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Research Paper

SMART EV WIRELESS POWER TRANSMISSION ALONG WITH LCD DISPLAY

KARRI PRIYA ABHINAYA[1]
Student, Dept. of Electronics and Communication Engineering Dr. Lankapalli Bullayya College, Visakhapatnam, Andhra Pradesh.

KOYI ANIL CHOWDARY[2]
Student, Dept. of Electronics and Communication Engineering Dr. Lankapalli Bullayya College, Visakhapatnam, Andhra Pradesh.

MOHAMMED NISARU ZAMA[3]
Student, Dept. of Electronics and Communication Engineering Dr. Lankapalli Bullayya College, Visakhapatnam, Andhra Pradesh.

MAJJI AKHILA[4]
Student, Dept. of Electronics and Communication Engineering Dr. Lankapalli Bullayya College, Visakhapatnam, Andhra Pradesh.

BORA NITHISH REDDY[5]
Student, Dept. of Electronics and Communication Engineering Dr. Lankapalli Bullayya College, Visakhapatnam, Andhra Pradesh.

OMMI U CH S BHAGYASRI[6].
Assistant Professor, Dept. of Electronics and Communication Engineering Dr. Lankapalli Bullayya College, Visakhapatnam, Andhra Pradesh

ABSTRACT

The increasing adoption of Electric Vehicles (EVs) has created a strong demand for charging systems that are safe, efficient, and user-friendly. This project, "Smart EV Wireless Power Transmission Along with LCD Display," presents a wireless charging system based on electromagnetic induction, enabling contactless power transfer between transmitter and receiver coils without physical cable connections. This approach enhances user convenience, minimizes wear and tear of charging connectors, and improves electrical safety. The proposed system is built around an ESP32 microcontroller, which acts as the central controller for wireless communication, motor control, and sensor data processing. A voltage sensor and an ACS712 current sensor continuously monitor battery parameters, while electrical power is calculated using $P = V \times I$. The measured voltage, current, power, and charging status are displayed in real time on a 16×2 I2C LCD and a web-based dashboard through the ESP32's built-in Wi-Fi Access Point. The dashboard also enables remote control of vehicle movement, including forward, backward, left, right, stop, and speed control. Experimental results demonstrate reliable wireless charging, accurate real-time monitoring, and efficient remote operation. The proposed prototype offers a compact, cost-effective, and intelligent solution for future smart EV charging systems, integrating Wireless Power Transfer (WPT), IoT communication, and real-time monitoring technologies.

Keywords: Electric Vehicle (EV), Wireless Power Transfer (WPT), ESP32, Electromagnetic Induction, IoT, Wireless Charging, ACS712 Current Sensor, LCD Display, Real-Time Monitoring, Smart Transportation.

1.INTRODUCTION

Electric Vehicles (EVs) are becoming increasingly popular due to their environmental benefits, improved energy efficiency, and reduced dependence on fossil fuels.

The rapid growth of the EV industry has created a demand for advanced charging technologies that are safer, more convenient, and highly reliable.

Conventional wired charging systems require physical connectors and cables, which are susceptible to wear and tear, electrical hazards, and user inconvenience. These limitations have motivated researchers to investigate Wireless Power Transfer (WPT) as a promising alternative for EV charging [1], [2].

Wireless Power Transfer is a technology that enables electrical energy to be transmitted without direct physical contact by using the principle of electromagnetic induction. In this technique, a high-frequency alternating current flowing through a transmitter coil generates a varying magnetic field, which induces an electrical voltage in a nearby receiver coil. The received energy is then rectified and used to charge the battery. This contactless charging approach enhances user convenience, minimizes maintenance requirements, and improves safety by eliminating exposed charging cables and connectors [3], [4].

