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Wireless Charging for EV on Road

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***Abstract*— Investigating the implementation of wireless charging systems for electric vehicles on roadways, aiming to simplify the charging process and enhance user convenience. By eliminating the need for physical plugs and cables, wireless charging systems offer a streamlined and efficient solution for on-the-go energy replenishment. Emphasizing the eco-friendly aspects, this technology aligns with a cleaner and more sustainable approach to electric transportation. The study delves into the practical benefits, envisioning a future where wireless charging on roads becomes a key driver in the widespread adoption of EVs.**

***Index Terms*— Dynamic charging, Wireless charging, EV, optimization, relay, coil, outcome.**

I. INTRODUCTION

This paper will explore the potential of wireless technology in revolutionizing the industry. In today's world, there is a significant shift towards electrified mobility to reduce pollutant emissions from non-renewable fossil-fueled vehicles and provide a more affordable alternative to traditional fuel for transportation. However, electric vehicles face challenges related to traveling range and charging processes, hindering their widespread adoption compared to conventional vehicles [7]. The advent of wireless charging offers a promising solution to these issues. Instead of waiting for hours at charging stations, electric vehicle owners can conveniently charge their vehicles by simply parking them in designated spots, whether in a parking lot or garage. Furthermore, wireless charging technology enables vehicles to charge continuously while in motion, particularly on highways or busy routes. This continuous charging capability extends the overall range of electric vehicles and reduces the need for frequent stops to recharge. Ongoing efforts focus on achieving critical outcomes such as successful RFID authentication, efficient voltage relay operation, and proper transmitter coil alignment. These milestones ensure that the wireless charging system is secure, safe, and capable of delivering reliable energy transfer to electric vehicles. The utilization of LED displays and Arduino UNO integration enhances user experience and manages the communication and control aspects of the system.

Beyond technical advancements, the expected outcomes include an extended driving range for EVs, reduced charging stops, and accelerated adoption, contributing to a cleaner environment and potential economic growth. Standardization, cost, efficiency, integration with existing infrastructure, and public acceptance are challenges that ongoing research and collaboration aim to address [3]. Despite these challenges, the progress made underscores the promising potential of wireless charging as a convenient, sustainable, widely accepted solution for the future of electric mobility on our roadways.

II. PROBLEM STATEMENT AND OBJECTIVES

Global warming has become a major issue, and internal combustion engine vehicles emit lot of CO_2, CO and NO_2.

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Electric vehicle is a promising solution for rising emission and fuel price. The only issue with electric vehicle is with the large charging time required to charge the vehicle typically 4-6 hours to charge.
Current system allows to charge vehicle when parked, there is no existing system when charge the electric vehicle in real time while it is moving.

- To build the wireless charging for electric vehicle
- Developing a system capable of automatic vehicle detection and power transmission, along with creating a cost-effective device
- Road system should be able to recognize car ID through RFID

III. LITERATURE REVIEW

In recent years, there has been a growing body of research exploring the potential of wireless charging tech-nology for electric vehicles (EVs), with a particular focus on its effect on battery size, charging efficiency, and range extension [8]. It investigated the relationship between battery size and wireless charging efficiency, questioning whether smaller batteries offer advantages in the situation of wireless charging systems. [1] Delved into the concept of wireless opportunity charging to reduce EV battery size and extend their range, providing insights into its potential benefits, especially within urban drive cycle scenarios. [3] Presented a novel approach to educate the efficacy and reliability of wireless charging systems by proposing an alternate arrangement of active and repeater coils, aiming to achieve quasi-constant power delivery. Additionally, [10] addressed the coordination challenges in managing the charging mandate of EVs within a network of dy-namic wireless charging systems, focusing on the efficient management of EV charging in a networked envi-ronment. Furthermore, provided valuable insights into the practical experiences and challenges associated with dynamic wireless power charging for EVs, emphasizing the necessity for additional research and devel-opment in this domain [9]. Collectively, these studies contribute to the understanding of wireless charging technology for EVs, addressing various aspects such as efficiency, reliability, range extension, network coor-dination, thus paving the way for its broader adoption and implementation in real-world scenarios.

