Automatic Brake Pad Tracking and Thickness Awareness System

A Project by

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May, 2025

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In partial fulfillment of the requirements for the Degree of Bachelor of Science in Mechanical Engineering.

May, 2025

Approval

This is to certify that the project work entitle , Automatic Brake Pad Tracking and Thickness Awareness System has been carried out by Md. Nazmul Islam (ID: ME2103025313), Md.Sajib Hossain (ID: ME2103025314), Mehedi Hasan (ID: ME2103025317), Pranta Paul (ID: ME2103025319) and Md .Sujon Hossain (ID: ME2103025437) thereby declared that the work presented here is original work done by me and has not been published or submitted elsewhere for the requirement of a degree of Bachelor of Science (B.SC.) in Mechanical Engineering in the year of 2025 Program in the Department of Mechanical Engineering ,Sonargaon University of Bangladesh (SU) has been carried out under by Supervisor.

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DECLARATION

We hereby, declare that the work presented in this project is the outcome of the investigation and research work performed by us under the supervision of Md Toriqul Islam, Lecturer and Assistant Coordinator, Department of Mechanical Engineering, Sonargaon University (SU). We also declare that no part of this project & thereof has been or is being submitted elsewhere for the award of any degree.

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ACKNOWLEDGEMENTS

We are thankful to our supervisor, teachers, parents, and all the friends who supported us in completing this project & Thesis. Without their support, it would not have been possible for us to complete this. We would like to extend our thanks and appreciation to Md. Mostofa Hossain sir, Head of the Mechanical Engineering Department at SU, for his continued encouragement. Lastly, we thank our project supervisor Md.Toriqul Islam sir for the unceasing encouragement, support, and attention.

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ABSTRACT

The safety and efficiency of motorcycle operations heavily depend on the performance and durability of brake pads. This study introduces a comprehensive monitoring system designed to evaluate the performance and longevity of motorcycle brake pads in real-time. By utilizing advanced sensors and data analytics, the system continuously tracks key performance indicators such as wear rate and braking efficiency. The monitoring system provides detailed insights into brake pad conditions, allowing for timely maintenance and replacement decisions. By analyzing usage patterns and environmental factors, the system enhances the understanding of brake pad performance over time, promoting rider safety and optimizing maintenance schedules. This innovative approach aims to improve the reliability of braking systems in motorcycles, ultimately contributing to enhanced road safety and reduced operational costs.

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CHAPTER-1

INTRODUCTION

Presently, lots of accidents may occur due to different reasons, one of the reasons is brake failure and is caused due to poor preservation as well as product defect. As per the National Crime Records Bureau, Ministry of Road Transportation & Highway, Law commission of India, 2 serious road accidents in the country occurs every minute and 24 dies on Indian highways every hour in India. For die in every minute to brake failure. In order to safe protector the valuable human for accident the accident monitoring of brake is very important thing in automobile. Safety of vehicle is the prevention of vehicle accidents or the minimization of harmful effects of accidents, particularly as concern to human life and health. Many researches are carried out to improve the efficiency of brake pad at the same time to monitor the brake pads by using various methods. In the present research paper, the overview is carried out to understand the present research on monitoring the brake pad and attempt is made to developed new system to monitor the condition of brake pad. The system which is presented in this research paper continuously monitors the brake pads with the help of position sensor.

A brake is nothing but a mechanical device that prevents the motion of vehicle by slowing down it. Brakes oppose the motion of a body, which creates friction between two working surfaces and convert the kinetic energy of the moving body into heat. Sometimes when the brake lining is cut-off, brake failure may occur. Brake pads are an important component of disk brakes used in vehicles. Brake pads are steel backing plates with friction material bound to the surface that faces the disk plate rotor. Due to the continuous friction between the brake pad and disc plate, heat generated and results in to the wear of brake pad and failure of brake. To avoid this problem, the solution has founded in the form of Brake Pad Wear Indicting System. This system provides the information about the condition of brake pad to the rider or user. The system which is presented in this research paper continuously monitors the brake pads with the help of position sensor. Sensor is connected along with the disc caliper and disc plate. The signal from the sensor is given to a microcontroller. When the brake pad is worn out, the sensor sends signal to the microcontroller and it blows the light according to the condition of brake pad given on the dashboard of vehicle, which informs the user about the condition of the brake. This system definitely helpful to save the valuable human life from accidents due to failure of brake.

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.

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 pads 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 is 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 your 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.

Objectives:

Our Project Objectives are:

1. Real-Time Wear Monitoring: To Provide continuous, real-time feedback on the condition of brake pads to ensure timely maintenance and replacement.
2. Enhanced Safety: By alerting the rider to brake pad wear or failure, the system helps prevent accidents caused by reduced braking efficiency.
3. Prolong Brake Life: To Monitor riding habits and braking patterns to optimize brake usage, potentially extending the lifespan of brake pads through more efficient use.
4. Cost Efficiency: To Reduce the need for premature brake pad replacement by allowing for precise tracking of wear, leading to cost savings over time.
5. Predictive Maintenance: To Enable proactive maintenance by predicting when brake pads will need replacement based on usage patterns, minimizing downtime for repairs.
6. Improve Rider Awareness: To Educate and inform riders about their braking habits, enabling them to modify their riding style to reduce excessive brake wear.
7. Integration with Other Systems: To Potentially integrate with other onboard systems for a holistic approach to motorcycle health monitoring, improving overall vehicle performance.

CHAPTER-2

LITERATURE REVIEW

In this section topics related to a Motorcycle Brake Pads Performance & Longevity Monitoring System are included. These provide a sampling of problems appropriate for application of a Load Sharing system. The references are summarized below.

The literature review is carried out to understand the important of brake pad and the present development in the brake pad performance & longevity 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.

Project is fully furnished and designed for safety of the automobile vehicles. Automatic brake failure meter and braking system is the most effective solution to this problem. It is the most active and the simplest methodology used to reduce the rate of accident due to brake failure. In this system the workings used are two-way relay, buzzer, battery, motor, wiring system. And finally, the braking system installed in the two-wheeler by using these components the most operative system is to be generate. In this system, if brake failure is occurred then the signal gives the indication to the driver in the form of sound and concurrently alternative braking system start their working and apply the secondary brakes by using motor fitted to the chassis as the result of these the speed of the vehicle gets reduced and vehicle is stop in some sec. The advantage of the system is that it is compact in size, and the installation cost is very less. If the system is installed in vehicle, then accident due to brake failure gets compact as the result of these the rate of accident due to brake failure get reduces .

The braking system of a car is certainly one of its more important features. The aim of this effort is to create a better braking system with indicator. Brake disappointment occurs only because of worn out of brake shoe and cut in liner. It consists two sensors. One sensor is connected with the brake shoe. The second sensor is the brake liner. The sign from the two sensors is given to a microcontroller. When the brake shoe is damaged out, the sensor senses signal to the microcontroller. Also, if the brake liner is cut, the sensor directs signal to the microcontroller. The microcontroller analyses the signal and operates the conforming indicator. It nothing mistaken, the vehicle will move and if any one critical, the vehicle will stop and the screen shows the indication of brake failure.

Since this specifies the status of the brake, the user can identify the condition of the brake and thus limiting the chances of malfunction. **[3]** Sarvendra Kumar Mehra, et al (2013), this work is meant to study the tribological properties difference of potentially new designed non-commercial brake pad materials with and without asbestos under various speed and nominal contact pressure. Binder resin and reinforcing fibers used in friction materials have substantial influence in causal the friction characteristics. Frictional heat generated during the brake application can easily raise the temperature at the interface beyond the glass change temperature of the binder resin resulting in an abrupt change in the friction force during braking. Brake pads change the kinetic energy of the car to thermal energy by friction. Two brake pads are controlled in the brake caliper with their rubbing surfaces facing the rotor. When the brakes are hydraulically applied, the caliper clamps or crushes the two pads composed into the spinning rotor to slow/stop the vehicle.

Sivarao, et al (2009) in this paper brakes and tires are the major providers for catastrophic failure of ground vehicles. Braking system is the highest important besides tire to confirm the safety of users and vehicle. Ensuring good condition of brake lining is very crucial to approve the efficiency of the braking system, where, the worn off brake lining not only risks life but also damages the entire brake linked parts such as hub, disk, shaft, etc. In this paper, Malaysian made luxury car Proton Perdana V6 brake pads were considered to be surrounded with a lining wear limit alert system. The current spring steel alert system has some disadvantages where, the alerting sound is only started while the car moves and secondly, when the car is on move, rarely the alerting sound extents the driver. Therefore, a critical investigation of the present pads manufactured in Malaysia and their classifications are conducted to identify the most suitable sensor spot on the brake pad. Later, a micro sensor is surrounded into the pad and fully tested on a specially designed test rig. The assessment 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 verified to be very efficient in alerting the driver upon reaching the maximum lining wear limit.

