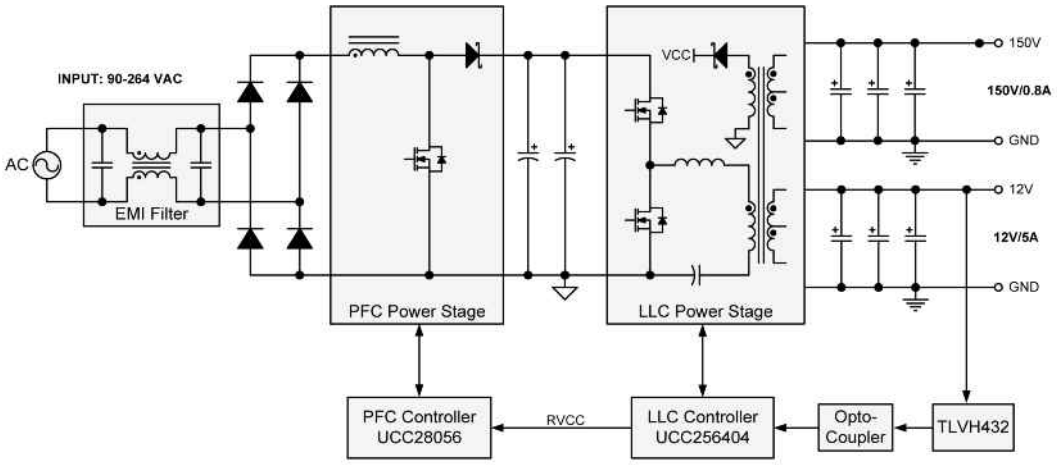
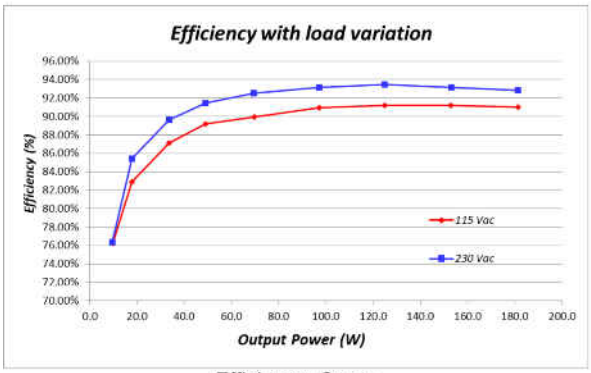
Test Report: PMP40580

180-W Universal Input PFC + LLC TV Power Supply Reference Design

Description

This AC to DC power supply design for TV application provides 12-V, 5-A and 150-V, 0.8-A output from universal AC voltage (90 Vac to 264 Vac). The design uses CRM/DCM PFC controller UCC28056, and LLC controller UCC256404 with enhanced burst mode which enabled for low standby power and smaller audible noise. The design achieves <250-mW standby power with 150-mW load and >93% peak efficiency at 230-Vac input.





Efficiency Curve

PMP40580A Board Photo

1 Test Prerequisites

1.1 System Specification

Table 1-1. Voltage and Current Requirements

PARAMETER	SPECIFICATIONS
Input Voltage	90 VAC – 264 VAC
Output #1, Voltage:	12 VDC
Output #1, Current:	5.0 A
Output #2, Voltage:	150 VDC
Output #2, Current:	0.8 A

1.2 Required Equipment

- Chroma 61503 AC source (VS1)
- Agilent E3630A DC source (VS2)
- Yokogawa WT210 power meter
- Chroma 63105A Electronic loads
- Oscilloscope (min. 100 MHz bandwidth)
- Current probe (min. 100 KHz bandwidth)
- Optional: infrared camera

1.3 Testing Conditions

The power supply has two outputs 12 V and 150 V and the feedback loop is closed to 12 V output (Output #1). It has been designed to work from 0 to 180 W with 90 VAC to 264 VAC input. For other outputs regulation, a minimum load (≥ 100 mW) on 12 V output, should be always present.

1. Connect the AC source VS1 to J100-3 and J100-2; earth connection to J100-1.
2. Connect the loads to J214.
3. Connect the DC source VS2 to TP205 and TP206, and set the output voltage to 3.3V or 5V.
4. Turn on VS2, and then Turn on VS1 (accepted range: 90 VAĈ 264 VAC).
5. Increase the load on the outputs.
6. After turn off, wait ~5 minutes until PFC capacitors and output capacitors are completely discharged

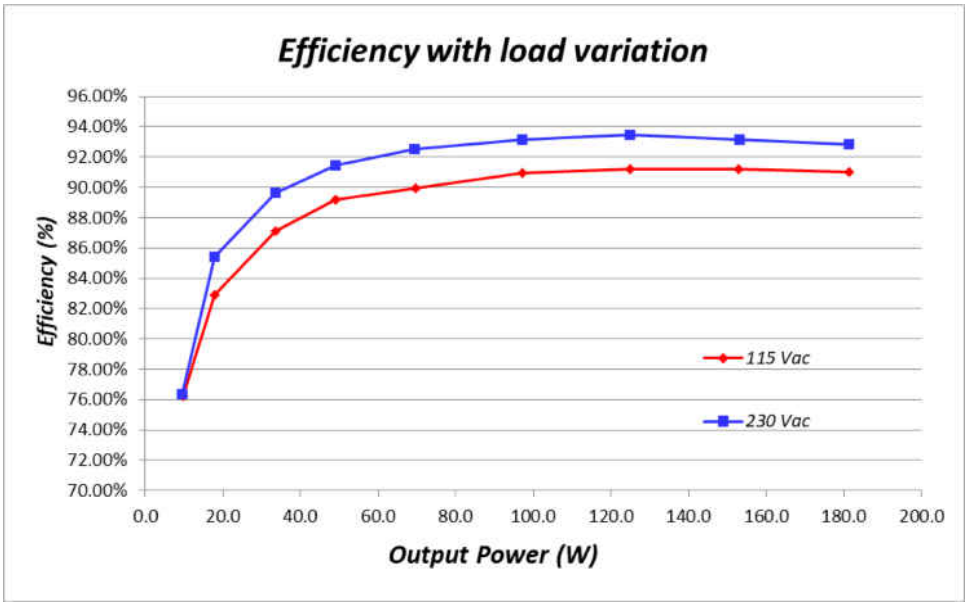
1.4 Considerations

While the PMP40580A board is energized, never touch the board or its electrical circuits, as they could be at high voltages capable of causing electrical shock hazard. High voltage may still be present after turning off the AC source. Check bulk capacitors and output terminals with a voltage meter, and make sure the bulk capacitors (C109, C110, C200) and output capacitors have completely discharged before handling the PMP40580A board.

