JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Wireless Electric Vehicle Charging System

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Abstract : This paper describes the development and deployment of a wireless charging system for EVs based on inductive coupling technology. The proposed system is intended to tackle the shortcomings of conventional conductive charging techniques, providing more convenient and approachable charging solution for the users of electric vehicles. The wireless charging system is built around two primary modules: Transmitter sector and receiver sector: Transmitter module has a high-frequency alternating current source that produces oscillating magnetic field. The receiver module which is incorporated in the battery management system of the EV converts this magnetic field to induce a current to coincide with wireless power transfer to charge the battery of the EV. The system uses Arduino microcontroller boards to monitor and control the charging process correctly and safely. The features include tuning the frequency, monitoring the power level, and communication interfaces, which enable the charging system to integrate well with the EV systems. A series of experimental tests show that the wireless electrical power transmission is effective and feasible at various distances and power levels. The document also addresses issues that need to be faced during creating the product, for example, electromagnetic compatibility issues and thermal issues, as well as their solutions.

IndexTerms **- electric vehicle, wireless power transfer, wireless charging**

I. INTRODUCTION

Most people have nowadays embraced eVs as a better environmentally friendly transport vehicle than the conventional, internal combustion engine vehicles. Secondly, there remain the problem concerning the limited autonomy and the charging time inasmuch as with regard to traditional conductive charging methods. Wireless charging technology has therefore emerged as the most ideal solution to this issue since it improves the charging experience of owners of the EVs. Wireless charging systems reduce the burden of direct electrical connections hence, it has a way of reducing the disadvantage of having to plug in and removing the charging cables. The following report outlines the theoretical and practical implementation of the wireless charging system of electric vehicles using IPT technology as demonstrated by the prototype system. IPT is another form of WPT that does not use radiation and has equal efficiency and power transfer rates and the other system of WPT that uses electromagnetic induction with two coils that are involved; the transmitting coil and the receiving coil. The proposed wireless charging system consists of two primary modules: Transmitter Unit There is also what could be referred to as Transmitter Unit Once there is need for a Receiver Unit, There is also a Receiver Unit. The transmitter module or the senders are usually placed at the charging station for instance at a charging station or parking space generates oscillating magnetic field with the help of oscillating high frequency AC. This magnetic field is detected by the receiver module which belongs to the Battery Management System of the EV and due to this induced current the wirelessly provided power charges the battery of the EV. In the system, Arduino microcontroller boards are used to have a better control and management of the overall charge control process including the frequency tuning, power level and communication systems. Such control mechanisms reduce the possibilities of operating the system and at the same time provide an interface compatible with the integrated systems of the EV.

II. Theoretical framework

Wireless electric vehicle (EV) charging, also known as inductive charging, involves the transfer of power wirelessly from charging pad to an EV's battery using electromagnetic fields.

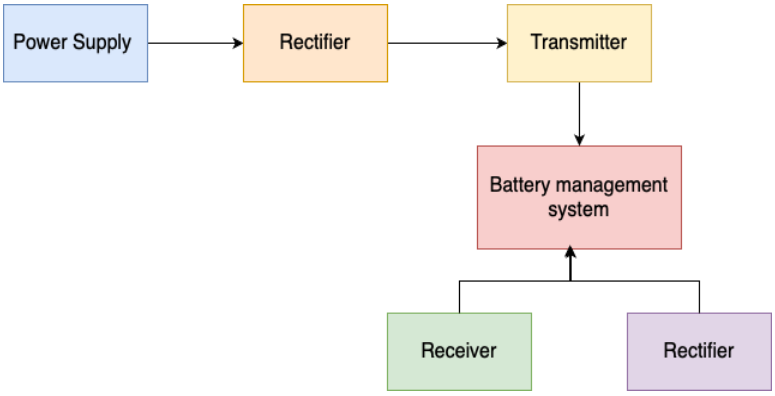

Figure 1: Block Diagram of the Wireless Electric Vehicle Charging System

Electromagnetic Induction

Wireless power transfer relies on Faraday's Law of Electromagnetic Induction. A time-varying magnetic field induces an electromotive force (EMF) in a nearby coil.

$$\mathcal{E} = -N\frac{d\Phi}{dt} \quad (1)$$

III. RESEARCH METHODOLOGY

The wireless EV charging system prototype is designed and implemented using a modular approach, consisting of two main components: there are two major modules the transmitter module and the receiver module. The methodology section describes the development and the implementation of the modules from the hardware point of view and the software tools that have been used.

