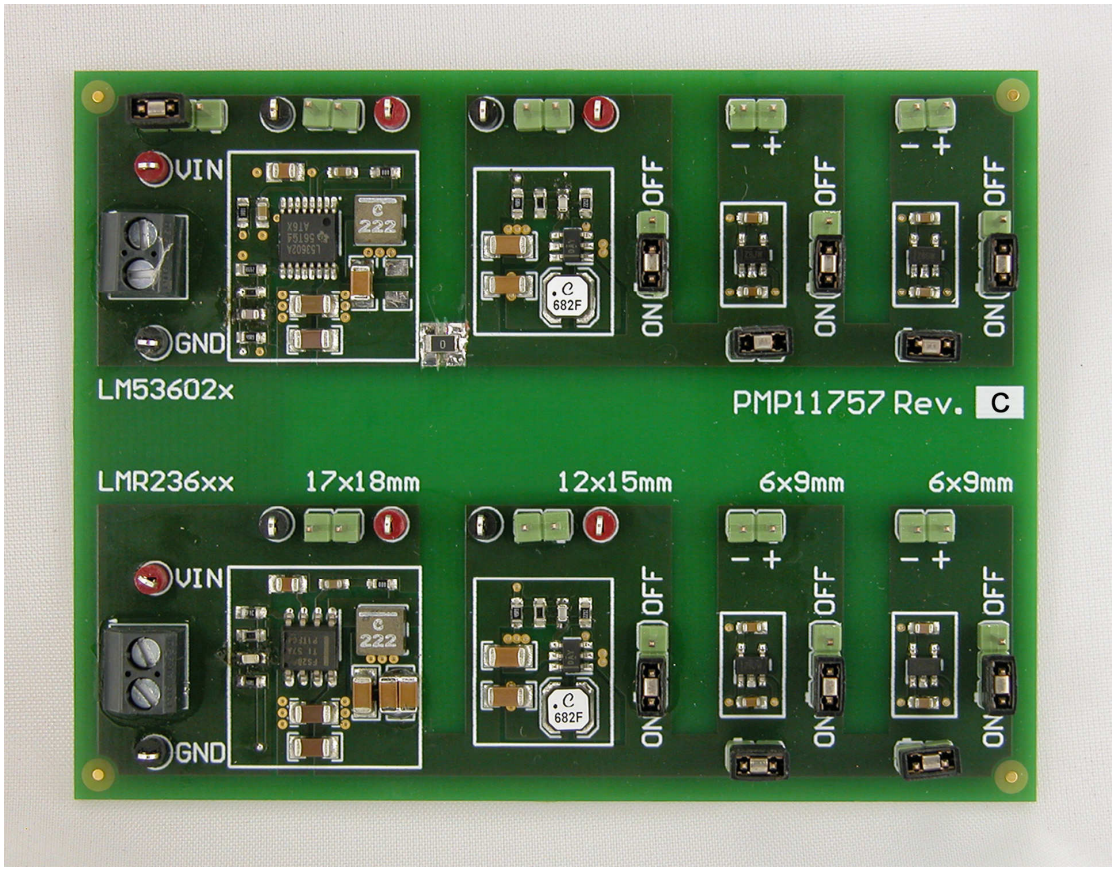
Automotive Point-of-Load Solution

- Input 6..28V DC
- Outputs

	LM53602A-Q1/LM536023-Q1	3.3V @ 1.6A
	LMR23625C-Q1	3.3V @ 1.6A
	TPS61071-Q1	5.0V @ 250mA
	TLV71325-Q1	2.5V @ 140mA
	TLV71310-Q1	1.0V @ 110mA

- Built on PCB PMP11757 Rev. B



1 +3.3V Buck Converter – LM53602A (Adjustable)

All measurements were done with C14 = 10pF and 2x 22uF output capacitance unless otherwise described.

1.1 Switching Node

The switching node is shown in Figure 1.
The input voltage is set to 12.0V with a 1.6A load.

Channel C2: **Switching node**, -1.0V min, 18.7V max
5V/div, 200ns/div

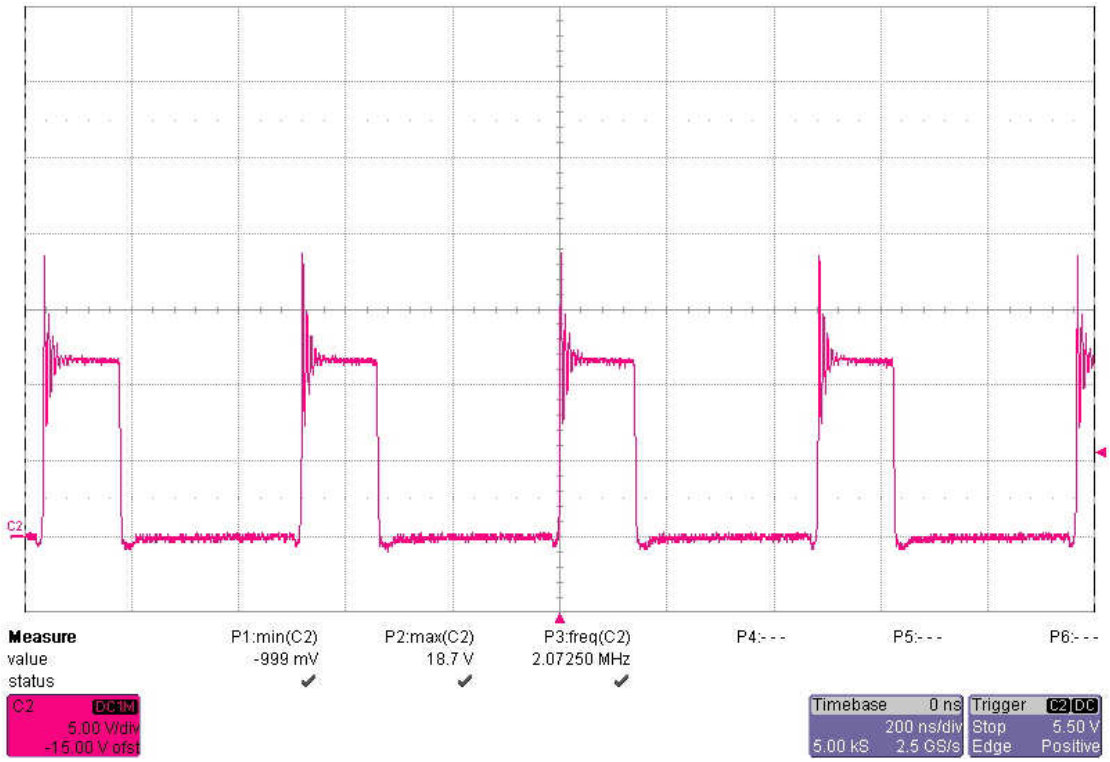


Figure 1

1.2 Transient Response with C14 = 10pF and 2x 22uF output capacitance

The response to a load step at 12.0V input voltage is shown in Figure 2.

Channel C2: **Output voltage**, -48mV undershoot (1.5%), 50mV overshoot (1.5%)
50mV/div, 1ms/div, AC coupled

Channel C1: **Load current**, load step 0.8A to 1.6A and vice versa
1A/div, 1ms/div

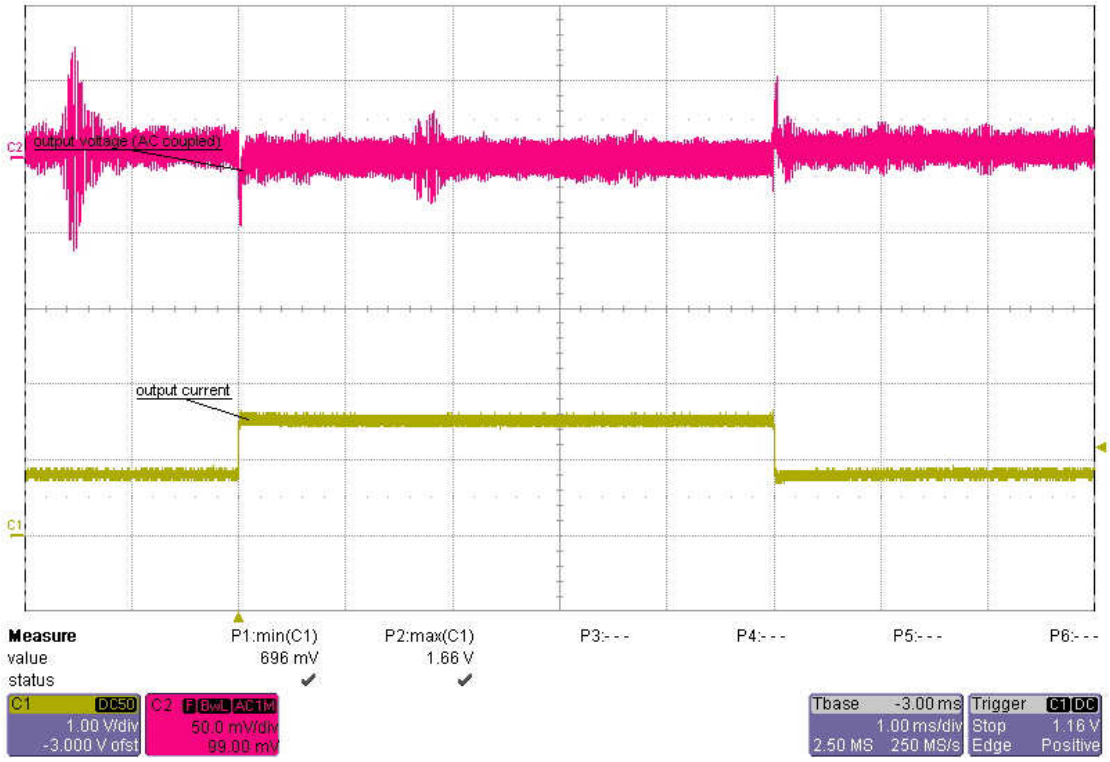


Figure 2

1.3 Transient Response with C14 = 33pF and 3x 22uF output capacitance

The response to a load step at 12.0V input voltage is shown in Figure 3.

Channel C2: **Output voltage**, -40mV undershoot (1.2%), 45mV overshoot (1.4%)
50mV/div, 1ms/div, AC coupled

Channel C1: **Load current**, load step 0.8A to 1.6A and vice versa
1A/div, 1ms/div

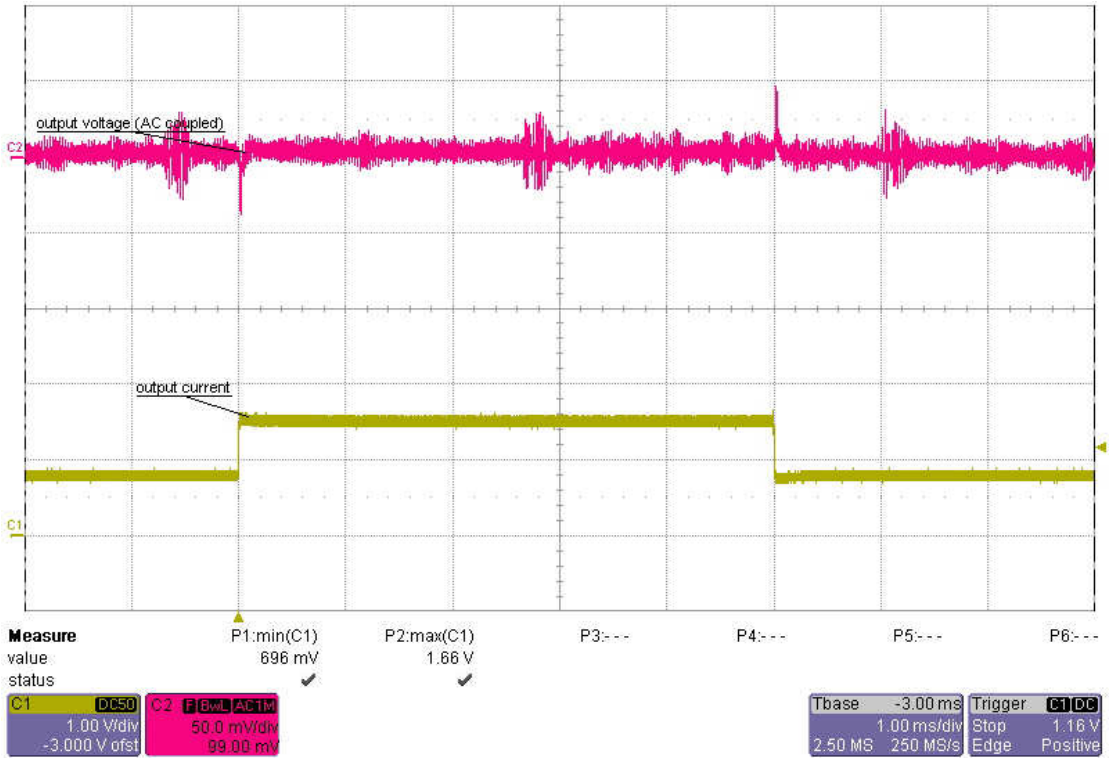


Figure 3

1.4 Frequency Response with C14 = 10pF and 2x 22uF output capacitance

Figure 4 shows the loop response at a load of 1.6A.