The proposed Smart EV Wireless Power Transmission Along with LCD Display system integrates Wireless Power Transfer technology with an ESP32 microcontroller to develop an intelligent electric vehicle prototype. The ESP32 functions as the central controller, managing wireless communication, motor control, sensor data acquisition, and real-time monitoring. A voltage sensor and an ACS712 current sensor continuously measure battery voltage and charging current, enabling the system to calculate electrical power using the equation $P = V \times I$. This real-time monitoring allows users to evaluate battery performance and charging efficiency effectively [5], [6]. To improve user interaction, the measured parameters such as voltage, current, power, and charging status are displayed on a 16×2 I2C LCD and simultaneously transmitted to a web-based dashboard through the ESP32's built-in Wi-Fi Access Point. The dashboard also enables users to remotely control the vehicle's movement, including forward, backward, left, right, stop, and speed control functions. The integration of IoT-based communication with wireless charging enhances system flexibility and provides a user-friendly interface for monitoring and controlling the EV [7], [8].

This project combines wireless charging, IoT communication, real-time monitoring, and intelligent control into a compact and cost-effective system. It demonstrates the practical implementation of Wireless Power Transfer technology for future smart electric vehicles while providing a platform for further developments such as dynamic wireless charging, cloud-based monitoring, battery management integration, and autonomous EV charging systems. The proposed system contributes to the advancement of smart transportation technologies by improving charging convenience, operational safety, and overall system efficiency [2], [4], [8].

PROBLEM STATEMENT

The rapid adoption of Electric Vehicles (EVs) has increased the demand for safer, more efficient, and user-friendly charging systems. Conventional wired charging requires physical cable connections, which are prone to wear and tear, require manual handling, and may pose electrical safety risks, particularly in adverse environmental conditions. In addition, most traditional charging systems offer limited real-time monitoring of battery parameters and lack remote control capabilities, making it difficult for users to track charging performance and vehicle status.

To address these challenges, this project proposes a **Smart EV Wireless Power Transmission Along with LCD Display** system using **Wireless Power Transfer (WPT)** based on electromagnetic induction and an **ESP32 microcontroller**. The system enables contactless battery charging while continuously monitoring voltage, current, and power. These parameters are displayed on a **16×2 LCD** and a Wi-Fi-enabled web dashboard, allowing real-time monitoring and remote vehicle control. The proposed solution enhances safety, convenience, reliability, and supports the development of next-generation smart electric vehicle charging systems.

2.LITERATURE REVIEW

Wireless Power Transfer (WPT) has emerged as a promising technology for charging Electric Vehicles (EVs) without the need for physical electrical connections. Researchers have focused on improving charging efficiency, user safety, and convenience through inductive power transfer techniques. This section reviews the major contributions related to wireless EV charging, ESP32-based smart control, and IoT-enabled monitoring systems.

2.1 Wireless Power Transfer for Electric Vehicles

Li and Mi [1] presented a comprehensive review of wireless power transfer technologies for electric vehicle applications. Their work discusses the principles of inductive power transfer, compensation topologies, power electronics, and system efficiency. The study concludes that WPT offers significant advantages in terms of safety, convenience, and reduced maintenance, making it a promising alternative to conventional wired charging.

Covic and Boys [2] investigated modern inductive power transfer systems for transportation applications. They demonstrated that resonant inductive coupling improves power transfer efficiency while allowing energy transmission across larger air gaps. Their research established a strong foundation for the development of practical wireless charging systems for electric vehicles.

2.2 Wireless Charging Standards

The SAE J2954 standard [3] defines the technical requirements for wireless charging systems used in light-duty electric vehicles. The standard specifies operating frequencies, power levels, safety guidelines, alignment methods, and interoperability requirements. It plays an important role in ensuring compatibility and safe operation among wireless charging systems developed by different manufacturers.

2.3 ESP32-Based Smart Control Systems

Espressif Systems [4] introduced the ESP32 microcontroller as a low-cost, high-performance embedded platform with integrated Wi-Fi and Bluetooth connectivity. Due to its dual-core processor, low power consumption, and extensive GPIO support, the ESP32 has become widely used in Internet of Things (IoT) applications, including smart vehicle monitoring, automation, and remote control systems.

