DEVELOPMENT OF MONITORING SYSTEM FOR A SMALL SCALE ENERGY HARVESTER FOR DOMESTIC USAGE

TAN KAI LOON
B071310460

UNIVERSITI TEKNIKAL MALAYSIA MELAKA
2016

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DEVELOPMENT OF MONITORING SYSTEM FOR A SMALL SCALE ENERGY HARVESTER FOR DOMESTIC USAGE

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Electronics Engineering Technology (Industrial Electronics) with Honours

by

TAN KAI LOON

B071310460

920620-07-5655

FACULTY OF ENGINEERING TECHNOLOGY

2016

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: **DEVELOPMENT OF MONITORING SYSTEM FOR A SMALL SCALE ENERGY HARVESTER FOR DOMESTIC USAGE**

SESI PENGAJIAN: **2016/17 Semester 1**

Saya **TAN KAI LOON**

mengaku membenarkan Laporan PSM ini disimpan di Perpustakaan Universiti Teknikal Malaysia Melaka (UTeM) dengan syarat-syarat kegunaan seperti berikut:

1. Laporan PSM adalah hak milik Universiti Teknikal Malaysia Melaka dan penulis.
2. Perpustakaan Universiti Teknikal Malaysia Melaka dibenarkan membuat salinan untuk tujuan pengajian sahaja dengan izin penulis.
3. Perpustakaan dibenarkan membuat salinan laporan PSM ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. **Sila tandakan (✓)

☐	SULIT	(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia sebagaimana yang termaktub dalam AKTA RAHSIA RASMI 1972)
☐	TERHAD	(Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)
☐	TIDAK TERHAD	

Disahkan oleh:

_____ _____

Alamat Tetap:

NO.5, JALAN RABANA 5,

TAMAN REBANA,

14200 SG BAKAP, PENANG.

Cop Rasmi:

Tarikh: _____ Tarikh: _____

** Jika Laporan PSM ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh laporan PSM ini perlu dikelaskan sebagai SULIT atau TERHAD.

DECLARATION

I hereby, declared this report entitled “Development of Monitoring System for A Small Scale Energy Harvester for Domestic Usage” is the results of my own research except as cited in references.

Signature	:	……
Author’s Name	:	TAN KAI LOON
Date	:	04 / 12 / 2016

APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Electronics Engineering Technology (Industrial Electronics) with Honours. The member of the supervisory is as follow:

……

Mr. WAN NORHISYAM BIN ABD RASHID

ABSTRAK

Penuai tenaga adalah mengumpulkan tenaga dari sumber alam sekitar seperti turbin air, tenaga solar, tenaga angin, dan tenaga kinetik dengan mengaplikasi konsep kuasa elektronik untuk mengecas bateri. Walau bagaimanapun, penuai tenaga yang dihasilkan melalui turbin air adalah kuasa yang kecil dalam kiraan milliwatt, tapi penghasilan kuasa ini sesuai digunakan untuk perkakas elektronik yang memerlukan penggunaan kuasa elektrik yang rendah. Sistem pemantauan bateri state-of-charge (SOC) untuk skala kecil tenaga harvester di atas bumbung tangki air simpanan perumahan sukar dipantau. Oleh itu, satu mekanisme system dihasilkan dalam projek ini mengandungi DC-DC boost converter, penjana kuasa, dan system pemantauan. Terdapat berberapa perisian digunakan untuk projek ini seperti Arduino IDE 1.6.7, Proteus 8.3 Professional and Multisim 13.0 untuk penghasilan litar and simulasi untuk sistem ini. Satu sistem pemantauan yang mantap untuk manupulasi data status 12V lead-acid battery dengan menyambung pembahagi voltan dengan menukar analog signal kepada digital signal dan menghantar data tersebut kepada telefon pintar melalui Bluetooth Module HC-05 untuk memaparkan data status bateri dalam telefon pintar. Satu aplikasi android dicipta dengan menggunakan perisian MIT App Inventor untuk memantau data status bateri di telefon pintar melalui modul Bluetooth. Seterusnya, fungsi bateri ini adalah untuk membekalkan voltan kepada 16x2 LCD dan Bluetooth module HC-05 dalam projek ini di manakala dalam situasi realiti fungsi bateri sebagai power simpanan untuk membekalkan kuasa kepada alarm sistem dan lampu perumahan ketika pemutusan pembekalan elektrik demi menjaga keselamatan anggota keluarga dalam perumahan.

