

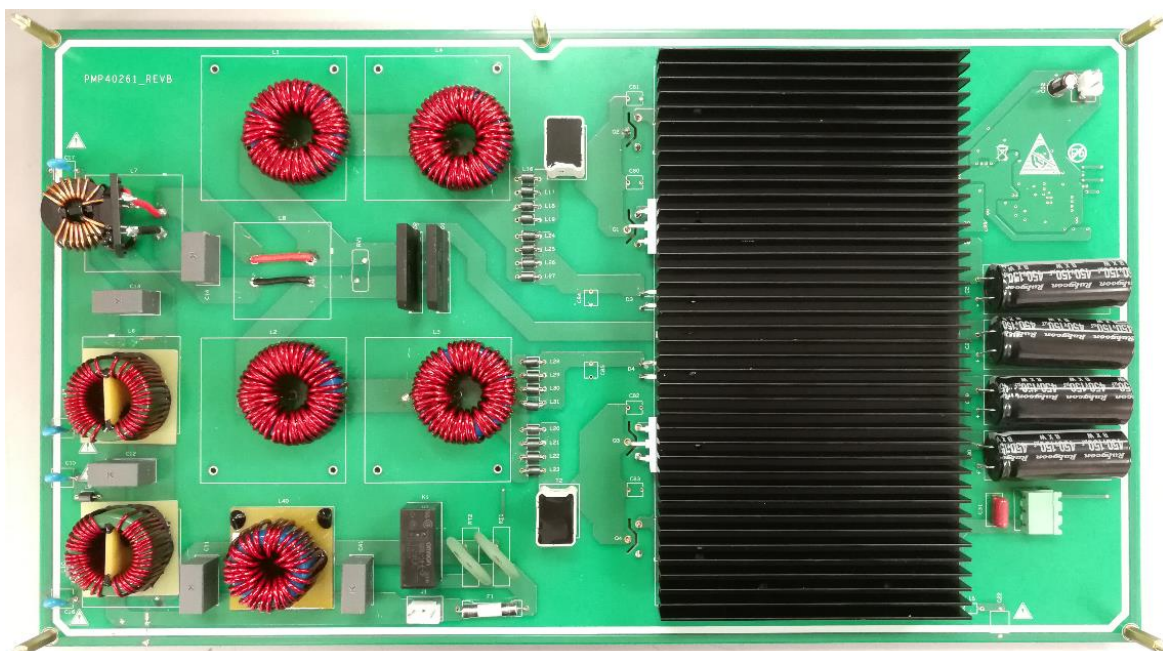
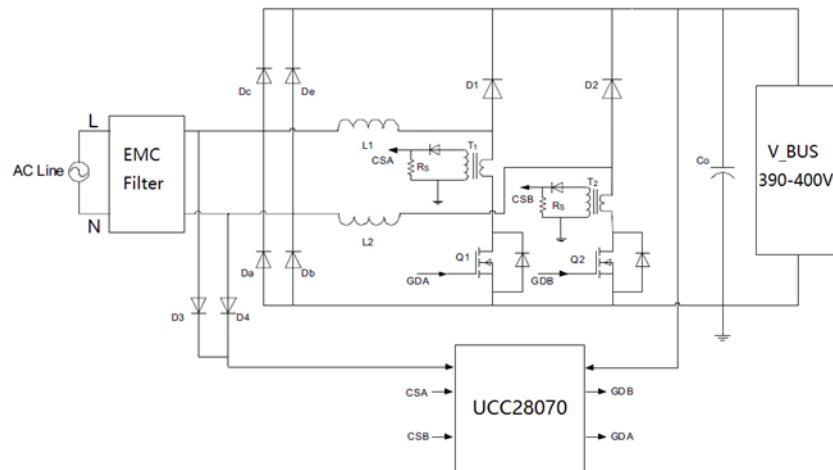
Test Report: PMP40261

800-W High efficiency bridgeless Power Factor Correction (PFC) reference design



Description

This reference design is a bridgeless Power Factor Correction (PFC) circuit using UCC28070 Interleaving CCM PFC controller to provide 390-V/2-A output from universal AC input. The circuit uses Average Current Mode PWM control with advanced internal current synthesizer for current sensing. This design achieves 96.57% peak efficiency at 115-VAC/60-Hz input and 98.07% peak efficiency at 230-VAC/50-Hz input. The Power Factor is above 0.994 at full load at 115-VAC and 230-VAC input. The thin height (<25 mm) design makes it suitable for TV and Appliances application.



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Test Prerequisites

1.1 Voltage and Current Requirements

Table 1. Voltage and Current Requirements

PARAMETER	SPECIFICATIONS
Input Voltage	90~264Vac
AC frequency	47~63Hz
Output Voltage	390V±5%
Maximum Output Current	2A

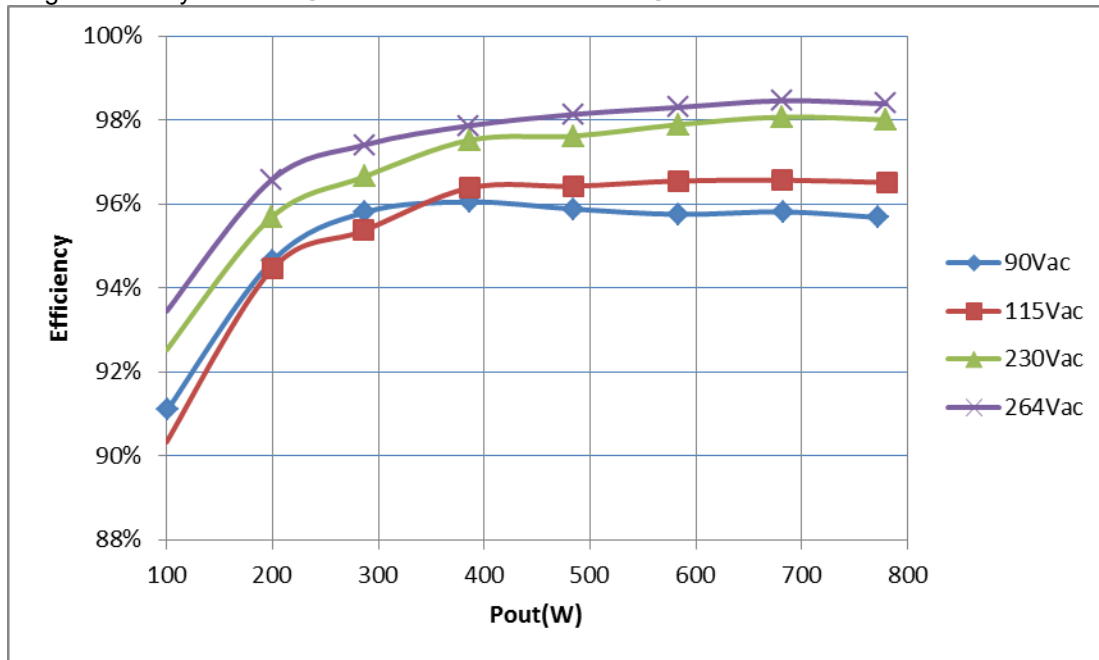
1.2 Required Equipment

- Chroma AC Source MODEL 61605
- Chroma DC E-load MODEL 63204
- Single Phase Power Analyzer PM100
- Tektronix DPO 3054
- DC Source GPS-3303C
- EMI Test Receiver KH3939
- Fluke TI9

2 Testing and Results

2.1 Efficiency Data

4-point average efficiency: 95.98%@115VAC/60Hz and 97.28%@230VAC/50Hz.



