Test Report: PMP31114

Synchronous SEPIC Suited for 3-V Cold Cranking Reference Design

Description

This reference design uses the LM25122-Q1 boost controller. The output voltage is 5 V with 5-A_{max} output current. The typical input voltage range is from 6 V to 18 V. The circuit is designed to withstand input voltages as low as cold crank 3 V and load dump up to 36 V. Switching frequency F_{SW} on this individual board is measured at 261 kHz.

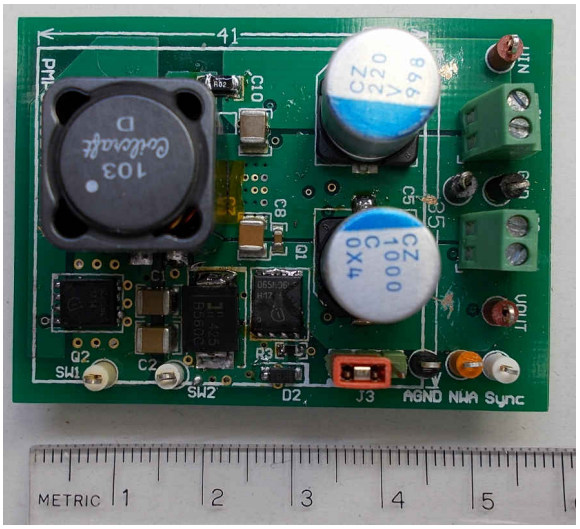
The additional jumper on the bottom side provides a needed ON and OFF feature.

Features

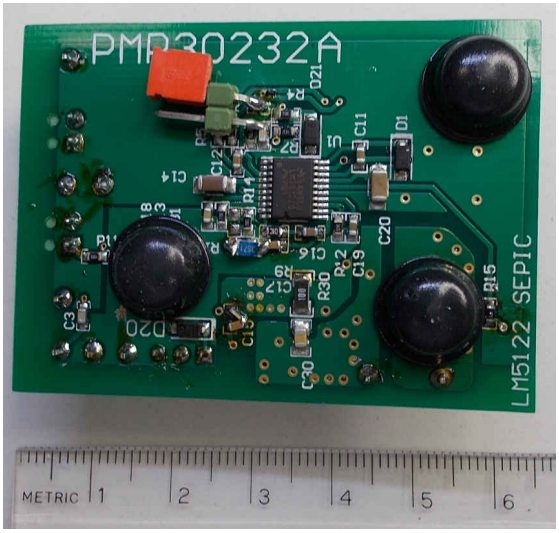
- Supports low cold cranking voltage as low as 3 V
- Synchronous rectification supports ≥ 90%
- 5-A output current enabled by dual inductor from stock

Applications

- Automotive auxiliary display



Top Photo



Bottom Photo

1 Test Prerequisites

1.1 Voltage and Current Requirements

Table 1-1. Voltage and Current Requirements

Parameter	Specifications
Input Voltage Range	6 V to 18 V
Output Voltage	5 V
Output Current	3 A_{cont}, 5 A_{max}

1.2 Considerations

The switching frequency is about 261 kHz. The circuit switches on at 6 V and switches of at 3 V. All measurements are done with the MODE: **Forced PWM**.

Unless otherwise mentioned, the output current was adjusted to a full load of 5 A with the resistor as load.

The jumper J100 is mounted on the bottom side of the board.

1.3 Dimensions

The size of the board is 41 mm × 56 mm.

2 Testing and Results

2.1 Efficiency Graphs

Figure 2-1 shows the efficiency graph and Figure 2-2 shows the loss graph.

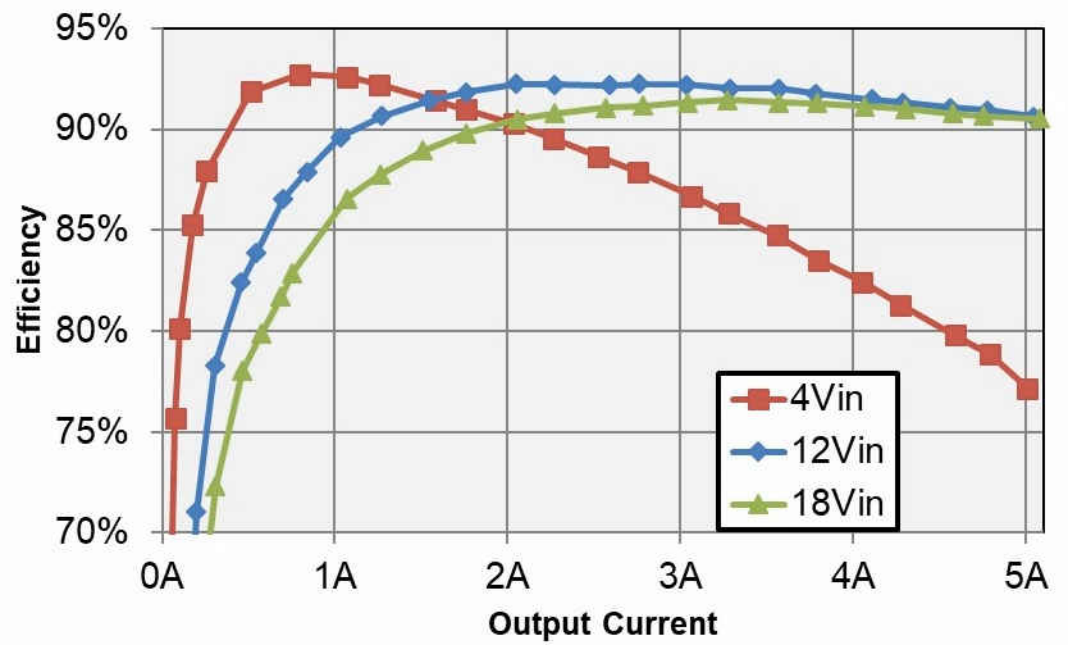


Figure 2-1. Efficiency Graph

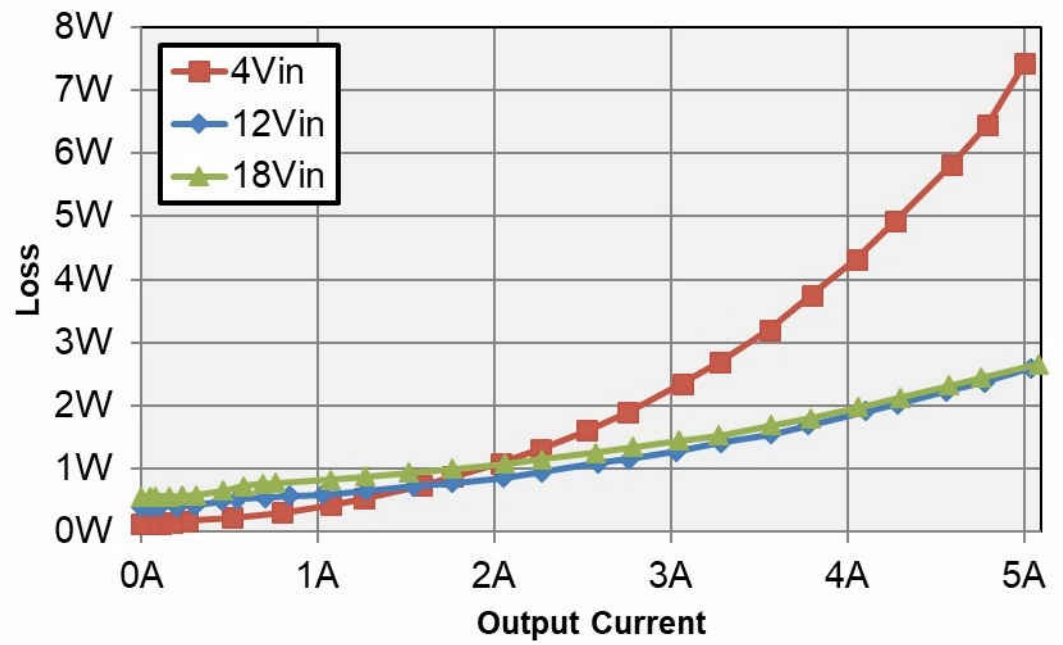


Figure 2-2. Loss Graph

2.2 Load Regulation

Figure 2-3 shows the load regulation graph.

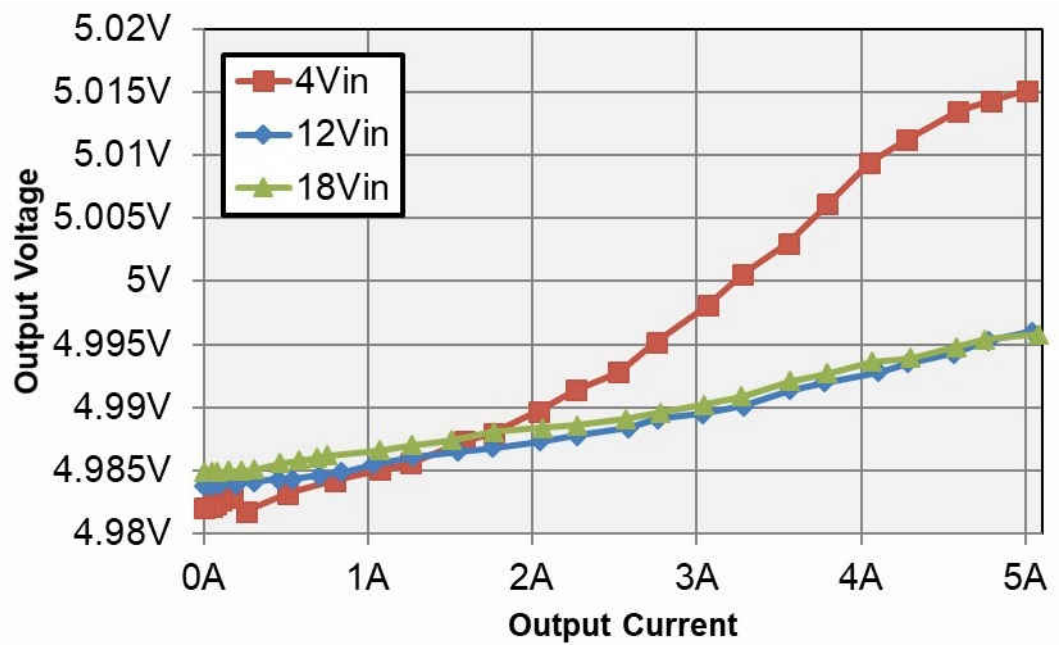


Figure 2-3. Output Current vs Output Voltage

2.3 Line Regulation

Figure 2-4 shows the line regulation input versus output voltage graph. Figure 2-5 shows the input voltage versus full load efficiency and loss graph.

