Test Report: PMP23331

19-W, AC/DC Multi-Output 12-V and 5-V, ZVS Flyback Reference Design for Server Applications

Description

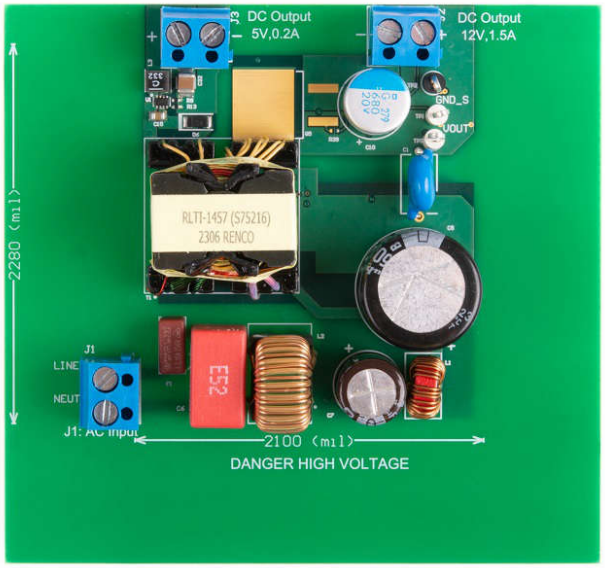
This reference design converts universal AC input to an isolated 12 V at 1.5-A output and an isolated 5 V at 0.2-A output. The design achieves a peak efficiency of 92.7%. The design features the UCC28781-Q1 which is a zero-voltage switching (ZVS) flyback controller to minimize switching losses, the UCC5350, a reinforced isolated gate driver to drive the synchronous rectifier MOSFET, and the TPS629203, a synchronous buck converter with low quiescent current.

Features

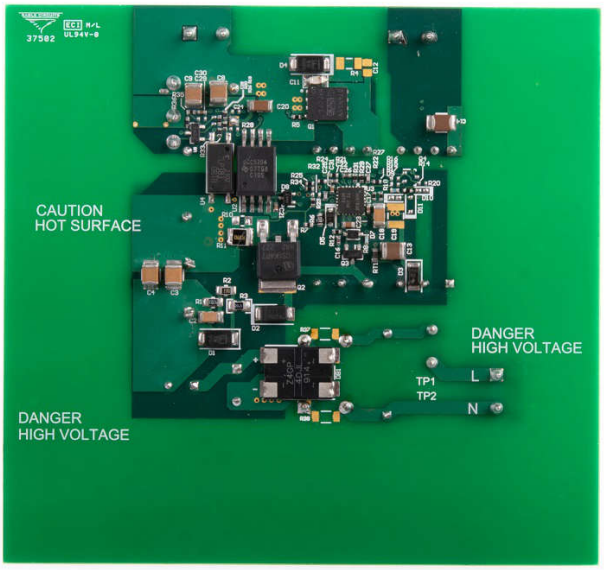
- Peak efficiency of 92.7%
- Zero voltage switching on the primary side
- Synchronous rectification to minimize conduction loss

Applications

- Industrial AC/DC
- Single phase line interactive UPS
- Single phase online UPS
- Medical PSU



PMP23331 Top Side



PMP23331 Bottom Side

1 Test Prerequisites

1.1 Voltage and Current Requirements

Table 1-1. Voltage and Current Requirements

Parameter	Specifications
Input voltage	90 V_{AC} – 265 V_{AC}
Input voltage frequency	47 Hz – 63 Hz
Output voltage 1	12 V_{DC}
Output voltage 1 maximum output current	1.5 A
Output voltage 2	5 V_{DC}
Output voltage 2 maximum output current	0.2 A

2 Testing and Results

2.1 Efficiency Graphs

Figure 2-1 shows the end-to-end efficiency of the PMP23331 with the 5-V output loaded with 0 A and Figure 2-2 with the 5-V output loaded with 0.2 A. Note that for 400-V DC input, the input voltage is applied directly across C5.

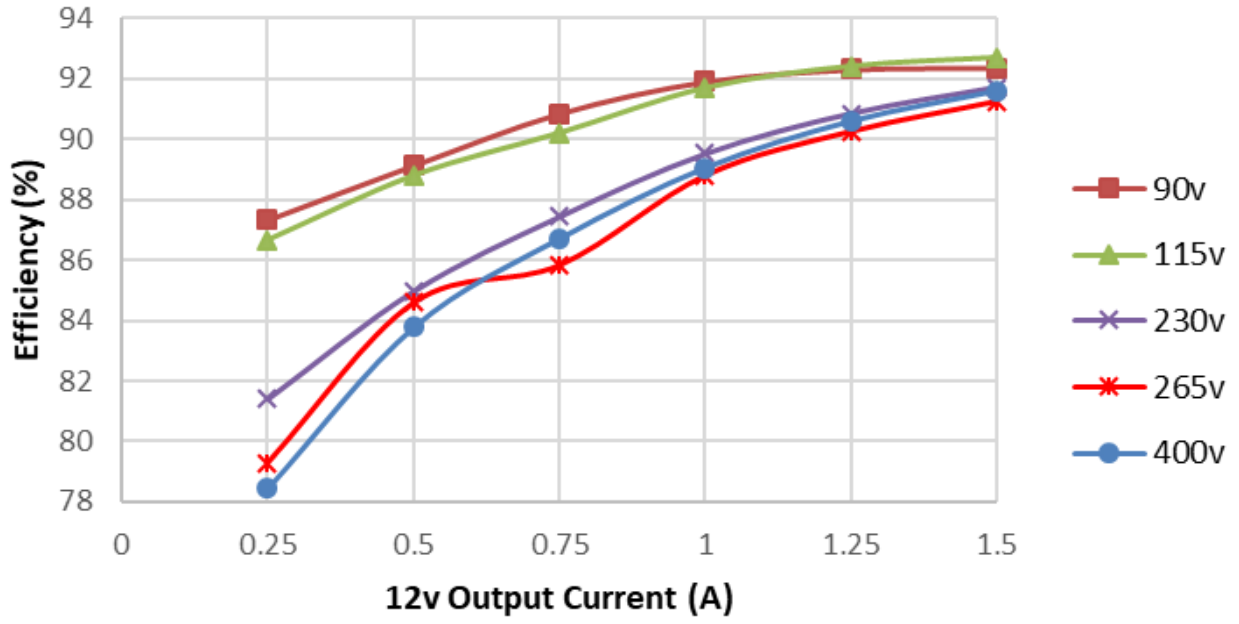


Figure 2-1. PMP23331 Efficiency Graph 5-V Unloaded

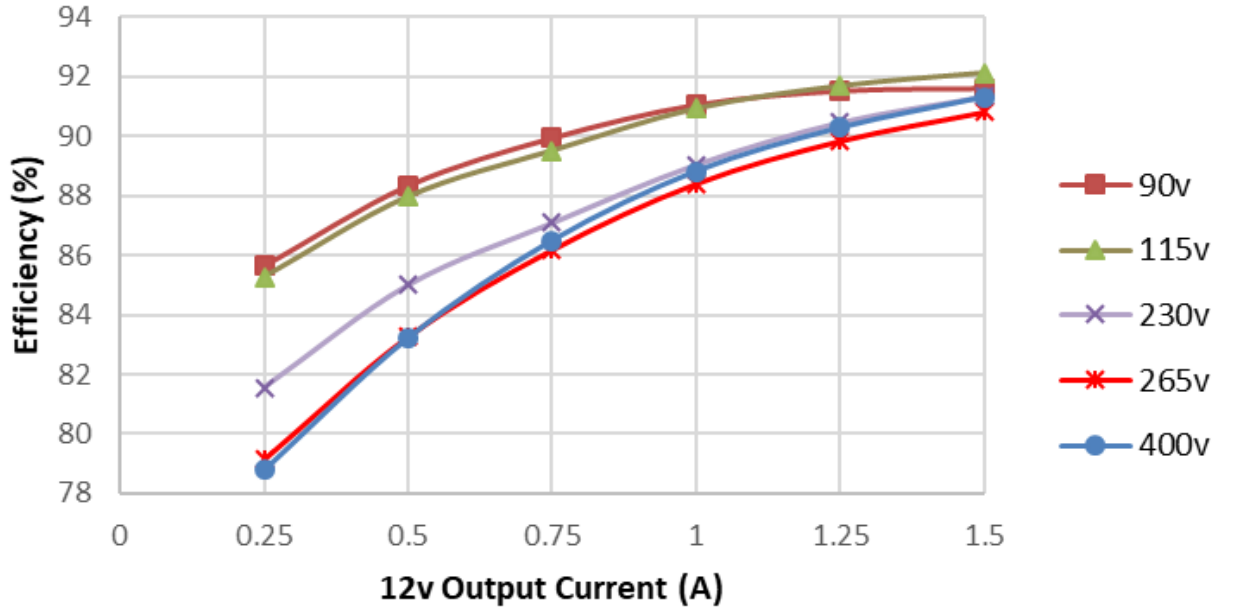


Figure 2-2. PMP23331 Efficiency Graph 5-V Loaded at 0.2 A

2.2 Efficiency Data

Efficiency data with the 5-V output at no load is shown in the following table.

