

THEORETICAL MODELLING OF ELECTROMAGNETIC FIELD RADIATION  
PROFILE FOR CELLULAR TRANSMISSION TOWER

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## **DEDICATION**

*To my beloved family, friends and loved ones for their support and sacrifices*

## **ACKNOWLEDGEMENT**

In the name of Allah, the Most Gracious, and Most Merciful. I would like to express my heartfelt gratitude to my supervisor, my family, and my friends.

## **ABSTRACT**

Electromagnetic waves are generally perceived to be harmful because of the radiation they produce and may result to numerous health issues such as depression, cancer, brain tumour, chronic fatigue syndrome, insomnia, suppressed immune function and more. Electromagnetic field (EMF) radiation from antennas used either for radio and television broadcast transmissions or wireless telecommunication transmissions such as cellular signals result in certain exposure levels on the ground. The levels of this radiation continue to increase due to more wireless systems. There is inadequate evidence regarding environmental exposures from transmitters, including television, radio, and military transmissions as well as mobile phone networks, due to lack of high-quality studies with accurate individual exposure assessment. There is very little work done by independent bodies to collect actual data and to accurately model the profile of the EMF radiation level surrounding cellular towers since the emergence of the 4G LTE technology in Malaysian environment. In this project, a mathematical model has been developed, using Maxwell's equations and Helmholtz's wave equations to determine power density of electromagnetic waves at discrete point from a source at different distances from the point of propagation. The equations were simulated using MATLAB software to show graphical representation and profile of power density which shows a continuous attenuation of the waves as opposed to uniform propagation in free space.

## **ABSTRAK**

Gelombang elektromagnetik secara amnya dianggap berbahaya kerana radiasi yang dihasilkannya dan dipercayai boleh mengakibatkan banyak masalah kesihatan seperti kemurungan, barah, tumor otak, sindrom keletihan kronik, insomnia, fungsi imun yang ditindas dan banyak lagi. Radiasi medan elektromagnetik (EMF) daripada antenna yang digunakan sama ada untuk penghantaran siaran radio dan televisyen atau transmisi telekomunikasi tanpa wayar seperti isyarat selular mengakibatkan tahap pendedahan radiasi tertentu di persekitaran. Tahap radiasi ini terus meningkat kerana lebih banyak sistem tanpa wayar digunakan. Namun, tidak terdapat bukti yang memadai mengenai pendedahan radiasi tersebut ke persekitaran, termasuk transmisi televisyen, radio, dan ketenteraan serta rangkaian telefon bimbit, kerana kurangnya kajian yang berkualiti dan penilaian pendedahan radiasi secara individu yang tepat. Disamping itu, tidak terdapat banyak kajian yang dilakukan oleh badan bebas untuk mengumpulkan data sebenar dan memodelkan profil tahap radiasi EMF dengan tepat di sekitar menara selular sejak munculnya teknologi 4G LTE di Malaysia. Oleh itu, dalam projek ini, model matematik telah dikembangkan, menggunakan persamaan Maxwell dan persamaan gelombang Helmholtz untuk menentukan ketumpatan kuasa gelombang elektromagnetik pada suatu titik yang tertentu dari pemancar dan pada jarak yang berbeza. Persamaan disimulasikan menggunakan perisian MATLAB untuk menunjukkan perwakilan grafik dan profil ketumpatan kuasa yang menunjukkan pelemahan gelombang adalah berterusan berbanding dengan penyebaran seragam di ruang bebas.

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## LIST OF SYMBOLS

$\sigma$	-	Conductivity
I	-	Current
J	-	Current density
F	-	Frequency
E	-	Electric field strength
H	-	Magnetic field strength
B	-	Magnetic flux density
$\gamma$	-	Propagation constant
M	-	Magnetic permeability
E	-	Permittivity of medium
$\beta$	-	Phase constant
$\alpha$	-	Attenuation constant
$\eta$	-	Intrinsic impedance
S	-	Power density
T	-	Time for analysis
Z	-	Range of space under analysis

# CHAPTER 1

## INTRODUCTION

### 1.1 Project Background

In recent years, the communications industry has undergone unprecedented growth, which has resulted in a dramatic increase in the number of wireless enabled devices. The telecommunications industry also considered to be one of the fastest growing industries due to the introduction of 5G technology as well as the fundamental technology of GSM which results in a plethora of cell towers reaching up to 22,682 towers for mobile communications as of September 2018, representing almost 2,000 mobile subscribers per tower as shown in figure 1.1

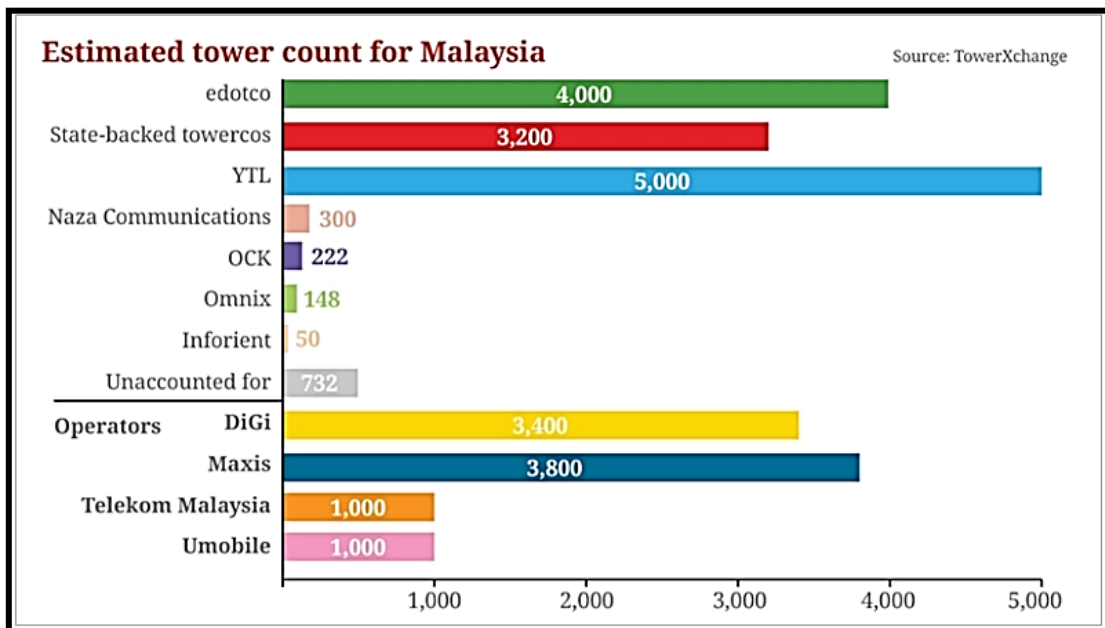


Figure 1.1 Number of cell towers in Malaysia

Besides the need for high coverage due to 5G, the state of the art multimedia communication requires higher processing power that leads to higher electromagnetic radiation from cell towers. Cell towers provide the link in which cell phones use for

communications, they are located in urban and rural areas. Recent studies discuss the benefits and disadvantages of cell towers due to their important concerns for health. Cell phones and cell towers produces electromagnetic radiations that due to poor regulations and monitoring may affect human health. Electromagnetic waves are synchronous oscillations of both electric and magnetic fields, which are caused by each other. Simply the EM waves are produced by interactions between an electrical field and a magnetic field as shown in figure 1.2. Moreover, the placement of cell towers is an ongoing research, most cell towers in urban areas are placed near schools and in dense populated areas which exposes the people to high electromagnetic radiations. Moreover, cell phone technology produced cell phones that contains more than one SIM card, which means more than one transceiver is in one phone. This kind of cell phones may expose a higher electromagnetic radiation on the owner of the cell phone. The increase in cell towers is justified to the rapid growth in telecommunication industry, this increase causes some concerns among researches. In this project we intend to explore the effects of electromagnetic field radiation of cell towers and come up with a theoretical model to overcome the higher electromagnetic field radiation.

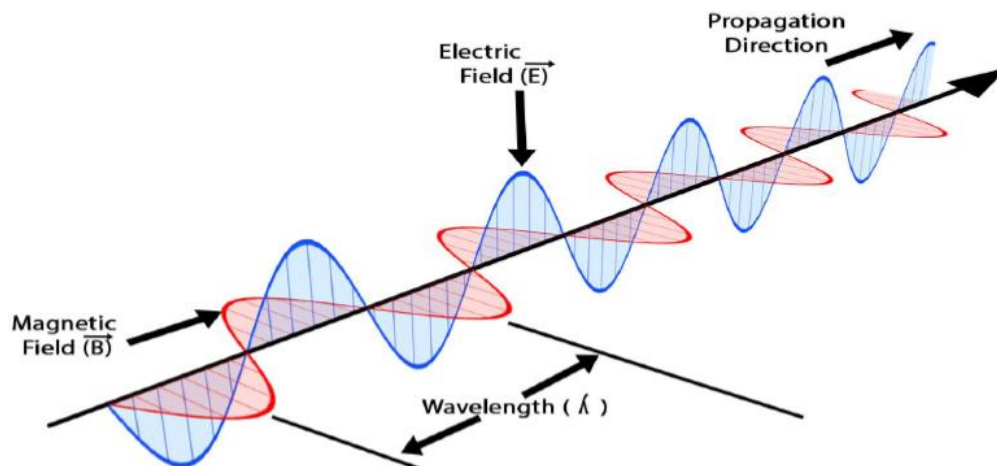


Figure 1.2 Electromagnetic wave

## **1.2 Problem Statement**

Despite the rapid growth in the telecommunications industry and the great value of the recent technologies, there is a great concern in the increase of Electromagnetic Field Radiation (EMF) due to the increase in number of cell phones and cell towers. Cellular transmission towers which are the core of telecommunication service providers cause health issue due to their high exposure of electromagnetic radiation to the public. Due to the poor placement regulations, telecommunication service providers deploy the cell towers near populated areas such as schools, hospitals, and public markets. This high EMF radiation exposure is believed to be harmful and may constitute to various health hazards including cancer, brain tumors, suppressed immune function, neuroendocrine disruption, chronic fatigue syndrome, and depression. These EMF emissions continue to increase due to the rapid growth of wireless telecommunication systems (cell towers). Hence, it is important to develop enough data using fundamental mathematical model to ascertain the strength of signal density of EM waves from a source, which can greatly help in reduction of EMF radiation exposure on public and prevent health issues caused by wireless telecommunication systems.

## **1.3 Project Goal**

This research focus on developing a theoretical model for EMF radiation profile for cellular transmission tower to predict the strength of signal density of EM waves from a source. This prediction can be used in developing and deploying future cell towers and wireless enabled devices that are expected in 5G.

## **1.4 Project Objectives**

The objectives of the research are:

1. To exploit mathematical model using Maxwell's equations and Helmholtz's wave equations to determine power density of electromagnetic waves at discrete points from a source
2. To use the developed model using Maxwell and Helmholtz's equations to show power density profile at different distances from source using MATLAB simulation.

### **1.5 Scope of Project**

The scope of this project is:

1. To Derive the Helmholtz's wave equation model.
2. The Model is to be used in Far Field Region only.
3. To simulate the signal density from the derived model using MATLAB software.

### **1.6 Contributions**

The main contribution of this project is to provide an adequate solution for determining the level of exposure to EMF radiation at certain distances from a source, and develop a model that can be used as a basis in understanding how EMF radiation affects our health. These contributions are expected to be standardized for the purpose of ease development and deployment of wireless enabled devices and cell towers.

### **1.7 Project Outline**

This project will present the development, and theoretical modelling of EMF radiation profile of cellular transmission tower. Chapter 1 presents the introduction,

problem statement, project objective, scope of the project, and main contributions of the research. Chapter 2 will discuss related works and studies on different aspects such as the electromagnetic field radiation in literature. Chapter 3 highlights the methodology of this project detailing the steps taken to develop the theoretical model and explains the tools and the mathematical methods used.

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