

USB Type-C Dual-Buck Reference Design



Description

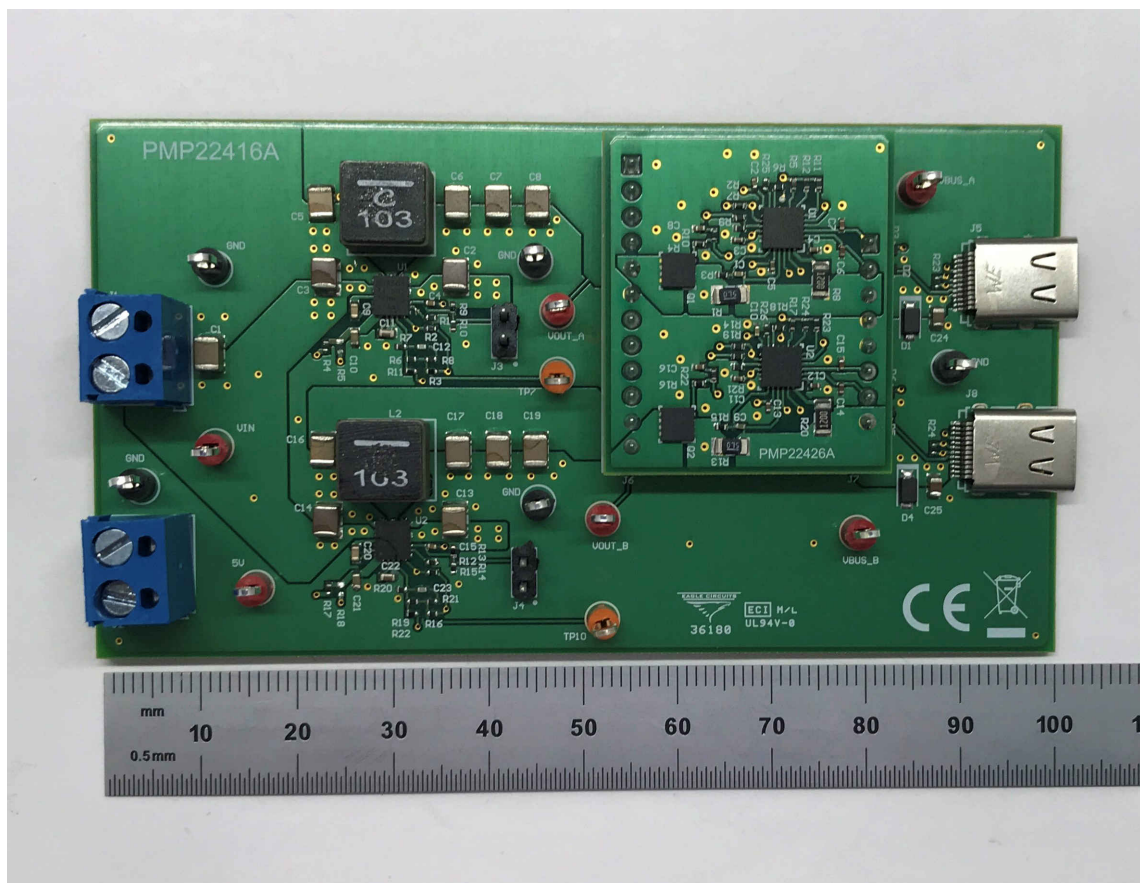
This reference design is a USB Type-C® dual-output buck with 65-W output power and 98.8% efficiency. The design uses two LM61460 buck converters to step down a 21-V input and includes the option for a 5-V bias voltage input to maximize efficiency. The USB Type-C design offers dual-output voltages of 5 V, 9 V, 15 V, and 20 V and was tested using the PMP22426 daughter card. The PMP22426 uses the TPS25740B, a USB Type-C Power Delivery (PD) controller, to control each output separately.

Features

- Two buck converters for dual-port USB Type-C PD
- 98.8% maximum efficiency at 20-V output
- Includes a socket for custom USB PD control cards
- Compact, single-side PCB

Applications

- [Consumer battery charger](#)



Board Top Side

1 Input Characteristics

1.1 DC Input Voltage Requirements

The 5-V bias supply is an optional requirement for output voltages below 15 V. An external bias supply increases efficiency. All tests in this report use the 5-V bias supply.

Table 1-1. Input Requirements

Parameter	Specifications	Units
Input Voltage	21	VDC
Bias Voltage	5	VDC

2 Testing and Results

2.1 Efficiency Graphs

The following graphs were measured at buck output (VOUT_A).

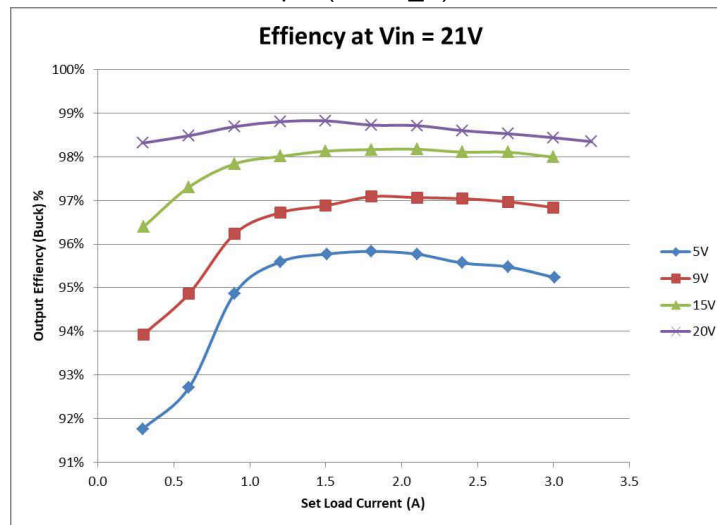


Figure 2-1. Efficiency by Output Voltage

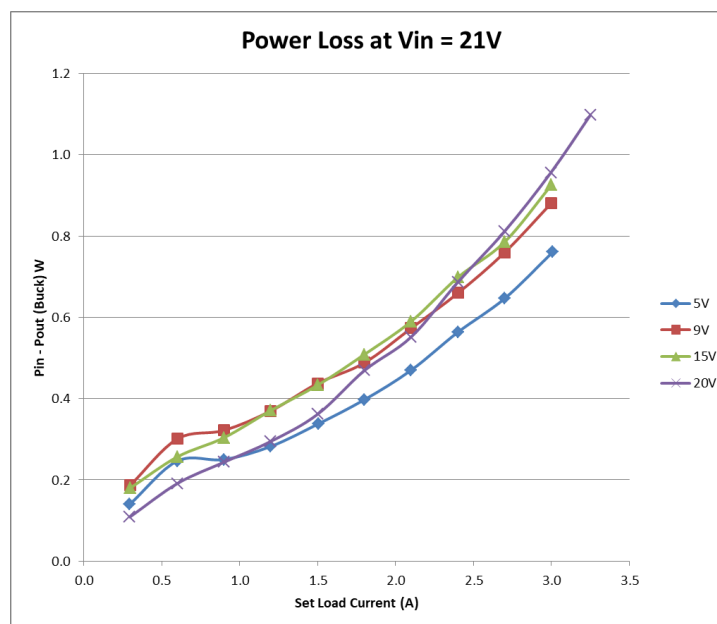


Figure 2-2. Loss by Output Voltage

2.2 Standby Power

No-load power consumption is measured with Fluke 8846 precision multimeter using 2-minute average. Output voltage is set to 5 V.

- 21-V main supply input: $P_{in} = 3.5 \text{ mW}$
- 5-V bias supply input: $P_{in} = 97 \text{ }\mu\text{W}$

2.3 Regulation

All measurements are taken with a 21-V input voltage.

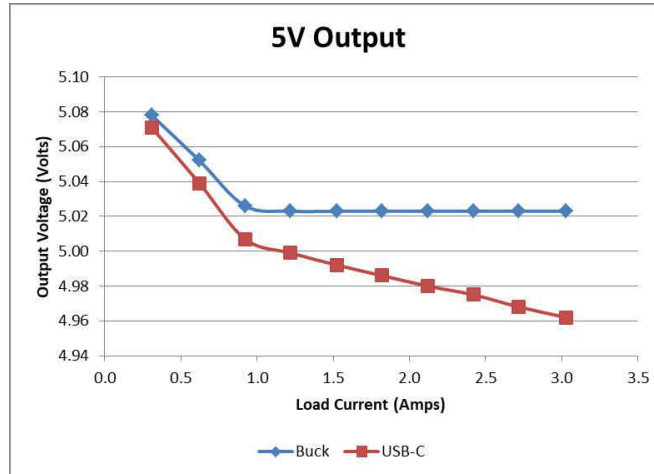


Figure 2-3. 5-V Output Regulation

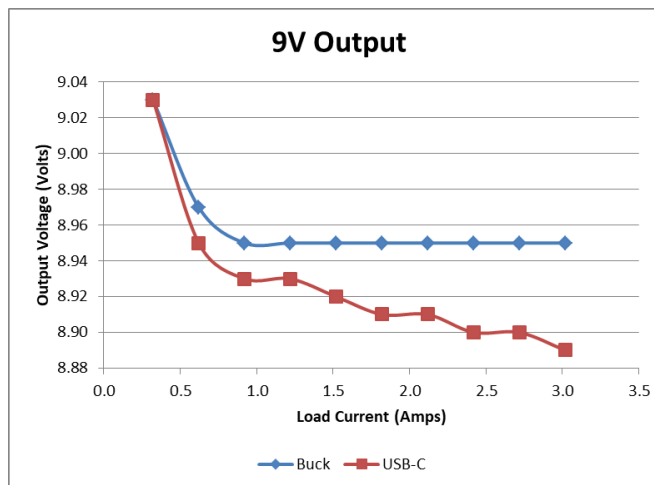


Figure 2-4. 9-V Output Regulation

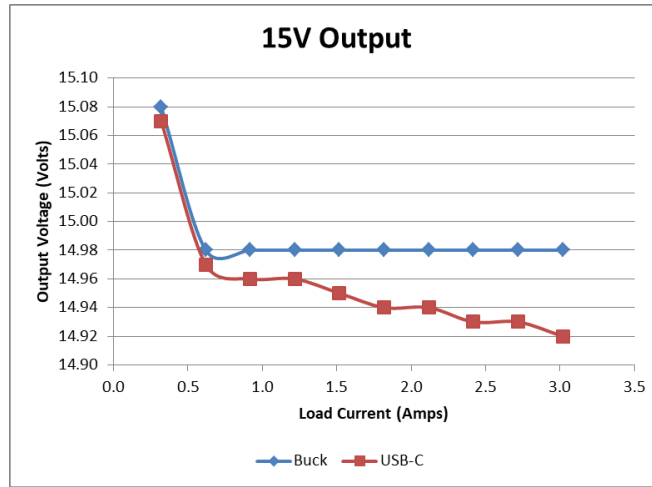


Figure 2-5. 15-V Output Regulation

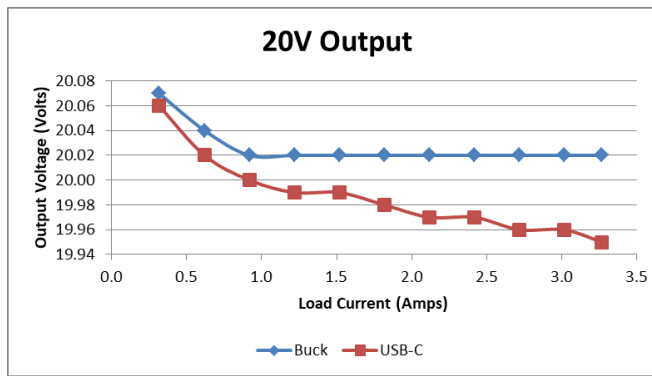


Figure 2-6. 20-V Output Regulation

2.4 Current Limit

The following image illustrates the current limit graph for this design.

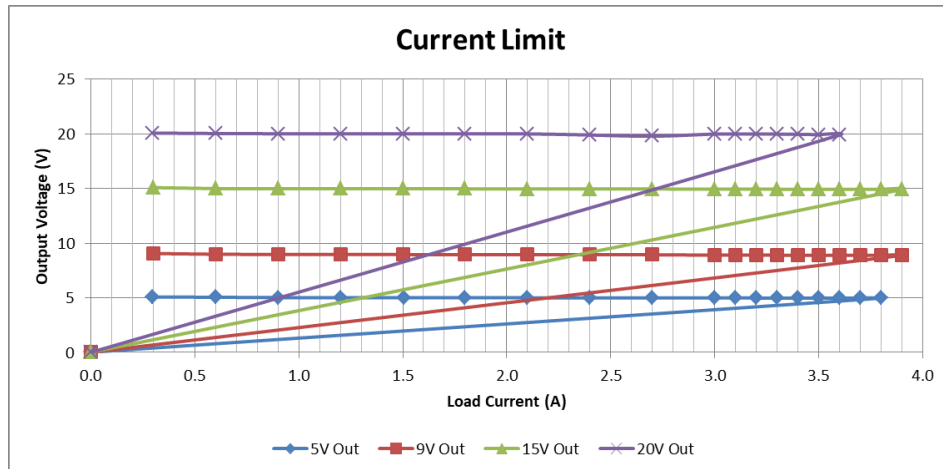


Figure 2-7. Current Limit

2.5 Thermal Images

The following thermal images show a top view of the board. The board is placed horizontally during the test. The ambient temperature is 25°C with no air flow. The output is loaded for 30 minutes. Input voltage is set to 21 V.



Figure 2-8. 5 V, 3 A, Top Side



Figure 2-9. 9 V, 3 A, Top Side

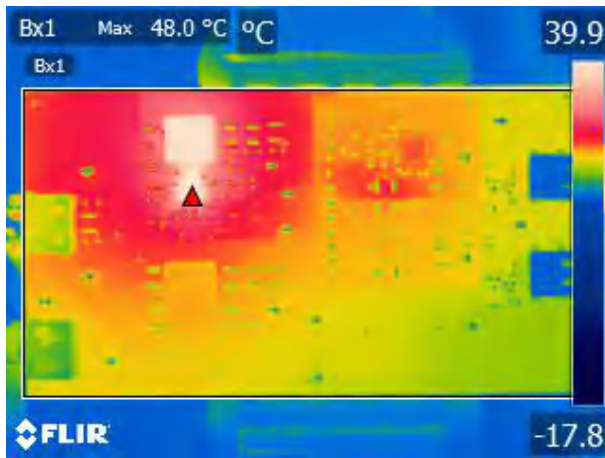


Figure 2-10. 15 V, 3 A, Top Side



Figure 2-11. 20 V, 3.25 A, Top Side

2.6 Bode Plots

All input voltage is set to 21 V.

