A REVIEW OF WIRELESS POWER TRANSMISSION VIA SOLAR POWER SATELLITE TECHNOLOGY

Dinesh kumar[1], Shweta Patle[2], Amita Barwa[3]

[1] Faculty, [2, 3] Student, Electronics and Telecom. Kirodimal Institute of Technology, Raigarh, (India)

ABSTRACT

A solar power satellite (SPS) is satellite dedicated to collecting solar energy on orbit, transforming it into microwave or laser energy, and beaming it to a receiving station on the ground. The recent increase in energy costs , predictions of the near-term exhaustion of oil and prominence of possible climate change due to the "green house effect" from burning of fossil fuels has again brought alternative energy sources to public attention, and the time is certainly appropriate to reexamine the economics of space based power. It mainly concerns about the conversion of energy obtained from the sun by satellite to microwaves using a externally placed device called magnetron. The DC power received on earth is converted into AC for various useful purposes. This paper gives a comprehensive study of various components of satellite based SPS and projects this technology as a bulk source of power generation in future.

Keywords: ***Microwaves, Magnetron, Photovoltaic, Rectenna, Wireless Power Transmission***

I. INTRODUCTION

The definition of Wireless Power Transmission (WPT) is efficient transmission of electric power from one point to another trough vacuum or an atmosphere without the use of wire or any other substance. This can be used for applications where either an instantaneous amount or a continuous delivery of energy is needed, but where conventional wires are un affordable, inconvenient, expensive , hazardous , unwanted or impossible. The power can be transmitted using microwaves, millimeter waves or lasers. WPT is a technology that can transport power to locations, which are otherwise not possible or impractical to reach [1].

The conventional methods for generating electrical power are insufficient for providing the increasing demand of electrical power. Thus, there is an urgent need to supplement the conventional sources. In “fig.1” shows Solar power generation with its associated technologies advanced few steps ahead in last several decades. It has been believed and investigated since last four decades that solar energy in space free from the weather conditions is quite different from that on the earth. The SPS system has great potential to harness solar power using bulk photovoltaic (PV) array in space and transmit it to the earth using microwave. The solar energy from sun while travelling a path to Earth is lost in the atmosphere because of the effects of reflection and absorption.

Therefore, it would be much beneficial to absorb solar energy from the geosynchronous orbit. A geosynchronous orbit is any orbit which has a period equal to the earth's rotational period. Accounting for efficiency, the PV cells produce 5 to 10% times more power at space than at ground [2].

Thus placing solar cells in space has a competitive advantage over solar power plants on the Earth. A photovoltaic cell can be placed on satellite revolving in geosynchronous orbit to absorb the solar energy. The

satellite is called as solar powered satellite. The generated DC by the photovoltaic cell can be converted into microwave by using magnetron, klystron or solid state devices. The generated microwave is transferred to the earth using antenna. The transmitted power is received by a device called rectenna. The received power is converted into DC power by filters and schottky diode. Power transmission using laser beam is also possible but, the power efficiency at both the transmitter and receiver of microwave transmission is more as compared with laser [3]

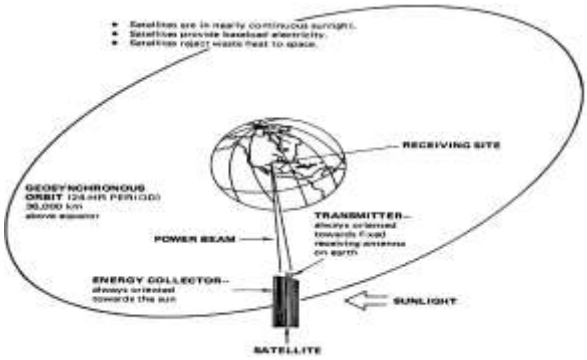

Fig.1 A Solar Power Satellite Concept

II. DESIGN OF THE SATELLITE BASES SYSTEM

The complete assembly of the satellite based system is shown in "Fig.2.1" and "Fig.2.2" shows the solar panels are connected on either sides of the satellite. These solar panels are the main source of DC power. Microwaves are generated using a device called magnetron powered by DC supply. Photovoltaic cells are used for converting solar radiations into DC power [3].

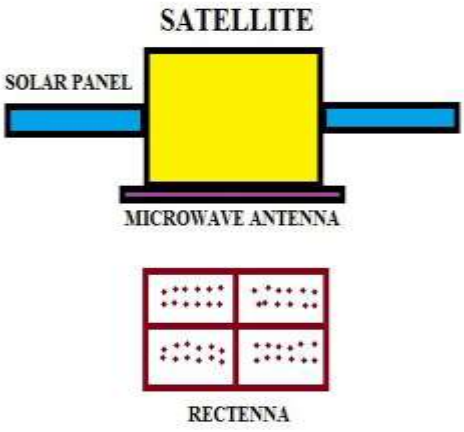

Fig.2.1 The Satellite Based System

Fig.2.2 Block Diagram of Satellite Based System

III. Components and Specification

3.1 Magnetron

Magnetron is a high powered vacuum tube device that generates microwaves owing to the motion of clouds of electrons in a crossed electric and magnetic fields. Magnetron originally developed in 1916 as an alternative to grid control in vacuum tubes. It was discovered during the DEO/NASA study of SPS that the microwave oven magnetron along with the external passive circuitry can perform as phase locked high gain of 30dB amplifier for

direct use in the transmitting section. For ground based transmitter, the microwave oven magnetron can be used directly [5]. However for space use, based on the same principle, special space magnetron is required.

