

# Offline Supercapacitor Backup Power Supply With Passive Cell Balancing Reference Design



## Description

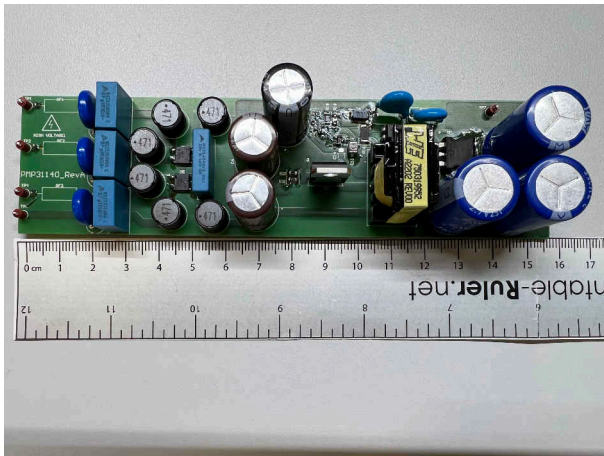
This reference design introduces an offline single-stage supercapacitor charger. An isolated constant-voltage, constant-current flyback controller UCC28740 charges three supercapacitors in series directly from a wide input (195 VAC to 480 VAC). The supercapacitor output voltage is limited to 6.5 V.

## Features

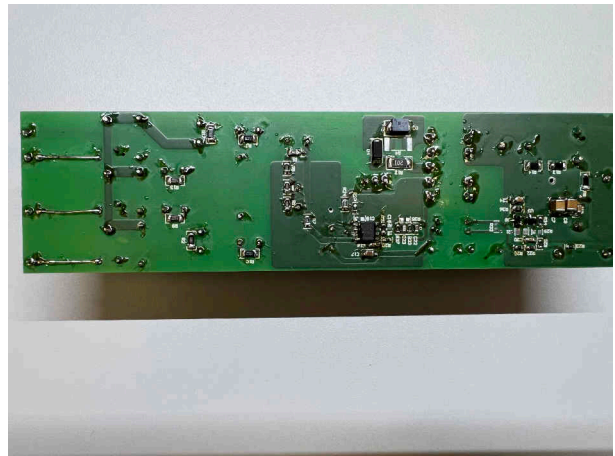
- Resonant-ring valley-switching operation
- Supercapacitor voltage limit: 6.5 V
- Wide input voltage range: 195 VAC–480 VAC
- Output overvoltage and overcurrent protection
- Complete tested design with available design files and test report

## Applications

- [Electricity meter](#)



Top of Board



Bottom of Board

## 1 Test Prerequisites

### 1.1 Voltage and Current Requirements

**Table 1-1. Voltage and Current Requirements**

Parameter	Specifications
Input voltage	195 VAC–480 VAC
Output voltage	6.5 V at 1.1 A

### 1.2 Required Equipment

- Oscilloscope: LeCroy WaveSurfer 200 MHz
- Electronic Load: Agilent 6060B
- Power Supply: Lambda GEN600-2.6 (600 V, 2.6 A)
- AC Power Source: California Instruments Model 1251P

### 1.3 Dimensions

157 mm × 41 mm

## 2 Testing and Results

### 2.1 Efficiency Graphs

The efficiency graph is shown in the following figure.

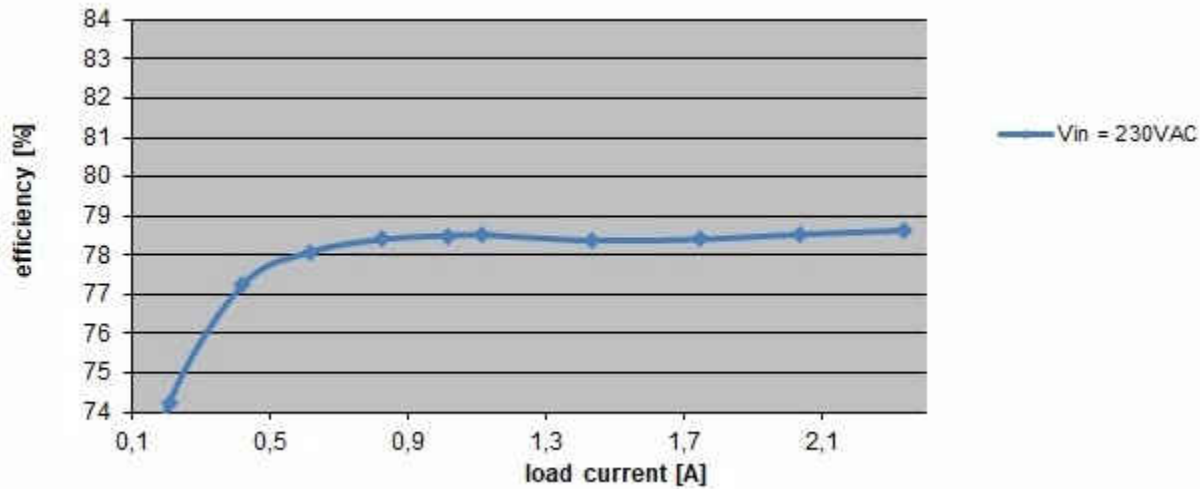


Figure 2-1. Efficiency Graph

### 2.2 Efficiency Data

The efficiency data is shown in the following table.

V <sub>IN</sub> (V)	I <sub>IN</sub> (A)	V <sub>OUT</sub> (V)	I <sub>OUT</sub> (A)	P <sub>IN</sub> (W)	P <sub>OUT</sub> (W)	P <sub>Loss</sub> (W)	Efficiency (%)
195 VAC	9.26	6.50	1.11		7.23		78.10
230 VAC	9.23	6.50	1.11		7.23		78.33
274 VAC	9.23	6.50	1.11		7.23		78.37

### 2.3 Thermal Images

The thermal images are shown in the following figure.

