



**DESIGN AND DEVELOPMENT OF ANTENNA  
WITH FREQUENCY SELECTIVE SURFACES (FSS)**

By

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 FREQUENCY SELEECTIVE URFACES

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## DEDICATION

I dedicate this thesis to my beloved mother

*Salmiah binti Othman*

And

To the loving memory of my father

*Rosly Bin Mohd Ghazalli*

You have successfully made me the person I am now

And

Will always be remembered

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With the name of ALLAH S.W.T, The Most Gracious and Merciful. Praise to ALLAH S.W.T Almighty for giving me the will and wisdom to complete this entire project and also giving me opportunity to participate in performing this 'Projek Sarjana Muda' program, we would have some help and certain guidelines from any of the respected persons; someone whose deserve this greatest gratitude. The completion of this report has given me much pleasure and satisfaction. A salute to University Teknikal Malaysia Melaka (UTeM) for conducting this program for my course Bachelor of Engineering in Electronics (Telecommunication).

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Last but not least, I would like to portrait my salutation for those whose are directly or indirectly supporting me throughout the process.

## **Abstract**

The project report that produce by the student with their own initiatives and capabilities to ensure the chronology of the report is perfect and completed. This report contents of all research study to support the project from the start till the end of the Final Year Project (FYP).

Microstrip Patch Antenna is miniature size antenna that can radiate a Microwave through air space; it categorized into transmitter and receiver that's included several complex circuits. However, this kind of antenna has weaknesses in maintaining the wave radiation. Hence, in this project will show with the aid of the Frequency Selective Surfaces (FSS) can overcome the problem by optimizing the return loss, gain and directivity. The FSS configuration will also help to increase the bandwidth without increasing the surface of the antenna. Henceforth, the antenna and FSS will designed, simulated and fabricated using specification of X – band frequency.

## Abstrak

Projek ini adalah hasil titik peluh pelajar dalam membuat persediaan dan kelengkapan dalam menyelesaikan projek ini; malah ia juga untuk memastikan kronologi laporan projek ini adalah lengkap dan dapan disempurnakan dengan jayanya. Ia terkandung beberapa bentuk pendapatan kajian untuk menyokong pelan projek daripada mula sehingga pengakhiran Projek Sarjana Muda (PSM).

‘Microstrip Patch Antenna’ merupakan antenna yang mampu meradiasi gelombang mikro melalui udara; ia tergolong diantara pemancar dan penerima terdiri daripada beberapa litar kompleks. Namun, antena jenis ini mempunyai kelemahan dalam mengekalkan tahap radiasi yang mampat. Oleh itu, di dalam projek ini menunjukkan dengan penambahan ‘Frequency Selective Surfaces, FSS’ ia mampu mengatasi masalah itu, dengan membantu mengoptimumkan beberapa parameter seperti ‘return loss’, ‘gain’, dan ‘directivity’. Konfigurasi FSS juga mampu meningkatkan lebar ‘bandwidth’ tanpa perlu menambah saiz permukaan antenna. Justifikasinya, antena dan FSS ini direkabentuk, simulasi dan fabrikasi bagi spesifikasi gelombang mikro frekuensi pada ‘X – band’.



# TABLE OF CONTENTS

<b>PROJECT TITLE</b>	<b>i</b>
<b>DECLARATION</b>	<b>ii</b>
<b>DEDICATION</b>	<b>iii</b>
<b>ACKNOWLEDGEMENT</b>	<b>iv</b>
<b>ABSTRACT</b>	<b>v</b>
<b>ABSTRAK</b>	<b>vi</b>
<b>TABLES OF CONTENTS</b>	<b>vii</b>
<b>LIST OF FIGURES</b>	<b>x</b>
<b>LIST OF TABLES</b>	<b>xiv</b>

## 1 Introduction

1.1	Introduction to Antennas .....	1
1.2	Microstrip Patch Antenna.....	1
1.3	Frequency Selective Surfaces (FSS).....	5
1.4	Antenna with Frequency Selective Surfaces .....	7
1.5	Problem Statement.....	8
1.6	Objectives .....	8
1.7	Scope of Work.....	8

