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ANALYSIS OF ABSORPTION AND REFLECTION OF ELECTROMAGNETIC WAVES ON ALUMINUM FOIL WITH CELL PHONES

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A R T I C L E I N F O

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A B S T R A C T

This research aims to determine the absorption and reflection characteristics of electromagnetic waves on aluminum foil material using a cellular cell phone as a signal source. The method used is experimental including measuring the intensity of electromagnetic signals absorbed and reflected by aluminum foil at various distances and angles of incidence. The research results show that aluminum foil has an absorption coefficient of 6% and a reflection coefficient of 25%. In principle, the level of reflection is very significant for electromagnetic waves that are absorbed and reflected from aluminum foil toward electromagnetic signals via mobile phones. In other words, the reflection value on aluminum foil is higher than the absorption value. These findings may provide insight into practical applications in the fields of wireless communications and signal interference control. In its use, aluminum foil is more effective at reflecting electromagnetic signals than absorbing them. These findings are in harmony and consistent with the theory of electromagnetic waves and the physical properties of metals.

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INTRODUCTION

Electromagnetic waves are waves that can propagate through space carrying electromagnetic energy. These waves are generated by electric fields and magnetic fields which oscillate perpendicular to each other to the direction of wave propagation. In this case, it is expressed in Maxwell's equations which describe how these fields interact and propagate, (Serway et al., 2008). Furthermore, the propagation speed depends on the electric field and is inversely proportional to the magnetic field produced. Frequency and wavelength are two important parameters in electromagnetic waves.

These waves occur due to a combination of vibrations from the magnetic field and electric field. According to its properties, it can propagate in a vacuum or without a medium, is a transverse wave, and has no electric charge so that when it propagates it is not influenced by either electric or magnetic fields, reflection, refraction, interference, and bending, (Situmorang et al., 2020). In terms of exposure to electromagnetic waves, one of the things used in the development of modern technology today is radio waves with the working principle of emitters, detectors and receptors. What is becoming more of a trend is the use of mobile phones, especially in communication, one of which is mobile phones.

Radiation on cellular cell phones is included in electromagnetic radiation, this occurs due to a combination of magnetic fields and electric fields which oscillate and propagate through space and carry energy from one place to another (Situmorang et al., 2020). In the context of communication, realistically mobile phones can change a very wide world into a narrow one. In wireless communication technology, essentially mobile phones are now changing the way we communicate and interact with the world around us, both prioritizing audio and visual in emitting electromagnetic waves at certain frequencies to transmit and communicate. receive information.

In its interactions, the propagation of these electromagnetic waves can interact with surrounding materials, which is very important, especially metallic materials. Metals are one of the natural resources that have chemical elements that readily form ions (cations) and have metallic bonds from three groups of elements which are differentiated by ionization and bonding properties, along with metalloids and non-metals. Metal is not transparent or translucent and can generally be polished to make it shiny (Putra et al., 2019). According to Nurdin (2019), metals have properties including chemical, physical, mechanical and technological properties. Based on chemical properties, one thing that is used in the modern communications industry to transmit, detect and capture electromagnetic waves well is to use aluminum metal.

According to Yunianto (2021), aluminum is a non-ferrous element which is a light metal that has light properties, is resistant to corrosion and conducts electricity and heat well, is easy to shape through forming and machining processes. Aluminum is a light metal that has corrosion resistance properties with good flowability so it is mostly used in various household appliance applications, one of which is aluminum foil in food packaging, automotive and telecommunications industries (Wisnujati & Sepriansyah, 2018). In the context of telecommunications, testing to detect other cell phones isolated in aluminum foil cannot be reached by the emission of paired electromagnetic waves. This is because aluminum foil is resistant to electromagnetic wave radiation where its function is as a shield.

According to Dharmawan et al., (2020) the effectiveness of aluminum foil as a shield is because it has the potential for reflection loss (most of the energy reflected by perization rather than penetration) and absorption loss (energy dissipated in the shield). Aluminum foil is generally ± 0.2 mm, called foil because sheets with a thickness of under 150 microns contain around 92% - 94% bauxite-based material (Agusti et al., 2022). Based on the reflective and absorptive properties of aluminum foil against electromagnetic waves, it makes it an interesting subject for research.

