CHAPTER 1

INTRODUCTION

Welcome to the future of sustainable transportation Dynamically Wireless Charging System of Electric Vehicles (DWCSEV). In a world where environmental concerns and technological innovation are at the forefront, this revolutionary system redefines the way we power and propel our vehicles. Gone are the days of frequent charging stops and range anxiety. With DWCSEV, we embark on a journey towards seamless, efficient, and eco-friendly mobility.

Imagine a world where electric vehicles glide effortlessly along roads and highways, continuously charging as they move. A Dynamically wireless charging system of electric vehicles (EVs) involves the transfer of energy from the infrastructure (charging station) to the EV without the need for physical cables or plugs. This technology is an advancement over traditional static charging methods, where the vehicle needs to be parked precisely over a charging pad to establish a connection. In a Dynamically wireless charging system, the charging occurs while the vehicle is in motion, providing several benefits and addressing specific challenges.

At its core, DWCSEV is not just a technology; it's a paradigm shift. By integrating wireless charging technology into the very fabric of our transportation networks, we unlock a host of benefits. The system maximizes vehicle uptime, minimizes the need for large and expensive batteries, reduces the demand on the grid during peak hours, and paves the way for the widespread adoption of electric vehicles.

How does it work? Imagine specially designed roads embedded with wireless charging coils. As electric vehicles equipped with compatible receivers drive over these roads, a Dynamically electromagnetic field is created, transferring power to the vehicle's battery. This continuous charging process ensures that the vehicle's energy reserves remain replenished, allowing drivers to focus on the journey ahead without the worry of running out of power.

The implications of DWCSEV extend beyond convenience. Reduced reliance on stationary charging stations means fewer resources dedicated to their installation and maintenance. The visual clutter of power cords and charging infrastructure disappears, blending seamlessly into the urban landscape. Furthermore, this technology opens doors to new possibilities for urban planning and design, as well as reduced greenhouse gas emissions, contributing significantly to our global sustainability goals.

As we delve deeper into the capabilities of the Dynamically Wireless Charging System of Electric Vehicles, this exciting innovation holds the potential to reshape not only how we move but also how we perceive the future of transportation. The era of Dynamically wireless charging is upon us, heralding an era of clean, efficient, and uninterrupted electric mobility. Join us as we accelerate into a future where roads power progress and sustainability drives us forward.

1.1 Background and Motivation :

Convenience and Seamless Charging: Traditional EV charging requires drivers to actively seek out charging stations and park their vehicles for an extended period. This can be inconvenient and time-consuming, especially during long journeys. Dynamically wireless charging eliminates the need for frequent stops, allowing EVs to recharge while on the move.

Range Anxiety Mitigation: Range anxiety, the fear of running out of battery power before reaching a charging station, is a significant concern for EV owners. Dynamically wireless charging can help alleviate this anxiety by maintaining a continuous flow of energy to the vehicle, increasing its effective range.

Urban Planning and Space Utilization: Static charging infrastructure requires designated charging stations, which can occupy valuable urban space. Dynamically wireless charging reduces the need for such dedicated spaces, as the charging can occur on existing roadways, reducing congestion around charging points.

Transition to Electric Mobility: As the world transitions toward sustainable transportation, the adoption of electric vehicles is increasing. Dynamically wireless charging can plays a crucial role in accelerating this transition by making EVs more practical and appealing to a wider range of consumers.

Efficiency and Energy Consumption: Dynamically wireless charging systems aim to improve charging efficiency. By enabling continuous charging during driving, the system can manage power distribution more effectively, optimizing energy transfer and utilization.

Seamless Integration with EVs: This technology aligns with the vision of fully autonomous vehicles, where human intervention is minimized. Dynamically wireless charging supports self-driving EVs by ensuring g they have a consistent power source without requiring human interaction for charging.

Extended Vehicle Utilization: Dynamically wireless charging extends the operational time of EVs, particularly in commercial applications such as electric buses, delivery vehicles, and taxis. These vehicles can remain on the road for longer periods, increasing productivity.

Reduced Battery Size and Cost: Continuous charging while driving reduces the need for large and expensive batteries. EVs equipped with Dynamically wireless charging systems can potentially have smaller, lighter, and cheaper battery packs, making electric vehicles more cost-effective.

Environmental Benefits: As more vehicles transition to electric power, overall carbon emissions from transportations can be significantly reduced. Dynamically wireless charging can further enhance this reduction by making electric vehicles even more convenient and versatile, encouraging more people to adopt them.

Incentive for Infrastructure Development: Governments and private enterprises have an incentive to invest in Dynamically wireless charging infrastructure, as it promotes sustainable transportation and enhances a country's technological image. ay we charge and use electric vehicles.

1.2 Objective:

The objective of the Dynamically wireless charging system of electric vehicle is to address the challenges of limited range and the inconvenience of recharging by enabling vehicles to charge seamlessly while in motion. This technology aims to revolutionize the EV industry by providing a continuous and efficient charging solution that eliminates the need for frequent stops at charging stations and minimizes range anxiety.

The key goals of this Dynamically wireless charging system include:

Seamless Charging While in Motion: The system should be capable of wirelessly transferring power from the charging infrastructure to the EV's battery while the vehicle is in motion. This enables EVs to be charged during daily commutes, long road trips, and even while waiting at traffic lights or intersections.

Optimal Energy Transfer Efficiency: The system should be designed to maximize energy transfer efficiency while minimizing losses. This ensures that the energy transferred from the charging infrastructure to the EV's battery is utilized effectively, reducing energy wastage and improving the overall efficiency of the charging process.

Adaptability and Scalability: The system should be adaptable to various types of roads, traffic conditions, and vehicle speeds. It should also be scalable to accommodate a growing number of EVs on the road without significantly impacting the overall power grid.

Safety and Reliability: Safety is paramount in any charging system. The Dynamically wireless charging technology should be designed with robust safety features to prevent accidents or hazards. The system should also be reliable, offering consistent charging performance without interruptions.

Integration with Smart Grids: The charging system should be able to communicate with the power grid and other vehicles to optimize energy distribution and manage charging loads. This integration contributes to grid stability and efficient energy management.

User-Friendly Experience: The technology should provide a user-friendly experience for EV owners. This includes intuitive interfaces for monitoring charging status, controlling charging preferences, and ensuring compatibility with various EV models.

Environmental Impact: The Dynamically wireless charging systems should contribute to the reduction of greenhouse gas emission by promoting the adoption of electric vehicles, which have lower or zero tailpipe emission compared to internal combustion engine vehicles.

By achieving these objectives, the Dynamically wireless charging system aims to accelerate the adoption of electric vehicle and make them a more practical and convenient choice for consumers, thereby contributing to a sustainable and greener transportation future.

1.3 Significance :

A Dynamically wireless charging system holds immense significance for electric vehicles (EVs) due to its potential to revolutionize the EV industry:

Effortless Charging: Dynamically wireless charging eliminates the need for physical connections, making EV charging as simple as parking.

Extended Range: Continuous charging on the go enhances EV range, reducing concerns about battery depletion during longer journeys.

Seamless Integration: Integrating charging infrastructure within roadways and urban environments encourages EV adoption without altering user behavior.

Reduced Infrastructure Demand: Dynamically charging reduces the necessity for multiple stationary charging stations, optimizing land use and infrastructure costs.

Minimal Downtime: EVs can be charged while in motion or at traffic stops, minimizing downtime and increasing overall efficiency.

Overcoming Range Anxiety: Dynamically charging mitigates range anxiety, a common concern for potential EV buyers.

Battery Downsizing: Smaller, lighter batteries can be utilized, reducing manufacturing costs and environmental impact.

Incentive for EV Transition: This technology accelerates the transition to EVs by enhancing convenience and accessibility.

Urban Air Quality: Increased EV adoption due to Dynamically charging contributes to improved urban air standard and reduced emissions.

In essence, Dynamically wireless charging has the potentials to reshaping the way we perceive and utilize electric vehicles, offering a more sustainable, convenient, and integrated future for transportation

CHAPTER 2

LITERATURE SURVEY

A literature survey on dynamic wireless charging systems for electric vehicles (EVs) reveals a rapidly growing field focused on enhancing the convenience and viability of electric mobility. The concept of dynamic wireless charging involves transferring energy to EVs while they are in motion, eliminating the need for frequent stops to recharge. Numerous studies have explored various aspects of this technology, including its benefits, challenges, and potential solutions. Researchers have investigated the efficiency of power transfer at different charging distances and speeds, aiming to optimize the system for real-world scenarios. Additionally, concerns about the impact of dynamic charging on road infrastructure, grid stability, electromagnetic interference, and overall system cost have prompted investigations into these potential hurdles. Some works have delved into the integration of energy storage systems with dynamic charging to ensure a steady power supply and efficient energy utilization. To address compatibility concerns, standardization efforts and interoperability studies have been undertaken to ensure seamless communication between charging infrastructure and EVs from different manufacturers. Moreover, a variety of wireless charging technologies, such as inductive, resonant, and capacitive systems, have been explored to identify the most suitable option for dynamic charging applications. From a practical perspective, researchers have examined the implementation of dynamic wireless charging in public transportation systems, highways, and urban environments to assess its feasibility and potential impact on EV adoption rates. Simulation tools and modeling techniques have played a crucial role in evaluating the performance of dynamic charging systems under various conditions. While significant progress has been made, the literature also highlights the need for further research to overcome technical, economic, and regulatory challenges. In conclusion, the literature survey underscores the substantial interest in dynamic wireless charging for EVs, emphasizing its potential to revolutionize the transportation sector by providing a seamless and continuous charging experience, ultimately contributing to the widespread adoption of electric vehicles and the reduction of carbon emissions.

