ELECTROMAGNETIC RADIATION CONCERNING HUMAN HEALTH AND ENVIRONMENTAL ISSUES

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To my beloved Father and Mother...

And my dearly friends...

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ABSTRACT

Reports about the possibility of adverse effects posed by electromagnetic radiation on humans and environment are being discussed more often these days. In conjunction with this, the main objective of this project focuses on the possible electromagnetic (EM) radiation risks, based on some simple experiments conducted in the laboratory. The scope of this study covers the fundamentals of Electromagnetic field theory, issues regarding health hazard of electromagnetic radiation to humans and environment, and some experiment the result and analysis carried out. The experimental work carried out in this project aims to study the extent of different types of materials such as wood, glass, polystyrene, plastic and cloth, to reducing of electromagnetic field exposure to humans and the environment. The source of electromagnetic wave used in this project is a microwave signal operating at a frequency of 9.40 GHz.

ABSTRAK

Laporan mengenai terdapatnya kebarangkalian bahaya daripada radiasi elektromagnetik kepada manusia dan persekitaran seringkali dibincangkan sejak kebelakangan ini. Sejajar dengan ini, objektif utama projek tertumpu kepada kemungkinan bahayanya radiasi elektromagnetik (EM), berdasarkan eksperimen yang mudah yang dijalankan di dalam makmal. Skop untuk kajian ini merangkumi asas elektromagnetik, isu-isu berkaitan dengan risiko radiasi elektromagnetik terhadap kesihatan manusia dan persekitaran serta keputusan dan analisis beberapa eksperimen yang telah dijalankan. Eksperimen yang dijalankan dalam projek ini bertujuan untuk mengkaji setahap mana beberapa jenis bahan seperti kayu, kaca, polisterin, kertas, plastik dan kain dapat menghalang kadar dedahan gelombang electromagnetik terhadap manusia dan persekitaran. Sumber gelombang elektromagnetik yang digunakan dalam eksperimen ini ialah gelombang mikro dengan frekuansi 9.40 GHz.

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CHAPTER 1

INTRODUCTION

1.1 Basic Principle of Electromagnetic Radiation

In this report, the concern is mainly on radiation phenomena associated with electromagnetic fields and how it relates to human health and environment. Basically the electromagnetic field deals with electric and magnetic fields. The fundamental fields equation for electromagnetic fields can be represented by Maxwell's equation. These are a set of partial differential equations, which describe the space and time behavior of the electromagnetic field vectors.

When plane electromagnetic waves propagate through space it carry energy, which is in the form of heat. For the creation of electromagnetic waves, specific structures with time-varying charge and currents are needed. The process of producing electromagnetic waves, which then propagate with no connection to the source, is known as electromagnetic radiation.

Electromagnetic radiation in our environment influences the human body and environment as a whole. It prohibits oxygen proper access to tissue and cells and eliminates certain micro substances that are necessary in a healthy human body. Some examples on the effect from exposure to electromagnetic radiation are cancer, changes in behavior, memory loss, Parkinson's and Alzheimer's diseases, and many others.

1.2 Objectives

Therefore in this research, I have set a few objectives as guidelines in order to complete this work.

1) To study on the possible danger posed by electromagnetic radiation on our health and environment.

2) To find out the risk of electromagnetic waves and how significant association between indicators of exposure to normal and above-average waves.

3) To do comparison on different types of materials such as wood, glass, polystyrene, paper, cloth and plastic in order to determine which materials has a potential to blocked electromagnetic radiation.

1.3 Thesis Outline

Chapter 1 briefly describes the project that being carried out. A short introduction on the fundamental of electromagnetic field and radiation has been explained in this section. It also stated the objective of this project.

In the Second Chapter, the basic principles related to electromagnetic radiation such as electric and magnetic field vectors, Coulomb's Law, Maxwell's Equation, Ampere's and Biot-Savart's Law, magnetic materials and many more are introduced.

