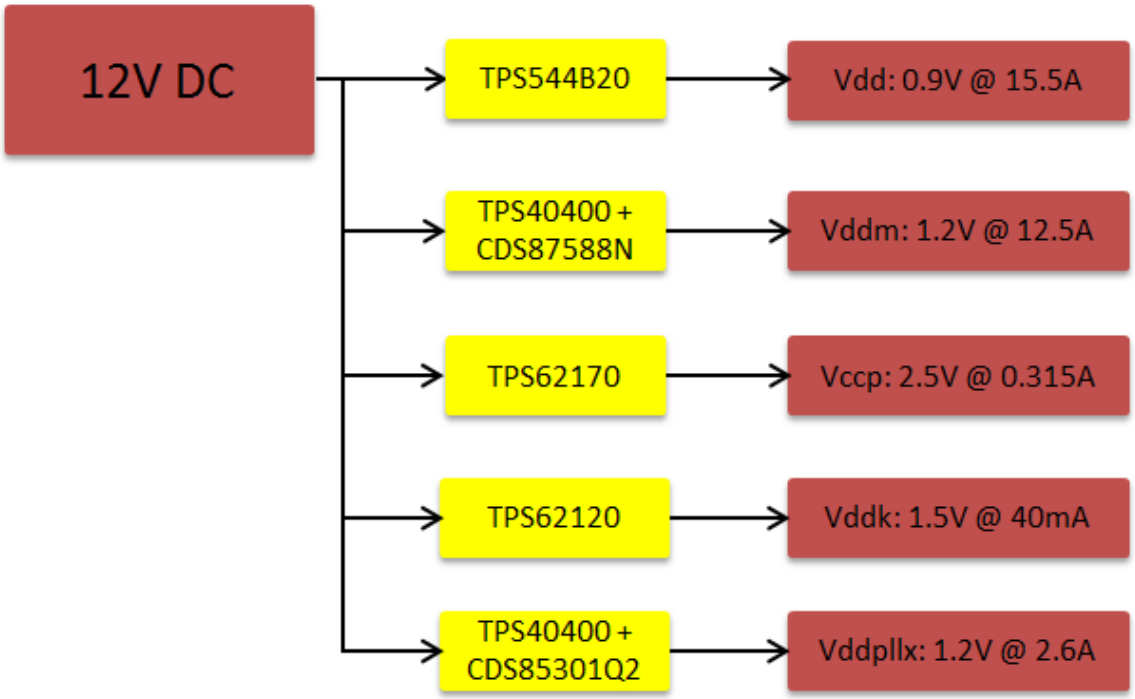
PMP20080 – Micron Hybrid Memory Cube (HMC) Gen2.0 power solution

For sake of convenience, the rails will be referred to by the following names throughout the report.

1. Rail 1 – Vdd – 0.9V @ 15.5A
2. Rail 2 – Vddm – 1.2V @ 12.5A
3. Rail 3 – Vccp – 2.5V @ 0.315A
4. Rail 4 – Vddk – 1. 5V @ 0.04A
5. Rail 5 – Vddpllx – 1.2V @ 2.6A



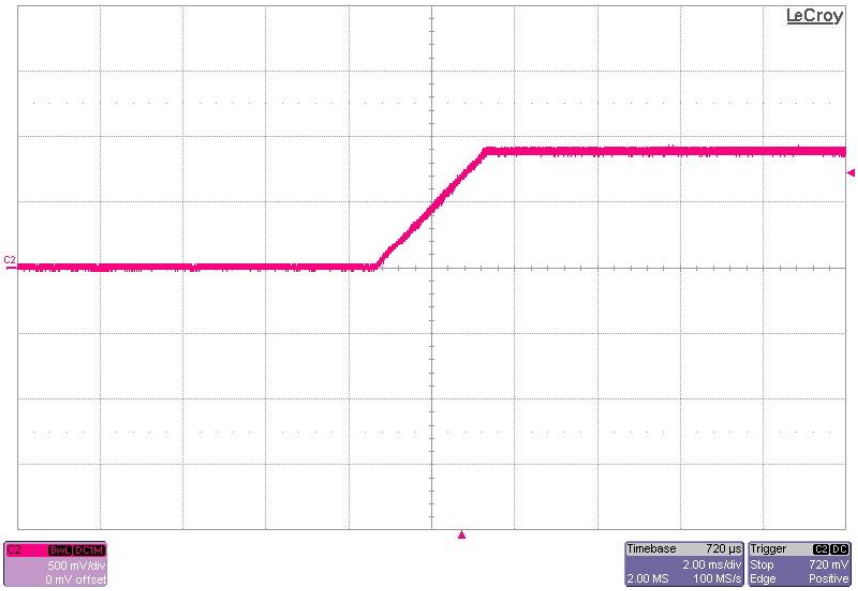
The tests performed were as follows:

1. Turn-On (No Load)
2. Turn-Off (Full Load Load)
3. Switch Node
    i. No Load (with BWL)
    ii. Full Load (with BWL)
    iii. Ringing Full Load (No BWL)
4. Output Voltage Ripple
    i. No Load
    ii. Full Load
5. Transient Response
6. Efficiency
7. Load Regulation
8. Gain and Phase
9. Board Photo
10. Thermal Images

1. Turn – On (No load)

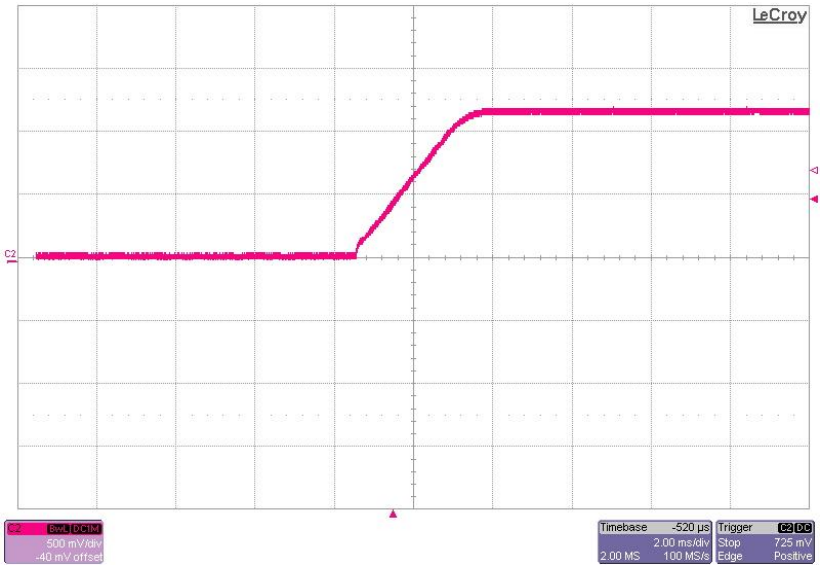
The photos below show the startup waveform. The input voltage is 12V, the output is not loaded.

Channel 2 – Pink: Output Voltage – (500mV/Division)
The time-base is set to 2ms/Division.



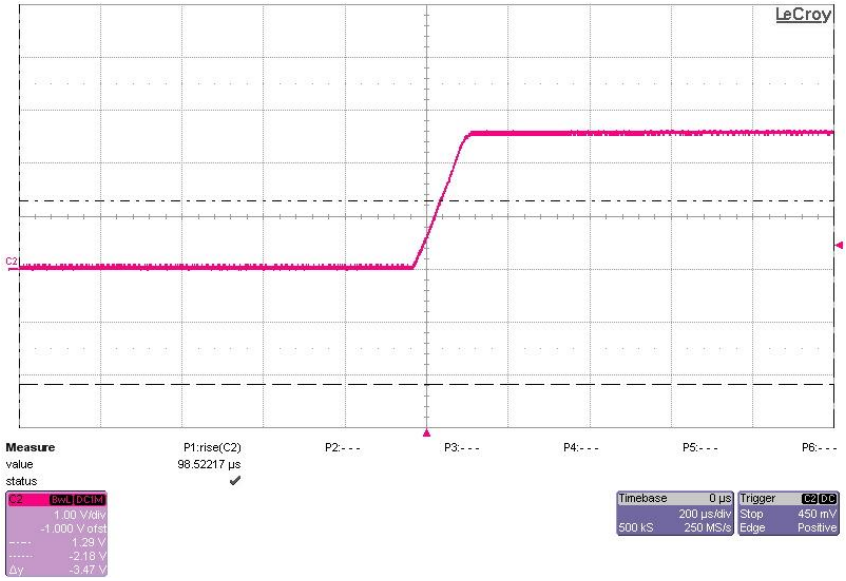
Rail 1

Channel 2 – Pink: Output Voltage – (500mV/Division)
The time-base is set to 2ms/Division.



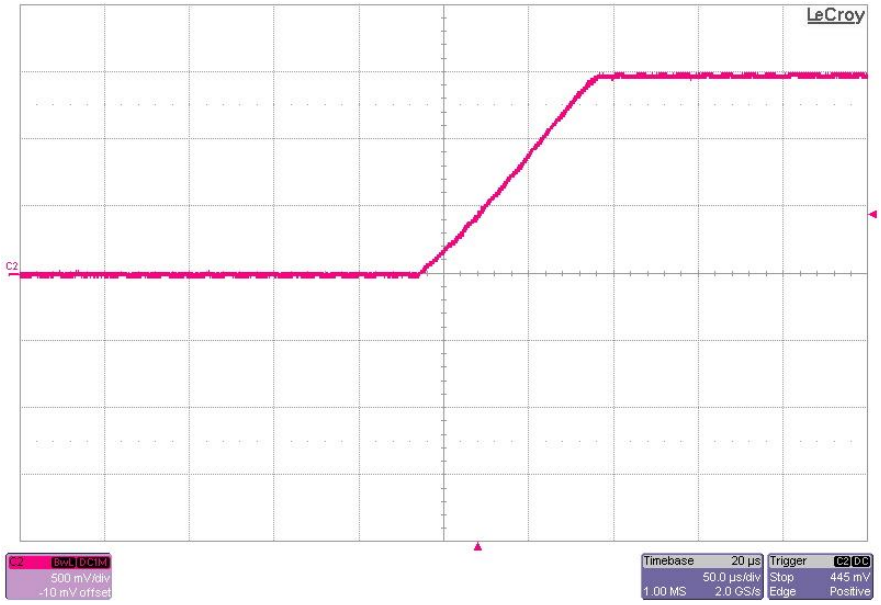
Rail 2

Channel 2 – Pink: Output Voltage – (1V/Division)
The time-base is set to 200µs/Division.



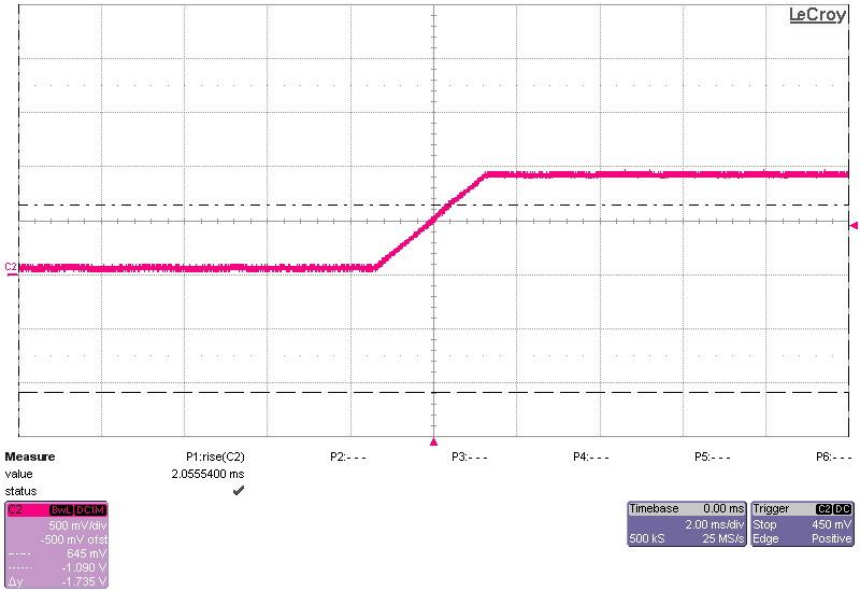
Rail 3

Channel 2 – Pink: Output Voltage – (500mV/Division)
The time-base is set to 50us/Division.



Rail 4

Channel 2 – Pink: Output Voltage – (500mV/Division)
The time-base is set to 2ms/Division.

