# Texas Instruments Inc.

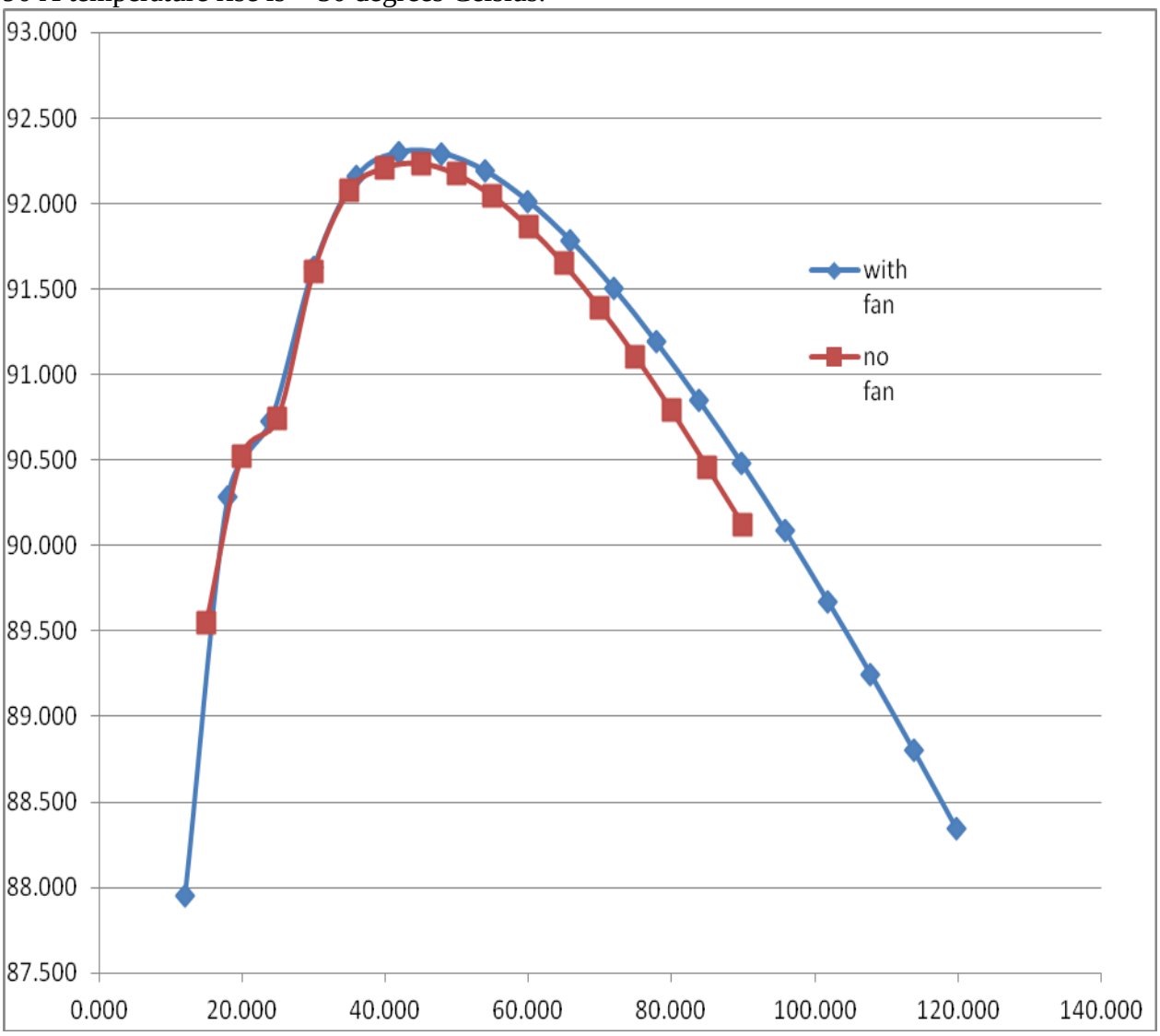
**TIDA-00324: POL Multiphase (3-phase) 120A Power Reference Design Test Report: 1.2Vout, 120A, 3 phases off 12Vin**

Table of Contents:



Note: Well calibrated efficiency & loss data added based upon March 17-18, 2015 testing with our automated efficiency tester. Testing was actually done to study our testing methodology and used the same board used to generate this test report. Once it was done and available it had to be added to this report. See pages 2-4.

Efficiency and  Losses: model t1: 12Vin, Vout set at 1.2V
Close in Vin & Vout senses, 12Vin  Well calibrated setup run March 17-18, 2015
Input shunt: 4.9853 mOhms
Output shunt: 0.50030 mOhms
All 4 meters: Agilent 34401A
Overall estimated max efficiency error now under 0.25%
With no fan, run only up to the 90 A that can be reliably drawn without forced cooling. Above 90 A temperature rise is > 50 degrees Celsius.



Detailed efficiency / loss data with fan (~200 LFM or 1 Meter per second): run March 18, 2015

| Vin | Iin | Vout | Iout | Efficiency% | Loss W |
|---|---|---|---|---|---|
| 11.999 | 0.147 | 1.205 | 0.00 | N/A | 1.76 |
| 11.999 | 0.750 | 1.205 | 5.93 | 79.52 | 1.84 |
| 11.999 | 1.363 | 1.206 | 11.93 | 87.95 | 1.97 |
| 11.999 | 1.995 | 1.206 | 17.92 | 90.29 | 2.33 |
| 11.999 | 2.650 | 1.207 | 23.91 | 90.73 | 2.95 |
| 11.999 | 3.282 | 1.207 | 29.90 | 91.62 | 3.30 |
| 11.999 | 3.918 | 1.207 | 35.89 | 92.16 | 3.69 |
| 11.999 | 4.567 | 1.208 | 41.88 | 92.30 | 4.22 |
| 11.999 | 5.221 | 1.208 | 47.87 | 92.29 | 4.83 |
| 11.999 | 5.884 | 1.208 | 53.87 | 92.19 | 5.51 |
| 11.999 | 6.552 | 1.209 | 59.86 | 92.02 | 6.28 |
| 11.999 | 7.229 | 1.209 | 65.85 | 91.79 | 7.13 |
| 11.999 | 7.913 | 1.209 | 71.84 | 91.51 | 8.06 |
| 11.999 | 8.605 | 1.210 | 77.83 | 91.19 | 9.10 |
| 11.999 | 9.306 | 1.210 | 83.83 | 90.85 | 10.22 |
| 11.999 | 10.015 | 1.210 | 89.83 | 90.48 | 11.44 |
| 11.999 | 10.733 | 1.211 | 95.82 | 90.09 | 12.77 |
| 11.999 | 11.461 | 1.211 | 101.82 | 89.67 | 14.20 |
| 11.999 | 12.198 | 1.212 | 107.82 | 89.25 | 15.74 |
| 11.999 | 12.946 | 1.212 | 113.82 | 88.80 | 17.39 |
| 11.999 | 13.703 | 1.212 | 119.82 | 88.34 | 19.17 |

Detailed efficiency / loss data with no fan run March 17, 2015

| Vin | Iin | Vout | Iout | Efficiency% | lossW |
|---|---|---|---|---|---|
| 11.999 | 0.147 | 1.205 | 0.00 | N/A | 1.76 |
| 11.999 | 0.649 | 1.205 | 4.95 | 76.66 | 1.82 |
| 11.999 | 1.157 | 1.205 | 9.94 | 86.28 | 1.91 |
| 11.999 | 1.676 | 1.206 | 14.94 | 89.54 | 2.10 |
| 11.999 | 2.213 | 1.206 | 19.93 | 90.52 | 2.52 |
| 11.999 | 2.762 | 1.206 | 24.93 | 90.74 | 3.07 |
| 11.999 | 3.285 | 1.207 | 29.93 | 91.60 | 3.31 |
| 11.999 | 3.816 | 1.207 | 34.93 | 92.08 | 3.63 |
| 11.999 | 4.357 | 1.207 | 39.93 | 92.21 | 4.07 |
| 11.999 | 4.903 | 1.207 | 44.94 | 92.24 | 4.57 |
| 11.999 | 5.454 | 1.208 | 49.95 | 92.17 | 5.12 |
| 11.999 | 6.010 | 1.208 | 54.95 | 92.05 | 5.74 |
| 11.999 | 6.572 | 1.208 | 59.96 | 91.87 | 6.41 |
| 11.999 | 7.139 | 1.209 | 64.96 | 91.65 | 7.15 |
| 11.999 | 7.713 | 1.209 | 69.97 | 91.39 | 7.97 |
| 11.999 | 8.293 | 1.209 | 74.97 | 91.11 | 8.85 |
| 11.999 | 8.879 | 1.209 | 79.98 | 90.79 | 9.81 |
| 11.999 | 9.471 | 1.210 | 84.98 | 90.46 | 10.84 |
| 11.999 | 10.069 | 1.210 | 89.98 | 90.12 | 11.93 |

