

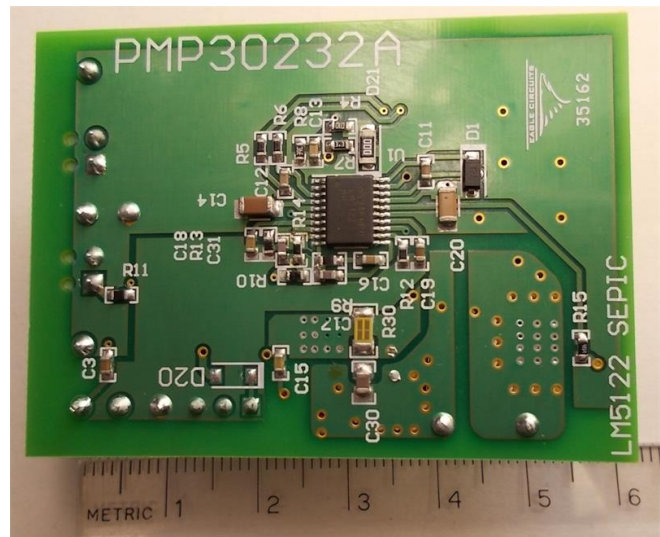
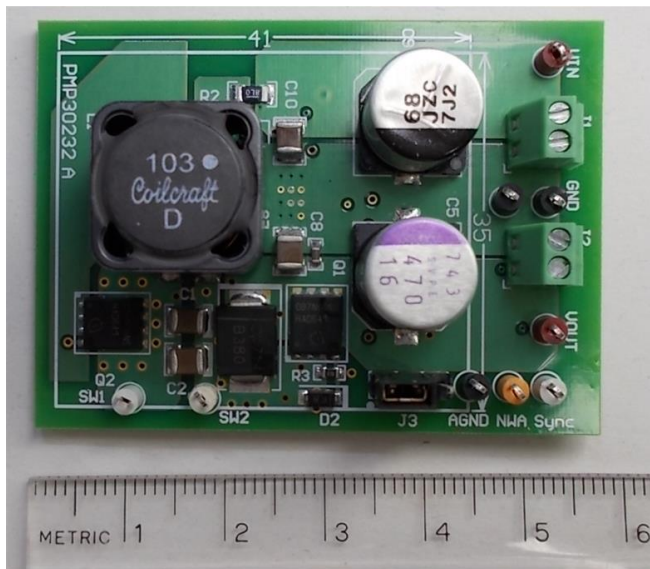
Test Report: PMP30491

Tiny SEPIC Reference Design With 12-V/ 2.5-A Output



Description

This reference design uses the LM5122 device. The output voltage is 12 V and has a 3-A_{max} output current. The input voltage range is from 6 V to 12 V. The circuit is designed to withstand input voltages as low as 5 V (automotive cranking) and load dump up to 36 V. Switching frequency (F_{sw}) has been measured for this board at 210 kHz.



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1 Test Prerequisites

1.1 Voltage and Current Requirements

Table 1. Voltage and Current Requirements

PARAMETER	SPECIFICATIONS
V_{IN}	6 V - 18 V
V_{OUT}	12 V
I_{OUT}	2.5 A _{cont} / 3 A _{max}

1.2 Considerations

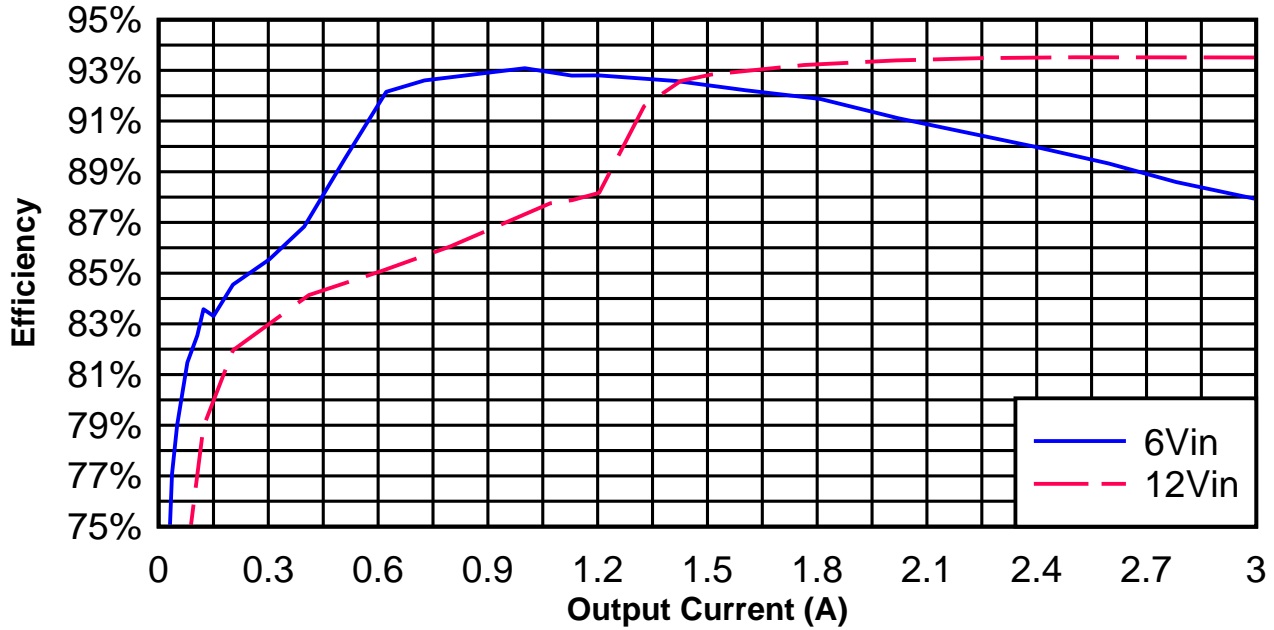
The switching frequency is approximately 210 kHz. With an output current of 1.13 A, the circuit switches on at 5.99 V and switches off at 4.78 V. All measurements were done using the MODE diode emulation that improves light load efficiency (LLE).

The output current was adjusted to a full load of 3 A with the resistor as the load.