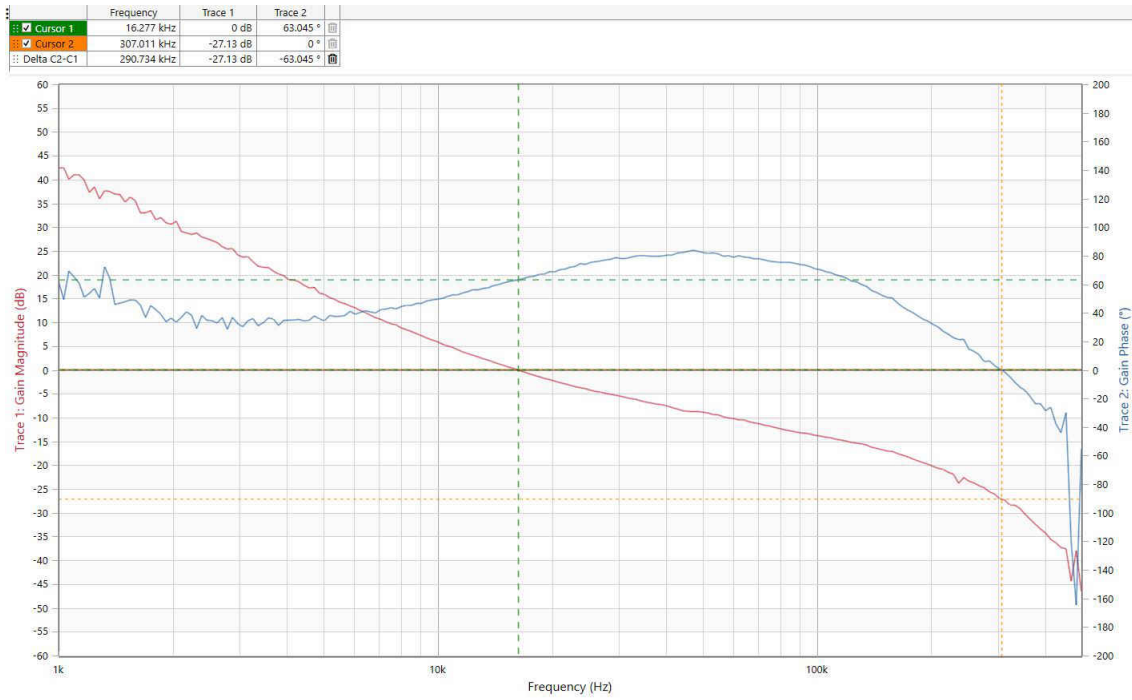


Figure 2-12. 5-V, No load

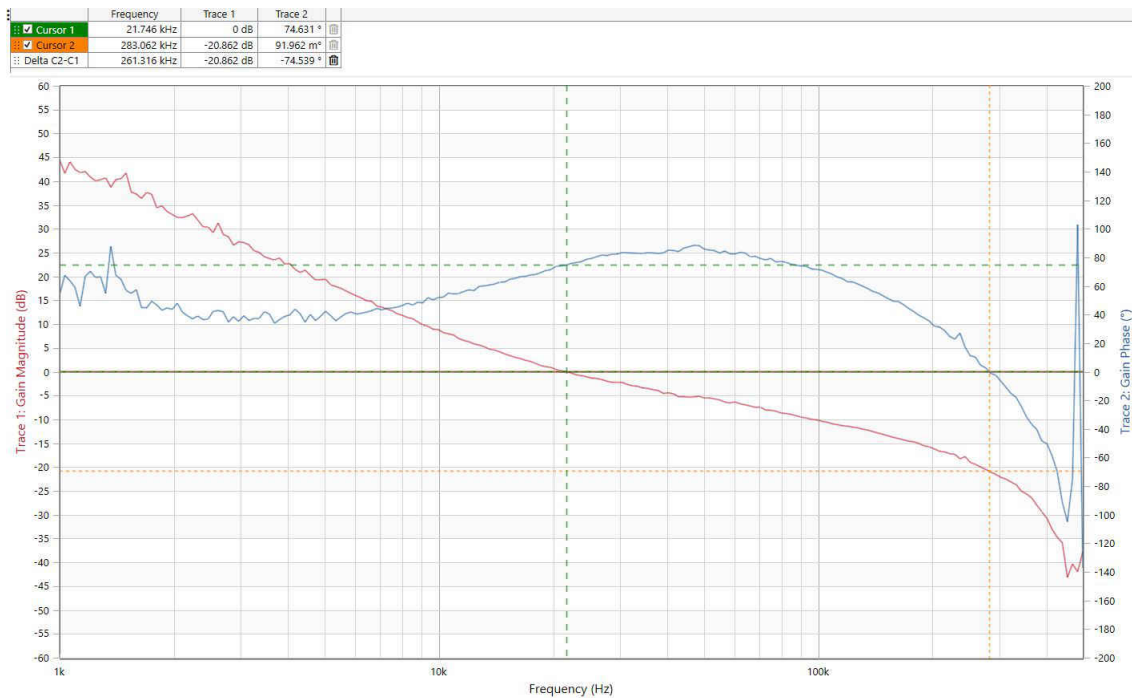


Figure 2-13. 9-V, No load

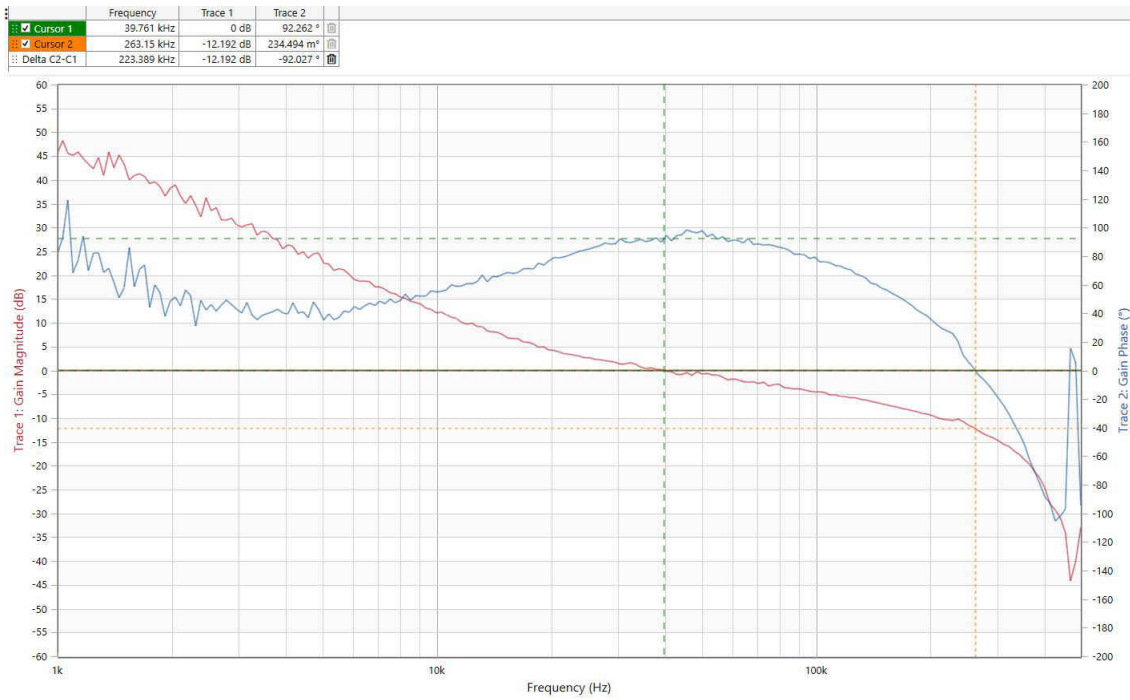


Figure 2-14. 15-V, No load

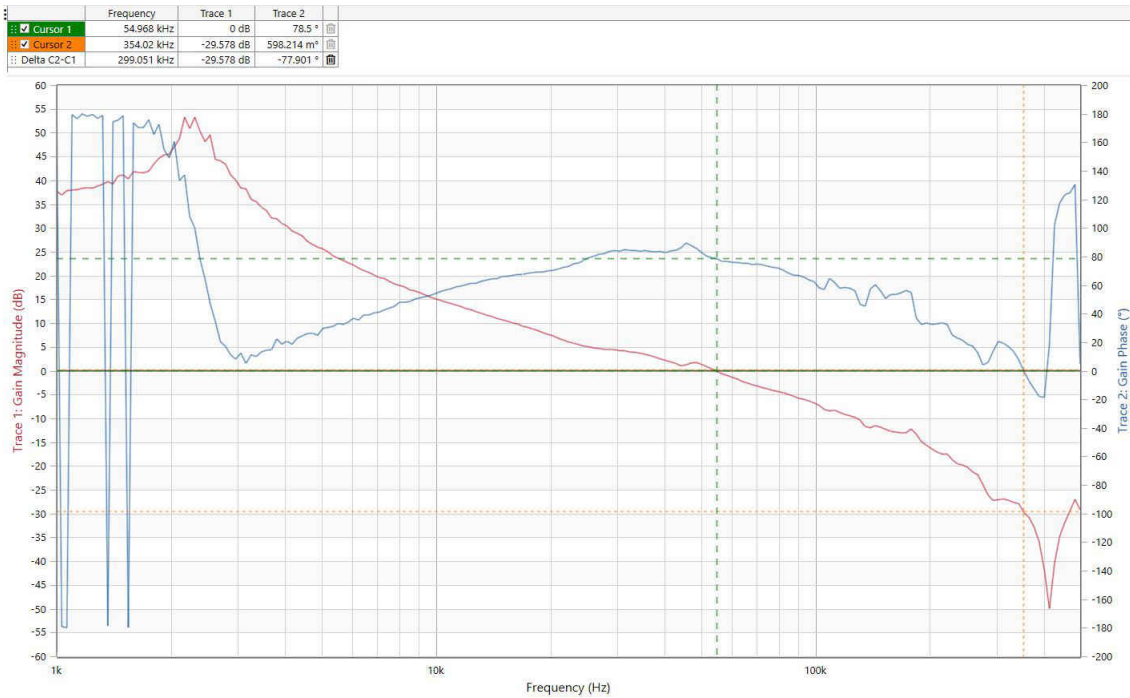


Figure 2-15. 20-V, No load

3 Waveforms

3.1 Switching

The switching characteristics waveforms are presented in the following images.

