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# STUDY ON DYNAMIC WIRELESS CHARGING

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**Abstract -** *This article looks at a new technique called dynamic wireless charging for electric cars (EVs), which transfers energy without requiring plugged wires or cords or a physical connection to a charging infrastructure. Dynamic wireless charging operates by an inductive power transfer system that consists of a receiver pad on the underside of the car and a transmitter pad in the road that generates an electromagnetic field. To optimize transmission efficiency and usable energy for the car battery storage system, the transmitter pad sends the highway energy to the vehicle energy management adjustment circuits. There is a main compensation circuit mounted on the ground that denotes transmission and associated efficiencies with a secondary compensation system located in the vehicle denoting receive efficiency. The AC/AC converter charges the energy received by the electrical grid to high-frequency AC which will be utilized for wireless transmission. However, the receiver side uses a converter known as AC/DC to produce usable energy to the battery storage system mounted periodically within the vehicle. There is also a power controller that is in place to manage the energy transactions, retain stability of the operations throughout the whole operation structure, and permit secure communications for vehicles and the wireless distribution infrastructure all for structured vehicle operations. There are valuable benefits associated with dynamic wireless charging; increasing driving range, reduced charging time when charging is necessary, reducing faith to charging the vehicles from only the siting of charging stations, the orders which will increase the smart future transportation systems and enhancing the vehicle to*

*everything both in cases of immediate consideration, and elsewise for all EV types.*

***Key Words: Inductive power Transfer, Charging Infrastructure, vehicle to grid communication***

## 1. INTRODUCTION

*Because internal combustion engines (ICEs) generate toxic gases that contribute to climate change and global warming, the widespread use of ICE-powered cars has resulted in significant environmental issues. Electric vehicles (EVs), which are powered by renewable energy sources, are the key to solving the sustainability and driveability problems. Implementation is still hampered by issues such energy density, high cost, bulky measures, driving range, and lengthy charging times. Though they are still expensive, challenging to set up, and less useful than traditional refuelling techniques, fast charging and battery switching are two recommended solutions.*

*Wireless Power Transfer (WPT) technology is one possible way to make EV charging safe, contactless, automated, and practical. In contrast to conductive charging methods, WPT removes cable-related risks and offers a higher degree of comfort for widespread use. WPT can function in three different modes: Quasi-Dynamic Wireless Charging (QDWC), Dynamic Wireless Charging (DWC), and Stationary Wireless Charging (SWC). These modes may be applicable to buses, private vehicles, and public transit systems. Although there are certain issues with charging speed and electromagnetic radiation, safety is continuously improved by design and shielding approaches, as well as several technological factors that affect WPT charging.*

*• In conclusion, WPT technology creates a feasible user experience when it comes to adoption, allowing travelling to be flexible and friendly. to misalignment. As research advances, developing reliable control strategies and efficient system designs remains key to enhancing the performance, safety, and adaptability wireless EV charging technologies.*

### 1.1 Historical context

*General Motors created the first electric vehicle in 1996, marking the beginning of the electric vehicle industry. But since Chevrolet and Nissan began producing and selling electric vehicles, electrification has begun a phenomenal journey through the technologies as well as public acceptance, and if users use it, it is sure not to harm the environment! Both stationary and dynamic wireless charging systems (WCSs) use mutual induction (or inductive charging) introduced by Nikola Tesla. When a current is activated through the transmitter coil (in or underneath the road), it creates an electromagnetic field through coil and induces the same current in the receiver coil (in or underneath the electric vehicle) and thus allows for power transfer without any physical connection. Electric vehicles (EVs) are gaining popularity as clean and environmentally friendly options to reduce pollution and the saving of fossil fuels by developing rechargeable batteries and regenerative braking technology together with new technologies. As the EV drives over the underlay charging coils, it charges without having to stop at charging stations. This would minimize time and reduce range anxiety, due to EVs limited range of battery. DWC has been tested in cities mostly at low speeds on highways but traveling more than 65 plus mph and slowing down for effective charging is not practical. Building more charging stations in an urban* *area is an inefficient and expensive use of valuable land and resources.*

### *1.2 Dynamic Wireless Charging's Opportunities and Difficulties*

*The following are the main obstacles to Dynamic Wireless Charging (DWC) for EVs:*

