CAR ENGINE VIBRATION BASED MICRO-POWER GENERATOR

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This Report Is Submitted In Partial Fulfillment Of Requirements For The Bachelor Degree of Electronic Engineering (Industrial Electronic)

Fakulti Kejuruteraan Elektronik dan Kejuruteraan Komputer
Universiti Teknikal Malaysia Melaka

June 2012

UNIVERSTI TEKNIKAL MALAYSIA MELAKA

FAKULTI KEJURUTERAAN ELEKTRONIK DAN KEJURUTERAAN KOMPUTER

BORANG PENGESAHAN STATUS LAPORAN

PROJEK SARJANA MUDA II

Tajuk Projek : CAR ENGINE VIBRATION BASED MICRO-POWER GENERATOR

Sesi Pengajian : 1 1 / 1 2

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ACKNOWLEDGMENT

Thanks to God. Finally I manage to complete this project very well which is entitle Car Engine Vibration Based Micro-Power Generator. This project report was prepared for University Teknikal Malaysia Melaka, UTeM for student final year to complete the degree of Bachelor of Engineering in Electronic.

I am very grateful and would like to express my deepest thanks to my supervisor, Dr Kok Swee Leong, who is always give me guidance, continuous encourage and support during this two semester 2011/2012. Without his guidance and advice, it would be hard for me to complete this project.

I also want to thanks to the lecturers and staffs of Faculty of Electronic and Computer Engineering for their cooperation and great commitment during completing the project. Deepest thanks to my family for their love, patience and sacrifice. There is no other word to describe how I appreciate for their devotion, support and faith in me.

Many thanks go to all my friend that have been support my work and help during project progress. Lastly, I would like to thanks to anyone that have contribute to my final year project directly or indirectly.

ABSTRACT

Low level power output estimation from the vibration of car engine based on Micro-power generator is presented. Piezoelectric cantilever is used to harvest energy from the vibration. This material has an ability to scavenge the mechanical energy and transform into electrical energy. The electrical energy harvested is then charging capacitor after gone through full wave rectifier. The main objective of this project is to harvest energy from the environment, which is vibration from the car engine by developing a miniature generator using a piezoelectric cantilever. Storage capacitor would be used to store the energy so that the energy can be used for later uses or directly use from strain energy to electrical energy. Voltage regulator is used to provide an output dc voltage to maintain at a set value. The experimental results demonstrate the potential of the device applied to power up LED or LCD display and this application can be used as a self generate mini torch light for a mechanic to repair car engine in the dark.

ABSTRAK

Projek ini berkaitan pembinaan sebuah mikro power generator bersasarkan getaran daripada enjin kereta bagi menghasilkan kuasa yang bertahap rendah. Piezoelektrik digunakan untuk jana tenaga daripada getaran tersebut. Piezoelektrik mempunyai kebolehan untuk menukarkan tenaga mekanikal daripada getaran kepada tenaga elektrik. Tenaga elektrik ini digunakan untuk mengecas kapasitor setelah melalui penerus gelombang penuh. Objektif utama projek ini ialah memperoleh tenaga daripada sumber persekitaran , iaitu daripada getaran kereta dengan menggunakan sebuah penjana mini yang berbentuk julur piezoelektrik. Kapacitor penyimpan digunakan untuk menyimpan tenaga elektrik yang dijanakan oleh piezoelektrik tersebut, kemudian tenaga itu boleh sama ada digunakan secara terus atau disimpan kemudian digunakan mengikut keperluan. Pengatur voltan digunakan untuk menghasilkan keluaran voltan yang ditetapkan. Hasil keputusan eksperimen menunjukkan ia boleh diaplikasikan pada LED dan digunakan sebagai penyuluh lampu mini untuk kegunaan mekanik untuk membaiki enjin kereta dalam keadaan gelap.

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INTRODUCTION OF PROJECT

1.1 INTRODUCTION

Nowadays, the most important trend in the electronic equipment technology is by using small size equipment with variety function. The size of the equipment becoming too small from days to days so that people can bring it everywhere. All those technology need an external power supply so that it is easier to be carrying, small and hand held. However, using conventional batteries supply to provide the energy is not effective way due to its limited lifetime and need to be recharging and be replaced. To overcome this problem, many researcher had came out with many alternatives solution by using self-power electricity source by harvest or scavenge energy that is available in the environment surrounding system.

