Loudspeakers for Guitars

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Historically, loudspeakers for electric guitars have had one main objective: they are to be LOUD. While for studio- or HIFI-speakers resonances are dampened via absorbers, the opposite holds for many guitar applications. The latter show many peaks and valleys in their transfer curve - which is indeed exactly what generates the desired sound. It is common knowledge that both alnico and ceramic magnets can support excellent sound quality - less widely known is the fact that the material (type of wood) used for the actual speaker box does not really contribute anything to the sound.

Loudspeakers have the job to generate sound i.e. air waves from electric current. For studio monitors this should happen in a very controlled way - for guitar speakers less so. The transfer coefficient of studio monitors needs to be independent of frequency while guitar speakers show strong deviations over frequency. These however need to be there so that the desired sound happens. Other than the transducers (i.e. the speaker chassis) themselves, the enclosure housing them has a significant influence. However, it is not the type of wood that is important but the enclosure dimensions. Which type of wood is used does not play any role as long as the enclosure walls are sufficiently thick. Looks and weight may profit from whether birch, fibre-board or chipboard are utilized - for the sound this is of no consequence. For the "standing waves" occurring within an enclosure, width, height and length are the frequency determining factors. The enclosure walls do vibrate, however compared to the effect of the vibrating loudspeaker membrane their effect on the sound is negligible. Fig. 1 shows measurements of the SPL generated in the anechoic chamber by a constant alternating voltage of 2,8 V at 1 m off the front of three loudspeaker enclosures of identical dimensions and construction but using three different kinds of woods. The black line designates pine while the red line is for poplar and the blue line for fibre-board. The differences are so small that the human hearing system cannot make any distinction.

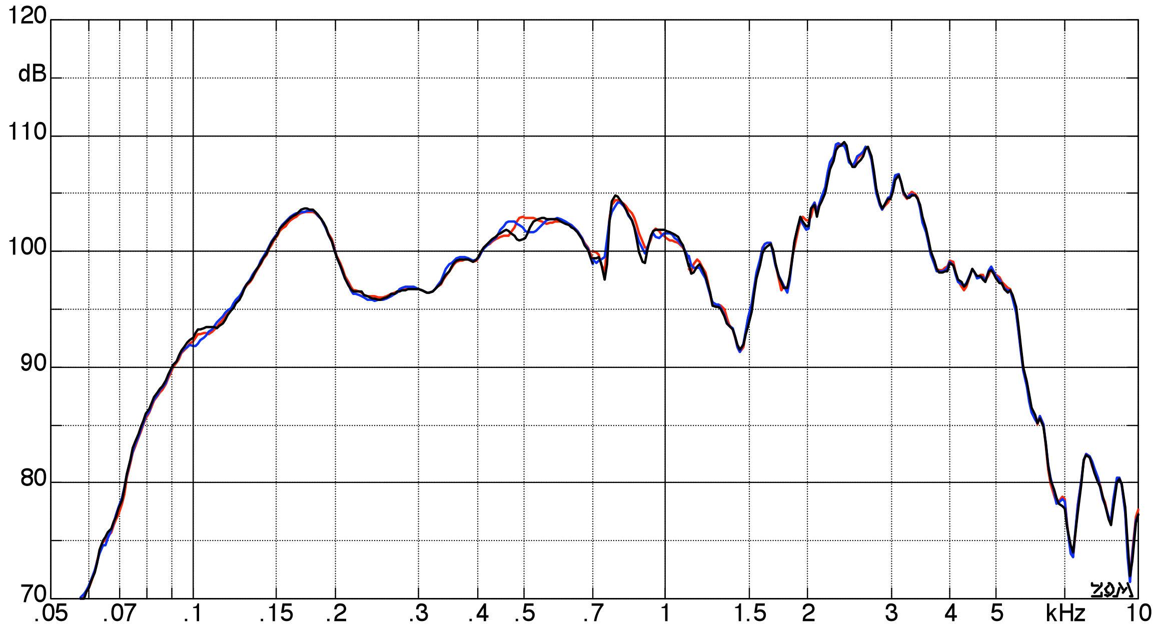

Fig. 1: SPL-measurement: enclosures of identical size and shape: pine (black), poplar (red), MDF (blue).

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The covering of the enclosure (e.g. Tolex or Naugahyde) has no influence on the sound – the cloth in front of the speaker-chassis however can. For example, some heavy cloth types used by Marshall for some of their boxes can attenuate high frequencies by about 1 dB per layer while the cloth Fender used on their Silverface amps has practically not attenuation at all.

One of the most important loudspeaker parameters is the electro-acoustic efficiency. Normally, this is not given as a percentage but by the sound pressure level generated at a distance of 1 m by an input power of 1 W. Some 12" speakers easily reach averaged SPL-values of in excess of 100 dB while low-efficiency HiFi-speakers may conversely generate less than 80 dB. To give the maximum reachable loudness, the power rating of a loudspeaker is insufficient. Only both power rating AND efficiency in combination point to maximum loudness. For example: if a speaker has a given efficiency of 80 dB / 1 W / 1 m and a power rating of 100 W, the maximum SPL which can be generated in 1 m distance is 100 dB. Another speaker with an efficiency of 100 dB / 1 W / 1m and a power rating of merely 30 W will generate 114,8 dB with this input power. The second speaker will generate the maximum SPL of the first speaker (operating at 100 W input power) at only 1 W input power i.e. it has in comparison a lot of reserves.

