Test Report: PMP41038

26.4-W Flyback Converter Reference Design for Smart Glass Application

Description

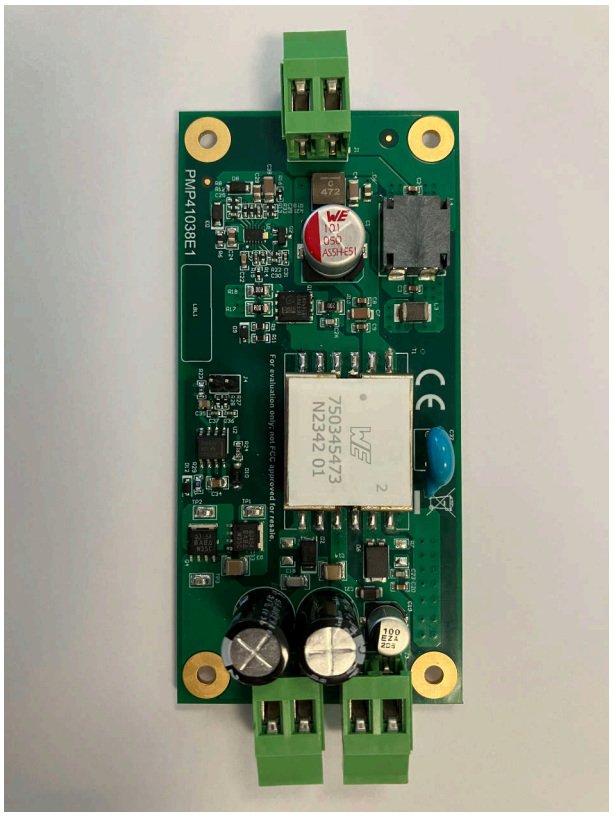
This reference design demonstrates an isolated flyback converter for a smart glass module. The converter uses the LM5156-Q1 device to convert the battery voltage to two different output rails. One output supplies the microcontroller (MCU) and another output provides the supply for smart glass. All the performances meet the smart glass power-supply specifications.

Features

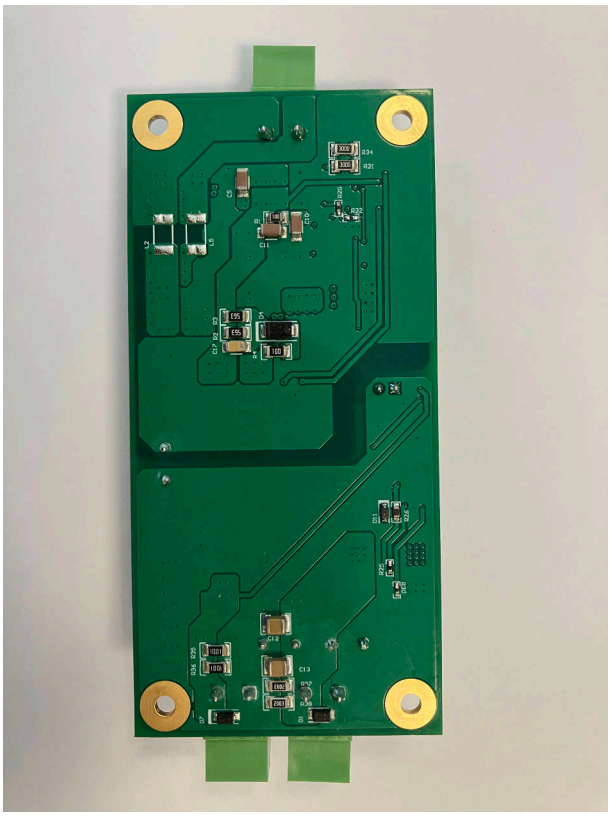
- Excellent load transient performance for smart glass module
- Efficient high-voltage power stages to generate the required power level for the smart glass

Applications

- Smart glass module



Top of Board



Bottom of Board

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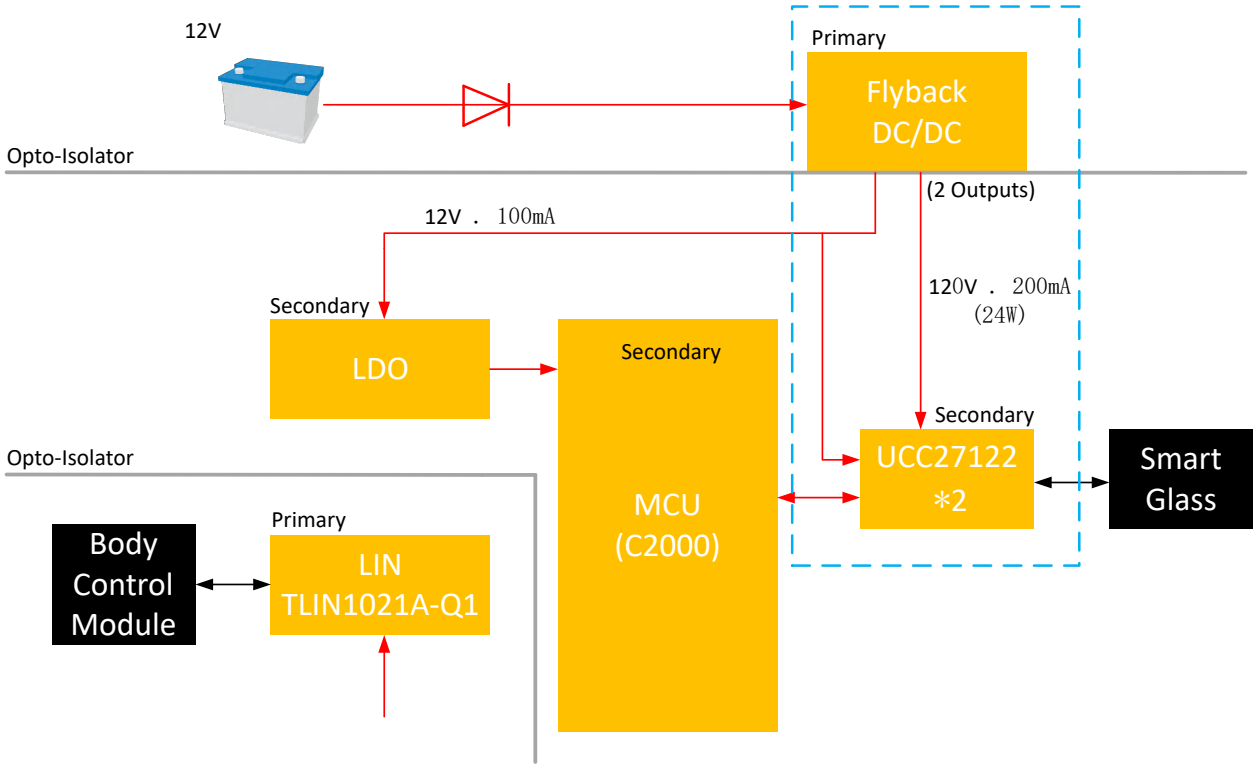

Smart Glass Block Diagram

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1 Test Prerequisites

1.1 Voltage and Current Requirements

Table 1-1. Voltage and Current Requirements

Parameter	Specifications
V_{IN}	9 V to 16 V
V_{OUT1}	12 V
I_{OUT1}	200 mA
V_{OUT2}	120 V
I_{OUT2}	200 mA

1.2 Required Equipment

- DC Source: Chroma 62006P-100-50
- DC electronic load: Chroma 6314A
- Oscilloscope: Tektronix DPO3054
- Electrical thermography: Fluke TiS55
- Digital Power meter: Yokogama WT310E
- Vector Network Analyzer: OMICRON Bode100
- Multimeter: Fluke 287C

1.3 Considerations

This reference design only covers the power stage marked in the blue rectangle on the *Smart Glass Block Diagram*. The power stage contains a flyback converter and driver part. As Figure 1-1 shows, external components are required to test the driver part. This test report only shows the detailed test results of the flyback converter, but no data about the driver part.

