“PREPAID AND POSTPAID EV CHARGING STATION”

BATCH CODE:21ECE-MP-B-08

Major Project Report

Submitted to
Jawaharlal Nehru Technological University Hyderabad

in Partial Fulfilment of the Requirements
for the Award of the Degree of

Bachelor of Technology

In

Electronics & Communication Engineering

Submitted by

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BHARAT INSTITUTE OF ENGINEERING & TECHNOLOGY

Mangalpally(v), Ibrahimpatnam (M), Rangareddy -501510, 2024-25

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

BHARAT INSTITUTE OF ENGINEERING AND TECHNOLOGY

(Affiliated to JNTUH Hyderabad, Approved by AICTE and Accredited with NAAC 'A' Grade & NBA for ECE,CSE)
Ibrahimpatnam, Telangana-501 510

Certificate

This is to certify that the project work entitled "PREPAID AND POSTPAID EV CHARGING STATION" *is the* Bonafide work done

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Viva-Voce held on……

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DECLARATION

We hereby declare that this Minor Project Report is titled **"PREPAID AND POSTPAID EV CHARGING STATION"** is a genuine work carried out by us in **B.Tech. (Electronics and Communication Engineering)** degree course of **Jawaharlal Nehru Technology University Hyderabad,** and has not been submitted to any other course or university for the award of the degree by us.

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Vision of the Institution

To achieve the autonomous & university status and spread universal education by inculcating discipline, character and knowledge into the young minds and mould them into enlightened citizens.

Mission of the Institution

Our mission is to impart education, in a conducive ambience, as comprehensive as possible, with the support of all the modern technologies and make the students acquire the ability and passion to work wisely, creatively and effectively for the betterment of our society.

Vision of ECE Department

The vision of the Department of Electronics and Communication Engineering is to effectively serve the educational needs of local and rural students within the core area of electronics and communication engineering and develop high quality engineers and responsible citizens.

Mission of ECE Department

The mission of the Department of Electronics and Communication Engineering is to work closely with industry, research organizations to provide high quality education in both theoretical and practical applications of electronics and communication engineering.

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PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

Program Educational Objective 1: (PEO1)

Graduates will be able to synthesize mathematics, science, engineering fundamentals, laboratory and work-based experiences to formulate and solve engineering problems in Electronics and Communication engineering domains and shall have proficiency in Computer-based engineering and the use of computational tools design of electronics systems.

Program Educational Objective 2: (PEO2)

Graduates will succeed in entry-level engineering positions within the core Electronics and Communication Engineering, computational or manufacturing firms in regional, national, or international industries and with government agencies.

Program Educational Objective 3: (PEO3)

Graduates will succeed in the pursuit of advanced degrees in Engineering or other fields where a solid foundation in mathematics, basic science, and engineering fundamentals is required.

Program Educational Objective 4: (PEO4)

Graduates will be prepared to communicate and work effectively on team-based engineering projects and will practice the ethics of their profession consistent with a sense of social responsibility.

Program Educational Objective 5: (PEO5)

Graduates will be prepared to undertake Research and Development works in the areas of Electronics and Communication fields.

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PROGRAM OUTCOMES

PO1:	**Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2:	**Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3:	**Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4:	**Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5:	**Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO6:	**The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequence responsibilities relevant to the professional engineering practice.
PO7:	**Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8:	**Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO9:	**Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10:	**Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO11:	**Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO12:	**Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

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PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO1:	**Professional Skills:** An ability to understand the basic concepts in Electronics & Communication Engineering and to apply them to various areas, like Electronics, Communications, Signal processing, VLSI, Embedded systems etc., in the design and implementation of complex systems.
PSO2:	**Problem-Solving Skills:** An ability to solve complex Electronics and communication Engineering problems, using latest hardware and software tools, along with analytical skills to arrive cost effective and appropriate solutions.
PSO3:	**Successful Career and Entrepreneurship:** An understanding of social-awareness & environmental-wisdom along with ethical responsibility to have a successful career and to sustain passion and zeal for real-world applications using optimal resources as an entrepreneur.

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ACKNOWLEDGEMENT

The satisfaction that accompanies the successful completion of the task would be put incomplete without the mention of the people who made it possible, whose constant guidance and encouragement crown all the efforts with success

We would like to thank Prof**. G. Kumaraswamy Rao,** Former Director & O.S. of DLRL Ministry of Defence, Director, BIET, **Dr.Ankur Saxena** ECE Academic In-charge for having provided all the facilities and support.

We are thankful to our Project Coordinator **Dr.papiya Dutta,** Asst. Professor, Electronics and Communication Engineering for his support and cooperation throughout the process of this project.

We are thankful to our Project Guide **Dr.satyabrata singha** Professor for his support and cooperation throughout the process of this project. His wise counsel and suggestions were invaluable We express our deep sense of gratitude and thanks to all the Teaching and Non-Teaching staff of our college who stood with us during the project and helped us to make it a successful venture.

We place highest regards to our Parent, our Friends and Well-wishers who helped a lot in making the report of this project.

ABSTRACT

Electric vehicles (EVs) are becoming more common, and there is a growing need for an easy and flexible charging system. This project presents a dual-mode EV charging setup that works with both prepaid and postpaid payment options. Users can start charging by scanning an RFID card. In prepaid mode, the system deducts money from the user's balance based on the amount of electricity used. In postpaid mode, users are charged after the charging session. This makes the system suitable for different types of users and helps manage billing more effectively. To ensure accurate tracking of electricity use, the system uses voltage and current sensors. A microcontroller like Arduino or ESP32 controls the process by reading sensor data, managing the relay that starts or stops charging, and checking user balance or billing status. The system also displays important information like energy usage, balance, and charging time on an LCD screen or web interface. Overall, this project provides a reliable and user-friendly solution for EV charging stations, making them more efficient and convenient

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CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION OF PREPAID AND POSTPAID EV CHARGING STATION:

The transition from fossil fuel-based vehicles to electric vehicles (EVs) is significantly transforming the landscape of modern transportation. As the number of EVs continues to grow, the demand for intelligent, secure, and efficient charging infrastructure becomes increasingly critical. Traditional charging systems often fall short in offering personalized authentication and precise energy tracking, resulting in operational inefficiencies and inaccurate billing for users.This project presents the design and implementation of a smart EV charging system that addresses these limitations. It features RFID-based identification to authenticate users, supporting both prepaid and postpaid payment models. This ensures that only authorized users can access the charging service, improving security and accountability.To monitor energy usage accurately, the system incorporates current and voltage sensors, enabling real-time tracking of power consumption. A relay is employed to control the charging process automatically, enhancing safety and operational efficiency. The integration of these components facilitates transparent billing, energy management, and ease of use.The primary goal of the project is to create a smart, reliable, and user-friendly EV charging solution that adapts to diverse user needs and encourages wider adoption of electric mobility. By improving energy tracking and user authentication, this system sets a foundation for the future of sustainable transportation.

- **Prepaid billing:** Charging stops automatically when the user's balance is depleted.
- **Postpaid billing:** Energy consumed is logged and billed later.
- **Real-time monitoring:** Accurate tracking of voltage, current, and energy usage.
- **Automated control:** Relay switches charging ON/OFF based on user status.

By incorporating IoT elements and smart metering, this system aims to bridge the gap between EV infrastructure demands and technological innovation, contributing to the advancement of sustainable transportation.

1.2 FUTURRE OF PREPAID AND POSTPAID EV CHARGING STATION

The future of prepaid and postpaid EV charging stations is evolving rapidly with rising electric vehicle adoption. Prepaid models will likely dominate casual and public use, offering flexibility and upfront cost control for users. Meanwhile, postpaid systems will expand in fleet, subscription-based, and home charging scenarios, providing convenience and billing consolidation. Integration with smart grids, real-time pricing, and mobile apps will further

streamline both models. The trend leans toward hybrid systems, allowing users to choose or switch between prepaid and postpaid options. Enhanced user experience, dynamic pricing, and interoperability will define the next phase of EV charging infrastructure.

As the electric vehicle (EV) ecosystem rapidly evolves, the demand for intelligent, accessible, and efficient charging infrastructure is growing exponentially. Prepaid and postpaid EV charging models represent a significant step toward flexible, user-centric charging solutions. In the future, these systems are expected to become more sophisticated and widespread, offering greater convenience and control to both service providers and users.

The prepaid charging model allows EV users to top-up their accounts in advance and consume electricity based on available credit. This approach not only offers transparency and budget control for individual users but also simplifies revenue collection for charging station operators. With the integration of RFID authentication and mobile wallet support, prepaid charging is poised to offer fast, secure, and contactless access to charging services. It is especially ideal for locations where short-term or casual users need a quick and easy method to charge their vehicles.

On the other hand, postpaid EV charging enables users to charge their vehicles first and pay later based on usage. This model is particularly suited for regular commuters, fleets, and subscription-based users who prefer a consolidated billing system. The future of postpaid charging lies in automated billing, cloud-based energy usage tracking, and dynamic pricing models. As smart meters and IoT-based sensors become more prevalent, real-time energy consumption can be accurately recorded, ensuring precise billing and energy efficiency.

Looking ahead, the convergence of prepaid and postpaid charging with digital technologies such as mobile apps, blockchain for secure transactions, and AI-based user analytics will revolutionize the EV charging experience. These systems will also be integrated with renewable energy sources, enabling load balancing and sustainable energy distribution. Government policies and incentives will further accelerate the deployment of smart charging infrastructure in public and private spaces.

In summary, the future of prepaid and postpaid EV charging stations is centered around automation, personalization, energy optimization, and digital innovation. These advancements will not only cater to growing user demands but also contribute significantly to the development of a smart and sustainable electric mobility ecosystem.

1.3APPLICATION OF PREPAID AND POSTPAID EV CHARGING TATION:

Prepaid Charging Stations:

- **Public Charging Hubs:** Ideal for malls, highways, and parking lots where users prefer one-time or pay-as-you-go access.
- **Tourism and Transit Areas:** Convenient for travelers needing quick, temporary charging access.
- **Smartphone App Integration:** Enables users to prepay via apps or RFID cards for seamless, contactless charging**.**
- **Promotional Use:** Used in loyalty programs and partnerships with retailers offering prepaid credits**.**

Postpaid Charging Stations:

- **Fleet Operations:** Suitable for logistics and taxi companies requiring consolidated monthly billing**.**
- **Residential Complexes:** Common in apartments where tenants are billed post-usage.
- **Corporate Campuses:** Allows employee usage tracking and monthly deductions.
- **Subscription Services:** EV providers offering bundled charging with postpaid invoicing.

1.4 PROBLEM STATEMENT:

Electric vehicle (EV) users often encounter issues such as rigid billing models, limited usage transparency, and inadequate security in current charging systems. Many existing solutions either support only postpaid billing or fail to monitor real-time power consumption, leading to inefficiencies, energy wastage, and reduced user control. These shortcomings highlight the need for a more advanced and adaptable charging infrastructure. A smart EV charging system is essential—one that supports both prepaid and postpaid billing options while ensuring accurate energy monitoring. By integrating user authentication and automated power control, such a system can enhance security, improve efficiency, and offer a more user-centric experience. Real-time tracking of power consumption not only ensures transparent billing but also enables users to better manage their energy usage. This approach promotes accountability and paves the way for a more reliable and secure EV charging network, ultimately supporting the broader adoption of electric vehicles.

1.5 OBJECTIVE:

The primary objective of this project is to develop a dual-mode EV charging system that supports both prepaid and postpaid billing using RFID authentication. The system ensures secure, user-specific access by assigning RFID cards to each user. Real-time energy usage is accurately monitored through integrated voltage and current sensors, enabling precise tracking and billing. The charging process is fully automated using relay control, which activates or deactivates power supply based on user status and account balance. Overall, the project aims to provide a convenient.

