SUPERVISORS DECLARATION

"We hereby declare that we have read this thesis and in our opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering (Automotive)"

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PC BASED DATA ACQUISITION SYSTEM FOR SCALED VEHICLE NAVIGATION SYSTEM

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This Report for "Projek Sarjana Muda II" is submitted to
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DECLARATION

I declare that this report is my own work except for any summary or quotation from every single source is explained.

Signature : ....

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Date : 30. MAY 2011

For my beloved father, mother, and family

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ABSTRACT

This paper presents the analysis about the scaled vehicle dynamics modeling by analytical and experimentation method. In this study, this research focused on the development of wireless data acquisition system used to validate a small racing car dynamic model for an Ackermann steering geometry where the vehicle is based on a static tire road friction and also contains with other law of mechanics. The mathematical model is used to develop a simulation model using SIMULINK block diagrams in MATLAB. Based on the simulation, the results are shown in two different types of results which are time versus yaw rate and time versus lateral acceleration. This will demonstrate vehicle behavior when certain steering input given for the vehicle. The simulation is validated with the experiment data analyzed by using the Matlab software. The experiment done a scaled vehicle by fixing sensors and data collected using data acquisition system. Arduino microcontroller will be used as the base design to collect the data from sensors. Based on the result, unwanted signal was identified as one of the disturbances and filtered using the analog filter. From the experiment, it showed that the dynamic model was quite accurate in predicting the transient behavior as represented by yaw and lateral acceleration. After validation, recommendations are proposed in order to show the vehicle behavior in yaw rate mode and lateral accelerations mode.

ABSTRAK

Kertas ini membentangkan analisis tentang sistem-sistem pemodelan dinamik untuk diskala kenderaan melalui kaedah percubaan dan analisis. Dalam kajian ini, fokus penyelidikan ini pada pembangunan sistem pengambil alihan data wayarles yang digunakan untuk mengesahkan model dinamik untuk geometri stereng Ackermann bagi sebuah kereta lumba kecil di mana kenderaan adalah diasaskan geseran jalan tayar statik dan juga bersalut undang-undang lain mekanik-mekanik. Model matematik digunakan bagi menghasilkan satu model simulasi menggunakan rajah-rajah blok SIMULINK dalam MATLAB. Berdasarkan simulasi, keputusan ditunjukkan dalam dua jenis keputusan berbeza yang mana masa lawan kadar rewang dan masa lawan pecutan sisi. Ini akan menunjukkan tingkah laku kenderaan apabila input stereng tertentu diberi bagi kenderaan. Simulasi disahkan dengan data uji kaji dimana ia dianalisis dengan menggunakan perisian Matlab. Eksperimen dibuat satu kenderaan diskala dengan memasang pengesan-pengesan dan data mengutip menggunakan sistem pemerolehan data. Berdasarkan hasil, isyarat tidak dikehendaki telah dikenalpasti sebagai satu daripada gangguan-gangguan dan menapis menggunakan turas analog. Daripada eksperimen, ia menunjukkan bahawa model dinamik yang cukup tepat dalam memprediksikan perilaku transien yang diwakili oleh yaw dan pemecutan lateral. Selepas pengesahan, cadangan-cadangan adalah dicadangkan supaya menunjukkan tingkah laku kenderaan dalam mod kadar yaw dan pemecutan-pemecutan sisi mod.

TABLE OF CONTENTS

CHAPTER	SUBJECT	PAGE
	DECLARATION	ii
	DEDICATION	iii
	ACKNOWLEDMENT	iv
	ABSTRACT	v
	ABSTRAK	vi
	TABLE OF CONTENT	vii
	LIST OF FIGURES	xiii
	LIST OF TABLES	xvii
	LIST OF SYMBOLS	xviii
CHAPTER I	**INTRODUCTION**	
	1.1 Background	1
	1.2 Problem of statements	2
	1.3 Objective	5
	1.4 Scope	5
	1.5 Research Contribution	6
	1.6 Outline Thesis	6

