Wireless Power Transmission using Magnetic Resonance

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Abstract - **With Electronics gadgets, appliances and products becoming a basic part of our life, their source of Power i.e. Electricity is always been a problem. Due to many reasons in country like India large percentage of population still don't have any access to electricity, due to which they can't even use electronic gadgets in their household activities. In this paper a new proposal has been made so as to provide electricity to electronic gadgets wirelessly i.e. without the use of wire. This is done with the help of Magnetic Resonance. In this paper I have investigated the need and usefulness of Wireless Power Transmission and the feasibility of using Magnetic Inductive coupling as the means of Wireless Power Transmission. This paper will outline the design process and will also tell about results that were observed with the help of simulating our setup in NI Multisim simulator. I have also discussed about repeaters that can be used to increase the range of transmission. These repeaters are made up of special kind of fiber material. With the above setup need for long and massy wire which is used to provide electricity to every individual will be eliminated. Also the transmission losses will be decreased to large extent. As a result large amount of electricity will be saved. And thus those who don't have access to electricity, even they can use it and it will make their life much better.**

Keywords—Wireless power transmission, Magnetic Resonance, Evanescent-wave coupling, Relaxation Oscillator.

I. LITERATURE SURVEY

Previous methods for wireless transmission include attempt by the late scientist Nikola Tesla and the Microwave Power Transmission. Both Tesla design and later microwave power were forms of radiative power transfer. Radiative power transfer used in wireless communication, is not suitable or feasible for power transmission due to its low efficiency and radiative loss because of its omnidirectional nature. There is also an alternative approach that exploited interaction between source and load, so that efficient power transfer was possible. The approach was evanescent wave coupling.

II. INTRODUCTION

Evanescent-wave coupling is basically identical to near field interaction in electromagnetic field theory. Electromagnetic induction works on the principal of primary coil generating a magnetic field and a secondary coil being within that field so a current is induced within its coil. This causes the relatively short range due to the amount of power needed to produce an electromagnetic field. Over larger distance this method is inefficient and wastes much of the transferred energy just to increase range. This is where resonance comes into picture and increases the efficiency drastically.

Theoretical analysis shows that by sending electromagnetic waves around in a highly angular waveguide, evanescent waves are produced which carry no energy. If a proper waveguide is brought near the transmitter, the evanescent can allow the energy to tunnel to the power drawing waveguide, where they can be rectified in DC power. Since the electromagnetic waves would tunnel, they would not propagate through the air to be absorbed or be dissipated, and would not disrupt electronics devices or cause any sort of injury or physical destruction.

III. DESGIN OF SYSTEM

Now a system is designed which can transmit power without using wires i.e. wirelessly. In which first of all we have designed a oscillator which would provide the carrier signal with which to transmit the power. Oscillators are not generally designed to deliver power, thus it was important to create a power amplifier to amplify the oscillating signal. The power amplifier would then transfer the output power to transmission coil. Next a receiver coil is constructed to receive the transmitted power. But the receiver power would have an Alternating current, which is not desirable for powering DC load. Thus we have to use rectifier to rectify the AC voltage to output a clean DC voltage. From where power will be transmitted to Load. In between Transmitter and Receiver coil repeaters can also be used in order to increase the distance between them.

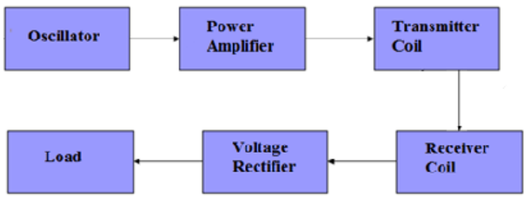

Fig. 1 Block diagram of Wireless system

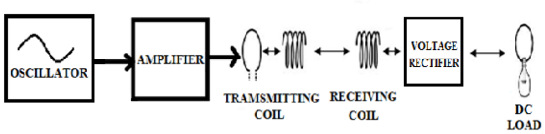

Fig.2 Block diagram of Wireless System

IV.OSCILLATOR

Oscillators are generally of two types, sinusoidal and relaxation. Op-amp sinusoidal oscillators operate with some combination of positive and negative feedback to drive the op-amp into unstable state, causing the output transition back and forth at a continuous rate. Relaxation op-amp oscillator operates with capacitor, a resistor or a current source to charge discharge the capacitor.

The oscillator design that we used was relaxation oscillator using a single operational amplifier. This oscillator was square wave generator and can be classified under astable multivibrator category.