The recent examination by N. Chand, S.A.R. Hashimi, S Lomash and A Naik was towards development of asbestos free brake pad. This experiment applications on physical of new material asbestos-free with wear properties. From their research, it is said that the asbestos-free friction lining material can be used for brake as well as other friction lining applications. **[6]** Mikael Eriksson, Filip Bergman, Staffan Jacobson have explored the surface classification of brake pads after running under silent and screeching conditions. This research focuses on the previously almost unknown area of the connection between brake pad surface structure and the occurrence of squeals. From the new result, they indicated that pads with many small contact tables have a larger tendency to create squeal than pads with

Friction layers and friction films on PMC brake pads were examined by W. Osterle, I. Urban, using Focused Ion Beam (FIB) technique, where, it was used to define superficial layers at micro-contact areas of a profitable brake pad. The friction material was a polymer matrix compound (PMC) with nearly 50% metal content (semi metallic) and the counter part was a cast iron rotor. Experiment depending on the component of the pad, one, two or three layers were identified. The experiment was mostly to show that the FIB technique provides additional information which in combination with the more conventional techniques LM, SEM and TEM increases the knowledge on the role of third body formation and artificial layers on brake pads **[8]** Zmago Stadler, Kristoffer Krnel and Tomaz Kosmac have researched friction behavior of sintered metallic brake pads on a C/CSiC composite brake disc. This experiment was expected studying on the frictional and wear properties of sintered metallic (MMC) brake linings in combination with a C/C– SiC brake disc. From the result they arrange 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 pad surface.

The effect of metal fibers on the friction presentation of automotive brake friction materials were explored by H. Jang, K. Ko, S.J. Kim, R.H. Basch and J.W. Fash This experiment explores the effect of different metallic fibers upon friction and wear presentation of various brake friction couples. The results show that when gray cast iron was used as a security 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. Perricone have explored failure analysis of a motorcycle brake disc. The failure has studied on small crack on the disc brake. These cracks were mostly located nearby the holes placed on flange to ventilate and refresh pads. From the result, it is stated that the lifespan of a motorcycle brake disc depends severely on the geometry (position of holes, shape of spokes, etc.), the material properties at high temperatures and working conditions. Werner Osterle and Ingrid Urban

Summary:

From the literature discussed above, we gained a wealth of knowledge that significantly inspired us to undertake this project. The insights we gathered helped shape our vision and approach, motivating us to explore new ideas and solutions. This project could not have been realized without the tireless dedication and hard work of everyone involved. Each team member brought their unique skills and perspectives, contributing to our collective success. Together, we overcame challenges and pushed boundaries, demonstrating the power of collaboration and commitment to a shared goal.

CHAPTER-03

HARDWARE AND SOFTWARE DETAILS

3.1 Introduction:

This Project has worked on two things, Hardware and Software. The project objectives, methods, literature evaluation, and other details were all clarified in the preceding chapter. The block diagram, circuit diagram, Working principle, and final project instrument cost analysis will all be covered in this chapter.

3.2 Required Instrument:

Hardware

1. Node MCU
2. Buck Converter
3. Laser Sensor
4. Battery
5. LCD Display
6. Buzzer
7. Brake Pad

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 Express if Non-OS SDK for ESP8266. It uses many open source projects, such as leucosin 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.

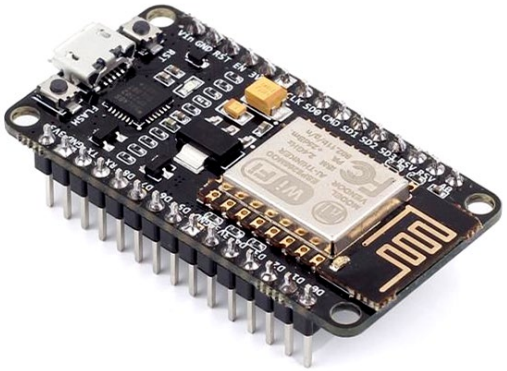


Figure : Node MCU

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 TensilicaXtensa LX106 core, widely used in IoT applications.

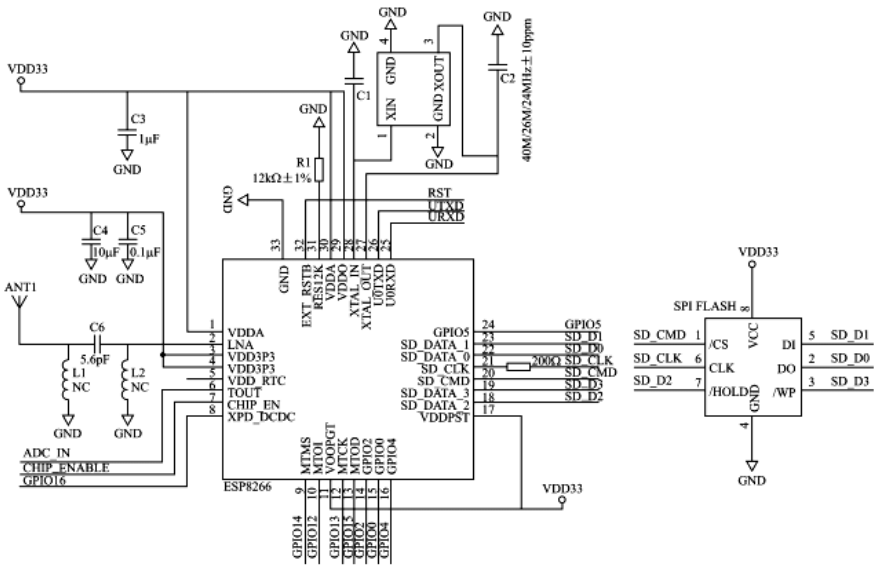


Figure : Node MCU Schematic Diagram

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.

ESP8266 came out. On December 30, 2013, Espressif Systems 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, , 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. Later that month, Tuan PM ported MQTT client library from Contiki to the ESP8266
SoC platform, and committed to Node MCU 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. By summer 2016 the Node MCU included more than 40 different modules. Due to resource constraints users need to select the modules relevant for their project and build a firmware tailored to their needs.

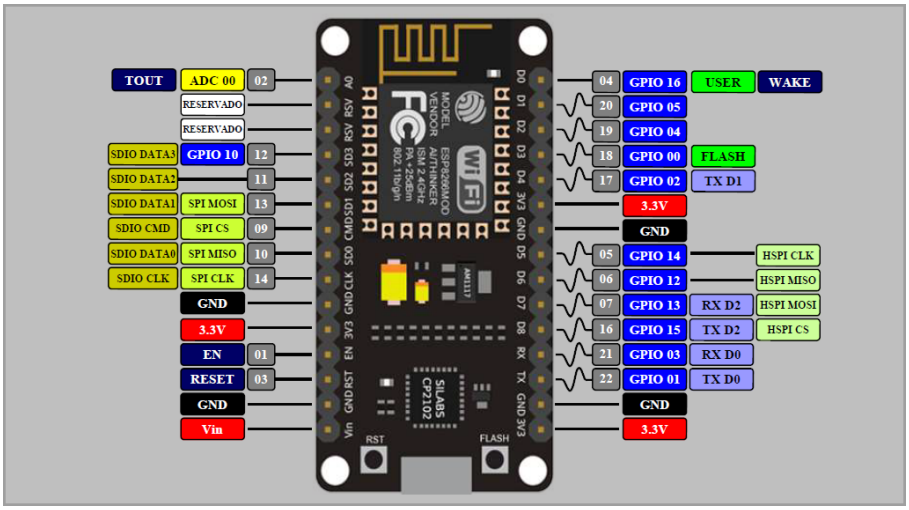


Figure : Node MCU Pin Out

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 breakout 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:
11. Transfer rate: 110-460800bps
12. Support UART / GPIO data communication interface
13. Remote firmware upgrade (OTA)
14. Flash size: 4Mbyte

Buck Converter:

The converter (step-down converter) is a DC-to-DC converter that reduces the voltage from the input (supply) to the output (load). It is an intermittent power supply (SMPS) project that usually involves at least two semiconductors (including a diode and a transistor), a capacitor, an inductor or two. To reduce the voltage, filters made of capacitors (sometimes combined with inductors) are usually added to the output (single-pass filter) and input (supply-side filter) of such a converter.



Figure DC -DC Buck Converter

DC-DC Buck Step Down Module LM2596 Power Supply is a 3-A load converter, capable of carrying a 3-A with a beautiful line and load pattern. These devices are available at an output voltage of 3.3 V, 5 V, 12 V, as well as a variable output voltage. The LM2596 system operates at a frequency change of 150kHz, thus allowing more precision filtering than would be required with high frequency converters

DC-DC Buck Converter Step Down Module LM2596 Power Supply is a step-down(buck) switching regulator, capable of driving a 3-A load with excellent line and load regulation. These devices are available in fixed output voltages of 3.3 V, 5 V, 12 V, and an adjustable output version. The LM2596 series operates at a switching frequency of 150kHz, thus allowing smaller sized filter components than what would be required with lower frequency switching regulators.

