Challenging Issues In Wire Less Power Transmission Methods A Survey

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Abstract: In this paper we review the potential challenges of the different Wireless power transfer methodologies. The Research of wireless power transfer started in the year 1891 by Nicolas tesla father of wireless power transfer technology this journey continued till today having a lot of research opportunity and challenges in the field of WPT. we discuss the challenging issues with respect to various parameters of wireless power transfer like Cost of transmission. Biological effect, Environmental hazard, & efficiency become more significant parameter. Depending upon the range of transmission there are mainly two methods of WPT known as far field and near field. we discuss the issues with respect to various types of WPT like inductive coupling, resonant inductive coupling, electrostatic induction, & Microwave power transfer (MPT), laser based power beaming, these methods are based on distance classified as near field and far field wireless power transmission.

Key words: Wireless power transfer (WPT), near field, far field, Microwave power transfer(MPT),power beaming.resonanat Inductive coupling

1. INTRODUCTION:

One of the major issue in power system is losses occurring during transmission and distribution hence increase in the demand of power increases this loss, in india the power loss during transmission distribution is significant around 26%.The main reason for power loss during transmission and distribution is the resistance of wires used for grid. wireless power transmission has became promising solution for this a lot of research is carried for minimizing this loss and to increase the efficiency of transmission, but even this also imposes some challenges like initial cost, health hazard, environmental effect. and efficiency of wireless transmission get reduced for long distance because of diffraction of EM signal. this paper discusses all these issues and survey research publications to find the feasibility of wireless power transmission in practical for coming days.[3]

2. CHALLENGES IN WIRELESS POWER TRANSMISSION METHODS:

There are mainly two types of wireless power transfer technology known as near field and far field among these methods we review the potential challenges faced by following WPT technologies [3][4].inductive coupling, resonant inductive couping ,are examples of near field wireless power transmission. Microwave power transmission laser based power beaming are examples far field wireless power transmission.

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2.1. Inductive coupling:

The principal of mutal inductance that is between two coils transformer is an example of inductive coupling this is suited for only short distance upto few centimeters the drawback is energy decays if distance between transmit coil and reciver coil increases. it employs the method of electromagnetic coupling between two coils[1][3]. Fig.1 shows the inductive copling method of WPT

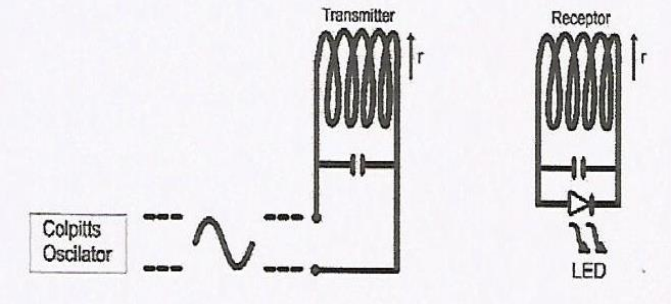

Fig.1:*Inductive coupling*

2.2 resonanant inductive coupling:

in this type of transmission a lot of research is taking place and also proven to be efficient WPT technology for mobile charging ,laptops and many hand held device like tablets, palmtops etc .fig.2 shows such resonant induction charging system A practical wireless power transmission system consisting of a larger rectangular wire loop and a small square wire loop with a parasitic square helical coil is proposed for efficient wireless power transmission in an indoor environment. The effects the non-resonant object such as the conducting box and the human body on the power transmission efficiency and the resonant frequency are investigated numerically The results show that the power transmission efficiency is reduced significantly when a non-resonant object is very close to the receiving element. However this reduction can be negligible when the relative distance between the receiving element and the non resonant is larger than 0.5m or 0.03λ at the resonant frequency of 19.22MHz [7]. Hence in this method also there are potential problems because of near the transmitter some obstacle exists that creates attenuation of power .the efficiency power transfer is very less beyond the distance of 5m .Whether or not it incorporates resonance, induction generally sends power over relatively short distances[8][9].

