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Graduation Project

Design and Fabrication of Microstrip Tools for Measurement of Gain and Circularly Polarized Radiation Pattern

Project Supervisor

Dr . Osama Ata

Prepared by

Ahmad Amro Sahar Ayaydeh Wafaa Abu-Alia

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كلية الهندسة والتكنولوجيا

دائرة الهندسة الكهربائية والحاسوب

اسم المشروع

Design and Fabrication of Microstrip Tools for Measurement of Gain and Circularly Polarized Radiation Pattern

أسماء الطلبة

أحمد عمرو   سحر عيايدة   وفاء أبو عليا

بناء على نظام كلية الهندسة والتكنولوجيا وإشراف ومتابعة المشرف المباشر على المشروع وموافقة أعضاء اللجنة الممتحنة تم تقديم هذا المشروع إلى دائرة الهندسة الكهربائية والحاسوب وذلك للوفاء بمتطلبات درجة البكالوريوس في الهندسة تخصص هندسة اتصالات وإلكترونيات

توقيع المشرف

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اهداء

بسم الله الرحمن الرحيم

(قل إعملوا فسيرى الله عملكم ورسوله والمؤمنون)

صدق الله العظيم

لا بد لنا و نحن نخطو خطواتنا الأخيرة في الحياة الجامعية ان نتوجه ب الشكر و الامتنان لكل الذين كانوا عونا لنا في بحثنا هذاونورا يضيء الظلمة التي كانت تقف أحيانا في طريقنا.

سحر و وفاء

اتقدم ب اهداء من نوع خاص الى مثلي الاعلى في حياتي و هو والدي العزيز و الى نور عيني ومن كانت بجانبي دوما امي الحبيبة و الشكر الاكبر الى من وقف بجانبي دوما زوجي و حبيبي واهداء من نوع خاص ايضا الي فلذة كبدي واخيرا و ليس اخرا الى اخوتي و اخواتي الاعزاء

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involved in the successful completion of this project work.

Abstract

An antenna is a device that is made to efficiently radiate and receive radiated electromagnetic waves .One type of antennas that fulfills most of the wireless system requirements is relatively microstrip antennas. A microstrip antenna is a kind of antenna used to radiate ultrahigh frequency signal. The demand of small size electronic systems has been increasing for several decades. The physical size of systems is reduced due to advancements in integrated circuits. With reduction in size of electronic systems, there is also an increasing demand of small and low cost antennas.

Conventional microstrip patch antennas, in general, have a conducting patch printed on a grounded substrates, and have the attractive features of low profile, light weight, a narrow impedance bandwidth, low efficiency, low gain, large ohmic loss in large feed network, low polarization purity and they can only be used in low power applications, easy fabrication and supports both linear and circular polarization. Micro strip antenna are widely used in various applications like in wireless communication system, satellite communication, Radar systems, Global positioning systems, Radio Frequency Identification (RFID), Worldwide interoperability for microwave access (WiMax).

The antenna training system that exists in the microwaves and antenna laboratory in the college of engineering and technology has a great ability for research if further tools could be created. From previous projects in the microstrip field, a great need rose to measure the gain of linearly polarized microstrip antennas as well as the radiation patterns of circularly polarization microstrip antennas in the available 1GHz frequency band.

Our goal is to design, fabricate and measure those tools that can be used by future research student to enable measurement of microstrip antenna gain and circularly polarized radiation patterns of any micrpstrip antenna made of FR4 or Duroid dielectric substrates of around 1.57 mm in thickness, operating in the 1 GHz frequency band.

The analysis of microstrip antenna is based on empirical formulas and finite difference methods that are utilized in special commercialized software simulations which we intend to use for design and analysis of the mentioned tools.

The developed tools can serve wide sectors in wireless and satellite applications. Specifically, it will serve future research students to utilize those tools as an extended capability of measuring gain and radiation patterns of microstrip antennas in the available 1 GHz band.

الملخص

أصبح الطلب على الأنظمة الالكترونية صغيرة الحجم يتزايد في الوقت الحاضر , بسبب تقدم المستمر في الدوائر المتكاملة فنتج عن ذلك الحاجة لتقليل الحجم الفعلي للأنظمة الالكترونية.

وقد لوحظ في الأونة الأخيرة تزايد الطلب على الهوائيات صغيرة الحجم منخفضة التكلفة ولعل أبرزها Microstrip Antenna وهو نوع من الهوائيات المستخدمة لإشعاع إشارات عند ترددات عالية جدا.

ويتكون هذا النوع الهوائيات التقليدية Microstrip Antenna بشكل عام من أربعة أجزاء رئيسية : طبقة معدنية Patch - طبقة عازلة و الطبقة الاساسية Ground وجزء خاص للتغذية . الطبقة المعدنية تتكون عادة من النحاس أو الذهب .

ومن ميزاته : خفة الوزن ,سهولة التصنيع , ودعمه كلٍ من الاستقطاب الخطي والدائري. ويستخدم على نطاق واسع في مختلف التطبيقات مثل : نظام الإتصالات اللاسلكية, وأنظمة الرادار , وفي الإتصالات عبر الأقمار الصناعية وغيرها.

بالرغم من ذلك , هناك عدة مساوئ لاستخدام هذا النوع من الهوائيات،لأنها تعمل على نطاقات ضيقة للتردد ,و كفاءتها قليلة حيث نسبة ضياع الطاقة فيها عالية.

وبناءاً على ما تقدم سنقوم بتصميم هوائيين على شكل " Square " و الثاني من نوع ثنائي القطب أي أننا سنستخدم هوائيين من نفس النوع حتى نتمكن من القياس الدقيق ل" Power " وبالتالي قياس قيمة ال" Gain "

وفي تطبيقات كثيرة وجدنا حاجة إلى قياس الإستقطاب الدائري , سوف نحاول ايجاد أدوات قياس ثابته , للحصول على قياس دقيق للإستقطاب الدائري وذلك عن طريق تصميم " Two Square Antenna " وهما عبارة عن هوائي مرسل وأخر مستقبل بحيث أن الإستقطاب لكلاهما دائري.

لقد أخذنا بعين الإعتبار ثلاثة معايير أساسية لتصميم : تردد الرنين , معامل العزل الكهربائي وسمك الطبقة العازلةϵ_r

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CHAPTER ONE
INTRODUCTION

1.1 Overview

An antenna is a device that is made to efficiently radiate and receive radiated electromagnetic waves. There are several important antenna characteristics that should be considered when choosing it for certain applications these are: antenna radiation pattern, power gain, directivity and polarization [1] .one type of antennas that fulfills most of the wireless system requirements is relatively microstrip antennas.

Microstrip antennas are a new and exciting technology. Invented about twenty years ago for application as conformal antennas on missiles , aircraft systems , GPS , remote sensing , medical usage and automobile collision avoidance, and have the attractive features of low profile , light weight , easy fabrication and supports both linear and circular polarization [2].

The microstrip antenna consists of a radiating metallic patch or an array of patches, it is act approximately as a resonant cavity , on one side of a thin no conducting , supporting substrate panel with a ground plane on the other side of the panel, and is characterized by its Length, Width, Input impedance, and Gain and radiation patterns .

The metallic patch is normally made of copper-foil plated with plated with a corrosion material , such as gold, thin , or nickel .Each patch can be made into a verity of shapes with the most popular shapes being rectangular , square and circular. Miccrostrip antennas in its simplest configuration are shown in Figure.1.1 [3]

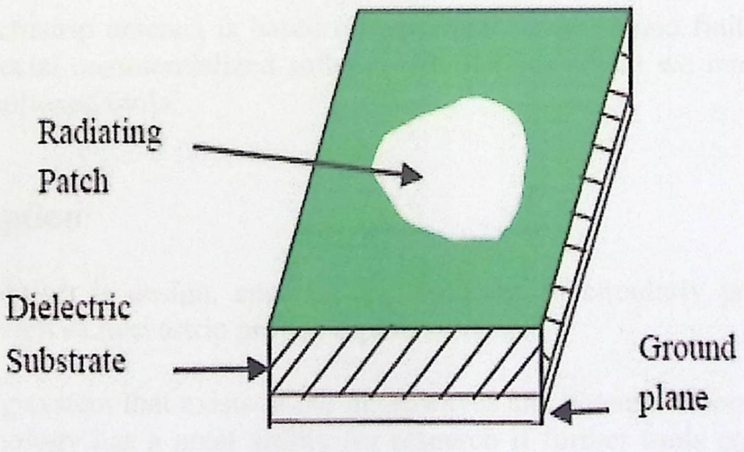

Fig.1.1 Microstrip antenna configuration

On the other hand the microstrip antenna, suffers from some disadvantages such as narrow bandwidth, low gain, large ohmic loss in large feed network, low polarization purity .Microstrip antennas are widely used as an efficient radiator in many communication systems.

Microstrip antennas are characterized by a larger number of physical parameters than are conventional microwave antennas .All microstrip antennas can be divided into four basic categories:

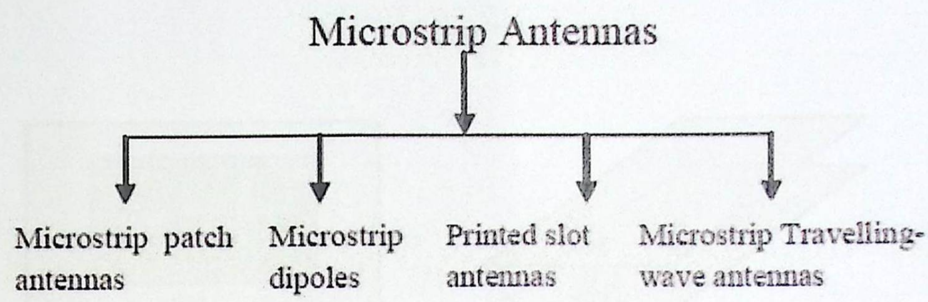

Fig. 1.2 Four basic categories for microstrip antennas

Microstrip dipole is a good and easy approach, for a system where an Omni directional pattern is required, as for example in a portable device. Micostrip or printed dipole antenna have been of the most popular type of antenna in the last twenty years .The bandwidth of micostrip dipole antenna is very high as compared to the microstrip patch antenna .

One of the most interesting applications is their use for transmitting or receiving system required for circular polarization. A circularly polarized microstrip antenna can be classified into categories ,e.g. single-or dual-fed type .The classification of an antenna is based upon the number of feeding points required for circularly polarized waves [4].

The analysis of microstrip antenna is based on empirical formulas and finite difference methods that are utilized in special commercialized software simulations which we intend to use for design and analysis of the mentioned tools.

1.2 Project Description

The aim of this project is design, analysis and optimize of circularly polarized square patch microstrip antenna as well as microstrip printed dipole antenna.

The antenna training system that exists in the microwaves and antenna laboratory in the college of engineering and technology has a great ability for research if further tools could be created. From previous projects in the microstrip field, a great need rose to measure the gain of linearly polarized microstrip antennas as well as the radiation patterns of circularly polarization microstrip antennas in the available 1GHz frequency band.

The design starts with simple Square patch Microstrip antenna with single feed. This antenna has been designed to operate at 1GHz, using FR4 (£r=4.4) and height (h=1.6mm), shown in Figure 1.3 .The microstrip antenna is simulated using the An soft HFSS software.

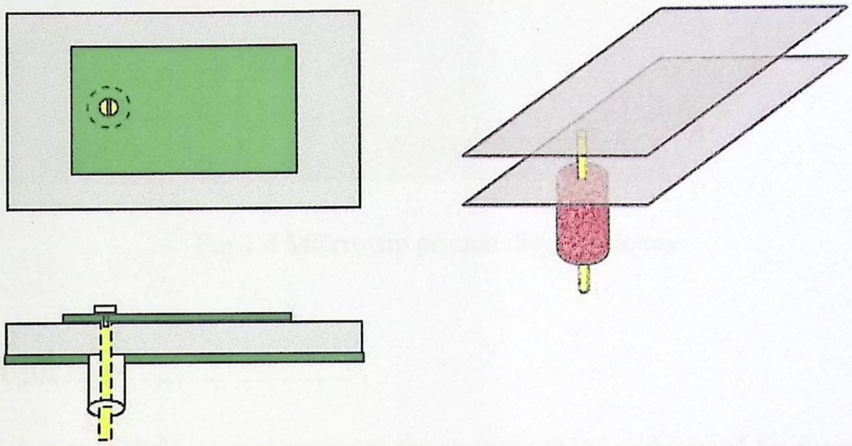

Fig. 1.3 Microstrip with coaxial probe feed patch antenna

Also the procedure for designing printed dipole microstrip antennas in software High Frequency Structure Simulator (HFFS) version 13 by An soft Corporation.

The first proposed antenna is circularly polarized square patch microstrip antenna design with and without X-slots, and also on different dimensions of the patch, ground, substrate, Transmission line and quarter wave length. And then compare and analyzed the return loss, bandwidth, VSWR, and the performance for each design.

Also, the design parameters of the 1GHz printed dipole antenna are shown in Figure1.2. The complete structure has simulated for several value of L, W and g parameters. Good agreement between simulated results on return loss and resonance bandwidth has been achieved. Simulated radiation pattern has also been specified for each value of L.W, and g parameters.

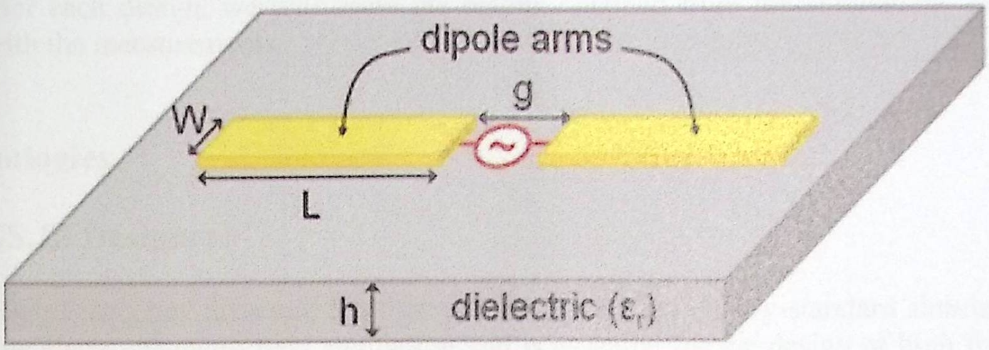

Fig.1.4 Microstrip printed dipole antenna

1.3 Project Objective

Our goal is to design, fabricate and measure those tools that can be used by future research student to enable measurement of microstrip antenna gain and circularly polarized radiation patterns of any micrpstrip antenna made of FR4 or Duroid dielectric substrates of around 1.6 mm in thickness, operating in the 1 GHz frequency band.

The objective is to present design, analyze, fabricate and measure dipole microstrip antennas as well as circularly polarized patch antennas as complementary tools for research to the available antenna training system in our lab.

Perform parametric study to optimize the design using CST or An soft /HFSS Designer software. Evaluate the performance of those tools, in comparison to other available microstrip antennas.

1.4 Motivation

We have an interest to design and develop tools to measure gain and circular polarized radiation pattern that would complement available tools for the antenna measurement system in our advanced facilities communications laboratory. Such tools enable future research students to measure gain of microstrip antennas and radiation patterns of circularly polarized patches.

Designing a circularly polarized microstrip antenna is challenging; it requires combination of design steps. The first step involves designing an antenna to operate at a given frequency. In the second step circular polarization is achieved by either introducing a perturbation segment to a basic single fed microstrip antenna, or by feeding the antenna with dual feeds equal in magnitude but having 90° physical phase shift. The shape and the dimensions of the perturbation have to be optimized.

Single feeding techniques are commonly used because they are simple, easy to manufacture, low in cost and compact in structure. Single fed circularly polarized microstrip antennas are considered to be one of the simplest antennas that can produce Circular polarization [5] .

Finally, for each design, we will show the results obtained from the simulations which will be compared with the measurements.

1.5 Technologies

1.5.1 HFSS.13 Designer:

HFSS (High Frequency Structure Simulator) software is the industry-standard simulation tool for 3-D full-wave electromagnetic field simulation and is essential for the design of high frequency and high-speed component design. This software automatically divides the geometric model into a large number of tetrahedron is a four -sided pyramid.

1.6 Project Organization

The completed project report is divided into 6 chapters; in the following lines we show a summary for each one:

Chapter 1. Introduction

It is the present chapter, which provides a brief introduction, motivation and overall project objectives, Technologies, time plan.

Chapter 2. Reviews of microstrip antenna.

Chapter 3. Microstrip Theory

It is present the antenna design methodology and its specifications and the Literature Surveys.

Chapter 4. Microstrip Patch Antenna Design and Results

Chapter 4 presents design verification for the designed antennas using HFSS simulation and the results of these antennas.

Chapter 5.Antenna Measurement Results

Chapter 6. Conclusion and future work

This chapter presents the conclusions of the project. It's also propose future lines to enhance the behavior of the antenna.

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Table1.2 ***Project Plan for first semester***

Weeks																
Activity	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Information collection	■	■	■													
Preparing the proposal		■	■													
Learning software (HFSS Ansoft)				■	■	■	■									
Design and analysis						■	■	■	■	■	■	■				
Learning fabrication								■	■	■						
Drafting chapters				■	■	■	■	■	■	■	■	■	■			
Dr. Osama's Deadline													■			
Submit the report to department														■		

Table1.2 *Project Plan for second semester*

Weeks																
Activity	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Design and analysis																
Research for offers																
Drafting chapters																
fabrication																
Measurement and Results																
Dr. Osama's Deadline																
Submit the report to department																

CHAPTER TWO

MICROSTRIP ANTENNA

2.1 Overview

In this chapter we are going to give overview about types of antenna, especially microstrip antenna, definition of some antenna's parameters, types of polarization, axial ratio definition, feeding techniques in circular polarization and the shape of slot that give our circular polarization which are going to be useful along the project development to describe the performance of our microstrip antenna design.

2.2Introduction for Antenna

An antenna is a part of a transmitting or receiving system, designed specifically to radiate or receive electromagnetic waves. The antenna is a passive linear reciprocal device that can convert electromagnetic radiation into electric current and vice-versa, so it is a transitional structure between the free space and a guiding device. We have many types of antenna some of these type:-

(1) Antenna tower:

A tall tower designed to support antennas (also known as aerials in the UK) for telecommunications and broadcasting.

(2) Dipole antenna:

A simple antenna usually constructed from two wires in opposite phases placed end to end.

(3) Directional antenna:

Or beam antenna, radiates greater power primarily in one direction.

(4) Horn antenna:

A type of directional antenna shaped like a horn.

(5) Met material antenna:

A class of antenna incorporating met materials to increase performance of miniaturized (electrically small) antenna systems.

(6) Omni directional antenna:

An antenna system which radiates power uniformly in all directions in one plane.

(7) Parabolic antenna:

An antenna shaped like a parabola in one or both planes.

(8) Power antenna (automotive):

A power antenna is an electrically motorized automotive radio antenna that raises and lowers either manually with a dash-mounted switch or automatically by turning the radio on or off.

(9) Antenna (radio):

Also known as an aerial, a transducer designed to transmit or receive electromagnetic (e.g. TV or radio) waves.

(10) Television antenna:

(Or TV aerial), is an antenna specifically designed for the reception of broadcast television signals.

(11) Antennae Galaxies:

The name of two colliding galaxies NGC 4038 and NGC 4039.

2.3 Overview of microstrip antenna

A microstrip antenna consists of conducting patch on a ground plane separated by dielectric substrate as shown in Fig.2-1 (a), (b) and(c).This concept was undeveloped until the revolution in electronic circuit miniaturization and large-scale integration in 1970. After that many authors have described the radiation from the ground plane by a dielectric substrate for different configurations. The early work of Munson on microstrip antennas for use as a low profile flush mounted antennas on rockets and missiles showed that this was a practical concept for use in many antenna system problems.

Various mathematical models were developed for this antenna and its applications were extended to many other fields. The number of papers, articles published in the journals for the last ten years, on these antennas shows the importance gained by them. The microstrip antennas are the present day antenna designer's choice. Low dielectric constant substrates are generally preferred for maximum radiation.

The conducting patch can take any shape but rectangular and circular configurations are the most commonly used configuration. Other configurations are complex to analyze and require heavy numerical computations. A microstrip antenna is characterized by its Length, Width, Input impedance, and Gain and radiation patterns. The length of the antenna is nearly half wavelength in the dielectric; it is a very critical parameter, which governs the resonant frequency of the antenna. There are no hard and fast rules to find the width of the patch.

In its most fundamental form, a Microstrip Patch antenna consists of a radiating patch on one side of a dielectric substrate which has a ground plane on the other side. The patch is generally made of conducting material such as copper or gold and can take any possible shape. The radiating patch and the feed lines are usually photo etched on the dielectric substrate. In order to simplify analysis and performance prediction, the patch is generally square, rectangular, circular, triangular, and elliptical or some other common shape.

For a rectangular patch, the length L of the patch is usually $0.3333\lambda o < L < 0.5\ \lambda o$, where λo is the free-space wavelength. The patch is selected to be very thin such that $t \ll \lambda o$ (where t is the patch thickness). The height h of the dielectric substrate is usually $0.003\ \lambda o \leq h \leq 0.05\ \lambda o$. The dielectric constant of the substrate (εr) is typically in the range $2.2 \leq \varepsilon r \leq 12$.