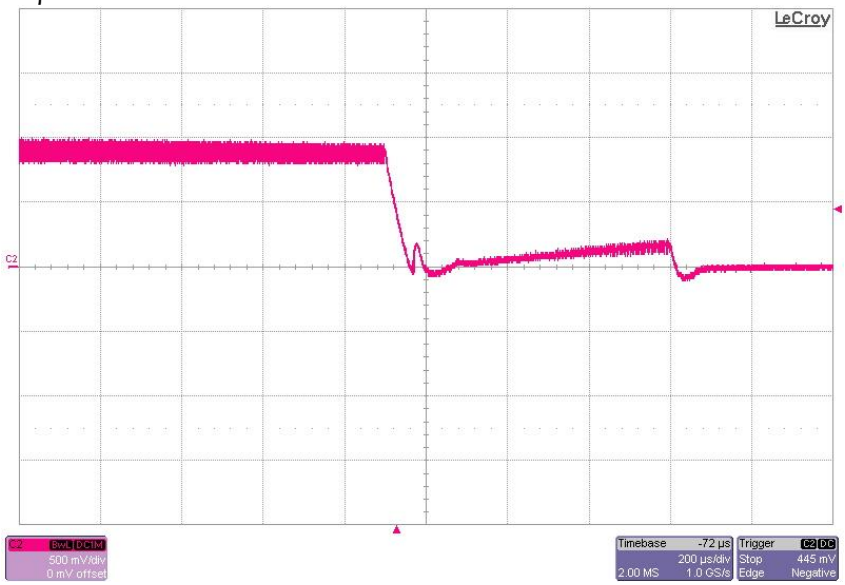


Rail 5

2. Turn – Off (Full load)

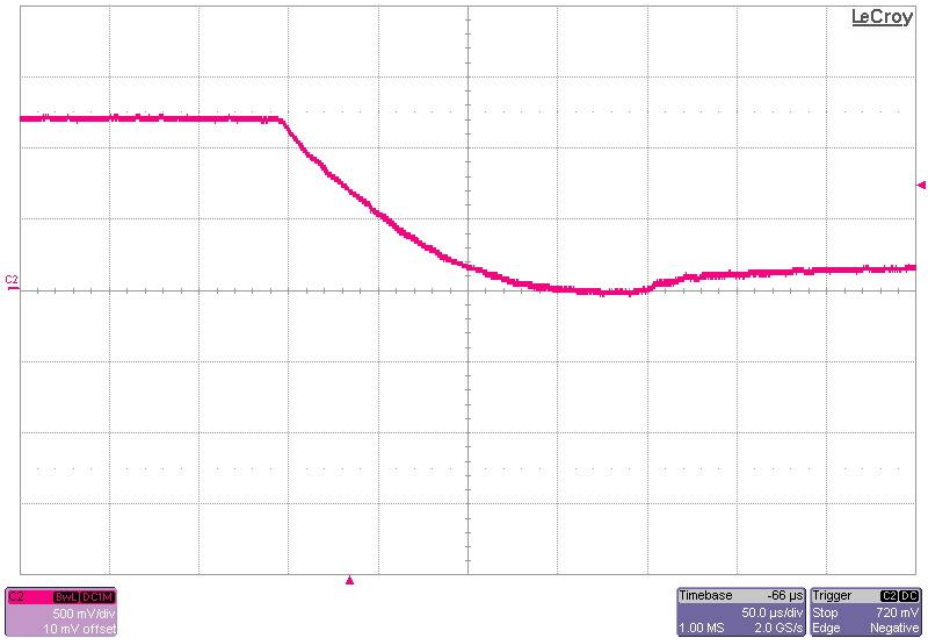
The photos below show the startup waveform. The input voltage is 12V. The output is load to full load rating of the rail.

Channel 2 – Pink: Output Voltage – (500mV/Division)
The time-base is set to 200µs/Division.



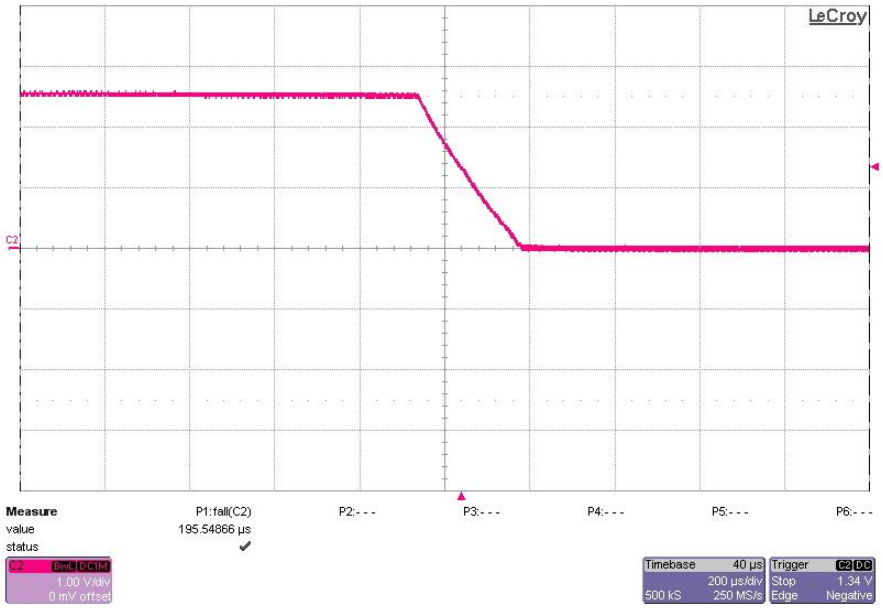
Rail 1

Channel 2 – Pink: Output Voltage – (500mV/Division)
The time-base is set to 50µs/Division.



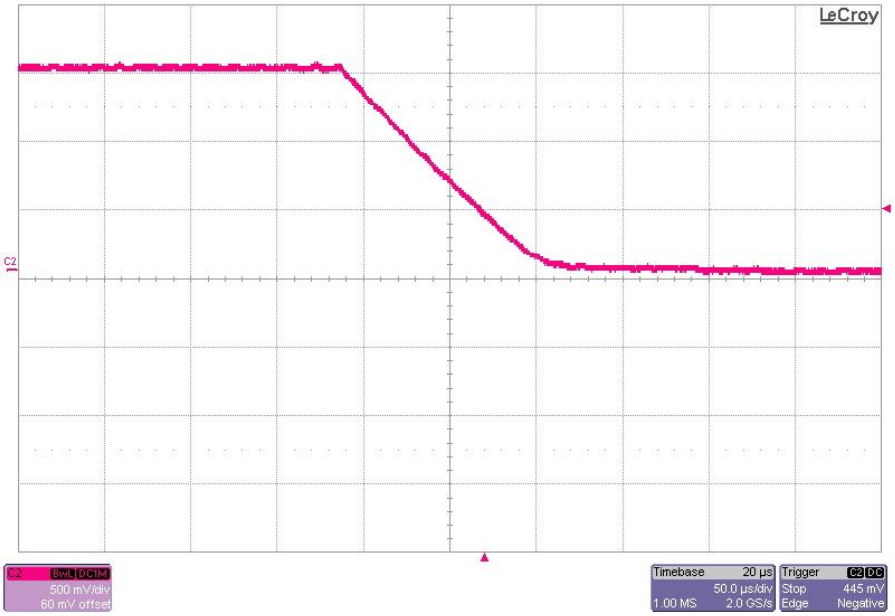
Rail 2

Channel 2 – Pink: Output Voltage – (1V/Division)
The time-base is set to 200µs/Division.



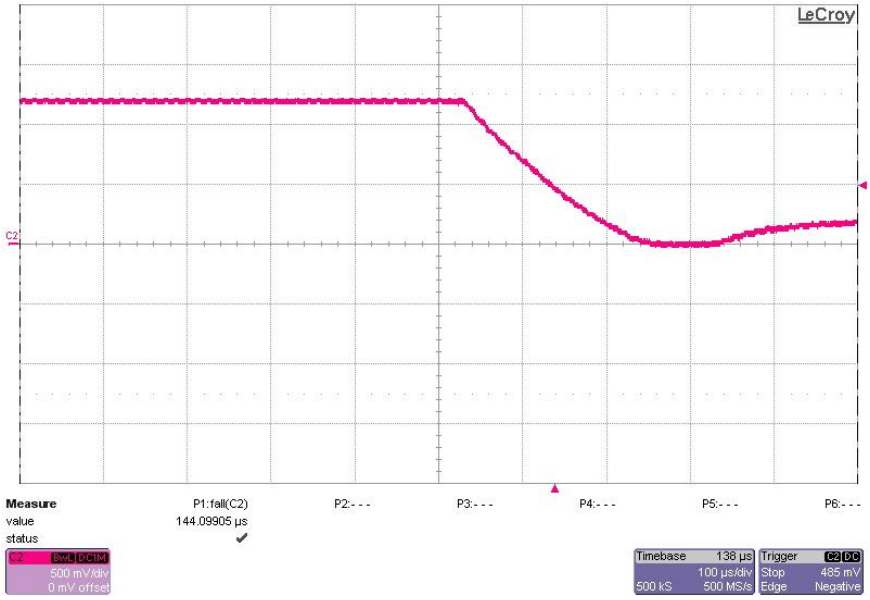
Rail 3

Channel 2 – Pink: Output Voltage – (500mV/Division)
The time-base is set to 50µs/Division.



Rail 4

Channel 2 – Pink: Output Voltage – (500mV/Division)
The time-base is set to 100µs/Division.



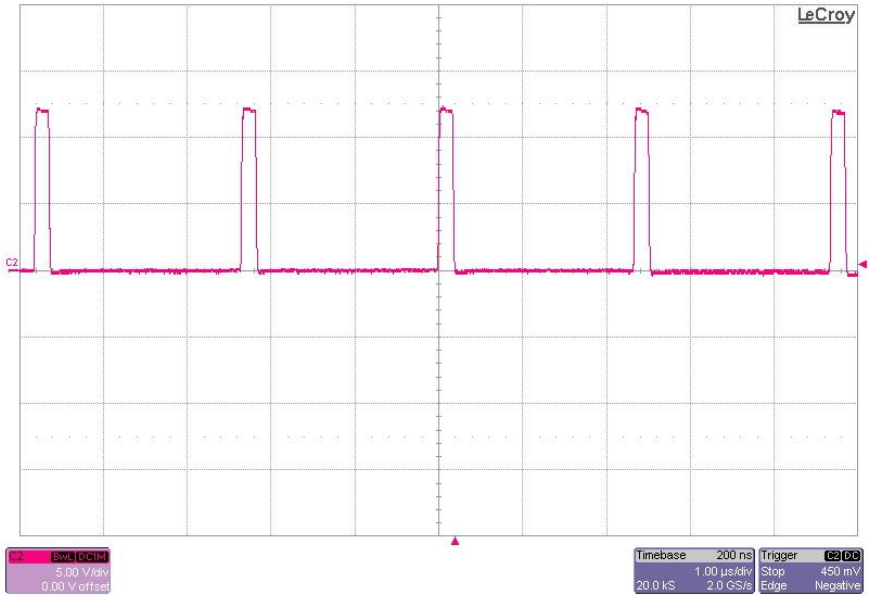
Rail 5

3. Switch Node

Rail 1 - No Load (with BWL)

The picture below shows the switching waveform for the converter without a load. The input voltage is 12V. The time-base is set to 1µs/Division.

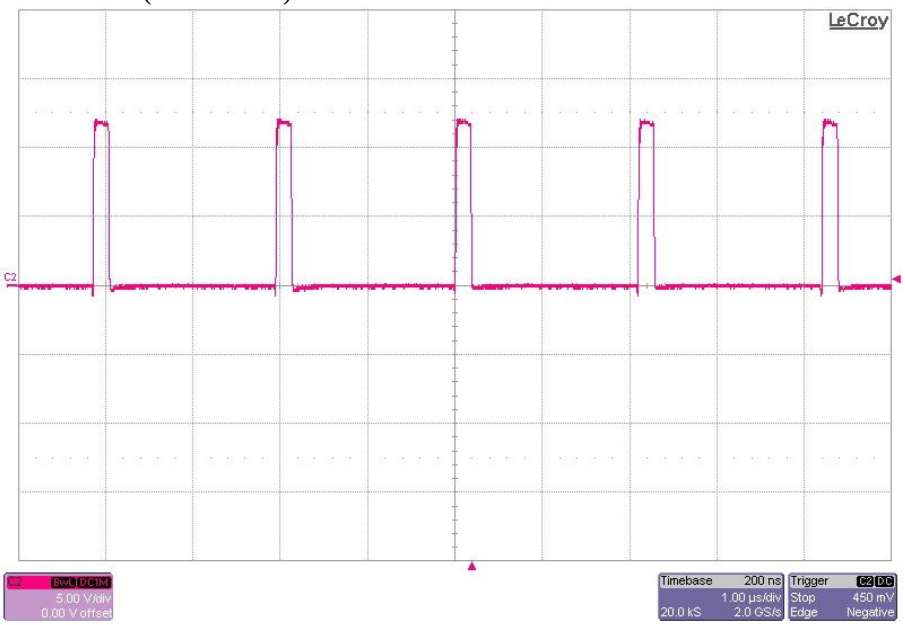
Channel 2 – Pink: Switch Node – (5V/Division)



Rail 1 - Full Load (with BWL)

The picture below shows the switching waveform for the converter without a load. The input voltage is 12V. The time-base is set to 1µs/Division. Switching frequency = 476.19 kHz.

