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Wireless Charging Techniques – A Survey

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Abstract: In recent years, there has been an enormous development in the field of wireless technologies. Wireless charging technologies uses Inductive power transfer, Magnetic resonance coupling transfer and RF radiation to charge the target device. However these techniques have low efficiency and power transfer capability. This paper presents the review on the advancements in the field of wireless charging techniques and a suggestion to overcome the disadvantages of the present techniques is by using active tuning approach.
Keywords: wireless charging; Inductive power transfer; Magnetic resonance coupling transfer, RF radiation,Active tuning approach.

I. INTRODUCTION

Fossil fuels are nonrenewable sources of energy. The extensive use of fossil fuels caused the depletion which led to the discovery of electric vehicles. The traditional way of charging these electric vehicles is through hardcore wires, but the major constraint in wired charging is distance of the target device from the plug-in station and availability of plug-in stations.

Majorly used portable electronic devices are mobile phones, tablets, laptops. Research on charging of these portable devices became a predominant topic in 1990's.The charging ports for each of these portable devices vary. Hence, they cannot be charged using a common charging cable. Due to the use of charging ports and cables, wear and tear can take place. These drawbacks of wired charging led to the discovery of wireless charging techniques. Nikola Tesla was the first person to propose the idea of wireless power transmission and hence, he is regarded as the "Father of Wireless".

II. WIRELESS CHARGING

Wireless charging is a technique of sending power through air medium to electronic devices without being in contact with the cords.

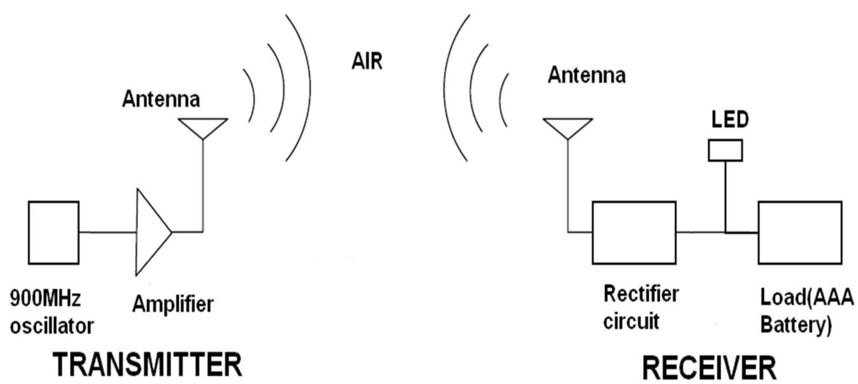

Fig 1: Transmitter and Reciver section

The basic block diagram of a wireless charging system consists of a transmitter and a receiver. The wireless battery charger is designed to operate at 900MHz. Here the power transmitter acts as the power source. The signals from the transmitter is sent to the receiver through air and then the rectifier circuit in the receiver converts RF/microwave signals to DC signal. After the signal is obtained, the charging circuit stores the power into the battery.

Wireless charging is basically implemented on:

A. Stationary Objects

The technologies used to charge stationary objects are: Inductive power transfer, Magnetic resonance coupling transfer and RF radiation.

B. Objects in Motion

In moving objects, the primary side of the coil is embedded under the road and the on board secondary side of the coil must be able to pick up the power while moving. But, it is very difficult to have small air gap with the roads.

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III. REVIEW

A. Inductive Power Transfer

Inductive power transfer (IPT) chargers have loosely coupled transformers in which there is no core that connects primary and secondary coils. That is why the coupler transfers power across the air gap. The tuning capacitors are mounted in series with the primary and in parallel with the secondary. These primary and secondary sides of IPT couplers are designed as pads. The distance between primary and secondary coils must be large enough to give good ground clearance.

Leakage inductance is a function of air gap and this leakage inductance increases sharply. Impedance matching is very much necessary in IPT. This is realized by adding capacitance in series or parallel with both the sides of transformer. Adding the capacitance in series or parallel to the sides of the transformer is advancement over the soft switching techniques. Poor coupling is the main problem which can be overcome by impedance matching. The capacitors along with inductors on both the sides of the transformer form resonant circuits. By this, the reactive power is not transferred across the air gap.

$$K=M/\sqrt{(L1L2)}$$

K should be as high as possible to transfer more power. To obtain high coupling coefficient, coil and core design are very important. In order to achieve greater power transfer and improved horizontal tolerance, larger pads are required.

