INTERNATIONAL JOURNAL OF ADVANCE RESEARCH, IDEAS AND INNOVATIONS IN TECHNOLOGY

ISSN: 2454-132X
Impact factor: 6.078
(Volume 6, Issue 3)
Available online at: www.ijariit.com

Wireless power transmission system using microwaves

Shashank Mohanty
shashank160798@gmail.com
Karunya Institute of Technology and Sciences (Deemed to be University), Coimbatore, Tamil Nadu

Deepak Kumar
deepak15303565@gmail.com
Karunya Institute of Technology and Sciences (Deemed to be University), Coimbatore, Tamil Nadu

ABSTRACT

It has become an important undeniable fact that power transmission be optimum and losses be decreased, and thus it is necessary to search out a new ways in which for power transmission which may be helpful to the industry, hence the need to use wireless systems is vital The transfer of power from source to receiver is a technology that has existed for over a century. Wireless power transfer (WPT) has been created possible in recent years thanks to advances in technology and higher implementations of transfer techniques, like Microwave Power Transfer (MPT). The MPT system works by converting power to microwaves through a microwave generator and then transmitted that power through free space wherever it is received and born-again back to power at a special device referred to as rectenna. The applications of MPT are numerous, not solely to alter the approach existing technologies work, however additionally as historical constructs for future constructs. Whereas the advantages are nice, there squared several measured limitations and drawn sides of MPT, necessitating the discussion of attainable strategies WPT. The transfer of power wirelessly has the potential to fully disrupt and revolutionize existing and future technologies.

Keywords— *Magnetron, Rectenna, Waveguide, Linear Regression, Near-Field Technique, Far-Field Technique, Boost Converter*

1. INTRODUCTION

One of the foremost heavy issue within the field of electric power grid are losses throughout the transmission and distribution of electric power. It is reported that percentage of loss during the transmission and distribution is around 26%. One of the main reason behind this problem is resistance of wire utilized by the grid. According to the report of World Resources Institute, (WRI), it states that, Indian electricity grid has the best transmission power and distribution power losses as compared to the opposite countries across the world. However any drawback are often corrected by the help of state-of-art-technology. Similarly, the above discussed problem can be rectified by an appropriate selection of a promising power transmission technique, which might offers higher potency with a less power loss and conjointly that provides low risk of energy thievery. The Microwave Power Transmission System (MPT), are often a promising technique of power transmission, which might act as an answer for the higher than above mentioned drawback. The main components of a standard microwave power transmission system (MPT) for this paper are, magnetron, waveguide, rectenna and an influenced power electronic device referred to as boost converter. Firstly, magnetron is a special sort of vacuum tube which produces microwaves at a frequency of 2.45 GHz. It needed a heating filament voltage of 3 volts (3V) and an anode voltage of 4 Kilo Volt (4KV) peak to produce microwaves. Then waveguide comes into an action, it is presupposed to guide this waves or offer a path to the current waves to the receiving antenna referred to as rectenna. An associate degree of rectenna is employed to convert this high frequency microwaves of 2.45 GHz into DC voltage through a dipole conductors and a schottky barrier diodes, that rectifies induced AC at dipole element to DC voltage. After that, boost converter plays an crucial role by stepping up voltage level to feed high voltage DC load. During this paper, power output an associated degree of rectenna was predicted as 0.527 Volts at a distance of 1.35 meters using simple regression method, and then stepped up by 5.385 V at a duty cycle of 0.9 by boost converter circuit to feed low power devices as an influenced power source.

2. MICROWAVE POWER TRANSMISSION

It is a budding technology within the field of wireless power transmission with having an extended vary of wireless power transmission as compared to alternative technologies like inductive coupling, resonant inductive coupling, capacitive coupling, magnetodynamic coupling etc. The biggest application of this technology is Solar Power Satellite, Fig.1 presents the block diagram of a standard Microwave Power Transmission system

2.1 Component of MPT

The core component of traditional microwave power transmission system are, Microwave Generator, Transmitting Antenna, and Receiving Antenna.

