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Dynamic Wireless Charging for Electric Vehicles Using Copper Coils

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***Abstract*—This paper presents the design and development of a wireless electric-vehicle charging system based on intelligent control and wireless power transfer. The proposed system enables an electric vehicle to charge dynamically while in motion, eliminating the need for physical connectors. It focuses on the use of inductive coupling and IoT-based monitoring to improve convenience, efficiency, and automation. A laboratory prototype demonstrates real-time wireless charging, automatic billing, and gate control via smartphone.**

***Index Terms*—Wireless Power Transfer, Inductive Coupling, Automated Gate Control, Dynamic Charging, IOT.**

I. Introduction

The transportation sector is one of the largest contributors to global energy consumption and environmental pollution, accounting for more than half of world's oil consumption and nearly a quarter of CO2 emissions. These emissions contribute significantly to the greenhouse effect and climate change. As a sustainable alternative, electric vehicles (EVs) have gained popularity due to their potential to reduce dependence on fossil fuels and minimize transportation-related pollutants.Despite advances in EVs technology, including improved battery capacity and driving range, charging infrastructure remains a major challenge. Many users experience range anxiety and are discouraged by the time required to recharge batteries, especially during long trips. To support the widespread adoption of electric vehicles, innovative charging solutions are essential.Dynamic wireless charging offers a promising solution that allows electric vehicles to charge while in motion. Unlike static charging systems that require vehicles to stop and connect to a power source, dynamic wireless charging uses magnetic induction to transfer energy across an air gap. The transmitter coils embedded beneath the road surface generate a time-varying electromagnetic field, which is captured by the receiver coils installed on the vehicle. This allows continuous contactless power transfer without interrupting travel.Wireless power transmission (WPT) eliminates the need for physical connectors, improving safety, mobility, and convenience. It is especially useful in environments where wired connections are impractical or hazardous. EV wireless charging technologies are generally.

A. classifications of Wireless Charging:

1. Static Wireless Charging: The vehicle charges while stationary, typically in a garage or designated parking space. The transmitter is installed underground, and the receiver is mounted on the vehicle's undercarriage. Charging efficiency depends on coil alignment, pad size, and power levels.

2. Dynamic Wireless Charging: The vehicle charges while driving over embedded coils in the road. This method reduces the need for large embedded batteries, alleviates range anxiety, and supports uninterrupted travel.

This project explores the design and implementation of a dynamic wireless EV charging system, incorporating smart features such as mobile-based payment and automated gate control to improve customer experience and promote sustainable transportation.

II. LITERATURE SURVEY

Dr.K.Shivarama Krishna et al [1] (2022). Integrating features of all the hardware components used have been developed in it. Presence of every module has been reasoned out and placed carefully, thus contributing to the best working of the unit. Secondly, using highly advanced IC's with the help of growing technology, the project has been successfully implemented. Thus the project has been successfully designed and tested. The offered solution produced less ripple in input/ output voltage and current while utilizing a low value of dc link, and filter capacitance values, respectively

Mohammed Aleem et.al [2] (2022) This project presents wireless power charging to an electric vehicle (EV). The concept of wireless power transmission was introduced by nikola tesla. Now-a-days electric vehicles involves in large range of vehicles which includes two Wheeler, three wheeler and cars. This paper deals with research and development of wireless charging systems for Electric vehicle using wireless power transmission.

Dr.V.Raveendra Reddy et al.[3] (2023) Advanced Charging System For Automobiles. Wireless charging is one of the most convenient charging infrastructures for electric vehicles. It is expensive, but still attracts many researchers. Because electric

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vehicles can drive for many hours without stopping to charge, they become truly autonomous. Perhaps the most exciting aspect is that electric vehicles equipped with wireless charging technology on the go can have significantly smaller batteries. As a result, this technology reduces both the environmental impact and the cost of introducing electric vehicles.

Akash Kharpude et al.[4] (2023) This paper proposes a wireless charging system for electric vehicles (EVs) that aims to address the limitations of traditional plug-in charging systems. The wireless charging system utilizes inductive power transfer technology to transfer energy wirelessly between the charging pad and the EV battery.