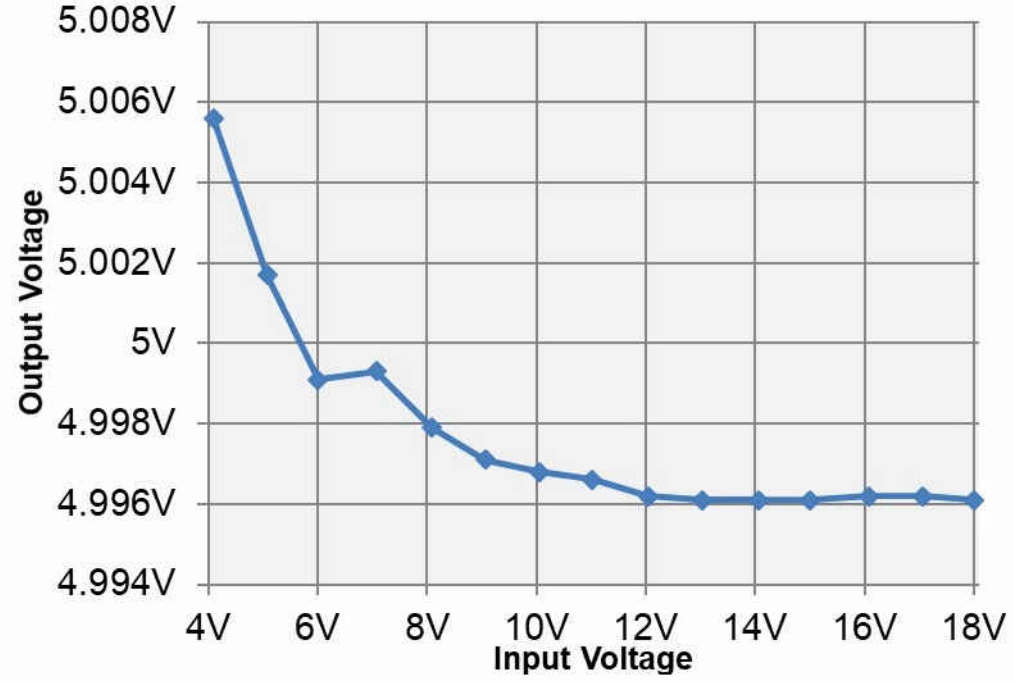


Figure 2-4. Input Voltage vs Output Voltage

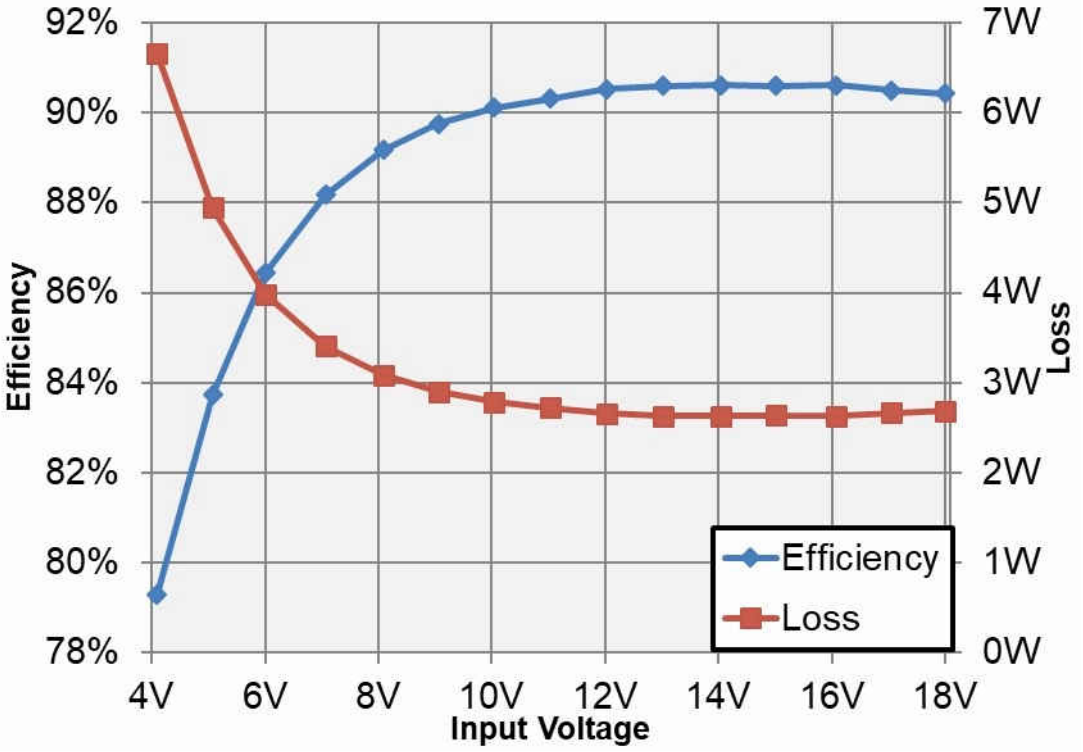


Figure 2-5. Input Voltage vs Full Load Efficiency and Loss

2.4 Thermal Images

2.4.1 4-V Input Voltage

2.4.1.1 3-A Output Current – Average Load Current

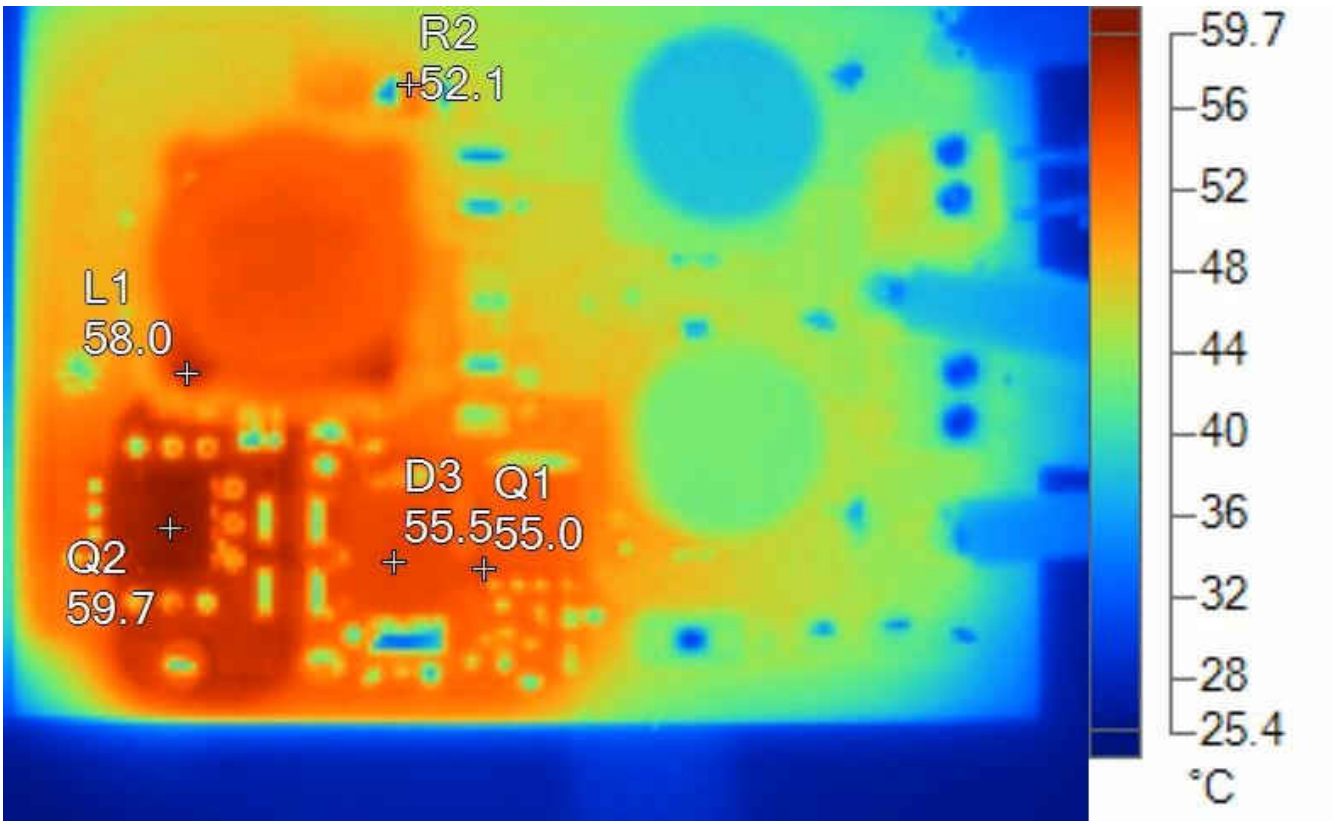


Figure 2-6. IR-Foto 4 V_{IN}, 3 A_{OUT}

Name	Temperature
D3	55.5°C
L1	58.0°C
Q1	55.0°C
Q2	59.7°C
R2	52.1°C

2.4.1.2 5-A Output Current – Peak Load Current

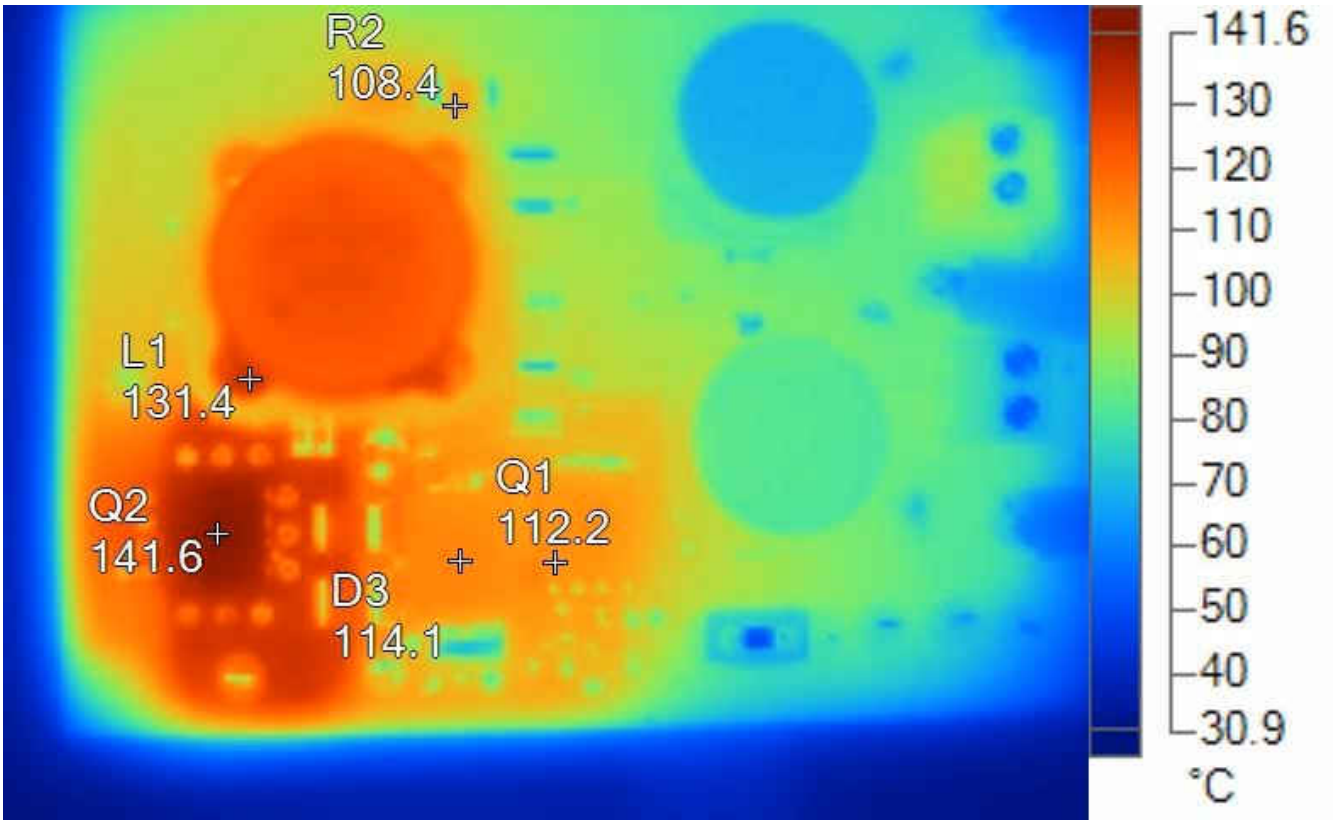


Figure 2-7. IR-Foto 4 V_{IN}, 5 A_{OUT}

Name	Temperature
D3	114.1°C
L1	131.4°C
Q1	112.2°C
Q2	141.6°C
R2	108.4°C

2.4.2 12-V Input Voltage

2.4.2.1 3-A Output Current

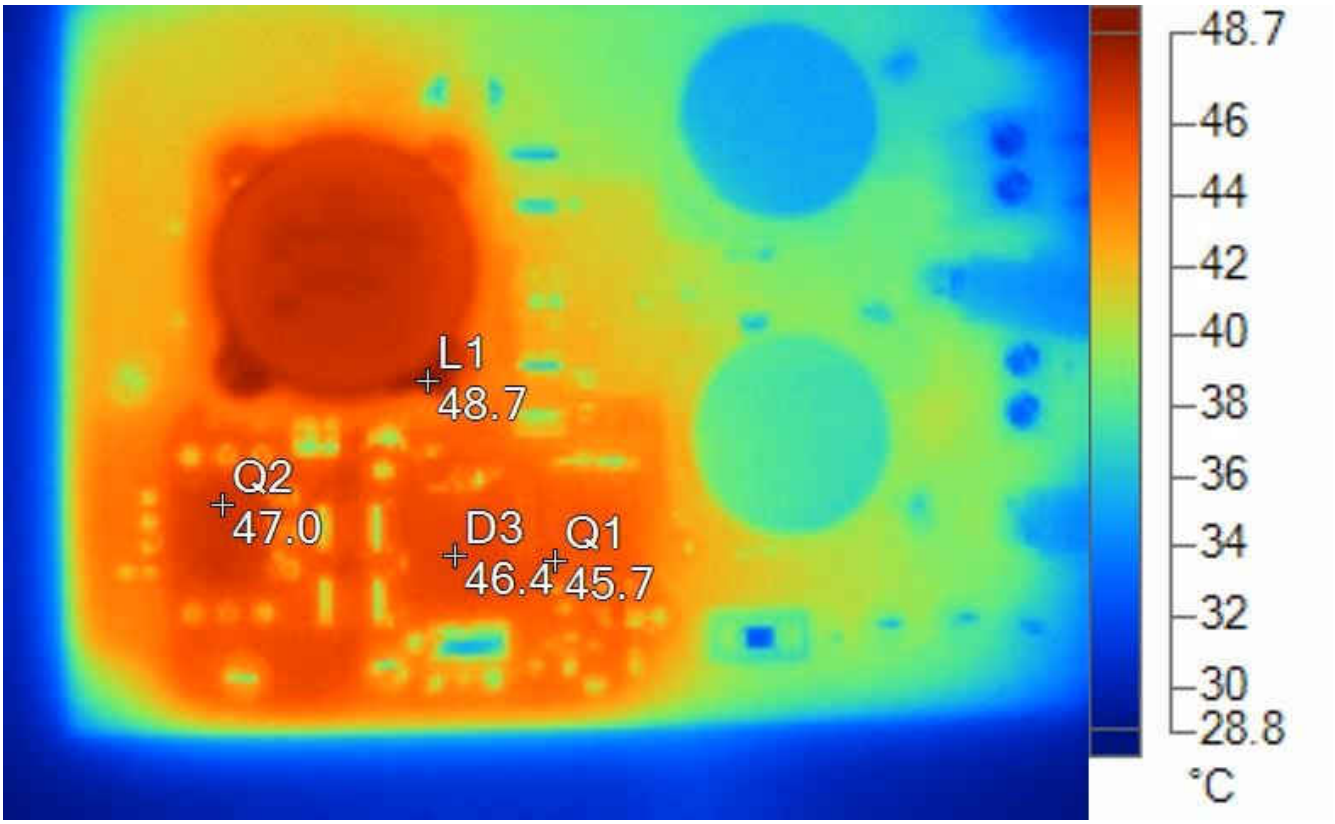


Figure 2-8. IR-Photo 12 V_{IN}, 3 A_{OUT}

Name	Temperature
D3	46.4°C
L1	48.7°C
Q1	45.7°C
Q2	47.0°C

2.4.2.2 5-A Output Current

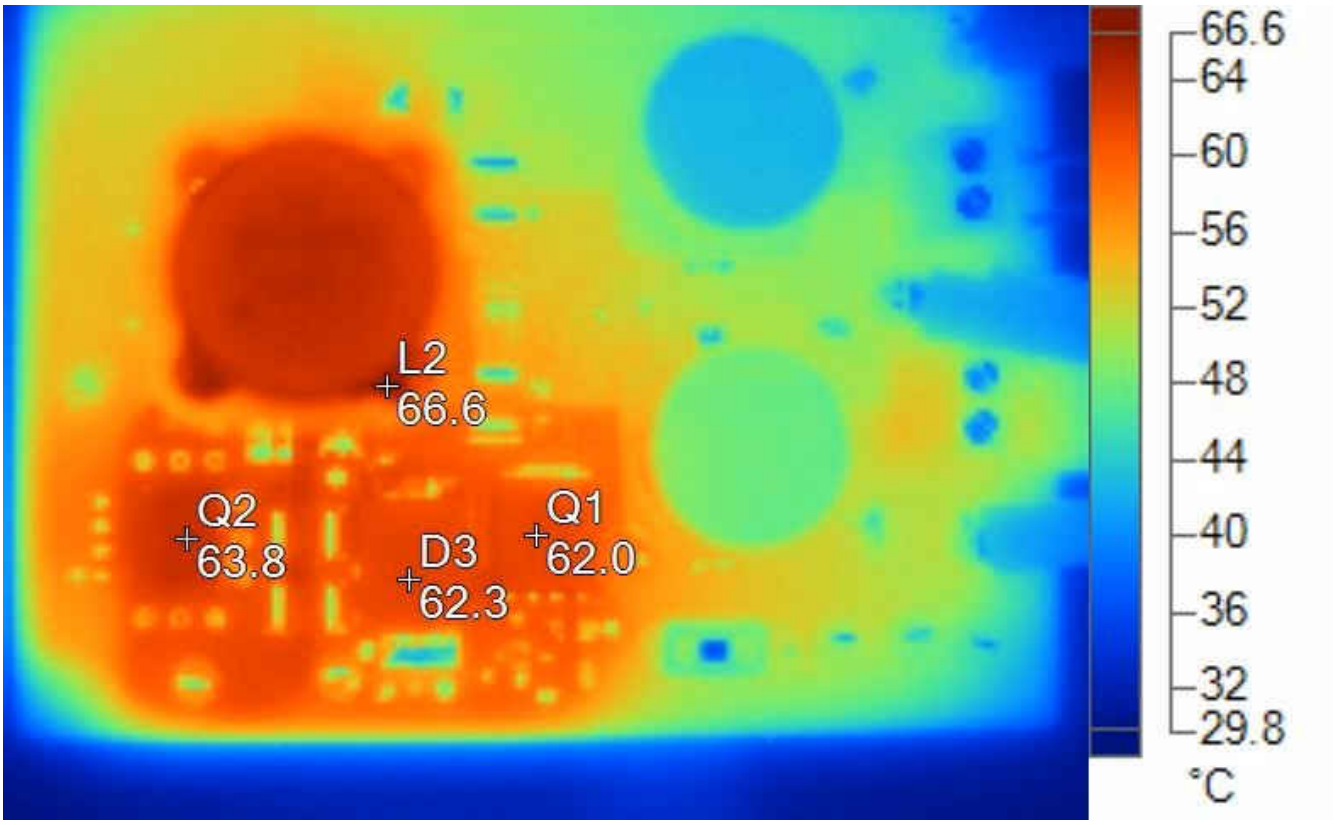


Figure 2-9. IR-Photo 12 V_{IN}, 5 A_{OUT}

Name	Temperature
D3	62.3°C
L2	66.6°C
Q1	62.0°C
Q2	63.8°C