IV. COMPONENTS

Roadside

a. *RFID Reader*: Used for user authentication and identification, authorizing vehicles for charging.
b. *Arduino Uno*: Controls the wireless EV charging system, manages communication, and processes sensor data.
c. *LED Display*: Provides visual feedback on charging status, authentication, and errors.
d. *Voltage Relay*: Controls electricity flow based on voltage levels, managing the charging procedure.
e. *Transmitter Coil*: Generates the electromagnetic field for wireless charging, inducing current in the receiver coil.
f. *Authorized and Unauthorized RFID Reade*r: Authorized readers grant interaction with RFID tags for legitimate purposes, while unauthorized readers pose security risks if not controlled.
g. *Power Adapter*: Essential for connecting electronic devices to power sources, ensuring efficient pow-er transmission.

Car Side

a. *Rechargeable Battery:* A 3800mAh battery providing robust power for extended device usage.
b. *Receiving Coil:* Transfers power from the charging pad to devices, operating at 5V 2A for rapid charging.
c. *Boost Converter*: Converts 5V to 9V efficiently, enabling higher power operation.
d. *Arduino Uno*: Interfaces with vehicle components, ensuring integration, receiving real-time charging status feedback.
e. *Motor Drive*: Controls motor speed, direction, and torque based on sensor input, ensuring precise operation.
f. *DC Motor*: Changes electrical into mechanical motion, facilitating vehicle alignment with the charg-ing pad.
g. *Bluetooth Module*: Enables wireless communication between the car and controller devices, facili-tating remote operation and real-time status feedback.

TABLE I. TECHNICAL SPECIFICATIONS

Components	Ratings
Arduino UNO	ATmega328P
Rechargeable battery	3800mAh

Receiving coil	5V,2A
Boost converter	5-9V
Transmitter coil	5V
Motor drive	L298N
Bluetooth Module	HC05
Voltage Relay	12V
RFID reader	RC-522
Transmitter side voltage relay	10A, 125VAC

V. METHODOLOGY

The arrangement is programmed to utilize the Arduino Uno for the purpose of reading RFID card data through the RFID reader. A database containing authorized RFID card information is established. Upon presentation of an RFID card, the system verifies the card data against the authorized list. Authorization grants access to the charging system, while an unauthorized prompt the display of a corresponding mes-sage. Rigorous testing is conducted, encompassing scenarios with both authorized and unauthorized cards to confirm the fidelity of the authentication process. The voltage relay is interconnected with both the pow-er source and the charging pad. The Arduino Uno is programmatically configured to regulate the voltage relay in accordance with predetermined system requirements. Various charging scenarios, encompassing diverse power levels and charging durations, are systematically simulated. The act of the voltage relay in managing the movement of electricity is vigilantly monitored. System responsiveness, particularly in initiat-ing and ceasing the charging process based on user authentication, is scrutinized. The physical alignment of the transmitter coil with the receiver pad on the electric vehicle is methodically ensured. Alignment tests are conducted under a spectrum of conditions, including different vehicle positions, speeds, and angles. Energy transfer efficiency is gauged through meticulous monitoring of charging time and power levels.

An automated alignment feature is implemented if deemed necessary, adjusting the coil position in real-time based on feedback. Iterative testing is undertaken to confirm the consistent alignment and efficacy of energy transfer under diverse circumstances.

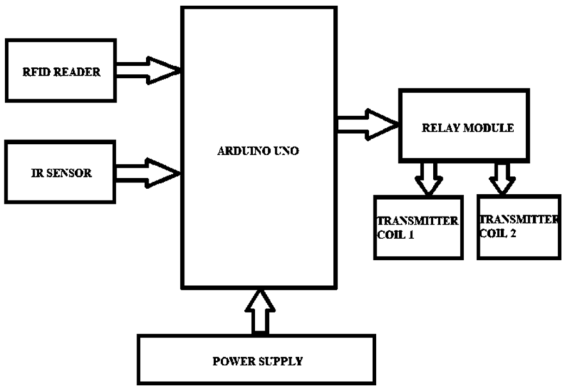

Figure 1. Block diagram of Roadside

Integration of the LED display with the Arduino Uno is undertaken to facilitate real-time status updates. Programmatic instructions are provided to the display for presenting pertinent information such as charging status, RFID authentication feedback, and potential error messages. Rigorous testing is conducted under varying conditions.