2 Testing and Results

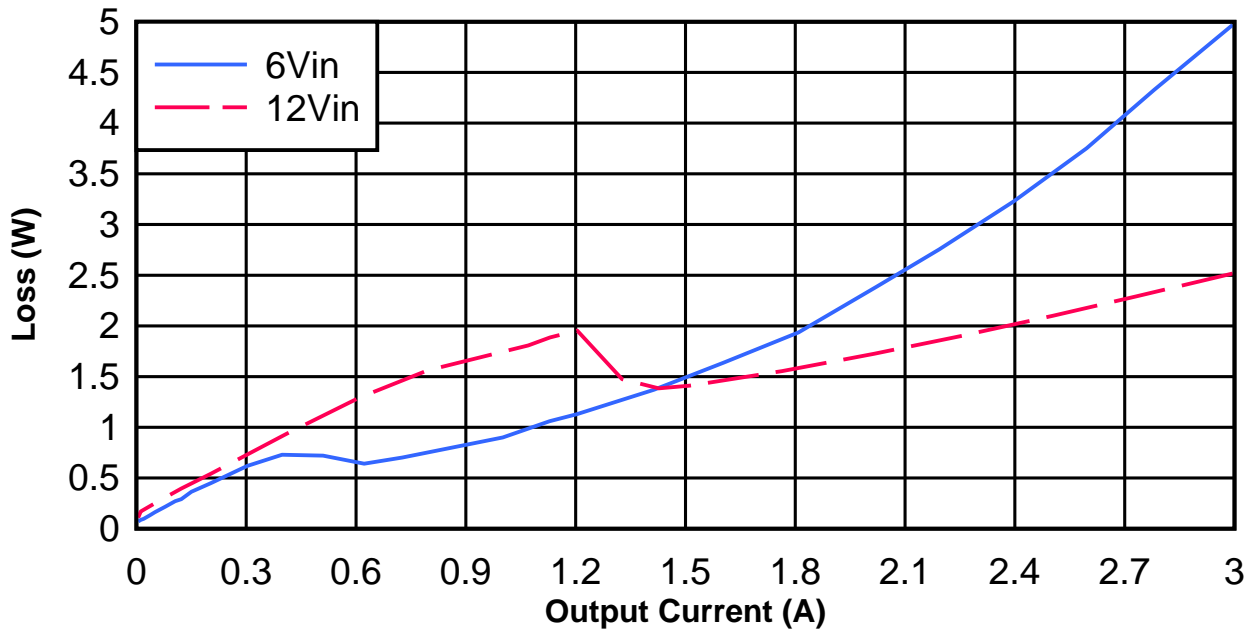
2.1 Efficiency Graphs

Figure 1. Efficiency vs Output Current



D001

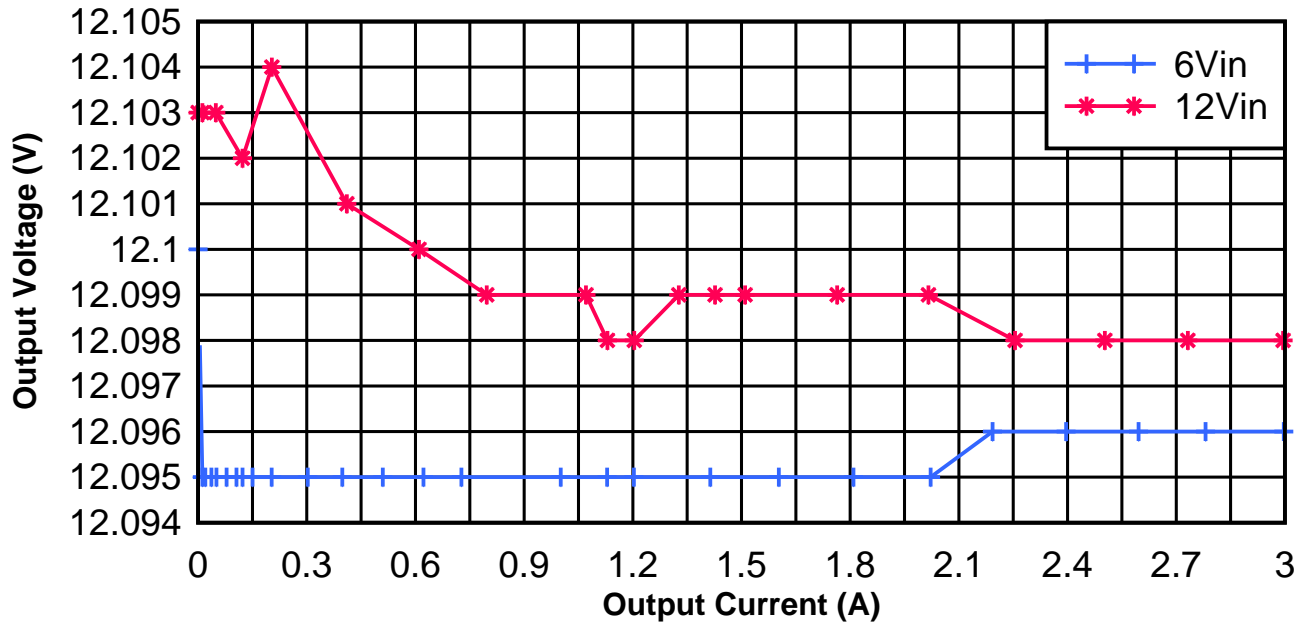
Figure 2. Loss vs Output Current



D002

2.2 Load Regulation

Figure 3. Output Current vs Output Voltage



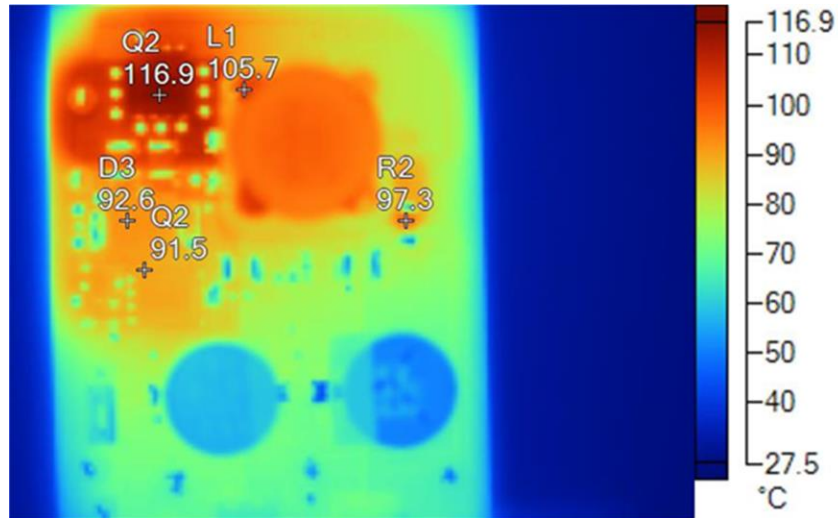
D003

2.3 Thermal Images

2.3.1 6-V Input Voltage

Figure 4 shows the thermal image at 6-V input voltage and 3-A output current. This enables short-term cranking of less than 60 seconds. This measurement was taken after 30 minutes of operation.

