Test Report: PMP31288

7.8W Wide AC Input Non-Isolated High-Side Buck Reference Design

Description

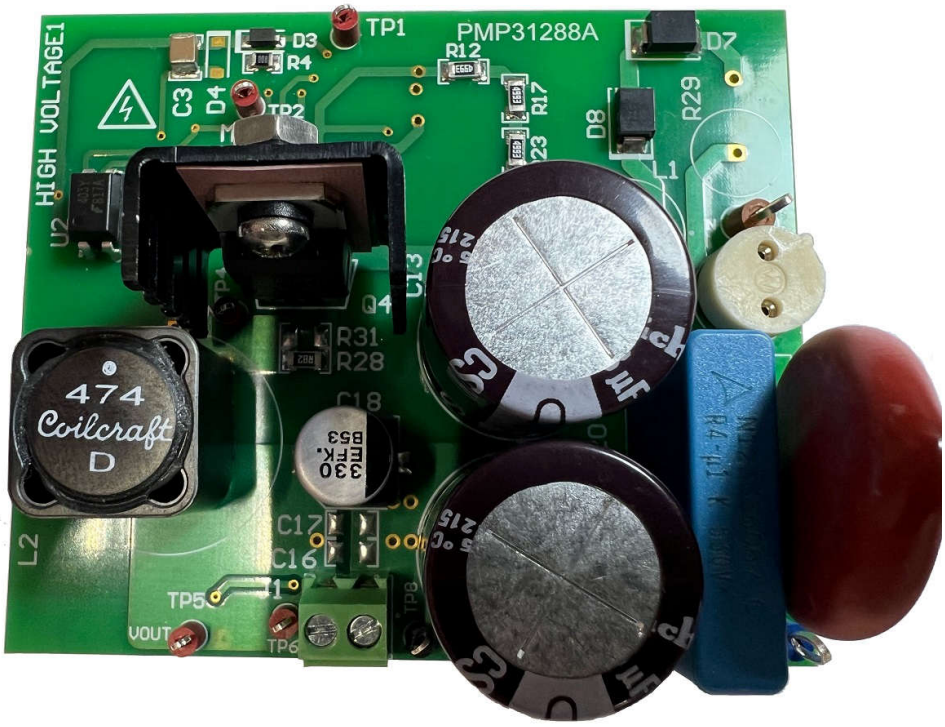
This reference design is an ultra-wide input offline high-side buck power supply that provides a 13V output at a maximum of 0.6A. The input accepts a voltage range of $85V_{AC}$ to $485V_{AC}$. The reference design uses the UCC28750 current-mode flyback controller with optocoupler feedback. The design is developed to be resistant to magnetic fields up to 200mT near the inductor.

Features

- Fixed-frequency operation for full load
- Frequency foldback and burst mode for improved light-load efficiency
- Very wide input voltage range: $85V_{AC}$ to $485V_{AC}$
- Overvoltage and undervoltage lockout
- Output short-circuit (OSC) protection
- Cycle-by-cycle peak overcurrent limit
- High magnetic resistance

Applications

- Electricity meter
- AC-input BLDC motor drive
- String inverter



Top of Board

1 Test Prerequisites

1.1 Voltage and Current Requirements

Table 1-1. Voltage and Current Requirements

Parameter	Specifications
Input Voltage Range	$80V_{DC}$ to $623V_{DC}$
Output Voltage	13V
Maximum Output Current	0.6A

1.2 Overcurrent Protection

Input Voltage	Maximum Output Current
$85V_{DC}$	0.82A
$325V_{DC}$	1.2A
$630V_{DC}$	1.8A

1.3 Dimensions

The outline of the two-layer board is 73.7mm × 62.2mm.

