Test Report: PMP23558

240W AC/DC PSU Using GaN Reference Design

Description

This reference design is a transition-mode, boost power factor correction (PFC) and half bridge LLC that accepts universal AC input and generates an isolated 24V, 10A output. The design utilizes LMG3622 GaN module on the primary side with integrated driver and current sense emulation for improved efficiency. This design achieves a full load efficiency of 93.62% at 90Vac input.

Features

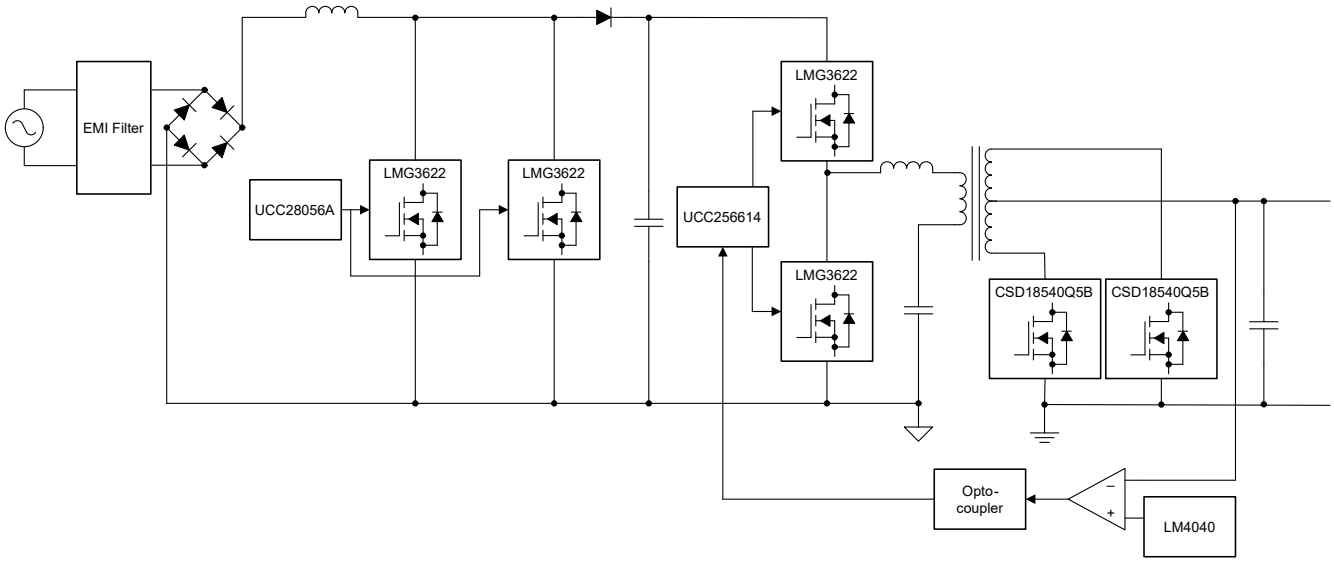
- Integrated current sense emulation in PFC stage (no shunt resistor required)
- Peak efficiency of 95.96%
- Full load efficiency of 93.62% at 90Vac input

Applications

- Industrial AC-DC

Resources

PMP23558	Design Folder
LMG3622REQR	Tool Folder
UCC28056ADBVR	Tool Folder
UCC256614DDBR	Tool Folder
CSD18540Q5B	Tool Folder
OPA2170AIDCUR	Tool Folder
LM4040D25QDBZR	Tool Folder



1 Test Prerequisites

1.1 Voltage and Current Requirements

Table 1-1. Voltage and Current Requirements

Parameter	Specifications
Input voltage range	90Vac to 264Vac
Input voltage frequency	47Hz to 60Hz
Output voltage	24V
Maximum total output power	240W

1.2 Required Equipment

- AC source: Chroma model 61601
- Digital power meter: Yokogawa WT310
- Electronic load: Chroma 6314A
- Oscilloscope: Tektronix, DPO3054
- Multimeter: Fluke, 287C

1.3 Dimensions

105mm × 71.825mm

1.4 Test Setup

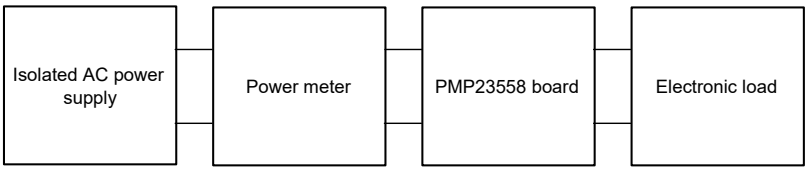


Figure 1-1. Test Setup

2 Testing and Results

2.1 Efficiency and PF/THD Graphs

Efficiency is shown in Figure 2-1 and Figure 2-3.

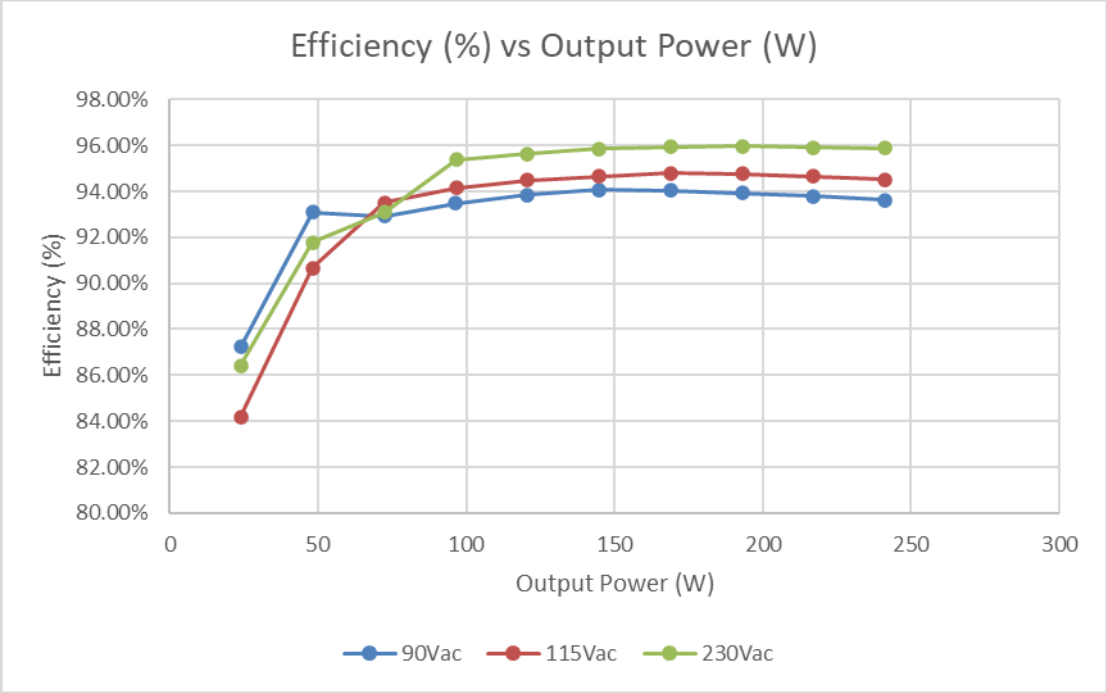


Figure 2-1. Efficiency vs Output Power

Power factor is shown in Figure 2-2.

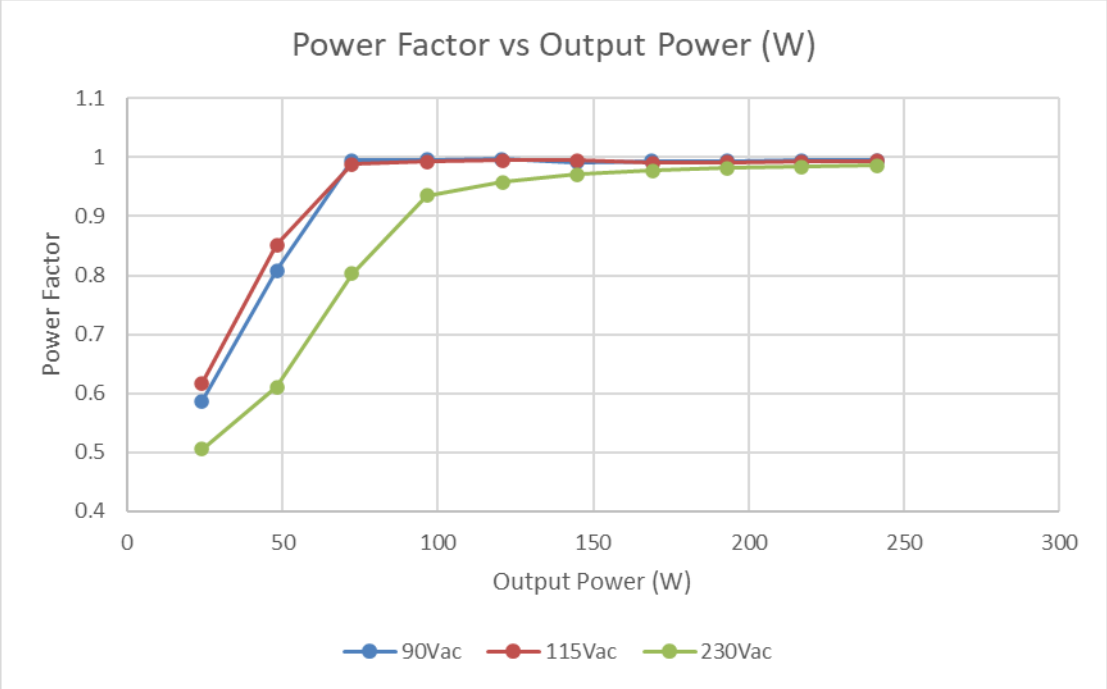


Figure 2-2. Power Factor vs Output Power

Input current total harmonic distortion is shown in Figure 2-3.

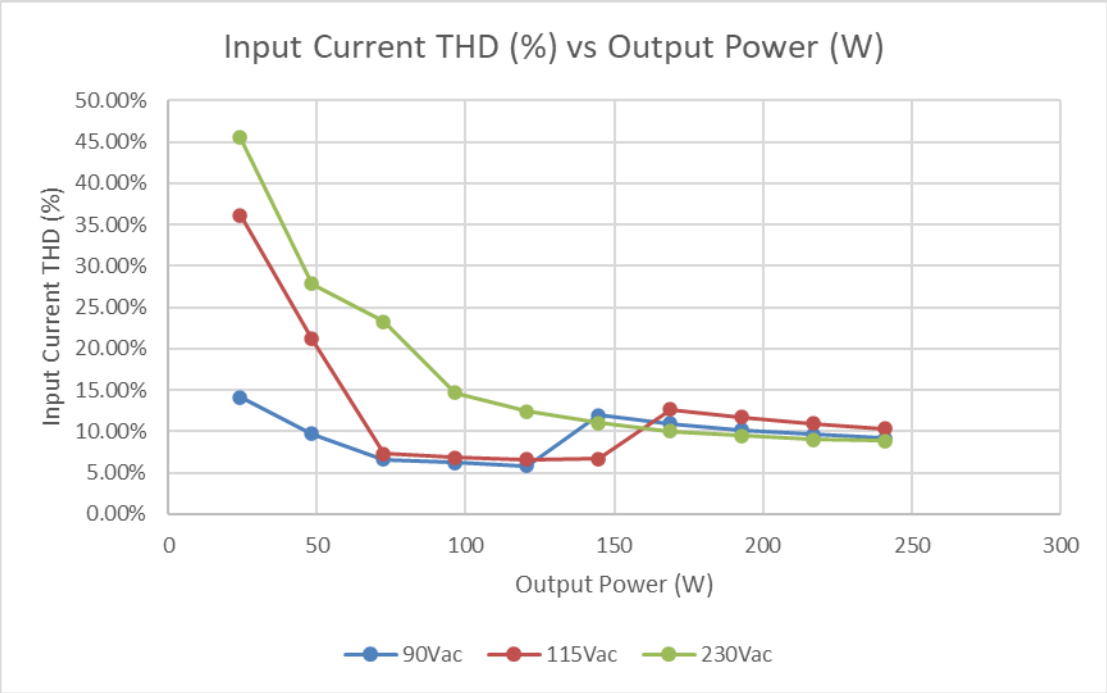


Figure 2-3. THD vs Output Power

2.2 Efficiency Data

Efficiency data is shown in Table 2-1.