2.1.1 90V_{AC}/60Hz Efficiency Measurement

Pin/W	PF	THD/%	Vout/V	Iout/A	Pout/W	Loss/W	Eff./%
807.1	0.995	2.42%	385.54	2.0031	772.28	34.82	95.69%
712.9	0.995	2.54%	385.53	1.7718	683.08	29.82	95.82%
608.9	0.995	2.88%	385.5	1.5125	583.07	25.83	95.76%
505	0.994	3.42%	385.46	1.2562	484.21	20.79	95.88%
402.5	0.994	6.44%	385.42	1.0031	386.61	15.89	96.05%
300.4	0.994	7.51%	385.4	0.7468	287.82	12.58	95.81%
211.2	0.992	10.63%	385.37	0.5187	199.89	11.31	94.65%
111.01	0.984	18.10%	385.34	0.2625	101.15	9.86	91.12%

2.1.2 115V_{AC}/60Hz Efficiency Measurement

Pin/W	PF	THD/%	Vout/V	Iout/A	Pout/W	Loss/W	Eff./%
809	0.996	2.67%	385.58	2.025	780.80	28.20	96.51%
706.1	0.996	3.06%	385.54	1.7687	681.90	24.20	96.57%
603.9	0.996	3.73%	385.51	1.5125	583.08	20.82	96.55%
502.2	0.996	4.72%	385.5	1.2562	484.27	17.93	96.43%
401.1	0.996	6.95%	385.42	1.0031	386.61	14.49	96.39%
300.5	0.995	9.80%	385.37	0.7437	286.60	13.90	95.37%
211.6	0.99	13.88%	385.36	0.5187	199.89	11.71	94.46%
110.6	0.988	15.73%	385.32	0.2593	99.91	10.69	90.34%

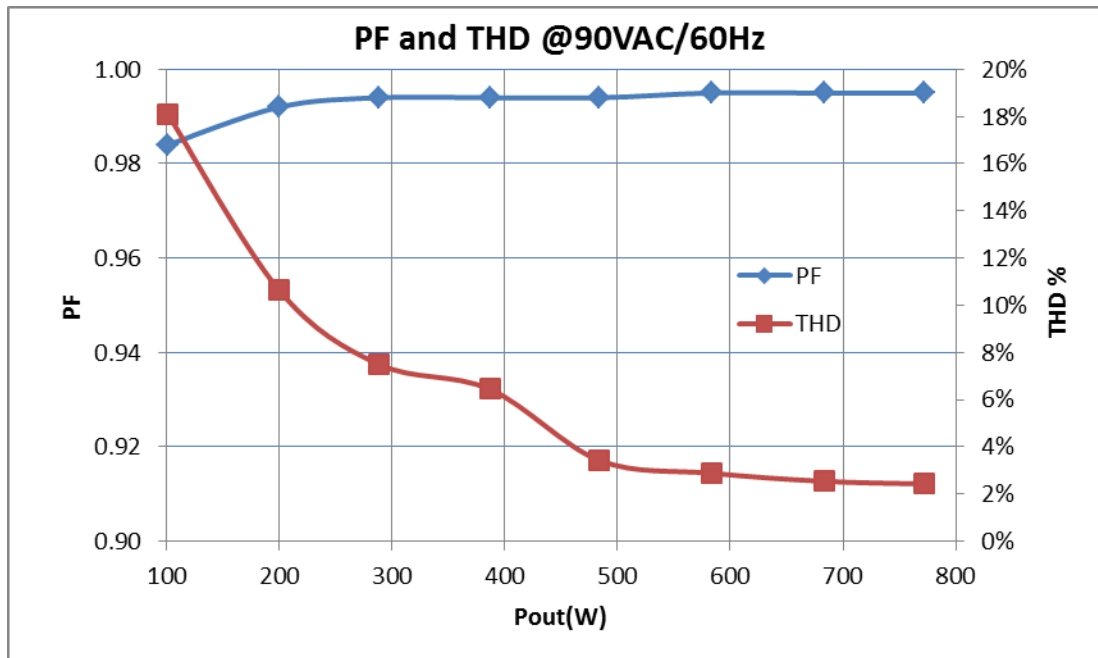
2.1.3 230V_{AC}/50Hz Efficiency Measurement

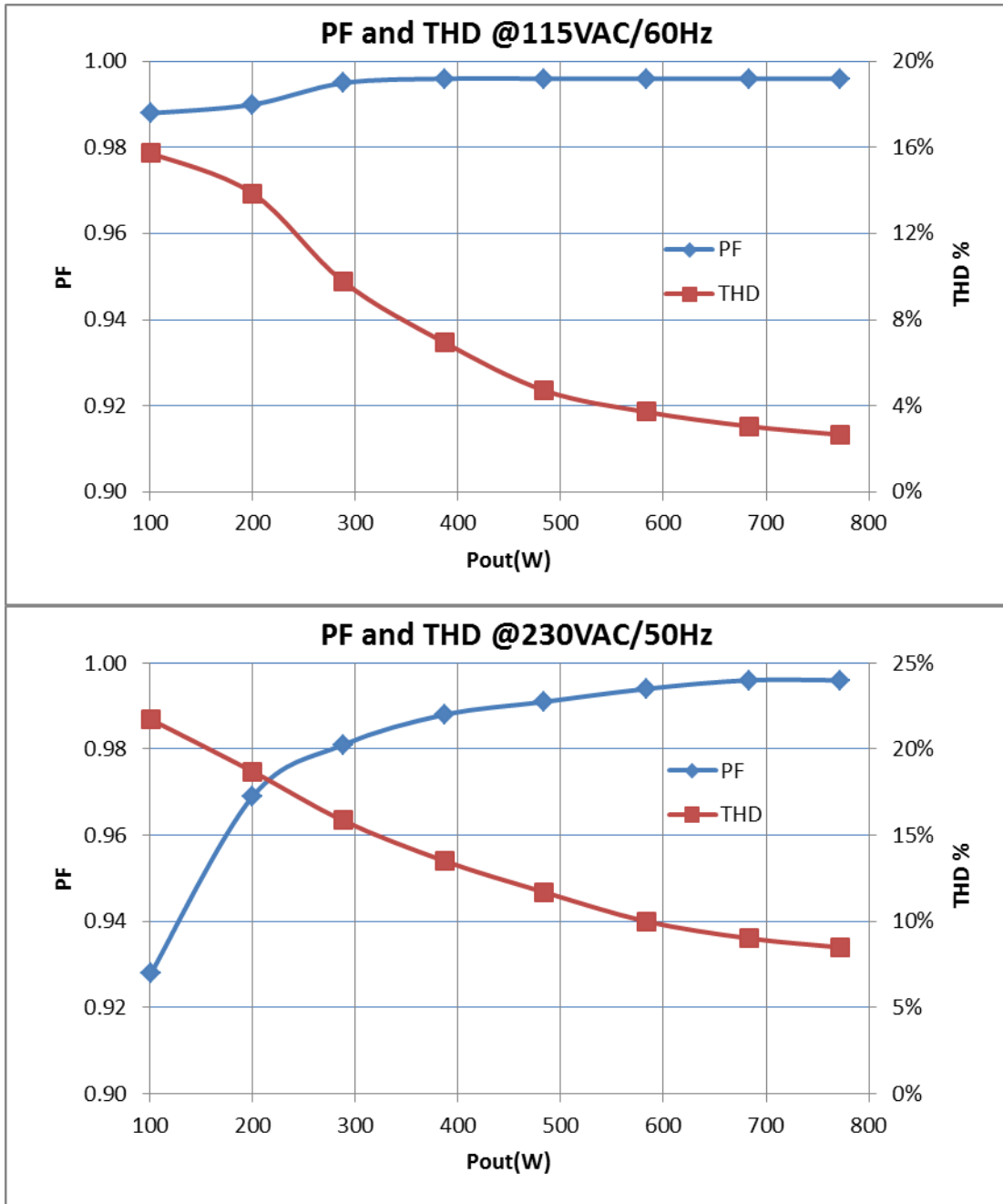
Pin/W	PF	THD/%	Vout/V	Iout/A	Pout/W	Loss/W	Eff./%
795.5	0.996	8.49%	385.62	2.0218	779.65	15.85	98.01%
695.4	0.996	9.02%	385.6	1.7687	682.01	13.39	98.07%
595.7	0.994	10.01%	385.56	1.5125	583.16	12.54	97.89%
496.1	0.991	11.69%	385.53	1.2562	484.30	11.80	97.62%
396.5	0.988	13.51%	385.5	1.0031	386.70	9.80	97.53%
296.6	0.981	15.86%	385.47	0.7437	286.67	9.93	96.65%
207.7	0.969	18.70%	385.43	0.5156	198.73	8.97	95.68%
108.01	0.928	21.71%	385.43	0.2593	99.94	8.07	92.53%