Specifications of DC-DC Buck Converter Step Down Module LM2596 Power Supply

1. Conversion efficiency: 92%(highest)
2. Switching frequency: 150KHz
3. Output ripple: 30mA9maximum)
4. Load Regulation: ± 0.5%
5. Voltage Regulation: ± 0.5%
6. Dynamic Response speed: 5% 200uS
7. Input voltage:4.75-35V
8. Output voltage:1.25-26V(Adjustable)
9. Switching Frequency: 150KHz
10. Rectifier: Non-Synchronous Rectification
11. Module Properties: Non-isolated step-down module (buck)
12. Short Circuit Protection: Current limiting, since the recovery
13. Operating Temperature: Industrial grade (-40 to +85) (output power 10W or less)

Laser Sensor

The VL53LXX-V2 is a compact and advanced Time-of-Flight (ToF) laser distance sensor manufactured by STMicroelectronics. It operates by emitting a tiny, invisible infrared laser beam and measuring the time it takes for the light to bounce back from a target surface. This method enables it to calculate distances with high accuracy and consistency, regardless of the target's color or reflectivity. The sensor supports a measurement range from 30 mm to approximately 2 meters, making it ideal for both close-range and short-range applications

One of the key features of the VL53LXX-V2 is its I2C communication interface, which allows easy integration with microcontrollers like Arduino or NodeMCU. It offers fast response times and low power consumption, making it suitable for battery-operated systems. The VL53LXX-V2 is widely used in applications such as robotics, smart devices, object detection, and brake pad monitoring systems, where accurate and non-contact distance sensing is required

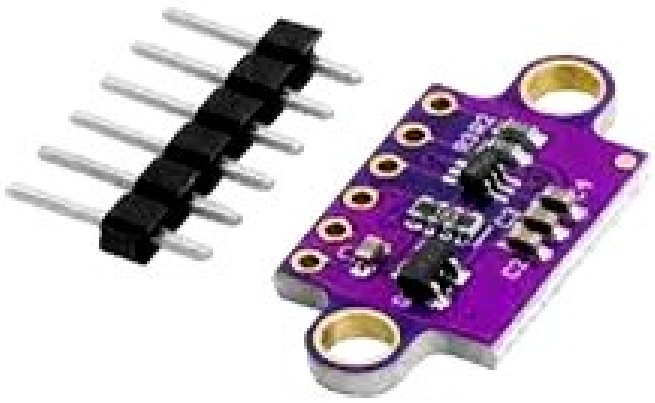


Figure : Laser Ranging Sensor

Specification

Product code: HCMODU0127

Supply Voltage: 2.6V to 5.5V

Average active ranging sensor current: 19mA

Interface: I2C

Dimension: 13mm x 11mm

Max ranging distance

Target reflectance level (Full FOV)	Conditions	Indoor (2)	Outdoor overcast (2)
White Target (88%)	Typical	200cm+ (1)	80cm
	Minimum	120cm	60cm
Grey Target (17%)	Typical	80cm	50cm
	Minimum	70cm	40cm

Table: Ranging Distance of Laser Sensor

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, 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



Figure: 3.7V BATTERY

Lithium batteries are widely used in portable consumer electronic devices. The term "lithium battery" refers to a family of different lithium-metal chemistry, 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.

Product Specification

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

LCD Display

The LCD (liquid crystal display) screen is an electronic display module and looks for various applications. A 16x2 LCD display is a very basic module and it is very commonly used in various devices and circuits. These modules are preferred over seven sections and many other segments



Figure: 16*2 LCD Display

The reasons for having LCD are economic; Easily programmable, special and even custom characters (different in seven sections), there are no restrictions on displaying animations. A 16x2 LCD means it can display 16 characters per line and contains 2 lines. Each character on this LCD is displayed in a 5x7 pixel matrix.

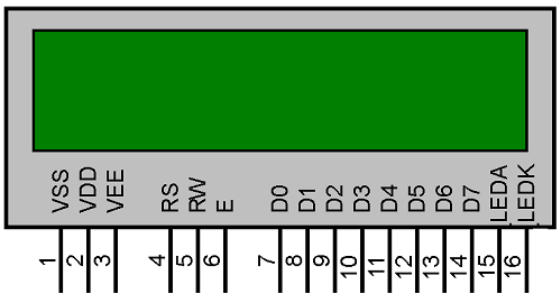


Figure: Pin out of 16*2 LCD Display

This LCD contains two articles called Command and Data. The command register stores the command instructions on the LCD. The command is a command given to the LCD to perform a predefined task such as starting it, clearing its screen, locating the cursor, controlling the display, etc.

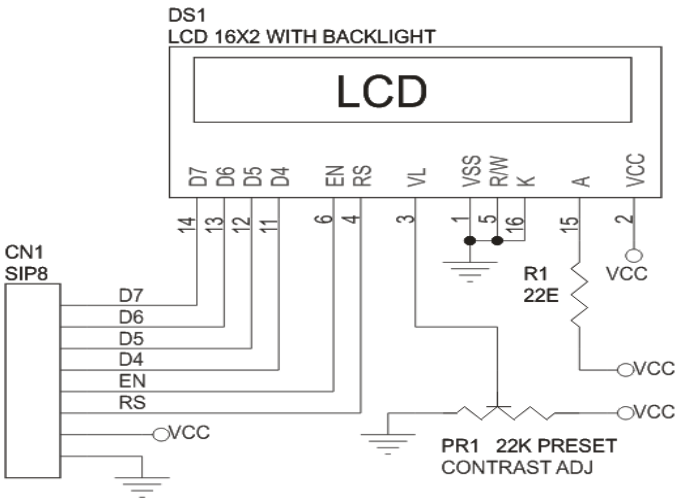


Figure 4.8: 16*2 LCD Display interfacing with Arduino

Feature

1. The features of this LCD mainly include the following.
2. The operating voltage of this LCD is 4.7V-5.3V
3. It includes two rows where each row can produce 16-characters.
4. The utilization of current is 1mA with no backlight
5. Every character can be built with a 5×8 pixel box
6. The alphanumeric LCDs alphabets & numbers

Buzzer

Piezo elements are actually one of the coolest crystals you'll play with. Flex them, they generate a voltage (pretty high, actually). Pass power through them, and they'll flex. Do it fast enough, and they'll start to make a sound! So besides making annoying little beep noises, you could use it as a sensor to detect a knock or other similar vibration



Specifications

1. Operating Voltage: 1.0 ~ 20.0V
2. Rated Voltage: 3.0V
3. Diameter: Ø12.5mm
4. Total Height: 6.3mm
5. Capacitance: 15,000Pf
6. Current Consumption: ≤2mA
7. Resonance Frequency: 4,000Hz

Break Pad

A brake pad is a crucial component of a motorcycle's braking system, responsible for creating friction against the brake disc (rotor) to slow down or stop the vehicle. Made from high friction materials like semi-metallic, ceramic, or organic composites, brake pads are mounted on the brake caliper. When the rider applies the brake lever, hydraulic pressure pushes the pads against the spinning disc, generating the friction needed to reduce wheel speed. Over time, brake pads wear down and must be replaced to maintain safe braking performance. Regular monitoring of brake pad thickness is essential to prevent brake failure and ensure rider safet y



Figure 4.9: Break Pad

SOFTWARE

The digital microcontroller 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 microcontroller 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 microcontroller 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 microcontroller units and has a number of facilities for communicating with a computer, another Arduino, or other microcontrollers. 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 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 Genuine hardware to upload programs and communicate with them

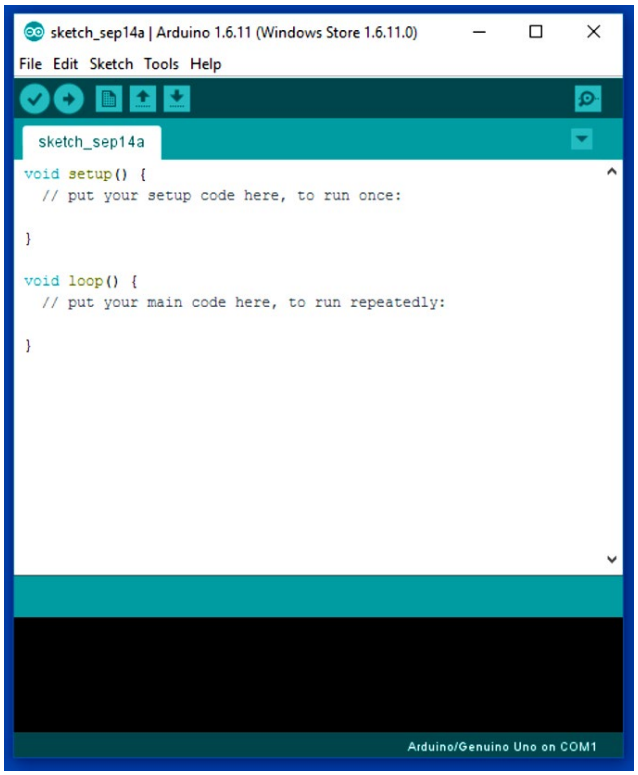


Figure 4.10: Arduino Software Interface IDE

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 microcontrollers, Atmel's development environment, AVR Studio or the newer Atmel Studio, may also be used to develop software for the Arduino.

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 righthand 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.

