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Time-domain modeling of porous media acoustics

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Sound waves propagating in porous media are subject to strong dissipation and dispersion. This paper elaborates upon several recent publications by the authors regarding the time-domain description of these effects. The foundation is a relaxational description of the viscous and thermal dissipation in a rigid porous medium, which is shown to possess an exact, analytical conversion from the frequency to the time domain. The complex density and bulk modulus operators transform to temporal convolutions between a causal response function and the acoustic field variables. When the convolutions are neglected, the equations reduce to the well known Zwikker-Kosten phenomenological model. The relaxation function can be inverted to provide an equivalent time-domain formulation from the complex volume and compressibility operators. Although a direct time-domain transformation of the specific impedance from the relaxation model has not been found, an accurate broadband approximation thereof can be transformed. The resulting time-domain boundary condition (TDBC) describes the absorptive and reactive response of the material. The response of the boundary decays slowly, as the inverse square root of time, but efficient numerical procedures are formulated that allow the TDBC to be approximated with a small number of recursive filters.