CERTIFICATE

This is to certify that Students **Ansari Mohd Kashif, Faiz Mansur Malpekar, Shaikh Mohammed Aadil, Mohammad Mohiuddin Siddiqui** are the Bonafide students of M.H Saboo Siddik College of Engineering, Mumbai.

They have successfully carried out the project titled ***"Next-Gen EV Charging roads: Wireless, Solar and Smart solutions"*** in partial fulfilment of the requirement of B.E. Degree in Electronics and Telecommunications Engineering of Mumbai University during the academic year 2024-2025. The work has not been presented elsewhere for the award of any other degree or diploma prior to this.

(Dr. Nayana Chaskar) **Project Guide**	**(Dr. Nayana Chaskar)** **Project Co-Ordinator**
(Er. Abdul Sayeed) **HOD**	**(Dr. Ganesh kame)** **Principal**

Project report Approval for B.E

This project entitled ***"Next-Gen EV Charging roads: Wireless, Solar and Smart solutions"*** by **Ansari Mohd Kashif, Faiz Mansur Malpekar, Shaikh Mohammed Aadil, Mohammad Mohiuddin Siddiqui** approved for the degree of Bachelor of Engineering in Electronics and Telecommunications from University of Mumbai.

Examiners

1. ______________________

2. ______________________

Date:

Place:

ACKNOWLEGEMENT

We are thankful to a number of individuals who have contributed towards our final year project and without their help; it would not have been possible. Firstly, we often our sincere thanks to our project guide Dr Nayana Chaskar for his constant and timely help and guidance throughout our preparation.

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Signature of all the Students in the group

(Ansari Mohd Kashif)

(Faiz Mansur Malpekar)

(Shaikh Mohammed Aadil)

(Mohammad Mohiuddin Siddiqui)

DECLARATION

We declare that this return submission represents our ideas in our own words and where others' ideas or words have been included; we have adequately cited and referenced the original sources. We also declared that we have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/facts/source in this submission. We understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permissions has been taken when needed.

Signature of all the Students in the group

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ABSTRACT

The increasing global demand for sustainable transportation solutions has led to significant innovations in the electric vehicle (EV) industry and innovative charging infrastructure. In this report, we propose the emerging concept of integrating renewable energy sources with wireless charging road systems, presenting a compelling synergy to address the challenges hindering widespread EV adoption. The current state of the electric vehicle market leads in reducing greenhouse gas emissions and dependence on fossil fuels Solar panels, wind turbines, and energy storage systems are incorporated to power the charging infrastructure, reducing its reliance on non-renewable energy sources and enhancing sustainability. Next, we present the concept of wireless charging roads, which have the potential to revolutionize EV charging. These systems leverage inductive charging technology embedded within road surfaces to replenish EV batteries while in motion, effectively. By harnessing clean energy sources, overcoming range limitations, and enhancing the overall EV experience, this technology represents a pioneering step towards a greener, more efficient, and sustainable future for mobility.

Keywords*: Electric Vehicle, infrastructure, renewable energy, Solar Panels, turbines, wireless charging.*

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CHAPTER 1
INTRODUCTION

Electric vehicles (EVs) are rapidly shaping the future of transportation, offering eco-friendly, energy-efficient, and cost-effective alternatives to traditional fossil-fuel-powered vehicles. However, the widespread adoption of EVs faces key challenges, particularly in charging infrastructure. To address these limitations, our project introduces a **dynamic wireless charging road integrated with renewable energy sources and an overhead locomotive system for heavy vehicles.** This system enhances efficiency, flexibility, and sustainability while reducing dependency on fossil fuels and improving charging convenience.

1.1 Motivation

The development of a **renewable energy-based EV charging road and locomotive infrastructure** is crucial for addressing modern transportation challenges. As climate change accelerates, reducing greenhouse gas emissions and improving air quality have become global priorities. Our project envisions a **hybrid charging model**—combining **dynamic wireless charging roads and an overhead locomotive system for trucks and buses**—to create a **highly efficient, cost-effective, and eco-friendly transportation network.**

By integrating **solar-powered energy storage, wireless charging coils placed on the road surface, and overhead power lines for heavy vehicles,** we aim to enhance energy efficiency, increase charging convenience, and provide a **scalable, flexible charging solution.** This project not only aligns with sustainable development goals but also **minimizes road maintenance disruptions** and **ensures continuous power supply while vehicles are in motion.**

1.2 Objective

The primary objective of this project is to **develop an advanced electric vehicle charging infrastructure** that:

- Utilizes **renewable energy sources (solar power)** for sustainable charging.

- Implements **wireless charging roads** to maintain vehicle battery levels dynamically.
- Integrates an **overhead locomotive charging system** for heavy transport vehicles.
- Optimizes **charging efficiency** by minimizing coil-to-vehicle distance.
- Enhances **infrastructure flexibility** by allowing coil replacements without road excavation.

1.3 Problem Statement

To design and implement a **hybrid electric vehicle charging infrastructure** that:

- Uses **wireless charging roads** powered by renewable energy sources.
- Integrates an **overhead locomotive charging system** for heavy vehicles.
- Addresses **efficiency and flexibility limitations** of conventional embedded-coil roads.

1.4 Outline

This project report is organized as follows:

Chapter 1: Introduces the topic.

Chapter 2: presents the literature survey on the existing techniques.

Chapter 3: provides a brief explanation of the design of the project.

Chapter 4: is dedicated to simulation and experimental results.

Chapter 5: presents the conclusions and future scope for this project.

