iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 10 **Issue:** II **Month of publication:** February 2022

DOI: https://doi.org/10.22214/ijraset.2022.40294

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 10 Issue II Feb 2022- Available at www.ijraset.com

Wireless Charging of Electric Vehicles Using Dual Spiral Coil Magnetic Resonant Coupling

Abhinav. K. S[1], Shivaprakash. S[2], Abhinav Saxena[3], Akshay. P. K[4], M. Jeethendhra[5]
[1, 2, 3, 4, 5] *Department of Mechanical Engineering, New Horizon College of Engineering, Bengaluru*

Abstract: As we get into a new decade in the 21st century, the progress of electric automobiles has been on a significant rise but still flawed with things like range anxiety, limited number of charging stations, high price range etc. But one of the most important flaw is the range anxiety especially in countries like India where we spend half the time stuck in traffic. So, to overcome that we have come up with a project whose technology is still in development and is being tested worldwide.
One method to avoid this is by the introduction of Wireless charging into Electric vehicles which is the main focus of this paper.

I. INTRODUCTION

Mankind has been using automobiles for transportation from one location to another. These automobiles use inner combustion (IC) engines to drive it. Due to increased number of automobiles, there are environmental pollutants caused through IC engines and reduction in fossil fuels. The trendy improvements with inside the Automotive Industry are helping to improve fuel efficiency and lessen emissions. One such technological advancement is Hybrid motors which use each IC engines and electric powered automobiles to force the motors or a vehicle in easy words, helping to lessen the number of emissions produced preserving the overall performance of the engine. However, with inside the future, the focus is on clean and green power producing net zero emissions.

Design and manufacture of electric powered motors has led to major interest in modern industry. Since those motors run on battery, the primary drawbacks are excessive cost, brief distance journey and prolonged charging time, and additionally thinking about the weight of the batteries which affects the distance. Consumers are continuously looking for a higher solution to enhance the journey efficiency. Hence, charging structures had been constructed at each fuelling station.

Currently, the only way to charge electric vehicles are plug-in systems. But these systems are cumbersome considering the need to carry bulky charging cables and, in a way, unsafe because of the wired connection. Although as of right now, plug-in chargers are the most efficient energy transfer systems with nearly 100% energy transfer from the source to the battery possible.

Wired charging also has some limitations like socket points, spacing occupied through the charging station, limited variety of wire, vehicle has to change its orientation to connect to the charger. These can be addressed through wireless charging structures for electric powered motors. This presents bendy and trouble-free unfastened charging and also, these structures can be constructed at home, parking lot, storage etc.

The figure 1 indicates a simplified diagram of vehicle and wireless charging device implemented in car industry. Many wireless power transfer strategies are used to put in force this technology. These techniques use coils to transmit power. The coil will produce a small magnetic field, when a 2nd coil is positioned, an electric current will flow through it. Creating magnetic flux, this has transferred power from one coil to other, known as Induction.

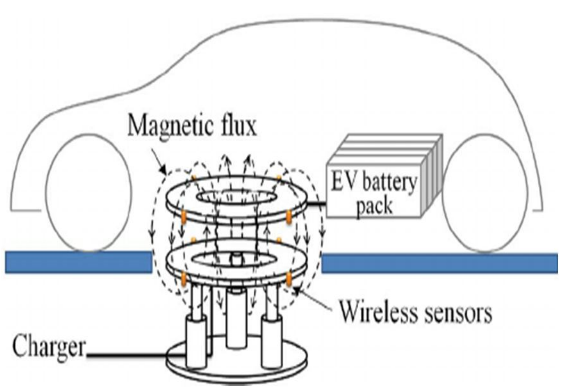


Figure 1

The methods used in today's day and age for any wireless transfer is called Electromagnetic Induction or inductive wireless charging. Inductive wireless charging works on the principle of mutual induction - same as the principle of a transformer. The most relevant example of inductive wireless charging in use would be the wireless charging of mobile phones. But while wireless chargers and smartphones are often in close contact and the coils need to be aligned accurately, it is difficult to position the vehicle accurately over the charger, and the distance between charger (transmitter) and the receiver installed on the vehicle is much bigger. This results in poor efficiency of the energy transfer in actual conditions. The solution to this is using Magnetic resonant wireless charging.

