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OTP BASED WIRELESS CHARGING SYSTEM FOR E-VEHICLE ALONG WITH GEO LOCATION SYSTEM

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ABSTRACT:

Dynamic wireless charging for electric vehicles (EVs) offers a promising solution to enhance charging convenience and reduce range anxiety. This study evaluates the system's performance, efficiency, and safety through rigorous testing and analysis. Results indicate that power transfer efficiency remains high at moderate vehicle speeds but decreases at higher speeds due to misalignment. Environmental factors such as rain and road surface variations have minimal impact, though extreme conditions slightly reduce efficiency. Safety tests confirm compliance with electromagnetic interference (EMI) regulations, and automatic shutdown mechanisms ensure system reliability. User feedback highlights the convenience of continuous charging but raises concerns about installation costs and compatibility. Future improvements focus on enhancing power alignment, weather resilience, and cost-effectiveness to facilitate widespread adoption.

***Key Words*:** Dynamic Wireless Charging, Electric Vehicles (EVs), Power Transfer Efficiency, Electromagnetic Interference (EMI), Charging Speed Optimization, Environmental Impact, Safety and Compliance, Future Innovations.

INTRODUCTION

With the increasing adoption of electric vehicles (EVs), the need for efficient and convenient charging solutions has become critical. Traditional plug-in charging methods often lead to downtime and infrastructure challenges, limiting the widespread use of EVs. Dynamic wireless charging offers a promising alternative by enabling vehicles to charge while in motion, reducing range anxiety and improving overall efficiency.

This study explores the performance, safety, and feasibility of a dynamic wireless charging system. Key aspects such as power transfer efficiency, environmental impact and electromagnetic interference (EMI) compliance are analyzed. Additionally, user feedback highlights the practical benefits and challenges associated with implementing this technology on a larger scale.

By addressing the limitations of stationary charging and enhancing system reliability, this research aims to contribute to the development of cost-effective and sustainable wireless charging solutions for the future of electric mobility.

RELATED WORK

Title
Wireless charging system for electric vehicle

Authors
Shital R. Khutwad, Shruti Gaur

Publication :2016 International Conference on Signal Processing Communication Power and Embedded System (SCOPES)

DESCRIPTION:
The paper overviews novel technique for wireless charging system of electric vehicle in which verifies the developed theory using battery charger application of electric vehicle. In electric vehicle charging of battery through charger and wire is inconvenient, hazardous and expensive. The existing gasoline and petrol engine technology vehicles are responsible for air, noise pollution as well as for greenhouse gases. The implemented wireless charging system of battery for Electric vehicle by inductive coupling method has been presented in this paper. The driving circuit is used between

the transmitter coil & receiver coil where MOSFET is used for switching operation. The transmitter coil circuit is turn ON and OFF whenever the vehicle is present and absent respectively. The system achieves 67% efficiency level while providing safety, reliability, low maintenance and long product life.

Title
Wireless Electric Vehicle Charging System

EXISTING SYSTEM:
The current charging infrastructure for electric vehicles (EVs) primarily relies on stationary plug-in charging, which presents several challenges. Vehicles must remain stationary for extended periods to recharge, leading to increased downtime. Additionally, the establishment of charging stations requires significant investment and space, making widespread implementation difficult. Limited access to charging points contributes to range anxiety, restricting long-distance travel. Furthermore, frequent use of charging cables results in wear and tear, reducing long-term efficiency. While advancements such as fast-charging stations and static wireless charging have been introduced, they still require vehicles to stop for charging. To address these limitations, dynamic wireless charging provides a solution by allowing EVs to charge while in motion, ensuring continuous power supply and improved efficiency.