The advantages of IPT are that it is safe for human use and its implementation is simple. However, the major disadvantages are

1) Short range of charging.
2) Heating effect.
3) Not suitable for mobile applications.
4) Needs tight alignment between charger and charging devices.

B. Magnetic Resonance Coupling Transfer

Electromagnetic resonant coupling technology is based on coupled mode theory. In this method, power can be transferred across a large air gap. This device has approximately 90% efficiency within the range of 1 meter. The couple has 2 antennas. These antennas resonate at the same frequency. This method is almost similar to the IPT concept. But, the difference is that the self-inductance of the antennas and the integrated capacitance form the resonance and frequencies are in terms of MHz range. Open-end and short-end helical antennas are used. To improve the efficiency, magneto plate wires are also used. 6.78 MHz frequency is selected. Proper ferrite material for coils must be used to obtain high efficiency. Primary coil has 5 turns, inductance of 1.58µH, and frequency of 6.78MHz and capacitance of 349pF. Secondary side consists of Rectifier Bridge, bulk capacitors and DC converter. Parallel resonance has been chosen.

The advantages of magnetic resonance coupling are

1) Loose alignment between chargers and charging devices.
2) Charging multiple devices simultaneously on different power.
3) High charging efficiency.
4) Non-line-of-sight charging.

However the disadvantages are

1) Semiconductor devices used has poor efficiency in high frequency ranges i.e., in MHz.
2) It is not suitable for mobile applications.
3) Limited charging distance.
4) The device has to transmit very high power. There is no suitable source which can operate at high frequency and transmit high powers.
5) In this method, efficiency decreases with increase in distance.
6) Complex implementation.

C. RF Radiation

The wireless charging panels usually consists of electromagnetic (EM) shield under the panel which prevents the ac magnetic field generated by the winding structures from entering into any metal object under the charging panel. To increase the signal strength for mobile phones, RF repeaters are used on top if the charging panel. The basic charging area for the charging device is provided by the multi layered winding structures.

When the mobile phones consisting of receiving coil, the two coils with highest mutual inductance is selected. The RF repeaters

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placed on the charging panel consists of a coupler and an antenna connected to the coupler. The transmission and reception performance increases with increase in the area of radiation pattern in all directions when EM shield is not used. However the EM shield reduces the magnitude of received power. For the condition where a thin wire repeater is used with the EM shield, repeater is placed between the charging panel and antenna. The performance under this condition is improved.

Radiation pattern with consideration of phone orientation is, when the phone is not oriented exactly on the charging surface effective charging does not take place and signal magnitude also decreases. To overcome this condition, two orthogonal repeaters are placed on the charging panel. When 1D and 2D multiple single thin wire repeaters are used, the region confined by the repeaters are increased to the entire charging panel. Hence, allowing any orientation of phones on the charging panel. This improves reception range.

The advantages of RF radiation technique are

1) Long effective charging distance.
2) Suitable for mobile applications.

However, the disadvantages are

1) Not safe when the RF density exposure is high.
2) Low charging efficiency.
3) Line-of-sight charging.

D. Planar Wireless Charging for Portable Electronic Products

As mobile phones are one of the most useful portable product, researches on its charging methods and its efficiency became an interesting topic in 1990. Besides the cord based charging, the RF radiation based "short range" wireless charging technology has emerged as an attractive method and a user

Features of planar charging are

1) Fixed location.
2) It can charge one or more devices. But, it should be placed on the surface.
3) Friendly approach for a wide range of portable e-devices.

However, the drawbacks of this system are

1) Planar charging has some critical issues that they neglect human safety.
2) The charging area has to be covered because, it may result in explosion of inflammable devices (example cigarette lighter).
3) It corrupts the system data when it is connected.

So, a good wireless charging system should have the capacity to cover its flux lines and should know about its compatibility. The system should easily communicate bi-directionally. The surface should be closed in order to avoid flux leakage.

IV. WIRELESS POWER STANDARD

A. Qi

Qi is a standard developed by the wireless power consortium for electrical power transfer over distance of up to 1.6 inches (4cm). It consists of a power transmission pad and a compatible receiver. The device is placed on top of the power transmission pad which charges the device via resonant inductive coupling. Currently over 140 smart phones, tablets and many other devices which are under the list of Qi enabled devices. It includes Asus, HTC, Huawei, LG Electronics, Motorola Mobility, Nokia, Samsung, BlackBerry and Sony.