CHAPTER II LITERATURE REVIEW

2.1 Introduction 7

2.2 Vehicle Dynamics Behavior 7

2.2.1 Analytical Method 8

2.2.2 Handling Characteristic 8

2.2.3 Steering Geometry 10

2.2.4 Transient Response Characteristics 11

2.2.5 Estimation graphs 12

2.3 Sensors

2.3.1 Overview 14

2.3.2 Yaw Rate Sensors 15

2.3.3 Accelerometer Sensors 16

2.3.4 Velocity Sensors

2.3.4.1 Encoders 17

2.3.4.2 Rotary Encoder 17

2.4 Data Acquisition System

2.4.1 Definition 18

2.5 Arduino Microcontroller

2.5.1 Definition Arduino 20

2.5.2 Definition Arduino Microcontroller 21

2.5.3 Design of the Arduino Microcontroller 22

2.5.4 Arduino Boards Layout 23

2.5.5 Example of arduino coding 24

	2.6 Wireless Sensor Network	
	2.6.2 Introduction	25
	2.6.1 XBee	
	(a) Design	26
	(b) Definition	26
CHAPTER III	**METHODOLOGY**	
	3.1 Introduction	28
	3.2 Flow Chart	28
	3.3 Details Description of Flow Chart	
	3.3.1 Literature Review	30
	3.3.2 Analytical Approach	30
	3.3.3 Development of Simulink Model	36
	3.3.4 Type of operating condition for Transient State	38
	3.3.5 Validation the experiment and simulink Results usingCarSimEd	41
CHAPTER IV	**EXPERIMENT PREPARATION**	
	4.1 Introduction	43
	4.2 Sensors and Equipment	43
	4.2.1 (a) Sensors Programming	45

4.2.2 (b) Software 49

4.2.2 (c) Sensors Installation 52

4.3 Experiment Track Preparation 57

4.3.1 Step Steer Test 58

4.3.2 Double Lane Change Test 59

CHAPTER V **TESTING AND RESULTS ANALYZING**

5.1 Introduction 60

5.2 Step Steer Test at 50 km/h 61

5.3 Double Lane Change at 30 km/h 64

5.4 Results and Analyzing

5.4.1 30 Degree Step Steer Test at 50 km/h 67

5.4.1.1 Comparison for lateral acceleration between simulink and experiment 68

5.4.1.2 Comparison for lateral acceleration between CarSimEd and experiment 69

5.4.1.3 Comparison for lateral acceleration between CarSimEd and simulink 70

5.4.1.4 Comparison for yaw rate between Simulink and experiment results 71

5.4.1.5 Comparison for yaw rate between CarSimEd and experiment results 71

5.4.1.6 Comparison for yaw rate between CarSimEd and simulink results 72

5.4.2 Double Lane Change Test at 30 km/h 73

5.4.2.1 Comparison for lateral acceleration between simulink and experiment 74

5.4.2.2 Comparison for lateral acceleration between CarSimEd and experiment 75

5.4.2.3 Comparison for lateral acceleration between CarSimEd and simulink 75

5.4.2.4 Comparison for yaw rate between Simulink and experiment results 76

5.4.2.5 Comparison for yaw rate between CarSimEd and experiment results 77

5.4.2.6 Comparison for yaw rate between CarSimEd and simulink results 77

CHAPTER VI **DISCUSSIONS**

6.1 Introduction 79

6.2 30 Degree Step Steer Final Comparison Result 79

6.2.1 Graph Lateral Acceleration Vs Time 80

6.2.2 Graph Yaw Rate Vs Time 81

6.3 Double Lane Change Final Comparison Result 82

	6.3.1 Graph Lateral Acceleration Vs Time	83
	6.3.2 Graph Yaw Rate Vs Time	84
	6.4 Overall comparison between scaled and real vehicle behavior	85
CHAPTER IV	**CONCLUSION AND RECOMMENDATION**	86
	REFFERENCES	88
	APENDICES	92

LIST OF FIGURES

NO.	TITLE	PAGE
1.1	Degree of Freedom of a Vehicle	3
1.2	Scaled Vehicle for the Project	4
2.1	Bicyle Model	9
2.2	Ackermann Steering Geometry	10
2.3	Measured input steering angle and estimated left and right wheel angles	12
2.4	Estimated and measured yaw rate	13
2.5	Estimated and measured acceleration in y-direction	13
2.6	Wireless Data Acquisition System	18
2.7	Arduino Microcontroller Design	22
2.8	Board Layout	23
2.9	XBee wireless sensor device	26
2.10	Xbee model mounting to an interface board	27
3.1	Flow Chart	29
3.2	Analysis of plane motion of a vehicle using axes fixed to vehicle body	31
3.3	Bicycle model of simplified vehicle model for analysis of transient response	33
3.4	The flow of simulation implementation	36
3.5	Transient 3DOF bicycle model	37
3.6	ISO 3888 Standard Double Lane Change	38
3.7	Steering input for Step Steer Test	41

