Chapter 1
Applications of Vibration-Based Energy Harvesting (VEH) Devices

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ABSTRACT
This chapter reviews present usage of vibration-based energy harvesting (VEH) devices and applications. The evolution of energy resources and advance in electronic technologies has resulting the need of self-sustainable wireless/portable electronic devices in current modern society. Batteries are non-beneficial in the miniaturization process of electronic designing and alternative power supplies are desperately needed to fill in the falling behind technologies gap to drive the advance of the wireless/portable development further. VEH mechanism is suggested in this chapter as the solution for the bottleneck. Various consideration of creating an optimal vibration energy harvester are suggested through an analytical model of a mechanical transducer. Useful applications and usages of VEH are presented and some suggestion for improvement are also given. Lastly, the trend of energy harvesting is annotated and commented in-line with the demand of electronic sensors market.

ENERGY RESOURCES
Since the last century, energy has been essential in building civilization revolution for modern society. In the 19th century, most of the energy resources were obtained from coal and timber. In the 20th century, crude oil and natural gas were added to the list and followed by hydroelectric and nuclear power. For the past decades, with the increasing demand and raising of global climate discussion, energy transi-
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Figure 1. Global Mobile Sensing Health & Fitness Sensor Shipments (Mareca, Darryl, & Chi, Q2 2013)

...tion at the global scale takes place by adding new green energy resources to the existing list, such as solar, wind, thermal, tidal and vibration. The European Commission has committed to reduce Europe’s greenhouse gas emissions by 80% before year 2050 compared to 1990 levels (European Commission, 2014). To achieve the low-carbon economy worldwide, all other developed and developing countries are expecting to endorse the objective by a similar degree.

In electronic technology, the advancement in silicon size and power consumption of CMOS technology has led to a wide research activities on wireless/portable devices. By removing the wires from the devices, there is a potential for embedding sensors in previously inaccessible locations, such as roof tops, underneath the raised-access floor panel, implant into the concrete wall and etc. At present, most of the remote electronic devices are still taken the energy from batteries with finite lifespan, which not only limit the miniaturization process of the device size, but also create environmental pollution caused by the improper disposal of used batteries. Not to mention the cost of labors and parts involved during the batteries replacement process, especially in the large-scale Wireless Sensor Network (WSN) and portable electronic device systems. Due to the increase in wireless sensing devices (Figure 1) that led to a large research effort to seek for alternative long lasting energy sources, especially in applications where the replacement of batteries is practically unfeasible or costly. For instance wireless sensors that use for health monitoring, animals tracking, security system and some military applications. With a self-powered energy resources, large amounts of saving can be achieved for the ownership of wireless sensor systems and portable electronic devices in long run.

According to the Law of conservation of energy, energy can be neither created nor destroyed. Heat, electricity, dynamic, chemical and biomass forms of energy are all stored differently, but can be converted from one form to the other. One of the promising solutions to a self-powered wireless device is by using energy scavenging from ambient sources such as solar, thermal, wind, vibration and etc. These energy resources are redundant and have almost infinite lifetime. Some of these energy sources have some limitations like in case of wind energy as the wind turbine cannot be used in lower altitude or urban areas, at where there is an inconsistent and weak wind density. In the case of solar energy, the effectiveness of the harvester will drops at location where there is absence of sunlight. Among these energy sources, vibration...
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