Early in the last decade, Massachusetts Institute of Technology (MIT), among others, explored ways of improving the efficiency of wireless charging systems. The institute targeted at the reality that magnetic field flux hastily falls off because the coils in an inductive wireless charging system are moved apart. Beyond some centimetres, the flux will become so susceptible that all power transfer stops. MIT researchers found out that a "non-radiating" wireless charging approach was needed to free power transfer from the inverse square law that ruled inductive techniques, which essentially means the density of flux lines are inversely proportional to the square of the distance.

MIT got here up with a system that transferred electricity between coils running at (identical) resonant frequencies. The approach is still "inductive" in that the oscillating magnetic field generated with the aid of using the primary coil induces a current in the secondary but it takes gain of the strong coupling that takes place among resonant coils, even if separated by tens of centimeters.

With magnetic resonant wireless charging, the wireless transfer is possible over greater distance compared to the minimal distance of Electromagnetic induction with nearly the same efficiency as electromagnetic induction. Perfect alignment is not required with Magnetic resonance, which is also a benefit. Resonant wireless charging addresses the main drawback of inductive wireless charging, the requirement to closely couple the coils which demands precise alignment from the user. Magnetic resonance is like a child on a swing. Once you push the child on the swing, the initial push is all is needed and proceeding it, we just need to tap the back of the child in order to keep the swinging action continuous. With the same principle, magnetic resonance is just working on a frequency, transferring power to the other coil.

II. CONCEPT & DESIGN

The magnetic resonance coupling principle is a mix of inductive coupling and the alternator's resonance frequency.

The magnetic resonance coupling system refers to two resonant circuits that have the same frequency and are connected through an interface. When both circuits are supplied with power, a tendency for power transmission from one object to another is known as mutual inductance, which accounts for around 10% of total inductance. With little energy squandered owing to unrelated resonant items, the exchange energy will occur efficiently.

For this system, it is important to raise the load power and prolong the transmission distance in the axial direction. Microwave transmission, despite its high power of kilowatts and long distance of several kilometres, is far from safe and stable when compared to MRC-WPT employing the non-radiative near field. When the electrical parameters are set, the maximum active power available to the load is determined by the coupling coefficient between resonators, the resonator quality factor, and the drive power. As a result, if we want to raise the load power, we need consider the aggregate contribution of the three characteristics listed above. The resonator quality factor can be improved in two ways, according to the calculation formula ($Q = L/R$): (1) by raising the ratio of inductance and resistance, and (2) by increasing the natural resonant frequency. In this paper, Litz copper wire could be utilised to overcome the current density induced by skin and proximity effects present in single strand and produce a high Q factor for wireless coils.

These are individual insulated thin wire strands that have been twisted together. Each strand, as well as the complete cable unit, is shielded in this manner. Coils made with 1mm diameter Litz wire provide outstanding performance and efficiency. Detailed parameters of improved wireless power link system are shown in Table 1.

Figure 2 depicts the general configuration of the MRC-WPT system, which is divided into three portions to perform the duties of power coupling, transformation, and transmission. Inductive coupling is used to obtain power on resonator a1,2 and to convert low voltage/high current to high voltage/low current between the resonators and the source or device coil. When the system is tuned into a resonant state, power is exchanged between the resonators via EM resonant coupling, resulting in a low transmission loss due to the high impedance performance. $V_{a1,2}$, $I_{a1,2}$, $C_{a1,2}$, and $R_{a1,2}$ are the voltage, current, capacitance, and resistance of the resonator $a_{1,2}$; $I_{1,2}$, $R_{S,D}$, and $L_{S,D}$ are the current, resistance, and induction of the source and device coils, respectively; V_S is the driving voltage; R_L is the load resistance; M_{S1}, $M_{1,2}$, and M_{2D} are mutual induction between the coils. The coupling effect between the non-resonant source and the device coil is not taken into account here.

To build a low-loss bridge for energy travelling between the source and the device, high-quality resonators are required.