Here are a few examples (data given by the manufacturers):

Type	max. power handling / W	dB/1W/1m	max. SPL (in 1m) / dB_{SPL}
Celestion G-10-C30	30	94	108.8
Celestion G-10-T100	100	97	117
Celestion G-12H	30	100	114.8
Celestion G-12M Greenback	25	97	111
Celestion G-12H-100	100	100	120
Celestion Vintage-30	80	100	119
Celestion Powercell 12-150	150	94	115.8
Celestion Powercell 15-250	250	99.5	123.5
Jensen P-12R	50	95	112
Jensen C-12K	200	99	122

To feed such high power levels to the loudspeakers without too much loss, hefty cables are customary. This is often exaggerated although the scientific basics are quite simple: your typical shielded guitar cable will be woefully inadequate, the robust but simple power cable you can pick up at the hardware store will be perfect. Some manufacturers will go to great lengths and put forth complicated effects such as relaxation, skin effect, copper oxidization, lattice preferences, etc. While this is commendable as a sales effort, the simple truth is that for guitar speakers we are not dealing with radio frequencies but with low frequencies up to about 10 kHz. In this frequency range, every cable with a (copper) cross section of 1,5 or more square millimeters will do fine. For more details see the book "Physics of the Electric Guitar", Section A.8.

The loudspeaker impedance (e.g. 8 or 16 Ohms) should be a match to the amplifier. There is no given rule how to measure or specify the impedance - it is typically measured using a frequency between 300 and 1000 Hz. Simple DC resistance instruments can therefore not yield a comparable value. The pure Ohm measurement from such devices will give a lower value compared to the "impedance". Typical 8-Ohm-speakers will show about 6 - 6,5 Ohms pure resistance but are still specified at 8 Ohms.

Although a slight mismatch is not likely to do any harm, in general such an 8-Ohm speaker should be matched to an 8-Ohm amplifier-output. For tube amplifiers, a load impedance smaller than specified (e.g. using an 8 Ohm speaker with a 16-Ohm amplifier output) can overload the plates of the power tubes. A higher load impedance can overload the screen grids and cause excessive voltages throughout the output stage. For transistor amplifiers, there will be normally no negative effect if the load impedance is too high (other than the maximum power offering will not be exhausted) - for too low a load impedance there might be ugly distortion, or the power stage might shut off. Older transistor amps could even break down completely. As a rule, tube amplifiers do better with a mismatch involving a too low speaker-impedance-rating, transistor amplifiers easily accept a too high impedance.

Recording the sound radiated by a loudspeaker with a microphone is a science in its own right. Finding the right position can be a lengthy process. The basic rule is: the sound one perceives in a normal listening position (i.e. several meters away from the loudspeaker in a live room) is not the sound that a near-field microphone will capture. First, with increasing distance from the speaker room reflections and reverb will play a bigger role. Second: a loudspeaker is not a point source of sound but the closer one gets to the speaker with a microphone, the more one captures only that specific point of the membrane which results in a very special filtering effect. The latter can actually sound really good and possibly even better than a reverb-drenched recording from a distance - but then again, it may sound worse.

Fig 2. shows how the frequency response changes when bringing the microphone as close as 2 cm to the speaker membrane. The corresponding SPL-increase has been calculated out. The strong frequency dependency is the result of interferences of the sound waves arriving from different points of the membrane.

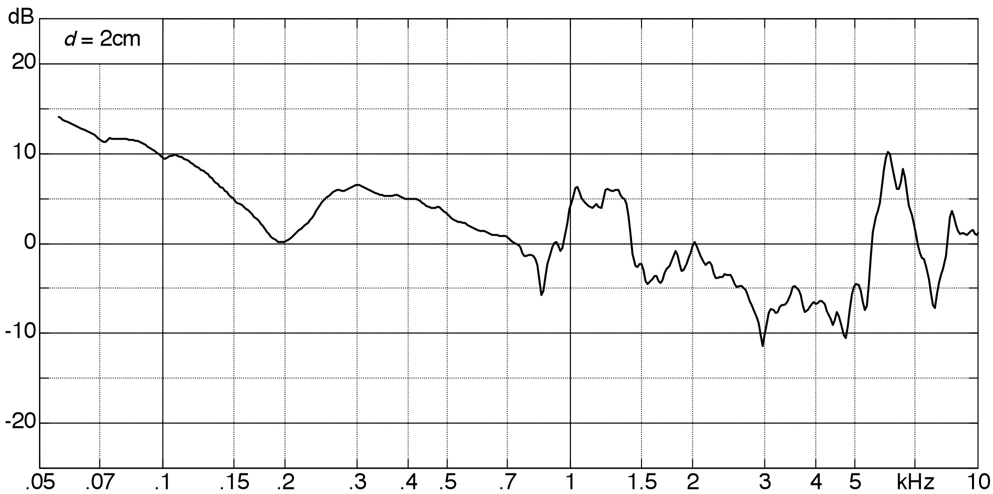

Fig. 2: Change of the speaker frequency response as the microphone is brought closer from 1 m to 2 cm. The additional 1/r-characteristic was taken out. The speaker is a Jensen P12R.

Open-back enclosures require a further consideration: not just the front of the membrane radiates sound into the room, but the rear as well. It may in fact be interesting to record this sound from the rear with a separate microphone and mix it with the signal from the front mike. Usually, it will be necessary to invert the phase of one microphone because the two sound waves are out-of-phase.

High-efficiency speakers can easily generate SPL-values of in excess of 140 dB directly in front of the membrane. Most studio-quality condenser microphones are not up to such levels and could even be terminally damaged. Dynamic microphones may or may not be up to the task - user discretion is certainly advised!

More about loudspeakers in Zollner M.: **Physik der Elektrogitarre**, Kap. 11, www.gitec-forum.de (translation in progress)

 Translation by Tilmann Zwicker