Test Report: PMP23089

90–265 VAC Input, 24-V, 12-W Isolated PSR Flyback Reference Design

Description

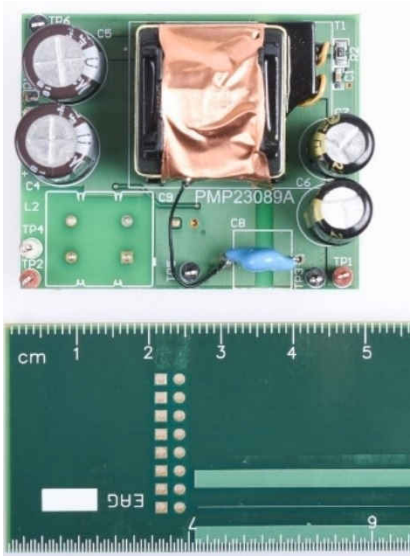
This primary-side regulated (PSR) flyback reference design outputs 24 V at 12 W from a 90-VAC to 265-VAC input. The design has a small form factor of 50 mm × 38 mm × 25 mm. The conducted EMI is well below the CISPR32 Class B limits.

Features

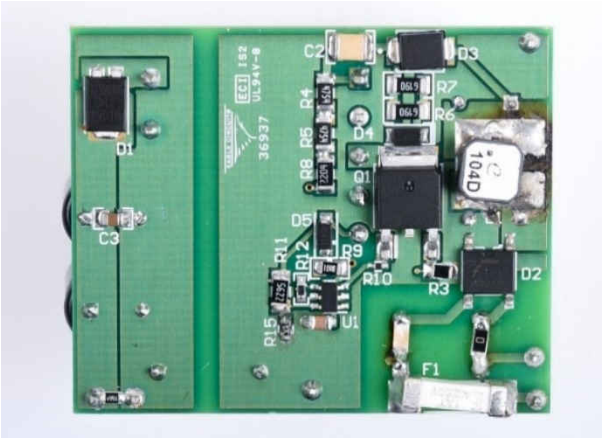
- Universal input
- Small form factor
- Excellent EMI
- Custom transformer design
- Cost-effective design

Applications

- POS printer



Top of Board



Bottom of Board

Profile of Board

1 Test Prerequisites

1.1 Voltage and Current Requirements

Table 1-1. Voltage and Current Requirements

Parameter	Specifications
Input Voltage Range	90 VAC–265 VAC
Output Voltage/Current	24 V, 500 mA

1.2 Required Equipment

- AC voltage source
- AC/DC power meter
- Electronic load
- Multimeters
- Oscilloscope

2 Testing and Results

2.1 Efficiency and Voltage Regulation

Efficiency and power loss are shown in the following figures.