6.0V input

- 64 deg phase margin @ crossover frequency of 149 kHz
- -19 db gain margin

12.0V input

- 64 deg phase margin @ crossover frequency of 148 kHz
- -19 db gain margin

28.0V input

- 61 deg phase margin @ crossover frequency of 138 kHz
- -12 dB gain margin

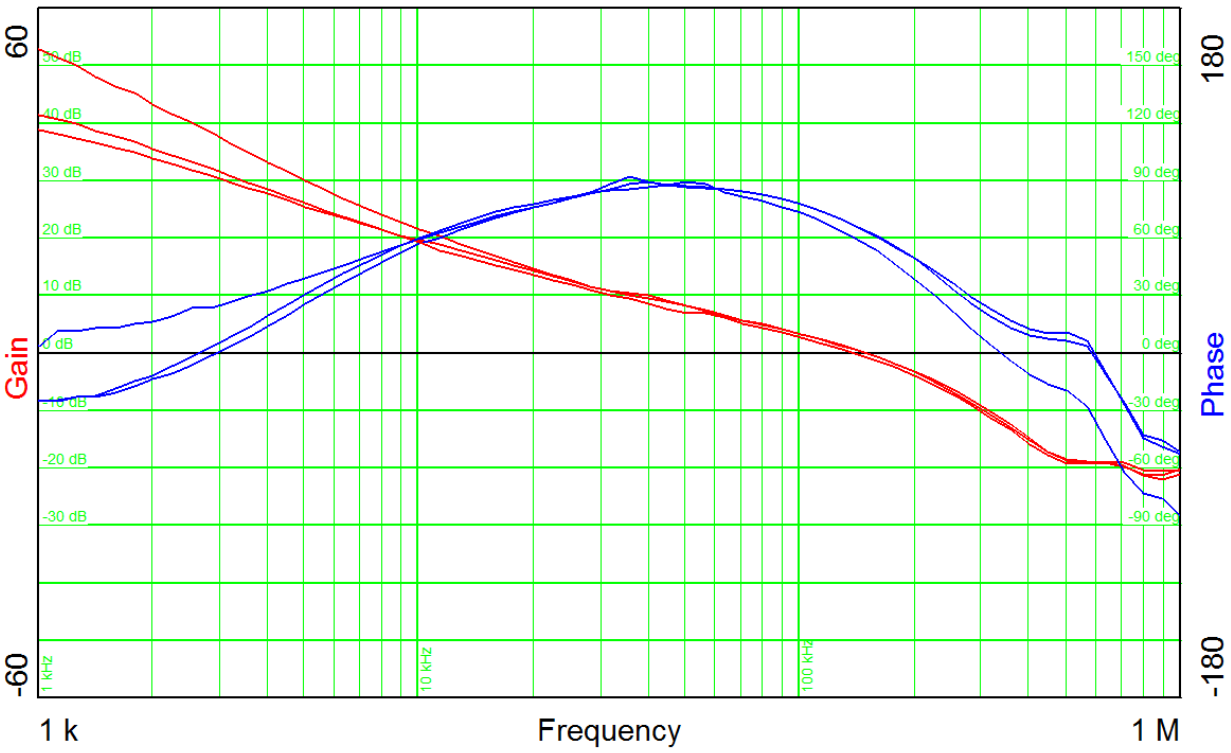


Figure 4

1.5 Frequency Response with C14 = 33pF and 3x 22uF output capacitance

Figure 5 shows the loop response at a load of 1.6A.

6.0V input

- 60 deg phase margin @ crossover frequency of 152 kHz
- -24 db gain margin

12.0V input

- 60 deg phase margin @ crossover frequency of 153 kHz
- -23 db gain margin

28.0V input

- 57 deg phase margin @ crossover frequency of 143 kHz
- -13 dB gain margin

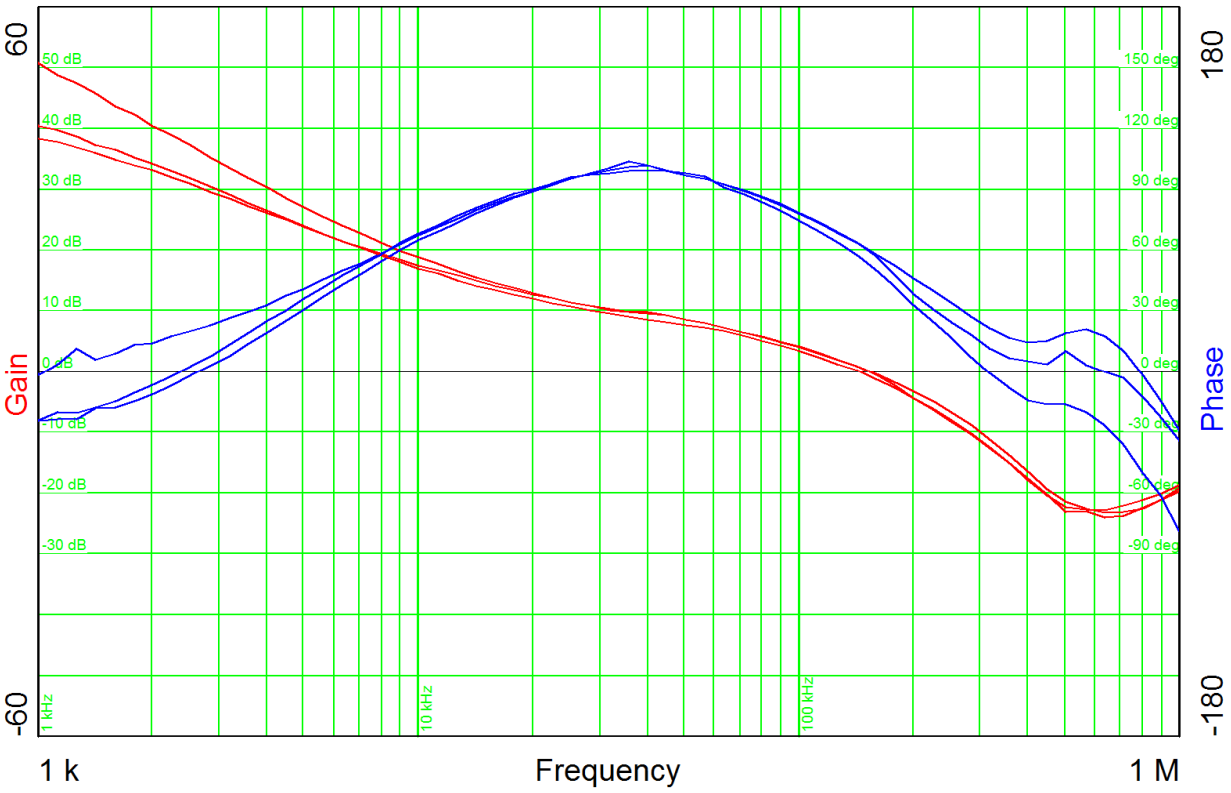


Figure 5

1.6 Efficiency

The efficiency and losses at 6.0V, 12.0V and 28.0V input voltage are shown in Figure 6 and Figure 7.

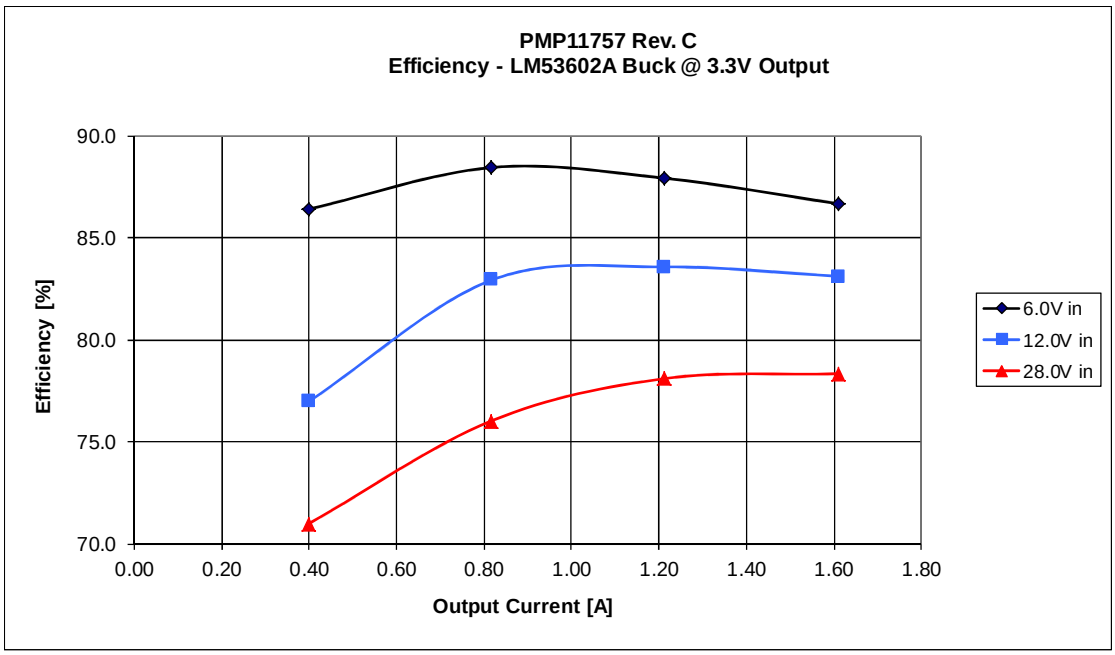


Figure 6

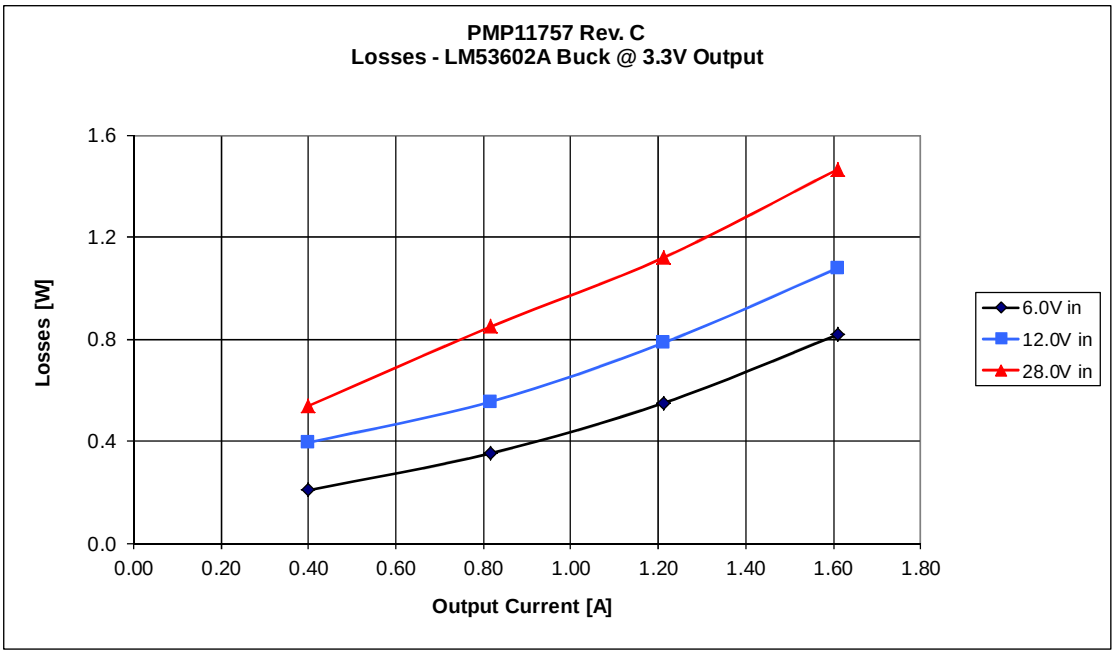


Figure 7

1.7 Load Regulation

The load regulation is shown in Figure 8.

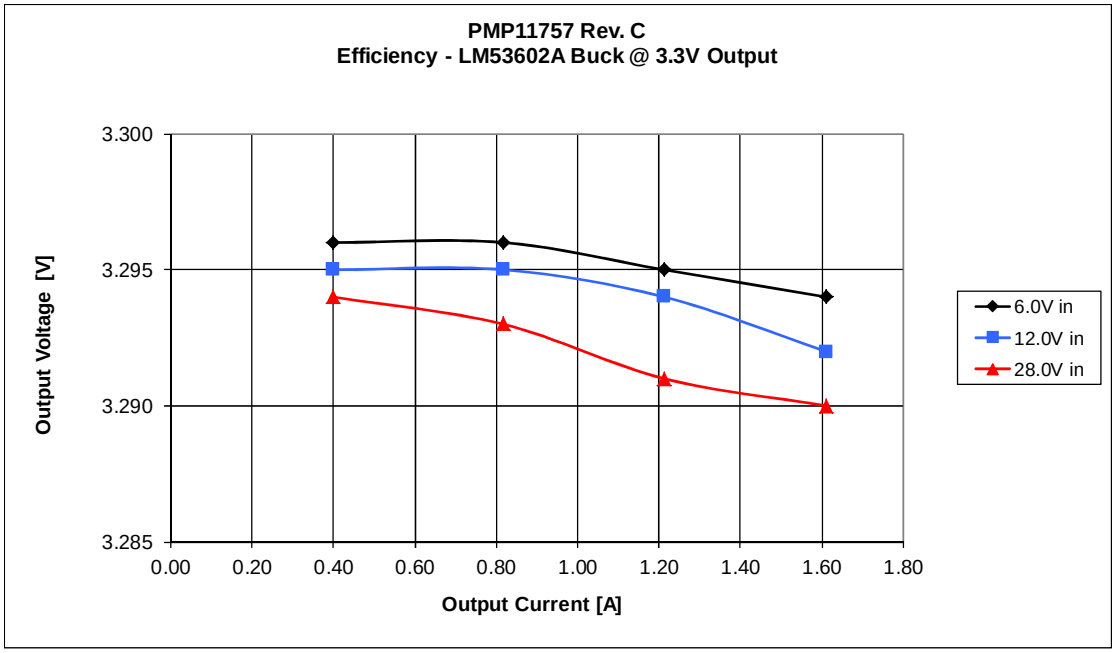


Figure 8

1.8 Output Voltage Ripple

The output ripple at 1.6A load is shown in Figure 9.
The input voltage is set to 6.0V, 12.0V and 28.0V.

