BANDWIDTH ENHANCEMENT OF MICROSTRIP ANTENNA USING U-SLOT, STACKING AND DEFECTED GROUND TECHNIQUES FOR S AND C-BAND APPLICATIONS

A

THESIS

Submitted towards the Requirement for the Award of degree of

DOCTOR OF PHILOSOPHY

IN

ELECTRONICS AND COMMUNICATION ENGINEERING

Under the faculty of Engineering and Technology

BY

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YEAR - 2022

P.K. UNIVERSITY, SHIVPURI (M.P.) -473665

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(Satyendra Kumar Swarnkar)

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II. has duly been completed,

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Dr. Zakir Ali

Signature of the Supervisor

Dr. Balveer Singh

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1. Name of the Research Scholar	:	Satyendra Kumar Swarnakar
2. Course of Study	:	Doctor of Philosophy (Ph.D)
3. Title of the Thesis	:	Bandwidth Enhancement of Microstrip Antenna Using U-Slot, Stacking and Defected Ground Techniques for S and C-Band Application
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SUMMARY

ESSENTIAL PARAMETERS

The main required designing parameters for the slotted microstrip patch radiator as follows:

Designing Frequency f_o

Designing frequency appropriately assuming for the radiator. We have to select designing frequency for this work is 6 GHz.

Constant for dielectric material ε_r

Constant for dielectric material ε_r chosen for this radiator design is as glass epoxy material, the material has a dielectric parameter of 4.4. Then the dimension of the radiator is very reducing in size because of chosen the high dielectric constant material.

Radiator substrate material height h

We know that the microstrip patch radiators used for the wireless communication like as cellular mobile phone ,so it is necessary the size of antenna is compact that why the chosen material as very light weight if not chosen light weight then the antenna is too bulky . So here we chose material dielectric constants for radiator is 1.6 mm of height.

NECESSARY REQUIREMENT FOR RADIATOR

The necessary designing parameters for microstrip patch radiator are as follows:

6 GHz	operating frequency	
100 mm	wavelength	
4.4	Constant for the dielectric material	
0.0012	tanδ material loss tangent	
1.6 mm	dielectric material height	h
11.32 mm.	Patch length of radiator	L_p
15.20 mm.	Patch width of radiator	W_p
20.92 mm.	Ground length of radiator	L_g
24.80 mm.	Ground width of radiator	W_g

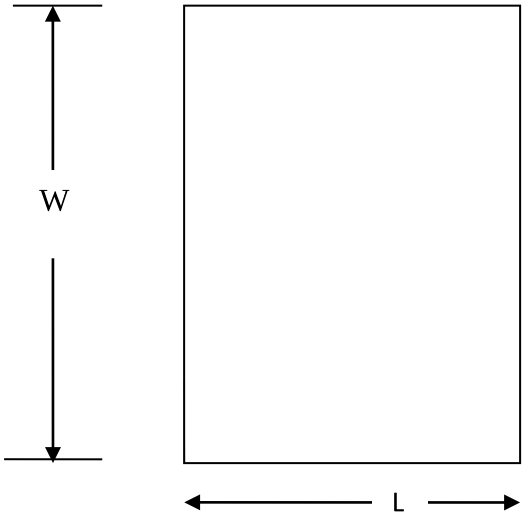

Figure S.1 Rectangular Shape Microstrip Patch Antenna

Following steps will be taken to design the antenna:

Formula expression for the width w: Microstrip patch radiator width is calculated by the given formula $w = \frac{c}{2f_0\sqrt{\frac{\varepsilon_r+1}{2}}}$

Formula expression for material effective dielectric constant (ε_{reff}): By the given formula, find out the value of effective dielectric material constant as

$$\varepsilon_{reff} = \frac{+1}{2} + \frac{\varepsilon_r - 1}{2}\left(1 + \frac{12h}{W}\right)^{-\frac{1}{2}}$$

Formula expression for extension of length (ΔL): Microstrip patch radiator extention length is calculated by the given formula

$$\frac{\Delta \mathrm{L}}{\mathrm{h}} = \frac{\delta_1 \delta_2 \delta_3}{\delta_4}$$

Formula expression for Effective length (L_{eff}): Microstrip patch radiator effected length is calculated by the given formula

Effective length L_{eff} $\quad L_{eff} = \mathrm{L} + 2\Delta\mathrm{L}$

Formula expression for length of the patch (L): Microstrip patch radiator actual length is calculated by the given formula

$$\mathrm{L} = \frac{\mathrm{c}}{2f_0\sqrt{\varepsilon_{reff}}} - 2\Delta L$$

Formula expression for microstrip patch radiator ground plane calculation (L_g and W_g): Microstrip patch radiator L_g *and* W_g is calculated by the given formula in Microstrip patch radiator infinite ground planes is used because of transmission line and fringing field. But, for the experimental observation, for antenna fabrication the finite ground is required. It is find out that in different research articles and papers it is observe there are both ,finite and infinite ground is considerable for designing , if we go for the finite ground so the finite ground is greater than the patch and ground is six time of substrate material thickness greater than patch size as:

$$L_g = \mathrm{L} + 6\mathrm{h}$$

$$W_g = \mathrm{L} + 6\mathrm{h}$$

Identify F P location (X_{FP} Y_{FP}): Designing of microstrip patch radiator is fabricated using coaxial probe feeding technique. And the ground is fabricated at the center and the feed location is denoted at the particular coordinate is X_{FP} Y_{FP} at the center. It is most important that the feed point is conforming at the patch radiator at that point on the patch, Then the return loss is must be less than -10dB for designing frequency.

ANTENNA ARCHITECTURE

Antenna Shape 1

Figure S.2 shows the proposed novel microstrip antenna initially the antenna shape which has been drawn on the IE3D simulation software was of diamond shape and then with the aim of getting high bandwidth for slots have been etched out and then the shape of the antenna looks like the two thick directional arrows connected from their backs.

As we know through various reference papers that the slot cutting is one of the most prominent technique to increase the bandwidth and i.e. in this novel shape we have etched out 4 slots.

The feed point is located at the center down corner (10.46 mm, 4.8 mm) of the shape, this is a single band high return loss antenna.

As far as the antenna architecture is concerned this microstrip configuration is novel and developed for the 6.0 GHz of application.

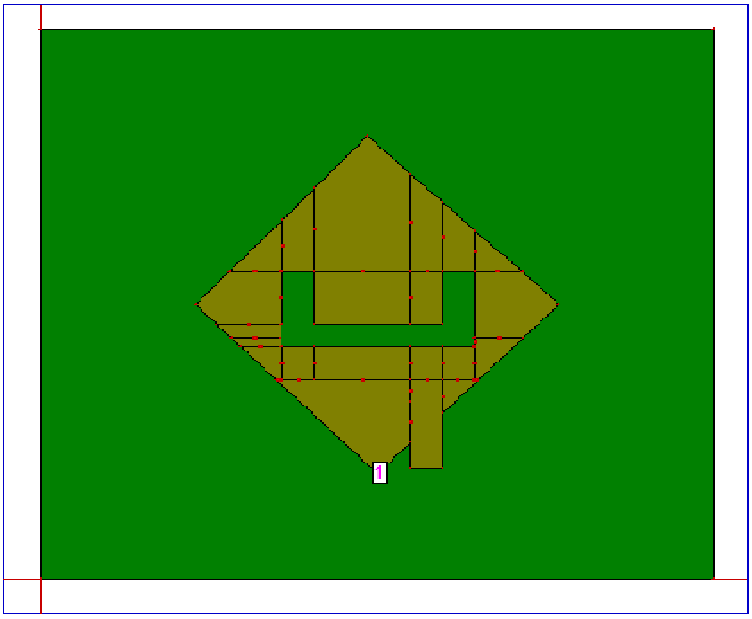

Figure. S.2: IE3D structure of the Antenna After Slots Etched Out

Table S.1: The following are the design specifications of this novel configuration shape 1

Substrate material used	Glass Epoxy
Relative dielectric constant	4.4
Thickness of the substrate	1.6 mm
Loss Tangent	0.0012
Length of the patch	11.32 mm.
Width of the patch	15.20 mm.
Slot Dimensions	(8 mm, 12 mm/ 1mm*3mm), (10.46 mm, 11 mm / 6mm*1mm), (13 mm, 12 mm / 1mm*3mm), slot fill (12 mm, 7 mm /1mm*4mm)
Feed Location(X_0,Y_0)	(10.46 mm, 4.8 mm)
Broadbanding technique used	Three Slots , Slanting Edges and One strip fill

Figure. S.3 : printed structure of the Antenna After Slots

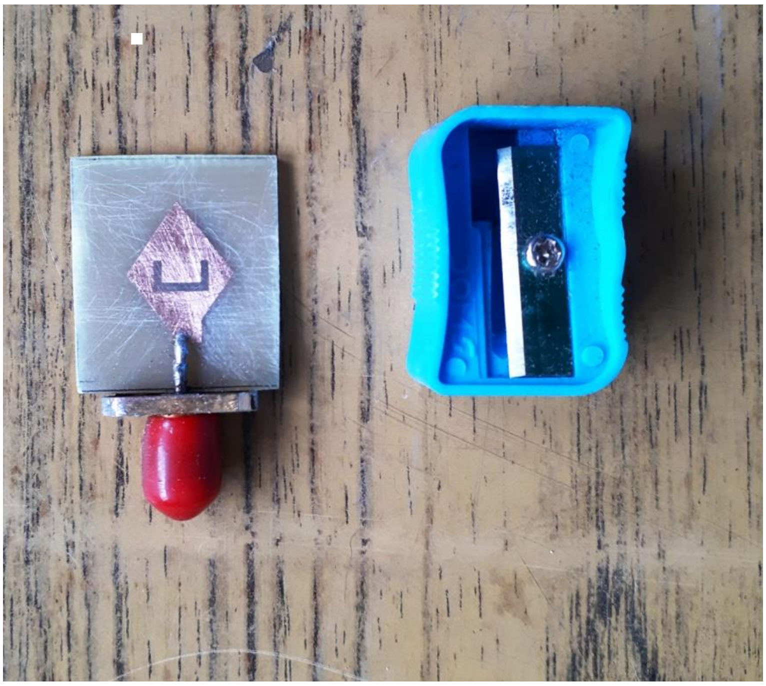

Figure S.4 : Hardware Size Comparision (pencil cutter) of Proposed Novel Shape

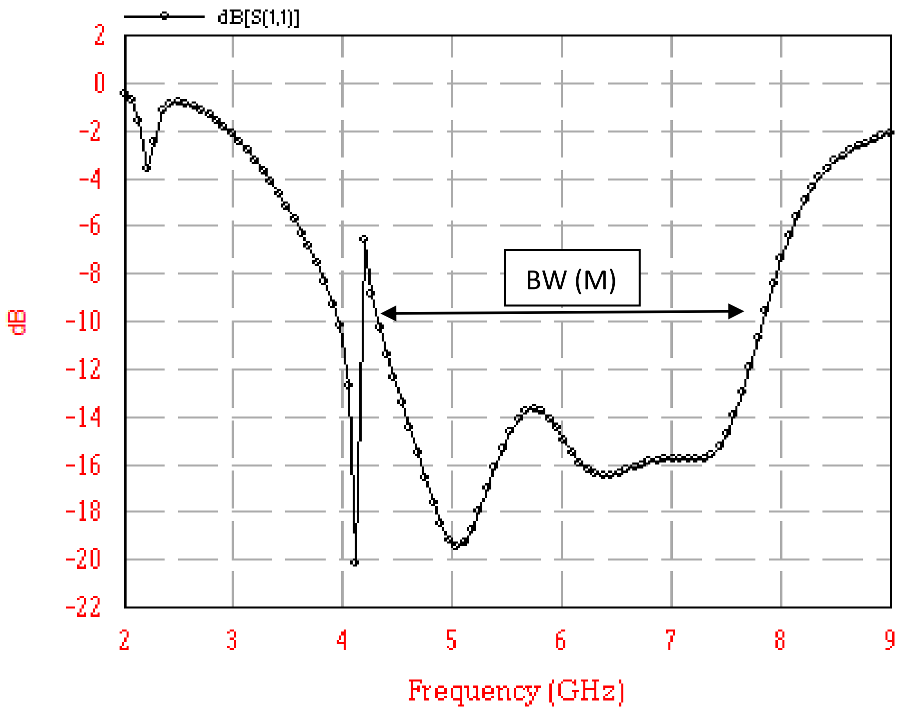

Figure. S.5: Simulator Generated Return Loss Graph of Proposed Antenna

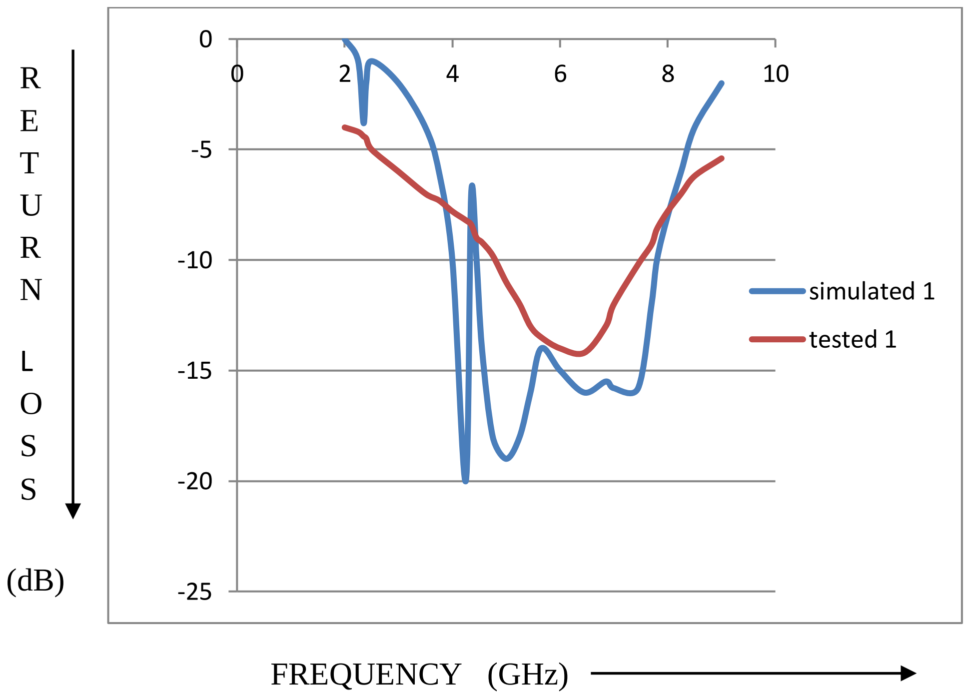

Figure S.6: Return Loss Graph Comparision of Software Simulated Results and Measured Results of Microstrip Antenna on Excel

4.3.2 Results And Discussion Shape 1

Figure S.5 represnts the return loss graph comparision of the software simulated results and the measured results of the novel configuration (proposed antenna shape 2), there are two curves clearly visible on the graph the black curve represents the return loss of the antenna which is produce by IE3D while the red curve represents the value of the return loss generated by the vector analyzer.

This is a double dip curve which shows that the proposed geomatry is double band antenna which can be used for the applications of 4.3 GHz to 7.8 GHz and thus a bandwidth = f2-f1 /(f2+f1/2) = 7.8-4.3/6.05 = 57.85 % has been obtained.

There are few more important parameters and agreements between parameters for microstrip antenna, which must need to be observed well before implementation of the microstrip antenna. Study of Smith Chart, Directivity Vs. Frequency, Gain Vs. Frequency, Radiation Pattern and Efficiency Vs. Frequency are those important parameters and agreements.

Table S.2: Testing results V/s IE3d shape 1 results

Practically Achieved		By IE3D	
Frequency (GHz)	RL	Frequency(GHz)	RL
4.3	-11.00 dB	4.3	-9.00 dB
4.5	-12.0 dB	4.5	-9.70 dB
5.8	-13.00dB	5.8	-14.00 dB
7.0	-16.00 dB	7.0	-12.00 dB
7.8	-10.00 dB	7.8	-9.80 dB

Antenna Shape 2

Figure S.7 shows the proposed novel microstrip antenna initially the antenna shape which has been drawn on the IE3D simulation software was of diamond shape and then with the aim of getting high bandwidth for slots have been etched out and then the shape of the antenna looks like the two thick directional arrows connected from their backs.

As we know through various reference papers that the slot cutting is one of the most prominent technique to increase the bandwidth and i.e. in this novel shape we have etched out 9 slots. The feed point is located at the right most down edge (16.12 mm, 6.5 mm) of the shape, this is a single band high return loss antenna.

As far as the antenna architecture is concerned this microstrip configuration is novel and developed for the 6.0 GHz of application.

Table S.3: The following are the design specifications of this novel configuration shape 2

Substrate material used	Glass Epoxy
Relative dielectric constant	4.4
Thickness of the substrate	1.6 mm
Loss Tangent	0.0012
Length of the patch	11.32 mm.
Width of the patch	15.20 mm.
Slot Dimensions	(11 mm, 13 mm/ 1mm*2mm), (13 mm, 13 mm / 1mm*2mm), (12 mm, 12 mm / 2mm*1mm), (11 mm, 8 mm /1mm*5mm) , (9 mm, 10 mm /1mm*3mm), (6 mm, 12 mm /1mm*2mm), (8 mm, 13 mm /1mm*2mm), (7 mm, 12 mm /2mm*1mm), (6 mm, 6 mm /6mm*3mm)
Feed Location(X_0,Y_0)	(16.12 mm, 6.5 mm)
Broadbanding technique used	Nine Slots and Slanting Edges

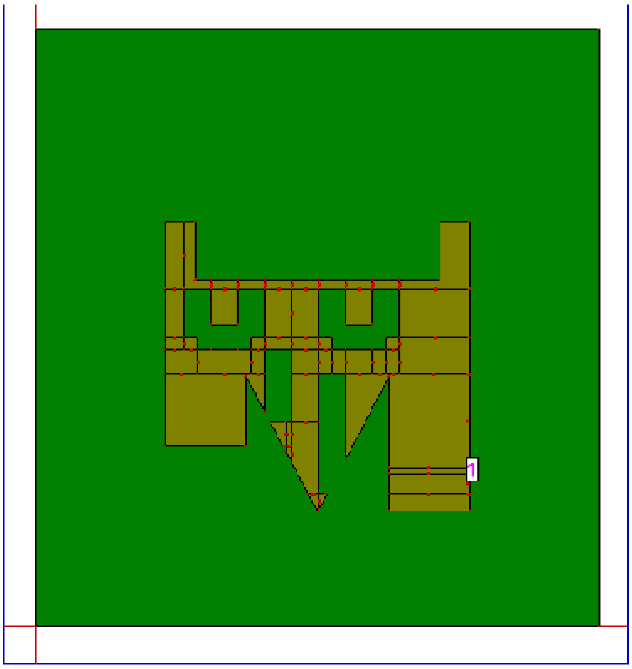

Figure. S.7: IE3D structure of the Antenna After Slots Etched Out

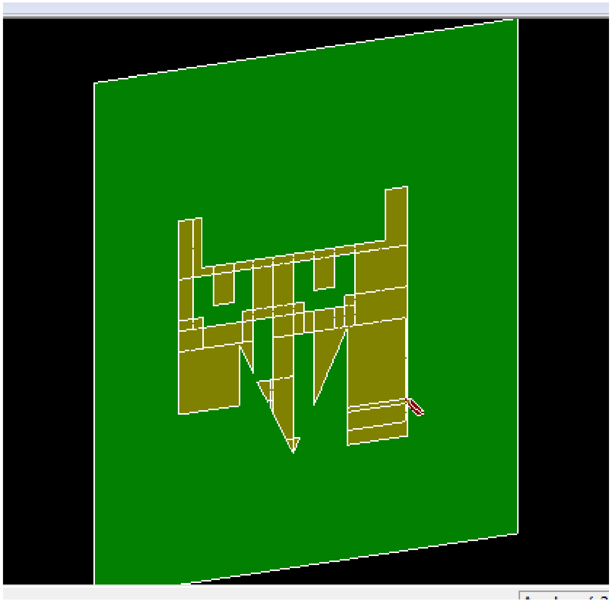

Figure. S.8: 3D Geometry of the Antenna After Slots Etched Out

Figure. S.9 : printed structure of the Antenna After Slots

Figure S.10 : Hardware Size Comparision (pen) of Proposed Novel Shape

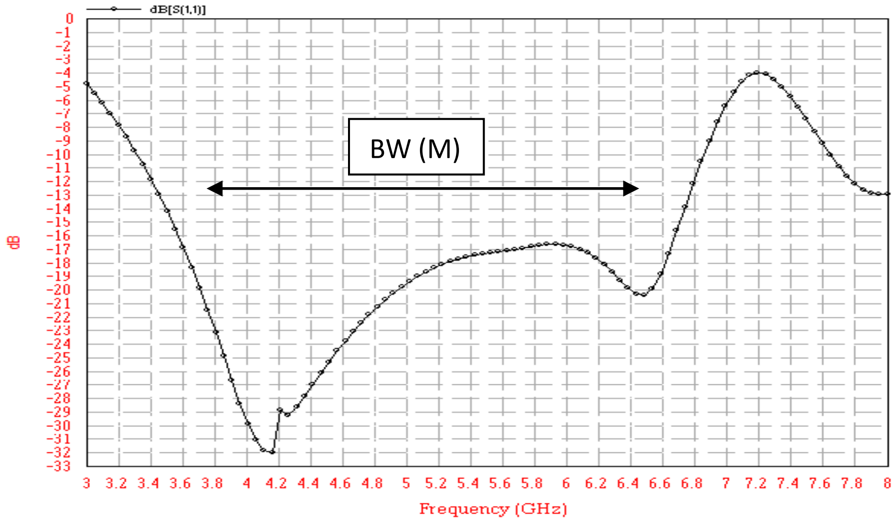

Figure. S.11: Simulator Generated Return Loss Graph of Proposed Antenna

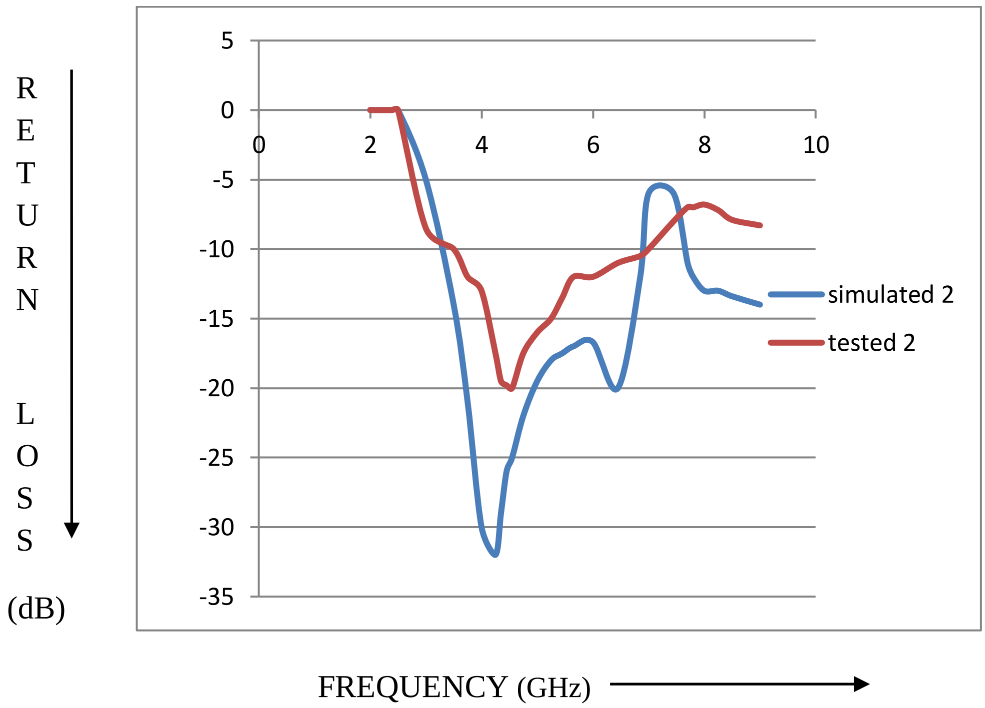

Figure S.12: Return Loss Graph Comparision of Software Simulated Results and Measured Results of Microstrip Antenna on Excel

Results And Discussion Shape 2

Figure S.11 represents the return loss graph comparision of the software simulated results and the measured results of the novel configuration (proposed antenna shape 2), there are two curves clearly visible on the graph the black curve represents the return loss of the antenna which is produce by IE3D while the red curve represents the value of the return loss generated by the vector analyzer.

This is a double dip curve which shows that the proposed geometry is double band antenna which can be used for the applications of 4.3 GHz to 7.8 GHz and thus a bandwidth = f2-f1 /(f2+f1/2) = (6.85-3.30) / 5.00 = 71.00 % has been obtained.

There are few more important parameters and agreements between parameters for microstrip antenna, which must need to be observed well before implementation of the microstrip antenna. Study of Smith Chart, Directivity Vs. Frequency, Gain Vs. Frequency, Radiation Pattern and Efficiency Vs. Frequency are those important parameters and agreements.

Table S.4: Testing Graph V/s IE3d Graph shape 2

Practically Achieved		By IE3D	
Frequency (GHz)	RL	Frequency(GHz)	RL
3.3	-10.00 dB	3.3	-9.80 dB
3.8	-24.0 dB	3.8	-13.00 dB
5.0	-19.00dB	5.0	-16.00 dB
6.0	-16.50 dB	6.0	-12.00 dB
6.8	-10.00 dB	6.8	-10.10 dB

Antenna Shape 3

Figure S.13 shows the proposed novel microstrip antenna initially the antenna shape which has been drawn on the IE3D simulation software was of diamond shape and then with the aim of getting high bandwidth for slots have been etched out and then the shape of the antenna looks like the two thick directional arrows connected from their backs.

As we know through various reference papers that the slot cutting is one of the most prominent technique to increase the bandwidth and i.e. in this novel shape we have etched out 4 slots.

The feed point is located at the center down corner (10.46 mm, 4.8 mm) of the shape, this is a single band high return loss antenna.

As far as the antenna architecture is concerned this microstrip configuration is novel and developed for the 6.0 GHz of application.

Table S.5: The following are the design specifications of this novel configuration shape 3

Substrate material used	Glass Epoxy
Relative dielectric constant	4.4
Thickness of the substrate	1.6 mm
Loss Tangent	0.0012
Length of the patch	11.32 mm.
Width of the patch	15.20 mm.
Slot Dimensions	(9 mm, 16 mm/ 0.5mm*2mm), (11 mm, 16 mm / 0.5mm*2mm), (10 mm, 15 mm / 3mm*0.5mm),(7.5mm,15mm/0.5mm*2mm), (12.2 mm, 15 mm /0.5mm*2mm), (10 mm, 14 mm /5mm*0.5mm), (10 mm, 18.75 mm /3mm*2.5mm)
Feed Location(X_0,Y_0)	(10.46 mm, 4.8 mm)
Broadbanding technique used	Seven Slots and Slanting Edges

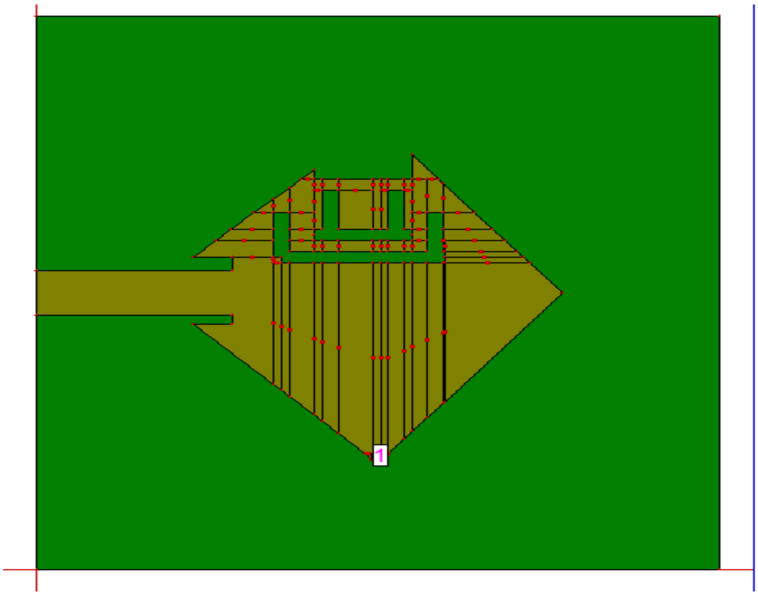

Figure. S.13: IE3D structure of the Antenna After Slots Etched Out

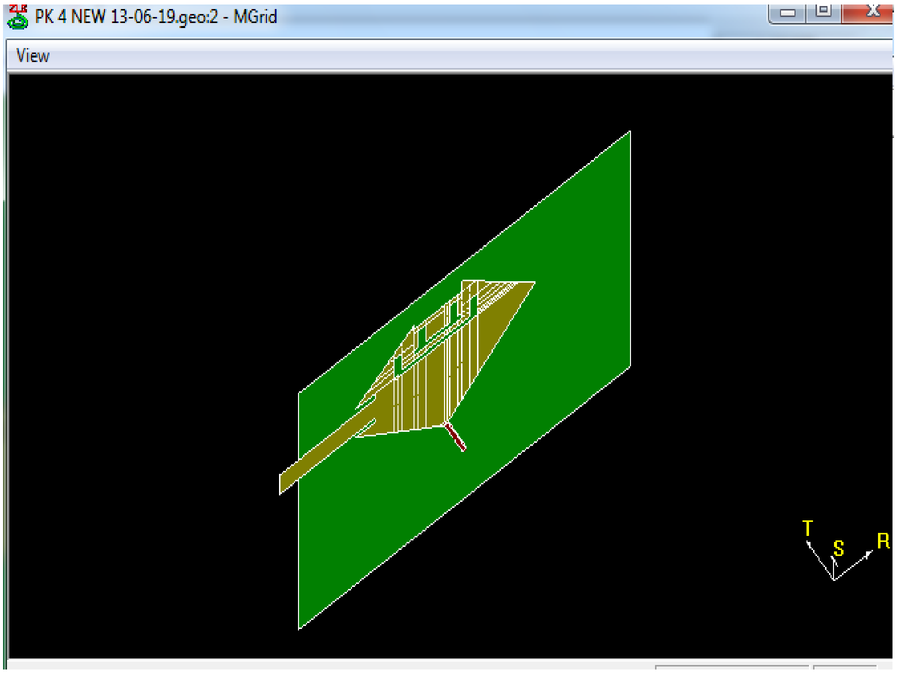

Figure. S.14: 3D View IE3D structure of the Antenna After Slots Etched Out

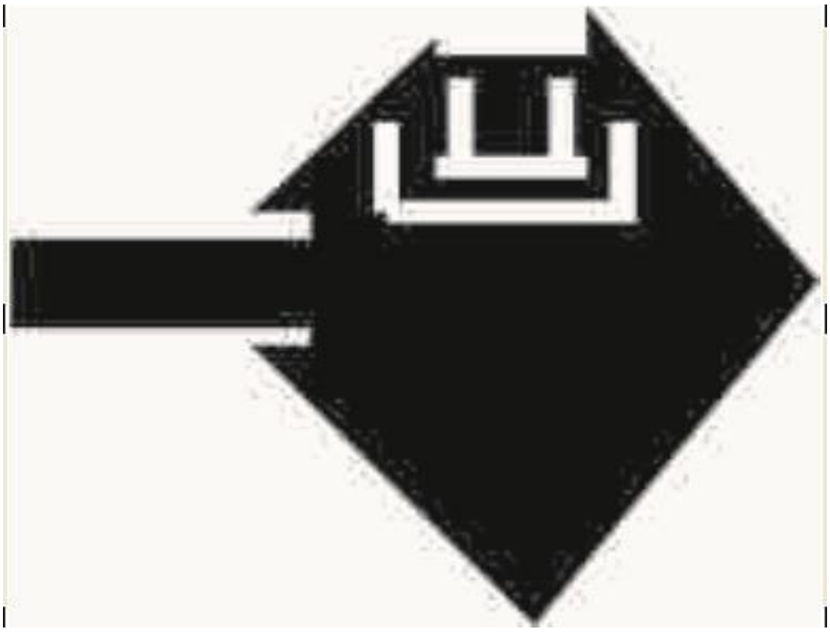

Figure. S.15 : printed structure of the Antenna After Slots

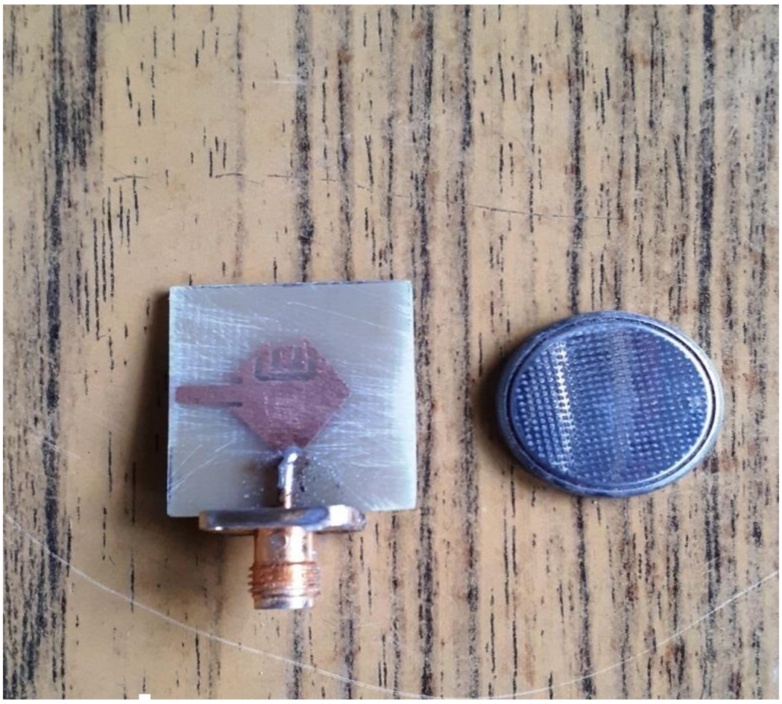

Figure S.16 : Hardware Size Comparision (Button cell) of Proposed Novel Shape

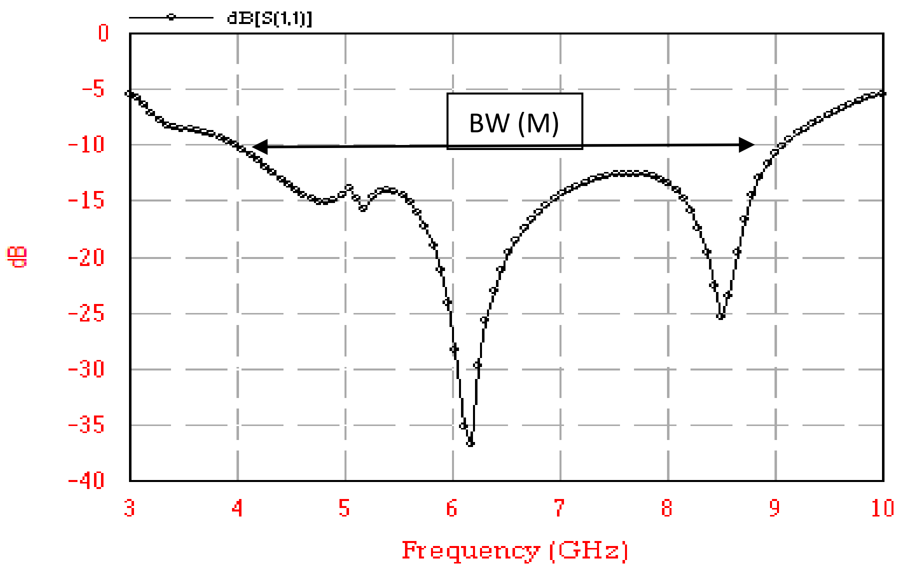

Figure. S.17: Simulator Generated Return Loss Graph of Proposed Antenna

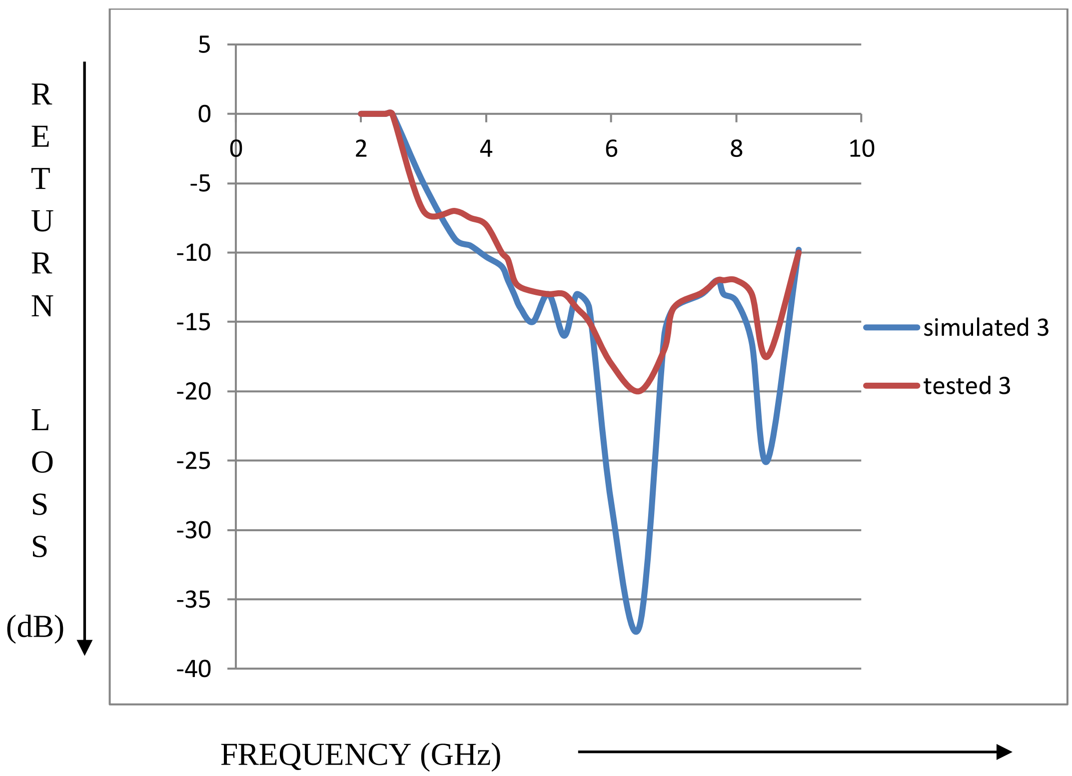

Figure S.18 : Return Loss Graph Comparision of Software Simulated Results and Measured Results of Microstrip Antenna

Results And Discussion Shape 3

Figure S.17 represents the return loss graph comparision of the software simulated results and the measured results of the novel configuration (proposed antenna shape 2), there are two curves clearly visible on the graph the black curve represents the return loss of the antenna which is produce by IE3D while the red curve represents the value of the return loss generated by the vector analyzer.

This is a double dip curve which shows that the proposed geometry is double band antenna which can be used for the applications of 4.3 GHz to 7.8 GHz and thus a bandwidth = f2-f1 /(f2+f1/2) = (8.8-3.8) / 6.30 = 80 % has been obtained.

There are few more important parameters and agreements between parameters for microstrip antenna, which must need to be observed well before implementation of the microstrip antenna. Study of Smith Chart, Directivity Vs. Frequency, Gain Vs. Frequency, Radiation Pattern and Efficiency Vs. Frequency are those important parameters and agreements.

