PUNE VIDYARTHI GRIHA's

COLLEGE OF ENGINEERING AND TECHNOLOGY

AND G K PATE (WANI) INSTITUTE OF MANAGEMENT,

PUNE – 411 009

PROJECT REPORT

ON

"Design and analysis of IoT interfaced E-bike."

SUBMITTED BY

Anuja Ashok Patil (B190072553)

Shivani Uday Tajane (B190072576)

Payal Sanjay Tadavi (B190072575)

Tanaya Dhananjay Jadhav (B190072523)

Class

BE (ELECTRICAL)

Year

2022-2023

GUIDED BY

Prof.Dr.M.S. Thakare

DEPARTMENT OF ELECTRICAL ENGINEERING

PVG's COET& GKPIM, PUNE-9

SAVITRIBAI PHULE PUNE UNIVERSITY (2022-2023)

PUNE VIDYARTHI GRIHA's

COLLEGE OF ENGINEERING AND TECHNOLOGY

AND G K PATE (WANI) INSTITUTE OF MANAGEMENT,

PUNE – 411 009

CERTIFICATE

This is to certify that the following students, studying in B. E. (Electrical) and having respective exam numbers, have satisfactorily completed the work for their Project (Semester I) under my guidance, in the following topic:

"Design and analysis of IoT interfaced E-bike."

The report is submitted as a partial fulfillment of the requirement of the Undergraduate degree course in Electrical Engineering, Savitribai Phule Pune University, during the academic year 2022-2023.

1. ***Anuja Ashok Patil(B190072553)***
2. ***Shivani Uday Tajane (B190072576)***
3. ***Payal Sanjay Tadavi (B190072575)***
4. ***Tanaya Dhananjay Jadhav (B190072523)***

Prof. Dr. M. S. Thakare
Guide
Dept. of Electrical Engg.
PVG's COET & GKPIM,
Pune-9

Dr. M. S. Thakare
Head of Department
Dept. of Electrical Engg.
PVG's COET & GKPIM,
Pune-9

SPONSORSHIP LETTER

OPULENCE POWER PRIVATE LIMITED
➤ EVOLVING WITH ENERGY ◄
7, GURUKRUPA, GROUND FLOOR, NEXT TO J.M. FINANCE, BHOSALENAGAR, PUNE 411007
email id: info@opulencepower.com Mobile: +91 8374 8374 84

Ref No: OPPL/SP/2022-23-1 May 23, 2023

SPONSORSHIP LETTER

Following students from Department Of Electrical Engineering, Pune Vidyarthi Griha's College of Engineering & Technology and G. K. Pate (Wani) Institute of Management, Pune have proposed '***Design and analysis of IoT interfaced E-bike.'*** as their final year project for the academic year 2022-23.

1. ***Anuja Ashok Patil(B190072553)***
2. ***Shivani Uday Tajane (B190072576)***
3. ***Payal Sanjay Tadavi (B190072575)***
4. ***Tanaya Dhananjay Jadhav (B190072523)***

We have gone through all technicalities and feasibility of above mentioned project and had provided technical and financial sponsorship for the given project in AY 22-23.

Opulence Power Private Limited

Miresh R Sheth
Director

OPULENCE POWER PRIV LIMITED

Solar PV Rooftop Systems ● Energy Management ● Solar Ground Mounted Systems ● Renewable Energy
CIN No. : U40106PN2016PTC165777

ACKNOWLEDGEMENT

We are profoundly grateful to Prof. Dr. M. S. Thakare for this expert guidance and continuous encouragement throughout this project.

We would like to express our deepest gratitude towards Prof. Dr. M. S. Thakare, Head of Department of Electrical Engineering and Dr. M. R. Tarambale Principal, PVG's COET and GKPIM whose invaluable guidance supported us for this project.

We would like to express gratitude towards Mr. Miresh Sheth, CEO Opulence Power pvt. ltd for sponsoring this project. We must express sincere heartfelt gratitude to all staff members of the Electrical Engineering Department who helped us directly and indirectly during this course of work.

ABSTRACT

The project entitled Design and analysis of IoT interfaced E-Bike. The major motivation of this project is that the use of green energy is becoming increasingly more important in today’s world. Therefore, electric vehicles are currently the best choice for the environment in terms of public and personal transportation. Many EVs use lithium-ion batteries wholesome use lead acid batteries. While selecting batteries for electric vehicles it is important to predict battery performance. The selection of battery mainly depends on power requirement. In today's market, there are many manufacturers of electric vehicles but these vehicles suffer from certain limitations such as low gradability, range and high price. In this project, electric vehicle is developed and efforts are made to overcome these limitations in existing vehicle. The components of electric vehicles are selected and purchased on the basis of their performance.

The integration of the Internet of Things (IoT) into the design and analysis of e-bikes has emerged as a promising avenue for enhancing the functionality, efficiency, and safety of these sustainable modes of transportation. This project explores the possibilities and benefits of incorporating IoT technology into e-bikes, enabling them to become intelligent and interconnected devices. By integrating sensors, actuators, and communication modules, real-time data acquisition, monitoring, and communication capabilities are achieved.

The objective of this project is to design an IoT interface for e-bikes, allowing for the collection and analysis of various parameters, including battery status, speed, location, and rider behavior. By leveraging IoT capabilities, e-bikes can exchange data with other devices, systems, and cloud platforms, enabling applications such as fleet management, theft prevention, remote diagnostics, personalized riding profiles, and energy optimization.

The analysis aspect of the project involves studying the collected data to identify patterns, optimize performance. Data analytics techniques are applied to extract valuable insights from the vast amount of data generated by IoT-enabled e-bikes. These insights which can be used to improve energy efficiency, enhance user safety, and develop predictive maintenance strategies.

The project is on the ongoing advancements in transportation by using IoT-enabled e-bikes. By leveraging IoT technology, e-bikes can provide a seamless riding experience while promoting sustainable transportation. The findings and outcomes of this project can serve as a foundation for further research and development in field of intelligent transportation systems.

INDEX

List of Figures

List of Tables

CHAPTER 1

INTRODUCTION

The rapid advancements in technology have paved the way for the integration of the Internet of Things (IoT) in various domains, revolutionizing the way we interact with everyday objects. Electric bikes, or e-bikes, have gained popularity as a sustainable and efficient mode of transportation. With the integration of IoT, e-bikes can be enhanced with smart features, enabling intelligent monitoring, analysis, and control systems.

The design and analysis of IoT interfaced e-bikes involve the integration of sensors, actuators, and communication modules into the traditional e-bike framework. These additions allow for real-time monitoring, data acquisition and communication between e-bike, the rider, and the surrounding environment. By collecting and analyzing various parameters, such as battery status, speed, location, and rider behavior, valuable insights can be obtained to improve the overall performance, safety, and user experience of e-bikes.

This project aims to explore the possibilities and benefits of incorporating IoT technology into e-bikes. By leveraging IoT capabilities, e-bikes can become intelligent and interconnected devices, capable of exchanging data with other devices, systems, and cloud platforms. This connectivity enables a wide range of applications, such as theft prevention, remote diagnostics, personalized riding profiles.

The analysis aspect of the project involves studying the collected data to identify patterns, optimize performance, and make decisions. Data analyzation techniques can be employed to extract meaningful information from the vast amount of data generated by IoT-enabled e-bikes. This information can be used to improve energy efficiency, enhance user safety, and develop predictive maintenance strategies.

In summary, the design and analysis of IoT interfaced e-bikes offer numerous possibilities for improving the functionality, efficiency, and safety of e-bikes. By leveraging IoT technology, e-bikes can be transformed into intelligent, connected devices that provide a seamless riding experience while promoting sustainable transportation. This project aims to explore the potential of IoT-enabled e-bikes and contribute to the ongoing advancements in smart transportation

1.1. Relevance of the project

Sustainable Transportation: Electric vehicles are an essential part of transitioning to a greener and more sustainable transportation system. By integrating IoT technologies, we can enhance the efficiency and performance of electric vehicles, contributing to reduced carbon emissions and a cleaner environment.

Remote Monitoring and Control: IoT integration allows for remote monitoring and control of electric vehicles. Fleet managers or vehicle owners can remotely access and analyze vehicle data, monitor charging status, and perform diagnostics, leading to enhanced maintenance scheduling, increased uptime, and improved operational efficiency.

Safety and Security technology can improve safety, security of electric vehicles. Real-time monitoring of vehicle parameters, such as speed, location, and battery status, can enable proactive alerts and notifications in case of emergencies or unauthorized access. Additionally, secure communication protocols and data encryption ensure the privacy and integrity of the vehicle's data.

User Experience and Convenience: IoT integration enhances the user experience by providing features like remote vehicle monitoring, over-the-air updates, and intelligent navigation. The applications like reverse motoring and cruise control in the vehicle enhances user experience.

1.2. Problem Statement

Although e-bikes have gained popularity as a sustainable and convenient mode of transportation, it is a need to improve connectivity and integration with IoT technologies to enhance their functionality, performance, and user experience.

1.3. Objective

The main objective of the Ebike is to provide smart and remote monitoring of the vehicle as well as features that provide ease and comfort of driving in affordable price. This can be achieved by providing features to the Ebike like cruise control which provide ease fatigue and stress to the driver’s hands, reverse mode which provides reversing with comfort, three speed mode which provides different speeds as per the range of travel, ignition lock and antitheft alarm for security.

Also using sensor and internet connectivity providing GPS tracking feature to monitor the vehicle’s location which leads to vehicles protection, temperature and speed monitoring for protection of the vehicle from damage and high temperature’s which lead to battery degradation.

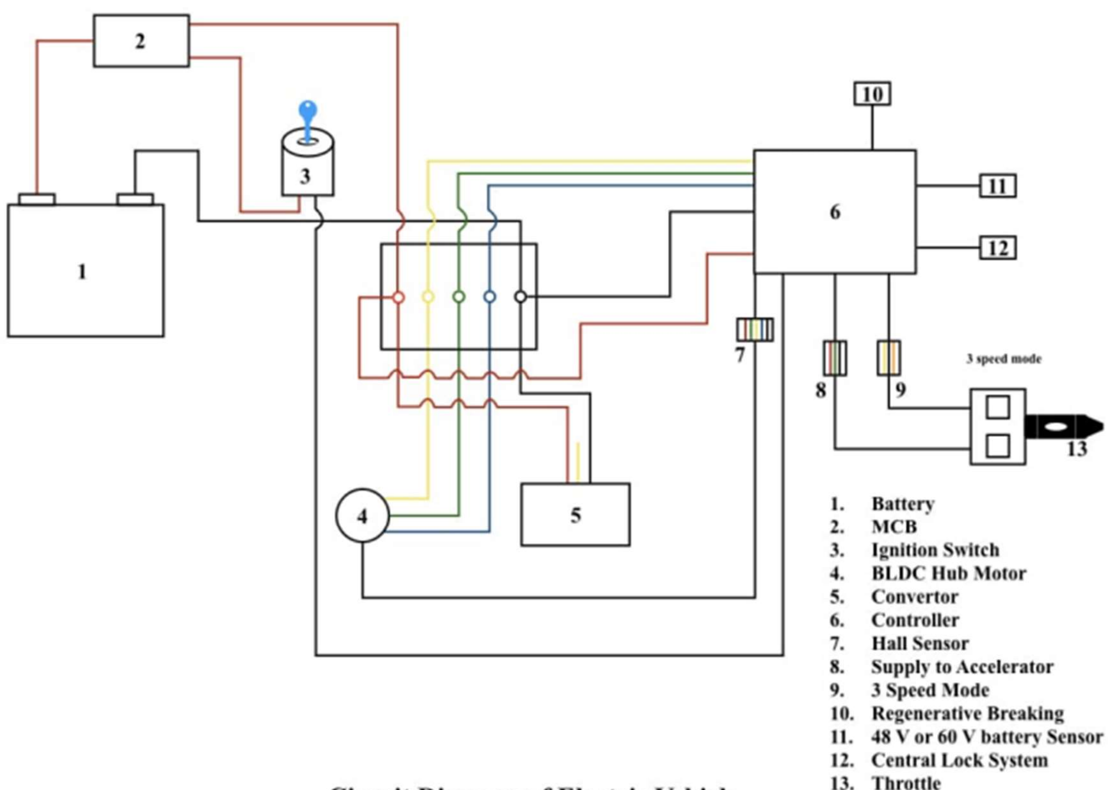
1.4. Methodology

Different sensors are mounted on the vehicle to measure the parameters like speed, temperature, Motion detection, etc.

Temperature sensor and Speed sensor (Hall sensor) is connected to Arduino Nano microcontroller through the I2C module and then displayed on the LCD screen on the EV.

GPS and GSM module are connected to ESP32 microcontroller, which is used for location tracking which uses Wi-Fi network and IP address.

Various features like cruise control, reverse mode, three speed, ignition lock are provided to the EV through the controller.



<u>**Circuit Diagram of Electric Vehicle**</u>

Fig.no. 1.

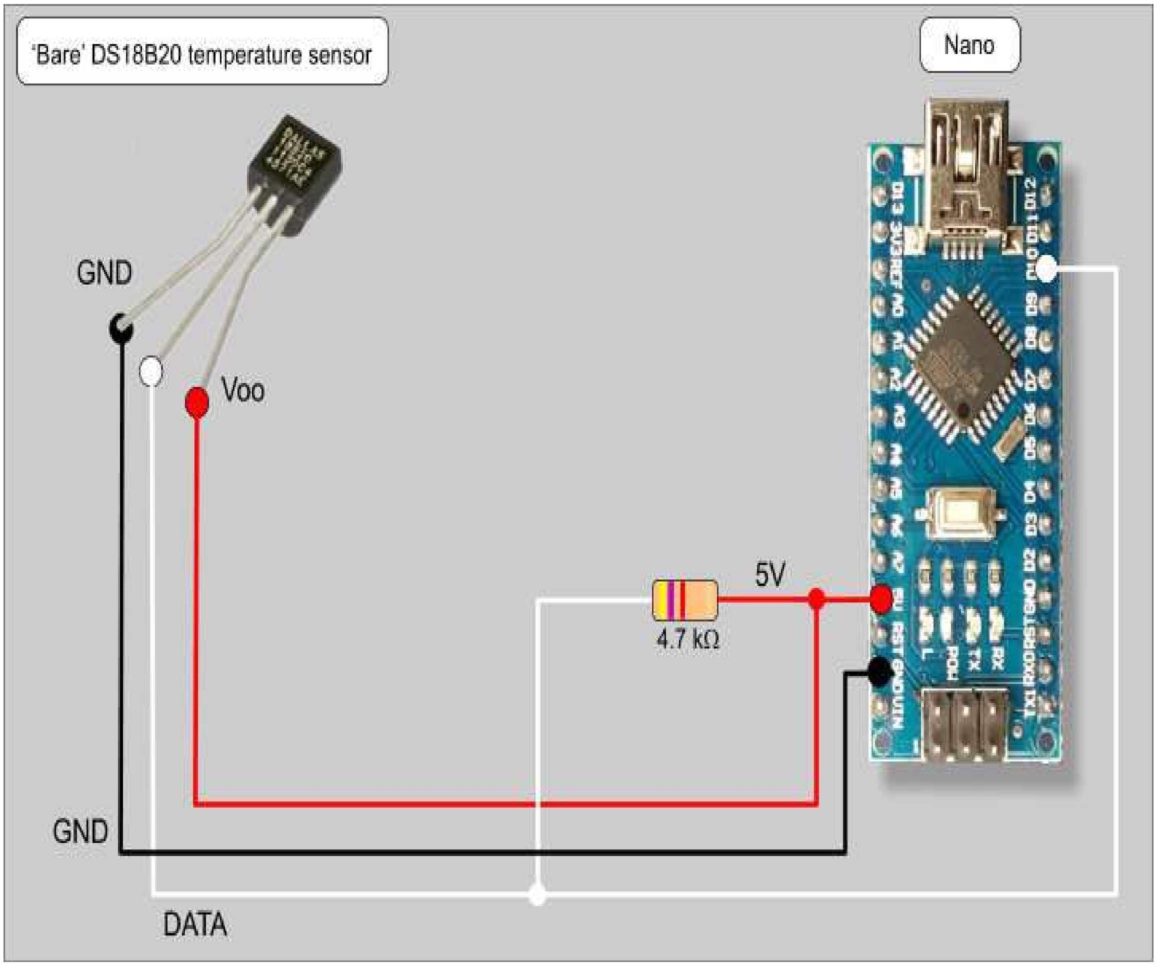


Fig no.2 Temperature sensor connection

Different sensors are mounted on the vehicle to measure the parameters like speed, temperature, Motion detection, etc.
Various features like cruise control, reverse mode, three speed, ignition lock are provided to the EV through the controller.

