# Test Report: PMP21000
Single Stage AC-DC Auxless LLC Resonant Converter Reference Design

Description

The PMP21000 reference design provides a 12-V/100-W output from either 120-Vac or 230-Vac input with a single LLC resonant converter stage. The BOM cost of this design is highly optimized with the single-stage structure and the use of UCC256302 LLC Resonant Controller. High voltage startup, integrated driver, as well as burst operation that UCC256302 provided allows minimum use of discrete components. Along with UCC24612-2 synchronous rectifier (SR) controller to optimize SR MOSFET's conduction time, this design is able to achieve 91.7% peak efficiency at 120-Vac input and 93.1% peak efficiency at 230-Vac input.
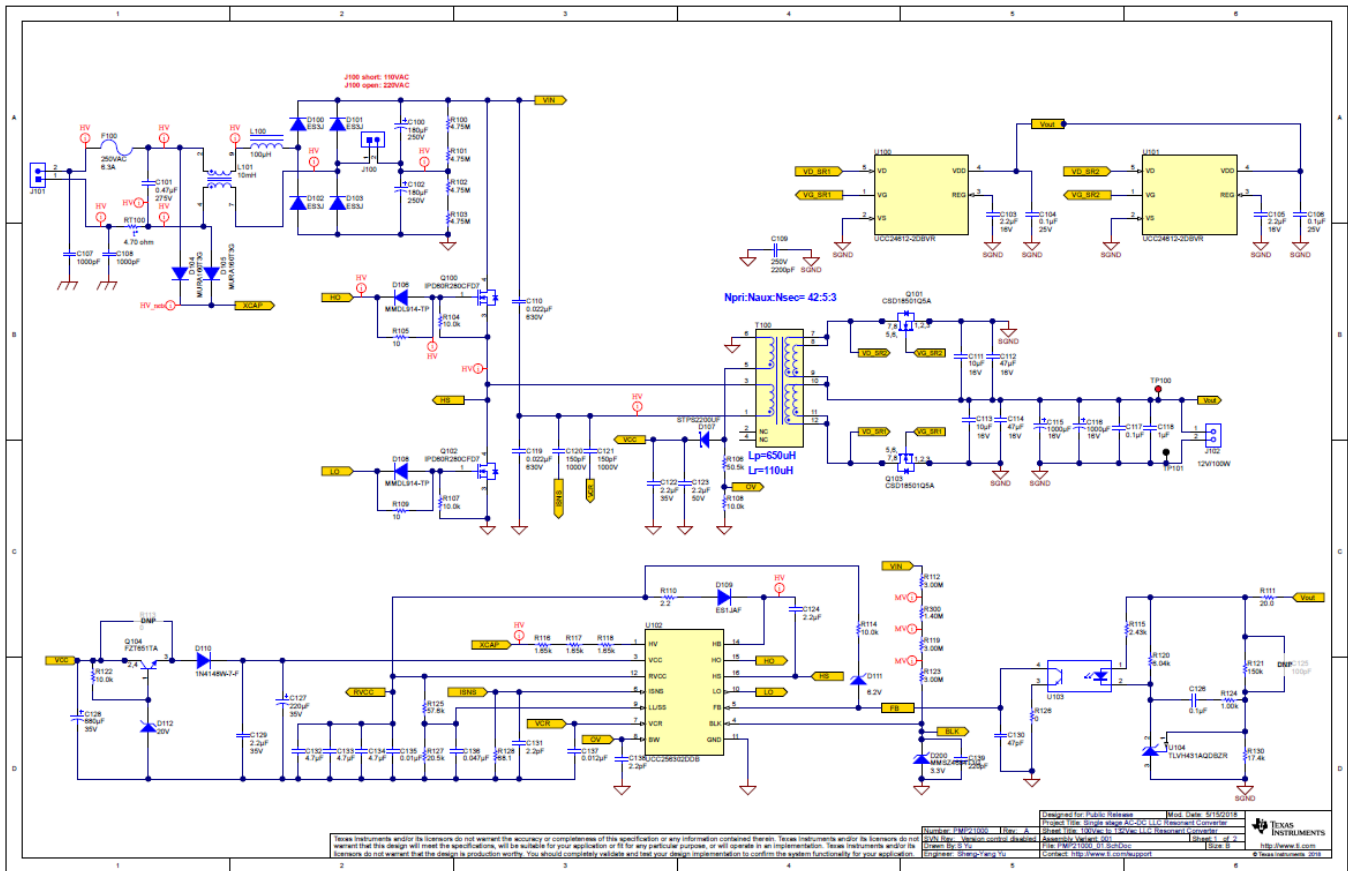
An IMPORTANT NOTICE at the end of this TI reference design addresses authorized use, intellectual property matters and other important disclaimers and information.
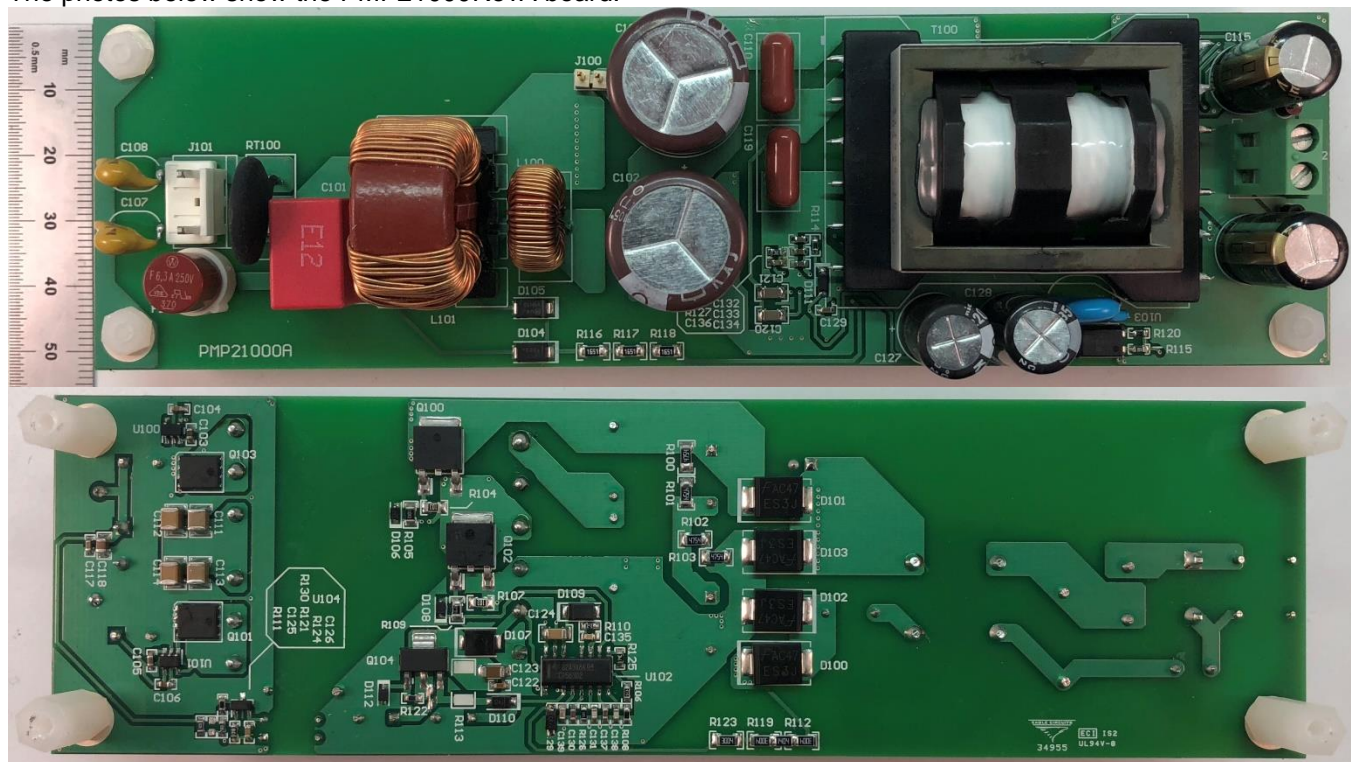
1 Test Prerequisites

1.1 *Voltage and Current Requirements*

Table 1.   Voltage and Current Requirements

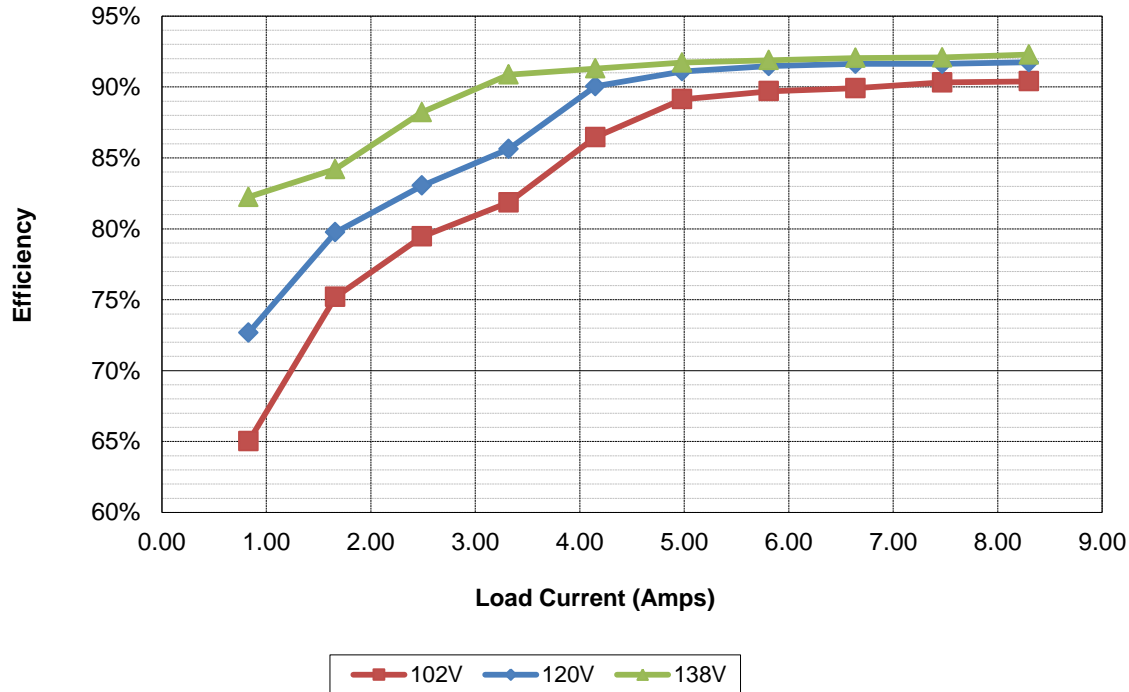| PARAMETER	SPECIFICATIONS
Vin	102VAC-138VAC, 195VAC-265VAC
Vout	12V
Iout	8.33A

1.2 *Dimensions*
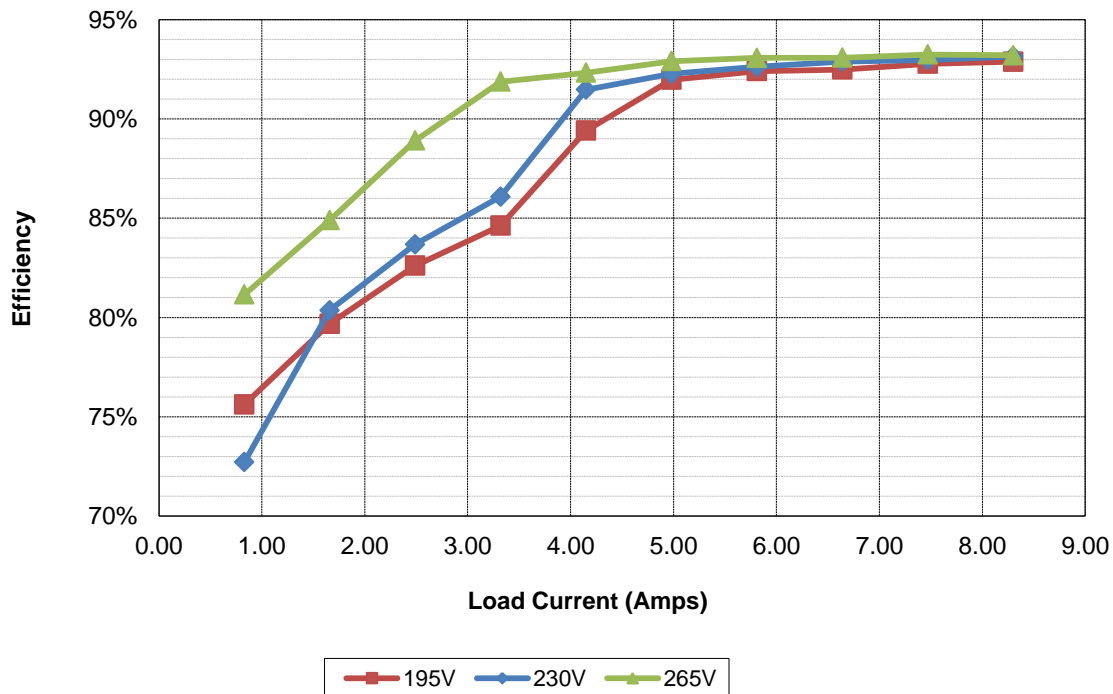
The photos below show the PMP21000RevA board.