Table S.6: Testing Graph V/s IE3d Graph shape 3

Practically Achieved		By IE3D	
Frequency (GHz)	RL	Frequency(GHz)	RL
3.8	-10.00 dB	3.8	-8.00 dB
5.0	-13.00 dB	5.0	-13.00 dB
6.0	-30.00dB	6.0	-18.00 dB
8.0	-13.00 dB	8.0	-12.00 dB
9.0	-10.00 dB	9.0	-10.00 dB

Results Comparision Of Shape 1,2and 3

Table S.7: Summary of results for all the designs

PATCH ANTENNA	BAND WIDTH	NUMBER OF **U** SLOT CUT
Design.1 Software base	57.85%	4 slots
Design 1Hardware base	41.50%	4 slots
Design.2 Software base	71%	9 slots
Design 2 Hardware base	65%	9 slots
Design.3 Software base	80%	7 slots
Design 3Hardware base	71.6%	7 slots

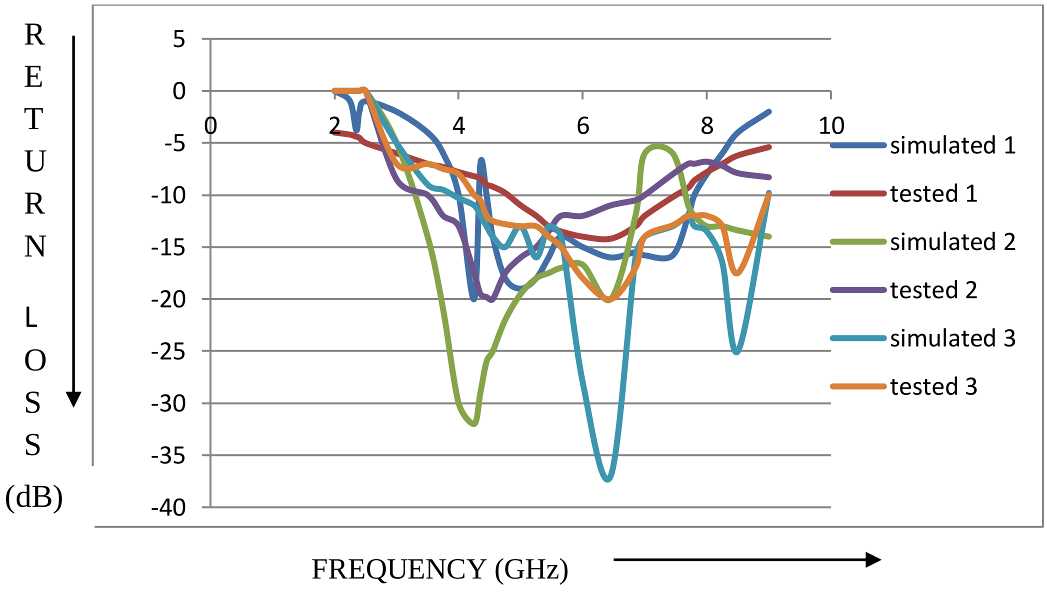

Figure S.19 : Comparision of Software Simulated Results and Measured Results of Microstrip Antenna

OBJECTIVE OF RESEARCH

As we discussed earlier that using various techniques we can enhance the performance of microstrip antenna in terms of bandwidth also. The maximum bandwidth achieved is 52%

using shorting pin technique which can be extended up to 70% as per my assumption, In this research this gap of 18% will be filled and some better results are expected to come.

DESIGN METHODOLOGY

Experimental set up requires Network analyzers, couplers, connectors, digital signal oscilloscope and doubled side PCBs.

The proposed antenna will be simulated using IE3D Software to get the frequency Vs return loss plot, VSWR plot, Smith Chart on IE3D EM simulator software, the suitable co-ordinates of each corners of antenna will be added on EM simulator software and antenna will be drawn. The three essential parameters for the enhancement and design of Antenna are:

- Operating Frequency of proposed antenna (f_o)
- Dielectric constant of the substrate glass epoxy (ε_r)
- The height of dielectric substrate (h)

These antenna parameters will record as per the simulation result of IE3D Software and will be verified by the **Network Analyzer or Spectrum analyzer.**

For the Analysis of Microstrip antenna before simulation and fabrication the analysis is a very important point. There are many techniques to analyze an antenna before its simulation and fabrication like FDTD, Cavity Model.

There are two techniques of deducing the performance characteristics of Microstrip patch antenna. One is to devise a physical model based on a number of simplifying assumptions; other is to solve the Maxwell's equations subject to the boundary conditions.

In this Proposed work first the analysis of antenna will be done with the help of FDTD model will be executed then depending upon the analysis the feed point will be decided and then by applying Broad banding techniques a broad band antenna or multiband will be achieved.

PROPOSED WORK

In Ultra High Frequency range where the frequency lies from 3-30 GHz the different UHF frequency is used for many applications, communication apparatuses and practical demonstrations purposes and a significant contribution in this range of frequency may lead to some better equipments.

The outcome of this proposed work will lead to a higher bandwidth, size reduction of MSA [54] for existing frequency using different techniques.

INDEX

APPENDIX 142

(A) CURRICULUM VITAE

(B) LIST OF PUBLICATION

(C) RM CERTIFICATE

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LIST OF FIGURES

LIST OF TABELS

ABBREVIATION

3D – Three Dimensional
2D – Two Dimensional
MOM – Methods of Moments
LCP – Liquid Crystal Polymer
RF – Radio Frequency
dB – decibel
c – Velocity of light
L – Length of the patch
h- Height of the substrate
ε_r – Dielectric Constant of the substrate
ε_{reff} – Effective Dielectric Constant
λ – Free space Wavelength
f_0- Resonant Frequency
MSA – Microstrip Antenna
PCB - Printed circuit board
HPBW –Half power beam width
FNBW -First null beam width
VSWR – Voltage standing wave ratio
GSM – Global satellite mobile
WLAN – Wireless local area network
GPS – Global positioning system
RFID –Radio frequency identification
GNSS – Global navigation satellite system
OCS – Operational control system
LNB – Low noise block
LNBF – Low noise block feed horn
IE3D – Integral equation three dimension
FDTD – Finite difference time domain
SSR – Secondary surveillance radar
MSSR – Mono pulse secondary surveillance radar
ATC – Air traffic control
IFF – Identification friend
DiSEqC – Digital satellite equipment control
USALS – Universal satellite automatic location system
VSAT – Very small aperture terminal
ATCRBS – Air traffic control radar beacon system

CHAPTER-1

INTRODUCTION

1.1 INTRODUCTION

Recently, particularly after in the year of 2001, planar antennas are striking for the applications in recent communication systems for 5.0/5.7GHz (WLAN), so standards of IEEE 803.12 (5.17-5.36 GHz and 5.67-5.9 GHz), 2.39 GHz IEEE 803.12 (2.39-2.5 GHz), 3.6 GHz (WiMAX) standards of IEEE 802.17 (3.39-3.59 GHz), 5.49 GHz high rating radio local area network [66-68] standards of IEEE 803.12 (5.5-5.699 GHz) and wireless personal area networks (WPANs) for IEEE 803.15.2.

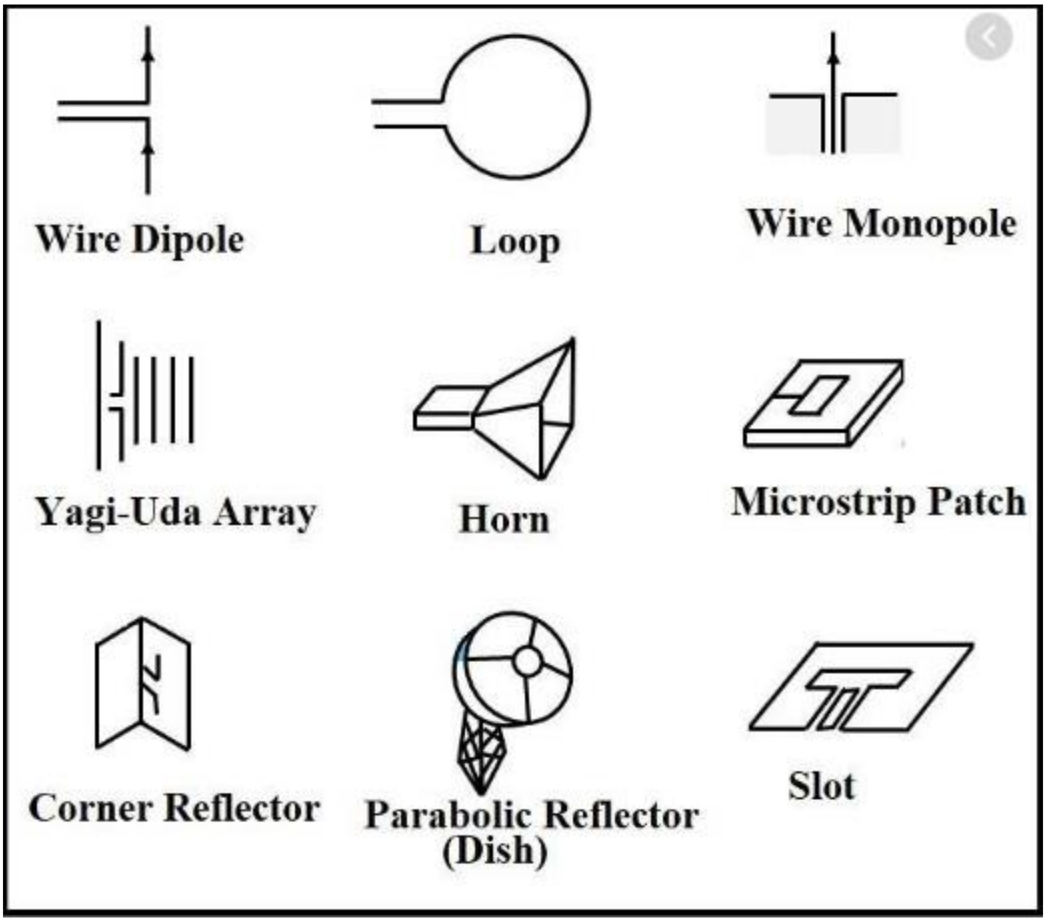

Figure 1.1:Different types of antenna

Figure 1.2:Some modified antenna with different properties

Figure 1.3:Satellite antenna

Figure 1.4:Different kind of satellite antenna

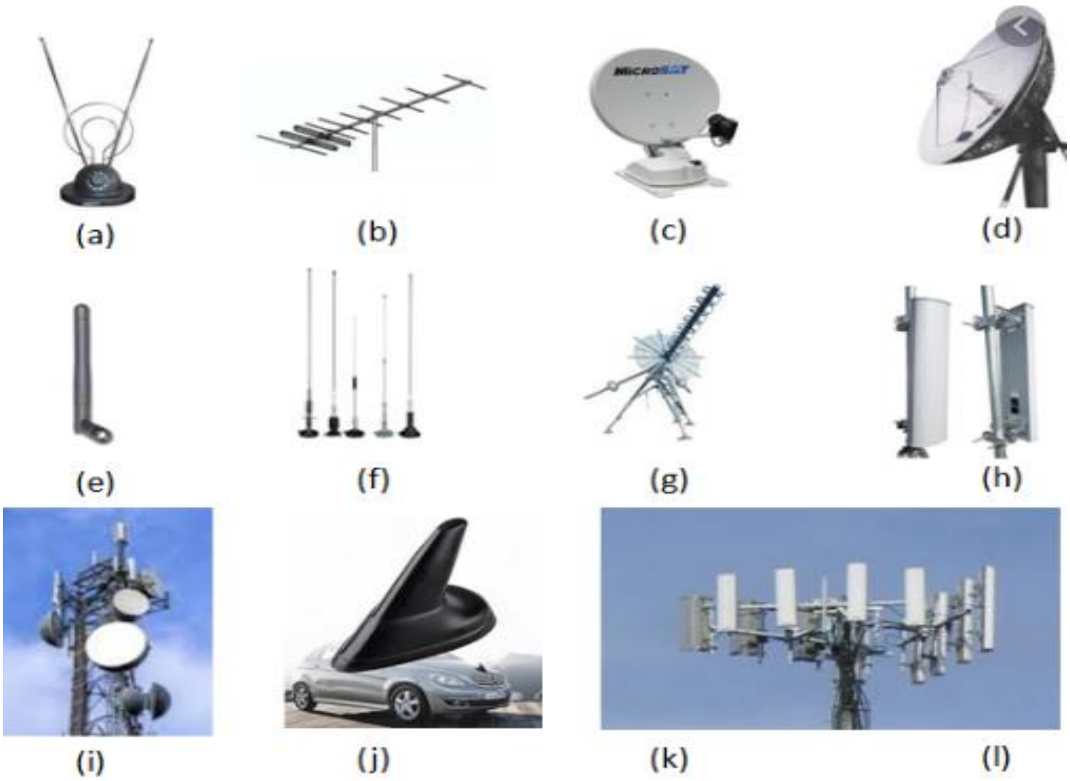

Figure 1.5:Several antennas for different application

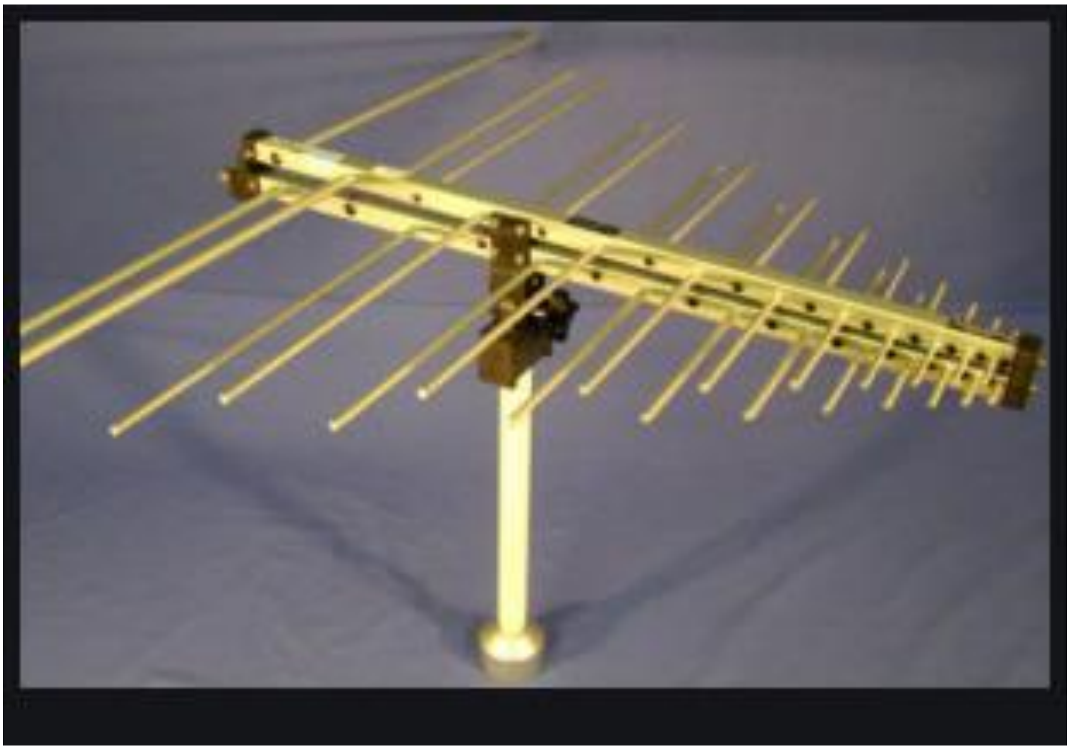

Figure 1.6:Log-periodic dipole antenna

PCB antenna	• Very low cost • Good performance at > 868 MHz • Small size at high frequencies • Standard design antennas widely available	• Difficult to design small and efficient PCB antennas at < 433 MHz • Potentially large size at low frequencies
Chip antenna	• Small size • Short TTM since purchasing antenna solution	• Medium performance • Medium cost
Whip antenna	• Good performance • Short TTM since purchasing antenna solution	• High cost • Difficult to fit in many applications
Wire antenna	• Very cheap	• Mechanical manufacturing of antenna
IP based antenna	• Support from IP company	• High cost compared to standard free PCB antenna designs. • Similar cost to Chip antenna

Figure 1.7: Different antennas and their properties

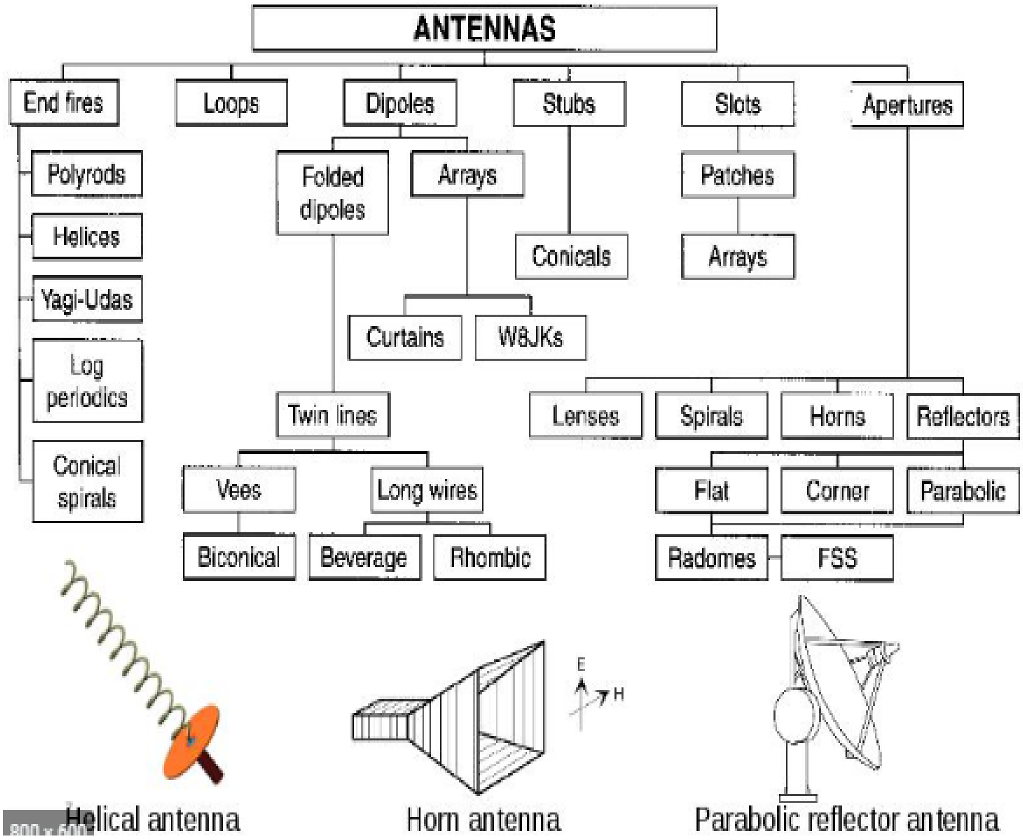

Figure 1.8:Basic antenna distribution

Figure 1.9:RF antenna for 2.4 ghz for wifi systems

Figure 1.10:FPV antenna for drone

Figure 1.11:Different types of BTS

Figure 1.12:Advanced wifi antenna for long distance

Figure 1.13:Satellite communication antennas

Figure 1.14 Special type of satellite Antenna

Figure 1.15:Geo Satellite

Figure 1.16:Geo Satellite and their communication

Figure 1.17:Dish antenna with three LNV

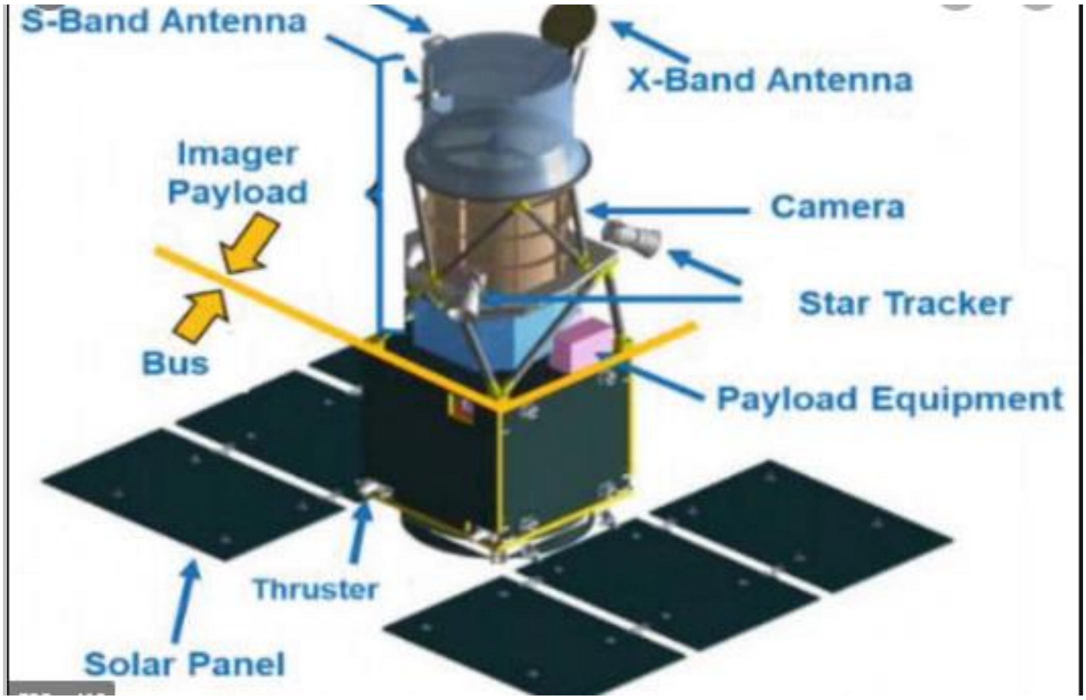

Figure 1.18: Geo Satellite with their different antennas

Figure 1.19 Grid Antenna

Figure 1.20 Transreceiver for satellite

Figure 1.21 S Band Architecture

Figure 1.22Navigation Radar

Figure 1.23 Moving object Radar

Figure 1.24Radar system

Figure 1.25 Radar for navigation

Figure 1.26 Satellite Dish

Figure 1.27 Dish satellite

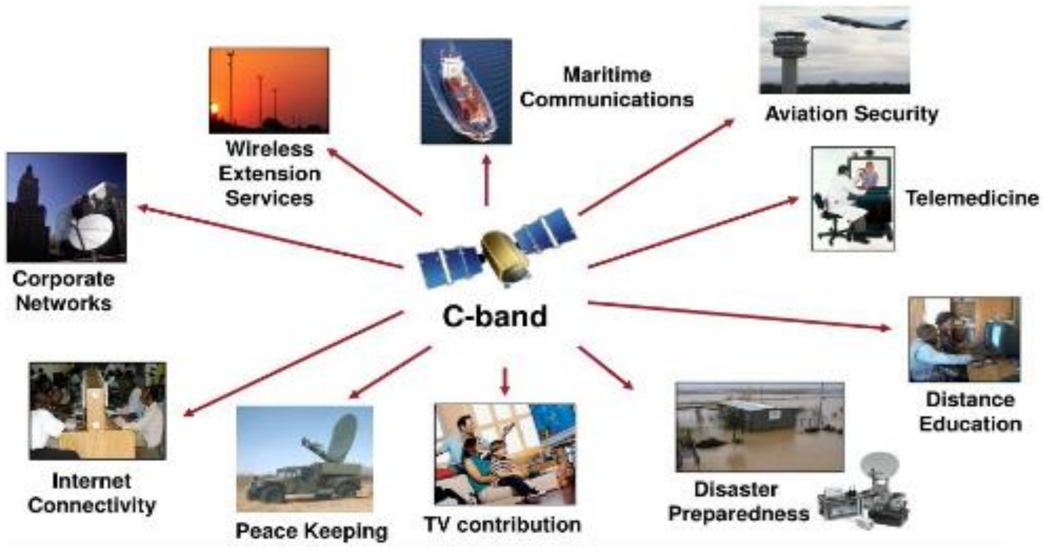

Figure 1.28 C Band architecture

Figure 1.29 satellite feeding

Nokia completes first successful U.S. based 5G trial in C-band spectrum, reaching speeds of over 1 Gbps using commercial 5G AirScale portfolio and is ready to deploy ahead of the expected U.S. spectrum auction in December 2020

Figure 1.30 5G Architecture

Figure 1.31 Cassegrain satellite

Figure 1.32 Broadcasting DTH

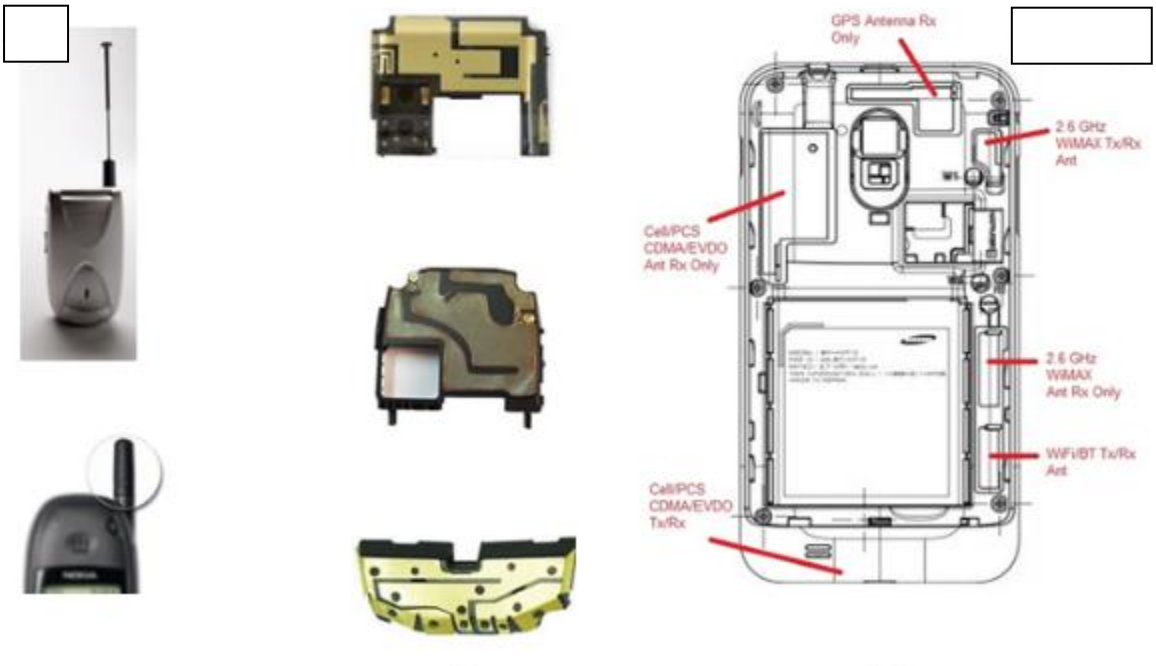

Figure 1.33 Different type of inbuilt mobile antennas

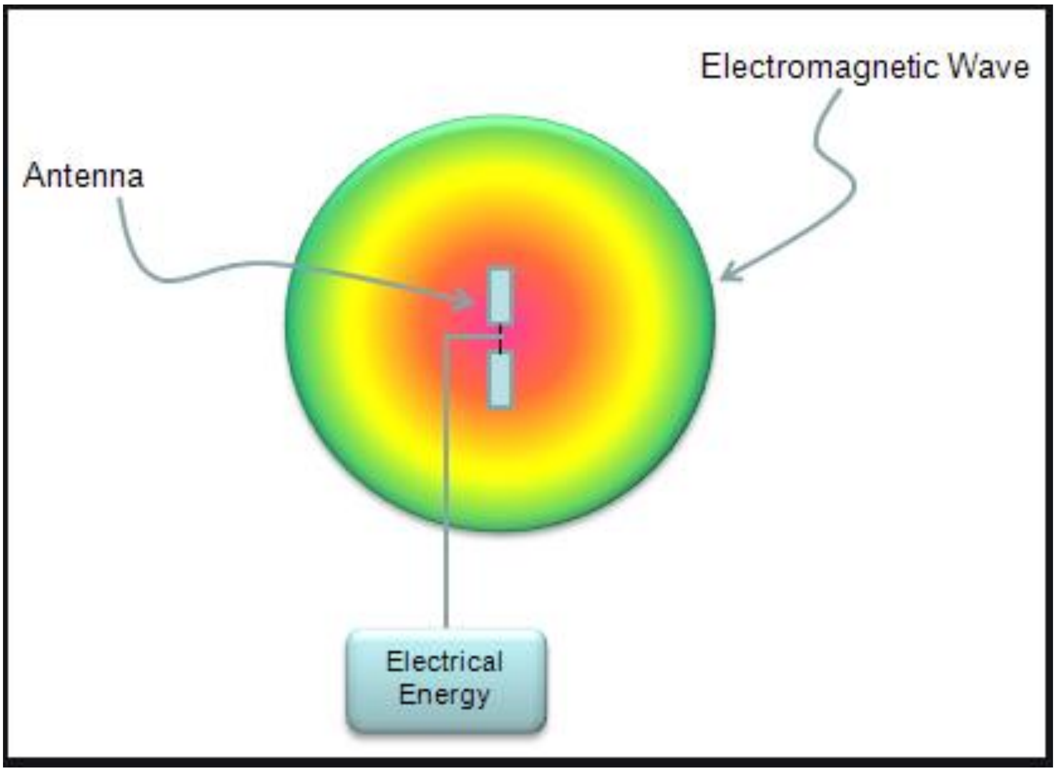

Figure 1.34 Radiation generation by an antenna

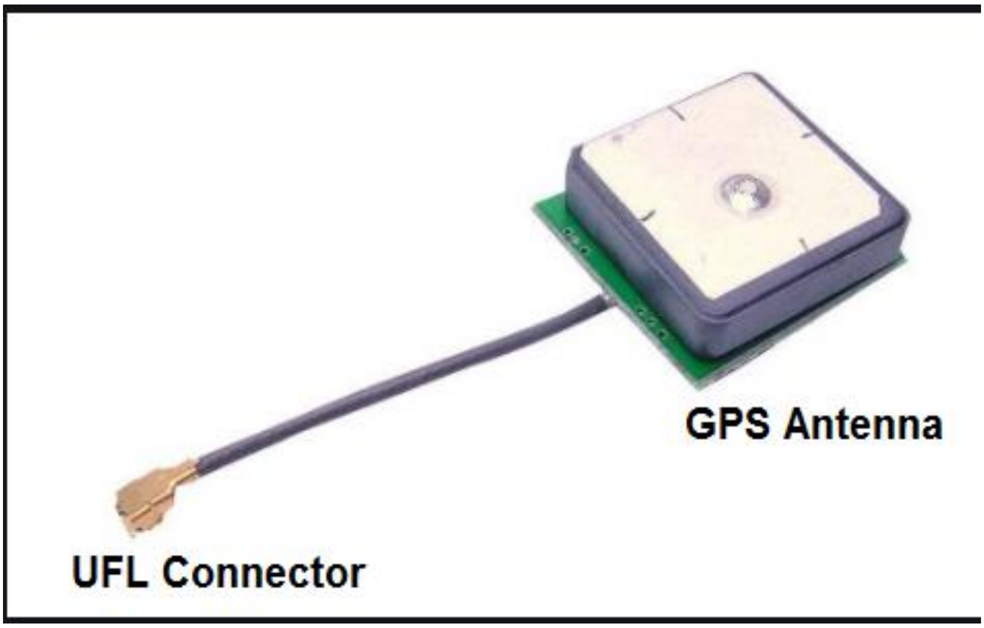

Figure 1.35 Cellular mobile GPS antenna

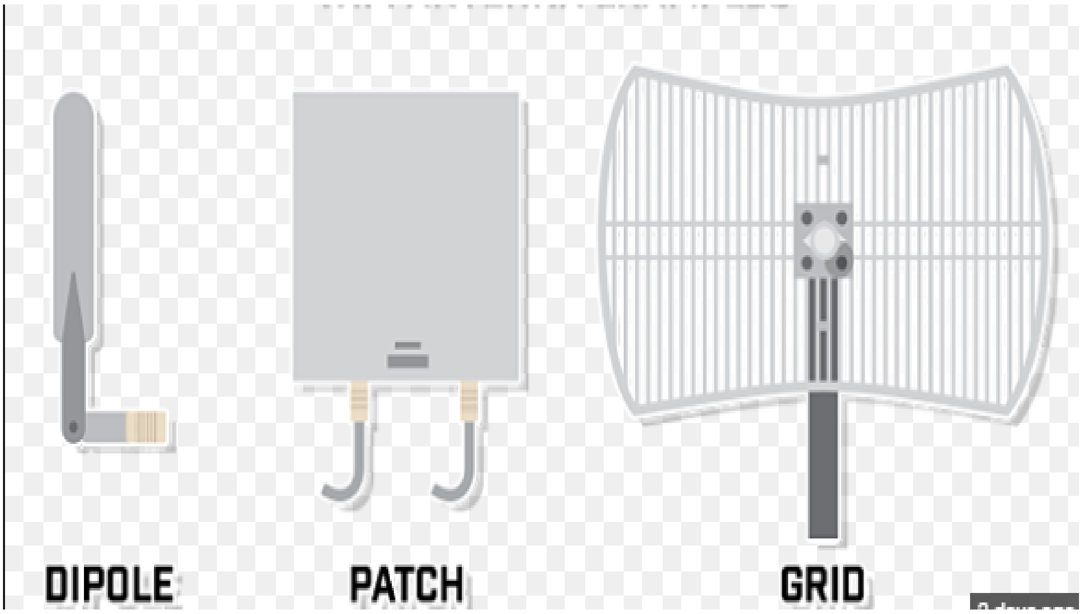

Figure 1.36 Different wifi antennas

Figure 1.37 External mobile antenna

Figure 1.38 WiFi Router

Figure 1.39 Long range cellular antenna

At before year 2001 many researcher are present papers on MSA have been reported for present days requirements. The antennas required high gain, small substrate size, large bandwidth, acceptability, internal installation. The required performance of the antenna for different operating frequency range. Antennas are used for several applications [8] like as mobile base terminal stations and wireless receiving points must have large gain and high radiation spread at the operating frequency range. MSA are also embedded in small devices as smart mobile phones, self digital devices , tablets ,laptops and personal computers[9-11]. They are well-organized in radiation and omni-directional in coverage. Most decisively, the antennas should be well impedance-matched over the functional frequency range.

The two main parameters are for the antenna for wireless designing are:

(1) Antennas Performance parameter

(2) Antennas cost and Size

Deschamps was the pioneer in the area of microstrip patch antennas and very first proposed the basic concept of the MSA in 1953 [1]. A MSA has a radiating plate at the one side of geometry , they are different types rectangular, circular, square, ring and ellipse and the other side a ground plane is formed and between both the radiating plate a substrate dielectric material are present .

Basic representative of patch radiator is given away in Figure 1.40

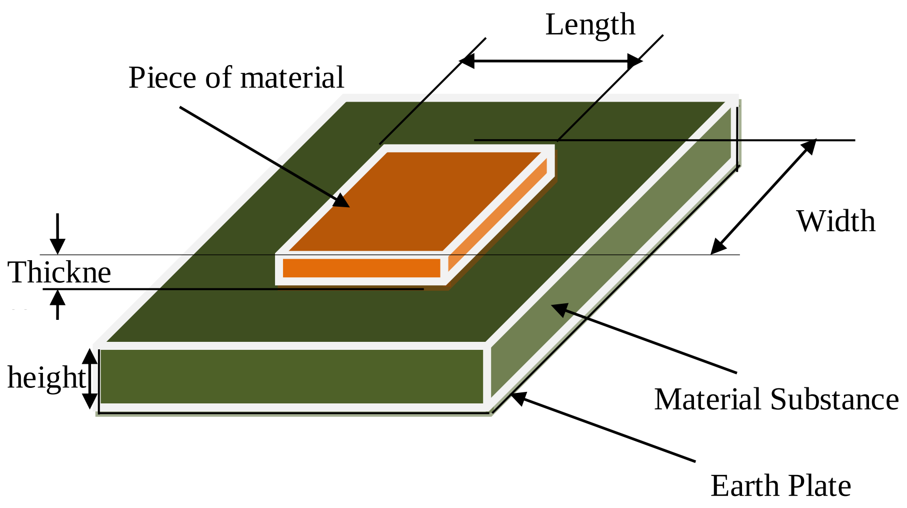

Figure 1.40: Fundamental arrangement of Microstrip Radiator

A patent was issued in 1955 to I. L. Gutton and G. Bassinot [2]. In the same year, L. Lewin [3] studied the radiation of strip lines due to discontinuities. On the other way, 20 years passed before practical antennas [57-66] were made-up and tested. The practically usable radiator is invented via Munson [4, 5] and Howell [6] in the 1970s. In which, a basic rectangular and circular microstrip patch antennas were developed. From 1970, the development of microstrip patch antennas was accelerated through by accessibility of high-quality substance by means of short pasting tangent and striking thermal and mechanical properties. The demands of miniature size of antenna have given by the idea regarding microwave integrated circuit, published circuit elements plus gadgets. Which made to develop microstrip antenna These became favorites amongst antenna makers plus are utilized into various uses into wireless communication system, in the army plus commercial parts.

1.2 RESPONSIVE ANTENNA DEFINATIONS

Antenna is a device which transmit and receive a electromagnetic signal [20] from free space [1]. The antenna is the device between transmission line and ground space .Than it used for transmit or receive [38,40] electromagnetic signal .

MSA has many shape and size such as dish antennas, parabolic [15] antennas and thin [53] antennas. loop antennas , helix antennas and Dipole antennas, they all are the form of the wire antennas but slot antennas and horn antennas are known as aperture radiator. For MSA, there are microstrip patch antennas and microstrip slot antennas.

1.2.1 Broadband Microstrip Antennas

Microstrip antennas consists various important constituents. However, an important limit regarding this antenna is its thin bandwidth property. Impedance bandwidth of an complex microstrip patched antenna must be low than 1% till few percentile regarding narrow substrates pleasing that limit $h/\lambda_0 < 0.023$ for $\varepsilon_r = 10$ to $h/\lambda_0 < 0.07$ for $\varepsilon_r = 2.3$. This is in contrast to 15% to 50% bandwidth regarding basically utilized antenna components like dipole, slots plus waveguide horns. Scientists are busy in order to eliminate the limitation since 15 years, numerous research papers [39-117] have been published and gained success to get an impedance bandwidth till 90% plus gaining bandwidth till 70% into particular antennas. Almost all the inventions utilized much greater than an single system, which boosts the dimensions, plus with an company via degrading of another property of antennas. Boost into bandwidth could too gained via fitting selection of feeding method plus impedance syncing network, and several innovative pattern structures with various types of slots and arrangements have been reported [7-66]. The details are given in this section of the thesis.

1.2.2 Dualband Microstrip Antennas

Dualband working is an essential topic regarding microstrip antenna pattern, plus various alike patters were familiar. Dualband microstrip antennas consist utilization of an quadrangular patch loaded within an set of thin slots, notch, shorting pins and multilayer stacked patches amongst another. Lately, various lone feed, lone slotted, dualband microstrip antenna patterns are shown, plus an exclusive pattern regarding an dual-frequency feed network used for feeding an microstrip ray consisting dual-frequency radiation components were made. However, those patterns were mostly used in normal dimension microstrip antennas. In order to obtain the dualband working into short dimension or short microstrip antennas, several stating patterns were resulted techniques.

In 2000, Y. X. Guo et al. presented a compact Dualband antenna was designed using slot loaded and short-circuited size reduction. After that, a novel triangular microstrip antenna by loading of slots for dual-frequency and broadband operation was proposed by J. H. Lu et al.. They were achieved the bandwidth greater than 2.6 times that of a conventional triangular patch antenna.

1.2.3 Multiband Microstrip Antennas

Nowadays compact and small wireless communication devices are used they are consisting many functions. Devices could give many modes of wireless communication like movies, information transferring, audio plus television. The task is forever in front of the antenna makers to make antenna which are handy, plus affordable, able to transfer heavy information, safety regarding humans, plus compatible to various communications into multi bands. Few of various frequency bands, which are significant regarding the use were GSM 900 plus 1800 (1.715-1.885 GHz) and UMTS (1.9-2.175 GHz), and WLAN and WPAN standards IEEE 803.21b/Bluetooth (2.4-2.485 GHz) and IEEE 803.11 (5.150-5.350 GHz 5.725-5.875 GHz).

1.3 Radiator Impedance

The impedance [25] of a radiator are match with the output impedance of the radiating line to achieve higher energy deliver between a radiating line and the radiator. Now the input impedance of the radiator does not match with the output impedance of the radiating line, a reflected signal are originated at the radiator end and signal return towards the input source. So output energy reflection the results were loss in the overall system efficiency. Failure into efficiency would be observed when the antenna is utilized to send or receiving power.

$$\text{I/P impedance} \quad (Z_A) = ZR_A + JX_A \qquad (1.1)$$

Where

Z_A = Radiator impedance

R_A = Radiator resistance

1.4 Voltage Standing Wave Ratio

By the definition voltage standing wave ratio is the proportion of the highest volts plus the minimum volts with the radiating line. The formula for voltage standing wave ratio [28] as:

$$\mathrm{VSWR} = (1 + \Gamma) / (1 - \Gamma)$$

$$\Gamma = (Z_L - Z_O) / (Z_L + Z_O)$$

Γ = returning parameter

Z_L = input impedance

Z_O = output impedance

In radio engineering and telecommunications, voltage standing wave ratio (VSWR) is the measurement of impedance syncing of loads to the properties impedance of an transmitting line else waveguide. Impedance not matching led into standing waves with the transmitting line, plus VSWR is the proportion of the standing wave's frequency at the anti nodes(highest) till the frequency at an node(lowest) within the path.

VSWR basically is an idea regarding into the highest plus lowest alternate current volts within the transmitting path, though known as the voltage standing wave ratio. E.g. voltage standing wave ratio numbers 1.2:1 shows a alternate current power because of standing wave with the transmitting path consists an top value 1.2 time comparing the lowest alternate current volt with particular path, given the path situated half wavelength span. SWR could be stated via the proportion of highest frequency till the lowest frequency of the transmitting path power, electric field power, else magnetic area power. Ignoring transmitting path losing, those proportions were same. VSWR is basically calculated via an gadget known as VSWR meter. Though VSWR is a measurement of the load impedance regarding the properties impedance of the transmitting path in utilization, an provided VSWR meter could just show the impedance it calculates in values of VSWR in case they were made regarding some properties impedance. Use of many transmitting paths are in this application were multi wires consisting impedance of either 50 else 75 ohms, that's why VSWR meters correlate with these.

Viewing VSWR is an descent method into an radio platform. Though matching data can be received via measurement of the load impedance along an impedance analyzing else impedance path, the VSWR meter is basic plus much strong regarding this use. Via calculating the immensity of the impedance inconsistency at the transmission result shows difficulty because of the antenna else the transmitting path.

