Test Report: PMP22495

176–264 VAC Input, 24-V, 150-W Active Clamp Forward Reference Design

Description

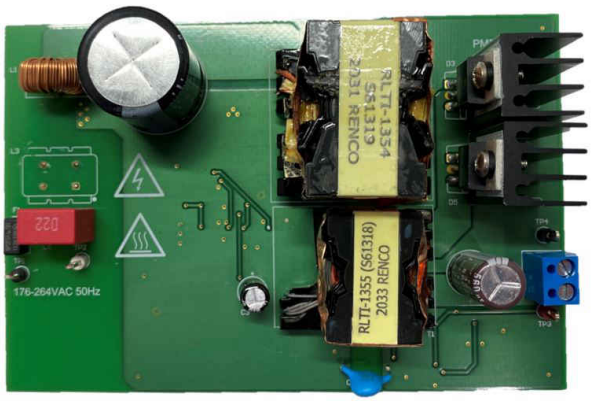
This reference design uses the UCC2897A active clamp forward controller to convert 176–264-VAC input to a 24-VDC output with a maximum power of 150 W. The UCC5304 isolated gate driver is used to drive the high-voltage clamp FET. The design achieves > 92% efficiency with diode rectification. Secondary-side current sense provides precise overcurrent protection through a constant-current regulation loop. This design is tested for CISPR 32 Class B conducted emissions.

Features

- > 92% efficiency with diode rectification
- Isolated gate driver allows use of high-voltage active clamp NFET
- Precise secondary side overcurrent protection
- Tested for CISPR 32 Class B conducted emissions

Applications

- DIN rail power supply



Top Board Photo

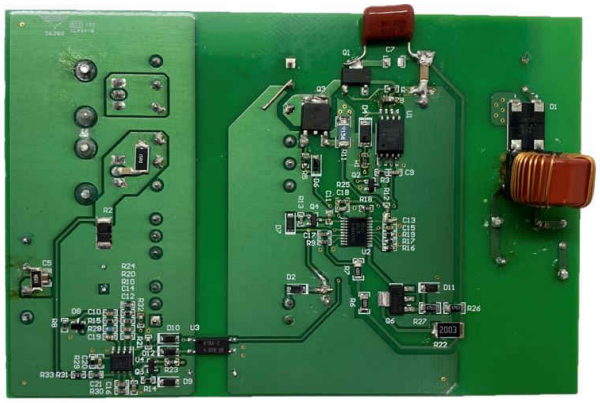


Figure 1-1. Bottom board photo

1 Test Prerequisites

1.1 Voltage and Current Requirements

Table 1-1. Voltage and Current Requirements

Parameter	Specifications	Unit
Input Voltage	176–264	VAC
Line Frequency	47–53	Hz
Output Voltage	24	VDC
Output Current	6.25	A

1.2 Dimensions

130 mm × 86.5 mm × 35 mm

2 Testing and Results

2.1 Efficiency Graphs

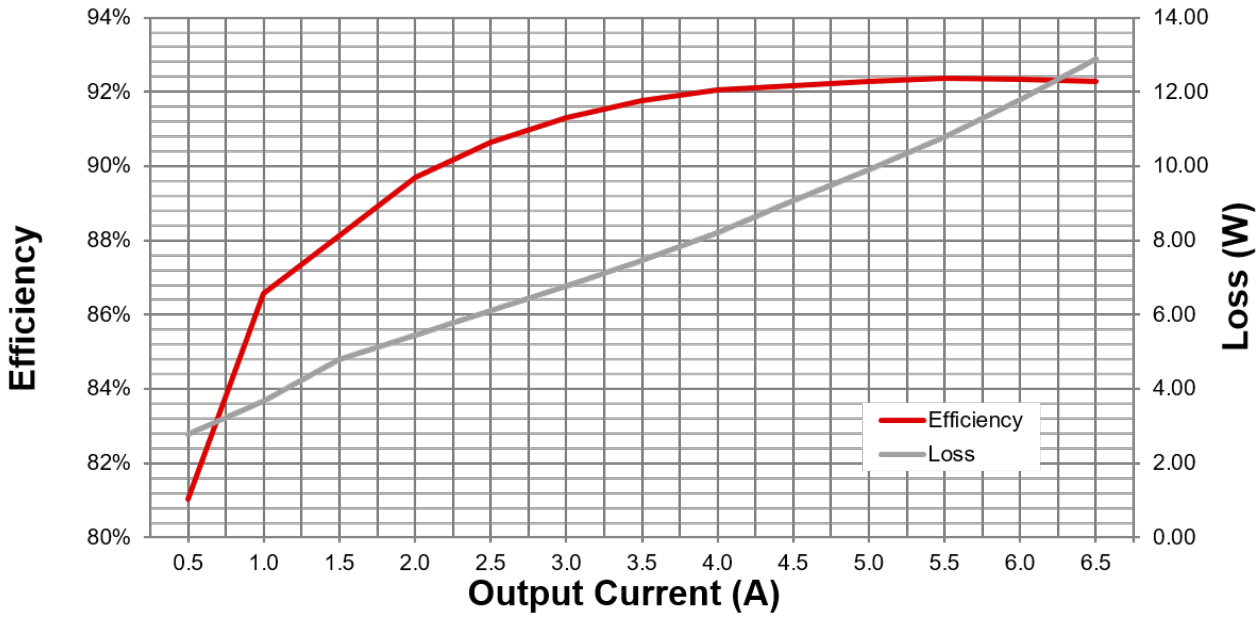


Figure 2-1. Efficiency, 230-VAC Input

2.2 Efficiency Data

V_{IN} (V)	I_{IN} (A)	P_{IN} (W)	V_{OUT} (V)	I_{OUT} (A)	P_{OUT} (W)	Eff (%)	Loss (W)
230.28	0.20	14.64	23.68	0.50	11.86	81.04%	2.78
230.27	0.35	27.38	23.68	1.00	23.70	86.57%	3.68
230.25	0.51	40.32	23.69	1.50	35.54	88.13%	4.79
230.24	0.64	52.82	23.69	2.00	47.38	89.70%	5.44
230.23	0.74	65.34	23.69	2.50	59.23	90.64%	6.12
230.17	0.85	77.84	23.69	3.00	71.07	91.30%	6.77
230.20	0.95	90.38	23.70	3.50	82.93	91.75%	7.45
230.18	1.05	103.00	23.70	4.00	94.80	92.04%	8.20
230.17	1.15	115.72	23.70	4.50	106.65	92.16%	9.07
230.15	1.24	128.40	23.70	5.00	118.50	92.29%	9.90
230.14	1.33	141.20	23.71	5.50	130.41	92.35%	10.80
230.12	1.42	154.05	23.71	6.00	142.26	92.35%	11.79
230.11	1.52	167.01	23.71	6.50	154.12	92.28%	12.90

