Analysis for an Efficient "Wireless Power Transmission"

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Abstract-We cannot imagine the world without electric power. Generally the power is transmitted through wires. Imagine a future in which wireless power transfer is feasible. In this paper, we present the concept of transmitting power without using wires i.e., transmitting power as microwaves from one place to another in order to reduce the transmission and distribution losses. This concept is known as Microwave Power transmission (MPT). We also discussed the technological developments in Wireless Power Transmission (WPT). The advantages & biological impacts of WPT are also presented. This paper includes the techniques of transmitting power without using wires with an efficiency of about 95%.

Index Terms- Microwave power transmission, Nikola Tesla Theory, Magnetron, klystron, microstrip patch antenna, Wireless power transmission

A. Introduction

The major amount of power loss occurs during transmission & distribution. The percentage of loss of power during transmission & distribution is approximated as 26%-30%. The cause of loss of the generated energy during transmission & distribution is resistance of the conductor. This loss implies that our present system of electrical distribution is only 70%-75% efficient. This is attributed to grid's inefficiencies. We can improve the efficiency of power transfer by using high strength composite over head conductor and underground cables that use high temperature super conductor. But the transmission is still inefficient. The reason of low efficiency is theft of energy.

We have to think of alternate state-of- art technology to solve above discussed problem which could provide much higher efficiency, low transmission cost & losses and avoid power theft. The transmission of without wires may be one of the noble alternatives for electricity transmission. Microwave Power Transmission is one of the promising technologies and may be righteous alternative for efficient power transmission.

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Another possibility is to use highly efficient fiber lasers for wireless power transmission where the possibilities are similar to microwave concept but laser emit energy at frequencies much higher then microwave.

B. The Technologies Till Now

Nikola Tesla "Father of Wireless" is the one who first conceived the idea Wireless Power Transmission and demonstrated "the transmission of electrical energy without wires" that depends upon electrical conductivity as early as 1891[1]. In 1893, Tesla demonstrated the illumination of vacuum bulbs without using wires for power transmission at the World Columbian Exposition in Chicago. The Wardenclyffe tower shown in Fig.1 was designed and constructed by Tesla mainly for wireless transmission of electrical power rather than telegraphy [2].

In 1961, Brown published the first paper proposing microwave energy for power transmission, and in 1964 he demonstrated a microwave-powered model helicopter that received all the power needed for flight from a microwave beam at 2.45 GHz [3] from the range of 2.4GHz – 2.5 GHz frequency band which is reserved for Industrial, Scientific, and Medical (ISM) applications. Experiments in power transmission without wires in the range of tens of kilowatts have been performed at Goldstone in California in 1975 [4] and at Grand Bassin on Reunion Island in 1997 [5].

Fig. 1 The 187-foot wardenclyffe Tower (Tesla Tower)

The world's first MPT experiment in the ionosphere called the MINIX (Microwave Ionosphere Non-linear Interaction Experiment) rocket experiment is demonstrated in 1983 at Japan [6]. Similarly, the world's first fuel free airplane powered by microwave energy from ground was reported in 1987 at Canada. This system is called SHARP (Stationary High – Altitude Relay Platform) [7]. In 2003, Dryden Flight Research Centre of NASA demonstrated a laser powered model airplane indoors. Japan proposed wireless charging of electric motor vehicles by Microwave Power Transmission in 2004. Powercast, a new company introduced wireless power transfer technology using RF energy at the 2007 Consumer Electronics Show [8]. A physics research group, led by Prof. Marin Soljacic, at the Massachusetts Institute of technology (MIT) demonstrated wireless powering of a 60W light bulb with 40% efficiency at a 2m (7ft) distance using two 60cm-diameter coils in 2007 [9]. Recently in 2008, Intel reproduced the MIT group's experiment by wirelessly powering a light bulb with 75% efficiency at a shorter distance [10].

C. Wireless Power Transmission System

WPT is a point-to-point power transmission. For the WPT, we had better concentrate power to receiver. It was proved that the power transmission efficiency can approach close to 100%.To concentrate the transmitted power and to increase transmission efficiency, we have to use higher frequency. By use of the magnetron and the klystron high-power microwaves, (1-10 GHz radio waves) can be transmitted.

