Performance Evaluation and Life Prediction of Motorcycle Brake Pads Using Sensor Based Monitoring.

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May, 2025.

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Thesis Submitted to the Department of Mechanical Engineering, Sonargaon University in partial fulfillment of the requirements for the award of the degree of Bachelor of Science in Mechanical Engineering.

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May, 2025.

DECLARATION

We, the undersigned, hereby affirm that the work presented in this project is the result of our own investigation and research, conducted under the guidance of M.I. Washif Rahman, Lecturer in the Department of Mechanical Engineering at Sonargaon University (SU). We further confirm that no portion of this project has been or will be submitted for the award of any other degree.

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CERTIFICATION OF APPROVAL

The thesis title "**Performance Evaluation and Life Prediction of Motorcycle Brake Pads Using Sensor Based Monitoring**" is submitted by Shipon Chandra Sheel (ID No: BME1702012134), MD.Jubaer Hossen (ID No: BME2001020256), Shimul Chandro Sarker (ID No: ME2103025009), Pranta Mondal (ID No: ME2103025012) and Probir Kumar Biswas (ID No: ME2103025041), has been accepted as satisfactory partial fulfillment of the requirement for the Degree of Bachelor of Science in Mechanical Engineering on 18 May, 2025.

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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

1.1 Introduction:

Today, numerous road accidents occur due to various factors, one of the major causes being brake failure—often resulting from poor maintenance or manufacturing defects. According to data from the National Crime Records Bureau, Ministry of Road Transport & Highways, and the Law Commission of Bangladesh, two serious accidents happen every minute in the country, and 24 people die on Indian highways every hour, with many fatalities linked to brake failure.

To safeguard human lives, monitoring the condition of vehicle brakes is critically important. Vehicle safety focuses on either preventing accidents altogether or reducing the severity of injuries when they do occur. Extensive research has been conducted to both improve the effectiveness of brake pads and to develop systems that can monitor their condition in real time.

This research paper presents a system designed to continuously monitor brake pad wear using a position sensor. Brakes, which are mechanical devices that slow or stop a vehicle by creating friction, convert the vehicle's kinetic energy into heat. Over time, the friction between the brake pad and the disc rotor causes the brake pad to wear down, which can lead to failure if left unmonitored.

Brake pads, essential components of disc brake systems, consist of a steel backing plate and a friction material that presses against the rotor. When the brake lining wears out, brake efficiency drops, increasing the risk of accidents. To address this issue, a Brake Pad Wear Indication System has been proposed. This system uses a position sensor mounted near the disc caliper and disc plate to monitor brake pad condition.

The sensor sends real-time data to a microcontroller, which then alerts the driver via an indicator light on the vehicle's dashboard when the brake pad is excessively worn. This proactive warning system enhances vehicle safety by ensuring timely maintenance, potentially preventing accidents.

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.

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 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.

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.

1.4 Objectives:

Our Project Objectives are:

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

CHAPTER-2

2.1 Introduction:

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.

2.2 Literature Review:

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.

[1] 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.

[2] 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.

[4] 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.

[5] 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 a few large plateaus. Moreover, in the silent pressure interval, the size of the contact plateaus increases speedily with brake pressure.

[7] 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.

[9] 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.

[10] 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.

2.3 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

3.1 Introduction:

This Project has worked on two things, Hardware and Software.

3.2 Required Instrument:

Hardware

- SMPS
- Buck Converter
- Ultrasonic Sensor
- Battery
- LCD Display
- Arduino Nano

3.3 SMPS:

A switched-mode power supply (SMPS), also known by names like switching-mode or switch-mode power supply, is an efficient electronic power supply that uses a switching regulator to convert electrical energy. Unlike linear power supplies, the switching element in an SMPS rapidly alternates between fully on and fully off states, minimizing the time spent in high power dissipation regions. This design significantly reduces energy loss, and in an ideal case, an SMPS would dissipate no power at all.

Voltage regulation in SMPS is achieved by adjusting the duty cycle—the ratio of on-time to off-time—of the switching component. In contrast, linear power supplies regulate output voltage by continuously dissipating excess energy through the pass transistor. The resulting high energy efficiency is one of the key benefits of SMPS technology.



Fig 3.1: SMPS. [11]

Switched-mode power supplies may also be substantially smaller and lighter than a linear supply due to the smaller transformer size and weight. Switching regulators are used as replacements for linear regulators when higher efficiency, smaller size or lighter weight are required. They are, however, more complicated; their switching currents can cause electrical noise problems if not carefully suppressed, and simple designs may have a poor power factor.

12V 5A Industrial SMPS Power Supply – 60W – DC Metal Power Supply – Good Quality – Non- Waterproof with Aluminum casing.

- Input Voltage: AC 100 – 264V 50 / 60Hz.
- Output Voltage: 12V DC, 0-5A.
- Output voltage: Adjustment Range: ±20%.
- Protections: Overload / Over Voltage / Short Circuit.
- Auto-Recovery After Protection.
- Universal AC input / Full range.
- 100% Full Load Burn-in Test.
- Cooling by Free Air Convection.
- High Quality and High Performance.
- LED power supply with a metal body for hidden installation for LED lighting.
- Design with Built-in EMI Filter, improve signal precision.
- Certifications: CE & RoHs.
- No Minimum Load.
- Compact Size Light Weight.
- High Efficiency, Reliability & low energy consumption.

Switched-mode power supplies are classified according to the type of input and output voltages. The four major categories are:

- AC to DC.
- DC to DC.
- DC to AC.
- AC to AC.

A basic isolated AC to DC switched-mode power supply consists of:

- Input rectifier and filter.
- Inverter consisting of switching devices such as MOSFETS.
- Transformer.
- Output rectifier and filter.
- Feedback and control circuit.

The input DC supply from a rectifier or battery is fed to the inverter where it is turned on and off at high frequencies of between 20 KHz and 200 KHz by the switching MOSFET or power transistors. The high-frequency voltage pulses from the inverter are fed to the transformer primary winding, and the secondary AC output is rectified and smoothed to produce the required DC voltages. A feedback circuit monitors the output voltage and instructs the control circuit to adjust the duty cycle to maintain the output at the desired level.

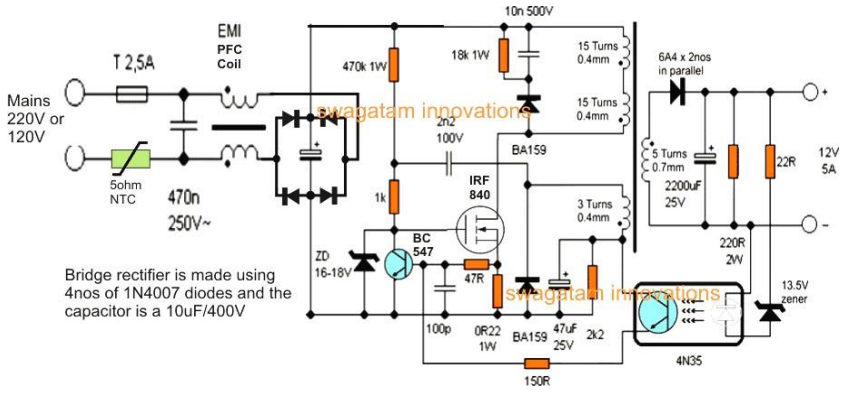


Fig 3.2: SMPS Circuit Design. [12]

Basic working concept of the SMPS:

In a Switch Mode Power Supply (SMPS), voltage regulation is handled by a switching regulator. It uses a series switch to rapidly turn the current flow to a smoothing capacitor on and off. The voltage across this capacitor is monitored and used to adjust the duration for which the switch remains on. This high-speed switching process ensures that the capacitor maintains a steady output voltage at the desired level.

Design basics:

The AC input typically first goes through protective fuses and a line filter to suppress noise and spikes. It is then converted into DC using a full-wave bridge rectifier. This rectified voltage is fed into a Power Factor Correction (PFC) pre-regulator, which optimizes efficiency and reduces line current distortion, followed by one or more downstream DC-DC converters for final voltage regulation.

Devices like computers and small appliances commonly use the IEC (International Electrotechnical Commission) input connector. However, aside from standardized systems like PC and Compact PCI, output connectors and pin configurations are generally not uniform and are determined by individual manufacturers.
Power supply designs use a variety of circuit topologies, each with its own operational characteristics, benefits, and applications. These topologies dictate how electrical power is processed from input to output. Popular isolated topologies—such as flyback, push-pull, half-bridge, and full-bridge—utilize transformers for galvanic isolation, voltage transformation, and multiple output generation. In contrast, non-isolated topologies lack a transformer and rely on inductive energy transfer for power conversion.

Advantages of switched-mode power supplies:

- Higher efficiency of 68% to 90%.
- Regulated and reliable outputs regardless of variations in input supply voltage.
- Small size and lighter.
- Flexible technology.
- High power density.

Disadvantages:

- Generates electromagnetic interference.
- Complex circuit design.
- Expensive compared to linear supplies.

Switched-mode power supplies are used to power a wide variety of equipment such as computers, sensitive electronics, battery-operated devices and other equipment requiring high efficiency.