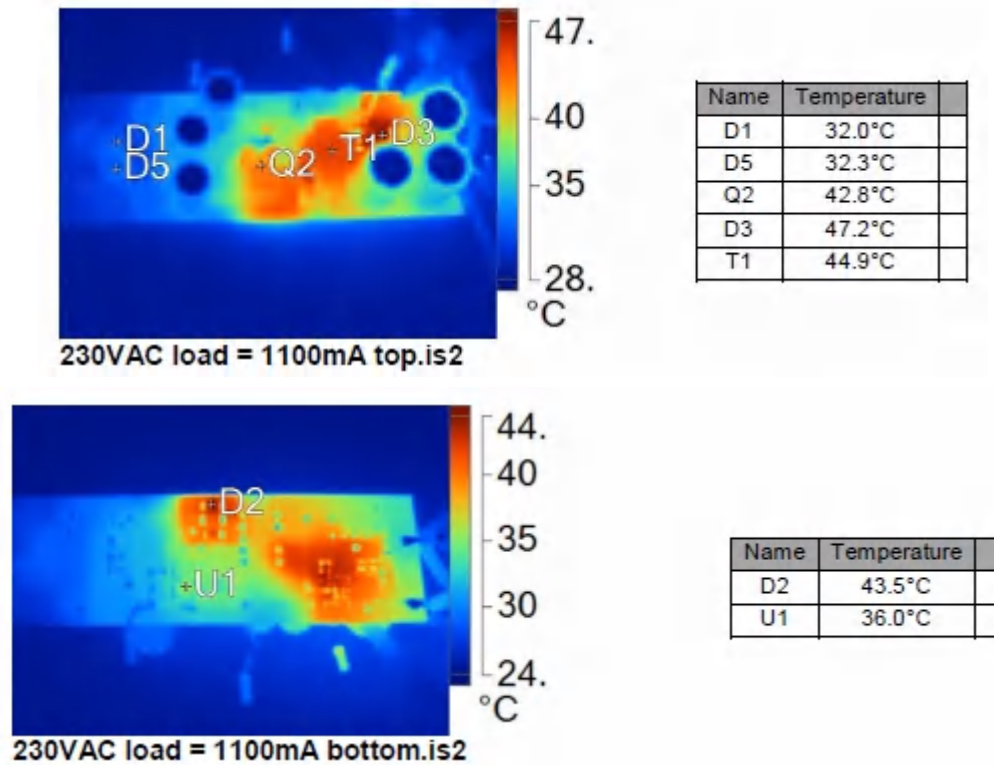


Figure 2-2. Thermal Images

### 2.4 Bode Plots

The PMP31140 bode plot is shown in the following figure.

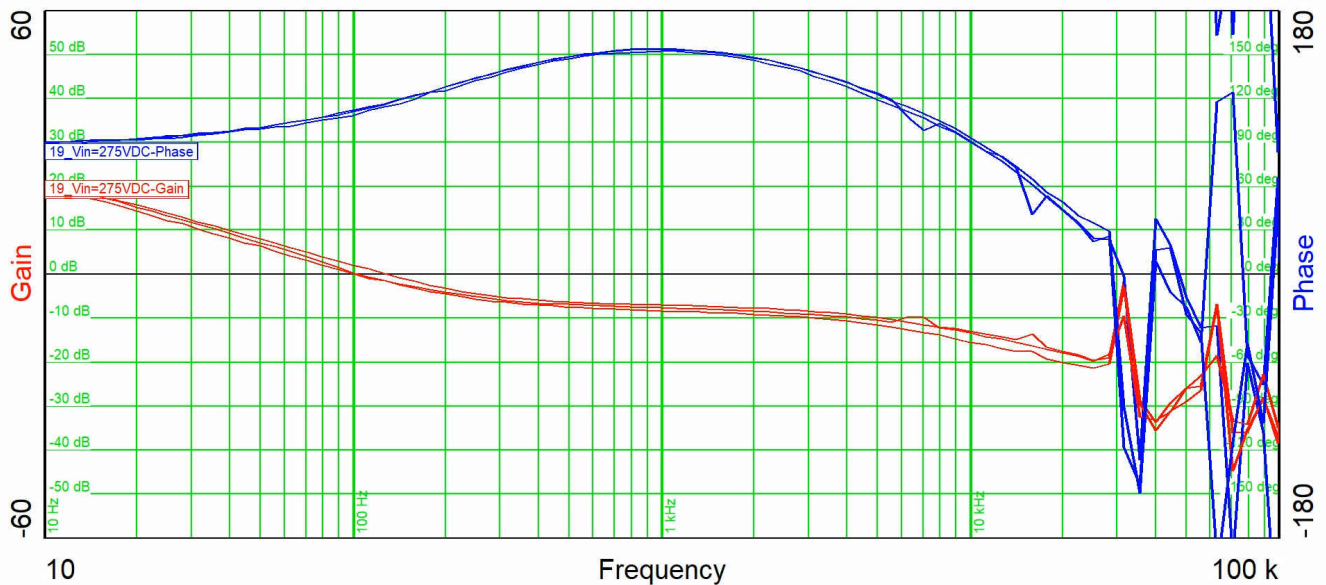
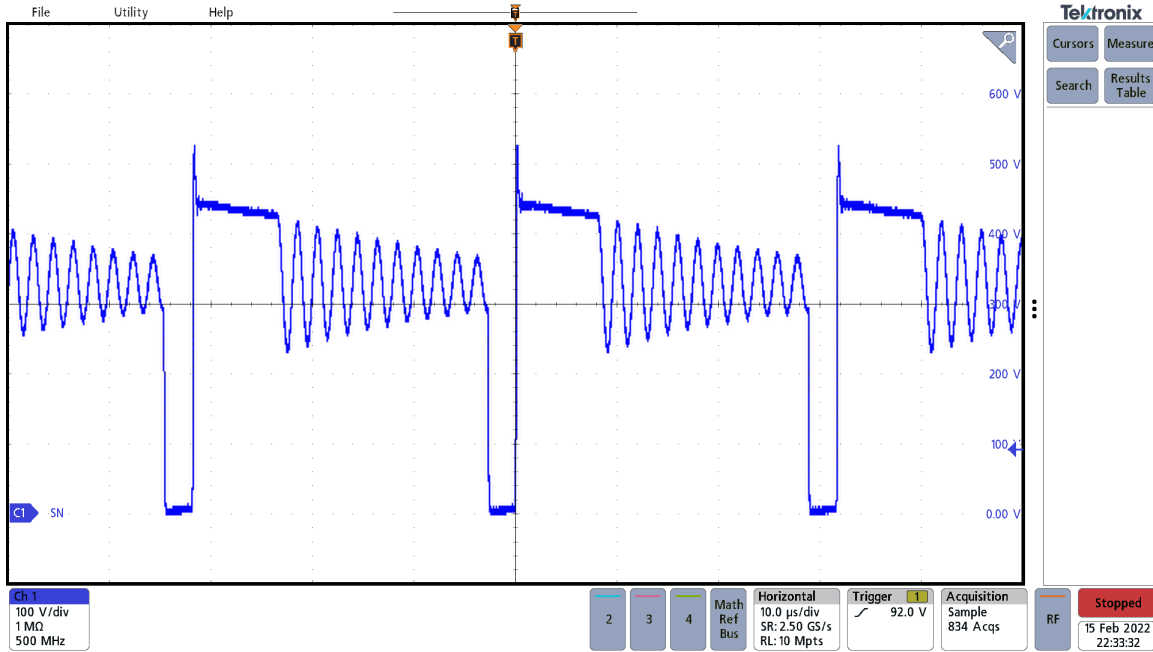


