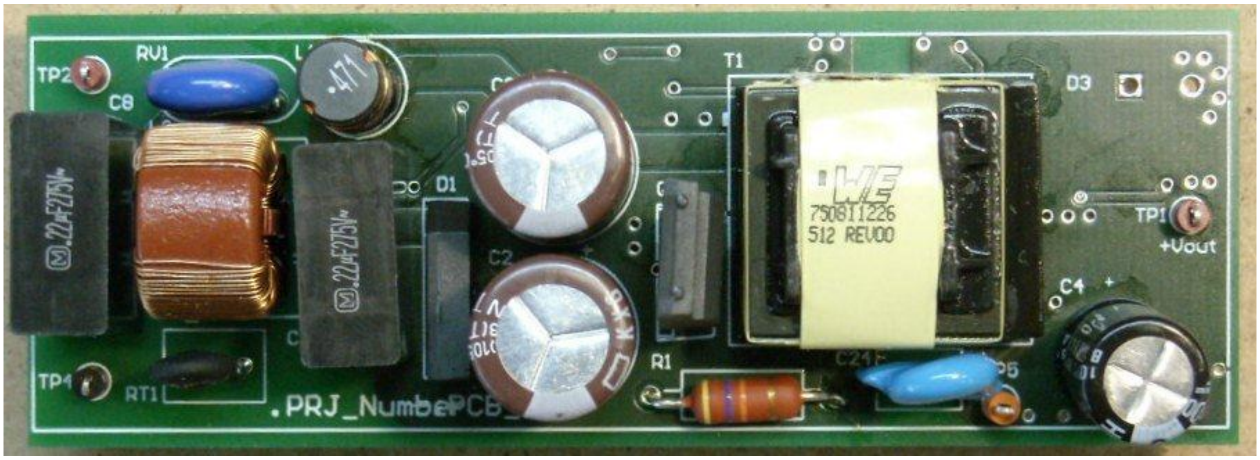
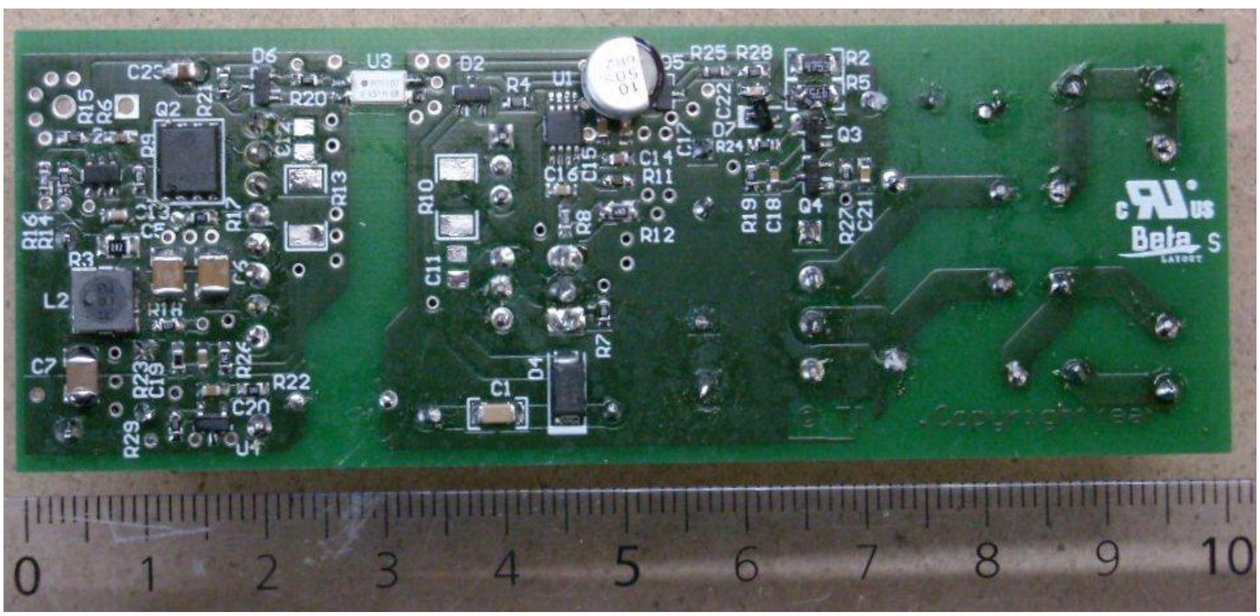
PHOTO OF THE PROTOTYPE

