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REVIEW ARTICLE

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WIRELESS POWER TRANSMISSION AND MEASUREMENT

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ABSTRACT

In this paper, we present the concept of transmitting power without using wires i.e. transmitting power as Magnetic waves from one place to another is in order to reduce the transmission and distribution losses. This concept is known as Inductive Coupling (IC). And also we measure the transmitted power using PIC Microcontroller board. We also discussed the technological developments in Wireless Power Transmission (WPT). The advantages and applications of WPT are also presented.

Keywords: Inductive Coupling (IC), PIC Microcontroller, Wireless Power Transmission (WPT)

I.INTRODUCTION

One of the major issue in power system is the losses occurs during the transmission and distribution of electrical power. As the demand increases day by day, the power generation increases and the power loss is also increased. The major amount of power loss occurs during transmission and distribution. The percentage of loss of power during transmission and distribution is approximated as 26%. The main reason for power loss during transmission and distribution is the resistance of wires used for grid. The efficiency of power transmission can be improved to certain level by using high strength composite over head conductors and underground cables that use high temperature super conductor. But, the transmission is still inefficient. According to the World Resources Institute (WRI), India's electricity grid has the highest transmission and distribution losses in the world – a whopping 27%. Numbers published by various Indian government agencies put that number at 30%, 40% and greater than 40% [1].

II. WIRELESS POWER TRANSMISSION

Nikola Tesla he is who invented radio and shown us he is indeed the "Father of Wireless". Nikola Tesla is the one who first conceived the idea Wireless Power Transmission and demonstrated "the transmission of electrical energy without wires" that depends upon electrical conductivity as early as 1891[2]. In 1893, Tesla demonstrated the illumination of vacuum bulbs without using wires for power transmission at the World Columbian Exposition in Chicago. The Wardenclyffe tower shown in Figure 1 was designed and constructed by Tesla mainly for wireless transmission of electrical power rather than telegraphy [3].

Figure1.The 187-foot Wardenclyffe Tower (Tesla Tower)

In 1904, an airship ship motor of 0.1 horsepower is driven by transmitting power through space from a distance of least 100 feet [4].

In 1961, Brown published the first paper proposing microwave energy for power transmission, and in 1964 he demonstrated a microwave-powered model helicopter that received all the power needed for flight from a microwave beam at 2.45 GHz [5] from the range of 2.4GHz – 2.5 GHz frequency band which is reserved for Industrial, Scientific, and Medical (ISM) applications. Experiments in power transmission without wires in the range of tens of kilowatts have been performed at Goldstone in California in 1975 [6] and at Grand Bassin on Reunion Island in 1997 [7] .

The world's first MPT experiment in the ionosphere called the MINIX (Microwave Ionosphere Non-linear Interaction Experiment) rocket experiment is demonstrated in 1983 at Japan [8]. Similarly, the world's first fuel free airplane powered by microwave energy from ground was reported in 1987 at Canada. This system is called SHARP (Stationary High – Altitude Relay Platform) [9].

In 2003, Dryden Flight Research Centre of NASA demonstrated a laser powered model airplane indoors. Japan proposed wireless charging of electric motor vehicles by Microwave Power Transmission in 2004. Power cast, a new company introduced wireless power transfer technology using RF energy at the 2007 Consumer Electronics Show [10].

A physics research group, led by Prof. Marin Soljacic, at the Massachusetts Institute of technology (MIT) demonstrated wireless powering of a 60W light bulb with 40% efficiency at a 2m (7ft) distance using two 60cm-diameter coils in 2007 [11].

MIT team experimentally demonstrates wireless power transfer, potentially useful for powering laptops, cell phones without any cords.

Imagine a future in which wireless power transfer is feasible: cell phones, household robots, mp3 players, laptop computers and other portable electronics capable of charging themselves without ever being plugged in, freeing us from that final, ubiquitous power wire. Some of these devices might not even need their bulky batteries to operate.

A team from MIT's Department of Physics, Department of Electrical Engineering and Computer Science, and Institute for Soldier Nanotechnologies (ISN) has experimentally demonstrated an important step toward accomplishing this vision of the future. Realizing their recent theoretical prediction, they were able to light a 60W light bulb from a power source seven feet (more than two meters) away; there was no physical connection between the source and the appliance. The MIT team refers to its concept as "WiTricity" (as in wireless electricity). Sony Corporation in 2009 announced the development of a highly efficient wireless power transfer system that eliminates the use of power cables from electronic products such as television sets. Using this system, up to 60 Watts of electrical energy can be transferred over a distance of 50cm (at an efficiency of approximately 80%, approximately 60% including rectifier) [8].

