

## Table of Contents:

History / discussion	page 1
Efficiency / losses	page 2
Main waveforms	page 3
Output ripple	page 4
Start up	page 5
Bode plot	page 6
Model t2 testing: with 744775247 smaller than 744776247:	
Efficiency / losses 48Vin	page 7
Efficiency / losses 57Vin & 36Vin	page 8
Thermal image: 150ma load of 5.37Vout: 57vin	page 8
Major waveforms at 150mA and 100ma loads	page 9
Bode plots / output ripple	page 10

Models modified from TPS54061EVM-142. For details of PCB see SLUV721.

Model t1 was built and shipped to meet a specific application that had 50mA max load:

Customer requirement is 80% efficiency at load of 20-30mA off the 5.4V output at 48Vin. Both datasheet curves and early testing with EVM showed that lower switching frequency will help with efficiency. Based upon this the TPS54061 which can be set to 50kHz was chosen over the TPS54062 which can only be set to 100kHz.

The design approach shown in the TPS54061 datasheet from page 23 onwards was used. Operating frequency is 50kHz and conduction mode is discontinuous. This design was able to get 80% efficiency at 5V 25mA output off 36Vin.

See schematic at top of page 23 of TPS54061 datasheet:

To set Vout at 5.4V vs. 5.0V, Rhs was increased from 52.3k to 57.6k.

To improve efficiency at 48V input, I changed inductor value from 220uH to 470uH and increased Ruvlo1 / Ruvlo2 resistors to 2.21 Mohm / 100k from 255k / 45.3k.

Because of lab availability, I used Würth inductors of the 744776xxx series instead of 744053xxx shown for Lo main inductor. I found that at 48Vin and 27mA off 5.4V, the 470uH value gave the lowest input current. With 220uH input current was 0.06mA higher and with 680uH input current was 0.03mA higher. Selected inductor part number is Würth 744776247 with “471” marking on it. Hence, increasing inductance from 220uH to 470uH saved 3mW of input power.

The higher UVLO resistors reduce the power dissipation in them from 7.7mW to 1.0mW. For 80% efficiency at 5.4V 25mA output overall loss budget is 34mW. Hence, savings of a few mW is critical here.

Model t2 was tested for more general use with a smaller inductor Würth 744775247 (but same 470uH) and to 150mA max load at which conduction becomes continuous. A Bode plot with our Venable 3120 shows the loop remains stable even then. The smaller inductor measurably increased input losses for loads above 20mA to 3.8mW added loss at 50mA load. Schematic & BOM now represent model t2 which I am holding onto for customer support.

Efficiency at 48Vin: **model t1:**

Vin Volts	Iin mA	Vout Volts	Iout mA	% Effi ciency	Losses in mW
48.10	6.619	5.353	50.06	84.2	50.4
48.10	5.370	5.354	40.05	83.0	43.9
48.10	4.738	5.354	35.08	82.4	40.1
48.10	4.098	5.353	29.98	81.4	36.6
48.105	3.747	5.3535	27.135	80.6	35.0
48.11	3.479	5.3535	25.00	80.0	33.5
48.11	2.857	5.354	20.00	77.9	30.4
48.11	2.234	5.353	15.01	74.8	27.1
48.11	1.609	5.353	10.00	69.2	23.9
48.11	0.987	5.353	5.00	56.4	20.7
48.11	0.615	5.353	2.00	36.2	18.9
48.11	0.176	5.353	0	0.0	8.5
48.11	0.034	off			

pulse skipping at about 0.9mA output and lower

## Efficiency at 36, 42, 54Vin:

Vin Volts	Iin mA	Vout Volts	Iout mA	% Effi ciency	Losses in mW
35.99	8.628	5.353	50.065	86.3	42.5
42.03	7.480	5.353	50.065	85.2	46.4
54.08	5.964	5.353	50.065	83.1	54.5
36.00	4.471	5.353	25.00	83.1	27.1
42.06	3.903	5.353	25.00	81.5	30.3
54.06	3.156	5.353	25.00	78.4	36.8
36.00	1.993	5.3535	10.00	74.6	18.2
42.02	1.773	5.3535	10.00	71.9	21.0
54.09	1.485	5.3535	10.00	66.6	26.8
36.00	0.183	5.353	0	0.0	6.6
42.11	0.179	5.354	0	0.0	7.5
54.03	0.177	5.354	0	0.0	9.6
36.04	0.026	off			
42.11	0.030	off			
54.03	0.035	off			