2 Testing and Results

2.1 Efficiency Graphs

The converter efficiency is shown in the figures below for a 102VAC-138VAC input with a 12V output.

The converter efficiency is shown in the figures below for a 195VAC-265VAC input with a 12V output.

2.2 Efficiency Data

Below is the efficiency data for 102VAC-138VAC input with 12V output

Iout	Vout	Vin AC	Iin Arms (mA)	Pin	PF	Pout	Losses	Efficiency
0.830	11.890	102.0	243.0000	15.1790	0.6140	9.87	5.31	65.0%
1.660	11.890	102.0	414.000	26.2500	0.6310	19.74	6.51	75.2%
2.490	11.890	102.0	596.000	37.2600	0.6200	29.61	7.65	79.5%
3.320	11.890	102.0	781.000	48.2200	0.6150	39.47	8.75	81.9%
4.150	11.880	102.0	931.000	57.0200	0.6050	49.30	7.72	86.5%
4.980	11.890	102.0	1.107	66.4300	0.6050	59.21	7.22	89.1%
5.810	11.890	102.0	1.266	77.0100	0.6010	69.08	7.93	89.7%
6.640	11.880	102.0	1.438	87.7300	0.6020	78.88	8.85	89.9%
7.470	11.880	102.0	1.610	98.2600	0.6020	88.74	9.52	90.3%
8.300	11.880	102.0	1.781	109.0800	0.6040	98.60	10.48	90.4%

Iout	Vout	Vin AC	Iin Arms (mA)	Pin	PF	Pout	Losses	Efficiency
0.830	11.890	119.8	198.0000	13.5800	0.5700	9.87	3.71	72.7%
1.660	11.890	119.8	356.000	24.7500	0.5800	19.74	5.01	79.7%
2.490	11.890	119.8	507.000	35.6500	0.5930	29.61	6.04	83.0%
3.320	11.890	119.8	659.000	46.1000	0.5880	39.47	6.63	85.6%
4.150	11.880	119.8	790.000	54.7500	0.5810	49.30	5.45	90.0%
4.980	11.890	119.8	946.000	65.0000	0.5760	59.21	5.79	91.1%
5.810	11.890	119.8	1.095	75.5200	0.5780	69.08	6.44	91.5%
6.640	11.890	119.8	1.246	86.1600	0.5780	78.95	7.21	91.6%
7.470	11.880	119.8	1.398	96.8500	0.5800	88.74	8.11	91.6%
8.300	11.880	119.8	1.548	107.4800	0.5820	98.60	8.88	91.7%

Iout	Vout	Vin AC	Iin Arms (mA)	Pin	PF	Pout	Losses	Efficiency
0.830	11.890	138.0	175.0000	12.0000	0.4960	9.87	2.13	82.2%
1.660	11.890	138.0	306.000	23.4400	0.5560	19.74	3.70	84.2%
2.490	11.890	138.0	429.000	33.5600	0.5700	29.61	3.95	88.2%
3.320	11.890	138.0	554.000	43.4400	0.5740	39.47	3.97	90.9%
4.150	11.880	138.0	690.000	54.0000	0.5700	49.30	4.70	91.3%
4.980	11.890	138.0	827.000	64.5600	0.5700	59.21	5.35	91.7%
5.810	11.880	138.0	964.000	75.1200	0.5680	69.02	6.10	91.9%
6.640	11.880	138.0	1.103	85.7000	0.5670	78.88	6.82	92.0%
7.470	11.870	138.0	1.242	96.3000	0.5650	88.67	7.63	92.1%
8.300	11.880	138.0	1.376	106.8500	0.5660	98.60	8.25	92.3%

Below is the efficiency data for 195VAC-265VAC input with 12V output

Iout	Vout	Vin AC	Iin Arms (mA)	Pin	PF	Pout	Losses	Efficiency
0.830	11.890	194.8	145.0000	13.0500	0.4620	9.87	3.18	75.6%
1.660	11.890	194.8	247.000	24.7700	0.5140	19.74	5.03	79.7%
2.490	11.890	194.8	346.000	35.8400	0.5320	29.61	6.23	82.6%
3.320	11.890	194.8	452.000	46.6500	0.5270	39.47	7.18	84.6%
4.150	11.880	194.8	533.000	55.1400	0.5290	49.30	5.84	89.4%
4.980	11.890	194.8	626.000	64.3800	0.5290	59.21	5.17	92.0%
5.810	11.890	194.8	725.000	74.7600	0.5300	69.08	5.68	92.4%
6.640	11.880	194.8	825.000	85.2900	0.5310	78.88	6.41	92.5%
7.470	11.880	194.8	922.000	95.6500	0.5330	88.74	6.91	92.8%
8.300	11.880	194.8	1.017	106.1600	0.5360	98.60	7.56	92.9%

Iout	Vout	Vin AC	Iin Arms (mA)	Pin	PF	Pout	Losses	Efficiency
0.830	11.880	229.9	129.5500	13.5600	0.4540	9.86	3.70	72.7%
1.660	11.880	229.9	213.800	24.5400	0.5000	19.72	4.82	80.4%
2.490	11.880	229.9	303.400	35.3500	0.5120	29.58	5.77	83.7%
3.320	11.880	229.9	390.000	45.8200	0.5080	39.44	6.38	86.1%
4.150	11.880	229.9	464.000	53.9000	0.5070	49.30	4.60	91.5%
4.980	11.880	229.9	544.000	64.1200	0.5120	59.16	4.96	92.3%
5.810	11.880	229.9	632.000	74.5200	0.5140	69.02	5.50	92.6%
6.640	11.880	229.9	720.000	84.9200	0.5130	78.88	6.04	92.9%
7.470	11.880	229.9	807.000	95.4500	0.5140	88.74	6.71	93.0%
8.300	11.870	229.9	893.000	105.7800	0.5160	98.52	7.26	93.1%

Iout	Vout	Vin AC	Iin Arms (mA)	Pin	PF	Pout	Losses	Efficiency
0.830	11.880	265.0	113.0000	12.1500	0.4040	9.86	2.29	81.2%
1.660	11.880	265.0	186.000	23.2300	0.4670	19.72	3.51	84.9%
2.490	11.880	265.0	257.000	33.2700	0.4880	29.58	3.69	88.9%
3.320	11.880	265.0	324.000	42.9300	0.4960	39.44	3.49	91.9%
4.150	11.880	265.0	400.000	53.4000	0.4970	49.30	4.10	92.3%
4.980	11.880	265.0	478.000	63.6800	0.4990	59.16	4.52	92.9%
5.810	11.880	265.0	560.000	74.1600	0.5010	69.02	5.14	93.1%
6.640	11.870	265.0	638.000	84.6700	0.5010	78.82	5.85	93.1%
7.470	11.880	265.0	718.000	95.1700	0.5000	88.74	6.43	93.2%
8.300	11.870	265.0	797.000	105.7000	0.5000	98.52	7.18	93.2%

2.3 Standby Efficiency Data

Iout	Vout	Vin AC	Iin Arms (mA)	Pin	PF
0.000	11.890	120	23.63	0.259	0.092
0.000	11.890	240	38.33	0.226	0.025
0.000	11.890	265	50.33	0.170	0.013

2.4 Thermal Images

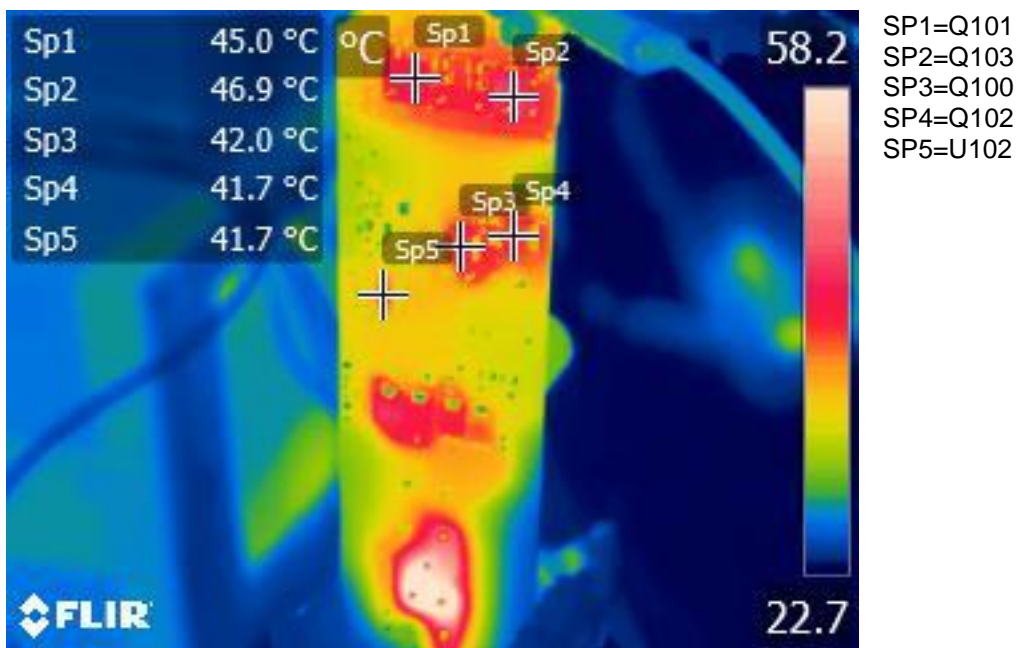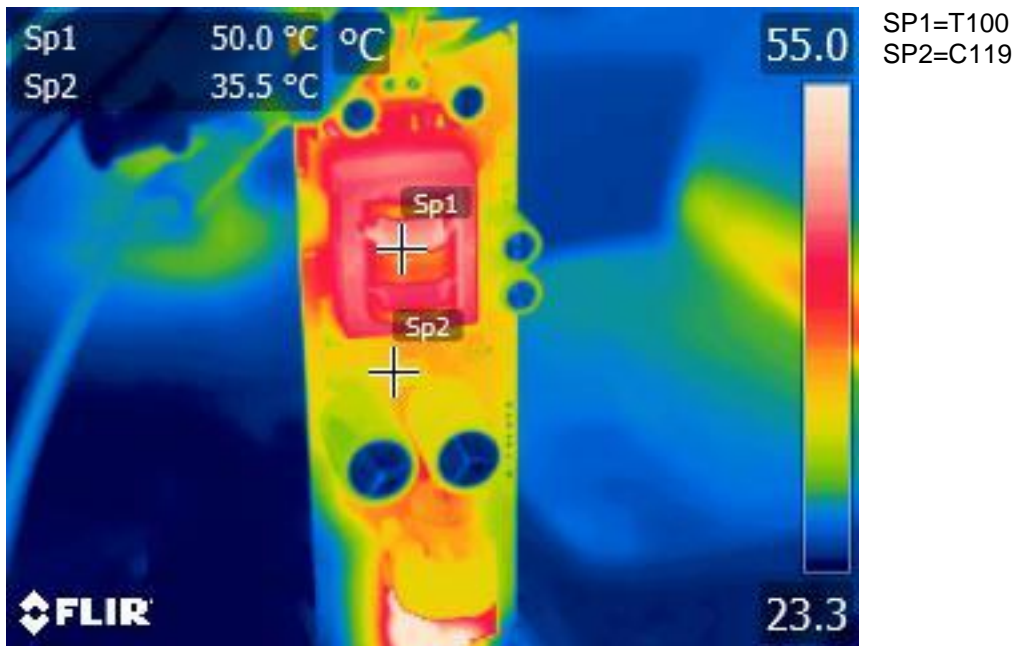The thermal image below shows operation at 120VAC input and 12V@8.3A output, with no airflow.
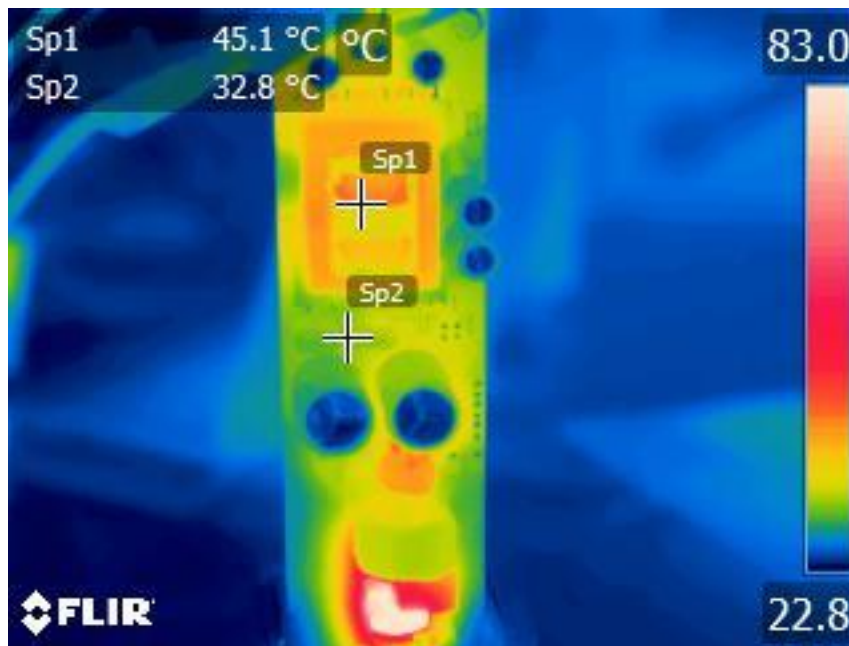
SP1=T100
SP2=C119
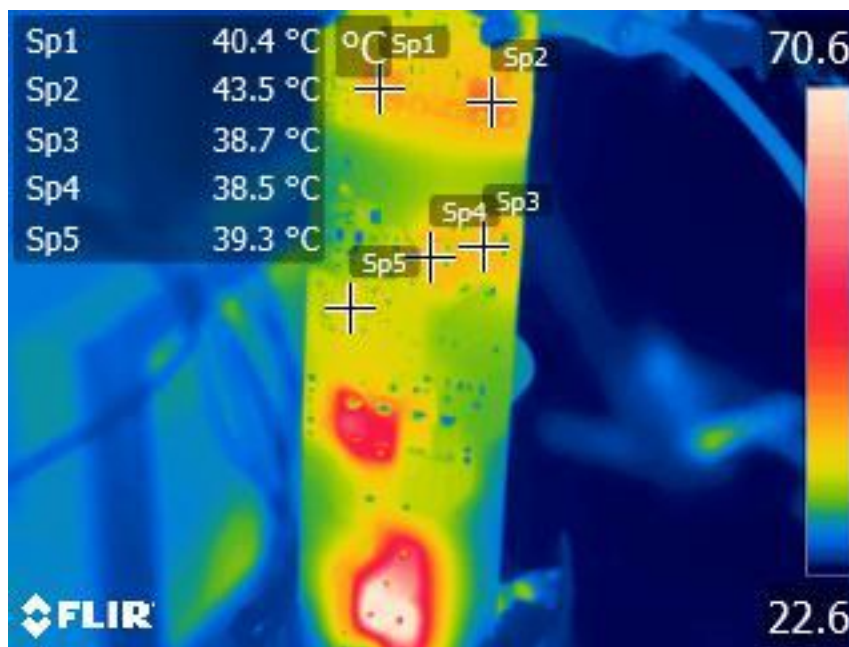
SP1=Q101
SP2=Q103
SP3=Q100
SP4=Q102
SP5=U102

