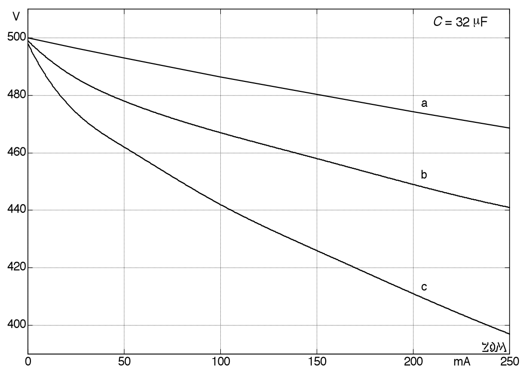
10.7.3 The internal impedance of the power supply

Strictly speaking, the constant DC supply-voltage generated by the power supply does not remain constant at all: it varies dependent on the load, and in addition, a hum-interference is superimposed onto it. Talking about a **constant DC-voltage**, we in fact refer to the arithmetic mean-value of the supply-voltage, measured across a short period of time, e.g. 20 ms. Only when not connected to a load does the power supply generate a supply-voltage that has no superimposed ripple. This maximum voltage corresponds almost to the peak value of the secondary mains transformer voltage in idle, e.g. 500 V. As a load is connected and draws current (e.g. 200 mA), this voltage decreases to e.g. 460 V – a behavior that may be equated to an ideal voltage-source with an internal impedance: in the above example R_i = (500 – 460)V / 0.2A = 200 Ω. The internal impedance depends on the transformer, the rectifier, the filter capacitor and the load-impedance, but unless the load changes dramatically, the load-dependence may be ignored, and the internal impedance may be seen as a constant characteristic of the power supply.

Fig. 10.7.5 indicates the dependency of the supply-voltage on the load-current for different configurations. The power supply (seen as ideal) contains an ideal voltage-source and an ideal rectifier; the load-dependent voltage-drop is exclusively due to the capacitor discharge. The other two curves were measured at a power supply with a real transformer having an internal impedance of 2x40 Ω. The reason for the fact that such small resistances can already have such a considerable effect is found in the high peak currents (Chapter 10.7.2).



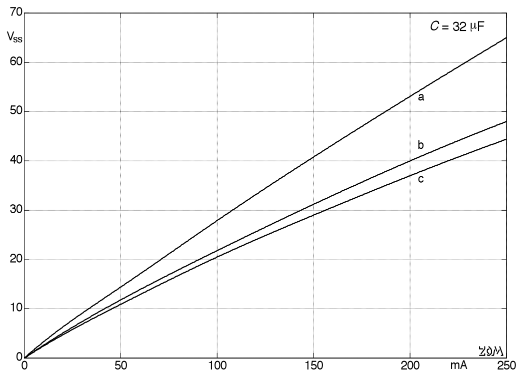


Fig. 10.7.5: Dependency of the supply- (left) and of the hum-interference-voltage (right) on the load current.
a = ideal power supply, b = Si-rectifier (1N4007), c = tube rectifier (GZ34). Pure RC-loading.

Of course, it makes a difference whether the supply-voltage sags by 30 V or by 100 V, because the operating points of the power tubes depend on this value. Depending on the filtering, such voltage fluctuations can have an effect even up to the preamplifier tubes (Chapter 10.1). The largest sag in Fig. 10.7.5 is found in the voltage at the tube rectifier: for I = 150 mA it amounts to U = 75 V. With U / I follows the absolute internal impedance (500 Ω), while dU/dI yields the differential version of it (300 Ω). Using a larger filter capacitance, both internal impedances may be reduced but this increases the peak current flowing through the diodes (compare to Fig. 10.7.2).

The hum-interference superimposed onto the supply-voltage is, according to Fig. 10.7.5, smallest for the tube rectifier because the relatively large internal impedance causes a large angle of current-flow. In push-pull power stages, the hum-currents compensate each other within the output transformer in the ideal case (Chapter 10.5.2) whereas in single-ended power stages, the hum-voltage causes audible interference.

 Translated by Tilmann Zwicker