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Optimization of Contactless Energy Transfer System Adaptive to Changes in Coil Separation

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Abstract **- The presented paper has the concept of transmission of electrical power without the use of any kind of electrical conductors, cables or wires. The main aim of this research work is to give an clear view of recent researches and development in the field of wireless power transmission. This paper has also has history related to the WPT systems and also some of the intentional changes to wireless power transmission (WPT) in the history. The basic design for implementation of wireless power system has also been given. Many techniques are there in wireless power transmission like Inductive resonance, Capacitive resonance, Electromagnetic induction, inductive wave coupling, beam forming technique, Near field communication and microwave were discussed.**

Keywords: wireless power transmission, witricity, power, inductive resonance, resonance frequency.

I. INTRODUCTION

In the past years engineers and researchers have been facing a lot of problems and challenges involved in the power design systems. The main power supply continuity, recharging of batteries, optimizing and adopting of sensors, and dealing with rotating or moving joints in mechanical systems. Wireless Power Transmission from the time of Tesla has been an underdeveloped technology [1]. The wireless power system has invented from Tesla had always tried to introduce worldwide wireless power distribution system. But due to lack of funding and technology of that time, he was not able to complete the task. Then after this wireless power technology was not have developed up to a certain level which will be completely applicable for any practical purpose. Research has been in process on the recent developments that have been observed in this field of power transfer [2]. Despite of any technological advancement, the concept of wireless power transmission has not been adopted for commercial use.

II. THEORY

At that time, the concept of "field" was unavailable, and Faraday's goal was to show that the current can be caused by "magnetism." He worked on this problem intermittently for 10 years, until finally he succeeded in 1831. He wound two separate windings in an iron toroid and placed one galvanometer in one circuit and one battery in the other. When the battery circuit was closed, he noticed an instantaneous deviation of the galvanometer; a similar deviation in the opposite direction occurred when the battery was disconnected [3]. This, of course, was the first experiment he did with a changing magnetic field, and he followed him with a demonstration that a moving magnetic field or moving coil could also cause deflection of the galvanometer.

In terms of fields, we now say that a time-varying magnetic field creates an electromotive force "emf", which can establish a current in a suitable closed loop. Electromotive force is simply a voltage that arises from conductors moving in a magnetic field or changing magnetic fields, and we will define it in this section. The Faraday law is usually established as

$$\text{emf} = -d\phi/dt \qquad (1)$$

Equation (1) implies a closed path, although not necessarily a closed path of motion; A closed path, for example, can include a capacitor, or it can be a purely imaginary line in space [4]. A magnetic flux is a stream passing through any surface whose perimeter is a closed path, and $d\Phi$ / dt is the rate of change of this flow in time. A non-zero value of $d\Phi$ / dt can be the result of any of the following situations:

1. Variable flow in time associated with a stationary closed road.
2. Relative motion between closed paths with steady-state flux density.
3. The combination of two minus t minus indicates that the EMF is in such a direction that it creates a current whose flow, if added to the original stream, will reduce the magnitude of the EMF. This is a test of the statement that the induced stress will act to create the opposite flow, which is known as the Lenz law. If the trajectory of a closed loop should be considered as a thread conductor in N, this is often enough to accurately view the turns as a coincidence, and then allow the emf.

$$\text{emf} = -N \cdot d\phi/dt \qquad (2)$$

Where, Φ is now interpreted as a flow that passes through any of the N coincident paths [5]. We need to define emf, as used in (1) or (2). The EMF is obviously scalar and (perhaps not so obvious), a dimensional test shows that it is measured in volts. We define EMF as

$$\text{emf} = \oint \mathbf{E} \cdot d\mathbf{L} \qquad (3)$$

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and keeping this voltage is on a certain closed path. If any part of the route is changed, the logo usually changes. The deviation of the static results is clearly shown in (3), since the electric field strength resulting from the static load distribution must lead to zero potential difference along the closed path [6]. In electrostatics, the integral of the line leads to a potential difference; with variable fields in time, the result is an emf. or tension. Replacing in (1) the surface integral of B.

$$\text{emf} = \oint \mathbf{E} \cdot d\mathbf{L} = -d/dt \int_S \mathbf{B} \cdot d\mathbf{S} \qquad (4)$$