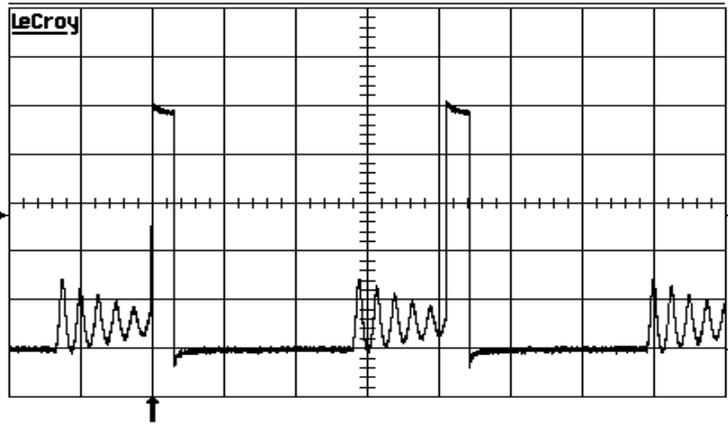
Qq

**model t1 (cont.)**

Major waveform: PH node out of TPS54061; 48V<sub>in</sub> and 50mA load of 5.35V<sub>out</sub>:

7-Jan-14 Reading Floppy Disk Drive  
16:41:40

5  $\mu$ s  
10.0 V



maximum(1) 51.3 V  
minimum(1) -4.1 V  
Freq(1) 48.5209 kHz  
Fall(1) 14.1 ns  
rise(1) 241.1 ns

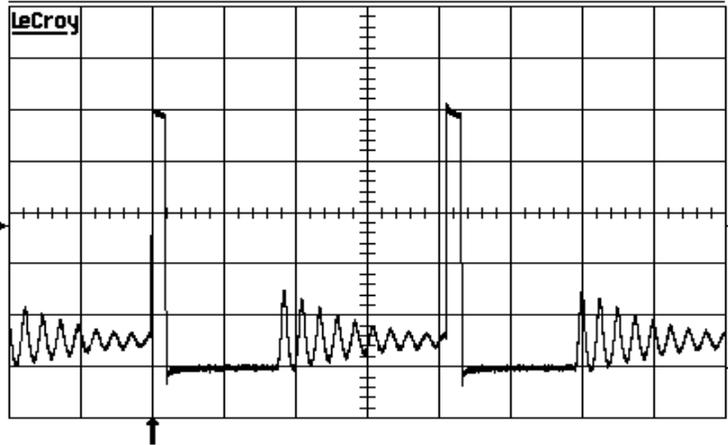
5  $\mu$ s  
 1 1 V DC  $\times$   
 2 50 mV DC  $\times$   
 3 50 mV DC  
 4 .2 V DC  
 1 DC 27.6 V  
 1 GS/s  
 STOPPED

**Qq**

Same, but load off 5.35V<sub>out</sub> at 20mA:

7-Jan-14  
16:53:38

5  $\mu$ s  
10.0 V



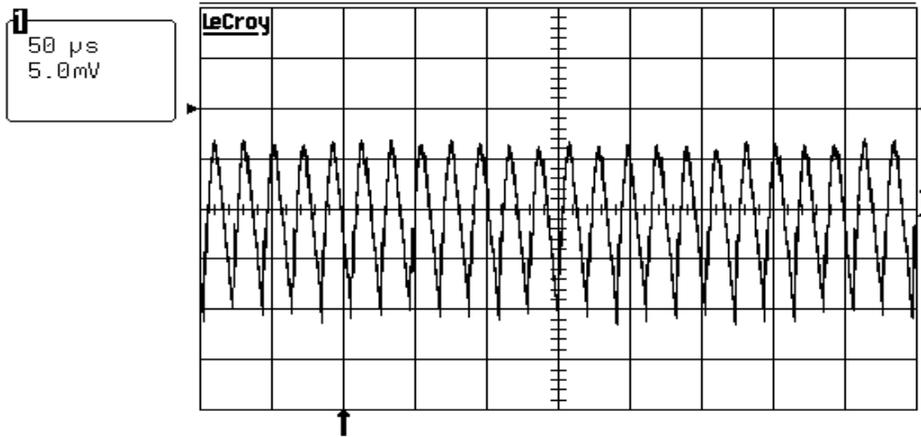
maximum(1) 51.3 V  
minimum(1) -3.8 V  
Freq(1) 48.5150 kHz  
Fall(1) 23.4 ns  
rise(1) 483.0 ns