Table 2-1. Efficiency Data

V_{INAC} (Vrms)	P_{IN} (W)	PF	THD (%)	V_{OUT} (V)	I_{OUT} (A)	P_{OUT} (W)	Efficiency (%)
89.9	27.6	0.5871	14.13	24.15	0.997	24.07755	87.24%
89.8	51.8	0.8081	9.703	24.15	1.997	48.22755	93.10%
89.61	77.89	0.9944	6.577	24.15	2.997	72.37755	92.92%
90.47	103.22	0.9959	6.19	24.14	3.997	96.48758	93.48%
90.33	128.54	0.9969	5.834	24.14	4.997	120.62758	93.84%
90.18	153.89	0.9918	11.98	24.14	5.997	144.76758	94.07%
90	179.54	0.9932	10.933	24.13	6.997	168.83761	94.04%
89.77	205.43	0.9941	10.14	24.13	7.997	192.96761	93.93%
89.74	231.46	0.9948	9.594	24.13	8.997	217.09761	93.79%
89.58	257.68	0.9953	9.13	24.13	9.997	241.22761	93.62%
116.02	28.61	0.6174	36.11	24.16	0.997	24.08752	84.19%
115.93	53.22	0.8517	21.15	24.16	1.997	48.24752	90.66%
115.76	77.41	0.9888	7.29	24.15	2.997	72.37755	93.50%
115.65	102.53	0.9925	6.829	24.15	3.997	96.52755	94.15%
115.53	127.71	0.9943	6.624	24.15	4.997	120.67755	94.49%
115.41	152.93	0.9952	6.671	24.14	5.997	144.76758	94.66%
115.29	178.2	0.9902	12.672	24.14	6.997	168.90758	94.79%
115.11	203.72	0.9917	11.72	24.14	7.997	193.04758	94.76%
115	229.36	0.9928	10.957	24.13	8.997	217.09761	94.65%
114.86	255.2	0.9936	10.35	24.13	9.997	241.22761	94.52%
230.44	27.87	0.5051	45.477	24.16	0.997	24.08752	86.43%
230.55	52.61	0.6106	27.8	24.18	1.997	48.28746	91.78%
230.61	77.78	0.8026	23.25	24.16	2.997	72.40752	93.09%
230.05	101.2	0.9349	14.633	24.15	3.997	96.52755	95.38%
230.01	126.18	0.9581	12.427	24.15	4.997	120.67755	95.64%
229.96	151.05	0.9706	11.042	24.14	5.997	144.76758	95.84%
229.9	176.05	0.9771	10.03	24.14	6.997	168.90758	95.94%
229.84	201.17	0.9813	9.476	24.14	7.997	193.04758	95.96%
229.78	226.35	0.9843	9.039	24.13	8.997	217.09761	95.91%
229.72	251.61	0.9861	8.812	24.13	9.997	241.22761	95.87%

2.3 Thermal Images

Top side thermal image at 115Vac input, full load for 20-minute soak is shown in Figure 2-4.

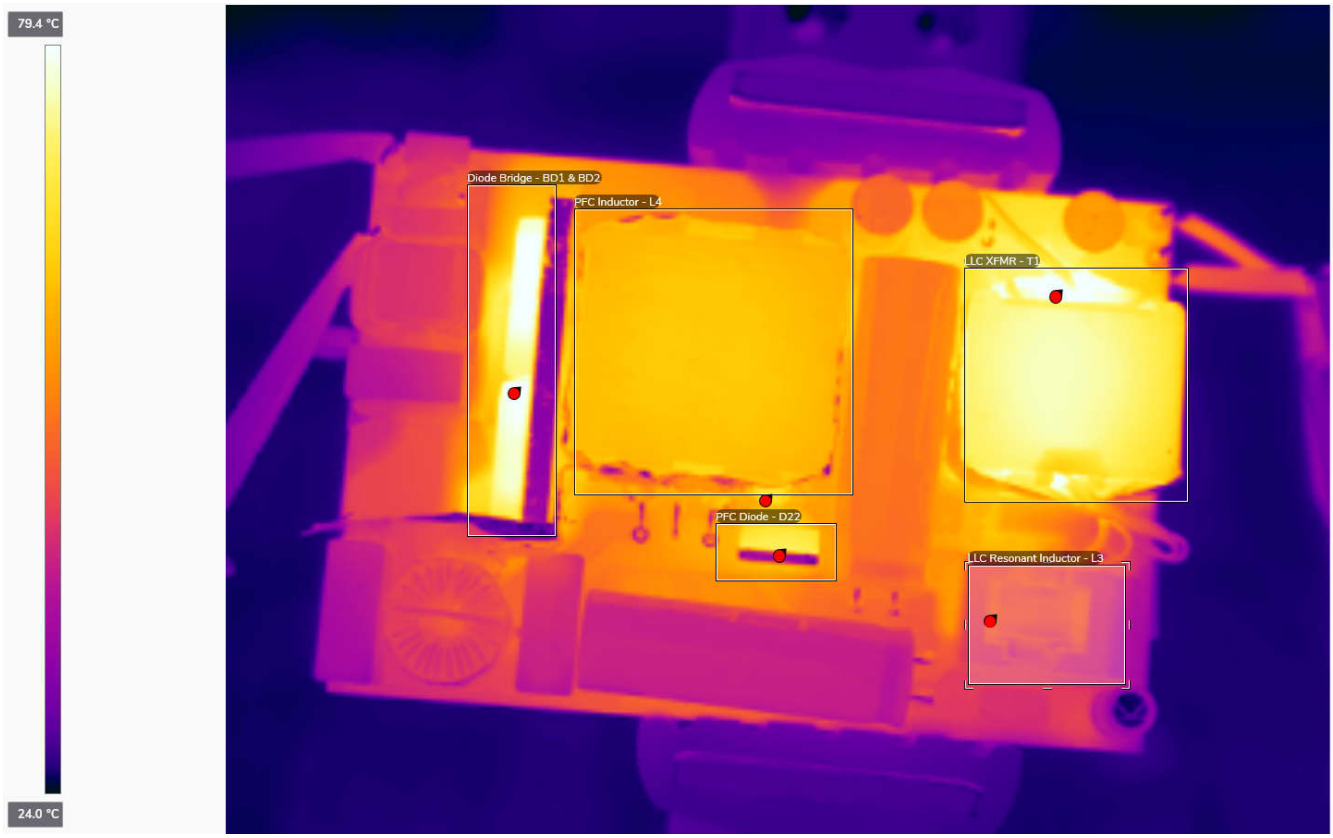


Figure 2-4. 115Vac, Full Load, Top Side Thermal Image

Table 2-2 summarizes the temperature of key components on the top side of the PCB.

Table 2-2. 115Vac, Full Load, Top Side Component Temperature

Component	Temperature (°C)
Diode Bridge BD1 and BD2	81.1°C
PFC Inductor – L4	69.7°C
PFC Diode – D22	72.8°C
LLC Resonant Inductor – L3	52.5°C
LLC Transformer – T1	87.1°C

Bottom side thermal image at 115Vac input, full load for 20-minute soak is shown in Figure 2-5.

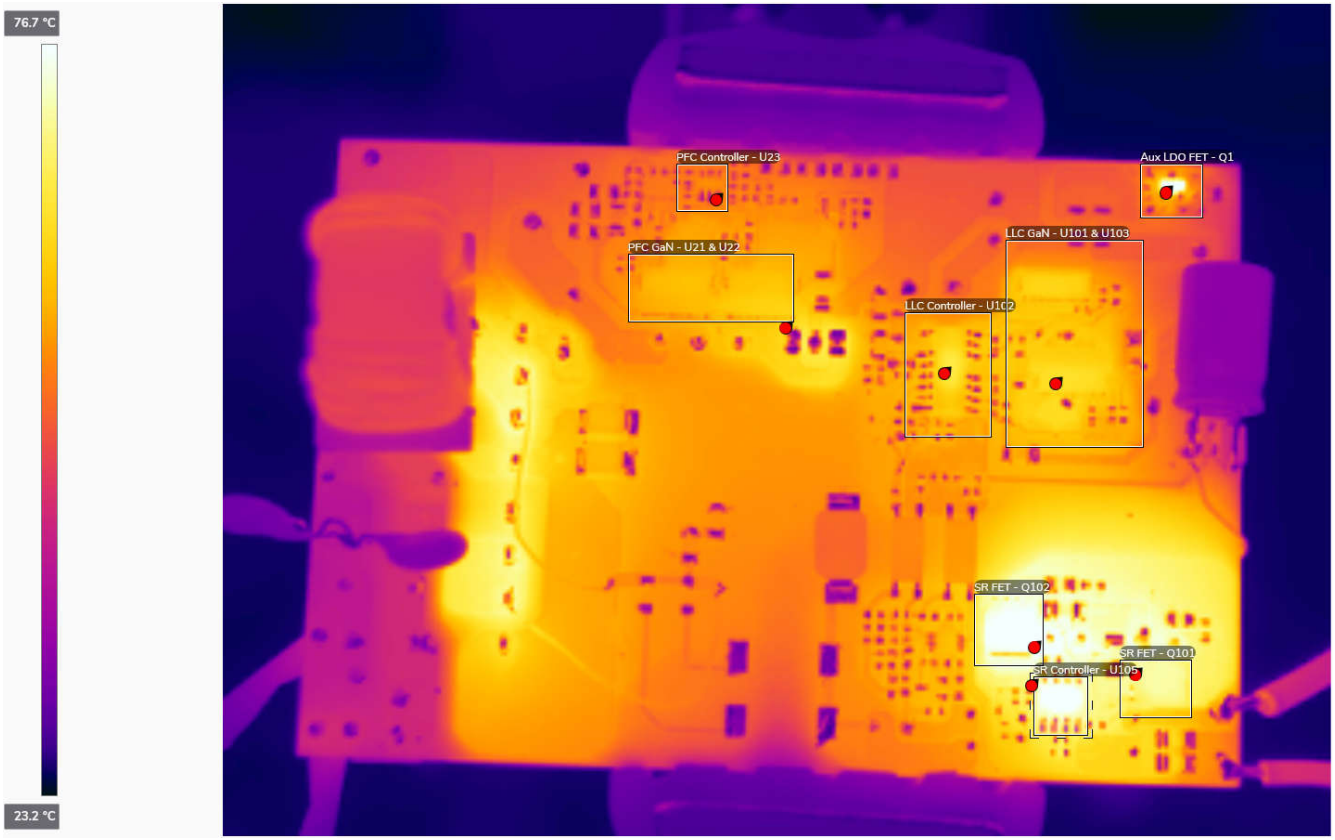


Figure 2-5. 115Vac, Full Load, Bottom Side Thermal Image

Table 2-3 summarizes the temperature of key components on the bottom side of the PCB.