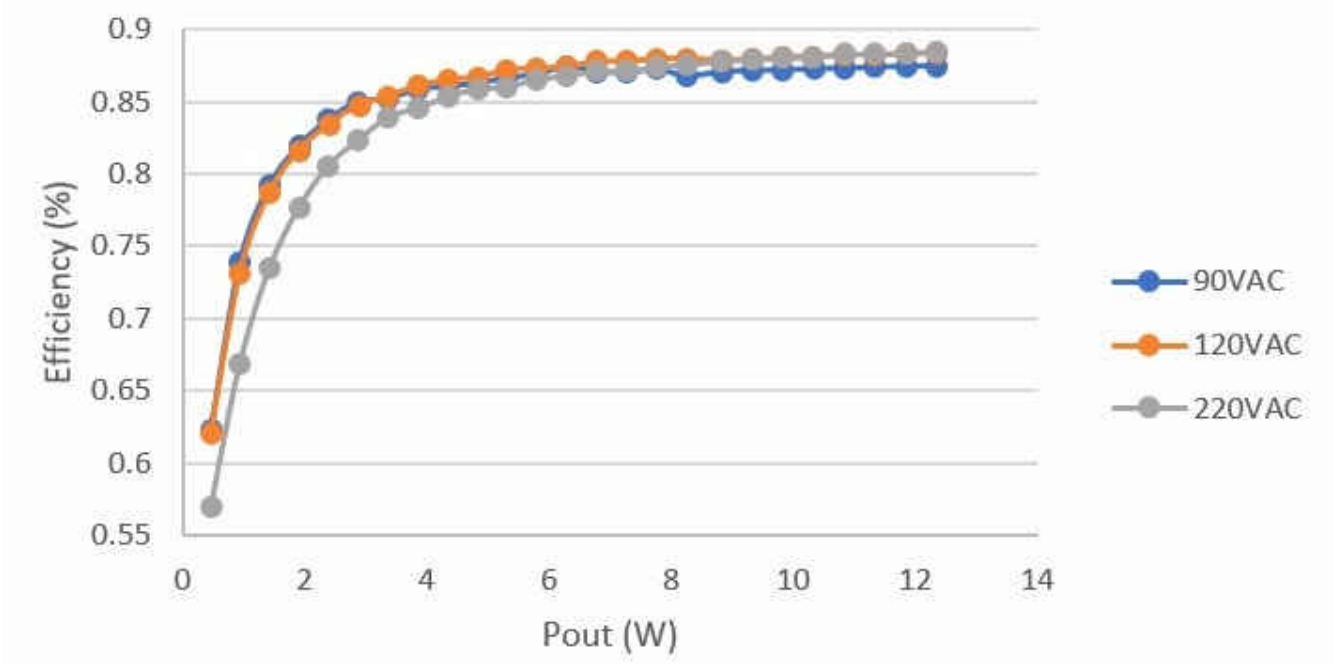


Figure 2-1. Efficiency vs Pout

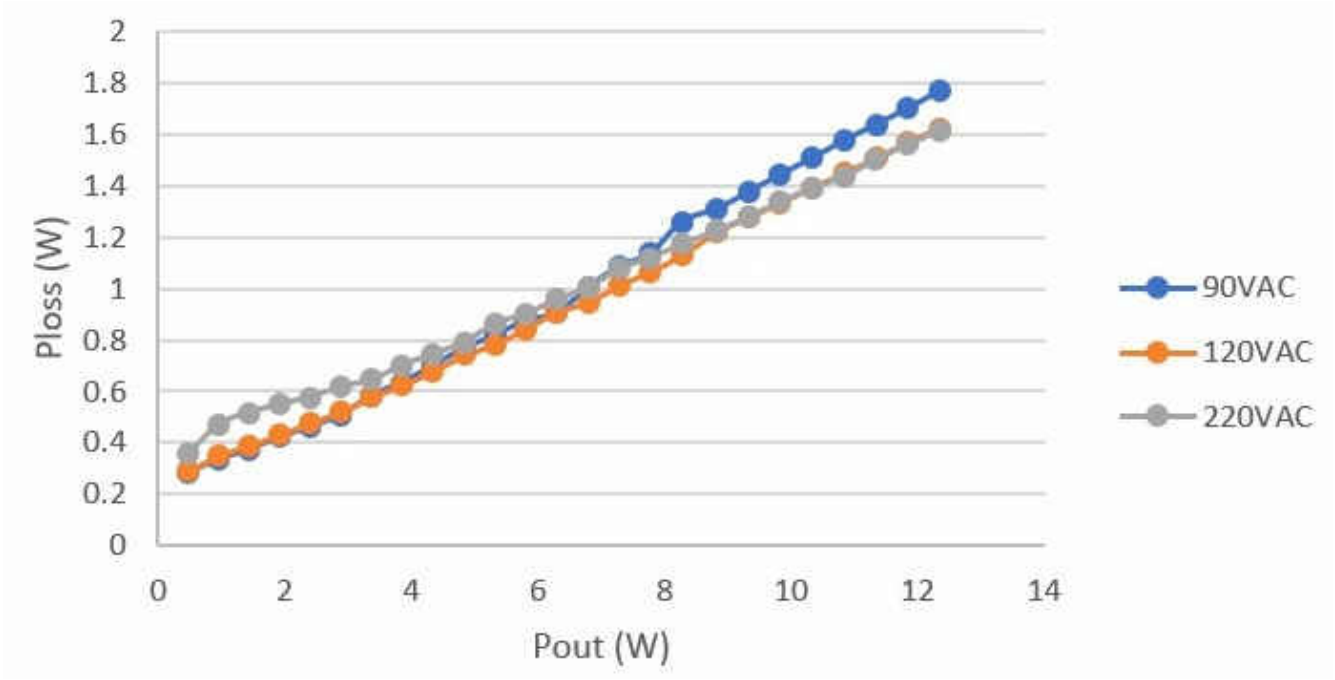


Figure 2-2. Ploss vs Pout

2.2 Efficiency Data

Efficiency data for 90 VAC, 120 VAC, and 220 VAC are shown in the following tables.

Table 2-1. Efficiency Data for 90-VAC Input

V_{IN} (VAC)	P_{IN} (W)	V_{OUT} (V)	I_{OUT} (A)	P_{OUT} (W)	Eff.	P_{loss} (W)
90.013	0.75908	23.90674	0.019785	0.472988	0.623107	0.286092
90.008	1.2864	23.90719	0.039755	0.950436	0.738834	0.335964
90.004	1.8068	23.93842	0.059774	1.430898	0.791952	0.375902
89.998	2.3343	23.96581	0.079781	1.912021	0.819098	0.422279
89.996	2.8591	23.998	0.099808	2.395193	0.837744	0.463907
89.995	3.3875	24.0254	0.119794	2.878104	0.849625	0.509396
89.984	3.9583	24.13297	0.139783	3.373379	0.852229	0.584921
89.98	4.4951	24.14459	0.159791	3.858098	0.85829	0.637002
89.974	5.0465	24.16077	0.179808	4.344293	0.860853	0.702207
89.964	5.5985	24.17649	0.199769	4.829714	0.86268	0.768786
89.974	6.1376	24.20149	0.219776	5.318916	0.866612	0.818684
89.967	6.6831	24.2155	0.239815	5.807239	0.868944	0.875861
89.945	7.2018	24.23581	0.259819	6.296934	0.874356	0.904866
89.953	7.7931	24.25651	0.279802	6.78701	0.8709	1.00609
89.961	8.3635	24.27497	0.299832	7.278422	0.87026	1.085078
89.958	8.9093	24.30007	0.319825	7.771772	0.872321	1.137528
89.936	9.5252	24.32137	0.339823	8.264963	0.867694	1.260237
89.931	10.137	24.53094	0.35983	8.826971	0.870768	1.310029
89.92	10.705	24.55862	0.379819	9.32783	0.871353	1.37717
89.922	11.274	24.58768	0.399796	9.830057	0.871923	1.443943
89.92	11.842	24.61494	0.419843	10.3344	0.87269	1.507601
89.904	12.414	24.64058	0.439828	10.83761	0.873015	1.576393
89.905	12.982	24.66819	0.459849	11.34364	0.873798	1.638356
89.906	13.549	24.69098	0.479838	11.84767	0.874431	1.701333
89.899	14.126	24.71816	0.499829	12.35486	0.874618	1.77114

Table 2-2. Efficiency Data for 120-VAC Input

V_{IN} (VAC)	P_{IN} (W)	V_{OUT} (V)	I_{OUT} (A)	P_{OUT} (W)	Eff	P_{loss} (W)
120.02	0.76436	23.91079	0.019849	0.474602	0.620914	0.289758
120.01	1.3012	23.90623	0.039789	0.95121	0.731025	0.34999
120.01	1.8183	23.9245	0.059782	1.430255	0.786589	0.388045
120.01	2.3433	23.95937	0.079823	1.912512	0.816162	0.430788
120.01	2.8842	24.10268	0.099834	2.40627	0.834294	0.47793
120	3.4115	24.12769	0.119811	2.890768	0.84736	0.520732
120	3.9512	24.12773	0.139797	3.372995	0.853663	0.578205
119.99	4.48	24.13718	0.159777	3.856567	0.860841	0.623433
119.99	5.0218	24.15446	0.17985	4.344169	0.865062	0.677631
119.99	5.5717	24.17624	0.199804	4.830518	0.866974	0.741182
119.99	6.101	24.19579	0.219812	5.318519	0.871746	0.782481
119.99	6.6505	24.21403	0.23979	5.806282	0.873059	0.844218
119.96	7.2057	24.24013	0.2598	6.29758	0.873972	0.90812
119.98	7.7354	24.26086	0.279812	6.788482	0.877586	0.946918
119.99	8.2949	24.28946	0.299819	7.282446	0.877943	1.012454
119.98	8.841	24.31313	0.319812	7.77563	0.879497	1.06537
119.94	9.3993	24.33647	0.339794	8.269392	0.879788	1.129908
119.94	10.051	24.53561	0.359845	8.829007	0.878421	1.221993
119.96	10.607	24.56318	0.379841	9.330109	0.879618	1.276891
119.95	11.165	24.5867	0.399801	9.829793	0.880411	1.335207
119.95	11.722	24.60521	0.41981	10.32951	0.881207	1.39249
119.95	12.283	24.63113	0.439835	10.83364	0.882003	1.449356
119.95	12.847	24.65865	0.459843	11.33909	0.882626	1.507906
119.94	13.416	24.68915	0.47981	11.84611	0.882984	1.569887
119.94	13.98	24.7166	0.499836	12.35424	0.883708	1.625756

