VERIFICATION

"I hereby declare that I have read through this thesis and found that it has complied the partial fulfillment in awarding the Bachelor Degree of Mechanical Engineering (Automotive)"

Signature : …………………………….

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Date : 9th April 2009

DEVELOPMENT OF DATA ACQUISITION SYSTEM FOR TYRE FORCE MEASURING DEVICE

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This Report is Submitted in Partial Fulfillment of Requirements for the Bachelor Degree of Mechanical Engineering (Automotive)

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DECLARATION

"I hereby declare that this project report entitled

DEVELOPMENT OF DATA ACQUISITION SYSTEM FOR TYRE FORCE MEASURING DEVICE

is written solely by me and with great effort and

that none of the parts have been plagiarized without citations."

Signature : …………………………….

Author's Name : LEE TZE JIAN ……………………………..

Date : 9^{th} April 2009 ……………………………..

DEDICATION

Dedicated to my beloved Family, Father (Mr. Lee Kwong Leong), Mother (Ms. Chai Siew May), Siblings (Mr. Lee Tze San & Ms. Lee Joe Ee), and not forgetting my dearest and closest fellow friends who have given me endless support and the greatest will to complete this project.

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From deep within my heart, I would like to portray my unbounded thanks for all the support, encouragements and inspirations I have received throughout the duration of this project.

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Deepest heartfelt for my family who has been supporting me from hundreds of miles away. They had always cared and worried about my well being.

The list goes on and to keep it short, lastly, I would like to thank everyone who has facilitated and helped me even the slightest in completing this project. To those whom I did not specifically mention, you have my gratitude for moving me closer to my goal.

Thank You.

ABSTRAK

Kajian ini menjelaskan tentang pembinaan sistem perolehan data untuk alat pengukuran daya tayar. Alat pengukuran daya tayar ini memerlukan dua belas tolok ketegangan di mana kesemua tolok-tolok ini adalah tolok aktif yang membolehkan penghasilan data daya dan daya tuas yang tertentu. 'Wheatstone Half Bridge' diaplikasikan pada setiap tolok ketegangank. Setiap daya dan daya tuas ditugaskan kepada dua tolok ketegangan di mana satu tolok akan mengalami keregangan manakala yang satu lagi akan mengalami tekanan. Penguat isyarat dan penapis isyarat tidak ditambah kedalam litar kerana sistem perolehan data mampu mengesan data daripada alat pengukuran daya tayar dan juga alat ini digunakan dalam aplikasi automotif di mana daya-daya yang dijangkakan adalah besar. Sebarang gangguan yang kecil boleh diabaikan Sebuah sistem perantaraan pengguna bergrafik dibina menggunakan MATLAB untuk membolehkan perhubungan antara pengguna dengan alat pengukuran daya tayar. Alat pengukuran daya tayar ini ditentu ukurkan melaui eksperimen. Sistem perantaraan pengguna bergrafik menghasilkan keputusan visual dari segi graf.

ABSTRACT

In this study, a data acquisition system for the tire force measuring device is developed. The tire force measuring device requires twelve strain gauges which all of them act as active gauges that produces output for a specific force or moment component. Wheatstone Half Bridge is applied in determining the changes in the resistance of the strain gauges which is then converted into voltage changes. Each force or moment is assigned to two strain gauges which one of the strain gauge is assigned to compression while the other strain gauge is assigned to tension. Amplifier and filter are not needed as the data acquisition system managed to detect outputs from the device and the device is applied solely in automotive applications where forces and moments are expected to be large, rendering small noises negligible. A graphical user interface is programmed using MATLAB to bridge the link between the user and the tire force measuring device. The tire force measuring device is calibrated through experimental means. The graphical user interface provides the means of graphical output in terms of graphs.

TABLE OF CONTENT

CHAPTER	CONTENT			PAGE

CHAPTER	CONTENT	PAGE

CHAPTER	CONTENT		PAGE

LIST OF TABLES

LIST OF FIGURES

NO.	TITLE	PAGE

NO.	TITLE	PAGE

LIST OF SYMBOLS

SYMBOL	TITLE
A	Area of grid of strain gauge
b	Width of the cross section of the beam
E	Elastic modulus
F_x	Longitudinal Force
F_y	Lateral Force
F_z	Vertical Force
h	Height of the cross section of the beam
I_g	Electrical current in strain gauge
L	Original length
L	Signal loss factor
ΔL	Elongation
M	Bending moment
M_x	Rolling Moment
M_y	Pitching Moment
M_z	Yawing Moment
P	Load
P_D	Power density of strain gauge
P_g	Power that can be dissipated by the strain gauge
R	Original resistance
ΔR	Change in resistance
R_g	Resistance in strain gauge
R_L	Resistance of a single lead wire
S_c	Sensitivity of the Wheatstone bridge circuit