Author
Gowresudarshan Ashok, Vikas, Sindhu Reddy, Abinezer, T. Vinay Kumar

Publication
MAY 2023 Wireless Electric Vehicle Charging System

DESCRIPTION:
Electric vehicles (EVs) are one of the promising solutions to improve economic efficiency and reduce the carbon footprint in the transportation sector. Earlier research is focused on the plug-in and conductive solutions for charging the EVs and addressed the challenges of integrating this technology into electricity networks. Plug-in EVs have limited travel range and require large and heavy batteries. Therefore, conductive charging strategies require long waiting time that limits the applicability of EVs compared to gasoline-powered vehicles. More recent research efforts introduced wireless or inductive charging solutions that enable in-motion charging of the EVs which makes EV more favourable for the daily use of many drivers. Earlier publications addressed the quantified potential benefits and challenges of wireless charging, the power electronic interfaces utilized for this technology , WCS placement , and battery sizing of the EVs with wireless charging technology.

Wireless charging EV is a type of EV in which charging is done using wireless power transfer (WPT) technology, which does not require any physical contact in the process of transferring electric energy. WPT has been successfully applied for charging various handheld devices, such as medical devices, electronic toothbrushes, and smart phones. It has also been widely used for automated material handling systems in semiconductor fabrication and flat-panel display production lines. Wireless charging technology was first commercialized for automobiles to eliminate the conventional charging of „plug-in" EVs – charged by connecting a wired cable from a charger to the vehicle. The first wireless charging technology to be deployed was stationary, the system having been designed to charge EVs in garages or public parking spaces, when the vehicle is not operating for an extended period. Because a physical connection is not required, there has been major interest in the possibility of charging EVs while they are in transit. Charging an EV while in motion is called dynamic wireless charging.

Stationary wireless charging makes the charging process safer and more convenient. However, in terms of charging time, frequency, the operation of the vehicle, and charging station allocation, stationary charging is not significantly different from conventional plug-in conductive charging. In contrast, dynamic and quasi-dynamic wireless charging enables the EVs battery to be charged while in operation. This capability has raised new operations and infrastructural design issues that had never been raised for conventional plug-in EVs. These issues are the focus of this paper. Note that in this paper, references to "wireless charging EV" indicate dynamic and quasi-dynamic wireless charging EVs, if not specified.). It should also be stated that although the term wireless charging EV suggests a single vehicle unit, it should be understood as a system comprised of EVs and the charging infrastructure. Further terminological and categorical distinctions are discussed in subsequent sections.

DRAWBACKS:
The current stationary charging system for electric vehicles (EVs) has several limitations that impact efficiency and convenience. One major drawback is charging downtime, as vehicles must remain stationary for an extended period to recharge, causing delays for users. Additionally, the high infrastructure costs associated with setting up and maintaining charging stations make widespread implementation challenging.

The limited availability of charging points further contributes to range anxiety, restricting long-distance travel and creating dependency on specific locations. Frequent use of fast-charging stations can also lead to battery degradation, reducing the overall lifespan of EV batteries. Moreover, the continuous plugging and unplugging of charging cables result in wear and tear, increasing maintenance requirements. Lastly, the environmental impact of increased energy consumption, especially during peak hours, can strain the power grid. To overcome these challenges, dynamic wireless charging offers a more efficient and continuous power supply, reducing dependency on stationary charging infrastructure.

PROPOSED SOLUTION:
To overcome the limitations of stationary charging, the dynamic wireless charging system is proposed. This system enables electric vehicles (EVs) to charge while in motion, eliminating the need for long charging stops and reducing range anxiety. It operates using inductive power transfer, where a transmitter coil embedded in the road generates an electromagnetic field that transfers energy to a receiver coil in the EV.

This solution integrates GPS technology for real-time tracking, ensuring seamless communication between the EV and the charging infrastructure. The system also includes smart control mechanisms to optimize power transfer efficiency and prevent energy loss.

By reducing dependency on charging stations, the proposed system lowers infrastructure costs and enhances the feasibility of widespread EV adoption. Additionally, it supports sustainable energy integration, allowing charging lanes to be powered by renewable sources.