The thermal image below shows operation at 230V input and 12V@8.3A output, with no airflow.

SP1=T100
SP2=C119

SP1=Q101
SP2=Q103
SP3=Q100
SP4=Q102
SP5=U102

3 Waveforms

3.1 Switch node

The photo below shows the switch node voltage (Q102 Vds, and C119 voltage). The input voltage is 120VAC and the 12V output is loaded to 8.3A. (100V/DIV, 10uS/DIV)
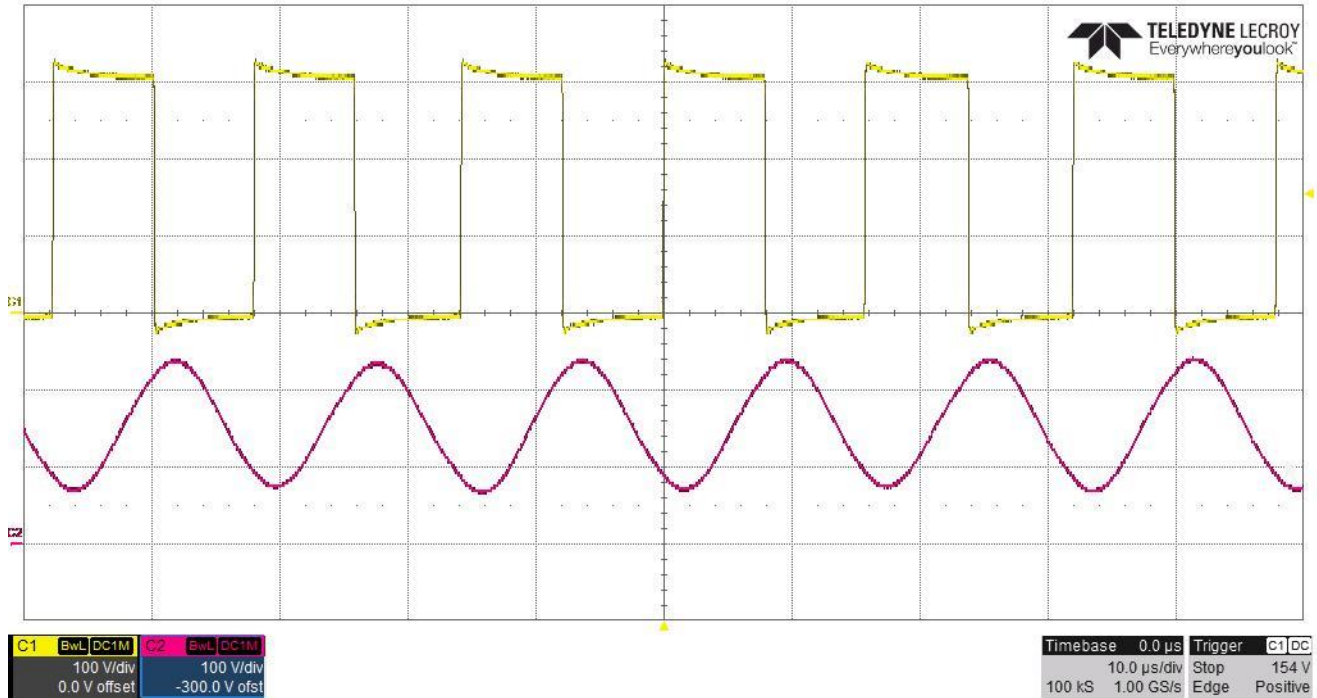
The photo below shows the switch node voltage(Q102 Vds, and C119 voltage). The input voltage is 230VAC and the 12V output is loaded to 8.3A. (100V/DIV, 20uS/DIV)
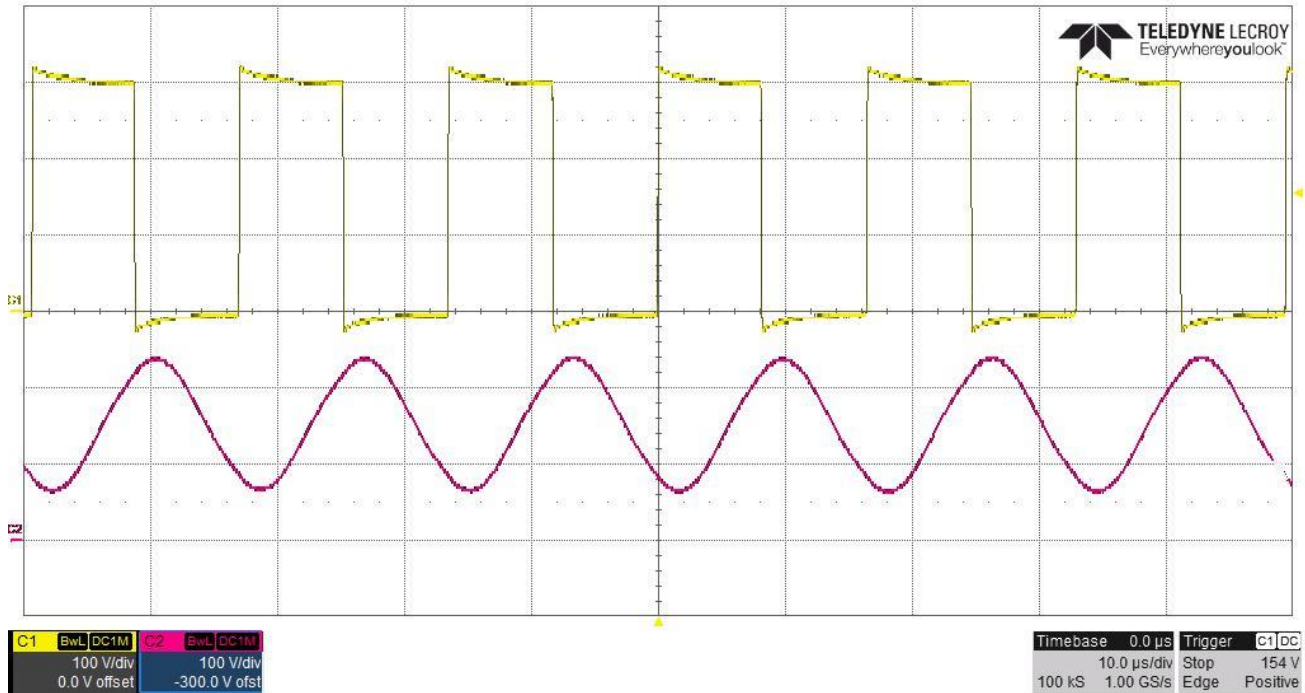
3.2 Synchronous rectifier waveforms

