148	4.809
10.995	5.374	0.900	60.009	91.442	5.056
10.995	5.814	0.900	65.013	91.569	5.389
10.995	6.255	0.900	70.021	91.656	5.739
10.995	6.699	0.900	75.027	91.702	6.112
10.995	7.145	0.900	80.031	91.710	6.513
10.995	7.594	0.900	85.041	91.691	6.938
10.995	8.045	0.900	90.052	91.652	7.383
10.995	8.498	0.900	95.061	91.593	7.855
10.995	8.953	0.900	100.073	91.519	8.348
10.995	9.410	0.900	105.085	91.429	8.867
10.995	9.871	0.900	110.100	91.322	9.418
10.995	10.333	0.900	115.116	91.212	9.983
10.995	10.797	0.900	120.131	91.087	10.581
10.995	10.785	0.900	120.000	91.085	10.571
10.995	11.250	0.900	124.985	90.947	11.198
10.995	11.719	0.900	129.984	90.799	11.855
10.995	12.190	0.900	134.986	90.644	12.540
10.995	12.665	0.900	139.988	90.479	13.257
10.995	13.142	0.900	144.987	90.307	14.006
10.995	13.621	0.900	149.988	90.135	14.773
10.995	14.104	0.900	154.991	89.949	15.585
10.995	14.589	0.900	159.993	89.761	16.423
10.995	15.077	0.900	164.994	89.566	17.296
10.995	15.568	0.900	169.999	89.371	18.193
10.995	16.062	0.900	175.002	89.168	19.128
10.995	16.558	0.900	180.008	88.968	20.084
10.995	17.058	0.900	185.014	88.757	21.086
10.995	17.561	0.900	190.020	88.547	22.114
10.995	18.067	0.900	195.029	88.330	23.180
10.995	18.576	0.900	200.034	88.114	24.275
10.995	19.088	0.900	205.044	87.894	25.405
10.994	19.605	0.900	210.055	87.669	26.579
10.994	20.123	0.900	215.065	87.443	27.782
10.994	20.646	0.899	220.076	87.210	29.033
10.994	21.172	0.899	225.089	86.975	30.319
10.994	21.702	0.899	230.103	86.738	31.644
10.994	22.236	0.899	235.119	86.500	33.003
10.994	22.774	0.899	240.135	86.254	34.417

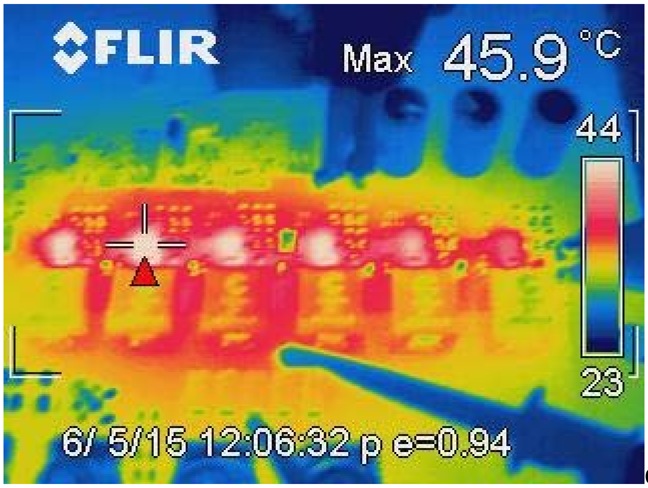
Q

Efficiency graph: All 3 Vin's and current range 20 to 240 A:
on Model t13 at 900mV / 300kHz / 6 phases:
1-2 Meters per second airflow 21 degrees Celsius ambient:
X axis is load current in A off 900mV output and Y axis is efficiency in percent



Q

Thermal images: Ambient is 21 degrees Celsius with 1-2 Meters per second airflow:
12Vin 900mV out 160A



