A Piezoelectric Passive Wireless Sensor for Monitoring Strain

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Abstract

Interest in passive wireless sensing has grown over the past few decades to meet demands in structural health monitoring.(Deivasigamani et al., 2013; Wilson and Juarez, 2014) This work describes a passive wireless sensor for monitoring strain, which does not have an embedded battery or chip. Without an embedded battery, the passive wireless sensor has the potential to maintain its functionality over long periods in remote/harsh environments. This work also focuses on monitoring small strain (less than 1000 με). The wireless sensing system includes a reader unit, a coil-like transponder, and a sensing unit. It operates in the Megahertz (MHz) frequency range, which allows for a few centimeters of separation between the reader and sensing unit during measurements. The sensing unit is a strain-sensitive piezoelectric resonator that maximizes the energy efficiency at the resonance frequency, so it converts nanoscale mechanical variations to detectable differences in electrical signal. In response to an external loading, the piezoelectric sensor breaks from its original electromechanical equilibrium, and the resonant frequency shifts as the system reaches a new balanced equilibrium. In this work, the fixture of the sensing unit is a small, sticker-like package that converts the surface strain of a test material to measurable shifts in resonant frequencies. Furthermore, electromechanical modeling provides a lumped-parameter model of the system to describe and predict the measured wireless signals of the sensor. Detailed characterization demonstrates how this wireless sensor has resolution comparable to that of conventional wired strain sensors for monitoring small strain.

Keywords: passive wireless sensor, structural health monitoring

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