2.1.4 264V_{AC}/50Hz Efficiency Measurement

Pin/W	PF	THD/%	Vout/V	Iout/A	Pout/W	Loss/W	Eff./%
792.3	0.974	22.30%	385.57	2.0218	779.55	12.75	98.39%
692.6	0.971	23.23%	385.57	1.7687	681.96	10.64	98.46%
593.2	0.966	25.13%	385.55	1.5125	583.14	10.06	98.30%
493.5	0.959	27.11%	385.53	1.2562	484.30	9.20	98.14%
393.9	0.95	29.44%	385.5	1	385.50	8.40	97.87%
294.3	0.936	32.01%	385.47	0.7437	286.67	7.63	97.41%
205.8	0.915	34.44%	385.45	0.5156	198.74	7.06	96.57%
106.96	0.847	35.56%	385.48	0.2593	99.95	7.01	93.45%

2.2 Power Factor and Total Harmonic Distortion

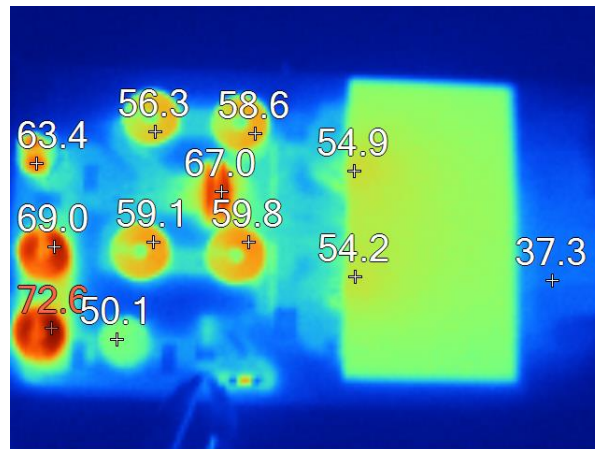




2.3 Thermal Images

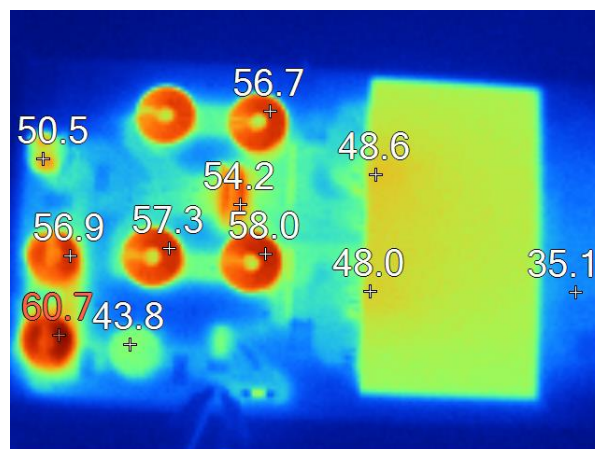
The thermal images below show a top view of the board because all the power components are on the top layer. The output load is 386V/2A. The ambient temperature was 26.5°C with no air flow.

2.3.1 90V_{AC}/60Hz



Component	Value
L40 (DM choke)	50.1°C
L5 (CM choke)	72.6 °C
L6 (CM choke)	69 °C
L7 (CM choke)	63.4 °C
D1,D2 (bridge)	67 °C
L1,L4 (PFC inductor)	58.6°C
L2,L3 (PFC inductor)	59.8 °C
Q1,D3	54.9 °C
Q3,D4	54.2 °C
C27~C30 (Bulk Cap)	37.3 °C

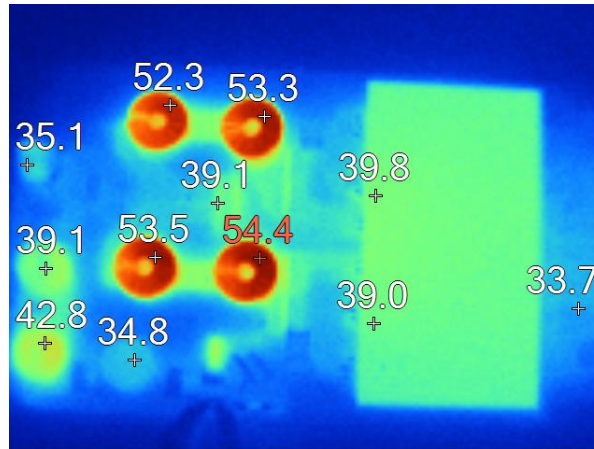
2.3.2 115V_{AC}/60Hz



Component	Value
L40 (DM choke)	43.8 °C
L5 (CM choke)	60.7 °C
L6 (CM choke)	56.9 °C
L7 (CM choke)	50.5 °C
D1,D2 (bridge)	54.2 °C
L1,L4 (PFC inductor)	56.7 °C
L2,L3 (PFC inductor)	58 °C

Q1, D3	48.6 °C
Q3, D4	48 °C
C27~C30 (Bulk Cap.)	35.1 °C

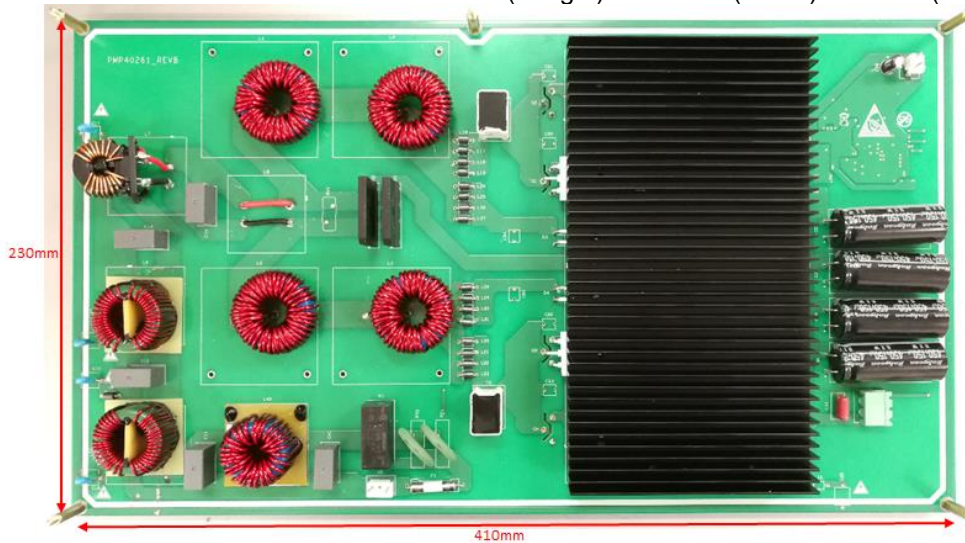
2.3.3 230V_{AC}/50Hz



Component	Value
L40 (DM choke)	34.8 °C
L5 (CM choke)	42.8 °C
L6 (CM choke)	39.1 °C
L7 (CM choke)	34.4 °C
D1,D2 (bridge)	40.6 °C
L1,L4 (PFC inductor)	52.8 °C
L2,L3 (PFC inductor)	53.9 °C
Q1,Q2,D3	40.5 °C
Q3,Q4,D4	39.3 °C
C27~C30 (Bulk Cap.)	33.0 °C

2.4 Dimensions

The Dimension of PMP40261 Board is 410 mm (Length) x230 mm (Width) x25 mm (Height).