The main objective of implementing prepaid and postpaid EV charging stations using RFID cards is to provide a convenient, secure, and efficient way to charge electric vehicles. By utilizing RFID technology, users can simply tap their card to access the charging station, eliminating the need for manual payment or authentication. This system enables seamless and automated transactions, making it an attractive solution for EV owners and charging station operators.

The dual-mode billing system, which supports both prepaid and postpaid options, offers flexibility and convenience to users. The prepaid option allows users to pay in advance for their energy consumption, while the postpaid option enables users to pay for their energy usage after consumption. The RFID-based system ensures accurate tracking of energy usage and billing, reducing errors and disputes. By providing a reliable and efficient charging experience, the system aims to promote the adoption of electric vehicles and support the growth of sustainable transportation infrastructure.

1.6 MOTIVATION:

The motivation behind prepaid and postpaid EV charging stations lies in offering flexible, user-centric solutions for diverse charging needs. Prepaid systems empower users with control over spending, convenience, and accessibility, especially in public and short-term use scenarios. They reduce payment friction and enable integration with mobile apps for easy top-ups. Postpaid models cater to regular users like fleets, residents, and employees, offering seamless charging without immediate payment, consolidated billing, and usage tracking. Both models support efficient energy distribution, improved user experience, and promote wider EV adoption by aligning with different usage patterns and preferences across commercial and private sectors.

The increasing global emphasis on sustainable energy and the growing demand for electric vehicles (EVs) have created a pressing need for efficient, secure, and user-friendly EV charging infrastructure. While electric mobility is being rapidly adopted as a cleaner alternative to conventional fossil-fuel transportation, the availability and accessibility of intelligent charging solutions still remain a challenge in many regions. This project is motivated by the necessity to bridge this gap by introducing an innovative, cost-effective, and automated EV charging station that supports both prepaid and postpaid modes using RFID technology.

Traditional charging stations often involve manual operations, lack of user authentication, and limited flexibility in billing mechanisms. These limitations not only hinder the user experience but also create challenges in energy monitoring, fair usage, and operational management. To overcome these issues, our system incorporates an **RFID-based authentication module**, allowing only authorized users to access the charging facility. This feature enhances security, prevents unauthorized usage, and makes the system highly reliable in public as well as private environments.

Moreover, integrating both **prepaid and postpaid billing options** introduces a versatile solution suitable for a wide range of applications—ranging from commercial EV stations to residential societies. Users can either pre-load their balance and charge as needed or use the service first and pay based on consumption. This flexible model caters to varying user needs and promotes wider adoption.

The inclusion of an **Arduino Uno microcontroller**, along with **current and voltage sensors**, ensures real-time monitoring and accurate billing. The **16x2 LCD display** provides instant feedback to users, enhancing usability. The system's modular design also enables easy expansion and integration with future smart grid and IoT-based platforms.

In essence, this project is driven by the vision of supporting the global shift toward electric transportation by developing a smart charging solution that is affordable, scalable, and user-centric. The motivation lies not only in solving a technical problem but also in contributing to a sustainable future where energy is used efficiently and responsibly.

CHAPTER-2
LITERATURE REVIEW

2.1 LITERATURE SURVEY:

As more people start using electric vehicles (EVs), there is a growing need for better and smarter charging systems. One important part of this is how users pay for the electricity they use. Prepaid and postpaid billing systems help make EV charging easier and more flexible. These systems often use technologies like RFID cards, IoT (Internet of Things), and microcontrollers to manage charging, check energy usage, and handle payments automatically.This review looks at recent research studies and projects that focus on prepaid and postpaid EV charging stations. It highlights how different systems work, the technologies they use, and how they help make charging more efficient and user-friendly.

1. Dr. D. Siva, S. Jameela, P. Lavanya, V. Surendra (2025)

Title: Smart RFID IoT Enabled EV Charging System

Publication: International Journal of Scientific Research in Engineering and Management (IJSREM)

Publisher: IJSREM

Source: [IJSREM April 2025 Issue, DOI: 10.55041/IJSREM43766]

Summary:

This paper presents an RFID and IoT-based smart EV charging system with real-time voltage monitoring and automated control. The system allows for secure user authentication via RFID, relay-controlled power delivery, and display feedback. Though not explicitly labeled as prepaid/postpaid, the secure access and charge control mimic prepaid operation. The integration of smart features makes it suitable for urban and private charging stations.

2. Vyankatesh Chavan, Aniket Kahandal, Sujal Sonavane, Ankur Saxena (2024)

Title: Prepaid & Postpaid Billing for EV Charging Station

Publication: Major Project Report

Publisher: Sandip Institute of Technology and Research Centre, Nashik

Source: [User-uploaded file]

Summary:

This project introduces a dual-mode EV billing system using Arduino Nano. In prepaid mode, credit is deducted based on energy use; in postpaid, energy consumed is billed after the session. The system uses a relay and sensors for real-time tracking of power and current. The concept aligns closely with smart metering and demand-response strategies seen in smart grid applications.

3. J. Liu, X. Wang, Y. Zhang (2022)

Title: RFID-based Smart Charging Station for Electric Vehicles

Publication: IEEE International Conference on Smart Grid Communications (SmartGridComm)

Publisher: IEEE

Source: Cited in

Summary:

This work proposes an RFID-based charging system for EVs enabling secure access control. It includes dynamic monitoring of energy usage and user identity verification. The RFID system can be tied into prepaid or subscription-based billing modes.

4. M. Patel, P. Shah, D. Joshi (2021)

Title: Design and Implementation of an RFID-Based Authentication System for EV Charging

Publication: IEEE Transactions on Industrial Electronics

Publisher: IEEE

Source: Cited in

Summary:

Focused on secure access using RFID, this paper details a smart authentication system suitable for prepaid billing. The integration of current sensors and microcontrollers offers billing accuracy and tamper-resistance.

5. A. Sharma, V. Kumar (2022)

Title: Smart Grid-Based EV Charging Station Using RFID Authentication and IoT Integration

Publication: IEEE Power and Energy Conference

Publisher: IEEE

Source: Cited in

Summary:The paper discusses IoT-enabled charging with RFID-based access control integrated with grid communication. It supports real-time pricing and user profiling, relevant for postpaid billing schemes.

6. T. Chen, L. He, W. Zhang (2023)

Title: Relay-Controlled EV Charging Station with RFID-Based User Authentication

Publication: IEEE Internet of Things Journal

Publisher: IEEE

Source: Cited in

Summary:

A technically detailed implementation of a relay-controlled system where user sessions are authorized via RFID. Real-time power data is captured for billing and usage analytics. Can be configured for both prepaid and postpaid models.

CHAPTER 3

HARDWARE & SOFTWARE DESCRIPTION

3.1 HARDWARE DESCRIPTION:

3.1.1 POWER SUPPLY:

The power supply section is the section which provide +5V for the components to work. IC LM7805 is used for providing a constant power of +5V.

The ac voltage, typically 220V, is connected to a transformer, which steps down that ac voltage down to the level of the desired dc output. A diode rectifier then provides a full-wave rectified voltage that is initially filtered by a simple capacitor filter to produce a dc voltage. This resulting dc voltage usually has some ripple or ac voltage variation.
A regulator circuit removes the ripples and also retains the same dc value even if the input dc voltage varies, or the load connected to the output dc voltage changes. This voltage regulation is usually obtained using one of the popular voltage regulator IC units.

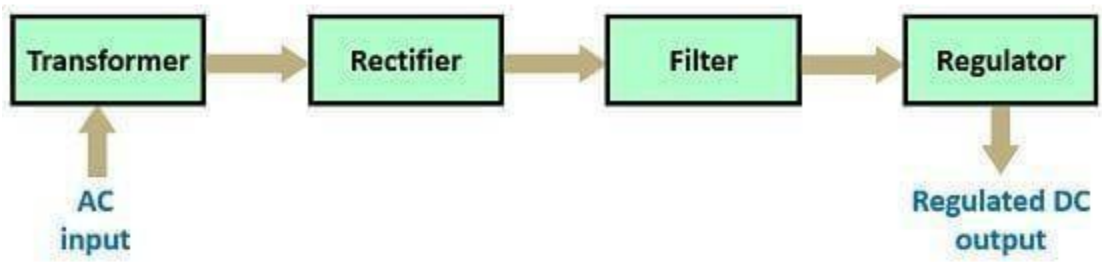

Fig .1 Block Diagram of Power Supply

3.1.2 TRANSFORMER

Transformers convert AC electricity from one voltage to another with little loss of power. Transformers work only with AC and this is one of the reasons why mains electricity is AC.Step-up transformers increase voltage, step-down transformers reduce voltage. Most power supplies use a step-down transformer to reduce the dangerously high mains voltage (230V in India) to a safer low voltage.The input coil is called the primary and the output coil is called the secondary. There is no electrical connection between the two coils; instead they are linked by an alternating magnetic field created in the soft-iron core of the transformer. Transformers waste very little power so the power out is (almost) equal to the power in. Note that as voltage is stepped down current is stepped up.The transformer will step down the power supply voltage

(0-230V) to (0- 6V) level. Then the secondary of the potential transformer will be connected to the bridge rectifier, which is constructed with the help of PN junction diodes. The advantages of using bridge rectifier are it will give peak voltage output as DC.

3.1.2 RECTIFIER

There are several ways of connecting diodes to make a rectifier to convert AC to DC. The bridge rectifier is the most important and it produces full-wave varying DC. A full-wave rectifier can also be made from just two diodes if a centre-tap transformer is used, but this method is rarely used now that diodes are cheaper. A single diode can be used as a rectifier but it only uses the positive (+) parts of the AC wave to produce half-wave varying DC

3.1.3 BRIDGE RECTIFIER:

When four diodes are connected as shown in figure, the circuit is called as bridge rectifier. The input to the circuit is applied to the diagonally opposite corners of the network, and the output is taken from the remaining two corners. Let us assume that the transformer is working properly and there is a positive potential, at point A and a negative potential at point B. the positive potential at point A will forward bias D3 and reverse bias D4.

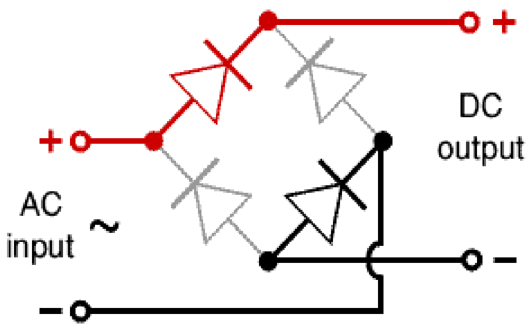

Fig.2 Bridge Rectifier

The negative potential at point B will forward bias D1 and reverse D2. At this time D3 and D1 are forward biased and will allow current flow to pass through them; D4 and D2 are reverse biased and will block current flow.One advantage of a bridge rectifier over a conventional full-wave rectifier is that with a given transformer the bridge rectifier produces a voltage output that is nearly twice that of the conventional full-wave circuit.

i. The main advantage of this bridge circuit is that it does not require a special centre tapped transformer, thereby reducing its size and cost.

ii. The single secondary winding is connected to one side of the diode bridge network and the load to the other side as shown below.

iii. The result is still a pulsating direct current but with double the frequency.

3.1.4 SMOOTHING

Smoothing is performed by a large value electrolytic capacitor connected across the DC supply to act as a reservoir, supplying current to the output when the varying DC voltage from the rectifier is falling. The capacitor charges quickly near the peak of the varying DC, and then discharges as it supplies current to the output.