Chirag Panchal, Sascha Stegen, Junwei Lu et al [5] (2018) provides a comprehensive review of both static and dynamic wireless charging technologies for electric vehicles. It discusses the principles of inductive power transfer, system architectures, and the technical challenges involved. The authors highlight dynamic charging as a promising solution to extend driving range and reduce battery size, while also addressing infrastructure and safety considerations.

Haijian Sun, Xiang Ma, Rose Qingyang Hu, and Randy Christensen [6], focuses on improving coil alignment in dynamic wireless charging for electric vehicles using RFID sensing. Their approach enhances lateral and vertical misalignment detection with coherent phase detection and a maximum likelihood estimation algorithm, achieving sub-10 cm precision. Through experimental validation, they demonstrate significant improvements in wireless power transfer efficiency, addressing key challenges in EV charging infrastructure.

III. PROPOSED SYSTEM ARCHITECTURE

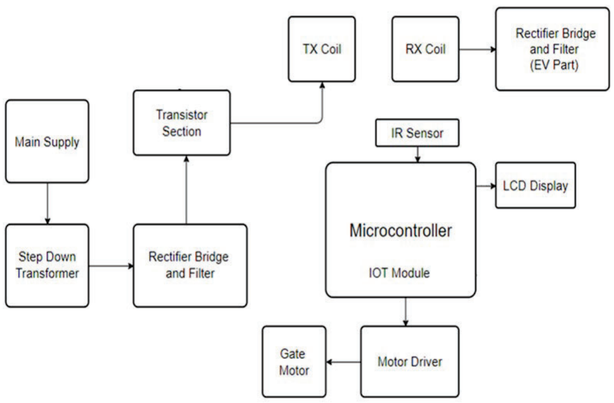

Fig. 1. Block Diagram

The system has two physical domains: Road-side Transmitter Domain (power generation and control embedded under the road) and Vehicle Receiver Domain(onboard receiver coil, control electronics).An IoT Backend handles billing, and remote control. A local Gate Control interacts with payment status to allow exit.

A. Methodology

- As shown in the block diagram, Main Supply is the input and starting point of our implementation. When power is supplied to the transistor,it will start switching and generate the wireless power with help of copper coils.
- The EV carries a receiver coil to pick up energy inductively without physical contact.
- A NodeMCU microcontroller manages system control, billing, and communication with a mobile device.
- An LCD displays IP Address and payment status.
- After payment confirmation, the gate motor activates for vehicle exit.

IV. HARDWARE AND SOFTWARE REQUIREMENT

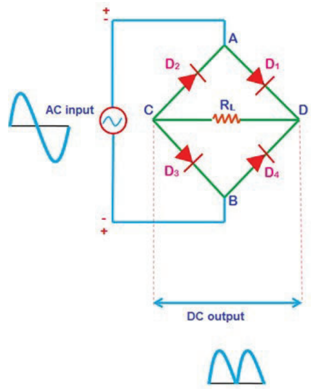

Fig. 2. Bridge Rectifier

A bridge rectifier consists of four diodes (D1–D4) and a load resistor R_L, arranged in a closed-loop bridge topology to convert alternating current (AC) into direct current (DC) efficiently. This configuration eliminates the need for a center-tapped transformer, thereby reducing both cost and physical size. During each half-cycle of the AC input, two diodes conduct to direct current through the load, ensuring full-wave rectification with improved output characteristics. A PCB-

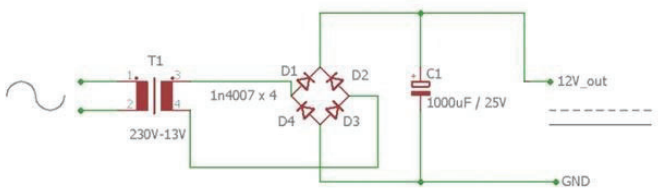

Fig. 3. Power Supply section

mounted step-down transformer rated at 230V AC to 12V AC, 1A, is employed to reduce the input voltage. The secondary

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output is rectified using four 1N4007 diodes configured in a full-wave bridge topology. This arrangement converts the 12V AC into pulsating DC. A filter capacitor C_1 is connected across the output to smooth the rectified signal and reduce ripple. Under load conditions, the transformer output voltage may drop slightly from its nominal 12V rating.

