



**DEVELOPMENT OF PIEZOELECTRIC ENERGY HARVESTING
UNIT FOR CAR SUSPENSION SYSTEM**



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**BACHELOR OF MECHANICAL ENGINEERING TECHNOLOGY
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**Faculty of Mechanical and Manufacturing Engineering
Technology**



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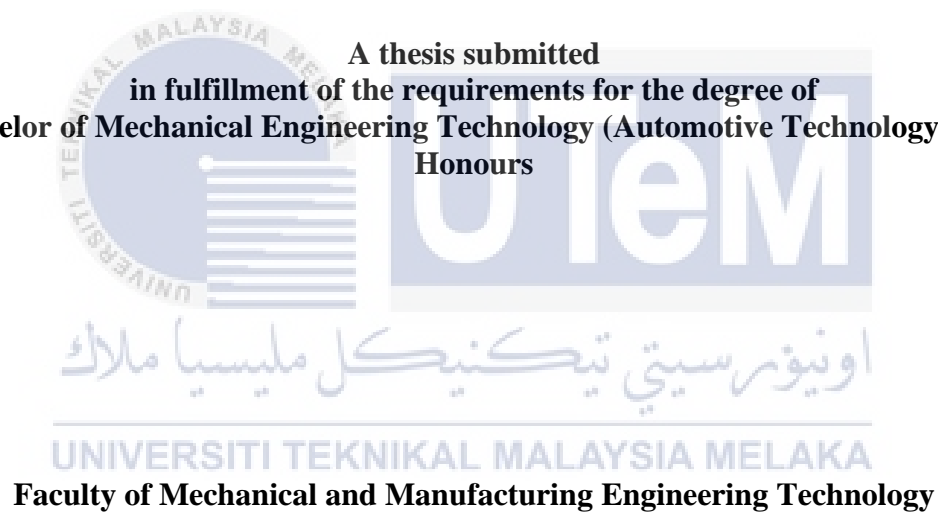
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**DEVELOPMENT OF PIEZOELECTRIC ENERGY HARVESTING UNIT FOR
CAR SUSPENSION SYSTEM**

Muhammad Amirul Adli Bin Muhammad Zulkarnain

**A thesis submitted
in fulfillment of the requirements for the degree of
Bachelor of Mechanical Engineering Technology (Automotive Technology) with
Honours**



UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2022

DECLARATION

I declare that this Choose an item. entitled “Development Of Piezoelectric Energy Harvesting Unit For Car Suspension System” is the result of my own research except as cited in the references. The Choose an item. has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature





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APPROVAL

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor of Mechanical Engineering Technology (Automotive Technology) with Honours.

Signature : 
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Date : 27/01/2022



DEDICATION

I dedicate this thesis to both my parents, Muhammad Zulkarnain Bin Baharum (Father) and Anita Binti Harun (Mother), who never tire of being by my side and supporting every effort I put in throughout the process of preparing this thesis. Also to my supervisor, Ts. Khairul Azri Bin Azlan for guiding me since the beginning of this thesis and project. Your contribution to my success is enormous and has left a deep impression on my lives. I wish goodness and well-being to you and your family. Not to forget also, to the friends who together helped me in this thesis study and always gave moral support to me. Lastly, I dedicate this thesis to someone who worked very hard in the effort to complete this thesis and got a degree to be a sign of life career that is myself, Muhammad Amirul Adli Bin Muhammad Zulkarnain. Without sacrifice and hardship, this thesis will not succeed. If I afraid of failing, then I will not graduate this study. If there is no effort, then do not expect a return. These verses became my stick to continue to walk in this life and in perfecting this thesis. Last word from me, thank you for everything.

