Automobile Brake Pads Performance and Longevity Monitoring System

A report submitted to the Department of Mechanical, Sonargaon University in partial fulfillment of the requirements for the Award of Degree of Bachelor of Science in Mechanical Engineering.

Submitted by

Md. Shahidul Islam Sajal	ID: BME-1903019183
Md. Sujon Mia	ID: BME-1903019101
Md. Ektharul Islam	ID: BME-1903019178
Zakaria	ID: BME-1903019062

Supervised by

Md. Sharful Insan (Lecturer)
Department of Mechanical Engineering
Sonargaon University (SU)
Dhaka-1205, Bangladesh

28,May, 2023

Letter of Transmittal

28,May, 2023

To

Md. Sharful Insan
Lecturer

Department of Mechanical Engineering.

Sonargaon University

Dhaka-1205, Bangladesh

Subject: Submission of Project Report.

Dear Sir,

We are pleased to submit the project report on "**Automobile Brake Pads Performance and Longevity Monitoring System ".** It was a great pleasure to work on such an important topic. This project has been done as per instruction of your supervision and according to the requirements of the Sonargaon University.

We expect that the project will be accepted by the concerned authority we will remain happy to further explanation that you may feel necessary in this regard.

Thank You

Sincerely yours,

Md. Shahidul Islam Sajal
BME 1903019183

Md. Sujon Mia
BME 1903019101

Md. Ektharul Islam
BME 1903019178

Zakaria
BME-1903019062

DECLARATION

We do hereby solemnly declare that, the work presented here in this project report has been carried out by us and has not been previously submitted to any University/ Organization for award of any degree or certificate

We hereby ensure that the works that has been prevented here does not breach any existing copyright.

We further undertake to indemnify the university against any loss or damage arising from breach of the foregoing obligation.

Md. Shahidul Islam Sajal
BME 1903019183

Md. Sujon Mia
BME 1903019101

Md. Ektharul Islam
BME 1903019178

Zakaria
BME-1903019062

ACKNOWLEDGEMENT

First, we started in the name of almighty Allah. This thesis is accomplished under the supervision of Md. Sharful Insan, Lecturer, Department of Mechanical, Sonargaon University. It is a great pleasure to acknowledge our profound gratitude and respect to our supervisor for this consistent guidance, encouragement, helpful suggestion, constructive criticism and endless patience through the progress of this work. The successful completion of this thesis would not have been possible without his persistent motivation and continuous guidance.

The author are also grateful to Prof. Md. Mostofa Hossain, Head of the Department of Mechanical Engineering and all respect teachers of the Mechanical Engineering Department for their co-operation and significant help for completing the thesis work successfully.

[Authors]

Md. Shahidul Islam Sajal
BME 1903019183

Md. Sujon Mia
BME 1903019101

Md. Ektharul Islam
BME 1903019178

Zakaria
BME-1903019062

Abstract

Brakes and tires are the major contributors for catastrophic failure of ground vehicles. Braking system is the utmost important besides tire to ensure the safety of users and vehicle.

Ensuring good condition of brake lining is very crucial to ensure the efficiency of the braking

system, where, the worn off brake lining not only endangers life but also damages the entire brake associated parts such as hub, disk, shaft, etc. It consists of a sensor. One sensor is connected with the brake shoe. The signal from the sensor is given to a micro-controller. When the brake shoe is worn out, the sensor senses signal to the micro-controller. The micro-controller analyses the signal and operates the corresponding indicator. Brake pad worn out detection sensor is mounted in the brake pad and it is connected to the Node MCU. Therefore, a critical investigation of the existing pads manufactured and their characterizations are conducted to identify the most suitable sensor spot on the brake pad. Later, a micro sensor is embedded into the pad and fully tested on a specially designed test rig. The evaluation of thickness, hardness, layer properties and critical wear region has enabled the spotting of exact sensor location. The embedment of the micro switch was successfully done and tested to be very efficient in alerting the driver upon reaching the maximum lining wear limit. Finally, when the brake pad is fully wasted then the system provides a signal the brake pad is in risk by the Blynk app.

TABLE OF CONTENTS

Letter of transmittal	ii
Declaration	iii
Acknowledgement	iv
Abstract	V
Table of Contents	Vi
List of Figure	Viii

CHAPTER-1 INTRODUCTION

1.1 Introduction	1
1.2 Background	2
1.3 Study on Different Pad Materials	3
1.4 Objective	5

CHAPTER 2 LITERATURE REVIEW

2.1 Literature Review	6
2.2 Brake Pad	9
2.3 Materials	10
2.4 Block Diagram	12
2.5 Circuit Diagram	12
2.6 Components List	13

CHAPTER-3 **HARDWARE ANALYSIS**

3.1 Node MCU 14
3.2 5V Regulator IC 17
3.3 Battery 18
3.4 Ultrasonic Sensor 19
3.5 LCD Display 22
3.6 Arduino IDE 22
3.7 Easy EDA Software 27
3.8 Remote XY 28

CHAPTER-4 **METHODOLOGY**

36
4.1 Methodology 36
4.2 Working Principle 37
4.3 Our Final Project View

CHAPTER-5 **RESULT AND DISCUSSION**

5.1 Result 38
5.2 Advantage 38
5.3 Application 38
5.4 Discussion 39

CHAPTER-6 **CONCLUSION**

6.1 Conclusion 40
6.2 Future Scope 40

References 41
Appendix 43

LIST OF FIGURES

FIGURE NO	FIGURE NAME	PAGE NO
2.1	Block Diagram	12
2.2	Schematic Diagram	12
3.1	Node MCU	14
3.2	Node MCU Schematic Diagram	15
3.3	Node MCU Pin Out	16
3.4	5v regulator IC	17
3.5	3.7V Battery	18
3.6	Ultrasonic Sensor	20
3.7	LCD Display	22
3.8	Arduino Software Interface IDE	24
3.9	EasyEDA Software Interface	28
3.10	Configure Remote XY	32
3.11	Module Interface	33
3.12	Module Interface	35
4.1	Our Final System Image	37

CHAPTER 1
INTRODUCTION

1.1 Introduction

In this paper, a review of previous research project that are related to this project will be discussed. These kind of surveys were held as one of the tools to have some ideas on how this project works. It is based on other achievement and also to formulate the advantage of proposed solution. This may help in problem solving skills and options required for design and develop of wear sensors. The brake pad wear sensor accurately informs the driver about the current condition of the vehicle's brake pad. Sensor is mounted on the brake pad, one sensor for the front axle and one sensor for the rear can be installed to determine and indicate when the driver needs to perform a replaced. Brakes are the most important safety system in our vehicles. Brakes give us the ability to slow down or stop the vehicle in an instant and can help us to avoid a serious accident.

If the Brakes aren't well maintained or regularly inspected then it can let you down when you need them the most. This brake pad wear sensor has longer life and no need to visually inspect the brake pad. 1.1 What are the most common brake system issues? The most common brake system problem include: a spongy brake pedal , a hardest brake pedal , squealing sound when braking, vibrations when braking and a persist brake warning light . A healthy brake system should not make noises or vibrate, and should be firm when pressed, rather than soft or hard. If you hear or feel something unusual when braking, it's important to contact your local car mechanic as soon as possible. To avoid expensive repair bills you should schedule regular services that include full brake and brake pad inspections.

1.2 Issues occurs due to brake pad wear One of the main issues is safety as brakes plays an very important role in our vehicle to immediately stop at every situations hence our braking system should be as well as proper condition When the brake pad wear out as driver doesn't know the brake pad status that can causes the brake disc damage where the cost of the disc is more than 80% as about brake pads. 1.3 What should my brake inspection include? All brake inspection should be include a test drive, so your car mechanic can test the effectiveness of your brakes firsthand. They should also conduct a visual inspection to The brake pad wear sensor accurately informs the driver about the current condition of the vehicle's brake pad.

Sensor is mounted on the brake pad, one sensor for the front axle and one sensor for the rear can be installed to determine and indicate when the driver needs to perform a replaced. Brakes are the most important safety system in our vehicles. Brakes give us the ability to slow down or stop the vehicle in an instant and can help us to avoid a serious accident. If the Brakes aren't well maintained or regularly inspected then it can let you down when you need them the most. This brake pad wear sensor has longer life and no need to visually inspect the brake pad. 1.1 What are the most common brake system issues? The most common brake system problem include: a spongy brake pedal , a hardest brake pedal , squealing sound when braking, vibrations when braking and a persist brake warning light. A healthy brake system should not make noises or vibrate, and should be firm when pressed, rather than soft or hard. If you hear or feel something unusual when braking, it's important to contact your local car mechanic as soon as possible.

To avoid expensive repair bills you should schedule regular services that include full brake and brake pad inspections .measure your brake pad and shoe thickness to ensure they are wearing evenly and meet all required safety standards. A car mechanic will also check your rotors for hotspots, your calipers for wear, and your wheel cylinders, brake lines and master cylinder for leaks. They will also check the levels and quality of your brake fluids and ensure that your brake and anti-lock brake sensors are properly placed and routed. Whether you are experience issues with your braking or you simply want to schedule an inspection. Brake pad sensor is used to indicate the status of your brake pad current condition. It is an essential element of the braking system. It is used for monitoring life of brake and brake pad. It is highly resistance to the high temperature.

1.2 Background

Though the world is getting modernized, we have to face so many problems. One of such problems is accidents. One of the things that everyone tried to avoid is while traveling is accidents, and sometimes it is inevitable. Now- a-days we can see accidents in every nook and corner of the world. It results in the death of thousands of lives. In foreign countries they take remedial measures for the prevention of accidents. When the driver brakes they are actually pushing a plunger into the master cylinder, which in turn pushes brake fluid through tubes and hoses to brake all the moving units in the vehicle. So many other devices are there

to predict brake failure like United States patent 3711827, United States patent 3914734, etc. The United States patent 3711827 is a self-test incorporated to determine if the warning light is operated properly. But my project can indicate brake pad condition by notification. Driver can aware from this notification and assure human safety from accident.

