"Tesla Coil Modification"

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Abstract- *Tesla coil is a high voltage ,high frequency testing source used in laboratories and testing departments of Mega Volt (MV) and High Volt (HV). Tesla coil is known as double tuned resonate transformercan produce high AC voltages at high frequency and low current. Scientist Nicola Tesla done huge research in this field. The purpose of tesla coil is to able to deliver power other than conducting wires and transmission lines too.Tesla coil has a medium of trasmission of elecrticity through air.The design needs low AC voltage and current. It uses high frequency transformer action and resonance occurs in the secondary circuit. The secondary circuit due to resonance action produces very high voltage in the range of tens to 100 kv.*

Keywords- NST(Neon Sign transformer), spark gap, Toroid, Capacitor bank.

I. INTRODUCTION

A Tesla Coil is an electrical resonant transformer circuit designed by inventor Nikola Tesla around 1891.Tesla coil was created to perform experiments in creating high-voltage electrical discharges. It consists of a power supply, a capacitor and coil transformer set so that voltage peaks alternate between two. Electrodes are set so that sparks jump between them through the air.

The Tesla coil is an air-core double-tuned resonant transformer which generates the high output voltage. Optimally, a capacitive electrode (top load)in the form of smooth metal sphere or torus attached to the secondary terminal of the coil. Its large surface area suppresses premature corona discharge and steamer arcs, increasing output voltage.

A high voltage supply transformer is used to step the AC mains voltage up to high enough voltage to jump the spark gap. Typical voltages are between 3-5 (KV).A capacitor that forms a tuned circuit with the primary winding of the Tesla transformer. A spark gap that acts as a switch in the primary circuit.

The Tesla coil uses high-frequency transformer action together with resonant voltage amplification to generate potentials in the range of tens to hundreds, or even thousands of kilovolts. We describe a range of experiments designed to investigate the Tesla coil action, ending up with the design and development of a touring Tesla coil with a carefully considered trade-off between portability and performance

The Tesla transformer is a fascinating device capable of creating spectacular effects: by generating high-voltage pulses with several Megavolts of amplitudes, it emits electrical discharges that easily extend for several meters and remind natural lightning. The tesla transformer is very familiar for more than a century to the scientific research and also used in several application nowadays.

Image: Tesla coil of our prototype

II. LITERATURE SURVEY

1. **M.B. Farriz, "A Simple Design of a Mini Tesla Coil with DC voltage Input"** International Conferance on Electrical and ControlEngineering, pp-4556-4559978-0- 7695-4031-3/10$26.00@ 2010 IEEE DOI 10.1109/iCECE.2010.1453.

The Tesla coil is an air core resonant transformer which generate the high output voltage. A capacitive electrode in the form of a smooth metal sphere or torus attached to the secondary terminal of the coil.

2. **Hardt N., Koeing,D.: Testing of insulating materials at high frequencies and high voltage based on the Tesla**

transformer principal. Conference record of the 1998 IEEE International Symposium on electrical Insulation,p.517-20,vol.2,1998.

The Capacitor and primary coil produces an LCR circuit that resonates at high resonant frequency. The secondary coil and top load also create an LCR circuit that must have a resonant frequency equal to the resonant frequency of the primary circuit .The high resonant frequency coupling of the primary coil with the secondary coil induces very high voltage spikes in the secondary coil.

3. **M. Sohel Rana, "Design and Construction of a Tesla Transformer using Microwave oven Transfer for Experimentation".** Innovative system design and Engineering ISSN 2222- 1727 (paper) vol, No. 12 2014.This papar focused on the step by step design of high frequency medIum size(1-3KW) air cored transformer commonly called called Tesla coil, that can be easily used for measurement and generally research

III. WORKING OF TESLA COIL

Tesla coil works on the principle of Elecromagnetic induction .which states that" A coil generating magnetic field induces a current in another coil as it placed into the field of former coil".

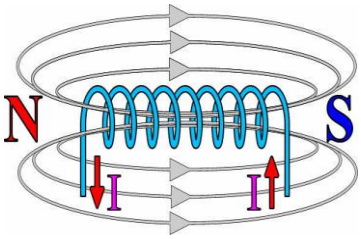

Fig: Mutual Induction

Capacitor charges from the high voltage power supply,the potential across the static spark gap electodes increases until the air between the spark gap ionizes allowing a low resistance path for a current to flow through the switch is closed. once the capacitor has discharged, the potential across the spark gap is no longer sufficient to maintain ionized air between the electrodes and the switch is open. This happens hundreds of times a second producing high frequency AC current through the primary coil. The capacitor and primary coil produces an LCR circuit that resonates at high resonant frequency.The secondary coil and top load also create an LCR circuit that must have a resonant frequency equal to the resonant frequency of the primary circuit.The high resonant frequency of the primary coil with the secondary coil induces very high voltage spikes in the secondary coil.

