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Initial testing with PMP2821 with all its updates, but Vin set to 48V and output 12V at 4.0A:

Vin = 48.07V Iin = 1.112A Vout = 12.07V Iout = 4.00A eff. = 90.3%; Losses = 5.17W

One hi side FET getting to 91 degrees Celsius from room ambient:

Major cause of loss and heating: slow turn off: For hi side using two P-FETs Si7465DP which have slow turn off. See waveforms next page.

Turn on much faster at under 10nsec, and not too fast to overvoltage low side FET rated at 60Vds.

Need faster high side FETs: Candidate FDMC5614P from Fairchild in power pad 3x3

Published on resistance is about 50% higher increasing conduction losses from 200mW for both to 300mW.

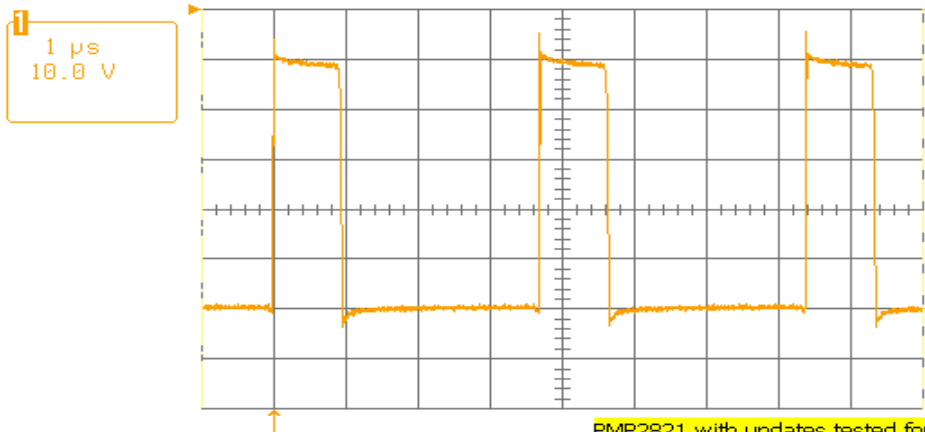
But published turn off time 11nsec vs. 30msec.

Even if actual speed only doubled, turn off losses will drop from 1.5W to 750mW.

Here is the overall major waveform:

10-Sep-09
17:34:10

Reading Floppy Disk Drive



maximum(1) 55.1 V
 Freq(1) 270.567 kHz
 pkpk(1) 59.4 V
 maximum(4) 1.8mV
 mean(4) -0.31mV