Figure 2-3. Bode Plot

### 3 Waveforms

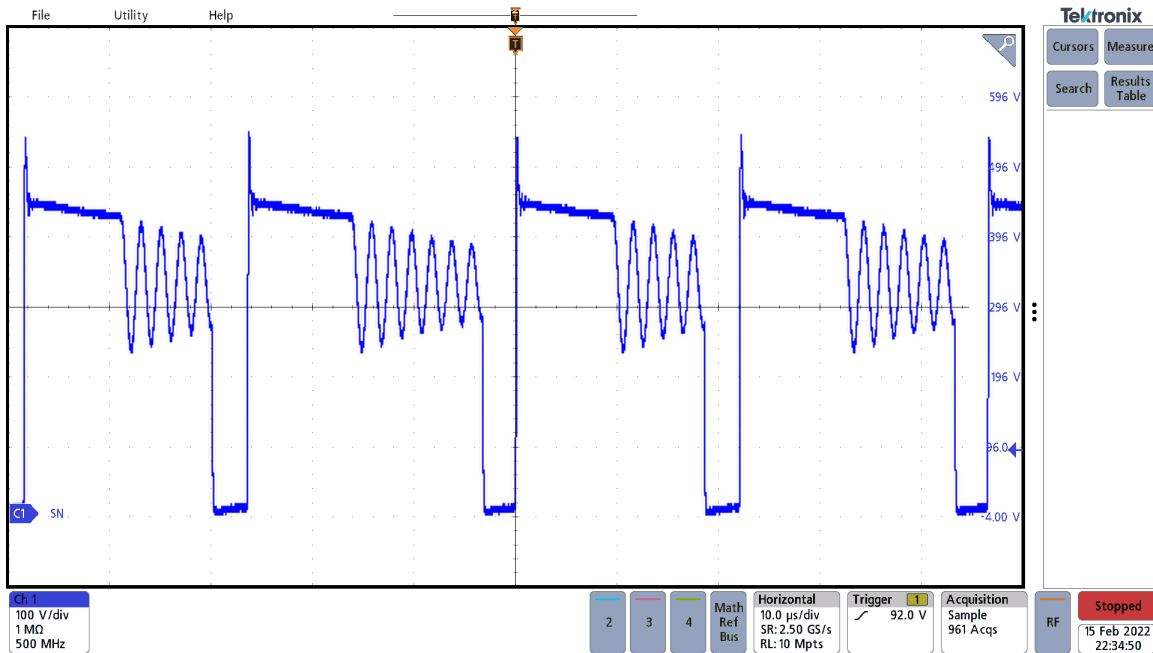
#### 3.1 Switching

Switching behavior is shown in the following figures.