A. Design

In this design of relaxation oscillator has been simulated as shown in Fig.3. Below, we used a high speed operational amplifier, AD828, which had very high frequency response. The operational amplifier was connected in Schmitt-trigger configuration with positive feedback through a resistor of 500 Ohms and a variable resistor of 1K. The inverting input of the op-amp with capacitor 20pF and resistor of 200 Ohms.

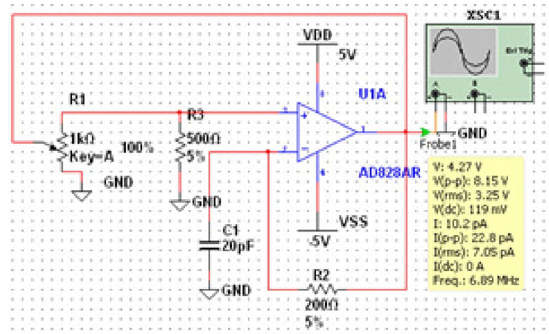

Fig.3 Circuit Diagram of Oscillator

B. Working Principle

Initially, the non-inverting input at the op-amp is biased at a voltage of V_{out} * R2 / (R1 + R2) and the op-amp output is saturated at that particular voltage level. Since the op-amp always attempt to keep both inverting and the non-inverting inputs, V_+ and V_- equal to each other, the feedback causes the 20pF capacitor to charge and make the value of V_- equal to V_+. When V_- reaches the value of V_+ , a switch to negative saturation at the output occurs and the capacitor begins to discharge. The charging and the discharging of the oscillator effectively causes oscillation signal to output.

The general equation for charging a capacitor is given by,

$$q= CV\,(1-e^{-t/RC}) + q_0e^{-t/RC}$$

In this case, V is $-V_{out}$ and if the voltage is V_+ is called as λVout, q_0 becomes CV_{out}.

The charging equation then becomes,

$$q= -CV_{out}\,(1-e^{-t/RC}) + \lambda CV_{out}\,e^{-t/RC}$$

When q gets to $-\lambda C_{Vout}$, another switch will occur. This time it is half the period of square wave. Therefore,

$$-\lambda CV_{out}= -CV_{out}\,(1- e^{-t/RC}) + \lambda CV_{out}\,e^{-t/RC}$$

Solving for T gives,

$$T = 2RC \ln [1+\lambda/1-\lambda], \text{ where } \lambda = R_2 /R_1+R_2$$

The frequency of Oscillation can be determined by 1/T.

B. *Results*

The waveform below shows the signal at the output from the Oscillator circuit that was simulated using NI Multisim software. The signal was very stable and free of any noise that may causes distortion. At different frequency ranges, the signal that we got was different.

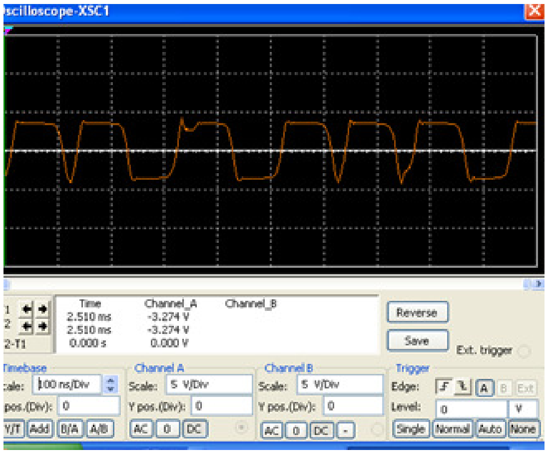

Fig.4 Waveform of Oscillator in frequency range between 16.89 MHz

At frequency ranges between 1 MHZ to 6.89 MHZ, the signal was a square wave.

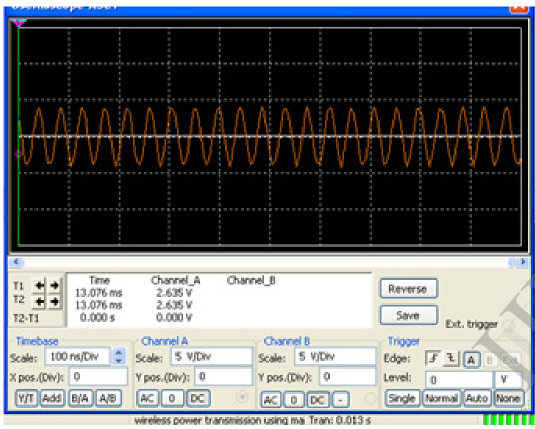

Fig.5 Waveform of Oscillator in frequency range between 7-22 MHz

In frequency range between 7 MHZ to 22 MHz the signal was a triangular in shape.