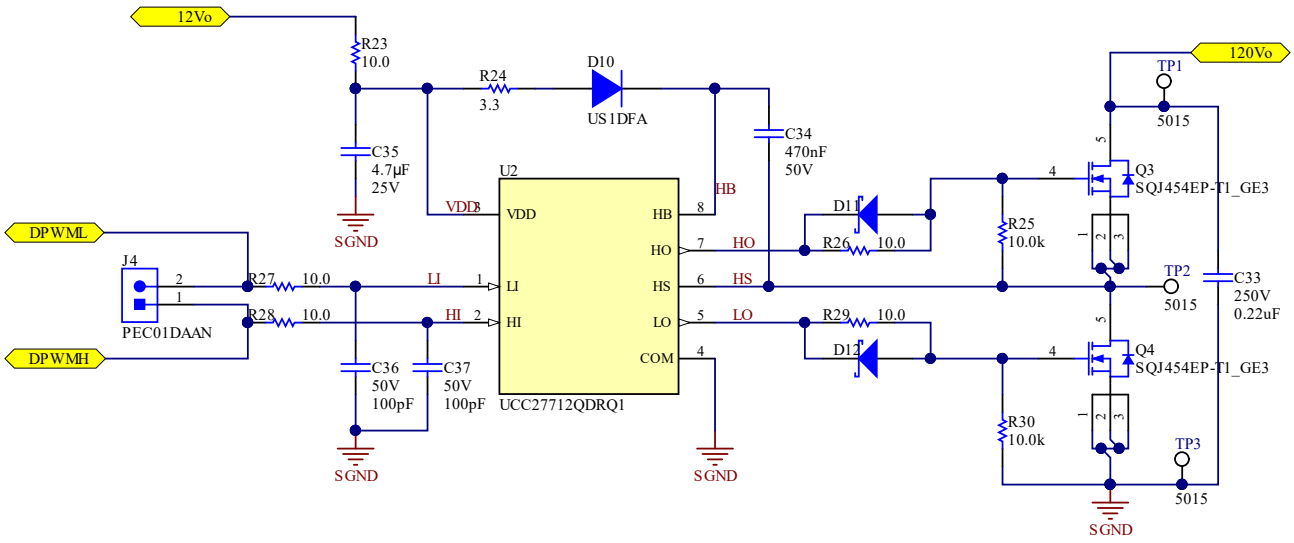

Figure 1-1. Driver Schematic

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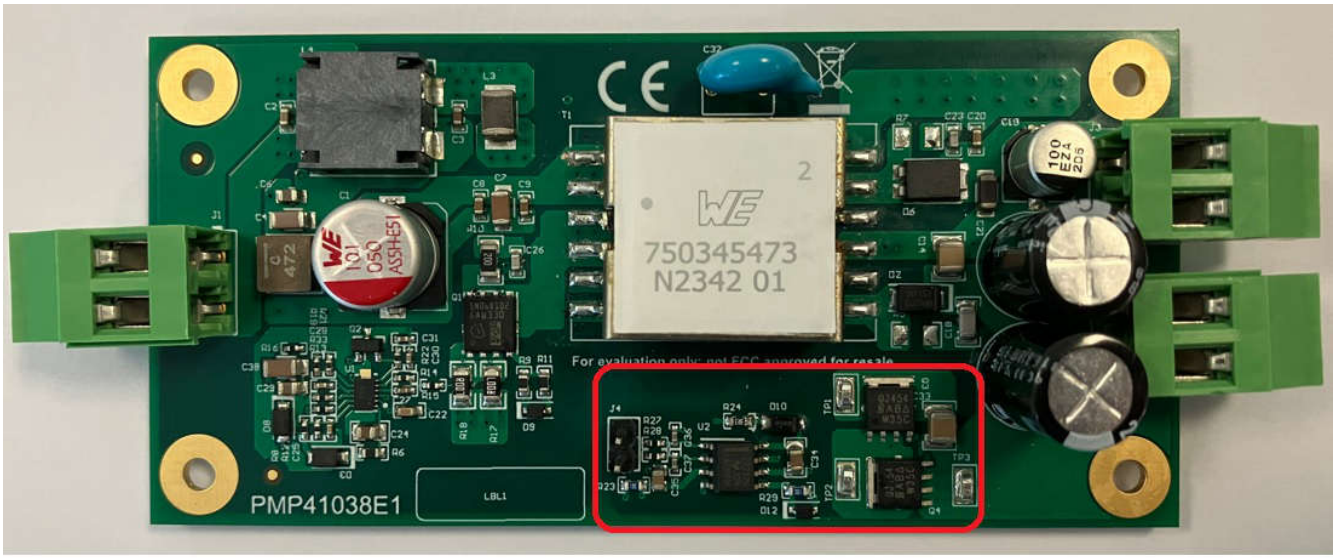

Figure 1-2. Driver in PCB

1.4 Dimensions

The board dimensions are 101.6 mm (Length) × 48.5 mm (Width) × 15 mm (Height).

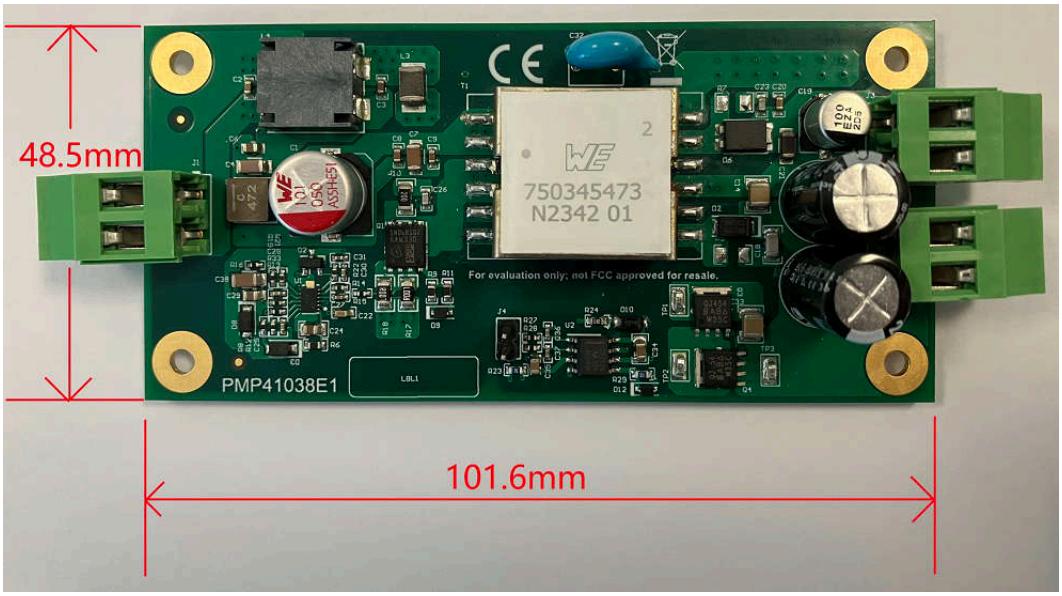

Figure 1-3. Board Dimension

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2 Testing and Results

2.1 Efficiency Graphs

Efficiency is shown in the following figure. The test conditions include room temperature, output1 is 12 V, 0.2 A, with no airflow.

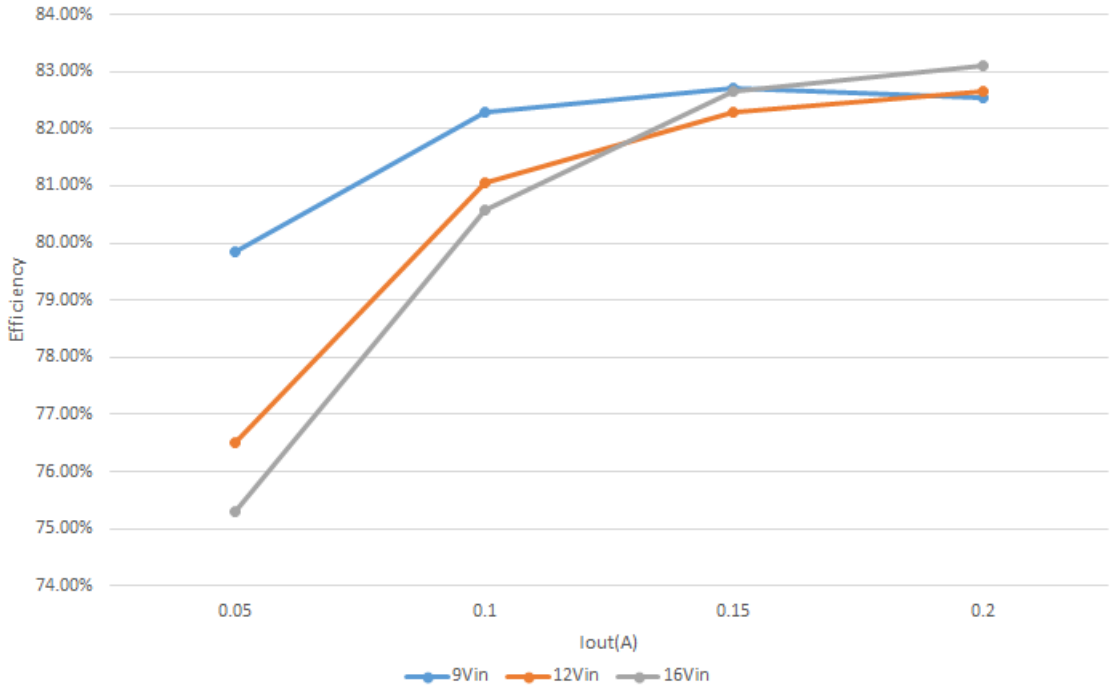

Figure 2-1. Efficiency Graph

2.2 Efficiency Data

Efficiency data is shown in the following table. The test conditions include room temperature, output1 is 12 V, 0.2 A, with no airflow.