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Advantages of microstrip antenna:

• Light weight and low volume.

• Low profile planar configuration which can be easily made conformal to host surface.

• Low fabrication cost, hence can be manufactured in large quantities.

• Supports both, linear as well as circular polarization.

• Can be easily integrated with microwave integrated circuits (MICs).

• Capable of dual and triple frequency operations.

• Mechanically robust when mounted on rigid surfaces.

Disadvantages of microstrip antenna:

• Narrow bandwidth.

• Low efficiency.

• Low Gain.

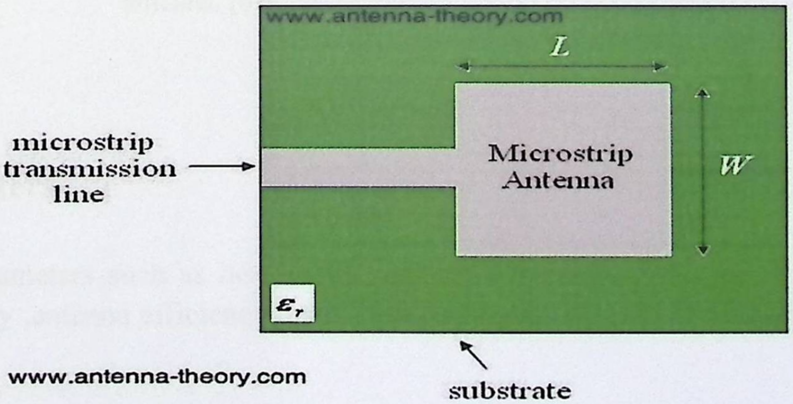
• Extraneous radiation from feeds and junctions.

• Poor end fire radiator except tapered slot antennas.

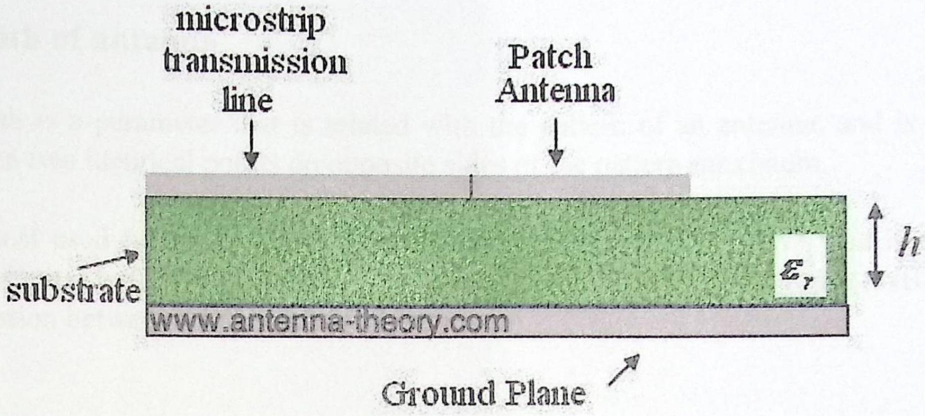
• Low power handling capacity.

• Surface wave excitation.

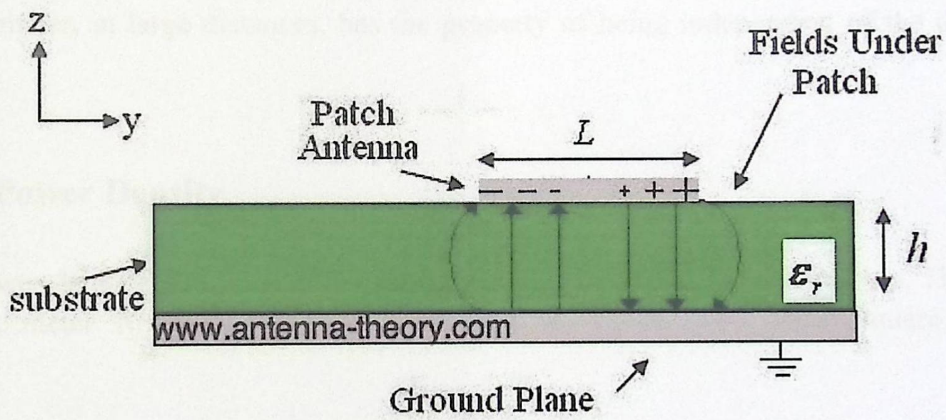
Microstrip shape as follow:



(a)Top view of microstrip antenna.



(b) Side view of microstrip antenna.



(c)The fields for microstrip antenna.

Fig.2.1 (a) Top view of microstrip antenna. (b) Side view of microstrip antenna. (c)The fields for microstrip antenna. [6]

2.4 Some of antenna parameters

We have many of antenna parameters such as beamwidth ,radiation intensity ,radiation power density ,radiation pattern, directivity ,antenna efficiency ,gain ,bandwidth and input impedance, they are discussed as follow:-

2.4.1 Beamwidth of antenna

The beamwidth is a parameter that is related with the pattern of an antenna, and is the angular separation between two identical points on opposite sides of the pattern maximum.

One of the most used beamwidth is the "half-power beamwidth" (HPBW), and is the angle at which the main lobe has half of its power. We have also the "first-null beamwidth" (FNBW) and it is the angular separation between the first nulls of the pattern.

2.4.2 Radiation Intensity

It is defined as the power radiated from an antenna per unit solid angle. Its units are watts per steradian. This parameter, in large distances, has the property of being independent of the distance that the antenna is.

2.4.3 Radiation Power Density

The radiation power density is defined as the power per unit area in a certain direction. The units are watts per square meter. It can be calculated from the RMS values (Root Mean Square) of the fields E and H.

2.4.4 Radiation Pattern

The radiation pattern is the spatial distribution of a quantity that characterizes the electromagnetic field generated by an antenna.

2.4.5 Directivity

According to the definition that has been given by IEEE , the directivity of an antenna is defined as "the ratio of the radiation intensity in a given direction from the antenna to the radiation intensity averaged over all directions. The average radiation intensity is equal to the total power radiated by the antenna divided by 4π. If the direction it is not specified, the direction of maximum radiation intensity is implied.

2.4.6 Antenna Efficiency

The total antenna efficiency takes into account the ohmic losses of the antenna through the dielectric material, the reflective losses at the input terminals and losses within the structure of the antenna.

2.4.7 Gain

Gain is a useful measure that helps to describe the performance of an antenna. It is defined by IEEE as "the ratio of the intensity, in a given direction, to the radiation intensity that would be obtained if the power accepted by the antenna were radiated isotropically .The gain it is linearly related with the directivity measurement through the antenna radiation efficiency.

2.4.8 Bandwidth

We cannot build an infinite antenna, so due to it finite geometry, the antenna is limited to operate successfully in a band or frequency range and this frequency range is known as bandwidth.For narrowband antennas, the bandwidth can be specified as the ratio of the frequency range in which the specifications are met and the center frequency.

2.4.9 Input Impedance

The input impedance of the antenna (ZA) is the relationship between voltage and current at the input terminals of the antenna, with no load attached.

The input impedance of an antenna is generally a function of frequency, so the relationship between voltage-current at the input of the antenna depends on the frequency, and ZA depend also on the frequency.

If at a given frequency, the reactance of the input impedance antenna is equal to zero, it is said that the antenna is resonant at that frequency.

2.5 Polarization

The polarization of an antenna in a given direction indicates the polarization of the radiated wave of the antenna in that direction. If the direction is not stated, the polarization is taken to be the polarization in the direction of maximum gain.

The polarization of a radiated wave is the property of an electromagnetic wave describing the time varying direction and relative magnitude of the electric-field vector at a fixed location in space, and the sense in which it is traced, as observed along the direction of propagation.

The polarization is indicated by the vector that describes the electric field at a point in space as a function of time. We have three classifications of antenna polarization: linear, circular and elliptical as shown in Figure 2.2. The circular and linear polarizations are special cases of elliptical polarization.The sense of rotation of the electric field, in both circularly polarized waves as elliptical, is said to be a right-hand polarization if the field is traced in a clockwise. elliptical, is said to be a right-hand polarization if the field is traced in a clockwise(CW), and if it is in the opposite way (counterclockwise) then is said to be a left-hand polarization.

The polarization is an important concept in satellite communications and radio systems; because the receiving antenna is only able to capture the power contained in the field polarization that coincides with their own.Now we are going to explain about the general characteristics and the necessary conditions that the wave must have in order to possess linear, circular, or elliptical polarization. [7]

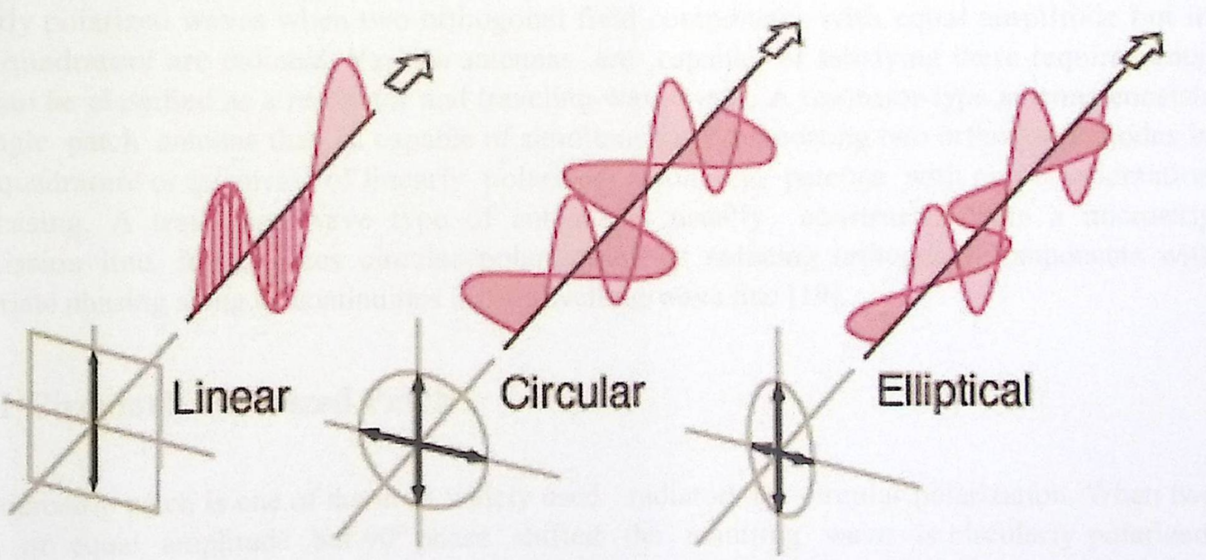


Fig2.2 Classifications of antenna polarization [8]

2.5.1 Linear Polarization

If the electric-field vector at a given point in the space is always oriented along the same straight line at every instant of time, we can say that the time harmonic wave is linearly polarized at that point.

This is accomplished if the electric field vector possesses the following Characteristics:
1 .Only one component
2 .Two orthogonal linear components that are in time phase or 180° (or Multiples of 180°) out-of-phase.

2.5.2 Circular Polarization

Generally antenna radiates an elliptical polarization, which is defined by three parameters: axial ratio, tilt angle and sense of rotation. When the axial ratio is infinite or zero, the polarization becomes linear with the tilt angle defining the orientation. The quality of linear polarization is usually indicated by the level of the cross polarization. For the unity axial ratio, a perfect circular polarization results and the tilt angle is not applicable. In general the axial ratio is used to specify the quality of circularly polarized waves. Antennas produce circularly polarized waves when two orthogonal field components with equal amplitude but in phase quadrature are radiated. Various antennas are capable of satisfying these requirements. They can be classified as a resonator and traveling-wave types. A resonator-type antenna consists of a single patch antenna that is capable of simultaneously supporting two orthogonal modes in phase quadrature or an array of linearly polarized resonating patches with proper orientation and phasing. A traveling- wave type of antenna is usually constructed from a microstrip transmission line. It generates circular polarization by radiating orthogonal components with appropriate phasing along discontinuities is the travelling-wave line [19].

2.5.2.1 Circularly Polarized Patch

A microstrip patch is one of the most widely used radiators for circular polarization. When two signals of equal amplitude but 90^{o} phase shifted the resulting wave is circularly polarized. Some patches such as square, circular, pentagonal, equilateral triangular,ring, and elliptical shapes which are capable of circular polarization operation. However square and circular patches are widely utilized in practice. A single patch antenna can be made to radiate circular polarization if two orthogonal patch modes are simultaneously excited with equal amplitude and out of phase with sign determining the sense of rotation. Two types of feeding schemes can accomplish the task as given in the Figure 2.3; first type is a dual- orthogonal feed, which employs an external power divider network. The other is a single point for which an external power divider is not required [19-20].

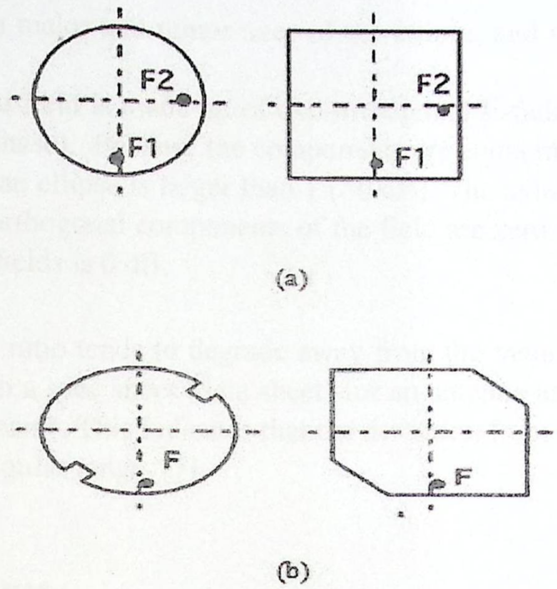


Fig.2.3 Two types of excitations for circularly polarized microstrip antennas: (a) dual-fed patch and (b) singly fed patch[19]

2.5.4 Elliptical Polarization

If the tip of the electric-field vector traces an elliptical locus in space, then the time-harmonic wave is elliptically polarized.

A wave is elliptically polarized if it is not linearly or circularly polarized, and in the real world there is no perfect linear or circular polarized antenna, but they are more or less elliptical.

The necessary and sufficient conditions to accomplish this are if the electric field vector possesses all of the following:

1) The field must have two orthogonal linear components, and
2) The two components can be of the same or different magnitude.
3) a) If the two components are not of the same magnitude, then the time-phase difference between the two components must not be 0∘ or multiples of 180 because then it will be a lineal polarization .
b) If the two components are of the same magnitude, then the time-phase difference between the two components must not be odd multiples of 90 because it will then be a circular polarization.

2.6 Axial Ratio

The axial ratio is the ratio of orthogonal components of an E-field; it is a very important parameter that helps to quantify the polarization of an antenna. The axial ratio of a wave elliptically polarized, is the relationship between major and minor axes of the ellipse, and it can take values among one and infinity

A circularly polarized field is made up of two orthogonal E-field components of equal amplitude (and 90 degrees out of phase). Because the components are equal magnitude, the axial ratio is 1 (or 0 dB). The axial ratio for an ellipse is larger than 1 (>0 dB). The axial ratio for pure linear polarization is infinite, because the orthogonal components of the field are zero. The ideal value of the axial ratio for circularly polarized fields is 0 dB.

In addition, the axial ratio tends to degrade away from the main beam of an antenna, so the axial ratio may be indicated in a spec sheet (data sheet) for an antenna as follows: "Axial Ratio: dB for +-30 degrees from main beam". This indicates that the deviation from circular polarization is less than 3 dB over the specified angular range. [7]

2.7 Feeding techniques

Microstrip patch antennas can be fed by a variety of methods. These methods can be classified into two categories- contacting and non-contacting.In the contacting method, the RF power is fed directly to the radiating patch using a connecting element such as microstrip line. In the non-contacting scheme, electromagnetic field coupling is done to transfer power between the microstrip line and the radiating patch. The four most popular feed techniques used are the microstrip line coaxial probe (both contacting schemes), aperture coupling and proximity coupling(both non-contacting schemes) [19-20].

2.7.1 Microstrip line feed

In this type of feed technique, a conducting strip is connected directly to the edge of the Microstrip patch as shown in Figure 2.4. The conducting strip is smaller in width as compared to the patch and this kind of feed arrangement has the advantage that the feed can be etched on the same substrate to provide a planar structure. This is an easy feeding scheme, since it provides ease of fabrication and simplicity in modeling as well as impedance matching. However as the thickness of the dielectric substrate being used, increases, surface waves and spurious feed radiation also increases, which hampers the bandwidth of the antenna. The feed radiation also leads to undesired cross polarized radiation performances [19-22].

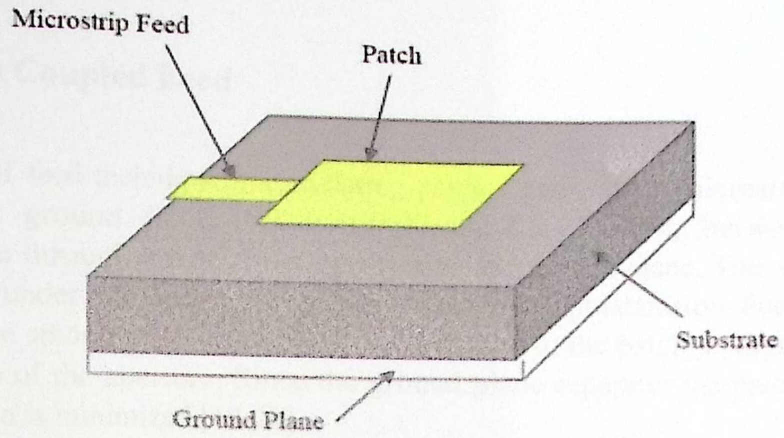


Fig 2.4 Microstrip line feed

2.7.2 Coaxial Feed

The Coaxial feed or probe feed is a very common technique used for feeding Microstrip patch antennas. As seen from Figure 2.5. The inner conductor of the coaxial connector extends through the dielectric and is soldered to the radiating patch, while the outer conductor is connected to the ground plane. The main advantage of this type of feeding scheme is that the feed can be placed at any desired location inside the patch in order to match with its input impedance. This feed method is easy to fabricate and has low spurious radiation. However, a major disadvantage is that it provides narrow bandwidth and is difficult to model since a hole has to be drilled in the substrate and the connector protrudes outside the ground plane, thus not making it completely planner for thick substrates ($h > 0.02\lambda o$).

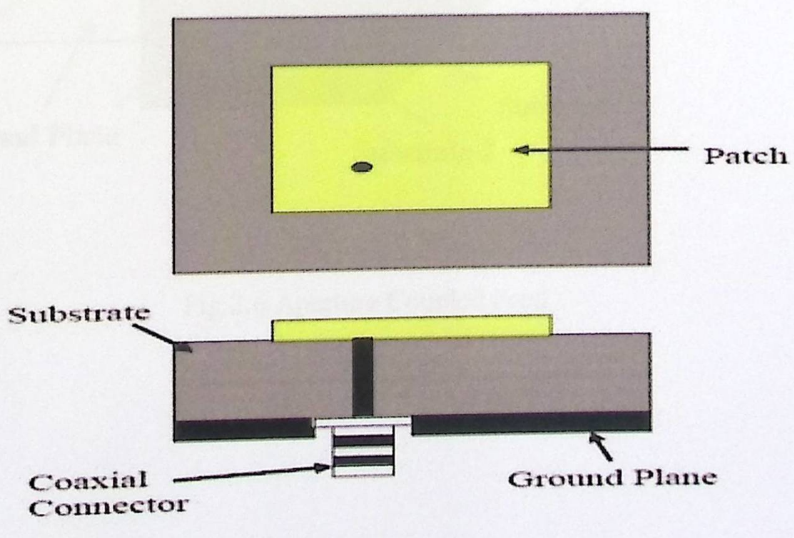


Fig 2.5 Probe fed rectangular microstrip antenna

2.7.3 Aperture Coupled Feed

In this type of feed technique, the radiating patch and the microstrip feed line are separated by the ground plane as shown in Figure 2.6. Coupling between the patch and the feed line is made through a slot or an aperture in the ground plane. The coupling aperture is usually centered under the patch, leading to lower cross polarization due to symmetry of the configuration. The amount of coupling from the feed line to the patch is determined by the shape, size and location of the aperture. Since the ground plane separates the patch and the feed line, spurious radiation is minimized [19-20].

Generally, a high dielectric material is used for bottom substrate and a thick, low dielectric constant material is used for the top substrate to optimize radiation from the patch. The major disadvantage of this feed technique is that it is difficult to fabricate due to multiple layers, which also increases the antenna thickness. This feeding scheme also provides narrow bandwidth [21-22].