1.5 Bandwidth of Antenna

The Bandwidth [12] is the range of frequency that, the antenna will radiate maximum where the antenna meets a certain set, that means the starting of signal and the reach out the last position, the difference of starting and the end signal is the bandwidth. A radiator operates at a wide frequency range and still maintains accurate performance must have operate circuits switched into the system to balance impedance matching.

To determine the BW from the return loss graph, so the dissimilarity in frequency is consider at parts where the graph curve cut the -10dB level. The dissimilarity then alienated via the resonant frequency for the % bandwidth. The voltage standing wave ratio, BW is considered to be the range of frequency which corresponds with a VSWR of less than 2.

$$B\,W = \frac{(VSWR-1)}{Q\sqrt{VSWR}} \qquad (1.4)$$

Where

Q = Quality factor

VSWR = Voltage standing wave ratio

1.6 Radiation and Half Power Beam Width

Into sector of antenna pattern word radiation design (else antenna design else far-field design) stands for the way (angle) dependent of the power of the proportion wave coming via the antenna else another supply.

A radiation lobe is an portion of radiating design surrounded via areas of comparatively feeble radiation strength.

(i) Main lobe

(ii) Minor lobes

(iii) Side lobes

(iv) Back lobes

Radiator radiation pattern were complex into mode of an polar area regarding an 360 degree design, and relative power into dB scale however the area power slides down to 0.707 (calculated in μ(V/m)) of highest volts on middle of the lobe.

Beamwidth: beamwidth regarding a antenna is main value of worth plus often utilized like an trade-off b/w them plus the vertices lobe altitude; i.e., sooner the beamwidth lowers, the side lobe gets high later in repetition of this process happens. Beamwidth regarding the antenna is utilized too in order to define the intention ability of the antenna in order to differentiate b/w 2 adjoining radiation origin else antenna prey.

The Half Power Beam width (HPBW): Into an surface consisting way regarding highest of an beam, gradient b/w 2 ways into that radiating immensity is half the merit comparatively with the beam.

First Null Beam width (FNBW): Angle separation b/w initial nulls of the design.

The radiation pattern expressions are as follows:

$F_E\ (\Theta) = \cos[(\beta l/2)\ \sin\theta]$ E-Plane with Ø = 0 (1.5)

$F_H\ (\Theta) = \cos\theta\ \sin\ [(\ \beta l/2)\ \sin\theta]((\ \beta l/2)\sin\theta)$ H-Plane with Ø = 90° (1.6)

Into an radio antenna design, halve of the energy beam breadth is the dual ray b/w the halve energy -3dB value of the major lobe, as shown to the top affective radiation energy of major lobe. Watch the beam dia. Beamwidth basically else ain't forever shown via degrees plus regarding the horizon flat area. The beamwidth could be calculated regarding arbitary antenna rays. Talking about the ray folds like the complex answer of m component antenna ray like A_θ, where A_θ stand for an matrix consisting rows, beam design is initially calculated.

Beam pattern $B(\theta) = 1/m\ (A\Theta_0)^*\ (A\Theta)$

$(A\Theta_0)^*$ is the conjugate transpose of A at the reference angle Θ_0

1.7 Radiator Gain

In electromagnetic, a radiator has energy gaining else basically gaining is an value they joins radiator directly plus signal efficient. For an transmission radiator, gaining is defines that the way radiator change inserted energy to RF signal into an particular way. Into an receipting antenna, gaining is defines the way antenna changes radio signals coming via particular side to electric energy. If none side was allotted, gaining will mean the top number of the gaining, gaining to the way of the antenna's major lobe. An area of gaining like the working of ways known as gaining design else radiating design. Antenna gaining basically described as proportion of energy generated via antenna coming via distant ground at antenna's beam ray till the energy generated via hypothetical lossy isotropic antenna, that is same responsive towards signals via all ways. Basically the proportion is shown as dB, plus the components are known as dB isotropic (dBi). Another describing shows the comparison of receipted energy an energy receipted via lossy halve of the wave dipole antenna, into the instance components wrote like dB. Though an lossy dipole antenna had an gaining of 2.15 dBi. Regarding an provided frequency, antenna's affected field is into proportion to the energy gaining. Antenna's affect longitude is in proportion to the root square of the antenna's gaining regarding an specific frequency plus radiating resistant power. Because of reciprocity, gaining of an returned antenna while receipting is same to the gaining during transmission. Direct gain is another calculation that don't want antenna's electric efficiency in play. Stated word is now and then much better in the time when an receipting antenna when an single is wanted in major part within the speciality of an antenna in receipting rays via single side during denial of intruded rays via another side.

Directivity

$$\text{Directivity}, D = (4\pi U)/P_{rad}) \quad (1.7)$$

Where, U = Radiation Intensity

P_{rad} = Total Radiated Power

$$\eta = \frac{R_{radiated}}{R_{radiated} + R_{dielectric}} \quad (1.8)$$

$$\text{Gain} = \eta D \quad (1.9)$$

1.8 Radiator Polarization

Radiator polarization [14] a radiator is an transmitter which changes radio frequency electrical charge into electromagnetic rays which later were went through radiation in gap. The electrical area or "E" slant decides polarization or inclination regarding radio signals. Commonly, in majority the antennas emit either linear or spherical polarization. Wave is ambience drifting along a tight cord e.g., an music device such as guitar cord. Relying onto the way cord is strummed, the sensations could be into an upright way, straight way, else at whichever angle upright towards the cord. In disparity, in horizontal rays, like resonance signals into an fluid else gas, the dislocation of the components into fluctuation is constantly towards the way of broadcast, hence those waves don't reveal polarization. Slanting rays which reveal polarization comprise electromagnetic rays like visual light plus radio signals, gravity signals, plus slanting resonance signals in hard substances.

Electromagnetic rays like glow comprises of joined oscillating electrical area plus attractive area that is constantly upright towards one another; via reunion, the "polarization" of electromagnetic waves defines towards way of the electrical way. In line division, area swing into an lone direction. In round or oval polarization, the area revolve at a steady speed to an flat surface sooner the ray passes. The turning round could consist 2 likely ways; when area turn around into an correct sensation within way of ray propagation it's known as right circular polarization, when area turn around into an left hand sensation, it's known as left circular polarization.

Immediate area of an plane ray, roving into -ve z way, could be

Wrote like

$$E\,(z,t) = a_x E_X(z,t) + a_Y E_Y(z,t \qquad (1.10)$$

the immediate elements were linked to it's compound sub parts via

$$E_X\,(z,t) = E_{X0}\cos\,(cot + kz + \emptyset_X) \qquad (1.11)$$

$$E_Y\,(z,t) = E_{Y0}\cos(\omega t + kz + \emptyset_Y) \qquad (1.12)$$

Where E $_{x0}$ and E_{y0} are, correspondingly the utmost magnitude of the x and y elements.

Into Linear Polarization, In electrodynamics linear polarization else slant polarization of electromagnetic emission is an captivity regarding electrical area vector else attractive area vector towards an familiar plane alongside to the way of broadcast. observe polarization plus plane of polarization regarding additional data. Compass reading regarding linearly polarized electromagnetic signal is described via way of electrical area vector. For instance, when the electrical area vector is upright (chance by chance upwards and downwards as the signal propagates) the emission is known as upright polarized.

Now the ray which consists linear polarization, the time-period dissimilarity b/w 2 elements should be

$$\Delta\emptyset = \emptyset_Y - \emptyset_X = n\pi \qquad n = 0, 1, 2 \qquad (1.13)$$

In Circular Polarization the flat surface revolves into an coil design forming an whole rebellion for every wavelength. In figur1.1, an circularly- polarized ray radiate power into straight, upright planes and each plane b/w. Circular polarization is establish after the magnitudes of the 2 mechanism are the similar plus time-phase dissimilarity b/w these is strange shows in figure1.1

$$E_{X0} = E_{Y0} \tag{1.14}$$

That is, $\emptyset_Y = \emptyset_X = (+(1/2 + 2n)\pi$ n = 0,1,2,3................. ….for CW)

$= (-(1/2 + 2n)\pi$ n = 0, 1, 2, 3………………...for CCW)

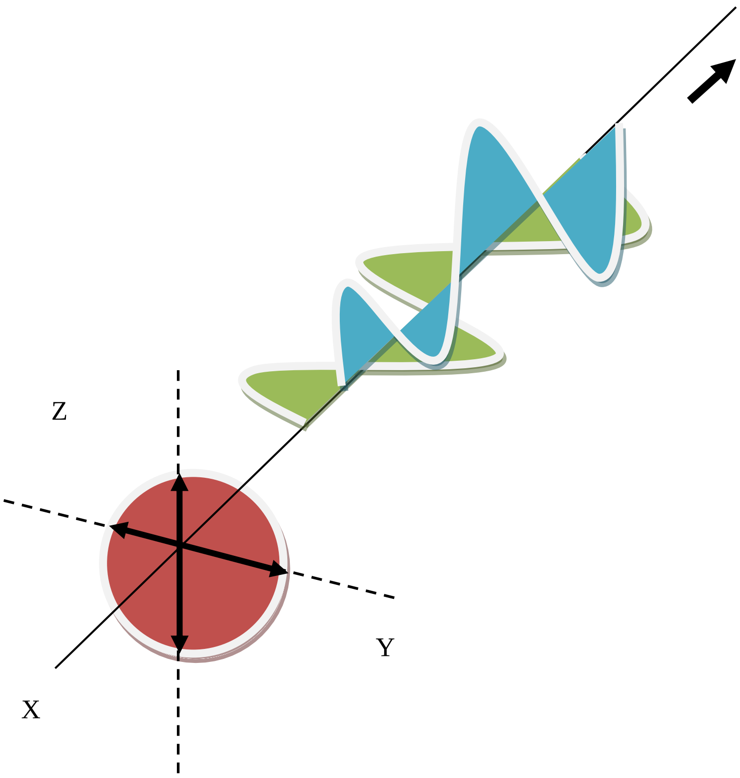

Figure 1.41 Radiator polarization

A typical basic patch antenna representation is shown in Figure 1.3

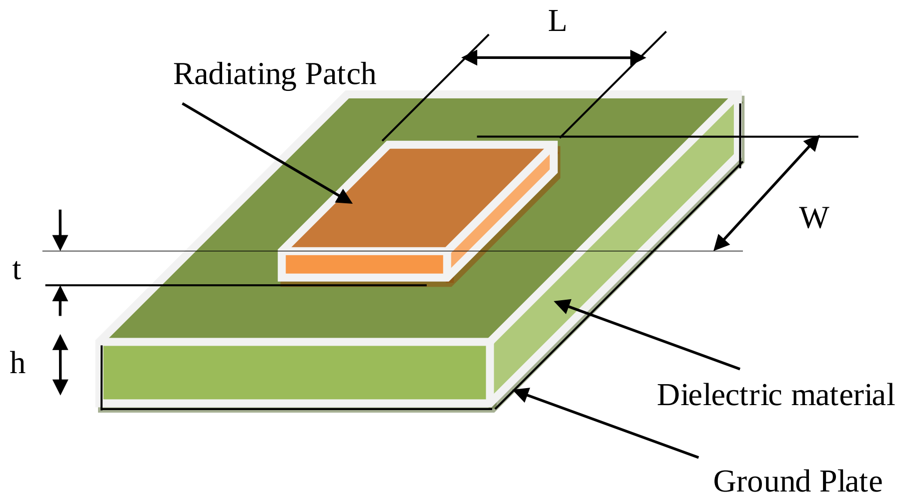

Figure 1.42: Basic Structure of Microstrip Patch Antenna

1.9 Microstrip Patch Antenna

Considering most basic form, a patch radiator [19] comprises of a rectangular patch on single side of a dielectric substrate that has a ground flat surface on the other side the patch is usually made up of conducting substance such as copper or gold also can take any likely shapes. The radiating patch and the feed lines are typically photo fixed on the dielectric substrate. The geometry of patch is chosen depending upon the necessary requirement. The standard geometry is primarily for solitary frequency process of patch antenna. In order to get the dual frequency environment of patch radiator, a few alterations to standard geometries are applied like circular division; annular loop etc for multiband process of patch radiator, one radiating patch is used with additional sponging patches. In this case, the size of radiator is increased. Some of the geometries related to the parasitic patch radiator. In order to reduce the radiator size for multiband operation, stacked patch is used. With two or more layer, patch is made at every layer of dielectric depending upon the requirement. Now a day, Active Integrated radiators are major focus for research and development. Plenty of work has been done on Active integrated Patch radiator, Varactor Diode, Gunn Diode, Barrit Diode, Pin Diode; MESFET etc. are embedded in patch radiator.

Different shapes of antennas shows in figure

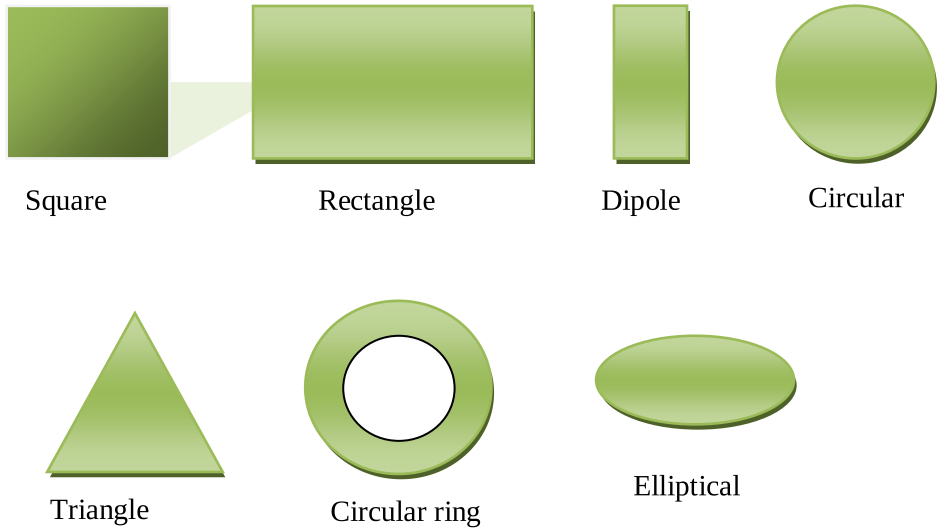

Figure 1.43 Different Shape's of microstrip patch elements

1.10 Geometry of Microstrip Patch Antenna [18]

A microstrip radiator or a printed radiator means a radiator contrived with photolithographic procedure on a in print circuit board PCB. This is a kind of inner radiator. There are usually worn microwave frequencies. A microstrip electric fire carries of a area of metal foil of similar shapes a area radiator on the plane of a in print circuit board, with the metal thin sheet ground plane on the another side of the in print board. Normally microstrip antenna consist of a variety of patches with 2-dimensional arrays. The radiator is generally associated to a transmitter and a receiver from first to last metal sheets microstrip broadcast lines. The RF current is applied or in receiving radiators the received signal is generated among the radiator and earth coat. Microstrip radiator have awfully significant in new decades due to their extremely thin planar outline , it can be integrated into the contact of user products, missiles and aircraft; production by means of radiator on printed circuit process; consequently the integrating radiator lying on the identical printed circuit, and the likelihood of addition in concert vigorous devices such as microwave integrated circuits(MIC) to the radiator itself to build active antennas .

1.11 Advantages of Microstrip Antennas

There are some advantages of patch antennas which make them more efficient for wireless applications over other antennas. Some properties of patch antenna are discussed as follows:

- Since patch antennas are low profile, the fabrication cost is comparatively less.
- Patch antennas be able to hold up both, linear in addition to circular polarization.
- Generation of Dual frequency and dual polarization antenna is easy in this case. Large numbers of geometries are available to generate dual frequency as well as dual polarization antenna.
- Patch antenna can also be integrated with Microwave Integrated Circuits. Many patch geometries are available to design patch antennas. Therefore, flexibility to design is very high.
- They be able to without difficulty be conventional to a curved plane of a means of transportation or creation.
- Multiband operation is possible with patch antennas.

1.12 Disadvantages of Microstrip Patch

Microstrip antenna compared the disadvantage through waveguide it is normally minor energy management ability, also upper fatalities. And, different waveguide, antenna is usually different, with the consequently vulnerable for cross-talk in addition near inadvertent radiation.

A microstrip device is built-up by the FR4 material on the standard PCB in the lower cost, but the dielectric losses of the FR4 material is very high at the microwave frequency .that’s why the material dielectric constant is not controlled, so the dielectric constant of the material is as high 4.4, so avoiding the reasons, alumina material substrate is generally preferred. Than monolithic integration perception microstrip antenna by mean of integrated path MMIC process may be possible through their presentation in control by the material dielectric coat and material breadth

A lofty swift digital PCB plan for microstrip appearance, somewhere data are in retreat on or after other division for congregation in the direction of an additional through least deformation, in addition to neglecting lofty cross-chat with radiation

1.13 Application of Microstrip Antenna

Patch radiator required more than a few purpose in wireless transmission. Such as, requirement in the satellite communication, a circularly polarized emission pattern is preferred, satellite communication be able to be realized using either square or circular patch radiator. Circularly polarized microstrip Patch radiator is worn for global positioning systems. Because of very high frequency the radiator size is very compact in addition to relatively costly owing because of their capabilities. At frequency 6.0 GHz the antenna is applicable for telemedicine. microstrip antenna are appropriate for WAN. Microstrip antenna is moreover used in the fields of RFID (radio frequency identification), mobile transmission and medical healthcare.

1.13.1 Global Positioning System (GPS)

A satellite based radio system governed by the U.S administrations and operated by the U.S space force, Global Positioning System (GPS), primarily NAVSTAR Global Positioning System. When location and time are the main factor of information we use global navigation satellite system (GNSS). Global positioning system near the earth. Where there is a clear (GNSS) that provides geo location and time information to a GPS recipient wherever on or close to the globe wherever there is a clear line of view to 4 or additional GPS satellites. Barriers like cliffs and establishments chunk the comparatively feeble GPS signals.

Global Positioning System does not necessitate the customer to broadcast any information, although, that works separately of several telephonic or internet welcome, even though mentioned technologies be able to improve the value of the GPS positioning data. Global Positioning System arranges critical positioning abilities to defense, non military, and business persons round the globe. U.S administrations designed the structure, uphold it, plus create it liberally available to anybody by a Global Positioning System recipient. The Global Positioning System scheme began via the Unites States. Section of protection during 1973, within the first sample spaceship set in motion during 1978 plus the complete constellation of 24 satellites prepared during 1993. Initially partial to utilize via U.S army, residents were allowed to use it from the 1980 subsequent an managerial instructions via leader Ronald Reagan. Advance into automation and up to date requests on the obtainable scheme have at the present led to the efforts to update the GPS and put into practice the upcoming production of GPS chunk III. An satellites and upcoming production Operational Control System (OCS).

1.13.2 Direct Broadcast Satellite (DBS) Systems

The satellite recipient after that interpret that T.V show to watch on an T.V system. Recipients could be exterior set-top system, otherwise an in-built T.V tuner. Satellite T.V arranges a broad range of shows and favors. That was basically an single T.V provided at most remote topographical places unaccompanied by earthly T.V as well as cord T.V assistance. Current assistance gestures were connected by an interactions satellite at X band (8–12 GHz) or else K_u band (12–18 GHz) frequencies have an need of just an tiny plate smaller that of a meter in diameter. Initial satellite Televisions sets are kind of outdated currently familiar just by T.V receipt. Those instruments receipted feeble analog gestures transferred into C-band(4-8 GHz) via FSS kind satellites, availability of huge 2-3 meter plates is must in these. Therefore, the arrangement was given an pet name as "big-dish" instruments, these are of high costs as well as of low popularity.

1.13.3 Medical Application

The Microwave representation being an branch of knowledge that changed itself as it was before an outdating distinguishing detecting process as the radar to gauging unseen as well as planted elements as in an system (else media) by the use of electromagnetic EM signals into microwave section (ranging, ~.30 GHz-300 GHz). Engineering as well as application oriented microwave representation for non-destructive testing is called microwave testing. The Microwave representation procedure could have been classified either as calculable else approximate. Calculable representation methods have another name i.e., reverse dispersal technique provides electrifying as well as attractive effects dispersal as well as computative framework (such as., form, dimensions as well as position) of an represented element by means of resolving an dynamical reverse issue. That of the dynamical reverse issue then transformed in an planer reverse issue use of born else twisted born estimate. Sooner knowing the reality that an straight matrix reversion techniques could also supplicate in order to resolve that reversal issues, it will then cost a lot if the issue's dimensions are huge. In order to control this issue, straight reversion then interchanged by repetitive fixer. Methods used into this class are known as forward iterative techniques that basically consumes a lot of time span. And on another side calculable microwave representation techniques compute an subjective outline that is known as the reflectivity function or subjective representation to denote unseen element. The methods uses estimate in order to clarify the representation issues later uses inverse-propagation as well as known as time turnaround, stage remuneration, as well as rear-relocation in order to remodel the undisclosed representation outline. Synthetic aperture radar (SAR), ground-penetrating radar (GPR), as well as frequency-signal digit relocation procedure were few techniques which are highly favored for subjective microwave representation.

Application for c Band: The C band range (4 to 8 GHz) probably utilized for different transmission transference, few wireless fidelity application, few wireless phones, few observations plus use for atmospheric tracker , satellite is a dish-shaped like parabolic radiator , receive and transmit data by radio frequency signals to satellites. The popular broadcast used by consumers to receive by satellite television in geostationary class. The parabolic radiator of a dish reflects the information from radiator point. Place at bracket so device called feed horn. The feed horn is necessary the fore-ending belonging to a waveguide which collects the gestures either at the centre of attention plus supervise these at a low-noise block down converter or the LNB. As LNB changes gestures as of electromagnetic else radio waves to electrical gestures plus moves the gestures arising out of the down linked C-band and/or K_u-band to the L-band span. Straight transmission satellite plates utilizes a LNBF that combines a feed horn with that of the LNB. An updated shape of multi directional satellite antenna, that do not utilize an directed parabolic plate plus could be utilized at an phone system .The actual gain 'directive gain' of an plate rise ass soon as the frequency expands. As the real gain is dependent on different elements comprising outside dimensions, correctness, feed complement. An complex figure for an customer kind .60 m satellite plate set at 11750 MHz is 36.95 dB. C-band, plate makers had a vast list of choices for contents. Huge dimensions that of the plate wanted regarding the bottom frequencies leading those plates as they are generated via metallic built mesh at an metallic project. A basic misunderstanding about the LNBF that is (low-noise block feed horn), that system fronting the plate, receipted that gesture straightly coming from the aerosphere. instance, single BBC

News\information downlink appears as an "red signal" when receipted via LNBF straightly rather than to be broadcasted on the plate, by the help of its figurative dimensions this collects all gestures in an tiny region later carry them in LNBF. Present time plates calculated to be used in residential T.V sets were basically 43 cm (18 in) extending till 80 cm (31 in) measured in diameters, plus they're fastened within an single location, as for Ku-band (now C band) receiving out of an orbital location. Earlier from the existence of DBS assistance, residential operators motorized C-band plates to an extent of 3 m diametrically used in transmission of shows within various satellites. Tiny plates could now even provide damage issues, though, counting rainwater lighten plus interference via adjoining satellites. Various countries, use of frequencies in DBS service i.e. 10.7–12.75 GHz within 2 circulations (Horizontal) H plus (Vertical)V. that is ranging between "low band" escorted by 10.7–11.7 GHz, plus an "high band" escorted by 11.7–12.75 GHz. That is resulting into 2 frequency belts, all comprising an bandwidth regarding 1 GHz, all comprising 2 attainable polarizations. Within the LNB that enhance down transformed into 950–2150 MHz, that is the range of recurrence allotted in order to the satellite services have an same axis cord betwixt LNBF together with the recipient. Bottommost recurrences are allotted for corded as well as tellurian televisions, frequency modulation walkman, et cetera. Just an single within those recurrence belts are of the right shape within co-axial cords, accordingly every belt requires an discrete cord via LNBF going to the shifting matrix or else to recipient requires to choose between an single possibilities within the four at an sort of time. An only recipient private insertion lies one and only co-axial coming via recipient top setting device into that structure through LNB at plates. DC voltaic energy towards LNB given via the only co-axial cord conveyors carrying gestures towards recipient. Plus commanding gestures were given out via recipient towards LNB via cords. Recipient utilizes various energy giving charge (13 / 18 V) in order to choose upright / flat antenna polarization, plus a on/off pilot pitch (22 KHz) for instruction to LNB in order to choose single among 2 frequency belts. Greater installing of every single belt plus circulation carried out in individual cords, therefore lies four cords via LNB towards an 'multi switch' converting matrix, allowing connections from various recipients towards that multi switch into star topology utilizing exact signaling technique like used for an lone recipient fitting. An satellite finding device could be used in focusing the satellite plate. Sophisticated satellite indicating devices allowing best plate coordination plus provides receipted gestures addition figures. An under operation plate which is placed at an edge plus working via small D.C motor else an servo could also operated plus revolved in order to face itself to each satellite location in space. 3 variants: DiSEqC, USALS, and 36 V locators. Several recipients allows each variants. However no issue regarding instrument's price, thing required is area to implement and building the implementation in vacuum regarding huge structured plate. Only average or handy structured plates could be utilized; though curious operators prefers the hugest available structures (not less than 120cm) to receipt gestures via isolated feeble satellite locations. Least valuable structures regarding C belts to an extent of 120 cm. Structures more than 120 cm having swift keen costs expands into contrast with normal trading implementations regarding normal watchers. That's why various prices regarding various places with no privilege to use C band, plus normal watchers are just permitted in receipting channel via C belt, often requiring dimensions 150cm or more than that. As we are aware, additional staged plates escorted by USALS motor requiring only finding plus exactly aiming towards initial location, other satellites locations were discovered plus initiated on its own. Each situations were nearly and could be ready in much small time span. Every now and then much recipients are adaptable towards USALS plus DiSEqC 1.1 as well as 1.2, exceptional plates to an extent of satellite locations. Each normally structured plate allows multi receiving via various distinguished satellite locations by not altering the position of the plate, only on attaching more LNB either by utilizing particular pair of LNB. An common kind propagator was an very small aperture terminal VSAT. Providing 2 ways for satellite network transmission regarding the buyer as well as personal lattice regarding companies. nowadays mostly VSAT arrange at C band. These radiators differentiate between .74 to 1.20 m (29 to 47 inch.) frequent implementation although C-band VSATs could be vast like 4 meter (13 ft) in size. Parabolic radiator also called DISH radiator are utilized for satellite T.V. These mean satellite plate have been identified in the period of 1978 in the starting of satellite T.V production, later known to as plate radiator which transmits and/or receipts gestures via transmission satellites. Taylor Howard from San Andreas, California, changed a ex-army plate during 1976 plus was known as the only one in receipting satellite T.V gestures by utilizing it. Initial satellite T.V plates are made in order to receipt gestures onto C-band analog the first, plus are huge in size. Anterior of 1979 Neiman-Marcus Christmas index had a print of initial residential satellite television stage. These plates be somewhat of 21 feet (6.1 m) diametrically. These satellite plates earlier in 1980s are of 11 up to 17 feet (3.0 up to 4.9 M) diametrically and fabricated using glass consisting a implanted surface using copper cord else copper sheet, or else hard copper else aluminum. Four large cable companies broadcasting ,using low energy satellites. Relatively powerful K_u band transference allowing to utilize plates tiny in size of 90 cm initially. Initial mainly utilized straight-transmission satellite T.V structure, providing plates smaller in size like 20 inches. Decrease in the size of the radiator resulted in installation of plates on automobiles. Still dish transfer its gestures onto the C-band analog using huge radiator because C-band gestures were fewer comparing to K_u band gestures.

Application for S Band: Though the S band mostly utilized at air station observation tracking system which helps in controlling air traffic, climate tracking system, surface ship tracking system, plus few transmission satellites, particularly the ones utilized in NASA used for communication between the Spacecraft and the Intl. Space Station

An antenna structure is utilized for air traffic control (ATC), not like the main antenna structures which calculates posture plus the extent of the prey by utilizing exposed mirroring of radio gestures, depends upon prey consisting an radar transmitter, which responds every questioning gesture just by transponding concealed information like a recognition cipher, spacecraft's height above the sea level plus more data depends on the selected manner. SSR depends onto military identification friend or foe (IFF) automation basically made in the time of the WW II, however these 2 structures are currently in use. Mono pulse secondary surveillance radar (MSSR), Manner S, TCAS plus ADS-B are alike contemporary procedure for subordinate observation.

Primary radar: speedy wartime developing of antenna have clear application regarding air traffic control (ATC) as to give observation in continuity of air traffic temperament. Perfect understanding regarding location of the flying machine will result in reducing for usual practical disconnection quality, then have stated the sized increase for coherence for airline structure, these tracking system "primary tracking system" could discover then announce the location regarding everything which strikes it's transferred radio gestures, which depends onto the pattern, flying machines, birds, climate plus ground characteristics. Regarding air traffic controlling purpose its an duo of superiority plus drawback. their prey don't have to collaborate, their task is to stay in their area plus to throw back radio waves, yet the only thing it do is to tell the location of prey, they don't know them. While the main tracking system is the only one to exist, connection of the single tracking system comes back with particular flying machine generally is attained via controller watching an expected roll of the flying machine. The main tracking system is currently utilized via ATC presently like an secondary structure or another option for subordinate tracking system, though the covered area by it and data is in low limit.

Secondary Radar: To recognize flying machines in an easy way plus sophisticatedly made to develop another tracking system, Identification Friend or Foe (IFF) structure, it was made to identify our own base's flying machines and the enemy's one. The structure came to be familiar for secular usage like secondary surveillance radar (SSR), else in United States like air traffic control radar beacon system (ATCRBS), depends onto an component on board the flying machine known as a transmitter. Transmitter is an radio receptor and transmitting duo that receipts at 1030 MHz and transmits on 1090 MHz prey flying machine transmitter reply to the gestures via a questioner (basically but not fixed, an land stage located held with an main tracking system) via transponding a cipher answered gesture which contains the data requested twain the common people SSR plus the army IFF had became extra compound in comparison of their war time predecessors, still remained usable with each other, isn't less to be allowed armed air machines to be operated in secular sky. Currently used SSR could give data in much detail, e.g., flying machine's height above the sea level plus straight interchange for information within the flying machine to avoid accidents. Almost all SSR structures depend onto mode C transmitters, that tells flying machine's enforcement height rely. Enforcement height don't depend onto how the flyer sets the altimeter, therefore helps to prevent incorrect height transponding even if altimeter set is wrong. The Air traffic controlling structures again calculates force reports of the height to the correct height whose base is its own allusion to force, even its important. Its stated that the main army part of knowing fellows correctly, IFF is having more safer memorandums which helps in preventing false info from the foe, plus its utilized onto much variants of armed stages e.g. aired, water, plus automobiles used on earth surface. Motive for SSR always is making itself better by improving the capability in detecting and knowing flying machines plus giving the flying height by its own(pressure altitude) of a flying machine. SSR land terminal coveys questioning impulses onto 1030 MHz (in continuation to Modes A, C plus choosy, in Mode S) when the antenna revolves else if electronically goes through an scan into gap. A flying machine transmitter lying into the sight limit “hears” those SSR questioning gestures and conveys a back gesture onto 1090MHz which gives flying machine data. Sent back gesture relies onto questioning style. Flying machine is shown like an labeled idol onto the tracking system’s display of the controller onto the calculated bearing plus limit. Any flying machine which do not have a working transmitter will now too could be identified by main tracking system, also could be shown onto the control system now with any help of SSR made information. Its comp lexically an want for having a operating transmitter to fly in control into air space plus, most flying machines have an backing up transmitter knowing that the requirement is fulfilled.

The mode-A questioning obtains an 12-pulse respond, which indicates a identifiable value linked to the air machine. That 12 information pulse were grouped via 2 mounting thudding, F1 plus F2. X pulse isn’t utilized. An mode-C questioning gives out a 11-pulse answer (pulse D1 isn’t utilized), which indicated that the flying machine height above the sea level that the altimeter indicates is increased by 100 foot. The Mode B gives an same answer towards mode A plus is utilized just an single instance into Australia. The Mode D hasn’t worked effectively. Up to dated mode, Mode S, have various questioning features. That consists pulses P1 plus P2 via the antenna primary support in making sure if Mode-A plus Mode-C transmitters don’t answer back, which also consists an lengthy period-regulated throb. Grounded antenna is mostly directive and can’t get another design if side lobes aren’t used. Flying machines can also recognize questioning arriving via those side lobes plus could answer back correctly. Howsoever those answer backs don’t have any difference between it and intentional answer back via that primary support plus could produce into an incorrect flying machine sign to a wrong posture. In order to remove the issue land antenna is given an another, important omnidirectional, support with an that outstrip that side lobes and not the primary support. An 3rd pulse, P2, is transponded via the 2nd support 2 μs later P1. A flying machine which detects P2 with much power used for P1 (however into side lobe plus into wrong primary flap bearing), don’t answer back.

CHAPTER-2

LITERATURE REVIEW

2. LITERATURE REVIEW

Jui-Han Lu, Chia-Luan Tang, and Kin-Lu Wong, were present in 2000,processing correctly placed parts into a equilateral- three edged microstrip patch, new double – frequency plus wide-belt processing regarding an lone-feed triple sided microstrip antenna are given. Regarding double-frequency processing, the proposed structure came out after implementing of 2 pairs of slim slot into the 3 edged patch, an implanted near to boundary edge of the patch plus the another one to the downward edge of the patch. Acquired 2 working frequencies were of identical polarization surface plus by changing locations plus length of the slots that are inserted to the down edge of the patch, an frequency that could be tuned with ratio of that 2 frequencies with range 1.16 to 2.06 is acquired. Moreover , its observed that via peeking an thin slot outside that implanted slot near the corner edge, broad-band processing of the three edged microstrip antenna nearer to its basic deep mode could be gained. Reports indicated that antenna bandwidth of the given broad-band structure could be more than 2.6 X compared to an modern 3 edged microstrip antenna. Information regarding the given dual-frequency plus broad-band structures were stated plus complex reports of the experiment were given and tallied.

Jaume Anguera, Gisela Font, Carles Puente, Carmen Borja, Jordi Soler, *has* present in 2003, An multifrequency microstrip patch antenna consisting of an driven patch plus many parasitic components which are placed below an driven patch is given. The antenna gives an multifriquency nature (5 working band) having same gain.

Ricky Chair, Chi-Lun Mak, Kai-Fong Lee, Kwai-Man Luk, and Ahmed A. Kishk , were present in 2005,The U-cuts radiator, an lone-sheeted single-patch antenna on an comparatively wide substrate (0 .08 λ), is an broad-band antenna consisting a impedance bandwidth within an range of 20%–30%, that is nearly a order of speed greater than the normal patch antenna. Currently, that’s proved that an half U-slot patch antenna, comprising equally divided size of the U-slot patch, maintaining same broad-band nature. Half-structured is an success too given towards U-slot having shot boundaries. Into this paper, latest reports regarding half structure, which aren’t printed before, were shown. Initially that shorting pin method is utilized in order to shorten the dimensions of the half U-slot patch antenna. Via twain duplicating plus experimenting researches, its known that impedance bandwidth, radiation designs, radiation regulations plus gains of half structures are in compare with correlated full shaped. Bandwidth of 28.6% plus propagation efficiency more than 90% were acquired for half U-slot patch consisting shorting pin. Propagation shapes were stabilized cross the similar belt. Secondly, we see that an shape acquired via making the E-shaped patch in half, that's an imitative regarding U-slot patch, it continues it's wide-band nature.

K.F.Lee, K.M.Luk, K.F.Tong, Y .L.Yung, T.Huynh *,had* present in IEEE 1996, Huynh plus Lee shown calculations that shows that an intersecting fed 4 edged patch consisting an U-structured slot could get 10-40% restriction bandwidth, consisting an better shaped specifications. Regarding to the techniques of bandwidth improvement utilizing sponging patches that increases the width else sideways dimensions of the antenna. That U-slotted patch being an lone-layered lone-patched wideband shape that saves that narrow profiled microstrip antenna plus its tiny dimensions superiority too. Into the paper, its shown lengthy experimented reports regarding U-slot patch, consisting across polarization calculations plus the results of the patch dimensions, slot dimensions plus feed location onto presentation. Reports of an 2-component arrangement of an U-slot patch were also shown. Huynh and Lee's calculations are carried out onto an patch of center frequency being 1 *GHz.* Into this experimentation the frequency is ramped up to 5 times.

In 2014, Cho-Kang Hsu and Shyh-Jong Chung, had present, the transmission proposed an handy U-shaped slot antenna consisting an coupling feed regarding 4^{th} generation mobile phone's apps. That antenna consists an basic open-end U-shaped slot plus an providing path consisting an surface of 58mm 12 mm.2 kinds of sonorous modes were excited, which includes slot mode and single pole mode. Constant experiments onto slot configuration were shown. Via keeping the connected parameters in control, bandwidth of the antenna could latently help in covering these phone bands of Long Term Evolution(LTE) Band 12 (698–742 MHz)/DCS (1710–1880 MHz)/PCS (1850–1990 MHz)/UMTS (1920–2170 MHz)/LTE Band 40 (2300–2400 MHz)/Band 41 (2496–2690 MHz)/Band 42 (3400–3600 MHz)/Band 43 (3600–3800 MHz). Better transmitting specifications, e.g. gain plus radiation efficiencies were obtained by the working bands. Mentioned antenna should be better used regarding the metalized covering of handy instruments.

In 2014, Jin-Sen Chen has present, the dual-frequency properties of a dual annular-ring slot antenna fed by coplanar waveguide (CPW) plus microstrip feedline are presented and experimentally studied. The proposed antenna was made using coextensive annular ring slots counterfeit onto FR4 membrane with lone feed. The proposed slot antennas have good impedance matching for the two operating frequencies comprising an frequency division ranging about 1.34 3.11 and 1.4 1.74 can be achieved for CPW-fed and microstrip-fed.

Kai-Fong Lee, Shing Lung Steven Yang, and Ahmed A. Kishk, has present in 2008, An broad band patch antenna fed via L-probe could be made regarding dual plus multi-band works by means of trimming U-slots onto the patch. Duplicating plus calculations reports were shown in order to decorate the pattern.

Mahmoud N. Mahmoud and Reyhan Baktur were present in2011, An basic exclusive pattern technique in order to get an dual band microstrip fed slot antenna was shown. That was presented whenever 2 slot antenna were kept into series, space gap b\w those 2 antenna could be compromised in order to get a successful subordinate vibration. Exclusive vibrations was observed to be caused by the mutual coupling b\w the 2 slot antennas. A approx circuit structure regarding the dual band antenna was shown in order for explaining the dual band mechanics plus to give an pattern outline. That structure was conformed consisting an idiomatic antenna which works on 4.22 GHz plus 5.26 GHz, that were basically utilized like downlink plus uplink into satellite transmissions. Calculated reports shows better return loss onto twain frequency, plus transmission designs agrees better within duplication. Given antenna have an basic configuration could be simply generated utilizing PCB methods regarding works in which compression plus multiband working were into notice.

Wing Chi Mok, Sai Hoi Wong, Kwai Man Luk, and Kai Fong Lee, were present in2011, recently, that’s presented that an dual- else an triple-band patch antenna could be made via trimming U-slots into patch of an broadband antenna, plus this procedure is used to L-probe fed patch, that M-probe fed patch, wheedle-fed piled up patches, plus opening combined piled up patches. Each of the instance consists an complex feed, else patches more than 1 and layers in multiple quantity. Into the transmission, the procedure that’s used in order to telecast U-slot patch antenna. Whenever an extra U-slot patch is trimmed into patch, an dual-band antenna reports whenever 2 extra U-slot patches were trimmed into the patch, an triple-band antenna reports. Plus points of aftermath arrangement were (1) feed remains basic plus (2) shape remains lone-sheeted. Twain duplication plus calculations reports were shown in order to reveal workability of the pattern.

Payam Nayeri, Kai-Fong Lee, Atef Z. Elsherbeni, and Fan Yang, were present in 2011, an exclusive pattern regarding lone-feed dual-band rounded polarized microstrip antenna were shown. An piled up patch arrangements was utilized regarding the antenna, plus rounder polarization is acquired via making random U-slots onto the patches. Structure of U-slot were advanced in order to acquire rounded polarization into both the hands. An sample was made in order to work into 2 frequencies within an division of 1.66. twain experimented plus theory reports were shown and tallied. Rounded polarized bandwidth of the antenna is 1.0% on 3.5 GHz (WiMax) and 3.1% at 5.8 GHz (HiperLAN).

M. N. Suma, Rohith K. Raj, Manoj Joseph, P. C. Bybi, and P. Mohanan, had presents in 2006, An handy dual band flattened antenna regarding an digital transmission structure (DCS)/2.4-GHz local area network app is shown. 2 deep modes of the shown antenna were linked with serious lengths of the lone poles, into that an long handed gives the lowest flattened frequencies plus an smaller hand regarding high flattened frequencies. Experimented reports shows that the antenna made could give better presentation regarding DCS/2.4-GHz local area network structures, which includes sufficient broad frequency band, moderated gain. Plus almost omnidirectional radioactivity alalysis. Result of the experimented reports consisting the pattern standard were shown into the paper.

