Test Report: PMP23518

3.6V, 1A Output Smart Meter Supercapacitor Backup Power Supply Reference Design

Description

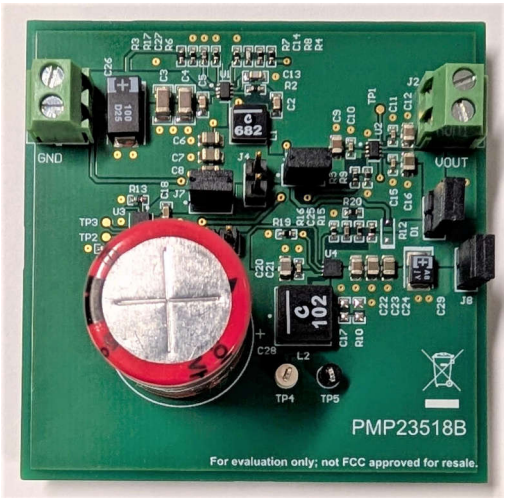
This reference design demonstrates a backup power supply design for smart meter applications. The TPS61022 boost converter has an extended operating range of 0.5V which maximizes the energy use of the supercapacitor energy. This results in a longer holdup time or a smaller supercapacitor. The BQ25173 provides constant current charging for the supercapacitor. The TPS2116 provides a seamless transition between the main power from the TPS62932 and the supercapacitor backup source.

Features

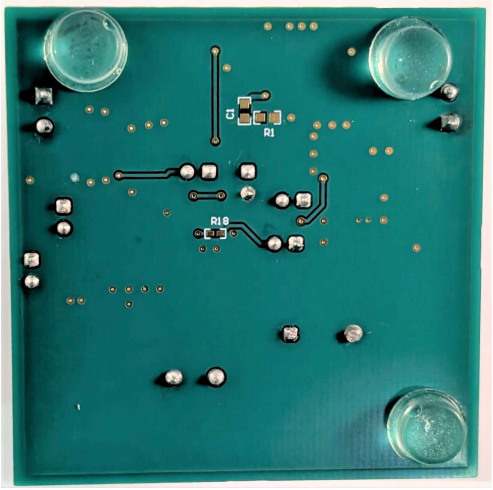
- 3.6V, 1A output from 12V input
- 3.6V holdup time when 12V is removed
- 0.5V minimum boost input maximizes utilization of supercapacitor energy
- Seamless switching between main power and backup power

Applications

- Electricity meter



Top of Board



Bottom of Board

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1 Test Prerequisites

1.1 Voltage and Current Requirements

Table 1-1. Voltage and Current Requirements

PARAMETER	SPECIFICATIONS
Input voltage	9.6VDC to 14.4VDC
Output voltage	3.6VDC ±3%
Output current	1A

1.2 Required Equipment

- Power supply, 0VDC to 16VDC, 1A
- Active load, 3.6VDC, 2A

1.3 Considerations

All testing is performed at +25Cº ambient temperature. Some testing required removing the supercapacitor from the PCB.

1.4 Dimensions

The board is 55.8mm × 55.8mm.

1.5 Test Setup

Install jumpers J3, J5, J7, and J9 before testing.

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2 Testing and Results

2.1 Efficiency Graphs

Figure 2-1 and Figure 2-2 show the efficiency graphs.

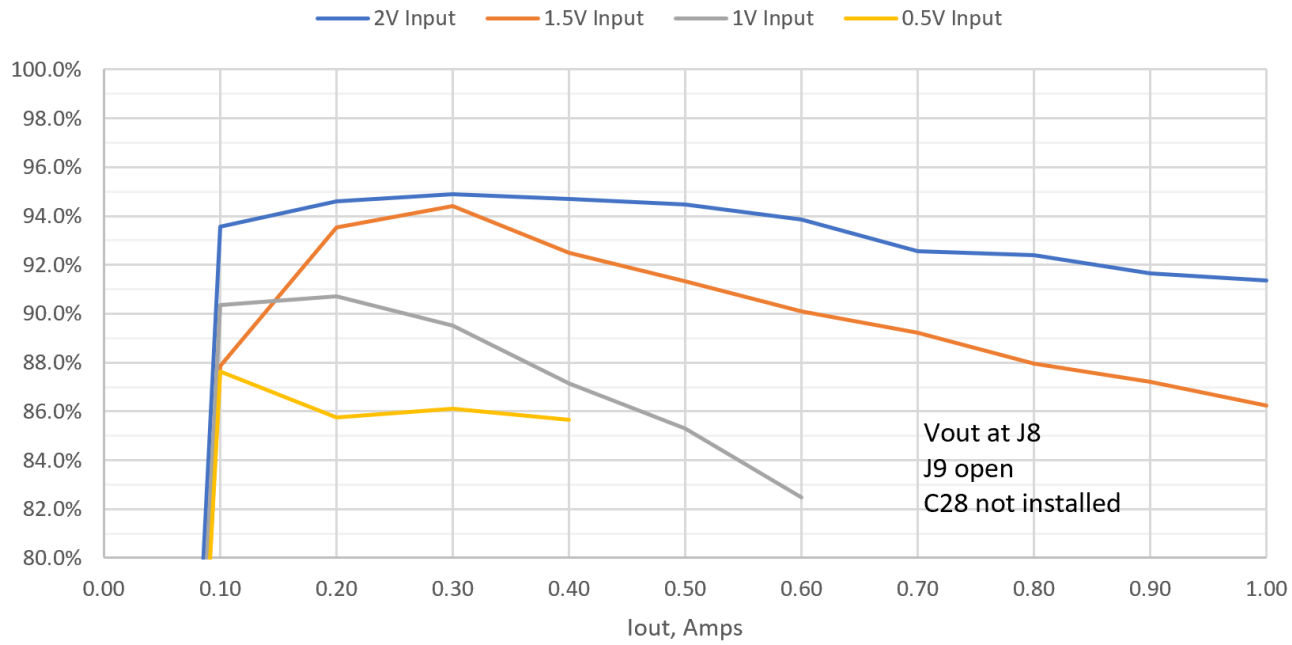

Figure 2-1. Efficiency Graph, TPS61022 Boost Converter

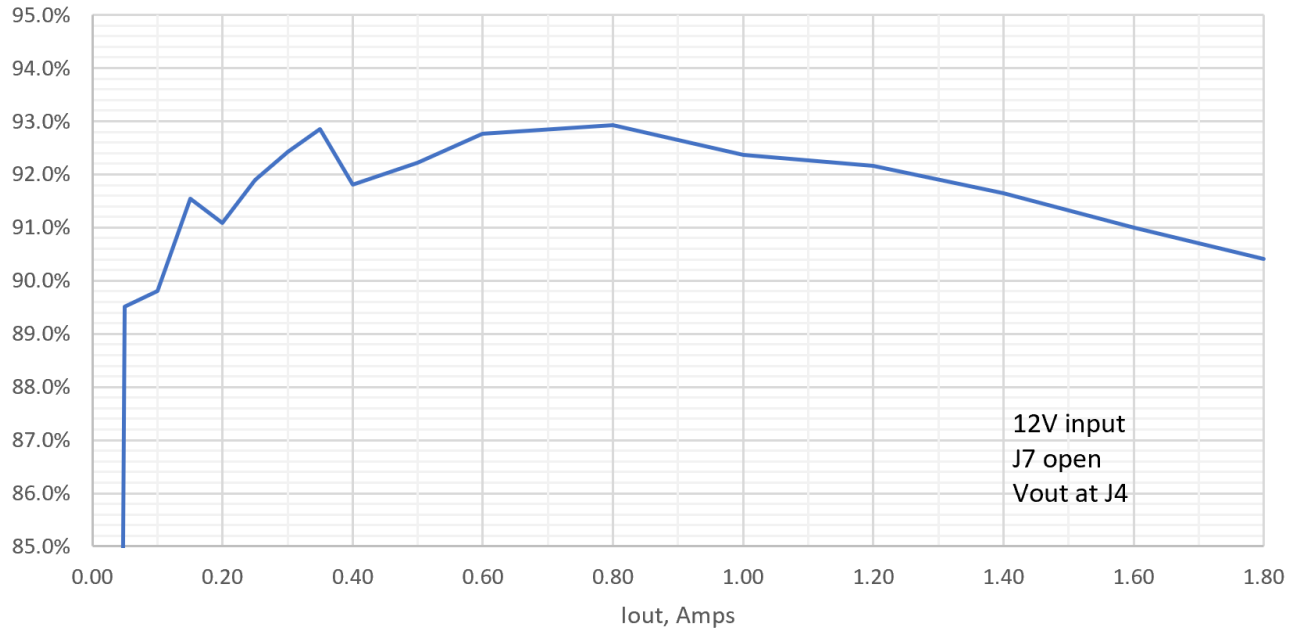

Figure 2-2. Efficiency Graph, TPS62932 Buck Converter

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2.2 Efficiency Data

Table 2-1 and Table 2-2 show the PMP23518 efficiency data.

