



**Faculty of Electrical and Electronic Engineering Technology**

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**DEVELOPMENT OF A LOW-COST WATER BASED  
TRANSPARENT ANTENNA FOR SUB 6 GHZ 5G  
COMMUNICATION SYSTEMS**

اونيورسيتي تيكنيكل مليسيا ملاك  
UNIVERSITI TEKNIKAL MALAYSIA MELAKA  
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**Bachelor of Electronics Engineering Technology (Telecommunications) with Honours**

**2023**

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TRANSPARENT ANTENNA FOR SUB 6 GHZ 5G  
COMMUNICATION SYSTEMS**

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**2023**

Tajuk Projek : Development of a Low-Cost Water Based Transparent Antenna for  
Sub 6 GHz 5G Communication System

Sesi Pengajian : 2019/2020

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## DEDICATION

*Thanks to Allah,*

*For giving me good health and strength to finish this work.*

*To my beloved mother and my lovely father,*

*I dedicate this study*

*to all of those who patiently stood by and comforted and encouraged me*

*during difficult and turbulent times.*

*They instilled in me desire to learn and made sacrifice.*

*They always support their moral, spiritual, emotional, and financial support.*

*They are also my source of inspiration and my source of strength when I wanted to give up.*

*To my brothers,*

*Thanks, with shared their words of advice and encouragement to finish this study.*

*To Dr. Muhammad Inam Abbasi,*

*Thanks for the guidance given. Hopefully I will be remembered.*

*and also,*

*this dedicated to my infinite friends*

*who have always supported me throughout my years of studies.*

## ABSTRACT

In this day and age, many people know about technology because with the advent of technology, it can make human life more enjoyable in doing daily activities. So, communication system is one of the technologies that can give a lot of impact in life. For example, in the old days, communication systems such as telephones that had a 3G bottom line, did not get response because they did not know about communication technology. So now, technology systems have evolved rapidly in the technology era and have evolved to 5G communication systems so that human beings can communicate with outsiders without restrictions. 5G communication systems provide many potentials and challenges for antenna designers. One of the challenges is to develop transparent antennas to provide freedom of antenna integration with other components. Many researchers have proposed different techniques for the design of transparent antennas. However, most of the proposed techniques use high -cost materials that make the antenna and the overall system, expensive. Therefore, in this work the development of a low -cost water -based transparent antenna for a 5G Sub 6 GHz Communication System has been proposed. In this paper, the design of water-based antenna has used CST Microwave Software to obtain the results that have been shown.

## ***ABSTRAK***

Pada zaman ini, ramai orang mengetahui tentang teknologi kerana dengan adanya teknologi, ianya dapat menyenangkan hidup manusia dalam melakukan aktiviti seharian. Jadinya, sistem komunikasi adalah salah satu teknologi yang dapat memberikan kesan yang banyak dalam kehidupan. Contohnya, pada zaman dulu, sistem komunikasi seperti telefon yang mempunyai line bawah 3G, tidak mendapat sambutan kerana mereka tidak mengetahui tentang teknologi komunikasi. Jadi sekarang, sistem teknologi telah berkembang pesat dalam era teknologi dan sudah meningkat kepada sistem komunikasi 5G supaya manusia dapat berhubung dengan orang luar tanpa sekatan. Sistem komunikasi 5G menyediakan banyak potensi dan cabaran untuk pereka antena. Salah satu cabaran adalah untuk membangunkan antena telus untuk memberikan kebebasan integrasi antena dengan komponen lain. Ramai penyelidik telah mencadangkan teknik yang berbeza untuk reka bentuk antena lutsinar. Walau bagaimanapun, kebanyakan teknik yang dicadangkan menggunakan bahan kos tinggi yang menjadikan antena dan sistem keseluruhan, mahal. Oleh itu, dalam kerja ini pembangunan antena lutsinar berasaskan air kos rendah untuk Sistem Komunikasi 5G Sub 6 GHz telah dicadangkan. Dalam kertas kerja ini, reka bentuk antenna berasaskan air telah menggunakan Perisian Gelombang Mikro CST untuk mendapatkan keputusan yang telah ditunjukkan.

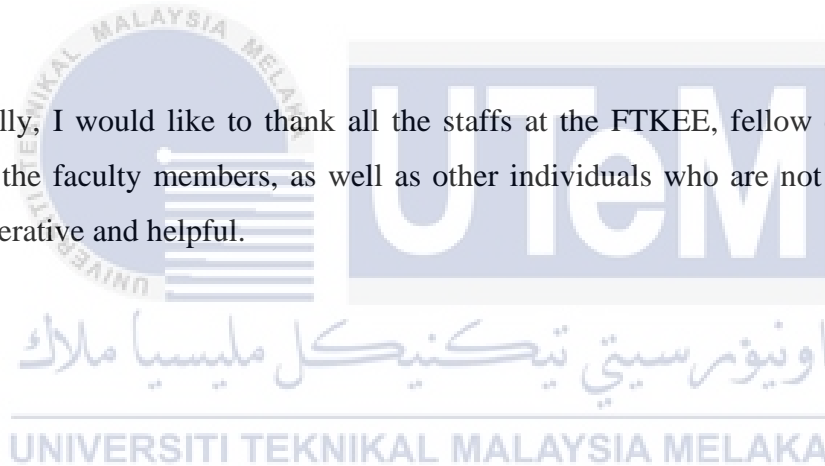


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## CHAPTER 1

### INTRODUCTION

#### 1.1 Background

An antenna that uses water to transmit and receive electromagnetic signals is known as a water-based antenna. Therefore, it is safe and simple to create, water has become a more preferred liquid medium for making low-cost antennas. Transparent antennas are useful for integrating antenna functions into surfaces such as automotive windshields and windows while maintaining visibility. The transparent antenna additionally includes a radiation patch is placed above the clear glass substrate and a frequency selective surface on the surface of the glass provides as the ground for a microstrip antenna.

#### 1.2 Problem Statement

For the designers of antennas, 5G communication systems present a wide range of opportunities and difficulties. To enable the freedom of antenna integration with other components, one issue is to design transparent antennas. Numerous academics have put forth various design methods for transparent antennas. However, the majority of the suggested approaches utilize pricey components, which raises the cost of the antenna and the entire system. Therefore, it has been suggested in this work to create a low-cost, transparent water-based antenna for sub 6 GHz 5G communication systems.

#### 1.3 Project Objective

The primary objective of this study is to develop a method for building a transparent low-cost antenna for sub 6 GHz 5G Communication Systems that is both effective and scientific. Specifically, the objectives are the following:

- a) To investigate the possibility of designing a water-based antenna for sub 6 GHz 5G communication system.
- b) To design the water-based antenna at 3.5 GHz using different types of water.
- c) To optimize the cost and performance of the proposed water-based antenna.

## 1.4 Scope of Project

The following is the project's scope:

- a) Water based antenna design using CST Microwaves.
- b) Analyze and optimize this performances using CST Microwaves.
- c) Measure the conductivity of different types of water sample using dielectric probe.
- d) Measure the scattering parameter using Network Analyze.

## 1.5 Expecting Outcome

In this project, the water-based antenna will be discussed to propose a systematic and effective methodology to develop the system which is transparent and low-cost for 5G communication systems operating at sub 6 GHz. Based on this project, this paper is investigating the possibility of designing a water-based antenna for sub 6GHz 5G communication system. Then, this paper is showing how to design the water-based antenna at 3.5 GHz using different types of water such as pure water, salt is water, sugar in water, sea water, water bottle and oil gas water. Lastly, in this paper also show how depending on the material used that improve the cost and performance of the proposed water-based antenna.

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## CHAPTER 2

### LITERATURE REVIEW

#### 2.1 Introduction

Nowadays, many people are interested in designing antennas using liquids such as water because they are flexible and reconfigurable. Therefore, the antennas that were built are expensive, difficult and high level. So, for this project, the antenna that was built is low cost using 6 GHz with the x-band is 3.5GHz. There are many kinds of material that are used in the transparent patch antenna.

In addition, the materials that others used are high cost and difficult to develop, so, we are using the water based transparent antenna to cut off the cost to become a low-cost water based transparent antenna. In recent years, water has become a more common liquid medium for antenna fabrication at low cost because it is safe and easy to develop. The materials that affect the cost are using microstrip with multilayer and metal mesh films, wideband water and dual-polarized stacked.

Furthermore, transparent antennas are helpful for integrating antenna functions into surfaces while keeping visibility, such as automobile windshields, windows and others. The transparent antenna is also made includes a radiation patch above the transparent glass substrate and a frequency-selective surface on the back of glass that operates as the ground of microstrip antenna. Therefore, for antenna designers, 5G communication technologies present several opportunities and problems. Developing transparent antennas that enable integration with other components is one of the issues with this project. Transparent antennas have been created using a variety of methods suggested by many researchers. However, the majority of the suggested methods need for pricey components, making the antenna and complete system expensive. This paper presents the development of a low-cost water-based transparent antenna for sub 6 GHz 5G communication systems.

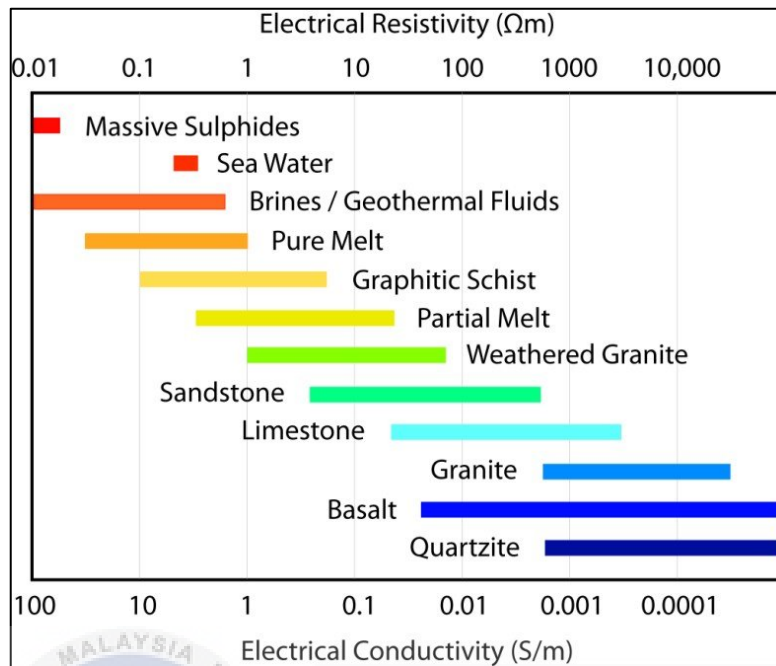
## **2.2 Transparent Antenna**

The antenna is made up of rectangular shaped branches that have been tuned for wideband performance. Using CST software to design the antenna and using the dielectric to construct it, it is composed of a radiation patch and a ground plane. One of the most critical elements to consider in order to fully exploit 5G technology is antenna design. However, the performance of an antenna can be harmed by a few design flaws. Aside from that, mechanical flaws and mistakes in the fabrication process might have an impact on antenna performance.

### **2.2.1 Conductivity of Water**

Water that is pure does not conduct electricity because it is an insulator. There are no ions in water that has been thoroughly particularly when it comes, or water that is absolutely clean. As a result, because no charge flows through pure water, it cannot transmit electricity. In distilled water, there are no particles and hence no ions. There are only neutral molecules, and these neutral molecules have no charge. As a result, distilled water is not electrically conductible.

Unwanted substances such as sodium, calcium and magnesium ions can be found in tap water, rainwater, and ocean. When they are present in water, they get charged, allowing electricity to flow through the liquid. To operate as a good conductor of electricity, water does not require a huge number of contaminants even a small number of ions can enable a water source to conduct electricity. In summary, the dissolved ions and contaminants in water allow it to conduct electricity. When a battery with positive and negative poles is submerged in water, positive ions are drawn to the positive pole, providing a closed circuit, whereas negative ions are drawn to the negative pole, creating a positive charge. Water has the ability of being amphoteric, which means it can perform as a solvent.[1]



*Figure 1: Electrical Conducting Water*

In figure 1, it shows the electrical resistivity and conductivity values. Simpson and Bahr (2005) and their sources provided the values. Electrical conductivity is a valuable characteristic for defining different Earth materials because this varies by many orders of magnitude. Value ranges are represented as bars, with blue representing high resistivity and red representing low resistivity that is conductive.