Channel C2: **6.0V input voltage**, 74mV peak-peak (Spikes!)
50mV/div, 200ns/div

Channel C2: **12.0V input voltage**, 85mV peak-peak (Spikes!)
50mV/div, 200ns/div

Channel C2: **28.0V input voltage**, 61mV peak-peak (Spikes!)
50mV/div, 200ns/div

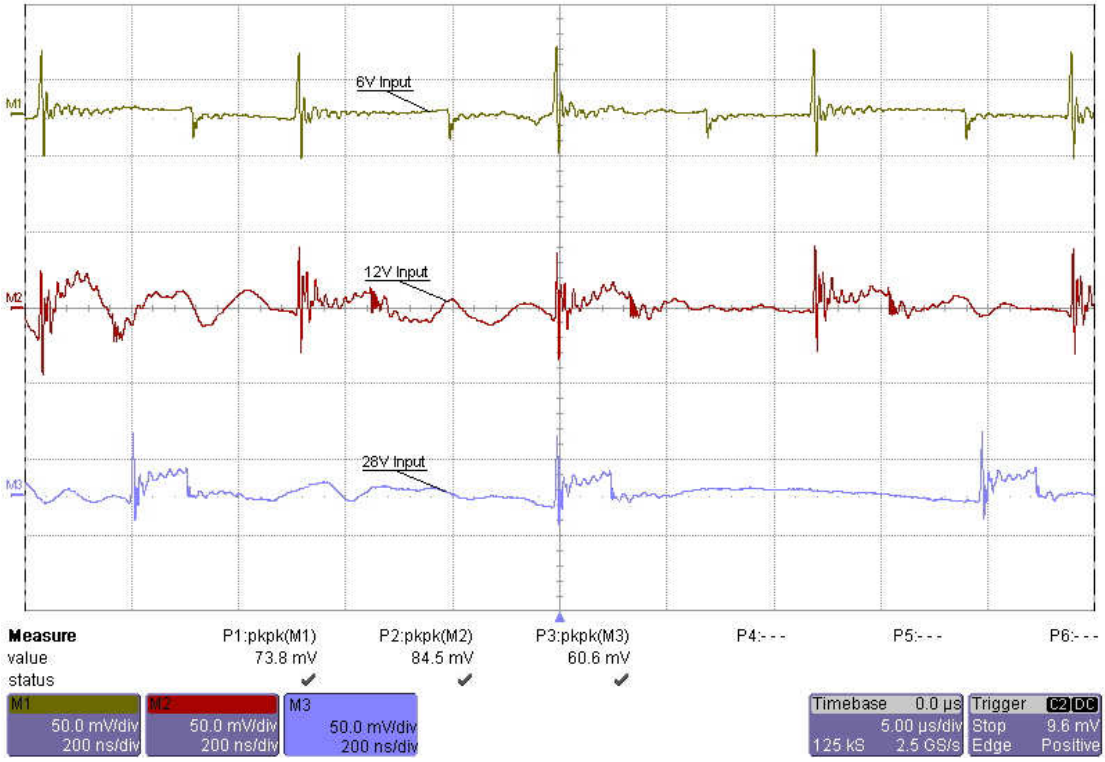


Figure 9

1.9 Startup

The startup at no load on the output is shown in Figure 10.

Channel C1: **12.0V Input voltage**
2V/div, 500us/div

Channel C2: **3.3V Output voltage**
1V/div, 500us/div

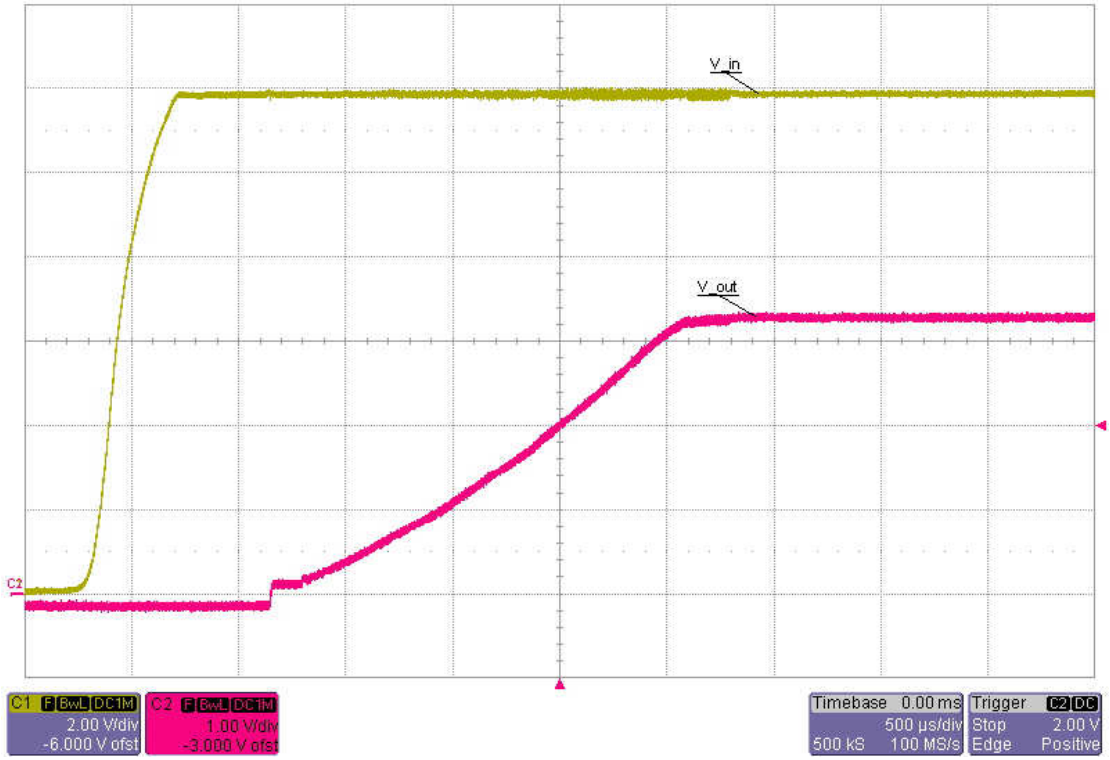


Figure 10

1.10 Shutdown

The shutdown at 1.6A load on the output is shown in Figure 11.

Channel C1: **12.0V Input voltage**
2V/div, 500us/div

Channel C2: **3.3V Output voltage**
1V/div, 500us/div

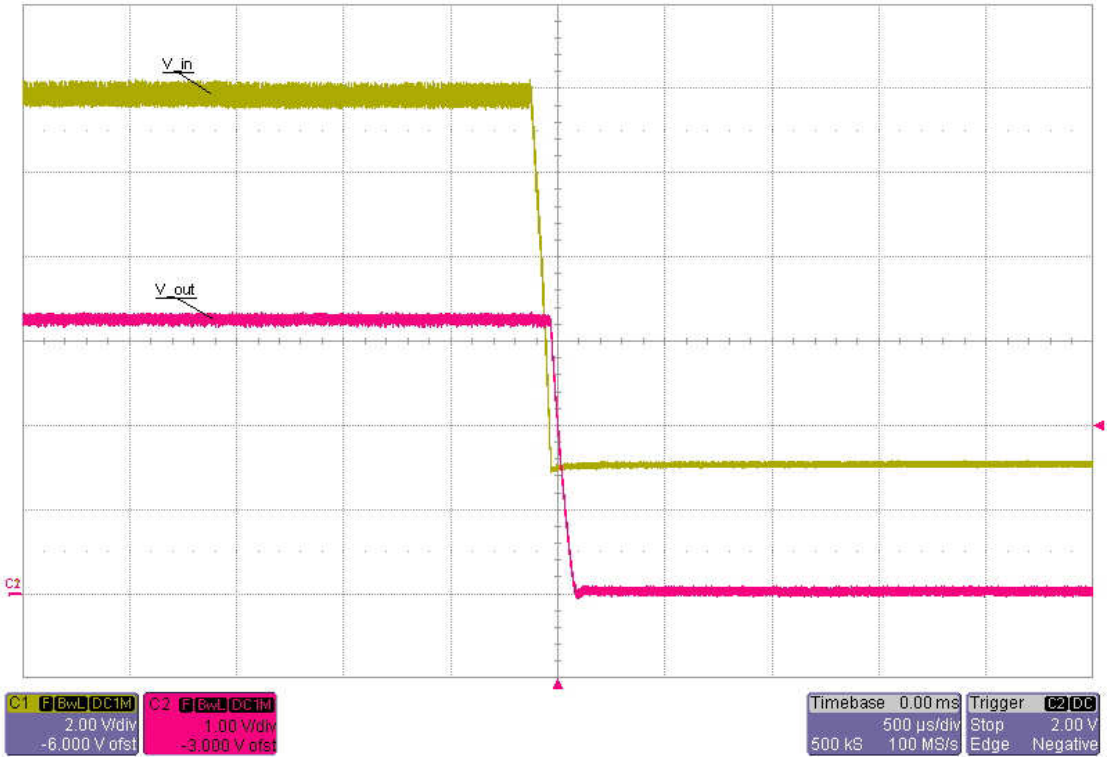


Figure 11

2 +3.3V Buck Converter – LM536023 (3.3V Fixed)

The transient and frequency response of this device is different, all other measurements (switching node, efficiency etc.) are the same as for LM53602A.

2.1 Transient Response with 2x 22uF output capacitance

The response to a load step at 12.0V input voltage is shown in Figure 12.

Channel C2: **Output voltage**, -38mV undershoot (1.2%), 37mV overshoot (1.1%)
50mV/div, 1ms/div, AC coupled

Channel C1: **Load current**, load step 0.8A to 1.6A and vice versa
1A/div, 1ms/div

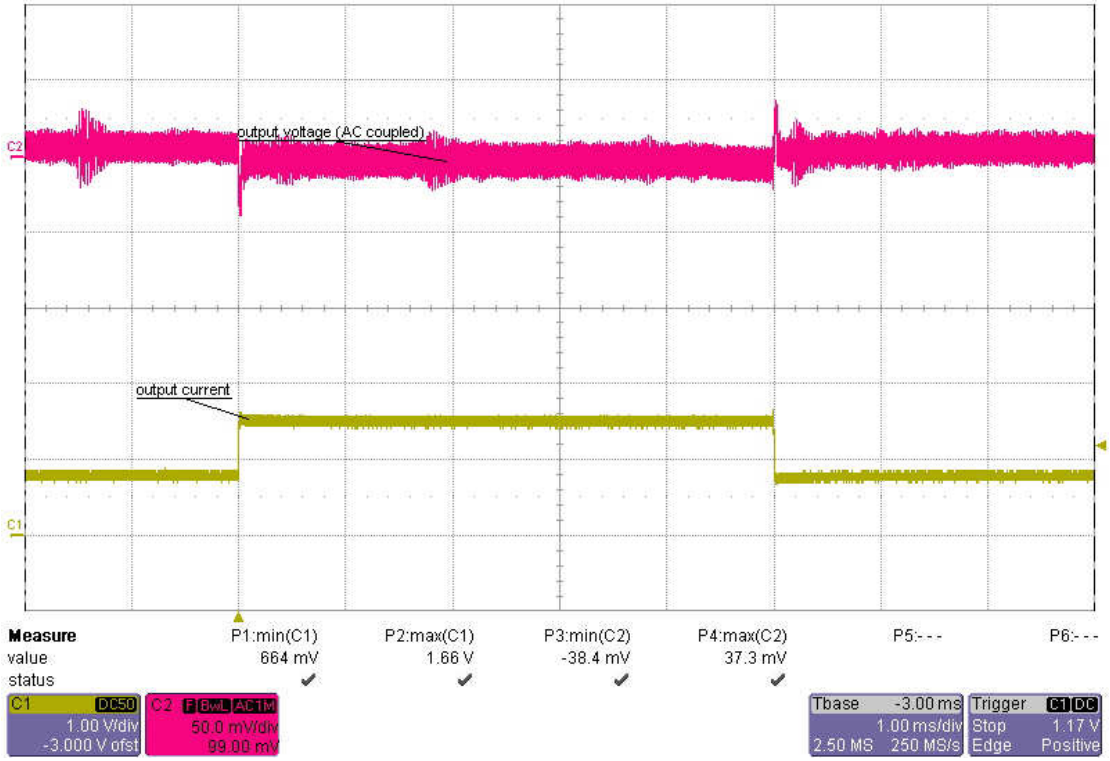


Figure 12

2.2 Transient Response with 3x 22uF output capacitance

The response to a load step at 12.0V input voltage is shown in Figure 3.

Channel C2: **Output voltage**, -39mV undershoot (1.2%), 40mV overshoot (1.2%)
50mV/div, 1ms/div, AC coupled

Channel C1: **Load current**, load step 0.8A to 1.6A and vice versa
1A/div, 1ms/div

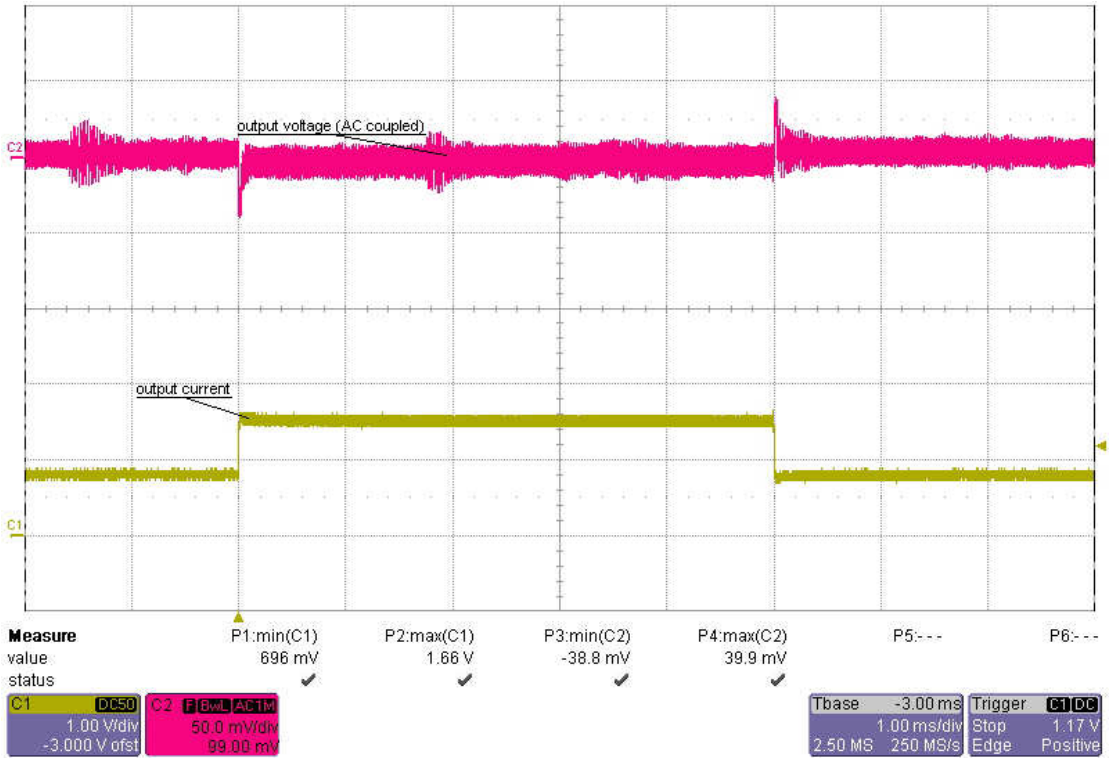


Figure 13

2.3 Frequency Response with 2x 22uF output capacitance

Figure 14 shows the loop response at a load of 1.6A.