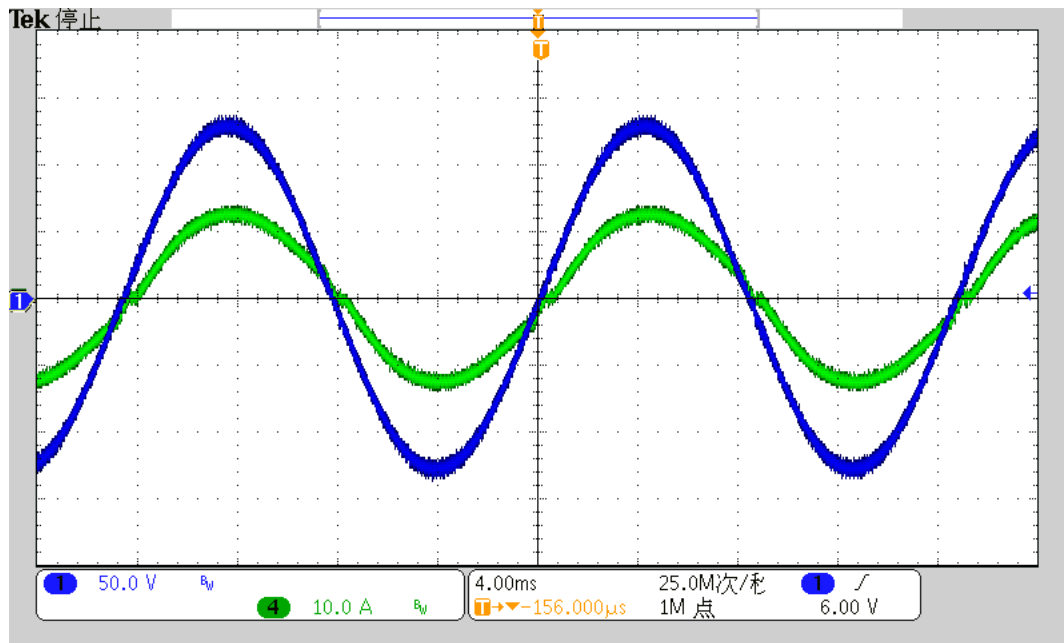


3 Waveforms

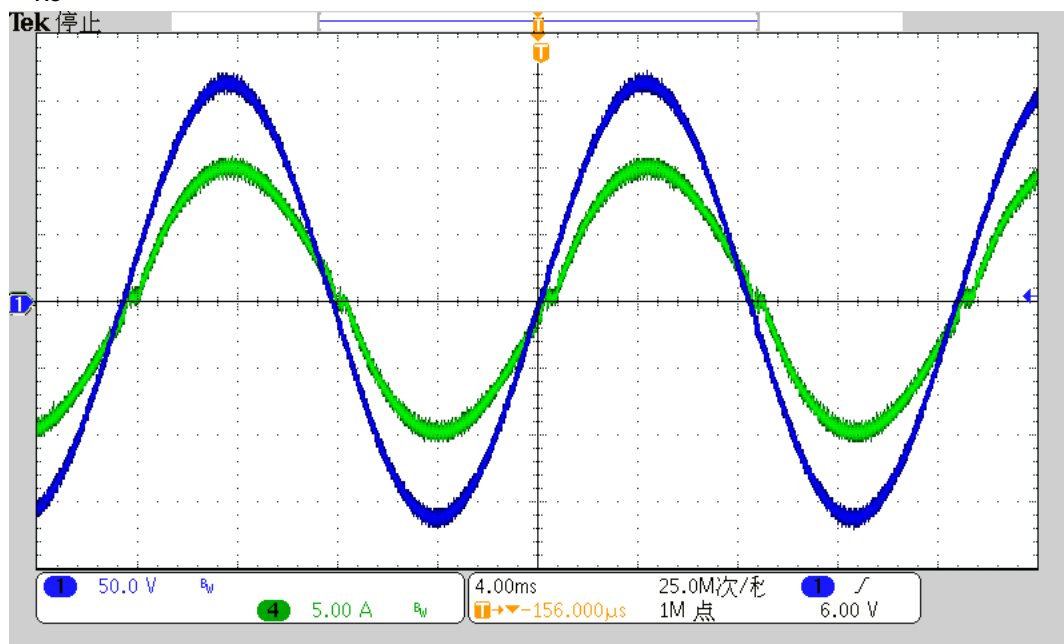
3.1 Normal Operation

The input currents corresponding to different input voltages are shown in the images below, where Channel 1 is the input voltage, Channel 2 is the input current.