Table 2-3. Efficiency Data for 220-VAC Input

V_{IN} (VAC)	P_{IN} (W)	V_{OUT} (V)	I_{OUT} (A)	P_{OUT} (W)	Eff	P_{loss} (W)
220.08	0.83319	23.92894	0.01982	0.474272	0.569225	0.358918
220.08	1.4224	23.90366	0.039785	0.951015	0.668599	0.471385
220.07	1.9466	23.92112	0.059781	1.430022	0.734625	0.516578
220.07	2.4607	23.94509	0.079804	1.910903	0.776569	0.549797
220.07	2.9695	23.96191	0.099841	2.392375	0.805649	0.577125
220.09	3.4926	23.99971	0.119827	2.875811	0.823401	0.616789
220.07	4.0193	24.14129	0.139767	3.374163	0.83949	0.645137
220.08	4.5619	24.14557	0.159815	3.858822	0.845881	0.703078
220.07	5.0893	24.15286	0.179852	4.343943	0.853544	0.745357
220.06	5.6221	24.17126	0.199819	4.82987	0.859086	0.79223
220.06	6.1812	24.19095	0.2198	5.317169	0.860216	0.864031
220.06	6.7071	24.20996	0.239799	5.805531	0.86558	0.901569
220.06	7.255	24.23668	0.259817	6.297096	0.867966	0.957904
220.05	7.7895	24.25405	0.27982	6.786767	0.871271	1.002733
220.05	8.3573	24.2785	0.299838	7.279606	0.871048	1.077694
220.05	8.8916	24.30517	0.319804	7.772893	0.874184	1.118707
220.04	9.4402	24.32908	0.339789	8.266754	0.875697	1.173446
220.05	10.05	24.52823	0.359779	8.824747	0.878084	1.225253
220.04	10.604	24.54807	0.379819	9.323822	0.879274	1.280178
220.04	11.158	24.56463	0.399803	9.821001	0.880176	1.336999
220.04	11.714	24.58891	0.419806	10.32257	0.881217	1.391428
220.03	12.264	24.61888	0.439834	10.82822	0.882927	1.435779
220.03	12.839	24.65112	0.459854	11.33592	0.882929	1.503076
220.03	13.404	24.68098	0.479817	11.84235	0.883494	1.56165
220.03	13.966	24.70785	0.499818	12.34942	0.884249	1.616582

2.3 Thermal Images

Thermal images for the top and bottom of the board at 90 VAC and 220 VAC are shown in the following figures.

The next two images reflect the thermal results at the following conditions; Figure 2-3 shows the top of the board and Figure 2-4 shows the bottom of the board:

- 90 VAC
- Full load
- 30-minute soak
- Room temperature
- No airflow

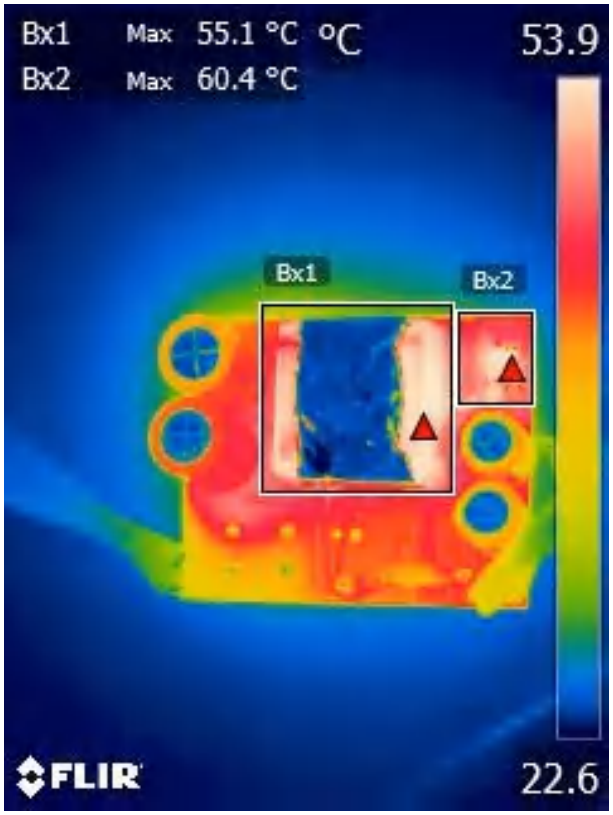


Figure 2-3. BX1 = Transformer, BX2 = Rsnub (R2)

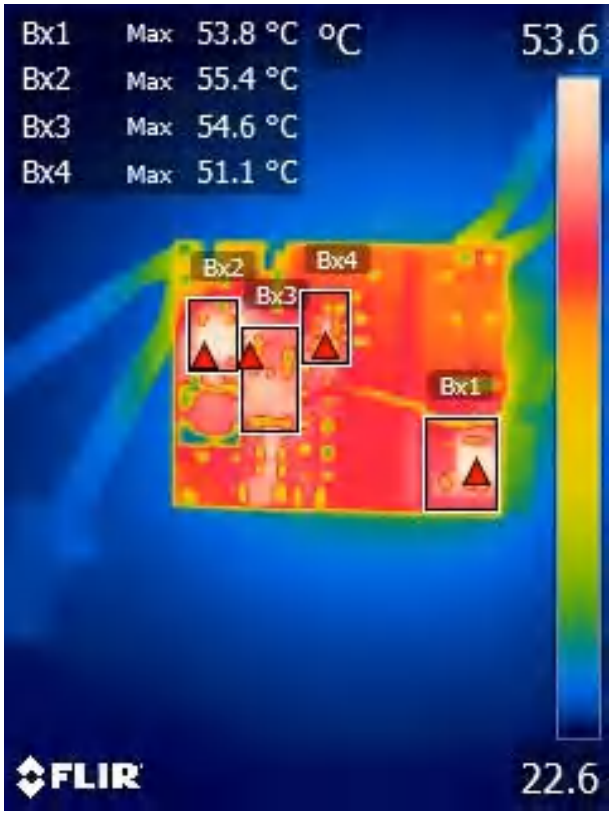


Figure 2-4. BX1 = Dsec, BX2 = D2, BX3 = Q1, BX4 = U1

The next two images reflect the thermal results at the following conditions; Figure 2-5 shows the top of the board and Figure 2-6 shows the bottom of the board:

- 220 VAC
- Full load
- 30-minute soak
- Room temperature
- No airflow

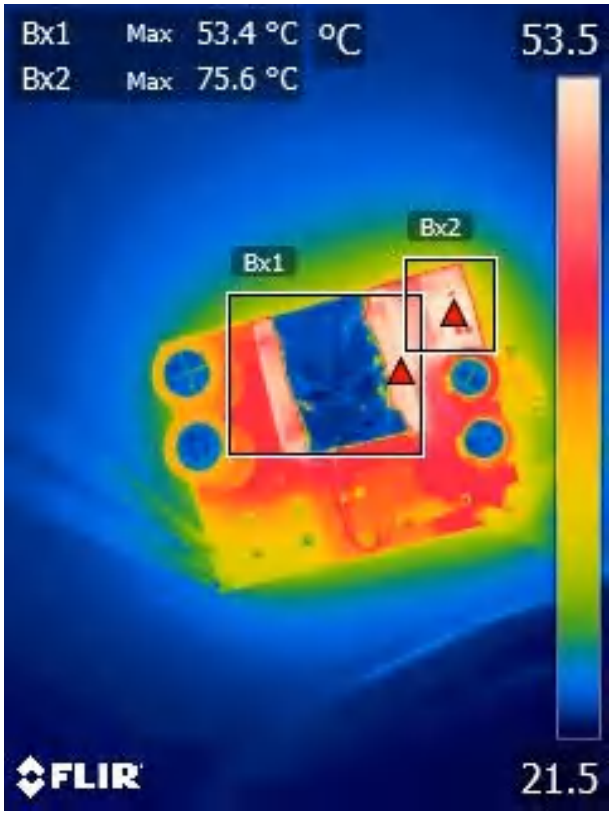


Figure 2-5. BX1 = Transformer, BX2 = Rsnub (R2)