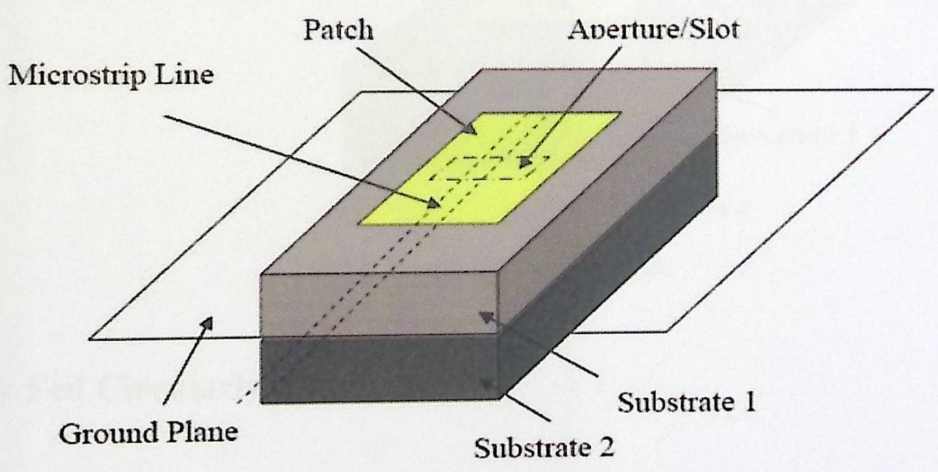


Fig 2.6 Aperture Coupled Feed

2.7.4 Proximity Coupled Feed

This type of feed technique is also called as the electromagnetic coupling scheme as shown in Figure 2.7. Two dielectric substrates are used such that the feed line is between the two substrates and the radiating patch is on top of the upper substrate. The main advantage of this feed technique is that it eliminates spurious feed radiation and provides very high bandwidth (as high as 13%), due to overall increase in the thickness of the microstrip patch antenna. This scheme also provides choices between two different dielectric media, one for the patch and one for the feed line to optimize the individual matching can be achieved by controlling the length of the feed line and the width to-line ratio of the patch. The major disadvantage of this feed scheme is that it is difficult to fabricate because of the two dielectric layers which need proper alignment. Also, there is an increase in the overall thickness of the antenna [19-21].

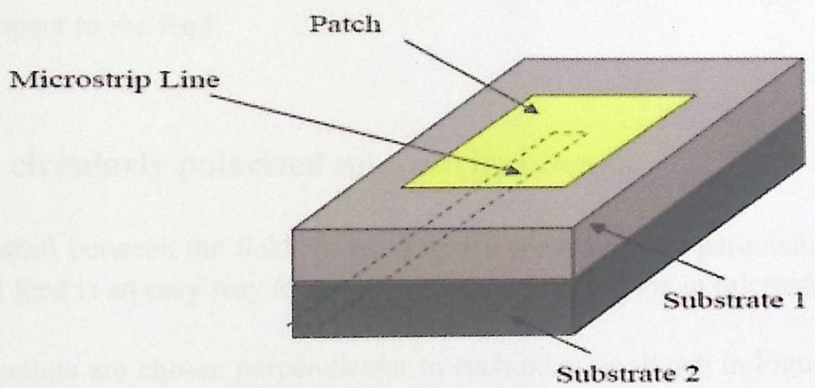


Fig 2.7 Proximity-Coupled Feed

2.7.5 Singly Fed Circularly Polarized Patch

Typical configurations for a singly fed CP microstrip antennas are shown in Figure 2.8. A single point feed patch capable of producing CP radiation is very desirable is situations where it is difficult to accommodate dual-orthogonal feeds with a power divider network.

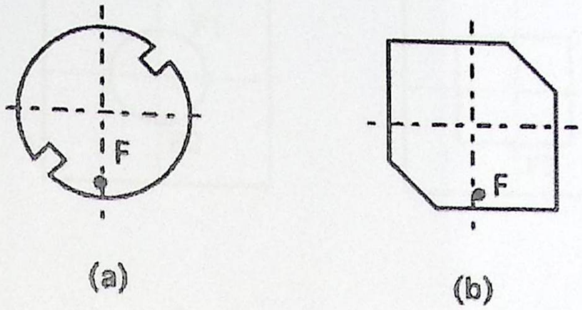


Fig 2.8 Typical configurations of singly fed circularly polarized microstrip antennas: (a)Circular patch and (b) square patch

Because a patch with single-point feed generally radiates linear polarization, in order to radiate CP, it is necessary for two orthogonal patch modes with equal amplitude an in-phase quadrature to be induced. This can be accomplished by slightly perturbing a patch at appropriate locations with respect to the feed.

2.7.6 Dual fed circularly polarized microstrip antenna

As 90° phase shift between the fields in the microstrip antenna is a perquisite for having Circular polarization, dual feed is an easy way to generate circular polarization in microstrip antenna.

The two feed points are chosen perpendicular to each other as shown in Figure 2.9. With the help of external polarizer the microstrip patch antenna is fed by equal in magnitude and orthogonal feed. Dual feed can be carried out using :

- quadrature hybrid
- ring hybrid
- Wilkinson power divider
- T-junction power splitter or two coaxial feeds with physical phase shift 90°

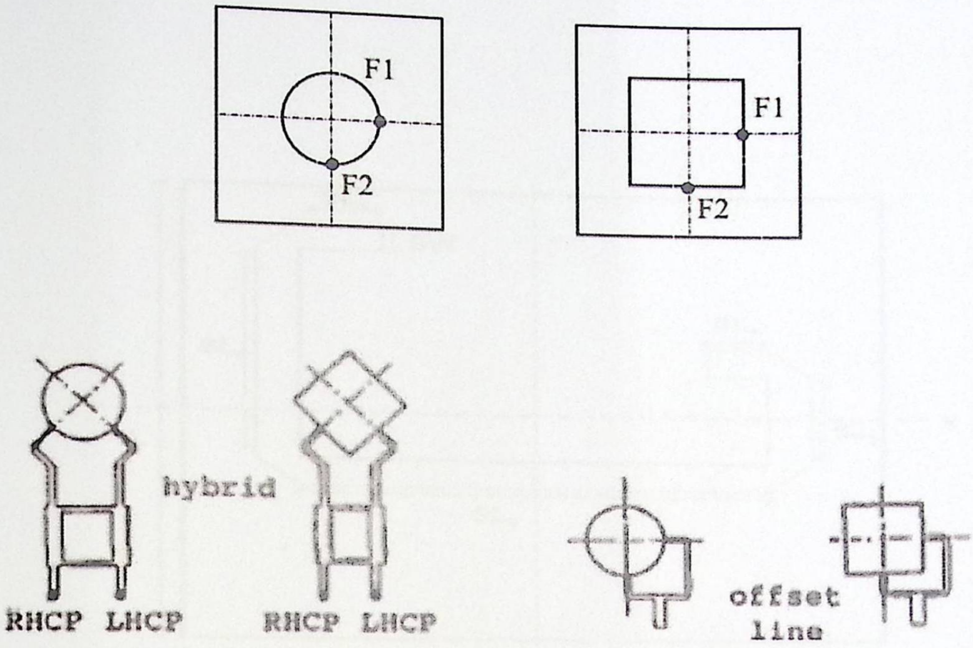


Fig2.9 Dual feed circularly polarized microstrip antenna

The sense of polarization of the circular polarization depends on the direction of rotation of the electric field vector from the phase leading component to the phase lagging component in a direction away from the observer.

If the electric field vector rotates clockwise, it is right-hand circular polarization and if the electric field vector rotates counter clockwise, it is left-hand circular polarization .

2.8 Slot shapes

To obtain circular polarization we cutting a slot in a microstrip patch antenna give the perturbation needed to produce circular polarization ,these slot have many shapes some of them:-

❖ C-shaped slot

Cutting C-shaped slot in a square patch microstrip antenna as shown in Figure 2.10 and mounting the substrate on a foam layer good circular polarization is achieved. The antenna structure is fed using aperture coupling feeding method. The dimensions of the slot are used to optimize the antenna design in the favor of axial ratio and impedance matching. The measured 3 dB axial ratio and 10 dB impedance bandwidths are 3.1 % and 16.4 % respectively.

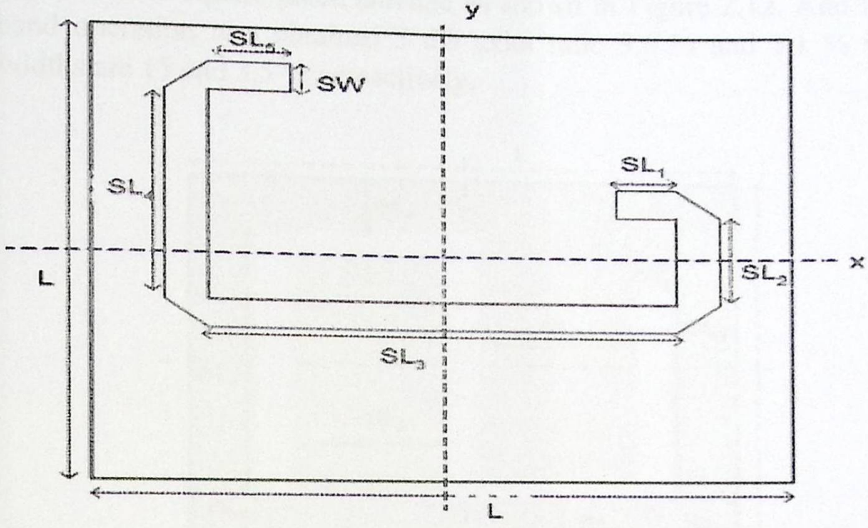


Fig.2.10 C-shaped slot

❖ F-shaped slot

Cutting F-shaped slot in the center of a square patch as shown in Figure 2.11. And fed with aperture coupling. Good circular polarization with 3 dB axial ratios and 10 dB impedance bandwidths are 3.2 % and 5.62 % respectively.

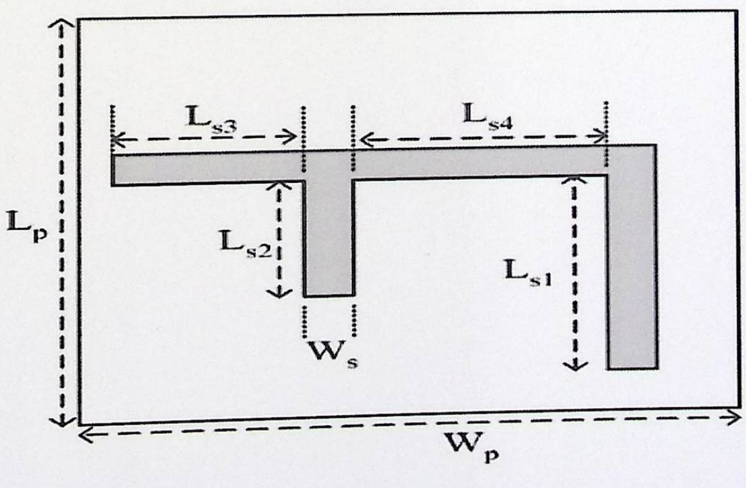


Fig.2.11 F-shaped slot.

❖ S-shaped slot

Cutting S-shaped slot in a square patch antenna as shown in Figure 2.12. And fed with aperture coupling. Dual-band operation was obtained 3 dB axial ratio 3.6 % and 1.1 % while the 10 dB impedance bandwidths are 15 and 3.5 % respectively.

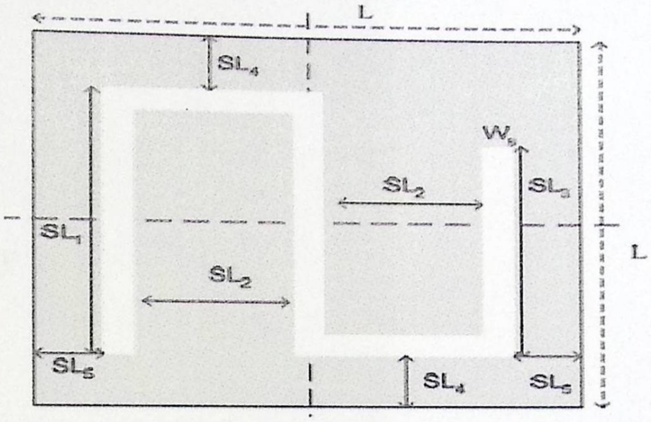


Fig.2.12 S-shaped slot

CHAPTER THREE

MICROSTRIP THEORY

3.1 Overview

3.2 Design methodology

3.3 Literature Surveys

3.1 Overview:

In this chapter we will introduce a general idea about square and half dipole microstrip patch antenna. And we will talk about some previous studies that correspond to it.

3.2 Design methodology

This project consists of two parts. In the first part designing a reference antenna from microstrip to measure the gain of any other microstrip antenna resonating in the same frequency band . In the second part designing circularly polarized microstrip antennas at 1GHz band. There are many ways to do that. One of them is a single patch antenna that can be made to radiate circular polarization if two orthogonal patch modes are simultaneously excited with equal amplitude and +90,-90 out of phase. We may employ an external power divider network to excite two orthogonal modes with equal amplitude but in-phase quadrature . We need a quarter –wavelength line in one of the O/P arms to produce a 90 phase shift at the two feeds .

3.3 Literature Surveys

We studied several scientific papers considering both square and half dipole antennas:

A DUAL BAND MICROSTRIP PATCH ANTENNA WITH CIRCULAR POLARIZATION S.C.GUPTA, NAZIA HASAN, This paper proposes design of a microstrip patch antenna having circular polarization. To achieve circular polarization two slots are created at 45 degree and 135 degree in 'X' shape, at centre of the patch. This antenna has dual band characteristics at 3.6GHz and 3.5GHz, the polarization at 3.6GHz is circular while at 3.5GHz is linear.

In this paper X-shape is used and micro-stripline feed along with a Quarter Wave Transformer (QWL) . The (QWL) is used is to match the impedance of patch antenna with that of 50 Ohm transmission line .

The patch antenna was designed on the basis of transmission line model (TLM).Using the formulas given by TLM approximation, parameters for the antenna were calculated at 3.6GHz frequency. The material used as substrate is Duroid (_r = 2.2) with height h = 1.57 mm.

To change the polarization of this antenna from linear to circular, a slot tilted at an angle of 45 degrees is etched at the centre of the Patch[1] Figure3.1. This slot changes the polarization from linear to circular . The bandwidth from this design of one slot is 170 MHz. Next step to create another slot at an angle of 135degrees crossing the first slot in the shape of ‘X’. This ‘X’ shape slot also gives circular polarization. Circular polarization can be observed by plotting axial ratio. The design of X slot antenna (XSA) is shown in Figure3.2.

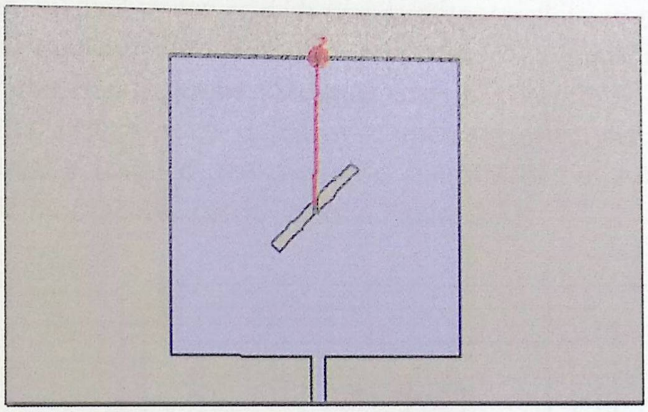


Fig3.1 Patch antenna with tilted slot.

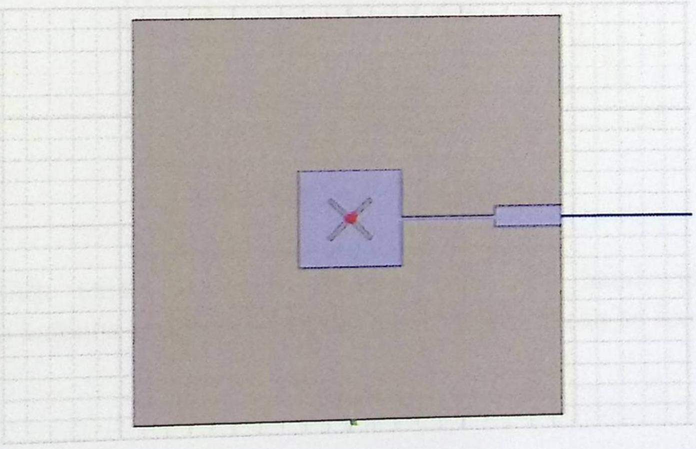


Fig3.2 Micro-strip patch antenna with X slot.

The X slot antenna provides better bandwidth as compared to patch antenna with single tilted slot. A comparison between the two was found that Patch antenna with X-slot or X-shape slot showed better performance than patch with single tilted slot in terms of bandwidth. Both of these antennas successfully showed circular polarization; which was confirmed with help of axial ratio. For simulation they used Ansoft (HFSS) .

A SLOTTED STACKED WIDEBAND MICROSTRIP PATCH ANTENNA WITH SQUARE SHAPED PARASITIC ELEMENT KUSHWAHA R.S.1*, SRIVASTAVA D.K.1 AND SAINI J.P.2 . In this design of square microstrip antenna, a printed wide-band stacked patch antenna for enhancing the bandwidth is presented.

A multi-layer microstrip antenna structure with two rectangular slots on the rectangular patch which results in a typical mathematical plus symbol is proposed. This paper is a modification of [2] in which the feed was simple coaxial probe. An impedance bandwidth of 15% was investigated ,The lower plus shaped slotted driven patch is fed by a microstrip line and the upper square parasitic patch is electromagnetically coupled ,the dielectric constant of the substrate is closely related to the size and the bandwidth of the microstrip antenna Figure 3.3.

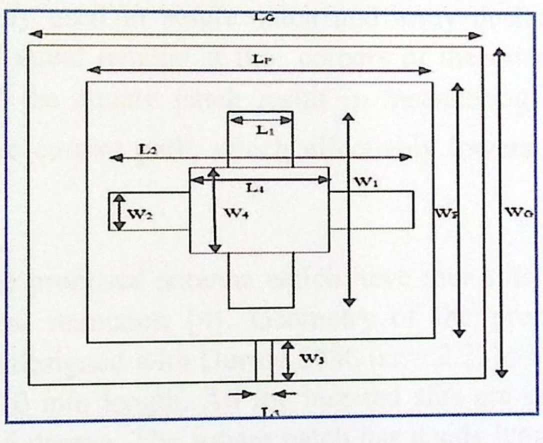


Fig 3.3. Top view of the antenna.

A trade-off relationship exists between antenna size and band-width [3]. The resonant frequency of microstrip antenna and the size of the patch radiation can be found by:

$$f \cong \frac{c}{2L\sqrt{\varepsilon_r}}$$

$$W = \frac{2}{f_r}\left(\frac{\varepsilon_r + 1}{2}\right)^{\frac{1}{2}}$$

$$L = \frac{c}{2f_r\sqrt{\varepsilon_r}} - 2\Delta l$$

Where f is the resonant frequency, c is the free space velocity of the light, L is the actual length of the current, εr is the effective dielectric constant of the substrate and Δl is the length of equivalent radiation gap. This antenna is built on a glass epoxy substrate with dielectric constants εr1 = εr2 = 4.2 and heights h1 = h2 = 1.6 mm. Microstrip line feeding, slot on the patch provide the wide band-width enhancement.

At the final result slotted microstrip patch antenna for enhancing the bandwidth has been designed and simulated success-fully. Simulation results of a wideband microstrip patch antenna covering 2.052 GHz to 3.754 GHz frequency have been present. With the use of 50 Ω microstrip line feed the proposed microstrip patch antenna achieves an impedance bandwidth of 58.62% at -10 dB return loss.

Circularly Polarized Microstrip Patch Antenna with Slits ,İmeci Ş. Taha, Kızrak M. Ayyüce and Şişman İsmail. A single-feed circular-polarization (CP) operation of the corners truncated square microstrip antenna is extensively used in single patch and array designs [4]. In this design the designers inserting four slits of equal lengths at the corners of the microstrip antenna [4]. These inserted slits at the corners of the square patch result in meandering of the excited fundamental-mode patch surface current path, which effectively lowers the resonant frequency of the modified square patch [5].

Subsequently, they designed the proposed antenna which have four slits of the equal lengths at the patch corners to achieve the size reduction [4]. Geometry of the proposed microstrip antennas is shown in Figure3.4 which is designed with Duroid 5880 (εr = 2.2, h=125mils). The 50-Ω feeding line has a width 9.89 mm and 10 mm length. All the inserted slits are of length 18 mm and width 1mm along the directions of ±45 degree. The square patch has a side length L=39 mm and a pair of truncated corners of dimensions 8.5 mm × 8.5 mm [4].