***1. Technical Difficulty***

*• Battery Management: Concerning battery safety and longevity*

*• Standardization: The coil design, frequency, and power level do not have any widely recognized standards.*

***2. challenges with Infrastructure***

*• High Installation Cost: Installing coils in roads and connecting them to the electrical grid come with a heft.*

*• system Load Management: In certain areas, DWC's enormous network of coils buried in a roadway may put a strain on the electrical system, necessitating smart grid management*

***3. Economic Difficulties***

*Initial cost: Compared to constructing a static EV charging station, DWC may require a substantial upfrontcost*

*• Cost-Benefit Uncertainty: The proportion of EV adoption in the country and possible government subsidies have a significant impact on the return on investment*

***4. Safety and Environmental Difficulties***

*• Safety of Humans and Animals: The safe exposure limits for magnetic fields must be adhered to by both humans*

*• Weather: Temperature changes, precipitation, and snow can all affect the insulation and dependability of batteries in DWC*

***5. Opportunities on policy***

*• Government Support: Makes green transportation-related policies, public-private partnerships, and subsidies possible*

*• Global Standardization: Cosmopolitanism encourages the creation of international standards for safety and universal procedures.*

## *2. LITERATURE REVIEW*

*Dynamic Wireless Power Transfer (DWPT) for electric vehicles has advanced significantly, according to the studied literature, with research focused on enhancing efficiency, correcting power factor, and allowing for misalignment. Several studies focused on coil configurations, compensation techniques and adaptive control schemes to provide stable and efficient energy transfer. Related research studies have included renewable energy integration, grid power quality, and intelligent forecasting models for charging demand management. Further optimization algorithms and IoT-based approaches provided further stability to the grid and energy management. When combined, these studies add to the expanding body of research on creating DWPT infrastructure that is dependable, scalable, and interoperable in order to enable seamless and sustainable electric vehicle charging for future transportation systems.*

### *2.1 overview of dynamic wireless charging*

*Electric vehicles (EVs) may now receive energy while moving thanks to Dynamic Wireless Charging (DWC), a complex Wireless Power Transfer (WPT) technology that eliminates the need for physical plugs and frequent stops at charging stations. In this system, transmitter coils are embedded under the road surface and create a magnetic field, which is received by receiver coils mounted under the EV. The transfer happens passively by means of inductive resonant coupling, which is converted into DC power and stored*

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*in the vehicles battery system. Power converters and compensation circuits manage the energy transfer process to ensure high efficiencies and stable energy transfer.*

*DWC systems reduce range anxiety, increase driving distance, and allow for an overall smaller and lighter battery, since vehicles can automatically charge while driving. DWC will also form part of smart transport networks, meaning its integration with IoT, smart grids and renewable energy resources will contribute to the infrastructure and formation of smart cities.*

*However, deterrents remain with efficient energy transfer at high speeds, route planning and following coil alignment, costs of relevant infrastructure, safety- especially with standard regulations, etc. Aside from these hurdles, DWC is a disruptive technology that can advance the adoption of EVs and reduce reliance on static charging stations, by contributing to the transformation of energy efficient, sustainable smart cities where transportation is less built around the demands of the internal combustion engine.*

### *3. CLASSIFICATION OF WIRELESS CHARGING*

*Although there are different systems, wireless EV charging technologies can be broadly classified based on operational mode and power transfer method into four types:*

***1. Stationary (Static) Wireless Charging***

***Definition:*** *The EV is stationary (parked or stopped) over a charging pad that contains a transmitter coil.*

***Working Principle:*** *A magnetic field is produced by the charging pad's transmitter coil. The EV's receiver coil charges the battery by absorbing energy from the magnetic field. The battery powers the car after it has been charged.*


***Fig 3.1*** *stationary wireless charging*

***Applications:***

*Home or workplace parking*

*Public charging stations.*

***2. Dynamic (In-Motion) Wireless Charging***

***Definition:*** *An electric vehicle charges while moving over embedded transmitter coils in the road.*

***Working Principle:*** *Multiple coils embedded in the roadway create overlapping magnetic fields. The EV's receiver coils capture energy from the overlapping magnetic fields while it is in motion. Advanced control systems adjust power transfer instantaneously based on EV speed and alignment.*

