International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Review on Wireless Electrical Vehicle Charging System

[1]Suggu Sravanthi, [2]Mudili Dharani, [3]Dr. M. Venkatesh, [4]Vuttaravilli Manoj, [5]Porapu Chitti Ayyappa, [6]Mula Pradeep, [7]Redlam Likitha, [8]Parusubotu Siva

[1,2,4,5,6,7,8] B. Tech Student, Department of Electrical and Electronics Engineering, GMR Institute of Technology, Vizianagaram District, A.P, India

[3] Professor, Department of Electrical and Electronics Engineering, GMR Institute of Technology, Vizianagaram District, A.P, India.

ABSTRACT

This paper details a wireless charging system for electric vehicles, addressing the dual issues of high gasoline costs and harmful emissions. The number of electric vehicles on the road is steadily increasing across various countries. Besides benefiting the environment, electric vehicles have demonstrated their ability to reduce transportation costs by replacing expensive fuel with more affordable electricity. Our solution involves designing an wireless electric vehicle charging infrastructure that allows for charging while the vehicle is in motion. This system is battery-powered and requires no additional power source. The construction of the system includes a battery, regulator circuitry, copper coils, an AC to DC converter, an Atmega controller, and an LCD display. This technology aligns with the concept that electric vehicles can be charged without stopping at a charging station, demonstrating the feasibility of a road-integrated, wireless charging system for EVs.

KEYWORDS: *AC to DC converter, Atmega controller, LCD display*

I. Introduction

Electric vehicles (EVs) are emerging as a significant contender in the automotive sector, with projections indicating their eventual dominance in the market. As this transition unfolds, it becomes increasingly vital to manage the charging process for EVs to ensure the stability and efficiency of power networks. However, the proliferation of EVs also presents an opportunity for two-way energy flow, where EVs contribute to the resilience and independence of the power grid. This integration of EVs into smart grids is seen as a pivotal technological advancement for the future. The advantages of EVs over traditional internal combustion engine vehicles are becoming more apparent, especially with the growing concerns about carbon dioxide emissions and the dwindling availability of fossil fuels. Despite these benefits, widespread acceptance of EVs has been hindered by various factors the dynamic wireless power transfer system proposed provides effective and dependable charging for electric vehicles while they are moving[5]. Among them are the initial high cost of EVs, the scarcity of fast-charging infrastructure, and the limited availability of all-electric vehicle models. Additionally, there is a distinction between fully electric vehicles, which rely solely on electric power, and plug-in hybrid electric vehicles, which combine electric power with traditional combustion engines. For wireless communication between the roadside controller (RSC) and the onboard controller (OBC) in Wireless Power Transfer (WPT) systems, the network must exhibit deterministic behavior to support real-time control loops. This includes ensuring reliable and timely transmission of critical data streams, essential for accurate control [1]. The absence of charging stations is frequently cited as a significant barrier for potential EV buyers. Incorporating wireless charging into existing wireless communication systems introduces a variety of challenging issues concerning implementation, scheduling, and power management [8].

II. Dynamic Wireless Power Transmission (DWPT)

Dynamic Electric Vehicle Charging Systems (DEVCS) represent an innovative approach to charging electric vehicles (EVs) while they are in motion, offering continuous power transfer without the need for stationary charging stations. The magnetic field causes a non-monotonic relationship between the coupling coefficient and the size of the coil [2]. This technology relies on various advancements in wireless power transfer (WPT) and roadway infrastructure, yet it also confronts several challenges that must be addressed for widespread adoption.

An electric vehicle has the capability to utilize a power transfer system for recharging the onboard Rechargeable Energy Storage System (RESS, i.e., the battery) or for supplying power to the electric motor [6] at the heart of DWEVCS is the ability to transfer electrical energy wirelessly from the infrastructure embedded in the roadway to the vehicle's onboard charging system while it's in motion also referred to as "resonant inductive coupling," this technique solves the main problem associated with non-resonant inductive coupling in wireless energy transfer [3]. This is achieved through a combination of advanced wireless power transfer technologies, such as inductive power transfer (IPT) or resonant magnetic coupling, integrated into the roadway infrastructure and the vehicle itself.

