



Design of Tesla Coil for Generation of Highvoltage

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ABSTRACT: The construction and design procedure for a high voltage generation Tesla Coil is presented in this paper. Here we can generate voltage in the range of 120KV-350KV from lower voltage of 230V and 50HZ frequency. Unlike a normal transformer Tesla coil uses air as its core and it is also known as doubly tuned resonant transformer. It produces high voltage at higher frequency and low current. It can be used for wireless electric power transmission.

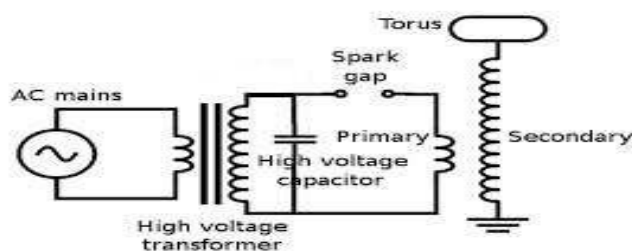
I. INTRODUCTION

Around 150 years ago, Nicola Tesla, a Serbian Scientist invented Tesla coil. It is experimented that it produces high voltage, low current and high frequency. Tesla coil uses air cores to operate at higher frequencies. Wireless power transmission uses an electromagnetic field at some frequency by which power is transmitted [1]. It employs AC power source, high voltage transformer, primary coil, secondary coil, capacitor, spark gap switch and toroid.

First level voltage step up will be done using Neon-Sign Transformer from 230-7.5Kv & 30mA. Then the voltage increment will be done using coil winding where primary will be connected to Neon Sign Transformer (NST) which will generate the electromagnetic field which will induce the voltage in secondary coil. Hence, it produces ozone gas and so it should be used in ventilated area and safety glasses should also be worn to protect eyes from exposure to spark gap [2].

Tesla coil used to conduct innovative experiments in electrical lightning, phosphorescence, X-ray , high frequency AC , electrotherapy and wireless transmission of electrical energy. Tesla coil circuits are mainly used in spark gap radio-transmitters for wireless telegraphy initially. The fundamental difference is that energy is converted to a spark instead of being propagated through a medium. When the coil produces arcs, it ionizes and heats the air which creates the periodic shift in the air pressure causes a sharp and powerful wave of sounds [5]. Nowadays they are mainly used in entertainment and educational display purpose. The small coils are used for detecting leaks for high vacuum system. In normal transformer, the output voltage depends upon the ratio of secondary and primary windings. But in Tesla transformer the output voltage does not depend on the winding, it is many times higher than that [7].

High DC voltages are mainly used in research work in the areas of applied physics. It is also used in insulation test on cables and capacitors. There are many methods for the generation of high voltage such as Flyback converter, Marx generator, Cockcroft Walton's Voltage multiplier and tesla coil.





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II. CIRCUIT DESCRIPTION AND OPERATION

The above figure shows the equivalent circuit of Tesla Coil. The high voltage transformer connected to AC mains, starts charging the capacitor and when the voltage exceeds the dielectric strength of air in the spark gap, the charge will flow through the air gap to the other side, connecting the capacitor to the primary coil. In primary coil the electrostatic energy transform to magnetic energy which induces the damped oscillation in the secondary coil. Then the high voltage is discharged from the top load (toroid).

Design and Construction:

1. Transformer: The Neon Sign Transformer has ratings of primary voltage 230V, secondary voltage 7500-0-7500V, volt-ampere ratings of 450VA at 50Hz and short circuit current of 30mA.

The maximum length of the spark can be found from the empirical formula from the output power of the transformer.



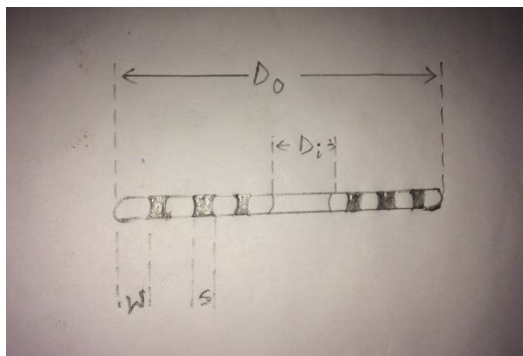
$$P = (L/1.7)^2$$

$$\text{or, } L = 1.7 \sqrt{P}$$

where, P = power (watts)

L = spark length

2. Primary Coil: To make a primary coil, we use 1/4 inch (6.35mm) diameter of copper plumbing tube. The wire spacing between the turns is also 1/4 inch.



