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An analytical model for piezoelectric/elastic axisymmetric bender disks radiating in water

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Flextensional transducers have been widely studied for low frequency SONAR application due to the low celerity of the flexion wave. In this work, we will describe in detail a complete analytical model for an axisymmetric disk made of one elastic plate on which two piezoelectric disks of smaller radius have been reported on each side. The model, starting from flexural axisymmetric theory and from the piezoelectric equations, finally comprises local radiation impedance and mutual coupling with neighboring disks. In particular, we will explain the continuity conditions that are to be imposed at the external radius of the piezoelectric disk. We also show how to include a radiation force opposed and proportional to the normal velocity inside the analytical solution given by a fourth order differential equation. The described model is then able to compute a large number of parameters such as Eigen modes, harmonic admittance, radiated pressure, coupling coefficient and static and dynamic stresses. The validity of the model is assessed by comparison to solutions of the coupled problem in water using classical FEM/BEM. We will show an extremely good agreement enabling us to use this simple model for geometry optimization and design improvement.