	Types	Conductivity (S/cm)
[17]	Pure Water	400
[18]	Salt in Water	0.018
[18]	Sugar in Water	0
[19]	Sea Water	400
[20]	Water Bottle	26.7
[21]	Oil Gas Water	0.008

Table 1: Conductivity Water

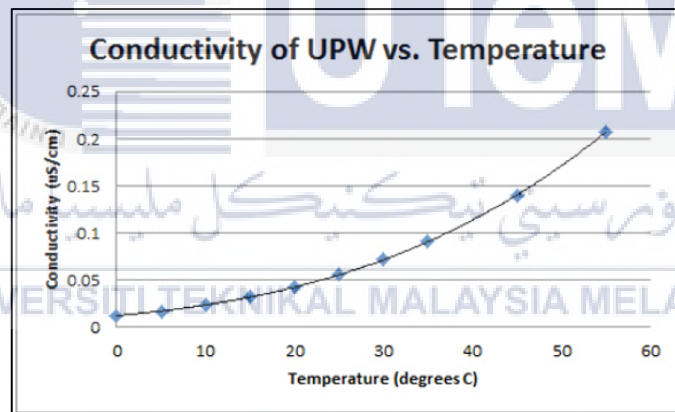


Figure 1. 1: Conductivity of Pure Water

In figure 1.1, the graph shows conductivity of pure water increasing because it starts from 0.01 $\mu\text{S}/\text{cm}$  and end with 0.21 $\mu\text{S}/\text{cm}$ . When the values of temperature increase, the conductivity is also increase.

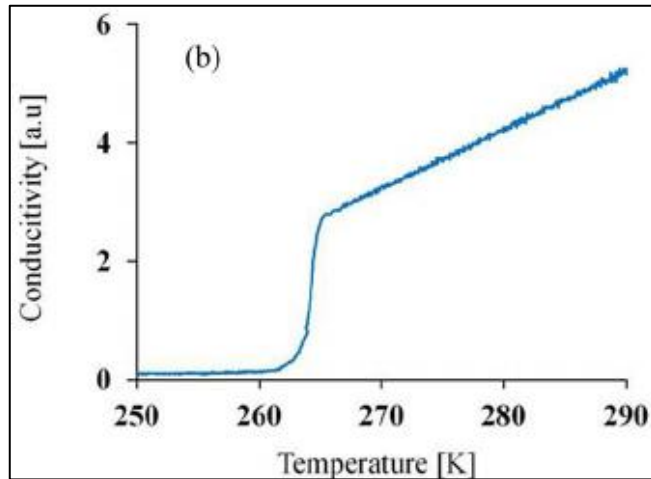


Figure 1. 2: Conductivity of Salt in Water

In figure 1.2, the graph shows conductivity of salt in water. Then, temperature from 250K to 262K constant at conductivity which is 0.2. Then, the graph increase start with 263K because when temperature increase, the conductivity is also increase.

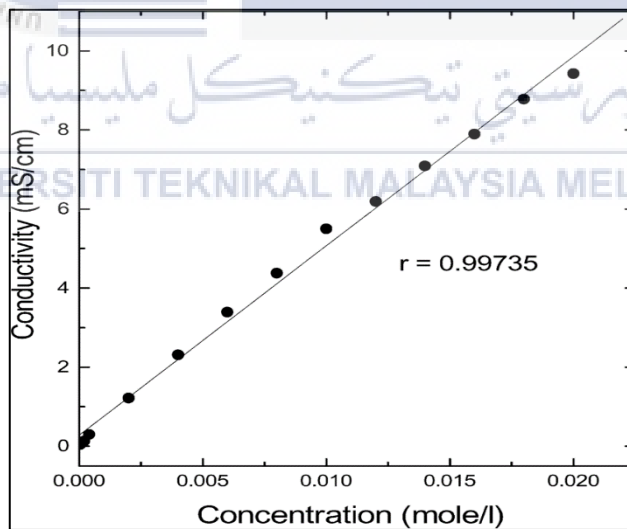


Figure 1. 3: Conductivity of Sugar in Water

In figure 1.3, the graph shows conductivity of sugar in water is increasing. When the values of concentration increase, the conductivity is also increase.