3.1.4 FILTER:

A filter is an electronic or signal-processing device used to remove unwanted components or features from a signal. Filters are commonly used in electrical and electronic systems to allow certain frequencies to pass while blocking others. There are several types of filters, including low-pass, high-pass, band-pass, and band-stop, each serving a specific function based on frequency range. Filters can be implemented using analog components like resistors, capacitors, and inductors, or digitally through software algorithms. They are widely used in audio processing, communication systems, power electronics, and instrumentation to enhance signal quality and ensure accurate data transmission or measurement.

3.1.5 VOLTAGE REGULATORS

Voltage regulators comprise a class of widely used ICs. Regulator IC units contain the circuitry for reference source, comparator amplifier, control device, and overload protection all in a single IC. IC units provide regulation of either a fixed positive voltage, a fixed negative voltage, or an adjustably set voltage. The regulators can be selected for operation with load currents from hundreds of milli amperes to tens of amperes, corresponding to power ratings from milli watts to tens of watts.A fixed three-terminal voltage regulator has an unregulated dc input voltage, Vi, applied to one input terminal, a regulated dc output voltage, Vo, from a second terminal, with the third terminal connected to ground.The series 78 regulators provide fixed positive regulated voltages from 5 to 24 volts. Similarly, the series 79 regulators provide fixed negative regulated voltages from 5 to 24 volts. Voltage regulator ICs are available with fixed (typically 5, 12 and 15V) or variable output voltages. They are also rated by the maximum current they can pass. Negative voltage regulators are available, mainly for use in dual supplies. Most regulators include some automatic protection from excessive current ('overload protection') and overheating ('thermal protection').Many of the fixed voltage regulator ICs has

3 leads and look like power transistors, such as the 7805 +5V 1Amp regulator. They include a hole for attaching a heat sink if necessary.

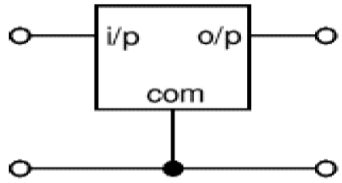

Fig.3 Regulator

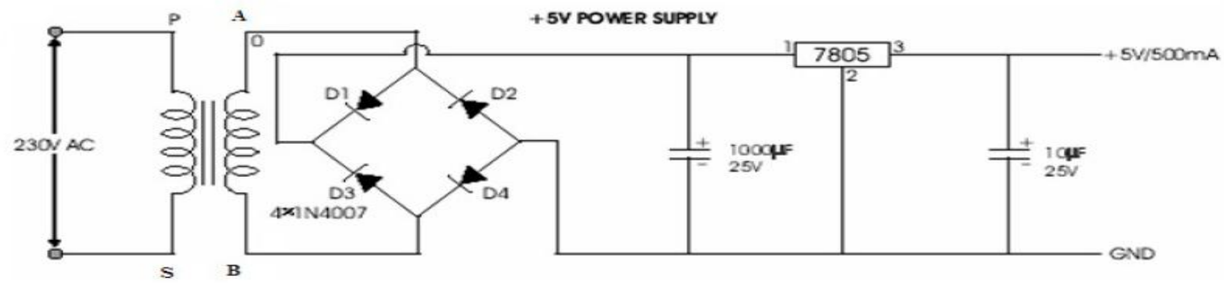

Fig:4 Circuit Diagram of Power Supply

3.3 MICROCONTROLLER

A Microcontroller (or MCU) is a computer-on-a-chip used to control electronic devices. It is a type of microprocessor emphasizing self-sufficiency and cost-effectiveness, in contrast to a general-purpose microprocessor (the kind used in a PC). A typical microcontroller contains all the memory and interfaces needed for a simple application, whereas a general purpose microprocessor requires additional chips to provide these functions.

A microcontroller is a single integrated circuit with the following key features:

- central processing unit - ranging from small and simple 8-bit processors to sophisticated 32- or 64-bit processors
- input/output interfaces such as serial ports
- RAM for data storage
- ROM, EEPROM or Flash memory for program storage
- clock generator - often an oscillator for a quartz timing crystal, resonator or RC circuit

Microcontrollers are inside many kinds of electronic equipment (see embedded system). They are the vast majority of all processor chips sold. Over 50% are "simple" controllers, and another 20% are more specialized digital signal processors (DSPs) (ref?). A typical home in a developed country is likely to have only one or two general-purpose microprocessors but somewhere between one and two dozen microcontrollers. A typical mid range vehicle has as many as 50 or more microcontrollers. They can also be found in almost any electrical device: washing machines, microwave ovens, telephones etc.

3.2 ARDUINO UNO BOARD:

Arduino Uno is a microcontroller board based on the ATmega328P (datasheet). It has14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. You can tinker with your UNO without worrying too much about doing something wrong, worst-case scenario you can replace the chip for a few dollars and start over again The Uno board and version 1.0 of Arduino Software (IDE) were the reference versions of Arduino, now evolved to newer releases. The Uno board is the first in a series of USB Arduino boards, and the reference model for the Arduino platform; for an extensive list of current, past or outdated boards see the Arduino index of boards.

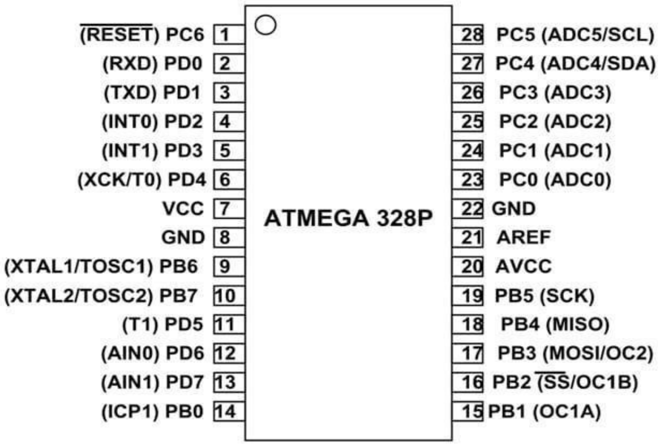

Fig. 5 Diagram of Arduino Board

Fig. 6 Pin Diagram of Arduino

DESCRIPTION:

The high-performance Atmel 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.

3.2.1 PIN DIAGRAM:

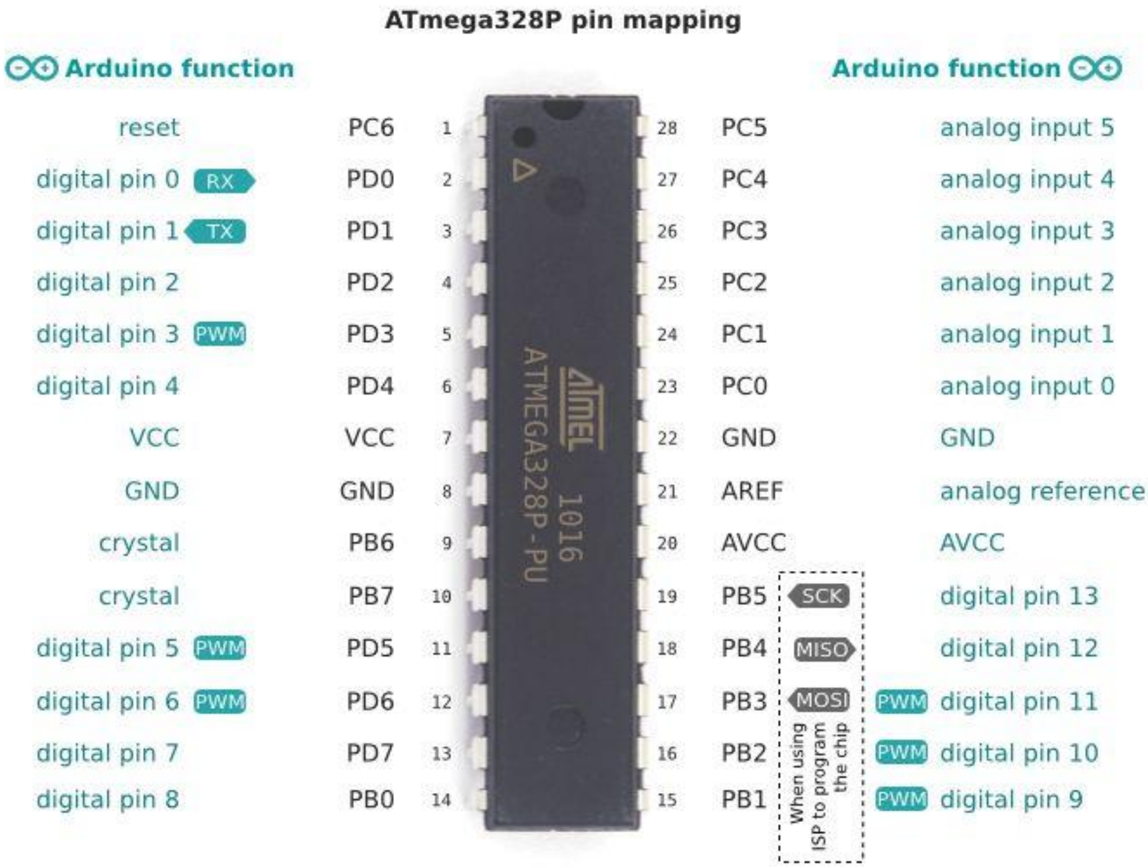

Fig 7 Pin Diagram Arduino

PIN DESCRIPTION:

VCC

Digital supply voltage.

GND

Ground.

Port B (PB7:0) XTAL1/XTAL2/TOSC1/TOSC2

Port B is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port B output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port B pins that are externally pulled low will source current if the pull-up resistors are activated. The Port B pins are tristated when a reset condition becomes active, even if the clock is not running. Depending on the clock selection fuse settings, PB6 can be used as input to the inverting Oscillator amplifier and input to the internal clock operating circuit.Depending on the clock selection fuse settings, PB7 can be used as output from the inverting Oscillator amplifier.If the Internal Calibrated RC Oscillator is used as chip clock source, PB7...6 is used as TOSC2...1 input for the Asynchronous Timer/Counter2 if the AS2 bit in ASSR is set. The various special features of Port B are elaborated in ”Alternate Functions of Port B” on page 82 and ”System Clock and Clock Options”.

Port C (PC5:0)

Port C is a 7-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The PC5...0 output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port C pins that are externally pulled low will source current if the pull-up resistors are activated. The Port C pins are tristated when a reset condition becomes active, even if the clock is not running.

PC6/RESET

If the RSTDISBL Fuse is programmed, PC6 is used as an I/O pin. Note that the electrical characteristics of PC6 differ from those of the other pins of Port C.If the RSTDISBL Fuse is unprogrammed, PC6 is used as a Reset input. A low level on this pin for longer than the minimum pulse length will generate a Reset, even if the clock is not running. The minimum pulse length is given in Table 29-11 on page 305. Shorter pulses are not guaranteed to generate a Reset.

Port D (PD7:0)

Port D is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port D output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port D pins that are externally pulled low will source current if the pull-up resistors are activated. The Port D pins are tristated when a reset condition becomes active, even if the clock is not running.

AVCC

AVCC is the supply voltage pin for the A/D Converter, PC3:0, and ADC7:6. It should be externally connected to VCC, even if the ADC is not used. If the ADC is used, it should be connected to VCC through a low-pass filter.
Note that PC6...4 use digital supply voltage, VCC.

AREF

AREF is the analog reference pin for the A/D Converter.