6.0V input

- 59 deg phase margin @ crossover frequency of 91 kHz
- -19 db gain margin

12.0V input

- 58 deg phase margin @ crossover frequency of 92 kHz
- -19 db gain margin

28.0V input

- 55 deg phase margin @ crossover frequency of 87 kHz
- -15 dB gain margin

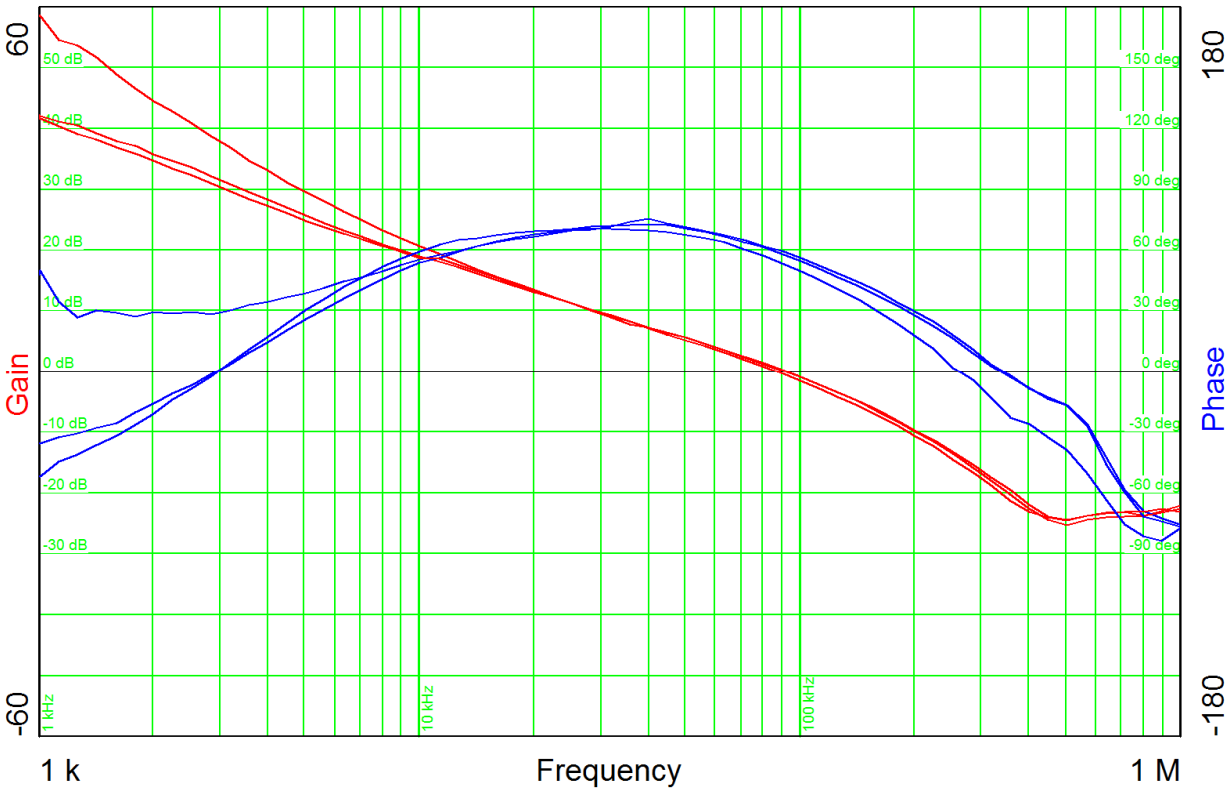


Figure 14

2.4 Frequency Response with 3x 22uF output capacitance

Figure 15 shows the loop response at a load of 1.6A.

6.0V input

- 66 deg phase margin @ crossover frequency of 62 kHz
- -23 db gain margin

12.0V input

- 65 deg phase margin @ crossover frequency of 63 kHz
- -23 db gain margin

28.0V input

- 64 deg phase margin @ crossover frequency of 60 kHz
- -20 dB gain margin

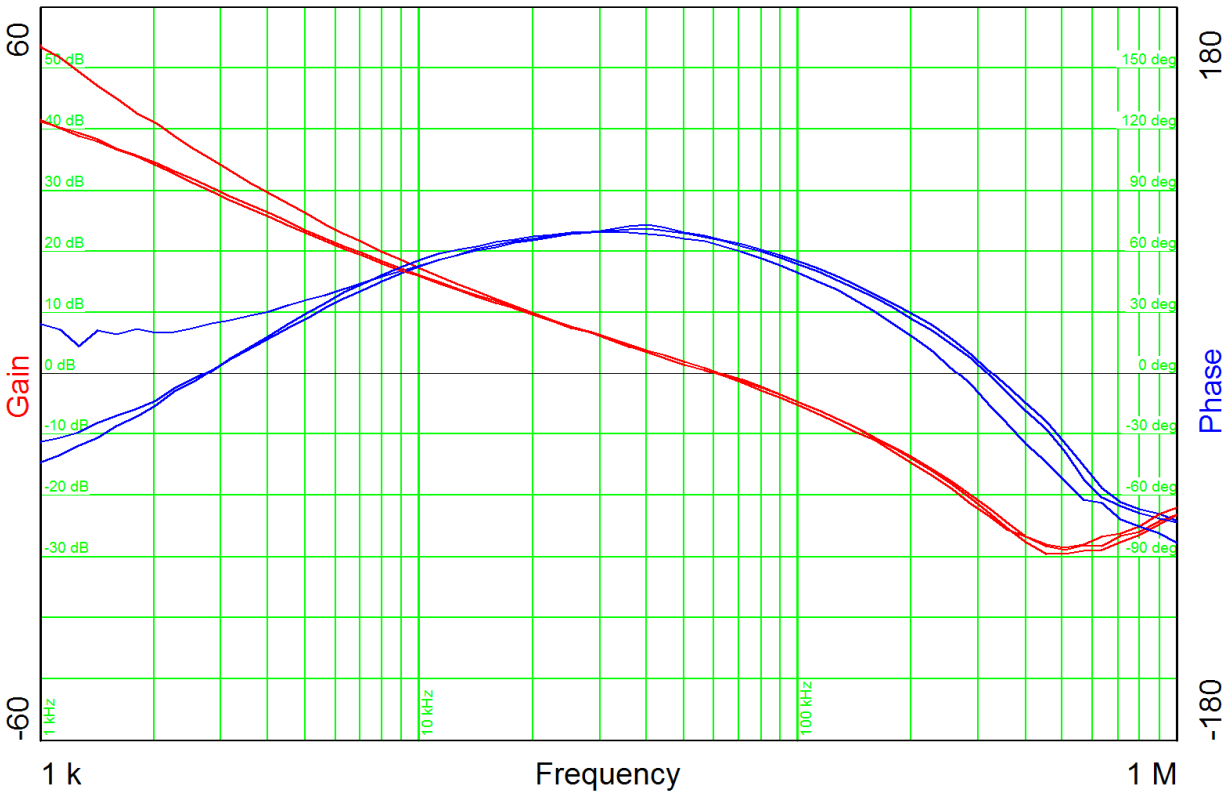


Figure 15

3 +3.3V Buck Converter – LMR23625C

All measurements were done with C21 = 56pF and 4x 22uF output capacitance unless otherwise described.

3.1 Switching Node

The switching node is shown in Figure 16.
The input voltage is set to 12.0V with a 1.6A load.

Channel C2: **Switching node**, -0.8V min, 12.0V max
5V/div, 200ns/div

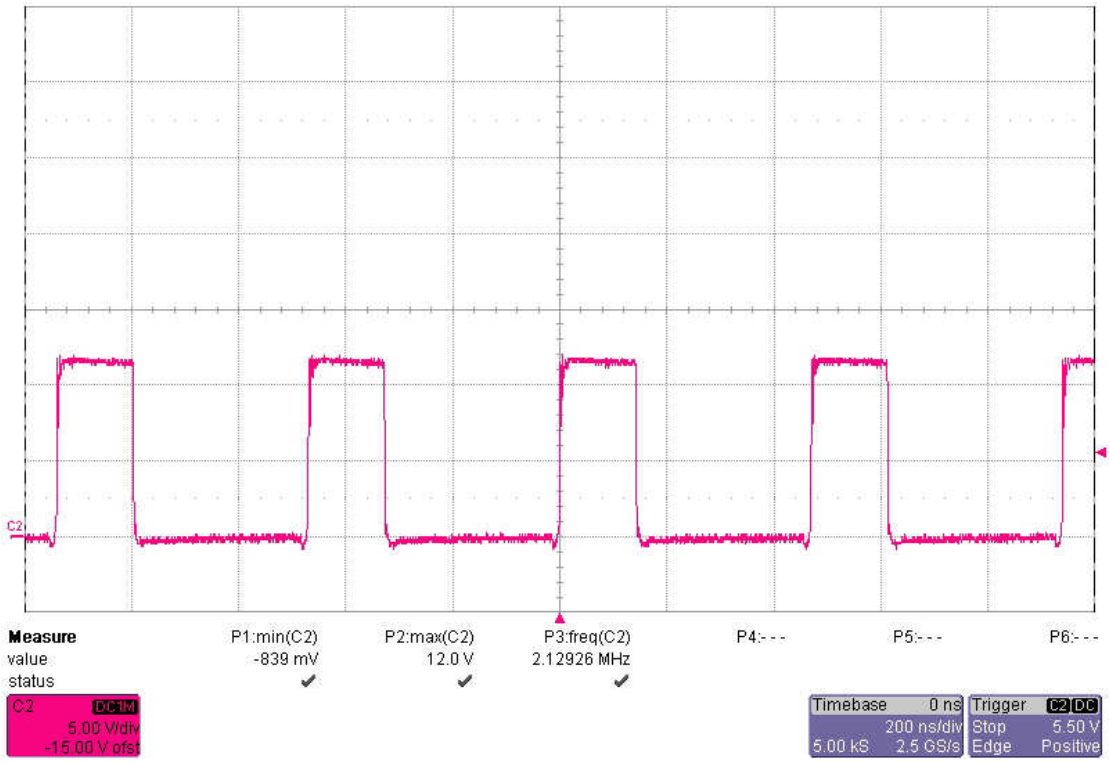


Figure 16

3.2 Transient Response with C21 = 22pF and 3x 22uF output capacitance

The response to a load step at 12.0V input voltage is shown in Figure 17.

Channel C2: **Output voltage**, -120mV undershoot (3.6%), 135mV overshoot (4.1%)
100mV/div, 1ms/div, AC coupled

Channel C1: **Load current**, load step 0.8A to 1.6A and vice versa
1A/div, 1ms/div

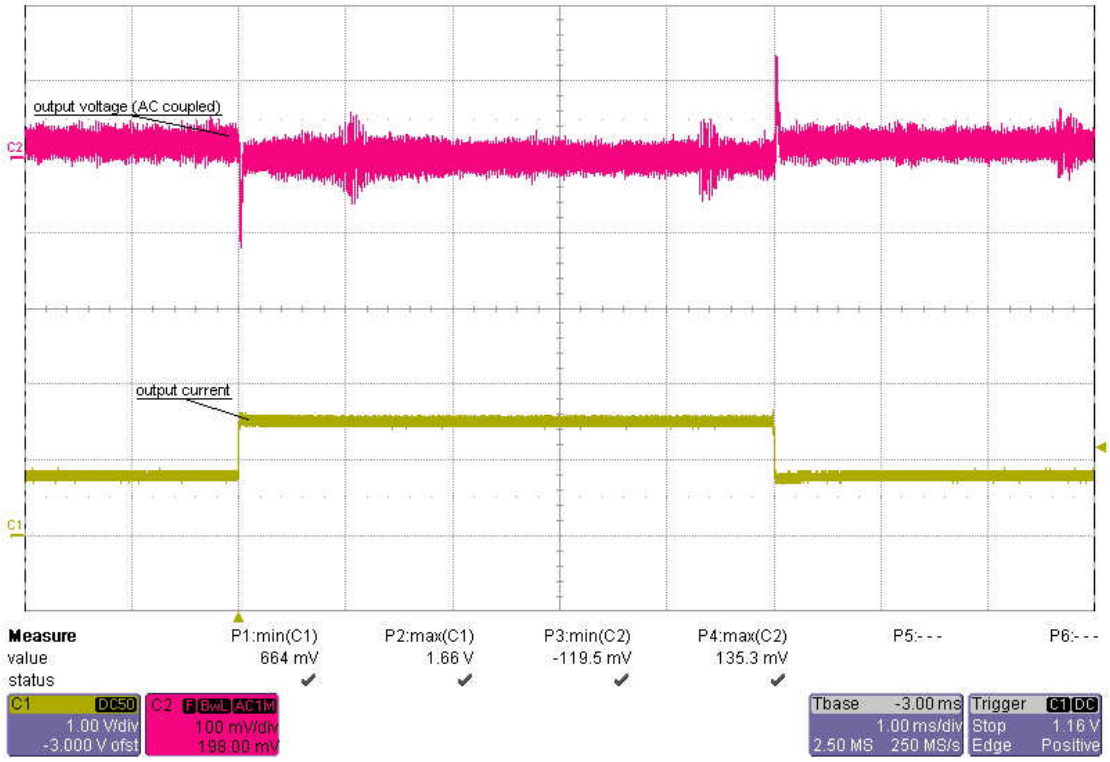


Figure 17

3.3 Transient Response with C21 = 56pF and 4x 22uF output capacitance

The response to a load step at 12.0V input voltage is shown in Figure 18.