ABSTRACT

The energy generated by the vibrations that occur in the suspension of a vehicle is often wasted and not properly utilized. If the vibrations on this suspension are utilized optimally, it can serve as an energy harvesting tool for vehicles. In this thesis, a study on energy harvesting tools is made to identify tools that have suitability for use in car vehicle suspension systems. There are several types of energy harvesting identified such as photovoltaic, electromagnetic, electrostatic, radio frequency, piezoelectric, thermoelectric and pyroelectric. All of these tools have the advantage of converting artificial energy into energy for storage. In realizing the study of this thesis, piezoelectric energy harvesting tools become the choice to be studied, because these tools can be utilized and used to harvest the energy resulting from suspension vibrations. In addition, introduction of engineering drawing systems used in methodology such as research design, conceptual design, embodiment design, detail design and detail drawing to obtain quality results and achieve the desired standards. In this methodology also, is told how to find the sketch and the final design of the product to be tested try on the car suspension. As a result of using this system, the result is the final design, the overall cost of the product, the test preparation of the product and the formula that will be used to find the value and energy obtained. Next, the prototype manufacturing process uses plastic materials and 3D printing Ender Pro 3 as the manufacturing machine. A further description of the prototype fabrication process is described in the fabrication and results section. The prototype is produced using the actual measurements of the project and through this prototype, will be tested to obtain the voltage and current values. The test process is used a stroke suspension measure. In this case, the value of the stroke suspension obtained is 100 mm and with this result, will be divided into 5 groups namely 0 mm stroke, 25 mm stroke, 50 mm stroke, 75 mm stroke, and 100 mm stroke. Each group will produce 10 outcomes to get more accurate and quality results. Results will be translated in the form of tables and graphs. If reference is made to the energy harvesting results, it can be concluded that the pressure applied to the piezoelectric sensor affects the increase in voltage and current obtained. As a result of the discovery of voltage and current values in each group, energy values can be obtained and recorded. From the energy value obtained, a calculation of the time required for a car battery to be fully charged from 0v to 12v has been obtained. Lastly, recommendations for improvement are discussed to maximize the results in future.

ABSTRAK

Tenaga yang dihasilkan oleh getaran yang berlaku dalam penggantungan kenderaan sering kali dibuang dan tidak dimanfaatkan dengan baik. Jika getaran pada penggantungan ini dimanfaatkan dengan optimum, ianya boleh menjadi sebagai alat penuaian tenaga untuk kenderaan. Dalam tesis ini, kajian mengenai alatan penuaian tenaga dibuat untuk mengenal pasti alatan yang mempunyai kesesuai untuk digunakan dalam sistem penggantungan kenderaan kereta. Terdapat beberapa jenis-jenis penuaian tenaga dikenal pasti seperti photovoltaik, electromagnetik, electrostatik, frekuensi radio, piezoelektrik, thermoelektrik dan pyroelektrik. Semua alatan ini mempunyai kelebihan untuk menukarkan tenaga buatan kepada tenaga untuk disimpan. Dalam merialisasikan kajian tesis ini, alatan penuaian tenaga piezoelektrik menjadi pilihan untuk diteliti, kerana alatan ini boleh dimanfaatkan dan digunakan untuk menuai tenaga yang terhasil daripada getaran genggantung. Selain itu, pengenalan sistem lukisan kejuruteraan yang digunakan dalam metodologi seperti reka bentuk penyelidikan, reka bentuk konsep, reka bentuk penjelmaan, reka bentuk terperinci dan lukisan terperinci untuk mendapatkan hasil yang berkualiti dan mencapai piawaian yang dikehendaki. Dalam metodologi ini juga, diberitahu bagaimana untuk mencari lakaran dan reka bentuk akhir produk yang akan diuji cuba pada penggantungan kereta. Hasil daripada menggunakan sistem ini, terhasilnya reka bentuk akhir, kos keseluruhan produk, persediaan percubaan produk dan formula yang akan digunakan bagi menemui nilai tenaga yang diperolehi. Seterusnya, proses pembuatan prototaip menggunakan bahan plastik serta 3D printing Ender Pro 3 sebagai mesin pembuatannya. Penerangan lebih lanjut mengenai proses fabrikasi prototaip diterangkan dalam bahagian fabrikasi dan keputusan. Prototaip dihasilkan dengan menggunakan ukuran sebenar projek dan melalui prototype ini, akan dilakukan uji cuba untuk mendapatkan nilai voltan dan arus. Proses ujian menggunakan ukuran penggantungan lejang. Dalam kes ini, nilai suspensi lejang yang diperolehi ialah 100 mm dan dengan keputusan ini, akan dibahagikan kepada 5 kumpulan iaitu lejang 0 mm, lejang 25 mm, lejang 50 mm, lejang 75 mm, dan lejang 100 mm. Setiap kumpulan akan menghasilkan 10 hasil untuk mendapatkan keputusan yang lebih tepat dan berkualiti. Keputusan akan diterjemahkan dalam bentuk jadual dan graf. Jika dirujuk kebahagian keputusan penuain tenaga, dapat disimpulkan bahawa tekanan yang dikenakan kepada sensor piezoelektrik mempengaruhi peningkatan voltan dan arus yang diperolehi. Hasil daripada penemuan nilai voltan dan arus di setiap kumpulan, nilai tenaga boleh diperolehi dan direkodkan. Daripada nilai tenaga yang diperolehi, pengiraan mengenai masa yang diperlukan untuk sesebuah bateri kereta dicas penuh dari 0v hingga 12v telah diperolehi. Akhir sekali, dibincangkan cadangan penambahbaikan bagi memaksimumkan dapatan hasil pada masa depan.

