

ELECTRIC POWER RESTORATION IN FLOOD AFFECTED AREA THROUGH WIRELESS POWER TRANSFER WITH SPACE BASED SOLAR POWER

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Abstract: Electric power restoration in flood affected area takes longer time by present wiring system, to overcome this we thought of WPT. A wireless power transmission using microwave is a system which contains satellite based solar power system (SPS), microwave generator, microwave transmitter (magnetron) and microwave receiver (rectenna). The DC power received on earth is converted into AC for various useful purposes.

Keywords—Microwaves, Microwave generator, Rectenna, Solar Power Satellites (SPS), Wireless Power transmission (WPT).

I. INTRODUCTION

During flood condition the power system gets affected and restoration of power supply to the affected area does not takes place in short span of period. Major problem faced during flood is power supply required to rescue people during night, power supply is essential mainly in hospital for treatment of people, also for storage and supply of food to those people. The space based solar power is one of the important renewable source of energy transfer and can be used for restoration of power in flood affected or any disaster affected area through wireless energy transfer. Wireless power transmission is the transfer of power using microwaves and avoiding the use of cables, tower and grid. The space based solar power harness solar power using bulk photovoltaic array in space and transfer the power to earth using microwave, Space based solar power is used for wireless energy transfer, the satellite is placed in earth orbit and satellite converts sunlight into microwave energy. Then the microwave signal is transmitted using antenna and these signals are collected on Earth's surface using rectenna.

The various methods of wireless power transfer are:

- Microwaves / Radio waves WPT.
- Resonance inductive coupling WPT.
- Inductive coupling WPT.
- Lasers WPT.

Wireless power transmission avoids the use of cables, tower and grid since it transfers the power using microwaves. The space based solar power tackle solar power using predominance photovoltaic array in space and transfer the power to earth using microwave. Space based solar power is essential for wireless energy transfer, because solar power is a major renewable source of energy. Satellite is placed in earth orbit and satellite converts sunlight into microwave energy. The rectenna on the Earth's surface collects the microwaves signal, which is transmitted using antenna.

The microwaves are more advantageous than other methods of wireless power transfer for longer distance with mature technology and higher efficiency. Highly efficient array configuration would have the potential of concentrated and directed microwave beam that can provide higher efficiency for longer distances. [5]

II. SATELLITE BASED SOLAR POWER

The fundamental scheme of SBSP is to accumulate the solar energy in the Earth's orbit and send it to the ground by microwaves. The concept of the SBSP energy system covered with vast formation of solar cells 22,300 miles above the Earth's equator in geosynchronous orbit. Sunlight irradiate each satellite 24 hours a day for most of the time in a year. Due to 23-degree tilt of the Earth's axis the satellites pass either above or below the Earth's shadow. With the help of solar cells, the sunlight energy is transformed into electricity then it will be converted into radio frequency energy by transmitting antenna on the satellite and transmitted to a receiver site on earth. [3]

Solar power is generated by collecting sunlight and converting it into electricity. This process is done by using solar panels, solar panel are large flat panels made up of multiple discrete solar cells. Space-based solar power (SBSP) is the concept of collecting solar power in space (a "solar-power satellite" or a "satellite power system") to utilize complete solar energy on Earth. It has been in research since the early 1970s.

SBSP is different from current solar collection methods in that the means used to collect energy from the orbiting satellite instead of on Earth's surface.

The complete assembly of the satellite-based system is shown in figure 1. The solar panels are connected on each sides of the satellite. The solar panels used in satellite are the major source of DC power. Dc power is supplied to magnetron to generate microwaves. Photovoltaic cells are used for converting solar radiations into DC power. The generated DC power is fed to the magnetron having microwaves in the range 2.45 GHz to 2.54 GHz [4]. The SPS systems use specially designed magnetrons

which generate 3 to 5 KW power [5] or more. Waveguide is a structure that guides waves such as electromagnetic waves, sound waves and microwaves. [1]