3.2 Construction

"Fig"3 shows the cut view of magnetron. It consists of a cathode which is placed at the centre. A ring shaped anode surrounds the cathode. In anode structure, there are resonant cavities. A permanent magnet is placed beneath the anode which produces magnetic field along the length of the cathode. The resonant cavities present in anode structure are channeled at one end of the magnetron where the produced microwaves are collected. This channeled section is called as a waveguide.

3.3 Working

Generally, in microwave magnetron the maximum anode voltage is 4.5kV and the maximum cathode filament voltage is3.75 V AC. There is a heated cathode at the centre. Hence electrons are released from it by the process called 'Thermo Ionic Emission'.

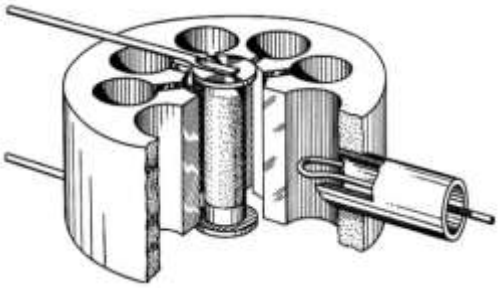

Fig. 3 Magnetron

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

3.4 Specifications

Table 1

Magnetron Rating [6]

	Minimum	Maximum	Unit
Filament voltage	2.85	3.75	V AC
Peak Anode Voltage	-	4.5	kVp
Output Frequency	2.45	2.75	GHz

IV. ANTENNA

The official definition of the antenna according to the IEEE (Institution of electrical and electronic engineers) is simply a means for radiating or receiving radio waves. An antenna or aerial is a system of elevated conductors which couples or matches the transmitter or receiver to free space.

4.1 Working

A transmitting antenna connected to a transmitter by a transmission line, forces electromagnetic waves into free space which travel in space with velocity of light, similarly, a receiving antenna connected to a radio receiver receives or intercepts a portion of electromagnetic waves travelling through space [7].In "fig. 3". Shown the space based solar power using the Antenna.

Efficiency of Antenna

$$\eta = \frac{\text{Power Radiated}}{\text{Total input Power}}$$

$$\text{Directive gain } G_d = \frac{\text{Radiation Intensity}}{\text{Average Radiated Power}}$$

$$\text{Directive gain} = \frac{\emptyset(\Theta, \phi)}{W_r/4\pi}$$

$$\text{Power Gain} = \frac{\text{Power Radiated}}{\text{Total input Power}}$$

$$\text{Power Gain} = \frac{\emptyset(\Theta, \phi)}{W_r/4\pi}$$

4.2 Rectenna

Brown was the pioneer in developing the first 2.45GHz rectenna. Rectenna is the microwave to dc converting device and is mainly composed of a receiving antenna and a rectifying circuit. Fig .4 shows the schematic of rectenna circuit [8]. It consists of a receiving antenna, an input low pass filter, a rectifying circuit and an output smoothing filter.

The input filter is needed to suppress radiation of high harmonics that are generated by the nonlinear characteristics of rectifying circuit. Because it is a highly nonlinear circuit, harmonic power levels must be suppressed.

For rectifying Schottky barrier diodes utilizing silicon and gallium arsenide are employed. Diode selection is dependent on the input power levels. The breakdown voltage limits the power handling capacity and is directly related to series resistance and junction capacitance through the intrinsic properties of diode junction and

material for efficient rectification the diode cut off frequency should be approximately ten times the operating frequency.

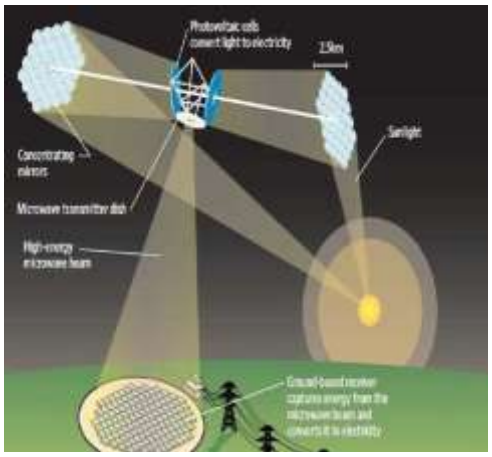

Fig. 3 Design of Space based Solar Power (SBSP) [4]

