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Wireless Powering Of 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 as solar power satellites (SPS). WPT via Resonance, for example, can be applied in the future to stable and CO_2-free space-based solar power satellites. Overall, WPT will support both future energy production and the environment. This paper provides an analysis of wireless power transfer with an assessment of its practical applicability in terms of power range and efficiency. There are four types of satellites are accessed, one is primary and others are secondary. The secondary satellites are placed in triangular axis and primary satellite is placed at center of triangle for maximum power transfer .This assessment is obtained through the design and construction of a resonant inductive wireless powering system(in secondary satellites) suited to supply a main satellite transceiver(i.e. primary) for power range from 480-1920 watts with efficiency 80-90%. In this paper the formula for calculating the mutual inductance between circular coils with lateral and angular misalignment by using the approach of F. W. Grover is presented. This system is evaluated and designed by using MATLAB 2012a coding.

***Index*-** Solar power satellites, Need, Assumption, Formula for Resonance, system block diagram & result.

I. Solar Power Satellite: Basic Concept

Basic idea of SPS is to collect the solar energy in orbit and send it to ground by microwave, laser beam or some other way.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. 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, 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 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. Figure 1 illustrates the concept. 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. Testing has demonstrated that wireless energy transmission to the Earth can be accomplished at very high efficiencies. Tests have also shown that the energy density in the radio-frequency beam can be limited to safe levels for all life forms. The concept is simple; the technology exists[1][2].

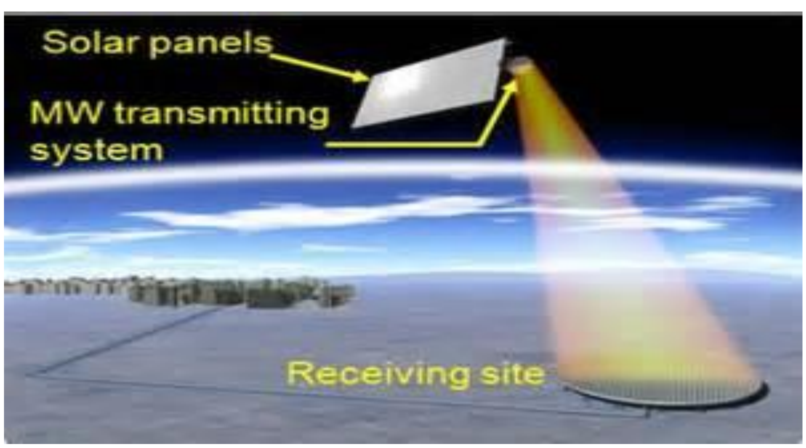

Figure 1. Components of Solar Power Satellites & Basic Conversion Process

II. Need

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Realization of external supplying power to satellite moving on its orbit can lead to weight reduction and miniaturization of power system. It can also reduce difficulties in launching satellite like launching cost. Standardization of wireless power transmission module has the effects of being on market faster and improvement of usability's effects. Thus, building of the Flexibility Power Supply Network which uses wireless power transmission technology expands potential of nano-satellites in space.

III. Formula for circular coils with both lateral and angular misalignments

In [4] and [5], Grover presented a formula for computing the mutual inductance *M* between two filamentary circular coils with inclined axes (e.g., see Fig. 2). The first coil has a radius R_P , and the second coil has a radius R_S. The distance between the coils' centers is *c*, and the distance between their axes is *d*. The resulting expression proposed by Grover for *M* is:

$$M = \frac{(2\times mew)}{\pi}\sqrt{Rs}Rp\int \frac{[cos\theta - \frac{d}{Rs}cos\emptyset]\varphi(k)]}{k\sqrt{v3}}d\emptyset \qquad \ldots (1)$$

Where

$\alpha = \frac{Rs}{Rp}$ &$\beta = \frac{c}{Rp}$

$$v = \sqrt{1 - \cos\emptyset^2 sin\emptyset^2 - 2(\frac{d}{Rs})cos\emptyset cos\theta + \left(\frac{d}{Rs}\right)^2} \qquad \ldots (2)$$