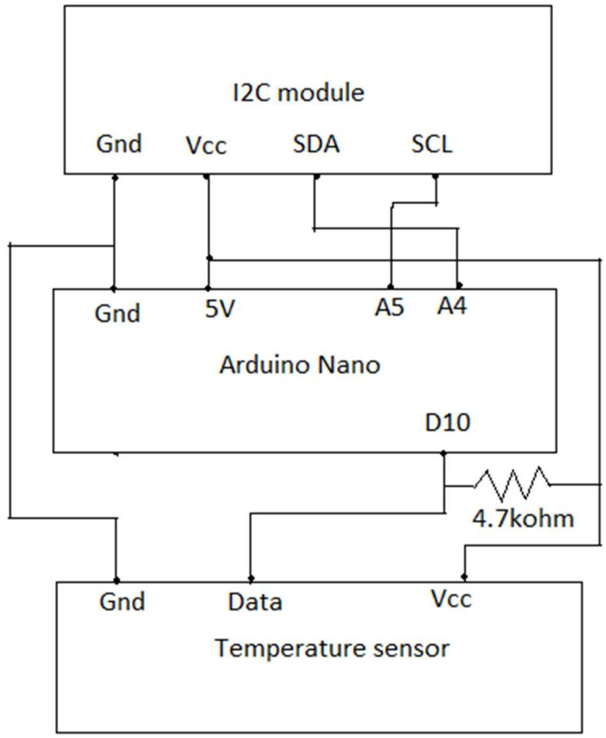


Fig no.3 Temperature sensor connection

Temperature sensor and Speed sensor (Hall sensor) is connected to Arduino Nano microcontroller through the I2C module and then displayed on the LCD screen on the EV. The temperature sensor with pins ground, data and Vcc are connected to the Arduino at ground (pin 29), D10 and +5V respectively and then the Arduino pins i.e. ground (pin 29), 5V, A5 and A4 is connected to the I2C module at ground, Vcc, SCL(Serial clock pin) and SDA(Serial data) respectively. The pull up resistor of 4.7kohm is required in between the data and the Vcc pin of the temperature sensor; without it the sensors will not work. The code for temperature and speed monitoring is fed in the Arduino nano and the temperature and speed can be seen on the LCD screen and also on arduino IoT cloud platform.

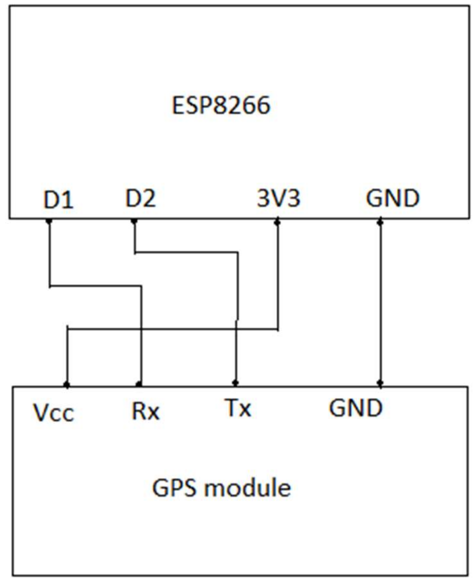


Fig no. 4 GPS Connection

GPS and GSM module are connected to ESP8266 microcontroller, which is used for location tracking which uses Wi-Fi network and IP address. The GPS module's pins Vcc, Rx, Tx and ground are connected to the ESP8622 microcontroller to the pins 3V3, D1, D2 and ground respectively. The code for GPS location tracking is fed in the ESP8622 and the location of the vehicle can be seen on Arduino IoT cloud platform.

CHAPTER 2

LITERATURE SURVEY

When it comes to vehicles, we have a variety of options to choose from when it comes to powering them. Firstly, we have the traditional gasoline and diesel vehicles that most of us are familiar with. They rely on internal combustion engines, where liquid fuel is burned to produce the energy needed to move the vehicle forward. While these vehicles have been the backbone of transportation for many years, there are now more environmentally friendly alternatives gaining popularity.

Secondly, we have hybrid vehicles that combine the traditional internal combustion engine with an electric motor. These vehicles can run on both gasoline and electricity, offering improved fuel efficiency and reduced emissions. They are a great choice for those who want to reduce their carbon footprint without completely transitioning to electric vehicles.

Thirdly, we have vehicles that utilize replaceable fuel, such as fuel cells or metal air batteries. These innovative technologies provide a more sustainable option by converting chemical energy into electrical energy, powering the vehicle. They offer the advantage of quick refueling times and long driving ranges, making them suitable for longer trips.

Fourthly, there are vehicles that can be powered directly from power lines. These electric vehicles can be charged by connecting them to charging stations or electric outlets, similar to how we charge our smartphones or laptops. They offer a convenient and efficient way to power our vehicles while reducing our reliance on fossil fuels.

Lastly, there are vehicles that store energy through alternative means like flywheels or supercapacitors. These vehicles often operate as hybrids, combining multiple power sources for optimal performance. Flywheels store energy by spinning rapidly and releasing it when needed, while supercapacitors store electrical energy for quick and efficient use. These technologies provide an extra boost of power when required, making them suitable for high-performance applications.

In summary, the world of transportation is evolving, and we now have a range of options for powering our vehicles. Whether it's through traditional fuels, hybrid systems, replaceable fuels, electric charging, solar energy, or innovative energy storage methods, there's a solution for everyone looking to drive in a more sustainable and efficient manner.

CHAPTER 3

SYSTEM COMPONENTS

3.1. Component Specifications: -

Major Components	Specifications
Battery	48V, 25Ah
Motor Controller	48V
BLDC motor	48V, 836W
Buck converter	5-12V
Arduino nano	ATmega328 microcontroller, 7-12V

Table A

3.2. Hardware Components:

1. Brushless DC Motor:

A BLDC (Brushless DC) motor is an electric motor that operates using direct current (DC) and does not have brushes for commutation. It is also known as a permanent magnet synchronous motor (PMSM) or electronically commutated motor (ECM).
BLDC motors are widely used in various applications, including electric vehicles, industrial machinery, robotics, HVAC systems, and consumer electronics. They offer several advantages over traditional brushed DC motors, such as higher efficiency, longer lifespan, lower maintenance requirements, and improved controllability.

features and components of a BLDC motor:

1. Stator: The stator is the stationary part of the motor and consists of a series of windings. These windings generate a rotating magnetic field when energized by an external power supply.
2. Rotor: The rotor is the rotating part of the motor and contains permanent magnets or electromagnets. The magnetic field generated by the rotor interacts with the stator's magnetic field, causing the rotor to rotate.
3. Commutation: BLDC motors use electronic commutation rather than brushes and a commutator found in brushed motors. Electronic commutation is achieved through a control circuit that energizes the stator windings in a specific sequence, synchronizing the magnetic field with the rotor's position.
4. Hall Effect Sensors: Hall effect sensors are often used in BLDC motors to provide feedback on the rotor's position. These sensors detect the magnetic field of the rotor magnets and help the control circuit determine when to switch the stator windings.
5. Electronic Speed Controller (ESC): An ESC is an essential component for controlling BLDC motors. It receives signals from the user or a control system and adjusts the motor's speed and direction by varying the timing and amplitude of the currents supplied to the stator windings.

Working Principles and Operation: -

A brushless DC (BLDC) motor is an electric motor that uses permanent magnets on the rotor and electromagnets on the stator to generate rotational motion. Unlike brushed DC motors, BLDC motors do not use brushes and commutators to switch the direction of current flow in the windings. Instead, they rely on electronic control systems to manage the motor operation.
When DC supply is given to pair A it yet magnetizes as A1 is south pole and A2 is north pole . This is the initial position of BLDC. When DC pulse is given to pair B it magnetizes and B1 as south pole and B2 as north pole. This will cause the magnetic rotor to rotate in clockwise direction and align. Thus, by giving sequential current to pair of winding magnets will rotate in clockwise direction and aligning itself to energized poles.

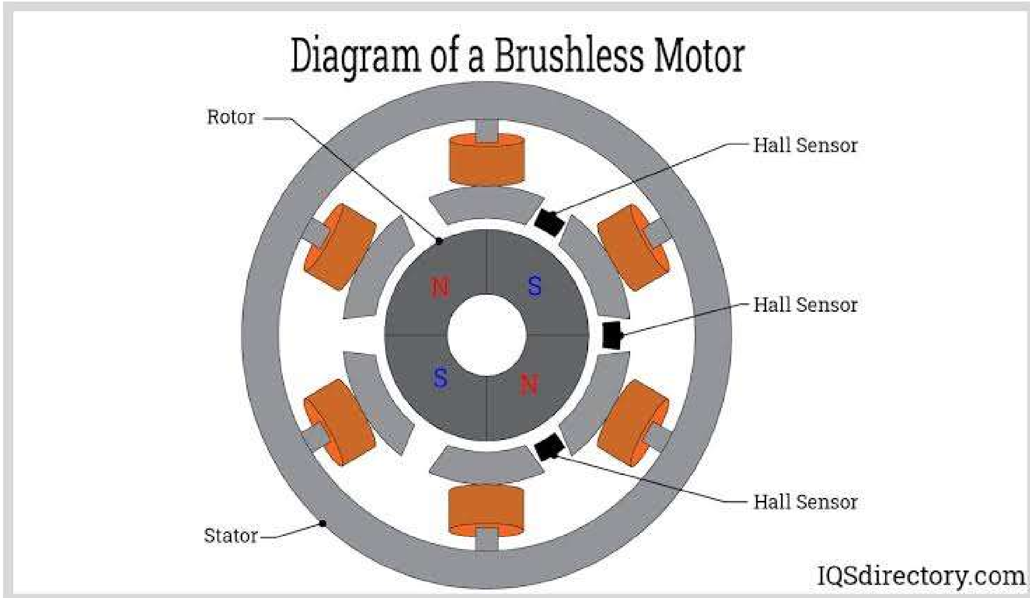


Fig 5 Diagram of Brushless DC Motor

Advantages of BLDC motor:

1. Higher efficiency: BLDC motors have higher efficiency due to the absence of brushes, which reduces friction and eliminates the energy loss associated with brush contact.
2. Improved reliability: The absence of brushes means there is no brush wear or arcing, resulting in longer motor life and reduced maintenance requirements.
3. Higher torque-to-weight ratio: BLDC motors can produce higher torque for their size and weight, making them suitable for applications where space and weight are critical factors.
4. Smooth and precise control: The electronic commutation in BLDC motors enables precise control over motor speed and direction, making them ideal for applications that require accurate positioning and variable speed control.
5. Quieter operation: Since there are no brushes generating friction and noise, BLDC motors tend to operate more quietly than brushed motors.

The specifications of a BLDC motor can vary depending on its intended application and design.

1. Voltage: BLDC motors have a specified operating voltage range. The voltage determines the motor's electrical characteristics and compatibility with power sources or motor control systems. Common voltage ratings for BLDC motors include 12V, 24V, 48V, or higher. The chosen voltage depends on the application requirements, power source availability, and desired performance.
2. Power Rating: The power rating of a BLDC motor indicates the maximum power it can handle or deliver. It is typically specified in watts (W) or kilowatts (kW). The power rating is crucial for determining whether the motor can handle the load and perform the required

tasks. It is important to match the motor's power rating with the application's power requirements to ensure optimal performance and avoid motor damage.

3. Speed: The speed specification refers to the rotational speed at which the BLDC motor operates and is typically measured in revolutions per minute (RPM). The speed can be controlled by adjusting the voltage supplied to the motor or using electronic control systems, such as pulse width modulation (PWM) techniques. The speed requirement is determined by the application, and different BLDC motors offer varying speed ranges to suit different needs.
4. Torque: Torque is the rotational force produced by the BLDC motor. It indicates the motor's ability to exert a twisting force to move or rotate an object. Torque is an important specification when considering the motor's capability to perform tasks requiring a certain amount of force. It is typically measured in Newton-meters (Nm) or ounce-inches (oz-in). The required torque depends on the application's mechanical requirements, such as the load to be moved or the force to be exerted.
5. Efficiency: Efficiency represents the motor's ability to convert electrical power into mechanical power with minimal energy losses. It is expressed as a percentage and indicates the motor's effectiveness in utilizing the input power. Higher efficiency means less energy is wasted as heat or other losses during motor operation. Efficient BLDC motors are desirable for applications where energy conservation and minimizing operating costs are important factors.
6. Frame Size: BLDC motors come in various sizes or frame sizes, typically specified by the motor diameter or the motor's physical dimensions. Frame sizes can be measured in millimeters (mm) or inches (in). The frame size determines the motor's physical form factor and mounting requirements, which is important for integrating the motor into the application or machinery. Different frame sizes offer different power ratings, torque capabilities, and mechanical dimensions to accommodate various application needs.
7. Number of Poles: BLDC motors have a specific number of magnetic poles on the rotor. The number of poles affects the motor's speed, torque, and overall performance characteristics. Common pole configurations include 4-pole, 6-pole, or 8-pole motors. Motors with more poles generally offer higher torque at lower speeds, while motors with fewer poles can achieve higher speeds but with lower torque. The choice of pole configuration depends on the application's torque and speed requirements.
8. Frame Size: BLDC motors come in various sizes or frame sizes, typically specified by the motor diameter or the motor's physical dimensions. Frame sizes can be measured in millimeters (mm) or inches (in). The frame size determines the motor's physical form factor and mounting requirements, which is important for integrating the motor into the application or machinery. Different frame sizes offer different power ratings, torque capabilities, and mechanical dimensions to accommodate various application needs.
9. Number of Poles: BLDC motors have a specific number of magnetic poles on the rotor. The number of poles affects the motor's speed, torque, and overall performance characteristics. Common pole configurations include 4-pole, 6-pole, or 8-pole motors. Motors with more poles generally offer higher torque at lower speeds, while motors with fewer poles can achieve higher speeds but with lower torque. The choice of pole configuration depends on the application's torque and speed requirements.

Specifications

1. Enhanced Driving Experience: BLDC motors contribute to an enhanced driving experience in electric vehicles. They provide instant torque, allowing for quick acceleration and responsive performance. This translates into a smoother and more enjoyable ride for the driver and passengers, offering a dynamic and engaging driving experience.
2. Reduced Noise and Vibrations: BLDC motors operate with significantly lower noise and vibrations compared to internal combustion engines. This contributes to a quieter and more comfortable driving environment, reducing noise pollution both inside and outside the vehicle. The absence of engine vibrations enhances the overall comfort and reduces driver fatigue during long journeys.
3. Energy Efficiency and Range: BLDC motors are highly efficient, converting electrical energy into mechanical power with minimal energy losses. This efficiency helps electric vehicles achieve longer ranges on a single charge. By utilizing energy more effectively, BLDC motors maximize the vehicle's driving range, providing convenience and peace of mind to EV owners.
4. Regenerative Braking: BLDC motors enable regenerative braking in electric vehicles, which is a key feature for energy recovery. During braking or deceleration, the motor acts as a generator, converting kinetic energy into electrical energy and storing it in the vehicle's battery. This regenerative braking system improves overall energy efficiency and extends the vehicle's range, while also reducing wear on traditional friction brakes.
5. Simplified Maintenance: BLDC motors have fewer moving parts compared to internal combustion engines, resulting in reduced maintenance requirements. The absence of brushes eliminates the need for regular replacement or maintenance, lowering the overall cost of ownership for electric vehicle owners. Additionally, the simplified design and reduced wear contribute to improved reliability and longer lifespan of BLDC motors.
6. Environmental Benefits: BLDC motors in electric vehicles have a positive impact on the environment. They produce zero tailpipe emissions, reducing greenhouse gas emissions and air pollution. By transitioning from fossil fuel-powered vehicles to electric vehicles with BLDC motors, we can contribute to cleaner air, mitigate climate change, and promote sustainable transportation.
7. Driving the Electric Revolution: BLDC motors are a driving force behind the ongoing electric vehicle revolution. Their efficiency, performance, and reliability have been instrumental in advancing the adoption of electric vehicles globally. BLDC motors have helped reshape the automotive industry, providing a sustainable and eco-friendly transportation solution that aligns with the evolving needs and concerns of individuals and society.

2. Controller:

A 48V DC-DC controller is an electronic device used to regulate and control the power flow between a 48V DC input source and a load or output. It ensures that the output voltage remains stable and within the desired range, regardless of any fluctuations or changes in the input voltage.

The DC-DC controller performs several functions to achieve this voltage regulation, including:

1. Voltage Conversion: The controller converts the 48V DC input voltage to a different voltage level suitable for the load or output. This conversion can be step-up (boost), step-down (buck), or a combination of both (buck-boost), depending on the specific requirements of the application.
2. Regulation and Control: The controller includes circuitry to monitor the output voltage and adjust it as needed to maintain the desired level. It uses feedback mechanisms, such as voltage feedback loops, to compare the actual output voltage with a reference voltage and make appropriate adjustments to the power conversion process.
3. Switching Control: DC-DC controllers often employ high-frequency switching techniques to regulate the voltage conversion process efficiently. They utilize switching devices, such as MOSFETs or IGBTs, to rapidly switch the current flow on and off, thereby controlling the average output voltage.
4. Protection and Safety Features: DC-DC controllers often incorporate various protection mechanisms to safeguard the system and components. These features can include overvoltage protection, undervoltage protection, overcurrent protection, short-circuit protection, and thermal protection, among others.
5. Control Interfaces: Depending on the application and system requirements, the controller may provide control interfaces such as analog control inputs, digital interfaces (e.g., I2C or SPI), or even wireless communication options for remote control and monitoring.

The specific implementation and features of a 48V DC-DC controller can vary based on the intended application, load requirements, efficiency targets, and other system considerations. They are commonly used in power conversion applications like renewable energy systems, electric vehicles, telecommunications, industrial equipment, and more.