## 2 Literature Review

2.1	Microstrip Patch Antenna Literature .....	10
2.1.1	Design, fabrication and characterization of microstrip square patch antenna array for X band applications.....	10
2.1.2	A Compact Microstrip antenna for X band Application.....	13
2.1.3	Design and Analysis of an X-band Phased Array Patch Antenna .....	15
2.1.4	Dual-band Microstrip Patch Antenna using Frequency Selective Surface for Satellite Communication Systems in S – Band.....	17
2.1.5	Rectangular Microstrip Patch Antenna with FSS and Slotted Patch to Enhance Bandwidth at 2.4 GHz for WLAN Applications.....	19
2.1.6	Summary for Microstrip Patch Antenna.....	21

2.2	Frequency Selective Surfaces (FSS) Literature.....	22
2.2.1	Designing FSS for Wireless Propagation Control within Buildings.....	22
2.2.2	Enhanced Gain UWB Slot Antenna with Multilayer Frequency-Selective Surface Reflector .....	24
2.2.3	Performance Improvement of a U-Slot Patch Antenna using a Dual-Band Frequency Selective Surface with Modified Jerusalem Cross Elements.....	26
2.2.4	Design of a Dual-band Antenna using a Patch and Frequency Selective Surface for WLAN and WiMAX.....	28
2.2.5	Effect of FSS Structure on Planar Patch Antenna .....	29
2.2.6	Summary for Frequency Selective Surfaces.....	32

### **3 METHODOLOGY**

3.1	Projects Literature .....	33
3.2	Hardware (Model) .....	34
3.2.1	Rectangular Microstrip Patch Antenna.....	34
3.2.2	Frequency Selective Surfaces (FSS) Model .....	39
3.3	Software Simulation (CST Microwave Studio).....	39
3.4	Project Flowchart.....	40

### **4 RESULT AND DISCUSSIONS**

4.1	Introduction .....	41
4.2	Microstrip Patch Antenna Design.....	41
4.2.1	Analysis and Parameters of Antenna.....	42
4.2.2	Performance Comparison of the Designed Antennas .....	49
4.3	Frequency Selective Surfaces Analysis .....	50
4.3.1	Square – Circular Slotted.....	50
4.3.2	Hexagon – Slotted Hexagonal Loop.....	51
4.3.3	Square – Square Slotted.....	52
4.3.4	Performance Comparison of Frequency Selective Surfaces.....	53
4.4	Integrated Antenna with Frequency Selective Surfaces .....	54
4.4	Construction and Experimental Results.....	57

## **5 CONCLUSION AND FUTURE WORK**

5.1	Conclusion.....	60
5.2	Future Work.....	61

APPENDIX I: Antenna Author's Comparison

APPENDIX II: FSS Author's Comparison

APPENDIX III: RT Duroid Data Sheet

APPENDIX IV: Novele™ IJ-220 Printed Electronics Substrate

## List of Figures

Figure 1.1: Various form of microstrip patch antenna.....	2
Figure 1.2: Microstrip patch antenna .....	4
Figure 1.3: Physical and effective length of a rectangular microstrip patch antenna ..	4
Figure 1.4: Rectangular microstrip patch antenna feedline .....	5
Figure 1.5: (a) Patch elements (b) Aperture elements.....	6
Figure 1.6: The type of FSS elements.....	6
Figure 2.1: E – plane pattern of 4-element patch antenna .....	11
Figure 2.2: H – plane pattern of 4-element patch antenna .....	12
Figure 2.3: Frequency response of 4-element patch antenna.....	12
Figure 2.4: Radiation characteristics of 4-element patch antenna .....	12
Figure 2.5: Antenna 1 configuration .....	13
Figure 2.6: Antenna 2 configuration .....	13
Figure 2.7: Comparison between measured and simulate return losses for antenna 1 .....	14
Figure 2.8: Comparison between measured and simulate return losses for antenna 2 .....	14
Figure 2.2.9: Side view of the ACSP antenna with ground shield, via cage and RF- transition.....	15
Figure 2.10: In dB as a function of frequency; $\Theta_s = 0^\circ$ .....	16

