UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DEVELOPMENT OF LOW-COST VEHICLE MOTION MODULE IN LONGITUDINAL DIRECTION USING ARDUINO

MOHAMAD AZAHAR BIN MOHAMAD NOH
B091910229

BACHELOR OF MECHANICAL AND MANUFACTURING ENGINEERING TECHNOLOGY (AUTOMOTIVE TEHNOLOGY) WITH HONOURS

2023

Faculty of Mechanical and Manufacturing Engineering Technology

DEVELOPMENT OF LOW-COST VEHICLE MOTION MODULE IN LONGITUDINAL DIRECTION USING ARDUINO

Mohamad Azahar Bin Mohamad Noh

Bachelor of Mechanical and Manufacturing Engineering Technology (Automotive Technology) With Honours

2023

DEVELOPMENT OF LOW-COST VEHICLE MOTION MODULE IN LONGITUDINAL DIRECTION USING ARDUINO

MOHAMAD AZAHAR BIN MOHAMAD NOH

A thesis submitted
in fulfilment of the requirements for the degree of
Bachelor of Mechanical and Manufacturing Engineering Technology (Automotive Technology) with Honours

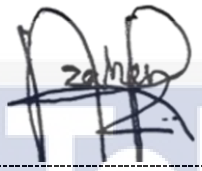
Faculty of Mechanical and Manufacturing Engineering Technology

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2023

DECLARATION

I declare that this Choose an item. entitled “Development of Low-Cost Vehicle Motion Module in Longitudinal Direction Using Arduino” is the result of my own research except as cited in the references. The Choose an item. has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : 

Name : MOHAMAD AZAHAR BIN MOHAMAD NOH

Date : 27 JANUARY 2023

APPROVAL

I hereby declare that I have checked this thesis, and, in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor of Mechanical and Manufacturing Engineering Technology (Automotive Technology) With Honours.

Signature : .....

Supervisor Name : Ts. Dr. Nur Rashid bin Mat Nuri @ Md Din

Date : 27 JANUARY 2023

.....

DEDICATION

I dedicate my dissertation work to my family and many friends. A special feeling of gratitude to my loving parents, Mohamad Noh bin Mohamad Zen and Enmie Rohaiza binti Abdullah whose words of encouragement, financially support my project and push me to the highest spirit. To my respectful supervisor, Ts. Dr. Nur Rashid bin Mat Nuri @ Md Din, who I personally admire and felt blessed to have as my guidance in aiming to successfully finish this project. My esteem co-supervisor, Ir. Ts. Dr. Mohamad Hafiz Bin Harun, who has also given us great consultation in development of an actual working prototype.

I also dedicate this dissertation to my many friends and teammate who have supported me throughout the process. I will always appreciate on what they have done for me to accomplish this project, especially to my brilliant teammate, Hoh Kin Fatt and Aimran, who always been there for me, giving motivation and inspiring words, suggest ideas when I out of resource and always believe in me in completing this project.

ABSTRACT

This abstract presents the development of a low-cost vehicle motion module in the longitudinal direction using Arduino. The early prototype is designed to measure and analyse the motion of remote control cars in longitudinal direction with proper result. The system uses an Arduino microcontroller to gather data from a 3-Axis Gyro Accelerometer Sensor Module and Linear Magnetic Hall Sensor Module. These sensors provide information about the car's Vehicle Roll (deg/s), velocity (m/s), wheel speed (RPM) and acceleration (m/s2). This sensor data is then processed and analysed by the Arduino, the resulting data is sent to MATLAB Simulink to simulate acquire data of the vehicle in real-time and to develop data in a form electrical signal on a graph. There are 3 condition that has been set to test the functionality of DAQ Device such as Straight line (Flat Surface), Side slope (left side) and Climbing-up Hills (incline). The acquired data that are display on Straight Line (Flat Surface) test during acceleration give most satisfied result since it began to increase its acceleration with an Acceleration Peak of 4 m/s^2 then purposely being decrease after 1 meter mark to see change in the graph resulting in Acceleration valley of 1 m/s^2 during 1.8 second. This shows that the respond of sensor and receiving proper data in Real-time for the longitudinal direction of the Model Remote Control Car. On the other hand, the cost of developing this device is efficient by using Ardunio Uno and 2 sensor module that can be easily purchase online or any shop that sell this component with a total of RM91.40 compare to existing DAQ Device in the market that cost 200 USD for the lowest model such as DEWEsoft SIRIUS R1DB/R2DB .