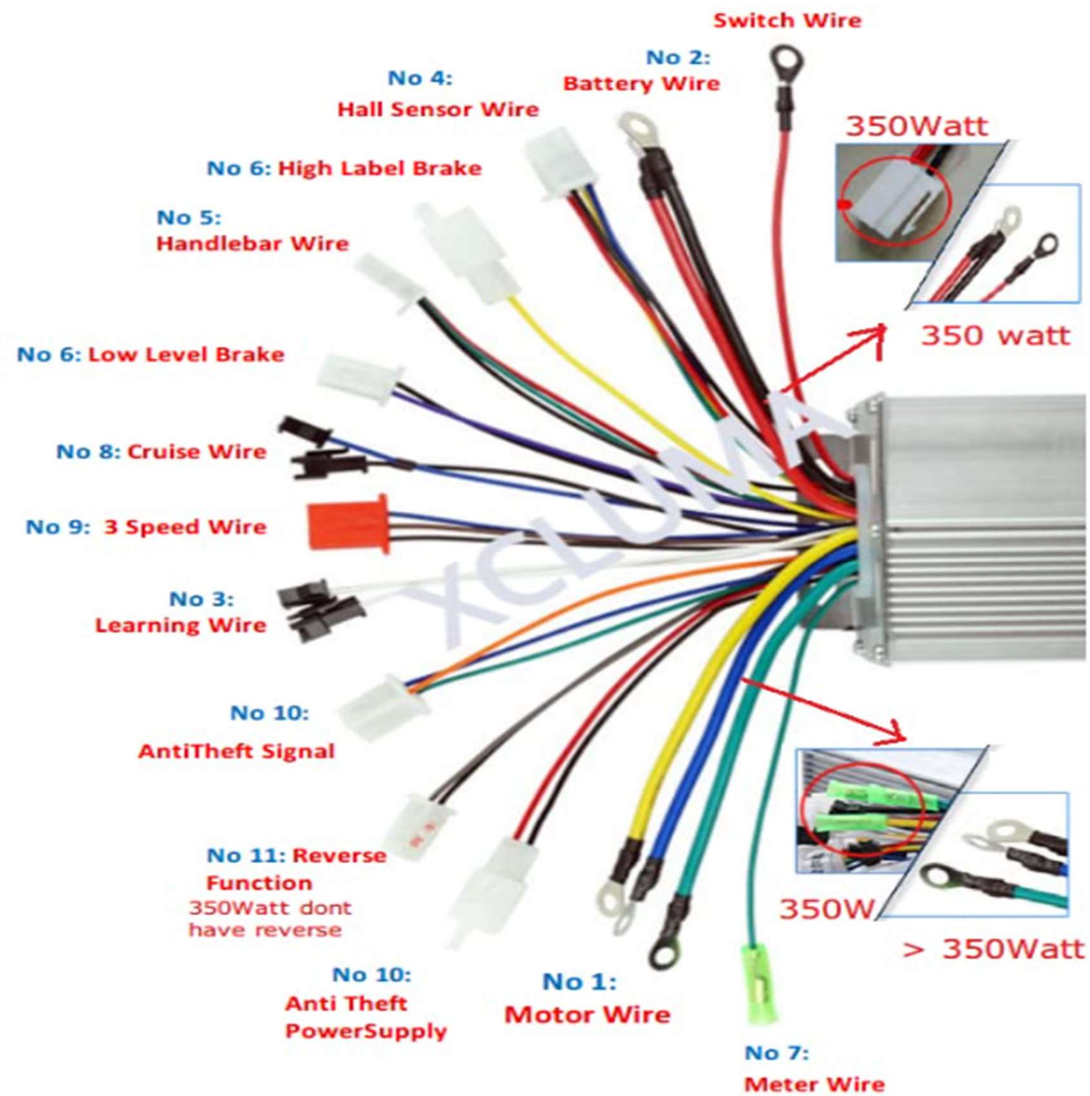


Fig 6 : Controller

Advantages of using a 48V DC-DC controller:

1. Voltage Conversion: A 48V DC-DC controller allows for efficient voltage conversion, enabling the integration of components or systems that operate at different voltage levels. It provides flexibility in designing and implementing systems that require different voltage levels for optimal performance. This is particularly useful in applications where multiple subsystems or components with varying voltage requirements need to be powered.
2. Power Distribution: A 48V DC-DC controller facilitates power distribution within a system. It can convert a 48V power source into lower voltage levels suitable for various subsystems, modules, or devices. This enables efficient power delivery to different parts of the system, ensuring proper operation and maximizing energy efficiency.

3. Energy Efficiency: DC-DC controllers are designed to be highly efficient in converting electrical power. By using a 48V DC-DC controller, energy losses during the conversion process can be minimized, leading to improved overall energy efficiency. This is particularly important in systems where energy conservation is a priority, such as electric vehicles, renewable energy systems, and data centers.
4. Compact Size: 48V DC-DC controllers are available in compact and space-saving form factors. They are designed to be lightweight and offer high power density, allowing for easy integration into various applications with limited space. The compact size and high power density make them suitable for applications where size and weight constraints are important, such as portable devices, automotive systems, and aerospace applications.
5. Voltage Regulation: DC-DC controllers provide voltage regulation capabilities, ensuring stable and reliable power supply to the load. They can compensate for voltage variations or fluctuations in the input power source and deliver a consistent voltage output. This helps protect sensitive electronic components and ensures the proper functioning of the system, even in the presence of varying input voltages.
6. Scalability: The use of a 48V DC-DC controller enables scalability in system design. As the demand for higher power or additional subsystems arises, multiple DC-DC controllers can be employed in parallel or in a modular configuration to meet the increased power requirements. This scalability allows for system expansion and adaptability to changing needs without the need for a complete redesign.
7. Compatibility: The 48V voltage level is becoming increasingly popular in various industries, such as automotive, telecommunications, data centers, and renewable energy. Using a 48V DC-DC controller ensures compatibility with the existing infrastructure and power systems within these industries. It provides a standardized voltage level that can be easily integrated into the existing ecosystem, simplifying system integration and interoperability.

3. Battery:

A 48V lithium-ion battery refers to a battery system or pack that utilizes lithium-ion chemistry and operates at a nominal voltage of 48 volts. It is composed of multiple lithium-ion cells connected in series to achieve the desired voltage level.

1. Voltage Level: A 48V lithium-ion battery has a nominal voltage of 48 volts, which represents the average voltage during normal operation. The actual voltage can vary depending on the state of charge and load conditions.
2. Lithium-Ion Chemistry: Lithium-ion batteries are known for their high energy density, long cycle life, and relatively low self-discharge rate. They use lithium ions to facilitate the movement of electrons during charging and discharging cycles. Common lithium-ion chemistries used in 48V batteries include lithium iron phosphate ($LiFePO4$), lithium nickel manganese cobalt oxide (NMC), and lithium nickel cobalt aluminum oxide (NCA).
3. Applications: 48V lithium-ion batteries find applications in various industries, including electric vehicles (EVs), hybrid electric vehicles (HEVs), energy storage systems (ESS) for residential or commercial use, telecommunications, data centers, renewable energy integration, and industrial equipment.
4. Capacity and Energy Storage: The capacity of a 48V lithium-ion battery pack is typically measured in ampere-hours (Ah) or kilowatt-hours (kWh). It determines the amount of energy the battery can store and deliver over a given period. The capacity can vary depending on the specific battery configuration and application requirements.
5. Charging and Discharging: 48V lithium-ion batteries require appropriate charging systems or chargers designed specifically for lithium-ion chemistry. They can be charged using various charging methods, including constant current (CC) and constant voltage (CV) techniques. The batteries can supply power to various devices or systems through controlled discharging processes.

It's important to consider that the specific characteristics of a 48V lithium-ion battery, such as capacity, size, weight, and performance, can vary based on the manufacturer, cell configuration, and intended application. Advancements in lithium-ion technology continue to drive improvements in energy density, cycle life, and overall performance of these batteries.

Lithium-ion (Li-ion) batteries are generally considered superior to lead-acid batteries for various applications due to several key advantages. Here are some reasons why lithium-ion batteries are often preferred:

1. Energy Density: Lithium-ion batteries offer a significantly higher energy density compared to lead-acid batteries. This means they can store more energy in a smaller and lighter package, making them ideal for portable electronic devices, electric vehicles (EVs), and renewable energy storage systems.

2. Longer Cycle Life: Li-ion batteries typically have a longer cycle life compared to lead-acid batteries. A cycle refers to one full discharge and recharge cycle. Lithium-ion batteries can endure hundreds to thousands of cycles, depending on the specific chemistry, whereas lead-acid batteries generally have a shorter lifespan and fewer cycles.

3. Higher Efficiency: Lithium-ion batteries have a higher charge and discharge efficiency compared to lead-acid batteries. They can convert stored energy more efficiently, resulting in less energy loss during charging and discharging processes.

4. Faster Charging: Li-ion batteries can be charged at a faster rate than lead-acid batteries. They have a higher charge acceptance, allowing them to absorb energy more rapidly. This feature is particularly beneficial for EVs, where quick charging is desirable.

5. Lighter Weight and Smaller Size: Lithium-ion batteries are lighter and more compact than lead-acid batteries with similar energy storage capacity. This advantage is crucial in applications where weight and size are important factors, such as portable electronics and electric vehicles.

6. Self-Discharge Rate: Li-ion batteries have a lower self-discharge rate than lead-acid batteries. This means they can retain their charge for a longer period when not in use, making them more suitable for applications that require long-term storage.

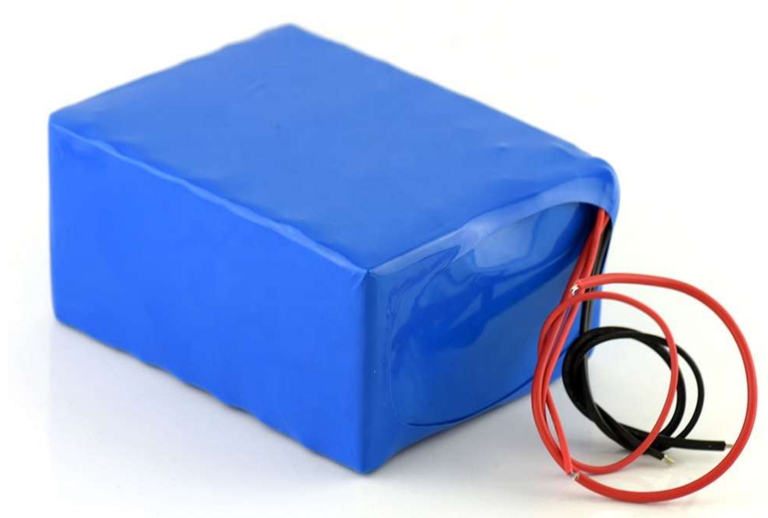


Fig 7 Battery

4. Buck Converter:

This Mini Adjustable DC-DC Buck Converter Module is Capable of giving Fix 12V, 3V3 , 9V and 5V output voltage just by shorting jumper pads

A DC-DC buck converter module, also known as a step-down converter module, is a device used to convert a higher DC voltage to a lower DC voltage with a regulated output. Here's some information about DC-DC buck converter modules:

Function: The primary function of a DC-DC buck converter module is to step down or reduce the input voltage to a lower level. It converts the higher input voltage into a lower output voltage suitable for powering specific components or systems.

Voltage Conversion: The DC-DC buck converter module operates based on the principle of pulse width modulation (PWM). It switches the input voltage on and off at a high frequency, controlling the duty cycle to regulate the output voltage. By adjusting the duty cycle, the module can achieve the desired voltage reduction.
Efficiency: Buck converter modules are known for their high efficiency. They can achieve efficiency levels above 90% in many cases, minimizing energy losses during the conversion process. The efficiency is influenced by factors such as the quality of the components, switching frequency, and load conditions.

Voltage Regulation: DC-DC buck converter modules provide voltage regulation capabilities. They can maintain a stable output voltage even when the input voltage or load conditions vary. Voltage regulation is achieved through feedback control mechanisms that adjust the duty cycle based on the difference between the desired output voltage and the actual output voltage.
Current Limiting: Buck converter modules often include current limiting features to protect the system and the module itself from excessive current. This helps prevent damage due to overcurrent situations and improves the overall reliability of the system.

Compact Size: DC-DC buck converter modules are available in compact form factors, making them suitable for applications where space is limited. Their compact size allows for easy integration into various electronic devices or systems.

Protection Features: Many buck converter modules include built-in protection features such as overvoltage protection, overcurrent protection, thermal shutdown, and short-circuit protection. These protections help safeguard the module and the connected components from potential damage in case of abnormal operating conditions.

Applications: DC-DC buck converter modules are widely used in various applications. They are commonly found in power supplies, battery chargers, LED lighting systems, portable electronic devices, automotive electronics, and more. They provide a convenient and efficient solution for voltage reduction and power management in these applications.

Design Considerations: When selecting a DC-DC buck converter module, factors to consider include input and output voltage requirements, output current capability, efficiency, operating temperature range, protection features, and the physical dimensions of the module to ensure compatibility with the application's needs.

Fig 8: Buck Converter

5. Arduino Nano:

The Arduino Nano is a compact and versatile microcontroller board based on the ATmega328P microcontroller. It is one of the popular variants in the Arduino family, known for its small size and wide range of applications.. It has specifications which are as follows:

Microcontroller	ATmega328
Built-in LED Pin	13
Digital I/O Pins	14
Analog input pins	8
PWM pins	6
I2C	A4(SDA), A5(SCL)
I/O Voltage	5V
Input voltage (nominal)	7-12V

Table B

Form Factor: The Arduino Nano is small in size, typically measuring around 45mm x 18mm. It is designed to be breadboard-friendly, with standard 0.1-inch pin spacing, allowing easy integration into prototype circuits or custom PCB designs.

Digital and Analog I/O: The Arduino Nano provides a range of digital and analog input/output pins. It offers 14 digital I/O pins, of which 6 can be used as PWM (Pulse Width Modulation) outputs, and 8 analog input pins. These pins can be used to connect and control various sensors, actuators, and other electronic components.

Serial Communication: The Arduino Nano supports serial communication through multiple interfaces. It has a built-in USB-to-serial converter, enabling easy connection to a computer for programming and communication. It also has hardware UART (Universal Asynchronous Receiver-Transmitter) serial ports, which can be used to communicate with other devices or modules.

Power Options: The Arduino Nano can be powered through a USB connection or an external power supply. It has a voltage regulator that allows it to accept a wide input voltage range (typically 7-12V), making it compatible with various power sources. The Nano also has a 5V output pin that can be used to power external components.

Programming: The Arduino Nano can be programmed using the Arduino programming language, which is based on C/C++. The Arduino development environment provides a user-friendly interface for writing, compiling, and uploading code to the Nano. It supports a wide range of libraries and examples, making it easy to get started with programming and building projects.

Expansion and Shields: The Arduino Nano is compatible with various expansion modules and shields designed for the Arduino ecosystem. These modules and shields offer additional functionalities, such as wireless communication (e.g., Wi-Fi, Bluetooth), motor control, display interfaces, and more, allowing you to expand the capabilities of your projects.

Versatility: The small size, versatility, and wide range of available libraries and resources make the Arduino Nano suitable for a broad range of applications. It can be used for prototyping IoT devices, robotics projects, home automation systems, sensor monitoring, data logging, and much more.

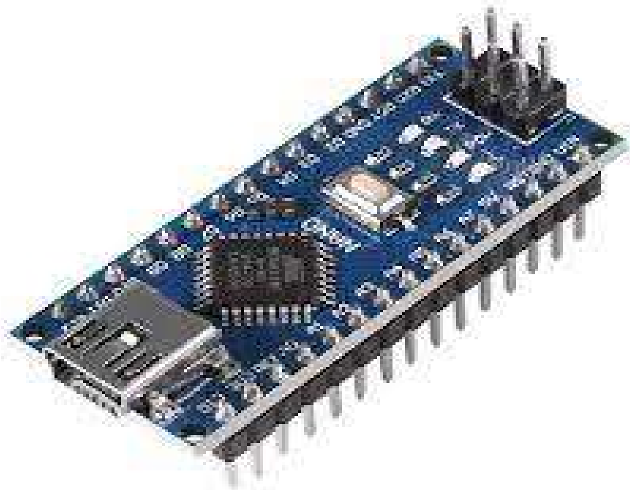


Fig 9 : Arduino Nano

6. I2C Module:

An I2C (Inter-Integrated Circuit) module, also known as an I2C interface or I2C controller, is a hardware component or module that facilitates communication between microcontrollers, sensors, and other devices using the I2C protocol. It acts as a bridge or mediator, allowing devices to exchange data over a two-wire serial interface.

An I2C module, also known as I2C interface module or I2C breakout board, is a hardware component that facilitates communication using the Inter-Integrated Circuit (I2C) protocol. It is designed to simplify the integration of I2C devices into electronic systems. Here's some information about I2C modules:

I2C Protocol: I2C (Inter-Integrated Circuit) is a popular serial communication protocol used for connecting and communicating between various electronic components, such as microcontrollers, sensors, displays, EEPROMs, and other peripherals. It uses a master-slave architecture, where the master device initiates and controls the data transfer to one or multiple slave devices.

Hardware Interface: An I2C module typically consists of a small circuit board or module that provides the necessary hardware components for I2C communication. It includes pull-up resistors for the I2C bus lines (SCL and SDA), level shifters (if required) to match voltage levels between devices, and connectors or pins for easy connection with other devices.

Voltage Compatibility: I2C modules are available in different versions to support various voltage levels. Common versions include 3.3V, 5V, and adjustable voltage level I2C modules. This allows for compatibility with different devices that operate at different voltage levels.

I2C Address Selection: Many I2C devices have a specific address to differentiate them on the I2C bus. Some I2C modules include features like DIP switches or solder pads to select the desired I2C address. This allows for connecting multiple devices with different addresses on the same I2C bus.

Simplified Connection: I2C modules provide standard pin headers or connectors that can be easily connected to the I2C bus of a microcontroller or other devices. This simplifies the wiring process and eliminates the need for complex circuitry to implement I2C communication.