Implementation of user-friendly messages and symbols is carried out to enhance interpretability. The prompt and accurate update of the display in response to system events is meticulously verified.

A comprehensive codebase is authored for the Arduino Uno, focusing on the seamless integration of all system components. The code is subjected to rigorous testing to ensure flawless communication between the RFID reader, voltage relay, transmitter coil, and LED display. Robust error-handling mechanisms are embedded within the code to address potential anomalies during system operation. Ongoing monitoring of resource utilization is undertaken to guarantee that the Arduino Uno operates within predefined parameters. Integration tests are systematically executed to confirm the harmonious communication and organization between all system components.

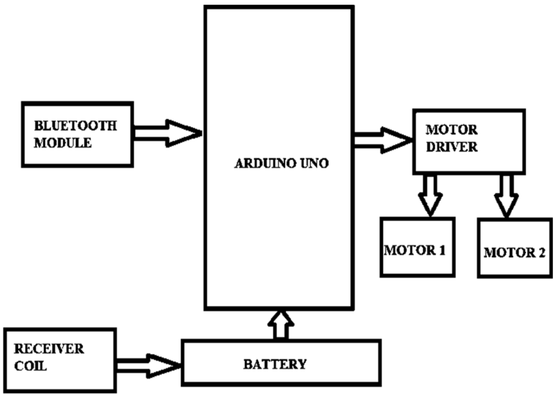

Figure 2. Block diagram of Vehicle side

Continuous investigation and progress efforts are focused on refining wireless charging methodologies for on-road applications. The successful integration of this knowhow could be a game-changer, offering a seamless and convenient charging experience that accelerates the acceptance of electric vehicles and con-tributes to a more sustainable transportation ecosystem. While challenges like standardization and cost must be addressed, the technology's ability to charge EVs while in motion suggests a hopeful solution to range limitations and infrastructure concerns. As research and development continue, the objective is to initiate a reliable and efficient wireless charging system that effortlessly take part with current road net-works, fostering widespread adoption of electric vehicles and reducing our reliance on traditional fossil fuel-based transportation.

IV. Results And Discussions

The setup includes a 3800mAh battery with an on-off switch connected to a voltage sensor, which in turn is connected to an Arduino UNO. The UNO hosts a Bluetooth module, and the receiving end of a coil is also connected to the voltage sensor, with a DC motor directly connected to the UNO. The arrangement ensures power supply to the motor from both the Arduino, powered by the battery, and the receiving coil. The coil's 5V voltage is boosted to 9V, and a diode in the motor drive ensures only the receiving voltage is stored, pre-venting the battery's voltage from entering the transmitter coil. The Bluetooth module connects directly to a phone, with additional components on the car side.

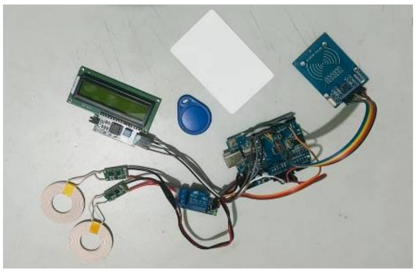

Figure 3. Roadside connection

Figure 4. Transmitter status when authorized card is tapped

Figure 5. Transmitter status when unauthorized card is tapped

On the roadside, a 230V to 12V adapter activates an LCD display upon switching on, showing "wireless charging" using a coded program connected to an Arduino UNO. This UNO is powered by 12V DC. An RFID reader detects a Fastag card in the car, determining if it's connected to wireless charging. If affirma-tive, this status is displayed on the LCD via the UNO, allowing the car to proceed. A voltage relay, pro-grammable to 20 seconds, facilitates subsequent actions. As the car moves, relay1 activates, followed by subsequent relays. An authorized card, present in the car, is detected by the RFID reader. The LCD then indicates the car's authorization, initiating the charging process. After 20 seconds, the relay activates and then deactivates.
The car-side battery switched on then the Bluetooth connection is established via a mobile app. The app's blinking lights indicate the status of the Bluetooth connection: continuous blinking suggests a disconnected state, while delayed blinking signifies a connected state. Upon confirmation of Bluetooth connectivity, the "run" command is initiated. Tapping the authorized card permits vehicle charging, with LED indicators dis-playing the charging voltage on the phone. The wireless voltage is maintained at 7.42V, ensuring optimal power transfer efficiency, while the battery voltage, displayed in real-time on the Bluetooth app, remains stable. This synchronization between the transmitted voltage and the battery's operational voltage guaran-tees efficient and safe charging processes, providing users with accurate feedback on the system's status and performance.