Switch Mode Power Supply:

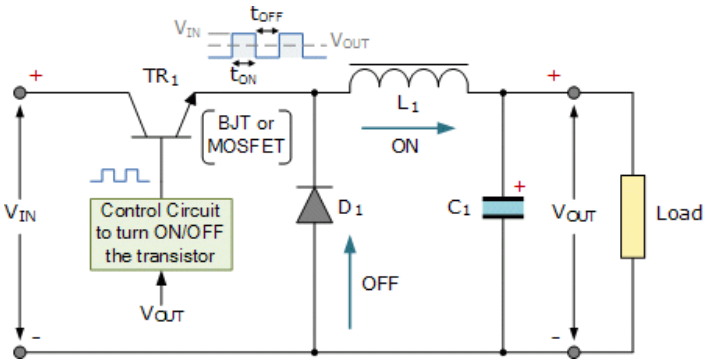


Fig 3.3: Power Supply Connection. [13]

Linear voltage IC regulators have been the basis of power supply designs for many years as they are very good at supplying a continuous fixed voltage output. Linear voltage regulators are generally much more efficient and easier to use than equivalent voltage regulator circuits made from discrete components such a Zener diode and a resistor, or transistors and even op-amps.

The most popular linear and fixed output voltage regulator types are by far the 78… positive output voltage series, and the 79… negative output voltage series. These two types of complementary voltage regulators produce a precise and stable voltage output ranging from about 5 volts up to about 24 volts for use in many electronic circuits.

There is a wide range of these three-terminal fixed voltage regulators available each with its own built-in voltage regulation and current limiting circuits. This allows us to create a whole host of different power supply rails and outputs, either single or dual supply, suitable for most electronic circuits and applications. There are even variable voltage linear regulators available as well providing an output voltage which is continually variable from just above zero to a few volts below its maximum voltage output.

Most DC power supplies comprise of a large and heavy step-down mains transformer, diode rectification, either full-wave or half-wave, a filter circuit to remove any ripple content from the rectified DC producing a suitably smooth DC voltage, and some form of voltage regulator or stabilizer circuit, either linear or switching to ensure the correct regulation of the power supplies output voltage under varying load conditions. Then a typical DC power supply would look something like this:

Typical DC Power Supply:

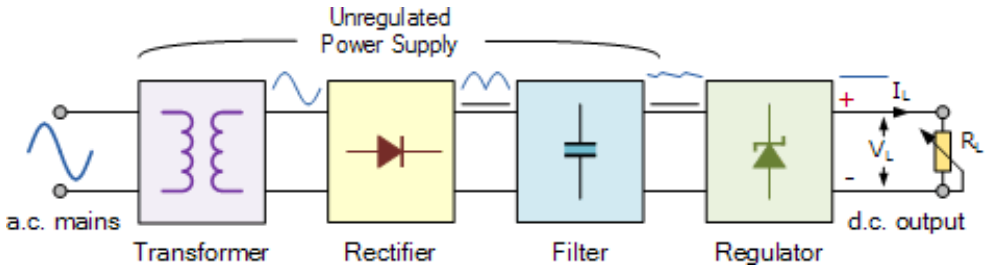


Fig 3.4: DC Power Supply Step. [14]

These typical power supply designs contain a large mains transformer (which also provides isolation between the input and output) and a dissipative series regulator circuit. The regulator circuit could consist of a single Zener diode or a three-terminal linear series regulator to produce the required output voltage. The advantage of a linear regulator is that the power supply circuit only needs an input capacitor, output capacitor and some feedback resistors to set the output voltage.

3.4 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.

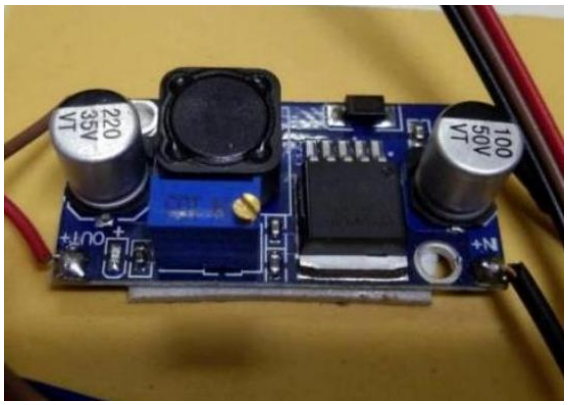


Fig 3.5: DC-DC Buck Converter.

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.

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

- Conversion efficiency: 92% (highest).
- Switching frequency: 150KHz.
- Output ripple: 30mA9max).
- Load adjustment: ± 0.5%.
- Voltage adjustment: ± 0.5%.
- Dynamic response rate: 5% 200 uS.
- Input voltage: 4.75-35V.
- Output voltage: 1.25-26 V (adjustable).
- Output current: rated current 2A, maximum 3A (additional heat sink required).
- Conversion efficiency: up to 92% (higher output voltage, higher efficiency).
- Switching frequency: 150KHz.
- Rectifier: Asynchronous straightening.
- Module properties: non-isolated top-down module (fee).
- Short circuit protection: current limitation since recovery.
- Operating temperature: industrial grade (-40 to +85) (output power 10 W or less).

3.5 Arduino Nano:

Arduino is open-source electronics prototyping platform based on flexible, easy-to-use hardware and software. It's intended for artists, designers, hobbyists, and anyone interested in creating interactive objects or environments. Arduino can sense the environment by receiving input from a variety of sensors and can affect its surroundings by controlling Lights, motors, and other actuators.

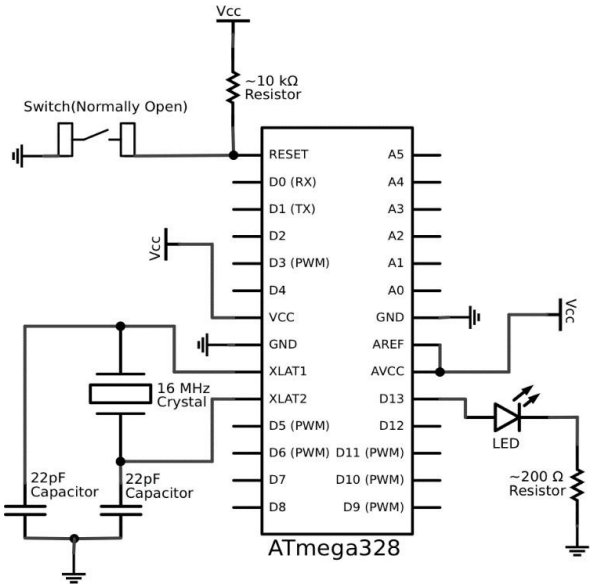


Fig 3.6: Schematic Diagram of Arduino Nano. [15]

The microcontroller on the board is programmed using the Arduino programming language (based on Wiring) and the Arduino development environment (based on Processing). Arduino projects can be stand-alone or they can communicate with software on running on a computer (e.g. Flash, Processing, Max MSP).

Arduino Nano is a surface mount breadboard embedded version with integrated USB. It is a smallest, complete, and breadboard friendly. It has everything that Diecimila/Duemilanove has (electrically) with more analog input pins and onboard +5V AREF jumper. Physically, it is missing power jack. The Nano is automatically sense and switch to the higher potential source of power.

Nanos got the breadboard-ability of the Boarduino and the Mini +USB with smaller footprint than either, so users have more breadboard space. It’s got a pin layout that works well with the Mini or the Basic Stamp (TX, RX, ATN, GND on one top, power and ground on the other). This new version 3.0 comes with ATMEGA328 which offer more programming and data memory space. It is two layers. That make it easier to hack and more affordable.

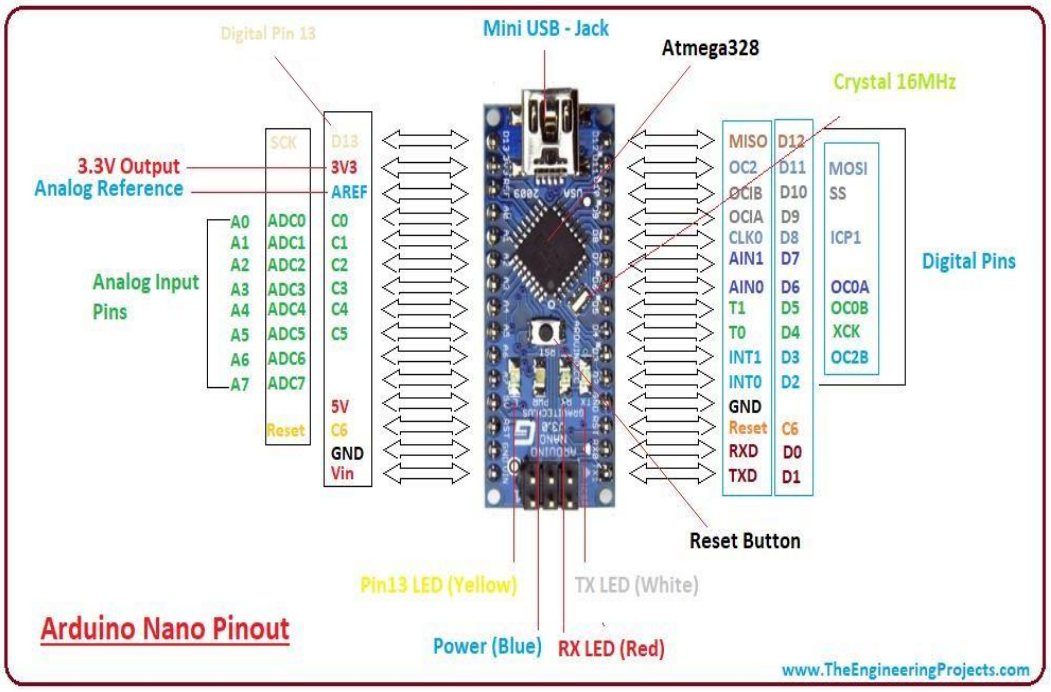


Fig 3.7: Arduino Pin Output. [16]