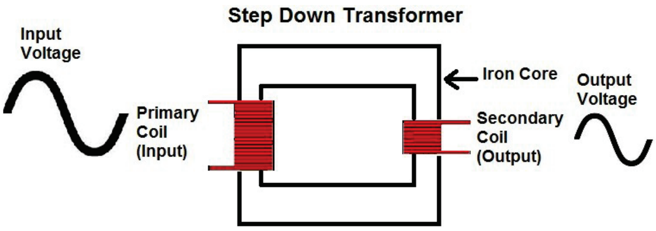

Fig. 4. Step Down Transformer

- Microcontrollor (Arduino Uno)

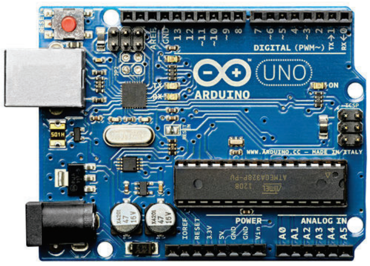

Fig. 5. Arduino Uno

Arduino Uno serves as a control unit in dynamic wireless charging systems for electric vehicles. It manages coil activation, vehicle detection, and power regulation using sensor inputs and switching logic. This enables efficient energy transfer via copper coils embedded in road infrastructure.

- IoT Module(NodeMCU) NodeMCU is an open-source

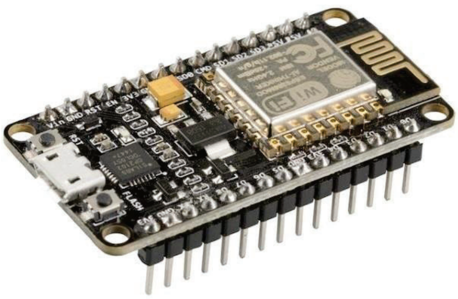

Fig. 6. IOT Esp8266 Node MCU

IoT platform based on the ESP8266 Wi-Fi SoC and ESP-12 module. It supports Lua scripting and offers built-in Wi-Fi, making it ideal for cloud-connected IoT development. Arduino compatibility and compact design enable versatile integration with gateways and remote services.

- LCD Display

Fig. 7. LCD Display 16x2

LCD modules are widely used in embedded systems for visual output due to their low cost, programmability, and support for custom characters. A standard 16×2 LCD operates with two registers: the command register and the data register. The Register Select (RS) pin determines the active register—RS = 0 selects the command register for control instructions (e.g., clear display, cursor positioning), while RS = 1 selects the data register for displaying ASCII characters. This dual-register architecture enables efficient control and data handling for dynamic display applications.

- IR Sensor

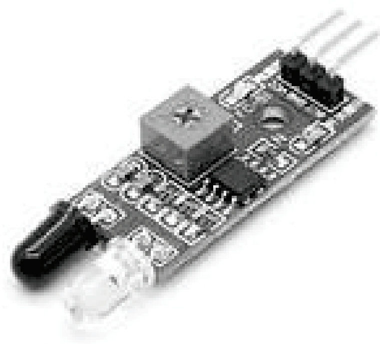

Fig. 8. IR Sensor

Infrared sensors are widely used in consumer electronics and industrial applications for motion detection, obstacle sensing, and thermal measurement. IR radiation spans wavelengths from 0.75µm to over 1000µm, categorized into near-, mid-, and far-infrared regions. IR sensors operate by detecting thermal radiation emitted by objects, invisible to the human eye. A typical IR sensor comprises an IR LED (transmitter) and an IR photodiode (receiver), forming an optocoupler. The photodiode's resistance and output voltage vary with incident IR intensity. Sensors are classified as active (with transmitter and receiver) or passive (receiver only). Active sensors include reflectance and break-beam types, while passive sensors include pyroelectric detectors and bolometers. The IR sensor circuit typically includes an LM358 IC, IR emitter-receiver pair, resistors, and indicator LEDs. These modules are essential in embedded systems for proximity sensing and automation.

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- Servo Motor

Fig. 9. Servo Motor

In dynamic wireless charging for electric vehicles, servo motors are employed to precisely align the receiver coil with the transmitter coil embedded in the roadway. This alignment maximizes inductive coupling efficiency during motion. Servo motors enable real-time mechanical adjustments based on sensor feedback, ensuring optimal energy transfer and system reliability.

