DESIGN AND DEVELOPMENT OF MINI VACUUM TUBE TESLA COIL (VTTC)

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This report is submitted in partial fulfillment of the requirements for the award of Bachelor of Electronics Engineering (Industrial Electronics) With Honours

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“I hereby declare that this report is the result of my own work except for quotes as cited in the references”

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"I hereby declare that I have read this report and in my opinion this report is sufficient in terms of the scope and quality for the award of Bachelor of Electronic Engineering (Industrial Electronic) With Honours."

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Date :30th APRIL 2008

Especially for my beloved father and mother, my siblings and family.

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ABSTRACT

This project was carried out to develop a Mini Vacuum Tesla Coil (VTTC) using high voltage transformer transformer based on the DC high voltage conservation with input range 8000VDc. A Tesla Coil is a specially designed transformer, technically termed an "air-core resonant transformer". It consists of a primary winding, with relatively few turns, and a secondary winding with hundreds, or even thousands, of turns. As with all transformers, the primary and secondary windings are physically arranged so that electrical energy may be transferred between them by transformer action - a changing current flowing in one winding induces a changing voltage in the other. The Tesla transformer is an electrical device capable of developing high potentials ranging from a few hundreds of kilovolts up to several megavolts; the voltage is produced as AC, with a typical frequency of 50 - 400 kHz This project is done by using special electronic parts which is 4000V 30MA current ltd open core transformer and .01 MFD 10KVAC polypropylene high current pulse capacitors..It will cause a gas discharge lamp, to glow up to a distance of several feet from the unit. The high voltage output coil terminal can actually be touched with a piece of metal held securely in the demonstrator’s hand, creating quite a conversation piece. Three element is going to be analyzed in this project are the voltage regulator circuit, arc sparking and the analysis of the transformer output.

ABSTRAK

Projek ini adalah untuk projek Mini Vacuum Tube Tesla Coil (VTTC) menggunakan alat ubah pengeluar tinggi dengan kuasa masukan 8000VDc.Tesla Coil adalah menggunakan alat ubah yang istimewa, juga di panggil alat ubah teras udara .Ianya mengandungi gelung pertama alat ubah dan gelung kedua alat ubah yang mana akan mengandungi seratus atau beribu gelung. Gelung pertama akan menghasilkan merangsang voltan kepeda gelung kedua untuk menghasilkan voltan yang tinggi.Perubahan arus yang melalui gelung akan juga merangsang kepada terhasilnya voltan tinggi.Transformer Tesla Coil adalah satu alat elektrik yang boleh mengasilkan voltan tinggi dari ratusan kilovolt dan akan meninggi ke megavolt.Voltage tersebut akan menghasilkan voltan AC dengan frekuensi biasa iaitu 50-400 kHz.Projek ini berjaya di siapkan dengan menggunakan 4000V 30MA arus ltd teras terbuka alat ubah, dan .01 MFD 10KVAC polypropylene kapasitor arus tinggi.Projek ini akan menyebabkan pengeluaran cas dengan jarak beberapa kaki.Voltan tinggi dapat di sentuh dengan menggunakan besi atau pengalir elektrik tetapi dengan mengambil kira aspek keselamatan yang tinggi.Terdapat 3 elemen akan di kaji iaitu litar mengawal boleh ubah,keluaran kilat dan keluaran alat ubah.

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LIST OF ABBREVIATION

FBT	-	Flyback Transformer
DC	-	Direct Current
VTTC	-	Vacuum Tube Tesla Coil
PCB	-	Printed Circuit Board
TPI	-	Turn Per Inch
SCR	-	Silicon Controlled Rectifier
HF	-	High Frequencies
VHF	-	Very High Frequency
UHF	-	Ultra High Frequency
HV	-	High Voltage

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CHAPTER I

INTRODUCTION

1.1 Introduction of the project

A Tesla coil is a high frequency resonant transformer. It differs from a conventional transformer in that the voltage and current relationships between the primary winding and secondary winding are independent of the winding turn's ratios. A working apparatus basically consists of secondary and primary coil. It is obvious that the primary circuit is dominant, and turning the primary circuit via taps along the primary coil alters the frequency accordingly, however this relative fine-tuning of the primary circuit to the secondary is mandatory for proper operation. Force driving the secondary coil will produce hot spot and an interwinding breakdown along with other negative result. This mini Tesla Coil was originally designed to run using project basically to design the circuit for Wind source can be an excellent complement of electric power requirement.

1.2 Objectives

1.2.1 To study and develop a high voltage DC up to 30KV by using Neon (high voltage) transformer

1.2.2 To produce arc using high voltage at the safe condition

1.2.3 To analyzed the arc sparking

1.2.4 To Design and Develop a Tesla Coil by using Neon (high voltage) transformer.

1.3 Problem Statement

Nowadays, so many type of Tesla Coil develop by others that use high voltage to produces arc (spark).The different with my project is develop Tesla Coil using basic application to produce arc (spark) by using Neon (high voltage) transformer.

1.4 Scope

This project is to develop Mini Vacuum Tube Tesla Coil by using Neon (high voltage) transformer to produced high voltage; low ampere from voltage input voltage 240AC and analyzed the output voltage and current from the arcs that Tesla Coil produced.

1.5 Methodology

Firstly, search a literature review to collect more information about this project. The literature review will take journal, report, internet and books as it reference. To design a Mini Vacuum Tube Tesla Coil (VTTC), the theory and all application about Tesla Coil circuit has been studies and understanding. Make a research about circuit theory and the characteristic of each component to redesign the Tesla Coil circuit. Later, some literature review will used to compare this project with previous experiment and related project for this title.

Then, the circuit of Tesla Coil has been design by refer the literature review have found. To design the circuit, make sure the Neon (high voltage) transformer and all component will use is more suitable for Tesla Coil circuit to generate a high voltage. The design circuit will be simulated using the Pspice and Multisim software. The output voltage is measured and the calculated of the voltage is very important because it will determine the sum of component and stage that the circuit required to get the right output voltage.

After the design is successful, the circuit will be constructed on strip board. Make sure all connection of component at strip board is right. Then, check the circuit output voltage by using the multimeter and the value is compared with simulation output value. Then, the circuit has been constructed on PCB board. All connection in circuit is confirmed right before the soldering process. For last inspection, test the hardware if function or not. If not function, the circuit will be troubleshooting. If the circuit already functions, the model has been designed.

CHAPTER II

Literature review

A Tesla coil is a type of resonant transformer circuit invented by Serbian-American scientist Nikola Tesla around 1891. It is generally used to generate very high voltage, low current, and high frequency alternating current. A Tesla coil consists of two, or sometimes three, coupled resonant electric circuits. A Tesla coil is difficult to define, as Nikola Tesla experimented with a large variety of coils and configurations. Tesla used these coils to conduct innovative experiments in electrical lighting, fluorescence, x-rays, high frequency alternating current phenomena, electrotherapy, and wireless power for electric power transmission.

Early Tesla coil designs usually employed a high voltage power source, one or more high voltage capacitor, and a spark gap to excite the primary side of the Tesla coil system with periodic bursts of high frequency current. Later and higher power coil designs had the primary and secondary circuits tuned so that they resonated at the same frequency (typically, between 25 kHz and 2 MHz). These larger Tesla coil designs are used to create long electrical discharges.

Tesla coil circuits were used commercially in spark gap radio transmitters for wireless telegraphy until the 1920, and in electrotherapy and quack medical devices such as violet ray. Today their main use is entertainment and educational displays. Tesla coils are built by many high-voltage enthusiasts, research institutions, science museums and independent experimenters. Modified Tesla coils are widely used as igniters for high power gas discharge lamps, common examples being the mercury vapor and sodium types used for street lighting. Although electronic igniters are available, Tesla's original spark gap design is much cheaper and has proven extremely reliable. A Tesla coil, named for its inventor Nikola Tesla, is a high-voltage resonant transformer that can be used to produce long electrical discharges.

To investigate the electrical realm of high-frequency and high-voltage, Tesla invented an apparatus that pushed the limits of electrical understanding. None of the circuit's typical components were unknown at the time, but its design and operation together achieved unique results not the least because of Tesla's masterful refinements in construction of key elements, most particularly of a special transformer, or coil, which is at the heart of the circuit's performance.

Such a device first appeared in Tesla's US patent No. 454,622 (1891), for use in new, more efficient lighting systems. In its basic form, the circuit calls for a power supply, a large capacitor, the coil (transformer) itself, and adjustable spark-gap electrodes.

2.1 Oscillators

Capacitors (or condensers) and inductors (or coils) are, electrically speaking, somewhat opposite in operation. Whereas current builds quickly in a capacitor as it charges up, voltage lags. In an inductor, voltage is felt immediately, while current is retarded as it works against the magnetic field its own passage builds in the coil. If a coil and condenser are sized and selected to act with exactly opposite timing with voltage peaking in the coil just as it reaches a minimum in the capacitor then the circuit may never reach an electrically quiet, stable state. A bit like the sloshing of water back and forth in a tub, current and voltage can be made to chase each other back and forth, from end to end of the circuit.

To set his oscillator "ringing" Tesla employed sudden discharges, sparks, across an adjustable gap between two electrodes. Voltage on a capacitor builds until it reaches a level at which air in the gap breaks down as an insulator. (Precision screws set the gap clearance, so that a larger or smaller gap selects a larger or smaller breakdown voltage.) The initial impulse is very powerful all the energy stored over several microseconds is released in a rush, and that impulse is itself transformed to a somewhat higher voltage in passing from the primary coil windings to those of its secondary. This, of course, completes but a single cycle in the circuit's operation. The air gap restores itself as an insulator, and the capacitor begins to charge until it reaches a breakdown value once again. The whole process can repeat itself many thousand times per second.

The transformer's secondary is rather special, too, designed by Tesla to react quickly to a sudden energy spike and, most importantly, to concentrate voltage at one end as a standing wave. Its length is calculated so that wave crests, as they reach the end and are reflected back, meet and exactly reinforce the waves behind them. The net effect is a wave, a voltage peak, which appears to stand still.

2.2 Applications

If, as happened in practice, Tesla made an antenna of the high-voltage end of his secondary, it became a powerful radio transmitter. In fact, in the early decades of radio, most practicable radios utilized Tesla coils in their transmission antennas. Tesla himself used larger or smaller versions of his invention to investigate fluorescence, x-rays, radio, wireless power, biological effects, and even the electromagnetic nature of the earth and its atmosphere.

Today, high-voltage labs often operate such devices, and amateur enthusiasts around the world build smaller ones to create arcing, streaming electrical displays it is not difficult to reach a quarter million volts. One of the very first particle accelerator designs, by Rolf Wideroe in 1928, generated its high voltage in a Tesla coil.) The coil has become a commonplace in electronics, used to supply high voltage to the front of television picture tubes, in a form known as the flyback transformer.

2.3 Building a Mini Tesla Coil

This mini Tesla Coil was originally designed to run using a previously built high voltage flyback circuit as a power supply. The circuit provided about 45watts at about 10kV. This means that there are limits to the size of arc that can be produced. My coil is capable of 4" arcs. Such a small coil provides a great talking point, and is small enough to be easily portable. Another point is that it is cheap to build.

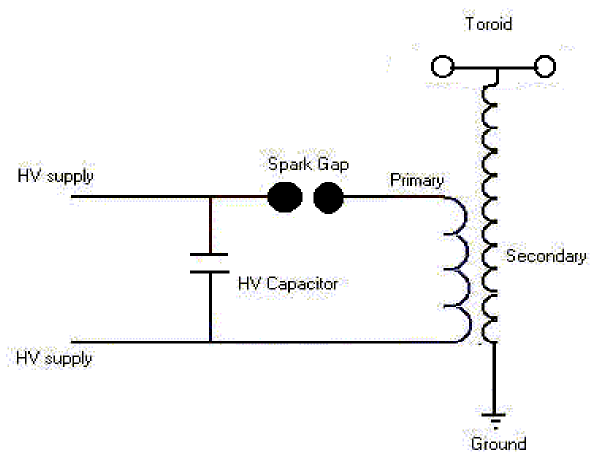

Figure 2.3 Coil Schematic

Figure 2.4 Finished Coil

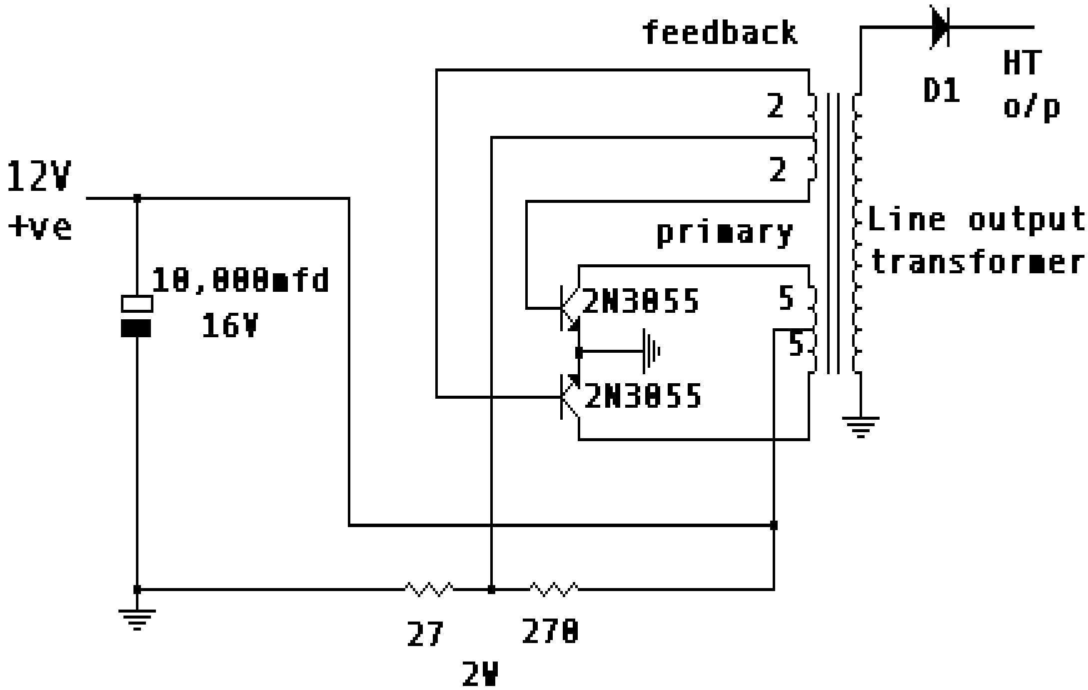

Figure 2.5 The oscillator circuit

D1 may be either an EHT rectifier stick from a tv or a string of lower voltage diodes for example 15 x 1N4007s. If you use a string of lower voltage diodes, they must all be of the same type. Despite what is often said in textbooks, don't use equalizing resistors across the diodes, modern diodes don't need them, and if one fails then too much stress will be placed on the diodes with spectacular results. Although the supply is shown as 12V, up to 18 is ok, but you will need to use a 25V smoothing capacitor rather than the 16V one. This circuit will draw 3-5A, depending on several factors but chiefly the current taken from the secondary (HT) winding. The 2N3055s need heat-sinks of a good size. The primary coil needs to be wound with thick insulated wire, 18swg is about right.

2.4 Baseboard

Various materials can be used for the baseboard, provided that they are good insulators. The coil shown in the picture used varnished MDF. A good alternative would be acrylic sheet or polycarbonate.

2.5 Capacitor

The capacitor used in this particular coil needed a value of approximately 5nF at about 10-15kV, since used it with 8.3nF with appropriate adjustments to the primary coil tapping. There are various ways of obtaining these values. Whilst many coilers would use a string of higher value capacitors in series, it used an alternative approach initially, building my own from double sided printed circuit board. For the 8.3nF capacitor used an MMC, consisting of 12 x 100nF 1k5V rated Philips capacitors. If you go this route, then it is essential that you use the correct type of capacitors, namely foil polypropylene capacitors rated at the appropriate voltage and of the appropriate construction for high discharge rates. A number of sites have details of the construction of MMCs, read what they have to say before going this way, it will save you a lot of time, effort, money and frustration. Other approaches include making rolled polythene or salt water capacitors. Both these latter approaches can be messy, and they end up with very bulky components. Bleeder resistors should be placed across capacitors, these need to be high voltage types, they also need to be of high value, for example for an MMC 10M across each capacitor.

2.6 Spark Gap

Various types of spark gap have been used, the simplest being a static gap consisting of two mild steel brackets with brass bolts forming the actual gap. The preferred gap and the one shown in the picture is a multiple gap of the RQ type. No