The photo below shows the synchronous rectifier waveforms. The input voltage is 102VAC and the 12V output is loaded to 8.3A.
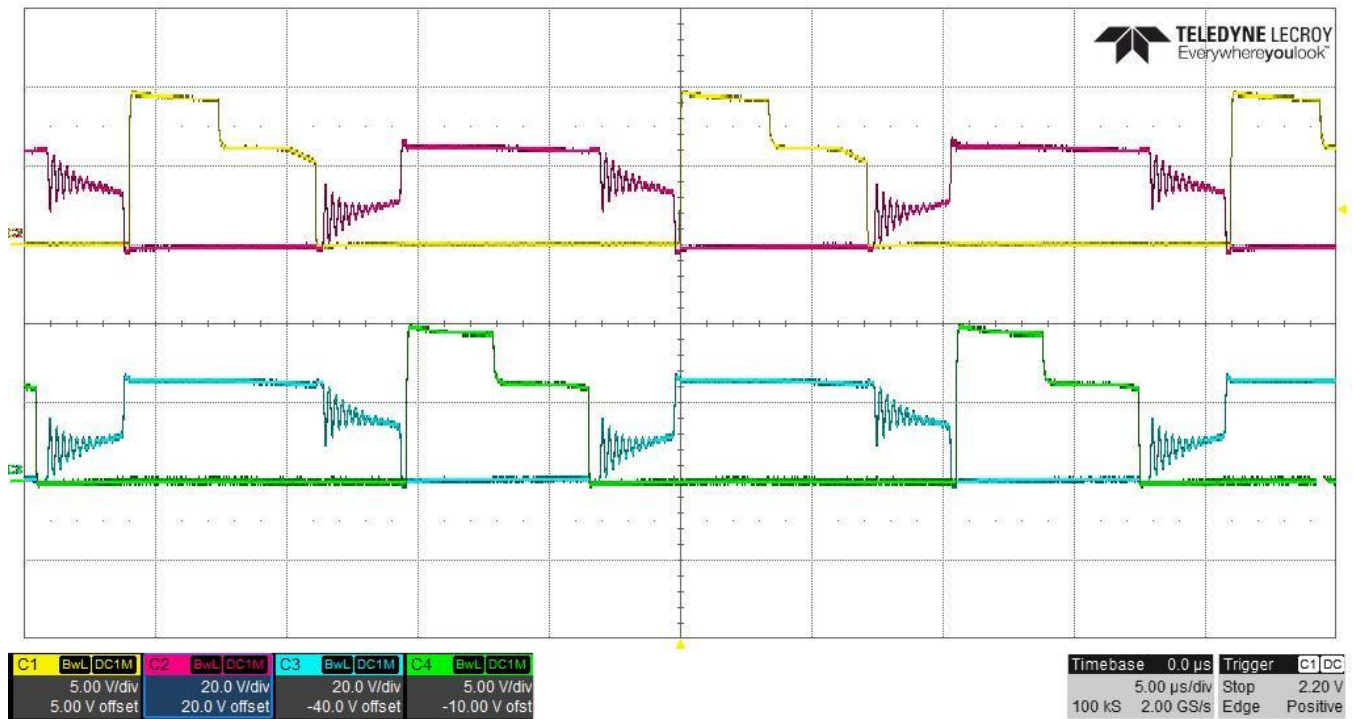
The photo below shows the synchronous rectifier waveforms. The input voltage is 120VAC and the 12V output is loaded to 8.3A.
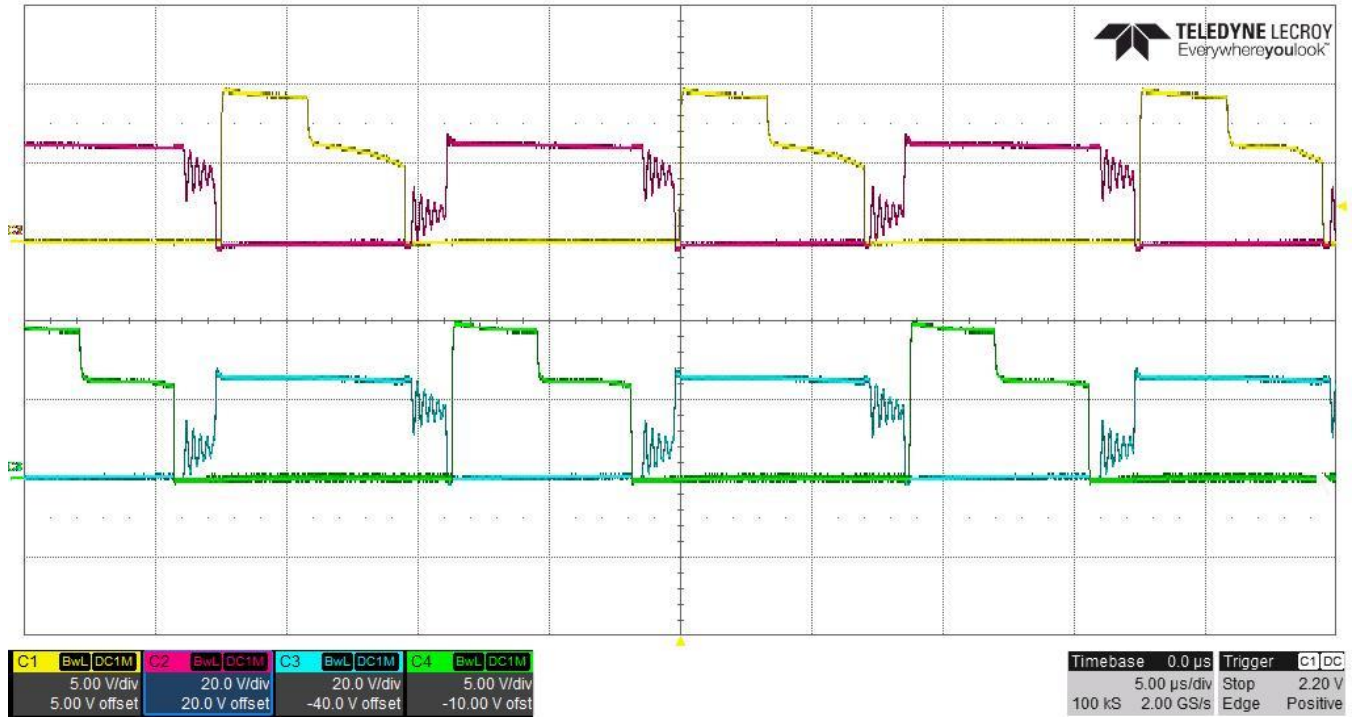
The photo below shows the synchronous rectifier waveforms. The input voltage is 138VAC and the 12V output is loaded to 8.3A.
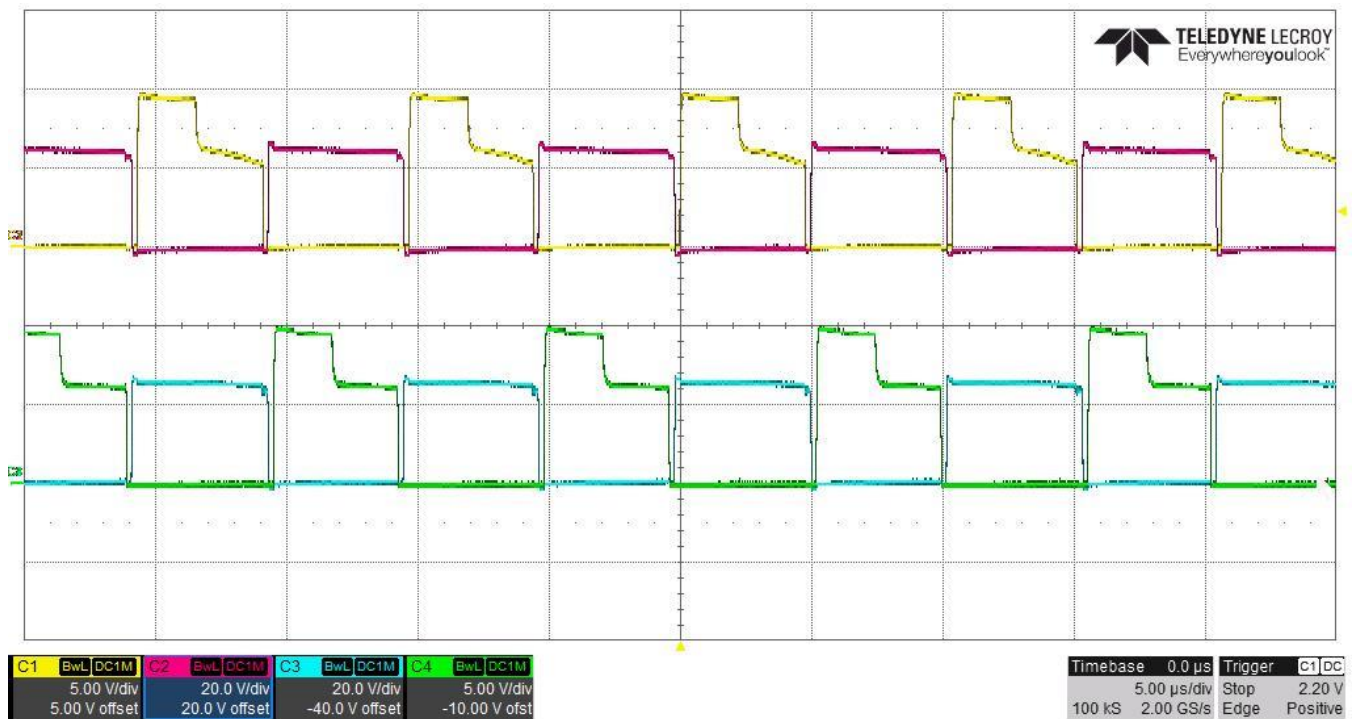
The photo below shows the synchronous rectifier waveforms. The input voltage is 195VAC and the 12V output is loaded to 8.3A.
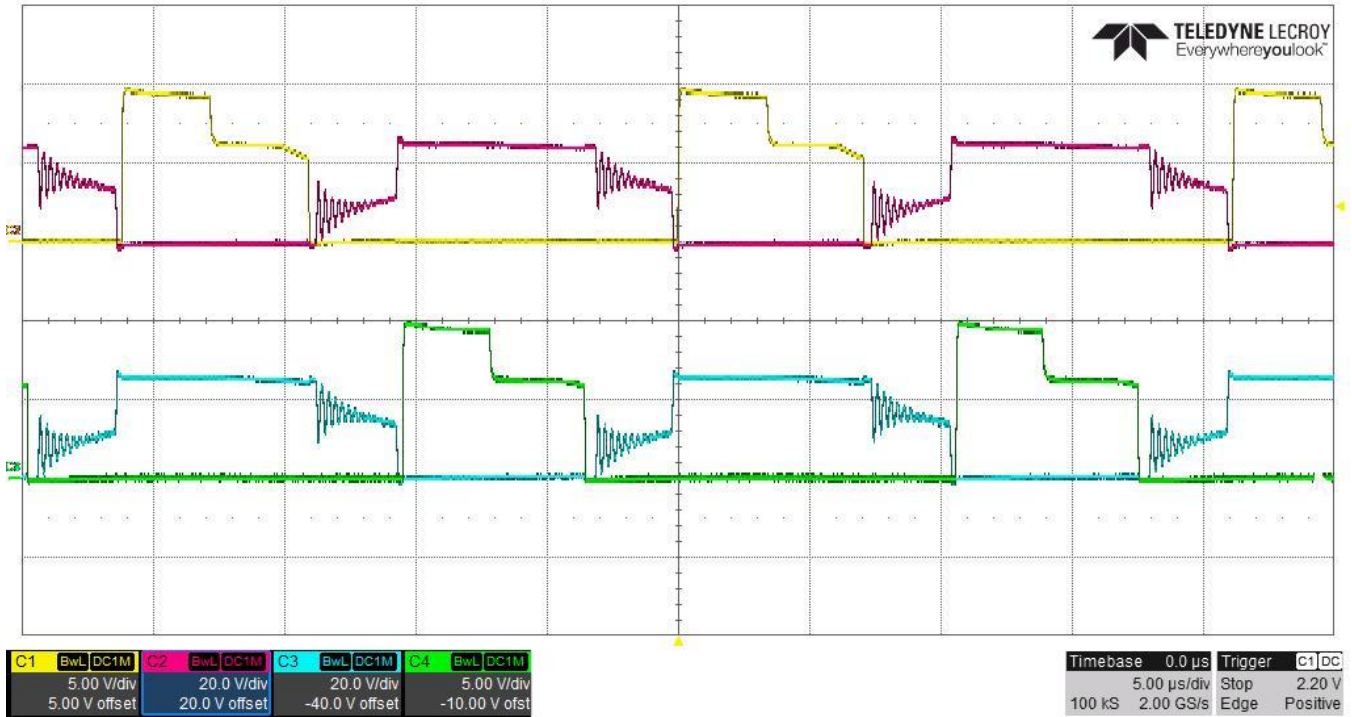
The photo below shows the synchronous rectifier waveforms. The input voltage is 230VAC and the 12V output is loaded to 8.3A.
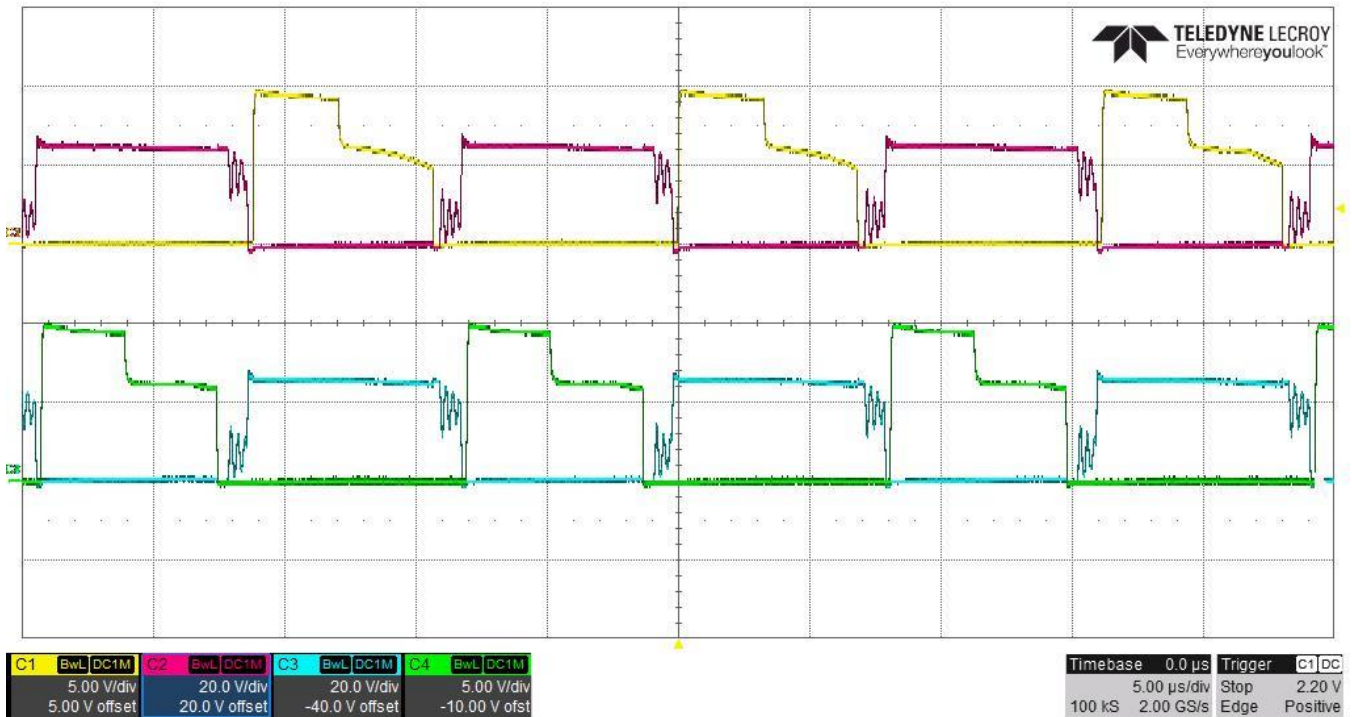
The photo below shows the synchronous rectifier waveforms. The input voltage is 265VAC and the 12V output is loaded to 8.3A.
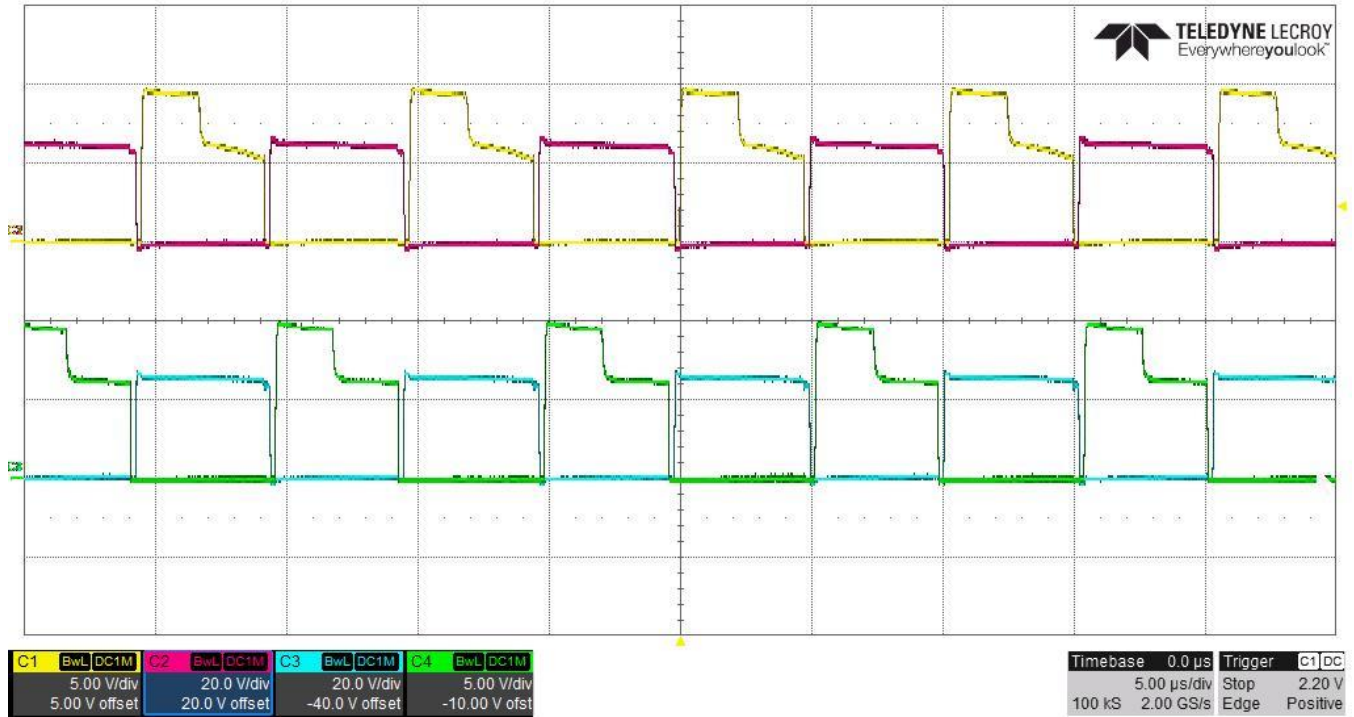
3.3   Output Voltage Ripple