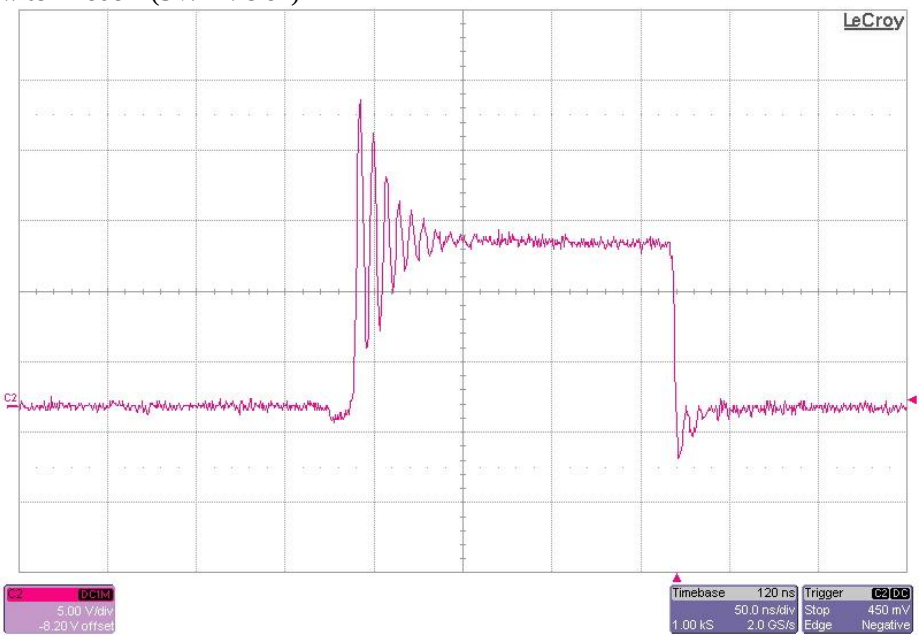
Channel 2 – Pink: Switch Node – (5V/Division)



Rail 1 – Ringing Full Load (without BWL)

The picture below shows the switching waveform for the converter without a load. The input voltage is 12V. The time-base is set to 50ns/Division. Max voltage = 21.1V

Channel 2 – Pink: Switch Node – (5V/Division)



Rail 2 – No Load (with BWL)

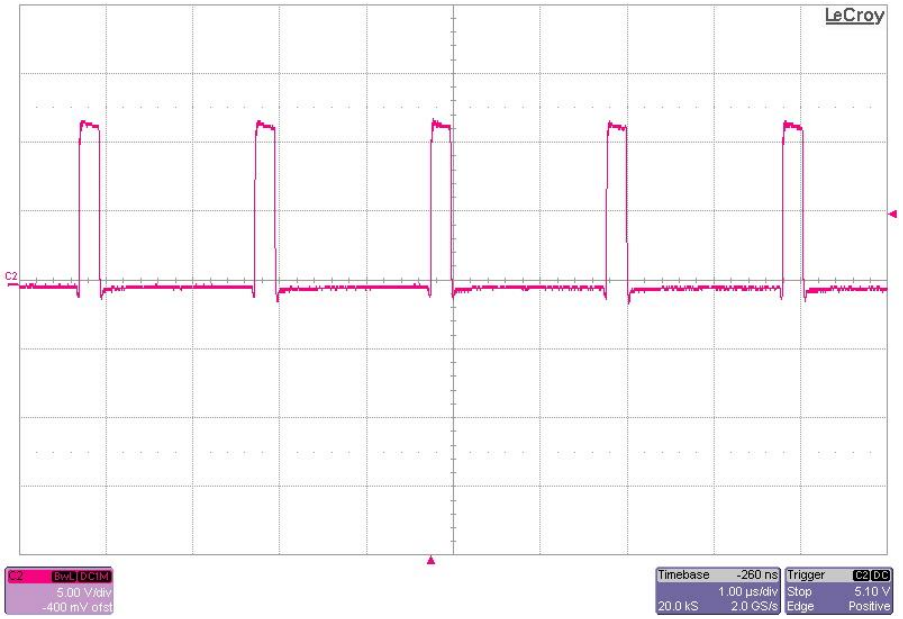
The picture below shows the switching waveform for the converter without a load. The input voltage is 12V. The time-base is set to 1µs/Division.

Channel 2 – Pink: Switch Node – (5V/Division)

Rail 2 – Full Load (with BWL)

The picture below shows the switching waveform for the converter without a load. The input voltage is 12V. The time-base is set to 1µs/Division. Switching frequency = 502.51 kHz.

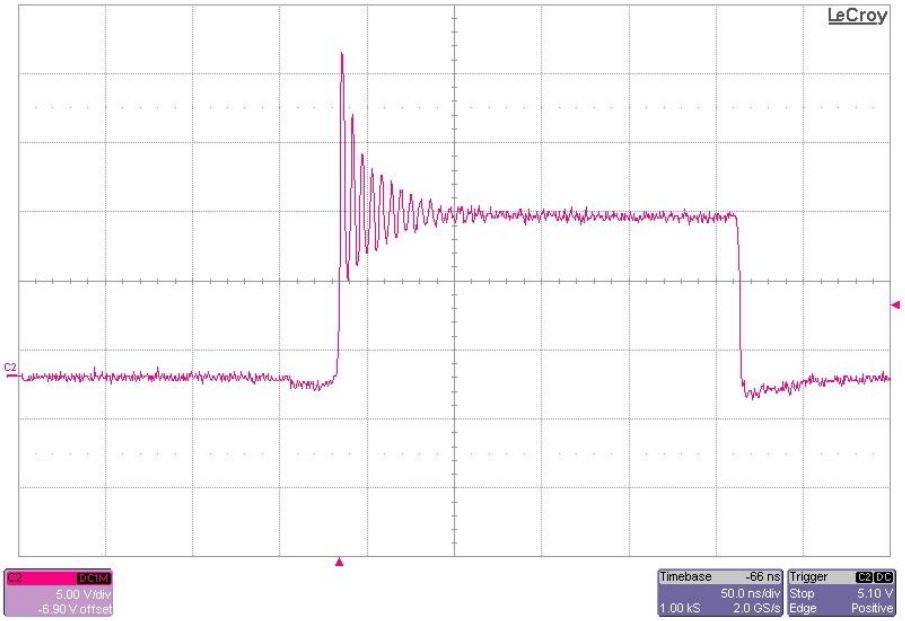
Channel 2 – Pink: Switch Node – (5V/Division)



Rail 2 – Ringing Full Load (without BWL)

The picture below shows the switching waveform for the converter without a load. The input voltage is 12V. The time-base is set to 50ns/Division. Max voltage = 22.8V

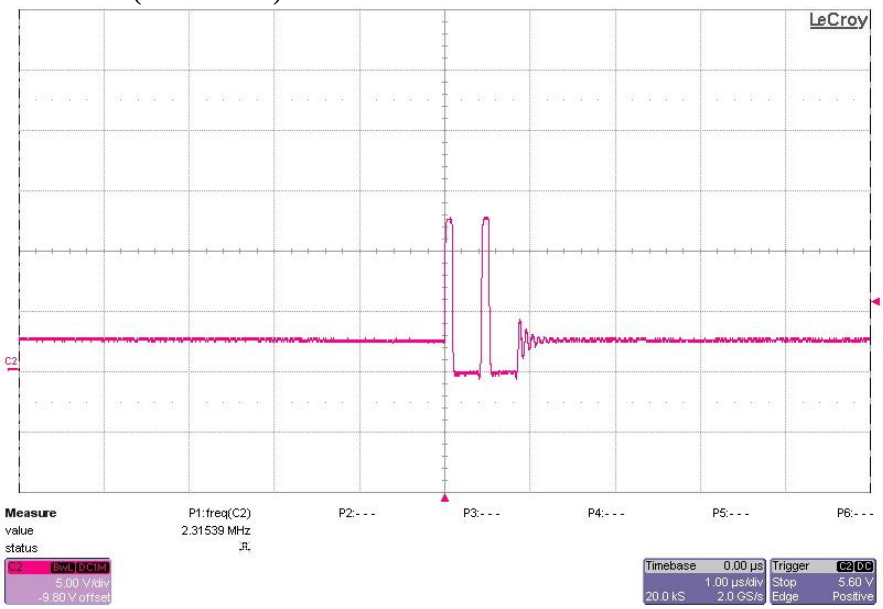
Channel 2 – Pink: Switch Node – (5V/Division)



Rail 3 – No Load (with BWL)

The picture below shows the switching waveform for the converter without a load. The input voltage is 12V. The time-base is set to 1µs/Division.

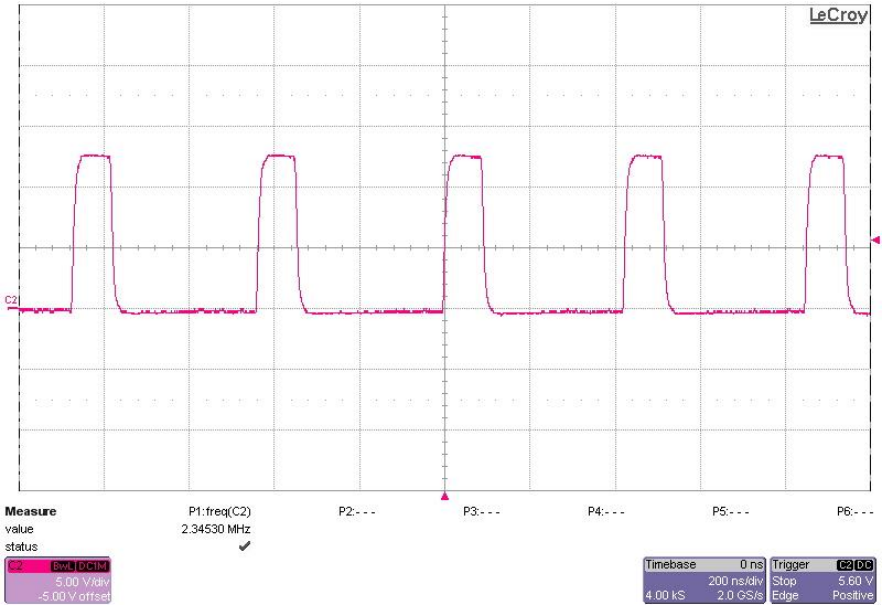
Channel 2 – Pink: Switch Node – (5V/Division)



Rail 3 – Full Load (with BWL)

The picture below shows the switching waveform for the converter without a load. The input voltage is 12V. The time-base is set to 200ns/Division. Switching Frequency = 2.345 MHz

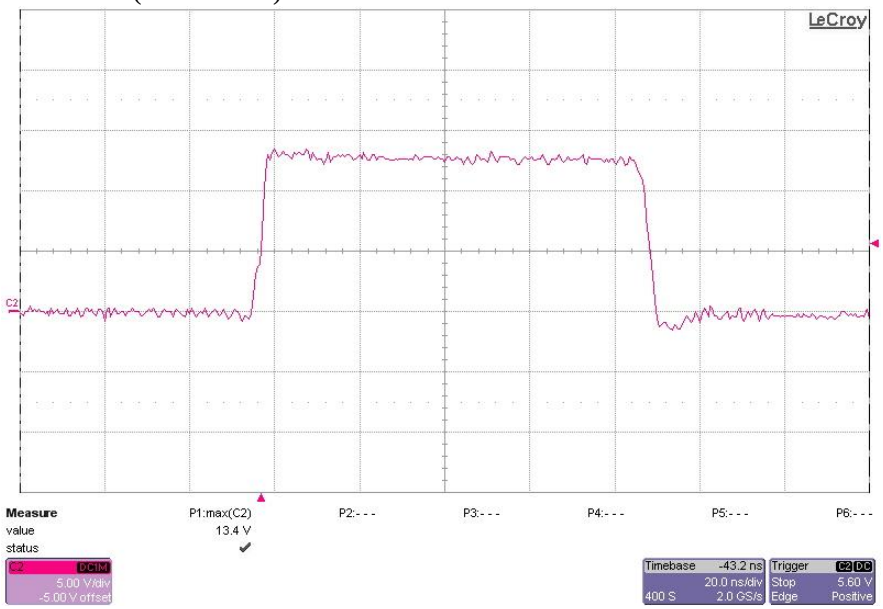
Channel 2 – Pink: Switch Node – (5V/Division)



Rail 3 – Ringing Full Load (without BWL)

The picture below shows the switching waveform for the converter without a load. The input voltage is 12V. The time-base is set to 20ns/Division. Max voltage = 13.4V

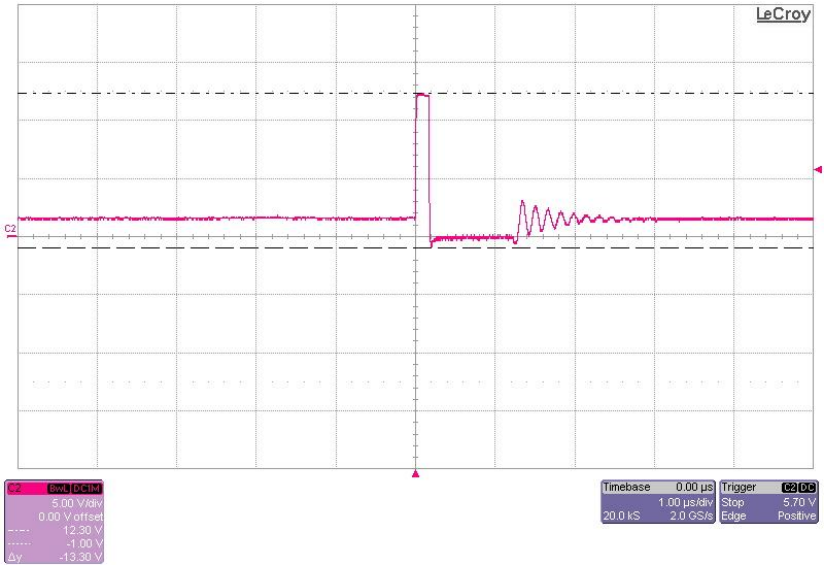
Channel 2 – Pink: Switch Node – (5V/Division)



Rail 4 – No Load (with BWL)

The picture below shows the switching waveform for the converter without a load. The input voltage is 12V. The time-base is set to 1µs/Division.