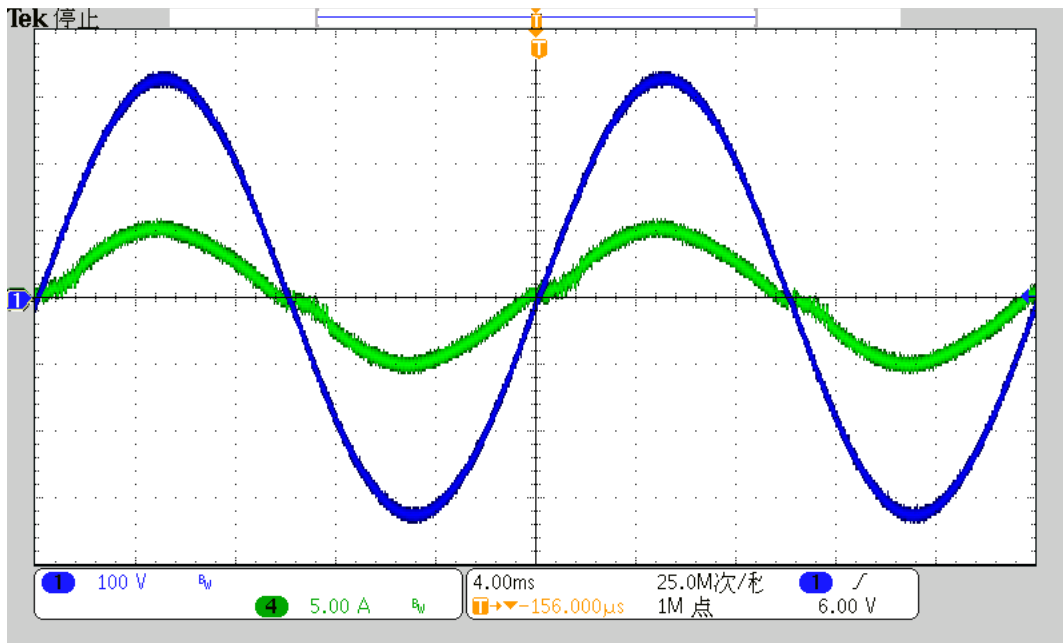
3.1.1 90V_{AC}/60Hz- 390V2A



3.1.2 115V_{AC}/60Hz- 390V2A



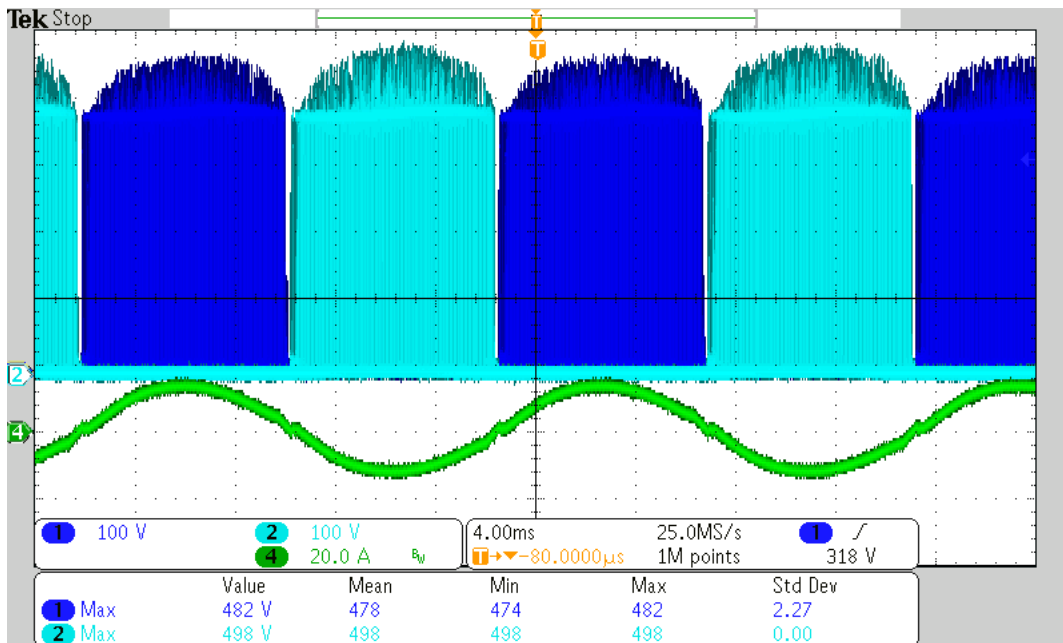
3.1.3 230V_{AC}/50Hz- 390V2A



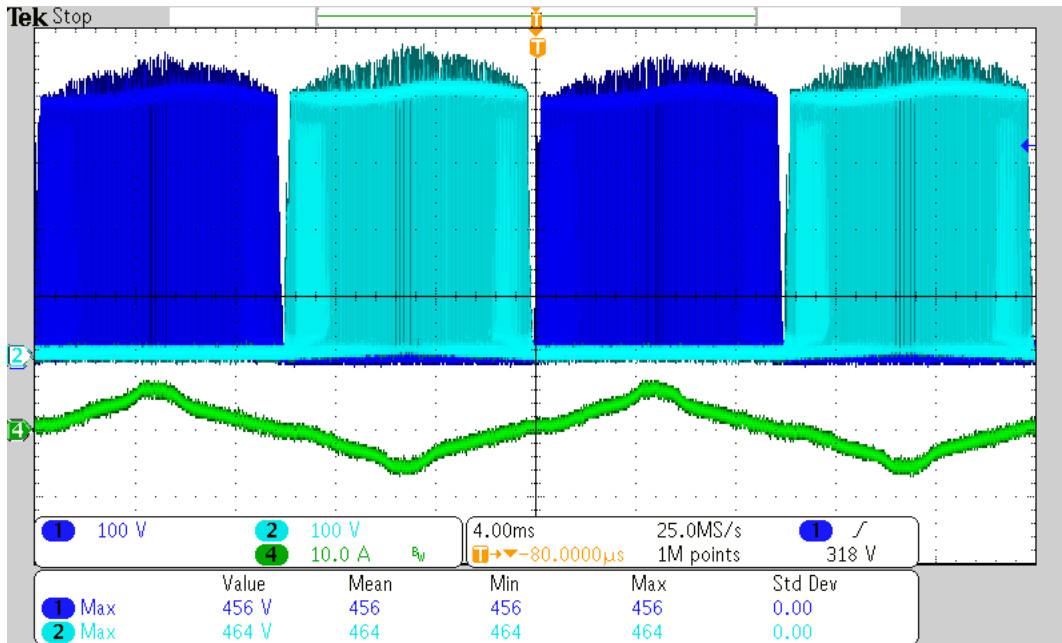
3.2 Switching

The Drain-Source voltage of MOSFETs are shown in the images below, where Channel 1 is the V_{DS} of Q1 and Q2, Channel 2 is the V_{DS} of Q3 and Q4, Channel 4 is the input current.

3.2.1 90V_{AC}/60Hz- 390V2A



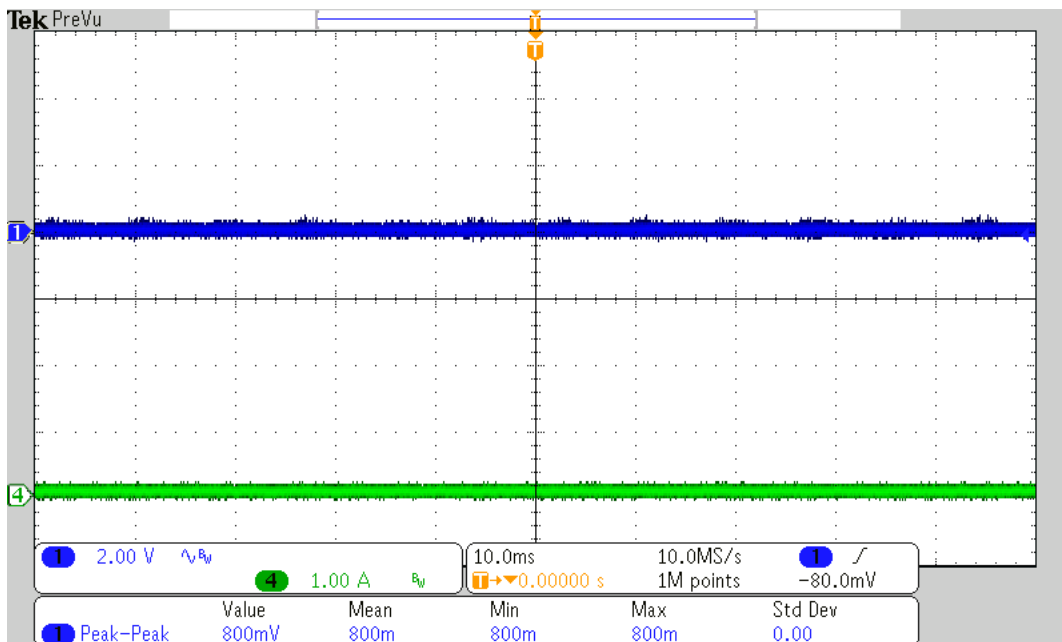
3.2.2 264V_{AC}/50Hz- 390V_{2A}



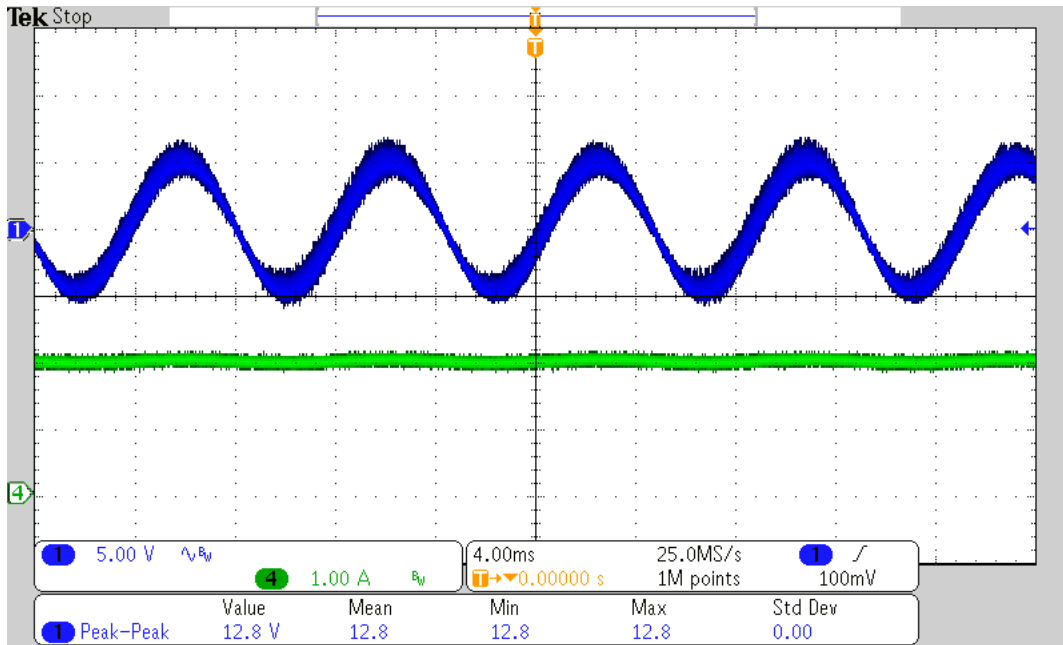
3.3 Output Voltage Ripple

The output voltage ripple are shown in the images below, where Channel 1 is the ripple voltage, Channel 4 is the output current.