Figure 4. 6 V_{in} / 3-A_{max} Output

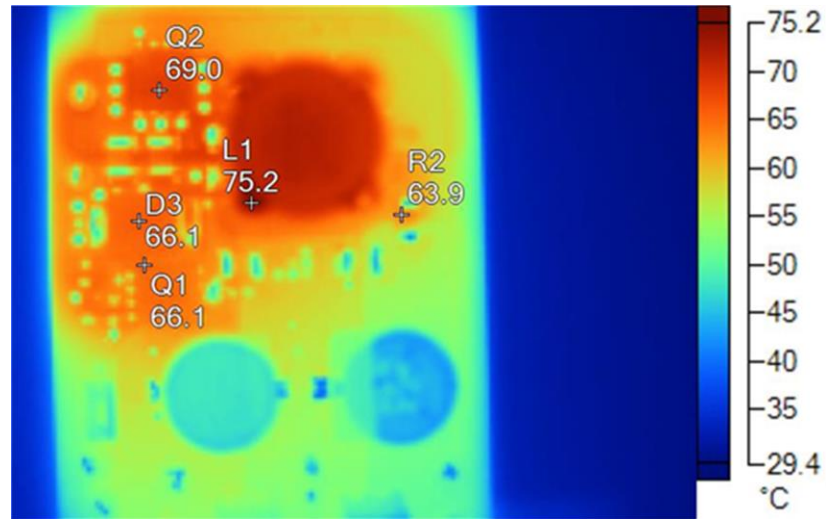


NAME	TEMPERATURE
D3	92.6°C
L1	105.7°C
Q2	116.9°C
Q2	91.5°C
R2	97.3°C

2.3.2 12-V Input Voltage

2.3.2.1 3-A Output Current

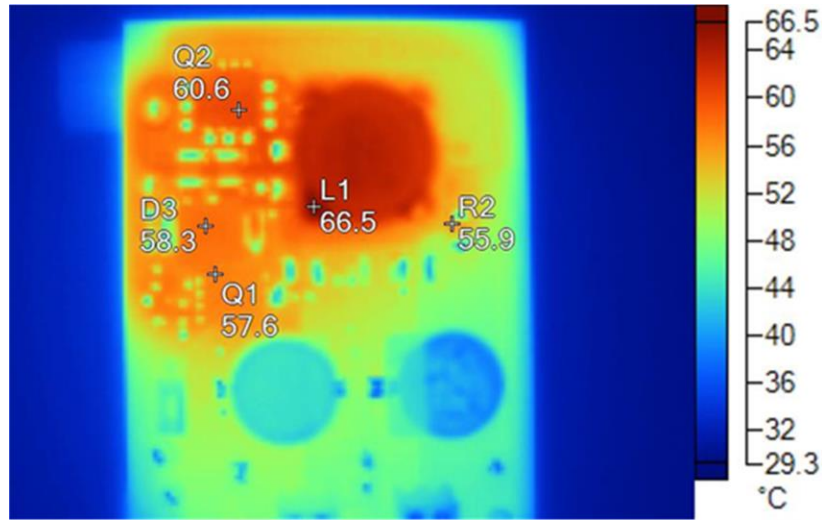
Figure 5. 12 V_{in} at 3-A_{max} Output



NAME	TEMPERATURE
D3	66.1°C
L1	75.2°C
Q1	66.1°C
Q2	69.0°C
R2	63.9°C

2.3.2.2 2.5-A Output Current

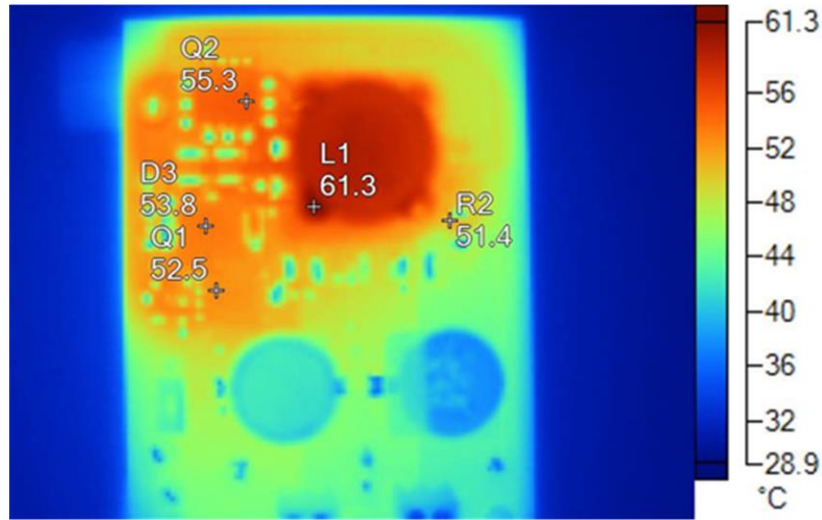
Figure 6. 12 V_{in} at 2.5 A_{out}



NAME	TEMPERATURE
D3	58.3°C
L1	66.5°C
Q1	57.6°C
Q2	60.6°C
R2	55.9°C

2.3.2.3 2-A Output Current

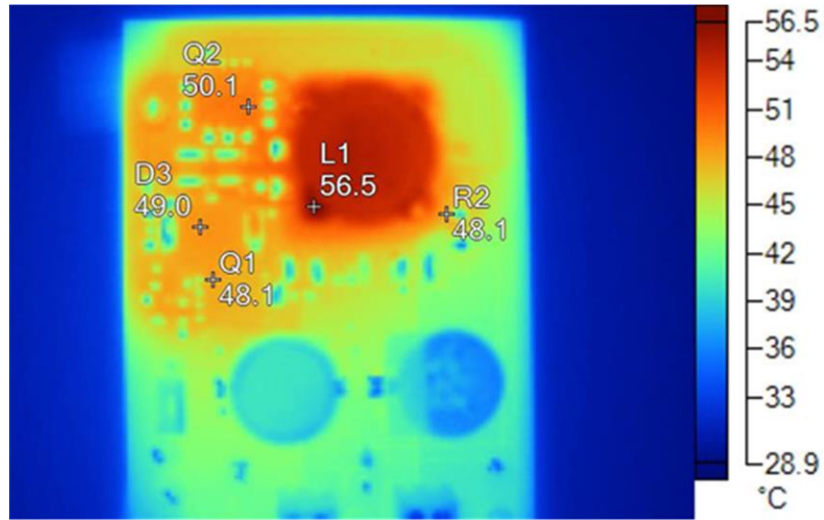
Figure 7. 12 V_{in} at 2 A_{out}



NAME	TEMPERATURE
D3	53.8°C
L1	61.3°C
Q1	52.5°C
Q2	55.3°C
R2	51.4°C

2.3.2.4 1.5-A Output Current

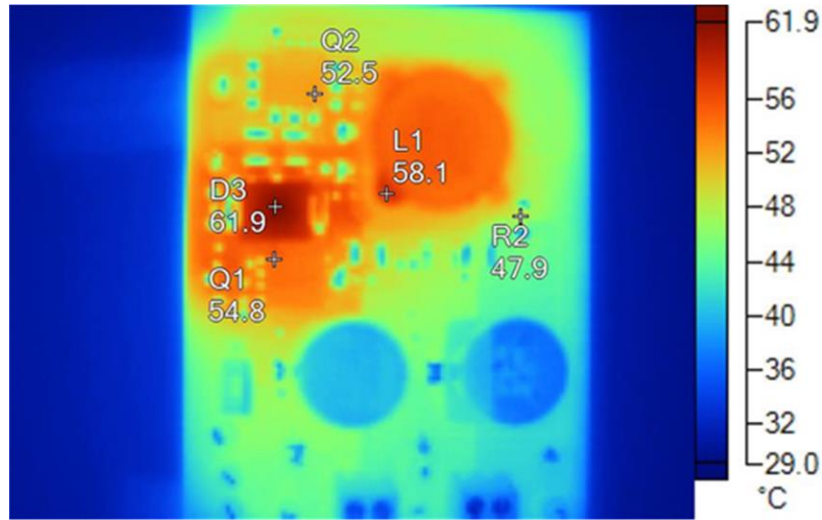
Figure 8. 12 V_{in} at 1.5 A_{out}



NAME	TEMPERATURE
D3	49.0°C
L1	56.5°C
Q1	48.1°C
Q2	50.1°C
R2	48.1°C

2.3.2.5 1-A Output Current

Figure 9. 12 V_{in} at 1 A_{out}



NAME	TEMPERATURE
D3	61.9°C
L1	58.1°C
Q1	54.8°C
Q2	52.5°C
R2	47.9°C

3 Waveforms

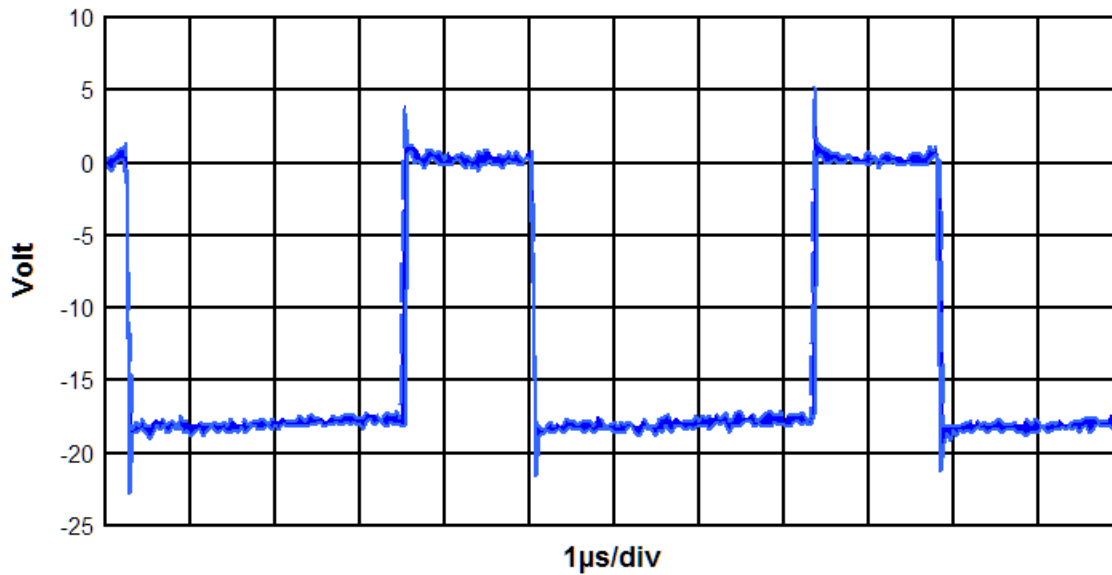
3.1 Switching

All switching waveforms in this section were measured with full bandwidth setting.