Table 2-1. Boost Converter Efficiency

I_{OUT} (A) J2	Efficiency (%) 2.0V Input J8	Efficiency (%) 1.5V Input J8	Efficiency (%) 1.0V Input J8	Efficiency (%) 0.5V Input J8
0.0	0.0	0.0	0.0	0.0
0.1	93.6	87.9	90.4	87.6
0.2	94.6	93.5	90.7	85.7
0.3	94.9	94.4	89.5	86.1
0.4	94.7	92.5	87.1	85.7
0.5	94.5	91.3	85.3	Current limit
0.6	93.9	90.1	82.5	Current limit
0.7	92.6	89.2	Current limit	Current limit
0.8	92.4	88.0	Current limit	Current limit
0.9	91.7	87.2	Current limit	Current limit
1.0	91.3	86.2	Current limit	Current limit

Table 2-2. Buck Converter Efficiency

V_{IN} (V) J1	I_{IN} (A) J1	V_{OUT} (V) J4	I_{OUT} (A) J4	Efficiency (%) J4
12.05	0.00024	3.670	0.00	0.00
12.04	0.017	3.664	0.05	89.5
12.04	0.034	3.676	0.10	89.8
12.03	0.050	3.671	0.15	91.5
12.02	0.067	3.668	0.20	91.1
12.02	0.083	3.667	0.25	91.9
12.01	0.099	3.663	0.30	92.4
12.00	0.115	3.661	0.35	92.9
12.00	0.133	3.663	0.40	91.8
12.04	0.165	3.664	0.50	92.2
12.03	0.197	3.664	0.60	92.8
12.00	0.263	3.666	0.80	92.9
12.03	0.330	3.667	1.00	92.4
12.00	0.398	3.668	1.20	92.2
12.03	0.466	3.670	1.40	91.7
12.00	0.538	3.672	1.60	91.0
12.03	0.608	3.674	1.80	90.4

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2.3 Thermal Images

Figure 2-3 and Figure 2-4 show the PMP23518 thermal images.

Measurements	
Sp1	43.1 °C
Sp2	35.1 °C
Sp3	30.7 °C
Parameters	
Emissivity	0.95
Refl. temp.	20 °C

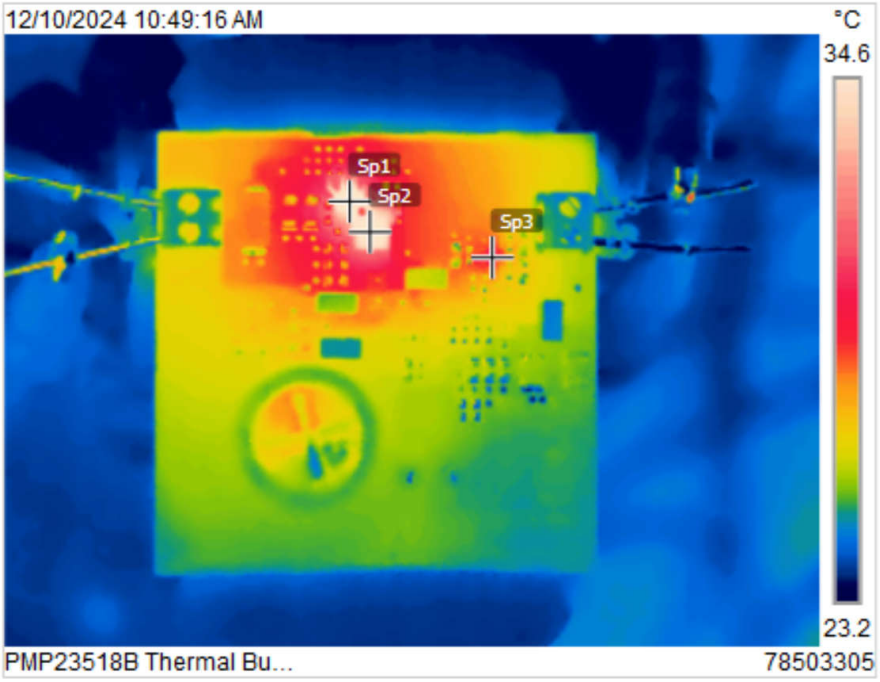

Figure 2-3. Buck Mode, Top of Board

Measurements	
Sp1	27.7 °C
Sp2	34.1 °C
Sp3	27.4 °C
Parameters	
Emissivity	0.95
Refl. temp.	20 °C

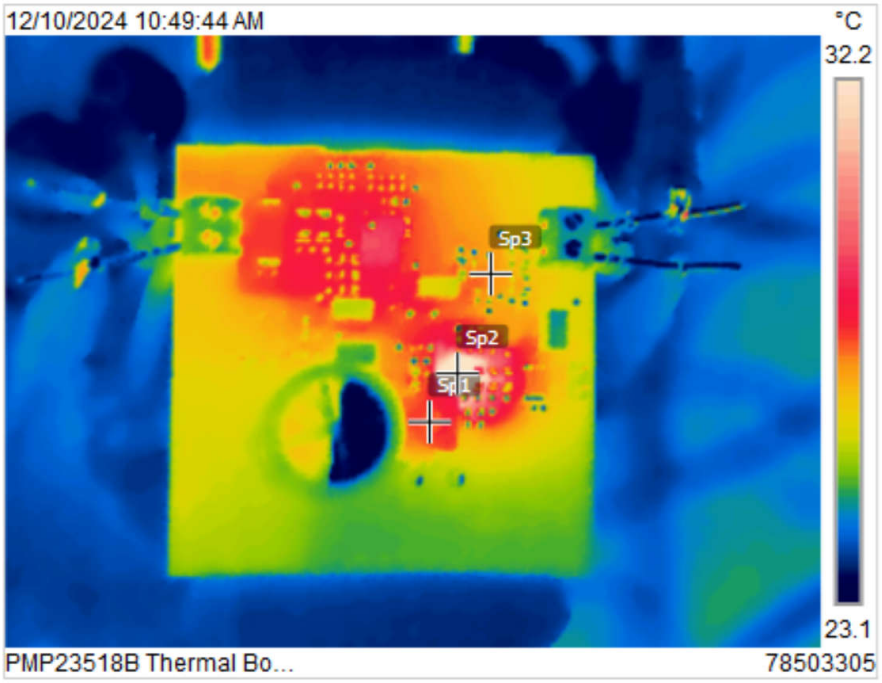

Figure 2-4. Boost Mode, Top of Board

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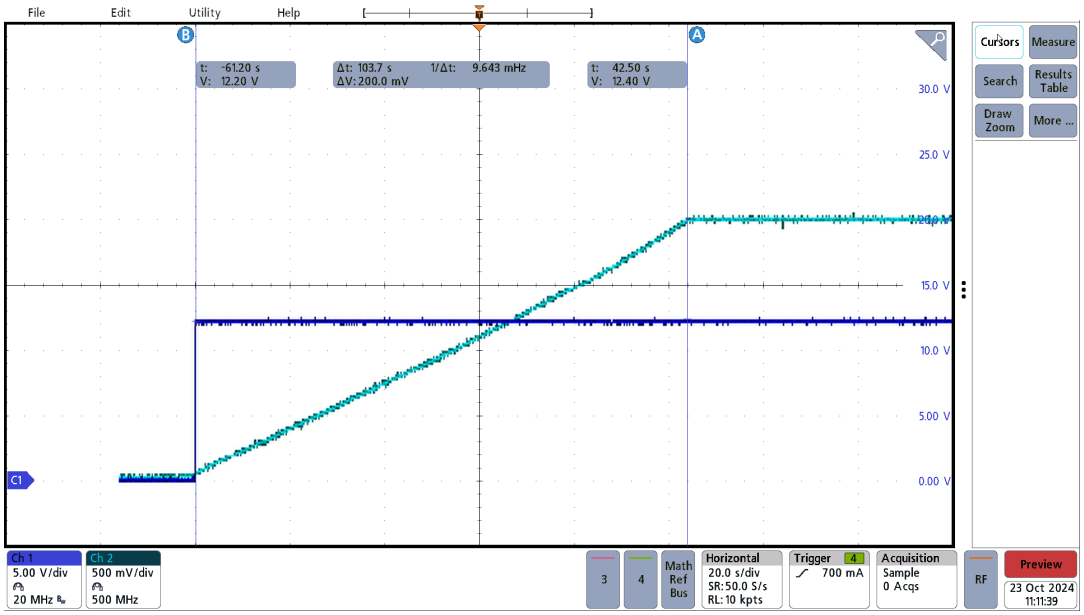
2.4 Charge Time and Holdup Time

