SUPERVISOR DECLRATION

„I/We hereby declare that had read this work and for my/our opinion this work is adequate in terms of scope and quality for receiving the Bachelor of Mechanical Engineering (Automotive)"

Signature :...

Supervisor :...

Date :...

ELECTRONICS STABILITY PROGRAM (ESP) OF THE AUTOMOTIVE VEHICLE

MUHAMMAD TAUFIK BIN ABDUL AZIZ

This technical report is submitted to

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Universiti Teknikal Malaysia Melaka

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DECLARATION

‘I hereby declare that the work in this report is my own except for summaries and quotations which have been duly acknowledge‟

Signature :...

Author :...

Date :...

Especially for

My beloved family

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First of all, I am grateful to Allah for blessing me good health in completing this project. I would like to dedicate my gratitude towards my parents for their love and supports. Without their support, I do not think that I can stand here completing this project.

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ABSTRACT

This thesis deals with the use of Electronic Stability Program in detecting and preventing the vehicle from oversteer or understeer during cornering. The content of this study is the development and modeling of a full vehicle model, which consist of ride, handling and tire subsystems as to study the vehicle dynamics behavior in lateral direction. This study also involve in Electronic Stability Program controller development in order to minimize the yaw rate. The control strategy incorporates a yaw rate reference model, which calculates a desirable yaw rate response depending on the driver"s steering angle and wind force.

ABSTRAK

Tesis ini mimbincangkan tentang penggunaan Program Kestabilan Elektronik dalam mengesan dan menghalang kenderaan dari “oversteer” atau “understeer” semasa membelok. Kandungan kajian ini adalah mengenai pembangunan dan permodelan model kenderaan penuh, yang terdiri daripada pengendalian perjalanan, dan subsistem tayar untuk mengkaji tingkah laku dinamik kenderaan ke arah sisi .. Kajian ini juga terlibat dalam pengawal pembangunan Program Kestabilan Elektronik untuk mengurangkan kadar rewang. Strategi kawalan menggabungkan model rujukan kadar rewang, yang mengira kadar rewang tindak balas yang diingini bergantung kepada sudut steering pemandu dan kekuatan angin.

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LIST OF SYMBOLS

a	-	distance between front of vehicle and *C.G.* of sprung mass
b	-	distance between rear of vehicle and C.G. of sprung mass
C_{sfl}	-	front left suspension damping
C_{sfr}	-	front right suspension damping
C_{srl}	-	rear left suspension damping
C_{srr}	-	rear right suspension damping
F_{fl}	-	suspension force at front left corner
F_{fr}	-	suspension force at front right corner
F_{rl}	-	suspension force at rear left corner
F_{rr}	-	suspension force at rear right corner
I_r	-	roll axis moment of inertia
I_p	-	pitch axis moment of inertia
K_{sfl}	-	front left suspension spring stiffness
K_{sfr}	-	front right suspension spring stiffness
K_{srl}	-	rear left suspension spring stiffness

K_{srr}	-	rear right suspension spring stiffness
m_b	-	sprung mass weight
$Z_{r,fl}$	-	road profiles at front left,
$Z_{r,fr}$	-	road profiles at front right,
$Z_{r,rl}$	-	road profiles at rear left,
$Z_{r,rr}$	-	road profiles at rear right,
Z_s	-	sprung mass displacement at body centre of gravity
$\dot{Z}_b$	-	sprung mass velocity at body centre of gravity
$\ddot{Z}_b$	-	sprung mass acceleration at body centre of gravity
$Z_{b,fl}$	-	front left sprung mass displacement
$Z_{b,fr}$	-	front right sprung mass displacement
$Z_{b,rl}$	-	rear left sprung mass displacement
$Z_{b,rr}$	-	rear right sprung mass displacement
$Z_{w,fl}$	-	front left unsprung masses displacement
$Z_{w,fr}$	-	front right unsprung masses displacement
$Z_{w,rl}$	-	rear left unsprung masses displacement
$Z_{w,rr}$	-	rear right unsprung masses displacement
$\dot{Z}_{w,fl}$	-	front left unsprung masses velocity
$\dot{Z}_{w,fr}$	-	front right unsprung masses velocity
$\dot{Z}_{w,rl}$	-	rear left unsprung masses velocity

$\dot{Z}_{w,rr}$	-	rear right unsprung masses velocity
$\ddot{Z}_{w,fl}$	-	front left unsprung masses acceleration
$\ddot{Z}_{w,fr}$	-	front right unsprung masses acceleration
$\ddot{Z}_{u,rl}$	-	rear left unsprung masses acceleration
$\ddot{Z}_{u,rr}$	-	rear right unsprung masses acceleration
w	-	wheel base of sprung mass
p	-	pitch angle at body centre of gravity
$\dot{p}$	-	pitch rate at body centre of gravity
$\ddot{p}$	-	pitch acceleration at body centre of gravity
r	-	roll angle at body centre of gravity
$\ddot{r}$	-	roll acceleration at body centre of gravity

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Chapter 1

Introduction

1.0 INTRODUCTION

Nowadays we can see that vehicle is a compulsory necessity for people. Without vehicle it can be said that people will be facing difficulties moving to one place to another place. But did we realize that the more vehicle in the road the more possibilities of vehicle accident to occur. According to The Malaysian Institute of Road Safety Research (MIROS) in 2010, Road Transport Department (JPJ) estimates the presence of some 900,000 registered commercial vehicle in Malaysia. From 1974 to 2004, traffic accident in Malaysia has been increasing at the average rate on 9.7 % per annum. Bosch had cited crash data from Germany that 20-25 percent of car crashes with injuries and fatalities resulted from loss of vehicle control (vehicle spinning). This causes from the difficulty faced by the driver in attempting to control their vehicle in limit scenarios and the tendency of driver to steer too much, worsen the situation.

