Analysis effect of winding on radiation-electromagnetic field on the tesla coil

D Mulhayatiah¹*, Y Setiawan¹, M F Rizaldi¹, H S Siregar², D Suherdiana³ and S D Nurdini¹

¹Department of Physic Education, UIN Sunan Gunung Djati Bandung, Jl. AH. Nasution No. 105, Cibiru, Bandung 40614, Indonesia
²Department of Islamic Education, UIN Sunan Gunung Djati Bandung, Jl. AH. Nasution No. 105, Cibiru, Bandung 40614, Indonesia
³Faculty of Da’wah and Communication, UIN Sunan Gunung Djati Bandung, Jl. A.H. Nasution No. 105. Bandung Indonesia

*diahlmulhayatiah@uinsgd.ac.id

Abstract. Utilization of modern technology has been widely felt by the public as well as utilizing wireless charging technology on android phones. The charging, of course, uses the concept of Tesla coil, namely the transfer of electricity without wires. The Tesla coil can emit electromagnetic radiation which depends on its input. This study aims to design a miniature tesla coil as a magnetic inductor. In this design, measuring electromagnetic radiation with a coil diameter of 0.3 mm, 0.4 mm and 0.5 mm with the same number of turns is 500 turns. The method used is an experimental method using determinants such as the diameter of the coil, the height of the measurement of electromagnetic radiation, and the distance measurement of electromagnetic radiation. Experiments carried out varying independent variables including diameter of the coil, measurement distance, height and number of turns as a constant quantity. The measurement uses the electromagnetic radiation detector DT-1130 to measure the electromagnetic radiation at several heights of the Tesla coil. The results showed that electromagnetic radiation which has the highest value is at the top or at the end of the coil for the position near the primary coil obtained the lowest electromagnetic radiation results among the three measurements, whereas for distance researchers get the result that the further measurement between the electromagnetic sensor and the Tesla coil electromagnetic radiation is getting weaker. At a winding diameter of 0.3 mm which produces the smallest radiation but when brought closer to the Neon lamp the light intensity of the Neon lamp is brighter compared to the diameter of the winding 0.5 mm which has the most radiation.

1. Introduction
The scientist Maxwell has proved mathematically, and Hertz verified experimentally, that light is an electromagnetic interference in ether, and thus added the subject to the electric field [1]. Advances in modern electricity technology have changed the world from the planet of wires into a wireless city [2]. The main reason for this is the possibility of utilizing the properties of the phenomenon of electromagnetic waves. In such a way that today, almost all wireless communication takes place through signals that are modulated on electromagnetic waves. This is caused by the inherent ability of waves to travel long distances without the need for media [3].
Wireless power transfer emerged as a promising technology for energy to electronic devices, this technology can be traced back to the early 20th century when Nikola Tesla patented a technique for transmitting power through the air [4-6]. In recent decades, wireless power transfer has become an area of intensive research to facilitate the penetration of electrical products into our lives. Common examples include wireless charging phones, electric vehicle implanted medical devices, robots, and home electronic equipment. Power is usually transferred through the electromagnetic field [7]. Power is combined to the transmitter resonator and out of the receiver resonator to the rectifier with a small coil that functions for impedance matching [8].

This technology has 2 main parts, namely the transmitter (sender) consisting of a copper coil that is supplied with high-frequency electric power and a receiver (receiver) as well as a copper coil that will receive electric power [9]. The transmitter is usually connected to a power source such as a main power cable to convert this power source to an electromagnetic field while the receiver converts the magnetic field and converts it back to the output needed to be ready for use by electric loads [10]. In wireless power transfer systems, large differences in transmission range and alignment sensitivity can occur when the dimensions of the transmission coil vary. A coil with a larger inner and outer diameter was found to provide a wider transmission range and lower alignment sensitivity [11]. The free-standing secondary coil is an electric resonant component, because it is inducted and configured so that the top end is free and the bottom end is grounded or grounded. The current in the primary winding induces a current in the secondary coil [12].

The secondary coil emits electromagnetic radiation, because the secondary coil is induced from the primary current. Electromagnetic radiation in the secondary coil can be determined by the diameter of the secondary wire. Craven said based on the observation found that in the secondary winding of the Tesla transformer was a very bad EM radiator [13]. Researchers are still devoted to increasing transfer efficiency and transfer distance using new materials and new coil structures [14]. However, magnetic flux leakage is produced by transmission coils in the wireless power transfer system, which will cause electromagnetic radiation and will decrease the efficiency of the system as well [14-16].

2. Media design
The circuit model design with transistor and resistor are arranged in parallel and the transistor used is transistor D718 which has three legs.

![Image of electromagnetic radiation measurements](image_url)

**Figure 1.** Placement of electromagnetic radiation measurements on secondary coils at 0.5 mm wire diameter.
Figure 1 shows the design of this prop. The primary coil is connected to the transistor D718's foot and connected to the end of the secondary coil and resistor. The primary coil has a total of 5 turns and for the secondary coil 500 turns. The conventional Tesla Coil circuit consists of a primary coil and an adjustable secondary coil. The design of the primary interrupter is very important to maximize the transfer of power to the secondary coil. The secondary coil is induced by the primary coil so that at the end of the primary coil is grounded. While the measurement of electromagnetic radiation using the DT-1130 sensor is placed at different distances and to focus between the DT-1130 sensor with each secondary coil, the researchers make varied measurements. Measurement of the focus of the sensor with a secondary coil. The researchers made three different measurements.

3. Methods

This research was conducted using the experimental method, by making a secondary solenoidal coil with wire diameter variations. Before taking measurements, researchers conducted a trial of an instrument in an integrated laboratory, after the tool was able to obtain the data the researcher measured the length of the secondary coil from each coil. The measurement is to determine the amount of radiation from various secondary coil points. The magnitude of electromagnetic radiation in the secondary coil is measured at various measurement distances and the instrument used to measure electromagnetic radiation uses the electromagnetic radiation sensor DT-1130. The data analyzed in the form of tables and graphs of experimental results. After obtaining data in the form of tables and graphs, researchers can draw conclusions from the results of electromagnetic radiation measurements using the electromagnetic radiation sensor DT-1130. Measurements were made on coils that have a diameter of 0.5 mm, 0.4 mm, 0.3 mm EMF resulting from three points of the secondary coil (each wire diameter differs from the point of measurement) by influencing the measurement distances of 21 cm, 25 cm, 30 cm. The input to the three secondary coils in the same Tesla coil circuit is 12 volts.

4. Results and discussion

Figure 2 explains the closest distance 21 cm with a coil has the largest value, so the further the EMF value will weaken because the EMF value is influenced by the distance in the magnetic field. The results of measurements in secondary coils with diameter showed that at the end of the coil had the largest EMF value so that the higher the measurements on secondary coils the EMF value would be even greater. The effect of distance on the EMF value, the further from the coil the EMF value is smaller because in the equation $B = \frac{\mu_0 NI}{4r^2 + h^2}$ is not linear as shown in figure 2 [17].

![Figure 2. The relationship between EMF and measurement distance.](image-url)
the secondary coil is grounded so that at the end of the secondary coil has the greatest electromagnetic radiation value [18].

![Electromagnetic Radiation Graph](image)

**Figure 3.** Electromagnetic radiation value at winding diameter 0.4 mm with selenoid length 22.5 cm.

Figure 3 show the results of measurements made using electromagnetic radiation sensors researchers get results with ten times the data retrieval and averaged. The closer the sensor is to the solenoid, the greater the radiation produced, therefore the researchers determine the measurement distance which includes 21 cm, 25 cm and 30 cm. Effect of length measurement on the secondary coil, the highest electromagnetic radiation values are at the top, this is contrary to the theory of the solenoid that the largest value is left on the center of the circle but the researchers found the greatest value is at the top point of the secondary coil and for the lowest value is on the coil bottom near the primary coil. It is show the same prediction as coil in distribution sistem [18].

The study above obtained the results of measurements using electromagnetic radiation sensors with a specified distance of 21 cm, 25 cm, 30 cm. Where the closer the electromagnetic radiation detector to the solenoid, the greater the radiation produced. The biggest radiation is the diameter of copper wire wound 0.5 mm with the number of turns used 500 turns and the lowest radiation in this study is the diameter of copper wire 0.3 mm. Coils with a diameter of 0.3 cm with an input voltage of 12 volts produce the lowest electromagnetic radiation, because $R = \rho \frac{l}{A}$ for searching currents I we can determine with $A = \frac{\pi}{4} d^2$ so the resistance value in the circuit is very influential. And review again from the equation $I = \frac{V}{R}$ I = V / R where V is the voltage and current I with Ampere units. As seen in figure 4.

![Electromagnetic Radiation Graph](image)

**Figure 4.** Electromagnetic radiation value at winding diameter 0.3 mm with a length of selenoid 17.5 cm.
Figure 4 shows the closer the electromagnetic radiation sensor is on the secondary coil which is given a 12 volt DC voltage, the greater the value of the electromagnetic radiation produced. The radiation is greatest at the measurement of 21 cm from the secondary coil.

Figure 5 show that the lowest electromagnetic radiation value in the coil diameter of 0.3 mm to produce 850.7 μT radiation and for the highest electromagnetic radiation value at a diameter of 0.5 mm produces 1911.9 μT radiation. So that the graph above is linearly shaped, the greater the diameter of the coil, the greater the value of the electromagnetic radiation [19].

This study prove the difference in diameter of copper wires against electromagnetic radiation, where the greater the diameter of the copper wire, the greater the electromagnetic radiation produced, even more so if the measurement using electromagnetic wave radiation sensors to the secondary coil then the electromagnetic radiation emitted by the secondary coil is getting bigger. This happens because the biggest electromagnetic radiation transmitter is at the top of the secondary coil, in this study also got the greatest radiation value, which is at the peak of the secondary coil [20].

5. Conclusion
Based on the research conducted, it can be concluded that the diameter of the copper wire is very influential on the electromagnetic radiation produced, the greater the diameter of the copper wire, the greater the electromagnetic radiation. In this study, the biggest radiation was 0.5 mm in copper wire diameter where the nearest measurement distance was 21 cm which produced electromagnetic radiation of 1911.9 μT and the lowest radiation was 269.4 μT. This research was conducted as an addition to knowledge about the Tesla Coil and radiation produced by this Tesla Coil.

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