2 Testing and Results

2.1 Efficiency Graphs

2.1.1 Efficiency vs Output Current

2.1.1.1 325V_{DC} Input Voltage

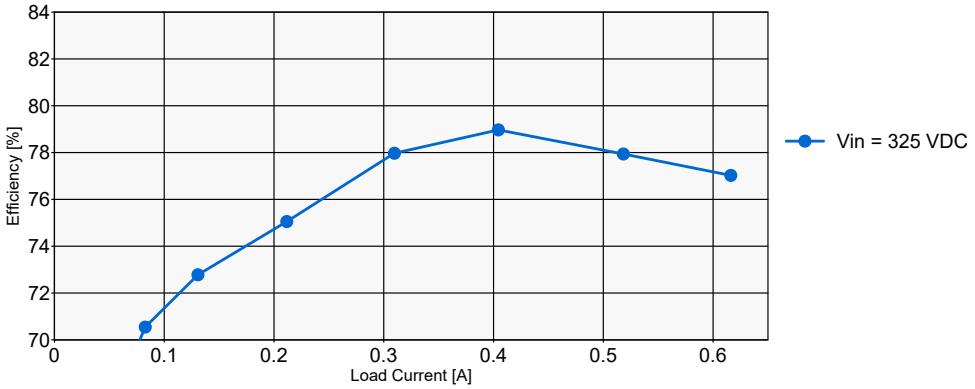


Figure 2-1. Efficiency vs Load Current at 325V_{DC} Input Voltage

2.1.1.2 240V_{AC} Input voltage

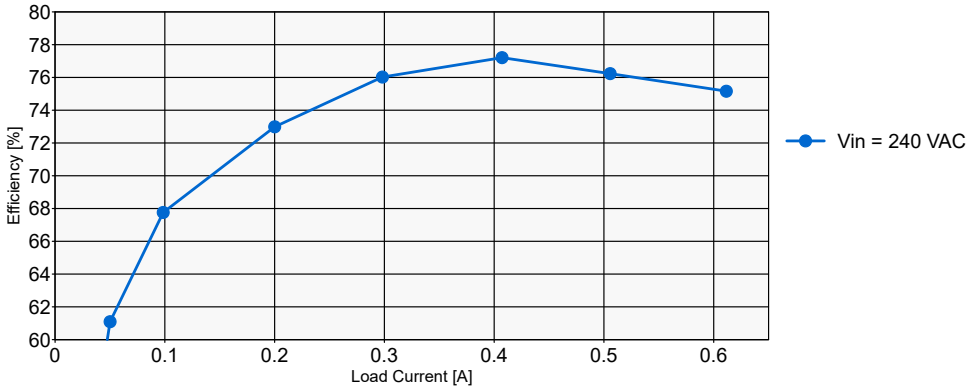


Figure 2-2. Efficiency vs Load Current at 240V_{AC} Input Voltage

2.1.2 Efficiency vs Input Voltage (DC)

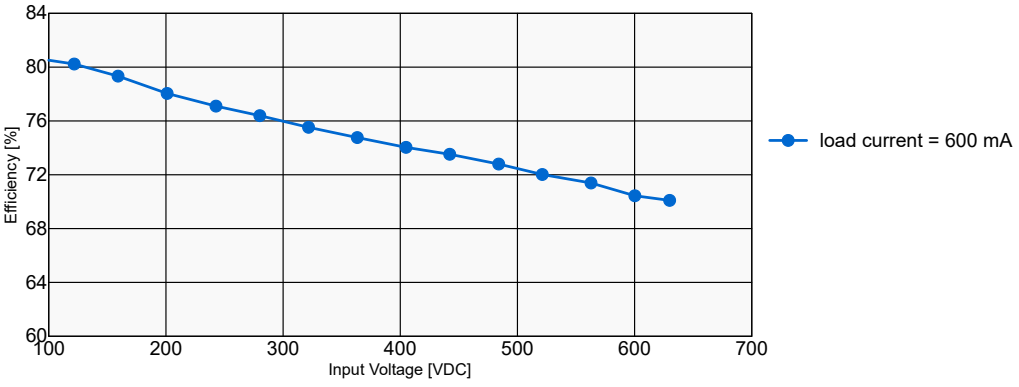


Figure 2-3. Efficiency vs Input Voltage (DC) at 600mA Output Current

2.2 Load Regulation

2.2.1 325V_{DC} Input Voltage

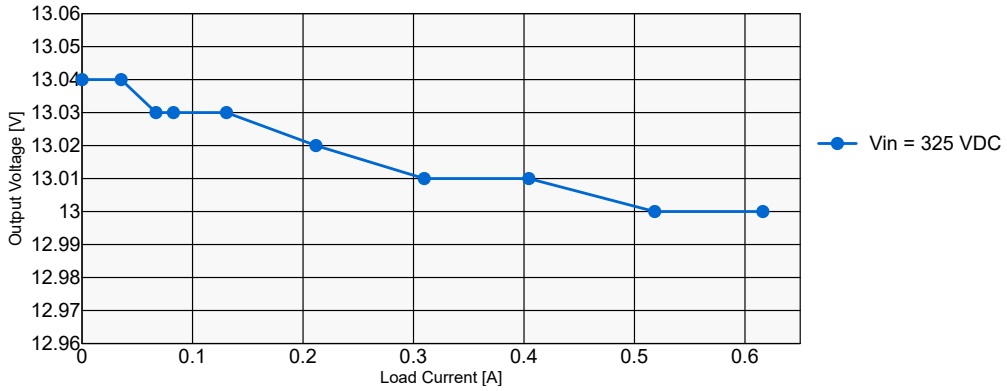


Figure 2-4. Output Voltage vs Load Current at 325V_{DC} Input Voltage

2.2.2 240V_{AC} Input Voltage

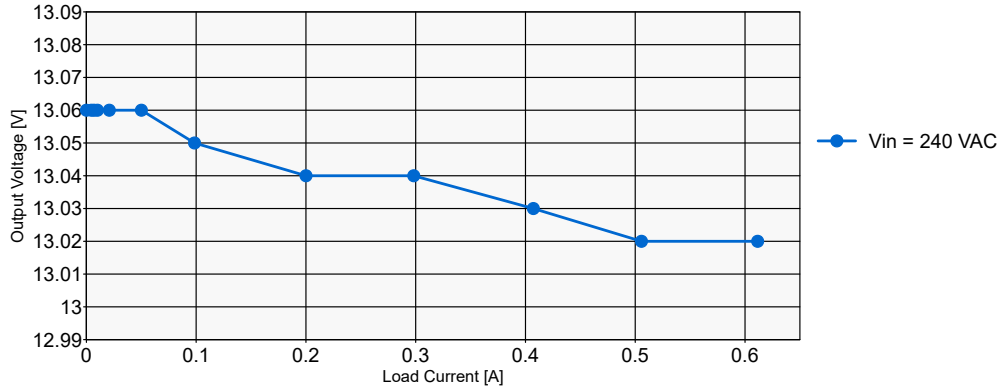


Figure 2-5. Output Voltage vs Load Current at 240V_{AC} Input Voltage

2.3 Line Regulation

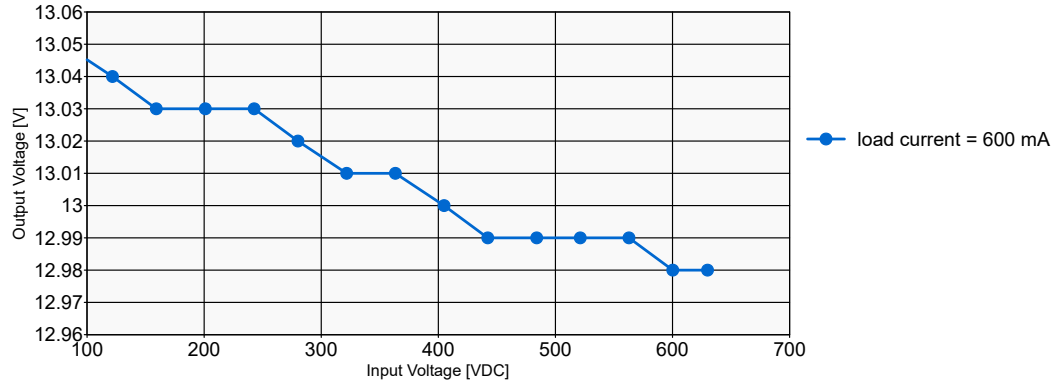


Figure 2-6. Output Voltage (DC) vs Input Voltage at 600mA Load Current

2.4 Thermal Images After 5 Minutes Operation

Input voltage was set to 230V_{AC} and load current was adjusted to 600mA.

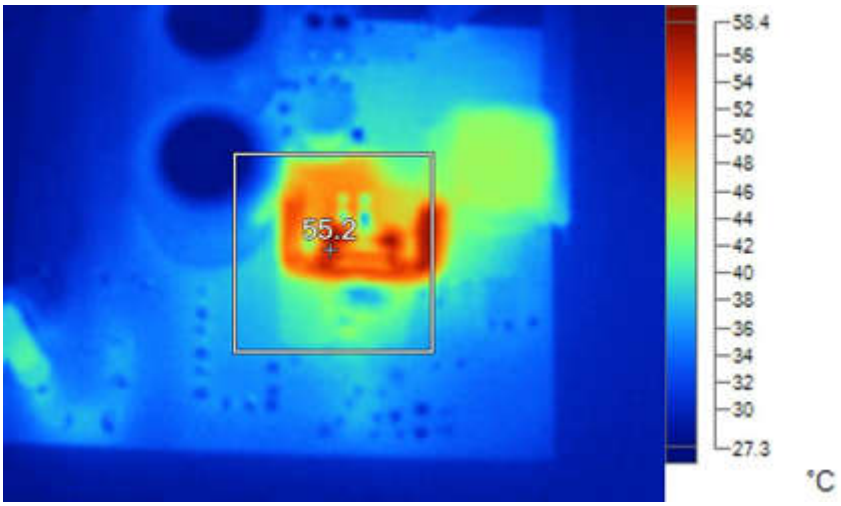


Figure 2-7. Top Side

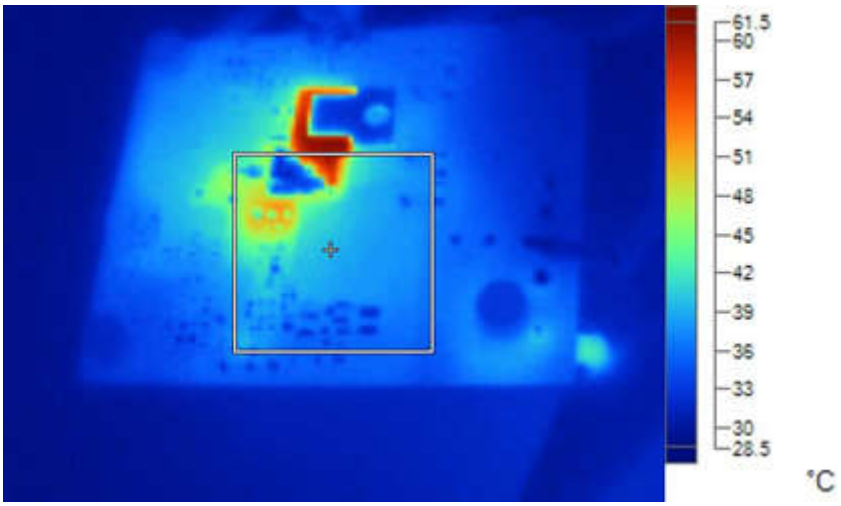


Figure 2-8. Bottom Side

2.5 Bode Plots

Bode plot is shown in the following figure.

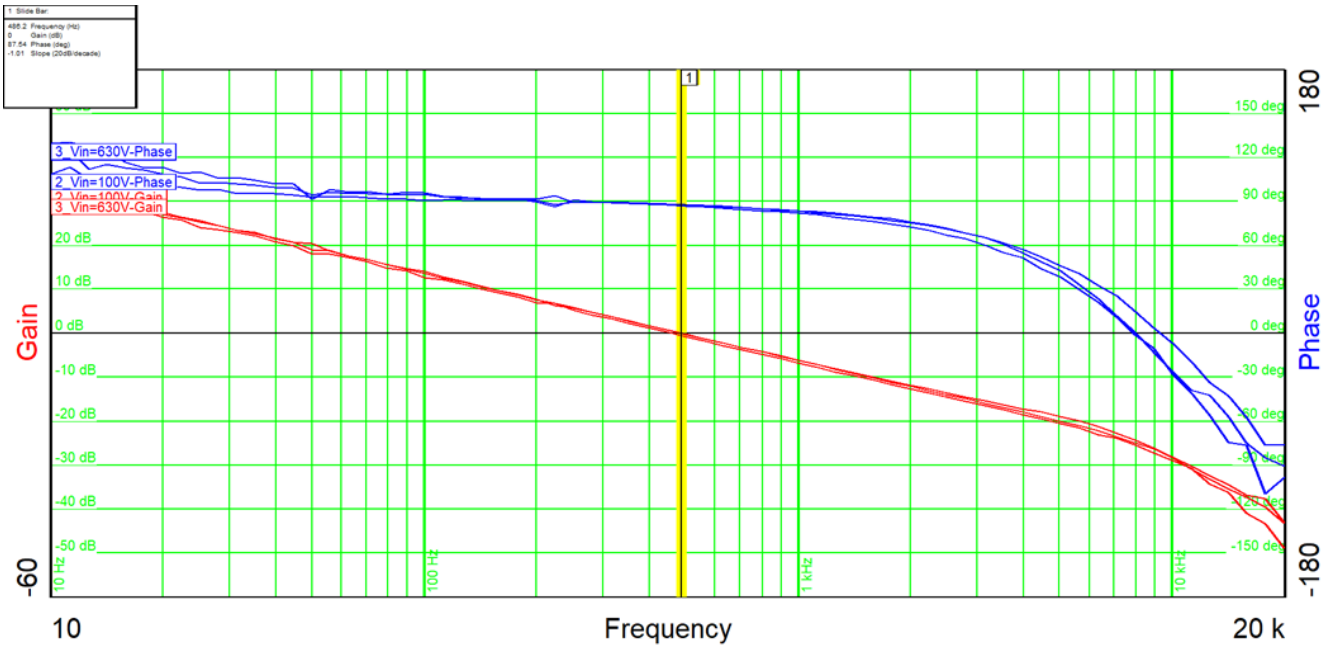


Figure 2-9. Bode Plot

Input voltage = $100V_{DC}$

Load current = 0.6A

Phase margin = 87° (deg)

Gain margin > 15dB

Bandwidth = 0.48kHz

Input voltage = $325V_{DC}$

Load current = 0.6A

Phase margin = 87° (deg)

Gain margin > 15dB

Bandwidth = 0.49kHz

Input voltage = $630V_{DC}$

Load current = 0.6A

Phase margin = 87° (deg)

Gain margin > 15dB

Bandwidth = 0.46kHz

3 Waveforms

3.1 Switch Node Voltage

3.1.1 325V_{DC} Input Voltage

The load current was adjusted to 600mA.