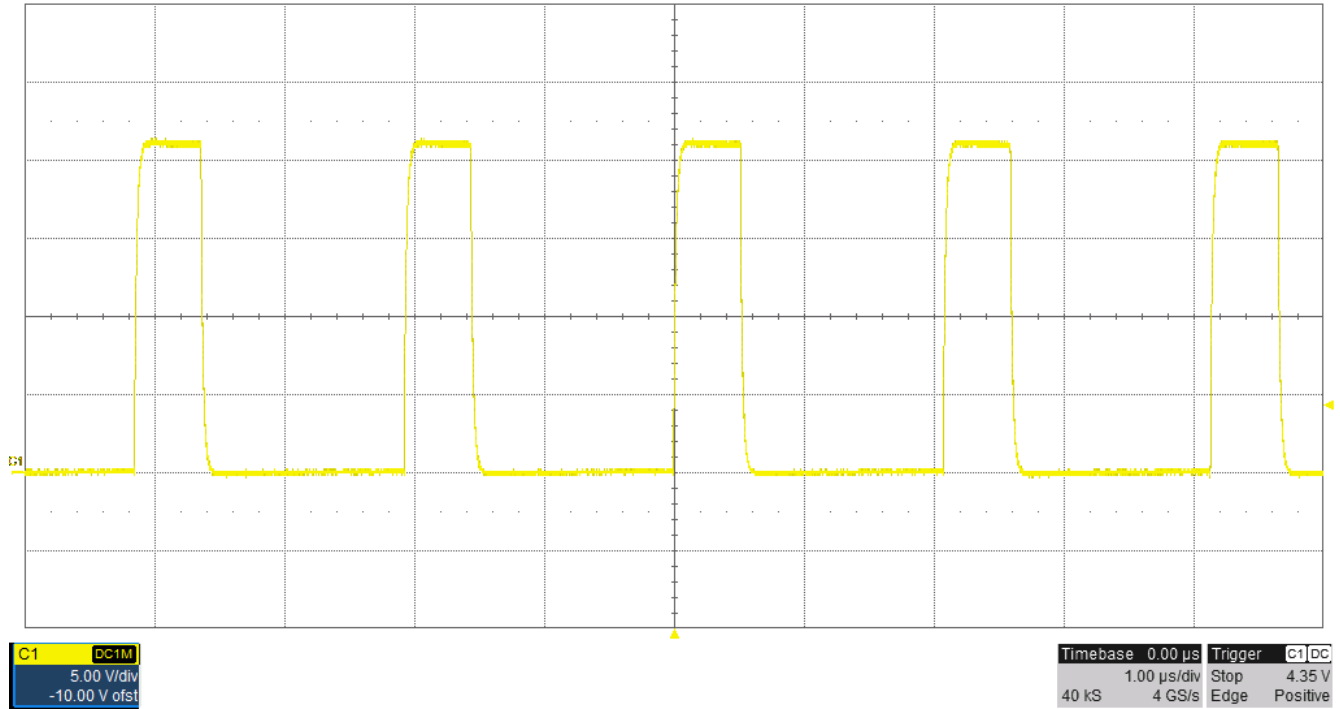


Figure 3-1. SW to GND, 5-V, 3-A Output

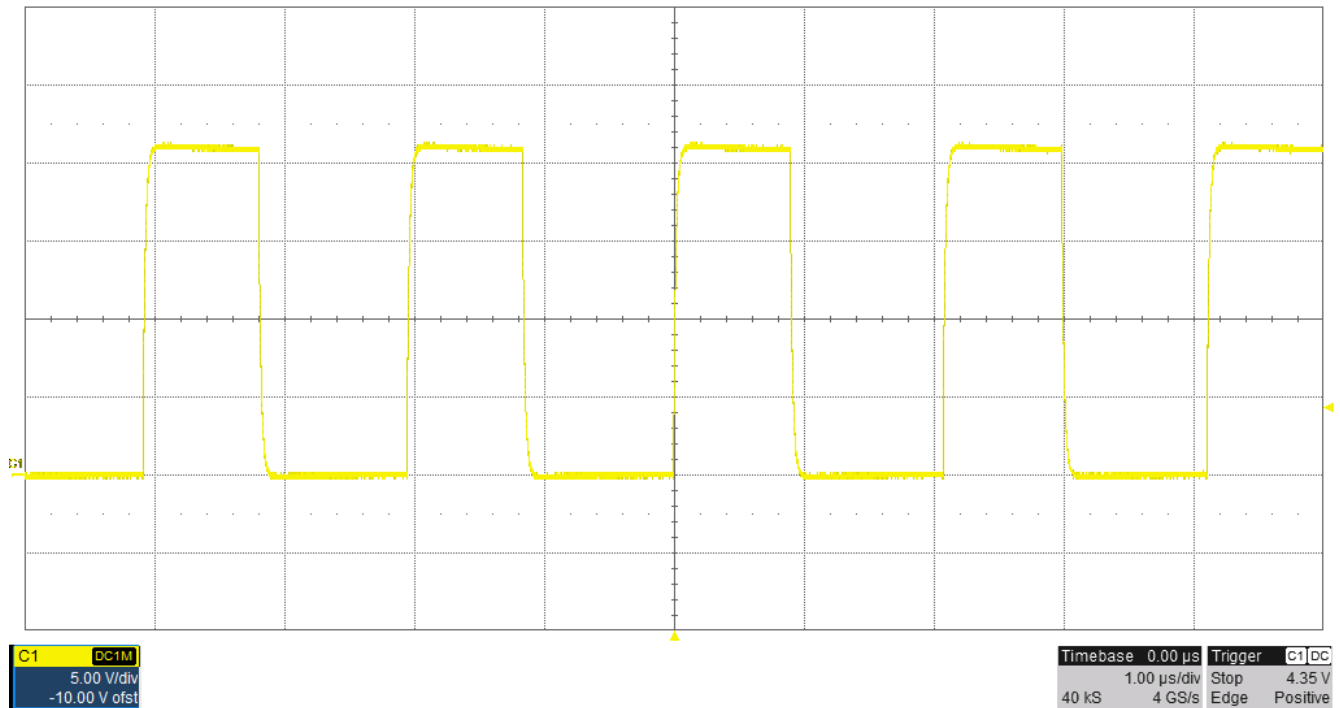


Figure 3-2. SW to GND, 9-V, 3-A Output

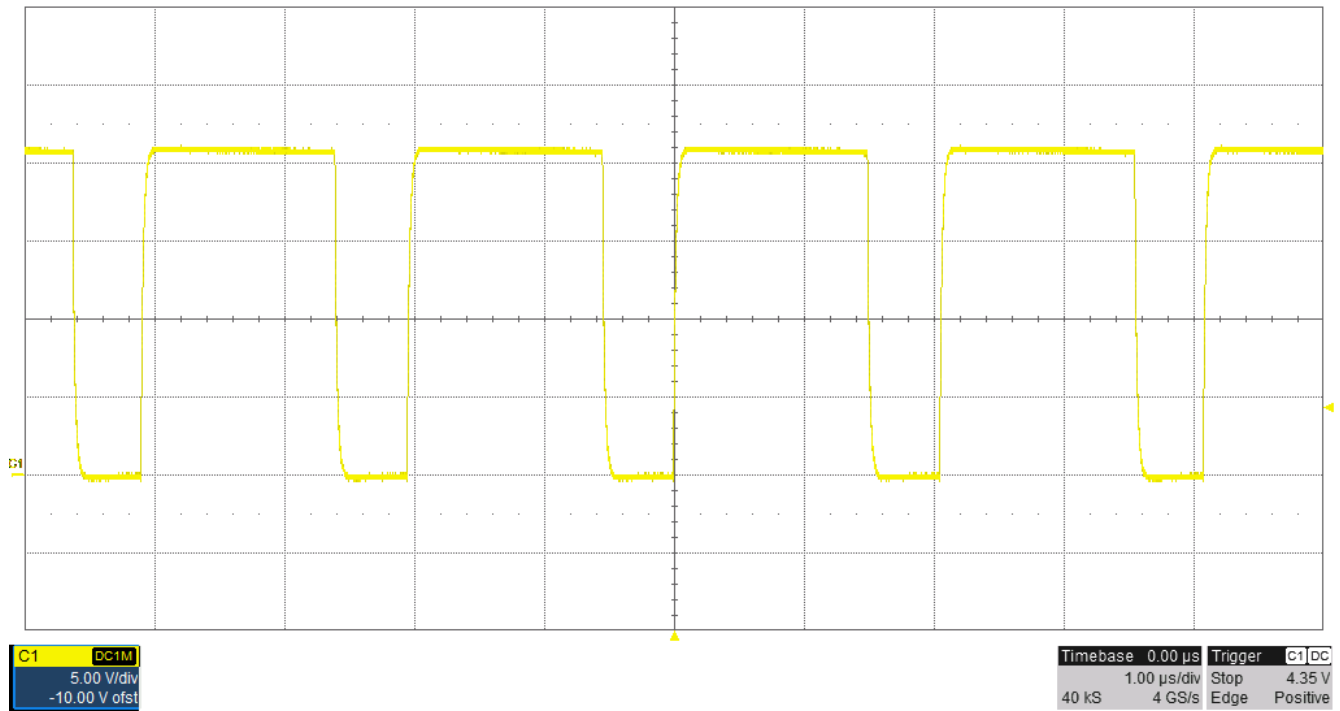


Figure 3-3. SW to GND, 15-V, 3-A Output

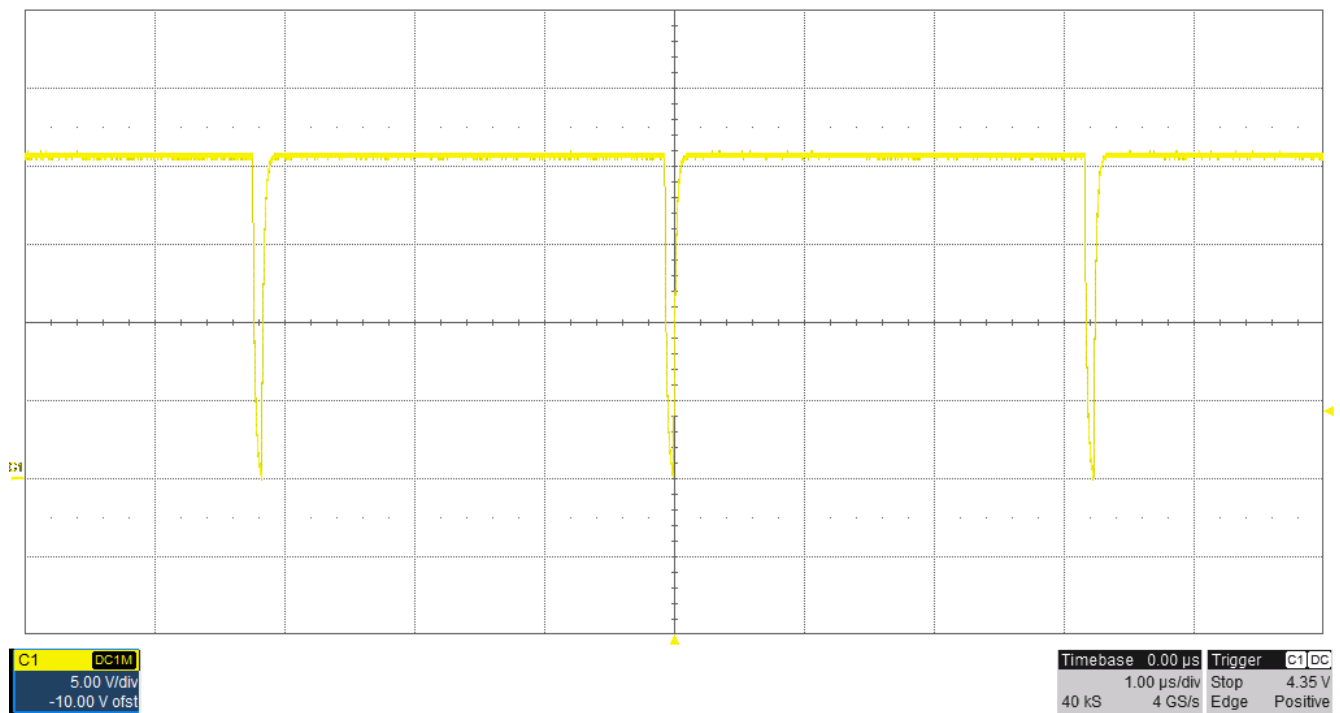


Figure 3-4. SW to GND, 20-V, 3.25-A Output

3.2 Output Voltage Ripple

The output ripple voltage is measured across the ceramic output capacitors using the tip and barrel method.

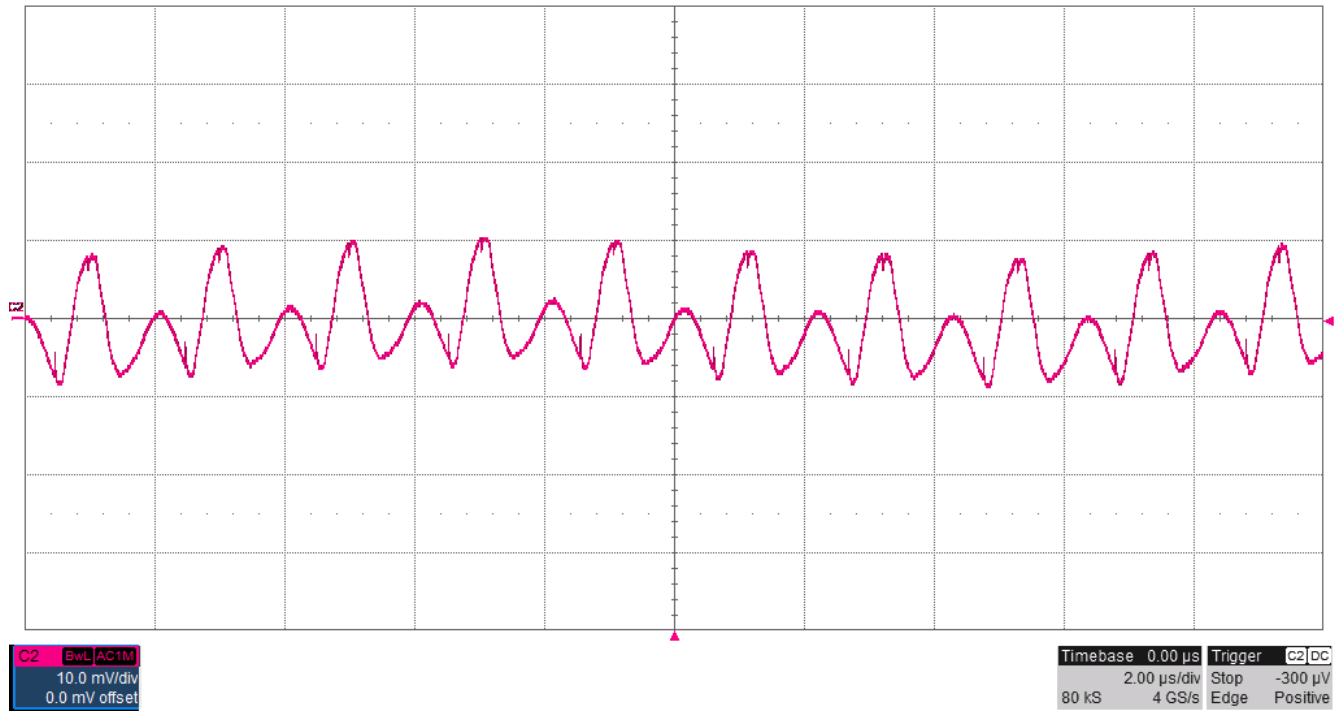


Figure 3-5. 5-V, 3-A Output

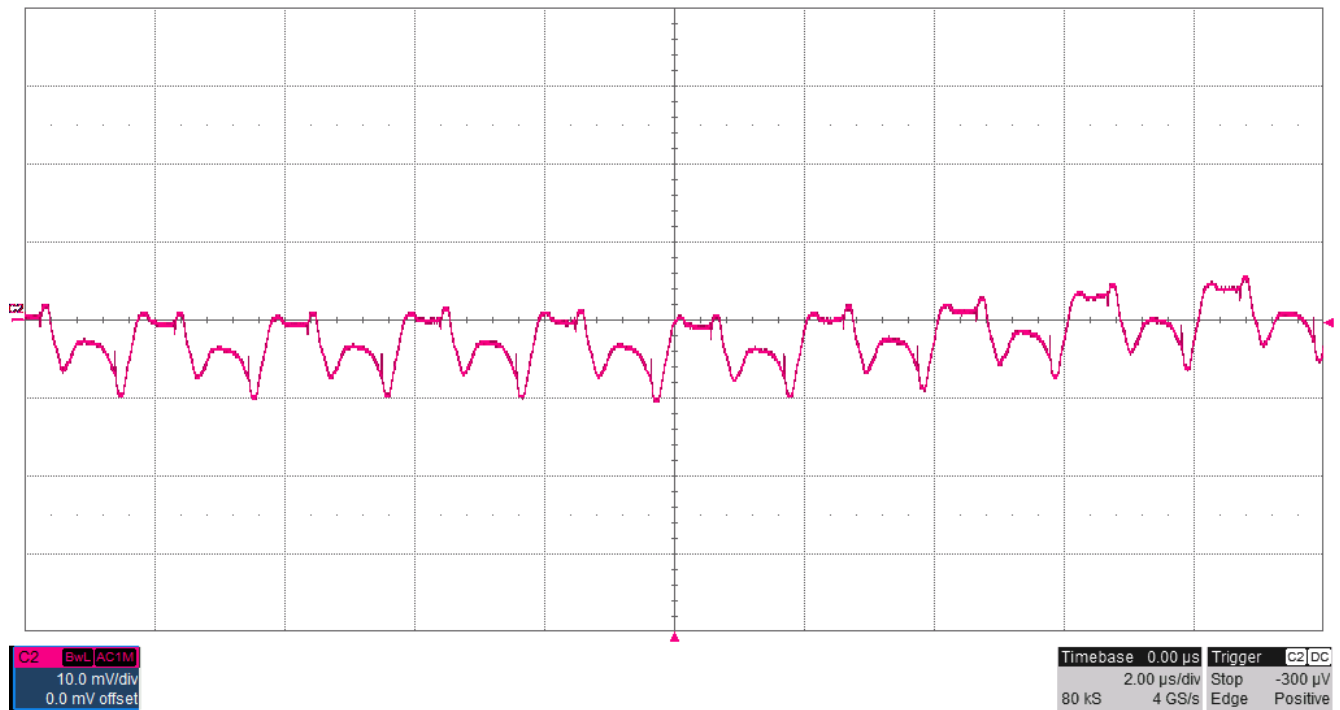


Figure 3-6. 9-V, 3-A Output

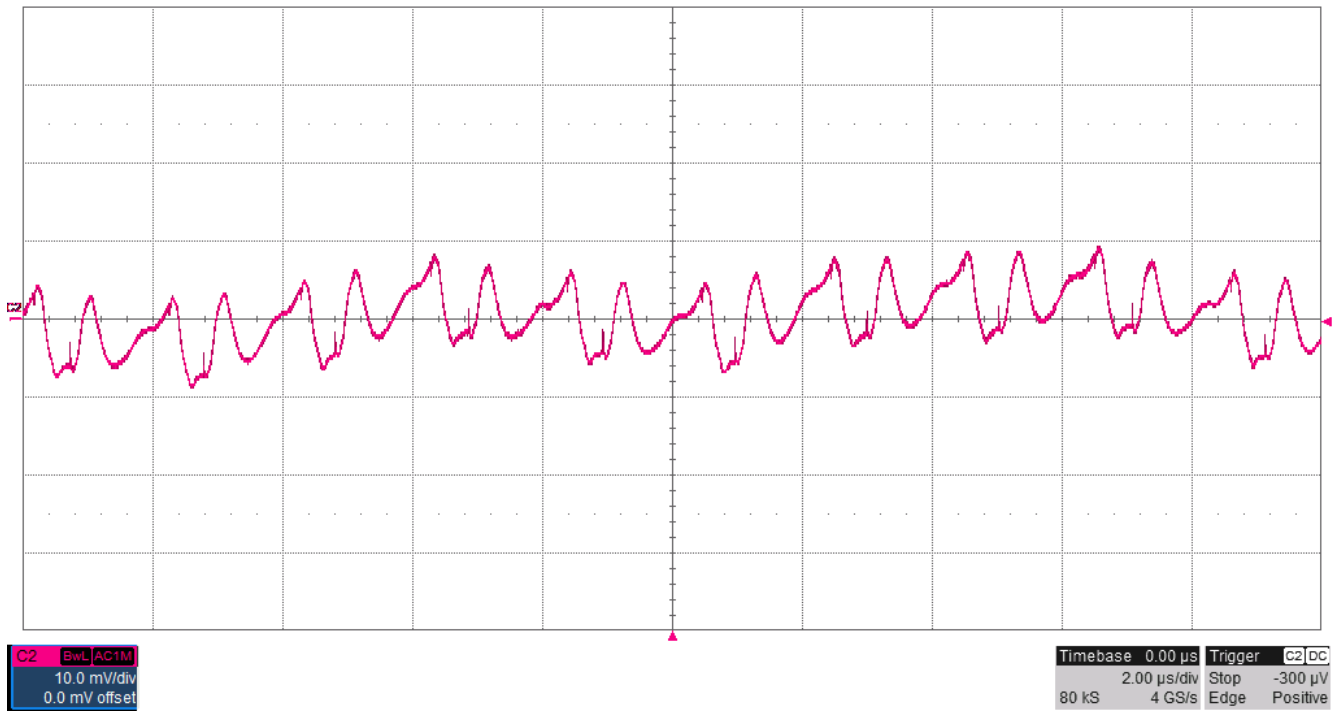


Figure 3-7. 15-V, 3-A Output



Figure 3-8. 20-V, 3.25-A Output

3.3 Load Transients

Load response is tested at 21-V input, where Channel 1 (Yellow) is the output voltage in AC level and Channel 4 (Green) is the output current.