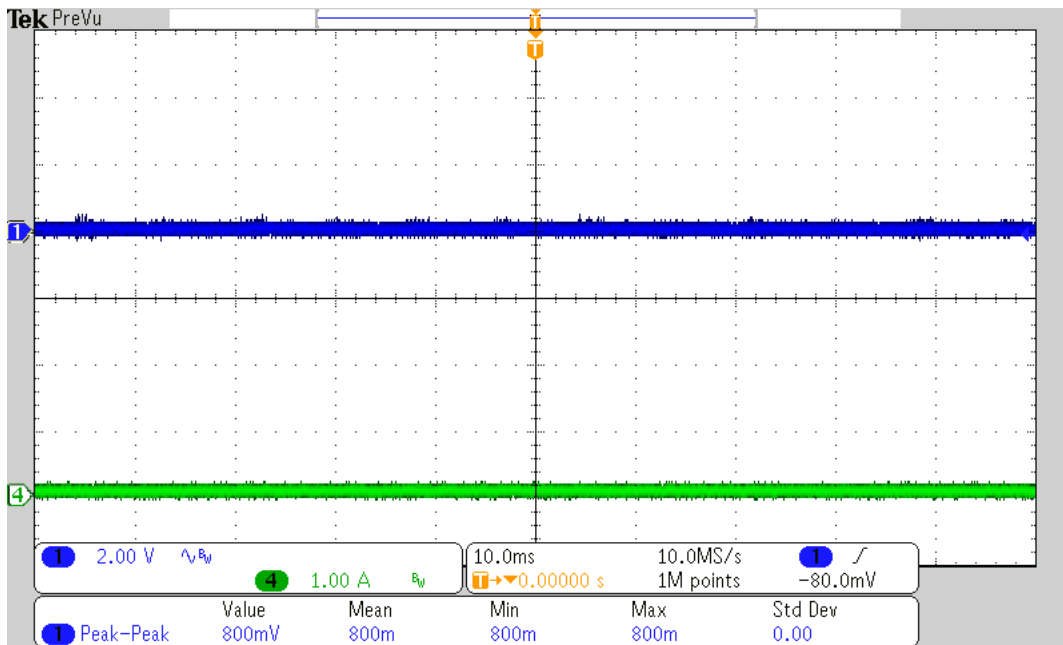
3.3.1 90V_{AC}/60Hz- No Load



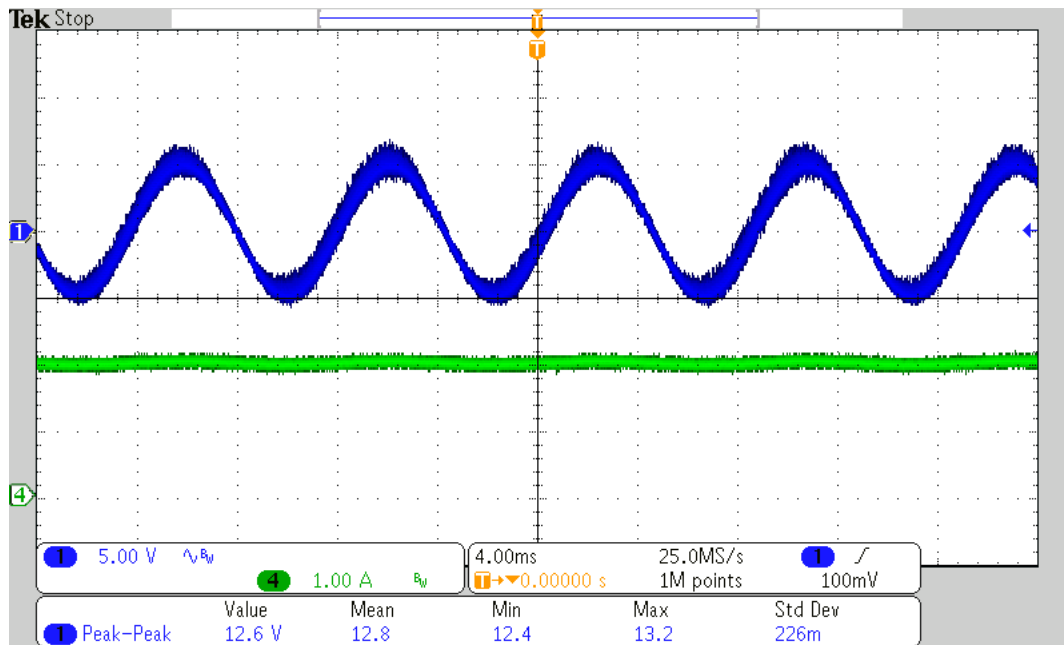
3.3.2 90V_{AC}/60Hz- 390V2A



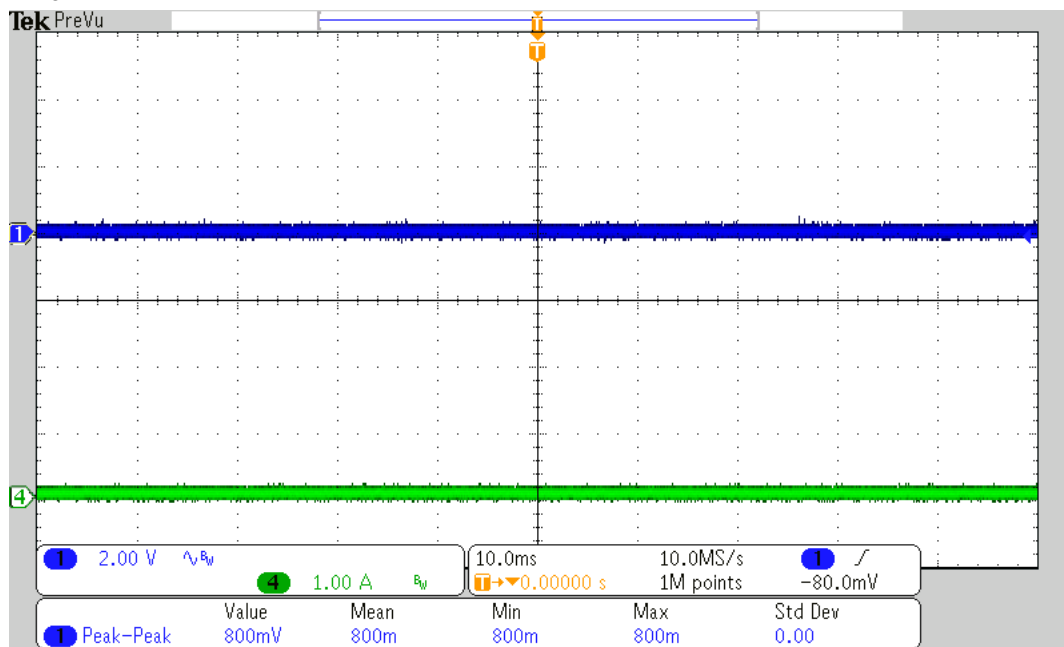
3.3.3 115V_{AC}/60Hz- No Load



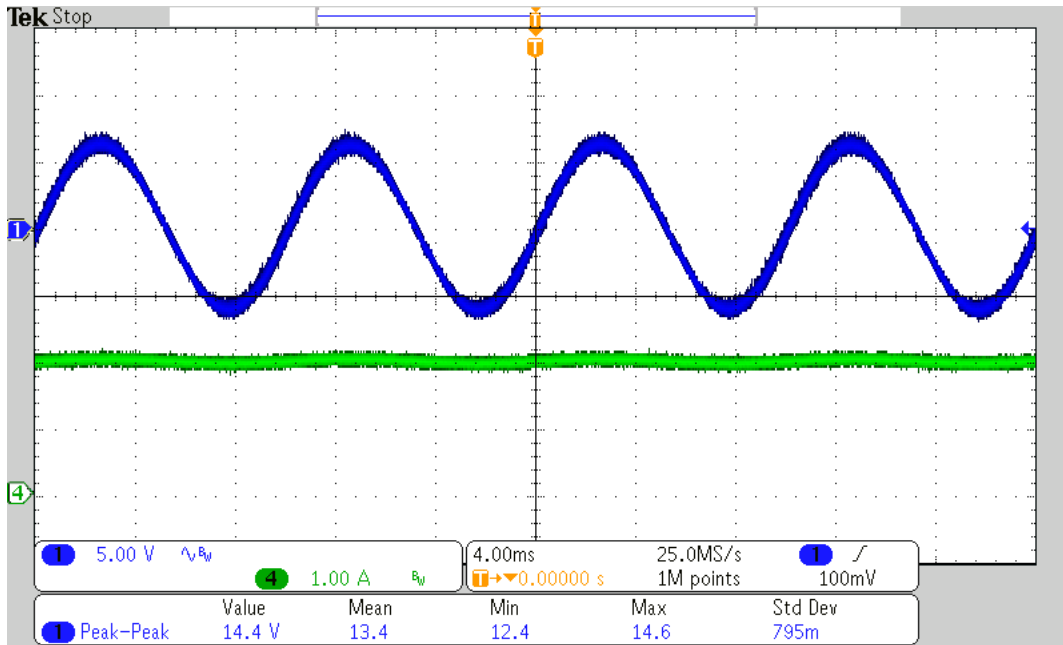
3.3.4 115V_{AC}/60Hz- 390V2A



