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Wireless Transmission of Electricity

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ABSTRACT

Wireless power transmission (WPT) depicts the transmission of electricity without using any physical medium such as wire. WPT is an old idea, as old as use of electricity. The experiments performed by Nikola Tesla in 1899 captured the imagination of young engineers even nowadays when we witness the proliferation of transmission methods previously deemed unfeasible, now being made commercially viable by advances in electronic devices manufacturing. This paper is about the well-known transmission methods as well as latest method yet to be implemented as technology. The most common wireless electricity transmission is based on strong coupling between electromagnetic resonant objects to transfer energy wirelessly between them. This is different from other methods like simple induction, microwave propagation, or air ionization. The system in it consists of transmitters and receivers that contain magnetic loop antennas critically tuned to the same frequency. Due to the operation in electromagnetic field, the receiving devices must not be more than about a quarter wavelengths from the transmitter .Unlike the far field wireless power transmission systems based on traveling of electromagnetic waves, Wireless Electricity employs near field inductive coupling through magnetic fields similar to those found in transformers except that the primary coil and secondary winding are physically separated, and tuned to resonate to increase the magnetic coupling. These are tuned magnetic fields generated by the primary coil can be arranged to interact vigorously with matched secondary windings in distant equipment but far more weakly with any surrounding objects or materials such as radio signals or biological.

In earlier research it was calculated that power transmitting by wireless method would give an efficiency of about 95%, where as physical medium gives efficiency of 70%. If used in a proper way it would be a boom to industrialization and for environment too. By using this we could use it to almost any place instead of chemical energy could be used. It may be used in the field of weapon development and security.

Keywords –

AC Electricity; Resonant Magnetic Coupling; Wireless Electricity Devices; Magnetic Resonance Imaging; Oscillating magnetic Field.

INTRODUCTION

Wireless transmission is the transmission of electrical energy from a power source to an electrical load without man-made conductor's .Wireless transmission is useful

in cases where interconnecting wires are inconvenient, hazardous, or impossible. The research indicate that efficiency of wireless power is would be more than that of man-made conductors of instrument are precise. The most common form of wireless power transmission is carried out using direct induction followed by resonant magnetic induction. Other means under consideration are electromagnetic radiation in the form of microwaves and electrical conduction through natural media (air and ground). Wireless Transmission of electricity is not a new concept of transmission of electricity but in 1899, Nicole Tesla performed the experiment and transmitted electricity across 25 miles and lifted 2000 lamps by it but the facility was not completed due to insufficient funding. On the theory "The earth has radius of 4,000 miles". All over this conducting earth there is atmosphere. Earth is a conductor; the atmosphere above is a conductor, only there is a little surface called stratum between the conducting atmosphere and the conducting earth which is insulating. Now, one can realize right away that if you set up differences of potential at one point, then one will create in the media corresponding fluctuations of potential. But, the distance from the earth's surface to the conducting atmosphere is small, as compared with the distance of the receiver at 4,000 miles, say, one can readily see that the energy cannot travel along this curve and get there, but will be immediately transform into conduction current, and these currents will travel like charge over a wire with a return. The energy will be recovered back in the circuit, not by a mean that passes along this medium and is reflected and absorbed, but it will travel by the process of conduction and will be recovered back in this way. He wanted to transmit electricity to entire globe without wire. He wanted to saturate the glob with electricity as a dynamo so that everyone on the surface of the glob could use it just by striking wire into the soil and an electric bulb would light. Teslas concept of wireless transmission used Tesla coil, it created millions of volt of electricity with frequency rate of 100,000 alteration per second.

Electrodynamics induction method

Electrodynamics induction wireless transmission procedure is near field over distance up to about one-sixth of wavelength used. The near field energy itself is non-radioactive but then too some radioactive losses do occur. In addition to this there are commonly resistive losses. With the process of electrodynamics induction, the electric current flowing through primary coil creates a magnetic field which acts on the secondary coil which produces a current within it. The coupling should be tight in order to gain high performance. As the area from the primary increases, more and more of the magnetic field misses the secondary coil. Over a comparatively short range, inductive coupling is grisly inefficient, wasting the transmitted energy.