CHAPTER 2
LITERATURE REVIEW

The Smart Grid and Electric Vehicles (EVs) with a focus on wireless charging. This study offers valuable insights into the convergence of these two domains, highlighting the potential synergies and challenges associated with their integration. By reviewing existing literature, the authors shed light on how smart grid technology can enhance the efficiency of EV wireless charging, manage grid load, and facilitate grid integration of renewable energy sources. The review emphasizes the importance of seamless communication and control systems for optimizing the charging process, reducing costs, and improving the reliability of EVs. This literature review is an essential resource for researchers and professionals seeking to understand the dynamic relationship between smart grid systems and electric vehicles, particularly in the context of wireless charging technology. [1]

The review encompasses a broad range of topics, including solar power generation, battery storage systems, and electric vehicle technology. It underscores the pressing need for sustainable transportation solutions in the face of environmental challenges and dwindling fossil fuel resources. The authors' analysis of the existing literature not only highlights the potential advantages of solar-based charging stations but also identifies the technical, economic, and environmental challenges that must be addressed for widespread adoption. This literature review serves as an essential resource for researchers, policymakers, and industry stakeholders seeking to advance the development and deployment of solar-based electric vehicle charging infrastructure. [2]

This study represents a crucial intersection of renewable energy and sustainable transportation infrastructure. The authors delve into various key facets, including solar panel technologies, energy storage solutions, charging infrastructure design, and efficient power management. Through an extensive literature review, they highlight the importance of integrating solar power with EV charging to reduce greenhouse gas emissions and reliance on non-renewable energy sources. [3]

This study makes a significant contribution to the growing body of research focused on sustainable and eco-friendly transportation solutions. The review delves into various facets of solar PV charging infrastructure, including solar panel technologies, energy storage systems, charging protocols, and grid integration. By synthesizing and analyzing the existing literature, the authors not only underscore the environmental and economic benefits of solar PV charging for EVs but also highlight the technical and regulatory challenges that must be addressed to ensure the seamless integration of these technologies. The review offers valuable insights into the current state of the field, shedding light on the innovative solutions and advancements that are paving the way for a more sustainable and efficient future in electric vehicle charging. [4]

This research delves into the innovative and sustainable integration of solar power with EV charging infrastructure, addressing the pressing need for eco-friendly and energy-efficient transportation solutions. The study conducts a thorough literature review, offering insights into the existing state of solar EV charging technology, its environmental benefits, and its potential to reduce greenhouse gas emissions. [5]

Wireless power transmission (WPT) is popular and gaining technology finding its application in various fields. The power is transferred from a source to an electrical load without the need of interconnections. WPT is useful to power electrical devices where physical wiring is not possible or inconvenient. The technology uses the principle of mutual inductance. One of the future applications finds in automotive sector especially in Electric Vehicles. This paper deals with research and development of wireless charging systems for Electric vehicles using wireless transmission. The main goal is to transmit power using resonance coupling and to build the charging systems. The systems deal with an AC source, transmission coil, reception coil, converter and electric load which are battery.[6]

This paper reviews wireless charging systems for electric vehicles (EVs), highlighting their advantages over wired systems in terms of convenience, environmental impact, and infrastructure needs. It explains key wireless power transfer methods—capacitive and inductive—and compares them. The study covers both stationary and dynamic charging systems, including models and design parameters for charging moving vehicles. It also discusses the role of control systems in improving efficiency and communication during charging. Finally, it reviews different EV battery types and their impact on charging, concluding with key findings and suggestions for future research.[7]

Electrified transportation will help to reduce green-house gas emissions and increasing petrol prices. Electrified transportation demands that a wide variety of charging networks be set up, in a user-friendly environment, to encourage adoption. Wireless electric vehicle charging systems (WEVCS) can be a potential alternative technology to charge the electric vehicles (EVs) without any plug-in problems. This paper outlines the current available wireless power transfer technology for EVs. In addition, it also includes wireless transformer structures with a variety of ferrite shapes, which have been researched. WEVCS are associated with health and safety issues, which have been discussed with the current development in international standards. Two major applications, static and dynamic WEVCS, are explained, and up-to-date progress with features from research laboratories, universities, and industries are recorded. Moreover, future upcoming concepts-based WEVCS, such as “vehicle-to-grid (V2G)” and “in-wheel” wireless charging systems (WCS) are reviewed and examined, with qualitative comparisons with other existing technology. [8]

This paper presents a new selectable regional charging wireless power transfer (SRC-WPT) system, which can charge multiple receivers simultaneously. Meanwhile, they are put on the charging area of the system. This SRC-WPT system employs a transmitter array for WPT, which rows are controlled by relays. Furthermore, the transmitters in each row have different frequency characteristics, which can be used as the natural switches. Thus, this SRC-WPT system can selectively activate the charging region for the receivers through the different frequencies and relays. Besides, when compared with the existing multi-to-multi WPT designs, the proposed control method of the SRC-WPT system is much more simple and reliable. Finally, a model is built to verify the performances of the proposed system and the corresponding control method. [9]

Electric vehicle (EV) users have the flexibility to fulfill their charging needs using either high-speed charging stations or innovative on-road wireless charging systems, ensuring uninterrupted travel to their destinations. These options present a spectrum of benefits, enhancing convenience and efficiency. The adoption of on-road wireless charging as a complementary method influences both the timing and extent of demand at fast-charging stations. This study introduces a comprehensive probabilistic framework to analyze EV arrival rates at fast-charging facilities, incorporating the impact of on-road wireless charging availability. The proposed model utilizes transportation data, including patterns from the US National Household Travel Survey (NHTS), to predict the specific times when EVs would need fast charging. To account for uncertainties in EV user decisions concerning charging preferences, a Monte Carlo simulation (MCS) approach is employed, ensuring a comprehensive analysis of charging behaviors and their potential impact on charging stations. A queuing model is developed to estimate the charging demand for numerous electric vehicles at a charging station, considering both scenarios: on-road EV wireless charging and relying exclusively on fast-charging stations. This study includes an analysis of a case and its simulation results based on a 32-bus distribution system and data from the US National Household Travel Survey (NHTS). The results indicate that integrating on-road EV wireless charging as complementary to fast charging significantly reduces the peak load at the charging station. Additionally, considering the on-road EV wireless charging system, the peak load of the station no longer aligns with the peak load of the power grid, resulting in improved power system capacity and deferred system upgrades. [10]

CHAPTER 3
METHODOLOGY

3.1 Design Methodology

The design of the Electric Vehicle Charging Infrastructure incorporates both Dynamic EV Wireless Charging Roads for smaller electric vehicles and an Overhead Locomotive Charging System for heavy transport vehicles such as trucks and buses. This dual charging approach ensures seamless energy transfer, reduces dependency on large onboard batteries, and enhances the efficiency of electric mobility.