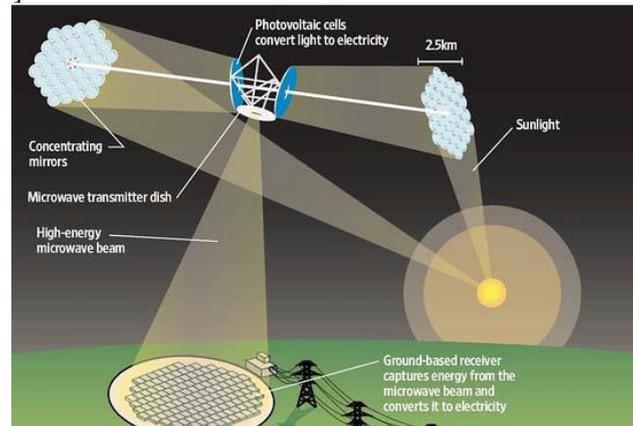


Figure 1: Design of Space based Solar Power (SBSP)

III. WIRELESS POWER TRANSMISSION

By using mathematical model in 1864, James C. Maxwell was envisaging the extent of radio waves. In 1884, John H. Poynting realized that Poynting vector would play a key responsibility in quantifying the electromagnetic energy. In 1888, radio waves were evidenced with experiment by his spark-gap radio transmitter which was shown by Heinrich Hertz.

The experiments with WPT was first started by Nikola Tesla in the early 1900s, he ended with the erection of a tower for WPT on Long island in New York. The main objective of Tesla was to develop the technology for transmitting electricity to any place in the world without wires. Tesla filed many patents, describing wireless power transmitters and receivers. He did not achieve the objective of WPT, but however his knowledge about electrical phenomena was largely empirical. Tesla was awarded the patent for wireless radio in 1901. The successful verification of a microwave beam-riding helicopter was performed in 1965. The verification proved that a WPT system could be designed and that effective microwave generators and receivers could be developed for efficient conversion of microwaves power into DC electricity.

In the 1960s the increasing interest in solar energy conversion methods and solar energy applications and the limitations for producing cost-effective base load power caused by adverse weather conditions and diurnal changes led to the solar power satellite concept in 1968 as a means to convert solar energy with solar cell arrays into electricity and feed it to a microwave power generator forming planar, phased-array antenna. The antenna would direct a microwave beam of very low power density precisely to one or more receiving antennas at particular locations on Earth, in geosynchronous orbit. At a receiving side antenna, the microwave energy would be very efficiently reconverted into electricity and then transmitted to users.

Raytheon developed a rectifying antenna or rectenna. The rectenna structure consists of a half-wave dipole placed above a reflecting plane. The resistive load is connected to output of the rectenna. The frequency of rectenna about 2.45GHz is widely used as the transmitting frequency because of advanced and efficient technology base, rectenna is mainly located at center of an industrial, scientific and medical (ISM) band and even during heavy rainstorms rectenna is minimal attenuation through atmosphere. The conversion efficiency of the rectenna was increased at 2.45GHz frequency from 1960's to the 1970's. [4]

The conversion efficiency of rectenna is closely linked to the microwave power. Rectenna element converts microwave power into DC power. In 1977 by Brown in Raytheon company used GaAsPt Schottky barrier diode, which led to the greatest conversion efficiency ever recorded by a rectenna element with 90.6% and an input microwave power level of 8W. The rectenna uses aluminum bars to build dipole and transmission line [5]. A printed rectenna design was developed at 2.45GHz with efficiency of about 85% [6]. Recently rectenna is used as a receiving antenna attached to a rectifying circuit by McSpadden and Chang, the efficient conversion of microwave into DC power was obtained by this rectifying circuit.

IV. COMPONENTS AND OPERATION

The Functional block diagram of Wireless Power Transmission System is shown in Figure 2. The transmission side consists of the microwave generator which generates the microwaves and the output power transmitted by transmitting antenna. The antenna radiates the power uniformly through free space to the rectenna. The receiving side consists of a rectenna which receives the transmitted power and converts the microwave power into DC power. It also consists of impedance matching circuit and filter, they are provided to setting the output impedance of a signal source equal to the rectifying circuit. The rectifying circuit consists of Schottky barrier diodes which converts the microwave power into DC power.