1 µs
 1 1 V DC 50
 2 .2 V DC
 3 .5 V AC 50
 4 10 mV 500

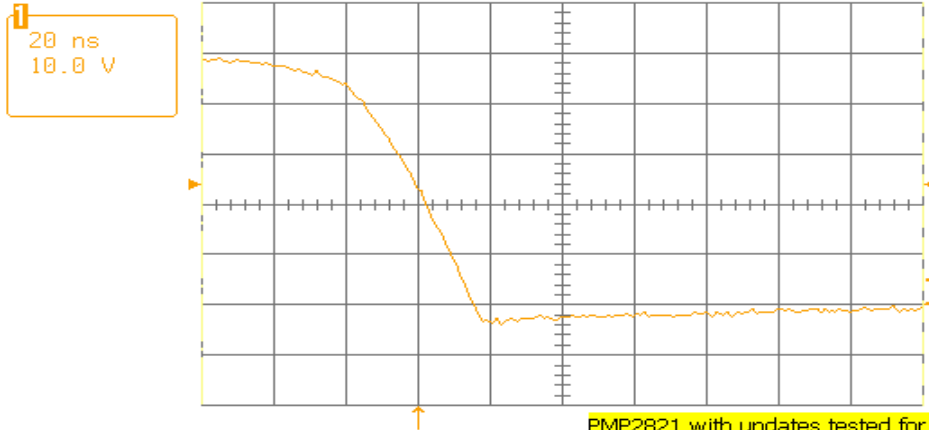
1 DC 59.8 V

PMP2821 with updates tested for PMP5133
 48.07Vin 1.112Ain 12.07Vout 4.00Aout 90.3% eff.
 Hi side: 2x Si7465DP R5=2.2; Lo side IRFZ44ES
 controller TPS40061
 Vds of lo side Q4 with 10x ripple probe right on part
 Cprobe=9.5pF; both probe & scope 500MHz
 max Vds = 55V rating 60V
 Problem: Hi side FETs reach 91 degrees Celsius

STOPPED

Turn off of hi side FETs:

10-Sep-09
17:42:10



maximum(1) 48.6 V
 Freq(1) - - -
 pkpk(1) 52.8 V
 maximum(4) 0.5 mV
 mean(4) -0.33 mV

20 ns

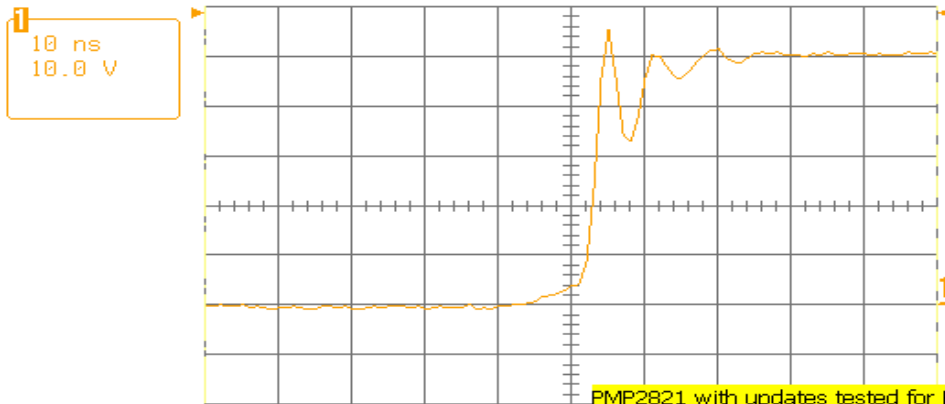
- 1 1 V DC \times
- 2 .2 V DC \times
- 3 .5 V AC \times
- 4 10 mV 50 Ω

1 DC 23.8 V

PMP2821 with updates tested for PMP5133
 48.07V_{in} 1.112A_{in} 12.07V_{out} 4.00A_{out} 90.3% eff.
 Hi side: 2x Si7465DP R5=2.2; Lo side IRF244ES
 controller TPS40061
 V_{ds} of lo side Q4 with 10x ripple probe right on part
 C_{probe}=9.5pF; both probe & scope 500MHz
 Fall time of high side FETs turning off
 about 40nsec fall time; current in choke then 5.67A
 Problem: Hi side FETs reach 91 degrees Celsius
 calculated fall time switching losses: 1.5W
 conduction losses only 200mW for both hi side FETs

Turn on of high side FETs:

10-Sep-09
17:43:32



maximum(1) 54.8 V
 Freq(1) - - -
 pkpk(1) 55.9 V
 maximum(4) 1.4 mV
 mean(4) -0.14 mV

10 ns

- 1 1 V DC \times
- 2 .2 V DC
- 3 .5 V AC \times
- 4 10 mV 50 Ω

1 DC 58.4 V

PMP2821 with updates tested for PMP5133
 48.07V_{in} 1.112A_{in} 12.07V_{out} 4.00A_{out} 90.3% eff.
 Hi side: 2x Si7465DP R5=2.2; Lo side IRF244ES
 controller TPS40061
 V_{ds} of lo side Q4 with 10x ripple probe right on part
 C_{probe}=9.5pF; both probe & scope 500MHz
 Rise time of high side FETs turning on
 about 5-10nsec fall time; current in choke then 2.33A
 Problem: Hi side FETs reach 91 degrees Celsius
 calculated rise time switching losses: <200mW
 conduction losses only 200mW for both hi side FETs