Figure 2.11: Reflection coefficient at different angles (a) E-plane scan ( $\theta$ ), (b) H-plane scan ( $\phi$ ).....	17
Figure 2.12: Without FSS (a) Return Loss (b) VSWR .....	18
Figure 2.13: With FSS (a) Return Loss (b) VSWR .....	19
Figure 2.14: Fabricated microstrip patch antenna.....	20
Figure 2.15: Fabricated FSS.....	21
Figure 2.16: Super dense 2 layer linear dipole FSS .....	23
Figure 2.17: 3x3 element for 2 layer square loop FSS array .....	23
Figure 2.18: Measured and simulated transmission responses for inkjet printer and etched FSS. Solid line: measured, dot-dash line: simulated (inkjet), dashed line: simulated (etched) .....	24
Figure 2.19: Unit cell of second layer FSS with dual band behaviour .....	25
Figure 2.20: Theoretical gain over a frequency band .....	25
Figure 2.21: A U-slot patch antenna and its dimensions .....	26
Figure 2.22: A FSS with regular Jerusalem cross elements implanted in the U – slot patch antenna.....	27
Figure 2.23: Comparison of return losses for the smaller U-slot patch antenna with a modified FSS and the original U-slot patch antenna without using a FSS .....	27
Figure 2.24: antenna geometry (a) patch antenna and (b) FSS .....	28
Figure 2.25: Simulated gain of the proposed antenna.....	29
Figure 2.26: Dimensions of the antenna (in mm) .....	29
Figure 2.27: Dimension of the FSS.....	30

Figure 2.28: Comparative graph of Return Loss for FSS .....	30
Figure 2.29: Comparative graph of return loss with frequency of patch antenna with FSS at 21.1 mm.....	31
Figure 3.1: A rectangular patch model.....	34
Figure 3.2: Rectangular Feedline .....	36
Figure 3.3: Smith Chart.....	38
Figure 3.4: Project Flow Chart by sequence .....	40
Figure 4.1: Rectangular patch antenna parameters .....	42
Figure 4.2: Computed Return Loss for the antenna printed on a 1.5 mm substrate (Rogers RT 5880, $\epsilon = 2.2$ ).....	43
Figure 4.3: Z – smith parameter of the antenna printed on a 1.5 mm substrate (Rogers RT 5880, $\epsilon = 2.2$ ) .....	43
Figure 4.4: Wave radiation pattern Rogers RT5880 (1.5 mm) .....	44
Figure 4.5: Rogers RT5880 (0.254 mm) Patch Antenna .....	44
Figure 4.6: Computed Return Loss for the antenna printed on a 0.254 mm substrate (Rogers RT 5880, $\epsilon = 2.2$ ).....	45
Figure 4.7: Wave Radiation Rogers RT5880 (0.254 mm).....	45
Figure 4.8: Rogers RO3010 (1.28 mm) Patch Antenna.....	46
Figure 4.9: Computed Return Loss for the antenna printed on a 0.254 mm substrate (Rogers R03010, $\epsilon = 10.2$ ) .....	47
Figure 4.10: Wave Radiation Rogers RO3010 (1.28 mm).....	47
Figure 4.11: Rogers RO3003 (1.52 mm) Patch Antenna.....	48

Figure 4.12: Computed Return Loss for the antenna printed on a 0.254 mm substrate (Rogers R03010, $\epsilon = 10.2$ ) .....	48
Figure 4.13: Wave Radiation Rogers RO3003 (1.52 mm).....	49
Figure 4.14: Square - Circular Slotted Unit Cell (a) front view (b) back view.....	50
Figure 4.15: Computed Return Loss for the FSS of Square - Circular Slotted.....	51
Figure 4.16: Hexagon - Slotted Hexagonal Loop Unit Cell (a) Front view.....	52
Figure 4.17: Computed Return Loss for the FSS of Hexagon – Slotted Hexagonal Loop .....	52
Figure 4.18: Square – Square Slotted Unit Cell (a) Front view (b) back view .....	53
Figure 4.19: Computed Return Loss for the FSS of Square - Square Slotted Loop .	53
Figure 4.20: Integrated antenna and FSS frequency response .....	55
Figure 4.21: Integrated antenna Rogers 3010 and FSS frequency response.....	56
Figure 4.22: Antenna Rogers RO3010 real structures .....	57
Figure 4.23: Printed FSS (a) Front and (b) Side view .....	58
Figure 4.24: Antenna with FSS practical measurement.....	58
Figure 4.25: Microstrip patch antenna 10 mm distance with FSS .....	59
Figure 4.26: Microstrip patch antenna 35 mm distance with FSS .....	59