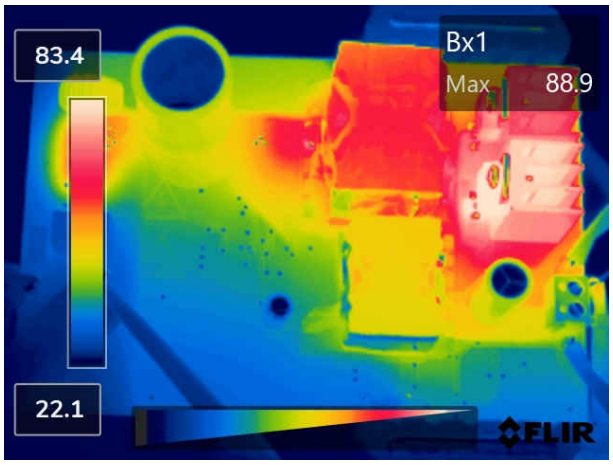
Standby power is measured using over a 2 minute average.

Table 2-1. Standby Power

V_{IN}	P_{IN}
230 VAC	1.18 W

2.3 Thermal Images

The following thermal images show a top view and bottom view of the board. The ambient temperature is 25ºC with no additional air flow. The supply is fully loaded for 30 minutes to reach thermal equilibrium.



Bx1 – D5, Rectifier diode

Figure 2-2. Top Side

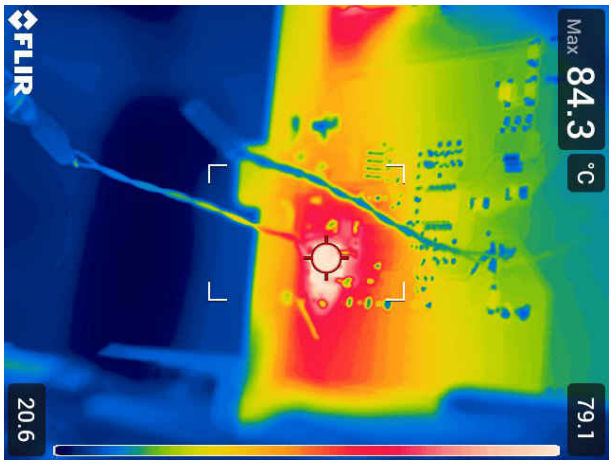


Figure 2-3. Q3 - Primary FET

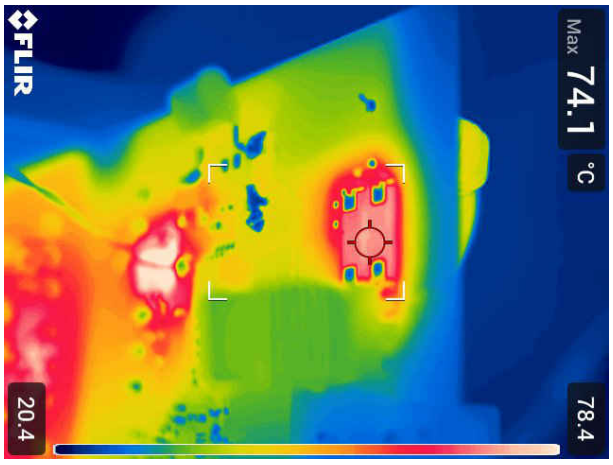


Figure 2-4. D1 - Bridge Rectifier

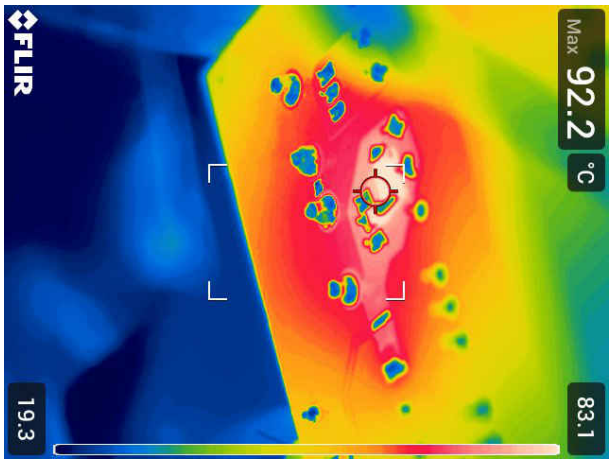


Figure 2-5. R101 - Snubber Resistor

2.4 Bode Plots

The bode plot in the following figure is measured at 230-VAC input and 24-V, 150-W output.