ADC7:6 (TQFP and QFN/MLF Package Only)

In the TQFP and QFN/MLF package, ADC7:6 serve as analog inputs to the A/D converter. These pins are powered from the analog supply and serve as 10-bit ADC channels.
Each of the 14 digital pins on the Uno can be used as an input or output, using pinMode(),digitalWrite(), and digitalRead() functions. They operate at 5 volts. Each pin can provide or receive 20 mA as recommended operating condition and has an internal pull-up resistor (disconnected by default) of 20-50k ohm. A maximum of 40mA is the value that must not be exceeded on any I/O pin to avoid permanent damage to the microcontroller.

Each of the 14 digital pins on the Uno can be used as an input or output,
using pinMode(),digitalWrite(), and digitalRead() functions. They operate at 5 volts. Each pin can provide or receive 20 mA as recommended operating condition and has an internal pull-up resistor (disconnected by default) of 20-50k ohm. A maximum of 40mA is the value that must not be exceeded on any I/O pin to avoid permanent damage to the microcontroller.

In addition, some pins have specialized functions:

Serial: 0 (RX) and 1 (TX). Used to receive (RX) and transmit (TX) TTL serial data. These pins are connected to the corresponding pins of the ATmega8U2 USB-to-TTL Serial chip.

External Interrupts: 2 and 3. These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value. See the attachInterrupt() function for details.

PWM: 3, 5, 6, 9, 10, and 11. Provide 8-bit PWM output with the analogWrite() function.

SPI: 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK). These pins support SPI communication using the SPI library.

LED: 13. There is a built-in LED driven by digital pin 13. When the pin is HIGH value, the LED is on, when the pin is LOW, it's off.

TWI: A4 or SDA pin and A5 or SCL pin. Support TWI communication using the Wire library.

The Uno has 6 analog inputs, labeled A0 through A5, each of which provide 10 bits of resolution (i.e. 1024 different values). By default they measure from ground to 5 volts, though is it possible to change the upper end of their range using the AREF pin and the analog Reference() function. There are a couple of other pins on the board:

AREF. Reference voltage for the analog inputs. Used with analogReference().

Reset. Bring this line LOW to reset the microcontroller. Typically used to add a reset button to shields which block the one on the board.

3.3 LIQUID CRYSTAL DISPLAY(LCD):

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. The reasons being: LCDs are economical; easily programmable; have no limitation of displaying special & even custom characters (unlike in seven segments), animations and so on.

A 16x2 LCD means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5x7 pixel matrix. This LCD has two registers, namely, Command and Data.

The command register stores the command instructions given to the LCD. A command is an instruction given to LCD to do a predefined task like initializing it, clearing its screen, setting the cursor position, controlling display etc. The data register stores the data to be displayed on the LCD. The data is the ASCII value of the character to be displayed on the LCD.

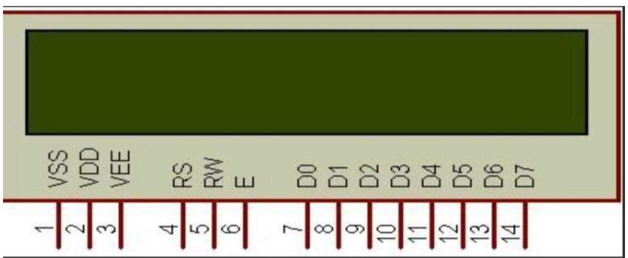

Fig. 8 16x2 LCD

3.3.1 Pin Description:

Most LCDs with 1 controller has 14 Pins and LCDs with 2 controller has 16 Pins (two pins are extra in both for back-light LED connections). Pin description is shown in the table below.

Pin Configuration table for a 16X2 LCD character display: -

Pin Number	Symbol	Function
1	Vss	Ground Terminal
2	Vcc	Positive Supply
3	Vdd	Contrast adjustment
4	RS	Register Select; 0→Instruction Register, 1→Data Register
5	R/W	Read/write Signal; 1→Read, 0→ Write
6	E	Enable; Falling edge
7	DB0	
8	DB1	
9	DB2	
10	DB3	Bi-directional data bus, data transfer is performed once, thru DB0 to DB7, in the case of interface data length is 8-bits; and twice, through DB4 to DB7 in the case of interface data length is 4-bits. Upper four bits first then lower four bits.
11	DB4	
12	DB5	
13	DB6	
14	DB7	
15	LED-(K)	Back light LED cathode terminal
16	LED+(A)	Back Light LED anode terminal

Table 9 Pin Description Of LCD

Data/Signals/Execution of LCD:

LCD accepts two types of signals, one is data, and another is control. These signals are recognized by the LCD module from status of the RS pin. Now data can be read also from the LCD display, by pulling the R/W pin high. As soon as the E pin is pulsed, LCD display reads data at the falling edge of the pulse and executes it, same for the case of transmission.

LCD display takes a time of 39-43μS to place a character or execute a command. Except for clearing display and to seek cursor to home position it takes 1.53ms to 1.64ms. Any attempt to send any data before this interval may lead to failure to read data or execution of the current data in some devices. Some devices compensate the speed by storing the incoming data to some temporary registers.

Instruction Register (IR) and Data Register (DR)

There are two 8-bit registers in HD44780 controller Instruction and Data register. Instruction register corresponds to the register where you send commands to LCD e.g LCD shift command, LCD clear, LCD address etc. and Data register is used for storing data which is to be displayed on LCD. when send the enable signal of the LCD is asserted, the data on the pins is latched in to the data register and data is then moved automatically to the DDRAM and hence is displayed on the LCD. Data Register is not only used for sending data to DDRAM but also for CGRAM, the address where you want to send the data, is decided by the instruction you send to LCD. We will discuss more on LCD instruction set further in this tutorial.

Commands and Instruction set

Only the instruction register (IR) and the data register (DR) of the LCD can be controlled by the MCU. Before starting the internal operation of the LCD, control information is temporarily stored into these registers to allow interfacing with various MCUs, which operate at different speeds, or various peripheral control devices. The internal operation of the LCD is determined by signals sent from the MCU. These signals, which include register selection signal (RS), read/write signal (R/W), and the data bus (DB0 to DB7), make up the LCD instructions (Table 3). There are four categories of instructions that:

- Designate LCD functions, such as display format, data length, etc.
- Set internal RAM addresses
- Perform data transfer with internal RAM
- Perform miscellaneous functions

3.4 RFID READER:

An RFID (Radio Frequency Identification) scanner operates similarly to a barcode scanner but uses electromagnetic waves instead of laser beams to read data. The scanner emits radio signals through its antenna, which are received by the antenna on an RFID tag. When the tag detects the incoming signal, it activates and sends the stored data from its internal chip back to the scanner. This exchange of information occurs wirelessly, making RFID systems more efficient and capable of scanning multiple tags without direct line-of-sight. The data on the RFID tag is stored in either Read-Only Memory (ROM) or Read/Write Memory. ROM-based tags contain fixed data that cannot be changed after manufacturing, commonly used for identification purposes. Read/Write Memory tags, on the other hand, are more flexible, allowing data to be modified or updated using compatible devices. RFID technology is widely used in applications such as access control, inventory management, contactless payments, and vehicle tracking.

Fig.10 RFID READER

Features:

- Reading Distance: 6-10 cm
- Dimension: 40mmx20mmx8mm (LxHxW)
- Frequency:125kHz
- Compatible Card codes:Manchester64-bit,modules64
- Current Rating: 35mA (Max)
- Operating Voltage:4.6V - 5.4VDC

Specifications

It is an ADC (Automated Data Collection) technology that:

- uses radiofrequency waves to transfer data between a reader and a movable item to identify, categorize, track..
- Is fast and does not require physical sight or contact between reader/scanner and the tagged item.
- Performs the operation using low cost components.
- Attempts to provide unique identification and backend integration that allows for wide range of applications.

3.5 RFID TAG:

An RFID tag is a compact electronic device used to store and transmit data to an RFID reader. These tags are primarily categorized into two types: active and passive. Active RFID tags are equipped with an internal battery, allowing them to transmit signals without relying on power from the RFID reader. This independent power source gives active tags a longer communication range, making them suitable for tracking assets over greater distances. In contrast, passive RFID tags are smaller, lighter, and more cost-effective. They do not have an internal battery and rely entirely on the energy transmitted by the RFID reader to power the chip and send data back. Due to this dependency, passive tags have a much shorter read range, typically limited to a few meters. Despite their shorter range, passive tags are widely used in applications like inventory control, access management, and retail due to their affordability, compact design, and ease of integration.

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Fig .11 RFID TAG

WORKING OF EM-18 RFID MODULE

The module radiates 125KHz through its coils and when a 125KHz passive RFID tag is brought into this field it will get energized from this field. These passive RFID tags mostly consist of CMOS IC EM4102 which can get enough power for its working from the field generated by the reader.

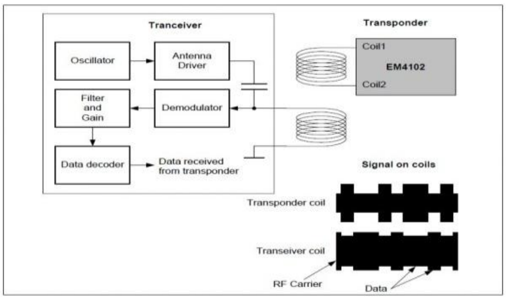

Fig 12 RFID TAG EM4102

By changing the modulation current through the coils, tag will send back the information contained in the factory programmed memory array.

PIN OUT

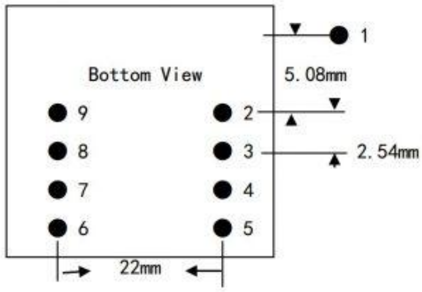

Fig 13 EM-18 RFID Reader Module – Bottom View

Pin No.	Name	Function
1	VCC	5V
2	GND	Ground
3	BEEP	BEEP and LED
4	ANT	No Use
5	ANT	No Use
6	SEL	HIGH selects RS232, LOW selects WEIGAND
7	TX	UART TX, When RS232 is Selected
8	D1	WIEGAND Data 1
9	D0	WIEGAND Data 0

ADVANTAGES OF RFID

- Non-line of sight identification of tags
- Unattended operations are possible, minimizing human errors and high cost.
- Ability to identify moving elements that have tags embedded.
- Larger area of coverage, Up to several feet.

- Can be used in diverse environments, including live stock, military, and scientific areas.
- RFID can be used in addition to Bar Code. These two technologies can be complementing each other.
- Automatic integration with back end software solutions provide end to end integration of data in real time.

3.6 RELAY:

A relay is an electrically controlled switch that uses an electromagnetic coil to operate one or more sets of contacts. It enables low-power circuits to control high-power devices, offering electrical isolation and enhancing safety. Relays are available in types like electromechanical, solid-state, and reed relays, each suited for specific applications. They are key components in automation systems, home appliances, automotive circuits, and industrial control panels. Relays are characterized by their coil voltage, contact rating, and configuration (e.g., SPDT, SPST). By converting electrical signals into mechanical action, relays provide a reliable way to manage and control complex electrical systems.

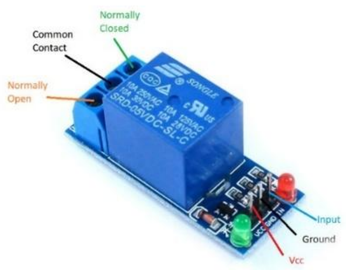

Fig.14 Relay

Advantage of relay:

A relay takes small power to turn ON, but it can control high power devices to switch ON and OFF. Consider an example; a relay is used t control the ceiling FAN at our home. The ceiling FAN may runs at 230V AC and draws a current maximum of 4A. Therefore the power required is 4X230 = 920 watts. Off course we can control AC, lights, etc., depend up on the relay ratings. Relays can be used to control DC motors in ROBOTICs.