CHAPTER 3

SYTEM ANALYSIS

3.1 Problem Statement:

The widespread adoption to electric vehicles has been hindered by several challenges, one of which is the limited range and inconvenience associated with recharging. Traditional plug-in charging requires EV owners to locate and connect to charging stations, which can be inconvenient and time-consuming. Additionally, the availability of charging infrastructure in certain areas might not be sufficient to support the growing number of EVs on the road. This poses a barrier to mass adoption of electric vehicles, as potential buyern is concern about range anxiety and the practicality of recharging.

3.2 Existing system

electric vehicle (EV) charging stations involves various components and considerations. Here's a high-level outline of the components and steps typically involved in such a project:

Site Selection and Planning:

Identify the suitable locations to charging stations based on factors like population density, proximity to major roads, and accessibility.

Consider the availability of power supply and the need to infrastructure upgrades.

Charging Station Types:

Determine the types of charging stations to be installed, such as Level 1, Level 2, and DC fast charging stations, based on target user base and charging requirements.

Power Supply and Electrical Infrastructure:

Analyze the power supply capacity at the chosen locations and plan for necessary upgrades if required.

Work with electrical engineers to design the electrical infrastructure, including transformers, switchgear, distribution panels, and wiring.

Charging Equipment Selection:

Choose charging equipment from reputable manufacturers that meet industry standards and safety regulations.

Decide on the number of charging points per station and their capabilities (e.g., power output).

Networking and Communication:

Implement a network connectivity solution to monitor and manage charging stations remotely.

Set up communication protocols for data exchanging between the charging stations, central management system, and user applications.

Payment and Access Systems:

Integrate payment systems for user billing, such as credit card, mobile app payments, or RFID cards.

Implement access control mechanisms to prevent unauthorized usage of charging stations.

Central Management System (CMS):

Develop a CMS to monitor and manage the entire network of charging stations.

Include features for real-time status monitoring, remote diagnostics, firmware updates, and reporting.

User Applications:

Create user-friendly mobile applications or web portals for EV drivers to find nearby charging stations, check availability, initiate charging sessions, and make payments.

Safety and Compliance:

Ensure that the charging stations meet safety standards and regulations related to electrical systems and EV charging equipment.

Implement safety mechanisms, such as ground fault protection and thermal monitoring.

Installation and Commissioning:

Carry out the physical installation of charging stations, including wiring, mounting, and signage.

Test the charging stations to ensure they were functioning properly and safely.

3.3 Proposed System :

A Dynamically wireless charging system of electric vehicles (EVs) is an innovative solution that aims to address the limitations of traditional plug-in charging methods. This system enables EVs to charge while in motion, eliminating the need for frequent stops at charging stations and extending the range of electric vehicles. Here's a proposed outline for such a Dynamically wireless charging system:

1. System Architecture:

The Dynamically wireless charging system consists of several key components:

Charging Infrastructure: This includes wireless charging stations embedded in the road or installed at specific locations, equipped with power transfer modules and communication systems.

Vehicle Unit: Each EV is equipped with wireless charging receiver and communication module, allowing to interact with the charging infrastructure.

Central Control System: A centralized control system manages the power distribution, communication between vehicles and charging stations, and ensures efficient charging operations.

2. Wireless Power Transfer:

The system uses inductive or resonant wireless power transfer technology. Charging pads are embedded into the road surface, and these pads generate a magnetic field. The EVs are equipped with receiver that can capture this energy and convert it back into electrical power to charge the vehicle's battery.

3. Communication and Positioning:

To enable precise alignment between the charging pad and the EV, a combination of communication and positioning technologies can be used. GPS, sensors, cameras, and vehicle-to-infrastructure (V2I) communication systems can help the EVs align themselves accurately with the charging pads.

4. Dynamically Charging Process:

The charging process takes place as vehicles move along the road equipped with charging pads. The system continuously adjusts the power transfer based on the vehicle's speed, position, and energy requirements. This Dynamically charging process ensures that vehicles maintain a consistent charging level without significant impact on their speed or driving experience.

5. Payment and Authentication:

A payment and authentication system can be integrated into the EVs and the charging infrastructure. Users may have accounts linked to their vehicles, allowing for seamless billing and access to the charging service. This can be managed through mobile apps or other digital platforms.

6. Safety Measures:

Safety is paramount for a Dynamically wireless charging system. Various safety mechanisms can be incorporated, such as automatic power cutoff if an obstacle is detected on the charging path, or a failsafe mechanism to disable charging if a critical fault is detected.

3.3.1 Advantages of Proposed System

The proposed dynamic wireless charging system for electric vehicles (EVs) offers a paradigm shift in sustainable transportation by addressing critical challenges associated with traditional EV charging methods. Unlike conventional plug-in charging, this innovative system allows EVs to charge while in motion, presenting numerous advantages. Firstly, it significantly extends the driving range of EVs by eliminating the need for prolonged charging stops, thus alleviating "range anxiety" and fostering their widespread adoption. Moreover, this dynamic charging system promotes efficient energy utilization, as it can harness renewable energy sources, such as solar or wind power, and transmit power wirelessly to moving vehicles, reducing dependency on fossil fuels and minimizing greenhouse gas emissions. The convenience factor is paramount, as EV owners no longer need to plan charging stops meticulously; instead, they can conveniently charge their vehicles while driving on highways or urban roads equipped with the charging infrastructure. Furthermore, the system's compatibility with various types of EVs, including electric buses and trucks, makes it versatile and conducive to electrifying diverse modes of transportation. The elimination of physical charging connectors and the associated wear and tear not only reduces maintenance costs but also enhances safety by minimizing risks of electric shock or damage due to corrosion. By mitigating the need for stationary charging stations, the system also helps decongest urban landscapes, freeing up valuable space currently dedicated to charging infrastructure. This innovation could lead to the creation of "charging lanes" on highways, optimizing land use and urban planning. With real-time communication capabilities between the charging infrastructure and vehicles, the system enables dynamic power adjustments, ensuring efficient power delivery and avoiding energy wastage. Additionally, the wireless nature of the technology reduces visual pollution caused by traditional charging cables and stations, contributing to the aesthetic improvement of the urban environment. The proposed system's grid-friendly features support the power grid by enabling smart charging coordination, smoothing out peak demand, and enhancing grid stability through demand-response mechanisms.

CHAPTER 4

SYSTEM REQUIREMENTS SPECIFICATION

4.1 System Requirements :

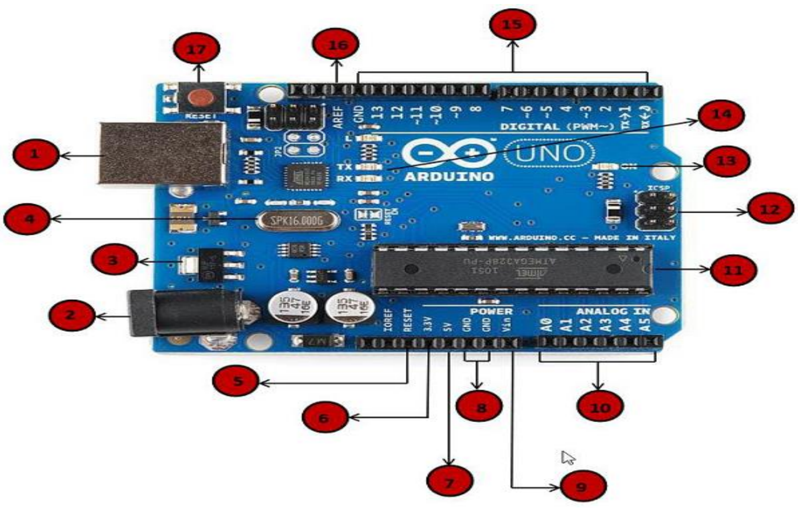
1. CPU – AMD Ryzen 5
2. RAM – Atleast 4 GB Of RAM or Higher
3. Windows 8 and above

4.2 Hardware Requirements :

1. Arduino Uno R3
2. Ultrasonic sensor – 2N
3. 5v Relay - 2N
4. 16 x 2 LCD display
5. 2N2222A Transistor - 2N
6. 10k ohm resistor – 2N
7. 26 gauge copper wire -15 meter
8. Connectors
9. Breadboard
10. Arduino USB

4.3 Components description:

4.3.1 Arduino Uno R3:



USB and Barrel Jack Power:

Powering the Arduino board can be achieved through two methods. The USB cable connects to a computer's USB port (1), while the Barrel Jack connection (2) allows direct AC mains power supply.

Voltage Regulation

A voltage regulator ensures stable DC voltages for the Arduino board's components and processor.

Crystal Oscillation:

The crystal oscillator (16 MHz) helps manage time-related functions in Arduino.

Resetting Arduino:

To restart the program, you can reset the Arduino board using either its onboard reset button (17) or an external button attached to the RESET pin (5).

Key Pins:

Several key pins provide power and grounding:

3.3V (6) supplies 3.3 volts.

5V (7) provides 5 volts, suitable for most components.

GND (8) serves as grounding points.

Vin (9) enables external power source, like AC mains.

Analog Input Channels

Inside the Arduino UNO board, you'll find a set of six analog input pins labeled as A0 through A5. These particular pins are designed to capture signals originating from analog sensors like temperature or humidity sensors. Once the analog signals are obtained, they are converted to digital values that the microcontroller can interpret.