2.4 Current and Voltage Monitoring

The ACS712 Hall-effect current sensor developed by Allegro MicroSystems [5] provides accurate measurement of AC and DC current while maintaining electrical isolation between the sensing and control circuits. When combined with voltage sensing circuits, it enables real-time monitoring of electrical parameters and power calculation using the equation $P = V \times I$, making it suitable for battery management and charging applications.

2.5 IoT-Based Vehicle Monitoring

Bonomi et al. [6] proposed the concept of Fog Computing to improve IoT applications by processing data closer to the edge devices. Their work demonstrated that combining embedded controllers with wireless communication enables real-time monitoring, faster response, and efficient remote control. These concepts are widely adopted in modern smart transportation systems.

2.6 Battery Charging Infrastructure

Yilmaz and Krein [7] reviewed battery charger topologies and charging infrastructures for electric vehicles. Their study compared conductive and wireless charging methods, highlighting that wireless charging offers superior convenience and improved user safety, although it generally exhibits slightly lower energy efficiency than conventional wired charging systems.

3.METHODOLOGY

3.1 Overview

The proposed **Smart EV Wireless Power Transmission Along with LCD Display** system is designed to provide contactless charging, real-time monitoring, and remote vehicle control using an ESP32 microcontroller. The methodology integrates **Wireless Power Transfer (WPT)**, sensor-based monitoring, motor control, Wi-Fi communication, and an LCD display into a single intelligent system. The complete operation consists of wireless energy transfer, battery charging, parameter measurement, data processing, and remote control through a web-based interface.

3.2 System Architecture

The system consists of the following major modules:

- Wireless Power Transfer (WPT) Unit
- Battery Charging Circuit
- ESP32 Microcontroller
- Voltage Sensor
- ACS712 Current Sensor
- L298N Motor Driver
- DC Motors
- 16×2 I2C LCD Display
- Wi-Fi Communication Module
- Mobile Web Dashboard

The ESP32 acts as the central controller by receiving sensor data, processing information, controlling vehicle movement, and communicating with the user through Wi-Fi.

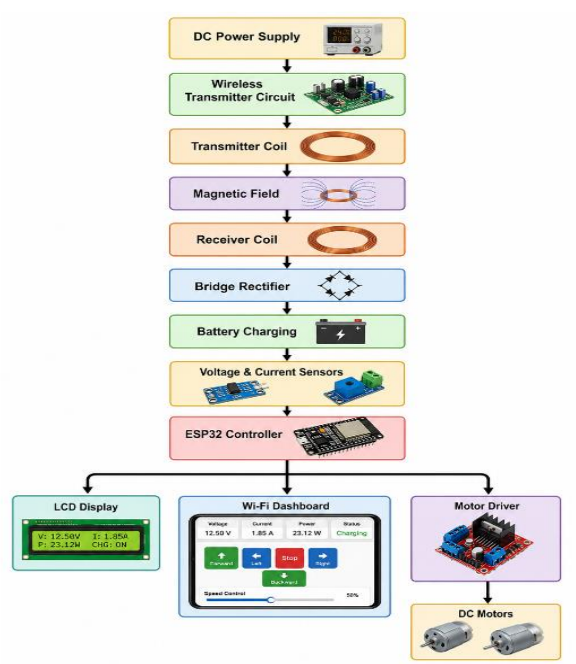
3.3 System Working Procedure

The complete operation of the proposed system is carried out through the following sequence:

1. The DC power supply energizes the wireless transmitter circuit.
2. The transmitter coil generates an alternating magnetic field.
3. The receiver coil captures the magnetic energy and converts it into electrical energy.
4. A bridge rectifier converts the received AC into DC.
5. The battery is charged using the rectified DC output.
6. Voltage and current sensors continuously measure battery parameters.