2.4.3 18-V Input Voltage

2.4.3.1 3-A Output Current

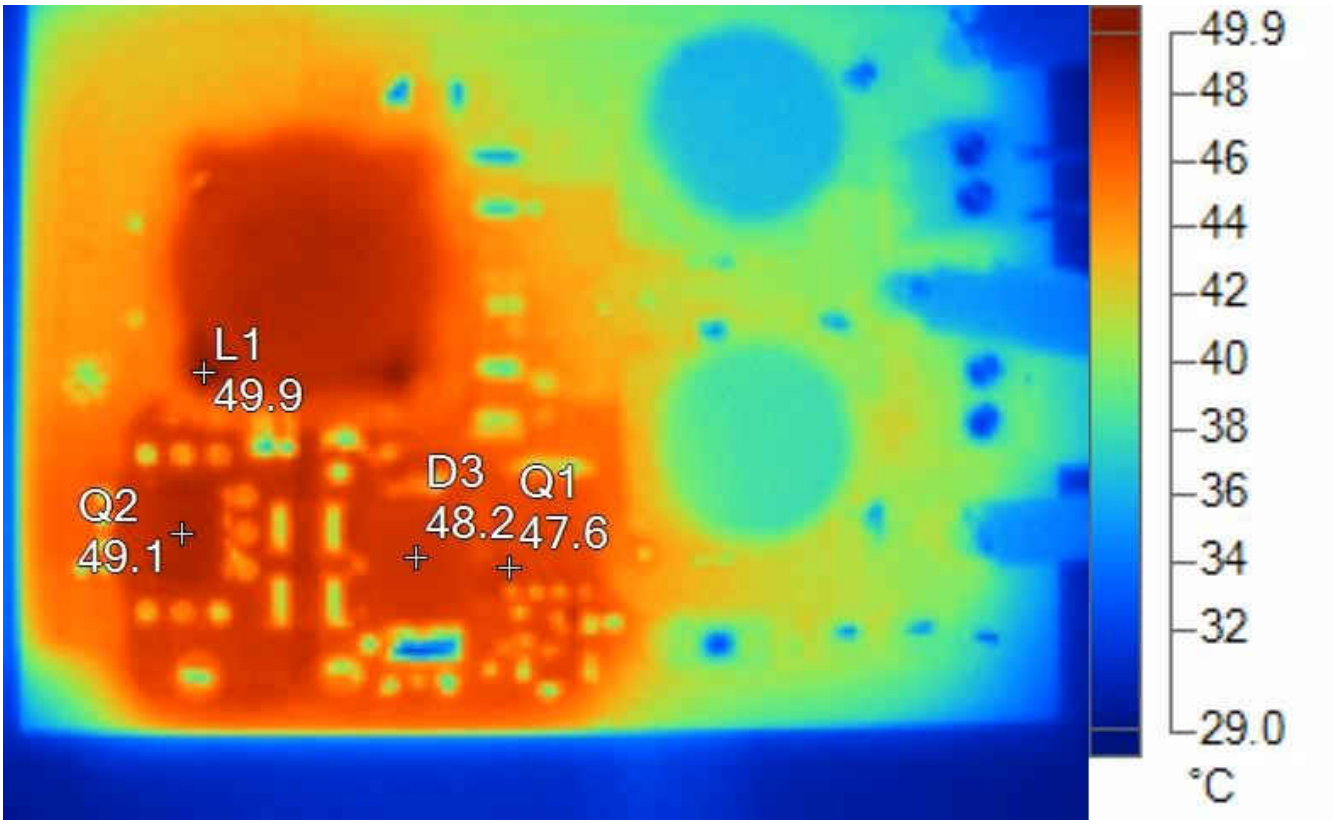


Figure 2-10. IR-Photo 18 V_{IN}, 3 A_{OUT}

Name	Temperature
D3	48.2°C
L1	49.9°C
Q1	47.6°C
Q2	49.1°C

2.4.3.2 5-A Output Current

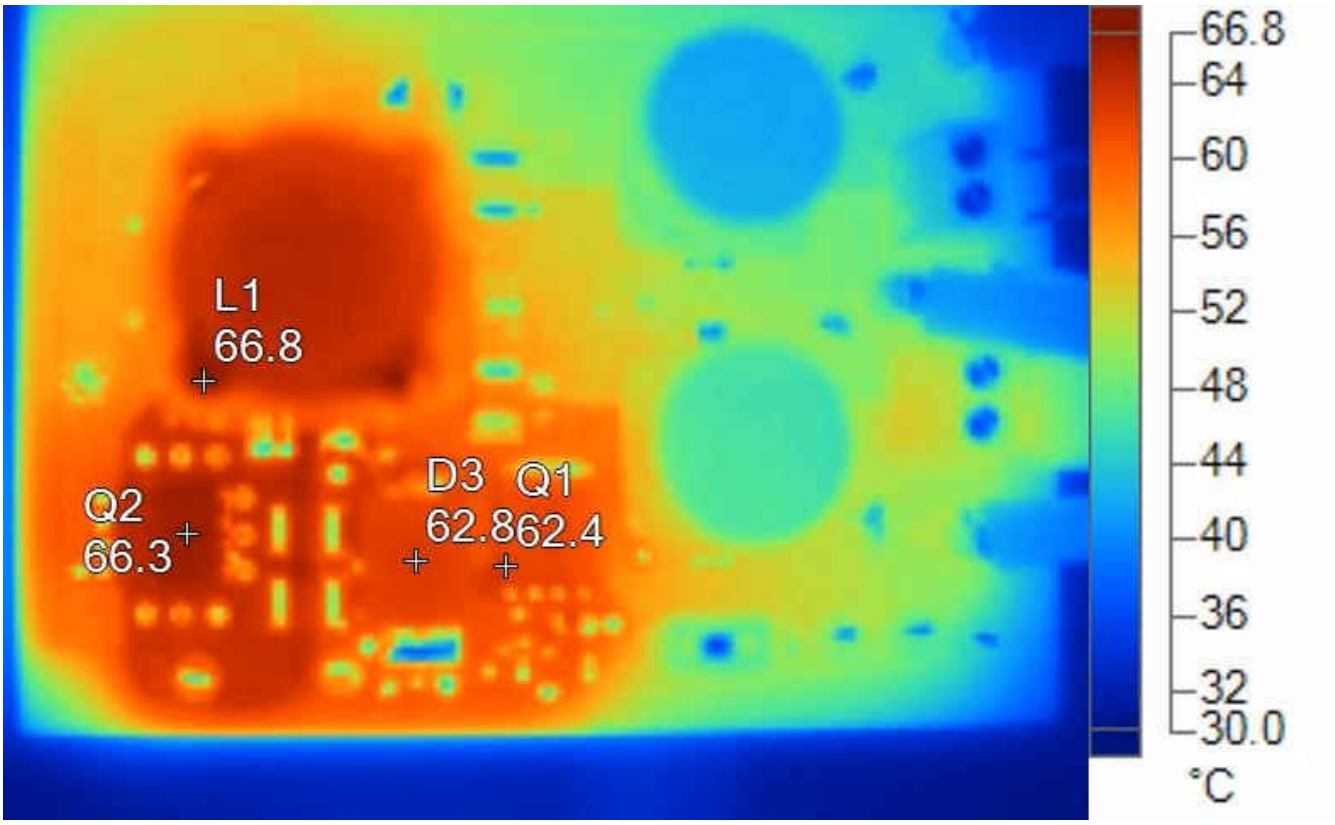


Figure 2-11. IR-Photo 18 V_{IN}, 5 A_{OUT}

Name	Temperature
D3	62.8°C
L1	66.8°C
Q1	62.4°C
Q2	66.3°C

2.5 Bode Plots

Figure 2-12 through Figure 2-16 show the PMP31114 bode plots.

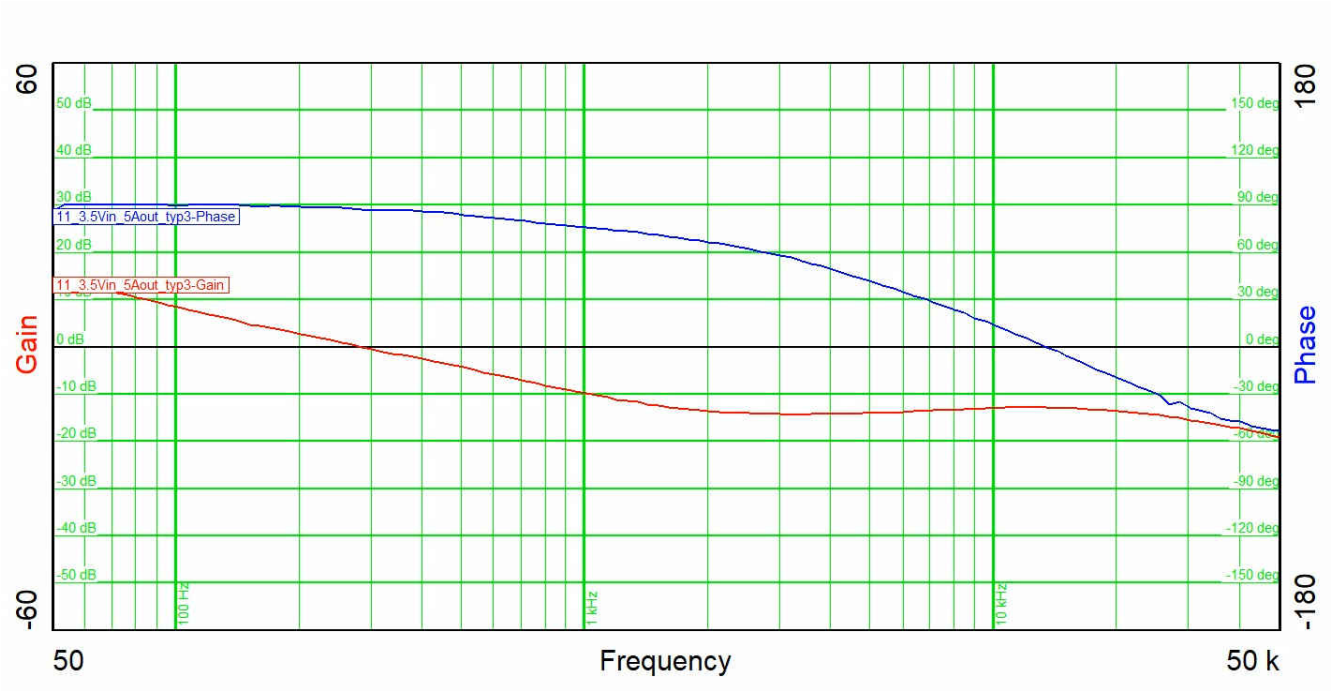


Figure 2-12. Bode Plot at 3.5-V Input Voltage

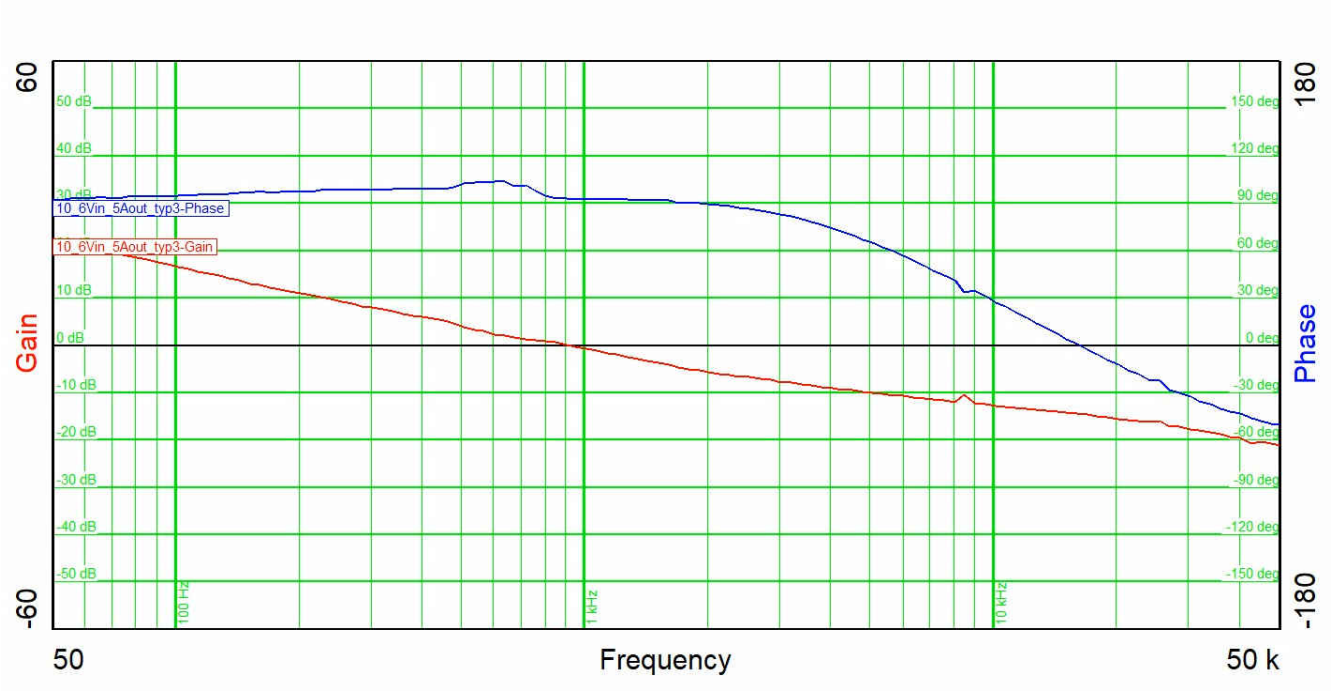


Figure 2-13. Bode Plot at 6-V Input Voltage

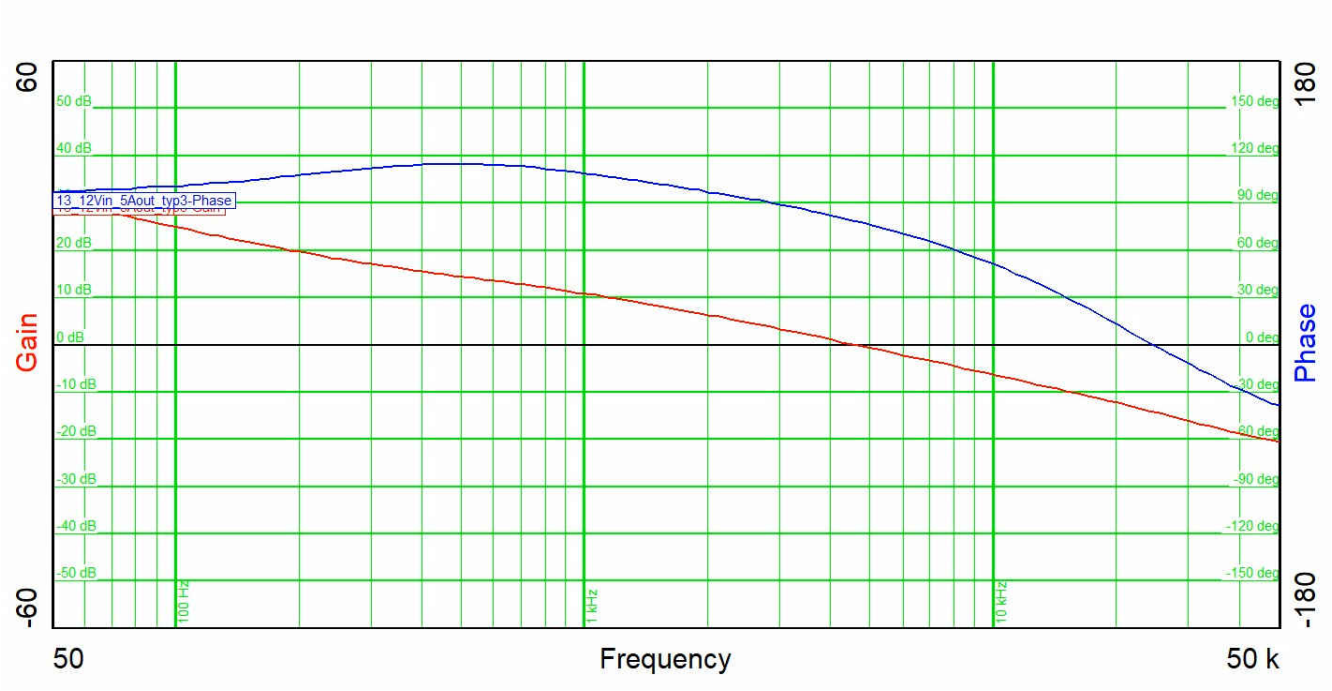


Figure 2-14. Bode Plot at 12-V Input Voltage

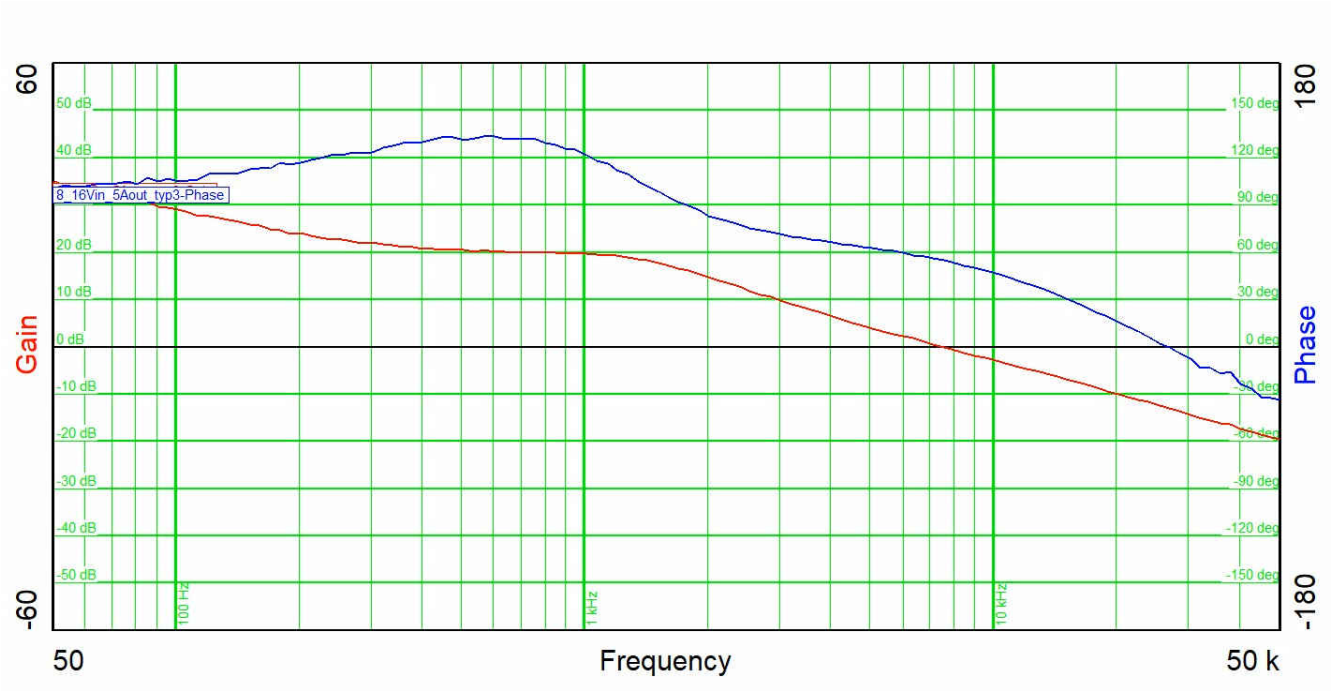


Figure 2-15. Bode Plot at 16-V Input Voltage

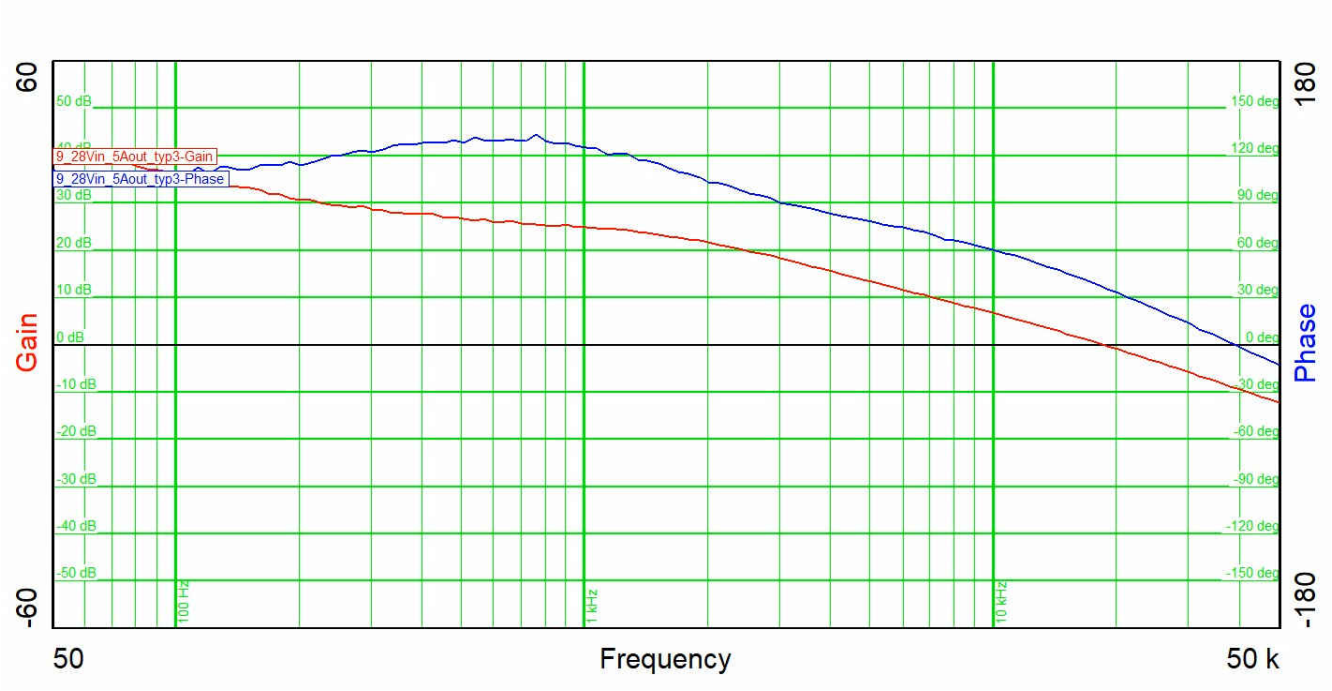


Figure 2-16. Bode Plot at 28-V Input Voltage

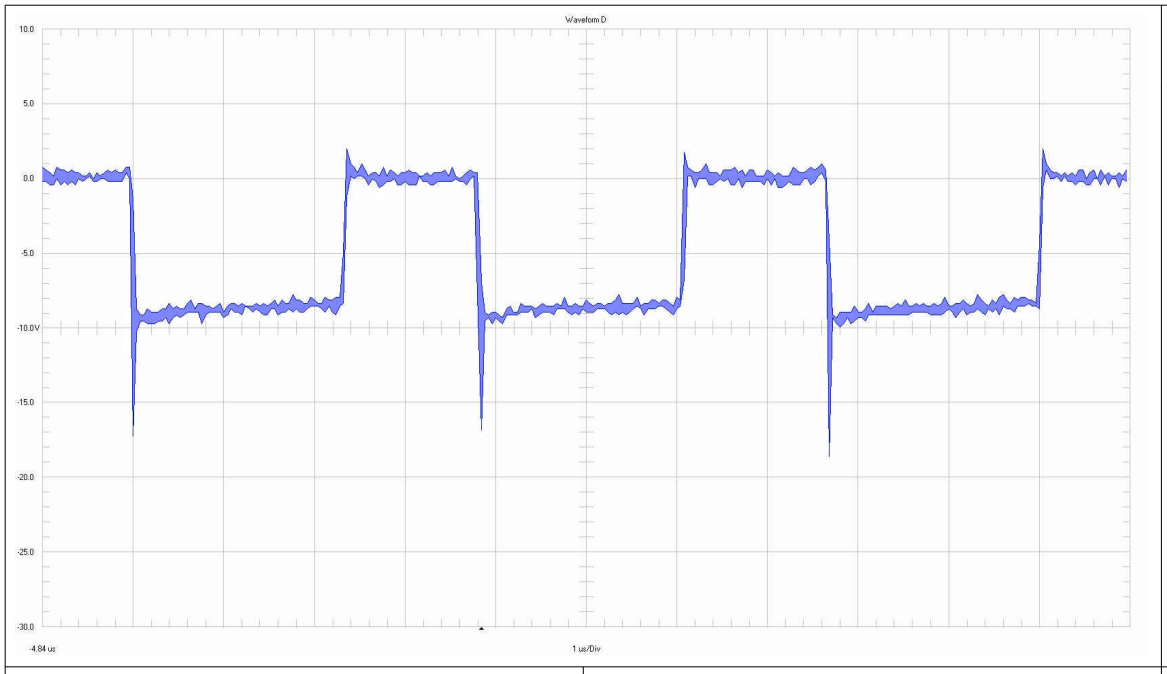
Table 2-1 details a summary of the test results from the bode plots.