Microcontroller Core

Each Arduino board is equipped with its own microcontroller (referred to as MCU), acting as the central processing unit. Notably, the main integrated circuit (IC) varies slightly between different Arduino models. In most cases, these microcontrollers are manufactured by the ATMEL Company. To ensure smooth program uploading through the Arduino IDE, it's important to identify the specific type of IC present on your board. This information can usually be found on the top of the IC. For a deeper understanding of the IC's design and functions, the data sheet provides valuable insights.

In-Circuit Serial Programming (ICSP) Pin

In Arduino boards like the Arduino Uno, the ICSP (In-Circuit Serial Programming) header is a set of pins used for programming and interfacing with the microcontroller. ICSP is typically used to program the bootloader or directly upload sketches to the microcontroller on the board. The ICSP pins are commonly used for advance users who want to program the microcontroller using an external programmer.

Power Status Indicator

Upon connecting your Arduino to a power source, the Power LED indicator should light up, confirming that the board is powered correctly. The absence of this illuminated LED suggests a potential connectivity problem.

Transmit and Receive Indicators

The Arduino board includes labels for Transmit (TX) and Receive (RX) functions. These labels are present in two key locations on the Arduino UNO board: firstly, at digital pins 0 and 1, indicating their role in serial communication; secondly, on the TX and RX LEDs themselves. The TX LED exhibits varying flash rates during the transmission of serial data, with the flashing speed determined by the board's baud rate. In contrast, the RX LED flashes when data is being received.

Digital Input and Output (I/O) Pins

With a total of 14 digital I/O pins (including 6 capable of Pulse Width Modulation - PWM), the Arduino UNO board offers versatile options. These pins can be configure for input, allowing the reading of logic values (0 or 1), or output, enabling control over various modules like LEDs and relays. Pins marked with the "~" symbol have the ability to generate PWM signals.

Analog Reference (AREF)

AREF, short for Analog Reference, is occasionally utilized to establish an external reference voltage ranging from 0 to 5 Volts. This external voltage sets an upper limit for the operations of the analog input pins.

4.3.2 Ultrasonic Sensor

Ultrasonic sensors are electronic devices that utilize ultrasonic sound waves to determine the distance to a target, converting these waves into electrical signals. The velocity of emitted ultrasonic waves surpasses that of audible sound. The core components consist of a transmitter and a receiver. The transmitter generates sound using piezoelectric crystals, which then travels to the target and reflects back to the receiver. Calculating the time taken for sound emission to travel from the transmitter to receiver allows the sensor to gauge the distance using the formula:

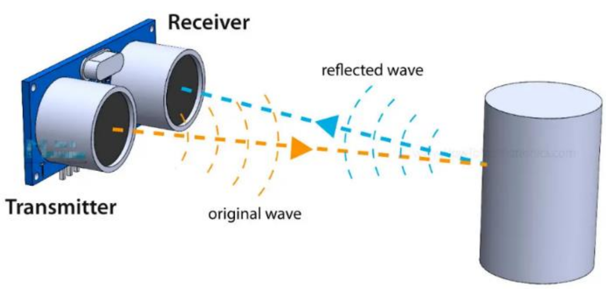
Distance (D) = 1/2 * Time (T) * Speed of a Sound (C)

Where:

'T' represents the time in seconds.

'C' represents the speed of sound, which is 343 m/s.

The working principle of ultrasonic sensors resembles that of sonar or radar, deciphering attributes of targets or objects by analyzing the echoes received from sound or radio waves. Emitting high-frequency sound waves, these sensors evaluate the returned echoes. By measuring the time interval between transmitted and received echoes, the sensor calculates the distance to the target.



Specifications of Ultrasonic Sensors

Familiarizing oneself with the specifications of an ultrasonic sensor aids in comprehending accurate distance approximations:

Sensing range: 40 cm to 300 cm

Response time: 50 milliseconds to 200 milliseconds

Beam angle: Approximately 50 degrees

Operating voltage: 20 VDC to 30 VDC

Precision: ±5%

Ultrasound wave frequency: 120 kHz

Resolution: 1 mm

Sensor output voltage: 0 VDC – 10 VDC

Weight of the sensor: Approximately 150 grams

Ambient temperature range: -25°C to +70°C

Maximum target dimensions for distance measurement: 5 cm × 5 cm

Vcc Pin: Connect this pin to a +5V power supply.

TRIG Pin: The Arduino board sends control signals to this pin, which serves as the sensor's triggering input.

ECHO Pin: Send signals to the Arduino board from this pin, allowing the Arduino to calculate pulse duration and determine distance. This pin functions as the sensor's ECHO output.

GND Pin: Establish a connection to the ground by attaching this pin.

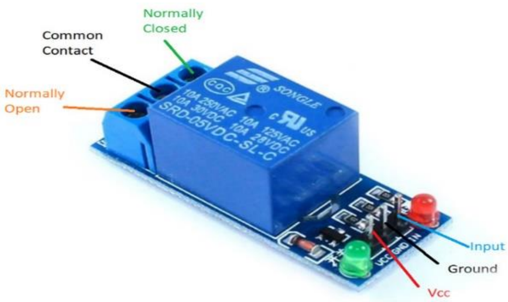
4.3.3 5V Relay

A relay functions as an electromechanical apparatus that employs an electric current to either initiate or terminate the connections within a switch. The singular-channel relay module goes beyond a simple relay by integrating elements that simplify switching and linking processes. Additionally, these components serve as indicators, displaying whether the module has power and if the relay is currently engaged or inactive.

Single-Channel Relay Module Specifications

- Supply voltage – 3.75V to 6V
- Quiescent current: 2mA
- Current when the relay is active: ~70mA
- Relay maximum contact voltage – 250VAC or 30VDC
- Maximum Voltage across Relay Contacts – 250VAC or 30VDC

Single-Channel Relay Module Pin Description



Pin Number	Pin Name	Description
1	Relay Trigger	Input to activate the relay
2	Ground	0V reference
3	VCC	Supply input for powering the relay coil

4	Normally Open	Normally open terminal of the relay
5	Common	Common terminal of the relay
6	Normally Closed	Normally closed contact of the relay

USUALLY OPEN VS. USUALLY CLOSED

Contained within the relay are two distinct categories of electrical contacts – usually open (NO) and usually closed (NC). The choice between the two is contingent upon whether the intention is to activate or deactivate the switch using the 5V signal. The 120-240V power supply current enters the relay via the shared (C) terminal in both setups. Employ the NO terminal to engage the usually open contacts, while the NC terminal is used to engage the usually closed contacts.

USUALLY OPEN

When operating under the usually open configuration, applying a HIGH signal to the relay results in the closure of the 120-240V switch, facilitating the current flow from the C terminal to the NO terminal. Disengaging the relay with LOW signal halts the current flow. Thus, if the objective is to activate the relay with HIGH signal, utilize the usually open terminal.

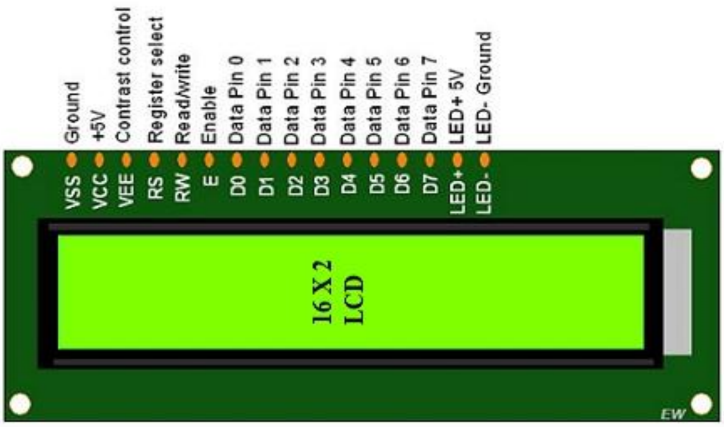
USUALLY CLOSED

Alternatively, when operating under the usually closed configuration, a HIGH signal prompts the opening of the switch, interrupting the 120-240V current. A LOW signal prompts the closure of the switch, enabling the current to move from the C terminal to the NC terminal. Consequently, when seeking to deactivate the 120-240V current with HIGH signal, make use of usually closed terminal.

4.3.4 16 x 2 LCD Display

The abbreviation LCD represents liquid crystal display, which is the type of electronic display component utilized in a wide array of applications, including diverse circuits and devices such as mobile phones, calculators, computers, and TV sets. These screens are particularly favored for applications involving multi-segment light-emitting diodes and seven-segment displays. The primary advantages of employing this module are its affordability, ease of programmability, support for animations, and the ability to display custom characters, special symbols, and animations without restrictions.

LCD 16×2 Pin Configuration



Shown below is the pin configuration for the 16×2 LCD display.

Pin 1 (Ground/Source Pin): This pin serves as the ground connection for the display. It is connected to the ground terminal of the microcontroller unit or power source.

Pin 2 (VCC/Source Pin): This pin is used to provide voltage supply to the display. It connects to the power source's supply pin.

Pin 3 (V0/VEE/Control Pin): This pin controls the display contrast and is connected to a variable POT that can supply a voltage range of 0 to 5V.

Pin 4 (Register Select/Control Pin): This pin switches between the command and data registers. It connects to a microcontroller unit pin and receives either a 0 or 1 (where 0 indicates data mode and 1 indicates command mode).

Pin 5 (Read/Write/Control Pin): This pin toggles the display between read and write operations. It is connected to a microcontroller unit pin and receives either a 0 or 1 (where 0 indicates Write Operation and 1 indicates Read Operation).

