GROUP NO.: 28

# DAYANANDA SAGAR COLLEGE OF ENGINEERING

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## DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

**Academic Year 2021-2022**

# SEE Report Mini Project -2 (21MP210)

## TESLA COIL LAMP

***Submitted by:***


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**Shavige Malleshwara Hills, Kumaraswamy Layout Bengaluru-560078 2018-2019**

**DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING**

## CERTIFICATE

Certified that the Mini project report entitled **"TESLA COIL LAMP" carried out by ANVITH SHANKAR B (1DS21EE017), GOWTHAM C (1DS21EE035), SURAJ MUKHERJEE (1DS21EE061), RAVI SHANKAR KUMAR (1DS21EE083),** bonafide students of **DAYANANDA SAGAR COLLEGE OF ENGINEERING,** an autonomous institution affiliated to VTU, Belagavi in partial fulfillment for the award of Electrical and Electronics Engineering during the year 2021-2022. It is certified that all corrections/suggestions indicated for Internal Assessment have been incorporated in the report deposited in the departmental library. The Mini project report has been approved as it satisfies the academic requirements in respect of work prescribed for the Bachelor of Engineering Degree.

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**Name of the Examiners:** **Signature with date:**

**1.....** **.....**

**2.....** **.....**

## ACKNOWLEDGEMENT

**The success and final outcome of this mini project required the guidance and assistance of many people. We would like to use this opportunity to express a few words of appreciation to everyone who have been a part of this project right from its inception.**

**Without their support, patience and guidance, this task would not have been completed. It is to them we owe our deepest gratitude.**

**We take this opportunity to express our deep regards to Dr. C P S Prakash, Principal, Dayananda Sagar College of Engineering for providing an opportunity to do this mini project as a part of our curriculum inthe partial fulfillment of the degree course.**

**We express our gratitude to Dr. P. USHA, HOD, Electrical and Electronics Engineering, Dayananda Sagar College of Engineering for providing valuable insights, making the resources available at right time and all the encouragement for the completion of our mini project.**

**We owe our profound gratitude to our project guide, Mrs. Kavana Salimath, Assistant Professor, Department of Electrical and Electronics Engineering, Dayananda Sagar College of Engineering, who took keen interest in our work and guided me all along, providing all the necessary information and references.**

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# CONTENTS

# ABSTRACT

This project discusses the problems faced by the wired transmission of electricity and the possibility of wireless energy transfer proposed by one of the greatest minds Nikola Tesla. It revolves around the concept of electromagnetic induction and mutual induction.

The Tesla coil works with the principle of Electromagnetic Induction. According to which, when a conductor is placed under a varying magnetic field, a small current will be induced inside the conductor. For a Tesla coil this conductor will be called as the secondary coil and the varying magnetic field will be produced by the primary coil by passing an oscillating current through the primary coil.

With this arrangement there is a primary coil which will have an oscillating current, and hence will produce a carrying magnetic flux around it. Now, this coil is wound around the secondary coil and hence according to the law of electromagnetic induction, a voltage will be induced in the secondary coil. Since the number of turns in the secondary coil is very large than the primary coil, this voltage will be a very high voltage and hence this coil will have a very strong electric flux around it that is powerful enough to excite the fluorescent gases present in CFL bulbs and makes it glow. This is used in Wireless Power Transmission.

Tesla coil accelerates any free electrons in the tube's low-pressure gas. These electrons pick up enough energy before they collide with another gas atom that they ionize. The ionized electrons are then accelerated and ionize further atoms. When electrons fall back onto the ionized atoms, visible light (as in a neon filled tube) or UV light (from mercury vapor in a CFL) is emitted. The phosphor coating on the inside of the fluorescent tube is excited by the UV photons or by the accelerated electrons directly. This excitation of the phosphor coating produces a visible array of rays. Hence the CFL glows.

# 1. INTRODUCTION:

A Tesla coil is a radio frequency oscillator that makes the air-core double-tuned resonant transformer to produce a high voltage with less current. It is an electric oscillator that produces signals in the frequency range of about 20kHz to 100GHz.