V_{IN}	P_{IN}	120 V_{OUT}	120 I_{OUT}	12 V_{OUT}	12 I_{OUT}	P_{OUT}	Efficiency
9	1.30	116.04	0.000	12.33	0.00		0.00%
9	9.70	111.45	0.047	11.94	0.21	7.75	79.85%
9	16.27	110.93	0.098	11.93	0.21	13.39	82.29%
9	22.58	110.58	0.147	11.91	0.21	18.68	82.70%
9	29.53	110.36	0.198	11.89	0.21	24.37	82.54%
12	1.27	116.19	0.000	12.34	0.00		0.00%
12	9.99	111.02	0.047	11.91	0.20	7.64	76.52%
12	16.46	110.81	0.098	11.92	0.21	13.34	81.04%
12	22.69	110.28	0.147	11.89	0.21	18.67	82.30%
12	29.36	109.91	0.198	11.87	0.21	24.27	82.66%
16	1.33	116.66	0.000	12.36	0.00		0.00%
16	10.23	111.14	0.047	11.92	0.21	7.70	75.29%
16	16.61	110.63	0.098	11.92	0.21	13.38	80.56%
16	22.61	110.42	0.147	11.91	0.21	18.69	82.66%
16	29.21	110.10	0.198	11.91	0.21	24.27	83.09%

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2.3 Thermal Images

The thermal image is shown in the following figure. The test conditions include room temperature, the input voltage is 12 V, output1 is 12 V, 0.2 A, output2 is 120 V, 0.2 A, with no airflow.

The temperature of the transformer is very high. The core used in the transformer is the EFD20.

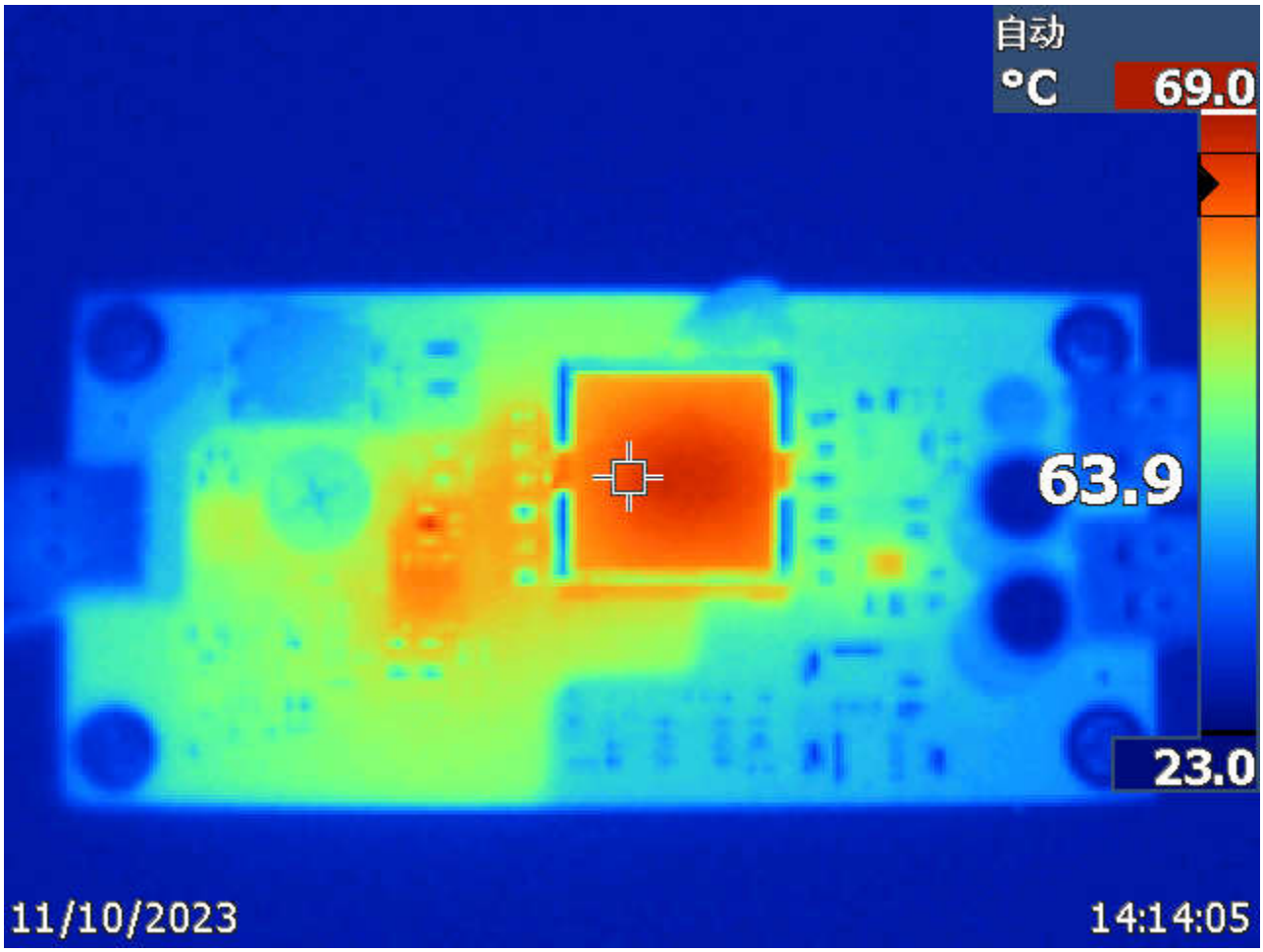

Figure 2-2. Thermal Image

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2.4 Bode Plots

The bode plots are shown in the following figures. The test conditions include room temperature, output1 is 12 V, 0.2 A, output2 is 120 V, 0.2 A, with no airflow.