This new wireless power transfer system incorporates a form of contactless electrical energy transmission technology based on magnetic resonance. With magnetic resonance, electromagnetic energy is only transferred to recipient devices that share the identical resonant frequencies as the energy source, so energy transfer efficiency is maintained, even when misalignment occurs. Furthermore, even if there are metal objects located between the transmitter and receiver, no heat induction occurs. With the growth in networked products, the number of cables used to connect these products has also increased. While data cables are rapidly being replaced with wireless communication systems such as Wi-Fi, the demand for wireless power transfer systems is also continuing to grow. Sony will proceed with its efforts to develop further technologies that meet customer needs for the wireless transfer of power across a wide range of products, distances and energy levels.

III. DESIGN AND IMPLEMENTATION

The block diagram for the overall wireless power transceiver is given in the following figure

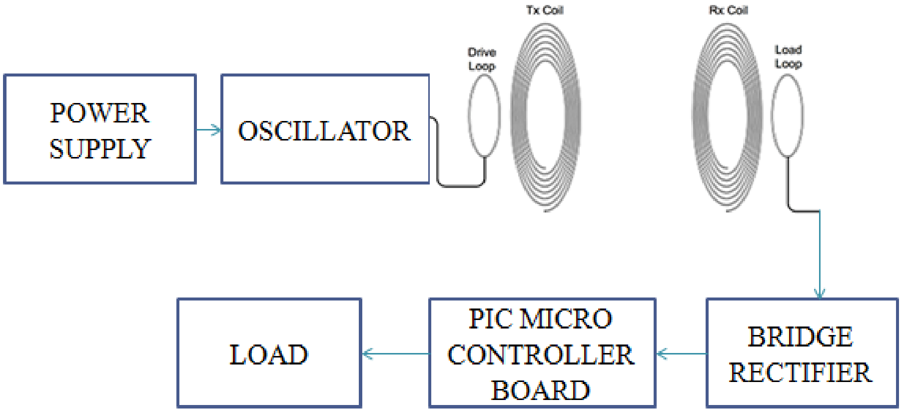

Figure2. Block Diagram of Wireless Power Transmission system

A.POWER SUPPLY

The D.C. Power Source consists of a simple step down transformer and a rectifier circuit. The transformer steps down the voltage to a desired level and the rectifier circuit convert the A.C. voltage to D.C.

B.OSCILLATOR

The prototype oscillator Circuit designed for the project is a modified Royer oscillator (Figure 3). This oscillator circuit is incredibly simple yet a very powerful design. Very high oscillating current can be achieved with this circuit depending on the semiconductor used. Here high current is necessary to increase the strength of the magnetic field. Although Insulated Gate Bipolar Transistors (IGBT) is recommended for this type of oscillator, but IGBTs have limitations in high frequencies. Thus, a HEXFET Power MOSFET was used for its properties. The HEXFET is ultra-low on resistance and has an operating temperature of 175°C. It has an advanced process technology and is very fast in switching.

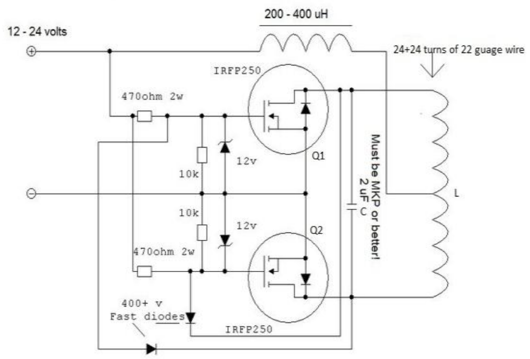

Figure3 oscillator circuit diagram

When power is applied, DC current flows through the two sides of the coil and to the transistors' drain. At the same time the voltage appears on both gates and starts to turn the transistors on. One transistor is invariably a little faster than the other and will turn on more. The added current flowing in that side of the coil does two things. One, it takes away drive from the other transistor. Two, the autotransformer action impresses a positive voltage on the conducting transistor, turning it hard on. The current would continue to increase until the coil (transformer) saturates. The resonating capacitor C causes the voltage across the primary to first rise and then fall in a standard sine wave pattern. Assuming that Q1 turned on first, the voltage at the drain of Q1's will be clamped to near ground while the voltage at Q2's drain rises to a peak and then falls as the tank formed by the capacitor and the coil primary oscillator through one half cycle. The oscillator runs at the frequency determined by the inductance of the coil, the capacitor value and to a lesser extent, the load applied to the secondary (Source coil). The operating frequency is the familiar formula for resonance,