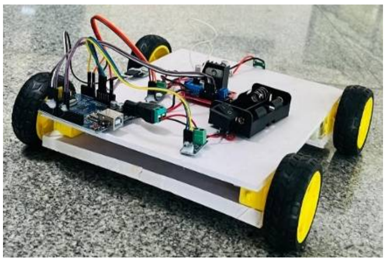

Figure 6. Car side connection

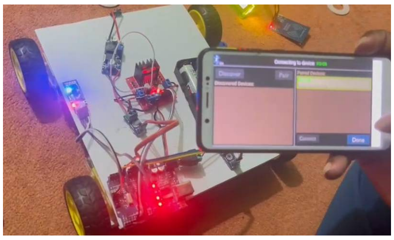

Figure 7. Car when connected to Bluetooth Electronics App

Figure 8. Wireless voltage while moving on tracks.

Figure 9. Battery voltage after dynamic charg-ing

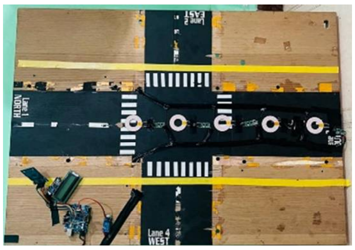

Figure 10. Track for dynamic charging for EV

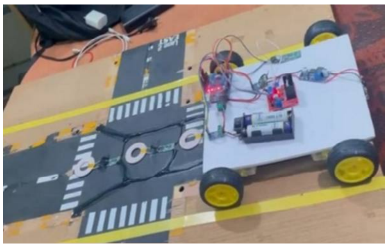

Figure 11. Completed model of wireless charging sys-tem for EV

V. Outcomes

a. *Successful RFID Authentication*: Authenticate that the RFID reader is capable of distinguishing be-tween authorized and unauthorized users. This confirms that individual approved users can access and utilize the wireless charging system.
b. *Effective Voltage Relay Operation*: Check that the voltage relay is functioning as intended. It should control the flow of electricity, ensuring a safe and efficient charging process for the electric vehicle.

c. *Transmitter Coil Alignment and Efficiency*: Validate that the transmitter coil is properly aligned with the receiver pad on the electric vehicle. This is crucial for efficient energy transfer. Confirm that the alignment works reliably under various driving conditions.
d. *LED Display Functionality*: It makes sure that the LED display provides clear and accurate infor-mation. This could include charging status, RFID authentication feedback, and any other appropriate data for the user.
e. *Arduino Uno Integration*: Confirm that the Arduino Uno is effectively managing the communication and control aspects of the system. It should facilitate the interaction between the RFID reader, voltage relay, transmitter coil, and LED display.

VI. Challenges

Throughout the development of wireless charging for electric vehicles on roads, numerous hurdles have arisen, prompting the incorporation of diverse solutions.

a. *Standardization Issues*: Initially, the deficiency of standardized protocols for wireless charging sys-tems led to compatibility concerns. The industry has since endeavored to establish common stand-ards, ensuring interoperability across different vehicle models, and charging infrastructures.
b. *Cost Considerations*: The initial expense of deploying wireless charging infrastructure presented eco-nomic challenges. Ongoing initiatives concentrate on cost reduction through technological progress, economies of scale, and government incentives, aiming to enhance the technology's economic viabil-ity.
c. *Integration with Existing Infrastructure*: Incorporating wireless charging into current road networks ne-cessitated overcoming engineering obstacles. Solutions involve developing retrofitting techniques and modular systems to effortlessly integrate wireless charging into various road surfaces.
d. *Public Acceptance and Perception*: Public awareness and acceptance of wireless charging technologies have been crucial. Efforts include educational campaigns, pilot projects, and demonstrating the ease and environmental benefits to garner public trust and support.

