Novel Technique for Wireless Power Transmission using ISM Band RF Energy Harvesting for Charging Application

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Abstract* — In current era everyone using the wireless technology according to wireless technology there is no need of wire connection, but still power transmission for low power device we are using wired device. As we know for every low power device continuous power supply is very important issue so there is need of wireless power transmission system. Through this system we can charge our battery by wireless power. Many researchers are performing several analyses about the energy harvesting circuit of wireless power system. In this paper, such approach was also performed, with radio frequencies used as input power of energy harvesting circuit low power devices. RF energy harvesting concept is not new but this system will not able to harvest a minute amount of energy which is not sufficient for low power devices. In this work, we present an new approach for generation of wireless energy using of ISM band (2.4GHz) with multiple stage of voltage multiplier. Advanced design system (ADS) simulator was used to design a multiple -stage voltage multiplier RF energy harvesting circuit Here our target distance is between 3-5m between transmitter and receiver antenna. We can also control the output voltage using of voltage regulator, according to connecting system we can set the certain range of voltage. In this work we are using Agilent HSMS-2860 Rf diode. The proposed system can be used to power low power devices like mobile, mp3 player, digital camera, laptop etc.

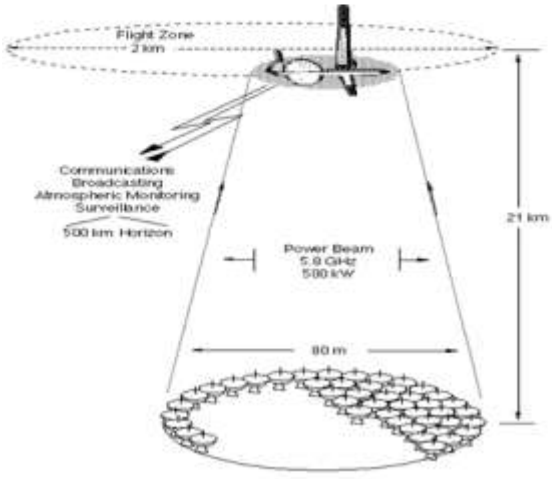
Keywords — *Conduction, Induction, IPT, WPT, WSN, Remotely.*

I. INTRODUCTION

The discussion of wireless power transmission as an alternative to transmission line power distribution started in the late 19th century. Both Heinrich Hertz and Nicolai Tesla theorized the possibility of wireless power transmission. Tesla demonstrated it in 1899 by powering fluorescent lamps 25 miles from the power source without using wires. Despite the novelty of Tesla's demonstration and his personal efforts to commercialize wireless power transmission, he soon ran out of funding because it was much less expensive to lay copper than to build the equipment necessary to transmit power through radio waves.

"In 1982, Brown (Raytheon) and James F. Trimer (NASA) announced the development of a thin-film plastic rectenna using printed-circuit technology that weighed only one-tenth as much as any previous rectenna". This new, lighter weight rectenna led to the development of the Stationary High Altitude Relay Platform (SHARP). The purpose of the sharp program, as its name suggests, was to develop unmanned aircraft that would maintain a circular trajectory above a microwave antenna field for the purpose of relaying communications from various ground terminals. No commercial development past the prototype stage has been funded.

Despite these advances wireless power transmission has not been adopted for commercial use except for the sole exception of pacemakers and electric toothbrush rechargers. However, research is ongoing because of the many promising applications suited for wireless power transmission.



SHARP System

As we know there is two type of power Transmission is exist and those are:

- Wire power Transmission
- Wireless power Transmission

The driving force behind system design is the overall system efficiency. The most current research and proposals use microwaves as the frequency range of choice for transmission. As you can see from figure 3 that 54% efficiency is currently attainable and 76% is possible using current technology for microwave power transmission.

Lower frequency waves would be hard to direct because of their large wavelengths. For transmission efficiency the waves must be focused so that all the energy transmitted by the source is incident on the wave collection device. There is a lot of practical experience with directional propagation of microwaves from the communications industry. Higher frequencies are also impractical because of the high cost of transmitters and the relative low efficiency of current optical and infrared devices. Bare in mind that when I talk of low efficiency I am speaking of low efficiency in energy transfer, not intelligence transfer. The fact that there is a lot of practical experience with microwave technology also makes it cheaper to produce instruments associated with microwave transmission and reception.