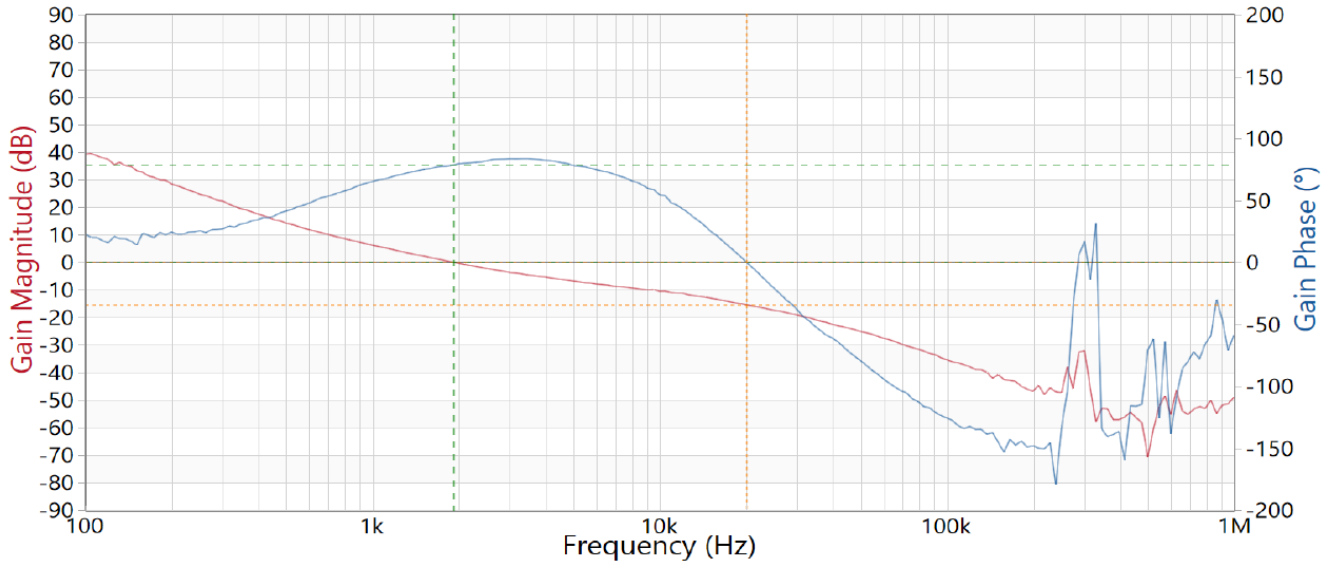

Figure 2-3. Bode Plot at 9-V Input

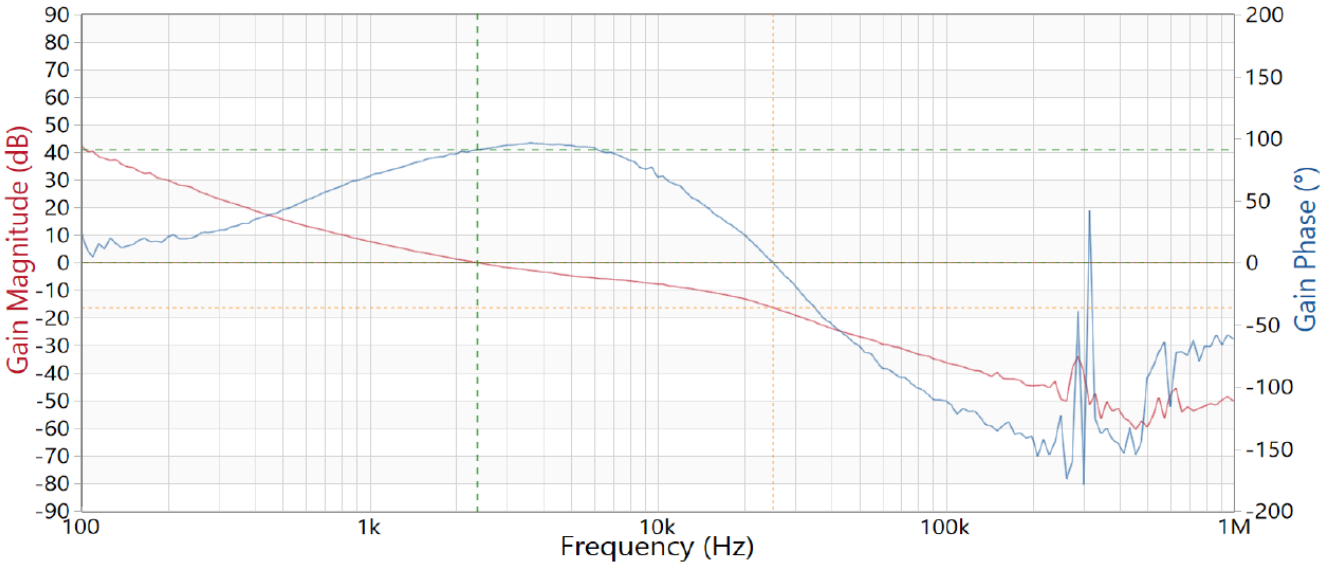

Figure 2-4. Bode Plot at 12-V Input

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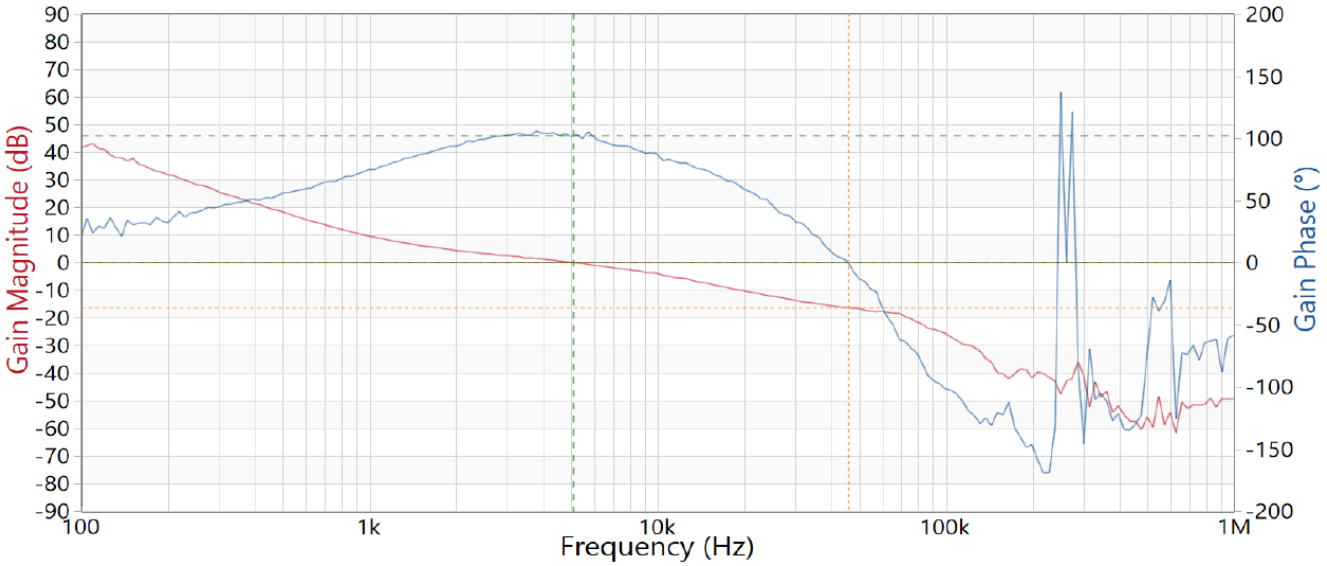

Figure 2-5. Bode Plot at 16-V Input

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3 Waveforms

Figure 3-1 shows the board schematic. This part tests the V_{DS} of the primary metal-oxide semiconductor field-effect transistor (MOSFET), output ripple, load on and off behaviors, and start-up waveform of the converter.

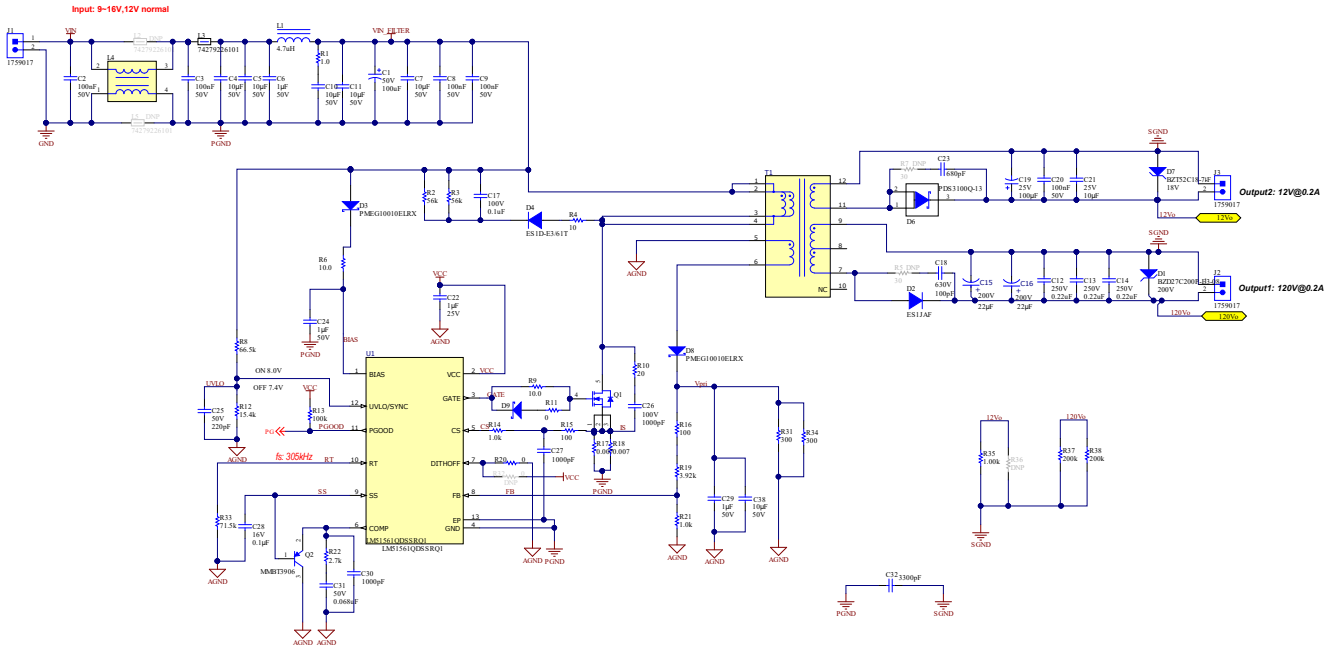

Figure 3-1. Schematic

3.1 Switching

Switching behavior is shown in the following figures.