3.3.5 230V_{AC}/50Hz- No Load



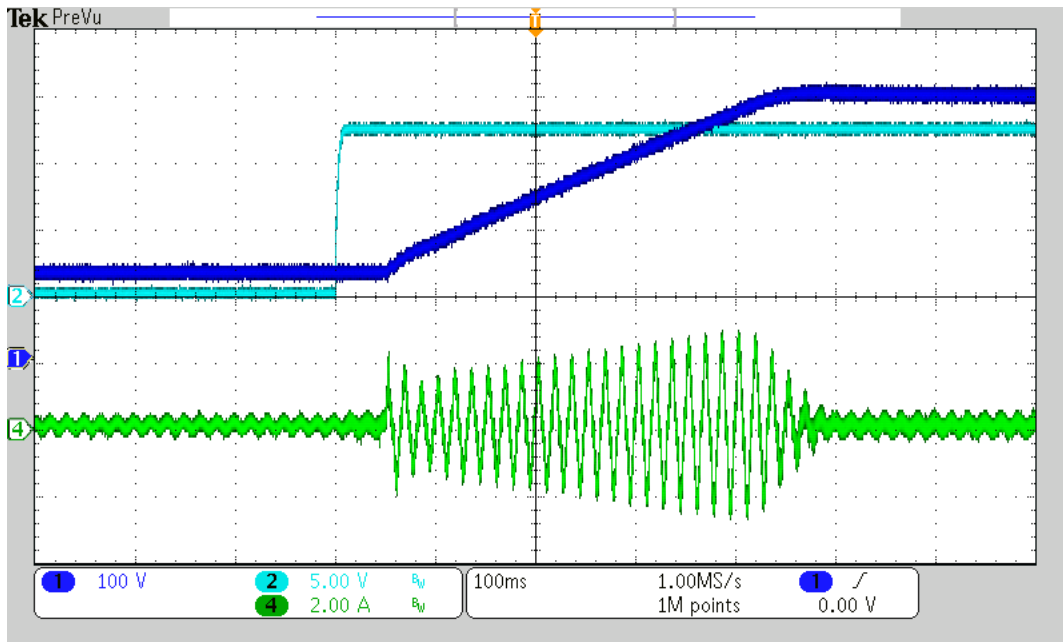
3.3.6 230V_{AC}/50Hz- 390V2A



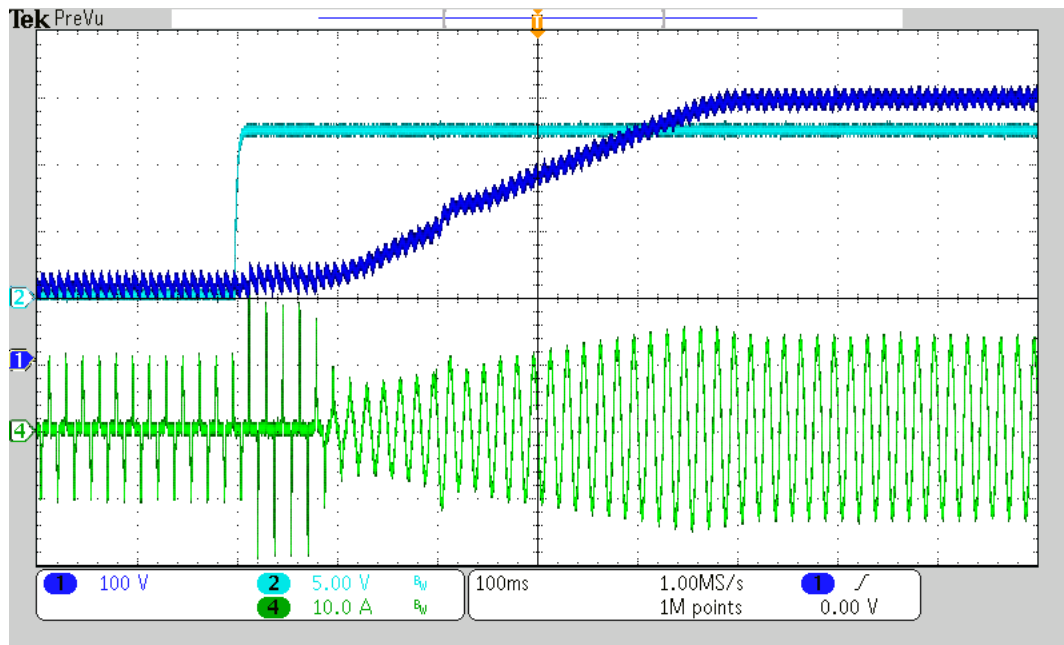
3.4 Start-up

The voltages of VCC Start-up are shown in the images below, where Channel 1 is the output voltage, Channel 2 is the VCC voltage, Channel 4 is the output current.

