10.8.4 Wah-Wah-Pedal

The Wah-Wah-pedal is an effects device performing speech-like formant-filtering. **Formants** are maxima in the speech spectrum that classify the speech-sounds [3]. The frequency F_1 of the lowest formant is about 400 Hz for the spoken vowel /o/, while for an /a/ it is around 800 Hz. If, while playing a guitar, a band-filtering is introduced with a time-variant center-frequency, and if the latter sweeps between 400 Hz and 800 Hz, we obtain a sound change that can be described by the vowel-sequence /oaoaoa/, or with "wahwahwah".

In some devices the filtering was achieved via an LC-filter, the coil inductance of which (or rather the air gap) was variable via moving a pedal. Most Wah-pedals, however, put to use an active filter circuit in which the filter capacitance is varied by changing the gain (Miller effect). This arrangement allowed for a sweep between about 400 Hz and 2 kHz – measurements with an old VOX-wah yielded 0.44 – 2.3 kHz. The boost of the frequency range around 2 kHz is typical for the formant of an /i/, so that using the full range of the pedal results in a vowel-sequence akin to /oaiaoaiao/. More sophisticated devices (marketed with the designation 'Yoy-Yoy' or 'Doing-Doing') offered two synchronously tunable filters – presumable to more precisely imitate the human voice. Tempi passati – long bygone times.
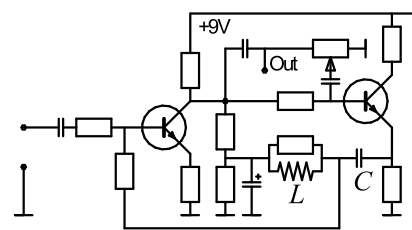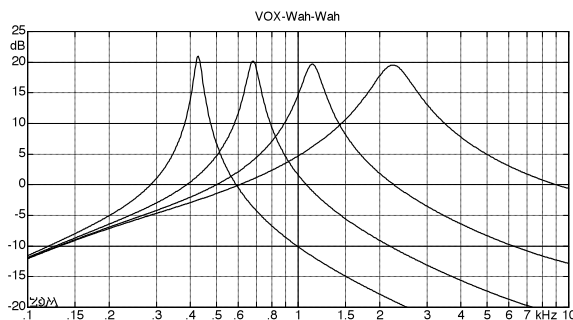

Fi. 10.8.19: Wah-Wah-pedal (VOX).

Fig. 10.8.19 shows the circuit as well as some transmission-frequency-responses of a VOX-Wah-Wah. The inductance (about 0.5 H) and the capacitance C (10 nF) determine the centre-frequency of the filter – the capacitance is however enlarged in its effect by the factor of the gain (0…27). The capacitance effective for the filter is thus 10…280 nF resulting in a pole-frequency of 0,44…2,3 kHz. Apart from some copper- and ferrite-losses, the resistor (33 kΩ) that is connected in parallel to the coil determines the **Q-factor of the filter**; the latter also depends on the centre frequency. From the systems-theory point-of-view, a pole-Q-factor and a (different) zero-Q-factor could be specified, but in practice the "Q-factor" usually is determined using the 3-dB-down-bandwidth. For the above circuit, this definition yields $Q = 3.3…15$.

"**Auto-Wah**" is the designation for a Wah-Wah-filter that automatically controls its center frequency. The control parameter is the signal strength i.e. approximately the loudness of the guitar signal. Without any signal, the system tunes to the lowest possible center frequency. As the strings are plucked lightly, the centre frequency rises slightly, for strong picking the band-filter quickly sweeps from low to high frequencies and returns more slowly to the starting state. This picking-strength-dependent filter-control enables the guitar player to use the wah-wah-effect without having to operate a pedal. There will be less versatility but also less stress for the foot.