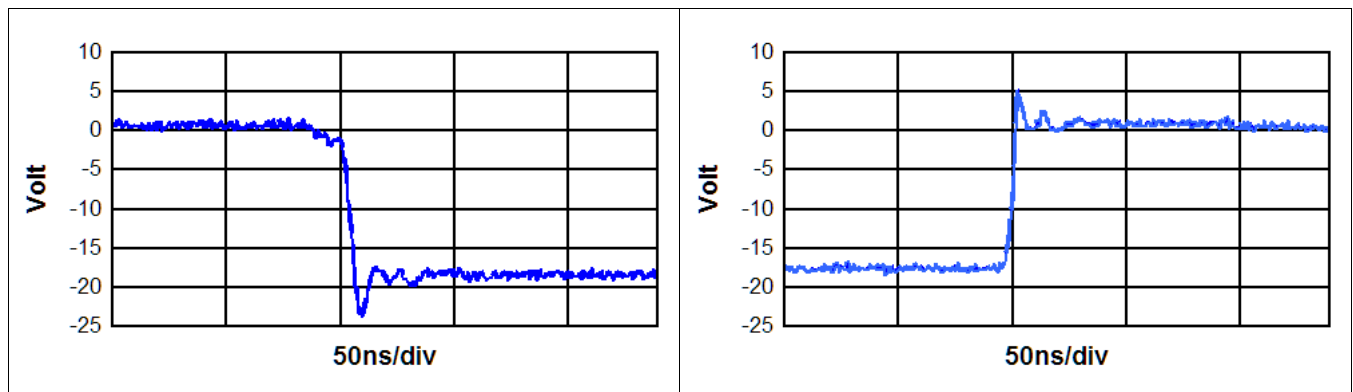
3.1.1 Q1 (HiSide FET) Source-Drain

3.1.1.1 6-V Input Voltage

Figure 10. Q1 Source to V_{OUT} at 6-V Input Voltage



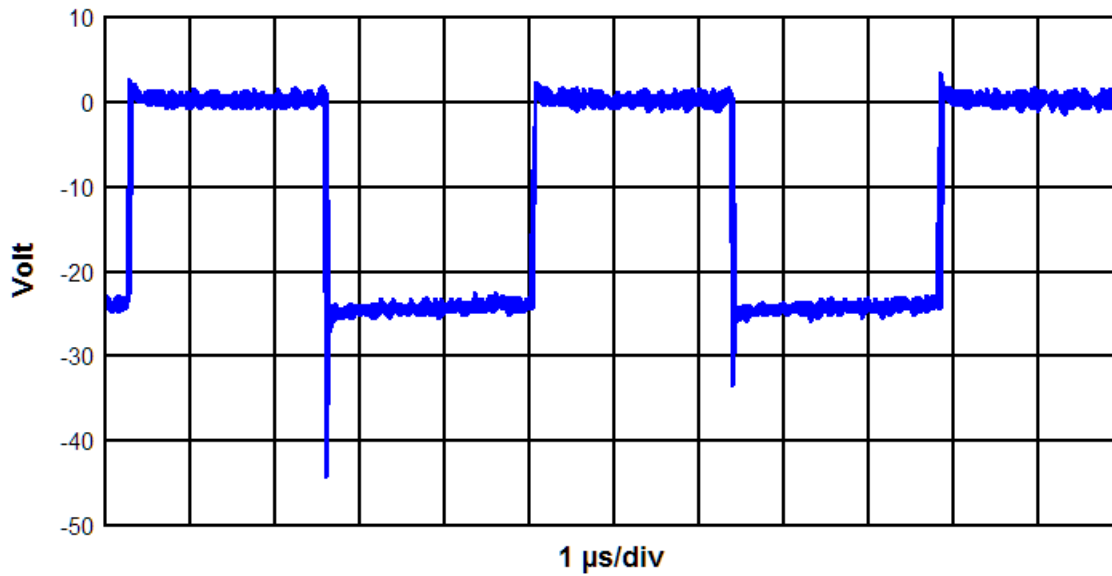
- 5 V/div
- 1 μ s/div



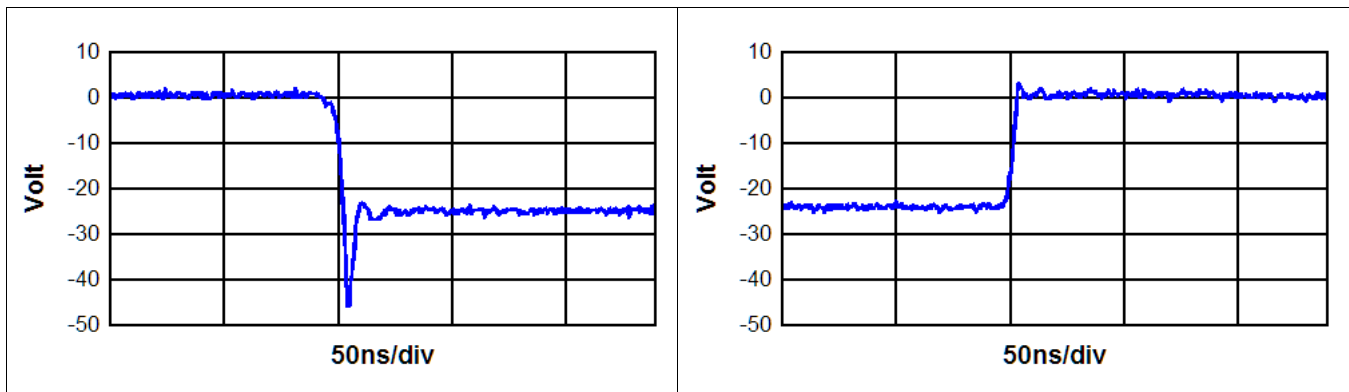
- 50 ns/major div

3.1.1.2 12-V Input Voltage

Figure 11. Q1 Source to V_{OUT} at 12-V Input Voltage



- 10 V/div
- 1 μ s/div

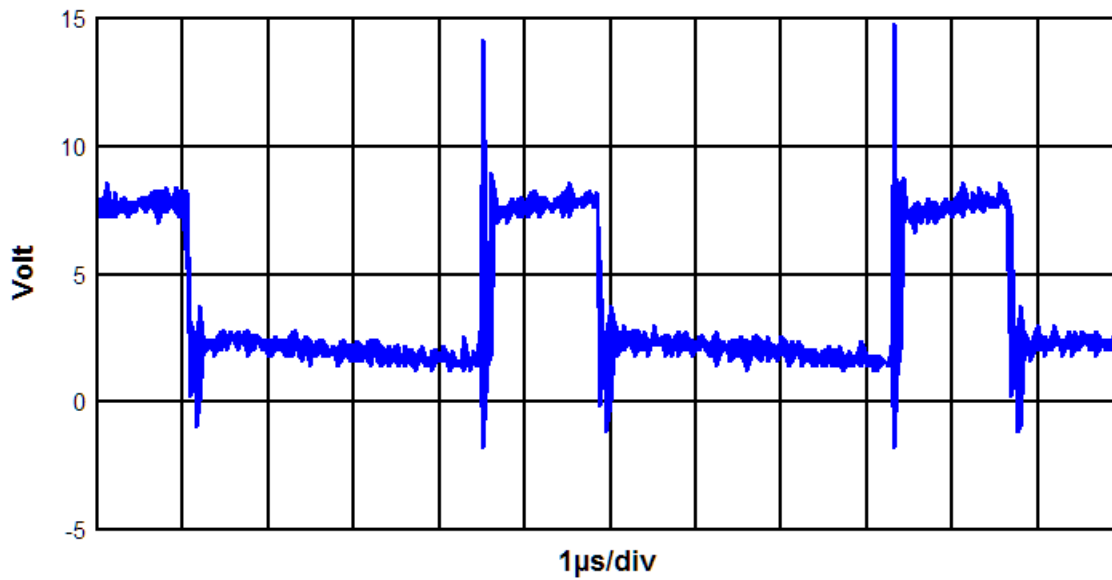


- 50 ns/major div

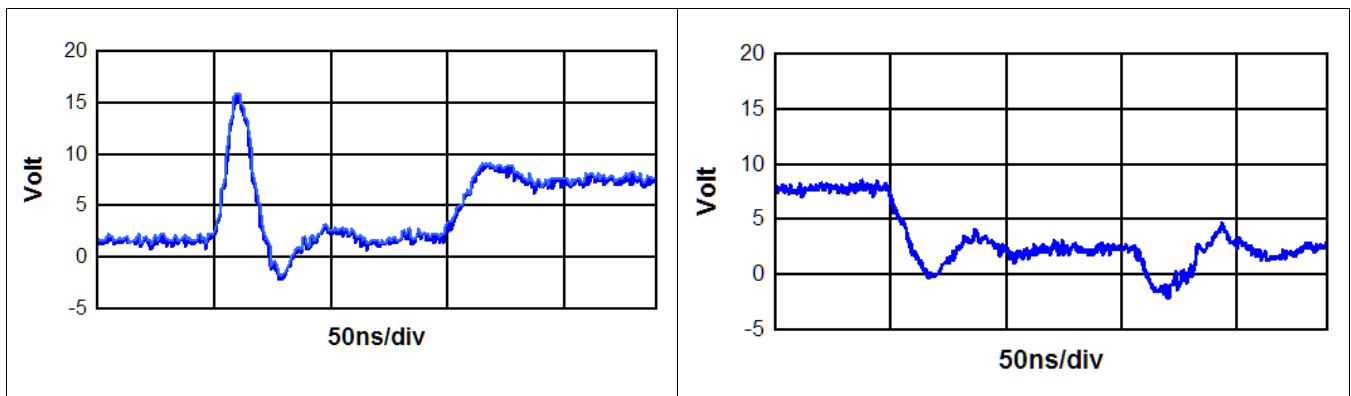
3.1.2 Q1 Gate

3.1.2.1 6-V Input Voltage

Figure 12. Q1 Gate to Secondary Switch Node at 6-V Input Voltage



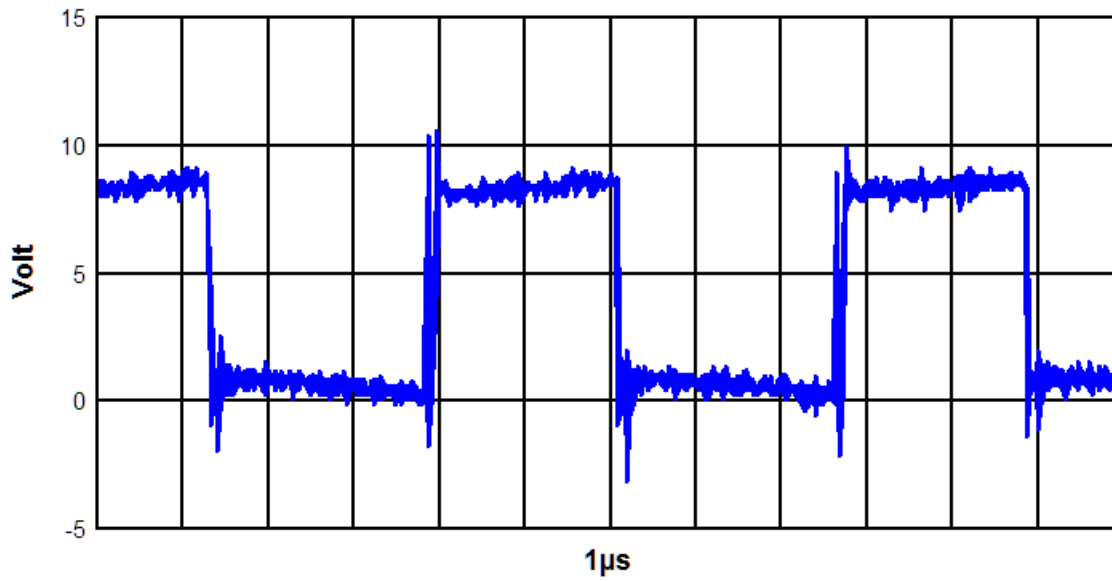
- 5 V/div