Table 2-1. Summary of the Bode Plots Test Results

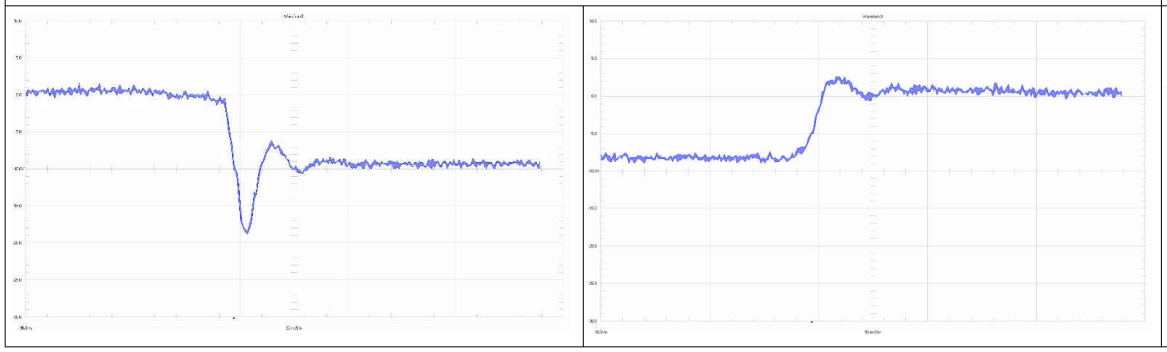
V_{IN}	3.5 V	6 V	12 V	16 V	28 V
Bandwidth (Hz)	281	913	4581	7427	18620
Phase Margin	87°	93°	78.7	55.3	36.6
Slope (20 dB / decade)	–0.93	–0.86	–0.91	–1.1	–1.3
Gain Margin (dB)	–13	–14.6	–14.2	–12.9	–9.1
Slope (20 dB/ decade)	–0.06	–0.474	–1	–1.4	–1.4
Frequency (kHz)	13.4	16.3	24.6	26.5	38.9

3 Waveforms

3.1 Switching



CH1 ⇒ 5 V / div
1-µs /div
full bandwidth



CH1 ⇒ 5 V / div
50 ns / major div
full bandwidth

Figure 3-1. Q1 (High Side FET) Source-Drain (Referenced to V_{OUT}), 4-V Input Voltage

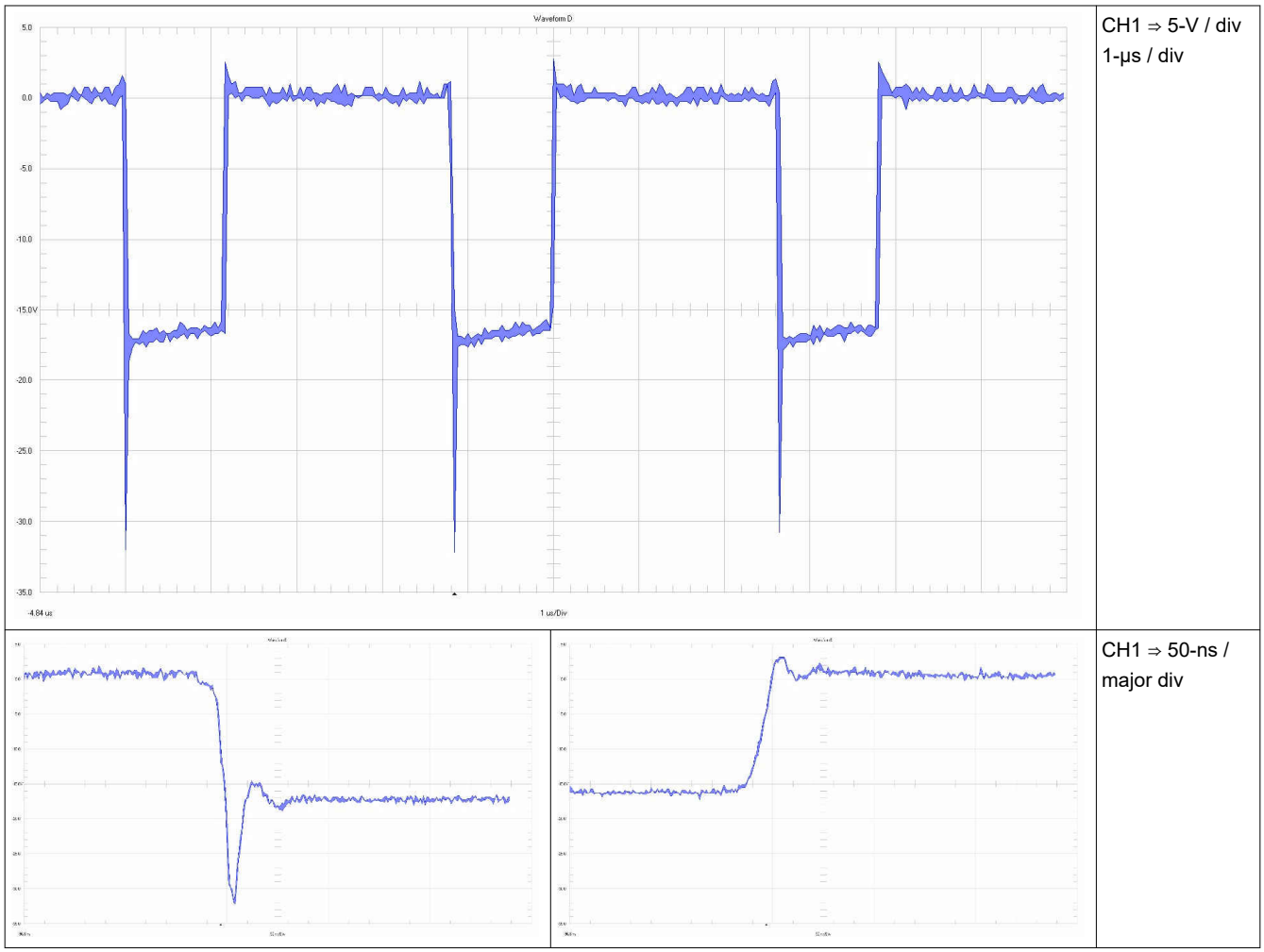


Figure 3-2. Q1 (High Side FET) Source-Drain (Referenced to V_{OUT}), 12-V Input Voltage

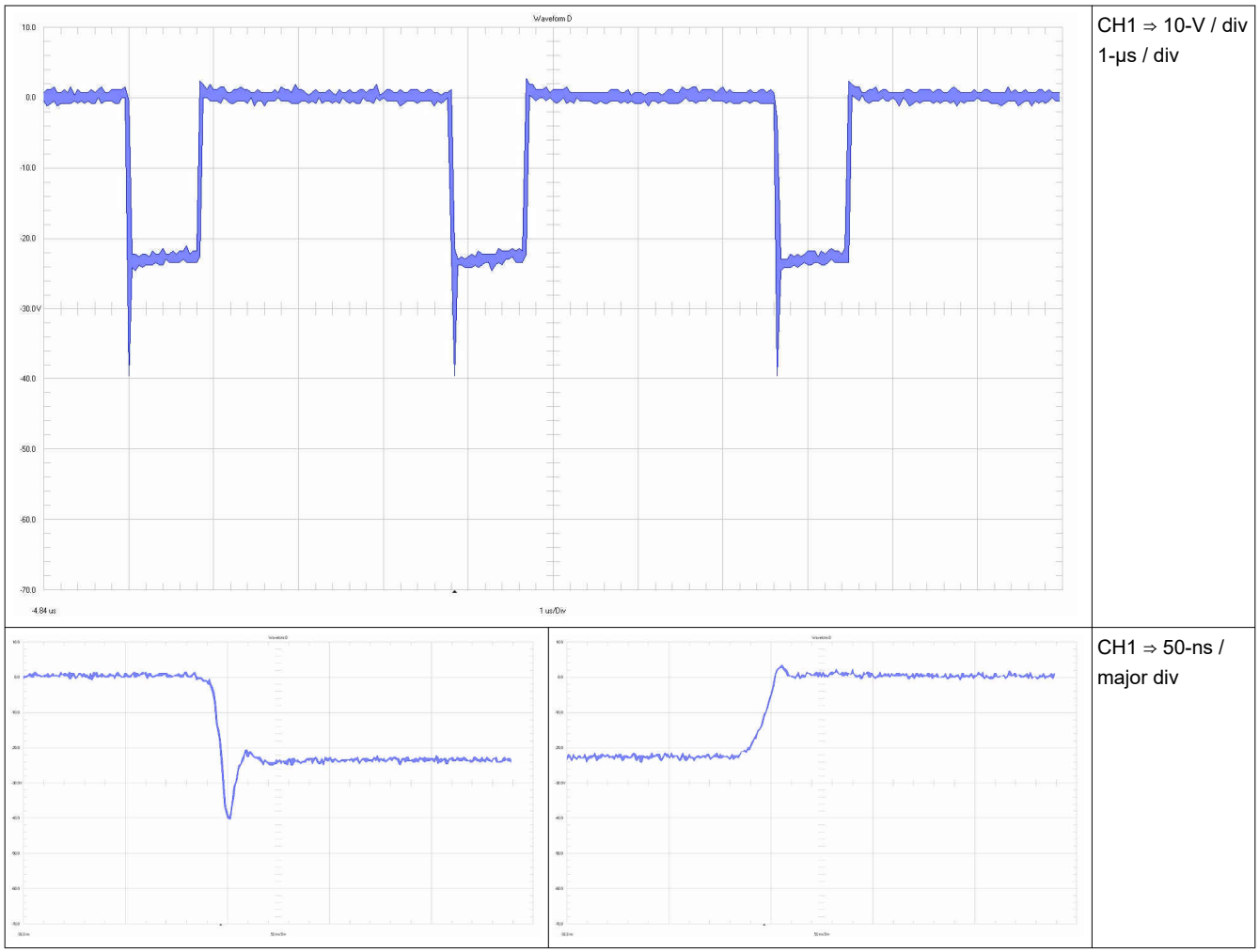


Figure 3-3. Q1 (High Side FET) Source-Drain (Referenced to V_{OUT}), 18-V Input Voltage

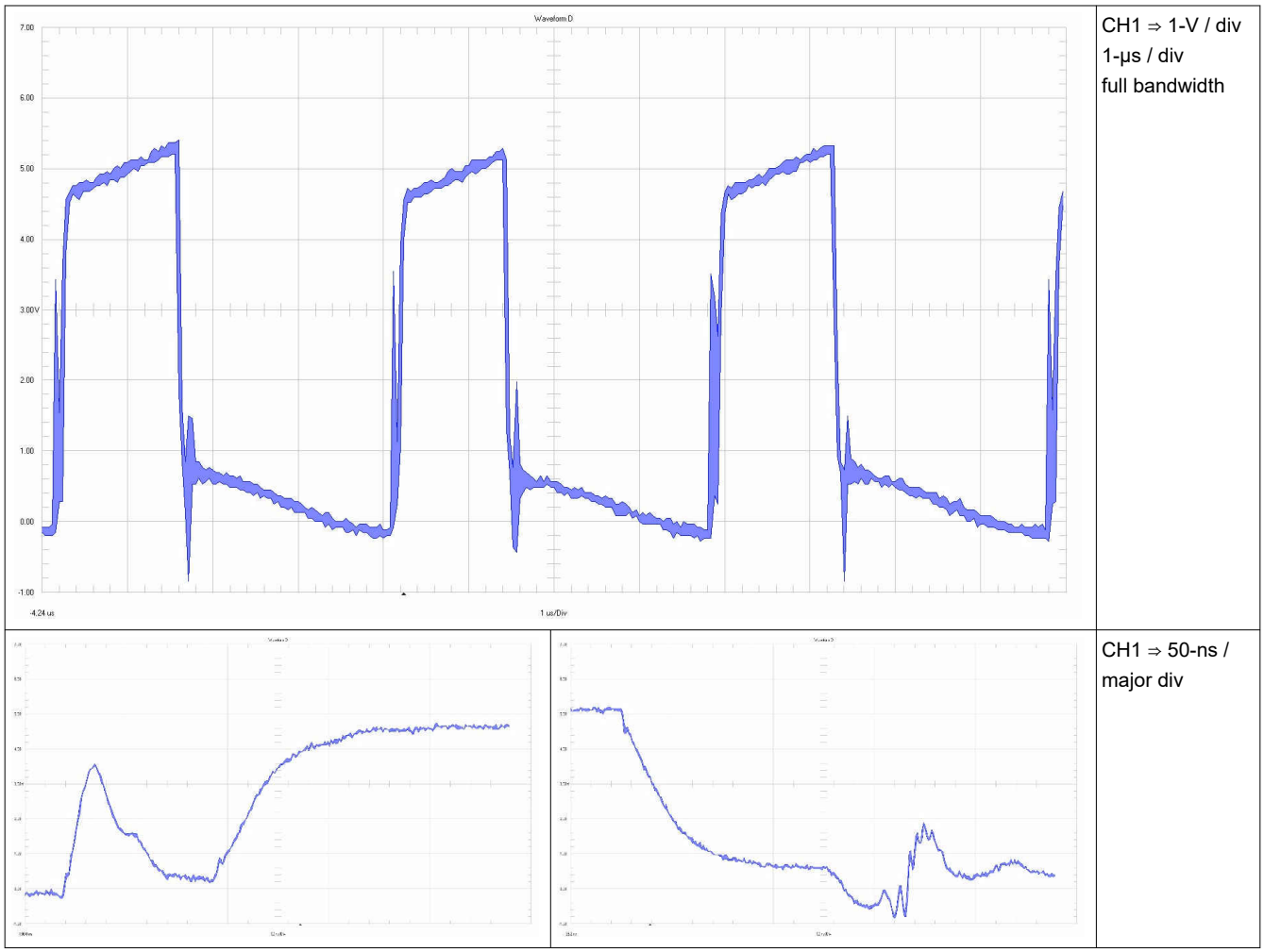
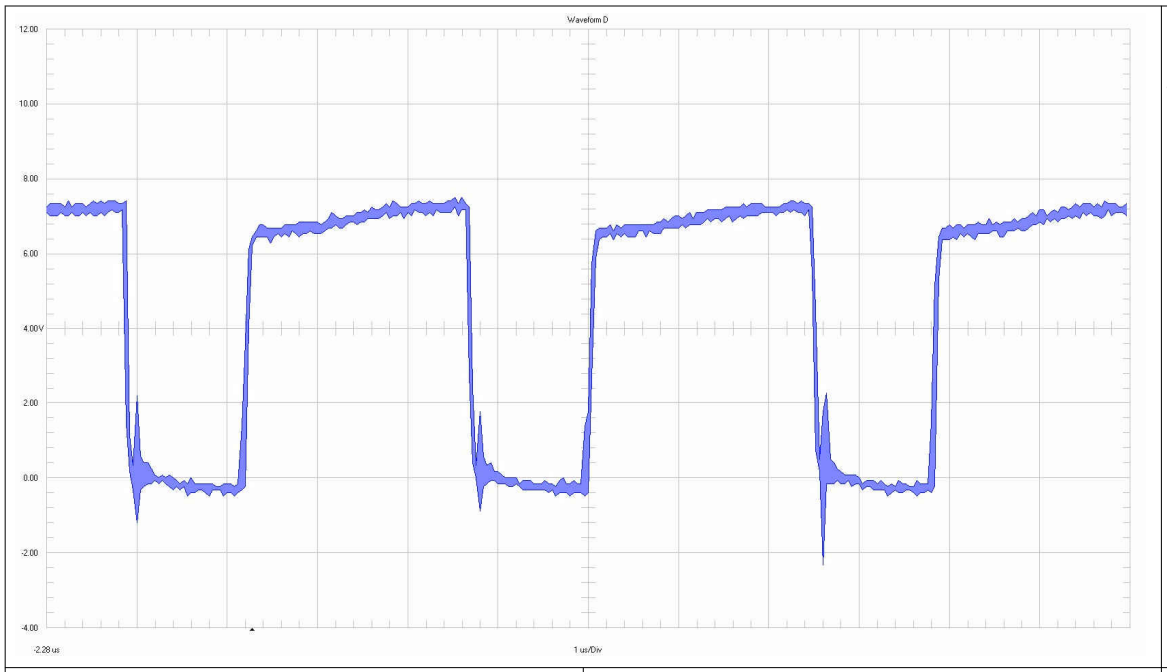


