ON-BOARD RECHARGING SYSTEM FOR PORTABLE BATTERY OPERATED VEHICLE: AN INVESTIGATION

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"It is hereby declared that all materials in this thesis are the effort of my own work and materials which are not the effort of my own has been clearly acknowledged"

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Specially dedicated to
My beloved family and those people who have guided and inspired me throughout my journey of education

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In The Name of God, The Most Beneficent The Most Gracious

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curious about how things work. Thanks for encouraging me to be an independent thinker, and having confidence in my abilities to go after new things that inspired me.

ABSTRACT

This thesis is about a research project entitled An Investigation On-Board Recharging System for Portable Battery Operated Vehicle. The importance of this research is to prove that the life of the battery can be expanded during the operation by reducing the frequency of recharging time. This can save the electrical energy which then saves the cost. In this research, a dynamo was used as a significant charging device from which it can provide a small voltage output. In this research two methods were used to rotate the dynamo. Method one or Experiment 1 used wheel of portable vehicle while Experiment 2 used bicycle's perwel and bicycle's gear. The output voltage from the dynamo was connected to the rectification circuit to convert an AC voltage into DC voltage. The DC output voltage was rectified and increased by using boost converter, which aimed to step up small value of voltage to higher voltage. Within this circuit, there was a JFET driver which was used to provide clock cycle for switching. From these two experiments, the first experiment gave better results where it produced higher voltage and current output as compared to the second experiment. The results from both Experiments 1 and 2 were compared with theoretical assumption using Orcad PSpice simulation. The research gave the researcher the idea on how to improve the life of the battery.

ABSTRAK

Kebanyakan kenderaan mudah alih seperti kereta permainan kanak-kanak menggunakan bateri yang boleh dicas semula. Masalah yang timbul ialah kuasa bateri tidak dapat bertahan lama sehingga ia digunakan berterusan. Kajian ini bertujuan untuk menyediakan alat yang boleh memanjangkan hayat bateri semasa kenderaan mudah alih digunakan. Ini akan menjimatkan kos tenaga elektrik kerana kekerapan mengecas bateri dapat dikurangkan. Dua eksperimen telah dijalankan dimana Eksperimen 1, sebuah dinamo telah dilekatkan pada roda kenderaan mainan kanak-kanan manakala Eksperimen 2 menggunakan perwel dan gear basikal. Voltan keluaran daripada kedua-dua dinamo di sambungkan kepada litar penurus dan ”Booster” untuk menghasilkan voltan DC yang diperlukan. Litar ini juga dilengkapi dengan daya pemacu JFET yang bertujuan untuk menyediakan kitaran jam yang berterusan untuk menghasilkan “switching”. Daripada kedua-dua eksperimen, Eksperimen 1 lebih praktikal kerana ia dapat menyediakan voltan dan arus yang lebih tinggi. Bagaimanapun, kedua-dua penemuan daripada eksperimen telah dibandingkan dengan andaian secara teori dengan menggunakan Orcad Pspice. Kajian ini dapat meyakinkan penyelidik untuk menghasilkan alat yang boleh memanjangkan hayat bateri kenderaan mudah alih.

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GLOSSARY OF ABBREVIATIONS

CD	-	Compact Disk
DC	-	Direct Current
AC	-	Alternating Current
RC	-	Rectification Circuit
IC	-	Integrated Chip
JFET	-	Junction Field-Effect transistor
EMF	-	Electric and Magnetic Field
BJT	-	Bipolar Transistor
PWM	-	Pulse Width Modulator
VCO	-	Voltage Controlled Oscillator
LED	-	Light Emitting Diode
BEV	-	Battery Electric Vehicles
DIP	-	Dual in Package
THR	-	Threshold
TR	-	Trigger

CHAPTER 1

INTRODUCTION

1.1 Overview

Electricity plays a vital and ever growing role in recent humanity. Throughout the last decades the utilization of electricity in the production of goods and services has increased strongly and rapidly than most other key indicators, partially at the expense of other energy carriers or sources. The increase is caused by the strong interplay of developments in the production, distribution and use of electricity, an easy-to-apply energy carrier. Researchers tried the very hard to find ways on how to decrease the usage of electricity. Due to this, this research has been on investigation On-Board Recharging System for Portable Battery Operated Vehicle. To prove by recharging the battery it may save cost due to less electrical usage and may extend the usage of the battery itself.

