10.2.3 Mixing stage

Most guitar amplifiers feature more than a single "channel" i.e. there are several input jacks that are associated with different amplifier branches. These branches may vary in sound, in the distortion and/or in switchable effects. All branches are, however, fed to one and the same power amplifier, and this requires that the respective signals be added. Rather then the term "adding", the term "mixing" is often used – note that this does not refer to the process of the same name used in RF-engineering and designating circuits for frequency conversion. For the present context, we mean: **mixing = adding**.

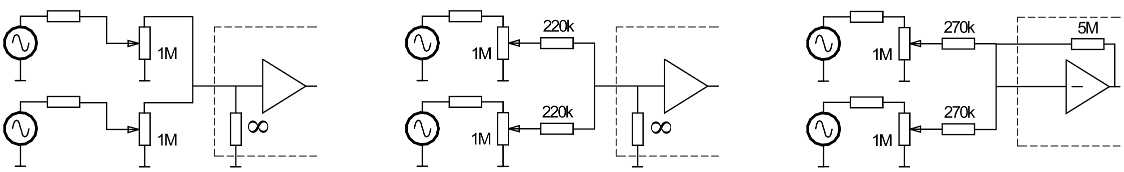

Fig. 10.2.17: Circuit concepts for signal addition: reverse-mode, standard-mode, active-mode (left to right).

Three often-implemented circuit concepts are shown in **Fig. 10.2.17**. The so-called reverse-mode was often found in early amplifiers; it was soon replaced by the standard-mode. Passive circuitry has the general disadvantage that the potentiometers influence each other: if the volume control in one channel is fully up (α = 100%), and if the second volume control is now also turned up (β = 100%), the gain factor of the first channel can be reduced by up to 6 dB because of the mutual loading between the two channels. **Fig. 10.2.18** shows this influence dependent on the center-tap position of the respective other potentiometer (β).

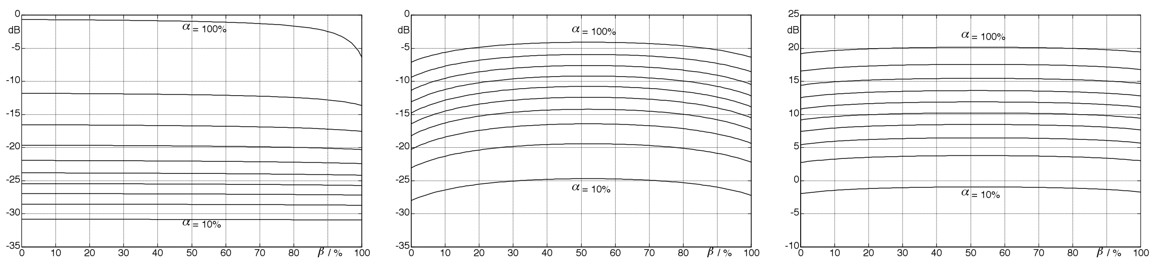

Fig. 10.2.18: Mutual influence of the two potentiometers; α = CH1, β = CH2. Figures assigned as in Fig. 10.2.17. Potentiometer = 1 MΩ, mixing resistors = 220 kΩ and 270 kΩ, respectively. Passive modes: gain up to the summation point. Active mode: gain incl. tube stage (v = -50).

The internal impedance of the sources (amounting to about 40 kΩ for triode-amplifier stages in common-cathode configuration: tube // plate-resistor) has an effect on the "counter-side" as the potentiometers are turned up, and attenuates the "other" signal. Additional summation-resistors (in series with the potentiometer center-tap) reduce this effect for the **standard-mode**. In the Fender Deluxe 6G3, for example, we see 220-kΩ-resistors at this point in the circuit, but there are also amps that use 470 kΩ (e.g. the Bassman 6G6). Larger summation-resistors give a higher-degree independence of the controls but do have the disadvantage that noise is likely to increase, and that the treble-response will probably get worse. In the third variant, the **active-mode**, a negative-feedback-resistor reduces the gain as well as the input impedance (current-voltage-feedback). Given high open-loop gain and strong feedback, the contra-lateral influence can be practically eliminated. A small dependency remains in the typical tube amp with $v = -(30 \dots 50)$ but this is practice is of no bother. As another effect of the negative feedback, maximum gain and harmonic distortion decrease.