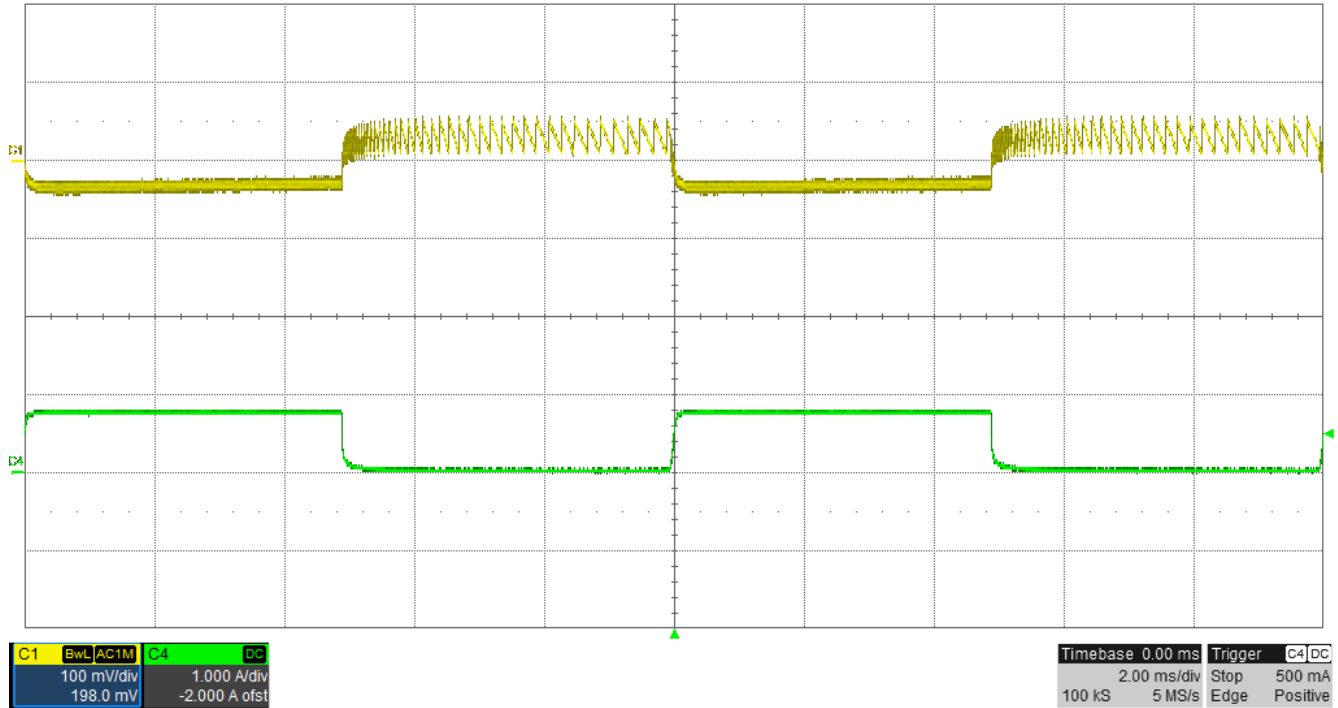


Figure 3-9. 5 V, Load Step From 0 A to 0.75 A

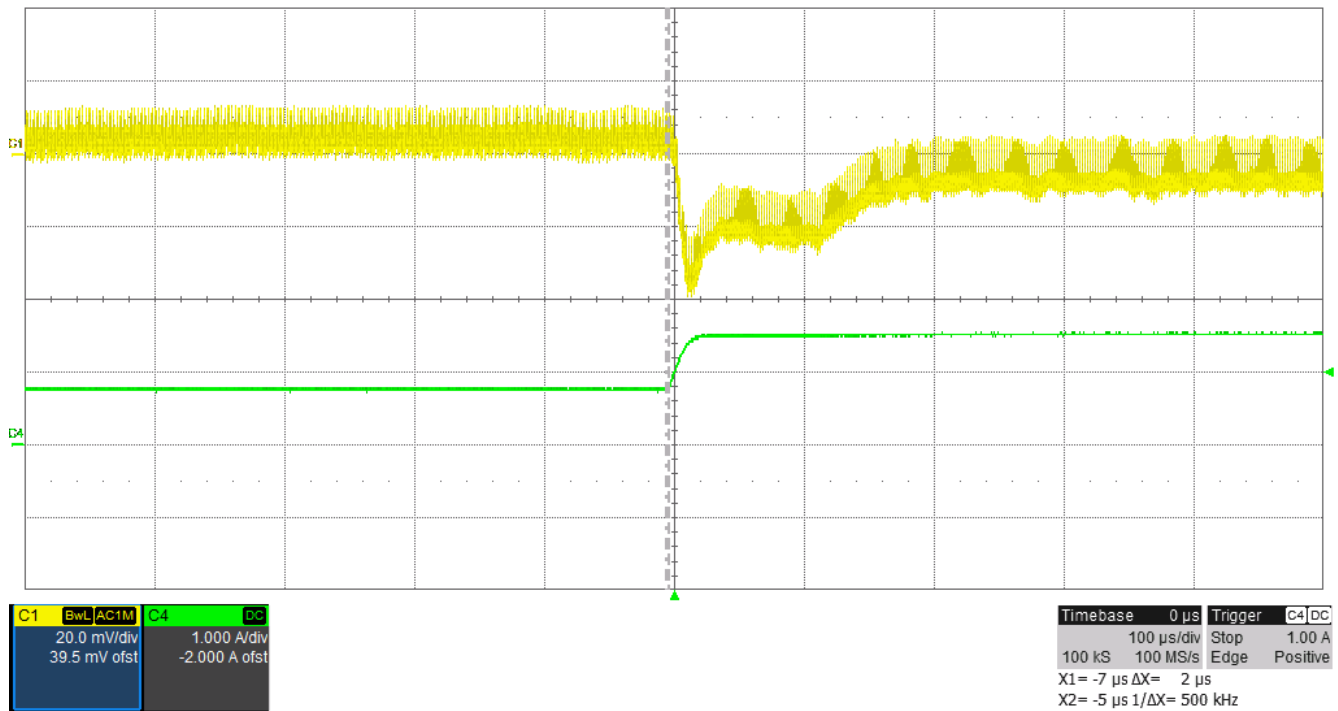


Figure 3-10. 5 V, Load Step From 0.75 A to 1.5 A

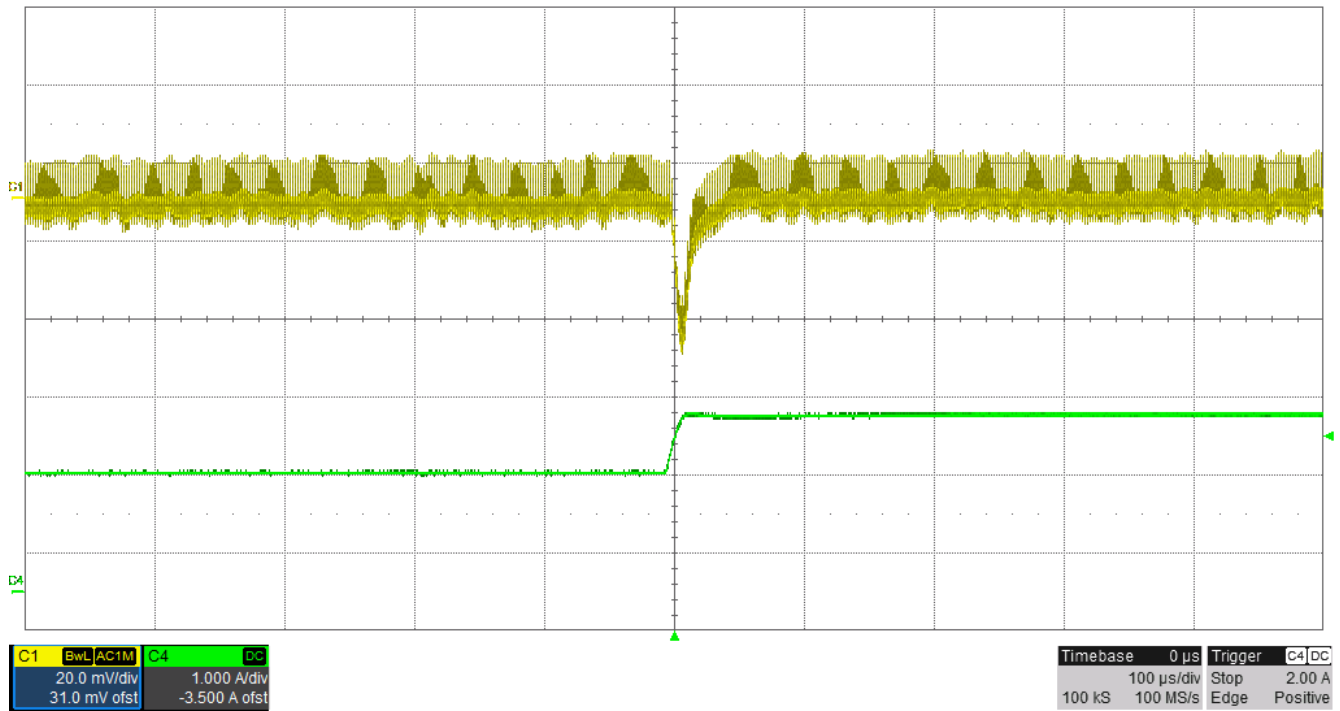


Figure 3-11. 5 V, Load Step From 1.5 A to 2.25 A

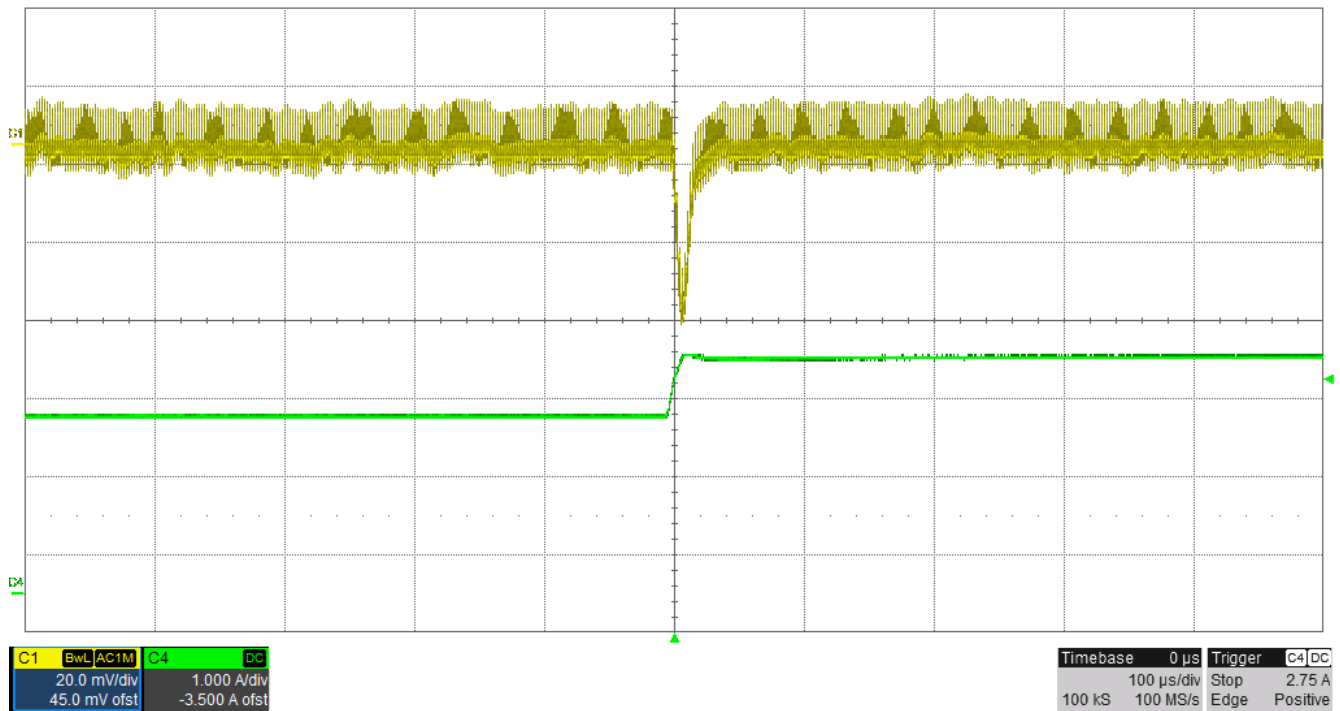


Figure 3-12. 5 V, Load Step From 2.25 A to 3.0 A

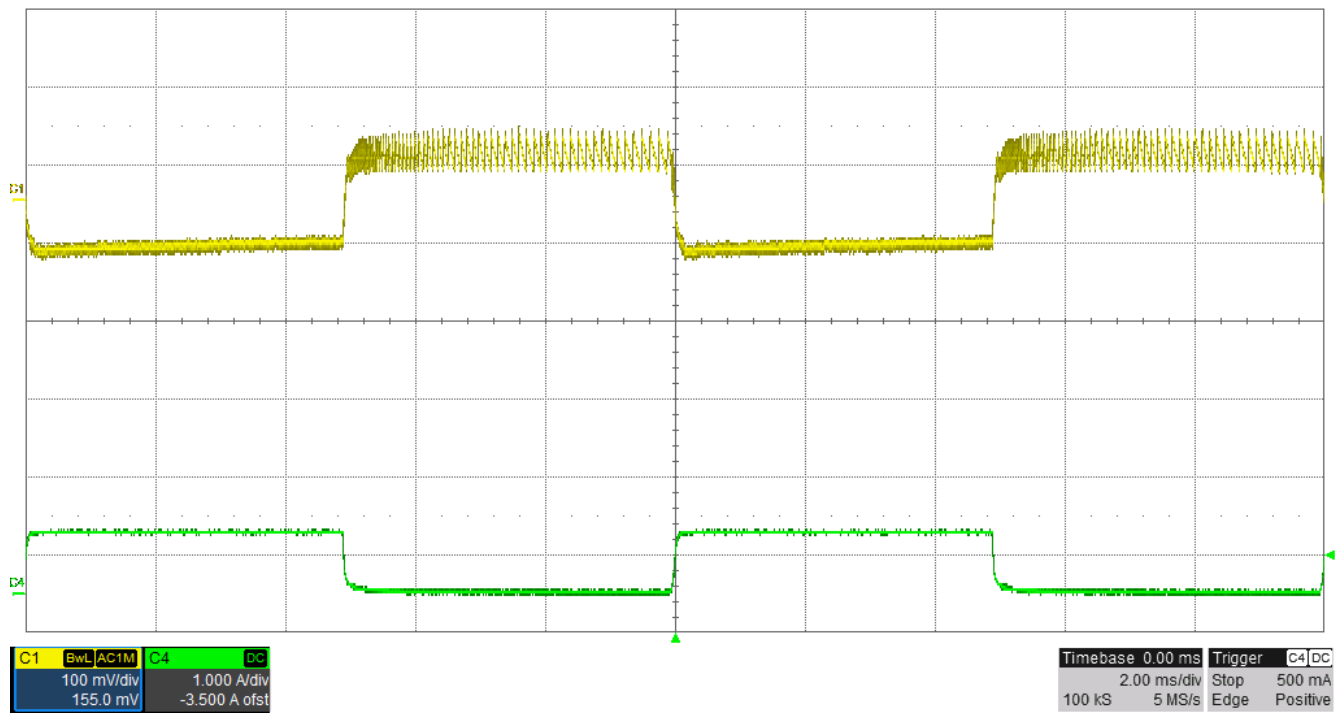


Figure 3-13. 9 V, Load Step From 0 A to 0.75 A

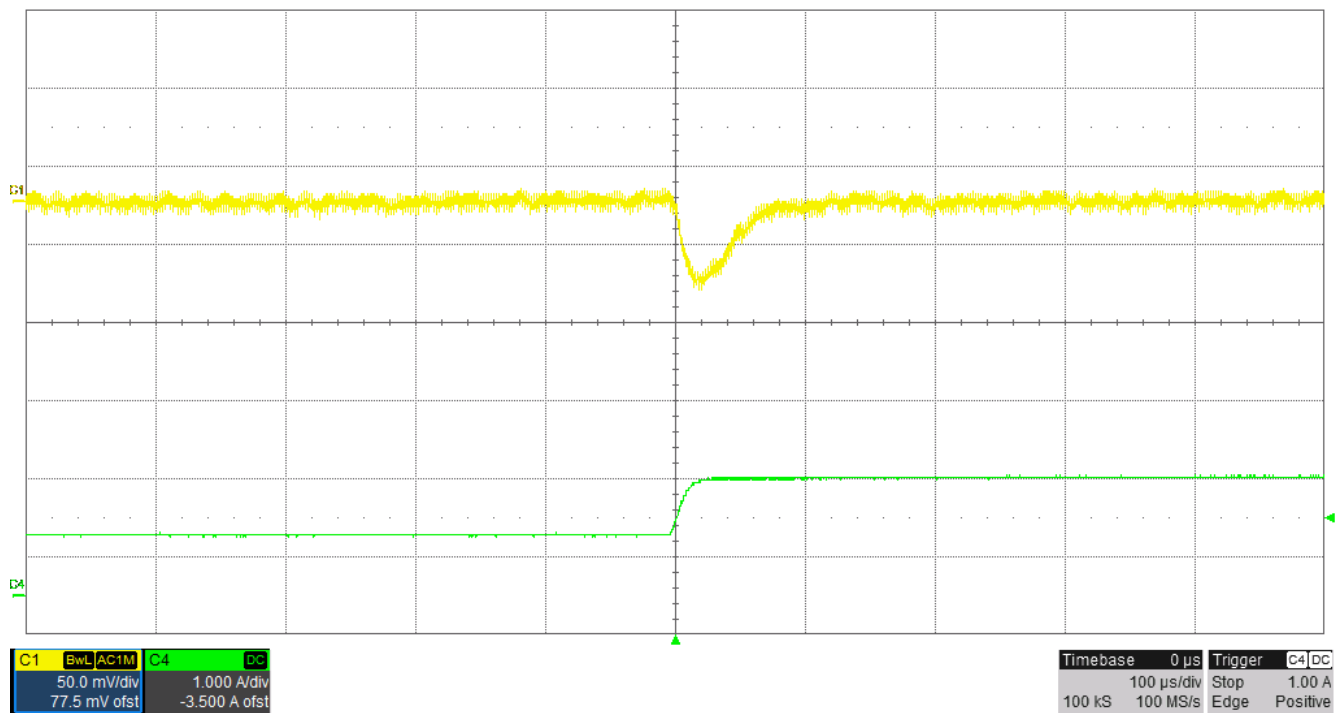


Figure 3-14. 9 V, Load Step From 0.75 A to 1.5 A

