

**CONVERSION OF INTERNAL COMBUSTION ENGINE TO ELECTRIC
VEHICLE: IMPLEMENTATION OF MOTOR CONTROL SYSTEM FOR
ELECTRIC VEHICLE**

By

Leonard Archie
11901018

BACHELOR'S DEGREE
in

MECHANICAL ENGINEERING STUDY PROGRAM
MECHATRONICS CONCENTRATION
FACULTY OF ENGINEERING & INFORMATION TECHNOLOGY



SWISS GERMAN UNIVERSITY

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

Revision after the Thesis Defense on 28 January 2025

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.



Leonard Archie

Student

11-February 2025
Date

Approved by:



Edward Boris F. Manurung, M.Eng

Thesis Advisor

11 February 2025
Date



Hartono, S.T., M.T.

Thesis Co-Advisor

11 February 2025
Date

Dr. Maulahikmah Galinium, S.Kom, M.Sc

Dean

Date

ABSTRACT

CONVERSION OF INTERNAL COMBUSTION ENGINE TO ELECTRIC VEHICLE: IMPLEMENTATION OF MOTOR CONTROL SYSTEM FOR ELECTRIC VEHICLE

By

Leonard Archie
Edward Boris F. Manurung, M.Eng, Advisor
Hartono, S.T., M.T., Co-Advisor

SWISS GERMAN UNIVERSITY

Electric vehicles (EVs) are becoming more and more reliable in society as a preferred option for transportation. Motor control systems, which utilize the technological advantages of electric motors, guarantee a pleasant driving experience, safety and cleaner energy usage edge over internal combustion engines (ICE). Having a choice to opt for various mode that use the advantages of electrical aspect of EV is essential to the overall experience of driving, giving it a more modern approaches to vastly growing automation industry. Having a reliable simple and easy to customize motor control system can result in further enticing prospect of retrofitting old automobiles with electrical aspect of EV. With a relatively simple and effective motor control system the vehicle itself can provide certain degree of awareness to the driver even to the vehicle itself, making all the benefits of electric vehicle far more enticing to use. To expand the area of electric vehicle technologies, this thesis explores the design, function, and optimization of motor control systems for electric go-karts. It also addresses potential development in this fast-improving industry.

Keywords: Motor control system, safety, pleasant driving experience, potential development.

© Copyright 2025
by Leonard Archie
All rights reserved

DEDICATION

I dedicate this research firstly to the
family, friends, peers and all who support
this project and to proof my expertise
in mechatronics engineering
sincerely, love.

ACKNOWLEDGEMENTS

I deeply thankful to God for granting me the chance to develop on this research journey and overcome all of the challenges. Without His guidance and blessings, none of this would have been possible. Blessed be God, King of the Universe.

I express my sincere appreciation to Mr. Edward Boris F. Manurung, M.Eng, Advisor, and Mr. Hartono, S.T., M.T., Co-Advisor, for their invaluable guidance, insightful feedback which has been a great opportunity to learn from such mastery. Their expertise and rich experience are crucial to the successful completion of this research.

I would also like to express my gratitude to all the lecturers for their dedication to teaching and their enthusiasm for knowledge, which greatly enhanced my academic experience.

To my cherished friends, your support and motivation provided me with continuous comfort and inspiration throughout this research.

Finally, I sincerely thank everyone who contributed to this work, whether directly or indirectly. Your assistance and encouragement were invaluable, and I truly appreciate all the help I received.