Fig 1: Dynamic wireless power transmission

The above fig.1 shows the roadway infrastructure consists of specially designed charging strips or coils embedded beneath the road surface at strategic locations, such as highways, urban roads, or designated EV lanes. Incorporating wireless charging into existing wireless communication systems introduces a variety of challenging issues concerning implementation, scheduling, and power management[9]. These charging strips generate electromagnetic fields or use other wireless power transfer mechanisms to transmit energy to the receiving coils installed on the underside of the EV.

Table 1: comparison of wired and wireless transmission

Feature	Wired Charging Systems	Wireless Charging Systems
Physical Connection	Requires a physical connection via cable	Does not require a physical connection, operates wirelessly
Convenience	Requires plugging and unplugging	Convenient, no need to handle cables
Efficiency	Typically more efficient due to direct connection	Slightly less efficient due to energy transfer wirelessly
Charging Speed	Can provide high charging speeds, depending on infrastructure	Generally slower compared to wired systems
Alignment Sensitivity	Less sensitive to alignment	Requires precise alignment for efficient charging
Infrastructure	Well-established infrastructure	Developing infrastructure
Cost	Generally lower cost due to mature technology	Higher initial cost due to newer technology
Installation	Easier to install in existing infrastructure	More complex installation due to induction technology
Flexibility	Fixed charging stations	Offers more flexibility in parking placement
Weather Resistance	Resistant to weather conditions, unaffected by rain or snow	Slightly impacted by weather conditions, especially heavy snow or flooding

III. Technologies

A. Wireless Power Transfer (WPT)

DEVCS utilize wireless power transfer technologies such as inductive power transfer (IPT) or resonant magnetic coupling to convey electrical energy from the infrastructure to the vehicle's onboard receiver coils. These systems generate electromagnetic fields or utilize resonant frequencies to efficiently transfer power over short distances, usually between the road surface and the vehicle's undercarriage.

B. Roadway Infrastructure

Charging infrastructure is embedded beneath the road surface, typically within designated lanes or highways, comprising charging strips or coils. These strips generate magnetic fields or employ other WPT mechanisms to transmit power to vehicles passing over them.

C. Onboard Vehicle Equipment

EVs equipped with DEVCS necessitate specialized receiver coils and power management systems installed on their under carriage. These onboard systems adeptly capture and convert the transferred energy to charge the vehicle's batteries while in motion.

D. Vehicle Detection and Control

To ensure efficient charging and safety, DEVCS incorporate vehicle detection and control systems that regulate power transfer and oversee charging protocols. These systems may encompass sensors, communication modules, and control algorithms to orchestrate charging between the infrastructure and the vehicle.

IV. Challenges

A. Efficiency and Power Transfer Rate

Sustaining high efficiency and power transfer rates across varying distances and speeds poses a notable challenge for DEVCS. Optimizing the design of charging infrastructure and onboard equipment to maximize energy transfer efficiency is crucial for minimizing energy losses.

B. Cost and Infrastructure Deployment

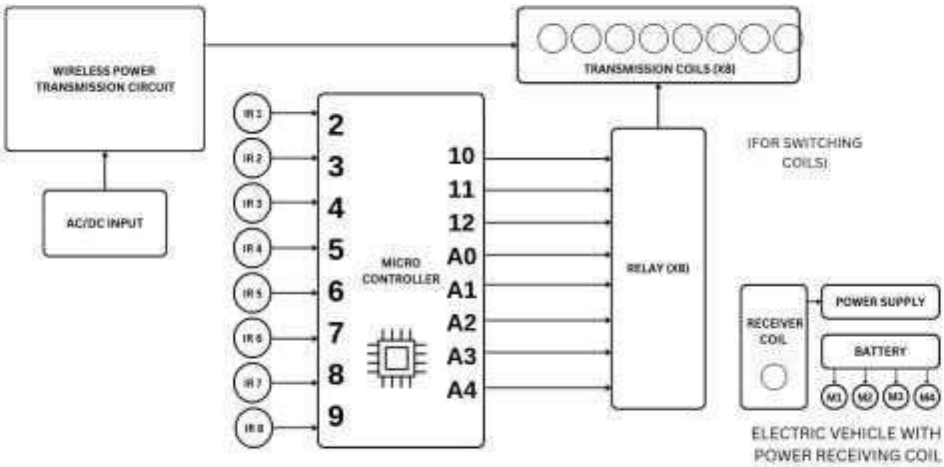
Deploying DEVCS necessitates substantial investments in infrastructure, including the installation of charging strips or coils along roadways. Striking a balance between the cost- effectiveness of deployment and the scalability and coverage of charging infrastructure presents a key challenge.

