Faculty of Mechanical Engineering

ENERGY HARVESTING FROM MECHANICAL VIBRATION OF AUTOMOTIVE COMPONENT

Nur Shakira Suhana Binti Abu Bakar

Bachelor in Mechanical Engineering

2018

ENERGY HARVESTING FROM MECHANICAL VIBRATION OF AUTOMOTIVE COMPONENT

NUR SHAKIRA SUHANA BINTI ABU BAKAR

A report submitted
in fulfillment of the requirements for the degree of
Bachelor of Mechanical Engineering with Honours

Faculty of Mechanical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2018

DECLARATION

I here declare that this thesis entitled "Energy Harvesting from Mechanical Vibration of Automotive Component" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : …….

Name : .....

Date : .....

APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Bachelor in Mechanical Engineering.

Signature :……

Supervisor Name :……

Date :……

DEDICATION

To my beloved mother and father

ABSTRACT

Vibration energy is a wasted energy that can be accumulated from the surrounding of us for beneficial power. Furthermore, energy harvesting devices are self generated that normally used for activating low power electronic components which have low power electrical consumption. According to this project, it is use vibration energy which is in the form of mechanical energy that needs to be transforming into the useful electrical energy using piezoelectric devices. Energy harvesting system using piezoelectric devices is a system that provides the user with free flowing energy that can be used without any consequences to the environment. This system enables users to generate energy for their uses by transform the mechanical energy produced by the car components vibration into electrical energy. The aims of this project is in general about designing and build a circuit to test the performance and characteristic of piezoelectricity. The system is then is installed at a car components to produce energy from the car vibration when the car is switched on. The output voltage of each component is compared whether it is produce a suitable vibration needed for the piezoelectric generating system or not. As a conclusion, this project shows a self-power sustainable electronic system for long lasting low power electronic application.

ABSTRAK

Tenaga getaran adalah tenaga yang terbuang yang dapat dikumpulkan dari sekeliling kita untuk kuasa yang bermanfaat. Selain itu, peranti penuaian tenaga dihasilkan sendiri yang biasanya digunakan untuk mengaktifkan komponen elektronik berkuasa rendah yang mempunyai penggunaan kuasa elektrik yang rendah. Menurut projek ini, ia menggunakan tenaga getaran yang berupa tenaga mekanikal yang perlu diubah menjadi tenaga elektrik yang berguna menggunakan peranti piezoelektrik. Sistem penuaian tenaga menggunakan peranti piezoelektrik adalah sistem yang menyediakan pengguna dengan tenaga mengalir bebas yang boleh digunakan tanpa apa-apa akibat kepada alam sekitar. Sistem ini membolehkan pengguna menjana tenaga untuk kegunaan mereka dengan mengubah tenaga mekanikal yang dihasilkan oleh getaran komponen kereta menjadi tenaga elektrik. Matlamat projek ini secara amnya merancang dan membina litar untuk menguji prestasi dan ciri piezoelektrik. Sistem ini kemudian dipasang pada komponen kereta untuk menghasilkan tenaga dari getaran kereta apabila kereta dihidupkan.Voltan keluaran setiap komponen dibandingkan sama ada ia menghasilkan getaran yang sesuai untuk sistem penjanaan piezoelektrik atau tidak. Sebagai kesimpulan, projek ini memperlihatkan sistem elektronik lestari berkuasa sendiri untuk aplikasi elektronik berkuasa rendah yang tahan lama.

ACKNOWLEDGEMENT

First of all, thanks to Allah for giving me strength, love and guidance until I finally completed my final year project. Next, I would like to express my gratitude and appreciation to all the person who have help me to complete my final year report and thank you for my Faculty of Mechanical Engineering, University Technical of Malaysia Malacca for giving me this opportunity to carry out this project.

I am very thankful and pay my gratitude to my supervisor on this project, Dr Kamarul Ariffin Bin Zakaria for his support, idea, guidance and encouragement throughout my final year project. Without his guidance and moral support, I would not be able to complete my final year project in this manner.