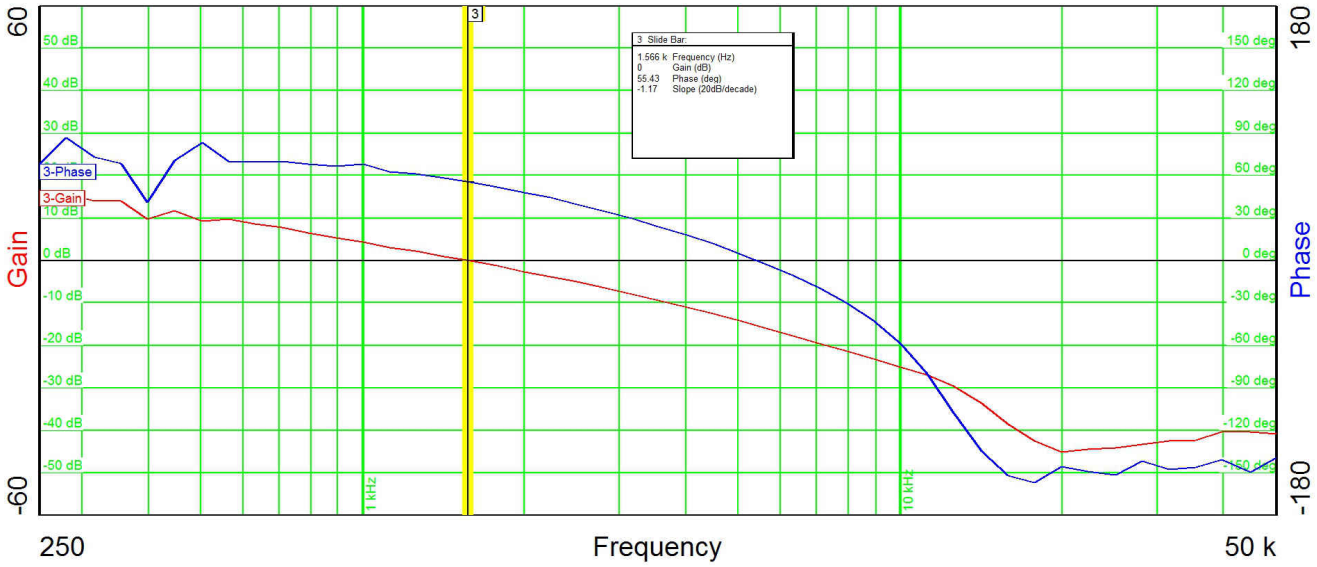


Figure 2-6. Bode Plot

2.5 Electromagnetic Interference (EMI)

Figure 2-7 and Figure 2-8 show the EMI measured at 2300-VAC input and 24-V, 150-W output. For the tests shown in these images, the common-mode choke was moved to the bottom side of the board and a copper shield is wrapped around the transformer.

