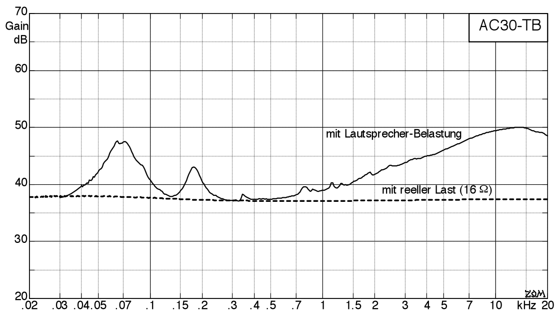
10.10.6 Comparison: frequency responses

Let's now go for the full enchilada: the mapping of the input voltage onto the sound pressure. We will not check the transfer function of individual parts to the circuit (as in Chapter 10.3) anymore, but the transfer behavior of the whole "**amp-plus-speaker**"-system. For the associated measurements, the speaker enclosure (for combos including the amplifier) was set up in an anechoic chamber (AEC), i.e. a room with fibrous wedges of 80 cm length mounted to all six boundary surfaces to substantially suppress any reflections. The sound pressure was picked up axially in front of the speaker using a precision microphone (B&K 4190), and analyzed with a workstation (Cortex CF 100). Beaming effects were not captured here – Chapter 11.4 is dedicated to the associated effects.

The ancestors of modern guitar amps did not differ much from other audio amps of the time. The design objective was apparently a reproduction as broadband and as frequency-independent as possible. Simple amps did not have any tone filter at all (e.g. early Fender Champs), or they sported – what luxury – a *single* tone knob (Fender Deluxe). Later, two-, three and even four-band tone filters were included, as well as tremolo and reverb – but, again, that came later. These old amps did not sound bad because the transmission was in fact not frequency-independent, after all – due to the frequency dependency of the **loudspeaker impedance** (Chapter 11.2), whether the designers were aware of this or not. Early power amps did not have any negative feedback (e.g. Champ 5C1, Princeton 5D2, Deluxe 5B3, Super 5B4, Pro Amp 5C5, VOX AC15, Gibson GA-20, Gibson GA-40, Rickenbacker M11, Epiphone EA-50, and many more), giving the pentode-power-stages a high-impedance output that leads, in combination with the speaker impedance, to a characteristic frequency-response. **Fig. 10.10.32** shows this exemplarily for the AC30 – this amp is not that old but it never had any negative power-amp-feedback in any of its incarnations. With a 16-Ω-resistor serving as load, the transmission is independent of frequency. However, as the speaker replaces the resistor, the speaker resonance appears at 65 Hz, an enclosure resonance shows up at 170 Hz, and towards the high frequencies we see the contribution of the voice coil. This situation is quite different for power amps including strong negative feedback such as the **JTM-45**: unless the presence control is turned up, the voltage levels for resistor- and speaker-load do not differ by more than ±1 dB. For the overall frequency response, three main sources can be identified: the tone filter (as far as it is present), the speaker-impedance, and the frequency response of the speaker. In addition, there are high-pass filters (the coupling capacitors) and low-pass filters (the Miller-capacitance), as already described earlier. The overall frequency response depicted in Fig. 10.10.32 shows a pronounced treble boost although there is no special filter for this – it is the result of the high-impedance power-amp-output + speaker impedance + frequency-response of the speaker. In the AC30, the treble could be attenuated with the Cut-filter but that is not in fact desirable. For many users, the Normal-channel featured too little treble – that is why the Treble-version and the TB-channel were developed.



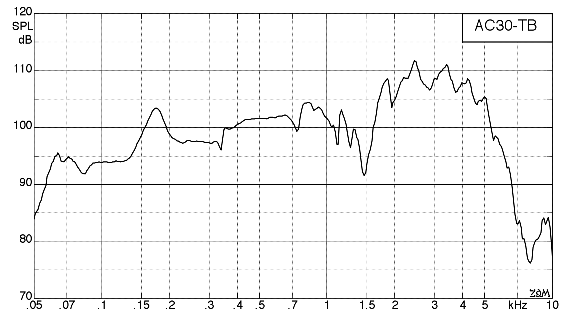


Fig. 10.10.32 left: VOX AC30-TB, transmission from phase-inverter-input to loudspeaker-output; dashed: with resistor; solid: with speaker; **right:** transmission from Normal-input to SPL in the AEC, volume = 12:00 h.

The frequency responses of some power amps (with corresponding loudspeaker) are shown in **Fig. 10.10.33**. For these measurements, the sweep-generator was directly connected to the input of the phase-inverter, and the microphone (B&K 4190) was at 2 m distance from the speaker. The lower curve shows the level of the speaker-voltage, referenced to 500 Hz (for the frequency dependency of the speaker impedance see Chapter 11.2). For power amps with strong negative feedback (e.g. the JTM-45) there is only little mapping of the speaker impedance maps onto the voltage level, while for power amps with weak or no negative feedback (Super Reverb, AC30), the speaker impedance strongly influences the voltage level. Moreover, the speaker itself and the enclosure construction (open or closed) of course influence the transmission behavior (Chapter 11).

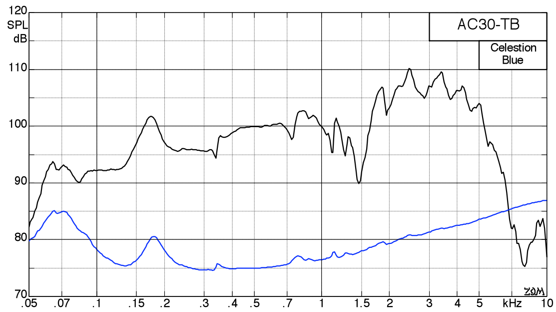


Fig. 10.10.33: SPL (d = 2m) and voltage level (lower curve). Reference: 1 W at 500 Hz.
SPL measured in the AEC on axis, sine sweep impressed onto the phase-inverter.
(N.B.: the parts of the figure not shown are reserved for the printed edition of this book.)

 Translation into English by Tilmann Zwicker

Taking the measurement not starting with the PI-input (as in Fig. 10.10.33) but starting with the input jack, the **tone filter** and other parts of the circuitry determine the transfer characteristic, as well. For the following measurements (**Fig. 10.10.34**), the tone filters were adjusted such that all amps had a similar, treble-heavy transmission; due to the limitations of some filters this was only possible as a rough approximation for several cases.

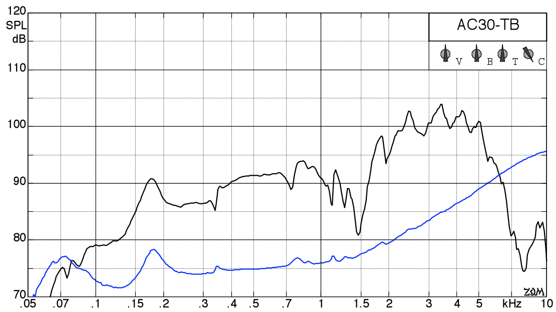


Fig. 10.10.34: SPL (*d* = 2m) and voltage level (lower curve).
SPL measured in the AEC on axis, sine sweep impressed onto the amplifier input.
(N.B.: the parts of the figure not shown are reserved for the printed edition of this book.)

As expected we find differences between the individual measurements. However, a comparison to the headroom-charts (Chapter 10.10.3) shows that the differences in the non-linear behavior are at least as big. As soon as an amplifier reaches substantial distortion, it is not sufficient anymore to merely determine the frequency-response (which, as stipulated by theory, is then anyway not defined anymore, either).