Table 2-1. PMP23331 Efficiency With 5-V Output at No Load

Input Voltage (V_{RMS})	Input Power (W)	Output Voltage (V)	Output Current (A)	Efficiency (%)
90	0.0647	12.05	0	0
90	3.45	12.05	0.25	87.31884
90	6.76	12.05	0.5	89.12722
90	9.948	12.05	0.75	90.84741
90	13.111	12.05	1	91.90756
90	16.318	12.05	1.25	92.30604
90	19.57	12.05	1.5	92.36076
115	0.069	12.05	0	0
115	3.476	12.05	0.25	86.66571
115	6.785	12.05	0.5	88.79882
115	10.019	12.05	0.75	90.20361
115	13.141	12.05	1	91.69774
115	16.299	12.05	1.25	92.41365
115	19.499	12.05	1.5	92.69706
230	0.117	12.05	0	0
230	3.7	12.05	0.25	81.41892
230	7.09	12.05	0.5	84.97884
230	10.336	12.05	0.75	87.43711
230	13.461	12.05	1	89.51787
230	16.58	12.05	1.25	90.84741
230	19.708	12.05	1.5	91.71402
265	0.142	12.05	0	0
265	3.799	12.05	0.25	79.29718
265	7.123	12.05	0.5	84.58515
265	10.53	12.05	0.75	85.82621
265	13.57	12.05	1	88.79882
265	16.69	12.05	1.25	90.24865
265	19.81	12.05	1.5	91.2418
400	0.128	12.05	0	0
400	3.84	12.05	0.25	78.45052
400	7.192	12.05	0.5	83.77364
400	10.424	12.05	0.75	86.69896
400	13.532	12.05	1	89.04818
400	16.628	12.05	1.25	90.58516
400	19.736	12.05	1.5	91.58391

Efficiency data with the 5-V output loaded with 0.2 A is shown in the following table.

Table 2-2. PMP23331 Efficiency With 5-V Output Loaded to 0.2 A

Input Voltage (V_{RMS})	Input Power (W)	Output Voltage1 (V)	Output Current1 (A)	Output Voltage2 (V)	Output Current2 (A)	Efficiency (%)
90	4.688	12.05	0.25	5.014	0.2	85.6505973
90	7.955	12.05	0.5	5.014	0.2	88.3444375
90	11.163	12.05	0.75	5.014	0.2	89.9426677
90	14.335	12.05	1	5.014	0.2	91.0554587
90	17.553	12.05	1.25	5.014	0.2	91.5245257
90	20.826	12.05	1.5	5.014	0.2	91.6056852
115	4.709	12.05	0.25	5.014	0.2	85.2686345
115	7.989	12.05	0.5	5.014	0.2	87.9684566
115	11.217	12.05	0.75	5.014	0.2	89.5096728
115	14.356	12.05	1	5.014	0.2	90.9222625
115	17.523	12.05	1.25	5.014	0.2	91.681219
115	20.71	12.05	1.5	5.014	0.2	92.1187832
230	4.923	12.05	0.25	5.014	0.2	81.5620557
230	8.268	12.05	0.5	5.014	0.2	85
230	11.53	12.05	0.75	5.014	0.2	87.0797918
230	14.66	12.05	1	5.014	0.2	89.0368349
230	17.76	12.05	1.25	5.014	0.2	90.4577703
230	20.89	12.05	1.5	5.014	0.2	91.3250359
265	5.073	12.05	0.25	5.014	0.2	79.1504041
265	8.44	12.05	0.5	5.014	0.2	83.2677725
265	11.65	12.05	0.75	5.014	0.2	86.1828326
265	14.765	12.05	1	5.014	0.2	88.4036573
265	17.883	12.05	1.25	5.014	0.2	89.8355981
265	21.01	12.05	1.5	5.014	0.2	90.8034269
400	5.096	12.05	0.25	5.014	0.2	78.7931711
400	8.444	12.05	0.5	5.014	0.2	83.2283278
400	11.608	12.05	0.75	5.014	0.2	86.4946589
400	14.696	12.05	1	5.014	0.2	88.8187262
400	17.796	12.05	1.25	5.014	0.2	90.2747808
400	20.896	12.05	1.5	5.014	0.2	91.2988132

2.3 Thermal Images

The following figures show the top and bottom thermal image of the PMP23331 at full load, taken after 20 minutes soak time, at 24°C ambient temperature and no forced airflow.

