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Short Communication

Wireless energy transfer by Tesla coil

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Abstract

This project aims to provide scientific study and experimentation directed towards the development of wireless energy transfer. The specific goal of the research program is to investigate the appropriates of Tesla type resonance transformer. If power is transmitted wirelessly on a larger scale used magnetic induction devices, then it will allow systems to operate remotely.

Keywords: Resonance, Coupled LC circuit, Energy transfer, Ionization, Q factor, Electromagnetics.

Introduction

The transmission of electricity through cables at longer intervals is still a problematic task which require towers and transformers installed at regular intervals with a lot of electronic devices and insulation in order to protect this system from faults. The idea of transmitting power without cables was one of the greatest inventions. Nikola Tesla proposed the idea of transferring energy wirelessly using resonant transformers. His vision was to distribute the power wirelessly over large distances using Earth's ionosphere[1].

Working Principle: Tesla coil, it is an electrical resonant transformer circuit that works on the law of electromagnetic induction given by Michael Faraday and resonance of LC circuits. It states that whenever a conductor is exposed to a changing magnetic field, an EMF is induced in it.

The polarity of EMF so induced is given by Lenz's law which states that the current so produced in the conductor opposes the change in magnetic field.

Resonance of an LC circuit is due to the transfer of energy between inductor and capacitor. Inductor discharges due to collapse in its magnetic field, capacitor gets charged due to increase in its Electrostatic field. When capacitor discharges then inductor gets charged and this cycle repeats[2,3].

To ensure maximum utilization of electrical energy, parallel LC circuits are used so that inductor supplies capacitor without affecting the resonant current in circuit.

Resonance condition:
Inductive reactance = Capacitive reactance

$$X_L = X_C$$

$$\omega L = \frac{1}{\omega C}$$

$$\omega = \frac{1}{\sqrt{LC}}$$

$$f = \frac{1}{2\pi\sqrt{LC}}$$

Where f= Resonant frequency.

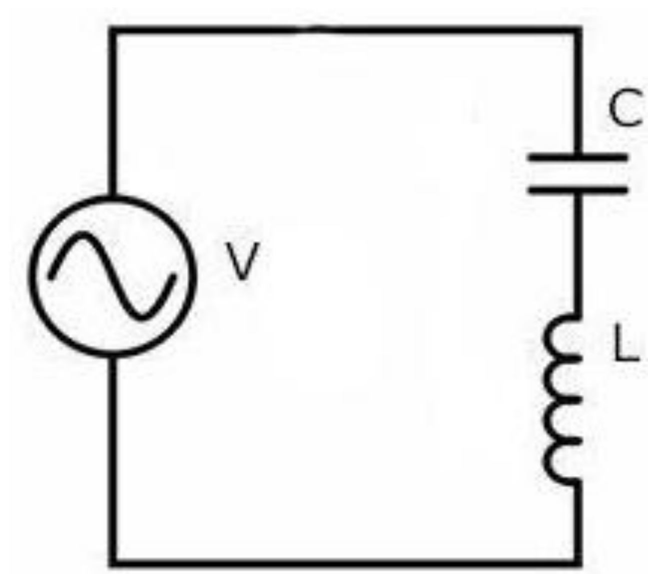

Figure-1: Parallel LC circuits[10].

Two circuits have maximum energy transfer when both are oscillating at same resonant frequencies that's why for wireless energy transfer by Tesla coil, both primary and secondary coil resonates at same frequency[4,5].

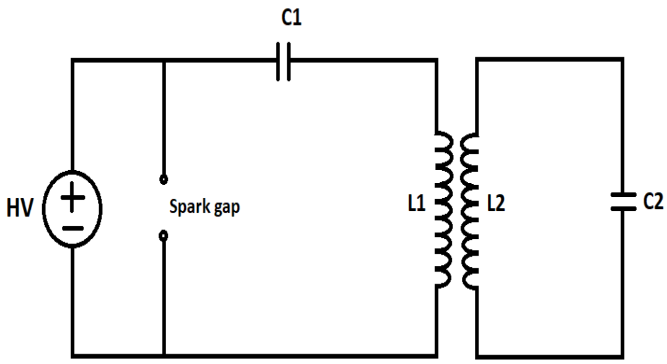

Figure-2: Basic Configuration of Tesla coil[7] circuit diagram.

Methodology

The secondary coil is grounded and a hollow metal ball is placed over its other end. The coils have high Q factor. The inductances L_1 and L_2 of primary and secondary coil respectively can be calculated using the formula,

$$L = \frac{N^2 \mu_o \mu_r A}{l}$$

∀,N – Number of turns of coil, A – Area of cross-section, l – Length of coil.

It is easier to first design the secondary coil with a resonant frequency and then tune the primary coil with the same resonant frequency.

The capacitance of secondary coil is the combination of two capacitances:

Self-capacitance of coil.

$C_{self} = 0.46 \times D$ {Medhurst Equation}

∀ D is the diameter of secondary coil.

Capacitance of hollow metal ball.

$$C_{ball} = 4\pi\varepsilon_o \left(\frac{rR}{R - r}\right)$$

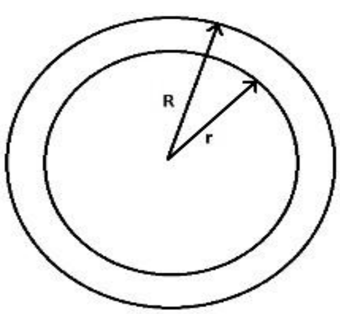

Figure-3: Schematic diagram of hollow metal ball.

Hence, the capacitance of secondary coil (C_2) will be,

$$C_2 = C_{self} + C_{ball}$$

For resonance, the circuits should have frequency,

$$f = \frac{1}{2\pi\sqrt{L_1 C_1}} = \frac{1}{2\pi\sqrt{L_2 C_2}}$$

$$L_1 C_1 = L_2 C_2$$

From this formula, the capacitance C_1 is calculated and consequently, two resonant coupled LC circuits is achieved[6].

A DC voltage is applied to the circuit. The spark gap prevents the supply from high frequency oscillation with short circuiting action. When a high voltage is produced in the secondary coil, the metal ball allows the discharge of surrounding air as it is not capable to withstand such a high voltage[7,8,9].

Observation: When a light bulb or fluorescent lamp is brought near the secondary coil it starts glowing.

Figure-4: Prototype of Tesla coil.

Figure-5: Lightning discharge through open end of secondary.

Results and discussion

Tesla coil can excite the electrons in the fluorescent lamp which emits energy in positive cycle and in negative cycle, photon hit the phosphor coating of the lamp and glows. Hence, we can say that there is a medium through which wireless energy transfer is possible near the circuit.

Conclusion

Hence, we can conclude that we have demonstrated a method of wireless power transmission by making an electrical resonant circuit.

Advantages: i. Produces high voltage, high frequency low magnitude AC electricity. ii. Allows uniform distribution of voltage all over the winding coils[5,10].

Disadvantages: i. Circuit construction is time consuming as it is hard to attain resonance. ii. High voltage capacitor is a bit expensive. iii. High voltage radio frequency emissionspose health risks including damage to the nervous system, skin burns etc[5,10].

Applications: Tesla coil is being used in X-ray generation, electrotherapy, detection of pores in vacuum tubes and to produce lightning strokes for entertainment purposes[10].

Future Scope: Continuous research is going on in various fields to make the best use of Tesla coils for biomedical engineering and electrical purposes.

Research has shown that when two LEDs are placed at a distance, the Tesla coil is able to assemble the nanotubes so that they form a complete circuit[11].

There is a scope that if Tesla coils can transfer energy at longer intervals, the complexity of the whole electrical system can be eliminated and the system will be economical[12].

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