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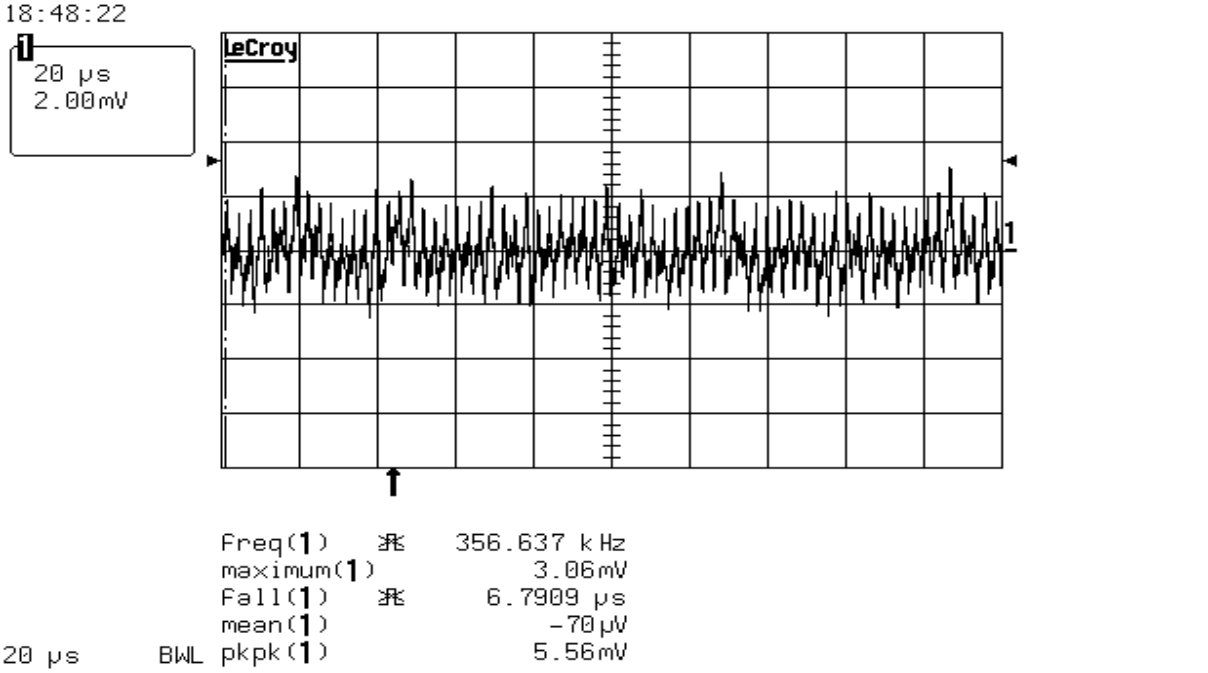
Early data at poorly calibrated setup to show frequency and thermal data:
Fan (~200 LFM) for loads down to 100A (first 3 lines below) and then no fan
100A load shows both without and then with fan. (Efficiency errors about 0.5% high based upon the well calibrated measurements)

| Vin Volts | Iin A | Vout Volts | Iout A | % Effi ciency | Losses in W | Notes: |
|---|---|---|---|---|---|---|
| | | | | | | |
| 12.044 | 16.10 | 1.2139 | 139.3 | 87.2 | 24.812 | 340.5kHz,84degIR544 |
| 12.011 | 13.664 | 1.2127 | 120.17 | 88.8 | 18.388 | 338kHz,67degCIR543 |
| 12.052 | 11.14 | 1.2115 | 100.08 | 90.3 | 13.012 | Fanon,~200lfmIR542_ 54degC,335kHz |
| 12.038 | 11.22 | 1.2112 | 100.1 | 89.8 | 13.825 | IR541,83deg,338.6kHz |
| 12.076 | 9.999 | 1.2106 | 90.33 | 90.6 | 11.394 | 336kHz,IR54069deg20min |
| 12.071 | 8.840 | 1.2096 | 80.35 | 91.1 | 9.516 | ~20min,nofan |
| 12.08 | 6.81 | 1.209 | 62.74 | 92.2 | 6.412 | T1,3ph,332kHz |

At 139A load each IOUT reads 44-45A or 133A in all, or about 4% low.