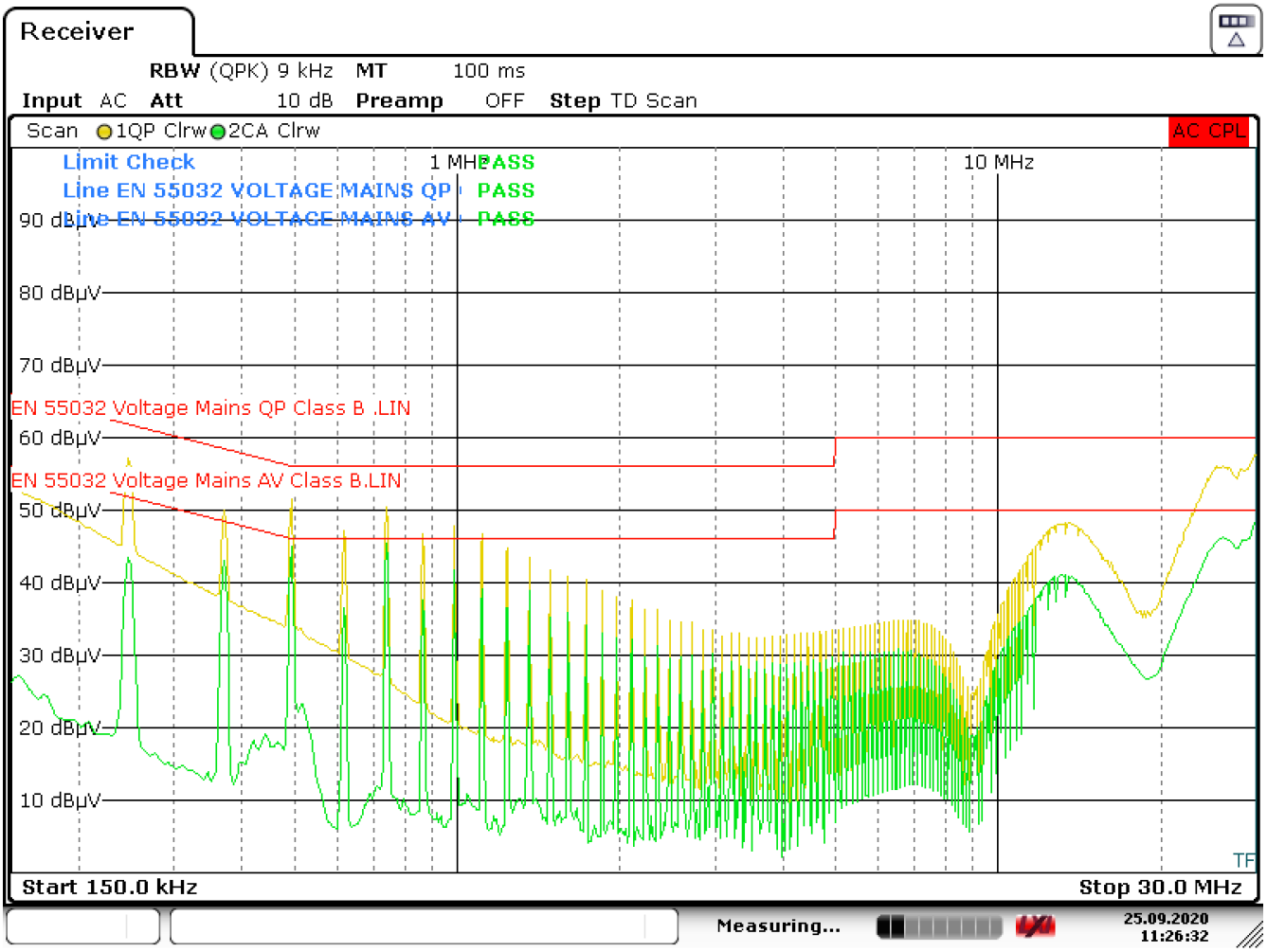


Figure 2-7. Line

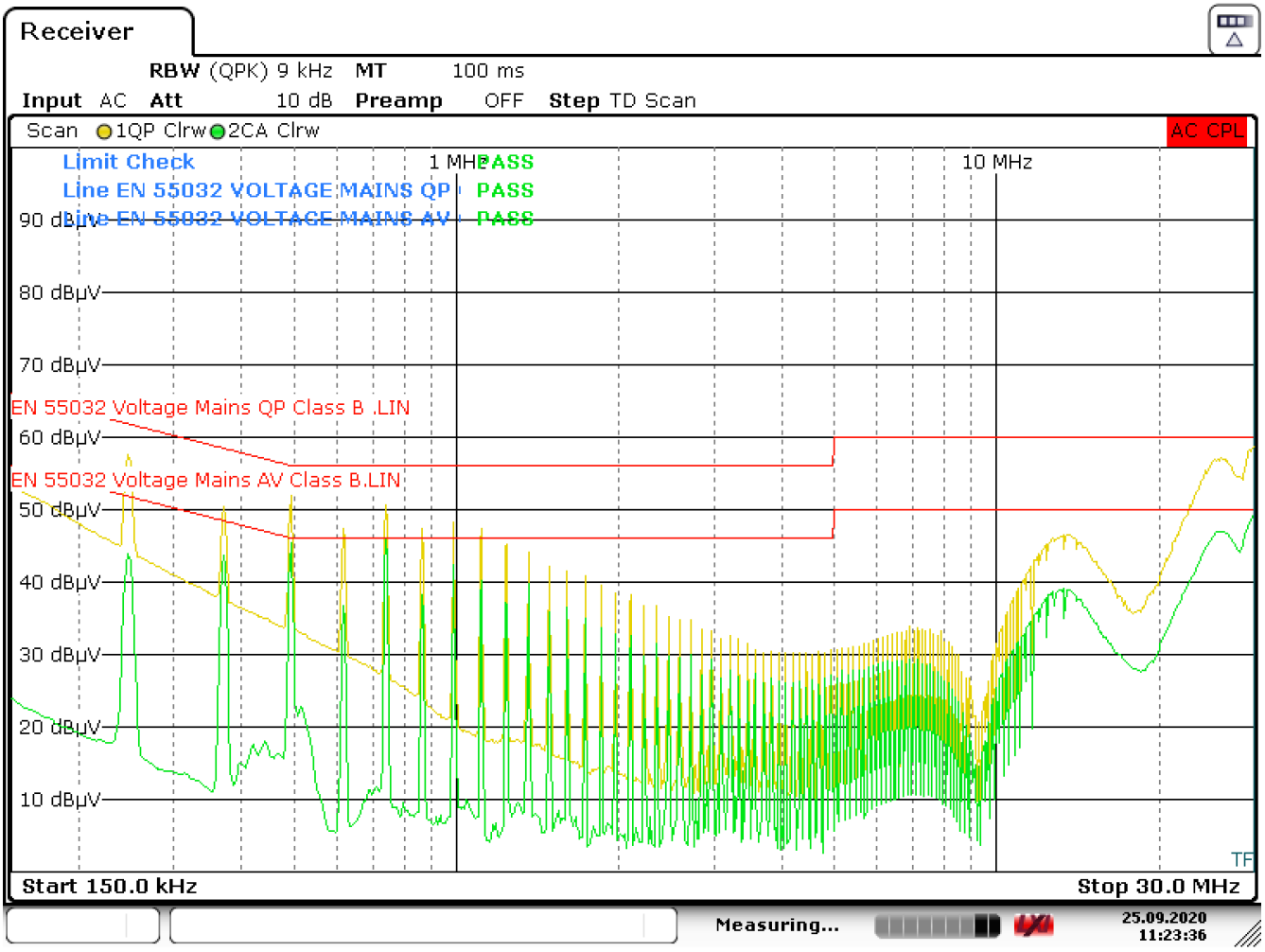


Figure 2-8. Neutral

3 Waveforms

3.1 Switching

Switching behavior is shown in the following figures.

