Medicon Engineering Themes
Volume 3 Issue 2 August 2022
Editorial Note

Piezoelectric Energy Harvester for IOT Application

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Received: August 01, 2022; **Published:** August 02, 2022

It is now possible to minimise the size and power requirements of electronics devices in the fields of wireless sensors and implantable medical devices (IMDs) thanks to the significant improvement in microelectronic VLSI technology. These IMDs, such as cardioverter defibrillators, cardiac pacemakers, artificial retinas, brain, and bone stimulators, sensors, and cochlear implants, among others, can be placed in human bodies for diagnostic and therapeutic purposes. The various implantable devices can be used as diagnostic tools to track blood pressure, heart rate, and temperature for a variety of medical conditions, and they can also help with the management of diseases like diabetes (e.g., stimulation of brain and muscles). The pacemaker helps treat irregular heartbeats brought on by sick sinus syndrome or a blocked heart.

Since Siemen's creation of the first pacemaker in 1958, there have been significant advancements made in the development, production, and use of IMDs. Over the past year, these IMDs' power consumption has decreased dramatically. For instance, the cochlear implant requires 145 μW [1] of power, the medication pump 400 μW [2], the neuro-stimulator 50 μW [3], and the pacemaker 8 μW [4]. These gadgets are all battery-powered. Due to the limitations in the existing technology, it is rather difficult to miniaturise the battery system. Despite the low power consumption of these gadgets, a further significant obstacle is the short battery life and chemical side effects that shorten their overall lifespan. For example, the life expectancy of a modern pacemaker is around 7-10 years, whereas that of a deep brain stimulator is roughly 3-5 years, implying that the battery will need to be replaced after some time. Although certain biocompatible batteries [5] have a longer lifespan, eventually they must be recharged or replaced, which may necessitate surgery, such as when a pacemaker's battery needs to be changed.

Recently, reports of in vivo devices' batteries being charged internally surfaced. By using an integrated energy harvesting system, which can collect energy from the patient's surrounding environment to power these devices, this aids in attaining the miniaturisation of medical devices. In the past ten years, various methods of energy conversion, including thermal, chemical, and mechanical sources, have been documented. The most well-known of these techniques, mechanical vibration can supply enough energy to power in vivo devices. The mechanical-based energy harvester can transform human activity, such as heart and lung movements, blood circulation, and muscular contraction, into electrical energy.

Electromagnetic [7], electrostatic [8], and piezoelectric mechanisms [9-15], among other methods, can convert mechanical vibrational energy into useable electrical energy. Without an external voltage source, the piezoelectric energy harvester may convert mechanical vibration into electricity. In contrast to electrostatics and electromagnetic mechanisms, this aids in creating the straightforward architecture of this mechanism. The piezoelectric mechanism's straightforward construction results in a smaller size through MEMS technology. In comparison to the other two mechanisms, it also has a significant electromechanical coupling effect. PZEH is chosen above competing products due to these benefits [10, 11].

The bulky and big energy harvesting mechanism is not appropriate for IMDs since it is incompatible with the device's permitted size limit. Since the PZEH functions more effectively close to the external excitation frequency, the cantilever's specified resonance frequency for the PZEH should be close to the ambient vibration frequency. The frequency of various human body parts is extremely low. Therefore, the design of any PZEH faces primarily two issues. The goal is to first attain a low frequency that should be in line with the vibration frequency of the targeted body part, and then to move up to a greater working frequency range. Electrical energy from finite frequency intervals can be harvested by a broadband energy harvester.

Piezoelectric materials demonstrate a linear relationship between mechanical and electrical properties. The direct piezoelectric effect is the ability of piezoelectric materials to produce electrical energy when an external stress is applied to their surface. When an electric field is placed across a piezoelectric plate, there will be mechanical de-formation in the piezoelectric plate. This occurrence is known as the reverse piezoelectric effect [9, 14, 15].

The resonant frequency of the piezoelectric based cantilever can be simply written as $\omega = \sqrt{\frac{K}{m}}$, where ω is the resonant frequency, k is spring constant and m is the mass of the cantilever [10, 11]. The different techniques used to improve the efficiency of the PZEH is to modify the structure of ha cantilever by various method (i) Use of proof mass [14] (ii) Structural Modification which means changing the shape and size of the structure [9-15]. The different methods that can be employed to improve the bandwidth can be achieved by the use of multiple beams connected together in order to increase the increase the degree of freedom [9]. The bandwidth of the cantilever can also increase by the use of stopper in the cantilever system. The mechanical stoppers in the cantilever induces the piece-wise-linear hardening restoring effect, where there are sudden jumps in spring stiffness when the cantilever and stopper touches each other. Non-linearity in PZEH can also improve the output voltage and increase the bandwidth [16]. One of the methods to introduce on-linearity is the use of magnetic tip mass as the proof mass in the magnetic environment. The relative alignment, position and arrangement of the magnet can introduce nonlinearity in the system. Many researchers try many different configurations to improve the efficiency and operating bandwidth of PZEH.

In the global deployment of Internet of things (IoTs) for smart cities, housing, healthcare, agriculture, transportation, industries, military, marine, and other applications, energy harvesting techniques can be a substantial advantage. The creation of a self-powered smart electronic device with integrated energy harvesting techniques that can function for a longer period of time without the need to replace the battery is the most promising, decisive, and important answer. Delaying battery replacement will result in significant financial savings and help create a more durable electrical equipment. The PZEH can be extended to include wind flow, rainfall, ocean waves, roadway stress, and other mechanical vibrations in addition to human motion and ambient mechanical vibration. The strength of flowing wind can be used to extend the PZEH application in a variety of ways because it is so prevalent in our environment. These harvesters can be utilised to supply electricity to electronic gadgets, wireless sensors in windy places, ventilation ducts, high-rise building ducts, and aero plane structures. In nature, rainfall occurs in essentially every place, with tropical regions seeing particularly heavy rainfall. Therefore, the piezoelectric energy harvester can scavenge electrical energy by using the force created by the impact of the rains. The tides generated by the ocean waves can also be used to generate electrical energy with the help of piezoelectric cantilever.

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Volume 3 Issue 2 August 2022