DEVELOPMENT OF FOUR WHEEL STEERING SYSTEM FOR RC VEHICLE

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COMFORMATION

I admit that have read this work and in my opinion this work was adequate from scope aspect and quality to award in purpose Bachelor of Mechanical Engineering (Automotive)

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Date :……

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2nd Supervisor's name:…….....

Date :……

DECLARATION

"I hereby, declare this thesis entitled Development of Four Wheel Steering System for RC Vehicle is the result of my own research except as cited in the reference"

Signature :……

Author name : MOHD HANIF BIN MD YUSUF

Date : 12 MAY 2009

DEDICATION

To my beloved father,

Md Yusuf B Ithnain

And to my beloved mother,

Faridah Bt Sulaiman

who keep me continuously motivated with their great support and encouragement throughout my Bachelor Degree program.

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ABSTRACT

Nowadays, the every vehicle existed mostly still using the two wheel steering system to control the movement of the vehicle whether it is front wheel drive, rear wheel drive or all wheel drive. But due to the awareness of safety, four wheel steering vehicles are being used increasingly due to high performance and stability that they bring to the vehicles. In this report, the performance of four wheels steered vehicle model is considered which is optimally controlled during a lane change maneuver in three type of condition which is low speed maneuver, medium speed maneuver and high speed maneuver. The configuration of this work is a technique for predetermination of system's stability based on pole placement method. Simulation results reveal the effectiveness of the proposed model and controller. The analysis will be conducted using MATLAB software to analyze and to prove whether four wheel steering system is better than the two wheel steering system. After that, the suitable configuration will be chosen that suit the remote control (RC) vehicle model to transform from two wheel steering system to four wheel steering system. The linkages will be installed according to the appropriate geometry based on the vehicle structure. After all the processes of modification completed, the RC vehicle will be tested to see the result given same as the simulation result or not.

ABSTRAK

Pada masa kini, kebanyakan kenderaan yang wujud masih lagi menggunakan sistem stereng dua tayar untuk mengawal pergerakan kenderaan sama ada ia adalah pacuan hadapan, pacuan belakang atau pacuan empat roda. Tetapi kerana untuk kepentingan keselamatan, kenderaan yang menggunakan sistem stereng 4 tayar telah banyak digunakan kerana mempunyai prestasi dan kestabilan yang tinggi yang diberikan oleh sistem stereng kepada kenderaan. Dalam laporan ini, prestasi untuk model kenderaan sistem stereng empat roda akan digunakan dan akan dikawal secara optimum ketika pergerakan perubahan lorong dalam tiga jenis keadaan iaitu pergerakan pada kelajuan rendah, pergerakan pada kelajuan sederhana dan pergerakan pada kelajuan yang tinggi. Konfigurasi untuk kerja ini ialah teknik pempratentuan tentang kestabilan sistem berdasarkan kaedah gambarajah kenderaan sistem stereng empat roda. Hasil dari simulasi akan menggambarkan tentang keberkesanan model yang di cadangkan berserta dengan data yang akan dikawal. Analisis akan dilakukan menggunakan perisian MATLAB untuk mengkaji sama ada sistem stereng empat roda adalah lebih baik daripada sistem stereng dua roda. Selepas itu, konfigurasi yang sesuai dengan model kereta kawalan jauh akan dipilih dan ditukarkan daripada sistem stereng dua roda kepada sistem stereng empat roda. Pemasangan sambungan akan dibuat berdasarkan kaedah yang bersesuaian dengan geometri model kereta kawalan jauh tersebut. Setelah semua proses telah lengkap dilaksanakan, model kereta kawalan jauh yang telah diubahsuai akan diuji untuk melihat adakah keputusan yang ditunjukan, sama dengan keputusan simulasi ataupun tidak.

