SPEED CONTROL OF 4-WHEEL ELECTRIC VEHICLE USING PI BASED CONTROLLER

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A report submitted
in fulfilled of the requirements for the degree of
Bachelor of Mechanical Engineering with Honours.

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Faculty of Mechanical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2021

DECLARATION

I declare that this thesis entitled “Speed Control Of 4-Wheel Electric Vehicle Using PI Based Controller” is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature :

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APPROVAL

I have checked this report and the report can now be submitted to JK-PSM to be delivered back to supervisor and to the second examiner.

Signature :.....

Name of Supervisor :.....

Date :.....

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DEDICATION

I will dedicate this thesis to my beloved family, lecturer and friends that always support me during my hard time.

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ABSTRACT

This thesis presents the modelling, simulate and control of an electric vehicle to investigate their performance after running for a 1500 second. This electric vehicle was built using individual components and each component selection based on the previous research and discussion with supervisor. The basic component for the electric vehicle drivetrain were electric motor, battery, power electronics, driver controller, vehicle body and a drive cycle. This drivetrain was validated with a real vehicle first before modelling it through a Matlab-Simulink software and it just viewed as a Vehicle Longitudinal Model. The regenerative braking system also included in this simulation cause by the ability of the dc motor to act as a generator during braking. Several simulation tests were performed by employing the same reference speed as the vehicle validation which were 40 km/h, 60 km/h, and another reference speed proposed by Society of Automotive Engineer (SAE), namely the Federal Test Procedure 75 (FTP75). The result of this study shows the simulation about the velocity, torque, power, current, voltage of the motor and the battery state of charge (SOC).

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ABSTRAK

Tesis ini berkaitan pemodelan, simulasi dan kawalan kenderaan elektrik untuk menyiasat prestasi kenderaan setelah berjalan selama 1500 saat. Kenderaan elektrik ini dibina menggunakan individu komponen dan setiap pemilihan komponen adalah berdasarkan kajian dan perbincangan sebelumnya dengan penyelia. Komponen asas untuk "drivetrain" kenderaan elektrik adalah motor elektrik, bateri, elektronik kuasa, pengawal pemandu, badan kenderaan dan kitaran pemacu. "Drivetrain" ini disahkan dengan kenderaan sebenar terlebih dahulu sebelum memodelkannya melalui perisian Matlab-Simulink dan ia hanya dilihat sebagai Model Longitudinal Kenderaan. Sistem brek regeneratif juga dimasukkan dalam simulasi ini disebabkan oleh kemampuan dc motor untuk bertindak sebagai penjana elektrik semasa menekan brek. Beberapa ujian simulasi dilakukan dengan menggunakan kelajuan rujukan yang sama dengan pengesahan kenderaan iaitu pada 40 km/jam, 60 km/jam dan kelajuan rujukan lain yang dicadangkan oleh "Society of Automotive Engineer" (SAE), iaitu "Federal Test Procedure 75" (FTP75). Hasil kajian ini menunjukkan simulasi mengenai halaju, daya kilas, kuasa, arus, voltan motor dan bateri "State of Charge" (SOC).

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ACKNOWLEDGEMENT

First and foremost, I want to thank my advisor Dr. Fauzi bin Ahmad. It has been an honour to be his Degree Project student. I appreciate all her contributions of time, and ideas to make my Degree Project experience productive and stimulating. The joy and enthusiasm he has for his research was contagious and motivational for me, even during tough times in the Degree pursuit. I am also thankful for the inspiration and encouragement during conducting this thesis.

Lastly, I would like to thank my family for all their love and encouragement. For my parents who raised me with a love of science and supported me in all my pursuits. And most of all for my loving, supportive, encouraging, and patient friend, Hazim Bin Hamzah whose faithful support during the final stages of this Degree Project is so appreciated.

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LIST OF ABBREVIATIONS

PI	Proportional Integral
N-PI	Nonlinear proportional integral
EV	Electric Vehicle
BEV	Battery electric vehicle
ICE	Internal Combustion Engine
ICEs	Internal Combustion Engines
SOC	State of Charge
DOF	Degree of Freedom
HEV	Hybrid Electric Vehicle
PID	Proportional integral derivative
AC	Alternate Current
DC	Direct Current
FTP75	Federal Test Procedure 75
WLTP	Worldwide harmonised light vehicle test Procedure
NEDC	New European driving cycle
KM/H	Kilometres Per Hour
KG	Kilogram
M	Metres

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V	Voltage
AH	Ampere-Hour
SAE	Society of automotive engineer
CG	Centre of gravity
CC	Cubic centimetres
PMSM	Permanent magnet synchronous motor

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CHAPTER 1

INTRODUCTION

1.1 Overview

The electric vehicles (EVs) are innovations in automobile industry that is powered by an electric motor rather than the petrol or diesel engine. The EVs are future transport for community, and this technology already available in the market but with a little value. This small value is a due to the shortcomings found in this technology that needs to be improved regarding infrastructure and modern technology accepted by the community. The EVs are safe to use to the environment and need to expand its use. Common issues that still bother many consumers as well as the limited driving range, battery charging issues, high costs and scarce charging infrastructure in markets. This problem needs to be researched to find the solution, but the actual studies will cause the high cost and take a long time. This research is conducting to develop an updated of EV be more advance and subsequently able to gain wider adoption in the market. Focus of this study are to model and validate an EV, simulation, control of EV model and to assess the ability of the design EV in the variable speed limit. The findings indicate the performance parameters for the speed, state of charge and current with a drive cycle through the simulation results. This may be a decent prediction to explore and improve this technology for the future.