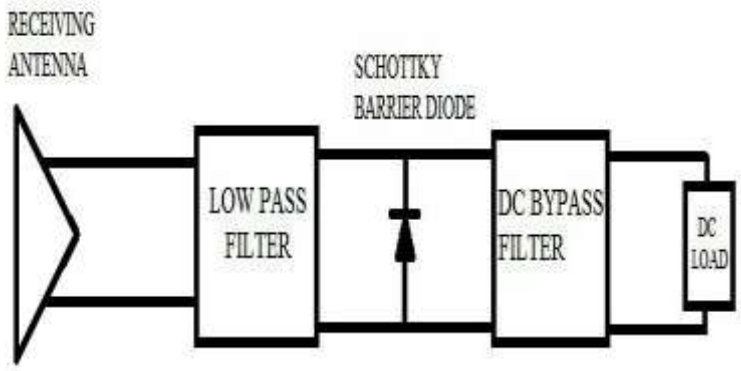

Fig. 4: Schematic of Rectenna Circuit. [9]

"Fig.5" shows Resent Trends In Power Systems (wireless power transmission system) Electricity plays a vital role in our day to day life & also there is a great demand for electricity today. Transmission losses are also one of the reasons for this demand .Since transmission is a main part of the power it should be more efficient. During trans mission there is a loss of 30%.To eliminate these losses we need a new technique which is called recent trend .The recent trend for efficient transmission of power is the wireless power trans mission system. This paper exposes a new method for wireless power trans mission using EM waves that comprises a transmitter and receiver in which we get a transmission efficiency of 95%.The receiver doesnot required an independent power source & it is comprised of an optical feedback to the transmitter & does not required a separate communication channel to the transmitter. The transmitter uses the optical feedback to locate and track the receiver. The transmitter can optionally employ a macro adjusters and micro adjusters that direct the beam on to the receiver for optimal power transmission. The system also optionally has a the tight loop beam detector to enhance the safety of the system. Either the receiver or transmitter may also encode data on the energy transmission, resulting in one -way or two- way data transmission.[10

V. ADVANTAGES

Energy delivered anywhere in the world. Zero fuel cost. Zero CO2 emission. Minimum long range environmental impact.[11] Unlike nuclear power plants, space solar power does not provide easy targets for terrorists. Unlike terrestrial solar and wind powerplants, space. Solar power is available 24 hours a day, 7 days a

Week in huge quantities. It works regardless of cloud over, daylight, or wind speed. Space solar power will provide true energy Independence for the nation that develop it, Eliminating a major source of national competition for limited Earth-based energy resource. Unlike oil, gas ethanol, and coal plants, space solar Power does not emit green house gases. [4]

VI. APPLICATION

There are many applications Example include fuel free airplanes, fuel free electric vehicles, moving robots and fuel free rockets, battery charging, car charging, remote control, game controller, headsets, sensors, computers, laptop charging, television and many more. [11]

VII. CONCLUSION

The solar power satellite would be in the earth's shadow for only a few days at the spring and fall equinoxes and even then for a maximum of an hour and a half late at night when power demands are at their lowest. As there are many storage systems like compressed air energy storage and battery storage available, the energy from SPS can be stored during low peak times and used efficiently during the peak load periods.

This concept offers greater possibilities for transmitting power with negligible losses and ease of transmission than any invention or discovery heretofore made. Dr. Neville of NASA states "You don't need cables, pipes, or copper wires to receive power.

REFRENCES

[1] Colorado springs notes

[2] Geoffrey A. Landis, "Solar Power from Space: Separating Speculation from Reality" XXIth Space Photovoltaic Research and Technology Conference (SPRAT-2009), Cleveland, OH, October 6-8 2009.

[3] Susumu Sasaki, Koji Tanaka, and Advanced Mission ssResearch Group, "Wireless Power Transmission Technologies for Solar Power Satellite," IEEE MTT-S International Microwave Workshop Series, Kyoto, Japan, May 12-13, 2011

[4] www.google.com

[5] William C. Brown, "Beamed Microwave Power Transmission and its Application to Space," IEEE Transactions on microwave theory and techniques. Vol, 40, No, 6, June 1992.

[6] www.delta-n.ru/Info/2M2121GKH(2M214240GP).pdf," LG Electronics.

[7] Prasad K.D.,"Antenna and wave propagation," 2nd edition satya prakashan new delhi.

[8] James O. Mcspadden & John C. Mankins,"Space solar power programs and microwave wireless power transmission technology" IEEE microwave magazine, pp.46-57, Dec 2002.

[9]. Hemant m. dighade and Akhilesh A. Nimje "Wireless Power Transmission Using Satellitess Based Solar Power System" International Journal of Application or Innovation in Engineering & Management, Volume 2, Issue 10, October 2013

[10] Vaibhav.R, S.Sai Bharathwaj "Wireless Power Transmission with Solar Power Satellite" International Journal of Inventive Engineering and Sciences (IJIES), ISSN: 2319–9598, Volume-1, Issue-11, October 2013.

[11] Landis, Geoffrey A 2006 IEEE 4th World Conference on Photovoltaic Energy Conversion 2 1939