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D_{ϕ}	=	Roll axis damping, Nm/rad
K_{ϕ}	=	Roll axis stiffness, Nm/rad
ϕ	=	Vehicle roll angle, rad
C_f	=	Front cornering stiffness, N/rad
C_r	=	Rear cornering stiffness, N/rad
F_{xij}	=	Tire longitudinal force, N
F_{yij}	=	Lateral force, N
G	=	Gravity acceleration, ms^{-2}
h_s	=	Distance of the sprung mass c.g. from the roll axes, m
I_{xx}	=	Moment of inertia about roll axis, kg m^2
I_{xz}	=	Sprung mass product of inertia, kg m^2
I_{zz}	=	Moment of inertia about yaw axis, kg m^2
L_f	=	Distance from c.g. to front axle, m
L_r	=	Distance from c.g. to rear axle, m
m	=	Vehicle total mass, kg
m_s	=	Vehicle sprung mass, kg
T_f	=	Front track width, m
T_r	=	Rear track width, m
u	=	Longitudinal velocity, ms^{-1}
v	=	Lateral velocity, ms^{-1}
X_{ij}	=	Longitudinal tire force, N
Y_{ij}	=	Lateral tire force, N
α_f	=	Front wheel slip angle, rad
α_r	=	Rear wheel slip angle, rad
β	=	Vehicle sideslip angle, rad
γ, Ψ	=	Yaw rate, rad/sec

δ_f	=	Front wheel steering angle, rad
δ_r	=	Rear wheel steering angle, rad

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CHAPTER 1

INTRODUCTION

1.1 Introduction

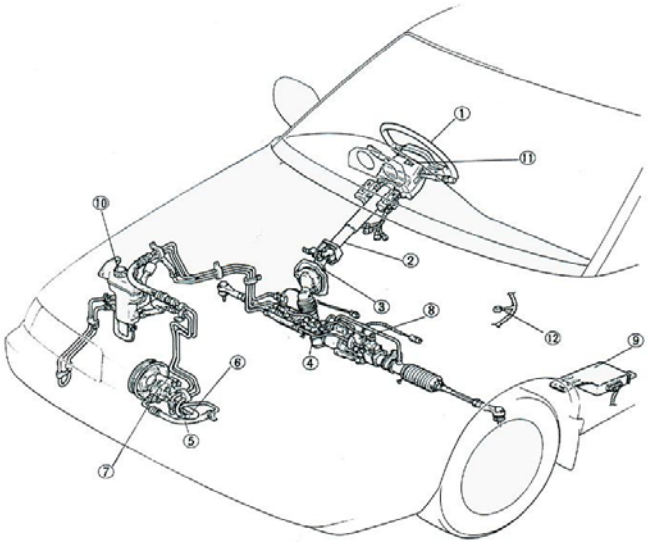

Figure 1.1: Steering system diagram (Basic structure, 2000).

Steering is a device that was used in most type of transport to control the movement of the vehicle. Steering system is the vehicle movement control system that includes the a few main components which are the steering wheel, the steering column, the steering rack and last but not least the wheel as shown in Figure 1.1.

In Figure 1.1, the steering system was build by the combination from a few components that help driver with the handling maneuver. The components are, : 1) steering wheel; (2) steering shaft; (3) intermediate shaft; (4) steering gear assembly; (5) pressure hose; (6) return hose; (7) oil pump; (8) solenoid valve; (9) ECU; (10) reserve tank; (11) steering angle sensor; (12) check connector.

A steering aid system called active steering is evaluated by simulating different driving events. The active steering solution, which is taken from a scientific paper, has been implemented in MATLAB. The input to the vehicle model is the steering wheel angle performed by the driver/ controller. Simulations are made by using constant speed as a reference and a specific changeable road adhesion coefficient as an input.

The control system takes the slip angle as input and derives a steering angle contribution to be added to the drivers command. The motivation for this work is to understand and characterize the response of a vehicle with a complementary steering system. Specific driving events are considered for the simulations such as a wind force disturbance and a severe double lane change.

The response of the controlled vehicle is similar to the response of the conventional vehicle for nominal driving, but the steering aid system reduces the effect of wind force disturbances. Improved stability is obtained for the vehicle during slippery road driving.

Four wheel steering vehicles are being used increasingly due to high performance and stability that they bring to the vehicles. In this project, a high performance four wheel steered vehicle model is considered which is optimally controlled during a lane change maneuver in three different type of maneuver; low speed maneuver, medium speed maneuver and high speed maneuver. The specific configuration of this work is a technique for predetermination of system's stability based on pole placement method. Simulation results reveal the effectiveness of the proposed model and the controller. Lastly, the testing will be conducted to support the data from

the simulation and the comparison will be discussed to determine if the experimental result follow the simulation data to prove that the 4WS is better than the 2WS vehicle.