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, and Compilation

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 an 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 microcontroller 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 microcontroller. The bootloader 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, bootloaders, 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. Please note that the Serial Monitor does not process control characters; if your sketch needs a complete management of the serial communication with control characters, you can use an external terminal program and connect it to the COM port assigned to your Arduino board.

Easy EDA

Easy EDA 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. Easy EDA 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.

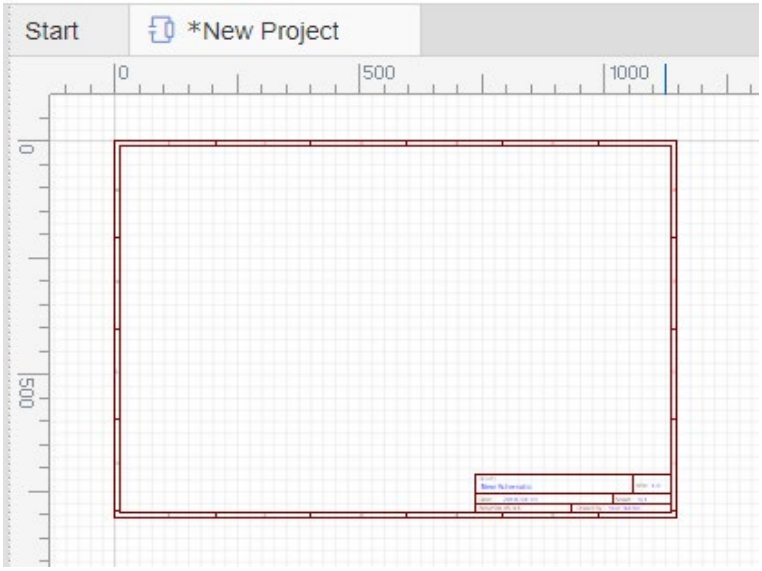


Figure : Easy EDA Software Interface

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, Easy EDA offers a PCB fabrication service. This service is also able to accept Gerber file inputs from third party tools

CHAPTER-04

SYSTEM ARCHITECTURE

Work Flow Diagram

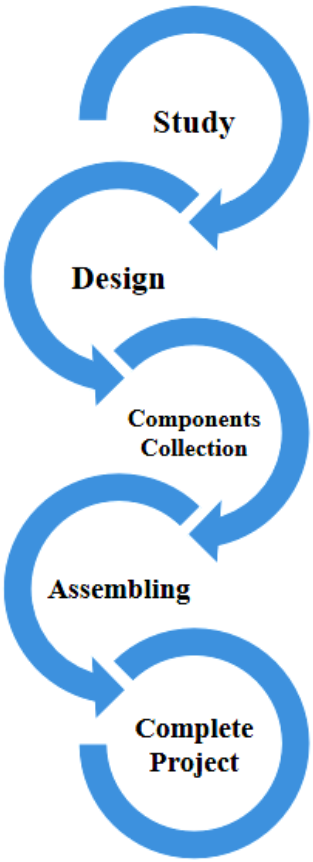


Figure : Working Flow Diagram

Block Diagram

Here is the block diagram of the Automated Brake Pad Monitoring and Tracking System with all the essential components. All of the components are shown in below as a block in this diagram.Here we use Node MCU Micro-controller of our project. Other equipment's are attached with this micro-controller and work together for perform as our desire outcome

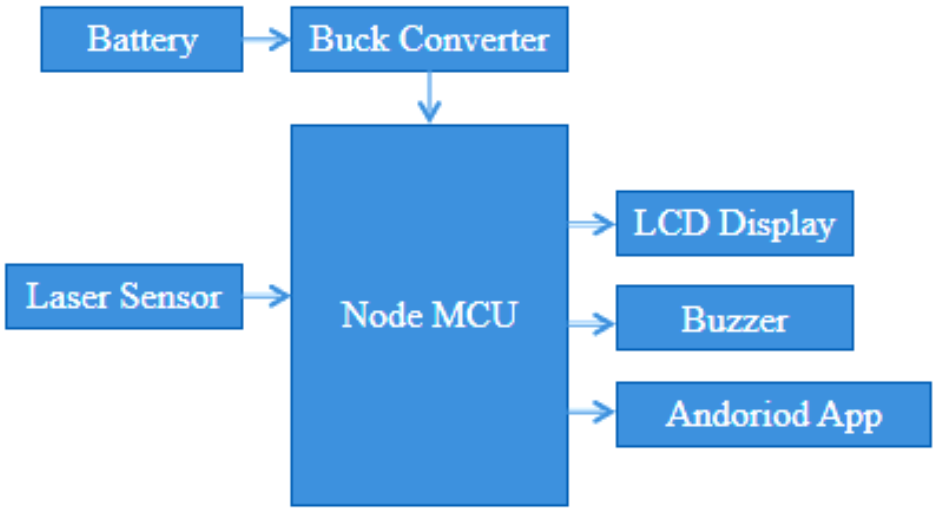


Figure : Block Diagram of Our Project

Circuit Diagram

The circuit diagram here is representing the electrical circuit and the components of the project. Here we have used standardized symbols and lines.

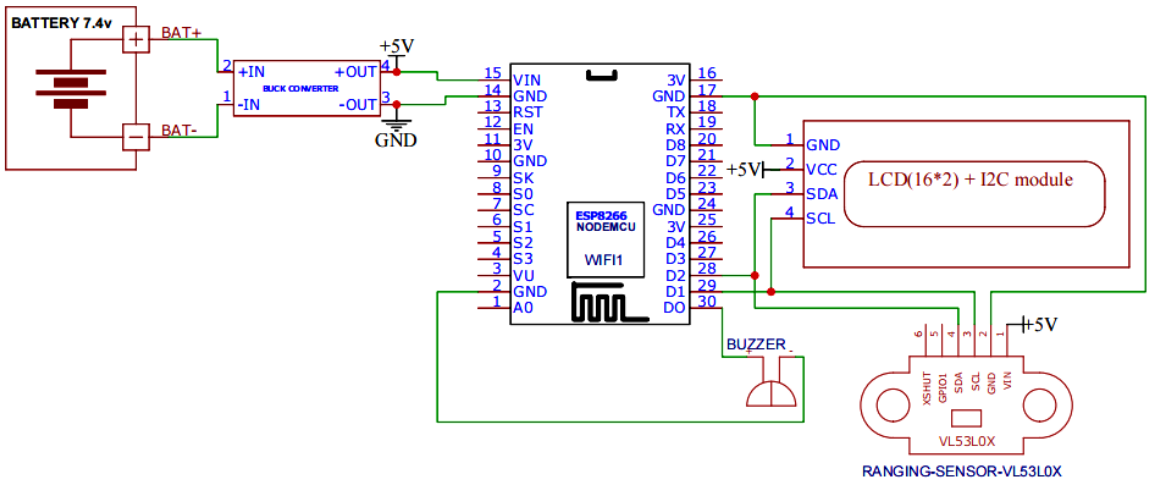


Figure : Circuit Diagram of Our Project

Working Principle

The motorcycle brake pad monitoring system operates by accurately detecting brake pad wear to ensure timely maintenance and enhance rider safety. The system is powered by a rechargeable battery, and a buck converter steps down the voltage to safely operate all electronic components. A high-precision laser sensor continuously measures the thickness of the brake pads. This data is sent to a NodeMCU, which functions as the central controller. When the pad thickness reduces by 50% of its original value, the NodeMCU activates a buzzer and displays a warning message on an LCD screen mounted on the bike. Simultaneously, it sends a real-time alert to a connected Android app via Wi-Fi, notifying the rider remotely. This smart monitoring system prevents unexpected brake failures and ensures the motorcycle's braking system remains in optimal condition.

Cost analysis

Sl. no	Particulars	Specification	Qty.	Unit Price (Taka)	Total Price (Taka)
1	Node MCU	ESP8266	1	750	750
2	Battery	3.7V	2	150	300
3	Buck converter	LM2596	1	150	150
4	LCD Display	16*2	1	450	450
5	Laser Sensor	VL53LXX-V2	1	550	500
6	Buzzer		1	50	50
7	Break Pad		3	700	2100
8	Others				3700
				Total	8000/=