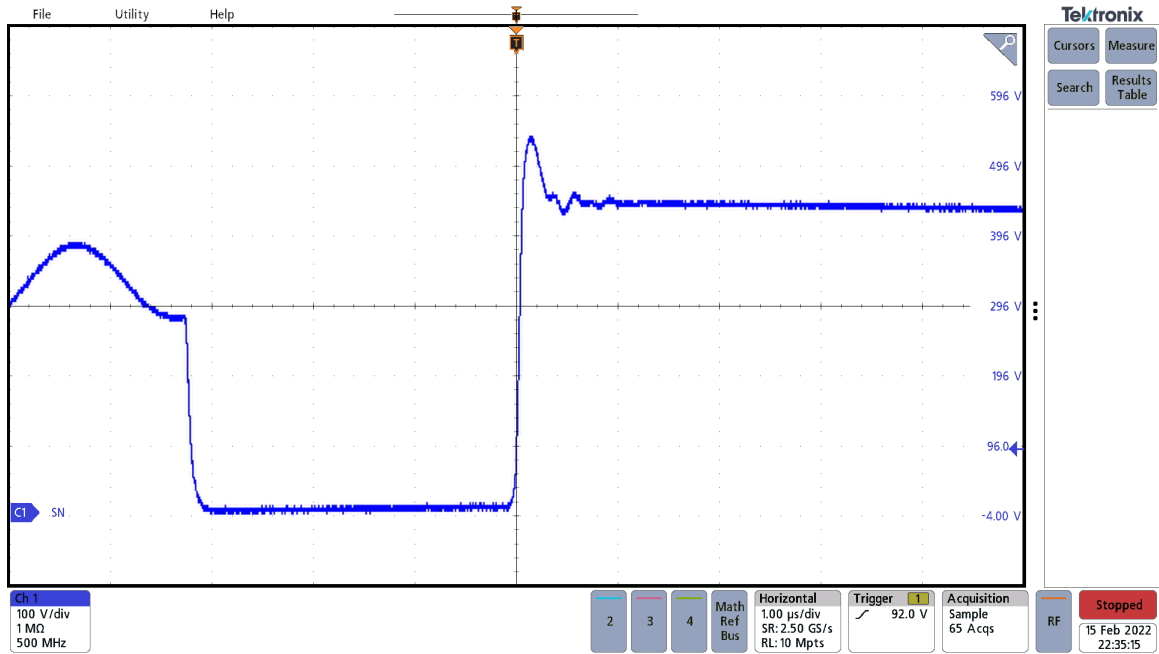
Input voltage = 325 VDC  
 Load = 1.1 A

**Figure 3-1. Switch Node Measurement 1**



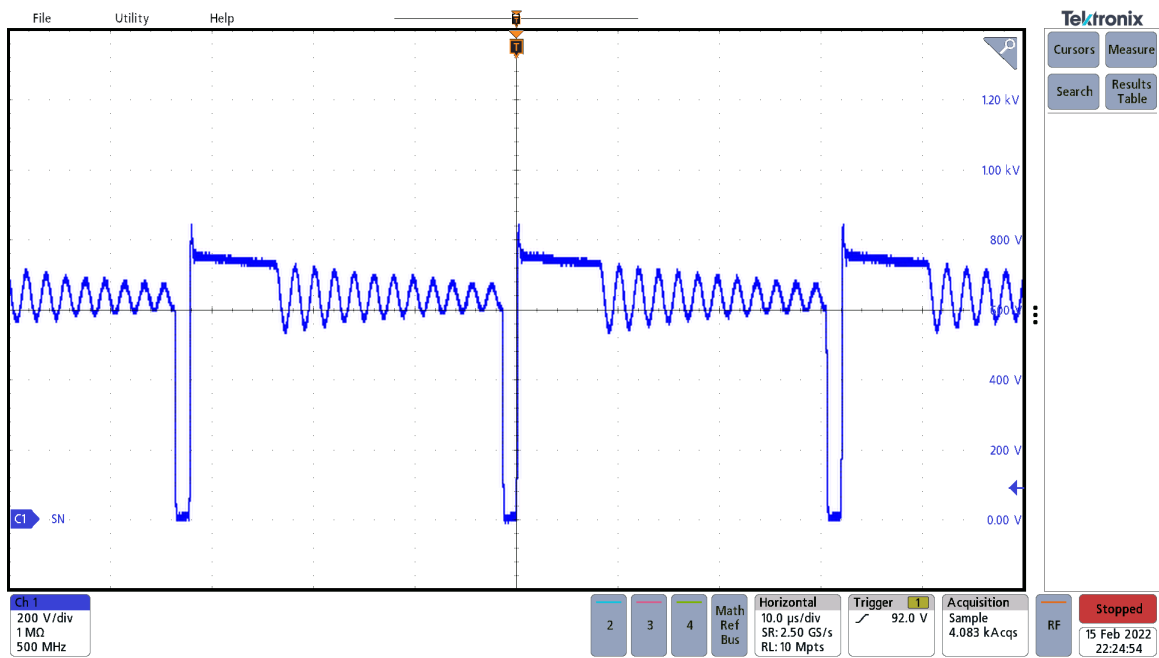
Input voltage = 325 VDC  
 Load = 2.2 A

**Figure 3-2. Switch Node Measurement 2**



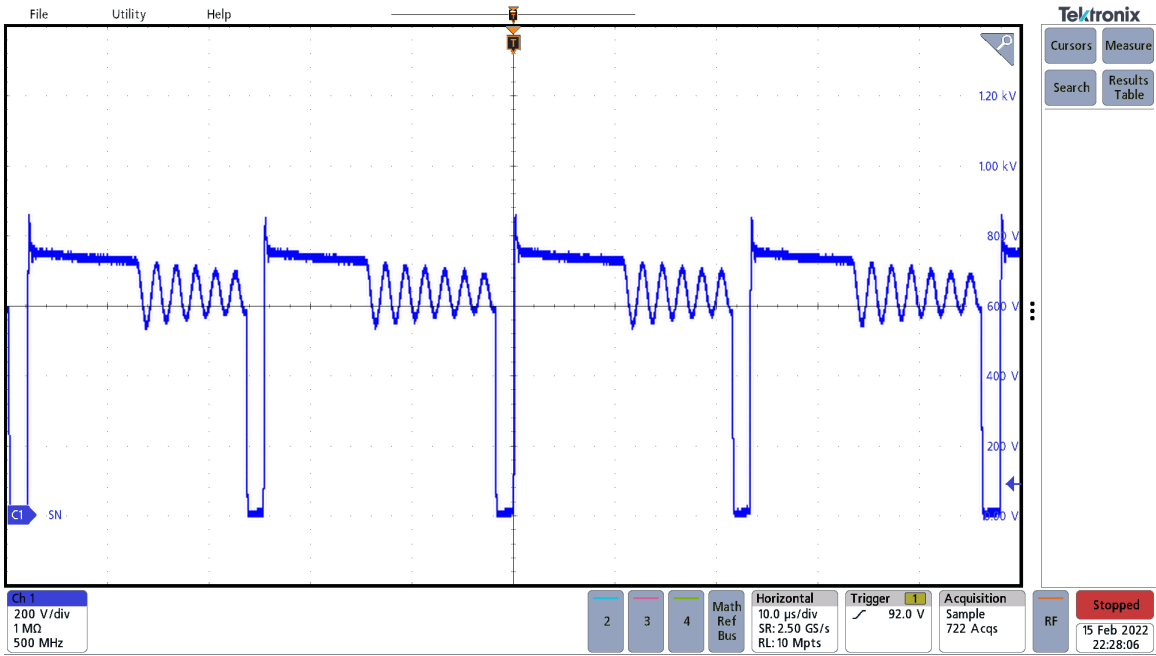
Input voltage = 325 VDC  
Load = 2.2 A

Figure 3-3. Switch Node Measurement 3



Input voltage = 630 VDC  
Load = 1.1 A

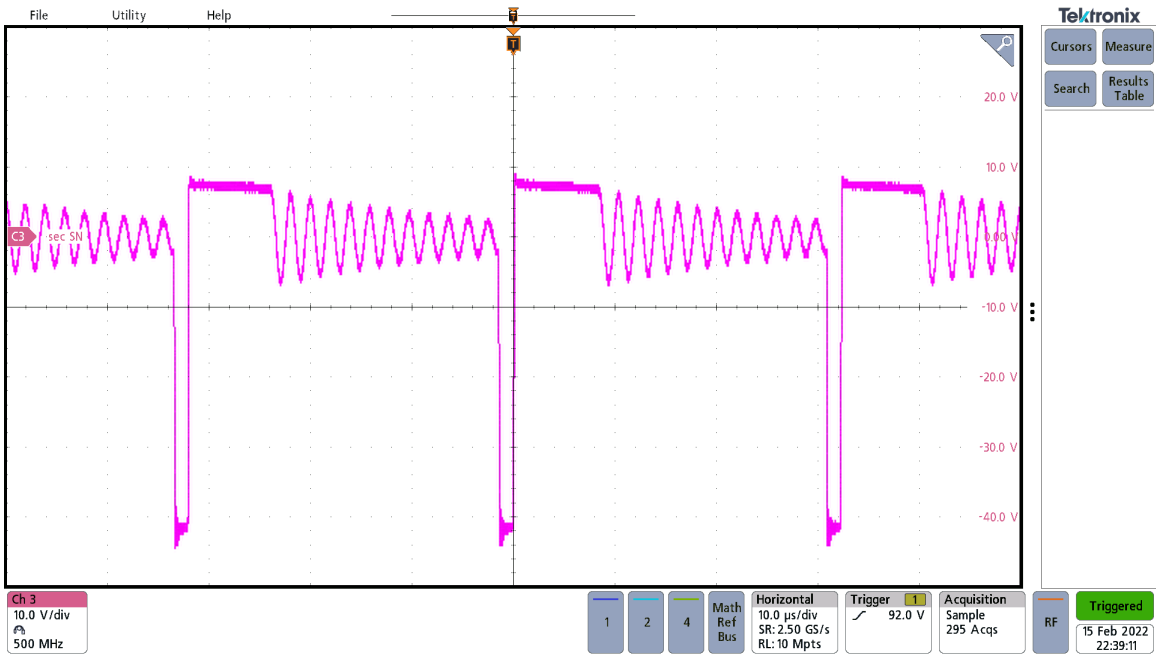
Figure 3-4. Switch Node Measurement 4



Input voltage = 630 VDC

Load = 2.5 A

