A
Mini Project Report
on

Smart EV Charging Station

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In the partial fulfillment of B. TECH in electronics and telecommunication engineering of Dr. Babasaheb Ambedkar Technological University, Lonere (Dist. Raigad) in the academic year 2024-25

Department of Electronics and telecommunication Engineering
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CERTIFICATE

This is to certify that the Mini Project entitled **"Smart EV Charging Station"** submitted by Samiksha Santosh Jorkar (2230331372062) and Shravani Hemant Gadkari (2230331372100) is record of bonafide work carried out by them in the partial fulfilment for the award of Degree in B.Tech. in Electronics and Telecommunication Engineering course of Dr. Babasaheb Ambedkar Technological University, Lonere (Dist: Raigad) in the academic year 2024-2025.

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The mini project has been a valuable and enriching part of our academic journey, contributing significantly to our personal and professional growth.

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ABSTRACT

The rapid shift towards electric mobility demands a smart and scalable EV charging infrastructure that is efficient, reliable, and sustainable. This project focuses on the design and implementation of a Smart Electric Vehicle Charging Station that integrates renewable energy sources, IoT technologies, and automated control systems to provide a next-generation charging experience. The system is designed to support both grid-based and solar-powered charging, utilizing solar panels and energy storage systems to reduce dependency on the power grid and ensure eco-friendly operation. It features RFID-based user authentication, real-time monitoring through IoT sensors, and a mobile application for users to locate stations, book slots, and monitor charging status remotely.

A smart energy management system is integrated to perform dynamic load balancing, fault detection, and automatic switching between power sources. The system can prioritize charging during off-peak hours and provide data analytics on energy consumption patterns. This project aims to not only reduce carbon emissions and enhance user convenience but also contribute to the development of a smart city ecosystem by promoting clean energy usage and digital connectivity. The proposed model is scalable, cost-effective, and adaptable to both urban and semi-urban areas.

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CHAPTER 1
INTRODUCTION

In the era of rapid urbanization and climate awareness, the global transportation sector is undergoing a transformative shift. Electric vehicles (EVs) have emerged as a promising alternative to conventional fuel-based automobiles, offering numerous environmental and economic benefits. By eliminating tailpipe emissions and significantly lowering carbon footprints, EVs contribute to cleaner air quality and energy sustainability. As governments and organizations worldwide strive toward net-zero targets, the demand for electric mobility continues to rise sharply.

Despite the promising outlook, several challenges hinder the mass adoption of EVs. A major concern is the limited driving range and the time-consuming nature of conventional charging methods, which require EVs to be stationary and physically connected to charging stations. This scenario not only causes inconvenience to users but also places a strain on existing charging infrastructure, especially during peak demand hours. To overcome these limitations, researchers and industries are increasingly focusing on intelligent and automated charging systems.

Among these advancements, wireless charging technology has attracted significant interest. Initially limited to static systems—where EVs are charged while parked—wireless charging is now evolving into more sophisticated solutions, including Dynamic Wireless Charging (DWC). DWC enables the continuous transfer of power to an EV while it is in motion, using inductive coupling between coils embedded in the road and receivers installed in the vehicle. This innovation eliminates downtime for charging, thus addressing range anxiety and improving operational efficiency, especially for commercial fleets and public transportation.

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improving operational efficiency, especially for commercial fleets and public transportation.

However, the successful deployment of DWC systems introduces new technical challenges. One of the most critical among them is power pulsation—a phenomenon characterized by irregular and fluctuating power flow during the dynamic charging process. This instability can reduce power transfer efficiency, increase thermal stress on electronic components, and degrade battery health over time. Research studies indicate that while compensation schemes are commonly implemented to alleviate power pulsations, these strategies alone are insufficient for achieving optimal charging performance.

Furthermore, the complex interplay between road infrastructure, vehicular speed, coil alignment, and system resonance makes DWC a highly dynamic and sensitive process. Ensuring consistent, high-efficiency power delivery under varying conditions remains a major engineering challenge. Addressing these issues is essential for the large-scale rollout of smart EV charging systems that are reliable, cost-effective, and user-friendly.