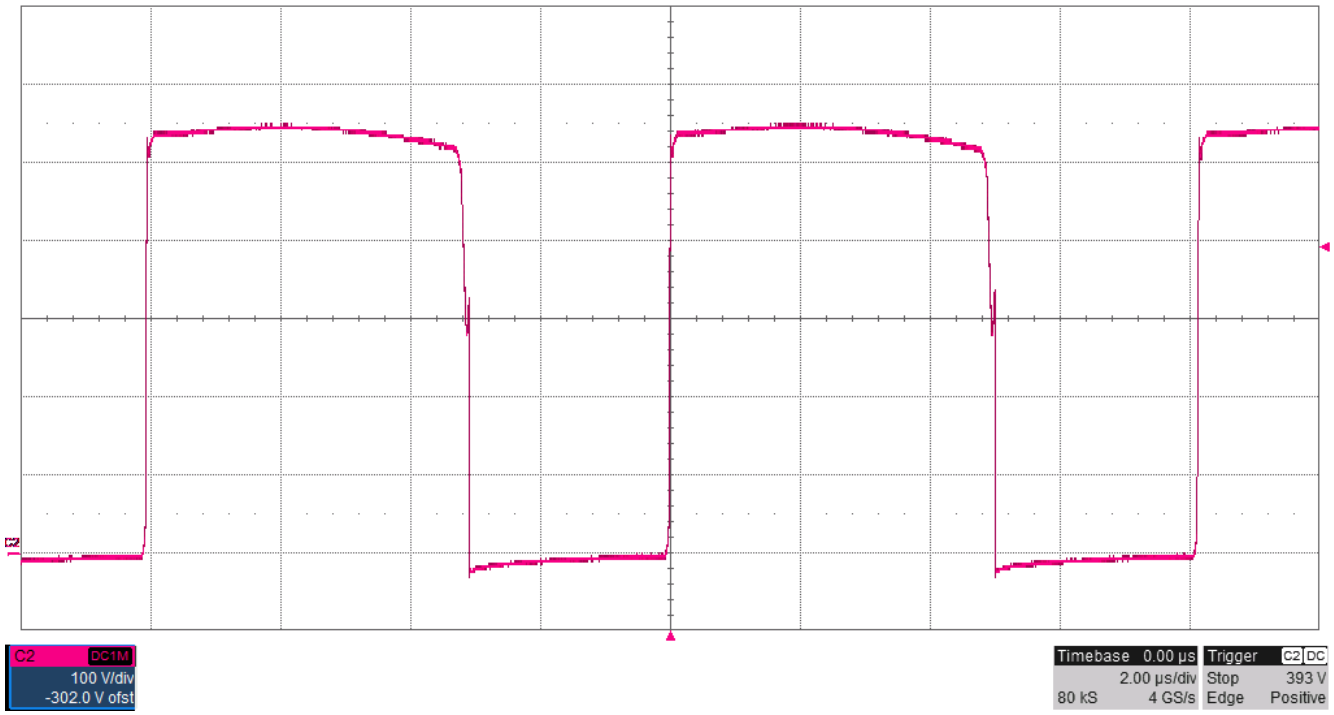


Figure 3-1. Primary FET VDS (Q3) - 230-VAC Input, 150-W Load

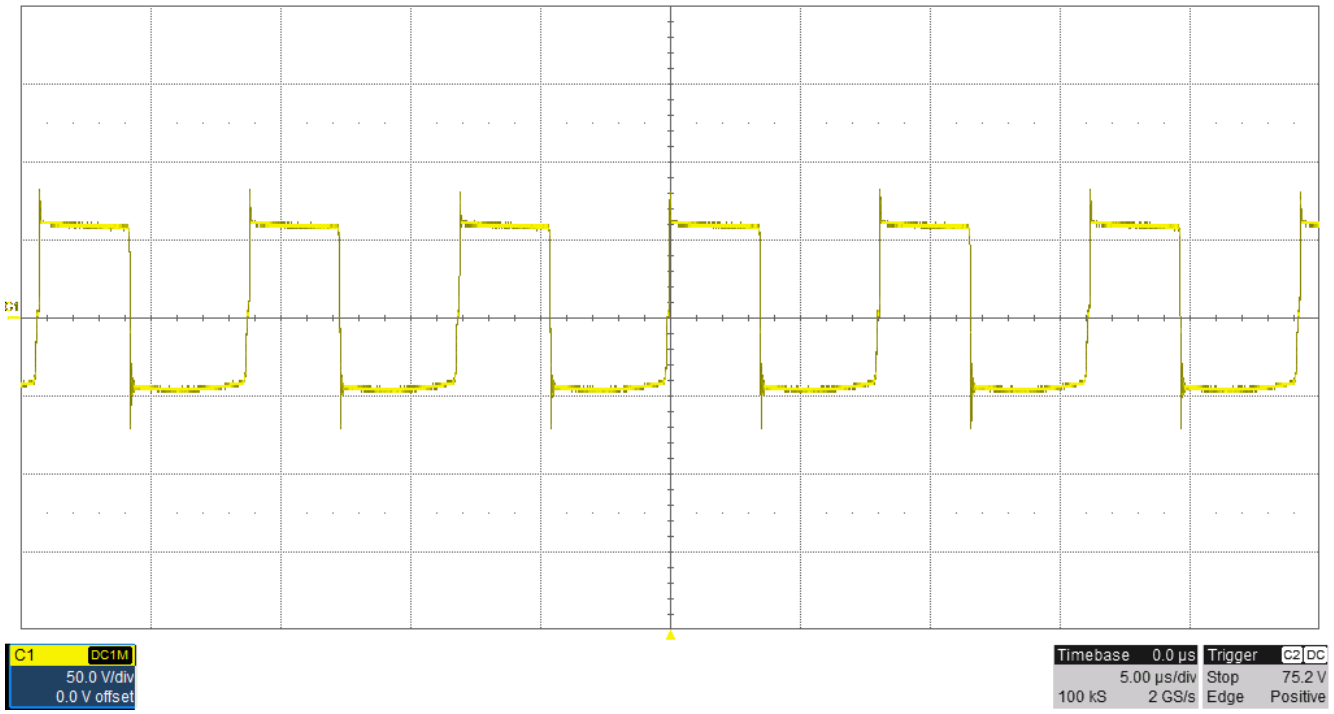


Figure 3-2. Rectifier Diode (D3) – 230-VAC Input, 150-W Load

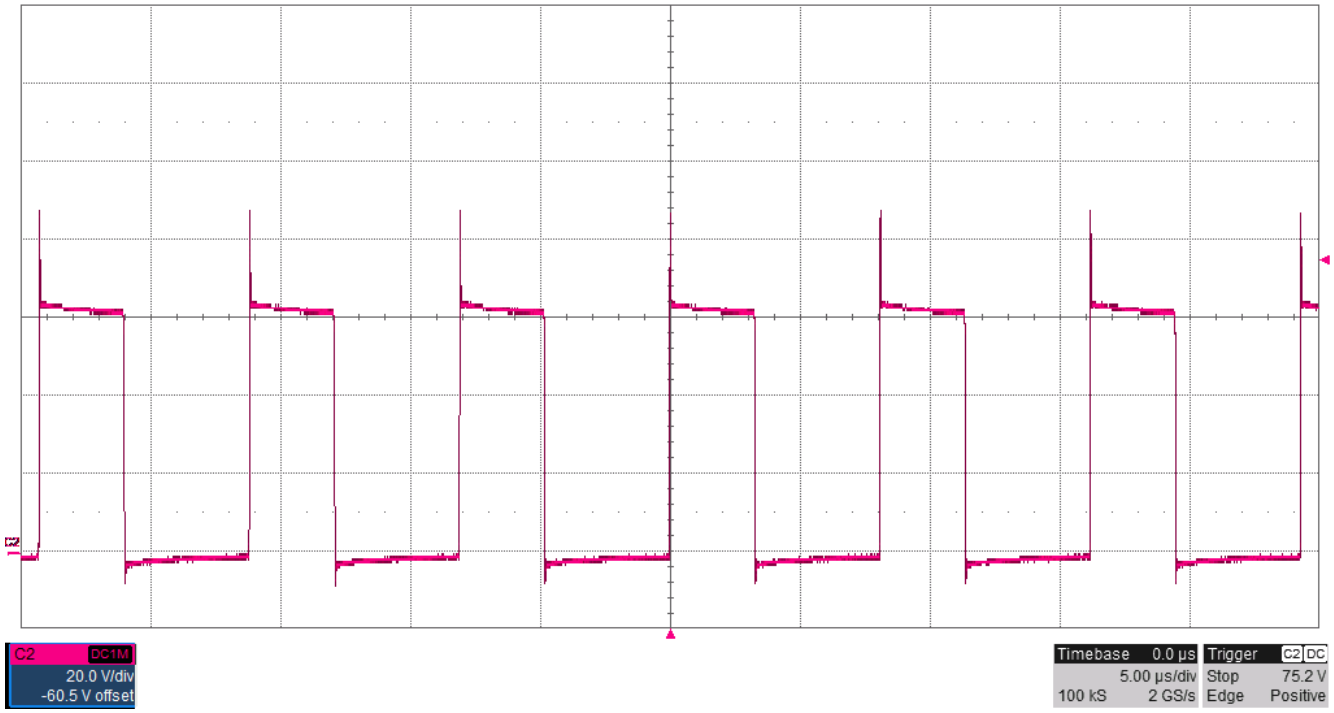


Figure 3-3. Rectifier Diode (D5) – 230-VAC Input, 150-W Load