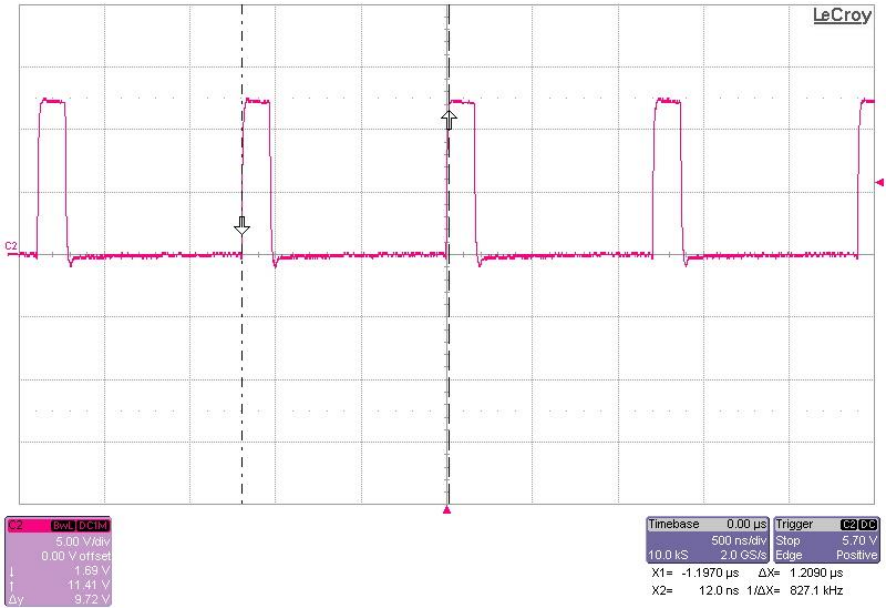
Channel 2 – Pink: Switch Node – (5V/Division)



Rail 4 – Full Load (with BWL)

The picture below shows the switching waveform for the converter without a load. The input voltage is 12V. The time-base is set to 500ns/Division. Switching Frequency = 827.1 kHz

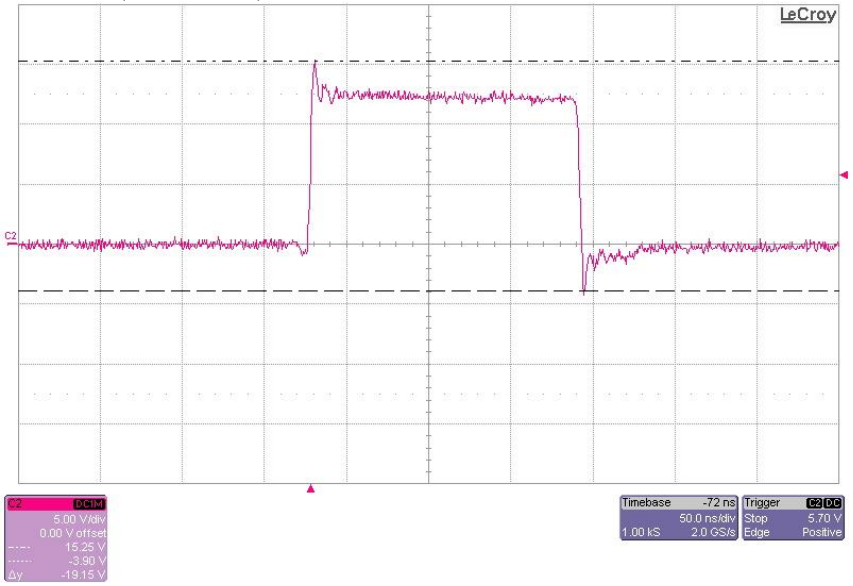
Channel 2 – Pink: Switch Node – (5V/Division)



Rail 4 – Ringing Full Load (without BWL)

The picture below shows the switching waveform for the converter without a load. The input voltage is 12V. The time-base is set to 50ns/Division. Max voltage = 15.2V

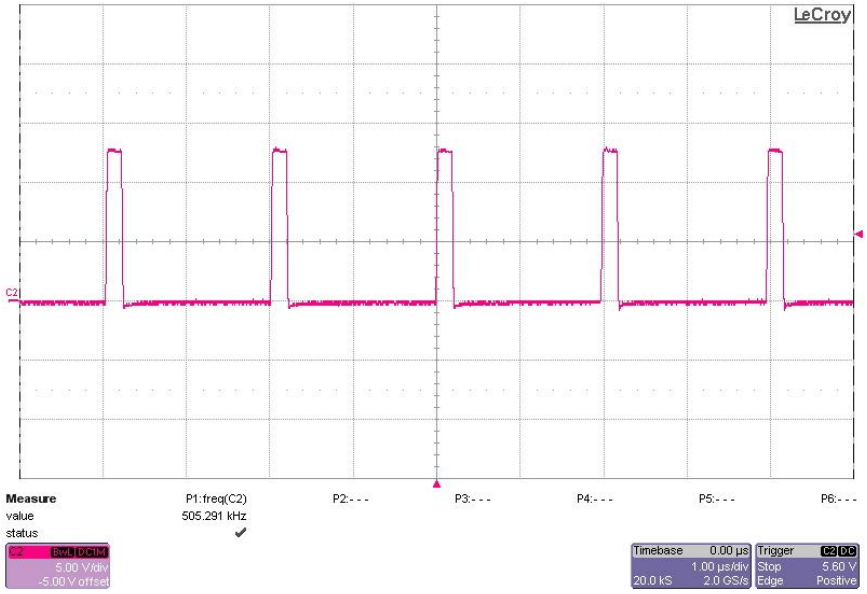
Channel 2 – Pink: Switch Node – (5V/Division)



Rail 5 – No Load (with BWL)

The picture below shows the switching waveform for the converter without a load. The input voltage is 12V. The time-base is set to 1µs/Division.

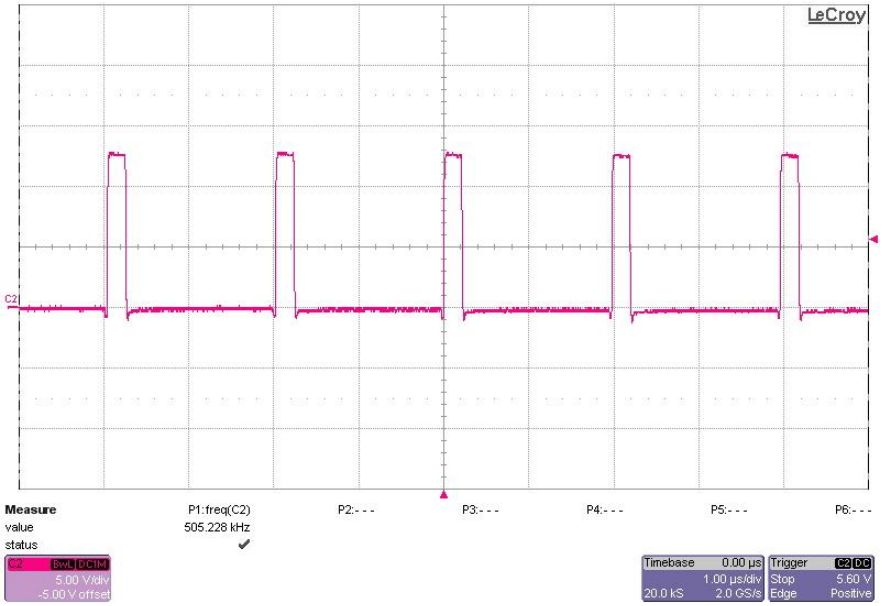
Channel 2– Pink: Switch Node – (5V/Division)



Rail 5 – Full Load (with BWL)

The picture below shows the switching waveform for the converter without a load. The input voltage is 12V. The time-base is set to 1µs/Division. Switching Frequency = 505.23 kHz

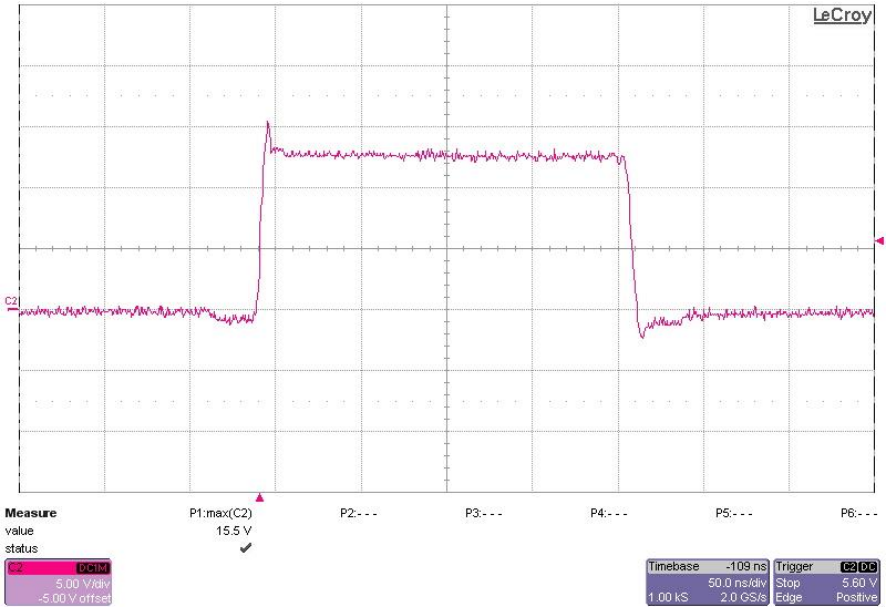
Channel 2 – Pink: Switch Node – (5V/Division)



Rail 5 – Ringing Full Load (without BWL)

The picture below shows the switching waveform for the converter without a load. The input voltage is 12V. The time-base is set to 50ns/Division. Max voltage = 15.5V

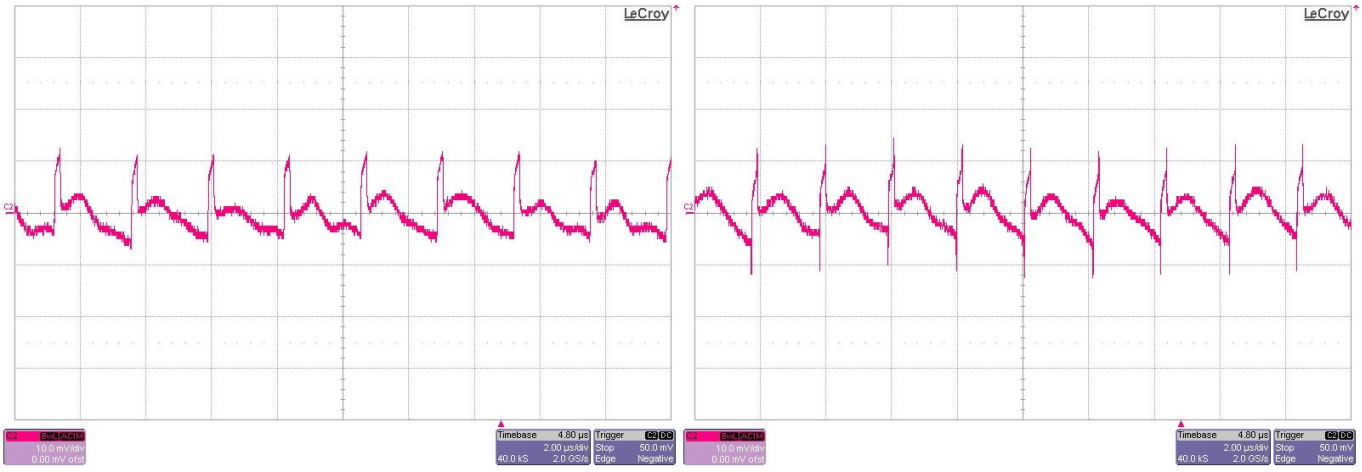
Channel 2 – Pink: Switch Node – (5V/Division)