2.1.1 Microwave Generator: Magnetron could be a tool that is employed for microwave generation. It is a special type of vacuum tube that produces microwaves at a high frequency of 2.45 GHz. It needs a heating filament voltage of 3 V peak and an anode voltage of 4KV peak via high voltage transformer to produce microwaves.

2.1.2 Waveguide: It is a hollow aluminous tube with an oblong cross sectional area, that squared measure accountable responsible to produce a path or to guide the microwaves to the receiving antenna referred to as an array of rectenna with marginal loss of energy by proscribing the transmission of energy to a one direction that us, towards the rectenna placed at a distance to works as a Transmitting Antenna.

2.1.3 Rectenna: It is the core element of microwave power transmission system, the function of rectenna is to convert microwave radiation into direct current that is, DC voltage. The GaAs Schottky barrier diode is employed, because it offers 92.5 % efficiency with is way higher as compared to Si and GaAs severally, as shown in Table 2. And Dipole type rectenna is employed because it has potency of 85%, that is on the top of different modes of rectenna like circular patch, square patch and printed dual rhombic rectennas severally, as shown in Table 1.

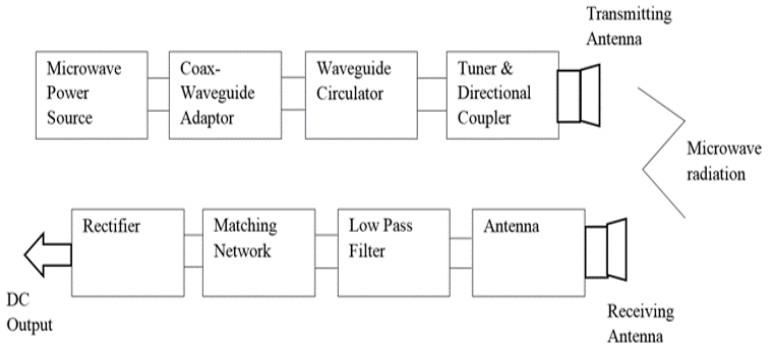

Fig. 1: Block Diagram of Microwave Power Transmission System

3. MICROWAVE GENERATION AND TRANSMISSION

Magnetron could be a special sort of a thermionic vacuum tube that produces microwaves at a high frequency of 2.45 GHz. It needs a heating filament voltage of around 3 V and an anode voltage of around 4 KV peak. The most parts needed for production of microwaves are magnetron, high voltage transformer, a high voltage condenser and a high voltage diode. The complete metal body of the magnetron is the anode. So, the anode is grounded in Microwave Power Transmission System (MPT). Ruther than swing a positive high voltage into anode, there is negative high voltage within the cathode anode is grounded. It is a directly heated cathode that states that the filament works as a cathode. High voltage condenser and high voltage diode are working as a voltage doubler for the magnetron, but it also works as electrical phenomenon pipet, limiting the current of magnetron. Because magnetron can't limit its current, the high voltage condenser is additionally within the resonance ways in which the transformer. So, it works as power factor correction by adjusting the zero crossing of output current and output voltage of secondary winding of step up transformer. The inductance of the transformer is in series with condenser, so the high voltage capacitor is not being rapidly discharged into the magnetron. Each cycle of the AC voltage at high voltage capacitor will be a sine wave, but of negative polarity with peak voltage of – 6 KV. It won't be loaded by the magnetron, however when some fraction of time the filament heats up and the voltage starts drawing current. The voltage drop a conventional magnetron is a fixed 4 KV peak, which means that the magnetron has more or less a constant voltage drop. Here the current switch is acting as a Zener or maybe a discharge lamp.

As the output current of the magnetron will be negative half cycle of sine wave, however the voltage is a lot or less a square wave. Which suggest that the voltage drop or free fall of voltage, of a magnetron doesn't depends on the current. It is not possible to increase the power output by employing a higher voltage; however, it is attainable to increase the power output by increasing the current. If current is increased, then the voltage drop is 4 KV and if the voltage is increased, then it will draw a crazy current. It will clamp with voltage drop of 4 KV at almost any current. So, if a high voltage capacitor is charged to more than 4 KV and discharge it into the magnetron, it will create an impulse with a very high power. So, the power will be generated and by the assistance of a hollow bimetal tube with an oblong cross sectional are referred as Rectangular Waveguide, it will be guided towards the receiving antenna called as Rectenna, with a borderline loss of energy by proscribing the transmission of energy to a one direction.