Pin 6 (Enable/Control Pin): This pin needs to be set high to initiate Read/Write processes. It is connected to the microcontroller unit and remains consistently high.

Pins 7-14 (Data Pins): These pins are used to transmit data to the display. They are connected in two-wire modes such as 4-wire mode and 8-wire mode. In 4-wire mode, only pins 0 to 3 are connected to the microcontroller unit, while in 8-wire mode, pins 0 to 7 are connected.

Pin 15 (+ve pin of the LED): Connected to +5V.

Pin 16 (-ve pin of the LED): Connected to ground (GND).

LCD 16×2 Features

This LCD has the following key features.

Operating voltage ranges from 4.7V to 5.3V.

Consists of two rows, each capable of displaying 16 characters.

Low current consumption of 1mA without backlight.

Each character can be represented in a 5×8 pixel box.

Displays alphanumeric characters and numbers.

Operates in both 4-bit and 8-bit modes.

Available with Blue and Green backlight options.

Supports custom character display.

LCD 16×2 Registers

A 16×2 LCD contains two registers: the data register and the command register. The Register Select (RS) pin is utilized to switch between these registers. When RS is set as '0', it indicates the command register. Conversely, when RS is set as '1', it indicates the data register.

Command Register

The command register's primary role is to store command instructions intended for the display. These instructions facilitate tasks like clearing the display, initialization, setting the cursor position, and controlling the display. The execution of commands takes place within this register.

Data Register

The data register's primary function is to store information will be displayed on the LCD screen. Information is transmitted to the data register in form of ASCII values representing characters. When data is sent to LCD, it is directed to the data register, initiating the display process. Setting the register to 1 selects the data register.

4.3.5 10k Ohm Potentiometer

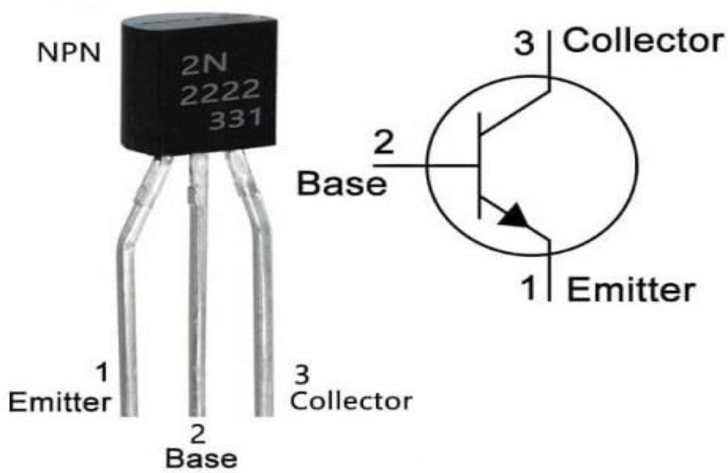
A potentiometer, often colloquially called a "pot," is an electronic device employed to regulate resistance within an electrical circuit. Serving as the type of variable resistor, this component comprises three terminals: two exterior ones and a central terminal known as the wiper. These exterior terminals connect to the extremities of the resistive element, while the wiper, positioned in the middle, links to a mobile contact capable of moving along the resistive element.

The potentiometer's resistance value is conventionally denoted in ohms (Ω); in this instance, it is a 10k ohm (10,000 ohms) potentiometer. This signifies that the total resistance of the potentiometer equals 10,000 ohms. By manipulating the potentiometer's knob or slider, the resistance between one exterior terminal and the wiper can be adjusted from 0 ohms to 10,000 ohms.

Potentiometers find diverse applications in electronics, including regulating volume in audio devices, managing brightness in displays, and functioning as adaptable voltage dividers in analog circuits. The precise utilization of a 10k ohm potentiometer hinges on the circuit and system into which it is integrated.

4.3.6 2N2222 Transistor

The 2N2222 stands as a prevalent NPN bipolar junction transistor (BJT) employed for amplification or switching in low-power general applications. Its design caters to low to medium current, low power, and medium voltage scenarios, with the ability to function at reasonably high speeds. Initially, it was manufactured in the TO-18 metal can configuration, as depicted in the image.

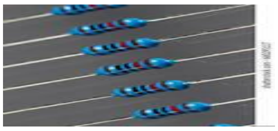


Pin1 (Collector): Serving as the initial pin of the transistor, this functions as an output pin. Its primary role involves supplying current from the transistor towards the output load.

Pin2 (Base): Positioned as the second pin, the base serves as a control pin within the transistor setup. Its primary function revolve around regulating the current flow from the emitter to the base.

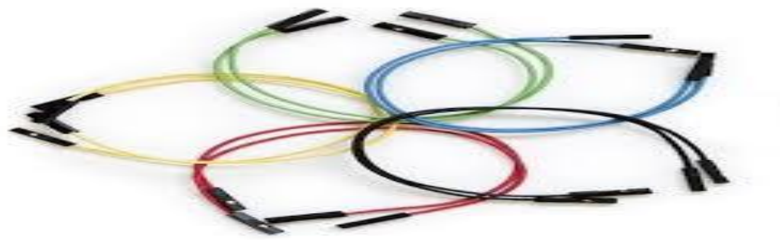
Pin3 (Emitter): Positioned as the third and final pin of the transistor, the emitter is responsible for completely facilitating the current drain from the transistor.

4.3.7 10k Ohm Resistor



Functioning as a passive resistor, the 10k resistor plays a significant role in regulating the passage of electrical current within a circuit. Refer to as a 10k ohm resistor, this designation stems from its resistance value of 10,000 Ohms.

4.3.8 Jumper Wires



Jumper wires are essential components in electronics and electrical prototyping. They are used to create temporary connections between different points on a breadboard, a circuit board, or other electronic components. Jumper wires are typically made of insulated copper wire with connectors or pins at each end, which can easily be inserted into the holes of a breadboard or attached to other components.

Jumper wires come in various lengths, colors, and styles, each suited for specific tasks:

Male-to-Male (M-M) Jumper Wires: These wires have male pins on both ends, making them suitable for connecting two female headers or pins on components like sensors, microcontrollers, or displays.

Male-to-Female (M-F) Jumper Wires: These wires have a male pin on one end and a female socket on the other. They are used to connect male pins on components to female headers on a breadboard or other components.

Female-to-Female (F-F) Jumper Wires: These wires have female sockets on both ends and are used to link two sets of male pins or headers.

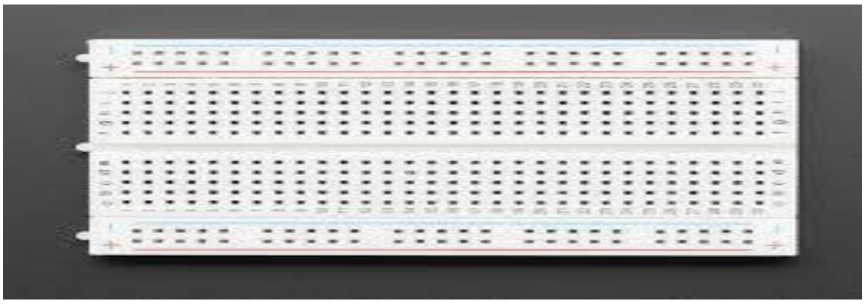
Jumper wires are widely used in various applications such as:

Breadboarding: They are using to create temporary connections on a breadboard for prototyping circuits before soldering them onto a permanent PCB.

Testing and Debugging: Jumper wires help in troubleshooting and verifying circuit connections during testing and debugging phases.

Prototyping: They are essential in creating quick and flexible connections between components while designing and testing new circuits.

4.3.9 Breadboard



A breadboard, also known as a protoboard, is a tool used in electronics to create temporary electrical connections for building and testing circuits. It's a fundamental tool for beginners and professionals alike in the field of electronics and electrical engineering. Breadboards are particularly useful for quick experiments with circuit designs without the need of soldering.

4.3.10 Copper wire

Copper wire is a type of electrical conductor made from copper metal. It is widely used in various applications due to its excellent electrical conductivity and other desirable properties.

Copper wire is commonly used in the construction of Tesla coils, which are electrical resonant transformer circuits used to produce high-voltage, low-current, high-frequency alternating-current electricity. Tesla coils consist of two main components: the primary coil and the secondary coil.

Copper wire is an excellent choice in constructing the coils due to its good electrical conductivity and low resistance. These properties are so important because Tesla coils operate at high frequencies and require efficient transfer of electrical energy between the coils.