Pull-Up Resistors: I2C modules often include built-in pull-up resistors for the SCL and SDA lines. Pull-up resistors are essential to maintain proper voltage levels on the I2C bus and ensure reliable communication. Having these resistors integrated into the module saves the user from manually adding external resistors.

Additional Features: Depending on the specific module, additional features may be included, such as voltage level indicators, power supply options, interrupt pins, on-board EEPROM, or programmable I2C addresses. These features enhance the functionality and flexibility of the module for different applications.

Software Libraries and Examples: I2C modules typically have extensive software support, including libraries and example code. These resources simplify the programming and integration of I2C devices into projects. They often provide functions for initializing the I2C bus, sending and receiving data, and handling specific device functionalities.

Application: I2C modules are widely used in various applications where I2C communication is required. They are commonly employed in robotics, automation, sensor networks, IoT devices, display modules, data logging systems, and more. The modules streamline the process of interfacing and controlling I2C devices, saving time and effort in development.

Overall, I2C modules offer a convenient solution for integrating I2C devices into electronic systems. They provide the necessary hardware components and simplify the connection and communication process, enabling easy implementation of I2C-based projects.

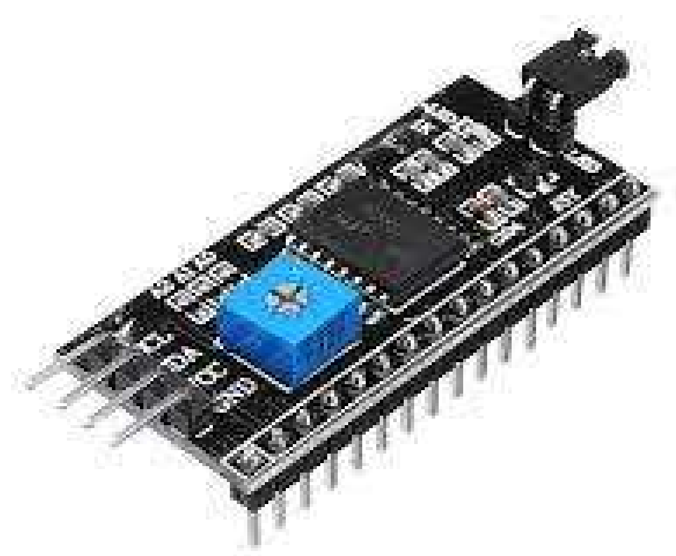


Fig 10 : I2C Module

7. LCD display (16*2):
An LCD display (16x2) refers to a Liquid Crystal Display module with a character display format of 16 columns and 2 rows. It is a common type of display used in various applications, such as microcontroller-based projects, electronic devices, and industrial control systems.
Temperature sensor:
Temperature sensors are designed to measure temperature over a range of temperatures. Some sensors may have a narrow range, such as -40°C to +85°C, while others may have a wider range, such as -200°C to +1200°C.
We are using it to measure the temperature of the battery.
An LCD display with a size of 16x2 refers to a liquid crystal display that can display 16 characters per line and has 2 lines of text. These displays are commonly used in various electronic projects and devices for displaying information or messages. Here's some information about LCD displays with a 16x2 configuration:

Character Display: The LCD display with a 16x2 configuration consists of 16 character spaces horizontally arranged in 2 rows. Each character space can display a single alphanumeric character, symbol, or custom-defined character.
Backlight: Many 16x2 LCD displays feature a built-in backlight, typically an LED, which provides illumination to the characters on the display. The backlight can be controlled to adjust the brightness or turned on/off as needed.

Programming: Interfacing and controlling a 16x2 LCD display typically involve writing code to send commands and data to the display. Many microcontroller platforms, such as Arduino, provide libraries and examples to simplify the programming process. These libraries abstract the low-level communication details, making it easier to display text and control the display's behavior.

LCD displays with a 16x2 configuration are popular for their compact size and versatility in displaying text-based information. They offer a simple and cost-effective solution for adding a visual output to electronic projects and devices.

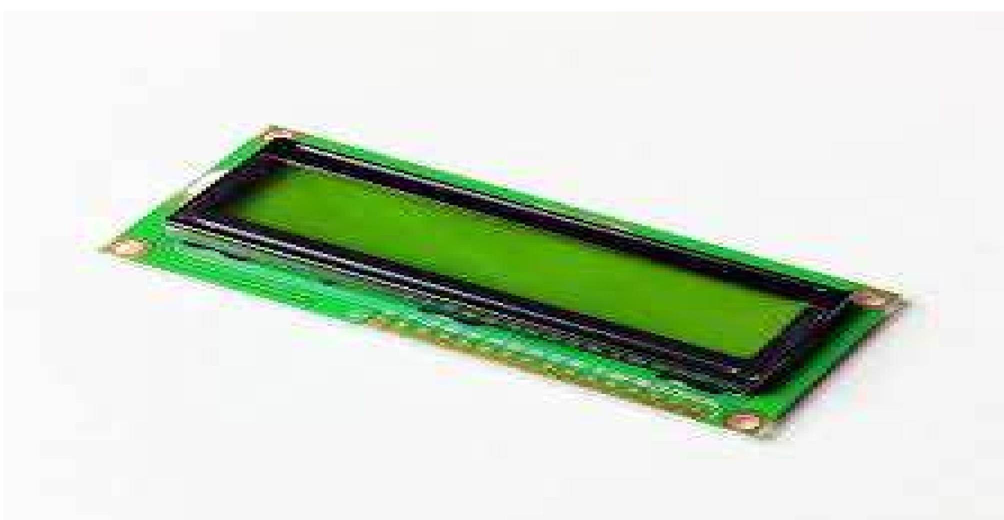


Fig 11: LCD Display

8. Neo-6M GPS Module with EPROM:
The Neo-6M GPS module with EPROM is a compact and affordable GPS (Global Positioning System) module that incorporates an EPROM (Erasable Programmable Read-Only Memory) for storing configuration settings and other data. It is commonly used in applications that require accurate positioning, tracking, and navigation capabilities

GPS Functionality: The Neo-6M GPS module is designed to receive signals from GPS satellites to determine its precise location, velocity, and time. It utilizes the GPS system's network of satellites to calculate latitude, longitude, altitude, speed, and other positioning data.

EPROM Chip: The EPROM chip integrated into the Neo-6M GPS module is an Electrically Programmable Read-Only Memory. It is a non-volatile memory chip that allows data to be programmed and retained even when the power is turned off. In the case of the GPS module, the EPROM chip is typically used to store configuration data, settings, or custom parameters specific to the module.

Configuration Storage: The EPROM chip in the Neo-6M GPS module allows the user to store and retain specific configuration settings. These settings can include parameters like baud rate, update rate, output formats, NMEA sentences, and other GPS-related settings. By storing these settings in the EPROM, they can be easily loaded and retained during power cycles, eliminating the need to reconfigure the module each time it is powered on.

Programmability: The EPROM chip in the Neo-6M GPS module is programmable, allowing the user to write data to it using appropriate programming tools or techniques. The specific process for programming the EPROM may vary depending on the module and the associated programming method or protocol.

Applications: GPS modules with EPROM, including the Neo-6M, find applications in various projects where GPS positioning and navigation data is required. They are commonly used in applications such as vehicle tracking, asset monitoring, geolocation-based systems, outdoor navigation devices, and other projects that require accurate positioning and timing information.

Fig 12: Neo-6M GPS Module

9. Ultrasonic distance sensor module:

An ultrasonic distance sensor module is a non-contact sensor that uses ultrasonic waves to measure distance. Ultrasonic distance sensor modules are used in various applications such as robotics, industrial automation, security systems, and more.
An ultrasonic distance sensor module is a device that uses ultrasonic waves to measure the distance between the sensor and an object. It is a popular sensor used in various applications for distance measurement and object detection. Here's some information about ultrasonic distance sensor modules:

Working Principle: Ultrasonic distance sensor modules work based on the principle of sound wave propagation. The sensor emits high-frequency ultrasonic waves (typically in the range of 40 kHz) and measures the time it takes for the waves to bounce back after hitting an object. By calculating the round-trip time and knowing the speed of sound, the sensor can determine the distance to the object.

Transducer: The ultrasonic distance sensor module consists of two main components: a transducer and a receiver. The transducer is responsible for emitting ultrasonic waves and converting electrical signals into sound waves. It typically consists of a piezoelectric crystal that vibrates when an electrical signal is applied to it, generating ultrasonic waves.

Receiver: The receiver component of the module detects the reflected ultrasonic waves. It also contains a piezoelectric crystal that converts the received sound waves back into electrical signals. These signals are then processed by the module to determine the distance to the object.

Measurement Range: Ultrasonic distance sensor modules have a specific measurement range, which is typically between a few centimeters to several meters, depending on the module. The range can be adjusted based on the sensor's specifications and the application requirements.

Accuracy and Precision: The accuracy and precision of ultrasonic distance sensor modules can vary depending on factors such as the quality of the module, environmental conditions, and the object's surface characteristics. In general, they provide reasonable accuracy for most applications, typically within a few millimeters.

Trigger and Echo Signals: To measure the distance, the ultrasonic distance sensor module typically requires a trigger signal to initiate the ultrasonic wave emission and an echo signal to measure the time taken for the wave to return. These signals are usually controlled by a microcontroller or other controlling devices.

Interface: Ultrasonic distance sensor modules commonly have a simple interface, usually consisting of a few pins. They often include power supply pins (VCC and GND) for providing the necessary voltage, a trigger pin for initiating the measurement, and an echo pin for receiving the reflected signal. Some modules may also have additional pins for advanced functionalities.

Applications: Ultrasonic distance sensor modules find applications in various fields, including robotics, automation, security systems, industrial control, parking assist systems, and more. They are used for proximity sensing, obstacle detection, distance measurement, liquid level detection, and other tasks that require accurate distance information.

Integration: Ultrasonic distance sensor modules can be easily integrated into electronic systems and microcontroller-based projects. They often communicate using digital interfaces such as GPIO pins or serial protocols, allowing for straightforward integration with popular microcontrollers like Arduino, Raspberry Pi, and other development boards.

Ultrasonic distance sensor modules provide a reliable and versatile solution for measuring distances and detecting objects. With their simple interface and reasonable accuracy, they are widely used in a variety of applications that require distance measurement and object detection capabilities.

Fig 13 : Ultrasonic Sensor

10. Charger:

An EV charger, also known as an electric vehicle charger or electric vehicle supply equipment (EVSE), is a device used to recharge the battery of an electric vehicle. EV chargers are essential for EV owners to conveniently charge their vehicles at home, workplaces, or public charging stations.

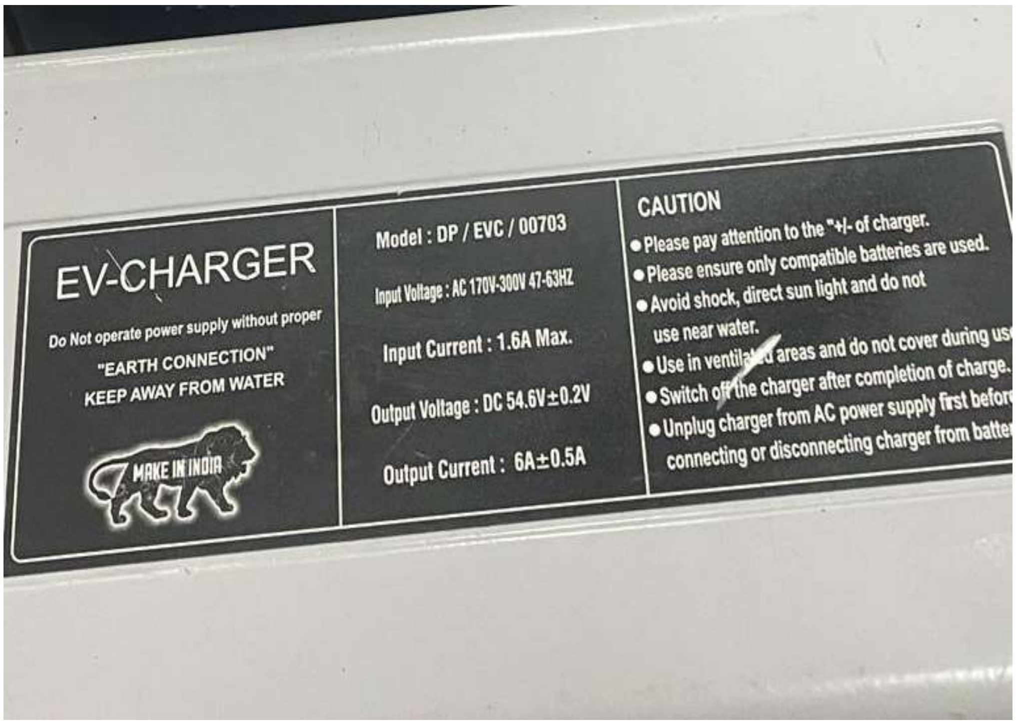
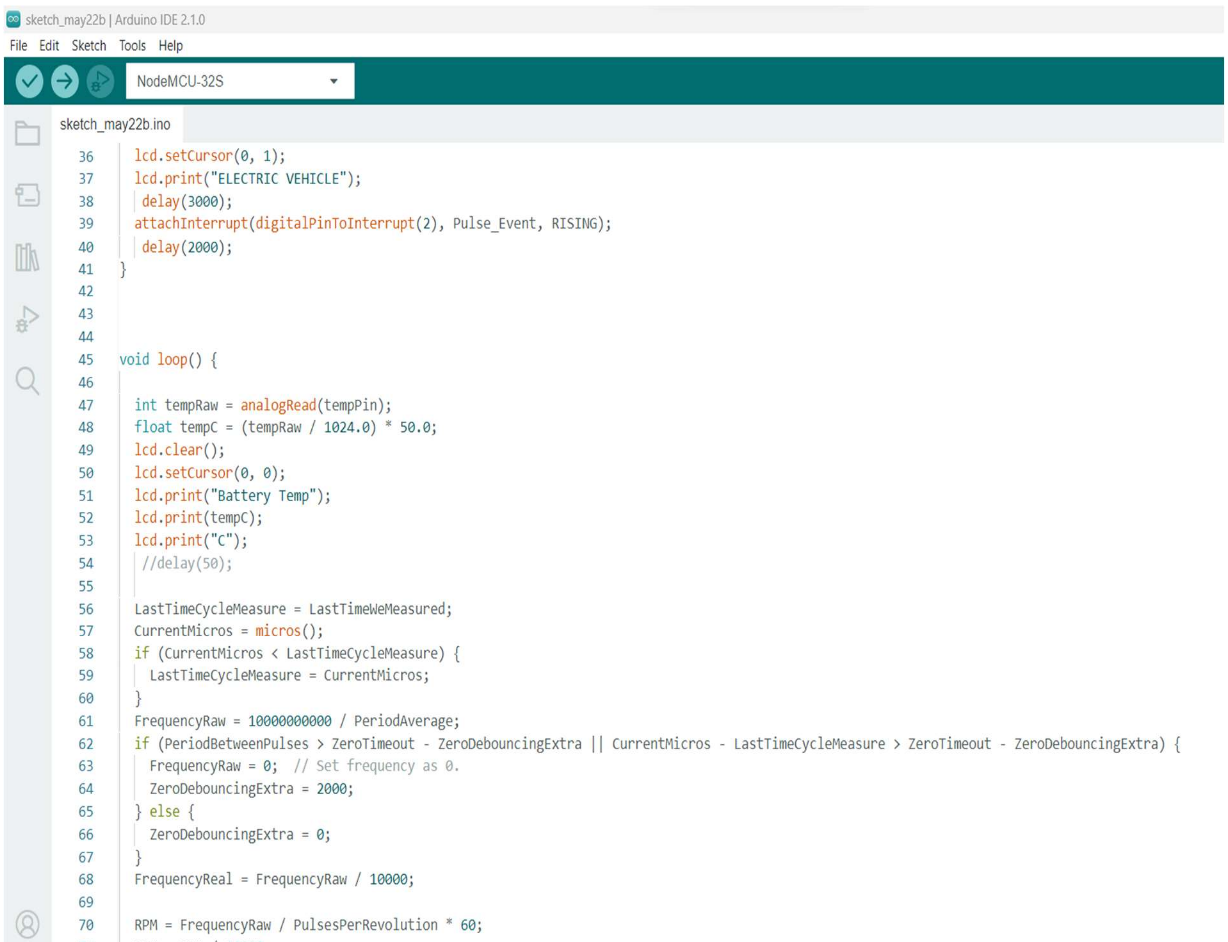