3.2 Output Voltage Ripple

Output voltage ripple is shown in the following figure.

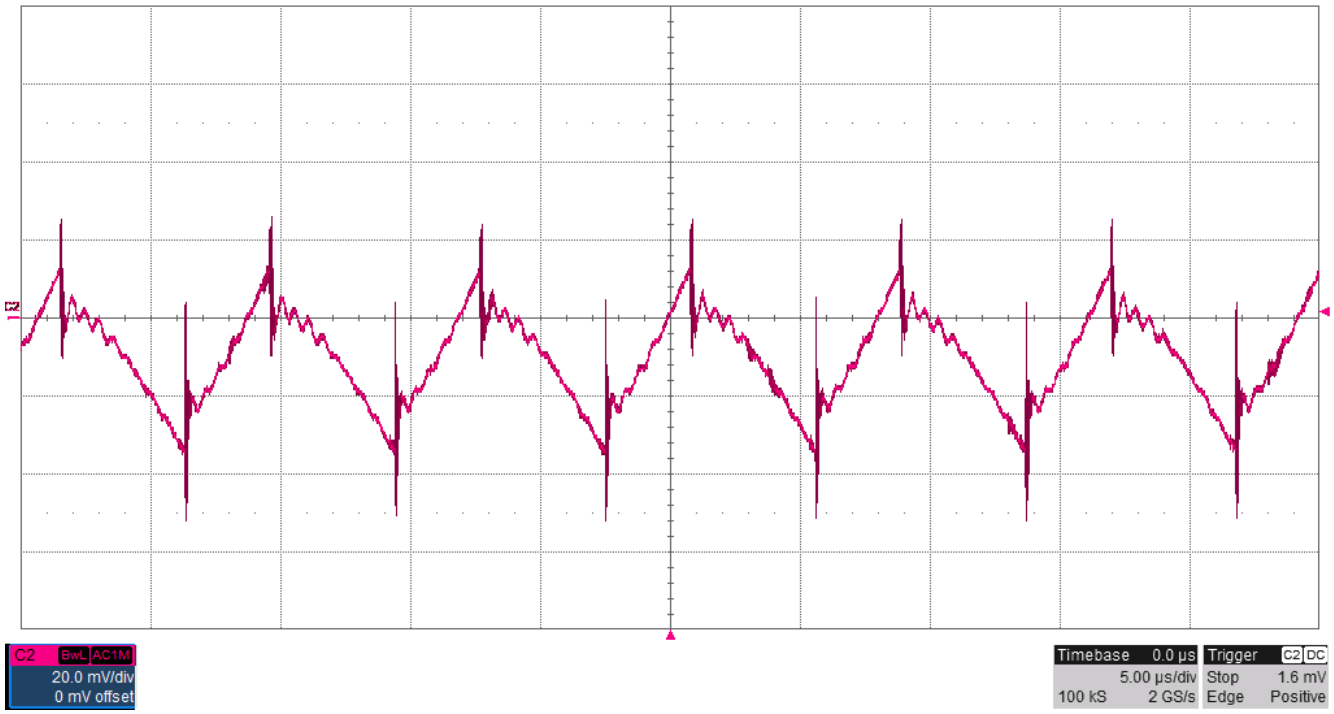


Figure 3-4. V_{OUT} (Measured at C5) – 230-VAC Input, 150-W Load

3.3 Short-Circuit Protection

Short-circuit protection is shown in the following figure.