Where the fingers of the right hand indicate the direction of the closed road, and our thumb indicates the direction dS. The flux density B in the dS direction and increasing with time gives an average value of E, which is opposite to the positive direction around the closed path. The relationship between the integral of the surface and the integral of the closed straight line in (4) must always be taken into account when integrating fluxes and determining the emf. We divide our research into two parts, first we will find the contribution to the total fan created by the changing field within the stationary trajectory (transformer frame), and then we consider the trajectory of motion within a constant (mot or generator, fem). First we consider a stationary road [7]. The magnetic flux is the only variable quantity in time on the right-hand side of (4), and the partial derivative can be taken under the integral sign,

$$\text{emf} = \oint \mathbf{E} \cdot d\mathbf{L} = -\int_S \partial\mathbf{B}/\partial t \cdot d\,\mathbf{S} \qquad (5)$$

Before applying this simple result to an example, we get the point form of this integral equation. Applying the Stokes theorem to the integral of a closed line, we have

$$\text{emf} = \int_S (\nabla \times \mathbf{E}) \cdot d\mathbf{S} = -\int_S \partial\mathbf{B}/\partial t \cdot d\,\mathbf{S}$$

$$(\nabla \times \mathbf{E}) \cdot d\mathbf{S} = -\partial\mathbf{B}/\partial t \cdot d\,\mathbf{S}$$

$$\nabla \times \mathbf{E} = -\partial\mathbf{B}/\partial t \qquad (6)$$

Where, the surface integrals can be taken on identical surfaces. The surfaces are completely general and can be chosen as differentials.

III. CURRENT TECHNOLOGY IN THE FIELD OF WIRELESS POWER TRANSMISSION

This wireless power transmission is not a new concept. Nikola Tesla demonstrated the transmission of electrical energy without wires in the early nineteenth century. Tesla used electromagnetic induction system principle in 1964; William C Brown showed a model helicopter with microwaves. He gets all the power needed for flights from the microwave beam.

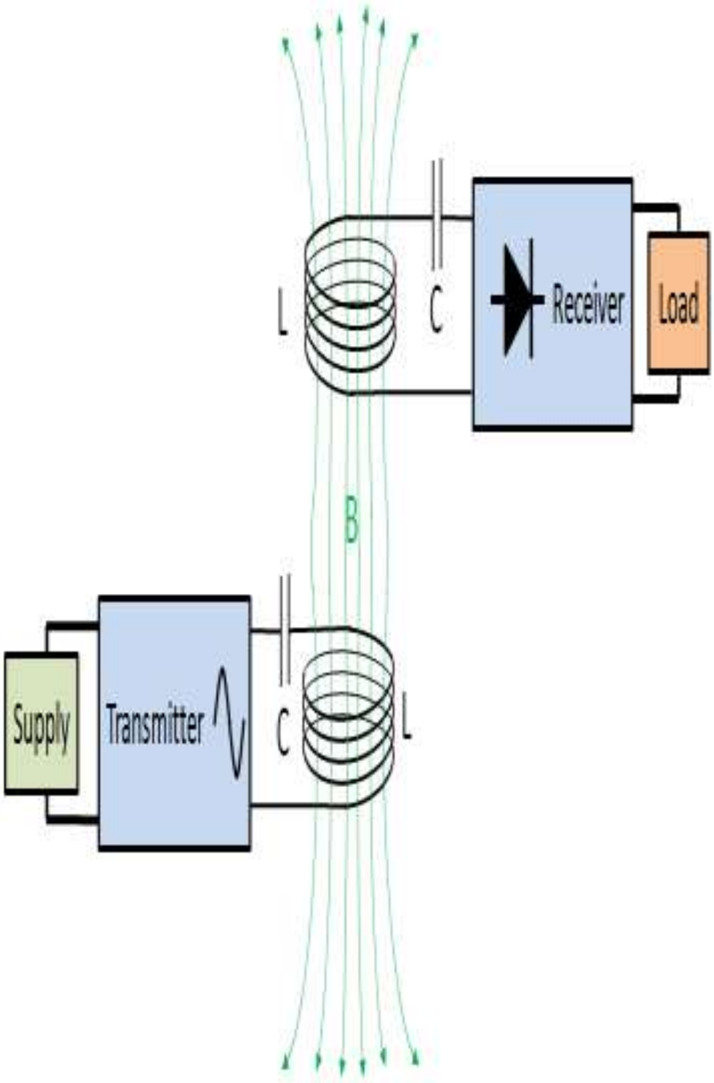

Figure-1: WPT coils (Transmitter and Receiver)

In 1975, Bill Brown transmitted 30 kW of power at a distance of 1 mile with an efficiency of 84% without the use of cables. Researchers have developed several methods for moving electricity over long distances without wires. Some exist only as theories or prototypes, but others are already in use. Consider the example in these rechargeable electrical devices without any plug-ins.