The output ripple voltage is shown in the figure below. The image was taken with the 12V output loaded to 8.3A and the input voltage set to 120VAC. (50mV/DIV, 10uS/DIV)
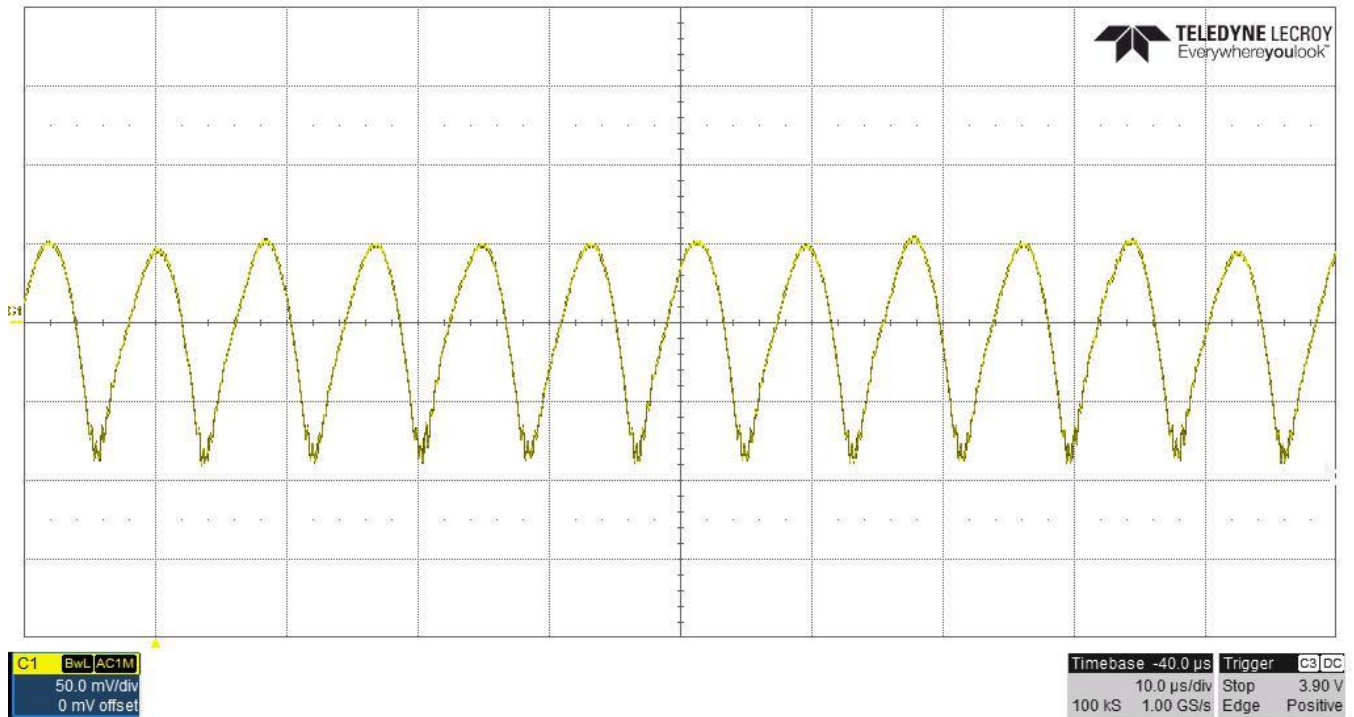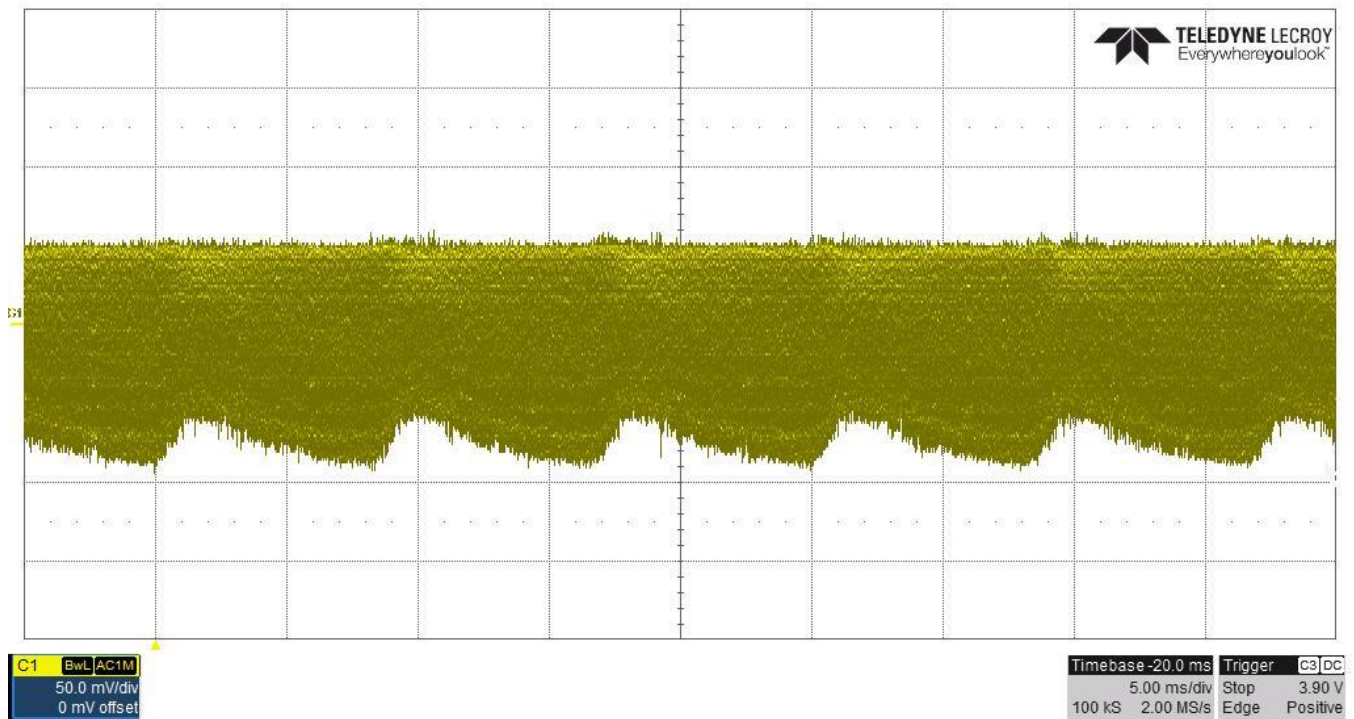
(50mV/DIV, 5mS/DIV)