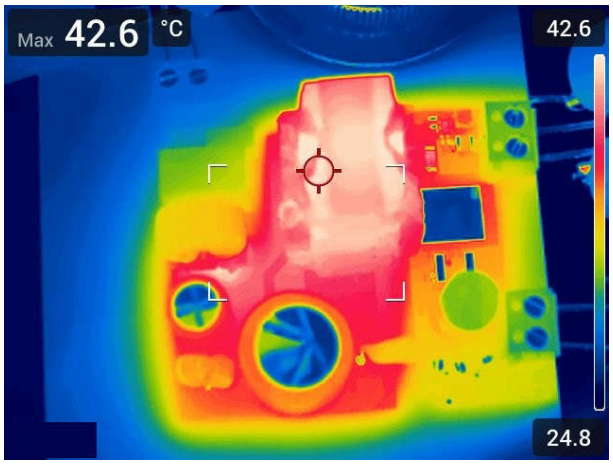


Figure 2-3. PMP23331 Thermal Image, 115-Vac Input, Top Side

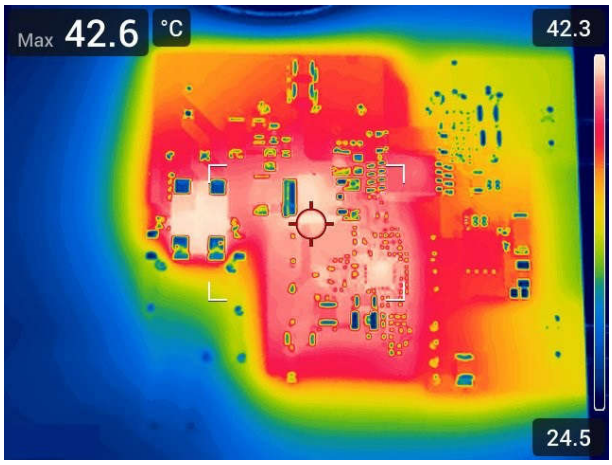


Figure 2-4. PMP23331 Thermal Image, 115-Vac Input, Bottom Side

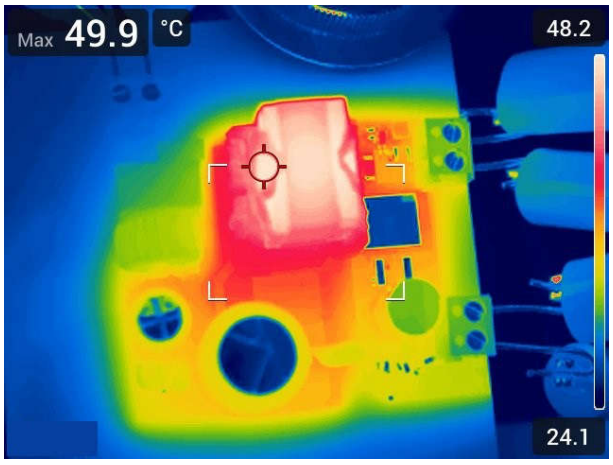


Figure 2-5. PMP23331 Thermal Image, 230-Vac Input, Top Side

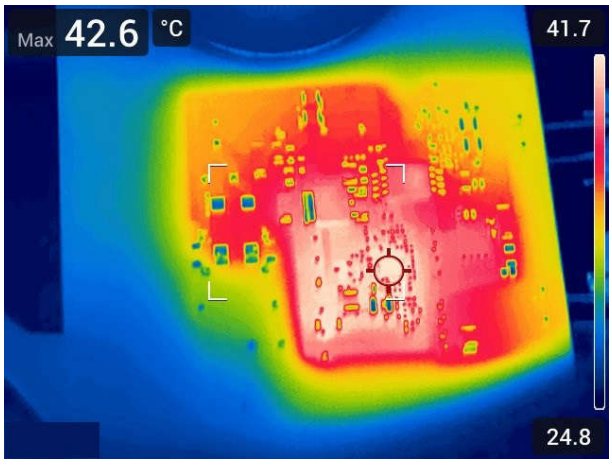


Figure 2-6. PMP23331 Thermal Image, 230-Vac Input, Bottom Side

2.4 Bode Plots

The following measurements show the loop response of the ZVS flyback at different AC input voltages and the 12-V output loaded to 1.5 A.