- 1 µs/div



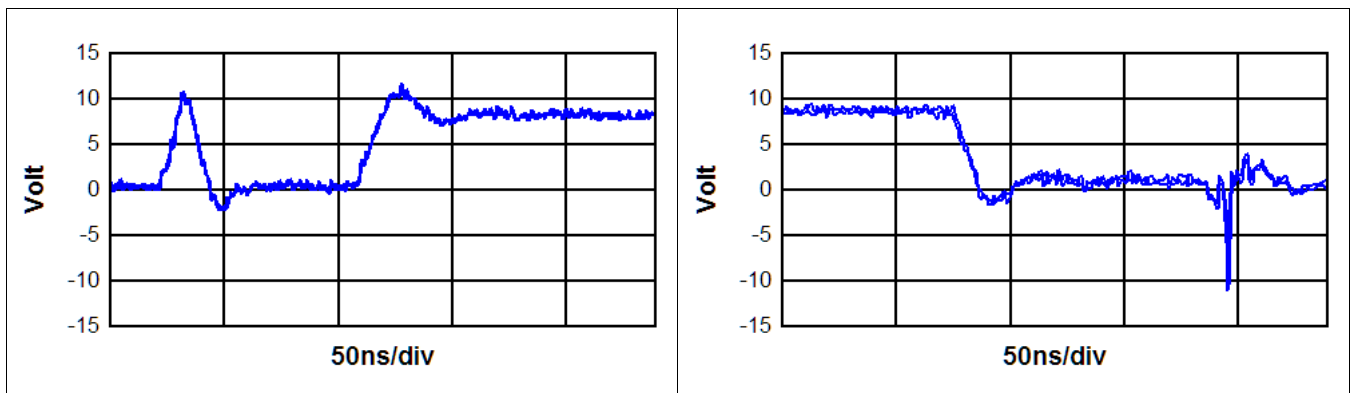
- 50 ns/major div

3.1.2.2 12-V Input Voltage

Figure 13. Q1 Gate to Secondary Switch Node at 12-V Input Voltage



- 5 V/div
- 50 ns/major div

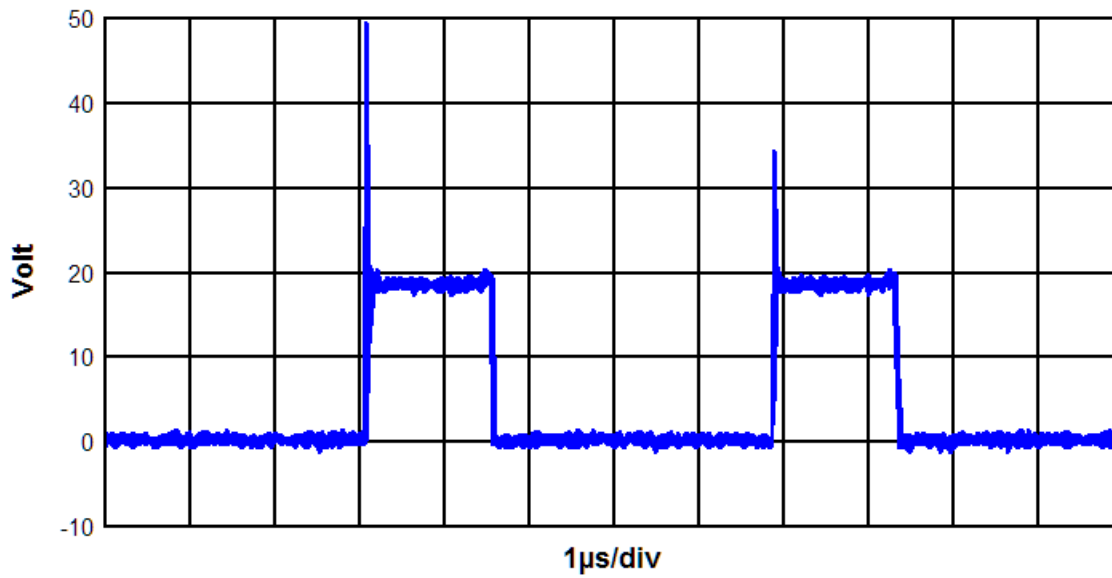


- 50 ns/major div

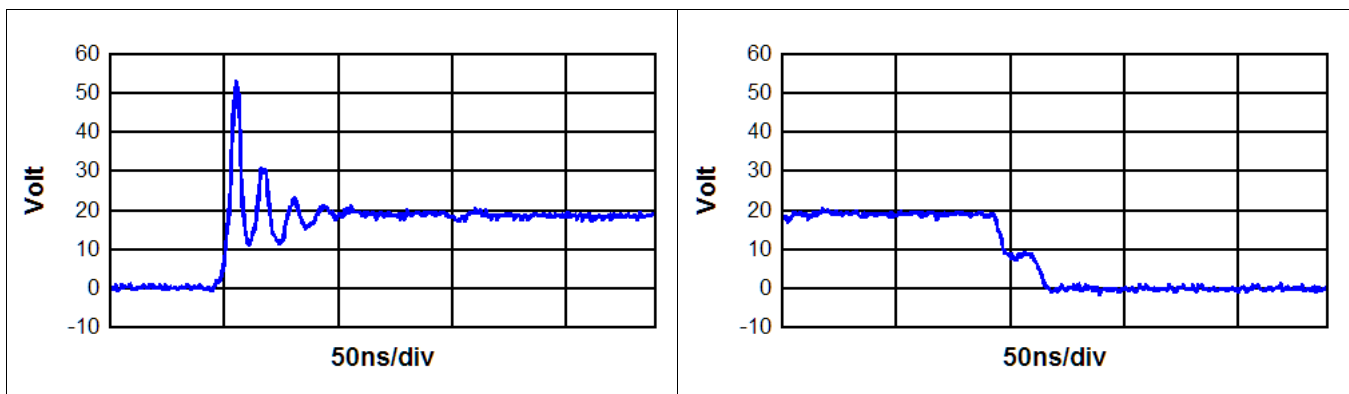
3.1.3 Q2 (LoSide FET) Drain-Source

3.1.3.1 6-V Input Voltage

Figure 14. Q2 Drain to GND at 6-V Input Voltage



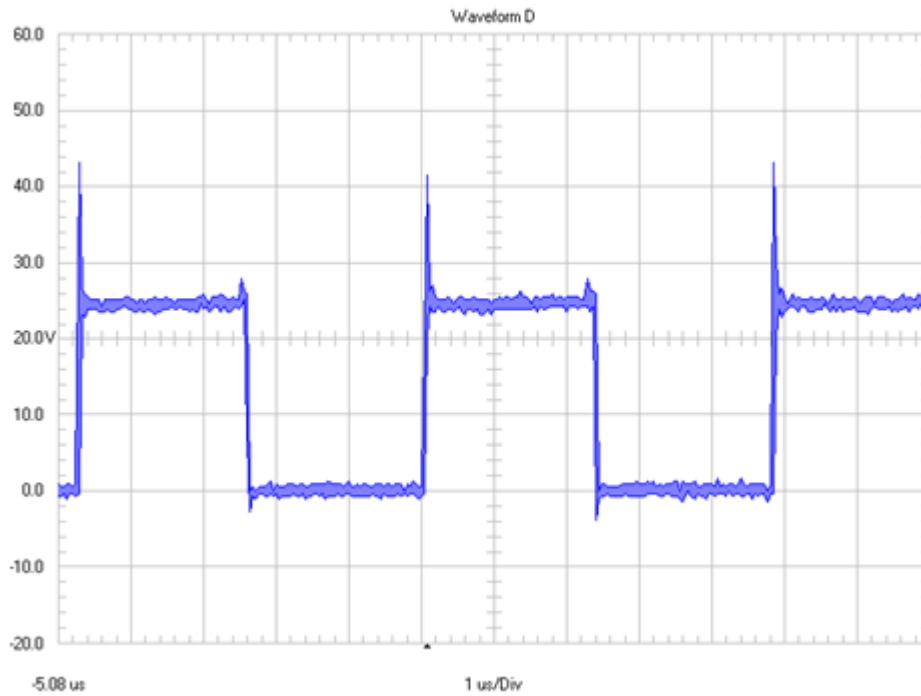
- 10 V/div
- 1 µs/div



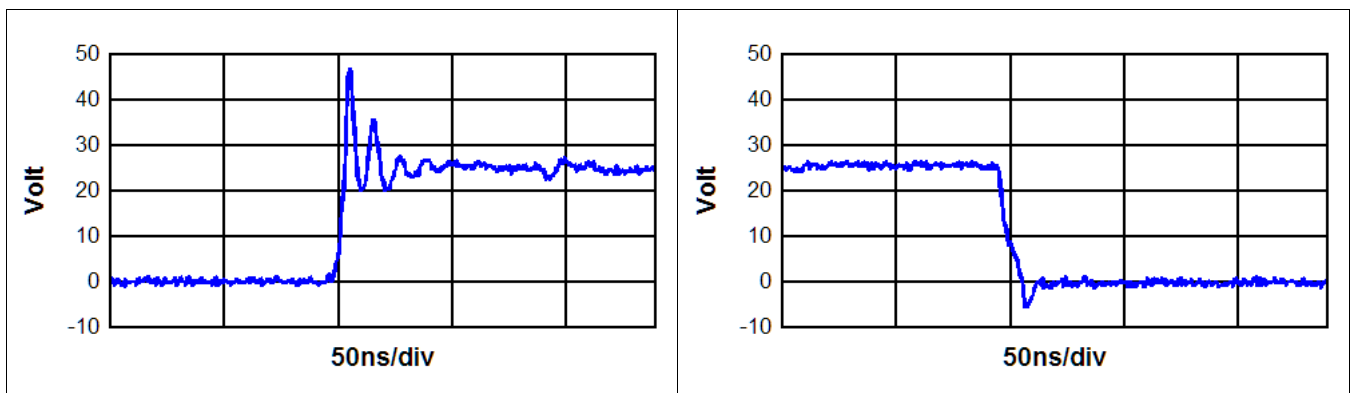
- 50 ns/major div

3.1.3.2 12-V Input Voltage

Figure 15. Q2 Drain to GND at 12-V Input Voltage



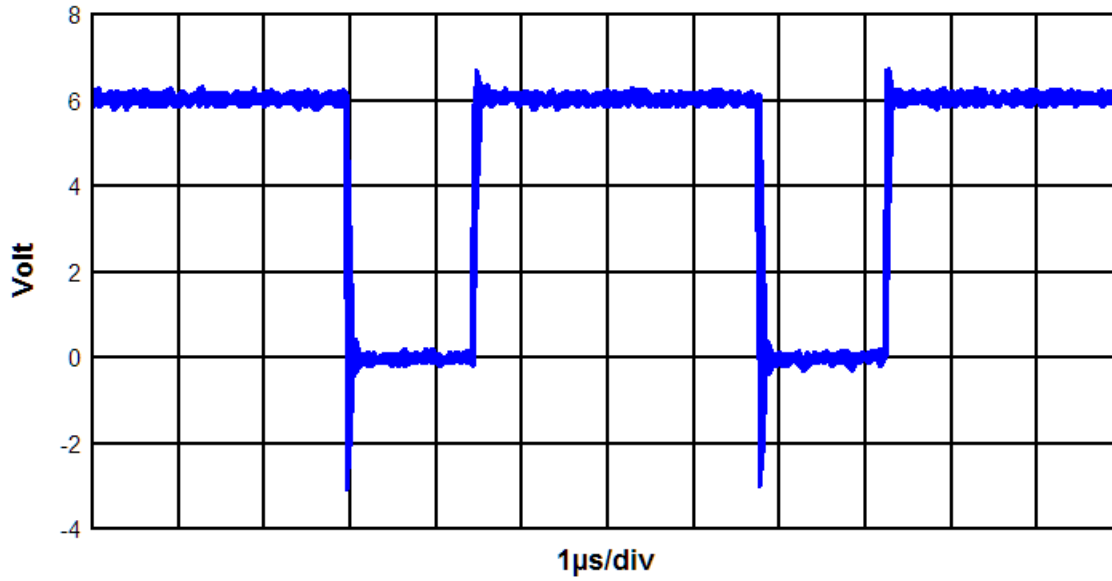