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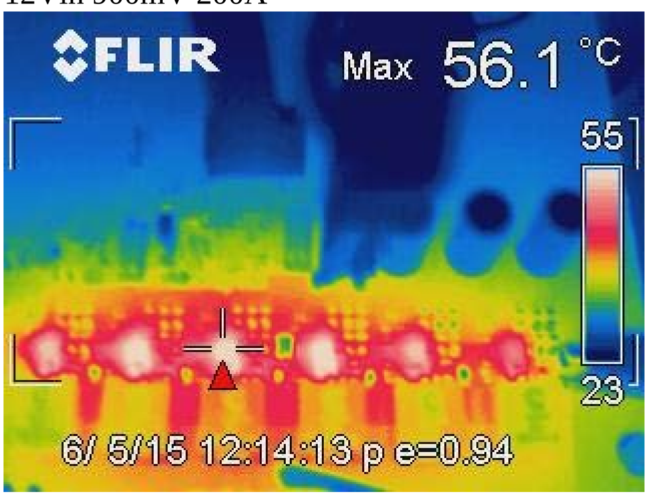
Q

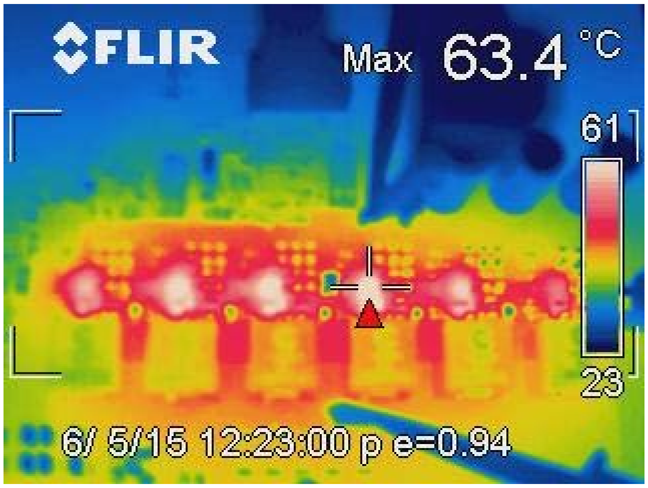
12Vin 900mV 200A



Q

Thermal images: Ambient is 21 degrees Celsius with 1-2 Meters per second airflow:

12Vin 900mV out 220A



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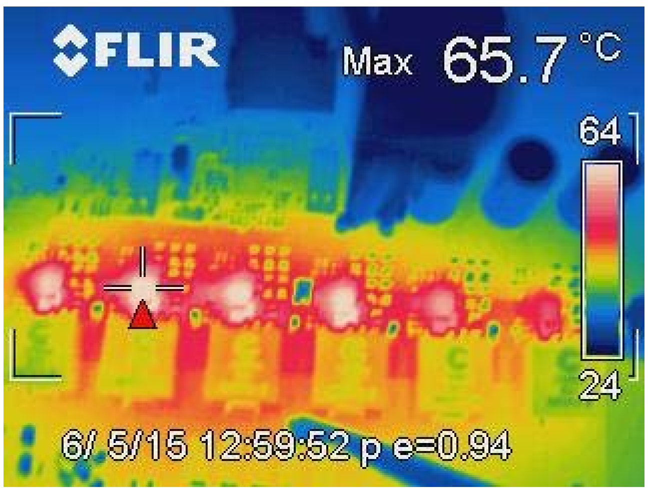
13Vin 900mV out 220A