In 2003 N. Misran, R. Cahill, and V. F. Fusco[126] Has proposed, A multi recurrence microstrip fix reception apparatus contained a determined fix and a majority of parasitic Components put underneath a determined fix is proposed. The radio wire includes a multi recurrence conduct (five Working band) with comparative increase.

In 2005 J. S. Chen [127] have characterize , The U-opening patch recieving wire, a solitary layer single-fix reception apparatus on a generally thick substrate (0.08 λ_0), is a wide-band radio wire with an impedance transfer speed in a scope of 20%–30%,which is about a significant Degree bigger than that of the Customary fix reception apparatus. As of late, it was demonstrated that a half U-opening patch reception apparatus, With half of one of the elements of the U-space fix , keeps up comparable wide-band conduct. The half-structure was Likewise effectively applied to the U-opening with shorting divider .In this paper, new outcomes on half structures, not Recently distributed, are introduced. To start with,The shorting pin procedure is utilized to decrease the size of the half U-space fix recieving wire. By both recreation and Test contemplates, it is presumed that the impedance data transfer capacities, radiation designs, radiation efficiencies. And increases of the half structures are practically identical to the relating full structures. Transfer speed of 28.6% and Radiation efficiencies surpassing 90% are acquired for the half U-opening patch with shorting pin. Radiation designs are Steady over the coordinating band. Second, it is indicated that a structure got from dividing the E-formed fix, which is a Subsidiary of the U-opening patch, likewise keeps up its wide-band Conduct.

In 1981 K. R. Carver and J. W. Mink [9] have considered a review on microstrip recieving wire, with Conspicuousness on hypothetical and functional plan methods. In course of the above exploration the connection Between dielectric steady and full recurrence of microstrip patches were investigated for substrate materials. Numerous Scholarly investigation procedures like transmission-line and modular extension (hole) strategies just as numerical Strategies, for example, the strategy for minutes and limited component methods were utilized for discovering surmising Of the examination. In this paper reasonable techniques for both benchmarked rectangular and round patches, just as Minor departure from those plans just as circularly spellbound microstrip patches were given. Two significant elements, Data transmission and proficiency, of average fix plans are examined. Besides microstrip dipole and conformal reception .Apparatuses are likewise summed up. Inevitably, basic requirements for additional examination and advancement for this Reception apparatus are perceived.

In 1981 C. Wood [12] has done the assessment of the roundabout microstrip circle, in This paper which utilizes a symmetrical mode delineation of the current conveyance on the plate. Here, joining results With number of modes is very much pondered. Fine concurrence with exploratory outcomes was acquired for full Recurrence, transfer speed computations demonstrates the hypothetical ideas. The outcomes were coordinated with Those of past assessed examinations, and the scope of recieving wire boundaries for which the rough outcomes were Valuable. This paper additionally gives instances of current circulations and radiation polar outlines. The consequences of The paper presume that the impact of the surface waves may restrict the upper recurrence at which the substrate might Be utilized. For a εr of 2.32, this is assessed as on 21 ghz.

In the year 1981 W. F. Richards, Y. T. Lo and D. D. Harrison [10] Have introduced a stage up to an as of late revealed hypothesis for the examination of the example and impedance loci of Microstrip radio wires. As per the proposed hypothesis the fields in the internal of the reception apparatuses need a Discrete arrangement of modes. The shafts relating to these modes were perplexing and rely upon the misfortunes in the Radio wire. The understanding of the fields regarding these modes is precise just for a bonafide hole with zero copper Misfortune. It is discovered that the subsequent articulations for impedance of the microstrip radio wire were in Acceptable simultaneousness with determined outcomes for all feed areas. The appraisal of impedance variety with feed Area, to multiport assessment and to the plan of circularly enraptured microstrip recieving wires are a few utilizations of This hypothesis. It is additionally having a favorable position of being straightforward and non costly when contrasted with Past techniques and thus is more significant.

In 1989 A. Reineix and B. Jecko [19] had examined the microstrip fix radio Wires in the space of time, utilizing the limited distinction time area (FDTD) technique. In this paper changes made in the Traditional FDTD technique so as to swat up the microstrip radio wires were examined. Here an appropriate decision of The excitation is accepted to discover , the recurrence reliance of the relevant boundaries by utilizing the Fourier change Of the transient current. As we probably am aware a nitty gritty investigation of one or a few dielectric interfaces is done in The FDTD technique. Other disparate sorts of excitation(coaxial, microstrip lines, and so on) can likewise be utilized for this Examination. Plotting the spatial circulation of the current thickness gives data about the reverberation modes. Finally ,number of models with the standard boundaries like information impedance, radiation design (for example that rely upon The recurrence) are given.

In year 1998 % K. M. Luk, C. L. Mak, Y. L. Chow and K. F. Lee [30] Had introduced their discoveries on broadband microstrip radio wire and the qualities of a rectangular microstrip Reception apparatus with a L formed test are examined. In this proposed strategy .7A froth layer with a thickness of around 10% of the frequency is utilized as the supporting substrate.By doing so we can accomplish a steady radiation design over the pass band and impedance transfer speed of 35%, a Normal increase of 7.5 dbi is additionally accomplished.

In year 1998 K. M. Luk, R. Seat and K. F. Lee [33] had suggested That microstrip fix recieving wires have the alluring highlights of low profile and light weight, and can be made conformal To mounting on a structures. Low microwave recurrence reaches can likewise be utilized for exceptionally huge Commonsense applications. A few strategies had been proposed to lessen the size of the traditional half-wave fix. One Methodology was to utilize costly and substantial high dielectric consistent material while another methodology utilizes Either a shorting divider or a shorting pin. A shorting divider prompts the quarter-wave fix while a shorting pin close to the Feed can decrease the fix size considerably further. In any case, in the two cases, the cross-polarization level is very high. This paper proposes a unique little collapsed fix recieving wire. The recieving wire presented is basic in structure and has Low cross-polarization .When contrasted with a customary fix radio wire with a similar surface zone, the full recurrence is Diminished inconceivably.

In year 1998, A uniqueness of the opening coupled stacked fix microstrip recieving wire had Been introduced by S. D. Targonski, R. B. Waterhouse and D. M. Pozar [31] , Which enormously improves its transfer speed. The proposed radio wire accomplished data transmissions of up to one Octave. This paper likewise thinks about the impedance execution of this radio wire with the first wide-band microstrip Radiators. Coordinating strategies for the reception apparatus were introduced and their overall favorable circumstances Were likewise examined. For getting some knowledge into the wide-band activity impacts of changing a few key physical Boundaries were likewise noted. This paper likewise shows consequences of minor departure from the plan for example Joining of extra fixes.

In 1998, electrically small microstrip patches fusing shorting ports are deliberately researched by R. B. Waterhouse, S. D. Targonski, and D. M. Kokotoff [32] , Explored reception apparatuses were appropriate for portable interchanges handsets where restricted recieving wire size Is an attractive necessity. The focal point of the exploration is to discover methods to improve the band width of these Reception apparatuses and show the presentation patterns. From these patterns, important understanding to the most Ideal plan, to be specific wide data transfer capacity, little size, and simplicity of assembling, was introduced.

In year 2000,K. F. Tong, K. M. Luk, K. F. Lee, and R. Q. Lee [35] Introduced, the 3D FDTD strategy to examine the recently created broadband U-opening rectangular fix recieving wires On microwave substrate. This exploration researches the broadband attributes of dielectric rectangular U-opening patch Radio wires. The outcomes acquired for impedance transfer speed, and far-field emanation design were introduced and Are upheld and demonstrated right by estimation. An inventive, U opening rectangular fix recieving wire is likewise Concentrated by utilizing FDTD technique. This new reception apparatus configuration can achieve an impedance data Transfer capacity in abundance of 30%, with amazing example qualities. The significant bit of leeway of this microstrip Recieving wires is that it holds low profile which is not at all like a large portion of the discretionary strategies in the writing. This radio wire holds the significant preferred position of microstrip reception apparatus – low profile. In this article, the FDTD technique is furthermore evolved to recreate a U-space fix scratched on a bit of microwave substrate of dielectric Steady 2.32.

In year 2000,C. L. Mak, K. M. Luk, K. F. Lee and Y. L. Chow [37] Had confirmed that L formed test is an appealing feed for the significant microstrip recieving wire (thickness around 10% of the working frequency). A Parametric learning on the rectangular Fix radio wire was offered in this exploration. It was discovered that the proposed radio wire accomplishes 36% impedance Data transmission (SWR 2) just as addition transfer speed and around 7-dbi normal increase. A two-component course of Action took care of by L tests is likewise anticipated. This exhibit plans can considerably smother the cross polarization of The proposed recieving wire was appeared by tests. Both the recieving wires have stable radiation designs over the Passband. There is fine arrangement between estimated thunderous frequencies of the proposed recieving wire with a Current equation and the L test didn't have a lot of impact on the resounding recurrence.

In year 2000 by K. F. Lee, Y. X. Guo, J. A. Hawkins, R. Seat and K. M. Luk [36] tested and Determined outcomes dependent on the limited contrast time-area (FDTD) technique and introduced on the impedance And radiation qualities of the exemplary shorted quarter wave fix. It was discovered that the transmission capacities of the Quarter wave patches were fundamentally bigger than the half wave patches, for froth substrates with relative permittivity Near solidarity. Then again, the Most extreme increase on account of froth dielectric material is in the range of 2-3.5dbi. The full consumption of a time division, but lessening the whole recurrence, with addition diminished the data sanding. Research paper is the use in the shorting-pin guideline to measure a smaller high bandwidth L for recieving wire.

In year 2001 A square microstrip radio wire with a flighty space recieving wire was investigated by M. Hurtado, H. E.Lorente and C. H. Muravchik for reverberation recurrence and info impedance. This exploration utilizes programming Recreations to show that the reverberation recurrence diminishes with the space inset. In this technique a feed purpose of 50 ohm input impedance was discovered, when the opening is appropriately moved. These outcomes were approved by Building the reception apparatus and estimating their properties. The blunder in the anticipated reverberation recurrence Is more modest than 2%. The blunders in input impedance, just as in the reverberation recurrence, can be diminished for the proposed radio wire.

In 2003 a novel procedure that improves the presentation of a customary fix reception apparatus Was proposed by C. K. Chiu, K. M. Shum, C. H. Chan and K. M. Luk [43] ,Here two distinct calculations (U-space and L-cut) were being researched tentatively with the incorporation of a collapsed Internal little fix, Author accomplished impedance data transfer capacities of 53% and 45% of a voltage standing wave Proportion under 2 for the U-opening and L-cut, individually. The Radiation designs were steady over the entire working Recurrence groups.

In this paper the goal of Hang Wong and Kwai-Man Luk [77] was to give the specific circumstance, Physical understanding, and point of view on reception apparatuses in remote interchanges. In spite of the fact that it Doesn't intend to be far reaching, the four key advancements identified with little recieving wire plans to be checked on And talked about, including multiband planar reversed F reception apparatuses, broadband collapsed fix radio wires, Conservative differentially took care of recieving wires, and smaller than expected circularly enraptured fix radio wires, Would cover a wide scope of effective interests and functional applications. A concise review of PC programming for Investigating these recieving wires is additionally given.

In year 2008, A plan for double recurrence (Dual Band) microstrip Reception apparatuses with cone shaped radiation designs has been introduced by S. J. Lin and J. S. Column . The double Recurrence activity is accomplished by energizing two distinctive thunderous methods of the square microstrip fix radio Wire with four balanced shorting dividers. At that point, a strategy to improve the impedance transmission capacities of The double recurrence radio wire is proposed, and the trial results show transfer speeds are expanded by 19 and 31% at the Lower and higher working frequencies, individually. Recreation investigations are likewise performed to help the deliberate Outcomes.

An epic square microstrip fix recieving wire with a solitary fix and single-layer structure has been introduced by Y. J. Wang, W. J. Koh, J. H. Tan, P. T. Teo, By joining an air-filled substrate with a duchess of around 0.008λ, and having one Fix edge shorted with three shorting-pins, an impedance data transfer capacity (return misfortune > - 10db) of 67.5% from 3.62 ghz to 7.32 ghz is acquired for this test took care of minimized and broadband recieving wire. Subtleties of radio Wire configuration, examinations, and estimation results are introduced and talked about.

In year 2010, A straightforward plan for circularly spellbound Single feed microstrip square fix radio wire have been introduced by Farooq, M. Javid Asad and Dr. Habibullah jamal. The Plan technique comprises of consolidating a thin space at the focal point of microstrip fix, delivering triangle over the Opening and setting a solitary feed along the corner to corner of square fix. By changing the measurements at slender Opening and triangle, circularly energized wave can be created. The data transmission of the microstrip recieving wire can Be changed by shifting the point of triangle delivered over the support. The deliberate outcomes are in acceptable Concurrence with the mathematical outcomes.

In year 2012, Kai-Fong Lee [58] proposed the fundamental math of a Microstrip fix reception apparatus (MPA) comprises of a metallic fix imprinted on a grounded substrate. In this examination Paper broadbanding strategies have been talked about, as it is consistently a test to get a broadband recieving wire, Specialists recommended barely any superb methods to plan a broadband reception apparatus. The microstrip fix radio Wire offers the benefits of low profile, comparability to a formed surface, simplicity of manufacture, and similarity with Incorporated circuit innovation, yet the fundamental calculation experiences tight transfer speed. Over the most recent Thirty years, broad obligation, improve the radiation of this radiator wire and MPA has find out different uses in the field of military purpose and the business purpose. The paper begins with a small depiction of the explaining types and required data of the radiator. The main fundamental for broadbanding technique, twice and many band plane.

In year 2012, [57] H. Wong, K. M. Luk, C. H. Chan, Q. Xue, K. K. Thus, and H. W. Lai Have give the unique circumstance, physical knowledge, and point of view on reception apparatuses in remote Correspondences. In spite of the fact that it doesn't intend to be thorough, the four key advancements identified with little Reception apparatus plans to be inspected and talked about, including multiband planar rearranged F recieving wires, Broadband collapsed fix radio wires, reduced differentially took care of reception apparatuses.

In 1981 K. R. Carver and J. W. Mink [9] have considered a Study on microstrip reception apparatus, with noticeable quality on hypothetical and handy plan strategies. In course of The above examination the connection between dielectric steady and thunderous recurrence of microstrip patches were Explored for substrate materials. Numerous scholastic investigation strategies like transmission-line and modular Extension (pit) procedures just as numerical techniques, for example, the strategy for minutes and limited component Methods were utilized for discovering derivations of the exploration. In this paper sound strategies for both benchmarked Rectangular and round patches, just as minor departure from those plans just as circularly spellbound microstrip patches Were given. Two significant variables, transmission capacity and effectiveness, of commonplace fix plans are examined. In Addition microstrip dipole and conformal radio wires are likewise summed up. In the long run, basic requirements for Additional examination and advancement for this reception apparatus are perceived.

In 1981 W. C. Moc [12] has done the Assessment of the roundabout microstrip plate, in this paper which utilizes a symmetrical mode delineation of the current Circulation on the circle. Here, joining results with number of modes is all around thought. Fine concurrence with trial Results was gotten for resounding recurrence, transfer speed estimations demonstrates the hypothetical ideas. The Outcomes were coordinated with those of past assessed examinations, and the scope of radio wire boundaries for which

The estimated outcomes were valuable. This paper likewise gives instances of current appropriations and radiation polar Charts. The consequences of the paper infer that the impact of the surface waves may restrict the upper recurrence at Which the substrate might be utilized. For a εr of 2.32, this is assessed as on 21 ghz.

In the exact year for plan 1981 W. F. Richards, Y. T. Lo and D. D. Harrison [10] Have introduced a stage up to an as of late announced hypothesis for the investigation of the example and impedance Loci of microstrip radio wires. As per the proposed hypothesis the fields in the inward of the recieving wires need a Discrete arrangement of modes. The posts relating to these modes were intricate and rely upon the misfortunes in the Recieving wire. The translation of the fields regarding these modes is precise just for a bonafide cavity with zero copper Misfortune. It is discovered that the subsequent articulations for impedance of the microstrip radio wire were in Acceptable simultaneousness with determined outcomes for all feed areas. The appraisal of impedance variety with feed Area, to multiport assessment and to the plan of circularly enraptured microstrip recieving wires are a few uses of this Hypothesis. It is additionally having a bit of leeway of being basic and non-costly when contrasted with past strategies and Consequently is more pertinent.

In 1989 A. Reineix and B. Jecko [19] had considered the microstrip fix reception Apparatuses in the space of time, utilizing the limited distinction time area (FDTD) strategy. In this paper changes made in The traditional FDTD strategy so as to swot up the microstrip recieving wires were examined. Here an appropriate decision Of the excitation is accepted to discover, the recurrence reliance of the pertinent boundaries by utilizing the Fourier Change of the transient current. As we probably am aware a definite investigation of one or a few dielectric interfaces is Done in the FDTD technique. Other disparate sorts of excitation (coaxial, microstrip lines, and so on) can likewise be Utilized for this investigation. Plotting the spatial dissemination of the current thickness gives data about the reverberation Modes. Finally, number of models with the typical boundaries like info impedance, radiation design (for example that rely Upon the recurrence) are given.

In year 1998 K. M. Luk, R. Seat and K. F. Lee [33] had recommended That microstrip fix recieving wires have the alluring highlights of low profile and light weight and can be made conformal To mounting on a structures. Low microwave recurrence reaches can likewise be utilized for enormous commonsense. Applications. A few procedures had been proposed to decrease the size of the traditional half-wave fix. One methodology Was to utilize costly and substantial high dielectric consistent material while another methodology utilizes either a Shorting divider or a shorting pin. A shorting divider prompts the quarter-wave fix while a shorting pin close to the feed can diminish the fix size much further. Be that as it may, in the two cases, the cross-polarization level is very high. This Paper proposes a unique little collapsed fix recieving wire. The radio wire presented is straightforward in structure and has Low cross-polarization. When contrasted with a customary fix reception apparatus with a similar surface territory, the Thunderous recurrence is decreased vastly.

In year 1998, A divergence of the opening coupled stacked fix microstrip Reception apparatus had been introduced by S. D. Targonski, R. B. Waterhouse and D. M. Pozar [31], Which incredibly improves its data transfer capacity. The proposed recieving wire accomplished data transmissions of up To one octave. This paper likewise analyzes the impedance execution of this reception apparatus with the former wideband Microstrip radiators. Coordinating strategies for the reception apparatus were introduced and their overall focal Points were additionally talked about. For getting some unerstanding into the wide-band activity impacts of changing a Few key physical boundaries were additionally noted. This paper additionally shows aftereffects of minor departure from The plan for example mix of extra fixes.

In 1998, electrically little microstrip patches consolidating shorting ports are Deliberately explored by R. B. Waterhouse, S. D. Targonski, and D. M. Kokotoff [32],Researched radio wires were reasonable for portable interchanges handsets where restricted recieving wire size is an Attractive prerequisite. The focal point of the exploration is to discover methods to upgrade the band width of these Recieving wires and show the exhibition patterns. From these patterns, important knowledge to the most ideal plan, in Particular expansive transfer speed, little size, and simplicity of assembling, was introduced.

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In year 2001 A square microstrip radio wire with a whimsical opening reception apparatus was broke Down by M. Hurtado, H. E. Lorente and C. H. Muravchik for reverberation recurrence and info impedance. This Examination utilizes programming reenactments to show that the reverberation recurrence diminishes with the opening Inset. In this technique a feed purpose of 50 ohm input impedance was discovered, when the opening is appropriately Moved. These outcomes were approved by building the reception apparatus and estimating their properties. The mistake In the anticipated reverberation recurrence is more modest than 2%. The blunders in input impedance, just as in the Reverberation recurrence, can be diminished for the proposed radio wire.

In 2003 a novel strategy that improves the Presentation of an ordinary fix recieving wire was proposed by C. K. Chiu, K. M. Shum, C. H. Chan and K. M. Luk [43],Here two unique calculations (U-opening and L-cut) were being explored tentatively with the consideration of a collapsed Inward little fix, Author accomplished impedance transmission capacities of 53% and 45% of a voltage standing wave Proportion under 2 for the U-space and L-cut, separately. The Radiation designs were steady over the entire working Recurrence groups.

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In year 2010, A straightforward plan for circularly Captivated single feed microstrip square fix radio wire have been introduced by Farooq, M. Javid Asad and Dr. Habibullah Jamal. The plan technique comprises of fusing a limited opening at the focal point of microstrip fix, creating triangle over The space and setting a solitary feed along the slanting of square fix. By changing the measurements at restricted space And triangle, circularly energized wave can be created. The data transmission of the microstrip radio wire can be changed By differing the point of triangle delivered over the brace. The deliberate outcomes are in acceptable concurrence with the mathematical outcomes.

CHAPTER-3

RESEARCH METHDOLOGY

3.1 RESEARCH METHDOLOGY

MSA's are almost indispensible now a day because of its unparalleled characteristics [94-110]. In electronics and communication, the data transfer is important and this phenomenon is still a bit easy if the receiver is stationary but if the receiver is in motion and that too in high speed the faithful reception of signal becomes a challenge, in this case Microstrip Antennas works as a boon for us, performance of microstrip antenna stands good even in the fast-moving condition.

This is one of the most important reason of my motivation to work in the field of microstrip antenna, the coming era will be completely mobile and things should be available instantly everywhere and for that we need few very nice high quality receiving antennas, so just to give a small contribution for the mobile field this instrument worldwide investigation is dedicated although recently published papers [109-123] shows that all over the world ,work is going on and researchers are enriching the technology day by day and giving new dimensions to the future generations.

3.2 PROBLEM FORMULATION

- The broad area of research is wireless communication.
- To choose antenna as a research element as it is an indispensible part of wireless communication.
- Frequency selection in such a way that the contribution is beneficial for the society and majority of wireless communication associated application can be served.
- Now a days the counting of application increasing by the user “Bandwidth” is coming out as one of the major issues.
- After intense literature survey on lower microwave frequency band has been selected as a frequency on which research should be done and the aim is to develop antennas which are having higher bandwidth than the existing ones, higher bandwidth is for reducing hardware requirements and increasing the capability of electronic devices and for their optimum use.

3.3 RESEARCH GAP

Based on the literature survey earlier it has been concluded that using various broad banding techniques [30-31,35-36,41-43,45,51,60,62-65,67-72,74] developers can enhance the application of radiating microstrip patch for the various desired parameters as well as in bandwidth also. Then maximum bandwidth achieved is 60% using shorting pin technique which can be extended up 70% as per my assumption, In this research, the gap of 10% will be filled and some better results are expected to come.

3.4 RESEARCH OBJECTIVES

- To understand the working of Microstrip Patch Antenna in details.
- To understand the current distribution and behaviour of excited radiating patches and the effects of slots which are etched out from the radiating patch.
- To extend the dimension of utility of "Broadbanding Techniques" for bandwidth enhancement of microstrip antenna.
- To understand the concepts of shorting patch, shorting pin, stacking, narrow slot cutting, Radiating limbs, Slanting edges and U-slot cutting techniques.
- To design and develop some microstrip antennas which is having bandwidth near about 70% for lower microwave frequency range.
- To design and develop the hardware of all the antennas and practically test them in laboratory and check their physical significance.

3.5 PATCH FEEDING TECHNIQUE

There are various techniques to feed the input signal into the antenna, some important techniques are –

3.5.1 Microstrip Line

There is a very simple method for the feeding of microstrip patch radiator the technique is called microstrip feed line. So within this mechanism, the patch antenna is fed to any edge (radiating edge or non-radiating edge) by Microstrip Line In order to remove one of the limitations of Microstrip Line Edge Feeding .The material thickness increased so the surface field and radiation increases. Than the experimental geometry limit the BW is 2-5%.

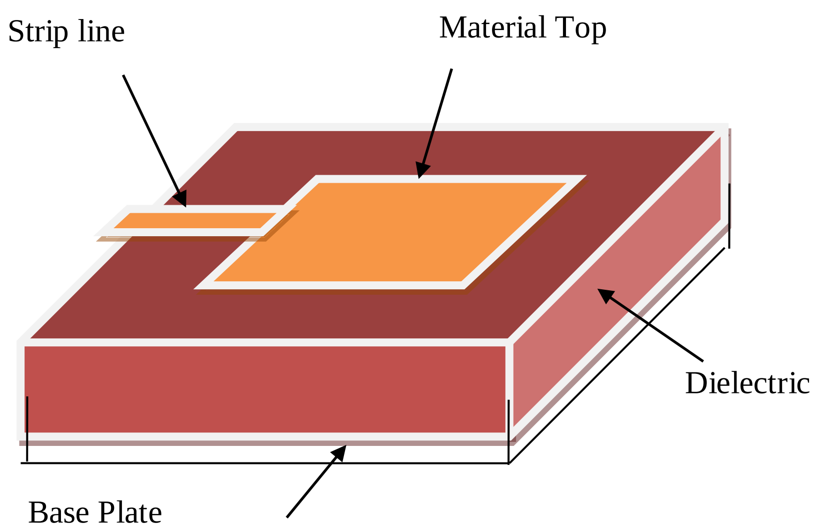

Figure 3.1 Strip line structure

3.5.2 Dual axial Probe

Coaxial probe or called strip line feed. In this technique the inner part of connector is attached in the radiating surface rather than outer part of connector also attached by the earth surface. The aim of this technique are that here it is easy to adjust input impedance by selecting feed point, but the inductive effect dominant. This is also very effortless to manufacture in addition to equal. But the main drawback of this type fabrication has low bandwidth and also to fabricate, especially for the heavy substrate material.

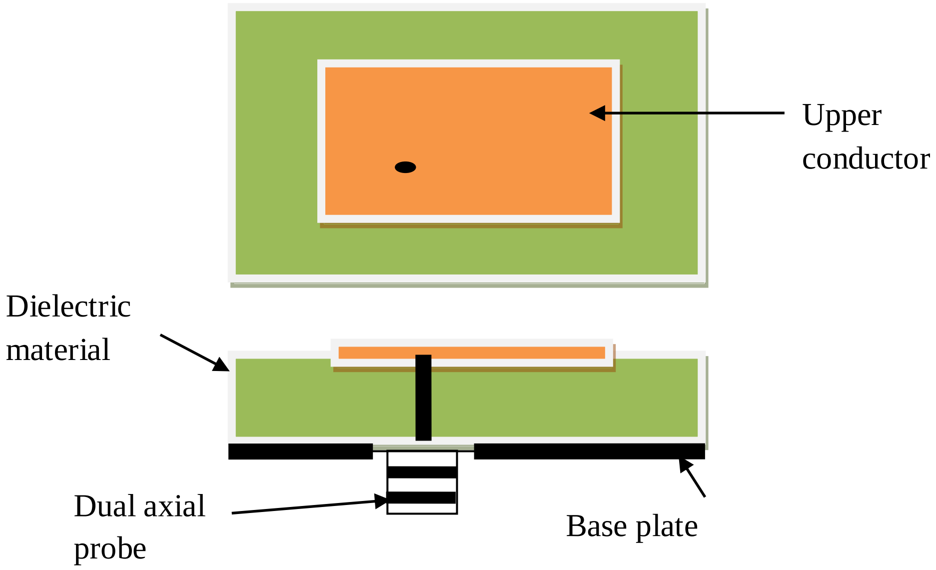

Figure 3.2 Dual axial probe Feed technique

3.5.3 Aperture Coupling

Direct feed mechanisms have disadvantage of having narrow bandwidth. There are some of the techniques which can, bandwidth increase of the microstrip radiator and also the technique aperture coupled feed is one of them [2]. Another technique also increase in bandwidth of radiator is electromagnetically combined Feed Mechanism It is dual coat structure where the lower coat is as the strip line and upper coat is patch radiator. That means the strip line finished at the other end. Now material selected during the process for feeding is heavy dielectric co efficient then the radiation of the process will reduce.

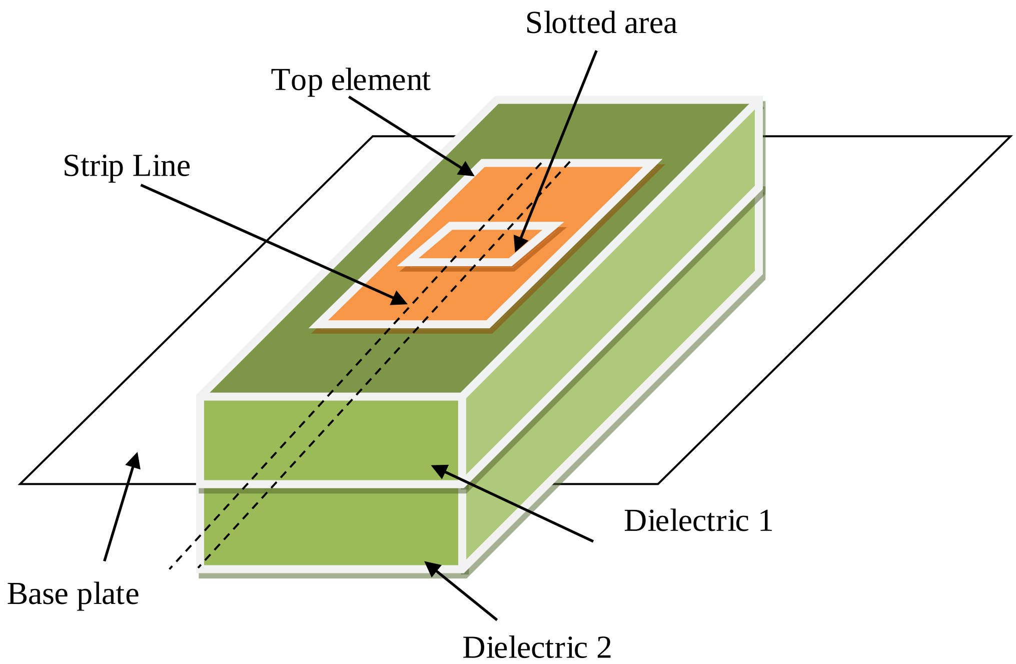

Fig 3.3 Aperture Coupling

3.5.4 Proximity Coupling

Proximity coupling is also two layered like aperture coupling and has the highest bandwidth of, as high 13%, so this is easy to manufacture in addition to small spread emission. But, the manufacturing is additionally hard and has spurious radiation from the feed. However real span refer for the feed part also be the correlation of the antenna. The feed line technique and the coaxial feed technique possess inherent non symmetric, so this kind of process generate large order modes so generate cross-polarization radiation. These asymmetries are not present in non-contacting aperture feeds. Hence these types of feeds are widely used.

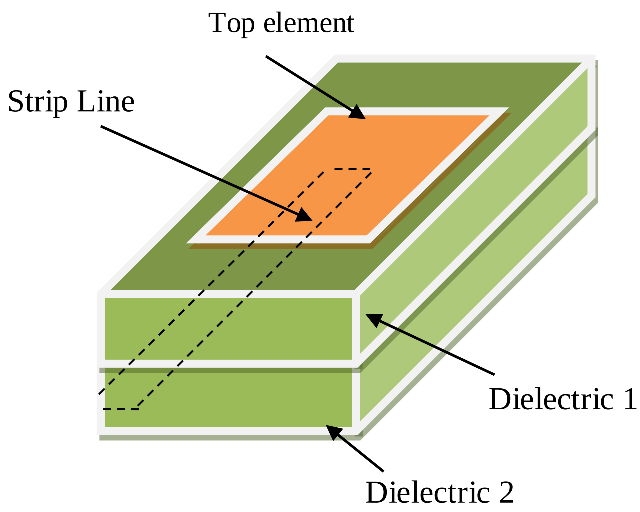

Figure 3.4 Proximity Coupling

Basic comparisons for different feed methods are given in the table below:

Table 3.1: Relationship of non identical feeding techniques

CHARACTERISTICS	LINE FEED	COAXIAL FEED	APERTURE COUPLED	PROXIMITY COUPLED
CONFIGURATION	Coplanar	Non-planar	Planar	Planar
SPURIOUS FEED RADIATION	More	More	More	More
POLARIZATION PURITY	Good	Good	Excellent	Poor
EASE OF FABRICATION	Easy	Soldering and drilling	Poor	Poor
RELIABILITY	Better	Poor due to soldering	Good	Good
IMPEDANCE MATCHING	Easy	Easy	Easy	Easy

Some basic techniques for analysis of the patch radiators as

- Microstrip transmission line analysis
- Microstrip cavity analysis

3.6 MICROSTRIP TRANSMISSION LINE ANALYSIS

This microstrip transmission line analysis is required for a different located line of two dielectrics material, the dielectric material are different substrate use in air medium. Microstrip line transmission make a microstrip radiator using dual cuts of altitude (H) and breadth (W) differentiate with a span (L) for the microstrip transmission line.

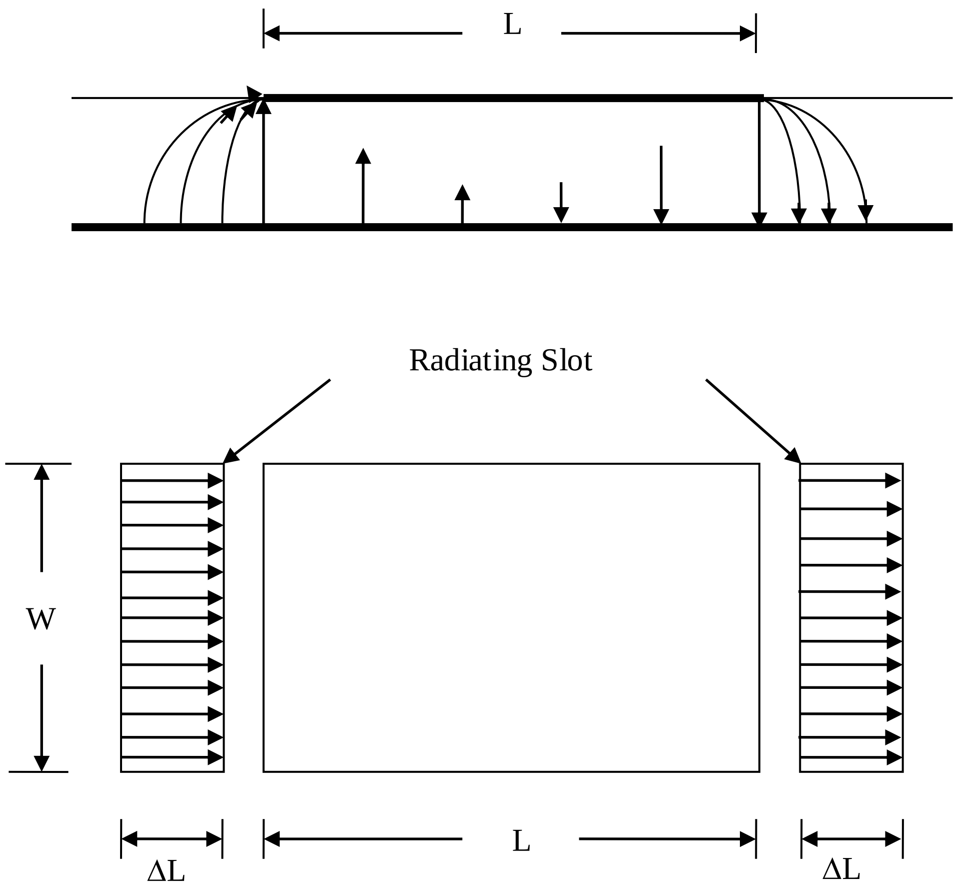

Figure 3.5 Electric Field

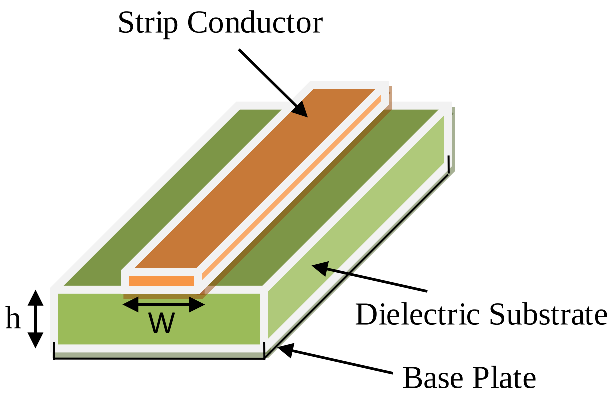

Figure 3.6 Radiator patch for electric field

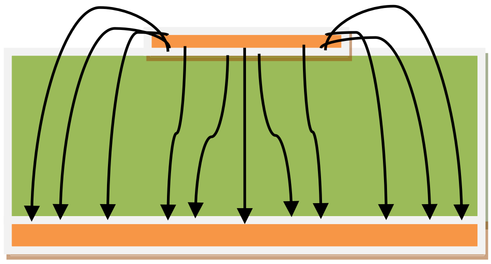

Figure 3.7 E field distribution

For vector field analysis usually field pattern is used in electric field line. The field vector consist a straight line at its tangent also consist with its length. So by figure 3.7 indicate that the field line characteristics bunch of neighbouring field line and representative scientific and calculated theory of the vector field so that it is called E field distribution line, the field shows the gravitational, magnetic and electric field lines and many more, as in liquid flow the mechanics field lines indicating the velocity field, they are knows as stream lines.

ε_{reff} [1] is represent by

$$\varepsilon_{reff} = \frac{1}{2} + \frac{\varepsilon_r - 1}{2}\left(1 + \frac{12h}{W}\right)^{-\frac{1}{2}} \qquad (3.1)$$

- $\boldsymbol{\varepsilon}_{reff}$ is effectual substance constant
- $\boldsymbol{\varepsilon}_{r}$ is substance constant
- h mm substance altitude
- W mm substance breadth

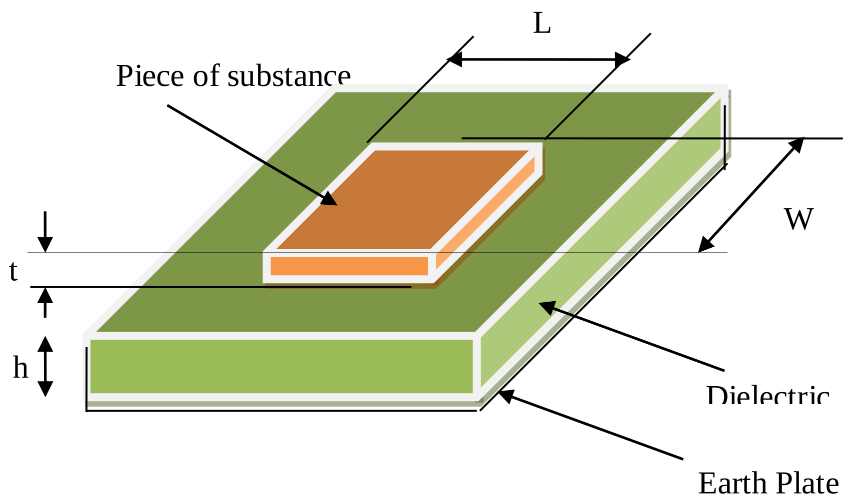

Figure 3.8 Basic microstrip radiator

Radiator radiation pattern are typically in the form of a polar plot for a 360 degree pattern, and relative power in dB scale however the field strength drops to 0.707 (measure in µ(V/m)) of the maximum voltage at the center of the lobe.

Beamwidth: The beamwidth of an antenna is a very important figure of merit and often is used as a trade-off between it and the side lobe level; that is, as the beamwidth decreases, the side lobe increases and vice versa. The beamwidth of the antenna is also used to describe the resolution capabilities of the antenna to distinguish between two adjacent radiating sources or radar targets.

Half Power Beam width (HPBW): In a plane containing the direction of the maximum of a beam, the angle between the two directions in which the radiation intensity is one-half value of the beam. First Null Beam width (FNBW): Angular separation between the first nulls of the pattern.

Into quadrangular waveguide, quadrangular modes figures were shown via 2 hyphen figures fixed into mode typed, like TE_{mn} or TM_{mn}, in which m stands for figure of half wave design cross the breadth of waveguides plus n represents figures of half wave designs cross the longitude of waveguide. Into rounded waveguides, rounded modes existed plus in this case m if the value of full-wave design alongside the circle plus n it hte value of half-wave design alongside the dia.

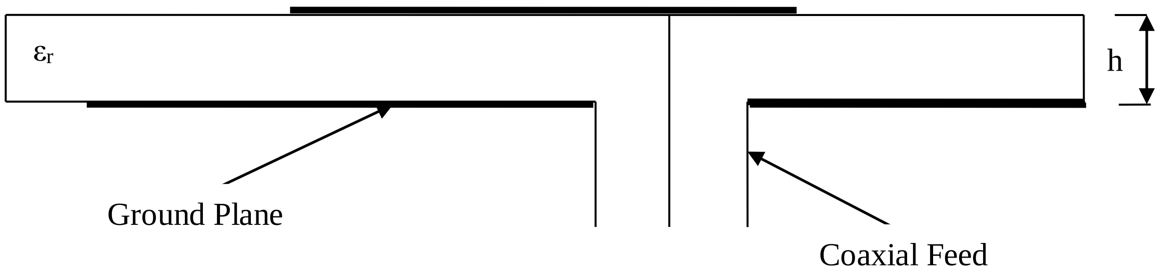

Figure 3.9 Side View of Antenna

The diverging elements (seen in Figure 3.5),those were into aspect, mean that the ensuring area combines in order to give the at most radiation areas normally into the area of the pattern. The Fringing fields with breadth could be the generated radiation cuts and electrically the radiator looks greater than its practical dimension. The patch along with its actual dimension, so the distance will be increased onto every ending via ΔL length. Therefore the vertices alongside the breadth could be shown as 2 radiation slot, in which space is λ/2 far plus in movement plus radiation into half gap over that base plane. Figure 3.5 indicate that the base field E at edge alongside with the W mm were opposite phase plus then outside of the phase so the radiator is λ/2 plus both are cancelled into the broadside path.

