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Electric Vehicle Wireless Charging on the Go

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Abstract-

The need of efficient, continuous charging solutions is rising in relation to the rising use of electric vehicles (EVs). Traditional plug-in charging facilities sometimes need extended vehicle stops, exacerbating range anxiety among electric vehicle users and leading to unnecessary delays. Wireless road charging, also known as Wireless Power Transfer (WPT), circumvents these limitations by enabling automobiles to charge on the go over wireless equipment already established in the road.By combining Bluetooth-operated robotic cars with wireless charging technology, the proposed technique provides an innovative and creative way to simulate real-life electric vehicle charging scenarios. The system's two primary components are the Vehicle Charging Unit (VCU) and the Vehicle Controlling Unit (VCU). Through the use of inductive coupling, the charging unit converts the electromagnetic field into useable electric power for storage. This energy is transferred from coils buried under the road surface to the receiving coil in the car. Electric vehicle (EV) charging, inductive coupling, wireless power transfer, dynamic charging, and related terms

I. INTRODUCTION

Electric vehicles (EVs) are revolutionizing the transportation industry by offering a cleaner, more eco-friendly alternative to traditional cars powered by internal combustion engines. However, huge hurdles to the widespread adoption of EVs include the inconvenience and unavailability of static charging stations. Electric car drivers sometimes have "range anxiety," or concern about the distance their vehicle can go between charges, due to the long pauses and charging durations needed by these stations.A game-changing solution to these limitations is wireless power transfer (WPT) technology, which is gaining increasing recognition. To enable electric vehicles to charge wirelessly while driving, WPT employs an inductive connection between coils buried under the road and receiver coils located within the vehicle. This kind of dynamic charging facilitates longer-distance travel by eliminating the need for frequent stops, which substantially improves the user experience. Aside from making things easier, the system also encourages people to use less energy and supports the development of smart transportation networks.A game-changing solution to these limitations is the emerging field of wireless power transfer (WPT). Using an inductive connection between coils placed under the road and receiver coils fitted inside the automobile, WPT enables wireless charging of electric vehicles while they are in motion. This kind of dynamic charging improves the user experience and makes long-distance travel more viable by eliminating the need for frequent breaks. Not only does the system make life easier, but it also encourages smart transportation infrastructure development and energy efficiency.

1.1 WIRELESS POWER TRANSFER (WPT)

Wireless power transfer (WPT) eliminates the need for traditional conductive lines and wires to transmit electrical energy from one place to another. This is achieved by transferring power using electromagnetic fields, which include electric fields, resonance, and magnetic induction. On the load side of a typical WPT system, a receiver picks up an electromagnetic field that is generated by a power source, or transmitter. After capturing energy, the receiver turns it back into electricity.This technology has been studied for a variety of applications, from small-scale charging devices like electric toothbrushes and cellphones to larger systems designed to power vehicles and other high-power machinery. A few advantages of WPT systems are the elimination of physical connections, reduced wear and tear, and a cleaner, safer environment as a result of the reduced hazards of exposed electrical cable. A more flexible and reliable energy transmission method is required on a global scale, making WPT a promising area for research and development because to its efficiency and practicality.

1.2 ELECTRIC VEHICLE (EV) CHARGING

Electric vehicle (EV) charging refers to the procedure of supplying electrical energy to the battery of an EV. The electric motor of an electric car gets its power from a battery pack, as opposed to the internal combustion engine of a traditional gas-powered vehicle. An integral part of the electric vehicle ecosystem, charging infrastructure determines whether EVs can become a mainstream form of transportation. There are a variety of charging systems available to accommodate the demands of electric vehicle users.From home charging stations that allow users to fuel their vehicles overnight to public charging networks that provide fast-charging alternatives at important locations, there is a wide variety of options. A charger's ability to efficiently charge an electric car depends on its charging method, power output, and the technology used to connect the charger to the vehicle. Improving charging speeds, extending battery life, and developing more flexible systems to accommodate the growing number of electric vehicles are the main objectives of research into electric vehicle charging infrastructure. Concerns about climate change and fossil fuel depletion have increased the urgency of developing efficient, cost-effective, and widely accessible electric vehicle charging infrastructure.