Table: Project Cost

Complete Project Prototype

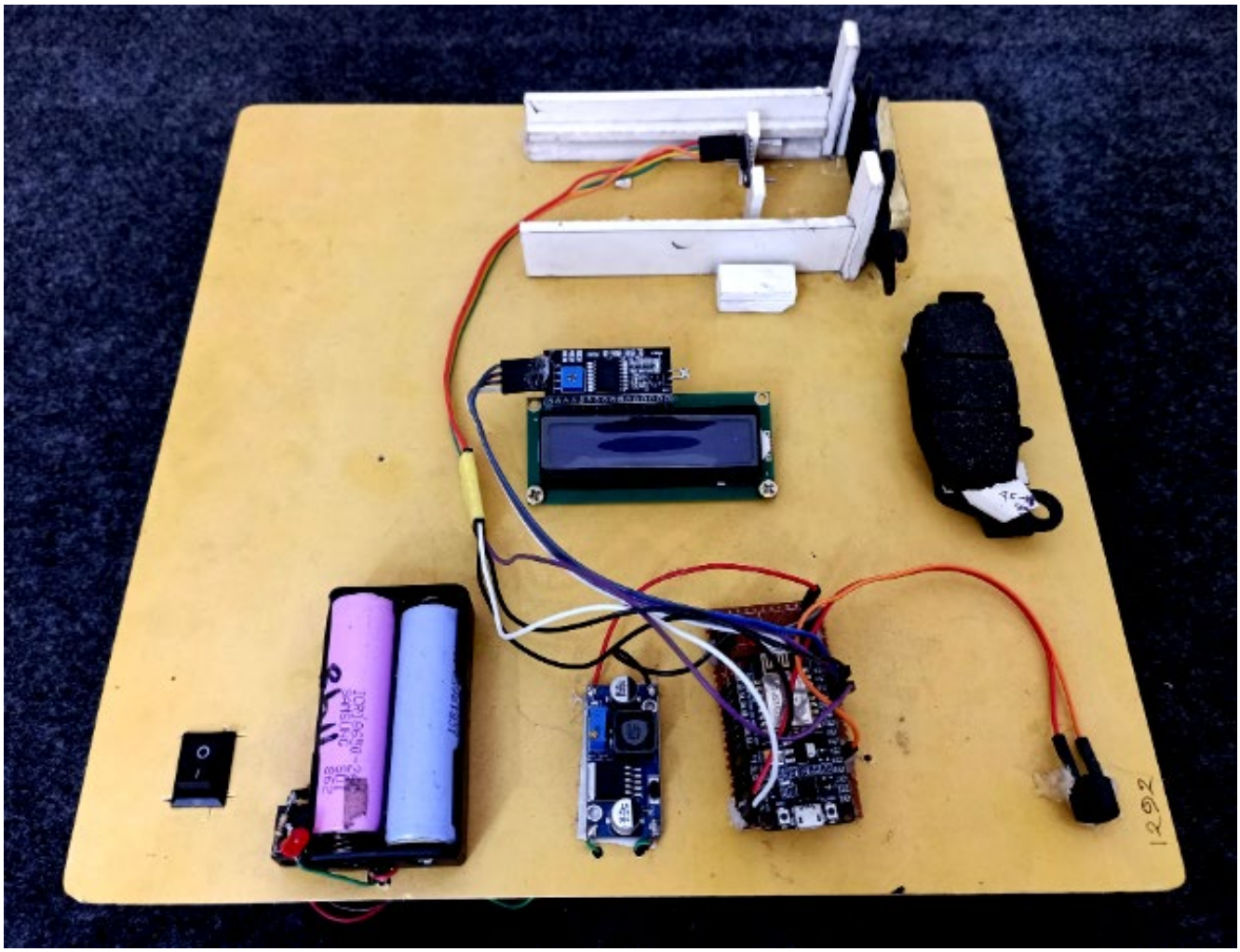


Figure : Automatic Brake Pad Monitoring and Tracking System

CHAPTER-05

RESULT AND DISCUSSION

Result:

Now, it's time to talk about the results. We have written our commands using the ArduinoIDE and the following things can happen: Our project is "Automotive Brake Pad Monitoring and Tracking 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 as reference.

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

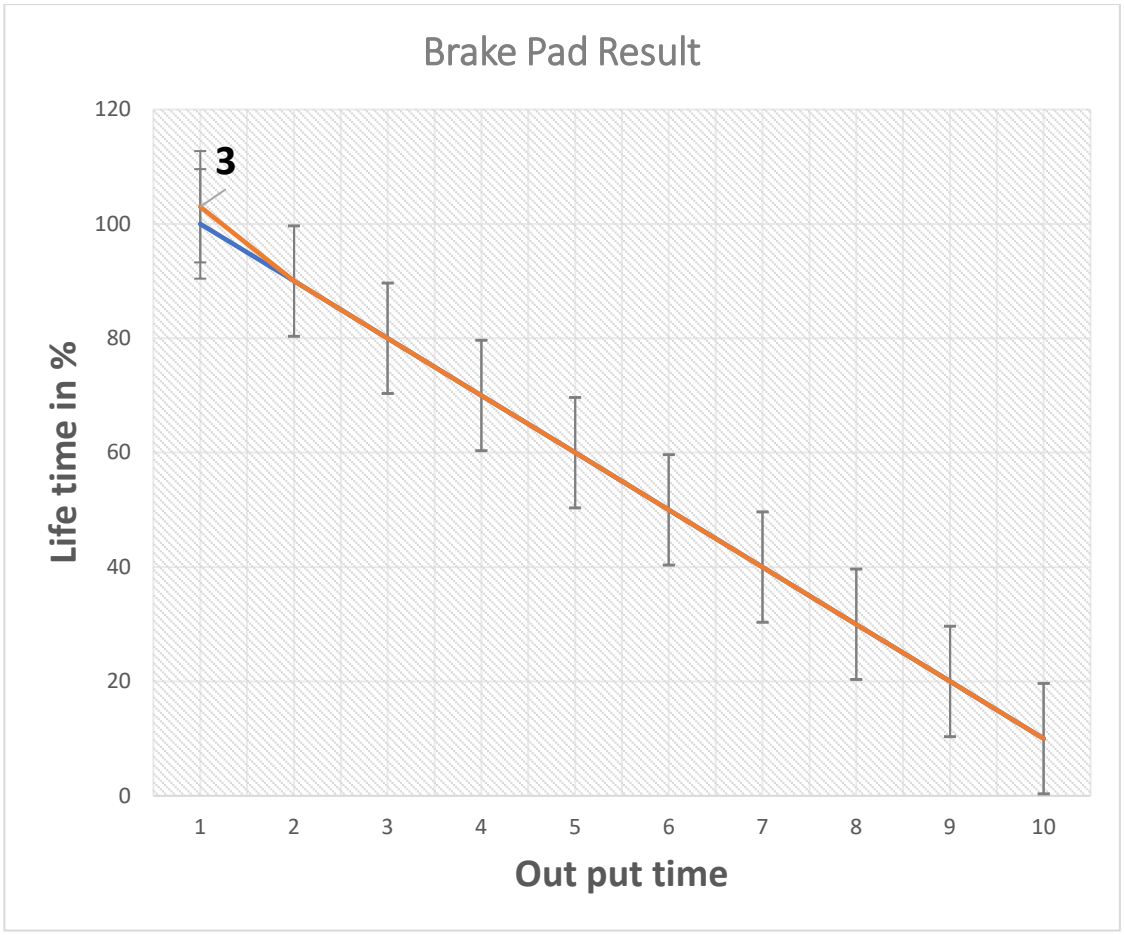


Figure Brake Pad lifetime 100%

Sl No	Brake Pad Thickness (%)	Result Showing Time	Vernier Caliper Measurement	Remarks
1	100%	3Sec	8.95mm	ok
2	100%	4Sec	8.95mm	ok
3	100%	3Sec	8.95mm	ok