NO.	TITLE	PAGE

3.8	Track Coordinates Inputs for Double Lane Change Test	41
4.1	Arduino Software Page	49
4.2	Results in the Serial Monitor	50
4.3	Realterm Software	51
4.4	LISY 300 AL	52
4.5	IMU 5 DOF	52
4.6	Arduino Microcontroller	52
4.7	Sensors on Strip board	53
4.8	Arduino Microcontroller USB cable Connection	53
4.9	XBee wireless device	54
4.10	Arduino Transmitter with 9V battery	55
4.11	Sensor Location	56
4.12	Sensors on the COG of scaled vehicle	57
4.13	Scaled vehicle on track for Step Steer Test	58
4.14	Track coordinates for double lane change	59
5.1	Scaled vehicle reach constant velocity	61
5.2	Scaled vehicle turn at 30 degree	61
5.3	Steering input to the scaled vehicle	62
5.4	End of step steer test	63
5.5	Track coordinates for double lane change test	64
5.6	First turning point of the scaled vehicle	65
5.7	Second turning point of the scaled vehicle	65
5.8	The scaled vehicle reaches the end point	66
5.9	Arduino receiver connect with laptop	67

NO.	TITLE	PAGE

NO.	TITLE	PAGE
5.10	Comparison graph between simulink and experiment, ay	68
5.11	Comparison graph between CarSimEd and experiment, ay	69
5.12	Comparison graph between CarSimEd and simulink, ay	70
5.13	Comparison graph between simulink and experiment, yaw rate	71
5.14	Comparison graph between CarSimEd and experiment, yaw rate	71
5.15	Comparison graph between CarSimEd and simulink, yaw rate	72
5.16	Comparison graph between simulink and experiment, ay	74
5.17	Comparison graph between CarSimEd and experiment, ay	75
5.18	Comparison graph between CarSimEd and simulink, ay	75
5.19	Comparison graph between CarSimEd and experiment, yaw rate	76
5.20	Comparison graph between CarSimEd and simulink, yaw rate	77
5.21	Comparison graph between simulink and experiment, ay	77
6.1	Comparison between experiment,simulink and CarSimEd for lateral acceleration,step steer	80

NO.	TITLE	PAGE

6.2	Comparison between experiment,simulink and CarSimEd for yaw rate,step steer	81
6.3	Comparison between experiment,simulink and CarSimEd for lateral acceleration, dlc	83
6.4	Comparison between experiment,simulink and CarSimEd for yaw rate, dlc	84

LIST OF TABLES

NO.	TITLE	PAGE
3.1	Parameter of Handling Transient Model Under Step Steer	37
3.2	Parameter of Handling Transient Model Under Double Lane Change	37
4.1	Sensors Description	44

LIST OF SYMBOL

V_s	=	side velocity
V_y	=	lateral velocity
Ω_z	=	yaw velocity
V_x	=	longitudinal velocity
t	=	time
Δt	=	time changes
V	=	velocity
$\Delta\theta$	=	angle changes
a_x	=	longitudinal axis of the absolute acceleration of the center of gravity
a_y	=	lateral axis of the absolute acceleration of the center of the vehicle
m	=	mass, kg
$\dot{\Omega}_z$	=	yaw rate
δ_f	=	steering angle
I_z	=	mass of moment of inertia
l_1	=	length of the car from front to CoG
l_2	=	length of the car from rear to CoG
F_{xf}	=	force at front wheel in x axes
F_{xr}	=	force at rear wheel in x axes
F_{yf}	=	force at front wheel in y axes
F_{yr}	=	force at rear wheel in y axes
α_f	=	slip angle for front wheel

α_r	=	slip angle for frear wheel
$C_{\alpha f}$	=	cornering stiffness front wheel
$C_{\alpha r}$	=	cornering stiffness rear wheel

CHAPTER I

INTRODUCTION

1.0 Introduction

This chapter describes the background about the scaled vehicle dynamics navigation systems. Next is followed by the problem statement to scale down the data occur from the sensors through wireless systems to the computer network. After that, objective of project being explained and the scope of the project being covered. This chapter will end with research contribution and outline of the Thesis.

1.1 Background

The scaled vehicle dynamics represents an overview of the vehicle and environmental characteristics that contribute to successfully modeling and controlling vehicle dynamic behavior. This research focus on development of a dynamic model for an Ackermann steering geometry where the vehicle is based on a static tire road friction and also contains with other law of mechanics.