1.3 Study on Different Pad Materials

Ceramic Brake Pads They are the most expensive types of brake pads are available but they are last longer than any other type. The ceramic compound brake pads are made of is great for absorbing the heat that results from any type of continuous and hard, violent braking. In fact even in endurance racing these ceramic brake pad can stand up to what you put them through, and they work efficiently whether your brakes or warm or cold. These are made with small amounts of copper and clay, which is molded into the compound to make for a strong and long-lasting brake pads

Motorcycle braking systems have varied throughout time, as motorcycles evolved from bicycles with an engine attached, to the 220 mph (350 km/h) prototype motorcycles seen racing in MotoGP. Most systems work by converting kinetic energy into thermal energy (heat) by friction. On motorcycles, approximately 70% of the braking effort is performed by the front brake. This however can vary for individual motorcycles; longer-wheelbase types having more weight biased rearward, such as cruisers and tourers, can have a ‘greater effort applied by the rear brake. In contrast, sports bikes with a shorter wheelbase and more vertical fork geometry can tolerate higher front braking loads. For these reasons, motorcycles tend to have a vastly more powerful front brake compared to the rear.

Low metallic brake pad these brake pads are made, they tend to be quite noisy and lot of brake dust. However they have excellent heat transfer capabilities and are made with up to 30% metal such as copper or steel. They are organic in nature and offered excellent braking capabilities. Low metallic brake pads are greatest when it comes to braking and heat transfer, and the materials that they are made of are completely organic.

Non-Metallic Brake Pads Non-metallic brake pads are the softest type of pads, being made of various rubbers, resins, and glasses, along with a small number of metal fiber. The composite material will wear away quickly and should only be used for regular, daily road-

driving. Because they are soft , non-metallic brake pad are not the top choice for people who drive a lot or put their vehicles through a lot each and every day , but for driver who do not put a lot of mileage on their vehicle every year, these pads are fine. If you do more driving, you should either purchase the metal-type brake pads or be prepared to change your non-metallic ones frequently. Regular organic pads cause a lot of dust to cover components located near the brakes, along with other materials that are thought to be toxic to human life, which is one of the many reasons that the non-metallic brake pads were developed. If your vehicle does not have large brake need these types of brake pads will suffice. If you choose alternatives the price may be a bit higher but they will last you much longer than regular non-metallic brake pads.

Non-Asbestos Organic (NAO) Brake Pads These types of brake pads are made of materials such as high-temperature resins, fibers, and fillers. They are softer than the semi-metallic type of brake pad and they create more dust in the long run. The brake pads also deteriorate rather quickly, so it behooves the car-owner to pay attention to their pros and cons before purchasing a set of these brake pads. Semi metallic brake pad In the majority of vehicles semi-metallic brake pads are mostly used. Made with a combination of metal and synthetic components, they are a mostly metallic hybrid compound. An organic resin seal all of the materials together, and they are molded into various shapes and baked in a furnace to hardened them. Semi-metallic brake pads are very durable, as well as heat-resistance and resistance to wear. However because these pads have a lower friction coefficient when it comes to lower temperature, they need a little more pedal power when the brake are cold.

Semi-metallic brake pads are usually made sintered graphite, iron, or steel, and therefore they are great when you need the high-performance capability in yours vehicle. In fact, these types of brake pads are perfect for heavy vehicles and performance of vehicles because they are study, well-made, and diverse brake pads. They contain up to 65% metal, but they also are noisier to operate , wearing down your rotor a lot faster than other types of brake pads, and don’t always perform well at low temperatures.

1.4 Objective:

The objectives of this project are:

a) To study about Automobile Brake Pads Performance and Longevity Monitoring System**.**

b) Monitor their brake pads, detect signs of wear and tear, and take the necessary action to replace worn-out brake pads.

c) To test the performance of the Automobile Brake Pads Performance and Longevity Monitoring System.

CHAPTER 2
LITERATURE REVIEW

2.1 Literature Review

The literature review is carried out to understand the important of brake pad and the present development in the brake pad monitoring system. Lots of researches work is carried out in order to understand the various characteristics of brake pads materials as well as the types of brake pads. Many authors try to focus their research on effect of various speed limits and normal contact pressure on brake pads. Some research also carried out to development of economical brake lining wear indicating system. The recent investigation by N.Chand S. A. R. Hashimi S. Lomash and A. Naik was toward development of asbestos free brake pads. This experiment focuses on physical of new material asbestos free with wearing properties. From their experiment, it is says that the asbestos-free friction lining material can be used for brake as well as other friction lining applications [1].

Mikael Erikson , Filip Bergman , Staffan Jacobson have investigated the surface characterization of brake pad after running under silent and squealing condition . This experiment focus on the previously almost unexplored area of the connection between brake pad surface topography and the occurrence of squeals. From the experimental result , they indicated that pads with small contact plateaus have a larger tendency to generate squeal than pads with a few large plateaus. More over in the silent pressure interval, the size of the contact plateaus increases rapidly with brake pressure [2] Friction layer and friction film on PMC brake pad were investigated by W. Osterle, I. Urban , using Focused Ion Beam technique, where, it was used to characterize superficial layers at micro-contact areas of a commercial brake pad.

The friction material was a polymer matrix composite (PMC) with approximately 50% metal content (semi metallic) and the counter part was a cast iron rotor. Experiment depending on the constituent of the pad , one , two or three layers were identified. The experiment is show that the FIB technique provides additional information which in combination with the more conventional technique (L M) , (S E M)and (T E M) increases the knowledge on the role of third body formation and superficial layers on brake pads. [3] Zmago Stadiler Kristoffer Krnel Tomaz Kosmac have researched friction behavior of

sintered metallic brake pads on a C/CSiC composite brake disc. This experiment was aimed studying on the frictional and wear property of sintered metallic (MMC) brake lining in combination with a C/C– SiC brake disc. From the result, they conclude that the friction performance of MMC-type brake pads on a C/C–SiC brake disc is dependent on the base metallic matrix composition and formation of a friction layer on the brake pads surface [4]. The effect of metal fiber of the friction performance of automotive brake friction materials were. The literature review is carried out to understand the important of brake pad and the present development in the brake pad monitoring system. Lots of research's work is carried out in order to understand the various characteristics of brake pads materials as well as the types of brake pads.

Many authors try to focus their research on effect of various speed limits and normal contact pressure on brake pads. Some research also carried out to development of economical brake lining wear indicating system. The recent investigation by N.Chand S. A. R. Hashimi S. Lomash and A. Naik was toward development of asbestos free brake pads. This experiment focuses on physical of new material asbestos free with wearing properties. From their experiment, it is says that the asbestos-free friction lining material can be used for brake as well as other friction lining applications [1]. Mikael Erikson, Filip Bergman , Staffan Jacobson have investigated the surface characterization of brake pad after running under silent and squealing condition . This experiment focus on the previously almost unexplored area of the connection between brake pad surface topography and the occurrence of squeals. From the experimental result, they indicated that pads with small contact plateaus have a larger tendency to generate squeal than pads with a few large plateaus.

More over in the silent pressure interval, the size of the contact plateaus increases rapidly with brake pressure [2]. Friction layer and friction film on PMC brake pad were investigated by W. Osterle, I. Urban , using Focused Ion Beam technique, where, it was used to characterize superficial layers at micro-contact areas of a commercial brake pad. The friction material was a polymer matrix composite (PMC) with approximately 50% metal content (semi metallic) and the counter part was a cast iron rotor. Experiment depending on the constituent of the pad , one , two or three layers were identified. The experiment is show that the FIB technique provides additional information which in

combination with the more conventional technique (L M) , (S E M)and (T E M) increases the knowledge on the role of third body formation and superficial layers on brake pads. [3] Zmago Stadiler Kristoffer Krnel Tomaz Kosmac have researched friction behavior of sintered metallic brake pads on a C/CSiC composite brake disc. This experiment was aimed studying on the frictional and wear property of sintered metallic (MMC) brake lining in combination with a C/C– SiC brake disc. From the result, they conclude that the friction performance of MMC-type brake pads on a C/C–SiC brake disc is dependent on the base metallic matrix composition and formation of a friction layer on the brake pads surface [4]. The effect of metal fiber of the friction performance of automotive brake friction materials were investigated by H. Jang K . Ko S.J. Kim R.H. Basch and J.W. Fash [5].

This experiment investigate the effect of different metallic fiber upon friction and wear performance of various brake friction couple . The results show that, when gray cast iron was used as a counter disk at low temperatures, the friction materials containing copper or steel fibers showed high speed sensitivity M.Boniardi F. D'Errico C. Tagliabue G. Gotti and G. Perriconne [6] have investigated failure analysis of a motorcycle brake disc. The failure has studied on small cracks on the disc brake. These crack were mainly located near by the holes placed on flange to ventilate and refresh pad .

From the result, it is stated that the lifespan of a motorcycle brake disc depend strictly on the geometry (position of holes, shape of spokes, etc.)the material properties at high temperatures and operating conditions Werner Osterle and Ingrid Urban [7] investigated about third body formation on brakes and rotors. The experiment was focused on the surfaces of a brake pads and rotors after a run-in period during which a stable coefficient of friction had been developed. The Focused Ion Beam technique (FIB) is used to reveal tribologically induced surface films and for cross-sectional preparation of superficial layers. It was found that the definitely exists a third body at the surfaces of both counterparts and it comprises of a Nano crystalline microstructure which implies that investigations on the nanometer scale are essential for understanding the frictional behaviors of such contacts.

2.2 Brake Pad

Brake pads are a component of disc brakes used in automotive and other applications. Brake pads are composed of steel backing plates with friction material bound to the surface that faces the disc brake rotors.

Function

Brake pads convert the kinetic energy of the vehicle to thermal energy through friction. Two brake pads are contained in the brake with their friction surfaces facing the rotor.[1] When the brakes are hydraulically applied, the caliper clamps or squeezes the two pads together onto the spinning rotor to slow and stop the vehicle. When a brake pad heats up due to contact with the rotor, it transfers small amounts of its friction material onto the disc, leaving a dull grey coating on it. The brake pad and disc (both now having the friction material), then "stick" to each other, providing the friction that stops the vehicle.