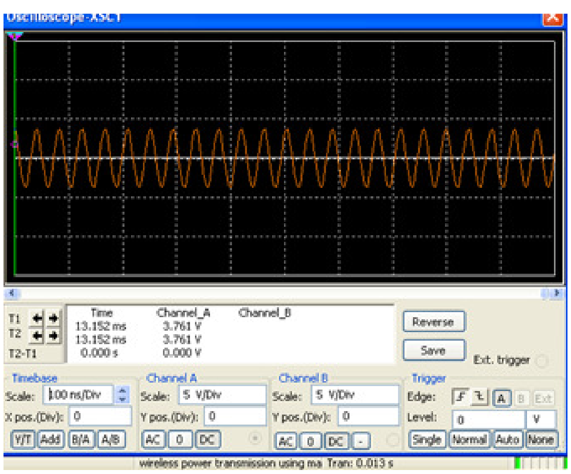

Fig.6 Waveform of Oscillator in frequency range between 22-30 MHz

And, as the frequency range increase the signal becomes triangular in shape. This shows and proves that as Frequency range increase the signal becomes more and more triangular in shape.

V. POWER AMPLIFIER

In order to generate the maximum flux which could induce the largest voltage receiving coil, a large amount to current must be transferred into the transmitting coil. The oscillator will not be able to supply this amount to current, so output from oscillator can be directly be passed through Power amplifier to amplify current. The most important aspect of using Power amplifier was to produce enough current. For this use we can use a simple switch-mode amplifier.

A. *Design*

The basic and main idea behind switch mode Power amplifier technology is to operate a MOSFET in saturation so that either voltage or current is switched on and off. Fig .7.below shows the power amplifier.

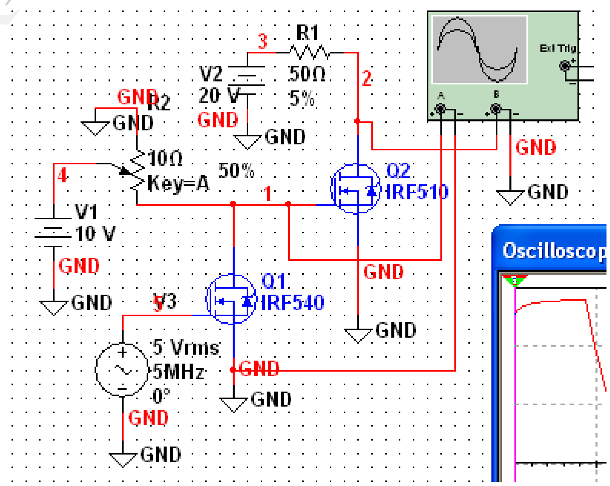

Fig. 7 Circuit Diagram of Power Amplifier

Our switched mode design consisted of a MOSFET IRF 510, which when turned on allowed large current from DC power supply to flow through resistor of 50 Ohms and through the transmitting antenna to transfer current from the power supply through the transmitting coil. The larger current from the transmitting coil was able to generate a large flux to induce a high voltage in receiving coil. The current and the voltage required to derive MOSFET IR 510 was supplied by IR 640.

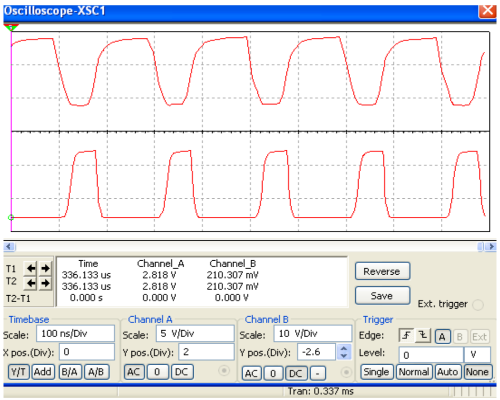

Fig.8 Waveform of Power Amplifier

VI. HARDWARE DESIGN

A. Transmitter and Receiver Coil

The transmitter and Receiver circuit is called as coupling circuit. It is the heart of entire system as the actual wireless power transmission takes place here. This circuit efficiency determines the amount of power available for receiver.

a. Design

The transmitter and Receiver coils that we can use have resonant frequency of 4.8 MHz – 5.3 MHz which could be tuned with our oscillator to get to resonant frequency of coils. The basic configuration of the design can be seen below.