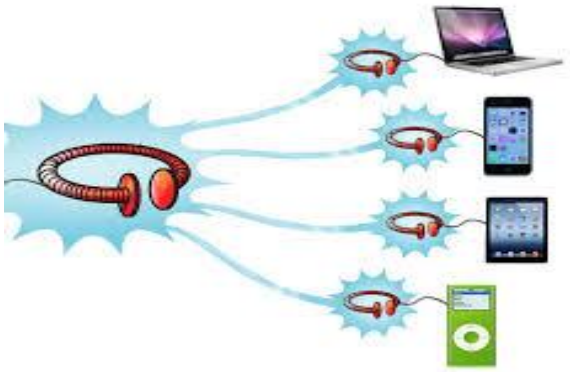

Fig.2 *resonant inductive coupling*

2.3 Electrostatic induction:

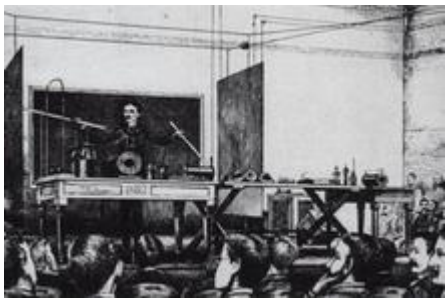

Fig.3 *Electro static induction in teslas experiment*

Much in the same way as two magnetic fields can couple together to produce power transfer, so toocan electric fields.WPT in this fashion is known as capacitive coupling, since the mechanism by whichpower is transferred is through the capacitance that builds up between the transmitter and receiver.The charge associated with the transmitter generates an electric field causes a charge build up of opposite sign on a conducting structure placed in the field's vicinity. Much like magnetic induction,the efficiency of power transfer associated with capacitive coupling decays exponentially with transfer distance. Research indicates that WPT systems based on capacitive coupling perform similarly to their magnetic counterparts, and they may even be less sensitive to misalignment between transmitter and receiver. The major drawback with capacitive WPT systems is that electric fields do not share the safety characteristics of magnetic fields, since their relative field strength is much greater, posing a hazard to both humans and electronic devices[4][5]. Fig.3 shows experimentation on electrostatic induction and noted that the electrostatic effects diminish nearly with the cube of the distance from the coil, where as the electromagnetic inductive effects diminish simply with the distance. the electrostatic effects diminish nearly with the cube of the distance from the coil, whereas the electromagnetic inductive effects diminish simply with the distance Thus, electrostatic induction proves viable for localized lighting applications, yet unsatisfactory for projecting energy over distance] [9].

2.4 Microwave power transmission:

In 1960's William C. Brown, the pioneer in wireless power transmission technology, has designed, developed a unit and demonstrated to show how power can be transferred through free space by Microwaves[2]. The fig.4 shows a microwave power transmission system. A complete microwave transmission system consists of three essential parts:

- Electrical power to microwave power conversion
- Absorption antenna that captures the waves
- (Re)conversion to electrical power

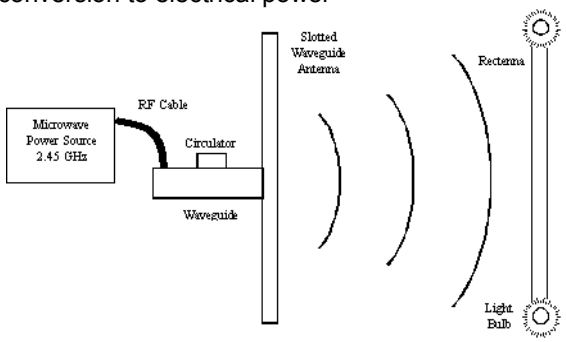

Fig.4 *microwave wireless power transfer technology (MPT)*

The challenges faced by Microwave power transmitted are discussed and research publication are reviewed with respect to some factors like antenna design, diffraction , interference, cost of the system , health hazard, and environ mental issues. For transmission efficiency the waves must be focused so that all the energy transmitted by the source is incident on the wave collection device[8]. electromagnetic radiation must diffract as it travels through space because he beam must pass through an aperture, which, at a shorter transmitted wavelength, will result in a more focused beam width. This is not the only factor as infinitely short wavelengths cannot optimize the beam width. However, atmospheric disturbances also account for losses in beamed power[6]. Microwave transmissions are not particularly hindered by significant attenuation loss due to Rayleigh scattering because the transmitted wavelengths tend to be long enough to mitigate this effect. However the Rayleigh criterion necessitates a receiving antenna proportional to the longer wavelength, and as such, proposals for microwave transmission over long distances, in both atmosphere and space, must account for large transmitting and receiving antennas .the size of antenna increases with low frequency hence the frequency chosen for MPT is in the range of 2.45 GHz and 5.8GHz. Microwave receivers are expected to have a large diameter and disperse the imminent energy across a large area, optimizing human safety[6]. The electromagnetic interference is important issue to be addressed for these frequencies because It is assumed that WPT systems working with microwaves use frequency bands around 2.45 GHz or 5.8 GHz. These bands are already allocated in the ITU-R radio regulation to a number of radio services. They are also designated for industrial science and medical (ISM applications). The ISM band is, as presently defined, for local use only. The 2.45 GHz is furthermore used for radio LAN and microwave ovens. The 5.8 GHz is also used heavily for various applications like Radiolocation service and DSRC(Dedicated Short Range Communications). More investigation is needed to get an image of the possible influencing between the systems[6] [11]. For the very short range (1-10 meters), preliminary demonstrations of WPT at low power levels (less then 1 kW) were in general quite costly, however, the cost estimates are coming down for larger power levels and longer ranges.The slightly over 1million dollar Goldstone test in 1975delivered 34 kW at 1.6 km. The costs of the test in Hawaii in 2008, where just under 1 million dollar and