Regarding this, a dynamo is used as a main generator to provide AC voltage. As we all know, a generator is a machine that produces electrical energy from a mechanical energy source. The process is known as electricity generation.

Other than that, a rechargeable battery also is used in this project. Rechargeable batteries are batteries that can be restored to full charge by the application of electrical energy. They come in many different designs using different chemistry. They are also

called storage battery or secondary cell. Attempting to recharge non-rechargeable batteries may lead to a battery explosion. Some types of rechargeable batteries are susceptible to damage due to reverse charging if they are fully discharged, other types need to be fully discharged occasionally in order to maintain the capacity for deep discharge. There exist fully integrated battery chargers that optimize the charging current [3].

Today, rechargeable batteries are everywhere. They run handheld video game systems, stereos, laptop computers, cell phones, cameras and camcorders, cordless telephones and an array of tools. For starters it can save money. A good set of rechargeable can pay for themselves many times over in a portable CD player, digital camera and other high-drain devices. And any time reuse an item, rather than throw it away, helping to save the earth's natural resources.

In conclusion, the complexity of the electricity supply, distribution, demand system, its impact on society and environment, and the various technological, behavioral and institutional as options to change this impact call for research into electricity futures that are compatible with sustainable developments.

1.2 Objective

The main objective of this project is to find ways to extend battery's life during its operation in order to save electrical usage by reducing the frequency of recharging the battery. During the development of this experiment, a number of criteria were defined which were thought to be important and essential. The two main criteria were:

a) The results calculated with the experiments and simulation from Orcad PSpice should be an adequate representation of reality.
b) The user interface ought to be user-friendly and interactive, to classify between two experiments, which one is the best method to be used in order to provide the high voltage and high output current.

In order to achieve the research goal, five steps were applied. First, basic concept of recharging the battery including their types, characteristic, application, advantages and disadvantages need to be reviewed. Next is to define a device other than the battery that could produce voltage output by using mechanical energy source. Thirdly, after having the voltage output, ways on how to gain DC voltage and also to boost the voltage by using rectification circuit and step up circuit. Then, the databases were also created by using the Orcad PSpice simulation. Lastly, the results from the experiments and simulation were compared.

1.3 Scope of the project

The project aims to test the capability of alternator used to recharge the battery in a portable vehicle to enable the battery to extend its life during operation. The alternator is attached to the motor via its wheel in order to generate power to charge the battery. The scopes of this project are as follows:

a) To determine the type and characteristic of the alternator that can be used.
b) To identify the appropriate technique to connect the alternator to the motor.
c) To determine the devices to be used in the rectification circuit, booster circuit to achieve the results that are desired.

1.4 Problem statement

Normally the rechargeable battery that has been used need to be charged frequently, and this will result in high cost for electricity. Other than that the users of the portable vehicle especially kids might be frustrated when the interruption occur due to the battery while they are playing with the portable vehicle. With this research, it is hoped that the battery's life can be extended during operation and it will reduce the cost of electricity for the user.

CHAPTER II

LITERATURE REVIEW

2.1 Introduction

This thesis involved the design and research regarding On-Board Recharging System for Portable Battery Operated Vehicle systems. In this chapter, the researcher reviews article and past research about the component and devices used to make this project a reality. The devices such as motor power window, sealed lead acid, dynamo, appropriate components had being identified even not even not exactly but they are similar in output and can be used. Followings are the reviews on various devices, components and the features that are able to support in the design of generating set for this study.