3.7 CURRENT TRANSFORMER:

A current transformer (CT) is an electrical device used to measure alternating current (AC) by producing a reduced current proportional to the current in its primary circuit. It consists of a primary winding, a magnetic core, and a secondary winding. The primary winding carries the main current, while the secondary winding, connected to measuring instruments or protective relays, outputs a scaled-down current. CTs are essential in power systems for monitoring and protection, especially in high-voltage networks where direct measurement is impractical. They provide electrical isolation between the high-voltage circuit and measuring instruments, enhancing safety. CTs are commonly rated by their transformation ratio (e.g., 1000:5), meaning a 1000 A primary current results in a 5 A secondary current. Accuracy, burden (load), and class are key specifications. They should never be operated with an open secondary circuit while energized, as this can cause dangerously high voltages.

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Fig. 15 Current Transformer

3.8 VOLTAGE REGULATOR LM7805:

The LM7805 is a popular voltage regulator that provides a stable 5V DC output from a higher input voltage, typically ranging from 7V to 35V. It belongs to the 78xx series of linear voltage regulators, where "xx" indicates the output voltage. The LM7805 is widely used in electronic circuits to power microcontrollers, sensors, and other 5V devices. It has three pins: input, ground, and output. Internally, it includes circuitry for overcurrent protection, thermal shutdown, and safe area compensation, ensuring reliable operation.

While it's simple to use, it is a linear regulator, so it dissipates excess voltage as heat, which may require a heatsink in high-load applications. The LM7805 offers excellent line and load regulation, making it suitable for many low-noise analog and digital projects. However, for higher efficiency, especially in battery-powered systems, a switching regulator (buck converter) may be preferred.

Fig. 16 voltage sensor

3.9 SOFTWARE DESCRIPTION:

Step 1: Arduino IDE Software

Install Arduino IDE software from the link http://www.arduino.cc/en/main/software.

Step 2: Arduino IDE Icon

After installing Arduino IDE icon is created on the Desktop as show in the figure. Installing