7. The ESP32 processes the sensor data and calculates electrical power.
8. The calculated values are displayed on the LCD.
9. The ESP32 creates a Wi-Fi hotspot for user communication.
10. The mobile dashboard displays real-time data and accepts control commands.
11. The ESP32 controls the L298N motor driver according to the received commands.
12. The motor driver drives the DC motors to perform the required vehicle movement.

3.4 Methodology Flow Chart



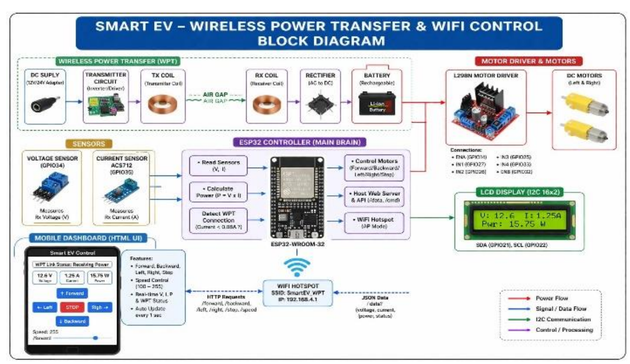
3.5 Methodology Summary

The proposed methodology integrates wireless charging, IoT communication, real-time monitoring, and intelligent motor control into a single embedded system. The ESP32 serves as the central controller, coordinating wireless power transfer, battery monitoring, web-based communication, and vehicle movement. This approach provides a compact, safe, efficient, and user-friendly solution for next-generation smart electric vehicle applications.

3.6 OBJECTIVES

- To implement **wireless power transfer** using electromagnetic induction
- To design a **contactless EV charging system**
- To enable **remote vehicle control using WiFi (ESP32)**
- To monitor **voltage, current, and power in real-time**
- To display data on **web dashboard and LCD**
- To develop a **smart and user-friendly EV system**

4.HARDWARE DESCRIPTION



3.7 The block diagram consists of the following components:

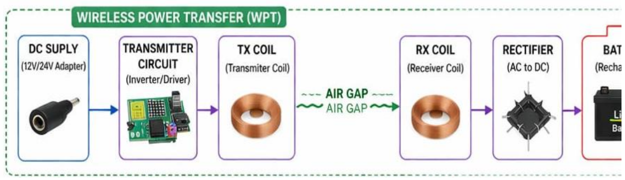
- Wireless Power Transfer (WPT) System

Motor Driver and Motors

- Sensor Module
- ESP32 Controller (Main Brain)
- LCD Display (16×2 I2C)

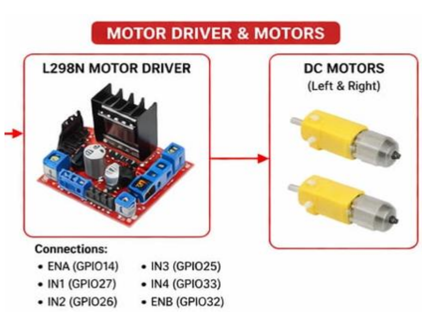
- Mobile Dashboard (HTML UI)
- WiFi Hotspot & Communication Module

3.8 WIRELESS POWER TRANSFER (WPT)



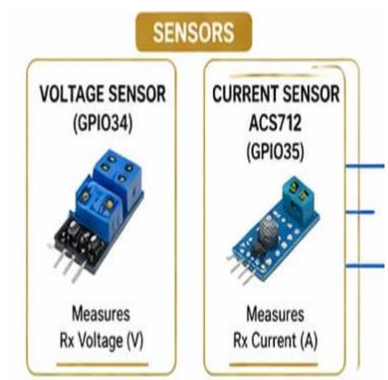
- The system uses **electromagnetic induction** for wireless charging
- DC supply provides power to the transmitter circuit
- Transmitter converts DC into high-frequency AC
- TX coil generates a magnetic field
- Energy is transferred across the air gap
- RX coil receives the magnetic field and converts it into electrical energy
- Rectifier converts AC into DC
- Battery stores the received energy