STOPPED

Now the high side MOSFETs were changed from Vishay Si7465DP (2x) to Fairchild FDMC5614P (2x). Then run at same conditions:

48Vin 12Vout at 4A room ambient:

Efficiency now 92.2% vs. 90.3% with loss reduction of 1.1W

Hottest FET Q1 (hi side) now 78 degrees C vs. 91 degrees C

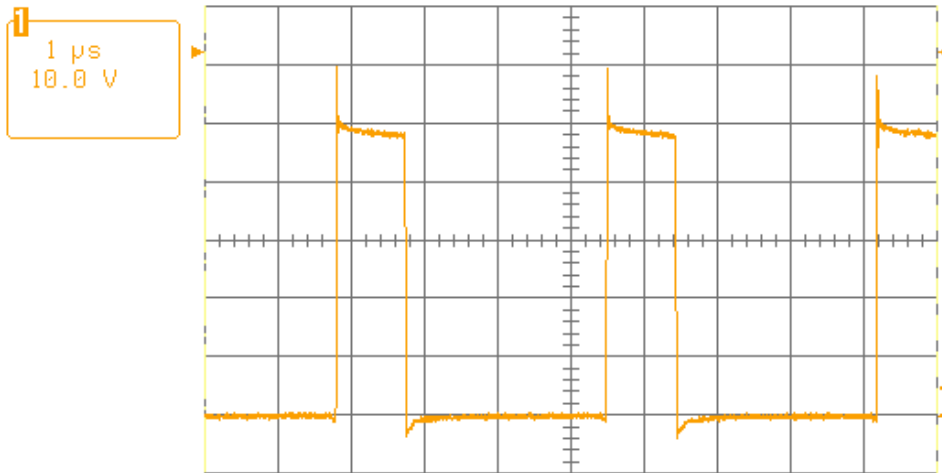
Max Vds stress on low side FET now 60V vs. 55 V before

Main waveform fall time 20 nsec vs. 40nsec before

Main waveform rise time from about 10%: 3nsec vs. 5nsec

Main waveform on low side Vds: 48Vin 12.07Vout at 4A FDMC5614P (2x) for hi side:

11-Sep-09
11:28:45



maximum(1)	59.7 V
Freq(1)	270.726 kHz
pkpk(1)	63.8 V
maximum(4)	1.1 mV
mean(4)	-0.25 mV

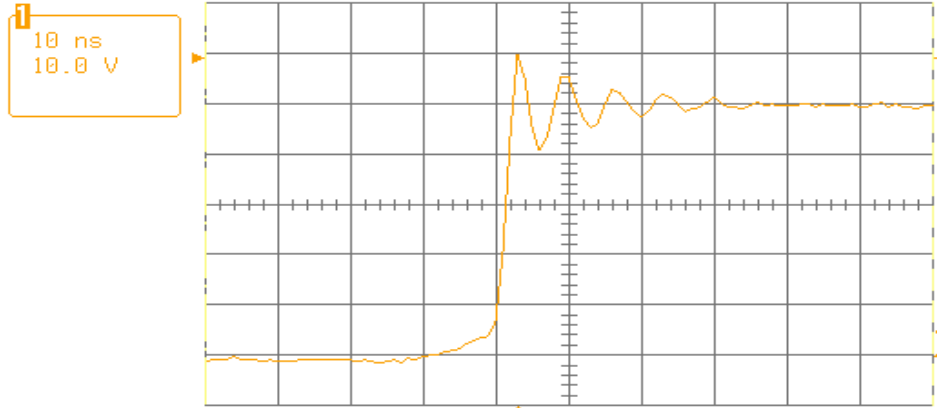
1	1	V	DC	\times	
2	.2	V	DC		
3	.5	V	AC	\times	
4	10	mV	500		

