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Model t2: Oct. 1-2, 2013

Updates in Test: (testing shown here done after updates)

- a) Temperature sense FETs Q2 & Q1 removed as they are too close to main FETs in current layout and can easily short to main switching waveform, as the main FET tops (CSD87384M) are tie to that signal and there is no plastic encapsulating material on them. With removed sensors the temperatures read are each -40 degrees Celsius.
- b) High side Main FET (Q3 & Q4 CSD87384M) turn on had to be slowed down significantly to prevent BOOTx signals from exceeding TPS40425 pin 30 & pin 20 max of 30V and damaging the TPS40425. BOOT resistors R17 & R21 increased from 2.2 ohms to 5.1 ohms. High side gate drive resistors were added for both Q3-1 & Q4-1 with value of 24.9 ohms. This got rise times of the main waveform when HS FET turns on to be about 3 nsec, and limits BOOTx voltages to less than 25V at 12Vin and up to 25A per phase. To keep turn off of HS FETs fast MBR0530s were added across these 24.9 ohms with cathode to the TPS40422 side. Fall times are about 2 nsec. Also, the snubber resistors R23 & R24 (size 2010) was changed from 1 ohms to 0.3 ohms to match recommendations given for the TPS40422 with similar FETs.
- c) Main control loop was sped up and "Type 3" lead compensation increased to move crossover from 40kHz with 45 degrees phase margin to 86kHz with 56 degrees phase margin. C1 increased from 1000pF to 1500pF and R6 reduced from 1k to 499 to increase phase margin. R7 increased from 4.99k to 10k and C2 reduced from 4700pF to 2200pF to speed up loop and transient response.

Afterwards same updates were done to model t1 to verify consistency. Results were very similar with main waveform peaks within 1V of model t2 peaks shown here, efficiencies slightly better (about 0.2% higher at 40A & 50A loads), and ripple / dynamics slightly higher (10% increase or less). Model t1 had slightly lower switching frequency with model t2 at 351kHz and model t1 at 2-5kHz lower. Model t1 was shipped to first application and model t2 still here for now.

On both models current sharing was very good with each phase within 1 A of the other based upon both GUI readings and upon manual readings of current sense voltages.

Model t2: Efficiency / losses 351kHz / phase measured at 50A & 30A loads  
 Close in Vin & Vout senses, 12V fan

Vin Volts	Iin A	Vout Volts	Iout A	% Efficiency	Losses in W
12.03	0.016	off			
12.02	0.083	1.0043	0	0.0	0.998
12.08	5.101	1.0170	50.01	82.5	10.760
12.02	3.982	1.0143	40.01	84.8	7.281
12.045	2.919	1.0118	30.00	86.3	4.805
12.025	2.421	1.0105	25.00	86.8	3.850
12.02	1.931	1.0092	20.00	87.0	3.027
12.01	0.982	1.0067	10.00	85.4	1.727
12.03	0.082	1.0043	0	0.0	0.986

Qq

GUI at 50A load:

Because TEMP sensors removed, both temperatures read -40 degrees Celsius

Cal gain = 0.5493mOhms

The screenshot shows the Fusion Digital Power Designer GUI. At the top, there are controls for 'System-Level Actions and Settings', including 'On/Off Config' (set to 'OPERATION Only'), 'Write Setting', 'Margining', 'Turn On', 'Immed Off', 'Clear Faults', 'Store User Defaults', and 'Restore User Defaults'. Below this is a 'Rails' section with a table:

