3rd URSI AT-AP-RASC, Gran Canaria, 29 May – 3 June 2022

Passive Wireless Harmonic Vibration Sensor based on Phase Modulation

Valentina Palazzi(1), Federico Alimenti(1), Paolo Mezzanotte(1), and Luca Roselli(1)
(1) Department of Engineering, University of Perugia, Perugia, Italy, 06125, https://ing.unipg.it/en/

Vibration monitoring is essential to assess the status of mechanical systems. In industrial applications, vibrations are monitored to verify the wear status of mobile parts, and, more generally, to assess the correct operation of machines [1]. Vibrations are used to check the integrity of airplanes and ships, and to perform structural health monitoring of buildings and infrastructures [2]. Therefore, real-time information on vibration features is pivotal to guarantee safety standars, and to perform preventive maintenance. Due to the large dimensions of relevant structures and industrial facilities to be monitored, and due to the tremendous progress in Internet of Things technology, wired vibration sensors are currently being replaced by wireless sensors wherever possible. The latter ones, in fact, require lower installation and maintenance costs, can be easily placed on mobile machines, and can be deployed even in remote areas. State-of-the-art wireless vibration sensors, though, rely on batteries for their operation, meaning that sensors must be periodically removed from the systems to be monitored to allow for the replacement of the depleated batteries, which is inconveninete in many applications. A few attempts have been made to develop battery-less wireless sensors based on alternative energy sources [3]. However, the operation of the sensors is limited by the availability of the these resources.

In this contribution, a zero-power approach is presented based on harmonic transponders. The block diagram of the proposed system is shown in Figure 1. The system consists of a reader and a wireless harmonic transponder. Part of

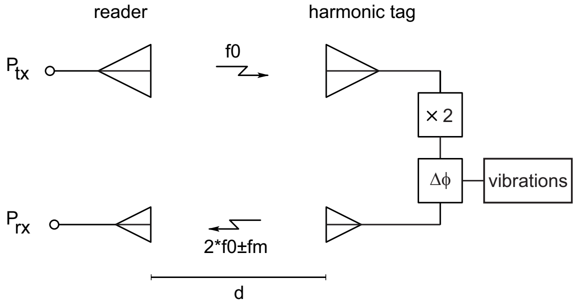

Figure 1. Block diagram of the proposed vibration sensing system.

the continuous-wave signal transmitted by the reader at f_0 is gathered by the input antenna of the tag and converted to the second harmonic by a frequency doubler. The vibration information is encoded in the phase modulation of the second harmonic. The obtained signal is finally transmitted back toward the reader. The sensor information (i.e., acceleration and frequency of the vibrations) is retrieved through the downconversion and demodulations of the received signal. The key element of this system is the trasducer, which must convert vibrations in phase variations, without requiring any active circuitry. A solution is proposed, based on a reflection-type phase shifter and a piezoelectric transducer. Some preliminary results of the transducer have been already shown in [4]. In the present contribution, the system will be described in detail, design optimization strategies will be outlined, and the performance associated with the complete transponder will be assessed and discussed.

References

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