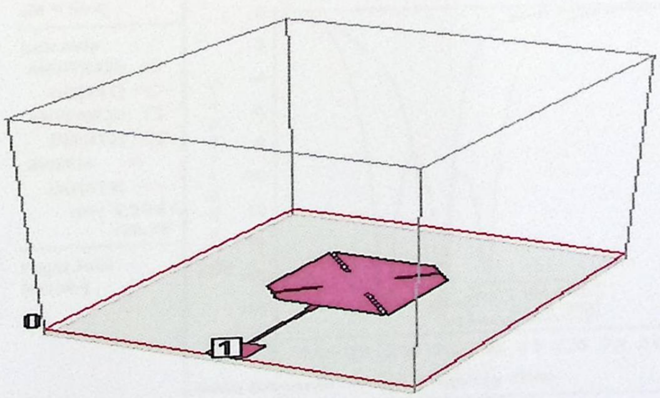


Fig. 3.4 3D View of the antenna

At the result the designers find that the dielectric height does not affect the results much, but when they changed the dielectric material (permittivity changed from 2.2 to 2.33) a slight frequency shift occurred. In both cases return losses at the resonance frequency is satisfactory. The imaginary part of the input impedances are close to zero, as they expected for the resonant antennas, and the real part of the input impedances are almost 50 ohm for the 3 different values of the dielectrics. In Figure 3.5, right hand circularly polarized radiation pattern has 5,6 dB gain and left hand circularly polarized radiation pattern has a value of minus 4,56 dB in polar plot. and the result of the return loss in this simulation is shown in Figure 3.6.

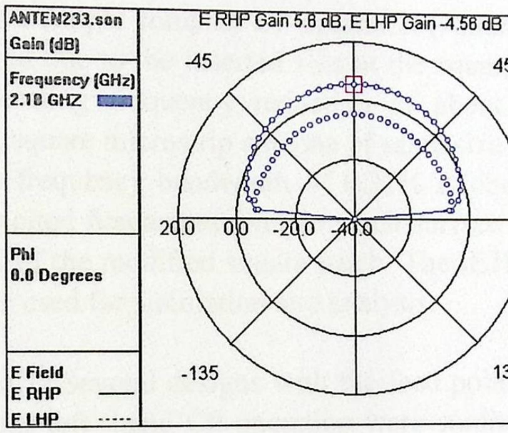


Fig3.5 Far field radiation pattern of the antenna.

Slits helped to reduce the antenna dimensions about 29%. Simulated results with different parameters show that antenna is tolerant for changes of possible fabrication losses

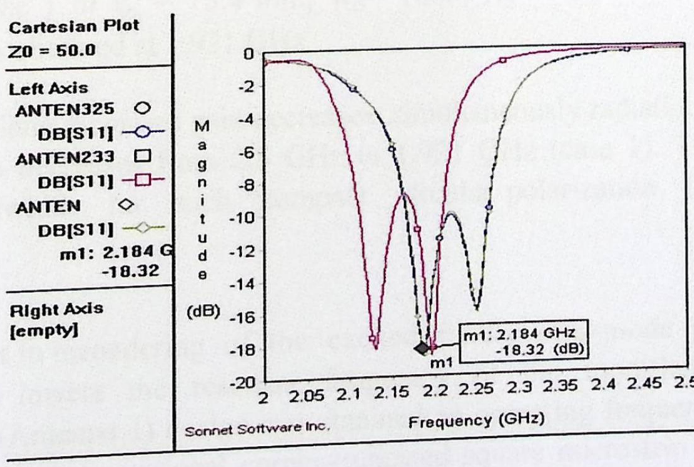


Fig3.6 Return loss for the proposed patch antenna with different dielectric heights.

Compact Circularly Polarized Square Patch Antennas Lolit Kumar Singh, Bhaskar Gupta, Partha P Sarkar[7] , this paper study ;at first a pair of corner truncated square microstrip patch with embedding a pair of slit in patch and four slits in the finite ground plane along the directions of $\pm 45^0$ to achieve a compact CP operation (Antenna 1). The compactness of the proposed CP design is achieved due to the inserted slits at the square patch and finite ground plane. The proposed compact CP design can have an operating frequency reduction of about 21.95% as compared to the conventional corner-truncated square microstrip antenna of same size without any slits in the patch and ground plane. Also, the 3 dB axial ratio (AR) centre frequency bandwidth is 0.43%.

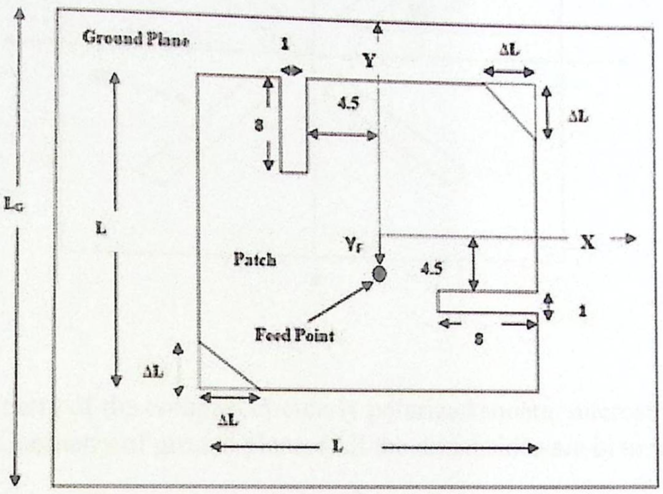
Another, a pair of corner truncated square microstrip patch with embedding four slits of equal length and width in patch to achieve a simple compact CP operation (Antenna 2). The compactness of the proposed CP design is achieved due to the inserted slits at the square patch. The proposed compact CP design can have an operating frequency reduction of about 23.16% as compared to the conventional corner-truncated square microstrip antenna of same size without any slits on patch. The 3 dB axial ratio (AR) centre frequency bandwidth of 0.21% is obtained. These inserted slits can result in meandering of the excited fundamental-mode patch surface current path, which effectively lowers the resonant frequency of the modified square patch. The IE3D simulation software based on Method of Moments (MoM) is used for simulation and analysis.

In the authors works ,Antenna 1: Several designs with the feed point position along Y-axis and slit length (L_S) on ground plane for left- hand CP operation were studied.and shows return loss, axial ratio (AR) against frequency for case 1 of L_s = 15 mm, W_S= 1mm, $X_S = Y_S = \pm$ 6.5 mm. The axial ratio bandwidth of 0.43% at centre frequency, total gain of 2.51 dBi and total directivity of 5.42 dBi are obtained at 1.966 GHz .

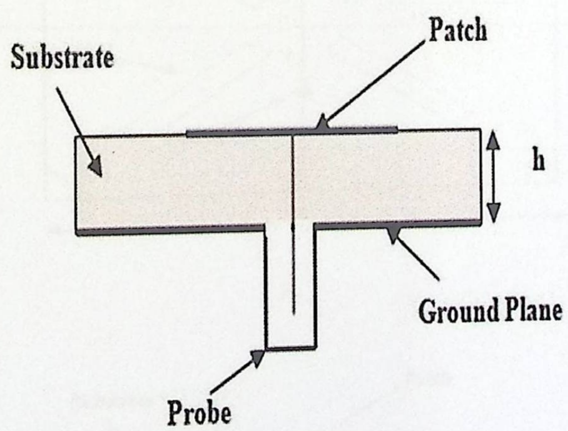
Antenna 2: Two different designs with the feed point position along Y-axis and slit length (L_S) in patch for right- hand CP operation were studied and shows return loss, axial ratio (AR), against frequency for case 1 of L_s = 15.4 mm, W_S= 1mm, $X_S = Y_S = \pm$ 6 mm. The 3 dB axial ratio bandwidth of 0.21% obtained at 1.921 GHz.

As slits size in ground plane increases gain decreases, simultaneously radiation efficiency decreases, operating frequency also decreases from 2.5 GHz to 1.921 GHz (case 1). The antenna gain and 3dB axial ratio bandwidth for such compact circular polarization (CP) designs are also decreased.

These inserted slits result in meandering of the excited fundamental-mode patch surface current path, which effectively lowers the resonant frequency of the modified square patch. The proposed compact CP (Antenna 1) design can obtained an operating frequency reduction of about 21.95% as compared to the conventional corner-truncated square microstrip antenna of same size without any slits on patch and ground plane. The radiation efficiency of the proposed CP microstrip antenna is about 46.3 %. The 3 dB axial ratio (AR) centre frequency bandwidth is 0.43%. Another, compact CP (Antenna 2) design can obtained an operating frequency reduction of about 23.16% as compared to the conventional corner-truncated square microstrip antenna of same size without any slits on (AR) patch.



a.



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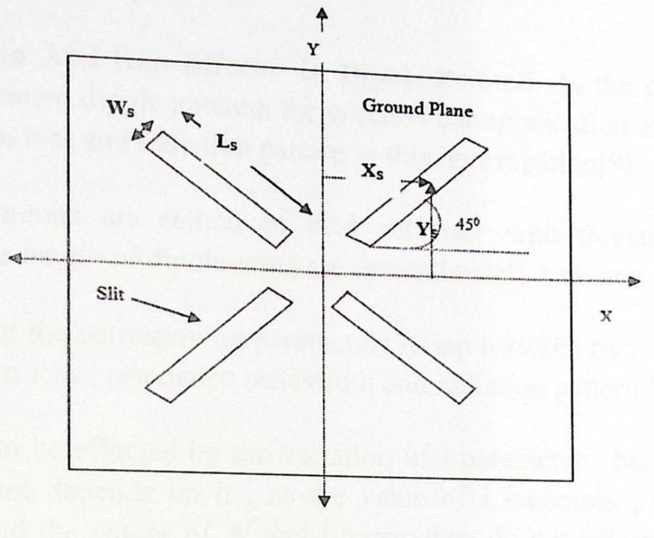
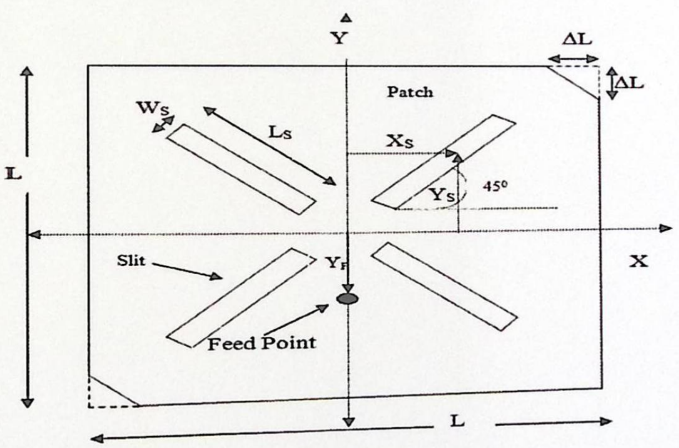
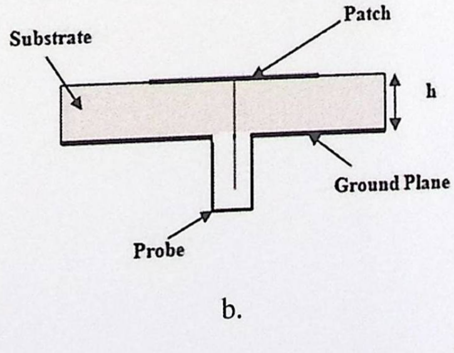


c.

Fig3.7 Antenna 1 a. Geometry of the compact circularly polarized square microstrip antenna b. Side view c. Geometry of ground plane. (All the dimensions are in mm).



a.



b.

Fig3.8 Antenna 2 a. Geometry of the compact circularly polarized square microstrip antenna b. Side view.

Measurements of Balun And Gap Effects In Dipole Printed In the present paper , design and analysis of a 2.4GHz printed dipole antenna for wireless communication applications are presented . Measurements on return loss and radiation pattern in this investigation[9] .

This printed dipole antenna are etched of FR4 substrate with thickness h equal 1.5mm and permittivity □r 4.4 . The length of dipole-arms are approximately a quarter- wavelength .

The variation's impact of the corresponing parameters I(Gap between two dipole-arms) and w(width of dipole-arms) on return loss , resonance bandwidth and radiation pattern have been investigation .

The return loss seems to be effected by the variation of I parameter , but resonance bandwidth and radiation diagram do not depends on it , as the value of I increases , the return loss of antenna becomes more flat .And the values of W and I parameters do not affect the radiation.

characteristics of printed dipole antenna .Return loss and resonance bandwidth seem to be independent of W parameter variation.

Chapter 4
Microstrip Patch Antenna Design and Results

4.1 Introduction

In this chapter, the procedure for designing a square microstrip patch antenna and printed dipole antenna in Ansoft HFSS are is explained. And the results obtained from the simulations are demonstrated.

4.2 Design Specifications

The three essential parameters for the design of a rectangular Microstrip Patch Antenna are:

• Frequency of operation (*fo*): The resonant frequency of the antenna must be selected appropriately. The resonant frequency selected for my design is 3.0 GHz.

• Dielectric constant of the substrate (εr): The dielectric material selected for my design is Glass epoxy (FR4) which has a dielectric constant of 4.4. A substrate with a high dielectric constant has been selected since it reduces the dimensions of the antenna.

• Height of dielectric substrate (h): For the microstrip patch antenna to be used in cellular phones, it is essential that the antenna is not bulky. Hence, the height of the dielectric substrate is selected as 1.6 mm.

Hence, the essential parameters for the design are:

- fo = 1.0 GHz
- εr = 4.4
- h = 1.6 mm

4.3 Design of Square Patch Microstrip Antenna for Circular Polarization using HFSS Simulator

4.3.1 Dual Feed loaded circularly polarized

In this section, a promising design of a dual feed circularly polarized microstrip antenna is presented. The dimensions of the patch, feed point locations and slots are optimized for good performance. The experimental results are in good agreement with the simulation results.

4.3.1.1 Dual Feed Antenna Geometry

The geometry of the proposed antenna is illustrated in figure4.1. It consists of a square patch of size L x W with two pairs of feed location at F1 and F2 from the center of the patch.

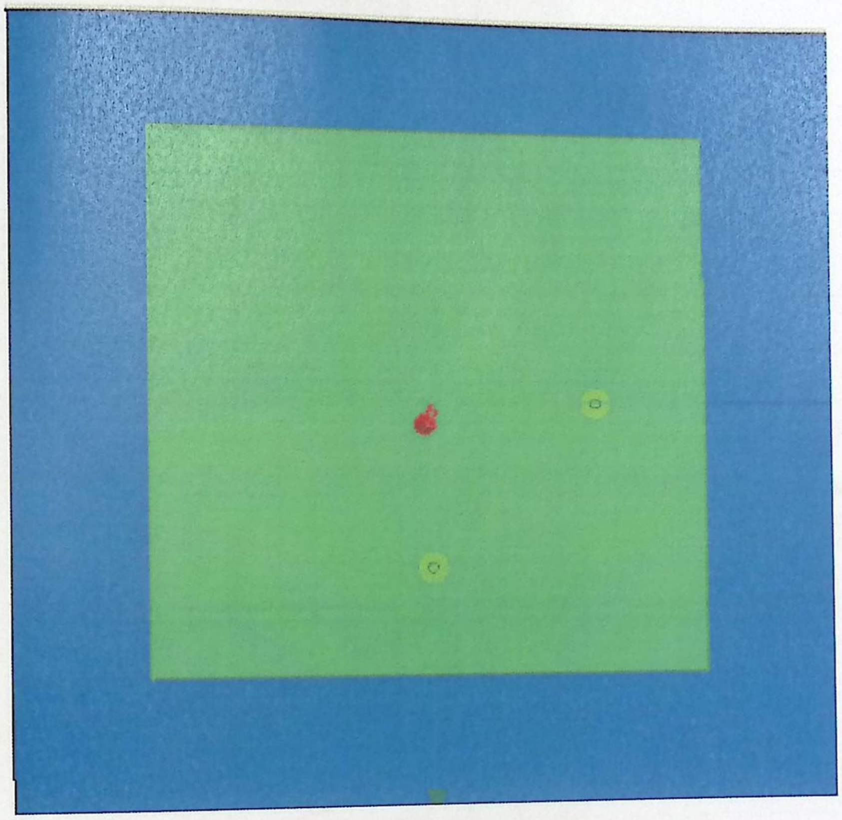


Figure 4.1 Geometry of circularly polarized cross patch antenna

4.3.1.2 Results of Simulation

In this section, the performance of the antenna is investigated through simulations. Figure 4-2 shows the result of return loss for square patch microstrip antenna return within 10 dB impedance and the bandwidth is 20.1 MHz using HFSSs from 1.0006 GHz to 1.0207GHz. In order to identify the resonant modes of the antenna, its input impedance is plotted against frequency in figure Figure4.3. Figure 4.4 shows the antenna VSWR versus frequency which is 1.0942.

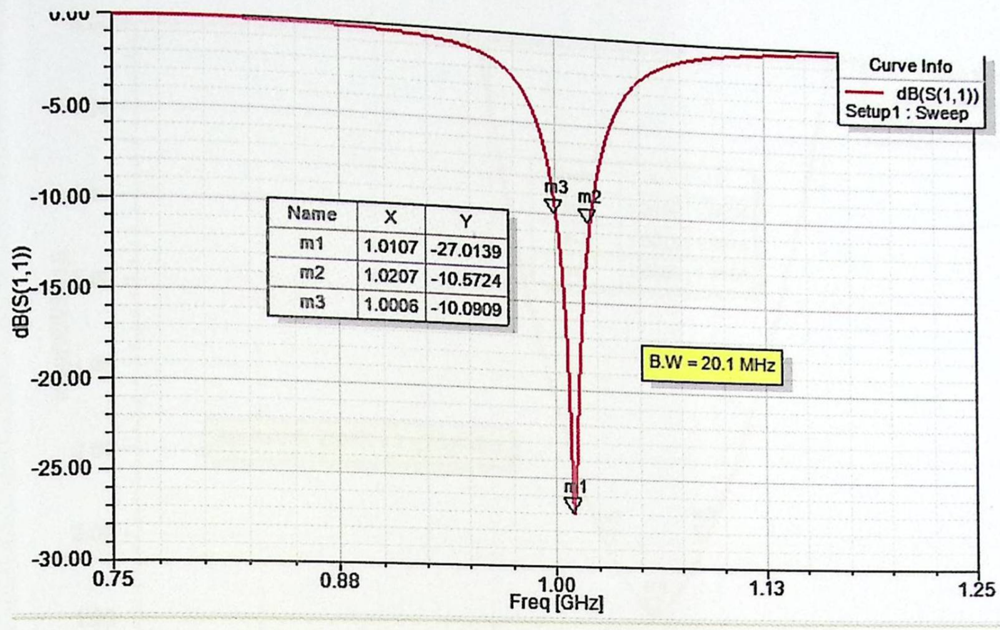


Figure 4.2 Return loss vs. frequency

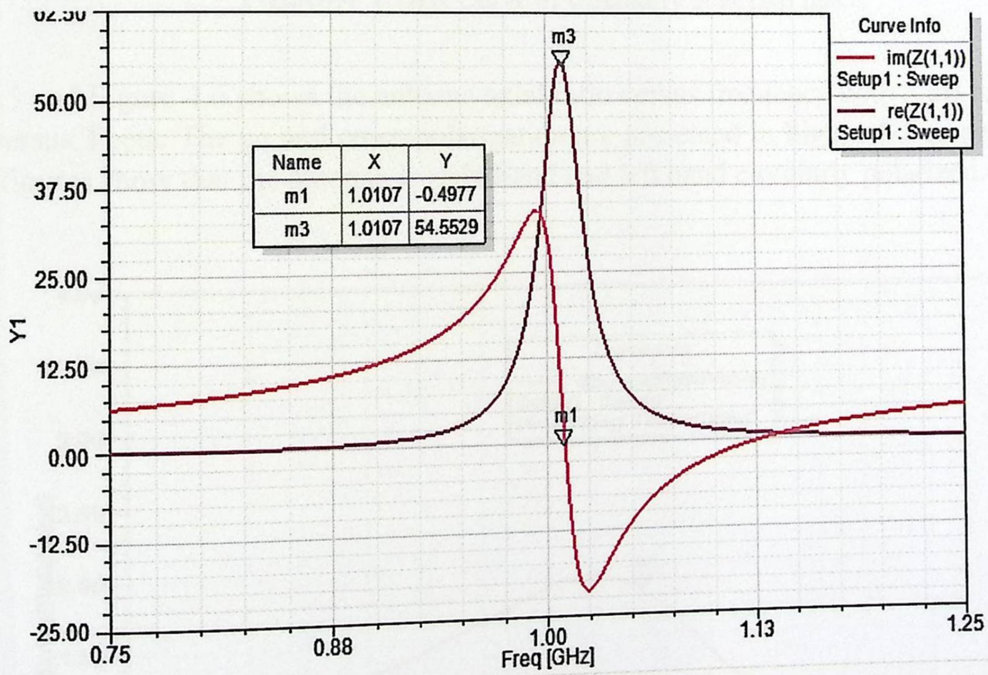


Figure4.3 Input impedance curve of circularly polarized patch.