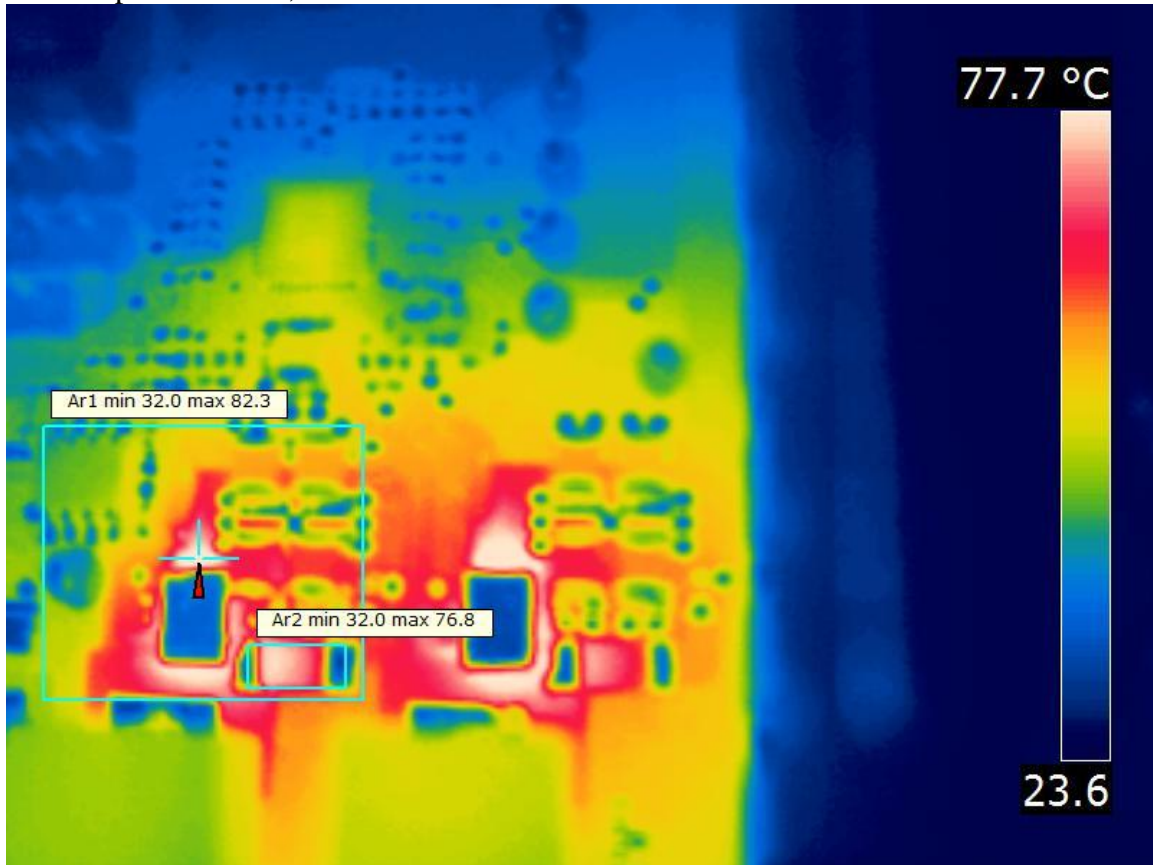
Device	Rail	Vout	Iout	Temp (USB)	Operation	On/Off Config
TPS40422 @ 24d	1 Channel #1	1.004 V	24.44 A	-40 °C High	<input checked="" type="radio"/> On <input type="radio"/> Immediate Off	0x1A OPERATION Only
TPS40422 @ 24d	2 Channel #2	0.002 V	24.81 A	-40 °C High	<input checked="" type="radio"/> On <input type="radio"/> Immediate Off	0x1A OPERATION Only

At the bottom, there is a 'Status Registers' window showing the following data:

	Channel #1	Channel #2
STATUS_WORD	OK	OK
STATUS_VOUT	OK	OK
STATUS_IOUT	OK	OK
STATUS_TEMPERATURE	OK	OK
STATUS_CML	OK	OK
STATUS_HWR_SPECIFIC	Two Phase Enabled	

Qq

PMP8999B model t2 with drive updates  
12.2Vin 1Vout at 50.3A 351kHz / phase  
12.0V fan 6.5" from board ambient at 23 deg. C  
Hottest PCB near Q3 at 87; near Q4 at 82  
choke tops at 53 & 49; snubbers 74 & 77



Qq

12.21Vin 3.939Ain 40.08Aout 1.0089 at TPs or 7.658W loss  
IR2862 with 66-67 max  
PMP8999B model t2 with drive updates  
12.2Vin 1Vout at 40.1A 351kHz / phase  
12.0V fan 6.5" from board ambient at 23 deg. C  
Hottest PCB near Q3 at 67; near Q4 at 63  
choke tops at 43 & 41; snubbers 61 & 62