4.4 Software Requirements :

1. Arduino IDE

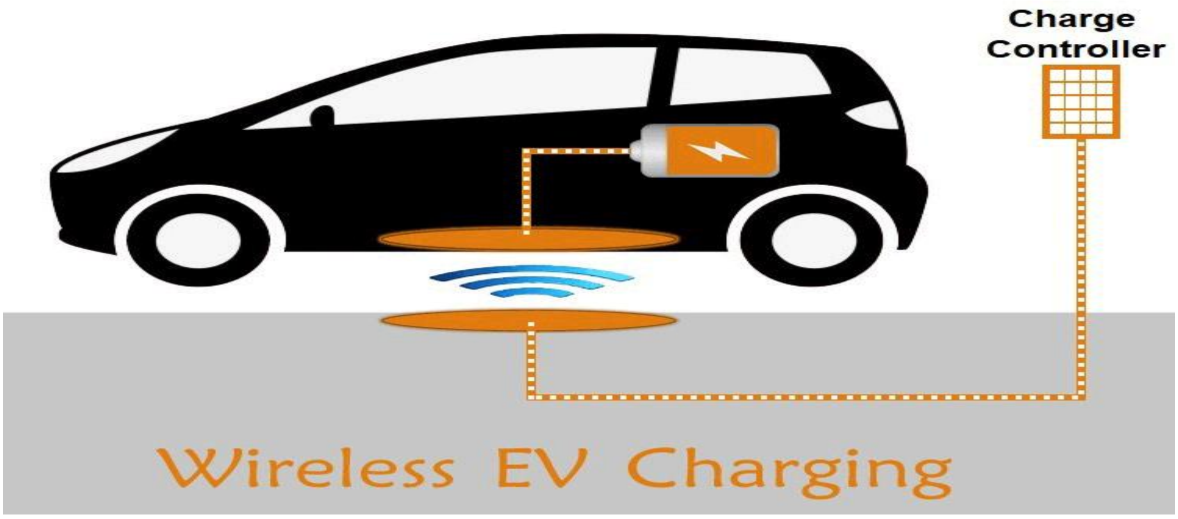
4.4.1 Arduino Programming :

Arduino stands as an open source platform designed for prototyping, featuring user-friendly hardware and software elements. It consists of programmable circuit board referred to as a microcontroller, accompanied by the Arduino IDE, a ready-made software used for coding and transferring code to physical board. The Arduino platform adheres to a standardized form, streamlining the microcontroller's functions into an easily accessible package.

To obtain Arduino IDE software, you can find different versions on the official Arduino website's Download page – available at https://www.arduino.cc/en/software. It's essential to select the version that match your operating system, whether it's Windows, iOS, or Linux. Once the download is complete, you can proceed to extract the downloaded file.

4.5 Electromagnetic Induction

These days, the global focus is shifting towards adopting electric mobility as a means to reduce the harmful emissions generated by traditional fossil fuel-powered vehicles and to provide a cost-effective alternative for transportation fuel. Nevertheless, electric vehicles face challenges related to their driving range and charging processes, which hinder their widespread adoption compared to conventional vehicles.



The emergence of Wire charging technology has revolutionized the charging experience, eliminating the need to spend hours waiting at charging stations. Instead, electric vehicles can now be charged simply by parking them in designated spots, whether it's in a parking lot, garage, or even while driving. This concept of transferring power wirelessly draws parallels with the familiar wireless transmission of audio, data and video signals.

Credit is owed to the brilliant scientist Nikola Tesla for his remarkable contributions, one of which includes wireless power transfering. Tesla began experimenting with wireless power transmissions in 1891 and developed the Tesla coil. In pursuit to create the new wireless power transmission systems, he embarked on the construction of Wardenclyffe Tower in 1901. This tower aimed to transmit high-voltage wireless energy over long distances. Tragically, the tower was destroyed for salvage in 1917 to settle Tesla's debts.

Nikola Tesla and his work on the Tesla coil

The fundamental principle for wireless charging closely resembles the operation of a transformer. In wireless charging, a system consists of a transmitters and receiver. A 220V, 50Hz AC supply of power is converted into high-frequency alternating current, which is then sent to transmitter coil. This generates an alternating magnetic field that intersect with the receiver coil, inducing the production of AC power output in the receiver coil. However, maintaining resonance frequency alignment between the transmitters and receiver is crucial for efficient wireless charging. Compensation network are employed on both ends to ensure resonance frequencies match. Subsequently, the AC power received is rectified to DC and channel to the vehicle's battery through a Battery Management Systems (BMS).

Illustration of a Wireless Charging System

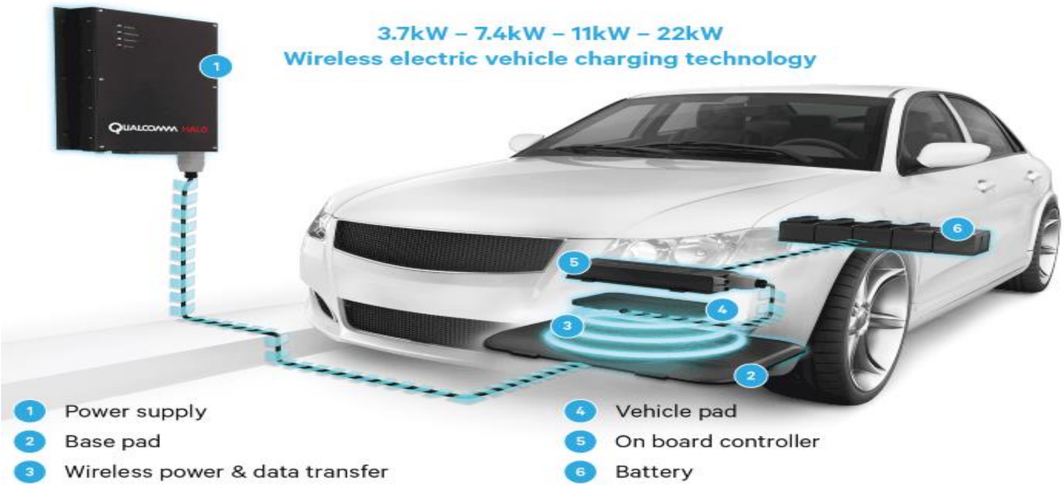
Electric vehicles on an EV Wireless Charging Lane

Static and Dynamically Wireless Charging

Wireless charging systems of electric vehicles can be categorized into two types on the basis of their application:

4.5.1 Static Wireless Charging (SWCS):

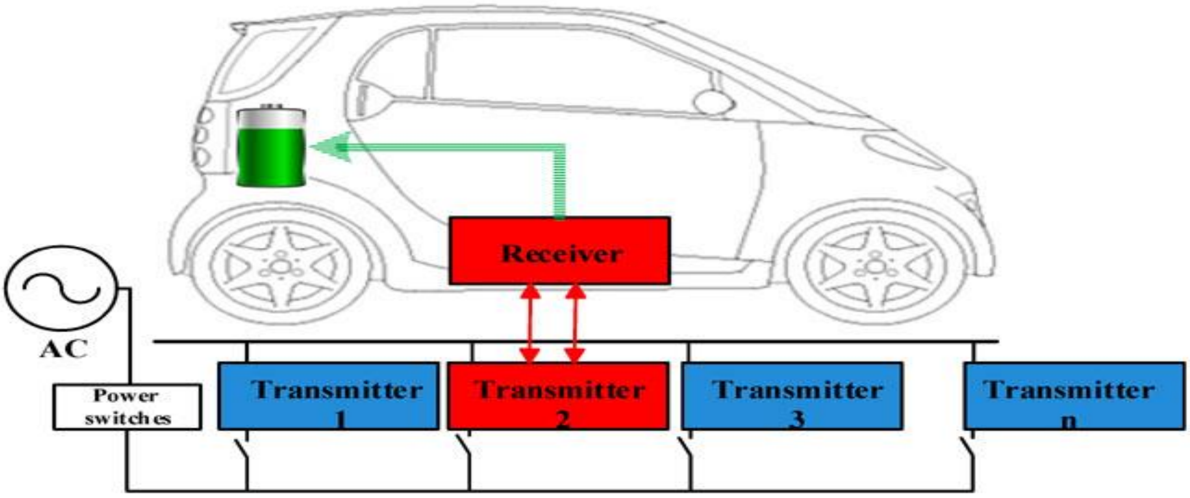
In this scenario, the vehicle will be charged while stationary. EVs are parked on charging spots or in garages equipped with Wireless Charging System (WCS). A transmitter is positioned underground, and a receiver is integrated beneath the vehicle. Charging is initiated by aligning the transmitter and receiver, allowing the vehicle to remain stationary during the charging process. Charging time depends on factors like AC power supply level, distance between transmitter and receiver, and pad sizes. SWCS is particularly suitable to areas where EVs are



parked for extended periods.

4.5.2 Dynamically Wireless Charging System (DWCS):

In this case, the vehicle is charged while in motion. Power is transmitted wirelessly from a stationary transmitter to a receiver coil within a moving vehicle. DWCS enables EVs to enhance their travel range by continuously charging the battery while driving on roads and highways. This approach reduces the need to large energy store and consequently trims the vehicle's weight.



4.5.3 Varieties of Electric Vehicles Wireless Charging Systems (EVWCS)

Electric Vehicle Wireless Charging System (EVWCS) come in various types based on their operational methods:

Capacitive Wireless Charging System (CWCS):

Energy exchange between the transmitter and the receiver occurs via displacement current generated due to fluctuations in the electric field. Instead of conventional coils or magnets, coupling capacitors facilitate wireless energy transmission. Initially, AC voltage is directed through a power factor corrections circuit for efficiency and voltage optimization. An H-bridge produces high-frequency AC voltage, applied to a transmitting plate, creating an oscillating electric field. This field induces displacement current in the receiver plate through electrostatic induction. The AC voltage is rectified to DC through rectifier and filter circuits before being sent to the battery using a Battery Management System (BMS). Parameters like frequency, voltage, coupling capacitor dimensions, and the gap between transmitter and receiver influence power transfer. Operating frequency is within range of 100 to 600 KHz.

Permanent Magnetic Gear Wireless Charging System (PMWC):

This method employs transmitter and receiver units, each comprising armature winding and synchronized permanent magnets. Application of AC current to the transmitter wind generates mechanical torque on transmitter magnet, leading to rotation. The magnetic interaction induces torque on receiver permanent magnet, resulting in synchronous rotation. Changes in the receiver's permanent magnetic field generate AC current in the winding, effectively converting the receiver into a generator. The generated AC power is rectified, filtered, and then directed to battery through power converters.