## List of Table

Table 1.1: Types of antenna with descriptions.....	2
Table 2.1: Antenna parameters .....	13
Table 2.2: Antenna array specifications.....	16
Table 2.3: Comparison of Simulated Results of Proposed Antenna.....	18
Table 2.4: Design parameters of microstrip antenna .....	20
Table 2.5: Comparison between simulated results microstrip patch and.....	21
Table 2.6: Comparison result of simulated and measured of antenna without FSS ..	31
Table 2.7: Planar patch antenna configuration.....	32
Table 4.1: Antenna Optimization.....	49
Table 4.2: Unit Cell Optimization.....	54
Table 4.3: Antenna Rogers RO3010 with FSS parameters.....	56



## CHAPTER 1

### INTRODUCTION

#### 1.1 Introduction to Antennas

This project describes on the “*Design and Development of Antenna with Frequency Selective Surfaces*”. The antenna is designed of a microstrip patch which operates in the X band. Frequency Selective Surface (FSS) is placed at the hollow of the antenna structure to optimize the transmissivity wave from the antenna with low loss. It will be a specific Frequency Selective Surface (FSS) for their design as to sustain the bandwidth for this undertaking. The antenna transmits the wave at X band frequency as it passes through the FSS; with an optimized bandwidth and frequency range. It is very challenging to keep the antenna size small but at the same time producing a larger bandwidth because the larger the antenna the bigger the bandwidth. Hence, to ensure the antenna in miniature size; the analysis is required to meet the specifications of the antenna in terms of normal impedance, efficiency, directivity and gain.

#### 1.2 Microstrip Patch Antenna

The basic terms of antenna will be linked up to the conducting and getting a radio waves for being capable to propagate in air space. The antenna is taken by any

recipient and transmitter complex with electronic circuit connection to check the wave direction.

A microstrip antenna consists of an upper conductor on top of a dielectric substrate. Various conductor shapes have been proposed and investigated for the microstrip patch antenna. Common form of printed patch antennas are square, rectangular, circle, ring, triangle, and elliptical which are shown in Figure 1.1;

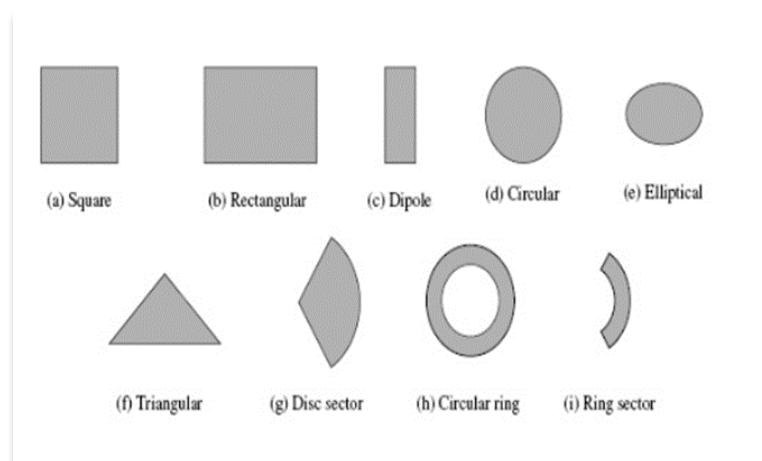


Figure 1.1: Various form of microstrip patch antenna

There are several types of antenna as shown in the table below;

Table 1.1: Types of antenna with descriptions

Antennas Profile	Type and Descriptions
On the basis of radiation	Omni-directional antenna - A weak directional antenna which radiate and receive in all directions.
	Directional antenna - It's radiate and receive in a particular direction.

On the basis of aperture	Wire antenna - Use everywhere such as buildings, ships, cars etc.
	Aperture antenna - Utilize in high frequencies; most useful in spacecraft and aircraft.
	Microstrip antenna - Most use in space, government and commercial applications.
	Array antenna - Gather several single antenna to maximize the radiation in particular direction.
On the basis of polarization	Linearly polarized antenna - E – Field propagate either in vertical polarize antenna or horizontal vertical antenna.
	Circularly polarized antenna - E – Field propagate in any orientation.

Recently antennas has been modified to smaller sizes to meet the requirements of mobile units. Hence, the size of the antenna is a major part that need to be observed; as for the size reduction and bandwidth optimization are the consideration for the physical and practical condition of the microstrip antenna.

The conventional design of a microstrip patch antenna consist of a conductor patch printed on a dielectric substrate that is mounted together. Yet this character of a conventional antenna has its flaw which is narrow bandwidth. Figure 1.2 shows the physical structure of a microstrip patch antenna.