3.1.1 Renewable Energy Integration and Charging Stations

The charging infrastructure is powered by solar panels and wind turbines, ensuring a sustainable and eco-friendly energy supply. These energy sources are carefully positioned to maximize efficiency based on local weather conditions and seasonal variations. The generated energy is stored in battery systems, which act as a buffer to supply power to the charging stations and road infrastructure. DC-DC converters regulate the power flow between renewable sources, storage systems, and charging modules.

The system is managed using Arduino Nano and ESP32 microcontrollers, enabling smart monitoring and control. The ESP32 functions as an IoT device, providing real-time updates on energy generation and distribution, while the Arduino Nano controls power flow and switching mechanisms. An LCD display shows the power source in use, whether from renewable sources or grid backup, ensuring transparency in system operation.

3.1.2 Dynamic EV Wireless Charging Roads

The Wireless Charging Road system is designed to provide on-the-go charging for electric vehicles. Transmitter coils are embedded within the road surface, powered by the renewable energy system. When an electric vehicle moves over the charging lane, IR sensors detect its presence and activate the corresponding transmitter coils. These coils induce current in the vehicle's receiver coil, enabling wireless power transfer without physical connectors.

An Arduino Nano microcontroller manages the coil activation process, ensuring that only the relevant section of the road is powered to optimize energy efficiency. As the vehicle moves forward, the previous coil section turns off while the next section activates, ensuring continuous charging. The charging status and power levels are monitored using voltage and current sensors, and the data is displayed on the system's dashboard via the ESP32 web interface.

3.1.3 Overhead locomotive Charging System

For heavy transport vehicles, an Overhead Locomotive Charging System is implemented. Overhead power lines are installed along designated lanes on highways, supplying direct grid power to electric trucks and buses. These vehicles are equipped with a pantograph system, which is manually deployed by the driver when entering the electrified lane.

The pantograph features a suspension-based adjustment mechanism, allowing it to adapt to variations in wire height while maintaining consistent contact with the overhead power lines. Arduino Nano microcontrollers are used to detect when the pantograph is connected to the overhead wire, ensuring smooth power transfer. When connected, the vehicle draws power directly from the grid while simultaneously charging its onboard battery.

If the pantograph disconnects due to lane changes or road conditions, the system automatically switches to battery mode, allowing the vehicle to continue operation seamlessly. The LCD display inside the vehicle indicates the current power source, displaying “Source: Overhead” when connected and “Source: Battery” when disconnected.

3.2 Hardware & Software Requirements

3.2.1 Hardware Specification

1) **ESP32:** Single or Dual-Core 32-bit LX6 Microprocessor with clock frequency up to 240 MHz’s 520 KB of SRAM, 448 KB of ROM and 16 KB of RTC SRAM. Supports 802.11 b/g/n Wi-Fi connectivity with speeds up to 150 Mbps. Support for both Classic Bluetooth v4.2 and BLE specifications.34 Programmable GPIOs. Up to 18 channels of 12-bit SAR ADC and 2 channels of 8-bit DAC. Serial Connectivity include 4 x SPI, 2 x I2C, 2 x I2S, 3 x UART. Ethernet MAC for physical LAN Communication (requires external PHY).1

Host controller for SD/SDIO/MMC and 1 Slave controller for SDIO/SPI. Motor PWM and up to 16-channels of LED PWM. Secure Boot and Flash Encryption.

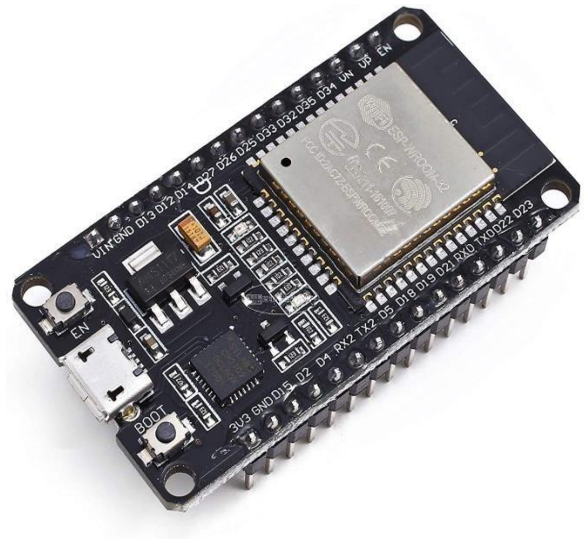


Figure 3.1 ESP-32

2) **Arduino nano**: The Arduino Nano is an open-source breadboard-friendly microcontroller board based on the Microchip ATmega328P microcontroller (MCU) and developed by Arduino.cc and initially released in 2008.

Nano is equipped with 30 male I/O headers, in a DIP-30-like configuration, which can be programmed using the Arduino Software integrated development environment (IDE), which is common to all Arduino boards and running both online and offline. The board can be powered through a type-B mini-USB cable or from a 9 V battery.

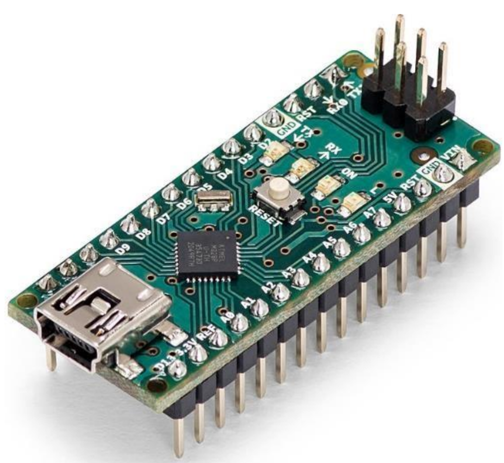


Figure 3.2 Arduino nano

3) **Solar Panels:**
Maximum Power (Pmax): 55w

Voltage Max. Power (Vmp): 12V

Current at Max. Power (Imp): 4.5A

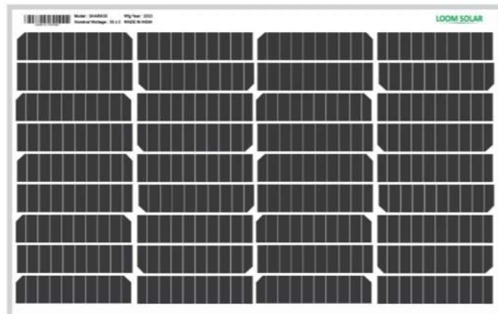


Figure 3.3 Solar panel

4) **Generator Motor:**
Poer source: DC

Voltage: 6-24 Volts

Frequency: 50 Hz

RPM: 4500

Figure 3.4 Generator Motor

5) **Voltage sensor and current sensor:**

Voltage Sensor:

Voltage Detection range: 0 – 25Volts

Current Sensor:

Current Detection range: 5A – 30A

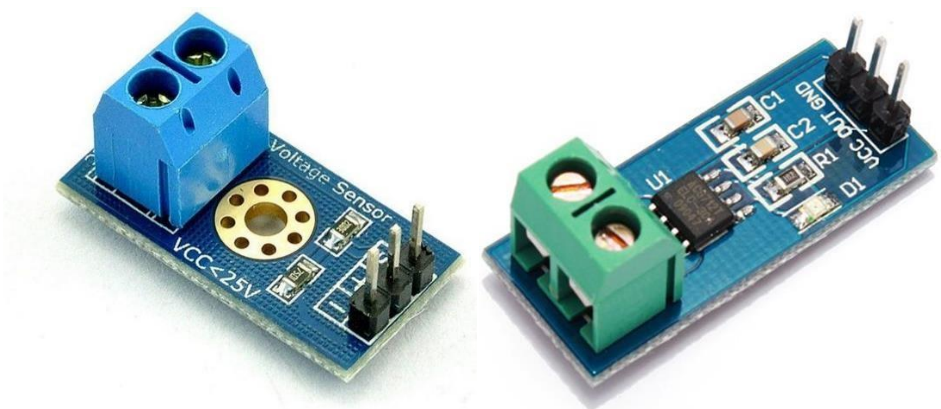


Figure 3.5 Voltage and current sensor

6) **DC-DC Buck/Boost Converter**:

input voltage: 3.2V- 40V DC

Output Voltage: 1.25V- 35V DC

Figure 3.6 DC-DC Buck/Boost

7) **AC-DC Power Supply Module 24V 6A:**

Input Voltage: 100-220

Output Voltage: 24V DC

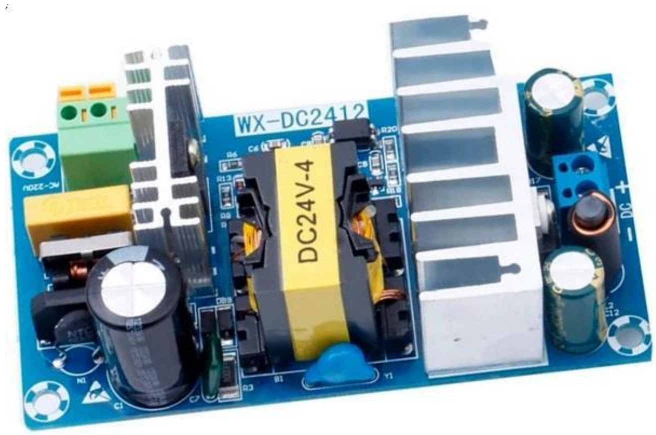


Figure 3.7 AC-DC Power Supply Module

8) **Charging Control Module:**

Input Voltage: DC 10-30V

Display Precision: 0.1V

Control Precision: 0.1V

Output Type: direct output

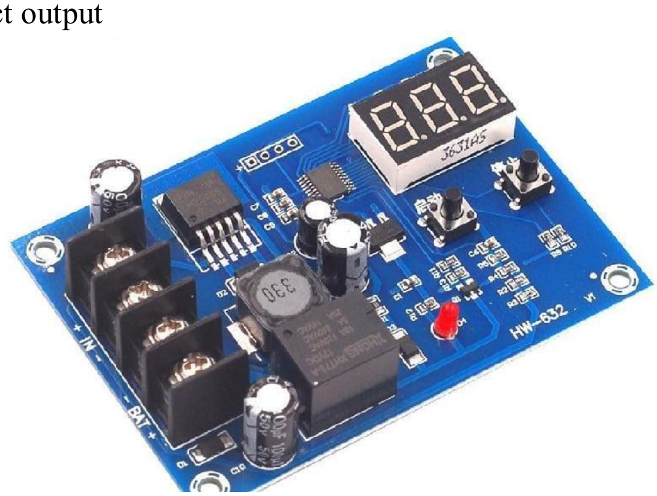


Figure 3.8 Charging Control Module

9) **Relay Module:**

Input Voltage: DC 10-30V

Display Precision: 0.1V

Control Precision: 0.1V

Output Type: direct output

Figure 3.9 Relay module

10) **Wireless Transmitter Receiver Charging Coil:**

Input Voltage: 12VDC Output: 5V / 1A current

Normal Use Distance: 2 ~ 10mm Operating Current: 1.2-2 A.

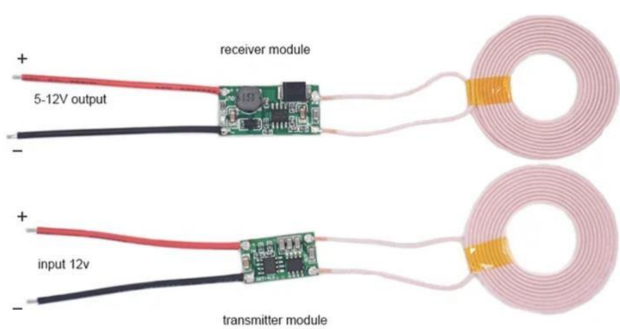


Figure 3.10 Wireless Transmitter and Receiver Coil

11) **RFID Scanner:**

13.56MHz contactless communication card chip. Working current：13 – 26mA / DC 3.3V

Standby current：10 – 13mA / DC 3.3V

Sleep current：<80uA Peak current：<30mA

Working frequency：13.56MHz

Card reading distance ：0～60mm （Mifare1 card)

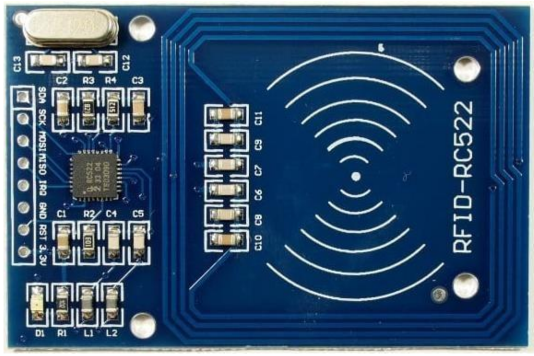


Figure 3.11 RFID Scanner

12) 20x4 LCD Display:

Characters: 20

Lines: 4

Character Color: Black Backlight: Yellow

Input Voltage (V): 5

Figure 3.12 20x4 LCD Display

13) Li-ion Battery:

Size: 18650.

