Development of an accurate low-cost device for structural vibration acquisition

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Abstract

Structural Health Monitoring (SHM) applications are getting tremendous attention from engineers; However, the expensive sensors and equipment needed for extracting the structures' modal characteristics made SHM application only applicable to singular structures with a high budget for their health assessment. For applying the SHM systems to structures with lower health evaluation budget, a new accurate and low-cost device is proposed for the measurements of structural vibrations. This is composed of five similar simultaneous accelerometers located on a same spot for measuring the same signal. For validating the accuracy of this device, laboratory experiments were carried on; subsequently, the out-puts of the proposed device were compared with two piezoelectric accelerometers (PCB 393A03 and PCB 356B18). The results of the experiments show that not only is the proposed device 14 times less expensive than PCB 393A03, but it can also acquire vibration on lower frequencies and acceleration amplitudes where the expensive sensors could not provide any outputs.

Keywords: Low-Cost Sensors, Accelerometers, Data acquisition, Structural Health Monitoring.

1 Introduction

Civil structures and infrastructures could be considered as the main foundation of present modern society and, hence, their soundness is of utmost importance [1]. Monitoring and evaluating the health state of these structures are required for the maintenance applications, for minimizing the reparation costs and, eventually, for guaranteeing infrastructure safety [2]. Structural Health Monitoring (SHM) applications provide information on the state of structures, their functioning and their structural response. As pointed out by many scholars (see, e.g. [3]), SHM can be used to calibrate structural models of real structures (digital twins) that mimic the infrastructure performance to assess the decision-making process during the maintenance phase [4].

Accelerometers are force-sensors attached to a seismic mass. When vibration is induced, this mass applies a specific force, which is proportional to the measured acceleration [5][6], and an electrical signal is obtained as a result. The most common type of vibration sensing technology is based on one of the following three main principles: piezoelectricity, piezoresistivity, and differential