Test Report: PMP31291

27W Inverting Buck Boost Reference Design

Description

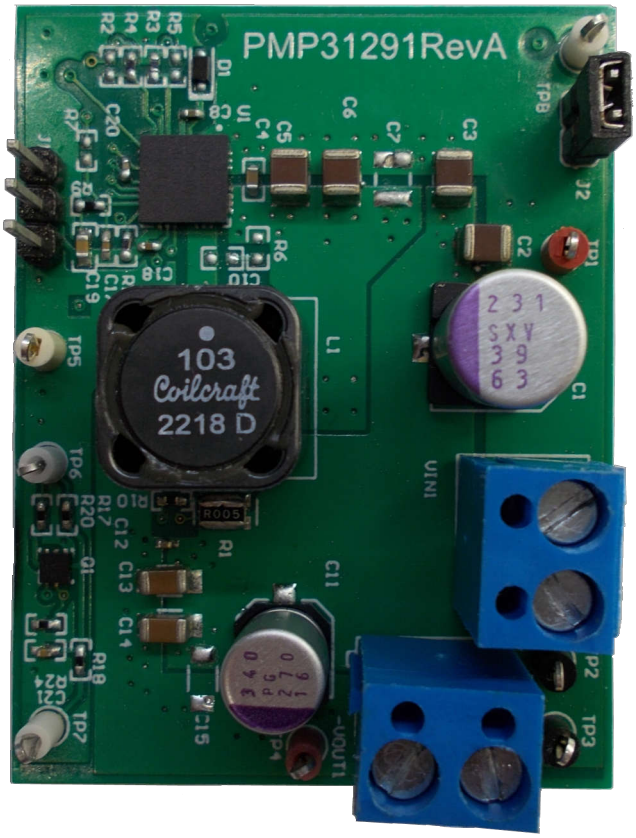
This reference design is a flexible and compact power supply providing a negative output voltage rail. The design includes a LM70880-Q1 device (a 80V, 8A high-efficiency buck converter). The output voltage value can be selected among three predefined settings: –7V, –10V, and –11V.

Features

- Negative output voltage
- Selectable output voltage(–7V to –11V)
- High-efficiency conversion due to use of synchronous rectification
- Level shifters for enable and power good signals
- Design is built and tested

Applications

- Active antenna system mMIMO (AAS)
- Macro remote radio unit (RRU)



Top Photo

1 Test Prerequisites

1.1 Voltage and Current Requirements

Table 1-1. Voltage and Current Requirements

Parameter	Specifications
Input Voltage	8V to 52V
Output Voltage	–7V, –10V, or –11V (selectable)
Output Current	2.5A

1.2 Dimensions

The size of the board is 53.5mm × 41.25mm. The board has four copper layers with 70µm on copper thickness on each outer layer and 35µm on both inner layers.

2 Testing and Results

2.1 Efficiency Graphs

2.1.1 –7V Output Voltage

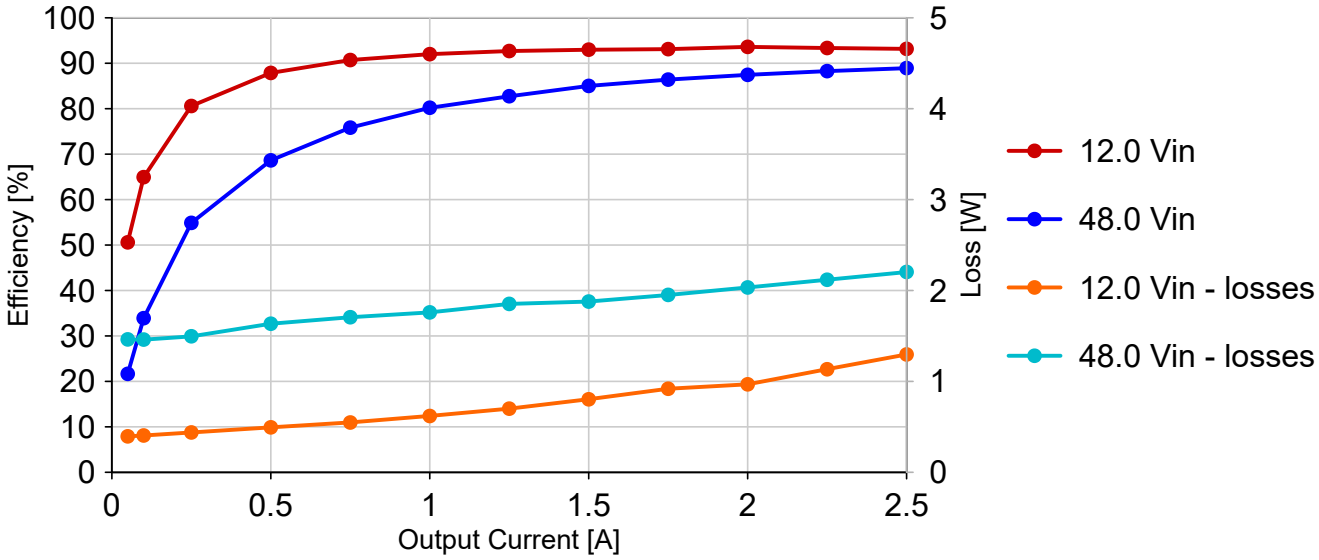


Figure 2-1. Efficiency vs Output Current at –7V_{OUT}

2.1.2 –11V Output Voltage

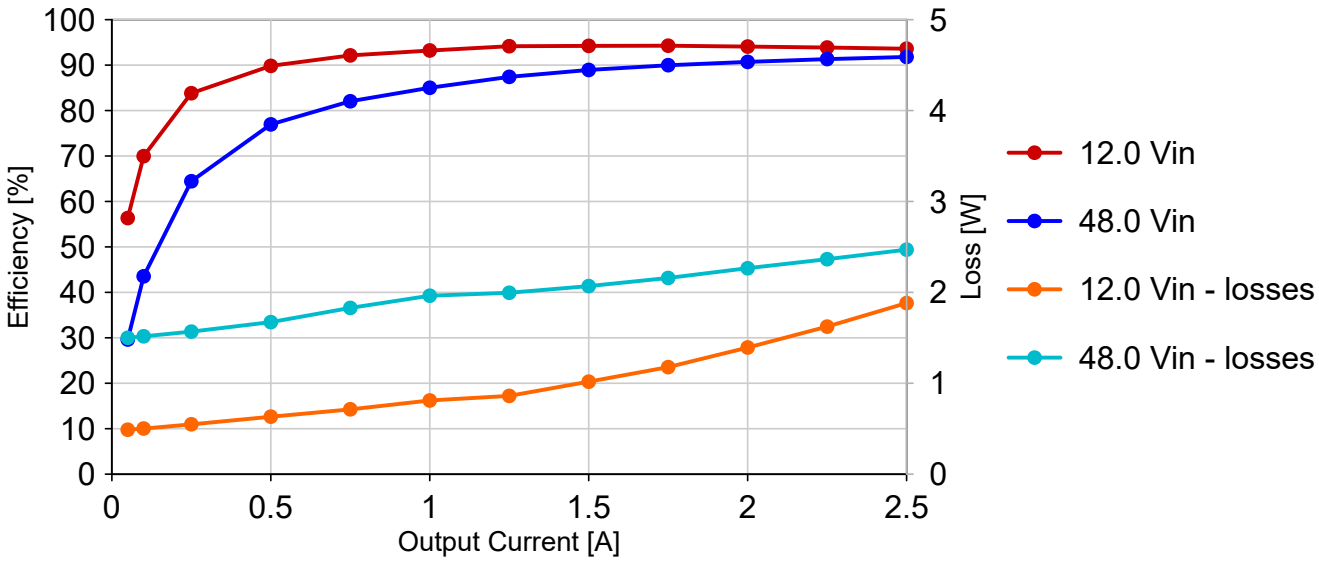


Figure 2-2. Efficiency vs Output Current at –11V_{OUT}

2.2 Efficiency Data

Table 2-1. Efficiency Data, 12V_{IN}, –11V_{OUT}

Voltage (V)	Current (A)	Voltage (V)	Current (A)	Losses (W)	Efficiency (%)
12.0500	0.0929	11.0460	0.0571	0.49	56.3
12.0400	0.1386	11.0450	0.1057	0.50	70.0
12.0500	0.2809	11.0430	0.2569	0.55	83.8
12.0000	0.5174	11.0390	0.5052	0.63	89.8
12.1000	0.7487	11.0360	0.7563	0.71	92.1
12.0500	0.9898	11.0330	1.0076	0.81	93.2
11.9900	1.2260	11.0270	1.2550	0.86	94.1
12.0500	1.4610	11.0220	1.5050	1.02	94.2
11.9900	1.7100	11.0180	1.7540	1.18	94.3
12.0400	1.9500	11.0150	2.0050	1.39	94.1
11.9800	2.2090	11.0110	2.2560	1.62	93.9
12.0100	2.4520	11.0090	2.5040	1.88	93.6

Table 2-2. Efficiency Data, 48V_{IN}, –11V_{OUT}

Voltage (V)	Current (A)	Voltage (V)	Current (A)	Losses (W)	Efficiency (%)
48.1000	0.0443	11.0530	0.0571	1.50	29.6
48.1000	0.0558	11.0520	0.1057	1.52	43.5
48.1000	0.0916	11.0500	0.2569	1.57	64.4
48.1000	0.1508	11.0480	0.5052	1.67	76.9
48.1000	0.2117	11.0460	0.7563	1.83	82.0
48.1000	0.2721	11.0440	1.0074	1.96	85.0
48.1000	0.3295	11.0390	1.2550	2.00	87.4
48.1000	0.3886	11.0380	1.5060	2.07	88.9
48.1000	0.4473	11.0360	1.7540	2.16	90.0
48.1000	0.5068	11.0340	2.0040	2.26	90.7
48.1000	0.5664	11.0330	2.2550	2.36	91.3
48.1000	0.6257	11.0330	2.5040	2.47	91.8