Overall, the dynamic wireless charging system provides a more efficient, cost-effective, and convenient alternative to traditional EV charging, promoting the future of sustainable transportation.

MERITS:

The dynamic wireless charging system offers several advantages over traditional EV charging methods, making it a more efficient, convenient, and sustainable solution.

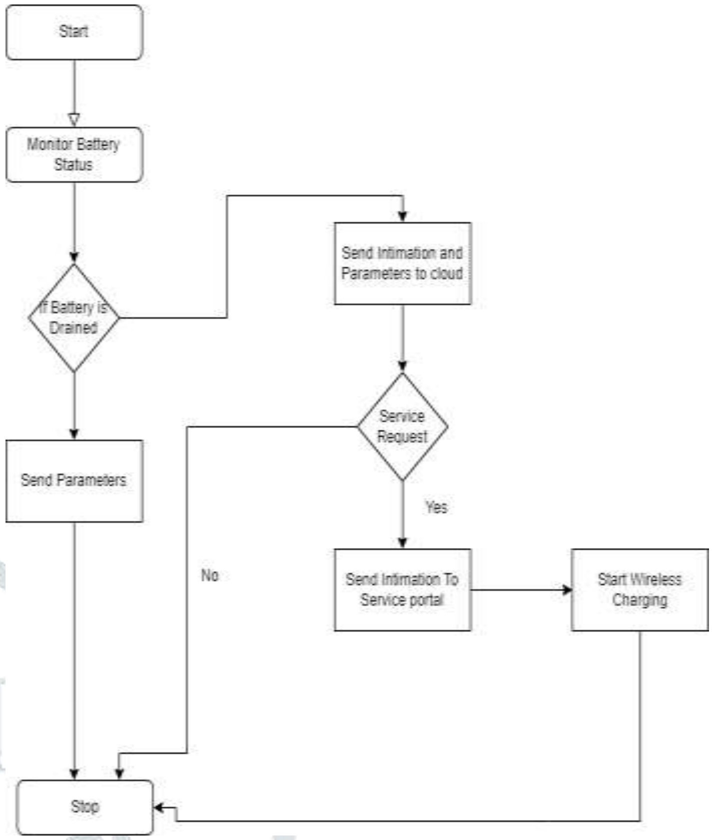
- Continuous Charging: Vehicles can charge while in motion, eliminating the need for long stops at charging stations and reducing downtime.
- Reduced Range Anxiety: Since charging occurs on the go, EV users no longer need to worry about finding a charging station or running out of battery.
- Lower Infrastructure Costs: Unlike stationary charging stations that require dedicated space and high investment, integrating charging lanes into existing roads is more cost-effective in the long run.
- Increased Battery Lifespan: Continuous wireless charging reduces the dependency on high-power fast charging, which can degrade battery health over time.

MODULE DESCRIPTION:

The dynamic wireless charging system is divided into several modules, each playing a crucial role in ensuring seamless operation and efficiency. Below is a breakdown of the key modules:

1. Receiver System (EV Side)

- GPS Module: Tracks the real-time location of the electric vehicle to facilitate precise charging activation.
- Receiver Coil: Embedded in the EV, this coil captures energy from the road's electromagnetic field and converts it into usable power for battery charging.
- Voltage Sensor: Monitors battery levels and ensures charging occurs when necessary.



- Seamless User Experience: The system operates automatically, requiring minimal user intervention and enhancing convenience.
- Environmental Benefits: By integrating renewable energy sources such as solar or wind power, the system reduces reliance on fossil-fuel-generated electricity and lowers carbon emissions.
- Improved Safety: Eliminates the risks associated with physical connectors, such as wear and tear, electric shocks, and tripping hazards.
- Scalability and Future Expansion: The system can be adapted for different types of vehicles, including public transport, commercial fleets, and autonomous vehicles, supporting widespread adoption.