**Figure 3-5. Switch Node Measurement 5**



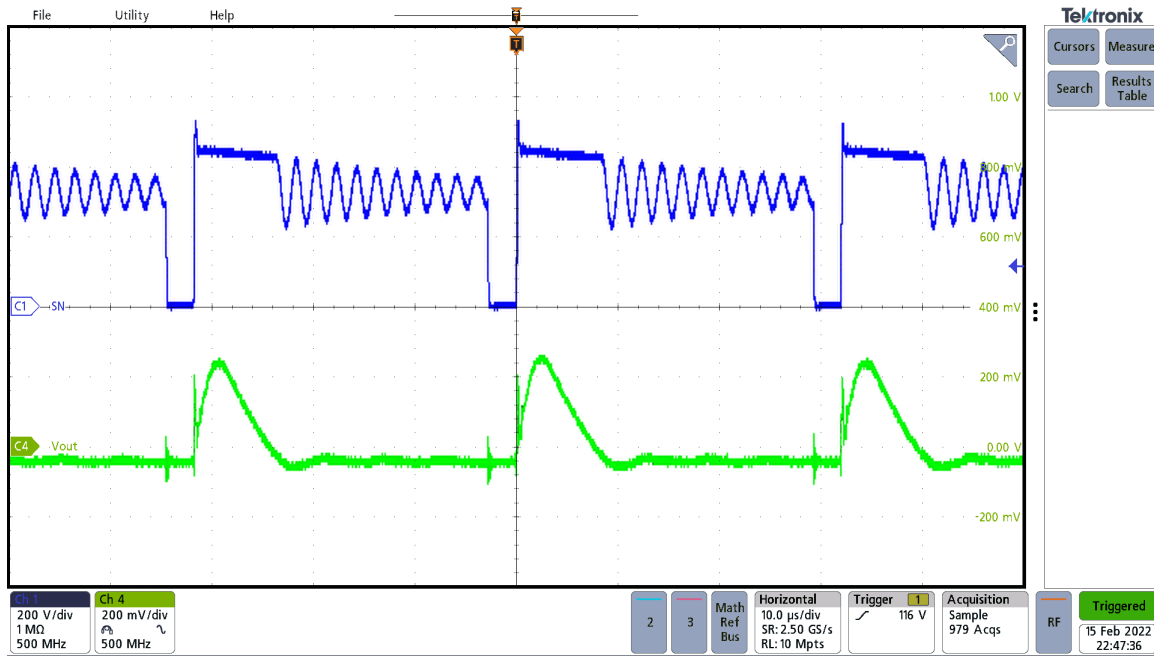
Input voltage = 630 VDC

Load = 1.1 A

**Figure 3-6. Secondary Side Switch Node Measurement 1**

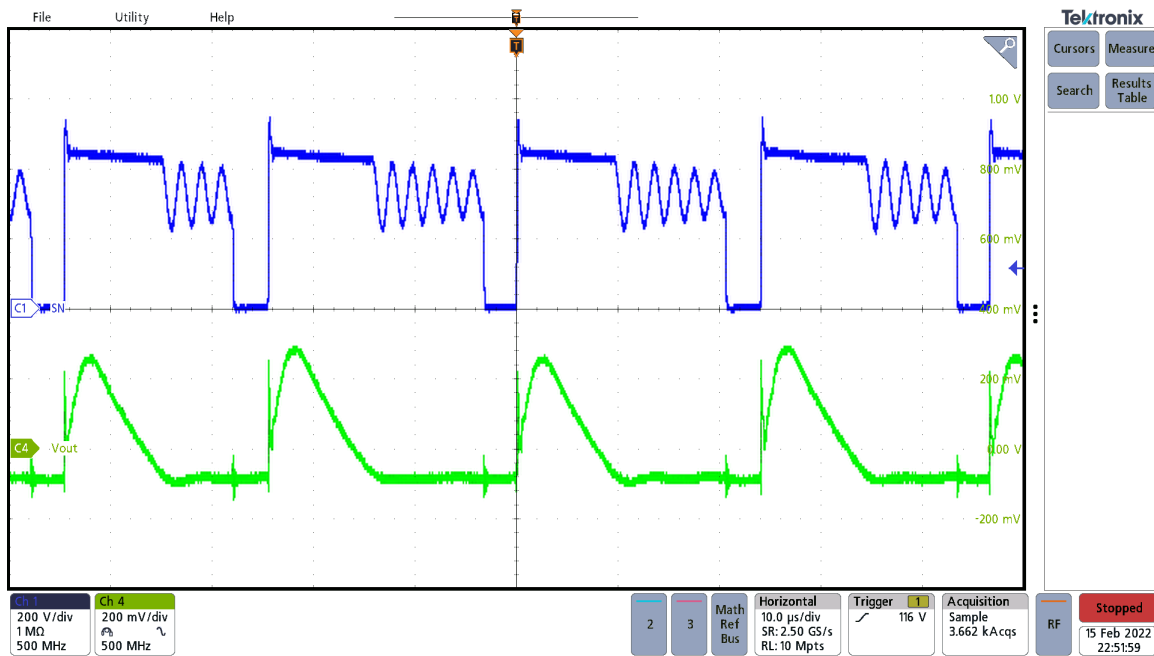
### 3.2 Output Voltage Ripple

Output voltage ripple is shown in the following figures.



Input voltage = 325 VDC  
Load = 1.1 A

**Figure 3-7. Output Voltage Ripple 1**



Input voltage = 325 VDC  
Load = 2.2 A

**Figure 3-8. Output Voltage Ripple 2**



### 3.3 Short-Circuit Protection

Short-circuit protection is shown in the following figure.