This circuit was invented by the Swedish-American inventor Nikola Tesla in the year 1891. This was the first system which could transmit electricity wirelessly. He used it in a number of his experiments on electrical lightning, X-Ray generation, high frequency AC phenomena, wireless electrical energy transmission and electrotherapy. At his Colorado Springs laboratory during 1899–1900, by using

fig 1- TESLA COIL

voltages of the order of 10 million volts generated by his enormous magnifying transmitter coil, he was able to light three incandescent lamps at a distance of about 100 feet (30 m)

This was a radical invention as it was later used on many devices like telephone and television systems. The looser coils in the tesla coil could tolerate more voltage than the conventional iron cored transformers could. This property made it have a wide range of application.

# 2. LITERATURE SURVEY:

[1] Wireless power transfer is the transmission of electrical energy from a power source to an electrical load without any conductive physical connection. Wireless electricity ensure that the cell phones, laptops, iPods, and other power electrical devices get changed on their own, with no need of plugging them that can prevent the sockets with all sorts of wires. Wireless power transfer is when the magnetic field is transferred over short distance. The magnetic field is created using inductive coupling between coils of wire or electric fields using capacitive coupling between electrodes. The most common form of wireless power transmission is carried out using direct induction followed by resonant magnetic induction. The carrying fluxes that induce in the inductor can be captured by another inductive coil that can produce an induced flux between the receiver coils that coupled to the primary coil. Since this technique using magnetic field to transfer the electrical energy, the flux that produces in the primary coil must be in high density with high frequency. Thus, the Tesla coil is used as a transmitter to produces high voltage, high frequency and low alternating current in order to produce high density flux. In this work, a Tesla coil is a main part of transmitter component in wireless electricity apparatus and need to develop with a view to demonstrate how magnetic induction is coupled to perform a wireless power transfer. In addition, the construction of winding coils of the Tesla coil would be the great effects in order to provide electricity to supply a load without wires in distances. The advantages of the wireless electricity system would be completely eliminating existing wires for electrical appliances between power sources. With wireless electricity, the electrical system will be more secure as it will prevent user from electrocution of current and the power failure due to short circuit and fault or power loss on cable would never exist.

[2] The aim of this paper is to highlight the development of Tesla transformer throughout the decades since its first patented design and to discuss the designing parameters required in construction and manufacturing of Tesla transformers and to see the applications where different types for the same transformers are used as per different specifications. The paper will also give information on health hazards or how to take personal care while operating a Tesla coil. The paper shall as well try to provide an understanding how the Tesla Coils can be used in various applications in brief. Also, the designing of Tesla Transformers in comprehensive stepped flow chart for the clear understanding of readers has been presented in successive sections of this journal article. The article being 'A Review ' paper does not include detailed explanation about the designing of the Tesla Coils and hence a numerous parameter which might be difficult to comprehend for common readers have been excluded and instead easy methodology for explanation has been adopted for better understanding.

[3] Wireless power transfer is becoming ubiquitous in consumer electronics and electrified

transportation, providing a convenient method to supply power or charge various devices, such as cell phones, watches, laptops, electric vehicles, and so on. Delivering power from one transmitter unit to more than one receiver can save space and reduce the cost of the overall system. For applications where the sizes of transmitter and receiver units are commeasurable, a frequently used design is the one with carefully overlapped D-shaped coils (also named bipolar pad) to achieve decoupling between coils. In this paper, an alternative optimized design of two concentric decoupled coils is proposed. The design allows the receiver coils to operate at close proximity, collecting power from a shared magnetic field generated by a single transmitter pad. The design methodology is based on a bucking coil layout where the coils' decoupling is achieved by means of flux cancellation caused by alternating the winding direction of turns in one of the coils. Apart from eliminating coupling between the two receivers, the proposed design maximizes the coupling between the transmitter and the second receiver coil and consequently increases the power transfer capability, offering the equivalent coupling coefficient similar to or better than a pair of bipolar DD coils. Finally, the number and space between turns are selected to improve the quality factor of the proposed receiver. The proposed solution is designable analytically and the second receiver can be added even after the first receiver is already built. Moreover, the proposed design demonstrates superior misalignment tolerance, particularly in the lateral direction, compared to other decoupled coil designs. The proposed methodology is validated through simulations and experimental tests and has proved to be accurate and easy for implementation.

[4] 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.

# 3. OBJECTIVES:

The main objective of this project was to design and construct a working model of a tesla coil lamp. This has been achieved and the results observed are also affixed in this project. The major objectives are to understand the working concept of the Tesla coil and to create a working model of a Tesla coil.

# 4. PROJECT METHODOLOGY:

The tesla coil used in this project consists of two coils, namely primary and secondary coils. Both are wound around the same non-conducting cylindrical object (PVC). But the secondary coil has a greater number of turns and is smaller in diameter when compared to the primary coil. The primary coil is connected to an oscillating power source. This produces a varying magnetic field around the primary coil. Since there is a relative motion between the magnetic flux lines produced by the primary coil and the secondary coil itself, an emf is induced in the secondary coil. Since the number of turns is very large in the secondary coil (about 200-300), the voltage produced is also very high compared to the input voltage supplied to the primary coil.

fig 2-TESLA COIL LAMP

The oscillating electric field generated by a Tesla coil, excites the gas, commonly, mercury vapor, inside the fluorescent light, which produces a UV light, which, in turn, excites the fluorescent material, commonly, phosphor coating, which produces a visible light.

With a Tesla coil a very high AC voltage is applied to a circuit that includes the bulb and very small capacitance between the coil, the bulb and other objects in the neighborhood. As a result, only a small fraction of the coil voltage is applied to the bulb, but, considering that even a small Tesla coil can generate voltages on the order of hundreds of kilovolts, its small fraction could be sufficient to ionize the gas. This implies that the tesla coil can even light a burnt-out lightbulb still, so long as the bulb is not cracked, meaning whatever gas it contains remains withing the bulb and since that is what reacts to the tesla coils energy and causes light to emit from it.

# 5. WORKING:

The Tesla coil works on the principles of electromagnetic induction (Faraday's laws) and resonance. Electromagnetic Induction was discovered by Michael Faraday in 1831, and James Clerk. Maxwell mathematically described it as Faraday's law of induction.

A Tesla coil consists of two coils. A primary coil with 3-5 turns, and a secondary coil with about 200-300 turns. A direct current is given through a 9V battery. This current then flows through the transistor. The positive terminal of battery is connected to the collector of the transistor, through the primary coil. The emitter is grounded. One end of the secondary coil is connected to the base of the transistor. This way the current is oscillated as it enters the primary coil.

The oscillating current creates a varying magnetic field around the primary coil, according to Faraday's laws of electromagnetic induction. As the primary coil is coiled around the secondary coil, the varying magnetic field causes an electromotive force in the secondary coil.

The voltage and the current produced in the secondary coil depend upon the number of turns in the primary coil and the number of turns in the secondary coil. The following equation relates them;

$$\frac{N_s}{N_p} = \frac{V_s}{V_p} = \frac{I_p}{I_s}$$

Where, $N_s$⇒ Number of turns in secondary coil

$N_p$⇒ Number of turns in primary coil

$V_s$⇒ Voltage across secondary coil

$V_p$⇒ Voltage across primary coil

$I_s$⇒ Current across secondary coil

$I_p$⇒ Current across primary coil

The EMF now generated in the secondary coil creates a high voltage electric field around it. This electric field ionizes the mercury and argon vapors present inside the CFL bulb. The excited mercury vapors, emit ultra-violet (UV) rays. These UV rays strike the surface of the glass tube which is coated with a layer of phosphorous. The phosphorous layer in turn emits visible light.

Hence, even burnt-out bulbs can light up; given that the glass tube containing the gases has not cracked. The uncracked-burnt out bulbs would still have the mercury vapors and hence they will also be able to emit light if they are brought near the Tesla coil.

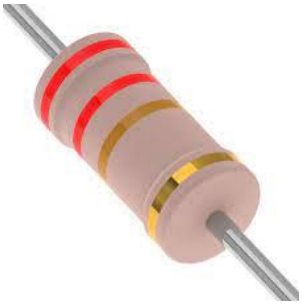
# 6. SYSTEM HARDWARE:

## 6.1 INSULATED COPPER WIRE:

These copper wires have a thin layer of insulation around them. Usually, they are coated with a layer of enamel. They have a wide range of applications in the electronics and automobile industries. They are used in the secondary coil in the Tesla coil.

fig 3- INSULATED COPPER WIRE

## 6.2 RESISTOR (2.2k OHM):



Resistor is a passive component used in every circuit to limit the amount of current entering or leaving the components as required. A 2200 OHM resistor is used in this circuit.

fig 4- 2.2 OHM RESISTOR

## 6.3 TRANSISTOR (2N2222):

The 2N2222 transistor is a NPN Bipolar Junction Transistor, which is used as a switching and amplifying component in most of the circuits. But in this circuit, it is used to convert direct current into oscillating current.

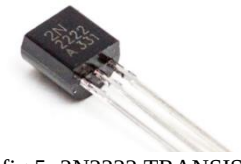



fig 5- 2N2222 TRANSISTOR

## 6.4 COMPACT FLUORESCENT LIGHT:

A CFL light bulb works differently from an incandescent or halogen bulb. Incandescent and halogen bulbs work by passing an electric current through a filament, which in turn heats up and produces light. CFLs instead send electric current through a tube filled mostly with argon gas, and a slight amount of mercury gas. These gases generate ultraviolet light, which excites atoms on the phosphorous coating of the tube, which in turn emits visible light.

fig 6- CFL BULB

## 6.5 PVC PIPE AS A NON-CONDUCTING TUBE:

fig 7- PVC PIPE

PVC stands for polyvinyl chloride. It is a chlorinated hydrocarbon polymer. In its natural state, it is rigid and brittle. But when combined with additives such as plasticizers, it becomes more resilient and malleable.

Some of its applications are in electrical insulation, medical tubing, flooring, furniture, signage and as a substitute for rubber. But its most widespread use is in the manufacture of pipes, which are used in water supply, plumbing and irrigation.

## 6.6 POWER SUPPLY:


fig 8- BATTERY (9V)

Power can be supplied by the means of a battery or a regulated power supply. Battery is a device which converts chemical energy into electrical energy. A commercially available 9V battery has been used in this project. A regulated power supply (RPS), gives a constant output, even if the input current fluctuates.

## 7. BLOCK DIAGRAM:

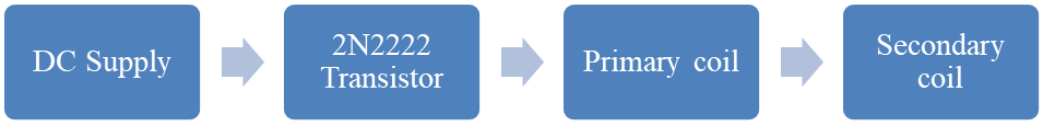



fig 9- BLOCK DIAGRAM

The above figure shows the block diagram for a miniature tesla coil circuit.

**DC Supply**: The DC is supplied using a 9V battery in this project. Any other constant supply of DC can be used.

**2N2222 Transistor**: This transistor converts the input DC into oscillating current. Oscillating current is very much necessary for the production of a varying magnetic field around the primary coil.

**Primary Coil**: The primary coil uses the AC from the transistor and produces a varying magnetic field around it.

**Secondary Coil**: An electromotive force is generated in the secondary coil due to the above mentioned varying magnetic field. This EMF causes the ionization of the surrounding air.

## 8. CIRCUIT DIAGRAM:

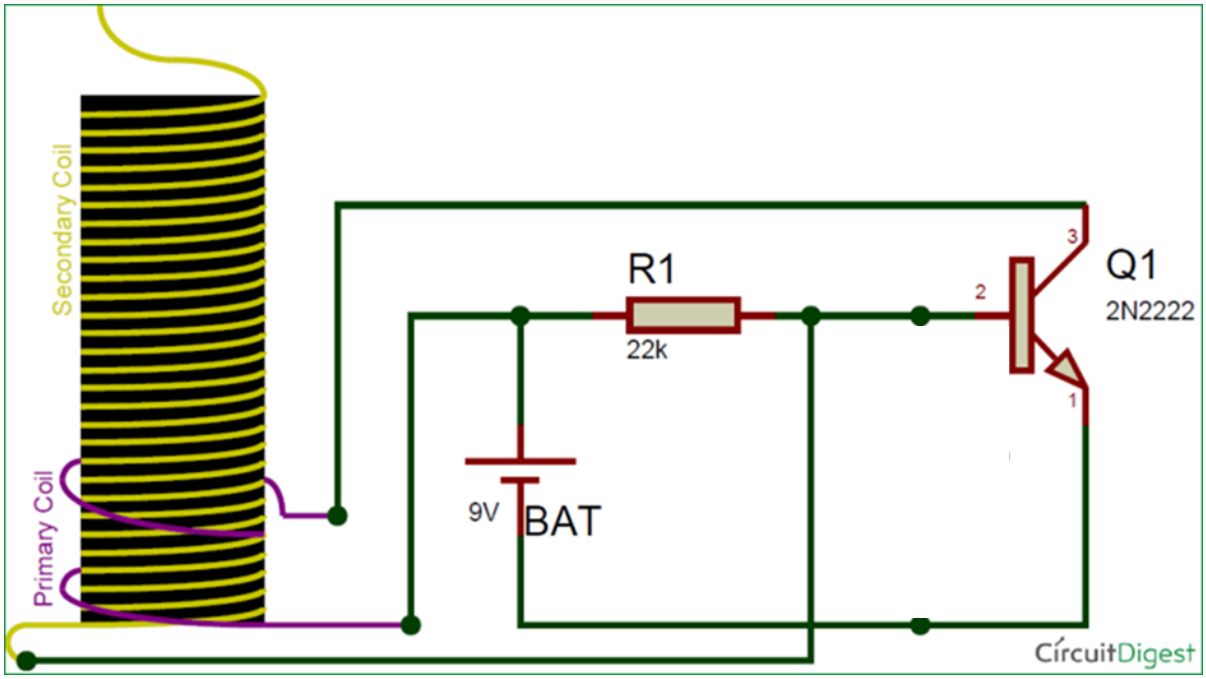



fig 10- CIRCUIT DIAGRAM

The above circuit diagram is of a Slayer Exciter Circuit. This circuit is also called as a poor man's tesla coil. It consists of a primary coil, a secondary coil, a 9V battery, a 2N2222 transistor and a 2.2k ohm resistor. The transistor is connected in a Common – Base Configuration. Both the input and output and the output terminals of the primary coil are connected to the base terminal of NPN transistor. The positive terminal of DC supply is connected to one end of the primary coil and to a 22k Ω resistor that is then connected the base terminal of the 2N2222 transistor. The emitter terminal is then connected to the other end of the primary coil, through the negative terminal of DC supply. One end of the secondary coil is connected to the positive terminal of the DC supply and the other end is left free, from which the output can be recorded.

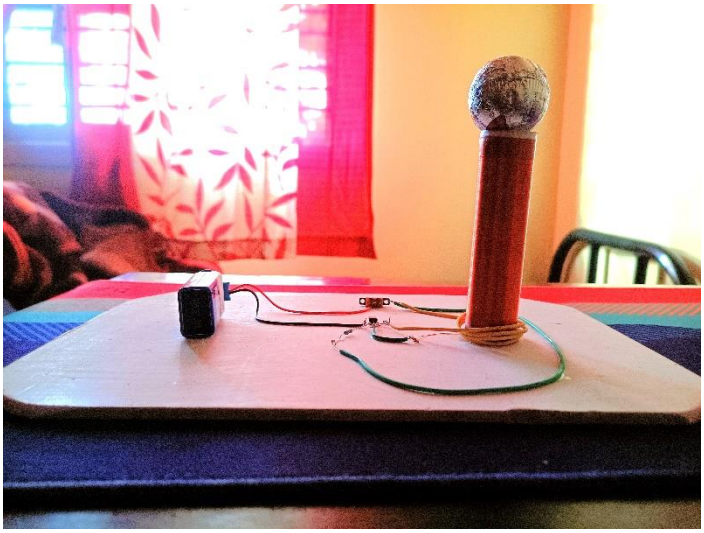


fig 11- COMPLETE PHYSICAL CIRCUIT

## 9. RESULTS:

The following images depict the illumination of the CFL bulb at different distances from the secondary coil. It may also be observed that, as the distance decreases, luminous intensity of the CFL increases.

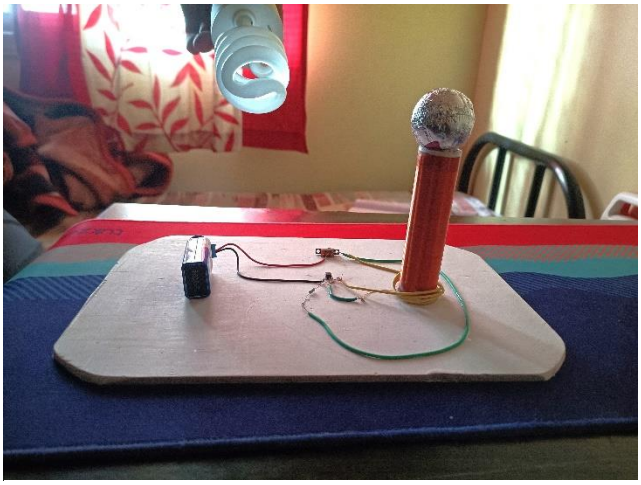


fig 12

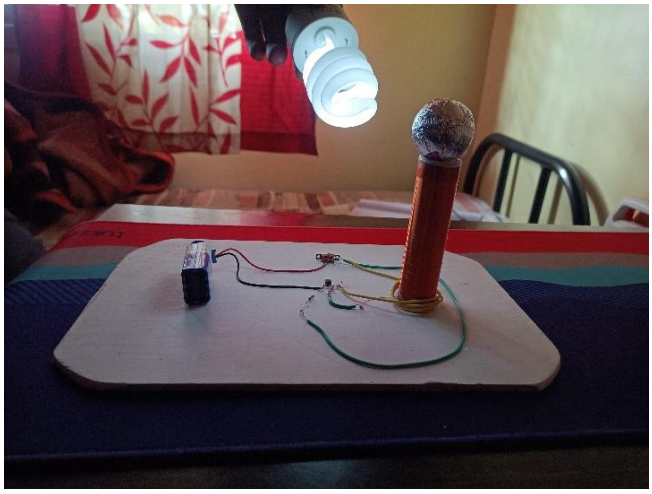


fig 13

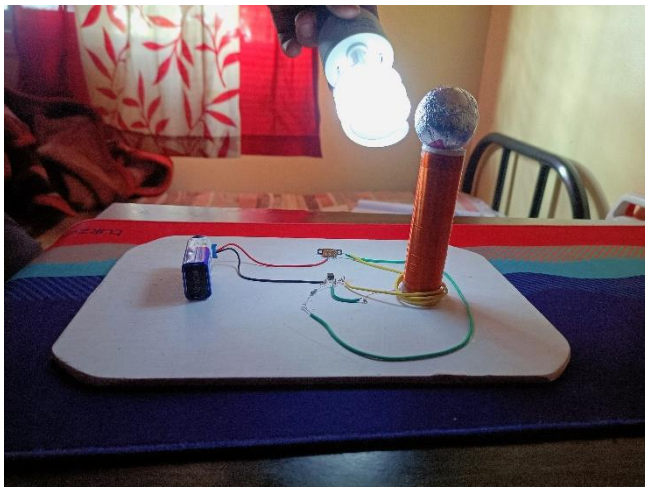


fig 15

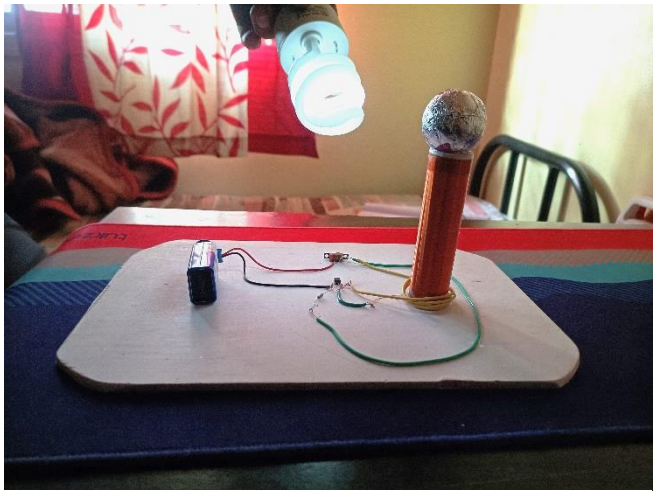


fig 14

### 9.1 CRO OUTPUT:

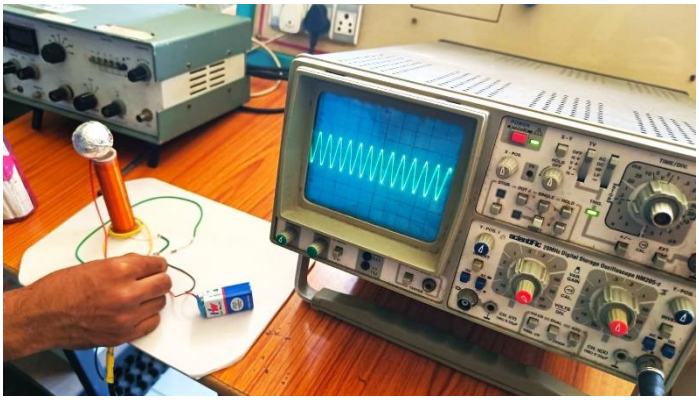


fig 15

The Cathode-Ray Oscilloscope (CRO) is a device generally used to display, measure and analyze various waveforms of an electric circuit in the form of a X-Y plotter that can display the graph of input signal vs time, or any other signal. The following figures are the output obtained by us.