RippleOut D003 at 6mV p-p 12Vin and 1.2Vout at 139A model t1 at C19

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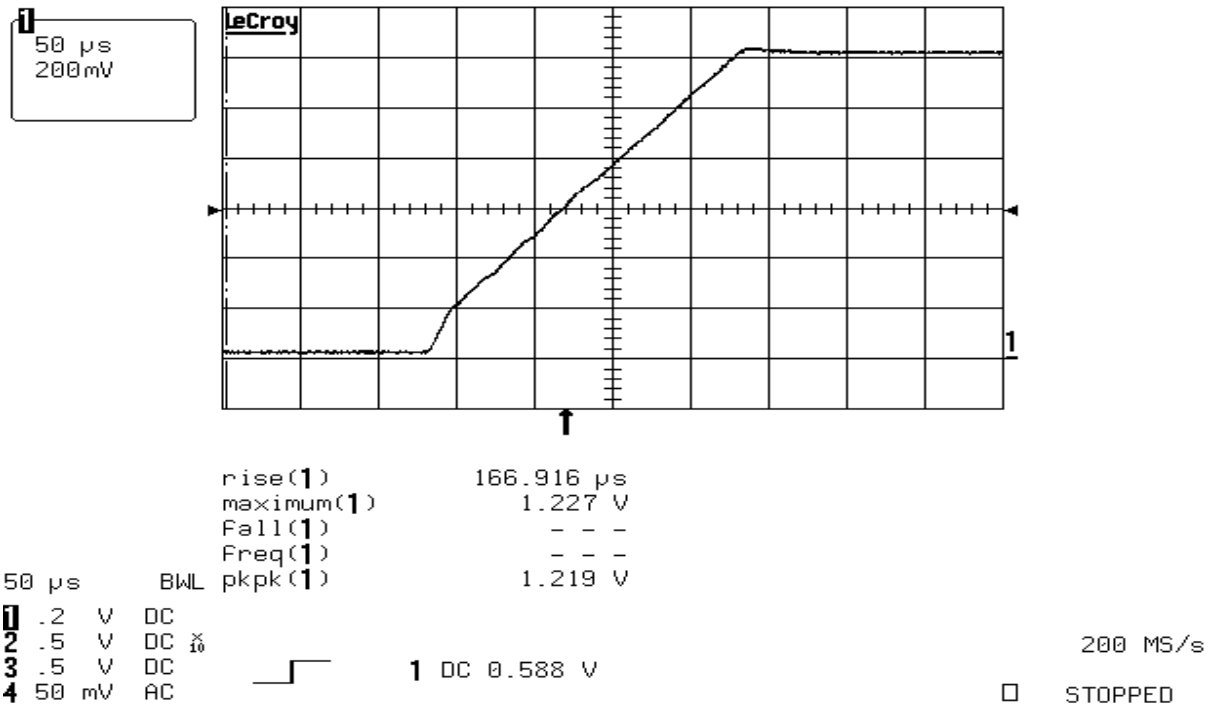
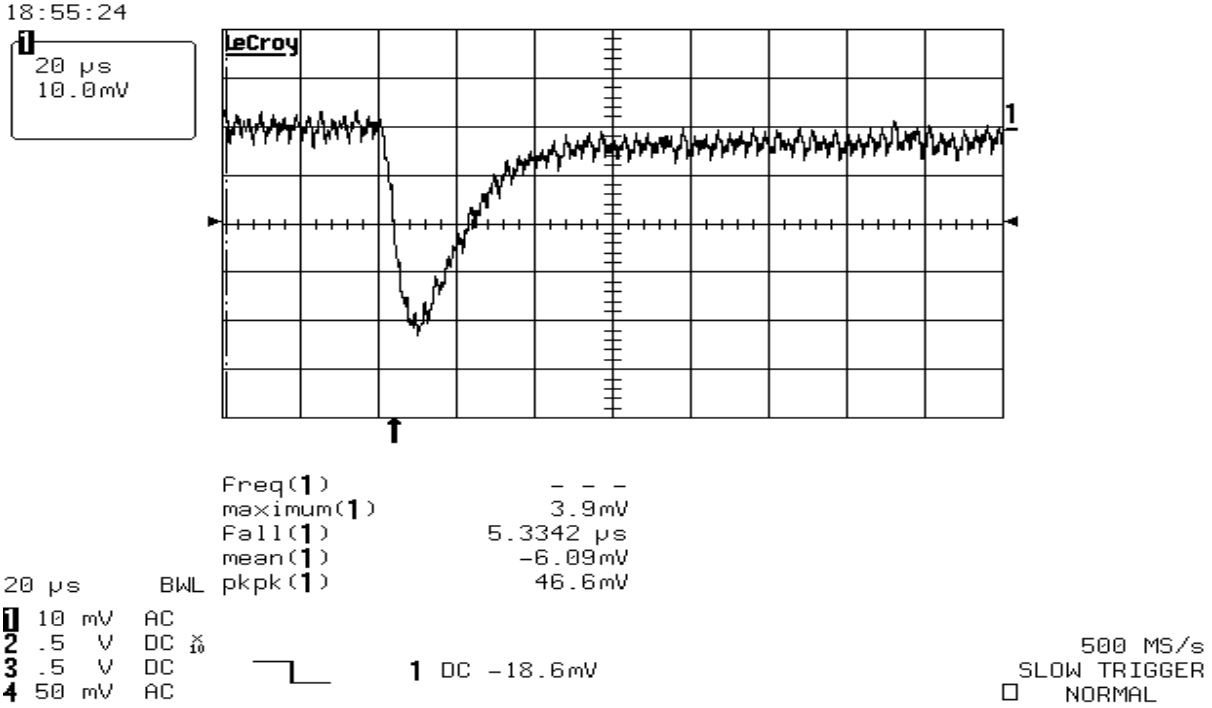
Boot up to 1.2V at 12Vin when operation command issued:

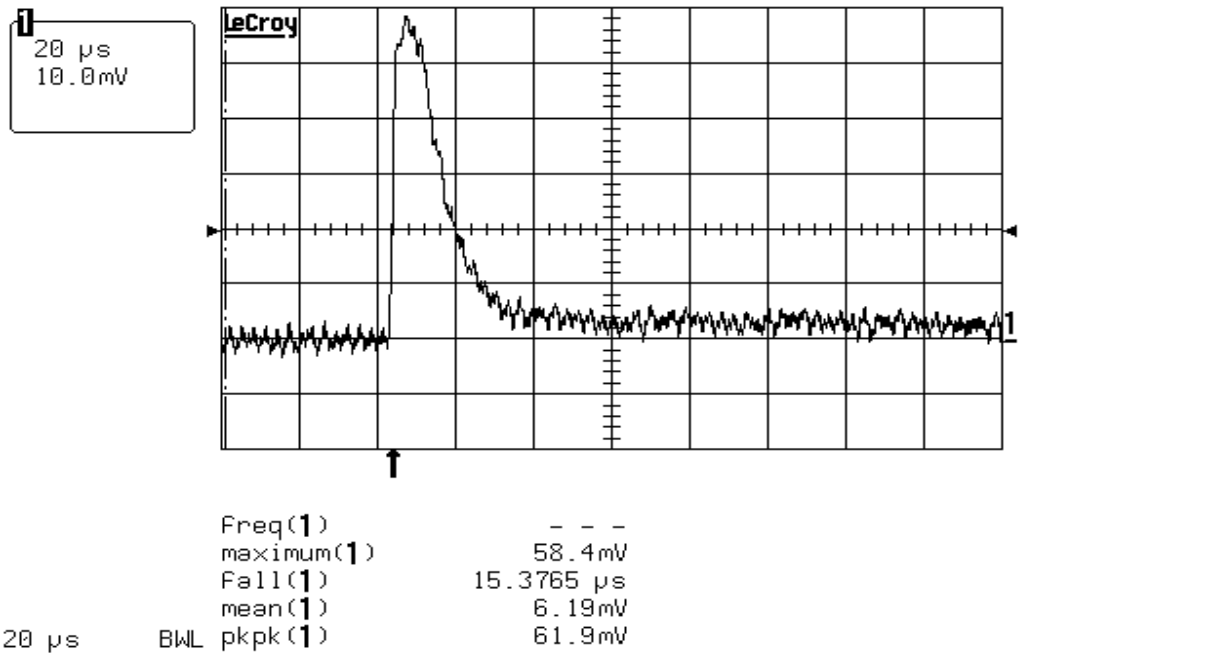
200usec rise time and 20-25 mV overshoot:



12.8Vin 1.2Vout setting Step load from 20A about 40mV undershoot; see next page for 80A step in about 10usec




load dump to 20A D005 at almost 60mV overshoot; see next page for >80 dump in 2usec

