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Non-negative intensity of a passively controlled underwater cantilever panel subject to turbulent boundary layer excitation

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ABSTRACT

Hydrofoils are subject to random pressure fluctuations due to the presence of a turbulent boundary layer (TBL) that forms due to incident turbulent flow. This results in unwanted structural vibration and noise that propagates to the surrounding environment. In this study, a passive control strategy is implemented to mitigate the vibroacoustic response of a fluid-loaded cantilever panel using shunted piezoelectric elements, in which a shunt circuit consists of a resistor and an inductor connected in series. A cantilever panel completely immersed in an infinite acoustic free field of water can be considered a simplified model of a hydrofoil. An analytical model of the underwater panel equipped with shunted piezoelectric patches is developed with the Rayleigh-Ritz method, and the random forcing functions due to turbulent boundary layer excitations are modelled with the wall pressure spectrum described by a semi-empirical TBL model. This analytical model of an underwater cantilever panel is verified against a finite element model that ingests uncorrelated wall plane waves targeted to the same wall pressure spectrum model. Finally, non-negative intensity, which identifies the regions on a vibrating surface that produce acoustic radiation to the far field, is evaluated at the surface of the panel to demonstrate the effectiveness of the control strategy.