Change of steering angle associated with change of lateral acceleration may drive vehicle to tendency of oversteer or understeer as in Figure 1. Oversteer is what occurs when a car turns (steer) by more than (over) the amount commanded by the driver meanwhile Understeer is what occurs when a car steer less than, or “under” the amount commanded by the driver.

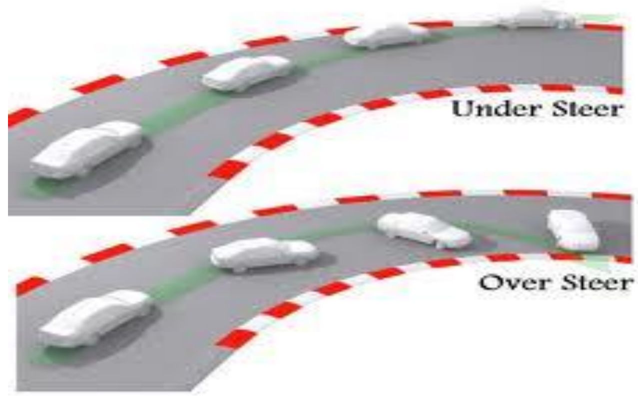

Figure 1.1: Vehicle Understeer and vehicle Oversteer

The goal of this study is to explore the possibility of vehicle dynamics performance by the use of Electronic Stability Program (ESP). The main works of this study include modeling of 14 Degree of Freedom (14-DOF) full vehicle model, validation of the model with instrumented experimental vehicle, derivation of the control strategy with disturbance rejection control and experimental evaluation of the system with the experimental vehicle. The research begins from the analytical studies using computer simulation on a full vehicle model. Then, mechanical realization of the model is constructed in an instrumented experimental vehicle. Finally, performance evaluation is conducted to study the potential benefits of ESP.

1.1 PROBLEM STATEMENT

This research ignited from a problem of a vehicle which when a car having a cornering at high speed, normally it will experience understeer or oversteer. Likewise, when the vehicle is having abrupt emergency maneuvers the drivel will experienced loss of steering control. All of this problem will lead to the vehicle loss control and drive off the road. Moreover, the vehicle may encounter crash and this will involves injuries and even worse casualties. To solve this problem, Electronic Stability Program (ESP) is proposed in this research for having a better vehicle handling.

1.2 BACKGROUND OF STUDY

When the vehicle is operating at the limits of road traction, the driver cannot control their vehicle because the vehicle response to driver inputs is different from normal. For example, if a vehicle is spinning out normally the driver will make a counter steering to regain control but in extreme maneuvers normal driver could not to do so. This will cause the vehicle to loss control and drive the vehicle off the road. In this situation, the side slips angle increase which will decrease the corrective yaw moment that can be applied through steering input hence the steer ability if vehicle decrease. In this situation, normally the driver will feel panic hence could make it even more difficult to regain control. In this situation, ESP can help the driver to regain control of the vehicle.

Electronic Stability Program (ESP) also known as Electronic Stability Control (ESC) is the generic term for system design to improve a vehicle handling particularly at the limits where the driver might lose control of the vehicle. According to studies done by the National Highway and Traffic Safety Administration in 2004, 35 percent of crash had been reduced since the existence of ESC.A 2006 study completed by the Insurance Institute for Highway Safety (IIHS) stated that 10,000 accident-related fatalities every year could be avoided if all vehicles had ESC. The study also concluded that ESC could reduce the chance of a fatal crash by 43 percent.

ESP system typically consist of wheel speed sensors, yaw rate sensors, lateral acceleration sensors, steering wheel angle sensor, and brake pressure sensor which the function of these sensors. As for wheel speed sensors, it measures the wheel speed. The second one is yaw rate sensor which it measure the rotation of the car. The data from this sensor is compared with the data from the steering wheel angle sensor to determine regulating action. Steering wheel angle sensor function is to check whether the car is travelling on its intended course. The fourth sensor is lateral acceleration sensor which it check whether the car is travelling on its intended course. As for brake pressure sensor it measures the high pressure in automotive braking system.

When ESP detects a probable loss steering control, it will estimates the direction of the skid, and then applies brakes to individual wheels asymmetrically to produce corrective yaw moment. This topic will be discussed in detailed in second chapter.

1.3 OBJECTIVE OF STUDY

The objective of this study is to modelling and control of Electronic Stability Program (ESP) for Automotive Vehicle using MATLAB & CARSIM software.

1.4 SCOPE OF STUDY

1. Mathematical derivation of full car model.
2. Vehicle modeling in MATLAB Software.
3. Vehicle validation with CARSIM Software.
4. Control design by simulator of Electronic Stability Program (ESP).
5. Performance evaluation of the proposed controller.

1.5 PROJECT ARRANGEMENT