1	DC	62.4 V
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PMP2821 with updates tested for PMP5133
 48.02Vin 1.090Ain 12.065Vout 4.001Aout 92.2% eff.
 Hi side: 2x FDMC5614P R5=2.2; Lo side IRFZ44ES controller TPS40061
 Vds of lo side Q4 with 10x ripple probe right on part
 Cprobe=9.5pF; both probe & scope 500MHz
 max Vds = 60V rating 60V
 Hi side FET Q1 reaches 78 degrees Celsius
 Loss reduction of 1.1W with 2x FDMC5614P vs. 2x

Details of rise and then fall waveform with FDMC5614Ps: 48Vin 12.07Vout at 4A

11-Sep-09
11:35:12



maximum(1)	59.7 V
Freq(1)	- - -
pkpk(1)	60.9 V
maximum(4)	0.8mV
mean(4)	-0.30mV

10 ns

- 1 1 V DC \times
- 2 .2 V DC \times
- 3 .5 V AC \times
- 4 10 mV 50 Ω

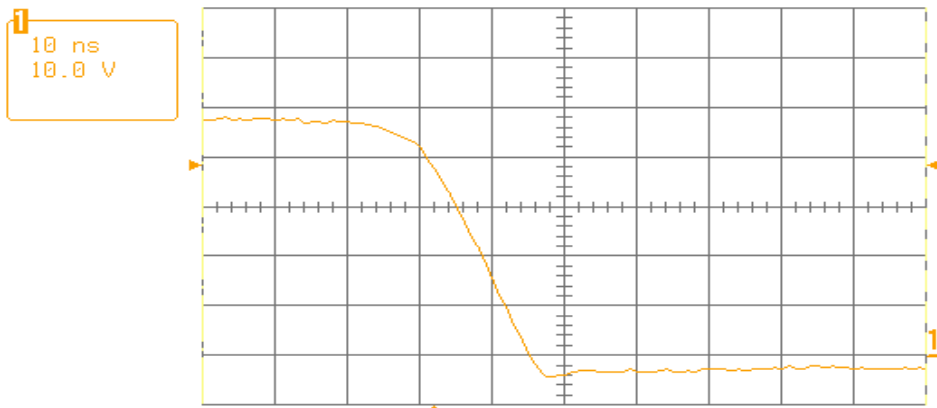
1 DC 59.2 V

PMP2821 with updates tested for PMP5133
48.02Vin 1.090Ain 12.065Vout 4.001Aout 92.2% eff.
Hi side: 2x FDMC5614P R5=2.2; Lo side IRFZ44ES controller TPS40061
Vds of lo side Q4 with 10x ripple probe right on part
Rise waveform shown as hi side turns on
Cprobe=9.5pF; both probe & scope 500MHz
max Vds = 60V rating 60V
most of rise in 3nsec, need to slow this down without affecting fall time to get Vds stress below

Qq

Fall time: 48Vin 12.07Vout at 4A

11-Sep-09
11:36:22



maximum(1)	48.1 V
Freq(1)	- - -
pkpk(1)	52.2 V
maximum(4)	0.5mV
mean(4)	-0.17mV

10 ns

- 1 1 V DC \times
- 2 .2 V DC \times
- 3 .5 V AC \times
- 4 10 mV 50 Ω

1 DC 38.6 V

PMP2821 with updates tested for PMP5133
48.02Vin 1.090Ain 12.065Vout 4.001Aout 92.2% eff.
Hi side: 2x FDMC5614P R5=2.2; Lo side IRFZ44ES controller TPS40061
Vds of lo side Q4 with 10x ripple probe right on part
Fall waveform shown as hi side turns off
Cprobe=9.5pF; both probe & scope 500MHz
max Vds = 60V rating 60V
Fall time about 20nsec vs. 40nsec with 2xSI7465
This saves the 1.1W loss reduction seen!!!

