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The design and implementation of electromagnetic vibration energy acquisition system

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Abstract

In our daily life environment, there are a lot of micro energy such as vibration, low thermal energy. In the past due to the limitations of technical capabilities, this micro energy has not been effectively collected and utilized. With people's increasing attention to the effective use of energy and environmental protection, this clean, renewable micro energy have become the focus of research in related fields. In this paper, by means of the research of electromagnetic vibration acquisition system at home and abroad, the working principle of the electromagnetic vibration collector is clarified. On this basis, the micro vibration energy acquisition system is designed and realized, and we also put forward some methods for improving the conversion efficiency of the circuit system. Finally, the feasibility and effectiveness of the system are verified by several experiments at the end.

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Keywords: Electromagnetic; energy collection; charging power

1. Introduction

With the rapid development of low-power wireless sensor networks and microelectromechanical system, the self-powered system is gradually applied to various areas of our daily life. Affected by the size and other factors, the system is often supplied by a small volume of lithium battery power supply. However, the limitations of the battery capacity have become a major obstacle to the large-scale and practical application of these micro systems getting into [1]. If we can give up the traditional power supply mode, and turn to making use of direct extraction of energy from

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the sensor network or micro-electromechanical systems (MEMS) working environment, it will reduce the system cost to a great extent, increase the effectiveness of the system, extend the working time, and expand the scope of application of the system.

In this paper, we first introduce the universal phenomenon of vibration, which contains weak energy. Next, we introduce the research status of electromagnetic energy acquisition technology both at home and abroad. Then we propose the acquisition scheme after analysing the principle and we select an easy to implement and more efficient acquisition scheme by comparing experiments. At the end of this paper, we summarize the research work. The research background will be described below.

1.1. Universal vibration

Vibration is ubiquitous in our everyday environment. The vibration caused by the nature of the wind, earthquake, tsunami and so on is with great energy that we are still unable to effectively control and use. As a matter of fact, the vibration of the industrial motor, the vibration of the vehicle on the road, and some other small vibration contain the micro energy we can use. Table 1 shows the classification of vibration sources in different environments.

Table 1. Different environment sources [2].

Industry	Structure	Vehicle	Human body	Natural environment
Electric machinery	Bridge Highway	Aircraft	Blood pressure	Wind
Compressor	Tunnel	Turbine	Breathing	Daily temperature
Pump blower	Air conditioner	Automobile	Walk	Ocean
Conveyor belt	Ventilation device	Brake	Finger movement	Sound
Vibration screen	Groove cleaner	Vibration absorber	Jump	Radio signal

If we choose an appropriate way, the energy produced by these tiny vibrations can be converted into electrical energy for storage and use. We look through lots of documents and find that the technique of collecting weak vibration energy by electromagnetic energy harvester has been developed maturely. Then it will introduce the research status of electromagnetic energy harvester.

1.2. Research status of electromagnetic energy harvester at home and abroad

At present, there are three main ways to collect vibration energy. They are electromagnetic way, piezoelectric way and electrostatic way. Similarly, both at home and abroad, electromagnetic vibration energy acquisition system is mainly divided into three categories, namely moving iron type, moving coil type, resonant type [3].

For the moving iron type energy harvester, the Williams research group at the University of Sheffield in the United Kingdom in 1995 established a general geometric model [4]. Fig. 1(a), around the coil, inside the magnet. The model is characterized that the coil does not move while the magnet moves relative to the coil. This can lead to the output power will be affected by the squeeze film damping effect materials selected in the energy harvester. However, the energy harvester of this type, whose performance is gradually improved after later research experts and scholars at home and abroad.

For the moving coil type energy harvester, the Amirtharajah research team of the Massachusetts Institute of Technology (MIT) used the self-made miniature electromagnetic vibration energy harvester to study the self-powered signal, and gave the relevant geometric model [5]. The characteristic of this structure is that the magnet does not move and the coil moves relative to the magnet. And a notable feature is the volume is relatively large. This can lead to severe restrictions on its application. Its schematic shows as Fig. 1(b).

For the resonant type vibration energy harvester, Haluk Kulah research group from The United States of Michigan State University proposed it in 2004. The characteristic of this structure is that the relative motion between the two. It has achieved a high frequency conversion with high energy conversion efficiency. It’s schematic shows as Fig. 1(c).