



Faculty of Electrical and Electronic Engineering Technology



**DEVELOPMENT OF TRANSPARENT ANTENNA USING WATER AS
CONDUCTING MATERIAL**

NURUL AIDA SUKMA BINTI AMRAN

Bachelor of Electronics Engineering Technology (Telecommunications) with Honours

2021

**DEVELOPMENT OF TRANSPARENT ANTENNA USING WATER AS
CONDUCTING MATERIAL**

NURUL AIDA SUKMA BINTI AMRAN

**A project report submitted
in partial fulfillment of the requirements for the degree of
Bachelor of Electronics Engineering Technology (Telecommunications) with Honours**



Faculty of Electrical and Electronic Engineering Technology

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2021

BORANG PENGESAHAN STATUS LAPORAN
PROJEK SARJANA MUDA II

Tajuk Projek :

Sesi Pengajian :

Saya Nurul Aida Sukma Binti Amran mengaku membenarkan laporan Projek Sarjana Muda ini disimpan di Perpustakaan dengan syarat-syarat kegunaan seperti berikut:

1. Laporan adalah hakmilik Universiti Teknikal Malaysia Melaka.
2. Perpustakaan dibenarkan membuat salinan untuk tujuan pengajian sahaja.
3. Perpustakaan dibenarkan membuat salinan laporan ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. Sila tandakan (✓):

SULIT*


(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia seperti yang termaktub di dalam AKTA RAHSIA RASMI 1972)

TERHAD*

(Mengandungi maklumat yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)

TIDAK TERHAD

Disahkan oleh:



(TANDATANGAN PENULIS)

Alamat Tetap:

NO 4 JALAN BUKIT ANGIN
3/1 TAMAN BUKIT ANGIN
28000 TEMERLOH
PAHANG

Tarikh: 6 FEBRUARY 2022



DR. MUHAMMAD INAM ABBASI

Senior Lecturer
Department of Electronic And Computer Engineering Technology
Faculty Of Electrical and Electronic Engineering Technology
University Teknikal Malaysia Melaka

(COP DAN TANDATANGAN PENYELIA)

Tarikh: 06/02/2022

DECLARATION

I declare that this project report entitled “Development of Transparent Antenna Using Water As Conducting Material” is the result of my own research except as cited in the references. The project report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature

:



Student Name

:

NURUL AIDA SUKMA BINTI AMRAN

Date

:


6 FEBRUARY 2022

اونيورسيتي تيكنيكل مليسيا ملاك

UNIVERSITI TEKNIKAL MALAYSIA MELAKA


APPROVAL


I hereby declare that I have checked this project report and in my opinion, this project report is adequate in terms of scope and quality for the award of the degree of Bachelor of Electronics Engineering Technology (Telecommunications) with Honours

Signature : 

Supervisor Name : DR MUHAMMAD INAM ABBASI

Date : 06/02/2022

Signature : 

Co-Supervisor : 

Name (if any)

Date :

DEDICATION

Special dedicated to

*My beloved family and friends for the help and encouragement throughout my study.
Thank you for my supervisor, Dr Muhammad Inam Abbasi and all the lecturers who gave
me guidance and advice throughout the process in finish my final year project.*



ABSTRACT

This research offers a low-profile transparent microstrip antenna using a substrate of lead glass and a conducting medium of water. The transparent microstrip antenna is made consisting of a thin lead glass substrate and an antenna patch with distilled water as the ground. Water is the principal conducting substance when compared to other transparent materials since it is readily available, inexpensive, and easy to make. According to early modelling data, the antenna operates at 2.45GHz. The return loss is less than -10dB. Because of its low cost and remarkable radiation performance, this revolutionary transparent patch antenna is projected to have a wide range of exciting applications in future transparent electronics and flexible electronics designs.



