INVESTIGATION ON 3D PRINTED FRACTAL BOW-TIE ANTENNA AT 28GHZ FOR 5G APPLICATION

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UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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This report is submitted in partial fulfilment of the requirements for the degree of Bachelor of Electronic Engineering with Honours

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DEDICATION

To you, my immortal

ABSTRACT

Generally, fractals antenna possessed a tremendous amount of potential in providing a multi-band solution through property of self-similarity that the fractals shape has. This thesis has focused on the modification of original Sierpinski fractal shape patch antenna onto a typical bow-tie antenna, providing additional parameters to optimize in order to get the required radiation characteristic. A Sierpinski Fractals Bow-Tie Antenna is designed by stacking an intermediate layer of a triangular patch whose size is equal to that of the triangular hole in the fractal structure. The gap is introduced for improving the radiation pattern. A prototype of the antennas is fabricated with polylactic acid (PLA), a high-strength thermoplastic material that are fabricated by using 3D printing technology. Due to complex geometry of fractal designs, these antennas are capable of resonating at multiple frequencies, making them excellent wideband antenna.

ABSTRAK

Umumnya, antena berbentuk fraktal mempunyai potensi yang amat besar dalam membantu menyediakan solusi kepada kepelbagaian-gelombang mikro melalui sifat persamaan diri yakni bentuk yang berulang membentuk bentuk fraktal. Tesis ini memberi tumpuan kepada kesan terhadap parameter dan penambahbaikan kepada antena berbentuk busur yang diasimilasikan dengan segi tiga berbentuk fraktal untuk memberikan nilai optimum kepada parameter-parameter yang berkaitan terutamanya ciri-ciri radiasi yang berketepatan. Antena berbentuk busur yang mempunyai fraktal Sierpinski ini direka dengan menimbunkan lapis antara lapis antenna berbentuk busur dan juga segi tiga berbentuk fraktal Sierpinksi dengan iterasi sebanyak 50% bagi setiap iterasi. Jarak di atas tampalan pancaran radiasi adalah untuk meningkatkan lagi hasil simulasi untuk mencari pola radiasi yang tepat. Sebuah contoh antena telah dihasilkan melalui kaedah teknologi percetekan 3D menggunakan bahan termoplastik berketumpatan tinggi. Oleh kerana rekaan antena busur berbentuk fraktal Sierpinski ini mempunyai corak berulang di atas tampalan pancaran radiasi, ia berupaya untuk digunakan di pelbagai frekuensi bernilai tinggi, justeru membuatkan ia sangat sesuai digunakan sebagai antenna yang mempunyai ciri-ciri gelombang yang luas.

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LIST OF SYMBOLS AND ABBREVIATIONS

3D	:	3-Dimensional
CST	:	Computer Simulation Technology
FBTA	:	Fractal Bow-Tie Antenna
PLA	:	Polylactic Acid
UWB	:	Ultrawide Band
VSWR	:	Voltage Standing Wave Ratio
HPBW	:	Half power Beamwidth
f/b	:	front to back ratio
IoT	:	Internet of Things
BNC	:	Bayonet Neill-Concelman
mmWave	:	Millimeter Wave
EMI/RFI	:	electromagnetic interference or radio frequency interference
RF	:	Radio Frequency

CHAPTER 1

INTRODUCTION

1.1 Introduction

In general, any wireless communication device does have antenna as their basic architecture in enabling them to be operate. It is an integral part of our everyday lives. Antennas are part of satellite assemblies that provide data transfer for the telecommunication industry and global positioning system. Communication media that are provided to people such as voice communication and internet are the results of the antennas that are in each cell phone and laptop. With the wireless communication continue to increase, so does the dependence of antennas in our lives.

With demands for wireless communications among user and provider is constantly increasing, the needs for higher transmission among consumer and rate alongside with

improved capacity area covered will also rises. Hence, radio spectrum with a more efficient usage is much more needed.

Generally, microstrip antennas possessed a light weight and thin profile configuration, therefore it is commonly used in theoretical research and application. Other than that, it also has a reliability and conformal structure. These type of antenna have a very distinct feature compared to rectangular patch because of its compact sized. Thus, many researcher and industry player shows their interest in exploring the future use for these kind of antenna. With increasing demands for equipment in operating communication devices, huge research operation had been conducted. In order to have an effective technique to design small, multiband and high gain antennas and low side lobe arrays, the design of antenna plays a very important part. Because of that, all kind of techniques has been introduced to broaden the impedance bandwidth of antenna with compact size and to optimize and investigate the characteristic of the broadband antennas widely.