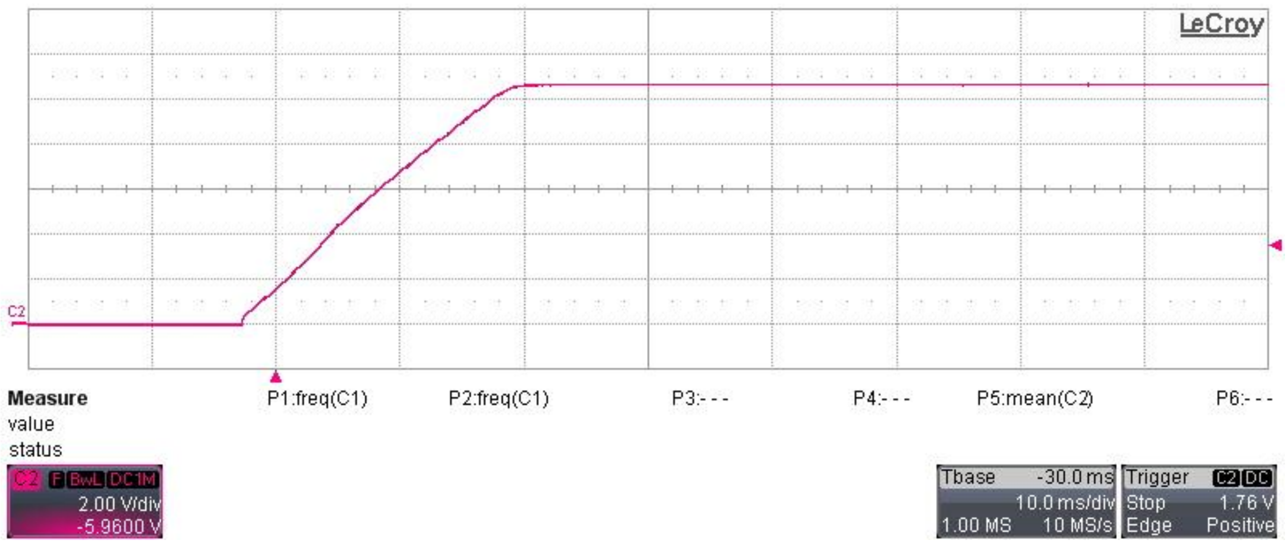




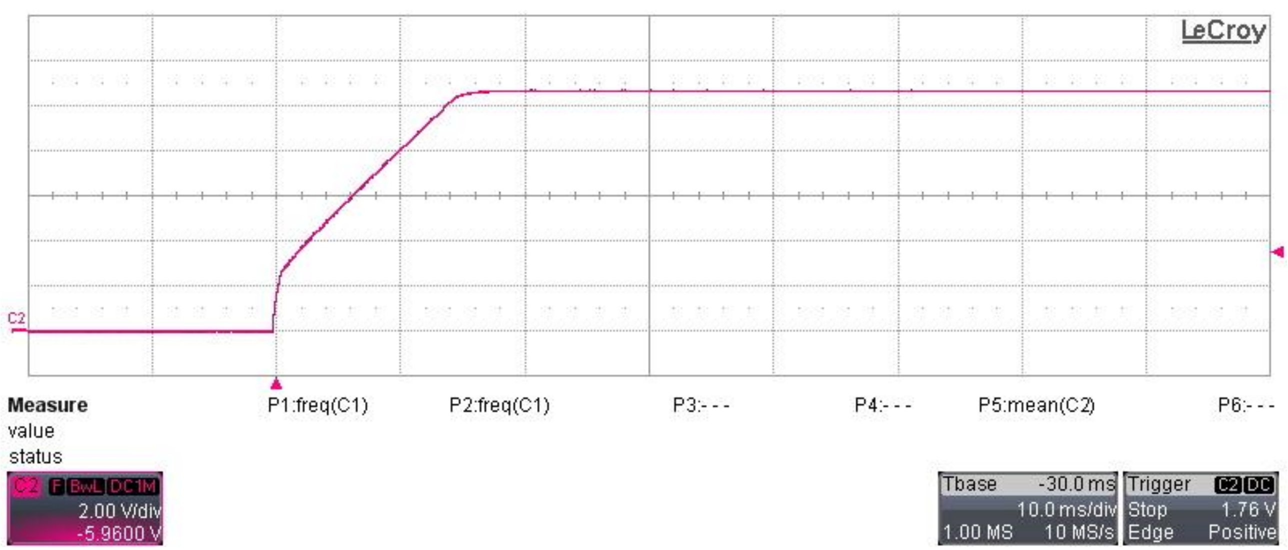
1 Startup

The output voltage behavior at startup is shown in the images below. The input voltage was set to 90Vac, 60Hz for the fully loaded case and 265Vac, 50Hz for the unloaded one.

Ch.2: Output voltage (2V/div, 10ms/div, 20MHz BWL, DC coupling)
Iout = 1.8A, Vin = 90Vac, 60Hz



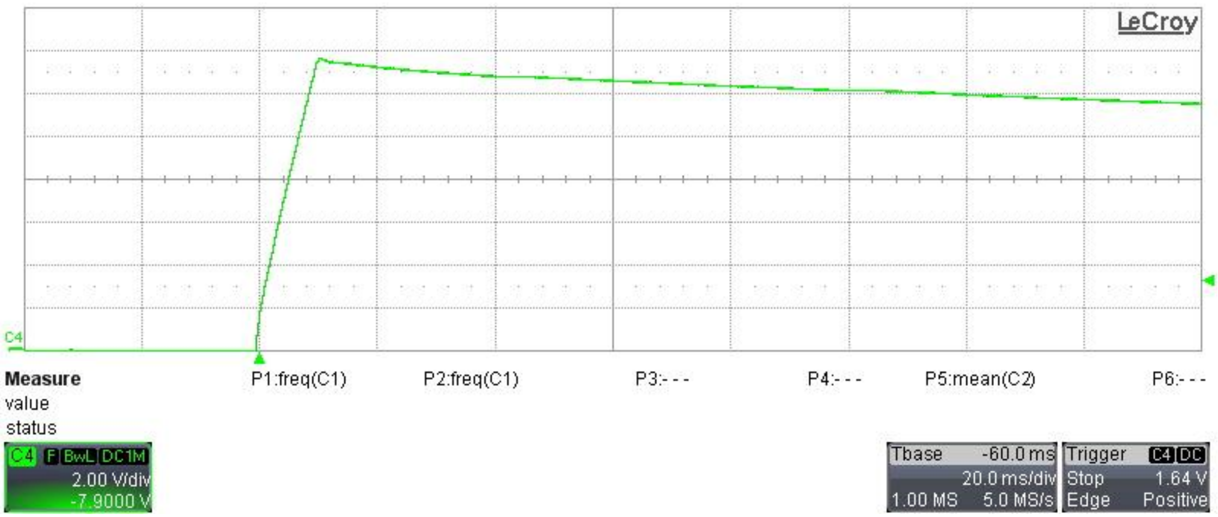
Ch.2: Output voltage (2V/div, 10ms/div, 20MHz BWL, DC coupling)
Iout = 0, Vin = 265Vac, 50Hz