In principle, an intrinsic understanding of aluminum foil in absorbing and reflecting electromagnetic waves can assimilate important insights in various applications, especially increasing the efficiency of wireless communications using mobile phones, controlling signal interference, and better device design. Cellular telephones use electromagnetic wave frequencies in the range of 900-1800 MHz, where the frequency of cellular telephones is in the non-ionizing type wave category (Rahmadiani, 2021). This can cause absorption symptoms in the aluminum foil material when electromagnetic waves pass through it.

This absorption of electromagnetic waves occurs when wave energy is transferred to the aluminum material through which it passes. In principle, this results in a decrease in wave intensity. So there is an absorption coefficient that occurs between the electromagnetic wave signals that it absorbs. This can be known by calculating the coefficient between the signal before and after passing through it. Therefore, the calculation of the absorption coefficient can be used as a parameter to measure how much energy is absorbed by the aluminum foil material. However, we must prioritize the factors that influence the absorption itself, including wave frequency, material thickness, and material properties so that reflection occurs.

Apart from absorption, electromagnetic waves also experience reflection when these waves meet the surface of the material and are reflected. According to (Jewett & Serway, 2018) this wave will change if there is a change in the medium it is directed at so that the wave energy that falls on the surface also undergoes transmission. To find out the magnitude of the reflection produced by aluminum foil, we can find out through the results of calculating the reflection coefficient. The reflection coefficient is a way to measure how much wave energy is reflected by the surface of the aluminum foil material.

The size of the reflection is influenced by the angle of incidence, the surface area of the aluminum, and the difference in impedance between the propagation medium and the aluminum foil. Judging from its conductivity characteristics, it can allow electrons to move freely. In the process of absorption and reflection, varying thicknesses of aluminum foil can affect the electromagnetic wave signal from cellular cell phones.

Cellular cell phones are devices that emit electromagnetic waves in a fairly high-frequency range, where these signals can be used for data and voice communications. In this research, cellular phones are used as a source of electromagnetic signals because of their ease of access and relevance to everyday applications, especially in accessing information based on user interests.

By measuring the signal intensity emitted by mobile phones, mobile phones can interact with aluminum foil to explore various practical and theoretical aspects of electromagnetic waves. This can be accessed via a signal meter application on a cellphone or an external detection device can be used to measure changes in signal intensity accurately.

METHOD

This research is experimental research aimed at exploring the absorption and reflection characteristics of electromagnetic waves on aluminum foil using a cellular cell phone as a signal source. By measuring the signal intensity absorbed and reflected by aluminum foil at various distances and angles of incidence. In other words, research can determine the existence of interactions between electromagnetic waves and metal materials in the form of aluminum foil when signal dispersion and reflection can be measured with the app's signal detector.

The tools and materials used in this research are a mobile phone, an aluminum foil sheet with a width of 30 cm and a length of 40 cm, and an electromagnetic signal detector application with a signal detector app, as well as an ultimate EMF detector. From the observation data, the absorption and reflection coefficient values can be calculated for analysis:

RESULT AND DISCUSSIONS

Absorption Measurement

Based on the results of measurements by the signal detector, the signal intensity received by the detector decreases when aluminum foil is placed in the signal path. The following figure shows the signal intensity received by the signal detector without aluminum foil Io is 106 units.

Figure 1: The condition of the cell phone is on aluminum foil

The absorbance measurement results are shown in the figure1.2, the signal intensity received by the signal detector after passing through the aluminum foil Io is 96.

Figure 2: Condition of cell phone away from aluminum foil

Based on the results of the signal detector detected by the signal detector, the absorption coefficient (∝) can be calculated using the following equation.

$$\propto = \frac{I_0 - I}{I_0} = \frac{106-99}{106} = \frac{7}{106} = 0{,}066 = 6{,}6\,\%$$

Based on the data above, the calculated absorption coefficient is 0.066 or 6.6% of the electromagnetic wave signal is absorbed by aluminum. In other words, 94% of electromagnetic wave signals are reflected. This value can be adjusted to the frequency of the incoming waves and the frequency of the electromagnetic waves emitted.