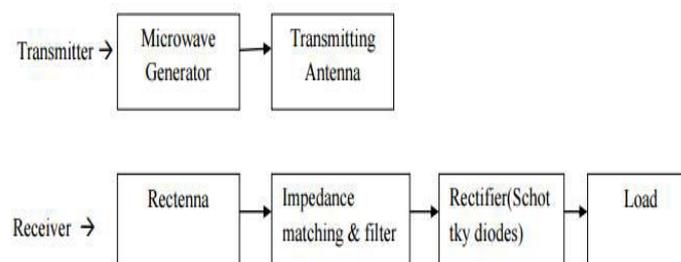


Figure 2: Functional Block Diagram of Wireless Power Transmission System.

Power supply

In ground-based model, for attaining superior efficiency, the DC power that is to be transferred should be 1 kW or more. The source of DC power can be a transformer linked with voltage doubler/multiplier circuit or the magnetron extracted from microwave oven along with its power supply components may be an appropriate alternative.

Magnetron

The DC power supply obtained from solar panel is convert to microwaves for the transmission through antenna in the direction of the earth’s receiving antenna, microwave oscillators like Klystrons, Magnetrons can be used. An alternating current is generated in the elements by applying a voltage at the antenna terminals in transmission, causing the elements to radiate an electromagnetic field. [3]

Working

In magnetron the maximum anode voltage is 4.5KV and the maximum cathode voltage is 3.75kV AC. In the center of magnetron heated magnetron is present and by the process of ‘ Thermo Ionic Emission’ electrons are released from the center of magnetron.

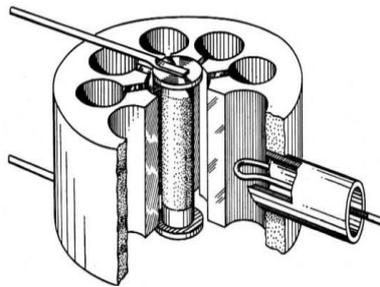


Figure 3: Magnetron.

The electrons liberated from center of the magnetron try to move towards anode. Because of crossed electric and magnetic fields, the electrons move in a circular path around anode. As the electrons moves in the circular path around anode, the cavities thus resonate and emit microwave radiations. Microwaves from all the cavities are added up in a channel at the end of the tube. Hence, in this way microwaves are collected from the one end of the magnetron.

Transmitting antenna

The most popular type of transmitting antenna used are slotted wave guide, micro strip antenna, and parabolic dish antenna. For power transmission with high aperture efficiency (>95%) slotted wave guide antenna is widely used and it also has high power handling capability.

Rectenna & Filter: The rectenna is used to harvest electric energy from the RF signals that have been radiated by communication and broadcasting systems at ISM band cantered in 2.45 GHz., Schottky barrier diodes (GaAs-W, Si, and GaAs) are usually used in the rectifying circuit due to the faster reverse recovery time and much lower forward voltage drop and good RF characteristics.

Waveguide

Different types waveguides are available depending upon the applications. The waves are usually confined in a waveguide because of total reflection from its inner surface. An external waveguide is required to obtain desire wave’s area even though magnetron have its own internal waveguide.

Rectenna

The combination of rectifier and an antenna is known as rectenna. A block diagram of rectenna is as shown in the fig. 4. Through filters and matching circuit wireless energy can be collected by the antenna attached to rectifying diodes. The load is matched with rectifier by low-pass filter and low-pass also block the higher order harmonics generated by the diode in order to achieve high energy conversion efficiency which is the most significant parameter of a device. Table 5.1 shows the variation in output voltage of different distances between transmitting antenna and rectenna.