Transmitting Coil	No of turns	10
	Diameter of each turn	60.32
	Diameter of copper tube	0.95 cm
Receiving Coil	No of turns	10
	Diameter of each turn	60.32
	Diameter of copper tube	0.95 cm
Transmitting Antenna	No of turns	1
	Diameter of each turn	56.1 cm
	Diameter of copper tube	0.23 cm
Receiving Antenna	No of turns	2
	Diameter of each turn	44.6 cm
	Diameter of copper tube	0.23 cm

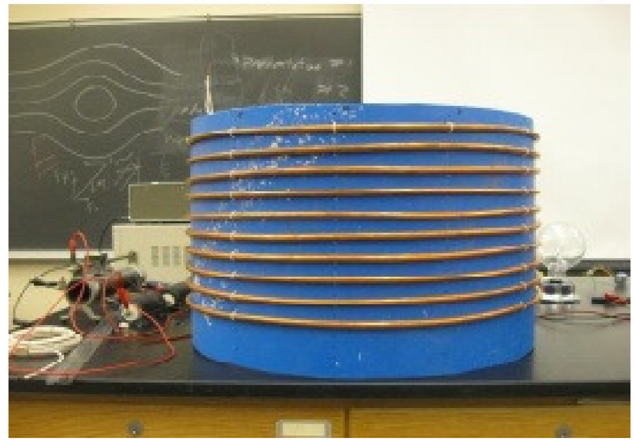

Fig.9 Transmitting coil

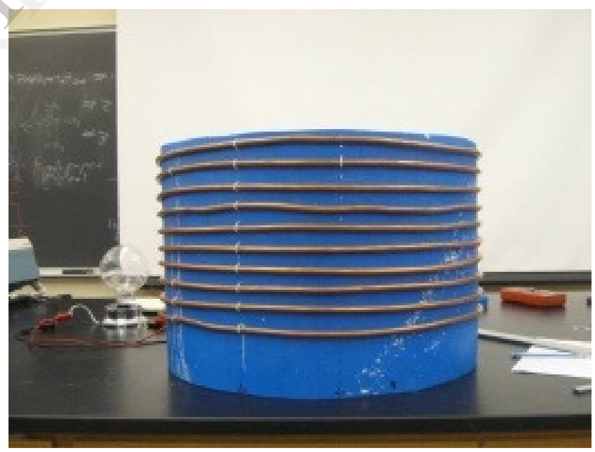

Fig.10 Receiving Coil

B. Repeaters

A Repeaters is a device that retransmit a received signal with more power and to extended geographical and topological network boundary than what would be capable with the original signal. These types of devices i.e. Repeaters are very helpful in Wireless Power Transmission as it will extend the length or area up to which we can transmit power without the use of wire. They are used in between Transmitting and Receiving coil.

C. Voltage Rectifier

A rectifier is also used to rectify AC Voltage received from the receiver coil to drive a DC load. A type of circuit that produces an output waveform that generates an output voltage which is purely DC is called as Full wave bridge rectifier. This type of single phase rectifier uses four individual rectifying diodes connected in a close loop "bridge" configuration to produce the desired output. The smoothing capacitor connected to the bridge circuit converts full-wave rippled output of the rectifier into a smooth DC output voltage.

IX. EXPERIMENTAL OBSEVATION AND ITS RESULTS

The coils that we can use in this systems had resonant frequency of 4.8 MHz to 5.3 MHz The oscillator that I simulated in NI Multisim Software gives square wave when frequency region is between 1 MHz-6.89 MHz .Moreover, the resultant waveform were free of distortion and noise. Thus, In between 1MHz to 6.89 MHz, the transmitting coil can be tuned very easily with Oscillator to get the resonant frequency of coils. And once the both the coil have reached to their resonance frequency, the power transmission between them will take place. Also, as the distance between them will increase the amount of power reached to the receiver coil will also decrease. This shows that there will be exponential decay in voltage as an increase in distance between transmitter and receiver coil. In that case we can use repeaters to transmit power for long distance depending upon strength of repeaters.

X. CONCLUSION

At the end of this paper, I was able to design a system through simulation in NI Multisim software for transmitting power wirelessly from transmitting coil to receiving coil. I also conclude that if the frequency range is between 1MHz to 6.89 MHz power transmission will be take place. But, ideally 4.8 MHz to 5.3 MHz is the range where power transmission will be most efficient. I was also able to simulate relaxation oscillator, switch mode power amplifier and a full bridge voltage rectifier for the system. The nature of waves at different frequencies at every level of the system was also studied.

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