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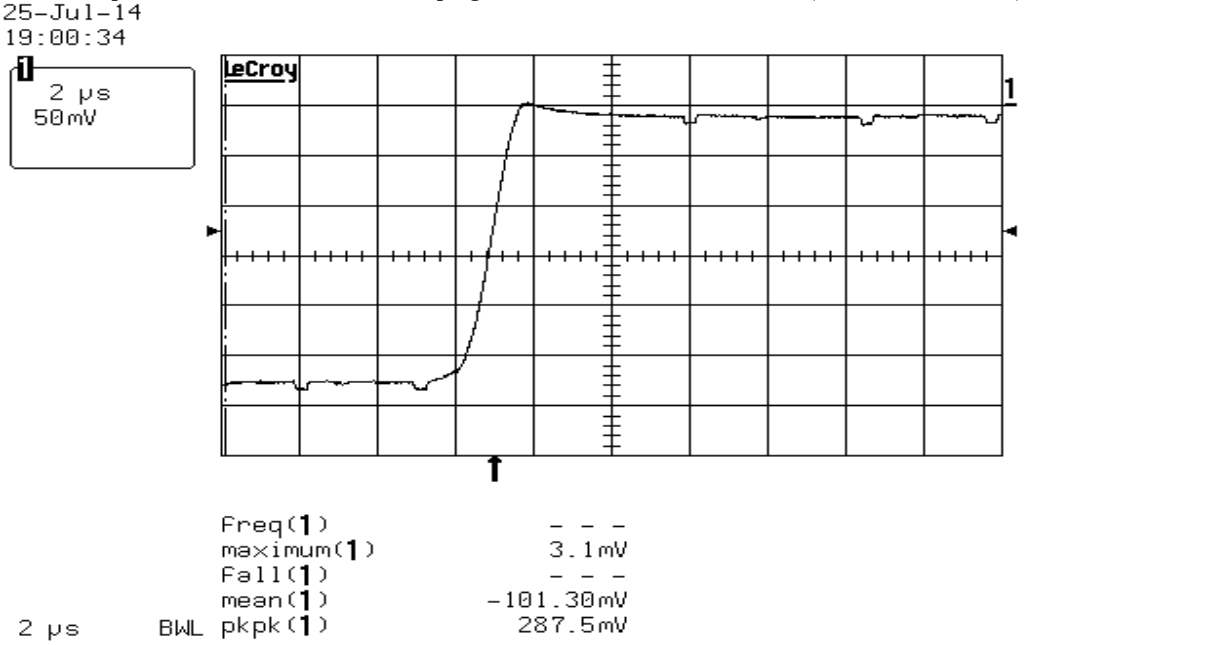
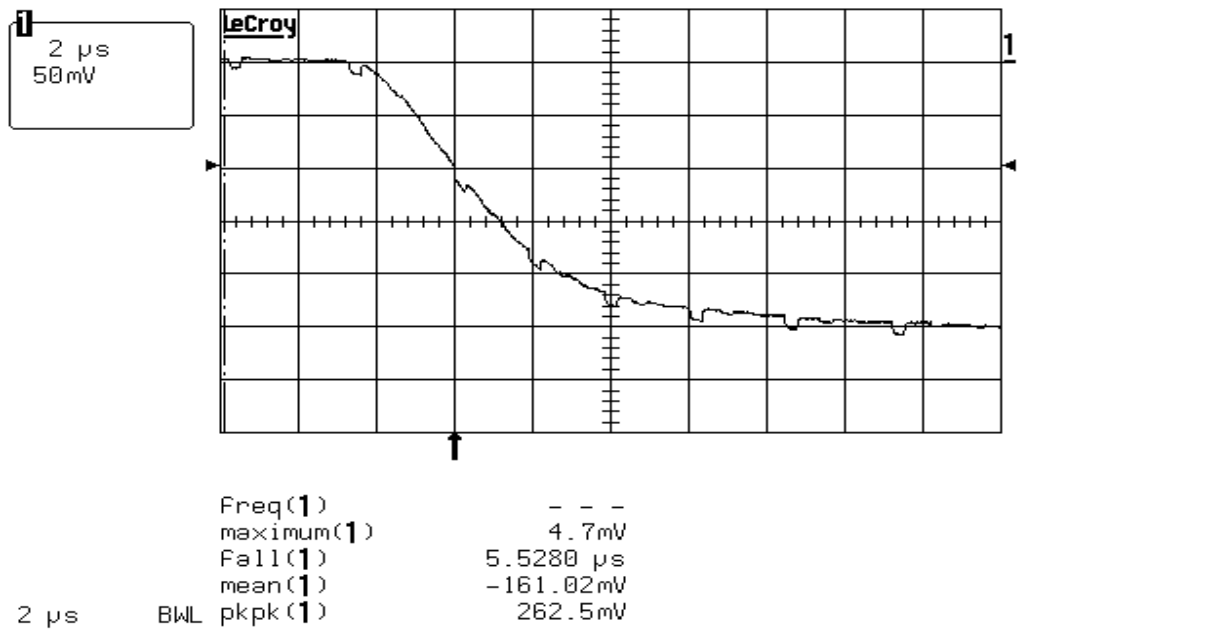
Load dump across 3mOhms R2 with scope ground at Vout; >80A in 2usec (>250mV/3mOhms)




Step load across same 3mOhms R2 about 80A in 10usec

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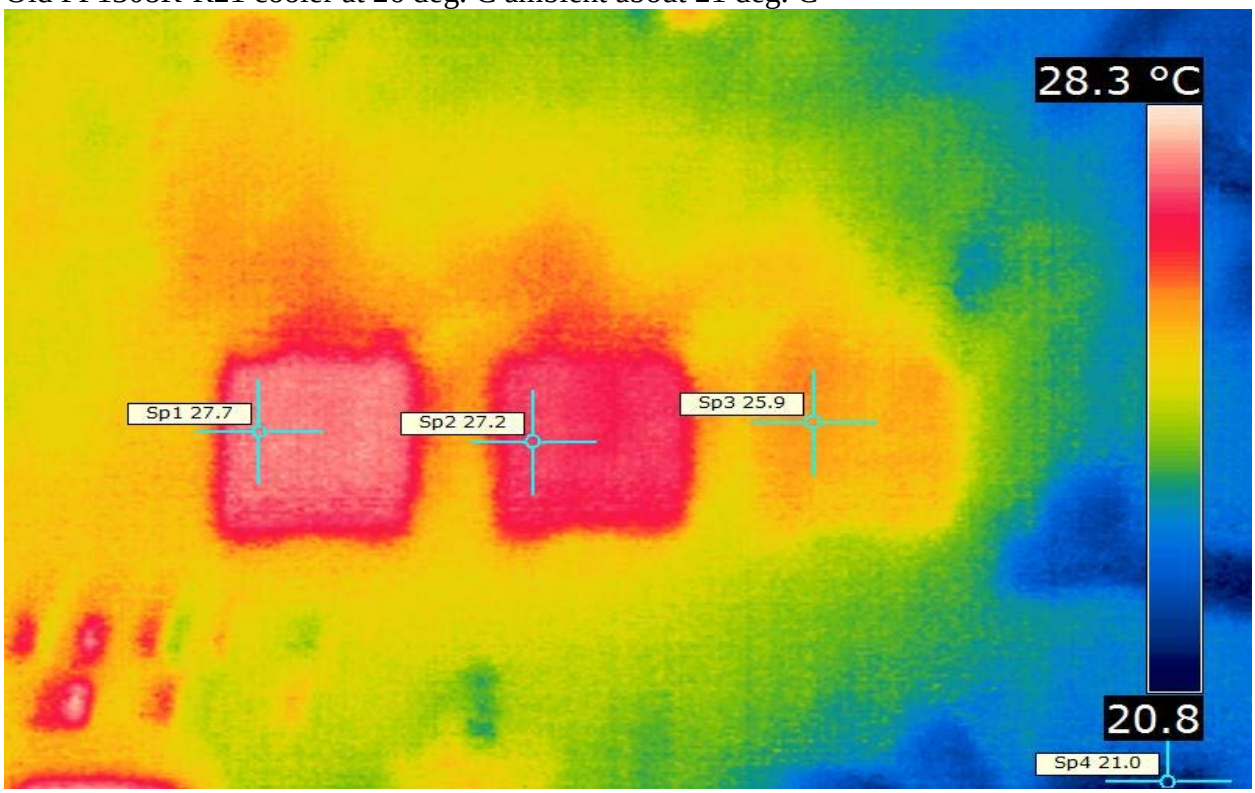
Thermal Images:
TIDA00324 model t1 12Vin 3 phases 1.326Vout 320kHz per phase 1.95W on PCB main inductors hottest
No load and No fan
New FP1308R3-R21 for L100 & L200 at over 27 deg. C
Old FP1308R-R21 cooler at 26 deg. C ambient about 21 deg. C