Table : 100% Calculation timing

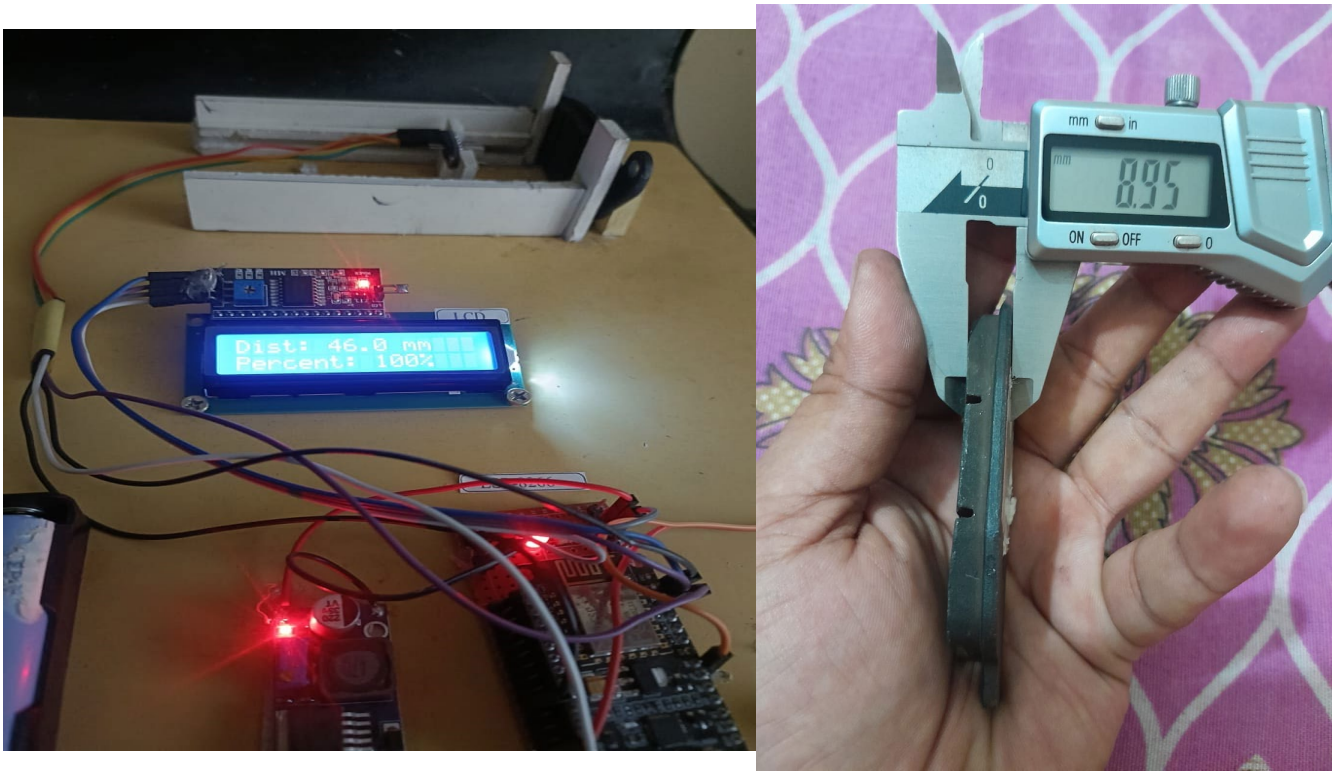


Figure: Brake Pad lifetime 100%

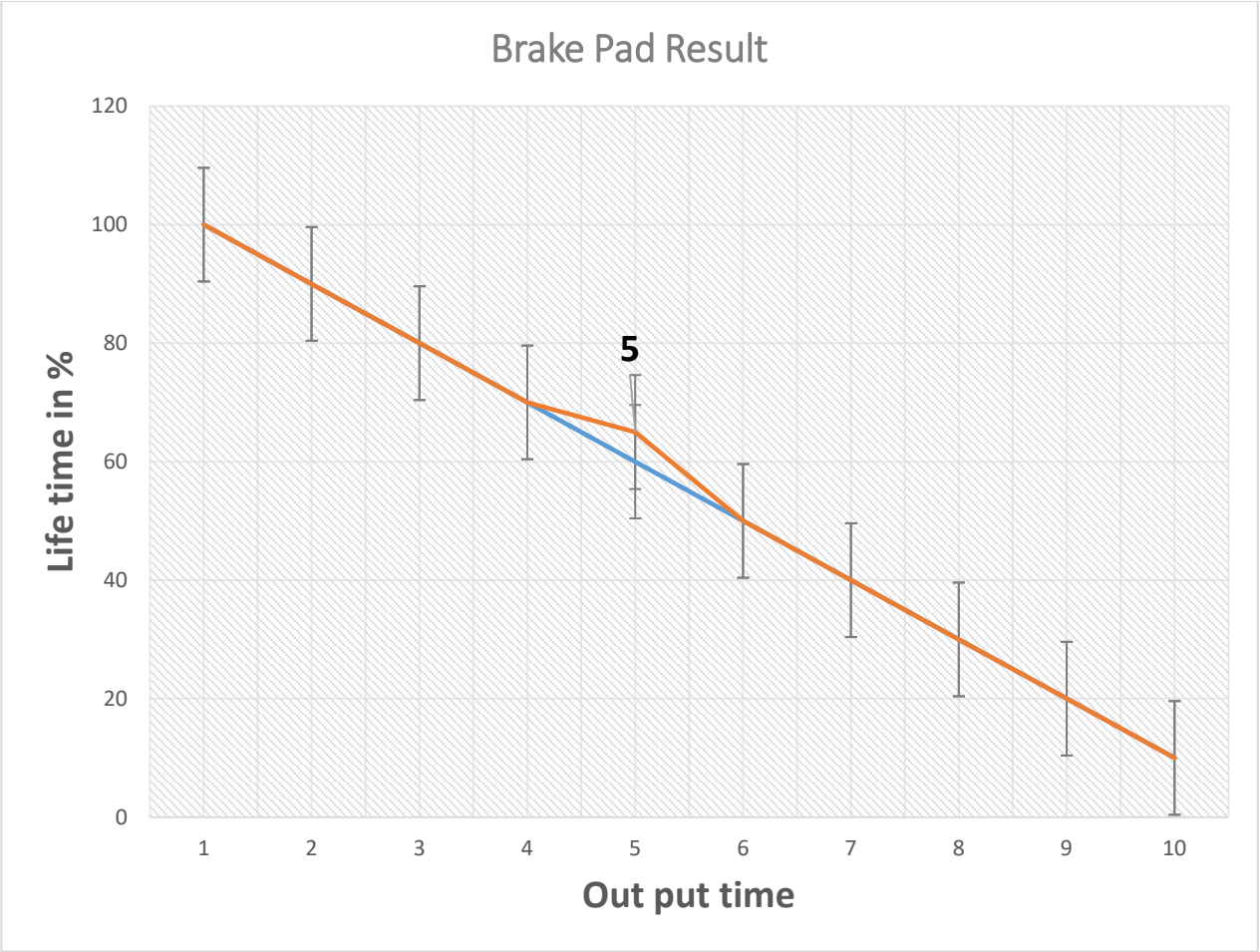


Figure: Brake Pad life time 60%

Sl No	Brake Pad Thickness (%)	Result Showing Time	Vernier Caliper Measurement	Remarks
1	60%	5sec	5.39mm	ok
2	60%	4sec	5.39mm	ok
3	60%	5sec	5.39mm	ok

