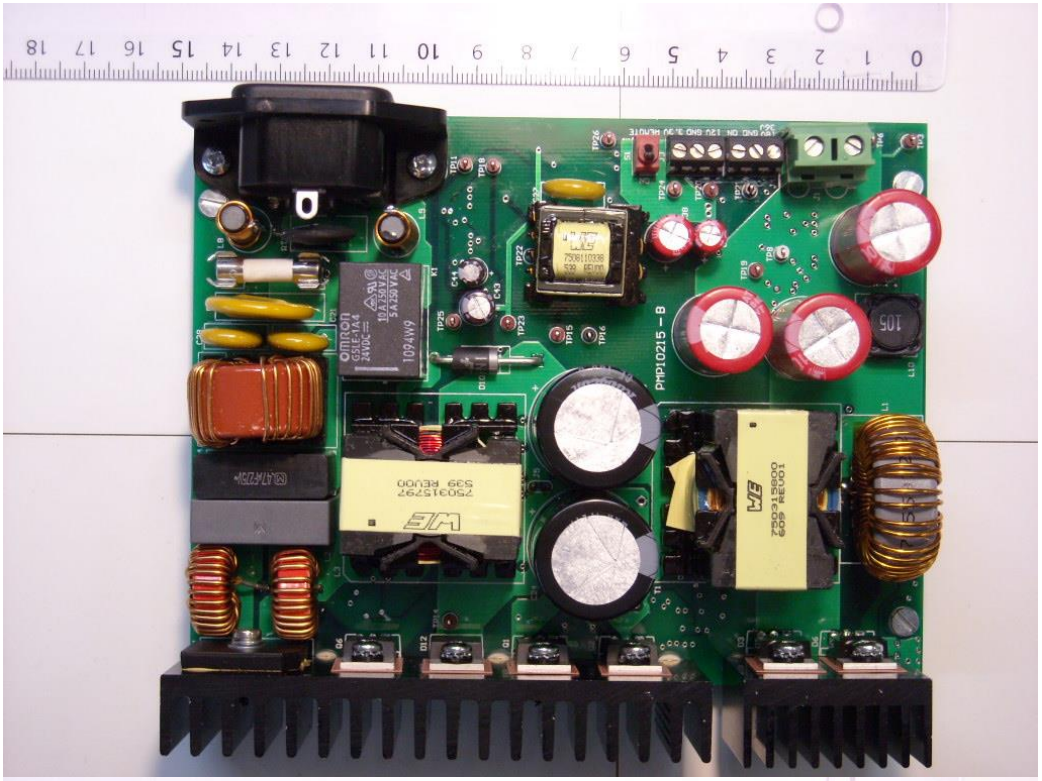
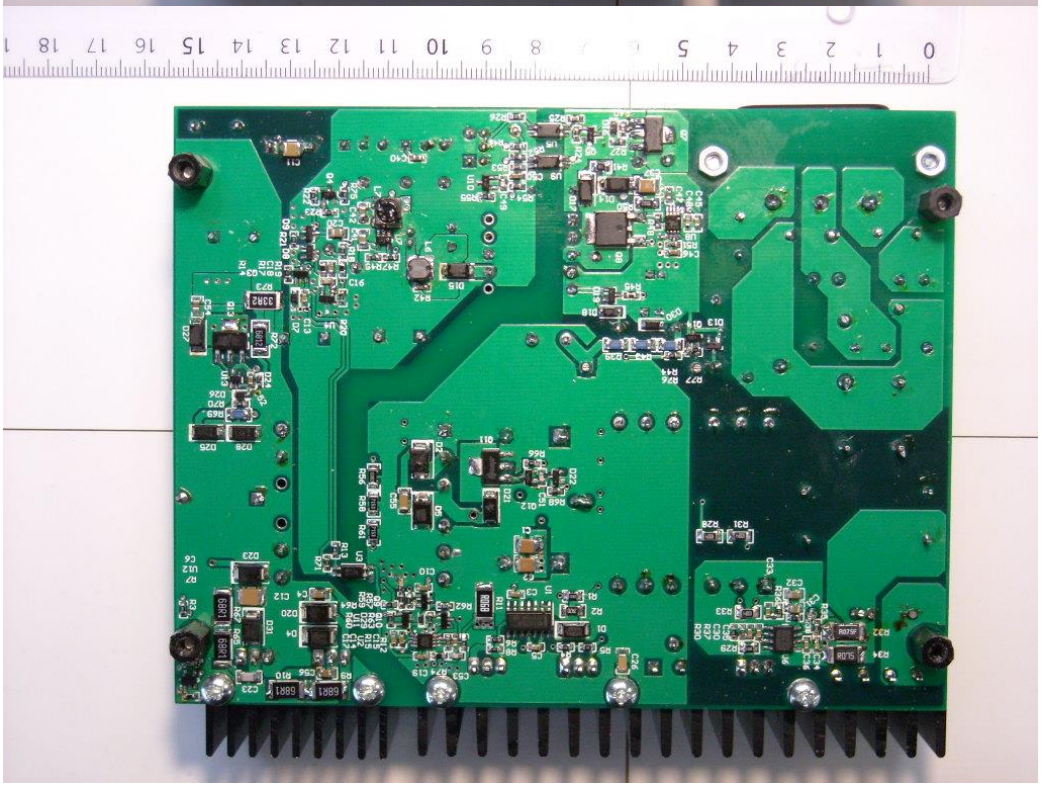
PHOTO OF THE PROTOTYPE

(The reference design PMP10215 Rev_D has been built on PMP10215 Rev_B PCB)

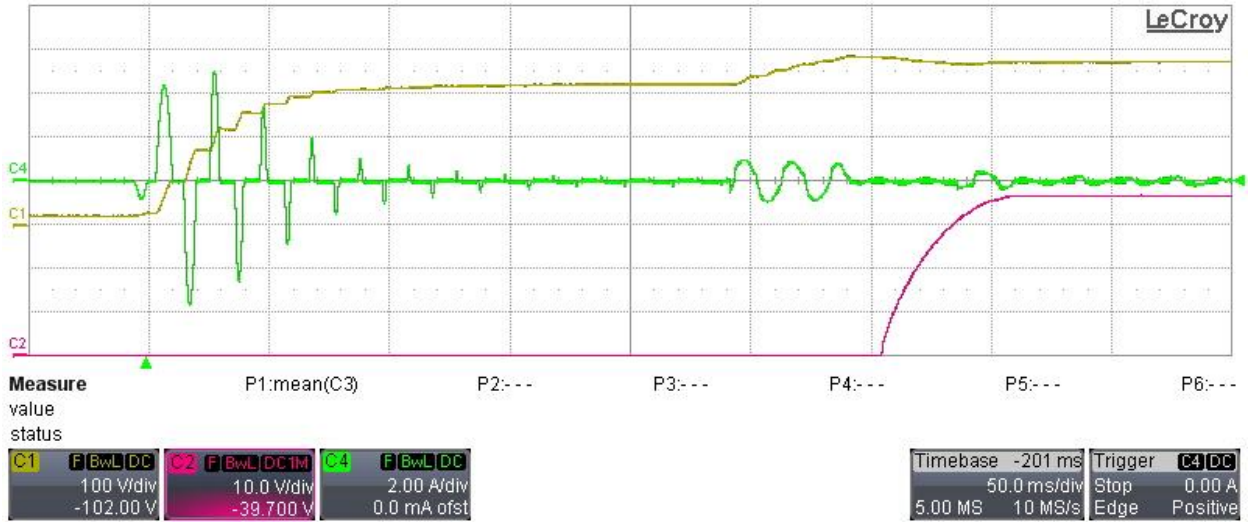




1 Startup behavior on PFC output voltage (TP15) and Vout

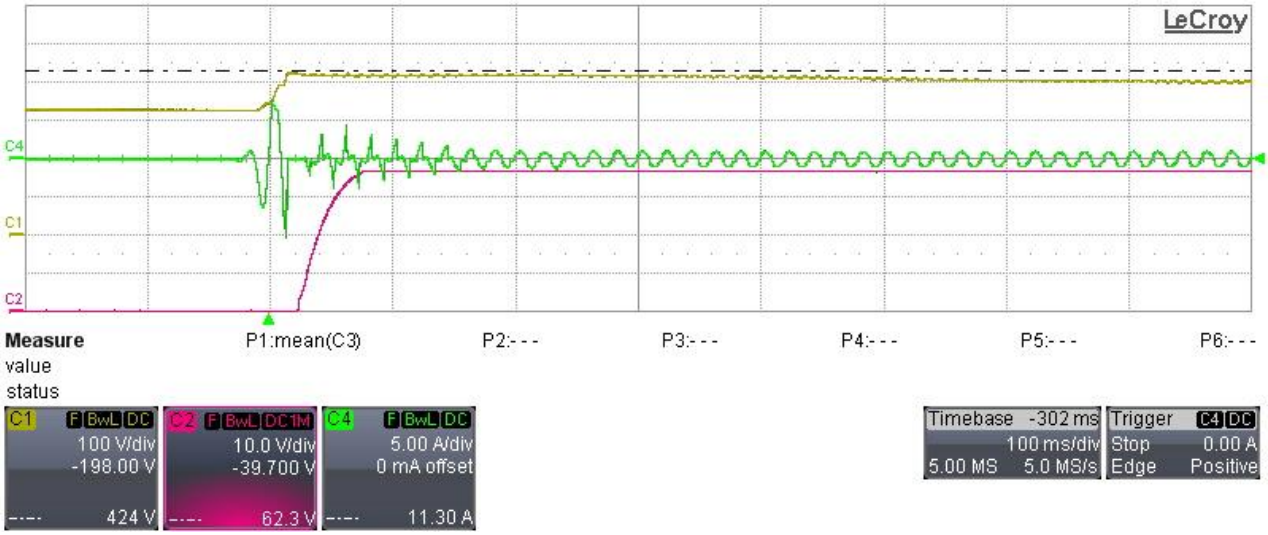
The behavior of the converter at startup is shown in the images below. The input voltage was set to 230Vac, 50Hz and all outputs unloaded (first image) and fully loaded (second image, 36Vout @ 4A). The AC voltage has been applied while switch S1 was ON.
The converter goes into short circuit protection if at startup the load is > 4A, therefore first switch the converter ON, then apply full load.

Ch1: PFC output voltage, TP15 (100V/div, 50ms/div), 20MHz BWL for all waveforms.
Ch2: Vout voltage, TP3 (10V/div)
Ch4: Input AC current (2A/div)
Vin = 230Vac, No load.