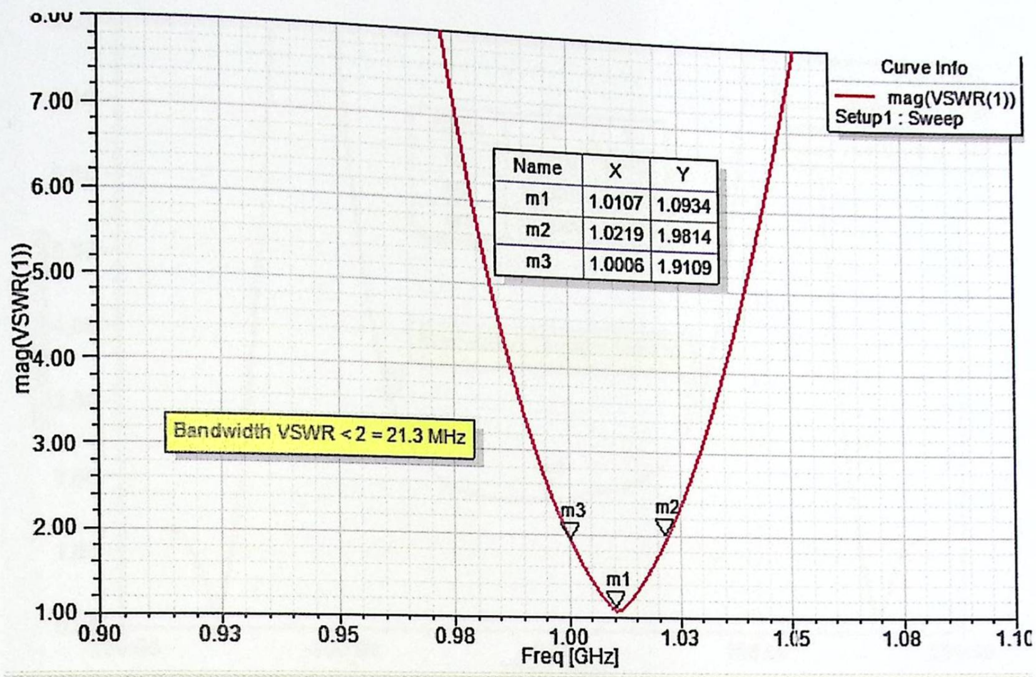


Figure4.4 VSWR Curve of Circularly polarized patch.

Figure 4.5 and Figure 4.6 shows the antenna axial ratio versus frequency with 3 dB axial ratio and axial ratio versus Theta. The co and cross-polarization are presented in Figure 4-7 respectively using HFSS. The figures show that the antenna is right hand and left hand circularly polarized.

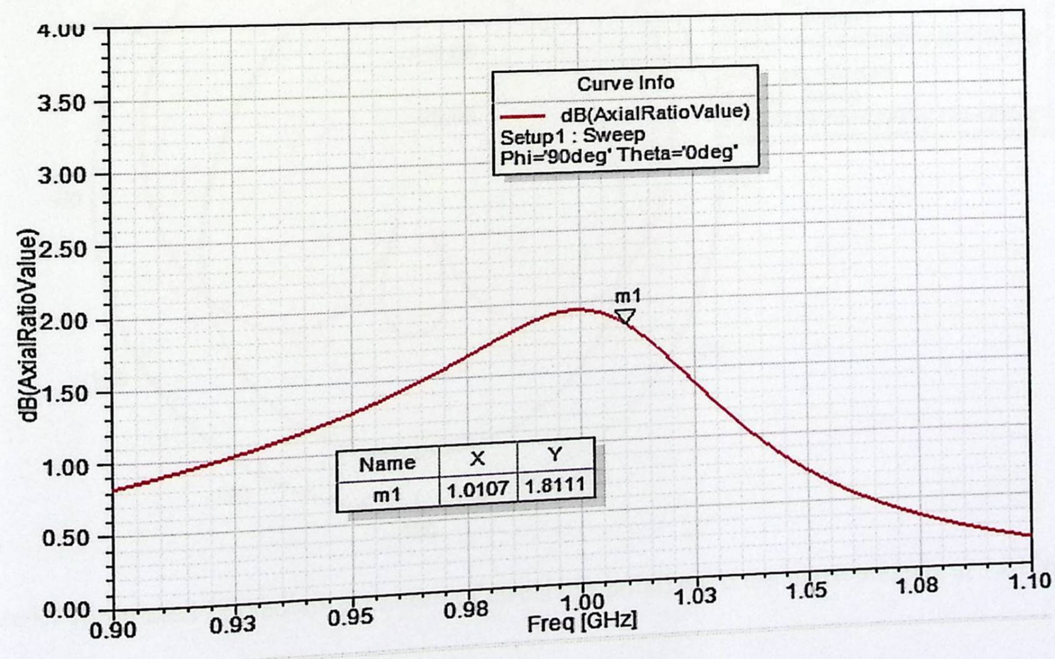


Figure 4.5 axial ratio vs. frequency

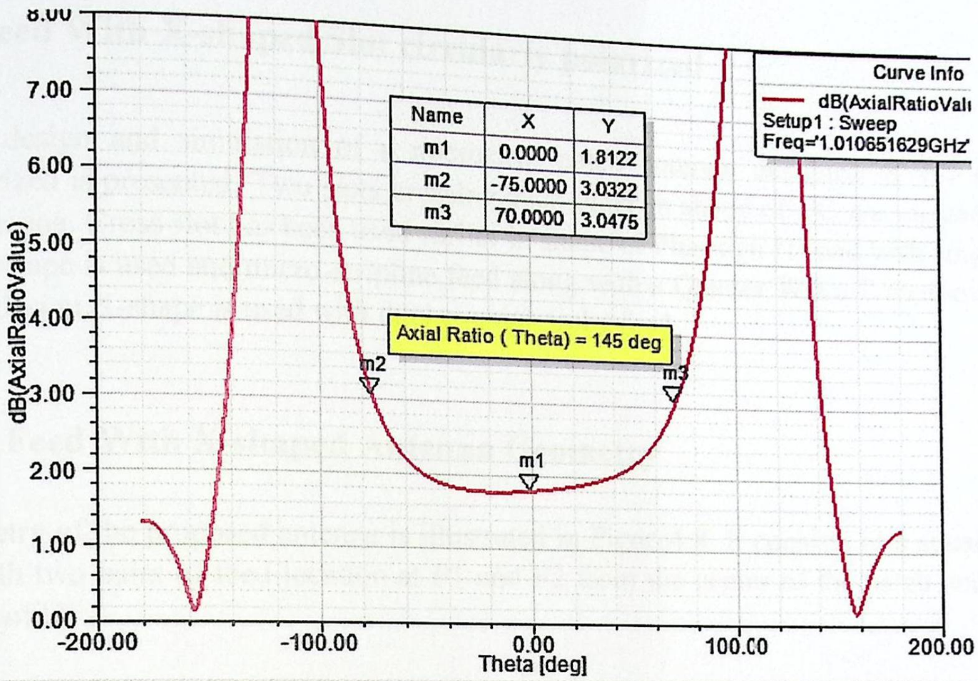


Figure 4.6 axial ratio vs. Theta

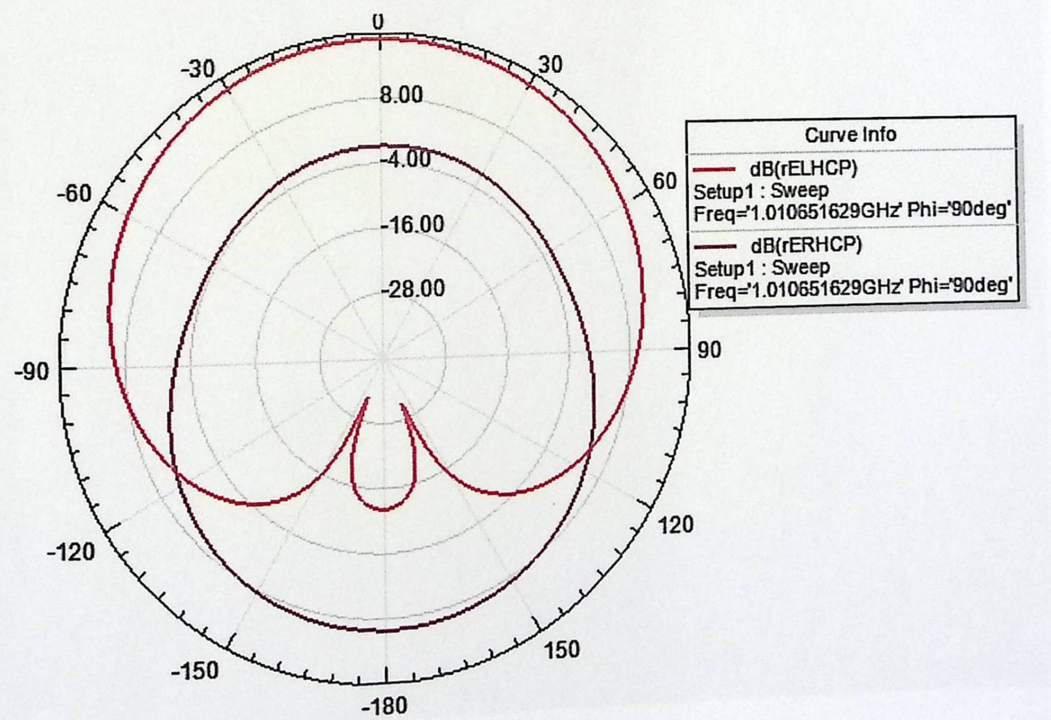


Figure4.7 Simulated 2D radiation pattern of circularly polarized cross patch antenna at 1.01065GHz.

4.3.2 Dual Feed With X-shaped Slot circularly polarized

The final design and simulation of a microstrip patch antenna designed at 1.0 GHz with circularly polarized is presented. Two slots crossing each other in shape of 'X' are created at centre of the patch antenna. Cross slot has been used earlier in shape of Plus sign [1] and with single coaxial probe. Also X-shape is used and micro-stripline feed along with a Quarter Wave Transformer is used [2], but in this design X-shape is used with dual coaxial probe feed.

4.3.2.1 Dual Feed With X-shaped Antenna Geometry

The geometry of the proposed antenna is illustrated in Figure4.8. It consists of a square patch of size L x W with two pairs of feed location at F1 and F2 from the center of the patch and with two slots in shaped of 'X'.

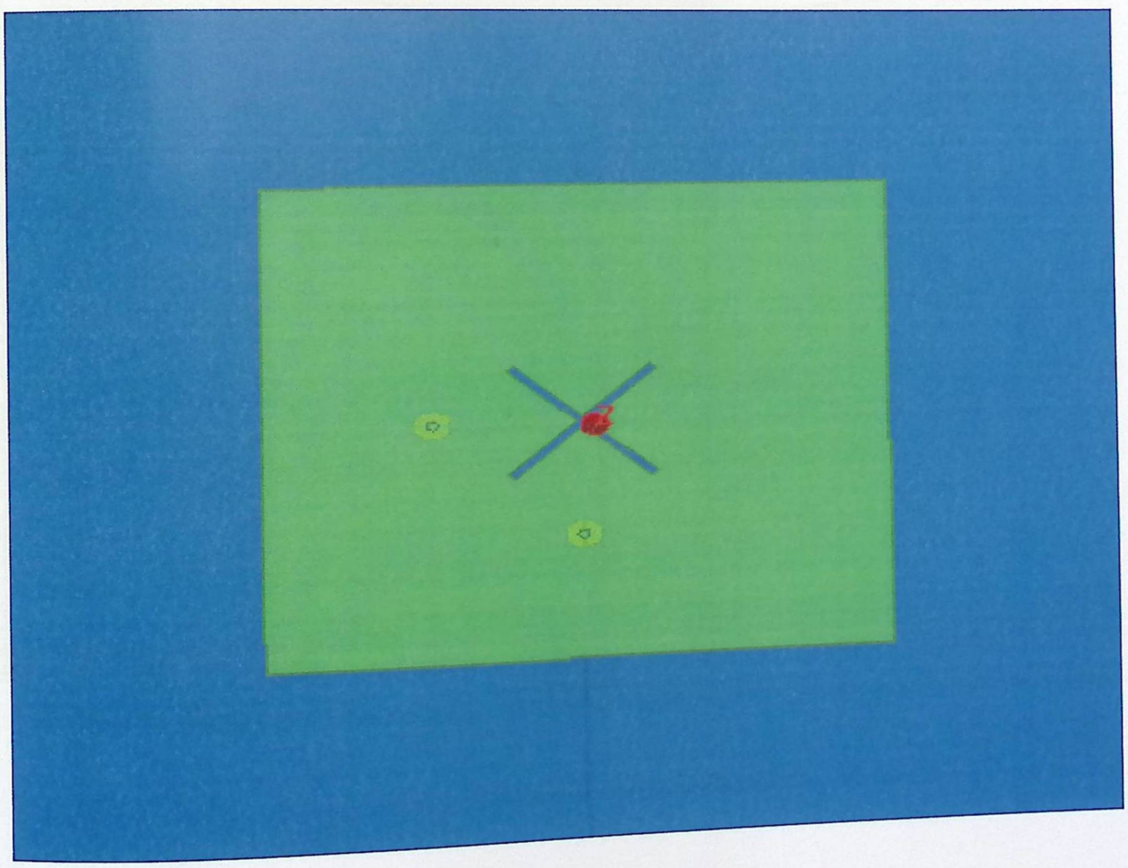


Figure 4.8 Geometry of circularly polarized cross patch antenna

4.3.2.2 Results of Simulation

In this section, the performance of the antenna is investigated through simulations. Figure 4.9 shows the antenna return loss versus frequency with 10 dB impedance bandwidth is 20 MHz using HFSSs from 0.9956 GHz to 1.0157GHz.

In order to identify the resonant modes of the antenna, its input impedance is plotted against frequency in figure Figure4.10. Figure 4.11 shows the antenna VSWR versus frequency which is 1.0034.

Figure 4.12 and Figure 4.13 shows the antenna axial ratio versus frequency with 3 dB axial ratio and axial ratio versus Theta. The co and cross-polarization are presented in Figure 4.14 respectively using HFSS. The figures show that the antenna is right hand and left hand circularly polarized.

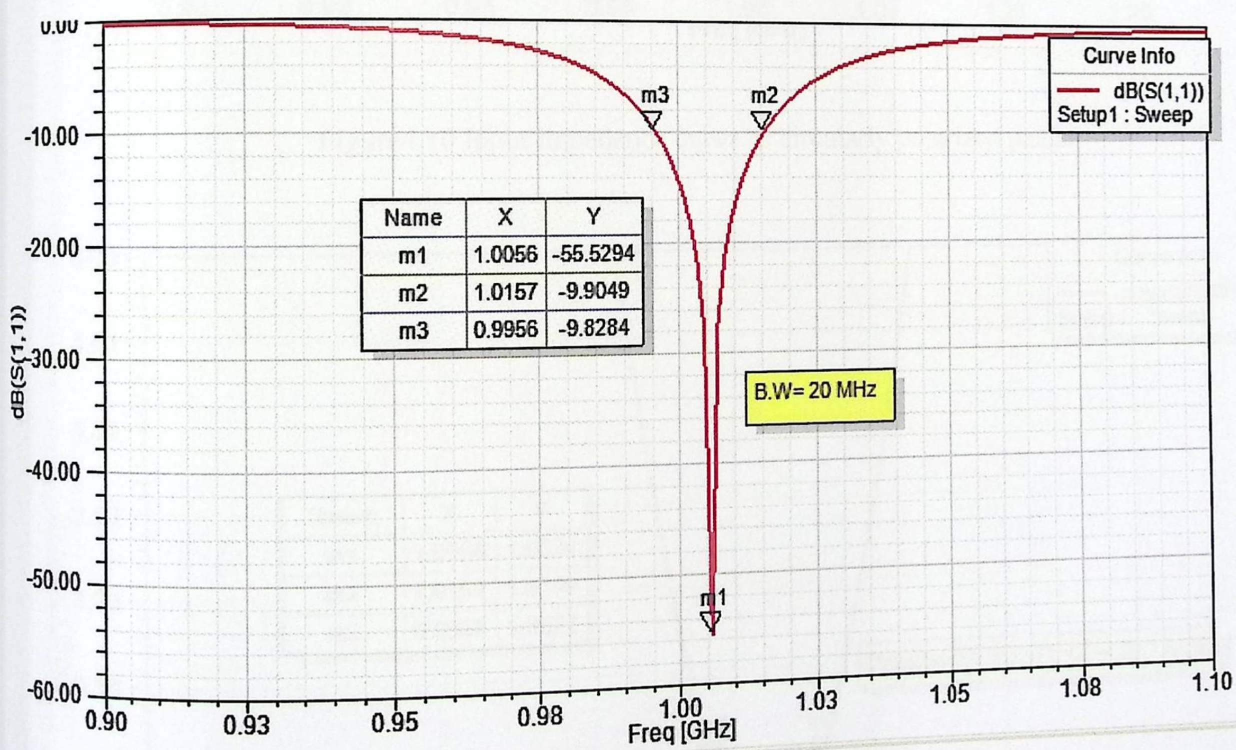
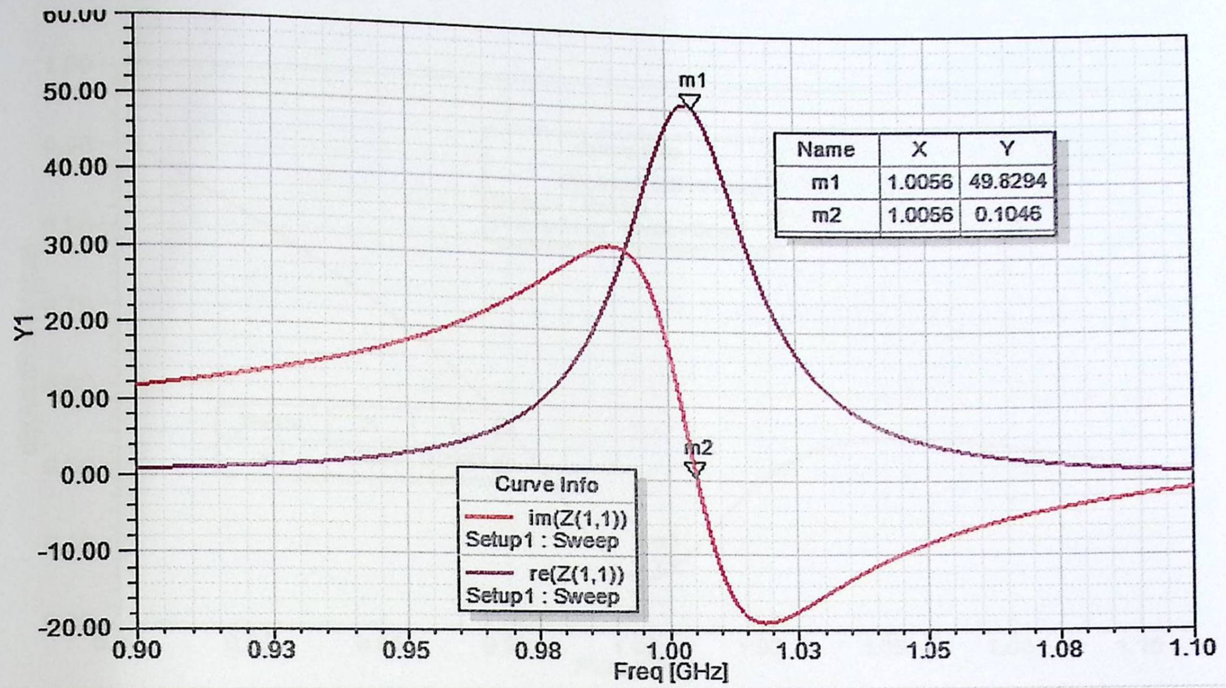
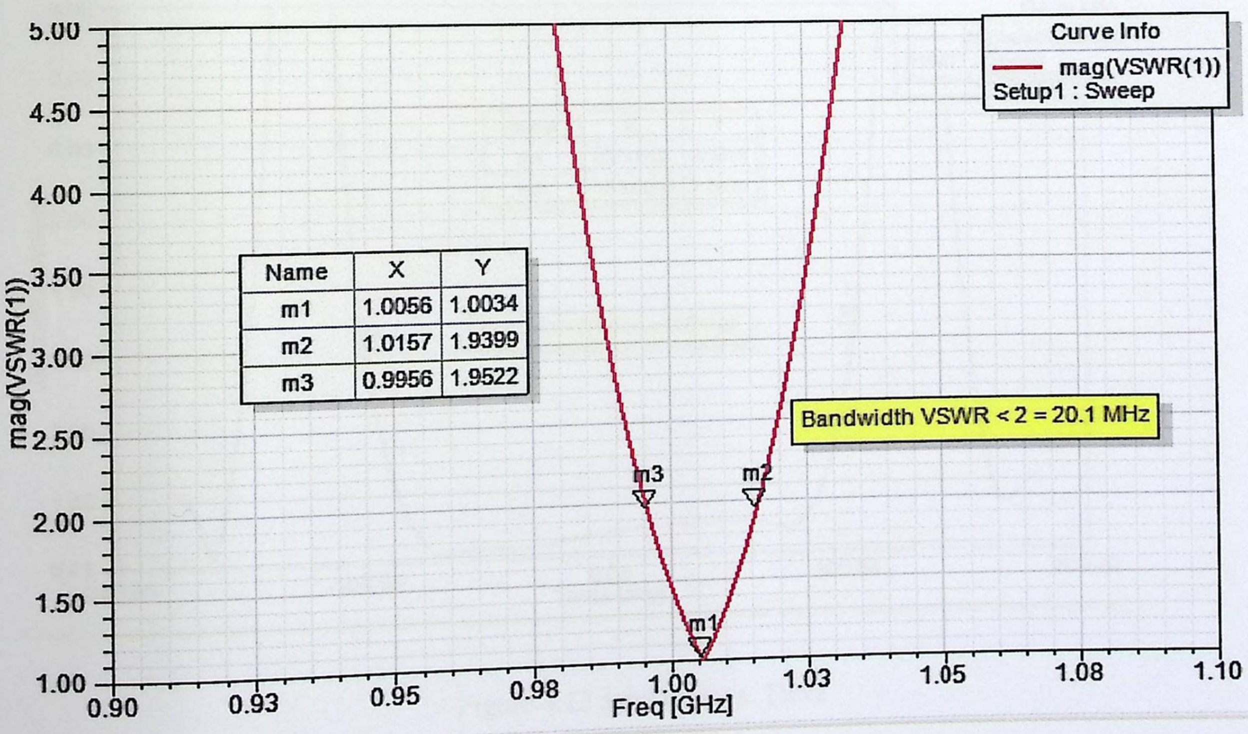


Figure 4.9 Return loss vs. frequency



Name	X	Y
m1	1.0056	49.8294
m2	1.0056	0.1046

Figure4.10 Input impedance curve of circularly polarized patch.