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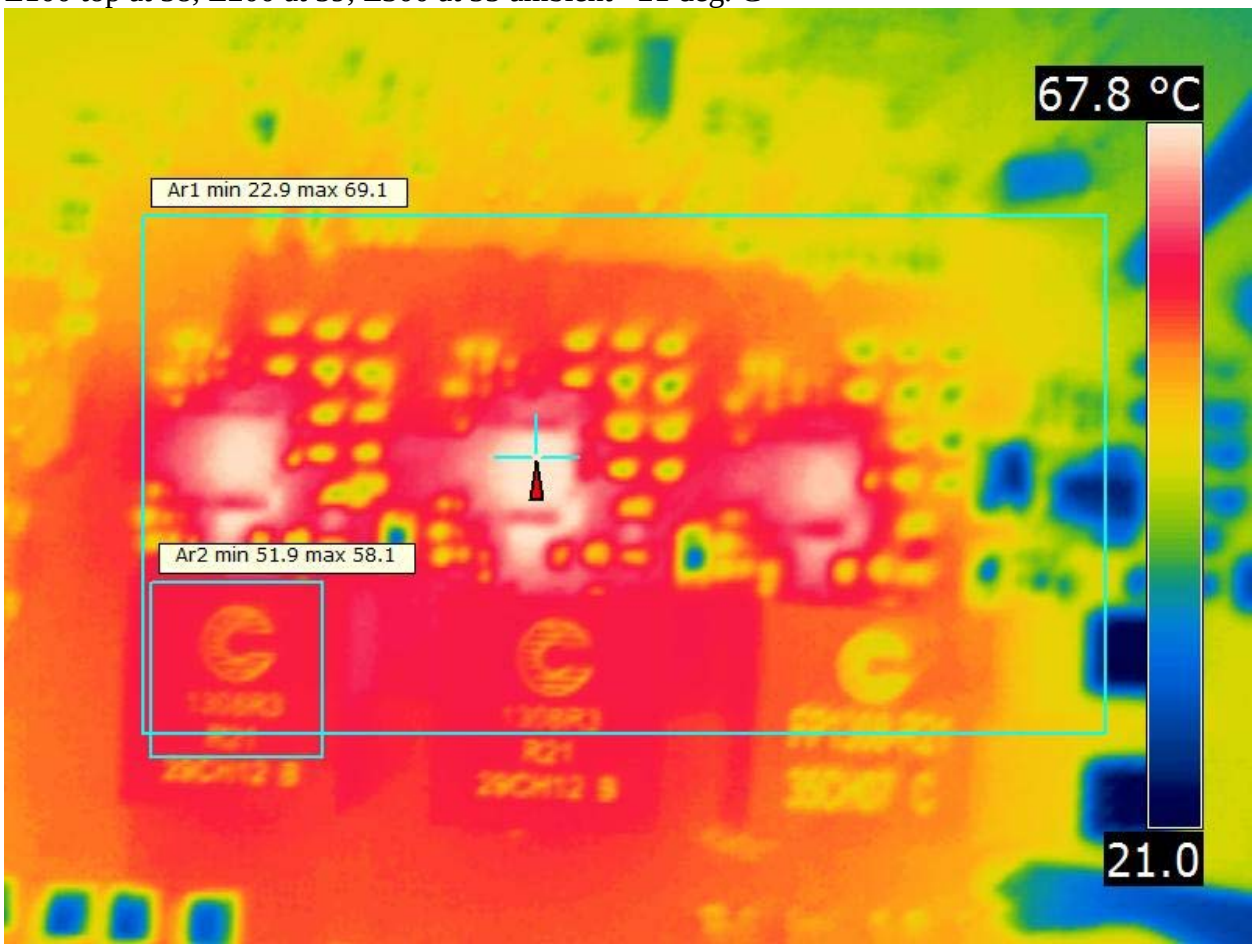
No load details at 1.2Vout, 1.32Vout and 1.0Vout

| Vin Volts | Iin A | Vout Volts | Iout A | % Effi ciency | Losses in W | |
|---|---|---|---|---|---|---|
| 12.02 | 0.1620 | 1.326 | 0 | | 1.947 | T1, 3ph, 320kHz |
| 12.03 | 0.1247 | 1.326 | 0 | | 1.500 | T1, 2ph, 324kHz |
| 12.03 | 0.0777 | 1.326 | 0 | | 0.935 | T1, 1ph, 318kHz |
| 12.03 | 0.0124 | off | | | 0.149 | T1 |
| | | | | | | |
| 12.03 | 0.1296 | 1.005 | 0 | | 1.559 | T1, 3ph, 295kHz |
| 12.03 | 0.1013 | 1.005 | 0 | | 1.219 | T1, 2ph, 293+kHz |
| 12.03 | 0.065 | 1.005 | 0 | | 0.782 | T1, 1ph, 291+kHz |
| | | | | | | |
| 12.02 | 0.1485 | 1.206 | 0 | | 1.785 | T1, 3ph, 319kHz |
| 12.03 | 0.1145 | 1.206 | 0 | | 1.377 | T1, 2ph, 323kHz |
| 12.03 | 0.0722 | 1.206 | 0 | | 0.869 | T1, 1ph, 318kHz |

TIDA00324 model t1 12Vin 3 phases 1.2Vout 90Aout 336kHz per phase
11.4W on PCB No fan & 20 minute run
U200 hottest at 69 degrees C, U100 at 67, U300 at 66
PCB between FETs and inductors very close to FET temperatures
L100 top at 58, L200 at 59, L300 at 55 ambient ~21 deg. C

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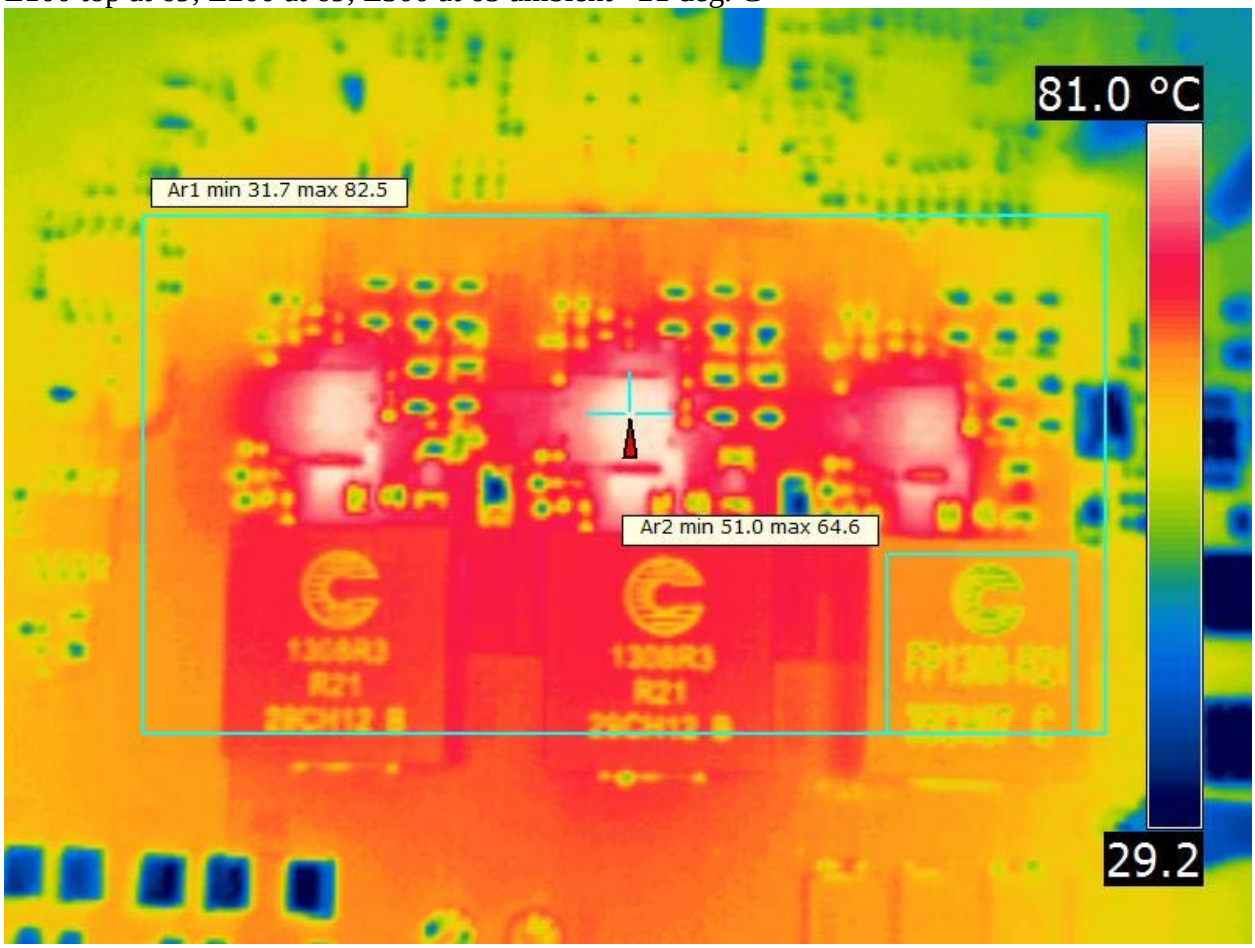
TIDA00324 model t1 12Vin 3 phases 1.2Vout 100A 338.6kHz per phase 13.8W on PCB No fan & 20 minute run
U200 hottest at 82.5 degrees C, U100 at 81, U300 at 79
PCB between FETs and inductors very close to FET temperatures
L100 top at 69, L200 at 69, L300 at 65 ambient ~21 deg. C

