SIMULATION AND EXPERIMENTAL INVESTIGATION ON A PNEUMATICALLY ACTUATED ACTIVE SUSPENSION SYSTEM USING GAIN SCHEDULING PI CONTROL

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"I admit that I have read this research and from my opinion this research is good enough in term of scope and quality for the purpose to graduate the Bachelor Degree of Mechanical Engineering (Automotive)."

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Date	: 10 April 2009

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DECLARATION

"I admit that this report is from my own work and idea accept for the summary and each of the extract that I was explain from its source"

Signature :………………

Writer name : Azman bin Ismail

Date : 10 April 2009

DEDICATION

To my beloved parents and my family for their guidance, support, love and enthusiasm. Without these things, this dissertation could not have been possible.

ACKNOWLEDGEMENT

All praises be to God, The Most Gracious, The Most Merciful for His Guide and Blessing.

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Endless gratitude goes to our beloved families for their continuous supports and motivation through the easiest and harshest of situations I have. Also thanks from to the management laboratory especially from the technician that help for preparing the experiment. For all team members, that work hard together under one roof, we suppose to be proud as a creative and innovative team members that eventually confident to get this project.

Last but not least, bundle of thanks to my friends that had been supporting me directly and indirectly throughout the whole semester.

ABSTRACT

The purpose of this project is to investigate the performance of adaptive PID control for pneumatically Actuated Active Suspension System using quarter car model. The Proportional Integral Derivative (PID) controller system will be used in this project to improve and to compare active suspension of the project with the existing passive suspension. A quarter-car is used by study its performance. For the simulation, MATLAB software is used and also experiment on quarter car test rig to complete this project.

ABSTRAK

Projek ini adalah bertujuan untuk menyelidik prestasi penyesuaian sistem kawalan PI untuk menggalakkan suspensi aktif di gerakkan oleh udara mampat menggunakan model satu perempat kereta. Sistem kawalan PI di gunakan dalam projek ini adalah untuk memperbaiki dan membandingkan sistem suspensi aktif dengan sistem yang telah sedia ada iaitu suspensi pasif . Model satu perempat kereta di gunakan bagi mempelajari prestasi sistem. Untuk simulasi, perisian MATLAB digunakan dan bagi ekperiment,model satu perempat kereta turut digunakan.

CONTENTS

LIST OF FIGURES

LIST OF SYMBOL

P_{out}	=	proportional output
K_p	=	proportional gain
e	=	error
t	=	time
K_i	=	Integral gain
I_{out}	=	Integral output
K_d	=	derivative gain
Zw	=	wheel displacement
Zb	=	body displacement
Cs	=	damper constant
Ks	=	spring constant

LIST OF ABBREVIATION

PID	**=**	**Proportional Integral Derivative**
MATLAB	**=**	**Matrix Laboratory**
GS	**=**	**Gain Scheduling**
RMS	**=**	**root mean square**

LIST OF APPENDIX

CHAPTER I

INTRODUCTION

1.1 Objective

In this project, there are two main objectives involved. These are to:

1) Investigate the performance of gain scheduling PI control for pneumatically actuated active suspension system using quarter car model.

2) Experimentally investigate the performance of gain scheduling PI control for pneumatically actuated active suspension system using quarter car test rig.

1.2 Scope

Two main scopes are covered in this project. These are:

1) Performance evaluation of gain scheduling PI control for pneumatically actuated active suspension system using computer simulation.

2) Performance evaluation of gain scheduling PI control for pneumatically actuated active suspension system experimentally using quarter car test rig.

1.3 Problem Statement

The vehicle suspension system is responsible for driving comfort and safety as the suspension carries the vehicle-body and transmits all forces between body and road. In order to positively influence these properties, semi-active or/and active components are introduced, which enable the suspension system to adapt to various driving conditions.

The active control of automobile suspension is used to improve the ride comfort without surrendering the body leveling and drivability. An ideal vehicle suspension system should have the capability of reducing the sprung mass displacement and acceleration and isolating driver and passengers from vibrations arising from road roughness. Several models and controllers have been developed in attempts to enhance and improve the ride and handling qualities in today's vehicles.

This project is to improve the riding characteristics of a vehicle by using the active suspension system to replace the existing passive suspension system. Active suspension is an automotive technology that controls the vertical movement of the wheels through a control system rather than the movement being determined entirely by the surface on which the car is driving.

1.4 Project Overview

For this project, the Proportional Integral Derivative (PI) control is used to improve the ride comfort and road handling of the active suspension system. A proportional–integral (PI controller) is a generic control loop feedback mechanism widely used in industrial control systems.