In disc brakes, there are usually two brake pads per disc rotor. These are held in place and actuated by a caliper affixed to the wheel hub or suspension upright. Racing calipers, however, can utilize up to six pads, with varying frictional properties in a staggered pattern for optimum performance. Depending on the properties of the material, the weight of the vehicle and the speeds it is driven at, disc wear rates may vary. The brake pads must usually be replaced regularly (depending on pad material) to prevent brake fade. Most brake pads are equipped with a method of alerting the driver when this needs to be done. A common technique is manufacturing a small central groove whose eventual disappearance by wear indicates the end of a pad's service life. Other methods include placing a thin strip of soft metal in a groove, such that when exposed (due to wear) the brakes squeal audibly. A soft metal wear tab can also be embedded in the pad material that closes an electric circuit when the brake pad wears thin, lighting a dashboard warning light.

History

The concept of brake pads or disc brakes as an alternative to drum brakes had been around at least as early as a patent by F. W. Lanchester in 1902. However, due to high cost and inefficiencies compared to drum brakes they were not commonly implemented until after World War II. Once disc brake technology improved, brake performance quickly

surpassed that of drum brakes. The performance difference was most noticeably exhibited in 1953 when a Jaguar outfitted with brake pads won the 24 Hours of Le Mans Grand Prix of Endurance race. The success of the Jaguar is commonly attributed to the car's disc brakes, which allowed the drivers to approach turns faster and brake later than their opponents, which ultimately led to its victory. As late as 1963 the majority of automobiles using disc brakes were European made, with American cars adopting the technology in the late 1960s after the invention of fixed calipers that made installation cheaper and more compact.

2.3 Materials

The most important characteristics that are considered when selecting a brake pad material are as follows:

- The material's ability to resist brake fade, caused by an increase in temperature the material will experience from the conversion of kinetic energy into thermal energy.
- The effects of moisture on brake fade. All brakes are designed to withstand at least temporary exposure to water.
- The ability to recover quickly from increased temperature or moisture, and exhibit approximately the same friction levels at any point in the drying or cooling process.
- The friction coefficient of modern brake pads should be low enough prevent locking of the wheels but high enough to provide sufficient stopping power. Friction coefficients are typically between 0.3 and 0.5 for brake pad materials.
- The ability to resist wear due to friction, but not to the extent that rotor wear occurs more quickly than brake material is sacrificed.
- The ability of the material to provide smooth and even contact with the rotor or drum, instead of a material that brakes off in chunks or causes pits, dents, or other damage to the surface in contact.
- The ability to apply appropriate frictional force while also operating quietly.

Another material requirement that is considered is how compressible the brake pads are; if they are too compressible then brake travel can be excessive. Brake pad material must also be porous so that water does not affect the friction coefficient.

Asbestos was added as a common ingredient to brake pads post-WWI, as car speeds began to increase, because research showed that its properties allowed it to absorb the heat (which can reach 500 °F) while still providing the friction necessary to stop a vehicle. However, as the serious health-related hazards of asbestos eventually started to become apparent, other materials had to be found. Asbestos brake pads have largely been replaced by non-asbestos organic (NAO) materials in first world countries. Today, brake pad materials are classified into one of four principal categories, as follows:

- **Non-metallic materials** - these are made from a combination of various synthetic substances bonded into a composite, principally in the form of cellulose, aramid, PAN, and sintered glass. They are gentle on rotors, but produce a fair amount of dust, thus having a short service life.
- **Semi-metallic materials** - synthetics mixed with varying proportions of flaked metals. These are harder than non-metallic pads, more fade-resistant and longer lasting, but at the cost of increased wear to the rotor/drum which then must be replaced sooner. They also require more actuating force than non-metallic pads in order to generate braking torque.
- **Fully metallic materials** - these pads are used only in racing vehicles, and are composed of sintered steel without any synthetic additives. They are very long-lasting, but require more force to slow a vehicle while wearing off the rotors faster. They also tend to be very loud.
- **Ceramic materials** - Composed of clay and porcelain bonded to copper flakes and filaments, these are a good compromise between the durability of the metal pads, grip and fade resistance of the synthetic variety. Their principal drawback, however, is that unlike the previous three types, despite the presence of the copper (which has a high thermal conductivity), ceramic pads generally do not dissipate heat well, which can eventually cause the pads or other components of the braking system to warp. However, because the ceramic materials cause the braking sound to be elevated beyond that of human hearing, they seem exceptionally quiet.

2.4 Block Diagram:

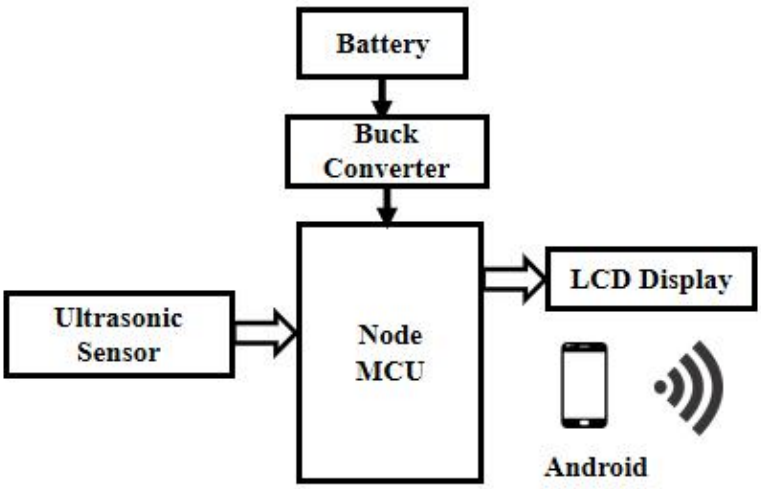


Figure 2.1: Block Diagram of Automobile Brake Pads Performance and Longevity Monitoring System.

2.5 Circuit Diagram

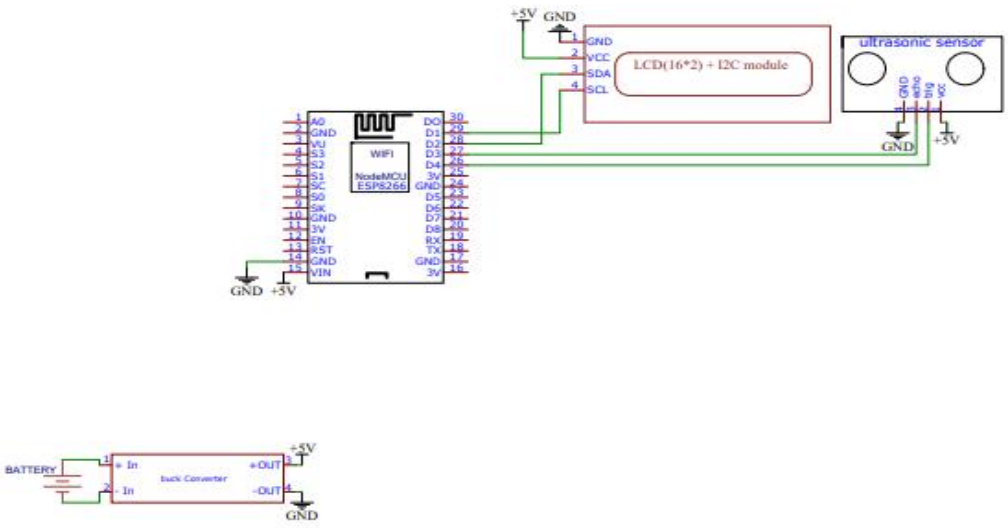


Figure 2.2: Schematic Diagram of Automobile Brake Pads Performance and Longevity Monitoring System.

2.6 Components List:

Hardware Part:

1. Node MCU
2. Battery
3. Buck Converter
4. Ultrasonic Sensor
5. LCD Display

Software Part:

1. Arduino IDE
2. Easy EDA
3. Remote XY

CHAPTER 3
HARDWARE AND SOFTWARE ANALYSIS

3.1 Node MCU

Node MCU is an open-source firmware for which open-source prototyping board designs are available. The name "Node MCU" combines "node" and "MCU" (micro-controller unit). The term "Node MCU" strictly speaking refers to the firmware rather than the associated development kits.

Both the firmware and prototyping board designs are open source. The firmware uses the Lua scripting language. The firmware is based on the eLua project, and built on the Espressif Non-OS SDK for ESP8266. It uses many open source projects, such as lua-cjson and SPIFFS. Due to resource constraints, users need to select the modules relevant for their project and build a firmware tailored to their needs. Support for the 32-bit ESP32 has also been implemented.

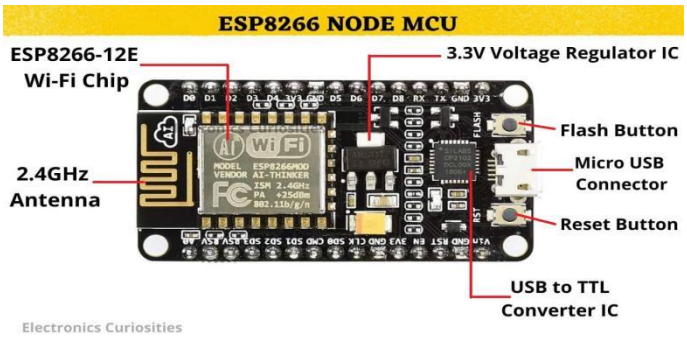


Figure 3.1: Node MCU

The prototyping hardware typically used is a circuit board functioning as a dual in-line package (DIP) which integrates a USB controller with a smaller surface-mounted board containing the MCU and antenna. The choice of the DIP format allows for easy prototyping on breadboards. The design was initially was based on the ESP-12 module of the ESP8266, which is a Wi-Fi SoC integrated with a Tensilica Xtensa LX106 core, widely used in IoT applications.