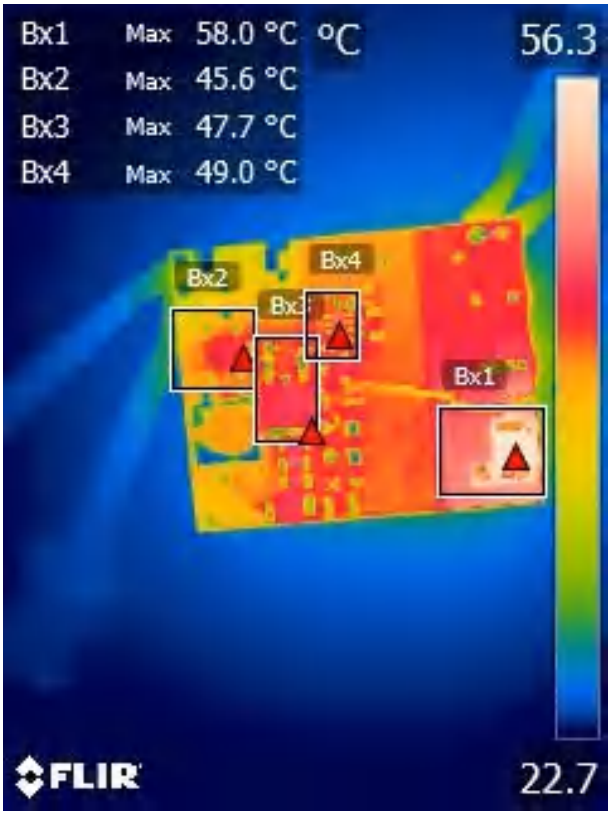


Figure 2-6. BX1 = Dsec, BX2 = Q1, BX3 = D2, BX4 = U1

2.4 EMI

EMI is shown in the following figures

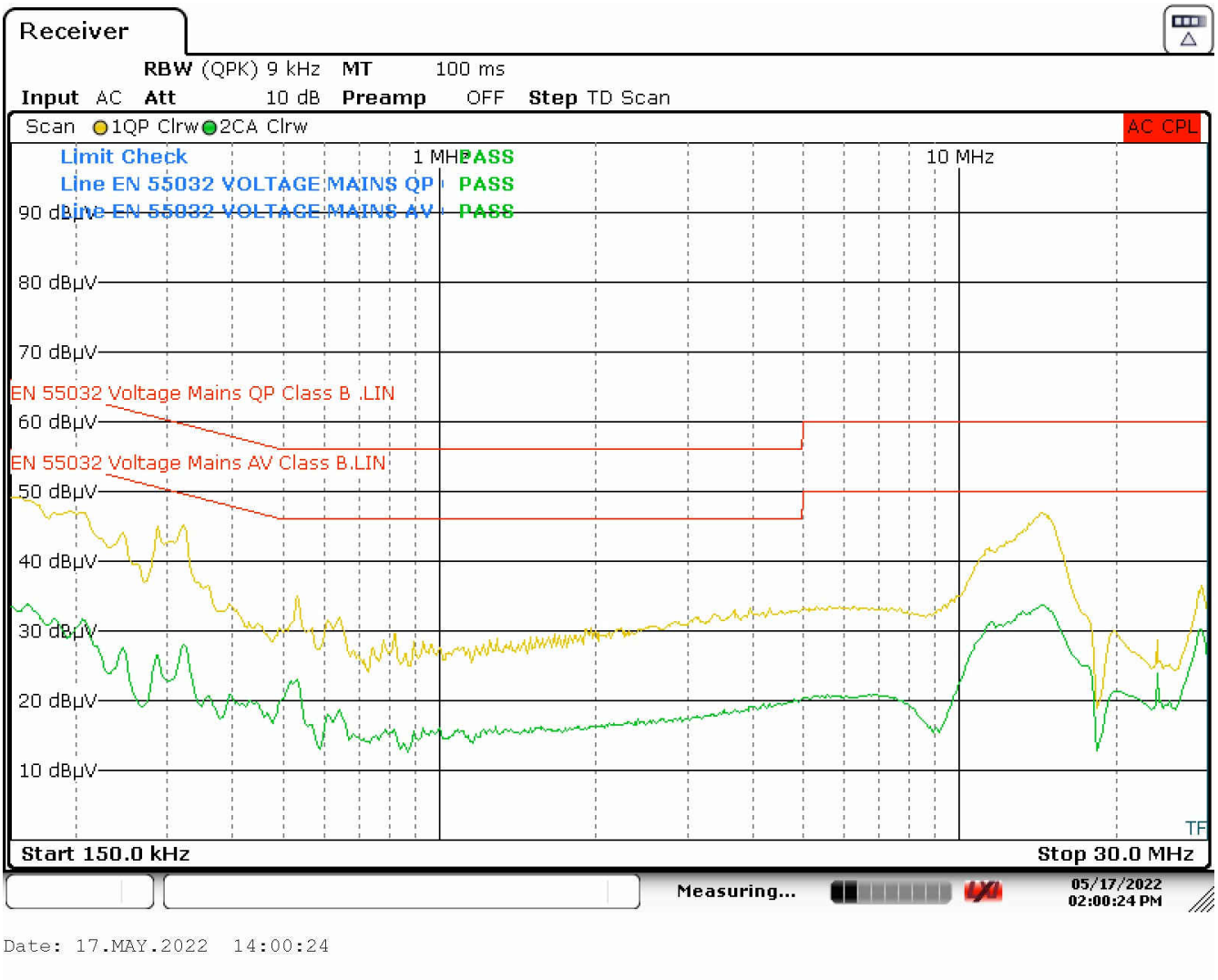


Figure 2-7. 120 VAC, Full Power, Line

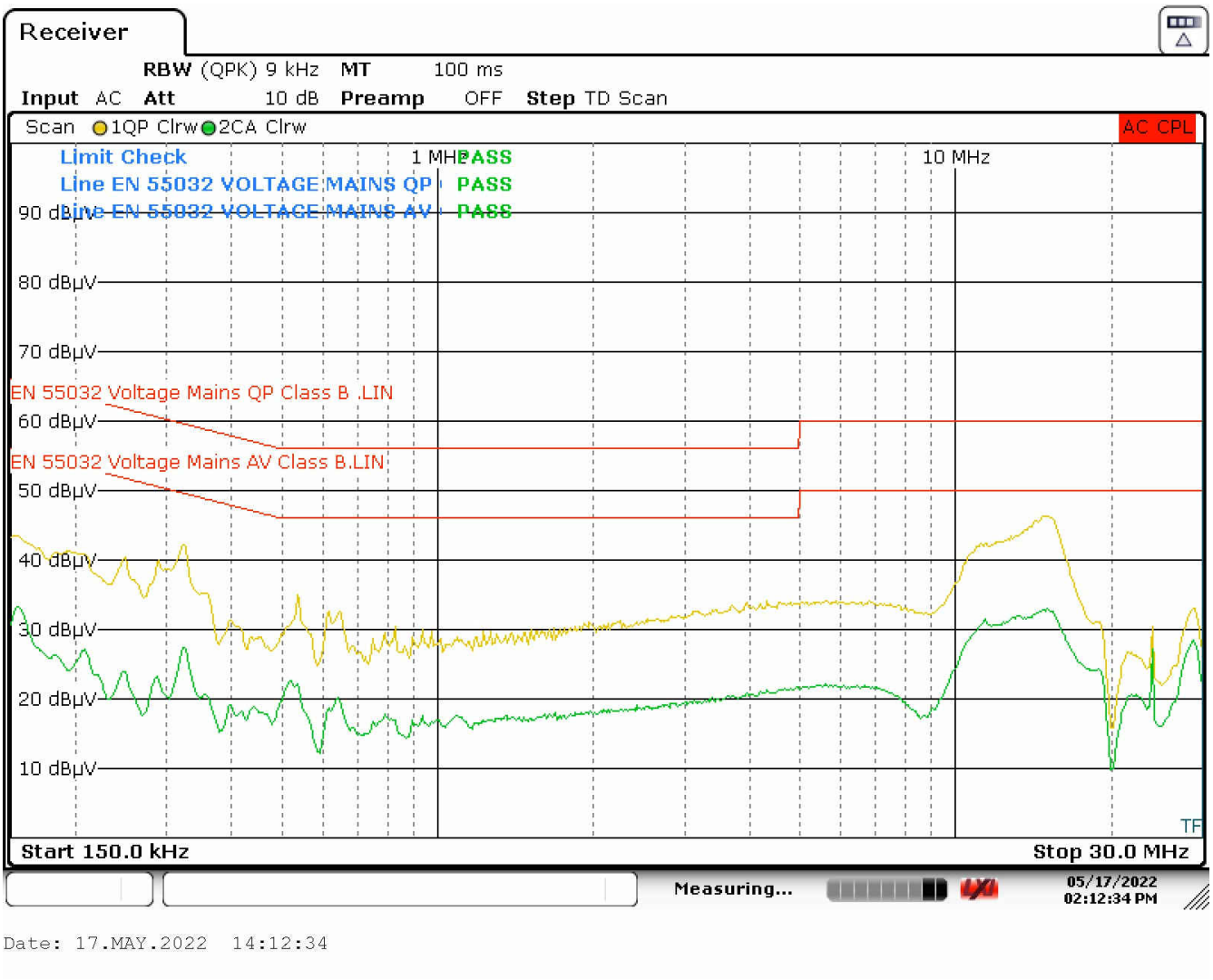


Figure 2-8. 120 VAC, Full Power, Neutral