The waveforms in Figure 3-1 and Figure 3-2 were done without applying an external magnetic field.

The waveforms in Figure 3-3 and Figure 3-4 were gathered by applying an external magnetic field with an distance of 2mm from the inductor of the circuit.

3.1.1.1 Without External Magnet Field

3.1.1.1.1 10µs / Division

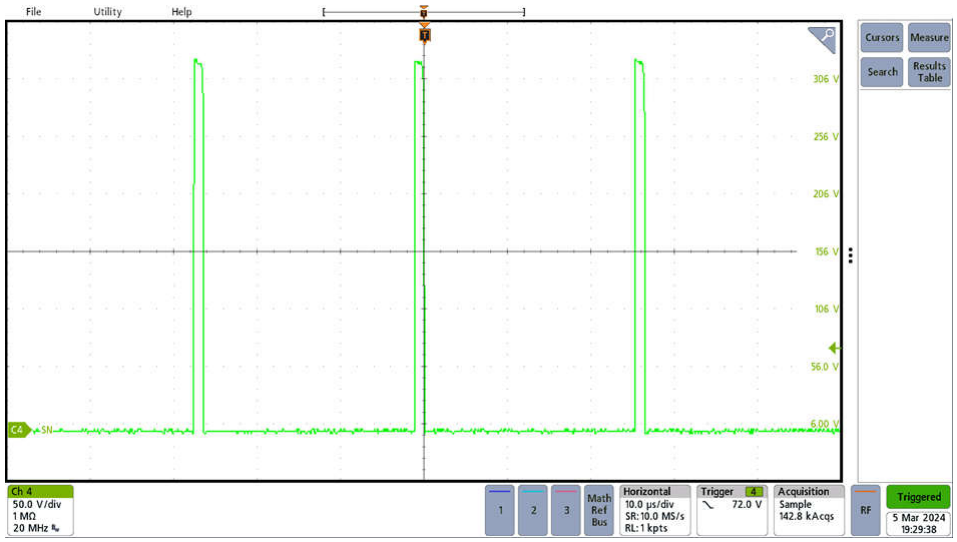


Figure 3-1. 600mA Load Current (10µs / div)

3.1.1.1.2 1µs / Division

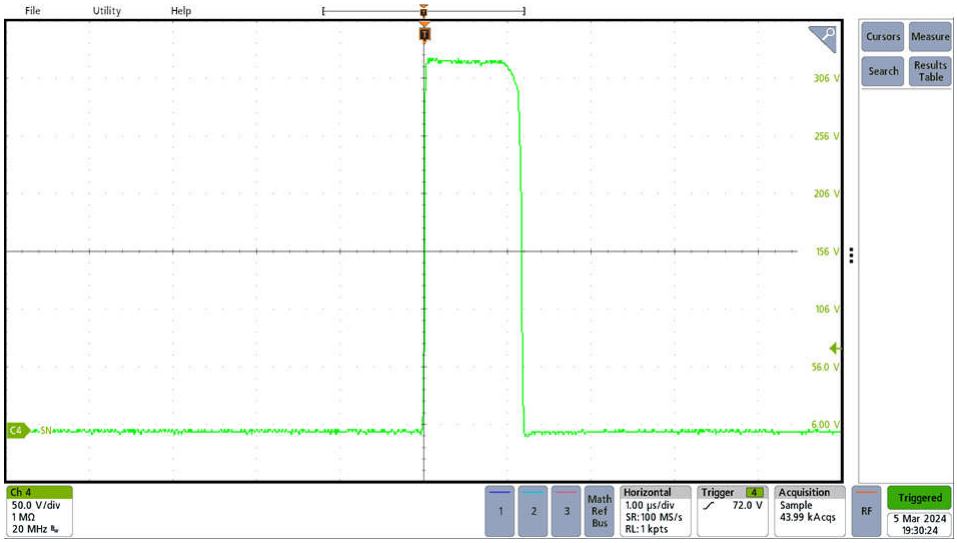


Figure 3-2. 600mA Output Current (1µs / div)

3.1.1.2 With an External Magnetic Field

3.1.1.2.1 10µs / div

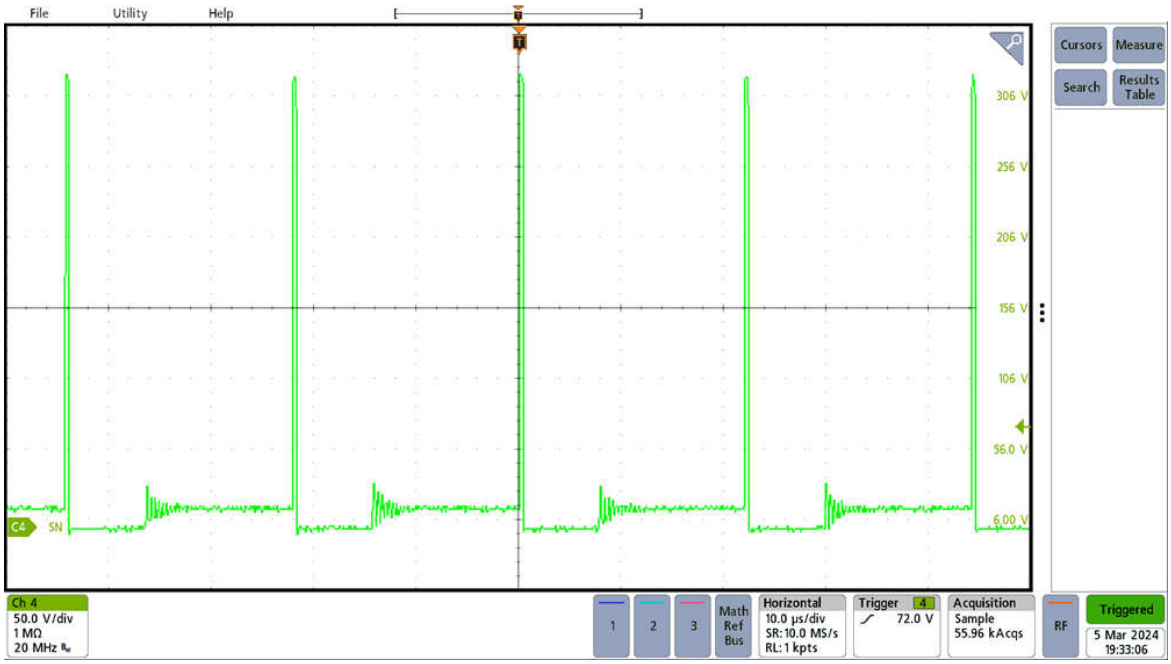


Figure 3-3. 600mA Load Current and External Magnetic Field (10µs / div)

3.1.1.2.2 1µs / Div

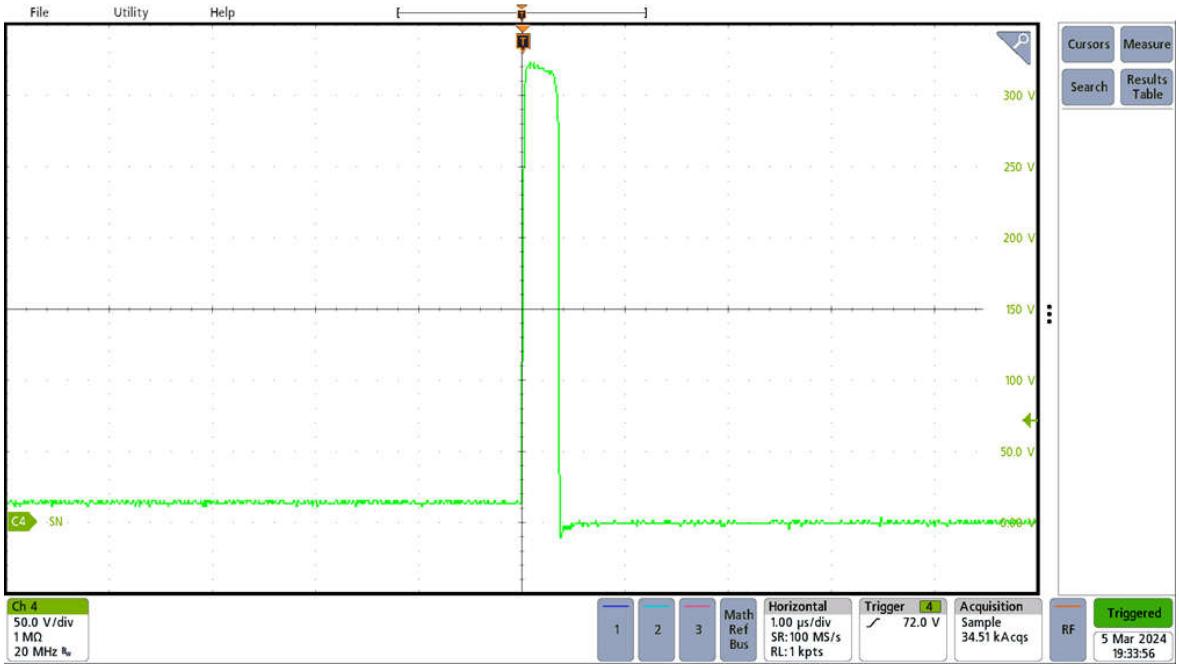


Figure 3-4. 600mA Load Current and External Magnetic Field (1µs / div)

