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Design of Tesla coil and its uses in Wireless Power Transmission (WPT)

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Abstract: This paper explores the current wireless power transmission schemes and their practicability. It also delves into theory, design and construction of a method to transmit power through space. To this end, the solid state Tesla coil configuration is used as the basis to generate high voltage, high frequency electrical power. Electrical power is crucial to modern systems. From the smallest of sensors and bionic implants to satellites, remote controlled airplanes/cars/robots and oil platforms, it is important to be able to deliver power by means other than wires or transmission lines. The use of wireless power transmission, on a scale larger than used by magnetic induction devices, would allow for systems to operate remotely without the need for relatively large energy storage devices or routine maintenance. It will also be employed in cases where interconnecting wires is inconvenient, hazardous or impossible such as in wet environments, rotating or moving joints as well as powering remote telecommunication equipment.

Keywords: WPT, Tesla coil, NST

I. INTRODUCTION

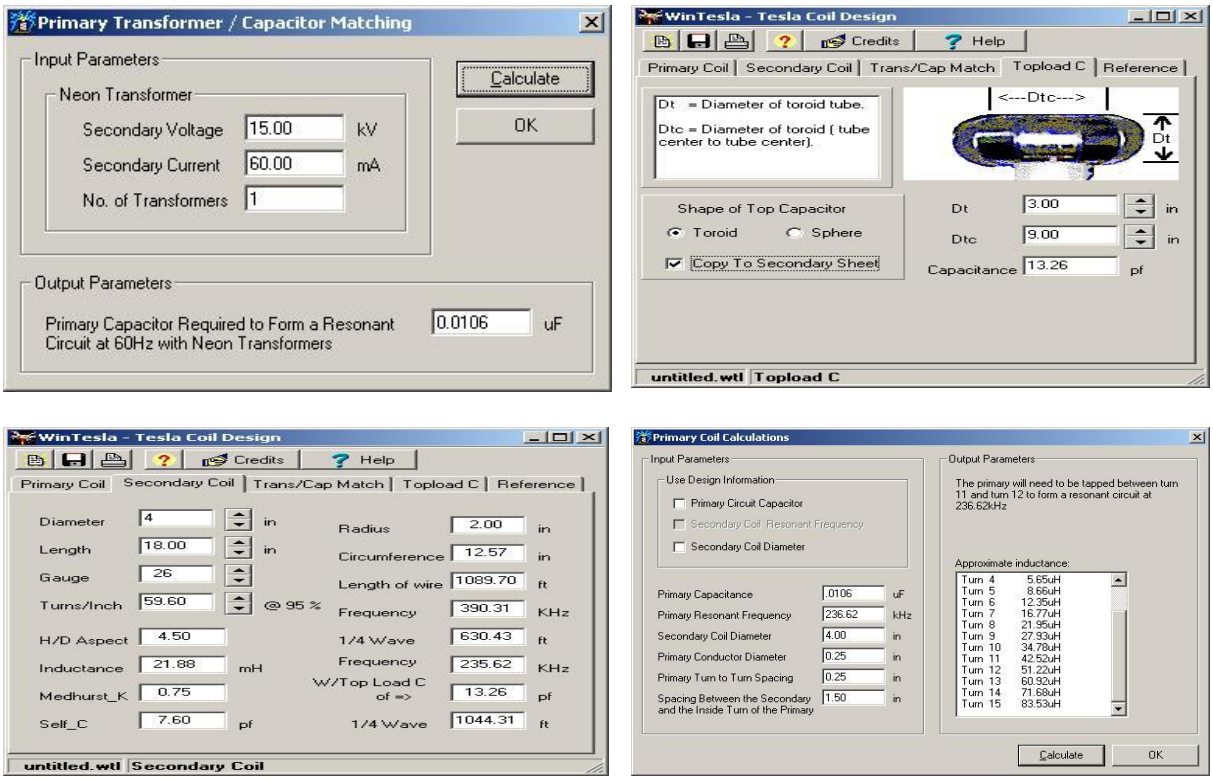
The idea of transmitting power through the space was conceived over a century ago, with Nikola Tesla's pioneering ideas and experiments perhaps being the most well-known early attempts to do so[1]. His vision was to wirelessly distribute power over large distances using the earth's ionosphere. Indeed, Tesla's pioneering work made extensive use of resonant induction, and many technologies available today (e.g., radio receivers, RFID tags, and cochlear implants) also rely on resonance, yet their efficiencies are not very good at mid-range distances. For the efficient power transfer, working in the strong-coupling regime is necessary, for which resonance is a precondition. [1] In this topic, we will discuss the theory of operation of Tesla coils in a general way. For the moment, let us introduce this short definition: "A Tesla coil is a device producing a high frequency current, at a very high voltage but of relatively small intensity". Basically, it works as a transformer and as a radio antenna, even if it differs radically from these. The largest application of the WPT is the production of power by placing satellites with giant solar arrays in Geosynchronous Earth Orbit and transmitting the power as microwaves to the earth known as Solar Power Satellites (SPS). WPT is used in moving targets like fuel-free-electric vehicles, fuel- free airplanes, fuel-free rockets and moving robots.