Figure 3-4. Q1 Gate, 4-V Input Voltage



CH1 ⇒ 1-V / div
1-µs / div
full bandwidth

CH1 ⇒ 50-ns / major div

Figure 3-5. Q1 Gate, 12-V Input Voltage

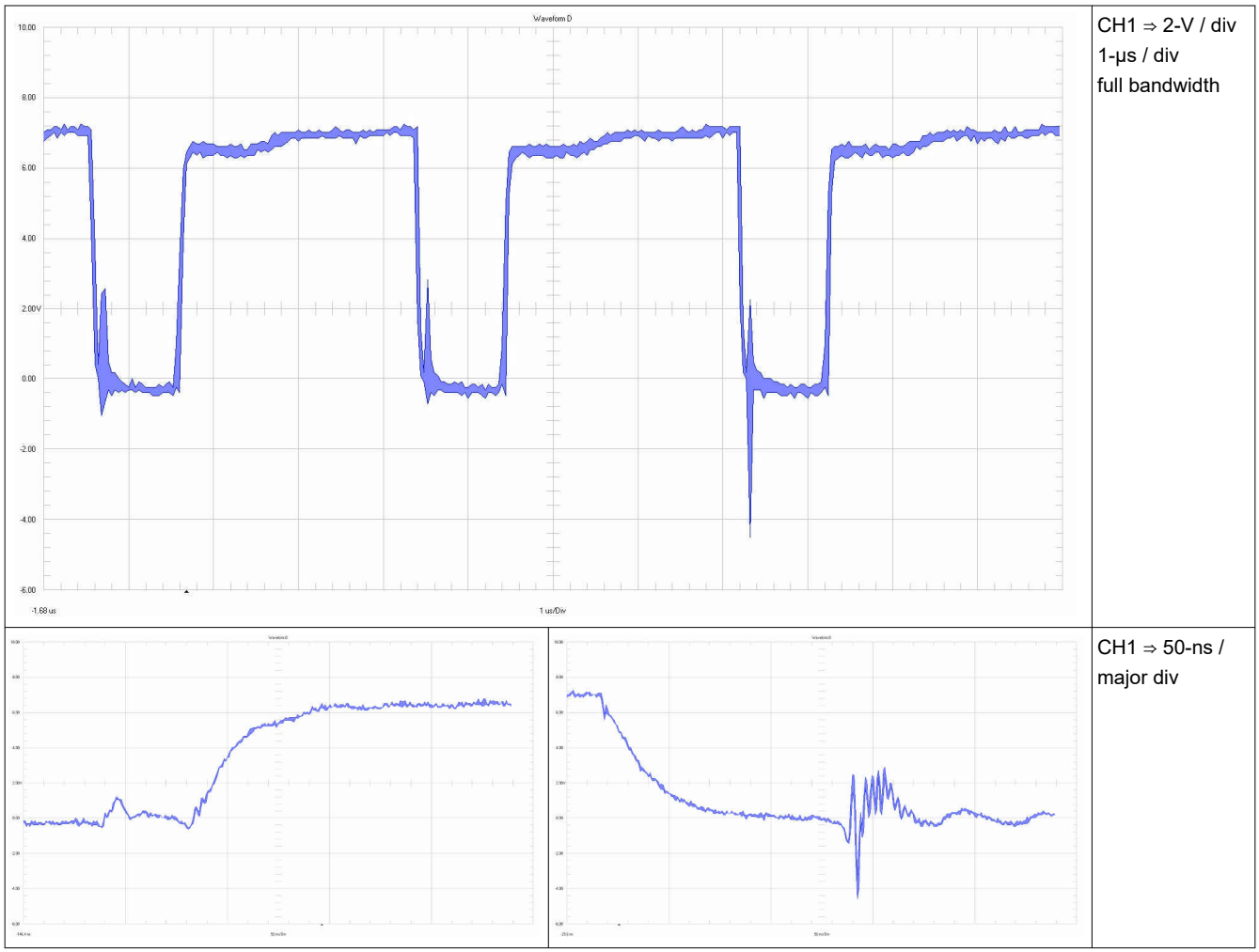
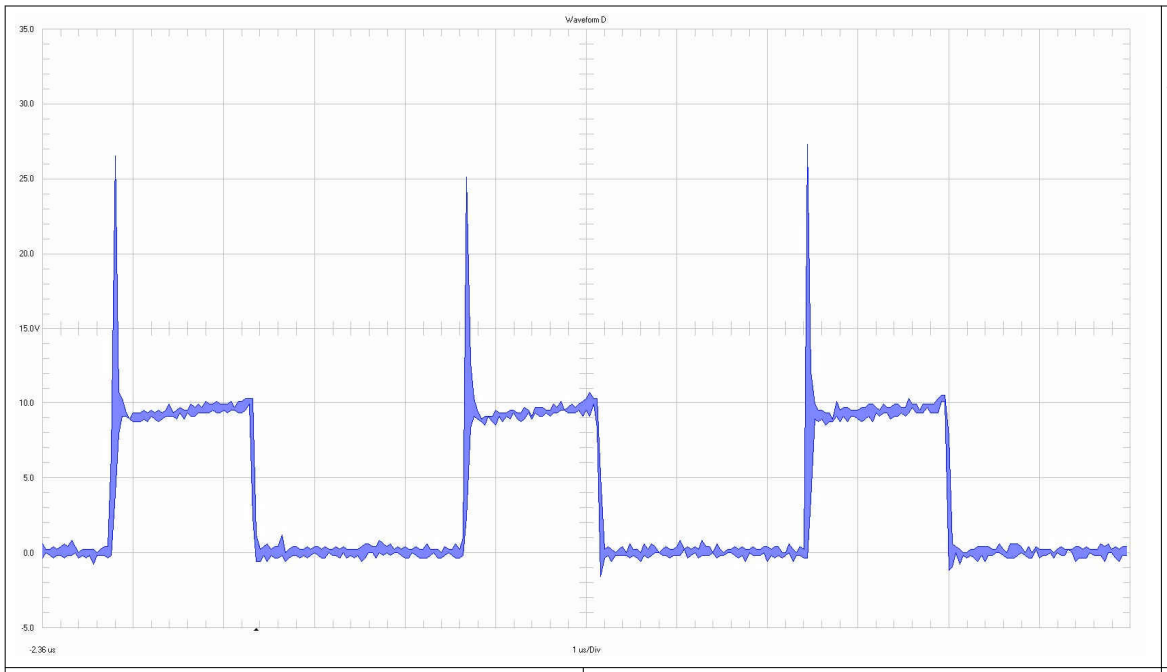