Name	X	Y
m1	1.0056	1.0034
m2	1.0157	1.9399
m3	0.9956	1.9522

Figure4.11 VSWR Curve of Circularly polarized patch.

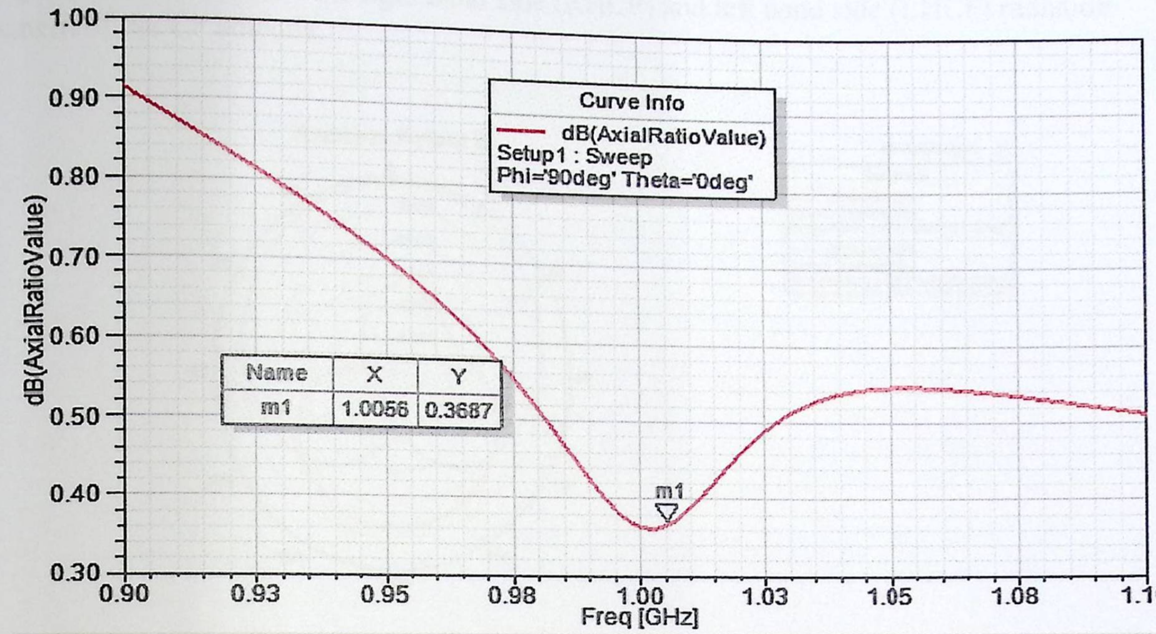


Figure 4.12 Axial ratio vs. frequency

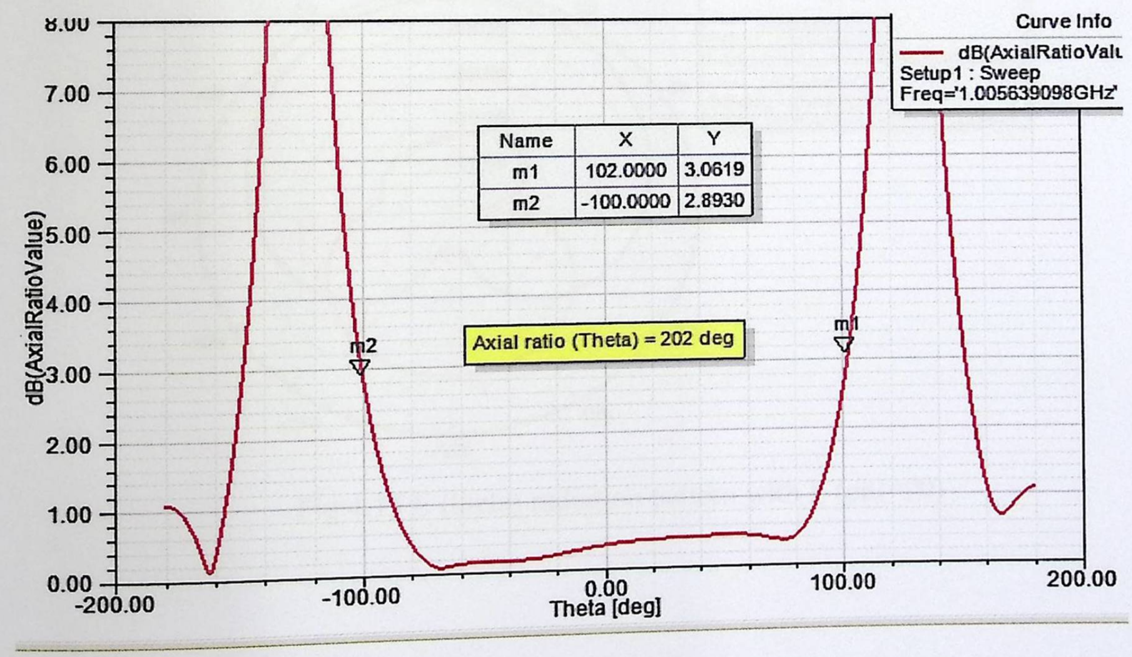


Figure 4.13 axial ratio vs. Theta

Figures 4.14-4.15 shows the right hand side (RHCP) and left hand side (LHCP) radiation pattern of the CP antenna.

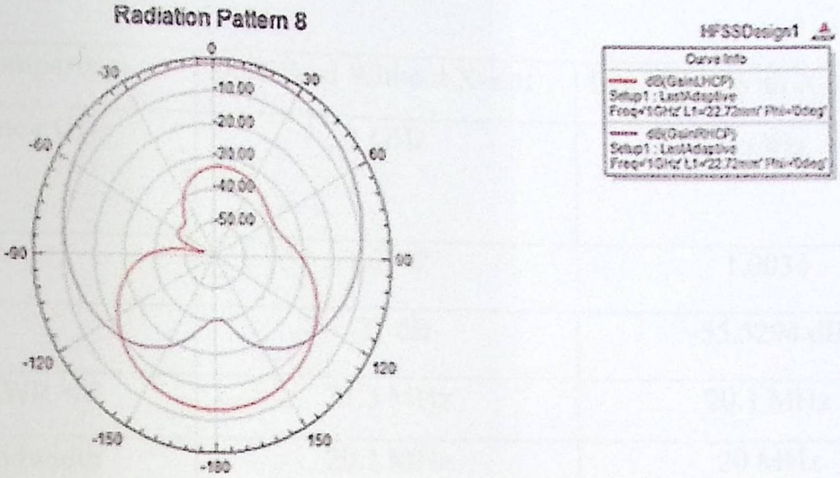


Fig 4.14 E (theta) radiation pattern with E (phi=0)

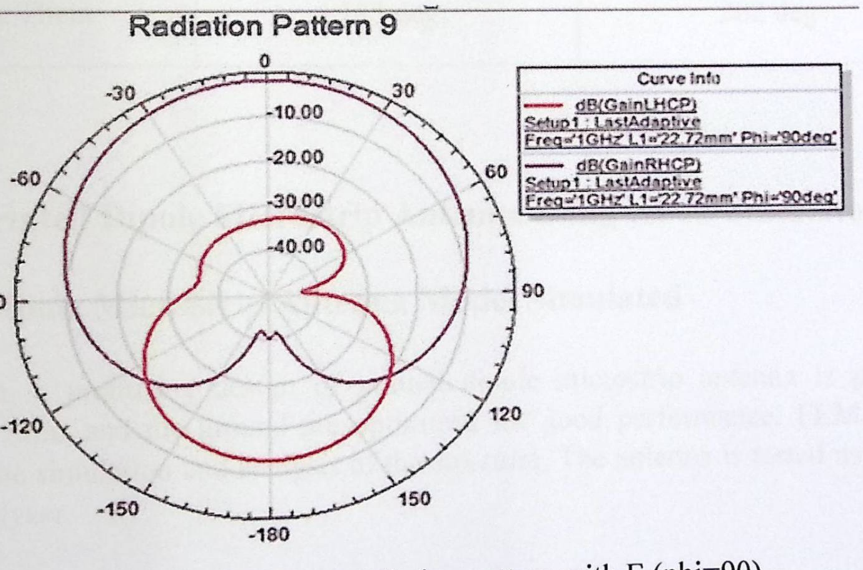


Fig 4.15 E (theta) radiation pattern with E (phi=90)

4.4 Comparison between the two antenna

Table 4.1 shows comparison between the two antennas in terms of radiation characteristics

Point of Comparison	Dual Feed Without X-slot	Dual Feed With X-slot
Design Frequency GHz	1 GHz	1 GHz
VSWR	1.0942	1.0034
Return loss	-27 dB	-55.5294 dB
Bandwidth VSWR < 2	21.3 MHz	20.1 MHz
Impedance Bandwidth	20.1 MHz	20 MHz
axial ratio at resonant freq.	1.0107	0.3687
Axial Ratio Vs. Theta	145 deg	202 deg

4.5 Design of Printed Dipole Microstrip Antenna using HFSS Simulator

4.5.1. Printed Dipole Microstrip Antenna Model Simulated

In this section, a promising design of printed dipole microstrip antenna is presented. The dimensions of the arms and the ground are optimized for good performance. FEM based Ansoft HFSS is used for the simulation and analysis of the structure. The antenna is tested using HP 8510C vector network analyzer.

4.5.1.1 Printed Dipole Microstrip Antenna Geometry

Design simulation and construction of the printed dipole antenna at 1.0 GHz resonance is assembled on copper double sided printed circuit board (FR-4). Microstrip dipole arm dimensions are designed as, arm length L=60mm, arm width W=12 mm, and the gap between two arms (g) =1.45567mm, with thickness of the dielectric (h) 1.6mm Figure 4.16.

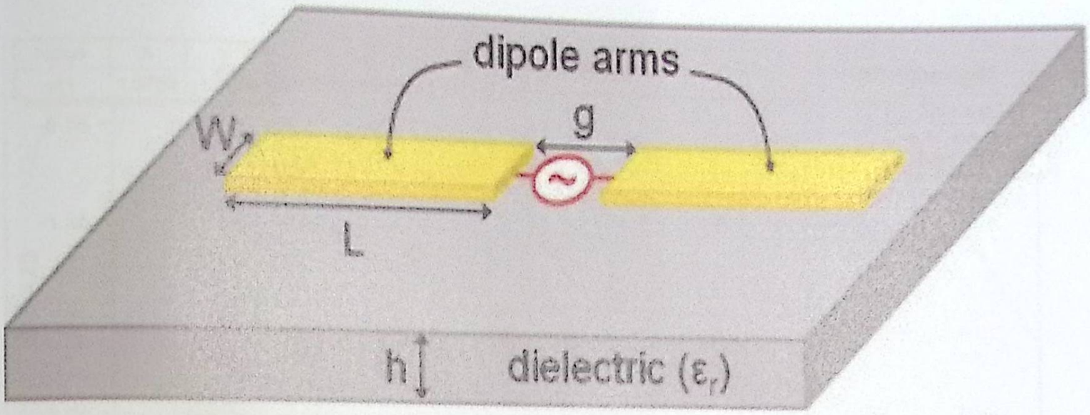


Fig.4.16Printed Dipole microstrip antenna

4.5.1.2 Results of Simulation

In proposed antenna, the ground plane is considered to be the same dimensions of the substrate as shown in Figure 4.16. The length and width of ground plane is Lg=3L and Wg=L. Figure 4.17 shows the antenna return loss versus frequency.

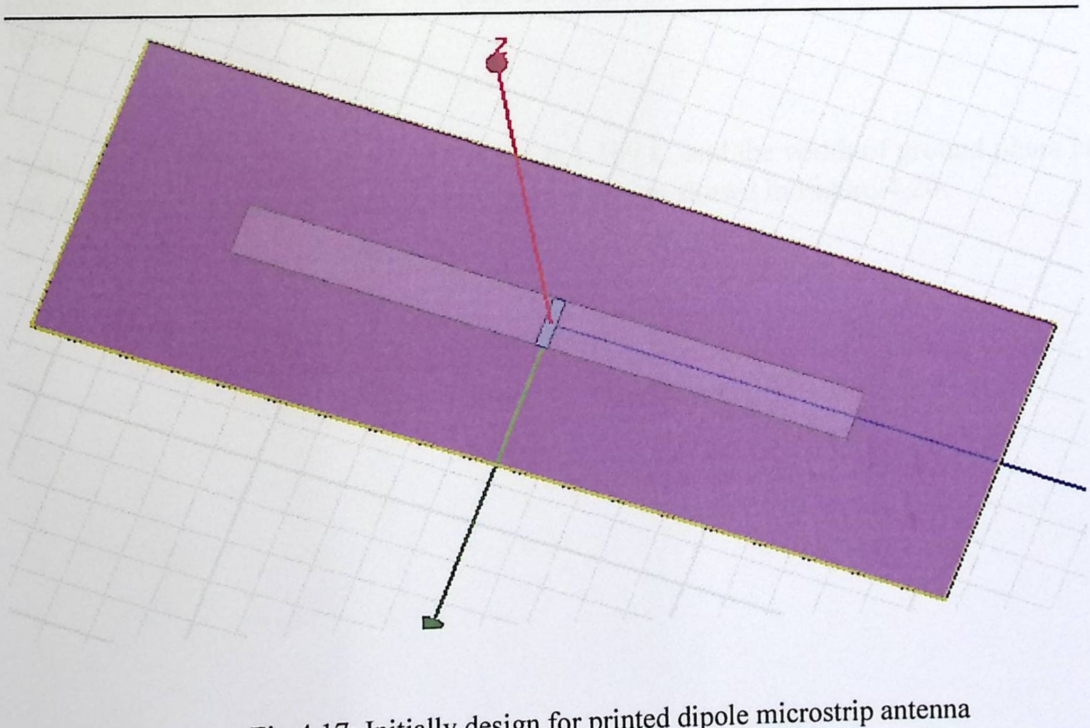


Fig.4.17: Initially design for printed dipole microstrip antenna

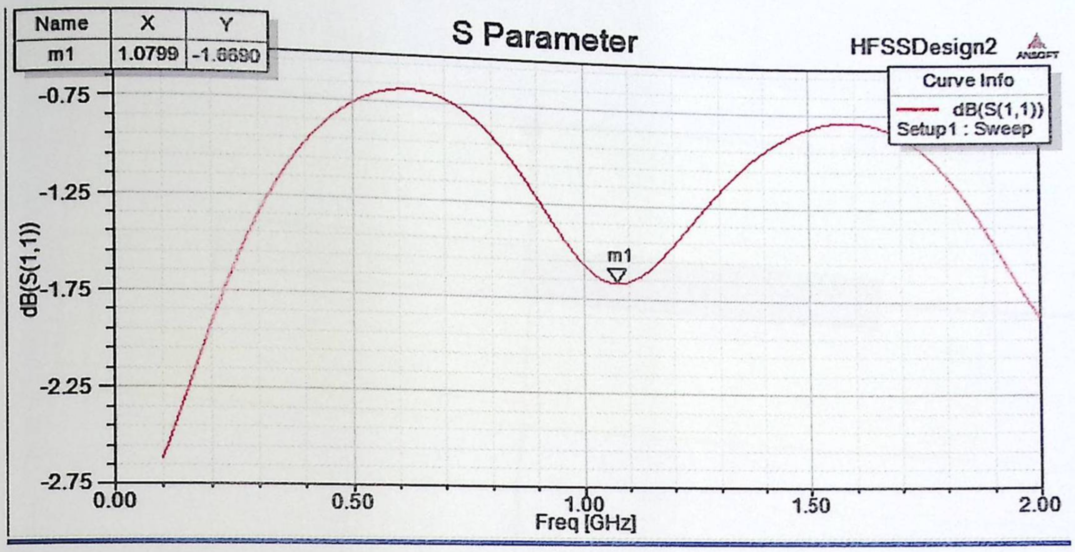


Fig.4.18 Return loss vs. frequency

After many simulations, we have been able to establish an approximate idea about how effects on the return loss and bandwidth. This idea concerns on used partial ground as shown in three designs below:

Design 1:

The total length of rectangular ground plane is 1.169 L, and the width of ground plane is 0.169 L it is shown in Figure 4.19 and the return loss for this design shown in Figure 4.20:

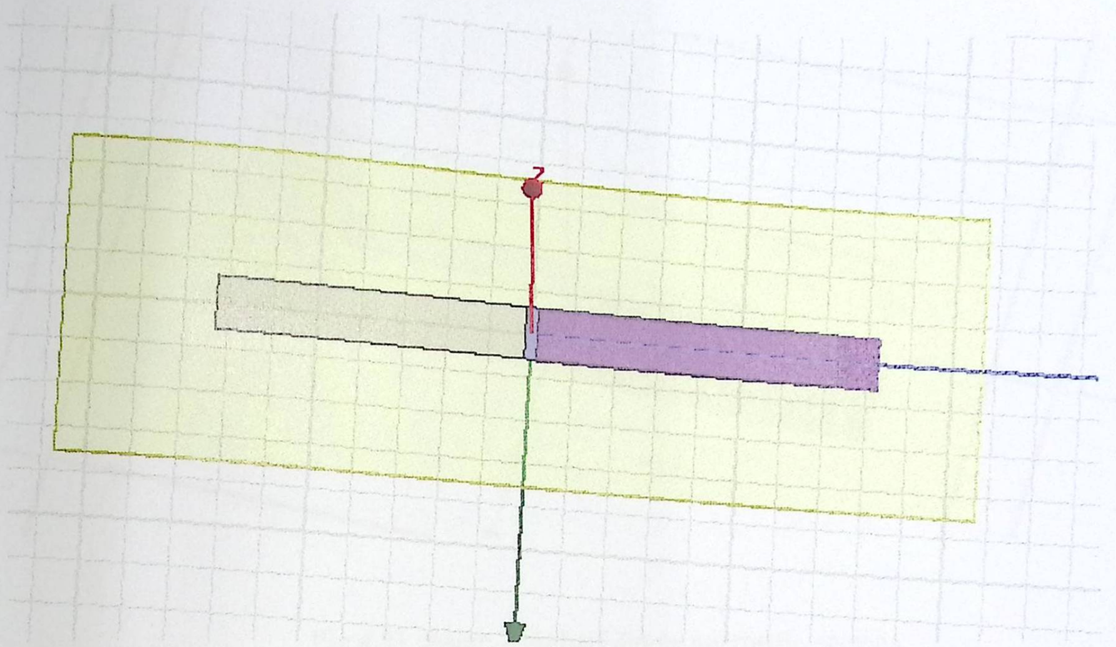


Fig 4.19 Design 1 for half dipole microstrip antenna

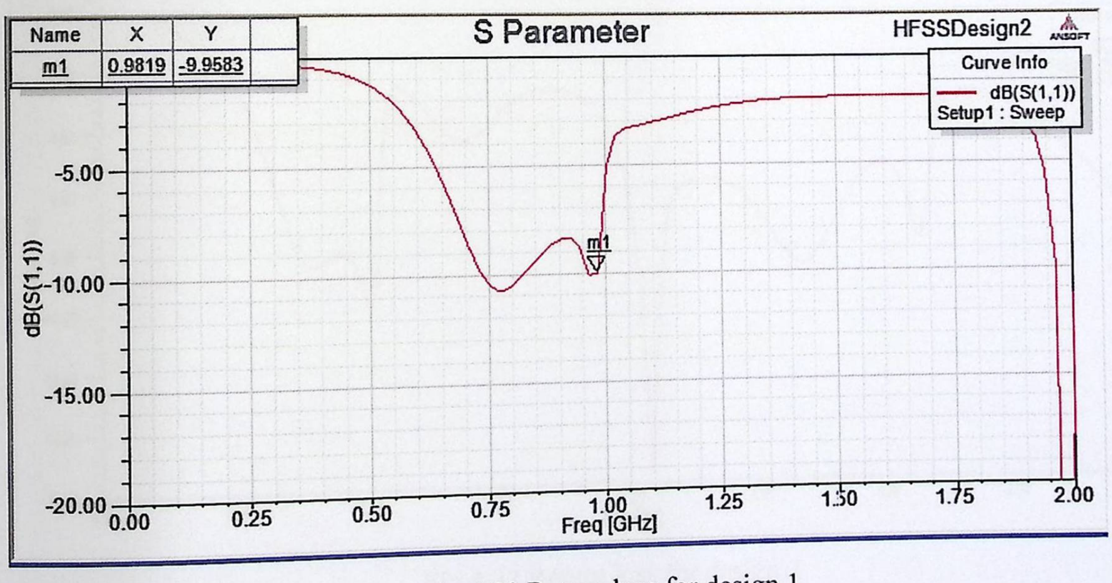


Fig 4.20 Return loss for design 1

The results for this design isn't good enough so that there is changes made on the partial ground as will be shown in design 2

Design 2:

In this design the total length of rectangular ground plane is 1.5 L, and the width of ground plane is 0.5 L as shown in Figure 4.21 and the return loss for this design shown in Figure 4.22.