Table 2-3. 115Vac, Full Load Bottom Side Component Temperature

Component	Temperature (°C)
PFC Controller – U23	58.0°C
PFC GaN – U21 and U22	64.3°C
LLC Controller – U102	67.9°C
LLC GaN – U101 and U103	66.2°C
Aux LDO FET – Q1	93.6°C
SR FET – Q101 and Q102	79.3°C
SR Controller	80.6°C

Top side thermal image at 230Vac input, full load for 20-minute soak is shown in Figure 2-6.

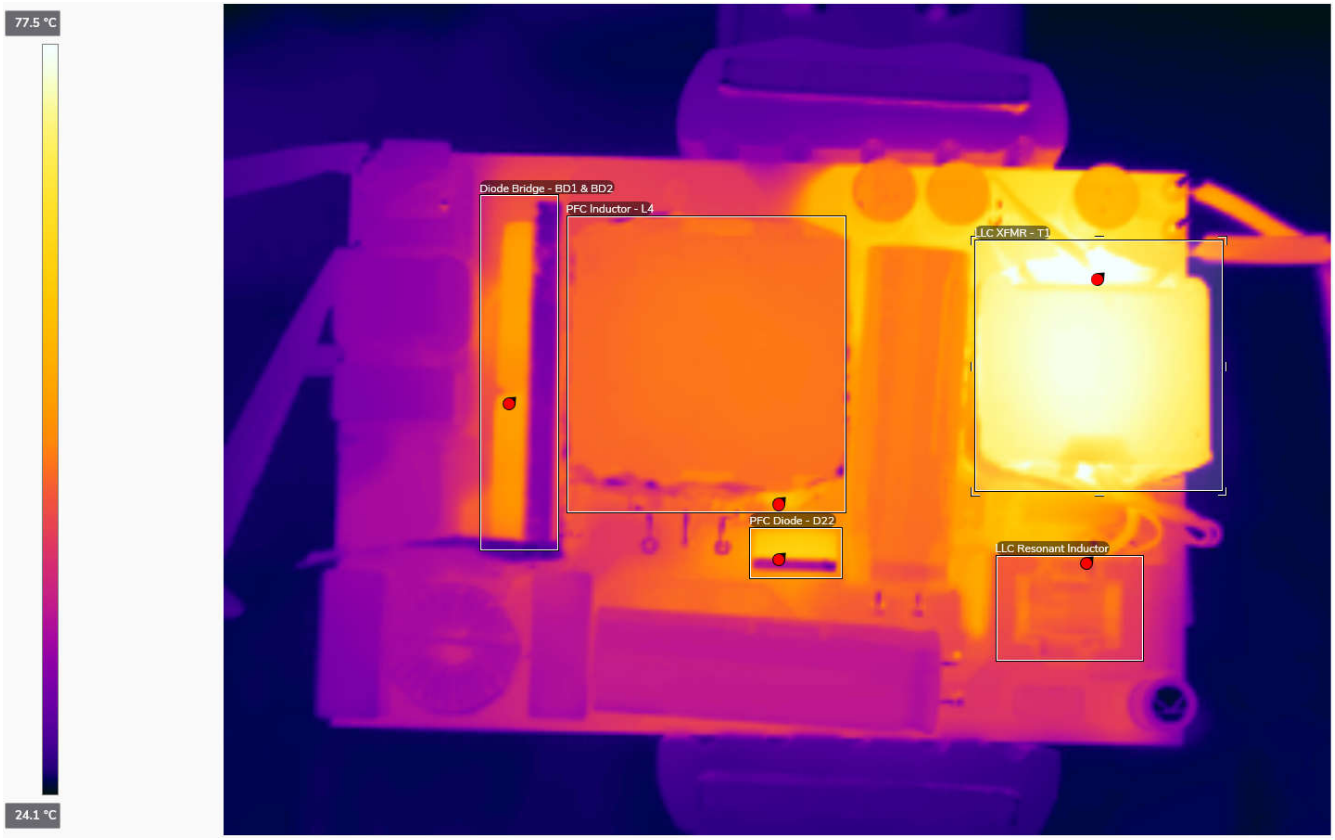


Figure 2-6. 230Vac, Full Load, Top Side Thermal Image

Table 2-4 summarizes the temperature of key components on the top side of the PCB.

Table 2-4. 230Vac, full load, top side component temperature

Component	Temperature (°C)
Diode Bridge BD1 & BD2	55.9°C
PFC Inductor – L4	61.1°C
PFC Diode – D22	64.4°C
LLC Resonant Inductor – L3	52.5°C
LLC Transformer – T1	87.0°C

Bottom side thermal image at 230Vac input, full load for 20-minute soak is shown in Figure 2-7.

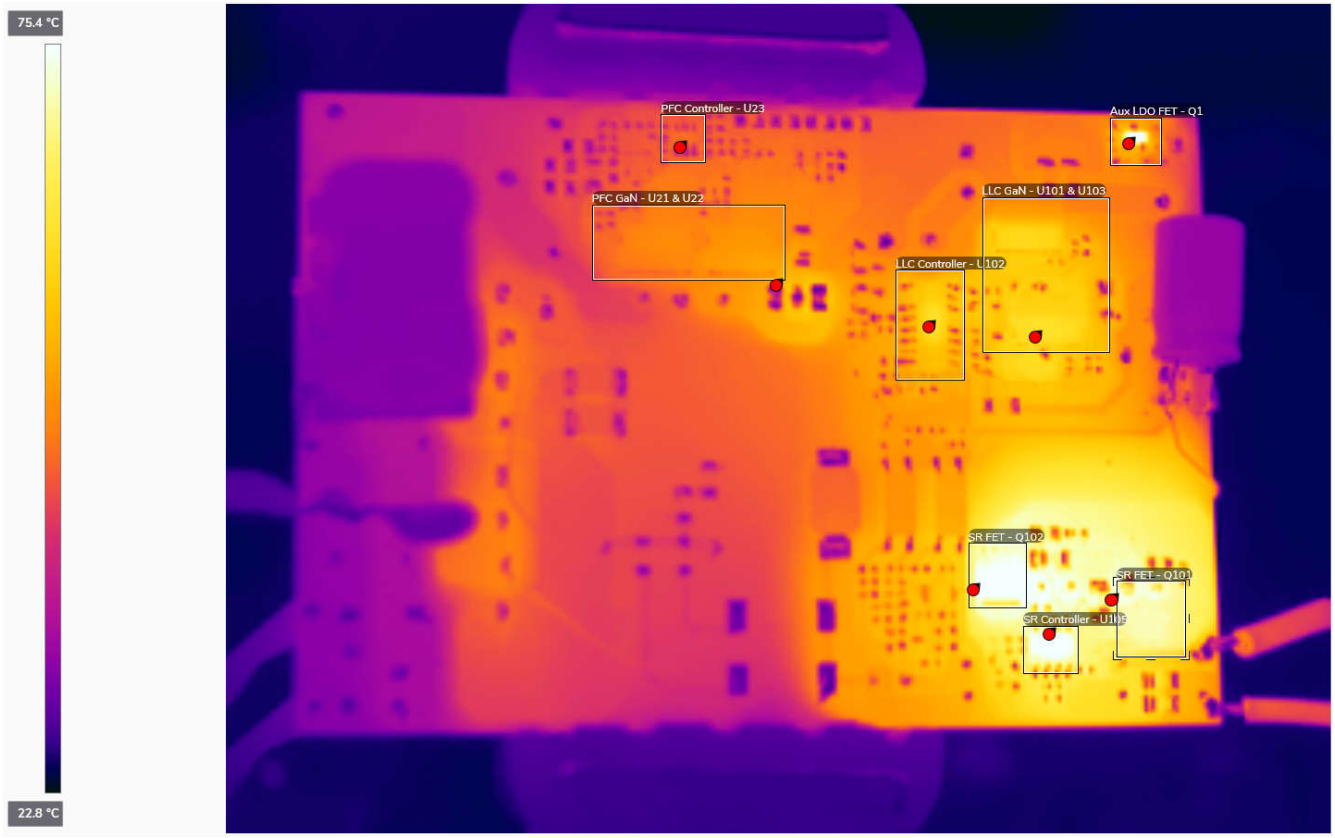


Figure 2-7. 230Vac, Full Load, Bottom Side Thermal Image

Table 2-5 summarizes the temperature of key components on the bottom side of the PCB.

Table 2-5. 230Vac, Full Load Component Temperature

Component	Temperature (°C)
PFC Controller – U23	49.5°C
PFC GaN – U21 and U22	57.5°C
LLC Controller – U102	63.9°C
LLC GaN – U101 and U103	64.0°C
Aux LDO FET – Q1	85.8°C
SR FET – Q101 and Q102	76.6°C
SR Controller	79.2°C

2.4 Bode Plots

Bode plot of the LLC control loop is shown in Figure 2-8.

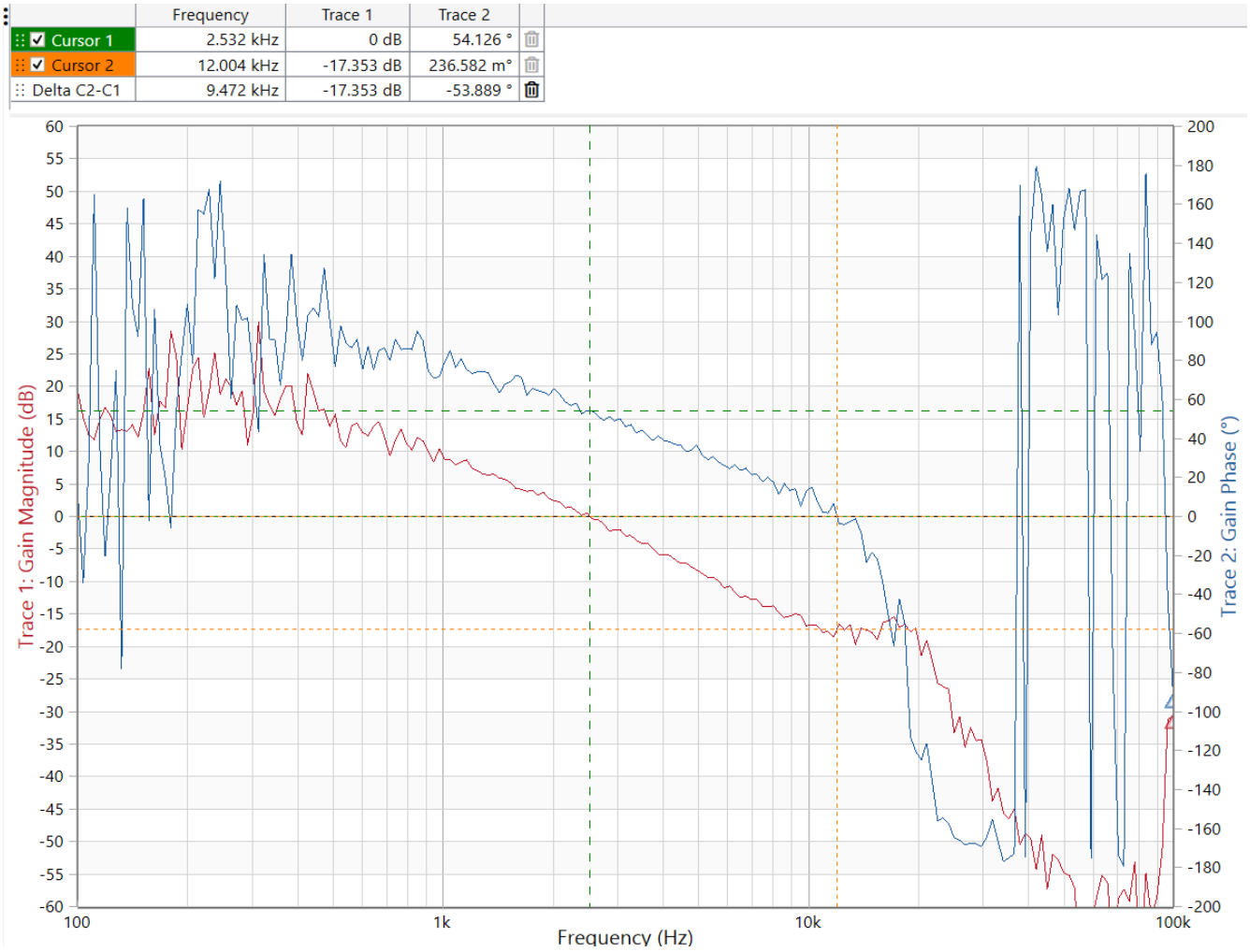


Figure 2-8. LLC Control Loop Measurement

2.5 EMI

Conducted EMI result of L1 at 115Vac, full load is shown in Figure 2-9.