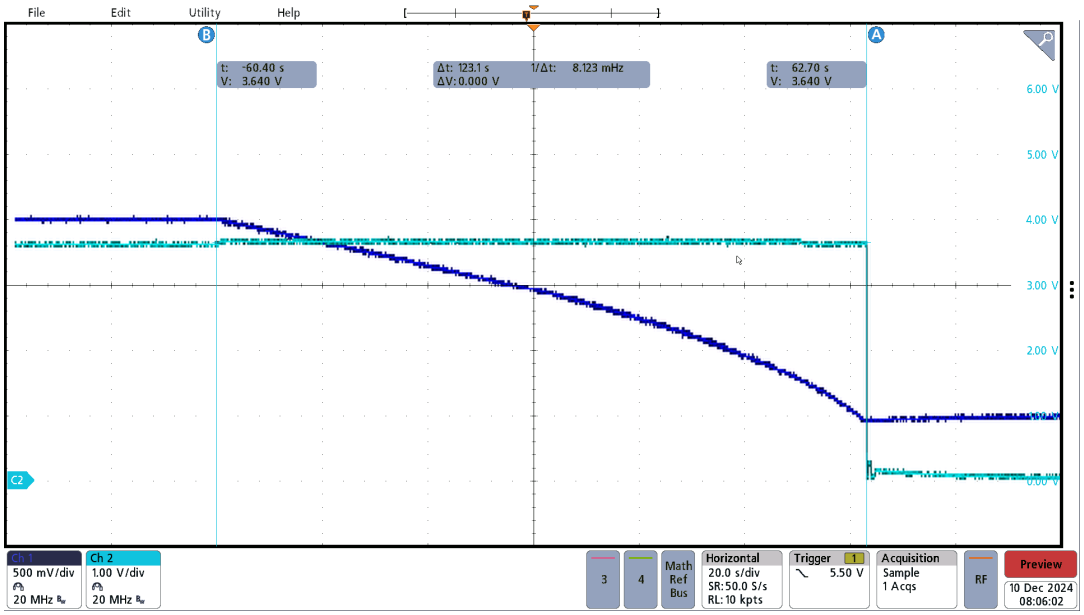
Figure 2-5 shows the supercapacitor charge time waveform.



Ch 1: Input voltage, 5V/div; Ch 2: Supercapacitor voltage, 500mV/div; 20s/div. Measured 103.7 seconds

Figure 2-5. Supercapacitor Charge Time to 2.0V

Figure 2-6 through Figure 2-15 show the output holdup time waveforms.



Ch 1: Supercapacitor voltage; Ch 2: Output voltage; measured 123.1 seconds

Figure 2-6. Output Holdup Time, 0.1A Load

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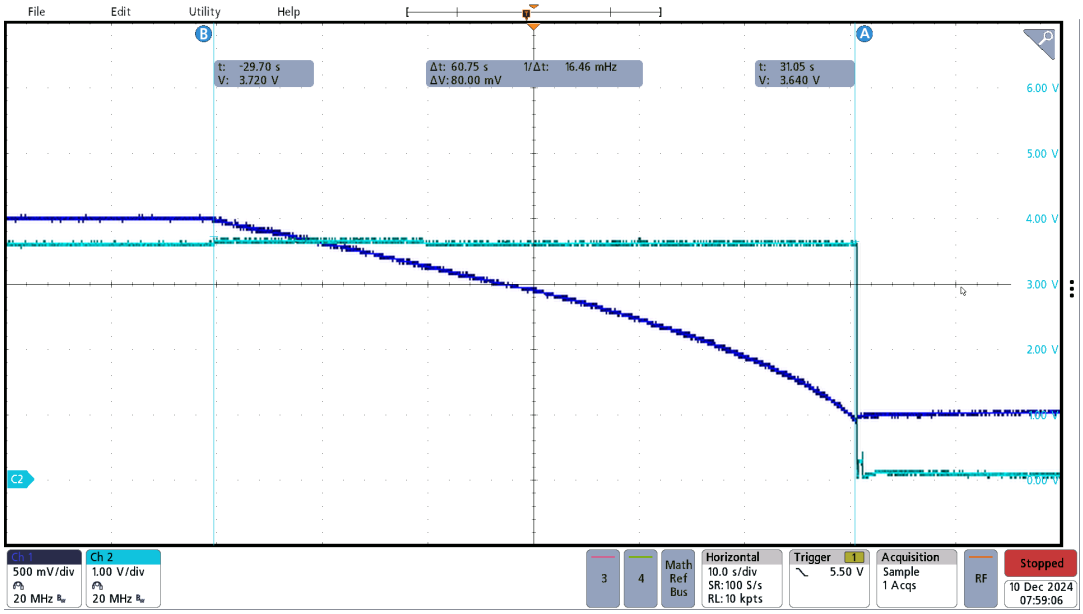
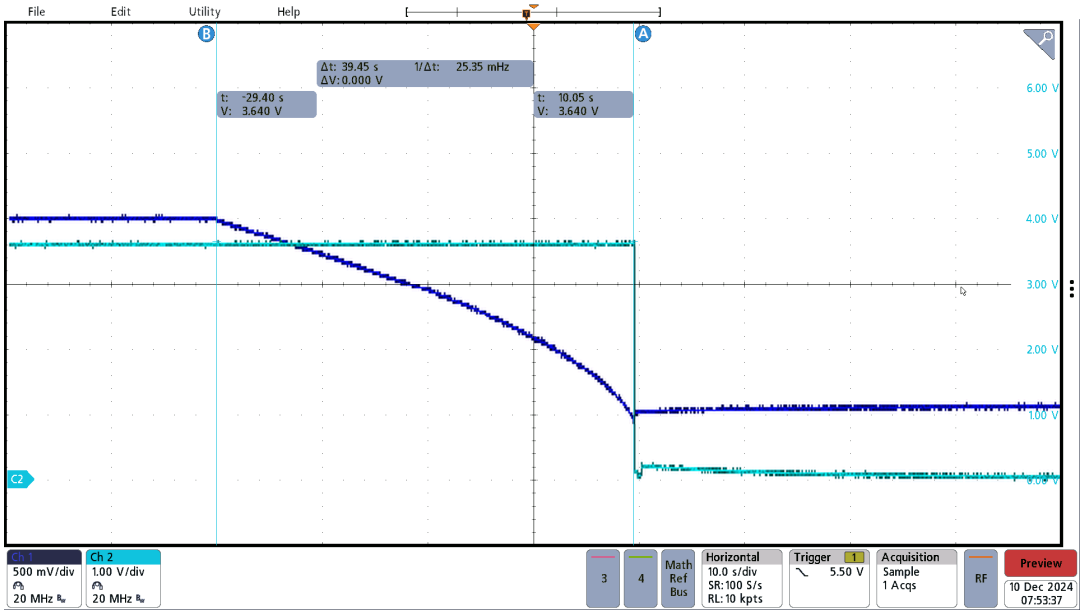