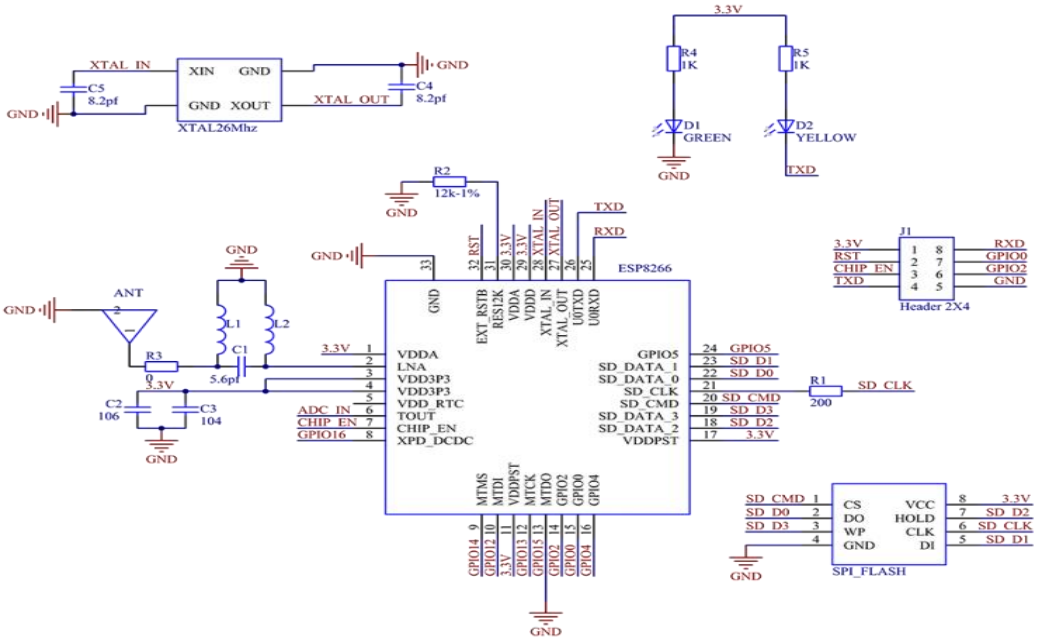


Figure 3.2: Node MCU Schematic Diagram

This an open source IoT platform. It includes firmware which runs on the ESP8266 Wi-Fi SoC from Express if Systems, and hardware which is based on the ESP-12 module. The term "Node MCU" by default refers to the firmware rather than the development kits. The firmware uses the Luascripting language. It is based on the eLua project, and built on the Espress if Non-OS SDK for ESP8266. Node MCU was created shortly after the ESP8266 came out. On December 30, 2013, Espressif Systems [6] began production of the ESP8266. The ESP8266 is a Wi-Fi SoC integrated with a Tensilica Xtensa LX106 core, widely used in IoT applications (see related projects). Node MCU started on 13 Oct 2014, when Hong committed the first file of node mcu-firmware to GitHub.[11] Two months later, the project expanded to include an open-hardware platform when developer Huang R committed the gerber file of an ESP8266 board, named devkit v0.9.[12] Later that month, Tuan PM ported MQTT client library from Contiki to the ESP8266 SoC platform,[13] and committed to NodeMCU project, then Node MCU was able to support the MQTT IoT protocol, using Lua to access the MQTT broker. Another important update was made on 30 Jan 2015, when Devsaurus ported the u8glibto Node MCU project,[15] enabling Node MCU to easily drive LCD, Screen, OLED, even VGA displays. In summer 2015 the creators abandoned the firmware project and a group of independent contributors took over.

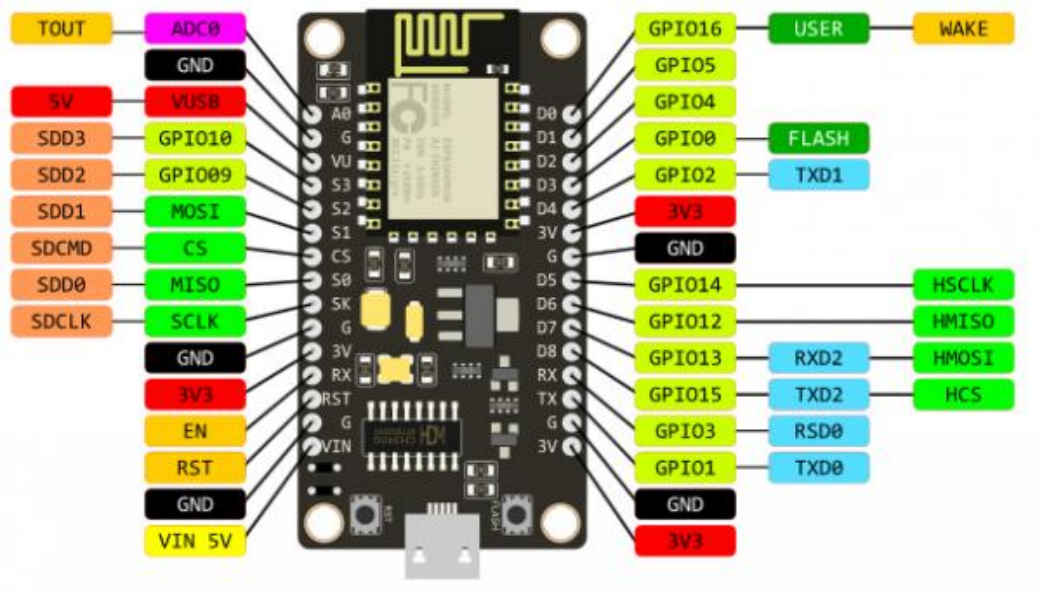


Figure 3.3: Node MCU Pin Out

Node MCU V3 ESP8266 ESP-12E is Wi-Fi development board that helps you to prototype your IoT product with few Lua script lines, or through Arduino IDE. The board is based on ESP8266 ESP-12E variant, unlike other ESP-12E, you won't need to buy a separate brakeout board, USB to serial adapter, or even solder it to a PCB to get started, you will only need a USB cable (Micro USB).

Features

1. Communication interface voltage: 3.3V.
2. Antenna type: Built-in PCB antenna is available.
3. Wireless 802.11 b/g/n standard
4. WiFi at 2.4GHz, support WPA / WPA2 security mode
5. Support STA/AP/STA + AP three operating modes
6. Built-in TCP/IP protocol stack to support multiple TCP Client connections (5 MAX)
7. D0 ~ D8, SD1 ~ SD3: used as GPIO, PWM, IIC, etc., port driver capability 15mA
8. AD0: 1 channel ADC
9. Power input: 4.5V ~ 9V (10VMAX), USB-powered

10. Current: continuous transmission: ≈70mA (200mA MAX), Standby: <200uA
11. Transfer rate: 110-460800bps
12. Support UART / GPIO data communication interface
13. Remote firmware upgrade (OTA)
14. Flash size: 4MByte.

3.2 5V Regulator IC

Voltage sources in a circuit may have fluctuations resulting in not providing fixed voltage outputs. A voltage regulator IC maintains the output voltage at a constant value. 7805 IC, a member of 78xx series of fixed linear voltage regulators used to maintain such fluctuations, is a popular voltage regulator integrated circuit (IC). The xx in 78xx indicates the output voltage it provides. 7805 IC provides +5 volts regulated power supply with provisions to add a heat sink.

7805 IC Rating:

- Input voltage range 7V- 35V
- Current rating Ic = 1A
- Output voltage range V. Max=5.2V ,V. Min=4.8V

Figure 3.4: 5V Regulator IC

3.3 Battery

Lithium batteries are primary batteries that have metallic lithium as an anode. These types of batteries are also referred to as lithium-metal batteries. They stand apart from other batteries in their high charge density and high cost per unit. Depending on the design and chemical compounds used, lithium cells can produce voltages from 1.5 V (comparable to a zinc–carbon or alkaline battery) to about 3.7 V.

Disposable primary lithium batteries must be distinguished from secondary lithium-ion or a lithium-polymer,[1] which are rechargeable batteries. Lithium is especially useful, because its ions can be arranged to move between the anode and the cathode, using an intercalated lithium compound as the cathode material but without using lithium metal as the anode material. Pure lithium will instantly react with water, or even moisture in the air; the lithium in lithium ion batteries is in a less reactive compound.

Lithium batteries are widely used in portable consumer electronic devices. The term "lithium battery" refers to a family of different lithium-metal chemistries, comprising many types of cathodes and electrolytes but all with metallic lithium as the anode. The battery requires from 0.15 to 0.3 kg of lithium per kWh. As designed these primary systems use a charged cathode, that being an electro-active material with crystallographic vacancies that are filled gradually during discharge.

Figure 3.5: 3.7V Battery

Product Specification

Voltage	3.7 V
Product Type	Lithium-Ion
Battery Capacity	2200mAh
Weight	45 g
Model Number	ICR 18650

3.4 Ultrasonic Sensor

An ultrasonic sensor is an electronic device that measures the distance of a target object by emitting ultrasonic sound waves, and converts the reflected sound into an electrical signal. Ultrasonic waves travel faster than the speed of audible sound (i.e. the sound that humans can hear). Ultrasonic sensors have two main components: the transmitter (which emits the sound using piezoelectric crystals) and the receiver (which encounters the sound after it has travelled to and from the target).

HC-SR04 Ultrasonic Sensor - Working

As shown above the **HC-SR04 Ultrasonic (US) sensor** is a 4 pin module, whose pin names are Vcc, Trigger, Echo and Ground respectively. This sensor is a very popular sensor used in many applications where measuring distance or sensing objects are required. The module has two eyes like projects in the front which forms the Ultrasonic transmitter and Receiver. The sensor works with the simple high school formula that

Distance = Speed × Time

The Ultrasonic transmitter transmits an ultrasonic wave, this wave travels in air and when it gets objected by any material it gets reflected back toward the sensor this reflected wave is observed by the Ultrasonic receiver module as shown in the picture below-

Figure 3.6: Ultrasonic Sensor

Now, to calculate the distance using the above formulae, we should know the Speed and time. Since we are using the Ultrasonic wave we know the universal speed of US wave at room conditions which is 330m/s. The circuitry inbuilt on the module will calculate the time taken for the US wave to come back and turns on the echo pin high for that same particular amount of time, this way we can also know the time taken. Now simply calculate the distance using a micro-controller or microprocessor.