- 10 V/div
- 1 μs/div



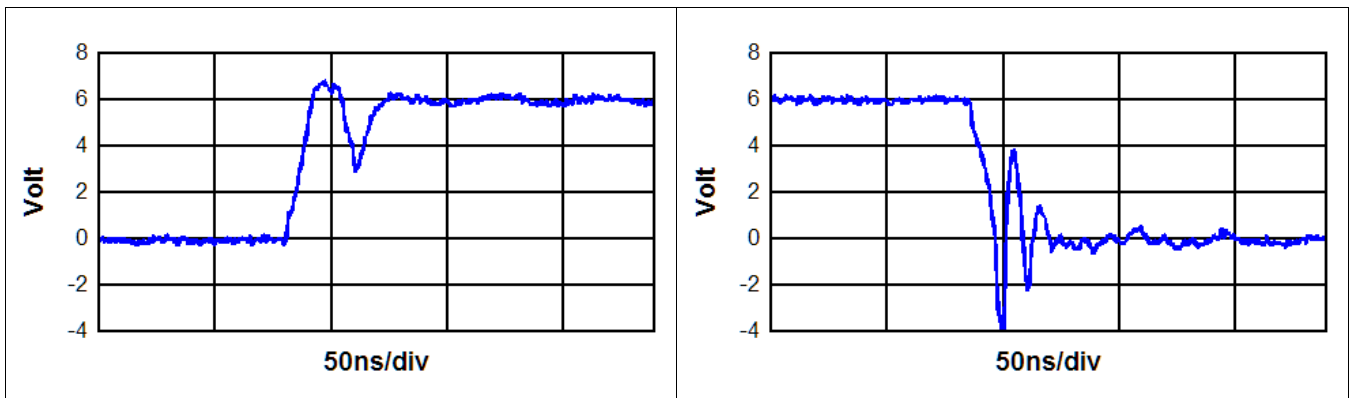
- 50 ns/major div

3.1.4 Q2 Gate

3.1.4.1 6-V Input Voltage



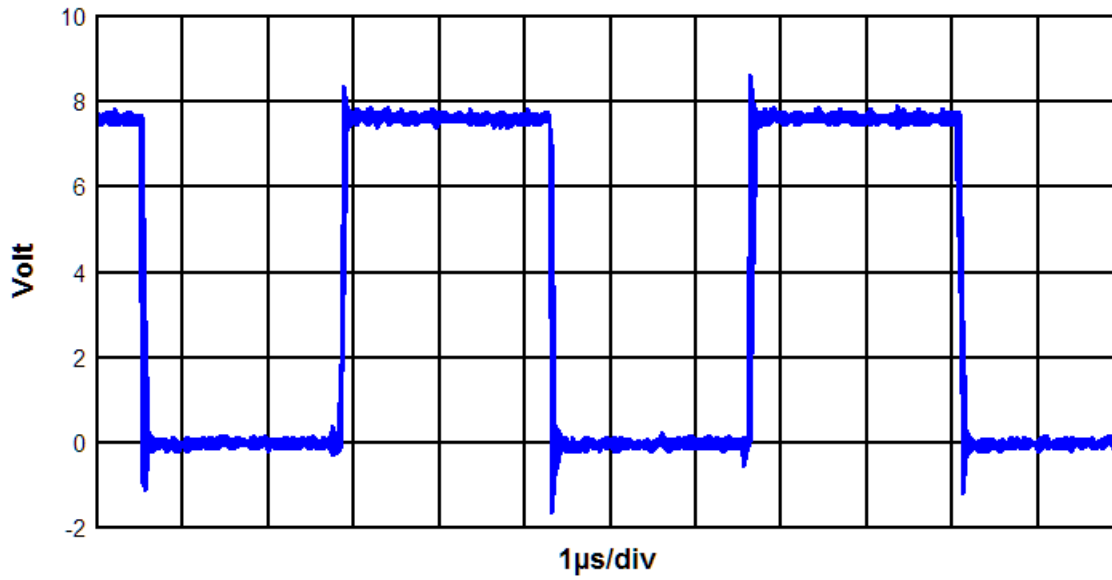
- 2 V/div
- 1 µs/major div



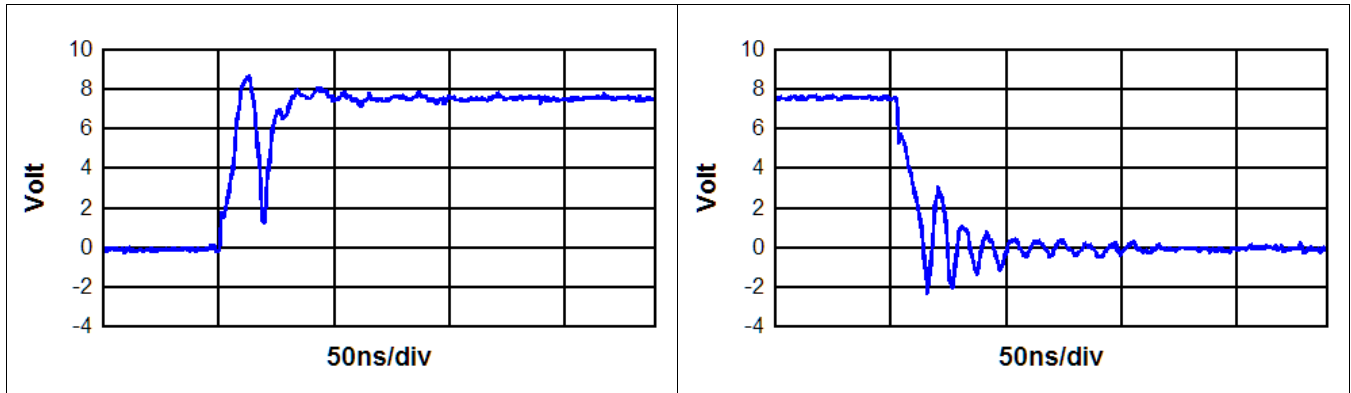
- 50 ns/major div

3.1.4.2 12-V Input Voltage

Figure 16. Q2 Gate to GND at 12-V Input Voltage



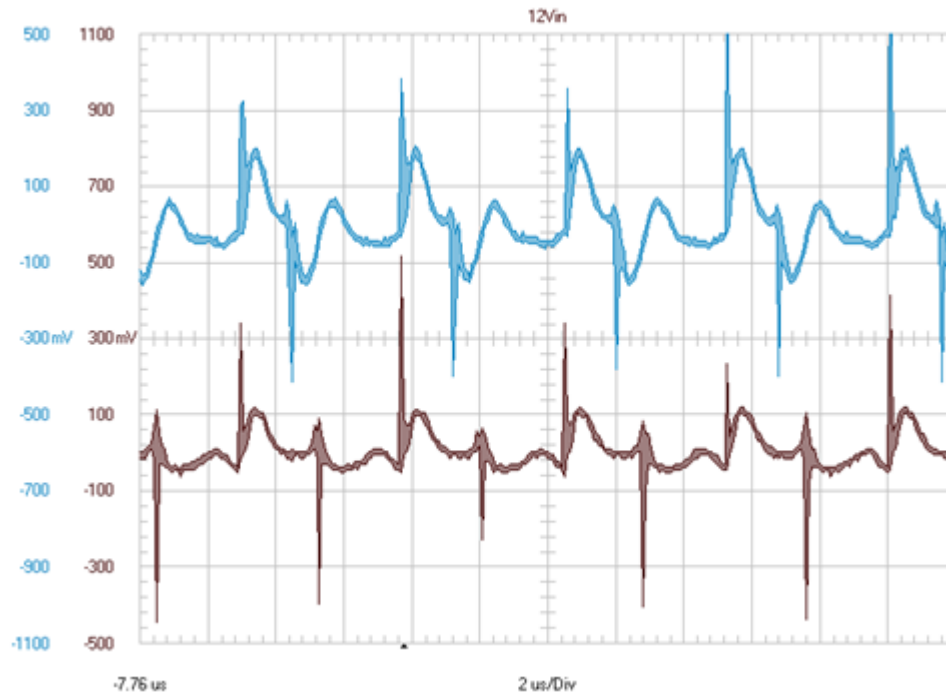
- 2 V/div
- 1 µs/div



- 50 ns/major div

3.2 Output Voltage Ripple (AC)

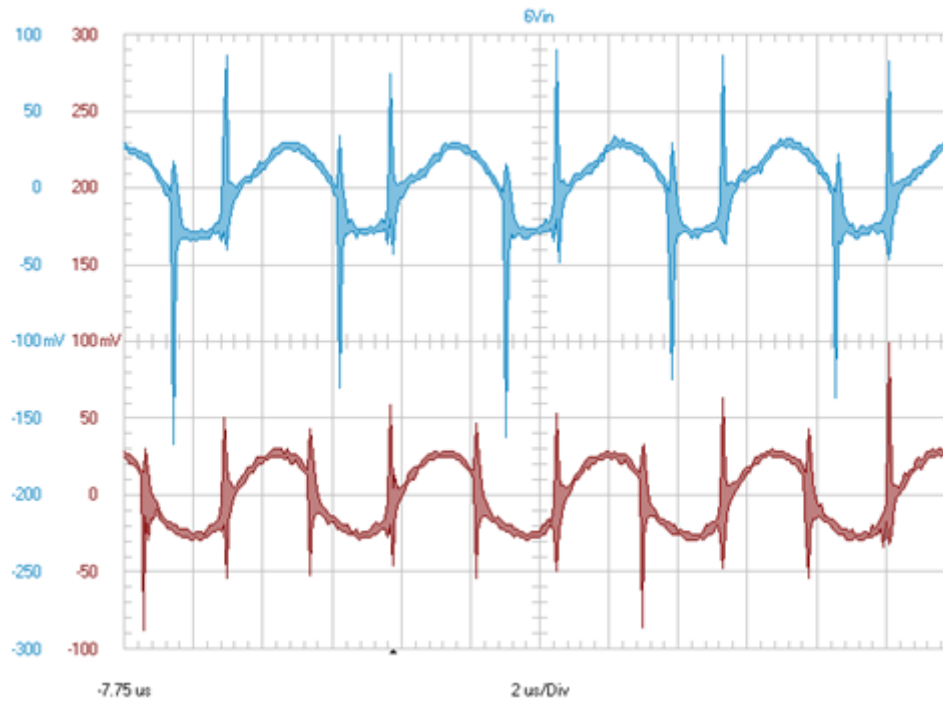
Figure 17. Output Voltage Ripple



- Ch1 (blue): 200 mV/div at 6 V_{IN}
- Ch2 (brown): 200 mV/div at 12 V_{IN}
- 2 µs/div
- 20-MHz bandwidth setting

3.3 Input Voltage Ripple (AC)

Figure 18. Input Voltage Ripple



- Ch1 (blue): 500 mV/div at 6 V_{IN}
- Ch2 (brown): 500 mV/div at 12 V_{IN}
- 2 μs/div
- 20-MHz bandwidth setting

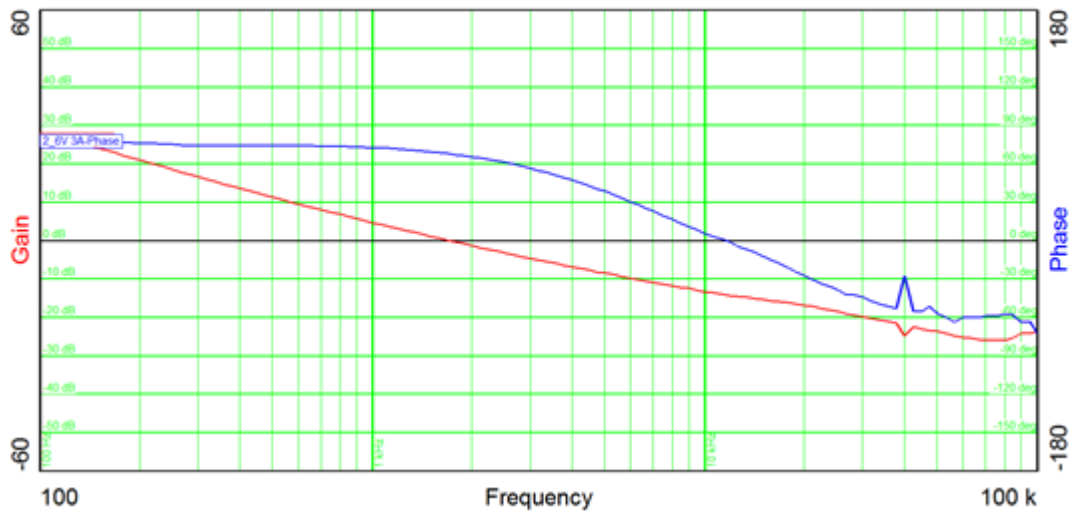
3.4 Control Loop Frequency Response

Table 2. Summary of the Following Figures

V _{in}	6 V	12 V
Bandwidth (kHz)	1.71	3.92
Phase margin	67.8°	69.6°
Slope (20 dB/decade)	-1	-1
Gain margin (dB)	-14.2	-17.6
Slope (20 dB/decade)	-0.7	-1.4
Frequency (kHz)	11.6	21.9

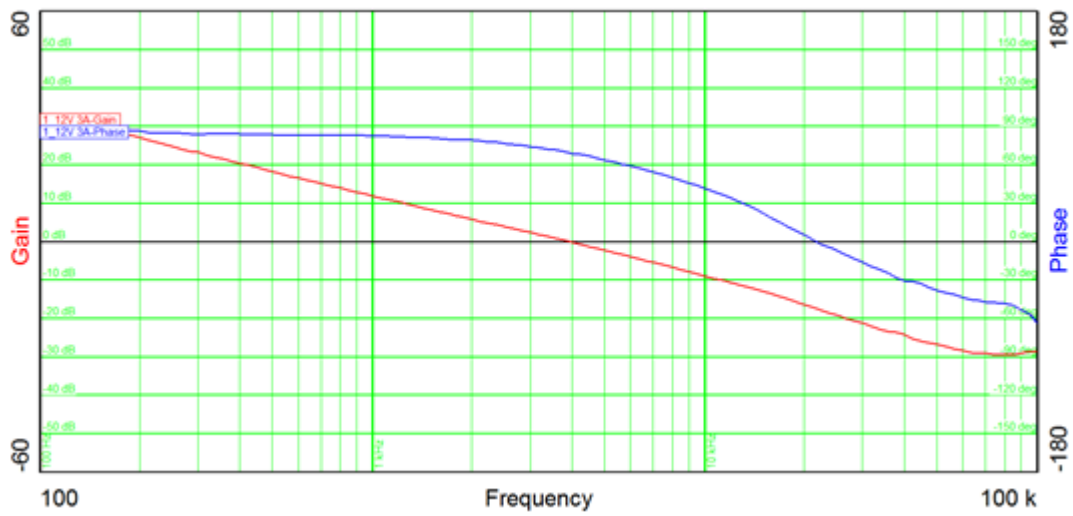
3.4.1 6-V Input Voltage

Figure 19. Bode Plot at 6-V Input Voltage



3.4.2 12-V Input Voltage

Figure 20. Bode Plot at 12-V Input Voltage

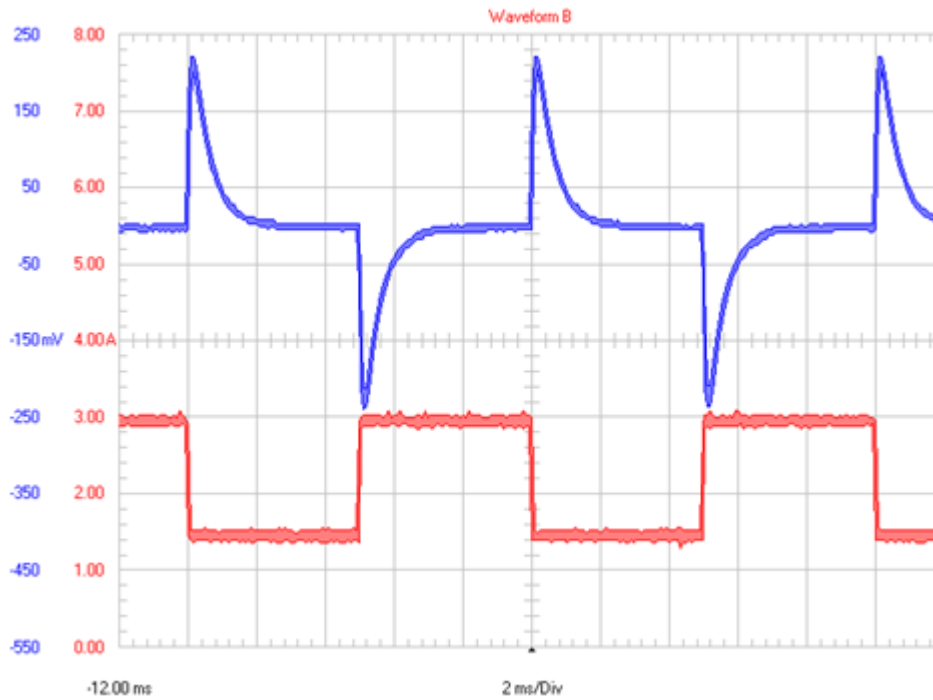


3.5 Load Transients

Electronic load was used in this measurement. The load switches from 1.5 A to 3 A with a frequency of 100 Hz.

3.5.1 6-V Input Voltage

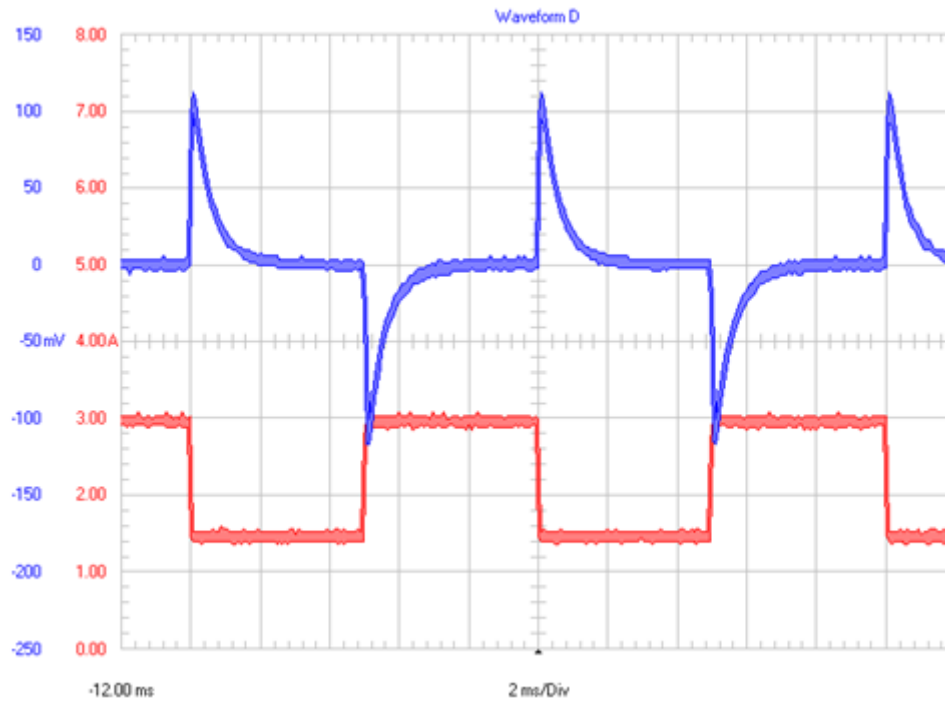
Figure 21. 1.5-A to 3-A Load Transient at 6-V Input Voltage