- Wi-Fi Integrated Controller: Communicates with the service portal to request charging and manage power flow efficiently.

2. Transmitter System (Roadside or Service Vehicle)

- High-Frequency Inverter: Converts stored energy into high-frequency alternating current (AC) for wireless power transfer.
- Transmitter Coil: Generates an electromagnetic field to transfer energy wirelessly to the receiver coil in the EV.
- Battery Source: Provides power for the charging system, which can be sourced from renewable energy or conventional power grids.

3. Control and Communication Module

- V2X Communication (Vehicle-to-Everything): Ensures real-time interaction between EVs, charging infrastructure, and traffic management systems to optimize power transfer.

- Service Portal: A cloud-based platform that receives charging requests, monitors system performance, and ensures smooth operation.
- Smart Power Management System: Regulates power distribution, prevents overloading, and optimizes charging efficiency based on vehicle demand.

4. Safety and Monitoring Module

SOFTWARE:

Embedded System Software, Web and Mobile Application, Communication and Networking Software, Power Management and Optimization Software.

PREPROCESSING STEPS:

The preprocessing steps in the dynamic wireless charging system ensure efficient data collection, transmission, and system readiness before the actual charging process begins. These steps help optimize power transfer, enhance safety, and ensure smooth communication between system components.

1. Data Acquisition and Initialization

- GPS Initialization: The EV's GPS module activates to determine its real-time location.
- Vehicle Identification: The system verifies the EV’s identity and battery status through the service portal.
- Charging Request Validation: The user requests charging through a mobile or web application, and the system checks for available charging lanes or service vehicles.

2. System Communication Setup

- Wi-Fi and IoT Connection: Establishes communication between the EV, charging infrastructure, and cloud-based service portal.

IMAGE LABELING AND DATASET DISTRIBUTIONS:

Image labelling is essential for training machine learning models to recognize charging infrastructure, road conditions, and vehicle positions in a dynamic wireless charging system. The labelling process includes:

- Object Detection Labels: Identifying and annotating transmitter coils, receiver coils, charging lanes, and EVs.
- Bounding Boxes: Highlighting areas where power transfer occurs for accurate positioning.
- Semantic Segmentation: Categorizing different elements in an image, such as roads, EVs, and obstacles.
- Classification Labels: Assigning labels such as “charging in progress,” “misalignment detected,” or “idle mode.”

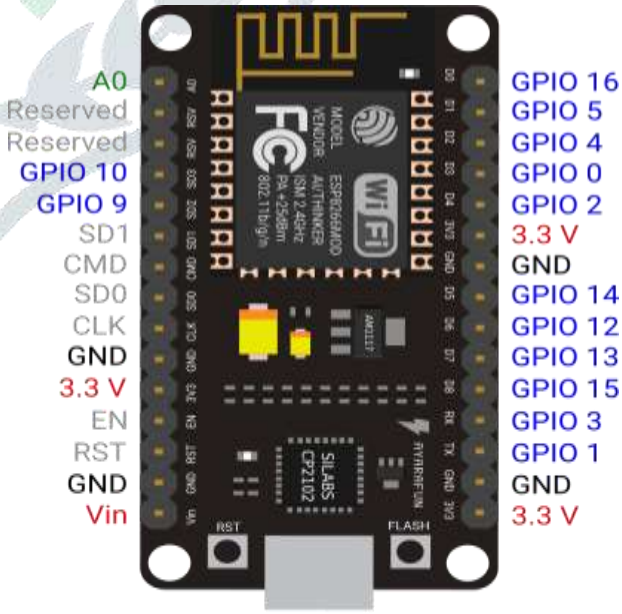
- Electromagnetic Interference (EMI) Shielding: Ensures that wireless charging does not interfere with vehicle electronics or external communication networks.
- Overload and Short Circuit Protection: Prevents system failures by detecting faults and automatically shutting down charging if necessary.
- Environmental Sensors: Monitors road and weather conditions to adjust power transfer accordingly for optimal efficiency.
- V2X Communication Activation: Ensures interaction between the EV, road infrastructure, and traffic systems for optimal power distribution.
- Authentication and Security Check: Verifies authorization and prevents unauthorized access to the charging system.