The top load allows a uniform electric charge distribution to build up and lightning like strikes are produced from this to a point of lowe potential ,in most cases ground.The coupling between the primary and secondary coils do not act in the same way as a normal transformer coil ,but works by high frequency resonant climbing or charging to induce extreamely high voltages.

Construction:

Tesla coil is an electrical resonant transformer was created to perform experiments in creating high voltage electrical discharges .capacitor charges from HV power supply. potential across the spark gap elctrodes increases until air between spark gap ionizes.This ionizes causes low resistance path for current to flow through it and path is like closed switch.

When capacitor gets totally discharge potential is no longer sufficient to maintain ionized air which acts like open switch.This happens hundreds of time a second which leads high frequency in primary. Primary coil, capacitor, resitance of primary coil togather produces LCR circuit.

Similarly tha secondary coil, top load (toroid) create another LCR circuit. This both circuits that is primary and secondary should have resonant frequency equal. It results high voltage spikes in secondary coil.

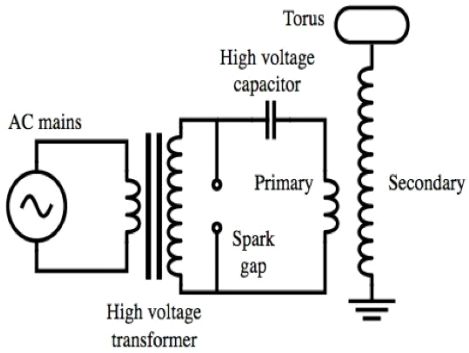

Fig: circuit of Tesla coil.

Tesla coil generates extream high voltages. It has six main parts first one is Neon sign transformer (15 KV). Second is capacitor bank (4.9μF).Third important part is spark gap which is made by two elecrodes seperated by air gap.

Forth part is primary coil haing(8)turns of guage wire which is at base of secondary coil.Fifth important part is secondary coil consisting of (918) turns which are of thin ,enamel guage wire.As Tesla coil is air core transformer no core present between primary and secondary windings.Sixth

important part is toroid which is made up of aluminium and placed at top of secondary coil. toroid acts as capacitor into the secondary circuit.

IV. DESIGN OF OUR PROTOTYPE

PRIMARY CAPACITANCE

The primary capacitor is used with the primary coil to create the primary LC circuit. A resonate sized capacitor can damage a NST, therefore a Larger Than Resonate (LTR) sized capacitor is strongly recommended. A LTR capacitor will also deliver the most power through the Tesla coil. Different primary gaps will require different sized primary capacitors.

Primary Resonate Capacitance (uF) = 1 / (2 × π × NST Impedance × NST F_{in})

Primary LTR Static Capacitance (uF) = Primary Resonate Capacitance × 1.2

Primary LTR Sync Capacitance (uF) = 0.83 × (NST Iout/ (2 × NSTF_{in}) / NST V_{out})

SECONDARY COIL

The secondary coil is used with the top load to create the secondary LC circuit. The secondary coil should generally have about 800 to 1200 turns. Some secondary coils can have almost 2000 turns. Magnet wire is used to wind the coil. There's always a little space between turns, so the equation assumes the coil turns are 97% perfect.

Secondary Coil Turns = (1/ Magnet Wire Diameter + 0.000001)) × Secondary Wire winding Height × 0.97

The capacitance of the secondary coil will be used to calculate the secondary LC circuit resonate frequency. Coil dimensions are given in inches.

Secondary Capacitance (pf) = (0.29 × Secondary wire winding Height + (0.41 × (Secondary Form Diameter / 2)) + (1.94 × √((Secondary Form Diameter / 2)^3) / Secondary Wire winding Height))

The height to width ratio should be about 5:1 for small Tesla coil, 4:1 for average sized Tesla coils about 3:1 for large Tesla coils.

Secondary Height Width Ratio = Secondary Wire Winding Height / Secondary Form Diameter

The length of the secondary coil is used to calculate the wire weight. In the past it was thought that the secondary coil length should match the quarter wave length of the Tesla coils resonate frequency. However, it has since been determined that it's unnecessary.