SYMBOL	TITLE
S_f	Fatigue strength of material used in beam fabrication
S_g	Strain gauge factor
S_s	Sensitivity of the strain gauge-Wheatstone bridge system
x	Distance of gauge from effective load
Ω	Ohm
v	Poisson’s ratio
V_i / v_s	Input/Source voltage
V_o	Output voltage
σ	Stress
ε	Strain
ε_t	Transverse strain
ε_l	Longitudinal strain
F_{x_B}	Longitudinal force at device
F_{y_B}	Lateral force at device
F_{Z_B}	Vertical force at device
M_{x_B}	Rolling moment at device
M_{y_B}	Overturning moment at device
M_{z_B}	Self aligning moment at device
R_T	Radius of tire
d	Length from the tire to the device
γ	Tire camber angle
y	Value of a point at the y-axis
x	Value of a point at the x-axis
m	Gradient of the graph line
c	A constant
g	Gravitational acceleration

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 The Wheel Dynamic Test Rig

The wheel dynamic test rig is designed by Goh C. K., a degree undergraduate of *Universiti Teknikal Malaysia Melaka* (UTeM), in favor of his final year project or also known as '*Projek Sarjana Muda'* (PSM). The purpose of the wheel dynamic test rig is to investigate the handling dynamics of a tire. The test rig is built based on a quarter car model which includes a supporting frame, wheel, shaft and a conveyor belt that simulates the road input on a spinning wheel. The belt on the conveyer is given roughness as to simulate a real tar road condition. The conveyor will be powered by an electric motor and will run at a desired linear speed of 60km/h.

The core of the test rig is a six-component force sensor. According to Sheng A. Liu and Hung L. Tzo (2002), a six-component force sensor is a unit which functions to simultaneously measure six forces of which are three orthogonal forces and three orthogonal moments and is used for wind-tunnel balances, thrust stand testing of rocket engines, automobiles, shipbuilding, and particularly quite common for adaptive real-time control purpose of machines such as robotic systems. The three orthogonal forces are longitudinal force (F_x), lateral force (F_y) and vertical force (F_z) while the three orthogonal moments are divided into the rolling moment (M_x), pitching moment (M_y) and yawing moment (M_z).

The six-component force sensor is a small structure that is placed on the wheel shaft of the test rig. Strain gauges are installed on the six-component force sensor to detect strains and stresses experience by the structure of the six-component force sensor. The loads experienced by the tire will be transferred to the shaft itself and hence being interpreted by the six-component force sensor. Steering angle of the tire can be manipulated with adjustable settings in the test rig itself to investigate the handling dynamics and effects of the tire in various wheel settings.

The wiring of the strain gauges will imply the use of Wheatstone bridge. A data acquisition card is used to collect data from the force sensor and feed it to a personal computer for data conversion. The data are obtained and recorded in the personal computer. The computer program used to interpret these data is MATLAB with its sub program of Simulink, Data Acquisition Toolbox and GUIDE.