Channel C2: **Output voltage**, -72mV undershoot (2.2%), 45mV overshoot (2.8%)
100mV/div, 1ms/div, AC coupled

Channel C1: **Load current**, load step 0.8A to 1.6A and vice versa
1A/div, 1ms/div

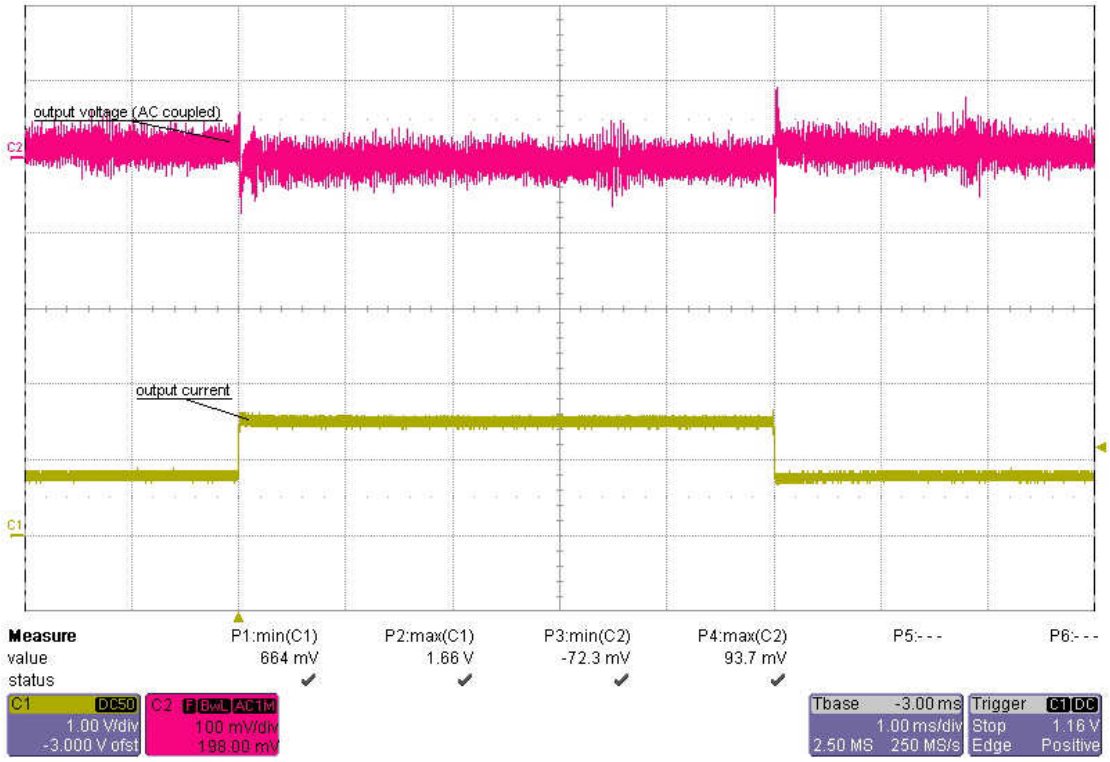


Figure 18

3.4 Frequency Response with C21 = 22pF and 3x 22uF output capacitance

Figure 19 shows the loop response at a load of 1.6A.

6.0V input

- 75 deg phase margin @ crossover frequency of 51 kHz
- -14 db gain margin

12.0V input

- 71 deg phase margin @ crossover frequency of 52 kHz
- -14 db gain margin

28.0V input

- 70 deg phase margin @ crossover frequency of 31 kHz
- -16 dB gain margin

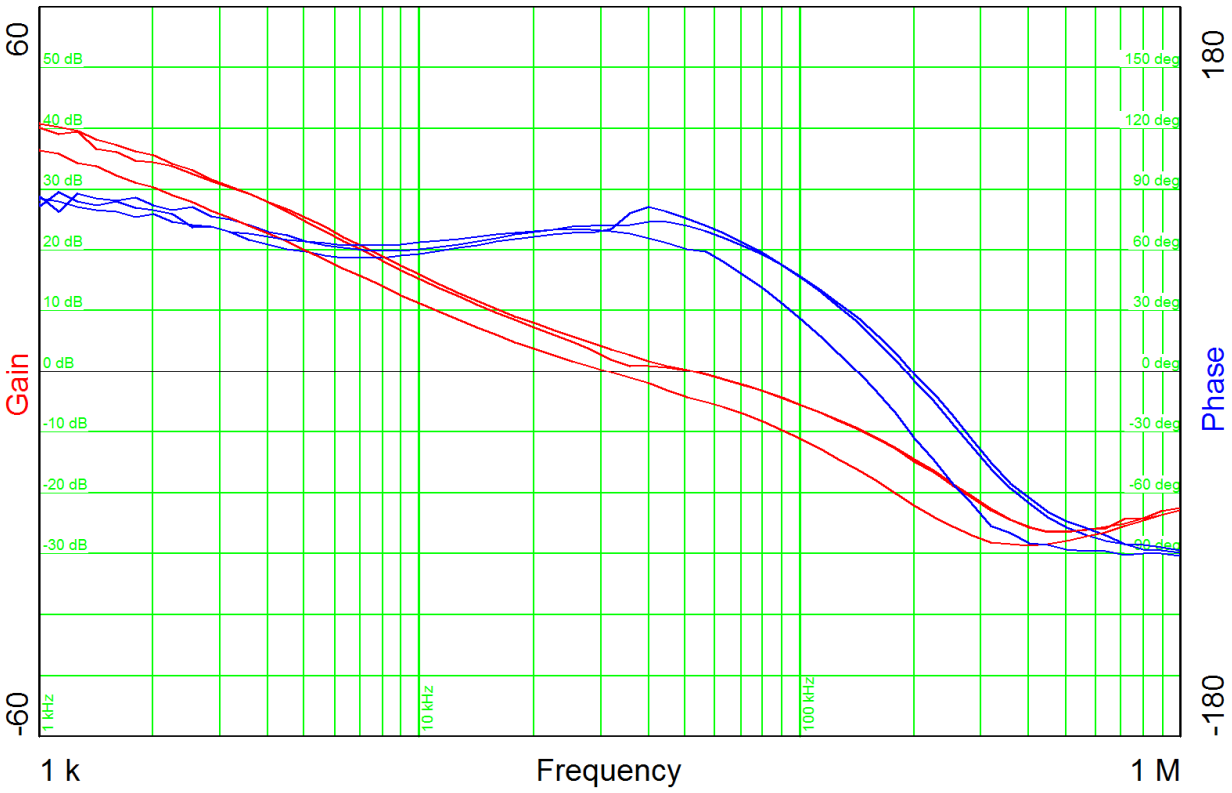


Figure 19

3.5 Frequency Response with C21 = 56pF and 4x 22uF output capacitance

Figure 20 shows the loop response at a load of 1.6A.

6.0V input

- 70 deg phase margin @ crossover frequency of 60 kHz
- -14 db gain margin

12.0V input

- 68 deg phase margin @ crossover frequency of 61 kHz
- -14 db gain margin

28.0V input

- 74 deg phase margin @ crossover frequency of 35 kHz
- -16 dB gain margin

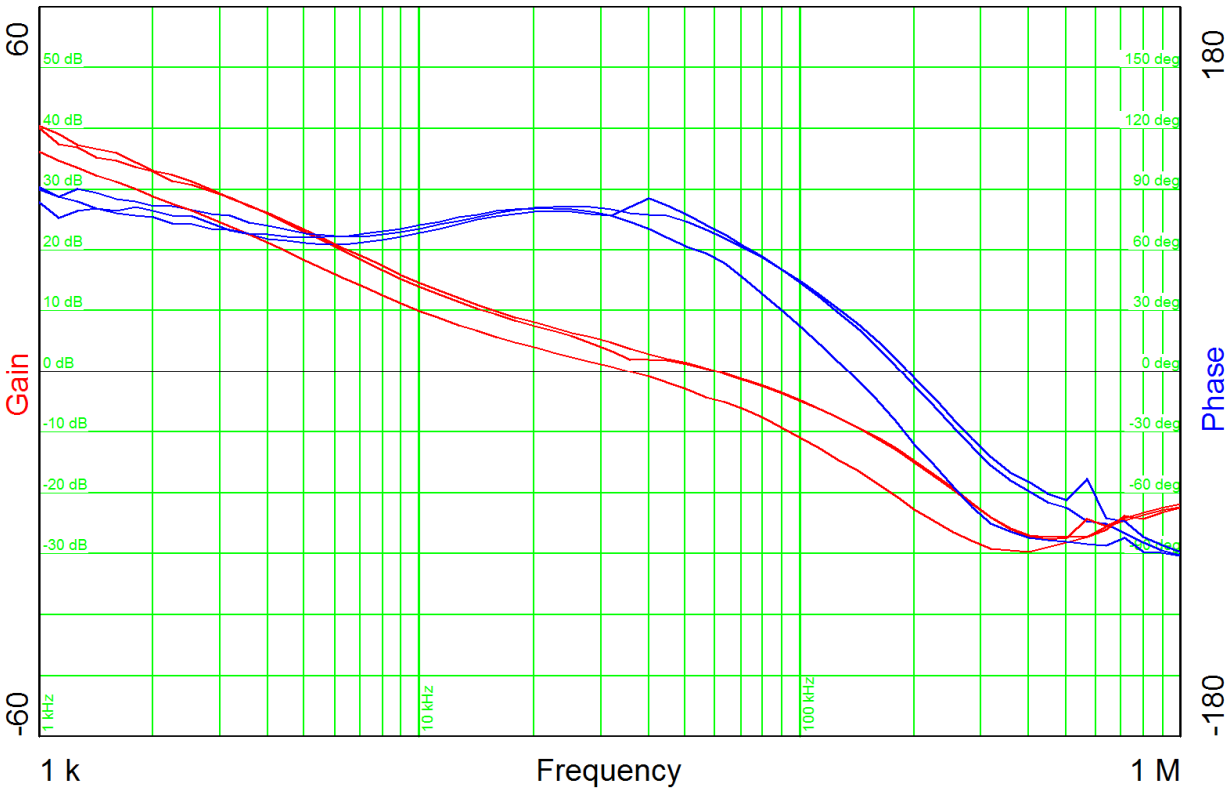


Figure 20

3.6 Efficiency

The efficiency and losses at 6.0V, 12.0V and 28.0V input voltage are shown in Figure 21 and Figure 22.

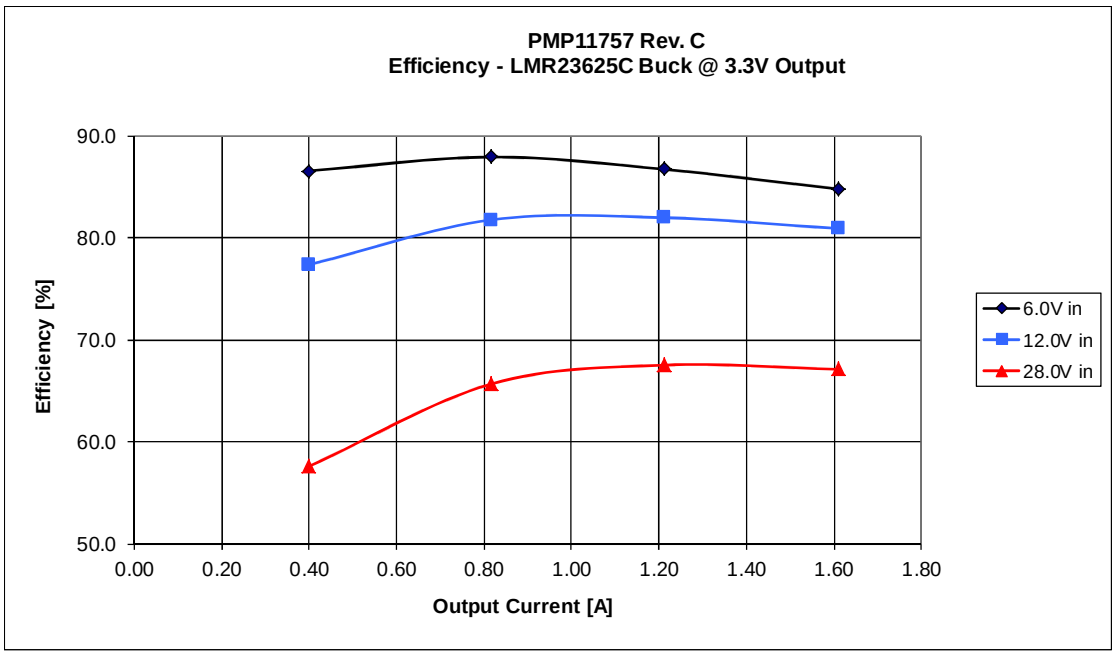


Figure 21

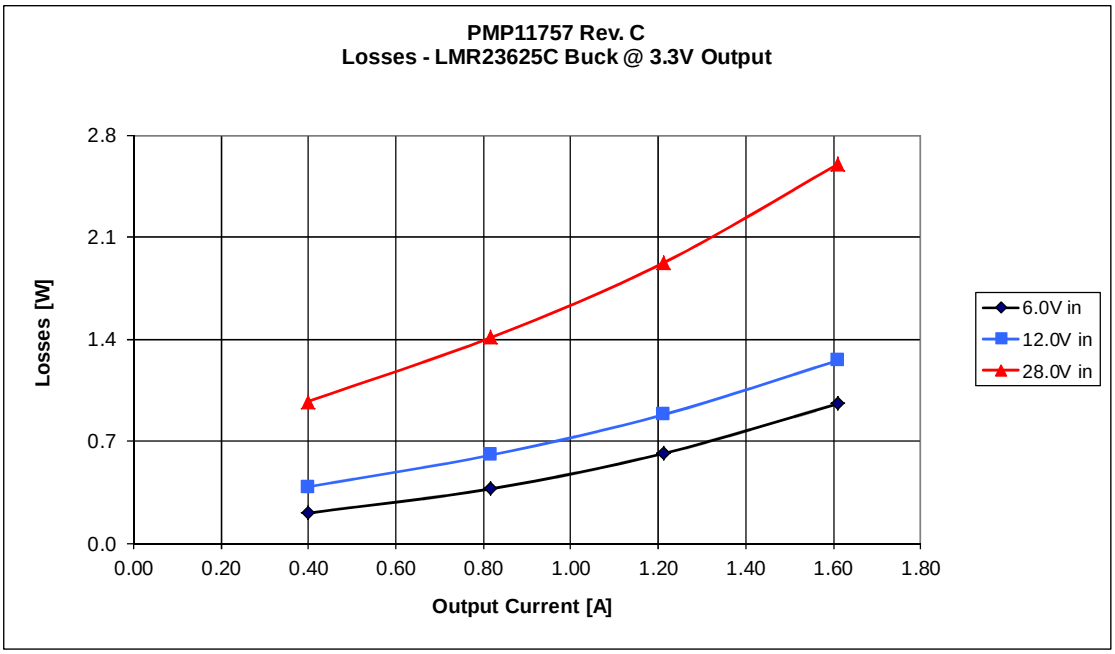


Figure 22

3.7 Load Regulation

The load regulation is shown in Figure 23.