Wireless power transmission system so again this system is divide in three sub part those are like:

- Electromagnetic
- Induction
- Magnetic

Again each sub part is devide in there sub part which are like:

- Microwave
- Laser
- Capacitive
- Resonant
- Inductive

This division of wireless power transmission system is show in fig. 1.1, this figure give the details about the classification of WPT system

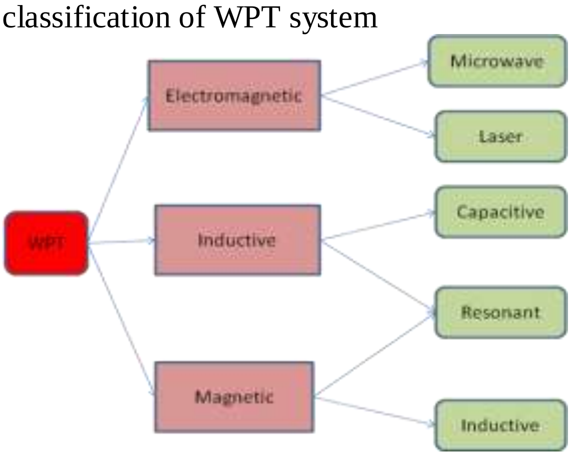


Fig.1.1 Division of wireless power transmission

According to This paper we provides the multiple exsisting techniques which is used for the wireless power transmisiion which aleardy we discuss previousaly. Wireless transmission is useful to power electrical devices in cases where interconnecting wires are inconvenient, hazardous, or are not possible. For example the life of WSN is its node which consists of several device controllers ,memory, sensors/actuators.

II. LITERATURE SURVEY

2.1 HISTORY

The literature review of WPT technologies will include the theoretical background and system concept. There are three basic methodologies to achieve wireless power transmission. They are longitudinal acoustic compression wave, inductive resonance coupling and electromagnetic propagation coupling. WPT by longitudinal acoustic compression wave was discontinued, therefore only a brief description is available as follows. The inductive resonance coupling and electromagnetic propagation coupling are modern methodology to achieve wireless power transmission. Both technologies will be described in detail latter.

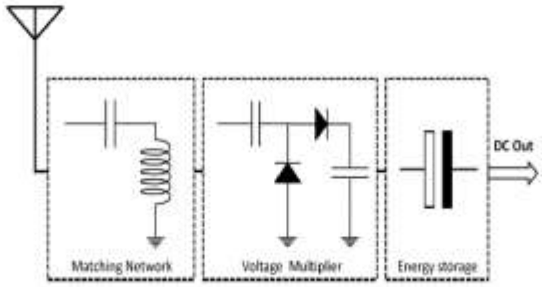
In 1826 André-Marie Ampère developed Ampère's circuital law showing that electric current produces a magnetic field. Michael Faraday developed Faraday's law of induction in 1831, describing the electromagnetic force induced in a conductor by a time-varying magnetic flux. In 1862 James Clerk Maxwell synthesized these and other observations, experiments and equations of electricity, magnetism and optics into a consistent theory, deriving Maxwell's equations. This set of partial differential equations forms the basis for modern electromagnetics, including the wireless transmission of electrical energy.[9] The capital cost for particle implementation of WPT seems very high WPT may cause interference with present communication systems.Biological ImpactsCommon beliefs fear the effect of microwave radiation.But the studies proven that the microwave radiation level would be never higher than the dose received while opening the microwave oven door,meaning it slightly higher.

2.2Tesla's experiment

Tesla demonstrating wireless power transmission in a lecture at Columbia College, New York, in 1891. The two metal sheets are connected to his Tesla coil oscillator, which applies a high radio frequency oscillating voltage. The oscillating electric field between the sheets ionizes the low pressure gas in the two long Geissler tubes he is holding, causing them to glow by fluorescence, similar to neon lights. Experiment in resonant inductive transfer by Tesla at Colorado Springs 1899. The coil is in resonance with Tesla's magnifying transmitter nearby, powering the light bulb at bottom. (right) Tesla's unsuccessful Wardenclyffe power station. Inventor Nikola Tesla performed the first experiments in wireless power transmission at the turn of the 20th century, and may have done more to popularize the idea than any other individual. In the period 1891 to 1904 he experimented with transmitting power by inductive and capacitive coupling using spark-excited radio frequency resonant transformers, now called Tesla coils, which generated high AC voltages. With these he was able to transmit power for short distances without wires. In demonstrations before the American Institute of Electrical Engineers and at the 1893 Columbian Exposition in Chicago he lit light bulbs from across a stage. He found he could increase the distance by using a receiving LC circuit tuned to resonance with the transmitter's LC circuit. using resonant inductive coupling. At his Colorado Springs laboratory during 1899–1900, by using voltages of the order of 10 megavolts generated by an enormous coil, he was able to light three incandescent lamps at a distance of about one hundred feet. The resonant inductive coupling which Tesla pioneered is now a familiar technology used throughout electronics and is currently being widely applied to short-range wireless power systems.[1][2] Here we presents some of the research on this area.