Chapter 3 introduces the nature and propagation of electromagnetic radiation in order to get a better understanding of the theory of electromagnetic energy radiation principle. In chapter 4 some properties of microwave in lossy media is discussed. This chapter is important because it state how microwave can affect human health.

Chapter 5 touched on the basic principle of antenna as it plays an important role in transmitting and/or receiving electromagnetic waves thus producing the electromagnetic radiation.

Chapter 6 focuses on the effects of electromagnetic radiation on human health and our environment and some discussion on the normal and above-average doses of radiation. Chapter 7 will include the experimental procedure and result. The experiment is based on the manual book of CASSY (Computer Assisted Science System) Directional Patterns. Therefore, the result is obtained using CASSY Pack-E Directional Patterns software (s/n: 524 782).

The final chapter concludes the overall project and some recommendation based on the problem faced in completing this project.

CHAPTER 2

FUNDAMENTALS OF ELECTROMAGNETIC

2.1 Introduction

Electromagnetism deals with the study of electric and magnetic fields. It is useful to be familiarizing with the concept of field, and in particular with electric and magnetic fields. These fields are vector quantities and their behavior is governed by a set of laws known as Maxwell's equation [1].

Limitations on the speed of modern computers, the range of validity of electrical circuit theory, and the principles of signal transmission are just a few examples of topics for which knowledge of electromagnetic is indispensable. Electromagnetic devices are almost everywhere: in TV receivers, car ignition systems, mobile phones and many others. Although it may sometimes be hard to see the fundamental electromagnetic concepts on which their operation is based, these devices certainly cannot be designed and how they work cannot be understood if we don't know the basic electromagnetic principles.

There are also some equation and laws which concern with the study of electromagnetism such as the Coulomb's Law where it showed the characteristic of two charged bodies which are separated by r distance that can be consider as point charges. Beside that, the Ampere's and Biot-Savart's Law, the Lorentz Force, Maxwell's Equations, magnetic material and the summary of equation for static fields will also be discussed.

2.2 The Field Vectors

In order to describe the electromagnetic field, 4 vectors are used [2]:

E = Electric field vector (stat volt/cm)
D = Electric displacement vector or dielectric displacement vector or, simply, displacement vector (stat volts/cm).
B = Magnetic displacement vector or magnetic field vector (gauss)*
H = Magnetic field vector (oersted)*

E and **B** is the fundamental field vectors, and that **D** and **H** can be obtained from these together with the properties of the medium in which the fields occur [2].

The mathematical relation that the field vectors satisfy cannot be derived, as they must be obtained from experiment [2]. Thus the law of electromagnetism that is valid for steady-state condition is discussed in the next section. The results of these considerations may be summarized in Maxwell's equations, which seem to be true and an accurate description of the behaviors of electromagnetic fields [2].

* The unit oersted and gauss are identical, but historically oersted is applied to H and gauss to B. (Heald M. A., Marion J. B., 1980)

2.3 Coulomb's Law

Experiments conducted by Coulomb showed that the following hold for two charged bodies that can be considered as *point charges* [1]:

1. The magnitude of the forces is proportional to the product of the magnitudes of the charges,
2. the magnitude of the forces is inversely proportional to the square of the distance between the charges,
3. the magnitude of the forces depends on the medium,
4. the direction of the forces is along the line joining the charges, and
5. like charges repel; unlike charges attract.

For free space, the constant of proportionality is $1 / 4\pi\varepsilon_0$, where ε_0 is known as the permittivity of free space, having a value 8.854×10^{-12} F/m. Thus, consider two point charges Q_1 C and Q_2 C separated R m in free space, as shown in Figure 2.3.1, then the forces $\mathbf{F}_1$ and $\mathbf{F}_2$ experienced by Q_1 and Q_2 respectively, are given by

$$\mathbf{F}_1 = \frac{Q_1 Q_2}{4\pi\varepsilon_0 R^2}\mathbf{a}_{21} \qquad \text{Eqn 2.3(i)}$$

and

$$\mathbf{F}_2 = \frac{Q_2 Q_1}{4\pi\varepsilon_o R^2}\mathbf{a}_{12} \qquad \text{Eqn 2.3(ii)}$$