$k^2 = \frac{4\alpha v}{(1+\alpha v)^2+\varepsilon^2}$,$\varepsilon = \beta - \alpha cos\emptyset sin\theta$

And $\varphi(k) = \left(1 - \frac{k^2}{2}\right)K(k) - E(k)$ … (3)

K (k) and E (k) are elliptical integral given as

$$K(k) = \int_0^{\pi}\frac{1}{\sqrt{1-k^2sin\theta^2}}d\theta \ \ ,E(k) = \int_0^{\pi}\sqrt{1-k^2sin\theta^2}\,d\theta$$

… (4)

For parallel resonance θ=0 & angular resonance θ=60.The derivation for the formula with magnetic vector is given in reference [3].

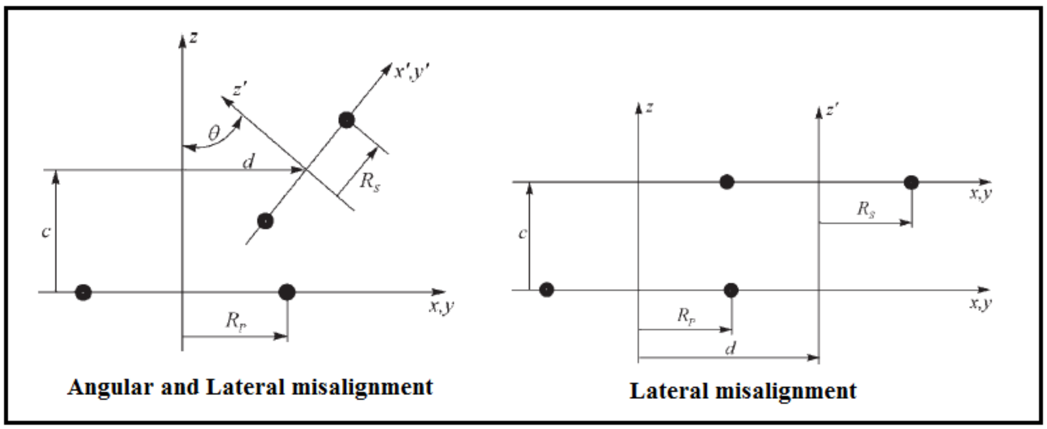

Figure 2. Filamentary circular coils with angular and lateral misalignment

IV. Block diagram

The diagram in fig.3 serves to clarify the distinction between the WPT systems two main functional parts, namely the Power train and the Control loop. Throughout the development phase, the control loop has been replaced by manual tuning of the operating frequency based on power readings from millimeters and an electronic DC load. As such, a greater part of the development effort has gone in to analysis and design of the Power train, which in the context of maximizing efficiency is by far the most critical component.

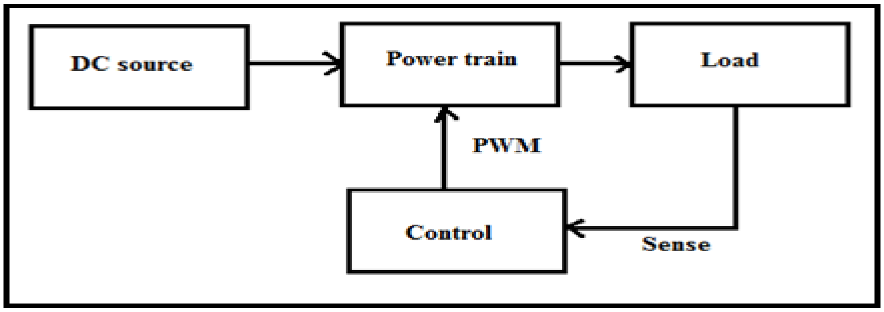

Figure 3. System Block diagram

The "Power Train" block constitutes the magnetic link from source to load, while the "Control Loop" senses the supply and load scenario and adjusts the operating frequency accordingly.The diagram in fig. 4 depicts the functional blocks of the power train which on the transmitting side consists of an inverter, matching capacitors and the transmitter coil. The secondary side similarly consists of a receiver coil and matching capacitors, along with rectification/smoothing and a DC-DC converter for output voltage regulation.