3.7 CAVITY MODEL ANALYSIS

In cavity model analysis the radiator transmission line already discussed before is somewhat very easy to have found out some unmatched disadvantages. It is used generally in respect to patch of quadrangular pattern plus it denies the area change alongside its transmitting side. Problems could be dealt via use of cavity analysis , in this the inner region of the dielectric material is modelled as a cavity which is covered by electric field at the topmost and bottom, according for this assumption is given in this text as the outcome for thin dielectric material. Here the substrate is thin; fields in the inner side do not have much change in the direction, which means they are normal to the patch. The electric fields are directed only the opposite components and, in the region is bounded by the patch metallization and the ground plant this observation provides for the electric walls situated at the top and the bottom. When power is provided to the microstrip patch, a distribution of charge is observed on the upper and lower surface of the patch. Two mechanisms, they are as first is attractive mechanism and the other is repulsive mechanism controls this charge distribution at the bottom of the ground plain. The first attractive mechanism is lies between the opposite charges on the bottom side of the radiator on the ground plain , which helps in keeping the concentration of the charge intact at the bottom of the patch, repulsive mechanism lies between the like charge and the bottom surface of the patch which is the reason behind the pausing of same charge from the bottom to the top of the patch. The consequences of this charged movement if that the current flows at the top and bottom surface of the patch, assumption by the cavity model is that the height to width ratio that is the height of the substrate and the width of the patch varies and therefore the attractive mechanism dominates and causes most of the charge concentration and the current below the patch surface. So less amount of current flows on the top surface of the patch, and the ratio of height to width further decreases the current at the top surface of the patch , it would be somewhat equal to zero thereby would not help in the creation of any tangential magnetic field components to the patch edges, therefore the four sidewalls can be modelled as excellent magnetic conducting surface this implies that the magnetic field and the electric field below the patch would not be altered. Nevertheless, in general, a finite ratio if width to height would be there and this would not make the tangential field to be completely zero, but as they are tiny, the side walls can be approximated to the perfectly magnetic conducting, after all the cavity walls, and the material within it are lossless, the cavity would not radiate at the input impedance would be purely reactive. Therefore, in order to account for radiation and a loss mechanism we must use a radiation resistance R_r as well as a load or loss resistance R_L. A cavity with loss will denoted a radiator and the loss is taken in account by the effective loss.

Q_{eff} *Effective loss tangent expressed as*

$$Q_{eff} = 1/Q \tag{3.2}$$

Formula expression for microstrip patch antenna quality factor as follows

$$1/Q_T = l/Q_R + l/Q_E + l/r \tag{3.3}$$

Formula expression for microstrip patch antenna quality factor for the dielectric material as follows

$$Q_d = \omega_r w_r / Pd = l/\tan\delta \tag{3.4}$$

Angular resonant frequency Q_d

Power of patch at resonance W_r

Dielectric loss P_d

Dielectric loss tangent tanδ

Formula expression for microstrip patch antenna quality factor Q *for the conductor material as follows*

$$Q = \omega_r w_r / P_C = h/\Delta$$

(3.5)

Conductor material loss P_c

Conductor material Skin depth Δ

Formula expression for microstrip patch antenna radiation quality factor Q_r *for the conductor material as follows*

$$Q_r = \omega_r w_r / Pr$$

(3.6)

Microstrip patch radiator is radiate power P_r

3.8 DESIGN CONSIDERATIONS

The motive of the pattern is gaining particular performing characteristic at an specific frequency to work. In case an micro strip antenna setting could attain the mentioned goals, later initially deciding of selection of worthy antenna configuration, an quadrangular patch antenna could get an design via process as mentioned.

3.8.1 Substrate Selection

The initial design process is to select an worthy dielectric substrate [23] of specific width h plus loss tangent. A much thick substrate, rather been instinctively muscular would boost radiator energy, low loss, and high bandwidth. So, gain the weight, constant loss, lossy wave, and more radiations at the coaxial probe field. Now the material constant ε_r makes a main role like as the material thickness. If consider low ε_r for the material constant will rising the fringing field at the radiator periphery, and the output power radiated. Therefore substrates with $\varepsilon_r < 2.5$ are preferred unless a smaller patch size is desired. An increase in the substrate thickness has a smaller effect on the antenna characteristic as a decrement in the value of ε_r. A high loss tangent increase dielectric loss hence decreases antenna efficiency. The four basically utilized substrate material are honeycomb (ε_r = 1.07), duroid (ε_r - 2.32), quartz (ε_r = 3.8), and alumina ε_r = 10).

3.8.2 Element Width & Length [29]

Radiating patch have small changes with the constants of width on the vibrant frequencies plus radiating designs of the radiator. So the inserted impedance plus bandwidth is highly enhanced. If the radiator width enhances so the radiated power and change in resonant resistance decreases, bandwidth enhancement, and radiation efficiency also enhance. Due to perfect exciting anyone can select an patch breadth bigger than the patch length L without excitation undesirable mode. So the main drawback is larger radiator width is, grating lobes formation in radiator arrays, plus an tiny patch dimension could be used in order to decrease the original estate needs. The patch breadth affects the cross-polarization specifications too. The breadth of the patch must be selected in order to attain excellent radiating power by chance real estate needs else an grating lobe were not overriding conditions. It's been advised that $1 < W/L < 2$.

The resonant frequency calculated the radiator length, and is an unknown value in shape because of the radiator bandwidth is very small this is the main constants. To a 0_{th}-order approximation, the patch length L for the TM_{10} mode is represented by

$$L = \frac{c}{2f_r\sqrt{\varepsilon_r}} \quad (3.7)$$

The factor $\sqrt{\varepsilon_r}$ is because of the processing via substrate plus only in validity for an much wide patch. In practice, the fields are not confined to the patch.

An part of the fields lies out of the physical size L x W of the patch. This is known as fringing field. The effects of fringing field alongside the fringes $y = 0$ and $y = W$ could be a part throughout the effectiveness of the dielectric constant ε_{re} regarding a microstrip line of breadth W onto the provided substrate. Via replacing ε_r by ε_{re},

$$L = \frac{c}{2f_r\sqrt{\varepsilon_{re}}} + \Delta L$$

(3.8)

Further enhancements is gained via counting the effects of fringing fields at the endings of the patch, i.e., alongside the fringes $x = 0$ plus $x = L$. This change could be mentioned via additional line length ΔL onto whichever endings of the patch span. accordingly, the effectual patch span L_e becomes $L + 2\Delta L$

$$\frac{\Delta L}{h} = \frac{\delta_1\delta_2\delta_3}{\delta_4} \quad (3.9)$$

Based on this approach, we obtain the following design value for L

$$L = \frac{c}{2f_r\sqrt{\varepsilon_{re}}} - 2\Delta L$$

(3.10)

3.8.3 Losses & Q Factor

The quality factor of a patch antenna needs to be determined to implement the cavity model. It is also useful in determining the VSWR bandwidth of the antenna. The total quality factor of the patch is defined in terms of the quality factors associated with various types of losses in the patch antenna. One can write

$$\frac{1}{Q_T} = \frac{1}{Q_d} + \frac{1}{Q_c}\frac{1}{+Q_r} + \frac{1}{Q_{sur}} \quad (3.11)$$

Where Q representing any of the quality factors on the right-hand side, is defined as

$$Q = \frac{\omega_r W_r}{\text{Associated Power Loss}} \quad (3.12)$$

Where,

$Q_T = \frac{1}{\tan\delta}$ tan δ: Loss tangent of the substrate material

(3.13)

$Q_c = \sqrt{hf\mu_0\sigma}$ σ : Conductivity of patch metallization

(3.10)

$Q_r = \frac{\omega_T W_T}{P_r}$

(3.14)

$W_T = \frac{1}{4}\varepsilon_0\varepsilon_r hLW$

(3.15)

3.8.4 Bandwidth

For an antenna, the bandwidth [17] can be defined in a number of ways depending on the characteristics selected. For example, for circularly polarized antennas the axial ratio bandwidth can be given precedence over other characteristics. Similarly, gain and pattern bandwidth are more important for arrays. In the absence of any such stated preference, the impedance bandwidth or VSWR bandwidth for microstrip antennas is specified. The bandwidth for a feed line VSWR < S can be shown to be

$$BW = \frac{S-1}{Q_r\sqrt{S}} \tag{3.16}$$

The bandwidth of the patch antenna could be boosted via boosting the inductance of the transmitters by piercing hole or slits into it by using reactive elements in order to enhance the matching of the transmitter towards the feed path or via sponging loading of the warmer.

3.8.5 Radiation Efficiency

The radiation efficiency [28] is described as the relation of the radiated power P_r to the contribution power P_i, i.e.,

$$e_r = \frac{P_r}{P_i} \tag{3.17}$$

The dissipated energy is usually tiny for low-loss substrates at microwave frequencies, we could say

$$e_r = \frac{P_r}{P_r + P_{sur}} \tag{3.18}$$

Emission effectiveness is dependent mainly onto the substrate width plus permittivity, plus isn't affected a lot either via patch design else the feed.

3.8.6 Feed Point Location

Lately choosing the patch dimensions L and W for a provided substrate, the further job is to determine the feed point (x_0, y_0) so in order to get an better impedance matching b\w the generator impedance plus the inserted impedance of the patch component.

The alteration in feed coordinates arises to an alteration into the inserted impedance plus providing an basic technique for impedance matching.

Observing that in case the feed is placed at $x_0 = x_f$ and $0 < y_f < W$, the inserted resistance at reverberation for the leading mode could be shown as

$$R_{in} = R_r \cos 2 (\pi x_f / L)$$

(3.19)

$R_r > R_{in}$

Here x_f is the inset space between the radiating fringe, plus R_r is the radiating conflict by reverberation as the patch is fed at an glowing fringe. The inset length x_f is chosen so R_{in} is same as the feed path impedance, basically selected 50Ω. Though, the feed tip could be chosen at any place alongside the patch breadth, its best to select y_f = w/2 if w > L so that TM_{10} (n odd) modes aren't into excitation alongside accompanied by the TM_{10} mode.

3.8.7 Effects of Finite Size Ground Plane

This was in assumption into study plus pattern of microstrip antenna that the dimensions of the earth area is infinite. Actually the use is just an finite dimension surface plane could be in implementation. Into few applications, regarding instances, into handy receivers, gap is at an finest. Moreover, regarding use of an microstrip antenna like an reflector feed, the earth surface dimensions must be in limit. The motive is to decrease the antenna dimensions plus the earth surface that is extended beside the patch dimensions to at least. mathematical plus logical methods are utilized in order to study antenna like these. limited earth surface gives birth to circulation of emission via edges of the earth surface which results into changes in emission design, emission conductance, plus reverberating incidence. Its observed that regarding an patch antenna within the earth surface dimension is same to the patch metallization, the reverberating frequency is greater in comparison with an infinitely dimensioned earth surfaced antenna plane antenna.

3.8 IE3D SOFTWARE

Zeland Software, Inc. has developed the IE3D Electromagnetic Simulation and Optimization Software Package. It has FIDELITY Full-3D Time-Domain Electromagnetic Simulator, the MDSPICE Mixed Frequency Domain and Time Domain SPICE Simulator and the COCAFIL Coupled Cavity Filter Synthesis Package. IE3D is a method-of-moments (MoM) dependant full-wave electromagnetic simulation system to be utilized in pattern plus in optimizing of 3dimensional plus multilayered high frequency systems of basic figure. Complex application including MMICs plus RF ICs into microstrip or CPW, microwave/millimeter-wave circuits in microstrip, CPW, striplines, suspended microstrip/striplines, or coaxial lines, speedy digital circuits, 3D interconnect, IC packages, PCB, MCM, HTS circuits plus filters, wired antennas, microstrip antennas, cone shaped plus cylinder shaped twisted antennas, inverted-F antennas, antennas on limited earth surface, plus further RF antennas.

The IE3D is a full-wave, technique of moment (MOM) simulation system solving the current distributing on 3D plus multi-layered shapes of basic structure. The FIDELITY is a full-wave, random finite-difference time-domain (FDTD) simulation sytem solving the close field in structures of complicated dielectrics. The MDSPICE is a new type simulator containing a time-domain simulation engine and a frequency domain simulation engine. The most significant feature of the MDSPICE is that it is capable in performing robust, accurate plus efficient time domain simulation based upon s-(y-,z-) parameter frequency responses. It also has the broad band SPICE representation removal ability for joined broadcast lines plus interconnect. The COCAFIL is a mode-matching based rectangular waveguide filter synthesis program. The 4 simulators are suitable for the pattern of microwave circuits, microwave plus milli-meter wave integrated circuits (MMICs), RF printed circuits, HTS circuits and filters, microstrip patch antennas, wired antennas, other types of wireless antennas, waveguide antennas plus circuits, IC transmission lines and circuits, IC packaging, EMC/EMI, electromagnetic applications in medical sciences. If you are a circuit or antenna designer or a research scientist, looking for accurate, efficient, flexible and economical tools, our products are the right choices for you.

IE3D Features:

1. Carving true 3D tinny structure into numerous dielectric layer in unlock, locked, else episodic border conditions. There isn't any restriction regarding the structure plus orientation of the metallic structures. IE3D can model true 3D structures such as conical vias, conical helix antennas, wire bonds and other 3D structures of general shape. Using IE3D, users can build and simulate a wide range of planar and 3D microwave and RF structures.
2. Great competence, great correctness plus small charge electromagnetic simulator gears for PCs consisting Windows as an base for graphic interface. Working on PCs, this simulation system is quicker in comparison with other field solvers on high end workplaces.
3. Microsoft based menu-driven graphic interface allow interactive construction of 3D and multi-layered metallic structures as a set of polygons. Numerous

editing capabilities are implemented to ease the construction and manipulation of polygons and vertices.

4. Build-in library for building of complex systems like, circles, rings, spheres, rectangular and circular spirals, cylindrical and conical vias, cylindrical and conical helices. One can build complicated 3D and multi-layered structures in seconds or minutes.
5. Automatic non-uniform web generator with quadrangular plus triangular cells. Numerical simulation requires sub-dividing a circuit into small cells. Both rectangular and triangular cells are employed in the IE3D. Rectangular cells are used in the regular region for the best efficiency (each rectangular cell is equivalent to at least 2 triangles). Triangular cells are utilized to fit the irregular boundary. The efficiency of rectangular cells and flexibility of triangular cells are combined to yield the best result.
6. Automatic fringe Cell characteristic makes the IE3D acquiesce specialist result for beginners. It is well known that current is concentrating on the edges of metallic strips. Precise modeling of the high current concentration along the edges is critical to accurate simulation of printed circuits, especially coupled structures.
7. “Simulate and Find Excitation” characteristic allow observation of array energy sharing on system. The “Simulate and Find Excitation” characteristic is extraordinary for pattern of antenna arrays plus shapes with complex chunked components. Allowing the operator to gain entry to the energy, voltage plus current which is distributed at all the parts of the shape one is energizing. Its much expensive regarding antenna array creators as it could tell us that their structure is much better. This characteristic is much better regarding the pattern of the shape consisting chunked components. e.g., one could know the radiation design of an antenna consisting complex chunked components.
8. The 3dimensional plus 2dimensional show of distribution of current, radiation designs plus nearer the fields. The CURVIEW post-processor of IE3D providing us with multi colour 3 dimensional plus 2 dimensional show of current dispersal plus radiation designs. CURVIEW helps with providing full details regarding directionality, return loss, regulation, lengthwise proportion, 3-dB beam breadth, plus RCS. Allowing an operator to name the commotion plus the burden in order to observe the radiation of packed antennas. These

multi coloured images could be fed as stack regarding pattern authentication. The post-processor helps providing the show of line form plus round polarization designs plus expulsion proportion.

9. Elastic usefulness specialty plus inbuilt circuit simulation system: IE3D is packed with an basic as well as friendly interface with its operators circuit simulation system. This is packed with various basic plus advanced services like searching feature impedance of an transmitting line, which creates the s-parameters regarding idealize transmitting line, plus reverse simulator in order to remove the s-parameters of part of the circuit from inside of an entire circuit.

Acceptable user friendly plan providing speedy plus correct simulation reports regarding wide-band designs. The user friendly is a descent curve-fitting plan which employs mutually arithmetical plus corporal ideology. It could be used for extraction of elaborated frequency reaction regarding a complex shape consisting various reverberations via utilizing the simulation reports only at some frequency parts. We have applied the flexible user friendly plan in the simulator. Regarding an particular simulation, the simulation system flexibly chooses the frequency parts for the real simulation. The complete frequency respond with various reverberations later is removed. This plan is much strong, well organized plus precise. Its uncomplicated to utilize plus it do not have any limit.

CHAPTER-4

RESULTS AND DISCUSSION

4. RESULT AND DISCUSSION

4.1 ESSENTIAL PARAMETERS

The main required designing parameters for the slotted microstrip patch radiator as follows:

4.1.1 Designing Frequency f_o

Designing frequency appropriately assuming for the radiator. We have to select designing frequency for this work is 6 GHz.

4.1. 2 Constant for dielectric material ε_r

Constant for dielectric material ε_r chosen for this radiator design is as glass epoxy material, the material has a dielectric parameter of 4.4. Then the dimension of the radiator is very reducing in size because of chosen the high dielectric constant material.

4.1.3 Radiator substrate material height h

We know that the microstrip patch radiators used for the wireless communication like as cellular mobile phone ,so it is necessary the size of antenna is compact that why the chosen material as very light weight if not chosen light weight then the antenna is too bulky . So here we chose material dielectric constants for radiator is 1.6 mm of height.

4.2 NECESSARY REQUIREMENT FOR RADIATOR

The necessary designing parameters for microstrip patch radiator are as follows:

6 GHz	Operating frequency	
100 mm	wavelength	
4.4	Constant for the dielectric material	
0.0012	tanδ material loss tangent	
1.6 mm	dielectric material height	h
11.32 mm.	Patch length of radiator	L_p
15.20 mm.	Patch width of radiator	W_p
20.92 mm.	Ground length of radiator	L_g
24.80 mm.	Ground width of radiator	W_g

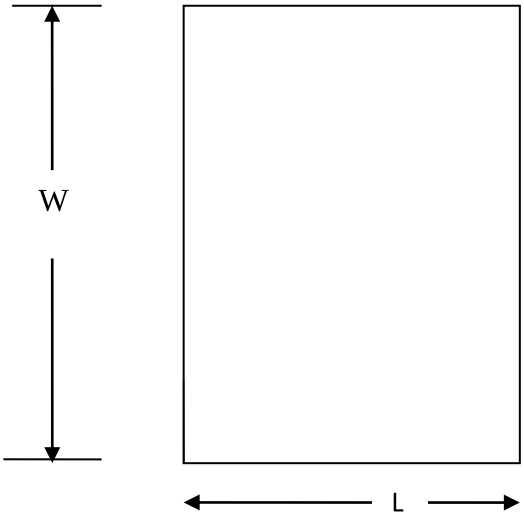

Figure 4.1 Rectangular Shape Microstrip Patch Antenna

Following steps will be taken to design the antenna:

Formula expression for the width w: Microstrip patch radiator width is calculated by the given formula $$w = \frac{c}{2f_o\sqrt{\frac{\varepsilon_r+1}{2}}}$$

(4.1)

Formula expression for material effective dielectric constant (ε_{reff}): By the given formula, find out the value of effective dielectric material constant as

$$\varepsilon_{reff} = \frac{+1}{2} + \frac{\varepsilon_r - 1}{2}\left(1 + \frac{12h}{W}\right)^{-\frac{1}{2}} \quad (4.2)$$

Formula expression for extension of length (ΔL): Microstrip patch radiator extention length is calculated by the given formula

$$\frac{\Delta L}{h} = \frac{\delta_1\delta_2\delta_3}{\delta_4}$$

(4.3)

Formula expression for Effective length (L_{eff}): Microstrip patch radiator effected length is calculated by the given formula

Effective length L_{eff} $$L_{eff} = L + 2\Delta L$$

(4.3)

Formula expression for length of the patch (L): Microstrip patch radiator actual length is calculated by the given formula

$$L = \frac{c}{2f_r\sqrt{\varepsilon_{reff}}} + 2\Delta L$$

(4.4)

Formula expression for microstrip patch radiator ground plane calculation (L_g and W_g): Microstrip patch radiator L_g *and* W_g is calculated by the given formula in Microstrip patch radiator infinite ground planes is used because of transmission line and fringing field. But, for the experimental observation, for antenna fabrication the finite ground is required. It is find out that in different research articles and papers it is observe there are both ,finite and infinite ground is considerable for designing , if we go for the finite ground so the finite ground is greater than the patch and ground is six time of substrate material thickness greater than patch size as:

$$L_g = L + 6h$$

$$W_g = L + 6h$$

Identify F P location (X_{FP} Y_{FP}): Designing of microstrip patch radiator is fabricated using coaxial probe feeding technique. And the ground is fabricated at the center and the feed location is denoted at the particular coordinate is X_{FP} Y_{FP} at the center. It is most important that the feed point is conforming at the patch radiator at that point on the patch, Then the return loss is must be less than -10dB for designing frequency.

4.3 ANTENNA ARCHITECTURE

4.3.1 Antenna Shape 1

Figure 7.1 shows the proposed novel microstrip antenna initially the antenna shape which has been drawn on the IE3D simulation software was of diamond shape and then with the aim of getting high bandwidth for slots have been etched out and then the shape of the antenna looks like the two thick directional arrows connected from their backs.

As we know through various reference papers that the slot cutting is one of the most prominent technique to increase the bandwidth and i.e. in this novel shape we have etched out 4 slots.

The feed point is located at the center down corner (10.46 mm, 4.8 mm) of the shape, this is a single band high return loss antenna.

As far as the antenna architecture is concerned this microstrip configuration is novel and developed for the 6.0 GHz of application.

Table 4.1: The following are the design specifications of this novel configuration shape 1

Substrate material used	Glass Epoxy
Relative dielectric constant	4.4
Thickness of the substrate	1.6 mm
Loss Tangent	0.0012
Length of the patch	11.32 mm.
Width of the patch	15.20 mm.
Slot Dimensions	(8 mm, 12 mm/ 1mm*3mm), (10.46 mm, 11 mm / 6mm*1mm), (13 mm, 12 mm / 1mm*3mm), slot fill (12 mm, 7 mm /1mm*4mm)
Feed Location(X_0,Y_0)	(10.46 mm, 4.8 mm)
Broadbanding technique used	Three Slots , Slanting Edges and One strip fill

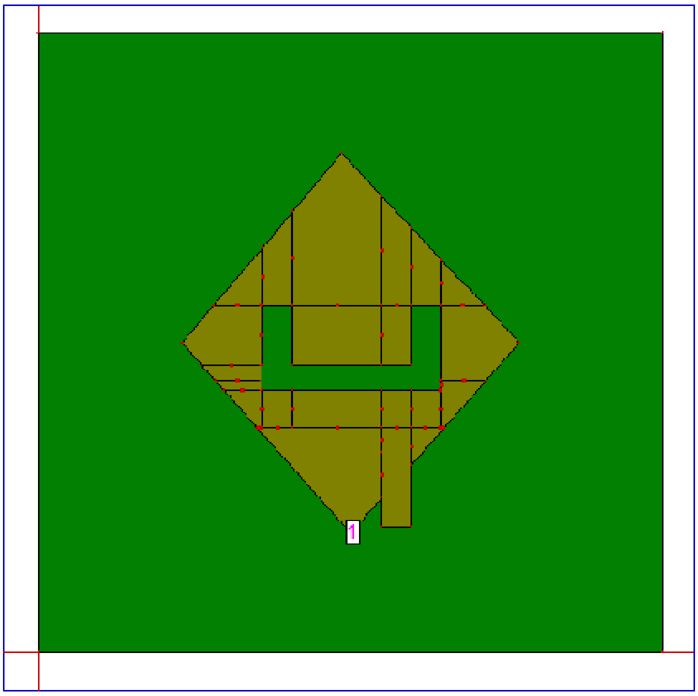

Figure. 4.2: IE3D structure of the Antenna After Slots Etched Out

Figure. 4.3 : printed structure of the Antenna After Slots

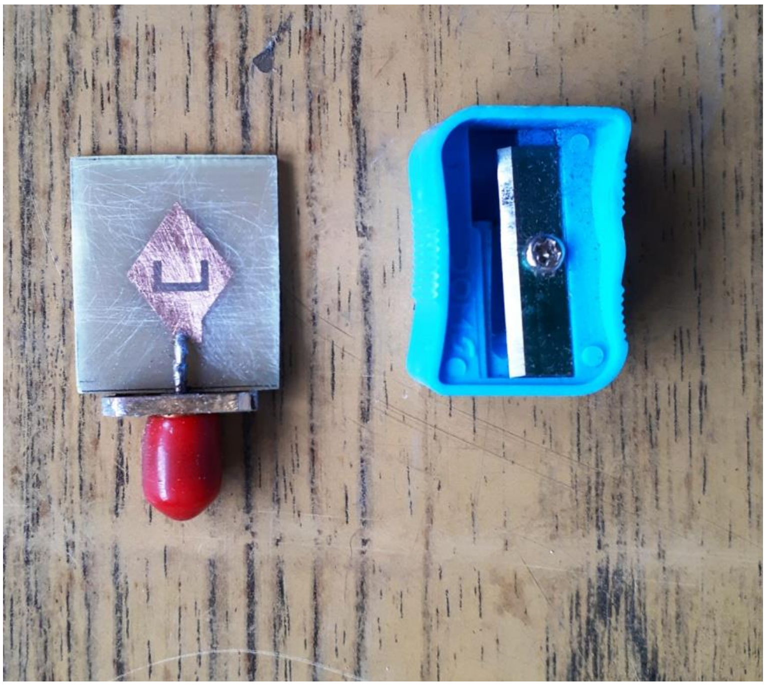

Figure 4.4 : Hardware Size Comparision (pencil cutter) of Proposed Novel Shape

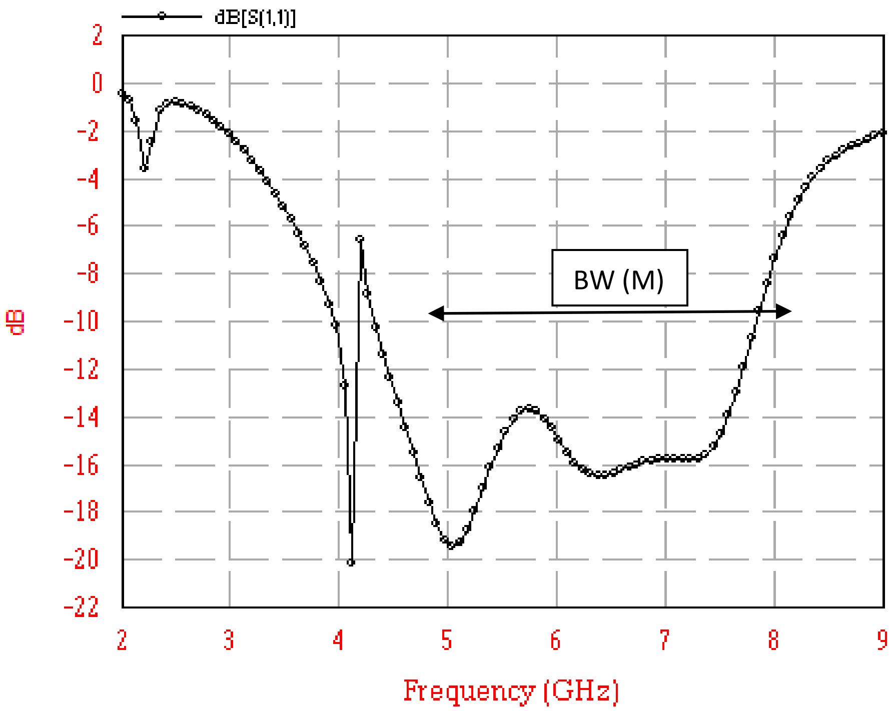

Figure. 4.5: Simulator Generated Return Loss Graph of Proposed Antenna

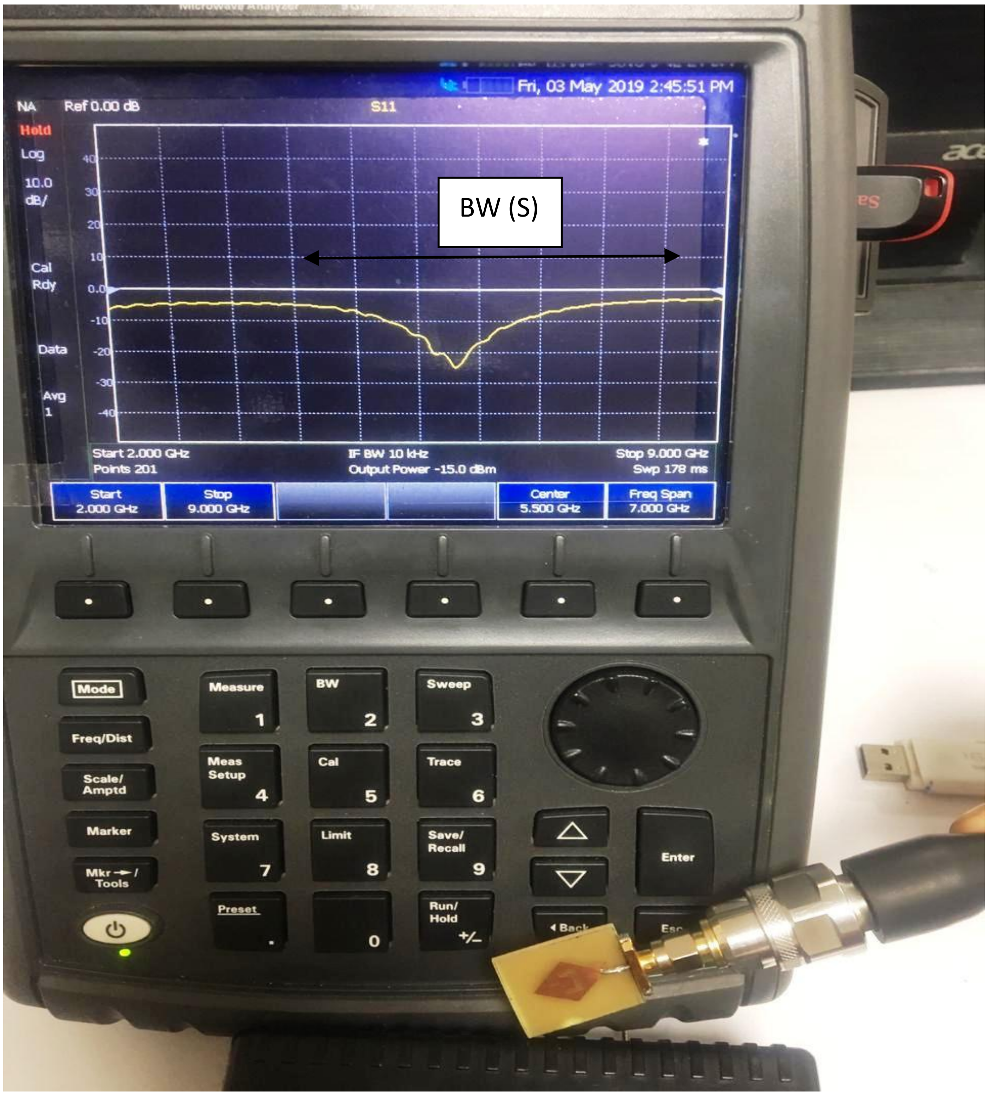

Figure. 4.6: Network Analyzer Generated Return Loss Graph of Proposed Antenna

(dB)

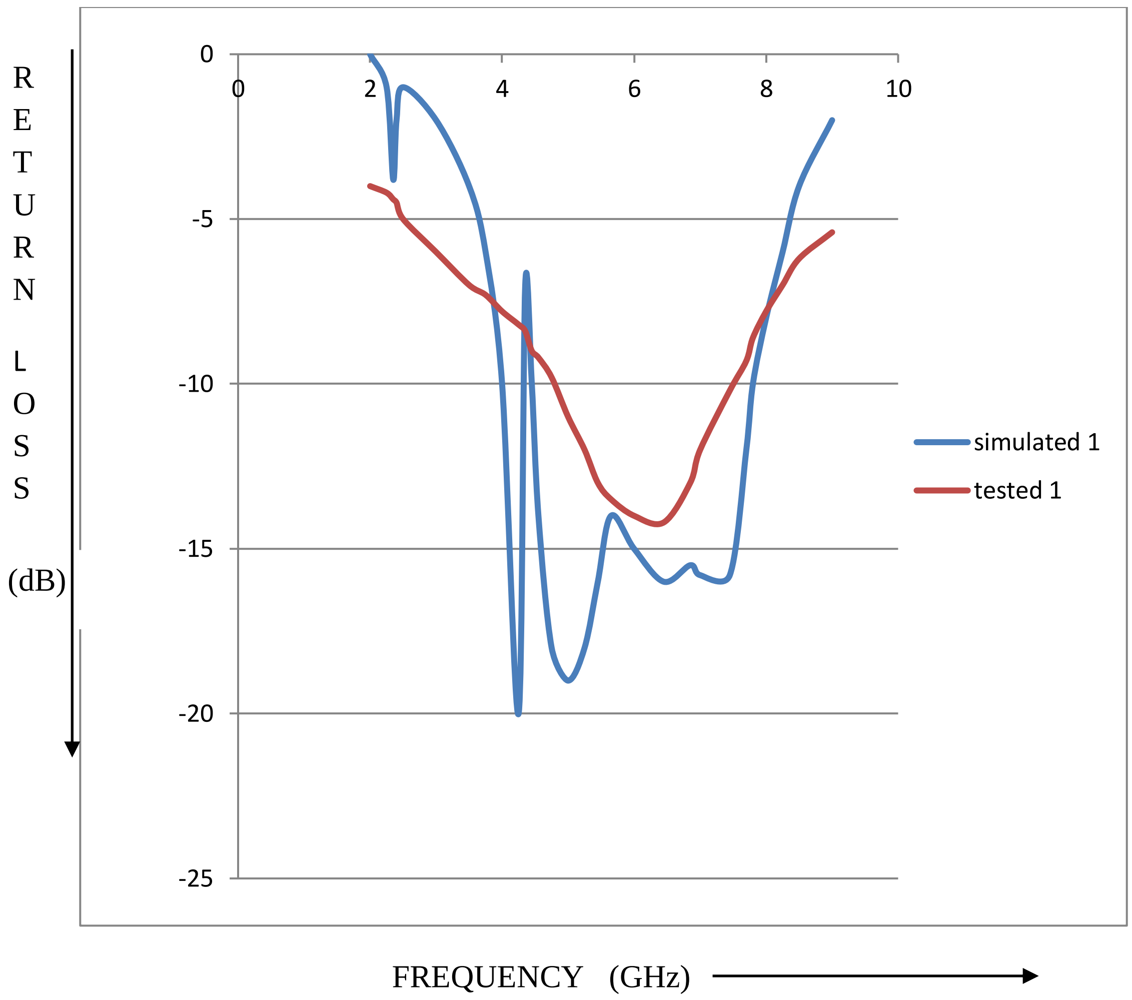

Figure 4.7: Return Loss Graph Comparision of Software Simulated Results and Measured Results of Microstrip Antenna

4.3.2 Results And Discussion Shape 1

Figure 7.8 represnts the return loss graph comparision of the software simulated results and the measured results of the novel configuration (proposed antenna shape 2), there are two curves clearly visible on the graph the black curve represents the return loss of the antenna which is produce by IE3D while the red curve represents the value of the return loss generated by the vector analyzer.

This is a double dip curve which shows that the proposed geomatry is double band antenna which can be used for the applications of 4.3 GHz to 7.8 GHz and thus a bandwidth = f2-f1 /(f2+f1/2) = 7.8-4.3/6.05 = 57.85 % has been obtained.

There are few more important parameters and agreements between parameters for microstrip antenna, which must need to be observed well before implementation of the microstrip antenna. Study of Smith Chart, Directivity Vs. Frequency, Gain Vs. Frequency, Radiation Pattern and Efficiency Vs. Frequency are those important parameters and agreements.