V. Methodology

The described electric vehicle (EV) design emphasizes simplicity and ease of construction compared to traditional gas-powered cars. It features essential components such as two motors and controllers, a battery pack, solar photovoltaic (PV) module with a charge controller, and a speed controller. Both motors share a common accelerator for triggering, and brake switches halt motor operation when brakes are applied. Turning the car in the opposite direction of a motor shuts it down, accomplished by switching two phases and two control wires while the vehicle is in motion. A reverse button is conveniently located on the steering column, and wireless power transmission (WPT) technology, utilizing magnetic resonance, eliminates the need for cumbersome cords.

WPT has seen significant advancements, with power transfer capabilities ranging from milliwatts to kilowatts and transfer distances extending from millimeters to several hundred millimeters. This progress makes WPT increasingly viable for both stationary and dynamic EV charging applications, addressing issues such as limited range, high costs, and inconvenient charging for EVs. With EVs reaching critical mass and battery technology no longer a limiting factor, the implementation of WPT offers a promising solution to further enhance the convenience and accessibility of electric transportation.

Fig 2: Block diagram of WPT charging system for EV’s



The wireless charging system operates by utilizing transmitter coils as shown in 2, which are charged by a 12v battery. This setup induces an electric current in the receiver coil as the magnetic flux from the stimulated spin system fluctuates, effectively wirelessly charging the receiver coil. The atmega controller is powered by the DC energy produced by the AC to DC converter once the alternating current has been converted. Additionally, the system may include an LCD screen integrated into the vehicle, capable of displaying relevant information such as the vehicle's initials.

VI. Modeling

Fig 3: 3D EV design for DWPT

The process began by sourcing all necessary components from electronics and online stores, prioritizing cost-effectiveness and appropriate ratings. Next, rigorous testing of each component ensured proper functionality, with assistance from lab assistants and faculty members. Fabrication involved assembling components on a breadboard according to the circuit diagram, meticulously checking connections with a 12V DC battery. The key contrast between a wireless charger and a conventional conductive or wired charger lies in the substitution of a transformer with a pair of loosely coupled coils.[7]. This included creating a development board for the electric vehicle and integrating all circuit components into a cohesive unit on the track as shown in fig 3.

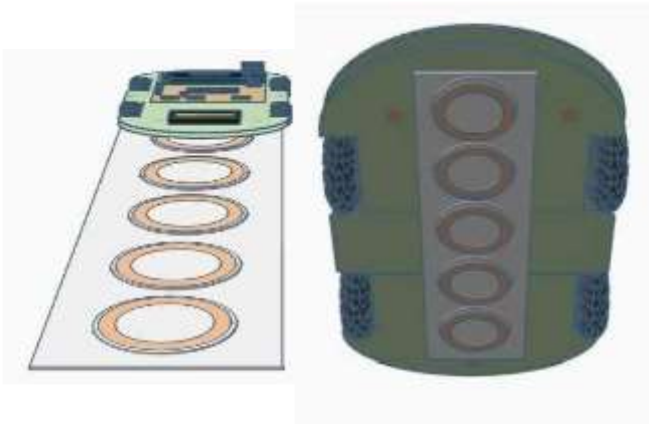


Fig 4: 3D prototype of transmitter coils and receiver coils

A comprehensive three-dimensional model was created using Fusion 360, detailing the assembly of the entire mechanism as shown in fig 4. To enhance visibility and clarity, a LED illuminates the components of the car, arranged in a circular pattern, providing a clear visualization.

