DESIGN OF DUAL BAND FREQUENCY SELECTIVE SURFACE

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UNIVERSITI TEKNIKAL MALAYSIA MELAKA
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DESIGN OF DUAL BAND
FREQUENCY SELECTIVE SURFACE (FSS)

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor's Degree in Electronics Engineering Technology (Telecommunications) with Honours

by

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This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the Bachelor's Degree in Electronics Engineering Technology (Telecommunications) with Honours. The member of the supervisory is as follow:

………………………………

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ABSTRAK

'Frequency Selective Surface' (FSS) boleh dianggap sebagai pembinaan permukaan berfungsi sebagai penapis bagi gelombang kapal terbang di mana-mana sudut tuju. Ia telah digunakan secara meluas dalam komunikasi jalur lebar, sistem radar, dan teknologi antena. Hari ini permintaan besar terhadap antena yang mempunyai pelbagai fungsi untuk sistem telekomunikasi semakin meningkat. Oleh itu, permintaan terhadap FSS dengan pelbagai ciri sangat diperlukan. Objektif projek ini adalah untuk mereka bentuk dwi-band FSS yang menggunakan frekuensi tertentu untuk mendapatkan FSS dengan prestasi yang cemerlang dengan memilih unsur yang sesuai atau gabungan unsur-unsur. Teknik yang digunakan untuk mencapai dwi-band FSS adalah dengan menggunakan struktur gelung persegi berganda kerana gelung persegi mempunyai kelebihan yang mudah di dalam struktur dan mudah untuk dianalisis, direka dengan kos bahan yang rendah dan struktur yang ringan serta mudah untuk dikendalikan. Akhir sekali, FSS telah direka dan simulasi dengan menggunakan perisian CST Studio Suite pada 8.0 GHz dan 10.3 GHz saluran frekuensi.

ABSTRACT

A Frequency Selective Surface (FSS) can be considered to be a surface construction serving as a filter for plane waves at any angles of incidence. It has been widely used in broadband communications, radar systems, and antenna technology. Today there is a growing demand on multifunctional antennas for telecommunication systems. Therefore the development of FSS with multiband characteristics is needed. The objective of this project is to design a dual band Frequency Selective Surface (FSS) by using certain frequency to obtain FSS with excellent performance by choosing a suitable element or combinations of elements. The technique used to achieve dual band FSS is by using Double Square loop structure because the square loop has the advantages which are simple in structure and easy to analyse and fabricate with low cost materials and exhibits a low weight and easy to handle structure. Finally, the FSS was designed and simulated by using CST Studio Suite software at 8.0 GHz and 10.3 GHz resonant frequency.

DEDICATION

To my beloved parents,
Mohd Saidi Bin Wahab and Ruseni Bt Mat Naam that have sacrificed so much and was always encouraging and support for the sake of your daughter to be beneficial person to the society.

Without enduring the bone chilling cold,
How could the plum blossom emit such a sweet fragrance?

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Syukur Alhamdulillah, all praises are due to Allah, finally this project report come to an end. In order to complete this report, I was in contact with many people. They have contributed towards my understanding and thought.

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TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

CST	-	Computer Simulation Technology
DSL	-	Double Square Loop
EM	-	Electromagnetic
FFT	-	Finite integration technique
FSS	-	Frequency Selective Surface
PCB	-	Print Circuit Board
RF	-	Radio Frequency
RFID	-	Radio Frequency Identification
RX	-	Receiving Antenna
TX	-	Transmitting Antenna
S_{11}	-	Reflector Coefficient
S_{21}	-	Transmission Coefficient
f	-	Frequecy
BW	-	Bandwidth
θ	-	Theta
λ	-	Wavelength

CHAPTER 1
INTRODUCTION

This chapter discussed about the introduction of this project such as general information about Frequency Selective Surface (FSS), problem statement, objective, scope of the project and explanation organization of project.