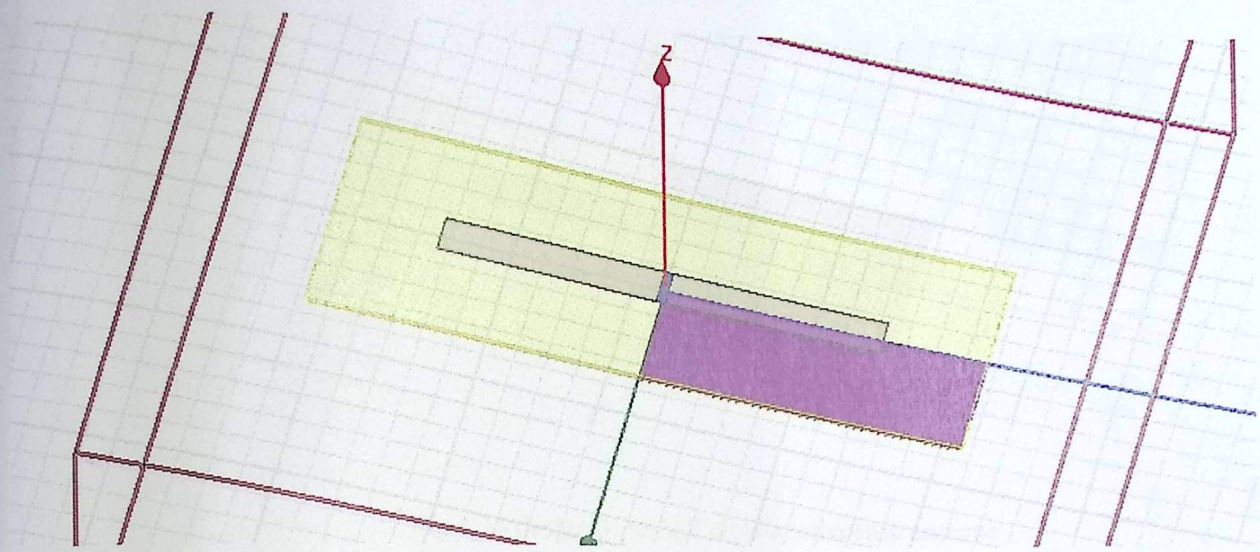


Fig 4.21 design 2 for half dipole microstrip antenna

Fig 4.22 Return loss for design 2

But the bandwidth in these results it is narrow so that there is another change made on the partial ground as shown in design 3 below.

Design 3:

In this design, the ground plane is considered to be half of the substrate. The length and width of ground plane is Lg=1.5L and Wg=L as shown in Figure 4.23 and the return loss in Figure 4.24 as shown below:

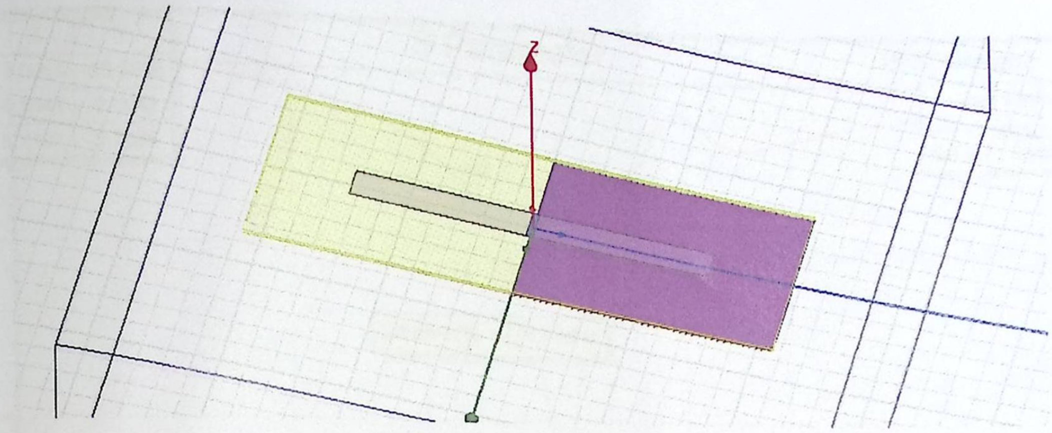


Fig 4.23 design 3 for half dipole microstrip antenna

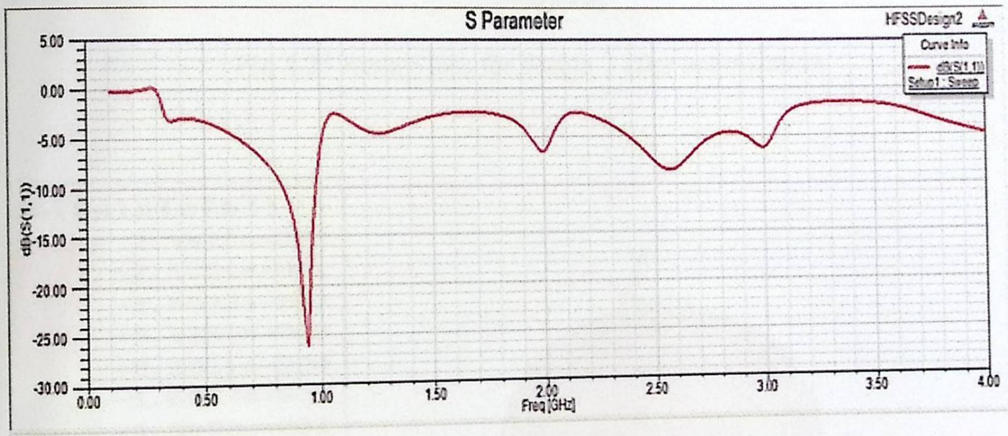


Fig 4.24 return loss for design 3

The best bandwidth and return loss occurred in desgin 3, so that some optimizations was made on design 3. After make some optimization to the length and width of arms, and optimization the width and length of dielectric, the results for design 3 shown below.

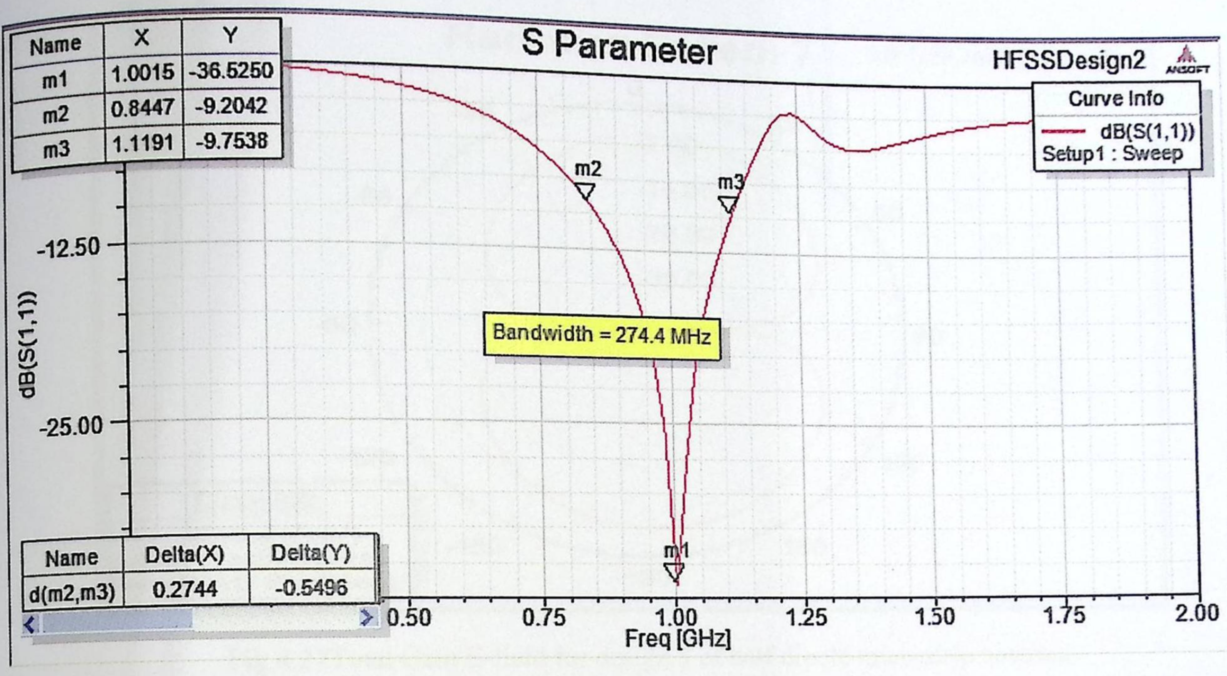


Fig 4.25 Return loss for design 3 after optimization

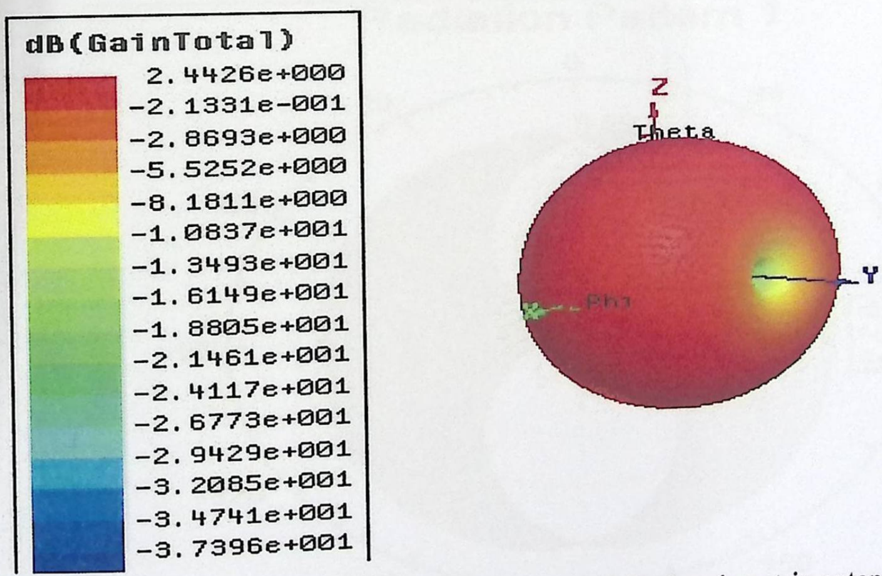


Fig 4.26 3D polar for design 3 half dipole microstrip antenna.

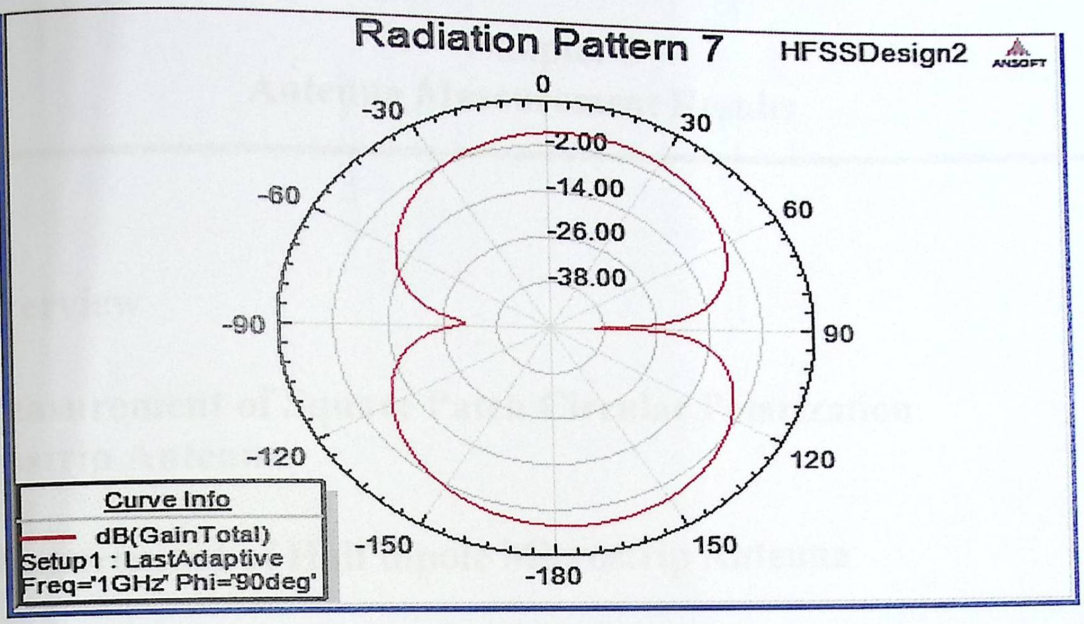


Fig 4.27Total Gain E-field for design 3 of half dipole microstrip antenna

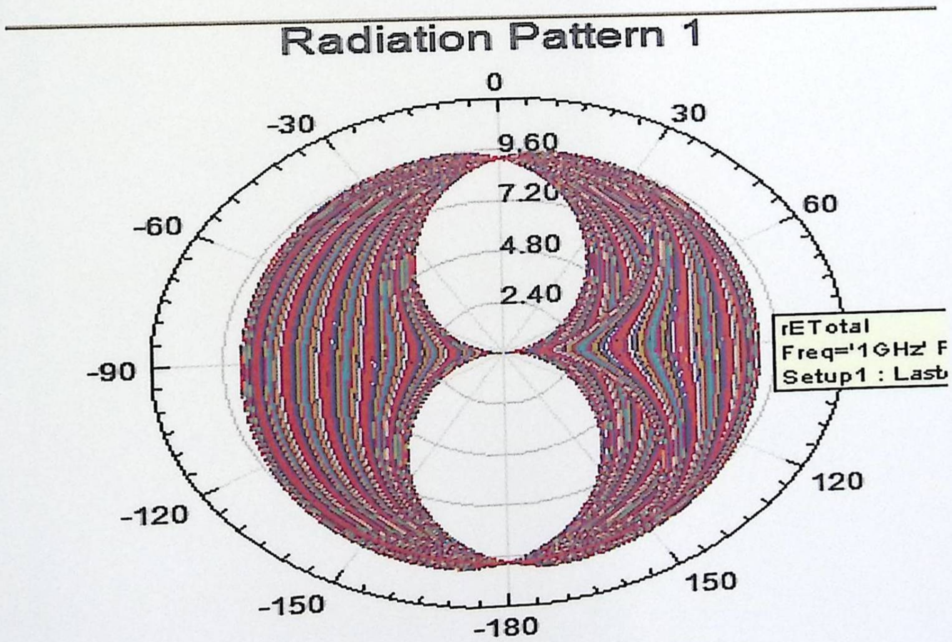


Fig 4.28 radiation pattern for design 3 of half dipole microstrip antenna

Chapter 5
Antenna Measurement Results

5.1 Overview

5.2 Measurement of Square Patch Circular Polarization Microstrip Antenna

5.3 Measurement of Half dipole Microstrip Antenna

5.1 Overview

In this chapter we measured the return loss ,VSWR and radiation pattern for circularly polarized square patch and half dipole micostrip antennas at 1.0 GHz .

We measure VSWR and rerun loss of the square patch and half dipole micostip antennas using Site Master system at al-wataniya mobile company because this system isn't available in our university.

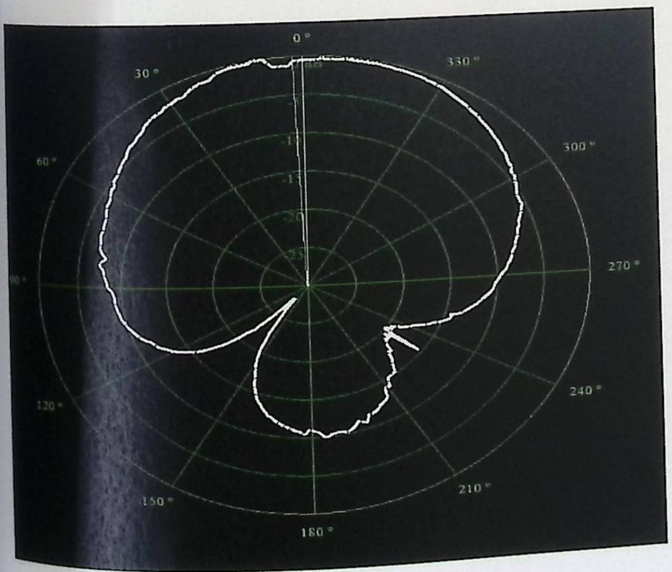
The system was first calibrate for open circuit load, shorts circuit load and matched load 50 ohm in order to establish the required reference points for the frequency range required. After that the microstrip antenna was connected to the Site Master via an SMA/N1 connector.

These antennas fabricated by using FR4 substrate with thickness 1.6mm using PCB prototype machine.

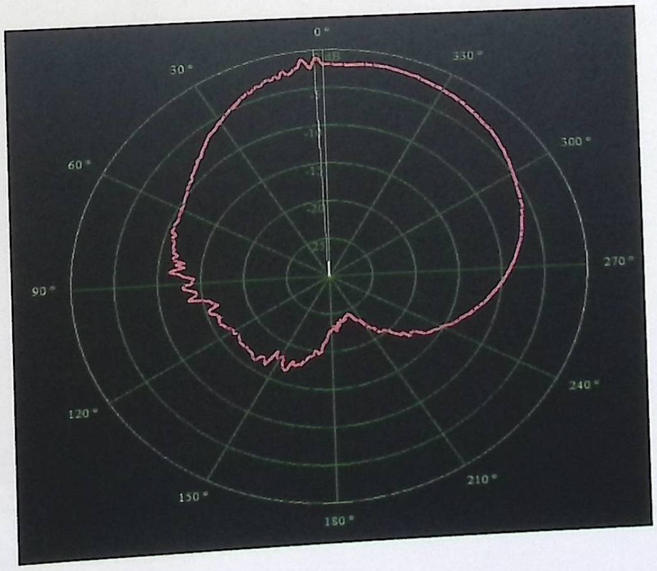
5.2 Measurement of Square Patch Circular Polarization Microstrip Antenna

We measured the radiation pattern ,VSWR and return loss and the measured value as follow:
VSWR=1.038
Bandwidth of antenna = 24MHz (from1.023 to 1.047GHz)

These results of measurement as shown on the following figures:



(a)



(b)

Fig.5.1 Radiation pattern of the antenna: (a) LHCP – (b) RHCP

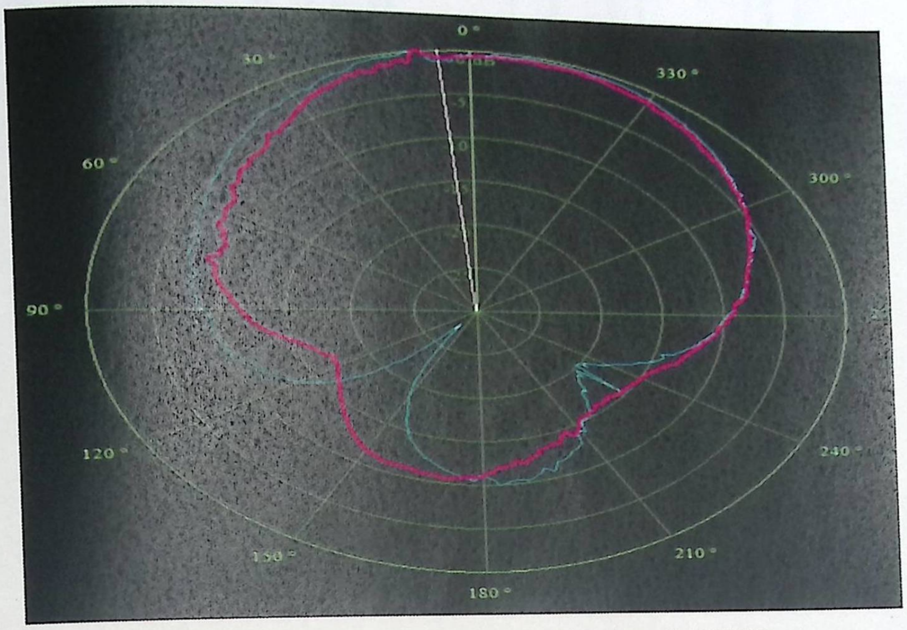


Fig.5.2 Radiation pattern for LHCP and RHCP

We have two antennas A&B as transmitter and receiver so that the result for antenna A and B as shown below :

