



### 350W 400Hz converter

16 april 2008

## 400Hz converter

8 August 2008 K.Bouwknegt

The 400Hz converter is based on a Compaq Proliant Server power supply. This hot-swappable PSU type PS4060 is rated for 750W at 220Vac input, or 500W at 120Vac input. It should be possible to make at least 300W output at 400Hz with this PSU.

From the PS4060, the chassis, fan, and primary electronics board were used, plus some coils and flat cable connectors from the secondary board.

Almost everything on the **main board** (on top of photo) was used: the input rectifier, the PFC circuit to get 382Vdc, the auxiliary converter to provide +9V and +15V voltages for the fan and PWM electronics, the heatsinks and 2 out of the 4 power fets that once drove the converter transformers on the secondary board.

**Board 2 was added** to the heatsink on the primaries board (orange board on photo) to create the 400Hz PWM drive signals for two power FETs on the main board. This board contains a 4800Hz oscillator ( 12 x 400Hz), a divide-by-12 shift register to make 6 square waves at 400Hz, each 30 degrees phase shifted from the previous one; a buffer amplifier to give these square waves a variable height, a summing amplifier that adds 5 square waves to a stepped wave at 400Hz that has no lower harmonics than the 11<sup>th</sup>, and the PWM chip.

This 400Hz sine wave is compared to a 18kHz saw tooth in a dedicated PWM circuit, resulting in one bit information whether the lower or upper fet should be "on".

A special "pole" driver circuit splits this signal into drive signals for the upper and lower power fet. Using this circuit, no drive transformers are needed.

**Board 3** on the bottom of the case contains the power output circuit.

On the left, two large capacitors form the midpoint of the DC supply as a return for the output circuit. A 2mH/4A ferrite core choke in series with a ring core choke and 4x 1uF capacitors filter the PWM waveform into a sine wave

The cut-off frequency is 1.8 kHz, near the fourth harmonic of 400Hz. This frequency is almost absent in the PWM modulator, as well as in the expected load current.

The filtering of the 18kHz carrier is enhanced by giving half the capacitors a series choke, thus forming a notch at the pwm frequency.



Finally, a C-core transformer with 1:1 turns ratio provides isolation between the mains and the 400Hz output. Behind the meters are some components that were salvaged from the original PS4060 secondary board to provide a 24Vdc/3A output, needed as well by most avionics .

### Metering

The voltmeter is straightforward. A 1mA moving coil instrument measures the average value of the rectified output voltage. This value is shown on a

volts rms scale, assuming an (almost) sinusoidal wave. Full scale at 1mAdc is 150Vac.

The amp meter is a 20mA moving coil instrument, connected to 200:2 current transformer via a schottky-diodes bridge. The secondary of the CT can produce 1Vrms above 300Hz without saturation. This gives a perfect linear scale to 3A ac.

Lateron I added a small switch to show either the 115V ac voltage and current or the 24Vdc voltage and current.

### Magnetics

#### PWM filter inductor 1.8mH/4Arms

The inductor is based on a ferrite core E55/28/21 from either Ferroxcube or EPCOS. The core halves are gapless, so I added 1.6mm printed circuit board as gap. The coil with 1.1mm dia wire has 88 turns in 4 layers, that is 14 metres, with 0.24Ω dc resistance.

#### Output transformer

The transformer was made on a C-core from Vacuumschmelze type SU48b with an iron section 15 x 25mm. Both primary and secondary have 144 turns of the same 1.1mm dia enameled wire in 4 layers, 2 layers on each leg. In total 40 meters, with 0.34Ω dc resistance for either primary or secondary. The copper loss is 6W at 300W output. The (only) core I had was made for 50/60Hz, wound from 0.3mm strip. To keep the losses reasonable at 400Hz, the peak induction is only 1.2T. With the fan used, both iron and copper stabilize at 48°C at 300W output.

The isolation between primary and secondary is 3 layers mylar, and withstands 2kV rms