Qq

12.18Vin 2901mA in 30.07Aout 1.0077Vout same 351kHz per phase

IR2863 with 51 max

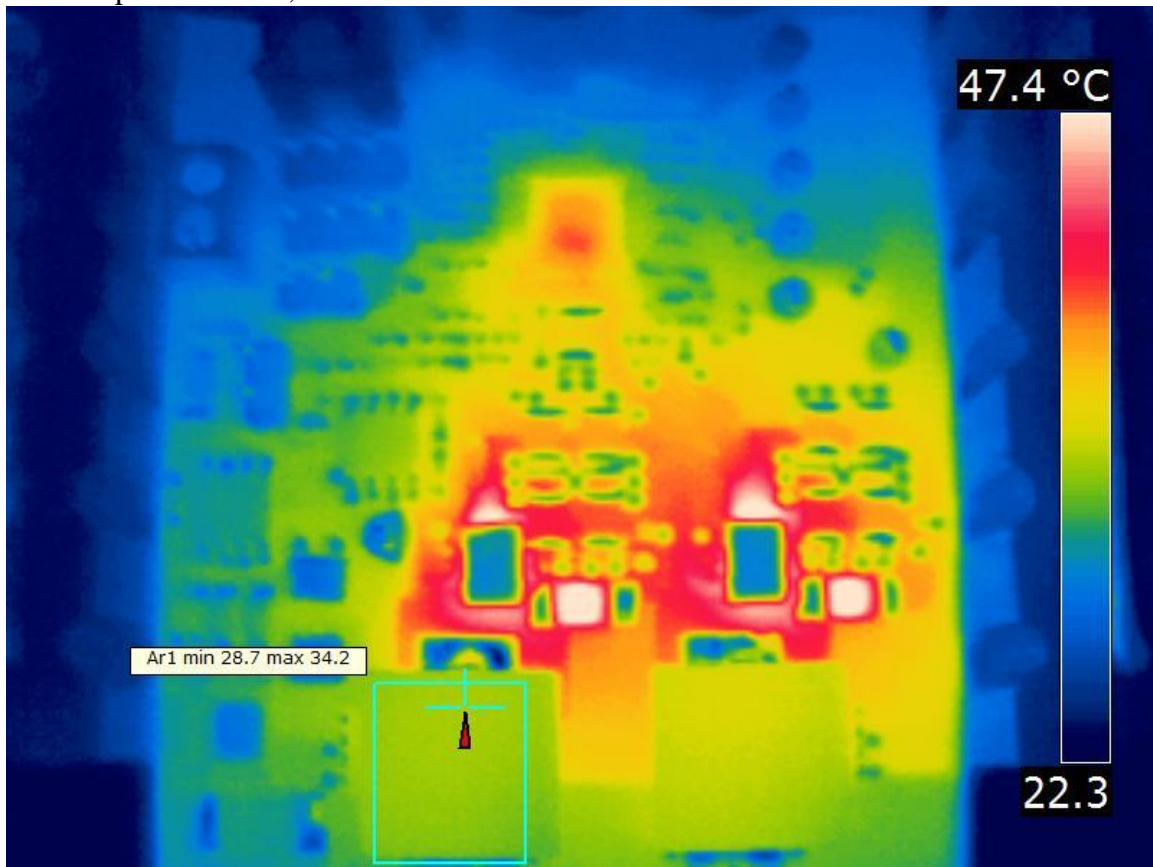
PMP8999B model t2 with drive updates

12.2Vin 1Vout at 30.1A 351kHz / phase

12.0V fan 6.5" from board ambient at 23 deg. C

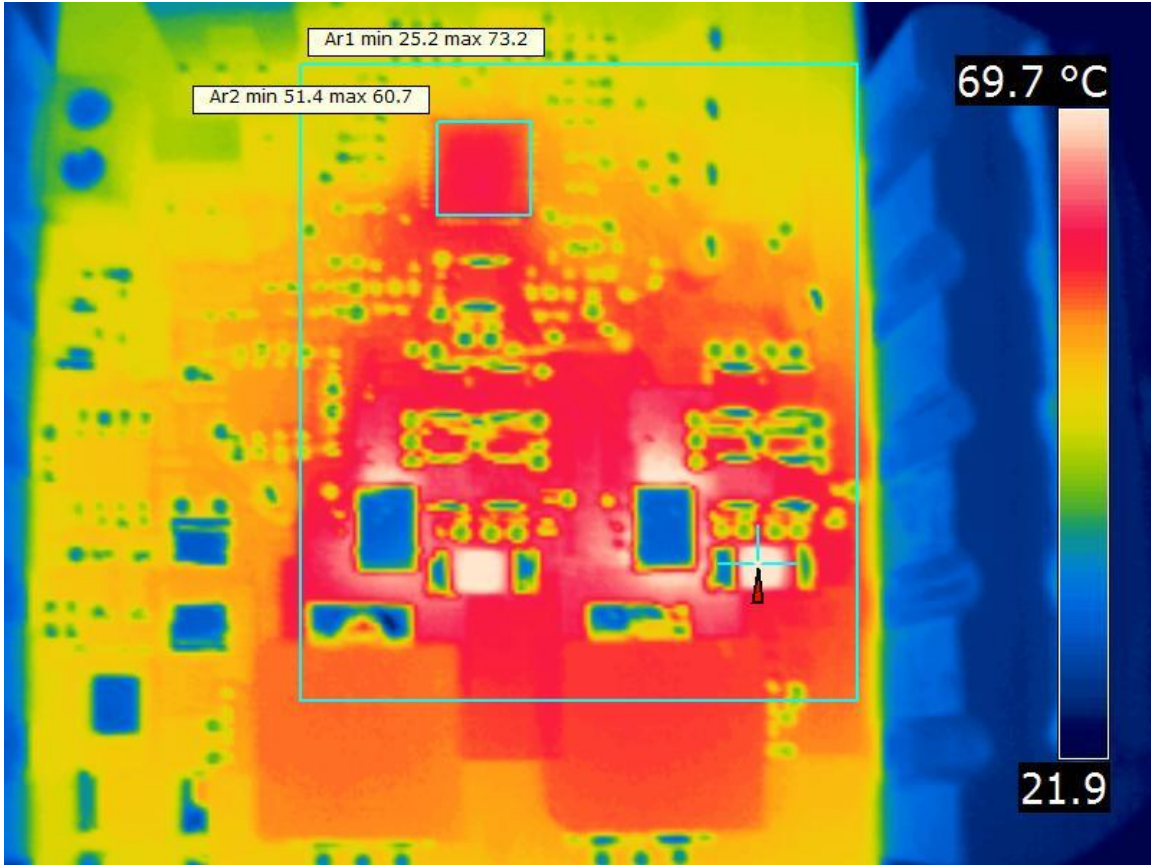
Hottest PCB near Q3 at 49; near Q4 at 47.5

