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Damping for Loudspeakers: Acoustical and Electromagnetic

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The most prominent resonance displayed by a loudspeaker is the bass resonance which, if lightly damped, is most objectionable, giving rise to "one note bass", "hang-over", and poor transient response. For any set of conditions and for any one listener, there is an optimum amount of damping, to give the most pleasing results. It is important to remember that the amount of damping has only a small effect outside the region of the bass resonant frequency. Taking a typical case with a bass resonant frequency as 85 c/s, the effects of damping would be small above 150 c/s.

Introduction to damping

Loudspeakers have some damping inherent in the speaker, but all additional damping to meet the requirements of good musical reproduction must come from external electro-magnetic or acoustical damping, or both. Most modern amplifiers and radio receivers use negative voltage feedback to give a low output resistance, that is, a high "damping factor". Damping factor is defined as R_L/R_o, where R_L is the nominal load impedance and R_o is the amplifier output resistance. High fidelity amplifiers are sometimes advertised as having very high damping factors. E.g. 45, or in another case infinity. This term "damping factor" is quite misleading, since the damping is in no way proportional to the damping factor. The writers prefer to express this in the alternative inverse form where the output resistance is given as a fraction or percentage of the load resistance (Ref. 1). Thus an output resistance of zero (corresponding to a "damping factor" of infinity) gives a more accurate impression, particularly the non-technical person. However, the use of the term "Damping Factor" is so strongly entrenched that it cannot be displaced, and it will therefore be used in this article.

The effects of damping are shown by the equivalent circuit of Fig. 1 (Ref. 2). This may be applied to an infinite flat baffle merely by short-circuiting C_v. It will be seen that this is a series resonant circuit, with an applied voltage E_s across R, L and C in series. The Q of the circuit is given by

$$Q = \frac{2\pi f\ L_u}{R_s + R_u} \qquad (1)$$

and the acoustical output of the loudspeaker is proportional to E_{Lv}.

$$\text{Now } R_S \propto \frac{B^2}{R_o + R_{vc}} \text{ at low frequency} \qquad (2)$$

where B = flux density in gap
R_o = output resistance of amplifier referred to the voice coil circuit
and R_{vc} = resistance of voice coil.

Two important facts are shown by eqn. (2). The first is that, so long as R_o is positive, the damping is limited by R_{vc}, and changing R_o from 10 to one-tenth of R_{vc} to zero (i.e. changing damping factor from 10 to infinity) only effects the damping resistance by 10%. The damping can only be truly infinite if R_o is made negative—ways of accomplishing this result will be described later in this article.

The second important fact shown by eqn. (2) is that R_S is directly proportional to the square of the flux density and inversely proportional to $R_o + R_{vc}$. Loudspeakers with low flux density may have insufficient damping even when R_o is made zero, whereas those with high flux density may be too heavily damped when R_o is zero. It is thus quite obvious that it is impracticable to select any value of "damping factor" which will give optimum results with any loudspeaker.