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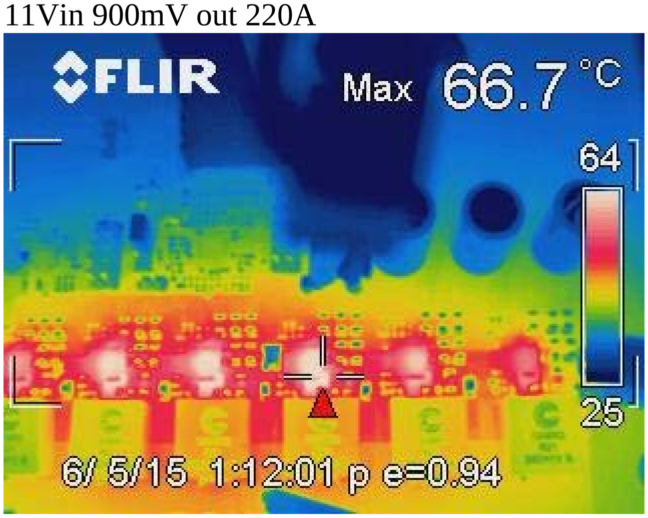
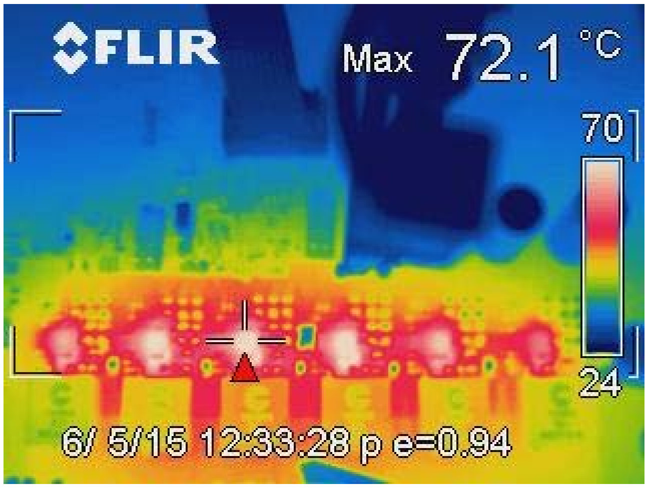
11Vin 900mV out 220A

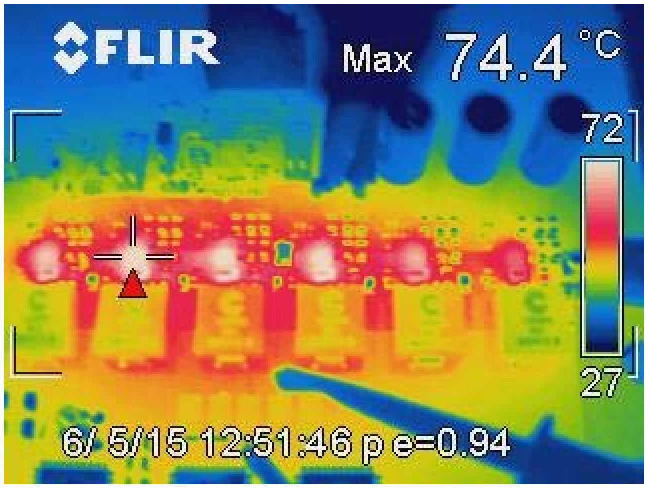


Q

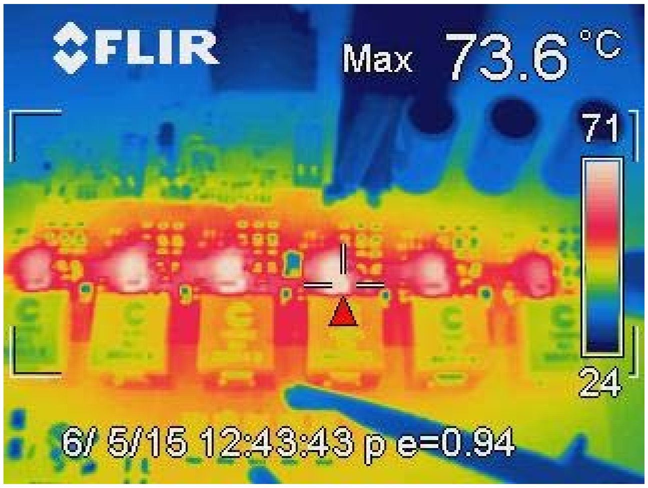
Thermal images: Ambient is 21 degrees Celsius with 1-2 Meters per second airflow:
12Vin 900mV out 240A



Q
13Vin 900mV out 240A



Q
11Vin 900mV out 240A



Q

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