The important of the project is where it can provide an alternative source of energy to power up our electronic devices so that we do not need to rely only on battery. It has an ability to self generating, self-charging and store the energy. Besides, it is also useful in industrial environment as an alternative source and also can be used as safety monitoring devices such as those remote working places in the dark tunnel or earthquake prone areas. In addition, due to the vibrations present almost at everywhere and in any environment such as

buildings, transporting example trains, human activities, military devices and even in our home such as washing machine and blender.
Therefore, the energy is continuous and not limited. The most important thing that this energy is environmental friendly. It is not produced any disposal waste and not use or produce any industrial water or industrial waste. Besides, it also does not produces any carbons dioxide which can contribute to the global warming and lesser in contributing toe any kind of environment pollutions.

The aim of this project is to harvest energy from mechanical of vibration by generate low level power on similar scale to batteries but without the need for battery replacement or disposal of potentially dangerous and polluting chemicals. For this reason, vibration produces by machine such as car engine can be explored further in producing electric power. It offers an alternative in scavenging electrical energy from environment based on vibration. Since, piezoelectric has the highest energy density compared to other mechanism such as electromagnetic and electrostatic, it will be used in this project to harvest energy from the vibration source, whereby piezoelectric material is used to transfer mechanical strain that induced when excited by the vibration of the engine car and transform into electrical charge.

In this report, an energy harvesting IC, LTC 3588-1 is being used for capturing the output electrical power from the micro-power generator and it result is compared with simulation result to determine the performance in term of average power output. In this piezoelectric harvesting system, it consists of a full-wave bridge rectifier, switching transistor, charging and discharging capacitor and DC-DC converter.

1.2 OBJECTIVE

The objectives of this project is;

- to investigate vibration as a way to harvest energy by using vibration level of car engine.
- to design the piezoelectric generator and integrated with rectifying circuit for the micro-power generator.
- To test the micro-power generator on vibration platform similar to the car engine.

1.3 PROBLEM STATEMENT

Most of conventional electronic devices are relied on the use of battery as a power source to function such as camera, torchlight and hand phone. However, there are several disadvantages when we are too dependent on battery source.

One of the major problems with the battery is that it needs to be replaced with the new one over the time. Battery replacement needs to be carried out periodically especially to travel or go to a place that takes a long time in preparation as an alternative source if the battery is drained out. The process of replacing the battery periodically imposing high cost and labour effort. Even though the price of battery is not very expensive but if the repetition of battery replacement is occurring ever often, it will be involving a lot of money being spent just to buy new batteries, let alone other expenses like labour costs and logistics.

There is also battery which is rechargeable. However, extra electronic devices like a portable charger is required to charge the battery. This charger also needs to be carried out periodically when to go somewhere or to travel. This would be a problem if there is no power supply provided at the place.

Besides, each battery has its limited lifetime. The lifetime of the battery would be reduced if the users not charge their battery properly. Examples, during charging the phone but user still use the phone by making call or texting in the same time. Thus, this would harm the battery and reduce the lifetime of the battery.

Limited life time of the battery often become the main problem for the wireless sensor network. In wireless sensor network, it has its own design topology network where in some case, it need lot of sensor node. Typically, battery will be used to power the sensor node. Wireless sensor network required the sensor node to operate up to 20 to 30 years but how come a battery can sustain its energy in 20 year. Therefore battery replacement is needed. It needs to be replace periodically. This is because if one of the nodes dies or low battery power, the network may not be able to perform and cannot transmit the data. To periodically replace the battery it is high cost. Just imagine how many time the battery need to be replaced in 20 to 30 years.

Besides, there is also disposal requirement to dispose the drain battery. Battery contains of heavy metal and some of chemical material that could endanger lives if it is not dispose or manage very well. The manufacturing of the battery use many type of different reactant chemical. A battery has been manufactured based on chemical material such as zinc-carbon, zinc-chloride, alkaline manganese dioxide, silver oxide, zinc-air, lithium thionyl chloride and lithium manganese dioxide [15].