ABSTRACT

Energy Harvester is a system which gather energy from the external environment sources such as water turbine, solar energy, wind energy and kinetic energy which is used in power electronics for battery charging. Even though energy harvester produces little amount of power which in term of milliwatt, but it is utilized for low power consumption electronics applications. Battery monitoring system state-of-charge (SOC) for small scale energy harvester at the domestic roof water tank are difficult to monitor. Therefore, a solution system will be designed which consists of DC-DC boost converter, generator and a monitoring system. In order to simulate and build the circuit of this system, the software will be used: Arduino IDE 1.6.7, Proteus 8.3 Professional and Multisim 13.0. To determine the SOC of the 12V lead-acid battery, a monitoring system that manipulate signal from the signal conditioning system which acquire signal from the DC-DC booster will be converted by using Analog-to-Digital Converter (ADC) and then transferred to smartphone through Bluetooth Module HC-05 for monitor the status of battery. The android apps for smartphone will be developed by using MIT App Inventor software in order to monitor the status battery data that transmitted to smartphone through Bluetooth module. Besides, the function of 12V lead-acid battery utilize for supply voltage to 16x2 LCD and Bluetooth Module HC-05 on this project. However, the application of the battery act as power back-up on reality and supply for domestic alarm system and lamps while black out to ensure all family members stay in safety environment.

DEDICATION

This thesis report dedicated to:

To my parents,

To my supervisor,

To my lecturers,

And my friends,

for unconditionally guidance, support and encouragement.

ACKNOWLEDGEMENT

First and foremost, I would like to express my deepest gratitude to Mr. Wan Norhisyam Bin Abd Rashid for giving me an opportunity working under her supervision throughout this project. The project would not be completed under the time frame without his supervision.

Not forgetting the staffs of Faculty of Engineering Technology; my academic advisors, Mr. Mohd Fauzi Bin Ab Rahman and Mr. A.Shamsul Rahimi Bin A.Subki for their professional advices in Power Electronic, lab engineers for their assistance during my laboratory sessions, and also the other staffs who had been helping me indirectly. Besides, thanks for lecturer, Mr. Aminurrashid Bin Noordin for advice and guidance in development of an android apps by using MIT App Inventor software.

Special thanks to my peers, my friends to had been providing me remarkable ideas to improve the project, my family who supported me physical, emotional, and financial support throughout the project.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVATIONS, SYMBOLS AND NOMENCLATURES

BCM	-	Base Controller Module
BMS	-	Battery Management System
BSTM	-	Base Status Transit Module
CAN	-	Controller Area Network
COM	-	Compare Output Mode
D	-	Duty Cycle
DC	-	Direct Current
ECU	-	Electronic Control Unit
EV	-	Electrical Vehicle
GPRS	-	General Packet Radio Service
IP	-	Instrument Panel
KVL	-	Kirchhoff's Voltage Law
LCD	-	Light Crystal Display
LED	-	Light-Emitting Diode
Li-on	-	Lithium-ion
MPPT	-	Maximum Power Point Tracking
Ni-Cd	-	Nickel-Cadmium
Ni-MH	-	Nickel-metal hydride
OCV	-	Open Circuit Voltage
PI Controller	-	Proportional Integrated Controller
PSoC	-	Cypress Power Programmable System on Chip
PWM	-	Pulse Width Modulation

Q(t)	-	Current Capacity
Q_n	-	Nominal Capacity
SOC	-	State-of-Charge
SOH	-	State-of-Health
WBMS	-	Wireless Battery Monitoring System
WGM	-	Wave Generation Mode

CHAPTER 1
INTRODUCTION

1.1 Introduction

This chapter will present the overview description of this research to develop the monitoring system for a small scale energy harvester for domestic usage. It consists of the background, objectives and the scope of this project. The objectives of this project will solve the problem statement that is declared in this chapter.

1.2 Background

In this technology era, energy harvester is widely used for domestic usage since it is a renewable energy source. Energy Harvester also known as power harvester or energy scavenger is a process to capture energy from environment then it is converted into usable electric power. Energy harvester permits electronic to work where there is no conventional power source, dispensing with the need to run the wire or make regular visits to replace batteries.

In our real life applications, energy harvesters are widely used. Monitoring system energy harvester for domestic usage often benefit from energy harvester power source. MIT App Inventor software is used to develop an app on smartphone which will display the state-of-charge (SOC) of 12V lead-acid battery by transmitting the data through Bluetooth devices to smartphone. Yeatman E.M. (2009) have described that energy harvester usually produced in small scale from ambient sources. The future development of energy harvester sources for portable electronic appliances such as smartphone and laptop that would attract customers.

K.W.E. Cheng et al. (2011) have implemented that battery management system (BMS) and SOC development for electrical vehicles play an important role to ensure safety operation and life of passenger relies on upon battery system. The SOC elimination has been actualized by utilizing Coulomb counting and open-circuit of voltage strategies in order to avoid the limitation of stand-alone Coulomb counting techniques.