delivered 20 Watts over 148 kilometers. Tens of km WPT systems are in the range of several $1,000,000/ MW-km, where as similar range wired systems are of order $10,000/MW-km, at least two orders of magnitude less[6] A general public perception that microwaves are harmful has been a major obstacle for the acceptance of power transmission with microwaves. A major concern is that the long-term exposure to low levels of microwaves might be unsafe and even could cause cancer. Since 1950, there have been thousands of papers published about microwave bio-effects. The scientific research indicates that heating of humans exposed to the radiation is the only known effect. There are also many claims of low-level non-thermal effects, but most of these are difficult to replicate or show unsatisfying uncertainties. Large robust effects only occur well above exposure limits existing anywhere in the world [6].The corresponding exposure limits listed in IEEE standards at 2.45 or 5.8GHz are 81.6 W/m2 and 100 W/m2 averaged over 6 minutes, and 16.3 or38.7 W/m2 averaged over 30 minutes[6][10][11].This low compared to average solar radiation of 1000 W/m2 .public acceptance of wireless power transfer by microwaves is needed for the success of WPT. More number of practical projects should validate the safe limits of MPT which encourages the public and govt in implementing such projects[6][10].

2.5 Laser based power beaming:

With a laser beam centered on its panel of photovoltaic cells, a lightweight model plane makes the first flight of an aircraft powered by a laser beam inside a building at NASA Marshall Space Flight Center .In the case of electromagnetic radiation closer to visible region of spectrum (10s of microns (um) to10s of nm), power can be transmitted by converting electricity into a laser beam that is then pointed at a solar cell receiver. This mechanism is generally known as "Power Beaming" because the Power is Beamed at a receiver that can convert it to usable electrical energy[12][13]. Fig.5 shows laser based power transmission to air flight. The following are disadvantages of wireless power transfer using laser based power beaming.

1. Conversion to light, such as with a laser, is moderately inefficient.
2. Conversion back into electricity is moderately inefficient, with photovoltaic cells achieving 40%-50% efficiency.(Note that conversion efficiency is rather higher with monochromatic light than with insulation of solar panels).

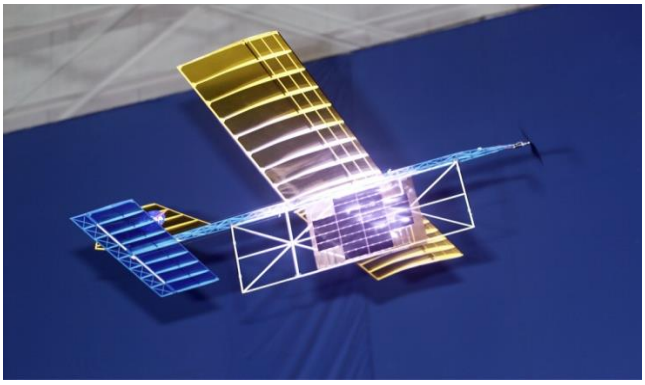

Fig.5 *Laser energy used to power a model airplane with solar cells. Source: Wikimedia Commons (Courtesy of NASA).*

3. A strong laser beam creates problem of human health Hazard.
4. This method is quite expensive to become in realty.
5. losses.due to atmospheric absorption and hence reducing of transmission efficiency