Nominal Capacity: 2600mAh Nominal Voltage: 3.6V

Discharge: 5.2A Max Continuous Positive: Flat

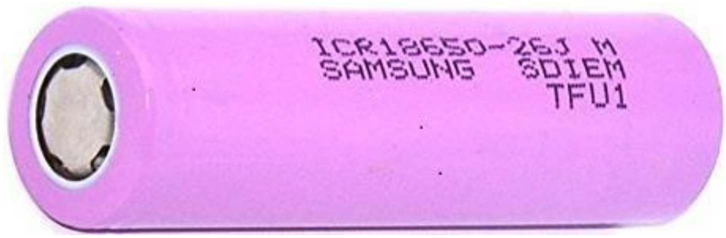


Figure 3.13 Li-ion Battery

14) IR Sensor:

VCC external 3.3V-5V

voltage GND external GND.

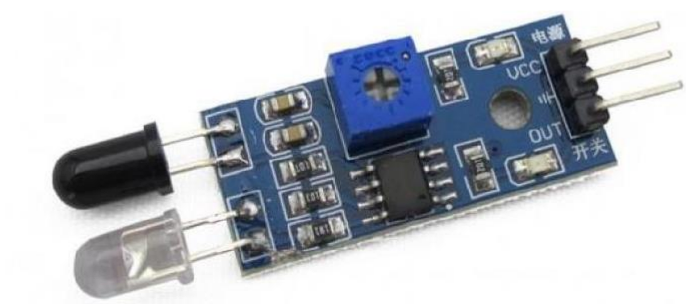


Figure 3.14 IR Sensor

15) LDR Sensor Module:

External 3.3V-5V VCC

DO digital output interface, a small plate (0 and 1)

AO small board analog output interface

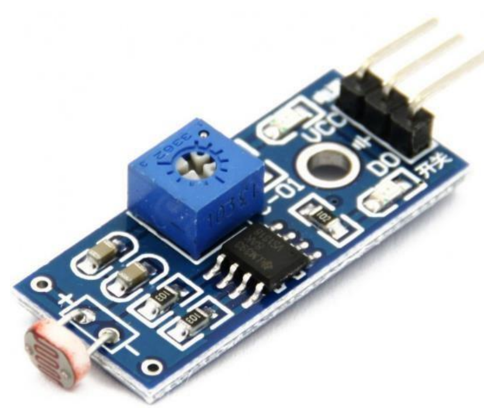


Figure 3.15 LDR Sensor Module

16) Servo Motor (SG90):

Model: SG90

Weight: 9 gm

Operating voltage: 3.0V~ 7.2V

Servo Plug: JR

Stall torque @4.8V: 1.2kg-cm

Stall torque @6.6V: 1.6kg-cm

Figure 3.16 Servo Motor SG90

17) Servo Motor (MG996):

Weight: 55g

Dimension: 40.7×19.7×42.9mm

Stall torque: 9.4kg/cm (4.8v); 11kg/cm (6.0v)

Operating speed: 0.19sec/60degree (4.8v); 0.15sec/60degree (6.0v)

Operating voltage: 4.8 ~ 6.6V

Gear Type: Metal gear

Dead band width: 1us

Figure 3.17 Servo Motor MG996

3.2.2 Software Requirement

1) Arduino IDE:

The Arduino Integrated Development Environment (IDE) is used to program the Arduino Nano and ESP32 in the rescue buoy. It allows writing, compiling, and uploading code to control various components like water pumps, motor driver, servo motor, LED modules, and sensors. The IDE supports C/C++ programming, enabling efficient communication between the microcontrollers and connected modules. It also facilitates debugging and serial monitoring to test and optimize the system's performance.

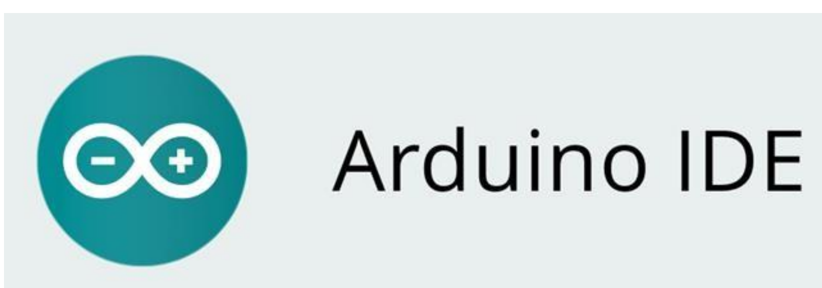


Figure 3.18 Arduino IDE

```
// Core Libraries (included by default)
#include <Arduino.h>      // Core Arduino functions
#include <Wire.h>         // I2C communication
#include <SPI.h>          // SPI communication
#include <EEPROM.h>       // Read/write to permanent storage
#include <Servo.h>        // Servo motor control

// Popular External Libraries (need to be installed)
#include <LiquidCrystal_I2C.h>  // I2C LCD displays
#include <DHT.h>                 // DHT temperature/humidity sensors
#include <Adafruit_NeoPixel.h>   // WS2812 LED strips
#include <ESP8266WiFi.h>         // WiFi functionality for ESP8266
#include <PubSubClient.h>        // MQTT client
#include <OneWire.h>             // OneWire protocol
#include <DallasTemperature.h>   // DS18B20 temperature sensors
#include <IRremote.h>            // IR communication
#include <FastLED.h>             // LED strip control
#include <Stepper.h>             // Stepper motor control

// Example usage of some common libraries:
```

Figure 3.19 libraries for each component in our project

This image shows a categorized list of Arduino libraries used in programming microcontrollers. It is divided into two sections:

1) **Core Libraries (included by default)**: These are standard libraries like Arduino.h, Wire.h, and Servo.h, used for basic functions, I2C/SPI communication, EEPROM access, and servo motor control.
2) **Popular External Libraries (need to be installed separately)**: These include libraries such as LiquidCrystal_I2C.h for LCD displays, DHT.h for temperature/humidity sensors, Adafruit_NeoPixel.h for LED strips, ESP8266WiFi.h for WiFi, and others for various sensor and communication functionalities.