choke tops at 36 & 34; snubbers 50 & 51



Qq

PMP8999B 12.00Vin 2.948Ain 1.0120Vout 30.0A no fan >20 minutes ambient 22 degrees Celsius 351kHz per phase  
Snubbers hottest at 73deg. C; area near Q3 max 71; near Q4 68.5; inductor tops 58 and 56; controller 61

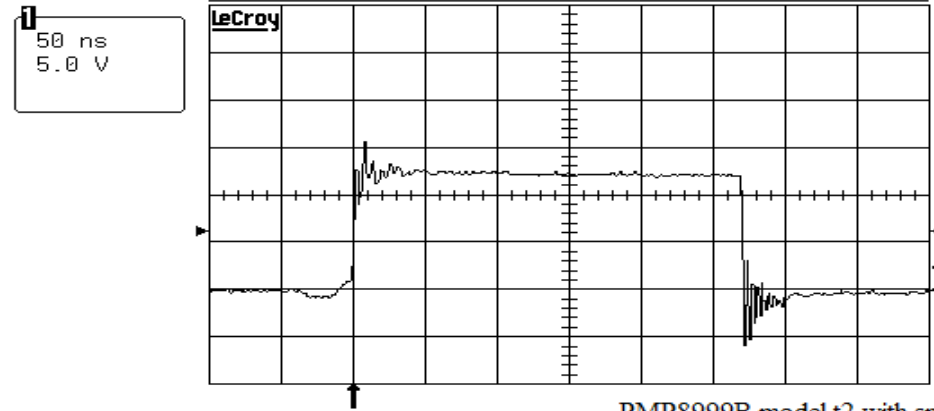


Qq

**Main switching Waveform** at 50A load off 12Vin:

First Q3 of first phase:

1-Oct-13 Reading Floppy Disk Drive  
17:54:03



maximum(1) 15.63 V  
minimum(1) -5.94 V  
width(1) 269.9 ns  
Fall(1) 1.8 ns  
rise(1) 3.4 ns

PMP8999B model t2 with snubber R=0.3;  
BOOTx R's 5.1; HS gate: 24.9//MBR0530  
each; 12.2Vin 351kHz operation and 25A per  
phase load  
500MHz close in 10x probe / scope  
main Q3 switching waveform  
30nsec riding diode before HS turn on  
<4V overshoot; 6V undershoot 1 GS/s

50 ns  
1 .5 V DC  $\tilde{x}$   
2 .2 V DC  
3 50 mV DC  
4 10 mV 500

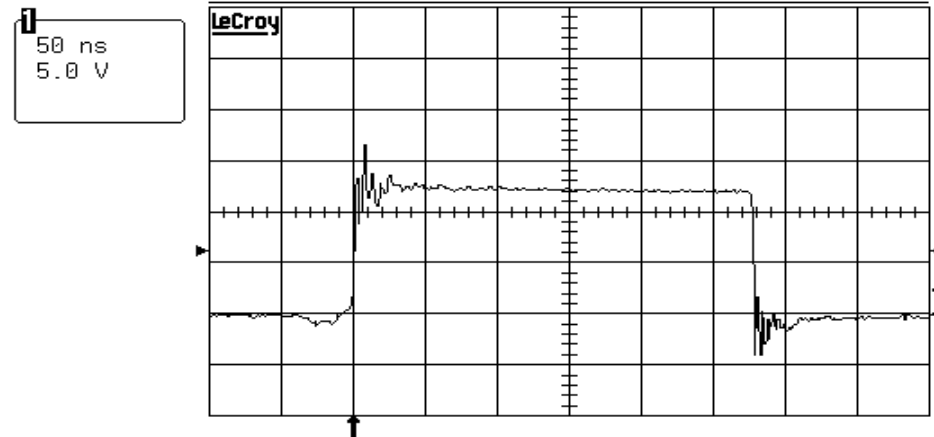
1 DC 6.4 V

STOPPED

Qq

Then Q4 of second phase:

1-Oct-13  
17:55:27



maximum(1) 16.56 V  
minimum(1) -4.06 V  
width(1) 276.8 ns  
Fall(1) 1.8 ns  
rise(1) 2.6 ns

PMP8999B model t2 with snubber R=0.3;  
BOOTx R's 5.1; HS gate: 24.9//MBR0530  
each; 12.2Vin 351kHz operation and 25A per  
phase load  
500MHz close in 10x probe / scope  
main Q4 switching waveform  
~30nsec riding diode before HS turn on  
<5V overshoot; 4V undershoot 1 GS/s

50 ns  
1 .5 V DC  $\tilde{x}$   
2 .2 V DC  
3 50 mV DC  
4 10 mV 500

1 DC 6.4 V

STOPPED

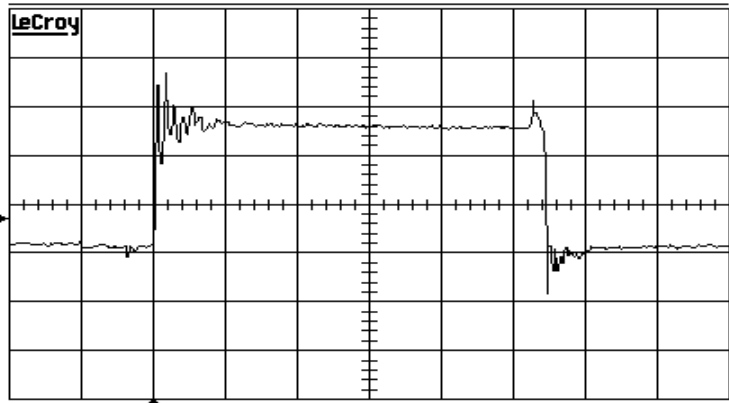
Qq

BOOTx waveforms at full load with updates:

First BOOT1 of first phase:

1-Oct-13  
17:56:20

50 ns  
5.0 V



maximum(1) 23.44 V  
minimum(1) 0.78 V  
width(1) 271.0 ns  
Fall(1) 1.8 ns  
rise(1) 1.3 ns

PMP8999B model t2 with snubber R=0.3;  
BOOTx R's 5.1; HS gate: 24.9/MBR0530 each;  
12.2Vin 351kHz operation and 25A per phase  
load  
500MHz close in 10x probe / scope  
BOOT1 at C13 waveform  
<24V peak vs. 30V TPS40422 max allowed

50 ns

1 .5 V DC  $\times 10$   
2 .2 V DC  
3 50 mV DC  
4 10 mV 50 $\Omega$



1 DC 8.7 V

1 GS/s

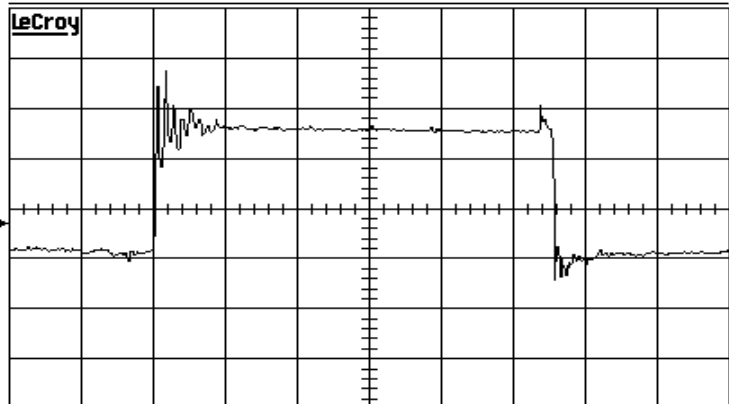
STOPPED

Qq

Then BOOT2 of second phase:

1-Oct-13  
17:57:48

50 ns  
5.0 V



maximum(1) 23.75 V  
minimum(1) 2.81 V  
width(1) 276.6 ns  
Fall(1) 1.6 ns  
rise(1) 1.4 ns

PMP8999B model t2 with snubber R=0.3;  
BOOTx R's 5.1; HS gate: 24.9/MBR0530  
each; 12.2Vin 351kHz operation and 25A per  
phase load  
500MHz close in 10x probe / scope  
BOOT2 at C10 waveform  
24V peak vs. 30V TPS40422 max allowed