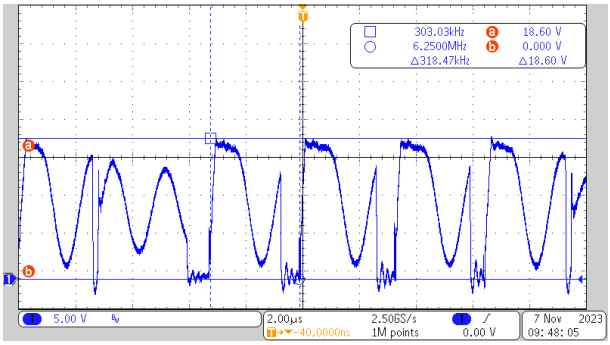

Figure 3-2. V_{DS} of Q1 at 9-V Input, 12-V Output 0 A, 120-V Output 0 A

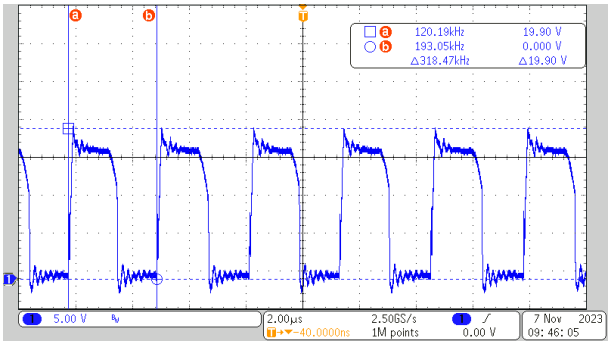

Figure 3-3. V_{DS} of Q1 at 9-V Input, 12-V Output 0.2 A, 120-V Output 0 A

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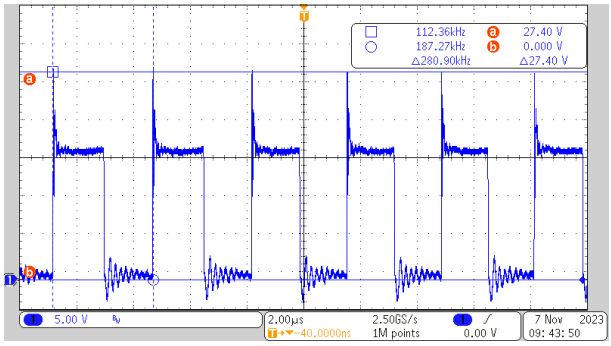

Figure 3-4. V_{DS} of Q1 at 9-V Input, 12-V Output 0 A, 120-V Output 0.2 A

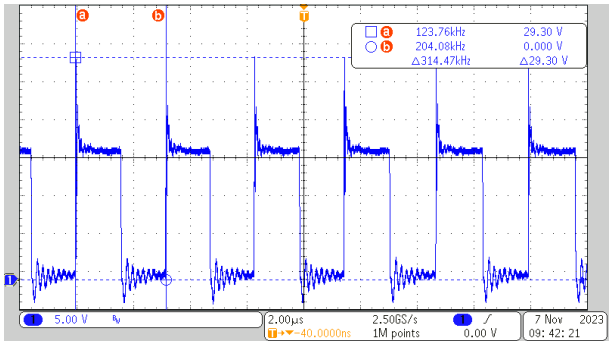

Figure 3-5. V_{DS} of Q1 at 9-V Input, 12-V Output 0.2 A, 120-V Output 0.2 A

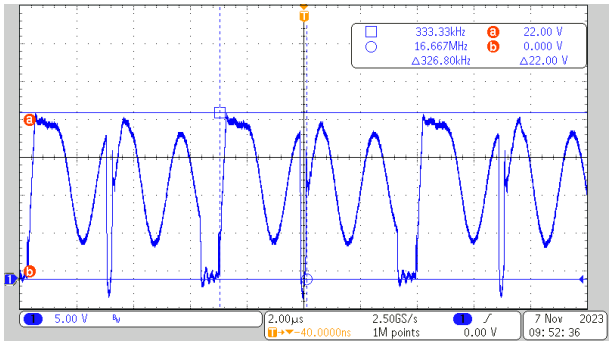

Figure 3-6. V_{DS} of Q1 at 12-V Input, 12-V Output 0 A, 120-V Output 0 A

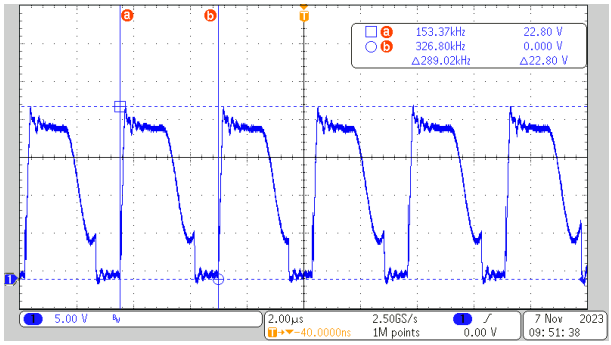

Figure 3-7. V_{DS} of Q1 at 12-V Input, 12-V Output 0.2 A, 120-V Output 0 A

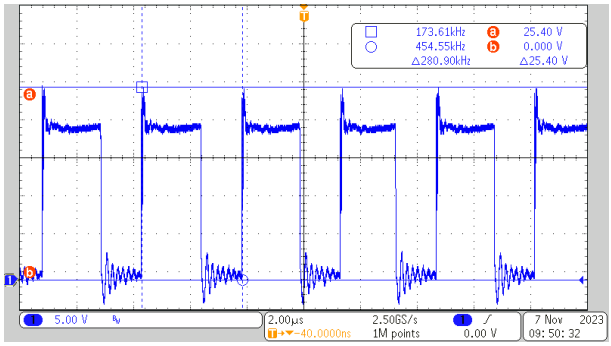

Figure 3-8. V_{DS} of Q1 at 12-V Input, 12-V Output 0 A, 120-V Output 0.2 A

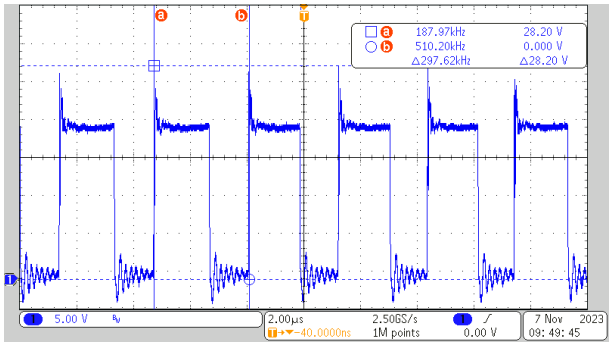

Figure 3-9. V_{DS} of Q1 at 12-V Input, 12-V Output 0.2 A, 120-V Output 0.2 A

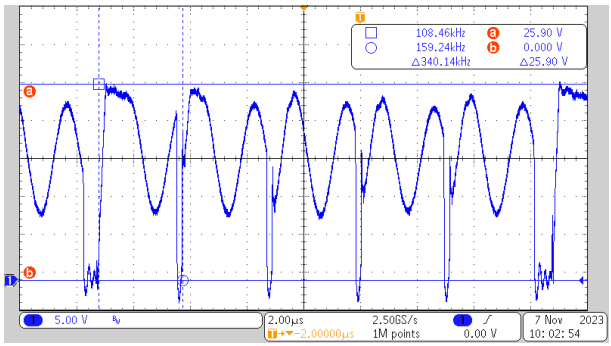

Figure 3-10. V_{DS} of Q1 at 16-V Input, 12-V Output 0 A, 120-V Output 0 A

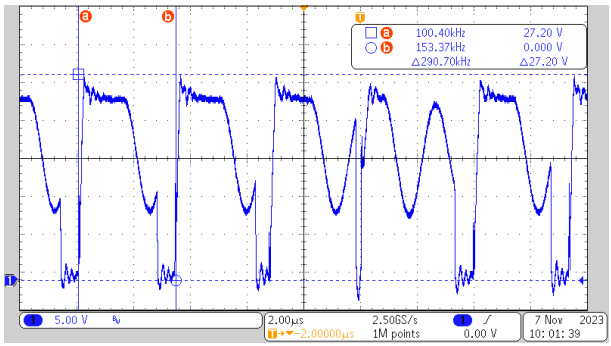

Figure 3-11. V_{DS} of Q1 at 16-V Input, 12-V Output 0.2 A, 120-V Output 0 A

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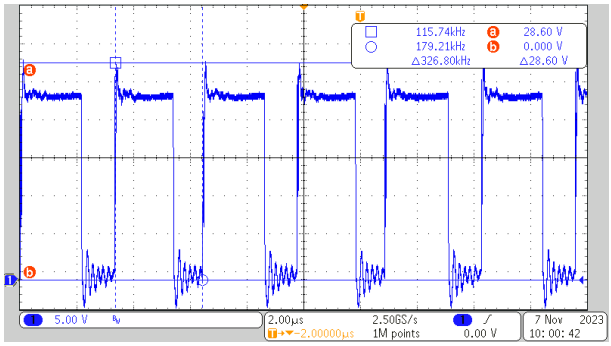

Figure 3-12. V_{DS} of Q1 at 16-V Input, 12-V Output 0 A, 120-V Output 0.2 A

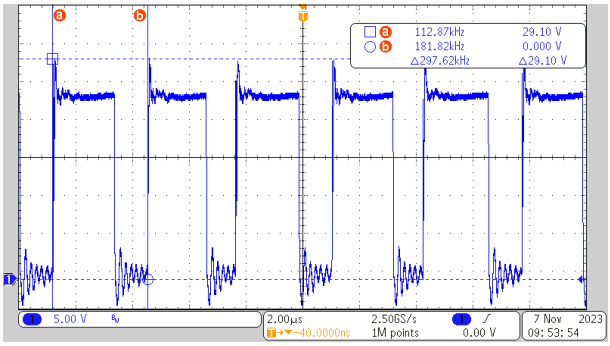

Figure 3-13. V_{DS} of Q1 at 16-V Input, 12-V Output 0.2 A, 120-V Output 0.2 A

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3.2 Output Voltage Ripple

The output voltage ripple waveforms are shown in the following figures. The test conditions include room temperature, output1 is 12 V, 0.2 A, output2 is 12 V, 0.2 A, with no airflow.