3.1.2 630V_{DC} Input Voltage

3.1.2.1 200mA Load Current

3.1.2.1.1 40µs / Division

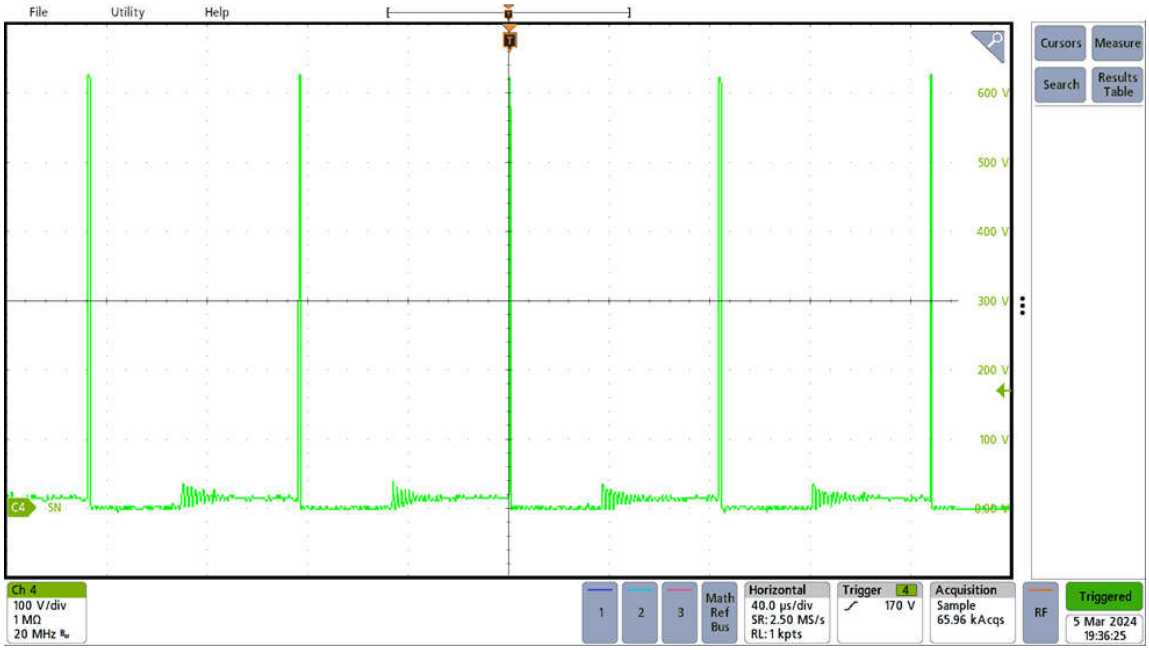


Figure 3-5. 200mA Load Current (40µs / div)

3.1.2.1.2 1µs / Division

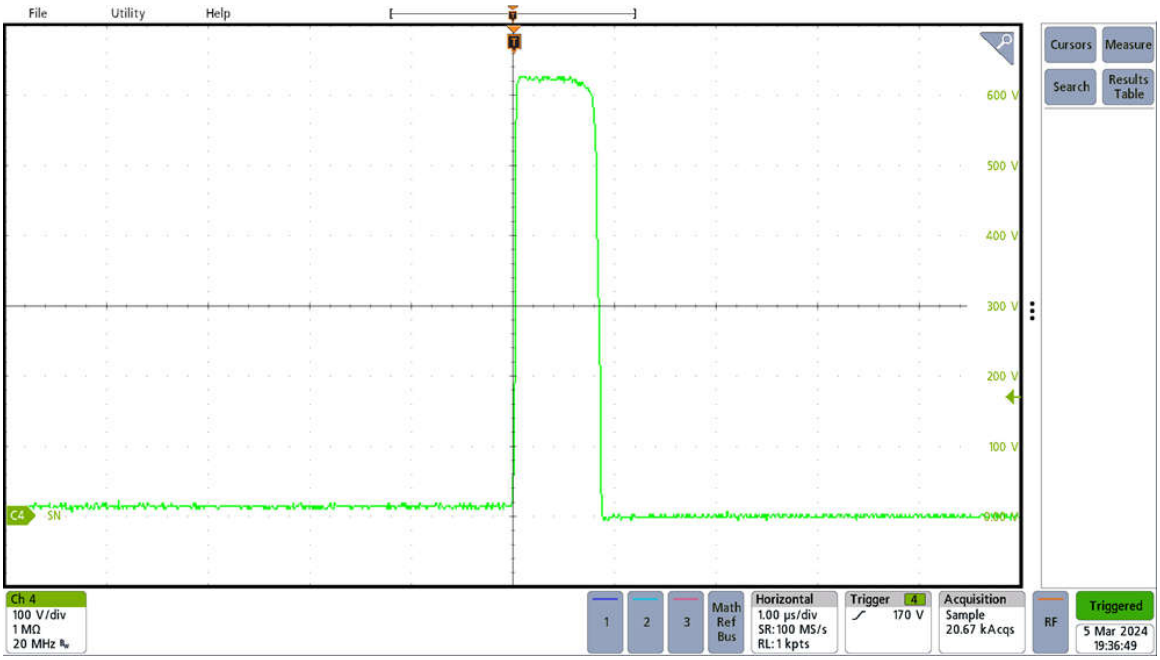


Figure 3-6. 200mA Load Current (1µs / div)

3.1.2.2 600mA Load Current

3.1.2.2.1 10µs / Division

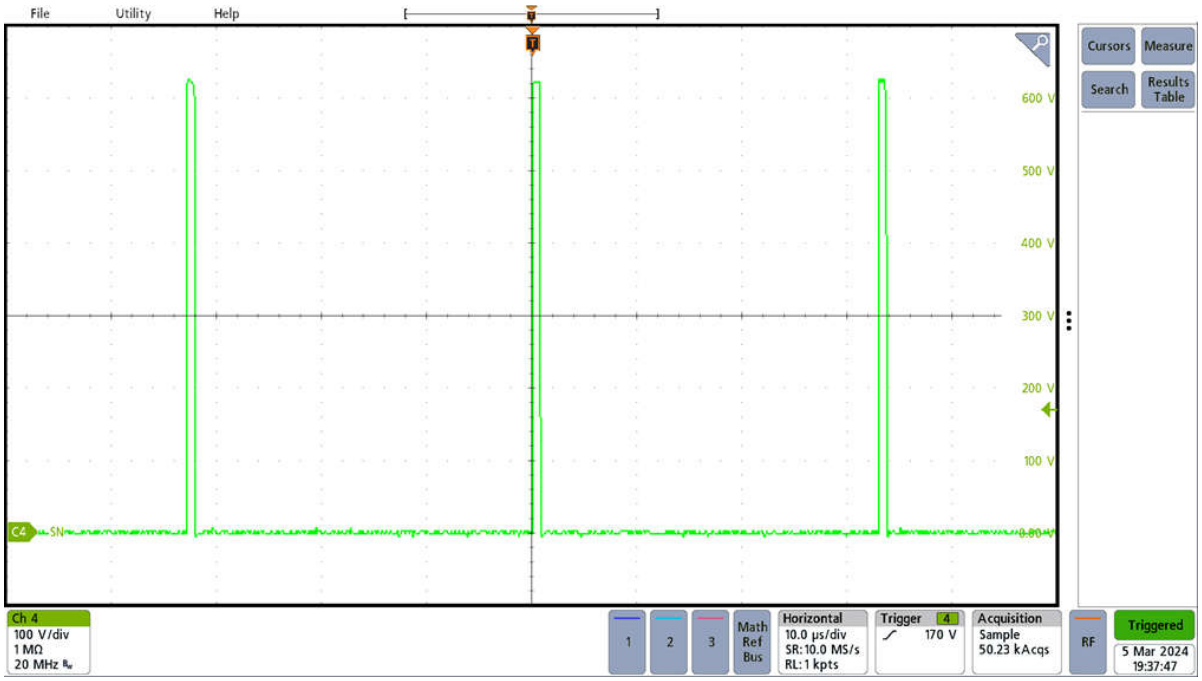


Figure 3-7. 600mA Load Current (10µs / div)