Fig. 4 shows the basic concept of proposed system.There are four satellites are used for required power level.

(i).For initial base load only Satellite-1 is accessed and tranmitts power upto 480 Watts.

(ii).For slightly increased load Satellite-1 & 2 are accessed and both transmit Power from 480-960 Watts.

(iii)For peak load Satellite 1,2 & 3 are accessed and system transmit power from 960-1440Watts.

(iv) For overload Satellte 1,2,3 & 4 are accessed and system transmit pwer from 1440-1920 Watts. The main satellite is covered with three satellite with triangle frame.

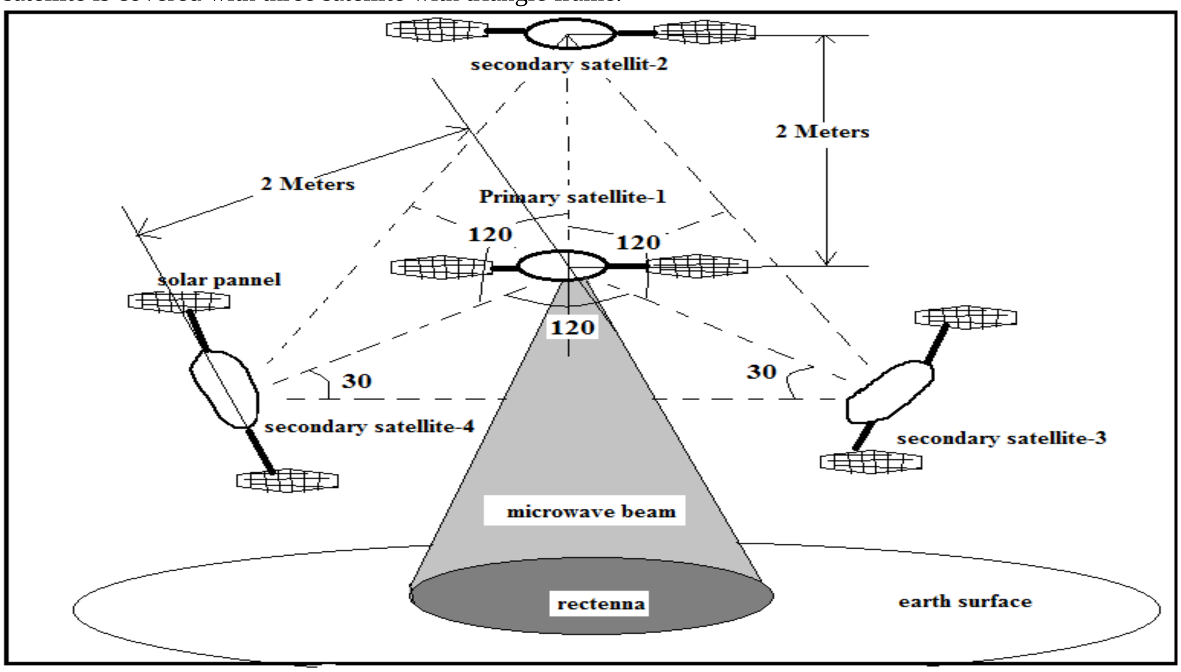

Figure 4.Basic Concept of wireless powering of SPS

V. Result

The system block diagram is designed by using MATLAB coding and results are as follow, this paper provides only the result of Satellite-2 which is designed with 480 watts power output and LLC with angular (60 degree) resonance with main SPS.Figure 5 & 6 are total DC power from solar panel of Sat.-2.Fig 7 shows output of half brigde D-inverter & fig.8shows the primary voltage of transformer with 220 volts.Fig-9,10 & 11 represents theinput impedance,input power & output power of LLC converter respectively at 200 KHz frequency.at last fig.12 shows the DC power from Sat.2 using resonance.