ABSTRAK

Penyelidikan ini menawarkan antena mikrostrip telus berprofil rendah menggunakan substrat kaca plumbum dan medium air pengalir. Antena mikrostrip telus dibuat terdiri daripada substrat kaca timah nipis dan tambalan antena dengan air suling sebagai tanah. Air adalah bahan pengalir utama jika dibandingkan dengan bahan lutsinar lain kerana mudah didapati, murah, dan mudah dibuat. Menurut data pemodelan awal, antena beroperasi pada 2.45GHz. Kerugian pulangan kurang dari -10dB. Antena tampalan telus yang inovatif ini diharapkan mempunyai pelbagai aplikasi menarik dalam reka bentuk elektronik telus dan elektronik fleksibel di masa depan kerana kos rendah dan prestasi radiasi yang luar biasa.



ACKNOWLEDGEMENTS

First and foremost, I would like to express my gratitude to my supervisor, Dr Muhammad Inam Abbasi for their precious guidance, words of wisdom and patient throughout this project.

My highest appreciation goes to my parents and family members for their love and prayer during the period of my study.

Finally, I would like to thank all my friends who took part in helping me in this project, as well as other individuals who are not listed here for being co-operative and helpful.



TABLE OF CONTENTS

	PAGE
DECLARATION	
APPROVAL	
DEDICATIONS	
ABSTRACT	i
ABSTRAK	ii
ACKNOWLEDGEMENTS	iii
TABLE OF CONTENTS	i
LIST OF TABLES	iii
LIST OF FIGURES	iv
LIST OF SYMBOLS	viii
LIST OF ABBREVIATIONS	ix
LIST OF APPENDICES	x
CHAPTER 1 INTRODUCTION	11
1.1 Background	11
1.2 Problem Statement	12
1.3 Project Objective	13
1.4 Scope of Project	13
CHAPTER 2 LITERATURE REVIEW	14
2.1 Introduction	14
2.2 Antenna	14
2.3 Transparent Antenna	16
2.4 Water as Conducting Material	23
2.5 Simulated and Measured Performances	32
2.6 Summary	39
CHAPTER 3 METHODOLOGY	41
3.1 Methodology	41
3.2 Project Flow	42
3.2.1 Gantt Chart	42
3.2.2 Flow Chart	43
3.3 Research Progress	44
3.3.1 Stage 1: Literature Review	44
3.3.2 Stage 2: Design Review	44
3.3.3 Different sample of water	47

3.3.4	Stage 3: Analysis of Simulation Result	49
3.4	Mathematical Formula and Calculation	49
CHAPTER 4	RESULTS AND DISCUSSIONS	51
4.1	Introduction	51
4.2	Calculation	51
4.3	Analysis	52
4.3.1	Dstilled Water	52
4.4	Results	68
CHAPTER 5	CONCLUSION AND RECOMMENDATIONS	71
5.1	Conclusion	71
5.2	Future Works	72
REFERENCES		73
APPENDICES		76



LIST OF TABLES

TABLE	TITLE	PAGE
Table 2. 1	Comparison of patch antennas made of water or copper	15
Table 2. 2	Comparison between different types of transparent antenna	16
Table 2. 3	Comparison of the measured performance of distilled water and salt water at room temperature of roughly 20 °C.	24
Table 2. 4	Structure of the antenna [18]	31
Table 4. 1	Frequency and S-Parameter value with different value of Lp	54
Table 4. 2	Frequency and S-Parameter value with different value of Hp	57
Table 4. 3	Frequency and S-Parameter value with different value of Wp	60
Table 4. 4	Frequency and S-Parameter value with different value of Hs	63
Table 4. 5	Frequency and S-Parameter value with different value of epsilon	66
Table 4. 6	Parameters value of the antenna	68

