

SOLAR-POWERED ELECTRIC BICYCLE

AMIRUL SHAFIQ BIN HSAN BASERI

This report is submitted in partial fulfillment of the requirements for the
Bachelor of Electrical Engineering (Control, Instrumentation and Automation)

FACULTY OF ELECTRICAL ENGINEERING
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2009

“I hereby declare that I have read through this report entitle “Solar-Powered Electrical Bicycle” and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Electrical Engineering (Control, Instrumentation and Automation)”

Signature :

Supervisor's Name : EN. KYAIRUL AZMI B. BAHARIN

Date :

I declare that this report entitle “Solar-Powered Electrical Bicycle” is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature :

Name : AMIRUL SHAFIQ B. HSAN BASERI

Date :

To my beloved parents

Mr. Hsan Baseri Che Wan & Mrs. Hasimah Arifin

My precious lecturer

En. Kyairul Azmi Baharin

My partner

Fahrulrazi Hashim

ACKNOWLEDGEMENTS

Special thanks to Allah S.W.T , my parents and all people who get involved or helped a lot into the completion of this project.

Thus, the completion of this project would not have been successful without supports, helps and encouragement from various people. Their valuable advice and encouragement had assisted me throughout the completion of this project. First of all, I would like to express my greatest gratitude to my supervisor En. Kyairul Azmi bin Baharin, who had encouraged, directed, and guided me throughout the entire project with much patience and support. Her excellent supervision had been the key factor for the success of the Projek Sarjana Muda II (PSMII). And not forgetting my fellow friends and lecturers who helped me a lot throughout the project.

ABSTRACT

A method of upgrades a conventional electric powered bicycle over to Solar-Powered Electrical Bicycle that is powered by an electric motor which gets its supply from photovoltaic (PV) panels. The PV panels must be mounted and installed at the electric bicycle without compromising riding comfortability. The method employs a small electric motor that are easily connected and separated for ease of transport. A solar collector is connected to the rechargeable batteries for collecting solar energy and converting such energy to electrical power that is delivered to the rechargeable batteries for recharging thereof. A rechargeable battery is operable connected to DC motor for providing electrical power to drive the motor.

ABSTRAK

Satu kaedah menaik taraf *electric powered bicycle* kepada *Solar Powered Electrical Bicycle* yang menggunakan motor electric dan mendapat bekalan elektrik daripada panel photovoltaic (PV). Panel photovoltaic dipasang dan diletakkan pada basikal elektrik tanpa mengganggu keselesaan penunggang. Kaedah menggunakan motor elektrik bersaiz kecil yang mudah dipasang dan ditanggalkan adalah untuk memudahkan ia untuk dibawa. Pengumpul solar disambungkan semula kepada bateri boleh dicas untuk mengumpul tenaga solar dan menukarkan tenaga tersebut kepada tenaga elektrik yang dihantar kepada bateri untuk dicas semula. Bateri boleh cas disambungkan ke motor DC untuk membekalkan kuasa elektrik bagi menggerakkan motor.

TABLE OF CONTENTS

CHAPTER	TITLE	PAGE
	ACKNOWLEDGEMENTS	ii
	ABSTRACT	iii
	TABLE OF CONTENTS	v
	LIST OF TABLES	ix
	LIST OF FIGURES	x
	LIST OF SYMBOLS	xi
	LIST OF APPENDICES	xii
1	INTRODUCTION	1
	1.1 Project Background	1
	1.2 Problem Statement	2
	1.3 Project Objective	2
	1.4 Scope of Project	3
	1.5 Layout of Thesis	4

2	LITERATURE REVIEW	5
2.1	Introduction	5
	2.1.1 Facts and Findings	6
	2.1.2 Domain	6
2.2	Solar Power	6
2.3	Electric Powered Bicycle	8
2.4	Previous Project (1)	8
	2.4.1 Components	9
	2.4.2 Motor	9
	2.4.3 Solar Bicycle Load	10
	2.4.4 Solar Bicycle Cost	10
2.5	Previous Project (2)	10
	2.5.1 Background of Invention	11
	2.5.1.1 Field of the Invention	11
	2.5.1.2 Description of the Prior Art	12
	2.5.2 Summary of the Present Invention	12
2.6	Previous Project (3)	13
	2.6.1 Background of the Invention	16
	2.6.2 Summary of the Invention	16
2.7	Previous Project (4)	17
	2.7.1 Electrical Schematic Diagram	18
2.8	Previous Project (5)	18
	2.8.1 Back ground of the Invention	19
	2.8.2 Hardware Designing	20
	2.8.3 Schematic Diagram	20
2.9	Previous Project (6)	20
2.10	DC Electric Motor	21
2.11	Solar – Powered Electrical Bicycle	22