Specifications:

- Microcontroller : Atmel ATmega328
- Operating Voltage (logic level) : 5 V
- Input Voltage (recommended) : 7-12 V
- Input Voltage (limits) : 6-20 V
- Digital I/O Pins : 14 (of which 6 provide PWM output)
- Analog Input Pins : 8
- DC Current per I/O Pin : 40 mA
- Flash Memory : 32 KB (of which 2KB used by boot loader)
- SRAM : 2 KB
- EEPROM : 1 KB
- Clock Speed : 16 MHz
- Dimensions : 0.70” x 1.70”

Features:

- Automatic reset during program download
- Power OK blue LED
- Green (TX), red (RX) and orange (L) LED
- Auto sensing/switching power input
- Small mini-B USB for programming and serial monitor
- ICSP header for direct program download
- Standard 0.1 spacing DIP (breadboard friendly)
- Manual reset switch

Micro Controller IC ATmega328p:

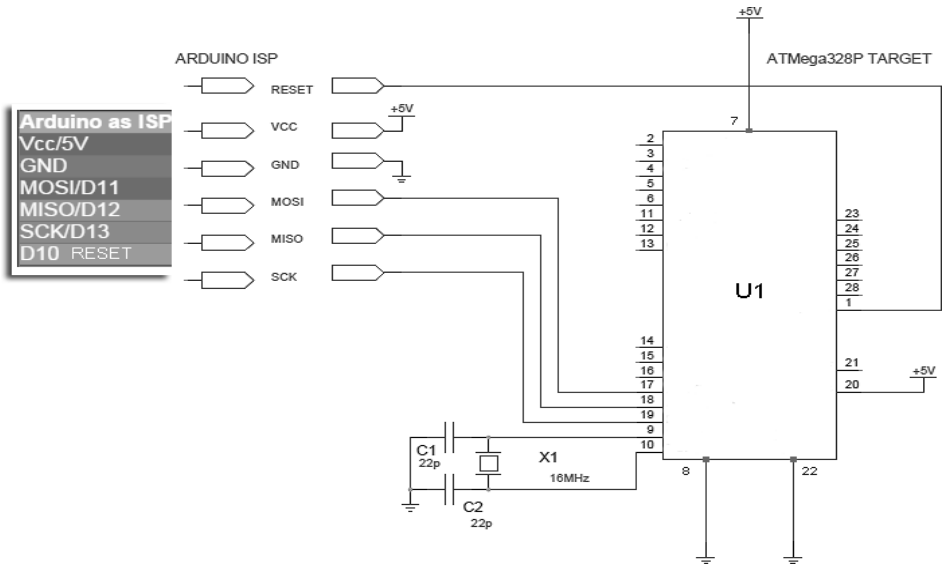


Fig 3.8: Schematic Diagram of Micro controller IC AT mega 328p. [17]

The high-performance Microchip picopower 8-bit AVR RISC-based microcontroller combines 32KB ISP flash memory with read-while-write capabilities, 1024B EEPROM, 2KB SRAM, 23 general purpose I/O lines, 32 general purpose working registers, three flexible timer/counters with compare modes, internal and external interrupts, serial programmable USART, a byte-oriented 2- wire serial interface, SPI serial port, a 6-channel 10-bit A/D converter (8-channels in TQFP and QFN/MLF packages), programmable watchdog timer with internal oscillator, and five software selectable power saving modes. The device operates between 1.8-5.5 volts. By executing powerful instructions in a single clock cycle, the device achieves throughputs approaching 1 MIPS per MHz, balancing power consumption and processing speed.

3.6 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.

HC-SR04 Ultrasonic Sensor – Working Method:

As shown above the HC-SR04 Ultrasonic (US) sensor is a 4 pins 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 –

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:

Distance = Speed × Time



Fig 3.9: Ultrasonic Sensor Working Procedure. [18]

Now, to calculate the distance using the above formula, we should know the Speed and time. Since we are using the Ultrasonic wave, we know the universal speed of Ultrasonic 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.

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

Ultrasonic Sensor Pin Configuration:

Table 01: Pin Configuration of Ultrasonic Sensor

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.



Fig 3.10: Ultrasonic Sensor Pin Out. [19]

3.7 LCD Display:

LCD (Liquid Crystal Display) screen is an electronic 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.



Fig 3.11: 16*2 LCD Display. [20]

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.

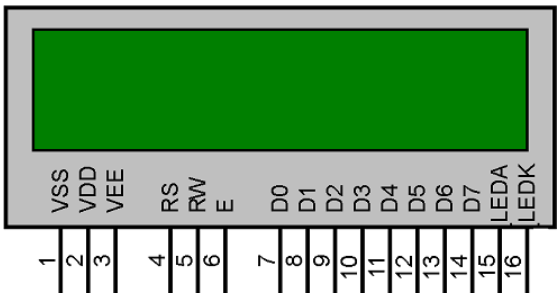


Fig 3.12: Pin out of 16*2 LCD Display. [21]

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.

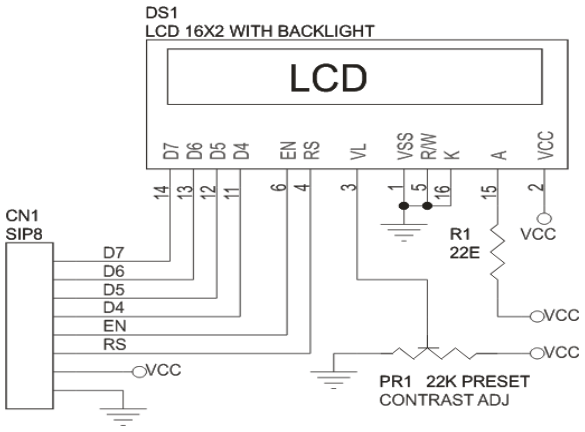


Fig 3.13: 16*2 LCD Display Interfacing with Arduino. [22]

The Arduino Pro Mini is a micro-controller board based on the ATmega328P. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, an on-board resonator, a reset button, and holes for mounting pin headers. A six-pin header can be connected to an FTDI cable to provide USB power and communication to the board.

Features:

The features of this LCD mainly include the following.

- The operating voltage of this LCD is 4.7V-5.3V.
- It includes two rows where each row can produce 16-characters.
- The utilization of current is 1mA with no backlight.
- Every character can be built with a 5×8-pixel box.
- The alphanumeric LCDs alphabets & numbers.
- Is display can work on two modes like 4-bit & 8-bit.
- These are obtainable in Blue & Green Backlight.
- It displays a few custom generated characters.

3.8 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 3.7V.

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.



Fig 3.14: 3.7V Battery. [23]

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.

Product Specification:

Table 02: Battery Specification

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

3.9 Arduino 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.

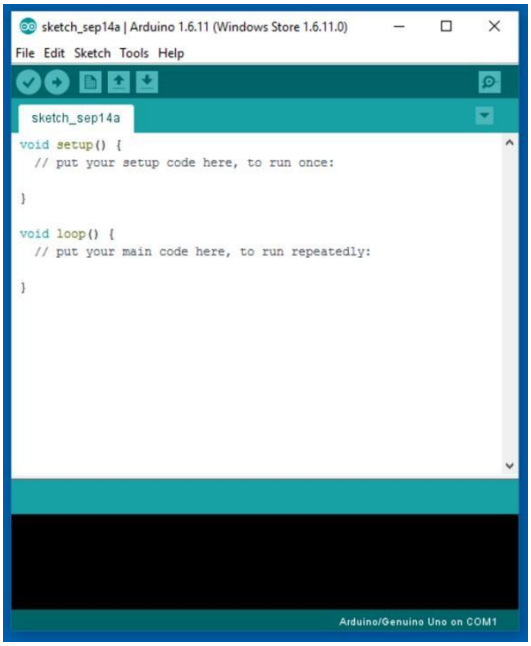


Fig 3.15: Arduino Software Interface IDE.

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. 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. It is possible to open these files with version 1.0, you will be prompted to save the sketch with the extension on save.

Verify

Checks your code for errors compiling it.

Upload

Compiles your code and uploads it to the configured board. See uploading below for details. Note: If you are using an external programmer with your board, you can hold down the "shift" key on your computer when using this icon. The text will change to "Upload using Programmer"

New

Creates a new sketch.

Open

Presents a menu of all the sketches in your sketchbook. Clicking one will open it within the current window overwriting its content.
Note: due to a bug in Java, this menu doesn't scroll; if you need to open a sketch late in the list, use the File | Sketchbook menu instead.

Save

Saves your sketch.

Serial Monitor

Opens the serial monitor.

Additional commands are found within the five menus: File, Edit, Sketch, Tools, Help. The menus are context sensitive, which means only those items relevant to the work currently being carried out are available.
New

Creates a new instance of the editor, with the bare minimum structure of a sketch already in place.

Open

Allows to load a sketch file browsing through the computer drives and folders.

Open Recent

Provides a short list of the most recent sketches, ready to be opened.