1.3 DYNAMIC CHARGING

Unlike conventional charging methods, dynamic charging enables the transmission of energy to a moving vehicle or device without the requirement for the device to remain stationary. The basic premise is to embed energy-transmitting technologies along a route, such a roadway, rail, or conveyor belt, so that moving machinery or vehicles may be powered continuously. Dynamic charging gets rid of the need to stop or wait for recharging since energy is effortlessly provided while movement happens.This may significantly alleviate the problems created by range constraints, as electric vehicles wouldn't have to stop for lengthy charging periods. Capacitive charging, inductive coupling, and other electromagnetic field-transfer techniques are common in dynamic charging systems. This plan has the potential to revolutionize city infrastructure by creating "smart" roads that can directly tap into underground power sources, which would improve transportation networks' operating performance. This is considered a forward-thinking approach to problems like the accessibility of charging infrastructure and the duration of current charging processes.

1.4 INDUCTIVE COUPLING

One method of wireless energy transfer is inductive coupling, which uses a pair of coils—one for transmission and one for reception. The process begins when an alternating current in the transmitting coil induces a current in the surrounding receiving coil, creating a magnetic field. A nearby conductor will experience a voltage when the magnetic field changes, according to the electromagnetic induction principle, which is the basis of this approach. The efficiency of an inductive connection is dependent on the size, alignment, and closeness of the coils.Industrial machinery, medical devices, and wireless charging systems for portable electronics are just a few of the many uses for inductive coupling.

Its benefits include a decrease in connector wear and tear, an elimination of hazards associated with exposed wires, and the elimination of the need for direct physical connections. This technology is ideal for use in environments where conventional connections are susceptible to moisture, corrosion, or dirt since it does not need physical contact and is therefore more durable. The ever-increasing need for safe and simple energy transmission has prompted research into inductive coupling for larger-scale applications like charging electric cars or powering distant equipment in challenging environments.

II. LITERATURE REVIEW

Wireless power transmission (WPT) is becoming more important in modern energy systems, and this paper by Patakula Eekshita et al. lays out the basic notions of WPT. They examine the historical development of WPT, focusing on significant technologies like as capacitive and inductive coupling, and their applications in areas such as electric vehicles, home electronics, and industrial automation. Wireless systems have less maintenance expenses and are more convenient, but the research also tackles concerns like energy efficiency and alignment sensitivity [1].

Effective mid-range wireless power transmission is proposed by Muhammad Furqan Haider et al. in this study by using magnetic resonance coupling. Resonant frequency matching between the transmitter and receiving coils significantly enhances energy transfer rates and allows for more flexible alignment, in contrast to typical inductive approaches, as shown in the research. Applications in areas including consumer electronics, medical devices, and electric vehicle dynamic charging are being studied with a focus on scalability, efficacy, and safety [2].
A comprehensive review of current advances and future directions in wireless power transmission (WPT) technology is proposed by Sagolsem Kripachariya Singh et al. in this article. They cover several WPT technologies, including inductive, capacitive, resonant, and microwave-based systems, and discuss their advantages, disadvantages, and real-world applications in fields such as healthcare, transportation, and renewable energy. Important challenges, such as cost, efficiency, and electromagnetic interference, are also highlighted in the report in an effort to encourage more innovation in the sector [3]. A wireless charging device based on coupled magnetic resonators has been proposed by Qiang Wang et al. to enable efficient energy transmission across short to medium distances. Electric vehicles (EVs) using charging lanes will find this technology particularly useful since it allows dynamic charging without the need for physical connections. In their analysis of the system's performance under different alignment and distance scenarios, the authors provide optimization approaches for coil design, resonant frequency tuning, and power management circuits [4].
The authors of this study, Vikash Choudhary et al., envision a future where ubiquitous wireless energy access is the norm and state that contemporary civilization is totally reliant on power. The authors highlight the problems with wired infrastructure and argue that WPT will revolutionize energy supply in the future. This study lays the groundwork for future WPT studies, which will be particularly useful in far-off and portable contexts, such as solar power in space and charging electric vehicles [5].