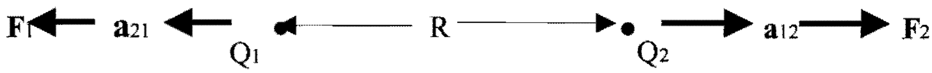

Figure 2.3.1: Repulsion forces experienced by two point charges Q_1 and Q_2

Where $\mathbf{a}_{21}$ and $\mathbf{a}_{12}$ are unit vectors along the line joining Q_1 and Q_2 as shown in Figure 2.3.1.Therefore Eqn 2.3(i) and 2.3(ii) represent *Coulomb's Law*. Since the unit of force is Newton, note that the ε_0 has the units (coulomb) ^{2} per (Newton-meter^2). These are commonly known as *farads per meter* (F/m), where a farad is (coulomb) ^{2} per Newton-meter [1].

2.4 The concept of Electric and Magnetic Field

Assume that the position of the charge Q_1 in Coulomb's law is known, and several charges close to charge Q_1 are of unknown magnitudes and signs and at unknown locations (figure 2.4.1).

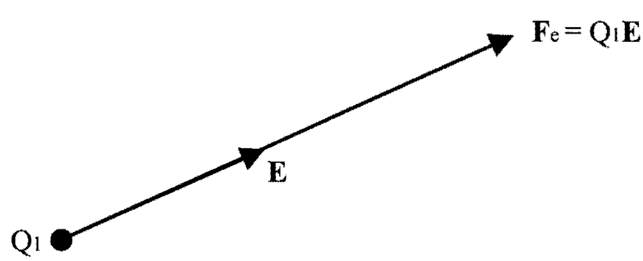

Figure 2.4.1: The electric field vector, **E**, is defined by the forces acting on a charged particles

The force acting on Q1 cannot be calculated using Coulomb's law, but from Coulomb's law, and knowing that mechanical forces add as vectors, we predict that there will be a force on Q1 proportional to Q1 itself given by [3]:

$$\mathbf{F}_e = Q_1\mathbf{E} \qquad \text{Eqn 2.4(i)}$$

This is the definition of the *electric field strength* denote by **E**. It is a vector equal to the force on a small charged body at a point in space, divided by the charge of the body [3]. The unit of electric field strength is Newton per coulomb, or more commonly volt per meter, where a volt is Newton-meter per coulomb. The test charge should be so small that it does not alter the electric field in which it is placed [1].

Note that **E** generally differs from one point to another, and that it frequently varies in time (for example, if we move the charges producing **E**). The domain of space where there is a force on a charged body is called the *electric field* [3]. Thus the electric field can be described by **E**, a vector function of space coordinates (and possibly of time). Obviously, sources of electric field are electric charges and currents. If source producing the field are not moving, the field can be calculated from Coulomb's law. This kind of field is termed the *electrostatic field*, meaning 'the field produced by electric charges that are not moving [3].

Another important property of the electric field is that it is *linear*. That is, the principle of superposition applies and the field due to a number of charges is just the vector sum of the individual fields. If it were not for this property, the analysis of electromagnetic phenomena would be virtually impossible [2].

Now consider the magnetic forces between two current elements for the case of two parallel short wire segments l_1 and l_2 with current I_1 and I_2, shown in Figure 2.4.2 is given by:

$$F_m = k_m \frac{(I_1 l_1)(I_2 l_s)}{r^2} \qquad \text{Eqn 2.4(ii)}$$

where k_m is a constant. The direction of the force in figure 2.4.2 (parallel elements with current in the same direction) is attractive. It is repulsive if the currents in the elements are in opposite directions [3].

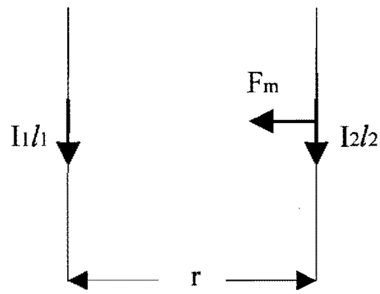

Figure 2.4.2: Magnetic force between two parallel current elements

Lets assume that there are several currents of unknown intensities, directions, and are positioned closed to current element $I_1 l_1$. The resulting magnetic force will be proportional to $I_1 l_1$. The current elements are nothing but small domains with moving charges. Let the velocity of charges in the current element $I_1 l_1$ be **v**, and the charge of individual charge carriers in the current element be Q. The force on the current element is the result of forces on individual moving charges carriers, so that the forces on a single charge carrier should be expected to be proportional to Q**v** [3]. Experimentally, the expression for this force is found to be of the form

$$\mathbf{F}_m = Q\mathbf{v} \times \mathbf{B} \qquad \text{Eqn 2.4(iii)}$$

Where the sign “x” implies the vector, or cross, product of two vectors.

The vectors **B** is known as the magnetic induction vector or the magnetic flux density vector [3]. If in a region of space a force of the form in Eqn 2.4(iii) exists on a moving charge, the region is termed as magnetic field.

2.5 The Laws of Ampére and Biot-Savart

Next we will show that electric currents produce magnetic fields* [2]. If a current ***I*** (stat amperes) flows in a wire, and if we map by some means the magnetic field that is produced in free space and compute the line integral of $\mathbf{B} \cdot d\mathbf{l}$ along any closed path that surrounds the wire, the result is proportional to ***I***, independent of the details of the path figure 2.5.1. This fact is expressed by the *Ampére' circuital law* [2]:

$$\oint_{\Gamma} \mathbf{B} \cdot d\mathbf{l} = \frac{4\pi}{c}\mathbf{I} \qquad \text{Eqn 2.5(i)}$$

The constant of proportionality, 4π/c, is a consequence of using the Gaussian units. The quantity c is the velocity of light in free space and the reason for its appearance in Ampere’s law will become apparent only after examining the wave properties of the electromagnetic field. The differential expression of Ampere’s law is given by:

$$\mathbf{curl B} = \frac{4\pi}{c}\mathbf{J} \qquad \text{(Total current)} \qquad \text{Eqn 2.5(ii)}$$

* Discovered in 1820 by Hans Christian Oersted (1777-1852)

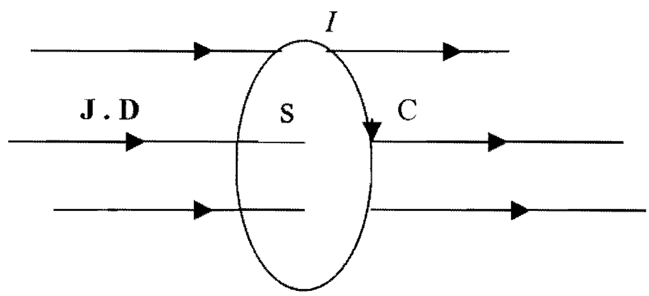

Figure 2.5.1: Illustrating Ampere's Circuital Law

The *Biot-Savart law* relates to the magnetic field produced by an element of a circuit in which a current flows [2]. The differential statement is

$$d\mathbf{B} = \frac{\mathbf{I}}{c}\frac{d\mathbf{l} \times \mathbf{e}_r}{\mathbf{r}^2} \qquad \text{Eqn 2.5(iii)}$$

where $\mathbf{e}_r$ = unit vector

$\mathbf{r}$ = distance between two charges

c = velocity of light

Portion of a circuit cannot be isolate and treat alone the effects of such an element; a circuit must form a complete loop in order that a steady current may flow. Therefore, by integrating Eqn 2.6(i) completely around the circuit, we obtain

$$\mathbf{B} = \frac{\mathbf{I}}{c}\oint\frac{d\mathbf{l} \times \mathbf{e}_r}{\mathbf{r}^2} \qquad \text{Eqn 2.5(iv)}$$

where the path of integration must correspond exactly with the circuit loop.