4. Output Voltage Ripple (No Load and Full Load)

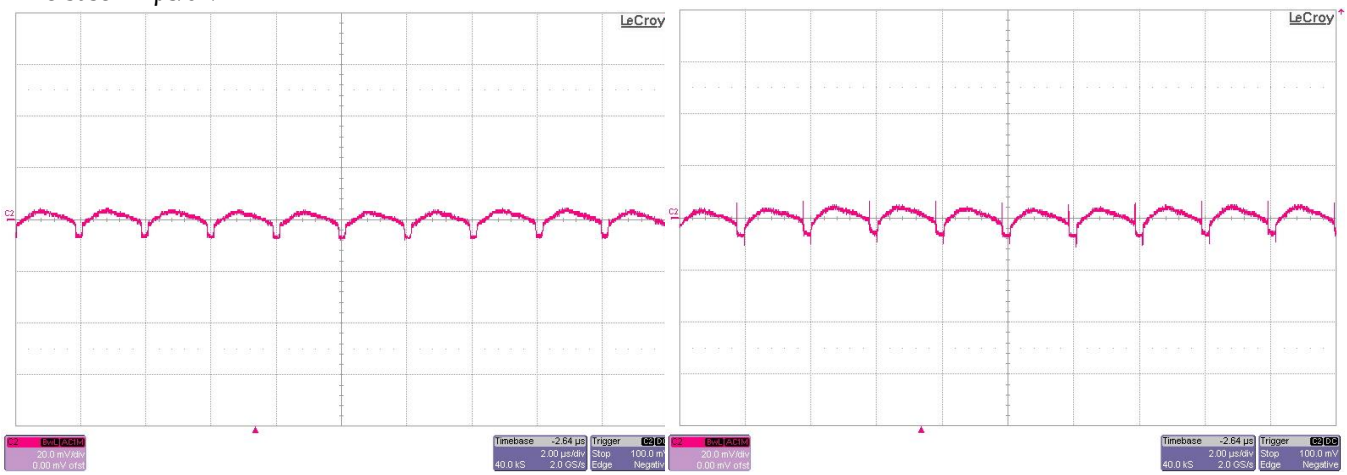
The output voltage ripple of the power rails is shown in the figures below. The input voltage is 12V.

Rail 1 - Channel 2 – Pink: Output Voltage (10mV/Division; AC Coupled)
Time base = 2µs/div



No Load Full Load

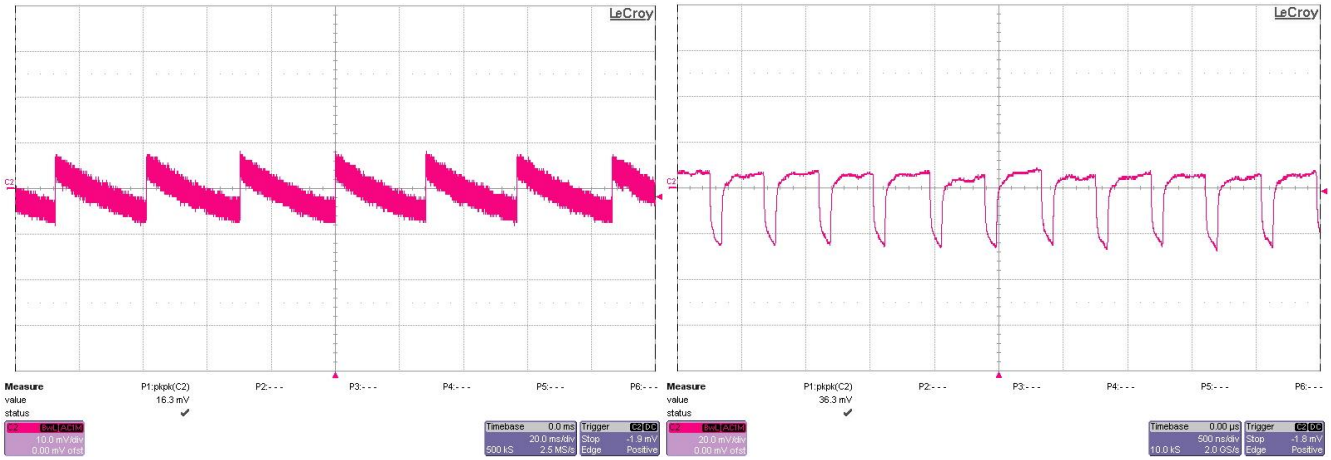
Rail 2 - Channel 2 – Pink: Output Voltage (20mV/Division; AC Coupled)
Time base = 2µs/div



No Load Full Load

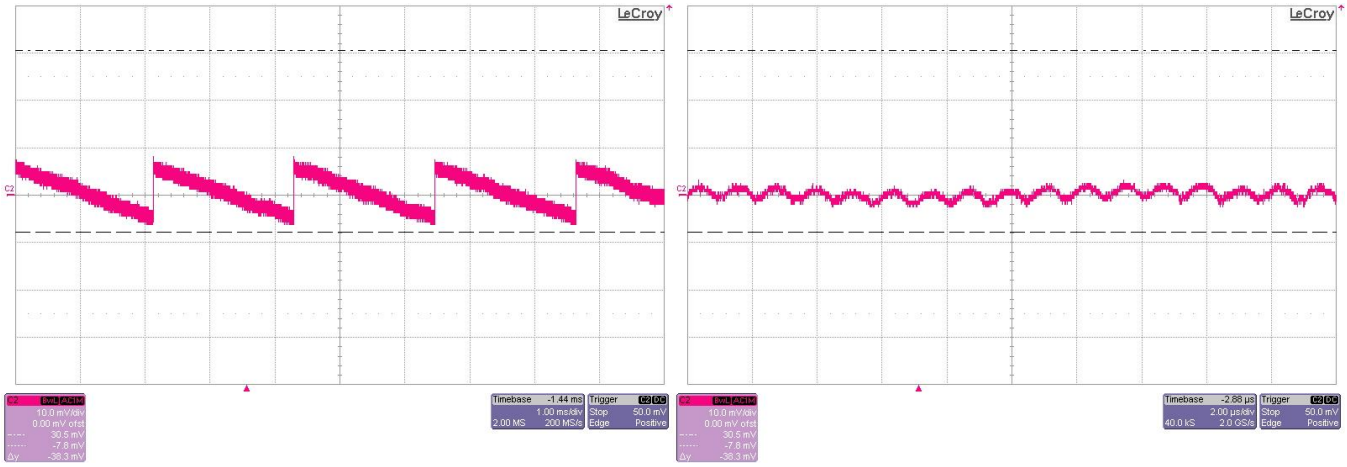
Rail 3 - Channel 2 – Pink: Output Voltage (10mV/Division; AC Coupled)
Time base = 20ms/div (left)

Channel 2 – Pink: Output Voltage (20mV/Division; AC Coupled)
Time base = 500ns/div (right)



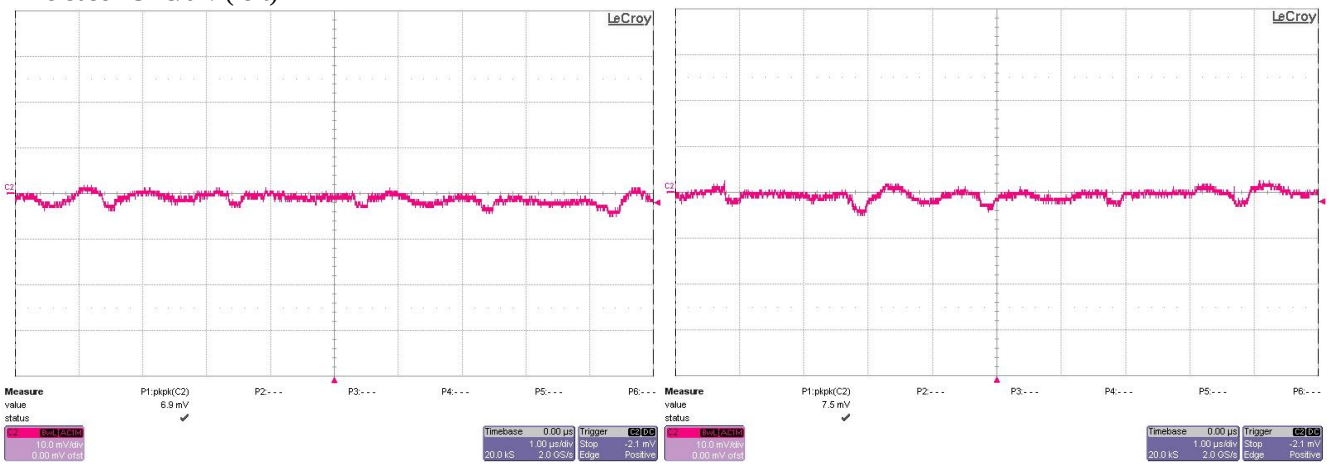
No Load Full Load

Rail 4 - Channel 2 – Pink: Output Voltage (10mV/Division; AC Coupled)
Time base =1ms/div (left)
Time base = 2µs/div (right)



No Load Full Load

Rail 5 - Channel 2 – Pink: Output Voltage (10mV/Division; AC Coupled)
Time base =5ms/div (left)

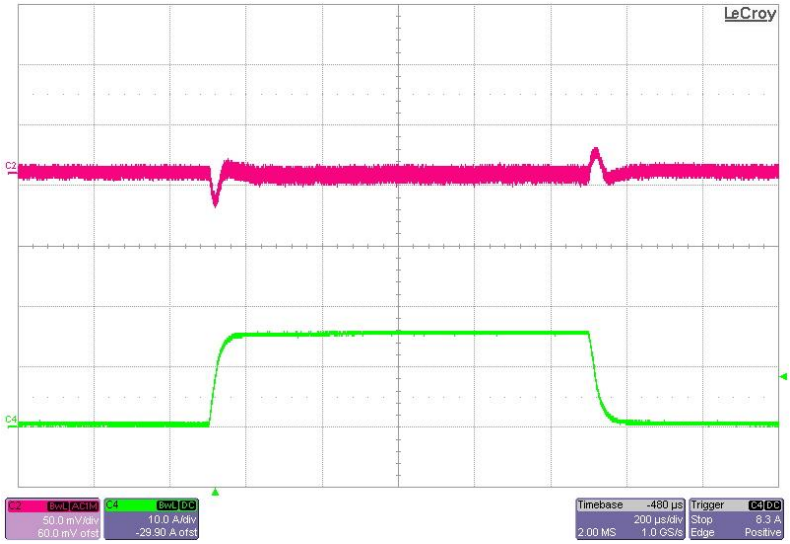


No Load Full Load

5. Transient Response

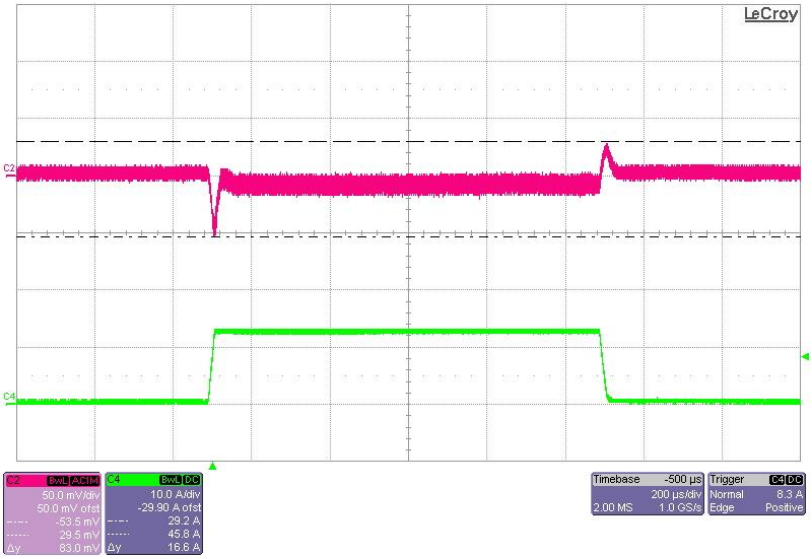
The transient response of the power rails from no load to full load is shown in the figures below. The input voltage is 12V.