Energy harvesting:

Energy harvesting In the context of wireless power, energy harvesting, also called power harvesting or energy scavenging, is the conversion of ambient energy from the environment to electric power, mainly to power small autonomous wireless electronic devices.[6] The ambient energy may come from stray electric or magnetic fields or radio waves from nearby electrical equipment, light, thermal energy (heat), or kinetic energy such as vibration or motion of the device. Although the efficiency of conversion is usually low and the power gathered often minuscule (milliwatts or microwatts),[it can be adequate to run or recharge small micropower wireless devices such as remote sensors, which are proliferating in many fields. This new technology is being developed to eliminate the need for battery replacement or charging of such wireless devices, allowing them to operate completely autonomously.



Kavuri 2012[11] presents an optimization of the voltage doubler stages in an energy conversion module for Radio Frequency (RF) energy harvesting system at 900 MHz band. The function of the energy conversion module is to convert the (RF) signals into direct-current (DC) voltage at the given frequency band to power the low power devices/circuits. The de- sign is based on the Villard voltage doublers circuit. A 7 stage Schottky diode voltage doublers circuit is designed, modeled, simulated, fabricated and tested in this work.

Gianfranco[12] presntes an idea according to that designing, measuring and testing an antenna and rectifier circuit (RECTENNA) optimized for incoming signals of low power density. The rectenna is used to harvest electric energy from the RF signals that have been radiated by communication and broadcasting systems at ISM band centred in 2.45 GHz. Venkateswara 2013[13] present the concept of transmitting power without using wires i.e., transmitting power as microwaves from one place to another is in order to reduce the cost, transmission and distribution losses. This concept is known as Microwave Power transmission (MPT). They also discussed the technological developments in Wireless Power Transmission (WPT).

Allen[14] presents a design and experimental implementation of a power harvesting metamaterial. There proposed design is working in the frecquency of 900MHz.

Tamal[15] presents a simulated and designed 1,7 & 9-stage voltage multipliers which led to the final statements that :1) Higher voltage can be achieved by increasing the number of circuit stages; and 2) Voltage gain decreases with increasing number of stages. Zahriladha[16] presents an overview and the progress achieved in RF energy harvesting, which involves the integration of antenna with rectifying circuit. Different combinations of antenna and rectifier topologies yield diverse results. Therefore, this study is expected to give an indication on the appropriate techniques to develop an efficient RF energy harvesting system.

Nahida[17] presents an optimization of the voltage doublers stages in an energy conversion module for Radio Frequency (RF) energy harvesting system at 950 MHz band is presented.Two 10 stage voltage multipliers were designed and the Agilent diode HSMS-2850 and HSMS-2822 were compared, Agilent's HSMS-286x family of DC biased detector diodes have been designed and optimized for use from 915 MHz to 5.8 GHz.

Prusayon[18] presents a twofold contribution. First, they propose a dual-stage energy harvesting circuit composed of a seven-stage and ten-stage design, the former being more receptive in the low input power regions, while the latter is more suitable for higher power range. TARIS [19] presents a guideline to design and optimize a RF energy harvester operating in ISM Band at 902 MHz. The circuit is implemented on a standard FR4 board with commercially available off-the-shelf devices. The topology of the impedance transformation block is selected to reduce the losses which improves the overall performances of the system.

3. Problems In Previous Research

Wireless power transmission is new and progressive area. As we are living in the era of wireless communication. So there is need of wireless power transmission system. But previous existing wireless power transmission is have some limitations are problem. According to previous coil based magnetic induction is very dangerous for human life. But still with some good efficiency & modification there is some PAD based charger is available which is based on magnetic induction. But those charger have the limitation of distance. Now for complete wireless power transmission is under research area. Some researchers are present there model which is based on WPT (wireless power transmission) but those approach are having the issue with distance, efficient power generation, radiation issue & costing issue

4. Future Scope on WPT

As we already see there is lots of issues in previous existing approaches. So in this section we represents the future objectives those objectives are followings:

- Try to make sufficient amount of Distance.
- Try to make sufficient amount of Voltage.
- Try to make sufficient amount of Current.
- Try to reduce the costing of the design.

5. PROPOSED METHODOLOGY

In this paper we will propose a design which is based on 2.4GHz ISM Band. According to my design, 2.4 GHz RF Transmitter which is generate RF signal with some amount of power. Using transmission antenna that signal is transfer to receiver section. At receiver section receiver antenna is receive transmitted RF signal with some amount of power. Now that signal is passing through the impedance matching network.