VII. Required components

A. Arduino

Arduino shown in fig 5, an open-source platform for electronics, offers accessible hardware and software solutions. Comprising a microcontroller board and a development environment, it appeals to hobbyists, artists, and professionals seeking to create interactive projects. Supported by a straightforward programming language and a strong community, Arduino enables the realization of a broad spectrum of projects, from simple LED tasks to complex robotics endeavors. Its affordability and ease of use have led to its widespread adoption in education, home automation, and prototyping sectors. By empowering users to bring their ideas to life, Arduino fosters innovation within the DIY electronics community.

Fig 5: Arduino

B. IR Sensors

Infrared (IR) sensors shown in fig 6, are instruments designed to detect and quantify infrared radiation emitted by objects. They operate on the principle that all objects above absolute zero temperature emit heat in the form of infrared radiation. Typically composed of an emitter and receiver, IR sensors emit infrared radiation, which then reflects off objects and is captured by the receiver.

Fig 6: IR sensor

C. Relay Module

A relay module shown in fig 7 integrates an electrical switch with a relay and essential components into a single unit. This relay, an electromechanical device, utilizes an electromagnet to toggle electrical circuits on and off. By energizing the coil, a magnetic field is produced, prompting the switch contacts to either open or close, depending on the relay's configuration. Included within relay modules are driver circuits, like transistors or optocouplers, enabling the control of the relay coil with low-voltage signals from microcontrollers or similar electronic devices. These modules find extensive use across diverse applications requiring electrical isolation or high-power switching, such as home automation, industrial control systems, and automotive electronics.

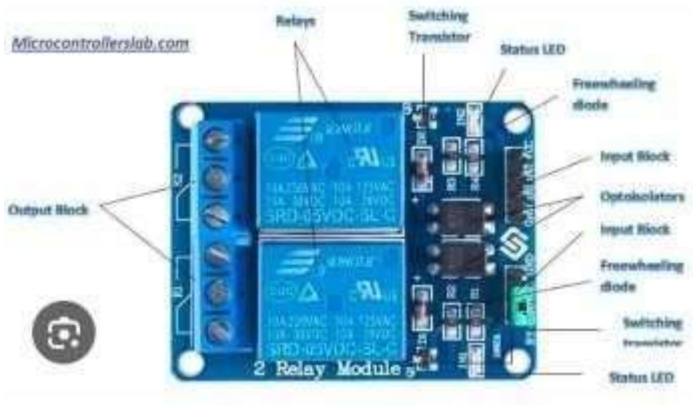


Fig 7: Relay module

D. DC Motors

A gear motor shown in fig 8 integrates an electric motor with a gearbox, merging motor and gear reducer functions within one unit. This gearbox is pivotal for adjusting the motor's output speed and torque to match specific requirements. Through employing different gear ratios, gear motors can deliver diverse levels of speed and torque output. They are prevalent in applications demanding precise speed and torque control, such as robotics, automation systems, and machinery. By employing a gear reduction mechanism, these motors enhance torque while decreasing speed, making them well-suited for tasks necessitating high torque output at low.

Fig 8:Dc motor

VIII. Results

Fig 10: Hardware design of the project

We designed the project as shown in fig 10, the road was laid using 8 copper coils with 45 turns in it. Beside the coils 8 IR sensors are placed respectively to which Arduino is connected. The Arduino is coded in such a way that its output turns on relay. The relay will be turn on based on the car detection from the IR sensor.

Fig 11: Project results

We have given the supply to the relay unit and Arduino is connected to the pc.Then placed the car on the first coil .The respective IR sensor detected and given the signal to the relay through Arduino .Then the first coil got activated and power transfer happened between the car coil and first coil and the result is displayed as shown in fig 11.

A. Convenience: WEVCs offer enhanced convenience to EV owners by enabling automatic and contactless charging. Vehicles equipped with WEVC technology can park over a charging pad, eliminating the hassle of manual cable connections.

B. Improved Efficiency: WEVC systems enhance charging efficiency by ensuring optimal alignment between the charging pad and the vehicle's receiver, maximizing the transfer of electrical energy and minimizing energy loss during charging it is stated that "the development of efficient and reliable wireless power transfer systems is critical for the widespread adoption of electric vehicles [4].