Table ： 60% Calculation timing

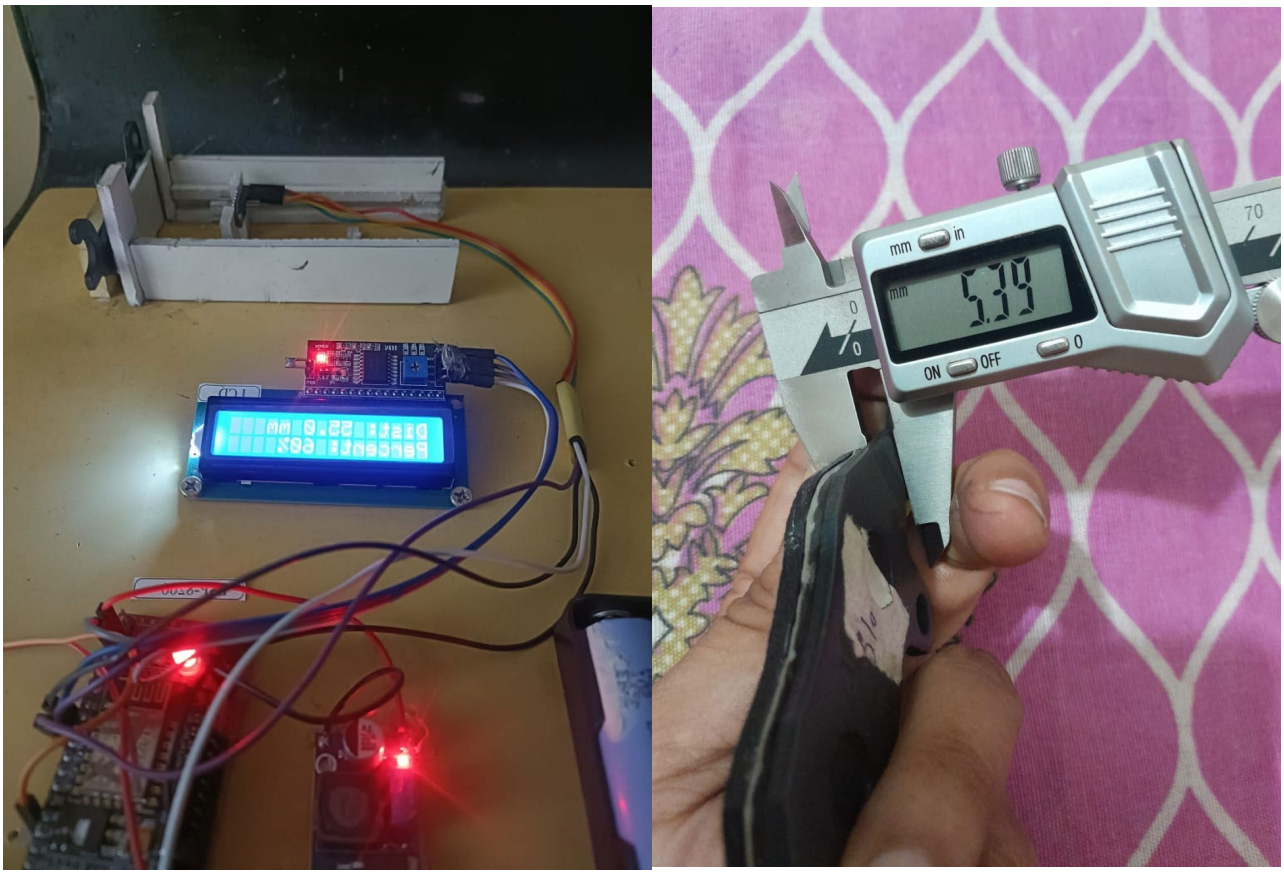


Figure : 60% Calculation timing

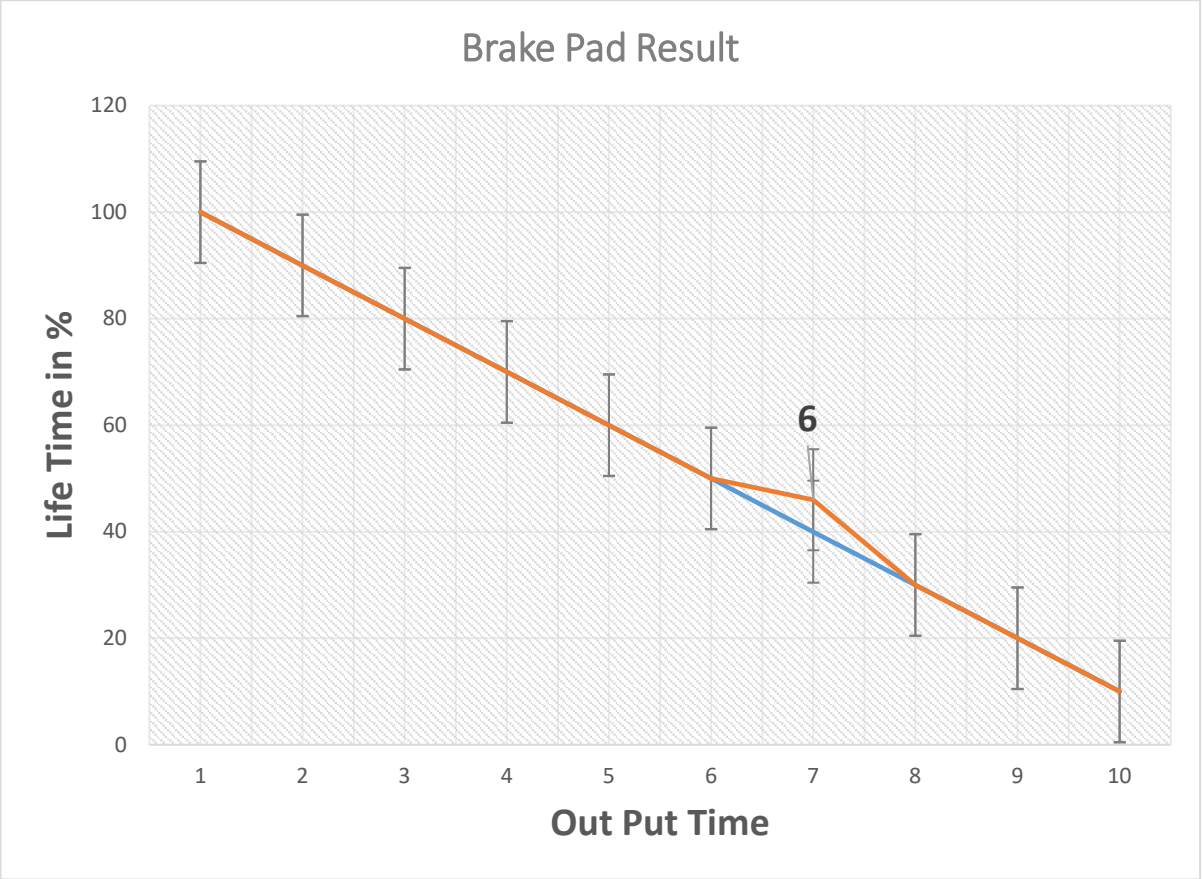


Figure : 40% Calculation timing

Sl No	Brake Pad Thickness (%)	Result Showing Time	Vernier Caliper Measurement	Remarks
1	40%	6Sec	3.59mm	ok
2	40%	7Sec	3.59mm	ok
3	40%	6Sec	3.59mm	ok

Table : 40% Calculation timing

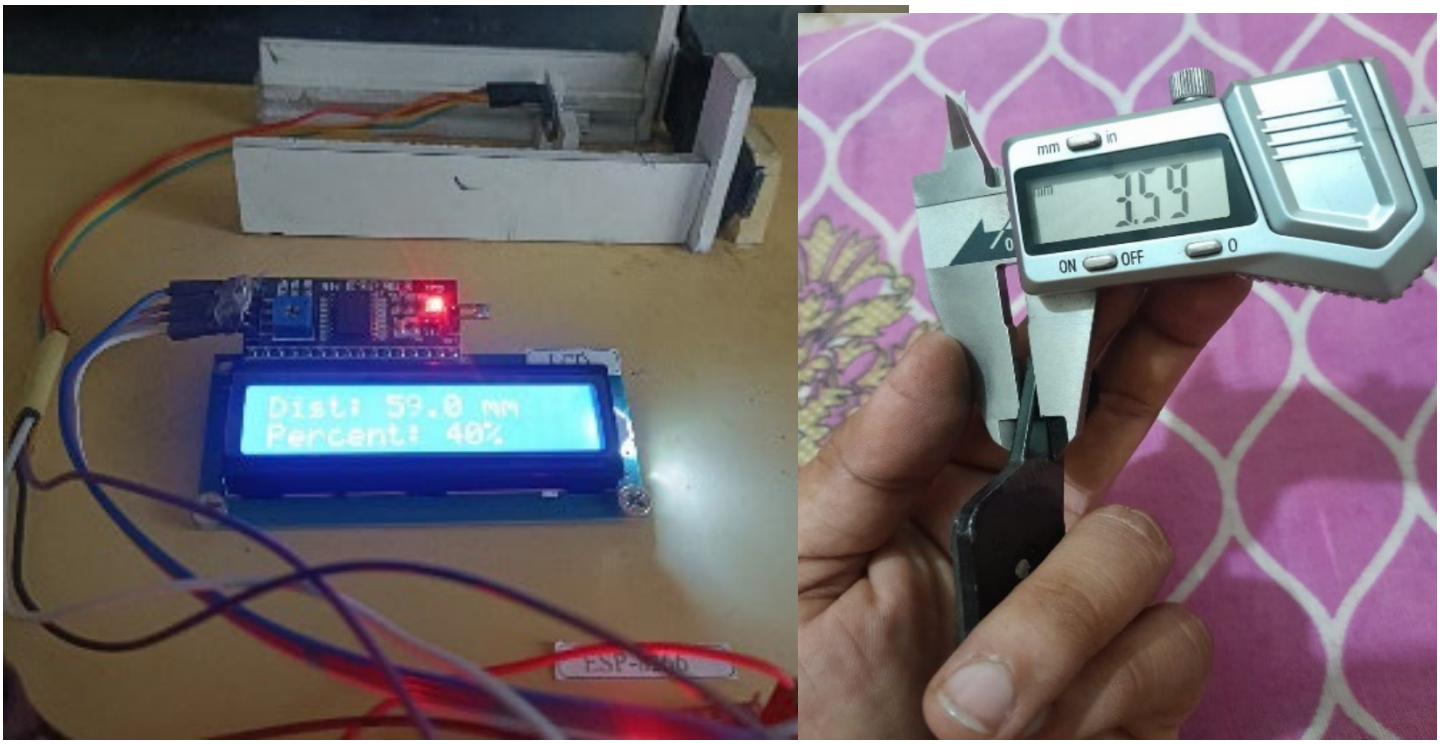


Figure : 40% Calculation timing

Benefits:

There are certainly many advantages of our project and some of the major ones have been given below:

Enhanced Safety: Continuous monitoring helps ensure that brake pads are in optimal condition, reducing the risk of brake failure and improving overall vehicle safety

Preventive Maintenance: By providing real-time data on brake wear, the system allows for timely maintenance, preventing costly repairs and extending the lifespan of braking components

Increased Efficiency: Monitoring systems can alert drivers to issues before they become serious, leading to more efficient driving and less downtime for repairs.

Improved Performance: Maintaining proper brake pad thickness ensures consistent braking performance, enhancing vehicle handling and response.

Cost Savings: Early detection of brake wear can save money on emergency repairs and replacements, as well as prevent damage to other braking components.

Driver Awareness: Alerts and notifications keep drivers informed about their brake status, promoting proactive vehicle care and responsible driving habits

Application:

Real-Time Wear Monitoring: Continuously tracks brake pad thickness and performance, providing instant alerts when replacement is needed.

Predictive Maintenance: Analyzes data to predict when brake pads will need servicing, allowing for proactive maintenance scheduling and reducing unexpected failures

Fleet Management: Used in commercial vehicle fleets to monitor the condition of brakes across multiple vehicles, improving overall fleet safety and reducing downtime.

Driver Alerts: Provides notifications to drivers regarding brake status, promoting responsible driving and timely maintenance actions.

Integration with Vehicle Systems: Can be integrated with onboard diagnostic systems, allowing for comprehensive vehicle health monitoring and streamlined maintenance processes.

Data Analytics: Collects and analyzes usage data to identify patterns in brake wear, enabling optimization of driving habits and brake performance.

Enhanced Vehicle Safety Features: Works alongside advanced driver-assistance systems (ADAS) to improve overall vehicle safety and performance through better braking management.