3.1.2.2.2 1µs / division

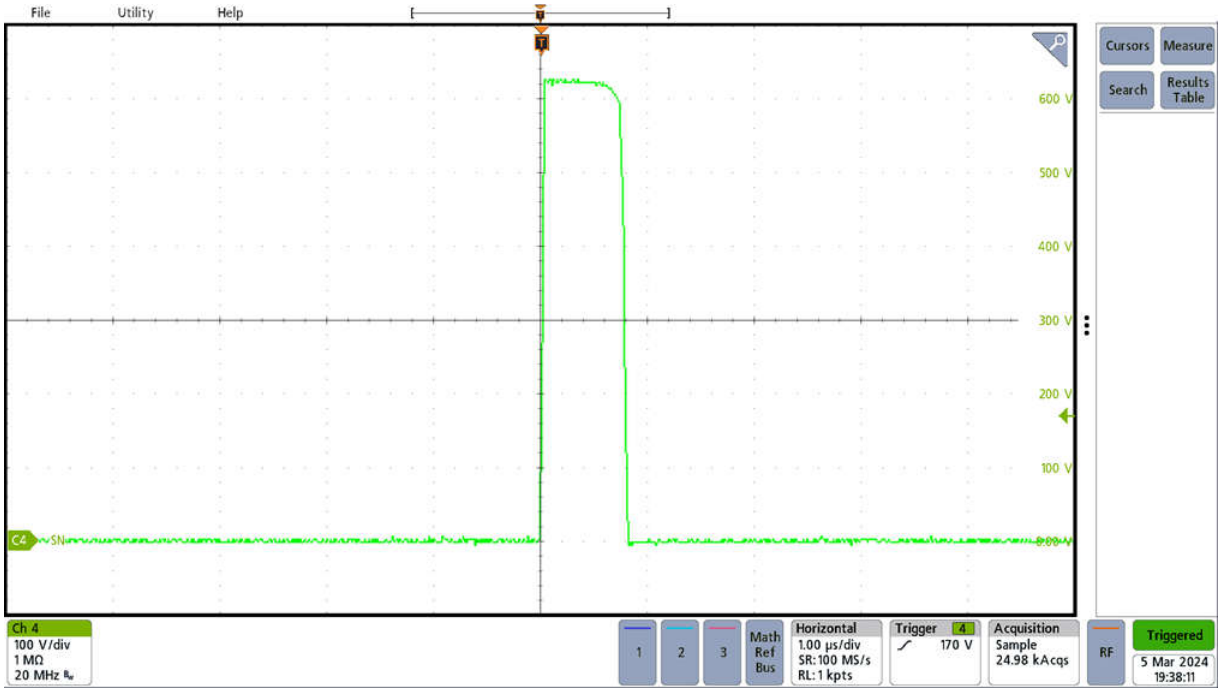


Figure 3-8. 600mA Load Current (1µs / div)