The PI controller calculation (algorithm) involves two separate parameters; the Proportional and the Integral values. The Proportional value determines the reaction to the current error and the Integral determines the reaction based on the sum of recent errors. By "tuning" the two constants in the PI controller algorithm, the controller can provide control action designed for specific process requirements. The response of the controller can be described in terms of the responsiveness of the controller to an error, the degree to which the controller overshoots the set point and the degree of system oscillation.

Gain scheduling PI control is used to enable the suspension system to adapt to various driving conditions or several of the road frequencies. A Computer simulation using MATLAB software will be performed to demonstrate the effectiveness of the proposed control scheme and the simulink model will be created by referring the quarter car suspension system and gain scheduling control equation. The control system then will be test experimentally on quarter car test rig to get the real result and the performance evaluation of this project.

CHAPTER 11

LITERATURE REVIEW

Literature review has been done in this chapter to gain more knowledge and also some idea before conducting this project. The previous works especially from the journals by other researchers are discussed.

2.1 Suspension Systems

The vehicle suspension system is responsible for driving comfort and safety as the suspension caries the vehicle body and transmits all forces between the body and the road. In order to positively influence these properties, semi-active and/or active components are introduced. These enable the suspension system to adapt to various driving conditions.

By adding a variable damper and/or spring, driving comfort and safety are considerably improved compared to suspension setups with fixed properties. This strategy requires that the control behavior of these components is known and that laws on how to adapt the free parameters depending on the driving excitations are known.This also requires the identification and fault detection of the involved components resulting in a mechatronic design.

2.2 Vehicle Suspension System

The vehicle suspension system consists of wishbones, the spring, and the shock absorber to transmit and also filter all forces between the body and road. The spring carries the body mass and isolates the body from road disturbances and thus contributes to drive comfort. The damper contributes to both driving safety and comfort. Its task is the damping of body and wheel oscillations, where the avoidance of wheel oscillations directly refers to drive safety, as a non-bouncing wheel is the condition for transferring road-contact forces.

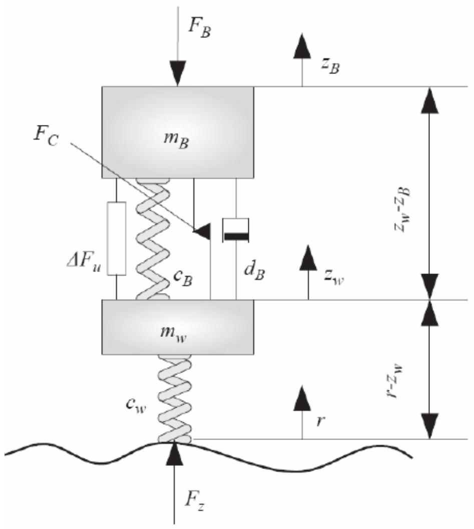

Figure 1: One-dimensional vertical vehicle representation the quarter-car model

2.3 Driving Safety

Driving safety is the result of a harmonious suspension design in terms of wheel suspension, springing, steering, and braking, and is reflected in an optimal dynamic behavior of the vehicle. Tire load variation is an indicator for the road contact and can be used for determining a quantitative value for safety

2.4 Driving Comfort

Driving comfort results from keeping the physiological stress that the vehicle occupants are subjected to by vibrations, noise, and climatic conditions down to as low a level as possible. The acceleration of the body is an obvious quantity for the motion and vibration of the car body and can be used for determining a quantitative value for driving comfort

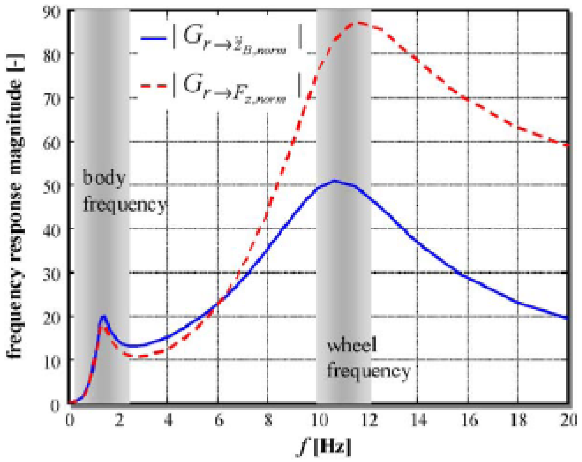

Figure 2: Frequency Response Magnitude for Normalized Body Acceleration and Tire Load for a Passive Suspension System

In order to improve the ride quality, it is necessary to isolate the body, also called the sprung mass, from the road disturbances and to decrease the resonance peak of the sprung mass near 1 Hz, which is known to be a sensitive frequency to the human body.

In order to improve the ride stability, it is important to keep the tire in contact with the road surface and therefore to decrease the resonance peak near 10 Hz, which is the resonance frequency of the wheel, also called the unsprung mass.

For a given suspension spring, the better isolation of the sprung mass from road disturbances can be achieved with a soft damping by allowing a larger suspension deflection.