2 Testing and Results

2.1 Efficiency Graphs

The converter efficiency is shown in the figures below for a 115 VAC, 60 Hz and 230 VAC, 50 Hz input.



2.2 Efficiency Data

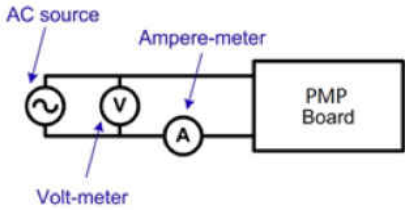
Below is the efficiency data for 115 VAC, 60 Hz and 230 VAC, 50 Hz input different load.

V_{INAC} (V)	I_{INAC} (A)	P_{IN} (W)	PF	THD_i (%)	V_{PFC} (V)	V_{O1} (V)	I_{O1} (A)	V_{O2} (V)	I_{O2} (A)	P_{OUT} (W)	Efficiency
115	0.181	12.9	0.625	47.87	391.48	11.86	0.2	143.55	0.05	9.8	76.25%
115	0.231	21.6	0.815	19.27	391.12	11.86	0.3	143.83	0.10	17.9	82.91%
115	0.344	38.5	0.974	4.57	389.15	11.86	0.4	143.71	0.20	33.5	87.09%
115	0.484	54.9	0.987	5.03	389.07	11.85	0.5	143.35	0.30	48.9	89.20%
115	0.679	77.3	0.993	7.22	389.18	11.83	1.0	144.25	0.40	69.5	89.96%
115	0.939	106.8	0.997	11.45	389.18	11.85	2.0	146.82	0.50	97.1	90.93%
115	1.200	136.8	0.998	9.43	389.25	11.86	3.0	148.75	0.60	124.8	91.22%
115	1.466	167.7	0.999	8.07	389.17	11.88	4.0	150.60	0.70	152.9	91.20%
115	1.740	199.1	0.999	7.12	389.16	11.88	5.0	152.28	0.80	181.2	91.03%
V_{INAC} (V)	I_{INAC} (A)	P_{IN} (W)	PF	THD_i (%)	V_{PFC} (V)	V_{O1} (V)	I_{O1} (A)	V_{O2} (V)	I_{O2} (A)	P_{OUT} (W)	Efficiency
230	0.127	12.5	0.409	38.34	390.12	11.86	0.2	143.60	0.05	9.6	76.35%
230	0.152	21.0	0.515	21.45	390.20	11.86	0.3	143.84	0.10	17.9	85.44%
230	0.203	37.4	0.797	13.45	389.15	11.86	0.4	143.70	0.20	33.5	89.64%
230	0.264	53.5	0.868	9.19	389.18	11.84	0.5	143.32	0.30	48.9	91.47%
230	0.351	75.1	0.930	6.76	389.53	11.84	1.0	144.16	0.40	69.5	92.52%
230	0.472	104.2	0.961	5.14	389.52	11.85	2.0	146.70	0.50	97.1	93.14%
230	0.596	133.6	0.975	4.76	389.54	11.88	3.0	148.76	0.60	124.9	93.46%
230	0.726	164.2	0.983	4.94	389.51	11.89	4.0	150.66	0.70	153.0	93.17%
230	0.861	195.4	0.988	5.60	389.38	11.91	5.0	152.32	0.80	181.4	92.86%

2.3 Standby Efficiency Data

Standby input power was measured with **5 minute averaging** under below conditions:

The following measurement was done with Yokogawa WT210 power meter and Chroma 61503 AC source. On the WT210 power meter, voltage range was set to 150V for low line input, 300V for high line input. Current range was set to Auto with crest factor 6 for low line and high line. Also, the voltage measurement and current measurement was configured as below:



Below is the standby load power measurement with PSON set to low and 150 V output unloaded.

V_{INAC} (V)	P_{IN} (mW)	V_{OUT1} (V)	V_{OUT2} (V)	P_{OUT1} (mW)	P_{OUT2} (mW)
90	161	9.72	135.05	100.00	0.00
115	179	9.72	135.00	100.00	0.00
230	193	9.74	135.00	100.00	0.00
264	199	9.73	135.13	100.00	0.00
90	231	9.73	137.66	150.00	0.00
115	231	9.72	137.74	150.00	0.00
230	242	9.73	137.65	150.00	0.00
264	253	9.71	137.73	150.00	0.00
90	302	9.73	140.80	200.00	0.00
115	300	9.72	140.80	200.00	0.00
230	311	9.72	140.63	200.00	0.00
264	319	9.73	140.80	200.00	0.00

2.4 Dimensions

The photos below show the top and bottom view of the PMP40580A board. Board dimension is 215mm x 165mm.

