Wireless Power Transmission via Solar Power Satellite

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Abstract: -
Wireless Power transmission (WPT) is a useful and convenient technology that can be employed to collect solar energy and concentrate on earth surface without the need for a wire connection called solar power satellites (SPS). Solar Power Satellite (SPS) is an energy system which collects solar energy in space and transmits it to the ground. It has been believed as a promising infrastructure to resolve global environmental and energy problems for human beings. One of the most important technologies for the SPS is the wireless power transmission from the geostationary orbit to the ground. Electrical power accounts for much of the energy consumed. In this paper, various technologies available so far for wireless transmission of electricity and the need for a Wireless Energy Transmission will be discussed to find its possibility in actual practices. This paper concentrates mainly on the microwave power transmission (MPT) called solar power satellite, the most popular concept known as Tesla Theory. This paper introduces the concept of SPS, and presents microwave power transmission technologies necessary for SPS.

KEYWORDS:- wireless power transmission, solar power satellite, tesla theory, microwave power transmission.

I. INTRODUCTION

A major problem facing planet earth is provision of an adequate supply of clean energy. It has been that we face "…three simultaneous challenges—population growth, resource consumption, and environmental degradation—all converging particularly in the matter of sustainable energy supply."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 consumer. The resistance of the wire used in the electrical grid distribution system causes a loss of 26-30% of the energy generated. This loss implies that our present system of electrical distribution is only 70-74% efficient. We have to think of alternate state - of - art technology to transmit and distribute the electricity. Now- a-days global scenario has changed a lot and there are tremendous development in every field. 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 noble alternative for electricity transmission. Projections of future energy needs over this new century show an increase by a factor of at least two and half, perhaps by as much as a factor of five. All of the scenarios indicate continuing use of fossil sources, nuclear, and large hydro. However, the greatest increases come from "new renewable" and all scenarios show extensive use of these sources by 2050. Indeed, the projections indicate that the amount of energy derived from new renewable by 2050 will exceed that presently provided by oil and gas combined. This would imply a major change in the world's energy infrastructure. It would be a herculean task to acquire this projected amount of energy.

Wireless transmission of power, also called wireless power transfer (WPT), is a means of delivering power to an end-use device without wires or contacts. One of the oldest known power transmission technologies, WPT is seeing a resurgence of interest. Scientists and engineers have known over the past century that transferring electric power does not require wires to be in physical contact. Wires typically allowed devices to receive both power and communicate with other devices. As wireless data transmission eliminates the need for wires to carry data, there is a growing need to find ways to provide power without wires making devices truly portable and mobile. With the explosive growth in wireless data applications, the market potential for wireless energy transfer technologies has seen a dramatic increase.
The Solar Power Satellite energy system is to place giant satellites, covered with vast arrays of solar cells, in geosynchronous orbit 22,300 miles above the Earth's equator. The solar cells will convert sunlight to electricity, which will then be changed to radio-frequency energy by a transmitting antenna on the satellite and beamed to a receiver site on Earth.

It will be reconverted to electricity by the receiving antenna, and the power would then be routed into our normal electric distribution network for use here on the Earth. As earlier mentioned, one of the major issue in power system is the losses that occurs during the transmission and distribution of electrical power. As the demand increases day by day, the power generation increases and the power loss is also increased. The efficiency of power transmission can be improved to certain level by using high strength composite

over head conductors and underground cables that use high temperature super conductor. But, the transmission is still inefficient.

According to the World Resources Institute (WRI), India's electricity grid has the highest transmission and distribution losses in the world – a whopping 27%. Numbers published by various Indian government agencies put that number at 30%, 40% and greater than 40%. This is attributed to technical losses (grid's inefficiencies) and theft. Any problem can be solved by state– of -the-art technology. The above discussed problem can be solved by choosing an alternative option for power transmission which could provide much higher Efficiency, low transmission cost and avoid power theft. Microwave Power Transmission is one of the promising Technologies and may be the righteous alternative for efficient power transmission.

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1. WIRELESS POWER TRANSMISSION:-

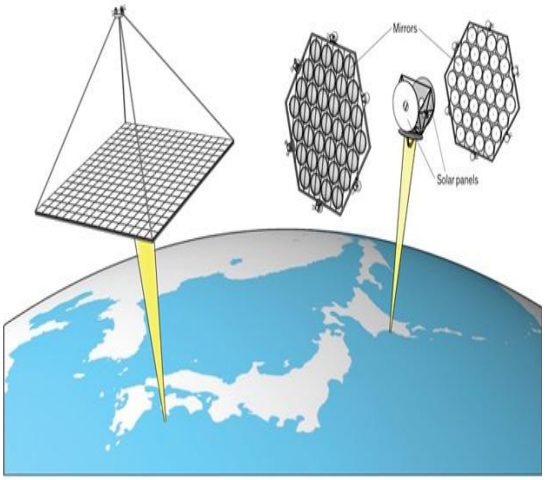
Wireless power transmission has been the subject of investigation since Nikola Tesla's experiments at the end of the 19th century. Nicola Tesla he is who invented radio and shown us he is indeed the "Father of Wireless". Nicola Tesla is the one who first conceived the idea Wireless Power Transmission and demonstrated "the transmission of electrical energy without wires" that depends upon Electrical conductivity as early as 1891.