Table 2-3. Efficiency Data, 12V_{IN}, –7V_{OUT}

Voltage (V)	Current (A)	Voltage (V)	Current (A)	Losses (W)	Efficiency (%)
12.0500	0.0663	7.0780	0.5710	0.39	50.6
12.0400	0.0957	7.0770	0.1057	0.40	64.9
12.0500	0.1872	7.0760	0.2569	0.44	80.6
12.0200	0.3384	7.0740	0.5052	0.49	87.9
11.9900	0.4917	7.0710	0.7563	0.55	90.7
12.0400	0.6429	7.0690	1.0074	0.62	92.0
12.0000	0.7974	7.0670	1.2550	0.70	92.7
12.0200	0.9514	7.0650	1.5050	0.80	93.0
11.9900	1.1097	7.0620	1.7540	0.92	93.1
12.0500	1.2550	7.0600	2.0050	0.97	93.6
12.0200	1.4190	7.0580	2.2560	1.13	93.4
11.9800	1.5830	7.0560	2.5040	1.30	93.2

Table 2-4. Efficiency Data, $48V_{IN}$, $-7V_{OUT}$

Voltage (V)	Current (A)	Voltage (V)	Current (A)	Losses (W)	Efficiency (%)
48.1000	0.0388	7.0800	0.0571	1.46	21.7
48.1000	0.0459	7.0790	0.1057	1.46	33.9
48.1000	0.0689	7.0780	0.2569	1.50	54.9
48.1000	0.1083	7.0760	0.5052	1.63	68.6
48.1000	0.1467	7.0750	0.7563	1.71	75.8
48.1000	0.1847	7.0730	1.0074	1.76	80.2
48.1000	0.2230	7.0710	1.2550	1.85	82.7
48.1000	0.2604	7.0700	1.5060	1.88	85.0
48.1000	0.2983	7.0680	1.7540	1.95	86.4
48.1000	0.3367	7.0670	2.0040	2.03	87.4
48.1000	0.3753	7.0660	2.2550	2.12	88.3
48.1000	0.4136	7.0650	2.5040	2.20	88.9

2.3 Thermal Images

2.3.1 8V Input Voltage

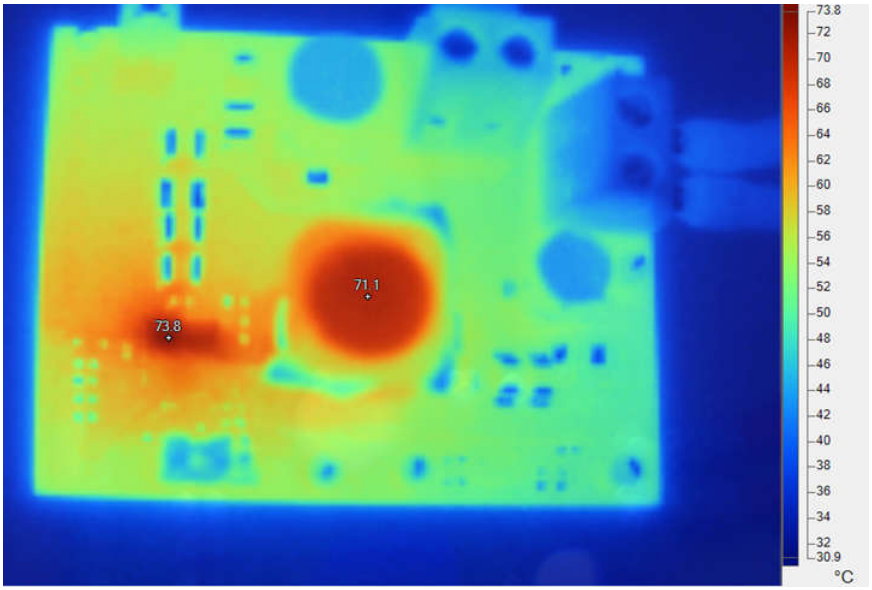


Figure 2-3. Thermal Image at $8V_{IN}$, $-11V_{OUT}$, 2.5A

2.3.2 48V Input Voltage

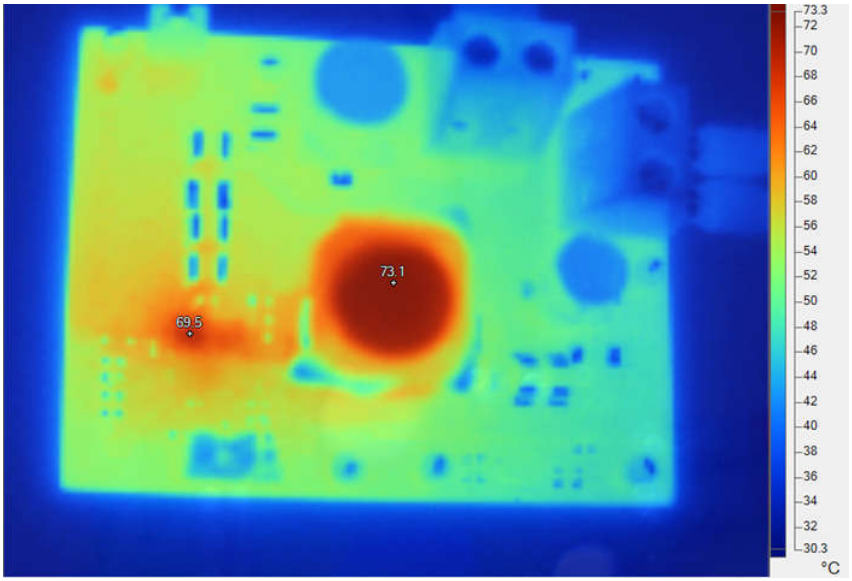


Figure 2-4. Thermal Image at $48V_{IN}$, $-11V_{OUT}$, 2.5A

2.4 Bode Plots

2.4.1 8V Input Voltage

2.4.1.1 –7V Output Voltage

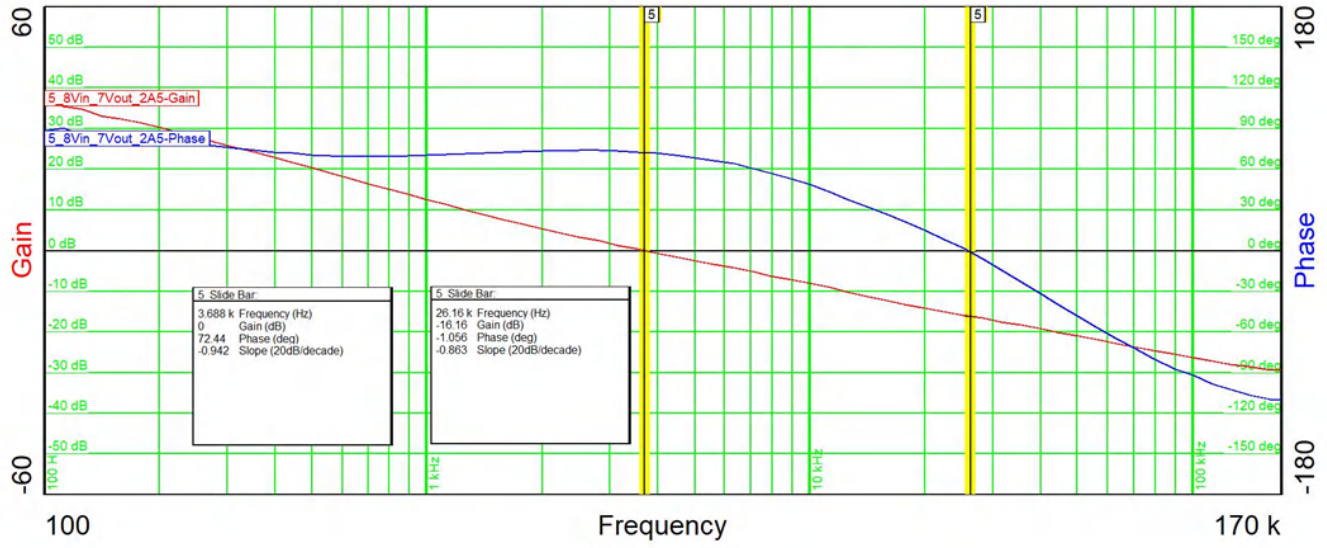


Figure 2-5. 8V_{IN}, –7V_{OUT}, 2.5A Load Current: f_{CO} 3.7kHz, 72° Phase Margin, –16dB Gain Margin