- Ch1 (blue): output voltage (AC) = 100 mV/div, 10-kHz bandwidth
- Ch2 (red): output current = 1 A/div, 20-MHz bandwidth
- 2 ms/div

3.5.2 12-V Input Voltage

Figure 22. 1.5-A to 3-A Load Transient at 12-V Input Voltage

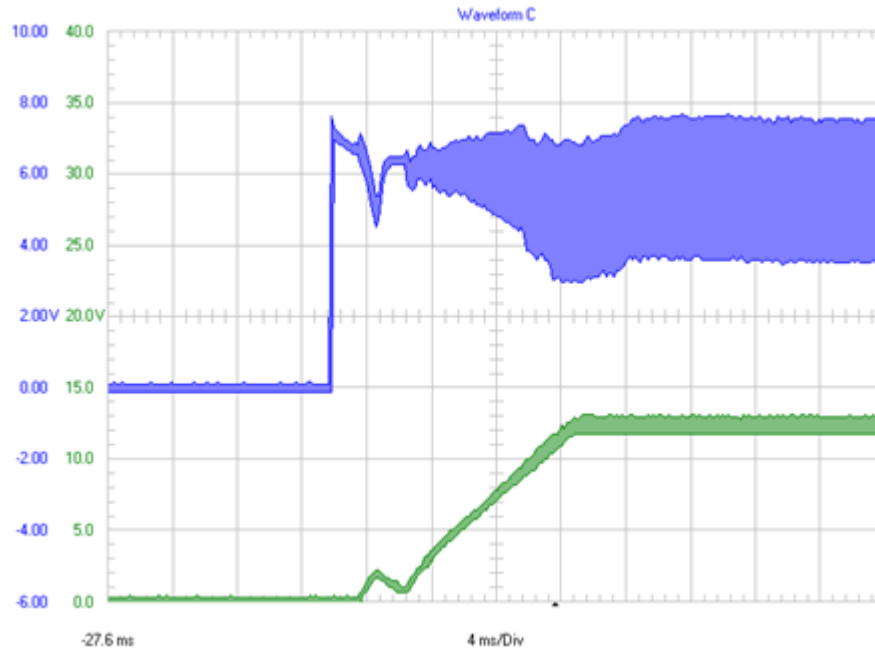


- Ch1 (blue): output voltage (AC) = 100 mV/div, 10-kHz bandwidth
- Ch2 (red): output current = 1 A/div, 20-MHz bandwidth
- 2 ms/div

3.6 Start-up Sequence

3.6.1 6-V Input Voltage

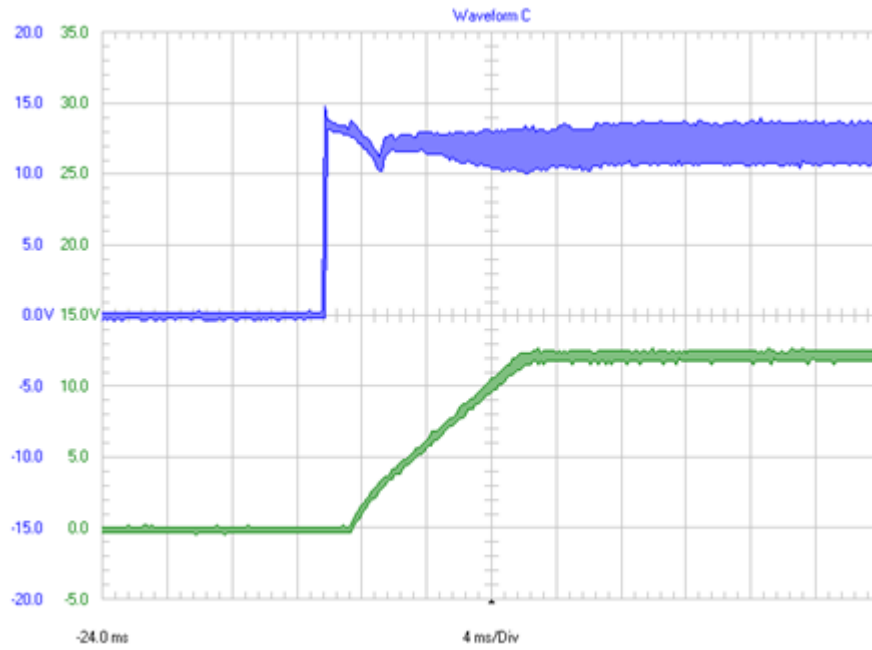
Figure 23. Start-up With 6-V Input Voltage



- Ch1 (violet): input voltage = 2 V/div
- Ch2 (green): output voltage = 5 V/div
- 4 ms/div

3.6.2 12-V Input Voltage

Figure 24. Start-up With 12-V Input Voltage



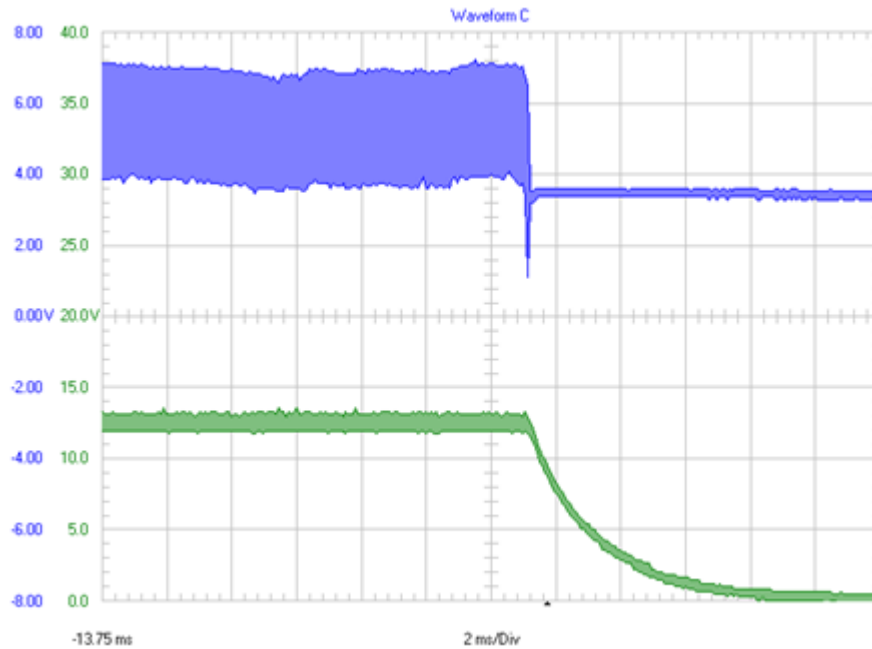
- Ch1 (violet): input voltage = 5 V/div
- Ch2 (green): output voltage = 5 V/div
- 4 ms/div

3.7 Shut-down Sequence

The power supply was disconnected in the following measurements. The waveforms were done with a 20-MHz bandwidth setting.

3.7.1 6-V Input Voltage

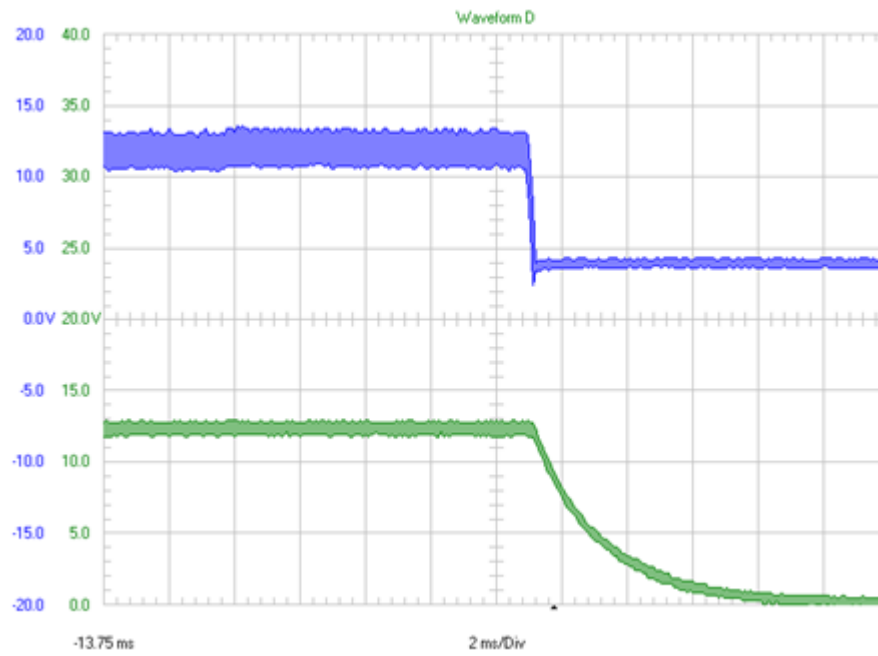
Figure 25. Shut-down With 6-V Input Voltage



- Ch1 (violet): input voltage = 2 V/div
- Ch2 (green): output voltage = 5 V/div
- 2 ms/div

3.7.2 12-V Input Voltage

Figure 26. Shut-down With 12-V Input Voltage



- Ch1 (violet): input voltage = 5 V/div
- Ch2 (green): output voltage = 5 V/div
- 2 ms/div

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