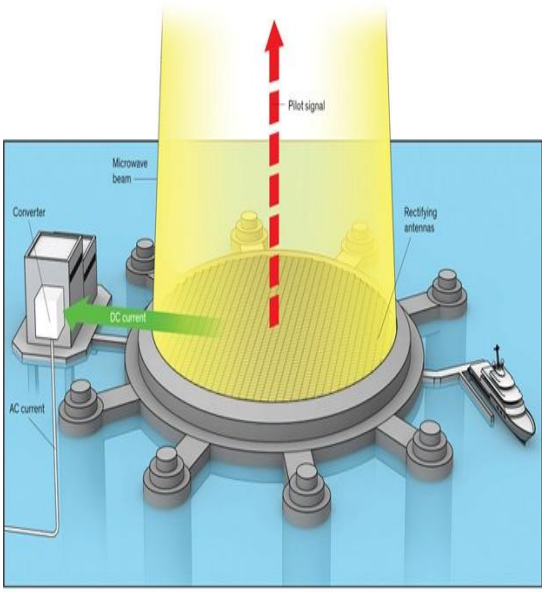
. The main components of Wireless Power Transmission are Microwave Generator, Transmitting antenna and Receiving antenna (Rectenna). These essential components are further described in detail

1) Microwave Generator: The Microwave generator takes the DC power generated by the solar cells and converts it to radiated RF output. It consists of a DC-RF conversion oscillator, which is typically low-power and followed by a gain stage and finally a power amplifier (PA).Typically the microwave generating devices are classified as microwave tubes (e.g. klystron, magnetron, TWT etc) or semiconductor MW devices.

2) Transmitting Antenna: The slotted wave guide antenna, micro strip patch antenna, and parabolic dish antenna are the most popular type of transmitting antenna. The slotted waveguide antenna is ideal for power transmission because of its high aperture efficiency (> 95%) and high power handling capability[3]. We need higher efficient generator/amplifier for the MPT system than that for the wireless communication system. For highly efficient beam collection on rectenna array, we need higher stabilized and accurate phase and amplitude of microwave when we use phased array system for the MPT.

3) Rectenna*:* The concept and the name „rectenna" was conceived by W.C. Brown of Raytheon Company in the early of 1960s. A Rectenna is a Rectifying antenna, a special type of antenna that is used to directly convert microwave energy into DC electricity. Its elements are usually arranged in a multi element phased array with a mesh pattern reflector element to make it directional. Rectennas are being developed as the receiving antennas in proposed microwave power transmission schemes, which transmit electric power to distant locations using microwave.



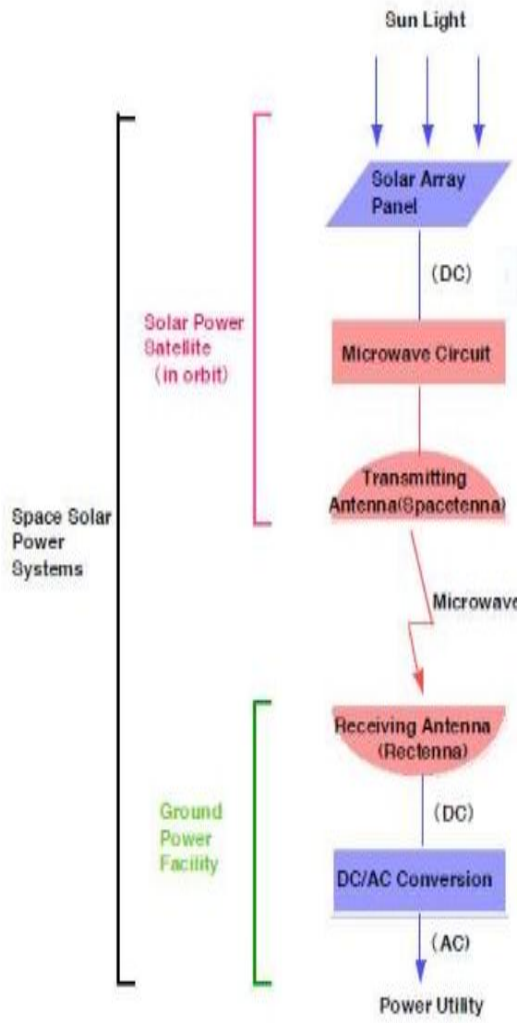


2. SOLAR POWER SATELITE

Basic idea of SPS is to collect the solar energy in orbit and the concept of the Solar Power Satellite energy system is to place giant satellites, covered with vast arrays of solar cells, in geosynchronous orbit 22,300 miles above the Earth's equator. . SPS is a technology that harnesses the sun's energy twenty-

