Energy Harvesting from Ambient Vibrations

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Abstract

The power harvesting technologies for low-power electronic devices, such as wireless sensor networks and biomedical sensor applications, has received a growing attention in recent years. Piezoelectric transducers are one of proved viable solution to collect energy from ambient vibrations. We are going to present the development of three piezoelectric MEMS generators, {3-1} mode, {3-3} mode and bimorph form, which have the ability to scavenge mechanical energy of ambient vibrations and transform it into useful electrical power. The three piezoelectric MEMS generators are all cantilever type made by a silicon process and which can transform mechanical energy into electrical energy through its piezoelectric PZT layers. We developed a PZT deposition machine which utilized aerosol deposition method to fabricate the high-quality PZT thin film efficiently.

For most energy harvesting applications, the energy harvested from the transducer must be accumulated in a storage device in order to power the intermittent use of sensors, transmitters, and other low power electronic devices. In most researches, batteries are used as an intermittent buffer and also the long-term energy storage. However, because of the memory effect of general chargeable batteries, the potential requirement field services on batteries replacement will limit the application of this technology. Ultra capacitors are an alternative of batteries on energy buffer stage or short-term energy storage stage. However, with the super capacitors as storage devices, conventional resistive modeling will not apply because of the capacitive nature. The transient charging behavior of a capacitive load for piezoelectric energy harvesting devices is modeled in depth for several circuit topologies. Specifically, the problem of charging a large storage capacitor, which is inherently a time-varying process, is considered. Three basic circuit layouts are studied – direct charging, Synchronized Switching and Discharging to storage Capacitor (SSDC), and Synchronized Switching and Discharging to a storage Capacitor through an Inductor (SSDCI). These cases are compared to the standard interface consisting of a matched resistive load after the rectifier. Analytical models are developed for these cases to predict the charging rates and output power for various values of storage capacitance. Experimental circuit designs are given and their results are compared to the theoretical predictions. It is shown that these predictions are accurate when the losses in the circuit are considered in the model. And the proposed SSDCI topology can raise the charging power four times theoretically and more than 2 times in experiment.