Active mixing-stages are not often seen in guitar amplifiers: they surfaced in Fender amps in the mid-1950's (5E4, 5E5-A, 5D6-A) but disappeared again shortly afterwards. The standard-mode is by far the most often used, with mixing resistors of 220 – 470 kΩ. Moderately reducing the mixing resistors does not bring much advantage regarding the gain but increases the upper cut-off frequency (while deteriorating the mutual interaction). With the potentiometer center-tap positioned mid-way, the source-impedance that the following tube-grid "sees" is about $(P/4 + R)/2$, with P = potentiometer-resistance and R = mixing resistor. Typical values of this source impedance are found to be in the region of 250 kΩ. In conjunction with the tube-input-capacitance (up to 150 pF due to the Miller-effect), a 1st-order **low-pass** with a cutoff-frequency of 4 – 8 kHz results. In some amplifiers, the corresponding slight treble-loss is counteracted via a **bridging-capacitor** that bridges potentiometer and/or mixing resistor. This may be implemented only in one of the two channels because otherwise the effect would suffer. Manufacturers like to designate the channel modified that way with terms such as "Bright" or "Treble or "Instrument", while the other channel is dubbed "Standard" or "Normal".

In **Marshall's JTM-45**, a guitar amplifier from the early 1960's, the signal addition is done via two 270-kΩ-resistors in the beginning – just like in the Fender the JTM was modeled after. Soon, however, there is a change to 470-kΩ-resistors; these remain for several model generations. To compensate the associated treble-loss, bridging capacitors with model-specific value-variations are installed. The early Marshall amps were available in versions for guitar (lead), for organ, for bass and for use as PA, with the technical distinction between them mainly being the differing values of the bridging capacitors and the mixing resistors.

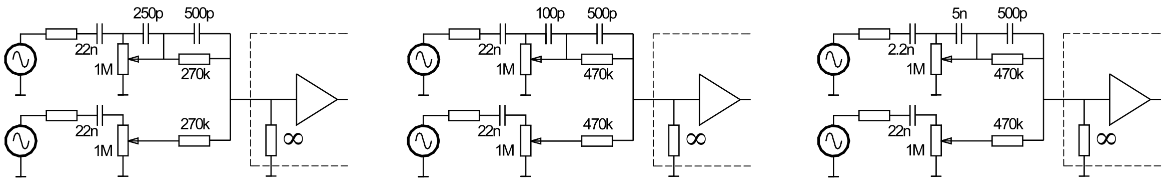

Fig. 10.2.19: Marshall-amplifier, adding stages with different-value components.

Fig. 10.2.19 shows three versions of the mixing stage; for the first (on the left), **Fig. 10.2.20** indicates the frequency-responses for different positions of the respective volume-control. The grey areas depict the ranges of mutual influence of the two controls. Depending on one's position in the hierarchy of Marshall-ites, these results may be interpreted as testimony to genius manifoldness, or as ghastly circuitry-botch-up.

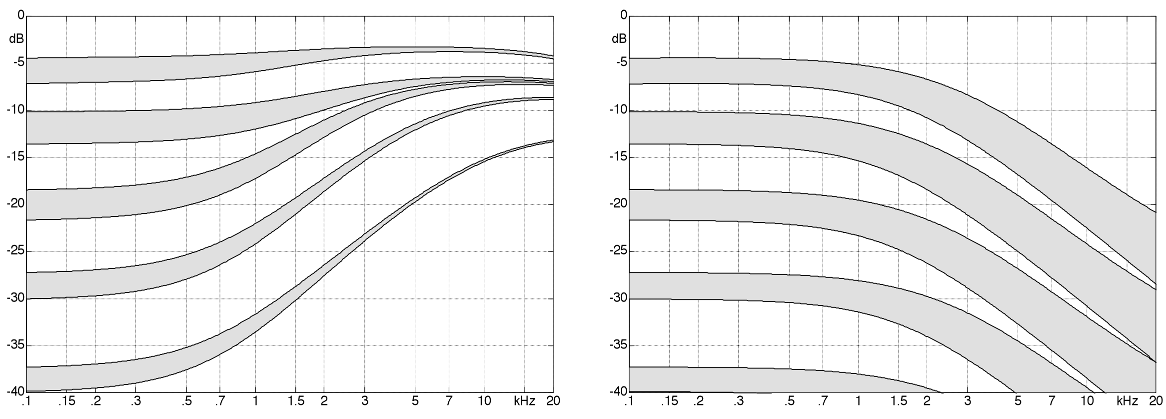

Fig. 10.2.20: Marshall JTM-45, mixing stage. Left: frequency-response of the "High Treble" channel, right: "Normal"-channel. The grey areas show the mutual influence between the two volume-pots.