ABSTRAK

Abstrak ini memperkenalkan penghasilan modul gerak kenderaan yang murah dalam arah longitudinal menggunakan Arduino. Prototaip awal direka untuk mengukur dan menganalisis gerak kenderaan radio kawalan dalam arah longitudinal dengan hasil yang baik. Sistem menggunakan mikrokontroler Arduino untuk mengumpulkan data dari Modul Sensor Acelerometer Gyro 3-Axis dan Modul Sensor Hall Magnet Linear. Sensor-sensor ini memberikan maklumat mengenai Roll Kenderaan (deg/s), kelajuan (m/s), kelajuan roda (RPM) dan pecutan (m/s2) kenderaan itu. Data sensor ini kemudian diproses dan dianalisis oleh Arduino, data yang dihasilkan kemudian dihantar ke MATLAB Simulink untuk simulasi data kenderaan dalam masa sebenar dan untuk mengembangkan data dalam bentuk isyarat elektrik pada graf. Terdapat 3 keadaan yang telah ditetapkan untuk menguji fungsi Alat DAQ seperti Garis lurus (Permukaan Rata), Sisi bukit (sisi kiri) dan Naik bukit (mendaki). Data yang diperolehi dari ujian Garis lurus (Permukaan Rata) semasa pecutan memberikan hasil yang paling memuaskan kerana ia mula meningkatkan pecutannya dengan Puncak Pecutan 4 m/s2 kemudian sengaja dikurangkan selepas tanda 1 meter untuk melihat perubahan pada graf yang menghasilkan Lembah Pecutan 1 m/s2 selama 1.8 saat. Ini menunjukkan tindak balas sensor dan menerima data dalam masa sebenar untuk arah longitudinal dari Model Kenderaan Kawalan Jauh. Selain itu, kos penghasilan peranti ini adalah efisien dengan menggunakan Ardunio Uno dan 2 modul sensor yang boleh dibeli dengan mudah dalam talian atau di mana-mana kedai yang menjual komponen ini dengan jumlah RM91.40 dibandingkan dengan Alat DAQ yang sedia ada di pasaran yang menelan kos 200 USD untuk model yang paling rendah seperti DEWEsoft SIRIUS R1DB/R2DB.

ACKNOWLEDGEMENTS

In the Name of Allah, the Most Gracious, the Most Merciful

First and foremost, I would like to extend my deepest praise to Allah S. W. T who has given me the patient, strength, determination, and courage to implement this task.

This project is a collaborative effort of many people. To begin with, my utmost thanks and gratitude goes to my respected supervisor, Ts. Dr. Nur Rashid bin Mat Nuri @ Md Din for the guidance and dedication that he gives to us through ideas and motivation along this journey. This special thanks also dedicated to our astounding co-supervisor, Ir. Ts. Dr. Mohamad Hafiz Bin Harun, who constantly open his door for consultation during this project.

Furthermore, this special thanks also devoted to my family that always have special place in my heart, especially my parents, Mohamad Noh bin Mohamad zen and Enmie Rohaiza binti Abdullah. I always feel grateful to be part of this loving and caring family that always give support through their time and energy, encouragement in what I aim to achieve, and motivation to rise my spirit.

Special thanks toward my fellow friends who always been there for me when I need helps, especially to my beloved friend, Hoh Kin Fatt and Aimran, who always been there for me, giving motivation and inspiring words, suggest ideas when I out of resource and always believe in me in completing this project.

I would also want to express my apologies for any mistakes in carrying out this job. To conclude, I am grateful to be given this opportunity to complete this project and hopefully it will bring benefit to others.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS AND ABBREVIATIONS

D,d	-	Diameter
DAQ	-	Data Acquisition
cm	-	Centimetre
SSD	-	Solid-state Drive
HHD	-	Hard disk drive
g	-	Gram
m/s	-	Meter per second
Rad/s	-	Radian per second
RPM	-	Rotational Per Minute

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background

Data acquisition, or DAQ as it is often referred, is the process of digitizing data from the world around us so it can be displayed, analysed, and stored in a computer. A simple example is the process of measuring the temperature in a room as a digital value using a sensor such as a thermocouple (Measurement Computing Corporation, n.d). A data acquisition system consists of three key elements: a sensor, a signal conditioner, and an analog-to-digital converter (Nexus Integra EN, 2021).

In automotive, data are important asset to be achieved because it will be used to find solution, acquired problems and making decision. Usually, a Data Acquisition Device, or DAQ Device, will be use in the process to achieve important data, then the data can be store inside hard disk drive (SSD or HDD) to be share and. An example of DAQ Device in vehicle is a piezoelectric accelerometer, which uses a piezoelectric crystal to convert mechanical stress into an electrical charge. This type of accelerometer is often used in vehicle testing and racing to measure acceleration, deceleration, and other dynamic forces.