This action of electrical transformer is simplest form of the transmitting wireless power. The primary and the secondary circuits of the transformer are not directly associated. The energy transfer takes place through the process which is known as

mutual induction process. The principal functions step the primary voltage either up or down or electrical isolation. Mobile phones and the toothbrush battery chargers (electric), and electrical power distribution transformers are the examples of how this convention is used. Induction cookers make use of this method. The major drawback of this basic form of the wireless transmission is diminished bounding. The receiver should be directly adjoining to the transmitter or the induction unit in order to couple efficiently with it.

The operation of resonance increases the range of transmission. When the resonant coupling is being used, the transmitter and the receiver inductors are tuned to same natural frequency. The efficiency could be further improved by converting the driving current from a sinusoidal to non- sinusoidal transient waveform. In this manner significant power might be transmitted between the two mutually-tuned circuits and have a relatively low coefficient of coupling.

Some common uses of the resonance-enhanced electrodynamics induction charge the batteries of the portable devices like cell phones, laptop, computers, and electric vehicles. A localized charging procedure selects an appropriate transmitting coil in multilayer winding array architecture. The resonance is used in both wireless charging pad transmitter circuit) and receiver module (embedded in load) to maximize the energy transfer performance.

Electrostatic induction method

The radiance of the two exhausted tubes by means of powerful, fast alternating electrostatic field which is created between the two vertical metal sheets and are suspended from the ceiling on the insulating cords. This involves physics of the electrostatic induction.

The electrostatic induction or the capacitive coupling is passage of an electrical energy through dielectric. It is an electric field gradient or the differential capacitance in between the two or more insulated terminals, nodes, electrodes, or plates which are elevated over conducting plane. Electric field is generated by charging the plates with high potential, and high frequency alternating current supply. The capacitance b/w two elevated terminals and powered device form a voltage divider.

The electric energy which is transmitted by means of an electrostatic induction could be utilized by a receiving device, like a wireless lamp. Nikola Tesla exhibited the radiance of the wireless lamps by energy which was coupled to it through an electric field.

For this objective I suspended a metal sheet a distance away from the ceiling on the insulating cords and connect one terminal of induction coil, and the other terminal being preferably attached to the ground. Or else the two sheets can be suspended such that each sheet being connected to one of the terminals of coil, and their size is being carefully examined. An exhausted tube might then be carried in hand anywhere in between the sheets or can be placed anywhere, it always remains luminous."

The objective of electrostatic induction is suitable to electrical conduction (wireless transmission method).

"In some of the cases when small amount of energy is required the high elevation of terminals, and particularly of receiving-terminal D', might not be necessary, especially when frequency of the currents is high, an ample amount of energy might be collected at that particular terminal by the process of electrostatic induction from the upper air strata, which is rendered conducting by an active terminal of the transmitter or through which the currents from it is conveyed."

Electromagnetic radiation

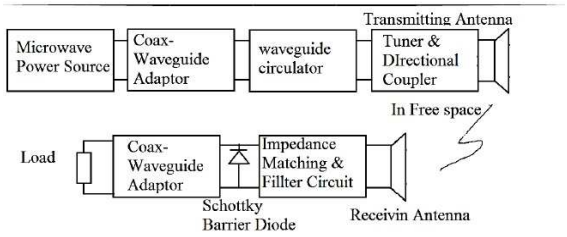
Far field techniques achieve longer ranges, often numerous kilometer ranges, where distance is much greater than diameter of the devices. The reason for longer ranges with the radio wave and the optical devices is the fact that the electromagnetic radiation in far-field can be made to meet the shape of the receiving area (using the high directivity antennas or the well-collimated laser beams) thereby delivering most emitted power at the longer ranges. The maximal directivity for the antennas is physically limited by the diffraction.

Microwave method

An artist's portraiture of a solar satellite which could send electric energy by microwaves to a space vessel or planetary surface.

Transmission of power through radio waves could be made more directional, by allowing longer distance power beaming, with the shorter wavelengths of the electromagnetic radiation, commonly in the microwave range. A rectenna might be used to convert microwave energy back to electricity. Rectenna conversion efficiencies exceed by 95% and this has been realized. Power beaming using the microwaves has been proposed for transmission of energy from the orbiting of solar power satellites to the Earth and beaming of power to the spacecraft leaving orbit has been given due consideration.