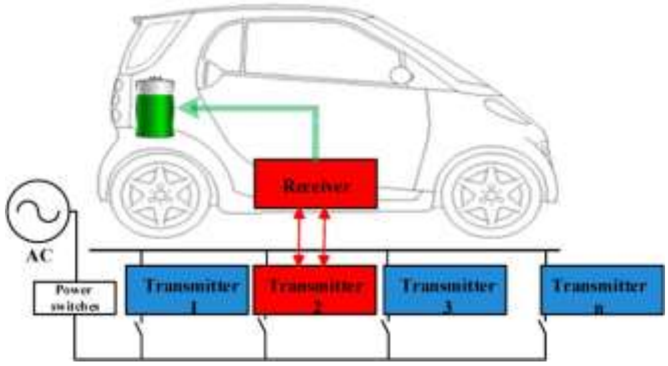


***Fig 3.2 Dynamic wireless charging***

***Applications:***

*Highways and express*

***3. Resonant Inductive Charging***

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***Definition:*** *An advanced version of inductive charging that uses resonant circuits to improve efficiency and power transfer distance.*

***Working Principle:***

*The resonance frequency of a transmitter coil and a receiver coil is set to coincide. Higher power transfer efficiency is possible with resonant inductive charging, even if the coils are not precisely aligned.*

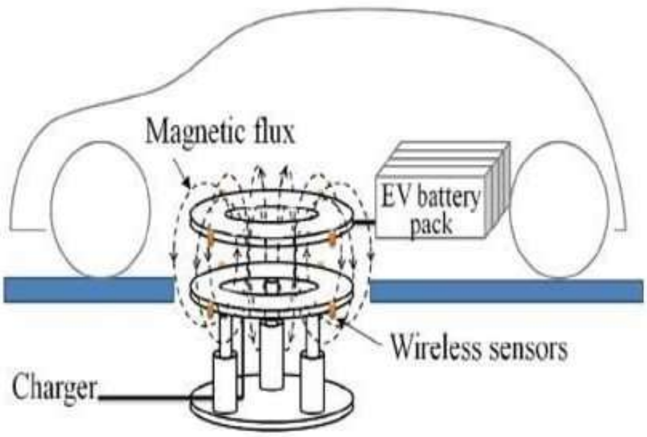



***Fig 3.3 Resonant Inductive charging***

***4. Laser or optical wireless charging***

***Definition:*** *It uses lasers or LED light beams to deliver power to a photovoltaic receiver on the electric vehicle (EV).*

***Working principle:***

*A cluster of high-powered lasers or LEDs creates a directed beam of light, and PV cells or photodiodes in the EV receiver convert the light into electricity.*

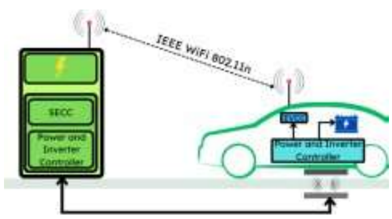
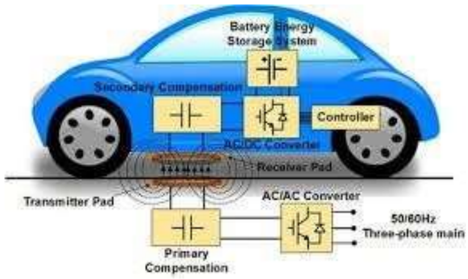



***Fig 3.4 optical wireless charging***

## *4. ARCHITECTURE OF DYNAMIC WIRELESS CHARGING OF EV*

*Dynamic wireless charging allows Evs to receive electrical energy wirelessly from power transmission located under the road surface while the EV is driving. Dynamic wireless electric vehicle charging is accomplished through electromagnetic induction or Resonant magnetic coupling.*




*This image also shows a dynamic wireless electric vehicle charging system that access the EV to continually be charged without physical wires,even while in motion.*

### 4.1 Classification of components

### 1. AC Supply (50/60 Hz Three-Phase Supply)

○ **Function:** Delivers electricity from the energy utility to the transmitter end of the system.

○ **working:**

• The three-phase AC is the raw input for the conversion to the needed high-frequency AC to provide proper wireless transfer above the noise level.

○ **Typical Rating:**

• Voltage: 400–480 V (3-phase retail supply)

• Frequency: 50/60 Hz

• Power Levels: 10 kW – 250 kW (depending on EV charging level)

**2. AC/AC Converter (High-Frequency Inverter)**

○ **Function:** Converts grid AC (50/60 Hz) to high-frequency AC (20–85 kHz) for seeded wireless inductive coupling.