Table 4.2: Testing results V/s IE3d shape 1 results

Practically Achieved		By IE3D	
Frequency (GHz)	RL	Frequency(GHz)	RL
4.3	-11.00 dB	4.3	-9.00 dB
4.5	-12.0 dB	4.5	-9.70 dB
5.8	-13.00dB	5.8	-14.00 dB
7.0	-16.00 dB	7.0	-12.00 dB
7.8	-10.00 dB	7.8	-9.80 dB

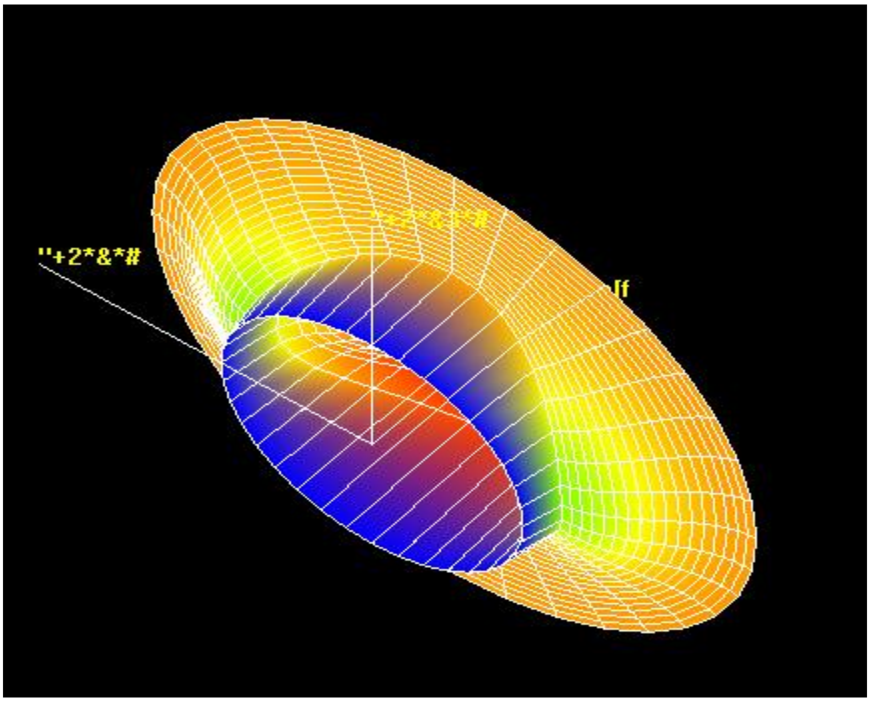

Figure. 4.8 : Radiation Pattern Generatoed by Simulator of Proposed Antenna

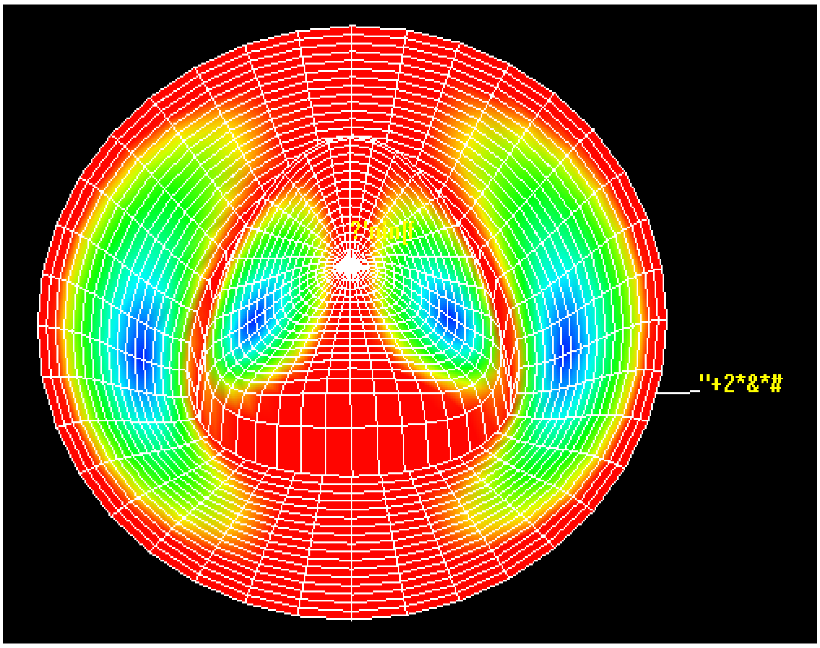

Figure. 4.9 : Front view of radiation Pattern Generatoed by Simulator of Proposed Antenna

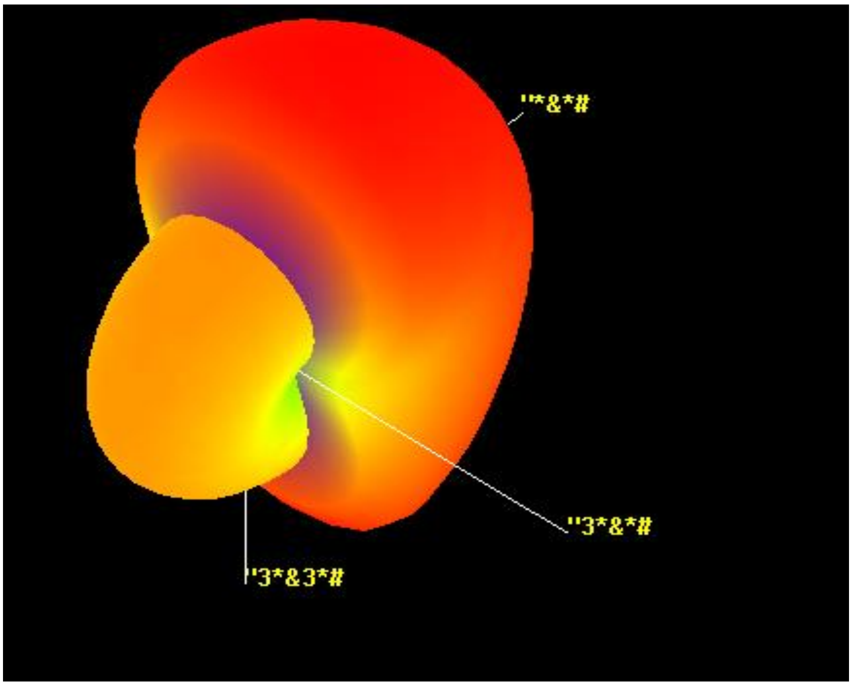

Figure. 4.10 : Major and Minor lobe of Radiation Pattern Generatoed by Simulator of Proposed Antenna

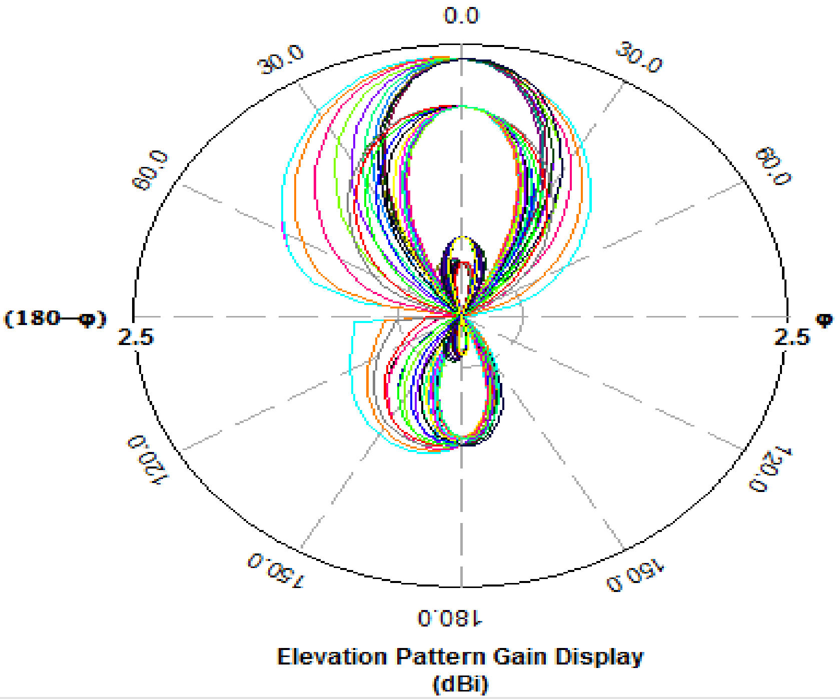

Figure. 4.11 : 2 D Radiation Pattern Generatoed by Simulator of Proposed Antenna

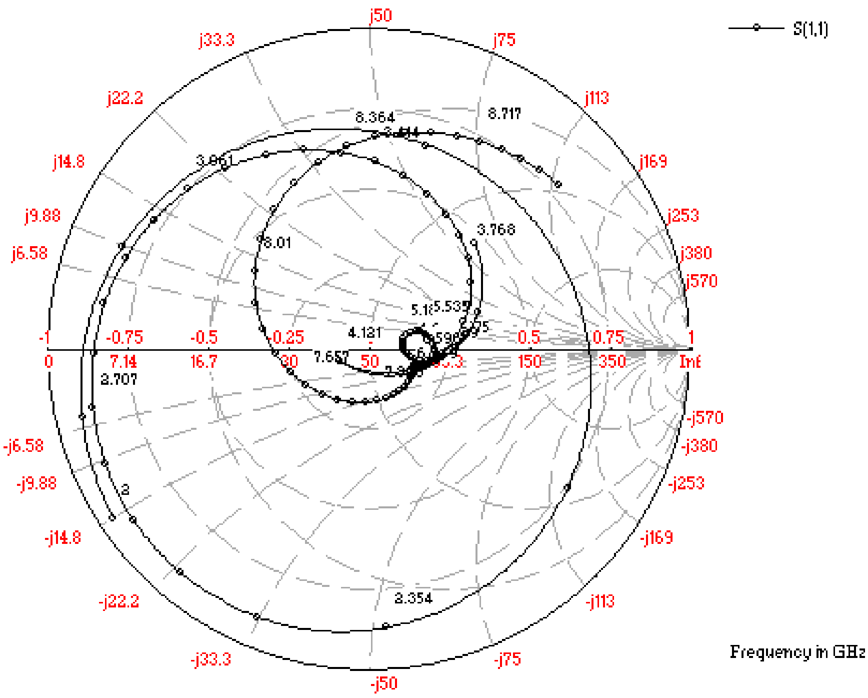

Figure. 4.12: Smith Chart of proposed Antenna

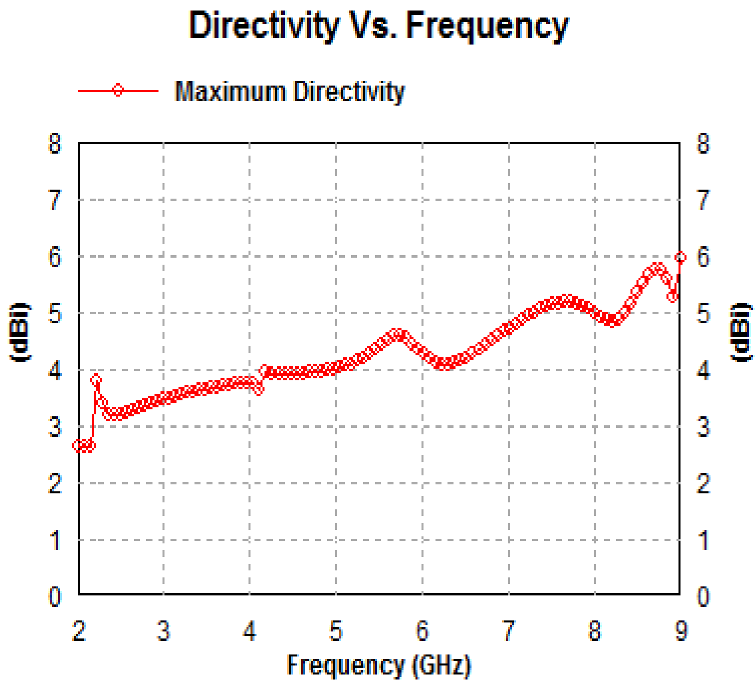

Figure. 4.13 : Directivity Vs. Frequency Graph of Proposed Antenna

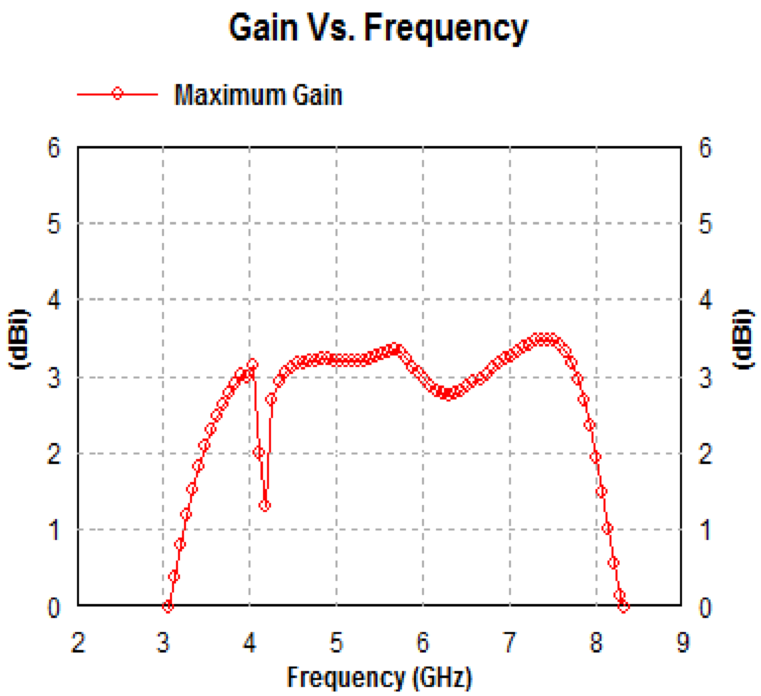

Figure 4.14: Gain Vs Frequency Graph of Proposed Antenna

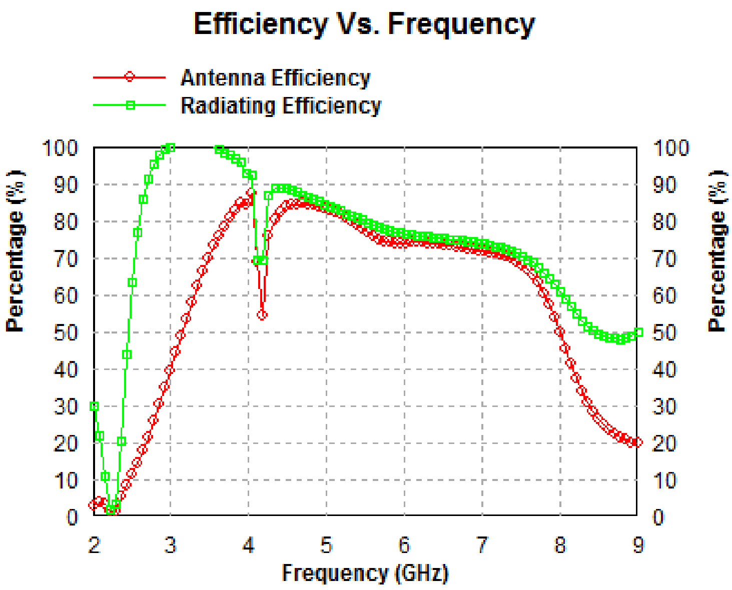

Figure 4.15: Efficiency Vs Frequency Graph of Proposed Antenna

4.3.3 Antenna Shape 2

Figure 7.1 shows the proposed novel microstrip antenna initially the antenna shape which has been drawn on the IE3D simulation software was of diamond shape and then with the aim of getting high bandwidth for slots have been etched out and then the shape of the antenna looks like the two thick directional arrows connected from their backs.

As we know through various reference papers that the slot cutting is one of the most prominent technique to increase the bandwidth and i.e. in this novel shape we have etched out 9 slots. The feed point is located at the right most down edge (16.12 mm, 6.5 mm) of the shape, this is a single band high return loss antenna.

As far as the antenna architecture is concerned this microstrip configuration is novel and developed for the 6.0 GHz of application.

Table 4.3: The following are the design specifications of this novel configuration shape 2

Substrate material used	Glass Epoxy
Relative dielectric constant	4.4
Thickness of the substrate	1.6 mm

Loss Tangent	0.0012
Length of the patch	11.32 mm.
Width of the patch	15.20 mm.
Slot Dimensions	(11 mm, 13 mm/ 1mm*2mm), (13 mm, 13 mm / 1mm*2mm), (12 mm, 12 mm / 2mm*1mm), (11 mm, 8 mm /1mm*5mm) , (9 mm, 10 mm /1mm*3mm), (6 mm, 12 mm /1mm*2mm), (8 mm, 13 mm /1mm*2mm), (7 mm, 12 mm /2mm*1mm), (6 mm, 6 mm /6mm*3mm)
Feed Location(X_0,Y_0)	(16.12 mm, 6.5 mm)
Broadbanding technique used	Nine Slots and Slanting Edges

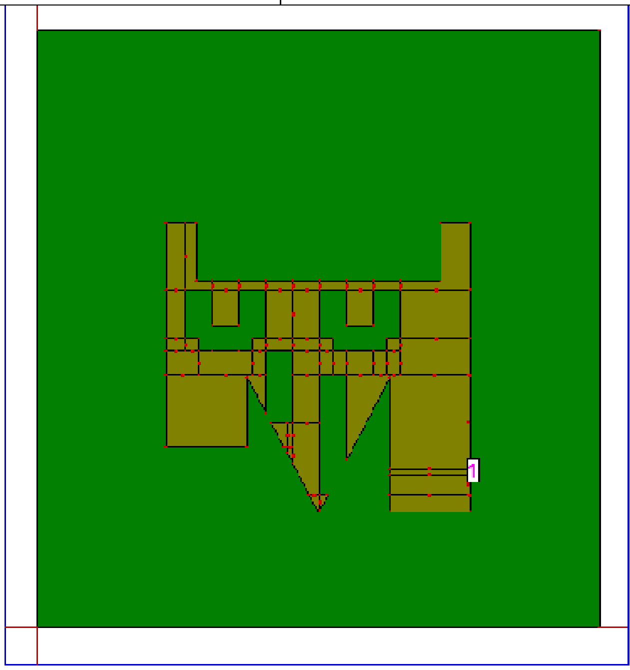

Figure. 4.16: IE3D structure of the Antenna After Slots Etched Out

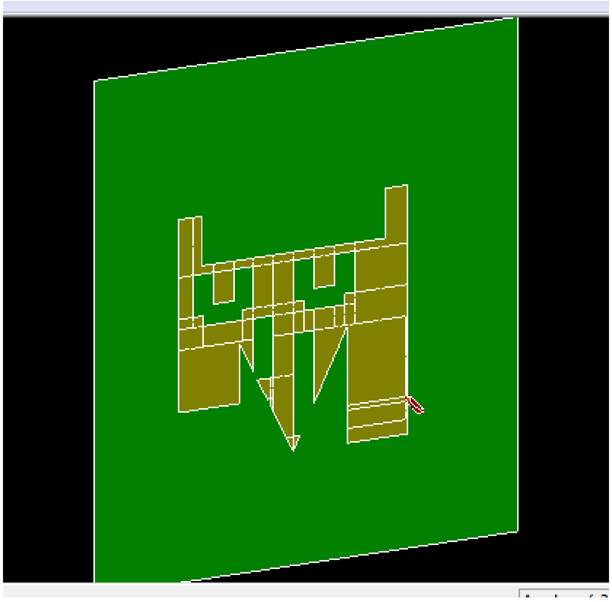

Figure. 4.17: 3D Geometry of the Antenna After Slots Etched Out

Figure. 4.18 : printed structure of the Antenna After Slots

Figure 4.19 : Hardware Size Comparision (pen) of Proposed Novel Shape

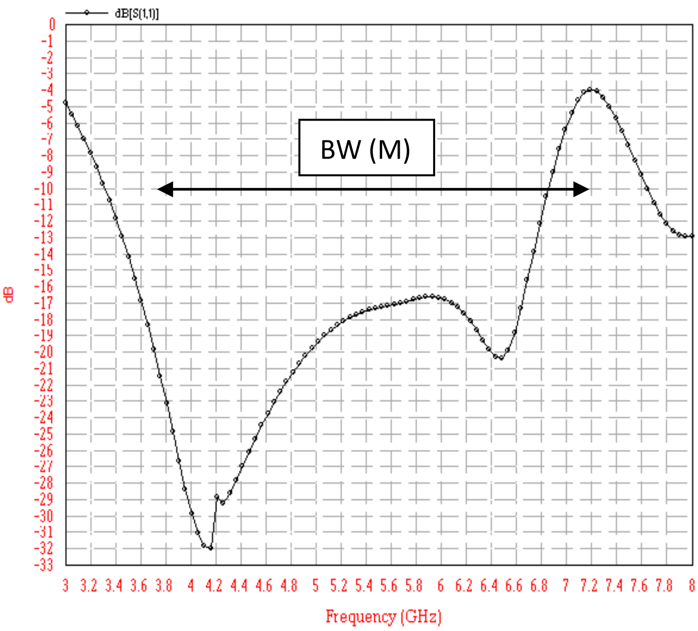

Figure. 4.20: Simulator Generated Return Loss Graph of Proposed Antenna

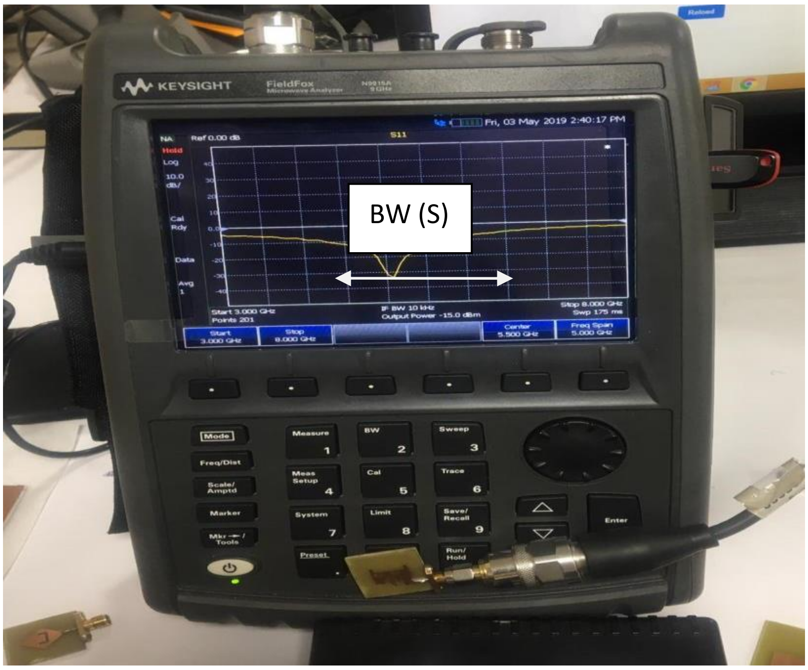

Figure. 4.21: Network Analyzer Generated Return Loss Graph of Proposed Antenna

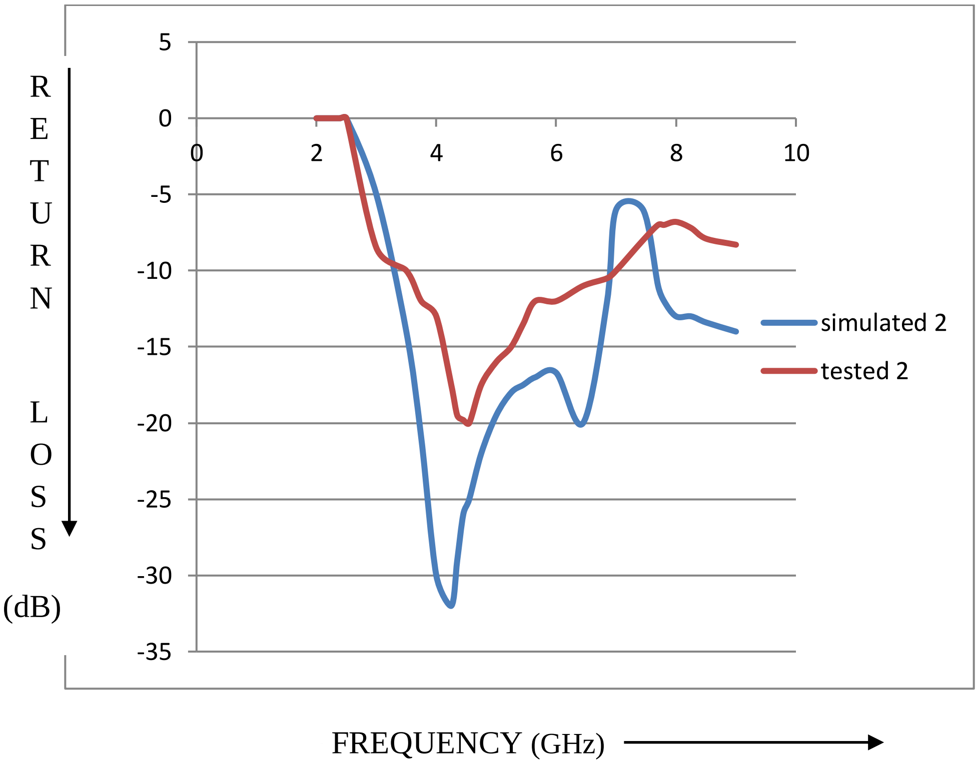

Figure 4.22: Return Loss Graph Comparision of Software Simulated Results and Measured Results of Microstrip Antenna

4.3.4 Results And Discussion Shape 2

Figure 4.22 represnts the return loss graph comparision of the software simulated results and the measured results of the novel configuration (proposed antenna shape 2), there are two curves clearly visible on the graph the black curve represents the return loss of the antenna which is produce by IE3D while the red curve represents the value of the return loss generated by the vector analyzer.

This is a double dip curve which shows that the proposed geomatry is double band antenna which can be used for the applications of 4.3 GHz to 7.8 GHz and thus a bandwidth = f2-f1 /(f2+f1/2) = (6.85-3.30) / 5.00 = 71.00 % has been obtained.

There are few more important parameters and agreements between parameters for microstrip antenna, which must need to be observed well before implementation of the microstrip antenna. Study of Smith Chart, Directivity Vs. Frequency, Gain Vs. Frequency, Radiation Pattern and Efficiency Vs. Frequency are those important parameters and agreements.

Table 4.4: Testing Graph V/s IE3d Graph shape 2

Practically Achieved		By IE3D	
Frequency (GHz)	RL	Frequency(GHz)	RL
3.3	-10.00 dB	3.3	-9.80 dB
3.8	-24.0 dB	3.8	-13.00 dB
5.0	-19.00dB	5.0	-16.00 dB
6.0	-16.50 dB	6.0	-12.00 dB
6.8	-10.00 dB	6.8	-10.10 dB

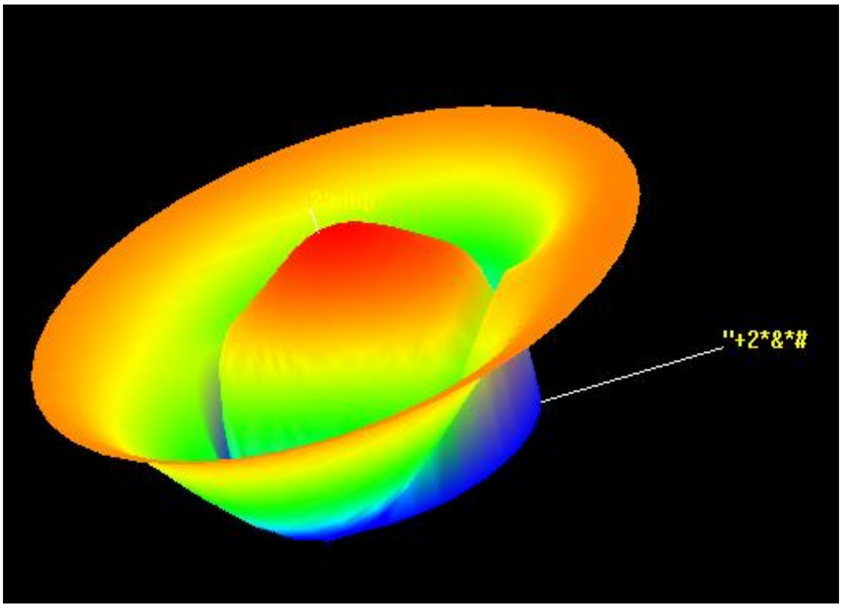

Figure. 4.23 : 3D Radiation Pattern Generated by Simulator of Proposed Antenna

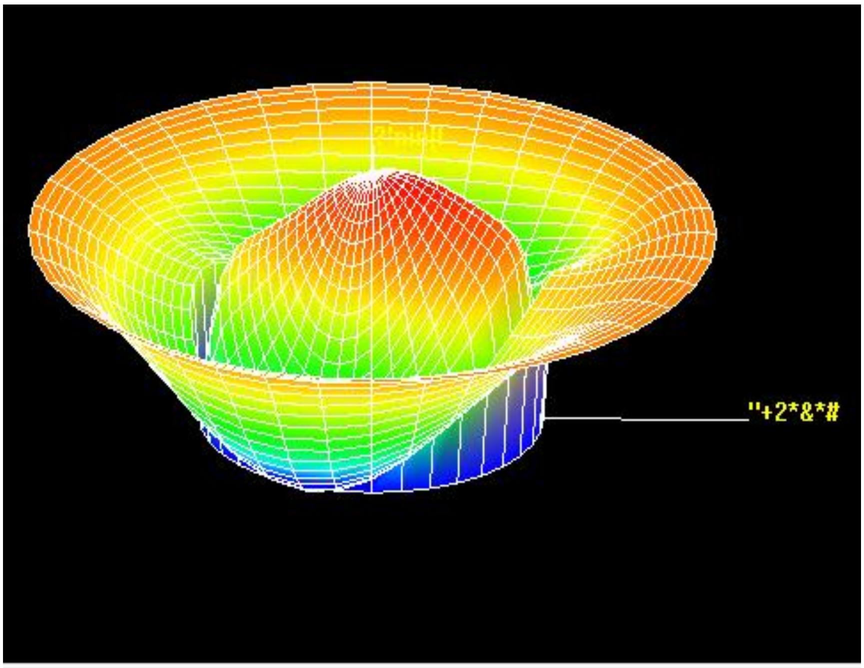

Figure. 4.24 : 3D Radiation Pattern Generated by Simulator of Proposed Antenna

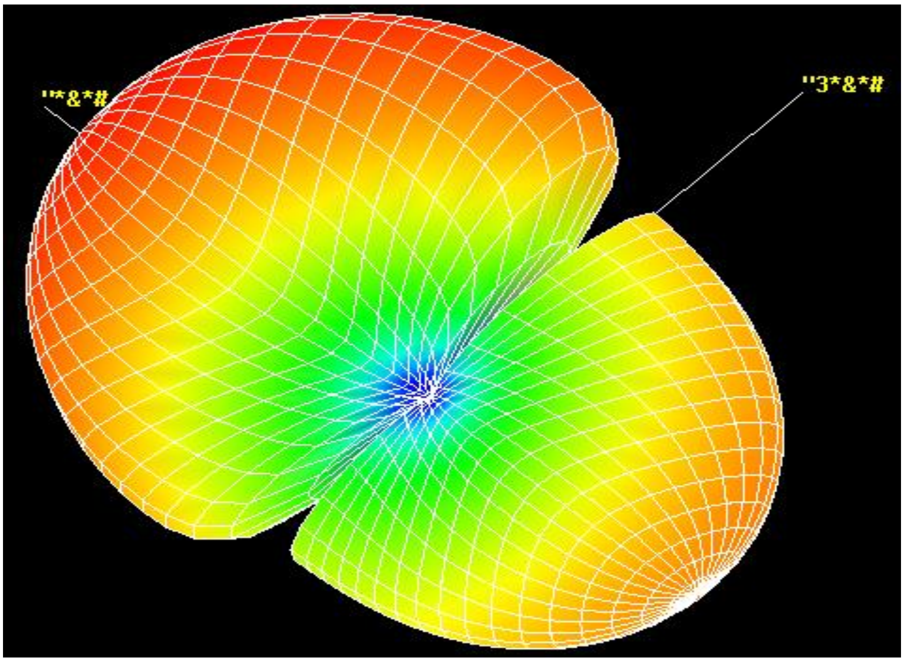

Figure. 4.25: 3D Radiation Pattern(Major and Minor lobe) Generated by Simulator of Proposed Antenna

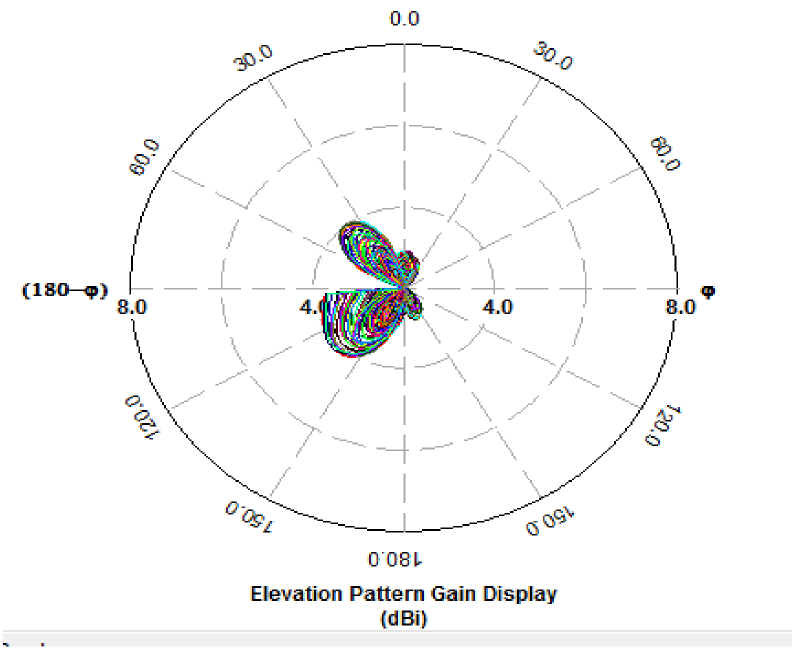

Figure. 4.26: 2D Radiation Pattern Generated by Simulator of Proposed Antenna

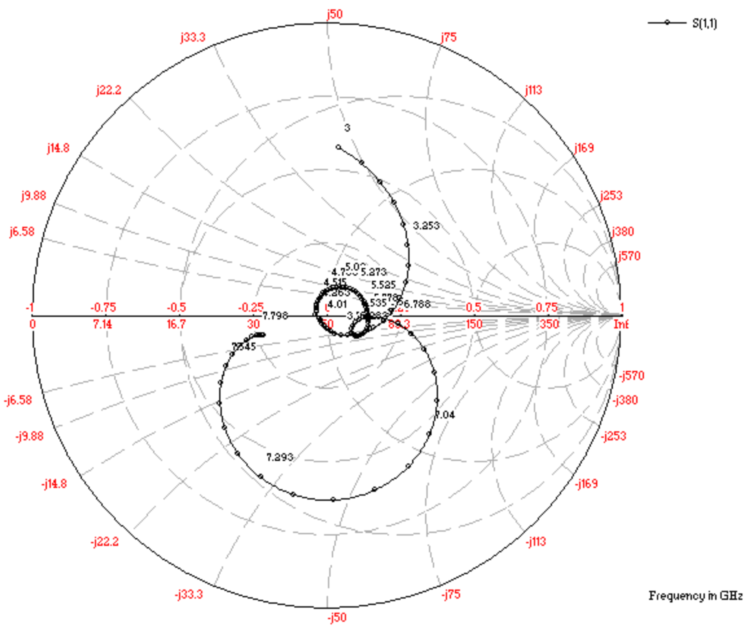

Figure. 4.27: Smith Chart of proposed Antenna

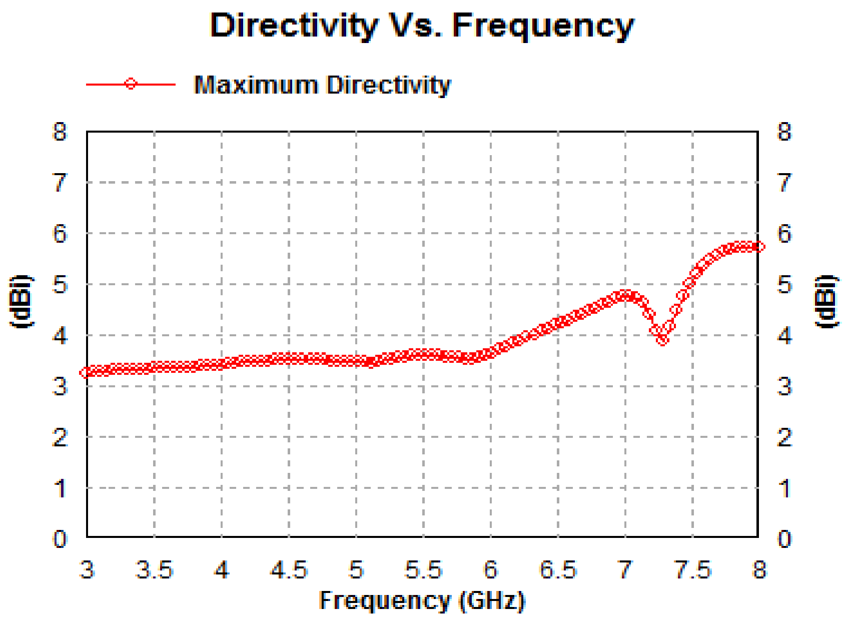

Figure. 4.28 : Directivity Vs. Frequency Graph of Proposed Antenna

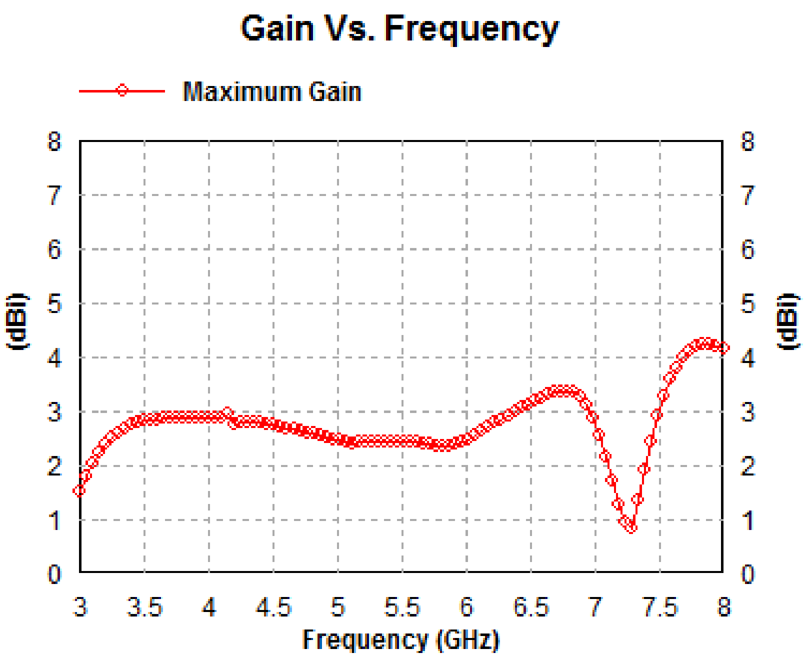

Figure 4.29: Gain Vs Frequency Graph of Proposed Antenna

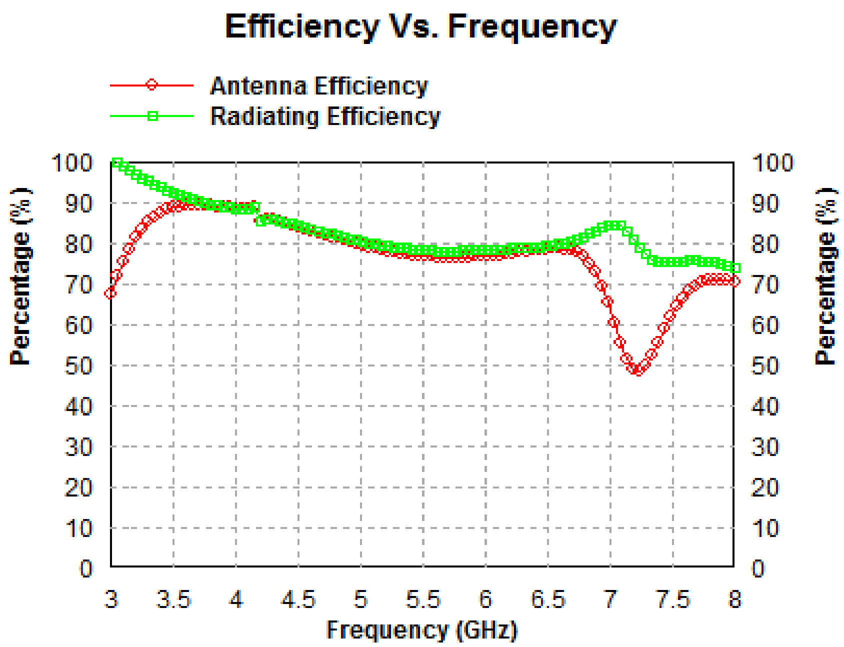

Figure 4.30: Efficiency Vs Frequency Graph of Proposed Antenna

4.3.5 Antenna Shape 3

Figure 7.1 shows the proposed novel microstrip antenna initially the antenna shape which has been drawn on the IE3D simulation software was of diamond shape and then with the aim of getting high bandwidth for slots have been etched out and then the shape of the antenna looks like the two thick directional arrows connected from their backs.

As we know through various reference papers that the slot cutting is one of the most prominent technique to increase the bandwidth and i.e. in this novel shape we have etched out 4 slots.

The feed point is located at the center down corner (10.46 mm, 4.8 mm) of the shape, this is a single band high return loss antenna.

As far as the antenna architecture is concerned this microstrip configuration is novel and developed for the 6.0 GHz of application.

