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Solar Based Wireless Power Transmission

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***Abstract*— In this paper we give a brief idea on wireless power transmission. We have explained various methods of power transmission and focused in detail regarding wireless power transmission and its types viz. near field techniques and far field techniques which includes inductive coupling, resonance inductive coupling, and microwave wireless power transmission, laser based wireless power transmission respectively. As wireless power transmission has wide area of application, attempt has been made to explain few among them. The major application being space solar power satellite**

I. INTRODUCTION

Electric power transmission is the bulk transfer of electrical energy, from generating power plants to substations located near to population centers.

In our present electricity generation system we waste more than half of its resources. Especially the transmission and distribution losses are the main concern of the present power technology. Much of this power is wasted during transmission from power plant generators to the consumers. The resistance of the wire used in the electrical grid system causes a loss of 26-30% of the energy generated. This loss implies that our electrical distribution system is only 70-74% efficient.

Now-a day's global scenario has been changed. If we don't keep pace with the development of new power technology we have to face a decreasing trend in the development of power sector. The transmission of power without wires may be one alternative for electricity transmission.

II. TYPES OF POWER TRANSMISSION

A. Overhead power transmission:

An overhead power line is an electric power transmission line suspended by towers or poles made of wood (as-grown or laminated), steel (either lattice structures or tubular poles), concrete, aluminum, and occasionally reinforced plastics

B. Underground power transmission

Electric power can also be transmitted by underground power cables instead of overhead power lines. They can assist the transmission of power across:

- Densely populated urban areas
- Areas where land is unavailable or planning consent is difficult

Underground power transmission has a significantly higher cost and greater operational limitations but is sometimes used in urban areas or sensitive locations.

C. Wireless power transmission:

Wireless Power transmission is the process that takes place in any system where electrical energy is transmitted from a power source to an electrical load without interconnecting wires.

1. History of wireless power transmission

Nicolas tesla is the pioneer of induction techniques. In 1891 he proposed the concept of wireless transmission. He was able to transfer energy from one coil to another. In 1899 he first successfully experimented by lighting 200 lamps from a distance of 25miles away. High frequency current, of a tesla coil, could light lamps filled with gas(like neon).The forgotten invention took its rebirth on 2007 by a team led by Marin Soljacic from Massachusetts Institute of Technology(MIT).This project was named as "Witricity" (wireless electricity). They lit the 60w bulb with a power source at a distance of 6.6 feet (2 meters) with no wires.

2. Types of wireless power transmission:

Wireless power transmission can be classified into following:

2.1 Near field technique:

In this technique the power can be transmitted to a comparable distance (few times the diameter of the device).

Following are the different methods practically adopted:

2.1. a. Inductive coupling method:

Inductive coupling works on the principle of electromagnetic induction. When a current passes through the wire (primary coil) it produces magnetic field in perpendicular direction, when anotherwire (secondary coil) is in proximity to a magnetic field it generates a current in it. Primary and secondary are not connected with wires, energy transfer device are usually air-cored. The magnetic field reduces quickly making inductive coupling effective only at short ranges

For example, a wireless mobile charger as shown in figure (fig 2) the primary coil is usually charging pad, on this pad mobile (secondary coil) is to be kept which charges the mobile battery.

Fig 1: wireless mobile charger

2.1. B Resonance inductive coupling:

Resonance is the tendency of a system to oscillate with larger amplitude at some frequencies than others. These are known as system's resonant frequencies. At these frequencies, even small periodic driving forces can produce large amplitude oscillations.

Resonance is a phenomenon which causes an object to vibrate when energy of certain frequency is applied. Resonance makes two objects interact strongly.

Resonant induction still uses the same principle as magnetic induction (magnetic fields to transfer current), but it uses resonance to increase the range at which the transfer can take place efficiently. With resonant induction power is transmitted between to resonant coils. The following practical circuit can be used to explain resonance inductive coupling:

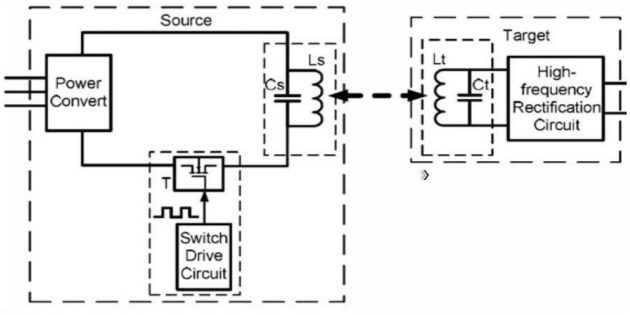

Fig 2: Block diagram depicting the working of resonance Inductive coupling

Coil produces the inductance, capacitor is connected in parallel to the coil, the resonance of source and target can be achieved by adjusting impedance components (R,L,C), energy will be shifting back and forth between magnetic field surrounding the coil and electric field surrounding the capacitor which reduces the radiation losses.