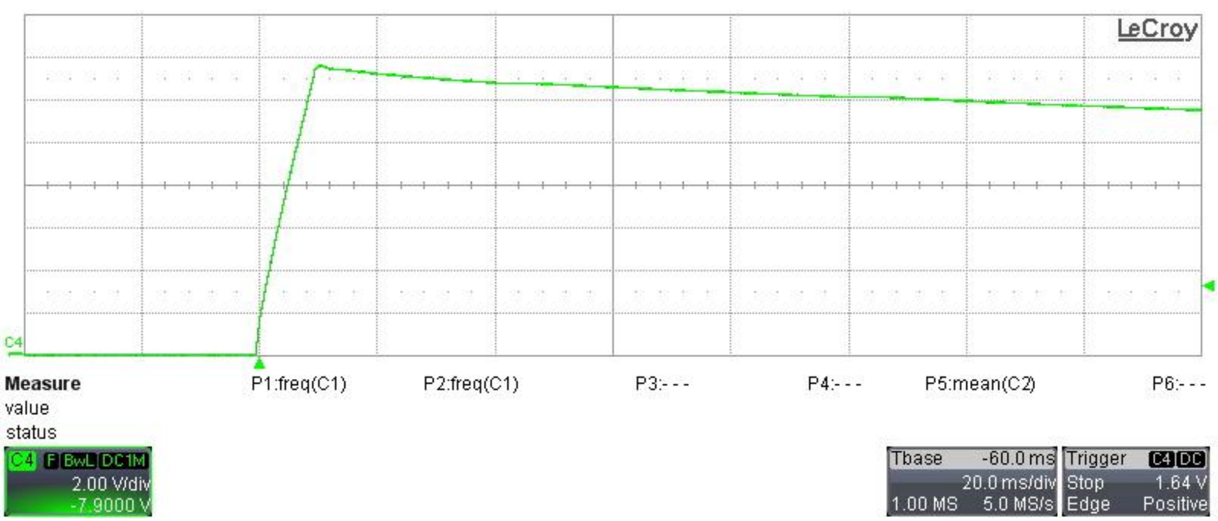
2 Optocoupler Fail Simulation

In the pictures shown below, we measured what happen to the output of the converter when the internal light emitter of the optocoupler was shorted, in practice by shorting the pins 1 and 2 of U3. The converter has been supplied at 190Vdc (upper picture) and 375Vdc (bottom one) while the output was unloaded. The converter stopped working (with latch) when the output voltage reached in both cases ~ 13.7V.
After waiting a couple of minutes (bulk capacitor discharge) and removing the short on the optocoupler, the converter started to run again.

Ch.4: Output voltage (2V/div, 20ms/div, 20MHz BWL, DC coupling)
Iout = 0, Vin = 190Vdc

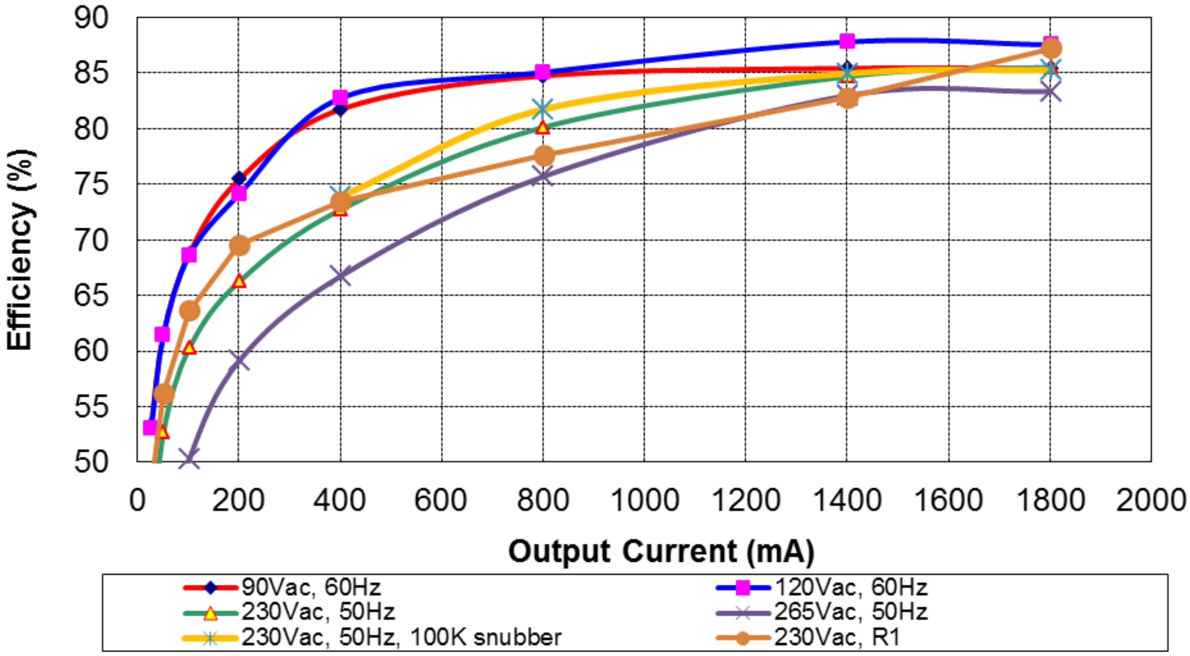


Ch.4: Output voltage (2V/div, 20ms/div, 20MHz BWL, DC coupling)
Iout = 0, Vin = 375Vdc



3 Efficiency

The efficiency data are shown in the tables and graph below. A digital power meter Yokogawa WT210 has been used and the input AC voltage set to 90V, 120V, 230 and 265V rms.



