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Optimized vibration harvesting system based on piezoelectric transducer and impedance matching voltage converter

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Mechanical energy in form of unintended mechanical vibrations arises in many applications of wireless sensors. Piezoelectric materials offer an outstanding performance for converting mechanical energy into electrical energy. Since those materials can, therefore, be utilized to provide electrical energy for wireless sensors, we get rid of batteries or at least extend recharge intervals. However, the challenge in such energy harvesting systems is the matching of exciting vibration source, piezoelectric material and electronic interface.

In this contribution, an energy harvesting system consisting of a piezoelectric transducer and a voltage converter is studied. The piezoelectric transducer comprises a piezoceramic material (e.g., M1100 from Argilon) featuring high piezoelectric charge constants as well as a vibrating cantilever, which is equipped with an additional tip mass. The voltage converter exploits inductive and switching devices to achieve an optimal matching of piezoelectric transducers and electronics. With the help of a feedback loop, the switching frequency of the converter is adapted to achieve the maximum power output depending on the electrical input signal. The voltage converter also exhibits an energy storage element, which is controlled at the optimum level to ensure the best efficiency of the converter.

By means of appropriate finite element (FE) simulations, we are able to compute the electrical energy provided from the piezoelectric transducer. Moreover, the interaction of piezoelectric transducer and subsequent electronic circuit is considered in a hybrid simulation approach through coupling of a reduced FE system with Matlab Simulink. We present a selected piezoelectric energy harvesting system, which is extensively characterized regarding its mechanical and electrical properties (e.g. vibration behavior).

Keywords: Energy Harvesting, piezoelectric materials, voltage converters, numerical simulation