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Equivalent circuit models derived from finite element models using structural dynamics techniques

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Electroacoustic transducers can be divided into an active part, the driver, and a passive part, the structure. The driver ensures electromechanical transduction, while the structure performs various mechanical and acoustical functions, such as support, shock and pressure protection, and impedance transformation. For design purposes, one often needs an equivalent circuit model which gives a relationship between the acoustic characteristics of the overall device and that of its components. Transducer equivalent circuits are usually either physical or modal. Physical equivalent circuits lend themselves to the treatment of a transducer as an assembly, but in general yield frequency dependant parameters. Modal equivalent circuits are more adequate for resonant transducers, but describe transducers as a whole. This works shows how these two types of equivalent circuits can be obtained from a full finite element model by using common structural dynamics techniques: substructuring and modal expansion. It also shows that a third, hybrid type of equivalent circuit can be obtained by using a component mode synthesis technique derived from the Craig-Bampton method. This hybrid equivalent circuit combines the advantages of physical and modal equivalent circuits, enabling to express transducer modal parameters in terms of driver and structure modal parameters.