III. EXISTING SYSTEM

The present electric vehicle (EV) charging infrastructure is mostly comprised of static plug-in charging stations. These stations require automobiles to come to a complete stop and connect to a power supply for a certain duration in order to recharge their batteries. Despite the development of fast-charging stations, vehicles still need to come to a complete stop before they can be charged. This method makes users feel even more anxious about their battery life, especially on lengthy trips. Additionally, in areas where there aren't enough charging stations, the infrastructure for EVs is stressed because of the frequent charging pauses that are required.Additionally, existing wireless charging solutions are either still in their infancy or have limited use due to their dependence on fixed inductive charging pads that need exact positioning over a charging coil. Although these systems eliminate cables and connections, they still only work in a static mode and can't charge when moving or under certain conditions. Alignment issues, inefficient power transmission, and infrastructure costs are only a few of the significant technical issues that persist with present systems. Consequently, there is a growing need for more advanced and versatile charging systems that can work even while cars are in motion. These systems should provide real-time energy transfer and improve the overall user experience of electric vehicles.

IV. PROPOSED SYSTEM

The proposed technology aims to revolutionize EV charging by introducing Wireless Road Charging, which enables EVs to charge while driving. Wireless power transfer (WPT) uses inductive or magnetic resonance coupling to do this. Subterranean transmitting coils generate an electromagnetic field, which the electric vehicle's receiver coils take up. Transforming the incoming energy into electrical power is the next step in charging the battery. This innovation effectively solves the problems associated with static charging, such as the need to wait at charging stations and the consequent worry about running out of juice.Two VCUs—a Vehicle Charging Unit and a Vehicle Controlling Unit—make up the system, which incorporates this technology for testing and modeling purposes. The Vehicle Charging Unit's job is to wirelessly charge the moving vehicle by drawing energy from the road surface. A transmitting coil generates a magnetic field whenever an automobile drives over it. To mimic the dynamic charging of a real electric car, the vehicle's receiver coil absorbs and stores this energy.Alternatively, the Vehicle Controlling Unit is a Bluetooth-enabled robotic automobile that drives itself in an electric car-like fashion. It can move in both directions, forward and backward, thanks to its two motor drivers and motors. With its built-in transmission coils, the VCU is set up to follow a designated charging lane. Using a smartphone app or a Bluetooth-enabled joystick, researchers may remotely manage the vehicle's progress along the charging route, allowing them to monitor its behavior and energy reception in real-time.Compared to the current state of traditional charging infrastructure, the proposed method is more efficient, less harmful to the environment, and more intelligent. It demonstrates that future electric transportation choices for dynamic charging are viable when WPT technology is combined with autonomous vehicle control. By implementing this plan, we can promote the continuous operation of electric vehicles, reduce the need for extensive charging infrastructure, and pave the way for smart transportation networks. It also paves the path for more advanced urban transportation systems, where the roads may theoretically provide energy to moving

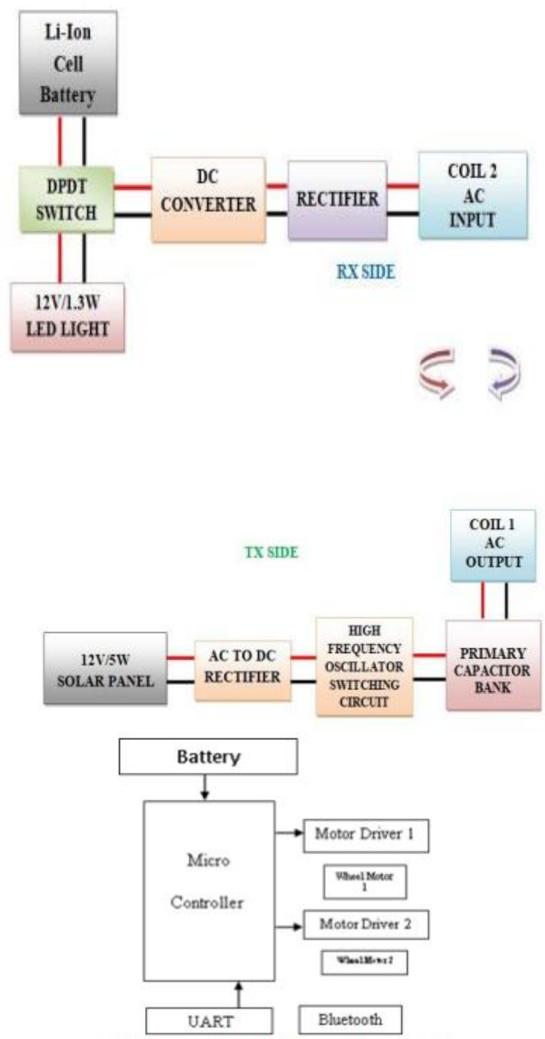

FIGURE 1. BLOCK DIAGRAM

vehicles.

