UNIVERSITI TEKNOLOGI MARA

DESIGN OF WIDE BAND UNDERWATER ANTENNA USING BUFFER LAYER STRUCTURE FOR UNDERWATER COMMUNICATION

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ABSTRACT

Utilization of electromagnetic wave (EMW) in underwater wireless communication systems is being investigated as the alternative to the conventional acoustic-based system, in order to provide higher data rate. However, underwater EMW systems has the drawback of the high signal attenuation, effecting the signal quality and data rate. In underwater environment, conventional antennas will perform poorly since they have reduced efficiency and poor near-field radiation properties. Hence, a proper optimized antenna design is required to enhance the antenna performances underwater. Existing works on the development of the underwater antennas mostly focus on the development on narrowband antennas operating at low frequencies. Moreover, most studies on EMW propagation in underwater investigate only the propagation of narrowband signal. While utilization of wider signal bandwidth permits a higher data rate, there are minimal study to investigate the wideband antenna design and propagation characteristics. The main aim of this study is to develop a wideband patch antenna, integrated with buffer layer configuration for enhanced underwater transmission. Accordingly, the present study investigates the parameters of a buffer layer in enhancing the proposed wideband underwater antenna performance, with experimental validation. For the buffer layer, this study proposes the utilization of a material with relative permittivity between the atmosphere and water, to enhance the antenna performance. Furthermore, the present study also analyses the wideband electromagnetic wave path loss in the underwater environment through measurement and validation with numerical evaluation. Two prototypes of underwater antenna were presented in this study which is presented as Antenna Design 1 and Antenna Design 2. Antenna Design 1 is the initial design consist of a circular patch antenna integrated with buffer layer structure. The buffer layer structure was design using the proposed solution consist of (7:1) of a mixture between methyl acetate and distilled water.The improvements of the antenna in term of its bandwidth, gain and S_{11} was presented by Antenna Design 2 due to its fully optimized antenna parameters such as the optimization on the antenna size and buffer material. Hence, Antenna Design 2 was chosen as the final proposed underwater antenna design due to its beneficial of achieving Ultra-Wideband (UWB) frequency ,minimized in size, better gain and S_{11}. From the results, it is demonstrated that the proposed antenna yielded a good return loss performance when operating underwater, nearly -10 dB from 380 MHz to 1000 MHz, occupying approximately 600 MHz bandwidth. This indicates the effectiveness of using the proposed buffer layer in the underwater antenna design to retain a good performance over a wide bandwidth. Next, the proposed antenna was used in the analysis of wideband path loss in underwater. The measurement results indicated that the wideband path loss at 2m distance underwater was approximately 65 dB, which is lower than its narrowband counterpart, marking 70 dB at the same distance. The result is verified by numerical simulations, with approximately 3 dB modelling error over the wide bandwidth. This reduction of path loss per distance is attributed to the frequency diversity effects brought by the wide frequency bandwidth. Overall, this study successfully proved that the proposed antenna design integrated with buffer layer structure was able to enhance the antenna performances in underwater environment over a wide signal bandwidth. In addition, the results presented from the wideband path loss measurement may facilitate improvements in wireless underwater communications using electromagnetic waves.

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TABLE OF CONTENTS

		Page
CONFIRMATION BY PANEL OF EXAMINERS		**ii**
AUTHOR'S DECLARATION		**iii**
ABSTRACT		**iv**
ACKNOWLEDGEMENT		**v**
TABLE OF CONTENTS		**vi**
LIST OF TABLES		**xi**
LIST OF FIGURES		**xiii**
LIST OF SYMBOLS		**xix**
LIST OF ABBREVIATIONS		**xxii**
CHAPTER ONE INTRODUCTION		**1**
1.1	Introduction	1
1.2	Research Background	1
1.3	Problem Statement	4
	1.3.1 Conventional antennas are not suitable to operate in underwater environment due to poor efficiency and near-field radiation properties.	5
	1.3.2 Existing designs of underwater antennas are not suitable and optimized for wideband signal	5
	1.3.3 Existing data on EMW propagation mechanism and its properties are mostly based on narrowband signal propagation without the analysis of the wideband characteristics.	5
1.4	Objectives of the Research	6
1.5	Scope and Limitation of Work	6
1.6	Thesis Organization	9
1.7	Conclusion	10
CHAPTER TWO LITERATURE REVIEW		**11**
2.1	Introduction	11

2.2 Ultra-Wideband (UWB) Communication System 11
2.2.1 The History of UWB System 15
2.2.2 Basic Theory of UWB 16
2.2.3 Advantages and Disadvantages of UWB System 17
2.2.4 UWB Applications 18
2.3 Underwater Communication Technology 19
2.3.1 Underwater Acoustic Communication System 19
2.3.2 Underwater Optical Communication System 21
2.3.3 Underwater Radio Frequency (RF) Communication System 22
2.3.4 Comparison between three wireless underwater communication technologies. 24
2.3.5 Frequency Band used for Underwater Communication 25
2.4 Antenna Technology 26
2.4.1 Underwater Antenna Design 27
2.4.2 Ultra-Wide Band (UWB) Microstrip Patch Antenna 29
2.5 The Development of Underwater Antenna using the Integration of Buffer Layer Structure Technique 31
2.6 The synthesizing of the dielectric materials 34
2.7 The Theory of Propagation Electromagnetic Wave (EMW) 35
2.7.1 Introduction Electromagnetic Wave (EMW) 35
2.7.2 Plane wave properties 37
2.7.3 Plane wave in Lossy Media 39
2.8 Water Parameters that Affected the Electromagnetic Propagation Performances Underwater 40
2.8.1 Permittivity 41
2.8.2 Conductivity 41
2.9 The Related Research on the Propagation of the EMW Underwater 42
2.10 Conclusion 45

CHAPTER THREE RESEARCH METHODOLOGY ON UNDERWATER ANTENNA INTEGRATED WITH BUFFER LAYER STRUCTURE 46
3.1 Introduction 46
3.2 Flowchart of the Overall Research Activities 46
3.3 Theory Antenna Parameters 11