1.1 Project Background

Since early 1960's, due to applications military potential, structures FSS has being intensive study matter. Marconi and Franklin, however are believed, to becoming early pioneer in this area for their contribution of a parabolic reflection made using half-wavelength wire sections in 1919. FSS as frequency selective materials have traditionally used in stealth technology to reduce radar cross section (RCS) communication system.

The use of frequency selective surface (FSS) has successfully proven as a means to enhance communication capabilities satellite platform. In space missions such as Voyager, Galileo, and Cassini, the use of a dual-reflector antenna with FSS sub reflectors has made it possible to share the main reflector among different frequency band. Furthermore, growing demand in on multifunctional antenna for communication systems has required the development of FSS with features multiband.

FSS structures to space waves are the counterparts of filters in transmission lines. Once revealed to electromagnetic radiation, FSS behaves like a spatial filter which is some frequency bands are transmitted and some are reflected. In a manner, FSS could be envelope because hide communication facilities. This may be first potential application FSS structures, because they had actually once used as coverage called radomes.

Thus, in some applications, the use of filters the signal is very important to get only the necessary signals from space. This is where the use of Frequency Selective Surface (FSS) becomes important. Use of FSS is to reduce interference between the signals and also acts as a filter signal. It only allows the signals required to pass through a given surface and reflects all any other unwanted signals into the air.

1.2 Problem Statement

For decades, many novel methods were proposed to obtain FSS with excellent performances but most result comes out with the complexity in the design and difficult to be analyzed. So due to this, there is a need to design of the dual band Frequency Selective Surface by using certain frequency to obtain FSS with excellent performances.

1.3 Objective

The objectives of this project are:

1. To design of dual band Frequency Selective Surface by using certain frequency to obtain FSS with excellent performance by choosing a suitable element or combinations of elements.
2. To design the FSS by using CST software that offers accurate, efficient computational solutions for the hardware developing for this project.

1.4 Scope of Project

Scope of this project is to design dual band FSS at resonant frequency 8 GHz and 10.3 GHz by using CST Studio Suite. Then, to obtain the S-parameters which are reflection coefficient (S_{11}) and transmission coefficient (S_{21}) respectively, the designed structure is simulated by using the software. This scope of project also will cover the study of resonance characteristics of FSS that are depends which is element dimensions and element of FSS design. This project will test by hardware will be done by etching and fabrication process and measurement by using network analyzer in order to get the required results which are close to the theoretical results then the result can be analyzed.

1.5 Project Overview

This report is organized into five chapters. For the first chapter, it is briefly discussed about the project background, the problem statement, the objective of this project and also the working scope for this project.

For the Chapter 2, the literature review was conducted throughout the entire project to gain knowledge and skills needed to complete this project. The main sources for this project are the previous projects and thesis that related to this project. And other sources are books, journals and articles obtained from the internet.

As for Chapter 3, this chapter brief the most important step in the design process of a desired FSS is the proper choice of constituting elements for the array. So in this chapter, it provides brief description the flow the design of dual band FSS consists of the most important part in the design FSS which is the elements of design and the elements geometries of FSS. All the steps taken to design the proposed FSS will be explained.

In Chapter 4, it is discussed about the simulation result from software and measurement result which is a dual-band frequency selective surface was designed, fabricated and measured with perfectly double square loop patch elements. The measurement results are compared with the simulation results obtained.

Lastly in Chapter 5, it is a conclusion and a recommendation chapter. This chapter will conclude about the whole project and this chapter also pointed a brief discussion on the recommendation of the future work.

CHAPTER 2
LITERATURE REVIEW

The literature review was conducted throughout the entire project to gain the knowledge and skills needed to complete this project. The main source for this project is the previous project and thesis related to this project and other sources are books, journals and articles obtained from the internet. In order to design this dual band of FSS, research had been made among previous project to studying the concept use, their method, making the best comparison and then implement in this project.