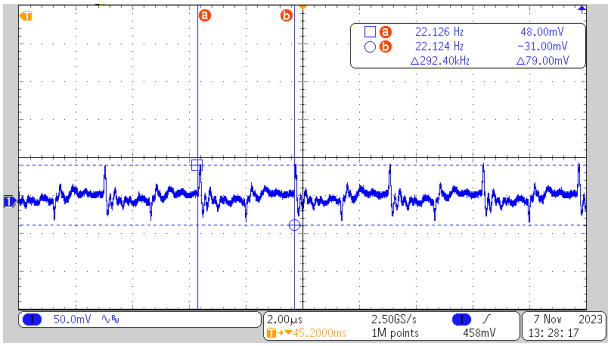

Figure 3-14. 12-V Output Voltage Ripple at 9-V Input

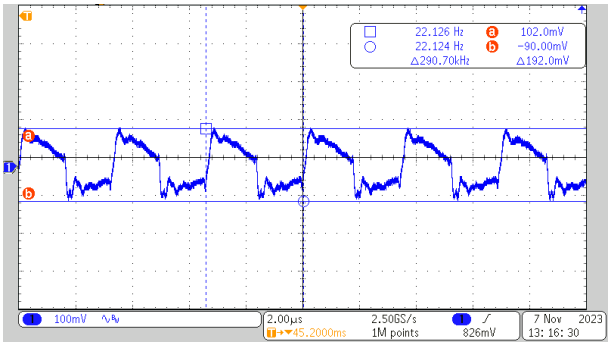

Figure 3-15. 120-V Output Voltage Ripple at 9-V Input

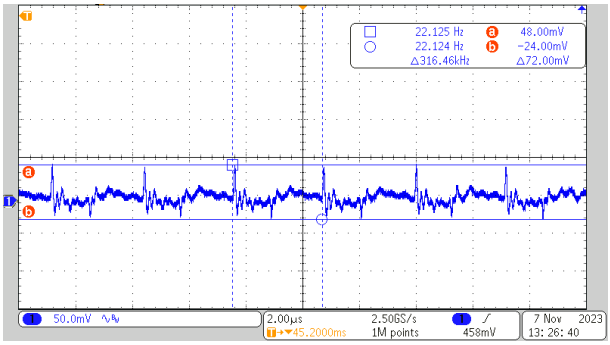

Figure 3-16. 12-V Output Voltage Ripple at 12-V Input

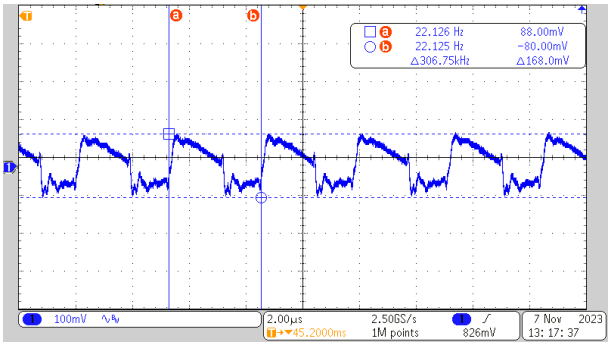

Figure 3-17. 120-V Output Voltage Ripple at 12-V Input

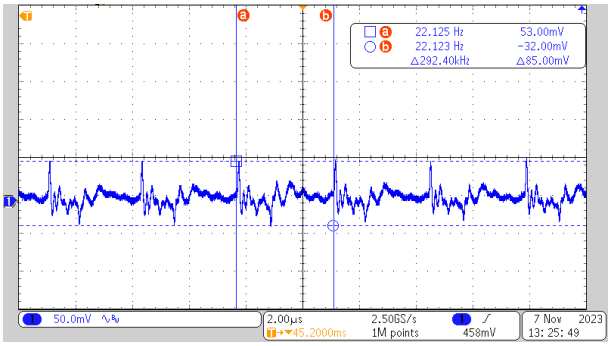

Figure 3-18. 12-V Output Voltage Ripple at 16-V Input

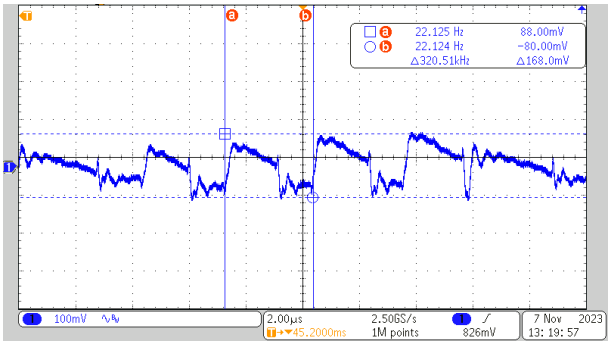

Figure 3-19. 120-V Output Voltage Ripple at 16-V Input

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3.3 Load Transients

The load transient waveforms are shown in the following figures. The test conditions for Figure 3-20 through Figure 3-25 include room temperature, output2 is 120 V, 0 A, with no airflow.

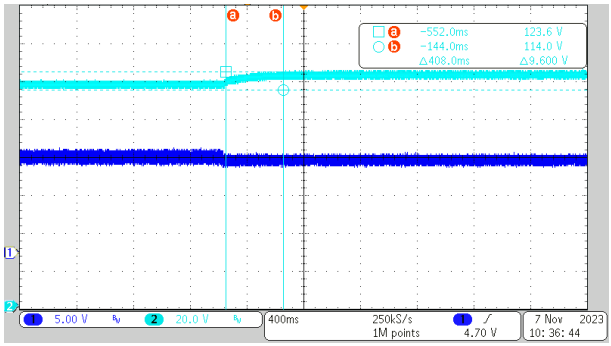

Figure 3-20. 120-V (Aqua) Output Behavior at 12-V (Blue) Loads From 0 A to 0.2 A With 9-V Input

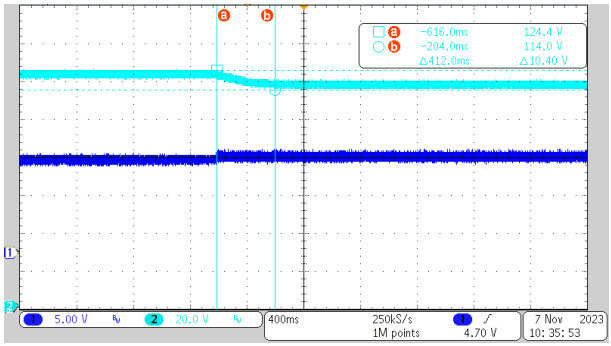

Figure 3-21. 120-V (Aqua) Output Behavior at 12-V (Blue) Loads From 0.2 A to 0 A With 9-V Input

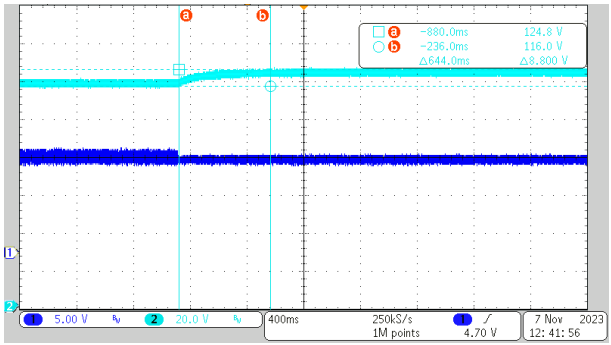

Figure 3-22. 120-V (Aqua) Output Behavior at 12-V (Blue) Loads From 0 A to 0.2 A With 12-V Input

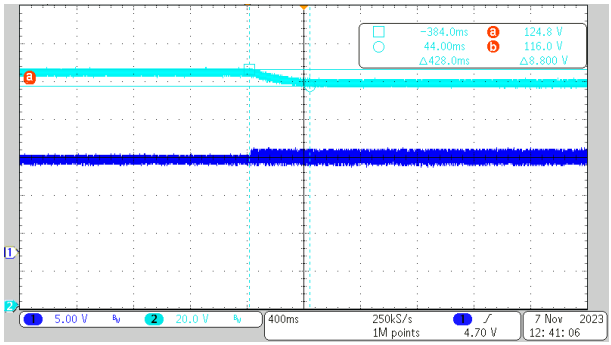

Figure 3-23. 120-V (Aqua) Output Behavior at 12-V (Blue) Loads From 0.2 A to 0 A With 12-V Input