CHAPTER 2

COMPONENT USED

2.1 Wireless Power Charging Coils

Wurth Electronics Qi Wireless Power Charging Coils (WE-WPCC) allow power to be transferred wirelessly through inductive coupling. These charging coils and receivers go beyond the Qi standard of 20W with many of the coils capable of handling up to 200W. The Qi wireless coils come with a transmit coil and the receive coil. These coils are inductively coupled and the AC current in the transmit coil generates a magnetic field that induces a voltage in the receive coil. The Qi wireless charging coils are winded with lit wire instead of bifilar that offers outstanding performance with lowest DCRs and highest Q values. These transmit and receive coils when used together achieve an efficiency of up to 93%.

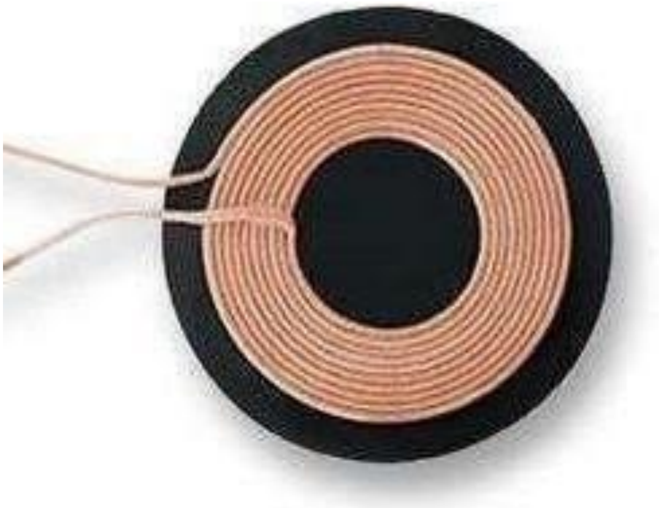

Fig 2.1: Tesla Coil

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2.2 Arduino Uno

The Arduino UNO is a standard board of Arduino. Here UNO means 'one' in Italian. It was named as UNO to label the first release of Arduino Software. It was also the first USB board released by Arduino. It is considered as the powerful board used in various projects. Arduino.cc developed the Arduino UNO board. Arduino UNO is based on an ATmega328P microcontroller. It is easy to use compared to other boards,such as the Arduino Mega board, etc. The board consists of digital and analog Input/Output pins , shields, and other circuits. The Arduino UNO includes 6 analog pin inputs, 14 digital pins, a usb connector, a power jack, and an In Circuit Serial Programming header. It is programmed based on IDE, which stands for Integrated Development Environment. It can run on both online and offline platforms. The IDE is common to all available boards of Arduino.