Sketchbook
Shows the current sketches within the sketchbook folder structure; clicking on any name opens the corresponding sketch in a new editor instance.

Examples

Any example provided by the Arduino Software (IDE) or library shows up in this menu item. All the examples are structured in a tree that allows easy access by topic or library.

Close

Closes the instance of the Arduino Software from which it is clicked.

Save

Saves the sketch with the current name. If the file hasn't been named before, a name will be provided in a "Save as." window.

Save as...

Allows to save the current sketch with a different name.

Page Setup

It shows the Page Setup window for printing.

Print

Sends the current sketch to the printer according to the settings defined in Page Setup.

Preferences

Opens the Preferences window where some settings of the IDE may be customized, as the language of the IDE interface.

Quit

Closes all IDE windows. The same sketches open when Quit was chosen will be automatically reopened the next time you start the IDE.

Edit

Undo/Redo

Goes back of one or more steps you did while editing; when you go back, you may go forward with Redo.

Cut

Removes the selected text from the editor and places it into the clipboard.

Copy

Duplicates the selected text in the editor and places it into the clipboard.

Copy for Forum

Copies the code of your sketch to the clipboard in a form suitable for posting to the forum, complete with syntax coloring.

Copy as HTML

Copies the code of your sketch to the clipboard as HTML, suitable for embedding in web pages.

Paste

Puts the contents of the clipboard at the cursor position, in the editor.

Select All

Selects and highlights the whole content of the editor.

Comment/Uncomment

Puts or removes the // comment marker at the beginning of each selected line.

Increase/Decrease Indent

Adds or subtracts a space at the beginning of each selected line, moving the text one space on the right or eliminating a space at the beginning.

Find

Opens the Find and Replace window where you can specify text to search inside the current sketch according to several options.

Find Next

Highlights the next occurrence - if any - of the string specified as the search item in the Find window, relative to the cursor position.

Find Previous

Highlights the previous occurrence - if any - of the string specified as the search item in the Find window relative to the cursor position.

Verify/Compile

Checks your sketch for errors compiling it; it will report memory usage for code and variables in the console area.

Upload

Compiles and loads the binary file onto the configured board through the configured Port.

Upload Using Programmer

This will overwrite the Bootloader on the board; you will need to use Tools > Burn Bootloader to restore it and be able to Upload to USB serial port again. However, it allows you to use the full capacity of the Flash memory for your sketch. Please note that this command will NOT burn the fuses. To do so a Tools -> Burn Bootloader command must be executed.

Export Compiled Binary

Saves a .hex file that may be kept as archive or sent to the board using other tools.

Show Sketch Folder

Opens the current sketch folder.

Include Library

Adds a library to your sketch by inserting #include statements at the start of your code. For more details, see libraries below. Additionally, from this menu item you can access the Library Manager and import new libraries from .zip files.

Add File...

Adds a source file to the sketch (it will be copied from its current location). The new file appears in a new tab in the sketch window. Files can be removed from the sketch using the tab menu accessible clicking on the small triangle icon below the serial monitor one on the right-side o the toolbar.

Tools

Auto Format

This formats your code nicely: i.e. indents it so that opening and closing curly braces line up, and that the statements inside curly braces are indented more.

Archive Sketch

Archives a copy of the current sketch in .zip format. The archive is placed in the same directory as the sketch.

Fix Encoding & Reload

Fixes possible discrepancies between the editor char map encoding and other operating systems char maps.

Serial Monitor

Opens the serial monitor window and initiates the exchange of data with any connected board on the currently selected Port. This usually resets the board, if the board supports Reset over serial port opening.

Board

Select the board that you're using. See below for descriptions of the various boards.

Port

This menu contains all the serial devices (real or virtual) on your machine. It should automatically refresh every time you open the top-level tools menu.

Programmer

For selecting a hardware programmer when programming a board or chip and not using the onboard USB-serial connection. Normally you won't need this, but if you're burning a Bootloader to a new microcontroller, you will use this.

Burn Bootloader

The items in this menu allow you to burn a Bootloader onto the microcontroller on an Arduino board. This is not required for normal use of an Arduino or Genuino board but is useful if you purchase a new ATmega microcontroller (which normally come without a Bootloader). Ensure that you've selected the correct board from the Boards menu before burning the Bootloader on the target board. This command also set the right fuses.

Help

Here you find easy access to a number of documents that come with the Arduino Software (IDE). You have access to Getting Started, Reference, this guide to the IDE and other documents locally, without an internet connection. The documents are a local copy of the online ones and may link back to our online website.

Find in Reference

This is the only interactive function of the Help menu: it directly selects the relevant page in the local copy of the Reference for the function or command under the cursor.

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 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 Bootloader, 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 Bootloader 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.

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.

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.

3.10 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.

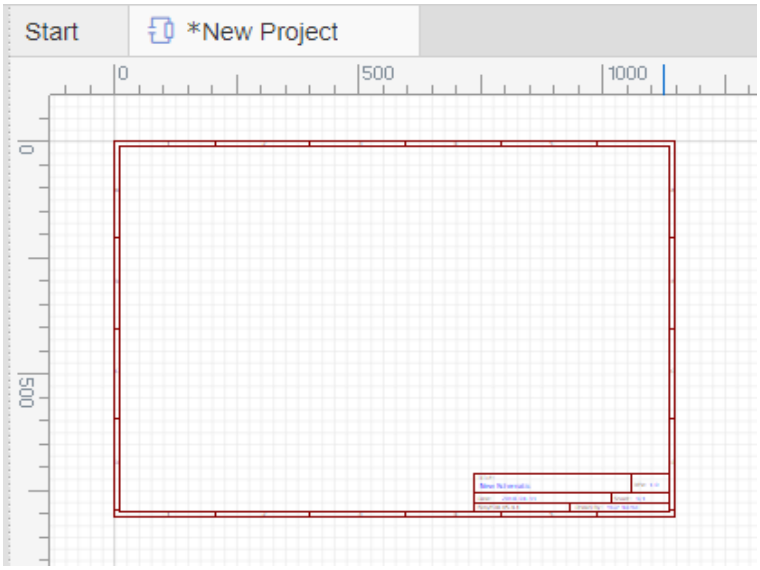


Fig 3.16: Easy EDA Software Interface.

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

4.1Block Diagram:

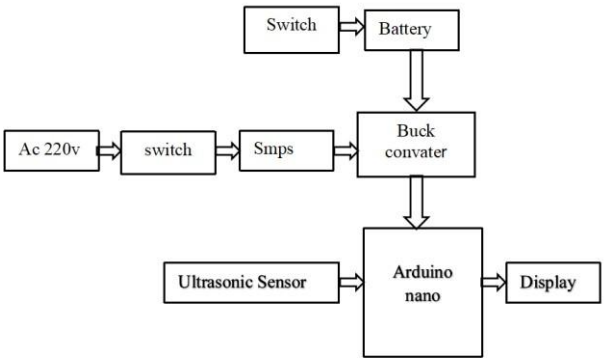


Fig 4.1: Block Diagram.

4.2 Circuit Diagram:

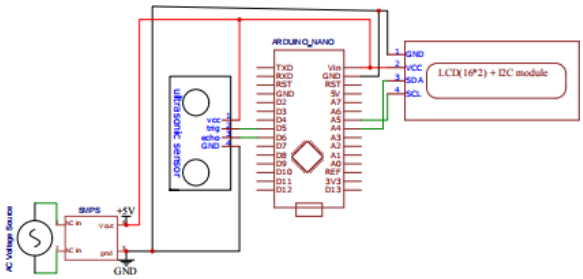


Fig 4.2: Circuit Diagram. [24]

The Motorcycle Brake Pads Monitoring System operates through a seamless integration of sensors, data processing, and user interaction. Initially, the system employs sensors, such as ultrasonic types, to continuously measure the thickness of the brake pads. As the rider gather real-time data on brake pad wear. This information is then transmitted wirily to a LCD display through micro control unit, where it is processed and analyzed & displayed given result. When the brake pad thickness falls below a predefined threshold, the system shows actual efficiency & lifetime of brake pads on LCD display. The user-friendly LCD displays the current status of the brake pads and maintenance history, ensuring that riders are well-informed about their motorcycle's brake pad condition. The system enhances rider safety and contributes to better overall performance.

4.3 Complete Project Prototype:



Fig 4.3: Complete Project View.