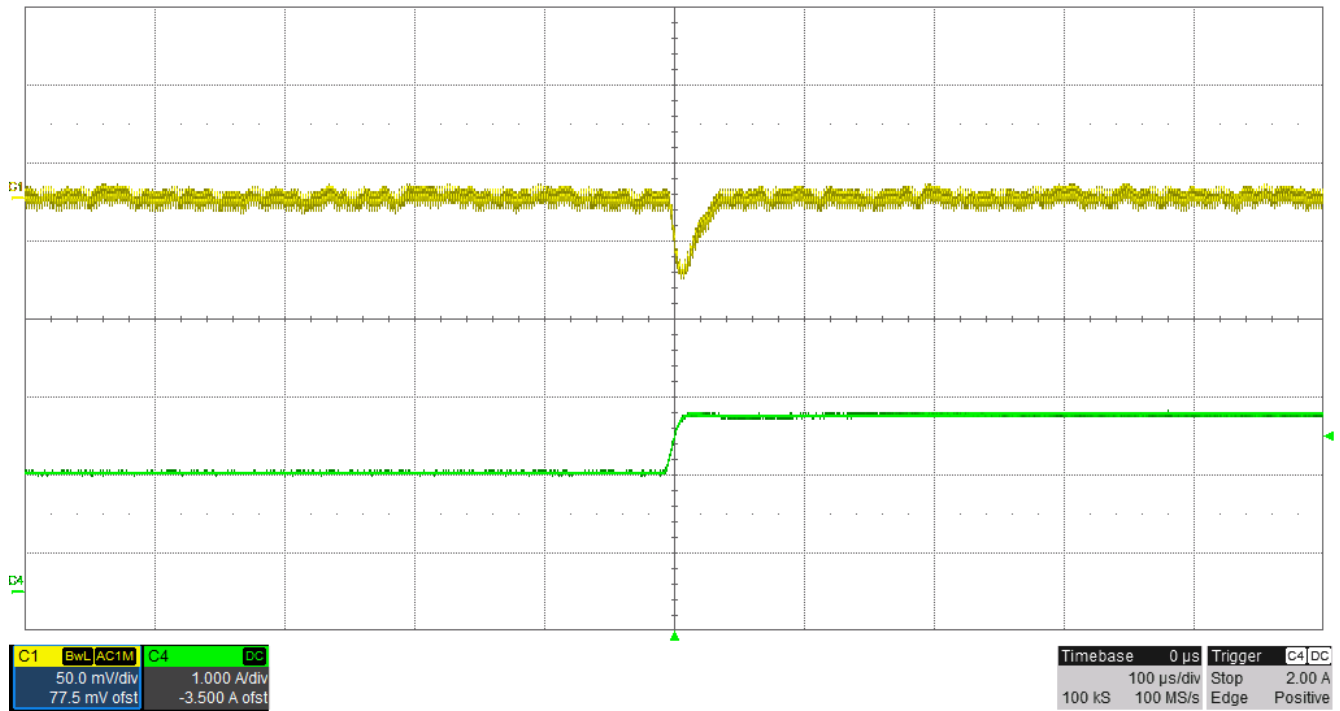


Figure 3-15. 9 V, Load Step From 1.5 A to 2.25 A

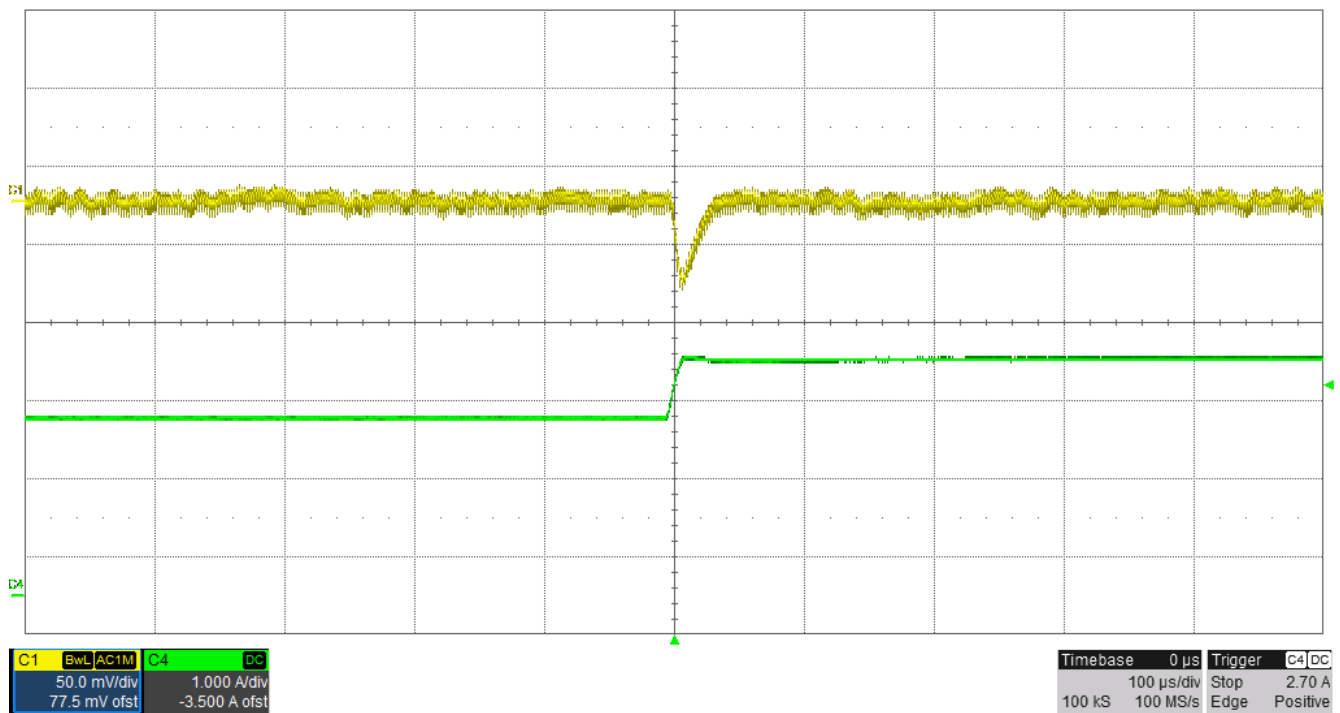


Figure 3-16. 9 V, Load Step From 2.25 A to 3.0 A

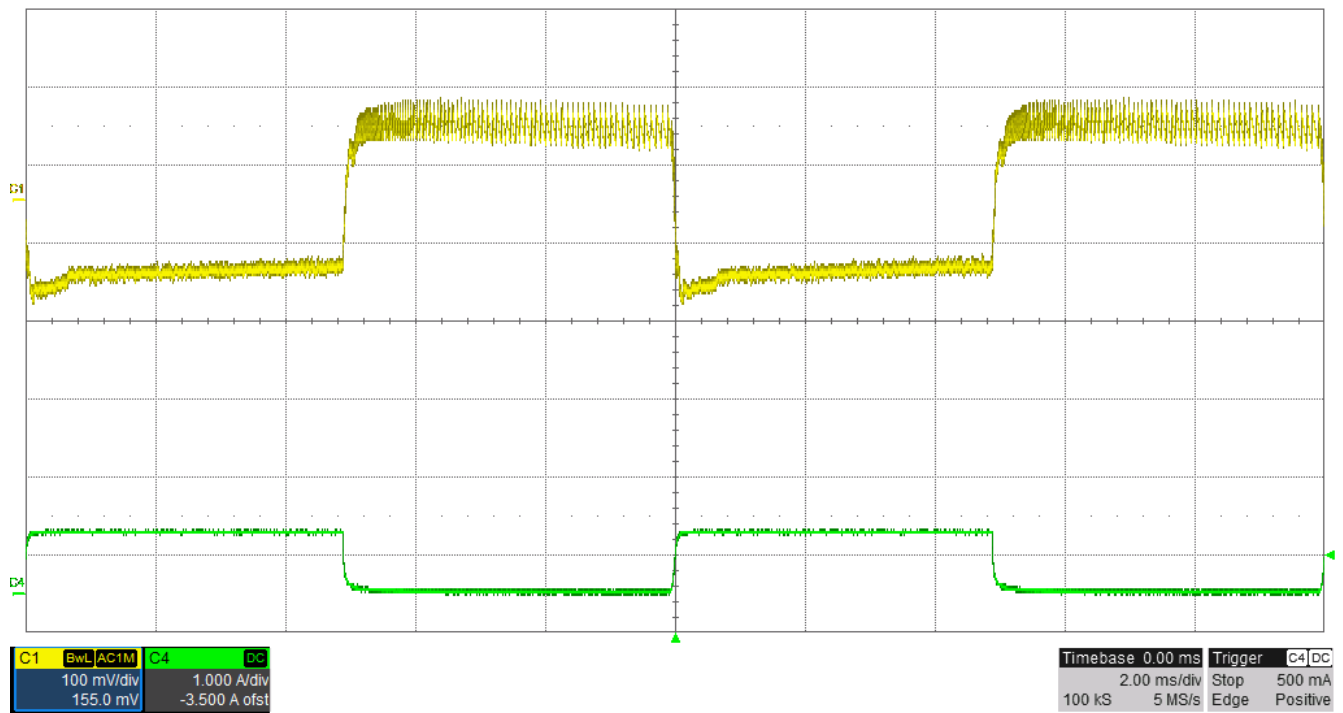


Figure 3-17. 15 V, Load Step From 0 A to 0.75 A

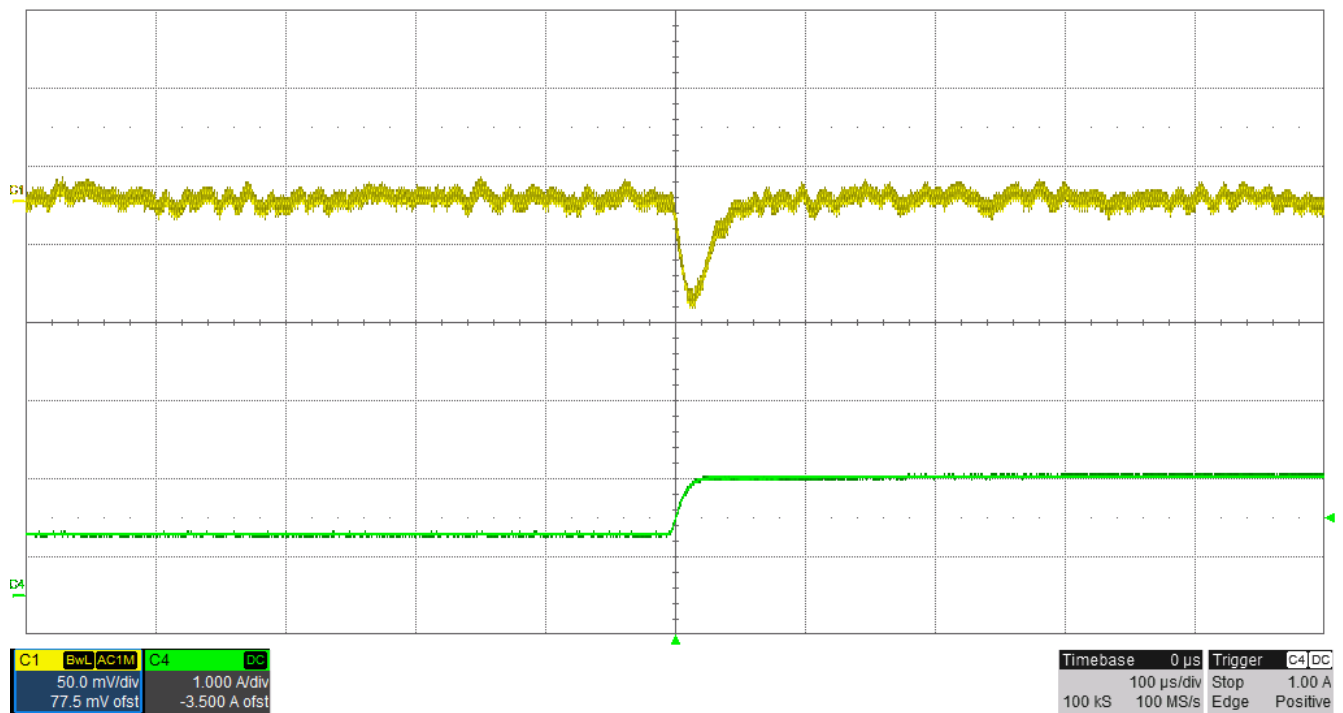


Figure 3-18. 15 V, Load Step From 0.75 A to 1.5 A

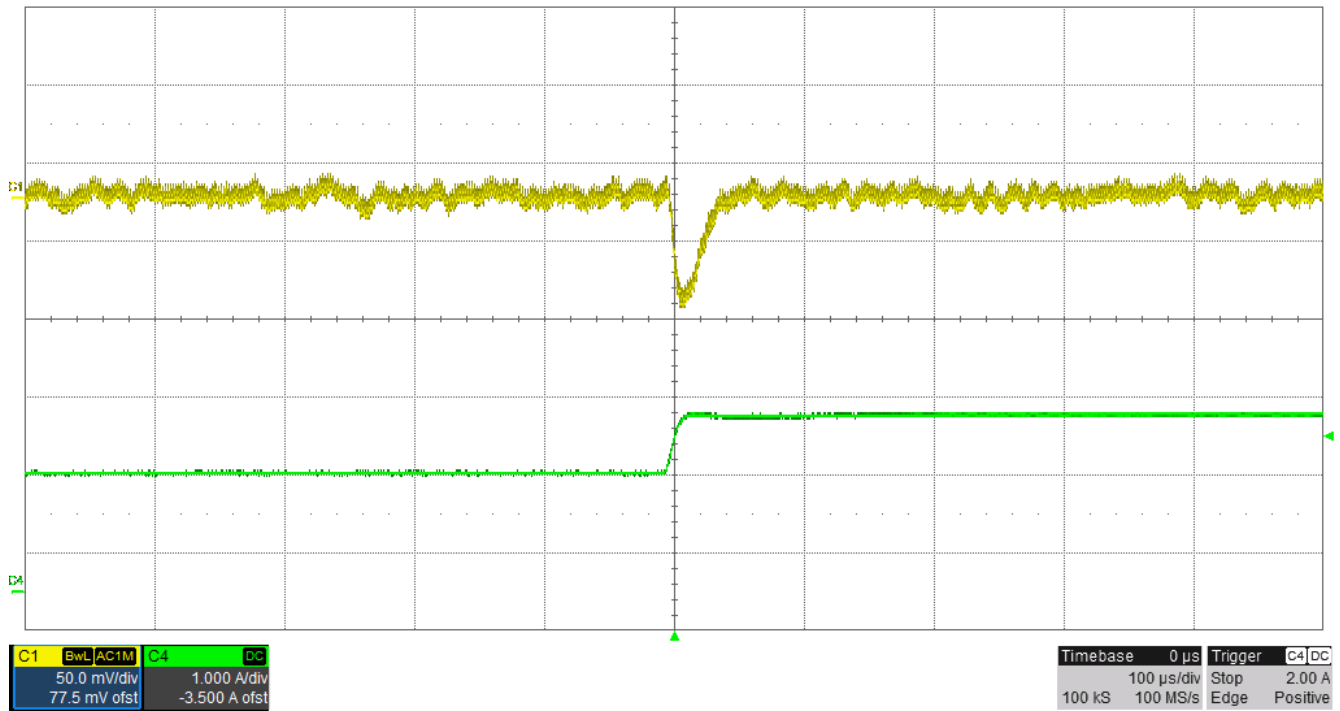


Figure 3-19. 15 V, Load Step From 1.5 A to 2.25 A

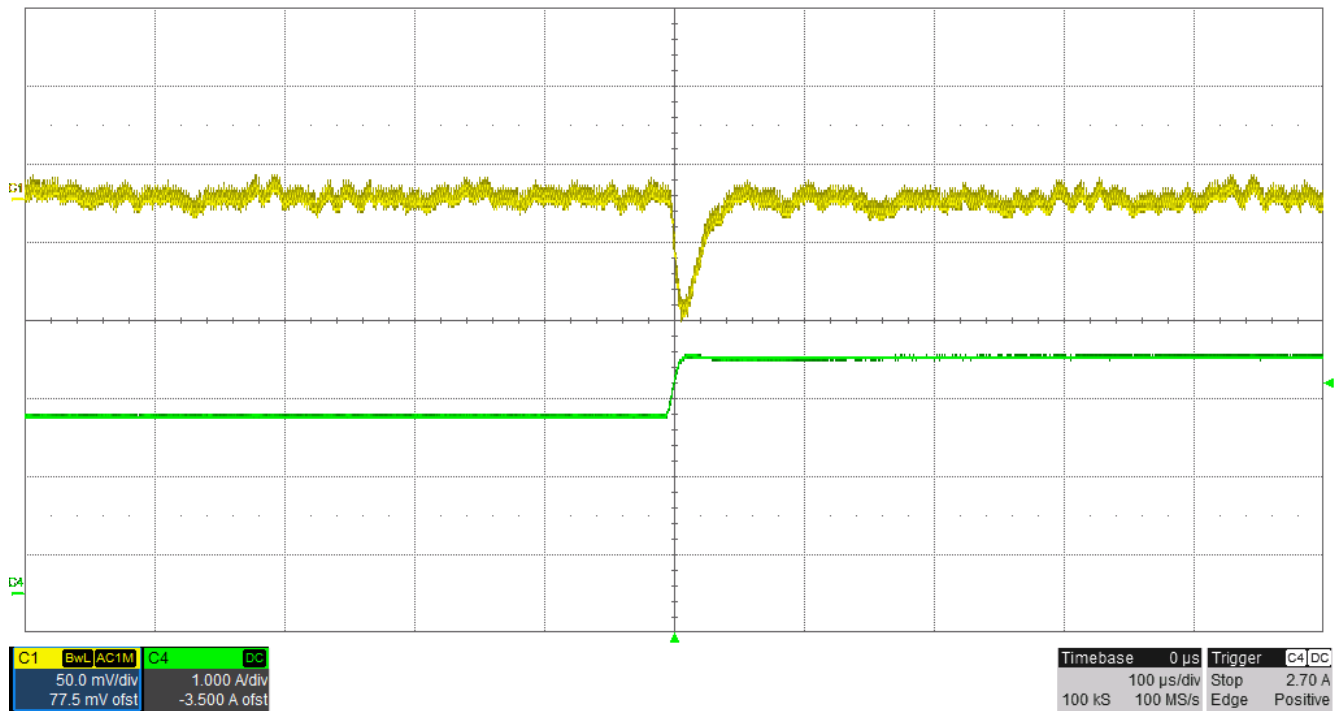


