SIMULATION STUDY OF PITCHING AND ROLLING CONTROL FOR PASSANGER CAR

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I/We* have read this thesis

and from my/our* opinion this thesis

is sufficient in aspects of scope and quality for awarding

Bachelor of Mechanical Engineering (Automotive)

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Date	: 24 May 2010

**Line which is irrelevant* —

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MAY 2009

"I declare this report is on my own work except for summary and quotes that I have mentioned its sources"

Signature :………………..

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To my beloved family

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Praise to Allah S.W.T from Whom i seek help and guidance and under His benevolence we exist and without his help this project could not have been accomplished.

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ABSTRACT

This report presents the project in developing a mathematical modeling for vehicle dynamics study specifically for the vehicle braking and cornering condition. The derivation of 7 DOF vehicle ride model is presented. Ride model includes the degree of freedom for roll, pitch and vertical motion of the sprung mass and also vertical motion of each unsprung mass. Additional simulation programming such as CarSimEd is combined and validated to the 7 DOF ride model to study and control the performance of active suspension. The performance comparison due to pitching and rolling of vehicle between passive suspensions with active suspension will also be discussed.

ABSTRAK

Laporan ini mempersembahkan projek dalam pembentukan model matematik untuk kajian dinamik kenderaan terutamanya untuk kenderaan dalam keadaan hentian mengejut dan selekoh. Penerbitan 7 darjah pembebasan model penungangan dipersembahkan. Model penungangan mengandungi darjah kebebasan untuk kecondongan, kegolekan dan gerakan keatas kenderaan dan juga gerakan keatas bagi semua tayar. Program simulasi tambahan seperti *CarSimEd* digabung dan disahkan dengan 7 darjah pembebasan membolehkan kita untuk mengkaji dan mengawal prestasi suspensi aktif. Pembezaan prestasi kecondongan dan golekan kenderaan antara suspensi pasif dan suspensi aktif akan dibincangkan.

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LIST OF SYMBOLS

C_{sfl} = Front left suspension damping coefficient

C_{sfr} = Front right suspension damping coefficient

C_{srl} = Rear left suspension damping coefficient

C_{srr} = Rear right suspension damping coefficient

F_{fl} = Front left suspension force

F_{fr} = Front right suspension force

F_{rl} = Rear left suspension force

F_{rr} = Rear right suspension force

F_{pfl} = Front left actuator force

F_{pfr} = Front right actuator force

F_{prl} = Rear left actuator force

F_{prr} = Rear right actuator force

h = Height of vehicle C.G.

I_{yy} = Pitch axis moment of inertia

I_{xx} = Roll axis moment of inertia

K_{sfl} = Front left suspension stiffness

K_{sfr} = Front left suspension stiffness

K_{srl} = Rear left suspension stiffness

K_{srr} = Rear right suspension stiffness

K_{rfl} = Front left tire stiffness

K_{rfr} = Front right tire stiffness

K_{rrl} = Rear left tire stiffness

K_{rrr} = Rear right tire stiffness

l_f = Distance of sprung mass C.G. from front axle

l_r = Distance of sprung mass C.G. from rear axle

m_b = Sprung mass

m_{wfl} = Front left unsprung mass

m_{wfr} = Front right unsprung mass

m_{wrl} = Rear left unsprung mass

m_{wrr} = Rear right unsprung mass

w = Track width

Z_{rfl} = Front left road profile

Z_{rfr} = Front right road profile

Z_{rrl} = Rear left road profile

Z_{rrr} = Rear right road profile

Z_b = sprung mass displacement

$\ddot{Z}_b$ = Sprung mass vertical acceleration at body C.G.

Z_{bfl} = Front left sprung mass displacement

$\dot{Z}_{bfl}$ = Front left sprung mass velocity

Z_{bfr} = Front right sprung mass displacement

$\dot{Z}_{bfr}$ = Front right sprung mass velocity

Z_{brl} = Rear left sprung mass displacement

$\dot{Z}_{brl}$ = Rear left sprung mass velocity

Z_{brr} = Rear right sprung mass displacement

$\dot{Z}_{brr}$ = Rear right sprung mass velocity

Z_{brl} = Rear left sprung mass displacement

Z_{wfl} = Front left unsprung mass vertical displacement

$\dot{Z}_{wfl}$ = Front left unsprung mass vertical velocity

$\ddot{Z}_{wfl}$ = Front left unsprung mass vertical acceleration

Z_{wfr} = Front right unsprung mass vertical displacement

$\dot{Z}_{wfr}$ = Front right unsprung mass vertical velocity

$\ddot{Z}_{wfr}$ = Front right unsprung mass vertical acceleration

Z_{wrl} = Rear left unsprung mass vertical displacement

$\dot{Z}_{wrl}$ = Rear left unsprung mass vertical velocity

$\ddot{Z}_{wrl}$ = Rear left unsprung mass vertical acceleration

Z_{wrr} = Rear right unsprung mass vertical displacement

$\dot{Z}_{wrr}$ = Rear right unsprung mass vertical velocity

$\ddot{Z}_{wrr}$ = Rear right unsprung mass vertical acceleration

φ = Pitch angle at the body C.G.

$\dot{\varphi}$ = Pitch rate at the body C.G.

$\ddot{\theta}$ = Pitch acceleration at the body C.G.

θ = Roll angle at the body C.G.

$\dot{\theta}$ = Roll rate at the body C.G.

$\ddot{\theta}$ = Roll acceleration at the body C.G.

CHAPTER 1

INTRODUCTION

This chapter will provide the information on simulating of vehicle when pitching and rolling. The importance of these simulating will be present in this chapter. The problem statement, objective and scope of this project will also be included.

1.1 Background

A vehicle will move naturally in pitching and rolling during cornering and braking. Too much pitching and rolling will reduce ride comfort and also cause driver hard to control and maintain the direction of motion of the vehicle.

During braking, the weight of the vehicle will transfer from rear tires to the front tires. This will make front vehicle move downward and rear vehicle to the upward. This motion is known as dive motion. When vehicle turn to the left, the weight will transfer from the left tires to the right tires. This weight transfer will happen in opposite way if vehicle turn to the right. This motion is known as roll motion. These motions are depend on driver input on vehicle, such as accelerating and also steering.

1.2 Problem statement

The behavior of vehicle motion due to the hard braking, cornering and others road condition will affect the vehicle handling and stability of the vehicle. This vehicle behavior especially pitching and rolling during braking and cornering are being analyzed and studied. A mathematical modeling based on vehicle model is build to represent the actual vehicle behavior while cornering, braking and other road condition. This mathematical modeling is then used to study and control the pitching and rolling of vehicle during braking and cornering.

1.3 Objective

The objective of this project is to study and control the pitching and rolling of a vehicle during braking and cornering.

1.4 Project scope

The scope of this project is developing a 7 DOF mathematical modeling ride model based on vehicle model. MATLAB Simulink Software will be chosen as computer design tools and also will use to simulate the dynamics behavior and evaluate the performance of the control structure. The research methodology implemented in this project takes the following steps of works; literature review on related field, study some previous works and the latest development on active suspension, development of equation of motion, simulation and comparison with the passive system.

1.5 Project Gantt chart

NO	TASK	WEEK															
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	Confirming title																
2	Literature review																
3	Collect The Data From Previous Study																
4	Solving problems																
7	Review study on 7 DOF of vehicle model																
8	Preparation of progress report																
9	Develop mathematical equation																
10	Preparation on technical report																
11	Edit technical report																
12	Submission of technical report																

Table 1: PSM 1 Gantt chart