Lenord Melvix J.S.M et al. (2014) have described the intelligence of battery monitoring system to help in keeping up lead-acid battery which apply by powering lighting systems. The intelligent monitoring system is created on embedded system application with the uses of method of Cypress Power Programmable System on Chip (PSoC) which control the sunlight energy source charge the lead-acid battery by using methods of Maximum Power Point Tracking (MPPT) algorithm and then monitor the performance status and SOC of lead-acid battery. The execution data is exchanged at general interims utilizing MOXA embedded web server for customers to screen the status of battery from remote areas and make a move in the event that any anomaly is accounted for.

1.3 Problem Statement

Energy harvester is a renewable energy resource which is widely used in our real life. However, battery monitoring system of state-of-charge (SOC) and state-of-health (SOH) for a small scale energy harvester at the domestic roof water storage tank was very difficult to monitor. These is due to water tank storage is placed on top of domestic roof which is very difficult and dangerous to climb the roof purposely to monitor the power supply energy that is generated by water turbine to charge the battery. The water tank storage place on the top of domestic roof which have potential to exploit that particular energy which generate the output voltage supply for battery charging. Therefore, the design of these project is the solution to determine the SOC battery monitoring system signals and status data that transmitted through Bluetooth module to the smartphone by developed the MIT App Inventor software.

1.4 Objectives

The objectives of this project are as stated in below:

i. To display data from 12V lead-acid battery on smartphone.
ii. To transfer data from output signal conditioning through Bluetooth devices to smartphone.
iii. To develop android apps by using MIT App Inventor to display output signal data on smartphone.

1.5 Scope

The scopes of this project are as stated as below:

i. A 12V lead-acid battery is used due to Li-on battery is too expensive and not the main purpose of these project equipment needed.
ii. Monitoring state-of-charge (SOC) of 12V lead-acid battery.
iii. Developed android apps by using MIT App Inventor software to monitor the output signal data that sent through Bluetooth Module HC-05 to the smartphone.

1.6 Thesis Organization

This project report consists of five chapters that will describe the flow of this research in structure. For the first chapter will contain of the background of this project, problem statement, objectives and the scope of this project.

For second chapter will contain the literature review that comparing the idea and method or techniques of other researcher used to do the analysis on battery monitoring system. Besides, this chapter will discuss about pros and cons of other researcher method uses and then design of this project by apply suitable techniques to improve this project.

For third chapter which will discuss about research methodology which will explicate the method of conducting the analysis of this research.

For fourth chapter will implement the result that obtained from the analysis by using NI Multisim, Proteus 8.3 Professional and Arduino IDE 1.6.7 software and then explain on the discussion made through the output that obtained from the analysis of this research project made.

Lastly, for fifth chapter which will conclude and summarise all the overall progress from the beginning until the end of the project.

CHAPTER 2
LITERATURE REVIEW

2.1 Introduction

This chapter will review the techniques utilized in this project based on the sources and information gathered from books, website or journal. Monitoring system is one of the methods for battery monitoring system application, the strengths and weakness of other techniques application for monitoring system and switching control of dc boost converter also will be discussed.

2.2 Energy Harvester

Davide Carli et al. (2011) have presented that measured design gathers the energy from each of the associated energy harvester subsystems in a simultaneous and free-way. A lithium-ion or nickel-metal hydride rechargeable battery connected to ensure the framework against long stretches of ambient energy shortage and enhances its general reliability. An energy harvester defined as interface between the renewable ambient energy sources and one or a few vitality customers or loads. The genuine test in the configuration of energy harvester system is to give consistent and stable power supply to the load compare to the accessibility attributes of the vitality sources. To perform the end-to-end power exchange with the most extreme conceivable effectiveness and it should act as a buffer between the variable power utilization of the last framework and the wide element range of the encompassing sources.