3.2 Output Voltage Ripple

3.2.1 325V_{DC} Input Voltage, Full Load

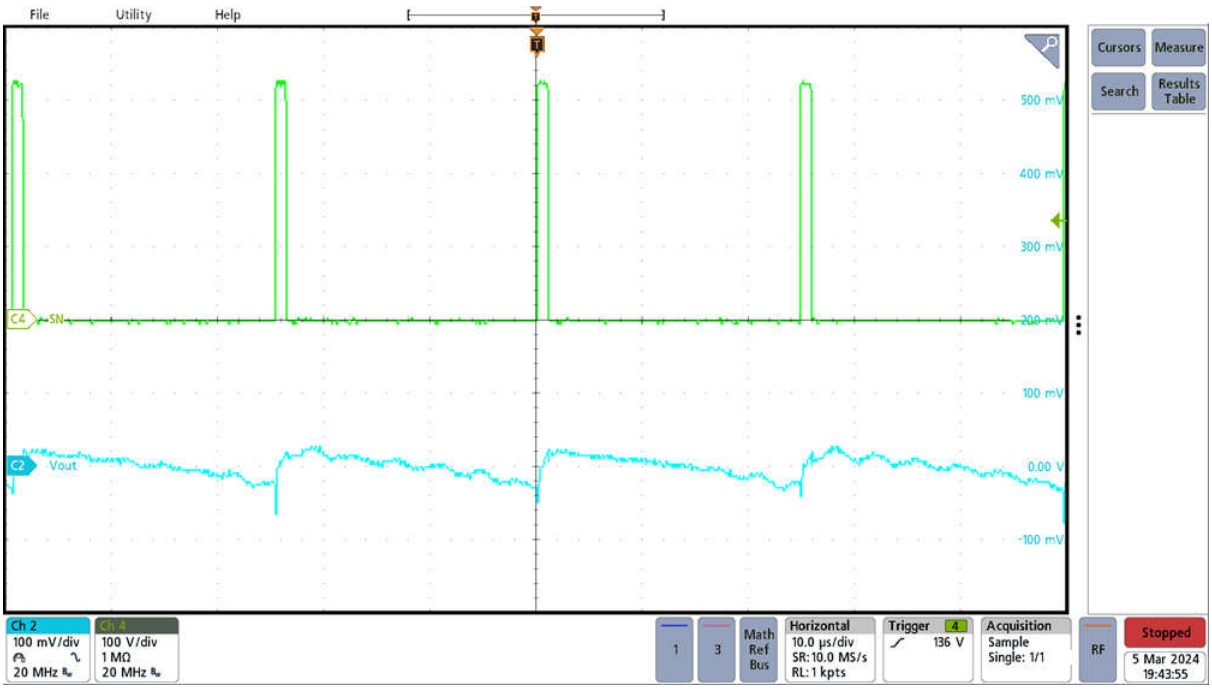


Figure 3-9. Output Voltage Ripple at 325V_{DC} Input Voltage

3.2.2 630V_{DC} Input Voltage, Full Load

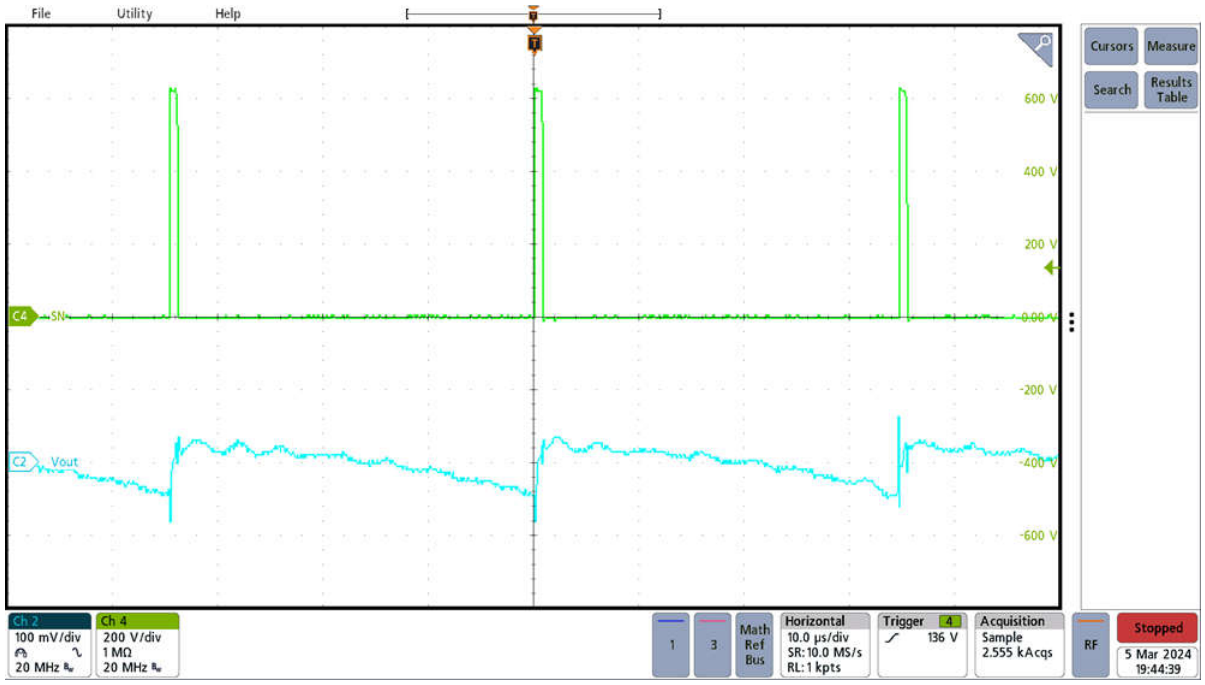


Figure 3-10. Output Voltage Ripple at 630V_{DC} Input Voltage

3.3 Input Voltage Ripple

3.3.1 80V_{AC} Input Voltage, 130mA Load Current

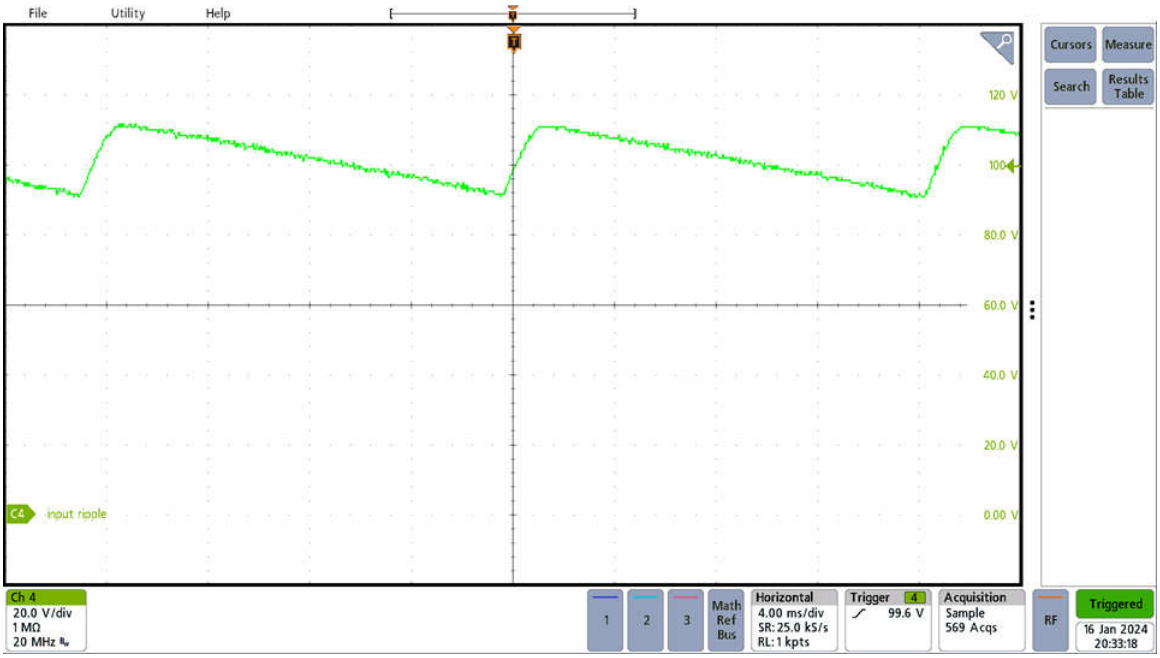


Figure 3-11. 80V_{AC} Input Voltage Ripple at 130mA Load Current

3.3.2 120V_{AC} Input Voltage, 600mA Load Current

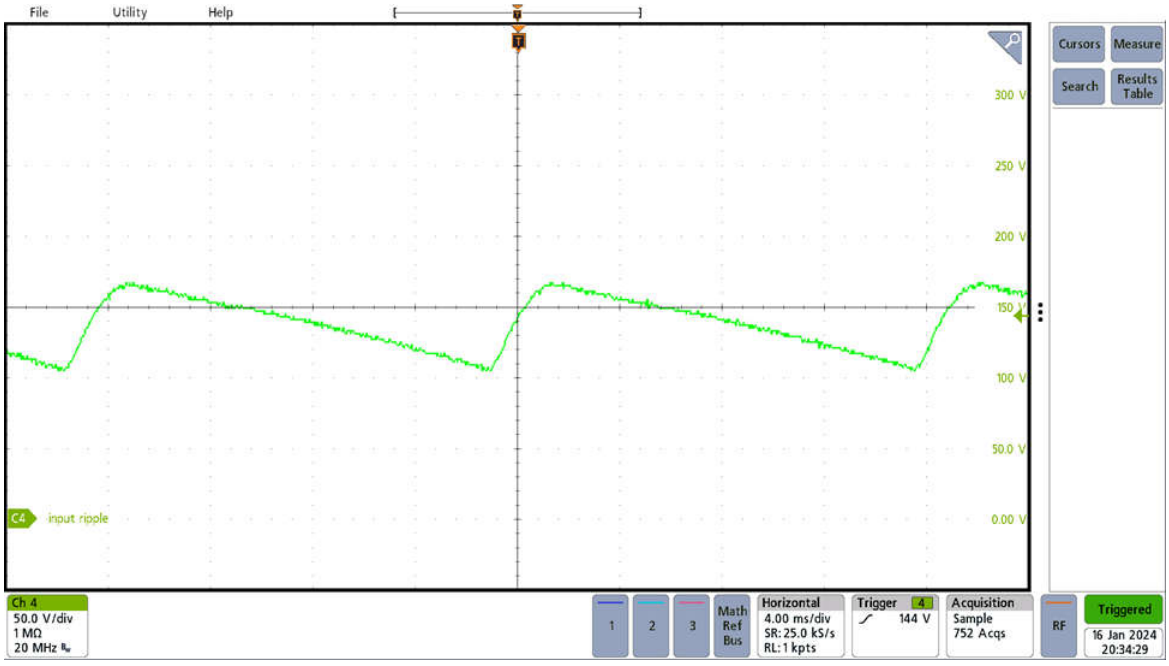


Figure 3-12. 120V_{AC} Input Voltage Ripple at 600mA Load Current

3.4 Load Transients

The electronic load switches between 100mA and 600mA.