Table 1

Parameters	Resonators	Load coil
Materials	Copper pipe	Silver-plating copper wire
Conductivity (10^7 S/m)	5.56~6	6.06
Number of turns	4.25	4
Radius of wire (mm)	3	2.5
Radius of the coil(cm)	30	10
Conductor spacing (cm)	6 ± 2.5	–
DC resistance (Ω)	0.046	0.002
Resonant frequency(MHz)	10.1–14.5	–
Quality factor	1000~1500	–

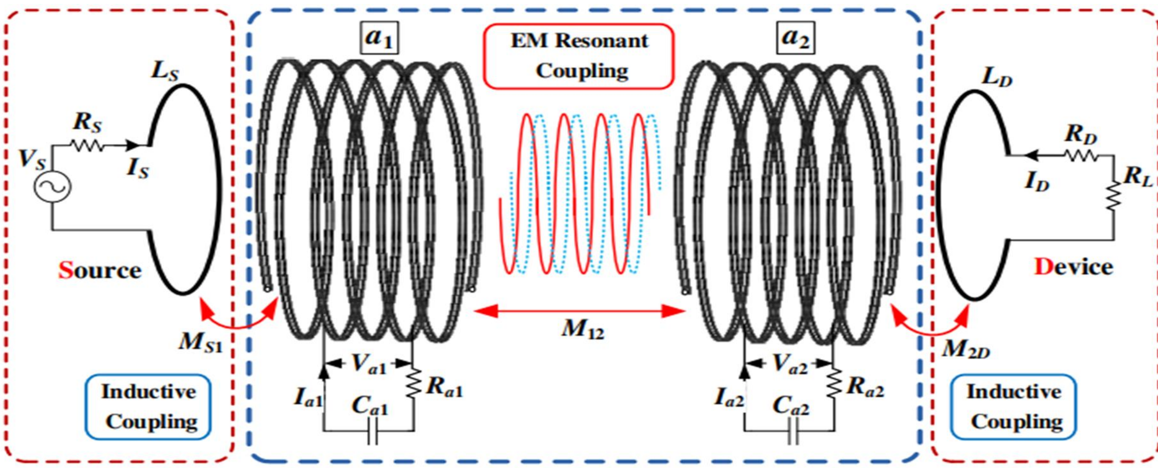


Figure 2

As illustrated in Fig. 2, the coupling mechanism of a wireless power transfer system is typically made up of four coils: a source coil, two resonators, and a device coil.

Impedance matching is accomplished by altering the distance between the source coil and the resonators. In mid-range applications, two resonators are required and to reduce transmission loss between the coils, electrical energy can be directly delivered to the resonator, eliminating the need for a source coil.

As a result, an enhanced four-coil wireless power link with a transmitting resonator, a receiving resonator, is proposed. Both the transmitting and receiving resonators are symmetric. In general, WPT system is intended to operate in a far enough distance to increase the flexibility of power supply. Therefore, the remaining method to reduce damping effect is to choose the coils with larger dimension and a greater number of turns. A centre feed method is applied to resonators to achieve good impedance matching.

A single-loop coil and a resonator make up the transmitter and receiver. The diameter of the spiral resonators was set at 24.2cm and winding turns were 26 times. The distance between the single-loop coil and the resonator was fixed to 4 cm, which is the point at which the two resonators' quality factors are most equal. The resonator coils are coaxially located on the same plane. The geometric parameters of the spiral resonator were determined using its self-resonant frequency and quality factor. Because 13.56 MHz is a promising frequency for WPT applications, it was chosen as the working frequency. In this study, the voltage source is applied without considering impedance matching. Therefore, the transmission efficiency η of the entire WPT system can be calculated as the ratio between the actual input power P_{in}, and actual output power P_{RL}, which is expressed as follows: $\eta = P_{RL}/P_{in}$.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 10 Issue II Feb 2022- Available at www.ijraset.com

The maximum transmission power values were found to be 13.1 kW for the MRC-WPT systems with dual spiral resonators. The theoretical values were obtained for the transmission distance and efficiency and tabulated as shown in Table 2.

d [cm]	η [%]
22.0	95.57
28.20	94.25
33.0	92.41
39.0	89.97
45.0	87.10
52.20	82.81
58.30	78.73

d- Distance between the spiral resonators in cm.

