WIRELESS POWER TRANSMISSION THROUGH SOLAR POWER GENERATION

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Abstract— In the age of wireless technology and increasing use of renewable energy there is a constant increase in the demand for wireless technology which is environment friendly. The phenomenon incorporated in here is to transfer power using a renewable source, without using wired medium. This paper mainly focused on combining both wireless and solar technologies together. This principle of wireless electricity transfer works on the principle of using coupled resonant objects for the transferring electricity. If the efficiency of transmitting the power wirelessly is increased slightly further, then wireless power transmission could become a standard means for charging any electronic gadget, and also if it is by means of a renewable and clean power source such as solar energy, it would be a cherry on top of the cake. The overall goal of this paper is to design and implement a clean power generation and wireless power transmission system.

Keywords— MOSFET/IGBT, Wavelength, WiTricity, Resonance

I. INTRODUCTION

The current scenario revolves around the depletion of fossil fuels and other non renewable sources of energy which is expensive and cannot reliable upon. So it is high time we shifted to renewable sources of energy. This paper focused on the technology of wireless power transfer, incorporating a renewable source solar energy. Transmission of electrical energy without the use of wires that depends upon electrical conductivity was first introduced by Sir Nikola Tesla in the year 1891[1][2]. Witricity, an abbreviation of wireless transfer of electricity, is a term introduced initially by Dave Gerding in the year 2005. Wireless electricity or witricity is the transfer of electric energy or power over a distance without the use of wires. In order for the energy to be transferred safely coupled resonators are used. Coupled resonators are two objects of the same resonant frequency that exchange energy efficiently without much leakage. Minimizing energy leakage is very important because the goal is to have as much energy as possible be transferred from one object to another . Wireless energy transfer can be useful in such applications as providing power to autonomous electrical and electronic devices. This energy which is transferred can be derived from a renewable source; the best available option is the Solar Energy. Solar energy is harnessed by the means of Solar Cells. The solar cells are made of silicon crystals that have been combined with other materials in such a way that there are extra electrons in one part of the cell, and missing electrons in another part of the cell. When the sunlight strikes the cell, photons in the light knock some of the extra electrons loose from the silicon, and they flow to the part of the cell that is missing electrons. This flow produces an electrical current that eventually reaches the inverter, where it gets converted into usable electricity. The overall goal of this paper is to design and implement a clean power generation and a wireless power transmission system.

Every WPT technology has its own advantages and disadvantages. The main research themes of all WPT technologies focus on improving the transmission efficiency and distance. In addition, driven by industrial needs, multiple transmitters/receivers design has attracted much attention. However, several open research challenges exist, hindering the public acceptance of WPT technologies. Hence, it is crucial to understand and address these challenges for paving the way for a brighter future of the WPT applications.

II.EXSISTING METHODS

In present days transmission and distribution of power in grid is done through wired medium. One of the major issue in power system is the losses 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 major amount of power loss occurs during transmission and distribution. The percentage of loss of power during transmission and distribution is approximated as 26%. The main reason for power loss during transmission and distribution is the resistance of wires used for grid. 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[3]. 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 [1].

Any problem can be solved by state–of-the-art technology. The above discussed problem can be solved by choose 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.

III. WIRELESS POWER TRANSMISSION

The technology for **wireless power transmission or wireless power transfer** (**WPT**) is in the forefront of electronic development[4]. Applications involving microwaves, solar cells, lasers, and resonance of electromagnetic waves have had the most recent success with WPT. The main function of wireless power transfer is to allow electrical devices to be continuously charged and lose the constraint of a power cord. Although the idea is only a theory and not widely implemented yet, extensive research dating back to the 1850's has led to the conclusion that WPT is possible. The three main systems used for WPT are microwaves, resonance, and solar cells. Microwaves would be used to send electromagnetic radiation from a power source to a receiver in an electrical device. The concept of resonance causes electromagnetic radiation at certain frequencies to cause an object to vibrate. This vibration can allow energy to be transmitted between the two vibrating sources. Solar cells, ideally, would use a satellite in space to capture the suns energy and send the energy back to Earth. This concept would help to solve the major energy crisis currently concerning most of the world. These ideas would work perfectly in theory, but converting the radio frequencies into electrical power and electrical power to radio frequencies are two main problems that are withholding this idea to become reality.

