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Loudspeaker Damping

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Part 1. A discussion of theoretical considerations of loudspeaker characteristics, together with a practical method of determining the constants of the unit as a preliminary step in obtaining satisfactory performance.

One of the considerations in the design and application of loudspeakers is the adequate damping of their motion. Thus, owing to the masses and compliances involved, the sudden application or removal of current in the voice coil tends to produce a transient oscillation of a damped sinusoidal nature.

In particular, the sudden cessation of current in the voice coil may find the loudspeaker continuing to vibrate in the manner described, so that the sound "hangs over". Any one who has experienced this unpleasant effect will seek ways and means to eliminate it.

In the case of a horn type loudspeaker, the horn imposes in general sufficient mechanical loading to damp out such transient response of "hangover", and also serves to limit the excursions of the voice coil so that it does not operate into the nonlinear portion of the air-gap magnetic field. The damping also serves to minimize nonlinear compliance of the suspension system by limiting the amplitude of oscillation.

However, if the horn design is limited by such considerations as maximum permissible mouth area and is operated at a frequency not too low to be transmitted by the horn taper yet low enough so that appreciable reflections occur at the mouth, then the horn may cease to act as a mechanical resistance, but instead become predominantly reactive, and thereupon cease to damp a resonance in the speaker unit occurring in this frequency range. In such an event other means of damping will be of value to the designer or applications engineer.

In the case of the direct-radiator loudspeaker unit, the air load is small, and is mainly reactive at the lower frequencies. Hence mechanical damping of the unit is small in magnitude, and "hangover" effects may be particularly noticeable.

A reflexed cabinet may help to load the loudspeaker, or at any rate to produce a two-mesh mechanical network exhibiting two resonance peaks, neither of which is as high as that of the unit by itself or in a flat baffle. Nevertheless, the damping may still not be sufficient to produce "clean" low-frequency tones.

Hence, in general, it is advisable or at least desirable to provide sufficient damping of the direct-radiator type of unit by means of its electrical characteristics, so that whether it is operated into a horn, reflexed cabinet, or simply a flat baffle, it will be adequately damped.

An important point about electrical damping is that it represents high rather than low efficiency of operation, just as a horn does. On the other hand, were some material such as viscaloid employed to provide the required damping, the electrical input power would in part at least be converted into heat energy in the material instead of into acoustic energy, and thus represent a decrease in efficiency. It will therefore be of interest to examine damping produced by the electrical characteristics of the system.

Motional Impedance

When an alternating current flows in a voice coil, it reacts with the constant magnetic field to produce an alternating force which causes the voice coil to vibrate at the frequency of the current.

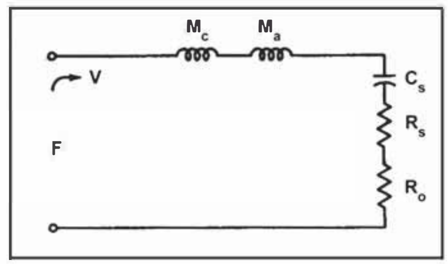

Fig. 1. Equivalent circuit of loudspeaker unit at low frequencies.

In so doing, the voice coil cuts through the magnetic lines, and generates a counter electromotive force, c.e.m.f.

The action is exactly similar to that of the rotating armature of a d.c. motor – the armature generates a c.e.m.f. by its rotation in the magnetic field. Consider the case of the loudspeaker voice coil. The electrical c.e.m.f. which is generated, tends to oppose the flow of current in the coil, just as if its impedance had gone up. After all, one ohm of impedance simply means a one volt drop in the unit for a one-ampere current flowing through it; i.e., volts per ampere. In the case of the loudspeaker the force,

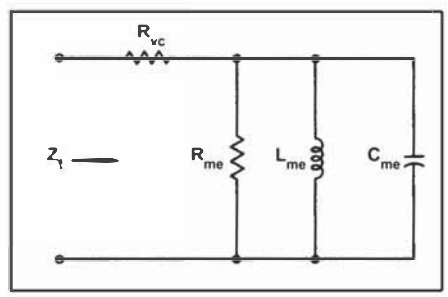

Fig. 2. Mechanical characteristics of speaker seen from voice-coil terminals.

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