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

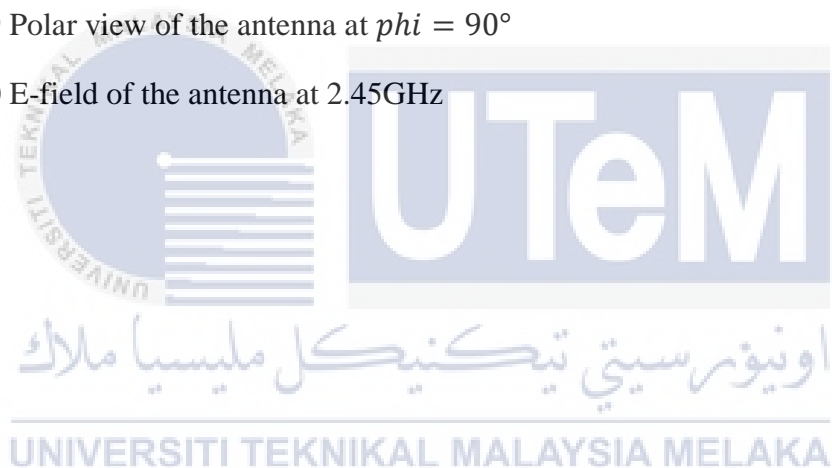
LIST OF FIGURES

FIGURE	TITLE	PAGE
Figure 2. 1	Microstrip Patch Antenna	15
Figure 2. 2	The water patch antenna's geometry [3]	17
Figure 2. 3	Side view antenna of [3]	17
Figure 2. 4	Single element of grid array [4]	18
Figure 2. 5	Photo of a solar cell with coordinate system definition and a cross section of the structure with material information [5]	18
Figure 2. 6	The optically transparent monopole antenna's geometry [6]	19
Figure 2. 7	Structure of the transparent microstrip antenna [7]	20
Figure 2. 8	Top and side view of antenna design [2]	20
Figure 2. 9	The antenna's configuration [8] (b) The absorbing metasurface unit cell from the top. (c) Transparent CPW feed microstrip antenna from the top.	21
Figure 2. 10	Structure of the element on top view and perspective view [8]	21
Figure 2. 11	Buffer layer and layers on Willow Glass including ITO [1].	22
Figure 2. 12	The microstrip patch antenna's design and dimensions [1] (a) top view. (b) side view	22
Figure 2. 13	The DRA's wideband and bandwidth-controllable hybrid glass arrangement [11]	23
Figure 2. 14	Dielectric constant and loss tangent of distilled water.	24
Figure 2. 15	Design of the water patch antenna [3] (a) 3-D view. (b) Top view. (c) Side View	25
Figure 2. 16	A sea-water monopole antenna is seen in this diagram. [13]	26
Figure 2. 17	Using a high-permittivity liquid substrate, a small monopolar water patch antenna is created. [14] (a) Side view. (b) Top view.	27
Figure 2. 18	Antenna configuration [2]. (a) Top view. (b) Side view.	27

Figure 2. 19 The proposed compact-size water patch antenna's configuration [15]	28
Figure 2. 20 Structure of a frequency-reconfigurable and optically transparent seawater antenna [16]	29
Figure 2. 21 The sea-water monopole antenna's geometry [17]	30
Figure 2. 22 Structure of the antenna [18]	31
Figure 2. 23 $ S_{11} $ and gain for the water patch antenna [3] of measured and simulated.	32
Figure 2. 24 Radiation efficiency of the water patch antenna [3]	33
Figure 2. 25 Frequency response [4]	34
Figure 2. 26 Return loss and bandwidth results [4]	34
Figure 2. 27 Simulated return loss of the antenna [6]	35
Figure 2. 28 Simulated and measure return loss of the transparent antenna [6]	35
Figure 2. 29 Simulated and measured gain pattern for the transparent antenna [7]36	
Figure 2. 30 Predicted and measured $ S_{11} $ of the water antenna [2] in free space, on flat phantom and under bending	37
Figure 2. 31 Return loss and Radiation Pattern of E plane and H plane of antenna U[8]	38
Figure 2. 32 Simulated and measured reflection coefficients of the antenna [13]	38
Figure 2. 33 Simulated and measured bandwidth and realised gain [14]	39
Figure 3. 1 Gantt Chart for PSM 1.	42
Figure 3. 2 Gantt Chart for PSM 2.	42
Figure 3. 3 Flow chart of the project.	43
Figure 3. 4 Configuration of the substrate antenna.	45
Figure 3. 5 Configuration of the patch antenna.	45
Figure 3. 6 Configuration of the ground antenna	46
Figure 3. 7 Front view	46

