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DIGITAL SELF-POWERED SEMI-ACTIVE UNIT FOR ADVANCED ENERGY-RECYCLING VIBRATION SUPPRESSION

Abstract

This paper demonstrates an innovative digital self-powered semi-active unit using a digital processor for the purpose of energy-recycling vibration suppression. The processor is connected to an electric circuit composed of a piezoelectric transducer, an inductor, an energy-harvesting device, and a selective switch. By selecting an appropriate switch point in sync of vibration phase, our already proposed method for multiple vibration suppression can be achieved effectively. The digital processor i) collects structural vibration phase, ii) calculates modal estimation using the Kalman filter, iii) determines switching criteria, and iv) changes switch point of an electric circuit. Surprisingly, this versatile and multifunctional processor is driven only by voltage from the piezoelectric transducer, which means this processor-piezoelectric control system is closed in terms of energy flow. In other words, any external energy is not at all necessary to drive sensors, processors, switches, and actuators.

Our digital self-powered system has a several significant advantages over conventional vibration suppression systems. Firstly, compared with awkward analog self-powered techniques, the digital self-powered system is programmable and is thus easy to tune various control parameters. For instance, it is practically impossible to achieve complicated Kalman filters on analog circuits; however, our digital system easily enables to implement any advanced filtering algorithm and to avail of any sophisticated control scheme. Secondly, the semi-active self-powered system takes advantage of semi-active methods' benefits, such as rigid stability and effectiveness, leading to the reliability in practical usage. Thirdly, the self-powered unit can be used at various sites even without external energy. There are many structures in sparsely-settled region that are subject to vibration and are, however, unable to exploit external energy in light of energy-saving and bothered wiring, such as space structures, large bridges, factory walls, noise-protective walls alongside high-ways, and so forth. To conclude, since our digital self-powered semi-active unit is versatile in functions and adaptable to various utilization, it can highly be expected to be used for many practical application of engineering.

In this paper, we demonstrate vibration suppression experiments carried out with our fabricated digital self-powered unit. First, we clarify the aim and significance of our project so as to provide a better understanding. Next, the detail explanation of unit components and fabrication is illustrated for researchers who want to do a similar work. In addition, a variety of experimental performances against vibration disturbances are assessed using quantitative indicators in various aspects.