COMPACT DUAL BAND FSS FOR MICROWAVE TRANSMISSION

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Tajuk Projek : COMPACT DUAL BAND FSS FOR MICROWAVE TRANSMISSION
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To my dearest and respected parents,

Pn. Nurhidayati Binti Hj. Mohd. Ihsan & Hj. Shahrowardi Bin Jazuli.

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ABSTRACT

One of the system engineering used in wireless technology is FSS which is stands for Frequency Selective Surface. The characteristic of FSS is capable to filter the desired signals or waves pass through the surface while any other unwanted signals or waves will be reflected back. In the wireless communication system, almost every wireless technology uses radio waves to communicate, specifically in microwave transmission. These signals or waves might be interfered with each other. Therefore, these signals must be isolated and the interference must be reduced. The objective of this project is to design a compact dual-band FSS for microwave transmission at a frequency of 2.4GHz and 5.2GHz. The technique used to achieve dual-band FSS is by using a double loop structure. This FSS is compactly designed whereby the FSS is capable in resonating dual pass band signal in a single unit structure. The compact design is required since many applications have a very limited space. The FSS was designed and simulated by using CST Studio Suite software. The result of the simulation shows an average return loss of -27.2dB at a resonant frequency of 2.4GHz, whereas -18.5dB at 5.2GHz. Meanwhile, the measurement results shows an average of -17.2dB return loss at 2.4GHz and -16.8dB at 5.2GHz. Some of the applications of FSS are RADOME, sub-reflectors of antenna, spatial signal filtering, energy saving glass (ESG), and satellite communications.

ABSTRAK

Salah satu daripada sistem kejuruteraan yang digunakan dalam teknologi wayarles adalah *FSS,* (*Frequency Selective Surface).* Ciri-ciri yang terdapat pada *FSS* mampu menapis isyarat dan gelombang yang dikehendaki melepasi permukaannya manakala sebarang gelombang yang tidak dikehendaki akan dipantulkan semula. Dalam sistem komunikasi wayarless, hampir setiap teknologi wayarles menggunakan gelombang radio untuk berhubung, secara khususnya dalam penghantaran gelombang mikro. Isyarat atau gelombang ini mungkin akan terganggu antara satu sama lain. Oleh itu, isyarat ini haruslah diasingkan dan gangguan haruslah dikurangkan. Objektif projek ini adalah untuk merekacipta dwi-jalur *FSS* yang kompak sebagai penghantaran gelombang mikro pada frekuensi 2.4GHz dan 5.2GHz. Teknik yang digunakan untuk mencapai dwi-jalur *FSS* adalah dengan menggunakan struktur gelung berganda. *FSS* ini direkacipta secara kompak dimana ianya mampu beresonansi pada isyarat melepasi dwi-jalur dalam struktur unit tunggal. Rekabentuk kompak ini diperlukan kerana banyak aplikasi yang mempunyai ruang yang terhad. *FSS* ini direkabentuk dan disimulasi menggunakan perisian *CST Studio Suite*. Keputusan simulasi menunjukkan purata *return loss* sebanyak -27.2dB pada resonan frekuensi 2.4GHz, manakala -18.5dB pada 5.2GHz. Keputusan ukuran pula menunjukkan purata *return loss* sebanyak -17.2dB pada resonan frekuensi 2.4GHz dan -16.8dB pada 5.2GHz. Antara aplikasi *FSS* adalah *RADOME*, sub-reflektor antena, penapisan ruang isyarat, kaca penjimatan tenaga (*ESG*), dan komunikasi satelit.