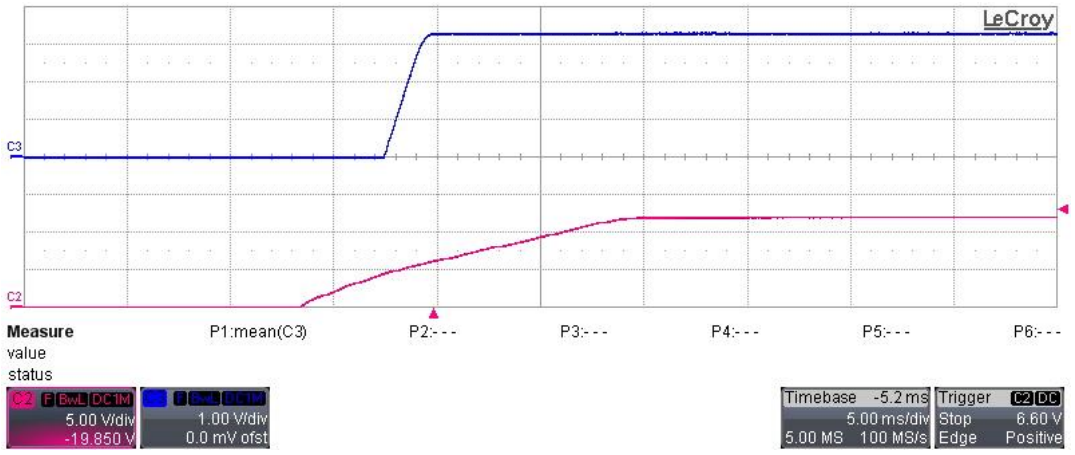


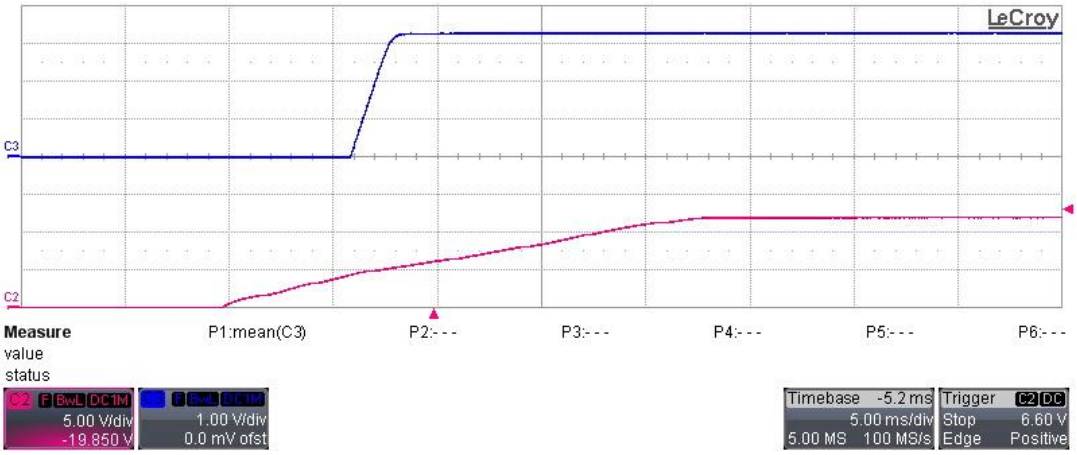
Vin = 230Vac, I36v = 4A, I12v = 300mA, I3v3 = 200mA

Restart after applying 230Vac with the sequence ON→OFF→ON (CH4 @ 5A/div)



The images below show how 12V and 3.3V outputs behave at startup; in top picture both outputs are unloaded and in the bottom one are fully loaded. The input voltage was set to 230Vac, 50Hz. Ch2: 12Vout, TP20 (5V/div, 5ms/div), 20MHz BWL, Ch3: 3.3Vout, TP24 (1V/div)

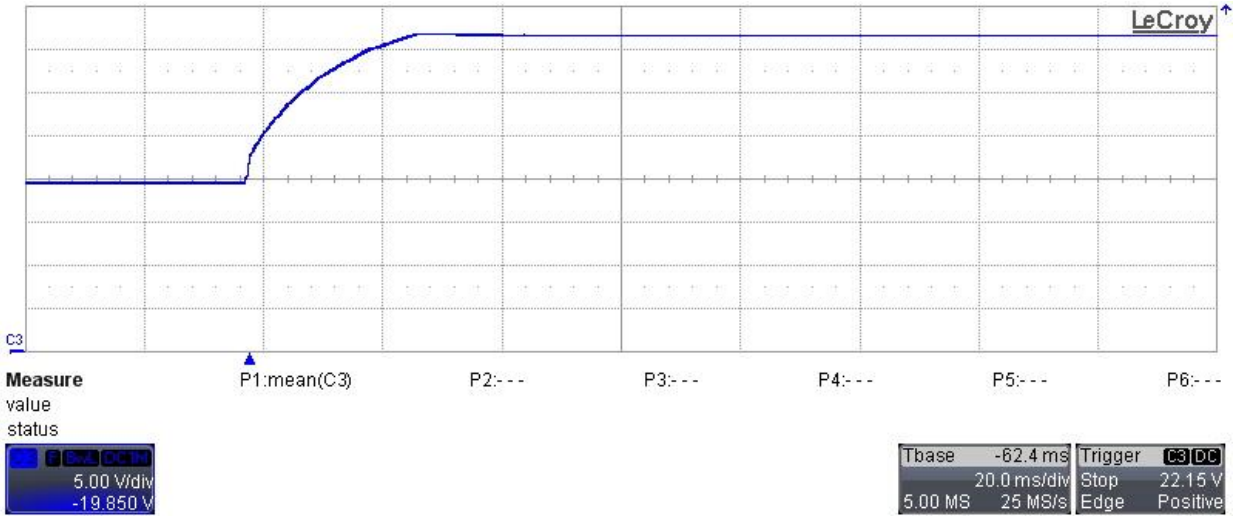




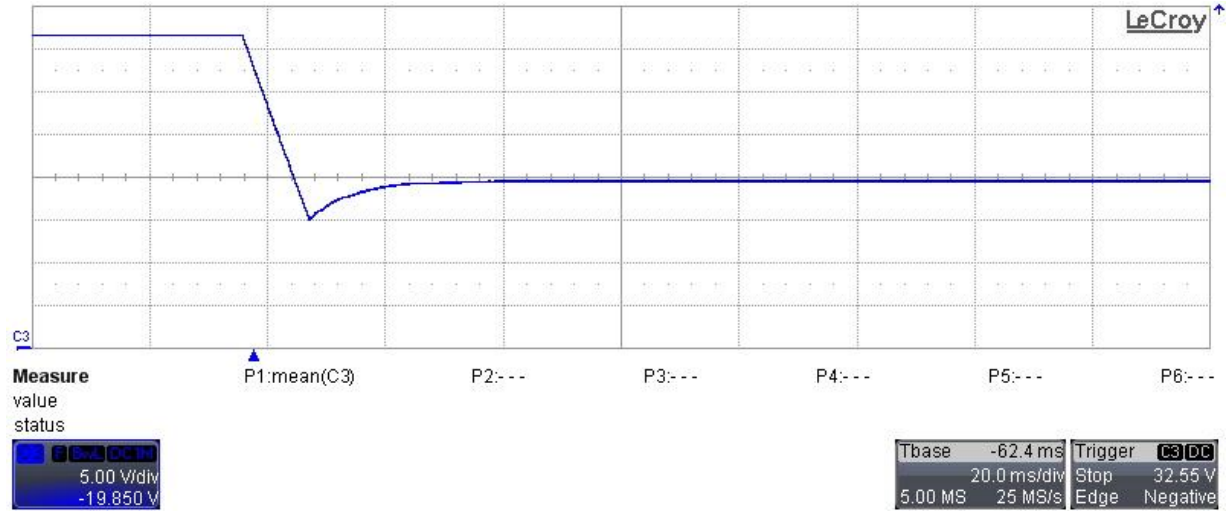
2 Output voltage switch between 19V and 36V

The main output voltage 36Vout can be switched between 19V and 36V by means of applying 3.3V on pin 1 of J4 (0V → 19Vout, 3.3V → 36Vout); in case of over-temperature protection (managed by U12, set to 80C, which measures H2 temperature), the voltage is reduced automatically.

