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GPS-Based Network Synchronization of Wireless Sensors for Extracting Propagation of Disturbance on Structural Systems

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Abstract: Wireless sensor networks (WSNs) have gained a positive popularity for structural health monitoring (SHM) applications. The underlying reason for using WSNs is the vast number of devices supporting wireless networks available these days. However, some of these devices are expensive. The main objective of this paper is to develop a cost-effective WSN based on low power consumption and long-range radios, which can perform real-time, real-scale acceleration data analyses. Since a detection system for vibration propagation is proposed in this paper, the synchronized monitoring of acceleration data is necessary. To meet this need, a Pulse Per Second (PPS) synchronization method is proposed with the help of GPS (Global Positioning System) receivers, representing an addition to the synchronization method based on real-time clock (RTC). As a result, RTC+PPS is the term used when referring to this method in this paper. In summary, the experiments presented in this research consist in performing specific and synchronized measurements on a full-scale steel I-beam. Finally, it is possible to perform measurements with a synchronization success of 100% in a total of 30 samples, thereby obtaining the propagation of vibrations in the structure under consideration by implementing the RTS+PPS method.

Keywords: wireless sensor networks; pulse per second; synchronization; GPS; real-time clock; structural health monitoring; acceleration; disturbance propagation

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1. Introduction

Nowadays, one of the most important philosophies used to assess the integrity of infrastructure is the well-known Structural Health Monitoring (SHM) approach [1]. Such a technique can be used to detect invisible or hidden damage that may be present in structures. Within this context, one of the main goals of the SHM philosophy is to detect unexpected changes in the main characteristics of structures, considering, in most of the cases, differences among the signals obtained by different sensors. As a result, the severity of the damage can be detected even in complex structural configurations [1]. In recent years, the SHM philosophy has been implemented in several structures around the world to prevent possible threats due to the inadequate structural condition that some structures, particularly the old ones, may be presenting. In general, the SHM of infrastructure can be implemented in different ways, and it can be defined as the detection and evaluation of damage in structures. Thus, the main objective of SHM can be established to be the estimation of structural damage to prevent a possible failure of structures, which may result in human and economic losses. Damage prevention by implementing SHM is