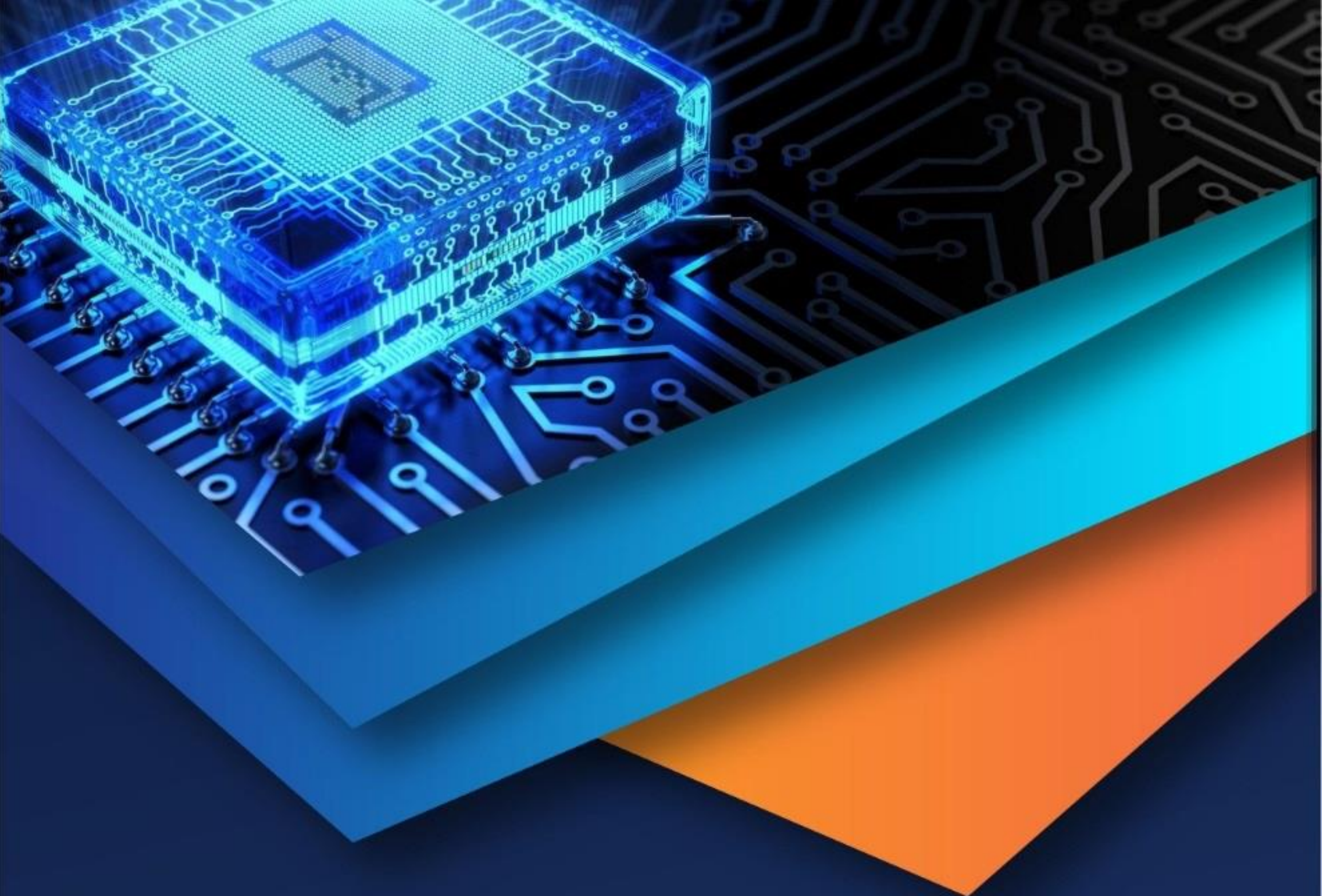
Table 2

III. CONCLUSION

EV popularity is predicted to rise dramatically in the next decade as EV technology, charging infrastructure, and grid integration facilities improve. Wireless charging has received a lot of interest in this area since it is spark-free, independent of the environment, and adaptable to unmanned operations. This paper provides a thorough overview of wireless charging technology for electric vehicles. WPT technology provides the potential for improved energy efficiency, reduced environmental impact, lower life cycle costs, and increased convenience and operational safety.