The output ripple voltage is shown in the figure below. The image was taken with the 12V output loaded to 8.3A and the input voltage set to 230VAC. (50mV/DIV, 200uS/DIV)
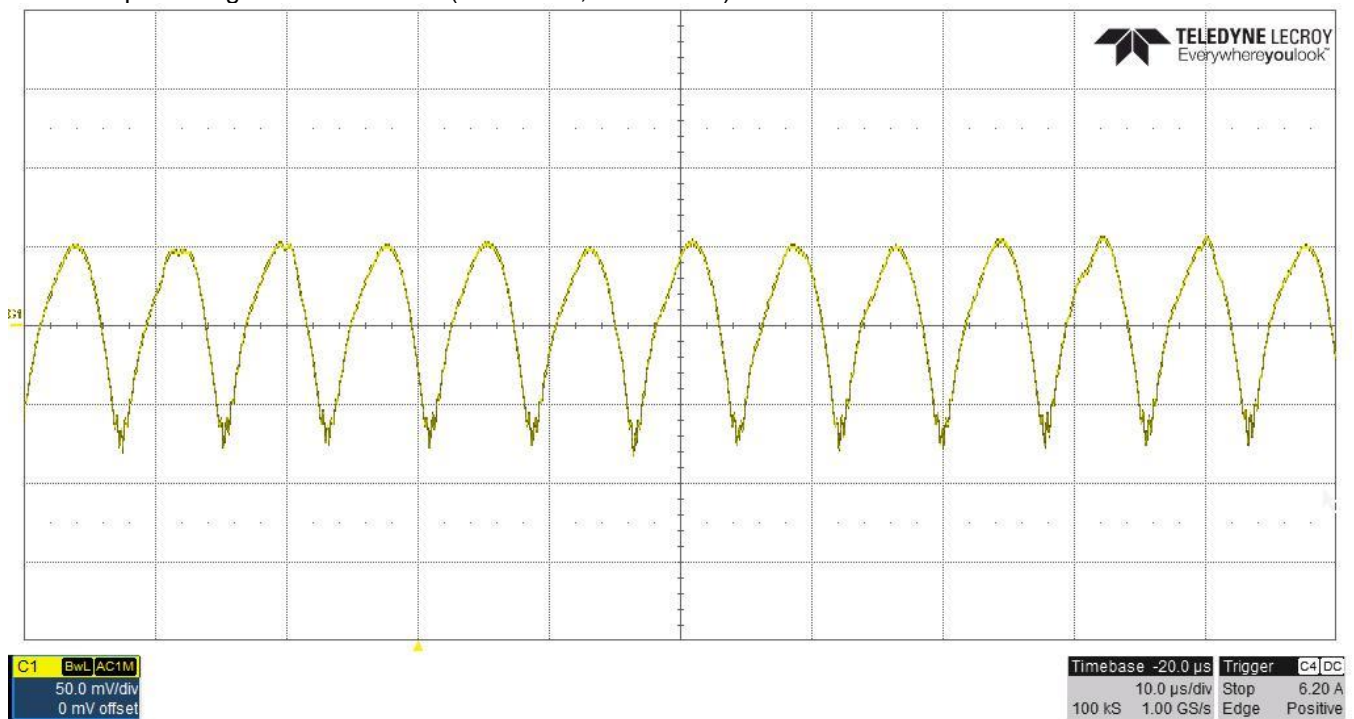
(50mV/DIV, 5mS/DIV)
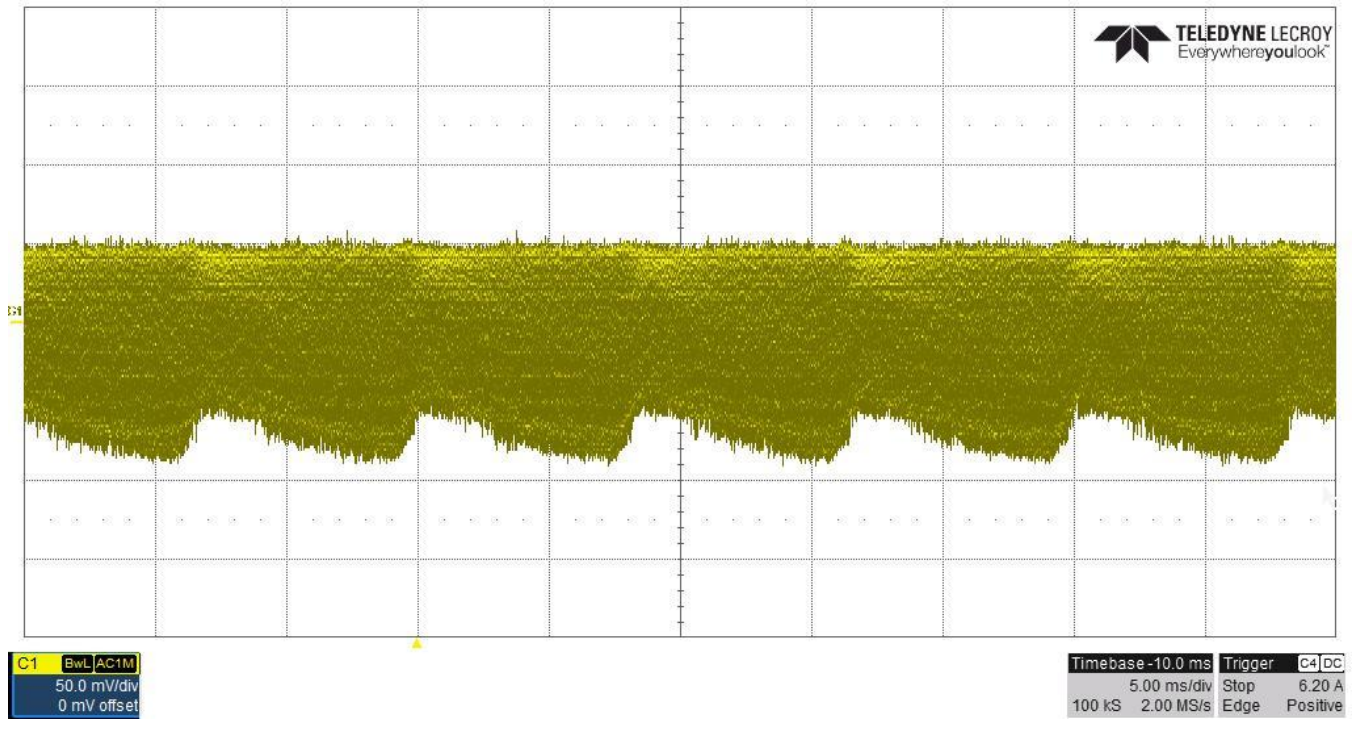
3.4 Load Transients

The photo below shows the 12V output voltage when the load current is stepped between 0A and 8.3A with an input voltage of 120VAC.
(50mV/DIV, 2A/DIV, 50mS/DIV)
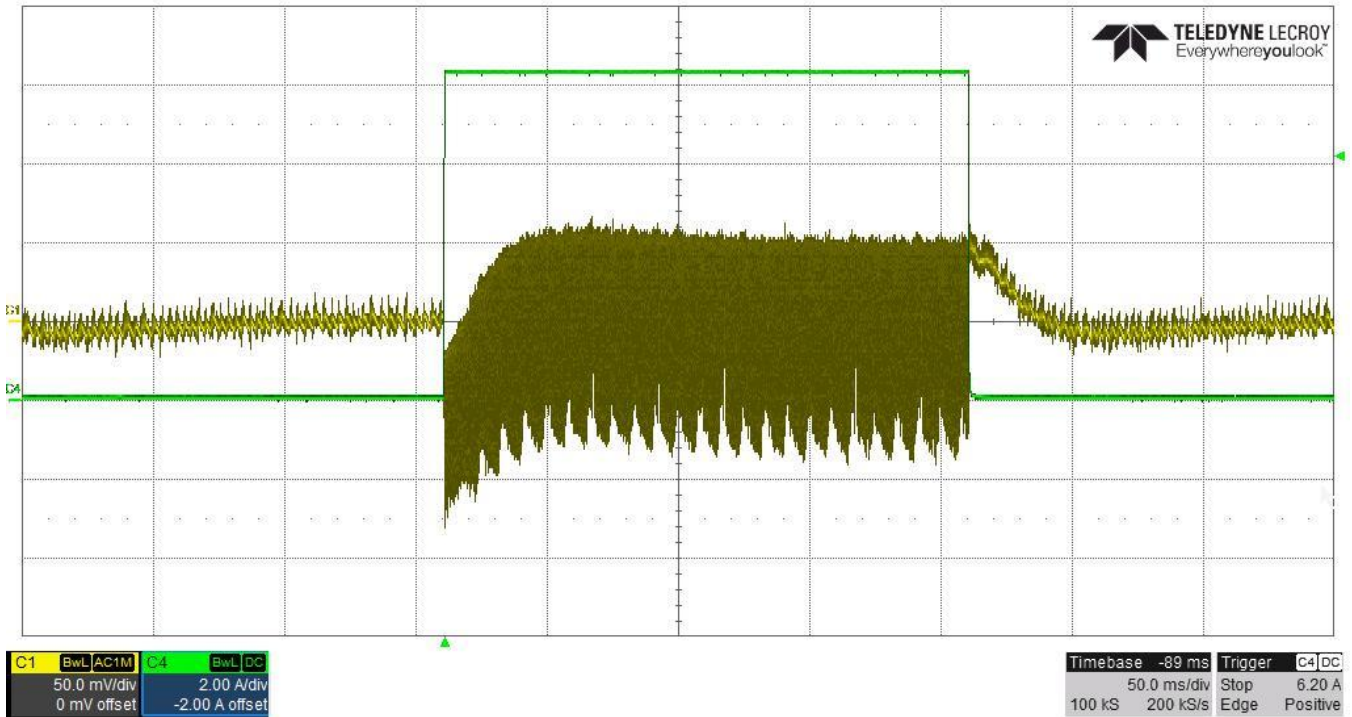
The photo below shows the 12V output voltage when the load current is stepped between 0A and 8.3A with an input voltage of 230VAC.
(50mV/DIV, 2A/DIV, 50mS/DIV)

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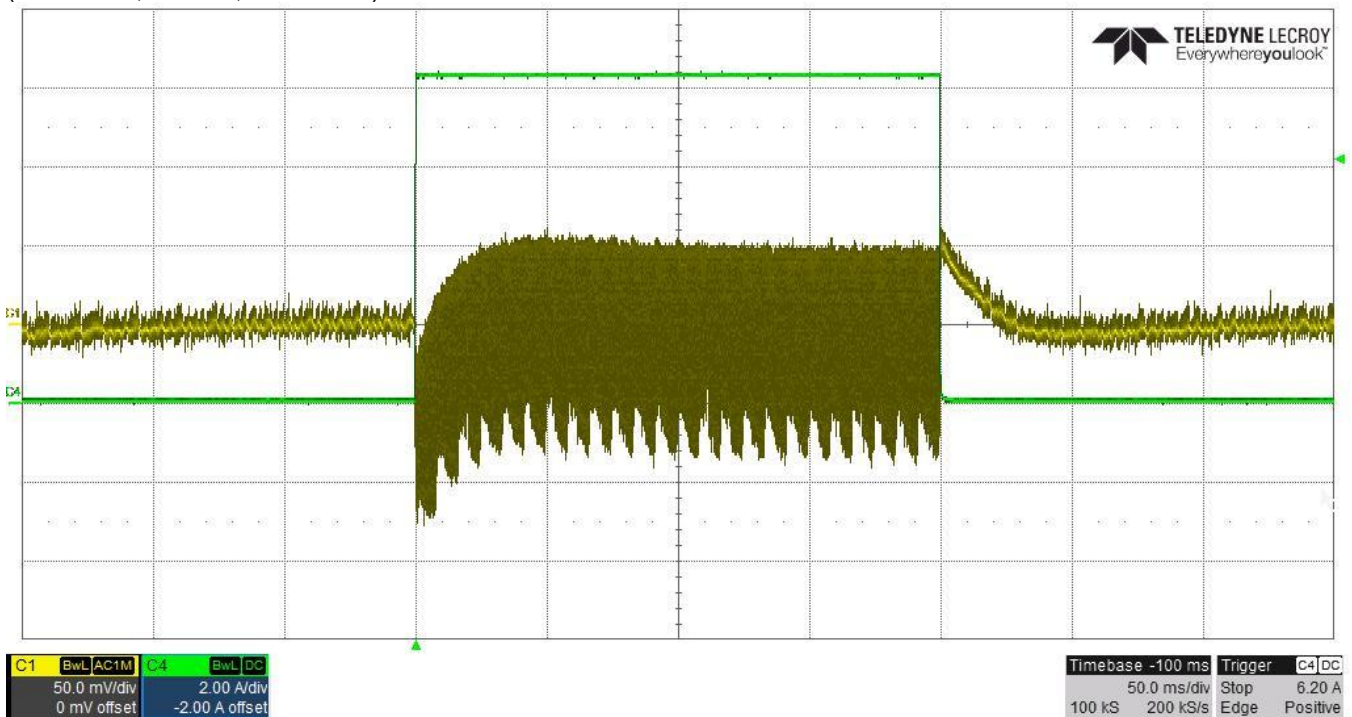
3.5 Start-up Sequence