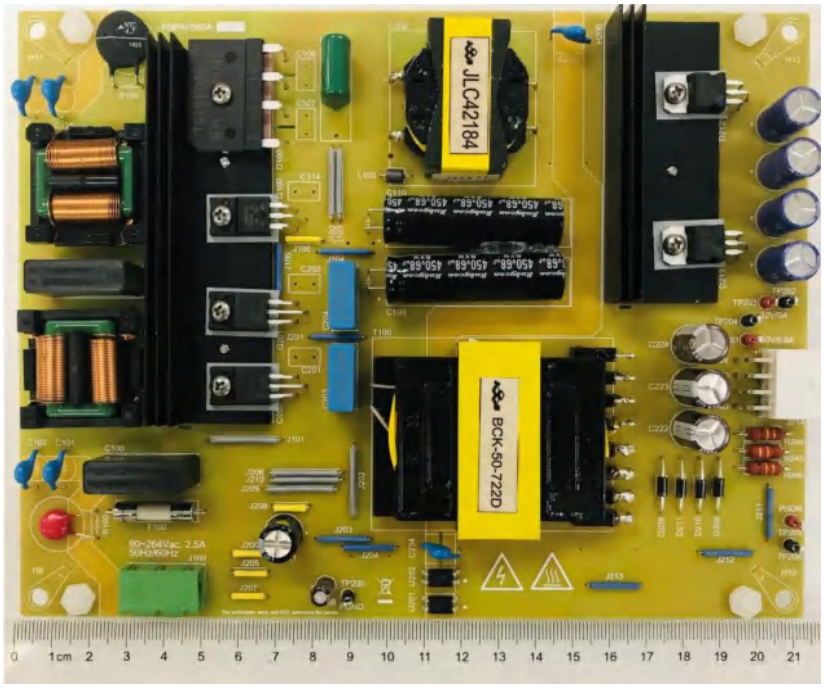


Figure 2-1. Top Side View

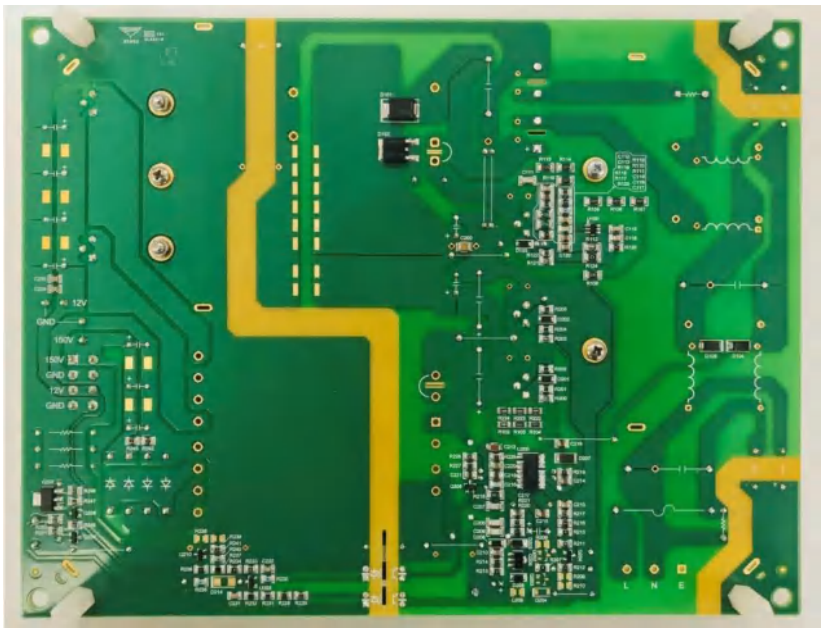


Figure 2-2. Bottom Side View

2.5 Thermal Images

The thermal images below show a top view and bottom view of the board. The ambient temperature was 25ºC with no air flow. The input voltage was 115Vac/60Hz and 230Vac/50Hz, the outputs were full loaded with 2 hours soak time.