Figure 3-20. 15 V, Load Step From 2.25 A to 3.0 A

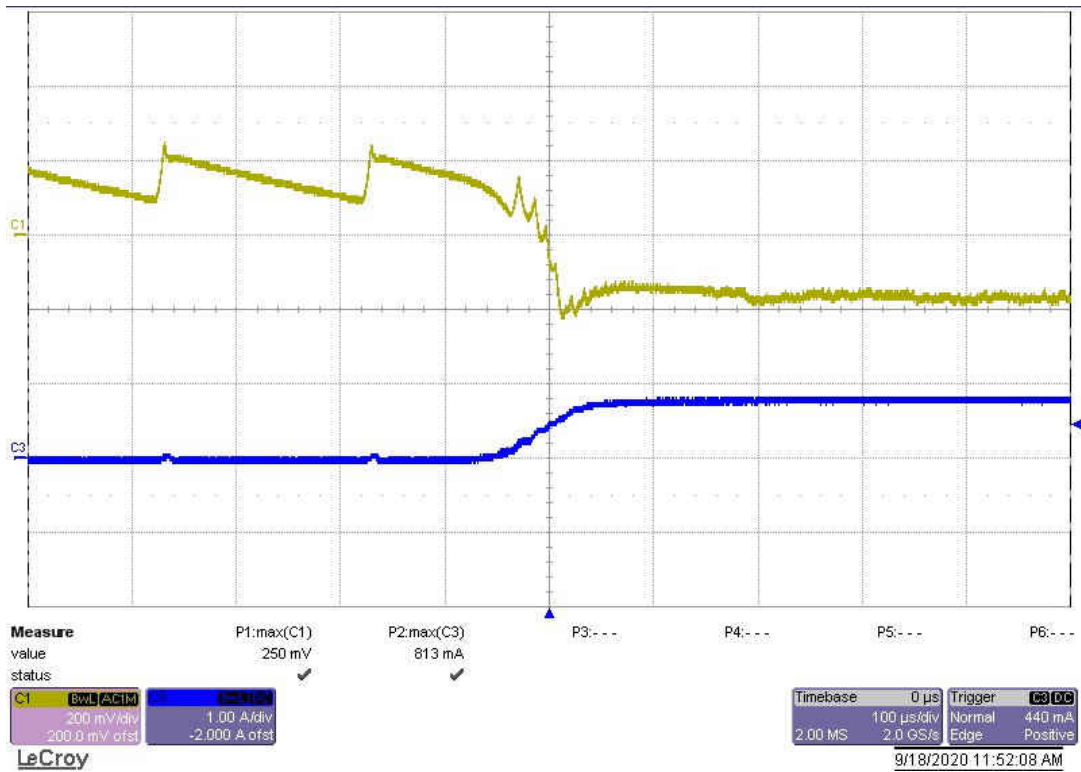


Figure 3-21. 20 V, Load Step From 0 A to 0.81 A

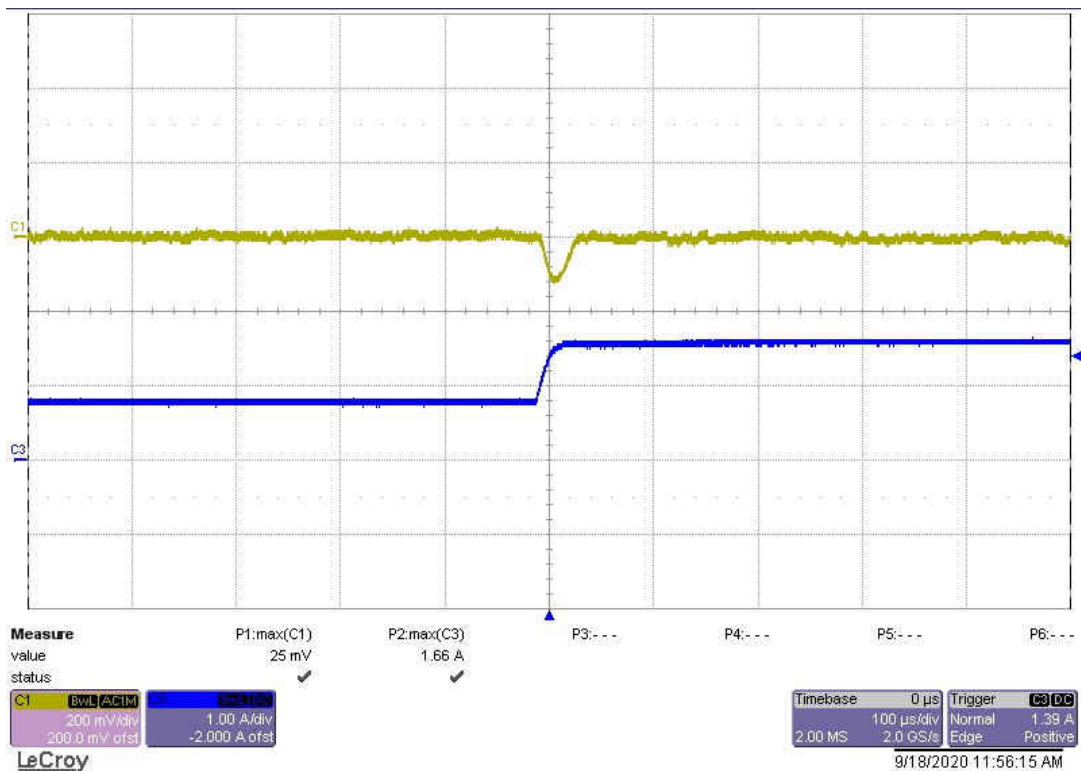


Figure 3-22. 20 V, Load Step From 0.81 A to 1.63 A

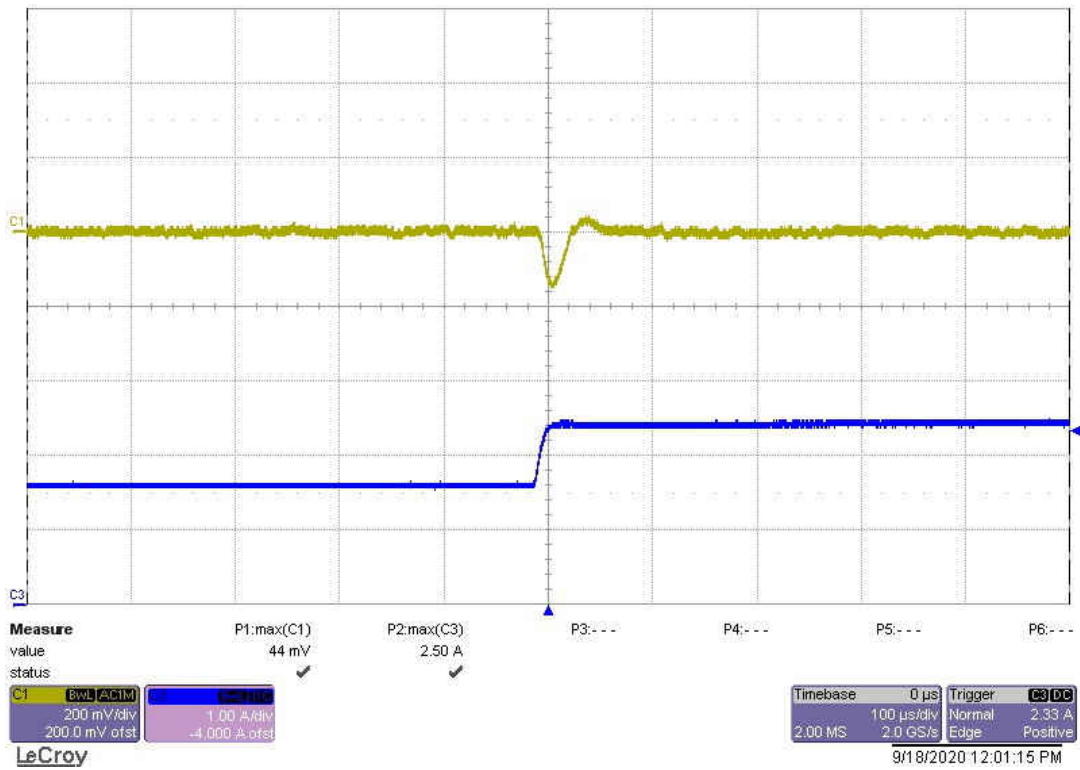


Figure 3-23. 20 V, Load Step From 1.63 A to 2.44 A

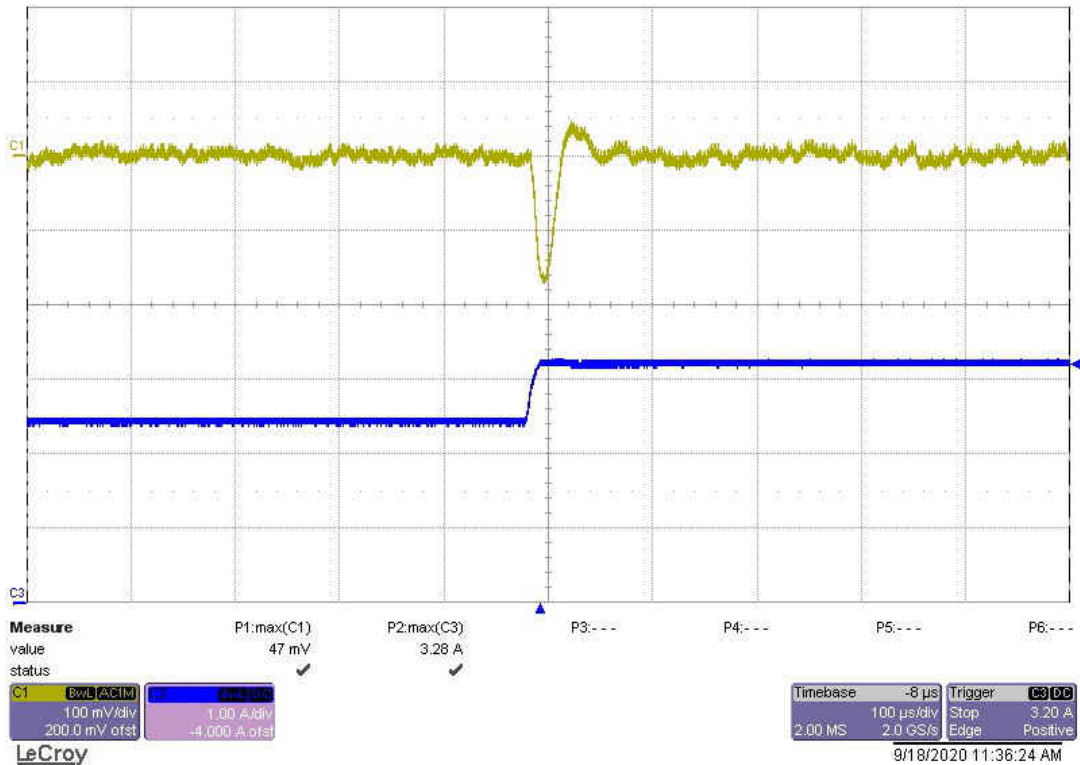


Figure 3-24. 20 V, Load Step From 2.44 A to 3.25 A

3.4 Dynamic Response

The following waveforms shows the transitions between 5 V, 9 V, 15 V, and 20 V. No load is applied.