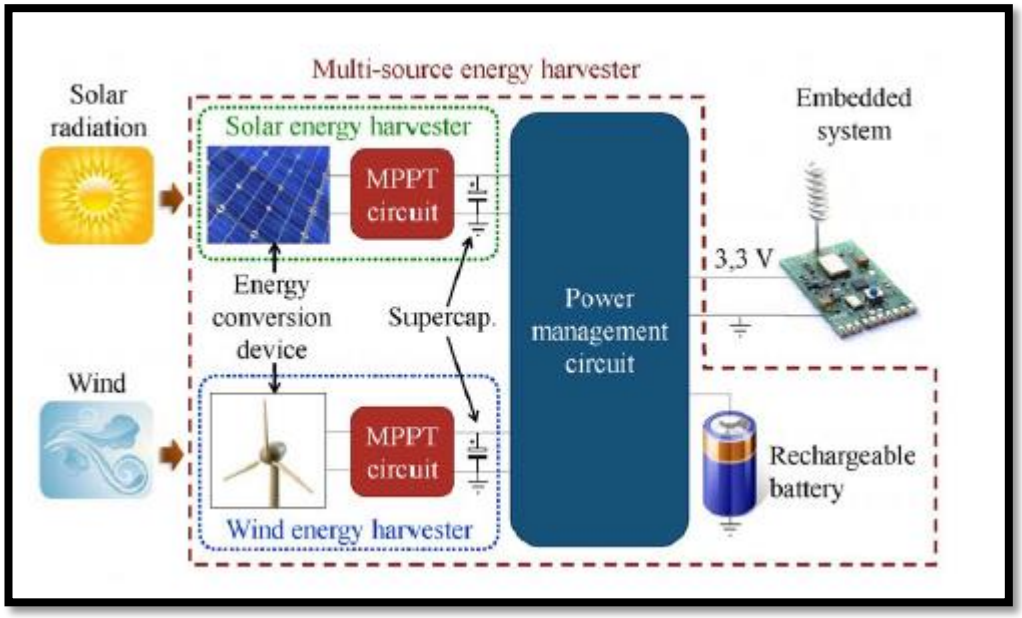

Figure 2.1: Architecture of the multi-source energy harvester. Source: Davide Carli et al. (2011)

2.3 DC-DC Boost Converter

Daniel W.Hart (2011) stated that DC-DC converter is a power electronic circuit which change over a dc voltage to an alternate dc voltage level, frequently provide a regulated output. The boost converter known as step-up converter which enable produces an output voltage is greater than or equal to the input voltage. The function of inductor operation in boost converter circuit is to limit in-rush current switching while the function of capacitor to filter fluctuation in output voltage or known as voltage ripple. The analysis for the switch is closed, the diode become reverse-biased. By applied Kirchhoff's voltage law, the rate of change of current at constant which current increases linearly when switched is closed. The rate of increase of current Δi_L while the switch is closed,

$$(\Delta i_L)_{closed} = \frac{V_s DT}{L}$$

The analysis for the switch is opened, the inductor current does not change instantaneously cause the diode become forward-biased to give a way to inductor current. The rate of decrease of current Δi_L when the switch is opened,

$$(\Delta i_L)_{opened} = \frac{(V_s - V_o)(1 - D)T}{L}$$

By assuming steady-state operation the net change in inductor current must equal to zero and the input voltage equal to output voltage with no power losses,

$$V_o = \frac{V_s}{1 - D}$$

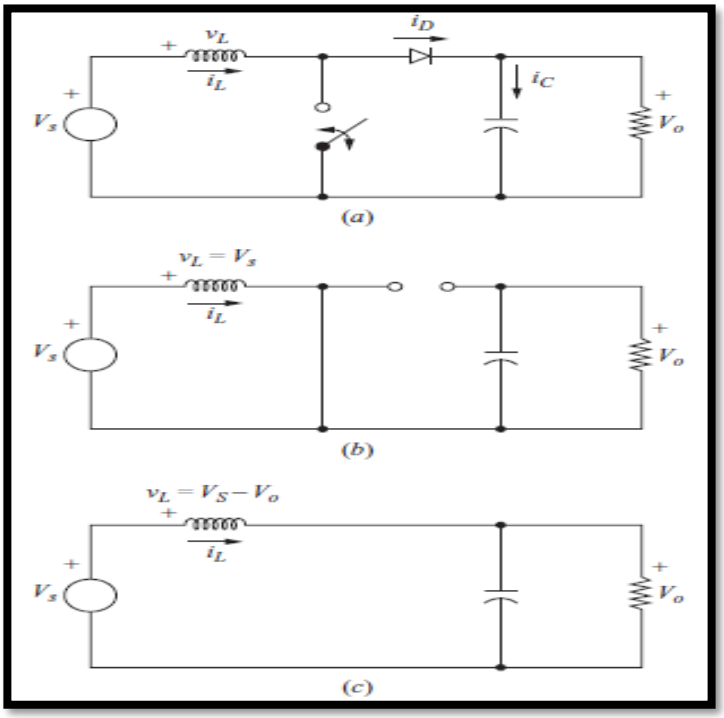

Figure 2.2: The boost converter: (a) DC-DC boost converter circuit; (b) Equivalent circuit for the switch closed; (c) Equivalent circuit for the switch open. Source: Daniel W.Hart (2011) pg.212