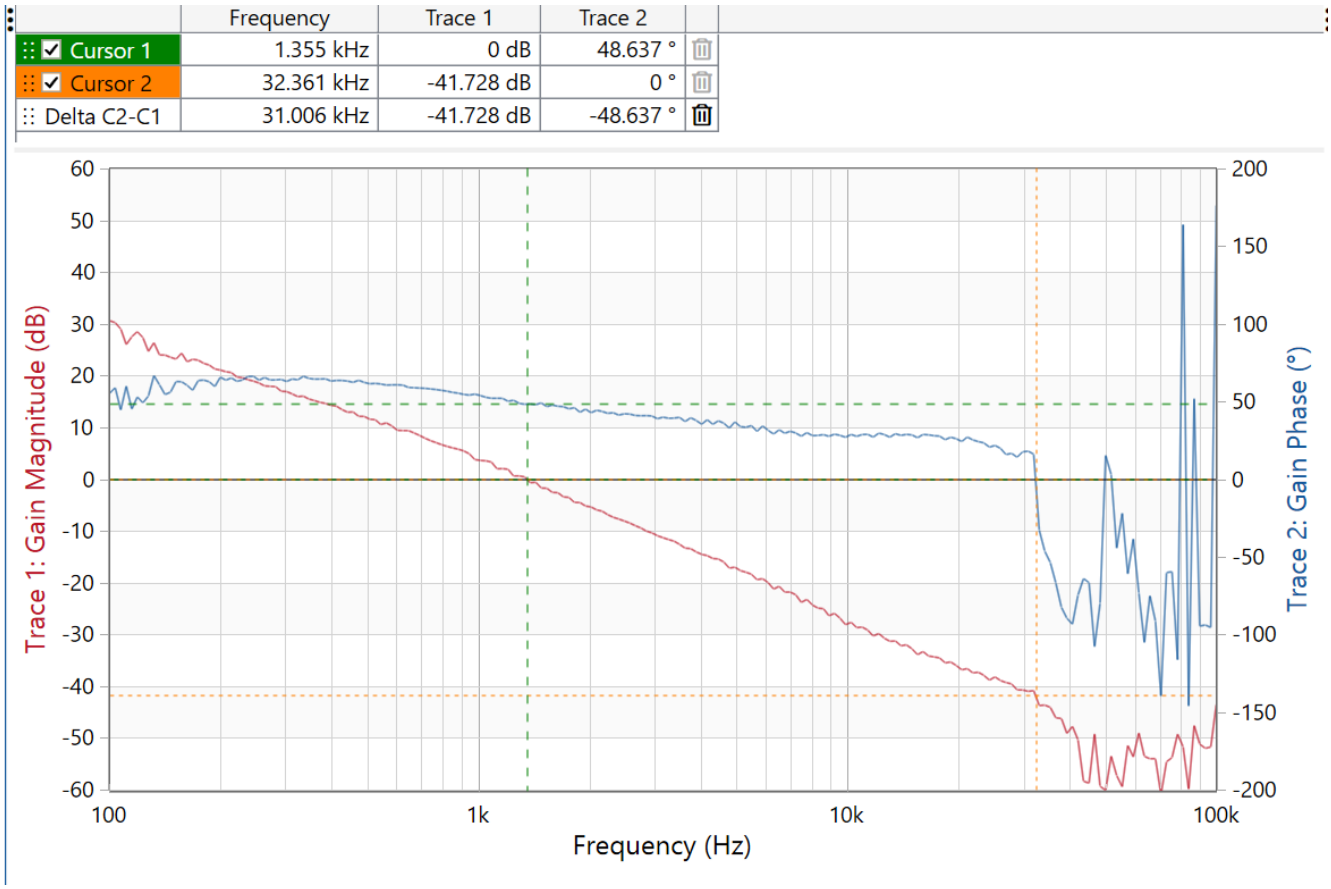


Figure 2-7. 90-Vac Input ZVS Flyback Loop Measurement

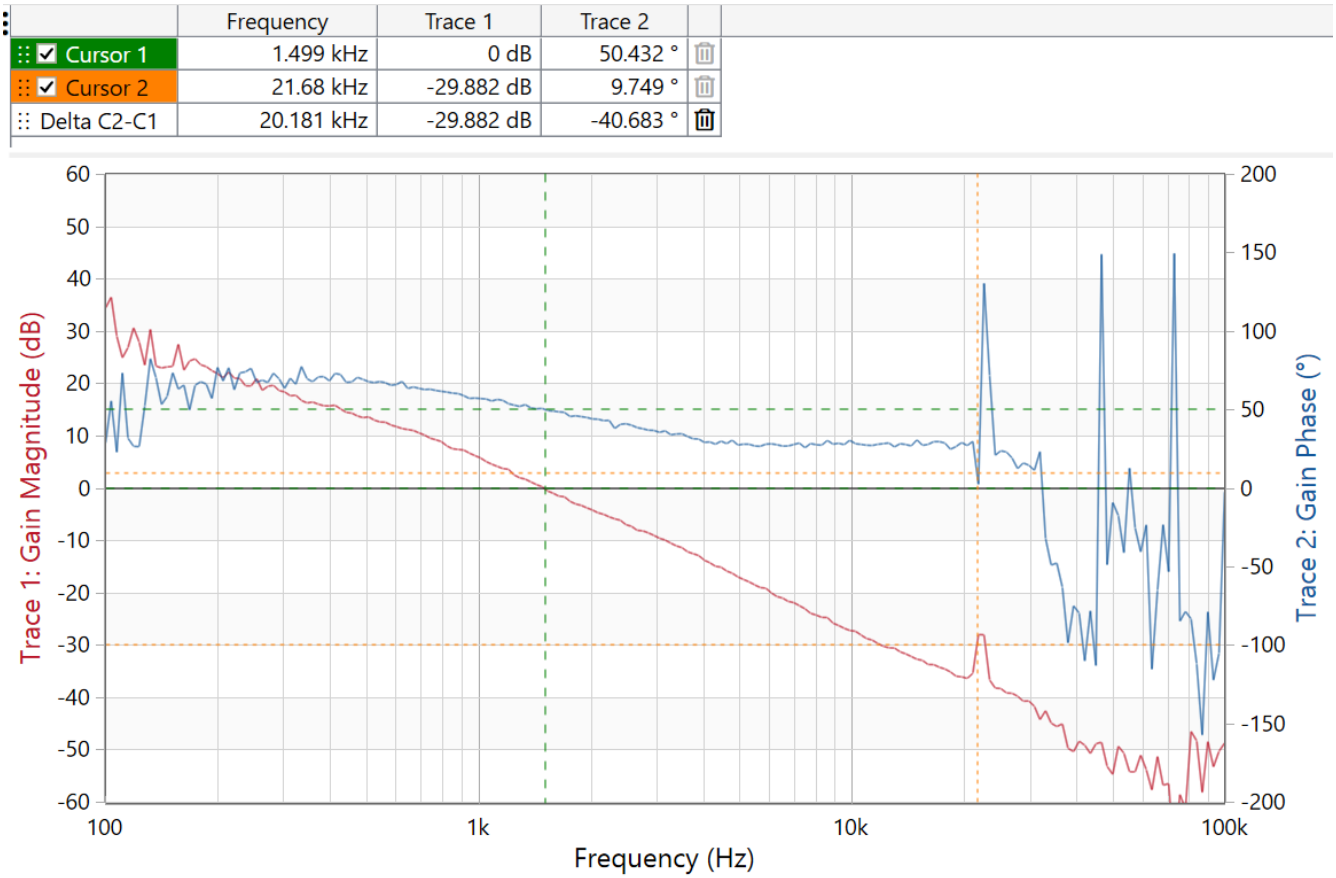


Figure 2-8. 115-Vac Input ZVS Flyback Loop Measurement

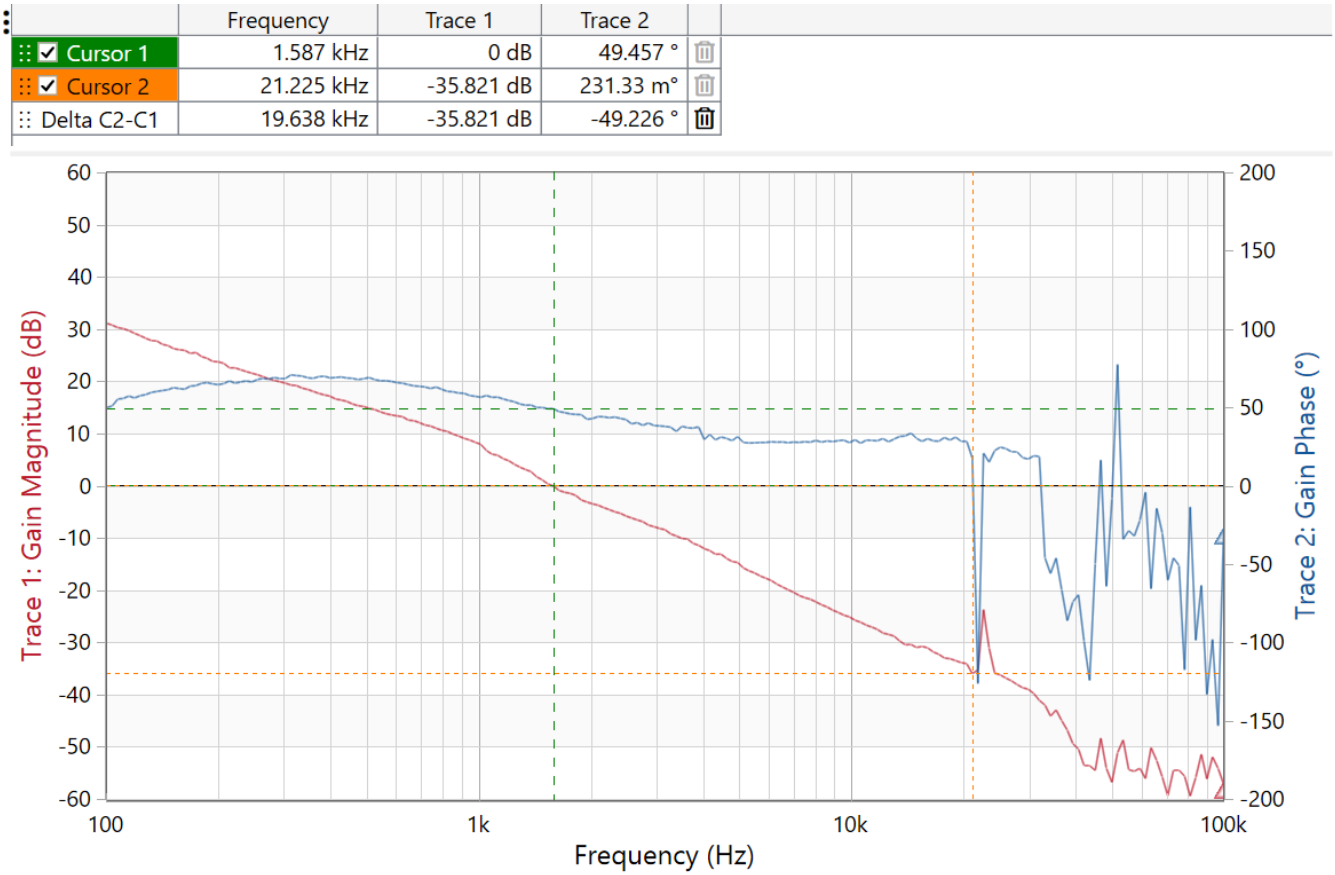


Figure 2-9. 230-Vac Input ZVS Flyback Loop Measurement