○ **Working:**

• Uses semiconductor switches (IGBTs, MOSFETs, or Sic devices).

• Operates as resonant converter with the aim of minimizing losses.

○ **Typical Rating:**

• Output: 20–85 kHz AC

• Power Rating: 10–250 kW

• Efficiency: >95%

**3. Primary Compensation Circuit**

○ **Function:** Resonating the transmitter coil at the intended operating frequency boosts efficiency.

○ **Working:**

• Compensating capacitors are used to cancel out the inductance of the coil leading to maximized power delivery and minimized reactive power.

○ **Typical Rating:**

• Capacitance: ranges from a few µF to hundreds of µF (considering the specific coil design and frequency)

• Voltage: Several hundred volts AC

**4. Transmitter Pad (Ground Side Coil)**

○ **Function:** Produces a magnetic field that can coherently wirelessly pass power.

○ **Working:**

• A large copper coil is embedded in the road. The magnetic field will induce current in the receiver coil mounted on the EV.

○ **Typical Rating:**

• Power transfer: 3.7 kW (slow charging) up to 250 kW (fast/dynamic charging)

• Efficiency: 90-95%

• Air gap, or distance between the two pads: 10-30 cm

**5. Receiver Pad (Vehicle Side Coil)**

○ **Function:** Takes magnetic energy from the transmitter pad and induces an AC current.

○ **Working:**

• The pad works as a secondary coil of a loosely coupled transformer.

○ **Typical Rating:**

• Same as the transmitter pad, or in the range of 3.7 to up to 250 kW.

• Efficiency: 85-95%

• Induction frequency: 20-85 kHz

**6. Secondary Compensation Circuit**

○ **Function:** Setup circuit to tune the receiver coil to resonance just like the transmitter side maintains the transmitter coil to resonance.

○ **Working:**

• Use budgets to cancel the inductance of the coil. Ensures maximum voltage/current delivery and given to the rectifier.

○ **Typical Rating:**

• Like the primary side capacitor range, or a few µF-100µF

**7. AC/DC Converter (rectifier)**

○ **Function:** Convert received AC to required DC to charge battery.

○ **Working:**

High frequency AC is rectified using waves diodes or active rectification and provides regulated DC voltage.

○ **Typical Rating:**

• Output: 200–800 V DC (depending on electric vehicle battery type)

• Power: 10–250 KW

• Efficiency: >95%

**8. Controller (Communication & Control Unit)**

○ **Function:**The controller manages power flow between transmitter and receiver and controls resonance frequency, voltage, and current.

○ **Working:**

• The controller communicates via wireless protocols (Wi-Fi, Bluetooth, PLC, etc.). The controller adjusts inverter switching for maximum performance, if needed.

○ **Typical Rating:**

• Low-power microcontroller/FPGA (Field Programmable Gate Array) based.

**9. Battery Energy Storage System (BESS)**

○ **Function:** The BESS stores the received DC energy in the vehicle battery.

○ **Working:**

• Lithium-ion battery packs (most common).

○ **Typical Ratings:**

• Voltage: 200–800 V DC

• Capacity: 30–120 kWh (depending on vehicle)

## 5. RESULTS AND DISCUSSIONS

The comprehensive exploration of Dynamic Wireless Charging (DWC) for electric vehicles indicates DWC to be a viable technology that enables vehicles to charge during operation while also decreasing the occurrence of stopping to charge at stations. The DWC system achieves this by transferring energy wirelessly through inductive power transfer where coils embedded below the road send power to a set of receiver coils installed beneath the vehicle. The experimental results indicate that DWC can reach 85–95% efficiency if the coils are aligned properly; however, it can lose as much as 25% efficiency if several factors such as coil misalignment or speed create inconsistencies.

The DWC also extends the driving range of electric vehicles (EVs) by 30 – 70%, using no additional battery cell battery size, decreases the time engaged in charging, and mitigates the effective range limitation of electric vehicles making for extended travel more feasible. The use of resonant coupling along with intelligent control (communication-based) systems help to improve reliability and safety to DWC within the EV environment.