	2.12 Power Management System	23
	2.13 Smaller Batteries and Larger Arrays–Battery Implications	24
	2.13.1 Array Inclination	25
	2.13.2 Batteries for Photovoltaic Application	25
	2.14 Lead Acid Solar Battery	25
	2.15 Electric Powered Bicycle Test	26
	2.16 Conclusions	27
3	PROJECT METHODOLOGY	28
	3.1 Introduction	28
	3.2 Design Methodology	28
	3.3 Methodology of Project	29
	3.4 Simulation Method	32
	3.5 Brief Theory about Components Used and Circuits Build	37
	3.6 Specification of Project	39
4	ANALYSIS	40
	4.1. Introduction	40
	4.2. Problem Analysis	40
	4.3. Background of the System	41
	4.4. Setting up the Solar–Powered Electric Bicycle	41
	4.5. System Design Project Functions	41
	4.6. Performance Measurement	42
	4.7. Trading System Charger with System Solar	44
	4.8. Observation Analysis	46
	4.9. Conclusion	47
5	RESULT AND DISCUSSION	48
	5.1 Preliminary Expected Result	48
	5.2 Problem and Constraint during Project	51

6	CONCLUSION AND RECOMMENDATION	52
	6.1 Conclusion	52
	6.2 Recommendation	53
	REFERENCES	54
	APPENDICES	56

LIST OF TABLES

TABLES	TITLE	PAGE
2.1	Solar Bicycle Load	16
2.2	Solar Bicycle Cost	17
4.1	Voltage Value	17
4.2	Voltage Value	18
4.3	Performance of Electric Bicycle Manufactured in Year 2004	37
4.4	Performance Measured without using a Solar Panel	38
4.5	Performance Measured using a Solar Panel	43
5.1	Performance Measured without using a Solar Panel	45
5.2	Performance Measured using a Solar Panel	46

LIST OF FIGURES

FIGURES	TITLE	PAGE
2.1	Photovoltaic Cell	7
2.2	Side Plane	8
2.3	Fragmentary and Sectional View	8
2.4	Enlarged Sectional View Taken Substantially along the Line 3-3	9
2.5	Pictorial Side View of the Left Side of the Bicycle Showing the Motor	10
2.6	Motor and Transmission are Coupled with Gear Sprockets, a Chain and a Chain Tensioner.	10
2.7	Sectional View as seen from above and behind the Continuously Variable Automatic Transmission Employed in the Bicycle	13
2.8	Simplified Schematic Diagram of the Variable Voltage Circuit Portion of the Throttle Means Employed in the Bicycle	22
2.9	Vehicle Night Illuminator circuit	23
2.10	Hardware Designing	24
2.11	Schematic Diagram	25
2.12	Relationship between Array Size, Battery Reserve, Availability and Cost	26
2.13	Variation between Minimum Daily Battery State of Charge and Array Inclination	27
3.1	Project Flow Chart	28
3.2	Simulation Flow Chart	29
3.3	Circuit of Solar System Connection	30
3.4	Flow Chart of a System without using Solar Panel	31
3.5	Flow Chart of a System using Solar Panel	32
3.6	Bicycle Prototypes and Solar Panel	33
3.7	PV Panel	34
3.8	Electric Motor	35

3.9	Battery	39
4.1	Block diagram of project functions	40
5.1	Project Planning (Gantt Chart)	40

LIST OF SYMBOLS

DC	–	Direct Current
PV	–	Photovoltaic
UTeM	–	Universiti Teknikal Malaysia Melaka
OOAD	–	Object Oriented Analysis & Design
PSM	–	Projek Sarjana Muda

LIST OF APPENDICES

APPENDICES	TITLE	PAGE
A	Project Schedules and Milestone	1
B	Input Design	3
C	Data Definition Language(DDL)	7
D	User Manual	12

CHAPTER I

INTRODUCTION

1.6 Project Background

A method of upgrades a conventional electric powered bicycle over to Solar-Powered Electrical Bicycle that is powered by an electric motor which gets its supply from photovoltaic (PV) panels. The PV panels must be mounted and installed at the bicycle without compromising riding comfortability. The method employs a small electric motor that are easily connected and separated for ease of transport. A solar collector is connected to the rechargeable batteries for collecting solar energy and converting such energy to electrical power that is delivered to the rechargeable batteries for recharging thereof. A rechargeable battery is operable connected to DC motor for providing electrical power to drive the motor.

1.7 Problem Statement

There are several problems that occur during upgrades a conventional electric powered bicycle to Solar-Powered Electrical Bicycle. The specifications of photovoltaic (PV) panels must be sufficient to generate the electric motor same as a conventional electric powered bicycle. The suitable connection of solar cells, rechargeable battery and DC electric motor with bicycle needed to make sure this project accomplish with more optimum energy use. The electric motor must to support the weight and size of the bicycle, size of solar panel and condition of the road surface.