4.4 Project Expenses:

S.N	Component	Specification	Qty	Unit Price (BDT)	Sub Total (BDT)
1	Arduino	Nano	1	1400	1400
2	Buck Converter		1	450	450
3	SMPS	5v 7A	1	1050	1050
4	LCD Display	16*2	1	450	450
5	Battery	3.7v	2	150	300
6	Ultrasonic Sensor		1	600	600
7	18650- 2 Cell Battery 3.7V Clip Holder Box Case Black Battery Chamber		1	50	50
8	Switch		2	10	20
9	Jumper Wires			100	100
10	AC Power Cord/Cable_Two PIN_Two Plug		1	80	80
11	Brake Pad		7	200	1400
12	Battery Charger		2	150	300
11	others			1500	1500
Grand Total					7700

CHAPTER-05

5.1 CALCULATION:

Backing plate + Friction Materials = Brake Pad

Or, 3 mm + Friction Material = 7.2 mm

Or, Friction Material = 7.2 mm – 3 mm

∴ Friction Material = 4.2 mm

Here,

Initial Thickness, $T_{(initial)} = 4.2$ mm

Current thickness, $T_{(current)} = 4.2$ mm

Minimum Thickness, $T_{(mini)} = 2$ mm

Wear Percentage = $[100 - \{(T_{(initial)} - T_{(current)})/(T_{(initial)} - T_{(mini)}) \times 100\}]$

Or, Wear Percentage $= [100 - \{(4.2 - 4.2)/(4.2 - 2) \times 100\}]$

$= [100 - \{(0/2.2) \times 100\}]$

$= [100 - \{0 \times 100\}]$

$= 100\%$

Remaining Kilometer $= T_{(current)} - T_{(mini)} / T_{(initial)} - T_{(mini)} \times$ Total expected life

$= (4.2 - 2)/(4.2 - 2) \times 15000$

$= 2.2/2.2 \times 15000$

$= 1 \times 15000$

$= 15000$ km

5.2 Validation:

$$\text{Percentage Error} = \left| \frac{\text{Real time Thickness} - \text{Vernier Thickness}}{\text{Vernier Thickness}} \right| \times 100$$

$$= \left| \frac{4.16 - 4.2}{4.2} \right| \times 100\ \%$$

$$= 0.95\ \% \approx 1\ \%$$

- The difference in thickness is minimal (0.04 mm).
- The wear percentage calculated for real-time data is 99%, which shows only a 1% deviation from the standard, supporting the calculated error.
- Similarly, the distance (Kilometer) comparison shows very close values, further validating data consistency.

Table: 1

Category	Thickness (mm)	Kilometer (Km)	Wear Percentage (%)
Vernier	4.2	15000	100
Real time data	4.16	14850	99

- The real-time data closely matches the standard Vernier measurement, with only ~1% deviation.
- This low error validates the reliability of the experimental method or measurement system used.
- The data is sufficiently accurate for practical applications, indicating that the real-time measurement system is effectively calibrated and consistent.

Table: 2

Validated Data							
Real Time				Vernier Scale			Percentage Error
S/N	Wear percentage (%)	Remaining Kilometer (Km)	Thickness (mm)	Thickness (mm)	Remaining Kilometer (Km)	Wear percentage (%)	
1	99%	14850	4.16	4.2	15000	100%	1%
2	99%	14850	4.16	4.0	13636	90%	4%
3	91%	13650	3.82	3.2	8182	55%	19.38%
4	72%	10800	3.02	3.1	7500	50%	2.58%

Annexure 3 : Preventive Maintenance Chart

Technical Bulletin
International Business

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To:
Distributors

Technical Bulletin
Product Category: Motorcycle
Model: Discover 110 & 125
Bulletin No.: NP : 79
Date: 12 / 02 / 2021

Sub: Introduction of Discover 110 & Discover 125

Sr. No.	PM check points	Recommended frequency: Service	1st	2nd	3rd	4th	5th	6th	7th	Remarks
			500	4500	9500	14500	19500	24500	29500	
		Kms								
			~	~	~	~	~	~	~	
			750	5000	10000	15000	20000	25000	30000	
1	Clean the vehicle with water wash & dry completely.		√	√	√	√	√	√	√	Ensure to prevent water entry in Petrol tank, Silencer & Electrical parts. Use caustic free detergent for washing.
2	Engine oil & engine oil filter	C, R	R	R	R	R	R	R	R	SAE 20W30 API 'SL' /JASO MA2
3	Oil strainer	CL	CL		CL		CL		CL	Oil strainer cleaning at the
4	Spark plug	CL,A,R			CL,A		CL,A		R	time of oil change.
5	Air cleaner element	CL, R	CL	CL	CL	R	CL	CL	R	Check O' ring at every service
6	***& cover 'O' ring Fuel cock sediment	CL				CL			CL	& replace if found
	bowl cleaning									
7	Carburetor rubber duct	C,R					C,R			Check & replace if required
8	Fuel pipe	C,R	C	C	C	R	C	C	R	
9	Valve tappet clearance	C, A	C, A	C, A	C, A	C, A	C, A	C, A	C, A	During 1st Free Service: Use lint free cloth for cleaning & OKS Chain Spray for lubrication without removing from vehicle. (If chain is excessively dirty, then chain to be removed, cleaned using diesel & lubricated using OKS Chain Spray. During all other services: Remove, clean using Diesel &
10	Non-Sealed drive chain cleaning & lubrication	CL,L,A	CL,L,A	CL,L, A	CL,L,A	CL,L,A	CL,L,A	CL,L,A	CL,L,A	
11	Engine air breather	C	C	C	C	C	C	C	C	lubricate using OKS Chain Replace if damaged
12	tube Silencer drain hole	CL		CL	CL	CL	CL	CL	CL	
13	cleaning Brake lining or pad wear & lubricate brake cam & pivot pin, check	C,L,R	C	C,L, R	C,L,R	R	C,L,R	C,L,R	R	Replace Brake shoe/pads at every 15,000 Kms
14	wear indicator Brake fluid level- top up	C,U,R				C,U			R	Use recommended(DOT3?
	/ replace Disc brake assly --									DOT 4) brake fluid.
15	Check functionality, leakage or any other damage.	C			C		C		C	Replace if damaged
16	All cables & rear brake pedal-free play	C,A	C,A	C,A	C,A	C,A	C,A	C,A	C,A	Use recommended free play gauge.

Fig 5.1: Preventive Maintenance Chart. [25]

Brake Pad Measuring Comparison:

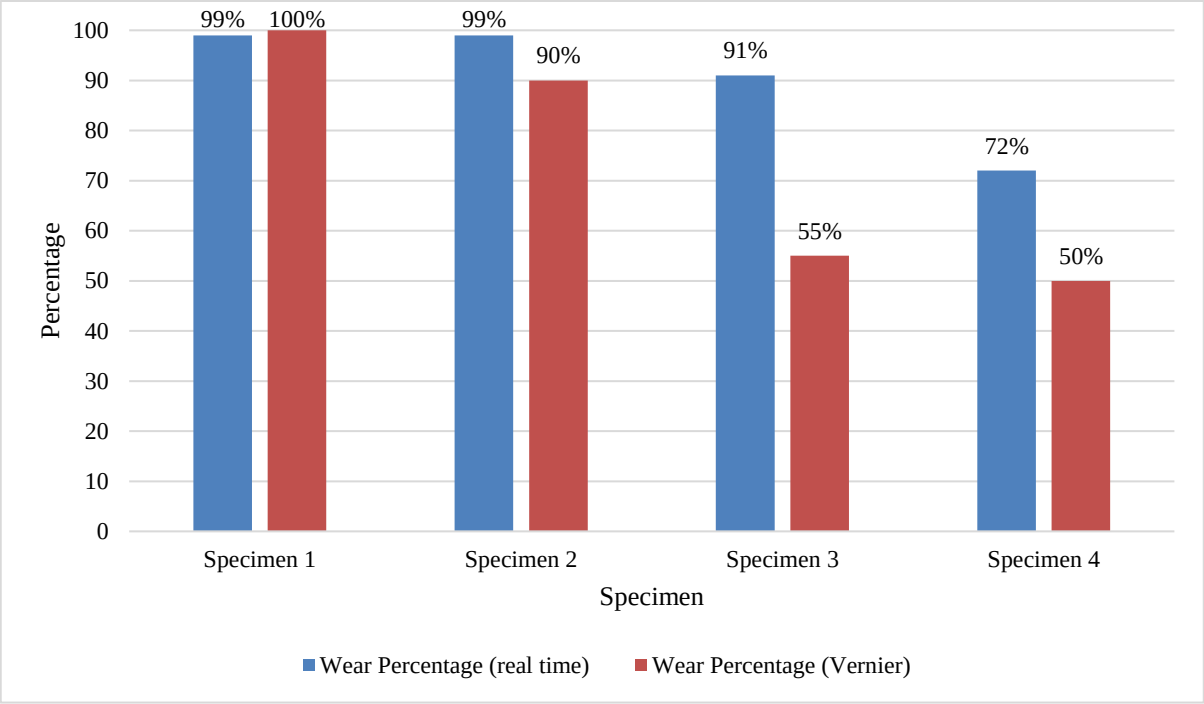


Fig 5.2: Wear Percentage (Real Time vs Vernier Scale).