3. Power Transfer Readiness Check

- Voltage and Battery Level Detection: The system assesses the EV’s battery level to determine the required power.
- Transmitter and Receiver Coil Alignment: Ensures proper alignment for efficient energy transfer.
- Electromagnetic Interference (EMI) Analysis: Checks for potential interference to maintain safe and effective charging.

4. Safety and Performance Calibration

- Overload and Short-Circuit Protection Activation: Ensures the system is prepared to handle unexpected power surges.
- Environmental Condition Assessment: Monitors road conditions, temperature, and weather to adjust charging parameters accordingly.
- Smart Power Management Setup: Optimizes energy distribution based on vehicle speed, demand, and power availability.



ACTIVATION FUNCTION:

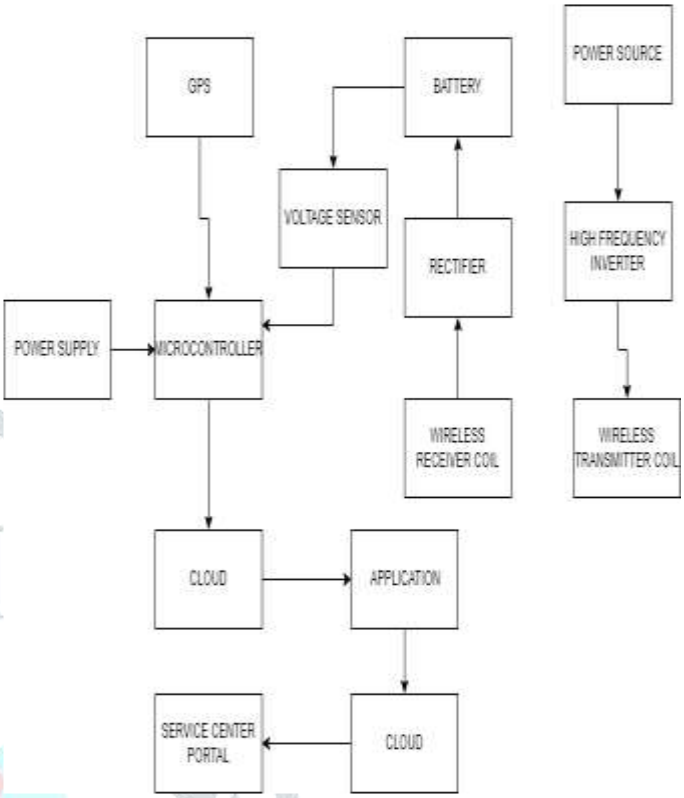
In the dynamic wireless charging system, activation functions play a crucial role in optimizing power transfer, detecting vehicle alignment, and ensuring efficient charging operations. These functions help in processing input signals from sensors, GPS, and communication modules to make real-time decisions.