1.3 Project objective

The objectives of this project are:

1. To upgrade a conventional electric powered bicycle to Solar-Powered Electrical Bicycle that can be used for leisurely rides.
2. To design and develop Solar-Powered Electrical Bicycle which gets its supply by using solar energy from photovoltaic panels.
3. To study the connection between solar cells, rechargeable battery and DC electric motor.
4. To compare the characteristics and performance between Solar-Powered Electrical Bicycle and electric powered bicycle.

1.4 Scope of project

The scope of this project is to design and develop a Solar-Powered Electrical Bicycle that is powered by an electric motor which gets its supply from photovoltaic (PV) panels and partially uses solar energy. This project will focus on how to apply the photovoltaic (PV) panels on the electric bicycle in term of:

1. Speed of a Solar-Powered Electrical Bicycle compared to electric powered bicycle
2. Performance of DC motor Solar-Powered Electrical Bicycle compared to electric powered bicycle

Because of the **high-cost** to develop an actual size of ordinary electric powered bicycle, the size of the electric powered bicycle will be **scale-down to (1: 4)**. The prototype dimensions of the electric powered bicycle is about length (0.64 meter) x width (0.33 meter) x height (0.33 meter). The unladen weight about 2 kg (4.4 lbs) and the load that can be support is about 25 kg (55.11 lbs). Below are the full characteristics and specifications of the Solar-Powered Electrical Bicycle project:

Theory Specification

Actual size specification of electric powered bicycle :

Bicycle dimensions : Length 1.7 meter x Height 0.97 meter

Motor type : DC Motor

Calculation Specification

Scale-down size \longrightarrow (Actual size: Project size) = (1: 4)

Scale-down size specification of electric powered bicycle prototype (1: 4):

Bicycle dimensions : Length 0.43 meter x Height 0.24 meter

Motor type : DC Motor

Prototype specification of electric powered bicycle

Bicycle dimensions	: Length 0.64 meter x Height 0.33 meter
Unladen weight	: 2.5 kg (5.51 lbs)
Maximum load	: 25 kg (55.11 lbs)
Motor type	: DC Motor

1.5 Layout of Thesis

Layout of thesis will tell the flow of the whole thesis and its contents. This could be the referring section for this project.

Chapter 1 shows the introduction of the project, the abstract as the initial summary for the whole project. Then it also contains a brief introduction that gives the idea of the whole project. Problems that bring the idea to implement this project also stated in this chapter. This chapter also includes the main objectives of the project and the scope of whole project.

Chapter 2 contains the theory of the whole project. It comprises the solar power, electric powered bicycle, previous project, DC electric motor and solar systems that similar with this project.

Chapter 3 indicates the methodology to complete and success the project. Project methodology is about defining fundamental principles, rules and manners to complete the project. It is a way to use all available techniques, tools and approaches used to achieve predetermined objectives. It shows the flow of the project from the beginning and illustrates with the flow chart that review the important methods that should be considered by developers before a project is carried out. It is important for a developer to demonstrate an awareness of methodological tools available and the understanding that is suitable for the project.

Chapter 4 and 5 likewise point out the analysis, result and discussion of the project.

Chapter 6 shows the final conclusions and recommendation for future work for this project. The recommendation includes the idea how to make this simulation package more reliable and efficient in the future.

CHAPTER II

LITERATURE REVIEW

2.1 Introduction

This chapter will be stressed on the literature review of related system. The main purpose of this chapter is to analyze, identify and make conclusion based on the research. A literature review means a collecting related data, analyzed business process, identify underlying patterns and create the conclusion (Strauss & Corbin 1990). Another description of the literature review is a systematic, explicit and reproducible method to identifying, evaluating and synthesizing the existing body of completed and recorded work produced by researcher, scholars and practitioners (Fink, 2005).

In order to develop a successful project, the current systems are identified. The system of conventional electric powered bicycle, solar system and its connection have been analyzed. Studies of these systems are significant to develop a valid, reliable and efficient upgrade project. The Literature Review part acts as a mean to discover which methodology should be chosen in developing this system.

2.3.1 Facts and Findings

Facts and findings establishes what the existing system does and what the problems are, and leads to a definition of a set of options from which users may choose their required system (Yeates and Wakefield, 2004a).

This section will be discussing about the domain of this project, the existing system and finally the other techniques that applicable to be used while developing this project. It focused on the how to design and develop the project systematically according to the requirement of minimize the functional of conventional project. In the other situation, these will be describing any element or method which is useful to be used for the purpose of searching and gathered useful information in developing this project

2.3.2 Domain.

Currently, electric powered bicycle that was studied for this project only uses a battery to get the electric powered supply by recharge it using conventional way. Electric powered bicycle only depends on power that charge in battery to make it functions unless using the manual way to move it. The project is wanted to change the way a battery charge to get the electric power and generate electricity to move the bicycle with optimum energy.

2.4 Solar Power

Solar cells (really called “photovoltaic” or “photoelectric” cells) that convert light directly into electricity, bypassing thermodynamic cycles and mechanical generators. PV stands for photo (light) and voltaic (electricity), whereby sunlight photons free electrons from common silicon.

A photovoltaic module is composed of individual PV cells. This crystalline-silicon module has an aluminum frame and glass on the front. In the field of photovoltaic, a photovoltaic module is a packaged interconnected assembly of photovoltaic cells, also known

as solar cells. An installation of photovoltaic modules or panels is known as a photovoltaic array or a solar panel. A photovoltaic installation typically includes an array of photovoltaic modules or panels, an inverter, batteries (for off grid) and interconnection wiring.

Solar energy is the utilization of the radiation energy from the sun. Solar power is used interchangeably with solar energy but refers more specifically to the conversion of sunlight into electricity by photovoltaic and concentrating solar thermal devices, or by one of several experimental technologies such as thermoelectric converters, solar chimneys and solar ponds.

Sunlight is composed of photons, or particles of solar energy. These photons contain various amounts of energy corresponding to the different wavelengths of the solar spectrum. When photons strike a photovoltaic cell, they may be reflected, pass right through, or be absorbed. Only the absorbed photons provide energy to generate electricity. When enough sunlight (energy) is absorbed by the material (a semiconductor), electrons are dislodged from the material's atoms. Special treatment of the material surface during manufacturing makes the front surface of the cell more receptive to free electrons, so the electrons naturally migrate to the surface. [7]

When the electrons leave their position, holes are formed. When many electrons, each carrying a negative charge, travel toward the front surface of the cell, the resulting imbalance of charge between the cell's front and back surfaces creates a voltage potential like the negative and positive terminals of a battery. When the two surfaces are connected through an external load, electricity flows. [7]

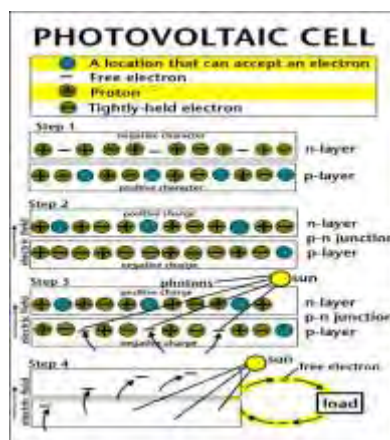


Figure 2.1: Photovoltaic Cell

2.5 Electric Powered Bicycle

An electric powered bicycle carries batteries or fuel cells that deliver electric power to a motor that is coupled to either wheel. In most electric bicycles the rider can choose to use muscle power to deliver all, part, or none of the propulsion power required to maintain his or her adopted travel speed. Some models even sense your pedal pressure and command the motor to deliver more power whenever you pedal hard. [5]

Many electric powered bicycles are specifically design and build for travel. Average travel speed, when compared to pedaled-only bicycles, can be increased by 8 to 10km/h (5 to 6 mph) above the speed an average person could travel by pedaling.[5]

2.6 Previous Project (1)

Early 2001, David Clay was built a solar-electric bicycle. On this solar and human powered rig, he rode from San Francisco, California, to Carbondale, Colorado, arriving just in time to start a summer of classes at Solar Energy International. In the summer of 2001, he went to China, and continued solar cycling around the world. [15]

The trip was also the ultimate test for developing the solar cycle. He realized that the bicycle needed a stronger PV mount after 30 miles traveling. Next, brakes needed for the trailer after 100 miles and after 1,000 miles the trailer needed with a spoke wheels. After 1,500 miles, powerful motor need to cover the performance of bicycle that remains constantly.

Performance of the bicycle is produce by a 24V DC system. 4 to 5 A can be produce in full sun by the array of four Solarex MSX Lite modules. His trailer weighs 190 pounds (86kg) empty, and he pulled an additional 85 to 100 pounds (39–45 kg) of gear. He can cruise on the flat ground at 18 mph (29kph) without pedaling, with the motor drawing 13 amps. He then tested the range of the bike on flat ground, with an unloaded trailer and a 150 pound (68 kg) rider, from full battery to empty battery (100% SOC to 20% SOC). It can cruise in range of 25 to 30 miles (40–50 km) without pedaling and sunshine. The range is increase to 35 to 40 miles (55–65 km) when it cruises with a pedaling and sunshine. When pedaling, the rider's fitness level becomes the only limit.