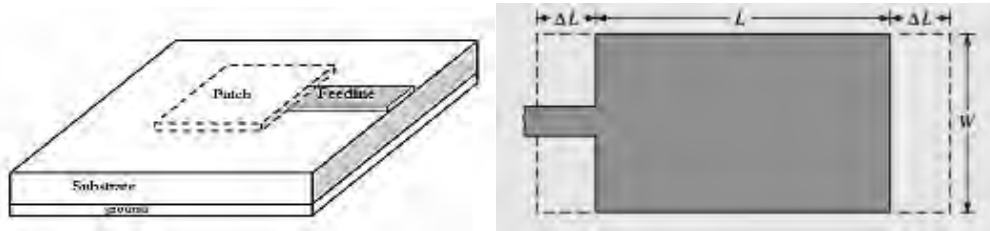


Figure 1.2: Microstrip patch antenna

This type of antenna radiate on the main plane because of the fringing fields that exist between the patch edge and the ground plane. The design can be explained based on the Transmission Line model.



Figure 1.3: Physical and effective length of a rectangular microstrip patch antenna

Figure 1.3 demonstrates the effective duration of a patch antenna radiation with the substrate material. The relationship between size and the dielectric constant of the dielectric substance is the element that will affect the frequency band of the microstrip patch antenna.

There are various methods of feeding in the design of a microstrip antenna:

- Microstrip Line.
- Coaxial Probe (coplanar feed).
- Proximity Coupling.
- Aperture Coupling.

The most significant matter to be debated is the maximum power transfer i.e (matching of the feed line with the input impedance of the antenna), which discussed in section. There are certain designs which have been put aside because of their poor feeding. Designer can construct an antenna with good features and good radiation parameter and high efficiency, but when the feeding is bad, the total efficiency could reduce to a low level which causes the whole system to be not optimize. An example of a feedline that is used in this project is shown in Figure 1.4;

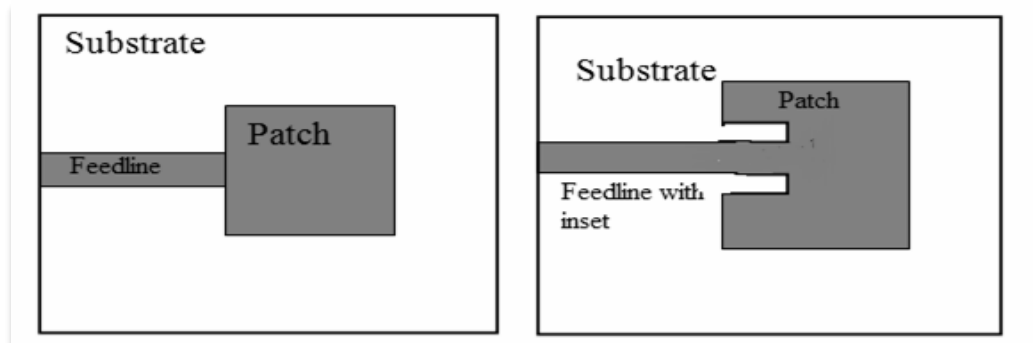


Figure 1.4: Rectangular microstrip patch antenna feedline

### 1.3 Frequency Selective Surfaces (FSS)

Frequency Selective Surface is defined as a periodic array of one or two dimensional patch elements or aperture elements combined with a dielectric substrate. The patch type show in Figure 1.5(a) represents capacitance which correspond to a low pass filter while the aperture type which is shown in Figure 1.5b) has an inductance effect which correspond to a high pass filter.

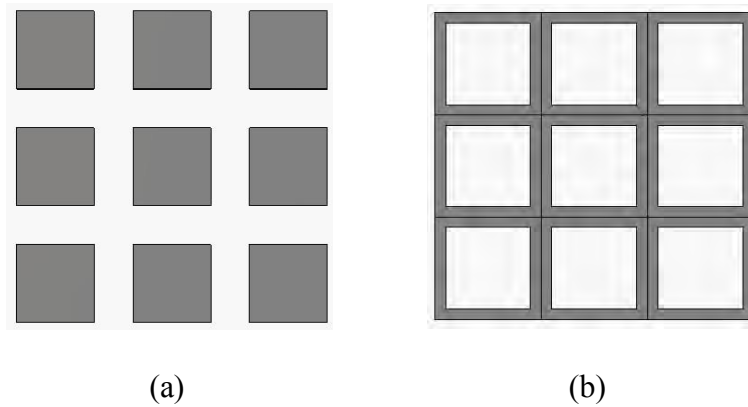


Figure 1.5: (a) Patch elements (b) Aperture elements

There are four major types of FSS, which can be seen in *Figure 1.6*. The first group includes the center connected elements for example simple straight element, three legged element, anchor element, Jerusalem cross and square spiral.