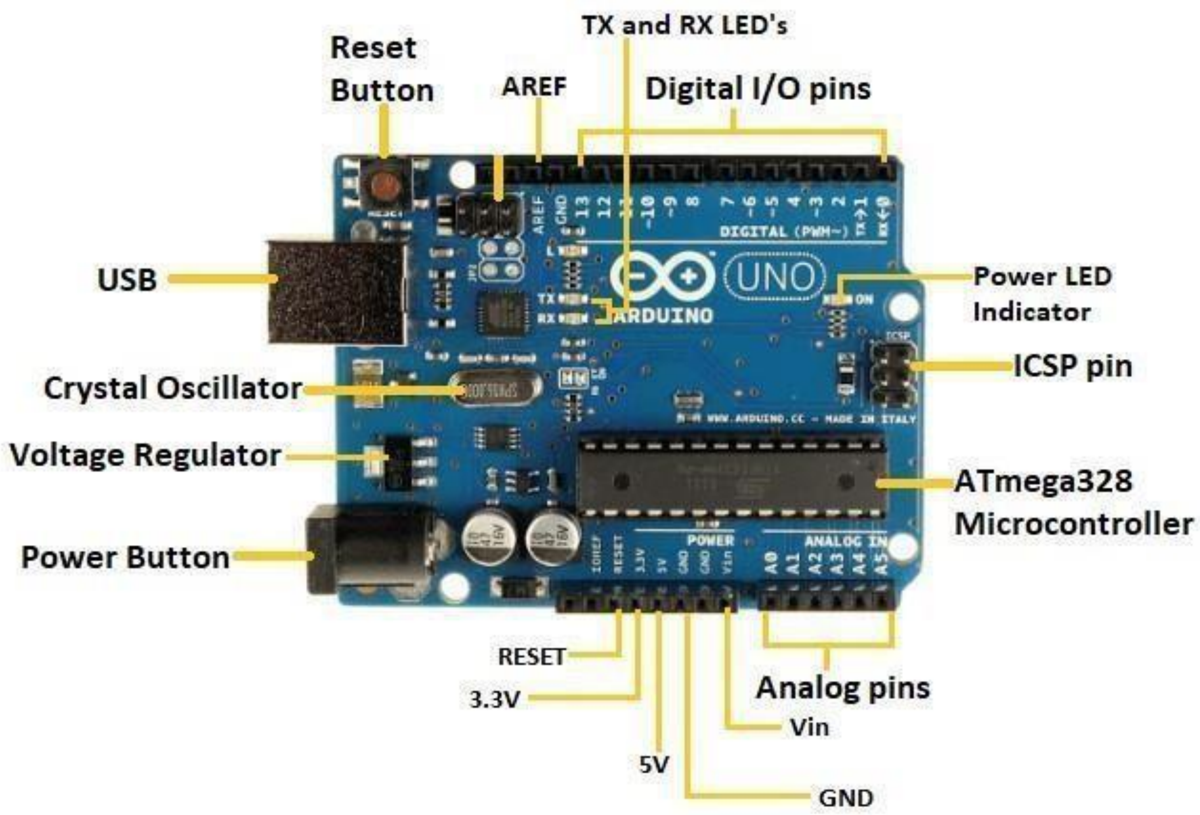

Fig 2.2: Arduino Uno

2.3 I2C LCD Display

The I2C LCD display is a widely used module that simplifies interfacing by using the I²C (Inter-Integrated Circuit) protocol, allowing communication with just two wires: SDA (data line) and SCL (clock line). Commonly used with microcontrollers like Arduino and Raspberry Pi, it typically features a 16x2 or 20x4 character display based on the HD44780 controller. The I2C interface reduces the number of required GPIO pins compared to traditional parallel LCDs, making it ideal for compact projects. Its ease of use, along with available libraries, makes it a popular choice for displaying data in embedded systems.display's. The I2C LCD display is a character display module that uses the I²C (Inter-Integrated Circuit) communication protocol to interface with microcontrollers. It typically features a 16x2 or 20x4 character screen, built around the HD44780 controller, which is capable of displaying alphanumeric characters and some custom symbols.

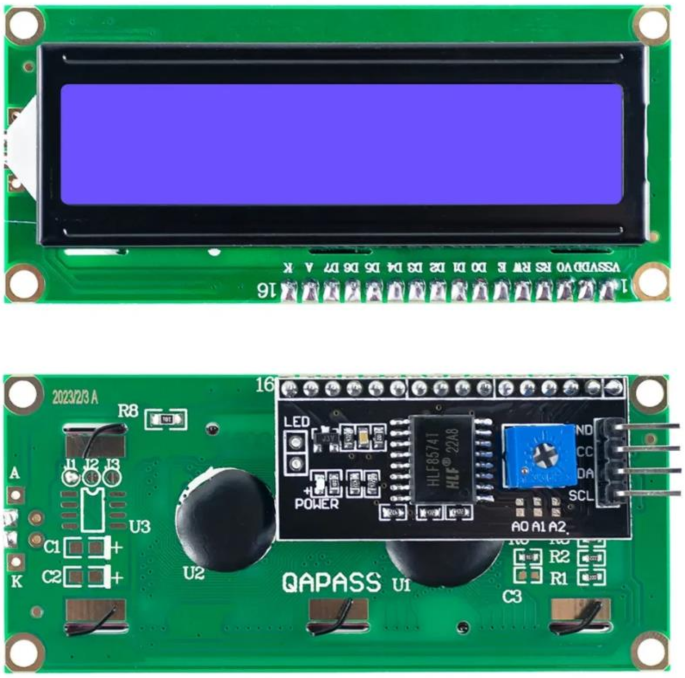

Fig 2.3: I2C LCD Display

2.4: LEDs

LEDs (Light Emitting Diodes) are simple but effective output devices used in the project to visually indicate the current operational status of the system. They serve as real-time, easy-to-understand alerts for users without the need to constantly monitor the LCD display.