II. DESIGN OF TESLA COIL

Introduction: When I was in the process of designing my first tesla coil in my research work. I was hard pressed to find one source that comprehensibly described the process of designing a tesla coil from scratch. Although there were multitudes of awesome websites devoted to tesla coiling, it was extremely difficult to find one that had a step-by-step process that was easy to follow and to the point. There were very informative websites that contained a plethora of design equations, but with no logical description of how to use them properly when designing a tesla coil. There were also many sites that had beautifully built tesla coils on their site, but with not much background information as to the specifications and design of those coils. In this document, my goal is to present a very easy to use step-by step process to create a simple tesla coil from scratch. I will provide examples using readily available Tesla Cad software as well as simple equations to create and validate a tesla coil design.

Design Steps: The first thing we need to know is that a conventional tesla coil is Comprised of five basic fundamental items: High Voltage Transformer, Primary Capacitor Primary Coil , Secondary Coil , Toroid (Secondary Top Load) **Our Design:** As there are five basic fundamental components of a tesla coil, there are five basic fundamental design parameters: Output Characteristics of High Voltage Transformer ,Size and Dimensions of Primary Coil , Size of Primary Capacitor, Size and Dimensions of Secondary Coil , Size and Dimensions of Toroid (Secondary Top Load). Designing a tesla coil is all about having some of the five parameters above known and then designing the unknown parameters. So the more parameters we have upfront,

the less design we need to do. After rooting through the shed for some time, I have found the following materials: I was try to design a tesla coil of 900 w (15kv * 60mA) - 4" Diameter PVC Pipe - 15kV / 60mA Neon Sign Transformer (NST) - Spool of 26 AWG Magnet Wire.



Finalized Design : So there you have a complete tesla coil design. The following table lists the specifications for this particular tesla coil:

Requirement Specification

High Voltage Transformer - 15kV / 60mA NST, Primary Capacitor - 0.0106uF, 15kV MMC

Primary Coil Type Flat Pancake ,Primary Coil Conductor Diameter - 0.25"

Primary Coil Turn-to-turn Spacing - 0.25", Distance between Primary Inner Turn and Secondary - 1.50"

Total Number of Primary Turns - 15 Turns ,Calculated Primary Tap Point for Resonant Frequency - 11-12 Turns

Secondary Coil Diameter - 4.00" ,Secondary Coil Wire Gauge - 26 AWG

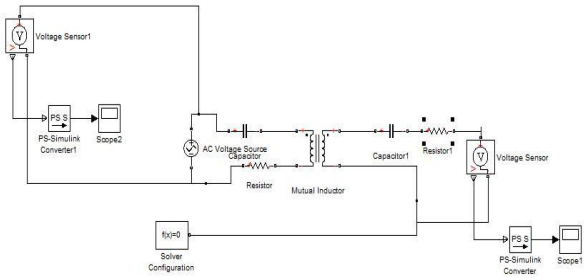
Secondary Coil Winding Length - 18.00" ,Secondary Coil Aspect Ratio (H/D) - 4:5 to 1