Wireless power transfer technology can be applied in a wide variety of applications and environments. The ability of our technology to transfer power safely, efficiently, and over distance can improve products by making them more convenient, reliable, and environmentally friendly. Wireless power transfer technology can be used to provide:-Automatic wireless charging and use of mobile electronics in car… while devices are in use and mobile. Direct wireless powering of stationary devices (flat screen TV's, digital picture frames, home theater accessories, wireless loud speakers, etc.) eliminating expensive custom wiring, unsightly cables .Etc… eliminating disposable batteries and awkward cabling.

IV.VARIOUS SCHEMES OF WIRELESS POWER TRANSFER

There are many techniques which are being used to achieve wireless power transfer. Some of the methods are being discussed below.

IV.1. WPT using Microwaves:

In the transmission side, the microwave power source generates microwave power and the output power is managed by electronic restrain circuits[5]. The purpose of the tuner is to match the impedance between the transmitting antenna and the microwave source. The attenuated signals gets divided based on the direction of signal propagation by Directional Coupler. The transmitting antenna emits the power uniformly through free space to the antenna. In the receiving section, a antenna receives the transmitted power and translates the microwave power to DC power. The impedance matching circuit and the filter is provided for setting the output impedance of a signal source equal to the rectifying circuit. The rectifying circuit have Schottky barrier diodes which converts the received microwave power into DC power.

IV.2. WPT using Magnetic Resonance:

In this technique, at first we design an oscillator, which generates the carrier signal to transmit the power. Oscillators are not usually designed to deliver power, thus a power amplifier is added to the oscillator to amplify the oscillating signal[5]. The power amplifier would hand over the output power to the transmission coil. Next, a receiver coil is constructed to receive the transmitted power. However, the power received in the receiver side have an alternating current. Thus, a rectifier is needed to rectify the AC voltage. Finally, an electric load is attached to finish the entire

V. SOLAR CELLS

Solar cells are devices in which sunlight releases electric charges so they can move freely in a semiconductor and ultimately flow through an electric load, such as a light bulb or a motor. The phenomenon of producing voltages and currents in this way is known as the photovoltaic effect[6]. The fuel for solar cells—sunlight—is free and abundant. The intensity of sunlight at the surface of the earth is at most about one thousand watts per

square meter. Thus the area occupied by the cells in a photovoltaic power system may be relatively large, and its cost must be considered in calculating the cost of the electricity produced. The primary factor that determines whether solar cells will be used to supply electricity in a given situation is the cost per unit output, relative to that of alternative power sources, of acquiring, installing, and operating the photovoltaic system. Solar cells are already being used in terrestrial applications where they are economically competitive with alternative sources. Examples are powering communications equipment, pumps, and refrigerators located far from existing power lines. It is expected that the markets for solar cells will expand rapidly as the cost of power from conventional sources rises, and as the cost of solar cells falls because of technological improvements and the economies of large-scale manufacture. The first of these sparticularly those employing fossil fuels— continues automatically, in part because the resource is limited. The second—reducing the cost of electricity from solar cell systems—is the subject of worldwide research and development efforts today. To increase the economic attractiveness of the solar cell option, one or more of the following must be done:

• Increase cell efficiencies.

• Reduce cost of producing cells, modules, and associated equipment,
and the cost of installing them.

• Devise new cell or system designs for lower total cost per unit power output.

V.1. Working of Solar Cell

The most important physical phenomena employed in all solar cells are illustrated schematically in Fig. 5.1. Sunlight enters the semiconductor and produces an electron and a hole—a negatively charged particle and a positively charged particle, both free to move. These particles diffuse through the semiconductor and ultimately encounter an energy barrier that permits charged particles of one sign to pass but reflects those of the other sign. Thus the positive charges are collected at the upper contact in Fig. 5.1, and the negative charges at the lower contact. The electric currents caused by this charge collection flow through metal wires to the electric load shown at the right side of Fig. 5.1. The current from the cell may pass directly through the load, or it may be changed first by the power-conditioning equipment to alternating current at voltage and current levels different from those provided by the cell. Other sub-systems that may also be used include energy-storage devices such as batteries, and concentrating lenses or mirrors that focus the sunlight onto a smaller and hence less costly semiconductor cell. If concentration is employed, a tracking subsystem may be required to keep the array pointed at the sun throughout the day.