How to use the HC-SR04 Ultrasonic Sensor

HC-SR04 distance sensor is commonly used with both micro-controller and microprocessor platforms like Arduino, ARM, PIC, Raspberry Pie etc. The following guide is universally since it has to be followed irrespective of the type of computational device used.Power the Sensor using a regulated +5V through the Vcc ad Ground pins of the sensor. The current consumed by the sensor is less than 15mA and hence can be directly powered by the on board 5V pins (If available). The Trigger and the Echo pins are both I/O pins and hence they can be connected to I/O pins of the micro-controller. To start the measurement, the trigger pin has to be made high for 10uS and then turned off. This action will trigger an ultrasonic wave at frequency of 40Hz from the transmitter and the receiver will wait for the wave to return. Once the wave is returned after it getting reflected by any object the Echo pin goes high for a particular amount of time which will be equal to the time taken for the wave to return back to the sensor.The amount of time during which the Echo pin stays high is measured by the MCU/MPU as it gives the information about the time taken for the wave

to return back to the Sensor. Using this information, the distance is measured as explained in the above heading.

Applications

- Used to avoid and detect obstacles with robots like biped robot, obstacle avoider robot, path finding robot etc.
- Used to measure the distance within a wide range of 2cm to 400cm
- Can be used to map the objects surrounding the sensor by rotating it
- Depth of certain places like wells, pits etc can be measured since the waves can penetrate through water

Ultrasonic Sensor Pin Configuration

Pin Number	Pin Name	Description
1	Vcc	The Vcc pin powers the sensor, typically with +5V
2	Trigger	Trigger pin is an Input pin. This pin has to be kept high for 10us to initialize measurement by sending US wave.
3	Echo	Echo pin is an Output pin. This pin goes high for a period of time which will be equal to the time taken for the US wave to return back to the sensor.
4	Ground	This pin is connected to the Ground of the system.

HC-SR04 Sensor Features

- Operating voltage: +5V
- Theoretical Measuring Distance: 2cm to 450cm
- Practical Measuring Distance: 2cm to 80cm
- Accuracy: 3mm
- Measuring angle covered: <15°
- Operating Current: <15mA
- Operating Frequency: 40Hz

3.5 LCD Display

LCD (Liquid Crystal Display) screen is an electronics display module and find a wide range of applications. A 16x2 LCD display is very basic module and is very commonly used in various devices and circuits. These modules are preferred over seven segments and other multi segment LEDs. The reasons being LCDs are economical; easily programmable, have no limitation of displaying special & even custom characters (unlike in seven segments), animations and so on. A 16x2 LCD means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5x7 pixel matrix. This LCD has two registers, namely, Command and Data. The command register stores the command instructions given to the LCD. A command is an instruction given to LCD to do a predefined task like initializing it, clearing its screen, setting the cursor position, controlling display etc.

Features of LCD Display:

5 x 8 dots with cursor

Built-in controller (KS 0066 or Equivalent) + 5V power supply (Also available for + 3V)

1/16 duty cycle B/L to be driven by pin 1, pin 2 or pin 15, pin 16 or A.K (LED) N.V. optional for + 3V power supply.

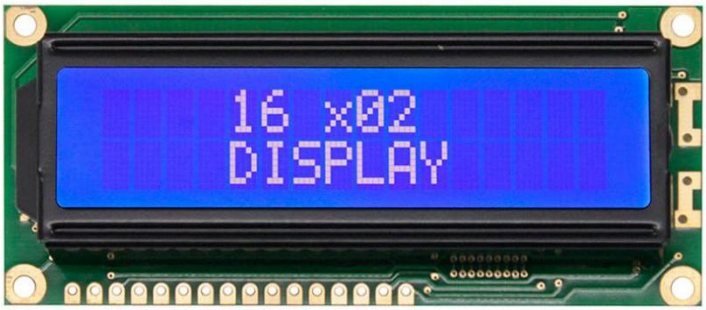


Figure 3.7: 16*2 LCD Display

3.6 Arduino IDE

The digital micro-controller unit named as Arduino Nano can be programmed with the Arduino software IDE. There is no any requirement for installing other software rather than Arduino. Firstly, Select "Arduino Nano from the Tools, Board menu (according to the

micro-controller on our board). The IC used named as ATmega328 on the Arduino Nano comes pre burned with a boot loader that allows us to upload new code to it without the use of an external hardware programmer.

Communication is using the original STK500 protocol (reference, C header files). We can also bypass the boot loader and programs the micro-controller through the ICSP (In Circuit Serial Programming) header. The ATmega16U2 (or 8U2 in the rev1 and rev2 boards) firmware source code is available. The ATmega16U2/8U2 is loaded with a DFU boot loader, which can be activated by:

On Rev1 boards: connecting the solder jumper on the back of the board (near the map of Italy) and then resetting the 8U2. On Rev2 or later boards: there is a resistor that pulling the 8U2/16U2 HWB line to ground, making it easier to put into DFU mode.

The Arduino Nano is one of the latest digital micro-controller units and has a number of facilities for communicating with a computer, another Arduino, or other micro-controllers. The ATmega328 provides UART TTL at (5V) with serial communication, which is available on digital pins 0 -(RX) for receive the data and pin no.1 (TX) for transmit the data. An ATmega16U2 on the board channels this serial communication over USB and appears as a virtual com port to software on the computer. The '16U2 firmware uses the standard USB COM drivers, and no external driver is needed. However, on Windows, an .in file is required. The Arduino software includes a serial monitor which allows simple textual data to be sent to and from the Arduino board.

The RX and TX LEDs on the board will flash when data is being transmitted via the USB-to-serial chip and USB connection to the computer (but not for serial Communication on pins 0 and 1). A Software Serial library allows for serial communication on any of the Nano's digital pins. The ATmega328 also supports I2C (TWI) and SPI communication. The Arduino software includes a Wire library to simplify use of the I2C bus. Arduino programs are written in C or C++ and the program code written for Arduino is called sketch. The Arduino IDE uses the GNU tool chain and AVR Lab to compile programs, and for uploading the programs it uses argued. As the Arduino platform uses Atmel micro-controllers, Atmel's development environment, AVR Studio or the newer Atmel Studio, may also be used to develop software for the Arduino.

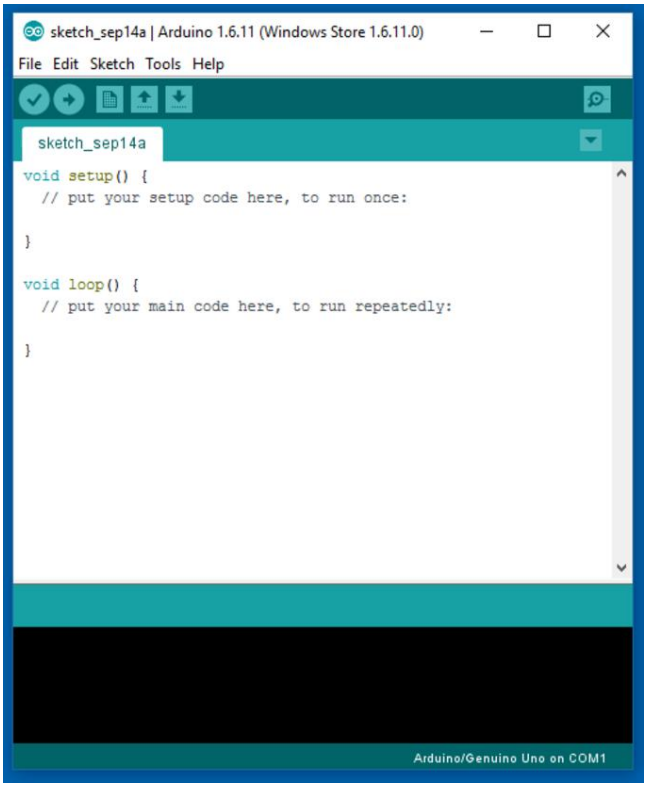


Figure 3.8: Arduino Software Interface IDE

The Arduino Integrated Development Environment - or Arduino Software (IDE) - contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions and a series of menus. It connects to the Arduino and Genuino hardware to upload programs an communicate with them.

Writing Sketches

Programs written using Arduino Software (IDE) are called sketches. These sketches are written in the text editor and are saved with the file extension .ino. The editor has features for cutting/pasting and for searching/replacing text. The message area gives feedback while saving and exporting and also displays errors. The console displays text output by the Arduino Software (IDE), including complete error messages and other information. The bottom right hand corner of the window displays the configured board and serial port. The toolbar buttons allow you to verify and upload programs, create, open, and save sketches, and open the serial monitor.

NB: Versions of the Arduino Software (IDE) prior to 1.0 saved sketches with the extension .pde. It is possible to open these files with version 1.0, you will be prompted to save the sketch with the .ino extension on save.

Sketchbook

The Arduino Software (IDE) uses the concept of a sketchbook: a standard place to store your programs (or sketches). The sketches in your sketchbook can be opened from the File > Sketchbook menu or from the Open button on the toolbar. The first time you run the Arduino software, it will automatically create a directory for your sketchbook. You can view or change the location of the sketchbook location from with the Preferences dialog.

Beginning with version 1.0, files are saved with a .ino file extension. Previous versions use the .pde extension. You may still open .pde named files in version 1.0 and later, the software will automatically rename the extension to .ino.

Tabs, Multiple Files, andompilation

Allows you to manage sketches with more than one file (each of which appears in its own tab). These can be normal Arduino code files (no visible extension), C files (.c extension), C++ files (.cpp), or header files (.h).