V. WORKING
ARDUINO

One of the main components of the Arduino Uno board is the ATmega328. Elements such as a 16 MHz crystal oscillator, 6 analogue inputs, 14 digital I/O pins (including 6 PWM outputs), a USB port, a power connector, an ICSP header, and a reset button are all part of its technical specifications. To begin, just connect it to a computer using a USB connection, or power it with a battery or an AC-to-DC converter; everything needed to support the microcontroller is supplied. What distinguishes the Uno from all its predecessors is that it does not make use of the FTDI USB-to-serial driver chip. Instead, it's set up using the Atmega8U2 as a converter from serial to USB. "Uno" means "one" in Italian, and it was selected to celebrate the upcoming release of Arduino 1.0.

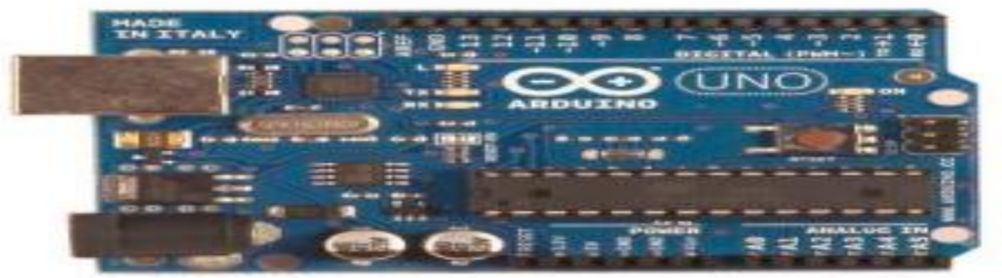

FIGURE 1. ARDUINO

POWER
In order to power the Arduino Uno, you may either use an external power supply or connect it to a USB port. The choice of the power source is made automatically. For power that doesn't come from a USB port, you may use a battery or an AC-to-DC converter. Enter the board's power jack with a 2.1mm center-positive connection to attach the adaptor. The Gnd and Vin pin headers of the POWER connection may accept battery leads. You may charge the board using an external power supply that has a voltage range of 6 to 20 volts. On the other hand, the board can become unstable and the 5V pin might not provide 5 volts if the voltage is below 7V.

BATTERY
One way to store chemical energy is in electrochemical cells; a battery can convert this into electrical energy. Ever since Alessandro Volta created the first battery (or "voltaic pile") in 1800, and especially after the highly developed Daniell cell was created in 1836, batteries have grown to be a common power source for several household and commercial uses. The worldwide battery industry is reportedly expanding at a rate of 6% per year and is valued at US$48 billion, according to a 2005 estimate. The main kind of battery is designed to be used once and then discarded; on the other hand, the secondary kind is designed to be recharged and used several times.

FIGURE 2. BATTERY

UART
The term "UART" (pronounced /ˈjuːɑrt/) refers to a piece of computer hardware that can convert data from one format to another. For the most part, UARTs work with common communication protocols such as TIA (formerly EIA), RS-232, RS-422, or RS-485. The data format and transfer rates are both modifiable thanks to the universal designation. The parameters and methods of electric communication (differential signaling, etc.) are controlled by a driver circuit that is external to the UART.For serial communications via a computer or peripheral device's serial port, a typical UART is a single integrated circuit (IC) or a component of an IC. In modern microcontrollers, UARTs are commonplace. A dual UART, sometimes known as a DUART, is a single chip that incorporates two UARTs. One device that incorporates eight UARTs into one is the NXP SCC2698, which is also known as an octal

UART or OCTART. Many modern integrated circuits (ICs) have a UART that can also communicate synchronously; these devices are called USARTs, which stands for universal synchronous/asynchronous receiver/transmitter.