The bar chart titled "Wear Percentage (Real Time vs Vernier Scale)" compares ware percentage measurements using two methods — Real Time and Vernier Scale — across four different specimens**.**

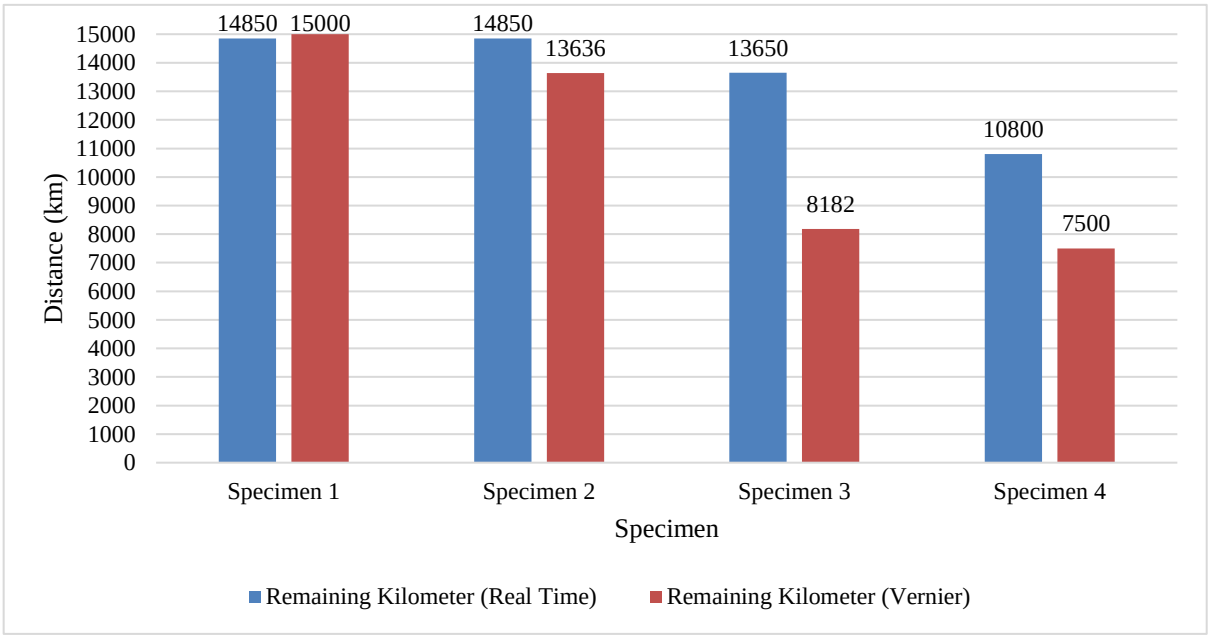


Fig 5.3: Remaining Kilometer (Real Time vs Vernier Scale).

The second bar chart, titled "Remaining Kilometer (Real Time vs Vernier Scale)," compares the estimated remaining distance (in kilometers) for four specimens using two measurement methods: Real Time and Vernier Scale.

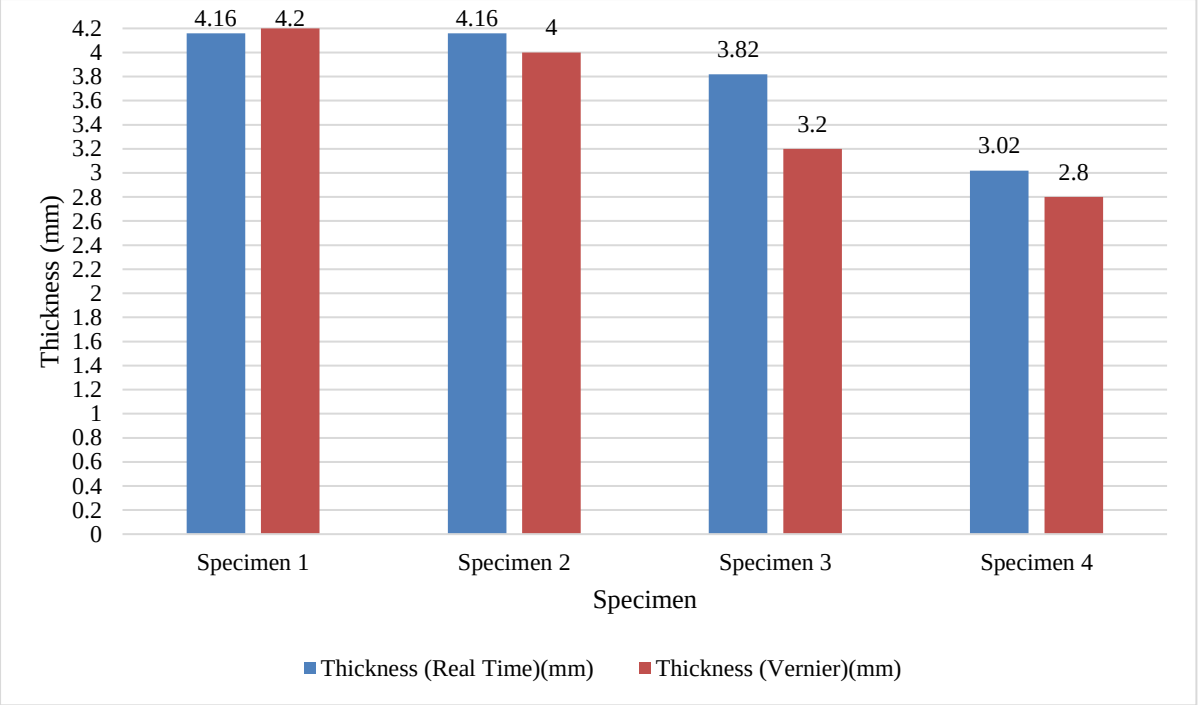


Fig 5.4: Thickness (Real Time vs Vernier Scale).

The third chart titled "Thickness (Real Time vs Vernier Scale)" compares the measured thickness (in mm) of four specimens using two different measurement methods: Real Time and Vernier Scale.

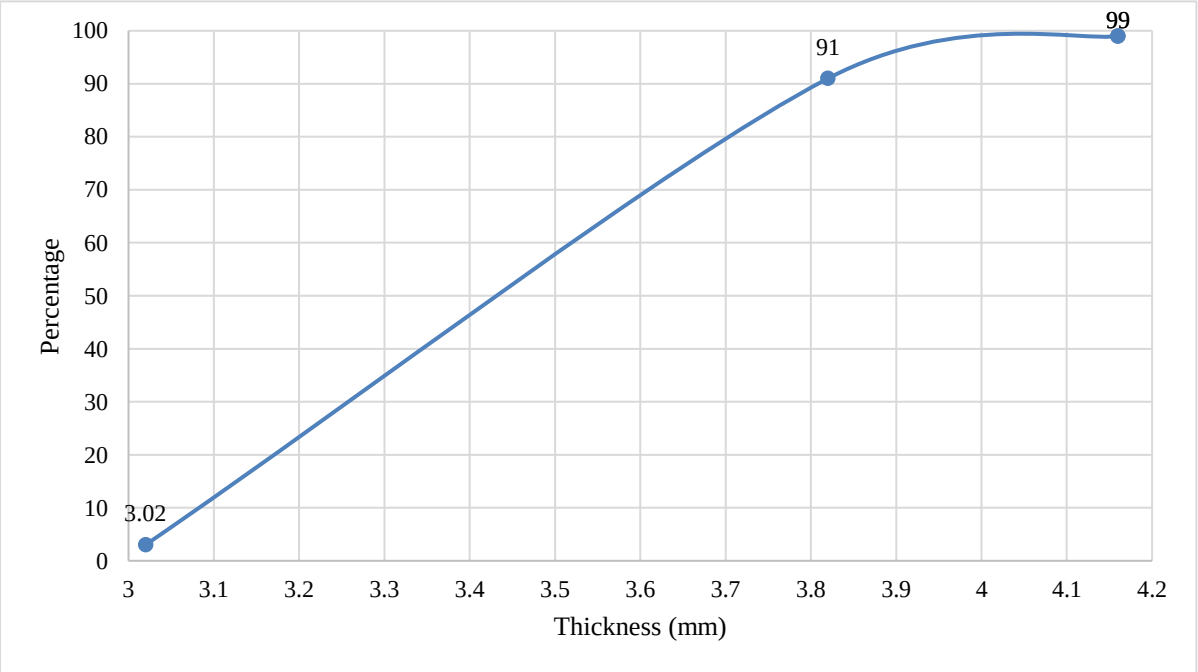


Fig 5.5: Wear Percentage vs Thickness Analysis.

The graph titled "Wear Percentage vs Thickness Analysis" illustrates the relationship between the measured brake pad thickness (mm) and the percentage of pad wear experienced during use.

- At 3.02 mm → Wear ≈ 5–10% remaining, so about 90–95% wear.
- At 3.82 mm → Wear ≈ 91% (as labeled).
- At 4.16 mm → Wear ≈ 99% (near full thickness).

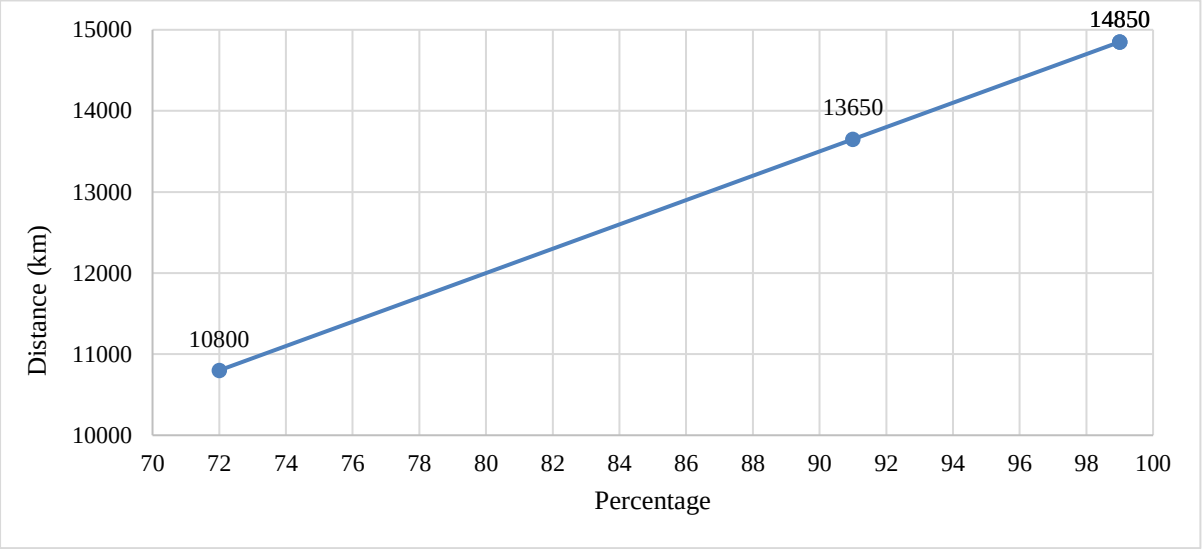


Fig 5.6: Wear Percentage vs Remaining Kilometer.