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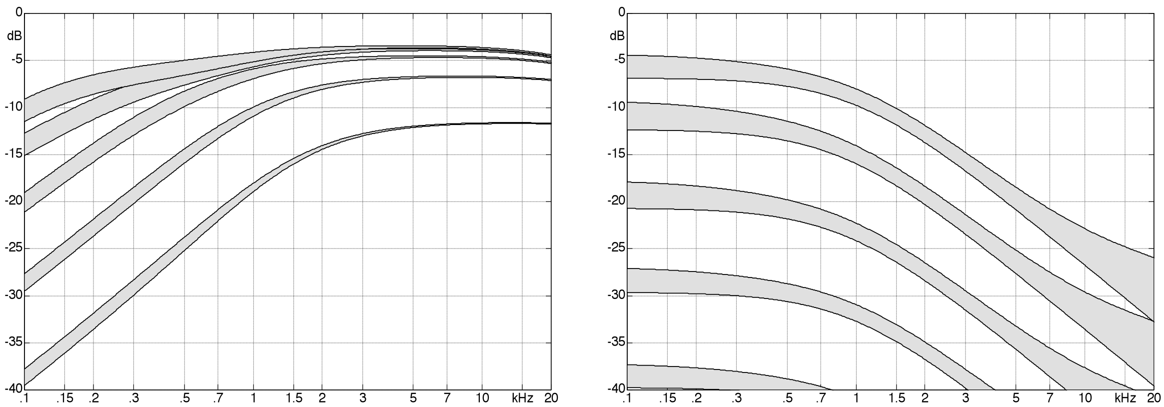

Fig. 10.2.21: Marshall Type 1987, mixing stage. Left: frequency-response of the “High Treble” channel, right: “Normal”-channel. The grey areas show the mutual influence between the two volume-pots

In **Abb. 10.2.21** we see the frequency-responses of the circuit shown on the right in Fig. 10.2.19. The change to the unusually large 5-nF-capacitor results in a special low-cut. Also, in the upper range of the volume control (i.e. where the user usually “lives”), it operates almost solely as an adjustable bass-cut. That is quite successful, as one can hear. The reduction of the coupling capacitor to 2.2 nF makes for an additional low-cut. Since apparently the sound was *still* not aggressive enough, the cathode-resistor was bridged not (as Fender would have it) with a large electrolytic capacitor, but with a 680-nF-capacitor (**Fig. 10.2.22**) that makes this stage run at maximum gain only for higher frequencies. At low frequencies, there is a slight negative feedback. Some Marshall amps had a further capacitor to bridge the cathode-resistor in the pre-amplifier, other completely dispensed with these caps. There is, after all, neither “the” Marshall-circuit nor “the” Marshall-sound.

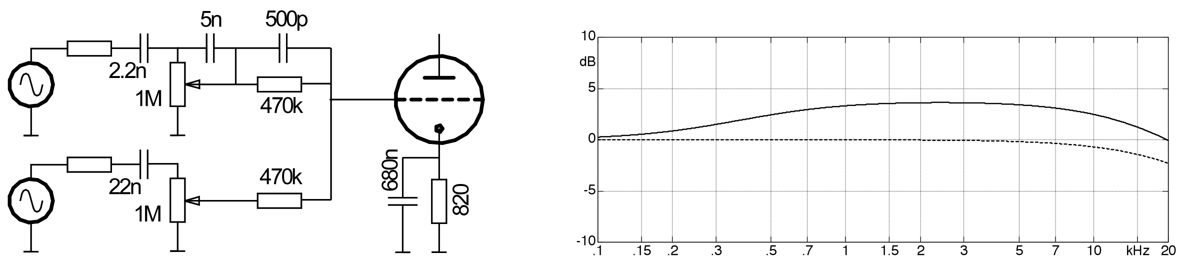

Fig. 10.2.22: Left: cathode-resistor bridged by a capacitor in the Marshall amp types 1987 and 1959. The right-hand picture shows the treble boost resulting from the cathode-capacitor.