Fig 14: Charger

3.2 Software Specification

1. Arduino IDE

The Arduino IDE (Integrated Development Environment) is a software platform used for programming and developing applications for Arduino boards. It provides a user-friendly interface that simplifies the process of writing, compiling, and uploading code to Arduino microcontrollers. Arduino IDE is an open-source software program that allows users to write and upload code within a real-time work environment. As this code will thereafter be stored within the cloud, those who have been searching for an extra level of redundancy often utilize it.
The following code was used for temperature and speed display on lcd screen and gps tracking of the vehicle and also ultrasonic application for accidental detection;




```
  lcd.setCursor(0, 1);
  lcd.print("ELECTRIC VEHICLE");
   delay(3000);
  attachInterrupt(digitalPinToInterrupt(2), Pulse_Event, RISING);
   delay(2000);
}



void loop() {

  int tempRaw = analogRead(tempPin);
  float tempC = (tempRaw / 1024.0) * 50.0;
  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("Battery Temp");
  lcd.print(tempC);
  lcd.print("C");
   //delay(50);

  LastTimeCycleMeasure = LastTimeWeMeasured;
  CurrentMicros = micros();
  if (CurrentMicros < LastTimeCycleMeasure) {
    LastTimeCycleMeasure = CurrentMicros;
  }
  FrequencyRaw = 10000000000 / PeriodAverage;
  if (PeriodBetweenPulses > ZeroTimeout - ZeroDebouncingExtra || CurrentMicros - LastTimeCycleMeasure > ZeroTimeout - ZeroDebouncingExtra) {
    FrequencyRaw = 0;  // Set frequency as 0.
    ZeroDebouncingExtra = 2000;
  } else {
    ZeroDebouncingExtra = 0;
  }
  FrequencyReal = FrequencyRaw / 10000;

  RPM = FrequencyRaw / PulsesPerRevolution * 60;
  RPM = RPM / 10000;
```

sketch_may22b | Arduino IDE 2.1.0

File Edit Sketch Tools Help

NodeMCU-32S

sketch_may22b.ino

```
  RPM = FrequencyRaw / PulsesPerRevolution * 60;
  RPM = RPM / 10000;
  total = total - readings[readIndex];
  readings[readIndex] = RPM;
  total = total + readings[readIndex];
  readIndex = readIndex + 1;

  if (readIndex >= numReadings) {
    readIndex = 0;
  }
  average = total / numReadings;



  Serial.print("Period: ");
  Serial.print(PeriodBetweenPulses);
  Serial.print("\tReadings: ");
  Serial.print(AmountOfReadings);
  Serial.print("\tFrequency: ");
  Serial.print(FrequencyReal);
  Serial.print("\tRPM: ");
  Serial.print(RPM);
  Serial.print("\tTachometer: ");
  Serial.println(average);
  lcd.setCursor(4, 1);
  lcd.print("RPM:");
  lcd.print(RPM);
    delay(100);
  lcd.print("   ");
}

void Pulse_Event() {
  PeriodBetweenPulses = micros() - LastTimeWeMeasured;
  LastTimeWeMeasured = micros();
  if (PulseCounter >= AmountOfReadings)  {
```

sketch_may22b | Arduino IDE 2.1.0

File Edit Sketch Tools Help

NodeMCU-32S

sketch_may22b.ino

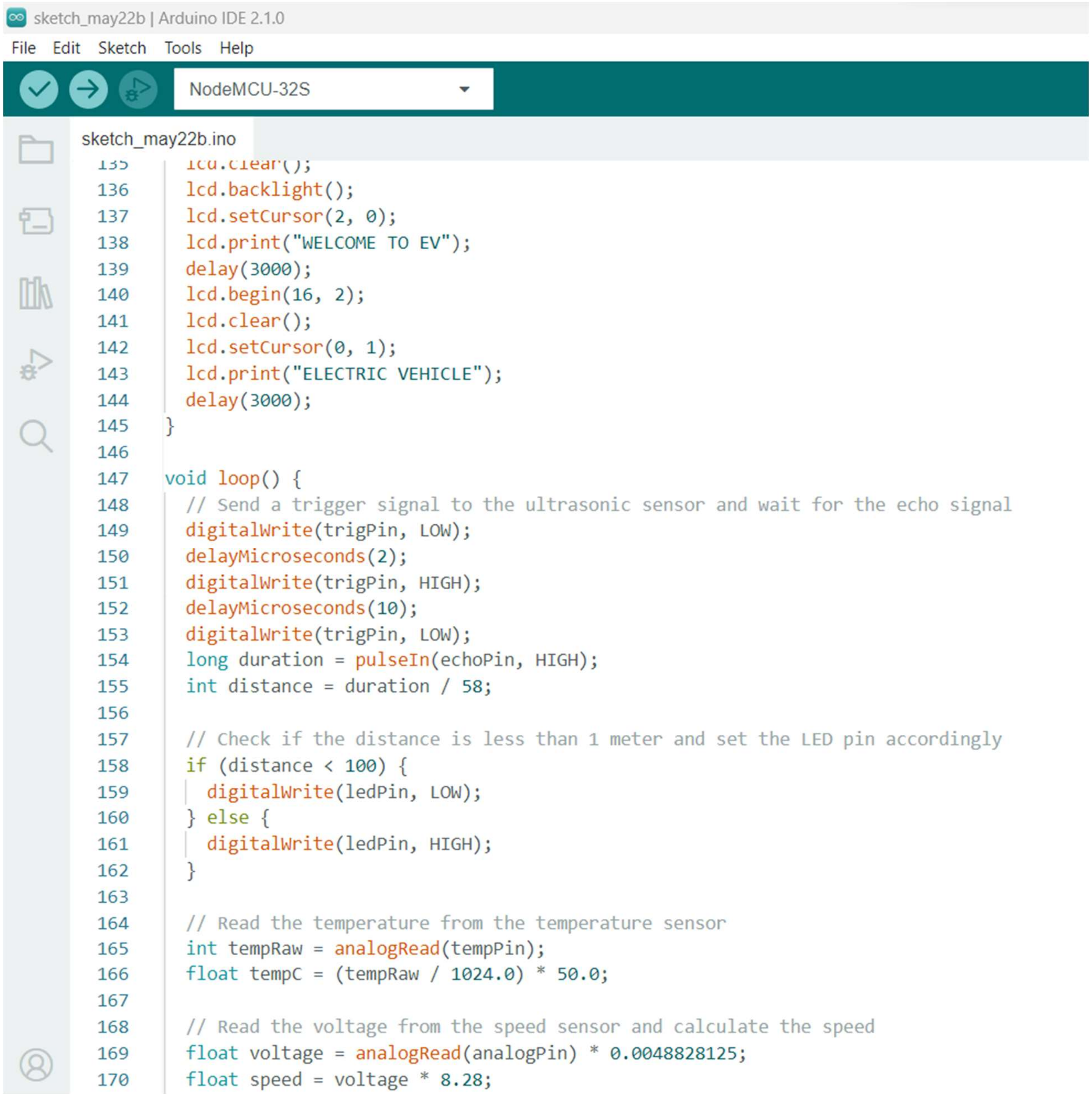
```
  PeriodBetweenPulses = micros() - LastTimeWeMeasured;
  LastTimeWeMeasured = micros();
  if (PulseCounter >= AmountOfReadings)  {
    PeriodAverage = PeriodSum / AmountOfReadings;
    PulseCounter = 1;
    PeriodSum = PeriodBetweenPulses;

    int RemapedAmountOfReadings = map(PeriodBetweenPulses, 40000, 5000, 1, 10);
    RemapedAmountOfReadings = constrain(RemapedAmountOfReadings, 1, 10);
    AmountOfReadings = RemapedAmountOfReadings;
  } else {
    PulseCounter++;
    PeriodSum = PeriodSum + PeriodBetweenPulses;
  }
}
// Initialize the LCD display
LiquidCrystal_I2C lcd(0x27,16,2);

// Define the pins for the ultrasonic sensor, temperature sensor, and speed sensor
const int tempPin = A0;
int analogPin = 1;
#define trigPin 9
#define echoPin 10
#define ledPin 2

void setup() {
  // Set the pin modes for the ultrasonic sensor, temperature sensor, and LED
  pinMode(trigPin, OUTPUT);
  pinMode(echoPin, INPUT);
  pinMode(ledPin, OUTPUT);

  // Initialize the LCD display and print some welcome messages
  lcd.init();
  lcd.clear();
  lcd.backlight();
  lcd.setCursor(2, 0);
```



sketch_may22b | Arduino IDE 2.1.0

File Edit Sketch Tools Help

NodeMCU-32S

sketch_may22b.ino

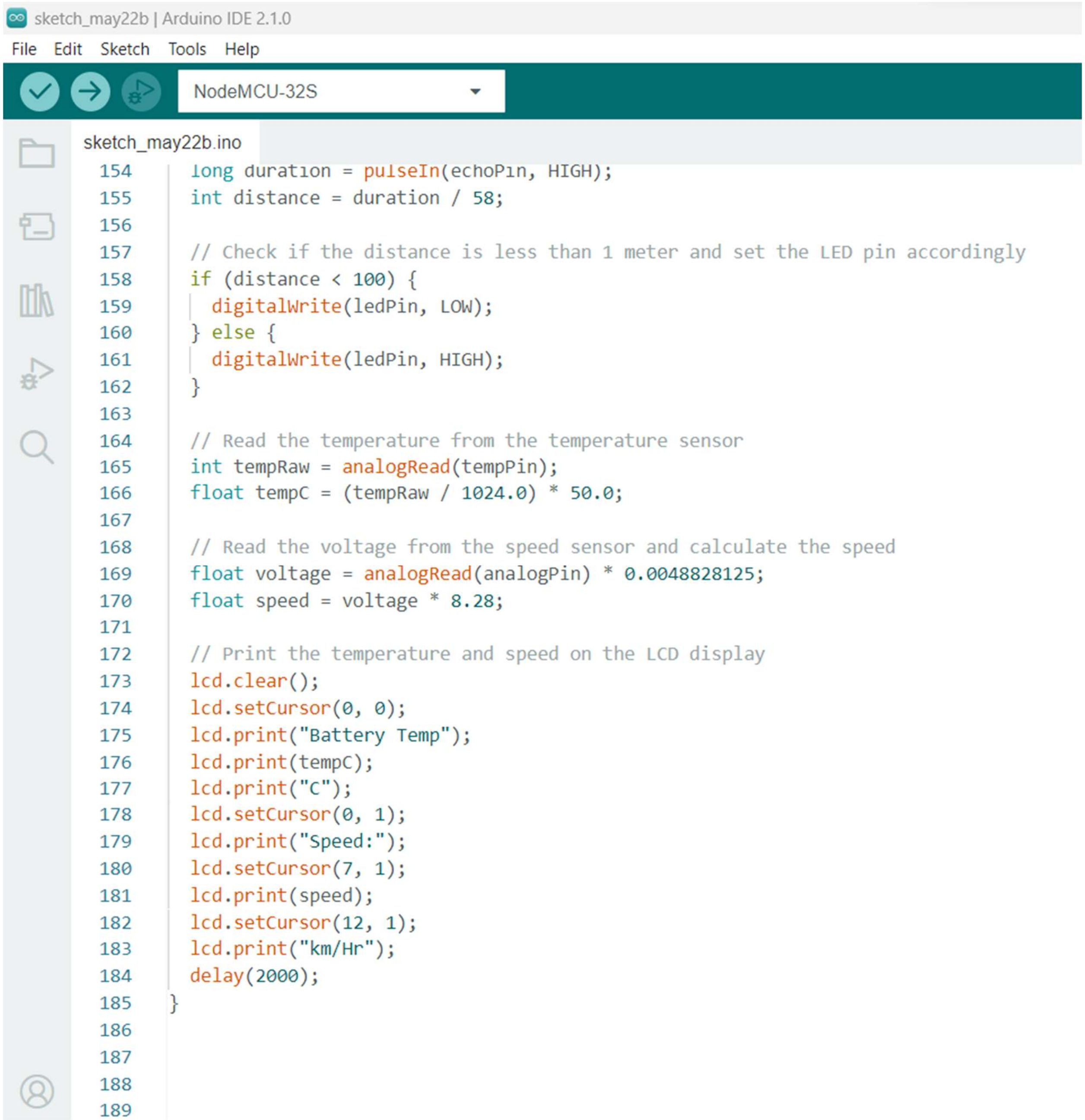
```
  lcd.clear();
  lcd.backlight();
  lcd.setCursor(2, 0);
  lcd.print("WELCOME TO EV");
  delay(3000);
  lcd.begin(16, 2);
  lcd.clear();
  lcd.setCursor(0, 1);
  lcd.print("ELECTRIC VEHICLE");
  delay(3000);
}

void loop() {
  // Send a trigger signal to the ultrasonic sensor and wait for the echo signal
  digitalWrite(trigPin, LOW);
  delayMicroseconds(2);
  digitalWrite(trigPin, HIGH);
  delayMicroseconds(10);
  digitalWrite(trigPin, LOW);
  long duration = pulseIn(echoPin, HIGH);
  int distance = duration / 58;

  // Check if the distance is less than 1 meter and set the LED pin accordingly
  if (distance < 100) {
    digitalWrite(ledPin, LOW);
  } else {
    digitalWrite(ledPin, HIGH);
  }

  // Read the temperature from the temperature sensor
  int tempRaw = analogRead(tempPin);
  float tempC = (tempRaw / 1024.0) * 50.0;

  // Read the voltage from the speed sensor and calculate the speed
  float voltage = analogRead(analogPin) * 0.0048828125;
  float speed = voltage * 8.28;
```



Arduino Iot Cloud as cloud platform

Arduino IoT Cloud is a cloud-based platform provided by Arduino that enables you to connect, manage, and control your Arduino devices and IoT projects remotely. It offers a simplified approach to IoT development, allowing you to easily monitor and interact with your connected devices through a user-friendly interface. Here are some key features and details about Arduino IoT Cloud:

CHAPTER 4

WORKING OF THE MODEL

Different sensors are mounted on the vehicle to measure the parameters like speed, temperature, Motion detection, etc. Temperature sensor and Speed sensor(Hall sensor) is connected to Arduino Nano microcontroller through the I2C module and then displayed on the LCD screen on the EV. The detailed flowchart for code explanation of the code for temperature and speed monitoring is as follows:

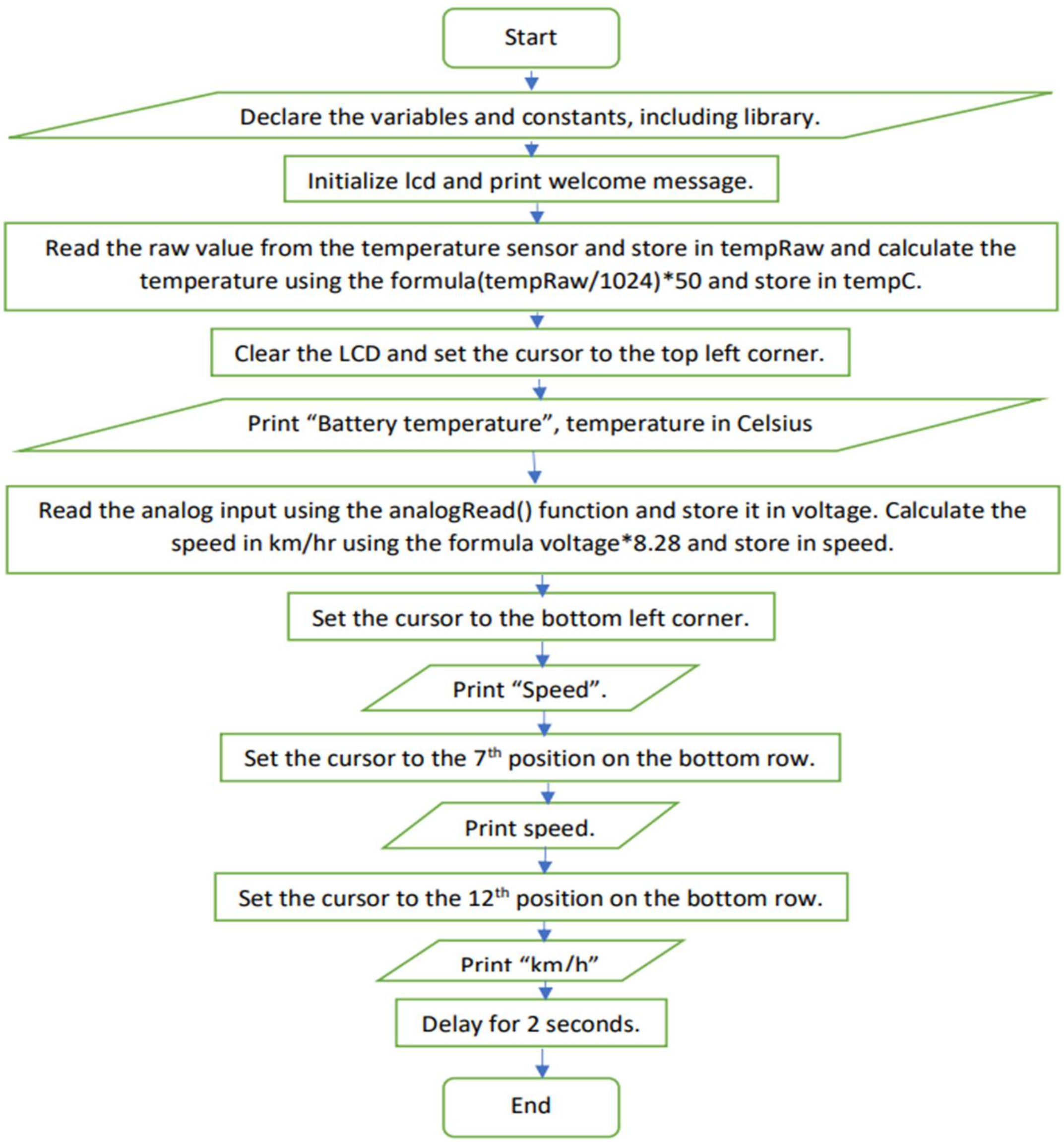
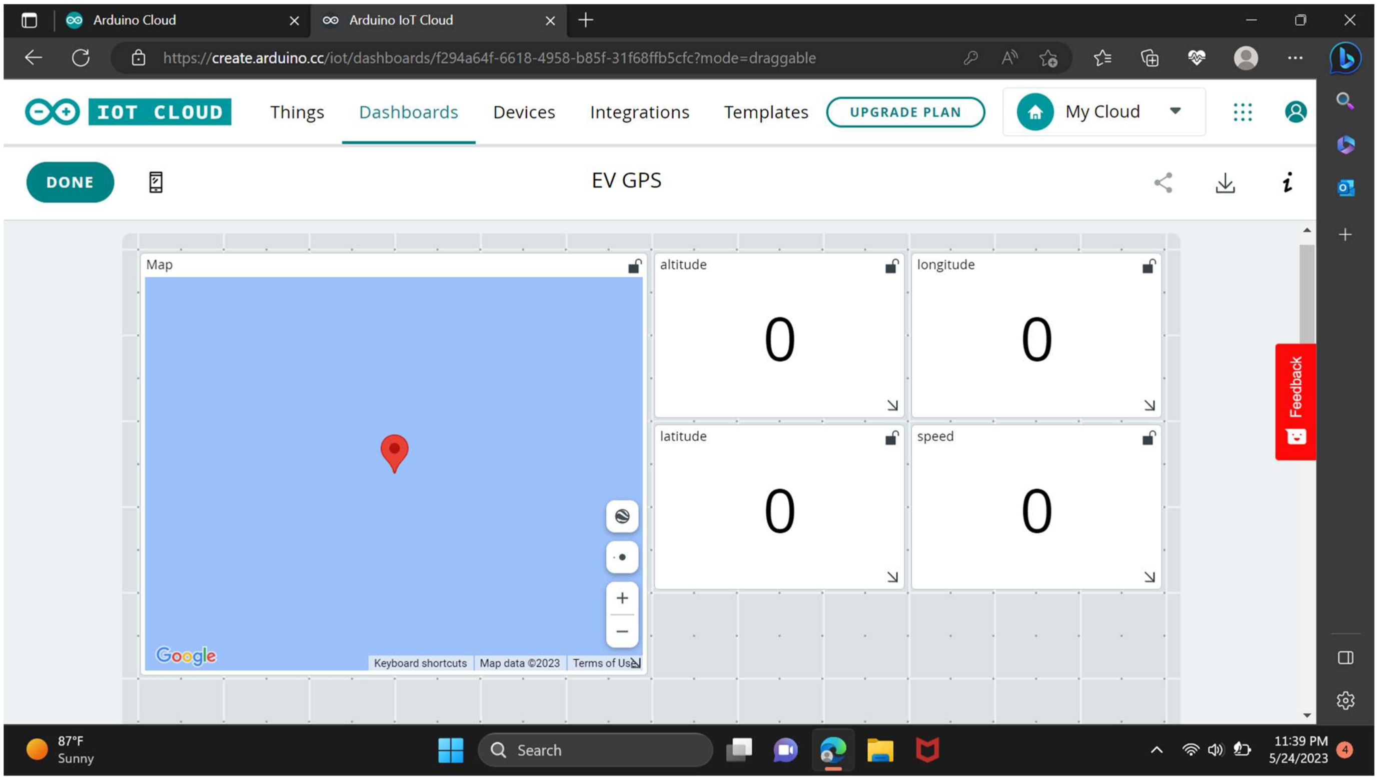
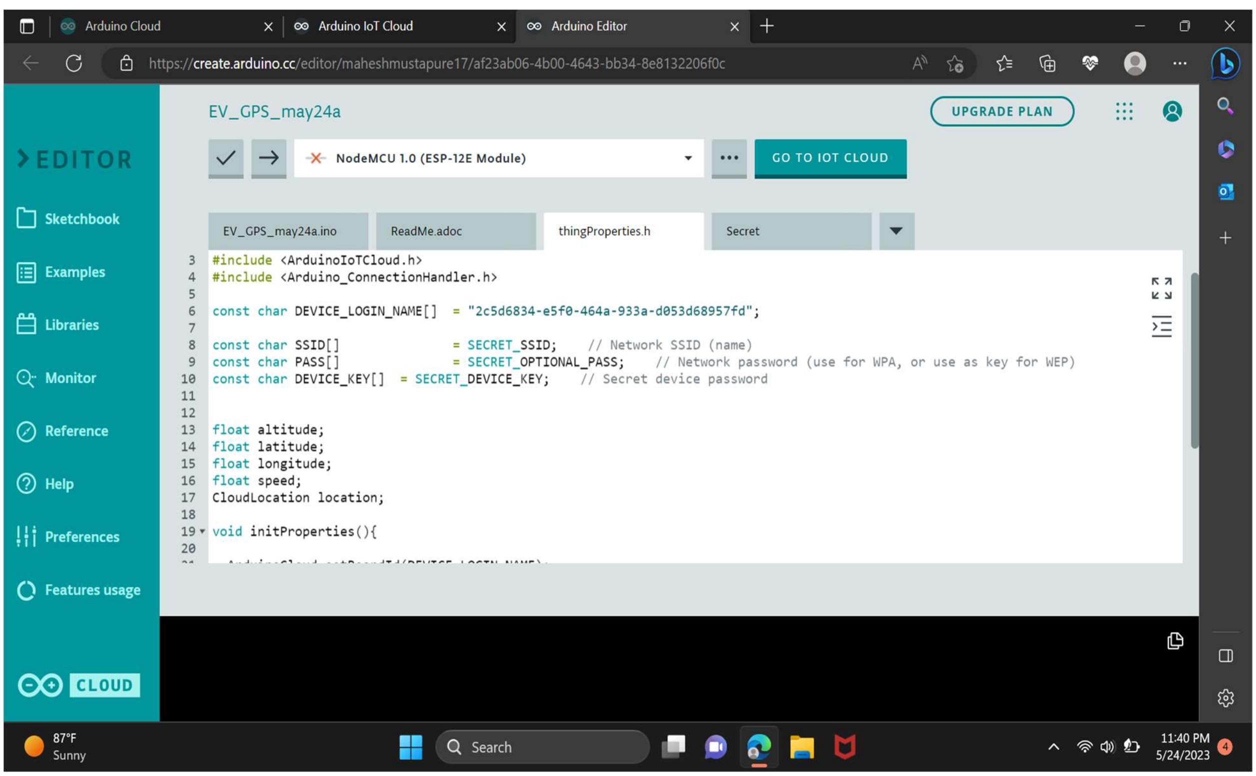
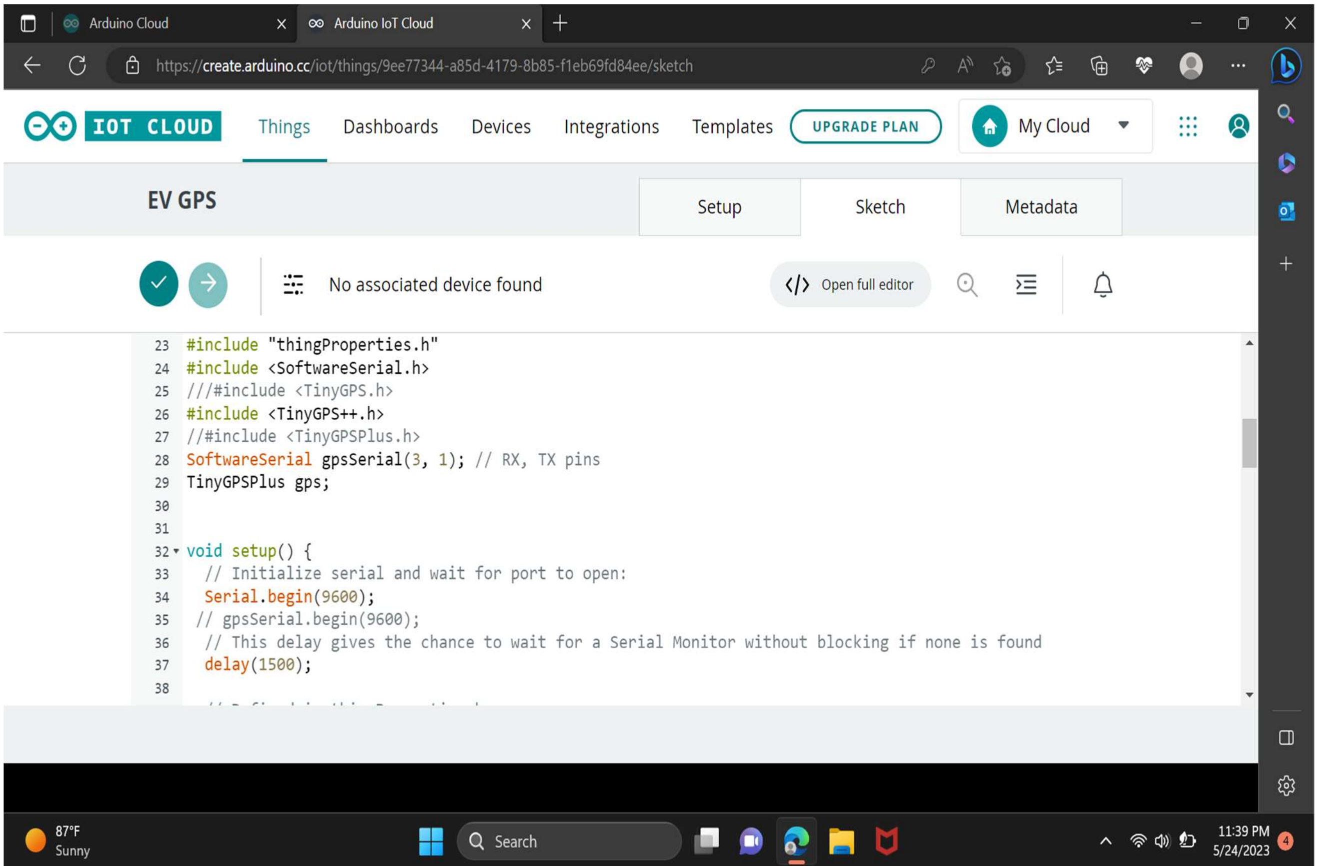


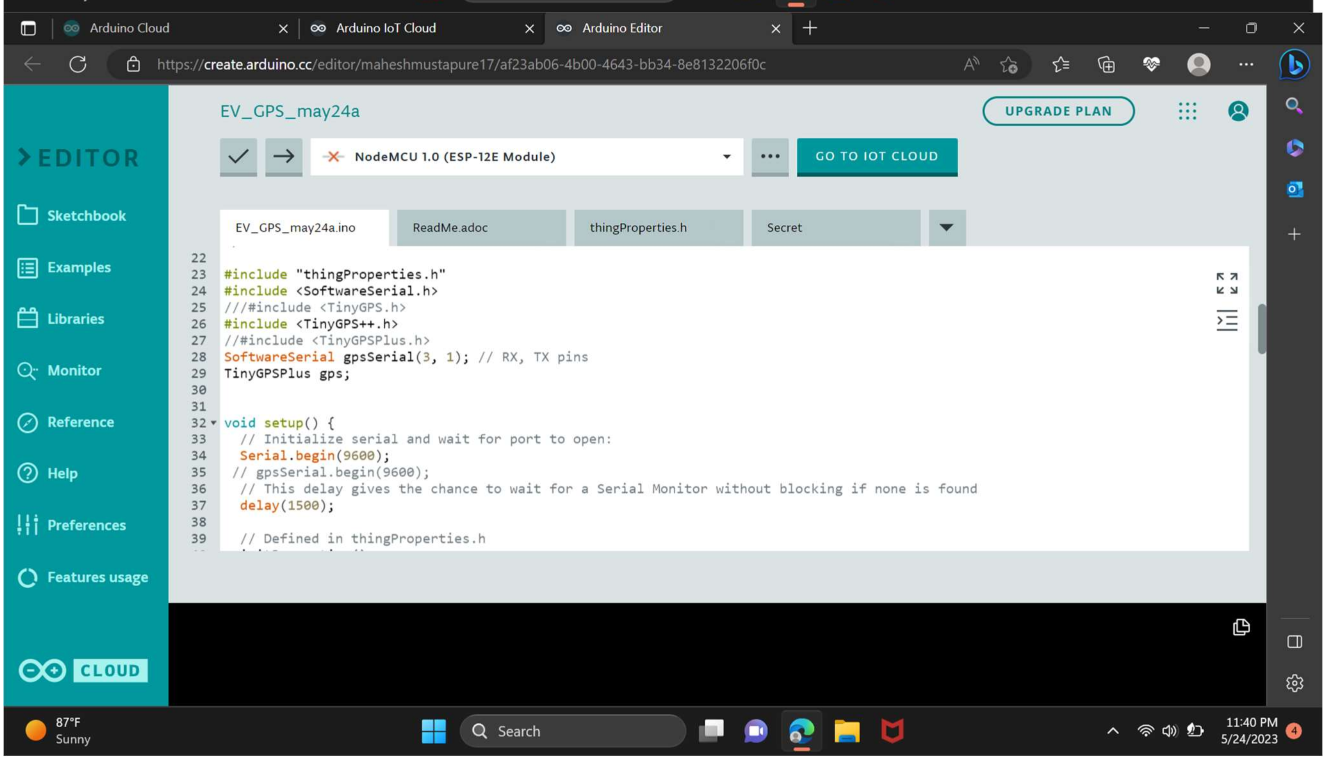
Fig 15: Flowchart of Speed and temperature monitoring

GPS and GSM module are connected to ESP32 microcontroller, which is used for location tracking which uses Wi-Fi network and IP address.






Arduino Cloud
Arduino IoT Cloud
https://create.arduino.cc/iot/things/9ee77344-a85d-4179-8b85-f1eb69fd84ee/sketch
IOT CLOUD
Things
Dashboards
Devices
Integrations
Templates
UPGRADE PLAN
My Cloud
EV GPS
Setup
Sketch
Metadata
No associated device found
Open full editor
#include "thingProperties.h"
#include <SoftwareSerial.h>
///#include <TinyGPS.h>
#include <TinyGPS++.h>
//#include <TinyGPSPlus.h>
SoftwareSerial gpsSerial(3, 1); // RX, TX pins
TinyGPSPlus gps;
void setup() {
// Initialize serial and wait for port to open:
Serial.begin(9600);
// gpsSerial.begin(9600);
// This delay gives the chance to wait for a Serial Monitor without blocking if none is found
delay(1500);
87°F
Sunny
Search
11:39 PM
5/24/2023


Arduino Cloud
Arduino IoT Cloud
Arduino Editor
https://create.arduino.cc/editor/maheshmustapure17/af23ab06-4b00-4643-bb34-8e8132206f0c
EV_GPS_may24a
UPGRADE PLAN
EDITOR
NodeMCU 1.0 (ESP-12E Module)
GO TO IOT CLOUD
Sketchbook
Examples
Libraries
Monitor
Reference
Help
Preferences
Features usage
EV_GPS_may24a.ino
ReadMe.adoc
thingProperties.h
Secret
#include "thingProperties.h"
#include <SoftwareSerial.h>
///#include <TinyGPS.h>
#include <TinyGPS++.h>
//#include <TinyGPSPlus.h>
SoftwareSerial gpsSerial(3, 1); // RX, TX pins
TinyGPSPlus gps;
void setup() {
// Initialize serial and wait for port to open:
Serial.begin(9600);
// gpsSerial.begin(9600);
// This delay gives the chance to wait for a Serial Monitor without blocking if none is found
delay(1500);
// Defined in thingProperties.h
CLOUD
87°F
Sunny
Search
11:40 PM
5/24/2023

CHAPTER 5

Features of IoT Interfaced Affordable E-bike

Reverse Mode:

In the context of an electric vehicle (EV) bike, the term "reverse mode" refers to the ability of the bike to move in the opposite direction, typically backward, with the assistance of the electric motor. While reverse mode is not a standard feature in all EV bikes, some advanced models may include it for specific purposes. Here are a few potential uses of reverse mode in an EV bike:

1. Maneuvering in Tight Spaces: Reverse mode can be beneficial when navigating in confined areas or when performing parking maneuvers. It allows the rider to move the bike backward with ease, making it simpler to park in crowded spaces or make tight turns.

2. Assistance on Inclines: Electric bikes equipped with reverse mode can be advantageous when starting or moving backward on steep inclines. Instead of having to push the bike manually or dismount, the rider can use the reverse mode to back up or gain traction when facing uphill challenges.

3. Easier Load Management: Reverse mode can assist with handling heavy loads or cargo attached to the bike. When loading or unloading items, the rider can use reverse mode to move the bike backward, facilitating better control and reducing strain on the rider.

4. Safety in Certain Situations: In emergency situations or when the rider needs to quickly evade an obstacle or dangerous situation, the ability to move in reverse can provide an extra level of safety. It allows the rider to back away from hazards or potential collisions more efficiently.

Cruise Mode:

Cruise mode, also known as cruise control or steady-speed mode, is a feature available in some electric bikes (e-bikes) that allows the rider to maintain a consistent speed without continuously applying throttle or pedaling. Here are some advantages of cruise mode in an e-bike:

1. Reduced Fatigue: By activating cruise mode, riders can relax and maintain a steady speed without the need to continuously twist the throttle or pedal. This reduces fatigue and strain on the rider, particularly during long rides or when riding against strong headwinds.

2. Enhanced Comfort: Holding a constant speed can provide a more comfortable riding experience. Riders can find a comfortable posture and relax their grip on the throttle or handlebars, as they don't need to constantly adjust the speed.

3. Extended Range: Using cruise mode intelligently can help optimize energy consumption and extend the e-bike's range. By maintaining a consistent speed, riders can avoid sudden bursts of

acceleration or deceleration, which can drain the battery more quickly. This can be particularly useful during long-distance rides or when trying to conserve battery power.

4. Improved Efficiency: Cruise mode assists in achieving a more efficient riding style. The e-bike's motor can optimize power delivery based on the set speed, resulting in a smoother and more balanced energy usage. This can contribute to a longer battery life and overall improved energy efficiency.