5  $\mu$ s  
 1 1 V DC  $\times$   
 2 50 mV DC  $\times$   
 3 50 mV DC  
 4 .2 V DC  
 1 DC 27.6 V  
 1 GS/s  
 STOPPED

**Qq**

**model t1 (cont.)** Output ripple: 48Vin 5.35Vout 25mA load at output cap C7 (22uF)  
 Overall ripple <20mV p-p

7-Jan-14  
 17:08:05



maximum(1) 7.53mV  
 minimum(1) -11.06mV  
 Freq(1) 48.5798 kHz  
 Fall(1) 9.2365 μs  
 rise(1) 4.7658 μs

50 μs

- 1 5 mV AC
- 2 50 mV DC  $i_o$
- 3 50 mV DC
- 4 .2 V DC

1 DC 10.6mV

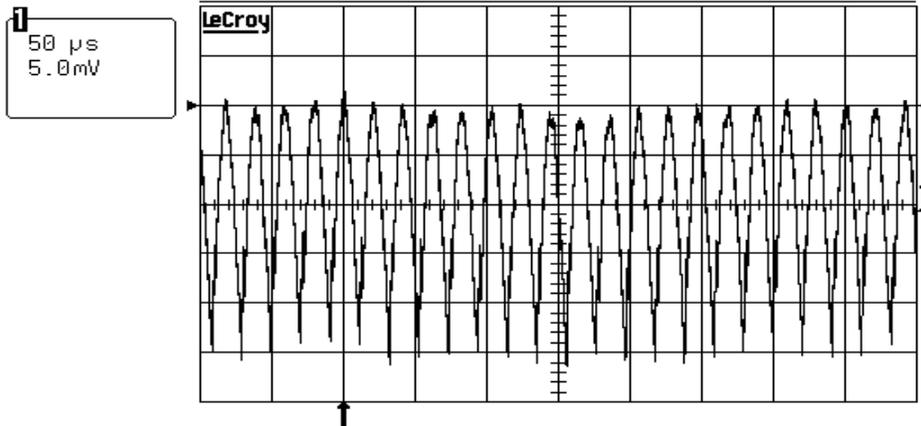
200 MS/s

STOPPED

Qq

Same, but load at 50mA: Overall ripple >30mV p-p

7-Jan-14  
 17:06:38



maximum(1) 12.22mV  
 minimum(1) -15.91mV  
 Freq(1) 48.4765 kHz  
 Fall(1) 8.1904 μs  
 rise(1) 5.9739 μs

50 μs

- 1 5 mV AC
- 2 50 mV DC  $i_o$
- 3 50 mV DC
- 4 .2 V DC

1 DC 10.6mV

200 MS/s

STOPPED

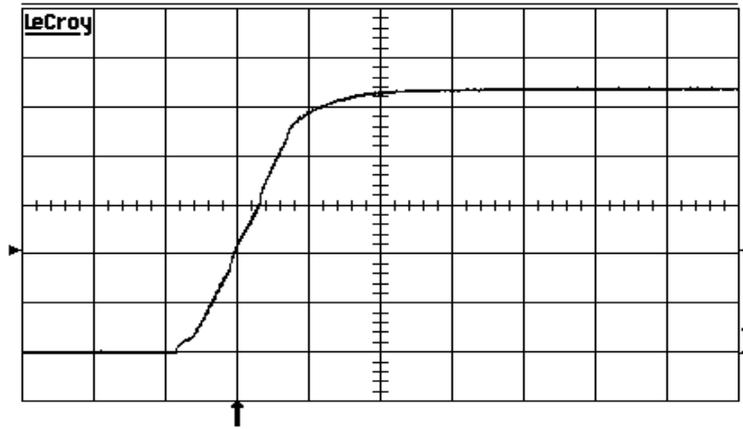
Qq

**model t1 (cont.)**

Start up when Enable jumper removed: 48Vin and 25mA load off 5.35Vout:

7-Jan-14  
17:13:30

10 ms  
1.00 V



maximum(1) 5.41 V  
minimum(1) -0.03 V  
Freq(1) - - -  
Fall(1) - - -  
rise(1) 13.9588 ms

10 ms BWL  
1 1 V DC  
2 50 mV DC  $\times$   
3 50 mV DC  
4 .2 V DC



1 DC 2.12 V

1 MS/s

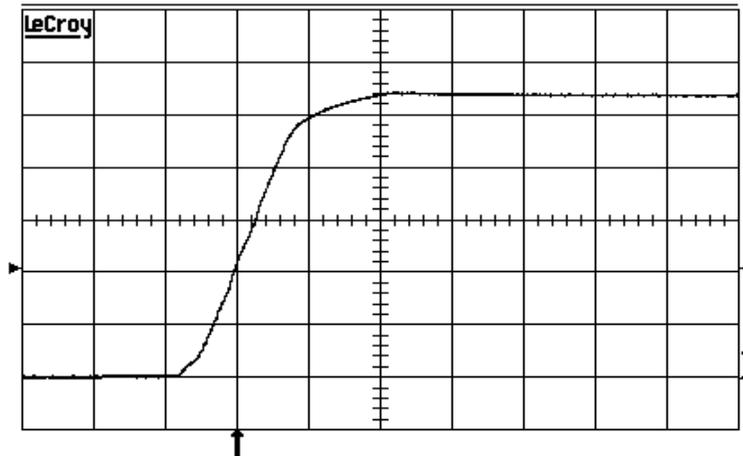
STOPPED

**Qq**

Same, but with no load off 5.35Vout:

7-Jan-14  
17:14:18

10 ms  
1.00 V



maximum(1) 5.44 V  
minimum(1) -0.03 V  
Freq(1) - - -  
Fall(1) - - -  
rise(1) 13.4218 ms

10 ms BWL  
1 1 V DC  
2 50 mV DC  $\times$   
3 50 mV DC  
4 .2 V DC



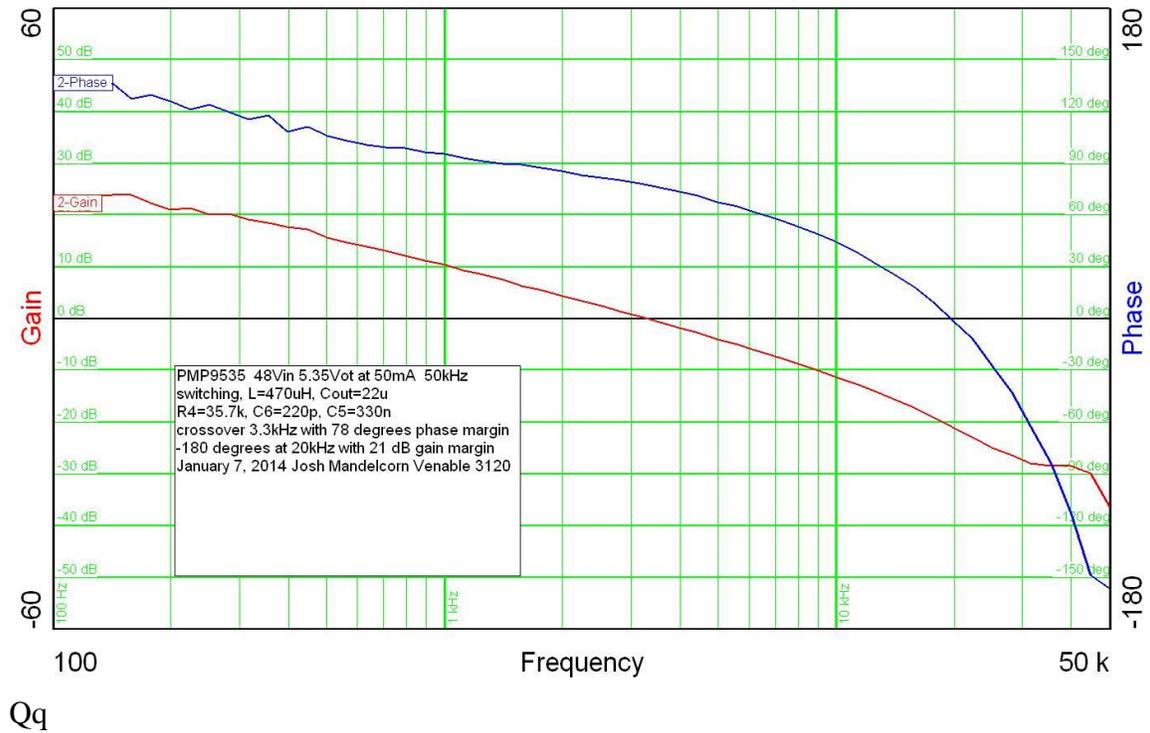
1 DC 2.12 V

1 MS/s

STOPPED

**Qq**

Bode plot of main control loop: model t1



**Model t2** with Würth 744775247:

This will be tested to 100mA, near max of discontinuous mode range

Efficiency at 48Vin: range 36-57V

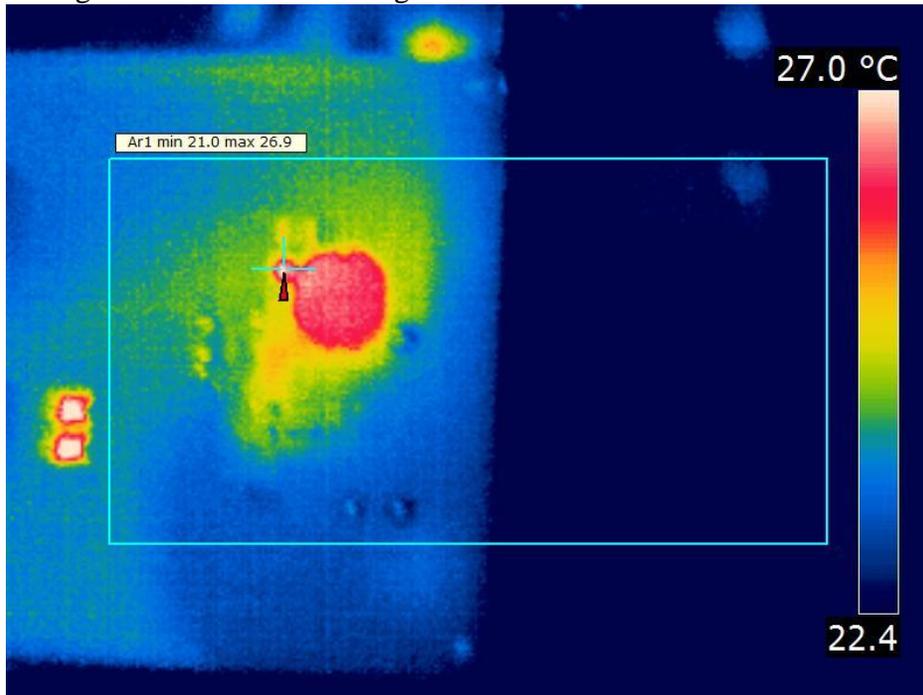
Vin Volts	Iin mA	Vout Volts	Iout mA	% Effi ciency	Losses in mW
48.01	19.561	5.369	150.37	86.0	131.8
48.02	16.434	5.369	125.85	85.6	113.5
48.03	13.170	5.369	100.11	85.0	95.1
48.03	11.906	5.369	90.19	84.7	87.6
48.03	10.533	5.369	79.53	84.4	78.9
48.03	9.341	5.369	70.27	84.1	71.4
48.04	8.020	5.369	60.07	83.7	62.8
48.04	6.745	5.369	50.25	83.3	54.2
48.04	5.418	5.369	39.90	82.3	46.1
48.045	4.152	5.370	30.05	80.9	38.1
48.045	3.506	5.370	24.97	79.6	34.4
48.05	2.874	5.370	20.00	77.8	30.7
48.05	2.241	5.370	15.006	74.8	27.1
48.05	1.605	5.370	9.990	69.6	23.5
48.05	0.982	5.370	4.997	56.9	20.4
48.05	0.603	5.370	2.000	37.1	18.2
48.05	0.174	5.370	0	N/A	8.4
48.05	0.032	off			

q

Efficiency & Losses at 57Vin and 36Vin **Model t2**

Vin Volts	Iin mA	Vout Volts	Iout mA	% Efficiency	Losses in mW
57.07	16.597	5.369	150.37	85.2	139.9
57.005	13.979	5.369	125.85	84.8	121.2
57.00	11.203	5.369	100.08	84.1	101.2
57.01	8.981	5.369	79.51	83.4	85.1
57.01	6.854	5.369	60.07	82.5	68.2
57.015	4.661	5.369	39.89	80.6	51.6
57.02	2.503	5.369	20.00	75.2	35.3
57.02	1.433	5.369	10.012	65.8	28.0
57.025	0.579	5.369	2.000	32.5	22.3
57.03	0.174	5.370	0	0.0	9.9
57.05	0.038		off		
36.00	25.80	5.369	150.46	87.0	121.0
36.00	21.61	5.369	125.85	86.9	102.3
36.055	17.252	5.369	100.02	86.3	85.0
36.06	13.775	5.369	79.515	85.9	69.8
36.07	10.467	5.369	60.07	85.4	55.0
36.08	7.018	5.369	39.89	84.6	39.0
36.08	3.661	5.369	20.00	81.3	24.7
36.085	1.993	5.369	10.011	74.7	18.2
36.02	0.672	5.369	2.001	44.4	13.5
36.00	0.180	5.370	0	0.0	6.5
36.00	0.027		off		

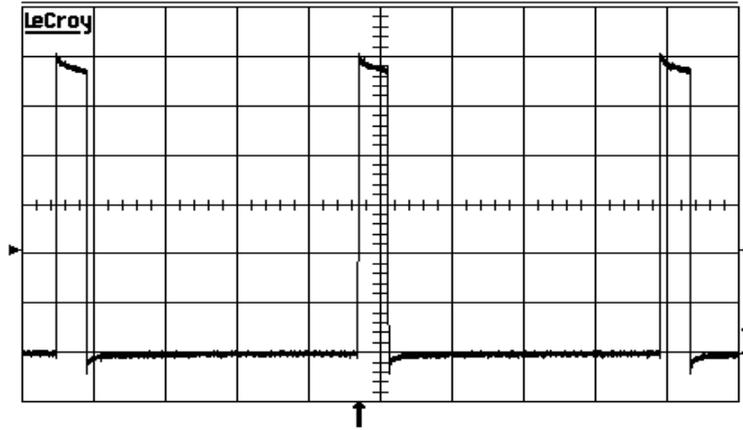
Thermal at 57Vin and 100ma & 150mA load: only main inductor showing any heating at 27 degrees C. Ambient ~22 degrees C. **model t2**



Major waveforms on **model t2**: 57Vin with 150mA off 5.37Vout:

8-Jan-14  
20:00:08

5  $\mu$ s  
10.0 V



minimum(1) -4.4 V  
maximum(1) 60.6 V  
Freq(1) 47.4362 kHz  
rise(1) 12.3 ns  
Fall(1) 8.5 ns

5  $\mu$ s

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

1 DC 21.2 V

1 GS/s

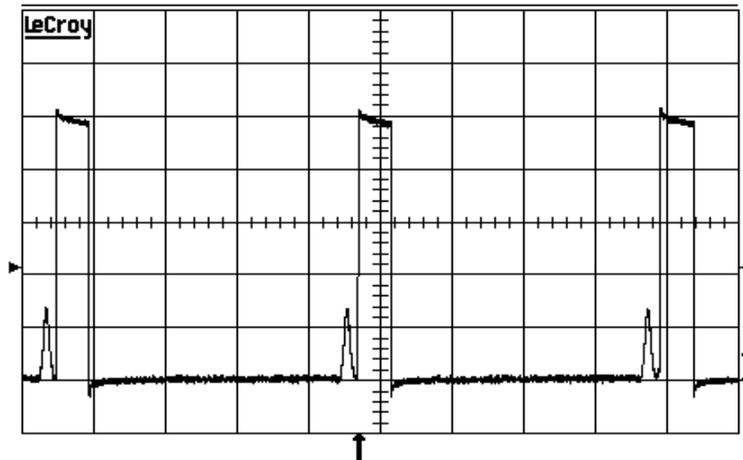
STOPPED

Q

Same, but load only 100mA off 5.37Vout:

8-Jan-14  
17:47:26

5  $\mu$ s  
10.0 V



minimum(1) -3.6 V  
maximum(1) 51.1 V  
Freq(1) 47.4429 kHz  
rise(1) 11.9 ns  
Fall(1) 9.4 ns

5  $\mu$ s

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

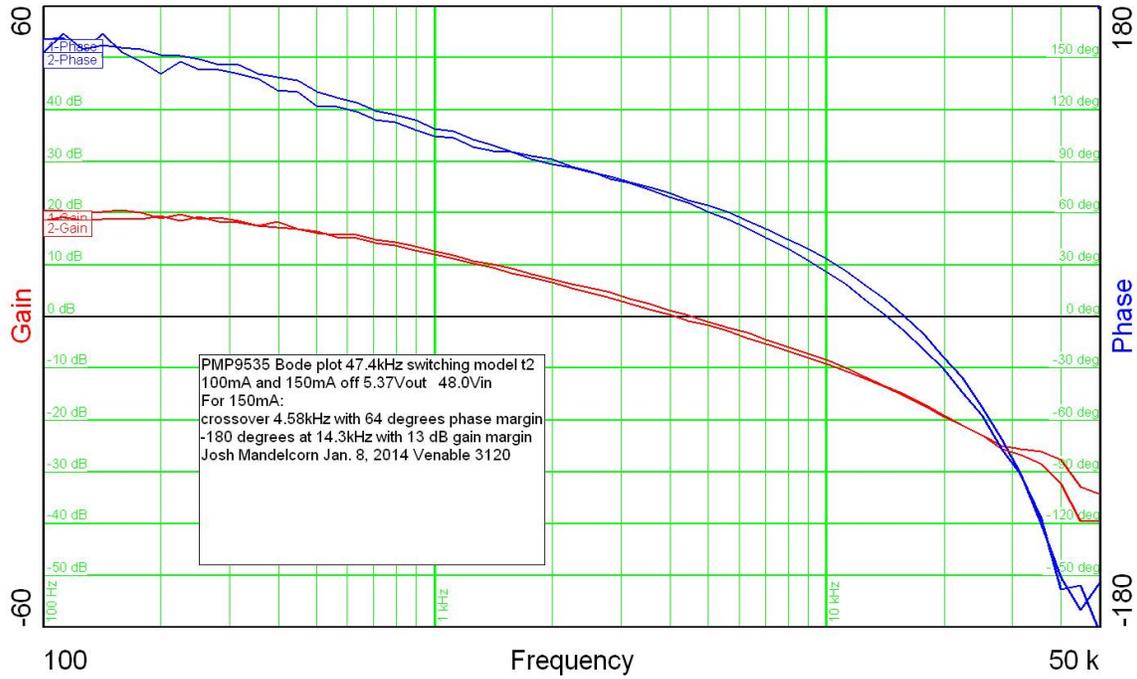
1 DC 21.2 V

1 GS/s

STOPPED

Conduction becomes continuous between 100 and 150mA load:

Bode plot: 48Vin 5.37Vout on **model t2** Loads of 100mA and 150mA shown:

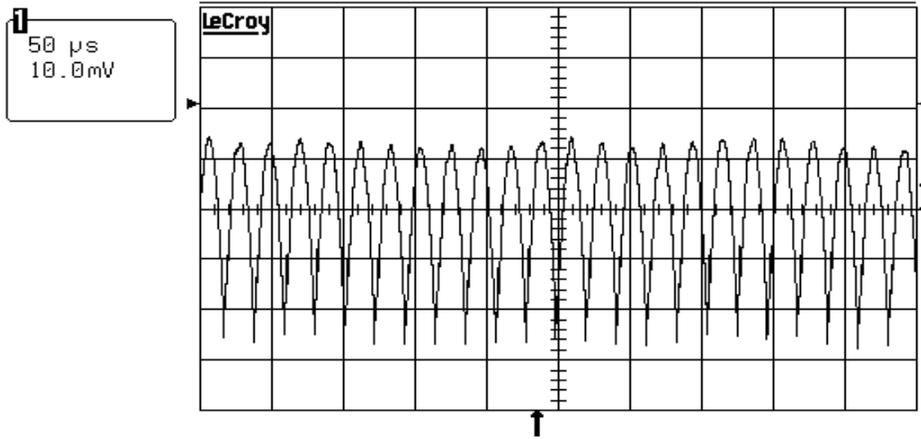


Transition to continuous mode does not affect Bode plot much!

**model t2: cont.**

Ripple Out at 150mA off 57Vin: Here 42mV p-p At 100mA ripple was 41mV p-p

8-Jan-14  
 19:55:53



50 μs	BWL	1	DC	21.2mV	200 MS/s
1	10 mV	AC			
2	1 V	DC	$i_o$		
3	50 mV	DC			
4	.2 V	DC			

minimum(1)	-27.8mV
maximum(1)	14.4mV
Freq(1)	47.4666 kHz
rise(1)	7.3774 μs
Fall(1)	6.4058 μs

Qq

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