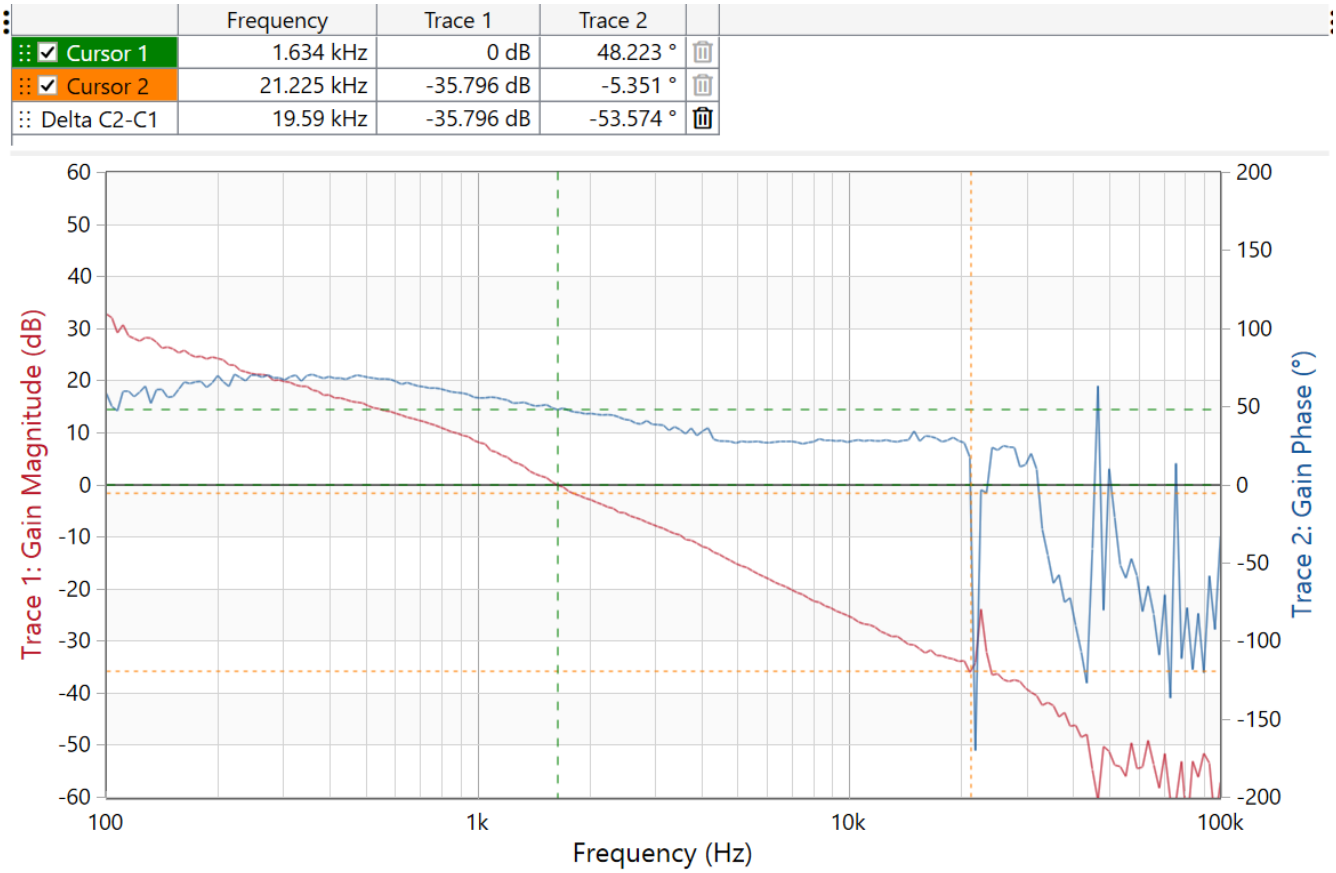


Figure 2-10. 265-Vac Input ZVS Flyback Loop Measurement

3 Waveforms

3.1 Switching Waveforms

The following images illustrate the switching waveforms. The channels are identified with the following:

C3 = Q2 Vds, C2 = 12-V output current

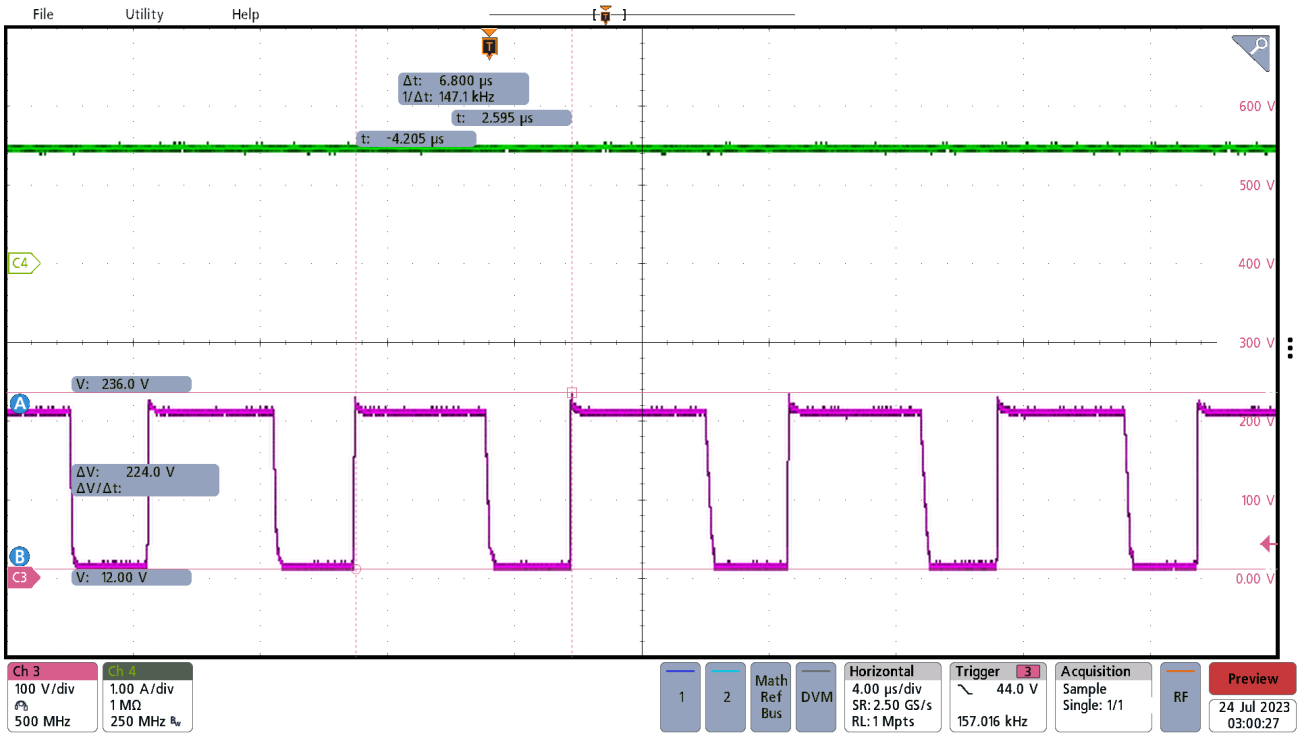


Figure 3-1. 115-Vac Input, 12-V Loaded to 1.5 A

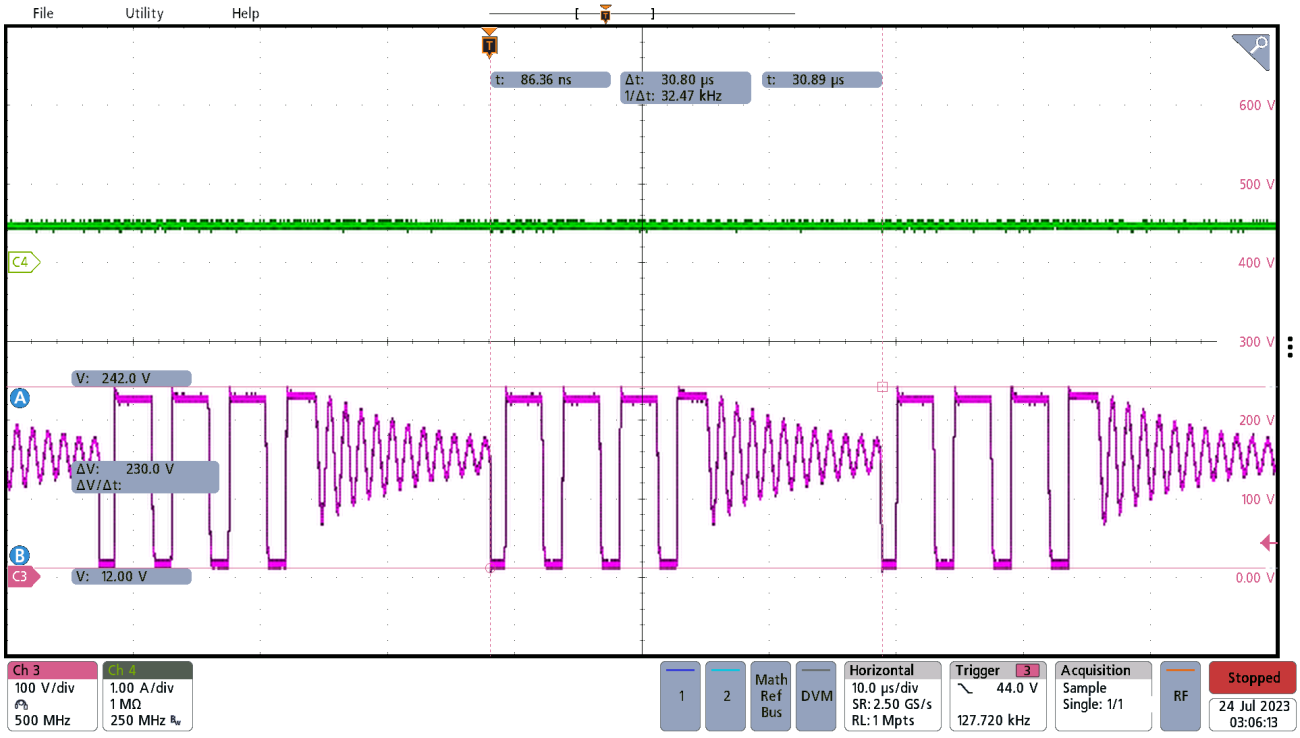


Figure 3-2. 115-Vac Input, 12-V Loaded to 0.5 A

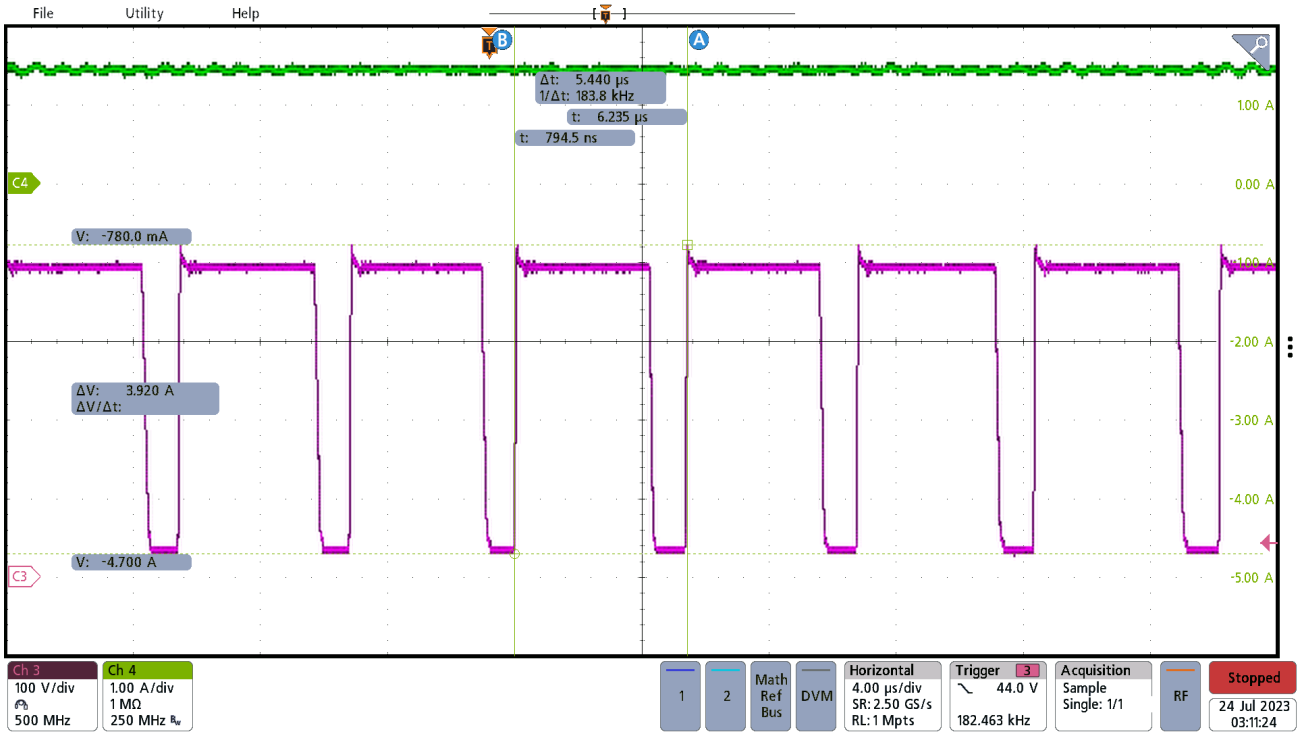


Figure 3-3. 230-Vac Input, 12-V Loaded to 1.5 A

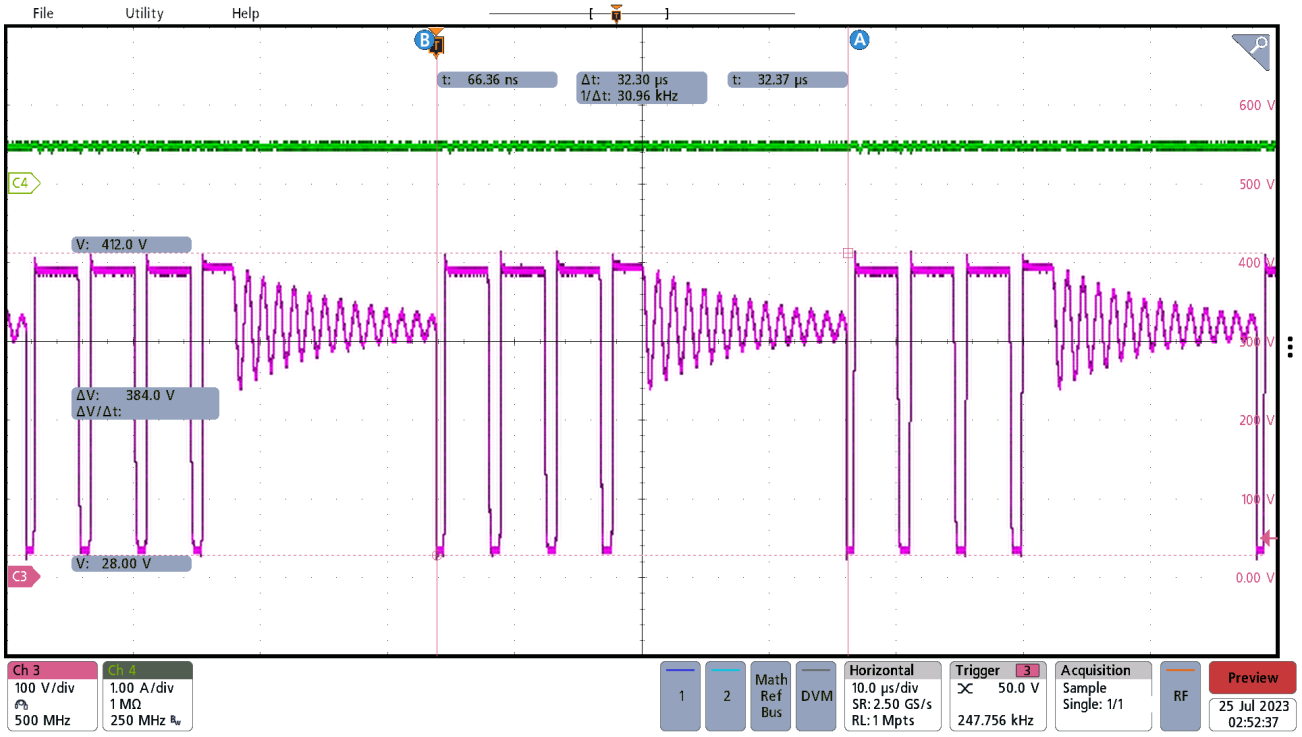


Figure 3-4. 230-Vac Input, 12-V Loaded to 0.5 A

3.2 Output Voltage Ripple

Output voltage ripple is shown in the following figures.