Ch 1: Supercapacitor voltage; Ch 2: Output voltage; measured 60.7 seconds

Figure 2-7. Output Holdup Time, 0.2A Load



Ch 1: Supercapacitor voltage; Ch 2: Output voltage; measured 39.4 seconds

Figure 2-8. Output Holdup Time, 0.3A Load

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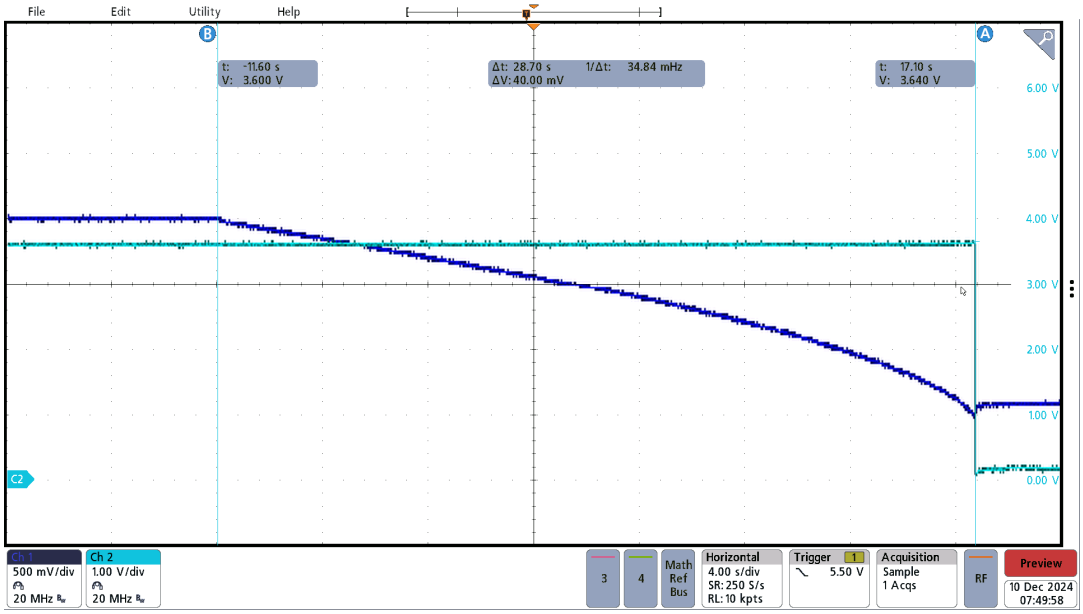
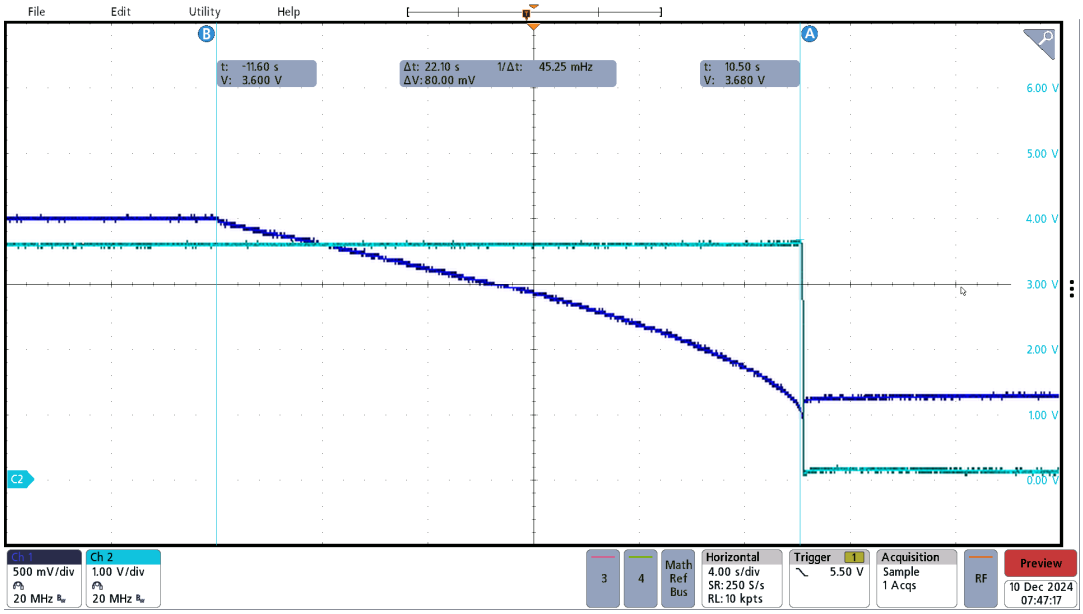


Ch 1: Supercapacitor voltage; Ch 2: Output voltage; measured 28.7 seconds

Figure 2-9. Output Holdup Time, 0.4A Load



Ch 1: Supercapacitor voltage; Ch 2: Output voltage: measured 22.1 seconds

Figure 2-10. Output Holdup Time, 0.5A Load

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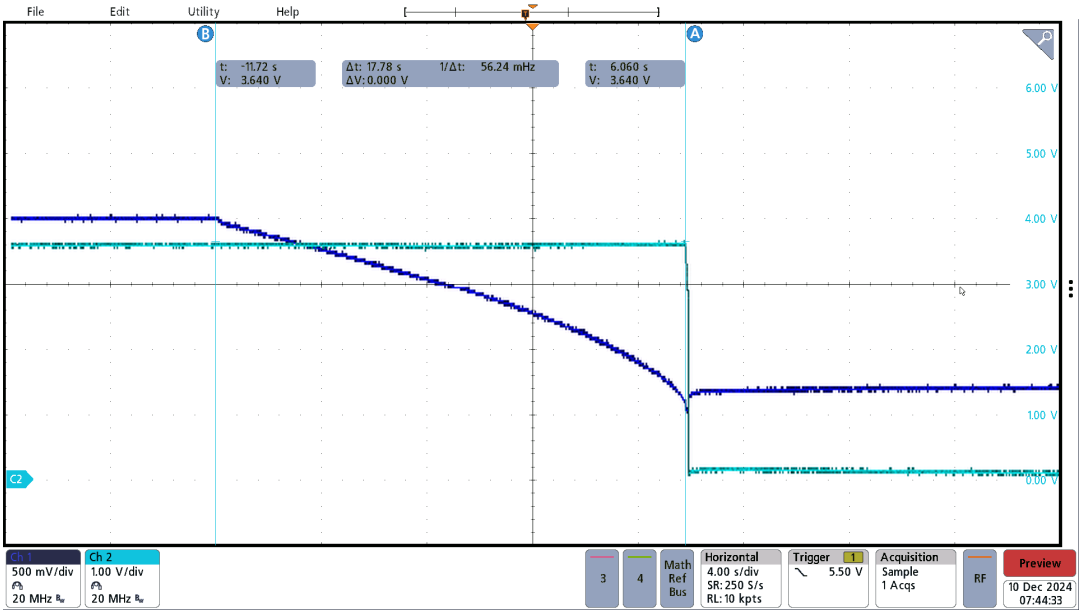
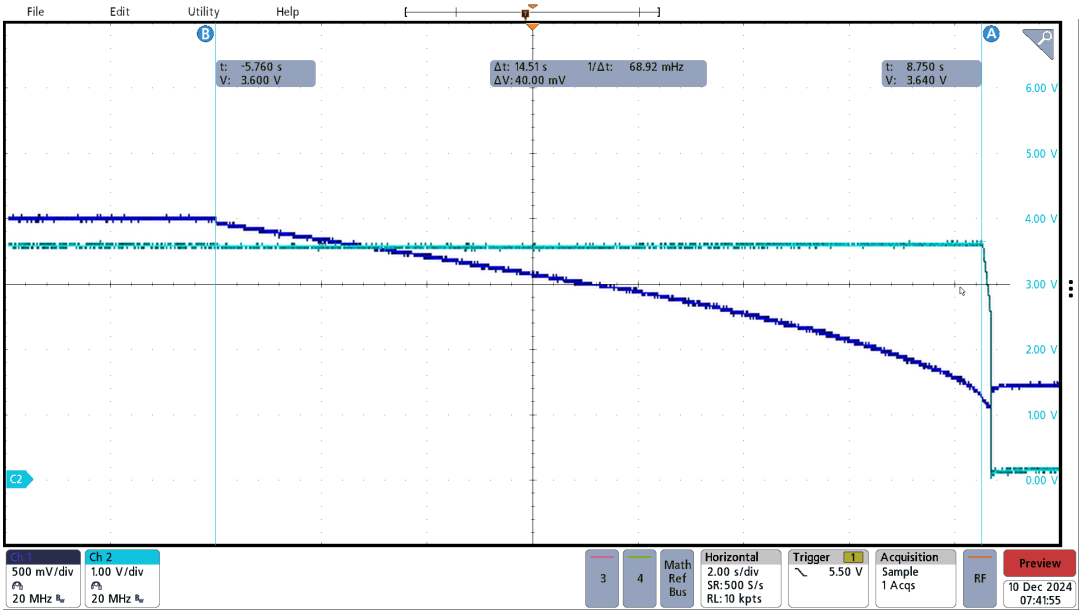