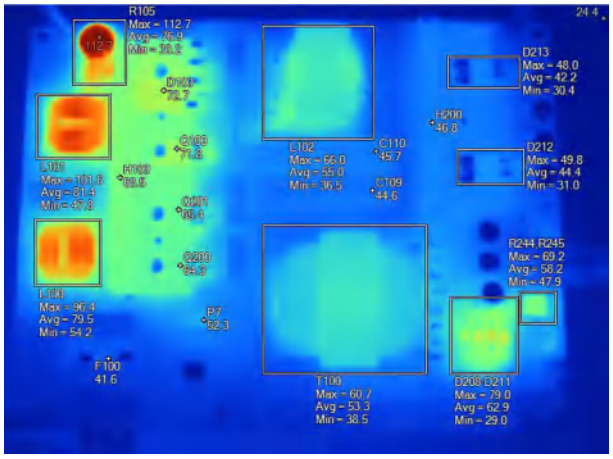


Figure 2-3. Top Side Thermal View @115Vac/60Hz, Full Loaded

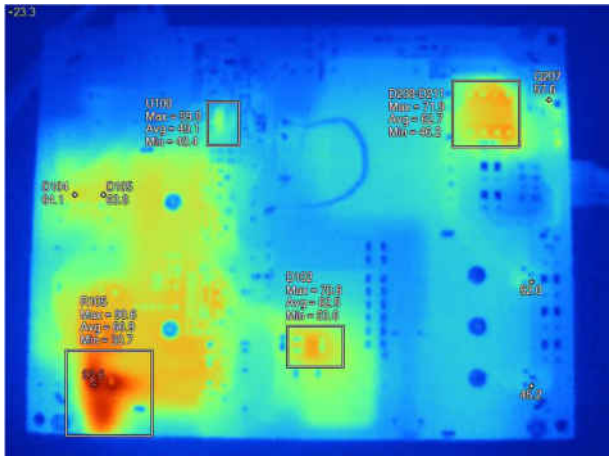


Figure 2-4. Bottom Side Thermal View @115Vac/ 60Hz, Full Loaded

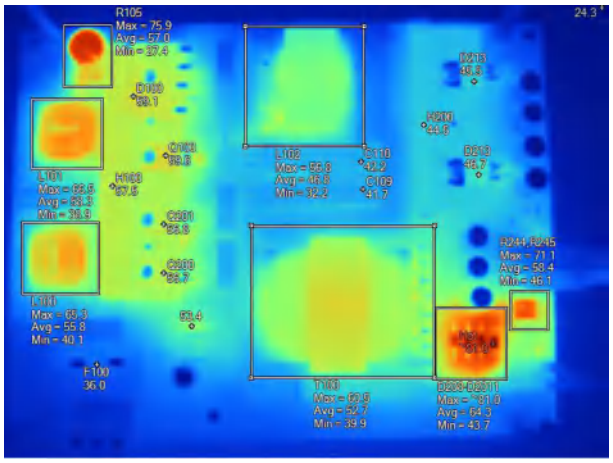


Figure 2-5. Top Side Thermal View @230Vac/50Hz, Full Loaded

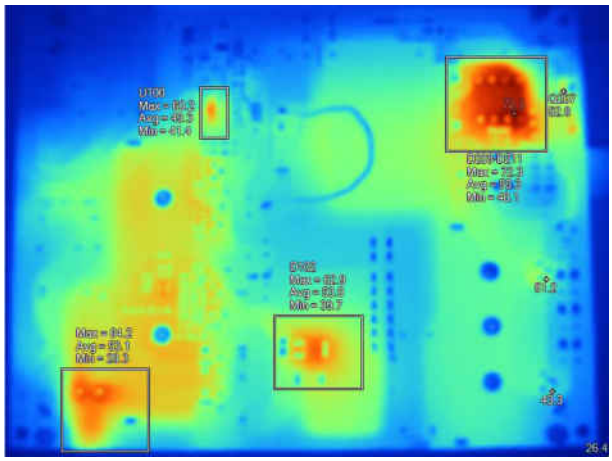


Figure 2-6. Bottom Side Thermal View @230Vac/ 50Hz, Full Loaded

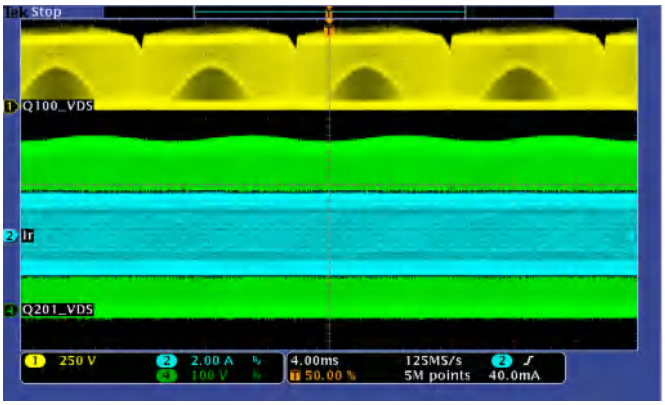
Table 2-1. Main Image Markers

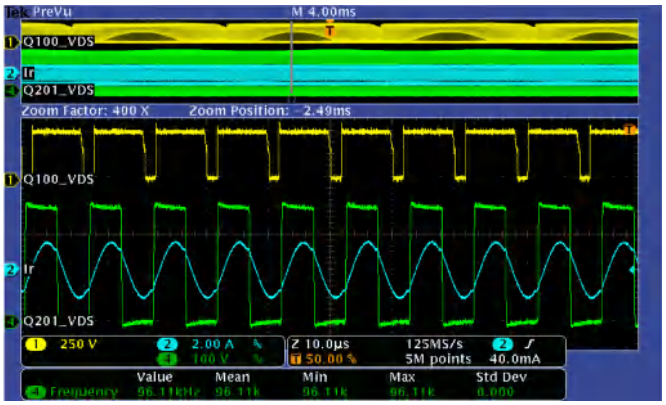
Name	Temperature @115Vac	Temperature @230Vac	Emissivity	Background
L100	96.4°C	65.3°C	0.96	25°C
L101	101.6°C	66.5°C	0.96	25°C
L102	66.0°C	56.8°C	0.96	25°C
T100	60.7°C	60.5°C	0.96	25°C
D100	72.7°C	59.1°C	0.96	25°C
D102	70.5°C	62.9°C	0.96	25°C
R105	112.7°C	75.9°C	0.96	25°C
Q100	71.8°C	59.6°C	0.96	25°C
Q200	65.4°C	56.8°C	0.96	25°C
Q201	64.3°C	56.7°C	0.96	25°C

3 Waveforms

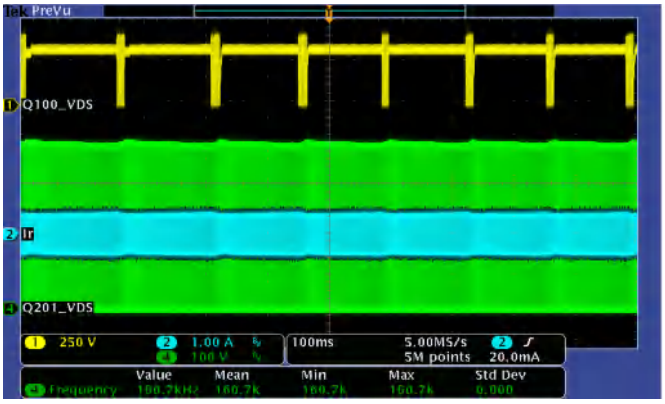
3.1 Switch Node

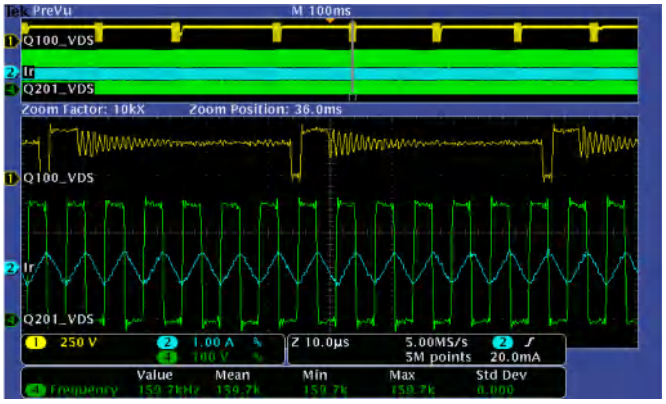
The photo below shows the switch node voltage (Q100 & Q201 Vds) and resonant current waveforms at full load. The input voltage is 230Vac and outputs full load. (CH1: Q100_Vds, CH2: Q201_Vds, CH4: resonant current)