The graph titled "Wear Percentage vs Remaining Kilometer" presents a clear positive correlation between the brake pad wear percentage and the remaining usable distance (in km) of the brake pads.

- At 72% wear, the remaining distance is 10,800 km.
- At 91% wear, the distance increases to 13,650 km.
- At 99% wear, the maximum measured remaining distance is 14,850 km

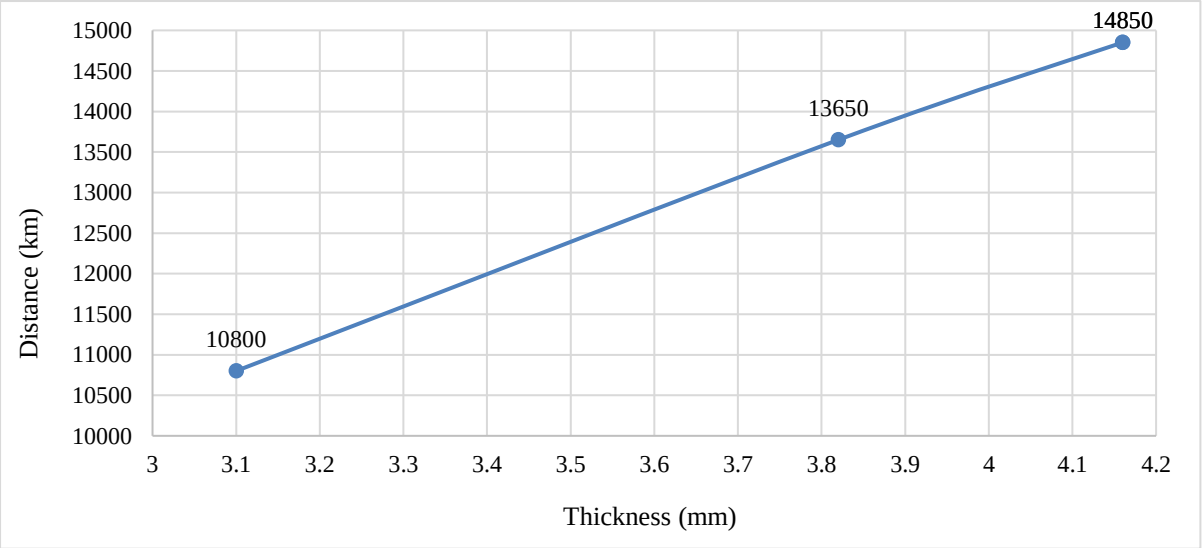


Fig 5.7: Thickness vs Remaining Kilometer.

The graph titled "Thickness vs Remaining Kilometer" provides valuable insight into the relationship between brake pad thickness (mm) and the remaining usable distance (km) of the brake pads, based on real-time data.

- At 3.02 mm → Remaining distance ≈ 10,800 km
- At 3.82 mm → Remaining distance ≈ 13,650 km
- At 4.16 mm → Remaining distance ≈ 14,850 km

5.3 Result:

- The percentage error increases as the thickness decreases**,** which is expected due to higher sensitivity in thinner brake pads**.**
- S/N 1 and 4 show low error (<3%)**,** indicating high measurement reliability.
- S/N 3 has the highest error (19.38%)**,** suggesting a larger discrepancy, possibly due to sensor limitations at lower thicknesses or measurement environment variations.

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 "Performance Evaluation and Life Prediction of Motorcycle Brake Pads Using Sensor Based Monitoring". 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.

- In this project first we setup a power source system. In real life we will connect us.
- 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.

Result 1:

Brake Pad Wear Percentage: 99%
Thickness: 4.16 mm
Lifetime: 14850 km

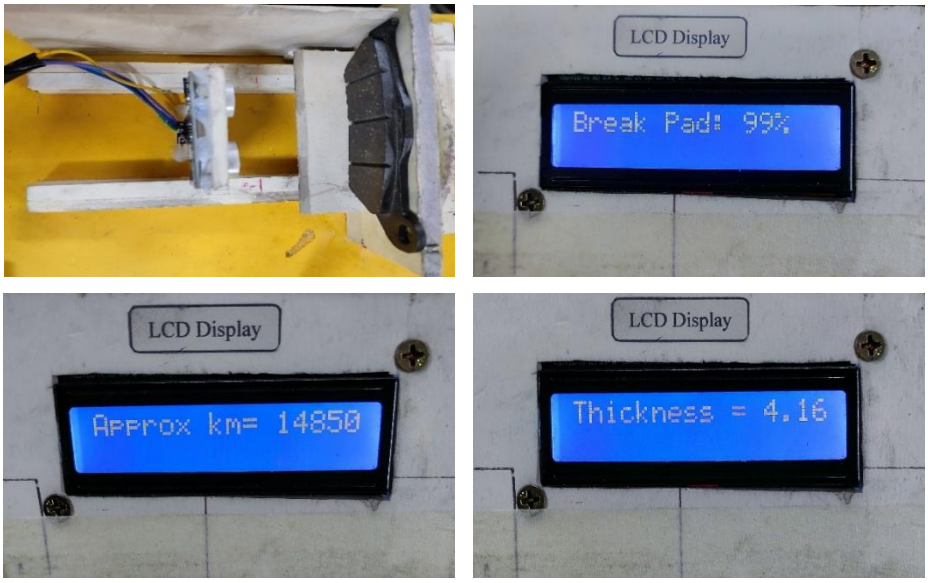


Fig 5.4: Real Time Data Observation 1.

Result 2:

Brake Pad Wear Percentage: 99%
Thickness: 4.16 mm
Lifetime: 14850 km

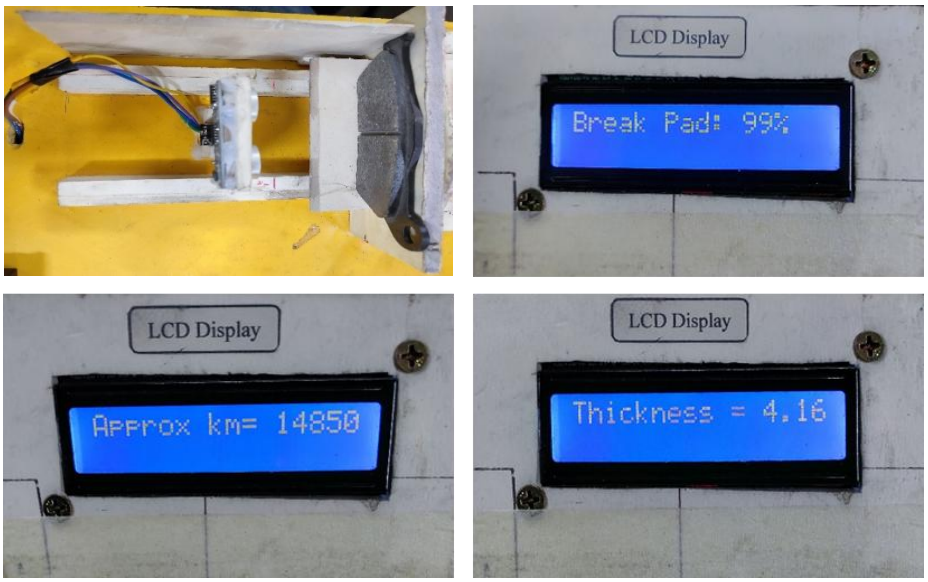


Fig 5.5: Real Time Data Observation 2.

Result 3:

Brake Pad Wear Percentage: 91%
Thickness: 3.82 mm
Lifetime: 13650 km

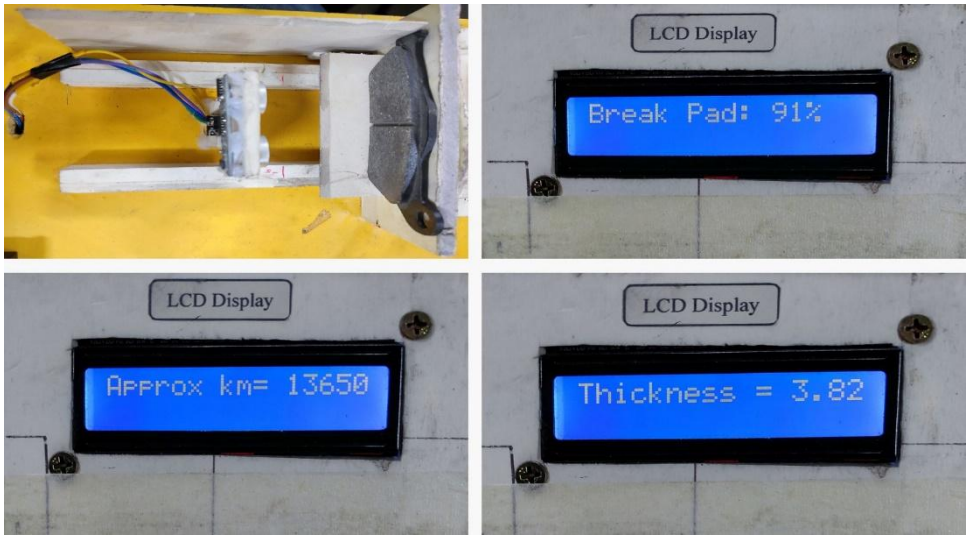


Fig 5.6: Real Time Data Observation 3.

