# HALF CAR ACTIVE SUSPENSION SYSTEM

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This report is submitted in partial fulfillment of the requirements for award of Bachelor of Electronic Engineering (Computer Engineering) With Honours

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**UNIVERSTI TEKNIKAL MALAYSIA MELAKA**
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**PROJEK SARJANA MUDA II**

**Tajuk Projek** : Half Car Active Suspension System

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Dedicated to my beloved family especially my father and mother, lecturer, and also to all my friends

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# ABSTRACT

An early design for automobile suspension systems focused on unconstrained optimizations for passive suspension system which indicate the desirability of low suspension stiffness, reduced unsprung mass, and an optimum damping ratio for the best controllability. Thus the passive suspension system, which approach optimal characteristics, had offered an attractive choice for a vehicle suspension system and had been widely used for passengers. However, the suspension spring and damper do not provide energy to the suspension system and control only the motion of the car body and wheel by limiting the suspension velocity according to the rate determined by the designer. To overcome the above problem, active suspension systems have been proposed by various researchers. The purpose of this project is to present a modeling and control of the half car active suspension system using Fuzzy Logic Controller techniques. In this project, a mathematical model is represented which will give a much more complete mathematical representation of a suspension system for the half car model. In order to achive the desired ride comfort and road handling and to solve the mismatched condition, a fuzzy logic control will be utilized to deal with the system uncertainties. Finally, a simulation of a half-car active suspension system will be carried out using Matlab/Simulink software. Some comparison and analyses will be made from the simulation results.

# ABSTRAK

Pada permulaan rekabentuk sistem aktif suspensi, ia hanya memfokuskan kepada ketiadaan kekangan optimum terhadap sistem pasif suspensi dimana ia menunjukkan keupayaan rendah terhadap kekakuan suspensi, mengurangkan berat tidak berspring, dan juga nisbah terdekat yang optimum untuk keseluruhan kawalan. Oleh kerana itu, sistem pasif suspensi yang mencapai kriteria yang optimum dapat menyumbangkan peluang yang menarik untuk sistem suspensi kenderaan dan pada masa kini telah ramai orang yang menggunakannya. Bagaimanapun, spring dan juga peredam bagi suspensi tidak menyediakan tenaga untuk sistem suspensi dan ia hanya mengawal pergerakan badan dan tayar kereta dengan melimitkan halaju sistem suspensi berdasarkan kepada kadar yang telah ditetapkan oleh pereka. Oleh kerana itu, sistem suspensi aktif telah diperkenalkan oleh pelbagai pihak terutamanya para penyelidik bagi menyelesaikan masalah tersebut. Tujuan tesis ini dijalankan adalah untuk memperkenalkan model dan juga kawalan terhadap sistem suspensi aktif bagi model separuh kereta dengan menggunakan teknik kawalan Fuzzy Logik. Didalam projek ini juga sebuah model matematik diperkenalkan dan ini akan melengkapkan matematik bagi sistem suspensi model separuh kereta. Bagi mencapai tahap keselesaan pemanduan, pengendalian jalan, dan juga ketidak sesuaian kondisi, kawalan fuzzy logik akan digunakan untuk mengatasi sistem yang tidak bersesuaian. Akhir sekali, simulasi untuk sistem suspensi model separuh kereta akan dilakukan dengan menggunakan perisian Matlab/Simulink. Perbandingan dan juga analisis akan dilakukan terhadap keluaran yang dihasilkan dari simulasi menggunakan Matlab/Simulink.

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# CHAPTER I

# INTRODUCTION

## 1.1 BACKGROUND

An ideal suspension system should isolate the car body from road disturbances and inertial disturbances associated with cornering and braking or acceleration [1]. Furthermore, the suspension must able to minimize the vertical force transmitted to the passengers for passengers comfort. These can be achieved by minimizing the vertical body acceleration. An excessive wheel travel will result in non-optimum attitude of tyre relative to the road that will cause poor handling and adhesion. To maintain good handling characteristic, the optimum tyre-to-road contact must be maintained on four wheels [2].