Ch3: 36Vout, TP3 (5V/div, 20ms/div), **19V → 36V transition**

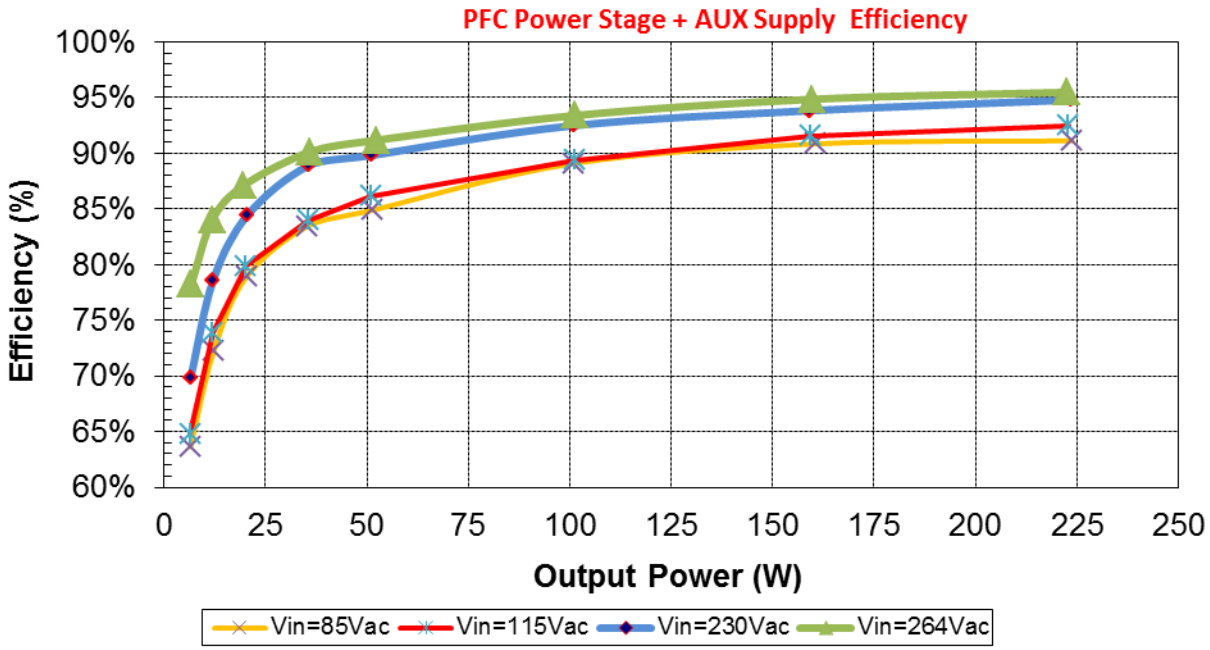


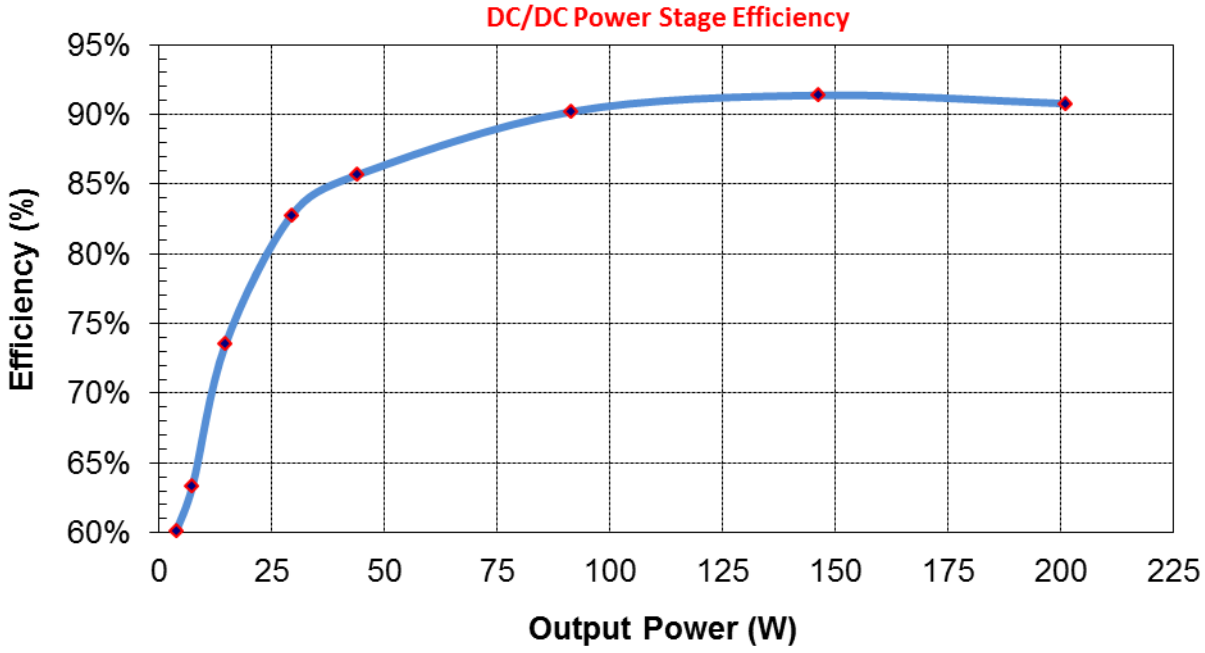
Ch3: 36Vout, TP3 (5V/div, 20ms/div), **36V → 19V transition**

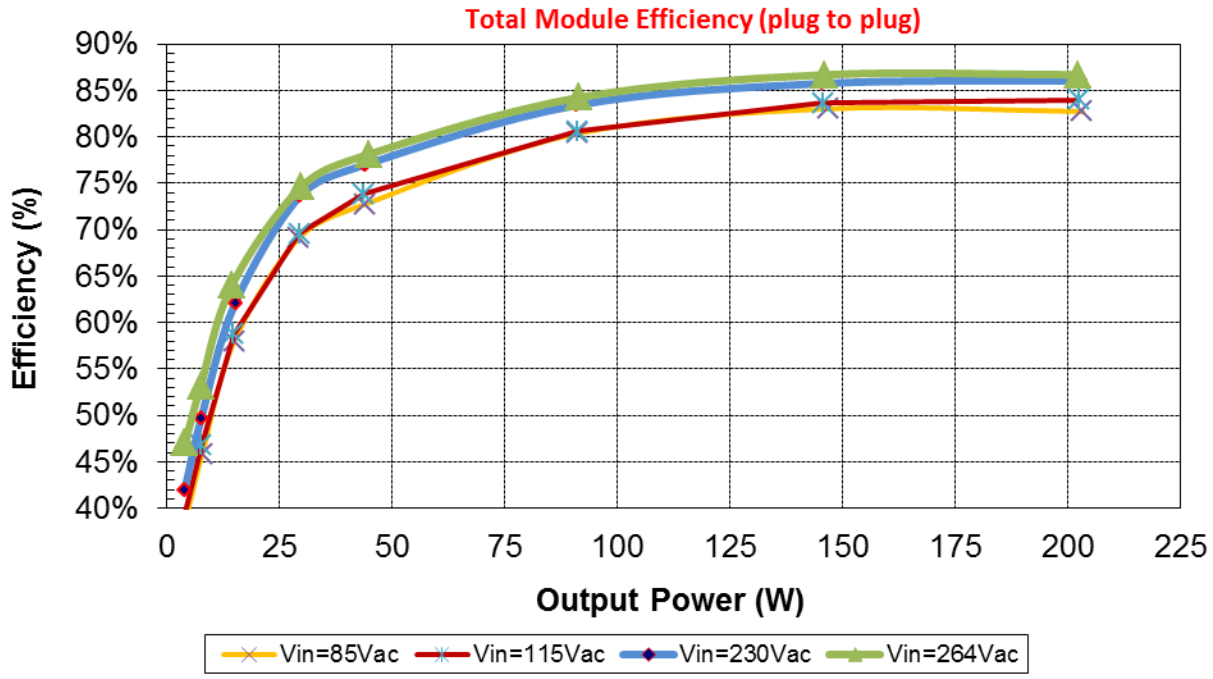


3 Efficiency

The efficiency data are shown in the tables and graphs below. The data show the PFC + AUX PSU efficiency, the DC/DC power stage (only) efficiency and the total plug-to-plug. The Auxiliary power supply was feeding only the housekeeping for this measurement.







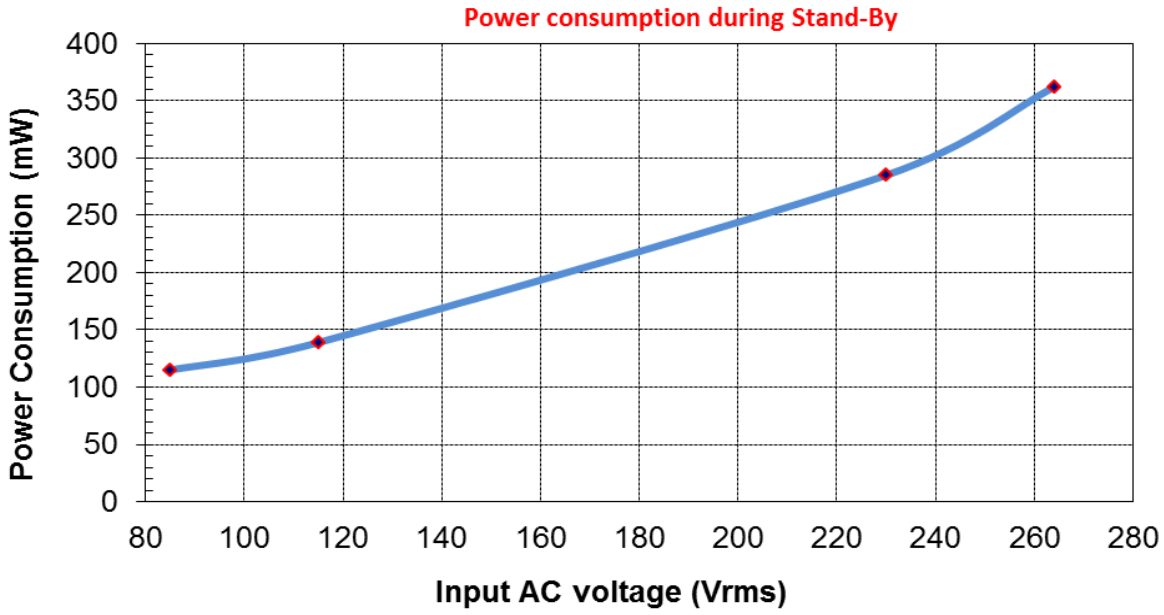
PFC Stage + AUX Supply, Vin = 85Vac, 60Hz									
Iout (mA)	Vout (V)	Pout (W)	Vin (V)	Pin (W)	PF	Eff_PFC (%)	Eff_DC (%)	Eff_Tot (%)	Pout_DC (W)
0.0	393.7	0.00	85	2.78	0	0.0%	0.0%	0.0%	0.0
16.5	393.7	6.50	85	10.21	94.7	63.6%	60.1%	38.2%	3.9
31.3	393.7	12.32	85	17.04	97.9	72.3%	63.3%	45.8%	7.8
51.6	393.7	20.31	85	25.75	98.4	78.9%	73.5%	58.0%	14.9
90.0	393.8	35.44	85	42.47	99.2	83.5%	82.8%	69.1%	29.3
130.4	393.8	51.35	85	60.49	99.7	84.9%	85.7%	72.8%	44.0
256.6	394.0	101.10	85	113.48	99.8	89.1%	90.2%	80.4%	91.2
407.2	394.2	160.52	85	176.7	99.9	90.8%	91.4%	83.0%	146.7
567.4	394.4	223.78	85	245.6	99.9	91.1%	90.8%	82.7%	203.2

PFC Stage + AUX Supply, Vin = 115Vac, 60Hz									
Iout (mA)	Vout (V)	Pout (W)	Vin (V)	Pin (W)	PF	Eff_PFC (%)	Eff_DC (%)	Eff_Tot (%)	Pout_DC (W)
0.0	393.2	0.00	115	2.92	0	0.0%	0.0%	0.0%	0.0
16.6	393.2	6.53	115	10.07	87.9	64.8%	60.1%	39.0%	3.9
30.7	393.2	12.07	115	16.33	94.4	73.9%	63.3%	46.8%	7.6
51.4	393.3	20.22	115	25.31	96.5	79.9%	73.5%	58.7%	14.9
90.3	393.3	35.51	115	42.29	97.9	84.0%	82.8%	69.5%	29.4
129.8	393.3	51.05	115	59.25	98.5	86.2%	85.7%	73.8%	43.8
257.2	393.4	101.18	115	113.22	99.7	89.4%	90.2%	80.6%	91.3
404.7	393.6	159.29	115	174.0	99.8	91.5%	91.4%	83.7%	145.6
566.2	393.8	222.97	115	241.1	99.9	92.5%	90.8%	84.0%	202.5

PFC Stage + AUX Supply, Vin = 23Vac, 50Hz									
Iout (mA)	Vout (V)	Pout (W)	Vin (V)	Pin (W)	PF	Eff_PFC (%)	Eff_DC (%)	Eff_Tot (%)	Pout_DC (W)
0.0	393.3	0.00	230	1.38	0	0.0%	0.0%	0.0%	0.0
16.7	393.3	6.57	230	9.40	58.0	69.9%	60.1%	42.0%	3.9
30.7	393.3	12.07	230	15.37	73.2	78.6%	63.3%	49.7%	7.6
52.4	393.3	20.61	230	24.40	82.3	84.5%	73.5%	62.1%	15.1
90.7	393.3	35.67	230	40.13	90.9	88.9%	82.8%	73.6%	29.5
130.1	393.5	51.19	230	57.00	92.1	89.8%	85.7%	77.0%	43.9
256.3	393.5	100.85	230	109.06	96.3	92.5%	90.2%	83.4%	91.0
404.5	393.6	159.21	230	169.7	98.2	93.8%	91.4%	85.8%	145.5
567.7	393.7	223.50	230	235.8	99.1	94.8%	90.8%	86.1%	202.9

PFC Stage + AUX Supply, Vin = 264Vac, 50Hz									
Iout (mA)	Vout (V)	Pout (W)	Vin (V)	Pin (W)	PF	Eff_PFC (%)	Eff_DC (%)	Eff_Tot (%)	Pout_DC (W)
0.0	393.4	0.00	264	1.34	0	0.0%	0.0%	0.0%	0.0
17.1	393.4	6.73	264	8.60	42.3	78.2%	60.1%	47.0%	4.0
30.1	393.4	11.84	264	14.10	58.4	84.0%	63.3%	53.2%	7.5
49.8	393.5	19.60	264	22.50	76.2	87.1%	73.5%	64.0%	14.4
91.7	393.5	36.08	264	40.03	86.8	90.1%	82.8%	74.6%	29.9
133.2	393.6	52.43	264	57.50	90.6	91.2%	85.7%	78.1%	44.9
257.7	393.6	101.43	264	108.60	94.9	93.4%	90.2%	84.2%	91.5
405.7	393.7	159.72	264	168.4	97.4	94.8%	91.4%	86.7%	146.0
565.5	393.7	222.64	264	233.2	98.6	95.5%	90.8%	86.7%	202.2

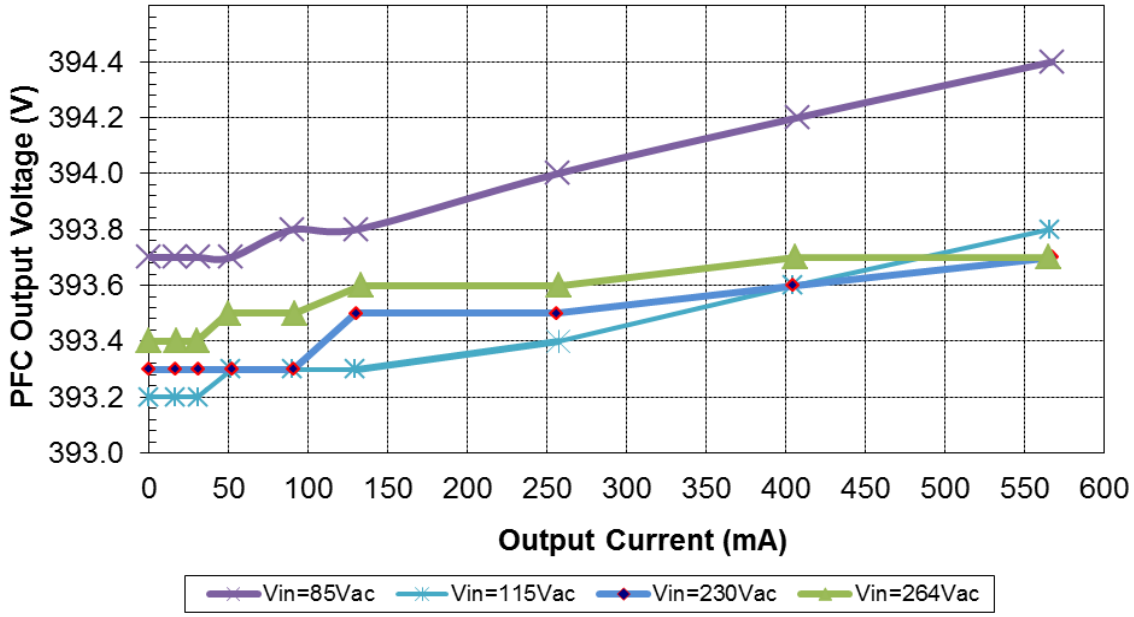
The converter has been switched OFF by S1 and the stand-by losses measured (3.3Vout and 12Vout are always ON, but unloaded). Four input AC voltages have been selected.



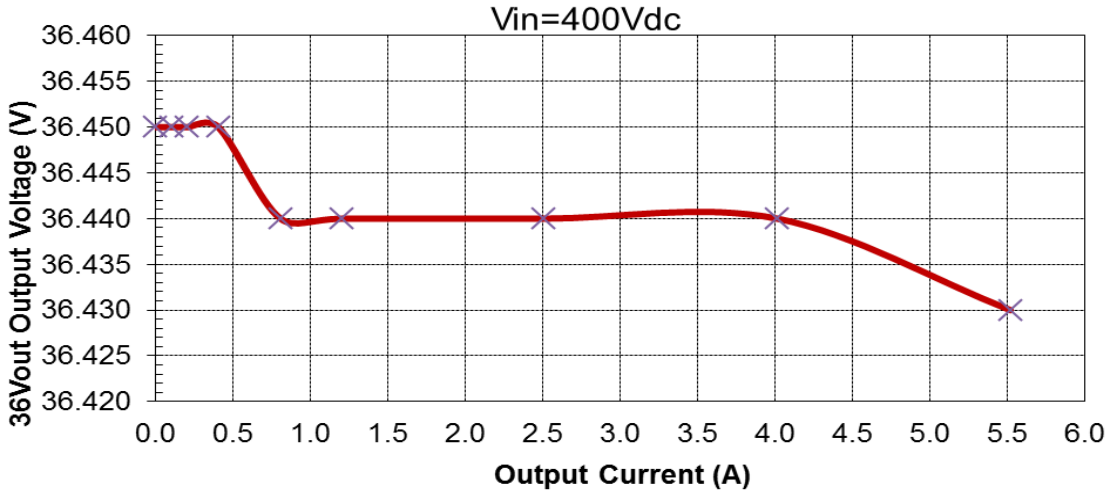
4 Output voltage regulation (PFC and 36Vout) vs. load

The graphs below show the static variation of output voltage versus load regarding PFC output (top picture, taken at different input AC voltages) and 36V output (taken at 400Vdc, which is the DC/DC input voltage).

PFC output voltage vs. load and Vin_AC:

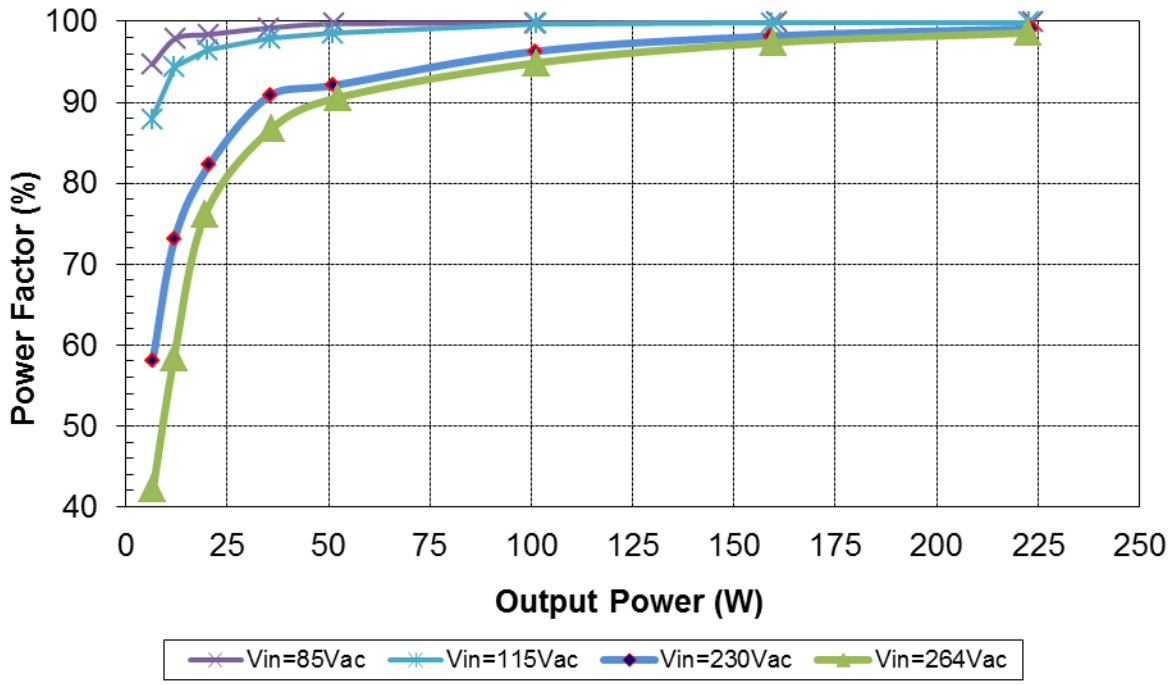


Main output voltage (TP3) vs. load:



5 Power factor

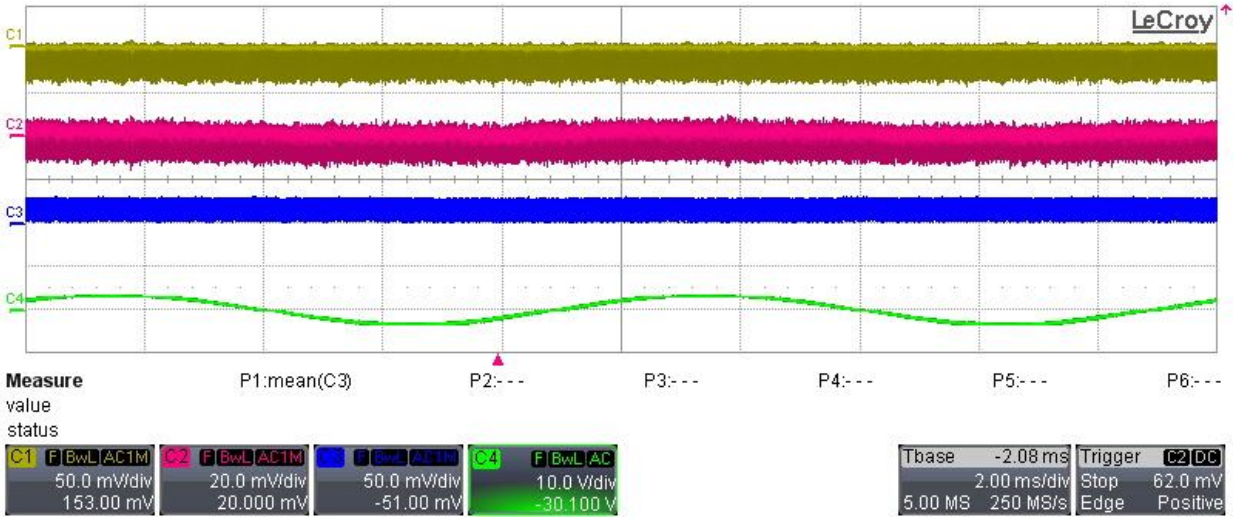
The Power Factor graph versus Vin and main output current is shown below (same loads condition of the efficiency tables):



6 Output ripple voltage

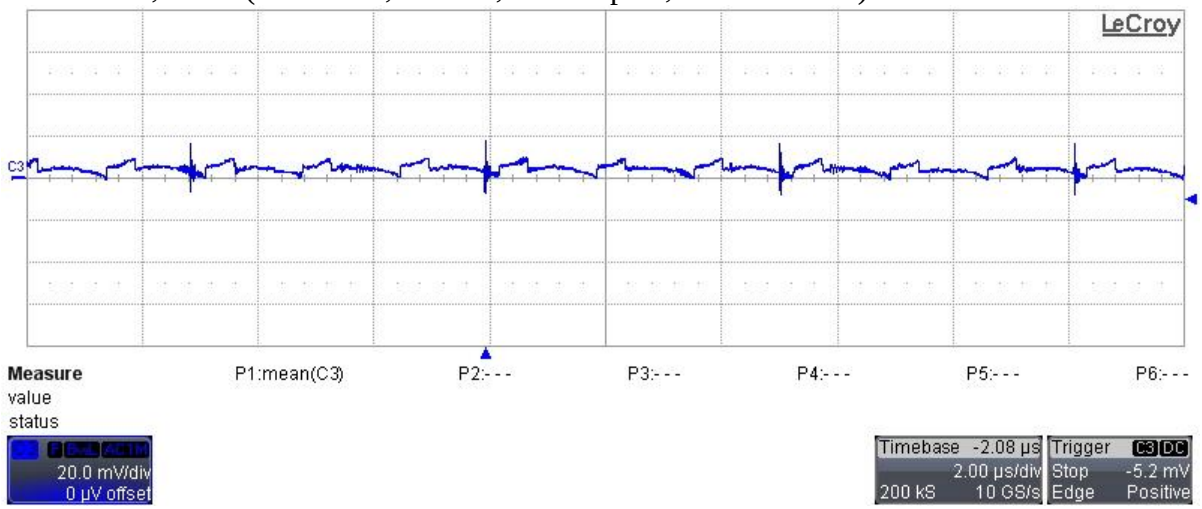
The output ripple voltages for all outputs are shown in the plot below. The input was set to 230Vac, 50Hz and all outputs fully loaded (Iout(36Vout) = 5.5A).

Ch1: 3.3Vout, TP24 (50mV/div), Ch2: 12Vout, TP20 (20mV/div)
Ch3: 36Vout, TP3 (50mV/div, Ch4: PFC output voltage, TP15 (10V/div)
All waveforms: 2ms/div, AC coupled, 20MHz BWL

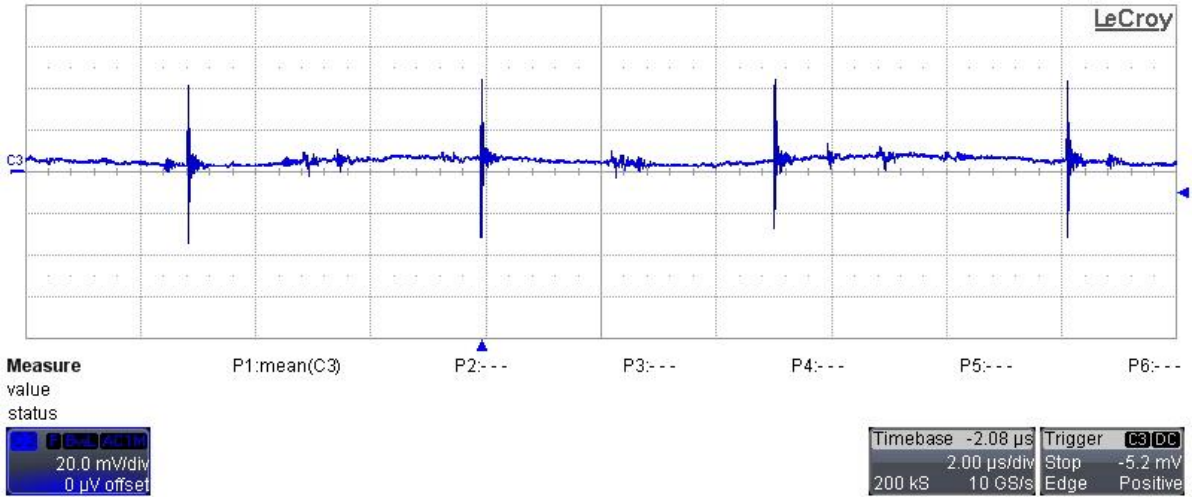


Single outputs ripple voltages (@ full load, Vin = 230Vac):

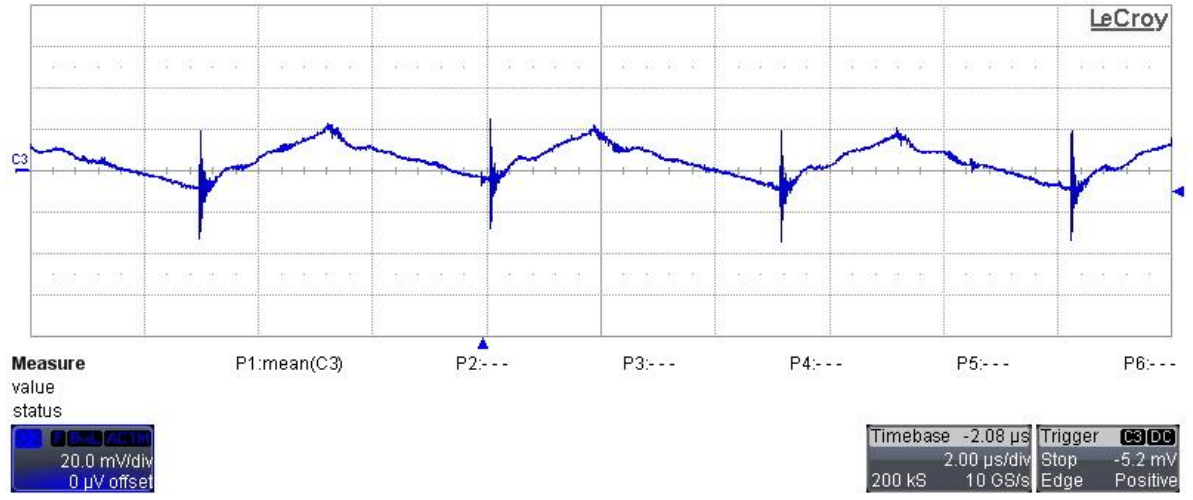
Ch3: 3.3Vout, TP24 (20mV/div, 2us/div, AC coupled, 20MHz BWL)



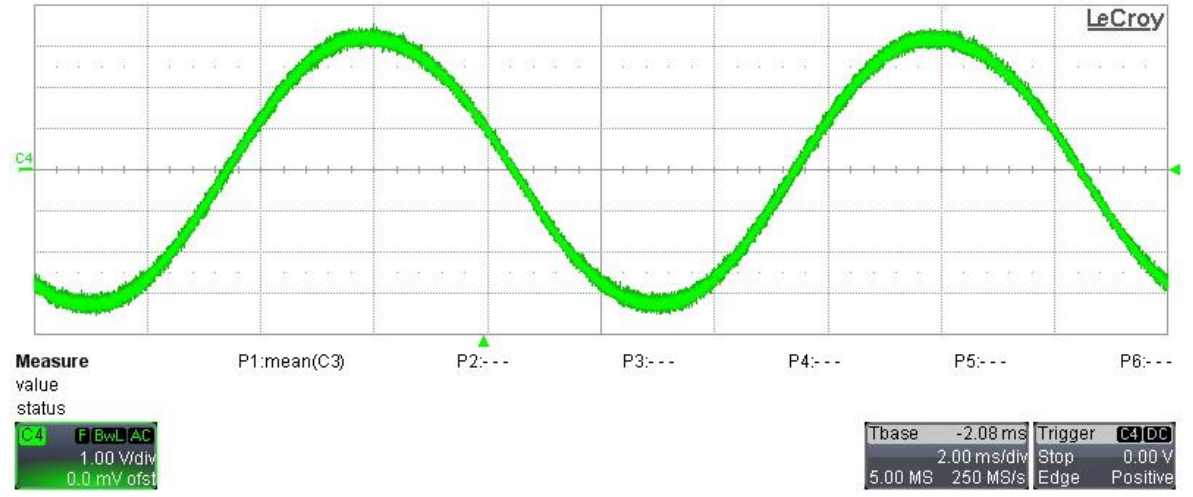
Ch3: 12Vout, TP20 (20mV/div, 2us/div, AC coupled, 20MHz BWL)



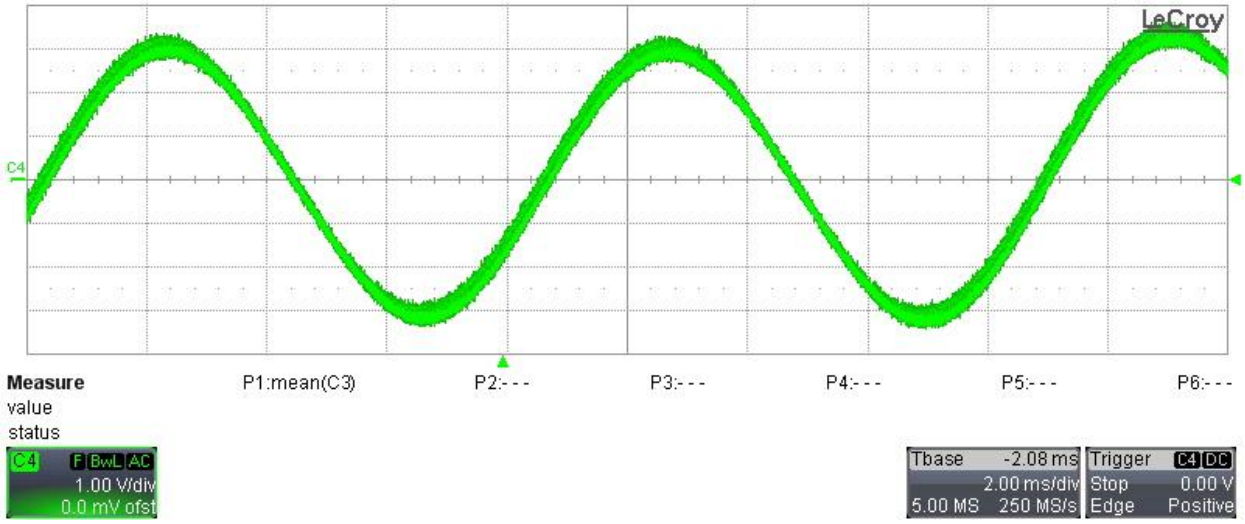
Ch3: 36Vout, TP3 (20mV/div, 2us/div, AC coupled, 20MHz BWL)



Ch4: PFC output voltage, TP15 (1V/div, 2ms/div, AC coupled, 20MHz BWL)



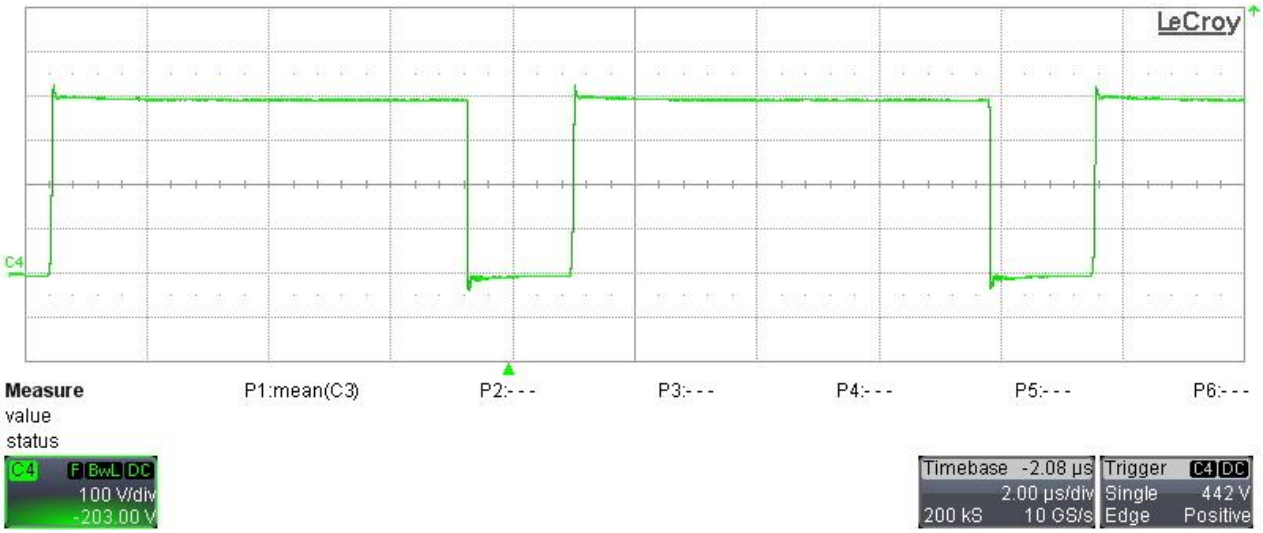
Ch4: PFC output voltage, TP15 (1V/div, 2ms/div, AC coupled, 20MHz BWL) @ 85Vac, 60Hz



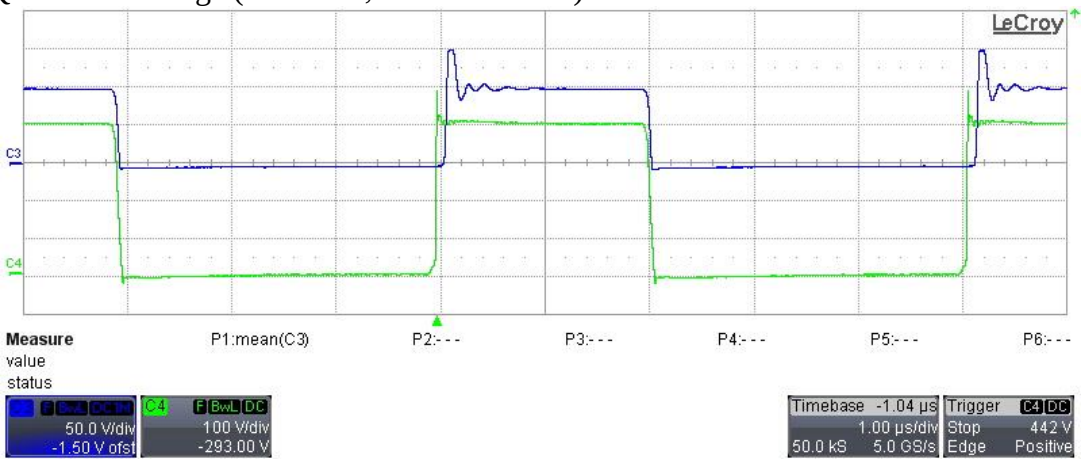
7 Switching Node Waveforms

The image below shows the PFC Boost switch node (Drain of Q6) at full load (225W) and Vin = 230Vac, 50Hz.

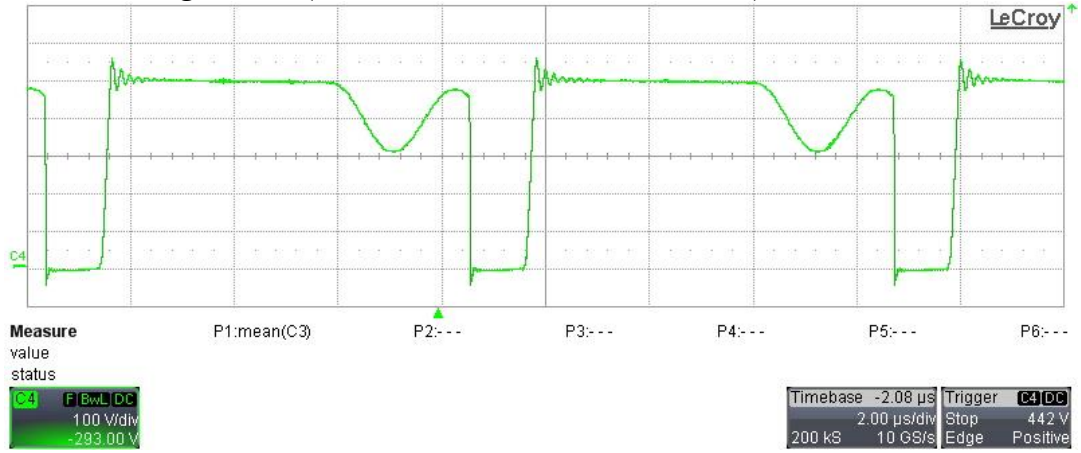
Ch4: Q6 Drain voltage, TP14 (100V/div, 2us/div, 200MHz BWL)



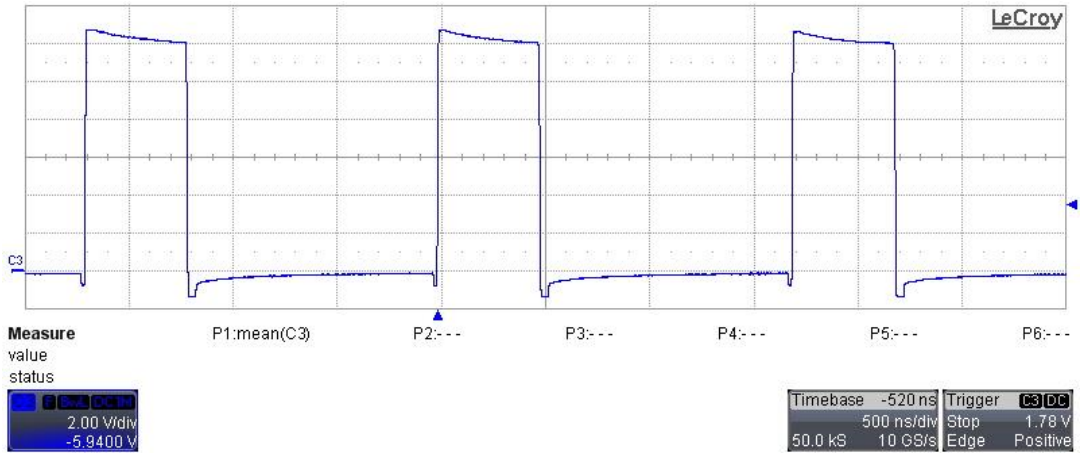
Two-switch forward waveforms, Vin = 230Vac, I36v = 5.5A:
Ch3: D6 Cathode voltage (50V/div, 1us/div, 200MHz BWL)
Ch4: Q1 Source voltage (100V/div, 200MHz BWL)



Auxiliary PSU switch-node, Vin = 230Vac, both outputs fully loaded:
Ch4: Q8 Drain voltage, TP22 (100V/div, 2us/div, 200MHz BWL)



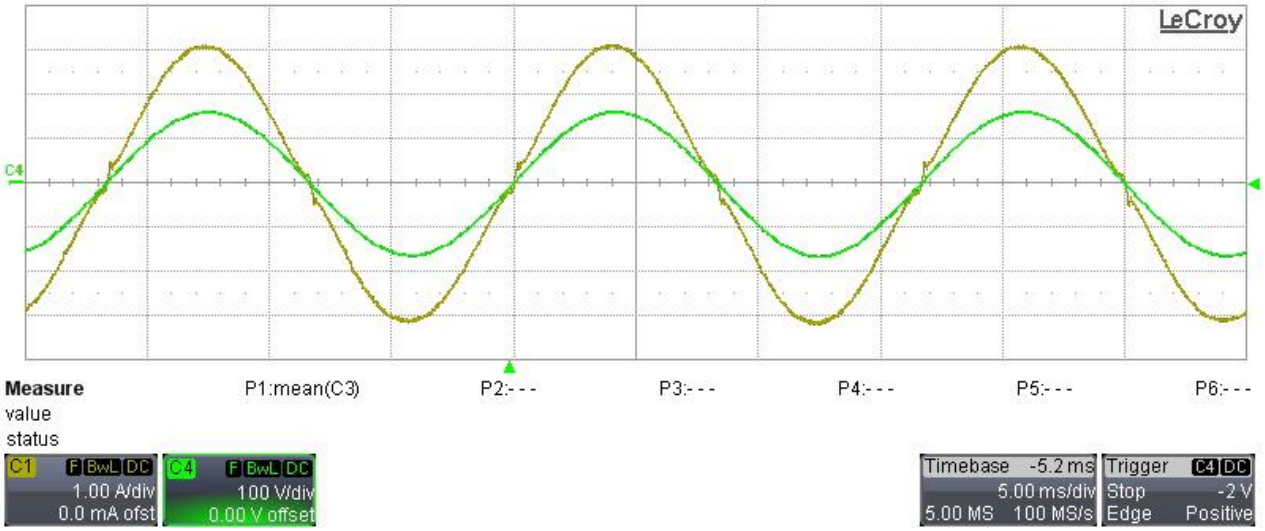
Buck switch-node, Vin = 230Vac, fully loaded:
Ch3: “PH” pin 3 voltage, (2V/div, 500ns/div, 200MHz BWL)



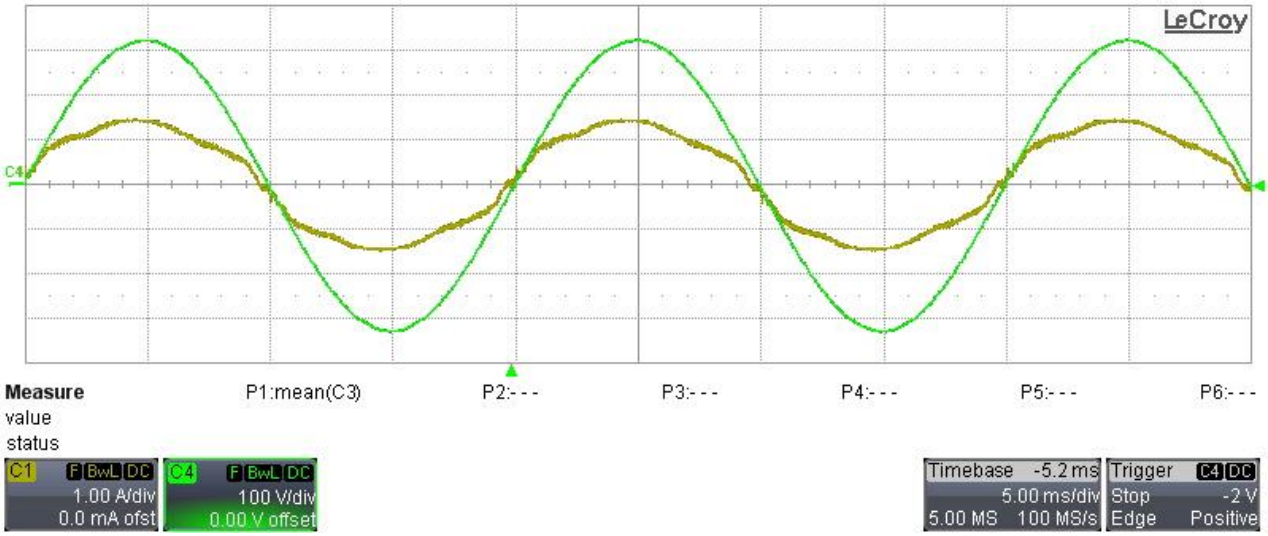
8 Input voltage and current waveforms

The images below show the input voltage and current waveforms while the source was set respectively to 115Vac, 60Hz and 230Vac, 50Hz. The main 36V output voltage was loaded at 5.5A while 12V and 3.3V were fully loaded.

Ch1: Input Current (1A/div, 5ms/div, 20MHz BWL)
Ch4: Input AC Voltage (100V/div, 20MHz BWL)
Vin = 115Vac, 60Hz

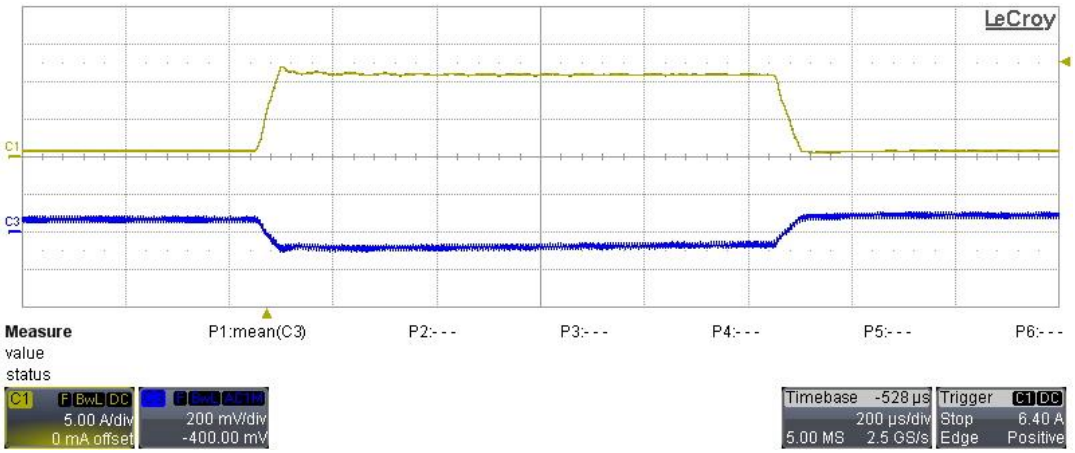


Ch1: Input Current (1A/div, 5ms/div, 20MHz BWL)
Ch4: Input AC Voltage (100V/div, 20MHz BWL)
Vin = 230Vac, 50Hz



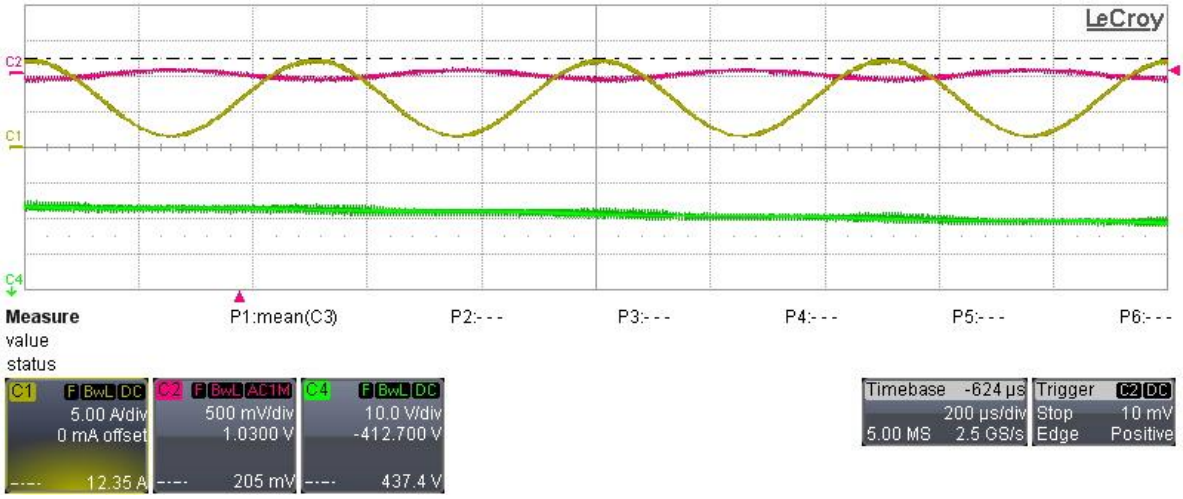
9 Transient response

The graph below shows the responses of the main output (36Vout) during output current variation between 1A and 11A, measured at 230Vac input.
Ch1: Output current (5A/div, 200us/div, DC coupling, 20MHz BWL)
Ch3: Output voltage (200mV/div, AC coupling, 20MHz BWL)

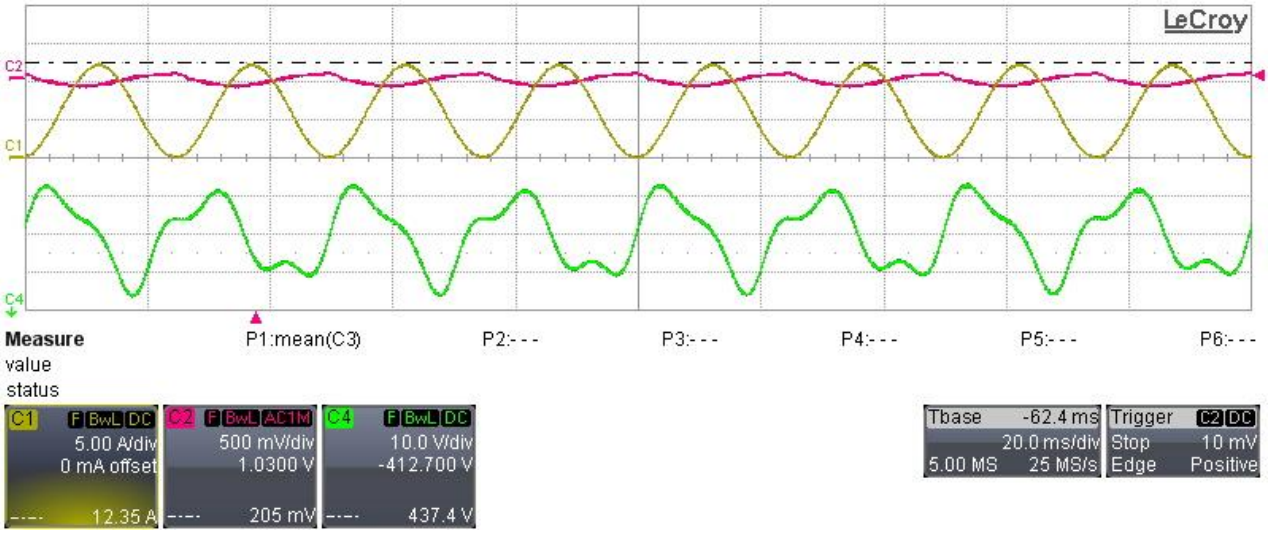


10 Tests with TPA3251D2 Class-D audio amplifier EVM

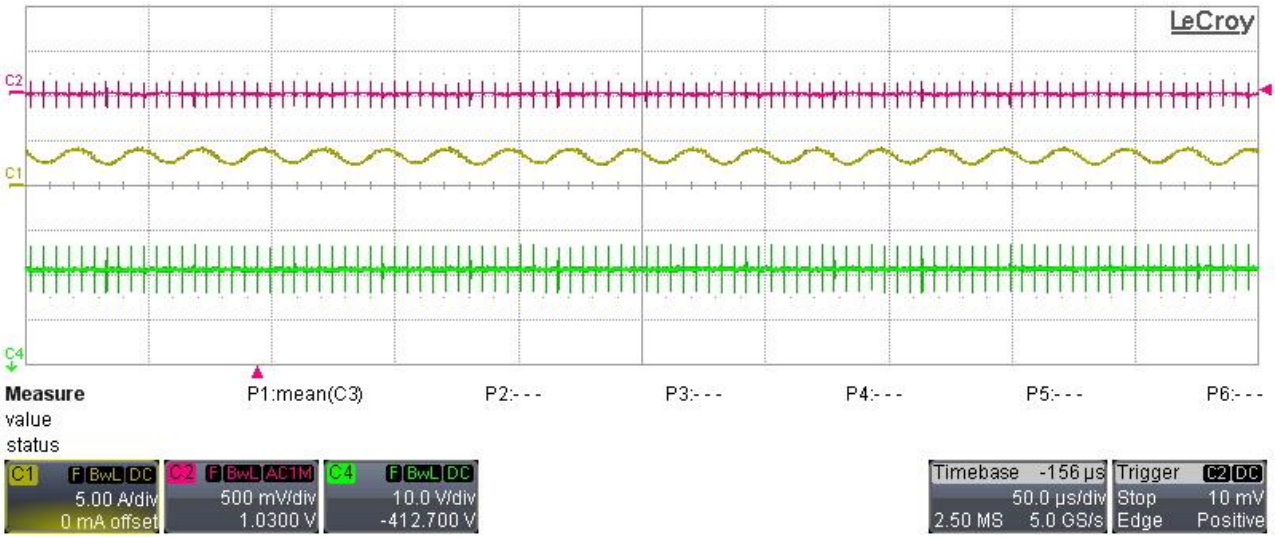
The power supply has been connected to a TPA3251D2 EVM and the voltage set to 36V.
The input AC voltage has been set to 230Vac, 50Hz and a sinusoidal signal has been applied on both inputs of the audio EVM, which has been set to work in stereo mode.
The frequency of the waveform (Fin) has been set to 20 Hz, 1 KHz and 20 KHz. The signal has been applied and the amplitude increased until clipping ("CLIP" LED) turned ON. The 36Vout voltage, 400V PFC output voltage and EVM input current have been captured by scope. The pictures below show these measurements.
Ch1: Power supply output current (5A/div, **200us/div**, DC coupling, 20MHz BWL)
Ch2: Power supply output voltage (500mV/div, AC coupling, 20MHz BWL)
Ch3: PFC output voltage (10V/div, DC coupling, 20MHz BWL, -412V offset), **Fin = 1 KHz**



Ch1: Power supply output current (5A/div, **20ms/div**, DC coupling, 20MHz BWL)
Ch2: Power supply output voltage (500mV/div, AC coupling, 20MHz BWL)
Ch3: PFC output voltage (10V/div, DC coupling, 20MHz BWL, -412V offset), **Fin = 20 Hz**

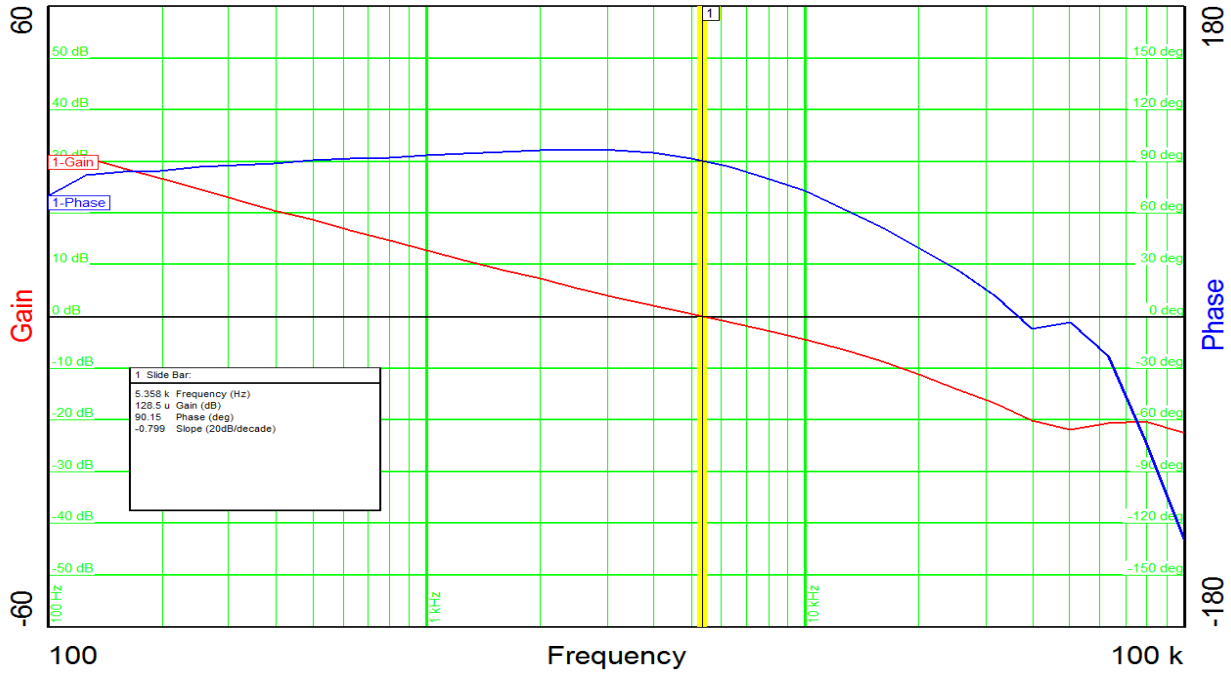


Ch1: Power supply output current (5A/div, **50us/div**, DC coupling, 20MHz BWL)
Ch2: Power supply output voltage (500mV/div, AC coupling, 20MHz BWL)
Ch3: PFC output voltage (10V/div, DC coupling, 20MHz BWL, -412V offset), **Fin = 20 KHz**

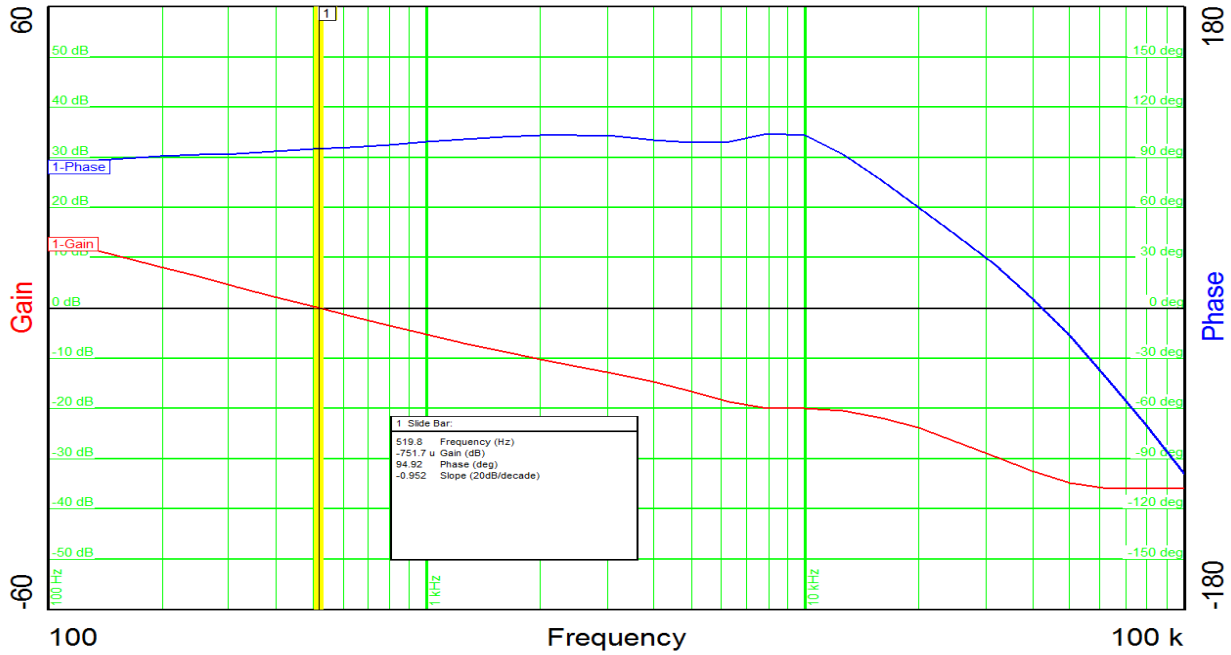


11 Loop Response

The graphs below show the bode plots of main DC/DC converter (36Vout) and auxiliary PSU (12Vout) when respectively loaded @ 5.5A and 300mA. The input voltage was always 230Vac.
36Vout loop (TP3, TP6, TP8): Fco = 5.358 KHz, PM = 90.15 deg, GM = 18.8dB.

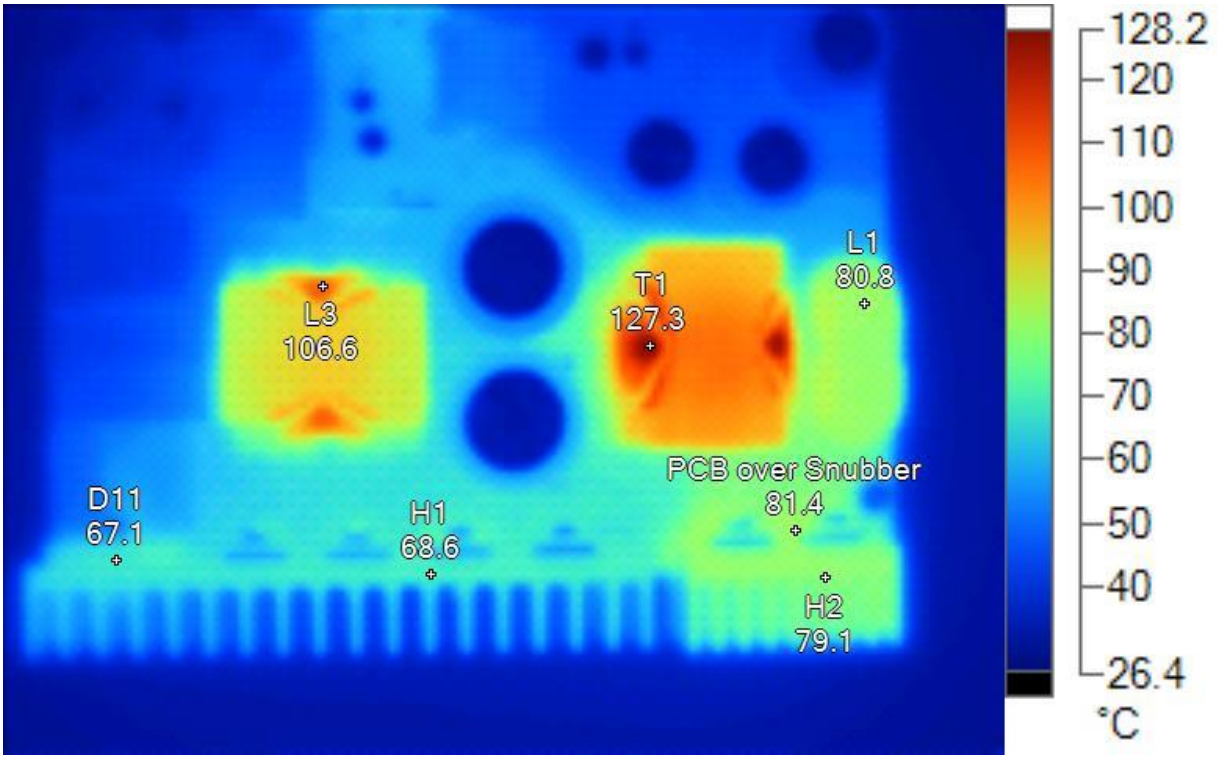


12Vout loop (TP19, TP21, TP26): Fco = 519.8 Hz, PM = 94.92 deg, GM = 33.19dB.



12 Thermal analysis

The thermal image has been taken after half hour in steady state condition and when the board was placed horizontally on the bench without any forced convection. The ambient temperature was 23C; the 36Vout load was 5.5A while 12V and 3.3V were fully loaded. The input voltage was 230Vac, 50Hz.



IR20160311_0722.is2
3/11/2016 5:16:52 PM

Main Image Markers

Name	Temperature	Emissivity	Background
T1	127.3°C	0.95	23.0°C
L3	106.6°C	0.95	23.0°C
H2	79.1°C	0.95	23.0°C
L1	80.8°C	0.95	23.0°C
D11	67.1°C	0.95	23.0°C
H1	68.6°C	0.95	23.0°C
PCB over Snubber	81.4°C	0.95	23.0°C

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