There are quite numbers of DAQ device for different brand with features that are offered in the market but most of them are quite expensive, and the size are quite large. The purpose of this project is to develop a low-cost vehicle motion module in longitudinal direction using Arduino. The DAQ Device will be use on Model Remote Control Car to obtain data for the vehicle roll (deg/s), velocity (m/s), wheel speed (RPM) and acceleration (m/s^{-2}) of a car when moving in a longitudinal direction. The data need to be collected in real-time and can

be store in a computer hard disk drive (HDD or SSD) to be analyse. Other features advantages for this DAQ Device, it is a low-cost and small since it will be using Arduino as its microprocessor, MPU 6050 GY-521 3 Axis Gyro Accelerometer Sensor Module to measure the vehicle roll (deg/s), velocity (m/s), and acceleration (m/s^2) while the KY-024 Linear Magnetic Hall Sensor Module for RPM is use to acquire the wheel speed (RPM) of the Model Remote Control Car.

1.2 Problem Statement

Most of the current existing DAQ Device for vehicle in the market are quite expensive. Data acquisition systems are sold by a variety of companies and are available with a broad range of capabilities and specifications, thus the prices can vary significantly. It is useful to provide general pricing for these various levels of DAQ systems, using the price-per-channel model. Estimated prices are given in USD (US dollars): Low-end DAQ systems typically range from $200 - 500 per channel, Mid-range DAQ systems typically range from $500-1000 per channel and High-end DAQ systems typically range from $1000-2000 per channel (Grant Maloy Smith., 2020). This lead to some of start-up or small company in the industry cannot afford to purchase this device. Furthermore, an expensive DAQ Device also lead to small purchase of quantities even for a large company that required it in a large quantity.

Other than that, the sizes of DAQ Device usually are quite large. Because of the large size, the weight is also become heavy to be move around, and it will take up some space to store the device.

By using Arduino Uno, development of low-cost vehicle motion module in longitudinal direction using Arduino can be made since Arduino Uno are being sell in affordable price and can be easily found on the market for around RM35-RM40. Other than that, the 3-Axis Gyro Accelerometer Sensor Module and Linear Magnetic Hall Sensor Module are both

being sold around RM5-RM15 in the market. The dimension of Arduino Uno is only 6.9cm x 5.3cm and only weight 25g, this distributes to saving time, space, and money.

1.3 Objective

The objective of this project is set to ensure that the goal will be achieved. Specifically, the objectives are as follows:

a) To develop a low-cost Data Acquisition (DAQ) Device for Model Remote Control Car using Arduino

b) To develop a Data Acquisition (DAQ) Device that can collect real-time data and store the data.

c) To analyze data for vehicle roll (rad/s), velocity (m/s), wheel speed (RPM) and acceleration (m/s^2) from aquired data.

1.4 Scope of Research

The scope of this research are as follows:

a) This project DAQ Device will be use on a Model Remote Control Car.

b) This project will be using an Arduino Uno, 3-Axis Gyro Accelerometer Sensor Module and Linear Magnetic Hall Sensor Module will be used to create the prototype.

c) This project will collect 4 important parameters of Longitudinal Direction for car: vehicle roll (rad/s), velocity (m/s), wheel speed (RPM) and acceleration (m/s^2).

1.5 Summary

The Development of Low-Cost Vehicle Motion Module in Longitudinal Direction using Arduino final report is divided into five chapters, each of which contains and

elaborates on a different topic, such as the Introduction, Literature Review, Methodology, Results and Discussion, and Conclusion and Recommendation. The following is a full description of the thesis outline for each chapter:

Chapter 1: The introduction to the project. The project's explanation will be provided in broad strokes. The problem statement will be thoroughly described. The project objectives will be thoroughly outlined. It is accompanied with a description of the project's scope.

Chapter 2: In preparation for the implementation of the car DAQ Device, a literature review was undertaken. This chapter goes further into the project's literature review. This entire section will be based on theory and conceptual notions, with an emphasis on the previous sensor model studied. Literature review is meant to build argument and not library.

Chapter 3: The project's Methodology. This chapter will approach over the overall project planning as well as the component and circuitry development.

Chapter 4: The outcome and the analysis. This chapter examines the system's performance and the result.

Chapter 5: Conclusion and Discussion. This chapter covered costing and commercialization, as well as potential recommendations. Finally, the project's conclusion also is being discussed.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

A literature study was undertaken throughout the project to gather information and develop skills needed to accomplish the assignment. Previous related works, research thesis, books, journals, and articles are among the key sources for this project. This chapter will concentrate on the critical concepts and theories that are crucial to the project's scope.