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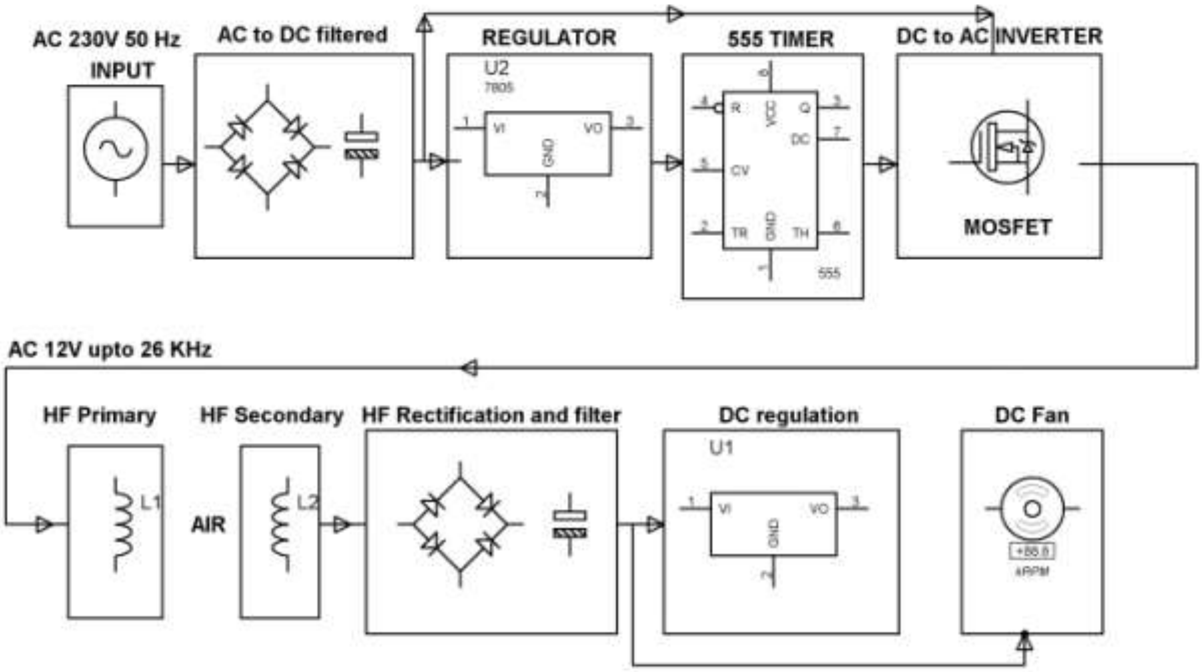

Figure-2: Block Diagram of Wireless power transfer system

A device that can be charged is placed in the charger. The power is supplied to the charger, and there is no electrical contact between the charger and the device. Previous schemes of wireless power transmission included the attempts of the late scientist Nikola Tesla and the transfer of microwave power. Both the design of Tesla, and the subsequent power of microwaves were forms of radiation transmission of power.