2.2 Motor Power Window

Figure 2.1: Motor for Power Window

Power windows use an arrangement of electric motors, drive mechanisms, switches and wiring to operate the windows. Power windows motor as shown in Figure 2.1 or an electric window are automobile windows which can be raised and lowered by depressing a button or switch of some sort, as opposed to using a hand-turned crank.

(Wikipedia, 20 September 2005)

The power moonroof, a transparent, retractable sunroof, may be considered as an extension of the power window concept. Table 2.1 shows the features of the motor for power window as used in this project.

Table 2.1: Motor Power window's features

	Features	**Data**
1	Working voltage	12V to 24V
2	No load speed	79rpm
3	No load current	<2.5A
4	Stall torque	6.5 - 11nm
5	Stall current	<26A
6	Rated load	2.94nm
7	Rated current	<12A

2.3 Sealed Lead Acid Battery

Figure 2.2: Sealed Lead Acid Battery

These types of batteries confine the electrolyte, but have a vent or valve to allow gases to escape if internal pressure exceeds a certain threshold. During charging, a lead-acid battery generates oxygen gas at the positive electrode [16]. Sealed lead-acid battery as shown as Figure 2.2 is designed so that the oxygen generated during charging is captured and recombined in the battery. This is called an oxygen recombination cycle and works well as long as the charge rate is not too high. Too high of a rate of charge may result in case rupture, thermal runaway, or internal mechanical damage. The valve-regulated battery is the most common type of sealed battery. It was developed for stationary and telecommunication battery applications [14].

These types of sealed batteries have a spring-controlled valve that vents gases at a predetermined pressure. Typical pressure thresholds are from 2 to 5 psig, depending on the battery design. Although the term "valve regulated" is often used synonymously to describe sealed lead-acid batteries, not all sealed batteries are valve-regulated. Some battery designs employ replaceable vent plugs or other mechanisms to relieve excess pressure. Sealed batteries were developed to reduce the maintenance required for batteries in active service [16]. Since electrolyte levels are preserved by trapping and recombining off-gasses, there should not be any need to add distilled water over the life of the battery. These batteries are often misnamed maintenance free. In fact, all maintenance practices applicable to unsealed type batteries are applicable to sealed type batteries. The only exception is that electrolyte levels cannot, and should not need to be, maintained [16].

Sealed type batteries are often avoided for backup power source applications for several reasons. One reason is that the state of charge of sealed type batteries cannot be ascertained by the usual specific gravity measurement. Reliable alternative methods to measure the state of charge for sealed type batteries are under development. A second reason is their sensitivity to high temperatures [14].

2.3 Dynamo

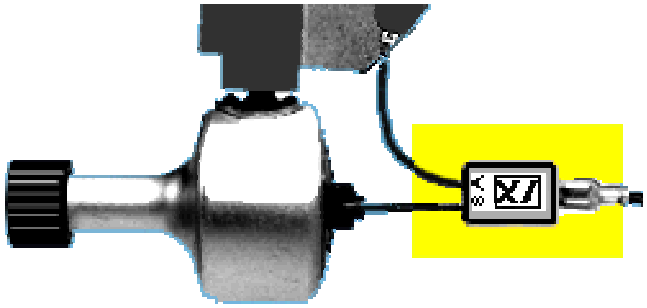

Figure 2.3: Dynamo 6V 3Amp

An electrical generator is a device that produces electrical energy from a mechanical energy source. The process is known as electricity generator. The dynamo as indicate in Figure 2.3 was the first electrical generator capable of delivering power for industry and is still the most important generator is use in 21st century. The dynamo uses electromagnetic principles to convert mechanical rotation into an alternating electric current. It is the most common way to generate electrical energy for bicycle lighting.

The first dynamo based on Faraday's principles was built in 1832 by Hippolyte Pixii, a French instrument maker [4]. It used a permanent magnet which was rotated by a crank. The spinning magnet was positioned so that its north and south poles passed by a piece of iron wrapped with the wire. Pixii found that the spinning magnet produced a pulse of current in the wire each time a pole passed the coil. Furthermore, the north and south poles of the magnet induced currents in opposite directions. By adding a commentator, Pixii was able to convert the alternating current to direct current [4].