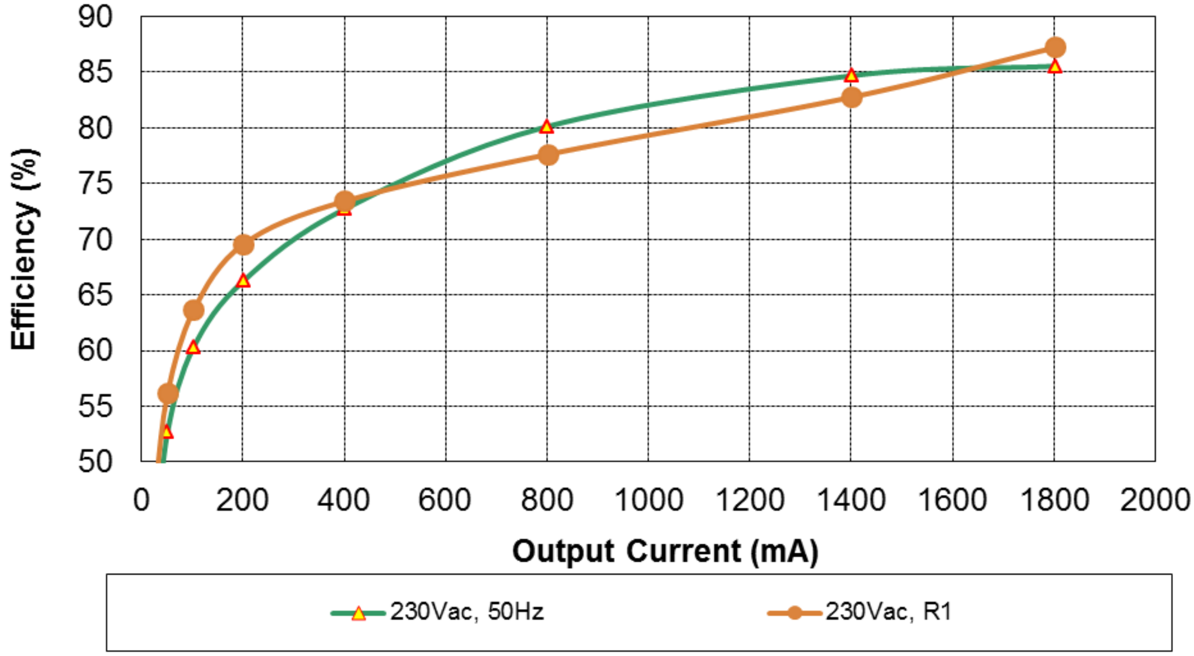
Iout (mA)	Vout (V)	Pout (W)	Pin (W)	Vin (Vac)	Ploss (W)	Eff (%)
0	10.640	0	0.121	90	0.121	0.00
26.9	10.640	0.286	0.537	90	0.251	53.30
51.1	10.640	0.544	0.884	90	0.340	61.50
101.9	10.640	1.084	1.577	90	0.493	68.75
200.7	10.640	2.135	2.831	90	0.696	75.43
401.4	10.639	4.270	5.224	90	0.954	81.75
800.5	10.636	8.514	10.047	90	1.533	84.74
1402	10.632	14.906	17.45	90	2.544	85.42
1803	10.630	19.166	22.44	90	3.274	85.41

Iout (mA)	Vout (V)	Pout (W)	Pin (W)	Vin (Vac)	Ploss (W)	Eff (%)
0	10.642	0	0.126	120	0.126	0.00
27.0	10.642	0.287	0.542	120	0.255	53.01
51.1	10.642	0.544	0.885	120	0.341	61.45
102.0	10.641	1.085	1.582	120	0.497	68.61
200.8	10.641	2.137	2.883	120	0.746	74.11
401.4	10.641	4.271	5.162	120	0.891	82.75
800.5	10.637	8.515	10.010	120	1.495	85.06
1402	10.633	14.907	16.98	120	2.073	87.79
1803	10.631	19.168	21.90	120	2.732	87.52
Iout (mA)	Vout (V)	Pout (W)	Pin (W)	Vin (Vac)	Ploss (W)	Eff (%)
0	10.643	0	0.213	230	0.213	0.00
27.0	10.643	0.287	0.684	230	0.397	42.01
51.2	10.643	0.545	1.035	230	0.490	52.65
102.0	10.643	1.086	1.802	230	0.716	60.24
200.8	10.643	2.137	3.226	230	1.089	66.25
401.4	10.642	4.272	5.874	230	1.602	72.72
800.4	10.641	8.517	10.630	230	2.113	80.12
1402	10.637	14.913	17.61	230	2.697	84.69
1803	10.636	19.177	22.42	230	3.243	85.53

Iout (mA)	Vout (V)	Pout (W)	Pin (W)	Vin (Vac)	Ploss (W)	Eff (%)
0	10.645	0	0.316	265	0.316	0.00
27.0	10.645	0.287	0.885	265	0.598	32.48
51.2	10.645	0.545	1.332	265	0.787	40.92
102.0	10.645	1.086	2.159	265	1.073	50.29
200.8	10.645	2.138	3.614	265	1.476	59.15
401.4	10.645	4.273	6.402	265	2.129	66.74
800.4	10.645	8.520	11.256	265	2.736	75.70
1402	10.642	14.920	17.98	265	3.060	82.98
1802	10.640	19.173	23.01	265	3.837	83.33

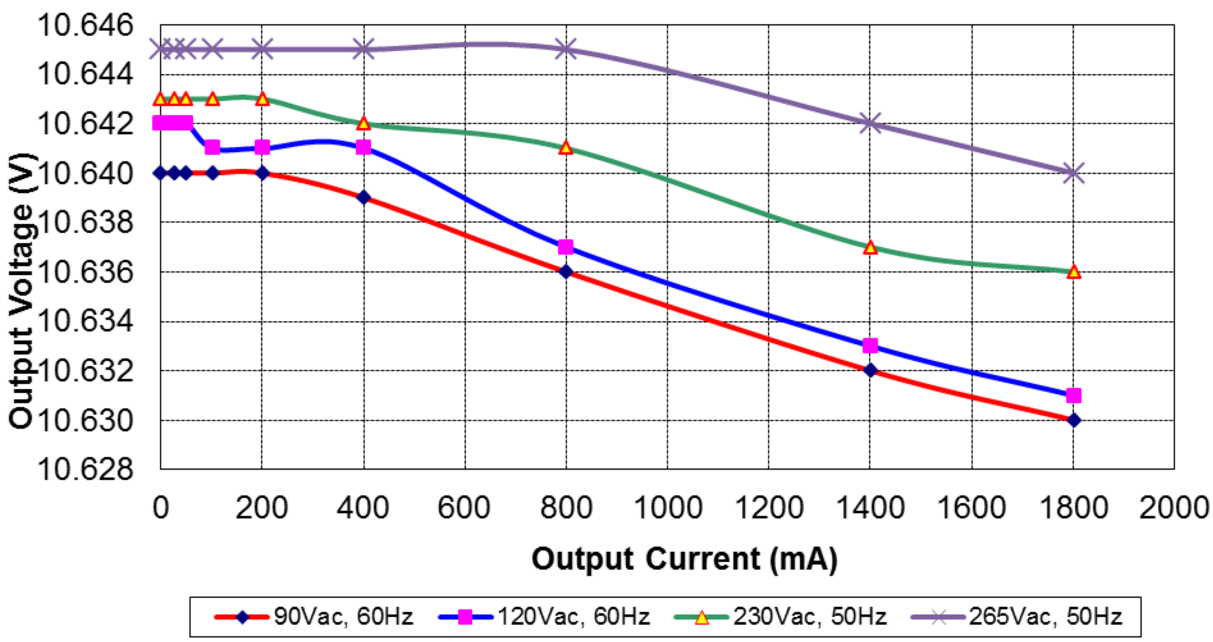
In the following table and graph, the RCD network has been replaced with a diode + TVS (and capacitor in parallel) and the “R1= revision 1” of the transformer (which showed slightly lower core losses). An improvement on efficiency values at light load has been observed and measured.