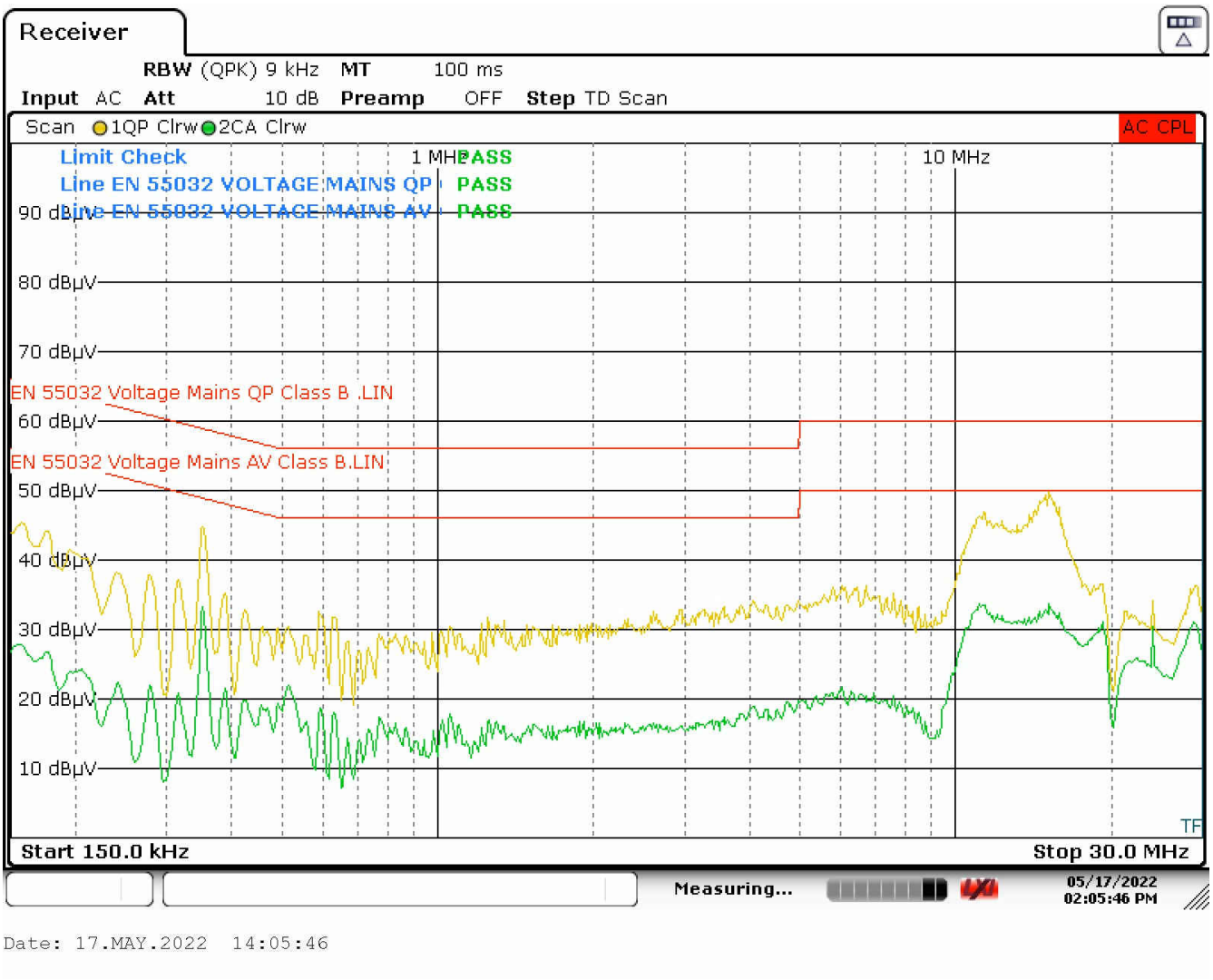


Figure 2-9. 220 VAC, Full Power, Line

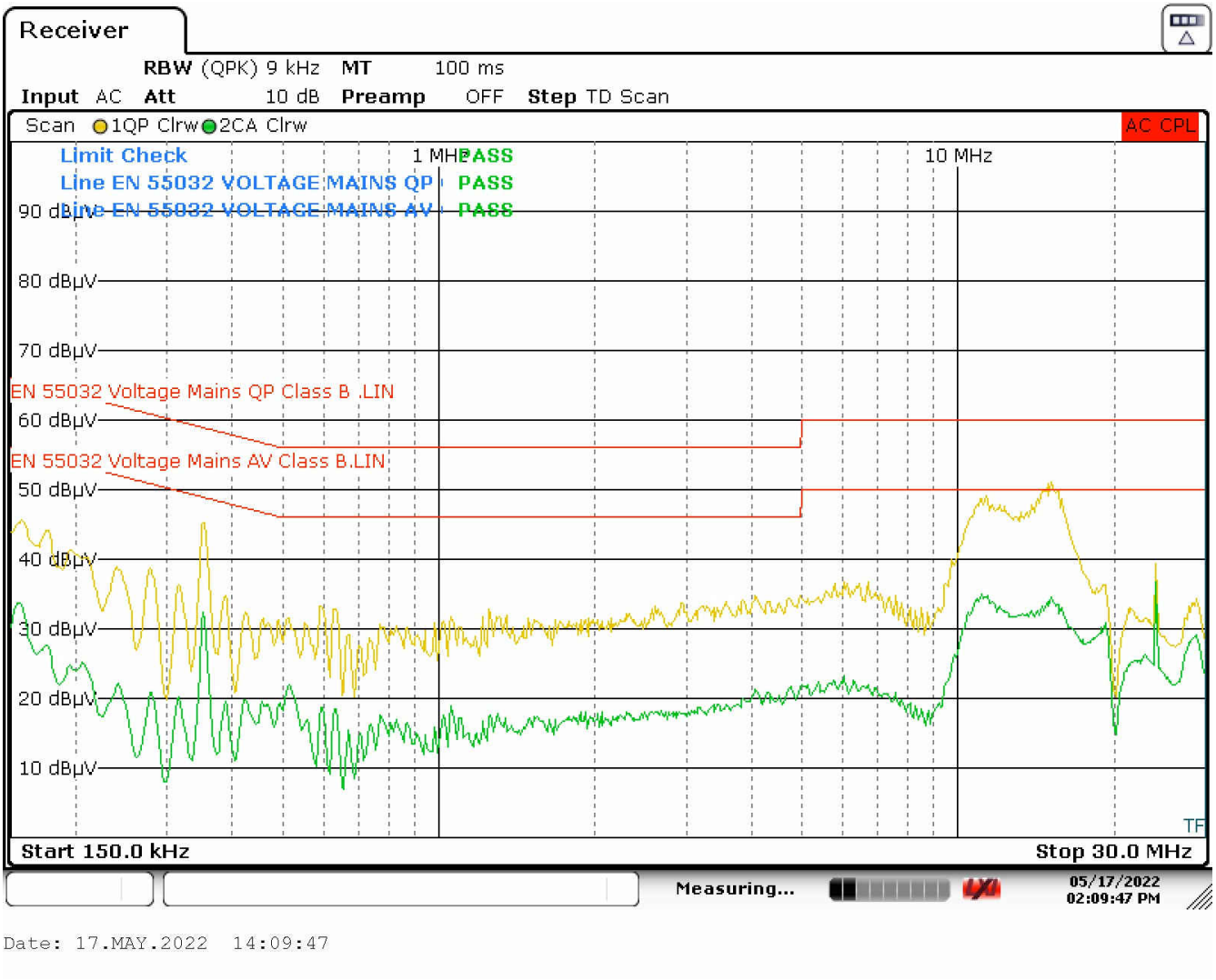
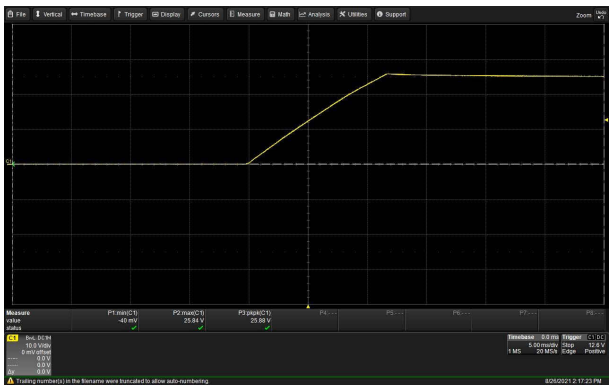


Figure 2-10. 220 VAC, Full Power, Neutral

3 Waveforms

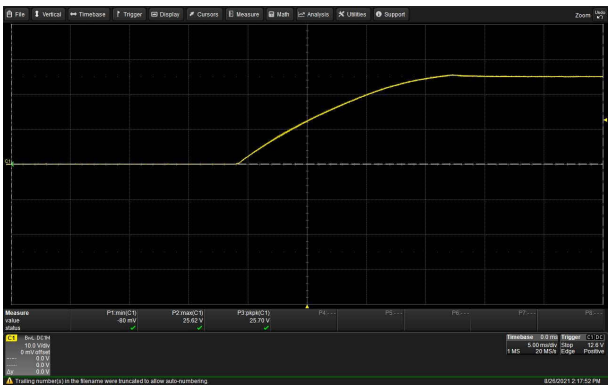
3.1 Start-Up Sequence

Start-up behavior is shown in the following figures.