2.1 FSS Theory

Frequency Selective Surface, FSS are periodic surfaces that behave as filter for electromagnetic wave. FSS is a mounting structure that behaves similar plane as filter EM [1]. FSS can also be defined as a metal surface designed to be frequency selective in nature indicating it's reflected or transmitted [6]. The frequency selective property described by Rittenhouse [3] proved the fact that surfaces can exhibit different transmission properties for different frequencies of incident wave. Based on geometries, FSSs can be categorized into four type of filter which is band-stop, band-pass, low-pass and high-pass as shown in Figure 2.1. Filtering characteristics of EM mainly depends on the type and shape of the FSS elements.

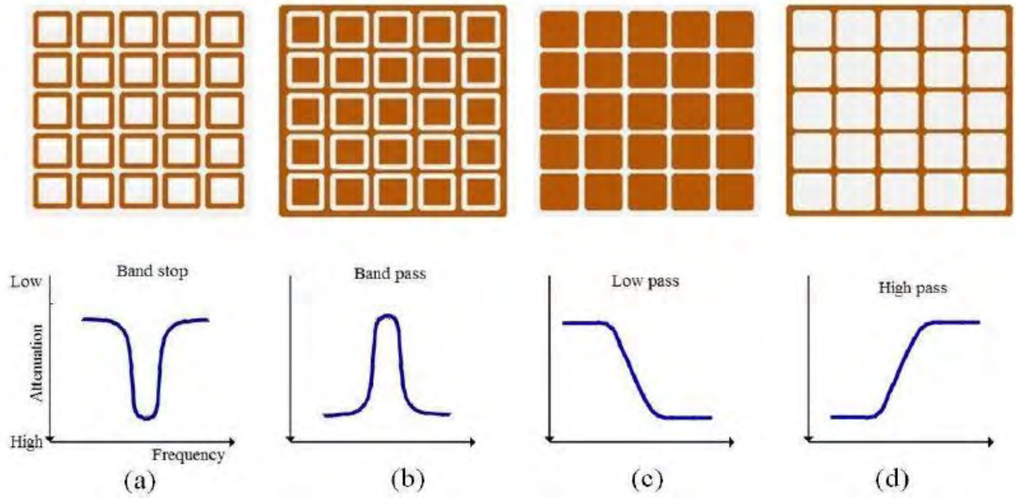


Figure 2.1: (a) band stop (b) band pass (c) low pass (d) high pass. Conductive part represent by brown color

Some types of FSS exist but they can be grouped into two main classes: band stop and band pass FSS. Both reached the behavior depends on their frequency resonance effects exploit periodic planar layout along the surface of the FSS own. In particular, the band stop FSS usually consists of several metal patch arbitrarily shaped printed on a dielectric substrate. Band pass FSS generally designed to create apertures in the metal plate. Both types of FSS can be formed by many layers stacked on top of each other.

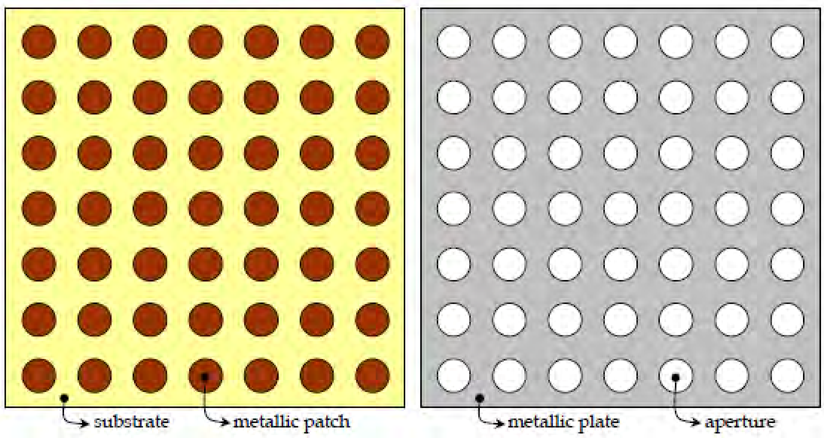


Figure 2.2: Schematic representation of band stop and band pass FSS

Due to the electromagnetic behavior of the FSS tied to a resonance phenomenon, a kind of band stop can achieve reflectance field incident despite the fact that the area covered by the metal is only a small part of the total area. Similarly, the type of band pass can achieve total transmission plane incident despite the fact that the apertures represents only a small fraction of the total area. To further realize the potential of these structures, the following simple example might help to give the proportion of resonance effects. Let's consider band stop FSS composed by metal patch shaped as dipoles, printed together on a regular layout on a dielectric substrate.