Meanwhile, the loop types are categorized in group 2 for example three and four-legged loaded element, circular loops, square and hexagonal loops. Group 3 include patch type of combinations.

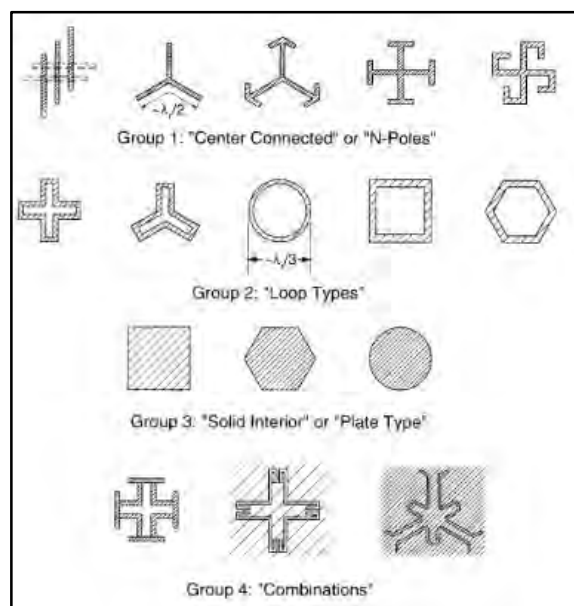


Figure 1.6: The type of FSS elements

Most of the research that has been carried out in last few decades focuses on one or two dimensional periodic array of resonant structures. Less attention has been paid to three dimensional FSSs. But in many practical applications, the underlying

surface is curved rather than categorical. A novel design of a three dimensional frequency selective surface is interesting and challenging.

The advantage of the 3D structure is its excellent space utilization. In theory, the resonant frequency is limited by the resonant length in a unit cell. The previous techniques researched on miniaturized FSS are essential to elongate the resonant length in two-dimensional. With the utilization of three-dimensional space, the unit cell size of the FSS can be further diluted. On the other hand, an FSS with a stable frequency response to different types of polarization of different oblique angles is needed.

#### **1.4 Antenna with Frequency Selective Surfaces**

FSS's can be utilized to determine the frequency and the angle response of an antenna. It depends on the shape of the FSS and the bandwidth of the transmitting aerial. On that point is more flexibility in choosing the element of the FSS to be fitted with the designated antenna besides from using the formal method.

From the image above, the wave beam direction will have an impingement on the FSS surfaces. The FSS plane cover all the wave radiated with proposed of low losses during the transmission. The main role of the FSS is either to be a filter or a reflector. If the antenna act as a filter, it will assist to optimize the wave while a reflector FSS will not allow frequency at specific bandwidths designated for the FSS to pass through the planer.

The microstrip patch antenna needs the FSS to overcome its weakness to obtain larger bandwidth with a miniaturized size of the transmitting aerial. It likewise helps to maintain and optimize the beam of the microstrip patch antenna.

## 1.5 Problem Statement

Grounded along the data, there are many types of antenna with FSS design. All of the designs shown different result of bandwidth range and wave optimization. It was known that the bigger the size of the antenna the bigger it will be for the bandwidth. Logically, it will not apply to have a bigger antenna at particular location, such as rooftop; it will waste space and energy consumption for the antenna.

## 1.6 Objectives

This research provides a comprehensive analysis for the carrying out optimization of both microstrip antenna and frequency selective surface.

The central aims of this research work are as follows:

To understand the relationship between antenna application and FSS.

To design an antenna and FSS for the selected frequency band.

To simulate the bandwidth enhancement of the selected antenna within the frequency range.

## 1.7 Scope of Work

This specific design of the microstrip patch antenna with FSS regarding with the antenna efficiency and bandwidth optimization. Therefore, the antenna reduces the return loss and enhances the bandwidth and gain in X band at the resonance of 8 GHz to 12 GHz; which in part of the X band range of frequency.

The microstrip patch antenna is mostly recognized for the discrepancy in terms of the possible pattern that make it applicable to diverse positions. Furthermore, this sort of antenna has a narrow bandwidth and then it can be tuned; also for it lightweight microwave integrated circuit.