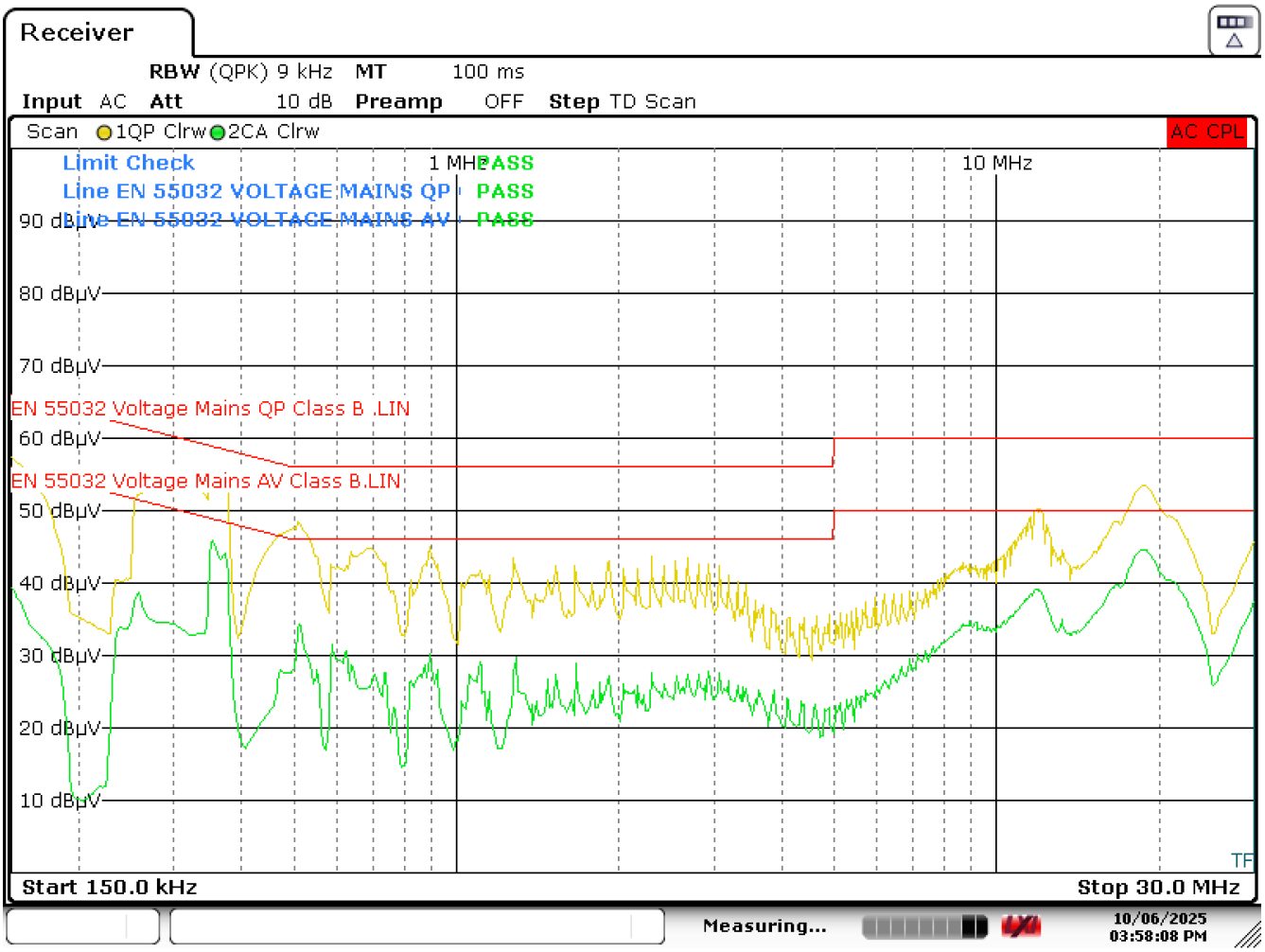


Figure 2-9. 115Vac, Full Load, L1

Conducted EMI result of L2 at 115Vac, full load is shown in Figure 2-10.

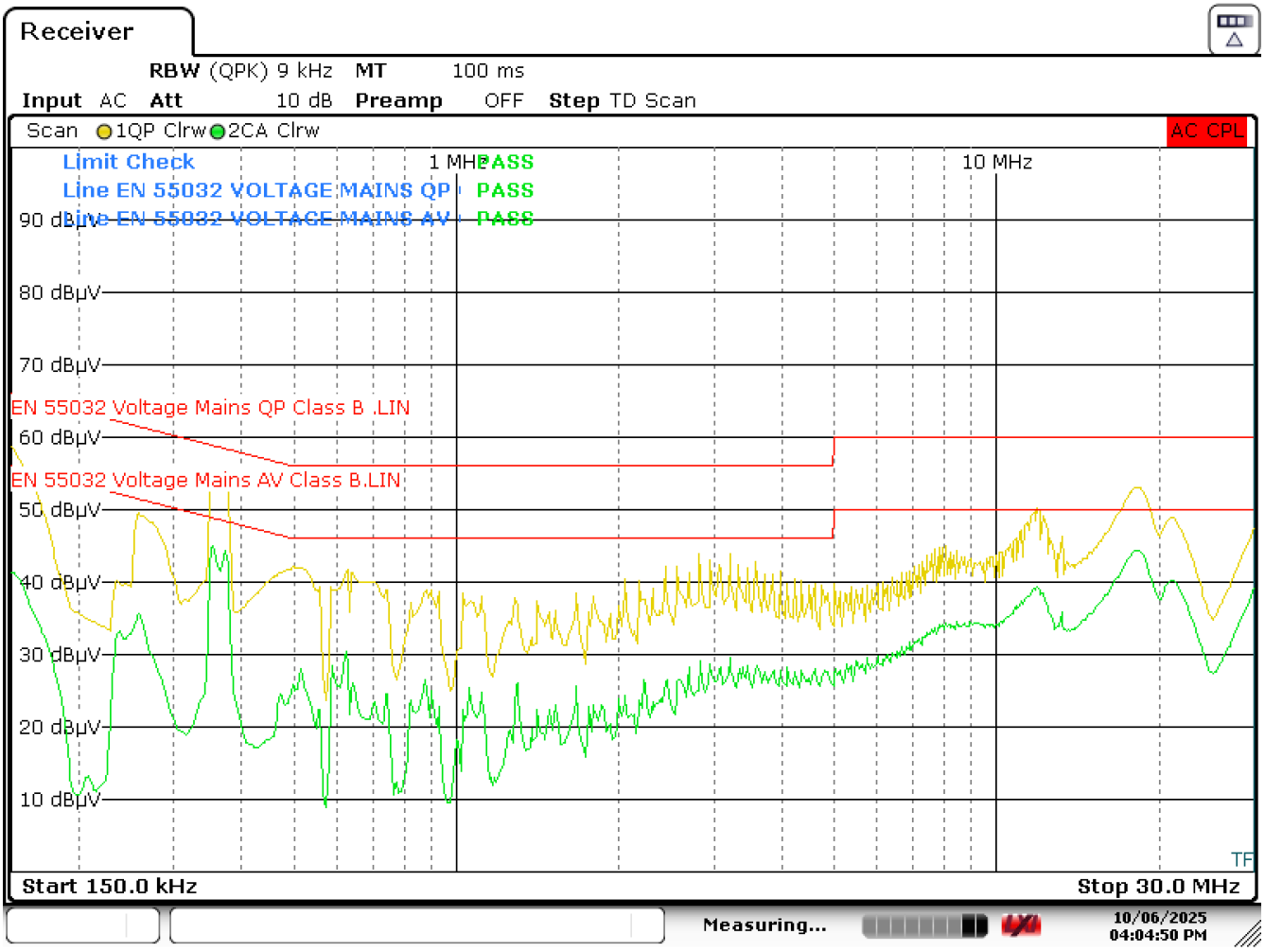


Figure 2-10. 115Vac, Full Load, L2

Conducted EMI result of L1 at 230Vac, full load is shown in Figure 2-11.

