WIRELESS TRANSMISSION OF ELECTRICAL POWER USING MICROWAVES AND ITS RECEPTION USING A METAMATERIAL

Akshit Sharma[1], Pallav kansal[1], Saurabh Sharma[1], Rahul[1]

[1]*Student, EEE, Bharati Vidyapeeth College of Engineering, Delhi, India*

Abstract

A wireless power transmission using microwave is a system which consists of a, microwave generator, microwave transmitter (magnetron) and microwave receiver (rectenna). As microwaves are electromagnetic waves, we can tap on to its energy and can directly fire a luminous object. We can also use an isolated inductor which can be charged using the energy of electromagnetic waves which can be converted into AC for various useful purposes. Many concepts, research papers, patents are available on wireless transmission of electricity but the commercial technologies are yet to be fabricated and implemented. The paper summarizes the possible way to get useful and practical results out of all research carried out so far.

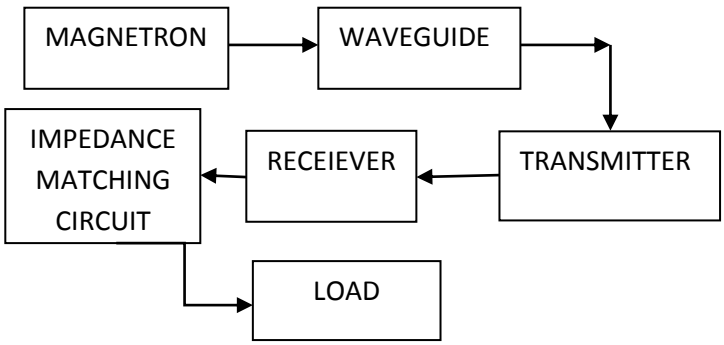
Key Words: *Wireless power transmission, microwave, magnetron, rectenna, metamaterial, Nikola tesla, Direct Convention voltage(DC).*

----------***----------

1. INTRODUCTION

Wireless Power Transmission (WPT), can be defined as the process that takes place in any system whereby electrical energy is transmitted from a power source (or radiator) to an electrical load without interconnecting wires. Wireless power transmission is employed in cases where instantaneous or continuous energy transfer is needed, but interconnecting wires are inconvenient, hazardous, costly, or impossible. The most common form of wireless power transmission is carried out using direct induction followed by resonant magnetic induction. Other methods under consideration include electromagnetic radiation in the form of microwaves or laser beam technology. The advent of low powered micro-controllers and sensors has created a huge industry for more powerful devices that consume a lot less power. This has encouraged the idea of wireless power transmission on another level. With lots of radio frequency energy all around us, from our cordless phones to the numerous mobile cell sites there has not been a better time to delve more into research on WPT. This has therefore motivated the design for more efficient rectenna circuits for use where low power sensors can be deployed. The idea for WPT was first given by Nikola Tesla. He discovered idea using radio waves more than a century ago. He attempted to distribute tens of thousands horsepower of electricity by radio waves. He said; "This energy will be collected all over the globe preferably in small amounts, ranging from a fraction of one to a few horsepower. One of its chief uses will be the illumination of isolated homes". He actually built a gigantic coil, which was connected to a 200-feet high mast with a ball 3 feet in diameter at its top. He fed 300 kW power to the Tesla coil, which resonated at 150 kHz. The RF potential at the top sphere reached 100 MV.

1.1 BLOCK DIAGRAM FOR WPT



As shown above is the circuit diagram of wireless transmission of electrical energy. An oscillator i.e. magnetron is used for generating microwaves i.e. electromagnetic waves at the frequency of 2.45 Ghz. As a

magnetron radiates wave radially we had to force channelize the microwave in one direction. For that we used a horn type antenna waveguide of 10db. The antenna acts as a transmitter that transmits the waves. At the other end a microstrip antenna was used which was fabricated and deigned for the frequency of 2.45 Ghz. To the antenna a rectifier circuit was connected for the impedance matching of 50Ω and for the conversion of ac power into dc power. The antenna was designed using a metamaterial. Metamaterial are those materials that are no present in the physical enviorment but are specifically designed or etched. The purpose of this is to give an artificial refractive index so that it can resonate at a particular frequency and can generate electrical pulses. The conversion efficiency of metamaterial is high than the conventional antenna used.
A single wafer has 38% of conversion efficiency

1.2 BLOCK DIAGRAM FOR TRANSMITTER

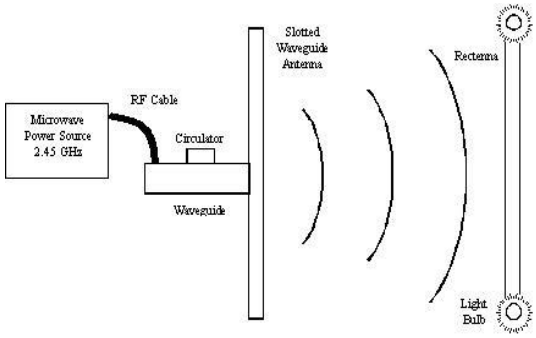


FIGURE-1 TRANSMITTER

As shown above the diagram or transmitting end. The direct system can be used for firing a bulb or a compact fluorescent lamp or any halogen lamp. With this technology even a fused light can be fired up directly. The microwave generator or the magnetron produces electromagnetic waves and we can tap on to its energy for firing up a light bulb. As for the bulb to glow , all we have to do is to excite the molecules present in the gas and then it can glow at any given frequency.

PHOTO-1: TRANSMITTER

1.3 BLOCK DIAGRAM FOR RECEIVER

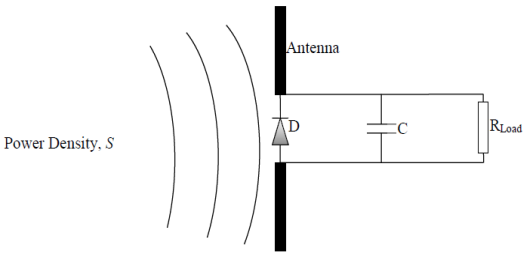


FIGURE-2: RECEIVER

The above diagram shows the block diagram of receiver circuit. It consist of an antenna which is connected to the diode and a capacitor so that the microwaves can be converted into Dc voltage.

2 COMPONENTS DISCRIPTION

2.1 TRANSMITTER CIRCUIT

2.1.1 MAGNETRON: Magnetron is a high powered vacuum tube device that is used as a oscillator for generation of microwaves at the frequency of 2.45 Ghz. It generates microwaves using interaction of electrons and magnetic fields.

2.1.2 WAVEGUIDE: Waveguide is a hollow metal structure that is used to guide sound waves or electromagnetic waves. There are different types of waveguide structure present in the market but we used horn type waveguide of 10db gain. The dimensions of the wave guide are received from pasternack.

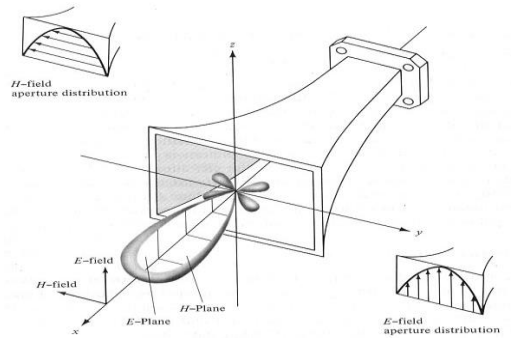
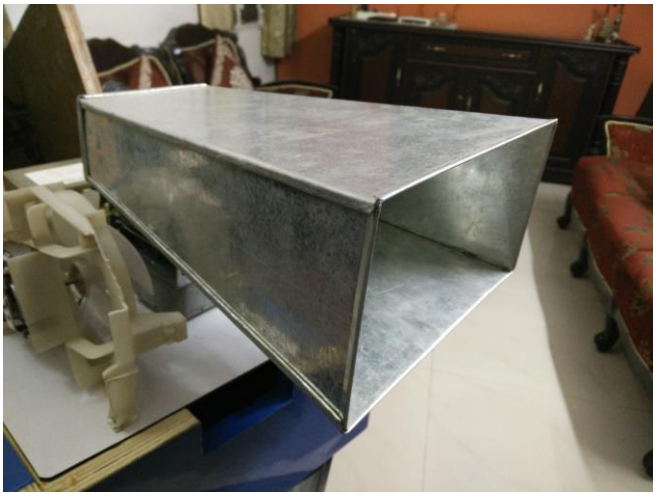


FIGURE-3: HORN ANTENNA



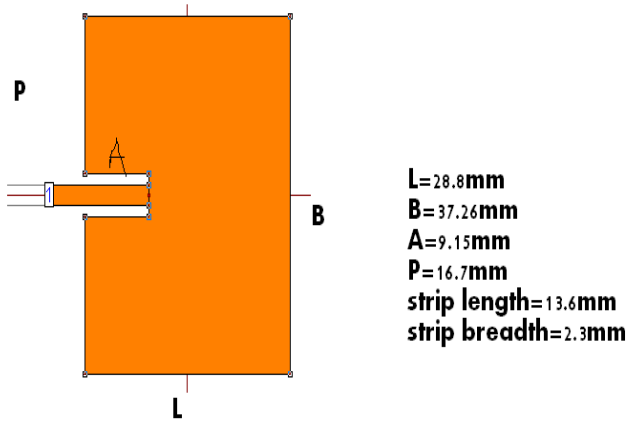
Through the setup we were able to transmit electrical energy to bulb at distance of 4 feet at efficiency of 60%. Different bulbs of different wattage were used at the different distances and different efficiencies were calculated.

It was found that the efficiency was maximum at the minimum distance and then it reduced as the distance increased.

Table -1: efficiency and wattage table

	Bulb 1-5 watt	Bulb-2 15 watt	Bulb-3 20 watt
Efficiency	60%	40%	30%
Distance in Meter	1.2192 meters	1.2912 meters	1.2912 meters

2.2 RECIEVER



The above figure shows our receiver that was used for receiving the direct microwaves at the frequency of 2.45 Ghz. This was kept in direct touch of microwaves through which electrical pulses were produced. These pulses were fed to our rectifier circuit and we got DC voltage in millivolts. This is a metamaterial and can be improved gradually.

2.3 RECTIFIER CIRCUIT

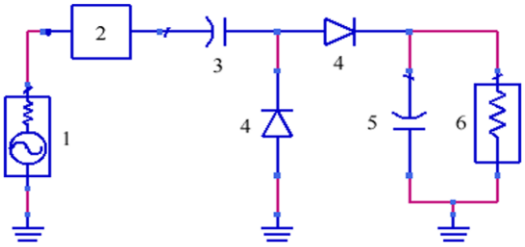


FIGURE-4: RECTIFIER CIRCUIT

The figure above shows the rectifier circuit that we used for conversion of power from microwaves in DC voltage.
The Greinacher voltage doubler is used tor boosting the output. This is formed by using RF schottky diodes 282x.
These are used as these have high switching frequencies and can provide high receivable of power for the frequency of 2.45 GHz. A smoothing capacitor is used for clearing out the ripples. A matching capacitor is used for matching the frequency at 2.45 Ghz. This value can be varied and this circuit can be used as an energy harvester for different frequencies. The conversion efficiency has been calculated according to

$$\eta = \frac{V2\ out}{Prf*Rload}$$

Where Vout is output DC voltage which was obtained by a Voltmeter paralleled with the load resistor.

3. CONCLUSIONS

In this work an efficient receiver has been presented which can be formed using a metamaterial. Experimental demonstration of the proposed topology has been conducted which led us to a result that this new technology is highly efficient and can be improved with time. The optimal input impedance matching for rectification was conducted efficiently by practical approach. The fabricated circuit was able to deliver maximum voltage of 3Volt of output voltage and at conversion efficiency of 60%

ACKNOWLEDGEMENTS

Acknowledgements go out to all those who have supported us in our journey to the unknown, to have come so far. It was rough and tough sometimes with hopes failing and strength draining, but the support of family and friends, has seen us through**.** I would like to acknowledge my supervisor, Mr. Bharat Singh for his unrelenting support and the direction for shaping my project and the research done on the project. I would like to acknowledge Mrs.Kusum Tharani for her unrelenting support and the direction my career has developed over a short time.

REFERENCES:

[1].http://scitation.aip.org/content/aip/journal/apl/103/16/10.1063/1.4824473

[2]. Avago Technologies, (2007), "Designing the virtual battery". Application Note 1088.
[3]. Avago Technologies, (2008), "Schottky Diode Voltage Doubler". Application Note 956-4.
[4]. Brown W. C., (1991) "An experimental low power density rectenna". IEEE MTT-S Digest,197-200.
[5]. Brown W.C., (1984) The History of Power Transmission by Radio Waves, volume MTT-32 no 9. IEEE Press.
[6]. Chang, K., (2000), "RF and Microwave Wireless Systems". John Wiley & Sons, Inc.
[7]. Curty, J., Declercq, M., Dehollain, C., Joehl, N., (2007), 'Wireless Power Transmission',
[8]. Design and Optimization of Passive UHF RFID Systems. Springer US. pp. 3-15.
[9]. Visser, H.J., (2009), "Approximate Antenna Analysis for CAD". John Wiley & Sons, Inc.
[10].Wikipedia,(2010),"PercentDifference" *http://en.wikipedia.org/wiki/Percent_difference*
[11]..https://www.newiching.com/blog/teslas-tower-of power/

BIOGRAPHIES

AKSHIT SHARMA: Akshit Sharma is a third year student of Bharati's Vidyapeeth College of Engineering, New delhi, pursuing electrical and electronics engineering. He is working on project based on wireless transmission of electrical power using microwaves and its efficient reception using a metamaterial. Recently he participated at student innovation exhibition, GRIDTECH organized by Power Grid corporation of India. His area of interest is Power system, Power electronics, Electrical machines, wireless power and renewable Energy. He is a RCU hobbyist.

PALLAV KANSAL: Pallav Kansal is a third year student of Bharati's vidyapeeth college of engineering, New delhi, pursuing electrical and electronics engineering. Further he is working on his project based on wireless transmission of electrical power using microwaves and its efficient reception with the help of metamaterial. Recently he participated at student innovation exhibition, GRIDTECH organized by Power Grid corporation of India.

SAURABH SHARMA: He is currently a second year student pursuing electrical and electronics engineering at Bharati Vidyapeeth college of Engineering, New delhi. Recently he participated at student innovation exhibition, GRIDTECH organized by Power Grid corporation of India. His area of interest include energy harvesting technologies, autonomous vehicles, and many other.

RAHUL: Rahul is a third year student of Bharati's Vidyapeeth college of engineering, New delhi, pursuing electrical and electronics engineering. He is working on project based on wireless transmission of electrical power using microwaves and its efficient reception using a meta material. Recently he participated at student innovation exhibition, GRIDTECH organized by Power grid corporation of India.