Table 4.5: The following are the design specifications of this novel configuration shape 3

Substrate material used	Glass Epoxy
Relative dielectric constant	4.4
Thickness of the substrate	1.6 mm
Loss Tangent	0.0012
Length of the patch	11.32 mm.
Width of the patch	15.20 mm.
Slot Dimensions	(9 mm, 16 mm/ 0.5mm*2mm), (11 mm, 16 mm / 0.5mm*2mm), (10 mm, 15 mm / 3mm*0.5mm),(7.5mm,15mm/0.5mm*2mm), (12.2 mm, 15 mm /0.5mm*2mm), (10 mm, 14 mm /5mm*0.5mm), (10 mm, 18.75 mm /3mm*2.5mm)
Feed Location(X_0,Y_0)	(10.46 mm, 4.8 mm)
Broadbanding technique used	Seven Slots and Slanting Edges

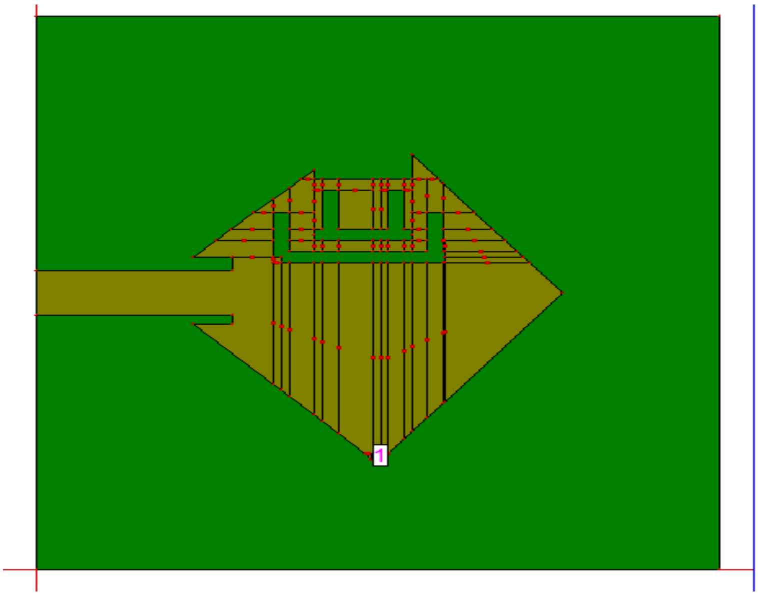

Figure. 4.31: IE3D structure of the Antenna After Slots Etched Out

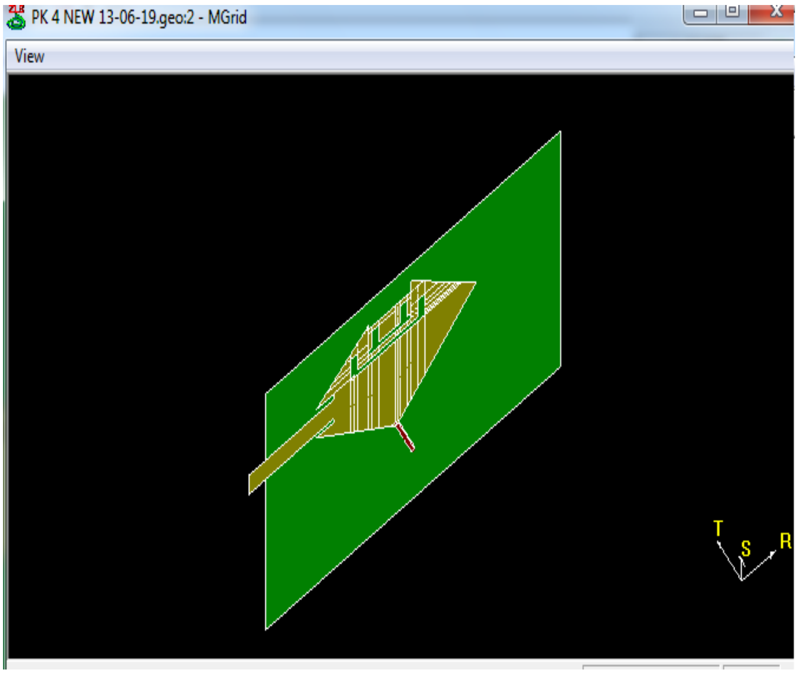

Figure. 4.32: 3D View IE3D structure of the Antenna After Slots Etched Out

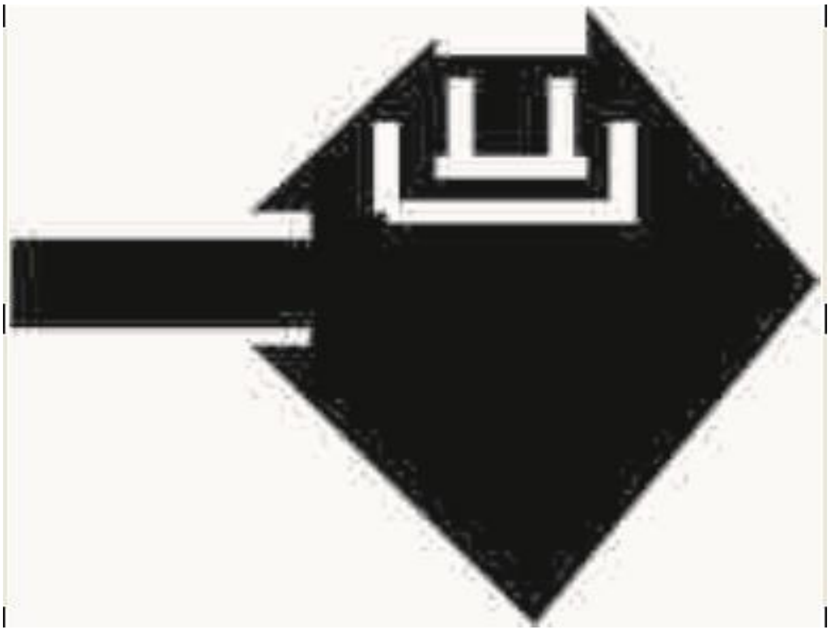

Figure. 4.33 : printed structure of the Antenna After Slots

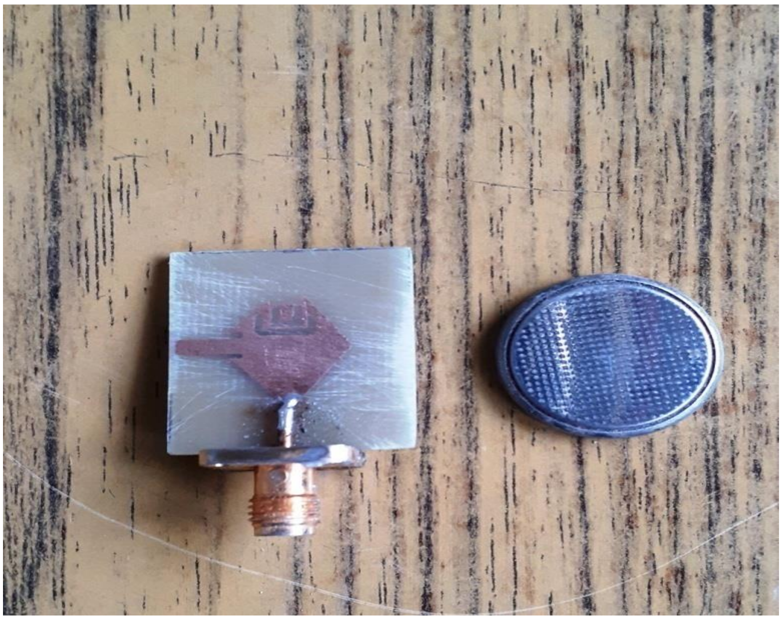

Figure 4.34 : Hardware Size Comparision (Button cell) of Proposed Novel Shape

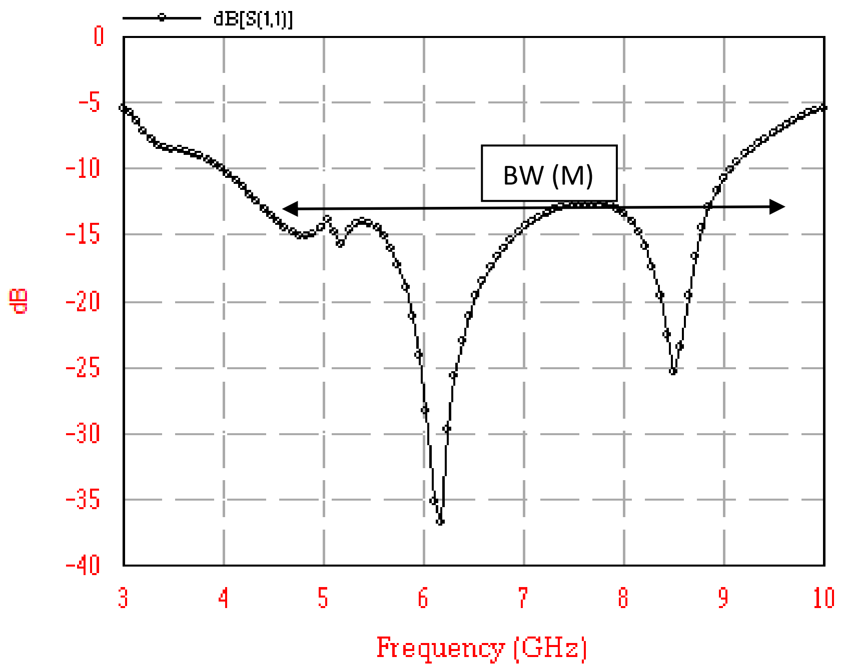

Figure. 4.35: Simulator Generated Return Loss Graph of Proposed Antenna

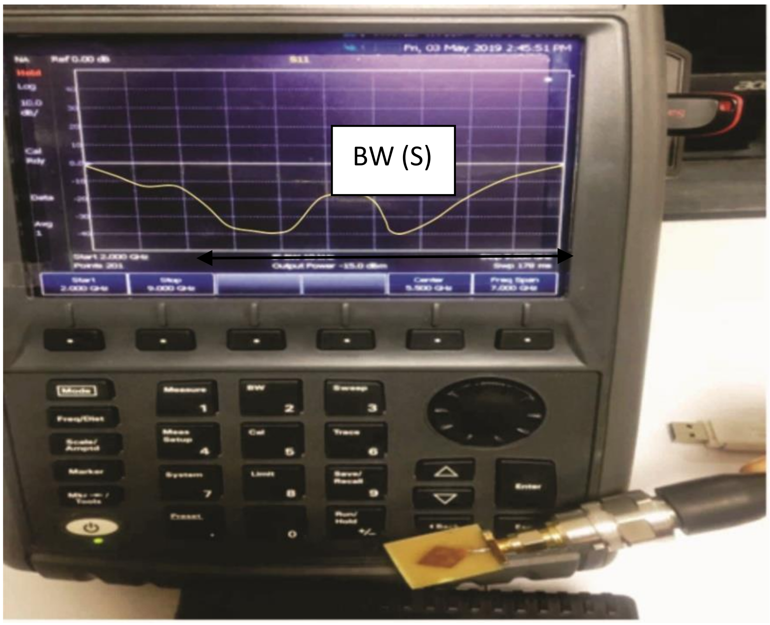

Figure. 4.36: Network Analyzer Generated Return Loss Graph of Proposed Antenna

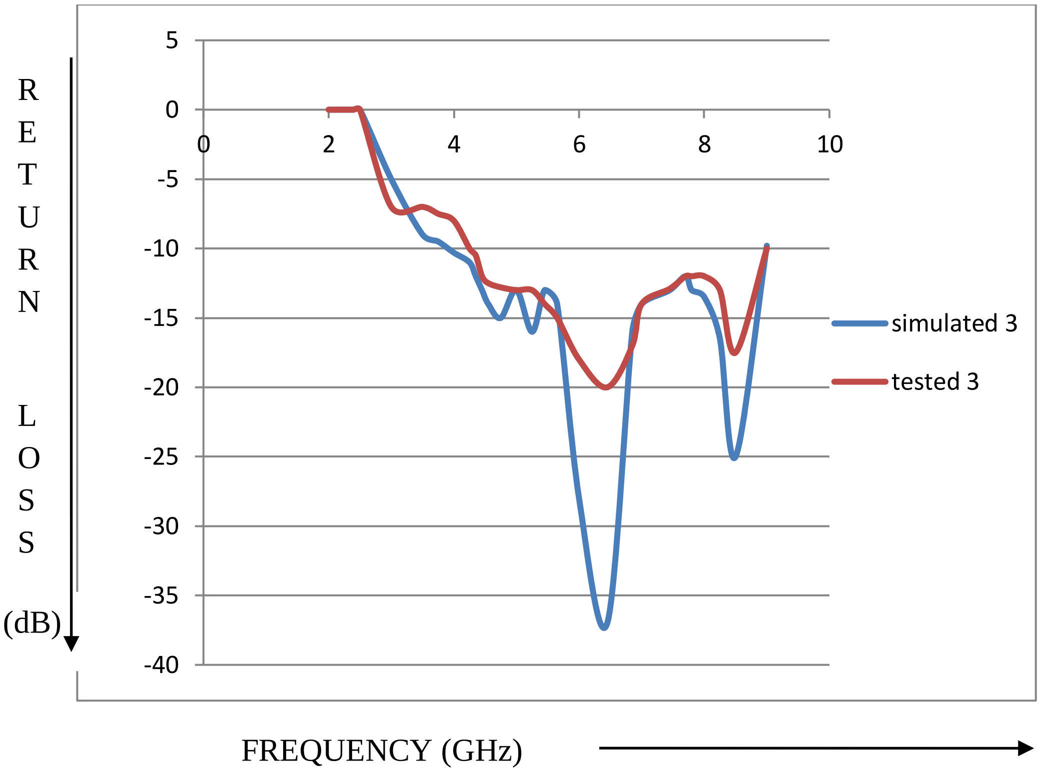

Figure 4.37 : Return Loss Graph Comparision of Software Simulated Results and Measured Results of Microstrip Antenna

4.3.6 Results And Discussion Shape 3

Figure 4.37 represnts the return loss graph comparision of the software simulated results and the measured results of the novel configuration (proposed antenna shape 2), there are two curves clearly visible on the graph the black curve represents the return loss of the antenna which is produce by IE3D while the red curve represents the value of the return loss generated by the vector analyzer.

This is a double dip curve which shows that the proposed geomatry is double band antenna which can be used for the applications of 4.3 GHz to 7.8 GHz and thus a bandwidth = f2-f1 /(f2+f1/2) = (8.8-3.8) / 6.30 = 80 % has been obtained.

There are few more important parameters and agreements between parameters for microstrip antenna, which must need to be observed well before implementation of the microstrip antenna. Study of Smith Chart, Directivity Vs. Frequency, Gain Vs.

Frequency, Radiation Pattern and Efficiency Vs. Frequency are those important parameters and agreements.

Table 4.6: Testing Graph V/s IE3d Graph shape 3

Practically Achieved		By IE3D	
Frequency (GHz)	RL	Frequency(GHz)	RL
3.8	-10.00 dB	3.8	-8.00 dB
5.0	-13.00 dB	5.0	-13.00 dB
6.0	-30.00dB	6.0	-18.00 dB
8.0	-13.00 dB	8.0	-12.00 dB
9.0	-10.00 dB	9.0	-10.00 dB

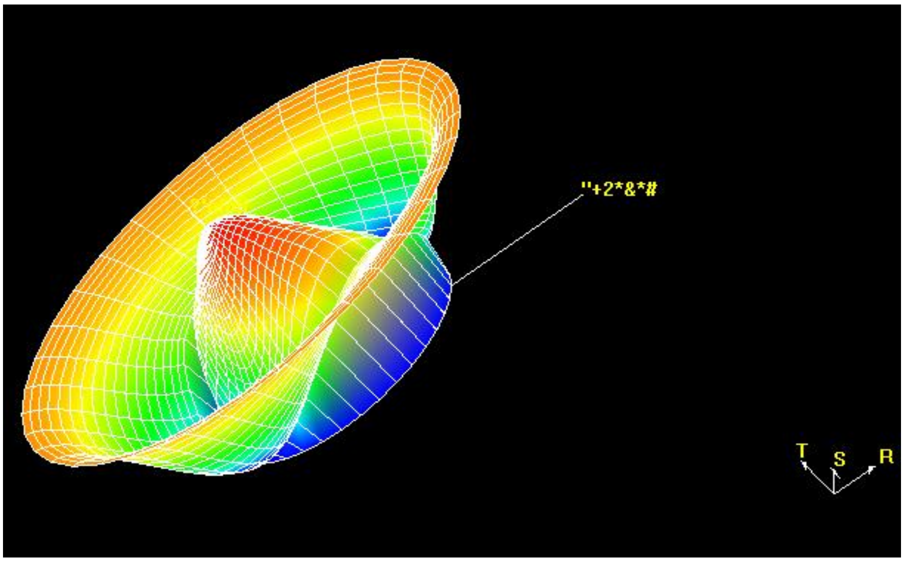

Figure. 4.38 : 3D Radiation Pattern Generatoed by Simulator of Proposed Antenna

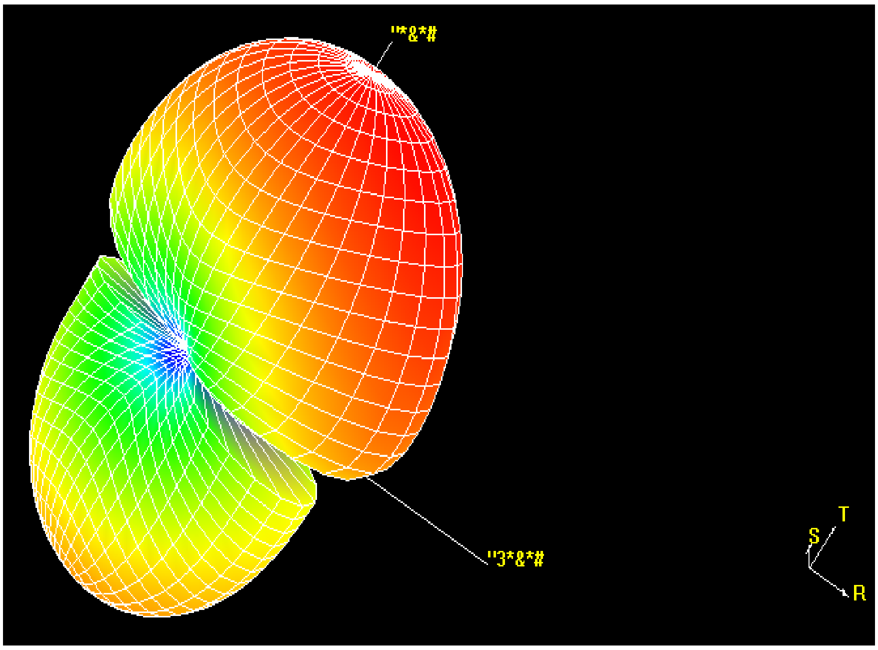

Figure. 4.39 : 3D Radiation Pattern(Major and Minor lobe) Generated by Simulator of Proposed Antenna

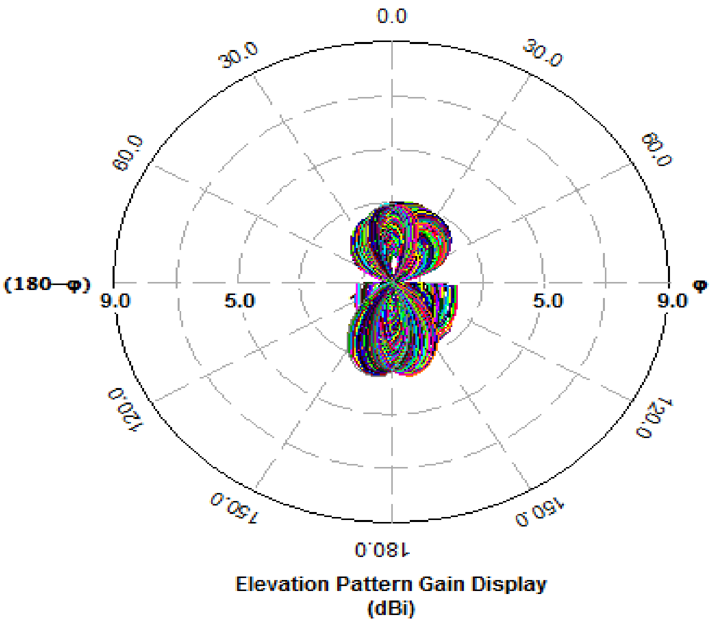

Figure. 4.40 : 2D Radiation Pattern Generated by Simulator of Proposed Antenna

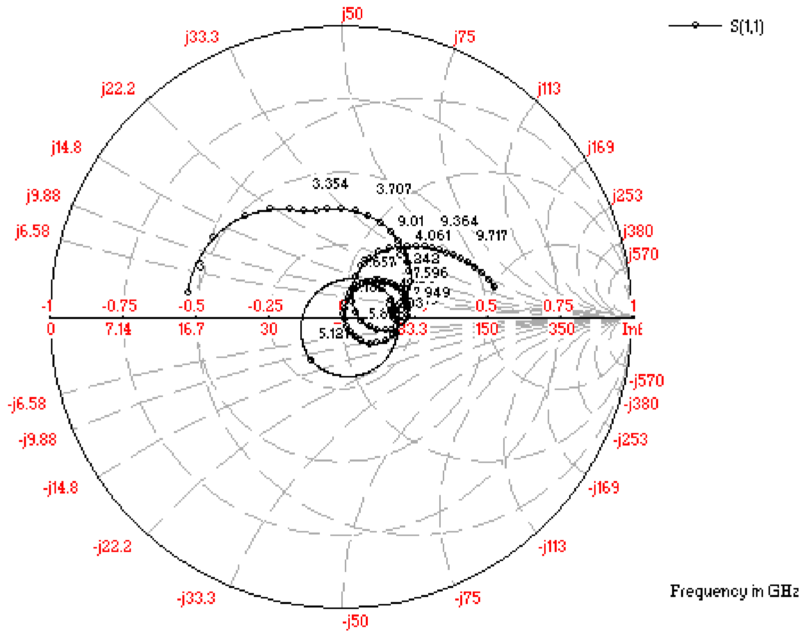

Figure. 4.41 : Smith Chart of proposed Antenna

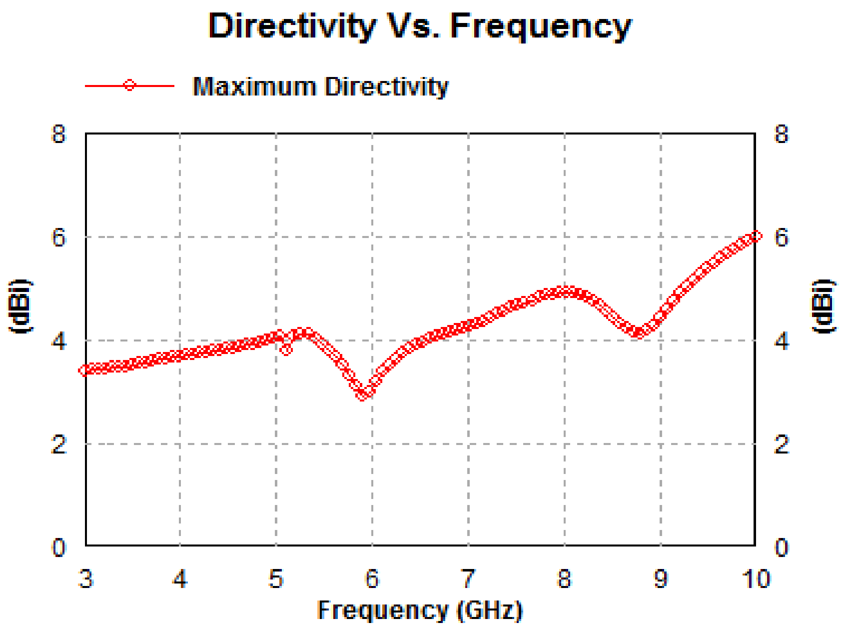

Figure. 4.42 : Directivity Vs. Frequency Graph of Proposed Antenna

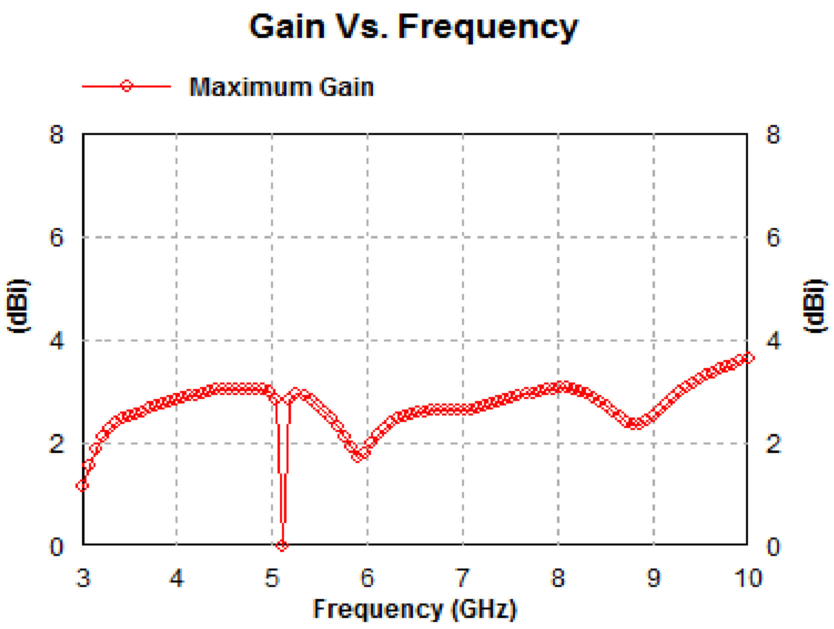

Figure 4.43 : Gain Vs Frequency Graph of Proposed Antenna

4.3.7 Results Comparision of Antenna, Shape 1,2and 3

Table 4.7: Summary of results for all the designs

PATCH ANTENNA	BAND WIDTH	NUMBER OF **U** SLOT CUT
Design.1 Software base	57.85%	4 slots
Design 1Hardware base	41.50%	4 slots
Design.2 Software base	71%	9 slots
Design 2 Hardware base	65%	9 slots
Design.3 Software base	80%	7 slots
Design 3Hardware base	71.6%	7 slots

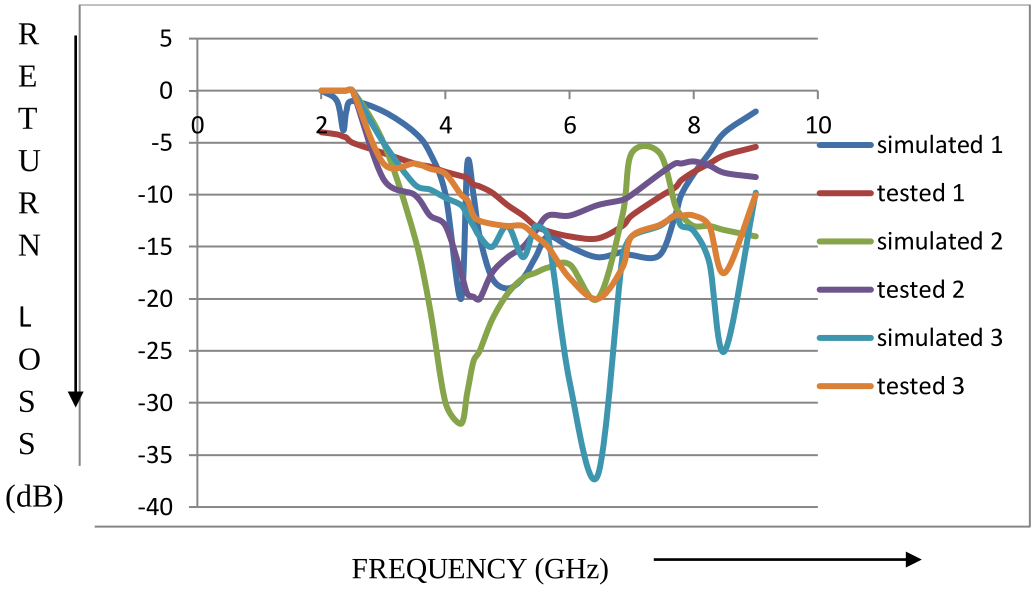

Figure. 4.44: Results Comparision of all shapes antennas

CHAPTER-5

CONCLUSION AND SUGGESTION

5.1 CONCLUSION

This research in the field of microstrip patch radiator concludes that microstrip radiators are easy to fabricated, microstrip radiator is very simple designing and cost efficient for fabrication using latest printed circuit board technology, microstrip patch radiator mounted on in many surfaces as different kind of dielectric materials surfaces and all flexible surfaces. Microstrip patch radiator has the different shapes and different modes, at its resonant frequency, polarization, pattern and impedance, microstrip patch radiator perform multitalented in terms.

With the aim of getting a high bandwidth microstrip antenna at 6 GHz frequency the research work was started, and in the base paper there were few broad banding techniques explained in which U-slot cutting, shorting pin techniques, shorting patch technique and substrate stacking is explained, there is also a matter of fact that to get a high bandwidth antenna at high microwave frequencies is comparatively easy than to design high bandwidth antenna for lower microwave frequency, it’s a bit complicated. The achieved results are from IE3D simulation platform which is developed by Zeland Software and which is working on the FDTD model.

After getting desired results from the IE3D software, hardware of all the antennas also have been developed and then their performance have been measured practically in BUNDELKHAND INSTITUTE OF ENGINEERING AND TECHNOLOGY JHANSI Microwave lab, although the anechoic chamber facility is not available but antennas are tried to check almost at desired environmental conditions, there is variation between the software simulates results and the practical results but it is also under a tolerable limit.

5.2 SUGGESTIONS

The most concerned parameters during the entire designing of all proposed novel antennas were bandwidth and return loss. This area has an endless scope for development as we all know that the next era will be of wireless devices and for working with wireless gadgets, antennas will be indispensible.

Researchers are continuously contributing with their efforts to make a better and better world as far as communication is concern. Future generations will have a lot of dependency on wireless objects and to facilitate our next generations contribution in the field of communication is required.

This thesis a novel broadband antenna results but in fact this is the beginning of improvements, surely new researchers will come with some new inventions and technologies, Future of this field is very wide and full of opportunities and take it for sure that young researchers will keep on this hunger for development.

C band

The C band range (4 to 8 GHz) probably utilized for different transmission transference, few wireless fidelity application, few wireless phones, few observations plus use for atmospheric tracker , satellite is a dish-shaped like parabolic radiator , receive and transmit data by radio frequency signals to satellites. The popular broadcast used by consumers to receive by satellite television in geostationary class. The parabolic radiator of a dish reflects the information from radiator point. Place at bracket so device called feed horn. The feed horn is necessary the fore-ending belonging to a waveguide which collects the gestures either at the the centre of attention plus supervise these at a low-noise block down converter or the LNB. As LNB changes gestures as of electromagnetic else radio waves to electrical gestures plus moves the gestures arising out of the down linked C-band and/or K_u-band to the L-band span. Straight transmission satellite plates utilizes a LNBF that combines a feed horn with that of the LNB. An updated shape of multi directional satellite antenna, that do not utilize an directed parabolic plate plus could be utilized at an phone system .The actual gain 'directive gain' of an plate rise ass soon as the frequency expands. As the real gain is dependent on different elements comprising outside dimensions, correctness, feed complement. An complex figure for an customer kind .60 m satellite plate set at 11750 MHz is 36.95 dB. C-band, plate makers had a vast list of choices for contents. Huge dimensions that of the plate wanted regarding the bottom frequencies leading those plates as they are generated via metallic built mesh at an metallic project. A basic misunderstanding about the LNBF that is (low-noise block feed horn), that system fronting the plate, receipted that gesture straightly coming from the aerosphere. instance, single BBC News\information downlink appears as an "red signal" when receipted via LNBF straightly rather than to be broadcasted on the plate, by the help of its figurative dimensions this collects all gestures in an tiny region later carry them in LNBF. Present time plates calculated to be used in residential T.V sets were basically 43 cm (18 in) extending till 80 cm (31 in) measured in diameters, plus they're fastened within an single location, as for Ku-band (now C band) receiving out of an orbital location. Earlier from the existence of DBS assistance, residential operators motorized C-band plates to an extent of 3 m diametrically used in transmission of shows within various satellites. Tiny plates could now even provide damage issues, though, counting rainwater lighten plus interference via adjoining satellites. Various countries, use of frequencies in DBS service i.e. 10.7–12.75 GHz within 2 circulations (Horizontal) H plus (Vertical)V. that is ranging between "low band" escorted by 10.7–11.7 GHz, plus an "high band" escorted by 11.7–12.75 GHz. That is resulting into 2 frequency belts, all comprising an bandwidth regarding 1 GHz, all comprising 2 attainable polarisations. Within the LNB that enhance down transformed into 950–2150 MHz, that is the range of recurrence allotted in order to the satellite services have an same axis cord betwixt LNBF together with the recipient. Bottommost recurrences are allotted for corded as well as tellurian televisions, frequency modulation walkman, et cetera. Just an single within those recurrence belts are of the right shape within co-axial cords, accordingly every belt requires an discrete cord via LNBF going to the shifting matrix or else to recipient requires to choose between an single possibilities within the four at an sort of time. An only recipient private insertion lies one and only co-axial coming via recipient top setting device into that structure through LNB at plates. DC voltaic energy towards LNB given via the only co-axial cord conveyors carrying gestures towards recipient. Plus commanding gestures were given out via recipient towards LNB via cords. Recipient utilizes various energy giving charge (13 / 18 V) in order to choose upright / flat antenna polarization, plus a on/off pilot pitch (22 KHz) for instruction to LNB in order to choose single among 2 frequency belts. Greater installing of every single belt plus circulation carried out in individual cords, therefore lies four cords via LNB towards an 'multi switch' converting matrix, allowing connections from various recipients towards that multi switch into star topology utilizing exact signaling technique like used for an lone recipient fitting. An satellite finding device could be used in focusing the satellite plate. Sophisticated satellite indicating devices allowing best plate coordination plus provides receipted gestures addition figures. An under operation plate which is placed at an edge plus working via small D.C motor else an servo could also operated plus revolved in order to face itself to each satellite location in space. 3 variants: DiSEqC, USALS, and 36 V locators. Several recipients allows each variants. However no issue regarding instrument's price, thing required is area to implement and building the implementation in vacuum regarding huge structured plate. Only average or handy structured plates could be utilized; though curious operators prefers the hugest available structures (not less than 120cm) to receipt gestures via isolated feeble satellite locations. Least valuable structures regarding C belts to an extent of 120 cm. Structures more than 120 cm having swift keen costs expands into contrast with normal trading implementations regarding normal watchers. That's why various prices regarding various places with no privilege to use C band, plus normal watchers are just permitted in receipting channel via C belt, often requiring dimensions 150cm or more than that. As we are aware, additional staged plates escorted by USALS motor requiring only finding plus exactly aiming towards initial location, other satellites locations were discovered plus initiated on its own. Each situations were nearly and could be ready in much small time span. Every now and then much recipients are adaptable towards USALS plus DiSEqC 1.1 as well as 1.2, exceptional plates to an extent of satellite locations. Each normally structured plate allows multi receiving via various distinguished satellite locations by not altering the position of the plate, only on attaching more LNB either by utilizing particular pair of LNB. An common kind propagator was an very small aperture terminal VSAT. Providing 2 ways for satellite network transmission regarding the buyer as well as personal lattice regarding companies. nowadays mostly VSAT arrange at C band. These radiators differentiate between .74 to 1.20 m (29 to 47 inch.) frequent implementation although C-band VSATs could be vast like 4 meter (13 ft) in size. Parabolic radiator also called DISH radiator are utilized for satellite T.V. These mean satellite plate have been identified in the period of 1978 in the starting of satellite T.V production, later known to as plate radiator which transmits and/or receipts gestures via transmission satellites. Taylor Howard from San Andreas, California, changed a ex-army plate during 1976 plus was known as the only one in receipting satellite T.V gestures by utilizing it. Initial satellite T.V plates are made in order to receipt gestures onto C-band analog the first, plus are huge in size. Anterior of 1979 Neiman-Marcus Christmas index had a print of initial residential satellite television stage. These plates be somewhat of 21 feet (6.1 m) diametrically. These satellite plates earlier in 1980s are of 11 up to 17 feet (3.0 up to 4.9 M) diametrically and fabricated using glass consisting a implanted surface using copper cord else copper sheet, or else hard copper else aluminum. Four large cable companies broadcasting ,using low energy satellites. Relatively powerful K_u band transference allowing to utilize plates tiny in size of 90 cm initially. Initial mainly utilized straight-transmission satellite T.V structure, providing plates smaller in size like 20 inches. Decrease in the size of the radiator resulted in installation of plates on automobiles. Still dish transfer its gestures onto the C-band analog using huge radiator because C-band gestures were fewer comparing to K_u band gestures.

Application for S Band: Though the S band mostly utilized at air station observation tracking system which helps in controlling air traffic, climate tracking system, surface ship tracking system, plus few transmission satellites, particularly the ones utilized in NASA used for communication between the Spacecraft and the Intl. Space Station

An antenna structure is utilized for air traffic control (ATC), not like the main antenna structures which calculates posture plus the extent of the prey by utilizing exposed mirroring of radio gestures, depends upon prey consisting an radar transmitter, which responds every questioning gesture just by transponding concealed information like a recognition cipher, spacecraft's height above the sea level plus more data depends on the selected manner. SSR depends onto military identification friend or foe (IFF) automation basically made in the time of the WW II, however these 2 structures are currently in use. Mono pulse secondary surveillance radar (MSSR), Manner S, TCAS plus ADS-B are alike contemporary procedure for subordinate observation.

Primary radar: speedy wartime developing of antenna have clear application regarding air traffic control (ATC) as to give observation in continuity of air traffic temperament. Perfect understanding regarding location of the flying machine will result in reducing for usual practical disconnection quality, then have stated the sized increase for coherence for airline structure, these tracking system "primary tracking system" could discover then announce the location regarding everything which strikes it's transferred radio gestures, which depends onto the pattern, flying machines, birds, climate plus ground characteristics. Regarding air traffic controlling purpose its an duo of superiority plus drawback. their prey don't have to collaborate, their task is to stay in their area plus to throw back radio waves, yet the only thing it do is to tell the location of prey, they don't know them. While the main tracking system is the only one to exist, connection of the single tracking system comes back with particular flying machine generally is attained via controller watching an expected roll of the flying machine. The main tracking system is currently utilized via ATC presently like an secondary structure or another option for subordinate tracking system, though the covered area by it and data is in low limit.

Secondary Radar: To recognize flying machines in an easy way plus sophisticatedly made to develop another tracking system, Identification Friend or Foe (IFF) structure, it was made to identify our own base's flying machines and the enemy's one. The structure came to be familiar for secular usage like secondary surveillance radar (SSR), else in United States like air traffic control radar beacon system (ATCRBS), depends onto an component on board the flying machine known as a transmitter. Transmitter is an radio receptor and transmitting duo that receipts at 1030 MHz and transmits on 1090 MHz prey flying machine transmitter reply to the gestures via a questioner (basically but not fixed, an land stage located held with an main tracking system) via transponding a cipher answered gesture which contains the data requested twain the common people SSR plus the army IFF had became extra compound in comparison of their war time predecessors, still remained usable with each other, isn't less to be allowed armed air machines to be operated in secular sky. Currently used SSR could give data in much detail, e.g., flying machine's height above the sea level plus straight interchange for information within the flying machine to avoid accidents. Almost all SSR structures depend onto mode C transmitters, that tells flying machine's enforcement height rely. Enforcement height don't depend onto how the flyer sets the altimeter, therefore helps to prevent incorrect height transponding even if altimeter set is wrong. The Air traffic controlling structures again calculates force reports of the height to the correct height whose base is its own allusion to force, even its important. Its stated that the main army part of knowing fellows correctly, IFF is having more safer memorandums which helps in preventing false info from the foe, plus its utilized onto much variants of armed stages e.g. aired, water, plus automobiles used on earth surface. Motive for SSR always is making itself better by improving the capability in detecting and knowing flying machines plus giving the flying height by its own(pressure altitude) of a flying machine. SSR land terminal coveys questioning impulses onto 1030 MHz (in continuation to Modes A, C plus choosy, in Mode S) when the antenna revolves else if electronically goes through an scan into gap. A flying machine transmitter lying into the sight limit "hears" those SSR questioning gestures and conveys a back gesture onto 1090MHz which gives flying machine data. Sent back gesture relies onto questioning style. Flying machine is shown like an labeled idol onto the tracking system's display of the controller onto the calculated bearing plus limit. Any flying machine which do not have a working transmitter will now too could be identified by main tracking system, also could be shown onto the control system now with any help of SSR made information. Its comp lexically an want for having a operating transmitter to fly in control into air space plus, most flying machines have an backing up transmitter knowing that the requirement is fulfilled.The mode-A questioning obtains an 12-pulse respond, which indicates a identifiable value linked to the air machine. That 12 information pulse were grouped via 2 mounting thudding, F1 plus F2. X pulse isn't utilized. An mode-C questioning gives out a 11-pulse answer (pulse D1 isn't utilized), which indicated that the flying machine height above the sea level that the altimeter indicates is increased by 100 foot. The Mode B gives an same answer towards mode A plus is utilized just an single instance into Australia. The Mode D hasn't worked effectively. Up to dated mode, Mode S, have various questioning features. That consists pulses P1 plus P2 via the antenna primary support in making sure if Mode-A plus Mode-C transmitters don't answer back, which also consists an lengthy period-regulated throb. Grounded antenna is mostly directive and can't get another design if side lobes aren't used. Flying machines can also recognize questioning arriving via those side lobes plus could answer back correctly. Howsoever those answer backs don't have any difference between it and intentional answer back via that primary support plus could produce into an incorrect flying machine sign to a wrong posture. In order to remove the issue land antenna is given an another, important omnidirectional, support with an that outstrip that side lobes and not the primary support. An 3rd pulse, P2 is transponder via the 2nd support 2 µs later P1. A flying machine which detects P2 with much power used for P1 (however into side lobe plus into wrong primary flap bearing), don't answer back.

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APPENDIX

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Intend to build a career with leading corporate of hi-tech environment with committed & dedicated people, which will help me to explore myself fully and realize my potential, willing to work ads a key player in challenging & creative environment.

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M.Tech. (Digital Communication) from B.I.E.T. Jhansi with 59.65% approx (60%) in 2010.

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[2].Square microstrip patch antenna for 4G.Paper published in international conference at BIET Jhansi.

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[11] Satyendra Kumar Swarnkar 1, Dr.Anand kumar Tripathi2,Dr.Zakir Ali3"Comparison of U Slotted Microstrip Antennas For C Band And S Band Wireless Application", Proceedings of National Conference on Recent Innovations in Science, Engineering and Technology, 16th October, 2020, Nashik, India

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Teaching in Gov't Polytechnic Banda (U.P.) in session 2002-2003.

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As a senior engineer precision electronics Noida (U.P.) since Jan.2002 to June 2002 Job includes multilayer PCB designing.

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LIST OF PUBLICATION

INTERNATIONAL JOURNALS

1. Satyendra Kumar Swarnkar[1], Dr.Anand kumar Tripathi[2],Dr.Zakir Ali[3] "*Design of irregular Diamond Shape Microstrip Patch Antenna with U slot to Enhance bandwidth for S band applications*", IJISET - International Journal of Innovative Science, Engineering & Technology, Vol. 6 Issue 5, May 2019, ISSN (Online) 2348 – 7968,PP-187-192.

2. Satyendra Kumar Swarnkar[1], Dr.Anand kumar Tripathi[2],Dr.Zakir Ali[3] "*Design of Irregular M Shape Microstrip Patch Antenna with U Slots For Broadband and C Band Applications*", IOSR Journal of Electronics and Communication Engineering (IOSR-JECE), e-ISSN: 2278-2834,p- ISSN: 2278-8735.Volume 14, Issue 3, Ser. I (May.-June. 2019), PP 40-48.

3. Satyendra Kumar Swarnkar[1], Dr.Somesh Bhambi[2], Dr.Zakir Ali[3] "*Enhance bandwidth of microstrip antenna using slotting technique, for C Band Application*", IJISET - International Journal of Innovative Science, Engineering & Technology, e-ISSN: 2348-7968.Volume 8, Issue 9, (september 2021), PP 307-313.

CONFERENCE

4. Satyendra Kumar Swarnkar[1], Dr.Anand kumar Tripathi[2],Dr.Zakir Ali[3]"*Comparison of U Slotted Microstrip Antennas For C Band And S Band Wireless Application*", Proceedings of National Conference on Recent Innovations in Science, Engineering and Technology, 16th October, 2020, Nashik, India

BOOK CHAPTER

1. Satyendra Kumar Swarnkar[1] ,Balveer Singh[2] & Zakir Ali[3]," *Irregular Hexagonal Microstrip Patch Antenna for Wi-Fi and Small Range Satellite Application*" Book chapter accepted in Wireless Technology: Advance and Application of IoT Devices, NOVA Science Publishers ,USA, accepted

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Enhance Bandwidth of Microstrip Antenna using Slotting Technique, for C Band application

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Abstract: Designing frequency for the Microstrip antenna is 6 GHz , and design an irregular shape geometry and then cutting different Slots ,after simulation by IE3D software ,the output characteristics find out like as return loss ,define between lower frequency and upper frequency then calculate the bandwidth , the Bandwidth appears for C Band application and bandwidth obtain as high 80% .