50 ns

1 .5 V DC  $\times 10$   
2 .2 V DC  
3 50 mV DC  
4 10 mV 50 $\Omega$



1 DC 8.7 V

1 GS/s

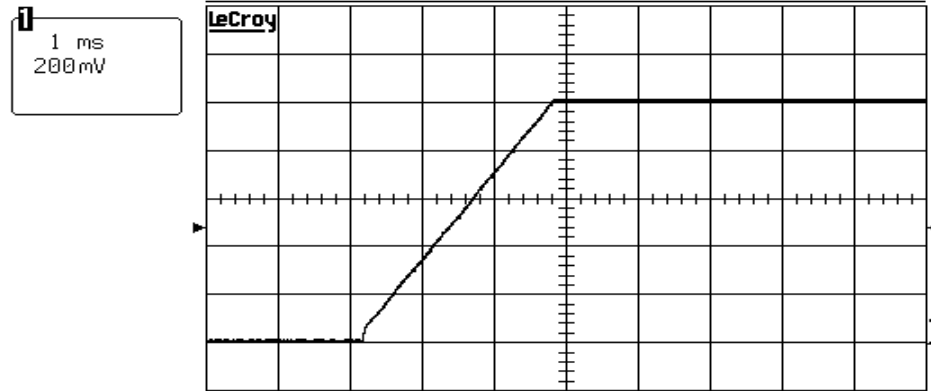
SLOW TRIGGER  
 NORMAL

Qq



**Start up waveform** from operation command:

2-Oct-13 Reading Floppy Disk Drive  
19:10:01



maximum(1)	1.012 V
minimum(1)	0 mV
Freq(1)	- - -
Fall(1)	- - -
rise(1)	2.20125 ms

PMP8999B output rise model t2  
when "operation" command given  
12Vin 1.0Vout  
Measured at C30  
20MHz bandwidth close in 1x probe  
target rise 2.7 msec, actual very close  
rise(1) shown is from 10% to 90%

1 ms BWL  
1 .2 V DC  
2 .2 V DC  
3 50 mV DC  
4 10 mV 50Ω

1 DC 0.484 V

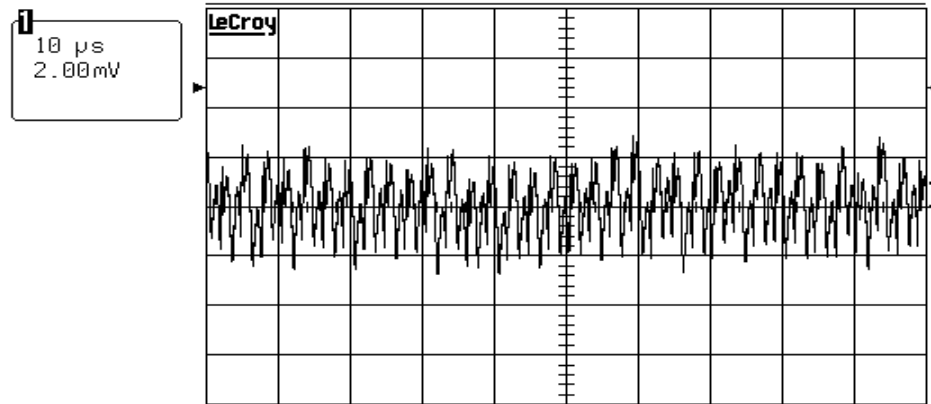
10 MS/s

STOPPED

Qq

**Ripple out at 50A load: 12Vin**

2-Oct-13  
19:12:19



maximum(1)	2.88 mV
minimum(1)	-2.75 mV
Freq(1)	557.057 kHz
Fall(1)	3.4898 μs
rise(1)	7.8186 μs

PMP8999B output ripple model t2  
12Vin 1.0Vout static load 50A  
Ripple measured at C30  
20MHz bandwidth close in 1x probe  
Loop crossover 86.5kHz per Venable  
<6mV peak to peak measured here