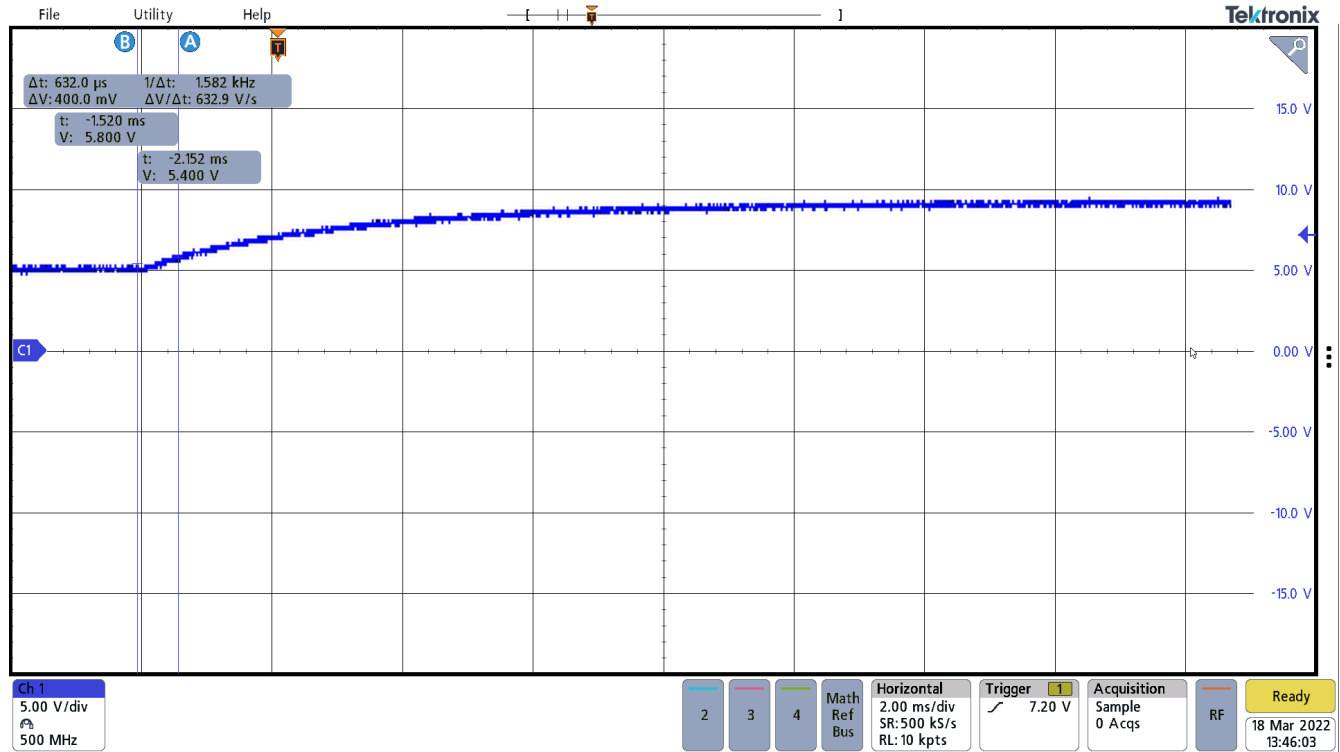


Figure 3-25. 5 V to 9 V

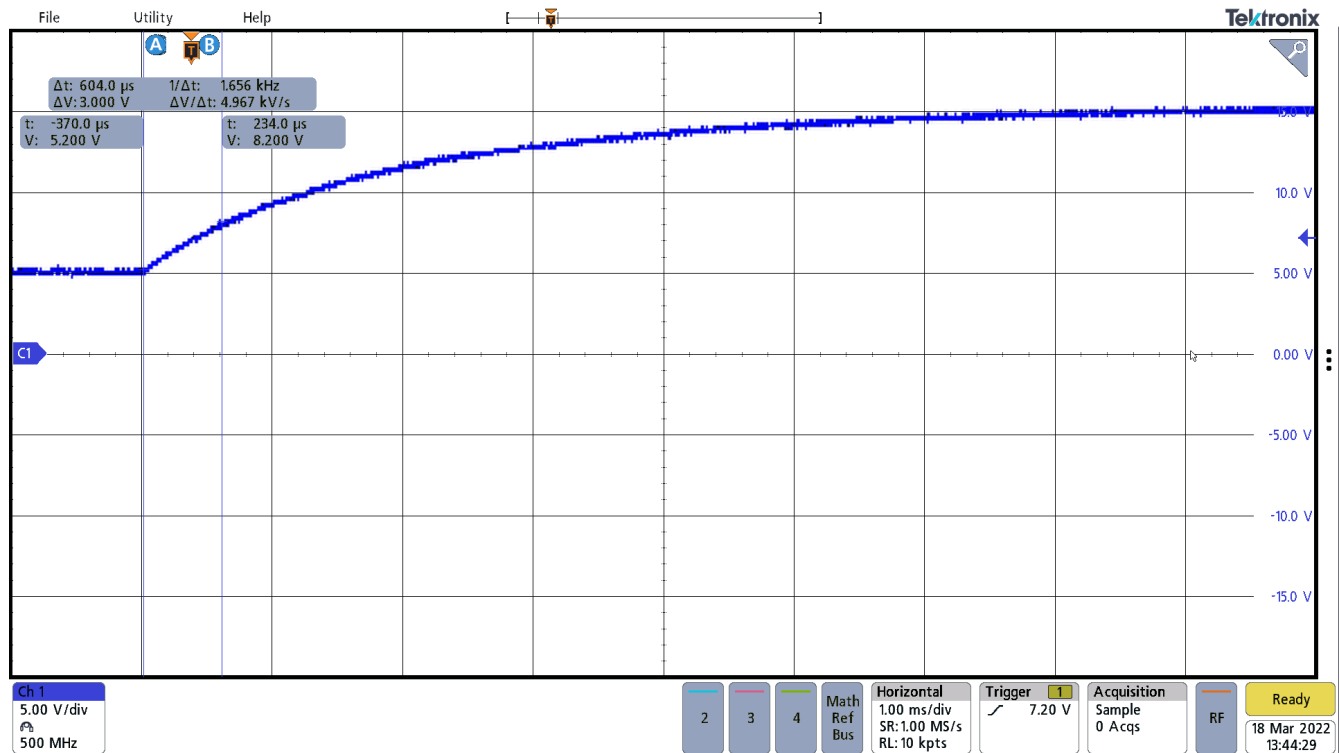


Figure 3-26. 5 V to 15 V

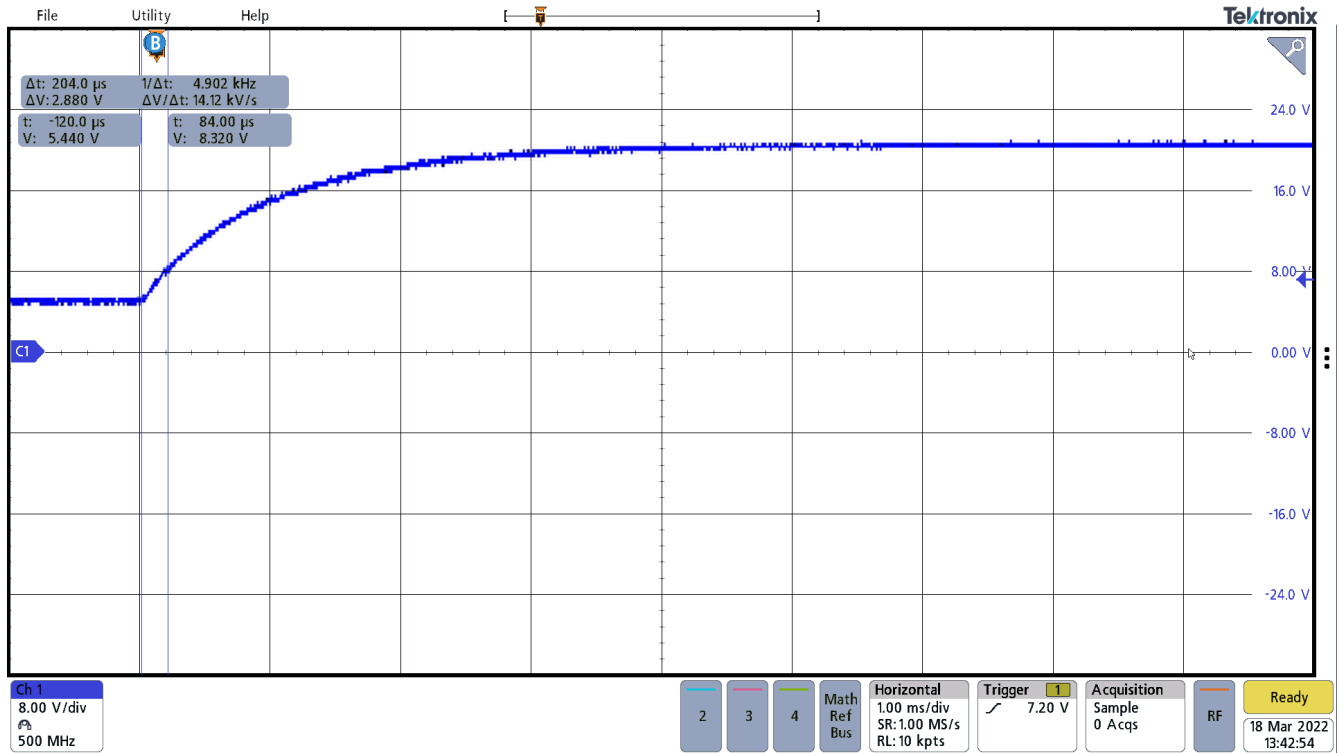


Figure 3-27. 5 V to 20 V

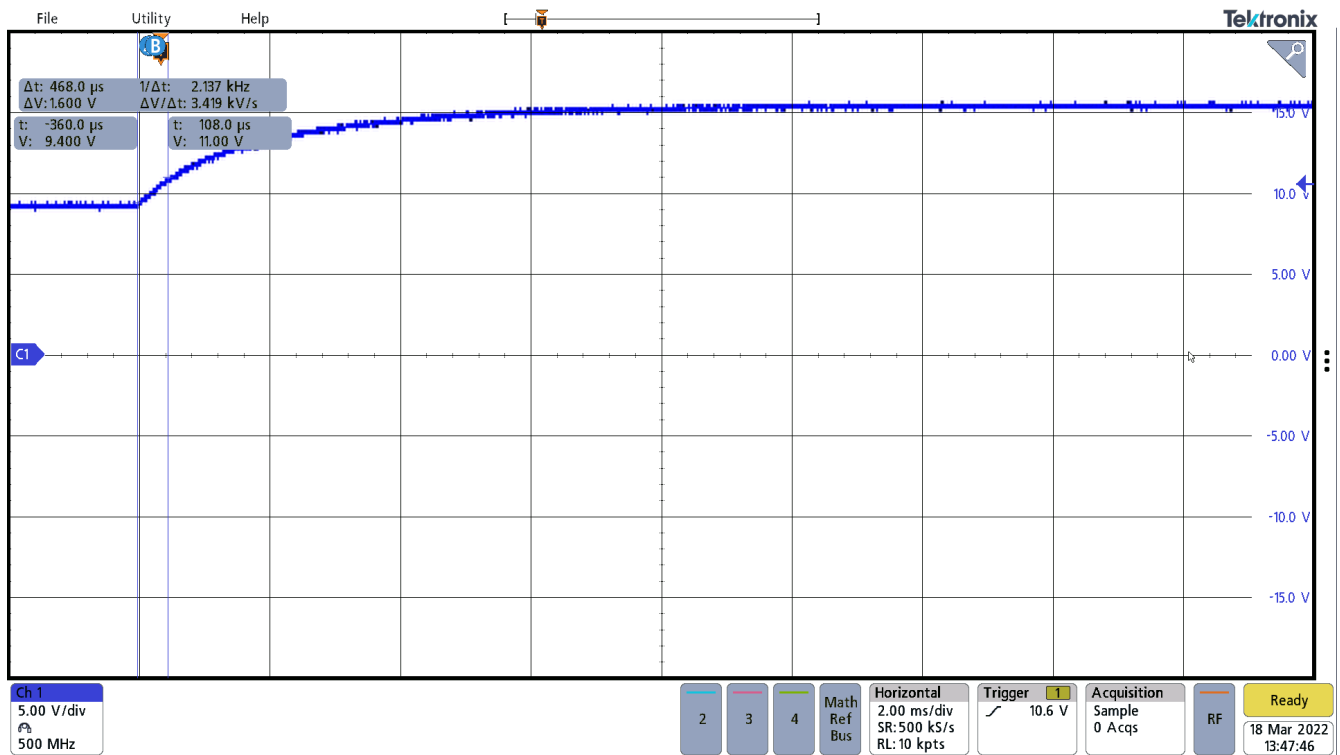


Figure 3-28. 9 V to 15 V

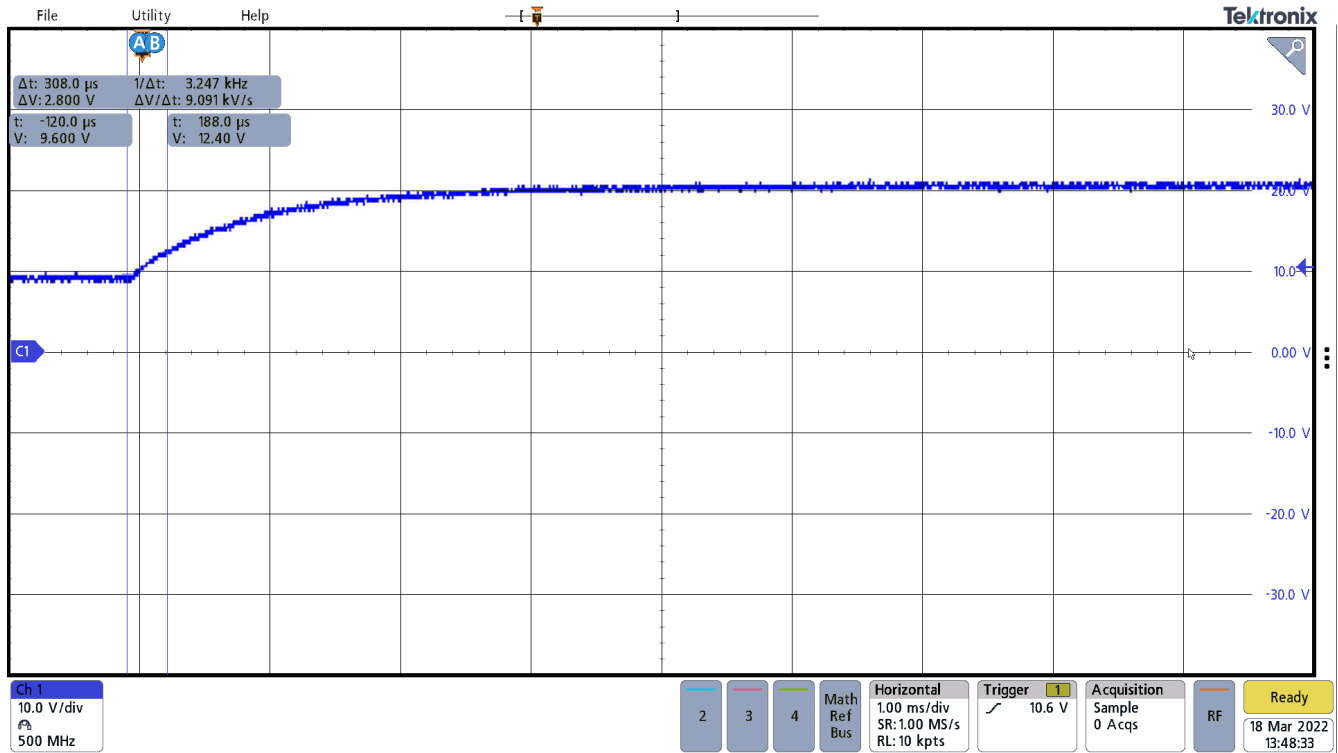


Figure 3-29. 9 V to 20 V

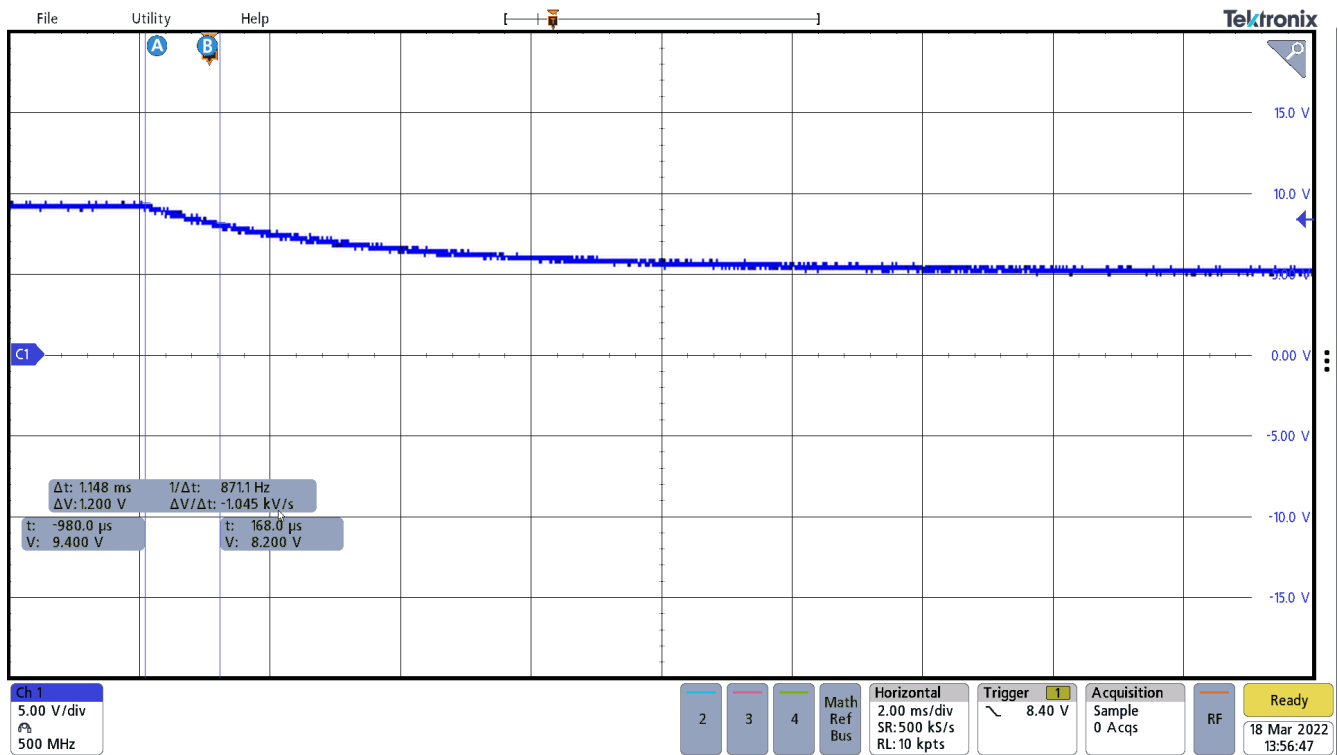