Uploading Before uploading your sketch, you need to select the correct items from the Tools > Board and Tools > Port menus. The boards are described below. On the Mac, the serial port is probably something like /dev/tty.usbmodem241 (for a Uno or Mega2560 or Leonardo) or /dev/tty.usbserial-1B1 (for a Duemilanove or earlier USB board), or /dev/tty.USA19QW1b1P1.1 (for a serial board connected with a Keyspan USB-to-Serial adapter). On Windows, it's probably COM1 or COM2 (for a serial board) or COM4, COM5, COM7, or higher (for a USB board) - to find out, you look for USB serial device in the ports section of the Windows Device Manager. On Linux, it should be /dev/ttyACMx , /dev/ttyUSBx or similar. Once you've selected the correct serial port and board, press the upload button in the toolbar or select the Upload item from the Sketch menu. Current Arduino boards will reset automatically and begin the upload. With older boards (pre-Diecimila) that lack auto-reset, you'll need to press the reset button on the board just before starting the upload. On most boards, you'll see the RX and TX LEDs blink as the sketch is uploaded. The Arduino Software (IDE) will display a message when the upload is complete, or show an error.

When you upload a sketch, you're using the Arduino Boot loader, a small program that has been loaded on to the micro-controller on your board. It allows you to upload code without using any additional hardware. The Boot loader is active for a few seconds when the board resets; then it starts whichever sketch was most recently uploaded to the micro-controller. The Boot loader will blink the on-board (pin 13) LED when it starts (i.e. when the board resets).

Libraries

Libraries provide extra functionality for use in sketches, e.g. working with hardware or manipulating data. To use a library in a sketch, select it from the Sketch > Import Library menu. This will insert one or more #include statements at the top of the sketch and compile the library with your sketch. Because libraries are uploaded to the board with your sketch, they increase the amount of space it takes up. If a sketch no longer needs a library, simply delete its #include statements from the top of your code.

There is a list of libraries in the reference. Some libraries are included with the Arduino software. Others can be downloaded from a variety of sources or through the Library Manager. Starting with version 1.0.5 of the IDE, you do can import a library from a zip file and use it in an open sketch. See these instructions for installing a third-party library.

Third-Party Hardware

Support for third-party hardware can be added to the hardware directory of your sketchbook directory. Platforms installed there may include board definitions (which appear in the board menu), core libraries, Boot loaders, and programmer definitions. To install, create the hardware directory, then unzip the third-party platform into its own sub-directory. (Don't use "Arduino" as the sub-directory name or you'll override the built-in Arduino platform.) To uninstall, simply delete its directory.

For details on creating packages for third-party hardware, see the Arduino IDE 1.5 3rd party Hardware specification.

Serial Monitor

This displays serial sent from the Arduino or Genuino board over USB or serial connector. To send data to the board, enter text and click on the "send" button or press enter. Choose the baud rate from the drop-down menu that matches the rate passed to Serial begin in your sketch. Note that on Windows, Mac or Linux the board will reset (it will rerun your sketch) when you connect with the serial monitor.

3.7 EasyEDA Software

EasyEDA is a web-based EDA tool suite that enables hardware engineers to design, simulate, share - publicly and privately - and discuss schematics, simulations and printed circuit boards. Other features include the creation of a bill of materials, Gerber files and pick and place files and documentary outputs in PDF, PNG and SVG formats.EasyEDA allows the creation and editing of schematic diagrams, SPICE simulation of mixed analogue and digital circuits and the creation and editing of printed circuit board layouts and, optionally, the manufacture of printed circuit boards.

Subscription-free membership is offered for public plus a limited number of private projects. The number of private projects can be increased by contributing high quality public projects, schematic symbols, and PCB footprints and/or by paying a monthly subscription. Registered users can download Gerber files from the tool free of charge; but for a fee, EasyEDA offers a PCB fabrication service. This service is also able to accept Gerber file inputs from third party tools.

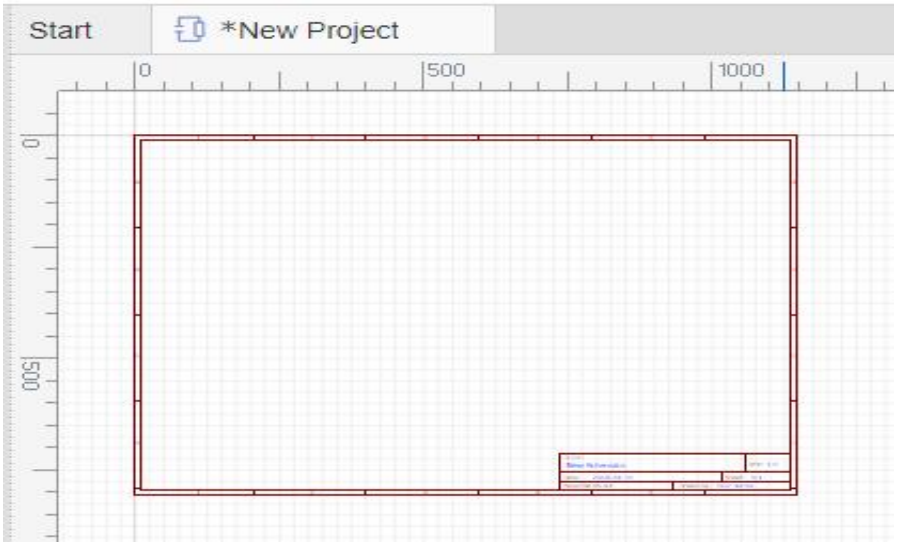


Figure 3.9: EasyEDA Software Interface

3.8 Remote XY:

Remote XY is easy way to make and use a mobile graphical user interface for controller boards to control via smartphone or tablet. The system includes:

- Editor of mobile graphical interfaces for controller boards, located on the site remotexy.com
- Mobile app Remote XY that allows to connect to the controller and control it via graphical interface. Download app.

Distinctive features:

- The interface structure is stored in the controller. When connected, there is no interaction with servers to download the interface. The interface structure is downloaded to the mobile application from the controller.
- One mobile application can manage all your devices. The number of devices is not limited.

Supported connection methods:

- Internet over Cloud Server;
- Wi-Fi client and access point;
- Bluetooth;
- Ethernet by IP or URL;
- USB OTG (Android only that support USB OTG);

Supported boards:

- Arduino UNO, MEGA, Leonardo, Pro Mini, Nano, MICRO and compatible AVR boards;
- ESP8266 boards;
- ESP32 boards;
- Chip KIT UNO32, Chip KIT uC32, Chip KIT Max32;

Supported communication modules:

- Bluetooth HC-05, HC-06 or compatible;
- Bluetooth BLE HM-10 or compatible;
- ESP8266 as modem;
- Ethernet W5100;

Supported IDE:

- Arduino IDE;

- FLProg IDE;
- MPIDE;

Supported mobile OS:

- Android;
- iOS;

Remote XY is easy way to make a unique graphical interface to control micro-controller device via mobile application, Arduino for example.

Remote XY allows:

- To develop any graphical management interface, using the control, display and decoration elements any combination thereof. You can develop the graphical interface for any task, placing the elements on the screen using the online editor. Online editor posted on the website remotexy.com.
- After the development of the graphical interface, you get the source code for the micro-controller that implements your interface. The source code provides a structure for interaction between your program with the controls and display. Thus you can easily integrate the control system into your task for which you are developing the device.
- To manage micro-controller device using your smartphone or tablet with the graphical interface. For manage used mobile application Remote XY.
- Using one mobile application, you can manage a large number of devices with different graphical management interfaces. As the interface description is stored on board the micro-controller device.

the source code for the micro-controller, for example a sketch for the Arduino, you opened it in the IDE. In the simplest case, you can download the sketch in Arduino board and test your interface immediately, connecting via a smartphone. But often you need to integrate the developed graphical interface with your problem you want to solve it using the Arduino. Next, we will show how it is easy to do.

The generated source code have a part that is starts with tag **Remote XY include library** and ends with tag **END Remote XY include**. This part of the code defines the structure of the graphical interface that you have created. In turn, this structure is also divided into parts. Consider the order.

Select connection mode and include library

The code contains a definition of how you use the connection of interface. This definition of the form REMOTEXY_MODE__ XXX. For example, if you use Software Serial, this definition would be REMOTEXY_MODE__SOFTWARESERIAL, if you use Hardware Serial - REMOTEXY_MODE__SERIAL respectively.

Additionally this section of code contains the necessary includes libraries to provide the necessary functionality. Also connects library Remote XY.h. There is no need to change this part of code.

Connection settings

This part of the code in more detail defines the characteristics of the selected connection. For example, if you are using a connection via Software Serial, you can determine which pins micro-controller will be connected to the Bluetooth module. You can also determine the rate of exchange with the Bluetooth module, if it is different from the default 9600 baud. All definitions are set by default, but you can change them as you need. This is the only section of code in the included section of Remote XY that you can change.

ESP8266 Wi-Fi module

ESP8266 module allows to use RemoteXY with micro-controller device for Wi-Fi. Implemented support for all Arduino boards. The source code of GUI can be download for the Arduino IDE and PLProg.

To use the ESP8266 module to select this module in the properties configuration settings.

Figure 3.10: Configure Remote XY

Remote XY allows to configure module for operate in one of two modes: access point and client. Client allows to connect the module to an existing Wi-Fi access point.

Access point mode of ESP8266 configures the module as an access point and allows to connect Arduino directly to this point. The access point is available to connect to it from smartphone or tablet within a radius of availability of the radio signal. It does not require any other network infrastructure. This connection mode can be used in the far away place where there is no computer networks and the Internet. To configure this mode in the configuration properties of editor need to select the type of connection "Wi-Fi access point."

Client mode of ESP8266 configures the module for automatically connect to an existing Wi-Fi access point, such as a home router or enterprise access point. At the same time connected to the Arduino module ESP8266 must be located in the physical availability of the radio signal of access point. Connecting to the device from smartphone or tablet will be not directly, but through the Ethernet network, an IP address provided by the DHCP server to ESP8266 module. It allows to connect to the Arduino device from anywhere in the local network as well as from the Internet. Connect from the Internet is possible with the correct configuration of the router, such as the use of the virtual server. To configure this mode in

the configuration properties of editor need to select the connection type "Ethernet" and select ESP8266 module.

The module is connected to the micro-controller board via serial interface. You can choose to use software serial or hardware serial. Module connection option is selected in the module interface settings of editor. The module is controlled via AT commands.