3.1 Power Supply:
This is in turn used to get the AC current need for coming up with the oscillating magnetic field The high frequency AC power supply is required to generate the required AC current. For efficient wireless power transfer, power supply unit has been designed to provide stable and adjustable output frequency range.

3.2 Coil Design:
The transmitter coil is used to produce the actual magnetic field which is a very important component of the system. The configuration, turn and the type of material used in the coil are the parameters that are well designed for the maximum output of the magnetic field and coupling of the receiver coil.

3.3 Compensation Network:
In order to rectify these issues a compensation network is incorporated into the system to enhance the efficiency of the system and its power handling ability . This network consists of capacitors and inductors connected in a particular topology to oscillate at the set frequency to boost the power transfer proficiency.

3.4 Control and Monitoring:
A transmitter module is used to control and monitor the operation of an Arduino microcontroller board. These abovementioned features explicitly involve the control of the microcontroller by writing coded commands to change the overall operating frequency, control and maintain the power levels, and establish and regulate the communication with the receiver module of the system for its subsequent integration and security measures.

3.5 Receiver Coil:
Like the transmitter coil this type of coil is used in order to pick up the magnetic field which is produced by the transmitter module. The geometry of the coil is selected and designed with due consideration to be able to maximize the degrees of coupling and hence the induced current produced.

3.6 Rectifier Circuit:
This current flowing in the receiver coil is an AC and this is turned into a DC through rectification process. This DC output is then passed directly to the battery management system of the EV for charging of the battery.

3.7 Power Conditioning:
Depending on what particular BMS of the EV requires, other PCC can be added to control the voltage, current and other parameters that are necessary for proper charging of the battery.

3.8 Control and Communication:

Another Arduino microcontroller board is incorporated into the receiver module to manage the communication with the transmitter module, to include security measures as well as to manage the charging process. This makes the modulation and demodulation process to be correctly aligned and lowers chances of interference between the transmitter and the receiver sub-modules.

3.9 Software Implementation:

Arduino Technologies both in the transmitter and receiver modules are provided with microcontroller boards of Arduino that is programmed using the Arduino Integrated Development Environment (IDE) as well as appropriate libraries for the control, monitor and communication functions. The software does entail usage of frequency tuning algorithms, power level control algorithms, fault detection algorithms and data sharing algorithms between the different modules.

Both unit tests and integration tests are performed during the development phase to identify the system's effectiveness in terms of functionality and performance besides general reliability. A number of circumstances, which can be positional, external object presence, and thermal conditions, are analyzed to analyze possible risks or drawbacks

IV. RESULTS AND DISCUSSION

Figure 2: Prototype Model of the Wireless Electric Vehicle Charging System

The Wireless Electric Vehicle Charging System demonstrated promising results in terms of efficiency and convenience. The system maintained high power transfer efficiency under optimal alignment between the transmitting and receiving coils, though efficiency dropped when misalignment occurred, highlighting the importance of proper coil positioning.

Charging times were comparable to traditional plug-in systems, with the added benefit of eliminating the need for physical connections. Thermal performance remained stable, and the system showed no significant overheating issues during extended charging periods. Overall, the wireless charging system proved to be a reliable alternative to conventional methods, with the potential for further optimization in coil alignment and power transfer capabilities

V. ACKNOWLEDGMENT

We would like to sincerely thank you for ensuring that the project was successfully completed in time. With many Thanks, it was so kind of us to appreciate our guide for his labor which makes it possible to implement this project smoothly and get high quality result. The Vishwakarma Institute of Technology in Pune upkeeps this model. We appreciate the support extended Prof.Jayant Gaikwad for providing us with invaluable assistance. Furthermore, we would be grateful to our other colleagues for the development and success.