Besides that, I would like to express my gratitude towards my parents and my siblings who are always supported me morally as well as economically. Last but not least, special thanks to all my friends who direct or indirectly support and help me during to complete this project. They had also given me some useful advices and never hesitated to lend me a hand in any situation.

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LIST OF ABBREVIATION

PCB	Printed Circuit Board
LED	Light Emitting Diode
AC	Alternating Current
DC	Direct Current
MEMS	Micro Electro Mechanical Systems
IC	Integrated Circuit
PZT	Lead Zirconate Titanate
Mw	Millimeter Watt
Si	Silicon
NdFeb	Neodymium Iron Boron

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CHAPTER 1

INTRODUCTION

1.1 Background

Energy harvesting is a system which involves in capturing and assembles by product energy into a usable electrical energy (Amos Kingatua, 2016). It is also defined as a technique of generating electrical energy from normally unused energy sources found in the surrounding environment. It is conversion of little amounts of readily available energy in the environment into usable electrical power. The energy can be achieved when there is collecting energy for a period of time and building it into a form that can be used afterwards. The example used in energy harvesting is to control the microprocessor with its limit.

Energy harvesting has its own criterion that can hold both promises for low voltage and low power applications in various movable or mobile markets. For example, these energy harvesting system applications are quite used in health equipments, transport, military, consumer devices and industrial controls. In other words, it provides a powerful challenger on behalf of applications that required a support battery, especially if the battery is in a remote location or hard to reach (Michele Kinman, 2010).

The good things about energy harvesting are it enabled a new circuit to capture and accumulate these small power packets and change it into functional outputs. Moreover, the performance provided by the circuit should have a high energy efficiency in order to capture and store this small power packet. Also it needs high energy retention to accumulate the

energy for a long time. Additionally, it requires proper power conditioning to complete the task of desire. According to Figure 1.1, it is show the step for vibration energy harvesting in block diagram. Energy management must be in good condition and allow for various voltage, current and waveform inputs. It is also include more voltage, more charge and other irregular input circumstances (Michele Kinman, 2010). Furthermore, this energy harvesting has their advantage which it very useful that it can reduce the energy consumption and its impact on the environment.

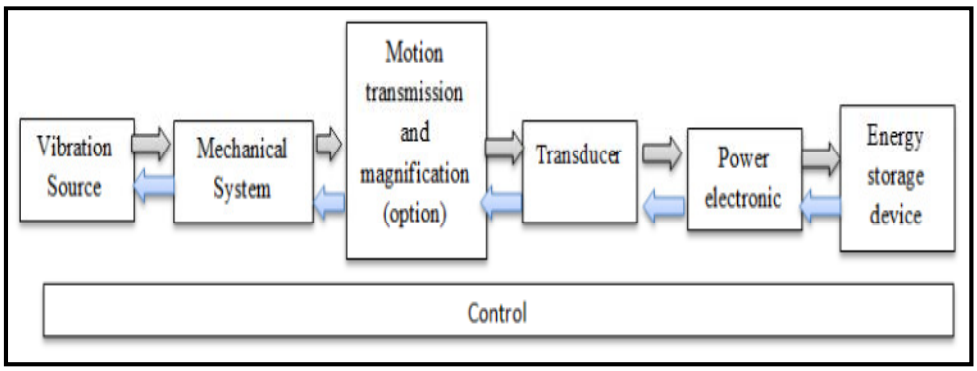

Figure 1.1: Vibration energy harvesting system in block diagram

(Source: Wang et.al, 2013)

There are a lot of materials or sensor that are commonly used to transform wasted energy into electricity. This sensor is available which it can be harvested, accumulated and conditioned used for wireless sensor applications and many low voltages wearable that previously vital batteries or AC power supplies. For instance, a crystal composite or piezoelectric fiber (PZT), a solar indicator coils are the example of energy generator. These materials provide currents and various output voltage. High efficiency is needed to capture,

accumulate and store the small packets of electricity energy. The effectiveness need to be increase because the energy used by the circuit is less than the energy provided by the vibration.