2.4.1.2 –11V Output Voltage

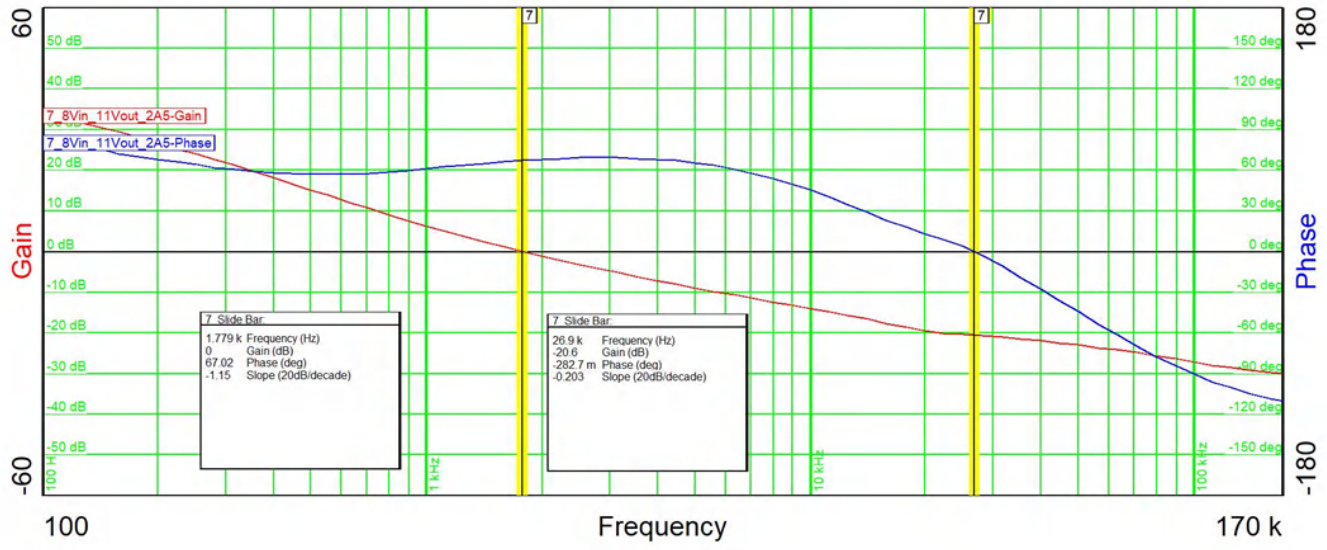


Figure 2-6. 8V_{IN}, –11V_{OUT}, 2.5A Load Current: f_{CO} 1.7kHz, 67° Phase Margin, –20dB Gain Margin

2.4.2 48V Input Voltage

2.4.2.1 –7V Output Voltage

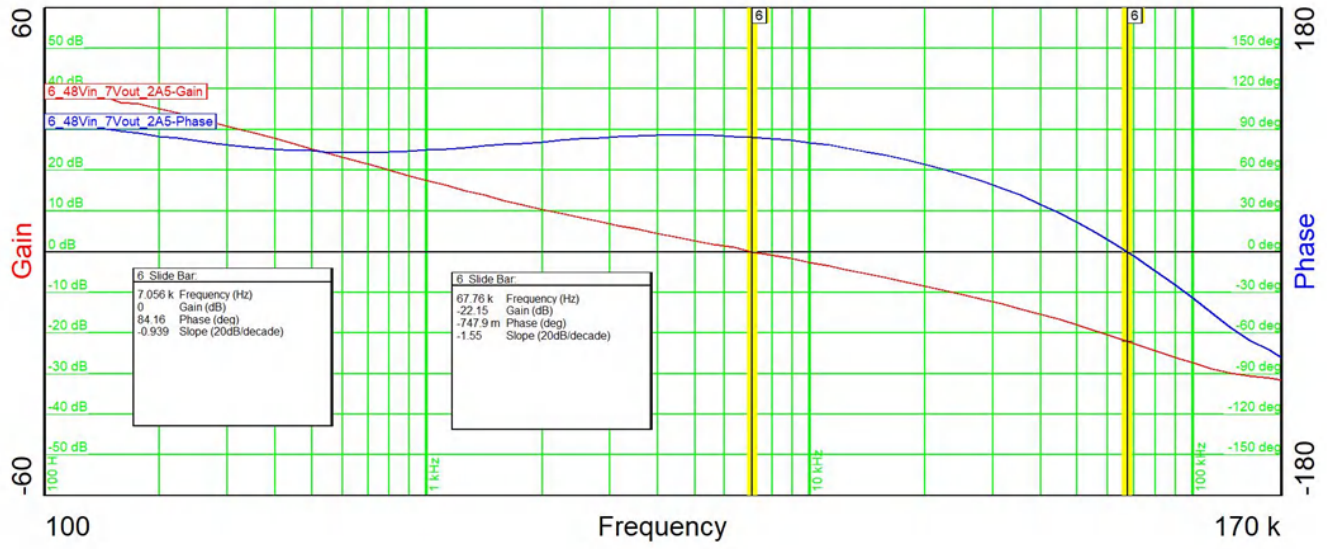


Figure 2-7. 48V_{IN}, –7V_{OUT}, 2.5A Load Current: f_{CO} 7.0kHz, 84° Phase Margin, –22dB Gain Margin

2.4.2.2 –11V Output Voltage

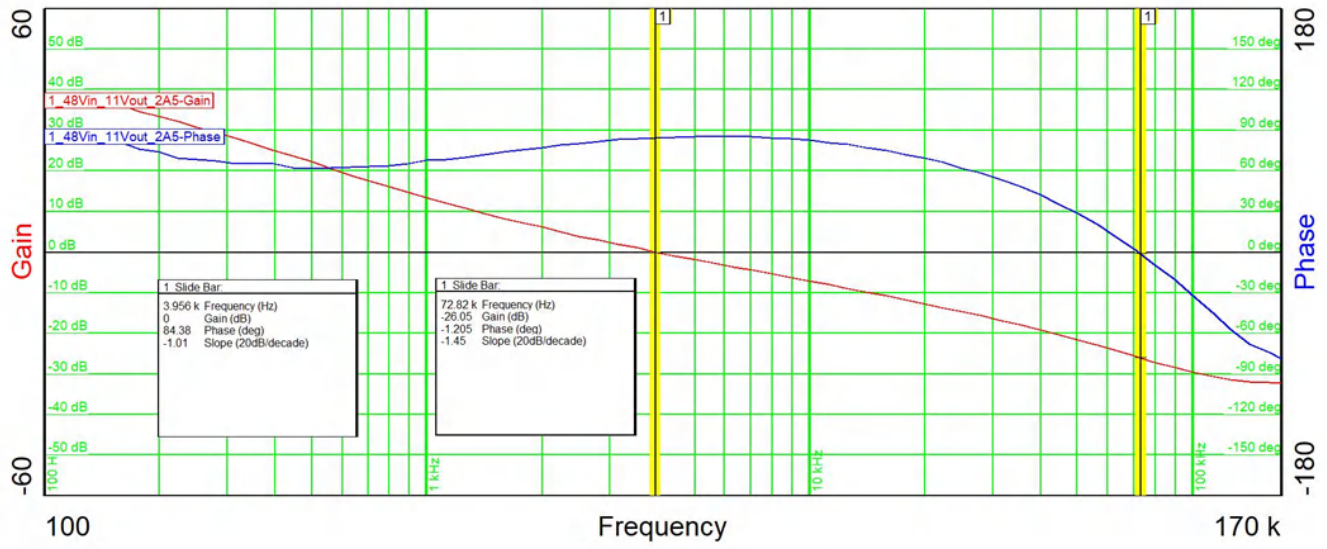


Figure 2-8. 48V_{IN}, –11V_{OUT}, 2.5A Load Current: f_{CO} 3.9kHz, 84° Phase Margin, –26dB Gain Margin