Power beaming by the microwaves has difficulty that for the most space applications the required aperture size is very large due to the directionality of diffraction limiting antenna. Such as, 1978 NASA Study of the solar power satellites required diameter of 1-km transmitting antenna, and diameter of 10 km receiving rectenna. For microwave beam at 2.45 GHz. These sizes could be considerably decreased by using the shorter wavelengths, though short wavelengths might have difficulties with the atmospheric absorption and blockage of beam by rain or water droplets. Because of "thinned array curse," it is not possible to make narrower beam by joining the beams of numerous smaller satellites.



For the earthbound applications, large area of diameter of 10 km receiving array allows a total power levels to be used although operating at low power density recommended for the human electromagnetic exposure safety. Human safe (power density) of 1 mW/cm2 which is distributed across diameter of 10 km area corresponding to 750 megawatts total power level. This power level is found in modern electric power plants.

Following World War II, shows the development of the high-power microwave emitters called as cavity magnetrons, the plan of adopting microwaves to transfer power was found. By 1964, a small helicopter impelled by microwave power had been manifested.

Japanese experimenter Hidetsugu Yagi studied wireless energy transmission by using directional array antenna which he designed. In Feb, 1926, Uda and Yagi presented their first paper on tuned high-gain directional array, it is now known as Yagi antenna. Though it did not turn out to be especially advantageous for power transmission. This beam antenna has been extensively adopted through broadcasting and wireless telecommunications industries through its excellent performance attributes.

The Wireless (high power) transmission using microwaves has been well proved. The experiments in tens of kilowatts have been executed at Goldstone, California in 1975 and more recently, in 1997 at Grand Bassin. These techniques achieve distance on order of kilometers.

It should be mentioned that the microwave conversion performance under the experimental conditions was determined to be about 54% efficient.

Electrical conduction

Disturbed charge - Air and ground technique

Wireless transmission of the alternating current through earth with an identical electrical displacement through air above it and achieves long range that is superior to the resonant electrical induction techniques and is favorably comparable to electromagnetic radiation techniques. The electrical energy could be transferred through inhomogeneous Earth with some loss as the net resistance between the antipodes of earth is less than 1 ohm. Electrical displacement which takes place predominantly by the electrical conduction through oceans, and metallic ore bodies and identical subsurface structures. Electrical displacement is by means of electrostatic induction through more dielectric regions like quartz deposits and some other non-conducting materials. Receivers could be energized by currents through Earth though a similar electric displacement occurs in atmosphere. This technique of transferring energy is suitable for the transmission of the electrical power in the industrial quantities and also for the wireless broadband telecommunications.

CONTRIBUTIONS

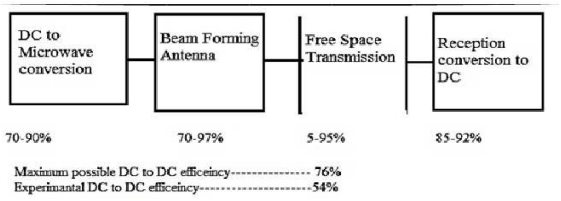
Nikola Tesla

Nikola Tesla, regarded as "Father of

Wireless", has been credited for his research in the field of Alternating current generation became first person to have the idea of wireless power transmission and demonstrated successfully the transmission of electricity without using wires, in early 1891. In 1893, Tesla won to illuminate World Columbian Exposition in Chicago, where he exhibited by illuminating vacuum tubes (bulbs) without using the wires. Tesla constructed Wardebclyffe tower, for wireless transmission of electrical power. Tesla organized his experiments in 1899 in Colorado Spring. He was able to power 200 (50W) in candescent lamps at a distance of 25 miles from power hour source without using a wire.

William C. Brown

William C. Brown is known for his modern research and is also known as 'father of microwave transmission of power. In 1961, his first research paper got published on microwave energy for transmission of power. In early 1960s, Brown created rectenna which directly converted microwave to Direct current and in 1964, he successfully exhibited a microwave-powered model helicopter which received the power needed for flight from a microwave beam at the speed of 2.45 GHz.



The figure shows Brown's schematic diagram for the microwave transmission of power. In 1982, Brown together with James F. Trimer (NASA) converted rectenna which led to development of a Stationary High Altitude Relay Platform field (SHARP). The objective of this was to make aircraft that would maintains a circular trajectory above the microwave antenna for relaying communications from various ground terminals.