Figure 3. 8 Side view	46
Figure 3. 9 The dimension of the transparent antenna	47
Figure 3. 10 Sample of sea water	47
Figure 3. 11 Sample of tap water	48
Figure 3. 12 Sample of rain water	48
Figure 3. 13 Sample of distilled water	49
Figure 4. 1 Comparison in S Parameter of different value of patch length	53
Figure 4. 2 Comparison in VSWR of different value of patch length	53
Figure 4. 3 Frequency versus Length Patch	54
Figure 4. 4 S Parameter versus Length Patch	54
Figure 4. 5 Bandwidth versus Length Patch	55
Figure 4. 6 Comparison in S Parameter of different value of patch height	56
Figure 4. 7 Comparison in VSWR of different value of patch height	56
Figure 4. 8 Frequency versus Height Patch	57
Figure 4. 9 S Parameter versus Height Patch	57
Figure 4. 10 Bandwidth versus Height Patch	58
Figure 4. 11 Comparison in S Parameter of different value of patch width	59
Figure 4. 12 Comparison in VSWR of different value of patch width	59
Figure 4. 13 Frequency versus Width Patch	60
Figure 4. 14 S Parameter versus Width Patch	60
Figure 4. 15 Bandwidth versus Width Patch	61
Figure 4. 16 Comparison in S Parameter of different value of substrate height	62
Figure 4. 17 Comparison in VSWR of different value of substrate height	62
Figure 4. 18 Frequency versus Height substrate	63
Figure 4. 19 S Parameter versus Height substrate	63

Figure 4. 20 Bandwidth versus Height substrate	64
Figure 4. 21 Comparison in S Parameter of different value of epsilon	65
Figure 4. 22 Comparison in VSWR of different value of epsilon	65
Figure 4. 23 Frequency versus epsilon	66
Figure 4. 24 S Parameter versus epsilon	66
Figure 4. 25 Bandwidth versus epsilon	67
Figure 4. 26 Simulation of transparent antenna using CST Studio Software	69
Figure 4. 27 S₁₁ parameter of the antenna	69
Figure 4. 28 VSWR of the transparent antenna at 2.45GHz	70
Figure 4. 29 Polar view of the antenna at $\phi = 90^\circ$	70
Figure 4. 30 E-field of the antenna at 2.45GHz	70



LIST OF SYMBOLS

δ	-	Voltage angle
ΔL	-	Length extension
$ S_{11} $	-	S-parameter
W	-	Width of patch
ϵ_{eff}	-	Effective dielectric constant
W_g	-	Width of ground
W_f	-	Transmission line width
L_{eff}	-	Effective length
L_g	-	Length of ground



LIST OF ABBREVIATIONS

PCB	-	Printed circuit board
ITO	-	Indium tin oxide
PDMS	-	polydimethylsiloxane
RCS	-	Radar cross-section
CP	-	Circularly polarized
PB	-	Pancharatam-berry
WLAN	-	Wireless local area network
VFH	-	Very high frequency
GHz	-	Giga hertz



LIST OF APPENDICES

APPENDIX	TITLE	PAGE
Appendix A	Example of Appendix A	Error! Bookmark not defined.
Appendix B	Example of Appendix B	Error! Bookmark not defined.



CHAPTER 1

INTRODUCTION

1.1 Background

An antenna is a device that connects radio waves to space-based electric currents. It works by absorbing the energy from radio waves and returning it to the transmitter or receiver. A transmitter or receiver is connected to an antenna by a series of cables. They can be designed to receive and transmit radio waves in all directions, or they can only be used in one. Horn, helical, dipole, and parabolic antennas are among the many types of antennas available. The most prevalent are micro strip patch antennas. Its structure is a thick metal sheet with a radiating patch.

A microstrip antenna is a kind of antenna built on a printed circuit board using photolithographic methods (PCB). Patch microstrip antennas are the most popular form of microstrip antenna. Patch antennas can also be combined with other antennas to form a bigger array. The entire system is supported by a ground plane, which is connected to the dielectric substance. Stimulation is also provided by feed wires linked to the antenna through the patch. Since it is one of the most popular designed of the antenna, the microstrip patch antenna will be proposed in this project with water as conducting material.

Next, transparent antennas operating in wireless frequency bands are useful in glass-mounted applications such as automobiles, homes, and businesses where transmission and reception are desired through or from a window. Transparent antennas were produced using AgHT materials, indium tin oxide (ITO), and fluorine doped tin oxide on glass and polyimide. The use of a transparent conductor can present difficulties in both fabrication and

application. This project are designing a transparent antenna using water as conducting material. Because this antenna will combined a transparent material which is 100% transparency and the water as conducting material. The sample of water will be tested to get the reading of conductivity in order to study the effect of conductivity of different sample of water on the antenna performance.