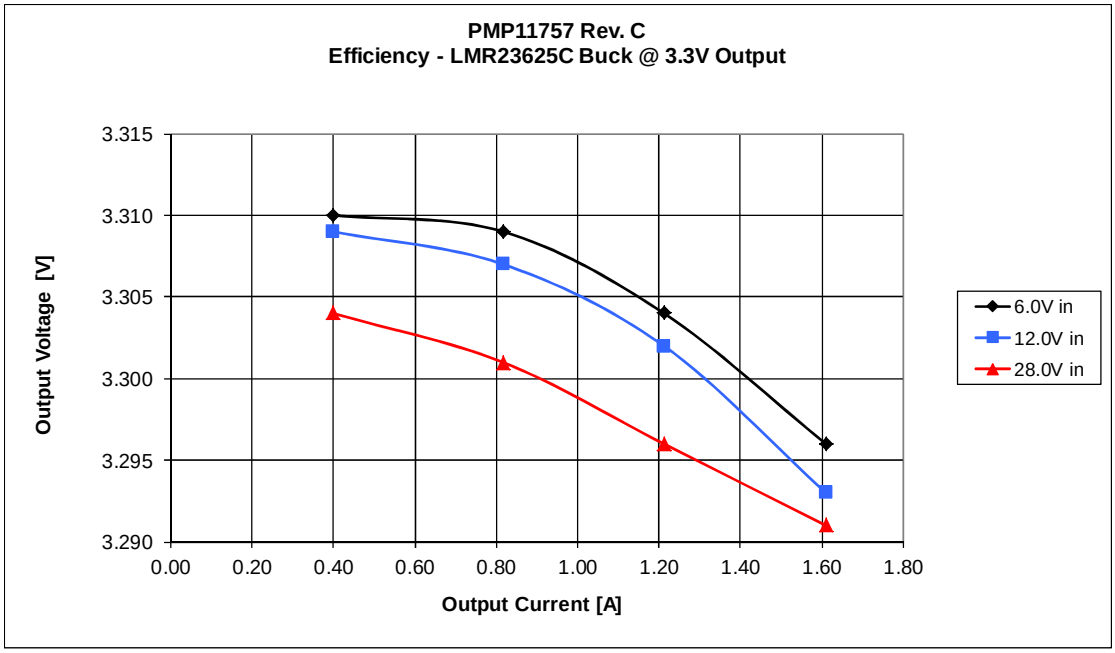


Figure 23

3.8 Output Voltage Ripple

The output ripple at 1.6A load is shown in Figure 24.
The input voltage is set to 6.0V, 12.0V and 28.0V.

Channel C2: **6.0V input voltage**, 16mV peak-peak
20mV/div, 200ns/div

Channel C2: **12.0V input voltage**, 24mV peak-peak
20mV/div, 200ns/div

Channel C2: **28.0V input voltage**, 28mV peak-peak
20mV/div, 200ns/div

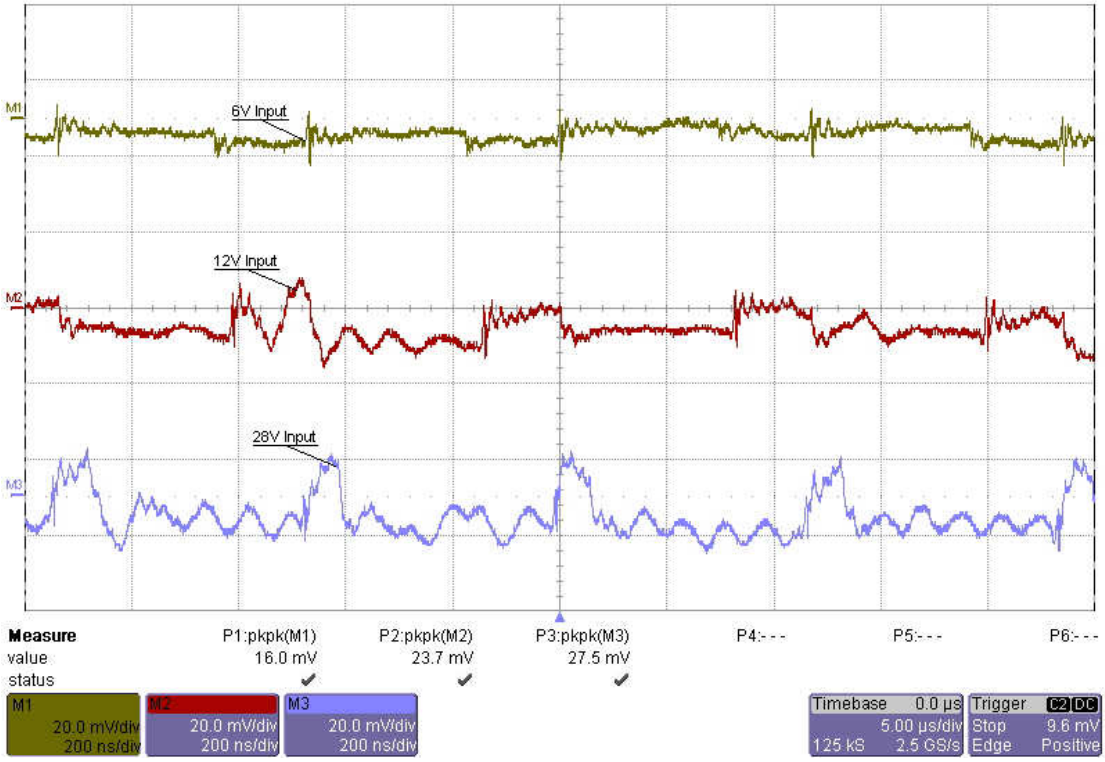


Figure 24

3.9 Startup

The startup at no load on the output is shown in Figure 25.

Channel C1: **12.0V Input voltage**
2V/div, 500us/div

Channel C2: **3.3V Output voltage**
1V/div, 500us/div

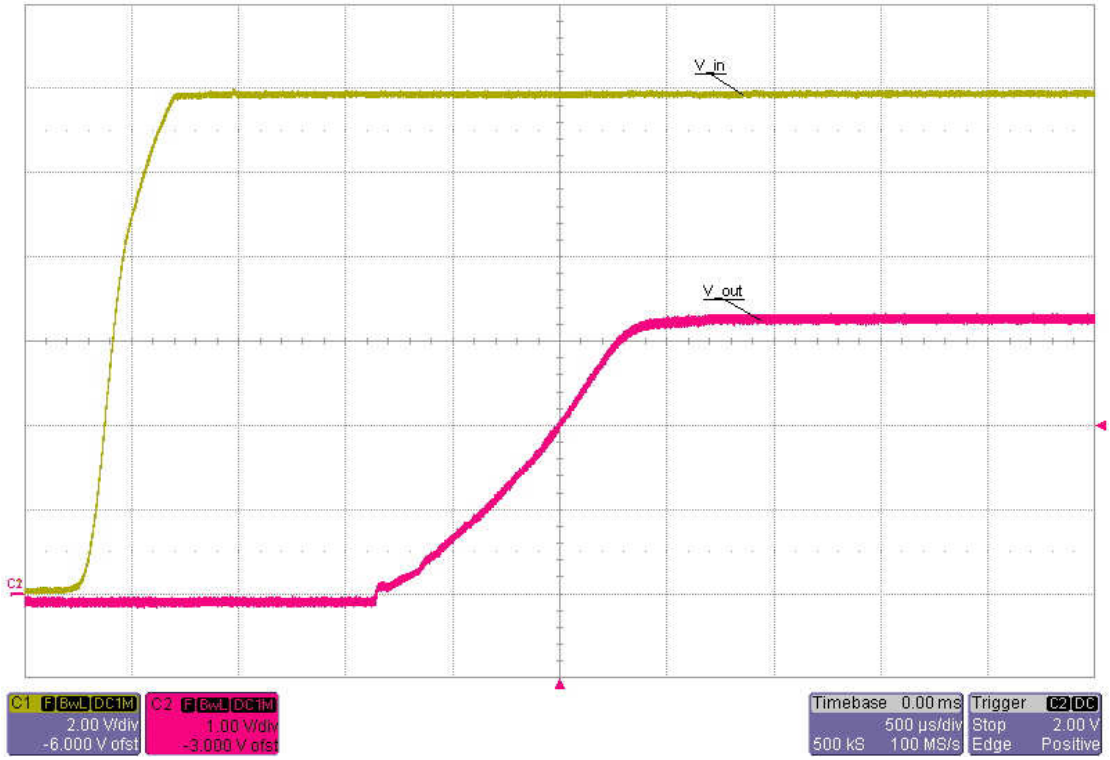


Figure 25

3.10 Shutdown

The shutdown at 1.6A load on the output is shown in Figure 26.

Channel C1: **12.0V Input voltage**
2V/div, 500us/div

Channel C2: **3.3V Output voltage**
1V/div, 500us/div

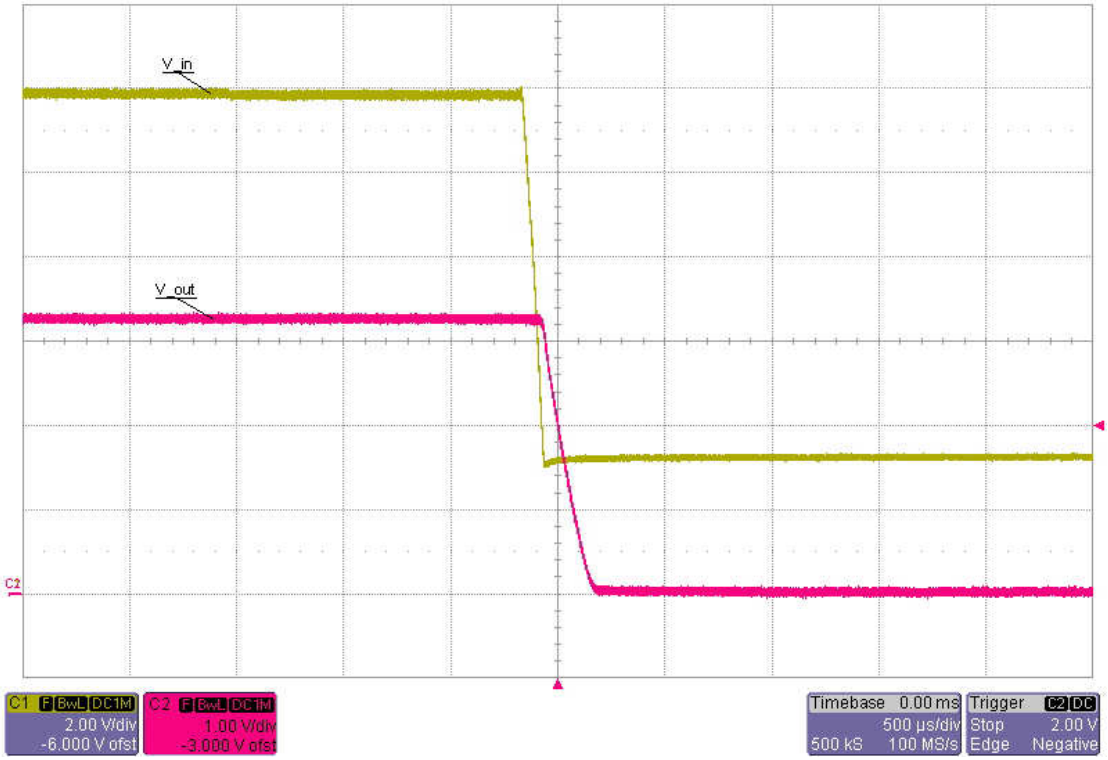


Figure 26

4 +5.0V Boost Converter – TPS61071

4.1 Switching Node

The switching node is shown in Figure 27.
The input voltage is set to 3.3V with a 0.25A load.