3.3 System Design:

3.3.1 Block Diagram:

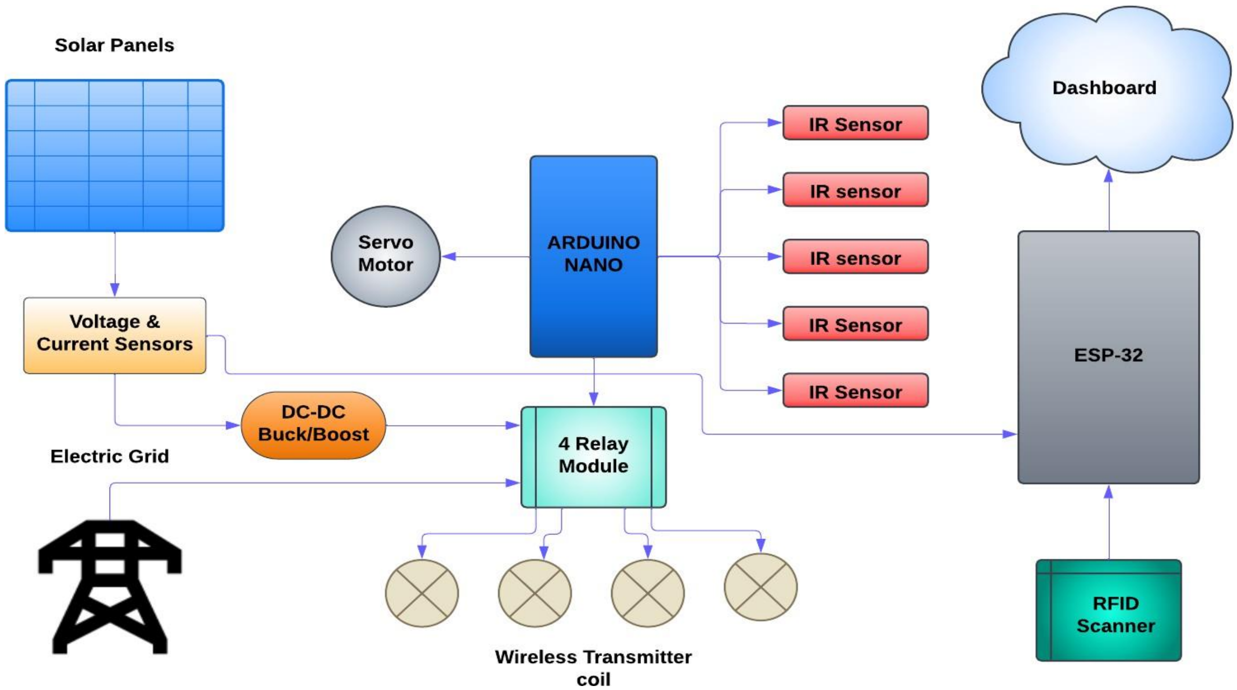


Figure 3.20 Block Diagram of Road

- **Solar Panels**: These provide renewable energy to power the system.
- **Voltage & Current Sensors**: These sensors monitor the energy from solar panels.
- **DC-DC Buck/Boost Converter**: This adjusts the voltage levels between the solar panels and the electric grid to ensure stable power delivery.
- **Arduino Nano**: Acts as the central controller of the system, controlling the relay module and interfacing with other components.
- **Servo Motor**: Likely used to move or adjust a mechanical part of the system.
- **4 Relay Module**: Controls the power delivery to the wireless transmitter coils that charge the vehicles.
- **Wireless Transmitter Coil**: These coils transfer power wirelessly to vehicles on the road.
- **IR Sensors**: These detect vehicles passing over the charging area.

- **ESP-32**: A microcontroller used for wireless communication, possibly sending data to the dashboard and monitoring the system.
- **RFID Scanner**: Could be used to identify vehicles for dynamic charging or track vehicle movements.