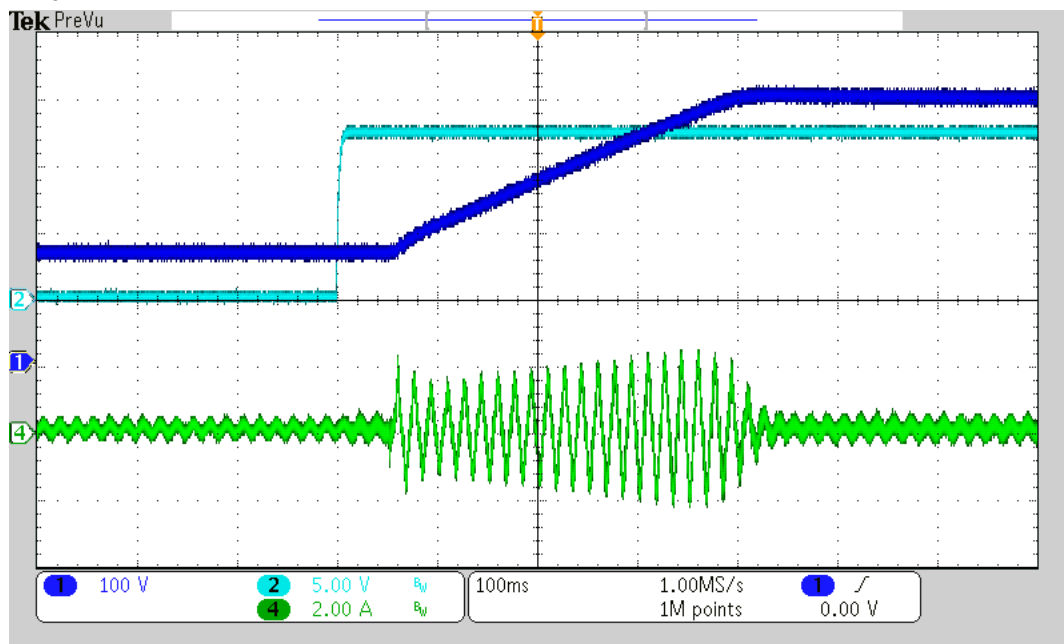
3.4.1 90V_{AC}/60Hz- No Load



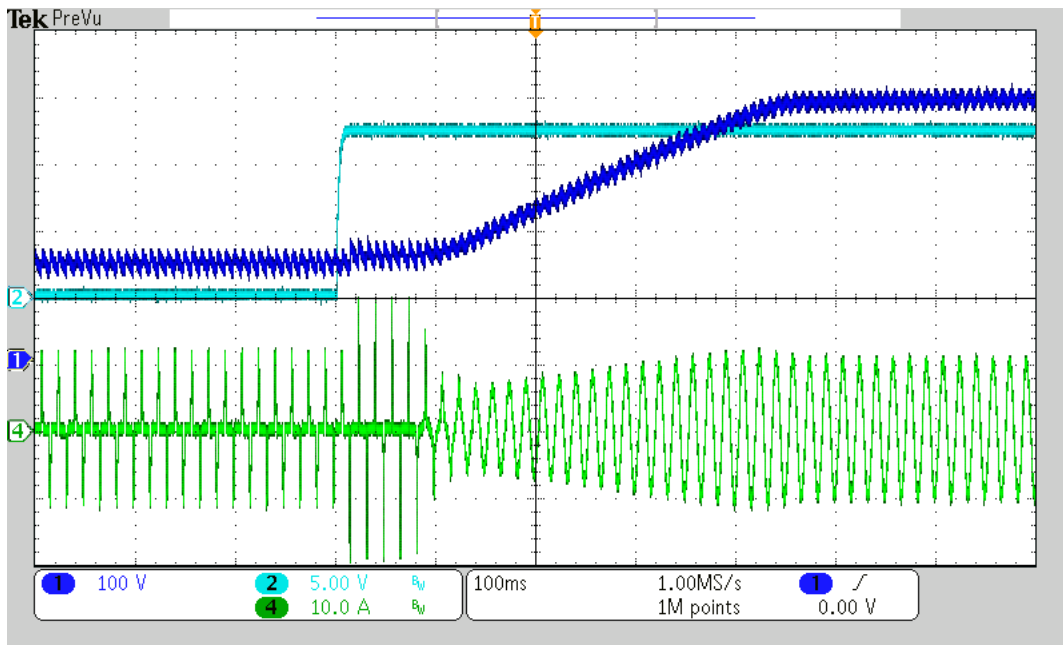
3.4.2 90V_{AC}/60Hz- 390V2A



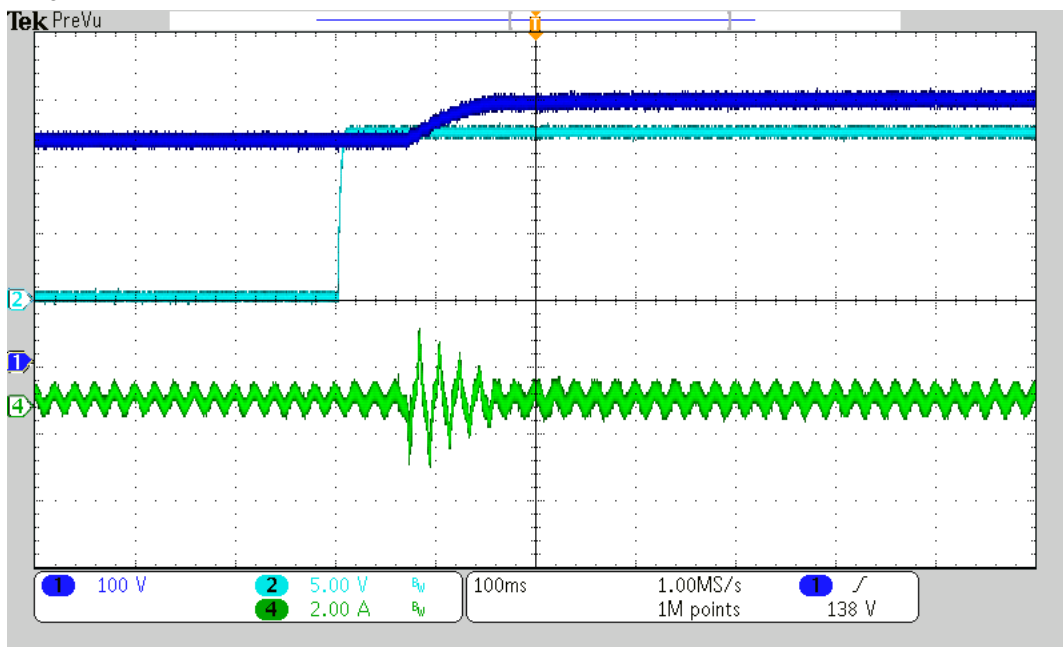
3.4.3 115V_{AC}/60Hz- No Load



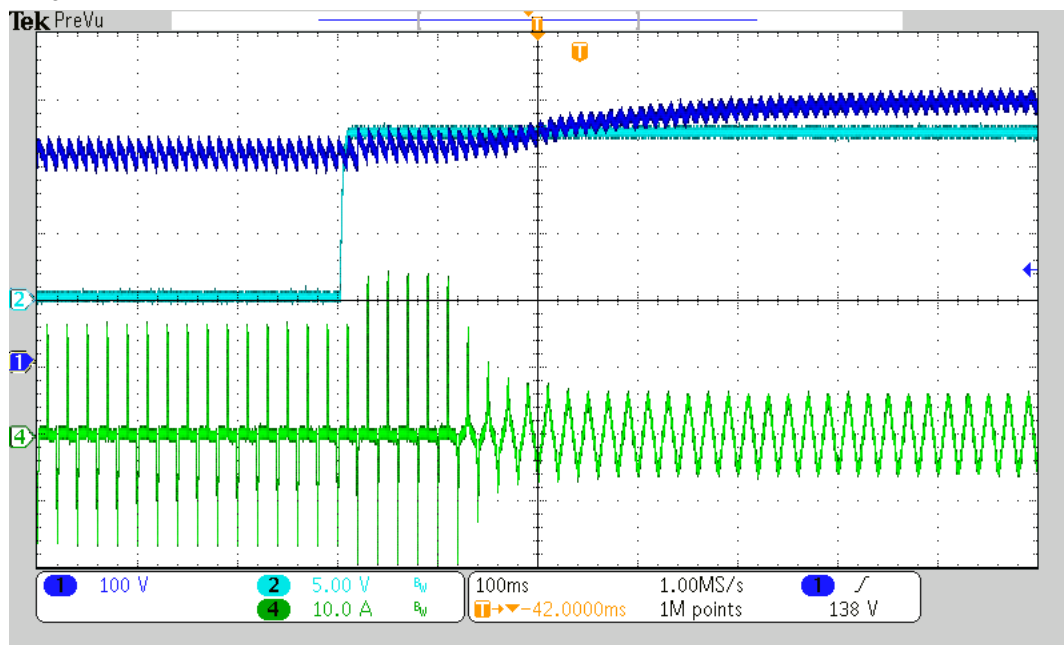
3.4.4 115V_{AC}/60Hz- 390V2A



3.4.5 230V_{AC}/50Hz- No Load



3.4.6 230V_{AC}/50Hz- 390V2A



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