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Various Coil Shape Performances in Development of Wireless Power Transfer

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Abstract
The transfer of power without conductor or physical connection is called wireless power transmission. The basic concept of power transfer using electromagnetic induction and performance changes using various shapes of coil with comparison of performance in transmission and receiving of power is introduced in this paper. Experimental prototypes are used to verify the results.

Keywords: *Wireless power transmission, electromagnetic induction, Efficient Communication, System Security*.

I. Introduction

Over a decade the dependency of human on gadgets such as phones and tablets has increased remarkably. People connect with the digital world through electronic mails and internet. Playing games and texting is now in the lifestyle of teenagers. On an average the battery in these gadgets can last up to 24hrs comfortably but due to excessive use of these gadgets the need of power for these devices increases. One way is to increase the battery storage which in turn makes the device bulky and expensive. On the other hand wireless charging stations can provide an alternate option to retain power. Wireless charging can effectively reduce the quality control issues associated with contacts of the charger. As wireless charging doesn’t require charger contacts, it can be very help full in conditions like medical environment where corrosion of the charger contacts or plugs due to disinfectants is a major problem. The complete encapsulation of the device will help in evolution of water proof mobiles and reduce risk of contamination due to corrosion.
Section 2 of the paper provides a glimpse of history on wireless power transfer. Working of the inductive coupling is explained in section 3 of the paper. Section 4 highlights the methods of implementation followed in this paper also section5 provides a comparison of different coil shapes. In section 6 the paper is concluded.

II. History of wireless power transfer

Nikola tesla in 1889 invented a tesla coil which can transfer power without any physical connection between two circuits [1]. Modern inductive power transfer techniques are mostly derived from tesla’s experiment. 1)tesla used strongly coupled resonant circuit to improve transfer of power in system. 2) To improve the quality factor self-capacitance were used in the secondary circuit. 3) Use of spark discharge above the air gap improved the power in resonant circuit. William C, brown in 1964 invented a point to point wireless power transfer scheme on the basis of microwave beam [2].in 1968 Peter Glaser an American scientist proposed a concept of a space solar power station and further proved that solar energy could be OPEN ACCESS energies in future which could be first converted into electrical energy and then can be transmitted in the form of microwaves [3]. During 1970 huge progress took place in solar power satellite (SPS) project [4]. Which marked the attainment of effective energy transmission system by the humans? In 2007 the research team head by professor Marin Soljacic of MIT proposed strongly coupled magnetic resonance (SCMR),which is able to transfer 60 watts wirelessly with more than 40% efficiency over a distance of 2 meter[5]. A prototype of roadway powered electric vehicles (EV) developed by Korean researchers of Advanced Institute of Science and Technology in 2008 possessed an efficiency of above 70%.

A direct induction followed by resonant magnetic induction is the most commonly used method for wireless charging. The other methods could be using electromagnetic radiation in the form of microwave or lasers and an electric wire with neutral media. The most common methods of transferring electrical power wirelessly are electromagnetic inducton, electromagnetic radiation, microwave method, laser method and electrical conduction.

1) Inductive coupling: The resonant coupling [6] effect between coils of two LC circuits enables the wireless power transfer. The maximum efficiency is achieved when distance between the transmitter and receiver is less.

2) Laser: The Laser is a coherent beam of electromagnetic energy where all the waves have the same frequency and phase. NASA [7] used this mechanism to send energy point to point in a line of sight for a remote-controlled aircraft wirelessly. An infrared sensitive photovoltaic cell act as the energy collector to convert Laser to electrical energy.
3) Piezoelectric principle: The piezoelectric effect [8] is the relation between a mechanical stress and an electrical voltage in solids. This method has feasibility of wirelessly transfer energy using piezoelectric transducers capable to emit and collect vibratory waves.
4) Radio waves and Microwaves: For Long distance high power energy transmission Microwaves [9] are ideal choice and also, there is a whole research field for rectennas which are antennas capable to collect energy from radio waves.