Each LED is connected in series with a current-limiting resistor 220Ω to 330Ω to protect it from excessive current and ensure safe operation.

Together, these LEDs act as simple but efficient status indicators to support the user experience of the smart EV charging station.

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2.5: Resistors

Resistors are passive electronic components used to limit the amount of electrical current flowing through a circuit. In this project, resistors are placed in series with each LED (Red and Blue) to ensure safe and stable operation .LEDs are sensitive to high currents, and applying excessive current directly can cause them to overheat, degrade, or burn out. Resistors are passive electronic components used to limit the amount of electrical current flowing through a circuit.

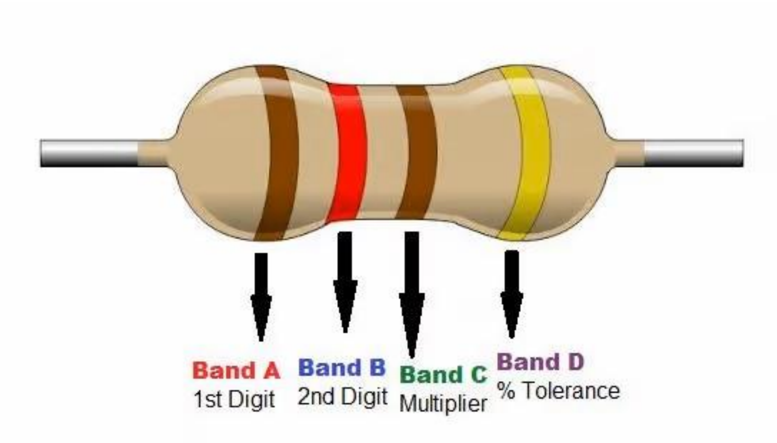

Fig 2.5: Resistors

2.6: Breadboard

The breadboard is a widely used prototyping tool that allows users to build and test electronic circuits without the need for soldering. It consists of a grid of interconnected holes into which electronic components and wires can be inserted. The internal metal strips form a connection between specific rows and columns, enabling components to be connected electrically.

Typically, the breadboard includes two power rails on each side to provide easy access to voltage and ground. It is especially useful for experimenting with circuit designs, testing functionality, and troubleshooting without permanent modifications. Due to its reusability and convenience, the breadboard is an essential tool in electronics labs and education.

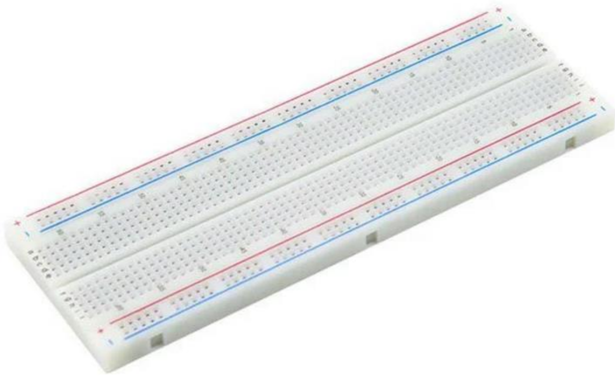

Fig 2.6: Breadboard

2.7: Jumper Wires

Jumper wires are short, insulated wires used to make connections between components on a breadboard or between points on a circuit without soldering. They come in three main types:

- **Male-to-male:** Pins on both ends, used to connect two female headers (like on a breadboard).
- **Male-to-female:** One pin and one socket, used to connect a breadboard to a module or sensor.
- **Female-to-female:** Sockets on both ends, used to connect two male header pins.