Connection via Software Serial

It allows to connect the module to an arbitrary micro-controller pins. The pins used must be select in the module interface settings of editor. Also in the settings must be select the baud rate for serial port. ESP8266 default configured to 115200 baud. To work through Software Serial, must configure the transmission speed ESP8266 to a lower speed. Stable operation of the module is possible at a speed of no more than 19200 baud. To change the speed of module serial interface, must to connect it to the console to the possibility of the AT commands. Module serial interface speed can be changed with the AT command "AT+UART_DEF=19200,8,1,0,0".

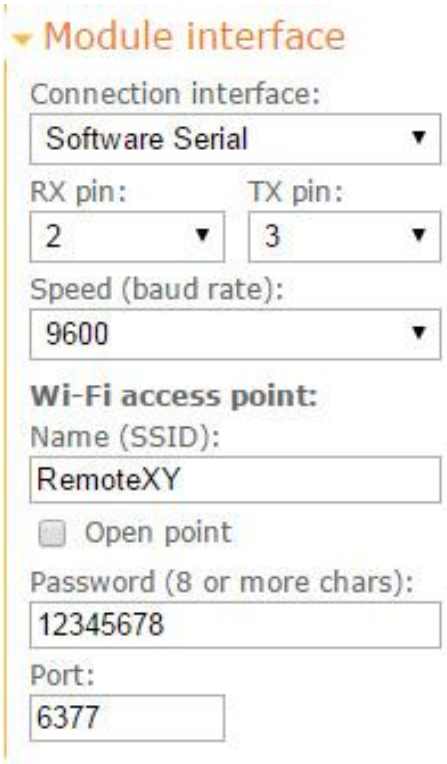


Figure 3.11: Module Interface

There are some limitations on the use of the RX pin for Arduino boards. Limitations associated with do not support to pins interrupt of the micro-controller.

- On **Arduino** RX doesn't work on pin 13;
- On **Mega** and **Mega2560** only the following can be used for RX: 10, 11, 12, 13, 14, 15, 50, 51, 52, 53, A8(62), A9(63), A10(64), A11(65), A12(66), A13(67), A14(68), A15(69);
- On **Leonardo** and **Micro** only the following can be used for RX: 8, 9, 10, 11, 14, 15, 16;

Also, when using Software Serial you should take the following limitations:

- No ability to work at high baud rates. It is not recommended to use a baud rate of more than 19200.
- Some libraries, which also uses interrupt may not work correctly. For example Servo library, the servos will twitch.

Connection via Hardware Serial

It allows to connect the module to the micro-controller pins, supporting one of the hardware serial ports. For different Arduino boards are different ports and contacts. Hardware serial allows to work module at a maximum connection speed of 115200 baud. The baud rate for Arduino is selected in the module interface settings of editor. ESP8266 must be to pre-configured to work at the same speed as the Arduino. The baud rate setting of modules can be made via AT commands. Next Arduino serial ports are available:

- **Arduino UNO and Nano**: Serial (RX-0, TX-1);
- **Arduino MEGA and MEGA2560**: Serial (RX-0, TX-1), Serial1 (RX-19 и TX-18), Serial2 (RX-17 и TX-16), Serial3 (RX-15 и TX-14);

>Which port to use, and therefore the pins should be connected to the module, you must select in interface settings of editor. It should also be borne in mind that for Arduino boards Serial port enabled for the micro-controller programming, and if you decide to use this port, you must disconnect the ESP8266 module when programming it. A good solution is to use the boards Arduino MEGA any port other than Serial.

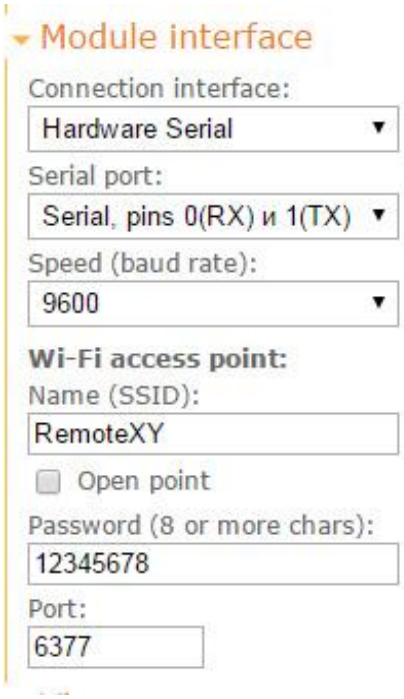


Figure 3.12: Module Interface

CHAPTER 4
Methodology

4.1 Our methodologies for the project:

- Creating an idea for the design and construction of Automobile Brake Pads Performance and Longevity Monitoring System. And designing a block diagram to know which components we need to construct it.
- Collecting all the components for our desired system.
- Setting up all the components in a system. Then assembling all the blocks in a system and finally running the system to check if it actually works or not.

4.2 Working Principle

The working principle of motorcycle brake pads is based on the frictional force between the brake pads and the rotor or drum. The brake lever or pedal, the brake caliper compresses the brake pads against the rotor or drum, creating friction that slows down or stops the motorcycle. Here we use a Node MCU micro-controller which is the main controller unit for this system. This micro-controller is mainly powered from the battery. Ultrasonic sensor is mounted in the brake pad and it is connected to the Node MCU. Here we divide the brake pad condition in four parts in Remote XY. When the condition of brake pad wasting rate will 25% then Buzzer will be Sound on in Remote XY. In this same process when brake pad wasting rate will 55%,75% then the condition will detect by the Ultrasonic sensor and send it by Node MCU through IoT. Here also use like Node MCU, Ultrasonic Sensor, Buck Converter, battery, LCD Display. Here all data shows in LCD Display. This is the main procedure of this system.

4.3 Final Project View

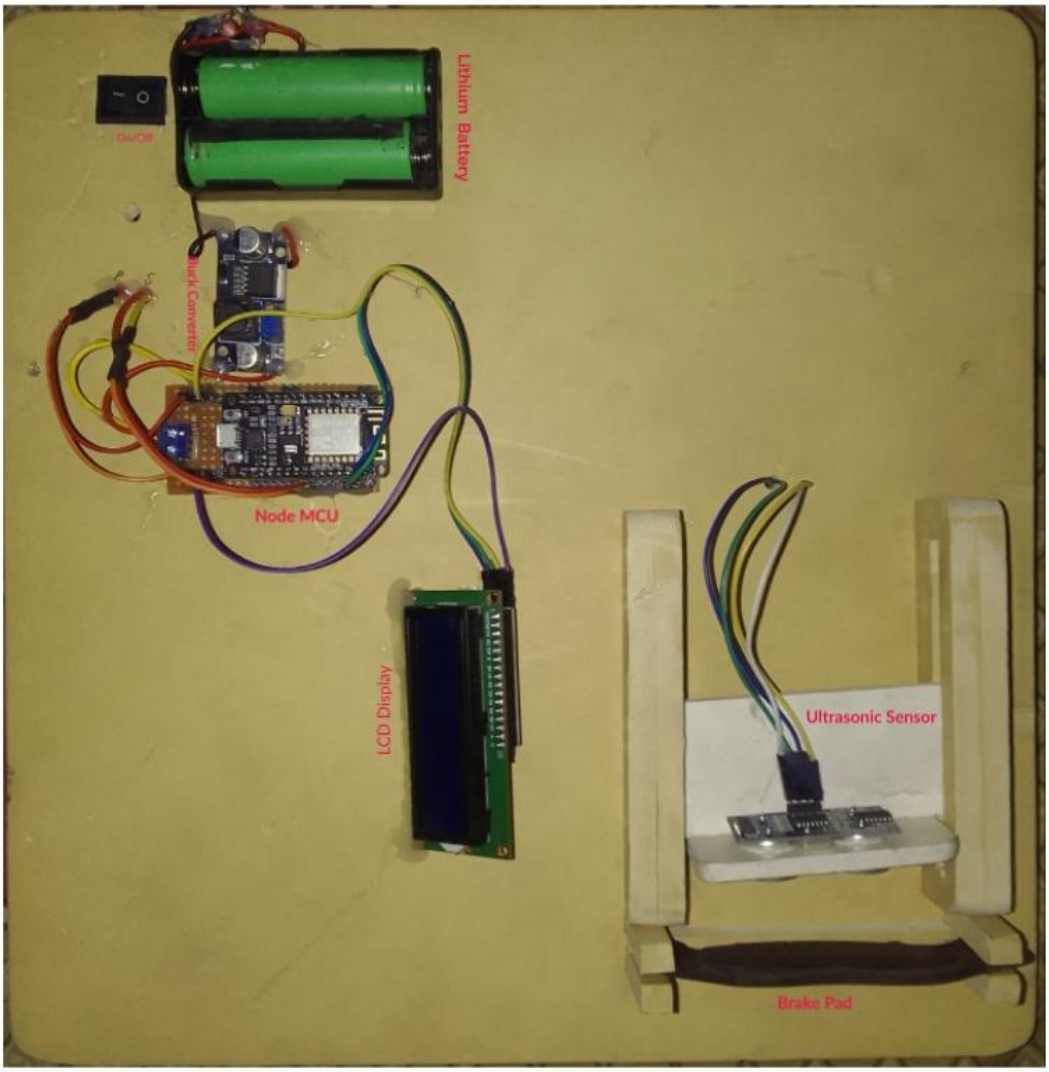


Figure 4.1: Final Project Overview

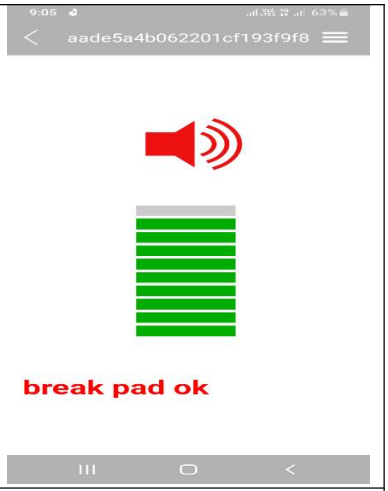
CHAPTER 5
RESULT AND DISCUSSION

5.1 Result

Now, it's time to talk about the results. We have written our commands using the Arduino IDE and the following things can happen: Our project is **Automobile Brake Pads Performance and Longevity Monitoring System.** In our project making we used PVC boards for total hardware making. After finally completing this project, we run it & we observed the output of this project. We can see that it is working well as expected. We took some photos and mobile screen shots as reference.