Fig. 17 Arduino software

Step 3: Click on tools and select board, select Arduino uno

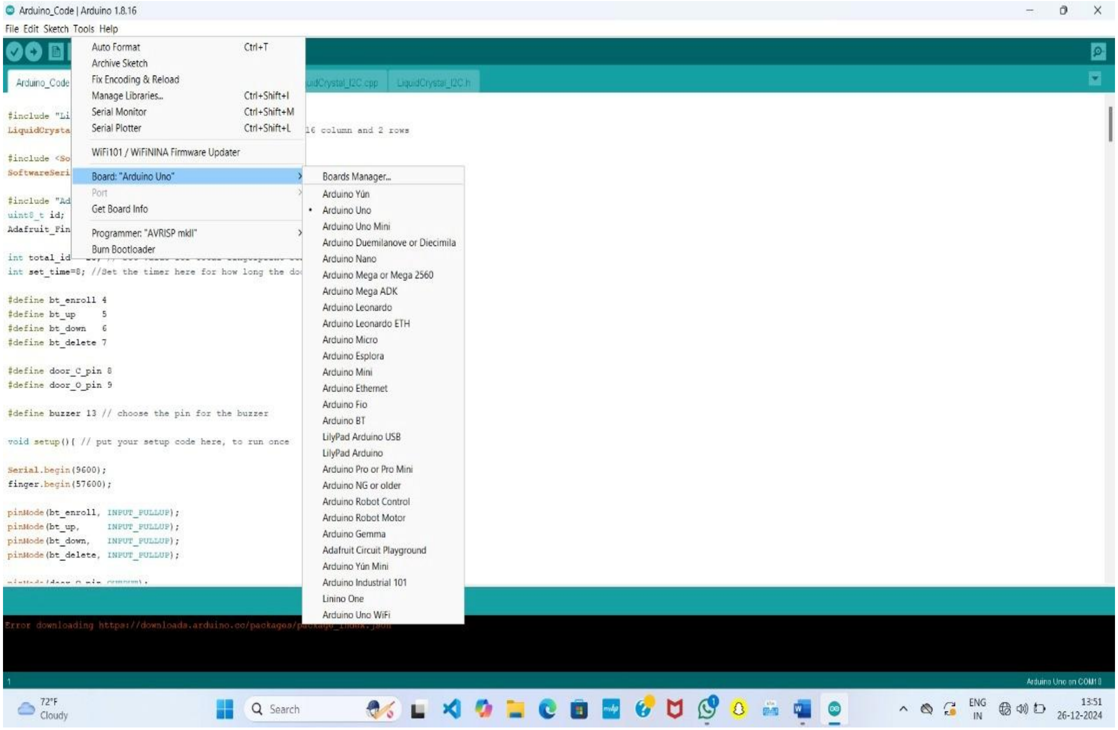

Fig.18 Arduino IDE

Step 4: Open the file and select the code as shown in figure

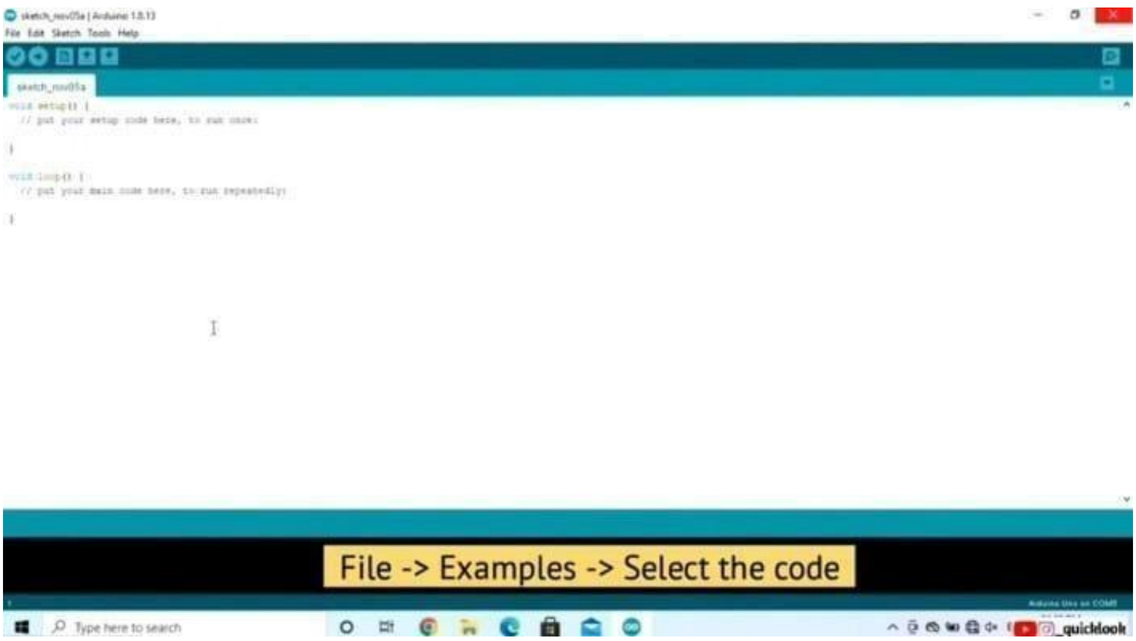

Fig. 19 Selecting the code

Step 5: Click on verify/compile the code

Fig. 20 Verifying the code

Step 6: Using USB cable connect the Arduino

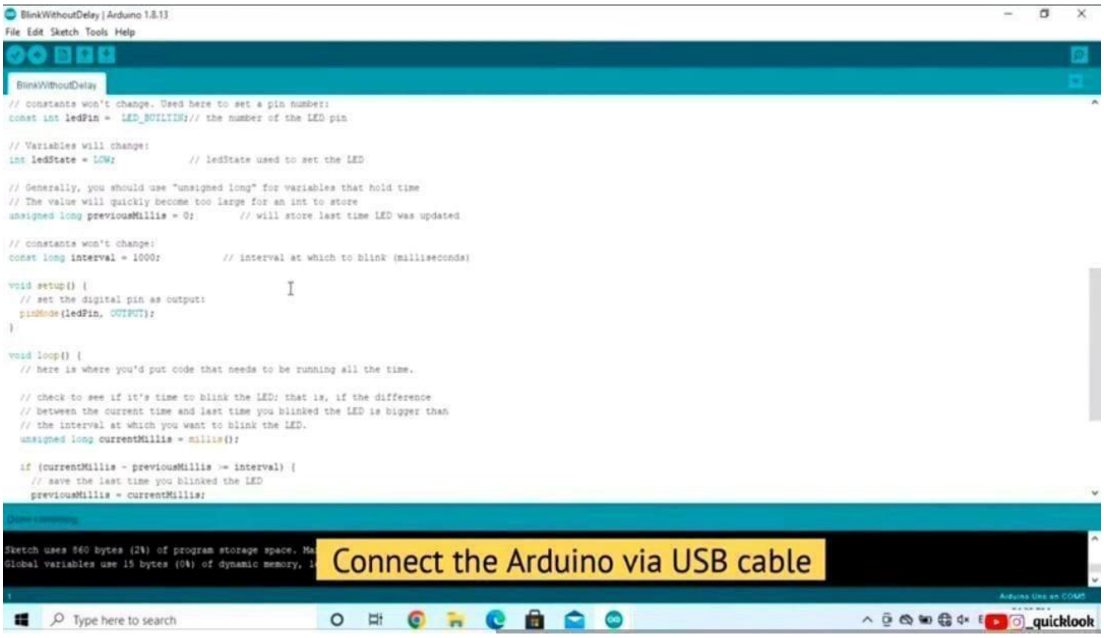

Fig. 21USB cable Arduino

Step7: Now go to tools

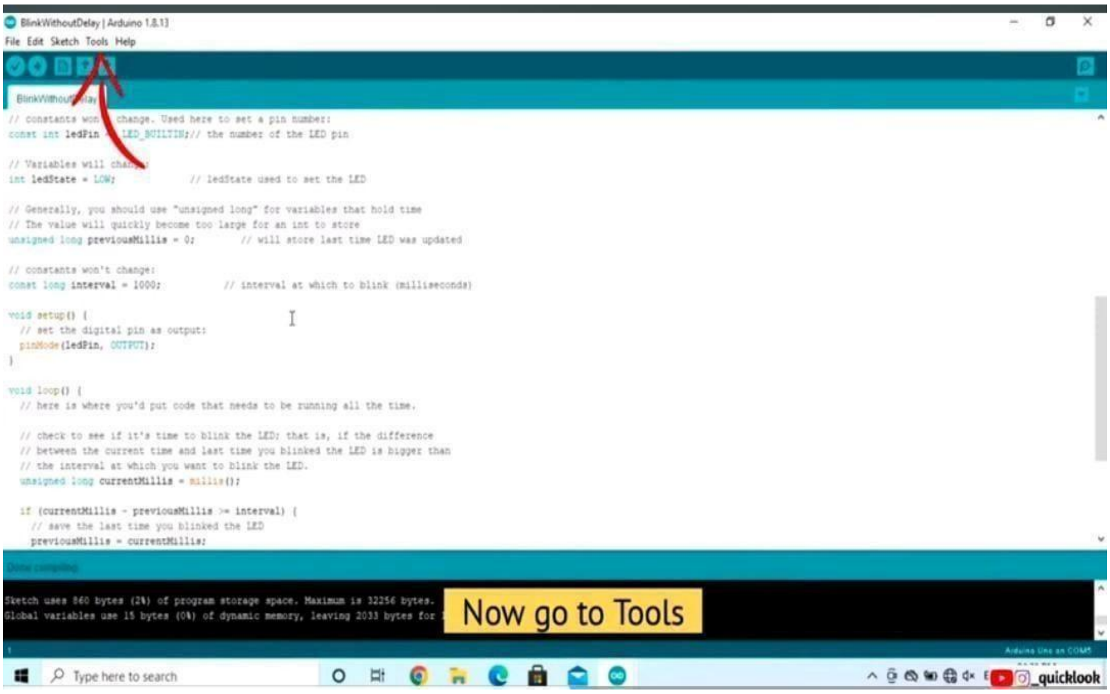

Fig. 22 selecting tools

Step 8: Click on tools and select board, select Arduino uno

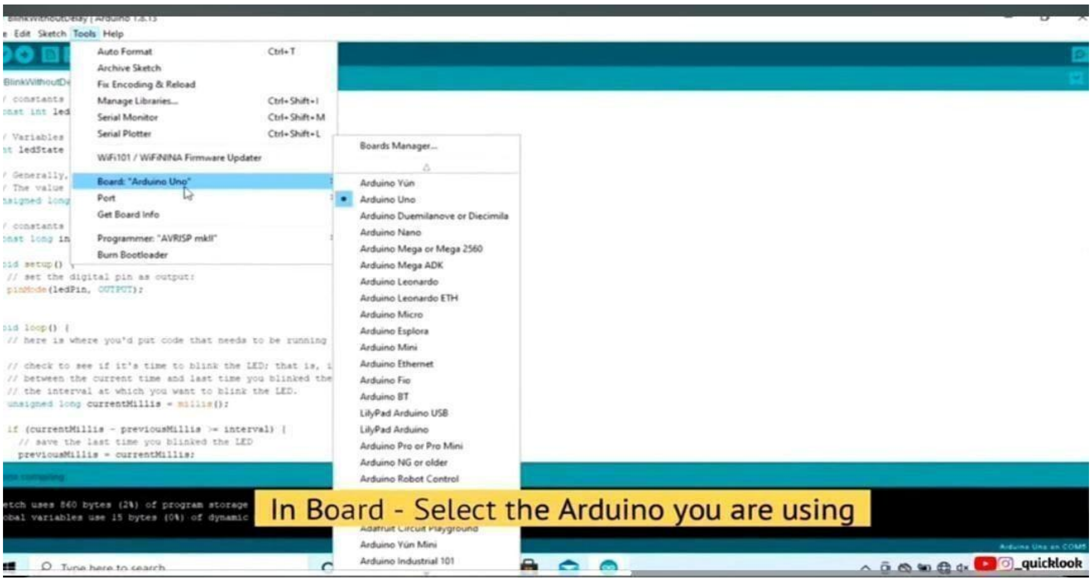

Fig. 23 Arduino Board

Step 9: Now select the port

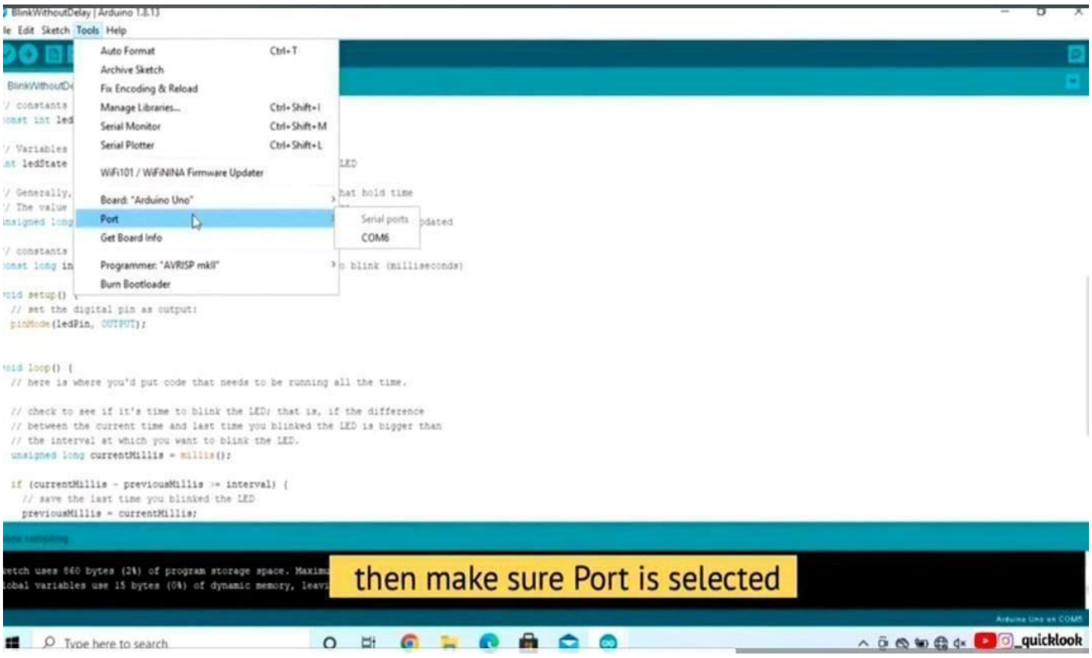

Fig. 24 Selecting the port

Step 10: Click on upload

Fig. 25 click on upload

Step 11: Uploading Completed

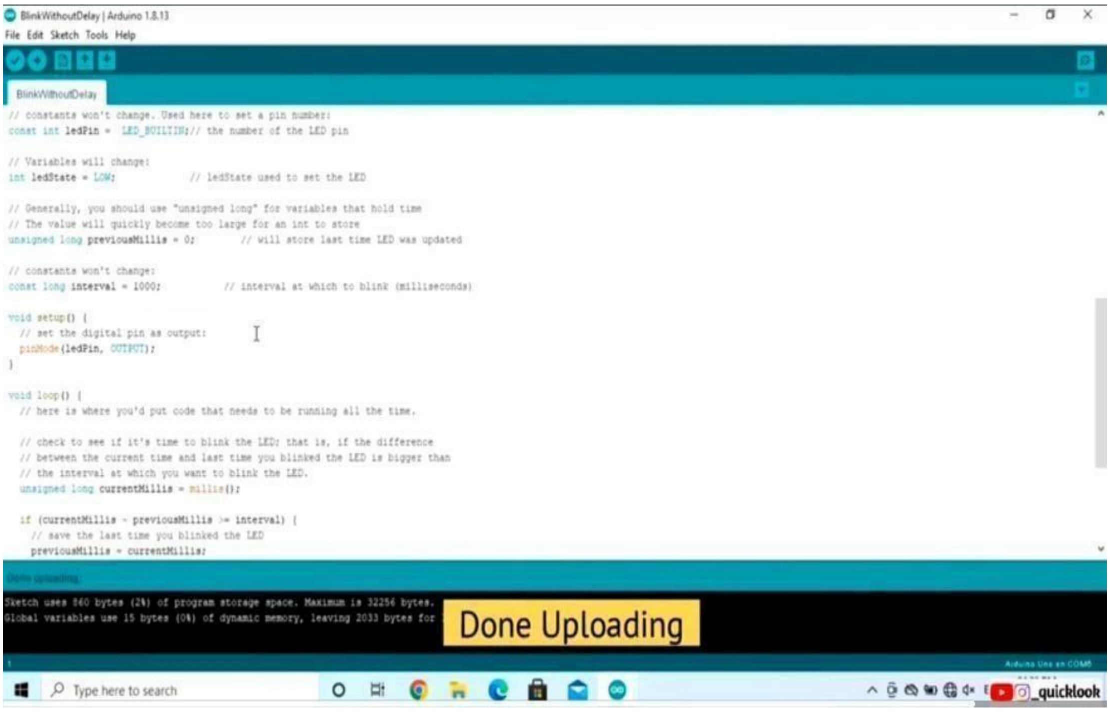

Fig. 26 Upload completed

CHAPTER 4
METHODOLOGY

3.1 EXISTING SYSTEM:

The current electric vehicle (EV) charging infrastructure is characterized by various models, each with its limitations. These models include:

1. Manual Metering & Billing

In this model, users plug in their EVs and manually record the meter readings. The billing process is typically done afterward by personnel, which can be time-consuming and prone to errors. This approach lacks real-time monitoring and automation, making it inefficient for large-scale EV charging infrastructure.

2. Smart Charging Stations

Smart charging stations offer a more advanced approach, often linking user accounts to mobile apps or cards. However, these systems are typically limited to postpaid models, where users are billed after consuming electricity. While this model provides some level of automation, it may not be suitable for users who prefer prepaid options or more flexible billing arrangements.

3. Token-Based Charging

Some EV charging systems use token or card-based access, which provides a basic level of authentication and authorization. However, these systems often lack real-time power monitoring, making it challenging to track energy consumption and manage billing accurately.

4. Lack of Dual Billing System

One significant limitation of existing EV charging infrastructure is the lack of a dual billing system that integrates both prepaid and postpaid options. Most systems are designed to support either prepaid or postpaid models, but not both. This limitation can make it difficult for users to choose their preferred billing method, potentially hindering the adoption of EV charging services.

Overall, the existing EV charging infrastructure models have limitations that can impact the efficiency, accuracy, and user experience of EV charging services. A more comprehensive and flexible system that incorporates real-time monitoring, automation, and dual billing options could help address these limitations and support the growing demand for EV charging infrastructure.

Limitations:

- No real-time power monitoring and control.
- Lack of flexible payment options (only prepaid or only postpaid).
- Risk of overcharging or misuse without proper authentication.
- No energy consumption feedback for the user.

3.2 PROPOSED SYSYTEM:

The proposed system introduces a smart EV charging station designed to enhance flexibility, efficiency, and security in electric vehicle charging. It incorporates RFID-based authentication to accurately identify users before initiating the charging process. A dual billing mechanism is implemented, offering both prepaid and postpaid options. In the prepaid mode, the system deducts the charging cost directly from the user's existing balance, while in the postpaid mode, it tracks energy usage for billing at a later time. Voltage and current sensors are integrated to continuously monitor power consumption during charging. A microcontroller, such as an Arduino or ESP32, serves as the core processor, responsible for reading sensor data, computing energy usage, and managing overall system functions. The relay module, controlled by the microcontroller, enables or disables the power supply to the vehicle based on the user's balance or tracked usage. This smart system provides a reliable and user-friendly solution adaptable to various EV charging scenarios.

3.3 BLOCK DIAGRAM:

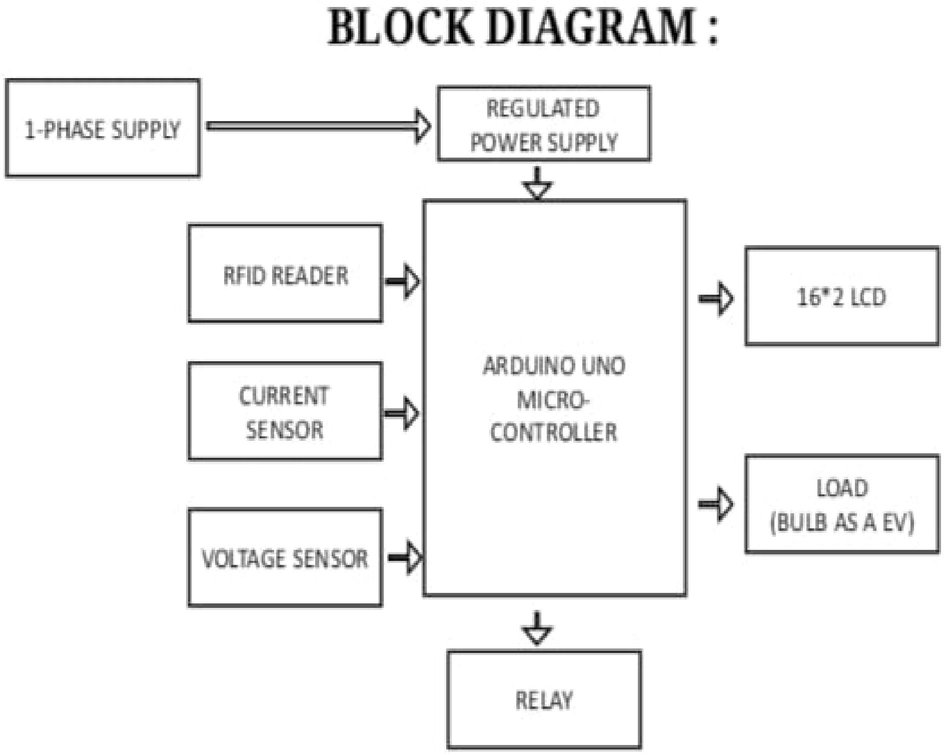

Fig 27 Block diagram

The block diagram illustrates the working of a **smart EV charging system** using an Arduino Uno microcontroller. Each block represents a functional unit essential for secure and efficient EV charging. Here's a breakdown of each component:

Phase Supply

This is the primary power source, typically a standard single-phase AC supply (230V). It provides electrical energy required to power the charging system and the connected EV (represented here by a bulb).