3.4.1 110V_{DC} Input Voltage

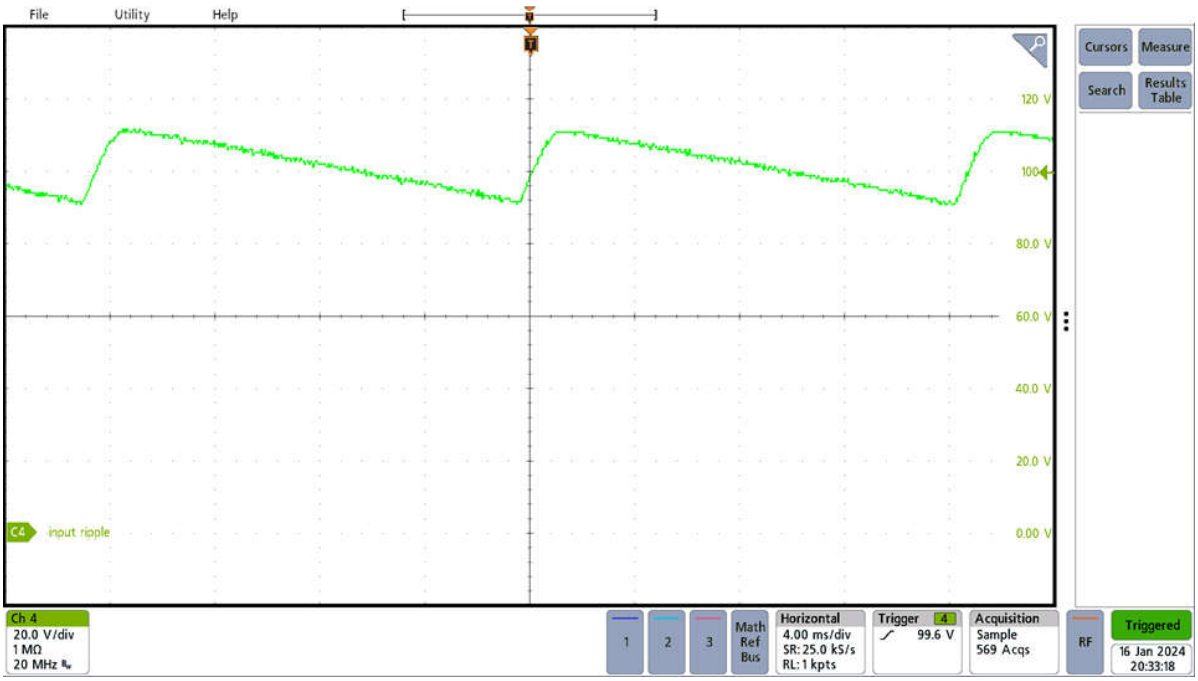


Figure 3-13. 100mA to 600mA Load Step at 110V_{DC} Input Voltage

3.4.2 325V_{DC} Input Voltage

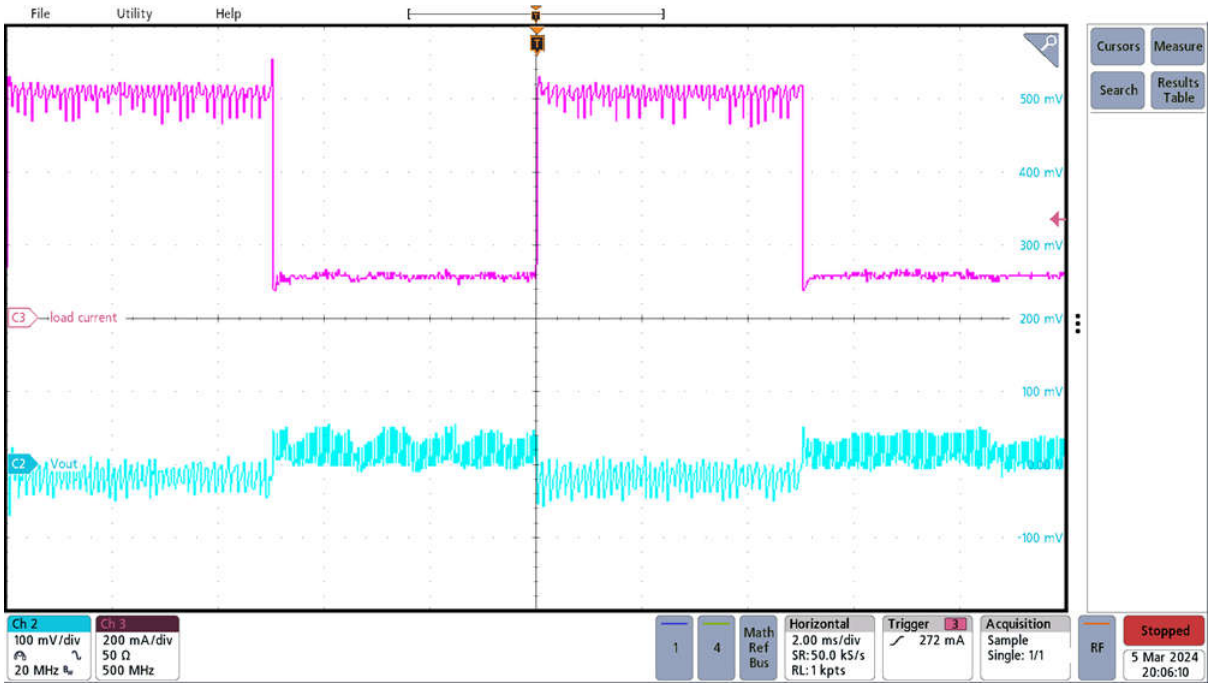


Figure 3-14. 100mA to 600mA Load Step at 325V_{DC} Input Voltage

3.4.3 630V_{DC} Input Voltage

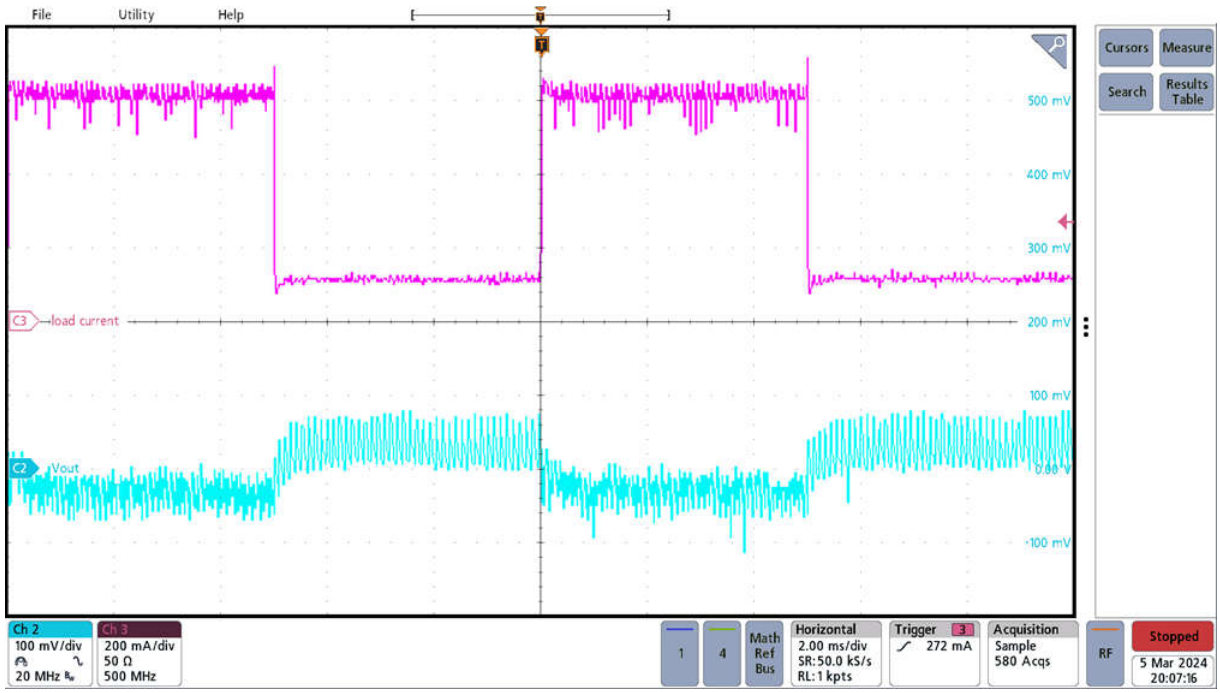


Figure 3-15. 100mA to 600mA Load Step at 630V_{DC} Input Voltage

3.5 Start-Up Sequence

3.5.1 80V_{DC} Input Voltage, 130mA Load Current

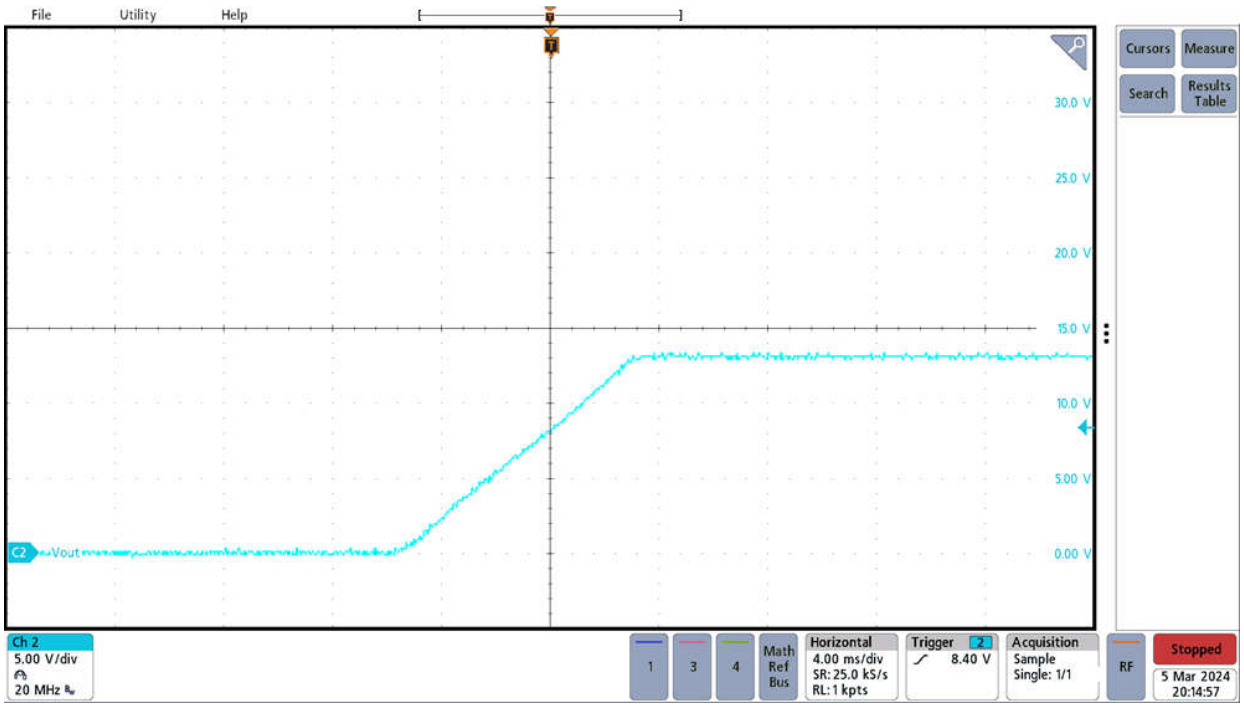


Figure 3-16. Start-Up at 80V_{DC} Input Voltage With 130mA Load Current

3.5.2 155V_{DC} Input Voltage, 600mA Load Current

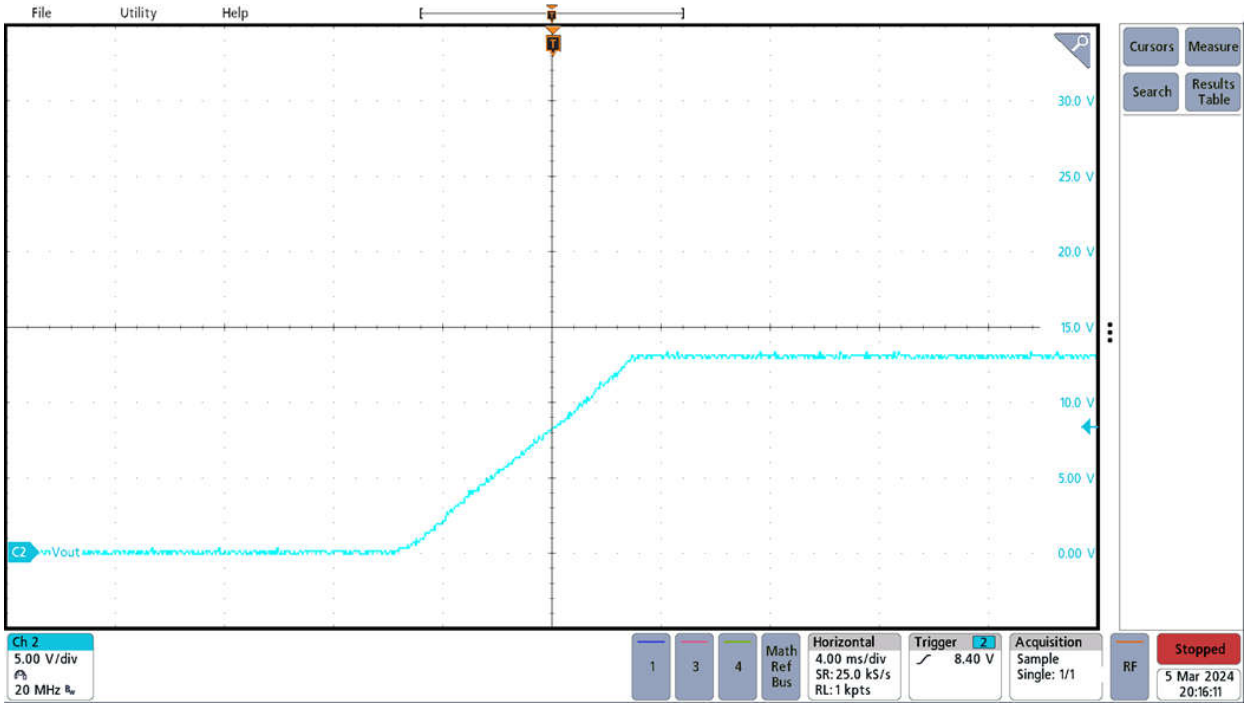