Hence, a combination of an antenna with a type fractal geometry are introduced. Fractals geometry represent itself in self-similarity and repetition in various and distinct dimension filling the space effectively. One of its particular attributes in various research and application besides its miniaturized and compact shape that can fill space effectively, it is also have the ability to manifold electrical dimension, either it is a multiband or wideband.

1.2 Background of The Project

A few years back, the evolution of most wireless equipment is becoming more and more smaller as the size reduction of a particular antenna develops a very substantial

matter. In any microwave system, the antenna can be considered as the most “are-consuming” component. Therefore, by reducing its size will be resulting in a great lessening in the size of the overall equipment. With the implementation of fractals with self-similar and space-filling geometrical assets, it can be used in miniaturization of antenna and multiband operations.

The bow-tie antenna with fractals is designed for multiband operation in the duration of emerging needs for communication system in 5G application. Consequently, with the use of 3-Dimensional (3D) printing, the antenna design is fabricated with suitable material and substrate for their component to be fully functioning like a regular antenna. This antenna that are developed can be used specifically at frequency of 28GHz, which is deemed as the most optimum frequency for operating 5G application.

In this project, Sierpinski gasket is introduced into the conventional triangular patch bow-tie antenna with microstrip feed to obtain better return and loss gain. In particular, Sierpinski gasket’s aspect, can be proved in increasing bandwidth, better gain and high rate of efficiency makes it a better choice for applications of communication system. The fractals design of the antenna is iterated 3 times by scaling down the main triangle by 50% followed by latter iteration in the similar manner. All the simulation of the design was done using CST (Computer Simulation Technology) Microwave Studio. In this design of antenna, it is expected that the bandwidth increases as compared to the conventional bow-tie triangular patch antenna.

As for methods of fabricating the antenna, the use of 3D printing has been selected because of its significant impact in different industry sectors and its capabilities to be a game-changing technology in the years to come. Also, it is increasingly becoming

more efficient, available, and affordable. In this work, the dielectric constant of the solid non printed polylactic acid (PLA) is referred in designing antenna that were simulated and fabricated.

In making sure the antenna fabricated are performing optimally at 28GHz frequency for 5G application, the basic understanding of ultra wideband (UWB) must be grasped. UWB is a technology that is used for sending a very large numbers of digital data above a wide spectrum of frequency bands with very low power for a very short distance. The antenna used must be compact as these characteristic is demanded for UWB application, specifically wireless communication. Furthermore, it must have and exceptional radiation characteristic, i.e. consistent outlines over the entire operating bandwidth and good time-domain characteristic. Other than that, to maintaining radiation efficiency as well as widen their impedance bandwidth have always been seen as a major challenge to design a suitable UBW antennas for this engineering application.

1.3 Problem Statement

Constraints on antenna designs include requirement for multi-band resonance. With increasing number of user day by day, frequency bands are being congested, therefore resulting limitations in data transmitting. Conventional design of antenna is deemed not being able to meet these requirements. Hence, recent developments have applied fractal approach to antenna design, resulting in new fractal antennas with multi-band behavior.

The commonly used way in fabricating antenna has a main loop hole as their fragileness and susceptibility to damage. The accelerating growth of 3D printing technologies has opened up many new possibilities in advance manufacturing of

complex product design. Therefore, it can be implemented to curb this problem in complying with the rise of technology evolution.

1.4 Objectives of The Project

This project aims to investigate and research in developing a 3D printed fractal bow-tie antenna that is specifically perform at 28GHz frequency for 5G application. To achieve that, the following objectives need to be accomplished. First objective is to design the bow-tie antenna that are implemented with Sierpinski triangle fractals. The second objective is to analyze and optimize design specification for the characterization of fractal bow-tie antenna and simulation of the antenna design by using CST Microwave Studio. The third and the last objective is to fabricate the fractals bow-tie antenna 3D model design by using 3D printing technologies.

1.5 Scope of the Project

The scope of the project consists of two main parts; simulation of antennas design and fabrication of antennas design, that are focus on the following areas: -

- Design and model a fractals bow-tie antenna with resonant frequency of 28GHz.
- Investigation of antenna parameters including S-parameters S_{11}, gain, radiation pattern, and cross correlation.
- Analyze the effect of fractals design specification on the characterization and functionality of the antenna fabricated.