4. ELECTRICITY GENERATION

At the cutoff frequency of waveguide, this microwaves at 2.45 GHz were guided towards the receiving antenna, which is an array of rectenna. It is conjointly referred to as rectifying antenna, that may be a special mode of receiving antenna that is employed for converting microwave energy into electrical energy or DC electricity. A standard rectenna is consist of a dipole antenna together with an RF diode connected across the dipole elements. According to contents from Table 1, dipole type rectenna or doublet has a highest measured peak conversion efficiency with 85%. Similarly, according to the content from Table 2, Gallium arsenide (GaAs) Schokkty diode offers potency of92.5 % at 2.45 GHz of frequency. It has an electron mobility of 900 cm^2/ (V.S) at (300K) and has band gap of 1.441 eV (at 300K). Schottky diodes were used because they offer a lowest voltage drop, high speed and low power loss due to conduction and switching. So, the core operate of this mode of Schokky diode is to rectify, the alternating current or AC power elicited within the array of rectenna elements by the microwaves via magnetron circuit, to produce a direct current or DC power, which can be a power supply, for the boost converter for stepping up this DC power at a certain level of power as per the load demand.

The cutoff frequency for the rectangular waveguide is given as:

$$f_c = \frac{c}{\sqrt{\varepsilon_r \mu_r}} \sqrt{\left(\frac{m}{2a}\right)^2 + \left(\frac{n}{2b}\right)^2} \quad (1)$$

Where, c=Velocity of Light in Vacuum, ε_r=Relative Permittivity of Waveguide, μ_r=Relative Permeability of Waveguide, a=Waveguuide Width, b=Waveguide Height, m=Half-wave variations in the 'a' direction, n=Half-wave variations in the 'b' direction.

Table 1: Performance of Printed Rectenna

Rectenna Type	Operating Frequency (GHz)	Measured Peak Conversion Efficiency (%)
Printed dipole	2.45	85
Circular patch	2.45	81
Printed dual rhombic	5.6	78
Square patch	8.51	66

Table 2: Rectenna Efficiency for Various Diodes at Different Frequency

Frequency GHz	Schokky Diode	Measured Efficiency (%)	Calculated Efficiency (%)
2.45	GaAs-W	92.5	90.5
5.8	Si	82	78.3
8.51	GaAs	62.5	66.2

5. SIMPLE LINEAR REGRESSION

Simple linear regression is a linear regression model with a single explanatory variable. That is, it considerations two-dimensional sample points with one independent variable and one dependent variable (conventionally, the x and y coordinates in a vary coordinate system) and finds a linear orprate (a non-vertical straight line) that, as accurately as doable, predicts the dependent variable values as a operate of the independent variables. The adjective easy refers to the very fact that the result variable is said to one predictor.[1]

The simple linear regression model is given as

$$y = \beta_o + \beta_1 x + s \quad (2)$$

The prediction or estimate is given by Eq.3

$$\hat{y} = \hat{\beta}_o + \hat{\beta}_1 x \quad (3)$$

The least square approach finds the model parameters which minimize RSS is given by Eq.4

$$\hat{\beta}_1 = S_{xy}/S_{XX} = \sum_{i=1}^{n} (x_i - \bar{x})(y_i - \bar{y}) / \sum_{i=1}^{n} (x_i - \bar{x})^2 \quad (4)$$

5.1 Voltage prediction using Python

Simple linear regression using python programming was used to predict rectenna voltage level at a certain distance, using Python 3.7– Spyder IDE software. The dataset of rectenna voltage with respect to distance (in cm) is as follows in table 3. To predict voltage value at 69 cm and 130 cm respectively and to write down the regression coefficients and asses overall accuracy of the model.

Table 3: Data set of rectenna voltage with respect to the distance

S.no.	D(cm)	V(DC)
1.	63	1.434
2.	65	1.404
3.	76	0.987
4.	79	0.965
5.	83	0.89
6.	88	0.53
7.	97	0.527
8.	109	0.512
9.	121	0.451
10.	130	0.40

Predicted values are shown in table 4.

Table 4: Predicted Values

S.no.	Given_D(cm)	Predicted_V(DC)
1.	69	1.133
2.	135	0.421

The following graph was obtained.

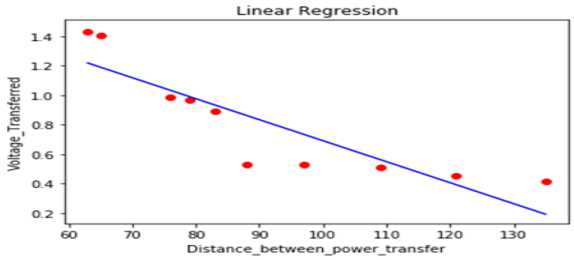

Fig. 2: Simple linear regression model for voltage prediction

Also, an R2 score of 80% was obtained. Which makes our model very accurate and highly sophisticated. Hence, Simple Linear Regression was performed to predict the rectenna voltages at different distances.

6. BOOST CONVERTER

It is an influence electronic circuit, that is employed to boost up the output voltage with relevancy the input equipped voltage to the convertor. In this microwave power transmission (MPT), boost convertor circuits is utilized to boost up the expected voltage of rectenna of 0.412 V at 0.35 meters to 5.385 V peak and 7.067 V average, to be a wireless power supply for electronic devices . Schematic diagram of boost convertor is shown in Fig.3 and Fig.4 shows up the output wave of boost convertor circuit. The stimulation boost convertor is performed by using called LTspice.

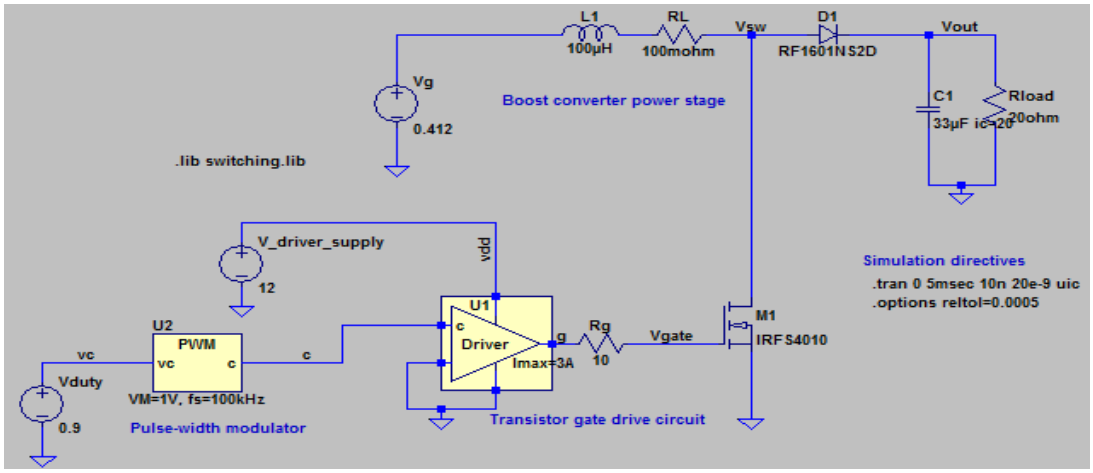

Fig. 3: Schematic diagram of boost converter

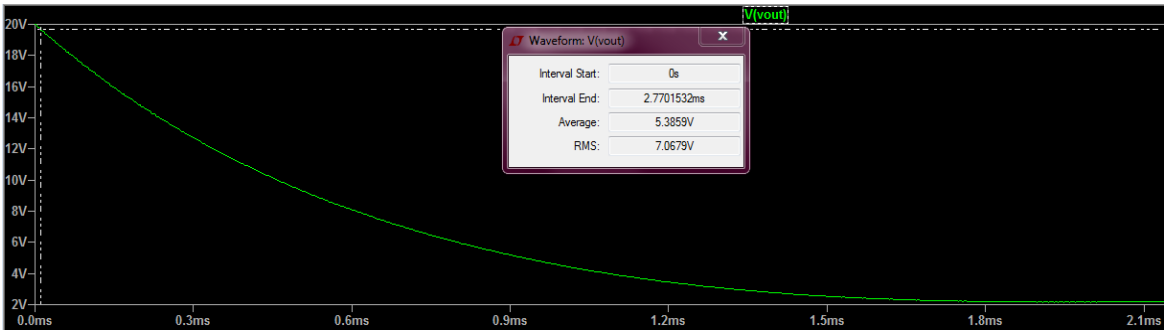

Fig. 4: Output waveform of boost converter

7. APPLICATIONS OF MPT

Generating power by putting golf shot satellites with giant star arrays in mounted Earth Orbit and causing the ability as microwaves to the planet referred to as solar energy Satellites (SPS) is the most important application of MPT. Another application of WPT is moving targets like fuel free airplanes, fuel free electrical vehicles, moving robots and fuel free rockets. The other applications of WPT are present Power supply (or) Wireless Power**.**

7.1 Field of Electronics

Electronics that is the biggest application field of exploitation Wireless charging system is being enforced in electronic products like portable computer by employing a wireless power supply deployed behind the corkboard. This device allows to deliver over 20 watts of power. It can even charge at a distance over a 40 cm from the wireless charging supply. The supply and device resonators are directed perpendicular to every different. Analysts expect that the advantages of charging over distance and with special freedom can lead to extremely resonant wireless power transfer capturing over 80% market share of all wireless charging systems by 2020. Mobile devices or smart phone that is capable to require charge from wireless charger is additionally good use of this technology. Within the same approach different devices like iPad or for camera charging in any time any moment even within the public places this wireless charging technology may be the best use for the humans. [2]

7.2 Electric Vehicle

Rechargeable hybrid and battery electric vehicles are often directly battery-powered with wireless charging systems. These systems deliver 3.3 kW at high potency over a distance of 20 cm. With victimization this technology, it permits the reliable and efficient of power transmission to electric vehicles while not the help of wires. Moreover, it is expected that wireless charging can immensely improve the charging expertise for EV owners, making such vehicles even more engaging to consumers.[3]

7.3 Far Field Energy Transfer

The far-field techniques are measuring the electrical load far from the power source. These techniques aim at high power transfer and wish line of sight. It can be separated into two categories, which are microwave power transmission and optical device referred as laser power transmission.[4]

7.4 Solar Power Satellites

It is the most application of MPT by victimization satellites with giant solar arrays and putting them in fixed Earth Orbit. These satellites play a polar role to generate and transmit the power as microwaves to the earth. Another application of MPT is Ubiquitous Power Source, Wireless sensors and RF Power Adaptive Rectifying Circuits (PARC).

8. CONCLUSION

The conception of Microwave Power transmission (MPT) is conferred. Microwave generation and transmission, electricity generation, rectenna voltage prediction mistreatment straight forward rectilinear regression model and boost convertor is mentioned. the anticipated rectenna voltage at 0.35 meter was expected as 0.421 V and stepped up to 5.385 V peak and 7.067 V average. Since, the array of rectnna was bit little, thus low voltage was generated at rectenna. however by having an oversized array of rectenna, Brobdingnagian voltage generation is feasible, to feed high voltage devices. one among the largest application of MPT system is “Solar Power Satellites”.

9. REFERENCES

[1] David A. Freedman(2009). Statistical Models: Theory and Practice. Cambridge University Press.

[2] Huang, H., and Castillo, E. (2012, May). Wireless interrogation of microwave transmission line for distributed sensing. In Millimeter Waves (GSMM), 2012 5th Global Symposium on (pp. 135-138). IEEE.

[3] Tseng, R.; von Novak, B.; Shevde, S.; Grajski, K.A., "Introduction to the alliance for wireless power loosely-coupled wireless power transfer system specification version 1.0," Wireless Power Transfer (WPT), 2013 IEEE, vol., no., pp.79,83, 15-16 May 2013

[4] Torkestani, S. S., Barbot, N., Sahuguede, S., Julien-Vergonjanne, A., and Cances, J. P. (2011, September). Performance and transmission power bound analysis for optical wireless based mobile healthcare applications. In Personal Indoor and Mobile Radio Communications (PIMRC), 2011 IEEE 22nd International Symposium on (pp. 2198- 2202). IEEE.