III. ELECTROMAGNETIC INDUCTION TYPE WIRELESS POWER TRANSFER

Inductive coupling consists of two coils placed close enough to one another such that they behave like an air-core transformer (weekly coupled) which transfer energy to the secondary circuit as the magnetic field radiations from the transmitting coil induces current in the receiving coil[10]. Due to the large bandwidth associated with the inductive coupling, less power is gained by the load as the gain bandwidth trade off. To achieve a resonant inductive coupling coil is loaded with a capacitor so that the inductor-capacitor (LC) combination will resonate at a specific frequency[11]. The narrow bandwidth and higher gain associated with resonant coupling improves the power transfer efficiency. Power can be transferred only in short distances(up to 10 cm) using inductive coupling.

Advantages of inductive coupling
(a) Simple design- theory and physical realization of the design are both very simple. The system is less complex with lesser component count.
(b) Lower frequency operation- the operating frequency is in kilohertz range. This makes it easy to experiment an test on breadboard. Also the risk of radiation is less in LF band.
(c) Low cost- all the components are readily available. No custom order parts were necessary for the design.
(d) Practical for short distance- this system is practical for short distances as long as the coupling coefficient is optimized

IV.IMPLEMENTING METHOD

The semi-sinusoidal wave generated by a full-bridge rectifier is double the line frequency, hence the frequency of oscillations mainly depend on the size and maximum flux density of the ferrite core of the transformer and the storage time of the transistor. As the cycle starts, the current increases and saturates the core. Drive of the active transistor is removed at this point, and ones its storage time passes, it turns off. Oscillation frequency would be 25to 40 kHz during this application. RC network at the base of the transistor is used to reduce the dependence on storage time, which in turn increases the rate of charge extraction from the base at turn-off condition. This arrangement also decouples the base from the oscillations caused by the base of transformer at turn-off, which in away prevents the unwanted turn-off of the device. The implementing block diagram is given in the figure1

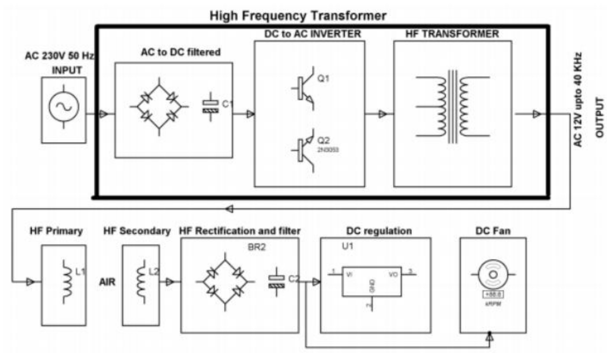

Fig.1 implementation block diagram

The parallel an series compensation as discussed in the literature [12,13] are the basic structure taken in this paper, series-series compensation to demonstrate CT. figure2 shows the equivalent circuit model of the system with two coils, in which, RS, R2(R3), L2(L3), C2(C3), M23 and RL represent the internal resistance of the voltage source the coil parasitic resistances, the coil self-inductance, the resonant capacitors, the mutual inductance and the load resistance, respectively.

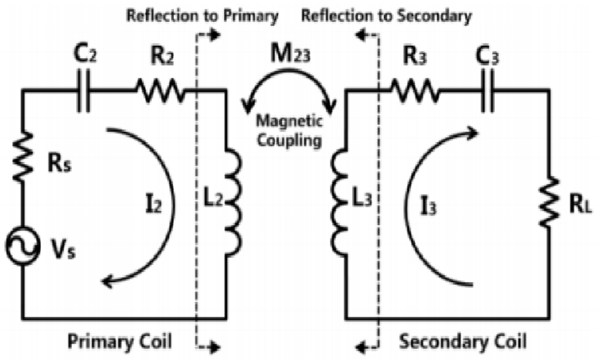

Fig2 equivalent diagram of inductive coupling coil

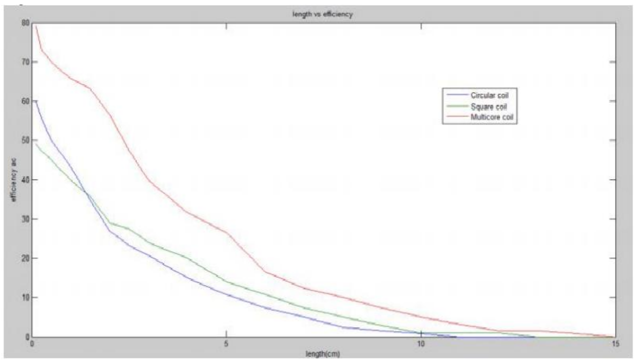

Fig4 efficiency of output vs. length between two coils

Coils of different shapes were used in implementing the project, readings were taken and efficiency of the respective coil was plotted.