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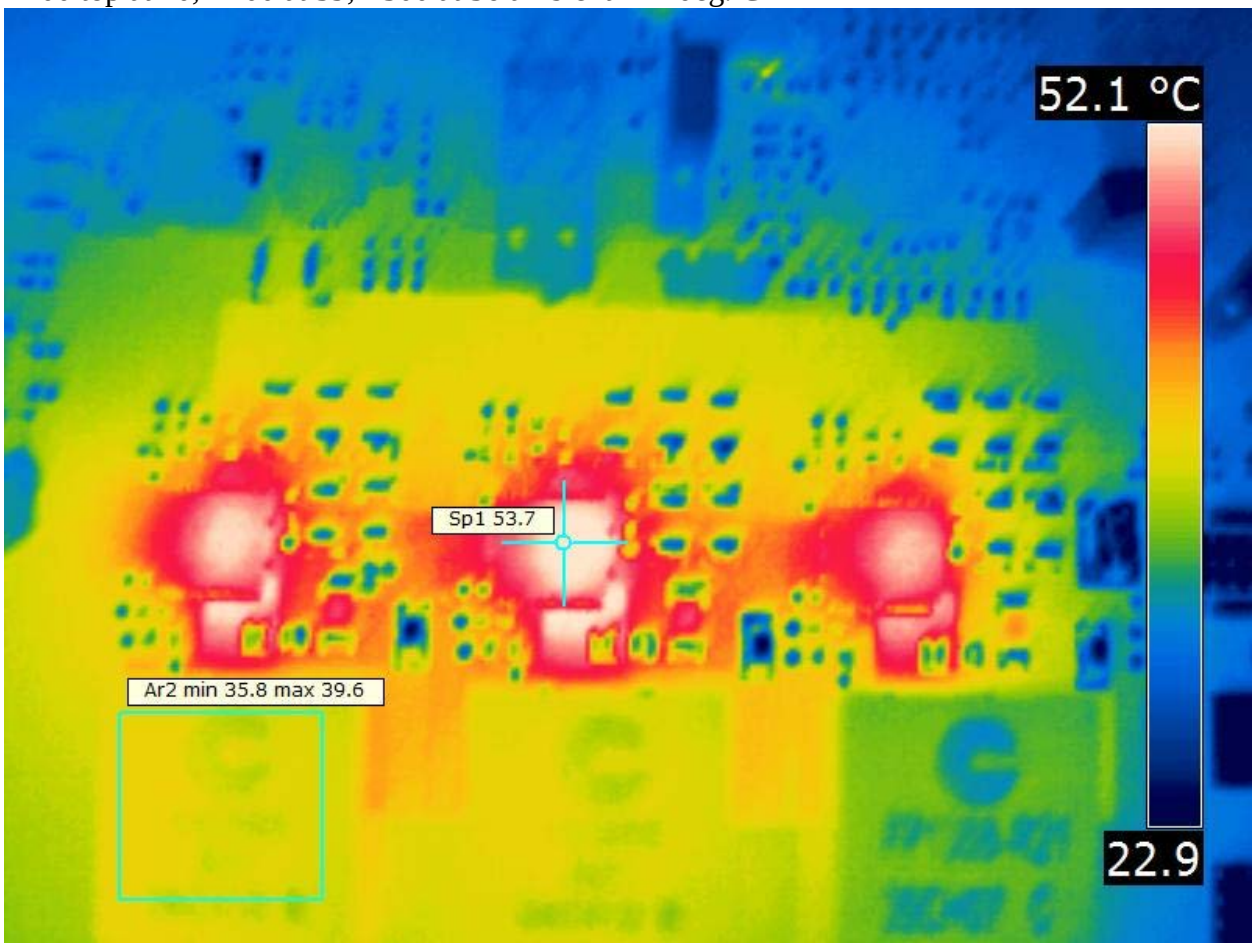
TIDA00324 model t1 12Vin 3 phases 1.2Vout 100A 335kHz per phase
13.0W on PCB ~200 LFM fan airflow
U200 hottest at 54 degrees C, U100 at 52, U300 at 51
L100 top at 40, L200 at 39, L300 at 36 ambient ~21 deg. C

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TIDA00324 model t1 12Vin 3 phases 1.2Vout 120A 338kHz per phase
18.4W on PCB ~200 LFM fan airflow
U200 hottest at 67 degrees C, U100 at 65, U300 at 63
L100 top at 46, L200 at 46, L300 at 41 ambient ~21 deg. C


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TIDA00324 model t1 12Vin 3 phases
1.2Vout 139A 340.5kHz per phase 24.8W on PCB ~200 LFM fan airflow
U200 hottest at 84 degrees C, U100 at 82, U300 at80
L100 top at 55, L200 at 54, L300 at 48 ambient ~21 deg. C


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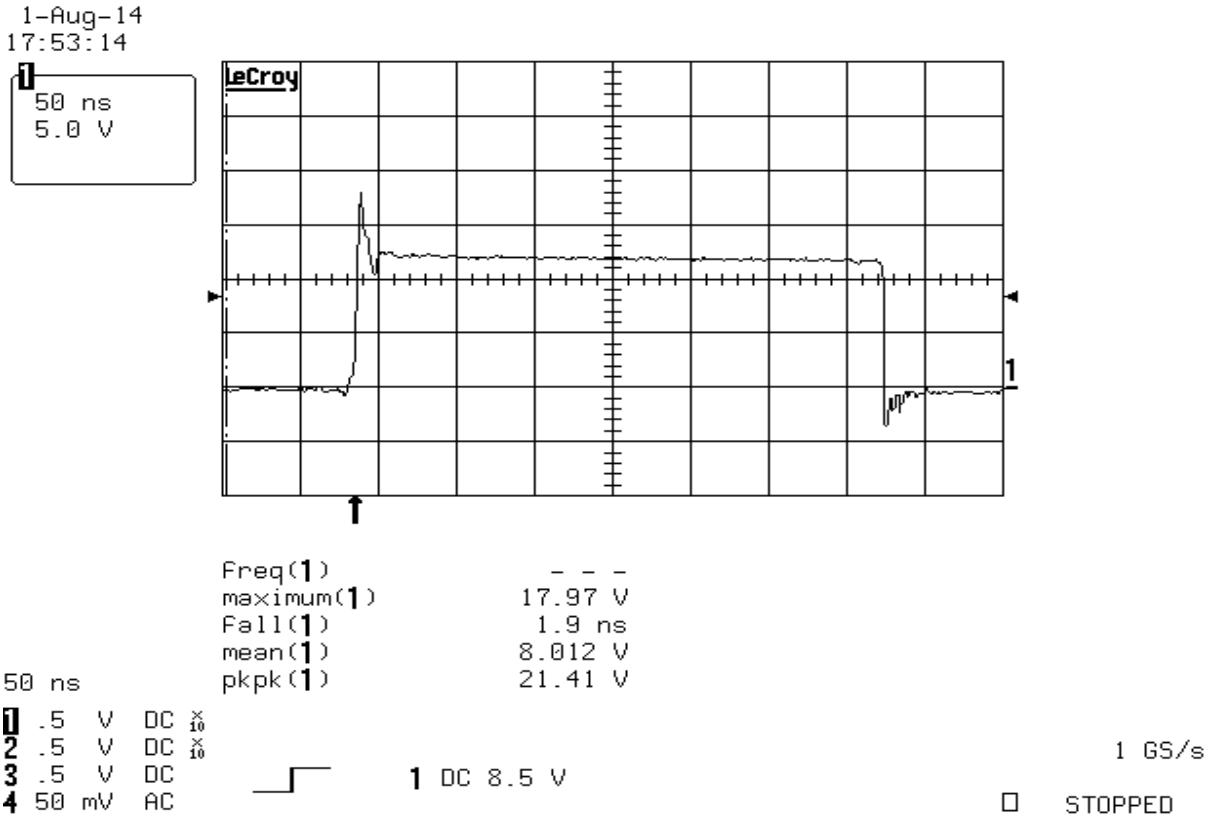
Main Waveform at max load 139A at 11.9vin and then at 13.2Vin: 341kHz