In 1880, two French physicists, Brothers Pierre and Paul-Jacques Currie had discovered the piezoelectric effect found in crystal of quarts, tourmaline and potassium sodium tartrate (Chris Woodford, 2017). Piezoelectricity is the form of electric potential or the voltage across the crystal sides when subject to mechanical pressure (Carmen Emily Yang, 2016). The characteristic of piezoelectricity is it can be reversible hence means the materials that exhibit electricity generation when the pressure is applied will exhibit pressure generating when an electric field is applied.

In 2009, Haresh Khemani stated that the piezoelectricity generator converts mechanical vibrations, tension or pressure into electrical voltage or current. Many different sources come from this mechanical tension, such as human motion, air plane or vessel ambiance, other low frequency seismic vibration and acoustic noise. Other than that, the piezoelectric effect operates in alternating current, requiring input time varying at mechanical resonances. It is consider as the most capable at generating energy. Most piezoelectricity produces larger voltage while the current produce is very small, generating the power that exists in the microwatts arrangements. In addition, the generating source for energy harvesting electronics is an ideal way but it is a bit too small for most system application.

1.2 Problem Statement

Lately, energy and global warming had drawn a lot of awareness in dissimilar kind of the world. Automobile is one of the largest consumers generated for movement wasted through heat and vibration. The use of capacitors as a way to store energy has been considered due to the past research on the power energy harvesting as well as can overcome the problem of traditionally battery that as limited power.

Initially, the concept and characteristic of piezoelectric that used in the energy harvesting will discuss. Those piezoelectric are use to generate the mechanical movement due to electric charges. In addition, this material can generate electrical charges by mechanical motion. However, it is need to future study which components of automotive is most suitable and capable for energy harvesting. In this study, the output voltage produces by three components will be comparing and characteristic of piezoelectric in mechanical vibration is investigated. Therefore, the piezoelectric energy harvesting circuits for circuit application design were studied.

1.3 Objectives

The objectives of this study embark:

I. To study the principle of piezoelectric circuit.

II. To study the characteristic of piezoelectric system.

III. To compare the output voltage produces by three automotive components when the sensor is connecting.

1.4 Scope of project

There are several parameters that can be discussed and varied in order to study the characteristic and performances of energy harvesting using piezoelectric. Piezoelectric is use as the sensor for harvesting design, where the main design is to harness the vibration energy. It is because piezoelectric can generate electrical charges by mechanical vibration or mechanical motion. In this study, the output voltage produce by three components will be compare and characteristic of piezoelectric will be the parameters studied.

1.5 Thesis Outline

In this thesis, there are consist of 5 main chapters. First and foremost, it is Chapter 1. This chapter will discuss briefly about the project introduction consists of background of the case study, problem statements, objectives, scope of project and thesis outline in order to conduct the project. Next, the thesis is continued with Chapter 2. This chapter contains the literature review which it is consists of a study about the past research and some theoretical concepts that related to this project study. This study referred from various sources such as books, journals, thesis and internet. While in Chapter 3 it is more focusing on the methodology used in order to complete this project. It is provides a flowchart including the process of identifies the flow of circuit, identify the sensor use and which automotive components produce a high vibration. In Chapter 4, consists of the discussion from the result obtained and the comparison between three automotive components that related to energy harvesting using piezoelectricity is investigated. Last but not least, in Chapter 5 a conclusion and recommendation is provided for future work about of this project study.

CHAPTER 2

LITERATURE REVIEW

In this section, it will discuss about the facts and information of the works involving energy harvesting before proceed to the project. This part also will study about energy harvesting devices use.

2.0 Introduction

With current improvements in the development of low power electronics such as microelectronics as well as microelectronics as well as wireless sensor nodes, and the importance of the world in the idea of "green" engineering, the subject of energy harvesting has gained considerable attention before decades. The power requirements of low power electronic components can be reduced progressively with an increase in the efficient circuit so that the energy harvesting system can be seen as a method that can be achieved in supplying energy to self-powered devices. Given that the wearable electronic device evolves and breed, there will be a growing need for more power transmission to circulate around the environment and human body. Nowadays, most of the storage is provided by the battery and power transmission through the wires (Kymissis et.al, 1998). The current approach to power distribution is clearly problematic when more tools are brought; the small use batteries require

replacements everywhere or run wires through our clothes to supply tools from central power sources. Both are unacceptable.