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LIST OF ABBREVIATIONS

EM	-	Electromagnetic
FSS	-	Frequency Selective Surface
GPS	-	Global Positioning System
IEEE	-	Institute of Electrical and Electronics Engineers
PCB	-	Printed Circuit Board
RADOME	-	Radar Dome
RF	-	Radio Frequency
UV	-	Ultraviolet
WLAN	-	Wireless Local Area Network

LIST OF SYMBOLS

c	-	Length of Loop
d	-	Distance Between Transmitter And Receiver
dB	-	Decibel
D_x,D_z	-	Inter-Element Spacing
E-field	-	Electric Field
f	-	Frequency
f_r	-	Resonant Frequency
G	-	Giga
GHz	-	Giga Hertz
Hz	-	Hertz
l	-	Length of Loop
L	-	Length of Substrate
LC	-	Inductor-Capacitor
mm	-	Millimeter
r	-	Radius of the Circular Loop
R_x	-	Receiver
s	-	Width of Loop
S_{11}	-	Reflection Coefficient
S_{21}	-	Transmission Coefficient

S1	-	Length Of Inner Loop From The Center Of FSS
S2	-	Lengt of Outer Loop From the Center of FSS
Tx	-	Transmitter
W	-	Width Of Subsrrate
ε_r	-	Dielectric Constant
ε_{ff}	-	Effective Dielectric
$\boldsymbol{\lambda}$	-	Wavelength

LIST OF APPENDICES

CHAPTER I

INTRODUCTION

This chapter discussed about the introduction of this project such as the general information about FSS, the problem statement, objective, scope of the project, the project methodology, and explanation about the project organization.

1.1 Background

The wireless communication technology has been developed rapidly these recent years. The most common wireless technologies use the electromagnetic wireless telecommunications which is used in so many kinds of applications. Some of the most popular applications of electromagnetic wireless telecommunications are radio, cellular telephones, GPS, satellite television, broadcast television, and wireless networking.

In the wireless telecommunication systems, there are so many types of microwave signals in the space or in the thin air that cannot be seen by human eyes. All those microwave signals are actually transmitted all over in the air. Since the uses of wireless technologies are very widespread among humans in all over the world, it cannot be imagined on how those signals can be transmitted and received purely for its

application. The microwave signals should be transmitted directly to its particular receiver without any disturbances or any other interference.

Therefore, in some certain applications, the use of signal filter is very significant in order to obtain only the required signals from space. This is where the used of Frequency Selective Surface (FSS) become significant. The use of FSS is to reduce interference between signals and it also acts as a signal filter. It only allows the required signals to pass through a particular surface and reflect all any other unwanted signals to the air.

1.2 Problem Statement

In the wireless communication system, almost every wireless technology uses radio waves to communicate, specifically in microwave transmission. But since many devices share frequencies which can cause interference, the signals need to be isolated and separated from any other unwanted signals.

Furthermore, as for any particular applications, there are only certain particular signals are required. In order to avoid those random signals from mixing or interfere with each other, the required signals need to be filtered. Thus, the Frequency Selective Surface let the useful waves to pass across and at the same time it will reflect all any other unwanted waves.

Since Wireless Local Area network (WLAN) technologies are very widely used nowadays, this project will adapt its requirements into the design of the compact dual-band Frequency Selective Surface. Besides that, the FSS is to be designed in a compact structure so that the system will be more efficient and also for mobility since most of the wireless technology has a very limited space.

1.3 Objective

The objective of this project is to design the dual-band compact Frequency Selective Surface (FSS) for microwave transmission at frequency of 2.4GHz and 5.2GHz.

1.4 Scope of Project

The scope of this project is to design a compact dual band FSS at a frequency of 2.4GHz and 5.2GHz by using CST Studio Suite software. Then, the designed structure is simulated using the same software to obtain the S-parameters which are S_{11} and S_{21} which represents the reflection coefficient and the transmission coefficient, respectively. The simulated FSS designed were then fabricated on the FR4 Board by using chemical etching. Lastly, the fabricated FSS designs were measured by using the network analyzer in order to obtain the reflection coefficient and the transmission coefficient. The results from the simulation and the measurement will be compared and discussed further in Chapter IV.

1.5 Methodology

In designing this project, the first method to be implemented is the literature review. Any reviews about the general information of FSS, techniques to design basic FSS, techniques to achieve single band and dual band FSS, and technique to obtain the required resonant frequency for the FSS, has been studied through the journals, technical papers, books, and some websites.