5. Focus on Surroundings: With the e-bike maintaining a constant speed, riders can divert their attention to the surrounding environment, scenery, or traffic conditions. It allows for better observation and reaction to potential hazards or changes on the road, contributing to safer riding.

6. Hands-Free Riding: Cruise mode enables riders to ride hands-free while maintaining a steady speed. This can be particularly useful in certain situations, such as when adjusting clothing, taking a drink, or signaling turns, without sacrificing speed or stability.

3 Speed Mode:

Here are some additional advantages of having a 3-speed mode in an e-bike:

1. Ease of Use: A 3-speed mode setup simplifies the operation of the e-bike for riders. Instead of continuously adjusting the level of assistance manually, riders can conveniently switch between three pre-configured speed modes. This makes it easier and more user-friendly, especially for riders who may not be familiar with advanced settings or prefer a more straightforward riding experience.

2. Enhanced Range: The 3-speed mode allows riders to optimize their e-bike's range and battery life. Lower speed modes provide more conservative assistance, reducing power consumption and enabling riders to cover longer distances before requiring a recharge. This is particularly useful for riders planning longer rides or who have limited charging options.

3. Adaptability to Riding Conditions: Different riding conditions may call for varying levels of assistance and speed. The 3-speed mode provides riders with the flexibility to adjust their e-bike's performance accordingly. For example, riders can choose a lower speed mode for leisurely rides or when riding in crowded areas, while a higher speed mode can be selected for faster commuting or riding on open roads.

4. Increased Riding Efficiency: With three distinct speed modes, riders can fine-tune their e-bike's performance to achieve optimal riding efficiency. The different modes cater to different riding scenarios, ensuring riders can strike the right balance between power assistance and physical effort. This can lead to a more enjoyable riding experience and potentially encourage riders to use their e-bikes more frequently.

5. Adaptation to Rider Fitness Level: The 3-speed mode accommodates riders of varying fitness levels. Riders who prefer a more challenging and physically engaging ride can opt for a lower speed mode that offers minimal assistance, allowing them to rely more on their pedaling power. In contrast, riders who require greater assistance can choose a higher speed mode that provides

more power output from the motor.6. Gradual Transition for Novice Riders: For new or inexperienced riders, the 3-speed mode can serve as a stepping stone to gradually acclimate to the e-bike's capabilities. Starting with a lower speed mode allows novice riders to gain confidence and improve their riding skills before gradually progressing to higher speed modes as they become more comfortable and skilled.

Temperature and Speed display using IoT:

Integrating temperature and speed display using the Internet of Things (IoT) in an e-bike can offer several advantages for riders. Here are some benefits of having temperature and speed display through IoT technology:

1. Real-Time Monitoring: With IoT-enabled temperature and speed display, riders can access real-time information about their e-bike's temperature and speed. This allows them to stay informed about the current operating conditions and make necessary adjustments or take appropriate actions if any anomalies are detected.

2. Performance Optimization: By monitoring temperature and speed data, riders can gain insights into the performance of their e-bike. They can analyze the information collected over time and make informed decisions about optimizing the bike's efficiency, battery usage, and overall performance.

3. Preventive Maintenance: IoT-enabled temperature monitoring can help detect any abnormal rise in temperature that may indicate potential issues with the e-bike's components, such as the motor or battery. By identifying these problems early on, riders can take preventive maintenance measures, reducing the risk of major failures or breakdowns and extending the lifespan of the e-bike.

4. Safety Enhancement: The ability to monitor speed in real-time can contribute to safer riding. Riders can ensure they are adhering to speed limits and adjust their riding style accordingly. Additionally, they can receive alerts or notifications if they exceed a predefined speed threshold, promoting responsible and safe riding.

GPS tracking:

GPS tracking in e-bikes offers several advantages:

1. Theft prevention: GPS tracking enables you to monitor the real-time location of your e-bike. In the unfortunate event of theft, you can quickly locate your bike and notify the authorities. This significantly increases the chances of recovering your stolen e-bike.

2. Recovery assistance: GPS tracking systems can provide precise location data, making it easier for law enforcement or recovery teams to locate and recover your e-bike. It streamlines the process and reduces the time it takes to find and retrieve your stolen property.

3. Peace of mind: With GPS tracking, you have peace of mind knowing that you can always find your e-bike. Whether you've parked it in a crowded area, at a bike rack, or in unfamiliar locations, you can easily locate it without any hassle.

4. Safety features: GPS tracking systems can incorporate safety features such as emergency alerts. In the event of an accident or a sudden fall, the system can detect the impact and automatically send an alert to pre-defined contacts or emergency services. This feature enhances rider safety and provides a valuable layer of protection.

Anti-theft Alarm:

Anti-theft alarms in e-bikes provide several advantages:

1. Theft deterrence: An anti-theft alarm system acts as a deterrent to potential thieves. The loud alarm sound produced when unauthorized tampering or movement is detected draws attention to the situation, discouraging theft attempts and increasing the chances of catching the thief in the act.

2. Increased security: The anti-theft alarm adds an extra layer of security to your e-bike. It alerts you and others nearby if someone tries to steal or tamper with your bike, giving you an opportunity to intervene or call for help.

3. Peace of mind: Knowing that your e-bike is equipped with an anti-theft alarm can provide peace of mind. Whether you're parking your bike in a public place or leaving it unattended for an extended period, you can feel more confident that your e-bike is protected against theft.

4. Easy installation and compatibility: Anti-theft alarm systems for e-bikes are often designed to be easily installed and compatible with various bike models. They can be retrofitted to existing e-bikes or integrated into the manufacturing process for new e-bikes.

5. Battery conservation: To prevent the alarm from draining your e-bike's battery, many systems have power-saving features. They consume minimal power during normal operation and may even have battery monitoring capabilities to alert you if the battery needs replacement or recharging.

.

Fig 16:Anti-theft Alarm

CHAPTER 6

RESULTS

We have tested the features like cruise mode, reverse mode,3 speed mode,GPS tracking, Anti-theft, Temperature Monitoring and the results are described below:

3 speed mode: -
The vehicle runs at 3 speeds (high, normal and low) and the speeds calculated are as follows:
For 50 kg person -Low speed (Mode 1) = 420 rpm(31kmph)
For 50kg person - Normal speed (Mode 2) = 528 rpm(38.97kmph)
For 50 kg person - High speed (Mode 3) = 561 rpm(41.40kmph)

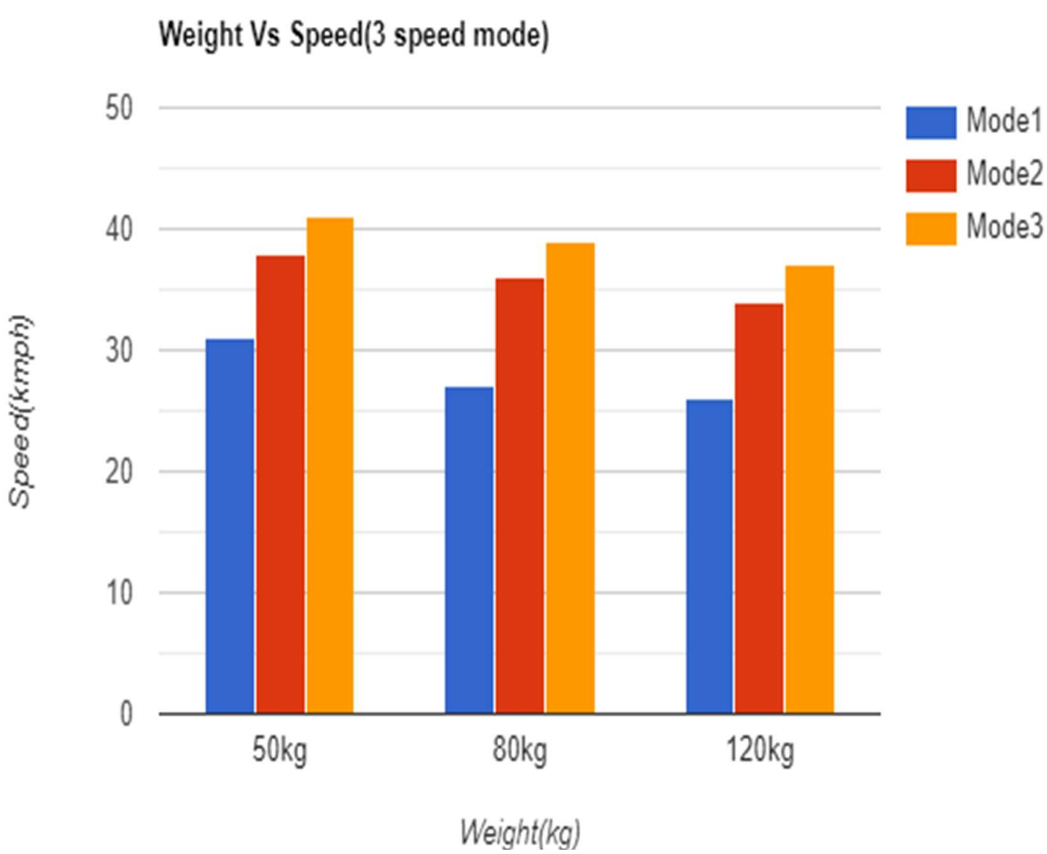


Fig 17:Bar Graph

Here,

- 50 kg weight is of person A of weight 50 kg
- 80 kg weight is addition of weight of person B and C
- 120 kg weight is addition of weight of person D and E

Reverse mode: -

It is the mode in which the forward motoring is reversed and the vehicle moves in the backward direction. The speed of reverse motoring is relatively much low as compared to forward motoring and it is 238rpm(17.56kmph)

Cruise mode:

Cruise mode, in the context of transportation or vehicles, typically refers to a mode of operation where a vehicle maintains a constant speed or setpoint without the need for continuous driver input. It is often associated with systems like cruise control or adaptive cruise control that help automate speed control on highways or long stretches of road.

Temperature and Speed display using IoT:

The speed and battery temperature displayed on the LCD screen and is shown as below:

- ❖ The Initial Speed and temperature of E-bike:

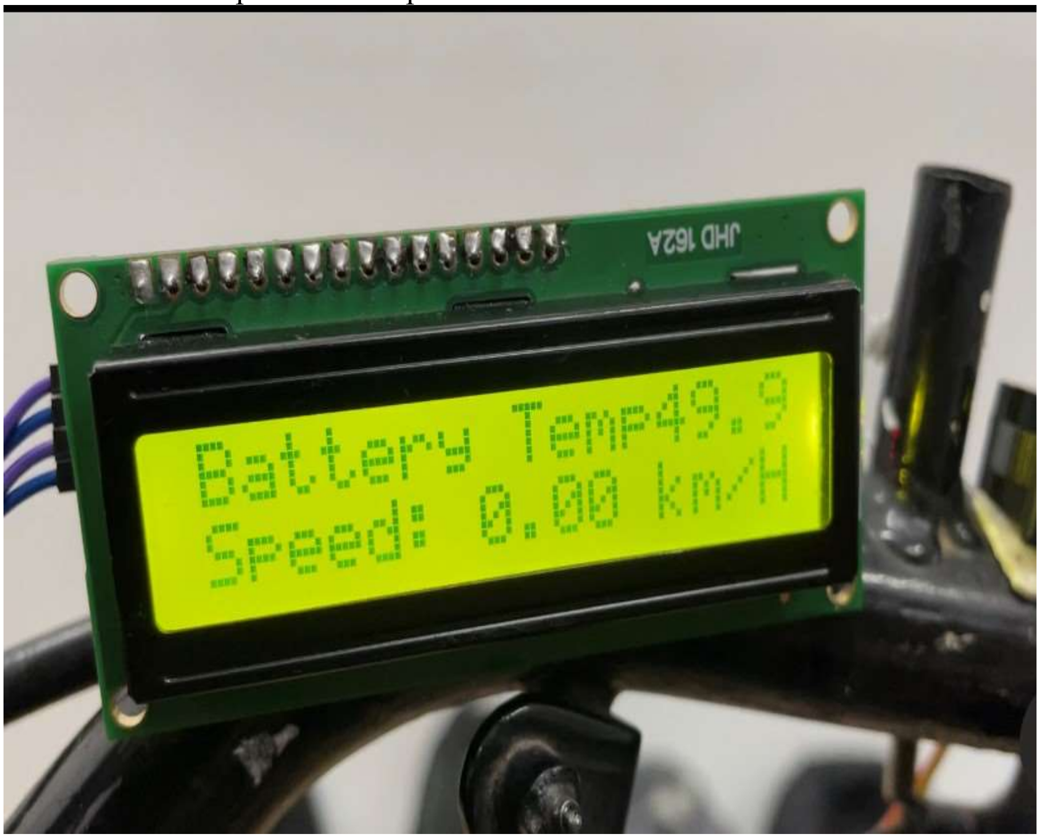


Fig 18: Initial Speed temperature display

❖ The Speed and temperature of E-bike in its highest speed:

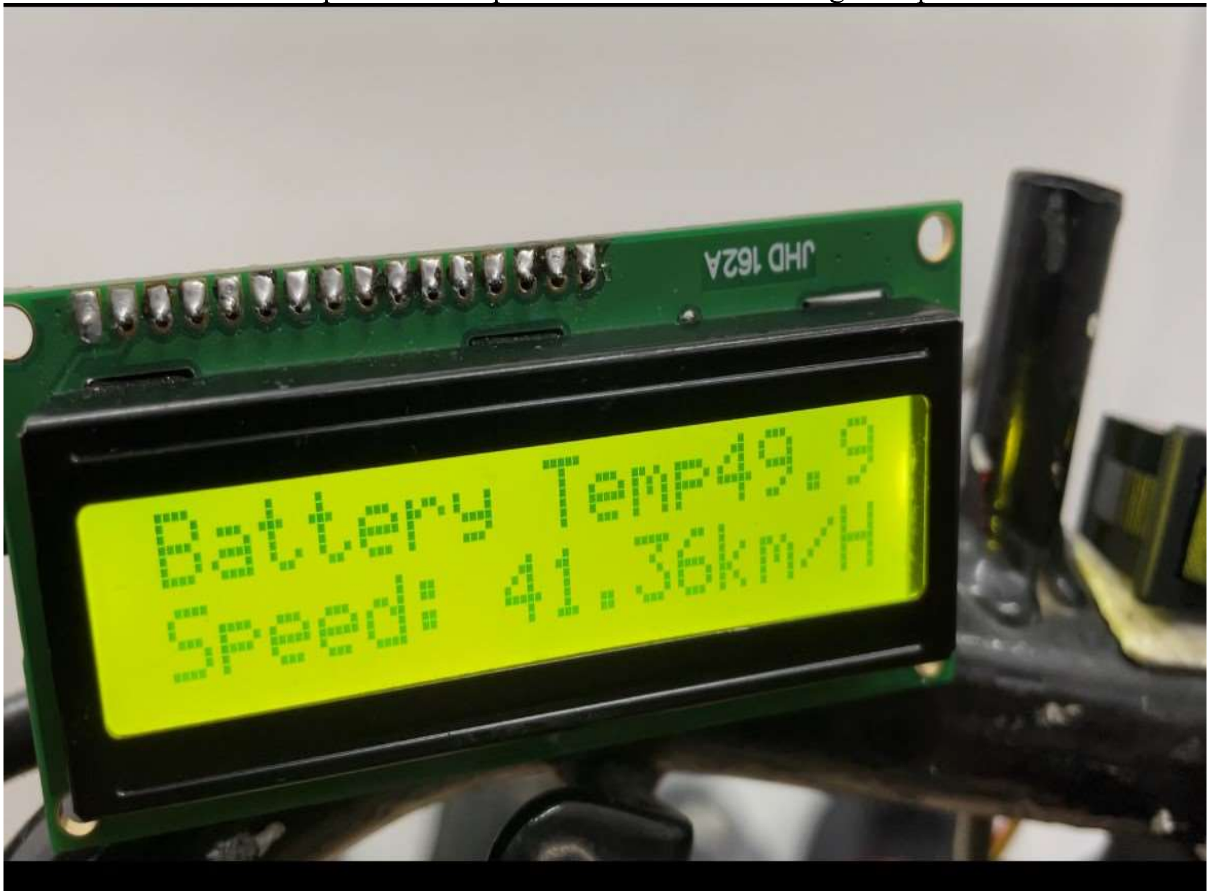


Fig 19 : The Speed and temperature of E-bike in its highest speed

Anti-theft alarm:

Anti-theft alarm is a protection device. When we switch on the antitheft alarm button the device will be in the mode of operation from thieves. If the motor is locked, the rotor of the motor cannot be rotated, and the vehicle will give alarm when there is an attempt to touch the vehicle and drive it and hence deterring thieves. When we press or switch to the unlock button, this mode of protection will release this antitheft function.

GPS tracking can enable us to track the location of the vehicle remotely.