Iout (mA)	Vout (V)	Pout (W)	Pin (W)	Vin (Vac)	Ploss (W)	Eff (%)
0	10.641	0	0.187	230	0.187	0.00
27.2	10.641	0.289	0.608	230	0.319	47.60
51.4	10.641	0.547	0.974	230	0.427	56.15
102.3	10.641	1.089	1.712	230	0.623	63.58
201.2	10.641	2.141	3.078	230	0.937	69.56
402.1	10.642	4.279	5.827	230	1.548	73.44
801.6	10.641	8.530	10.990	230	2.460	77.61
1401	10.638	14.904	18.01	230	3.106	82.75
1802	10.637	19.168	21.98	230	2.812	87.21



4 Output Voltage Regulation

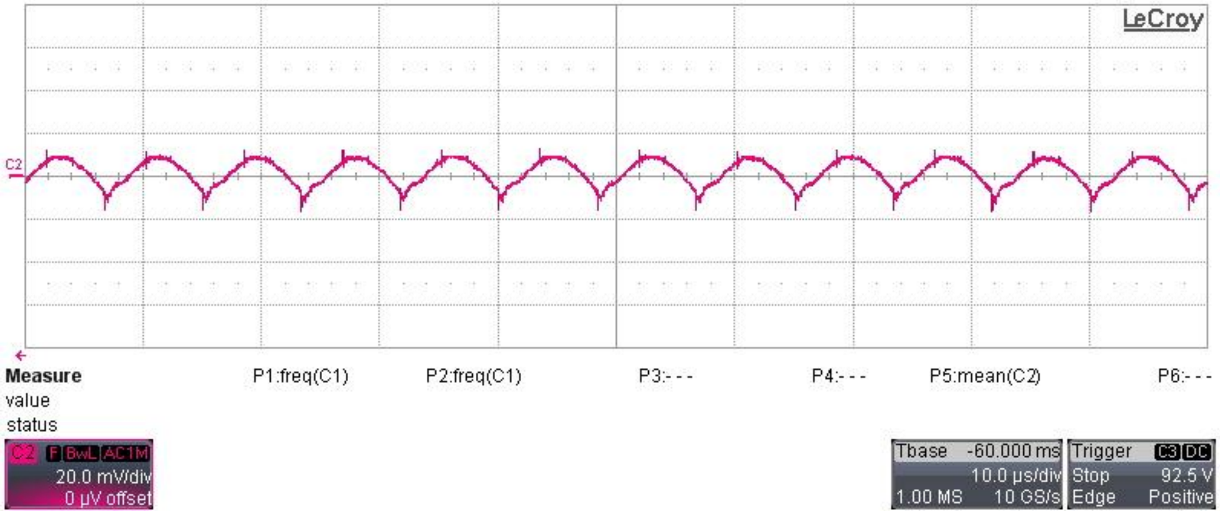
The output voltage variation as function of load and input voltage is shown below:



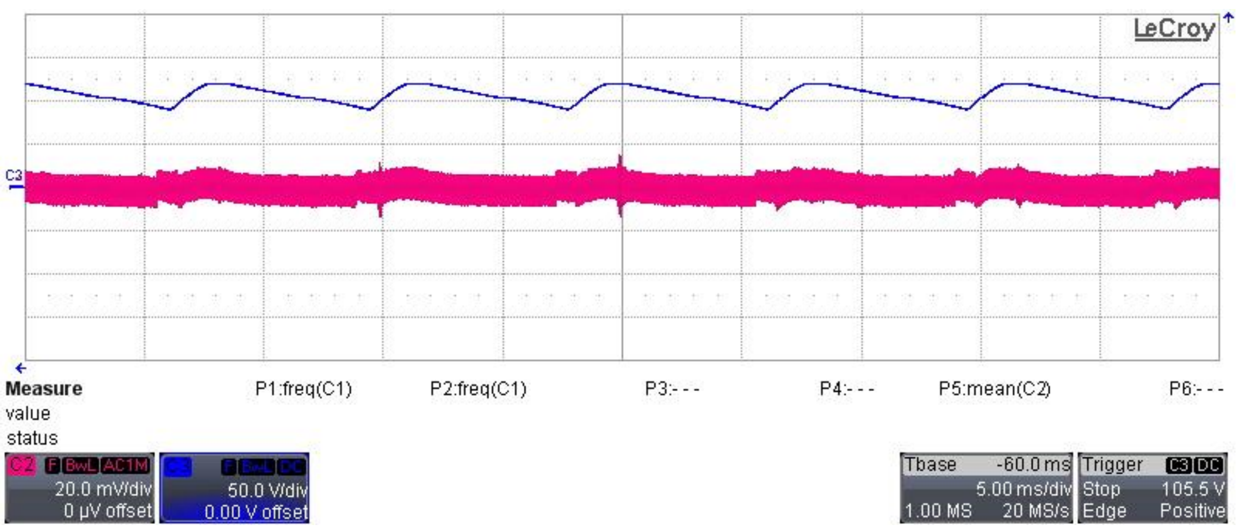
5 Output Ripple Voltage

The output ripple voltage is shown in the plots below. The input was set to 90Vac, 60Hz (worst case for output ripple). In the bottom picture also the bulk voltage (C3) is shonw.