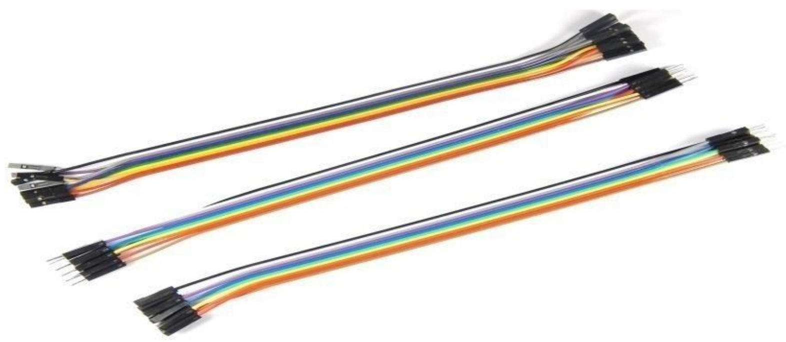

Fig 2.7: Jumper Wires

CHAPTER 3

CIRCUIT DIAGRAM

3.1: Circuit Introduction

The circuit diagram is a graphical representation of the electrical connections and components used in the project. It plays a crucial role in understanding how the entire system functions. This project uses an Arduino Uno microcontroller along with various sensors, indicators, and a display unit.

3.2: Circuit Description

The circuit was designed using Tinkercad Circuits. Key components include an Arduino Uno as the main controller, an LCD with I2C for displaying messages, and an IR sensor for object detection. Two LEDs (green and red) indicate system status. A 220-ohm resistor limits current to the green LED. Copper loops act as sensor inputs, and a breadboard is used for temporary connections.

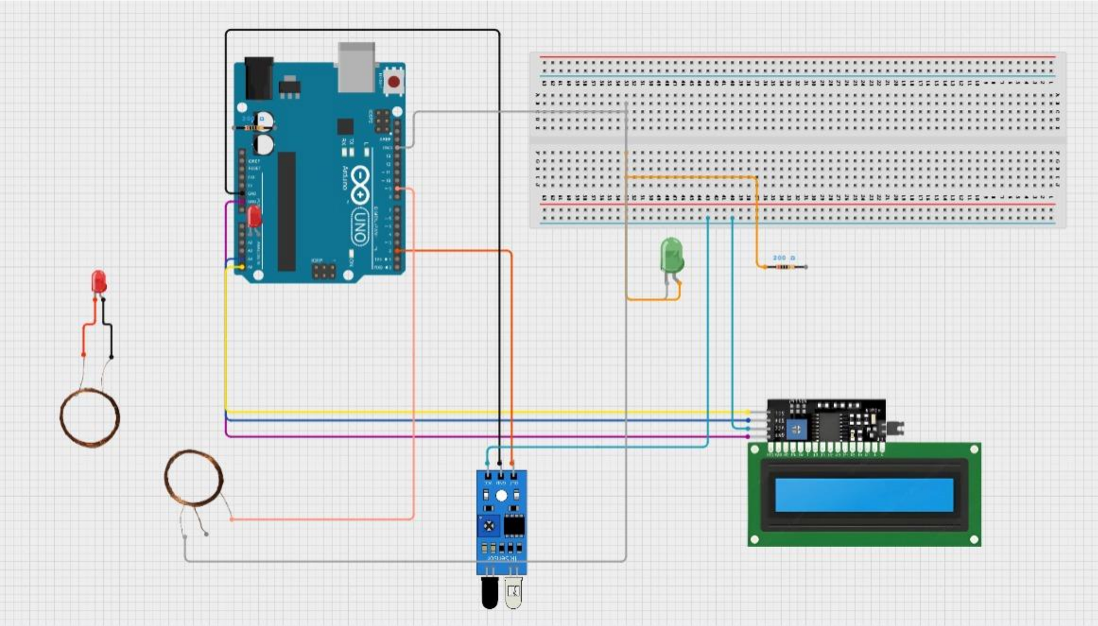

Fig 3.1: Circuit Diagram

3.3: Circuit Diagram

The circuit diagram designed in Cirket Designer IDE shows all components and connections clearly. This helps in better understanding the wiring and functioning of the system**.**