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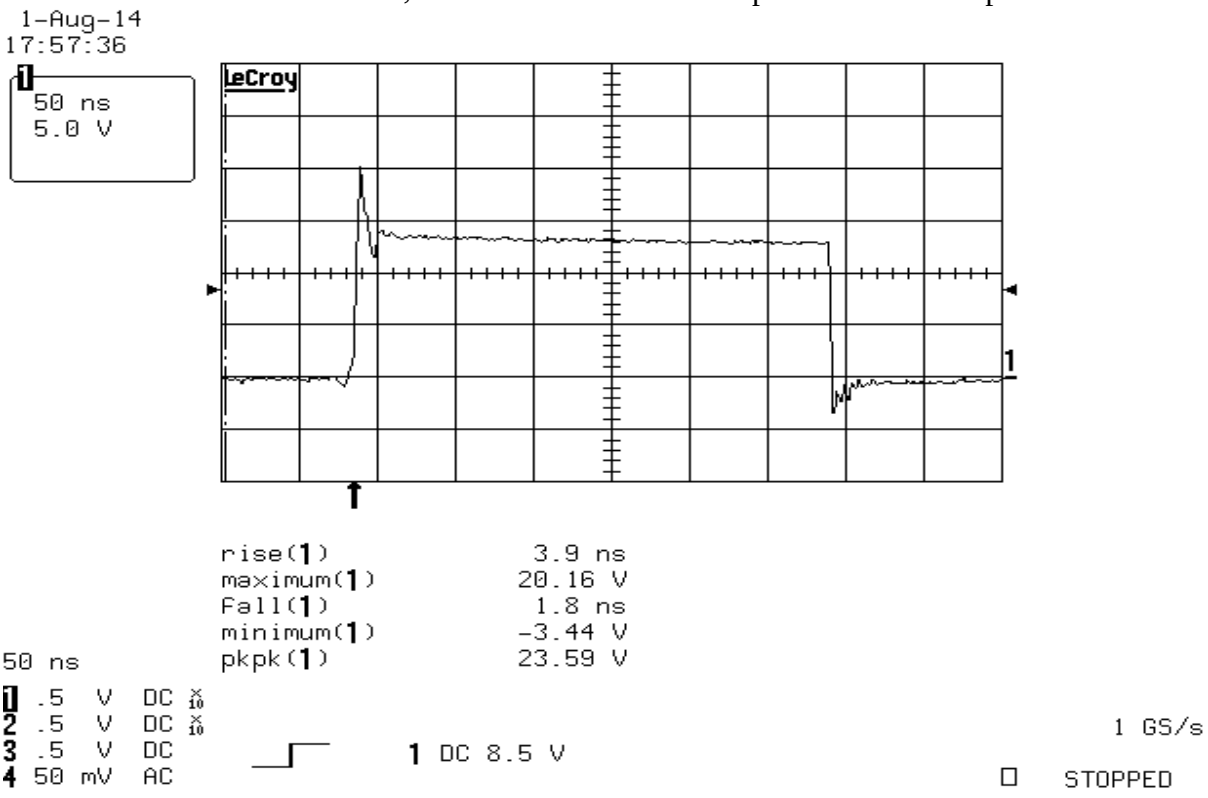
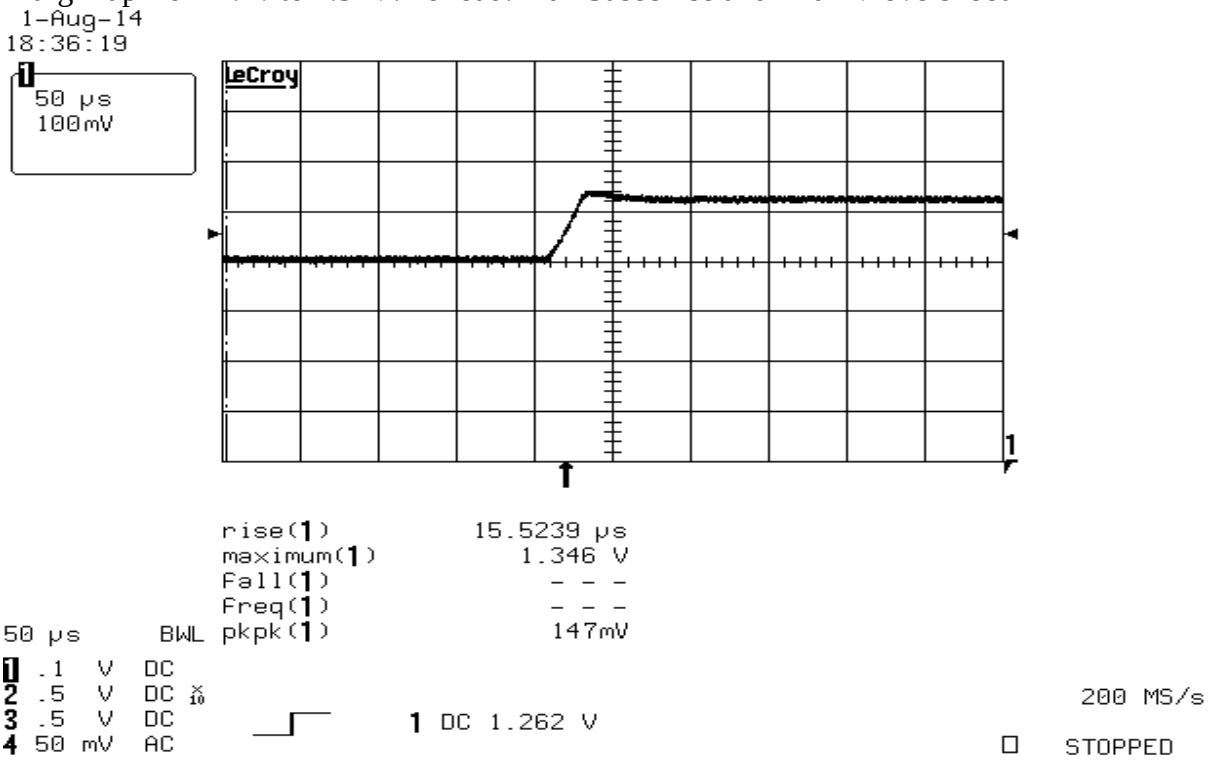
And at 13.2Vin: 20V measured, 23V allowed for >10nsec per CSD95372B spec