1.2 Problem Statement

Due to the increasing cost of materials necessary for complex design features and application requirements, antennas have become exceedingly expensive. Transparent antennas are frequently used in a wide range of communication system applications when device space is limited and antenna integration with other components is necessary. In transparent antennas, indium tin oxide (ITO) or a metal mesh are often employed as conducting materials, however this material has low transparency (70 percent). Furthermore, these two elements are expensive, especially the rare-earth Indium component (ITO).

Because water is clear, cheap, and easily available, glass will be used as a substrate and water will be used as a conducting medium for the transparent antenna. When compared to currently use transparent antennas, the proposed antenna is expected to provide a number of advantages and benefits when utilized properly.

1.3 Project Objective

The objectives of this project are as follows:

- a) To study the feasibility of optimum antenna design using water as a conducting material.
- b) To characterize the properties of different samples of water in order to study the effect of conductivity on antenna performance.
- c) To propose an optimum water based microstrip patch antenna.

1.4 Scope of Project

The scope of this project is to study a very transparent antenna that does not interfere with other passive or active modules. In order to obtain the needed antenna radiation performance, the electrical properties of the chosen material must also be carefully addressed. In this project, water will also be used as the conducting medium of the antenna.

The different type of water used will be simulate using CST Studio Suite. The substrate of the antenna will use lead glass material and the patch and ground will use different type of water. This project will simulate four types of antenna with different source water. The water consist of distilled water, sea water, tap water and rain water.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter will discuss about the analysis of the literature review from several related articles or journals. All related articles and journals are discussing based on the theoretical background.

2.2 Antenna

The link between radio waves traveling across space and electric currents flowing through metal conductors is an antenna. Antenna, also known as Aerial, is a mechanism for directing incoming and outgoing radio waves, such as those used in radio, television, and radar. It is an electrically linked array of components that may be configured to transmit and receive radio waves in an omnidirectional manner, radiating energy about evenly in all directions, with energy radiating more in one direction than others. Any radio transmitter or receiver must couple its electrical connection to the electromagnetic field in order to function. Radio waves (electromagnetic waves) are electromagnetic waves that transport signals across the air with nearly negligible transmission loss.

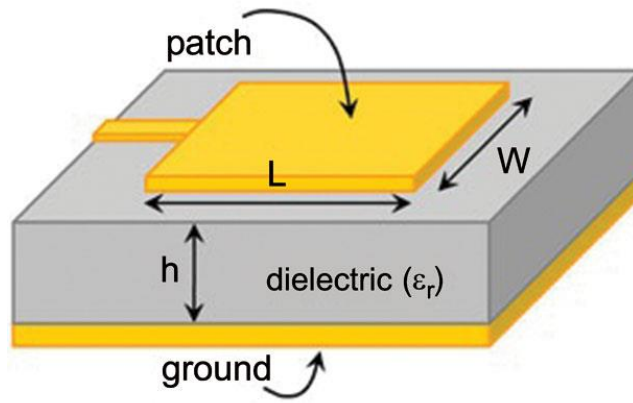


Figure 2. 1 Microstrip Patch Antenna

Table 2.1 compares patch antennas composed of water and copper. A patch antenna with a metallic patch ground has a higher gain than a patch antenna with water as the ground plane. This is because some electromagnetic waves travel through the sea floor and reach the back zones. As a result, the number of electromagnetic waves that reach the main beam is reduced [3].

Table 2. 1 Comparison of patch antennas made of water or copper

	Patch	Ground plane	BW ($ S_{11} \leq -10$ dB)	Max. Gain (dBi)
This work	Water	Water	35% (2.0-2.85 GHz)	4.0
Case 1	Copper	Copper	39% (1.75-2.61 GHz)	7.0
Case 2	Copper	Water	35% (1.95-2.78 GHz)	5.1
Case 3	Water	Copper	38% (1.8-2.65 GHz)	6.7