1.2 Design of the six-component force sensor.

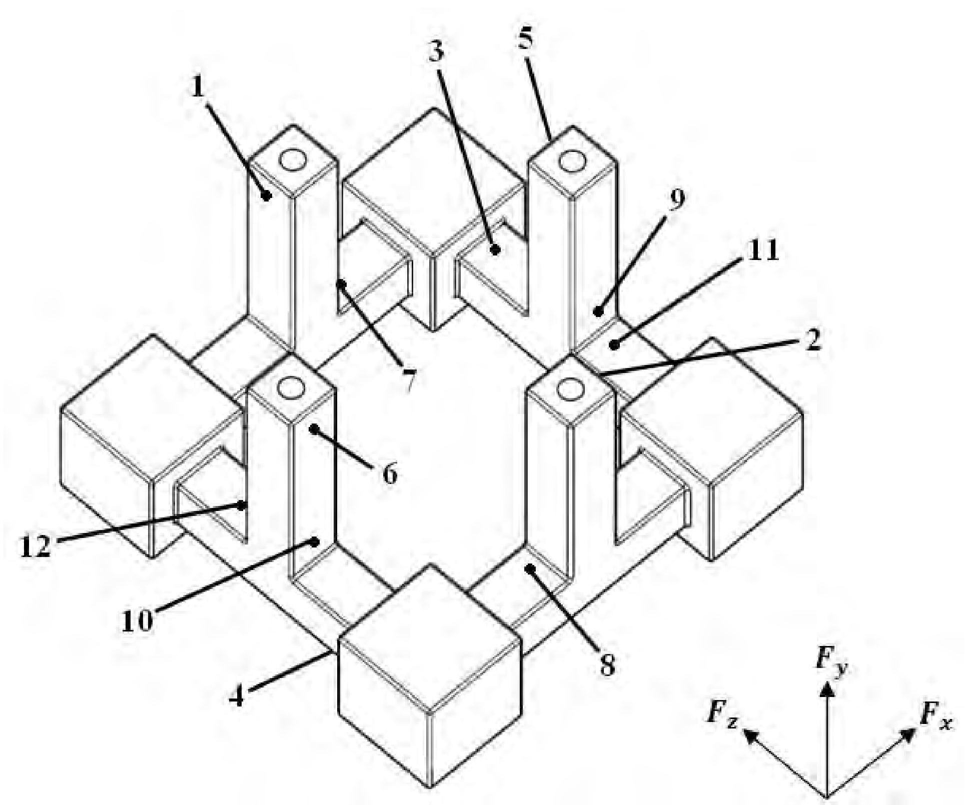

Figure 1: Six-component force sensor

The design of Goh C. K.'s six-component force sensor is improvised from Sheng A. Liu and Hung L. Tzo's original design. Strain gauges are placed on the positions indicated by numbers in Figure 1. There are a total of 12 strain gauges placed on the device.

1.3 User Interface

The author is responsible for the digital parts of the project. An interface is needed to bridge between the user and the six-component force sensor. The interface functions by translating the data and information acquired from the device into a more comprehendible output. The interface also provides user friendly features as the user would only key in the inputs and automatically, outputs will be generated with ease. Other important outputs such as graphs or other visual outputs can be generated automatically with a touch of a button. In this context, the forces and moments that are acting towards the tire cannot be measured using the naked eye. These parameters can only be detected using measuring devices and the user interface forms a visible bridge between these parameters and the user.

The User Interface (UI) or also known as Human Computer Interface is the aggregate of means that enables human to interact with the system. The system can be a particular machine, device, computer program or other complex tools. The user interface provides means of input which allows the users to manipulate the system and output which allows the system to produce the effects of the users' manipulation. Graphical User Interface (GUI) accepts input via devices such as computer keyboard and mouse and provides articulated graphical output on the computer monitor or digital display. Software is the shift from computation-intensive design to presentation-intensive design. As computers and machines have become more powerful throughout the decades, the steadily increasing fraction of that power is used to improve presentation. The software patterns shifted from computation-intensive design to presentation-intensive design, such as GUI. The pattern progressions can be concluded into three eras: batch (1945-1968), command-line (1969-1983) and graphical (1984 - current). Other explanation on user interface is that a user interface is a linkage between a human and a device or system that allows the human to interact or exchange information with that device or system. An interface is a shared boundary or connection between two dissimilar objects, devices or systems through which information is passed and the connection can be either physical or logical.

The MATLAB programming language will be used to build the user interface. Raw data will be obtained and recorded via a sub program of MATLAB which is the Data Acquisition Toolbox. The data from the strain gauges, which are in terms of change of electrical resistances, ohm (Ω), will be converted into the three orthogonal forces and three orthogonal moments using the Wheatstone bridge and MATLAB program. The data from the strain gauge will be fed into the data acquisition card which is connected to a personal computer. The graphical user interface will be done using GUIDE which permits the user to input the duration of the force measurement process and obtain results in forms of tables and graphs.

1.4 Problem Statement

Building a user interface requires not only the comprehension of the MATLAB program, but also the logical equations in converting the data acquired from the strain gauges on the tire force measuring device. A user interface provides the data conversions function and graphical results. The possibilities of errors in the strain gauges used and the built-structure of the six-component force sensor need to be considered. The possible problems that might occur during the study are as follow:

i) The strain and stress experienced by each strain gauge for detecting the same force or moment might not be equal to each other due to errors in atomic level structure of the material used, the accuracy in the dimension of the device and strain gauge installation process. This can cause inaccuracy in data conversion.

ii) The value of the data acquired from the six-component axis might be very small and negligible.

iii) The strain gauges may pick up unnecessary noise

1.5 Objectives of Study

It is crucial to overcome the problem statements mentioned or at least to minimize them in order to achieve the most accurate results possible.

i) To acquire data from the tire force measuring device through an instrumentation system.

ii) To convert the acquired data into respective forces and moments.

iii) To design a user interface program.

1.6 Scope of Study

The scopes in this study include:

i) To design a graphical user interface for the tire force measuring device using GUIDE.

ii) To determine the most suitable method of data acquisition of the strain gauge.

iii) To convert raw data into a readable or required form of data.