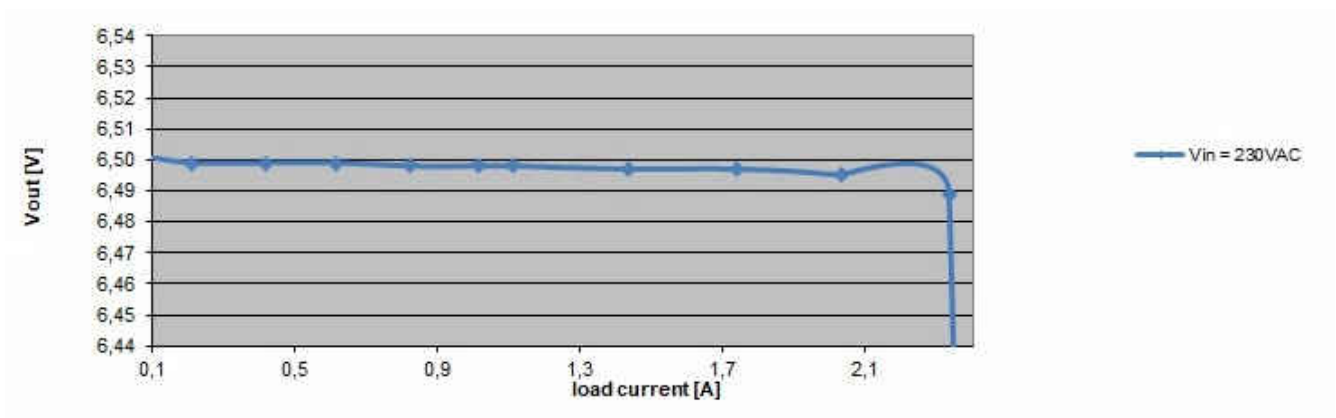
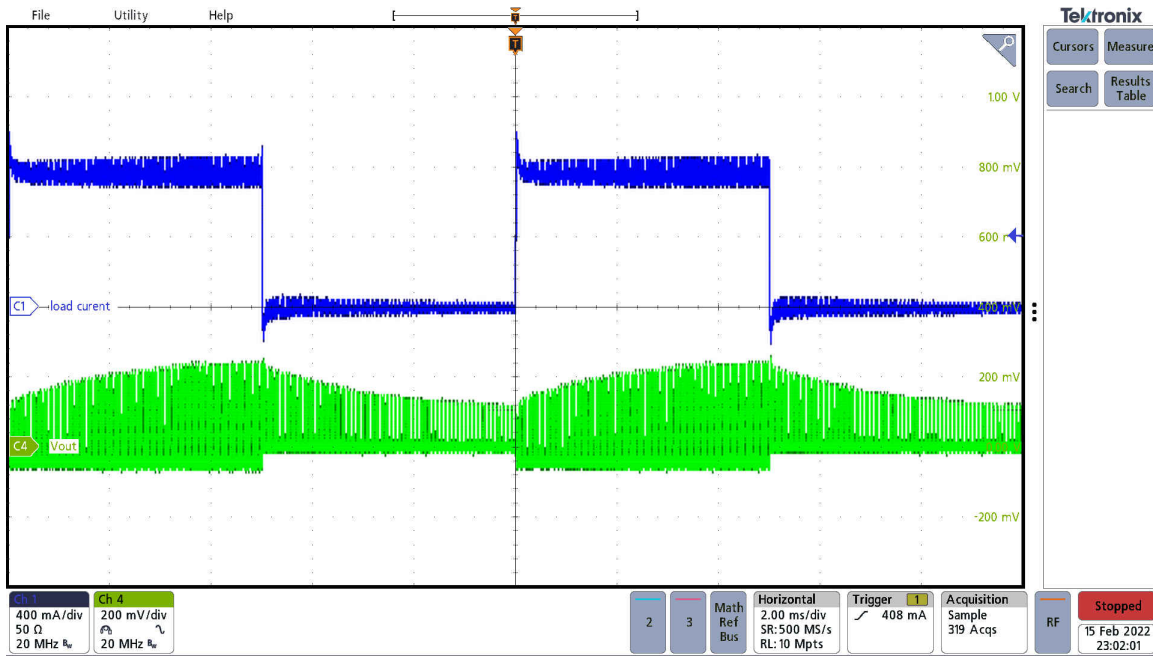


Figure 3-9. Short-Circuit Protection 1

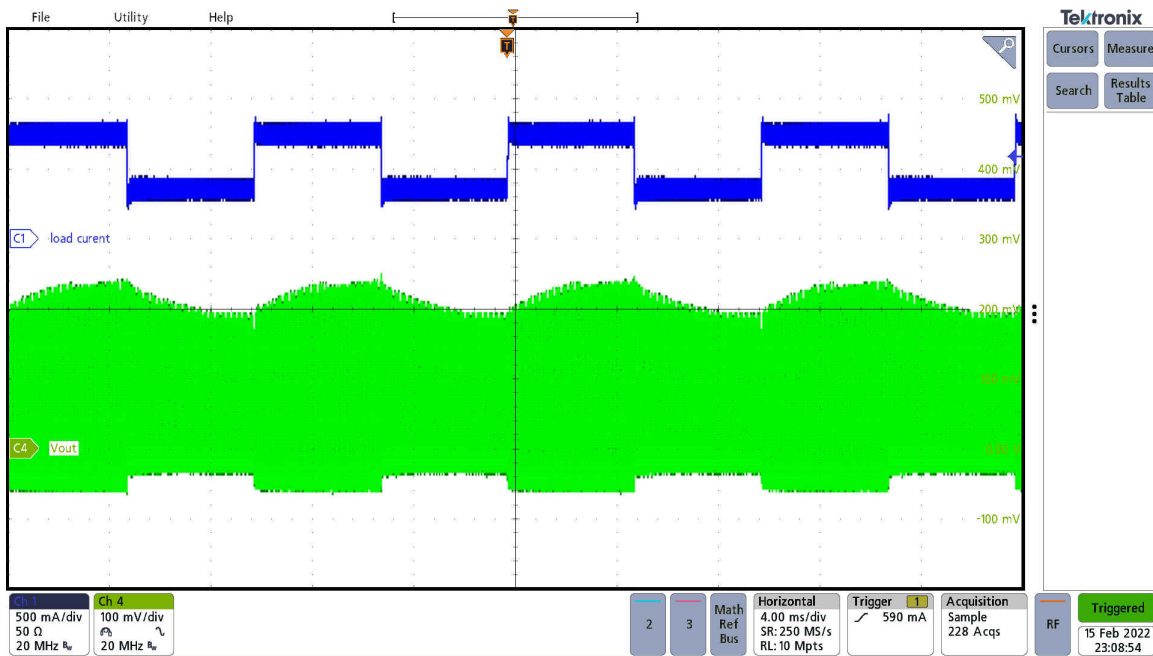
### 3.4 Load Transients

Load transient response waveforms are shown in the following figures.