Figure 3-30. 9 V to 5 V

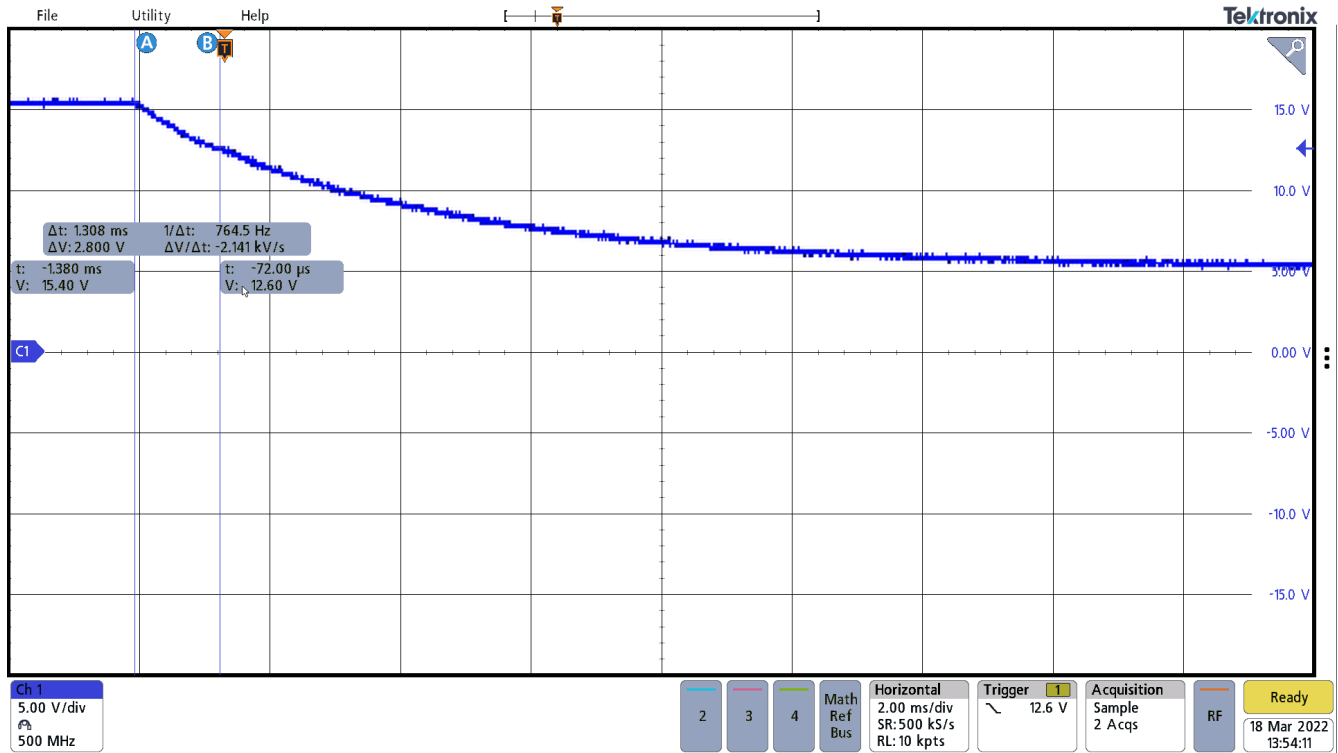


Figure 3-33. 15 V to 5 V

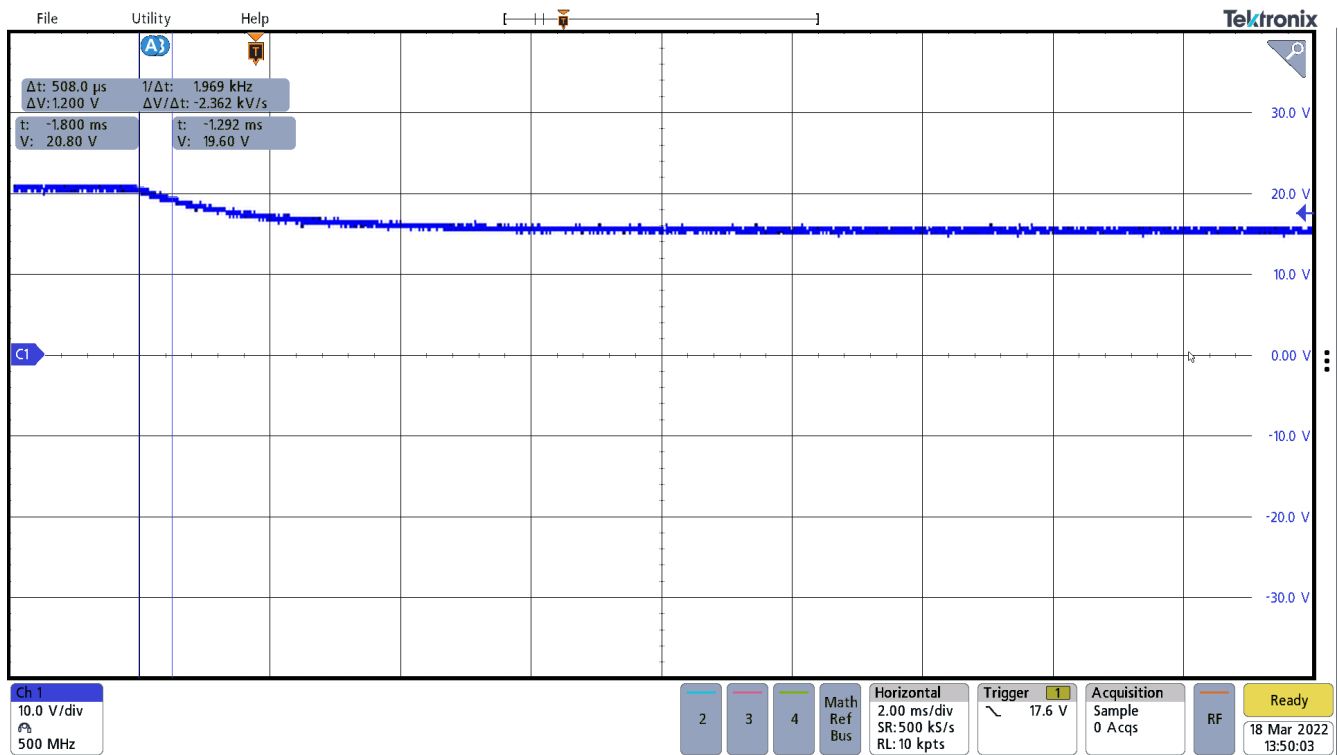


Figure 3-34. 20 V to 15 V

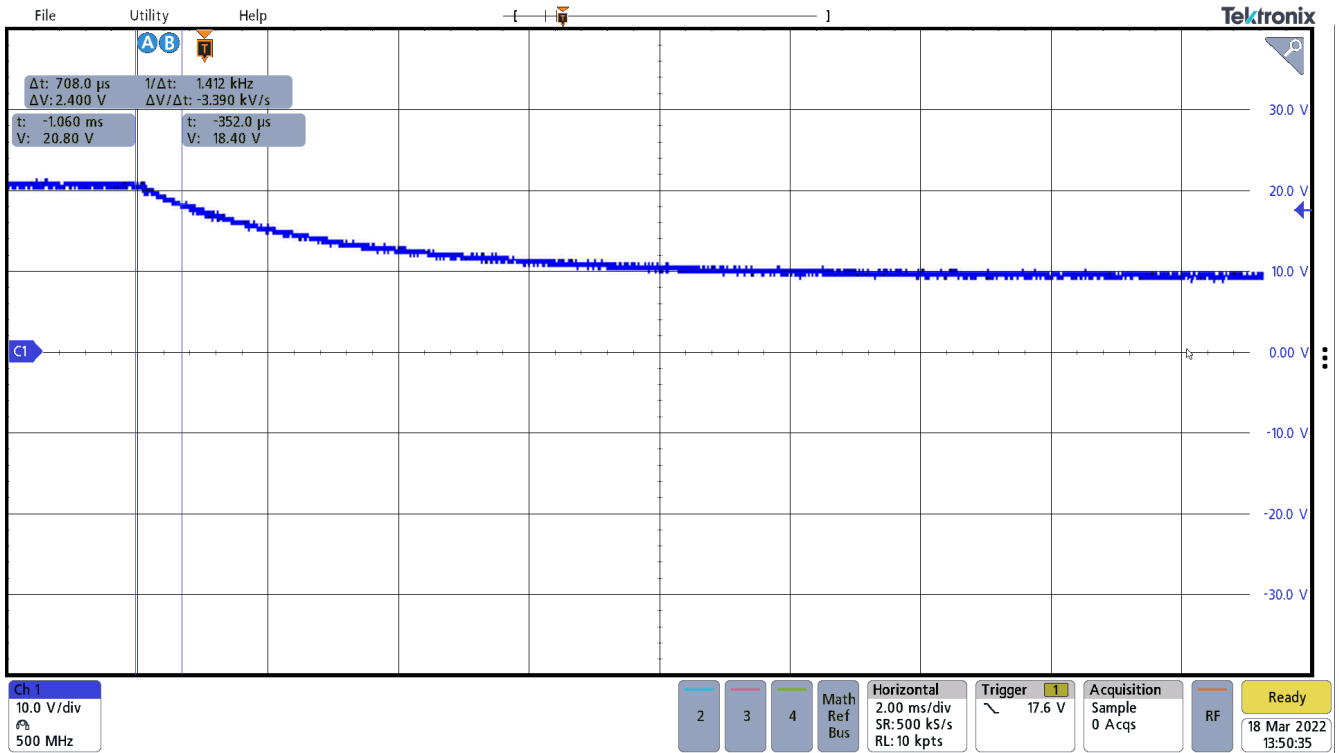


Figure 3-35. 20 V to 9 V

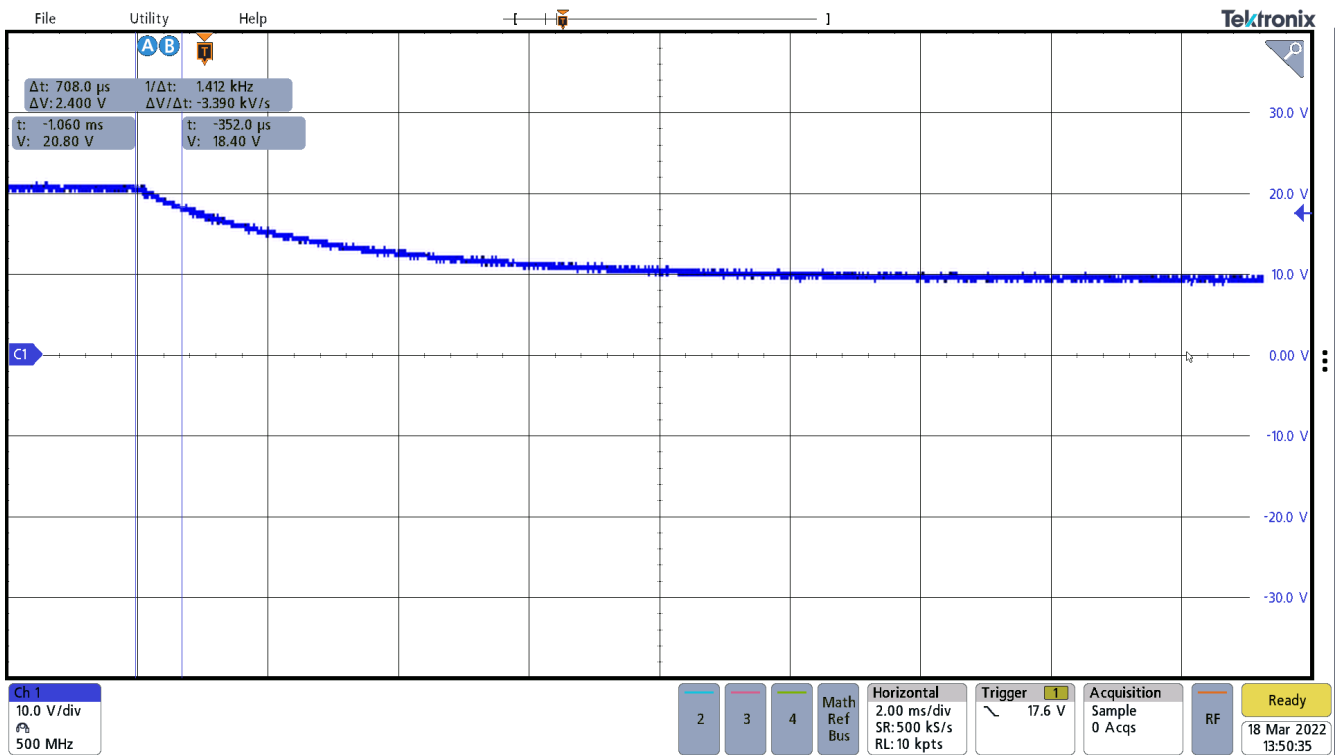


Figure 3-36. 20 V to 5 V

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