10 μs BWL  
1 2 mV AC  
2 .2 V DC  
3 50 mV DC  
4 10 mV 50Ω

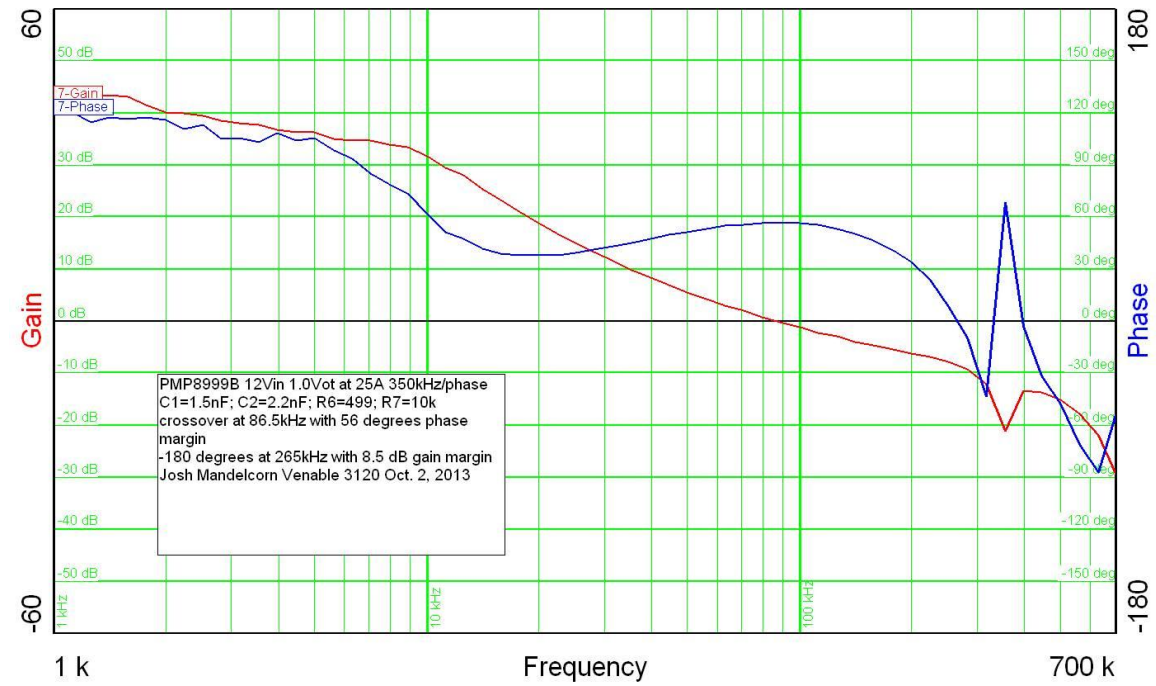
1 DC 4.84 mV

1 GS/s

STOPPED

Qq

Bode Plot of loop:

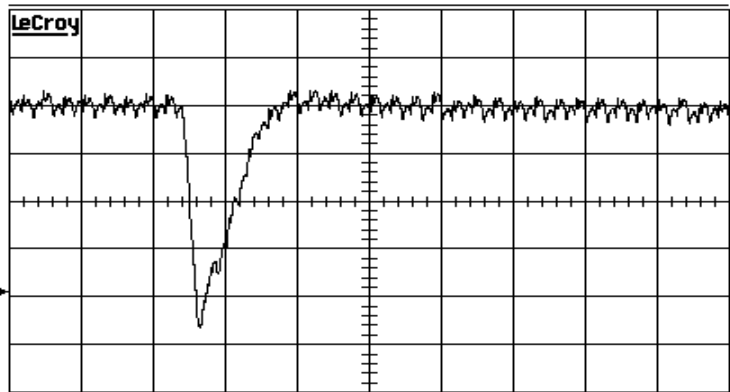


qq

Step load response:

2-Oct-13  
19:02:23

10  $\mu$ s  
10.0mV



maximum(1)	3.1mV
minimum(1)	-46.6mV
Freq(1)	- - -
Fall(1)	1.7204 $\mu$ s
Rise(1)	8.0084 $\mu$ s

PMP8999B Dynamic Load Response  
12Vin 1.0Vout static load 10A  
measured at C30  
Step of 40A in 2usec  
undershoot 46mV  
Loop crossover 86.5kHz per Venable  
model t2

10  $\mu$ s BWL  
1 10 mV AC  
2 .2 V DC  
3 50 mV DC  
4 10 mV 50 $\Omega$



1 DC -38.6mV

1 GS/s

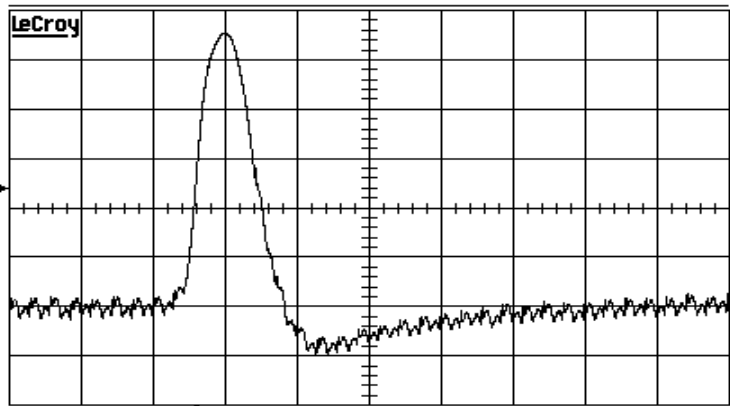
STOPPED

Qq

Load dump response:

2-Oct-13  
19:05:01

10  $\mu$ s  
10.0mV



maximum(1)	55.3mV
minimum(1)	-9.7mV
Freq(1)	- - -
Fall(1)	5.0630 $\mu$ s
Rise(1)	3.2050 $\mu$ s

PMP8999B Dynamic Load Response  
12Vin 1.0Vout static load 10A  
measured at C30  
Dump of 40A in 2.4usec  
overshoot 55mV  
Loop crossover 86.5kHz per Venable  
model t2

10  $\mu$ s BWL  
1 10 mV AC  
2 .2 V DC  
3 50 mV DC  
4 10 mV 50 $\Omega$



1 DC 24.2mV

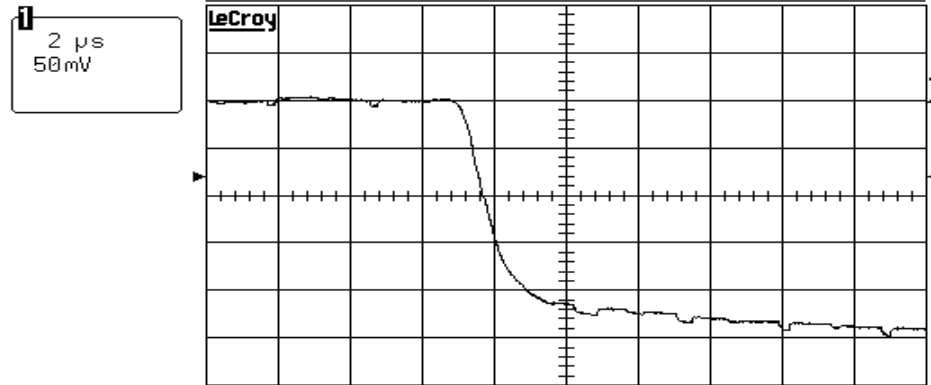
1 GS/s

STOPPED

Qq

Details of step load as seen across R207, 5mOhms tied to Vout:

2-Oct-13 Reading Floppy Disk Drive  
18:58:19



PMP8999B Dynamic Load  
Details of step load across 5mOhms R207  
For 5mOhms: 50mV / div = 10A / div  
about 40A step in 2 usec  
model t2

maximum(1)	6.2mV
minimum(1)	-248.5mV
Freq(1)	- - -
Fall(1)	2.0809 µs
rise(1)	- - -

2 µs BWL  
 1 50 mV DC  
 2 .2 V DC  
 3 50 mV DC  
 4 10 mV 50Ω

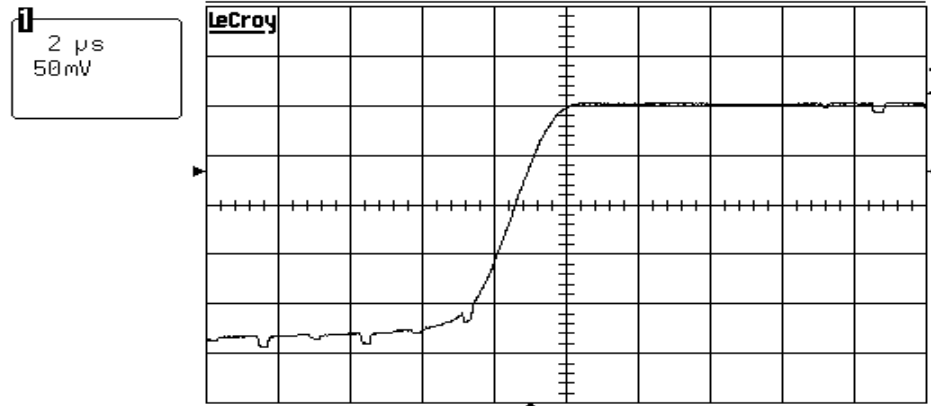
1 DC -78mV

1 GS/s

STOPPED

Q  
Load dump details across same R207

2-Oct-13  
18:59:15



PMP8999B Dynamic Load  
Details of load dump across 5mOhms R207  
For 5mOhms: 50mV / div = 10A / div  
about 40A dump in 2.4 usec  
model t2

maximum(1)	-9.4mV
minimum(1)	-256.3mV
Freq(1)	- - -
Fall(1)	- - -
rise(1)	2.1317 µs

2 µs BWL  
 1 50 mV DC  
 2 .2 V DC  
 3 50 mV DC  
 4 10 mV 50Ω

1 DC -78mV

1 GS/s

STOPPED

Qq

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