This network will match the input and output voltage means input voltage on RF-DC is equal to receive voltage at antenna. Now in next step receive voltage is pass from multi stage of RF-DC which will generate sufficient amount of voltage at filter. Filter is combination of RC network. Generated voltage is very heavy so we have to use voltage regulator which will set output voltage at particular level. Finally regulated voltage is passing through voltage regulator & at last final generated output voltage is pass on Low power devices.

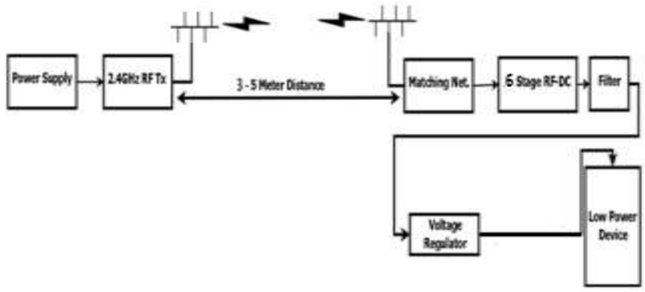


Fig. 4.1 Proposed Wireless Power Transmission System

So in this design we will create 6 stage systems where we create two. 3 stage of voltage multiplier than we will connect those 3 stage voltage multiplier to our impedance match circuit.

On both 3 stage circuit is connected with load circuit. At last both load is connected with final load which will generate final amount of voltage. Now this generated voltage is basically in terms of DC pulse so we are not able to apply those output voltage to any electronics system for that we have to convert those DC pulse into DC voltage which is converting by using of bridge circuit and filter. So in this propose work we design a new approach for wirless power transmission which require only 6 stage so our propose system is cheaper in cost as compare to previous existing approach.

For analysis point of view we are taking these parameters:

Scientific Parameters:

Here I will present the scientific output in followings:

1. Voltage
2. Current
3. Power
4. Number Of Stages (Voltage Doublers)
5. Distance Between Transmitter & Receiver
6. Cost

6. IMPLEMENTATION DETAILS

According to my proposed design when we create hardware system so the cost of that system will be less as compare to previous existing design. In this work I will try to reduce the number of voltage doublers stage & try to achieve a good distance between transmitter & receiver. Here I will present all simulation result which is based in Advance Design System Software**.**

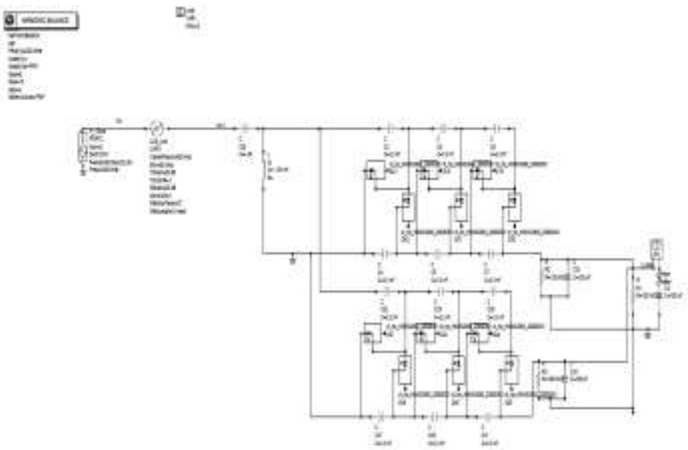
According to my propose design it is combination of 4 Steps:

1. Transmission Power Section
2. Transmission & Reception Section
3. Match Network
4. Voltage Multiplier
5. Load Circuit

Here for match network we are using these particular formula:

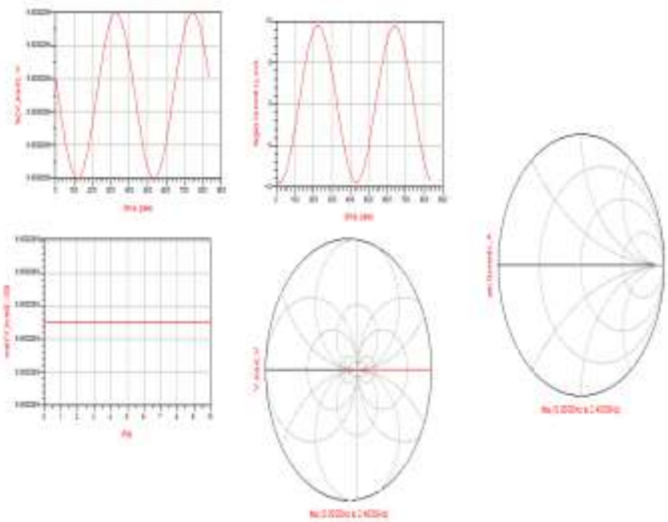
$$f = \frac{1}{2\pi\sqrt{LC}}$$

So here we will take value of L=1.125nH, C=4pF. Which is equivalent to our target frequency 2400 MHz.



