6.9 Microphonics

Piezo pickups do not only react to vibrations caused be the guitar strings (desirable), but also to vibrations generated by the airborne sound impinging on the guitar (not desired). A sound-wave arriving at the top of the guitar sets the bridge (and thus also the pickup) in motion. Since due to its mass- and spring-loading, the small piezo plate will not join in with this movement in an identical fashion, and a change in thickness generating a corresponding piezo-voltage will result. If the latter is amplified and reproduced by a loudspeaker positioned close-by, a loud feedback-howl might happen. The following investigations will target the quantitative description of this sensitivity to airborne sound (termed “microphonics”).

In systems theory, the term **feedback** designates a signal path back to the input; this may be in-phase (positive feedback) or with opposite phase (negative feedback). In the studio- or stage-environment, the term “feedback” usually indicates that the feedback loop has already reached self-excitation, and oscillation occurs in the form of howling or whistling noises. Self-excitation requires a value of equal to or larger than one for the magnitude of the loop gain, and a phase of 0°. For example: a microphone generates a voltage of 50 mV at an SPL of 1 Pa, and a loudspeaker fed from this microphone generates, at the location of the microphone, an SPL of 1 Pa from an operation with 10 V input voltage. If the microphone voltage is amplified by a factor of 200, feedback howling could start (given a matching phase shift).

In practice, reaching self-excitation depends on many details: the directivity of microphone and loudspeaker, the filters, the transmission function of the room. With the **Ovation** Adamas-SMT guitar as test-object, the following will exemplarily illustrate the difference in feedback-sensitivity between operation with a microphone, and operation with the pickup. Other guitars, other speakers and other rooms will lead to similar but of course not identical scenarios.

If an acoustic guitar is to be captured and amplified live via a microphone, we will try to position the microphone as close as possible to the guitar. In this setting, the top of the guitar will act as a reflector that may, depending on the circumstances, direct the impinging sound in an unfavorable manner to the microphone. **Fig. 6.26** depicts a setup as it was put together in the anechoic chamber for orientation measurements. A loudspeaker radiated sound to a guitar that had a measuring microphone (B&K 4190) set up in front of it. The right hand graph shows the comb-filer effects caused by the reflections.

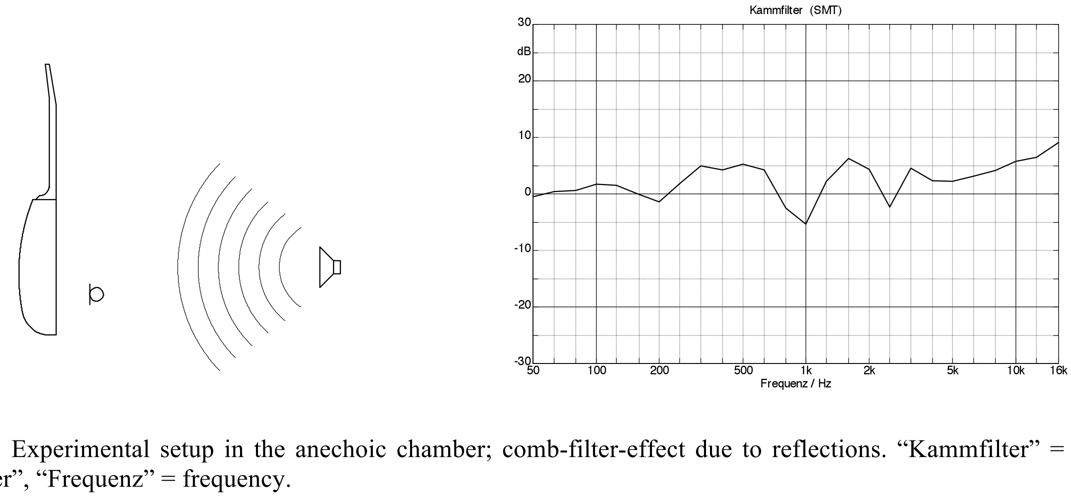

Fig. 6.26: Experimental setup in the anechoic chamber; comb-filter-effect due to reflections. “Kammfilter” = comb-filter”, “Frequenz” = frequency.

At low frequencies, the dimensions of the guitar are small compared to the wavelength, and the reflections are insignificant. Around 200 Hz, the guitar acts as an absorber – and at mid-range frequencies we see the typical **comb-filter** peaks. Due to the irregular shape of the guitar, the diffraction waves have slightly different delay times, with the result being that at high frequencies we find an even curve. The increase in the two highest octaves is due to the microphone directionality: nominally, the 4190 is omni-directional, but at high frequencies it does feature increasing beaming – as do all ½"-microphones. With studio-microphones having stronger directionality, the corresponding effects will show up already in the mid-frequency range. Such microphones may be able to attenuate the sound coming from the loudspeaker, but not the sound reflected by the guitar. This example is meant to highlight *that* the guitar as reflector can distinctly deteriorate the resilience against feedback. The degree of this deterioration (and its frequency-dependency) will be a function of the given microphone-distance and –directionality, and of the specific guitar- and microphone-geometry.

To arrive at a statement regarding the sensitivity to feedback in the piezo pickup, we first need to take care that the microphone and the piezo lead to the same sound. For this reason, the microphone signal was filtered such that the same transmission function was achieved with both microphone and piezo. In a second step, we introduced a slight mid-cut, combined with a slight treble boost – adjusted according to artistic criteria. Both via microphone, and via piezo, the sound of the guitar corresponded to the taste of the guitarist. Now the guitar was subjected to the sound emitted by the loudspeaker according to Fig. 6.26, and the loop gain was measured (**Fig. 6.27**). The origin of the ordinate was assigned to the maximum of the airborne sound.

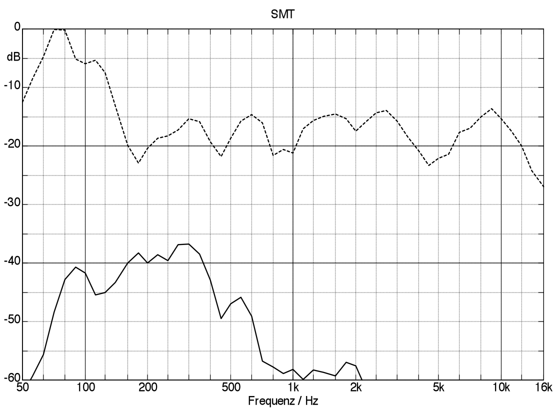

Fig. 6.27: loop-gain for microphone-use (---) and for piezo-use (——). Both transmission paths equalized for the same sound. "Frequenz" = frequency

Fig. 6.27 shows a high loop-gain in the bass range when using the microphone pickup – this will quickly lead to howling feedback as the volume-control is turned up. Clearly, the filtering used here is unsuitable for live-conditions, and it will be mandatory to attenuate the bass – and make do with a more "slender" sound. Not that the latter would be unusable; it is just less full than the sound heard from the unamplified guitar. Compared to using the microphone with the attenuated bass, the piezo offers – in this example – an advantage of 20 – 25 dB. This is the degree to which the level generated by the loudspeaker can be increased before feedback occurs. As already mentioned, this value is for orientation – in every individual case, many parameters will determine the onset of feedback. In any case, however, the differences are so pronounced that a piezo bridge-pickup will always drastically reduce the danger of feedback.