Ch1 (yellow): 24 V_{OUT} (10 V/div)

Figure 3-1. 120 VAC, 5-mA Load

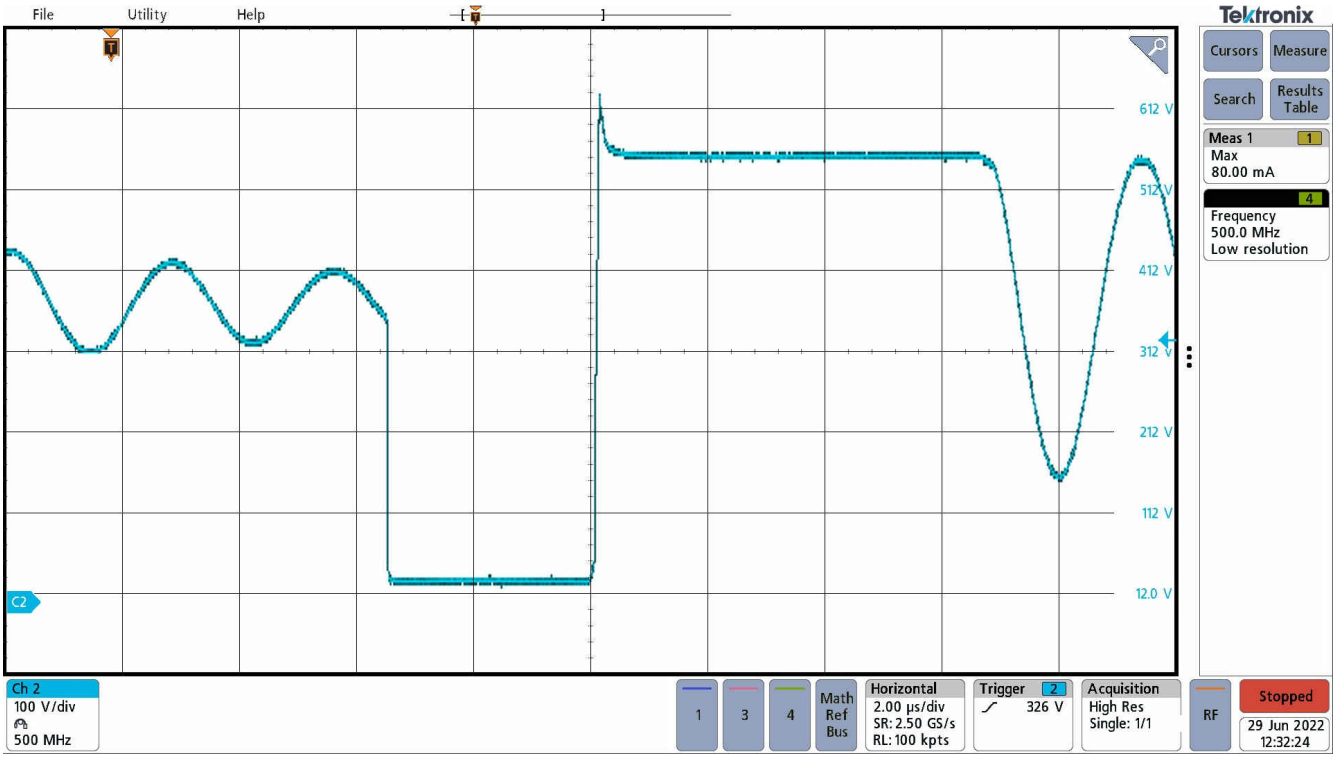


Ch1 (yellow): 24 V_{OUT} (10 V/div)

Figure 3-2. 120 VAC, Full Load, Resistor

3.2 Switching

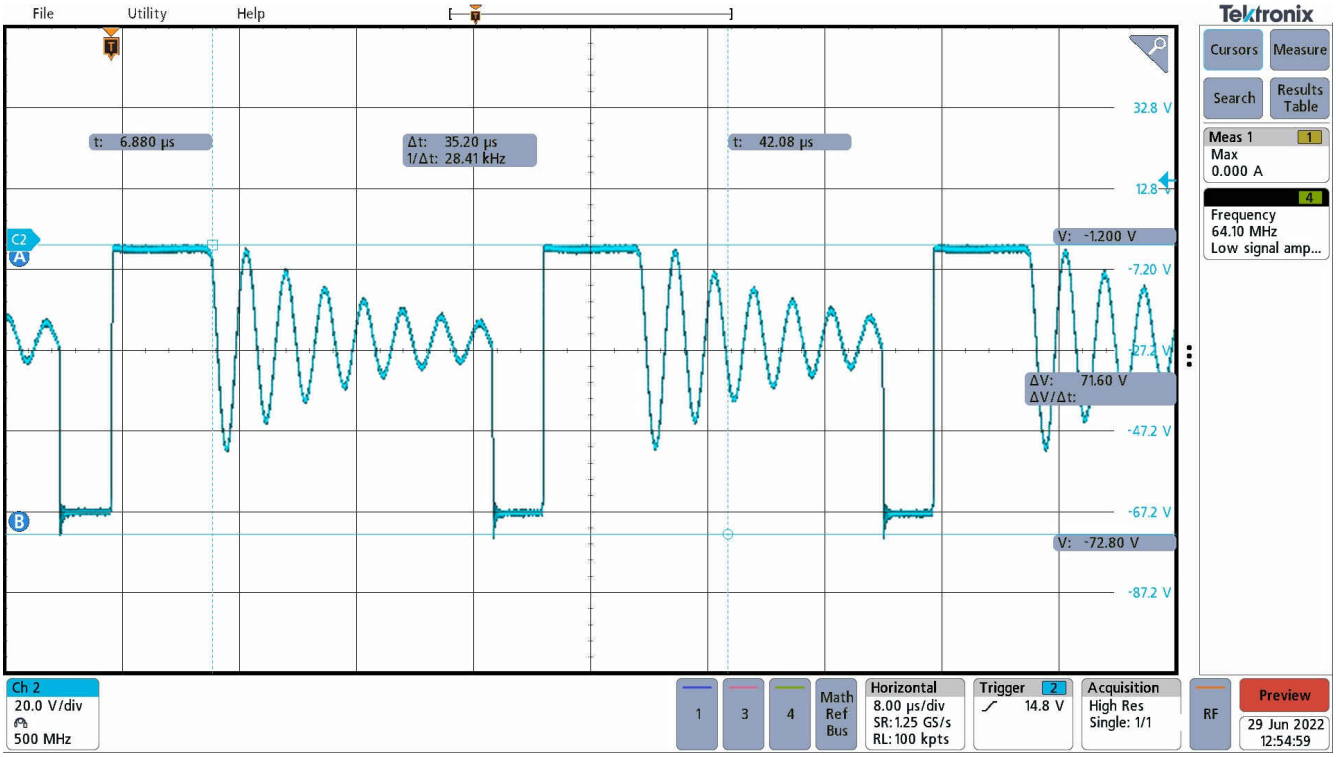
FET and diode stress is shown in the following switching waveforms at 265-VAC input.