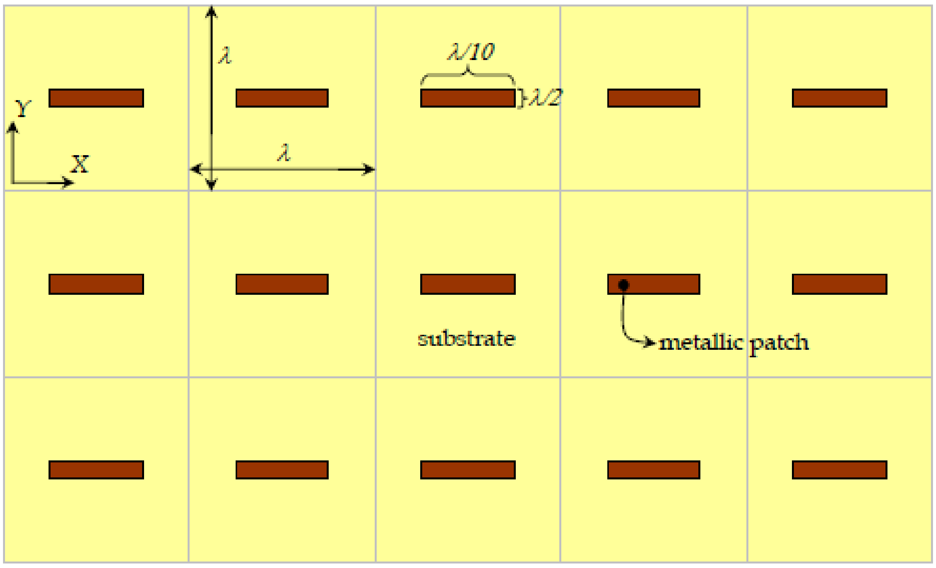
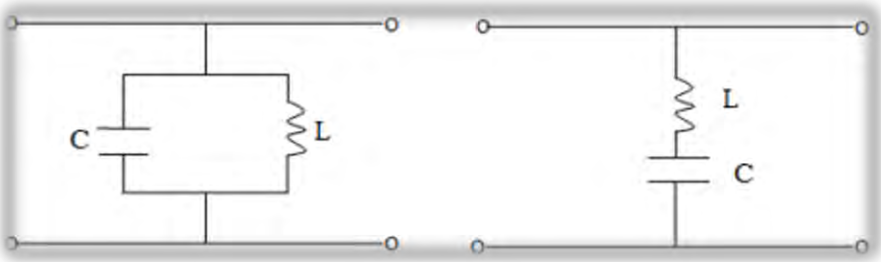


Figure 2.3: Example of band stop FSS with dipole like metallic patches

2.1.1 Equivalent Circuit FSS



Patch Element Aperture Element

Figure 2.4: Equivalent Circuit FSS

As shown in Figure 2.4, patch elements can be seen as a parallel connection of capacitors and inductors, and various elements of the aperture is represented by a series LC circuit, where the conducting element provides inductance and the distance between the elements represents capacitance. From this simple analysis, it is easy to show that the resonant frequency is given by:

$$f = 1/(2\pi\sqrt{LC})$$

Equation 2.1

The fractional bandwidth is defined as the difference between the lower and upper frequency at -10 dB which is proportional to

$$BW \propto \sqrt{L/C}$$

Equation 2.2

Therefore, increasing the length of the conducting element can reduce the resonant frequency and increase bandwidth. A lower resonant frequency can also be achieved by increasing the capacitance, but resulted in a narrow bandwidth.