Result 4:

Brake Pad Wear Percentage: 72%
Thickness: 3.02 mm
Lifetime: 10800 km

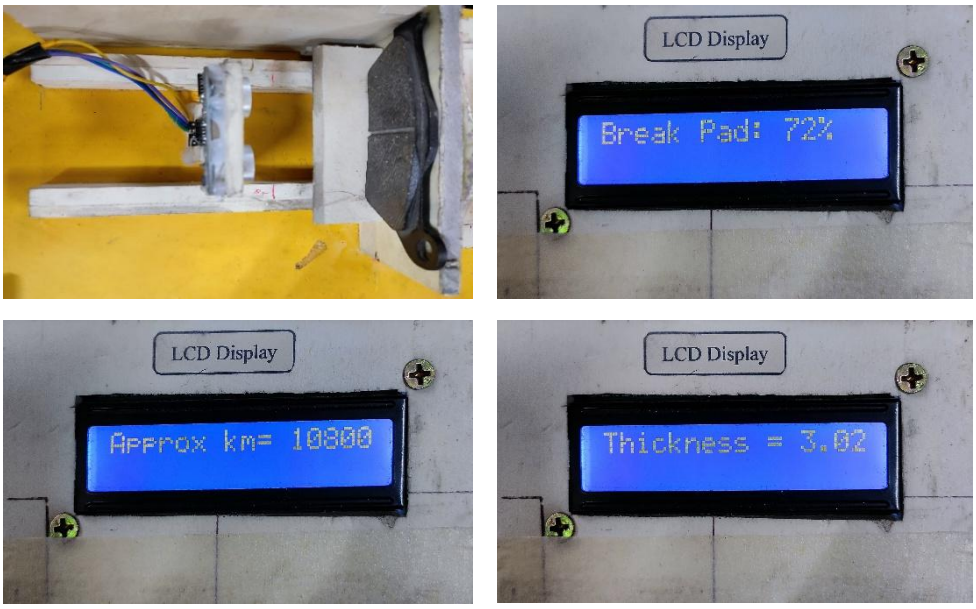


Fig 5.7: Real Time Data Observation 4.

5.4 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.
- **Data Analytics**: Advanced systems can collect data over time, providing insights into driving habits and wear patterns, which can help in optimizing brake use and improving overall vehicle maintenance strategies.

5.5 Limitations:

- **Sensor Durability:** Continuous exposure to extreme heat, moisture, and dust can reduce the effectiveness of sensors used to monitor brake pad wear.
- **Data Accuracy:** The system may have difficulty providing accurate real-time data due to factors like sensor calibration, varying riding conditions, or inconsistent brake usage.
- **Limited Predictive Capability:** It might not account for unexpected events or irregular wear patterns caused by sudden braking or environmental factors like mud and rain.
- **High Cost:** Advanced monitoring systems with embedded sensors can be expensive, increasing the overall cost of the motorcycle, and may not be feasible for all riders.
- **Compatibility Issues:** Retrofitting such systems onto older motorcycles may not always be possible or efficient, and some systems may not be universally compatible across different motorcycle brands and models.
- **Maintenance Requirements:** Monitoring systems may require regular maintenance or calibration to ensure proper functioning, adding to the overall upkeep of the motorcycle.
- **Battery or Power Consumption:** If the system is powered by the motorcycle's electrical system, it could increase power consumption and affect the battery life.
- **Potential for False Alerts:** Inconsistent braking behavior or incorrect sensor data can trigger false warnings about brake pad wear, leading to unnecessary checks or replacements.

5.6 Applications:

- **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.

5.7 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.

5.8 Discussion:

The focus of this project was on designing the controller. Initially, we gathered all the components required and assembled them according to our circuit layout, ensuring proper connections. The core of the system is the Arduino Nano, which manages all the connected devices.

During development, we encountered several challenges due to the complexity of the system. However, the final outcome was quite satisfying. We tested the complete setup through multiple tasks to verify its functionality and documented key observations for future enhancements. For future improvements, we recommend refining the system's design and wiring, as well as integrating features that would allow the entire system to be operated online.

5.9 Conclusion:

To sum up, a brake pad monitoring system plays a crucial role in improving both vehicle safety and performance. By delivering real-time information about brake wear, it helps drivers maintain effective braking, thereby minimizing the chances of malfunctions or accidents. Detecting wear at an early stage enables prompt maintenance, which not only cuts down repair expenses but also extends the life of brake components. Furthermore, the system's data can be used to encourage better driving practices and streamline maintenance routines. With ongoing technological advancements, incorporating such systems into vehicles promotes safer, more efficient, and responsible driving. Ultimately, investing in a brake pad monitoring system enhances both the dependability and safety of any vehicle.

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Appendix

```
#include <LiquidCrystal_I2C.h>
LiquidCrystal_I2C lcd(0x27, 16, 2);
#define trigPin 11
#define echoPin 12
float duration;
float distance;
float fresh=3.60;
int percentage;
float km1;
float thickness1;
void setup()
{
// put your setup code here, to run once:
Serial.begin(9600);
lcd.clear();
lcd.init(); // initialize the lcd
lcd.backlight(); // open the backlight
pinMode(trigPin, OUTPUT);
pinMode(echoPin, INPUT);
}
void loop()
{
// put your main code here, to run repeatedly:
digitalWrite(trigPin, LOW);
delayMicroseconds(2);
digitalWrite(trigPin, HIGH);
delayMicroseconds(10);
digitalWrite(trigPin, LOW);
duration = (float)pulseIn(echoPin, HIGH);
distance = (float)duration * 0.034 / 2;
//Map the distance to percentage inversely (assuming distance from 1 to 9)
//percentage = map(distance, 1, 9, 100, 0);
percentage= 100.00- (float)((abs(fresh-distance)/fresh)*100);
km1= (float)((15000*percentage)/100);
thickness1= (float)((4.2*percentage)/100);
Serial.print("distance ");
Serial.println(distance);
//delay(1000);
if (distance >= 3.00 && distance <=3.65)
```

```
{
// Add code for less than 70% if needed
lcd.clear();
lcd.setCursor(0, 0);
Serial.print("Break Pad: ");
Serial.print(percentage);
Serial.println("%");
Serial.print("Approx km= ");
Serial.println(km1);
Serial.print("Thickness = ");
Serial.println(thickness1);
lcd.print("Break Pad: ");
lcd.print(percentage);
lcd.print("% ");
delay(3000);
lcd.clear();
lcd.setCursor(0, 0); // start to print at the first row
delay(3000);
lcd.clear();
lcd.setCursor(0, 0);
lcd.print("Approx km= ");
lcd.print(km1);
delay(3000);
lcd.clear();
lcd.setCursor(0, 0);
lcd.print("Thickness = ");
lcd.print(thickness1);
delay(3000);
}
if (distance >=3.66 && distance <=4.31)
{
lcd.clear();
lcd.setCursor(0, 0);
Serial.print("Break Pad: ");
Serial.print(percentage);
Serial.println("%");
Serial.print("Approx km= ");
```

```
Serial.println(km1);
Serial.print("Thickness = ");
Serial.println(thickness1);
lcd.print("Break Pad: ");
lcd.print(percentage);
lcd.print("% ");
delay(3000);
lcd.clear();
lcd.setCursor(0, 0); // start to print at the first row
delay(3000);
lcd.clear();
lcd.setCursor(0, 0);
lcd.print("Approx km= ");
lcd.print(km1);
delay(3000);
lcd.clear();
lcd.setCursor(0, 0);
lcd.print("Thickness = ");
lcd.print(thickness1);
delay(3000);
}
if (distance >=4.32 && distance <=4.75)
{
lcd.clear();
lcd.setCursor(0, 0);
Serial.print("Break Pad: ");
Serial.print(percentage);
Serial.println("%");
Serial.print("Approx km= ");
Serial.println(km1);
Serial.print("Thickness = ");
Serial.println(thickness1);
lcd.print("Break Pad: ");
lcd.print(percentage);
lcd.print("% ");
delay(3000);
lcd.clear();
```

```
lcd.setCursor(0, 0); // start to print at the first row
if(percentage<70)
{
lcd.setCursor(0, 1); // start to print at the first row
lcd.print("Change Break pad");
delay(3000);
}
delay(3000);
lcd.clear();
lcd.setCursor(0, 0);
lcd.print("Approx km= ");
lcd.print(km1);
delay(3000);
lcd.clear();
lcd.setCursor(0, 0);
lcd.print("Thickness = ");
lcd.print(thickness1);
delay(3000);
}
if(distance >=4.76 && distance<=4.90)
{
lcd.clear();
lcd.setCursor(0, 0);
Serial.println("Empty slot ");
lcd.print("Empty slot ");
delay(3000);
}
}
```