After the literature review has been done, the FSS structure is started to be designed. There are four elements in designing the FSS that should be considered which are the design structure, the design material, the design parameters, and the design

process. The design structure is basically the structure of the FSS itself, and the design material is obviously the material used for the designed FSS whereby an FR4 board is used as the substrate, and copper (annealed) is used as the conducting patch. The design parameters are the symbol or any alphabet used in order to name all the parameters of the design such as the length, width, or the radius. Lastly, the design process is a process in obtaining every parameter that has been named earlier. The process include some calculation or by using parametric study.

Then, the simulation of the designed FSS can be run using CST Studio Suite software. The simulation was carried out to gain the S-parameters which are S_{11} and S_{21} which indicate the reflection coefficient and the transmission coefficient, respectively.

After the result of the designed FSS from simulation has been obtained and satisfied the design specification, it was then fabricated on FR4 board using chemical etching process. The fabricated designs were finally measured to obtain the S-parameters. The measurement of the FSS has been done by setting up two horn antennas acted as receiving and transmitting antennas, while the FSS under test was then placed in between the horn antennas. The input and the output of the antennas were connected to the network analyzer, so that it could shows the S-parameters obtained. Figure 1.1 shows the flowchart of the methodology of this project.

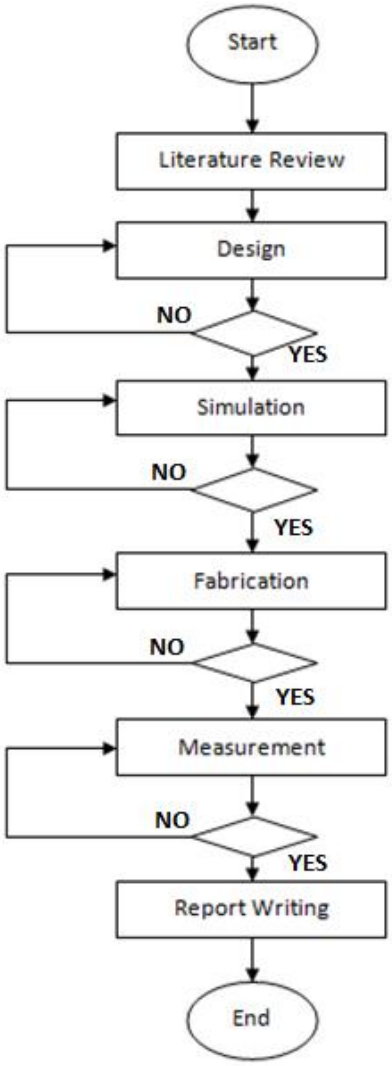

Figure 1.1: Flowchart of the Project Methodology

1.6 Organization of the Report

This report has been organized in five chapters. For the first chapter, it is discussing about the introduction of the project. It consists of six sub-titles, firstly it discuss about the background of the project, or the general information about the project. Then, there are some explanations on the problem statement of the project, the brief objective of the project, the project scope, the project methodology.

Chapter II of this report will be discussing about the literature review on the project. The chapter will explain in details on the information of the FSS, and all the techniques used to achieve single band and dual band. All the reviews were obtained from the research in the journals, technical papers, books, and some reliable source on the websites.

As for Chapter III, it will be discussing on the methodology of the project. All the steps taken in order to design the proposed FSS will be clarified. Starting from the design of the basic FSS structure, until the design of dual band structure of variety structures, the methods will be discussed.

In Chapter IV, the content to be discussed is about the results of the simulation and the measurement of the designed FSS. There are several designs that has been fabricated and measured. All the measurement results were to be compared with the simulation result obtained. All the comparison has been tabulated so that it is easier to be observed. The chapter will be discussing further about the structures affecting the results and which design has the best performance.

Lastly in Chapter V, it is a conclusion and a recommendation chapter. This chapter will conclude about the whole project. It will be enlightened the results of different structures and the best structure that meets the design specification. Besides, the chapter also pointed a brief discussion on the recommendation of the future work.