CHAPTER 4

PROJECT IMPLEMENTATION AND WORKING

4.1 Project Implementation

- **Component Arrangement**: All components were placed on a virtual breadboard in CIRKIT DESIGNER IDE Circuits. The Arduino Uno was used as the central controller to manage all inputs and outputs.
- **Sensor Integration**: An IR sensor module was connected to a digital pin (e.g., D2) on the Arduino. It was powered using the Arduino's 5V and GND pins. The sensor detects obstacles and sends a HIGH or LOW signal based on detection.
- **LED Indicators**: Two LEDs (green and red) were connected to digital pins (e.g., D6 and D7). A 220-ohm resistor was used in series with the green LED to limit the current. These LEDs serve as visual indicators for object detection and system status.
- **LCD Display with I2C**: A 16x2 LCD module with an I2C interface was used for efficient wiring. The I2C SDA and SCL pins were connected to A4 and A5 on the Arduino, respectively. This display was programmed to show system messages such as "Object Detected", "System Ready", etc.
- **Copper Loop Sensors**: Copper loops were used as touch or proximity sensors, connected to analog pins (e.g., A0, A1). They were used to simulate user input or sensor triggers.
- **Power Supply**: The Arduino was powered through the USB port during simulation and testing. It can also be powered via an external 9V adapter if used in physical hardware.
- **Code Uploading and Testing**: The Arduino was programmed using the Arduino IDE. The code was uploaded to the board via USB. Tinkercad's serial monitor and live simulation helped in verifying the circuit's functionality before physical implementation.

4.2 Working

The system works as follows:

- The IR sensor detects the presence of an object in its range.

- When an object is detected, the Arduino receives the signal from the IR sensor and processes it.
- Based on the logic in the code, the Arduino turns on the appropriate LED (green or red) to indicate the system status.
- The LCD display, connected via I2C, shows relevant messages or sensor readings.
- Copper loops act as touch or input sensors, and their signals are also processed by the Arduino to perform specific actions.

This setup allows real-time detection and indication, making it suitable for interactive or monitoring-applications.

CHAPTER 5
OUTPUT AND RESULT

The output of the vehicle detection system was observed through the actual working hardware model. The system was tested under different conditions to verify its response to the presence and absence of a vehicle. The Arduino Uno was successfully programmed to control the logic based on input from the IR Sensor.

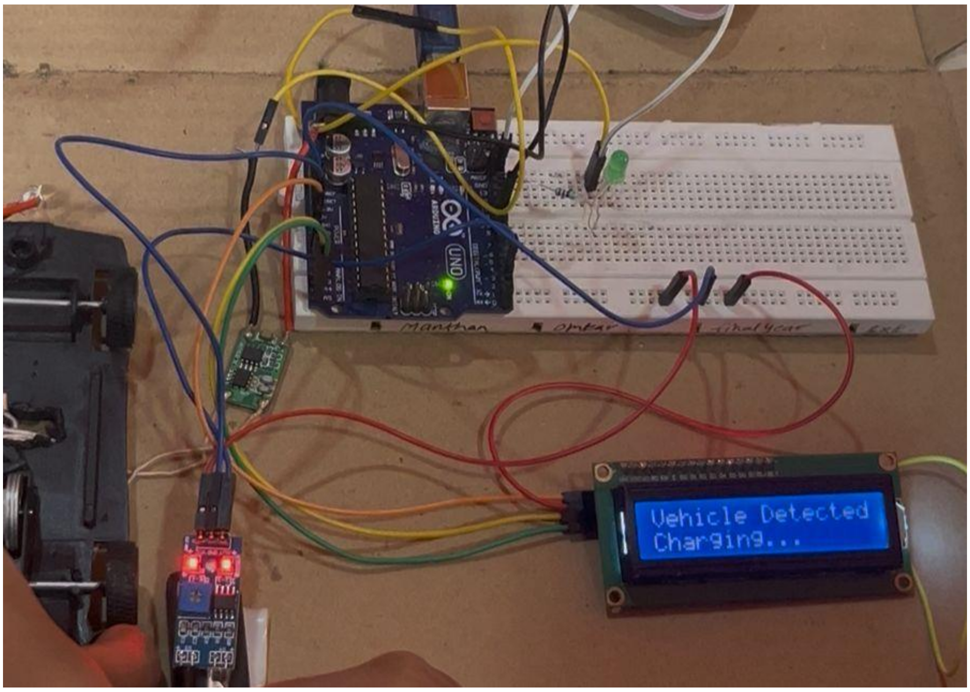

Fig 5.1: Output

When a vehicle was placed in front of the IR sensor, it accurately detected the object. As a response, the red LED turned ON to indicate vehicle presence, and the LCD displayed the message **“Vehicle Detected.”** This visual output confirmed that the system could recognize and signal an occupied space or vehicle presence effectively.
In the absence of a vehicle, the IR sensor did not detect any object. Under this condition, the green LED remained ON, and the LCD displayed **“No Vehicle.”** This output showed the idle or ready state of the system, indicating a clear area or no vehicle in the detection range.