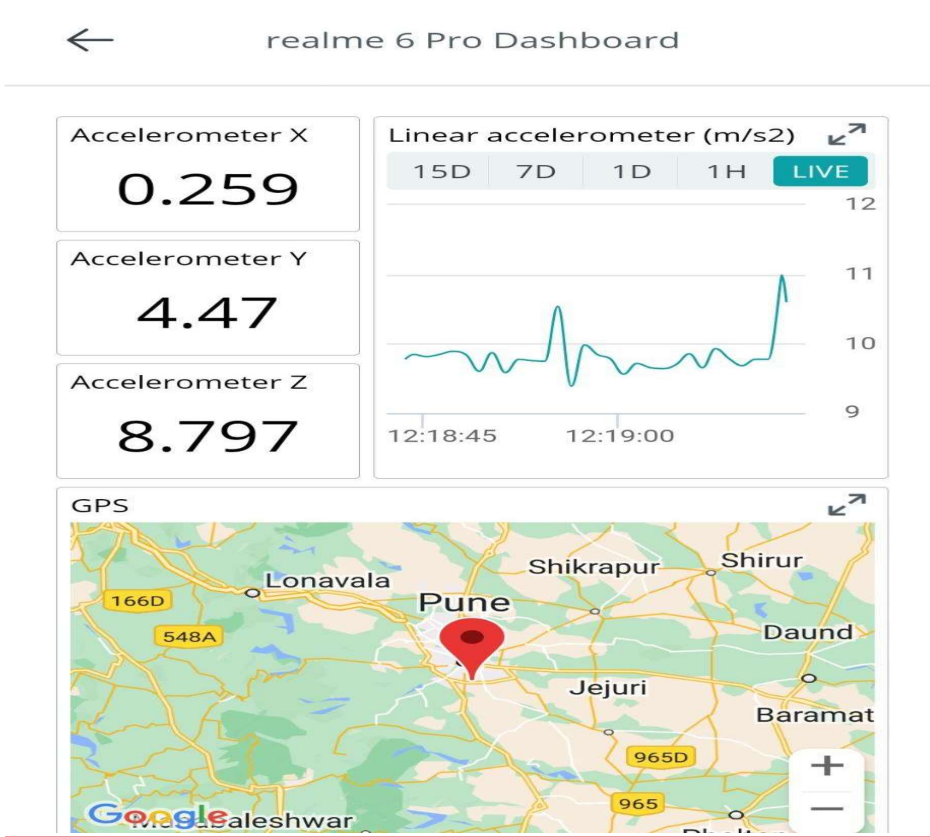


Fig 20: GPS Tracker

An IoT (Internet of Things) interfaced vehicle, when compared to a non-IoT electric vehicle, offers several advantages and improved functionality.

1. Connectivity and Communication: IoT enables seamless connectivity and communication between vehicles and various external systems. An IoT interfaced electric vehicle can exchange data with other vehicles, infrastructure, and smart city systems. This connectivity allows for real-time information exchange, enabling intelligent decision-making and enhancing overall efficiency.

2. Enhanced Safety and Security: IoT in vehicles can improve safety and security features. For example, IoT sensors can monitor and transmit data related to road conditions, traffic patterns, and weather conditions. This information can be used to alert drivers and even control vehicle systems to optimize safety. Additionally, IoT connectivity can help track and locate stolen vehicles through GPS and provide remote immobilization features.

3. Energy Efficiency and Range Optimization: IoT interfacing can contribute to better energy efficiency in electric vehicles. By analyzing data on driving patterns, traffic conditions, and energy consumption, IoT systems can optimize vehicle performance and range. This can lead to more efficient use of battery power, improved charging strategies, and overall enhanced range for electric vehicles.

IoT interfacing enhances the capabilities of electric vehicles, enabling improved safety, efficiency, range optimization, remote monitoring, and personalization. The connectivity and data exchange facilitated by IoT technology enable a more intelligent and integrated ecosystem for electric vehicles, making them a preferred choice for futuristic mobility solutions.

Payback Period:

The length of time required for an investment to recover its initial cost in terms of profits or savings is known as payback period.
Payback period for developed E- bike is estimated as given below.
As we can see in the above calculations, there is a major difference in prices of the power required in the conventional bikes and the E-bike which are because of the resources they are using to generate this power required for operation of the vehicle. Hence it is seen that investing in the E-bike not only protects the environment but also is economical as it has a payback period as less as 2 years which is a great choice as compared to other conventional vehicles. Hence the investment is justifiable which provides low cost with many smart features.

Assumptions:

Maximum range in one day is considered as 50 km.

Conventional bike	Improved E-bike(Price of bike = ₹40255)
Mileage 50 km/liter	Units required for 50 km
Price for 1L of petrol = ₹106.59	Price for 1.2unit = ₹12 [approx..]

After 5-year battery must be replaced

Price of battery=₹20000

Maintenance on bike= ₹2500
Total expenditure on electric bike = 40255+20000+2500=62755
Saving: -
Saving/day= Fuel cost for Conventional bike – Fuel cost for Improved E-bike
=₹106.59-₹12
=₹94.59
In 1 year, saving= 94.59*365= ₹34525.35
Payback period = (62755/34525.35)

Payback period = 1.81 years = 661 days

As we can see in the above calculations that there is major difference in prices of the power required in conventional bikes and E-bike which are because of the sources they are using to generate this power required for operation of the vehicle. Hence it is seen the investing in the E-bike is not only protect the environment but also is economical as it has payback period as less as 2 years which is great choices as compared to other conventional vehicles. Hence the investment is justifiable which provides low cost with many smart features.

CHAPTER 7

COSTING

Components	Price
BLDC Hub motor	8960
Controller	3330
Throttle set	380
Battery(48v,25Ah,LiFePO4))	18000
Charger	3000
DC-DC Converter	380
Chassis from scrap	2500
Ignition Lock	120
MCB	110
I2C Module	100
Temperature sensor	100
Arduino nano	475
ESP 32S	400
Digital line sensor	35
Neo-6M GPS Module	320
LCD display(16*2)	150
Ultrasonic distance sensor module	70
Relay Module	50
Gyroscope	125
Miscellaneous	1000
Total	40,225

Table C

CHAPTER 8

FUTURE SCOPE

The demand for electric vehicles (EVs) is rising because of its properties like environment friendly nature, light weight, etc, but, because of some parameter like low range and low power density it has less efficiency than fuel vehicles hence overcoming these disadvantages by using supercapacitor and regenerative braking and also SoC estimation, etc increases efficiency and will increase its scope after such improvements.

Vehicle-to-Vehicle Communication: Investigating the potential of vehicle-to-vehicle communication among e-bikes can enhance safety, coordination, and efficiency. E-bikes equipped with IoT capabilities can be interfaced to share real-time information about traffic, road conditions, and potential hazards, enabling synchronized movements and better traffic flow.

CHAPTER 9

CONCLUSION

The design and analysis of an IoT-interfaced e-bike offer numerous benefits and advancements in the field of electric mobility. By integrating IoT technology into e-bikes, a new level of connectivity, functionality, and efficiency can be achieved.

The IoT interface enables real-time monitoring and control of various aspects of the e-bike, including battery status, location tracking. This connectivity enhances the overall user experience by providing valuable insights and control over the e-bike's operations.

The integration of IoT also contributes to the development of a smarter and more sustainable transportation system

This also addresses crucial concerns such as theft prevention and vehicle safety. Anti-theft alarm systems and GPS tracking features provide enhanced security, reducing the risk of theft and increasing the chances of recovering stolen e-bikes..

It presents significant opportunities for improving electric mobility, enhancing user experiences, promoting sustainability, and revolutionizing transportation systems. As technology continues to advance, further innovations and advancements in this field can be expected, leading to a more connected, efficient, and intelligent e-bike ecosystem.

PLAGIARISM REPORT

Plagiarism Checker X - Report

Originality Assessment

7%

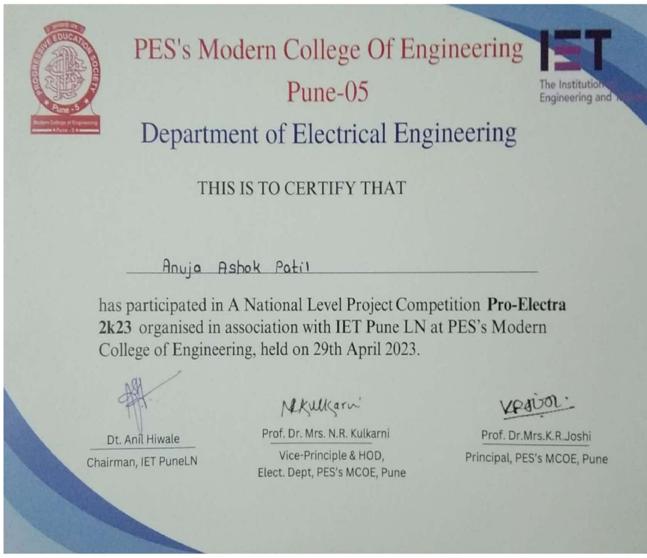
Overall Similarity

Date: May 31, 2023
Matches: 719 / 10518 words
Sources: 46

Remarks: Low similarity detected, check with your supervisor if changes are required.

Verify Report:
Scan this QR Code

ACHIEVEMENTS


PES's Modern College Of Engineering
Pune-05
Department of Electrical Engineering

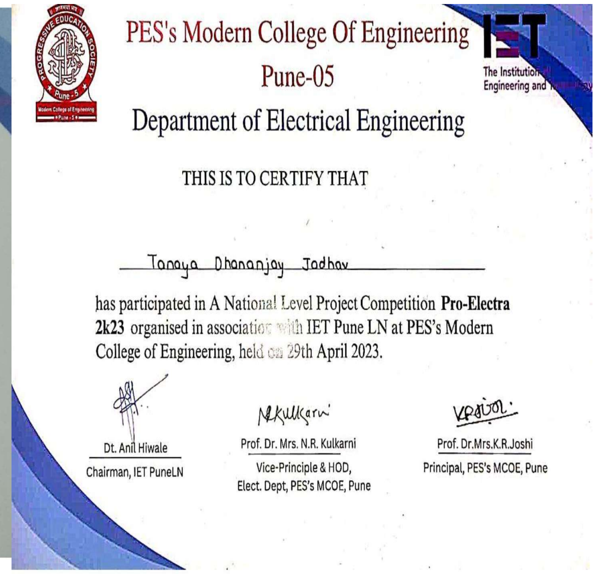
IET The Institution of Engineering and Technology

THIS IS TO CERTIFY THAT

Anuja Ashok Patil

has participated in A National Level Project Competition **Pro-Electra 2k23** organised in association with IET Pune LN at PES's Modern College of Engineering, held on 29th April 2023.

Dt. Anil Hiwale	Prof. Dr. Mrs. N.R. Kulkarni	Prof. Dr.Mrs.K.R.Joshi
Chairman, IET PuneLN	Vice-Principle & HOD, Elect. Dept, PES's MCOE, Pune	Principal, PES's MCOE, Pune


PES's Modern College Of Engineering
Pune-05
Department of Electrical Engineering

IET The Institution of Engineering and Technology

THIS IS TO CERTIFY THAT

Tanaya Dhananjay Jadhav

has participated in A National Level Project Competition **Pro-Electra 2k23** organised in association with IET Pune LN at PES's Modern College of Engineering, held on 29th April 2023.

Dt. Anil Hiwale	Prof. Dr. Mrs. N.R. Kulkarni	Prof. Dr.Mrs.K.R.Joshi
Chairman, IET PuneLN	Vice-Principle & HOD, Elect. Dept, PES's MCOE, Pune	Principal, PES's MCOE, Pune


PES's Modern College Of Engineering
Pune-05
Department of Electrical Engineering

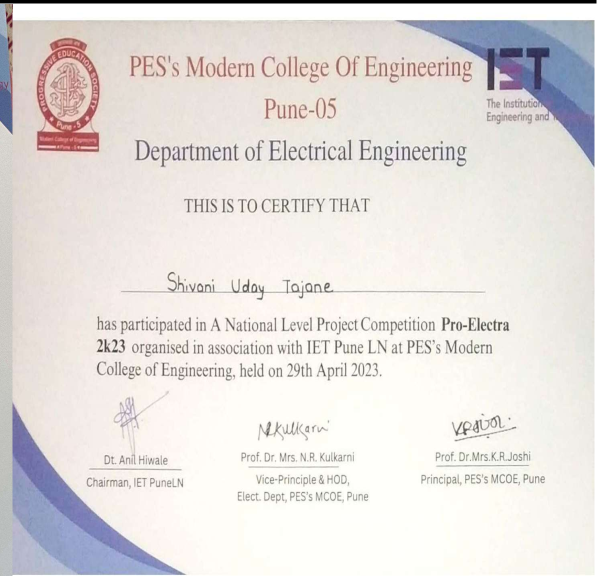
IET The Institution of Engineering and Technology

THIS IS TO CERTIFY THAT

Payal Sanjay Tadavi

has participated in A National Level Project Competition **Pro-Electra 2k23** organised in association with IET Pune LN at PES's Modern College of Engineering, held on 29th April 2023.

Dt. Anil Hiwale	Prof. Dr. Mrs. N.R. Kulkarni	Prof. Dr.Mrs.K.R.Joshi
Chairman, IET PuneLN	Vice-Principle & HOD, Elect. Dept, PES's MCOE, Pune	Principal, PES's MCOE, Pune


PES's Modern College Of Engineering
Pune-05
Department of Electrical Engineering

IET The Institution of Engineering and Technology

THIS IS TO CERTIFY THAT

Shivani Uday Tajane

has participated in A National Level Project Competition **Pro-Electra 2k23** organised in association with IET Pune LN at PES's Modern College of Engineering, held on 29th April 2023.

Dt. Anil Hiwale	Prof. Dr. Mrs. N.R. Kulkarni	Prof. Dr.Mrs.K.R.Joshi
Chairman, IET PuneLN	Vice-Principle & HOD, Elect. Dept, PES's MCOE, Pune	Principal, PES's MCOE, Pune

PVG'S COLLEGE OF ENGINEERING AND TECHNOLOGY
& G. K. PATE (WANI) INSTITUTE OF MANAGEMENT, PUNE.
Approved by AICTE,DTE (Code:6274)|Affiliated to SPPU,PUNE
Accredited by NACC Second cycle 'A' Grade

Department of Electrical Engineering
Accredited by National Board of Accreditation (NBA)

CERTIFICATE OF ACHIEVEMENT

PRESENTED TO,

Anuja Patil (B.E project)

In recognition of your exceptional accomplishments during the academic year 2022-23, we proudly present you with this Certificate of Achievement. Your dedication, passion, and outstanding talent have made a lasting impact on our community.

Prof. P. G. Jamdade, EESA CO-ORDINATOR | Prof. Dr. S. T. Gaikwad, EESA CO-ORDINATOR | Prof. Dr. M. S. Thakare, HOD ELECTRICAL ENGINEERING

PVG'S COLLEGE OF ENGINEERING AND TECHNOLOGY
& G. K. PATE (WANI) INSTITUTE OF MANAGEMENT, PUNE.
Approved by AICTE,DTE (Code:6274)|Affiliated to SPPU,PUNE
Accredited by NACC Second cycle 'A' Grade

Department of Electrical Engineering
Accredited by National Board of Accreditation (NBA)

CERTIFICATE OF ACHIEVEMENT

PRESENTED TO,

Tanaya Jadhav (B.E Project)

In recognition of your exceptional accomplishments during the academic year 2022-23, we proudly present you with this Certificate of Achievement. Your dedication, passion, and outstanding talent have made a lasting impact on our community.

Prof. P. G. Jamdade, EESA CO-ORDINATOR | Prof. Dr. S. T. Gaikwad, EESA CO-ORDINATOR | Prof. Dr. M. S. Thakare, HOD ELECTRICAL ENGINEERING

PVG'S COLLEGE OF ENGINEERING AND TECHNOLOGY
& G. K. PATE (WANI) INSTITUTE OF MANAGEMENT, PUNE.
Approved by AICTE,DTE (Code:6274)|Affiliated to SPPU,PUNE
Accredited by NACC Second cycle 'A' Grade

Department of Electrical Engineering
Accredited by National Board of Accreditation (NBA)

CERTIFICATE OF ACHIEVEMENT

PRESENTED TO,

Shivani Tajane (B.E Project)

In recognition of your exceptional accomplishments during the academic year 2022-23, we proudly present you with this Certificate of Achievement. Your dedication, passion, and outstanding talent have made a lasting impact on our community.

Prof. P. G. Jamdade, EESA CO-ORDINATOR | Prof. Dr. S. T. Gaikwad, EESA CO-ORDINATOR | Prof. Dr. M. S. Thakare, HOD ELECTRICAL ENGINEERING

PVG'S COLLEGE OF ENGINEERING AND TECHNOLOGY
& G. K. PATE (WANI) INSTITUTE OF MANAGEMENT, PUNE.
Approved by AICTE,DTE (Code:6274)|Affiliated to SPPU,PUNE
Accredited by NACC Second cycle 'A' Grade

Department of Electrical Engineering
Accredited by National Board of Accreditation (NBA)

CERTIFICATE OF ACHIEVEMENT

PRESENTED TO,

Payal Tadavi (B.E. Project)

In recognition of your exceptional accomplishments during the academic year 2022-23, we proudly present you with this Certificate of Achievement. Your dedication, passion, and outstanding talent have made a lasting impact on our community.

Prof. P. G. Jamdade, EESA CO-ORDINATOR | Prof. Dr. S. T. Gaikwad, EESA CO-ORDINATOR | Prof. Dr. M. S. Thakare, HOD ELECTRICAL ENGINEERING

CHAPTER 10

REFERENCES

[1] IEEE_ research paper, ”IOT Based Real-Time Vehicle Tracking System”, Abdullah; Mardeni Roslee; Mohamad Y. Alias

[2] IEEE_ research paper, “The Working Principle Of An Arduino.” Yusuf Abdullahi Badamasi Nigerian Turkish Nile University Abuja, Nigeria

[3] IEEE_ research paper, “GPRS, general packet radio service.” Sven rfkesson Ericsson Radio Systems AB S- 16480 Stockholm Sweden