Toroid Dimensions - 12" x 3" ,Toroid Capacitance - 13.26pF, Resonant Frequency of Secondary w/ Toroid - 236.62kHz

III. SIMULATION AND EXPERIMENTAL RESULTS

we have studied and analyzed the tesla coil output voltage and find out the efficiency at different distance. We have try to make a Simulink model of a big tesla coil and a practical model of a mini tesla coil to study the output characteristics of the mini tesla coil. This analysis is done by using the simulation model in a mat lab software and also the done with the help of our mini tesla coil practical model. Our practical model contains a primary coil of 3 to 4 turns, a secondary coil of approx 300 turns, a 9v dc battery source, a npn

bipolar transistor 2N2222, a 22kohm resister and a led bulb. The **2N2222** is a common NPN bipolar junction transistor (BJT) used for general purpose low-power amplifying or switching applications. It is designed for low to medium current, low power, medium voltage, and can operate at moderately high speeds.



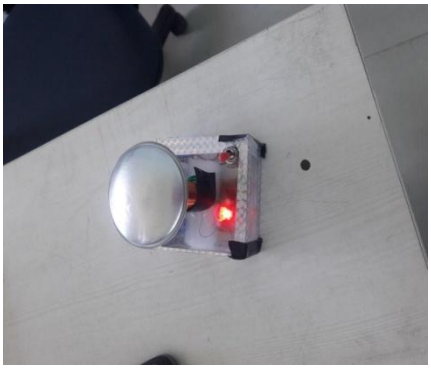
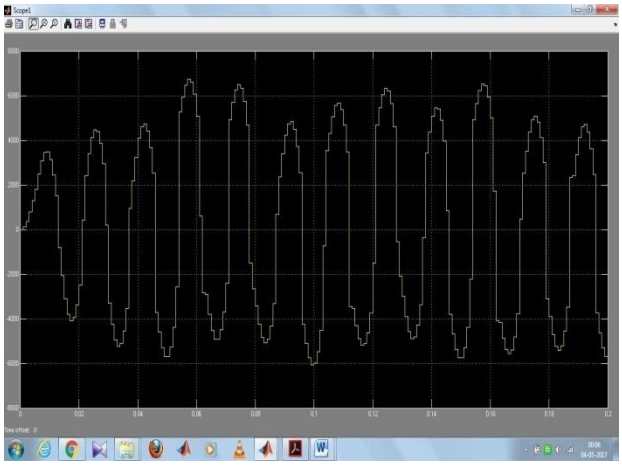


Fig.1.Simulation Model in MATLAB **Fig.2.Our Tesla model**

In our Simulink model we put the value of (these data we get from the tesla coil cad software) primary capacitance = 0.0127 microF, primary inductor = 78.85 microH, secondary capaticance = 12.40 picoF ,secondary inductor = 29.39miliH.



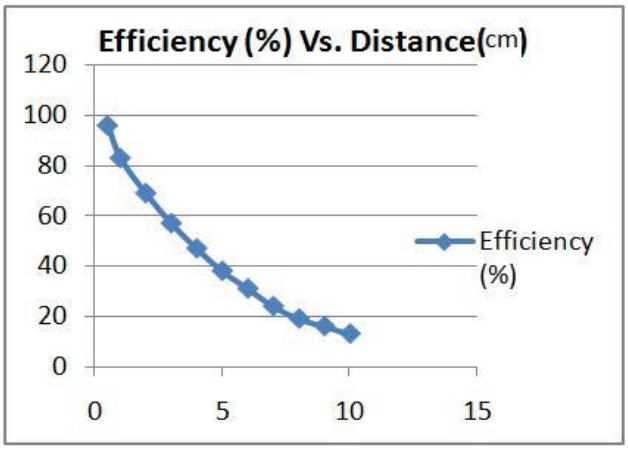


Fig .3. Output of tesla coil Fig .4. Efficiency-distance graph

We know that the voltage gain of tesla coil is Cp= 0.127microF, Cs = 12.40picoF ,Output voltage = 10.1kv Simulink model output = 7kv, So error in our design is 30.69%.