Rail 1 - Channel 2 – Pink: Output Voltage (50mV/Division; AC Coupled)
Channel 4 – Green: Output Current (10A/division)
Time base = 200µs/div
Max deviation = 29mV = 2.55%



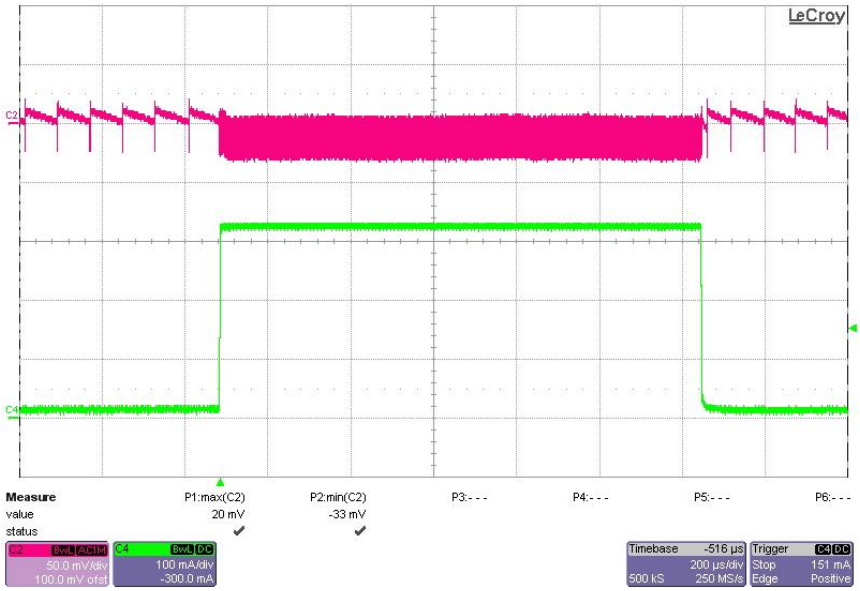
Rail 1

Rail 2 - Channel 2 – Pink: Output Voltage (50mV/Division; AC Coupled)
Channel 4 – Green: Output Current (10A/division)
Time base = 200µs/div
Max deviation = 53.5mV = 4.45%



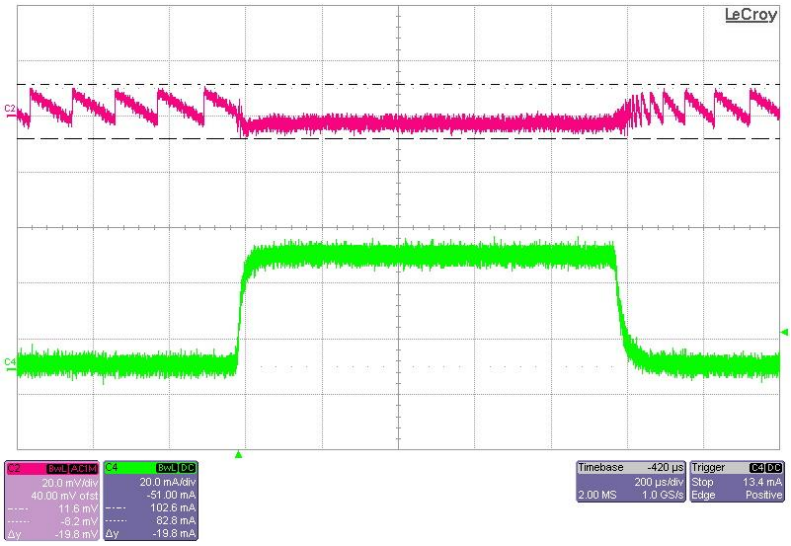
Rail 2

Rail 3 - Channel 2 – Pink: Output Voltage (50mV/Division; AC Coupled)
Channel 4 – Green: Output Current (100mA/division)
Time base = 200µs/div
Max deviation = 33mV = 1.32%



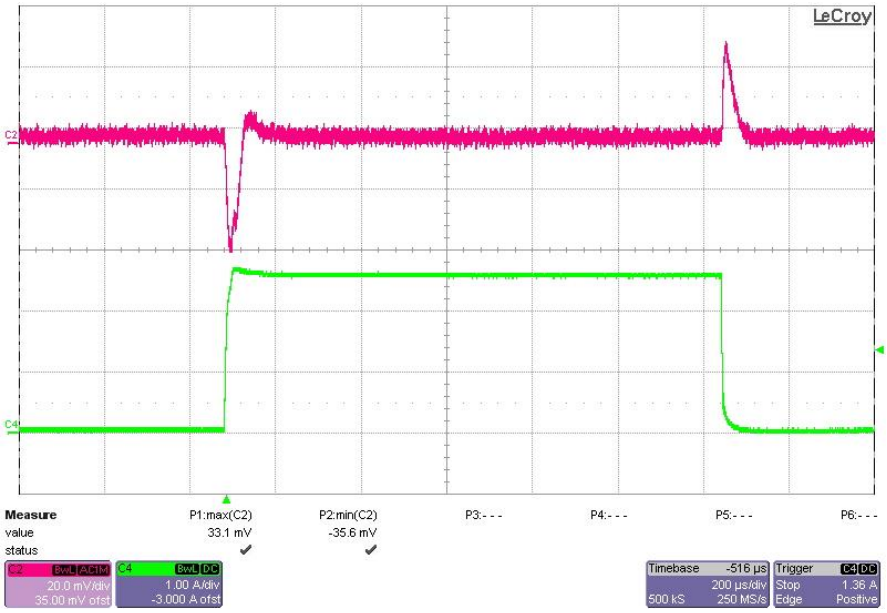
Rail 3

Rail 4 - Channel 2 – Pink: Output Voltage (50mV/Division; AC Coupled)
Channel 4 – Green: Output Current (20mA/division)
Time base = 200µs/div
Max deviation = 11.6mV = 0.77%



Rail 4

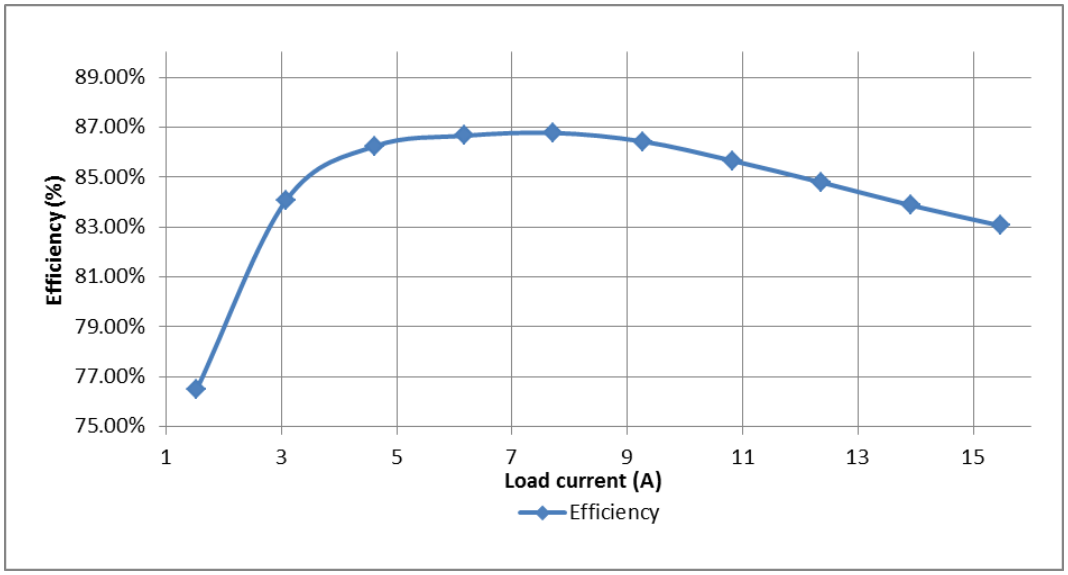
Rail 5 - Channel 2 – Pink: Output Voltage (20mV/Division; AC Coupled)
Channel 4 – Green: Output Current (1A/division)
Time base = 200µs/div
Max deviation = 35.6mV = 2.97%



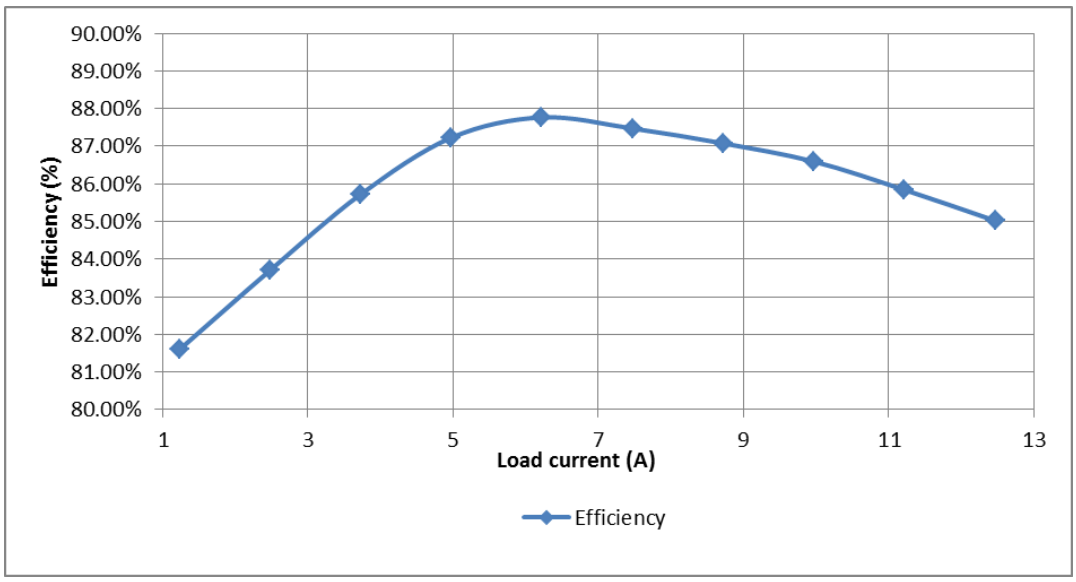
Rail 5

6. Efficiency

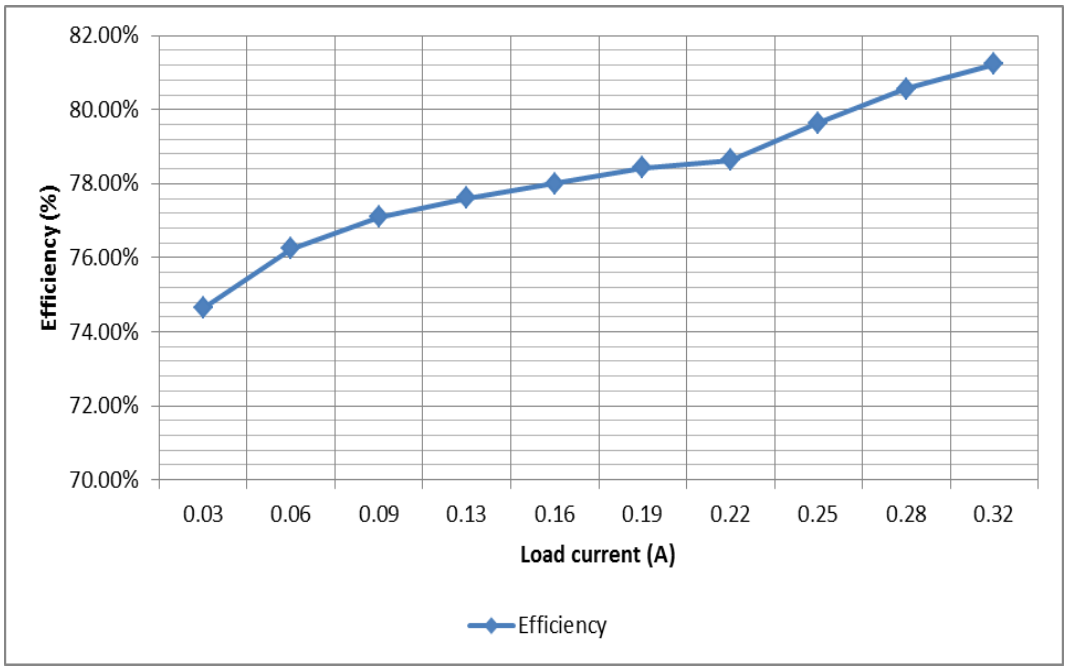
The figures below highlight efficiency data of each power rail from 10% load to full load.