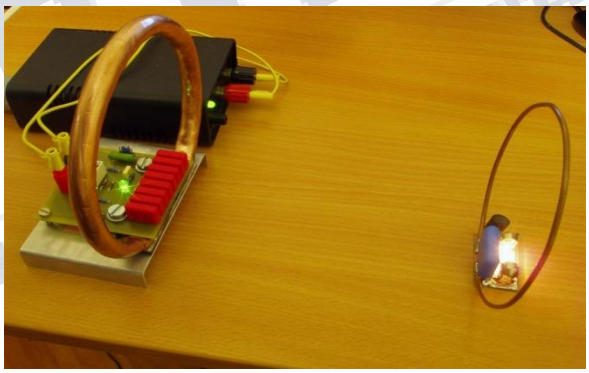

Fig 3: Practical application of Resonance inductive coupling

2.1. c. Advantages of near field:

- No wires
- No e-waste
- Need for battery is eliminated
- Efficient energy transfer using RIC
- Harmless if field strengths are at safety levels
- Isolation is provided between device and mains.

2.1. d. Disadvantages:

- Distance constraint
- Field strengths have to be at safety level
- Initial cost is high

2.2 Far field techniques:

Far field methods achieve longer ranges, often multiple kilometer ranges, where the distance is much greater than the diameter of the device(s) .Far field techniques can be further classified into following:

2.2. a. Microwave wireless power transmission (MPT):

MPT is the technique to transfer high power between two places which are in line of sight.

The working of MPT system can be explained using following block diagram.

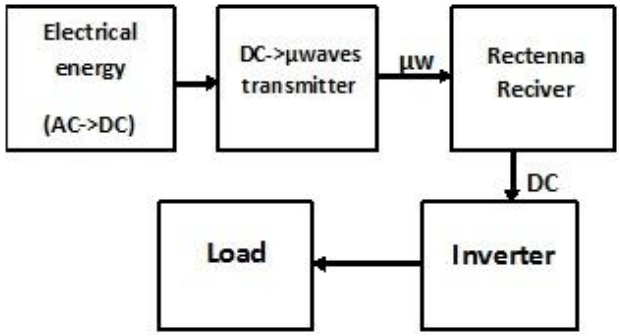

Fig 4: Block diagram depicting the working of microwave Power transmission

- **Electrical energy:** AC energy cannot be directly converted to microwave energy , so in this block AC is being rectified to DC.
- **DC-> Microwave Transmitter:** Here DC is converted to microwaves using magnetron and is transmitted in space
- **Rectenna Receiver:** In this stage, the microwave received is rectified to DC output which is transmitted to further stage trough wire. Rectenna is an antenna comprising a mesh of dipoles and diodes for absorbing microwave energy from a transmitter and converting it into electric power. Microwaves are received with about 85% efficiency.
- **Inverter:** In this stage, DC is converted back to AC.
- **Load:** The device for consumption is connected.

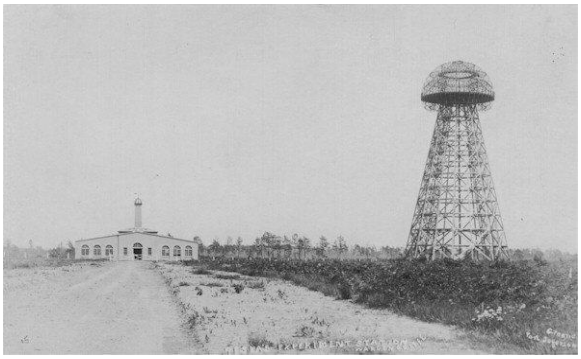

Fig 5: Rectenna

It finds its major application in solar power satellites (SPS) placed in the geostationary orbit (36000 km).P.E.Glaser proposed this concept.SPS mainly consists of following segments

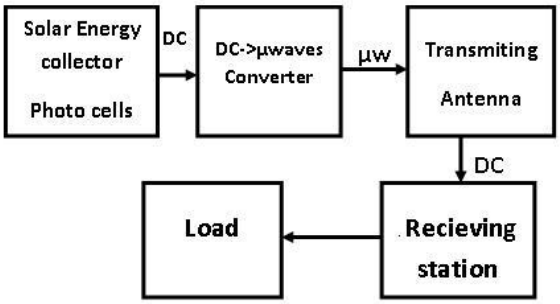

Fig 6: Block diagram depicting the working of SPS

- **Solar energy collector:** Solar energy is captured using photocells or solar thermal turbine. It converts the solar energy into DC(direct current).
- **DC->microwave converter:** It can be either microwave tube system or semiconductor system to convert DC to microwave energy form.
- **Transmitting antenna:** This energy is transmitted to earth using microwave from the SPS. Power can be beamed to the location it is needed. Accurate target detection and high efficient beam forming are important. Retro directive system is always used for SPS.
- **Receiving Station:** Using rectenna(rectifying antenna) this energy is converted back to electrical energy. Waste heat is radiated back to atmosphere.