VI. CONCLUSION

The design and implementation of this wireless EV charging system prototype demonstrate the feasibility and potential of inductive power transfer technology for enabling convenient and efficient charging of electric vehicles. Through the use of carefully designed transmitter and receiver modules, coupled with robust control and monitoring mechanisms, the system successfully achieves wireless power transfer over a range of distances and power levels.The modular approach adopted in the system's design allows for scalability and adaptability to different EV models and charging requirements. The integration of Arduino microcontroller boards ensures precise control over various aspects of the charging process, including frequency tuning, power level adjustment, and communication protocols, enhancing the overall system's efficiency and safety.Experimental results and rigorous testing have validated the system's functionality, highlighting its ability to overcome challenges such as misalignment, foreign object detection, and thermal management. However, further research and development are required to address remaining limitations and optimize the system's performance for real-world deployment.Looking ahead, the widespread adoption of wireless EV charging technology has the potential to revolutionize the transportation sector by offering a seamless and user-friendly charging experience. By eliminating the need for physical electrical connections, wireless charging can significantly reduce the hassle associated with traditional conductive charging methods, encouraging more individuals to embrace electric vehicles as a sustainable and convenient mode of transportation.Furthermore, the integration of wireless charging systems with smart grid technologies and renewable energy sources can contribute to a more efficient and eco-friendly energy ecosystem, reducing the reliance on fossil fuels and promoting a greener future.While the current prototype represents a significant step forward, continued research and development efforts are necessary to address remaining challenges, such as standardization, cost optimization, and large-scale deployment strategies.

Collaboration between academia, industry, and government agencies will be crucial in overcoming these hurdles and realizing the full potential of wireless EV charging technology.

VII. REFERANCES

[1] N. Tesla, "The transmission of electrical energy without wires," Electrical World and Engineer, 1904.

[2] S. Li and C. C. Mi, "Wireless power transfer for electric vehicle applications," IEEE Journal of Emerging and Selected Topics in Power Electronics, vol. 3, no. 1, pp. 4-17, 2015.

[3] J. Sallan, et al., "Inductive energy transfer for wireless electric vehicle charging: Electromagnetic analysis and practical results," IEEE Transactions on Industry Applications, vol. 56, no. 3, pp. 2199-2209, 2020.

[4] A. P. Sample, et al., "Analysis, experimental results, and range adaptation of magnetically coupled resonators for wireless power transfer," IEEE Transactions on Industrial Electronics, vol. 58, no. 2, pp. 544-554, 2011.

[5] C. Liu and A. P. Hu, "Steady electric field analysis for wireless capacitive power transfer," IEEE Transactions on Power Electronics, vol. 33, no. 11, pp. 9917-9925, 2018.

[6] M. Budhia, et al., "Comparison of SWIPT techniques for EV applications: Determining the solution based on transfer rating and range criteria," IEEE Circuits and Systems Magazine, vol. 19, no. 2, pp. 44-64, 2019.

[7] J. Shin, et al., "Single-receiver wireless electric vehicle on-road charger integration practice," IEEE Transactions on Transportation Electrification, vol. 5, no. 2, pp. 428-443, 2019.

[8] M. Ibrahim, et al., "Multi-receiver wireless power transfer system for electric vehicles," IEEE Transactions on Power Electronics, vol. 36, no. 9, pp. 10248-10259, 2021.

[9] S. Y. R. Hui, et al., "An overview of wireless EV charging systems for vehicular emissions control," IEEE Transactions on Vehicular Technology, vol. 68, no. 7, pp. 6185-6196, 2019.

[10] J. Deng, et al., "Roadway wireless charging system for electric vehicles: Simulations and analysis," IEEE Transactions on Vehicular Technology, vol. 70, no. 2, pp. 1164-1177, 2021.

[11] K. A. Kalwar, et al., "Coil design for high efficiency and constant leaked EMF in a vehicle wireless charging system," IEEE Transactions on Magnetics, vol. 53, no. 6, pp. 1-4, 2017.

[12] C. C. Mi, et al., "Modern prospective of signal and power integrity for wireless charging of electric vehicles," IEEE Transactions on Transportation Electrification, vol. 4, no. 2, pp. 517-537, 2018.

[13] SAE International, "Wireless power transfer for light-duty plug-in/ electric vehicles and alignment methodology," SAE Standard J2954, 2019.

[14] S. Habib, et al., "Wireless EV charging: Integrating renewable energy sources and smart grid," IEEE Transactions on Transportation Electrification, vol. 6, no. 3, pp. 1126-1138, 2020.

[15] M. Budhia, et al., "Addressing the cost of ownership of electric vehicle wireless charging infrastructure through technological and business model innovations