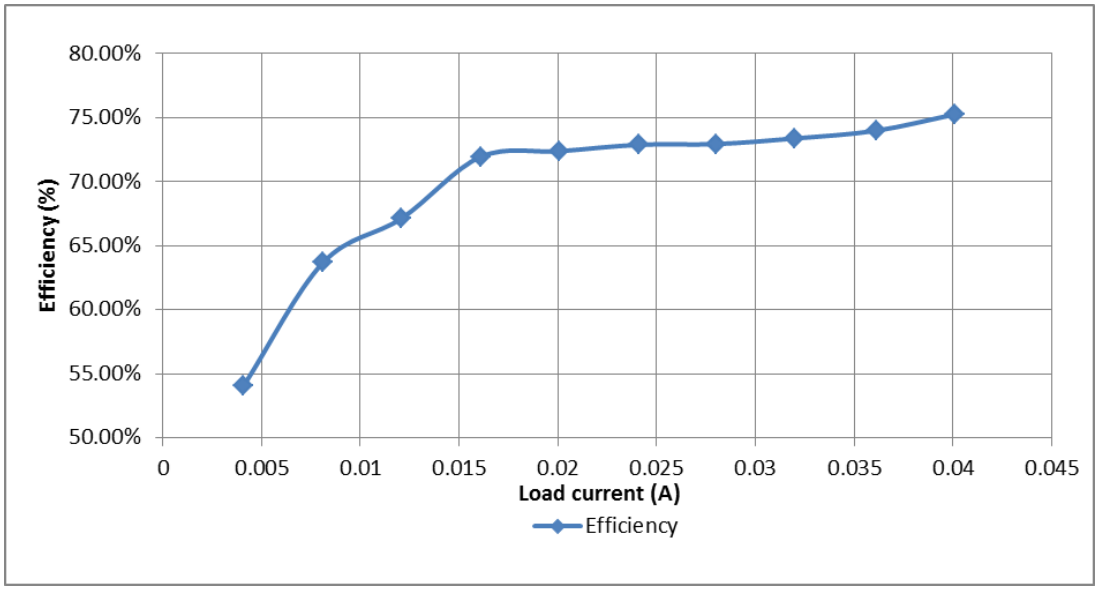
Rail 1


90.00%
89.00%
88.00%
87.00%
86.00%
85.00%
84.00%
83.00%
82.00%
81.00%
80.00%
Efficiency (%)
1
3
5
7
9
11
13
Load current (A)
Efficiency

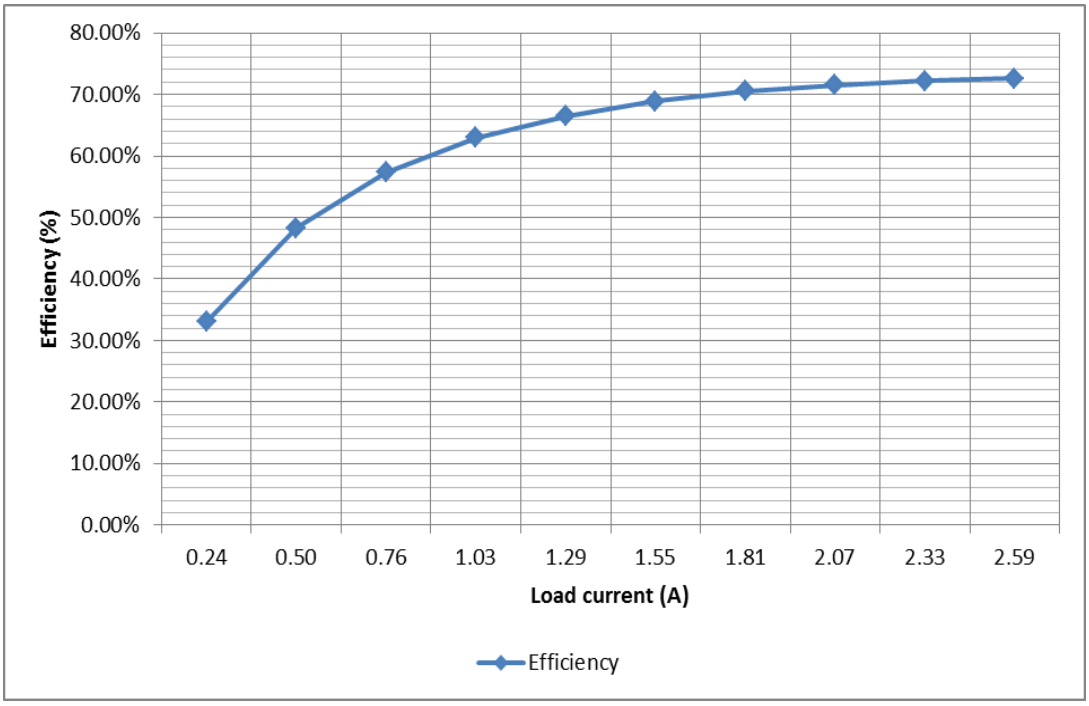
Rail 2


82.00%
80.00%
78.00%
76.00%
74.00%
72.00%
70.00%
Efficiency (%)
0.03
0.06
0.09
0.13
0.16
0.19
0.22
0.25
0.28
0.32
Load current (A)
Efficiency

Rail 3


80.00%
75.00%
70.00%
65.00%
60.00%
55.00%
50.00%
Efficiency (%)
0
0.005
0.01
0.015
0.02
0.025
0.03
0.035
0.04
0.045
Load current (A)
Efficiency

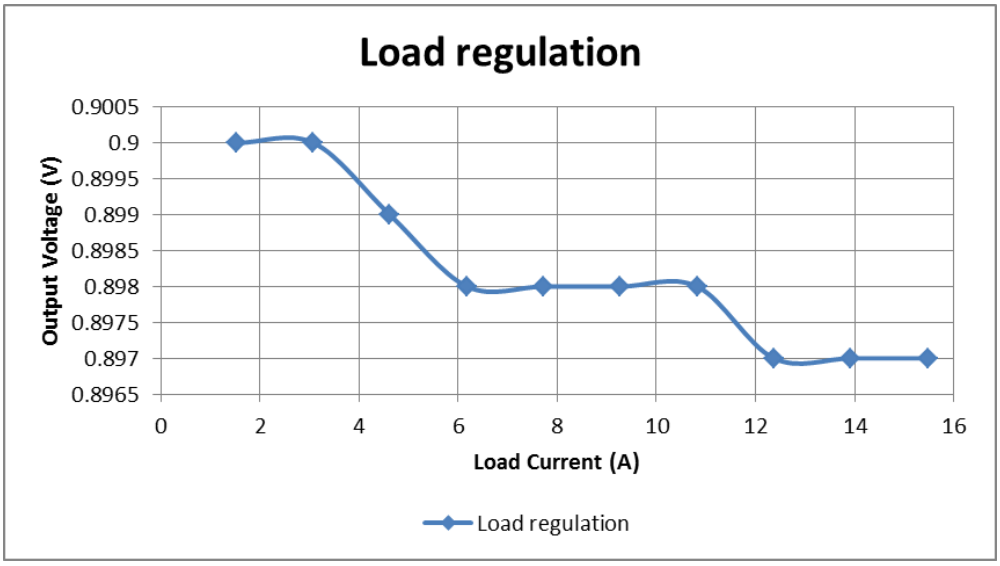
Rail 4


80.00%
70.00%
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
Efficiency (%)
0.24
0.50
0.76
1.03
1.29
1.55
1.81
2.07
2.33
2.59
Load current (A)
Efficiency

Rail 5

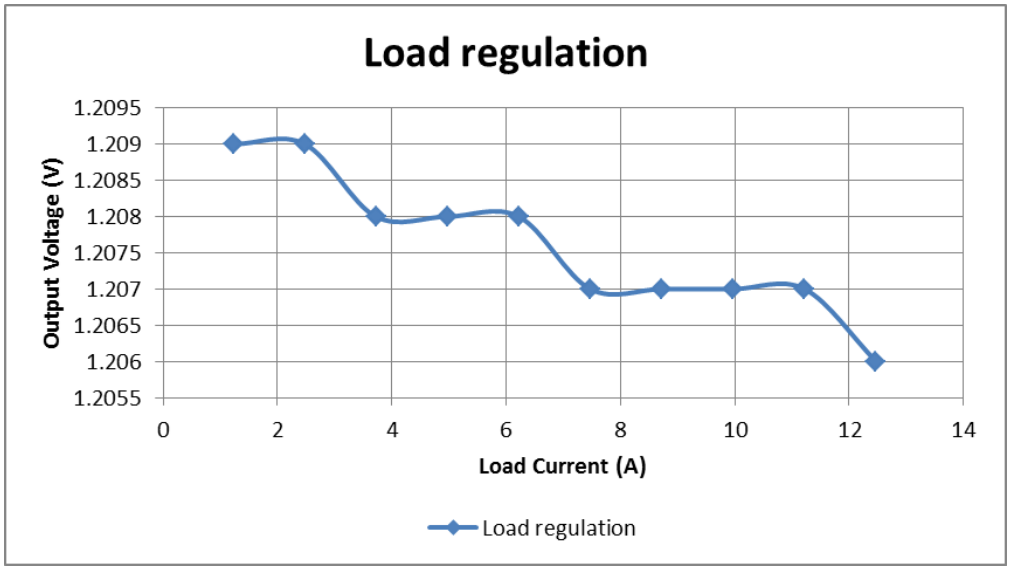
7. Load Regulation

The figures below show output voltage variation of the power rails from no load to full load.