Input voltage = 325 VDC  
Load = 0 A to 1.1 A

Figure 3-10. Load Transient 1

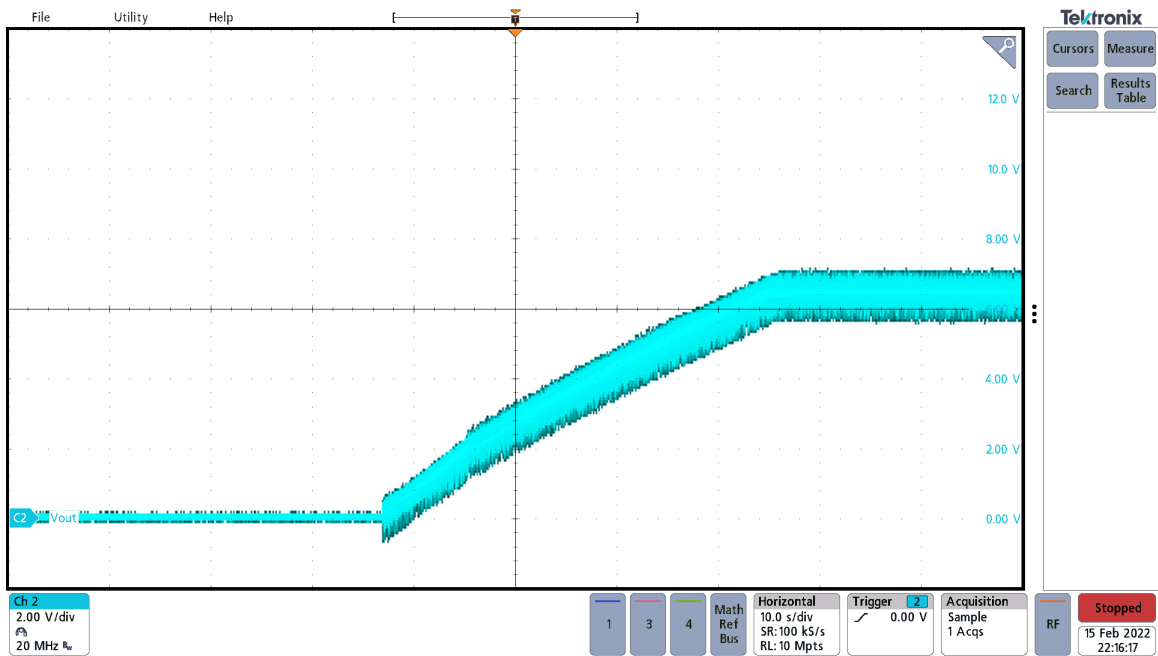


Input voltage = 325 VDC  
Load = 0.5 A to 1.1 A

Figure 3-11. Load Transient 2

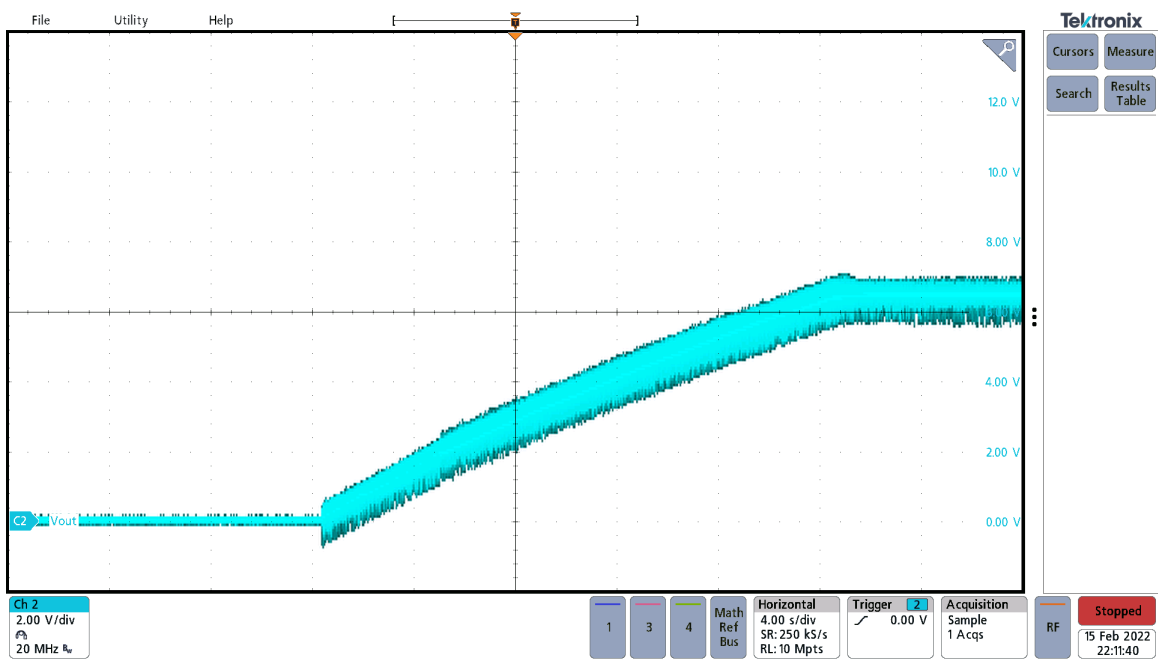
### 3.5 Start-Up Sequence

Start-up behavior is shown in the following figures.