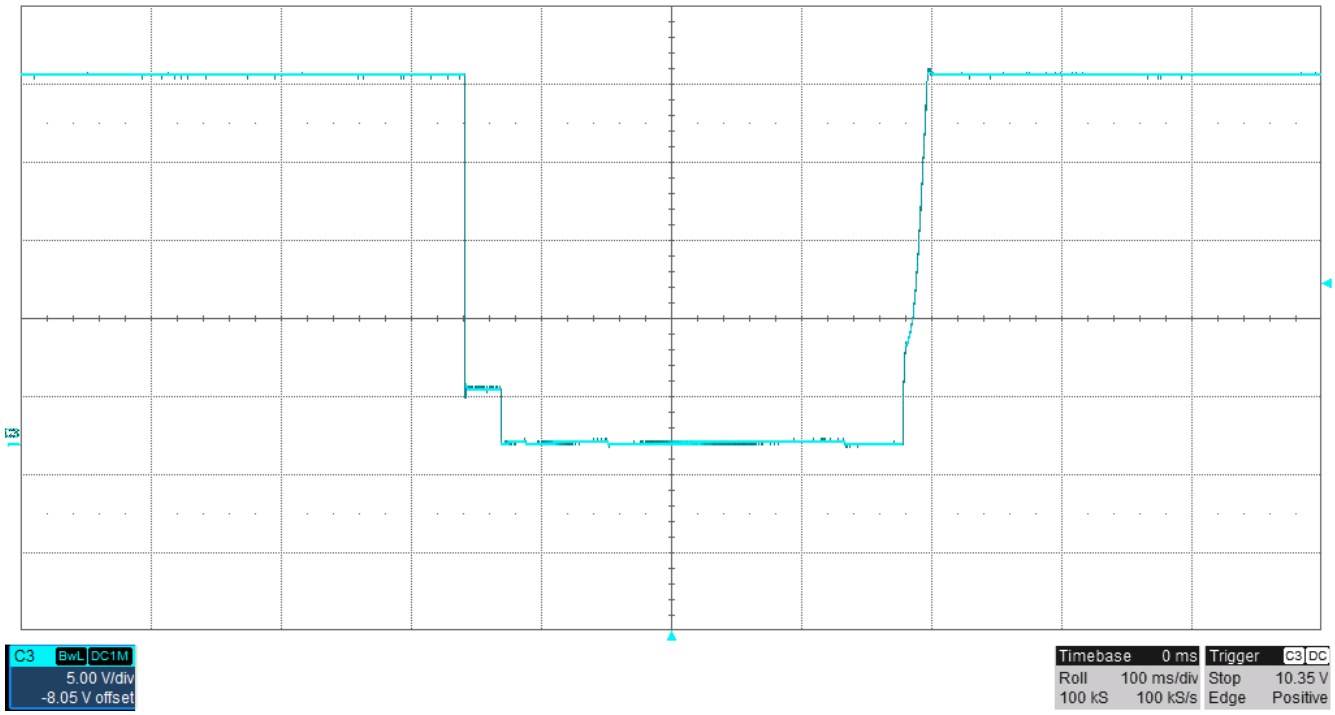
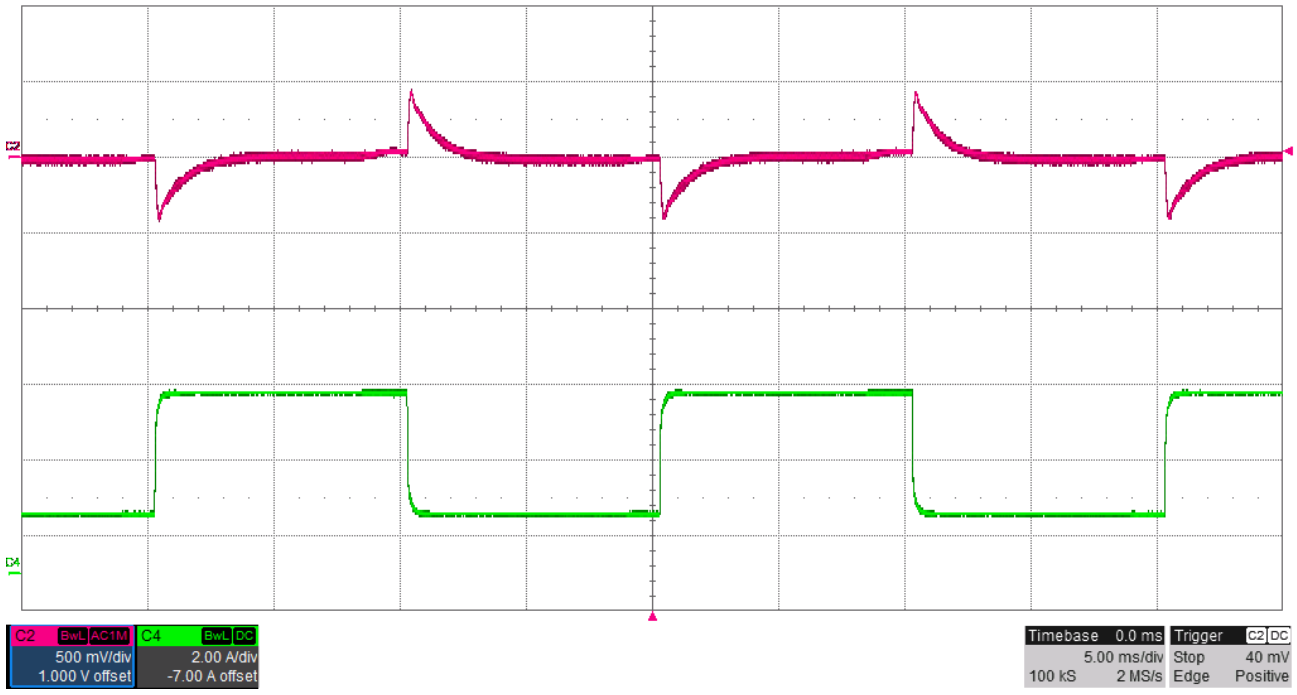


Figure 3-5. VOUT – Load Short + Restart

3.4 Load Transients

Load transient response is shown in the following figure.



C2 – V_{OUT}, AC coupled (Pink)
C4 – I_{OUT} (Green)

Figure 3-6. V_{OUT}, I_{OUT} – 230-VAC Input, 25%–75% Load Step

3.5 Start-up Sequence

Start-up behavior is shown in the following figures.