The photo below shows the output voltage startup waveform after the application of 120VAC and output loaded to 0A.
(2V/DIV, 50mS/DIV)
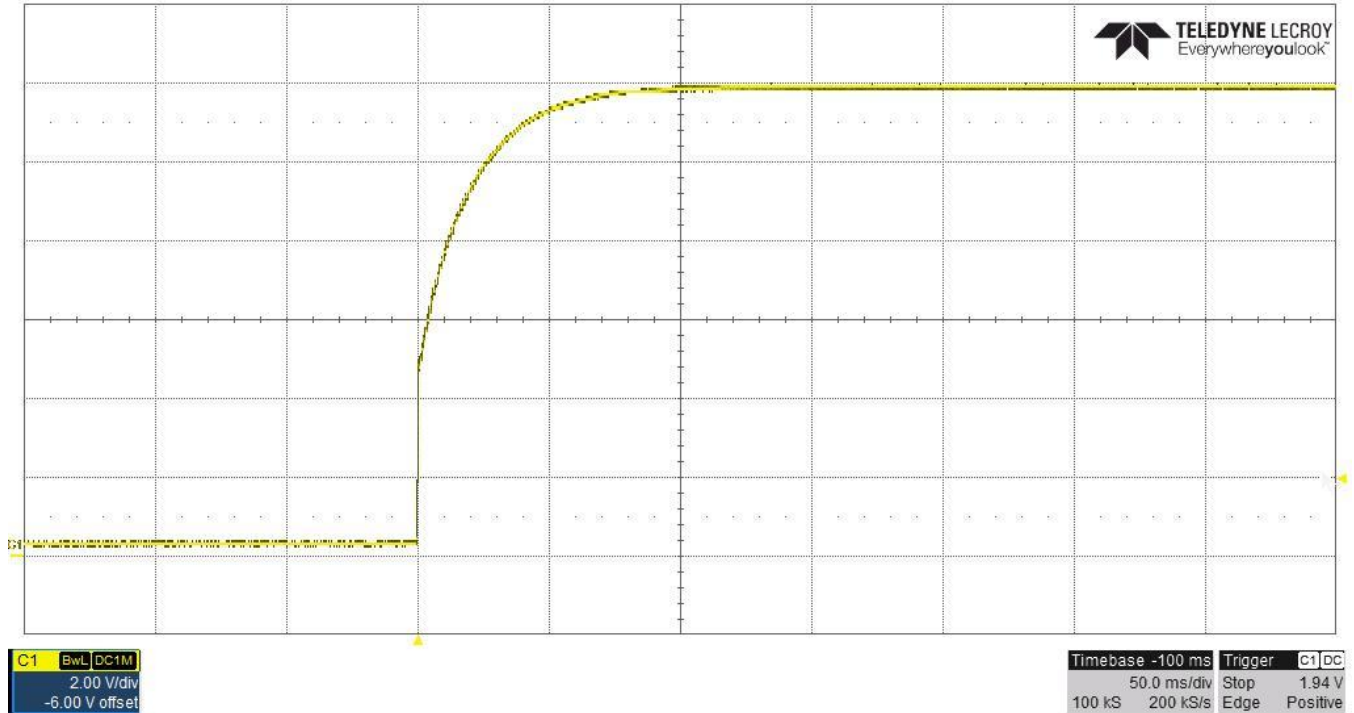
The photo below shows the output voltage startup waveform after the application of 120VAC and output loaded to 8.3A.
(2V/DIV, 50mS/DIV)
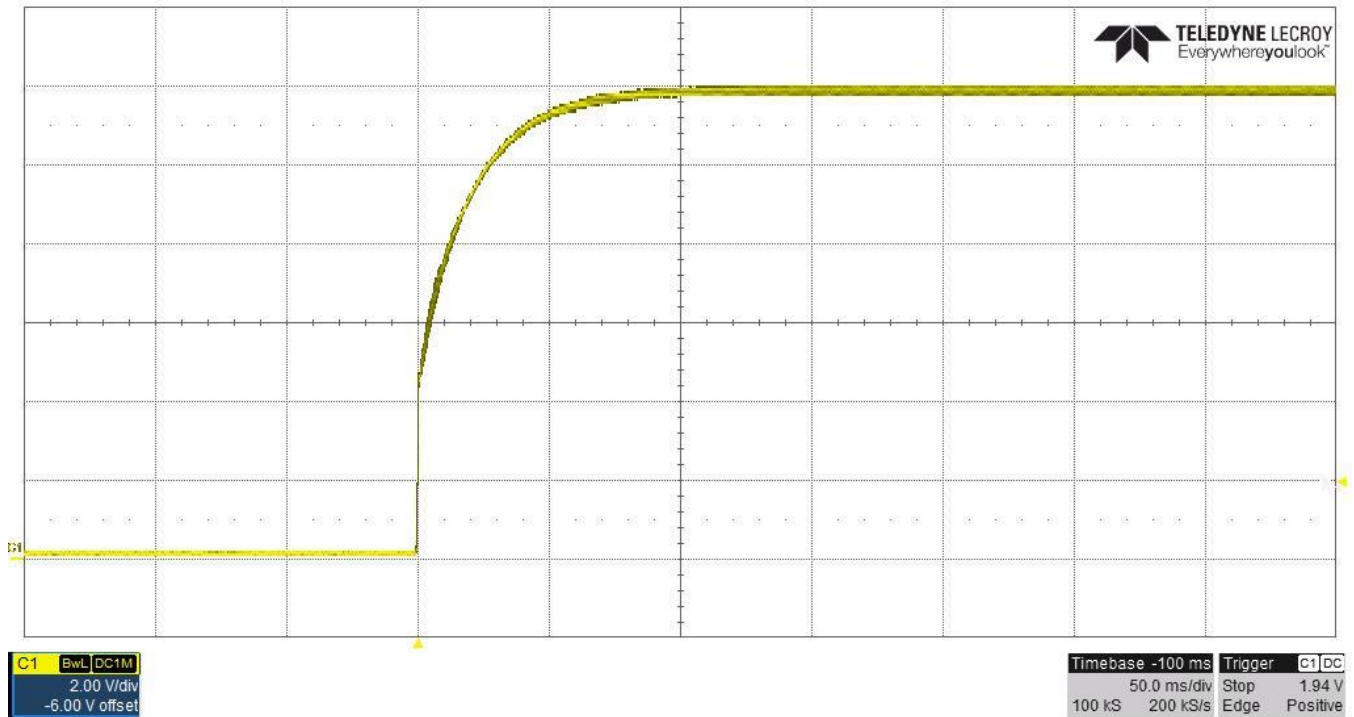
The photo below shows the output voltage startup waveform after the application of 230VAC and output loaded to 0A.
(2V/DIV, 50mS/DIV)
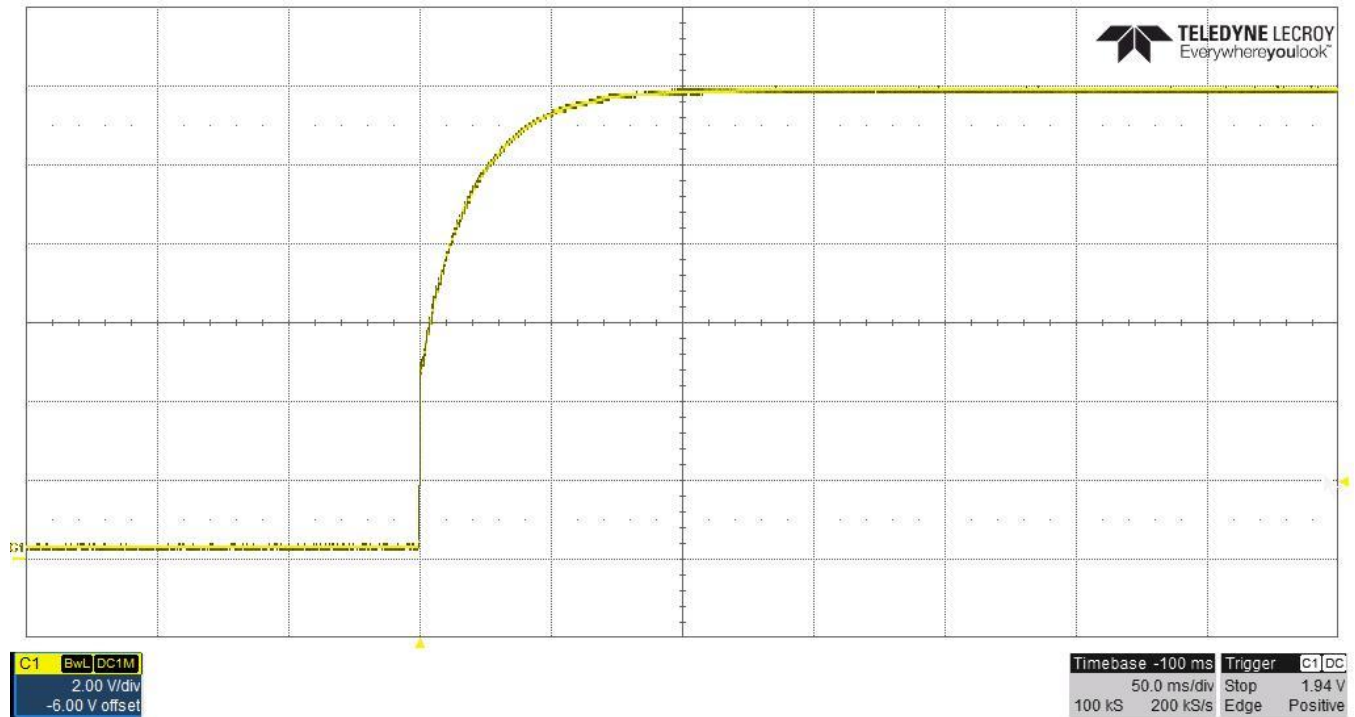
The photo below shows the output voltage startup waveform after the application of 230VAC and output loaded to 8.3A.
(2V/DIV, 50mS/DIV)
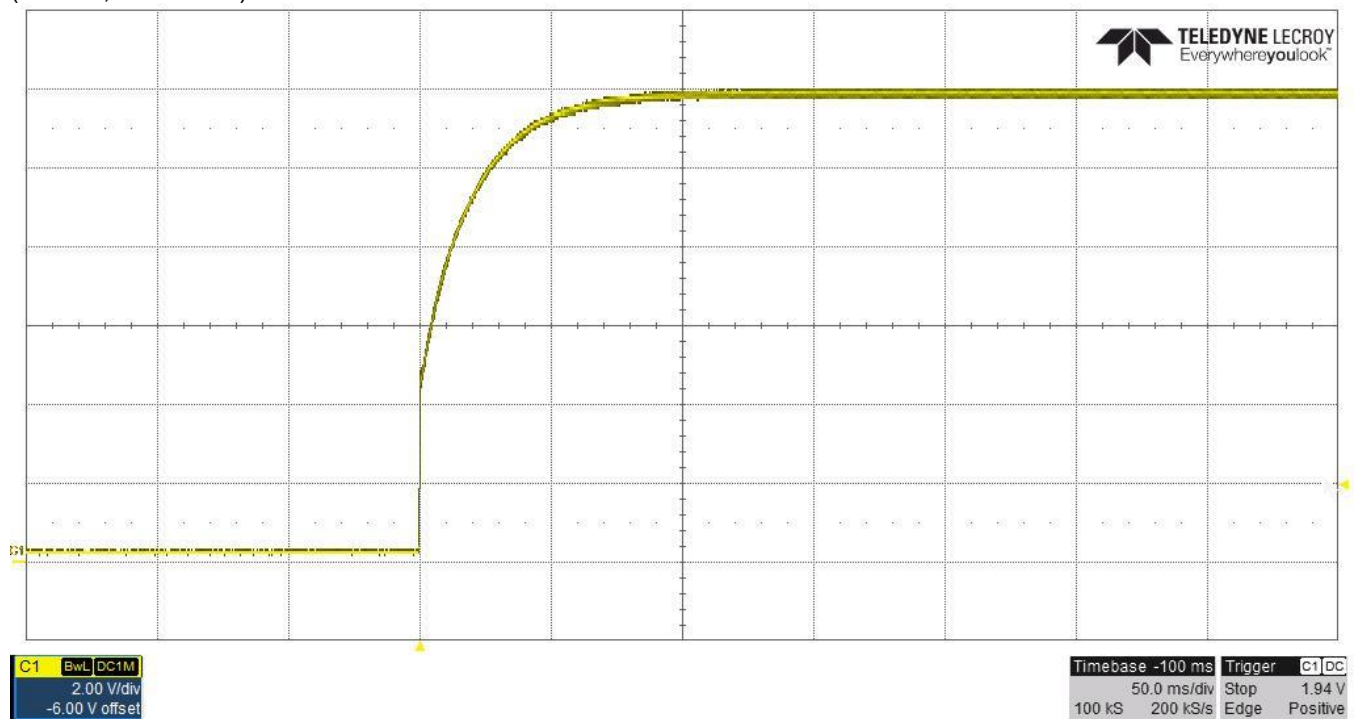
3.6 Loop Response