3.9 MOTOR DRIVER & MOTORS



- L298N motor driver controls the **speed and direction** of motors
- It receives control signals from the **ESP32 controller**
- Converts low-power signals into high-power output for motors
- DC motors provide movement to the vehicle
- Supports movements:
  - Forward
  - Backward
  - Left
  - Right

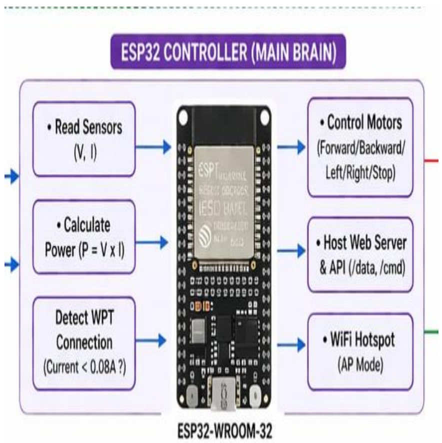
SENSORS



- Voltage sensor measures **battery voltage**
- Current sensor (ACS712) measures **current flow**
- Sensor data is sent to **ESP32 controller**
- Used to calculate **power (P = V × I)**
- Helps in monitoring:

- Battery status
- Charging condition

ESP32 Controller (Main Brain)



- ESP32 acts as the **main controller of the system**
- Reads sensor data (voltage & current)
- Calculates power using **P = V × I**
- Detects wireless charging condition
- Controls motors (forward, backward, left, right, stop)
- Hosts web server for user interaction
- Creates WiFi hotspot for communication

LCD Display (I2C 16x2)

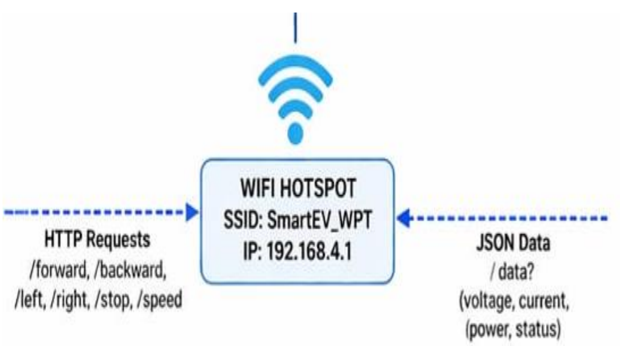
- Displays real-time system parameters
- Shows:
  - Voltage (V)
  - Current (I)
  - Power (P)
- Connected to ESP32 using **I2C communication**
- Uses only 2 pins:
  - SDA (GPIO21)
  - SCL (GPIO22)
- Provides easy on-device monitoring

Mobile Dashboard (HTML UI)

- Web-based interface for **remote control**
- Displays real-time data:
  - Voltage
  - Current
  - Power
  - Charging status