Shapes of coils used

1. Circular coil
2. Multicore circular coil
3. Rectangular circular coil

Fig3 various types of coil used for experiment

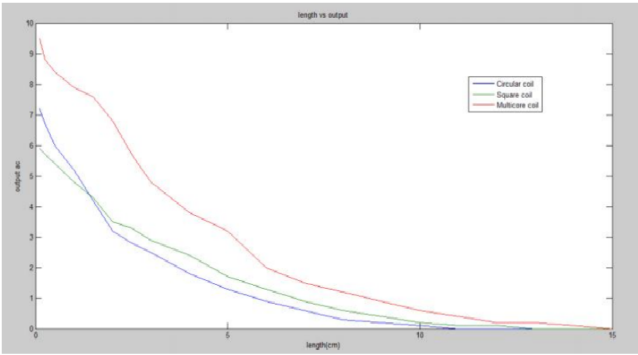

Fig5 output energy transmitted vs. length between two coils

V. COMPARISON OF COILS

The input supply is fed to the transmission coil while keeping the transmission and receiving coil in straight line. The distance between the coils is kept low at the beginning and then gradually increased while the transmission voltage is measured at the receiving end. The experiment is further continued by changing different types of coils of different shapes.

VI.CONCLUSION

In this paper wireless power transfer using electromagnetic induction and comparison of performance of coils of different shapes are examined. Result shows that the coil with circular twisted pair has higher performance while compared to the other shapes of coils. The performance of prototype coils is plotted in graph.

References

[1] Brown, W.C. The history of power transmission by radio waves. IEEE Trans. Microw. Theory Tech.1984, 32, 1230–1242.

[2] Brown, W. Experiments in the Transportation of Energy by Microwave Beam. In Proceedings of the IRE International Convention Record, New York, NY, USA, 21 –25 March 1966; pp. 8–17.

[3] Glaser, P.E. Power from the sun: Its future. Science 1968, 162, 857–861.

[4] Brown, W.C. Status of the microwave power transmission components for the solar power satellite

(SPS). IEEE Trans. Microw. Theory Tech. 1981, 29, 1319–1327.

[5] Kurs, A.; Karalis, A.; Moffatt, R.; Joannopoulos, J.D.; Fisher, P.; Soljacic, M. Wireless power transfer via strongly coupled magnetic resonances. Science 2007, 317, 83–86

[6] Basset, P., Andreas Kaiser, B. L., Collard, D. &Buchaillot, L. (2007). Complete systemfor wireless powering and remote control of electrostatic actuators by inductivecoupling,IEEE/ASME Transactions on Mechatronics12(1)

[7] NASA (2003). Beamed laser power for uavs,Dryden Flight Research Center

[8] Hu, H., Hu, Y., Chen, C. & Wang, J. (2008). A system of two piezoelectric transducers and a storage circuit for wireless energy transmission through a thin metal wall,IEEE Transactions on Ultrasonics, Ferroelectrics, and Frequency Control55(10).

[9] Glaser, P. E. (1973). Method and apparatus for converting solar radiation to electrical power,U.S.A Patent

[10] Sample, A.P.; Meyer, D.A.; Smith, J.R. Analysis, experimental results, and range adaptation of magnetically coupled resonators for wireless power transfer. IEEE Trans. Ind. Electron. 2011,58, 544–554.

[11] Raju, S.; Wu, R.; Chan, M.; Yue, C.P. Modeling of mutual coupling between planar inductors in wireless power applications. IEEE Trans. Power Electron. 2014, 29, 481 –490

[12] Sandrolini, L.; Reggiani, U.; Puccetti, G.; Neau, Y. Equivalent circuit characterization of resonant magnetic coupling for wireless transmission of electrical energy. Int. J. Circuit Theory Appl. 2013, 41, 753–771.

[13] Xun, L.; Ng, W.M.; Lee, C.K.; Hui, S.Y.R. Optimal Operation of Contactless Transformers with Resonance in Secondary Circuits. In Proceedings of the Twenty -Third Annual IEEE Applied PowerElectronics Conference and Exposition (APEC 2008), Austin, TX, USA, 24–28 Febuary 2008; pp. 645–650