Figure 3-6. Q1 Gate, 18-V Input Voltage



	CH1 ⇒ 5-V / div 1-µs / div full bandwidth
	CH1 ⇒ 50-ns / major div

Figure 3-7. Q2 (LoSide FET) Drain Source, 4-V Input Voltage

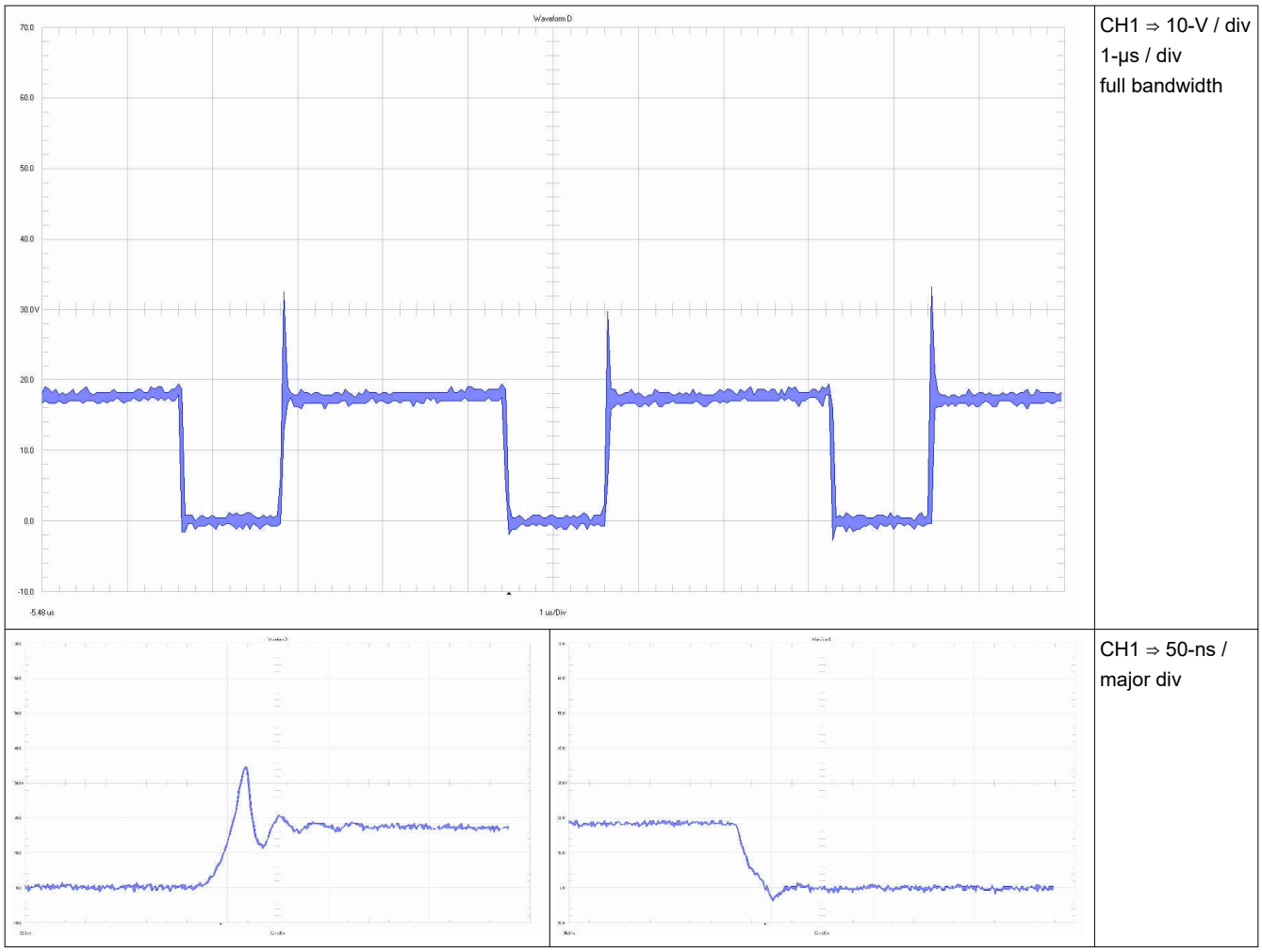


Figure 3-8. Q2 (LoSide FET) Drain Source, 12-V Input Voltage

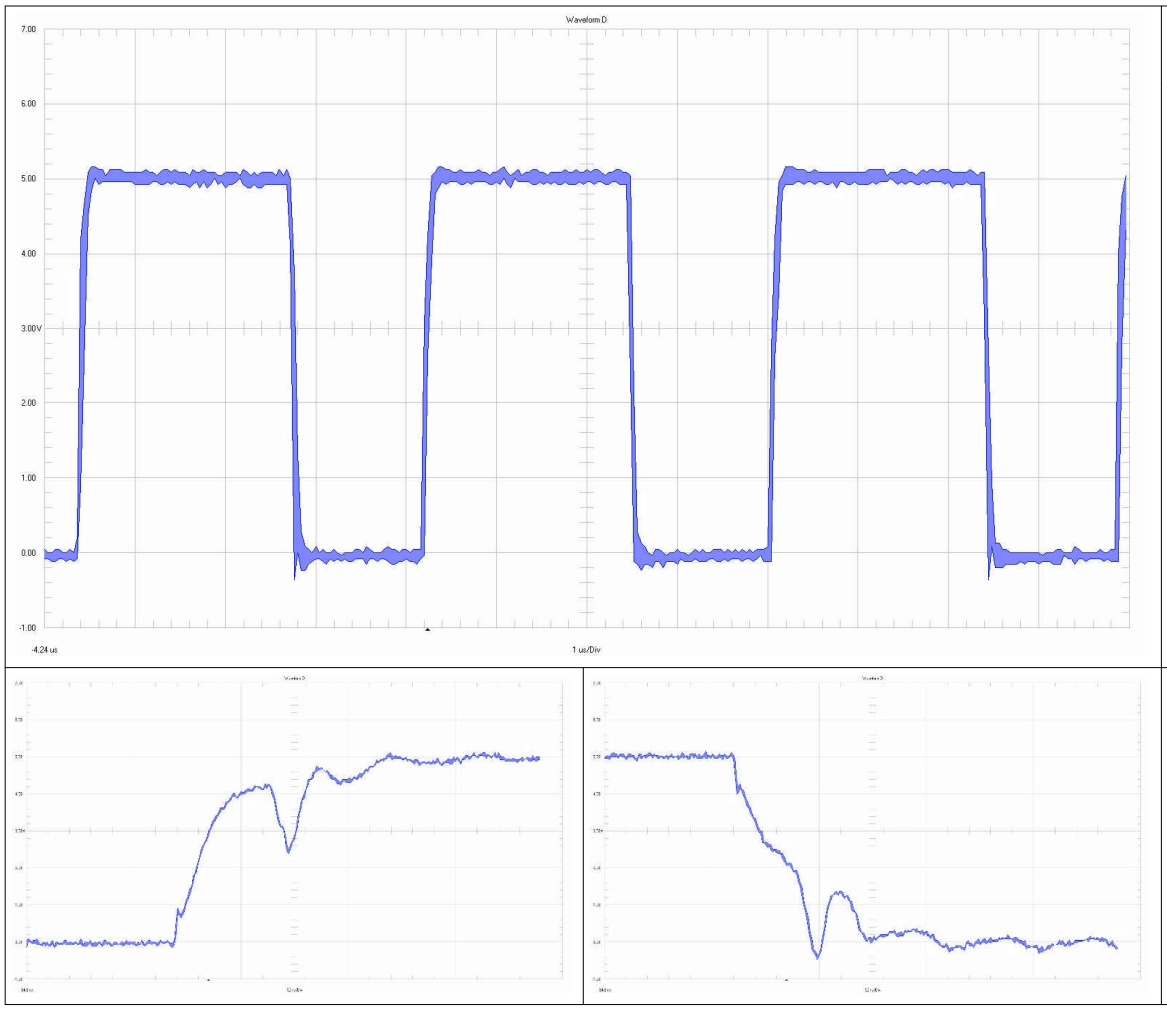


Figure 3-9. Q2 (LoSide FET) Drain Source, 4-V Input Voltage

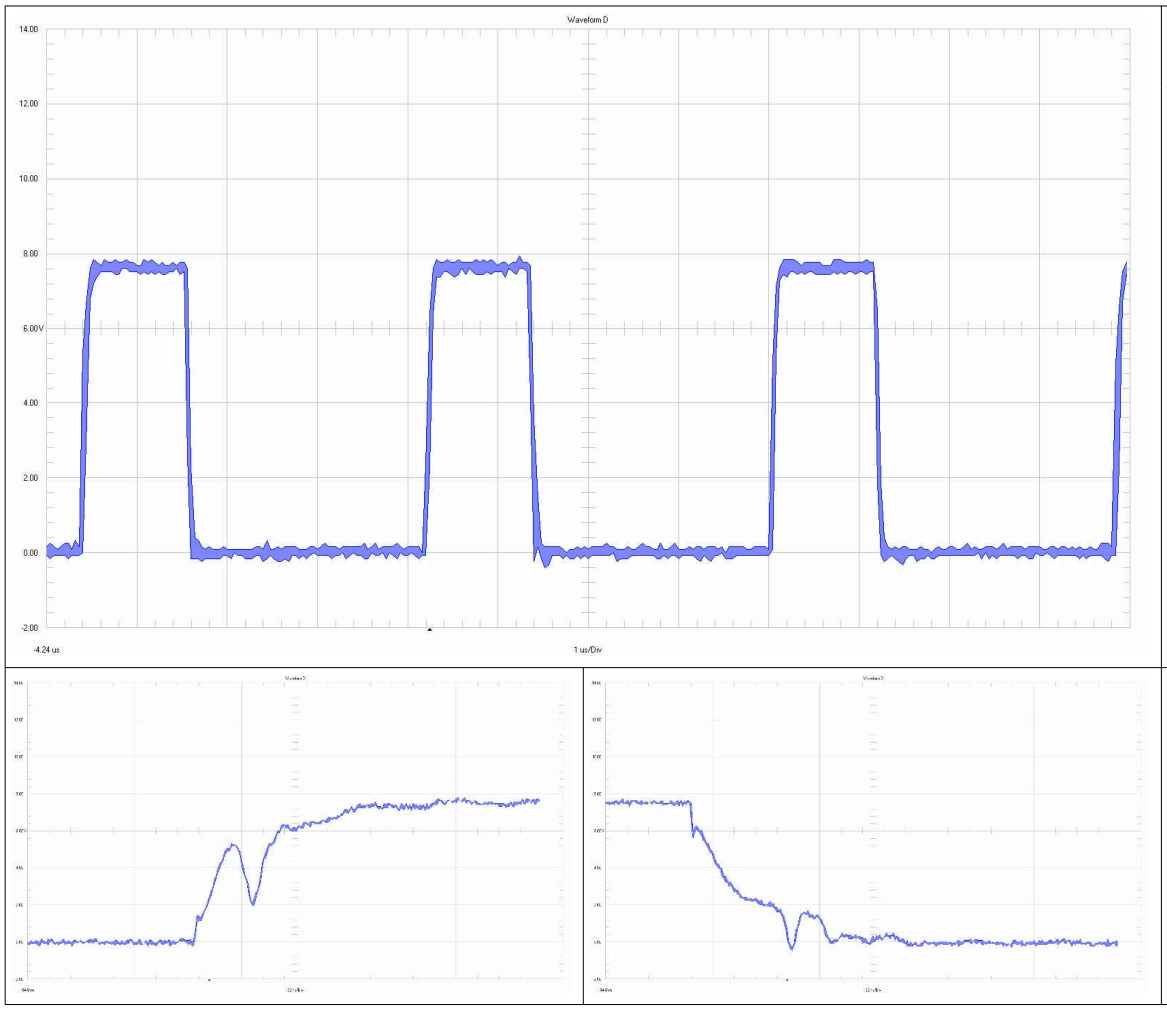


Figure 3-10. Q2 Gate, 12-V Input Voltage

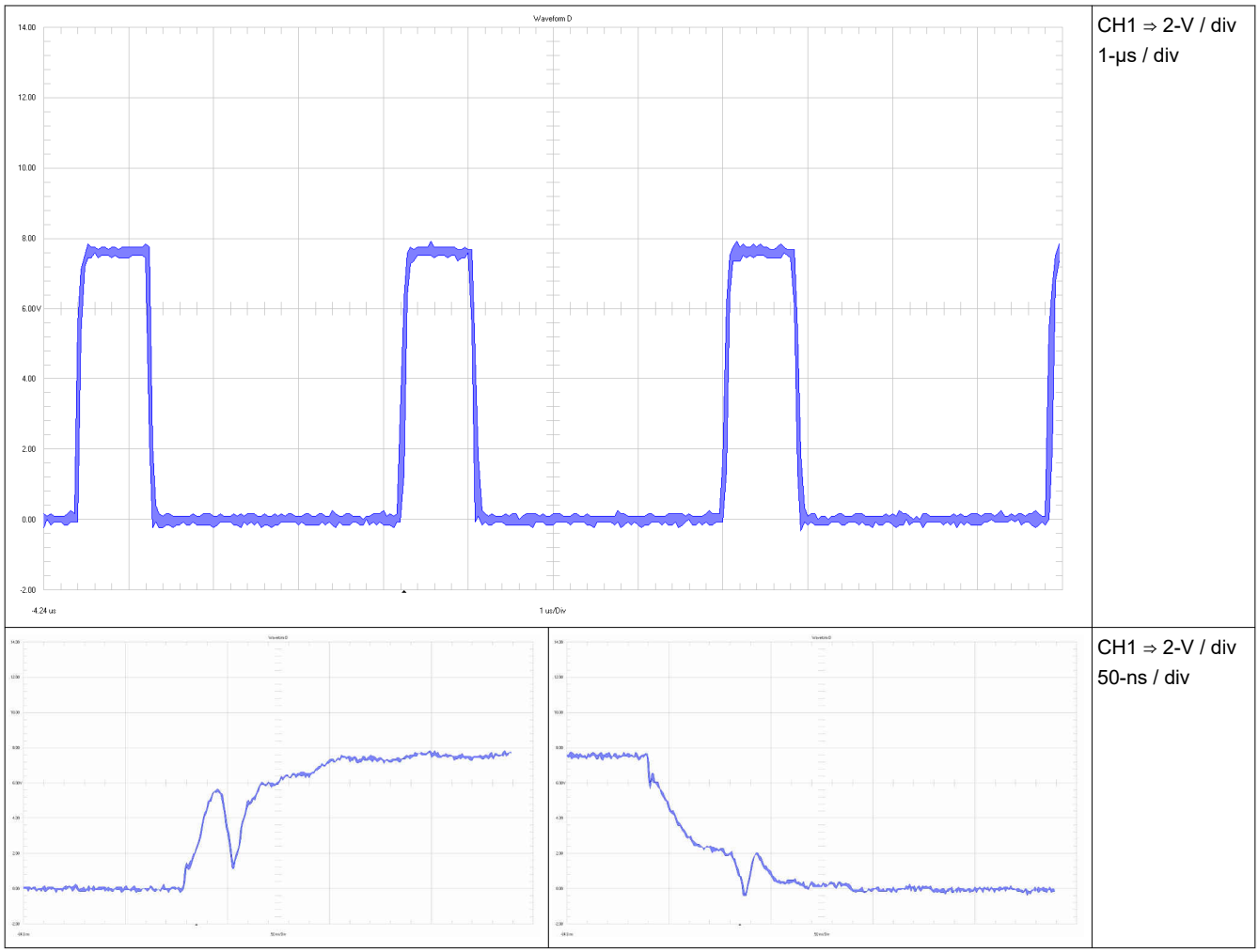
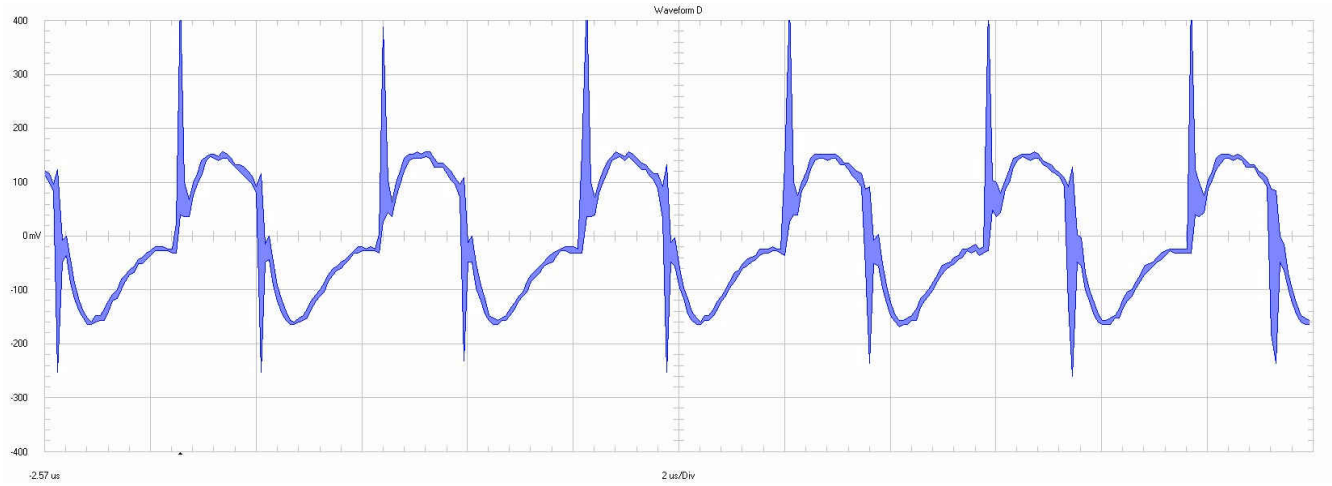


Figure 3-11. Q2 Gate, 18-V Input Voltage

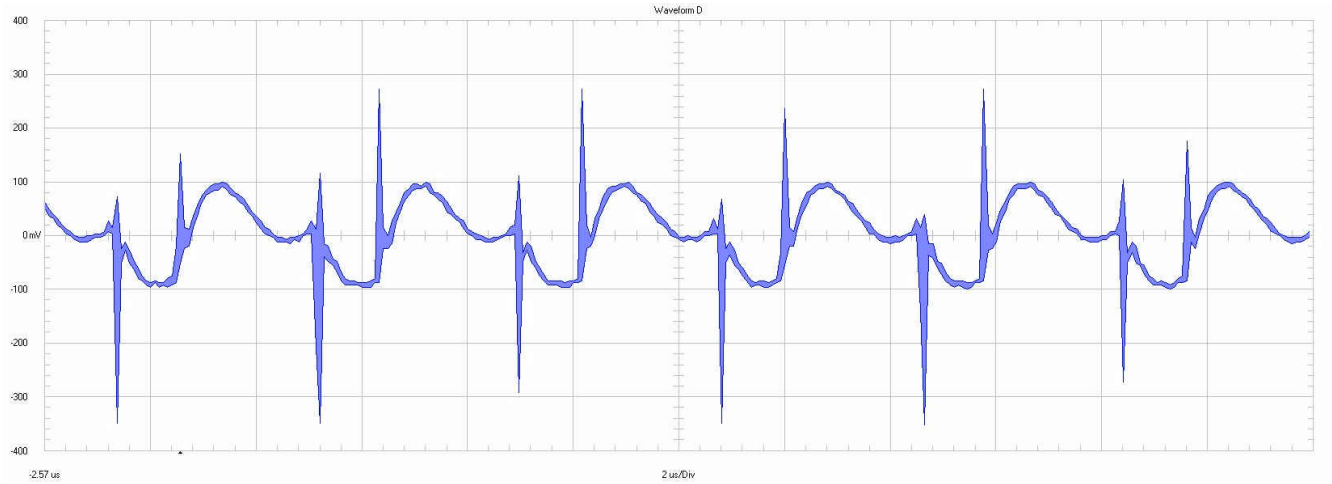
3.2 Output Voltage Ripple

Output voltage ripple (AC coupled) is shown in the following figures.



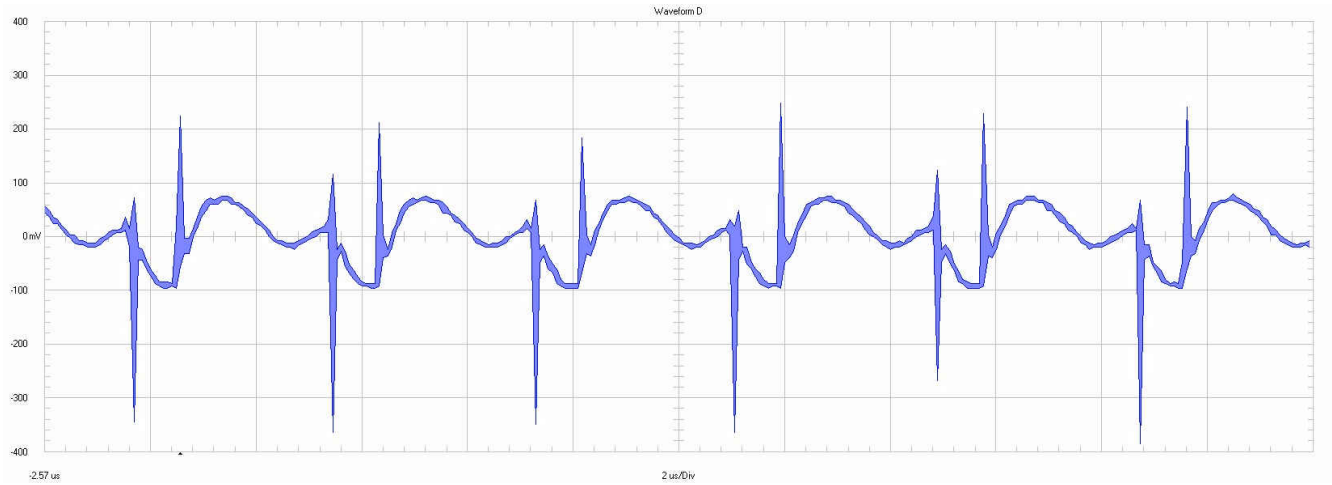
100 mV / div, 20-MHz bandwidth, 2-µs / div

Figure 3-12. Output Voltage Ripple at 4 V_{IN}



100 mV / div, 20-MHz bandwidth, 2-µs / div

Figure 3-13. Output Voltage Ripple at 12-V_{IN}

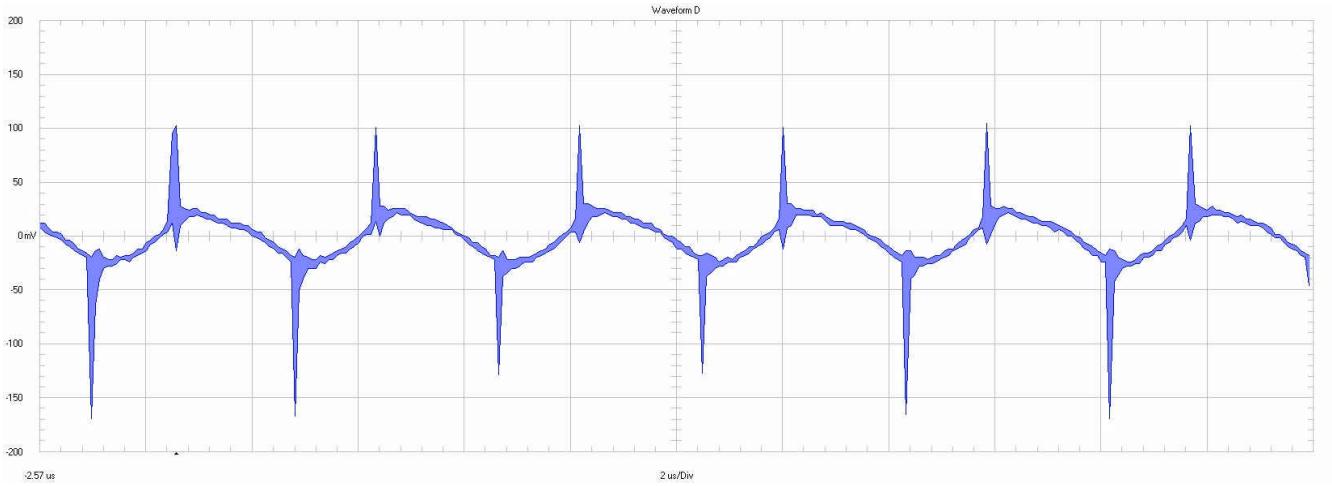


100 mV / div, 20-MHz bandwidth, 2-µs / div

Figure 3-14. Output Voltage Ripple at 18-V_{IN}

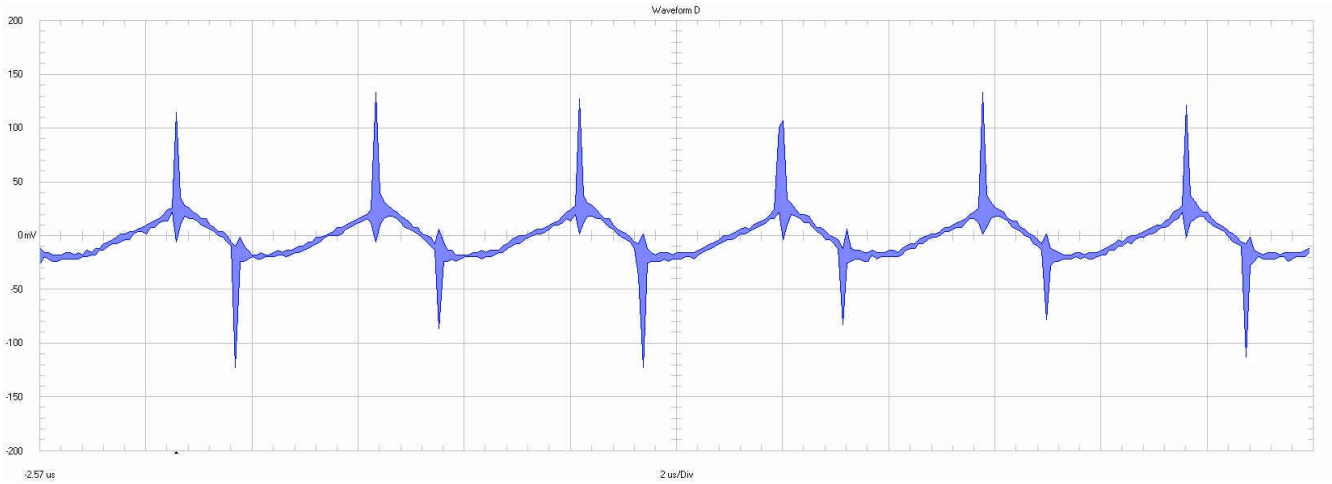
3.3 Input Voltage Ripple

Input voltage ripple (AC coupled) is shown in the following figures.