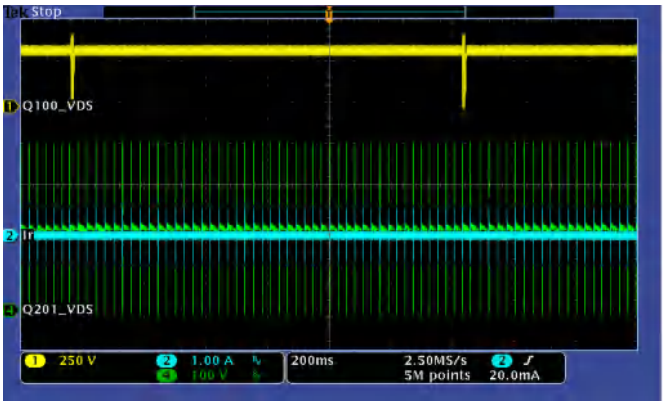


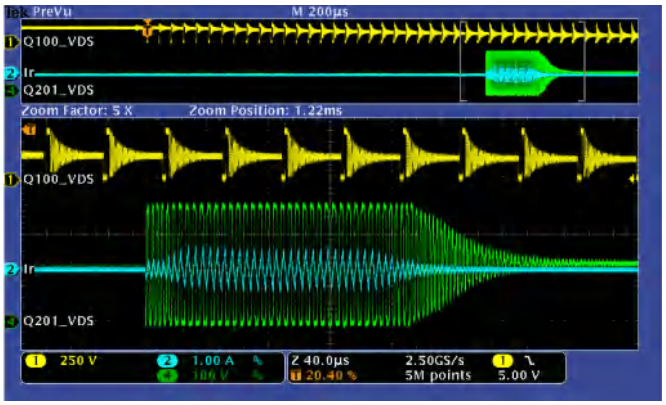
The photo below shows the switch node voltage (Q100 & Q201 Vds) and resonant current waveforms at no load. The input voltage is 230Vac and outputs no load. (CH1: Q100_Vds, CH2: Q201_Vds, CH4: resonant current)



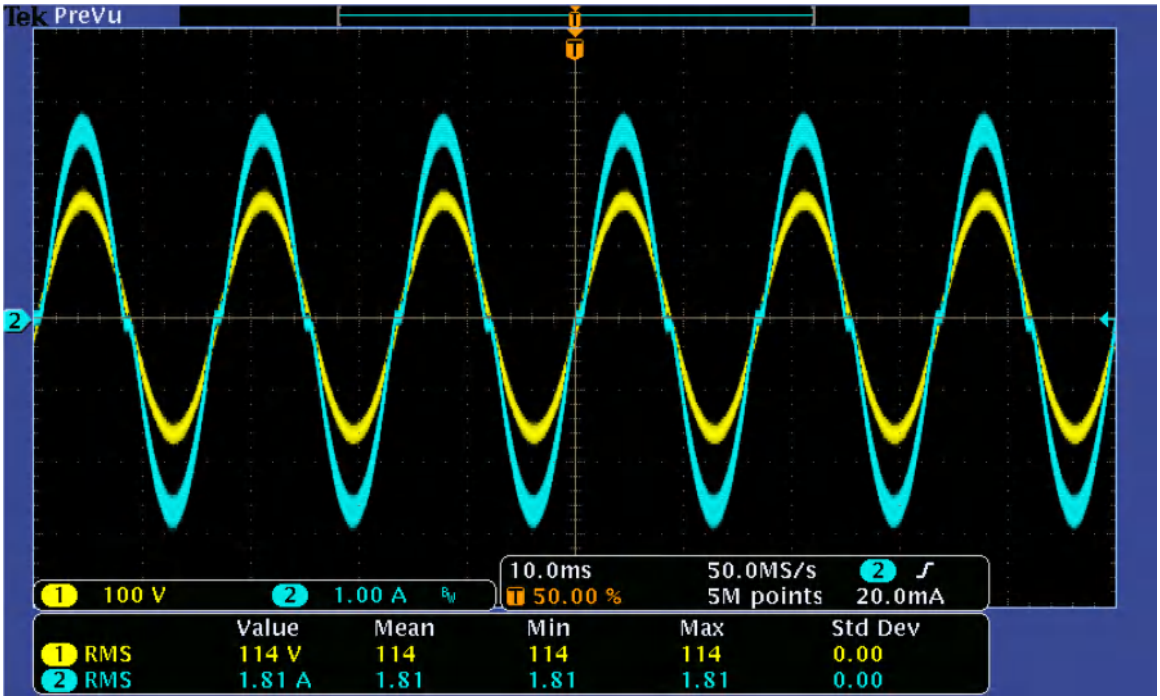


The photo below shows the switch node voltage (Q100 & Q201 Vds) and resonant current waveforms at standby. The input voltage is 230Vac and outputs no load. (CH1: Q100_Vds, CH2: Q201_Vds, CH4: resonant current)

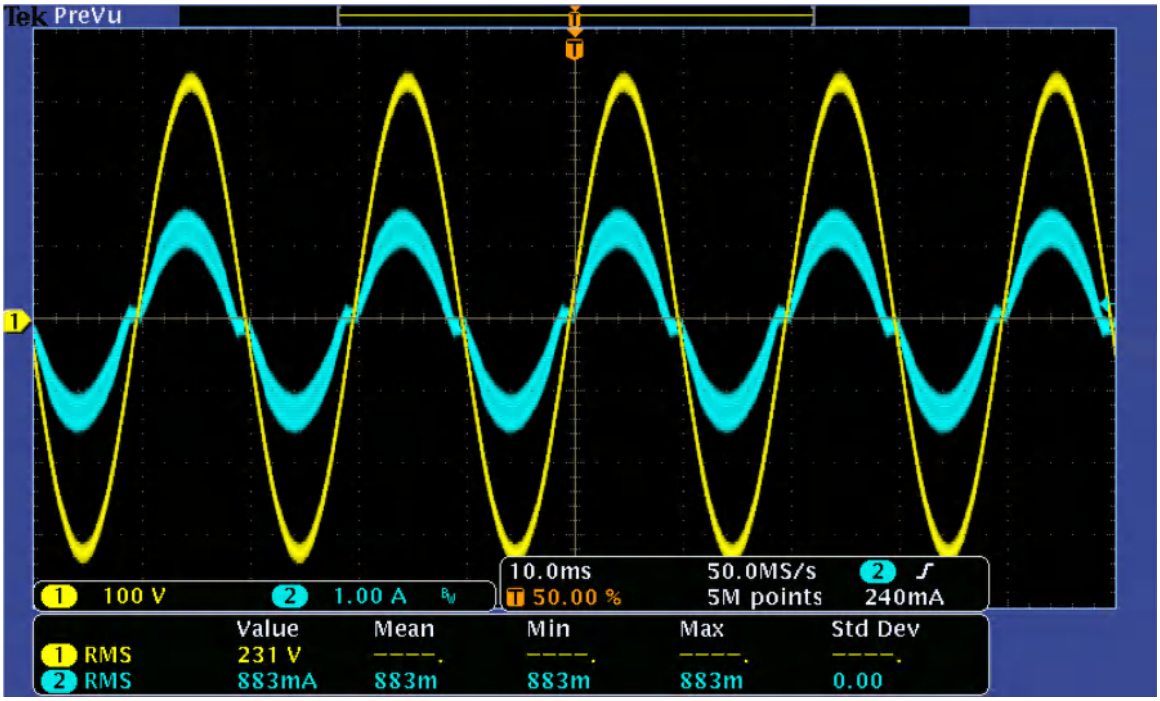




The photo below shows the input voltage and input current of PFC stage at 115Vac/60Hz and full load conditions (CH1: Input Voltage; CH2: Input Current)