Margin up from 1.2v to 1.32V: no load: 20-25usec rise and ~10mV overshoot

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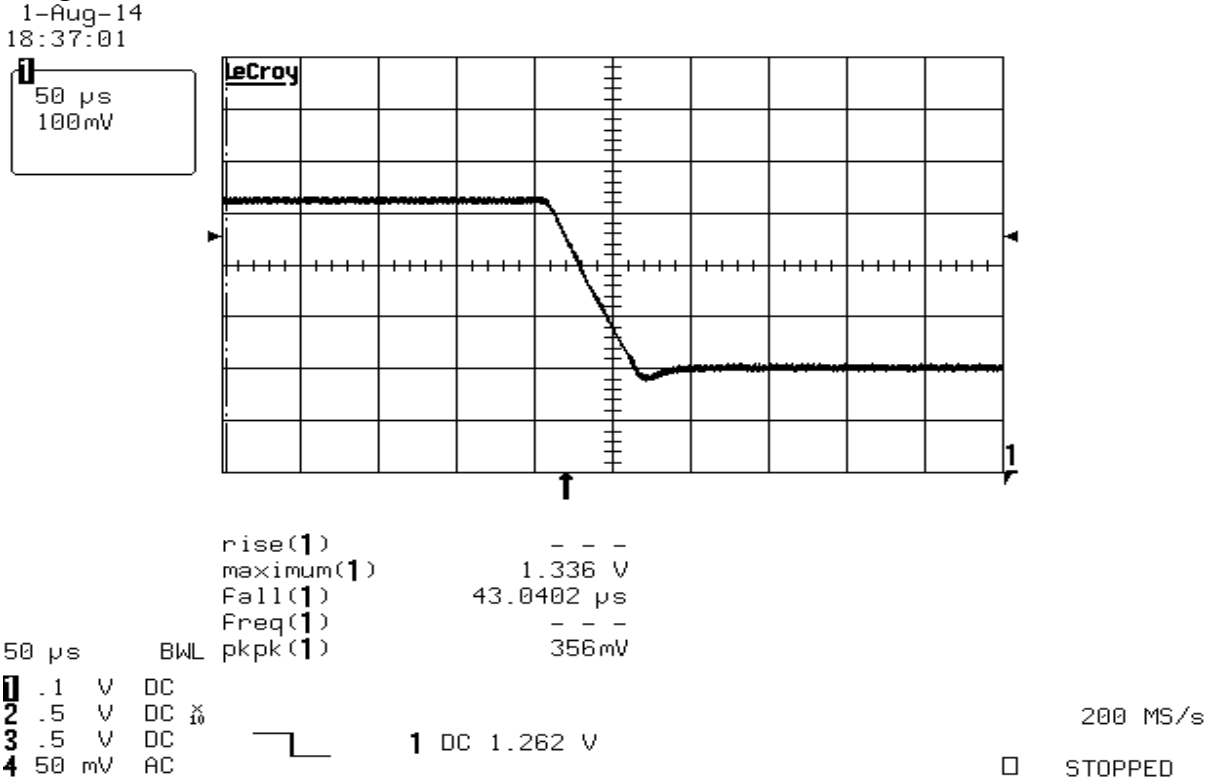
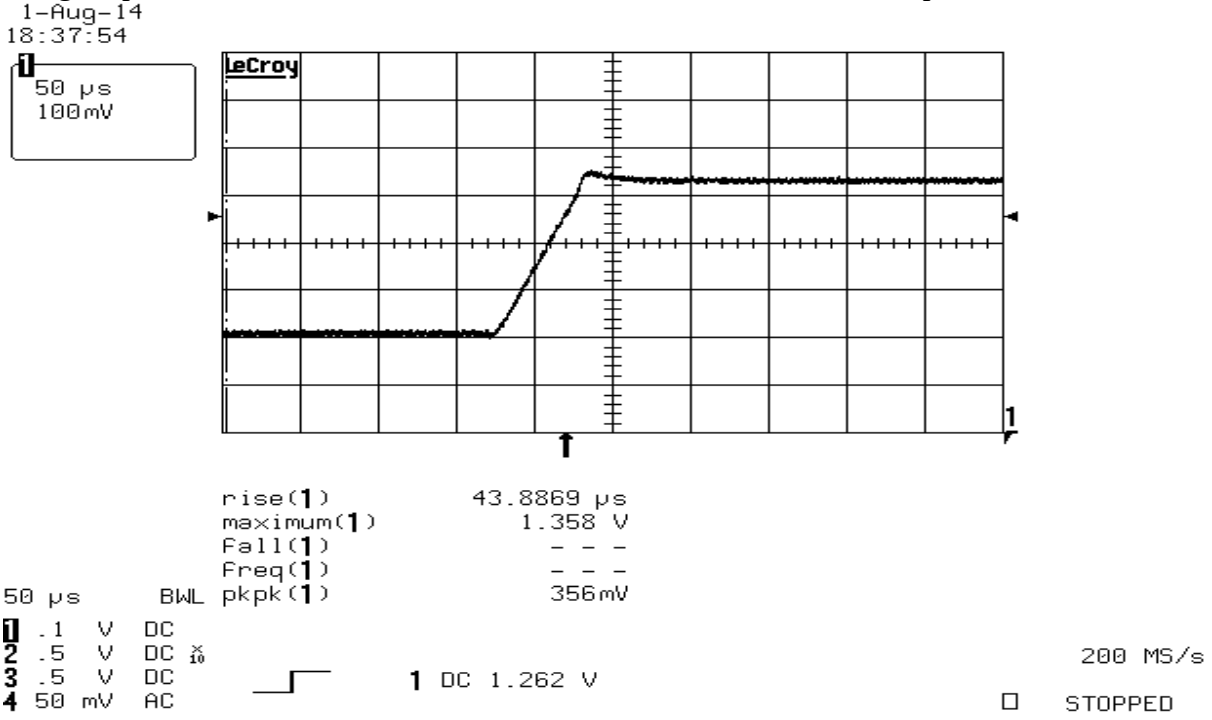
Margin down: No load: 1.32V to 1.0V in 60usec with 20mV undershoot



Margin low set at 1.0V and margin high at 1.32V: Load 80A
Margin up: 60 usec rise and 25mV overshoot: 3.2V in 60usec or 53mV per usec

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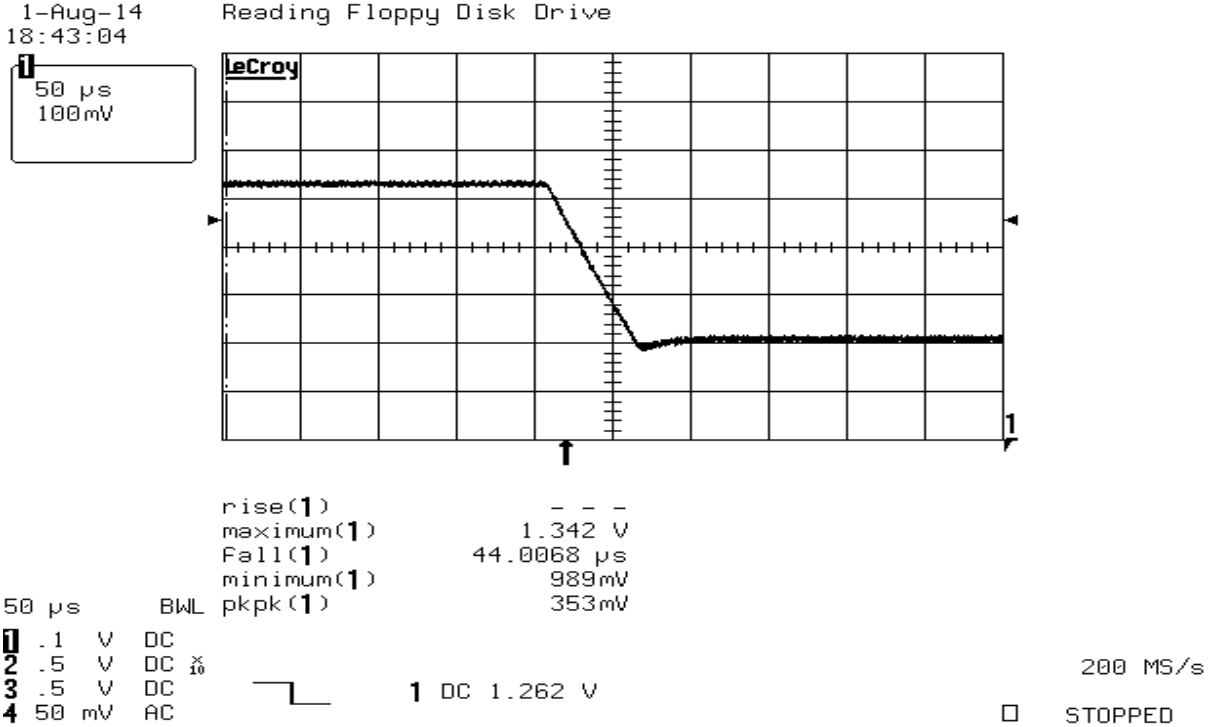
Margin down: 80A load: 1.32V to 1.0V in 60 usec with 20mV undershoot

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