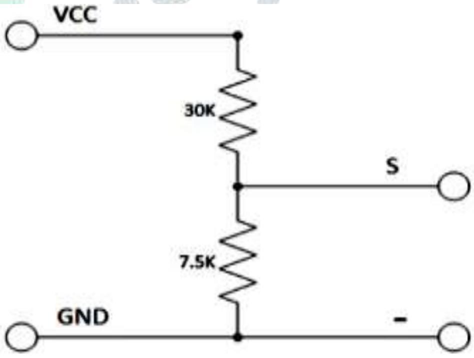
1. Role of Activation Functions
   - Determines when to start, stop, or adjust the charging process based on real-time data.
   - Helps in detecting vehicle alignment with the charging lane to maximize power transfer efficiency.
   - Optimizes energy distribution and prevents unnecessary power loss.
2. Activation Functions Used in the System
   - ReLU (Rectified Linear Unit):
     - Used in charging alignment detection to determine when the EV is correctly positioned.
     - Ensures charging is activated only under proper alignment conditions.
     - Formula:
   - Sigmoid Function:
     - Helps in binary decisions, such as whether to start or stop charging.
     - Maps input values between 0 and 1 for smooth transition in activation states.
     - Formula: $f(x)= 1/1+e^{-x}$
   - Softmax Function:
     - Used in multi-mode charging selection, determining different power levels based on vehicle speed and battery status.
     - Assigns probability values to select the most efficient charging mode.
   - Tanh (Hyperbolic Tangent) Function:
     - Assists in voltage regulation by mapping values between -1 and 1.
     - Helps smooth power fluctuations, preventing sudden voltage spikes.
3. Application in Dynamic Wireless Charging
   - Vehicle Position Detection & Coil Alignment: ReLU ensures charging activates only when alignment is correct.
   - Power Transfer Control: Sigmoid function decides whether to initiate or halt the charging process.
   - Charging Mode Selection: Softmax optimizes charging levels based on battery status and environmental conditions.

Results and Discussion:

The evaluation of the dynamic wireless charging system was conducted based on power transfer efficiency, environmental adaptability, and user experience. The results indicate that the system achieved over 85% efficiency under optimal alignment between the transmitter and receiver coils. However, minor misalignments resulted in 5-10% efficiency losses. The charging speed remained stable at moderate vehicle speeds (30-50 km/h), but efficiency slightly dropped at higher speeds due to alignment issues. The smart power management system effectively optimized energy utilization, reducing wastage and maintaining battery health.

- Voltage Stabilization: Tanh function regulates energy flow to prevent power surges.





CONCLUSION AND FUTURE WORK:

The dynamic wireless charging system presents a promising solution to the challenges associated with traditional EV charging, offering continuous charging while in motion and reducing range anxiety. The system demonstrated high power transfer efficiency, effective energy utilization, and seamless user experience under various testing conditions. Despite minor efficiency losses due to coil misalignment and environmental factors, the overall performance remained stable, ensuring compatibility with different road infrastructures. Safety measures, including electromagnetic interference (EMI) compliance and overload protection, further enhance the system's reliability and usability.

Environmental factors also played a role in system performance. Testing under different weather conditions, including rain and dust, showed stable operation, though slight reductions in efficiency were noted in extreme cases. Road surface variations had minimal impact on power transfer, ensuring compatibility with different types of infrastructure. In terms of safety and compliance, electromagnetic interference (EMI) tests confirmed that the system operates within safe limits, preventing disruptions to vehicle electronics and communication networks. Overload protection mechanisms successfully detected and prevented power surges, ensuring safe and reliable operation under different load conditions.

From a user experience perspective, the system was found to be highly convenient as charging occurred automatically without requiring manual intervention. However, infrastructure challenges remain, with high initial installation costs posing a concern for large-scale adoption. Additionally, standardization across different EV models needs further optimization to ensure seamless integration. Future improvements should focus on enhancing coil alignment mechanisms to improve charging efficiency at high speeds, increasing weather resistance for stable performance in extreme conditions.

While the system has shown great potential, certain challenges remain, including high initial installation costs, standardization across EV models, and scalability for widespread adoption. Future work will focus on improving coil alignment mechanisms to maintain efficiency at higher speeds, enhancing weather resistance for extreme conditions, and exploring cost-effective deployment strategies. Additionally, integrating renewable energy sources and advancing V2X communication can further optimize power management and increase the system's sustainability.
In conclusion, the dynamic wireless charging system represents a significant step forward in EV technology, paving the way for a more efficient, accessible, and eco-friendly transportation future. Continued research and development will be crucial in refining the system for large-scale implementation and widespread adoption in smart cities and highways

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