Ch2 (blue): Q1 switch node voltage (100 V/div) - full bandwidth

Timebase: 2 µs/div

Figure 3-3. Voltage Stress for Primary MOSFET

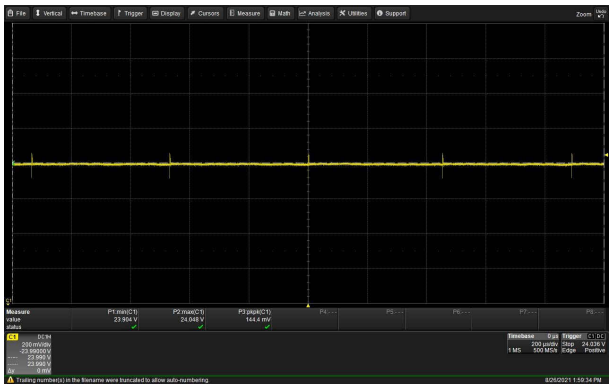


Ch2 (blue): Diode voltage (20 V/div) - full bandwidth
Timebase: 8 µs/div

Figure 3-4. Voltage Stress for Output Diode

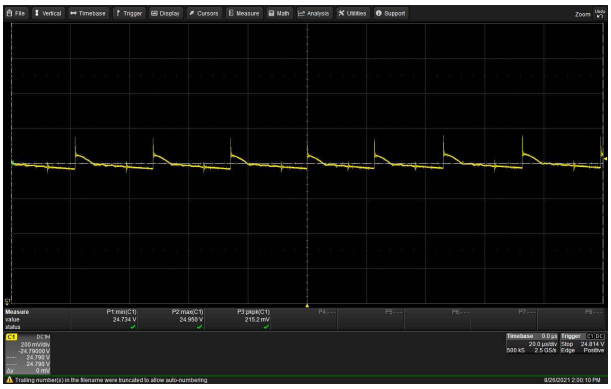
3.3 Output Voltage Ripple

Output voltage ripple is shown in the following figures.



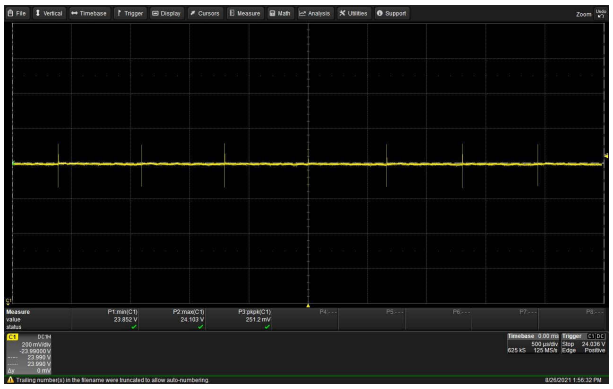
Ch1 (yellow): 24 V_{OUT} (200 mV/div)
Timebase: 200 µs/div

Figure 3-5. 120 VAC, No Load



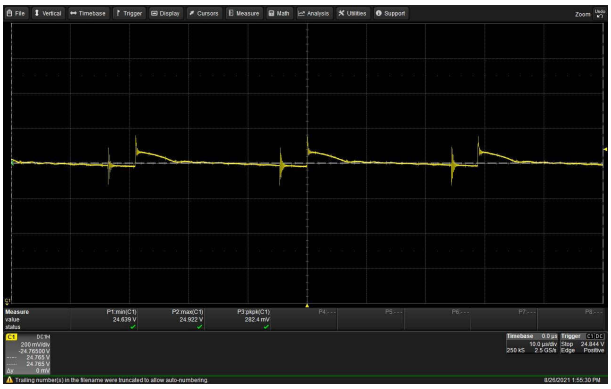
Ch1 (yellow): 24 V_{OUT} (200 mV/div)
Timebase: 20 µs/div

Figure 3-6. 120 VAC, 500-mA Load



Ch1 (yellow): 24 V_{OUT} (200 mV/div)
Timebase: 500 µs/div

Figure 3-7. 220 VAC, No Load

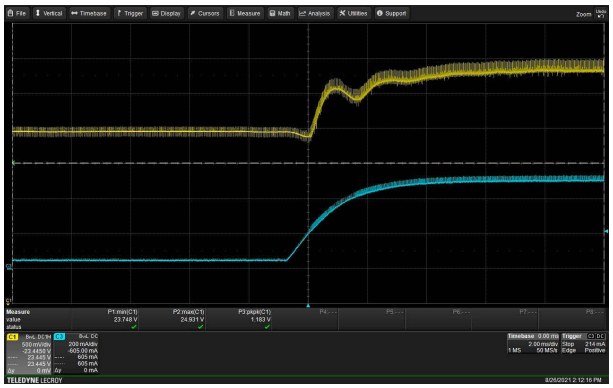


Ch1 (yellow): 24 V_{OUT} (200 mV/div)
Timebase: 10 µs/div

Figure 3-8. 220 VAC, 500-mA Load

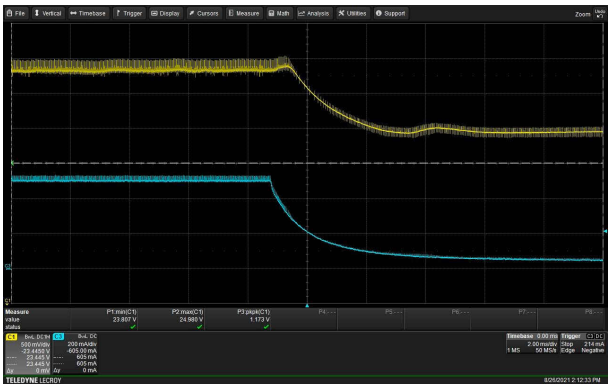
3.4 Load Transients

Load transient response is shown in the following figures.



Ch1 (yellow): V_{OUT} (500 mV/div)
Ch3 (blue): I_{OUT} (200 mA/div)
Timebase: 2 ms/div

Figure 3-9. 120 VAC, 20-mA to 500-mA Transient



Ch1 (yellow): V_{OUT} (500 mV/div)
Ch3 (blue): I_{OUT} (200 mA/div)
Timebase: 5 ms/div

Figure 3-10. 120 VAC, 500-mA to 20-mA Transient

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