B. Open Dots

It is a wireless power standard which was promoted by the open dots Alliance, a non-profit organization. It is a specification for charging devices via conductive wireless power technology. In May 2015, the open dots alliance stated that the open dots standard was used in more than 12 vehicle models, amongst five major automotive brands are Ford, Chrysler, RAM, Dodge and Scion.

C. Power Matters Alliance

Power matters alliance is an international, non-profit organization whose aim is to advance the standards and protocols for wireless power transmission. PMA is one of the networking technology companies which guarantees the consumers' interoperable devices which employ wireless power technology. PMA standard describes analog power transmission (both inductive and resonant), digital transceiver communication, cloud based power management and environmental sustainability.

PMA board includes representatives from AT&T, Duracell, Starbucks, FCC, Flextronics, Powermat Technologies and Energy Star.

D. Rezence

It is also one of the competing wireless charging standard and the Alliance for wireless power. The system consists of a single power transmitter unit and one or more power receiver units. The system supports power transfer up to 50 watts and distances up to 5cm. The power transmission frequency is 6.78MHz and eight devices can be powered from a single power transmitter unit.

The board includes Gill Electronics, Broadcom, Intel, Integrated Device Technology, Qualcomm, Samsung Electronics and WiTricity.

V. PROPOSED METHOD

A. Tuning Approach using Variable Capacitor

This method overcomes several methods disadvantages of the previously mentioned methods of wireless charging. In this method, secondary side design is not too complicated since, it would be integrated into mobile phones. Efficiency and power transfer capability (PTC) is also high. The efficiency and PTC decreases if the resonant frequency of primary and secondary sides does not match. This technology presents an active approach to tune the system to resonant frequency. A maximum reflected impedance checking method is used to measure the secondary resonant frequency of the secondary side. A variable capacitor is used to tune the primary resonant frequency to the secondary resonant frequency. Here, both primary and secondary sides are taken into consideration. Measurement and tuning steps are done in the primary side. Hence, the design cost in the secondary side is reduced.

B. Secondary Resonant Frequency Measurement

R2 is very small value; therefore Zreq would reach the maximum at ω2. Thus, Zreq is much larger compared to jωL1. We can measure the secondary resonant frequency in two ways.

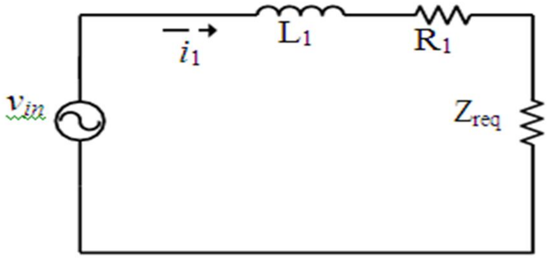

Figure 2: Equivalent detecting circuit

$$Zreq = \frac{\omega^2 M^2}{R2}$$

Firstly, measure the current value passing in the primary circuit. When this current value is minimum, the corresponding frequency is the resonant frequency. Secondly, measure the phase angle between the input voltage and the current. According to the condition Zreq is much larger compared to jωL1, phase angle would be 90degrees at ω2.

C. Primary Resonant Frequency Tuning by a Variable Capacitor

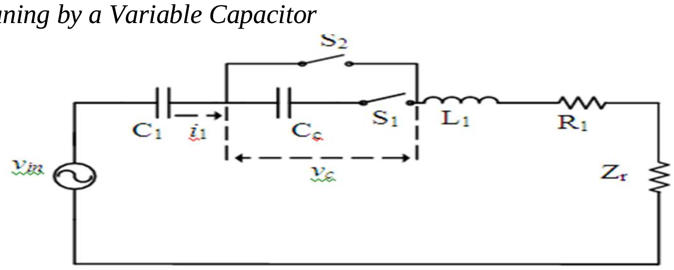

Figure 3: Equivalent circuit of variable capacitor

Cc is the tuning capacitor.S1 and S2 are the two switches shown in fig b. S2 is always close and S1 is always open. A variable capacitor is used in the primary side for series compensation. The resonant is maintained at the secondary frequency by changing the voltage across capacitor.