four hours a day that works not only when we have daylight, but also at night, during rain or snow and even on cloudy days. Each satellite will be illuminated by sunlight 24 hours a day for most of the year. Because of the 23" tilt of the Earth's axis send it to ground by microwave. The satellites pass either above or below the Earth's shadow. It is only during the equinox period in the spring and fall that they will pass through the shadow. They will be shadowed for less than 1% of the time during the year. the photovoltaic panels would generate DC current, which would be converted to microwaves aboard the satellite. The satellite's many microwave-transmitting antenna panels would receive a pilot signal from the ground, allowing each transmitting panel to separately aim its piece of the microwave beam at the receiving station far below. Once the microwave beam hits the receiving station, rectifying antennas would change the microwaves back to DC current. An on-site converter would change that current to AC power, which could be fed into the grid.

A more efficient way to gather solar energy is to launch satellites into orbit around the Earth, where the satellites can capture solar energy, change it into another wavelength and send it to Earth where power stations convert it into usable electricity. The SPS is a gigantic satellite designed as an electric power plant orbiting the Geostationary Earth Orbit (Geo). It consists of mainly three segments; solar energy collector to convert The solar energy into DC (Direct Current) electricity, DC-to-Microwave converter, and large antenna array to beam down the microwave power to the ground. The first solar collector can be either photovoltaic cells or solar thermal turbine. The second DC-To-Microwave Converter of the SPS can be either microwave tube system and/ or semiconductor system. it may be their combination. The third segment is a gigantic antenna array. The solar cells will convert sunlight to electricity, which will then be changed to radio-frequency energy by a transmitting antenna on the satellite and beamed to a receiver site on Earth. It will be reconverted to electricity by the receiving antenna, and the power would then be routed into our normal electric distribution network for use here on the Earth. The great advantage of placing the solar cells in space instead of on the ground is that the energy is available 24 hours a day, and the total solar energy available to the satellite is between four and five times more than is available anywhere on Earth and 15 times more than the average location. To complete and operate an electricity system based on such satellites, we would have to demonstrate mastery of six different disciplines: wireless power transmission, space transportation, construction of large structures in orbit, satellite attitude and orbit control, power generation, and power management.



3. MICROWAVE POWER TRANSMISSION

To send power over distances measured in millimeters or centimeters—for example, to charge an electric toothbrush from its base or an electric vehicle from a roadway—electromagnetic induction works fine. But transmitting power over longer distances can be accomplished efficiently only by converting electricity into either a laser or a microwave beam. The laser method's main advantages and disadvantages both relate to its short wavelength, which would be around 1 micrometer for this application. Such wavelengths can be transmitted and received by relatively small components: The transmitting optics in space would measure about 1 meter for a 1-GW installation, and the receiving station on the ground would be several hundred meters long. However, the short-wavelength laser would often be blocked by the atmosphere; water molecules in clouds would absorb or scatter the laser

beam, as they do sunlight. No one wants a space-based solar power system that works only when the sky is clear.

But microwaves—for example, ones with wavelengths between 5 and 10 centimeters—would have no such problems in transmission. Microwaves also have an efficiency advantage for a space-based solar power system, where power must be converted twice: first from DC power to microwaves aboard the satellite, then from microwaves to DC power on the ground. In lab conditions, researchers have achieved about 80 percent efficiency in that power conversion on both ends. Electronics companies are now striving to achieve such rates in commercially available components, such as in power amplifiers based on gallium nitride semiconductors, which could be used in the microwave transmitters.

ADVANTAGES

Wireless Power Transmission system would completely eliminates the existing high-tension power transmission line cables, towers and sub stations between the generating station and consumers and facilitates the interconnection of electrical generation plants on a global scale. It has more freedom of choice of both receiver and transmitters. Even mobile transmitters and receivers can be chosen for the WPT system. The cost of transmission and distribution becomes less and the cost of electrical energy for the consumer also would be reduced. The power could be transmitted to the places where the wired transmission is not possible. Loss of transmission is negligible in the Wireless Power Transmission; therefore, the efficiency of this method is very much higher than the wired transmission. Power is available at the rectenna as long as the WPT is operating. 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.

DISADVANTAGES

The Capital Cost for practical implementation of WPT seems to be very high and the other disadvantage of the concept is interference of microwave with present communication systems.

CONCLUSION:-

The concept of Microwave Power transmission (MPT) and Wireless Power Transmission system is presented. The technological developments in Wireless Power Transmission (WPT), the advantages, Disadvantages, and applications of WPT are also discussed. This concept offers greater possibilities for transmitting power with negligible losses and ease of transmission. Furthermore, it appears almost certain that there will be a shift towards renewable sources and that solar will be a major contributor. It is asserted that if the energy system of the world is to work for all its people and be adequately robust, there should be several options to develop in the pursuit of and expanded supply. While the option of Space Solar Power may seem futuristic at present, it is technologically feasible and, given appropriate conditions, can become economically viable.

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