The solar power photovoltaic generation facility is one of the most mature technologies employed in WPT system. A typical photovoltaic system has planar solar arrays for power generation and chemical batteries to store excess solar array energy during periods of sunlight and provide

power during periods when the load station is in shadow. It is expected that the batteries will only provide survival power during eclipse. Rectenna in USA receives 5000MW of power from SPS.

Fig 7: Solar energy is captured using photocells, this energy is transmitted to earth using laser and received by rectanna

2.2. b. Laser based wireless power transmission:

Laser is highly directional and coherent. The simple receiver using this technique is a photovoltaic cell. Recent technologies show that laser can be substituted in place of microwaves.

2.2. c. Laser vs. microwave

- The most important benefit of laser beam over microwaves is the reduction size of the transmitting and receiving antennas. The beam diameter needed to carry a givenamount of power varies approximately with the wavelength of the beam.
- Microwaves can face interference (two frequencies can be used for WPT 2.45 GHz and 5.4 GHz).
- Laser has high attenuation loss and it gets diffracted by atmospheric particles easily.

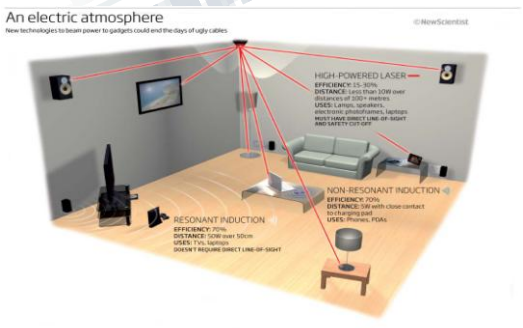

Fig 8: single transmitter can supply power to multiple consumer appliances in a room.

2.3Advantages of far field techniques

- The need for substations and grids is eliminated.
- Maintaince cost is minimum
- Power can be transmitted to remote areas also
- Efficient as wastage of power is small

2.4Disadvantages

- It is more effective if the transmitting and receiving stations are in the line of sight.
- Initial cost for construction is high
- When microwaves are used interference can arise.
- When lasers are used conversion is ineffective since laser beam gets attenuated in atmosphere.

3. Application:

- Automatic charging of mobile electronics at home, car, office etc.
- Direct wireless power interconnections and automatic wireless charging for implantable medical devices (ventricular assist devices, pacemaker, defibrillator, etc.).
- Automatic wireless charging and for high tech military systems (battery powered mobile devices, unmanned mobile robots and aircraft, etc.).
- Direct wireless powering of stationary devices thereby eliminating expensive custom wiring, unsightly cables and “wall-wart” power supplies.
- Canadian group succeeded fuel-free airplane flight experiment with MPT in 1987 which was called SHARP (Stationary High Altitude Relay Platform) with 2.45 GHz.
- Can broadcast energy globally even in remote areas (in future).

Fig 9: wireless transmission implemented on a TV

Wireless power transmission can take major application in public transport. Automatic wireless charging for future hybrid and all-electric passenger and commercial vehicles, at home, in parking garages.

If recharge centers (bus stop) are provided at a periodic distance for the electric buses, the recharge center acts as transmitter and the bus acts as the receiver. Hence the bus gets charged whenever it terminates at bus stop.

By implementing this system, mileage of buses increase, reduces air and noise pollution.

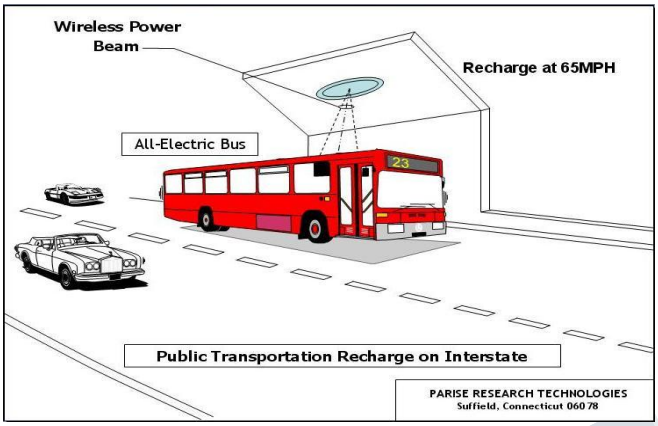

Fig 10: Automatic wireless charging for future hybrid and all-electric passenger and commercial vehicles

4. Future of Witricity:

MIT's Witricity is only 40 to 45% efficient and they have to be twice as efficient to compete with the traditional chemical batteries. The researchers have said that in another five years, they will come up with a witricity system for commercial use.

III. CONCLUSION

Human beings or other objects placed between the transmitter and the receiver don't hinder the transmission of power. However magnetic fields tend to interact very weakly with the biological tissues of the body, and so are not prone to cause damage to any living beings.Witricity products are being designed to comply with applicable safety standards and regulations.

No more messy widespread wires and elimation of costly batteries. One stationary coil in a room could power multiple devices with receiving coils.

Hence we conclude use of wireless power transmission has no hazardous effects and it reduces the transmission cost .Effective utilization of power due to elimination of intermediate transmission wires.

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