10.7.5 The filter-chain

As Fig. 10.7.5 shows, a sawtooth-shaped AC-voltage (hum interference) with a peak-to-peak voltage of easily 20 – 40 V is superimposed onto the supply-voltage. Such a high AC-component is problematic for the preamplifier because it will contaminate the signal-flow via the plate-resistor. This is the reason why the supply-voltage needs to be cleaned up using several filter-stages. Such a “filter-chain” typically consists of several consecutive low-pass filters containing, in the series branch, high-power resistors (e.g. 10 kΩ, 2 W), and in the respective parallel branch high-voltage electrolytic capacitors, e.g. 50 µF. In high-grade power supplies, the first series element is in fact not a resistor but an inductor. A filter choke (e.g. L = 3 H) is used here because its AC-resistance Z is much higher than its DC-resistance R. At 100 Hz, a 3-mH-choke has about Z = 1885 Ω which is about the nineteen-fold of the copper-resistance (typically about 100 Ω). In combination with a 32-µF-filter-cap, the choke results in a 2nd-order low-pass with a cutoff frequency of 16 Hz and an attenuation rising with a slope of 12 db/oct above that frequency.

That would be the case in an ideal world. In reality, we need to consider that filter-caps may loose part – or all – of their capacitance at higher frequencies (the may even become inductive). Therefore, it is recommended to connect high-voltage foil-capacitors (10 – 47 nF) in parallel with the filter-caps. Hold on: higher frequencies in a power supply operated at 50 Hz (or 60 Hz)? Sure: the rectifiers operate as a kind of switch, and every switching action represents a broadband event. In particular, the Si-rectifiers will interrupt the current-flow abruptly as the voltage at the filter cap drops below the voltage provided by the transformer. Integration♣ results in a sawtooth-shaped voltage that contains significant spectral lines up into the kHz-range. The reverse recovery time of the rectifier diodes may possibly cause additional interference: it takes a few µs until the charge carriers are “cleaned” out of the depletion layer, and during this minor time, needle-shaped peaks occur in the current-flow. With a correct circuit-layout, the interference-effect will, however, be rather small. If problems still ensue, it is possible to either use fast-recovery diodes, or to bridge the diodes with appropriate capacitors.

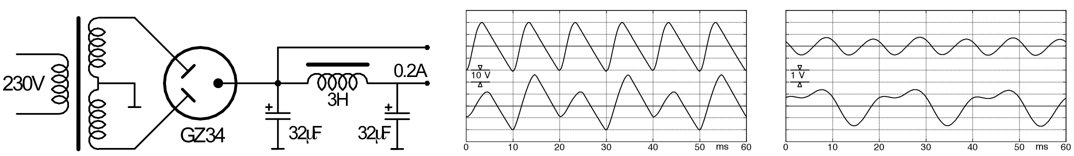

Fig. 10.7.7: Power supply with filter-choke. The two diagrams show the voltage curve at the filter capacitors: left at the first capacitor, right at the second capacitor. Top: with a faultless rectifier tube; bottom: with defective tube. In some countries, the mains voltage will of course be different from 230 V (e.g. 110 V).

Fig. 10.7.7 indicates the filter-cap-voltages of a power supply operating with a GZ34. Cooperating with a 32-µF-cap, the choke (3 mH) reduces the ripple to about 0.5 V_{eff}, although only with a faultless rectifier tube. In the defective “selected” tube measured in comparison, the two diodes had very different characteristics, and a strong 50-Hz-component dominated the voltage. Higher-frequency signals are not apparent in this example. The faultless tube generates (on top of the DC-voltage) an almost perfect 100-Hz-tone the amplitude of which can be further reduced via the subsequent RC-filters.

♣ $I = \mathrm{d}Q / \mathrm{d}t = C \cdot \mathrm{d}U / \mathrm{d}t$.

 Translated by Tilmann Zwicker