Learning Piezoelectric Hysteresis in In-Ear MEMS Loudspeakers from Acoustic Measurements

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Abstract

Piezoelectric MEMS loudspeakers represent a viable technology for in-ear audio applications, offering several key advantages for the audio market geared towards miniaturization. Yet, their nonlinearities, particularly hysteretic effects in electro-mechanical transduction, pose challenges for accurate modeling and distortion compensation. We address this by introducing a hybrid MEMS loudspeaker equivalent circuit model that embeds a Recurrent Neural Network (RNN) to represent hysteretic transduction as a nonlinear predistortion block, driving a Wave Digital Filter (WDF) implementation of a linear equivalent circuit model of the loudspeaker mechanical and acoustic domains. The RNN is trained end-to-end within the differentiable WDF simulation using voltage–pressure measurements. Experiments confirm close agreement with measured responses and highlight the model potential for MEMS loudspeaker linearization applications.