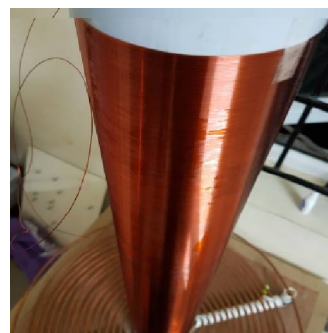
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To find inductance of flat spiral coil is given,
 $L = (N^2 * A^2) / (30A - 11Di)$

Power Range	Secondary Diameter
Less than 500w	3 to 4 inches
500w to 1500w	4 to 6 inches
1500w to 3 kw	6 to 10 inches



Where,

$$A = (Di + N(W + S)) / 2$$

Di = Inner diameter

N = No. of turns

W = Wire diameter

S = Turn spacing

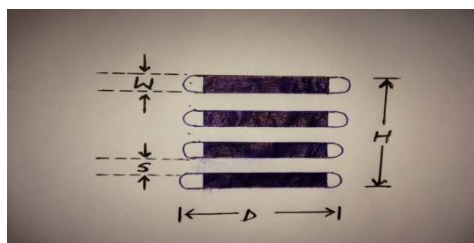
3. **Secondary coil** : Since the power consumption is less than 500w for the NST. The secondary diameter is chosen to be 4 unit.

Power vs Secondary Diameter

Secondary coil form Dimensions

For 4 inches, the aspect ratio is 5:1 and the coil length from the table can be written as 20 inches. The inductance of secondary helical coil is calculated from:

Form Diameter	Aspect ratio	Coil Length
3 inches	6 to 1	18 inches
4 inches	5 to 1	20 inches
6 inches	4 to 1	24 inches
8 inches & above	3-5 to 1	24 inches & above



$$L = (N^2 * R^2) / (9R + 10H)$$

where ,

$$R = D/2$$

D = diameter

N = number of wire

W = wire diameter

S = turn spacing

H = Height of the coil

4. **Capacitor Bank**: The capacitor bank value depends on the ratings of the NST and it can be obtained by the formula:

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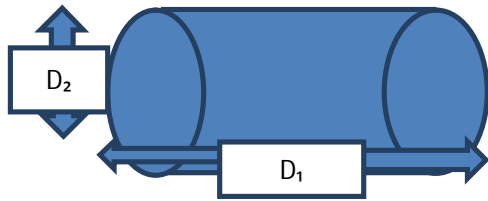
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$$Z = E \text{ (output voltage)} / I \text{ (rated current)}$$

5. **Top Load(Toroid):**For easy construction, the top load is considered as toroid which is the most efficient shape. The minor diameter is about the same size of the secondary coil diameter and major diameter is the 4 times of the minor diameter.

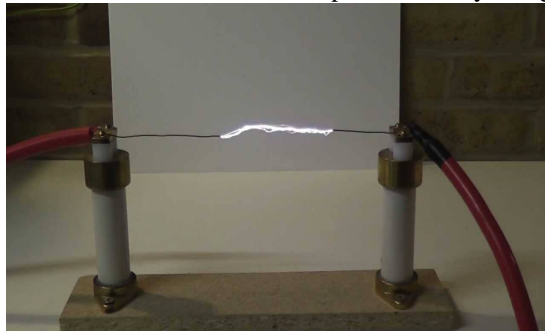


$$C = 2.8 * (1.2781 - (D_2 / D_1)) * \sqrt{(2 * (D_1 - D_2) * (D_2 / 2)) / 4}$$

Where,

D₁ = Major Diameter
D₂ = Minor Diameter

6. **Spark Gap:**Spark gap acts as high power switch which initiates the discharge of the capacitor into primary winding of the Tesla coil. The air between the electrodes breaks when the capacitor is fully charged.





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III. CONCLUSION

This paper contains the designing of Tesla coil. It generates the high voltage at high frequency and can be used for insulation testing. It transmits the electrical power wirelessly upto 2m and above. It is used to conduct innovative experiments in electrical lightning, phosphorescence, X-ray generation and the transmission of electrical energy without wires.

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