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Cvariable = C1Cceq/ (C1Cceq)

Where Cceq = Cc/(√(2F)/√π)

$$F = \pi - 2\alpha - 3/2 sin(2\alpha) - \pi/2 cos(2\alpha) + \alpha cos(2\alpha)$$

By choosing the appropriate values of C1,Cc and F, value of Cvariable is found. When this value of Cvariable is used in the circuit, primary side gets tuned to the resonant frequency of the secondary side. This method can be simulated in Simulink. Hence, by using this method most of the disadvantages like low efficiency, low power transfer capability of the already existing methods can be overcome.

VI. CONCLUSION

The major issues in the Inductive power transfer, Magnetic resonance coupling transfer and RF radiation are power transfer capability and efficiency. In the proposed method of active tuning approach, the efficiency and PTC are improved. To measure the resonant frequency of the secondary side, the reflecting impedance checking method is used. In the primary side, to trace the resonant frequency of secondary side, the active series variable capacitor is used. Moreover, the implementation is not too complicated and hence it is cost efficient. This method is suitable for mobile applications. This approach can be verified using Simulink.

REFERENCES

[1] S.Y. Hui, “Planar wireless charging technology for portable electronic products and qi,” Proceedings of the IEEE, vol. 101, no. 6, pp. 1290– 1301, 2013.

[2] D. van Wageningen and T. Staring, “The qi wireless power standard,” in Power Electronics and Motion Control Conference (EPE/PEMC), 2010 14th International, 2010, pp. S15–25–S15–32.

[3] Kwun-Chiu Wan, QuanXue, Xun Liu, and S. Y. (Ron) Hui, “Passive Radio-Frequency Repeater for Enhancing Signal Reception and Transmission in a Wireless Charging Platform”in IEEE Transactions on Industrial Electronics, vol. 61, no. 4, pp. 1750-1757, 2014.

[4] Wei-Siang Jhong1, Wen-Jiao Liao1, “Serially-Fed Beam Scanning Antenna for Wireless Charging Application”, Microwave Technology & Computational Electromagnetics (ICMTCE), 2011 IEEE International Conference, pp. 297-300, 2011.

[5] EskoStrömmer, Marko Jurvansuu,TuomoTuikka, ArtoYlisaukko-oja,HarriRapakko, JarmoVesterinen, “NFC-enabled Wireless Charging”, Near Field Communication(NFC), 2012 4th International Workshop, pp. 36-41, 2012.

[6] Shuo Wang,David Dorrell, “Review of Wireless Charging Coupler for Electric Vehicles”, Industrial Electronics Society, IECON 2013- 39th Annual Conference Of IEEE, pp. 7274-7279, 2013.

[7] Xiaoyin Bai∗, Yen-Kheng Tan †, Zhi-Hui Kong∗, and Siek Liter∗, “Novel Active Tuning Approach for Resonant-mode Wireless Charging System”, Industrial Technology(ICIT), 2014 IEEE International Conference, pp. 342-347, 2014.

[8] Hiroki Shibuya, TatsuakiTsukuda, Hiroko Suzuki, Tadashi Shimizu, Masahiro Dobashi, Shinji Nishizono, Mikio Baba, Hideki Sasaki and Katsushi Terajima, “A Wireless Charging and Near-field Communication Combination Module for Mobile Applications ”, 2014 IEEE 64th Electronic Components and Technology Conference(ECTC), pp. 763-768, 2014.

[9] Werachet Khan-ngern and Heinz Zenkner,”Wireless Power Charging on Electric Vehicles”, Electrical Engineering Congress(iEECON), 2014 International, pp.1-4,2014.

[10] Xiao Lu†, Ping Wang‡, DusitNiyato‡, Dong In Kim§, and Zhu Hano,”Wireless Charging Technologies: Fundamentals, Standards, and Network Applications”, IEEE Communications Surveys & Tutorials, vol. PP, no. 99, pp. 1-1,2015

[11] F. Pellitteri, A. O. Di Tommaso, R. Miceli,”Investigation of inductive coupling solutions for E-bike wireless charging”, Power Engineering Conference(UPEC), 2015 15th International Universities, pp. 1-6,2015.

[12] Wikipedia https://www.google.co.in/search?q=wireless+mobile+charging&biw=1366&bih=705&source=lnms&tbm=isch&sa=X&sqi=2&ved=0ahUKEwiP3-DN3JzMAhXKJI4KHcneBpMQ_AUIBygC#imgrc=ocxI3Iku_RucJM%3A