Channel C2: **Switching node**, -0.02V min, 8.1V max
2V/div, 500ns/div

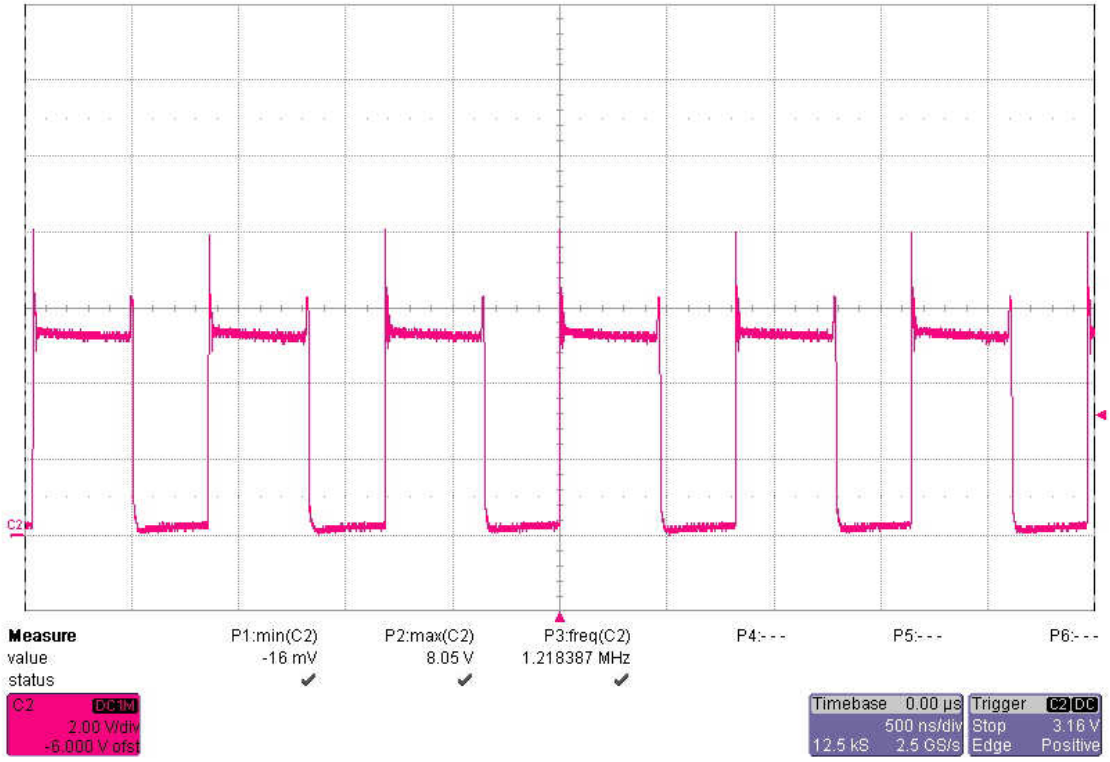


Figure 27

4.2 Transient Response

The response to a load step at 12.0V input voltage is shown in Figure 28.

Channel C2: **Output voltage**, -79mV undershoot (2.4%), 76mV overshoot (2.3%)
100mV/div, 2ms/div, AC coupled

Channel C1: **Load current**, load step 0.1A to 0.25A and vice versa
100mA/div, 2ms/div

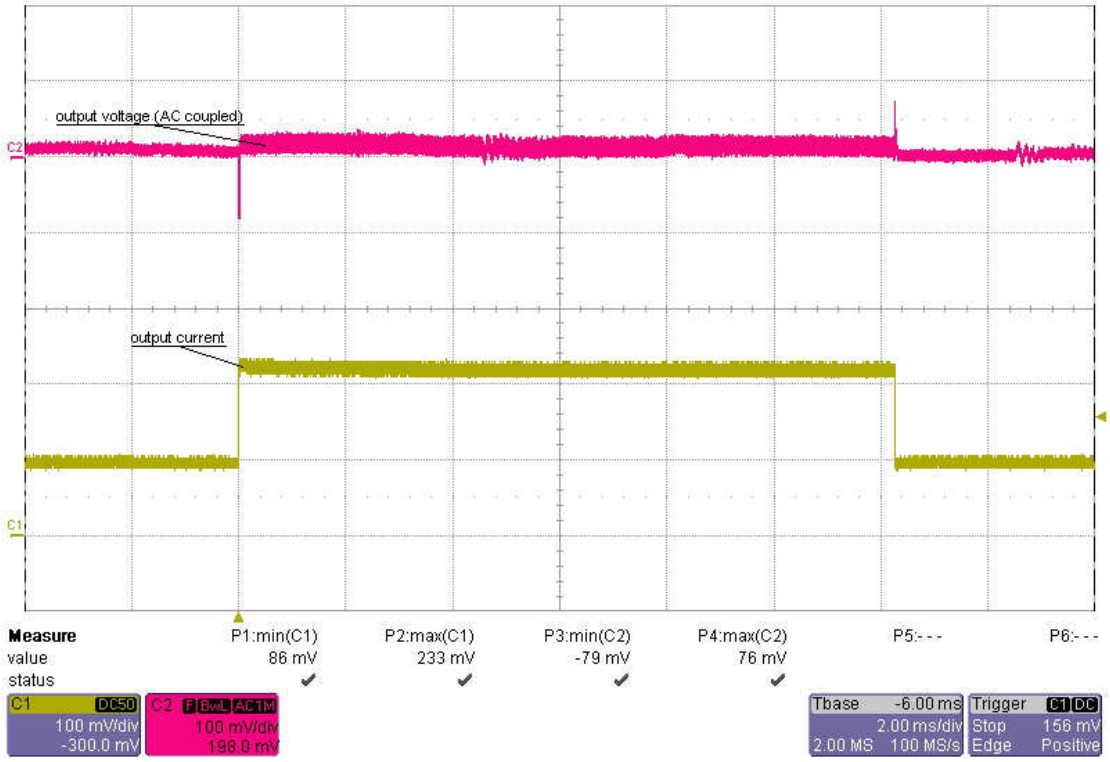


Figure 28

4.3 Frequency Response

Figure 29 shows the loop response at a load of 0.25A.

3.3V input

- 60 deg phase margin @ crossover frequency of 14 kHz
- -14 dB gain margin

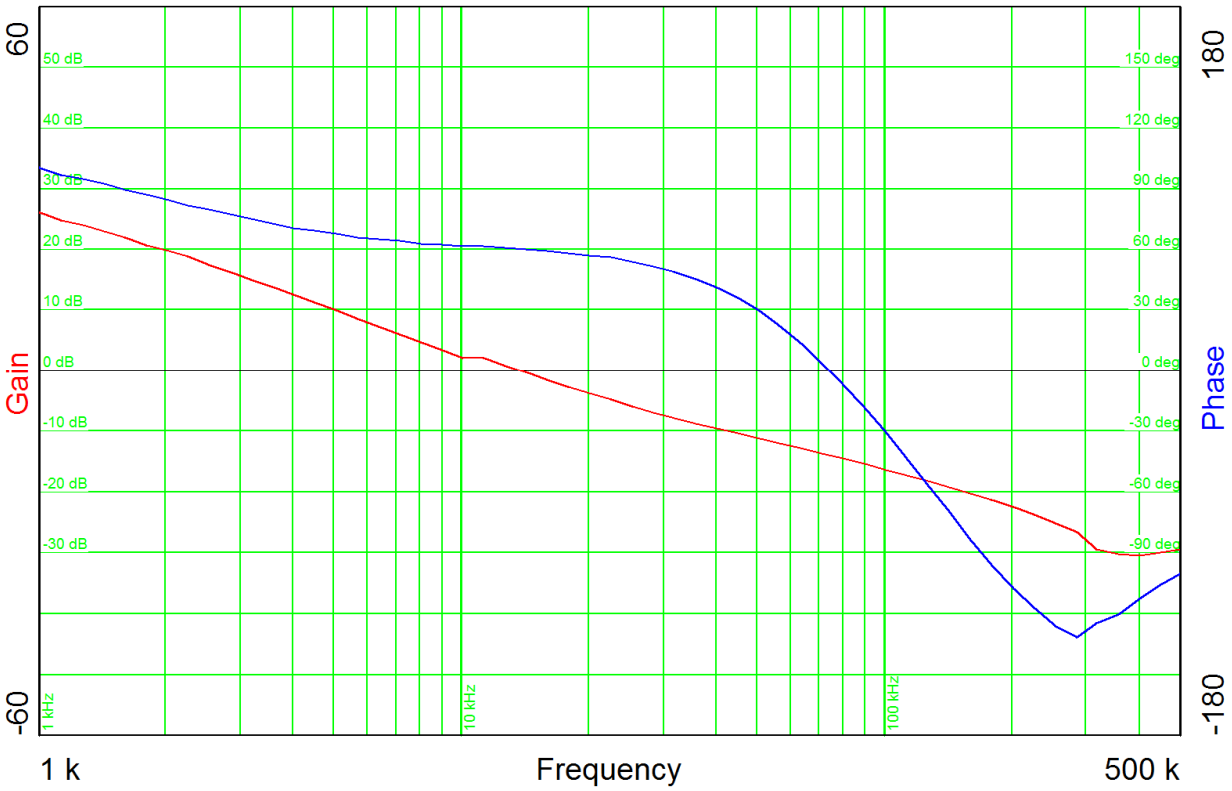


Figure 29

4.4 Efficiency

The efficiency and losses at 3.3V input voltage are shown in Figure 21 and Figure 22.

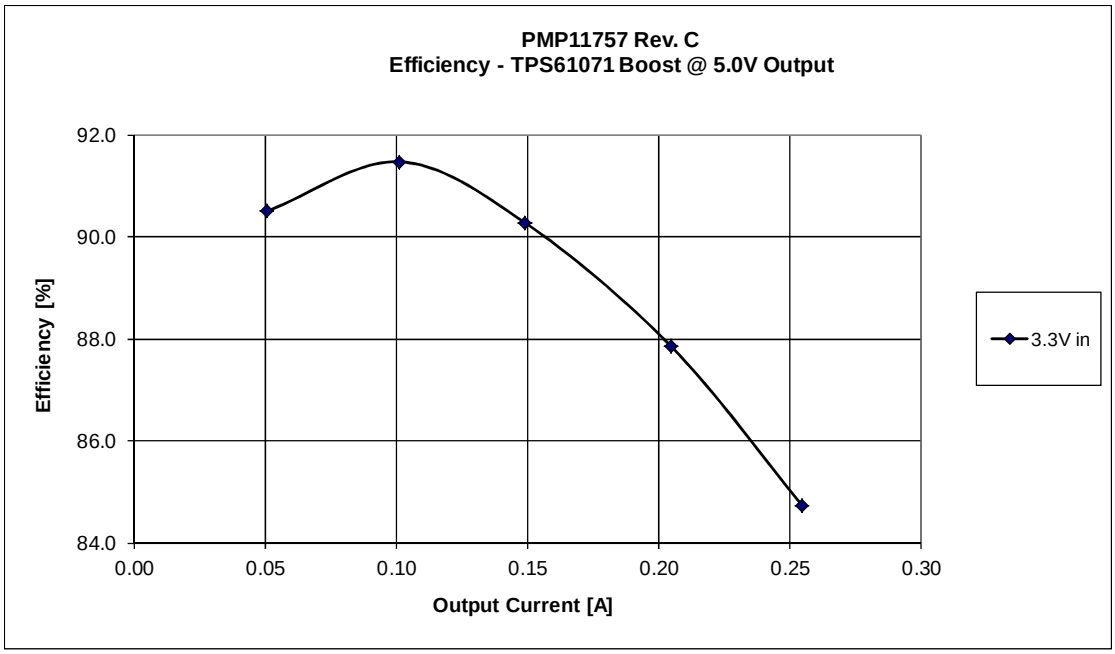


Figure 30

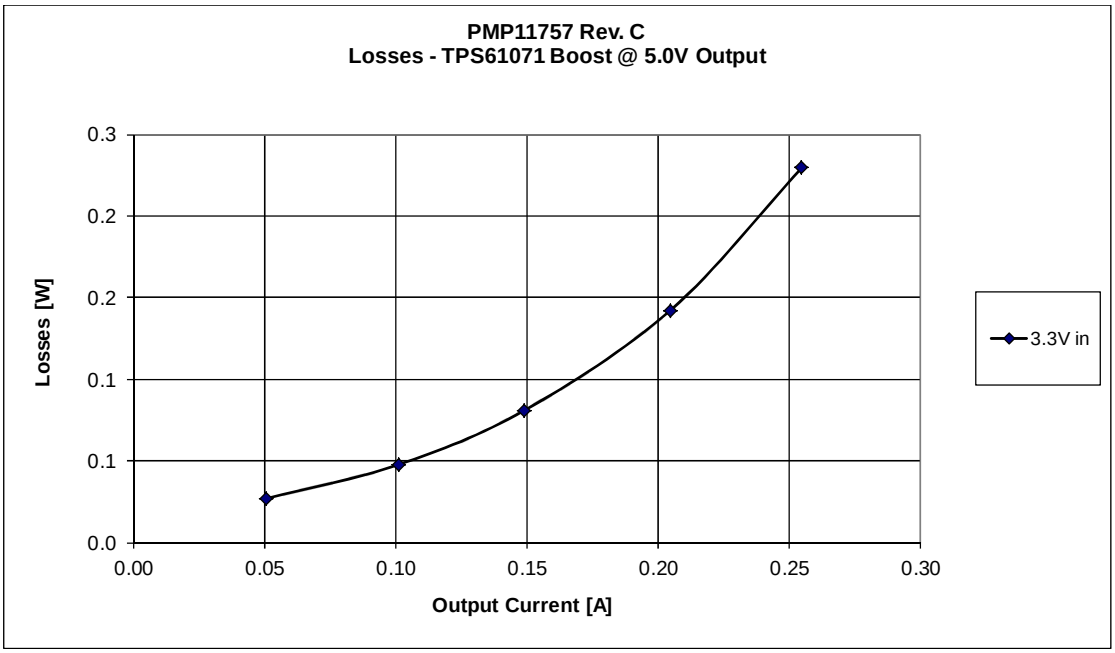


Figure 31

4.5 Load Regulation

The load regulation is shown in Figure 23.

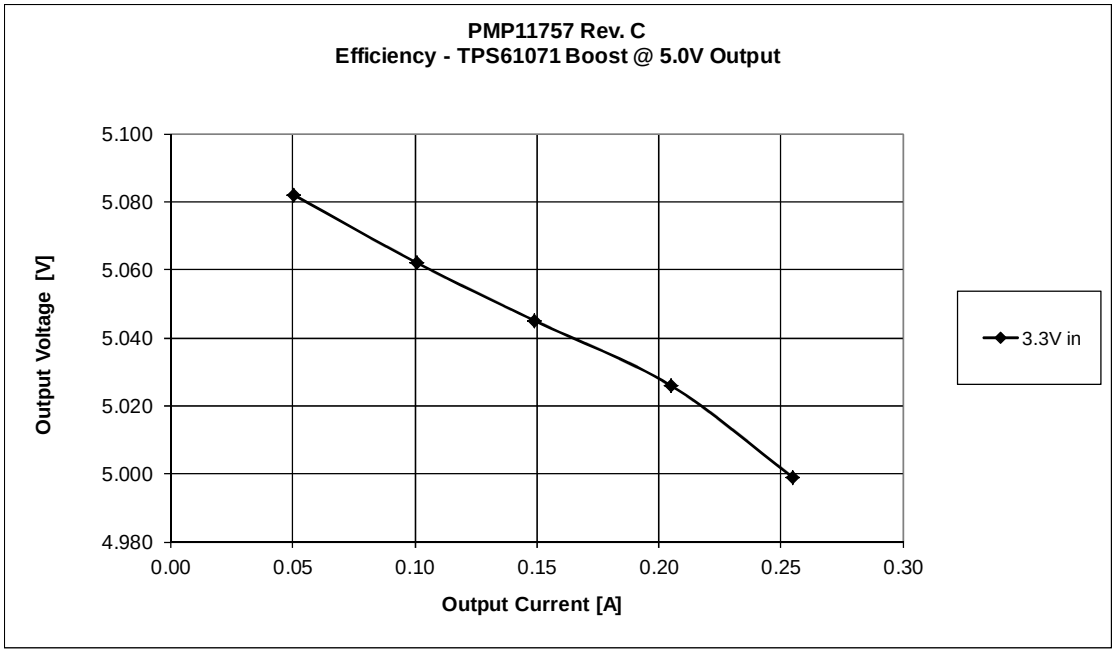


Figure 32

4.6 Output Voltage Ripple

The output ripple at 0.25A load is shown in Figure 33.
The input voltage is set to 3.3V.

Channel C2: **3.3V input voltage**, 58mV peak-peak (Spikes!)
20mV/div, 1us/div

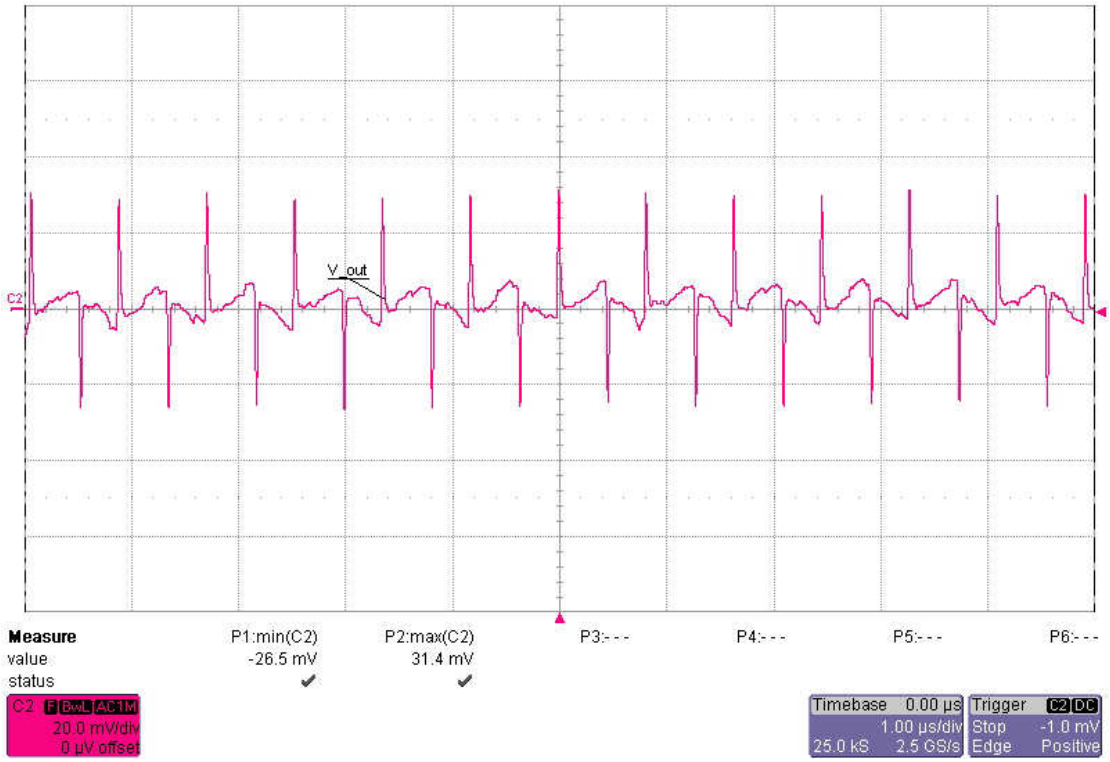


Figure 33

4.7 Startup

The startup at no load on the output is shown in Figure 34.

Channel C1: **3.3V Input voltage**
2V/div, 500us/div

Channel C2: **5.0V Output voltage**
1V/div, 500us/div

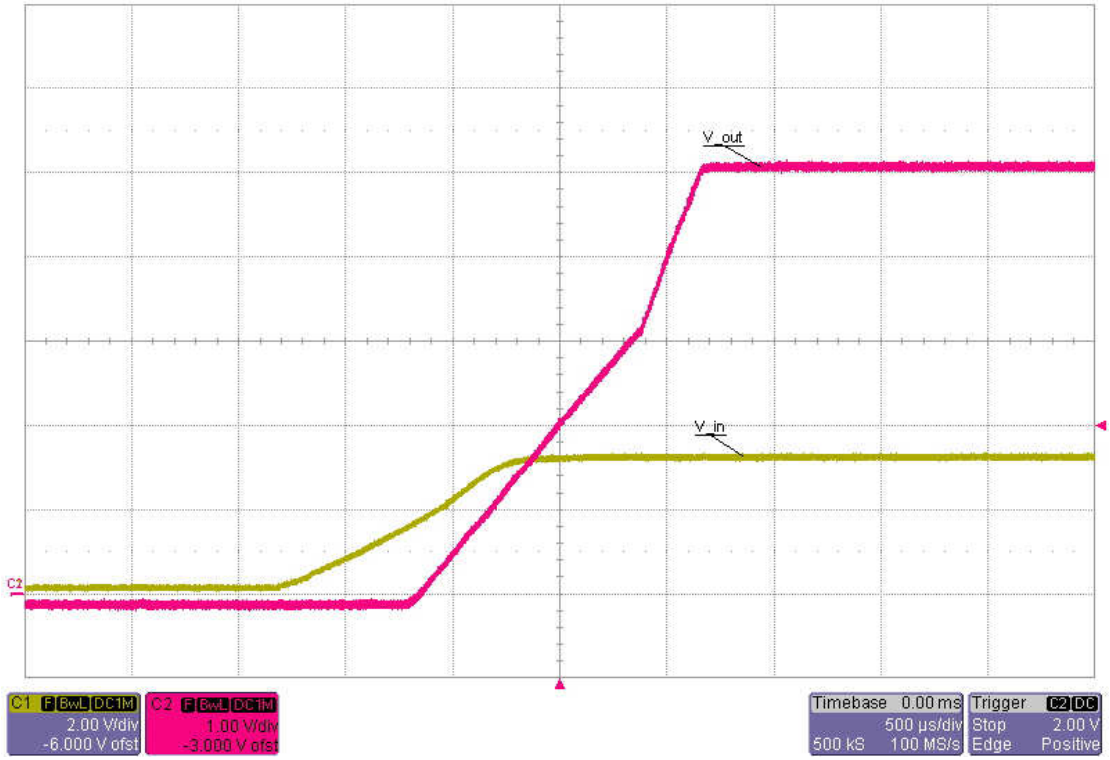


Figure 34

4.8 Shutdown

The shutdown at 0.25A load on the output is shown in Figure 35.

Channel C1: **3.3V Input voltage**
2V/div, 500us/div

Channel C2: **5.0V Output voltage**
1V/div, 500us/div

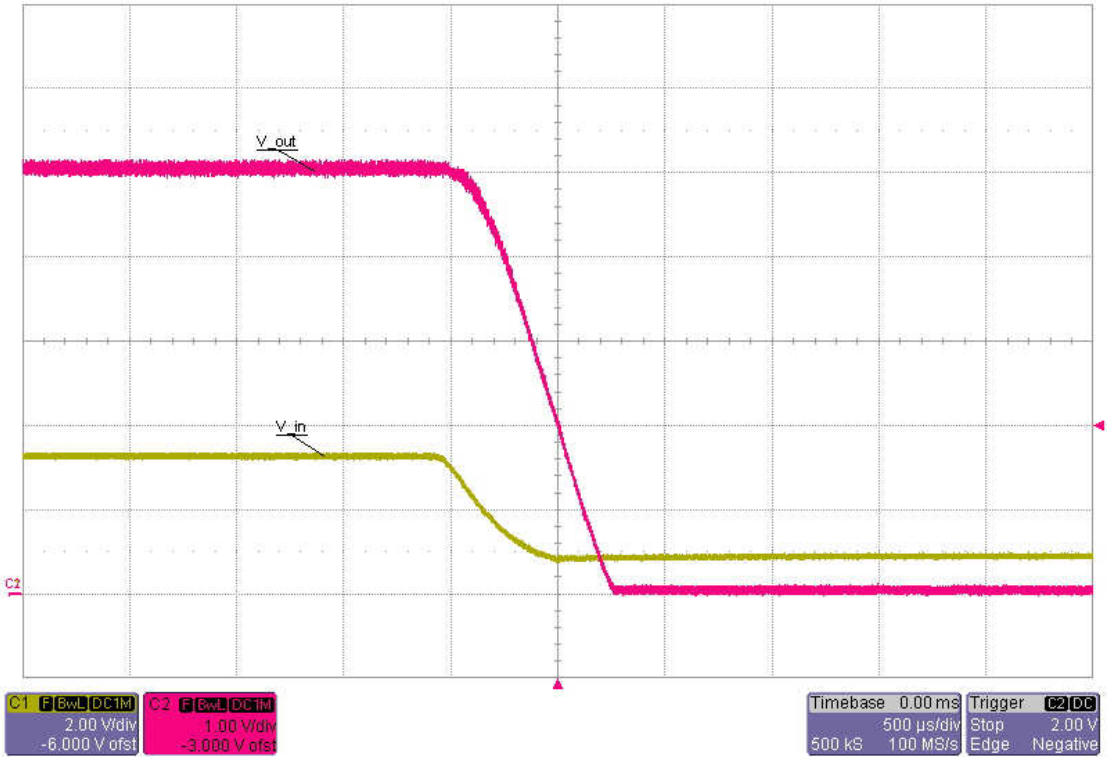


Figure 35

5 Thermal Measurement – LM53602A

The thermal image (Figure 36) shows the circuit at an ambient temperature of 21 °C with an input voltage of 12.0V and full power on all rails.

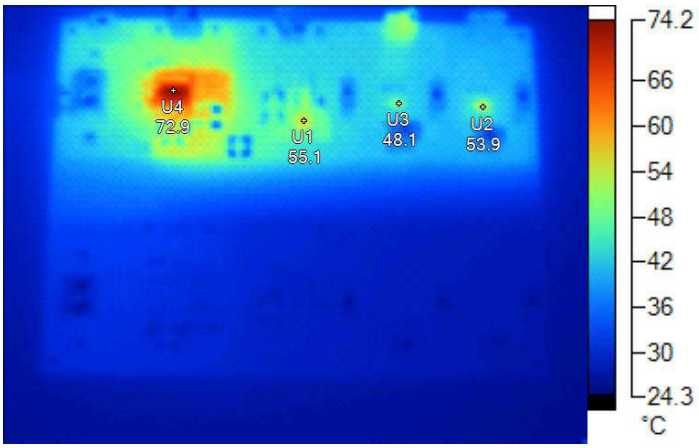


Figure 36

Name	Temperature	Emissivity	Background
U4	72.9°C	0.95	21.0°C
U1	55.1°C	0.95	21.0°C
U3	48.1°C	0.95	21.0°C
U2	53.9°C	0.95	21.0°C

6 Thermal Measurement – LMR23625C

The thermal image (Figure 37) shows the circuit at an ambient temperature of 21 °C with an input voltage of 12.0V and full power on all rails.

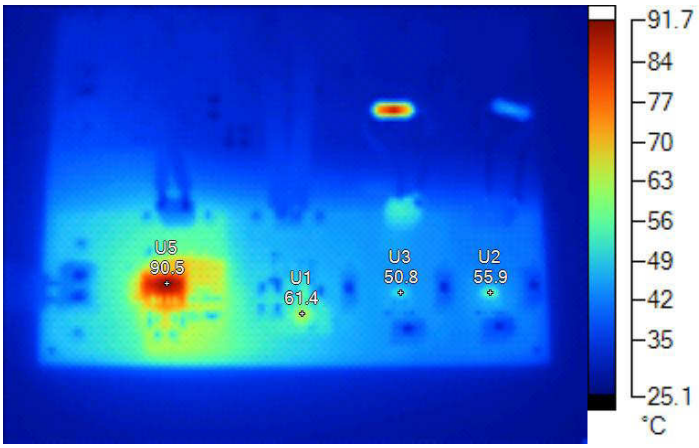


Figure 37

Name	Temperature	Emissivity	Background
U5	90.5°C	0.95	21.0°C
U1	61.4°C	0.95	21.0°C
U3	50.8°C	0.95	21.0°C
U2	55.9°C	0.95	21.0°C

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