Future Scope Work:

We are thinking about adding many features to our project in the future to get more desirable outcomes. Some of the steps that we are thinking about taking are given below:

In future, we are looking forward to improving our whole system design to make it more efficient.

Braking system can be done depending on the speed and add some sensors. So that the accident will be reduced.

Depending on the sensor, the automatic brake system can be done without pressing the pedal.

The blend of swirl present and attractive powers makes this brake more successful.

Discussion:

The system is focusing on the controller design. At first, we collected all of the elements which are used in this project and connected it perfectly as our circuit design. The main controller is Arduin Nano. All of this instrument is controlled by Arduino Nano.

While working on our project, we did face some difficulties as it is a very complex system but the end results, we came up with were quite satisfactory. We have put the whole system through several tasks to validate our work and also have taken necessary notes for future improvements. Some future recommendations that we have involves improvement in system design and wiring, adding features to serve the whole system online

Conclusion:

In conclusion, a brake pad monitoring system is an essential tool for enhancing vehicle safety and performance. By providing real-time insights into brake wear, these systems enable drivers to maintain optimal braking conditions, significantly reducing the risk of failure and accidents. Early detection of wear allows for timely preventive maintenance, leading to cost savings on repairs and prolonging the lifespan of braking components. Additionally, the data collected can inform better driving habits and optimize vehicle maintenance strategies. As technology advances, integrating such monitoring systems into vehicles not only promotes safer driving but also supports efficient and responsible vehicle ownership. Overall, a brake pad monitoring system is a valuable investment that ensures the reliability and safety of any vehicle.

REFERENCES

[1] RadhakishanMaske, Satesh Surwase, Balbhim Moharir, Vrushabh Mahajan, Vijay Kedar, Prof.Amol Adkine "Automatic brake failure indicator and braking system" in International Journal of Advance Research and Innovative Ideas in EducationVol-3 Issue 32017http://ijariie.com/AdminUploadPdf/AUTOMATIC_BRAKE_FAILURE_INDICATOR_AND_BRAKING_SYSTEM_ij ariie5483.pdf

[2] N.Venkatachalapathi V. Mallikarjuna "Automatic Brake Failure Indicator and Over Heating Alarm"in International Journal of Engineering Science and Computing, Volume6 IssueNo.7July2016http://ijesc.org/upload/99d41a4418e5e416d392fe63ff706e92 .Automatic%20Brake%20Failure%20Indicator%20and%20Ove r%20Heating%20Alarm.pdf

[3] Sarvendra Kumar Mehra, "A review of experimental study of brake pad material" in International Journal of Emerging Trends in Engineering and Development Issue 3, Vol.6

[4] Sivarao, M. Amarnath, M.S.Rizal and A.Kamely, "An Investigation Toward Development Of Economical Brake Lining Wear Alert System" in International Journal of Engineering & Technology IJET-IJENS Vol:09 No 09

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

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

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

[8] Zmago Stadler, 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.

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.

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

[10] https://en.m.wikipedia.org/wiki/Switched-mode_power_supply

https://en.m.wikipedia.org/wiki/Switched-mode_power_supply

https://easyeda.com/modules/12V-5A-POWER-SUPPLY_049de4e1115f4c008d75604205daef7d

https://www.electronics-tutorials.ws/power/switch-mode-power-supply.html

https://www.researchgate.net/figure/Schematic-Diagram-of-Arduino-Nano_fig2_362509565

https://www.hackatronic.com/ultrasonic-sensor-without-arduino-using-555- timer/

https://www.hackatronic.com/ultrasonic-sensor-without-arduino-using-555- timer/

https://store.roboticsbd.com/display/661-standard-lcd-16x2-display-yellow- backlight-robotics-bangladesh.html

https://circuitdigest.com/article/16x2-lcd-display-module-pinout-datasheet

https://www.electronicwings.com/arduino/lcd-16x2-interfacing-with-arduino-uno

https://en.m.wikipedia.org/wiki/AA_battery

https://www.electroduino.com/distance-measurement-using-ultrasonic-sensor- and-arduino-with-lcd-display/

https://bajajauto.sharepoint.com/sites/GO2/After%20Sales/Product/Discover_April%202020%20Onwards/NPC/NP-79_Introduction%20of%20Discover%20110%20-%20125.pdf

Appendix

```
#define BLYNK_TEMPLATE_ID "TMPL6jAp1hSdI"
#define BLYNK_TEMPLATE_NAME "Monitoring"
#define BLYNK_AUTH_TOKEN "tUASE0G3-JUmyBEB-8qCu2JrTGsWyCKF"

#include <Wire.h>
#include <Adafruit_VL53L0X.h>
#include <LiquidCrystal_I2C.h>
#include <ESP8266WiFi.h>
#include <BlynkSimpleEsp8266.h>

// Wi-Fi credentials
char ssid[] = "abcde";           // Replace with your Hotspot name
char pass[] = "123456789";       // Replace with your Hotspot password

#define buzzer D7 // Buzzer pin

Adafruit_VL53L0X lox = Adafruit_VL53L0X();
LiquidCrystal_I2C lcd(0x27, 16, 2); // I2C address and 16x2 LCD

void sendNotification() {
  Serial.println("Notification: Brake pad thickness is 50% or lower. Please change it!");
  Blynk.logEvent("brake_alert", "Warning! Brake pad thickness is low. Please check.");
}
void connectToWiFi() {
  WiFi.begin(ssid, pass);
  Serial.print("Connecting to Wi-Fi");
```

```
  int retry = 0;
  while (WiFi.status() != WL_CONNECTED && retry < 30) {
    delay(500);
    Serial.print(".");

    retry++;
  }

  if (WiFi.status() == WL_CONNECTED) {
    Serial.println("\nWi-Fi connected.");
    Serial.print("IP Address: ");
    Serial.println(WiFi.localIP());
  } else {
    Serial.println("\nFailed to connect to Wi-Fi. Please check credentials or hotspot.");
  }
}

void setup() {
  Serial.begin(115200);
  pinMode(buzzer, OUTPUT);
  digitalWrite(buzzer, LOW);

  lcd.init();
  lcd.backlight();
  lcd.setCursor(0, 0);
  lcd.print("Initializing...");

  if (!lox.begin()) {
    Serial.println("Failed to initialize VL53L0X!");
```

```
    lcd.setCursor(0, 1);
    lcd.print("Sensor Failed!");
    while (1);
  }

  lox.setMeasurementTimingBudgetMicroSeconds(100000);

  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("Project is Ready");
  delay(1000);
  lcd.clear();

  connectToWiFi();

  Blynk.config(BLYNK_AUTH_TOKEN);
  if (WiFi.status() == WL_CONNECTED) {
    Blynk.connect();
  }
}

float getStableDistanceMM() {
  const int samples = 11;
  uint16_t distances[samples];
  int validCount = 0;

  for (int i = 0; i < samples; i++) {
    VL53L0X_RangingMeasurementData_t measure;
    lox.rangingTest(&measure, false);
```

```
    if (measure.RangeStatus == 0) {
      distances[validCount++] = measure.RangeMilliMeter;
    }

    delay(10);
  }

  if (validCount == 0) return -1.0;

  // Sort for median
  for (int i = 0; i < validCount - 1; i++) {
    for (int j = 0; j < validCount - i - 1; j++) {
      if (distances[j] > distances[j + 1]) {
        uint16_t temp = distances[j];
        distances[j] = distances[j + 1];
        distances[j + 1] = temp;
      }
    }
  }

  return (float)distances[validCount / 2];
}

void loop() {
  if (WiFi.status() != WL_CONNECTED) {
    Serial.println("Wi-Fi disconnected. Reconnecting...");
    connectToWiFi();
    Blynk.connect();
  }
```

```
Blynk.run();

float distanceMM = getStableDistanceMM();
int pad = 0;

lcd.setCursor(0, 0);
lcd.print("Dist:           ");
lcd.setCursor(0, 1);
lcd.print("Percent:        ");

if (distanceMM > 0) {
  Serial.print("Distance: ");
  Serial.print(distanceMM, 1);
  Serial.println(" mm");

  lcd.setCursor(6, 0);
  lcd.print(distanceMM, 1);
  lcd.print(" mm ");

  lcd.setCursor(9, 1);

  if (distanceMM >= 45 && distanceMM <= 49) {
    pad = 100;
    lcd.print("100%   ");
  } else if (distanceMM >= 50 && distanceMM <= 52) {
    pad = 40;
    lcd.print("40%    ");
  } else if (distanceMM >= 53 && distanceMM <= 59) {
```

```
    pad = 60;
      lcd.print("60%    ");
    } else {
      lcd.print("N/A    ");
    }

    Blynk.virtualWrite(V1, pad);  // Send pad % to Blynk

    if (pad > 0 && pad <= 50) {
      sendNotification();         // Send alert
      digitalWrite(buzzer, HIGH); // Turn on buzzer
    } else {
      digitalWrite(buzzer, LOW);  // Turn off buzzer
    }

  } else {
    Serial.println("No valid measurement.");
    lcd.setCursor(0, 1);
    lcd.print("Out of range    ");
    digitalWrite(buzzer, LOW);
  }

  delay(5000);
}
```