3.3.2 Circuit Diagram:

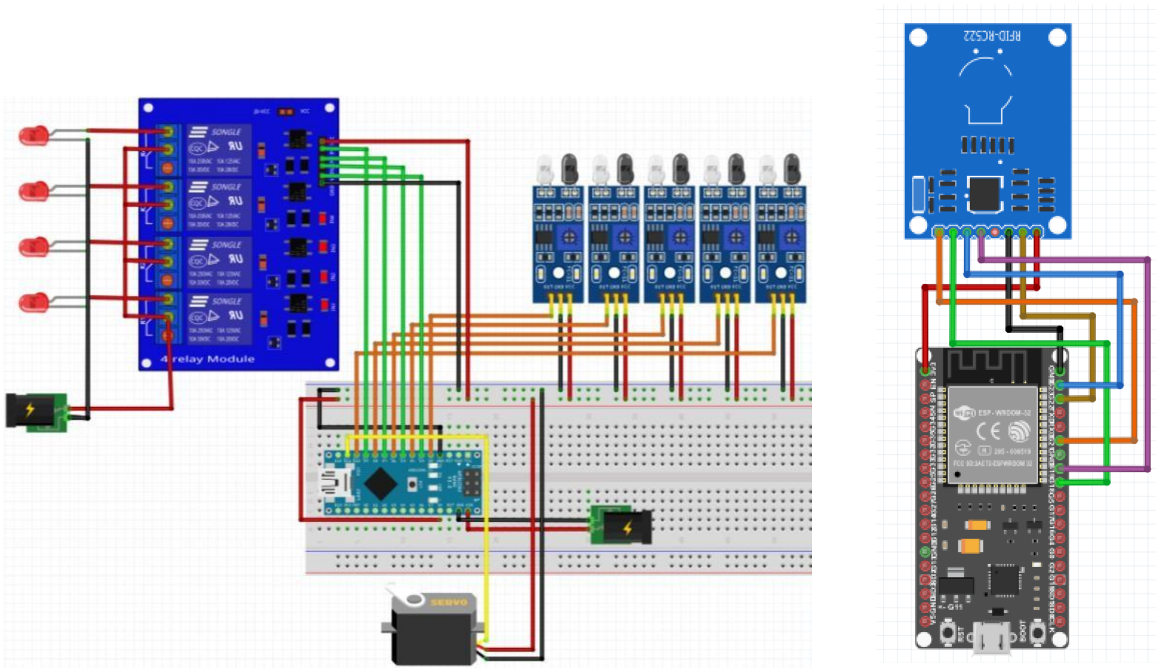
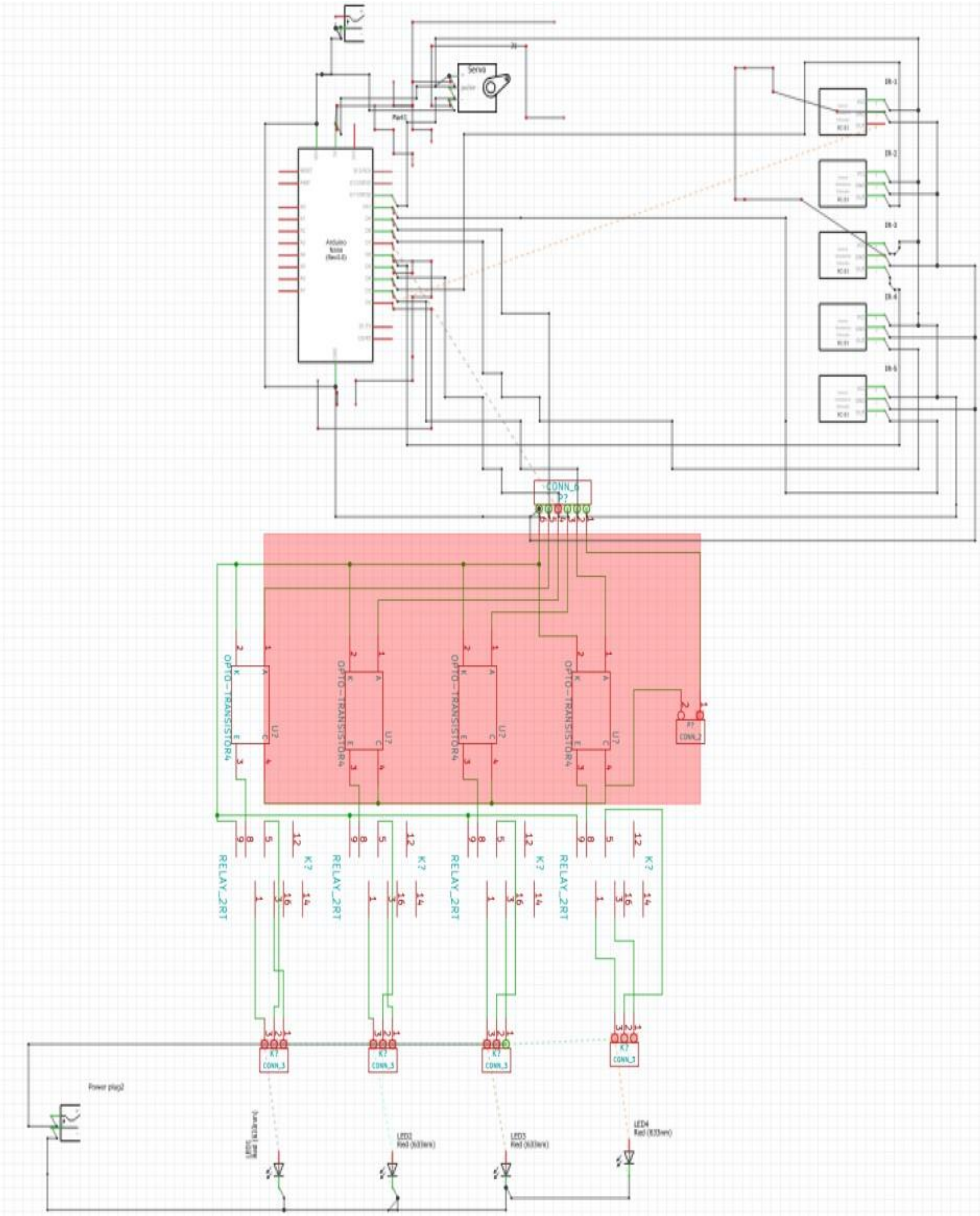


Figure 3.21 Circuit Diagram of Road

- **Arduino Nano** connected to various **IR sensors** for vehicle detection.
- **Relay Module** linked to the **wireless transmitter coils** for switching the power on and off for charging.
- A connection between the **DC-DC converter** and the relay module ensures stable power supply.
- The **ESP-32** is wired to an **RFID scanner**, which likely reads vehicle data for monitoring or billing purposes.

- The power components, including a **servo motor** and **battery connections**, are also shown, indicating how the system is powered and controlled.

