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**Driver-Array Based Flat-Panel Loudspeakers: Theoretical
Background and Design Guidelines**

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Abstract

This thesis relates to the simulation and design of flat-panel loudspeakers using moving-coil driver elements. A brief history of the industry is given, including a collection of products and patents from 1925 until the present, an overview of research papers, and a discussion of current products available. The mechanics of bending flat panels are developed with respect to localized driving forces, both in the frequency domain and the time domain as an impulse response. These simulations are compared to measurements on prototype panels. Additional resonant systems influence the behavior of the system: an optional ported box and the resonant characteristics of the drivers. The governing equations for these systems are derived and solutions are implemented using equivalent mechanical circuits and a numerical approach. The idea of using driver arrays to independently actuate modes of the panel is discussed at length, with respect to modal addressability, modal spillover, and experimental validation. The numerical approach to determining the optimal driver placement for a given set of modes is derived and experimentally validated. An investigation of the acoustic behavior of flat panel loudspeakers is presented, using mechanical simulation results to predict acoustic radiation. The simulations are compared to measurements and found to be very accurate. It is demonstrated that a driver array, with the proper biasing, is capable of creating a flat-panel loudspeaker which acts more like a piston than a "diffuse radiator" flat-panel loudspeaker. The techniques of "Modal Crossover Networks" are introduced, which use multi-band filters to bias the driver array differently for different frequency bands, optimized for audio reproduction. The question of how many drivers are necessary for a modal crossover network is addressed and found to be dependent on the estimated quality factor (Q) of the panel material and edge conditions.