Focusing these tasks has demanded collaboration among industry stakeholders, regulatory bodies, and re-search institutions. Continuous innovation and adaptation to feedback have played a vital role in sur-mounting obstacles, making wireless charging for electric vehicles on roads a more feasible and widely ac-cepted solution for sustainable transportation.

VII. Conclusion

To conclude, the project "Wireless Charging for EV on Road" represents a significant step towards revolu-tionizing electric vehicle (EV) charging infrastructure. By leveraging wireless charging technology, the pro-ject seeks to tackle the issue of prolonged charging times and enhance user convenience, ultimately con-tributing to the extensive use of EVs. The projected system integrates various components, including RFID technology, voltage sensors, Arduino UNO microcontrollers, and Bluetooth modules, to enable seamless communication and power transmission between the charging infrastructure and EVs in real-time. Through rigorous testing and application of safety measures, such as voltage relays and authentication protocols, the project ensures the reliability and efficiency of the wireless charging system. Despite the challenges and complexities involved in developing such innovative infrastructure, the project demonstrates promising results and offers a glimpse into a future where electric vehicles can be charged while on the move, reducing emissions and promoting sustainability. As efforts continue to refine and optimize wireless charging tech-nologies, the possible benefits for the environment, economy, and society at large become increasingly ap-parent, underscoring the status of continued investigation and development in this field.

Future Scope

a. *Reliability Evaluation*: Future endeavors will involve conducting comprehensive tests to evaluate the reliability of the entire system, focusing on assessing connectivity, stability, and performance across various scenarios.
b. *Enhanced EV Range*: As part of future developments, dynamic charging on roads will be explored to significantly extend the dynamic variety of electric vehicles, thereby alleviating range anxiety and en-couraging longer journeys.
c. *Increased EV Adoption*: Future initiatives will focus on leveraging enhanced convenience and extend-ed range to accelerate the adoption of electric vehicles, thereby contributing to a reduction in green-house gas emissions.

d. *Improved Urban Air Quality:* Addressing future challenges will involve promoting the higher adoption of electric vehicles to mitigate air pollution in urban areas, ultimately fostering cleaner and healthier environments.

REFERENCES

[1] C. Lee, G. Jung, K. Hosani, B. Song, D. Seo and D. Cho, Wireless Power Transfer System for an Autonomous Electric Vehicle IEEE Wireless Power Transfer Conference, Nov 15-19. 2020.

[2] F. Lu, H. Zhang and C. Mi, A review on the recent development of capacitive wireless power transfer technology, MDPI Energies, vol. 10, no. 11, pp. 1752, 2017.

[3] C. Zhu, J. Jiang, K. Song and Q. Zhang, Research progress of the key technologies for dynamic wireless charging of electric vehicle, Automation of Electric Power System, vol. 41, pp. 61-65, 2017.

[4] H. HeA.H. Aswathy, G.M. Sukumar, M.S. Swapnil, C.A. Asha and V.R. Pandi, Solar Powered intelligent electric Wheelchair with health monitoring System, Proceedings of 2017 IEEE International Conference on Technological Advancements in Power and Energy2017, pp. 1-5, 2018.

[5] Quinn JC, Limb BJ, Pantic Z, Barr P, Zane Rkd. "Techno-economic feasibly and environmental impact of wireless power transfer roadway electrification", IEEE , July 2015.

[6] Sumer Inamdar; Jimmy Fernandes, Review of Wireless Charging Technologies for Electric Vehicles,10th Power India International Conference (PIICON), IEEE February 2023

[7] Article by M.A. Khan et al, Challenges and Barriers of Wireless Charging Technologies for Electric Vehicles (2023)

[8] Philip Machura, Quan Li, A critical review on wireless charging for electric vehicles, Renewable and Sustainable Energy Reviews, Volume 104, April 2019, Pages 209-234

[9] Miller JM, Jones PT, Li J-M, Onar, Experience and challenges facing dynamic wireless power charging of EV's, IEEE May 2015

[10] Eiman ElGhanam; Hazem Sharf; Yazan Odeh; Mohamed S. Hassandh, On the Coordination of Charging Demand of Electric Vehicles in a Network of Dynamic Wireless Charging Systems, IEEE June 2022