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1.2 Research Background

Petroleum derived from the fossil fuels is a major source of energy used in ICE. These fossil fuels take a long time to produce because it is formed from natural processes such as embedded anaerobic decay of dead life. However, the rate of utilization of the fuel advances higher than the rate of creations. It will be totally depleted without any petroleum

products to satire the high demand. Electric vehicles are seen as one of the best solutions to this problem because of its advantages such as more efficient, environmentally friendly, quiet, and more powerful than ICE regarding speed. To drive the EV system, one or two electric motor each can be used for each wheel, in this study, the case of two-wheel drive electric motor is to be considered.

In addition, an EV generally uses a battery as its main power source (Bambang Sri Kaloko *et al*, 2011) (Dhameja "S", 2003) (Husain, I. 2003). Meanwhile, vehicle energy resource is a major challenge affecting driving distance, long charging time and a high cost. The power source or battery pack of an EV should have enough power for a certain driving range and sufficient power capability for the accelerations and decelerations. To estimate the energy consumption of an EV, it is very important to have a proper model of the vehicle (Gao *et al*., 2007; Mapelli *et al*., 2010; Schaltz, 2010). The model of an EV is very complex which it contains many components such as electric machines, battery, power electronics and transmission while each of the component need to be modelled properly to prevent wrong result. The design or rating each component's parameters is a difficult task because it will affect the power level of another one. If one of the components is rated inappropriately, it might make the vehicle unnecessary expensive or inefficient.

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Next, the limitation of regenerative braking system because not all braking energy can be recycled. It is influenced by many factors such as braking intensity and battery state of charge (SOC). For a conventional car, only 20 percent of the energy efficiency will be recycled and remaining 80 percent of its energy being converted to heat through a friction. The focus of this study will be on modelling, control and simulate an EV. The less consideration will be put on determination of each component for power system as this is a tremendous task in itself.

1.3 Problem Statement

The problem statement of this study are as follows:

i. Misunderstanding concept of the electric vehicle's operation. Electric vehicle is powered by an electric motor or traction motor to generate torque instead of an internal combustion engine. The main component for the EV are electric motor, the battery pack, and the power controller. Rapid development of this technology makes it is difficult to learn and understand.

ii. High cost for prototyping construction. Any new technology that will use in EV need to be tested and must be validated its durability.

iii. Limitation of driving range for the EV comparing with the petrol or diesel engine. This cause by the limitation of the charging station in the market and then make it is difficult to improve the capability of EV.

1.4 Objectives

The objectives of this project are as follows:

i. To model and validate a longitudinal model using Proton Iswara to be used in the simulation.

ii. To simulate and control of electric vehicle by using PI based controller.

iii. To evaluate the speed control of the designed EV and regenerative braking system in variable speed driving conditions.

1.5 Scope Of Project

The scopes of this project are:

i. The Electric Vehicle model utilized in this investigation is viewed as Vehicle Longitudinal Model.

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ii. Only considered 5 degrees of freedom (DOF) on handling and ride model in this investigation.

iii. The braking characteristic like tire longitudinal slip, stopping time and stopping distance would not been focused since this study just to grasp the ability of the braking system to generate current during braking.

iv. Only use the constant speed at 40 km/h, 60 km/h and Federal Test Procedure 75 (FTP75) as a simulation reference.

v. Note that, all the simulations are made in programme MATLAB Simulink software.

1.6 Thesis Outline

The thesis.is organised as follows, with each section containing a substantial amount of knowledge on the topic:

Chapter 1: This section includes a general summary, the context of the research, a statement of issues, the study's objective, scope, and relevance.

Chapter 2: This part presents a literature review with respect to the EV system. This chapter also included the modelling and simulation studies of an EVs that have been made before.

Chapter 3: This section presents about the methodology that used in this thesis. Two (2) phases to be discuss in this section that are Phase.1: Modelling and validation the Electric Vehicle Model and Phase 2: Simulation and Control of Electric Vehicle. The Vehicle Longitudinal Model is considered to modelling the EV

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model. When the Electric Vehicle Model has been approved, simulations of Electric Vehicle can be conduct with a various configuration and parameters through the drive cycle.

Chapter 4: This part examines the discoveries and discussions that emerge from simulation and testing. It explained about the result of the simulation of an EV. The discoveries of the connection among the simulation result and experimental are discussed.

Chapter 5: Next, this stage consists of the summary about the study's completion. This section also provides a last comment on the new idea as a commitment in the EV research zone. Finally, recommendations and directions for future research are discussed.

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CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

As an alternative toward the green transportation in this world, the electric vehicle (EV) technology began to get attention from the public. This technology appeared a few centuries ago, but it still could not match the capabilities of the internal combustion engine and caused it failed to be a competitor in the market. Through much advancement has been made in the past decade, the wide adoption of this technology still in question. In this chapter, the history respect to the EVs technology and previous research about it such as for modelling, control and simulate are also discussed.

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2.2 History of Electric Vehicle

An EVs started to appear after the invention of the power source that is a battery. In 1821, electric motor has been created by the English chemist Michael Faraday. In 1822, the Faraday's motor was applied to turn a wheel by Peter Barlow, English Mathematician and Physicist. In 1831, the world's first dynamo was created by Faraday than can create an electrical energy by the use of mechanical. Then, the electric locomotive was made in 1838. In 1841, Galvani that the name of larger loco was created by Davidson, but it did not last long in the market due to high price which caused their invention went to the end. After that, a Dutch chemistry professor, and Sibrandus Stratingh were invented a more practical battery-powered carriage which caused a good performance, but it was very noisy, smoky, and uncomfortable while being tested. Then, the way to recharge battery was found by Gaston