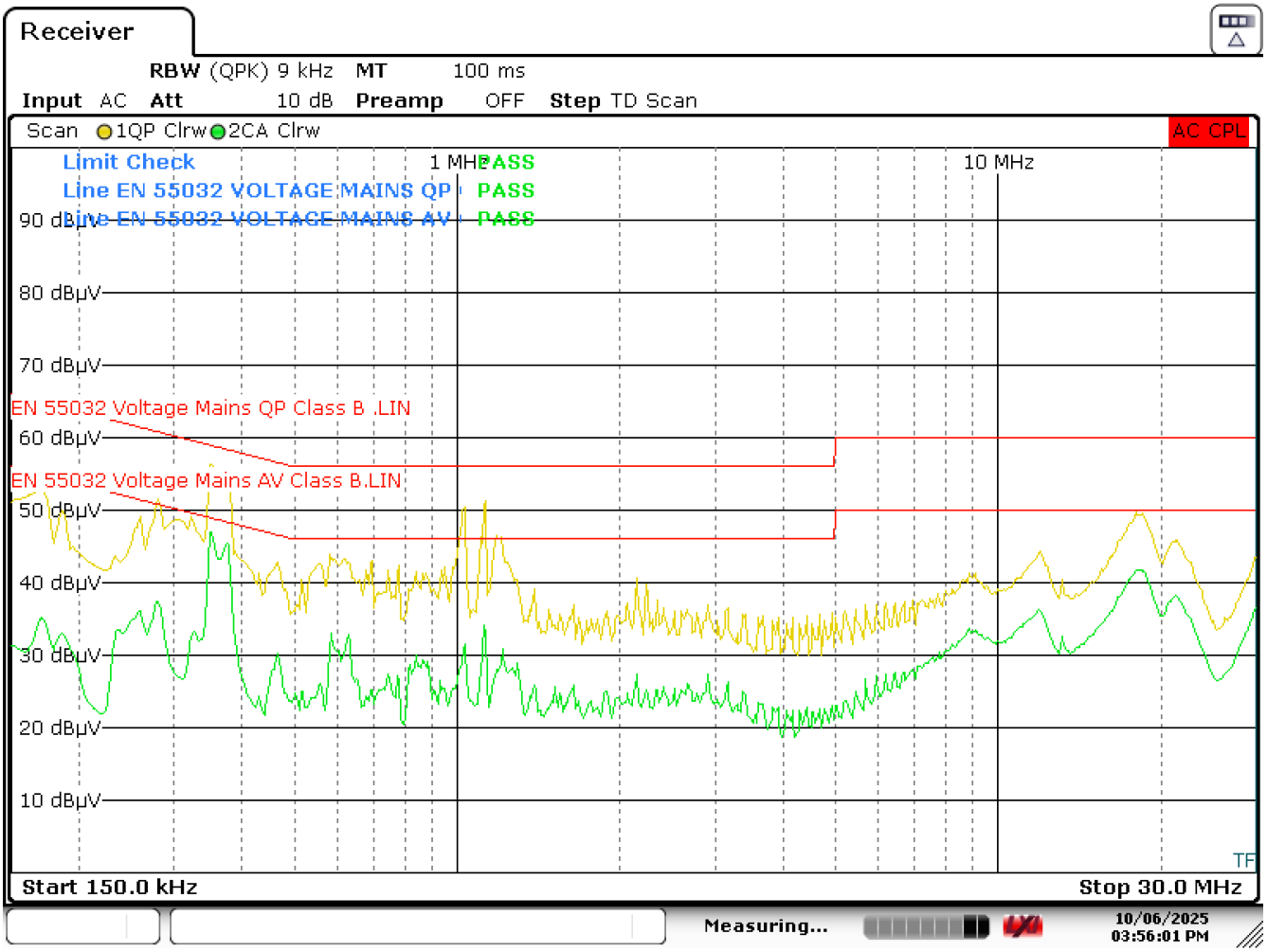
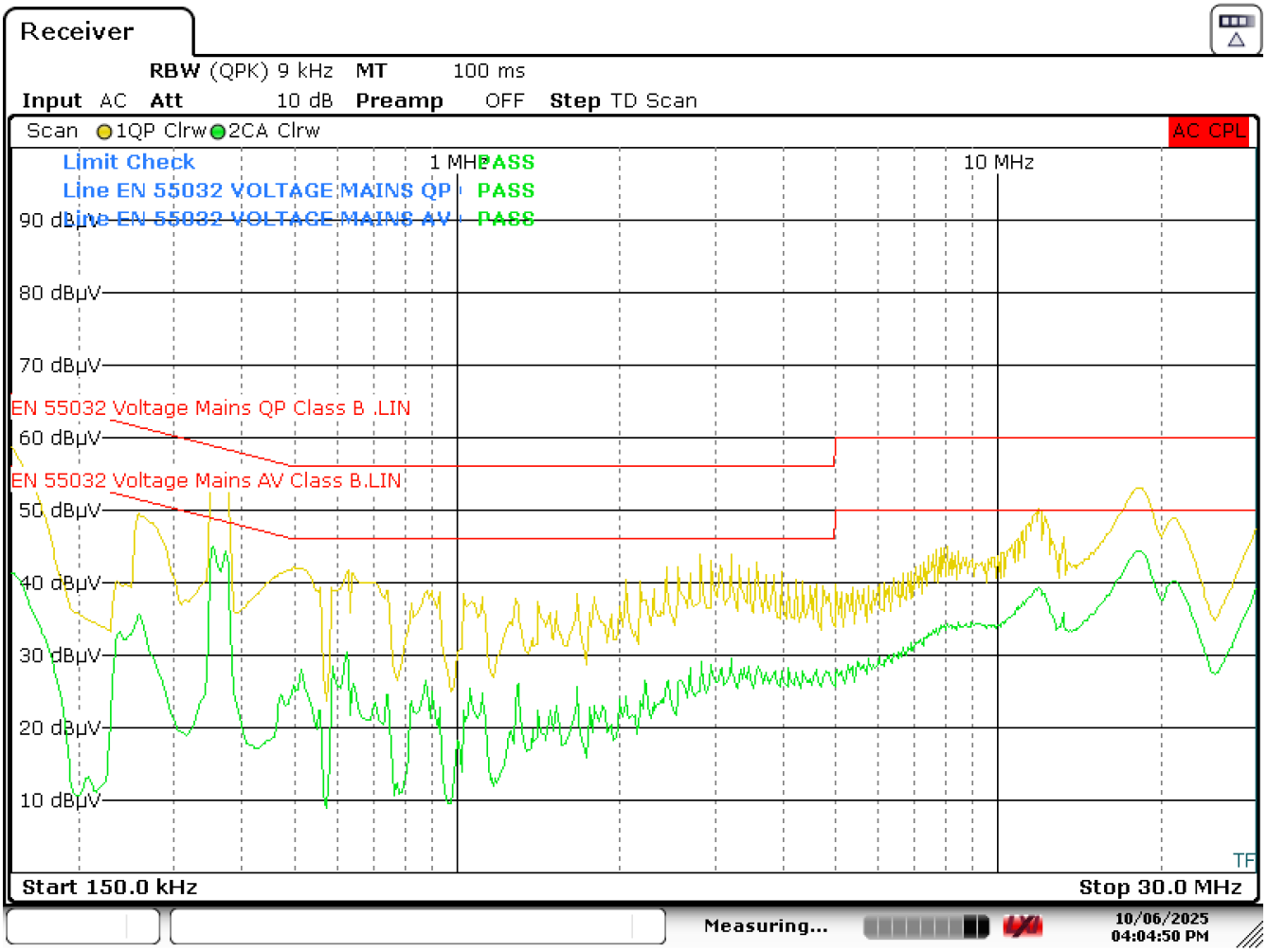


Figure 2-11. 230Vac, Full Load, L1

Conducted EMI result of L1 at 230Vac, full load is shown in Figure 2-12.



Date: 6.OCT.2025 16:04:50

Figure 2-12. 230Vac, Full Load, L2

3 Waveforms

3.1 Switching

The steady state input voltage, input current and PFC switch node at 115Vac input, full load is shown in Figure 3-1.

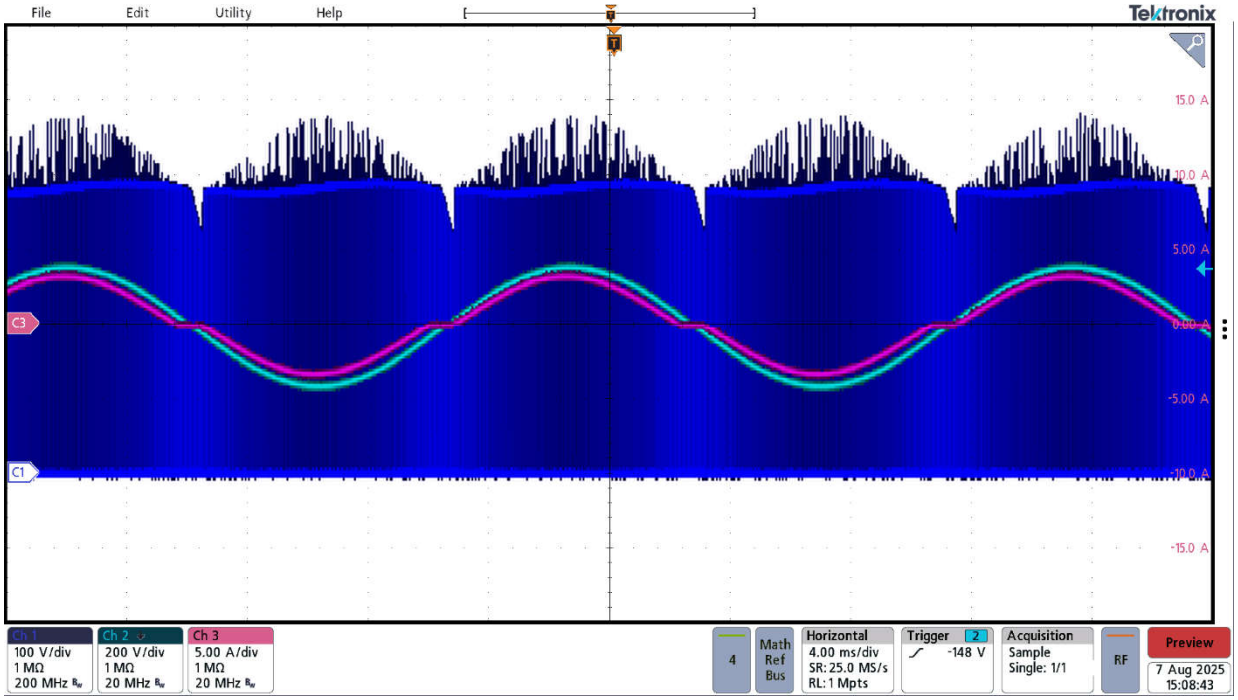


Figure 3-1. 115Vac Input, Full Load, PFC Steady State

The PFC switch node at the peak of the line for 115Vac input, full load is shown in Figure 3-2.

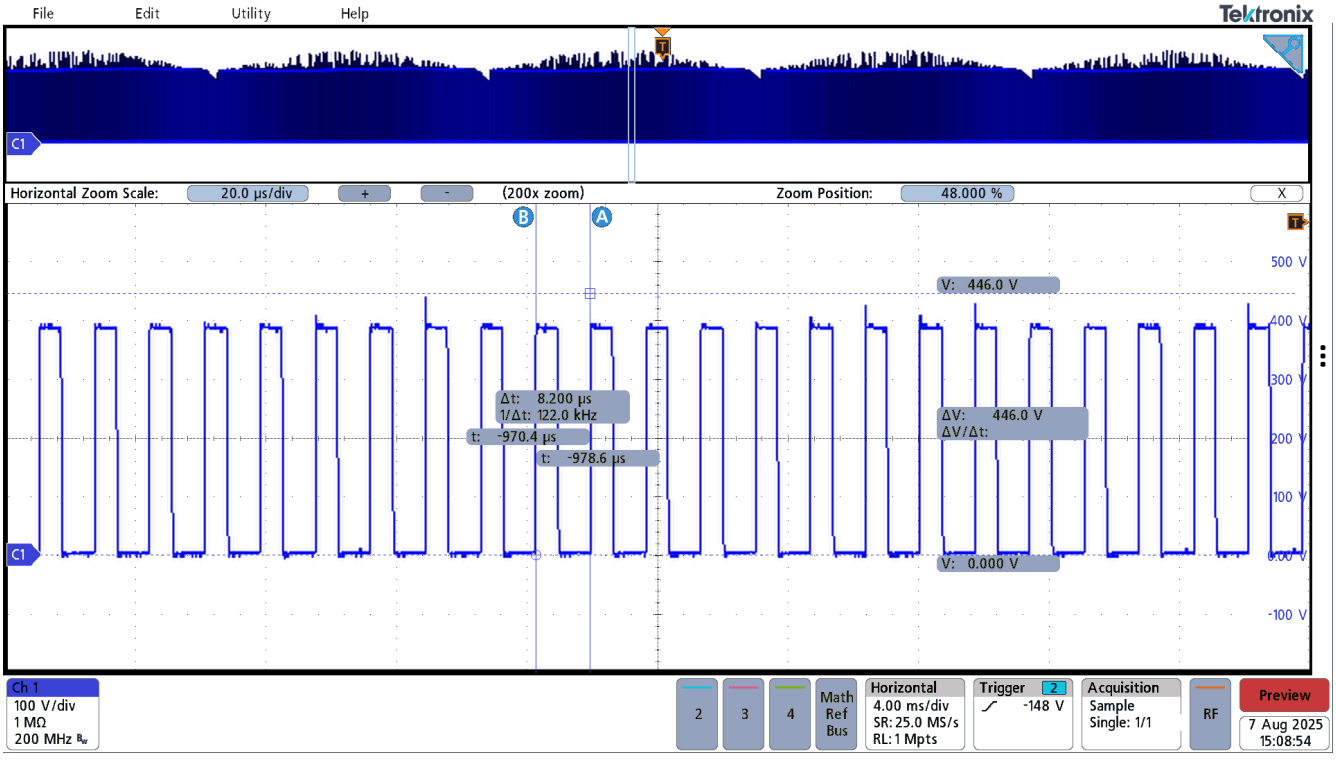


Figure 3-2. PFC Switch Node, 115Vac Input, Full Load

The steady state input voltage, input current and PFC switch node at 115Vac input, full load is shown in Figure 3-3.