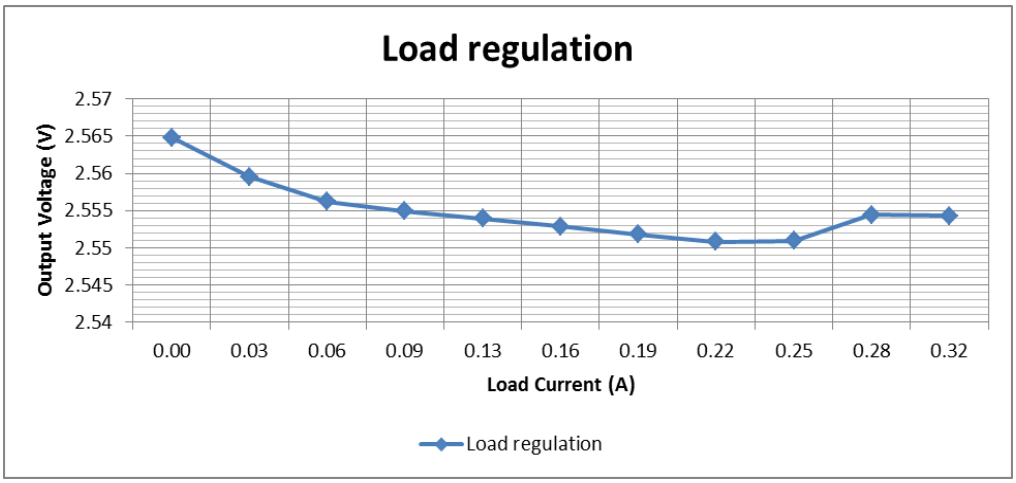
Rail 1

Voltage at full load = 0.897V
Rail 1 load regulation at full load = 0.3%



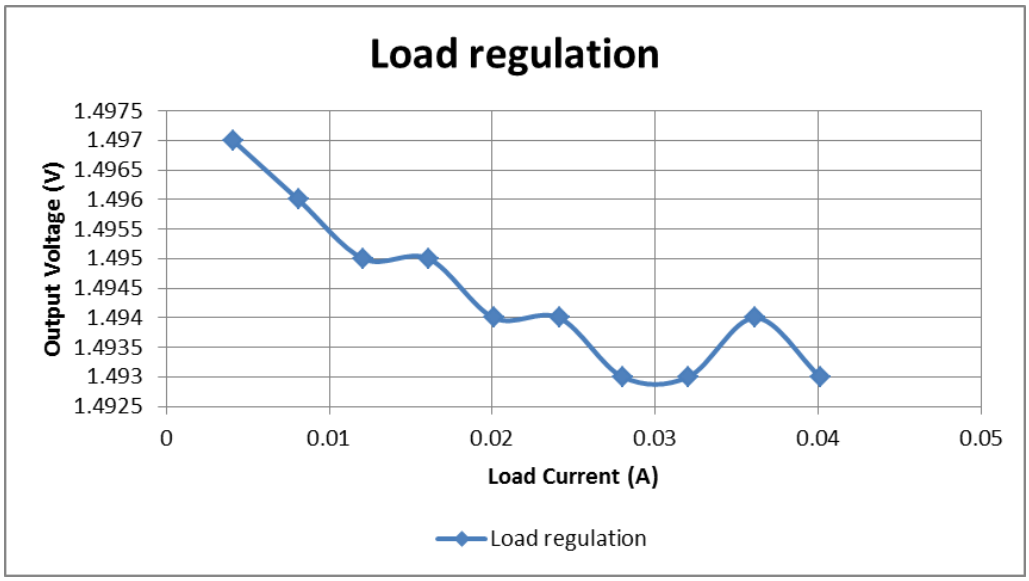
Rail 2

Voltage at full load = 1.206V
Rail 2 load regulation at full load = 0.24%



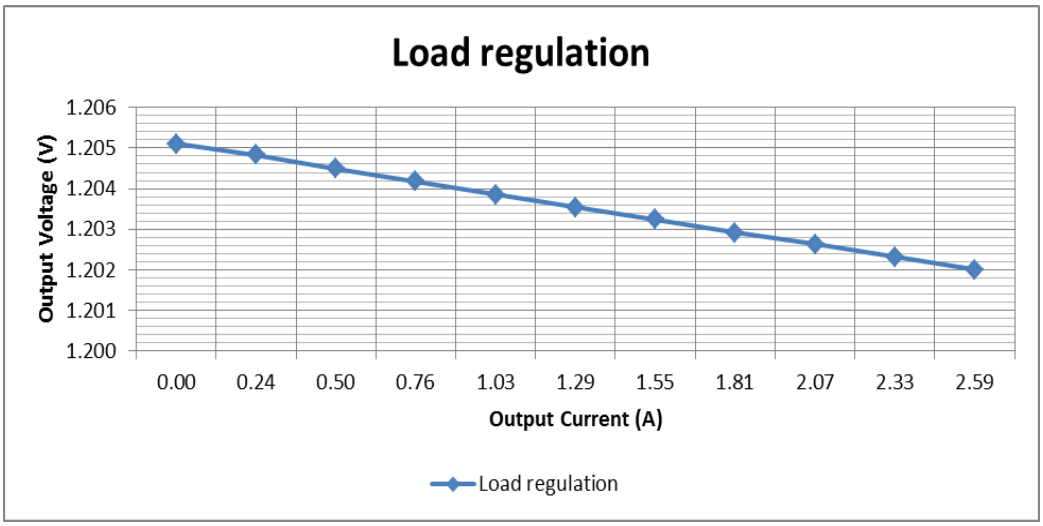
Rail 3

Voltage at no load = 2.56V
Rail 3 load regulation at no load = 2.59%



Rail 4

Voltage at full load = 1.493V
Rail 4 load regulation at full load = 0.53%

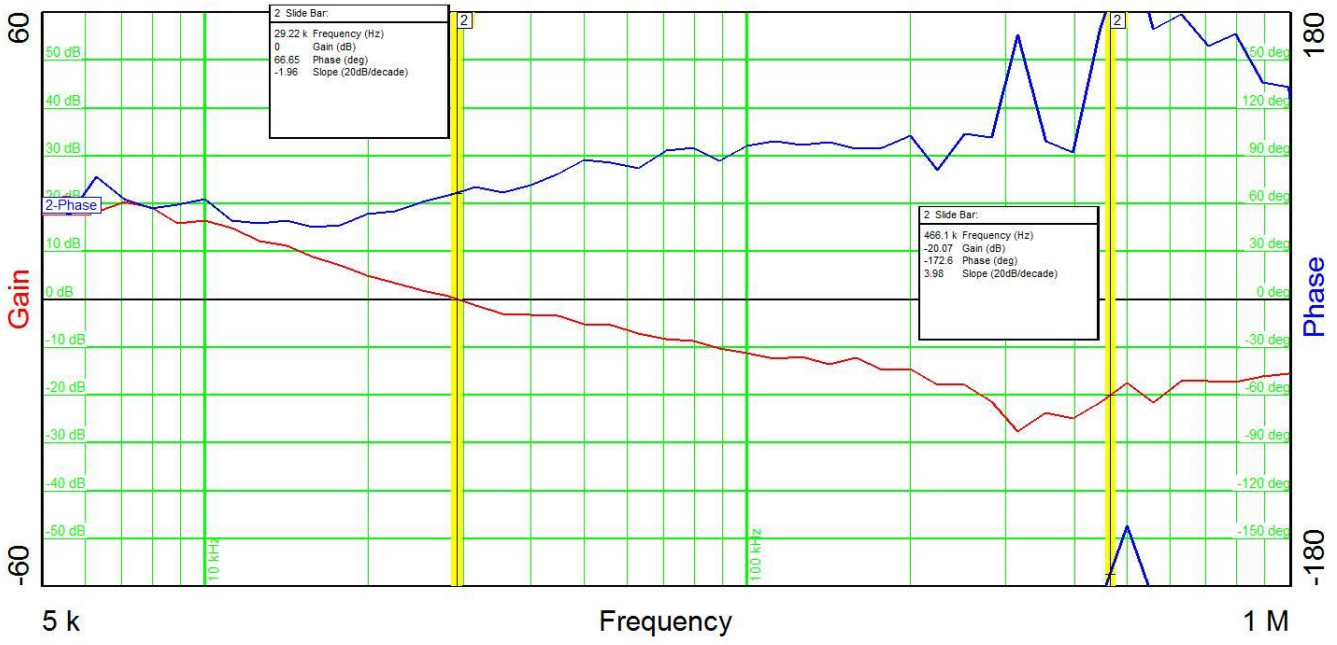


Rail 5

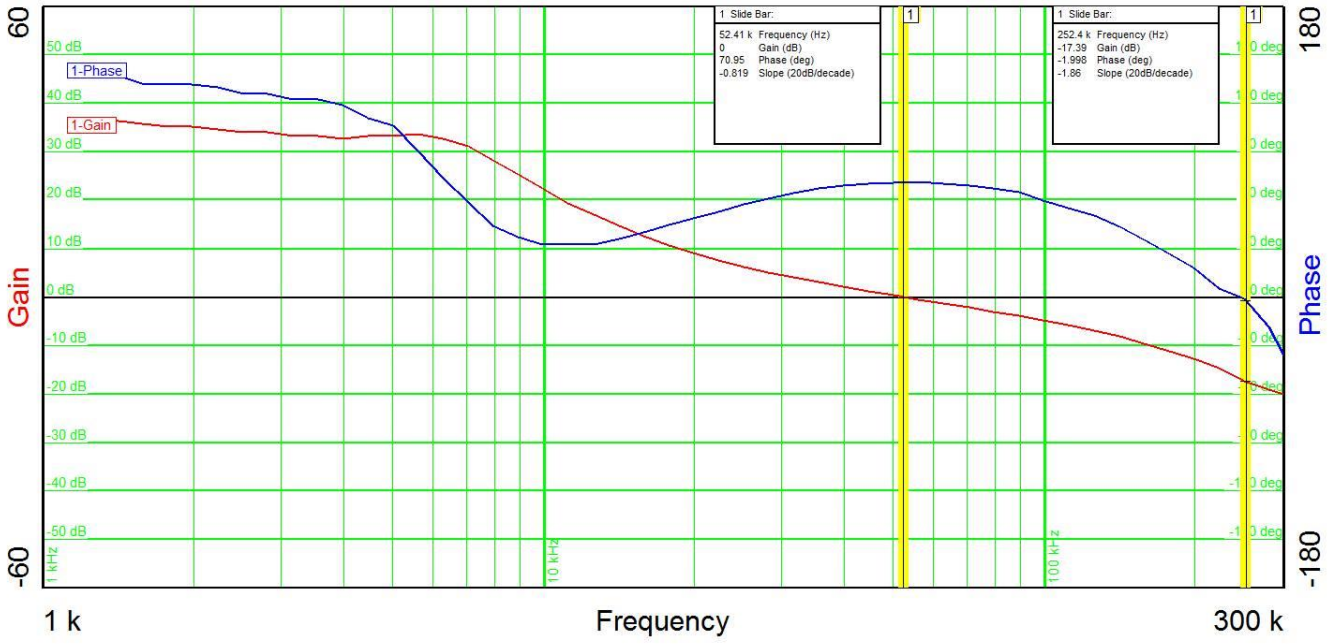
Voltage at no load = 1.205V
Rail 5 load regulation at no load = 0.42%

8. Gain and Phase

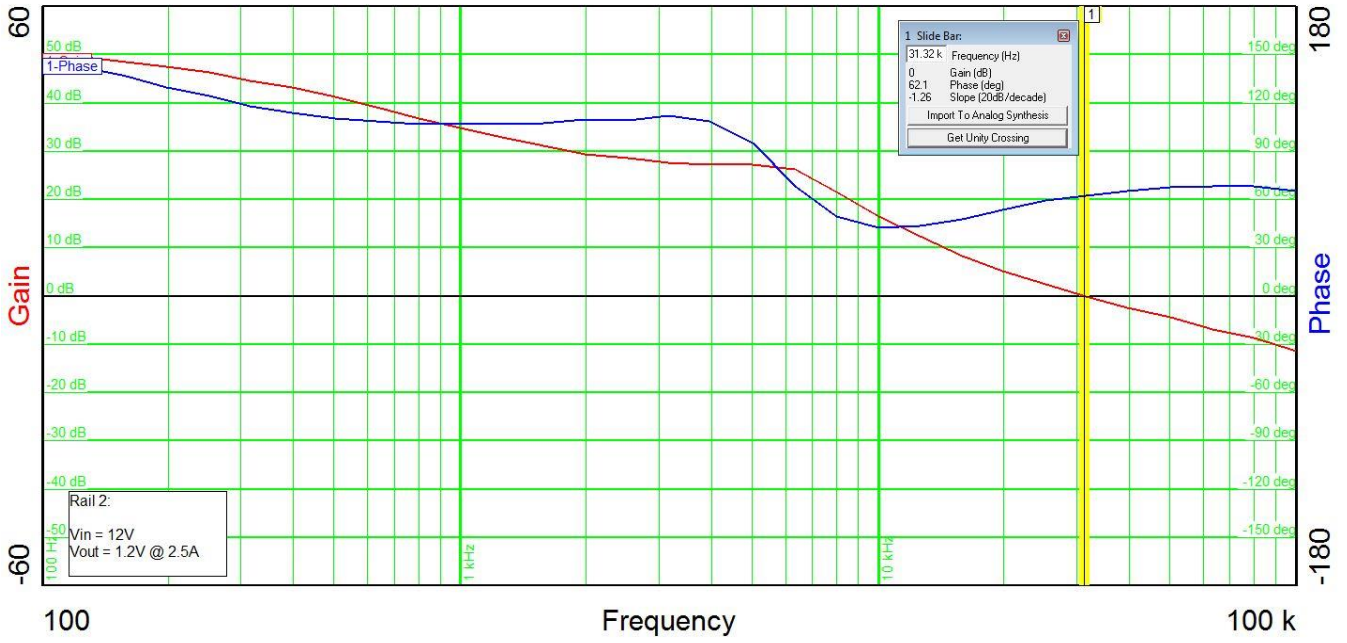
Gain and phase measurements performed for power rails with voltage mode and current mode compensation only.



Rail 1


1 Slide Bar:
52.41 k Frequency (Hz)
0 Gain (dB)
70.95 Phase (deg)
-0.819 Slope (20dB/decade)
1 Slide Bar:
252.4 k Frequency (Hz)
-17.39 Gain (dB)
-1.998 Phase (deg)
-1.86 Slope (20dB/decade)
1-Phase
1-Gain
60
50 dB
40 dB
30 dB
20 dB
10 dB
0 dB
-10 dB
-20 dB
-30 dB
-40 dB
-50 dB
-60
Gain
180
0 deg
-180
Phase
1 kHz
10 kHz
100 kHz
1 k
Frequency
300 k

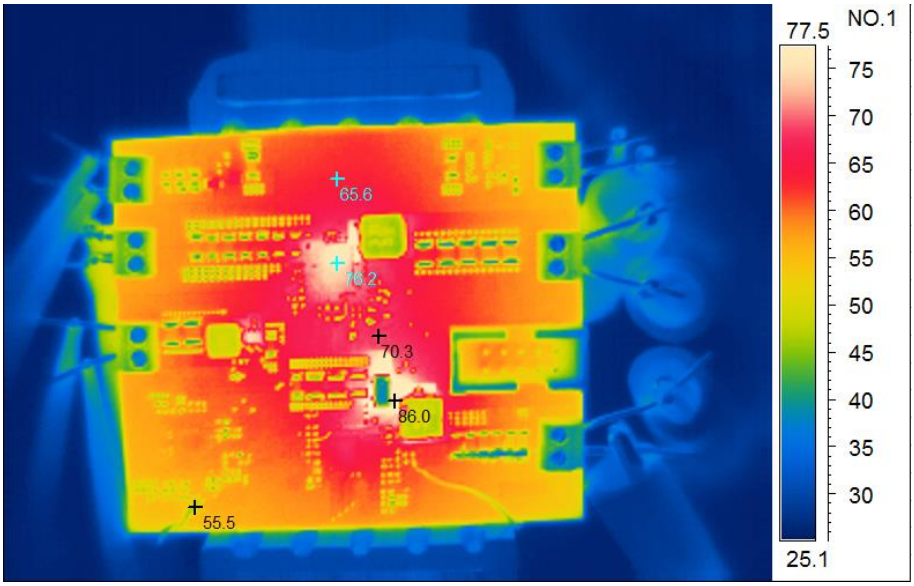
Rail 2


1 Slide Bar:
31.32 k Frequency (Hz)
0 Gain (dB)
62.1 Phase (deg)
-1.26 Slope (20dB/decade)
Import To Analog Synthesis
Get Unity Crossing
1-Phase
60
50 dB
40 dB
30 dB
20 dB
10 dB
0 dB
-10 dB
-20 dB
-30 dB
-40 dB
-50 dB
-60
Gain
180
150 deg
120 deg
90 deg
60 deg
30 deg
0 deg
-30 deg
-60 deg
-90 deg
-120 deg
-150 deg
-180
Phase
Rail 2:
Vin = 12V
Vout = 1.2V @ 2.5A
100 Hz
1 kHz
10 kHz
100
Frequency
100 k

Rail 5

9. Thermal Images

The figure below shows a thermal capture of the board with all power rails running at full load.



Circuit Element	Temperature at Full Load (C)
Rail 1 – IC	76.2
Rail 1 – Inductor	52.3
Rail 2 – IC	61.7
Rail 2 – Inductor	53.1
Rail 2 - FETs	86.0
Rail 3 – IC	32.8
Rail 3 – Inductor	33.6
Rail 4 – IC	30.3
Rail 4 – Inductor	26.6
Rail 5 – IC	31.5
Rail 5 – Inductor	34.7
Rail 5 - FETs	40.3

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