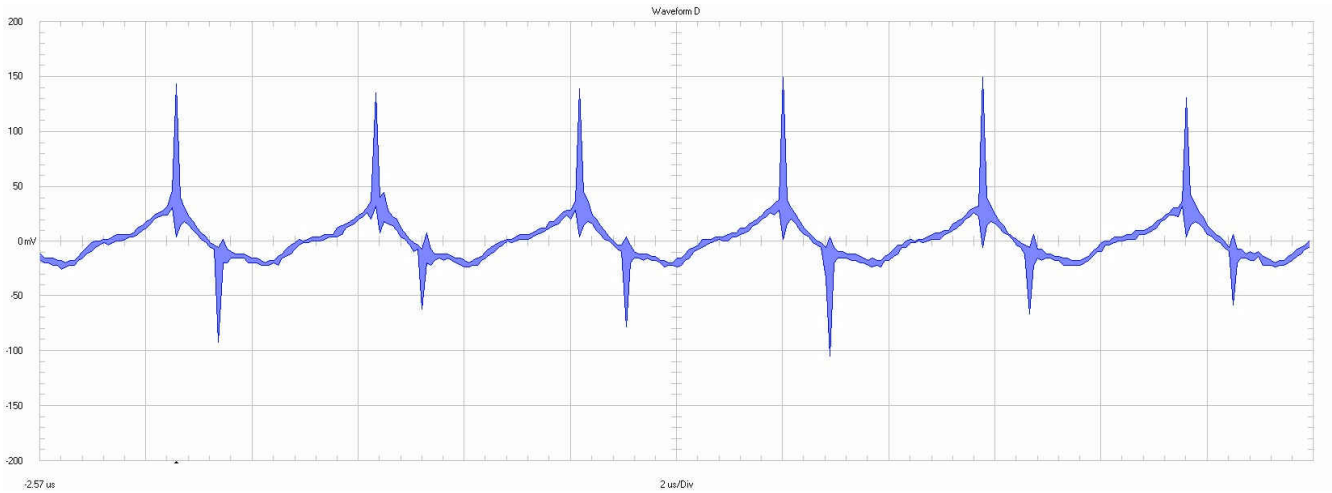
50-mV / div, 20-MHz bandwidth, 2-µs / div

Figure 3-15. Input Voltage Ripple (4 V_{IN})



50-mV / div, 20-MHz bandwidth, 2-µs / div

Figure 3-16. Input Voltage Ripple (12 V_{IN})



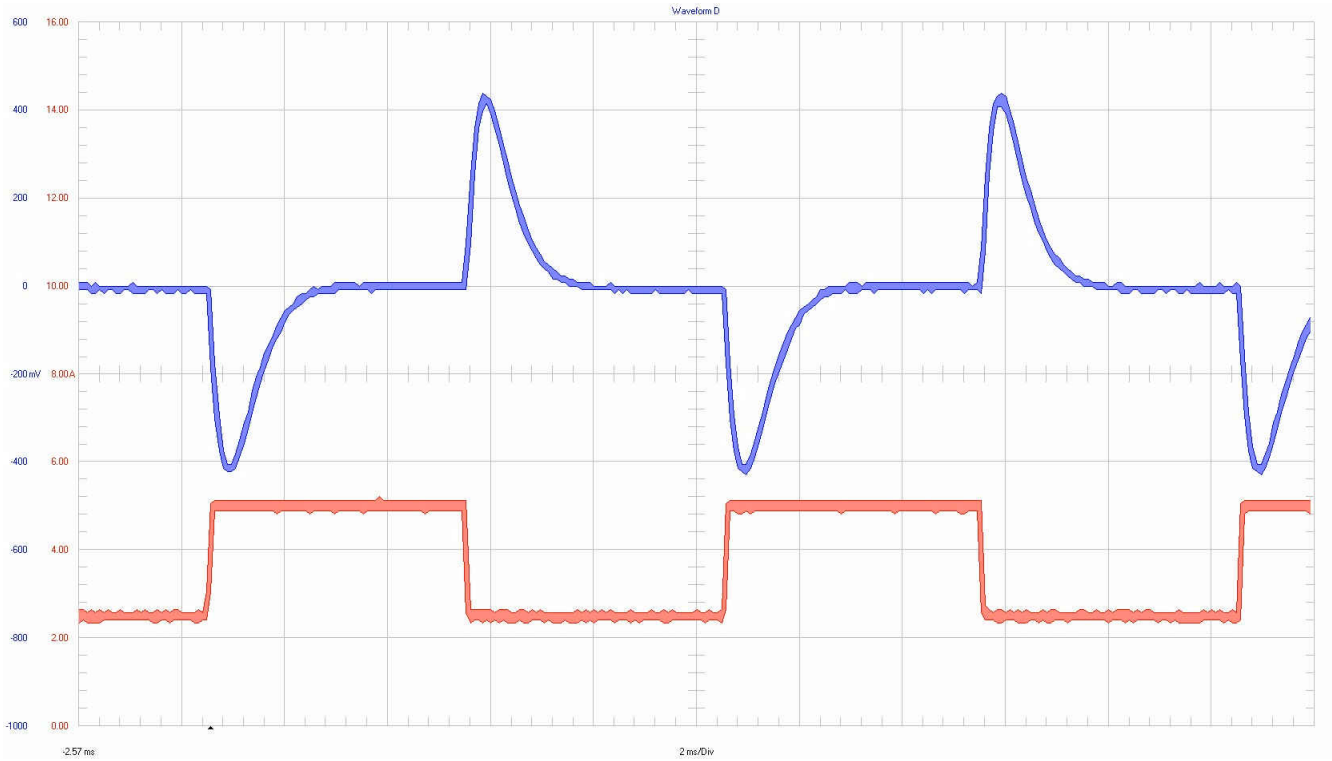
50-mV / div, 20-MHz bandwidth, 2-µs / div

Figure 3-17. Input Voltage Ripple (18 V_{IN})

3.4 Load Transients

Electronic load was used for the waveforms taken in the following images. The load is switching from 2.5 A to 5 A with a frequency of 100 Hz.

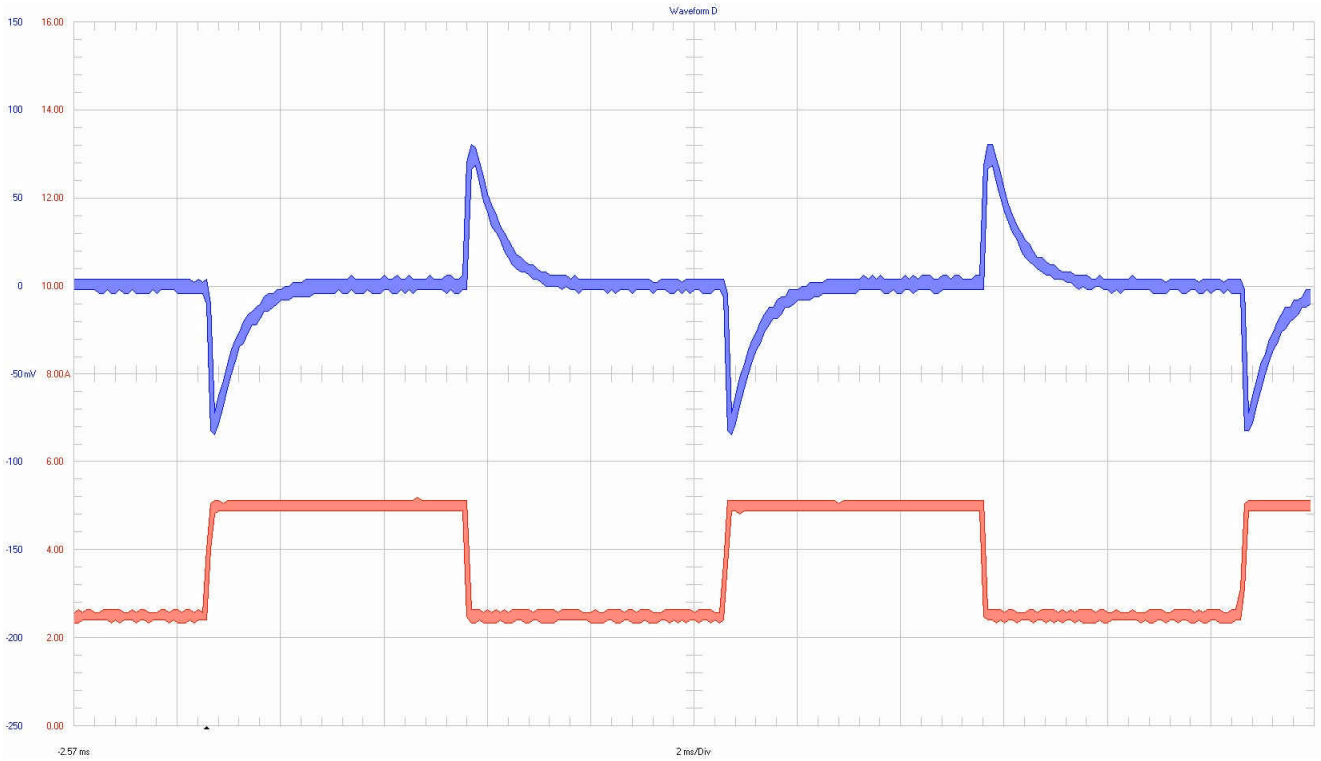
4-V Input Voltage



Ch1 ⇒ output voltage; 200 mV / div; AC-coupling; 10-kHz bandwidth
Ch2 ⇒ output current; 2 A / div; 20-MHz bandwidth
2-ms / div

Figure 3-18. 2.5-A to 5-A Load Transient at 4-V Input Voltage

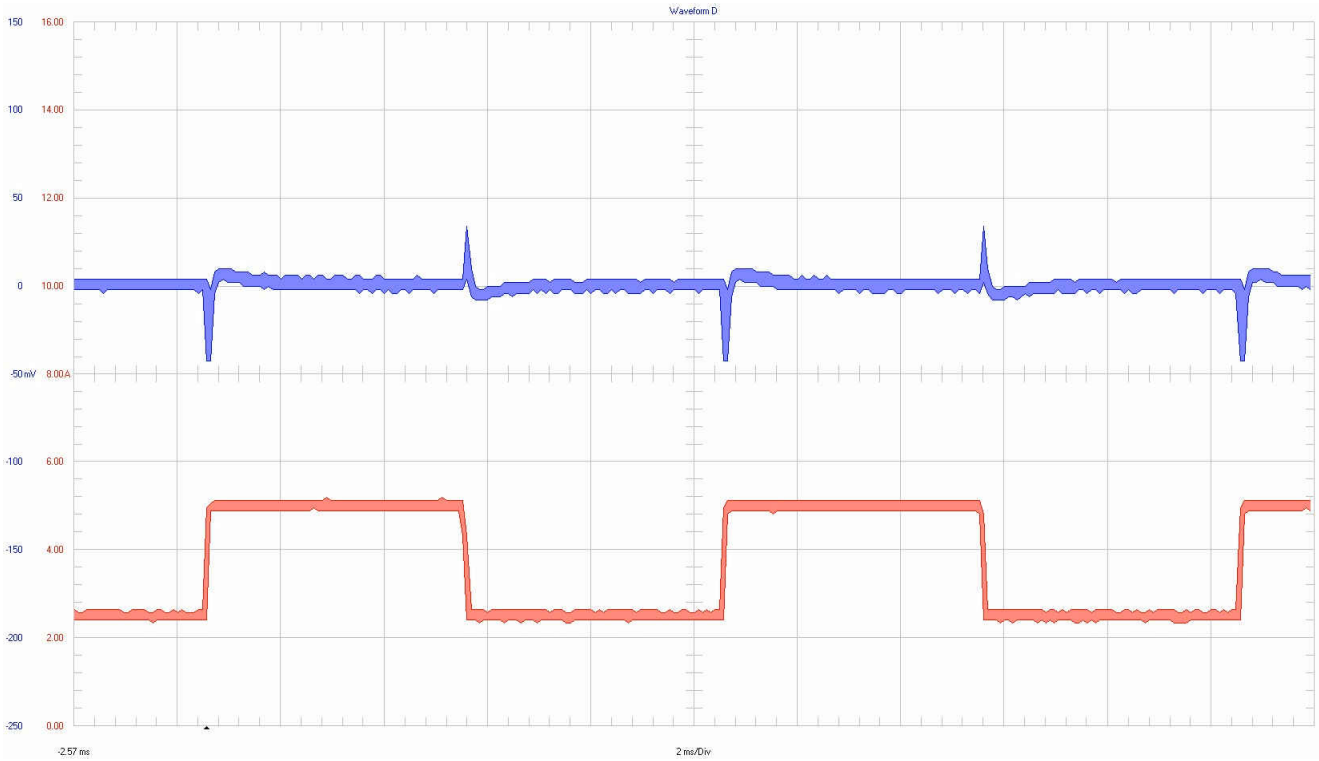
12-V Input Voltage



Ch1 ⇒ output voltage; 50 mV / div; AC-coupling; 10-kHz bandwidth
Ch2 ⇒ output current; 2 A / div; 20-MHz bandwidth
2-ms / div

Figure 3-19. 2.5-A to 5-A Load Transient at 12-V Input Voltage

18-V Input Voltage



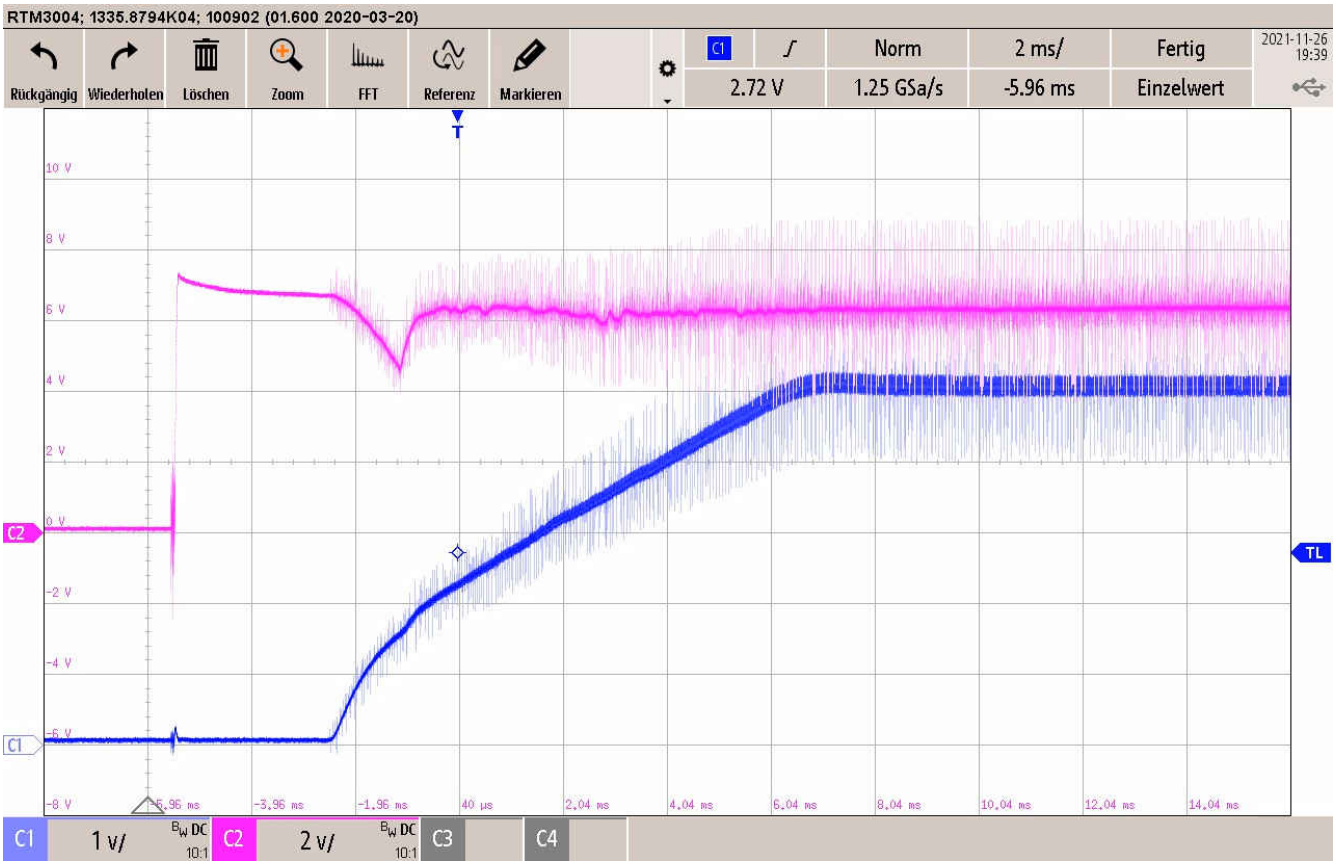
Ch1 ⇒ output voltage; 50 mV / div; AC-coupling; 10-kHz bandwidth
Ch2 ⇒ output current; 2 A / div; 20-MHz bandwidth
2-ms / div

Figure 3-20. 2.5-A to 5-A Load Transient at 18-V Input Voltage

3.5 Start-Up Sequence

The power supply was plugged in for the waveforms taken in the following images.