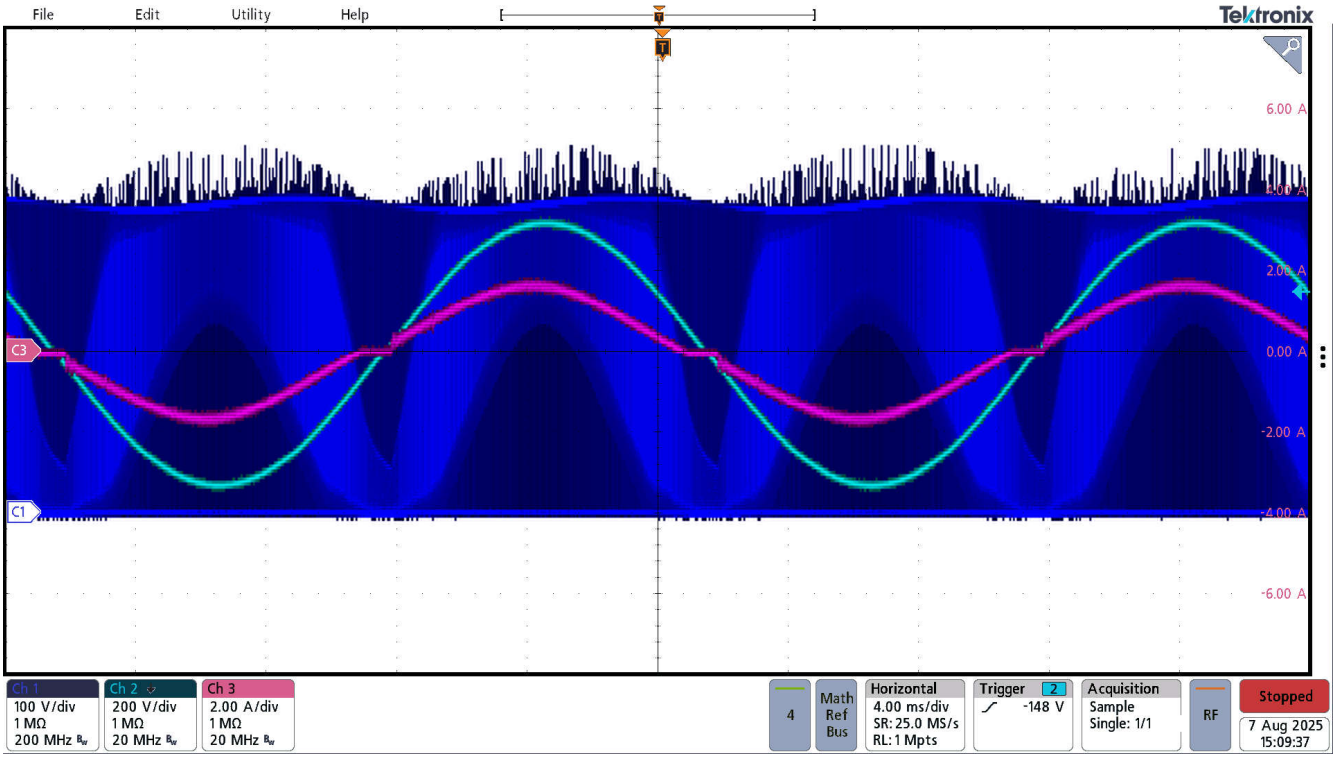


Figure 3-3. 230Vac Input, Full Load, PFC Steady State

The PFC switch node at the peak of the line for 230Vac input, full load is shown in Figure 3-4.

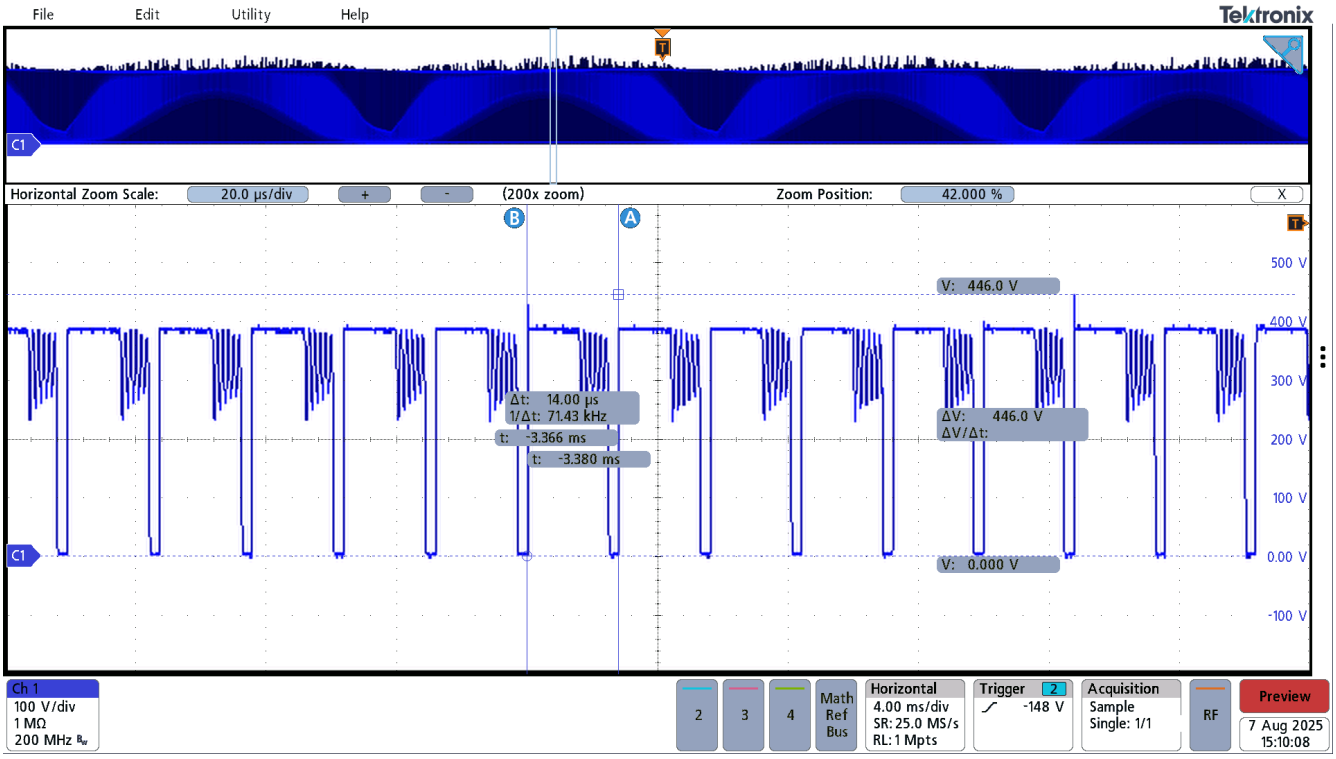


Figure 3-4. PFC Switch Node, 230Vac Input, Full Load

The LLC switch node at full load is shown in Figure 3-5.

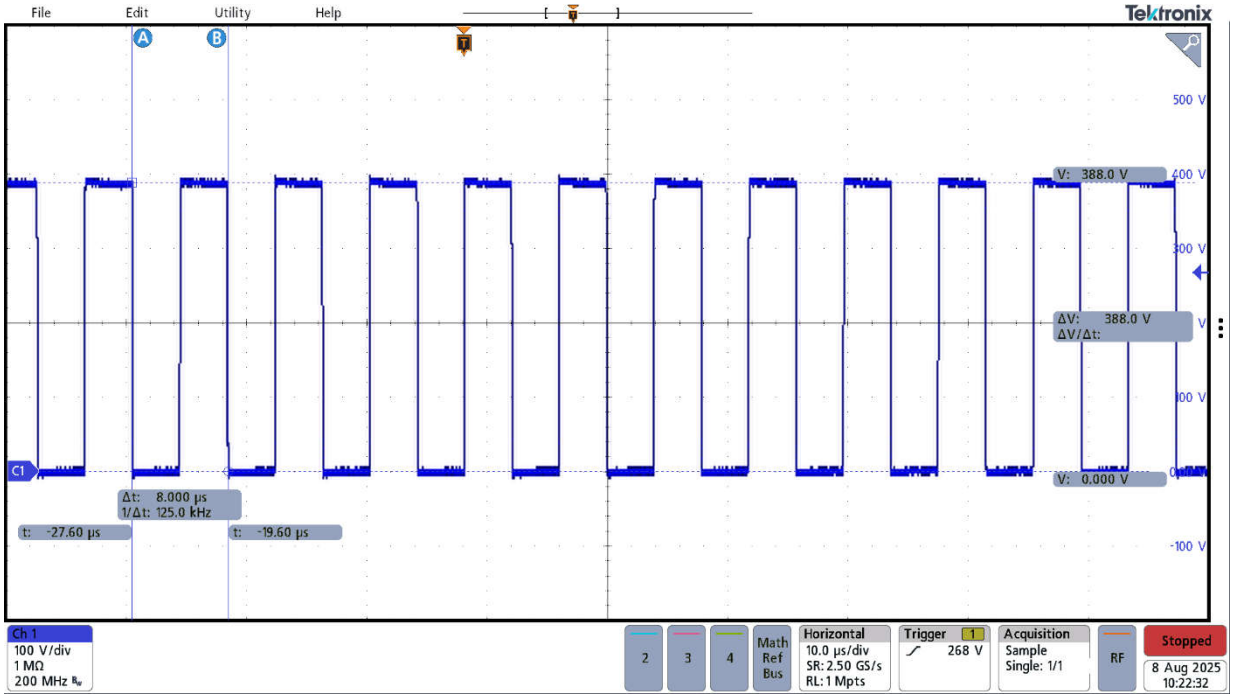


Figure 3-5. LLC Switch Node, Full Load

3.2 Output Voltage Ripple

Output voltage ripple at no load is shown in Figure 3-6.