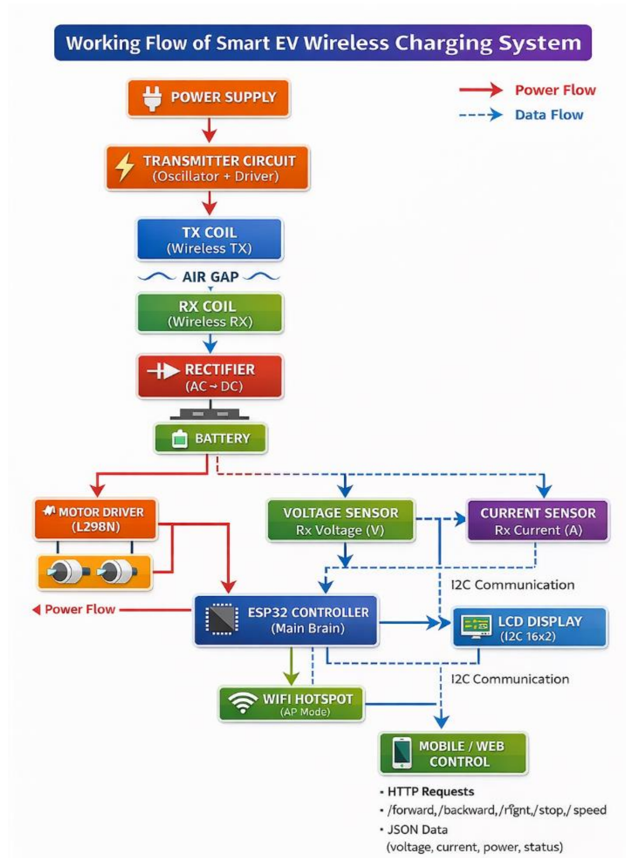
- Controls vehicle movement:
    - Forward
    - Backward
    - Left
    - Right
    - Stop
- Provides **speed control (PWM)**
- Auto-updates data continuously

WIFI HOTSPOT & COMMUNICATION



- ESP32 creates a **WiFi hotspot (AP mode)**
- Allows user to connect using mobile or laptop
- Uses IP address (e.g., **192.168.4.1**) for access
- Receives control commands via **HTTP requests**
- Sends data in **JSON format**:
    - Voltage
    - Current
    - Power
    - Status
- Enables real-time communication between user and EV

SYSTEM WORKING FLOW



- The system starts with a **DC power supply**
- Power is converted and transferred wirelessly using **transmitter and receiver coils**
- The received AC power is converted into DC using a **rectifier**
- The **battery stores energy** and supplies power to the system
- **Voltage and current sensors** measure battery parameters
- The **ESP32 controller** processes data and controls the system

- It calculates power using **P = V × I**
- The ESP32 controls the **motor driver and motors** for movement
- It creates a **WiFi hotspot (AP mode)** for communication
- Users can monitor and control the system using a **mobile/web interface**

COMPARISON – WIRED VS WIRELESS EV CHARGING

WIRED CHARGING (CONVENTIONAL EV)

- Requires **physical cable connection**
- Risk of **electric shock and wear/tear**
- Manual effort needed for plugging
- Generally **higher efficiency**
- Widely used and **commercially available**

WIRELESS Charging (Proposed System)

- **Contactless charging** using electromagnetic induction
- Safer (no exposed wires)
- **Easy and convenient to use**
- Slightly **lower efficiency** compared to wired
- Emerging technology with future potential

ADVANTAGES

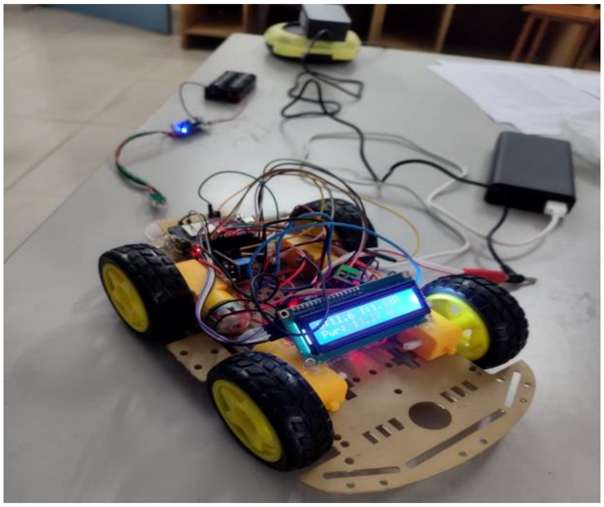
- Enables contactless wireless charging
- Enhances safety by eliminating physical connectors
- Provides real-time monitoring of system parameters
- Easy to operate with user-friendly interface
- Cost-effective and low maintenance