TABLE OF CONTENTS

STATEMENT BY THE AUTHOR.....	1
ABSTRACT.....	2
DEDICATION.....	4
ACKNOWLEDGEMENTS.....	5
TABLE OF CONTENTS.....	6
LIST OF FIGURES	8
LIST OF TABLES	9
CHAPTER 1. INTRODUCTION	10
1.1 Background.....	10
1.2 Research Problems.....	12
1.3 Research Objectives.....	12
1.4 Significance of Study.....	12
1.5 Research Questions.....	13
1.6 Hypotheses.....	13
CHAPTER 2 - LITERATURE REVIEW.....	14
2.1 BLDC Motor Speed Controller.....	14
2.2 PID Controller.....	15
2.3 Sensors	15
2.3.1 Perceptive Sensor	16
2.3.2 Hall Sensor	16
2.4 Energy Efficiency	17
2.4.1 Regenerative Braking	17
CHAPTER 3 - RESEARCH METHODS.....	19
3.1 Hardware Components	19
3.1.1 Sensors.....	20
3.1.2 Microcontroller, Actuators, and Display	20
3.2 Motor Control System	21
3.2.1 PID Controller Design.....	21
3.2.2 Various Mode Design.....	25
3.2.3 Reverse Mode.....	28

3.3 Supporting Component	29
3.3.1 Bluetooth Transceiver	29
3.3.2 Gearbox Bracket.....	29
3.4 Final Design	30
3.5 Testing and Data Taking.....	31
3.5.1 No Load Motor Speed	31
3.5.2 Motor and Wheel Speed; Lifted	31
3.5.3 Motor And Wheel on The Floor with Driver	32
CHAPTER 4 – RESULTS AND DISCUSSIONS.....	33
4.1 Results No Load Motor Speed Tests	33
4.2 Results for Loaded Motor Speed; Lifted Tests	34
4.3 Results for Loaded Motor with Driver Speed Tests	36
4.4 Results for Prolonged various Mode Experience	38
4.5 Results of Added Features	39
4.5.1 Auto Stop Reverse Mode	39
4.6 Data Evaluation.....	40
4.6.1 RPM Parameters Development and Response	40
4.6.2 Efficiency	41
4.6.3 Cruise Control and Auto Brake Reverse	41
4.7 Discussion.....	42
4.7.1 Mode 2 and 3 Speed Saturation.....	42
4.7.2 Increased Speed Accuracy and Efficiency	42
4.7.3 Motor control system in Uncontrolled Condition	43
4.8 Unforeseen Problem and Solution	43
4.8.1 Unspecified Details Regarding the Provided Component.....	43
4.8.2 Noise.....	43
4.8.3 Failure of The Electrical and Powertrain Component.....	44
CHAPTER 5 – RESULTS AND DISCUSSIONS.....	45
5.1 Conclusion	45
5.2 Recommendations.....	46
GLOSSARY	47
REFERENCE.....	48
CURRICULUM VITAE	50

LIST OF FIGURES

Figure	Page
1. Schematic Diagram for BLDC Drive	14
2. PID Controller Design	22
3. A Comparison of Normal PID and PID Anti Windup with Input of 1000 RPM.....	25
4. Gearbox Bracket Design	30
5. Final Designs	30
6. RPM Parameters Development and Response.....	40
7. The Relation Between The voltage Consumed From The Battery and Shows Changes Between The System	41

LIST OF TABLES

Table	Page
1. Tuning Parameter from Simulation	23
2. A Comparison of Normal PID and PID Anti Windup with Input of 1000 RPM.....	25
3. The Connection of The VCU To 4-Way Relay	26
4. Test 1 – (20/11/2024) No Load Motor parameters	33
5. Test 1 – (20/11/2024) No Load Motor parameters	33
6. Test 2 – (27/11/2024) No Load Motor parameters	33
7. Test 2 – (27/11/2024) No Load Motor PID	34
8. Test 3 – (20/12/2024) Loaded Motor parameters	35
9. Test 3 – (20/12/2024) Loaded Motor PID	35
10. Test 3 – (23/12/2024) Loaded with driver	36
11. Test 3 – (23/12/2024) Loaded with driver	37
12. Test3 – (23/12/2024) No Load Motor parameters	38
13. Test 3 – (23/12/2024) No Load Motor parameters	38
14. Additional Test – (24/12/2024) speed time from 0-MAX	39
15. Additional Test – (24/12/2024) speed time from 0-MAX (PID)	39
16. Additional Test – (24/12/2024) Safety Reverse Measure	39