- Transistor

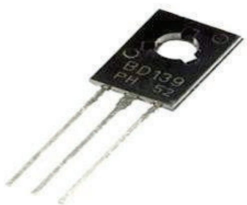

Fig. 10. Transistor

The BD139 is a medium-power NPN bipolar junction transistor (BJT) housed in a SOT-32 plastic package. It supports collector currents up to 1.5A and collector-emitter voltages up to 80V, making it suitable for driving loads such as motors, relays, and high-power LEDs. With a power dissipation of 12.5W and a low saturation voltage of 0.5V, it is commonly used in audio amplifier and switching applications. Pin Configuration
Pin 1 (Emitter): Connected to ground, drains current
Pin 2 (Collector): Connected to load, supplies current
Pin 3 (Base): Controls transistor biasing and switching

- Copper Coils

Fig. 11. Copper Coils

Copper coils are fundamental to dynamic wireless charging systems for electric vehicles. Transmitter coils embedded in the roadway generate alternating magnetic fields, while receiver coils in the vehicle capture this energy via resonant inductive coupling. Copper's high conductivity ensures efficient power transfer, enabling continuous charging as the vehicle moves over the coils.

- PCB Board

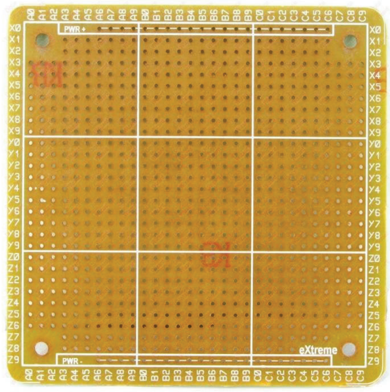

Fig. 12. PCB Board

General-purpose PCBs support flexible circuit prototyping without predefined tracks. BD139 is a medium-power NPN transistor ideal for switching and amplification up to 1.5A.

- Software (Arduino IDE)

Fig. 13. Arduino IDE

Arduino IDE is an open-source software platform used for writing, compiling, and uploading code to Arduino microcontroller boards. It supports C/C++ and generates a HEX file from user-written sketches for execution on devices such as Arduino Uno, Mega, and Leonardo. The IDE includes a text editor, compiler, and output pane, along with integrated tools for debugging and serial communication. Its intuitive interface and cross-platform compatibility make it ideal for embedded system development and rapid prototyping.

V. RESULT

The prototype successfully demonstrated dynamic wireless charging. The receiver coil efficiently received power across an

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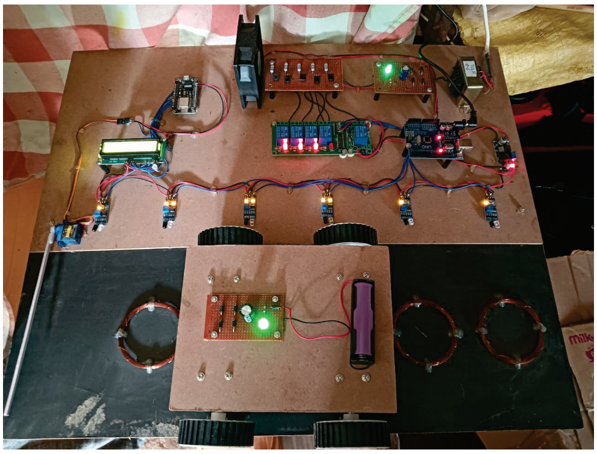

Fig. 14. Result

air gap, and the LCD displayed charging status and payment details. After successful payment through the IoT module, the gate motor operated automatically.The system showed stable power transmission and minimal energy loss. Dynamic charging reduces downtime and increases efficiency.

VI. Conclusion

This project presents a functional prototype of a dynamic wireless charging system designed for electric vehicles (EVs). The system utilizes resonant inductive coupling between copper coils embedded in the roadway and receiver coils mounted on the vehicle to enable continuous power transfer while in motion. This eliminates the need for stationary charging stops, thereby enhancing convenience and operational efficiency. Integrated IoT-based monitoring enables real-time data acquisition, system diagnostics, and remote control, contributing to improved automation, safety, and energy management. The combination of wireless power transfer and intelligent sensing forms a scalable solution for future smart transportation infrastructure.

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