Ch.2: Output Voltage (20mV/div, 10us/div, AC coupling, 20MHz BWL), Iout = 1.8A



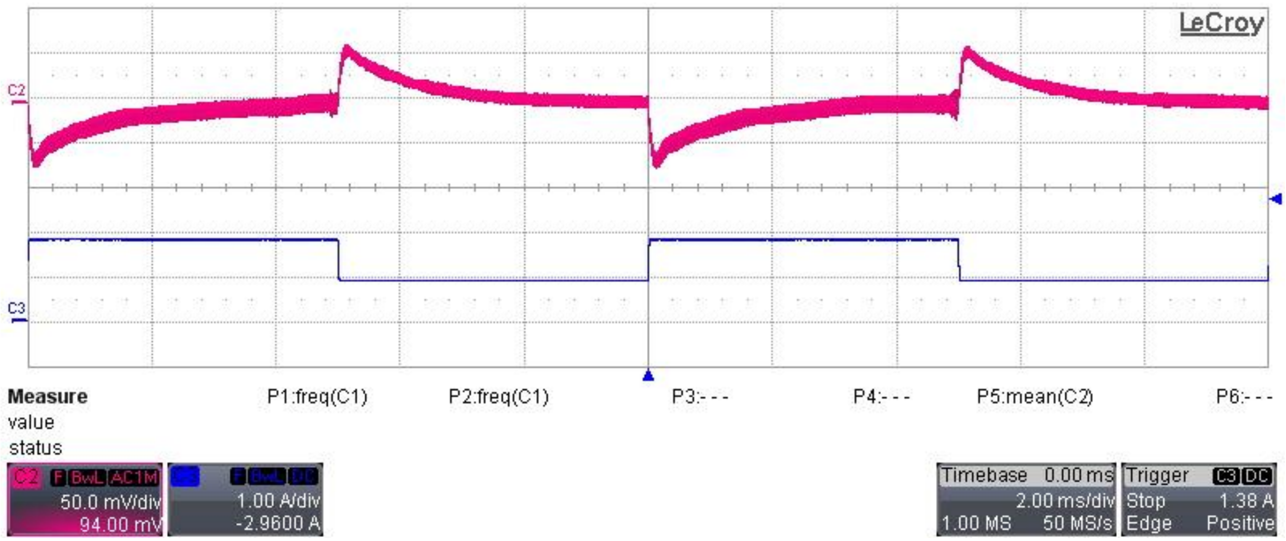
Ch.2: Output Voltage (20mV/div, 5ms/div, AC coupling, 20MHz BWL), Iout = 1.8A
Ch.3: C3 Bulk Voltage (50V/div, DC coupling, 20MHz BWL)



6 Transient Response

The image below shows the transient response on the output voltage when the load has been switched between 50% and 100% of the nominal value, measured at 90Vac.

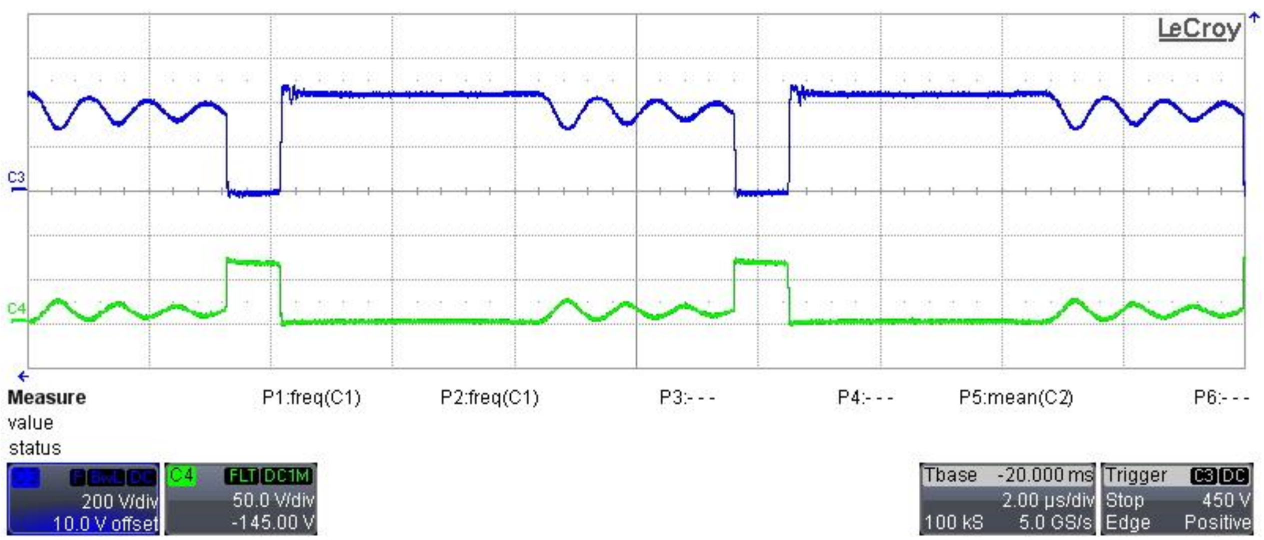
Ch2: Output Voltage (50mV/div, 2ms/div, AC coupled, 20MHz BWL)
Ch3: Output Current (1A/div, DC coupled, 20MHz BWL)



7 Switching Node Waveform

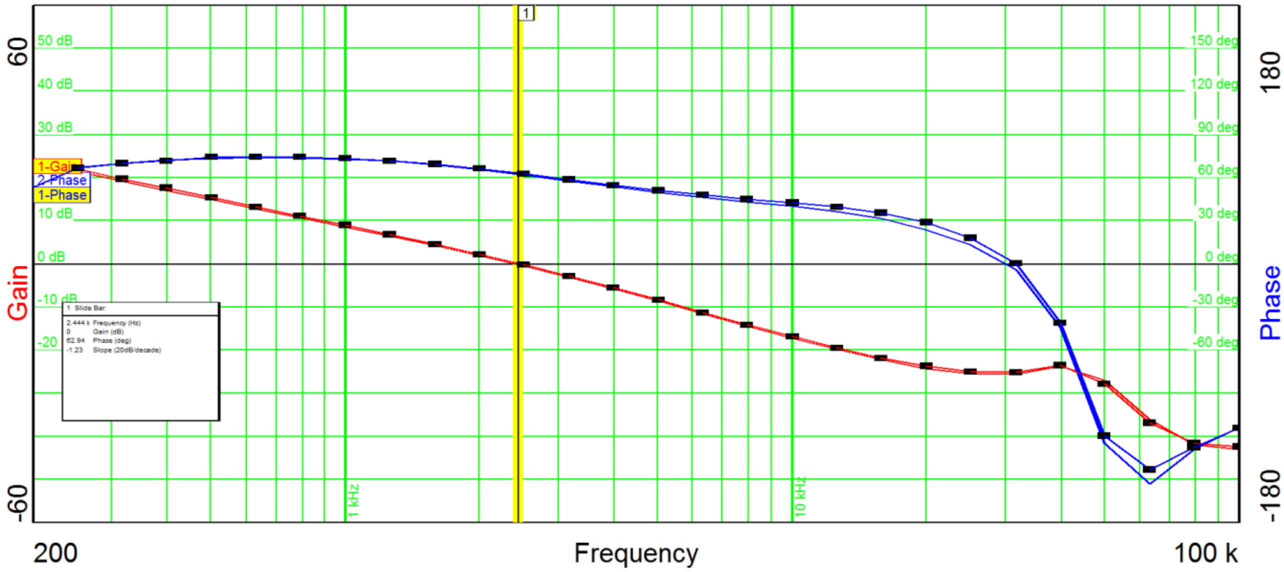
The image below shows the peak voltage on the drain of the FET Q1 and the drain of Q2 with the converter supplied at 265Vac and full load.

