LOAD OF ELECTRONICS POWER SUPPLIES ON THE 220V MAINS

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ABSTRACT

This report draws attention to a possible overload of the 220V mains due to the special nature of a load consisting of electronics power supplies. We found that the electronics equipment in NA11 (a typical SPS experiment) draws its power with a duty cycle that requires that mains cables, transformers and fuses be rated at a factor of about 17% above what would be expected for the usual loads and 40% above what would be found from a simple current measurement.
1. **INTRODUCTION**

Following the unexpected blowing of mains fuses in several racks equipped with modern electronics, an investigation was made into the reasons for this apparent overload.

2. **SETUP**

A typical rack is supplied from 220V single phase mains and contains 1 ventilator of 160 W, 5 crates (1 CAMAC of 500 W + 4 with Drift Chamber electronics, each equipped with a switching power supply 5.2V-100A) and a Mains Switch Box with a Power Contactor and a thermal relay adjusted at 25A.

3. **MEASUREMENTS**

The current consumption of the electronics in the rack, measured with the aid of a 1:1000 current transformer and a moving coil instrument with rectifier, is 14.9A. It should be taken into account that the moving coil instrument (Metrix Mx2028) in reality measures average current but its scale is calibrated in R.M.S. value. The average current is \( \frac{14.9}{1.11} = 13.42 \) A. The wave-shape of the consumed current is given in Fig. 1.

![Fig. 1](image)

**Output current transformer across 200 Ω**

**Horizontal sensitivity 5ms/div.**

**Vertical sensitivity 5V/div.**

This shape is explained by the type of load that electronics power supplies represent. Essentially they consist of a full wave rectifier that charges a large capacitor. Charge current flows principally only at the peak of the sine wave.
In view of the particular wave-shape, measurements on the heat effect and real power were done with the aid of an analog multiplier from Analog Devices, Type 429A.

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\begin{align*}
\text{x input} & \quad \text{max} \pm 10 \, \text{V} \\
\text{y input} & \quad \text{max} \pm 10 \, \text{V} \\
\text{output} & \quad \frac{x \times y}{10} \, \text{V}
\end{align*}
\]

The first measurements concerned the heat effect of the load current on power leads, fuses etc. Since the developed heat is proportional to \(I^2\), the output of the 1000:1 current transformer across 200 \(\Omega\) was connected to the \(x\) and \(y\) inputs in parallel. The output of the analog multiplier is proportional to \(I^2\) and was +1.72V. The R.M.S. value of the sine wave that had to be applied to the \(x\) and \(y\) inputs in parallel in order to obtain the same output voltage was 4.18V. Which means that the heat effect of the load current is equal to that of a sine wave current of \(1000 \times \frac{4.18V}{200 \, \Omega} = 20.9 \, \text{A} \quad \text{R.M.S.}\)

In combination with a reduced current rating of the thermal relay, due to insufficient thermal compensation, this explains the repeated overload cut-outs. The second measurement was the real power taken from the mains.

Here the \(x\) input was connected to the output of the current transformer across 200 \(\Omega\). The \(y\) input was connected to a fraction \(\frac{1}{35.15}\) of the mains voltage. The output is proportional to the power and was +2.23V = \(\frac{xy}{10}\). The actual power consumption of the rack is \(2.23 \times 10 \times \frac{1000}{200} \times 35.15 = 3920 \, \text{W}\). Which would correspond to an R.M.S. value of \(\frac{3920}{220} = 17.82 \, \text{A}\).

4. CONCLUSIONS

From the above measurements, it is concluded that electronics power supplies can constitute an appreciable overload of transformers, cables and fuses that is not easily detected. With respect to the measured current the overload factor is around \(\frac{20.9A}{14.9A} = 1.4\), thus of the order of 40%. With respect to the real power the overload factor is about \(\frac{20.9 \, \text{A}}{17.82 \, \text{A}} = 1.17\), thus 17%.

Needless to say that, depending on the types of power supplies used, these values may vary considerably.