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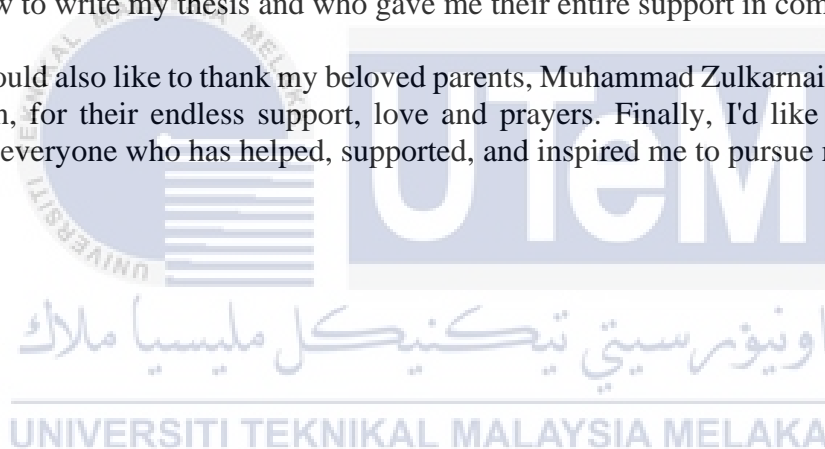


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LIST OF SYMBOLS AND ABBREVIATIONS

UTeM	-	Universiti Teknikal Malaysia Melaka
PV	-	Photovoltaic
DC	-	Direct Current
AC	-	Alternating Current
TE	-	Thermoelectric Effect
RF	-	Radio Frequency
PZT	-	Piezoceramic Zirconate Titanate Ceramics
IFS	-	Independent Front Suspension
IRS	-	Independent Rear Suspension
mb	-	Sprung Mass
ma	-	Unsprung Mass
ks	-	Suspension Spring
cs	-	Damper
xb & xa	-	Corresponding Displacements
HOQ	-	House of Quality
FMEA	-	Failure Modes And Effects Analysis
CA	-	Criticality Analysis
V	-	Voltage
RMS	-	Root Mean Square

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CHAPTER 1

INTRODUCTION

1.1 Background

Natural energy sources and artificial energy sources are the daily needs of human beings in this era. Human beings at this time are very concerned about energy resources to depend on for life and if these resources are depleted, will cause a great conflict between humans that can cause the human species to become extinct. For example, there are some people who cannot live without a source of electricity for 24 hours. This is proven by some Universiti Teknikal Malaysia Melaka (UTeM) students themselves when they lose their electricity, they will feel anxious and mentally disturbed after a few hours of losing their electricity. This proves the importance of energy resources to human beings.

In Malaysia, several energy sources have been identified and become the main source of Malaysia in producing fuel and electricity. The main sources of such energy are hydroelectric power, solar energy, coal, nuclear power, biomass, petroleum, and natural gas. All these resources have harvested their energy optimally since the time of the medieval industrial renaissance again. Therefore, it is undeniable that energy resources will dwindle day by day and there will be a time when these resources may be depleted. In addition, scientists are trying to create various methods to reduce the use of energy sources that can be depleted by utilizing unlimited energy sources such as sunlight and various other sources that can be harvested to be used as electricity. It is not strange if at this time the use of tools driven by electricity is actively developed and expanded to replace irreplaceable energy sources. For example, in this era, electric vehicles are increasing day by day, increasing on the road and it is not strange if one day all vehicles will only use electricity to move.

However, the increasing use of electricity every year is becoming more and more worrying. This increase is due to the factors of technological development and the increasing human population using electricity. This causes the demand for electricity to increase. Therefore, several new discoveries to produce electrical energy to meet human needs have been discovered such as triboelectric, electromagnetic, piezoelectric, and various other harvesting technologies. The discovery of this technology is good because this can be a backup energy to replace the existing energy and even if developed very well, maybe no longer need to rely on existing energy sources. But unfortunately, technology as good as this is underdeveloped in its use, especially in this country. Malaysia is very focused on existing resources considering finding and developing reserve energy sources (Qin *et al.*, 2020).

Nevertheless, it took the initiative to conduct research on piezoelectric energy harvesting and develop it so that the results obtained are optimum and will also develop piezoelectric technology by applying this technology to vehicles, especially in the suspension part. Because the part has a lot of vibration and the piezoelectric itself requires pressure to produce electrical energy itself. Therefore, this project will focus on Development of piezoelectric energy harvesting unit for suspension system. In addition, the methodology to conduct the study is to design a piezoelectric on the suspension system and produce a product model and then perform experiments on it. As a result of this, hoped that through the harvesting of piezoelectric energy can contribute to the driven vehicle.