An early design for automobile suspension systems focused on unconstrained optimizations for passive suspension system which indicate the desirability of low suspension stiffness, reduced unsprung mass, and an optimum damping ratio for the best controllability [3]. Thus the passive suspension system, which approach optimal characteristics, had offered an attractive choice for a vehicle suspension system and had been widely used for passengers. However, the suspension spring and damper do not provide energy to the suspension system and control only the motion of the car body and wheel by limiting the suspension velocity according to the rate determined by the designer.

To overcome the above problem, active suspension systems have been proposed by various researchers [4] and [5]. Active suspension systems dynamically respond to changes in the road profile because of their ability to supply energy that can be used to produce relative motion between the body and wheel. Typically, active suspension systems include sensors to measure suspension variables such as body velocity, suspension displacement, and wheel velocity and wheel or body acceleration. An active suspension is one in which the passive components are augmented by actuators that supply additional forces. These additional forces are determined by a feedback control law using data from sensors attached to the vehicle. In the conclusion, a comparison of active and passive suspension system are shown using MATLAB simulations.

## 1.2 Objectives

1.1.1 To develop the mathematical model of half car passive suspension system.

1.1.2 To develop the mathematical model of half car active suspension system.

1.1.3 To develop and design a half car active suspension system by using Matlab.

1.1.4 To develop fuzzy logic control strategy for the system.

1.1.5 To simulate and control the active suspension system.

## 1.3 Problem Statement

1.3.1 In passive suspension system**,** it only focused on unconstrained optimizations which indicate the desirability of low suspension stiffness, reduced unsprung mass and an optimum damping ratio or the best controllability.

1.3.2 However, the suspension spring and damper in passive suspension do not provide energy to suspension system and control only the motion of the car body and wheel.

## 1.4 Scopes of Work

This project primarily covered on the several parts, which are:

1.4.1 Familiarization of half car active and passive suspension system.

1.4.2 Mathematical derivation of half car active and passive suspension system.

1.4.3 Design fuzzy logic controller for half car active and passive suspension system.

1.4.4 Perform a simulation works for half car active and passive suspension system.

1.4.5 Compare the performance of active and passive suspension system with fuzzy logic controller.

## 1.6 Project Methodology

To ensure a successful outcome in the project, the project objectives shall be achieved first. The flow chart below shows the flow of work that will be done step by step until the goal of the project is achieved.

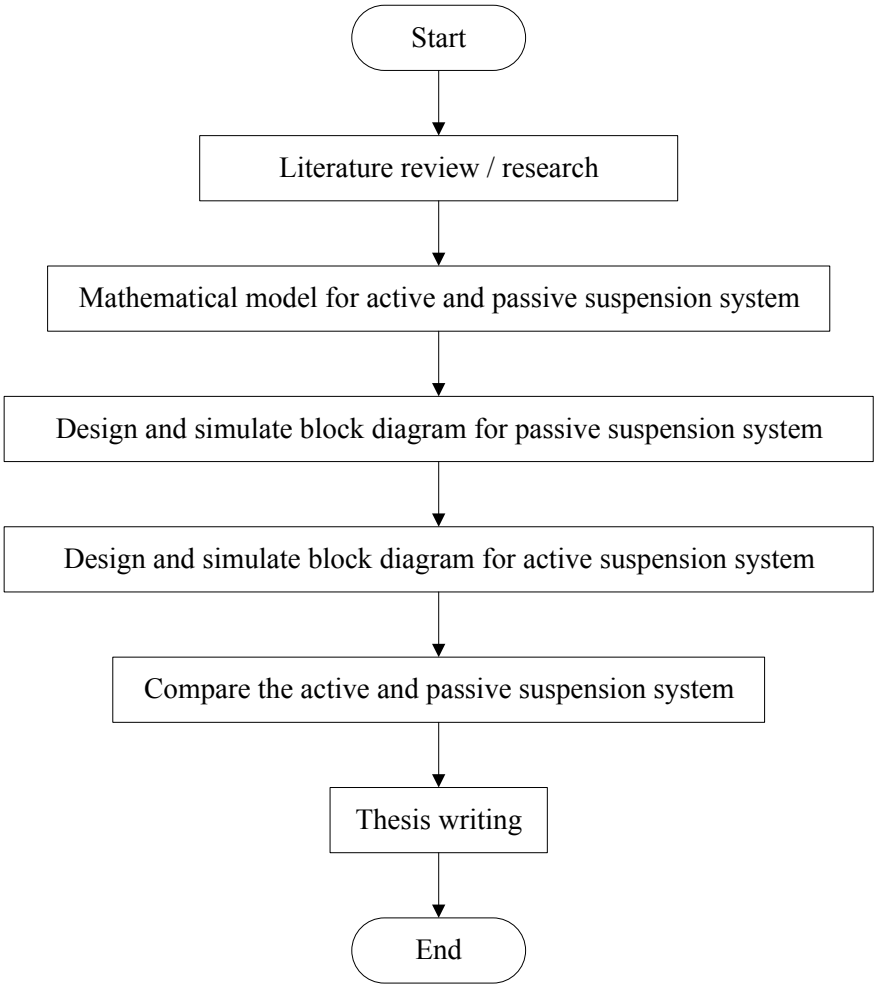


**Figure 1.1 Methodology Flowcharts**

This project will involve four phases of work:

i) First Phase : Literature Review

ii) Second Phase : Design and Simulation

iii) Third Phase : Implementation

iv) Fourth Phase : Thesis Writing

i) First Phase : Literature Review

- Information gathering about the project via internet, journals, magazines, published work and reference books.
- Study of the software implementation (Simulink, Matlab).
- Make research to know more detail about active and passive suspension system and Matlab.

ii) Second Phase : Design and Simulation

- The mathematical model for both active and passive suspension system of a half car model will be derived.
- The state space representation of the dynamic model for both active and passive suspension system are outlined.
- The various road profiles that represent the uncertainty will be used as the disturbance to evaluate the performance of the designed controller.
- Use Matlab software to simulate passive and active suspension system.

iii) Third Phase : Implementation

- The simulation results will be observed and presented.

iv) Fourth Phase : Thesis writing

- State all the ideas concentrated regarding to this project.
- Show flow of ideas during the implementation of this project.
- State the project conditions (from the beginning until the end of the project).

Detail explanation of the project methodology will be explained in Chapter III (Project Methodology).

## 1.7 Report Structure

Summarization of each chapter included in the report:

i) Chapter I : Introduction

ii) Chapter II : Literature Review

iii) Chapter III : Project Methodology

iv) Chapter IV : Results and Discussion

v) Chapter V : Conclusion and Recommendation

i) Chapter I : Introduction

This first chapter is more on the general overview of the project. In this chapter, the background of the problem and the emergence of the project are stated first. The project objectives, scope of project and the methods used are also included in this chapter.

ii) Chapter II : Literature Review

This second chapter discusses the background of study related to the project. This chapter consists of literature study through books, internet, and lecture notes previous PSM, thesis, and journal papers. In this chapter, the trend, direction and research issues are also identified. It can be said that this chapter is more on the evidence of not repeating what others have done.

iii) Chapter III : Project Methodology

In project methodology, the materials, subjects, and equipment or apparatus used are identified. Besides, the methods or procedures during the project implementation are also stated. Insufficient, the justification for choosing the method or approach is also stated.

iv) Chapter IV : Results and Discussion

In this chapter, the observation and result obtained from the data analysis are presented. Then, the project discovery is arranged tidily using the aid of figures and tables. Besides, the result or discovery is explained and compared with previous studies. Then, the result from the comparison is discussed.

v) Chapter V : Conclusion and Recommendation

The conclusion part is about the summarization of main findings of the projects. A brief recommendation for future study is stated at the recommendation part.