CHAPTER 6

ADVANTAGES

The vehicle detection system designed in this project offers several practical advantages that make it suitable for real-world applications. Some of the key benefits are listed below:

1. The system provides immediate response when a vehicle is detected or removed, ensuring quick and reliable operation.
2. The circuit is built using affordable and widely available components such as an Arduino Uno, IR sensor, and LEDs, making it cost-effective for small-scale installations.
3. The components used in the system consume minimal power, making the setup energy-efficient and suitable for battery-operated or solar-powered environments.
4. The hardware setup is simple and compact, which allows it to be installed in various locations with limited space, such as parking lots, gates, or garages.
5. The system can be easily modified to include additional sensors or features, such as automatic gate control, sound alerts, or GSM modules for remote alerts.
6. The use of an LCD display with clear messages and LED indicators allows users to understand system status instantly without needing technical knowledge.
7. The automation reduces the need for human involvement, increasing efficiency and reducing chances of error.

These advantages make the project not only technically effective but also practical and scalable for various smart automation applications.

CHAPTER 7

APPLICATION

The Smart EV Charging Station has several practical applications in today's growing electric vehicle ecosystem. Below are the key areas where this system can be effectively utilized:

1. Allows EV owners to charge vehicles conveniently at home with features like scheduled charging and power monitoring.
2. Can be installed in malls, office complexes, and public parking areas to offer efficient, user-managed EV charging.
3. Useful for managing multiple electric vehicles in delivery companies, cab services, or government transport systems.
4. Ideal for installation on highways and expressways to support long-distance EV travel with fast and smart charging.
5. Can be integrated with IoT infrastructure to enable real-time monitoring, user authentication, and remote control.
6. Can work in combination with solar or wind energy sources to promote eco-friendly and sustainable vehicle charging.
7. Helps balance power demand by charging during off-peak hours and reducing grid stress during peak load times.
8. Can be linked with smart parking systems to offer reserved charging spots with automatic billing and user alerts.

CHAPTER 8

FUTURE SCOPE

The Smart EV Charging Station has great potential for further development and real-world deployment. As electric mobility continues to grow, the system can be expanded and improved in the following:

1. Adding a dedicated mobile app can allow users to monitor charging status, book slots, and make payments remotely.
2. Future versions can include variable pricing based on peak and off-peak hours to manage demand and optimize energy use.
3. Enable bi-directional charging so EVs can supply power back to the grid during high demand, improving grid stability.
4. Artificial Intelligence can be used to predict energy consumption patterns and optimize charging schedules automatically.
5. Integration with solar tracking systems and smart inverters can make charging stations fully self-sustainable.
6. Expand the system to support simultaneous charging for multiple vehicles with balanced power distribution.
7. Use technologies like RFID cards, QR codes, or biometric authentication for secure and user-specific billing.
8. Store charging data on cloud platforms for analysis, performance tracking, and maintenance planning.
9. Future upgrades can include compatibility with fast DC charging standards (like CCS or CHAdeMO).
10. The system can be scaled to contribute to a nationwide EV charging infrastructure integrated with smart grid systems.

CONCLUSION

The Smart EV Charging Station project successfully demonstrates a practical solution to meet the growing needs of electric vehicle infrastructure. By integrating essential components such as Arduino, sensors, and a user interface (LCD/LED), the system offers efficient and automated vehicle charging management. The use of real-time detection, status indication, and possible integration with renewable energy makes this model both sustainable and future-ready.

Throughout the development and testing phases, the system performed as expected, responding accurately to input conditions and controlling outputs accordingly. The project not only highlights the importance of smart energy management but also opens up opportunities for further innovation through IoT, AI, and grid integration.

In conclusion, this project lays the foundation for scalable and intelligent EV charging systems, contributing to the advancement of clean mobility and smart urban infrastructure. It serves as a valuable step toward creating a more energy-efficient and eco-friendly future.

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