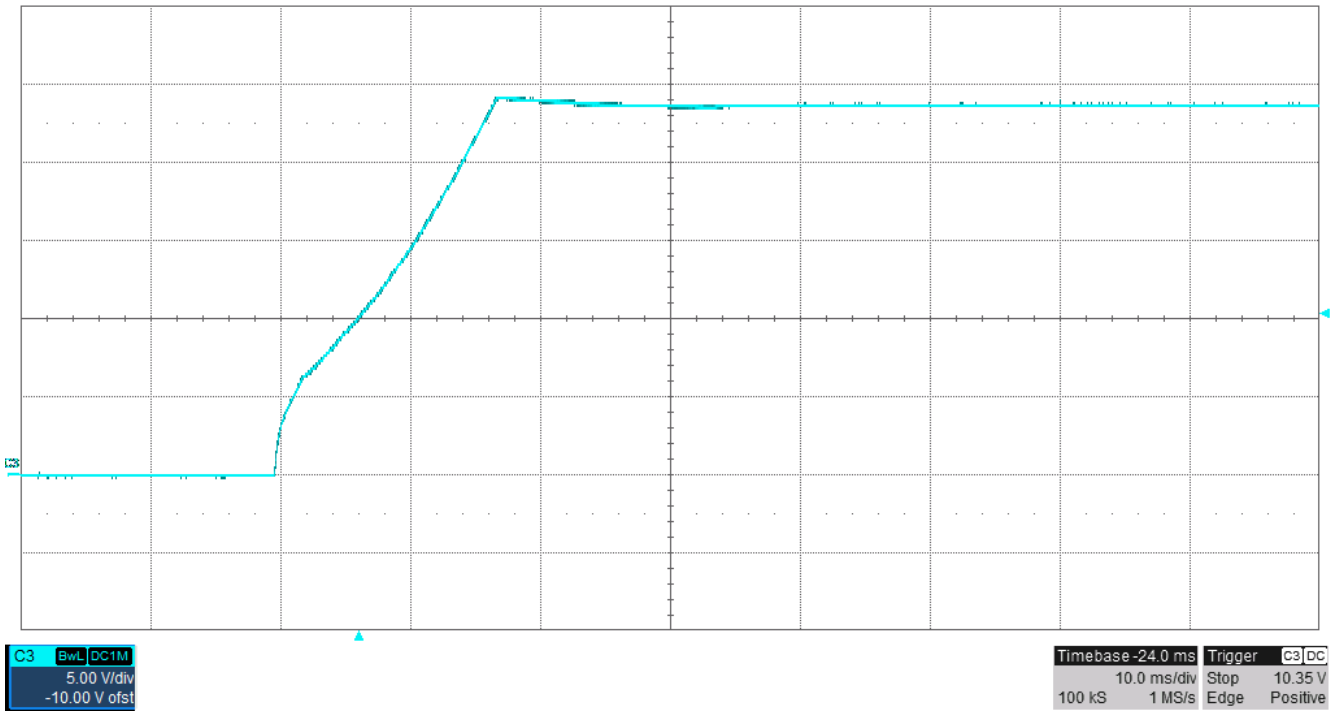


Figure 3-7. V_{OUT} (TP3) – 230-VAC Input, 0-W Load

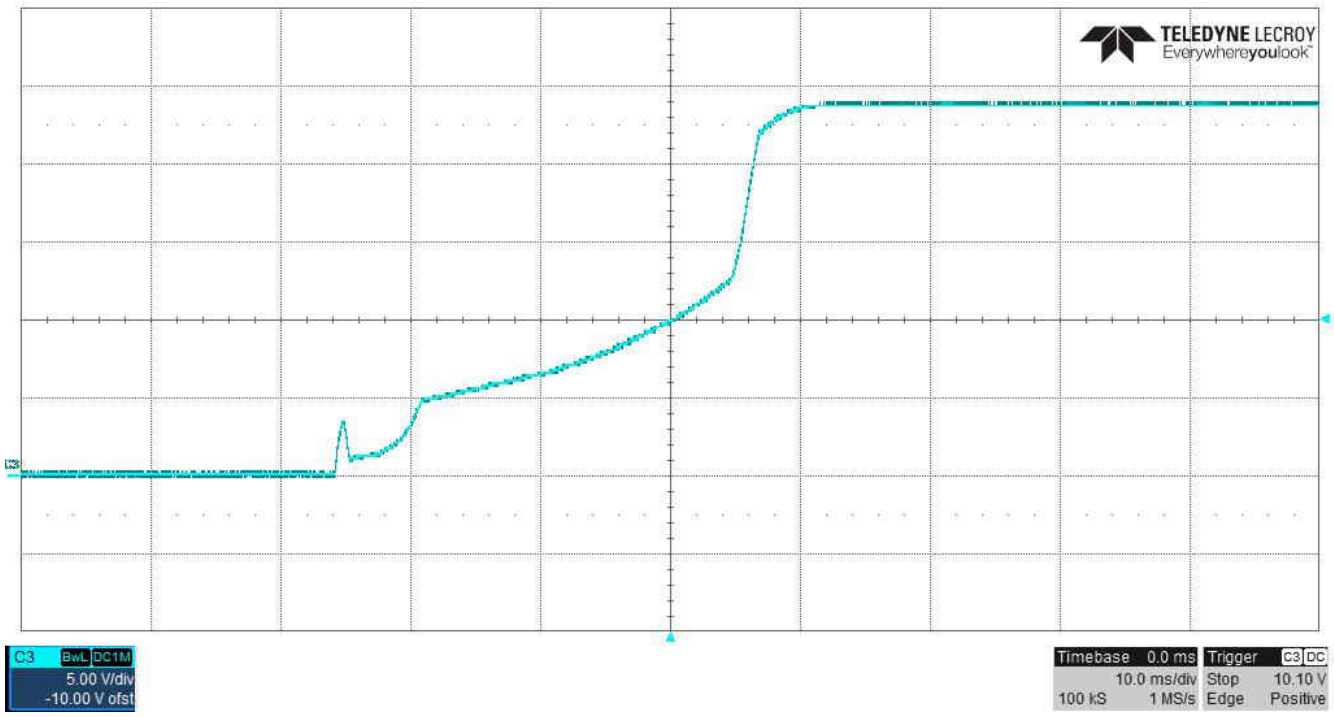


Figure 3-8. V_{OUT} (TP3) – 230-VAC Input, 150-W Load

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