Steering angle of the wheels in front and rotational velocities of the drive wheels in the back of the vehicle as the input for this model. It delivers a 3 DOF output in terms of CoG vehicle velocity, body slip angle and the yaw rate of the vehicle in x-y plane. The scaled vehicle dynamic used to show the vehicle dynamic behaviors which are equivalent to those of real vehicle. We can prove the dynamics behaviors in a scaling environment interactively with human operator. We can use certain equipments such as sensors, instrument, wireless communication systems, microcontroller and vision on board. Several measurements devices were developed for measuring the moment of inertia and cornering stiffness. Experimental verification of the obtained model is given for the Smart testing vehicle platform, where a separate analysis is done for directly measured as opposed to estimated parameters of the model. The simulation data and experiments data observed and compared to analysis the vehicle dynamic behavior.

1.2 Problem Statements

In this research, the vehicle dynamic behavior can be identified by testing the handling characteristic of the vehicle. Handling characteristics of a road vehicle are concerned with its response to steering commands and to environmental inputs affecting the direction of motion of the vehicle such as wind and road disturbances. There are two basic problems in vehicle handling. One of them is the control of the vehicle to a desired path and the other is the stabilization of the direction of motion against external disturbances. The vehicle as a rigid body has six degrees of freedom as shown in the figure. The motions associated with side slip are:

(a) Motion along the y axis (side velocity, or lateral velocity, V_s or V_y),
(b) Rotation about the z axis (yaw velocity, Ω_z, and
(c) Rotation about the x axis (roll velocity) is usually referred to as lateral motions of the vehicle.

A simplified linear vehicle model in which the suspension is neglected will be examined as a study of vehicle handling. This model demonstrates the effects of tire properties, location of the center of gravity, and forward speed of the vehicle on the handling behavior.

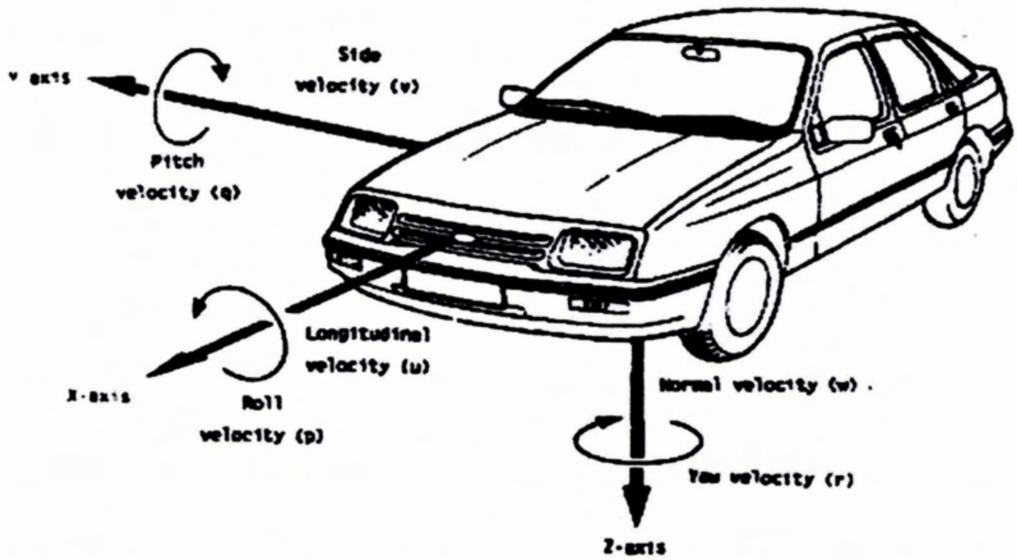

Fig. **A moving vehicle has up to 17 different degrees of freedom that must be considered about the three main axes**

Figure 1.1: Degree of Freedom of a Vehicle (Source from Rajamani, R. (2006). *"Vehicle dynamic and control."*)

In this research, the consideration will be done on 3degree of freedom (DOF) only which is yaw rate, lateral acceleration and roll velocity. Smart vehicle used as the experimental vehicle to complete the testing. As the measuring device, sensors are used to determine the three degree of freedom motions. Sensors used in this project to determine the input and output for the testing. All the inputs can be recorded using a data acquisition system. This device can record more than one input sensors and send for verification. The output sensors installed inside a microcontroller board with the wireless receiver. The microcontroller was programmed using Mathlab software to read the data obtained. The data transmitted to the computer using the microcontroller receiver where it connected to the computer through the USB port. All the data plotted in the graph form to show the results obtained during the experiment. From here, we can compare the experiment data and the simulations data.

Figure 1.2: Scaled Vehicle for the project