- In this project first we setup a power source system. In real life we will connect our project with vehicle battery.
- After that we will establish a circuit where we use a micro-controller and a sensor.
- Sensor will measure the brake pad condition and Show the LCD Display.
- All Data Show in LCD Display.

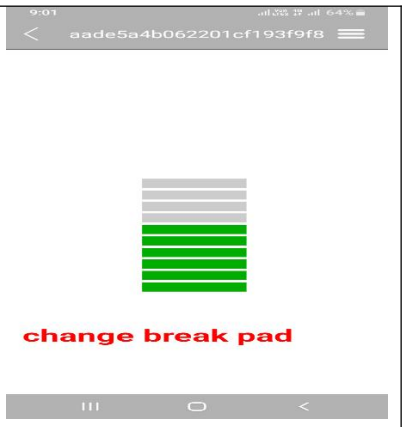
Experiment 1:

		
Brake Pad Position 1	Results on system display	Results on mobile screen

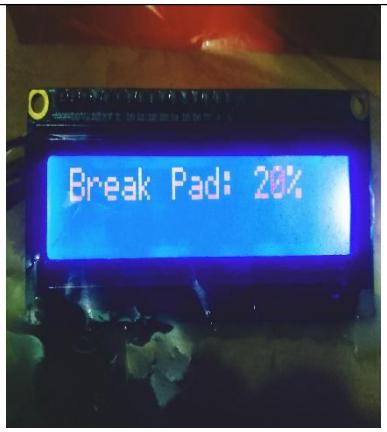
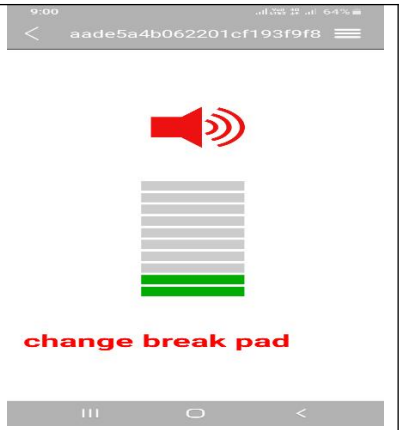
Experiment 2:

		
Brake Pad Position 2	Results on system display	Results on mobile screen

Experiment 3:

		
Brake Pad Position 3	Results on system display	Results on mobile screen

Experiment 4:

		
Brake Pad Position 4	Results on system display	Results on mobile screen

5.3 Advantage

- Improved safety.
- Extended lifespan of brake pads.
- Cost savings.
- Improved performance.
- Peace of mind.
- Simple construction
- Ease of operation

5.4 Application

It can be used for various type of vehicle Likes:

- ❖ Motorcycle
- ❖ Car
- ❖ Auto Rickshaw
- ❖ Motor Van

5.1 Discussion

Maintaining the brake system of a motorcycle is crucial for rider safety, and monitoring the brake pads is an essential aspect of brake system maintenance. Worn-out brake pads can lead to longer stopping distances, reduced braking performance, and even brake failure, which can cause accidents. Therefore, it is vital for motorcycle riders to know how to monitor their brake pads and take the necessary action to replace them when necessary. Regular inspection is crucial for monitoring brake pads. The frequency of inspection will depend on how frequently the motorcycle is used, but it is recommended to inspect the brake pads every 3,000 miles or every six months. During inspection, the rider should look for visual signs of wear, such as uneven wear patterns, cracks, or a shiny appearance. When replacing worn-out brake pads, it is essential to use high-quality pads from reputable manufacturers. Inferior quality brake pads may wear out faster and not provide adequate stopping power, which can compromise rider safety. Proper maintenance of the brake system can help prolong the life of the brake pads and ensure optimal braking performance. Keeping the brake system clean and free from dirt and debris and using the recommended brake fluid can help prevent premature wear of the brake pads.

CHAPTER 6
CONCLUSION

6.1 Conclusion:

Monitoring the performance of a brake pads system makes it possible to conduct real-time assessment of its various components and to decide on whether the design is adequate to achieve the desired performance outcomes. The work presented in this paper features research effort undertaken to design, construct, and brake pads monitoring system. The various measurable parameters relevant to brake performance have been system. We are proud to express our delight as the project we embarked upon is successfully finished within the target date. The project gave us more confidence that we will be able to put in practice, whatever theoretical knowledge. we gained during our course of study till now. If really persuades us to do more and more, perhaps in better way in our future. Brake failure indicator is a early warning system. it constantly monitors the condition of the brake and give audio visual indication.

6.2 Future Scope

The model can be improved by making some changes some components. Some suggestions are given below.

- We will improve advanced Brake Monitoring System.
- We will add an engine shut down feature. The vehicle will remain shut down until the brake pads are changed.

References

[1] N. Chand, A.R. Hashmi, S. Lomash, A Naik, ―Development of Asbestos Free Brake Pad‖. Wear, Vol. 85, pp. 13-16. 2004.

[2] Mikael Eriksson Filip Bergman Staffan Jacobson―Surface characterization of brake pads after running under silent and squealing condition Wear Vol. 63, pp.163-167, 1999.

[3] W. Osterle , I.Urban, ―Fric on layers and fric on films on PMC brake pads‖ Wear, Vol. 86, pp.215-226, 2004.

[4] Zmago Stadiler, et al., ―Fric on behavior of sintered metallic brake pads on a C/C-SiC composite brake disc Journal of the European Ceramic Society, pp. 1-7, 2006.

[5] H. Jang, et al. ―The effect of metal fibres on the fric on performance of automotive brake friction materials‖ Wear, Vol. 88, pp.406-414.

[6] M. Boniardi et al ―Failure analysis of a motorcycle brake disc Journal of Engineering Failure Analysis Vol. 35, pp. 933-945, 2006.

[7] Werner Osterle & Ingrid Urban, ―Third body formation on brake pads and rotors‖ Journal of Tribology International, Vol. 11, pp. 401408, 2006.

[8] Dr N Venkata cahalapathi, V. Mallikarjuna, Automatic brake failure indicator & over heating alarm, ISSN 2321 3361, Jul 2016.

[9] Sivarao, M. Amarnath, M.S. Rizal & A. Kamely, An investigation towards the development of brake lining wear alert system, 1951091-IJET-IJENS, Oct 2009.

[9] Mohan & G. Pugazhendhi, Accident avoiding system indicator due to Brake failure, Jun 2017.

[10] Chetan C. Harlapur, Priyatam kumar Kadiyala, Ramakrishna S, Brake Pad wear detection using Machine Learning, ISSN: 2454-132 X, 2019.

[12] Anders Soderberg, Soren Andersson, Simulation of wear & contact pressure distribution at pad to rotor interface using FEA software, Wear 267 2243-2251, Sep 2009.

Appendix

```
#include <LiquidCrystal_I2C.h>
LiquidCrystal_I2C lcd(0x3F, 16, 2);  // I2C address 0x3F, 16 column and 2 rows 27or3F
#define trigPin D5
#define echoPin D6
long duration;
long distance;
int math=130;
int pad;
#define REMOTEXY_MODE__ESP8266WIFI_LIB_CLOUD
#include <ESP8266WiFi.h>

#include <RemoteXY.h>

// RemoteXY connection settings
#define REMOTEXY_WIFI_SSID "abcde"
#define REMOTEXY_WIFI_PASSWORD "123456789"
#define REMOTEXY_CLOUD_SERVER "cloud.remotexy.com"
#define REMOTEXY_CLOUD_PORT 6376
#define REMOTEXY_CLOUD_TOKEN "aade5a4b062201cf193f9f8bac453e79"



// RemoteXY configurate
#pragma pack(push, 1)
uint8_t RemoteXY_CONF[] =   // 34 bytes
  { 255,0,0,34,0,27,0,16,31,1,66,0,22,35,18,39,133,31,69,0,
  24,9,17,17,1,67,4,2,85,60,7,36,31,31 };

// this structure defines all the variables and events of your control interface
struct {
```

```
    // output variables
  int8_t level_1; // =0..100 level position
  int16_t sound_1; // =0 no sound, else ID of sound, =1001 for example, look sound list in app
  char text_1[31];  // string UTF8 end zero

    // other variable
  uint8_t connect_flag;  // =1 if wire connected, else =0

} RemoteXY;
#pragma pack(pop)

void setup()
{
  RemoteXY_Init ();

   Serial.begin(115200);
  lcd.clear();
 lcd.init();      // initialize the lcd
  lcd.backlight(); // open the backlight
 pinMode(trigPin,OUTPUT);
  pinMode(echoPin,INPUT);
  // TODO you setup code

}


void loop()
{
  RemoteXY_Handler ();


  // TODO you loop code
```

```
  // use the RemoteXY structure for data transfer
  // do not call delay()
  RemoteXY.level_1 = pad;

digitalWrite(trigPin, LOW);
  delayMicroseconds(2);
  digitalWrite(trigPin, HIGH);
  delayMicroseconds(10);
  digitalWrite(trigPin, LOW);
  duration = pulseIn(echoPin, HIGH);
  distance= (duration*0.034/2)*17;
  pad=math-distance;

   Serial.print("distance ");
  Serial.println(distance);
   lcd.setCursor(0, 0);  // start to print at the first row
    lcd.print("Brake Pad: ");
    lcd.print(pad              );
    lcd.print("%");
  delay(200);
if (pad<70 ) {
  RemoteXY.sound_1 = 2001;
   strcpy  (RemoteXY.text_1, "change brake pad");
}
if (pad>70 ) {
  RemoteXY.sound_1 = 0;
   strcpy  (RemoteXY.text_1, "brake pad ok");
}
}
```