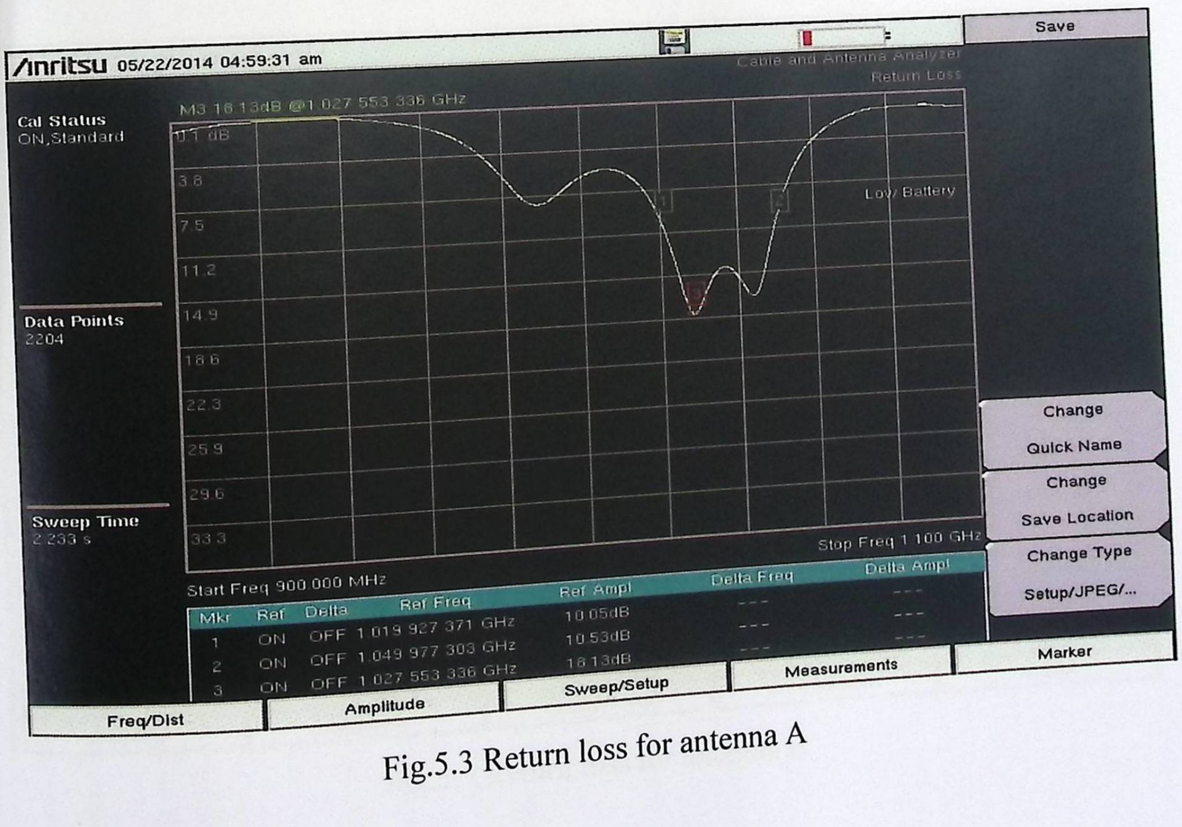


Fig.5.3 Return loss for antenna A

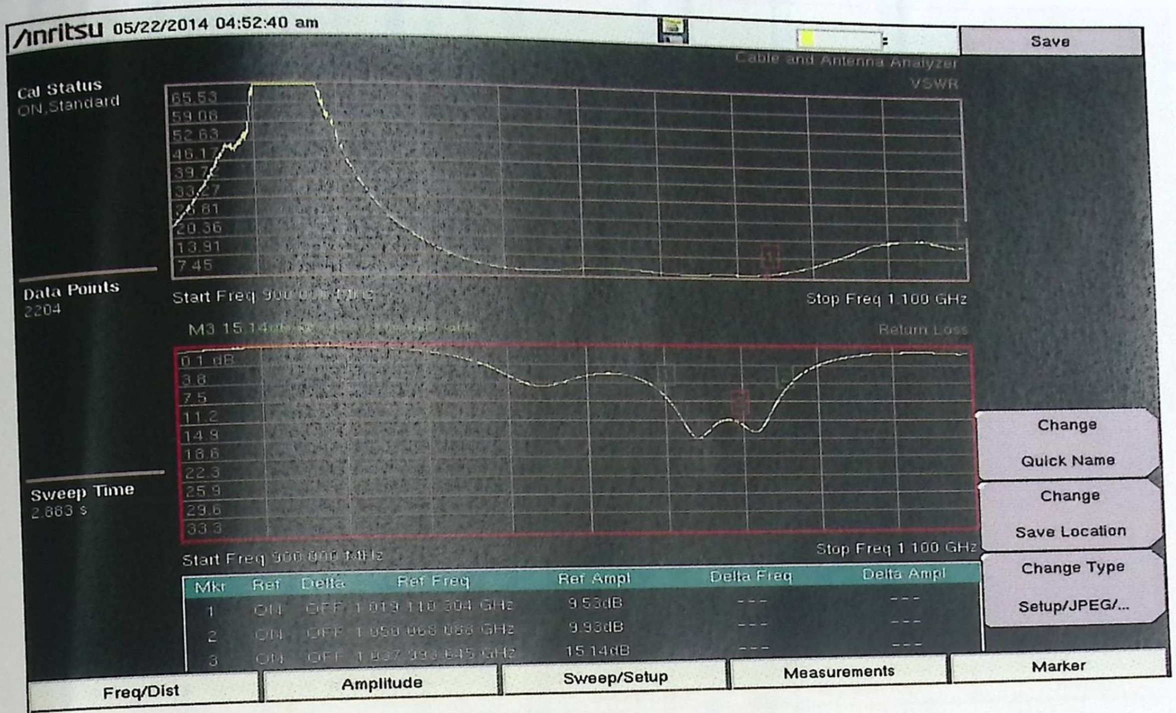


Fig .5.4 VSWR versus return loss for antenna A

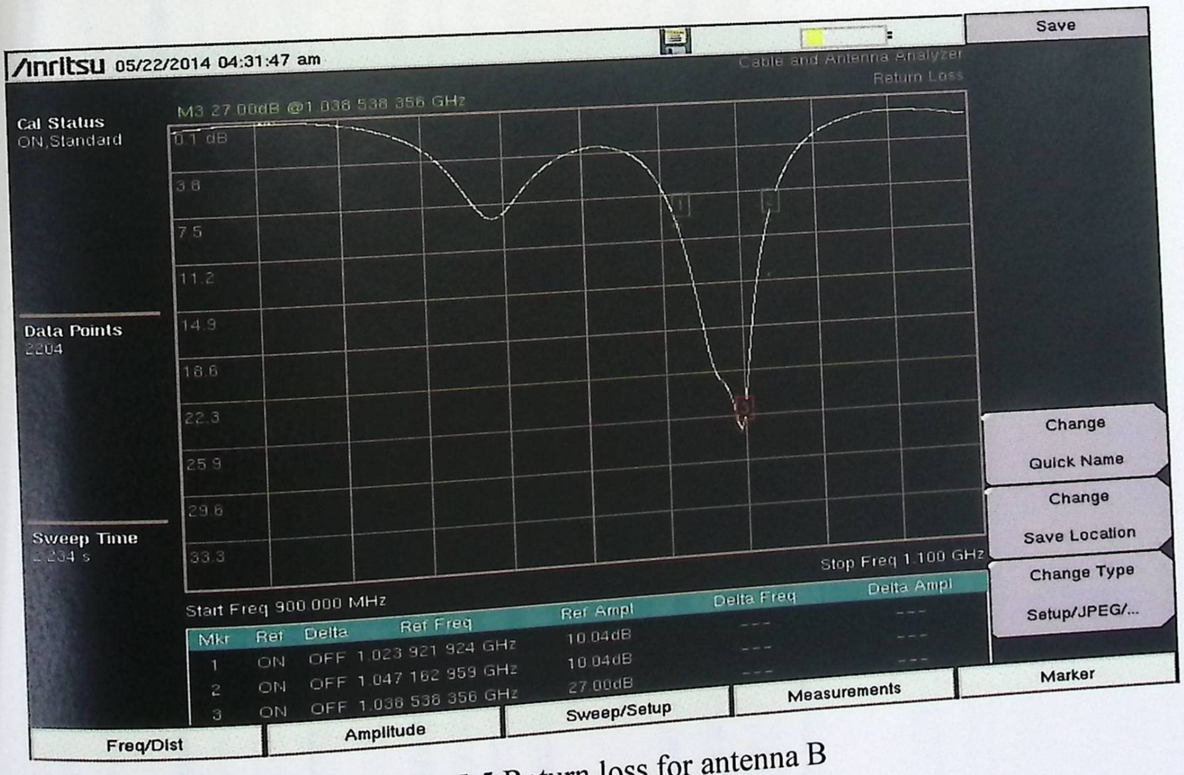


Fig.5.5 Return loss for antenna B

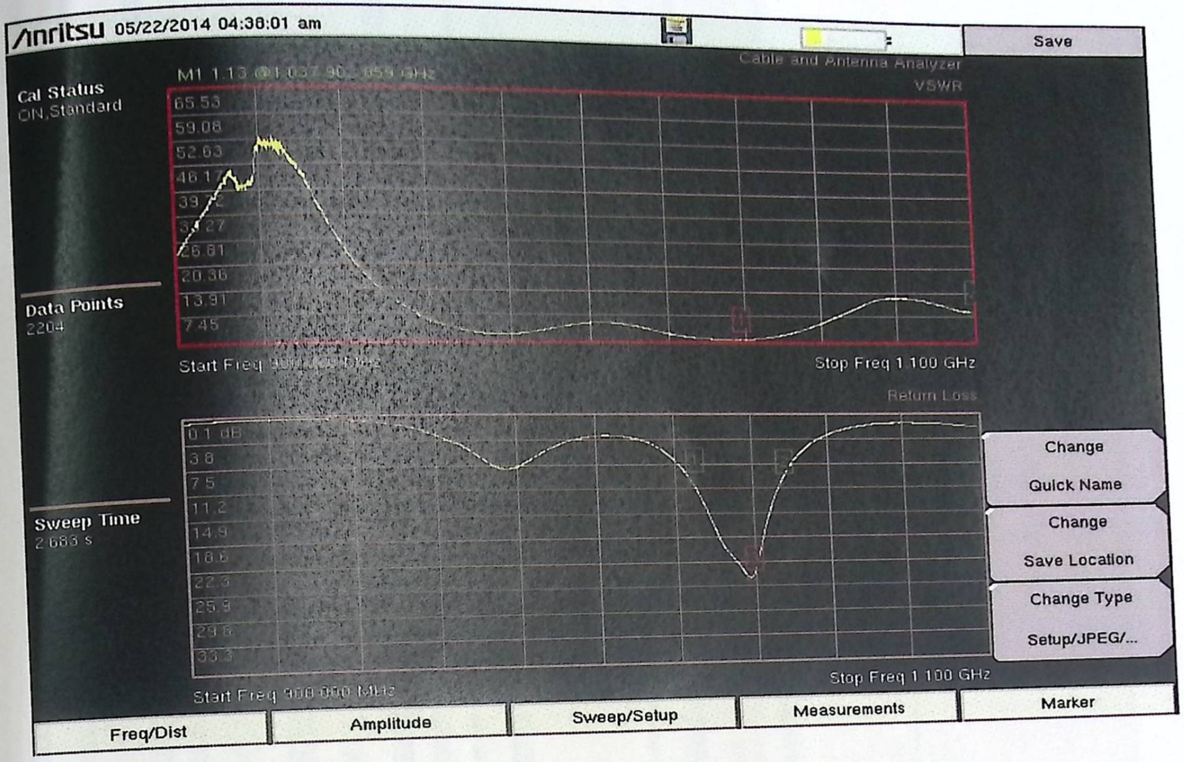


Fig .5.6 VSWR versus return loss for antenna B

5.3 Measurement of Half Dipole Microstrip Antenna

We measured the radiation pattern and return loss as shown below:

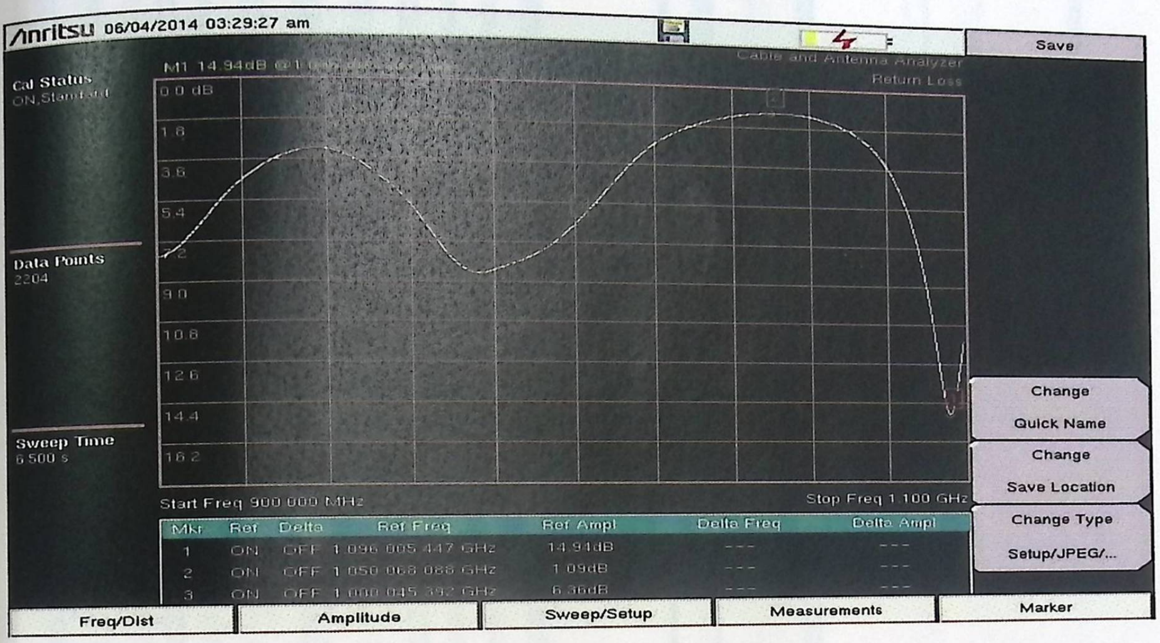


Fig.5.7 Return loss for half dipole microstrip antenna

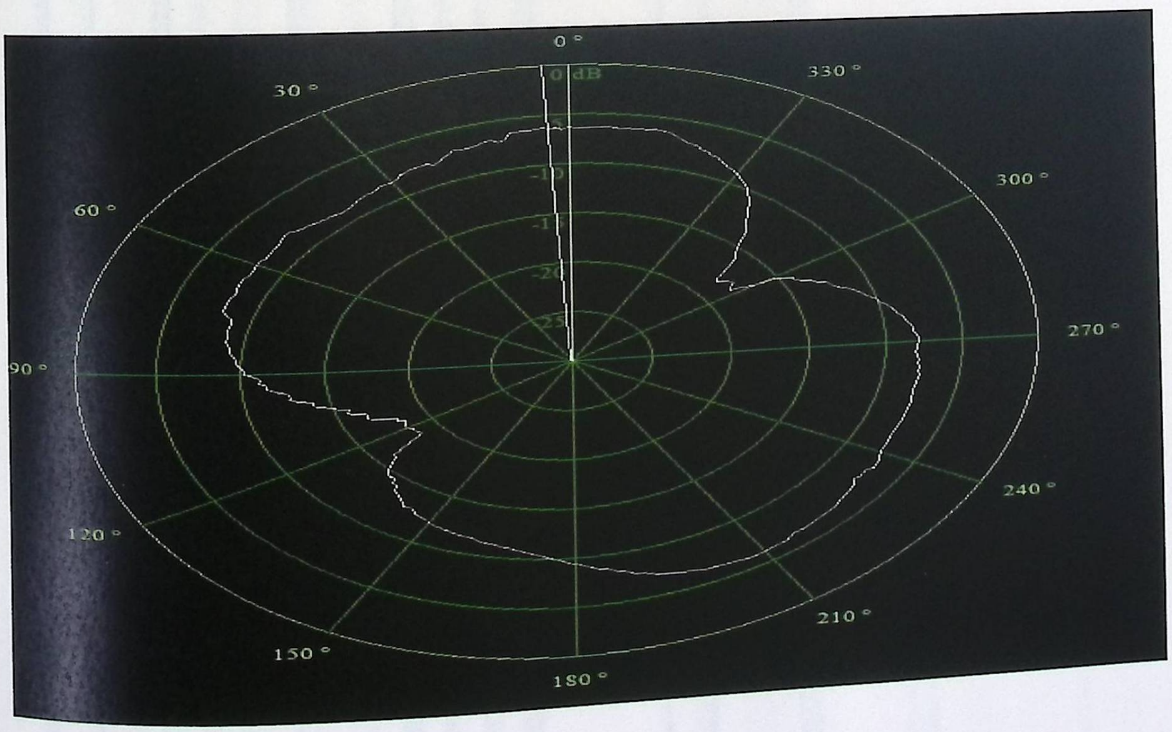


Fig.5.7 Radiation pattern for half dipole microstrip antenna

Chapter 6
Conclusion and future work

6.1 Conclusion

6.2 Challenges

6.3 Future work

6.1 Conclusion

The work presented focused first on designing a circularly polarized microstrip antenna operating at 1.0 GHz. The thesis presented a new design based on dual feed with X-shaped slots on a square patch antenna. Two design versions were presented. The first design used dual feed, the second used dual feed with X-shaped slots.

The design of a circularly polarized is presented , first a dual feed Circular Polarization was design and results were analyzed, then the effect of adding two slots at 45 and 135 degrees in shape of 'X' was studied. A comparison between the two was also done. It was found that Patch antenna with X-slot or X-shape slot and dual feed showed better performance than patch with dual feed in terms of axial ratio. Both of these antennas successfully showed circular polarization; which was confirmed with help of axial ratio or by noting the behavioral pattern of theta and phi components of Electric field.

The design requires three parametric studies for determining the optimum values for antenna axial ratio, the location of the coaxial probe from the patch center, the length and width of slots, and the length and width of patch. The slot dimensions affect the circular polarization production. The feed location affects the antenna return loss value, but doesn't have much effect on the axial ratio value.

The design of Square patch dual feed (Probe Feed) antenna for circular polarization has been completed using HFSS software. The simulation gave results good enough to satisfy our requirements to fabricate it on hardware .A square patch circularly polarized microstrip antenna design has been proposed and successfully implemented.

Circularly polarized microstrip patch antennas are widely employed in radar, GPS and mobile communication systems. Achieving 3dB axial ratio bandwidth along with the 2:1 VSWR bandwidth is a challenging task for designers.

Main inferences obtained from the investigation of cross shaped microstrip antenna can be summarized as below.

(i) A cross patch antenna with an embedded X-slot in the center excites compact orthogonal resonant modes.

(ii) Mechanical tuning of the two orthogonal resonant modes can be varied by varying the length of the X-slot.

(iii) The X-slot induces symmetric current distributions for the orthogonal resonant modes and can be easily modified to reconfigurable antenna with greater area reduction.

(iv) A square MSA with a rectangular slot along its diagonal and the feed along its central axis produces CP.

In this study, a printed dipole which works at 1.0 GHz is designed. For dipole design, HFSS (High Frequency Structure Simulator) software developed by Ansoft Company is used.

The performance of microstrip dipole antenna with different ground plane has been analyzed at a frequency of 1.0 GHz for wideband application. Shorting plate between the ground plane and dipole arm improve the bandwidth of antenna as well as provide double band. By using this shorting plate we obtain maximum bandwidth of 274.4 MHz with minimum return loss of -36 dB. The simulated and measured results show that the antenna has perfect impedance matching. It is suitable for designing antennas for measure gain.

6.2 Challenges

Circularly polarized microstrip patch antennas are widely employed in radar, GPS and mobile communication systems, defense applications, surveillance and countermeasures etc. Achieving 3dB axial ratio bandwidth along with the 2:1 VSWR bandwidth is a challenging task for designers.

Improvement bandwidth of printed dipole microstrip antenna .The bandwidth of the antenna depends on the patch shape, resonant frequency, dielectric constant and the thickness of the substrate. The bandwidth enhancement of a microstrip antenna has been directed towards improving the impedance bandwidth of the antenna element. Impedance bandwidth is usually specified in terms of a return loss.

6.3 Future work

The main and unique feature of this Microstrip antenna is its simplicity to get higher performance. In much application essentially in radar and satellite communication In future this antenna may be made reconfigurable in frequency and polarization. Also work could be done in order to improve its bandwidth.

This work can be extended by investigating the design of an antenna array that uses the antenna presented as its unit element. The future array structure should investigate the use of the 3 feeding techniques .It should also investigate the arrangement of the array elements.

The design of printed dipole antenna for gain measurement has been completed using HFSS software. The simulation gave results good enough to satisfy our requirements to fabricate it on hardware which can be used wherever needed. The investigation has been limited mostly to theoretical studies and simulations due to lack of fabrication facilities. Detailed experimental studies can be taken up before our presentation in this semester to fabricate the antenna.