Inductive Wireless Charging System (IWC) and Resonant Inductive Wireless Charging System (RIWC)

Inductive Wireless Charging System (IWC) is grounded in Faraday's law of induction, leveraging the mutual magnetic field induction between transmitter and receiver coils. The transmission process involves applying AC current to the transmitter coil, generating an AC magnetic field. Consequently, the receiver coil responds by generating AC power through electron displacement. Following this, the AC output is rectified, filtered, and directed towards charging the electric vehicle's energy storage system. Several factors, including frequency, mutual inductance, and the spatial gap between transmitter and receiver coils, influence the efficiency of power transfer. The operational frequency of IWC spans between 19 and 50 KHz.

In contrast, the Resonant Inductive Wireless Charging System (RIWC) operates by utilizing resonators characterized by high-quality factors, leading to optimized energy transfer. The principle of resonance enables substantial power transmission with relatively weaker magnetic fields, a notable improvement over the IWC. This enhancement allows for the transmission of power across more extended distances without necessitating physical connections. To achieve the highest efficiency, it's crucial that the resonant frequencies of both the transmitter and receiver coils are in alignment. To further refine the system, supplementary compensation networks are integrated into both coils, promoting resonance and minimizing any incidental losses. The frequency range within which RIWC operates spans from 10 to 150 KHz.

4.6 Working Demonstration of project

The objective of the Dynamically wireless charging system is to minimize the charging duration. Our project incorporates a pair of ultrasonic sensors, two 5v relays, an Arduino Uno, two transmitter coils, and a receiver coil. The electrified road employs Tesla coils as transmitter coils for power transmission. Our transmitter coil consists of 15 turns of 26-gauge copper wire, followed by another 15 turns with exposed ends and a loop. One end of the copper coil links to the collector of the 2N2222A transistor, while the other end connects to one terminal of a 10k Ohm resistor, whose other end is connected to the transistor's base. The transistor's emitter is

grounded. This setup readies the transmitter coil to provide wireless power to the receiver coil, comprising 30 turns of copper wire and an attached LED to indicate power transfer. The transmitter requires a power supply regulated by a 5v relay module.

A relay serves as a power control device, capable of initiating or terminating power flow. It possesses GND, VCC, and IP pins. GND connects to the ground supply, VCC to a 5v power source, and IP to digital pin 2 of the Arduino. The specific digital pin for IP corresponds to the Arduino code. Sending a HIGH signal from the Arduino to the relay through IP activates the Normally Closed connection, channeling power to the transmitter coil. The middle port of the coil connects to the 5v power supply, while the left port is linked to the coil loop. The relay activation is dictated by the Arduino's HIGH signal.

The Dynamically system aims to electrify the road upon detecting vehicles, which triggers the relay to transfer power. Ultrasonic sensors detect electric vehicles, with their GND pin grounded, VCC pin powered by 5v, ECHO pin connected to digital pin 4, and TRIG pin linked to digital pin 5. As per the Arduino program, the Ultrasonic sensor's TRIG pin emits high-frequency sound when the Arduino signals HIGH. If the emitted sound reflects off an object and is received by the sensor's ECHO pin, the Arduino recognizes a detected object within range and triggers a HIGH signal to the relay for power transmission.

Monitoring the project's progress involves a 16x2 LCD display connected to the Arduino. VCC and BLA connect to a 5v power source, while GND, RW, and BLK are grounded. RS, E, D4, D5, D6, and D7 link to digital pins 13, 3, 11, 10, 9, and 8 of the Arduino, respectively. The display can present various information such as voltage readings or detected object distances. Adjusting the LCD's clarity can be achieved using a potentiometer connected by attaching the VO pin to the potentiometer's IP pin, with VCC and GND tied to 5v and ground.

The project showcases alternating voltage readings from the power supply using the A0 analog pin of the Arduino. The Arduino takes a central role in controlling devices like the ultrasonic sensor, relay, and LCD display. Jumper wires facilitate data and power transmission between devices, while the breadboard provides power and ground connections for all components.

Wireless power transmission occurs between the road's transmitters and the vehicle's receiver through electromagnetic induction. When a magnetic field passing through a copper coil changes, it induces relative motion between the field and electrons in the wire. This motion generates a voltage across the coil, resulting in an electric current flow when the circuit is closed.

4.7 REQUIREMENT ANALYSIS

4.7.1 Functional Requirements:

A Dynamically wireless charging system for electric vehicle (EVs) involves a complex interplay of technologies to enable charging while the vehicle is in motion. Here are some functional requirements to consider for such a system:

1.Wireless Power Transfer Efficiency:

The system should achieve a high efficiency of power transfer to minimize energy losses during charging.

Efficiency should be maintained across varying distances between the charging infrastructure and the vehicle.

2.Safety and Electromagnetic Compatibility (EMC):

The system should comply with safety standards to ensure user and bystander safety during charging.

Electromagnetic interference with the other electronic devices should be minimized to prevent disruptions.

3.Dynamically Alignment and Positioning:

The system must Dynamically adjust the alignment and positioning of the charging coils on the road and the vehicle to ensure efficient power transfer.

Real-time communication and coordination between the road infrastructure and the vehicle are necessary for accurate alignment.

4.Vehicle Identification and Authentication:

The system should be able to identify and authenticate authorized vehicles before initiating charging.

Secure communication protocols are essential to prevent unauthorized access.

5.Dynamically Power Control:

The system should adjust the power delivery based on the vehicle's speed and power requirements.

Power control algorithms must ensure that the charging power is sufficient without exceeding safety limits.

4.7.2 Non-Functional Requirements:

Non-functional requirements define the qualities or characteristics of system that are essential for its overall performance, usability, security, and other aspects. When it comes to a Dynamically wireless charging system of electric vehicles, there are several non-functional requirements to consider:

1.Reliability and Availability:

The system should have high reliability, ensuring uninterrupted charging services to minimize downtime.

The charging system should be available for use at a high percentage of time, aiming for minimal outages.

2.Efficiency:

The wireless charging efficiency should be optimized to minimize energy losses during transfer.

The system should efficiently manage power distribution to multiple vehicles, avoiding overloads or underutilization.

3.Scalability:

The system should be designed to accommodate a growing number of electric vehicles without significant performance degradation.

It should be easy to add new charging stations and expand the network as demand increases.

4.Security:

The charging system should implement strong authentication and authorization mechanisms to prevent unauthorized access.

Data communication between vehicles, charging stations, and the central control should be encrypted to protect sensitive information.

5.Safety:

The wireless charging process should adhere to safety standards to prevent overheating, short circuits, and other potential hazards.

4.9 Coding

```
#include <LiquidCrystal.h>
const int rs = 13, en = 3, d4 = 11, d5 = 10, d6 = 9, d7 = 8;
LiquidCrystal lcd(rs, en, d4, d5, d6, d7);

const int trigPin1 = 7;
const int echoPin1 = 6;
const int trigPin2 = 5;
const int echoPin2 = 4;
int relay1 = 12;
int relay2 =2;
const int g_read= A1;
const int supply_read= A0;
const int p_read= A3;
float p_sensor= 0,g_sensor= 0,supply_sensor= 0;
  void setup() {
  lcd.begin(16, 2);
  lcd.print("Dynamically wireless Power Transfer");

  pinMode(trigPin1, OUTPUT);
  pinMode(trigPin2, OUTPUT);

  pinMode(echoPin1, INPUT);
  pinMode(echoPin2, INPUT);

 pinMode(relay1, OUTPUT);
 pinMode(relay2, OUTPUT);

 digitalWrite(relay1, HIGH);
 digitalWrite(relay2, HIGH);
```

```
pinMode(g_read, INPUT);
pinMode(supply_read, INPUT);
pinMode(p_read, INPUT);

  Serial.begin(9600);
}
void loop() {
  digitalWrite(trigPin1, LOW);
  delayMicroseconds(2);
  digitalWrite(trigPin1, HIGH);
  delayMicroseconds(10);
  digitalWrite(trigPin1, LOW);
  long duration1 = pulseIn(echoPin1, HIGH);
  int distance1 = duration1 / 58;
  digitalWrite(trigPin2, LOW);
  delayMicroseconds(2);
  digitalWrite(trigPin2, HIGH);
  delayMicroseconds(10);
  digitalWrite(trigPin2, LOW);
  long duration2 = pulseIn(echoPin2, HIGH);
  int distance2 = duration2 / 58;

  Serial.print("Distance 1: ");
  Serial.print(distance1);
  Serial.print(" cm, Distance 2: ");
  Serial.print(distance2);
  Serial.println(" cm");

p_sensor=analogRead(p_read);
float p_voltage = p_sensor* (5.0 /1023.0);
g_sensor=analogRead(g_read);
float g_voltage = g_sensor* (5.0 /1023.0);
```

```
supply_sensor=analogRead(supply_read);
float supply_voltage = supply_sensor* (5.0 /1023.0);
if ((distance1 < 5) || (distance2 < 5) )
{
  if ((distance1 < 5) && (distance2 < 5)){
    lcd.setCursor(0,0);
    lcd.print("both are charging");
    lcd.setCursor(0,1);
    lcd.print("d1,d2=");
    lcd.print(distance1);
    lcd.print(distance2);
    digitalWrite(relay1, LOW);
    digitalWrite(relay2, LOW);
  }
  if ( distance1 < 5 ) {
    lcd.setCursor(0,0);
    lcd.print("slot 1 is charging");
    lcd.setCursor(0,1);
    lcd.print("d1=");
    lcd.print(distance1);
    digitalWrite(relay1, LOW);
    digitalWrite(relay2, HIGH);
  }
  else {
    lcd.setCursor(0,0);
    lcd.print("slot 2 is charging");
    lcd.setCursor(0,1);
    lcd.print("d2=");
    lcd.print(distance2);
    digitalWrite(relay1, HIGH);
    digitalWrite(relay2, LOW);
  }
}
```

```
else{
 lcd.setCursor(0,0);
 lcd.print("both are off");
 lcd.setCursor(0,1);
 lcd.print( supply_voltage );
 lcd.print("v");
 lcd.print( p_voltage);
 lcd.print("v");
 lcd.print( g_voltage);
 lcd.print("v");
 digitalWrite(relay1, HIGH);
 digitalWrite(relay2, HIGH);
}
delay(100);}
```