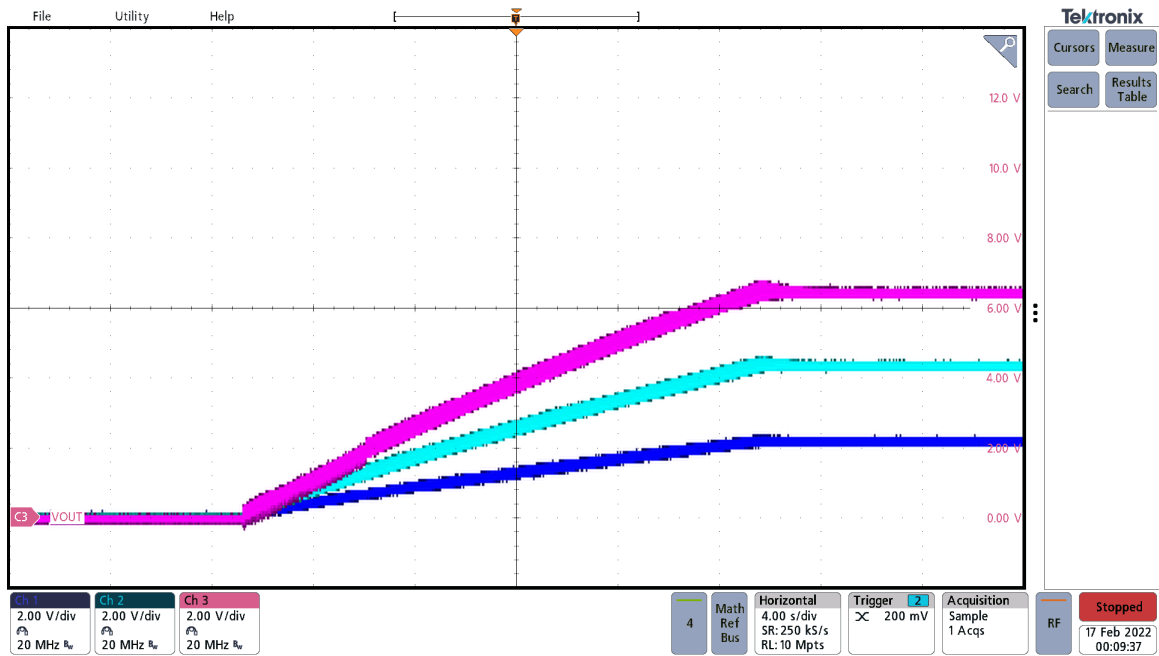
Input voltage = 630 VDC  
 Load = 1.1 A

Figure 3-12. Start-Up 1



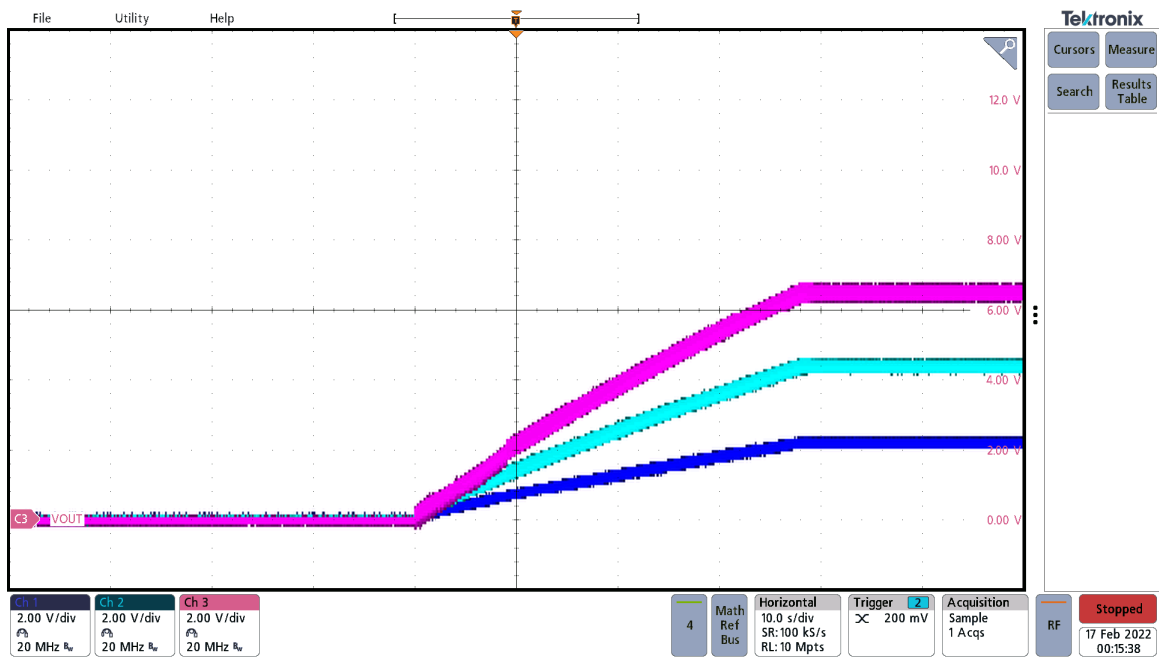
Input voltage = 630 VDC  
 Load = 0 A

Figure 3-13. Start-Up 2



Input = 230 VAC  
Load = 0 A

Figure 3-14. Start-Up 3 (With Supercap Balancing Voltages)

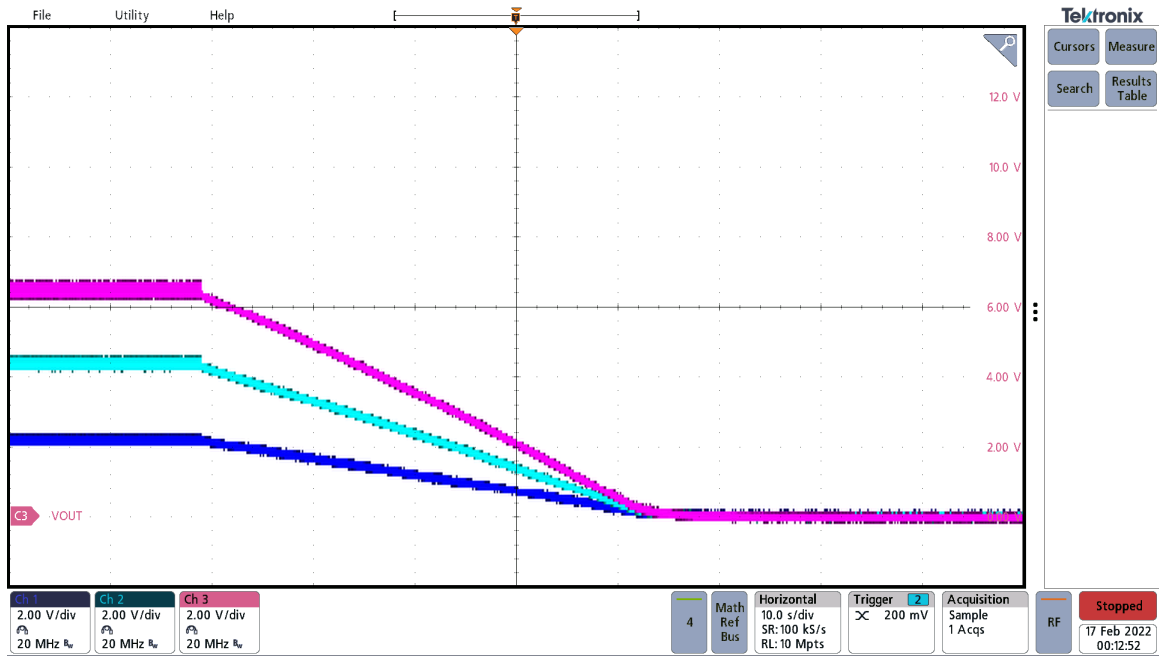


Input = 230 VAC  
Load = 1.1 A

Figure 3-15. Start-Up 4 (With Supercap Balancing Voltages)

### 3.6 Shutdown Sequence

Shutdown behavior is shown in the following figure.



Input voltage = 230 VAC  
 Load= 1.1 A

**Figure 3-16. Shutdown With Supercap Balancing Voltage**

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