Figure 3-17. Start-Up at 155V_{DC} Input Voltage With 600mA Load Current

3.5.3 630V_{DC} Input Voltage, 600mA Load Current

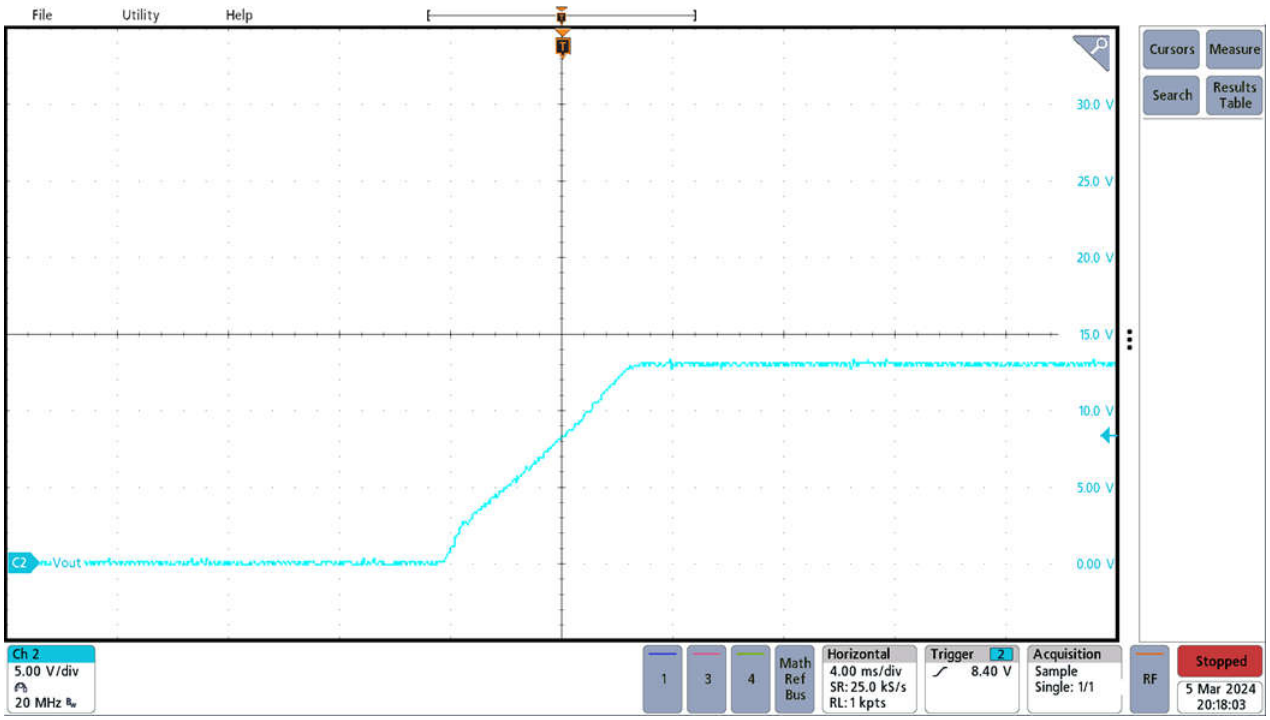


Figure 3-18. Start-Up at 630V_{DC} Input Voltage With 600mA Load Current

3.5.4 325V_{DC} Input Voltage, 600mA Load Current

3.5.4.1 No External Magnetic Field Applied

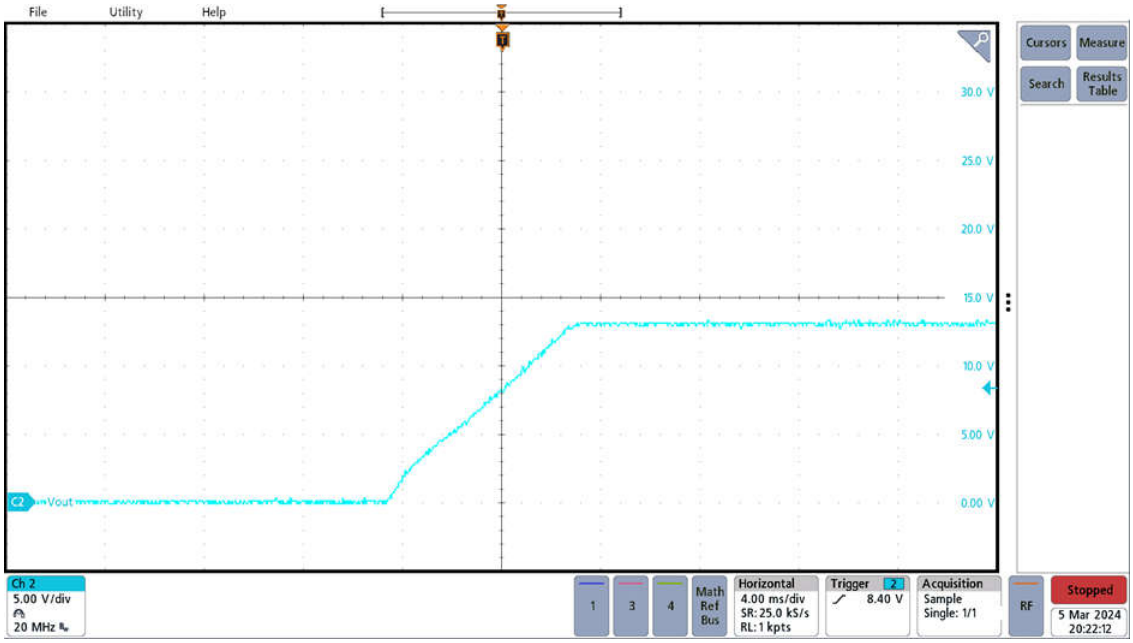


Figure 3-19. Start-Up With 625V_{DC} Input Voltage Without External Magnetic Field

3.5.4.2 With Magnetic Field Applied (2mm Distance Between Magnet and Inductor)

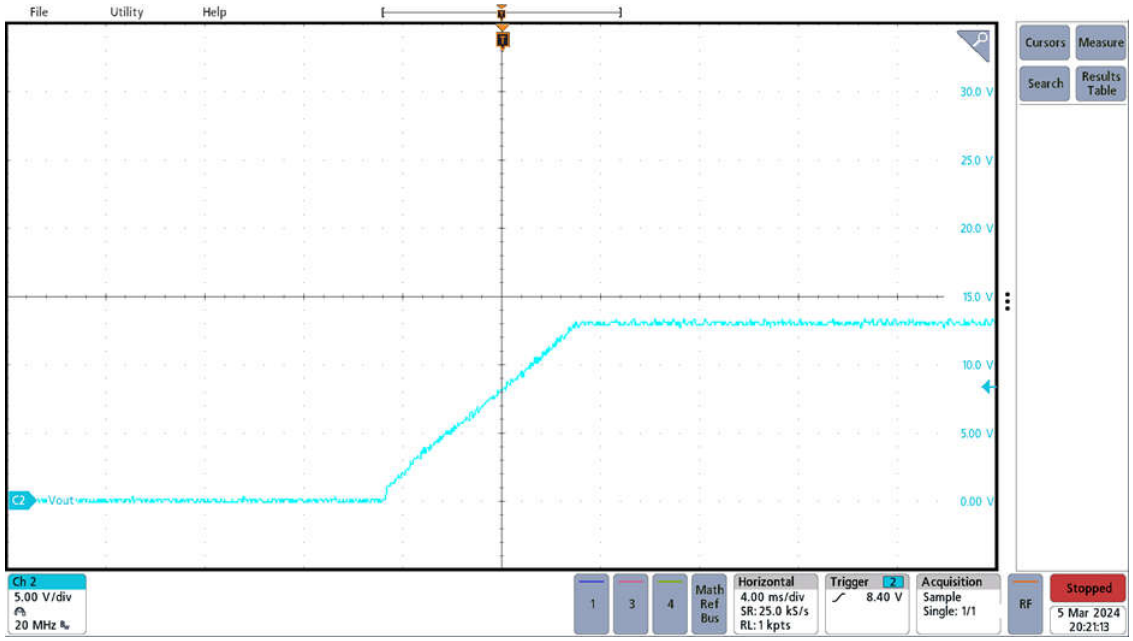


Figure 3-20. Start-Up With 625V_{DC} Input Voltage With External Magnetic Field

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