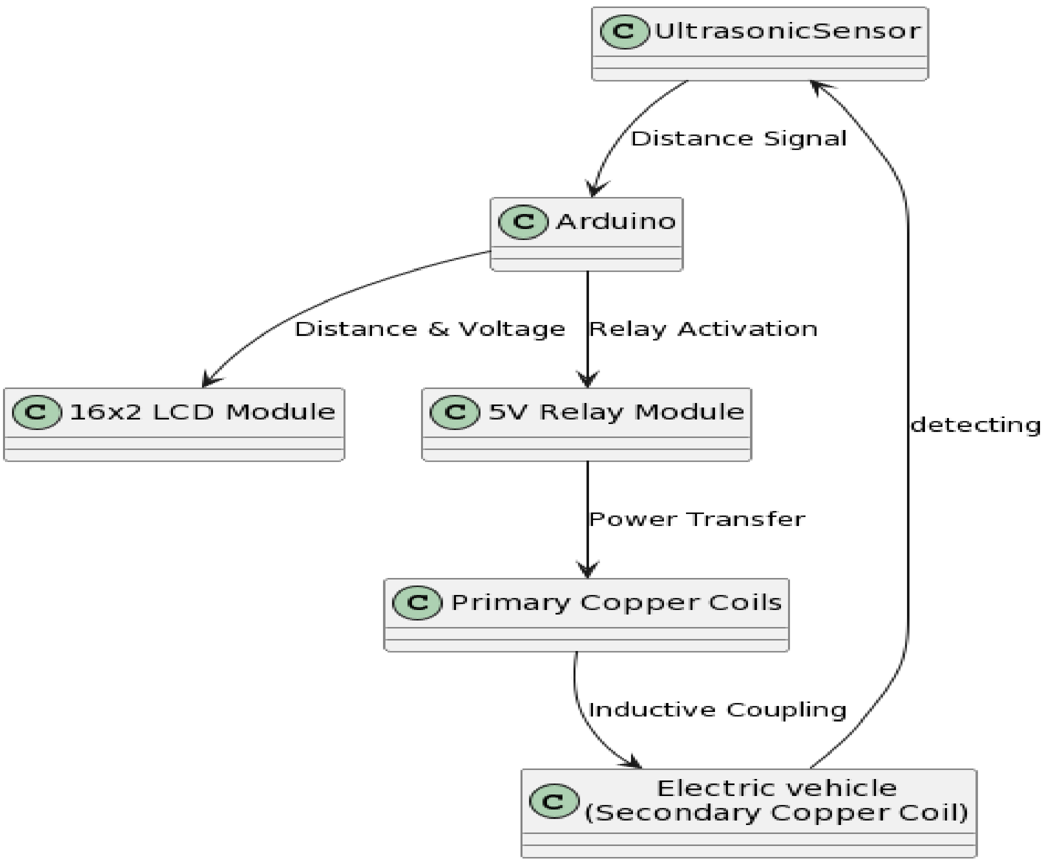
CHAPTER 5

DETAILED DESIGN

5.1 Component Diagram

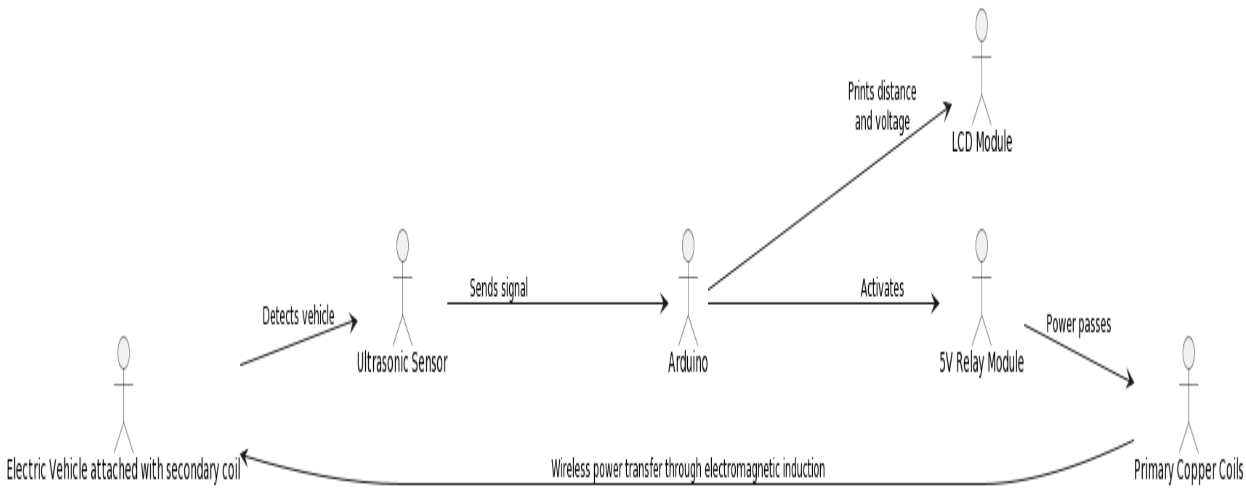
A component diagram illustrating the key elements of a Dynamically wireless charging system for electric vehicles (EVs) is essential for understanding the system's architecture. At the core of this diagram would be the Dynamically wireless charging infrastructure itself, which comprises several interconnected components.

The central component would be the 'Charging Station Controller,' responsible for managing the overall operation of the charging system. It coordinates communication between various components and makes decisions based on real-time data. Connected to this controller would be the 'Grid Connection Interface,' which enables the charging system to interact with the power grid, regulating the flow of electry based on demand and availability.



5.2 Usecase Diagram

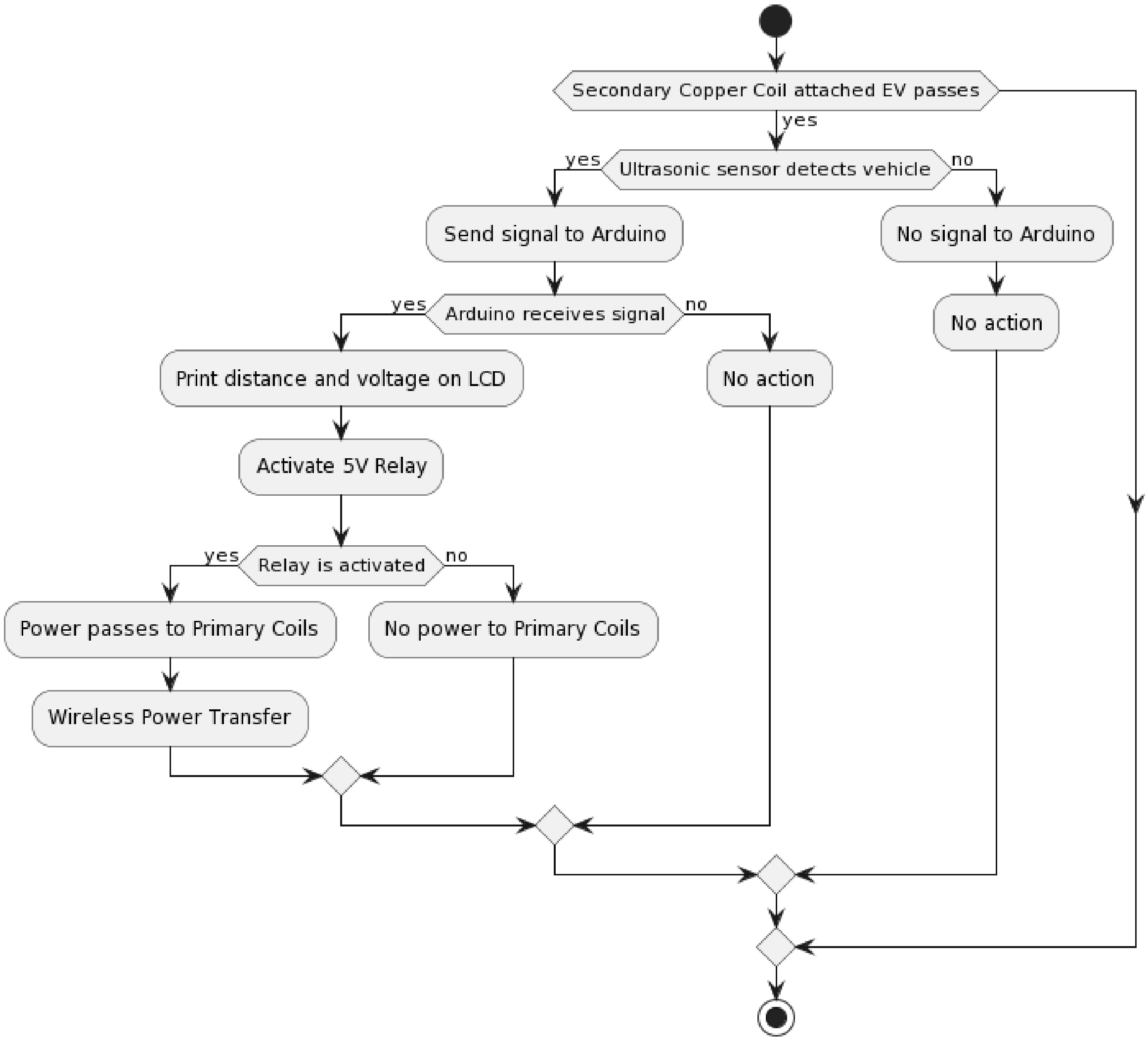
A use case diagram is a visual representation within the field of software engineering that depicts the interactions between various actors (users or external systems) and the system itself. It provides a high-level view of the functionalities or behaviors that the system offers, showcasing how different actors engage with the system to achieve specific goals. The diagram employs actors and use cases as its main elements, where actors represent entities that interact with the system and use cases represent specific functionalities or processes the system can perform.