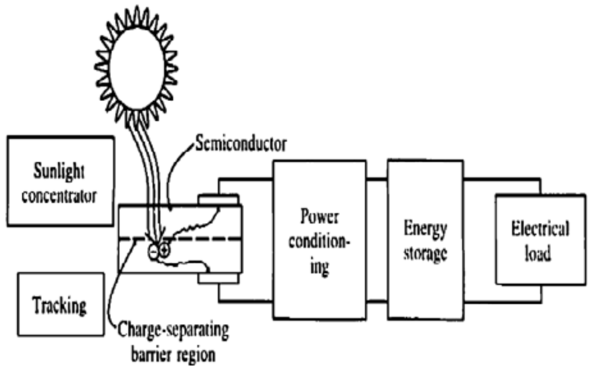


Fig 5.1 Sketch showing elements of a solar cell

V.2.Maximum power point tracking

Maximum power point tracking (MPPT) is a technique used with wind turbines and photovoltaic (PV) solar systems to maximize power output.

PV solar systems exist in several different configurations. The most basic version sends power from collector panels directly to the DC-AC solar inverter, and from there directly to the electrical grid. A second version, called a hybrid inverter, might split the power at the inverter, where a percentage of the power goes to the grid and the remainder goes to a battery bank. The third version is not connected at all to the grid but employs a dedicated PV inverter that features the MPPT. In this configuration, power flows directly to a battery bank. A variation on these configurations is that instead of only one single inverter, micro inverters are deployed, one for each PV panel. This allegedly increases PV solar efficiency by up to 20%. New MPPT equipped specialty inverters now exist that serve three functions: grid-connecting wind power as well as PV, and branching off power for battery charging.

This article about the application of MPPT concerns itself only with PV solar. Solar cells have a complex relationship between temperature and total resistance that produces a non-linear output efficiency which can be analyzed based on the I-V curve[7]. It is the purpose of the MPPT system to sample the output of the PV cells and apply the proper resistance (load) to obtain maximum power for any given environmental conditions. MPPT devices are typically integrated into an electric power converter system that provides voltage or current conversion, filtering, and regulation for driving various loads, including power grids, batteries, or motors.

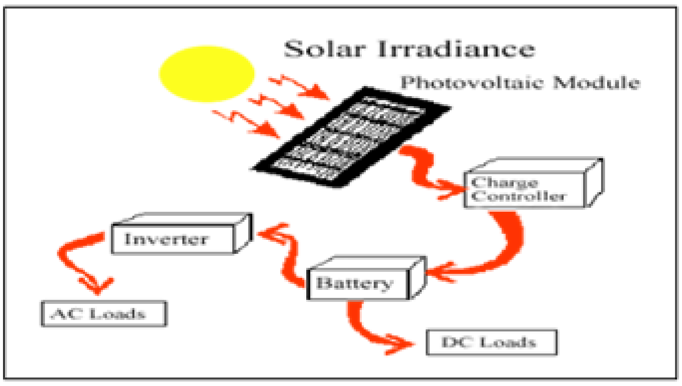
- Solar inverters convert the DC power to AC power and may incorporate MPPT: such inverters sample the output power (I-V curve) from the solar modules and apply the proper resistance (load) so as to obtain maximum power.