Therefore, there are a lot of efforts that need to be done to resolve the problem of using the use of battery. In 2006, about 40 billion disposal batteries were sold

worldwide. Americans has been purchase it in about 3 billion disposal battery every year[15]. However, it is very difficult to find a place that to recycle disposal of battery. Wireless grid has been introduced that include of wireless sensor network and wireless power transmission [22] by optimized the transmission scheduling of the data, design and efficient low-power radio front-end [16] and lowering the sample frequency and using efficient sleep modes between samples [17].

Based on the problems being discussed above, it shows that it is inconvenient to rely only on battery as an electrical source that is the reason this project is carried out to address the problems.

1.4 SCOPE

There are many issue have to be resolve in replacing batter with vibration based energy harvester, however the scope can be very big, therefore in this project, the scope of the project is limited to the list below, which is,

- to design a miniature generator which is not bigger than 50 cm^3 .
- to generate low level power (less than 1mW) that operates on low-power electrical devices.
- to be tests in lab, the micro-power generator with a vibrator as a simulation similar to the car engine.

1.5 SIGNIFICANT OF THE PROJECT

A miniature generator is developed based on the vibration principle with the capability of self generating, self charging and storing of the energy. The miniature generator has a dimension of not bigger than $50cm^3$ which is easy to be mounted on and easy to be customized to suit to any car engine design.

As a simulation to the vibration lever of a car engine, this micro-generator is tested in lab with shaker. The shaker is set to the vibration level of car engine to generate oscillation to excite piezoelectric cantilever based micro-power generator. As a result, this micro-power generator produces low electrical power that less than 1miliWatt, which is able to power-up low power electronic devices such as LED.

With this innovation, it can provide a low cost, compact, vibration harvest power supply solution. It will eliminate the need to constantly replacement of dead batteries which is not economical. Besides that, it can provide a green, environment friendly, virtual infinite power source to replace the traditional energy source, the battery.

CHAPTER II

LITERATURE REVIEW

One of the best solutions to replace battery is to get the energy that can self-power, self-generate, self-charge and can be store. This can be done by renewable source of energy continuously from the environment where the energy is continuous and not limited.

Energy harvesting or also known as energy scavenging is a process of capturing energy sources from the environment such as solar power, thermal energy, wind energy and mechanical energy. The energy source will be captured and stored and can be used for powering low-power electronic devices. For transforming mechanical/kinetic energy to electrical energy, it can be categorized in three types; electromagnetic, electrostatic and piezoelectric. Among these three types, piezoelectric has the largest energy density. Piezoelectric materials have the ability to transfer mechanical strain energy into electrical charge [8]. It allows a charge build up in them in response to mechanical strain.

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2.1 ENERGY HARVESTER TECHNOLOGY

Energy harvesting is the process to capture the energy from the environment, a naturally source by accumulate them and storing them to be used later. U K Sigh and R H Middleton [4] states that, the process of acquiring the energy surrounding a system and converting it into usable electrical energy is termed power harvesting. Common sources of energy harvest are mechanical energy from the vibration, mechanical stress and strain, and light energy from sunlight, solar panel and photo diodes, natural energy from the wind flow or ocean, biomass energy that is from biological organism in the ecosystem or thermal energy that is from human activity. Table 2.1 shows the comparison of energy scavenging and energy storing methods.. (Thesis by Shadrach Joseph Roundy [1]).

Table 2.1: Comparison of energy scavenging and energy storage methods. Note that leakage effects taken into consideration for batteries. (Thesis by Shadrach Joseph Roundy [1]).

		Power density($\mu W/cm^3$) 1 year lifetime	Power density($\mu W/cm^3$) 1 year lifetime
Scavenged Power Sources	Solar (outdoors)	15,000-direct sun 150 – cloudy day	15,000 – direct sun 150 – cloudy day
	Solar(indoor)	6 – office desk	6 – office desk
	Vibrations	200	200
	Acoustic noise	0.003@75 Db 0.962100Db	0.003@75 Db 0.962100Db
	Daily Temp. Variation	115 @ 10^0 gradient	115 @ 10^0 gradient
	Temperature gradient	330	330
	Shoes Inserts	45	3.5