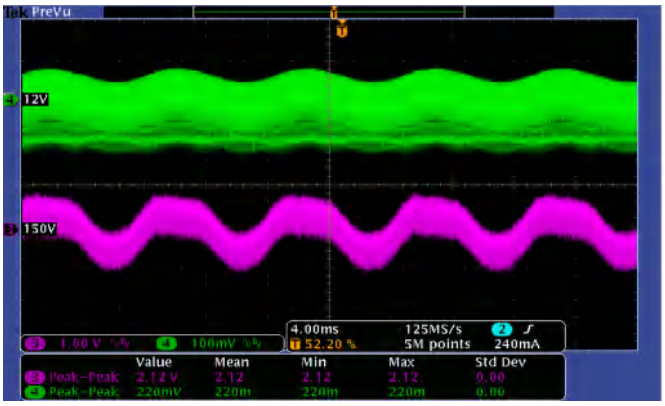


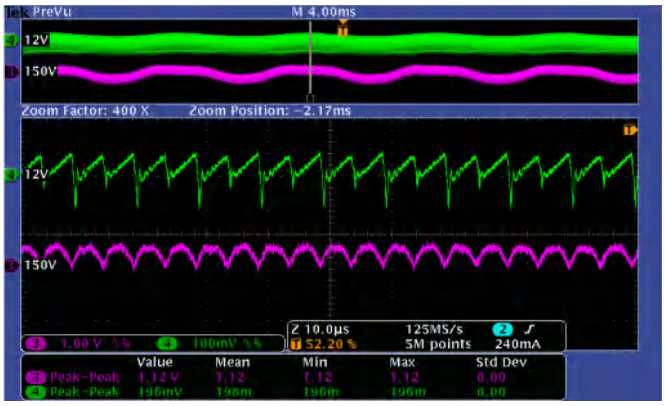
The photo below shows the input voltage and input current of PFC stage at 230Vac/50Hz and full load conditions (CH1: Input voltage; CH2: Input current)



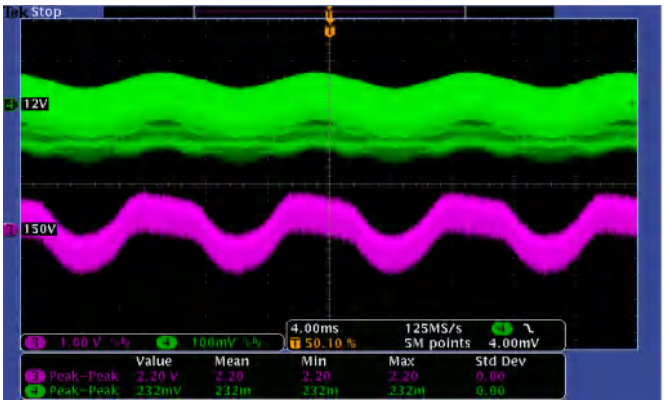
3.2 Output Voltage Ripple

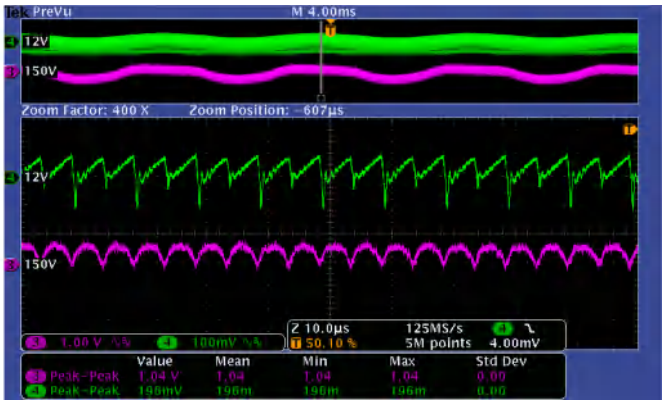
The following waveforms show the output voltage ripple at full load condition with 115 VAC, 60 Hz applied to the AC input. The oscilloscope probes are AC coupled. (CH3: 150V output, CH4: 12V output)



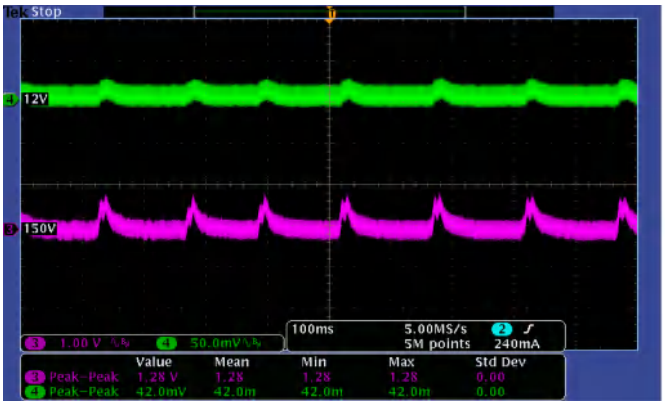


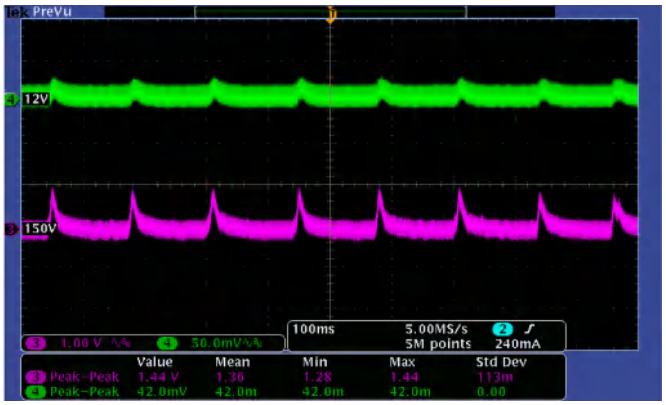
The following waveforms show the output voltage ripple at full load condition with 230 VAC, 50 Hz applied to the AC input. The oscilloscope probes are AC coupled. (CH3: 150V output, CH4: 12V output)