Ch 1: Supercapacitor voltage; Ch 2: Output voltage; measured 17.7 seconds

Figure 2-11. Output Holdup Time, 0.6A Load



Ch 1: Supercapacitor voltage; Ch 2: Output voltage; measured 14.5 seconds

Figure 2-12. Output Holdup Time, 0.7A Load

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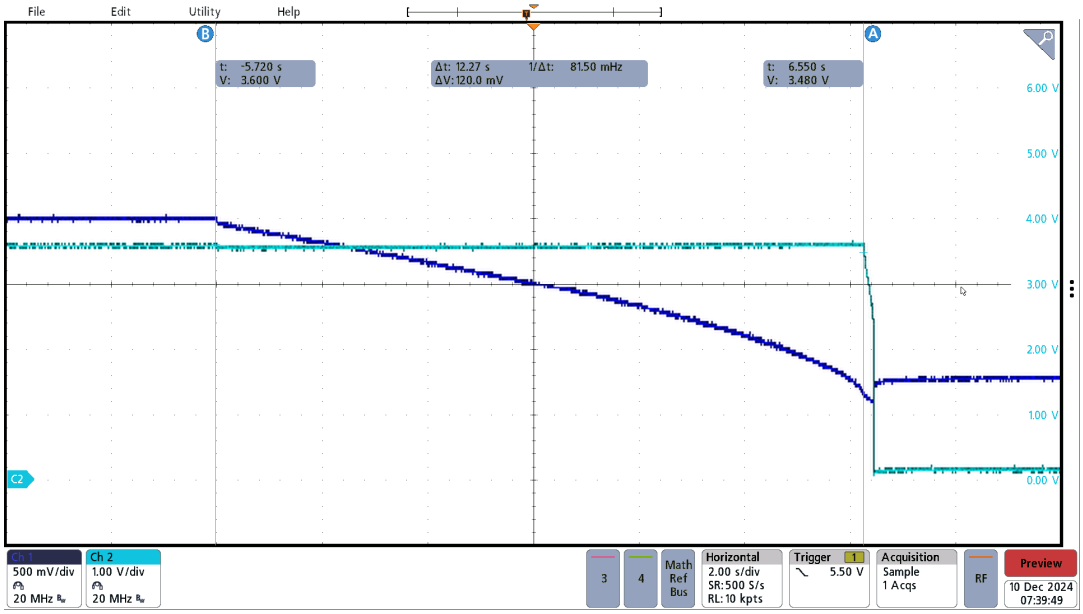
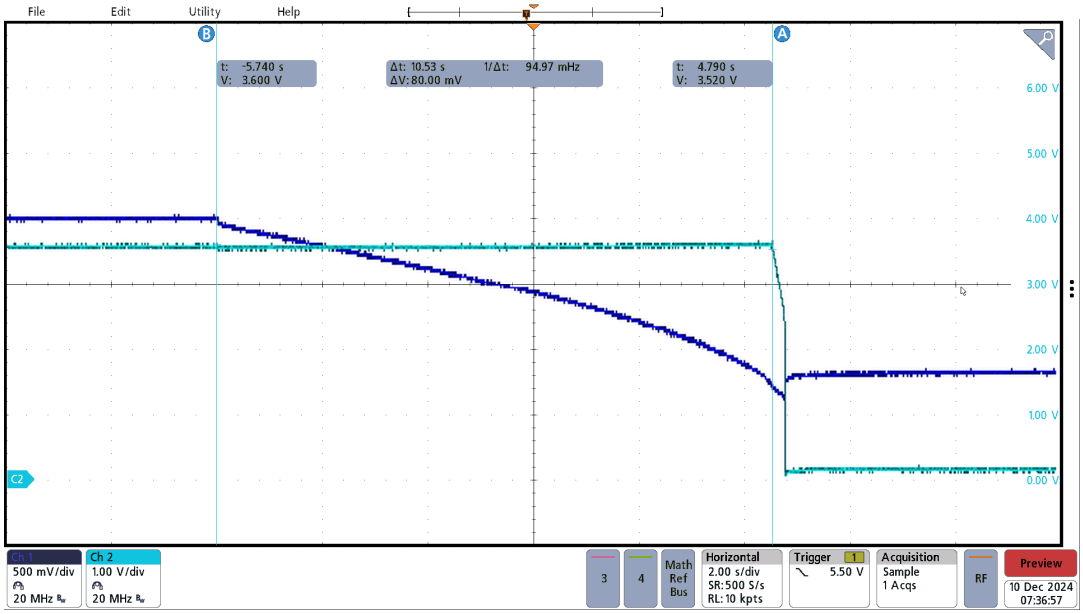


Ch 1: Supercapacitor voltage; Ch 2: Output voltage; measured 12.2 seconds

Figure 2-13. Output Holdup Time, 0.8A Load



Ch 1: Supercapacitor voltage; Ch 2: Output voltage; measured 10.5 seconds

Figure 2-14. Output Holdup Time, 0.9A Load

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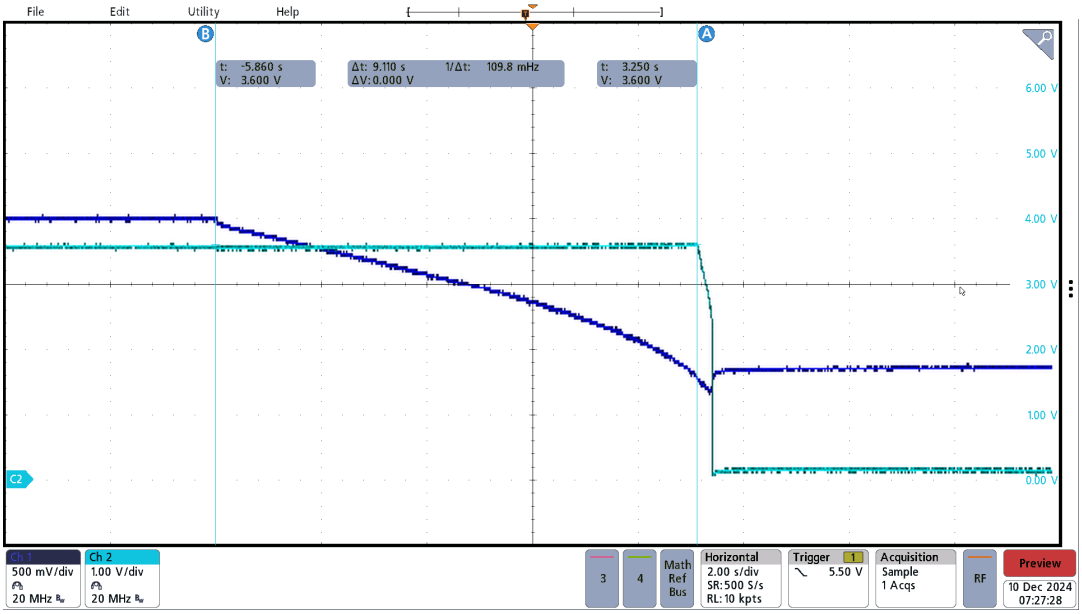

Ch 1: Supercapacitor voltage; Ch 2: Output voltage; measured 9.1 seconds

Figure 2-15. Output Holdup Time, 1A Load

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3 Waveforms

3.1 Switching

Figure 3-1 and Figure 3-2 show the switching behavior waveforms.