L293D MOTOR DRIVER IC

The L293D H-bridge driver is the industry standard for applications requiring bidirectional motor driving. This L293D IC allows a DC motor to operate in either direction. The L293D, a 16-pin integrated circuit, allows for the simultaneous control of two DC motors in either direction. It shows that two DC motors may be driven by a single L293D IC.
because it incorporates a pair of H-Bridge circuits. Additionally, the L293D can power big, whisper-quiet motors. There are many ways to construct control circuits for H-bridge motors. Some of these approaches include using relays, transistors, and L293D/L298. Before getting into the details, let's have a look at how the H-Bridge circuit is defined.

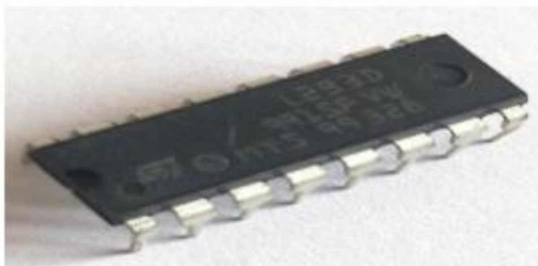

FIGURE 3. MOTOR DRIVER

DC MOTOR

Direct current (DC) motors are devices that convert electrical energy into mechanical energy. As this article has shown, engineers should not only thoroughly investigate the behavior of the DC motor, but also consider how important it is for the current industry. Understanding the dc motor's operation requires an analysis of its structural characteristics.The basic layout of a direct current motor (dc motor) is as shown in the figure below: a current-carrying armature is placed between the permanent or electromagnetic poles and linked to the supply end via commutator segments and brushes. To understand the DC motor's operation in its entirety, one must be familiar with Fleming's left-hand rule, which determines the direction of the force exerted on the armature conductors of the motor.

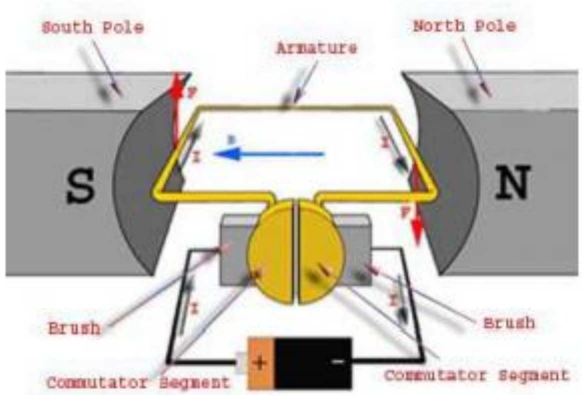

FIGURE 4. DC MOTOR

VI. IMPLEMENTATION

Three main modules make up the system's implementation: Mobility & Drive, Intelligent Control, and Energy Generation & Management. A step-down transformer is used to turn 230V AC mains electricity to a more secure 12V AC in the Energy Generation & Management Unit. After passing the AC via a bridge rectifier and a smoothing capacitor, the resulting DC voltage is ready for use. Electronic components like microcontrollers and sensors rely on a steady supply of voltage, which is provided by a voltage regulator like the 7805 or 7812. A high-frequency oscillator and switching circuit further process the DC supply, transforming it into high-frequency AC for wireless power transfer. The first transmitter coil (Coil 1) relies on a primary capacitor bank to keep the current constant and allow for short bursts of energy. A Li-Ion battery stores the converted DC power once the secondary coil (Coil 2) wirelessly receives it from the transmitter. The other components of the system, including the motors, control circuits, and LEDs, are powered by this battery. A microcontroller, such an ESP32 or Arduino Nano, forms the central nervous system of the Intelligent Control Unit. It controls and communicates with the rest of the system and runs on the energy that the Li-Ion battery stores. The microcontroller may establish wireless connection with a smartphone or distant device by connecting a Bluetooth module (HC-05 or HC-06) via UART. The Arduino IDE is used to program the microcontroller using Embedded C, which can comprehend instructions like turning on and off LEDs or controlling movement in a certain direction. A motor driver circuit (e.g., L298N) receives these instructions and converts them into signals that the system's two DC motors use to move. Remote control of motion is made possible via the Mobility & Drive Unit, which may be activated by sending out Bluetooth instructions such as forward, backward, left, right, and stop. In order to ensure effective mobility and ongoing operation, the system also incorporates wireless charging, which allows the battery to be recharged via the receiver coil without physical connections.