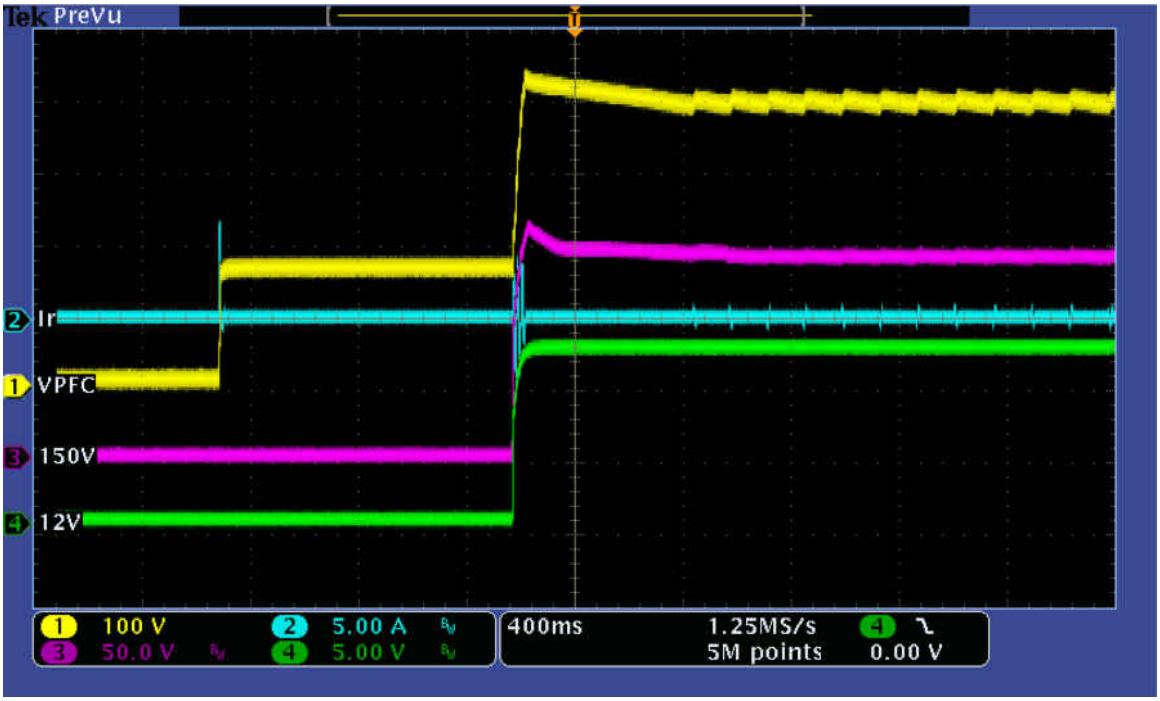
The following waveforms show the output voltage ripple at no load condition with 115 VAC, 60 Hz (right photo) and 230 VAC, 50Hz (left photo) applied to the AC input. The oscilloscope probes are AC coupled. (CH3: 150V output, CH4: 12V output)