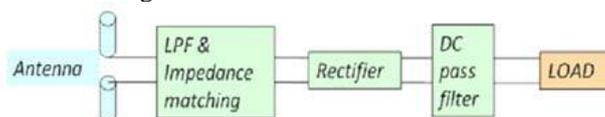


Figure 4: Block diagram of a rectifier with a load

Distance between Transmitting antenna and rectenna	Input voltage In Volts	Output voltage with PCB in Volts	Output voltage with PCB in Volts
Test 1(1M)	220	38	52
Test 2(1.5M)	220	30	46
Test 3(1.8M)	220	23	32

V. ENERGY HARVESTING CIRCUIT

In wireless energy transfer, energy harvesting is also known as power harvesting or energy scavenging. The energy harvesting is a conversion of ambient energy from environment to electric power, It mainly powers small wireless autonomous electronic devices. The ambient energy comes from stray electric or magnetic fields or radio waves from nearby light, heat, electrical equipment or kinetic energy such as vibration or from motion of the device. It can be possible to run or recharge small micro power wireless devices such as remote sensors, although the efficiency of conversion is usually low and the power is gathered often microwatts. This type of new technology is being developed to eliminate the requirement for battery replacement or to charge wireless devices.

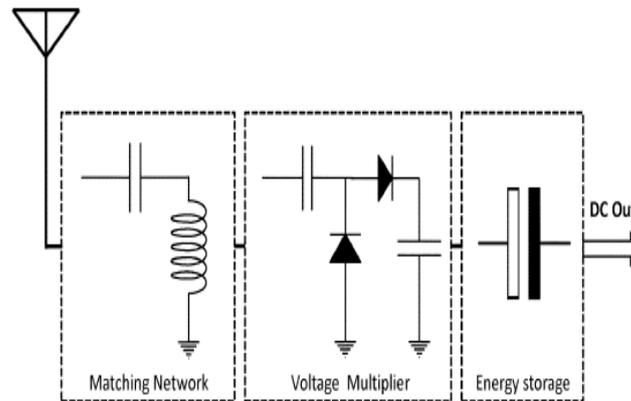


Figure 5: Energy harvesting circuit.

VI. ADVANTAGES

- Wireless Power Transmission system is capable of eliminating the power cables, towers and substation between generating station and consumers.
- The wireless energy transfer also helps in the interconnection of electrical generation plants on a global scale.
- The WPT/WET has freedom of choice of both transmitters and receivers. can choose mobile transmitter and receiver.
- The cost of transmission and distribution become less and the cost of electrical energy for the consumer would be reduced.
- The power could be transmitted to certain place wherever the wired transmission is not possible.
- Efficiency of WPT is higher than the wired transmission because of less transmission loss.
- Within transmission the power failure due to short circuit and fault on cables would never exit.
- The development of SBSP gains the benefits of abundant, low cost, nonpolluting energy.
- The major advantage of inserting solar cells in space instead of on ground is that the energy available is 24 hours and the energy available to the satellite is 4 to 5 times more than on earth.

VII. DISADVANTAGES

- This project is a onetime expense but involves lot of initial expenditure.
- The technology used is limited to use of few technologies like solar satellites and Tesla grid.
- The transmission of electric current through this mode is susceptible to security risk like cyber war fare.

VIII. BIOLOGICAL IMPACTS

- Common belief fear that the effect of microwave radiation. But the studies carried out in this in field constantly proves that the radiation level would never higher than those received while opening the microwave oven door.
- The radiation obtained are slightly higher than cellular telephones.
- The cellular telephones usually operate at or below the ANSI/IEEE exposure standards.
- However, Tests carried out have shown that the energy density in the radio-frequency beam can be limited to safe levels for all life forms.[6]

VI. CONCLUSIONS

Electric power can be easily restored in flood affected area through WPT using SPS. SPS is the most promising technology in the future compared to all other renewable resources. WPT using microwaves need high installation cost but it can replace all wires, poles and we can use power like Wi-Fi. The output voltage obtained for various distances is shown in table. Here the efficiency is less due to a smaller number of microstrip patches in the rectenna and low power magnetron which can be improved by using large number of arrays of microstrip patch antenna and high-power magnetron.

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