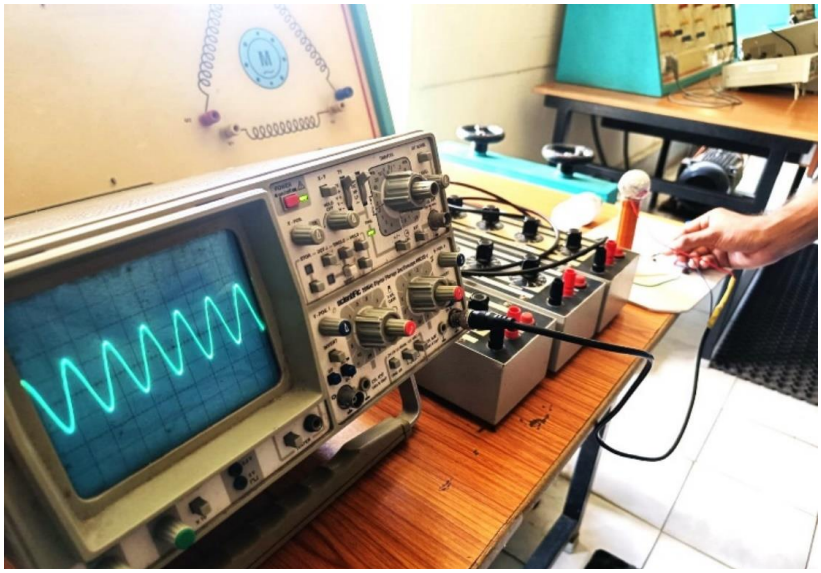


fig 16

**9.2 CALCULATIONS:**
**For a Transformer**,

$$\frac{N_s}{N_p} = \frac{V_s}{V_p} = \frac{I_p}{I_s}$$

Where, $N_s$=No. of turns in secondary winding

$N_p$=No. of turns in primary winding

$V_s$=Voltage in secondary winding

$V_p$=Voltage in primary winding

Here, $N_s$= 236, $N_p$= 3, $V_p$= 9 V

Therefore, $V_s$= 708V.

**From C.R.O,**

Voltage, V= No. of divisions on y-axis × Volts/Div.

= 3 × 5= 15V

Time period, t= No. of divisions on x-axis × Time/Div.

= 0.8 × 0.5 µs= 0.40 µs

Frequency, f= 1/t

= 1/ (0.4 µs) = 1/ ($0.4 \times 10^{-6}$)

= $2.5\times 10^{6}$ Hz

= 2.5 MHz

From Multimeter, current I= 0.8 mA and voltage, V= 705 V

## 10. ADVANTAGES AND DISADVANTAGES:

The advantages of using tesla coils are;

- Performance of the circuit increases.
- The device will not be easily damaged as the voltage of the coil slowly increases.
- A constant voltage is maintained all around the coil.

The drawbacks of Tesla coils are;

- Construction requires lot of time as there is a necessity to maintain resonance condition.
- The circuit is expensive to make as is might require a huge SC smoothening capacitor.
- It poses a threat to human and animal health as it emits signals at very high frequency. Major risks involve; heart burns, skin burns, damage to nervous system etc.

## 11. APPLICATIONS:

- Education and entertainment.
- Vacuum system leak detectors.
- CRT displays.
- Cochlear implants.
- Spark ignition in IC engines.
- Arc welding devices.

## 12. CONCLUSION:

In this project we have done the working principle and the components required to build a miniature Tesla coil. These tesla coil lamps can be used to transmit electrical energy wirelessly. Further research is required to implement this. But it will take out wired transmission out of the scene if this is effectively implemented. Tesla coils are also used to detect leaks in vacuum systems. We have also constructed a miniature Tesla coil and witnessed its wireless power transmission, through the usage of a Compact Fluorescent Lamp (CFL). We have calculated the theoretical values and compared it with the recorded values. We have also recorded the output waveform and its frequency through a Cathode Ray Oscilloscope (CRO).

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## 14. PO'S MAPPING:

| Group No. | Project Title | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PS O1 | PS O2 | PS O3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 28 | "TESLA COIL LAMP" | ✓ | ✓ | ✓ | | ✓ | | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

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