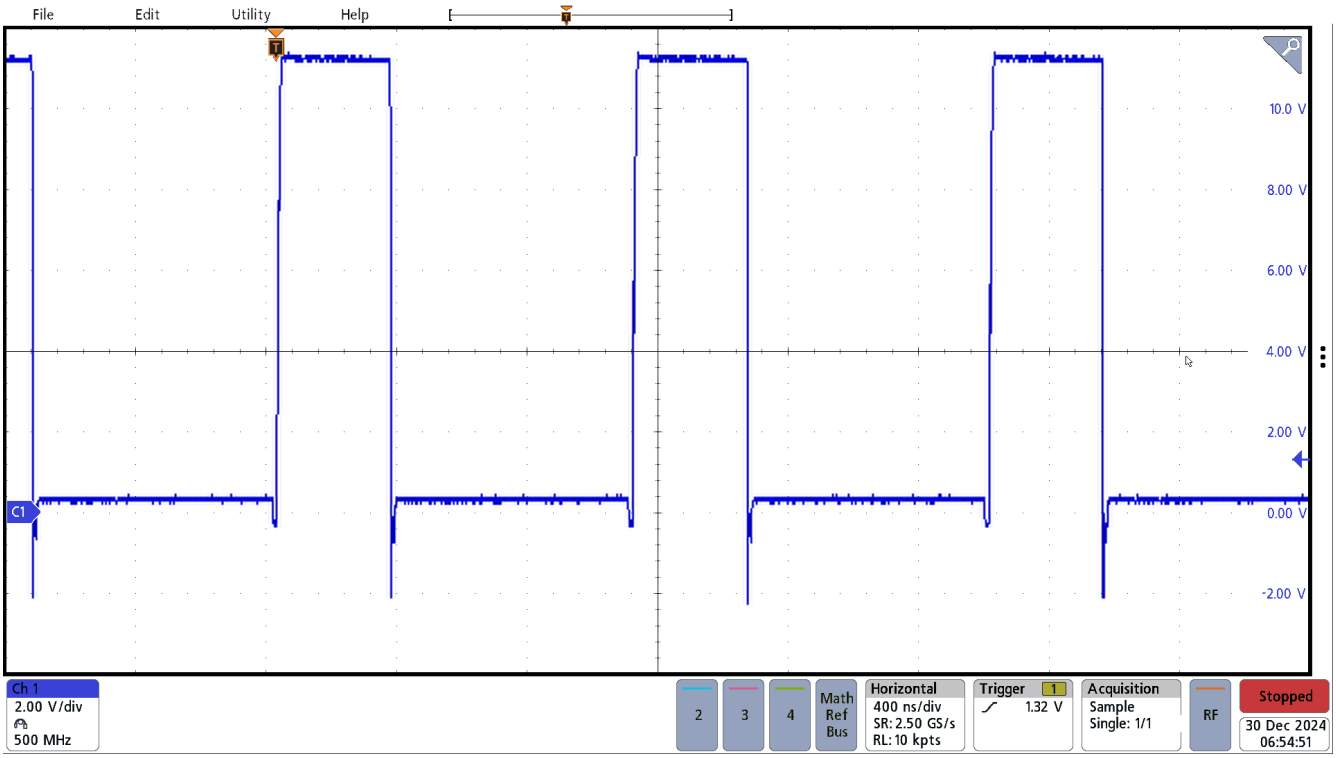

Figure 3-1. Buck Converter Switch Node

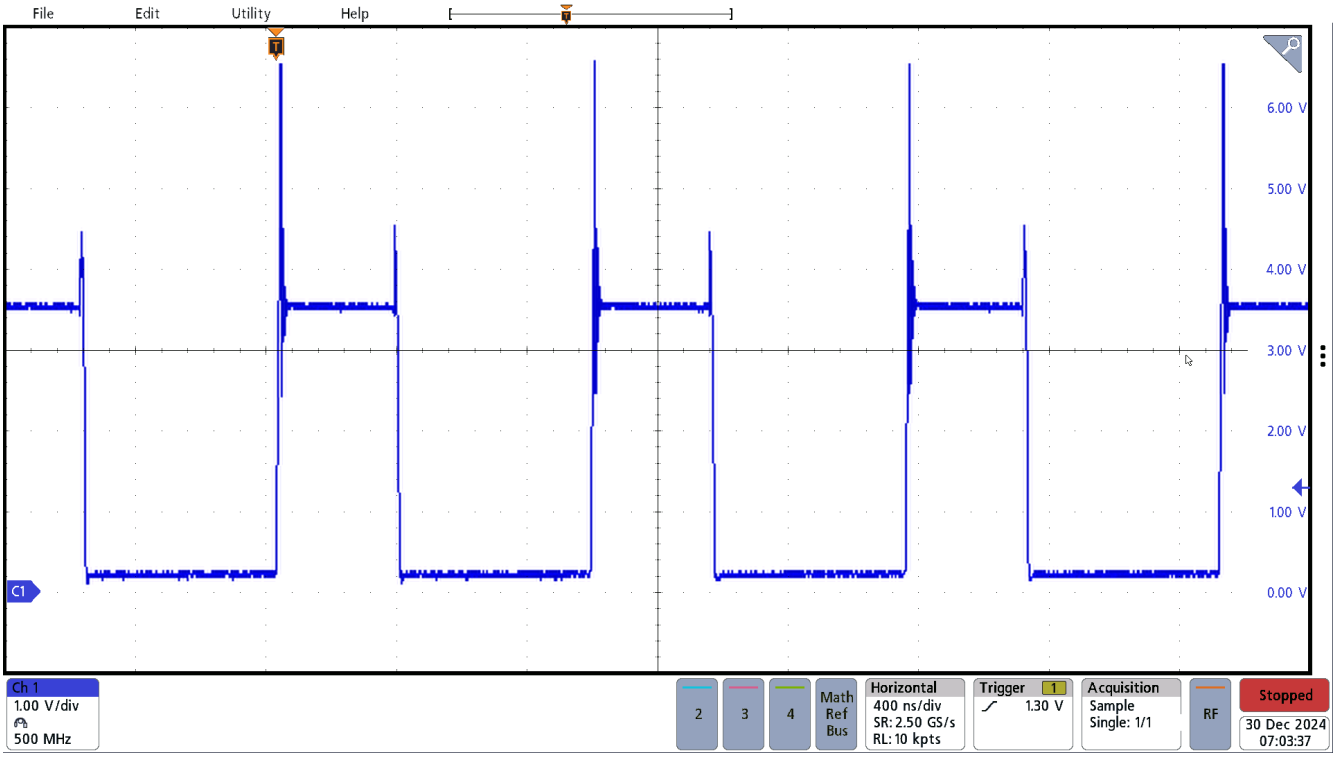

Figure 3-2. Boost Converter Switch Node

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3.2 Input and Output Voltage Ripple

3.2.1 Buck Converter

Figure 3-3 shows the input ripple, buck converter waveform and Figure 3-4 shows the output ripple, buck converter waveform.