Ch3: Q1 Drain voltage (200V/div, 2us/div, 200MHz BWL)
Ch4: Q2 Drain voltage (50V/div, 200MHz BWL)



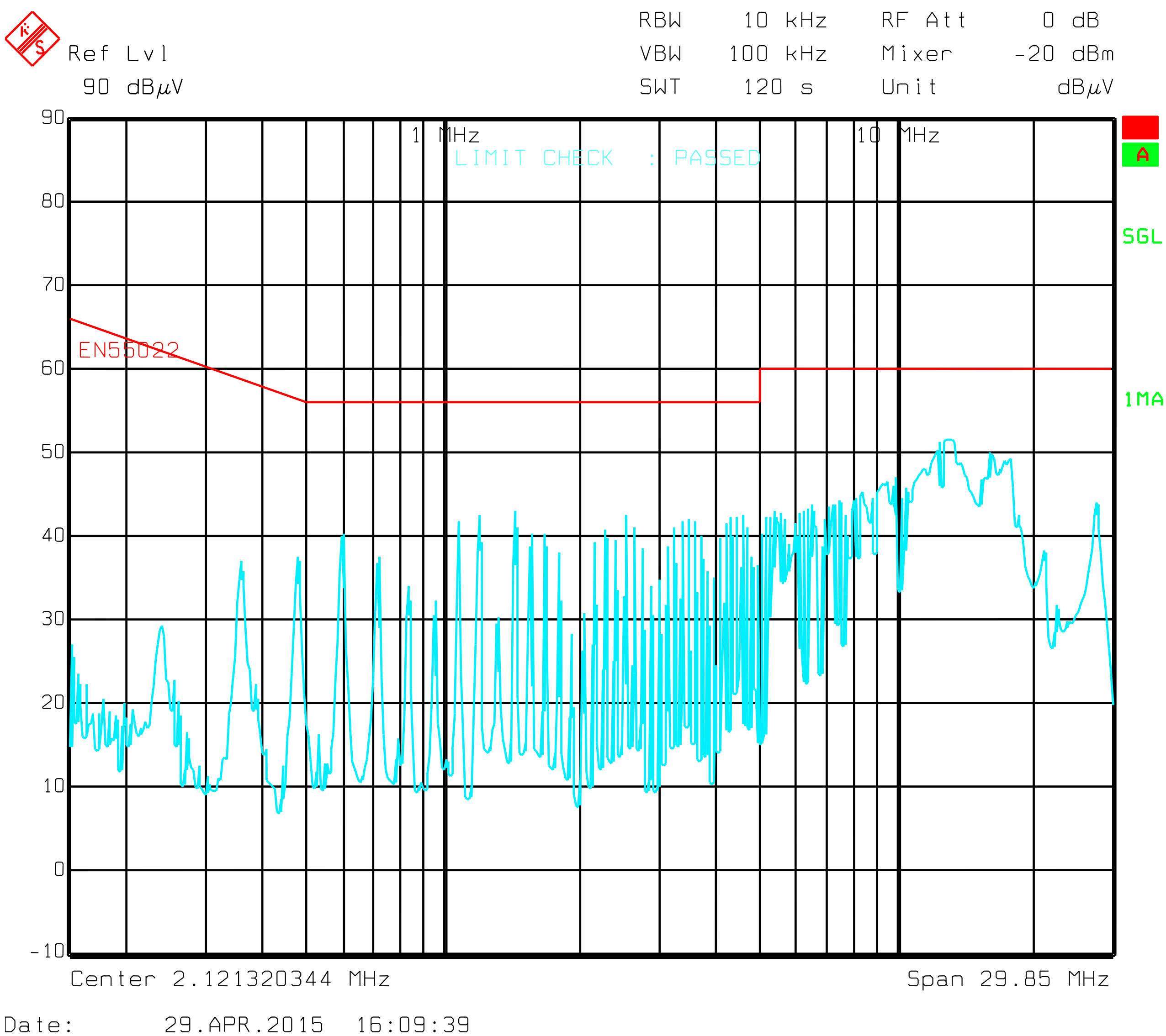
8 Stability Analysis

The open loop gain and phase has been measured by supplying the converter @ 115Vac, 60Hz and 230Vac, 50Hz while it was fully loaded. The crossover frequency was 2.44 KHz, the phase margin 62.94deg. and the gain margin 25.2dB. Almost no difference is visible between the measurements at 115Vac and 230vac.