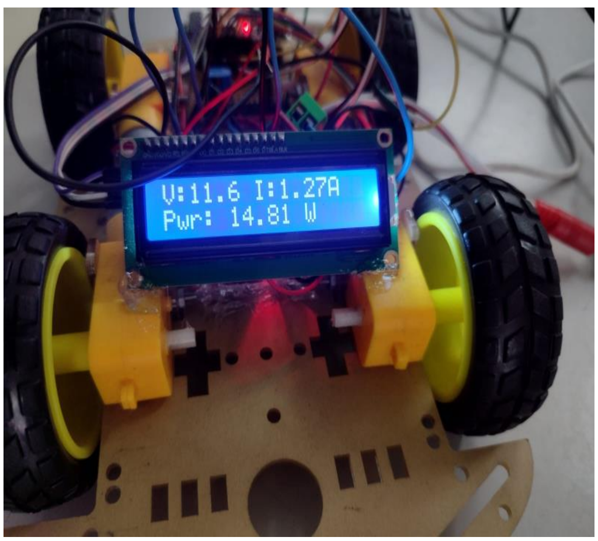
RESULTS

The proposed Smart EV Wireless Power Transmission Along with LCD Display system was successfully designed and implemented. The Wireless Power Transfer (WPT) module efficiently transferred electrical energy from the transmitter coil to the receiver coil using electromagnetic induction, enabling contactless battery charging. The receiver circuit successfully converted the received AC power into DC for charging the battery.

The ESP32 microcontroller effectively controlled the overall system by processing sensor data, managing motor operations, and providing Wi-Fi-based communication. The voltage sensor and ACS712 current sensor accurately measured battery voltage and charging current, while the system calculated real-time power consumption using the equation P = V × I.

The measured parameters, including voltage, current, power, and charging status, were displayed successfully on the 16×2 I2C LCD as well as on the web-based dashboard. The Wi-Fi interface enabled users to remotely monitor system performance and control vehicle movement (forward, backward, left, right, stop, and speed control) through a mobile device or laptop. Experimental results confirmed stable wireless charging, reliable real-time monitoring, and smooth remote operation. The developed prototype demonstrated improved user convenience, enhanced electrical safety by eliminating physical charging connectors, and effective integration of wireless charging with IoT-based monitoring and control. These results indicate that the proposed system is suitable as a prototype for future smart electric vehicle charging applications.





CONCLUSION

The **Smart EV Wireless Power Transmission Along with LCD Display** project successfully demonstrates a contactless charging system for electric vehicles by integrating **Wireless Power Transfer (WPT)**, an **ESP32 microcontroller**, real-time monitoring, and IoT-based remote control. The system effectively transfers electrical energy through electromagnetic induction, eliminating the need for physical charging cables and improving user safety and convenience.

The ESP32 efficiently manages wireless communication, motor control, and sensor data processing. Voltage and current sensors accurately monitor battery parameters, while the calculated power consumption is displayed in real time on both the **16×2 I2C LCD** and the web-based dashboard. The Wi-Fi interface allows users to remotely monitor charging status and control vehicle movement, making the system intelligent and user-friendly.

The developed prototype achieved reliable wireless charging, stable communication, and efficient real-time monitoring, demonstrating the feasibility of integrating wireless charging technology with IoT-based vehicle control. Although the wireless charging efficiency is slightly lower than that of conventional wired charging, the advantages of improved safety, reduced maintenance, and enhanced user convenience make it a promising solution for future electric vehicles.

Overall, the proposed system provides a compact, cost-effective, and scalable platform for next-generation smart EV charging applications. Future enhancements such as higher-power wireless charging, dynamic charging while the vehicle is in motion, cloud-based monitoring, battery management integration, and AI-based energy optimization can further improve the system's performance and support the development of intelligent transportation systems.

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