The photo below shows the Bode plot for 102V with a 12V output loaded to 8.3A.
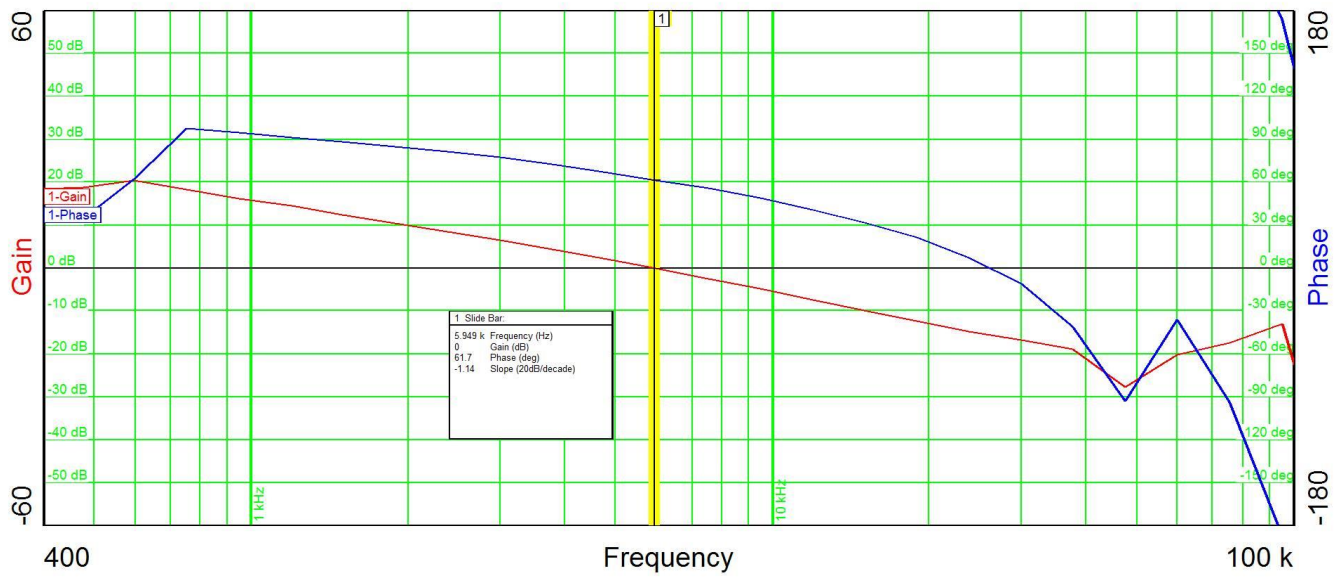
The photo below shows the Bode plot for 120V with a 12V output loaded to 8.3A.
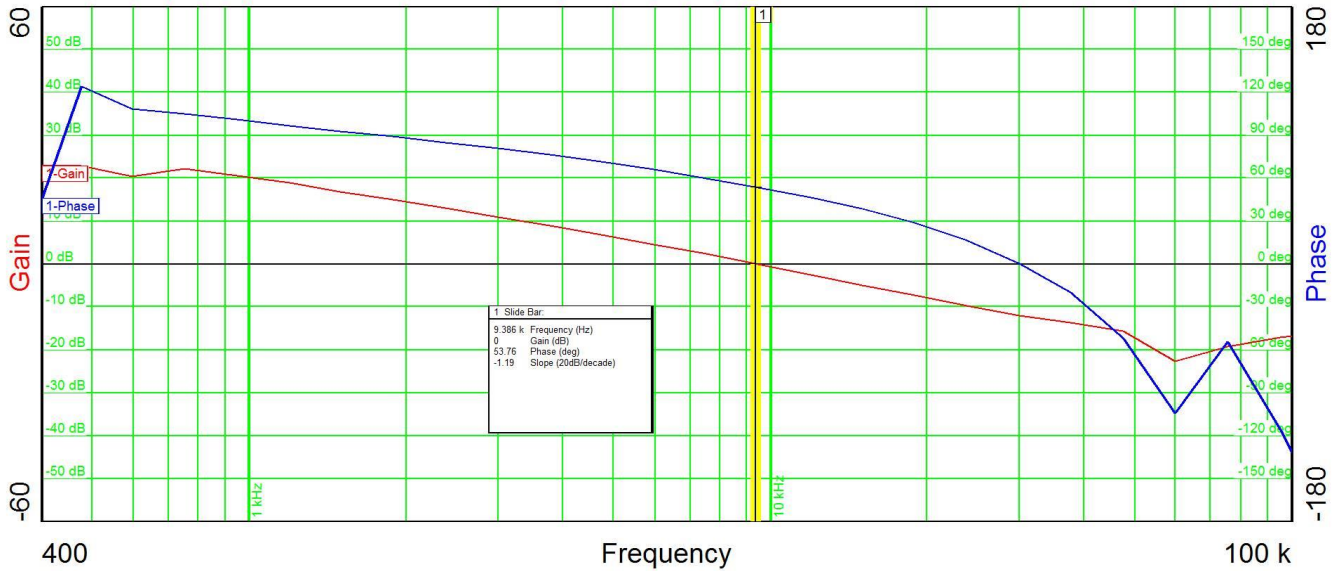
The photo below shows the Bode plot for 138V with a 12V output loaded to 8.3A.
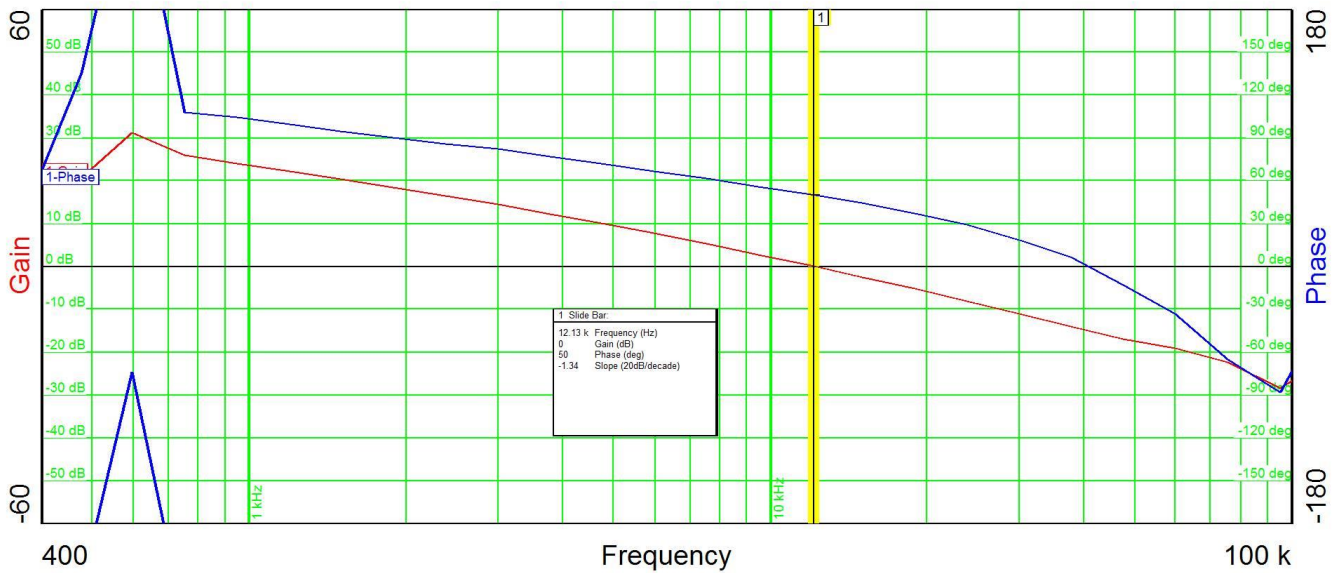
The photo below shows the Bode plot for 195V with a 12V output loaded to 8.3A.
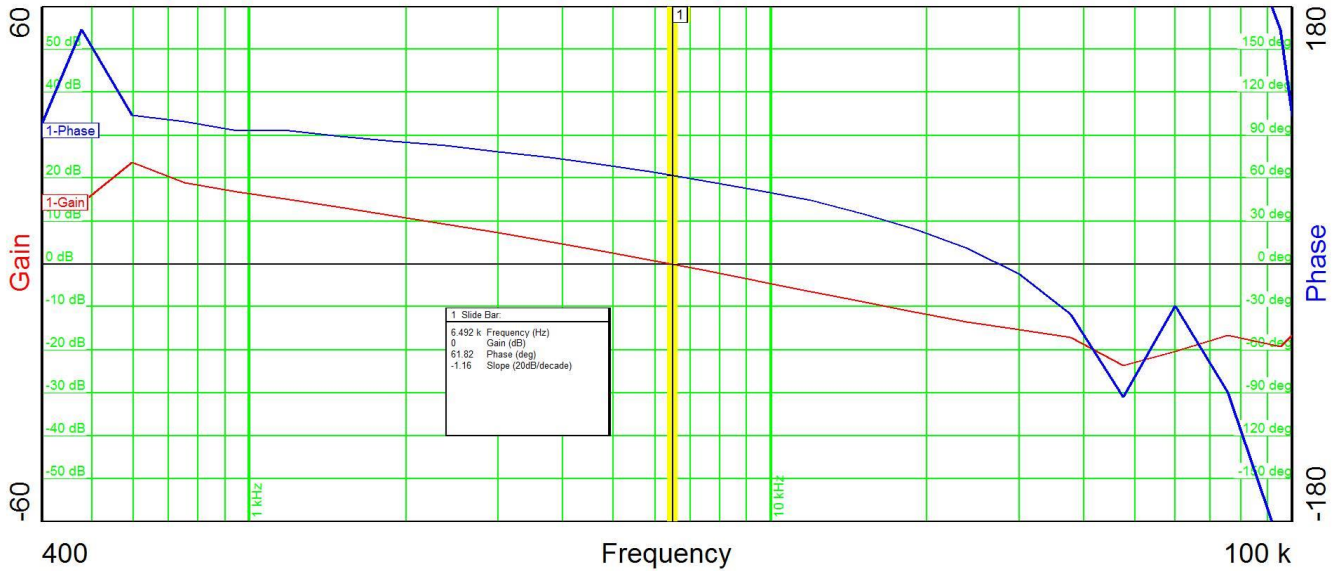
The photo below shows the Bode plot for 230V with a 12V output loaded to 8.3A.
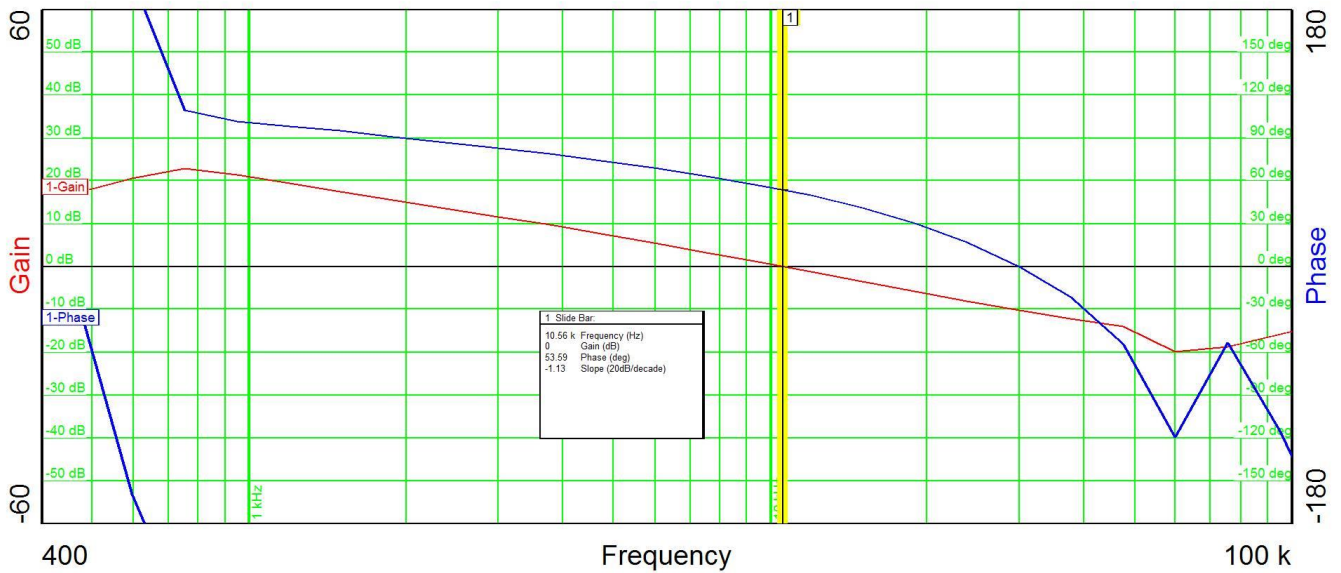
The photo below shows the Bode plot for 265V with a 12V output loaded to 8.3A.
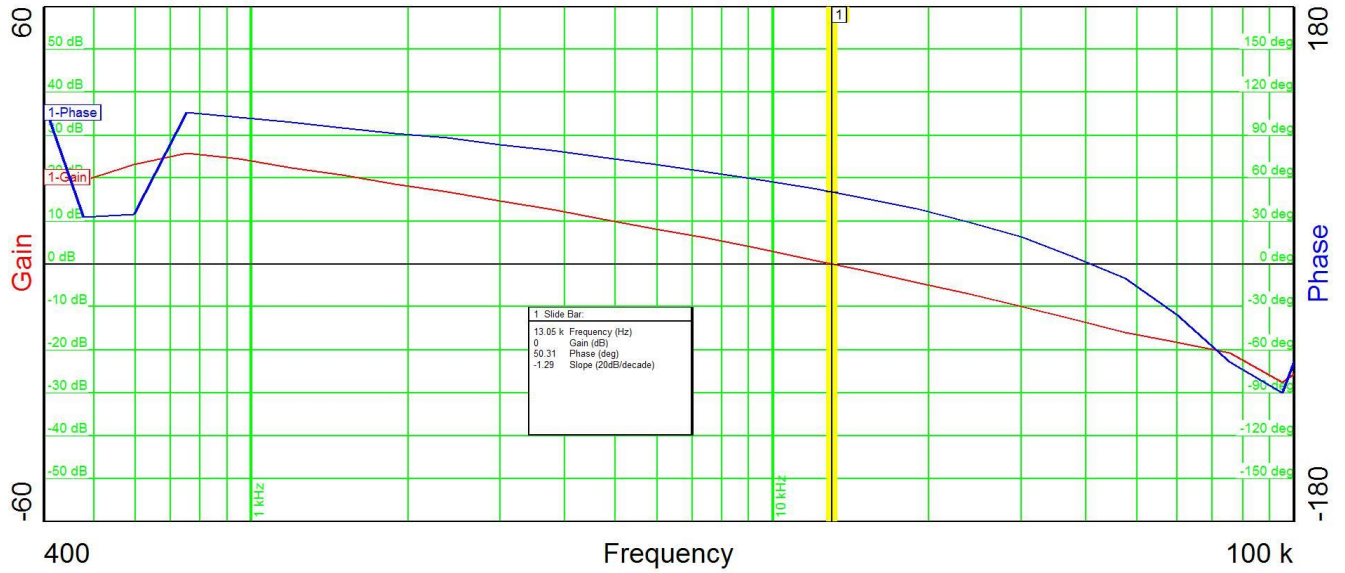
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