Nonetheless, the costs of infrastructure (embedding coils) in roadways can be expensive - however with the potential related benefits of smaller batteries, fewer factors contributing to pollution, and a general smooth roadway traffic experience are achievable. DWC is a step towards sustainable and intelligent transport and with adjustable improvements of better alignment, and communication control or reduced cost restraints, the function of DWC within smart city development and the future of electric mobility could provide comfort to both sustainable and clean electric energy to EV transportation seamlessly.

## 6. CONCLUSION

Dynamic Wireless Charging (DWC) of electric vehicles helps in sustainable transportation because it allows continuous transfer of energy, contactless, while the vehicle is in motion. DWC addresses major issues - limiting driving range, long charging times, and reliance on battery size - that could have stifled widespread EV adoption. The study shows that high efficiency and reliable operation of DWC retain throughout time with appropriate design of coil, compensation, and resonant inductive power transfer. However, there are obstacles to widespread DWC adoption, including as the expense of capital and ongoing charging infrastructure, maintaining vehicle alignment, electromagnetic interference, and uniformity. Efficiency and sustainability will rise with the use of renewable energy sources and smart grid integration. DWC technology has the ability to make capital potential simple and effective while bringing electric mobility to a new scale in American cities with sustained advancements, legislative support for electric mobility, and public-private cooperation.

## 7. REFERENCES


- Kiddm, W. A., Mortazavi, S. S., Saniei, M., & Monadi, M. (2025). Enhancing efficiency and regulation current in dynamic wireless charging of electric vehicles: Phase-Shift control methods in resonant inductive power transfer systems. *IEEE Access*, 1. https://doi.org/10.1109/access.2025.3583200
- Mahesh, A., Chokkalingam, B., & Mihet-Popa, L. (2021). Inductive Wireless Power Transfer Charging for Electric Vehicles–A Review. *IEEE Access*, *9*, 137667–137713. https://doi.org/10.1109/access.2021.3116678
- Tenllado, I. C., Cabrera, A. T., & Lin, Z. (2023). Simultaneous wireless power and data transfer for electric vehicle charging: a review. *IEEE Transactions on Transportation Electrification*, *10*(2), 4542–4570. https://doi.org/10.1109/tte.2023.3309505
- Ahmad, F., Alam, M. S., & Shariff, S. M. (2019). A Cost-Efficient energy management system for battery swapping station. *IEEE Systems Journal*, *13*(4), 4355–4364. https://doi.org/10.1109/jsyst.2018.2890569
- Jeong, S., Jang, Y. J., & Kum, D. (2015). Economic analysis of the dynamic charging electric Vehicle. *IEEE Transactions on Power Electronics*,*30*(11),63686377,https://doi.org/10.1109/tpel.2015.2424712
- Farajizadeh, F., Vilathgamuwa, D. M., Jovanovic, D., Jayathurathnage, P., Ledwich, G., & Madwala, U. (2019). Expandable N-Legged converter to drive closely spaced Mult transmitter wireless power transfer systems for dynamic charging. *IEEE Transactions on Power Electronics*, *35*(4), 3794–3806. https://doi.org/10.1109/tpel.2019.2939848
- De Marco, D., Dolara, A., Longo, M., & Yaïci, W. (2019). Design and Performance Analysis of Pads for Dynamic Wireless Charging of EVs using the Finite Element Method. *Energies*, *12*(21), 4139.https://doi.org/10.3390/en12214139

- Patil, D., McDonough, M. K., Miller, J. M., Fahimi, B., & Balsara, P. T. (2017). Wireless Power Transfer for Vehicular Applications: Overview and challenges. *IEEE Transactions on Transportation Electrification*, *4*(1), 3–37. https://doi.org/10.1109/tte.2017.2780627

- Nguyen, T., Li, S., Li, W., & Mi, C. C. (2014). Feasibility study on bipolar pads for efficient wireless power chargers. *2022 IEEE Applied Power Electronics Conference and Exposition (APEC)*, 1676–1682. https://doi.org/10.1109/apec.2014.6803531

- Boys, J., Covic, G., & Green, A. (2000). Stability and control of inductively coupled power transfer systems. *IEE Proceedings - Electric Power Applications*, *147*(1), 37. https://doi.org/10.1049/ip-epa:20000017

- Xiang, L., Li, X., Tian, J., & Tian, Y. (2018). A crossed DD geometry and its Double-Coil excitation method for electric vehicle dynamic wireless charging systems. *IEEE Access*, *6*, 45120–45128. https://doi.org/10.1109/access.2018.2864999