	Batteries (non-rechargeable Lithium)	7	0
	Hydrocarbon fuel(micro heat engine)	333	33
	Fuel Cells (methanol)	280	28
	Nuclear isotopes(uranium)	6×10^6	6×10^5

Recently, several approaches have been made to harvest energy from the environment to power wireless sensor networks. It was because batteries are not recommended to power the wireless sensor since the power source would limit the life time of the sensor. Based on Gui.L [23], energy harvesting from the ambient vibration offers an attractive means of powering small-scale systems which is not only offer a clean, regenerative power sources but also offer a tremendous advantages for system to replace the battery. In his paper, he presented a solution to create a new kind of low-frequency energy harvesting device (a coupling impact vibration energy harvest) that offers both an efficient energy conversion and compact design to be suitable for MEMS implementation.

Noel Eduard[ ] presented a model and designed of MEMS-scale piezoelectric-based vibration energy harvesters (MPVEH). In his thesis, he showed that harvesting mechanical vibration is a source of power, well matched to the needs of wireless sensor nodes.

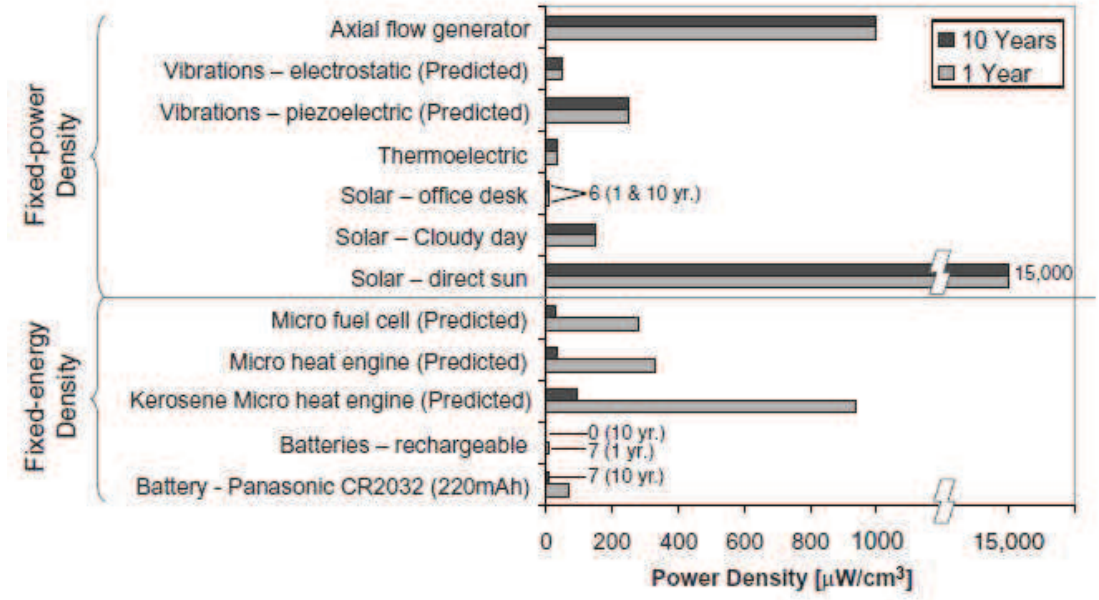

Figure 2.1: Comparison of power sources for wireless sensor nodes. Adapted from Noel Eduard [2].

Power or energy source for the nodes can be divided into two groups which is sources with a fixed energy density such as battery and sources with a fixed power density such as ambient energy harvest. Figure 2.1 showed the comparison of power sources for wireless sensor nodes. Fixed energy density sources have limited life and need to be replaced or fuel replenished. Therefore fixed power density sources, which are ambient energy harvesters, are better suited for long term implementation than fixed energy density sources. Based on Noel Eduard [2], there is limited to design a wireless node application using technology of battery due to the size ,weight and cost. Besides that, batteries contains of chemicals that can hazardous.

Francesco Cottone [3] in his thesis proposes a new method based on the exploitation of the dynamical features of stochastic nonlinear oscillators. The work has concerned the theoretical study, numerical and finite element modelling, implementation and experimental test of stochastic bistable piezoelectric oscillators employed for scavenging energy from irrational noise. Experimental tests have been