1.2 Problem Statement

The world is showing a significant change in the direction of progress with the development of electronic technology in human daily activities. Every year, the process of changing the use of technology from mechanical to electronic and electrical is becoming more and more so especially in the automotive industry. Vehicles now use a lot of electrical devices that used to use mechanical devices. With this development, there has been the emergence of vehicles in several categories, such as vehicles that use petrol, hybrid and fully electric (Qin *et al.*, 2020).

Due to the use of many electronic and electrical devices in the vehicle causes the vehicle to be less energy storage, electronic or safety device not perform well and vehicle battery power can not support the use of the device. For this reason, studies on energy harvesting sources use electronic devices to help solve this problem were conducted.

1.3 Research Objective

The main aim of this research is to create a piezoelectric based product that will be applied to the car suspension system. Specifically, the objectives are as follows:

- a) To develop design of piezoelectric energy harvesting unit for car suspension system.
- b) To fabricate the piezoelectric energy harvesting unit for car suspension system.
- c) To perform functionality test for the prototype of piezoelectric energy harvesting car suspension system.

1.4 Scope of Research

These project scope have a focus on works in order to achieve the objective :

- Using the design concept selection process to determine the final design.
- Do create the drawing design using Catia V5 Software and the simulation.
- Create a prototype base on this project to collect data.
- Prototype can harvest energy and supply charge to batteries.



CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

A literature review is a study of scientific sources on a certain topic. This provides a broad perspective of current knowledge, helping to find relevant research ideas, methodologies, and gaps. In this thesis, writing a literature review involves finding relevant publications such as books, articles, or journals, analyzing it critically and explaining what is found. This literature review not only summarizes the sources, but it analyzes, synthesizes, and critically evaluates to give a clear in this thesis, a description of the sources of knowledge related to the topic of piezoelectric energy harvesting in automobile vehicles is discussed in more detail. These sources are obtained from reliable sources and proven in the reference section. This section, provide a clear picture of the project to be implemented. Picture of the state of knowledge about the subject being studied.

2.2 Energy Harvesting

In recent decades, microelectronics has resulted in the development of wearable gadgets such as garments and accessories that are powered by batteries or energy harvesting devices. Chemical batteries' energy density must be improved, despite developments in low-power integrated circuit technology, because the power requirements for the applications are difficult to achieve (Covaci and Gontean, 2020). As a result, new energy collection mechanisms will need to be developed in order to keep such self-powered gadgets running. Energy harvesting in self-sustaining self-powered systems is not only necessary as a

sustainable and cost-effective alternative to batteries, but it also aids in the reduction of greenhouse gas emissions and environmental preservation. There are three parts to a conventional energy harvesting system: the energy source, which is the energy that will be used to generate electrical power, and this energy could be ambient. External energy sources, such as sunshine, ambient heat, or wind, or external energy sources that are intentionally deployed. Next, the structure that turns ambient energy into electrical energy makes up the harvesting mechanism and also the load, or sink, is where the electrical output energy is consumed or stored.

The process of obtaining energy from an external source is known as energy intake. Just a few examples include solar energy, thermal energy, wind energy, salinity gradient, and kinetic energy. Furthermore, energy intake is also known as ambient energy, which is captured and stored for small wireless autonomous devices, such as those utilised in electronic networks and wearable wireless sensors. Low-energy electronics require only a minimal quantity of energy, which is provided via energy harvesters. Oil, coal, and other resources are produced as input fuels for some big sources. Energy sources for energy harvesters can be found in the backdrop (Caliò *et al.*, 2017).

Energy harvesting devices have aroused a lot of interest and demand since they convert ambient energy into electrical energy. Ocean waves, for example, are converted into energy by some systems, which is then utilized by autonomous oceanographic monitoring sensors. High-power output devices in remote areas could be employed as reliable power sources for huge systems in the future. Wearable electronics, for example, can use energy harvesting devices to power or recharge cell phones, laptop computers, radio transmission equipment, and more. All of these devices must be durable enough to withstand long-term exposure to harsh environments and have a wide dynamic range of sensitivities in order to

utilise the entire spectrum of wave motion. The next sections go through these energy harvesting technologies in further depth (Pozo *et al.*, 2019).

2.2.1 Type of energy harvesting

i) Photovoltaic



Figure 2.1 Figure of photovoltaic energy harvesting

One or more solar panels, an inverter, and other electrical and mechanical components make up a photovoltaic (PV) system, which uses the Sun's energy to generate electricity. PV systems are available in a variety of sizes, ranging from small rooftop or portable units to massive utility-scale power plants. Although PV systems can operate independently as off-grid PV systems, the focus of this article is on grid-connected PV systems. Although PV systems can function on their own as off-grid PV systems, this article focuses on grid-connected PV systems.