Secondary Coil Wire Length (ft) = (Secondary Coil Turns) × (Secondary Form Diameter × π) / 12

Magnet wire is typically sold by weight, so it's important to know the required wire weight.

Secondary Coil Weight (lbs) = π × ((Secondary Bare wire Diameter / 2)^2) × Secondary Coil Wire Length × 3.86

The inductance of the secondary coil will be used to calculate the secondary LC circuit resonate frequency.

Secondary Inductance = ((((Secondary Coil Turn^2) × ((Secondary Form Diameter / 2)^2)) / ((9 × (Secondary Form Diameter / 2)) + (10 × Secondary Wire Winding Height))))

TOP LOAD

The top load is used with the secondary coil to create the secondary LC circuit. Generally a toroid or sphere shape is used. The ring diameter refers to the widest length from edge to edge of a toroid shape. I've found several equations for different sized top loads. Without knowing which is the most accurate in any case, I use the average of all the equations.

For large or small toroids with ring diameter < 3" or ring diameter > 20", use the average of the 3 toroid capacitance calculations.

Toroid Capacitance 1 = ((1 + (0.2781 – Ring Diameter / (Overall Diameter – Ring Diameter))) × 2.8 × sqrt((π × (Overall Diameter × Ring Diameter)) / 4))

Toroid Capacitance 2 = (1.28 – Ring Diameter / Overall Diameter) × sqrt(2 × π × Ring Diameter × (Overall Diameter – Ring Diameter))

Toroid Capacitance 3 = 4.43927641749 × ((0.5 × (Ring Diameter × (Overall Diameter – Ring Diameter))$^{0.5}$)

Toroid Capacitance = (Toroid Capacitance 1 + Toroid Capacitance 2 + Toroid Capacitance 3) / 3

Ring diameter between 3" and 6"

Toroid Capacitance Lower = 1.6079 × Overall Diamete

Toroid Capacitance Upper = 2.0233 × Overall Diamete

Toroid Capacitance = (((Ring Diameter – 3) / 3) × (Toroid Capacitance Upper – Toroid Capacitance Lower)) + Toroid Capacitance Lower

Ring diameter between 6" and 12"

Toroid Capacitance Lower = 2.0233 × Overall Diamete

Toroid Capacitance Upper = 2.0586 × Overall Diamete

Toroid Capacitance = (((Ring Diameter – 6) / 6) × (Toroid Capacitance Upper – Toroid Capacitance Lower)) + Toroid Capacitance Lower

Small Tesla coils may use a sphere shaped top load.

Sphere Capacitance = 2.83915 × (Sphere Diameter / 2)

The total secondary capacitance includes the capacitance in the secondary coil and the capacitance of the top load. If you use multiple top loads, add their capacitance to calculate the total secondary capacitance. The total secondary capacitance will be used to calculate the secondary resonate frequency.

Total Secondary Capacitance = Secondary Coil Capacitance + Top Load Capacitance

The Secondary LC circuit resonate frequency will be used to calculate the amount of primary coil inductance required to tune the Tesla coil.

Secondary Resonate Frequency = 1 / (2 × π × √((Secondary Inductance ×0.001) × (Total Secondary Capacitance)))

V. TEST RESULT

When the distance between primary and secondary coil was very small then breakdown occuring at 20 KV.

we found that there were no spark between electrode so we tried changing distance between electrode at same voltage**.**

For resonance between primary and secondary coil we increased distance between coils by 3 inches for mutual induction.

	Primary values	**Secondary values**
Capacitance value	4.9µf	15.36µf
Turns used	7	918
Breakdown at voltage	15 kv for charging capacitor & dicharge through spark gap	15kvforincrease voltage in the secondary coil for dicharge through toroid
Spark gap distance	1 mm	1mm
Distance between primary and secondary	3 inches from secondary	3 inches from primary

At the above values sparks of high voltages occuring at 15kv supply.

VI. CONCLUSION

We are now able to transmit power without using wires but distance is limited as per our ratings.

We can now do the detail analysis of working ,design and operation of tesla coil.

Working principle of basic Tesla coil helps to design our model to produce sparks at high voltage across the toroid capacitor.

It is very efficient method for developing high voltage ,low currents,high frequency outputs.

Tesla coil cad and Tesla map software's are very useful in Tesla coil design as we can use it for experimental study and small ,medium & big Tesla coil model design.

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