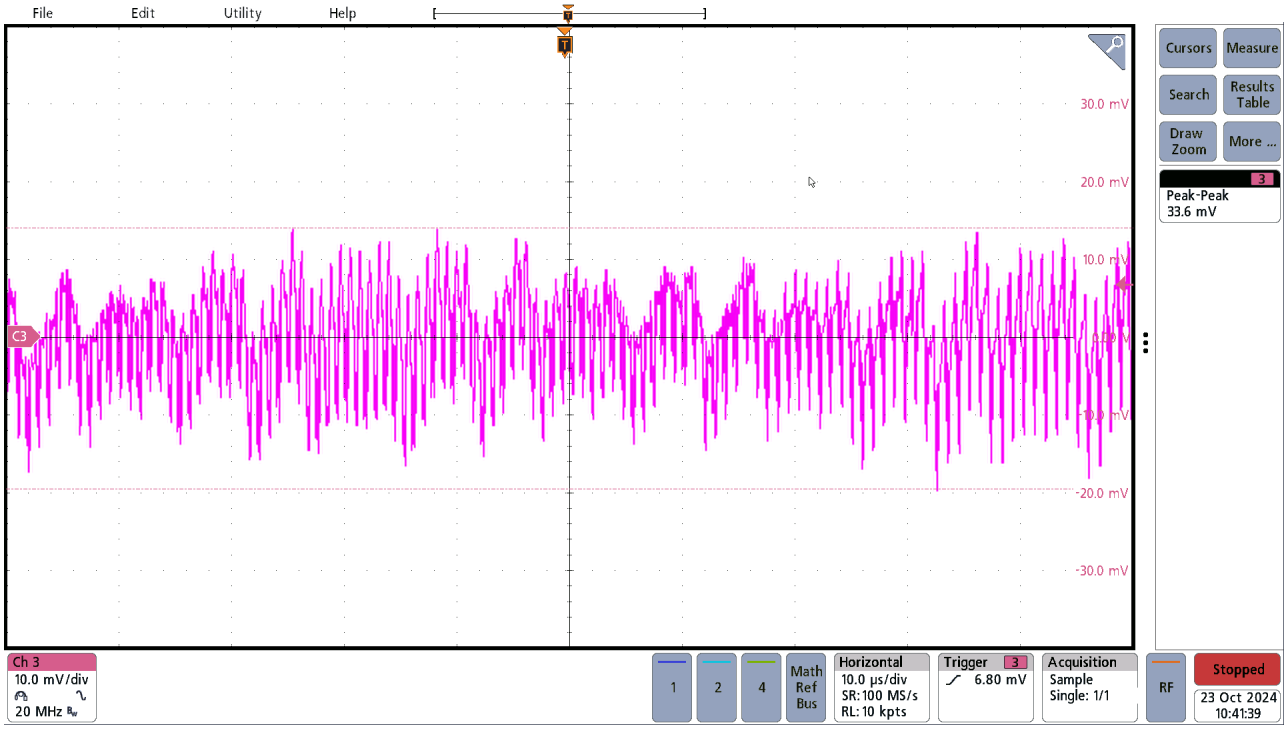

Figure 3-3. Input Ripple, Buck Converter, Measured 33.6mV at J1

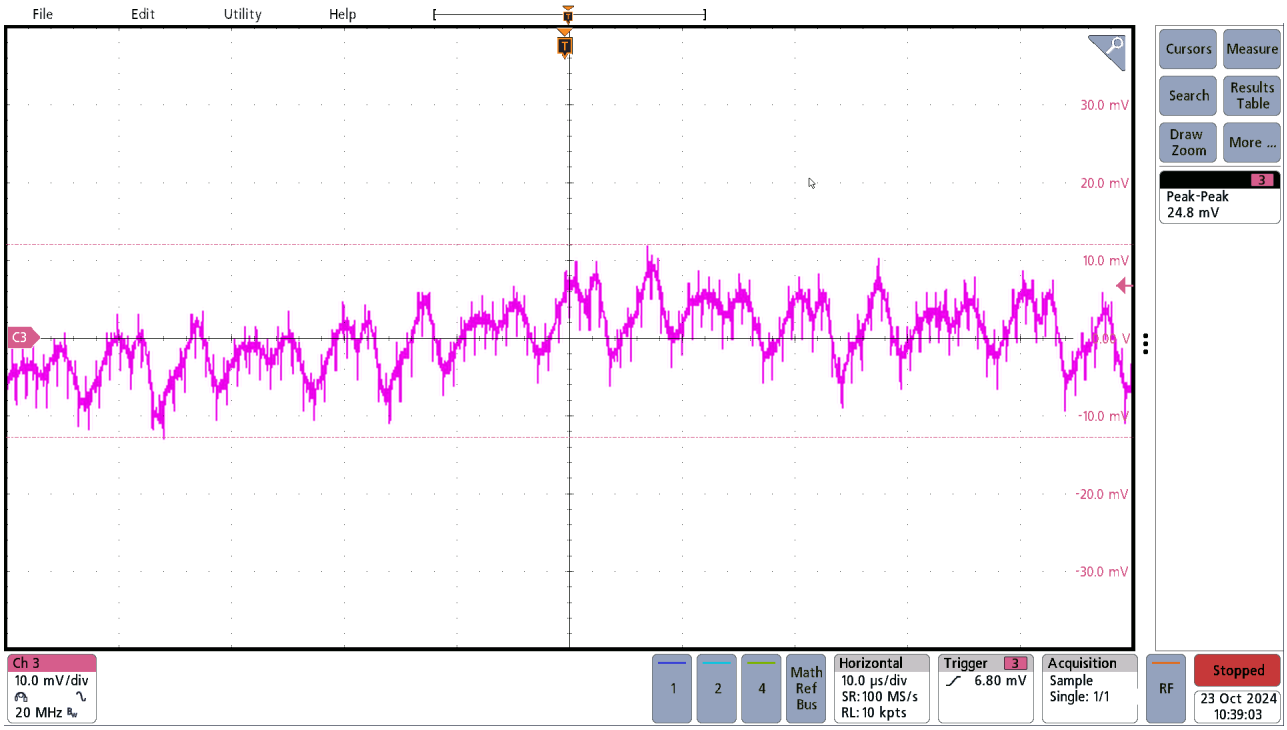

Figure 3-4. Output Ripple, Buck Converter, Measured 24.8mV at J4

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3.2.2 Boost Converter

Figure 3-5 shows the input ripple, boost converter waveform and Figure 3-6 shows the output ripple, boost converter waveform.

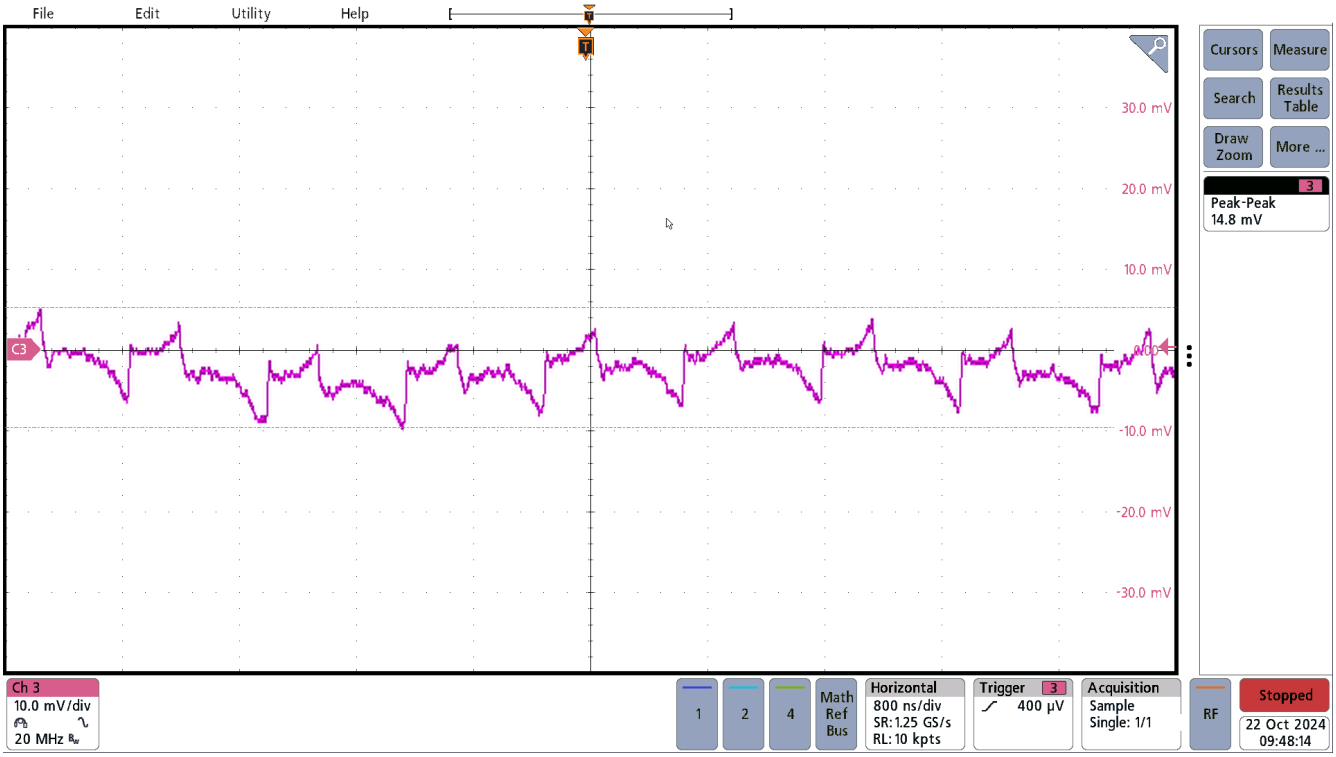

Figure 3-5. Input Ripple, Boost Converter, Measured 14.8mV at TP4 and TP5 (Supercapacitor Not Installed)

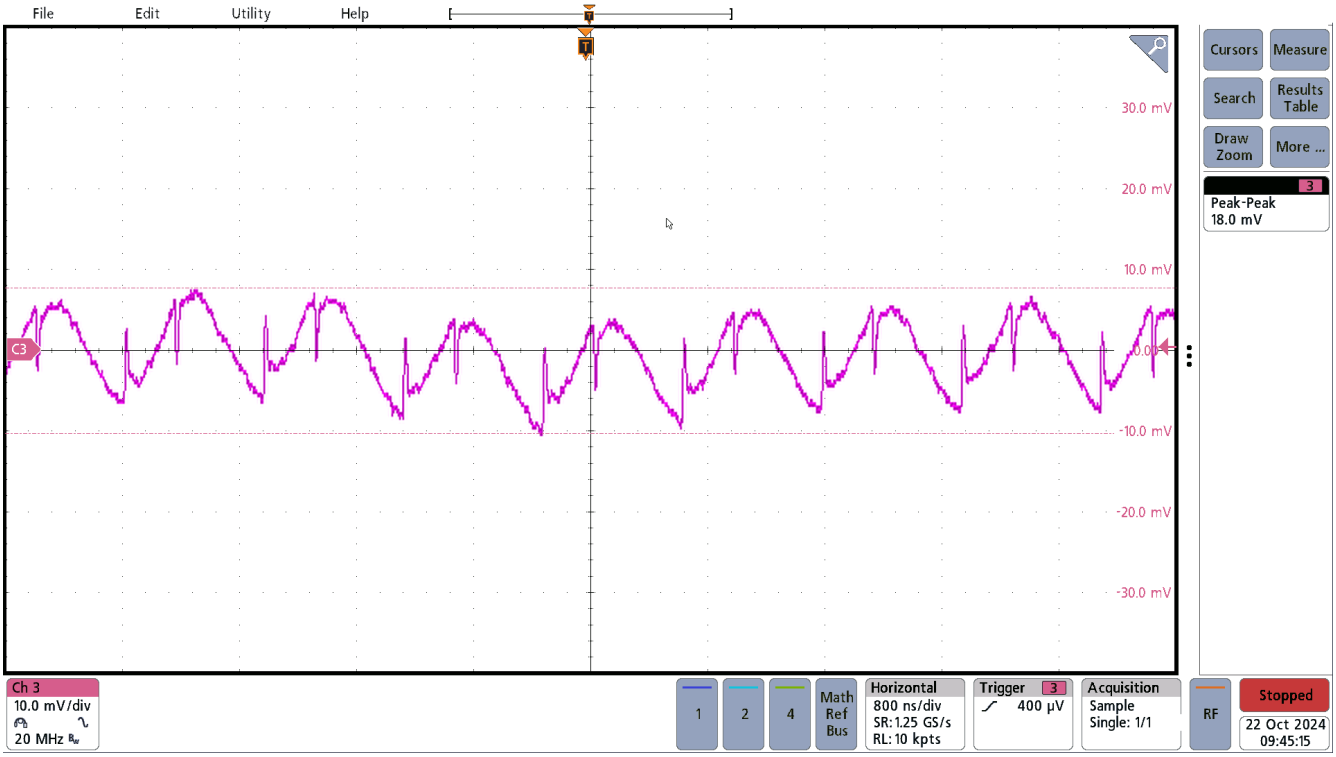

Figure 3-6. Output Ripple, Boost Converter, Measured 18.0mV at J8 (Supercapacitor Not Installed)

