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Dynamics of nonlinear fluidic energy harvesters and arrays

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ABSTRACT

Unique opportunities exist to increase the power harvested with fluidic piezoelectric generators by almost two orders of magnitude higher than existing methods by exploiting dynamic nonlinearities and deploying multielement arrays in carefully selected positions in a flow field. These ac-coupled generators convert fluid kinetic energy, which otherwise would be wasted, into electrical energy. The available power in a flowing fluid is proportional to the cube of its velocity and if it is properly harvested can be used for continuously powering very small electronic devices or can be rectified and stored for intermittent use. Our earlier and current experimental and analytical works involving the testing of short length, flexible piezoelectric energy harvesters with different tip shapes in a large scale wind tunnel under resonance and random excitation have shown that it is possible to generate high levels of voltages through interactions with uniform flows, vortices, and turbulence in a boundary layer or in nearly homogeneous and isotropic flows. Additional experimental study has shown that nonlinear arrays of such energy harvesters can produce high output voltages in a very broadband range of frequencies. In our study, we investigate the effect of geometric parameters such as spatial arrangement of and the mutual interference between the elements of a nonlinear array have on their overall performance and efficiency characteristics. The study also includes the synergistic development of analytical and computational tools based on the nonlinear van der Pol oscillator and the lattice Boltzmann method in Finite Element formulation for a Large Eddy Simulation platform, which are being used to obtain pertinent performance parameters.