Marin Soljacic

A physics research group which was led by Prof. Marin Soljacic at MIT i.e. Massachusetts Institute of Technology exhibited wireless powering of a light bulb of 60W with 40% performance at2m (7ft) distance by using two 6o cm – coils in 2007. They used the resonant induction to transmit the power wirelessly. His came as chance when Prof. Soljacic's phone rang in kitchen and this let him know that he forgot to charge his phone. Soon after success of experiment the term for technology was given as WiTricity and to carry out the technology forward from the laboratories of MIT, WiTricity Corporation was launched.

MERIT, DEMERIT AND CHALLENGES OF WPT

Merit

Wireless Power Transmission will easily lead to global scale connectivity of the power system. This would eliminate high-tension transmission of power line cables, towers and substations, which are seen not as a very

efficient way of transmission of energy. Thus, cost of transmitting and receiving of energy becomes less expensive by reducing the cost. Using this system, electricity would reach any places regardless of the geographical situations. The natural hazards like earthquake, flood, landslides and others cannot cut power as long as the Wireless Power Transmission system accomplishes there by reliability is more as compared to wired transmission of the energy. The failure of power due to short circuit, fault in cable lines would never occur. The waste which is produced would be strikingly reduced and thus it becomes more of environment friendly. The space occupied by the infrastructure like transmission grid lines, dam, power house, and substations will be eliminated. The adjustability of electrical devices would increase as receiver could be embedded to any of the electrical devices and appliances that it need not to use battery.

Demerits

The initial cost is very high for practical implementation. The use of microwave interference is very high. Even if the LASE is used conversion is difficult, goes through attenuation losses and is diffracted by the atmospheric particles. The main concern remains safety of wave item and its biological impact. But the safety study has been taken that the radiation level would not be higher than those received while opening microwave oven door, which means it is slightly higher than emissions which are generated by cellular telephones.

Challenges

To sustain constant power level, there are some challenges for Wireless Power Transmission. This is because of electromagnetic waves which scatters freely in space as it proliferates, which causes the performance to be much lower and this leaves some energy unused or transfer is unused. But by using multiple antennae arrays we will be able to solve this problem. Some other major challenges that are in front for success of Wireless Power Transmission are the outer space transmission system. There are some concerns that some environmentalists are depleting the ozone layer by radiations which come out. But this is young technology and many scientists are underway to incorporate the drawbacks. Considering, the world is lit by wires and each and every electrical device is fed with wires, and this will be biggest challenge to implement the technology of wireless transmission. There should be revolution in the electrical world for the manufacturing and designing. Still, safety of the microwaves remains a question for public. Some countries which depend on the electrical energy for economy such as a country Bhutan. It will be a heavy blow. This was main reason that caused Tesla to fail. To convince the sponsors and entrepreneurs of his time to carry out the project.

SUGGESION

From the above study we can say that there are different ways of transmission of electricity but there are many problem which are faced in those ways, like electromagnetic induction it has much greater loss then used

in present technology, microwave method in it the frequency used for transfer but it has worse effect on the body. The best way to transfer electricity is by using Electrical conduction in this method electricity could be transferred by using earth or air (ozone) as a medium.

Earth is a great medium and could be easily used to transfer electricity at a much large distance, just having the resistance of 1 ohm at whole but the problem that could arise in this method is that anyone could use electricity anywhere without paying for it thus it would create economic unbalance. Thus the best way to transfer electricity is using air (ozone layer) as using it we could transfer electricity at long range and the resistance is low too.

CONCLUSION

The Wireless Power Transmission is the technology which was put forward by Nikola Tesla. It has potential to change face of this planet. Initially, from charging the handset to changing effect of global warming Wireless Power Transmission has the answer. Microwave power transmission will replace the conventional and inefficient technology. It will minimize the dependence on fossil fuels and other products of petroleum that directly leads to the global warming. Presently, the technology is in progress and researchers are trying their best to overcome the challenges. Though, practical implementation is limited due to lack of knowledge, and limited frequency ranges yet the study is on and there could be alternatives to Earth's burden of other harmful methods. Presently, wireless power transfer is the most sustainable and marketable alternative to fossil fuel power plants.

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