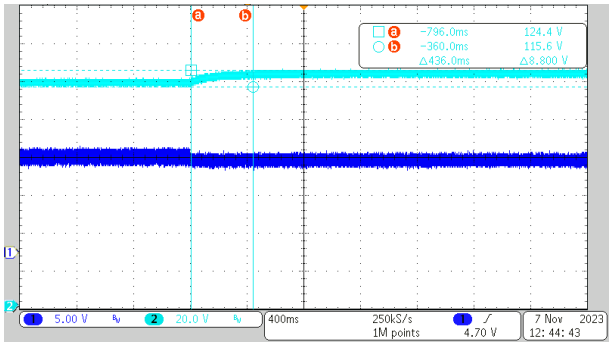

Figure 3-24. 120-V (Aqua) Output Behavior at 12-V (Blue) Loads From 0 A to 0.2 A With 16-V Input

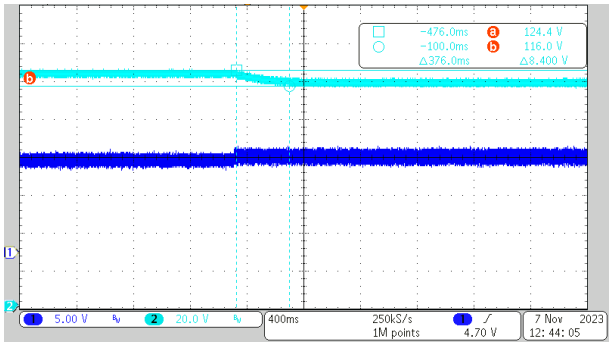

Figure 3-25. 120-V (Aqua) Output Behavior at 12-V (Blue) Loads From 0.2 A to 0 A With 16-V Input

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The test conditions for Figure 3-26 through Figure 3-31 include room temperature, output1 is 12 V, 0.2 A, with no airflow.

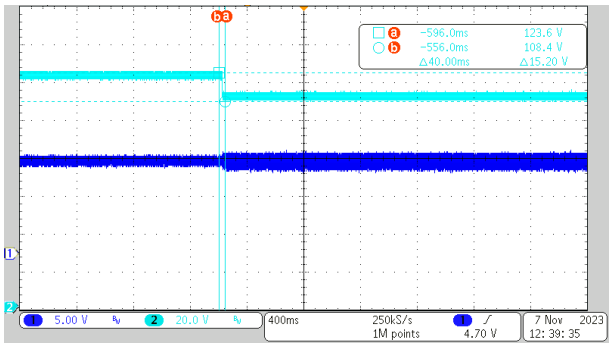

Figure 3-26. 120-V (Aqua) Output Behavior at 120-V (Blue) Loads From 0 A to 0.2 A With 9-V Input

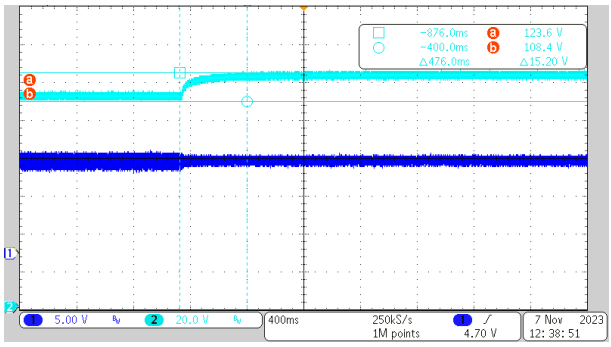

Figure 3-27. 120-V (Aqua) Output Behavior at 120-V (Blue) Loads From 0.2 A to 0 A With 9-V Input

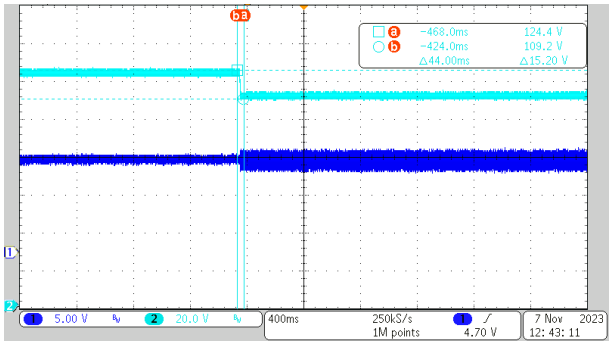

Figure 3-28. 120-V (Aqua) Output Behavior at 120-V (Blue) Loads From 0 A to 0.2 A With 12-V Input

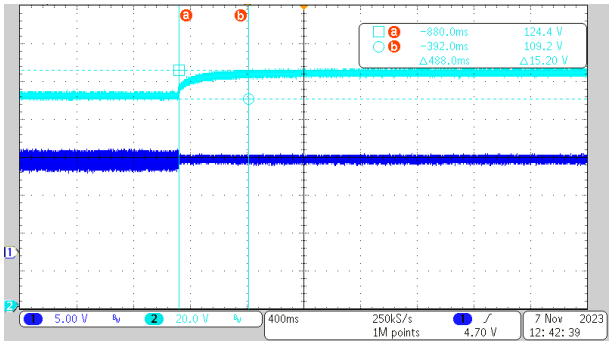

Figure 3-29. 120-V (Aqua) Output Behavior at 120-V (Blue) Loads From 0.2 A to 0 A With 12-V Input

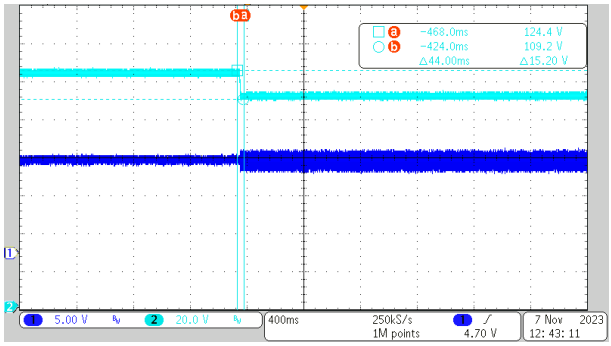

Figure 3-30. 120-V (Aqua) Output Behavior at 120-V (Blue) Loads From 0 A to 0.2 A With 16-V Input

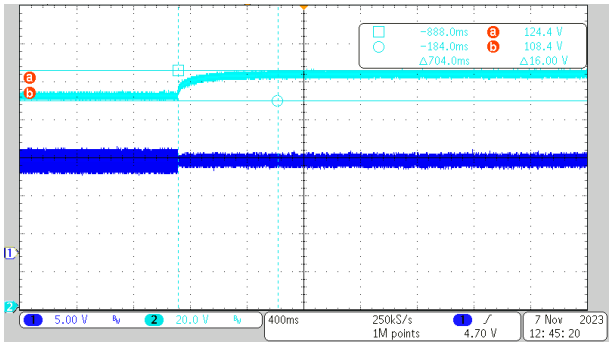

Figure 3-31. 120-V (Aqua) Output Behavior at 120-V (Blue) Loads From 0.2 A to 0 A With 16-V Input

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3.4 Start-Up Sequence

Start-up behavior is shown in the following figures.

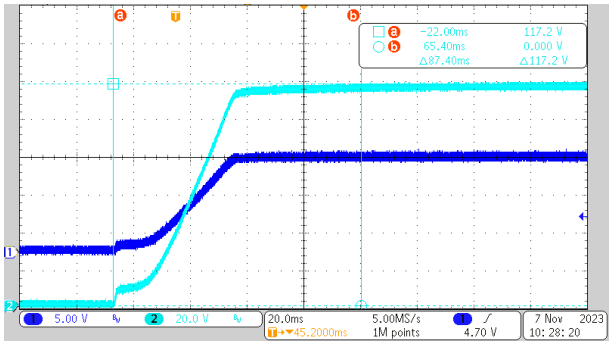

Figure 3-32. Start-Up Waveforms of 12 V, 0 A(Blue) and 120 V, 0 A (Aqua) With 9-V Input

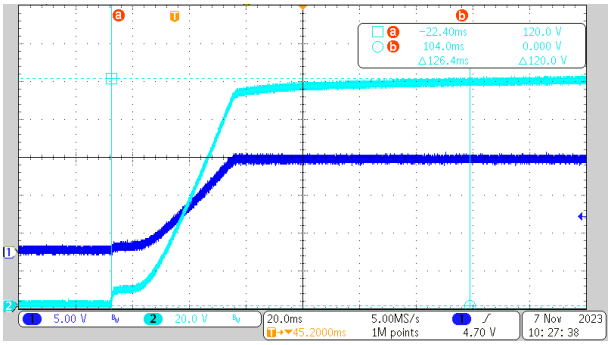

Figure 3-33. Start-Up Waveforms of 12 V, 0.2 A (Blue) and 120 V, 0 A (Aqua) With 9-V Input

