SIMULATION OF AUTOMATIC STEERING SYSTEM

ZULFADLI BIN KASMANI

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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# SIMULATION OF AUTOMATIC STEERING SYSTEM

ZULFADLI BIN KASMANI

Laporan ini dikemukan sebagai
memenuhi sebahagian daripada syarat penganugerahan
Ijazah Sarjana Muda Kejuruteraan Mekanikal (Automotif)

Fakulti Kejuruteraan Mekanikal

Universiti Teknikal Malaysia Melaka

APRIL 2010

"I admit that this report is from my own work and idea except for the summary and a few sections which were extracted from other resources as being mention"

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This final year project report is dedicated to my lovely parents, who has given countless efforts in motivating me during my 4 years undergraduate studies. and also to all my friends burning the midnight oil for countless nights in order to fulfill the project requirements. may we someday materializing our dreams in becoming successful engineers. ameen.

# ACKNOWLEDGEMENT

I would like to express my highest gratitude to my project supervisor, Dr. Khizbullah Hudha for his countless guidelines and motivation to ensure the completion of the project. Not to forget his constant financial support in order to materialize the requirement of the project. This project cannot be completed without the assistance of master students, Mr. Zubir and Mr. Em Poh Ping and I should thank them personally for all the informations regarding the project.

Cooperation from my friends, lecturers, or laboratory technicians directly or indirectly in assisting me during the project is greatly appreciated. Hopefully this final year project report successfully serves as a valuable source and guidelines for junior students.

# ABSTRAK

Sistem stereng automotif telah mengalami revolusi selama beberapa dekad berikutan aplikasi elektronik yang telah mengubah rekabentuk sistem stereng biasa. Kemajuan sistem stereng yang telah membawa kepada penciptaan stereng automatik dimulakan dengan sistem stereng hidraulik yang diubahsuai kepada sistem stereng elektrohidraulik kepada penciptaan sistem stereng elektrik dan akhirnya kepada stereng dengan wayar (SBW). Stereng automatik telah menukar kesemua sistem tersebut dengan menyingkirkan hubungan mekanikal antara stereng syaf dengan stereng rack. Skop kajian projek ini berkisar tentang permodelan matematik sistem stereng automatic dengan menggunakan model Simulink di MATLAB dan untuk mengesahkan ciri-ciri stereng automatik. Walaubagaimanapun, kerana tiada model ujian yang telah direkabentuk, projek ini juga berkisar tentang rekabentuk model ujian untuk sistem stereng automatic. Kerana kos dan rekabentuk yang mudah, sistem stereng dan suspensi Perodua Kancil telah dipilih untuk eksperimen. Projek ini diteruskan dengan permodelan kenderaan 9 DOF berdasarkan beberapa jurnal dan seminar persidangan. Untuk mengesahkan permodelan kenderaan yang dicadangkan, CarSim telah dipilih sebagai tujuan perbandingan. Permodelan pemandu beserta kawalan PID telah dibangunkan dan projek seterusnya diteruskan dengan menganalisis dan mengesahkan ciri-ciri stereng automatik daripada permodelan kenderaan yang dicadangkan di dalam MATLAB Simulink. Keputusan simulasi telah mengesahkan bahawa permodelan kenderaan yang dicadangkan telah menunjukkan ciri-ciri stereng automatik di dalam MATLAB Simulink.