2.5 Rectification

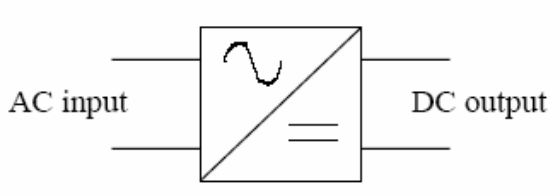

Figure 2.4: Basic block diagram of rectification

A rectifier is an electrical device, comprising one or more semiconductive devices such as diodes, arranged for converting alternating current to continuous current. Rectification is a process whereby alternating current (AC) is converted into direct current (DC). Almost all rectifiers comprise a number of diodes in a specific arrangement for more efficiently converting AC to DC than is possible with just a single diode. Figure 2.4 shows the block diagram of the rectification process. Rectification is commonly performed by semiconductor diodes.

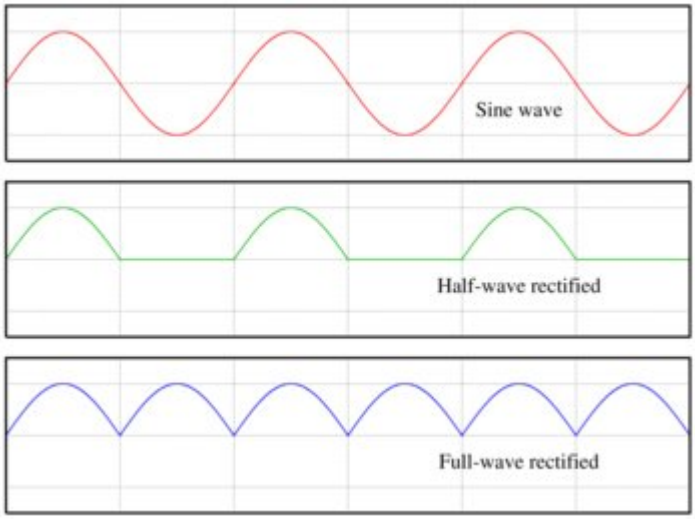

Figure 2.5: Sine wave, half wave and full wave rectified signals

There are 2 types of rectification for single phase either half wave rectifier or single-phase, full wave rectifier. Figure 2.5 shows sine wave, half wave and full wave rectified signals. Specifically for this project, the researcher used single-phase, full wave rectifier in terms of continuous and discontinuous current mode.

2.5.1 Full-wave rectification

Full-wave rectification converts both polarities of the input waveform to DC, and is more efficient. However, in a circuit with a non-center tapped transformer, four rectifiers are required instead of the one needed for half-wave rectification. This is due to each output polarity requiring 2 rectifiers each, for example, one for when AC 'X' is positive and one for when AC terminal 'Y' is positive. The other DC output requires exactly the same, resulting in four individual junctions.

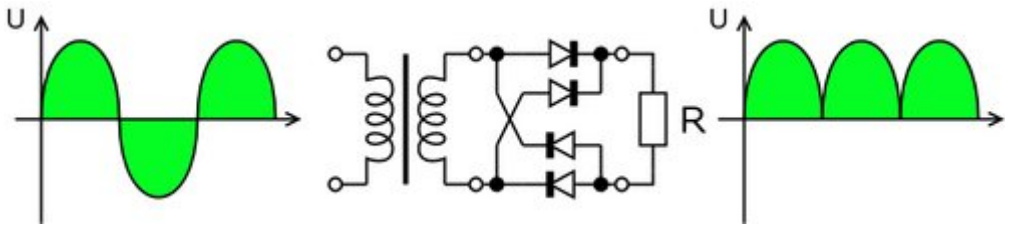

Figure 2.6: Four rectifiers arranged this way are called a bridge rectifier.