MPP (Maximum power point) is the product of the MPP voltage(Vmpp) and MPP current(Impp)

Incremental conductance method

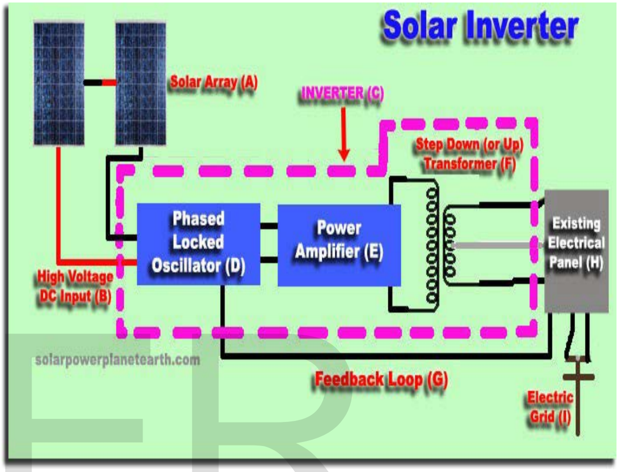
This method uses the incremental conductance dI/dV to compute the sign of dP/dV . When dI/dV is equal and opposite to the value of I/V the algorithm knows that maximum power point has reached and there it ends and returns the corresponding value of operating voltage for MPP. One problem is that it requires many sensors like voltage and current to operate. In this method the MPP is reached by comparing incremental conductance with instantaneous conductance. If change in voltage is not equal to zero then incremental conductance is compared with instantaneous conductance. If both are equal, then it gets terminated and returns the desired value. If not, both are made equal by increasing or decreasing reference voltage. Once the MPP is reached, the point is maintained until change in irradiance, temperature occurs. The problem with Incremental conductance method is that the operating point keeps on oscillating for larger increment and for smaller increment time to track MPP is longer

VI. MATERIALS AND METHODS

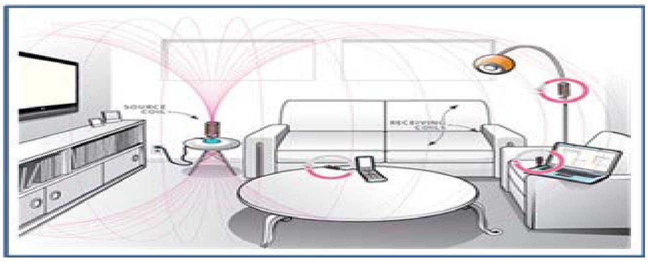


The Photovoltaic module (PV) or Solar panels are installed on the roofs, they convert the sunlight into the direct current(DC) power . The charge controller limits the rate at which the electric current is added or drawn from the electric batteries. The batteries being one of the main component of the solar power system, the charge controller protects the batteries from overcharging and also against overvoltage. This surely does increase the life span of batteries.The DC power from the solar panel is sent to the inverter where it is converted into Alternating current (AC) power.

VII.SOLAR INVERTER-



The block diagram schematic of the Solar inverter clearly shows us that it implements a Phase Locked Loop oscillator wit a Power Amplifier and finally a step up/down transformer connected to the out section .The basic function of a Phase Locked Loop oscillator is ,it generates a output signal whose phase is related to the phase of the input signal. The oscillator's function is to generate a periodic signal. The phase detector compares the phase of that signal with the phase of the input periodic signal and adjusts the oscillator to keep the phases matched. The power amplifier as the name suggests is used for a greater level of amplification of the signal. The transformer which is connected to the out section of the amplifier can be used for stepping up or stepping down the signal, which can done according the application. This Alternating current is then made to flow in the AC line[8]. The power from these AC lines is then transferred wirelessly for powering the domestic devices. Here the principle of witricity comes into picture. Witricity is based on strong coupling between electromagnetic resonant objects to transfer energy wirelessly between them. This differs from other methods like simple induction, microwaves, or air ionization. The system consists of transmitters and receivers that contain magnetic loop antennas critically tuned to the same frequency. Due to operating in the electromagnetic near field, the receiving devices must be no more than about a quarter wavelengths from the transmitter[9] .Unlike the far field wireless power transmission systems based on travelling electro-magnetic waves, Witricity employs near field inductive coupling through magnetic fields similar to those found in transformers except that the primary coil and secondary winding are physically separated, and tuned to resonate to increase their magnetic coupling. These tuned magnetic fields generated by the primary coil can be arranged to interact vigorously with matched secondary windings in distant equipment but far more weakly with any surrounding objects or materials such as radio signals or biological tissue.