3 Waveforms

3.1 Switching

3.1.1 12V Input Voltage

3.1.1.1 –7V Output Voltage

3.1.1.1.1 Switchnode Referenced to $-V_{OUT}$

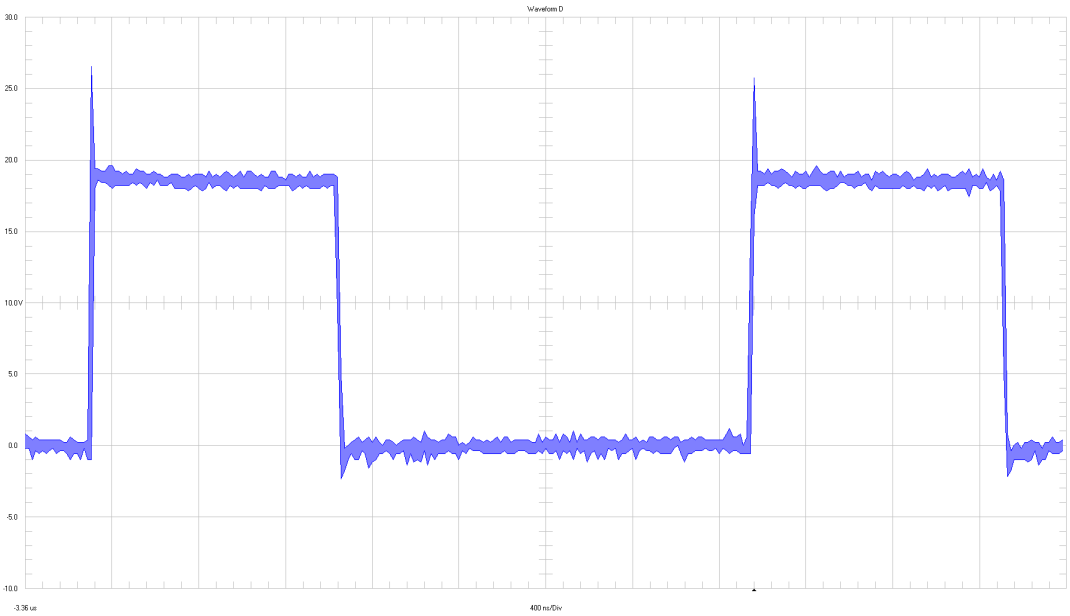


Figure 3-1. Switching Node (D2) at $12V_{IN}$, $-7V_{OUT}$ and 2.5A Load Current

3.1.1.1.2 Switchnode Referenced to V_{IN}

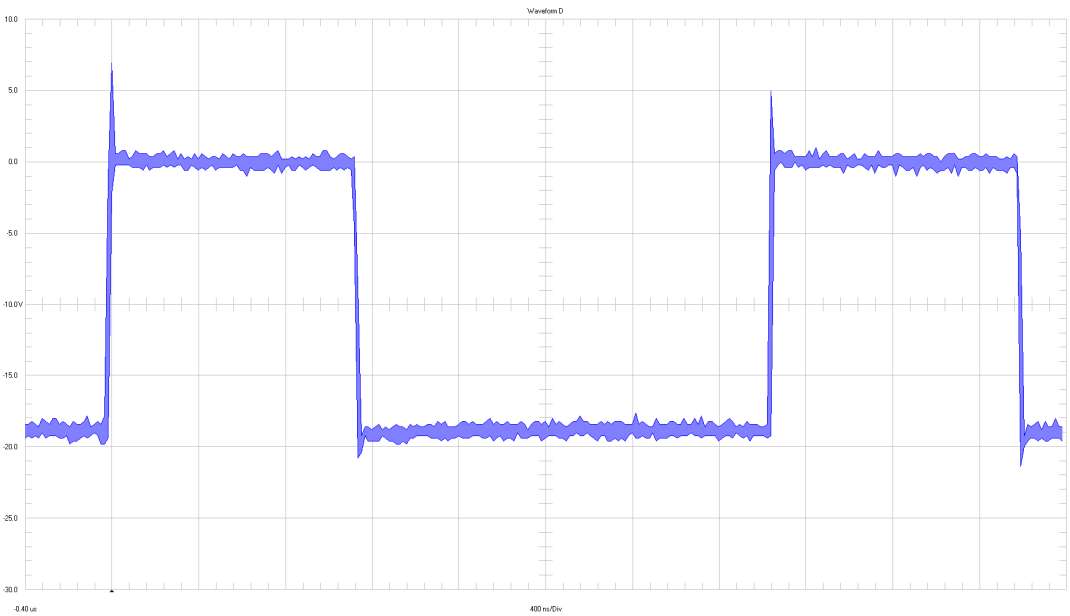


Figure 3-2. CH1: Switching Node at $12V_{IN}$, $-7V_{OUT}$ and 2.5A Load Current

3.1.1.2 –11V Output Voltage

3.1.1.2.1 Switchnode Referenced to $-V_{OUT}$

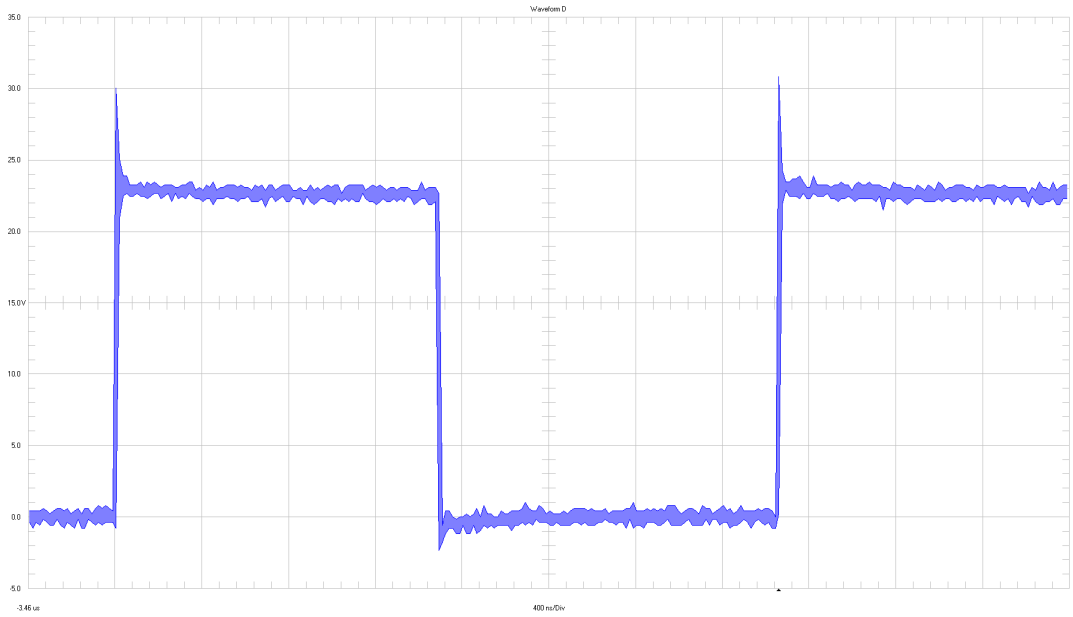


Figure 3-3. CH1: Switching Node (D2) at $12V_{IN}$, $-11V_{OUT}$ and 2.5A Load Current

3.1.1.2.2 Switchnode Referenced to V_{IN}

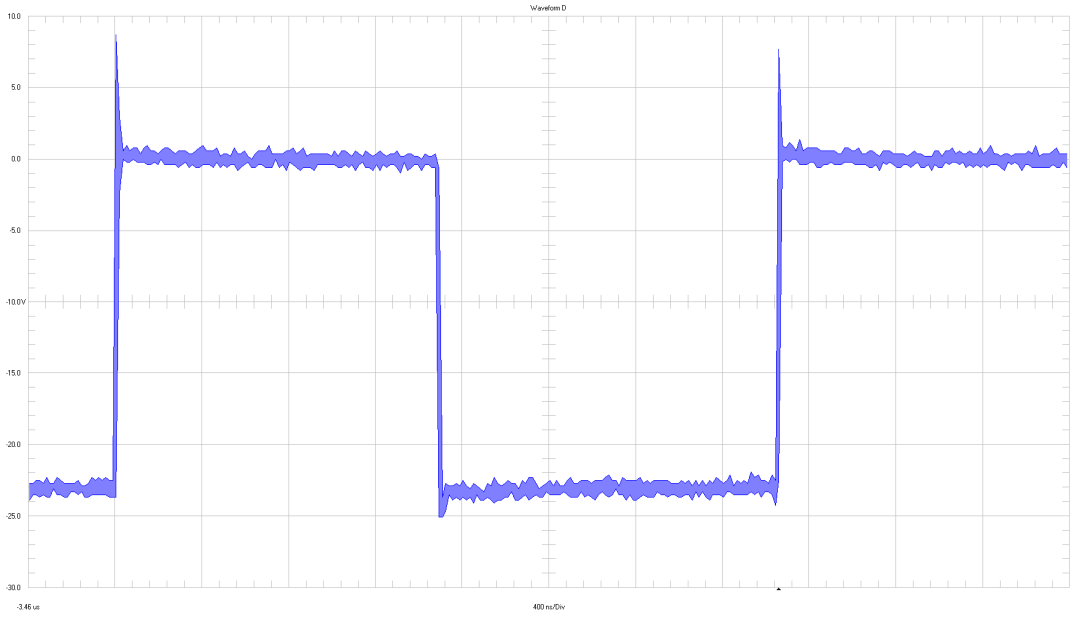


Figure 3-4. CH1: Switching Node at $12V_{IN}$, $-11V_{OUT}$ and 2.5A Load Current

3.1.2 48V Input Voltage

3.1.2.1 –7V Output Voltage

3.1.2.1.1 Switchnode Referenced to $-V_{OUT}$

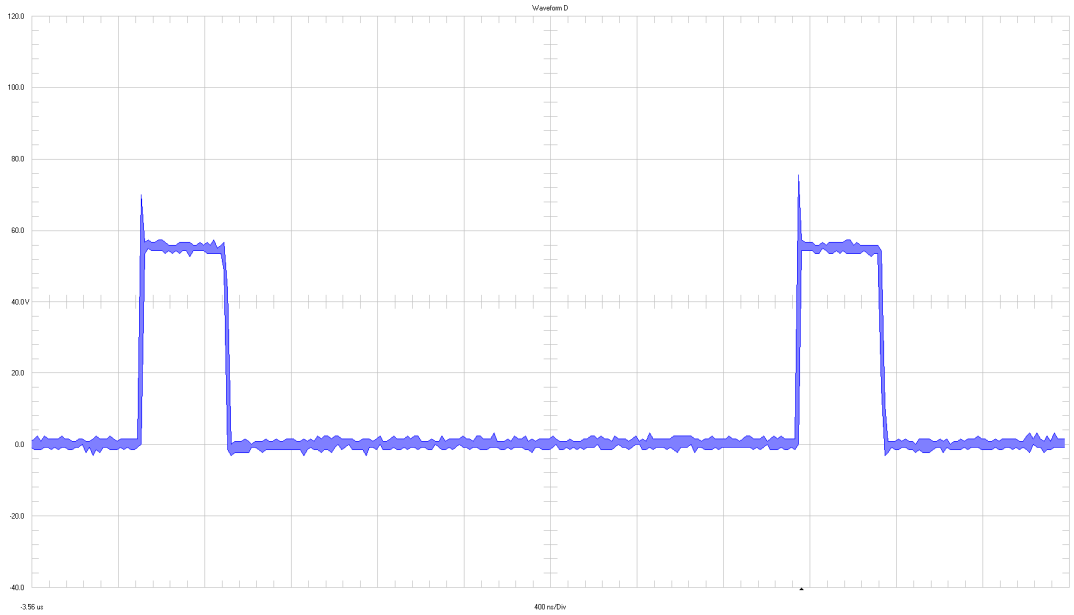


Figure 3-5. CH1: Switching Node (D2) at $48V_{IN}$, $-7V_{OUT}$ and 2.5A Load Current

3.1.2.1.2 Switchnode Referenced to V_{IN}

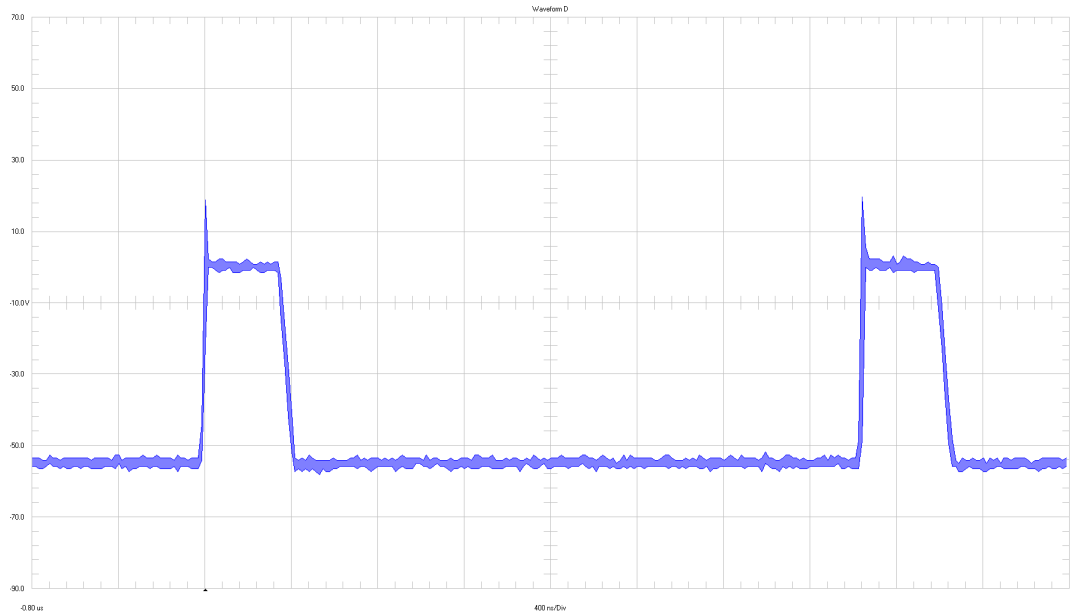


Figure 3-6. CH1: Switching Node at $48V_{IN}$, $-7V_{OUT}$ and 2.5A Load Current

3.1.2.2 –11V Output Voltage

3.1.2.2.1 Switchnode Referenced to $-V_{OUT}$

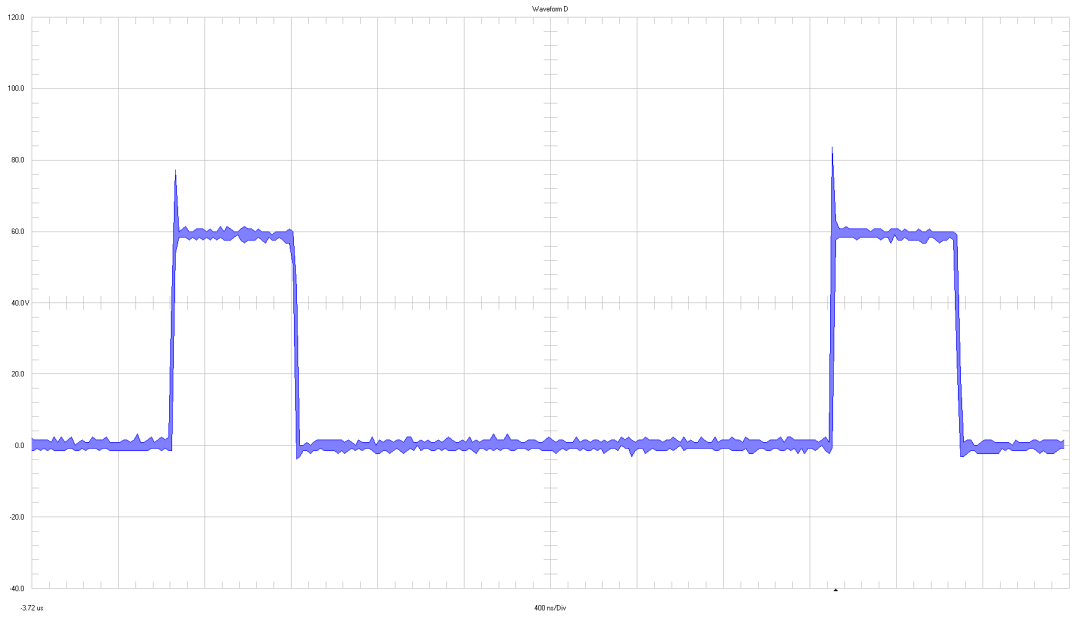


Figure 3-7. CH1: Switching Node (D2) at $48V_{IN}$, $-11V_{OUT}$ and 2.5A Load Current

3.1.2.2.2 Switchnode Referenced to V_{IN}

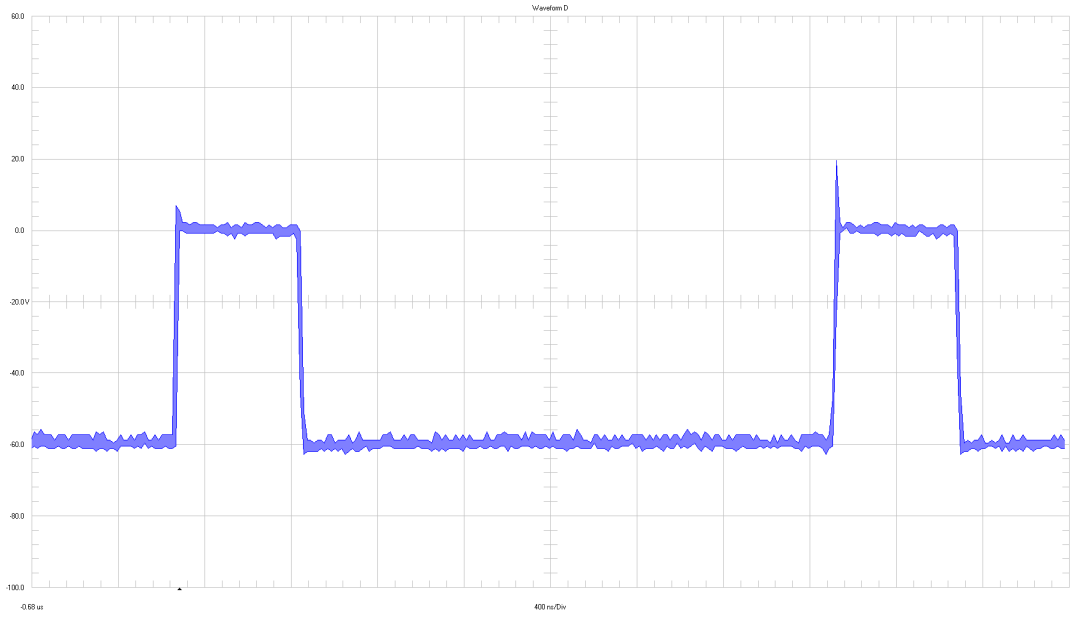


Figure 3-8. CH1: Switching Node at $48V_{IN}$, $-11V_{OUT}$ and 2.5A Load Current

3.2 Input Voltage Ripple

3.2.1 12V Input Voltage

3.2.1.1 –7V Output Voltage

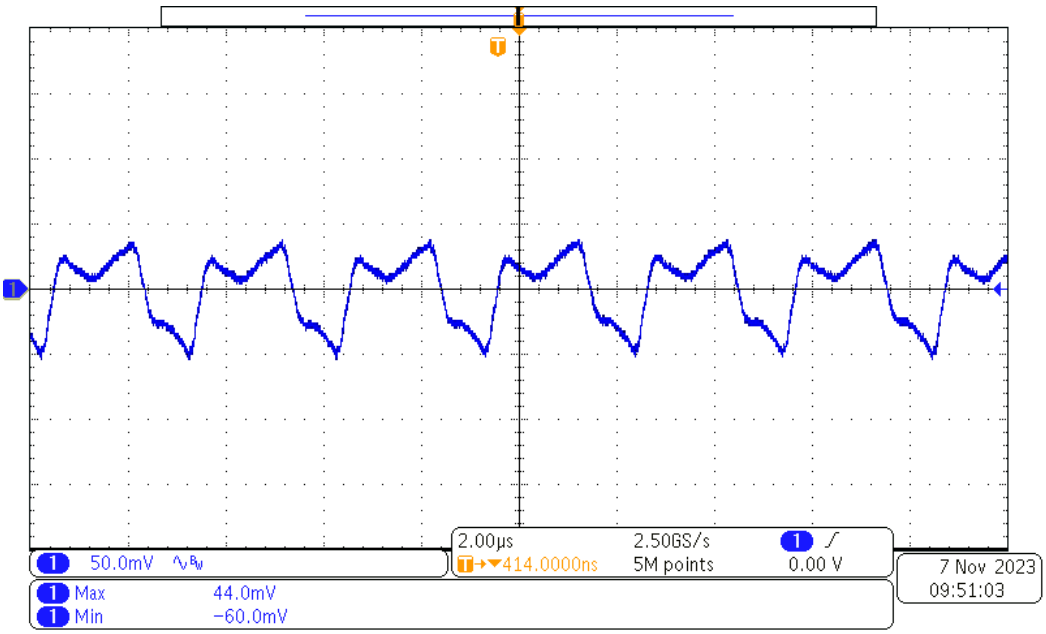


Figure 3-9. CH1: AC-Coupled Input Voltage at $12V_{IN}$, $–7V_{OUT}$ and 2.5A Load Current,Bandwidth Limited (20MHz)

3.2.1.2 –11V Output Voltage

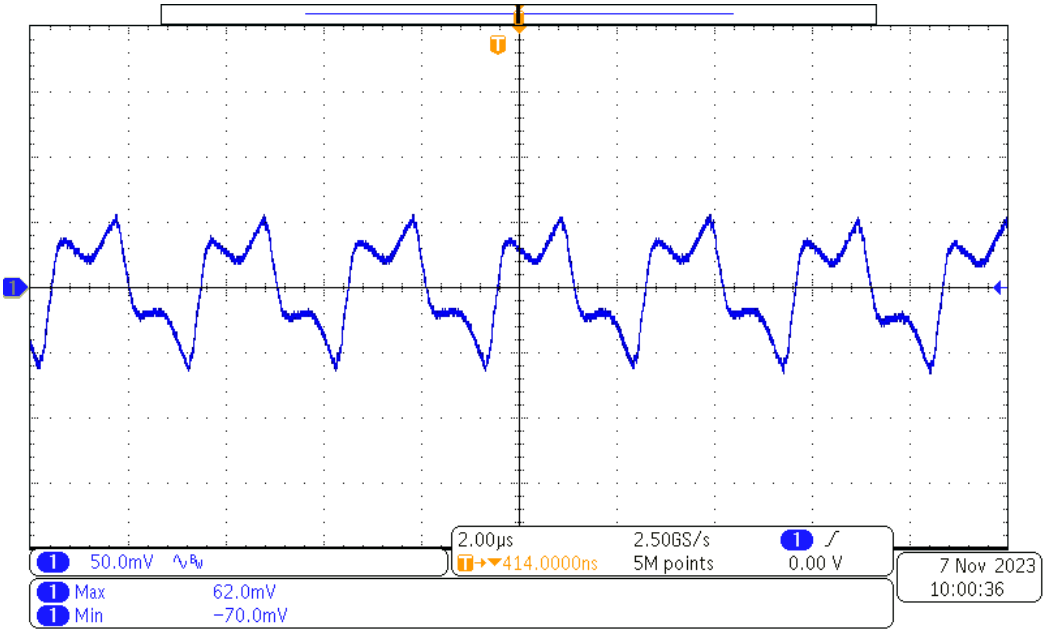


Figure 3-10. CH1: AC-Coupled Input Voltage at $12V_{IN}$, $–11V_{OUT}$ and 2.5A Load Current, Bandwidth Limited (20MHz)

3.2.2 48V Input Voltage

3.2.2.1 –7V Output Voltage

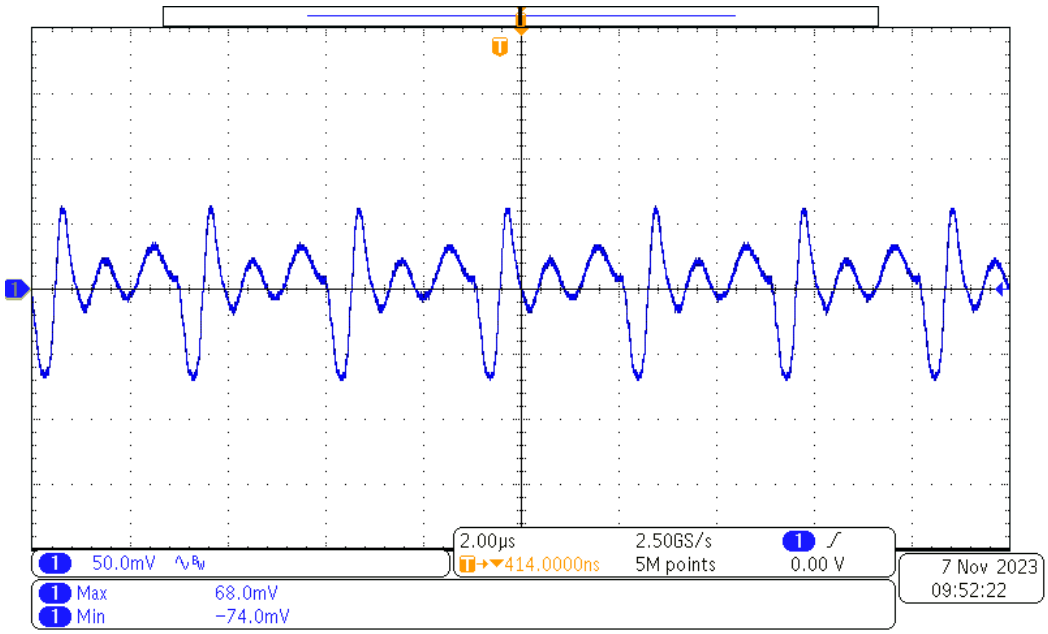


Figure 3-11. CH1: AC-Coupled Input Voltage at 48V_{IN}, –7V_{OUT} and 2.5A Load Current, Bandwidth Limited (20MHz)

3.2.2.2 –11V Output Voltage

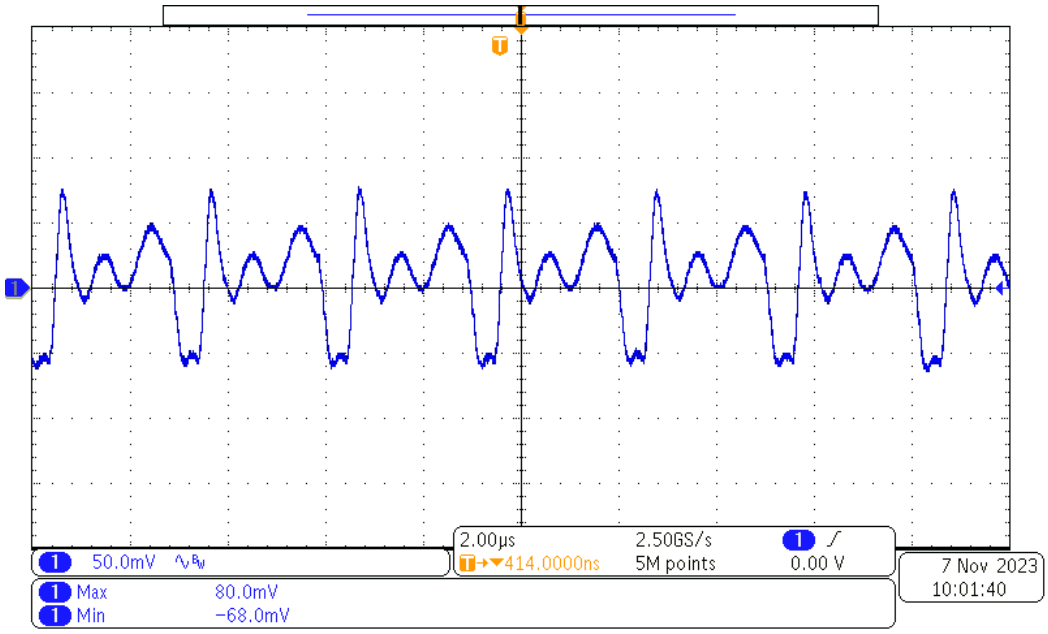


Figure 3-12. CH1: AC-Coupled Input Voltage at 48V_{IN}, –11V_{OUT} and 2.5A Load Current, Bandwidth Limited (20MHz)

3.3 Output Voltage Ripple

3.3.1 12V Input Voltage

3.3.1.1 –7V Output Voltage

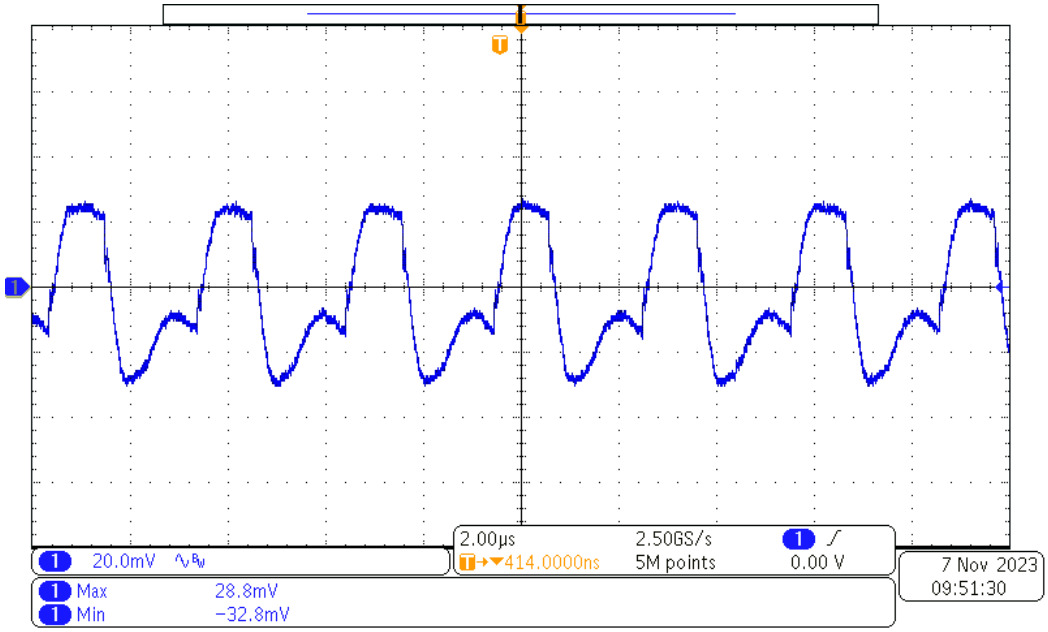


Figure 3-13. CH1: AC-Coupled Output Voltage at $12V_{IN}$, $–7V_{OUT}$ and 2.5A Load Current, Bandwidth Limited (20MHz)

3.3.1.2 –11V Output Voltage

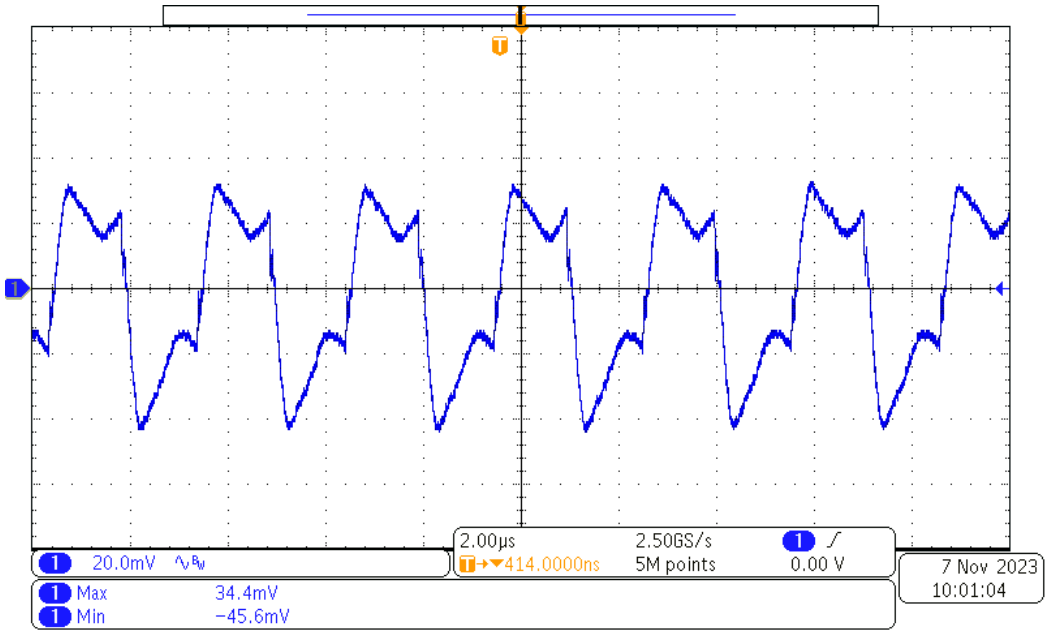


Figure 3-14. CH1: AC-Coupled Output Voltage at $12V_{IN}$, $–11V_{OUT}$ and 2.5A Load Current, Bandwidth Limited (20MHz)

3.3.2 48V Input Voltage

3.3.2.1 –7V Output Voltage

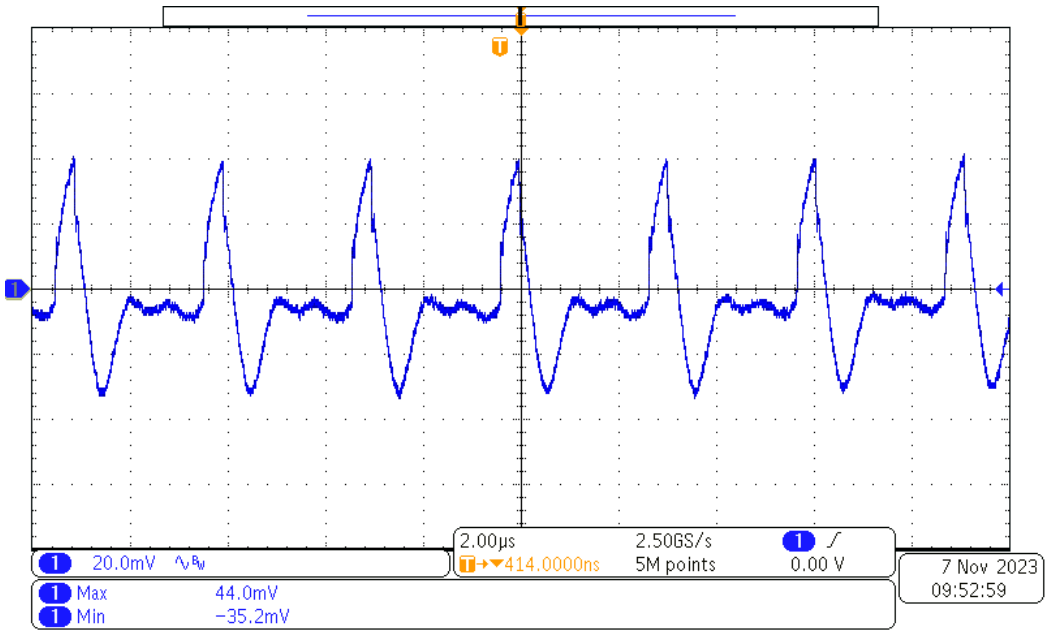


Figure 3-15. CH1: AC-Coupled Output Voltage at 48V_{IN}, –7V_{OUT} and 2.5A Load Current, Bandwidth Limited (20MHz)

3.3.2.2 –11V Output Voltage

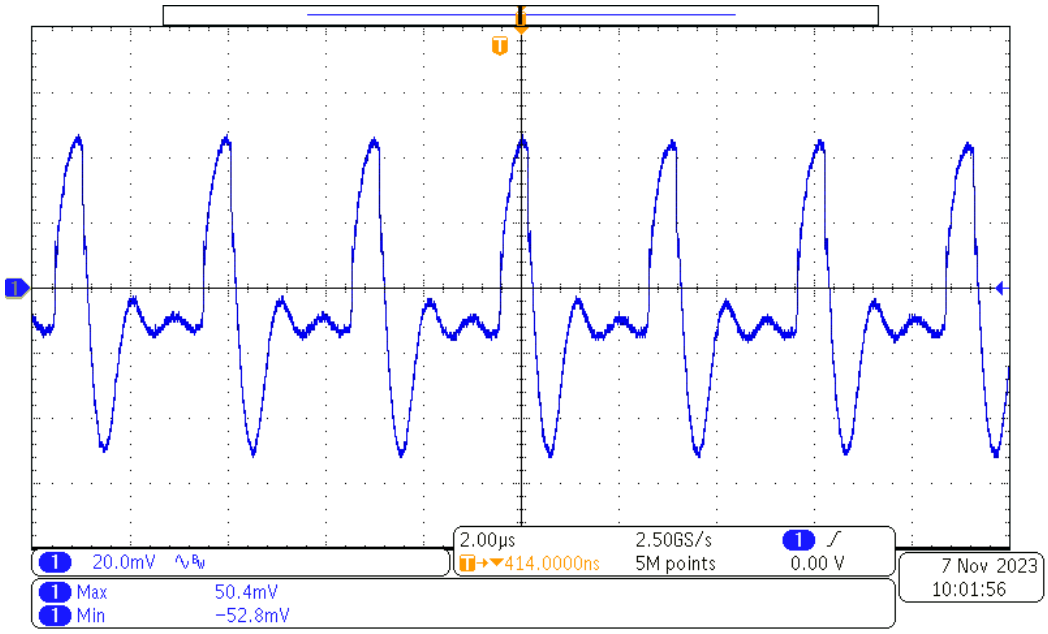
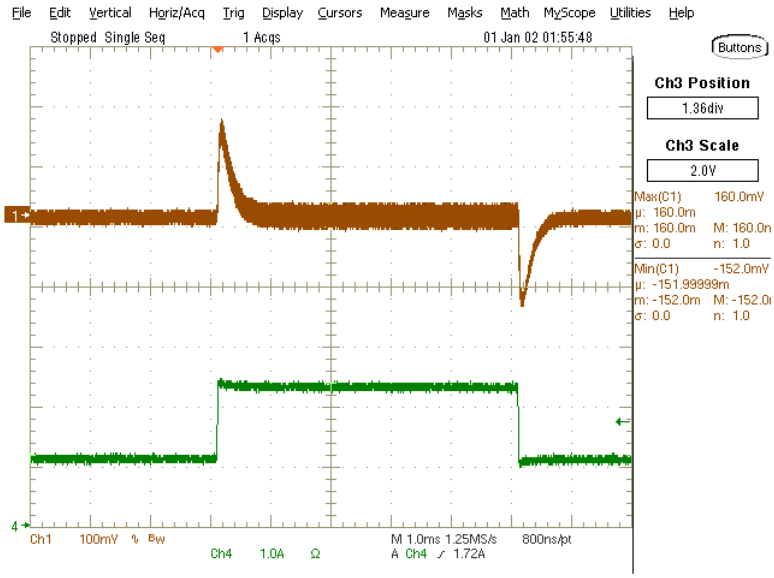


Figure 3-16. CH1: AC-Coupled Output Voltage at 48V_{IN}, –11V_{OUT} and 2.5A Load Current, Bandwidth Limited (20MHz)