1.2 Objectives

There are two objectives need to be achieved by the end of the semester which are:

i. To develop an active control of four wheel steering system on RC vehicle.
ii. To analytically study the advantages of additional rear wheel steering system in reducing the turning radius during maneuver.

1.3 Scope

The main scopes for this project are:

i. Deriving mathematical model of four wheel steering system.
ii. To modify the existing Forward Wheel Steering (FWS) of RC vehicle into 4 Wheel Steering (4WS) systems.
iii. Simulation studies on the controller design of 4WS system by using the MATLAB Simulink.

1.4 Problem Statement

Nowadays, many vehicles are still using the two wheel steering system as their main handling system for their vehicle. But the efficiency of the two wheel steering (2WS) vehicle is proven that it is still low compared to the four wheel steering (4WS)

system car. So, this project is base on how to prove that the 4WS is better than 2WS through Simulink and experimental result.

For the initial step, various designs must be made to search for the right mechanism to make the rear wheel to become the steerable rear wheel system, combine with the front wheel steering system and become the four wheel steering (4WS) system. For the requirement of this project, 4WS system must be installed to the remote control (RC) vehicle to make all the wheel steerable and a few testing procedures must be done, where a lot of data can be measure and record to the final result comparison.

CHAPTER 2

LITERATURE REVIEW

Literature review is the initial step to collect all the information and data about the topic that for this research, and from the information gathered, it will be analyze and the experiment testing will be done according to the journal or research, to get the real result from the real situation. When gathering the information about this topic, several sources have been used, such as journal, references book, website and other source regarding to the research topic from the already made product as guidance to learn more about the topic for this project. Therefore, this initial stage is very important to learn more the topics, to get know the problems arise and how to solve it before doing the simulation and experiment procedures.

2.1 Steering system

The handling characteristics of a road vehicle refer to its response to the steering commands and to the surrounding inputs, such as wind gust and road disturbances, that effect the direction of the vehicle. There are two basic problems in vehicle handling: one is the control of the direction of motion of the vehicle; the other is its ability to stabilize its direction of motion against external disturbances (Wong, 2001).

The vehicle as a rigid body has six degrees of freedom, translations along the x, y and z-axis, and rotations about this axis shown in Fig.2.1. The primary motions due to the handling behavior of a vehicle are longitudinal, lateral, and yaw motion. During turning maneuver, the vehicle body rolls about the x- axis. This roll motion may cause the wheels to steer, thus affecting the handling behavior of the vehicle. Furthermore, bounce and pitch motions of the vehicle body, may also affect the steering response of the vehicle. However, the inclusion of these motions only become necessary in the analysis when considering the limits of handling characteristics (Wong, 2001).

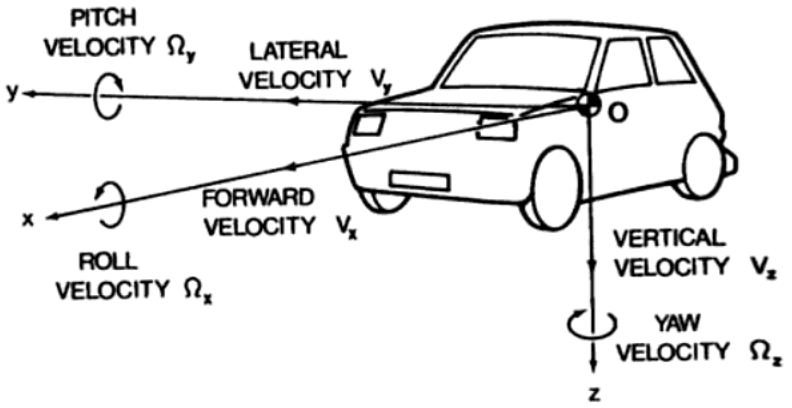

Figure 2.1: Vehicle six degree of freedom (Wong, 2001).

Simplified linear model for the handling behavior of passenger car in which suspension characteristics are not taken into account will be discussed. The model demonstrate the effects on handling behavior of major vehicle design and operational parameters, such as tire properties, location of the center gravity, and forward speed and lead to conclusions of practical significance concerning directional control and stability. The response of the vehicle to steering input and its directional stability associated with a fixed steering wheel, which are usually referred as fixed control- characteristics will be analyzed (Wong, 2001).

Nowadays, there are two types of steering system that are commonly used, that are Front Wheel Steering (Two Wheel Steering) and Four Wheel Steering.