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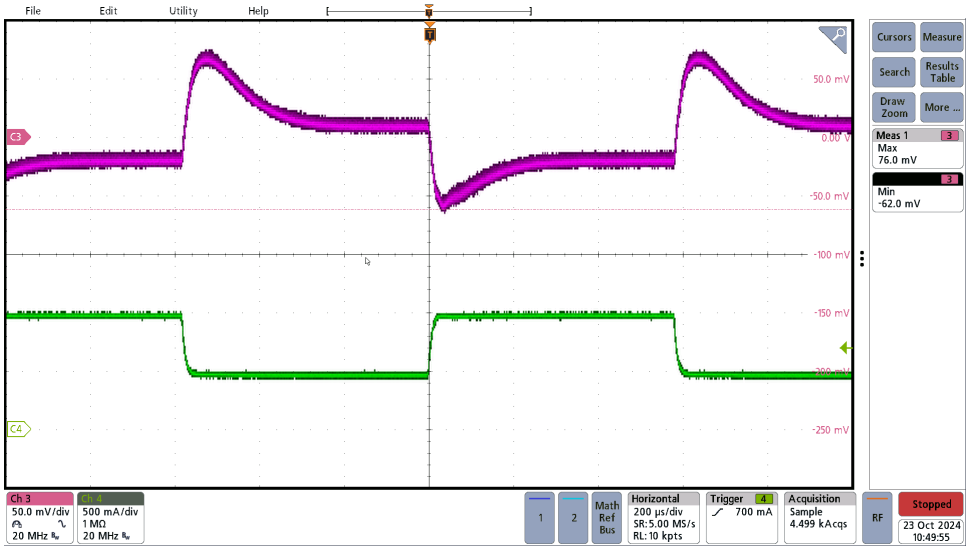
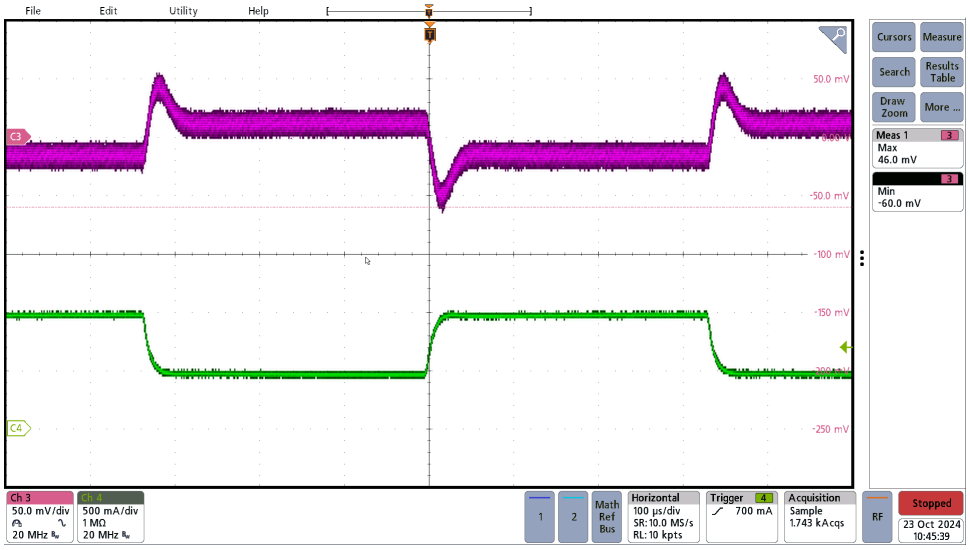
3.3 Load Transients

Figure 3-7 and Figure 3-8 show the load transient response waveforms.



Ch 3: output voltage at J2, AC coupled; Ch 4: output current at J2; measured 76mV overshoot and 62mV undershoot

Figure 3-7. Boost Converter Load Transient, 0.5A to 1A, 1.5V Input



Ch 3: output voltage at J2, AC coupled; Ch 4: output current at J2; measured 46mV overshoot and 60mV undershoot

Figure 3-8. Buck Converter Load Transient, 0.5A to 1A, 12V Input

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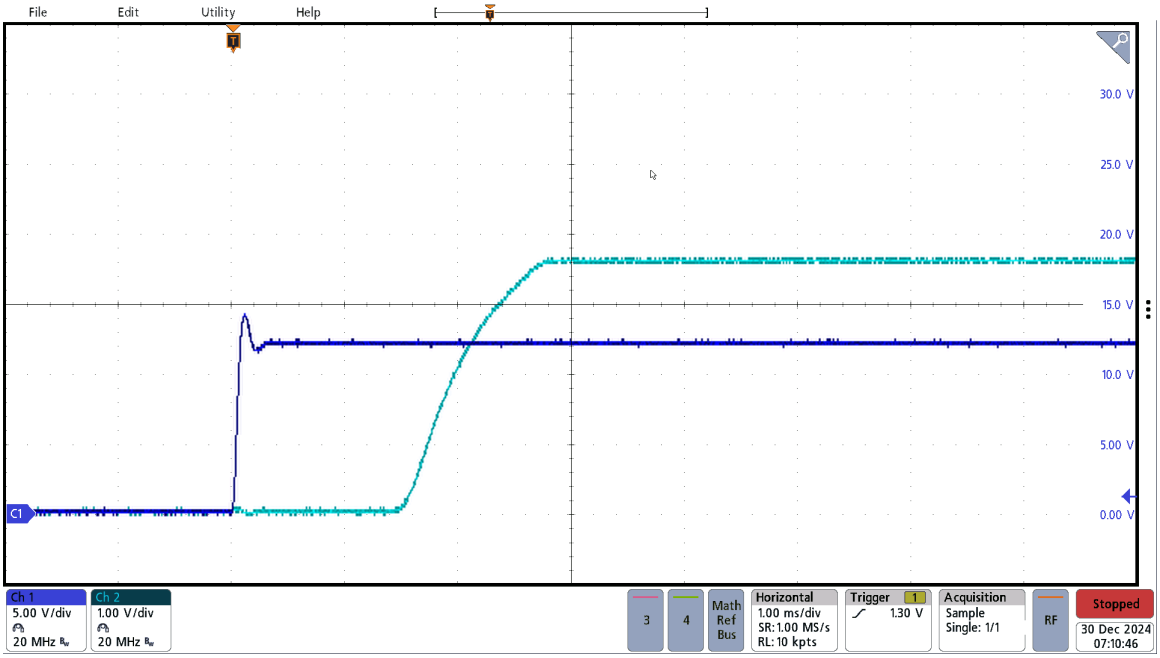
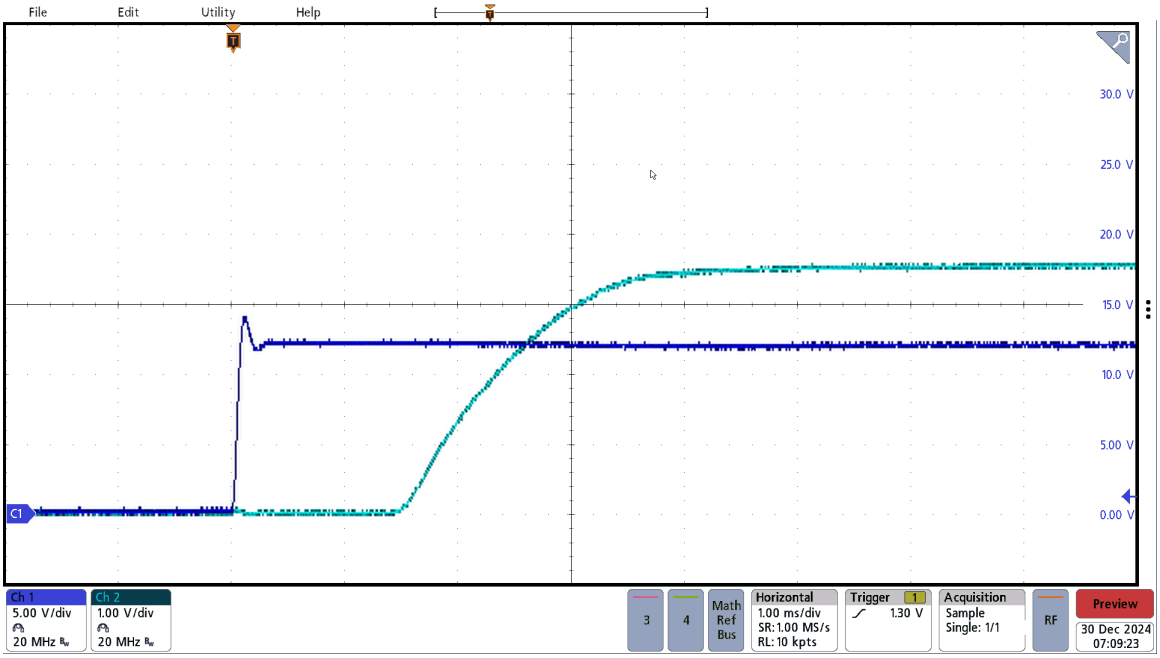
3.4 Start-up Sequence

Figure 3-9 and Figure 3-10 show the buck converter start-up behavior waveforms.



Ch 1: input voltage at J1; Ch 2: output voltage at J2

Figure 3-9. Buck Converter Turn-On, 0A Load



Ch 1: input voltage at J1; Ch 2: output voltage at J2

Figure 3-10. Buck Converter Turn-On, 1A Load

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