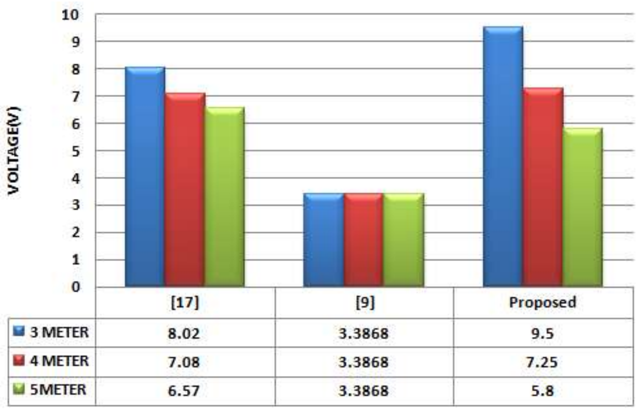
7. RESULT & ANALYSIS

In this paper we will do comparative analysis between previous existing approach and proposed approach. Here we will do comparative analysis for different-different distance range. Here we will show the comparative study in terms of Voltage, Current, Cost. Here we are using Advance design system for designing and analysis if our proposed design.



Voltage Level Analysis of Different Distance:

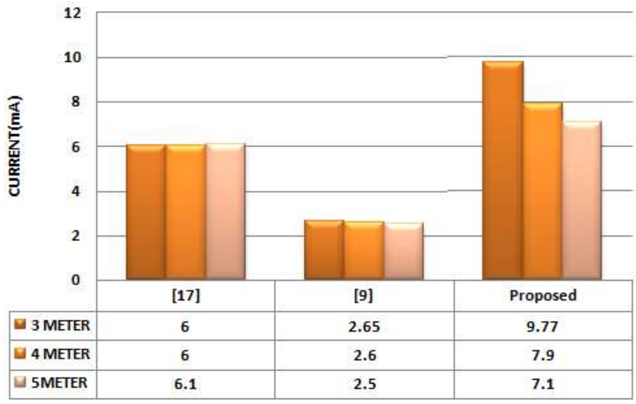
PARAMETER	[17]	[9]	Proposed
3 METER	8.02	3.3868	9.5
4 METER	7.08	3.3868	7.25
5METER	6.57	3.3868	5.8



As we can see our proposed design will give better improvement in terms of voltage level for different distance.

Current Level Analysis of Different Distance:

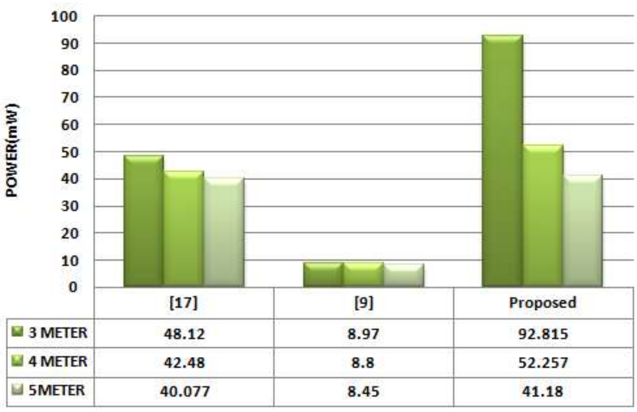
PARAMETER	[17]	[9]	Proposed
3 METER	6	2.65	9.77
4 METER	6	2.6	7.9
5METER	6.1	2.5	7.1



As we can see our proposed design will give better improvement in terms of current level for different distance.

Power Level Analysis of Different Distance:

PARAMETER	[17]	[9]	Proposed
3 METER	48.12	8.97	92.815
4 METER	42.48	8.8	52.257
5METER	40.077	8.45	41.18



As we can see our proposed design will give better improvement in terms of power level for different distance.

8. CONCLUSION

In this paper basically we design a system which is use for wireless power transmission. Our designed system is basically based on electromagnetic approach with operating frequency of 2400MHz. As we already save previous existing issues of electromagnetic approach, so here we resolve some of those issues like we resolve distance problem here we are easily to make more than 7V for 5 meter distance. Similar in our design cost is very less as compare to previous approach because in our approach we are using total 12 RF diode which lesser than previous existing approach. Here our system is working for 20dbi so its easy to make this type of design because total number of radiation is less because it will generate approach 100mW, which is not dangerous for human life.

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