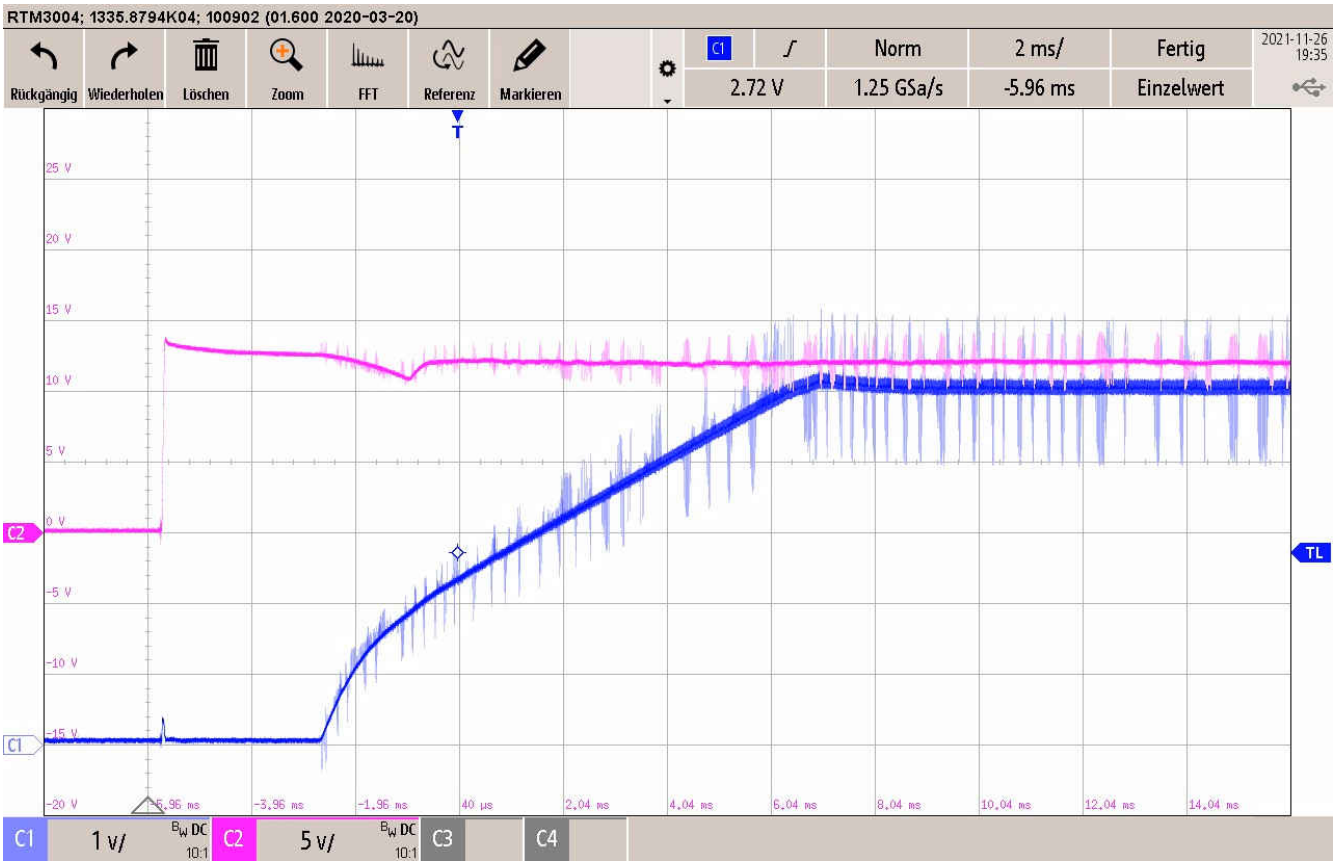
6-V Input Voltage



C2 ⇒ input voltage; 2 V / div
C1 ⇒ output voltage; 1 V / div
(All) 2 ms / div; 20-MHz bandwidth

Figure 3-21. Start-up With 6-V Input Voltage

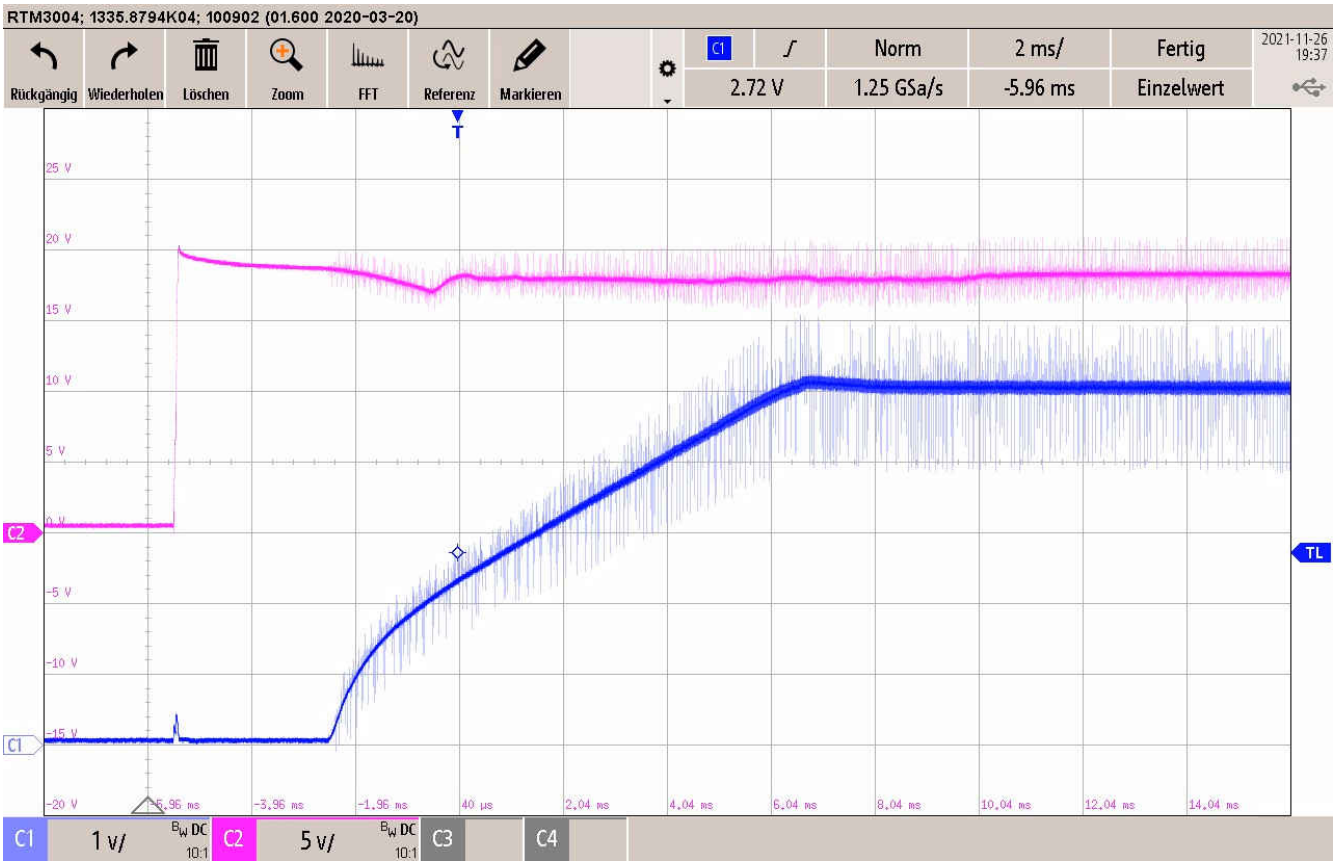
12-V Input Voltage



C2 ⇒ input voltage; 5 V / div
C1 ⇒ output voltage; 1 V / div
(All) 2 ms / div; 20-MHz bandwidth

Figure 3-22. Start-up With 12-V Input Voltage

18-V Input Voltage



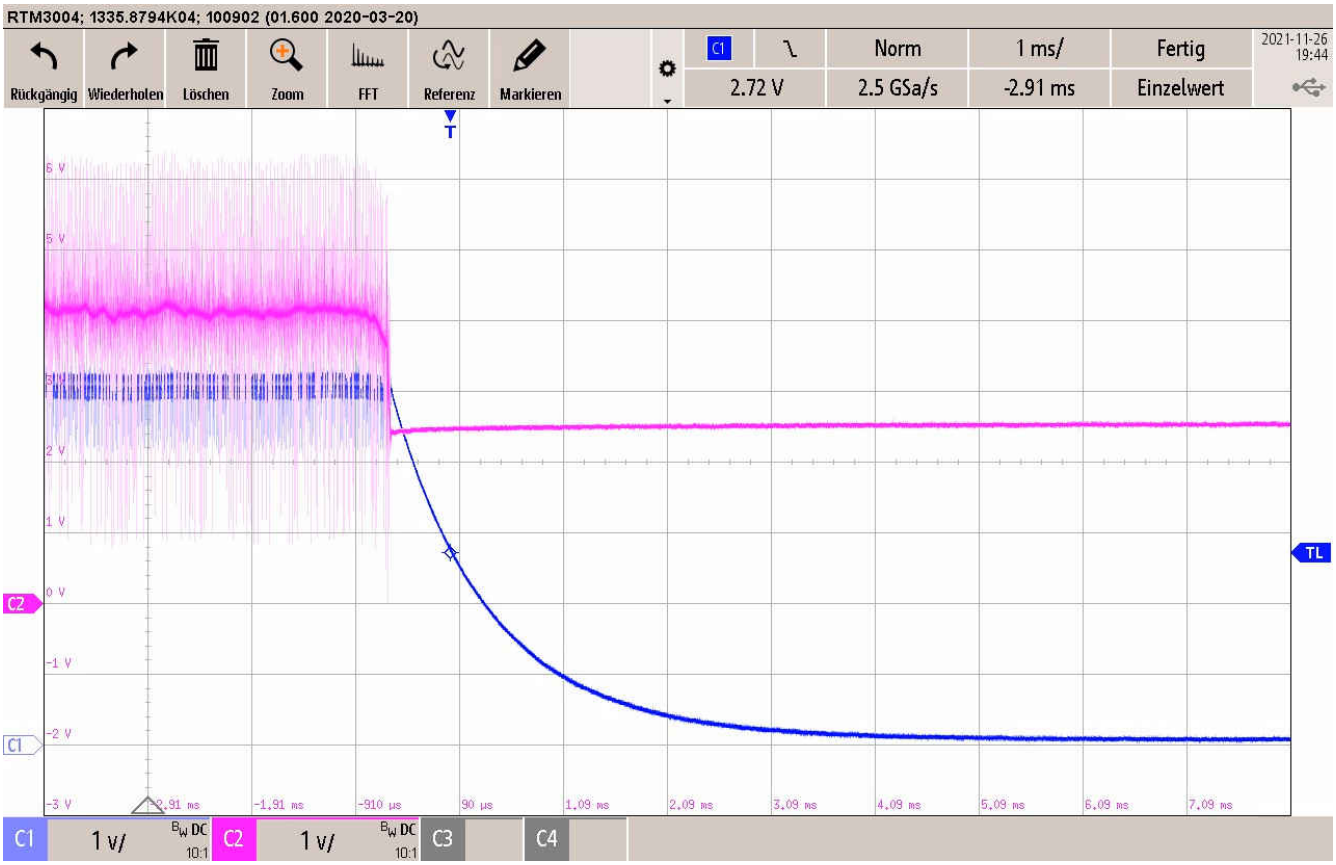
C2 ⇒ input voltage; 5 V / div
C1 ⇒ output voltage; 1 V / div
(All) 2 ms / div; 20-MHz bandwidth

Figure 3-23. Start-up With 18-V Input Voltage

3.6 Shutdown Sequence

The power supply was disconnected for the waveforms taken in the following images.

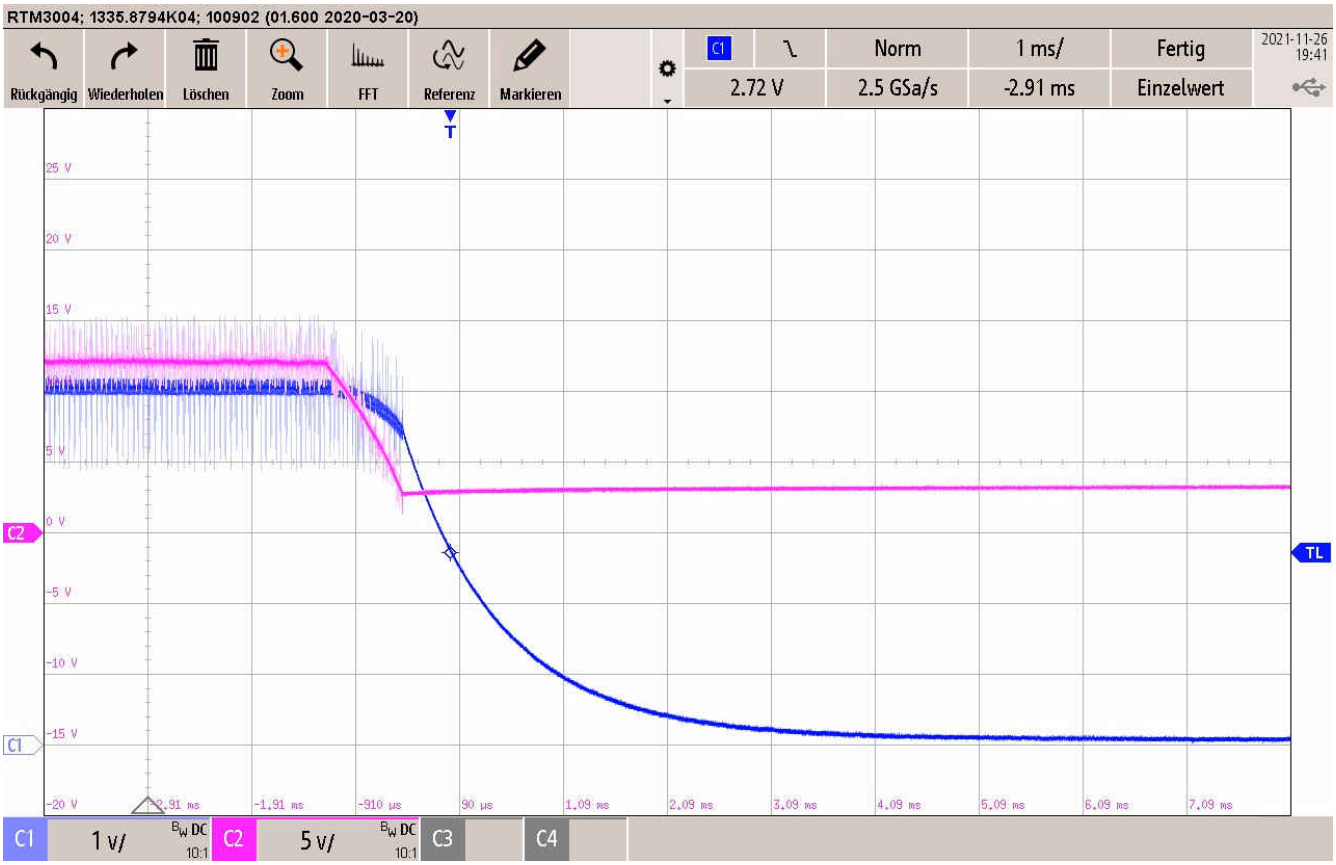
4-V Input Voltage



C2 ⇒ input voltage; 1 V / div
C1 ⇒ output voltage; 1 V / div
(All) 1 ms / div; 20-MHz bandwidth

Figure 3-24. Shutdown With 4-V Input Voltage

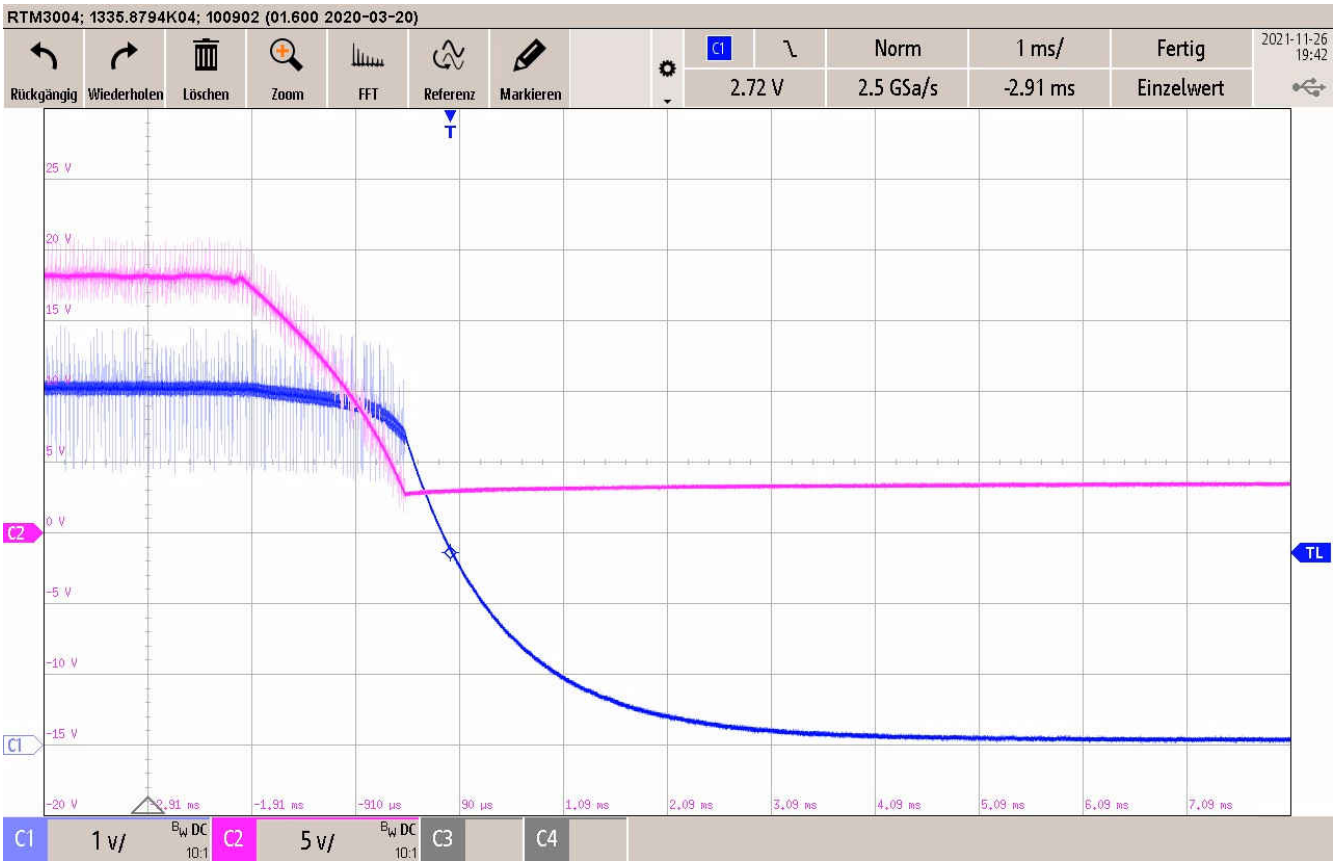
12-V Input Voltage



C2 ⇒ input voltage; 5 V / div
C1 ⇒ output voltage; 1 V / div
(All) 1 ms / div; 20-MHz bandwidth

Figure 3-25. Shutdown With 12-V Input Voltage

18-V Input Voltage



C2 ⇒ input voltage; 5 V / div
C1 ⇒ output voltage; 1 V / div
(All) 1 ms / div; 20-MHz bandwidth

Figure 3-26. Shutdown With 18-V Input Voltage

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