Reflection Measurement

Based on the intensity of the electric field and magnetic field obtained through measurements on the EMF detector before it is reflected and after it is reflected by the aluminum foil, it can be seen in the following picture.

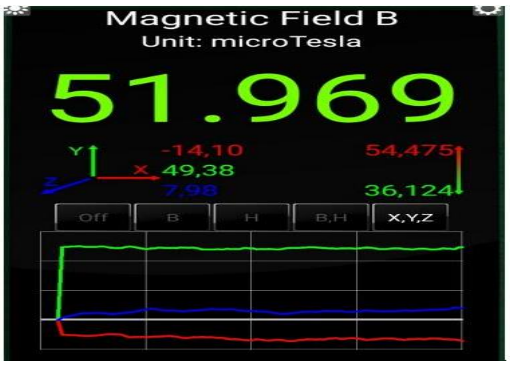

Figure 3: The intensity of the magnetic field and electric field before reflection

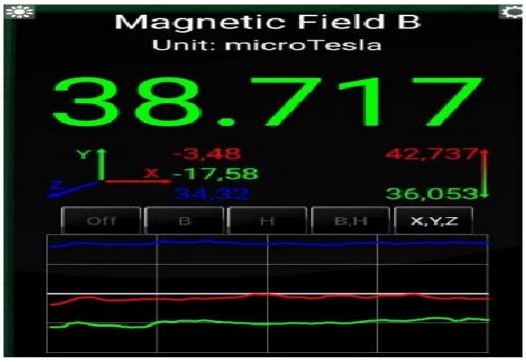

Figure 4: The intensity of the magnetic field and electric field after being reflected through aluminum foil

Under the results of the electric field intensity before being reflected, EI = 14.10 V/m, and after being reflected, ER = 3.48. Meanwhile, the magnetic field intensity before being reflected was 7.98 μT and after being reflected was 34.42 μT. Thus, the signal reflection results can be calculated based on the electric field intensity according to the Fresnel equation. Fresnel equation for reflection coefficient (R) is:

$$R = \frac{ER}{EI} = \frac{3,48}{14.10} = 0,25 = 25\ \%$$

From the calculation results, the reflection coefficient of the reflected signal is 0.25 or 25%. In other words, electromagnetic waves are reflected by the aluminum foil when it falls on the aluminum foil sheet.

Based on the results of reflection coefficient calculations, aluminum foil has a high reflection coefficient, which is in line with theoretical predictions about the reflective properties of metals against electromagnetic waves. From the findings, both detective data on the detector and absorption coefficient calculation data show that aluminum foil has high reflective properties against electromagnetic waves. This property is caused by the free electrons in the metal interacting directly with the electromagnetic field. Absorption also occurs but in a smaller proportion compared to reflection.

Based on the results of the analysis above, it can be concluded that the role of aluminum foil is very good for use in the communication industry. Thus, knowledge of the absorption and reflection of electromagnetic waves by aluminum foil has practical implications in the design of communication devices and signal interference control techniques. Aluminum foil can be used as a shielding or controlling material to direct electromagnetic signals as needed. On the other hand, it can have negative implications for cellphone electronic devices that are inserted into the aluminum foil circle. In this principle, there are no electromagnetic wave signals that can propagate or penetrate the aluminum foil itself, making it difficult to detect its presence.

CONCLUSIONS

Based on the experimental results obtained, it shows that the absorption coefficient produced by aluminum foil is 6.6% while the reflection coefficient is 25%. It can be concluded that aluminum foil has a significant ability to absorb and reflect electromagnetic waves emitted by cellular cellphones even though the cellphone signal strength reaches - 84 dbm (decibel-milli) 55 Arbitrary Strength Unit (ASU). In other words, the reflection coefficient of aluminum foil is higher than the absorption coefficient. Thus, in its use aluminum foil is more effective in reflecting electromagnetic signals than absorbing them. These findings are in harmony and consistent with the theory of electromagnetic waves and the physical properties of metals.

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