VIII. WORKING.

STEP 1:- A circuit [A] attached to the wall socket converts the standard 60-hertz current to 10 megahertz and feeds it to the transmitting coil [B]. The oscillating current inside the transmitting coil causes the coil to emit a 10-megahertz magnetic field.

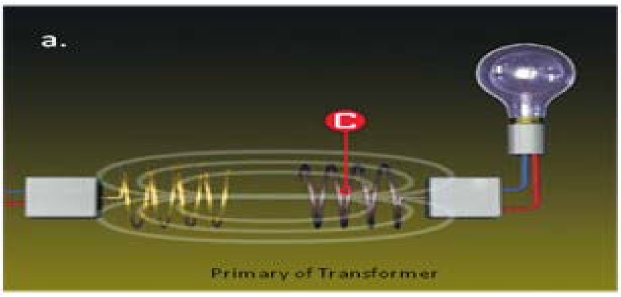


Fig 8.1 Working.

STEP 2:- The receiving coil [C] has the exact same dimensions as the sending coil and thus resonates at the same frequency and, in a process called magnetic induction, picks up the energy of the first coil's magnetic field.

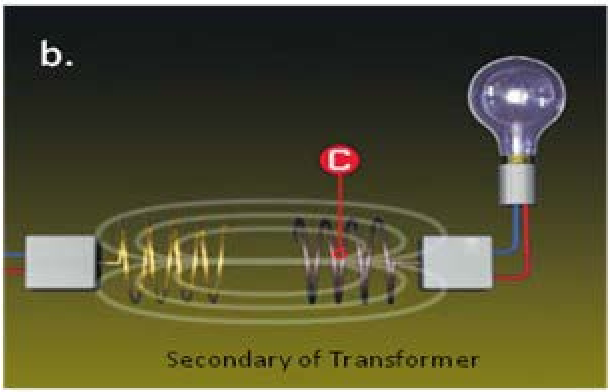


Fig 8.2 Working

STEP 3:- The energy of the oscillating magnetic field induces an electrical current in the receiving coil, lighting the bulb [D].