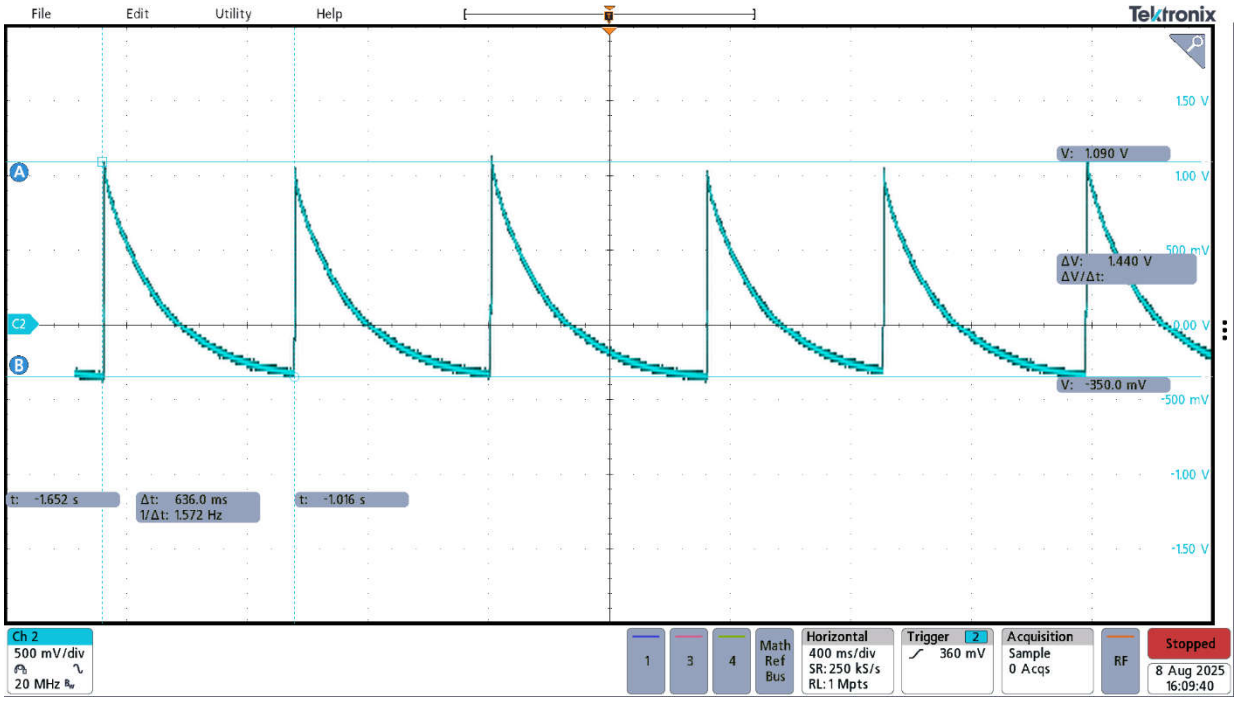


Figure 3-6. Output Ripple, No Load

Output voltage ripple at full load is shown in Figure 3-7.

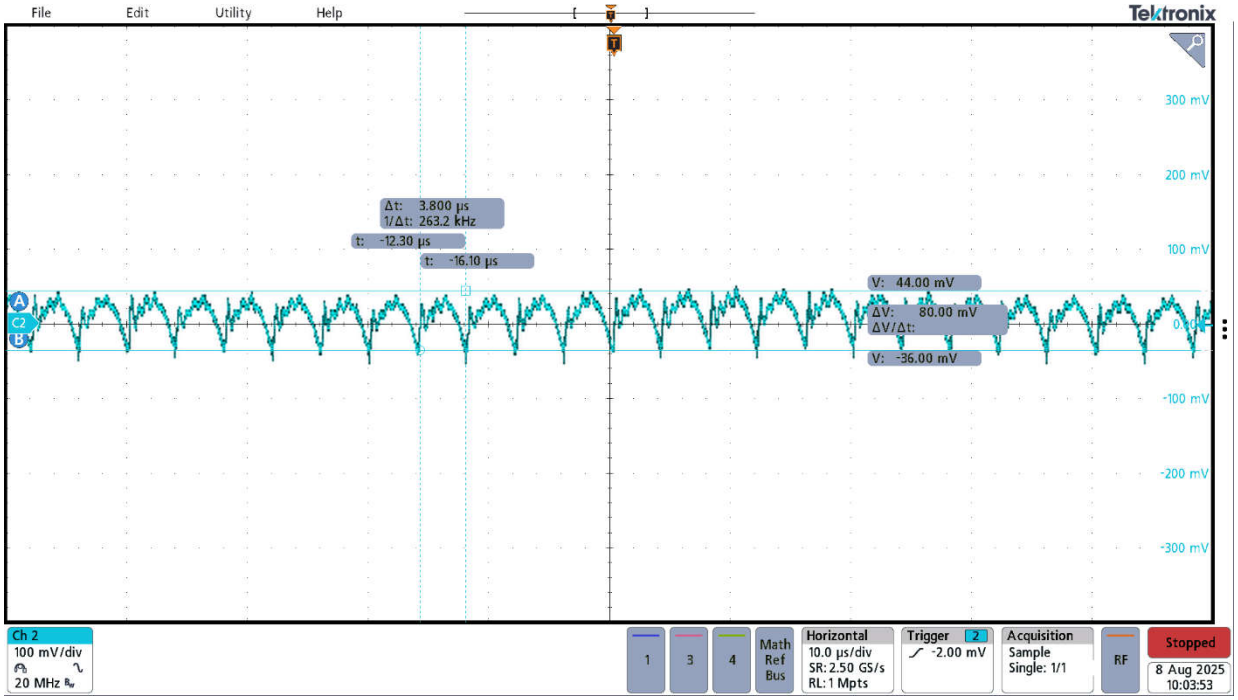


Figure 3-7. Output Ripple, Full Load

3.3 Load Transients

Load transient from 2.5A to 7.5A is shown in Figure 3-8.

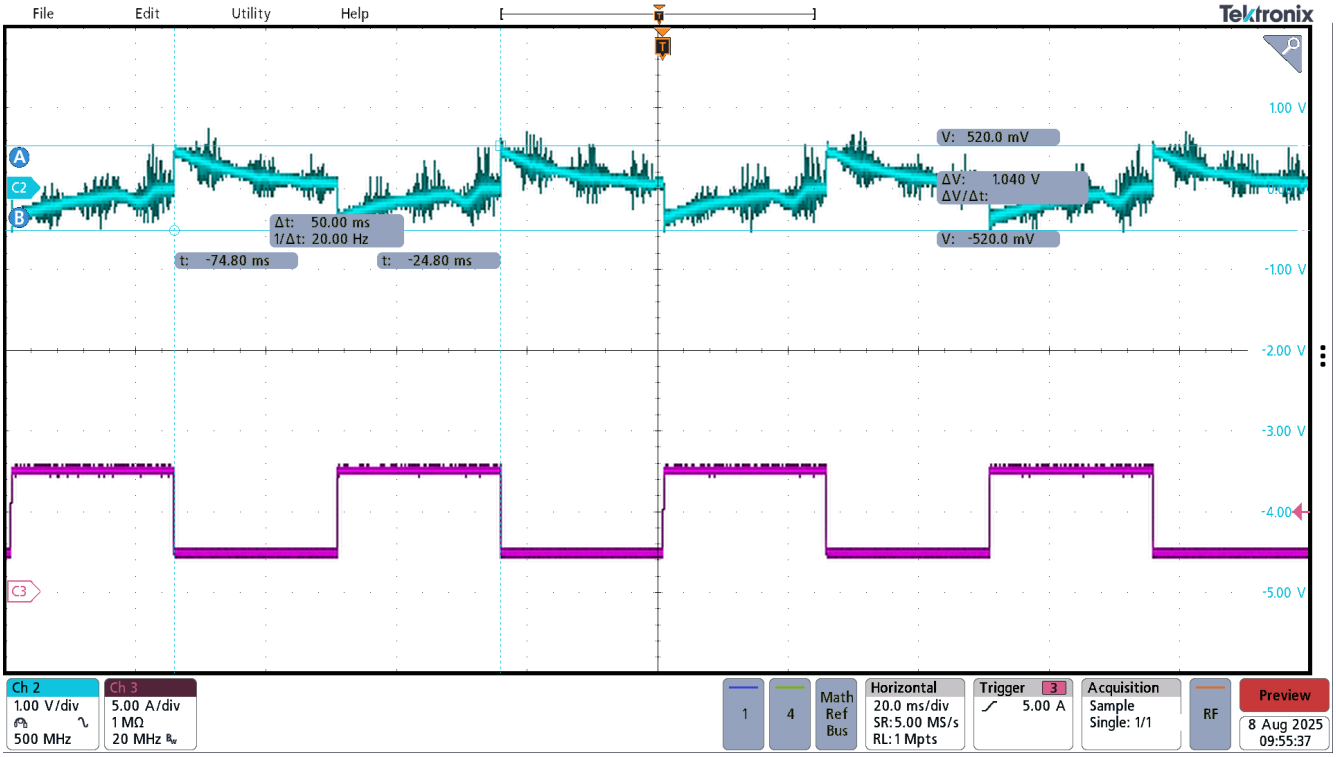


Figure 3-8. PMP23558 Load Transient

3.4 Start-up Sequence

Start-up behavior with 115Vac input, no load is shown in Figure 3-9.

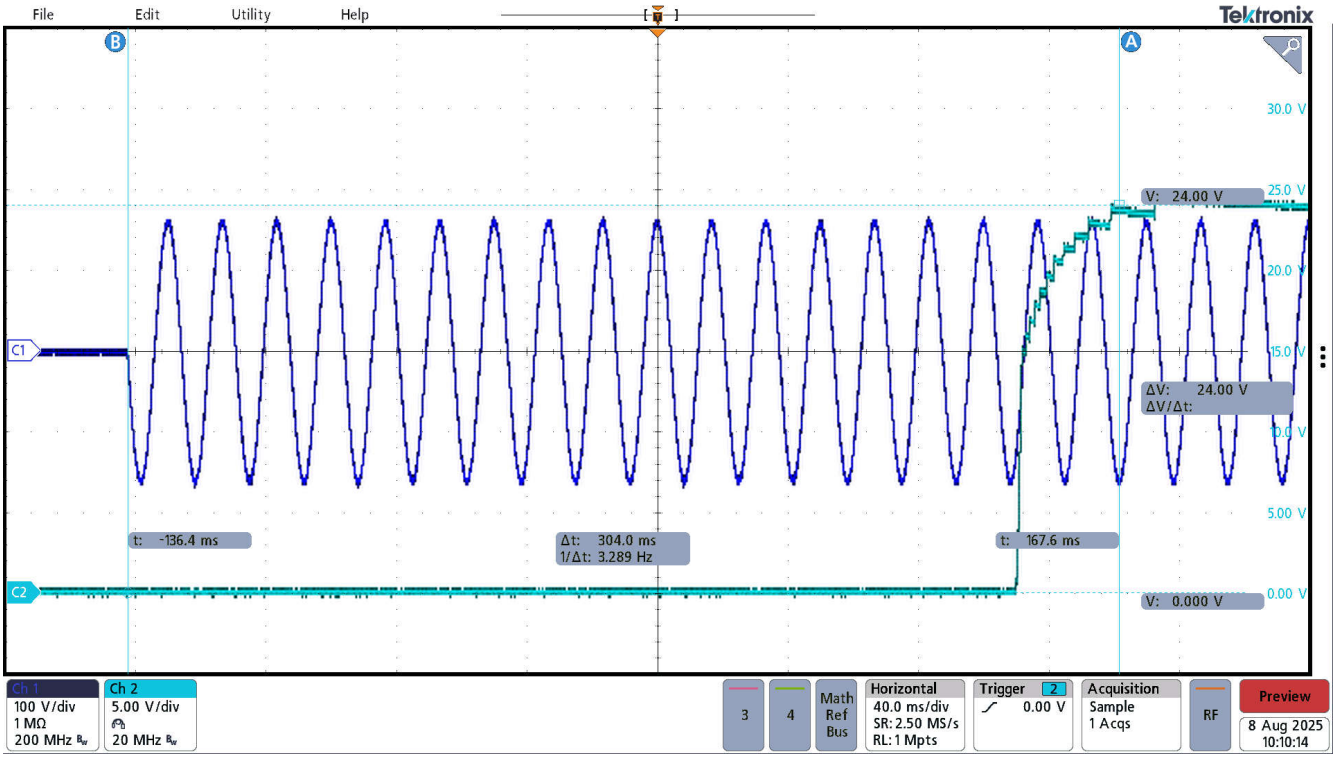


Figure 3-9. Start-up With 115Vac Input, No Load

Start-up behavior with 115Vac input, full load is shown in Figure 3-10.