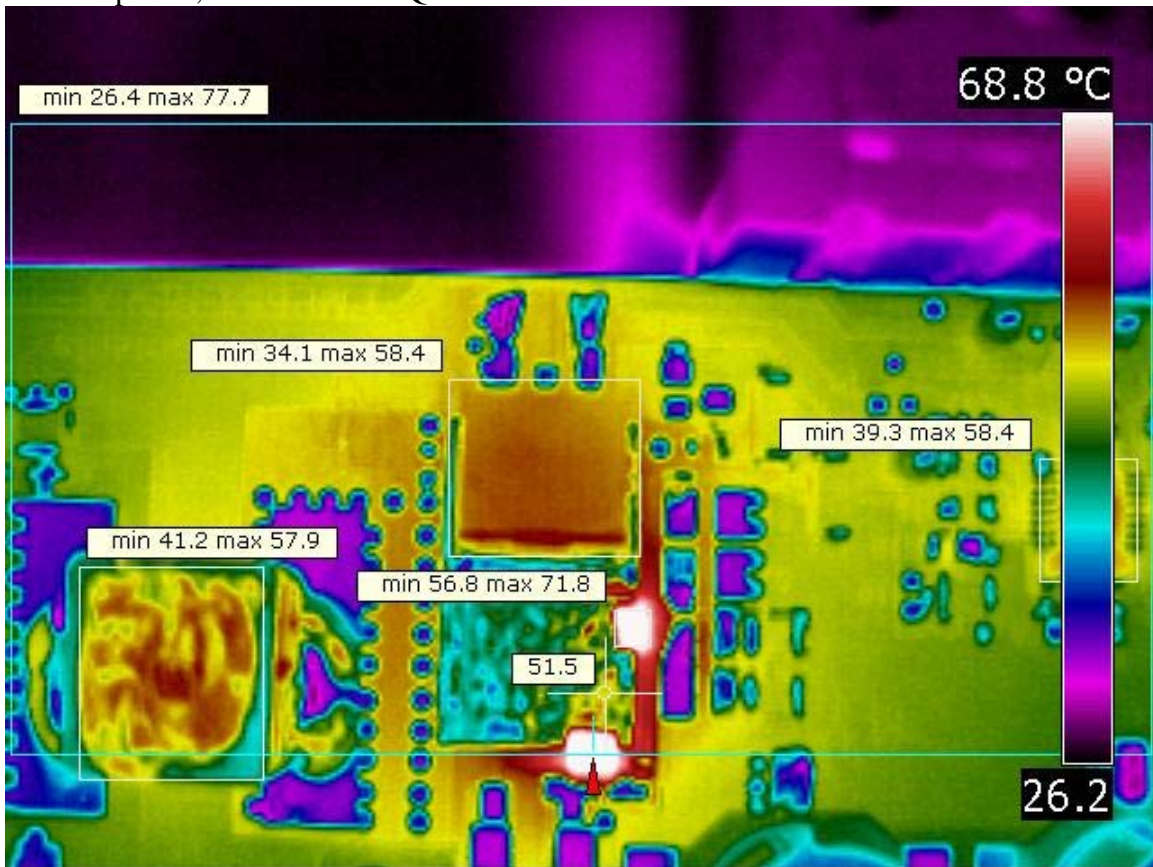
Qq

Next: a 4.7ohm resistor placed in series with hi side gate drive bias cap C10 to slow down turn on, but not turn off. Losses increased by about 50mW, but peak Vds on low side Q4 dropped from 60V to below 56V.

PMP5133 with 2xFDMC5614P 4.7Ohms C10, R5=2.2

48.01Vin 1.0915Ain 12.06Vout 4.0035Aout 4.12Watts on bd

ambient 23-25; Hot spot Q1 hi side 77.7, Q2 at 71.8, Lo side Q4 at 58.4, controller 58.4, choke top 57.9, Heat sink near Q1:51.5



Qq

The high temperatures on Q1 & Q2 are due to the less than ideal coupling of their thermal pads to the “heat sink” copper pad on the board. This pad was painted black along with the top of the choke, so the thermal camera could properly detect the surface temperature. There is a 26 degree drop from the Q1 hot spot to the pad location shown only about 3 mm from the part.