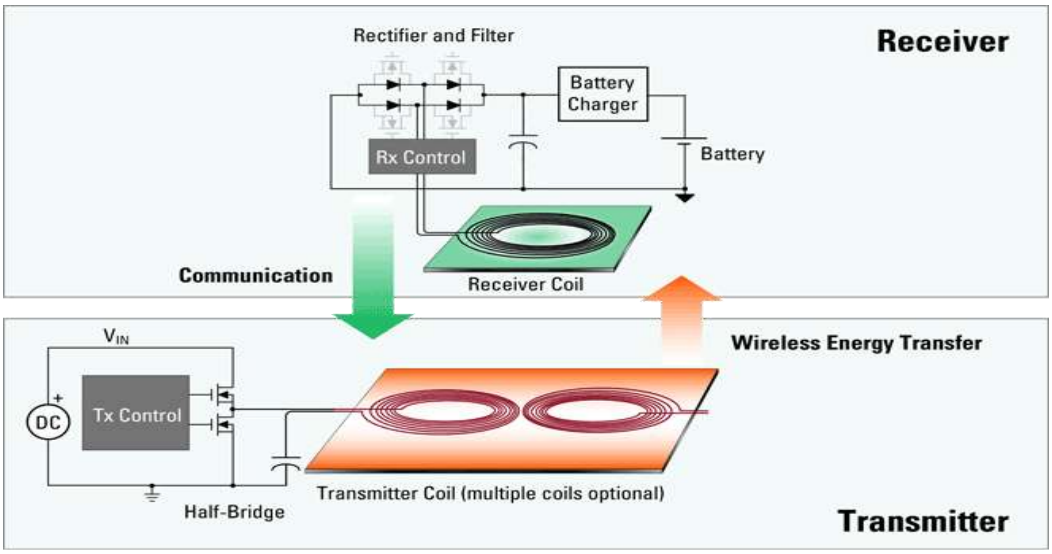

Figure-3: Block Diagram of reactive circuits with coils

One of the essential factors of an efficient wireless transmission system is the quality factor of the resonators. The quality factor (Q) is related to the internal loss rate (γ0) of the resonator at $Q = \omega/2\gamma_0$. We measure this own quality factor using the experimental configuration. We connect two voice coils with a vector network analyzer (VNA) and orient the coils to minimize the direct connection between them. Then we put them next to the resonator and measure transmission spectrum between these two probing coils. The quality factor is extracted from the form of the transmission spectrum line.

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This quality factor is intended for a resonator loaded with test coils. By increasing the distance between the voice coils and the resonator, we can reduce the coupling between the probing coils and the resonator. When we reach a point where an additional decrease in the coupling does not change the shape of the transmission line, we get an internal Q of the resonator.

We measure the efficiency of wireless power transmission. To illustrate the experimental configuration and to establish a reference for comparison, we first use this configuration to measure the power transfer between two resonators, as described in Section A, without metal plates. The separation between the resonators is the transmission distance. Two single loop loops that serve as input and output ports are connected to the VNA and placed next to the source and receiver resonator. The transmission spectrum is read directly from the VNA.

The transmission of radiation used in wireless communication is not particularly suitable for power transmission because of its low efficiency and the loss of radiation due to its omni-directional nature. The principle of evolutionary wave coupling expands the principle of electromagnetic induction. Electromagnetic induction operates on the principle of a primary winding, which generates mainly a magnetic field and a secondary coil within this field, so a current is induced in its coils. This results in a relatively short range due to the power required to create an electromagnetic field. At large distances, the non-resonance induction method is inefficient and takes up most of the energy transmitted only to increase the range. In this case, a resonance occurs and dramatically increases the efficiency of the "tunneling" of the magnetic field on the receiver coil, which resonates at the same frequency.

IV. RESULT AND DISCUSSION

This is the hardware design and controller of the proposed system. As we showed in the previous section, the resonant frequency and the quality factor of the resonator are affected by the environment. From the theory of coupled mode, it can be seen that the performance of the wireless power transmission system will also change. In particular, the proximity of the metal plate will greatly affect the energy transmission system.

The maximum transmission efficiency of the optimized wireless transmission system is 96% at a transmission distance of 60 cm. Now we place the aluminum plate at a distance of 20 cm from one of the resonators in the optimized system, ie, close enough to interact with the weak electric bands of the nearest resonator field. Since the distances between the plate and the two resonators are different, the frequencies of the resonance self-resonance vary in different ways and do not coincide anymore. the transmission efficiency will also decrease. Our transmission efficiency estimates confirm that the transmission efficiency decreases. The maximum transmission efficiency drops from 96% to 37%.

V. APPLICATIONS

This technology is already widely used to develop chargers for laptops, tablets, smart phones and similar devices. It is expected that it will enter the market in the second half of this year.