VII. RESULT ANALYSIS

Evaluation was based on the system's ability to demonstrate controlled movement along a specified route and wireless energy transmission. Following the charging unit's successful energy transfer across the air gap, the receiver coil efficiently gathered and stored the transmitted energy. A continual electromagnetic interaction between the transmitter and receiver ensured that the vehicle model received energy at all times while it was in motion.As it faithfully followed the planned path, the Bluetooth-controlled car showcased its seamless navigation and consistent alignment with the implanted transmitting coils. As an example of how well wireless charging and remote-controlled navigation work together, the system kept receiving energy even when the direction changed. Small misalignments did not significantly impact the energy transmission, proving the coupling design's longevity. Overall, the system demonstrated the viability of wireless dynamic charging, highlighting its promise as a greener and more efficient alternative to regular stationary charging methods.

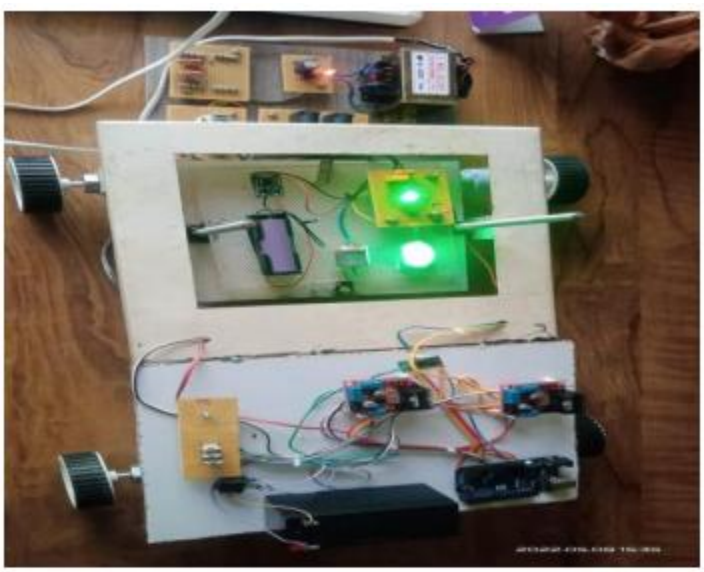

FIGURE 5. OUTPUT

VIII. CONCLUSION

The proposed method represents a significant improvement to the EV infrastructure as it provides a functional prototype of wireless road charging using inductive coupling. It improves customer convenience and advances sustainable transportation goals by allowing a continuous energy supply while a vehicle is in motion, which eliminates traditional difficulties like long charging periods, station dependence, and restricted trip range.There seems to be a practical and feasible experimental usage for the system's two-module design, which comprises a Bluetooth-operated Vehicle Controlling Unit for simulating vehicle movements and a Vehicle Charging Unit for inductive energy transfer. By demonstrating how embedded infrastructure can coordinate with moving vehicles, the idea lays the groundwork for future improvements and is extensible. By creating a working prototype and a theoretical framework, the project lays the groundwork for dynamic wireless charging to be more widely used in transportation networks.With further improvements in energy efficiency, material strength, and system safety, wireless road charging could play a pivotal role in the smart transportation systems of the future, facilitating the shift to widespread electric mobility and increasing vehicle autonomy.

IX. FUTURE WORK

The reliability and efficiency of wireless energy transmission across a variety of distances and speeds might be the focus of further versions of this technology. Potentially increasing power delivery efficiency and decreasing energy losses include advancements in alignment mechanisms, coil design, and magnetic coupling methods. Research may also look at integrating complex control algorithms to automate car navigation along charging lanes without requiring external human operation.Extending the prototype to accommodate other vehicle types and load circumstances would help in comprehending scalability and resilience. Integrating energy management technologies that adjust power output on the fly to meet vehicle needs would further enhance performance. Transmitting and receiving equipment may be made more environmentally resistant and durable to extend their working lifespans. Investigating protocols for vehicle-to-road infrastructure communication is another avenue for future study that might lead to smarter and more efficient transportation ecosystems by enhancing coordination and safety.

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