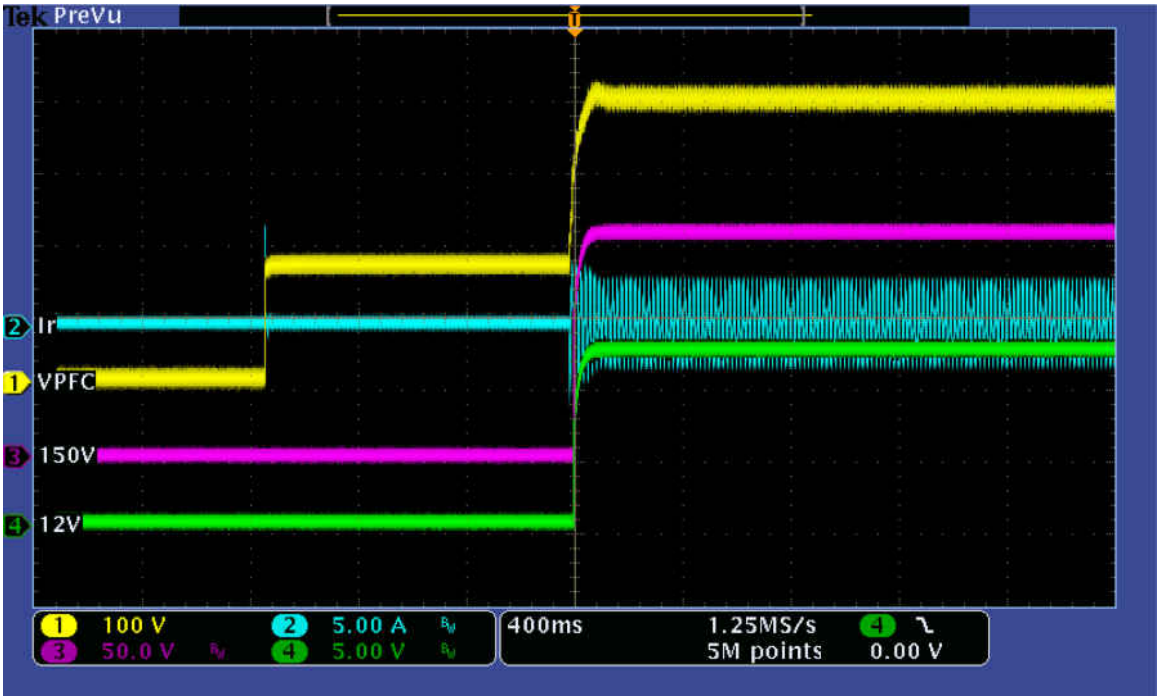


3.3 Start-up Sequence

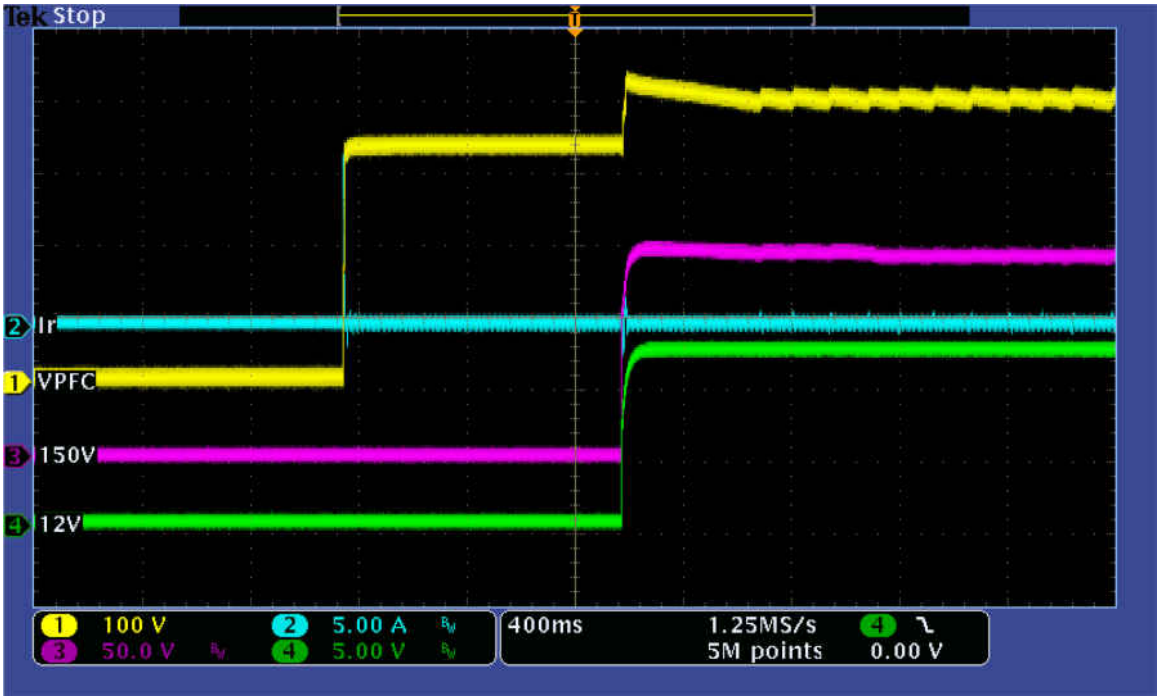
The photo below shows the output voltage startup waveform after the application of 115Vac/60Hz and loaded to 0A. (CH1: PFC output voltage, CH2: input current, CH3: 150V output voltage, CH4: 12V output voltage)



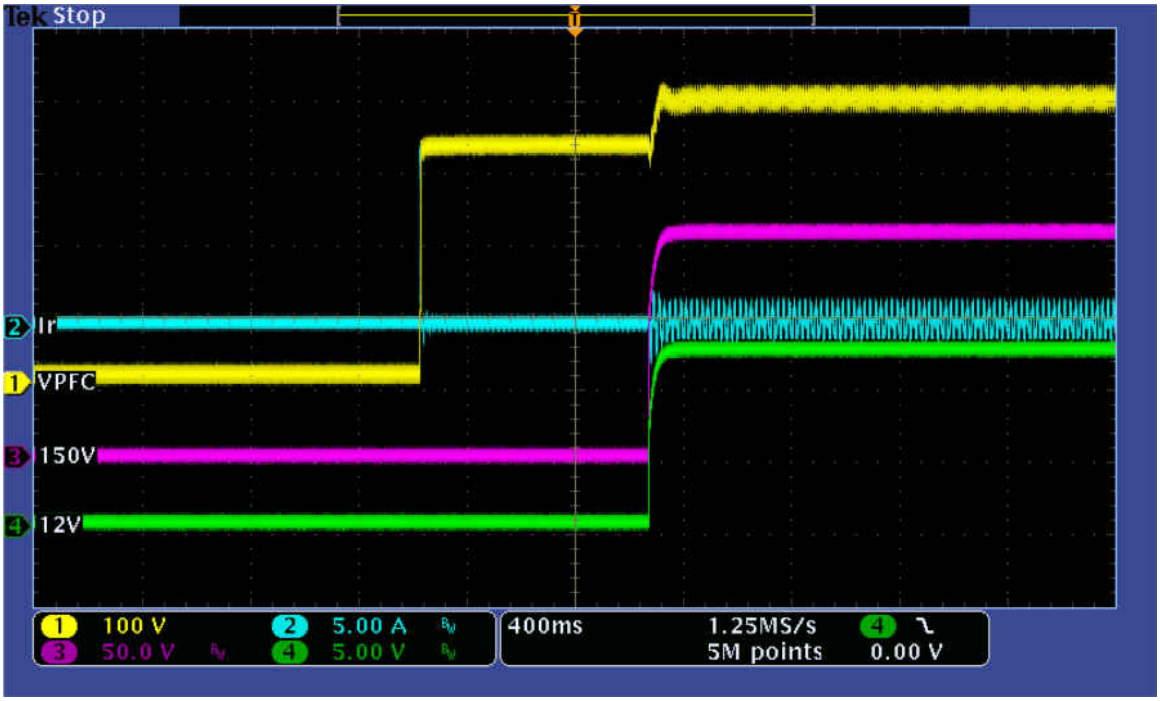
The photo below shows the output voltage startup waveform after the application of 115Vac/60Hz and outputs full loaded. (CH1: PFC output voltage, CH2: input current, CH3: 150V output voltage, CH4: 12V output voltage)



The photo below shows the output voltage startup waveform after the application of 230Vac/50Hz and loaded to 0A. (CH1: PFC output voltage, CH2: input current, CH3: 150V output voltage, CH4: 12V output voltage)



The photo below shows the output voltage startup waveform after the application of 230VAC/50Hz and outputs full loaded. (CH1: PFC output voltage, CH2: input current, CH3: 150V output voltage, CH4: 12V output voltage)



4 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Revision * (May 2020) to Revision A (April 2023)	Page
• Updated the numbering format for tables, figures, and cross-references throughout the document	1

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