$$F= 1/2 \times \pi \times \surd (LC)$$

C.TRANSMITTOR AND RECEIVER COILS

Transmitter and Receiver coils are of same frequency. For making a coil we need 22 gauges copper wire and turn it to 24 times with a radius of 2.5cm.

D.BRIDGE RECTIFIER

For the rectifying purpose the simple full wave bridge model is used just for the simplicity of the project. At the same time the capacitor is used for smoothing the output curve. The circuit diagram is given below.

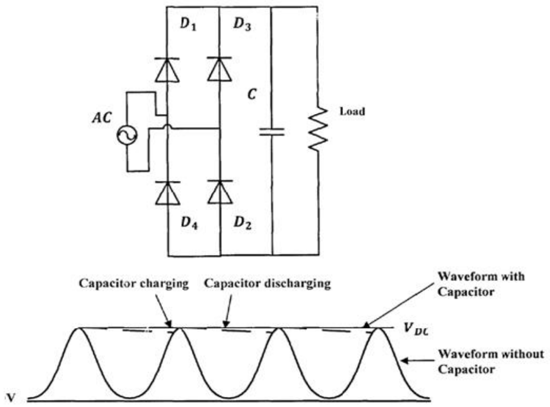

Figure4 Full wave bridge rectifier with smoothing capacitor

The main advantages of a full-wave bridge rectifier is that it has a smaller AC ripple value for a given load and a smaller reservoir or smoothing capacitor than an equivalent half-wave rectifier. Therefore, the fundamental frequency of the ripple voltage is twice that of the AC supply frequency (100Hz) where for the half-wave rectifier it is exactly equal to the supply frequency (50Hz).

E.PIC MICROCONTROLLER

For the measuring purpose we designed a digital power meter using PIC16F877A, the circuit diagram shown in figure 5.We can measure voltage, current and power at a time.

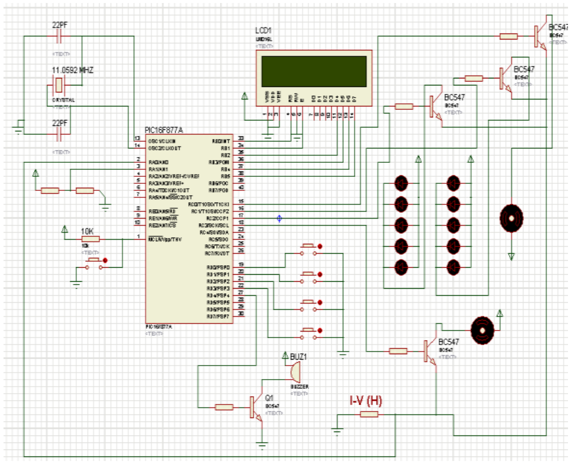

Figure5 Digital power meter using PIC16F877A

The advantage of PIC microcontroller is it gives accuracy value, less expensive, high performance, current sinking and sourcing is high and its has 5 input/output ports .

The signal from bridge rectifier is given to the PIC microcontroller PIC16F877A which has 40 pins and it has 5 input output ports and fifteen interrupts and its stability is maintained with a crystal oscillator circuit. This signal will be controlled by the PIC microcontroller and the status of the parameters of the signal is being informed with a help of an LCD display. The flow of operation of PIC microcontroller is shown in figure 6

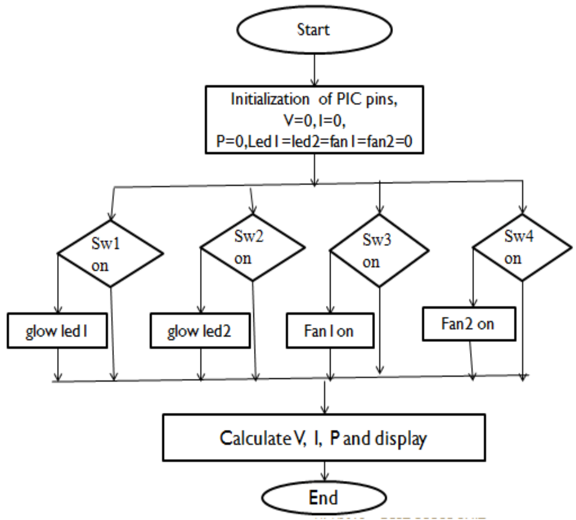

Figure6 Flowchart for operation of PIC microcontroller

IV RESULT

12 volts is applied to the transmitter, we were getting around 24 volts at the receiver end.