3. Outcome of survey:

The research articles survey shows that among the near field, resonant inductive coupling is promising since it uses resonant tunneling of electromagnetic wave non-radiative. although it has drawback of nearby conductive objects and human being affected if the distance between resonant inductive transmitter and conductive objects and human being is less than 0.03λ or 0.5m this need to be analyzed for different frequency. and the cost of resonant induction is less and many private company like wirtricty, intel are working to promote this type of transmission. Among the far field transmission Microwave transmission and laser Laser power transmission systems are still considered as less mature than microwave based systems. However, it is argued that due to recent advances in direct solar pumped lasers, the potential integration of space and terrestrial based solar power plants and potentially radical simplifications on the space system design; however the initial cost and environmental effect and health hazard, laser-based wireless power transmission concepts should be matured further in order to represent a credible alternative.

4. Conlusion:

Wireless energy transmission has been the subject of many studies in the past, and will continue to be so in the future The challenge to design a more sophisticated, convenient, and efficient method of energy production presents applications in various technological disciplines. the convenience and minimal impact to the environment might justify the implementation of wireless power transfer technology, Thus to assure environmental health and safety, the proposed limit for the "center-of-beam" power densities is approximately 25 mW/cm2 for microwave transmission. Note that the average absorption remains fairly stable for frequencies above 2GHz except when the frequency becomes much higher,i.e10GHz], where the skin effect takes over, the maximum tolerable exposure at 5.8 GHz would be essentially the same as for 2.45GHz.and another important issue is cost of the system in case of Microwave power transmission (MPT) and laser based power beaming is very high.due to intal cost only Nikola tesla experiment on Wardenclyffe tower also known as tesla's tower (187 foot) has not succeeded to reach the public in those days. and there is a long history concerning the safety of microwave energy. the need to guarantee widespread access to this energy, proper identification of potential health hazards, and the implementation of adequate regulations would affect the timeline of commercialization of this technology.

5. Referenes:

[1] Nikola Tesla, —The Transmission of Electrical Energy Without Wires as a Means for Furthering Peace, Electrical World and Engineer. Jan. 7, p. 21, 1905

[2] Brown.w.c (September 1984) " the history power transmission by radio waves"Microwave theory and techniques IEEE Transactions on (Volume: 32, Issue: 9 On page(s): 1230- 1242

[3] Vikash Choudhary, Satendar Pal Singh Vikash Kumar and Deepak Prashar "Wireless Power Transmission: An Innovative Idea".International Journal of Educational Planning & Administration. ISSN 2249-3093 Volume 1, Number 3 (2011), pp. 203-210.

[4] Luke Goodman Alexander Karp, Peter Shorrock ,Thomas Walker "THE FEASIBILITY OF WIRELESS ENERGY" project report submitted for partial fulfillment of Bachelor of science degree at Worcester Polytechnic Institute May 17, 2013

[5] Sagolsem Kripachariya Singh, T. S. Hasarmani, and R. M. Holmukhe "Wireless Transmission of Electrical Power Overview of Recent Research & Development,"Journal of Computer and Electrical Engineering, Vol.4, No.2, April 2012

[6] P. Vessen, "wireless Power transmission," Leonardo energy; briefing paper

[7] Qiaowei Yuan1, Qiang Chen, Kunio Sawaya" Effect of Human Body on Near-Field Resonant Coupling Wireless Power Transmission System"

[8] Kilaru Kalyan, Shaik Avaes Mohsin, Angadi Suresh "Transmission of Power through Wireless Systems" International Journal of Engineering and Advanced Technology (IJEAT) ISSN: 2249 – 8958, Volume-2, Issue- 4, April 2013

[9] Charles L. Moorey, William Holderbaum & Ben Potter The University of Reading, UKs A Review of Modelling Techniques Used in the Analysis of Wireless Power Transfer Systems.

[10] Ritesh Diwan and Divya Vaishnav "Interaction of solar power satellite with the space and atmosphere environment" Recent Research in Science and Technology 2014, 6(1): 51-56 ISSN: 2076-5061

[11] White paper on Solar Power Satellite Systems, URSI, September 2006

[12] Shahram Javadi, Aliasghar Mohamedi "A General Review of different methods for Wireless Power Transmission"International conference .wireless network.ICWN'13

[13] Yugant A.Parate, Pranav D.Chauhan "Wireless Transmission of Electricity" International Journal of Engineering Trends and Technology (IJETT) – Volume 14 Number 2 – Aug 2014