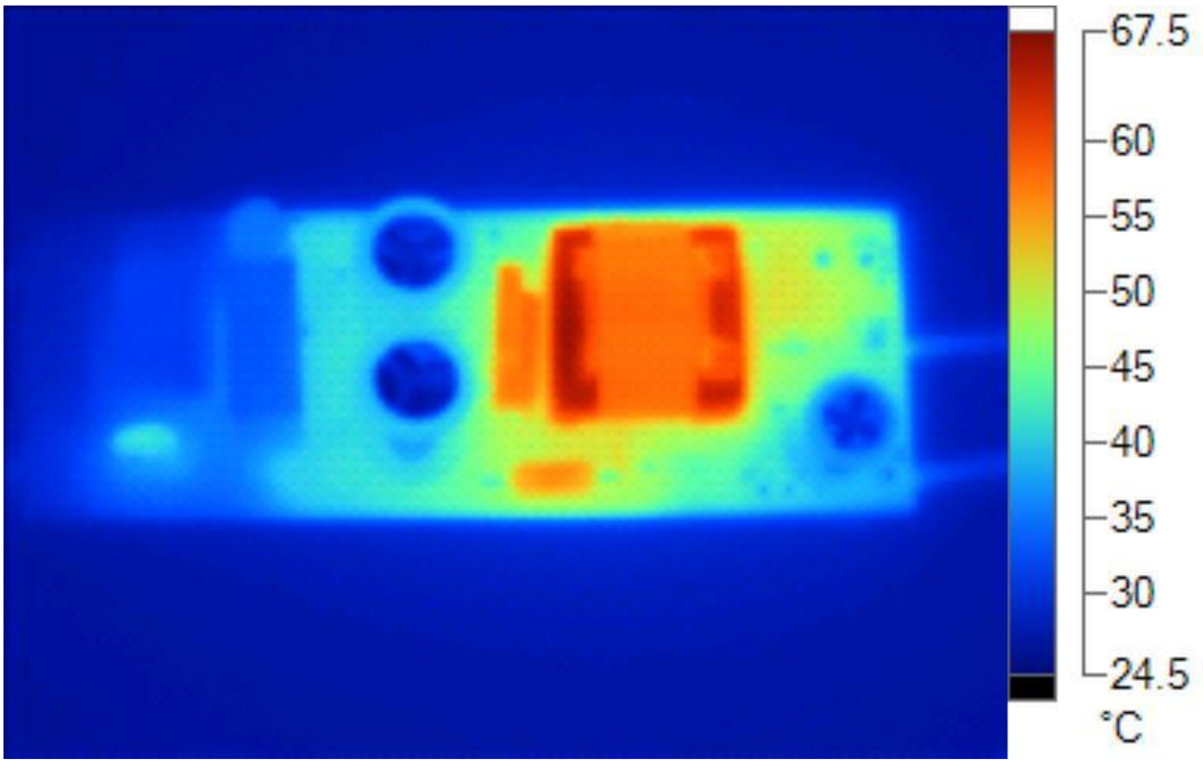
9 EMI measurement

The graph below shows the EMI measurement of the converter connected to an isolation transformer plus an Hameg HM6050-2 LISN. The supply voltage was 230Vac.
The converter has been loaded with a passive resistor set to draw 1.8A from the output. The output negative terminal of the converter has been connected to the ground of the LISN.



10 Thermal Analysis

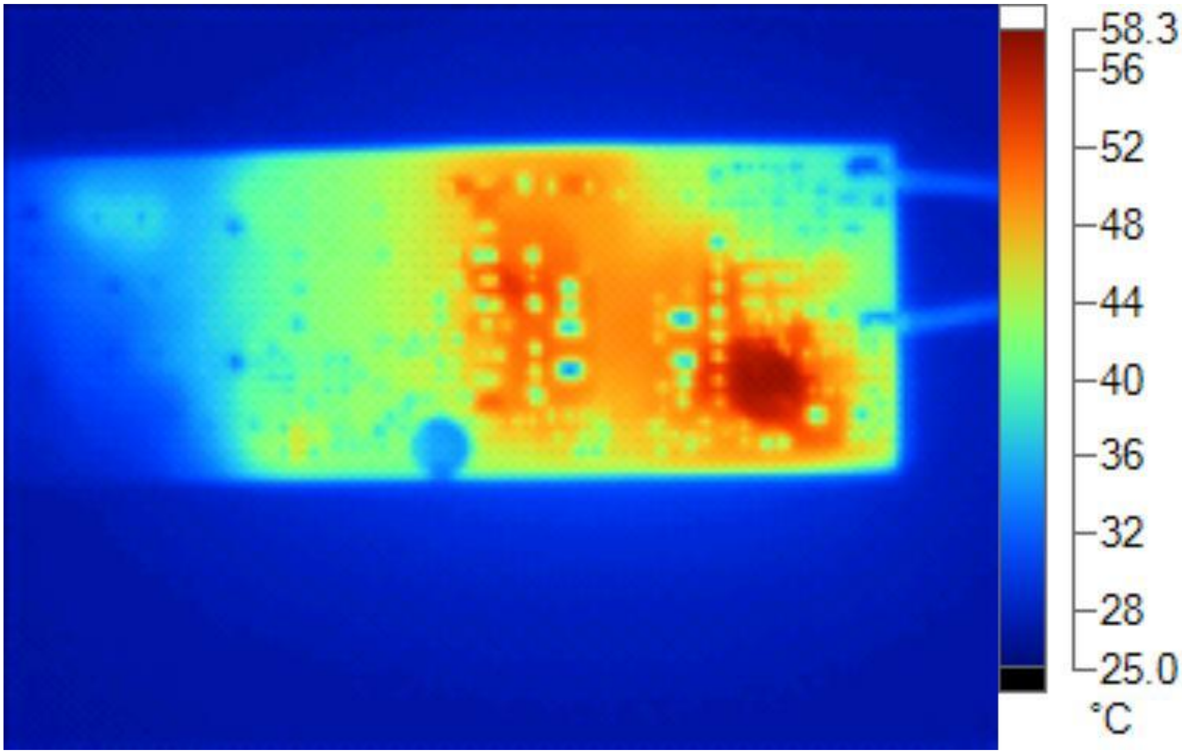
The graph below shows the thermal shot, taken in still air condition; the converter has been placed horizontally on the bench and supplied at 230Vac and fully loaded.
The first picture shows the top side of the board, while the second one gives the information about bottom side temperatures.



PMP10164 Top 230Vac FL.is2
4/29/2015 5:07:56 PM

Image Info

Background temperature	20.0°C
Average Temperature	32.3°C
Image Range	25.5°C to 66.4°C
Camera Model	Ti40FT
Camera Manufacturer	Fluke
Image Time	4/29/2015 5:07:56 PM



PMP10164 Bottom 230Vac FL.is2
4/29/2015 5:09:03 PM

Image Info

Background temperature	20.0°C
Average Temperature	33.0°C
Image Range	26.0°C to 57.3°C
Camera Model	Ti40FT
Camera Manufacturer	Fluke
Image Time	4/29/2015 5:09:03 PM

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