Table 1: Result of current by varying distance at receiver

Distance(cm)	Voltage (V)	Current(mA)	Power(mW)
10	12	3.7	44
5	18	15.2	273
0	24	21.9	526

V. ADVATAGES

1. Wireless Power Transmission system would completely eliminates the existing high-tension power transmission line cables, towers and sub stations between the generating station and consumers and facilitates the interconnection of electrical generation plants on a global scale.
2. It has more freedom of choice of both receiver and transmitters. Even mobile transmitters and receivers can be chosen for the WPT system.

3. The power could be transmitted to the places where the wired transmission is not possible. Loss of transmission is negligible level in the Wireless Power Transmission; therefore, the efficiency of this method is very much higher than the wired transmission.
4. Power is available at the rectenna as long as the WPT is operating. The power failure due to short circuit and fault on cables would never exist in the transmission and power theft would be not possible at all.

VI. APPLICATIONS

Wireless power transfer technology can be applied in a wide variety of applications and environments. The ability of our technology to transfer power safely, efficiently, and over distance can improve products by making them more convenient, reliable, and environmentally friendly. Wireless power transmission can be used to provide:

A. AUTOMATIC WIRELESS POWER CHARGING

When all the power a device needs is provided wirelessly, and no batteries are required. This mode is for a device that is always used within range of its Wireless power source. When a device with rechargeable batteries charges itself while still in use or at rest, without requiring a power cord or battery replacement. This mode is for a mobile device that may be used both in and out of range of its Wireless *power* source.

B. CONSUMER ELECTRONICS

i. Automatic wireless charging of mobile electronics (phones, laptops, game controllers, etc.) in home, car, office, Wi-Fi hotspots… while devices are in use and mobile.
ii. Direct wireless powering of stationary devices (flat screen TV's, digital picture frames, home theater accessories, wireless loud speakers, etc.) … eliminating expensive custom wiring, unsightly cables and wall wart power supplies.
iii. Direct wireless powering of desktop PC peripherals: wireless mouse, keyboard, printer, speakers, display, etc… eliminating disposable batteries and awkward cabling.

C. INDUSTRIAL

Direct wireless power and communication interconnections across rotating and moving joints (robots, packaging machinery, assembly machinery, machine tools) eliminating costly and failure prone wiring. Direct wireless power and communication interconnections at points of use in harsh environments (drilling, mining, underwater, etc.) where it is impractical or impossible to run wires. Direct wireless power for wireless sensors and actuators, eliminating the need for expensive power wiring or battery replacement and disposal.

D.TRANSPORTATION

Automatic wireless charging for existing electric vehicle classes: golf carts, industrial vehicles. Automatic wireless charging for future hybrid and all electric passenger and commercial vehicles, at home, in parking garages, at fleet depots, and at remote kiosks. .

E.OTHER APPLICATIONS

i. Direct wireless power interconnections and automatic wireless charging for implantable medical devices (ventricular assist devices, pacemaker, defibrillator, etc.).
ii. Automatic wireless charging and for high tech military systems (battery powered mobile devices, covert sensors, unmanned mobile robots and aircraft, etc.).
iii. Direct wireless powering and automatic wireless charging of smart cards.
iv. Direct wireless powering and automatic wireless charging of consumer appliances, mobile robots, etc.

VII. CONCLUSION

The goal of this project was to design and implement a wireless power transfer system via Inductive coupling. After analyzing the whole system step by step for optimization, a system was designed and implemented. Experimental results showed that significant improvements in terms of power-transfer efficiency have been achieved. Measured results are in good agreement with the theoretical models. It is described and demonstrated that magnetic resonant coupling can be used to deliver power wirelessly from a source coil to a load coil.

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