REFERENCES

[1] Reduction in Human Interaction with Magnetic Resonant - Coupling WPT Systems with Grounded Loop by Xianyi Duan, Junqing Lan, Yinliang Diao, Jose Gomez-Tames, Hiroshi Hirayama, Masashi Hotta, George Fischer and Akimasa Hirata
[2] WIRELESS CHARGING OF ELECTRIC VEHICLE by Asst. Prof.Swapna Manurkar, Harshada Satre, Bhagyashree Kolekar, Pradnya Patil, Samidha Bailmare
[3] A DEVELOPMENT OF ELECTRICAL VEHICLE CHARGING SYSTEM USING WIRELESS POWER TRANSFER by Amaluddin Zainuddin, Syafeeza Ahmad Radzi, Mazree Ibrahim and Norihan Abdul Hamid
[4] Transmitter Module Optimization for Wireless Power Transfer - Systems with Single Transmitter to Multiple Receivers by Joungha Lee and Seung Beop Lee
[5] An improved three-coil wireless power link to increase spacing distance and power for magnetic resonant coupling system by Xian Zhang, Hao Meng, Bin Wei, Songcen Wang and Qingxin Yang
[6] Simulation-Assisted Design Process of a 22 kW Wireless Power - Transfer System Using Three-Phase Coil Coupling for EVs by Chia-Hsuan Wu, Ching-Ming Lai, Tomokazu Mishima and Zheng-Bo Liang
[7] Wireless Power Transmission by Vikash Mishra, Lavya Nigam, Anand Mohan
[8] Duan, X.; Norodin, N.S.A.; Sakata, A.; Hotta, M. Fundamental characteristics of some modified shape spiral-resonators used for resonator-coupled type wireless power transfer system. In Proceedings of the 21th IEEE Hiroshima Section Student Symposium (HISS), Okayama, Japan, 9–10 November 2019; pp. 294–297.
[9] https://en.wikipedia.org/wiki/Litz_wire
[10] XIAOLIN MOU, (Member, IEEE), DANIEL T. GLADWIN, (Senior Member, IEEE), RUI ZHAO, HONGJIAN SUN, (Senior Member, IEEE), AND ZHILE YANG, (Member, IEEE) - Coil Design for Wireless Vehicle-to-Vehicle Charging Systems (September 22, 2020)
[11] DINH HOA NGUYEN , (Member, IEEE) - Electric Vehicle – Wireless Charging-Discharging Lane Decentralized Peer-to-Peer Energy Trading (September 30, 2020)
[12] MUHAMMAD ADIL , (Student Member, IEEE), JEHAD ALI (Member, IEEE), QUI THANH HOAI TA, MUHAMMAD ATTIQUE , AND TAE-SUN CHUNG - A Reliable Sensor Network Infrastructure for Electric Vehicles to Enable Dynamic Wireless Charging Based on Machine Learning Technique (October 14, 2020)
[13] Yashwanth Bezawada and Yucheng Zhang - A Case Study: Influence of Circuit Impedance on the Performance of Class-E2 Resonant Power Converter for Capacitive Wireless Power Transfer (June 18, 2021) – MDPI
[14] AGANTI MAHESH , BHARATIRAJA CHOKKALINGAM , (Senior Member, IEEE), AND LUCIAN MIHET-POPA, (Senior Member, IEEE) - Inductive Wireless Power Transfer Charging for Electric Vehicles – A Review (October 13, 2021)
[15] M. SangCheol, K. Bong-Chul, C. Shin-Young, A. Chi-Hyung, M. Gun-Woo, Analysis and design of a wireless power transfer system with an intermediate coil for high efficiency, Indust. Electr., IEEE Trans. 61 (2014) 5861– 5870.
[16] S. Lukic, Z. Pantic, Cutting the cord: static and dynamic inductive wireless charging of electric vehicles, Electr. Magazine, IEEE 1 (2013) 57–64.
[17] J.L. Villa, J. Sallan, J.F.S. Osorio, A. Llombart, Highmisalignment tolerant compensation topology For ICPT Systems, IEEE Trans. Indust. Electr. 59 (2012) 945–951.
[18] FKA, 2015. Unplugged - interoperable inductive charging for electric vehicles. In: FABRIC Conference, Brussels (Presentation). FABRIC.
[19] A. W. Green and J. T. Boys, "10 kHz inductively coupled power transfer-concept and control," in roc. 5th Int. Conf. Power Electron. Variable-Speed Drives, Oct. 1994, pp. 694–699.
[20] H. Barth, M. Jung, M. Braun, B. Schmülling, U. Reker, ''Concept Evaluation of an Inductive Charging System for Electric Vehicles", Presented at the 3rd European Conference SmartGrids and E-Mobility, Munchen, Germany, 2011



10.22214/IJRASET

INDEX COPERNICUS

45.98

IMPACT FACTOR: 7.129

TOGETHER WE REACH THE GOAL

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY