

**DEVELOPING A MPPT CHARGE CONTROLLER FOR SOLAR
PHOTOVOLTAIC SYSTEM WITH IMPROVED PERTURB AND OBSERVE
ALGORITHM**

By

Bagas Sinar Bintang
11301008

BACHELOR'S DEGREE
in

MECHANICAL ENGINEERING – MECHATRONICS CONCENTRATION
FACULTY OF ENGINEERING AND INFORMATION TECHNOLOGY

SWISS GERMAN UNIVERSITY



SWISS GERMAN UNIVERSITY
The Prominence Tower
Jalan Jalur Sutera Barat No. 15, Alam Sutera
Tangerang, Banten 15143 - Indonesia

January 2018

Revision after Thesis Defence on January 18th, 2018

STATEMENT BY THE AUTHOR

I hereby declare that this submission is my own work and to the best of my knowledge, it contains no material previously published or written by another person, nor material which to a substantial extent has been accepted for the award of any other degree or diploma at any educational institution, except where due acknowledgement is made in the thesis.

Bagas Sinar Bintang

Student

Date

Approved by:

Erikson Ferry S. Sinaga, ST, M.Kom

Thesis Advisor

Date

Dr. Irvan Kartawiria, S.T, M. Sc.

Dean

Date

ABSTRACT

DEVELOPING A MPPT CHARGE CONTROLLER FOR SOLAR PHOTOVOLTAIC SYTEM WITH IMPROVED PERTURB AND OBSERVE ALGORITHM

By

Bagas Sinar Bintang

Erikson Ferry S. Sinaga, ST, M.Kom

SWISS GERMAN UNIVERSITY

The purpose of this thesis is to design and develop a MPPT charge controller using ZETA converter with improved perturb and observe algorithm for solar photovoltaic system. The measurements of the parameters will be sent to a website.

This thesis project is focusing on the performance of MPPT charge controller by using ZETA converter which is not a common converter and with improved perturb and observe algorithm that is capable of wireless monitoring and controlling of solar photovoltaic system. The ZETA converter is used to regulate the voltage input from the solar PV module to a voltage level that is needed by the load with minimum loss. The voltage is regulated by switching of the MOSFET dynamically depending on the state of the battery with maximum peak power point at that moment. The improved perturb and observe algorithm produced the maximum power that can be generated from the solar photovoltaic cell to charge the battery with faster response time.

Keywords: MPPT, PWM, Solar PV Modules, Efficiency, ZETA Converter, P&O, Perturb and Observe



SWISS GERMAN UNIVERSITY

DEDICATION

I dedicate this thesis solely for the research and development in renewable energy in
Indonesia.



ACKNOWLEDGEMENTS

First and foremost, I would like to thank Allah SWT for blessing me with health, wellbeing, guidance to complete this thesis report.

I would like to express my gratitude to my beloved family; Ayah, Bunda, Paksi and Ken for their endless support, attention and love.

I would like to thank my one and only advisor, Erikson Ferry S. Sinaga, ST, M.Kom for his advices and guidance to achieve the thesis objectives. Secondly, I would like to thank Mr. Yohanes Freddy for his aid whenever a problem is occurred.

Lastly, I would like to thank all of my friends and several people who helped me to finish this thesis report.



SWISS GERMAN UNIVERSITY

TABLE OF CONTENTS

STATEMENT BY THE AUTHOR.....	2
ABSTRACT.....	3
DEDICATION.....	5
ACKNOWLEDGEMENTS.....	6
TABLE OF CONTENTS.....	7
CHAPTER 1 – INTRODUCTION.....	13
1.1 Background.....	13
1.2 Objectives.....	14
1.3 Research Problems.....	14
1.4 Thesis Scope.....	14
1.5 Thesis Limitation.....	14
1.6 Thesis Organization.....	15
CHAPTER 2 – LITERATURE REVIEW.....	16
2.1 Introduction.....	16
2.2 Photovoltaic Solar System.....	16
2.2.1 Photovoltaic Solar Cell.....	16
2.2.1.1 Characteristics of Photovoltaic Cell [6].....	17
2.2.2 Battery.....	20
2.2.3 Sensor System.....	21
2.2.3.1 Voltage Sensor.....	21
2.2.3.2 Current Sensor MAX471.....	21
2.2.4 Microcontroller and Arduino IDE.....	22
2.2.5 Wi-Fi Based System.....	22
2.2.5.1 ESP8266 Wi-Fi Based System.....	22
2.3 Maximum Power Point Tracking (MPPT) Solar Charge Controller [1].....	23
2.3.1 MPPT Method.....	23
2.3.1.1 Conventional Perturb and Observe.....	23
2.3.1.2 Improved Perturb and Observe Method [7].....	24
2.3.2 ZETA Converter [3].....	27
2.3.2.1 ZETA Converter Basic Operation.....	27
2.3.3 ThingSpeak and IoT.....	29
2.4 Previous Studies.....	30
2.4.1 Constructing a Wi-Fi Based MPPT System to Improve and Record the Performance of Solar PV Module [2].....	30
2.4.1.1 MPPT Flowchart.....	30
2.4.1.2 Battery Charging Flowchart.....	31
2.4.1.3 Result and Conclusion.....	32
2.4.2 Developing a MPPT System for Renewable Energy [3].....	33

2.4.2.1	MPPT Algorithm	33
2.4.2.2	Battery Charging Algorithm	34
2.4.2.3	Result and Conclusion	35
CHAPTER 3 – RESEARCH METHODS		36
3.1	System Design Overview	36
3.2	Electrical System Design	37
3.2.1	Photovoltaic Module.....	37
3.2.2	Battery.....	38
3.2.3	Voltage Measurement Design.....	38
3.2.4	Current Sensor Measurement Design	41
3.2.5	ZETA Converter Design.....	42
3.2.5.1	Inductor Calculations	42
3.2.5.2	Capacitor Calculations	44
3.2.5.3	MOSFET Selection	46
3.2.6	Printed Circuit Board Design.....	47
3.2.7	Electrical Working Principle	47
3.3	Programming System Design.....	49
3.3.1	MPPT Flowchart.....	49
3.3.2	Battery Charging Flowchart	50
3.3.4	Arduino Uno R3	52
3.3.5	ESP8266 Wi-Fi Module	53
3.3.6	Logic Shifter of 5V to 3V.....	54
3.3.7	ThingSpeak as Web Server and Database Server.....	55
3.4	MATLAB Simulation.....	56
3.4.1	Simulink Diagram	56
3.4.2	Simulation Results	57
3.5	Testing Strategy.....	58
3.5.1	ZETA Converter Partial Testing with Power Supply.....	58
3.5.2	First on-Field Testing	60
3.5.3	Second on-Field Testing.....	60
CHAPTER 4 – RESULTS AND DISCUSSIONS		61
4.1	Introduction	61
4.2	Electrical Results	61
4.2.1	Printed Circuit Board.....	61
4.2.2	Result of ZETA Converter Partial Testing with Power Supply	62
4.3	System Results.....	67
4.3.2	Result of First on-Field Testing.....	67
4.3.3	Result of Second on-Field Testing	71
CHAPTER 5 – CONCLUSIONS AND RECOMMENDATIONS		74
5.1	Conclusions	74
5.2	Recommendations	75
GLOSSARY		76
REFERENCES		77
APPENDIX A – MPPT ELECTRICAL DESIGN		78

APPENDIX B – DATASHEET	79
APPENDIX C - PROGRAMMING	89
APPENDIX D – BILL OF MATERIAL	104
CURRICULUM VITAE	105