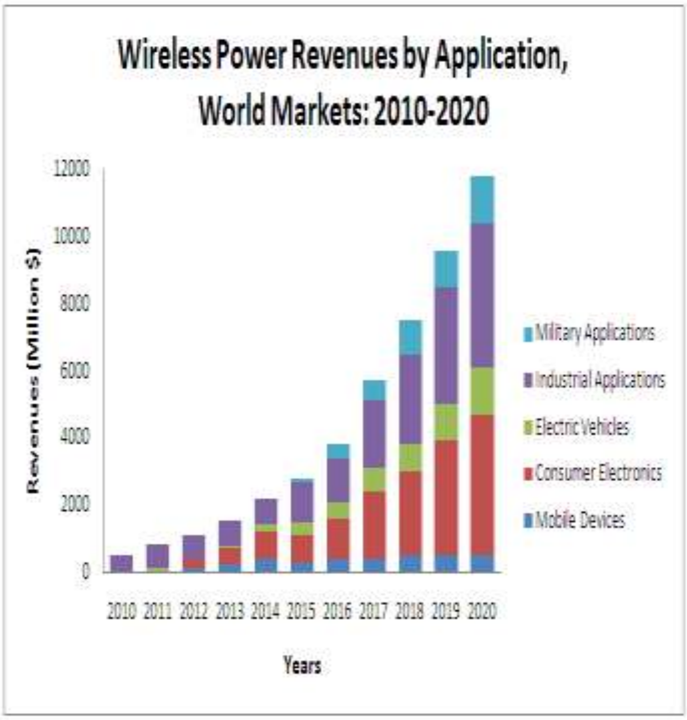

Figure-4: Wireless power revenues by application in world markets: 2010-2020

Many car companies cooperate with companies that are engaged in wireless energy transmission technology and get new boots inside their cars.

VI. CURRENT STATUS OF WIRELESS POWER

Industries are very interested in finding the latest wireless energy technologies to improve cost reduction, compatibility, versatility and eliminating the need to replace batteries. Power plants are interested in using WPT as a power source for sensors and converters. In the electronics industry, charging and wireless transmission proved that it is an excellent opportunity for contactless and in many cases non-contact charging for a wide range of devices, from mobile phones to electric vehicles and unmanned aerial vehicles.

Methods evolved to transfer tens of watts in tens of kilometers. There is an active and growing industry, such as General Motors and General Electric, as well as new companies such as Witricity, Power Cast, Pure Energy Solutions and Power Mat. The maturity of technology depends

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on the degree of commercialization of a particular technology. The WPT can be commercial, quasi-commercial and investigate. In WPT Commercial and near commercial they are in short ranges or a very short range. Electromagnetic induction is the technology of WPT available today.

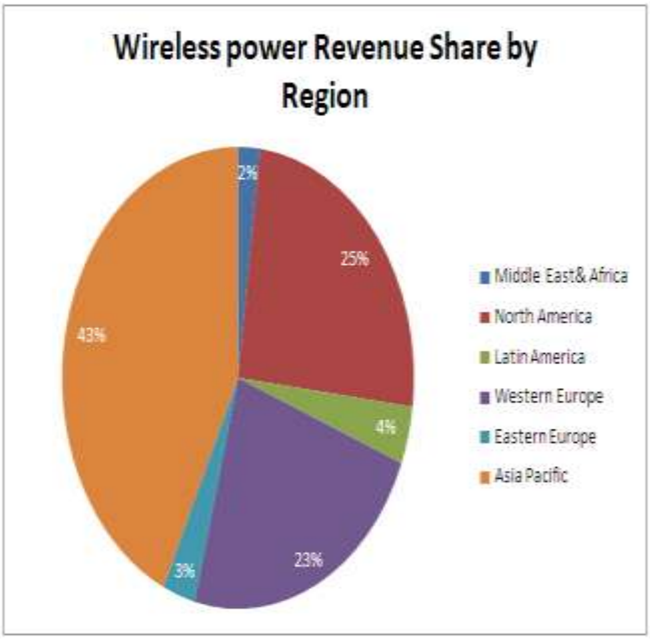

Figure-5: Wireless power revenue share by region

According to Pike's research, global revenues from wireless transmission and charging systems will reach $ 11.8 billion. The United States in 2020, and the aggregate growth rate (CGAR) will be 36%.

VII. CONCLUSION

The purpose of this research was the design and implementation of a wireless power transmission system through magnetic resonance coupling. Analyzing the whole system step by step for optimization, the system was developed and implemented. Experimental results have shown that significant improvements have been made in terms of energy transfer efficiency. The measured results are in good agreement with the theoretical models. He showed that a resonant circuit with an inductively coupled coupling can be used to supply AC power through the wireless network from the source coil to the load coil with intermediate coils located between the transmitter and the receiver with an inductor and capacitors at the coil terminals. This mechanism is potentially reliable and allows very efficient transmission of wireless power to the source coil receiver.

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