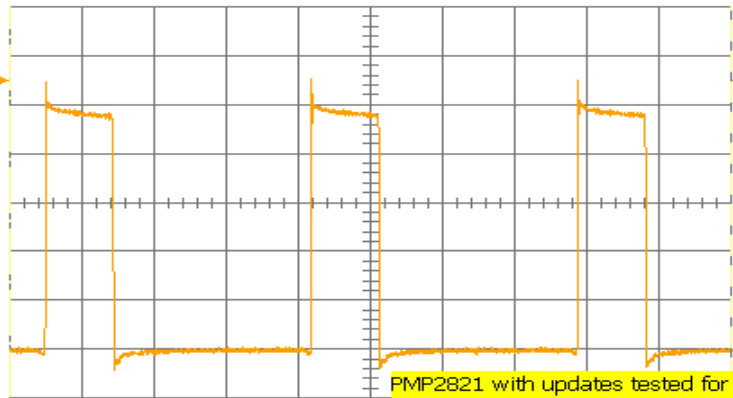
The thermal pad for the hi side FET(s) were designed for either one TO-220 SMD or two 5mm by 6mm power pad devices. With the smaller 3mm by 3mm parts that the FDMC5614Ps are, once the gate and source connections are made, very little thermal pad gets connected to the part. With a layout dedicated to 3x3 parts, much better heat sinking should be achieved.

Qq

Major waveform with 4.7ohms added to C10:

11-Sep-09
13:46:33

1 μ s
10.0 V



PMP2821 with updates tested for PMP5133
48.01Vin 1.0915Ain 12.06Vout 4.0035Aout 92.1% eff.
Hi side: 2x FDMC5614P R5=2.2; Lo side IRFZ44ES
controller TPS40061
4.7ohms added in series of hi side gate drive bias
C10 to slow turn on, but not turn off
Vds of lo side Q4 with 10x ripple probe right on part
Cprobe=9.5pF; both probe & scope 500MHz
max Vds=55V rating 60V
Hi side FET Q1 reaches 78 degrees Celsius
Loss reduction of 1.05W with 2x FDMC5614P vs. 2x
Si7465DP (slowing with 4.7ohms adds 50mW loss)

maximum(1) 55.3 V
Freq(1) 270.944 kHz
pkpk(1) 59.7 V
maximum(4) 1.4 mV
mean(4) -0.23 mV

1 μ s
1 V DC
2 .2 V DC
3 .5 V AC
4 10 mV 500

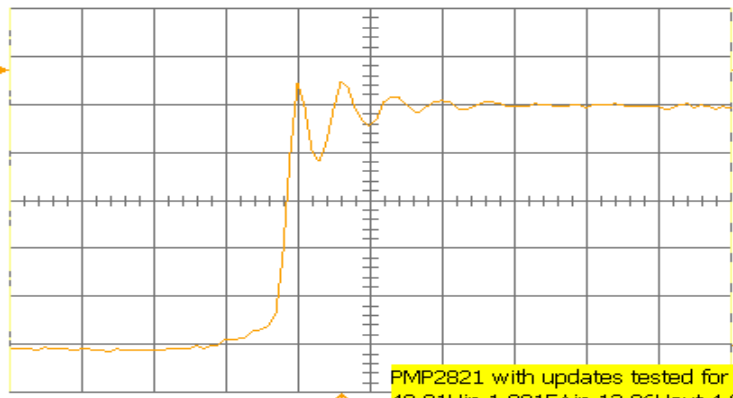
1 DC 55.0 V

Qq

Rise time detail:

11-Sep-09
13:50:05

10 ns
10.0 V



PMP2821 with updates tested for PMP5133
48.01Vin 1.0915Ain 12.06Vout 4.0035Aout 92.1% eff.
Hi side: 2x FDMC5614P R5=2.2; Lo side IRFZ44ES
controller TPS40061
4.7ohms added in series of hi side gate drive bias
cap C10 to slow turn on, but not turn off
Vds of lo side Q4 with 10x ripple probe right on part
Cprobe=9.5pF; both probe & scope 500MHz
Details of rise shown here: rise time about 4nsec
max Vds=55V rating 60V
max Vds was 60V before adding 4.7ohms

maximum(1) 54.7 V
Freq(1) - - -
pkpk(1) 55.9 V
maximum(4) 1.1 mV
mean(4) -0.39 mV

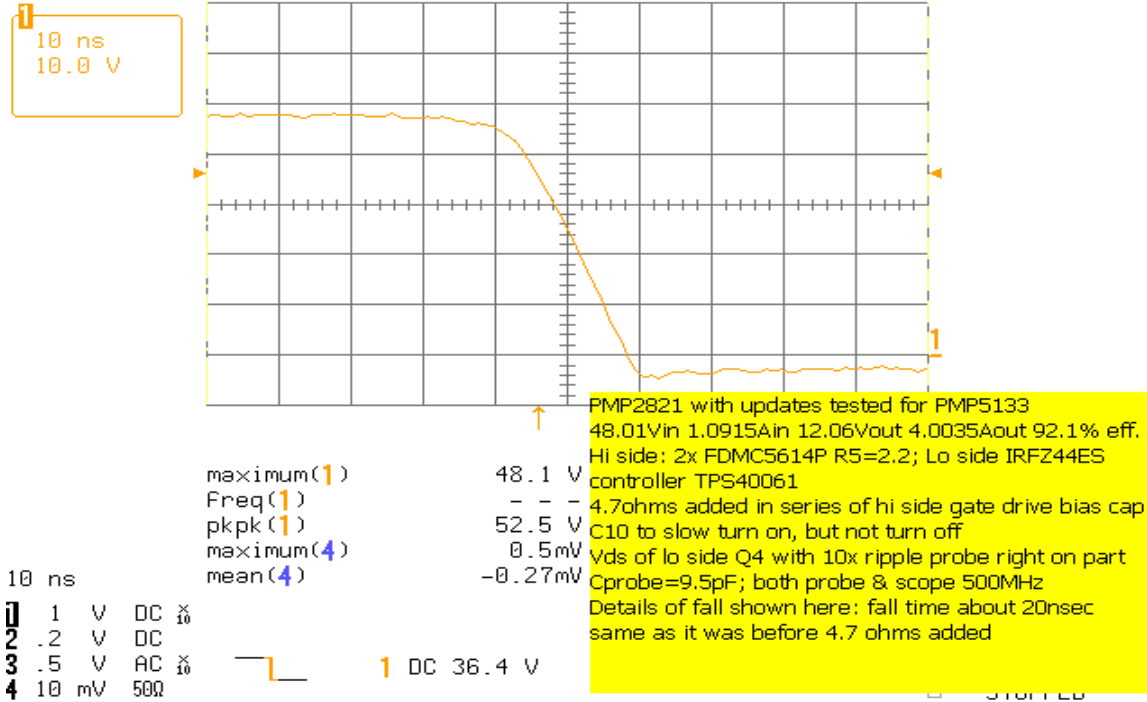
10 ns
1 V DC
2 .2 V DC
3 .5 V AC
4 10 mV 500

1 DC 57.4 V

Qq

Fall time detail:

11-Sep-09
13:48:45



General conclusion:

When switching losses are several times conduction losses as in the high side MOSFETs, you are overinvested in silicon!!! In this application as the high side MOSFETs the FDMC5614Ps have 50% more on resistance than the Si7465DPs, but still managed to reduce losses by over 1 Watt!

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