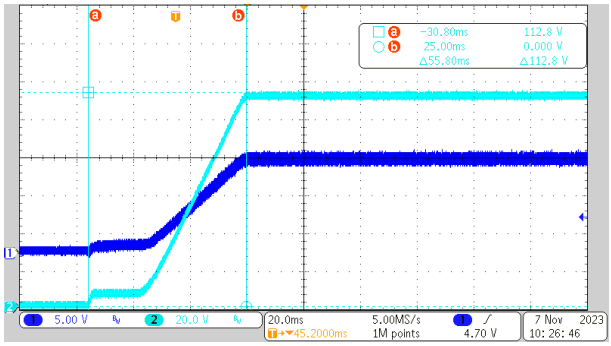

Figure 3-34. Start-Up Waveforms of 12 V, 0 A (Blue) and 120 V, 0.2 A (Aqua) With 9-V Input

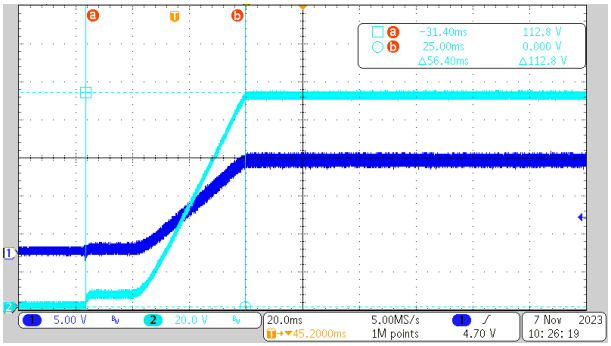

Figure 3-35. Start-Up Waveforms of 12 V, 0.2 A (Blue) and 120 V, 0.2 A (Aqua) With 9-V Input

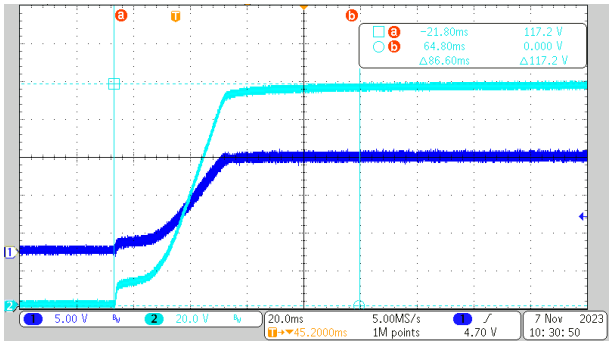

Figure 3-36. Start-Up Waveforms of 12 V, 0 A (Blue) and 120 V, 0 A (Aqua) With 12-V Input

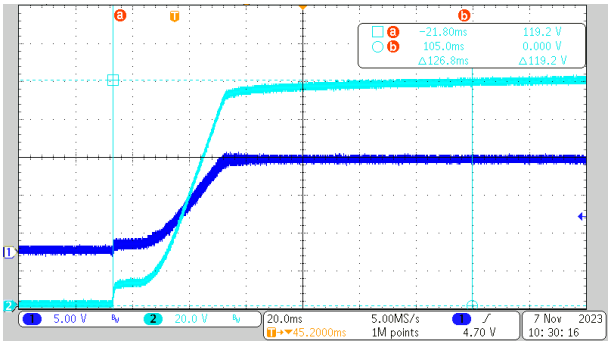

Figure 3-37. Start-Up Waveforms of 12 V, 0.2 A (Blue) and 120 V, 0 A (Aqua) With 12-V Input

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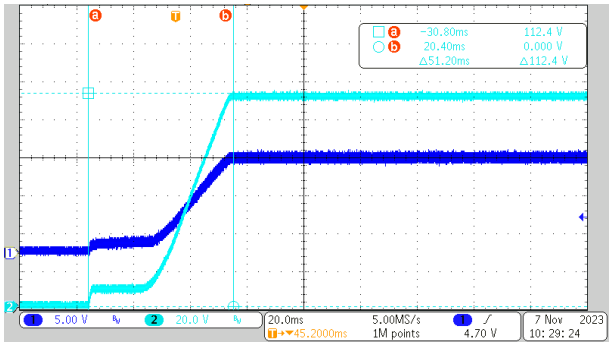

Figure 3-38. Start-Up Waveforms of 12 V, 0 A (Blue) and 120 V, 0.2 A (Aqua) With 12-V Input

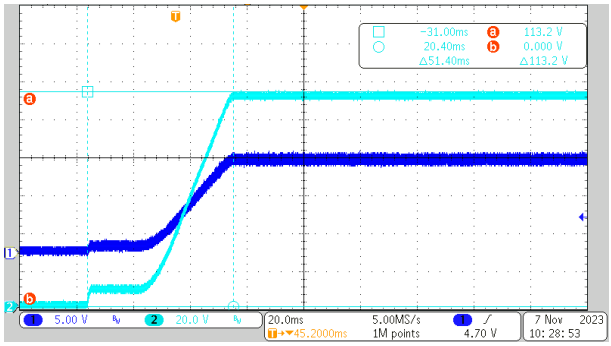

Figure 3-39. Start-Up Waveforms of 12 V, 0.2 A (Blue) and 120 V, 0.2 A (Aqua) With 12-V Input

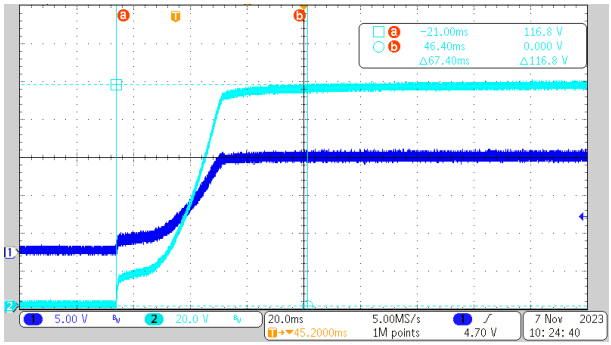

Figure 3-40. Start-Up Waveforms of 12 V, 0 A (Blue) and 120 V, 0 A (Aqua) With 16-V Input

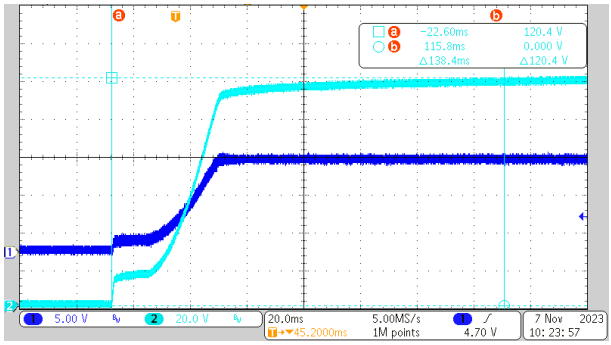

Figure 3-41. Start-Up Waveforms of 12 V, 0.2 A (Blue) and 120 V, 0 A (Aqua) With 16-V Input

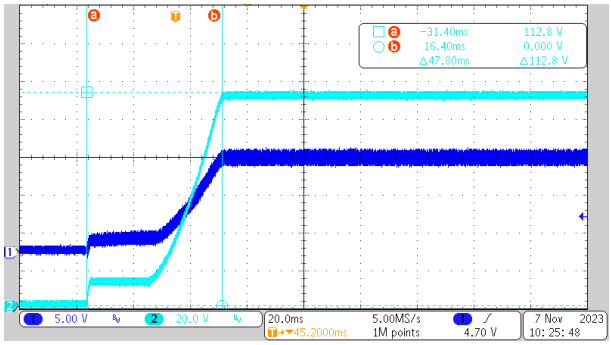

Figure 3-42. Start-Up Waveforms of 12 V, 0 A (Blue) and 120 V, 0.2 A (Aqua) With 16-V Input

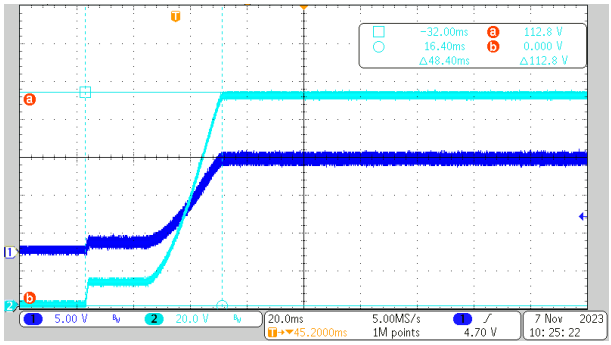

Figure 3-43. Start-Up Waveforms of 12 V, 0.2 A (Blue) and 120 V, 0.2 A (Aqua) With 16-V Input

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