IV. CONCLUSION

In the present research work a Tesla coil is designed that works on mutual inductive coupling. In this work a Tesla coil is simulated as well as designed practically. For the simulation design of Tesla coil WIN TESLA AND TESLA COIL CAD SOFTWARE is used. The design was made in three steps. First of all a primary coil was made by taking the data such as conductor size of diameter 4□ and types of conducting coils(26 AWG). With the help of this inductance and capacitance value were determined. After this a secondary coil was designed by using the same procedure as that was used for primary coil design. Now a supply was needed for the primary coil for the purpose of charging it. Hence a high voltage was chosen for the supply from NST (Neon Sign Transformer). This chosen voltage supply was given to the primary coil. After getting fully charged the primary coil generated a spark and closed spark gap which was present in the primary circuit. In this way the primary circuit was completed, the transformer got insulated from the primary coil circuit and the remaining circuit started behaving as LC circuit. As the primary and secondary circuit was mutually connected, so a EMF induced in the secondary coil circuit due to mutual inductance between them. A high voltage is generated in the secondary circuit in the range of KV. The main spark gap present in secondary coil circuit closed, a circuit completed and supplied the power to the load wirelessly. Since now LC circuit were suppling

the power to the load, so the capacitor of secondary as well as primary coil circuit were discharging. As a result the spark gap of the primary coil circuit opened again and high voltage transformer again started charging the primary coil capacitor. A practical Tesla Coil circuit was also designed. The simulated tesla coil was of 900 w. Due to unavailability of resources practical design of 900 w Tesla Coil could not made, so a mini tesla coil of 5 w was designed and its operation was checked and it was found that the simulation result and practical result was well matched. In this way it was observed that the power can be transferred wirelessly due to high voltage generated by tesla coil because of mutual inductance

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REFERENCES

[1]. Fei Zhang, Steven A. Hackworth, Xiaoyu Liu, Haiyan Chen, Robert J. Sclabassi, and Mingui Sun, "Wireless Energy Transfer Platform for Medical Sensors and Implantable Devices", 31st Annual International Conference of the IEEE EMBS, Minneapolis, Minnesota, USA, September 2-6, 2009.

[2]. L.A. Bessonov Theoretical bases of electrical technology - M.:Vysh. shk., 1986 – 212 p.

[3]. S.G. Kalashnikov Electric Power -M.: Nayka, 1985. - 576 p.

[4]. K.A. Krug Electrical Technology Basis – M.-L.: Gos.energ.izdatelstvo, 1946. - 947 p.

[5]. N. Tesla Apparatus for transmission of electrical energy US Patent No. 649621/15.05.1900. - 17 p.

[6]. M. Denicolai, Report TKK-SJT-52, High Voltage Institute, Helsinki University of Technology, Helsinki, 2001

[7]. D.S. Strebkov, A.I. Nekrasov Resonance method of electric power transmission. GNU VNECKh M., 2006.-304 p.

[8]. J. Choi and C. Seo, "High-Efficiency Wireless Energy Transmission Using Magnetic Resonance Based On Metamaterial with Relative Permeability equal to -1", Progress in Electromagnetics Research, vol. 106, 33-47, 2010

[9]. Wireless Power May Cut the Cord for Plug-In Devices, Including Cars http://news.nationalgeographic.com/news/energy/2012/12/121228-wireless-power/,Date: 02/10/13 29