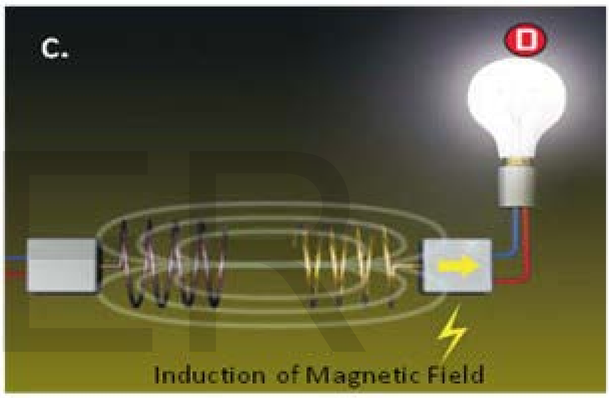


Fig 8.3 Working

IX. BLOCK DIAGRAM

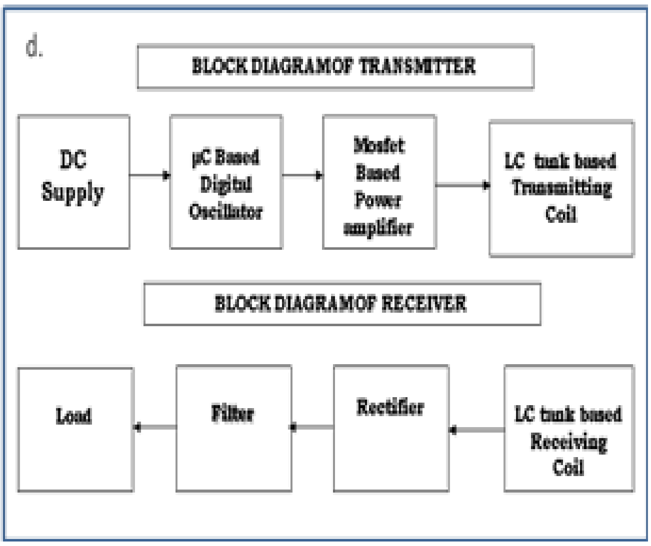


Fig 9.1 Block Diagram

IX.1Working of Transmitter

The input from mains is given to the power and frequency controller.[10] The output of this system is given to MOSFET/IGBT. The main purpose of using MOSFET/ IGBT is to convert DC to AC and also for amplifying square wave at the gate input. The voltage given to the transmitting coil generates magnetic field around it. The capacitor is connected to the coil parallel and hence the resonating circuit is formed. Until the resonant frequency of receiving coil matches with the resonant frequency of the transmitting coil magnetic field won't get induced in the receiving coil. For this purpose of matching the resonant frequency we used different values of "L" and "C" for resonant frequency matching purpose. To match the resonant frequency of the receiver and the transmitter coil we used the switches to vary the time periods of the square wave by which we are controlling the frequency at output.

IX.2Working of Receiver

As the receiving coil comes in the range of the magnetic field of the transmitting coil, the voltage across the transmitting coil gets induced in the receiving coil because of mutual inductance and matching of resonance frequency The received voltage is in AC form, we have to convert it into DC for DC load hence we used a rectifier circuit which provides constant DC at the output for driving the load. And if the load is ac load then we can give direct output to it.[11]

X. CALCULATION

The transmitter is supplied with 18 volts AC and the current circulating in it will induce an electromotive force in the receiving coil that will drive the light bulb. The electromagnetic wave is used to radiate energy with its oscillating electric and magnetic fields. To make sure the field stays strong, the two sides will be made to resonate at the same magnetic frequency of 40 kHz. For calculating the resonant frequency we used the following formula:

Where,

F=resonant frequency.
L=inductance value of coil.
C=capacitance value of coil.

X.1 **Formula For Finding Inductance**

$$L = \frac{N^2 \mu A}{l}$$

Where,
L=Inductance of Coil in Henrys
N=Number of turns in Coil
μ=Permeability of air (core material)
A=Area of coil in square meters
l=Average length of coil in meters

Efficiency: During the transferring of energy there are some of the losses which takes place which reduces the efficiency There are hysteresis losses, eddy current losses ,attenuation, etc. which are responsible for the same.

Less Range: As witricity is under the research sector, the range of wireless transferring of energy is still not upto the mark.

Solar efficiency-

Solar efficiency refers to the amount of light that can be converted into usable electricity.
Solar efficiency is dependent on 2 parameters-
Solar cell efficiency-Solar cell efficiency is the amount of light that the individual solar cell coverts into electricity. It is the ratio of the electrical output of the solar cell to the incident energy in the form of sunlight. This is calculated by dividing a cell's power output (in watts) at its maximum power point (P_m) by input light (E, in W/m^2) and the surface area of the solar cell (A_c in m^2).

$$\eta = \frac{P_m}{E \times A_c}$$

Solar panel efficiency: - Solar panel efficiency is the amount of light that the entire module converts into electricity. The efficiency of solar panel is less than that of solar cell, due to the spacing which is present in between the cells and because of the glass covering over the panel which reflects some of the sunlight.

How to improve the efficiency of the solar panel:-

Increasing the amount of electric current produced by the solar panel can be done by augmenting its light surface with aluminum nanostructures. Another way to increase the electric current produced by solar panel is by studying the light receiving surface of Gallium Arsenide (GaAs) devices with aluminum nano cylinders. This magnified the scattering of light in the visible part of the spectrum which dominates the energy in sunlight, the scattered light then travels a longer path so that more photons can be absorbed and converted into current.

XI. CONCLUSION

The concept of wireless power transmission through renewable power generation is presented . Mainly focused on providing clean and efficient power transmission through wireless medium, this would offer a major advancement in the field of solar and wireless technology. Avoidance of cables in power transfer reduces high cost affairs. Wireless technology can be useful for providing power to autonomous electrical and electronics devices .This energy which is transferred can be derived from a renewable source, here we use solar energy. Solar energy is harnessed by means of solar cells. If the efficiency of transmitting power wirelessly is slightly increased , then wireless transmission become a standard means of charging any electronic gadgets. Also solar energy adds more efficiency to this scheme.

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