Furthermore, conventional low-power electronic devices, such as wireless indicator nodes, rely on batteries to power the device. Battery use sometimes presents many negatives such as battery costs with changes along with the limitations imposed by appropriate access requirements for devices for battery conversion purposes. Wireless indicator nodes are usually found in remote destinations or incorporated into structures which cause access to tool can be difficult or impossible. By saving ambient energy around electronic devices, energy saving methods can offer long-term energy sources that do not require periodic replacements. Such systems may run in their own autonomous way, minimizing costs associated with battery replacement. It is obviously to generate power where it is used, by passing storage and distribution problems altogether. As a collapse of power requirement for most wearable devices, it is no longer easy to harvest some useful energy from the environment.

2.1 Energy Harvesting System

Energy harvesting has become more popular and the most popular technique is energy harvesting from surroundings. The past or background of energy harvesting started since the windmill and the waterwheel. Over decades, there are a lot of techniques to accumulate the power from heat and ambiance. The main purpose behind the look for a latest energy harvesting system is the need to master the energy of sensor network also moveable devices exclusive of batteries. Over the past few years, energy harvesting had experienced important growth required to increasing need as to create moveable devices and wireless network. Besides that, the energy recruitment and opportunities they make to use components

continuously, out of the grid and for long periods, have gained considerable attention in trading and military use. Therefore, leveraging energy harvesting networks will enable to develop new medical, environmental, monitoring and security applications (IEEE, 2015).

Energy harvesting is a technique to accumulate energy from ambient sources including sunlight, vibrations, heat, and etc (Gibran Ali et.al, 2015). Besides that, energy harvesting is a process which a device associated with capturing residual energy. It is allowed to accumulate and manage amounts of natural energy and converts them into electrical energy, so that it can supply low power devices or use it later (Liew Hui Fang et.al, 2016). Wind turbine, water turbine, ocean wave and many more are example of system which can convert motion into electrical energy.

Nowadays, different energy sources has its own method to harvest the energy have been founded. Vibration energy harvesting is the most popular technique that can be used to convert mechanical energy into electrical energy. The example mechanisms to convert mechanical vibration into electrical energy can be found in electrostatic, electromagnetic and piezoelectric transducer.

2.1 Vibration Energy Harvesting based on different forms of sources

There are many variety of method or technique conversion mechanisms that can be used to convert the vibration based energy as mechanical energy to useful electrical energy as well as the vibration conversion can be implemented through piezoelectric, electromagnetic and electrostatic (Maheshwari et.al, 2013). This harvested energy can be stored into energy devices or it can be used directly. It is based on to the magnitude of output power also impedance.

2.1.1 Piezoelectric Energy Harvester

Vibration energy harvesting is an attractive solution to replace or to charge the battery which is commonly used in application. Monitoring sensors or wireless communication devices are example of application. This energy harvesting can convert waste vibration energy into useful electrical energy (Syahrul et.al, 2015). This study discuss about linear assumptions and stationary excitation characteristic that had been used in earlier analysis. The challenge by using vibration is that linear oscillator which it is well suited for stationary and narrow band excitation near their natural frequency. Furthermore, the vibration energy becomes less efficiency when it is distributed over wide spectrum.

In recent years, the piezoelectric energy harvester had received comprehensive attention. Instead of rotating, the piezoelectric materials are well suited to the reciprocating material. Among the vibration found on MEMS piezoelectric energy harvester, a structure of cantilever beam can develop the maximum and deflection and compliance constant which is the cantilever beam is the comprehensive used (Gongbo Zhou et.al, 2014). The longitudinal vibration frequency and torsional vibration frequency are higher than the bending vibration frequency. Commonly, because of simple process and relatively high efficiency, the rectangle shaped cantilever structures are widely used as shown in Figure 2.1.