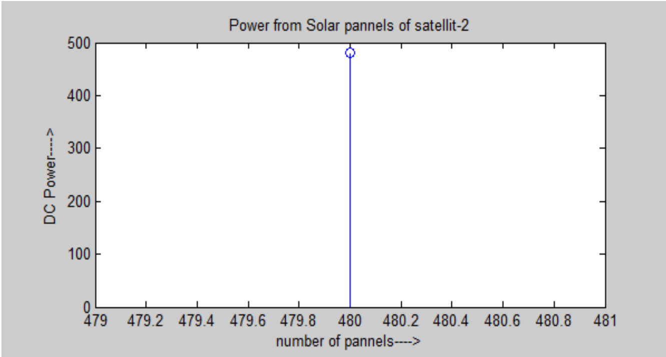

Figure 5. Output Power of 480 Watts from solar panels of sat.-2

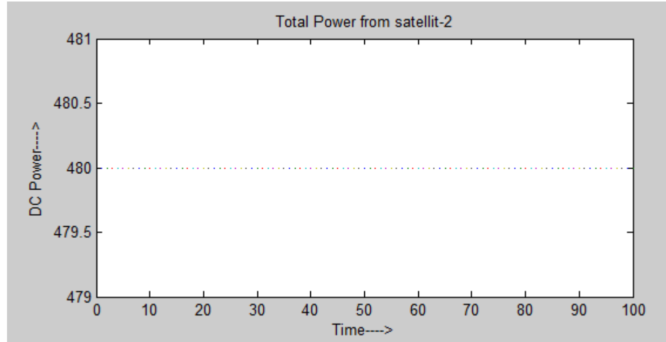

Figure 6. DC waveform of output voltage of Satellite-2

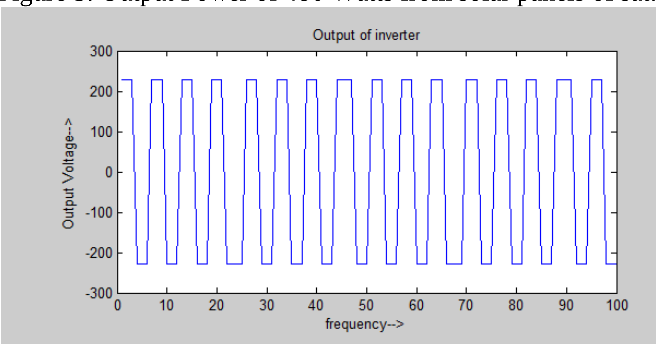

Figure 7.Output Voltage of Inverter

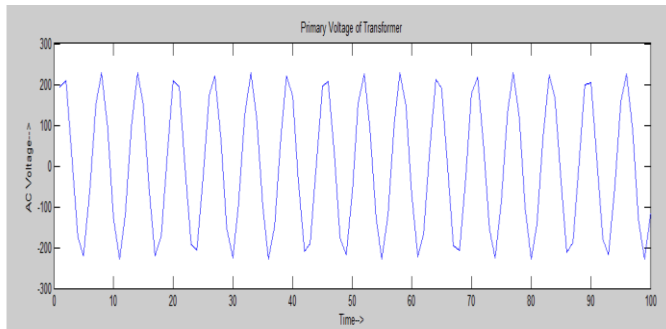

Figure 8.Primary voltage of Transformer

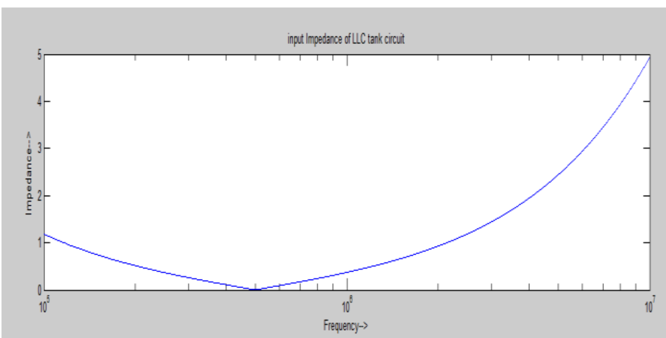

Figure 9.LLC impedance at resonance frequency of 200 KHz.