C. Flexibility: WEVCs provide flexibility in charging infrastructure placement and design. Charging pads can be installed in various locations, including parking spaces, garages, or embedded in roadways, offering greater accessibility for EV users.

D. Safety: WEVC systems integrate safety features to prevent unintended charging and mitigate risks like electric shock or fire hazards. Advanced communication protocols and sensors ensure safe and reliable charging operations.

E. Scalability: WEVC technology is scalable and adaptable to different vehicle types and charging needs, accommodating a wide range of EV models from passenger cars to commercial vehicles. This versatility makes it suitable for diverse applications and environments.

IX. Conclusions

Dynamic Wireless Electric Vehicle Charging (DW-EVC) systems represent a significant advancement in electric vehicle (EV) technology, aiming to address the limitations of battery capacity and charging infrastructure. These systems offer a promising solution to extend the driving range of EVs, reduce charging downtime, and potentially lower the overall cost of EV ownership. The key benefits include:

A. Increased Range and Convenience: By enabling continuous charging while driving, DW-EVC systems can significantly increase the effective range of EVs. This reduces the need for frequent stops at charging stations and addresses range anxiety, which is a major barrier to EV adoption.

B. Enhanced Efficiency: Dynamic charging can optimize energy usage by maintaining the battery within an optimal charge range, improving the overall efficiency of the vehicle. This can lead to longer battery life and better performance.

C. Infrastructure Synergy: Integrating DW-EVC systems with existing road infrastructures, such as highways and urban roads, can make efficient use of public and private investments. This can also pave the way for smart city developments, where vehicles and infrastructure communicate seamlessly.

X. References

[1] Sauras, pablo & gil, andrea & taiber, joachim. (2014). Communication requirements for dynamic wireless power transfer for battery electric vehicles. 10.1109/ievc.2014.7056176.

[2] Bareli, sahar & geri, lidor & nikulshin, yasha & nahum, oren & hadas, yuval & yeshurun, yosef & yaniv, eyal & wolfus, shuki. (2021). Effect of coil dimensions on dynamic wireless power transfer for electric vehicles. 10.36227/techrxiv.14852559.v1.

[3] Singh, sagolsem & hasarmani, totappa & holmukhe, rajesh. (2012). *Wireless transmission of electrical power overview of recent research & development*. International journal of computer and electrical engineering. 207-211. 10.7763/ijcee.2012.v4.480.

[4] C. Qiu, k. T. Chau, c. Liu and c. C. Chan, "overview of wireless power transfer for electric vehicle charging," 2013 world electric vehicle symposium and exhibition (evs27), 2013, pp. 1-9, doi: 10.1109/evs.2013.6914731.

[5] Bertoluzzo, manuele & di monaco, mauro & buja, giuseppe & tomasso, giuseppe & genovese, antonino. (2020). Comprehensive development of dynamic wireless power transfer system for electric vehicle. Electronics. 9. 1045. 10.3390/electronics9061045.

[6] Kumar, sujit & paliwal, himani & vyas, shripati & sekhor, sasanka & dave, vikramaditya & rao, srawan. (2021). Dynamic wireless power transfer in electric vehicles. Journal of physics: conference series. 1854. 012014. 10.1088/1742-6596/1854/1/012014.

[7] D.m. vilathgamuwa and j.p.k. sampath “wireless power transfer (wpt) for electric vehicles (evs)— present and future trends”.

[8] Siqi li, member, ieee, and chunting chris mi, fellow, ieee “wireless power transfer for electric vehicle applications”.

[9] Xiao lu, ping wang, dusit niyato, dong in kim, and zhu han” wireless charging technologies: fundamentals, standards, and network applications”

[10] S. Y. Choi, b. W. Gu, s. Y. Jeong and c. T. Rim, "advances in wireless power transfer systems for roadway-powered electric vehicles," in ieee journal of emerging and selected topics in power electronics, vol. 3, no. 1, pp. 18-36, march 2015, doi: 10.1109/jestpe.2014.2343674.