Chapter 18

Self-Powered Height Sensor With ZigBee Networks for Intelligent Systems

Mochen Li
Purdue University, USA

H. Henry Zhang
Purdue University, USA

Li Tan
Purdue University Northwest, USA

Wangling Yu
Purdue University Northwest, USA

ABSTRACT

With the development of micro-electro-mechanical systems (MEMS), wireless communication technology, and embedded systems, wireless sensor network (WSN) has been a focus for research among various fields. Wireless sensor technology inspires many innovations for industrial applications and medical robots, and breaks many limitations and inconvenience for such sensing devices. A self-powered height sensing system with ZigBee technology is presented. It specifically targets to replace an original wired system with an integrated wireless sensor that is comprised of all necessary parts: sensing module, processing module, RF transceiver, and power supply. First, the authors present the system framework design including the layout of a wireless sensor node based on ZigBee. Second, with the vibration environment, a self-powered generator was developed through the comparison between piezoelectric and electromagnetic generation. Then several experiments are conducted to test and analyze the feasibility of the whole system. Finally, a future upgraded design is proposed to improve system performance.

INTRODUCTION

Modern vehicles are intelligentized with various sensors in different systems. These sensing systems will monitor driving conditions, detect the abnormal problems, and alert the driver through the vehicle computer. At the same time, more and more automobile manufactures start to equip their vehicles with
automated driving system or develop the autonomous car like the Google Self-Driving Car or Tesla Autopilot. Thanks to utilization of a great variety of sensors in those cars, it can easily obtain real-time surrounding environment information and make proper timely responses. One can assert that more sensors will be applied in vehicles in the near future. In comparison with the current wired sensing system, wireless sensor networks (WSN) can bring more convenience for the layout design of a vehicle. With the development of this burgeoning technology, it shows a great advantage in distributed, automatic detection.

With the development of wireless sensor networks (WSN), this burgeoning technology for distributed, automatic detection can be applied in many parts of a vehicle, and these small computing devices are increasingly embedded in different sensors to work as monitoring devices or for emergency response (Hersent, Boswarthick, & Elloumi, 2011). Thus, it is profitable to research the possibility of replacing a wired sensor with a wireless sensor node in some appropriate parts. Typically, a wireless sensor node has four main parts: a power supply unit, a processing unit, a physical sensor and a RF transceiver (Labiod, Afifi, & Santis, 2007). One of main limitations for a WSN is the power consumption of each node. Normally, one solution is to focus on energy saving techniques by establishing a low-cost, low-power wireless network to extend the functional life with limited battery (Hersent, Boswarthick, & Elloumi, 2011). Another employs the environmental energy harvesting devices as the power supply (Bibo & Daqaq, 2013). The height sensors in truck suspension air spring provide a good way to research these two problems. Originally, the height sensor is powered by an external wire. But considering the inside vibration environment of the truck suspension air spring, an energy scavenger may supply the power for the whole wireless sensor nodes by converting the vibration kinetic energy into available electrical energy.

As a direct method of converting kinetic energy to electrical energy, piezoelectric materials have been the research focus of power supply for small devices (Bibo & Daqaq, 2013). Experiments show that the produced polarized charge is proportional to the applied stress. This feature of the stress-dependent charge output has typically been applied to many different devices, including physical sensors, actuators, microphones, etc. (Galchev & Najafi, 2009). A huge amount of research has been done in the field of power harvesting to enable power up wireless sensor nodes (Bibo & Daqaq, 2013; Galchev & Najafi, 2009; Choi, Jeon, Jeong, Sood, & Kim, 2006; Kim, Kim, & Kim, 2011).

ZigBee is a specification for low-cost, low-power and wireless mesh network based on the IEEE 802.15.4 standard (Hersent, Boswarthick, & Elloumi, 2011). With the development of this specification more and more companies begin to develop their own products (Baronti et al., 2007). ZigBee technology is gradually applied in the field of smart home, industrial control, intelligent transportation, etc. As a basic application of wireless sensor networks, the remote sensor is also one of the research hotspots (Guo, Healy, & Zhou, 2010; Xu et al., 2010).

In fact, the major role of the WSN is to monitor the surrounding physical environment at a low-cost way. Meanwhile, the detected data of surrounding world is precisely processed by biomedical robotics. The current WSN have many types of sensors to apply that can detect a wide range of phenomena including seismic, electromagnetic, temperature, humidity, noise, light intensity, pressure soil composition, velocity etc. On the other hand, the WSN also includes many different communication protocols, such as: WirelessHART, Z-Wave, etc. In this chapter, only one example—the combined application of height sensor and ZigBee—will be described.