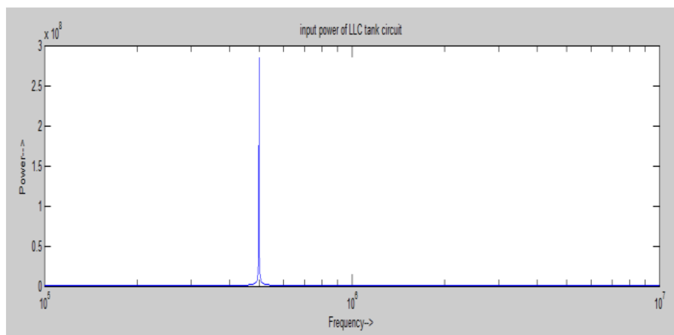

Figure10.LLC input power at resonance frequency of 200 KHz.

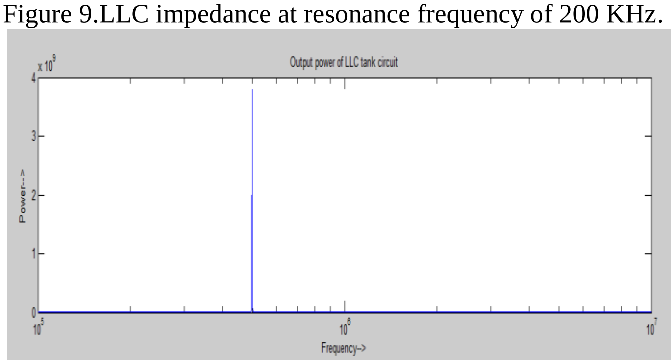

Figure11.LLC output power at resonance frequency of 200 KHz.

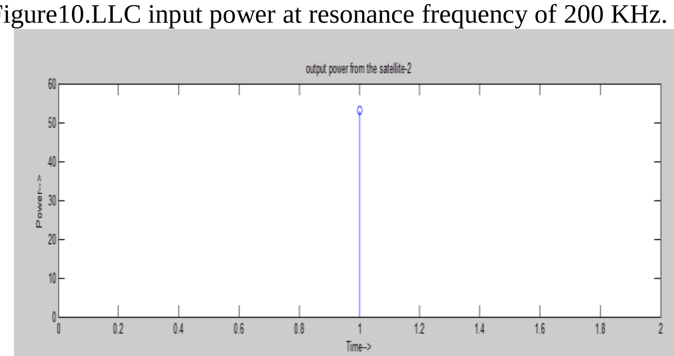

Figure 12.Total DC power from satellite-2

VI. Conclusion

A wireless power transfer system capable of transferring the required amount of power has been studied successfully with resonance concept. The copious amount of applications for wireless power transmission delivers no small amount of motivation to this pursuit and certainly promises a beginning of an exciting new future in the energy industry and will have massive impacts throughout our everyday lives. However the technology is still young and it will be interesting to monitor its development through the course of the

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next ten years. It's easy to see where wireless power transfer will better our lives, eliminating excess cables and wires, removing unnecessary clutter and the need for cleaning, allowing us even greater mobility with our devices and also allowing us to inhabit, in today's standards,uninhabitable areas,it will bring us one step close in solving the worlds energy crisis. and future uses. This paper provides basic idea and development for solar power satellite which is the best option for present energy demand problem. The proposed system can be used for Farm-Houses, Industrial site for their power requirement.

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