I. Microwave Generator

Magnetron is suitable device for the MPT because of high efficiency and low cost and unsuitable device because of its unstable frequency and uncontrollable phase. If we do not make a phased array to control beam direction electrically, the magnetron can be applied for the MPT system. However, the cooker-type magnetron itself cannot be applied for the phased array-type MPT because it is only a generator and we cannot control/stabilize the phase and the amplitude. The cooker-type magnetron was considered as noisy device. It is however confirmed that spurious emissions from the cooker-type magnetron with a stable DC power supply is low enough and this can be applied to the MPT system[12]. Peak levels of higher harmonics are below -60 dBc and other spurious is below -100 dBc.

The klystron is also a linear beam tube with cavities. The klystron is high power amplifier from tens of kilowatts to a few megawatts with high efficiency, over 70%. It require a ponderous power supply and also a heavy magnet. The klystron was used in MPT demonstration in 1975 at venus site of JPL goldstone facility. One klystron transmitted microwave of 450 KW and 20388 GHz. The klystron is suitable for large MPT. In present, new materials are developed fore the semiconductor device to increase output power and efficiency. They are called wide-band gap devices such as SiC and GaN. When band gap increase, frequency also increases for WPT high frequency is required [13].

II. Antennas for Microwave Power Transmission

Different types of antennas can be applied for both the MPT system and communication system, for example, Yagi-Uda antenna, horn antenna, parabolic antenna, microstrip antenna, phased array antenna or any other type of antenna. A patch antenna is a narrowband, wide-beam antenna fabricated by etching the antenna element pattern in metal trace bonded to an insulating dielectric substrate, such as a printed circuit board, with a continuous metal layer bonded to the opposite side of the substrate which forms a ground plane. Microstrip antennas are relatively inexpensive to manufacture and design because of the simple 2-dimensional physical geometry. They are usually employed at UHF and higher frequencies because the size of the antenna is directly tied to the wavelength at the resonant frequency. A single patch antenna provides a maximum

directive gain of around 6-9 dBi. It is relatively easy to print an array of patches on a single (large) substrate using lithographic techniques. patch antennas is an easy way to make a phased array of antennas with dynamic beam forming ability[14]. An advantage inherent to patch antennas is the ability to have polarization diversity. Patch antennas can easily be designed to have vertical, horizontal, right hand circular (RHCP) or left hand circular (LHCP) polarizations, using multiple feed points, or a single feed point with asymmetric patch structures [15]. This unique property allows patch antennas to be used in Microwave power transmission.

D. Merits and biological impact

I. Merits

An electrical distribution system, based on this method would eliminate the need for an inefficient, costly, and capital intensive grid of cables, towers, and substations. The system would reduce the cost of electrical energy used by the consumer and rid the landscape of wires, cables, and transmission towers. The electrical energy can be economically transmitted without wires to any terrestrial distance, so there will be no transmission and distribution loss. More efficient energy distribution systems and sources are needed by both developed and under developed nations. In regards to the new systems, the market for wireless power transmission is enormous. To transmit wireless power to any distance without limit. It makes no difference what the distance is. The efficiency of the transmission can be as high as 96 or 97 per cent, and there are practically no losses. The power failure due to short circuit and fault on cables would never exist in the transmission and power theft would be not possible at all. Interference is low of microwave by microstrip patch antenna with present communication systems.

II. Biological Impact

Common beliefs fear the effect of microwave radiation. But the studies in this domain repeatedly proves that the microwave radiation level would be never higher than the dose received while opening the microwave oven door, meaning it is slightly higher than the emissions created by cellular telephones[16].

E. Conclusion

The transmission of power without wires is not a theory or a mere possibility, it is now a reality. The electrical energy can be economically transmitted without wires to any terrestrial distance. Many researchers have established in numerous observations, experiments and measurements, qualitative and quantitative. Dr.N.Tesla is the pioneer of this invention.

F. Result

Wireless transmission of electricity using microwave patch antenna have tremendous merits like high transmission integrity and Low Loss (90 – 97% efficient) and can be transmitted to anywhere in the globe and eliminate the need for an inefficient, costly, and capital intensive grid of cables, towers, and substations. The system would reduce the cost of electrical energy used by the consumer and get rid of the landscape of wires, cables, and transmission towers. It has negligible demerits like reactive power which was found insignificant and biologically compatible.

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