2.2 Data Acquisition (DAQ)

Data acquisition (commonly abbreviated as DAQ or DAS) is the process of sampling signals that measure real-world physical phenomena and converting them into a digital form that can be manipulated by a computer and software. Data Acquisition is generally accepted to be distinct from earlier forms of recording to tape recorders or paper charts. Unlike those methods, the signals are converted from the analog domain to the digital domain and then recorded to a digital medium such as ROM, flash media, or hard disk drives (Grant Maloy Smith, 2020). As mentioned by Measurement Computing Corporation (n.d), inside a common modern DAQ system, there would be consist of four essential component that would form the flow for the entire measurement chain of physics phenomena, as shown in figure 2.1. The four essential components would include:

a) Sensors

b) Signal Conditioning

c) Analog-to-Digital Converter (ADC)

d) Computer with DAQ software for data logging and analysis

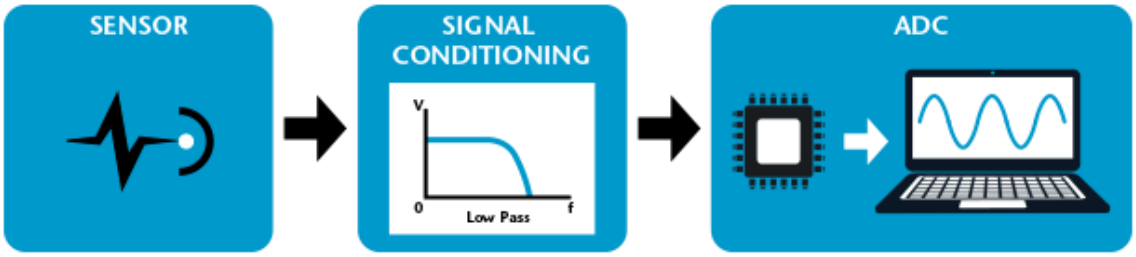


Figure 2.1 Data Acquisition System Flow Block Diagram

The process of data acquisition to digitizing data from the world around us has been one of the important factors that contribute to development of new, improved, and useful technologies that simply can be found in our own surroundings such as Air Conditioning Sensors that designed to measure the temperature in the room then regulate the temperature of the air according to the setting on the control panel. Without data acquisition, development of useful technology that facilitate our everyday routine from getting one place to another, taking a photo, or making a coffee in the morning would be almost impossible. Thus, acquisition of data is important for our evolution toward a better future because with data acquisition we could use the collected data to perform further research and development of technology especially in automotive.

2.3 Vehicle Motion (Longitudinal Direction)

Motion is defined in physics as the phenomena through which an object's location changes over time. Displacement, distance, velocity, acceleration, speed, and time are all mathematical terms used to describe motion. A body's motion is observed by attached a frame of reference to an observer and measuring the change in location of the body relative to that frame with change in time. The branch that studies the forces and their effect on motion is dynamics. While vehicle motion refers to its translation along and rotation about all three axes (William, Norman, & Leslie, 2003).

Namely the axis can be referred as follow:

a) Longitudinal Direction (X-axis)

b) Lateral Direction (Y-axis)

c) Vertical Direction (Z-axis)

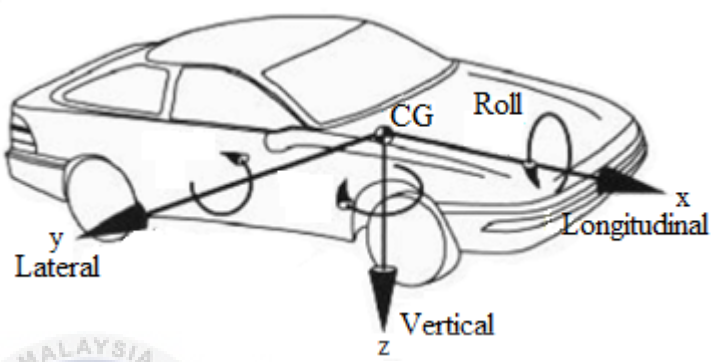


Figure 2.2 Three axis parameter for Vehicle Motion

A shown on Figure 2.2, three axis parameters for vehicle motion refer to the three different directions in which a vehicle can move: longitudinal, lateral, and vertical.

a) Longitudinal motion refers to the movement of a vehicle in the direction parallel to its length, such as acceleration and deceleration.

b) Lateral motion refers to the movement of a vehicle in the direction perpendicular to its length, such as turning or swerving.

c) Vertical motion refers to the movement of a vehicle in the direction perpendicular to both its length and width, such as going over bumps or changes in elevation.

These three axis parameters are important in understanding and measuring a vehicle's motion, and are often used in vehicle dynamics and control research and development to improve performance, safety and efficiency.