Regulated Power Supply

This unit converts the high-voltage AC from the 1-phase supply into a stable, lower DC voltage (usually 5V or 12V) required for powering the electronic components like the Arduino, sensors, and display.

Arduino Uno Microcontroller

The Arduino Uno acts as the **central processing unit** of the system. It receives inputs from sensors and the RFID reader, processes data, controls the relay for charging, and sends output to the LCD. It also calculates power ($P = V \times I$) and energy consumption ($E = P \times t$).

RFID Reader

This device reads the unique RFID tag assigned to each user. When the user scans their RFID card, the reader sends the card's ID to the Arduino for authentication. It determines whether the user is allowed to charge based on their prepaid/postpaid status.

Current Sensor

This sensor measures the current flowing to the load. It sends analog data to the Arduino, which helps calculate real-time power consumption.

Voltage Sensor

It measures the voltage supplied to the load. Like the current sensor, it provides necessary input for calculating power and energy usage.

Relay

The relay acts as a **switch** controlled by the Arduino. It connects or disconnects the power to the load (EV) based on authentication and balance conditions.

Load (Bulb as EV)

This simulates the electric vehicle. In a real-world scenario, it would be the EV's charging circuit.

16×2 LCD Display

This displays key information such as user ID, charging status, energy consumed, and billing details, enhancing user interaction and transparency.

This project introduces an intelligent Electric Vehicle (EV) charging system designed to enhance efficiency, security, and user flexibility. The system incorporates RFID-based user authentication to ensure secure access and proper identification of users. A dual billing mechanism supports both prepaid and postpaid options—deducting energy costs directly from a user’s prepaid balance or logging usage data for later billing in the postpaid mode.The relay module functions as the switch for charging, activating or deactivating power flow based on the user’s account balance or consumption limits. This combination of hardware and logic ensures an automated, user-friendly EV charging process tailored for smart energy management and flexible billing.

CHAPTER 5

WORKING OF THE SYSTEM

5.1 SCHEMATIC DIAGRAM:

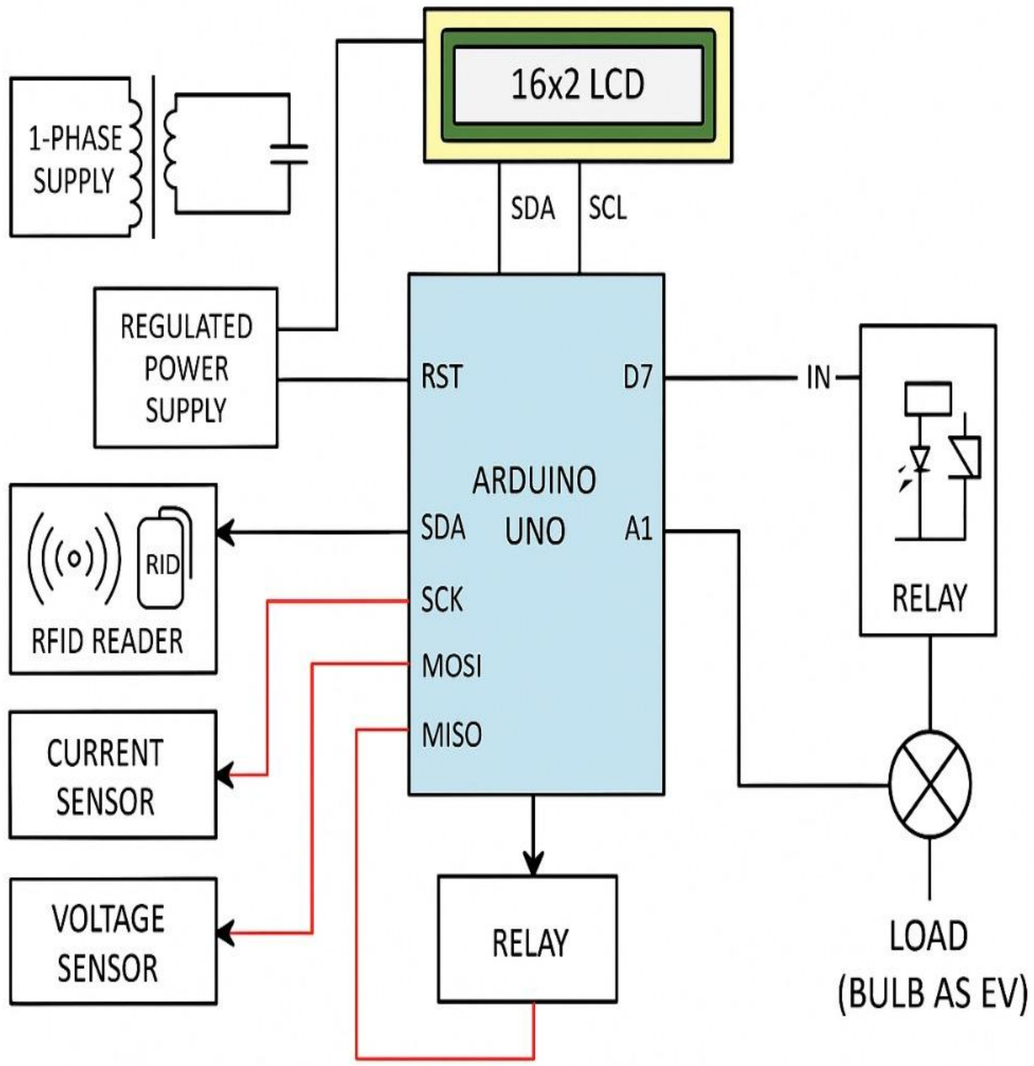

Fig. 28 Schematic Diagram

5.2 WORKING PROCESS:

The working process of the smart electric vehicle (EV) charging system is structured into several critical stages to ensure secure, efficient, and user-specific charging. The process begins with RFID authentication, where each user is assigned a unique RFID card. When the card is scanned at the charging station, the system reads the RFID tag and verifies the identity by checking the stored user ID in a database or EEPROM memory. This step ensures that only authorized users can access the charging facility, adding a layer of security.

After authentication, the system proceeds to user type identification, where it checks whether the user is on a prepaid or postpaid billing plan. For prepaid users, the system verifies if the available balance is sufficient to begin charging. If the balance meets the required threshold, or if the user is registered as postpaid, the system advances to the next phase—charging process control.

In this stage, a relay module is activated to allow the controlled flow of electricity from the power supply to the EV. During charging, voltage and current sensors continuously measure the amount of power being delivered. These real-time readings are processed by a microcontroller, such as an Arduino or ESP32. Power is calculated using the formula $P = V \times I$, where *P* is power, *V* is voltage, and *I* is current. To calculate energy consumed, the system uses $E = P \times t$, where *E* is energy and *t* is the charging duration.

This data is then used in the monitoring and display stage, where the microcontroller updates the energy usage continuously. For prepaid users, the system deducts the corresponding amount from their balance. For postpaid users, the total consumption is logged for billing at a later time. All relevant information, including energy consumed, session time, user ID, and billing status, is displayed either on an LCD screen or through a web-based interface, providing transparency and real-time updates to the user.

Finally, the system manages termination conditions effectively. For prepaid users, the session ends automatically once the balance reaches zero, triggering the relay to switch off the power. For postpaid users, the session can be terminated by removing the RFID card or selecting a manual stop option. This ensures a flexible, secure, and user-friendly EV charging experience.

5.3 FLOW CHART:

PREPAID SYSTEM

POSTPAID SYSTEM

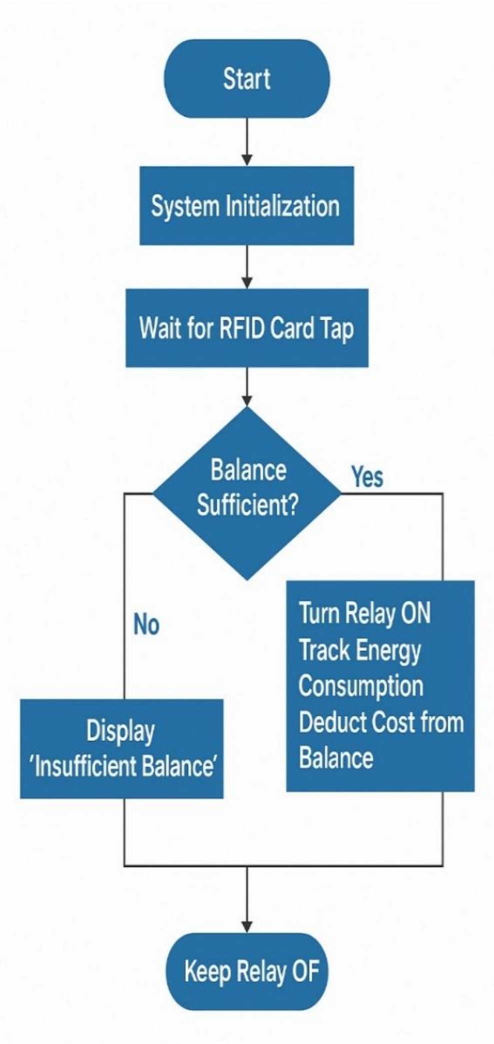

Fig.29 Prepaid flowchart

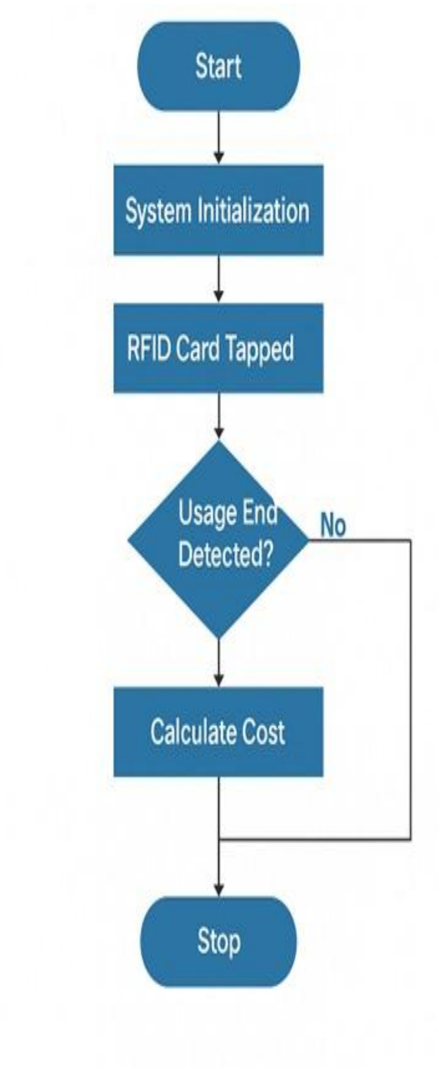

Fig. 30 postpaid flowchart

CHAPTER 6

RESULT & CONCLUSION

6.1 RESULT

This project presents a smart and secure electric vehicle (EV) charging system using RFID technology. It allows only authorized users to access the charging station by scanning an RFID card. The system includes a voltage sensor and an LCD display to show real-time charging status. A relay module is used to safely control the power supply. This setup makes EV charging more convenient, automated, and efficient.