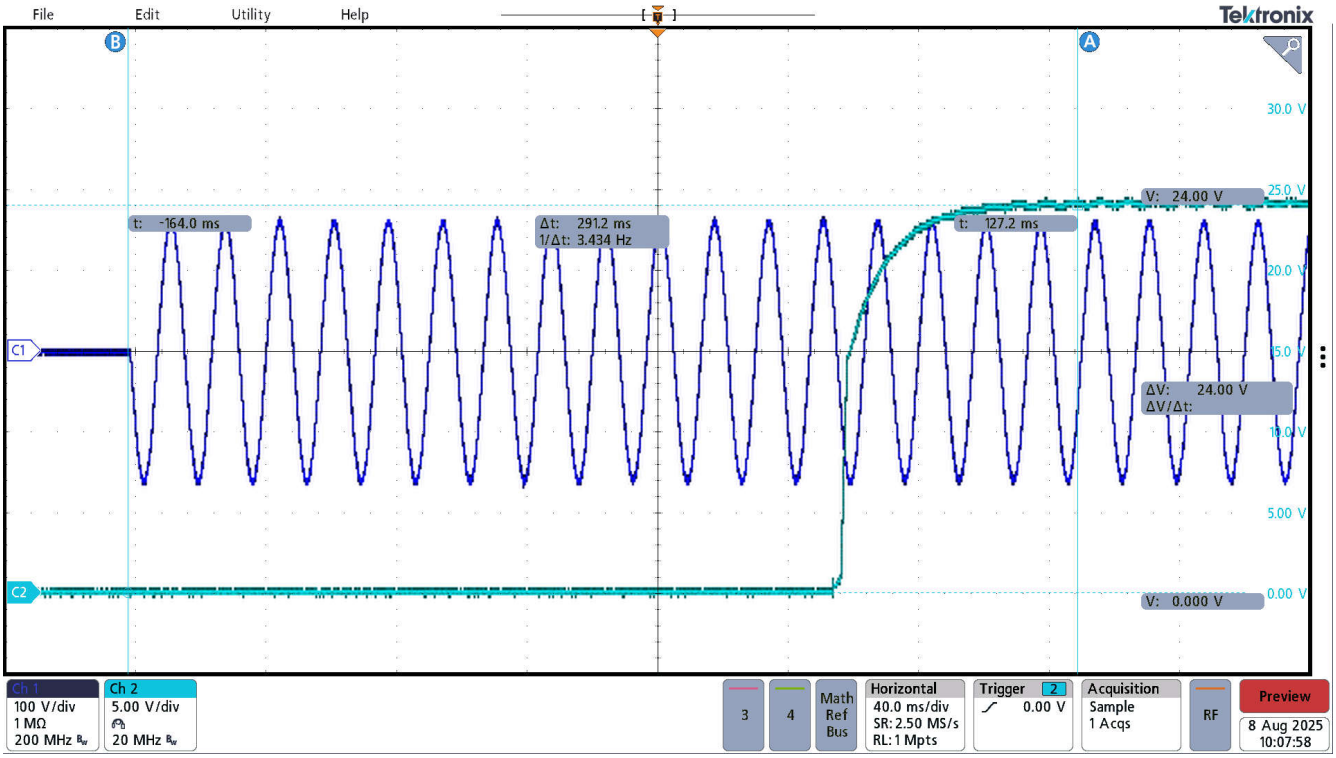


Figure 3-10. Start-up With 115Vac Input, Full Load

Start-up behavior with 230Vac input, no load is shown in Figure 3-11.

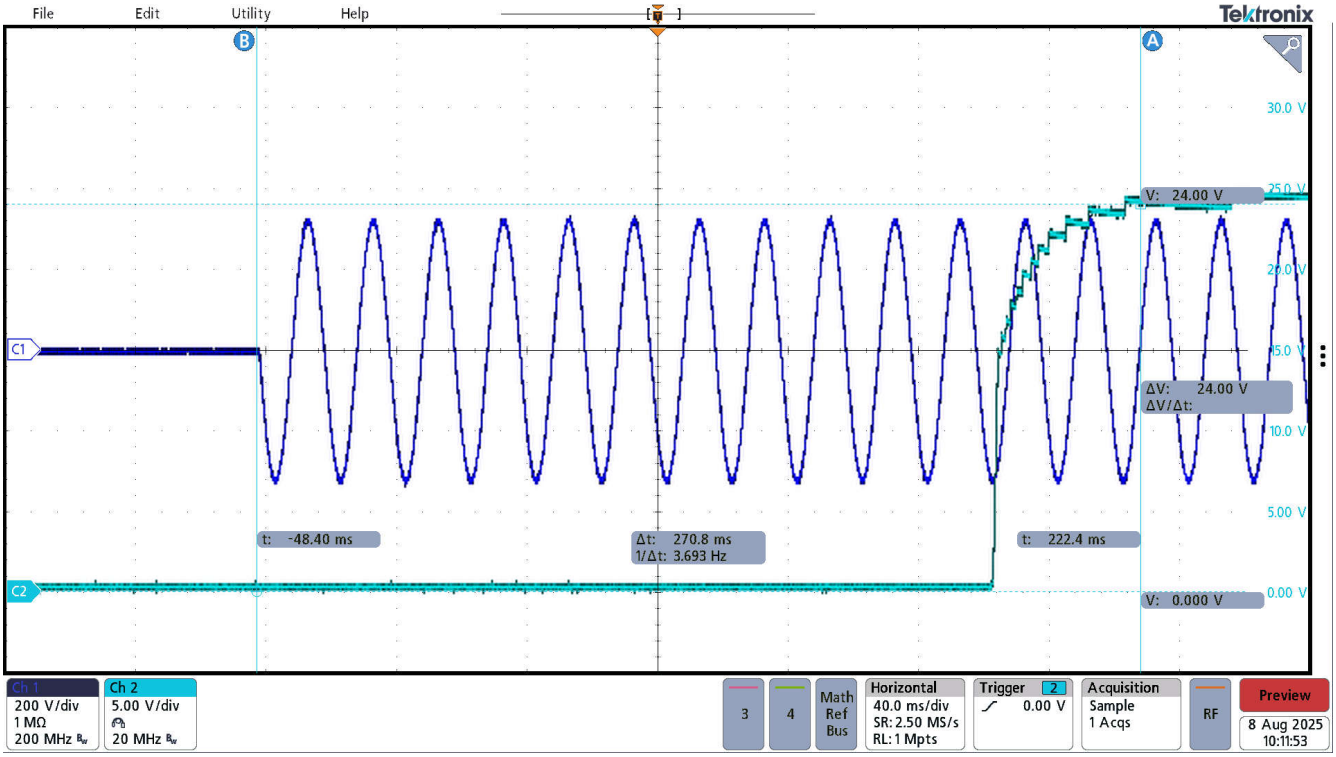


Figure 3-11. Start-up With 230Vac Input, No Load

Start-up behavior with 115Vac input, full load is shown in Figure 3-12.

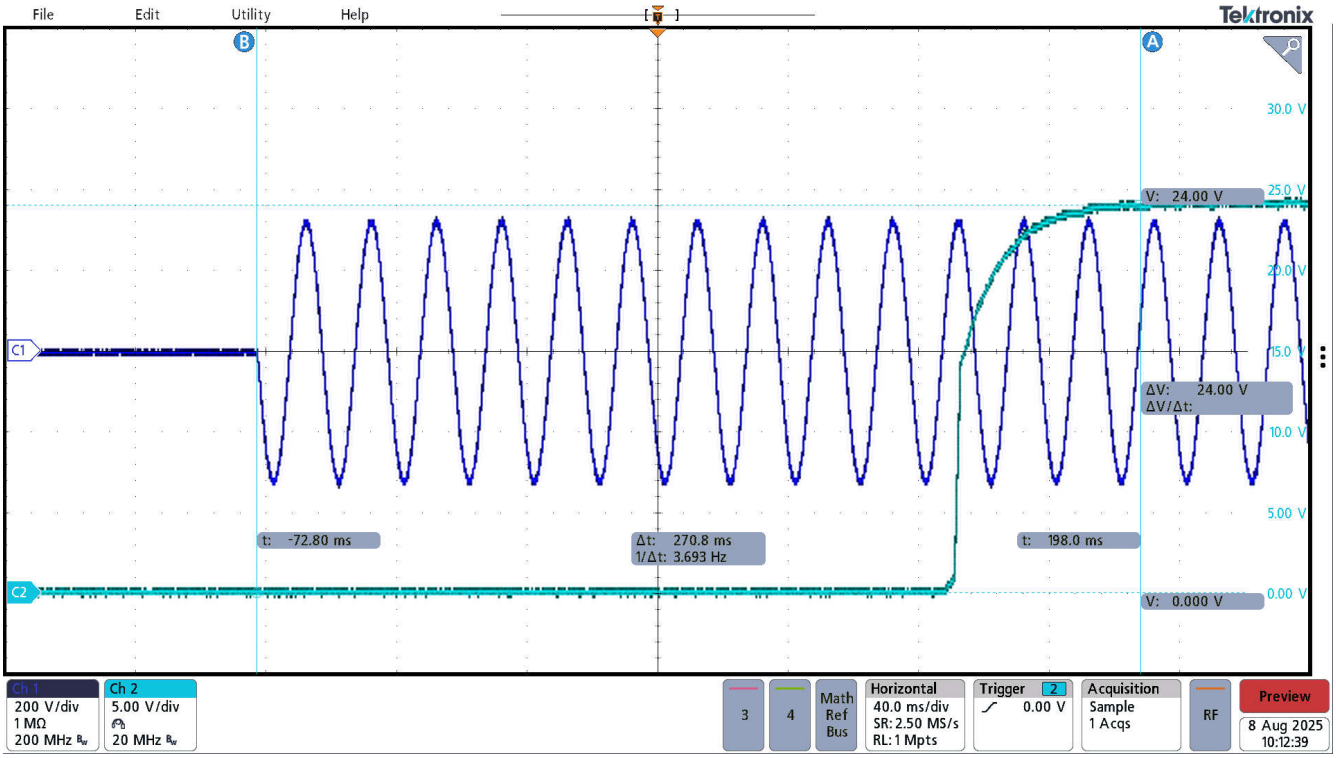


Figure 3-12. Start-up With 230Vac Input, Full Load

Trademarks

All trademarks are the property of their respective owners.

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATASHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES “AS IS” AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you fully indemnify TI and its representatives against any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI’s products are provided subject to TI’s Terms of Sale, TI’s General Quality Guidelines, or other applicable terms available either on ti.com or provided in conjunction with such TI products. TI’s provision of these resources does not expand or otherwise alter TI’s applicable warranties or warranty disclaimers for TI products. Unless TI explicitly designates a product as custom or customer-specified, TI products are standard, catalog, general purpose devices.

TI objects to and rejects any additional or different terms you may propose.

Last updated 10/2025