3.4 Load Transients

3.4.1 12V Input Voltage

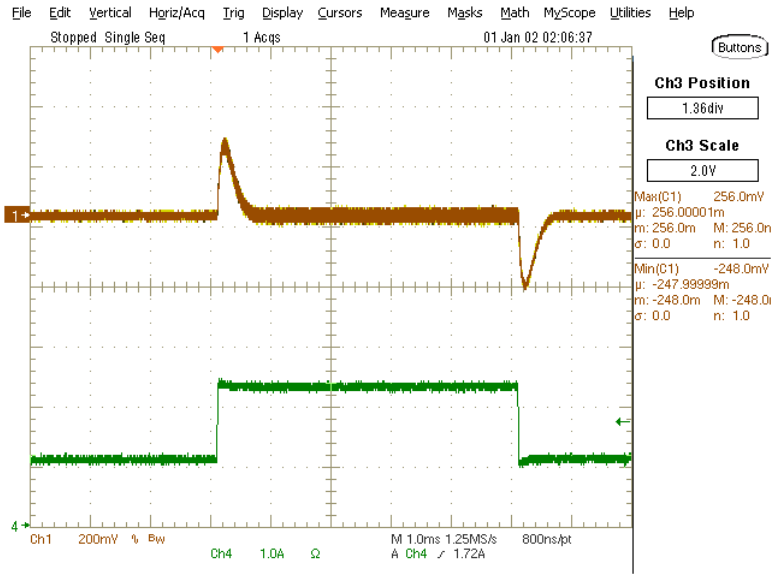
3.4.1.1 –7V Output Voltage



CH1: AC-coupled output voltage at $12V_{IN}$, $–7V_{OUT}$, bandwidth limited (20MHz)
CH4: Load transient 1.2A ⇔ 2.5A

Figure 3-17. Load Transient at $12V_{IN}$, $–7V_{OUT}$

3.4.1.2 –11V Output Voltage

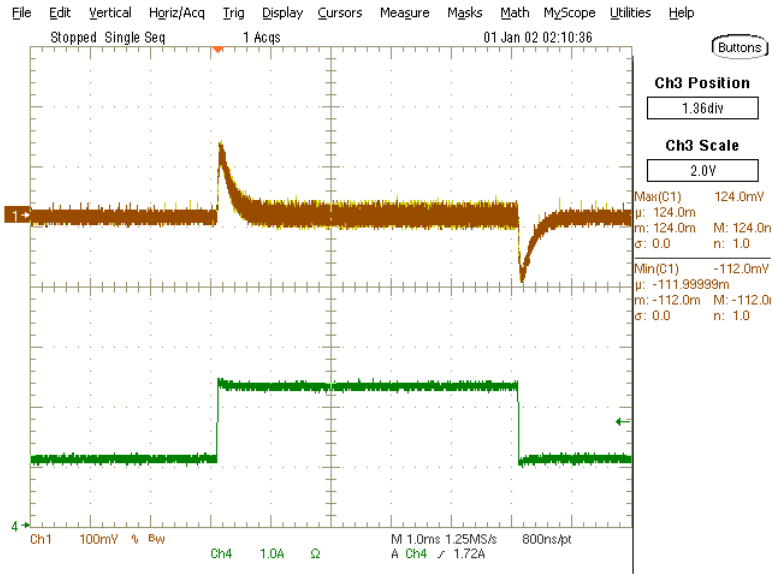


CH1: AC-coupled output voltage at $12V_{IN}$, $–11V_{OUT}$, bandwidth limited (20MHz)
CH4: Load transient 1.2A ⇔ 2.5A

Figure 3-18. Load Transient at $12V_{IN}$, $–11V_{OUT}$

3.4.2 48V Input Voltage

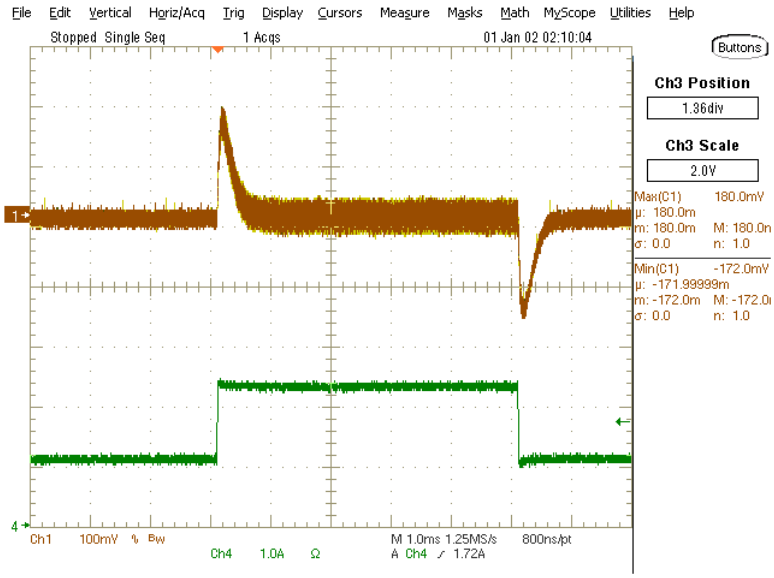
3.4.2.1 –7V Output Voltage



CH1: AC-coupled output voltage at $48V_{IN}$, $–7V_{OUT}$, bandwidth limited (20MHz)
CH4: Load transient 1.2A ⇔ 2.5A

Figure 3-19. Load Transient at $12V_{IN}$, $–7V_{OUT}$

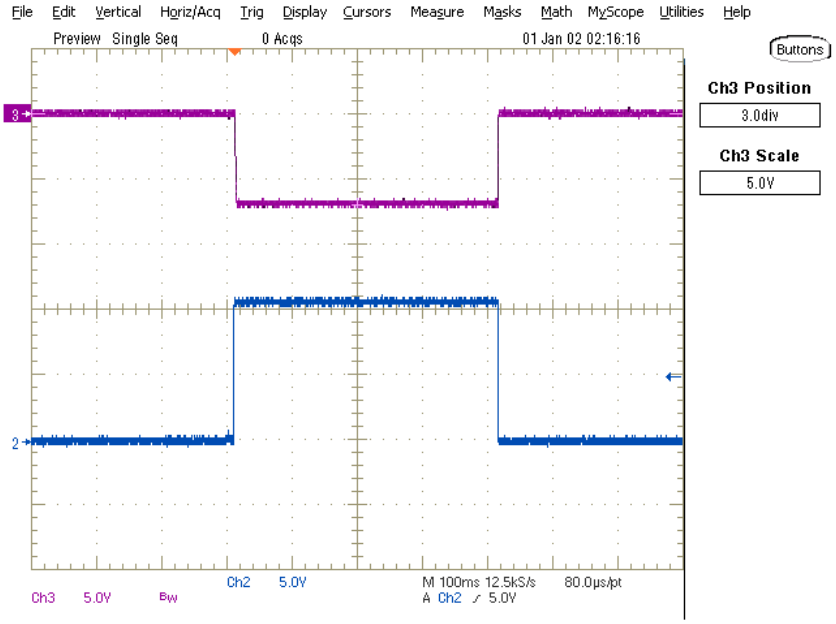
3.4.2.2 –11V Output Voltage



CH1: AC-coupled output voltage at $48V_{IN}$, $–11V_{OUT}$, bandwidth limited (20MHz)
CH4: Load transient 1.2A ⇔ 2.5A

Figure 3-20. Load Transient at $12V_{IN}$, $–11V_{OUT}$

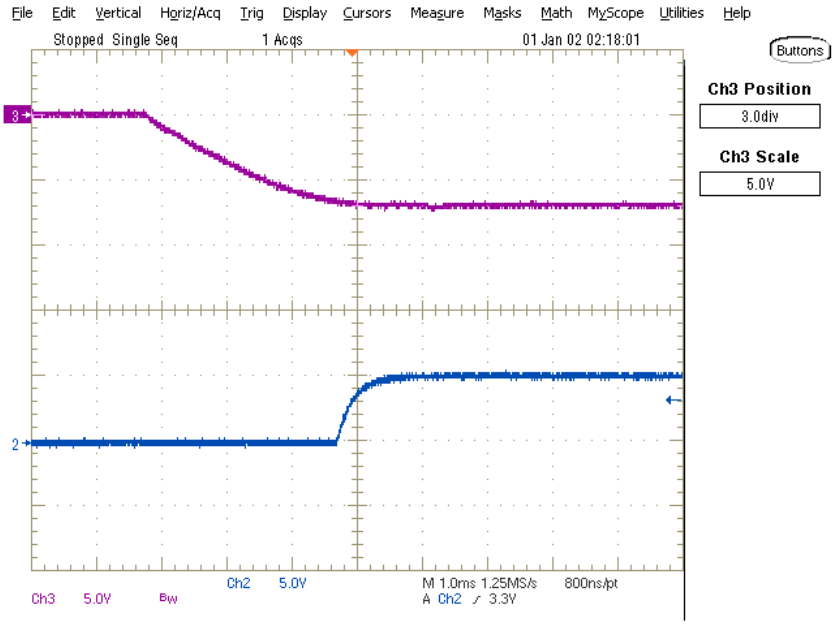
3.5 Level Shifters



CH3: output voltage at $12V_{IN}$, $–7V_{OUT}$
CH2: external enable signal (TP8)

Figure 3-21. Level Shifters

3.6 Start-Up Sequence



CH3: output voltage at $12V_{IN}$, $–7V_{OUT}$
CH2: external PG signal (TP7)

Figure 3-22. Start-Up at $12V_{IN}$, $–7V_{OUT}$

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