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)**

\[ I_{out} = 0, \text{Vin} = 190\text{Vdc} \]

![Graph showing output voltage for 190Vdc supply](image)

**Ch.4: Output voltage (2V/div, 20ms/div, 20MHz BWL, DC coupling)**

\[ I_{out} = 0, \text{Vin} = 375\text{Vdc} \]

![Graph showing output voltage for 375Vdc supply](image)
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.

<table>
<thead>
<tr>
<th>Iout (mA)</th>
<th>Vout (V)</th>
<th>Pout (W)</th>
<th>Pin (W)</th>
<th>Vin (Vac)</th>
<th>Ploss (W)</th>
<th>Eff (%)</th>
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<tr>
<td>0</td>
<td>10.640</td>
<td>0</td>
<td>0.121</td>
<td>90</td>
<td>0.121</td>
<td>0.00</td>
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<tr>
<td>26.9</td>
<td>10.640</td>
<td>0.286</td>
<td>0.537</td>
<td>90</td>
<td>0.251</td>
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<tr>
<td>51.1</td>
<td>10.640</td>
<td>0.544</td>
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<td>0.493</td>
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<td>101.9</td>
<td>10.640</td>
<td>1.084</td>
<td>1.577</td>
<td>90</td>
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<tr>
<td>200.7</td>
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<td>2.831</td>
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<td>1.533</td>
<td>84.74</td>
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<tr>
<td>401.4</td>
<td>10.639</td>
<td>4.270</td>
<td>5.224</td>
<td>90</td>
<td>2.544</td>
<td>85.42</td>
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<td>800.5</td>
<td>10.636</td>
<td>8.514</td>
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<td>3.274</td>
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<td>19.166</td>
<td>22.44</td>
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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.
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 shown.

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.

![Thermal Image](image-url)

**Image Info**

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