5.3 Activity Diagram

An activity diagram is a visual representation used in the field of software engineering and systems analysis to depict the flow of activities or processes within a system, application, or business process. It is part of the Unified Modeling Language (UML) and is particularly useful for capturing the Dynamically behavior of a system.

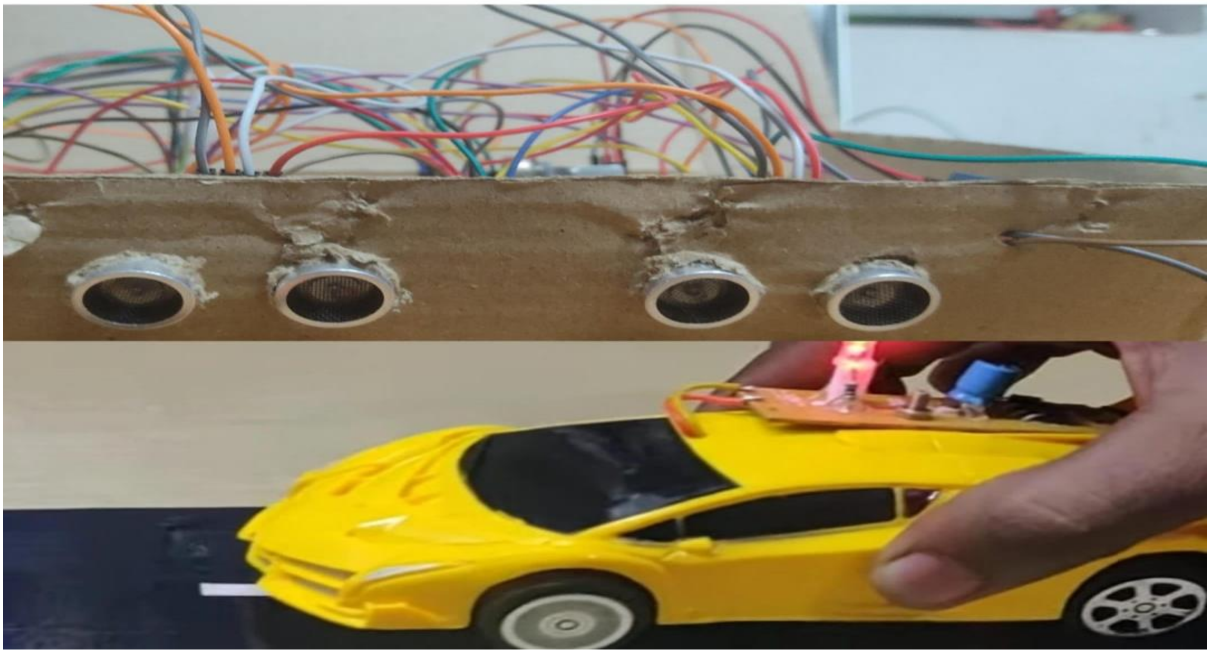
In an activity diagram, activities are represented as nodes, and the transitions between these nodes illustrate the sequential flow of activities. Nodes can also be connected by decision points, which are diamond-shaped symbols representing conditional branches in the process. These decision points guide the flow of activities based on certain conditions or events.


Secondary Copper Coil attached EV passes
yes
yes
Ultrasonic sensor detects vehicle
no
Send signal to Arduino
No signal to Arduino
yes
Arduino receives signal
no
No action
Print distance and voltage on LCD
No action
Activate 5V Relay
yes
Relay is activated
no
Power passes to Primary Coils
No power to Primary Coils
Wireless Power Transfer

PROJECT IMAGES

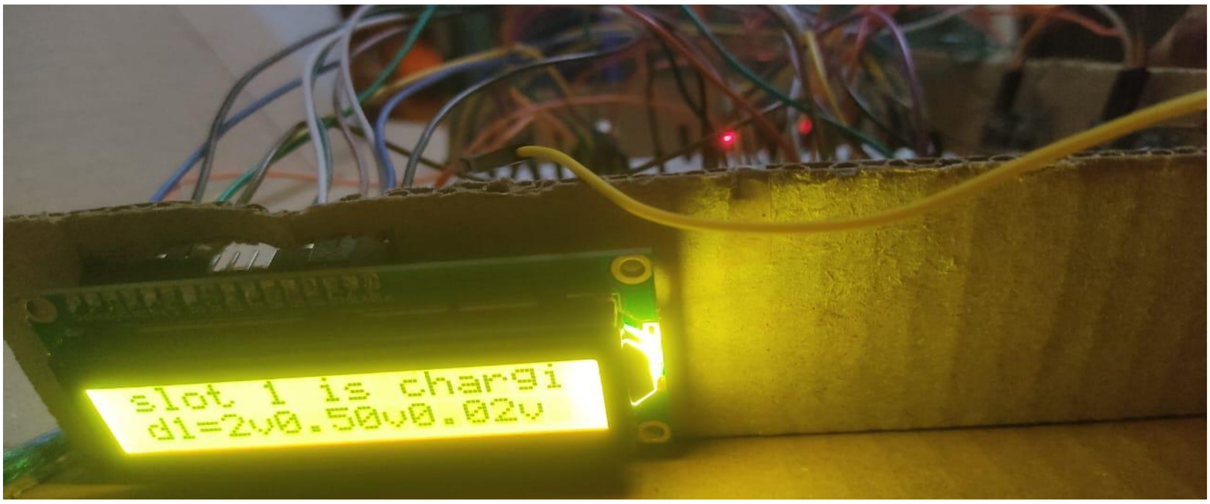
Charging of elctric vehicle

The image which demonstrates wireless power transfer to electric vehicle. when electric vehicle detects from ultrasonic sensor



Distance and Voltage readings in LCD

The image which shows the distance and voltage reading in LCD when electric vehicle charging in slot 2 of the road



CONCLUSION

The dynamically wireless charging system for electric vehicles (EVs) represents a groundbreaking advancement in sustainable transportation. This inventive technology addresses the limitations of traditional stationary charging methods, offering a promising solution.Unlike stationary methods, this system enables EVs to recharge while on the move, eliminating the need for frequent refueling stops. This improves convenience for EV owners and extends the driving range, making long journeys more feasible.

Moreover, it contributes to reducing carbon emissions and air pollution by alleviating "range anxiety" and infrastructure concerns, thus promoting EV adoption. Seamlessly integrating charging into the driving experience encourages more people to transition to electric vehicles, furthering sustainable transportation goals.

However, challenges must be acknowledged. Infrastructure investment and standardization are necessary for compatibility across various vehicle models and charging networks. Energy efficiency, electromagnetic interference, and cost-effectiveness also require careful consideration.

This wireless charging system holds great potential to transform EV charging, driven by its convenience, range extension, and positive environmental impact. Yet, successful implementation demands collaboration among governments, industry stakeholders, and researchers to overcome technical, economic, and regulatory obstacles. Addressing these challenges could position dynamically wireless charging as a pivotal force in shaping the future of sustainable transportation.

FUTURE ENHANCEMENTS

Future enhancements for dynamic wireless charging systems for electric vehicles (EVs) are poised to revolutionize the way we power our vehicles, offering greater convenience, efficiency, and sustainability. These enhancements will drive the widespread adoption of EVs by addressing key challenges and expanding the capabilities of dynamic wireless charging technology.

the pursuit of sustainable transportation solutions, the integration of solar energy into dynamic wireless charging systems for electric vehicles (EVs) holds immense promise. This innovation combines the benefits of solar power generation with the convenience of wireless charging, presenting a compelling solution for the growing EV market.

Future enhancements in this domain are poised to revolutionize how EVs are powered and charged. Dynamic wireless charging systems utilize advanced technology to transfer power between the road infrastructure and vehicles in motion. Integrating solar panels into these systems enhances their efficiency and sustainability.

Firstly, improvements in charging efficiency and power delivery will be a primary focus. Advancements in resonant inductive coupling and magnetic resonance technologies will enable higher power transfer rates, reducing charging times significantly. This will be crucial for making dynamic wireless charging systems as efficient as traditional plug-in chargers, ensuring that EV users can conveniently charge their vehicles on the go without compromising on charging speed.

Secondly, increased interoperability will be a key development area. Standardization efforts will lead to a uniform wireless charging protocol adopted by major automakers and infrastructure providers. This will ensure that a wide range of EV models can seamlessly utilize various dynamic wireless charging networks, eliminating the need for multiple incompatible charging systems.

Thirdly, integration with smart grids and renewable energy sources will enhance the sustainability of dynamic wireless charging systems. These systems will be designed to tap into renewable energy generation and grid data, enabling EVs to charge when renewable energy

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Dr. A. Singaraj
Chief Editor

e-mail : chiefeditor@eprajournals.com

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