3.3.3 Schematic diagram:



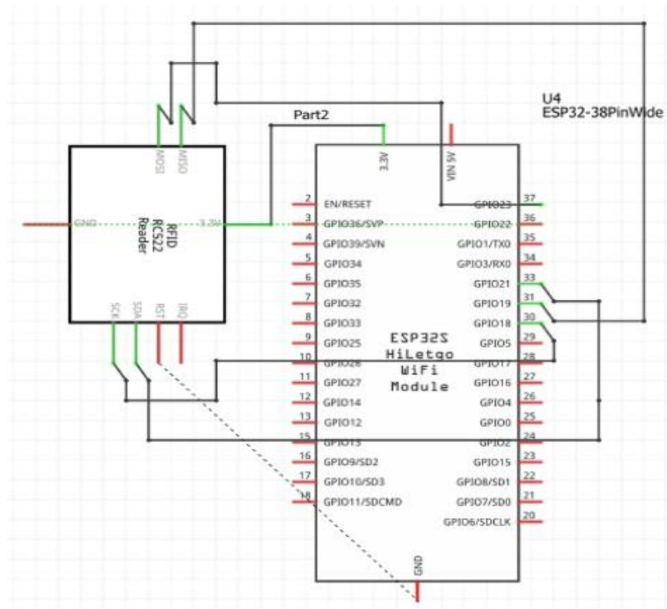


Fig 3.22 Schematic Diagram of Road

CHAPTER 4
SIMULATION AND EXPERIMENTAL RESULTS

4.1 Dynamic EV Wireless Charging Roads

The Wireless Charging Roads working starts with the Arduino Nano and ESP-32. The ESP- 32 has RFID Scanners connected to it, when someone wants to charge the EV while on go, then he has to switch to the Wireless Charging Lane, firstly user has to scan the correct RFID Card after the authentication is proper the Dashboard of the Road will update the RFID status and allow the user to move ahead. Now when the EV comes in front of IR sensor the IR sensor will detect the EV and send the signal to the Arduino Nano, the Arduino Nano will then send signal to the servo connected to it to open the barrier, now the barrier will open, and the EV will move ahead on the road. The Wireless charging road is made up of Magment which is Cement with small magnet particles mixed in it. Also, the road has transmitter coils laid on it and on the side IR sensors are placed. When the vehicle comes in front of the IR the IR detects it and the Arduino Nano turns a particular Relay to ON, which turns that region coils ON and the current is induced in the receiver coil of the EV. When the EV moves to the next IR the previous relay goes OFF and the next relay turns ON, and the cycle continues till the EV does not go away from the lane. The energy supplied to the coils are generated by the Solar Panels and in inappropriate weather conditions the AC grid supplies the power to the coils.

The Arduino Nano and ESP-32 are the micro controllers available in the project. Both the micro controllers are connected to the voltage and current sensors. The role of Arduino Nano is to take the Analog inputs from the voltage and current sensors and calculate the values and show the values on the 20x4 LCD display. On the other hand, ESP-32 here acts as an IoT device which is also acting as a web server, it shows the Voltage, Current and Watts generated by Solar Panels and Wind Turbines on the Dashboard. It has an RFID scanner connected to it, so when someone shows the correct RFID card the ESP-32 turns the Relay to ON due to which the wireless charging coils turns ON and the RFID status is also updated on the dashboard.

Fig 4.1 Prototype Model of Wireless Charging Road

4.2 Renewable Energy based Electric Vehicle Charging Station

The Charging Stations working starts form the solar panels and wind turbines. The Solar Panels and Wind Turbines generate energy and then the energy is measured by the Voltage and Current sensors. After that the energy is then passed through the DC-DC Buck/Boost Converters, these devices stabilize the voltage and current generated and then this stabilized energy is passed through the Charging Control Module. The Charging Control Module plays a very important role in the system, it is connected to the batteries on the station, it automatically turns the charging ON and OFF according to the battery voltage. If the battery is at low voltage the charging will be turned ON and if the battery is at its max voltage the charging will be turned OFF. The batteries are then attached to the charging points available at the charging station.

Also, there is a backup option of AC charging available, when the conditions are not good to generate sufficient amount of energy through the renewable resources then the AC supply will be used to charge the vehicles. The grid is connected to a AC-DC Power Supply which drops the high voltage to low voltage and converts the AC power to DC, and then this DC power transferred to the Charging Ports available on the station.

4.3 Overhead Locomotive Charging System

The **Overhead Locomotive Charging System** is designed to provide a continuous power supply to heavy-duty electric transport vehicles, such as trucks and buses, while they are in motion. This system utilizes overhead power lines, similar to electric railway networks, with manually operated pantographs that establish a connection between the vehicle and the power source. The overhead power lines are strictly supplied by the grid, ensuring a stable and high-power energy supply. Unlike automated systems, RFID and IR sensors are not used in this project. Instead, the driver manually deploys the pantograph when approaching the overhead wire lane. The pantograph is equipped with a suspension system that adjusts its height dynamically, ensuring stable contact with the overhead wire even if the wire position varies. Once connected, the Arduino Nano detects the connection and allows power flow from the overhead line to the vehicle.

While connected, the vehicle runs directly on the overhead power supply while simultaneously charging its onboard battery. If the pantograph disconnects, such as due to a lane change or reaching the end of the electrified section, the system automatically switches to battery mode to continue the journey. An LCD display on the vehicle indicates the current power source, showing "Source: Overhead" when connected to the overhead line and "Source: Battery" when running on stored battery power.

This system offers several advantages, including high power efficiency due to direct energy transfer, reduced battery dependency, and enhanced adaptability through its suspension-based pantograph. By integrating overhead charging for heavy vehicles alongside dynamic wireless charging for regular EVs, this project establishes a comprehensive, scalable, and efficient electric transportation infrastructure.

Fig 4.3: Overhead wire system

CHAPTER 5
CONCLUSION & FUTURE SCOPE

5.1 Conclusion

The establishment of a renewable energy-based EV charging infrastructure marks a significant step towards a sustainable and eco-friendly future. By integrating wireless charging roads and overhead locomotive systems powered by solar and wind energy, this initiative not only reduces carbon emissions but also enhances the feasibility of electric vehicle adoption. The project aligns with global climate goals, offering a smarter, more efficient, and greener transportation network.

This holistic approach benefits not only the environment but also individuals and industries seeking cost-effective and energy-efficient mobility solutions. As a next-generation EV charging system, "Next-Gen EV Charging Roads: Wireless, Solar, and Smart Solutions" stands as a beacon of progress, paving the way for a cleaner, smarter, and more sustainable world.

5.2 Future Scope

The future scope for your project, a renewable energy-based EV charging station, is rich with potential advancements. Explore advanced energy storage solutions to ensure uninterrupted service. Implement grid integration for bidirectional energy flow for vehicle-grid interaction. Develop high-speed charging infrastructure for faster replenishment of electric vehicles. Utilize smart grid technology and demand response for efficient energy management. Employ energy management software and seek green certifications and incentives. Expand the charging network to serve a wider area and enhance user experience. Conduct educational outreach for greater EV adoption, promising a more sustainable and efficient transportation ecosystem. locomotive charging employs specialized overhead catenary systems and ground-level third rail solutions capable of rapid power transfer. For locomotives, static charging stations at terminals complement dynamic charging systems along electrified routes, ensuring continuous operation.

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