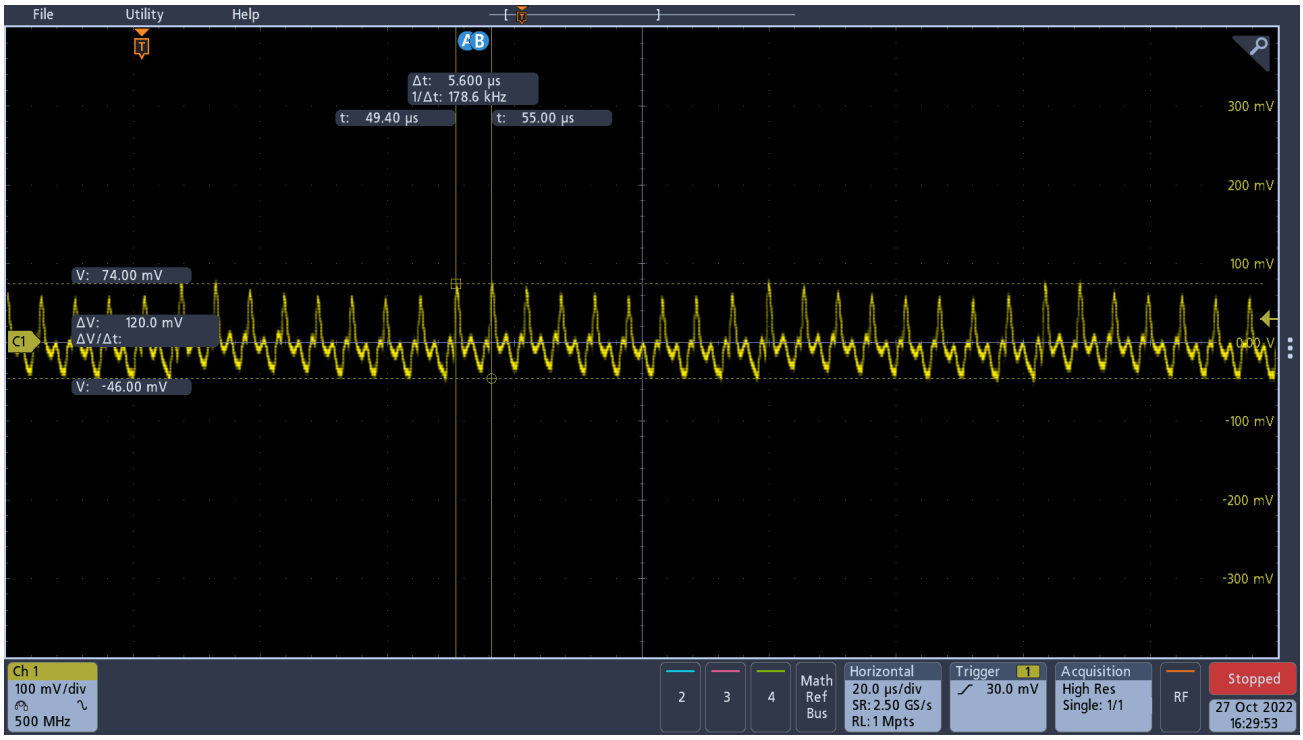


Figure 3-5. 12-V Output Voltage Ripple Full Load

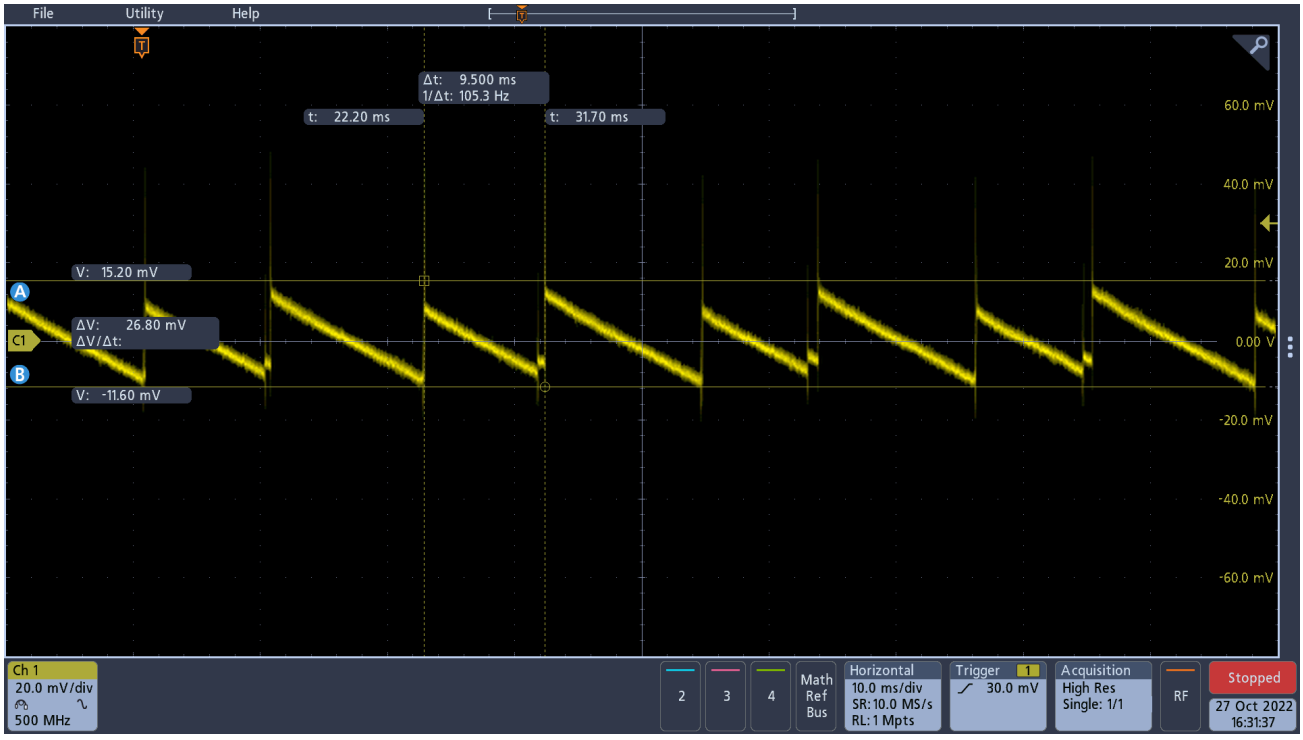


Figure 3-6. 12-V Output Voltage Ripple No Load

3.3 Load Transients

Load transient response is shown in the following waveforms. For Figure 3-7, the channels are identified with the following:

C1 = 12-V output, AC coupled, C4 = 12-V output current

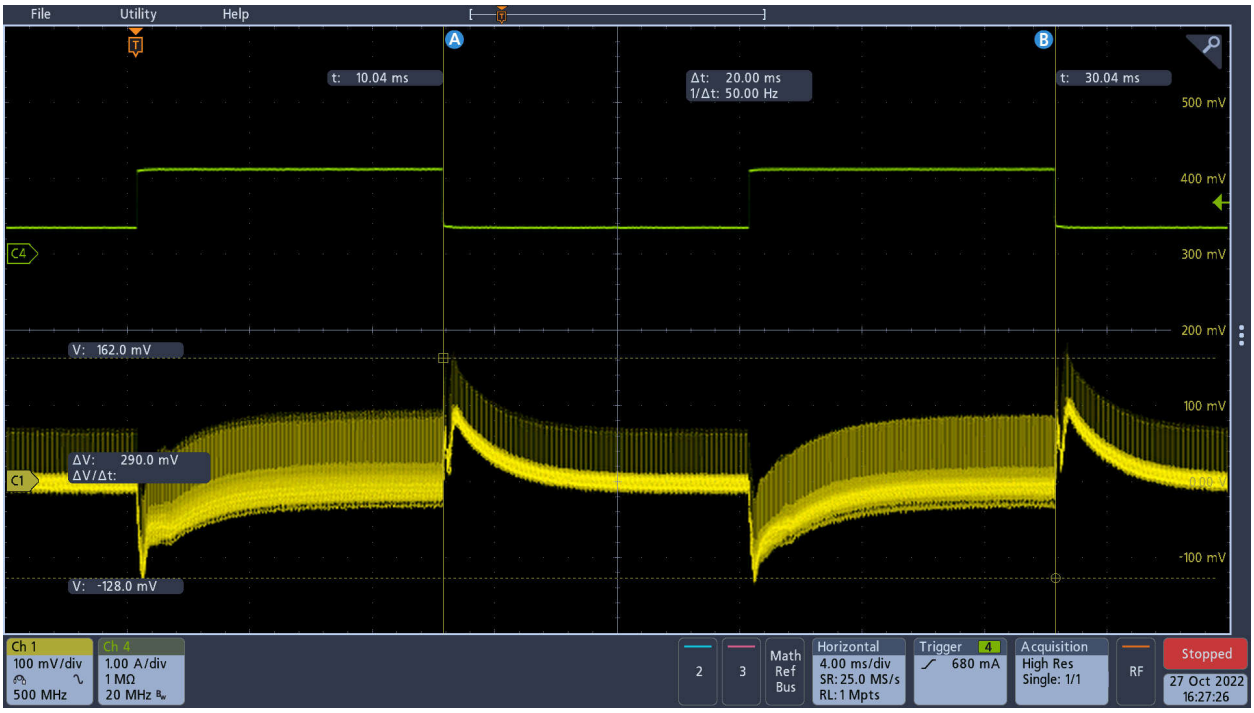


Figure 3-7. 12-V Output, 0.375-A to 1.125-A Load Step

For Figure 3-8, the channels are identified with the following:

C3 = 12-V output, AC coupled, C4 = 12-V output current

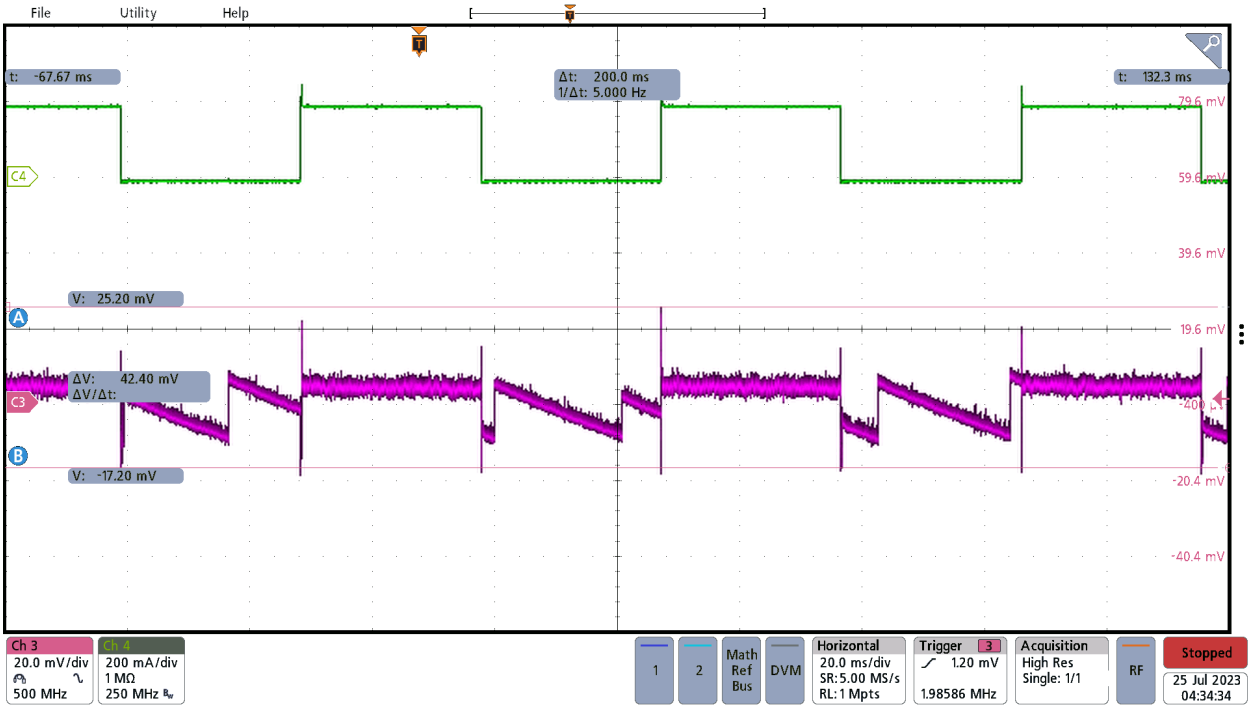


Figure 3-8. 5-V Output, 0-A to 0.2-A Load Step

3.4 Start-Up Sequence

Figure 3-9 and Figure 3-10 show the start-up behavior waveforms. The channels are identified with the following:

C1 = 12-V output, C2 = 5-V output, C4 = AC Input

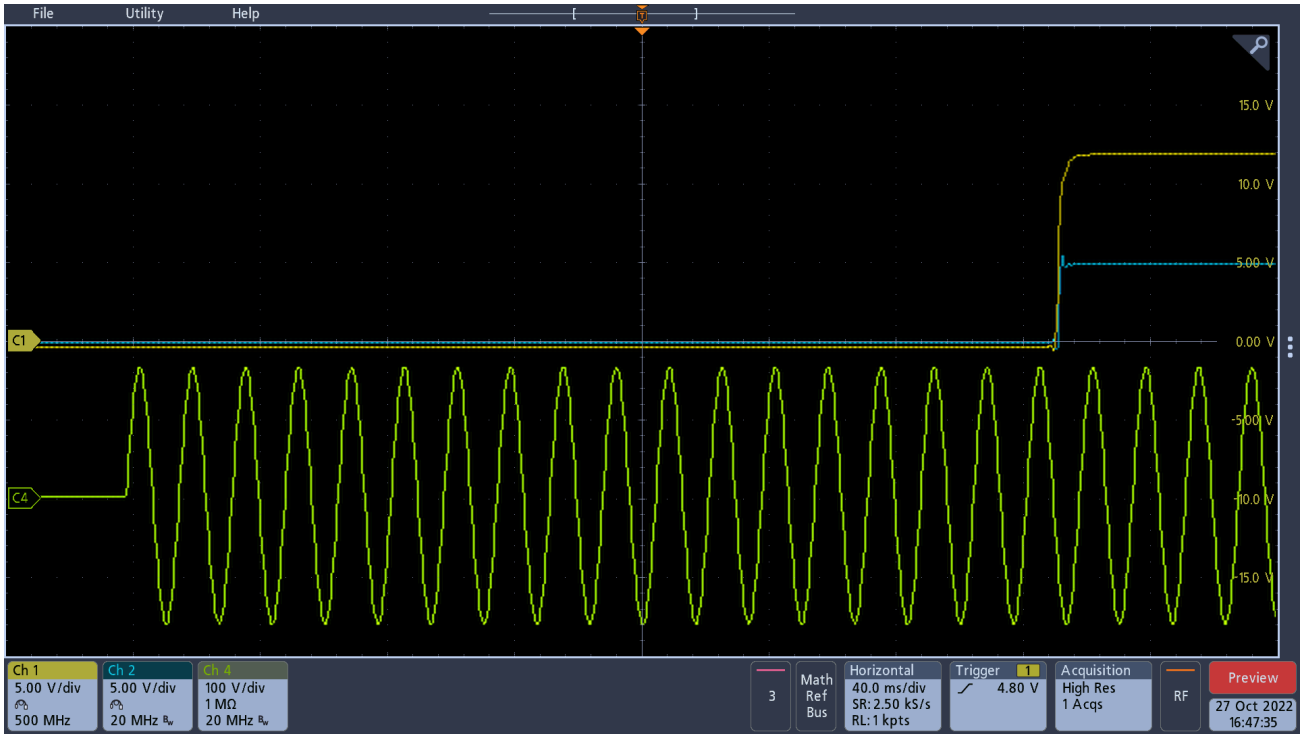


Figure 3-9. 115-Vac Input

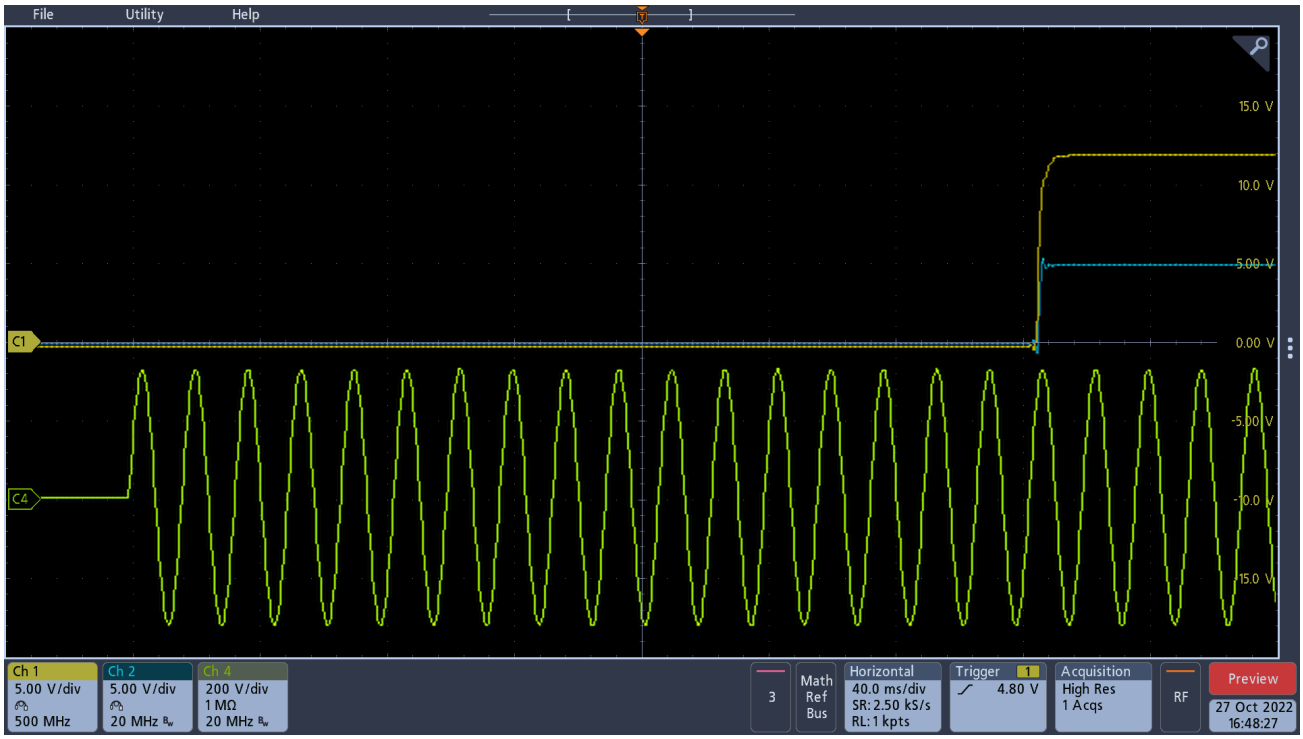


Figure 3-10. 230-Vac Input

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