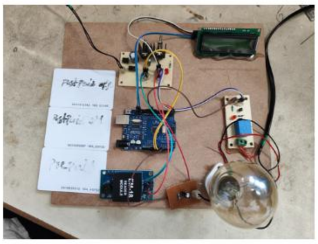

Fig.31(a) when the system is in off condition

Fig.31(b) when system is on

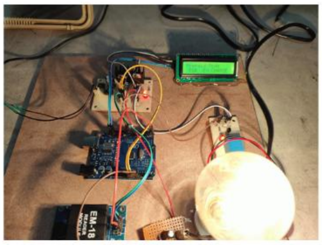

Fig.31(c) when we tap prepaid card it display details of prepaid mode

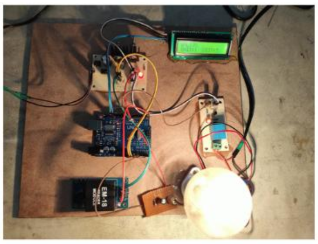

Fig.31(d) it displays the deducted amount and available balance

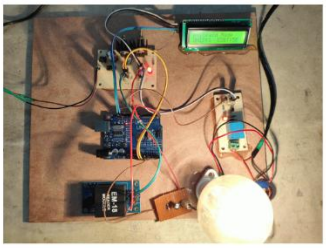

Fig.31(e) when we tap postpaid card it display details of postpaid mode

Fig. 31 Result of prepaid and postpaid Ev charging station

6.2 CONCLUSION

The RFID-based prepaid and postpaid billing system significantly improves the efficiency, security, and convenience of electric vehicle (EV) charging stations. This system allows users to authenticate themselves using RFID cards, enabling secure and personalized access to charging services. With the dual billing option, users can choose between prepaid—paying in advance by deducting from their balance—or postpaid—where energy usage is tracked and billed later. This flexibility caters to various user preferences and usage scenarios. The system ensures precise energy monitoring and billing through automated tracking, eliminating the need for manual intervention. It also helps prevent unauthorized usage and reduces the risk of fraud or misuse. By automating the charging and billing process, it lowers human effort, improves operational efficiency, and enhances the overall user experience. The integration of RFID technology with smart billing makes EV charging stations more reliable, scalable, and aligned with the growing demand for intelligent transportation solutions in the electric mobility sector.

FUTURE SCOPE:

- **Mobile App Integration**: Users can track usage and recharge balance via smartphone.
- **Online Payment Gateway**: Prepaid balance recharge through UPI, credit cards, etc.
- **Cloud Storage**: Usage data stored and analyzed for optimization.
- **Fast Charging Compatibility**: Upgrade to handle higher loads and faster EV charging.
- **Solar Integration**: Combine with solar panels for eco-friendly power sourcing.
- **Advanced Security**: Use encrypted RFID or biometric authentication.
- **Increased Adoption of Smart Charging:** Smart EV charging stations with advanced technology, such as Wi-Fi connectivity, will become more prevalent, enabling real-time monitoring and remote control of charging sessions.
- **Wireless Charging Infrastructure:** Wireless charging roads and dynamic charging technology will emerge, allowing for seamless and efficient energy transfer without physical connectors.
- **Bidirectional Charging**: Bidirectional charging capabilities will become more widespread, enabling electric vehicles to act as mobile power supplies and increasing resilience, especially in microgrids.
- **Standardization and Interoperability:** Standards like Open Charge Point Protocol (OCPP) 2.0.1 and Plug and Charge will promote faster charge rates, more data sharing, and lower power requirements for EV charging stations.

- **Market Growth**

The global EV charging station market is expected to reach $299.58 billion by 2032, growing at a CAGR of 30.3% from 2022 to 2032.

The APAC region will dominate the global EV charging station market, with the market size expected to reach over $9 billion by 2026 .

- **India-Specific Developments**

India will need to add over 4 million charging stations annually to reach a total of 1.32 million chargers by 2030, ensuring a ratio of 1 charger for every 40 electric cars.

Companies like Tata.ev are working to establish large-scale EV charging networks, with plans to set up 400,000 charging stations across India.

Advancements in wireless charging technology, such as magnetic resonance-based systems, will likely play a significant role in India's EV infrastructure development .

- **Government Initiatives**

The Indian government will prioritize EV production and charging infrastructure development to meet its net zero emissions target by 2070.

Schemes like FAME II will continue to support the growth of the EV ecosystem and charging infrastructure

REFERENCE

[1] 2025, International Journal of Scientific Research in Engineering and Management (IJSREM) Volume 9, Issue 4, April 2025 – Dr. D. Siva, S. Jameela, P. Lavanya, V. Surendra "Department of Electronics & Communication Engineering, Sai Rajeswari Institute of Technology, Proddatur, Andhra Pradesh" titled as SMART RFID IOT ENABLED EV CHARGING SYSTEM.

[2] 2024, Major Project Report – Vyankatesh Chavan, Aniket Kahandal, Sujal Sonavane, Ankur Saxena "Department of Electronics and Telecommunication Engineering, Sandip Institute of Technology and Research Centre, Nashik, Maharashtra, India" titled as PREPAID & POSTPAID BILLING FOR EV CHARGING STATION.

[3] 2022, IEEE International Conference on Smart Grid Communications (SmartGridComm) – J. Liu, X. Wang, Y. Zhang titled as RFID-BASED SMART CHARGING STATION FOR ELECTRIC VEHICLES.

[4] 2021, IEEE Transactions on Industrial Electronics Volume 68, Issue 5, May 2021 – M. Patel, P. Shah, D. Joshi titled as DESIGN AND IMPLEMENTATION OF AN RFID-BASED AUTHENTICATION SYSTEM FOR EV CHARGING.

[5] 2022, IEEE Power and Energy Conference – A. Sharma, V. Kumar titled as SMART GRID-BASED EV CHARGING STATION USING RFID AUTHENTICATION AND IOT INTEGRATION.

[6] 2023, IEEE Internet of Things Journal Volume 9, Issue 3, February 2023 – T. Chen, L. He, W. Zhang titled as RELAY-CONTROLLED ELECTRIC VEHICLE CHARGING STATION WITH RFID-BASED USER AUTHENTICATION.

[7] S. Negarestani, M. Fotuhi-firuzabad, M. Rastegar, A. Rajabi-ghahnavieh, Optimal Sizing of Storage System in a Fast-Charging Station for Plug-in Hybrid Electric Vehicles 2 (4) (2016) 443– 453.

[8] S. Negarestani, M. Fotuhi-firuzabad, M. Rastegar, A. Rajabi-ghahnavieh, Optimal Sizing of Storage System in a Fast-Charging Station for Plug-in Hybrid Electric Vehicles 2 (4) (2016) 443– 453.

[9]I. S. Bayram, G. Michailidis, M. Devetsikiotis, B. Parkhideh, "Strategies for Competing Energy Storage Technologies for DC Fast Charging Stations", 2012 IEEE Third International Conference on Smart Grid Communications, Smart Grid Comm 2012

[10]Mburu, P. T., & Sathyamoorthi, C. R. (2014). Switching from post-paid to pre-paid models: customer perception and the organisational role in managing the change: a case study of botswana power corporation. Journal of Management Research, 6(3), 175.

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APPENDICES

CODE:

```
 #include<SoftwareSerial.h>
#include <String.h>
#include <stdio.h>
#define relay 10
#define ctPin A0
#define v0 A2
int bal=100;
int b=0;
int re_bal = 0;
int units = 0;
String read_msg = "\0";
int f1 = 1;
int f2 = 1;

int ct = 0;
#include <Wire.h>//i2c communication library
#include <LiquidCrystal_I2C.h>//i2c lcd library
// Set the LCD address to 0x27 for a 16 chars and 2 line display
LiquidCrystal_I2C lcd(0x27, 16, 2);
void setup() {
  // put your setup code here, to run once:
Serial.begin(9600);

lcd.init();
lcd.backlight();
pinMode(relay,OUTPUT);
pinMode(ctPin,INPUT);
pinMode(v0,INPUT);
lcd.clear ();
lcd.setCursor (0,0);
lcd.print("RFID BASED PREPAID        ");
```

```
lcd.setCursor (0,1);
lcd.print(" POSTPAID EV CHARGE  ");
delay(2000);
Serial.println(F("RFID BASED PREPAID AND POSTPAID EV CHARGING  "));
lcd.clear();


}


void loop() {
  // put your main code here, to run repeatedly:
lcd.setCursor (0,0);
lcd.print("SCAN RFID TAG       ");
lcd.setCursor (0,1);
lcd.print(" FOR  EV CHARGE  ");
delay(1000);
if (Serial.available()>0)//4500A0C2587F
{
  String a=Serial.readString();//4500A95C9727
  Serial.println(a);
  delay(2000);
if(a=="4500A0C2587F")
{
  digitalWrite(relay,HIGH);
  delay(1000);
  delay(50);
  ct = analogRead(ctPin);


Serial.print(F("ct = ")); Serial.println(ct);
 lcd.setCursor(0,0);
    lcd.print("Prepaid Mode     ");



if(ct>10)
   {
    b++;
```

```
    String s="UNIT:"+String(b)+"    ";
    String s1="COST:"+String((b*5));
    delay(5000);
   int cost=b*5;
    bal=bal-cost;
    String s2="BAL:"+String(bal);
    //String s3="RE-BAL:"+String(bal);
    lcd.clear();
    lcd.setCursor(0,0);
    lcd.print(s2);

    lcd.setCursor(0,1);
    lcd.print(s);
    lcd.setCursor(8,1);
    lcd.print(s1);
    delay(2500);
    digitalWrite(relay,LOW);
}
}
else if((a=="4500A95C9727")&&(f1==1))
{
  digitalWrite(relay,HIGH);
  delay(1000);
  delay(50);
  ct = analogRead(ctPin);

Serial.print(F("ct = ")); Serial.println(ct);
 lcd.setCursor(0,0);
    lcd.print("Postpaid Mode      ");
if(ct>10)
    {
    f1=0;
   for(b=0;ct>10;b++)
    {
    ct = analogRead(ctPin);
```

```
    String s="UNIT:"+String(b)+"   ";
    String s1="COST:"+String((b*5));
    delay(5000);
    lcd.setCursor(0,1);
    lcd.print(s);
    lcd.setCursor(8,1);
    lcd.print(s1);
    delay(500);
    if (Serial.available()>0)//4500A0C2587F
{
  String a=Serial.readString();//4500A95C9727
  Serial.println(a);
  delay(2000);
    if((a=="4500A8F28F90")&&(f1==0))
{
  ct = analogRead(ctPin);
  f1=1;
  digitalWrite(relay,LOW);
    lcd.print("CHARGING OFF    ");
    delay(2000);
}
}
   }
   }


}
else
{
   lcd.setCursor(0,0);
    lcd.print("NO CHARGING     ");
    digitalWrite(relay,LOW);
}
}
}
```