# ABSTRACT

The automotive steering system has been evolved for several decades due to the electronics revolution which has changed completely the landscape of conventional steering system. The development of steering system that leads to the creation of automatic steering system can be portrayed as pure mechanical steering system developed to hydraulic power steering to electrohydraulic power steering to electric power steering (EPS) and finally to SBW system. Automatic steering system has changed completely the aforementioned systems by eliminating the mechanical connection of steering shaft to the steering rack. The scope of the research project is to construct the mathematical modeling of automatic steering system using Simulink Models in MATLAB for simulation and to verify the automatic steering behavior of simulated vehicle model in MATLAB Simulink. Although the project scope lies between mathematical modeling and simulation, the project also covers the design of automatic steering test rig since there is no existing test rig to be experimented. Due to the simplicity of steering system mechanisms and lower cost, Perodua Kancil steering and suspension system has been chosen to be experimented. The design development of automatic steering test rig covers the conceptual design phases before final design is produced to be fabricated. The project continues with the development of 9 DOF vehicle model derived from several journals and conference proceedings. To verify the proposed vehicle model, CarSim has been chosen for comparison purpose. The driver model integrated with PID controllers which functions as the vehicle model controller is developed before the automatic steering behavior of simulated vehicle model is analyzed and verified in MATLAB Simulink. Simulation results have verified that the proposed vehicle model has shown the automatic steering behavior in MATLAB Simulink.

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# CHAPTER 1

# INTRODUCTION

## 1.1 Background

The purpose of this project is to investigate and evaluate automatic steering system of driverless vehicle by means of simulation through the development of mathematical model of Automatic Steering System in MATLAB.

The purpose of steering system is to turn the front wheels. It also helps maneuvering the vehicles in desired lateral directions such as switching lanes, rounding sharp turns, and avoiding roadway obstacles. In some cases, steering system can also be used to turn the rear wheels, as recent technological development have shown that Four Wheel Steering (4WS) is practically viable in automotive steering system. However, as the project is focused primarily on front wheel steering, Four Wheel Steering (4WS) will not be presented on this paper.

Automobile steering systems can be classified under two systems, which are the less commonly used recirculating ball steering system and rack and pinion steering system which can be considered the most commonly found in automobile. Focusing on rack and pinion steering system, we could discover that various technological advancements have been implemented into the system such as

hydraulic assisted rack and pinion steering system, electrohydraulic steering system, electric power steering, and the recent state-of-the-art active steering system.

However, those aforementioned systems still retaining mechanical linkages found in conventional steering system such as steering column and steering shaft. Automatic Steering System presents a major challenge as well as major breakthrough discoveries in automotive steering technology by eliminating completely mechanical connection found in conventional steering system. The pinion shaft of the steering wheel that produces steering rack displacement has been substituted by an electric motor that controls the front wheels angle. For general definition, automatic steering system of driverless vehicle can be defined as an autonomous motion of the vehicle which is following the desired trajectory path specified by the driver.

## 1.2 Problem Statement

One of the contributing factors that mobilize me to choose Automatic Steering System as final year research is due to its various future advantages that eliminate various drawbacks regarding conventional steering system. Since Automatic Steering System uses electric motor to produce road wheel rotation, it is different from conventional hydraulic steering system which causes major inefficiency to the engine since the hydraulic pump is a constant engine driven pump regardless whether the car is stationary or in motion. Additionally, the steering shaft is also a major problem in terms of safety since the impact from frontal crash will exert the force to the steering wheel via steering shaft, injuring or killing the driver instantly. By the introduction of Automatic Steering System, which eliminates completely mechanical connection (steering shaft) found in conventional steering system, it has a potential to improve the safety of automobile. Various advantages of implementing the automatic steering system of driverless vehicle such as the implementation of driver model, ITS (intelligent transportation system), and automobile safety related issues will be discussed further in this paper.

## 1.3 Objective

- To develop the driver model with PID controller.
- To verify the automatic steering behavior of simulated vehicle model in MATLAB Simulink.

## 1.4 Scope

- Development of 9 Degree of Freedom (9 DOF) vehicle model in MATLAB Simulink.
- Verification of vehicle model with Carsim Educational Vehicle Dynamics Software.
- Development of driver model with PID controllers which function as vehicle model controller.
- Verify the automatic steering behavior of simulated vehicle model in MATLAB Simulink.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Evolution of Automotive Steering System

The steering mechanisms can be defined as converting the driver's rotational input at the steering wheel into a change in steering angle of the vehicle steering road wheels. According to Paul Yih (2005), the basic design in automotive steering system began with the invention of steering wheel on which the driver's steering input is transmitted by a shaft through some type of gear reduction mechanisms (generally refers to rack & pinion steering system). This system that will later generate steering motion at the front wheels can be precisely described as purely mechanical steering system.

However, advances in electronics have revolutionized many aspects of automotive engineering, especially in the areas of engine combustion management and vehicle safety systems such as Anti-Lock Braking System (ABS), Electronic Stability Control (ESC), and Adaptive Cruise Control (ACC). Various benefits have been identified by applying electronic technology for automotive application: improved performance, safety, and reliability with reduced manufacturing and operating costs. Unlike Throttle By Wire (also known as Electronic Throttle Control) and Brake By Wire (also known as Electrohydraulic Brakes, EHB/Electromechanical Brakes, EMB) as described in figure 2.1 which have been implemented in

automotive application, only recently electronic technology have found its way into automotive steering system which will lead into the discovery of automatic steering system.

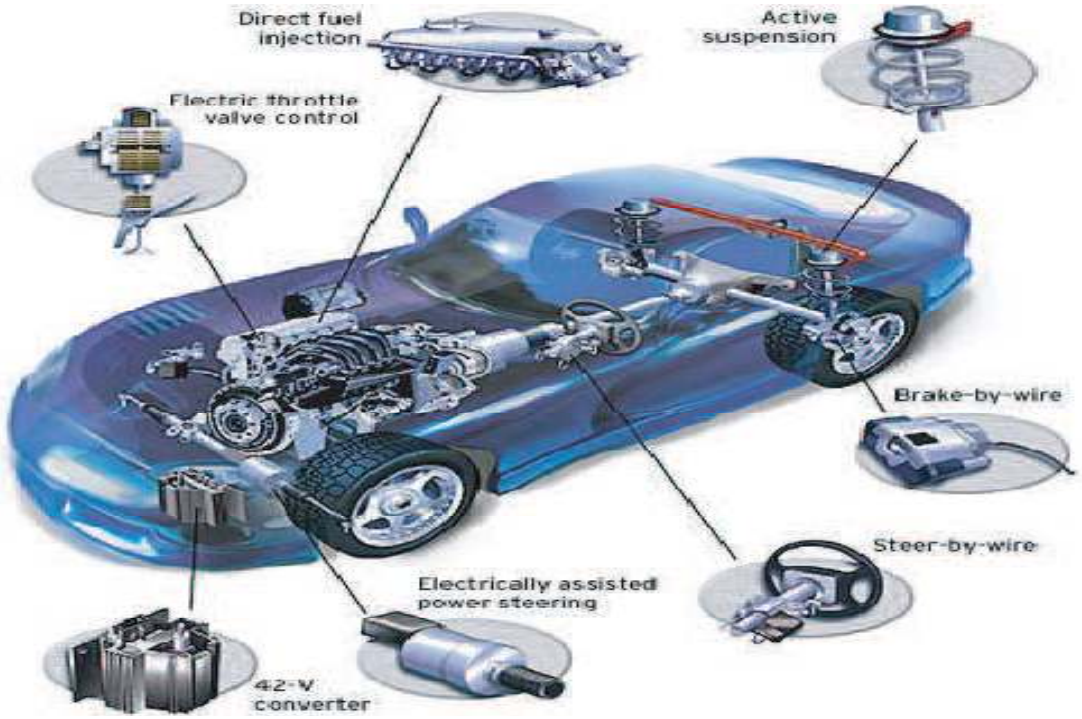


Figure 2.1: Automotive Applications For By Wire Technology

(Source: H. Inagaki et al. 1992)

The following is the chronological order of essential steps and breakthroughs in automotive steering system which indirectly created a path for the discovery of automatic steering system.

### 2.1.1 Hydraulic Power Assisted Steering

Due to the increasing size and weight of automobiles, purely mechanical steering system gradually becomes impractical to maneuver the vehicles. This situation leads to the creation of hydraulic power assisted steering to assist the