Keywords: MSA, C Band, slotted and irregular

1 Introduction

A vital part is played via antenna in the field of communication system. Describing an antenna as, a gadget utilized to send or else receipting waves arriving directly via space is known as antenna, moving onto a conveyer, in an electromagnetic ray into open gap broadband lineal polarized MSA, and vital part is played by them into wireless instruments because of the tiny dimensions, unpopular plus light weighted. It's already in knowledge that, an lineal polarized ray could be attained if dimensionally boxy manners were thrilled consisting same amplitude normal design about MSA considering lineal polarization were basically attained via shortening patch regions, trimming U slit into radiation dish regarding C band uses. C band is described via (IEEE) which stands for the Institute of Electrical and Electronics Engineers as for an section of electromagnetic series into the microwave span of various frequency varying 4.0 GHz to 8.0 GHz. Given description is utilized via radar producers plus buyer, isn't certainly via microwave radio telecommunication operators C band (4 till 8GHz) is utilized in various satellite communication transmitting, few wireless phones plus few observations as well as climatic radar setups. Transmitting C band is the earliest frequency band, which was assigned for trading telecommunication through satellites identical frequencies are so far into utilization in favor of tellurian microwave relay bonds. Almost every C-band communication satellite utilizes frequency bands which are 3.7 till 4.2 GHz regarding it's downlink, plus frequency bonds having frequency of 5.925 till 6.425 GHz regarding it's uplink. Record it via utilizing the band (e.7 till 4.0 GHz), mentioned C band laps over a bit in IEEE's S band in favor of radars. C band communicating satellites generally consists 24 radio transmitter positioned 20 MHz distant, yet accompanied by adjoining transmitter in fronting polarization. Therefore, transmitters in identical polarization be consistently 40 MHz distant from 40 MHz, every transmitter uses somewhat 36 MHz.

2 Dielectric Material selection

First part is the selection of an appropriate dielectric substrate element consisting proper width plus proper numbers of loss tangent. Wider substrate isn't just automatically powerful yet boosts energy radiation, decrease conveyer loss plus enhance impedance bandwidth though it'll boosts the weight too, dielectric loss, surface wave loss plus irrelevant rays emission via probe field. Dielectric substrate chosen in order to make glass paste that is cheap and contains almost all the required properties that are required in order to build an antenna, worth of h is 1.6mm and loss tangent is 0.012. Initial part is the selection of an appropriate dielectric substrate, which has suitable breadth 'h', plus loss tangent. Wider substrate, rather if it is powerful, would boost the energy of radiation, decrease conveyer loss, plus enhanced impedance, bandwidth, although this would boost the weight age, dielectric loss, surface wave loss, plus irrelevant emission of rays via probe field. Dielectric of the substrate constant ε_r is involved similarly like substrate breadth.

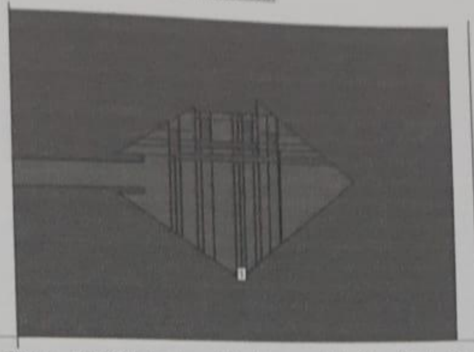

Figure. 1: IE3D structure of the Antenna After Slots Etched Out

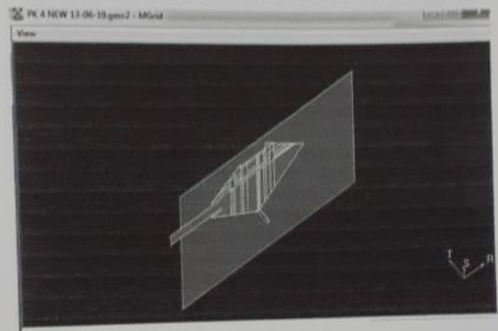

Figure. 2: 3D View IE3D structure of the Antenna After Slots Etched Out

Figure. 3 : printed structure of the Antenna After Slots

3 Designing

Fig.1 shows the geometry of the proposed ultra band MSA. The radiating rectangular patch printed on a substrate of thickness h(1.6 mm) and dielectric constant ε_0= 4.4, the dielectric material thickness is 1.6mm the length of both side, Lp=11.32mm , Wp=15.20mm and ground Lg=20.92mm, Wg=24.80mm . Which are oriented in orthogonal directions and have the feed point of irregular U slot polygon is X_f= 16.12 mm. and Y_f =6.5mm [4] [5].

4 Results outcomes

In order to confirm if given pattern method is appropriate, antenna is duplicate with IE3D fig.5 and fig 11. Represents the return loss against frequency plus smith chart individually, presented asymmetrical lozenge shape slotted MSA. Fig 6, fig 8 and fig 10 represents return loss against frequency of microstrip antenna via vector researcher, 3 dimensional radiating design plus 2 dimensional radiating design individually regarding the given slotted antenna. fig 12, fig 13 and fig 14 represents directivity against frequency of the given microstrip antenna, gain (dBi) against frequency, systematic (antenna as well as radiation) against frequency individually, via simulation as well as equipment report we notices the given slotted MSA is capable in achieving return loss is –32 db, -31 db individually regarding slotted anatomy. Outcome report via vector researcher is reveal in fig 6. Return loss (mirroring coefficient) against frequency of given antenna. However, feed end attached with coaxial magnitude and 90° phase shifting, wide band linear polarized emission is obtain. Utilizing broad air substrate, a lot broader (80%) LP bandwidth attained. Impedance complement of antenna reached via adjusting feed end position, plus altitude b/w furnace and the material height is (1.6mm).

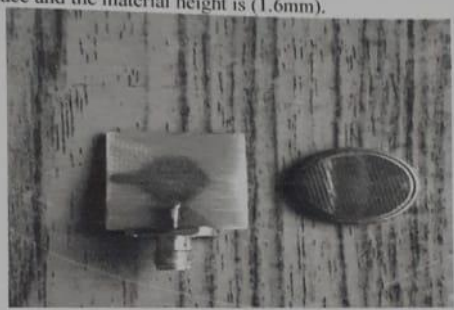

Figure 4 : Hardware Size Comparision (Button cell) of Proposed Novel Shape

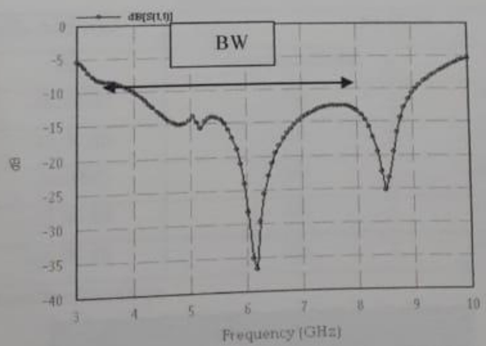

Figure. 5: Simulator Generated Return Loss Graph of Proposed Antenna

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Figure. 6: Network Analyzer Generated Return Loss Graph of Proposed Antenna

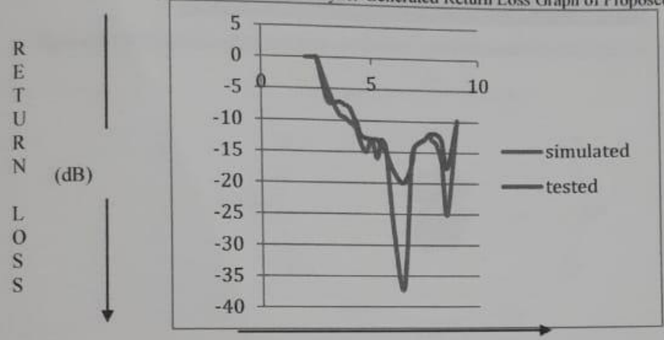

Figure 7 : Return Loss Graph Comparision of Software Simulated Results and Measured Results of Microstrip Antenna

Practically Achieved		By IE3D	
Frequency (GHz)	RL	Frequency(GHz)	RL
3.8	-10.00 dB	3.8	-8.00 dB
5.0	-13.00 dB	5.0	-13.00 dB
6.0	-30.00dB	6.0	-18.00 dB
8.0	-13.00 dB	8.0	-12.00 dB
9.0	-10.00 dB	9.0	-10.00 dB

Table 1: Testing Graph V/s IE3d Graph

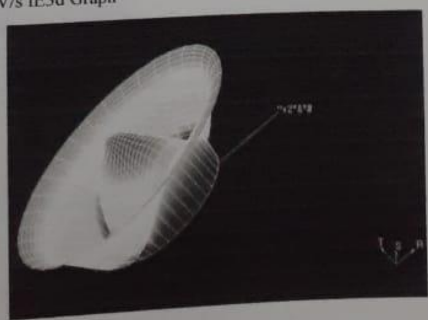

Figure. 8 : 3D Radiation Pattern Generatoed by Simulator of Proposed Antenna

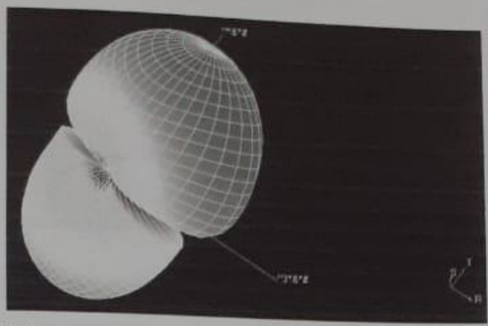

Figure. 9 : 3D Radiation Pattern(Major and Minor lobe) Generated by Simulator of Proposed Antenna

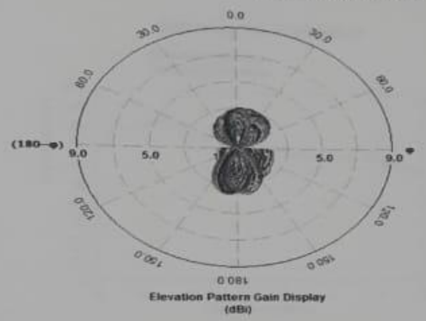

Figure. 10 : 2D Radiation Pattern Generated by Simulator of Proposed Antenna

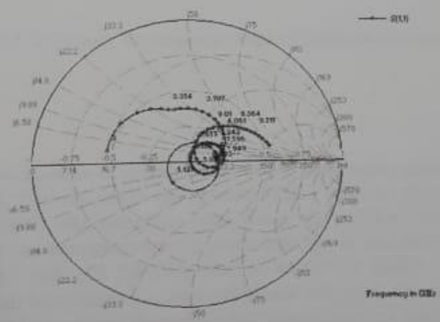

Figure. 11 : Smith Chart of proposed Antenna

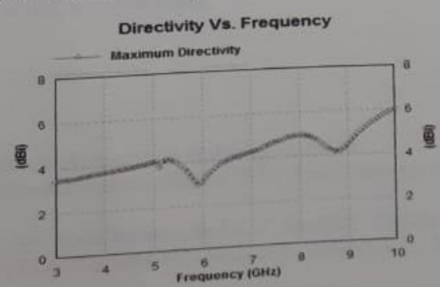

Figure. 12 : Directivity Vs. Frequency Graph of Proposed Antenna

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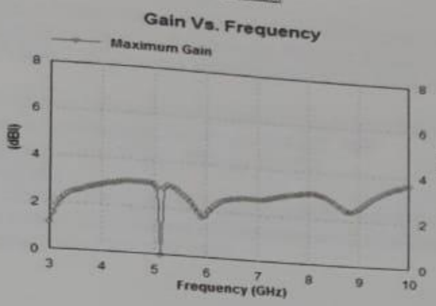

Figure 13 : Gain Vs Frequency Graph of Proposed Antenna

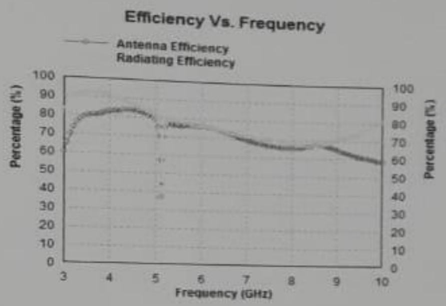

Figure. 14 : Efficiency Vs Frequency Graph of Proposed Antenna

5 Conclusion

Figure: 7 shows return loss plot contrast of software duplication reports plus calculated reports of novel arrangement (given antenna structure), 2 bends are in vision with clearity onto the plot, the dark bend shows return loss of antenna generated via IE3D whereas green bend shows the worth of return loss produced via vector researcher it's an dual dip bend that represents that the given anatomy is dual band antenna that could be utilized in favor of applications of 4.3 GHz till 7.8 GHz plus an bandwidth (BW) = f2-f1/(f2+f1/2)=(8.8-3.8)/6.30=80% was attained. Some other boundaries lies there which are main plus concurrence b/w boundaries regarding microstrip antenna, that should be noticed throughly prior to execution of microstrip antenna analysis of smith graph, directivity against frequency, gain against frequency, emmission design plus efficiency against frequency be the major boundaries as well as concurrences.

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COMPARISON OF U SLOTTED MICROSTRIP ANTENNAS FOR C BAND AND S BAND WIRELESS APPLICATION

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Abstract - Comparison two microstrip antenna and both antenna's frequencies are the same range which is lies from 3GHz to 7 GHz a central frequency as 6 Ghz select for designing, and design two antennas of different U Slot after simulation by IE3D software one antenna range in C Band application and another one Applicable for S Band. the material used for testing antennas are Glass Epoxy (FR4),and analyze by the Network Analyzer .The dimension of radiating element is adjusted to achieve desired resonant frequency. Coaxial probe feeding technique is used for its simplicity, the different characteristics obtains. These characteristics are efficiency, bandwidth, directivity, and gain of microstrip antenna and can be increased by some changes in structure with cutting slot. The bandwidth is found as 57.85% and the return loss as -19.5dB for antenna 1 and the next bandwidth is71% which is higher than antenna 1

Keywords - Bandwidths, Return Loss, Glass Epoxy, Efficiency, VSWR.

I. INTRODUCTION

Micro strip patch antenna have been one of the most commonly and groundbreaking idea in antenna theory. The micro strip patch antennas back about 56 years in the U.S.A by Deschamps and in Franceby Gutton and Baissinot [1]. Today's scenario, need for micro strip antennas gaining much attention in wide range of multifunctional wireless communication systems such as radar, satellite, wireless local area network (WLAN),wifi ,Bluetooth and some kind of microwave devices .The micro strip antennas shape can be of irregular, triangular, square ,and rectangular shape. And out of these shapes the rectangular patch is by far used to the highest degree. Although it is easy to examine by transmission line model. Therefore the Single band patch antenna can be recast into a dual band, triple band or multiband antenna by introducing slots in the patch at appropriate position. The shape and position of the slots plays a crucial role in determining the resonance frequency.Antenna is the most essential component of the integrated low-profile wireless communication systems. Some wireless applications of antennas crave for operating concurrently for Wireless LAN, Worldwide Inter-operability for Microwave Access (WiMAX) . The adaptability of these applications have become possible due to their several interesting features including compact size, low profile, light in weight, planar configuration, ease in fabrication and integration with their microwave components. However there are two major drawback in their applications which are narrower bandwidth and low gain in collation to that of variant Microwave Antennas so by loading U slots in irregular radiating patch is simple and efficient technique for procuring the desired bandwidth The S band is covering frequencies from 2 to 6 GHz. Thus it crosses the conventional boundary between the UHF and SHF bands at 3.0 GHz. This frequency band is used by airport surveillance radar , weather radar, surface ship radar, and some satellites. The mini radar short-band ranges from 1.55 to 5.2 GHz. The S band also contains widely used for low power microwave devices such as wireless headphones, cordless phones, (Wi Fi), and microwave ovens (typically at 2.495 GHz). Printed microstrip patch antennas [3-5] are getting popular for modern communication system due to their features which includes small size, low cost and ease of fabrication. An extensive work on simple microstrip geometries including rectangular, circular and triangular shaped structures have been reported [5]. The advantages of patch antennas are that they radiate with moderately high gain in a direction perpendicular to the substrate and can be fabricated in a low cost material. Efficiency and Bandwidth of a Microstrip radiator depends upon many factors for as size, shape, substrate thickness, dielectric constant of substrate, feeding techniques and its location, etc. For good performance, a thick dielectric substrate having a low dielectric constant is desirable for higher bandwidth, better efficiency and better radiation [6-8]. Rectangular microstrip patch has been modified for some applications to other shapes. Irregular Diamond shape microstrip antenna has smaller size compared to the square for the high frequency range .At high frequency range, antenna size will very reduce. The small size is an important requirement for portable communication equipments [6-9]. Coaxial probe feed is used to feed the antenna. Thick substrate properties are used for improvement of proposed antenna. Zeland IE3d simulation software is used for output characteristics. IE3D simulation software used for electromagnetic analysis and design in the high frequency range.

II. ANTENNA DESIGNING AND GEOMETRY

2.1 Resonance Frequency of Antenna

The resonance frequency f_{mn} depends on the patch size, cavity dimension, and the filling dielectric constant, as follows [9][10]:

$$f_{mn} = \frac{k_{mn}c}{2\pi\sqrt{\varepsilon_r}} \quad (1)$$

Where m = 0, 1, 2, and n = 0, 1, 2..., k_{mn} = wave number at m, n mode, c is the velocity of light, ε_r is the dielectric constant of substrate, and

$$k_{mn} = \sqrt{\left(\frac{m\pi}{W}\right)^2 + \left(\frac{n\pi}{L}\right)^2} \quad (2)$$

For TM_{01} mode, the length of non-radiating rectangular patch's edge at a certain resonance frequency and dielectric constant according to equation (1) becomes

$$L = \frac{c}{2f_r\sqrt{\varepsilon_r}} \quad (3)$$

$$W = \frac{c}{f_r}\sqrt{\frac{2}{\varepsilon_r + 1}} \quad (4)$$

Where f_r = resonance frequency at which the rectangular microstrip antennas are to be designed. The radiating edge W, patch width, is usually chosen such that it lies within the range L<W>2L, for efficient radiation. The ratio W/L = 1.5 gives good performance according to the side lobe appearances. In practice[18] the fringing effect causes the effective distance between the radiating edges of the patch to be slightly greater than L. Therefore, the actual value of the resonant frequency is slightly less than f_r. Taking into account the effect of fringing field, the effective dielectric constant for TM_{01} mode is derived using [15,16]

By using above equation we can find the value of actual length of the patch as,

$$L = \frac{c}{2f_r\sqrt{\varepsilon_{eff}}} - 2\Delta l \quad (5)$$

Where ε_{eff} = effective dielectric constant and Δl = line extension which is given as:

$$\varepsilon_{eff} = \frac{(\varepsilon_r + 1)}{2} + \frac{(\varepsilon_r + 1)}{2}\left[1 + 12\frac{h}{W}\right]^{-\frac{1}{2}} \quad (6)$$

$$\frac{\Delta l}{h} = 0.412\frac{(\varepsilon_{eff} + 0.3)\left(\frac{W}{h} + 0.264\right)}{(\varepsilon_{eff} - 0.258)\left(\frac{W}{h} + 0.8\right)} \quad (7)$$

2.2 Design of the Microstrip Antenna

A conventional microstrip antenna includes a ground plate, radiator unit and power unit. The substrate of L × W × h, the size of radiator slab L × W .The antenna dimensions calculated by microstrip theory [18]. Based on wireless communication standard, the band of the microstrip antenna should be lies between 3-6 GHz Simply taking the work frequency of the microstrip antenna as f = 6 GHz, we get the antenna length L_p = 11.32 mm, the antenna width W_p = 15.20 mm, by using Eq. (1-7) and conceder the finite ground length(L_p+6h), L_g = 20.92 mm and the ground width(W_p +6h), W_g = 24.80 mm, and the thickness of dielectric board h = 1.6 mm.

2.3 Simulation and Result Analysis

Now find the value of return loss on feeding point (10.46mm, 4.8mm) , the basic Geometry of proposed antenna shown in Fig.1 , and simulate the proposed antenna with EM simulator IE3D .All formulas taken by references, then run on operating frequency 6 GHz and evaluates maximum (return loss) reflection coefficient S_{11} with high bandwidth and also find VSWR which is less than 2.

After theoretical analysis we find the reflection coefficient -20.32 dB where simulated and measured result are -20.32dB and -22.75 dB at the resonance frequency 4.5 GHz, 4.5 GHz, respectively which shown in Fig.3 and fig 6., and the VSWR is less than 2 for all resonant frequency as shown in Fig.4 .
BW = f2-f1 / (f2+f1/2) = 7.8-4.3/6.05 = 57.85 %

Fig.5, Fig.7, Fig.8 indicate the Smith chart of proposed microstrip antenna, 3D radiation Pattern and 2D radiation pattern of the proposed geometry by software analysis respectively.Fig.9, Fig.10, Fig.11propesed the Gain (dBi) Vs Frequency, Directivity Vs Frequency and Efficiency (Antenna and Radiating) respectively.

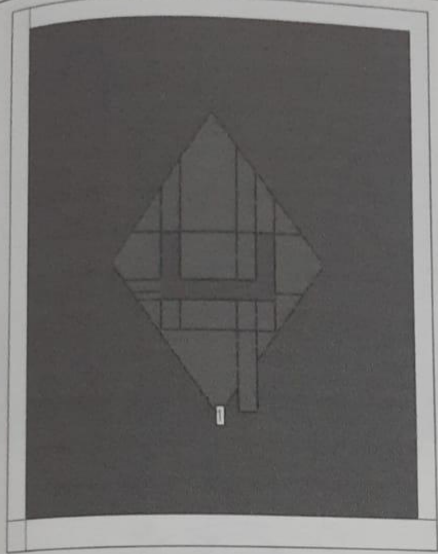

Fig. 1: Proposed Geometry of irregular Diamond slotted antenna on IE3D shape 1

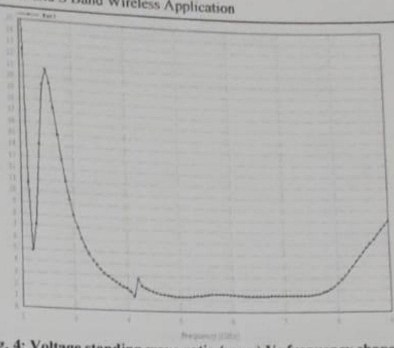

Fig. 4: Voltage standing wave ratio (vswr) Vs frequency shape 1

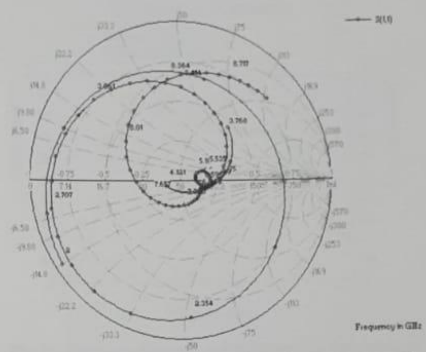

Fig. 5: Smith chart of proposed microstrip antenna shape 1

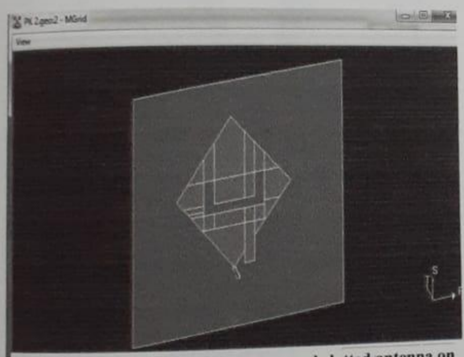

Fig. 2: 3D Geometry of irregular Diamond slotted antenna on IE3D shape 1

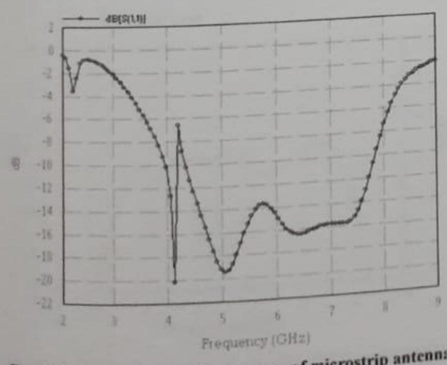

Fig. 3: S_{11} (Return Loss) Vs frequency of microstrip antenna shape 1

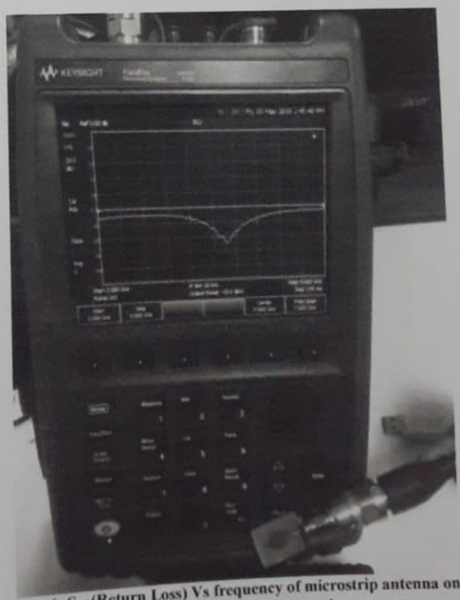

Fig. 6: S_{11} (Return Loss) Vs frequency of microstrip antenna on Vector analyzer for shape 1

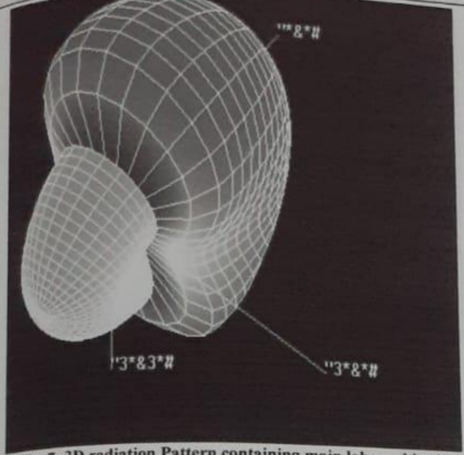

Fig. 7: 3D radiation Pattern containing main lobe and back lobe of antenna shape 1

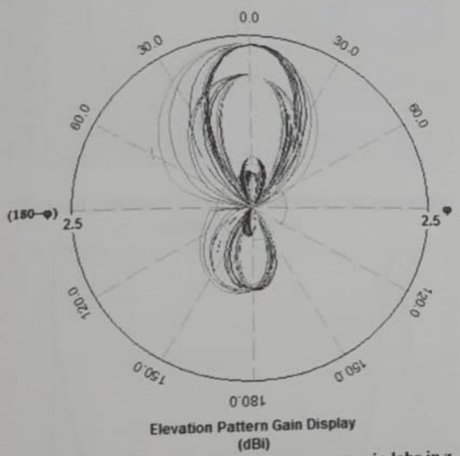

Fig. 8: 2D radiation pattern indicate greater main lobe in z direction shape 1

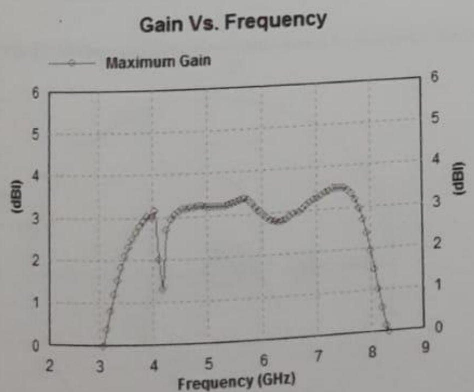

Fig. 9: Gain (dBi) Vs Frequency of microstrip patch radiator shape 1

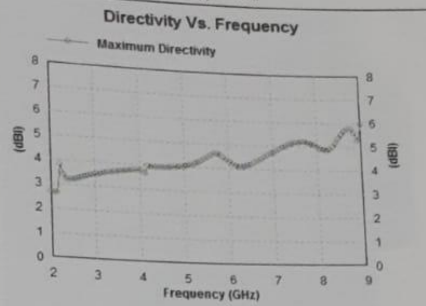

Fig. 10: Directivity Vs Frequency of microstrip antenna shape 1

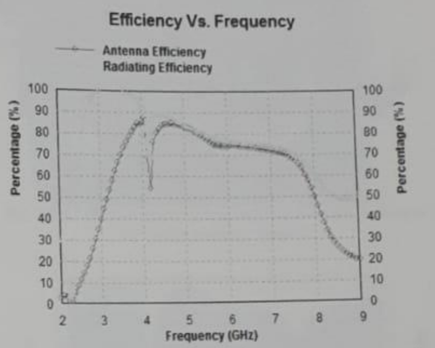

Fig. 11: Efficiency (Antenna and Radiating) Vs Frequency of microstrip patch radiator shape 1

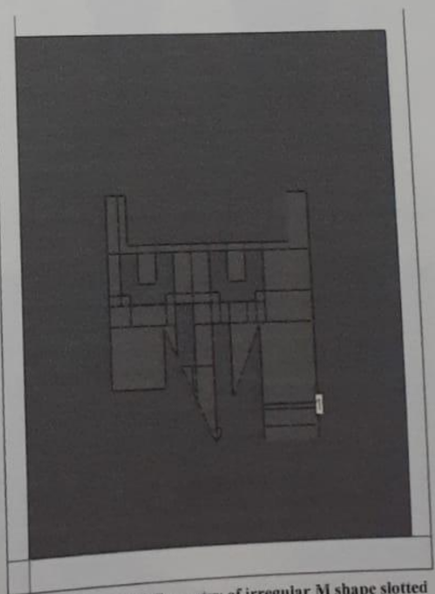

Fig. 12: Proposed Geometry of irregular M shape slotted antenna on IE3D shape 2

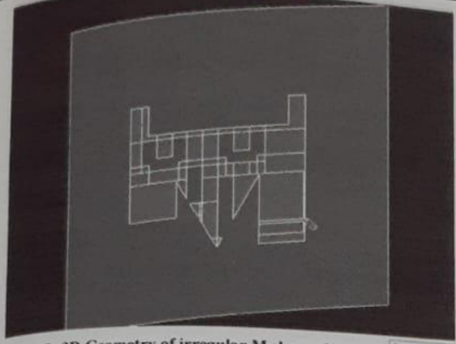

Fig. 13: 3D Geometry of irregular M shape slotted antenna on IE3D shape 2

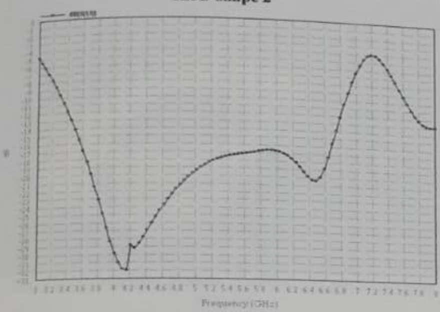

Fig. 14: S_{11} (Return Loss) Vs frequency of microstrip antenna shape 2

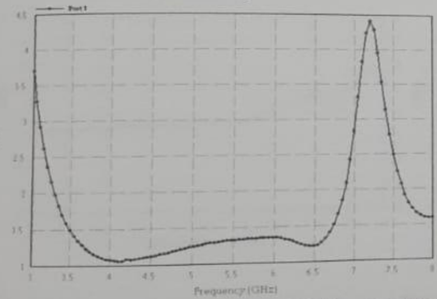

Fig. 15: Voltage standing wave ratio (vswr) Vs frequency shape 2

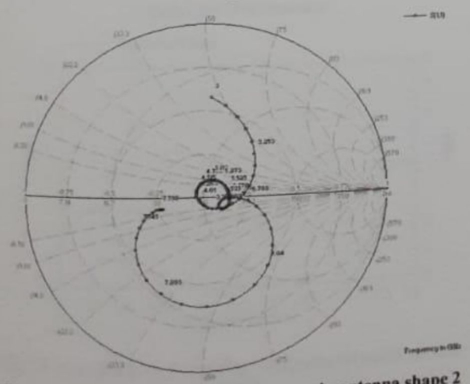

Fig. 16: Smith chart of proposed microstrip antenna shape 2

Fig. 17: S_{11} (Return Loss) Vs frequency of microstrip antenna by Vector analyzer shape 2

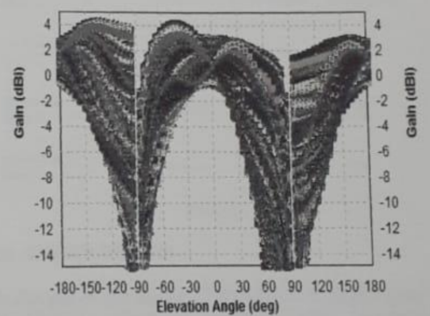

Fig. 18: Gain Vs Elevation angle of microstrip antenna by IE3D shape 2

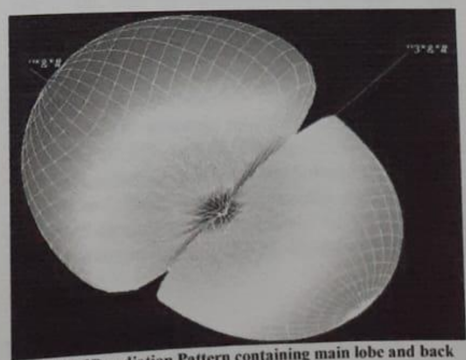

Fig. 19: 3D radiation Pattern containing main lobe and back lobe of antenna shape 2

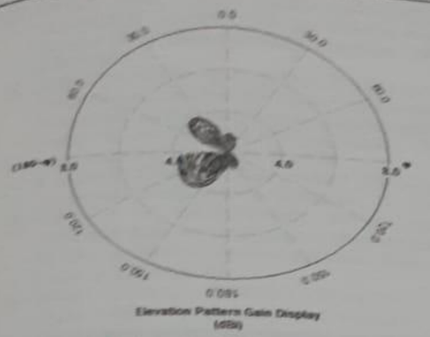

Fig. 20: 2D radiation pattern indicate greater main lobe in z direction shape 2

Fig. 21: 3D radiation pattern of microstrip patch radiator shape 2

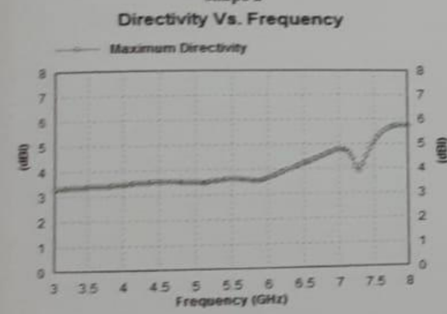

Fig. 22: Directivity Vs Frequency of microstrip antenna shape 2

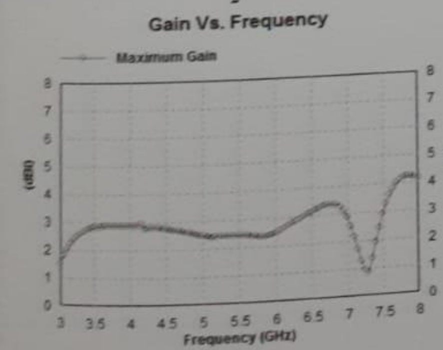

Fig. 23: Gain (dBi) Vs Frequency of microstrip patch radiator shape 2

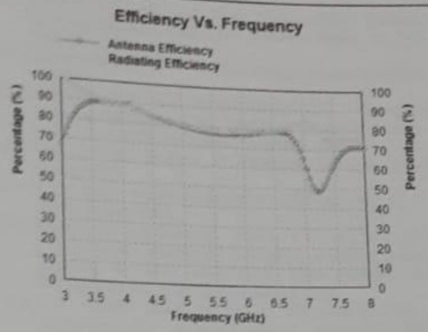

Fig. 24: Efficiency (Antenna and Radiating) Vs Frequency of microstrip patch radiator shape 2

Here the table contain reflection coefficient S_{11} (return loss) and bandwidth by simulated and hardware analysis as shown below in "table.1".

Different parameter of the antenna on IE3D and Analyzer				
Parameter	Operating frequency (GHz)	Resonance frequency (GHz)	Hardware	Simulated
Return loss Shape 1	6	4.5	-22.75 (dB)	-20.32 (dB)
Bandwidth shape 1	6	4.5	41.50%	57.85%
Return loss Shape 2	6	4.2-6.4	-32dB	31dB
Bandwidth shape 2	6	4.2-6.4	58%	71%

Table 1

III. CONCLUSIONS

In this paper, the design of broadband irregular single U slotted microstrip radiator with operating frequency 6.0 GHz and the other double U slots with same operating frequency ,conclusion is that if we cut two U slot then the bandwidth will increase . The antenna has an output by using IE3D simulation software and verify with the hardware result. A glass epoxy substrate is used in the present proposed design, and impedance matching by coaxial connector. The software result shows the bandwidth is achieve 57.85% and 41.50% and for the other 71% and 58% which is usable for the S Band applications as well as C band application, results shows that the proposed antenna is able to achieve VSWR less than 2 and the return loss is -22.75.dB and -32dB.

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Design of Irregular M Shape Microstrip Patch Antenna with U Slots For Broadband and C Band Applications

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Abstract: *This paper presents the enhance in bandwidth of a Microstrip patch Antenna using an irregular polygon (M shape)and using U slots technique for enhancing bandwidth for broadband and fed by Microstrip line using coaxial probe. The main aim of proposed work is to obtain a Hues bandwidth and the size of antenna is reduced. The proposed microstrip antenna has a wide bandwidth, the range from3.30-6.85 GHz. The wide bandwidth achieved 71% and the VSWR is less than 2.The other parameters are as our research requirements antenna simulated on the Zeeland IE3D software.*

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I. Introduction

Antennas are a very important device of communication systems [1]. By definition, an antenna is a device used to transform an RF signal, traveling on a conductor, in to an electromagnetic wave in free space the broadband linear polarized MSA, play a important role in wireless system due to its low-profile, small-size and light weight. As well known, a linearly polarized wave can be obtained when spatially orthogonal modes are excited with equal amplitude. Conventional designs [2] of MSA for linearly polarization are usually achieved by truncating patch corners, cutting U slots in the radiating plate for the C Band Application.The C band is a designation by the Institute of Electrical and Electronics Engineers (IEEE) for a portion of the electromagnetic spectrum in the microwave range of frequencies ranging from 4.0 to 8.0 GHz, this definition is the one used by radar manufacturers and users, not necessarily by microwave radio telecommunications users. The C band (4 to 8 GHz) is used for many satellite communications transmissions, some Wi-Fi devices, some cordless telephones as well as some surveillance and weather radar systems.The communications C band was the first frequency band that was allocated for commercial telecommunications via satellites. The same frequencies were already in use for terrestrial microwave radio relay chains. Nearly all C-band communication satellites use the band of frequencies from 3.7 to 4.2 GHz for their downlinks, and the band of frequencies from 5.925 to 6.425 GHz for their uplinks. Note that by using the band from 3.7 to 4.0 GHz, this C band overlaps somewhat into the IEEE S band for radars.The C-band communication satellites typically have 24 radio transponders spaced 20 MHz apart, but with the adjacent transponders on opposite polarizations.Hence, the transponders on the same polarization are always 40 MHz apart of the 40 MHz, each transponder utilizes about 36 MHz[10].

II. Material Used

The first design step is to choose a suitable dielectric substrate with appropriate thickness and appropriate value of loss tangent. A thicker substrate is not only being mechanically strong but also will increases the radiated power, reduce conductor losses and improve impedance bandwidth however it will also increase the weight, dielectric loss, surface wave loss and extraneous radiations from the probe field. The substrate[2] taken for the designing is Glass epoxy which is very cost effective (Rs. 600 for 1 Sq. foot) and possesses nearly all appropriate characteristic for designing an antenna, value of h is 1.6 mm and loss tangent is 0.012. The first design step is to choose a suitable dielectric substrate of appropriate thickness h and losstangent [3]. A thicker substrate, besides being mechanical strong, will increase the radiated power, reduceconductor loss, and improved impedance, bandwidth, however it will also increase the weight, dielectric loss,surface wave loss, and extraneous radiations from the probe field. Substrate dielectric constant ε_r plays a rolesimilar to that of the substrate thickness.

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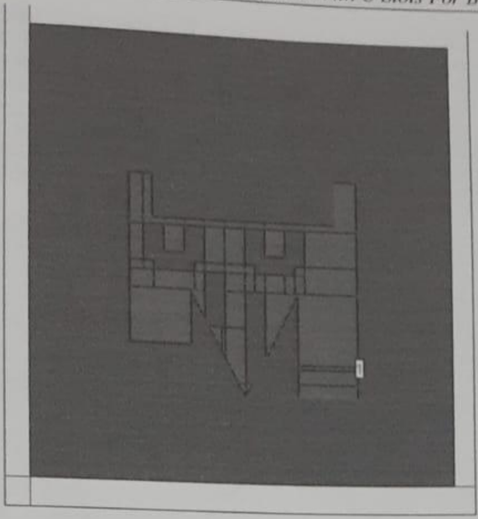

Fig. 1: Proposed Geometry of irregular M shape slotted antenna on IE3D

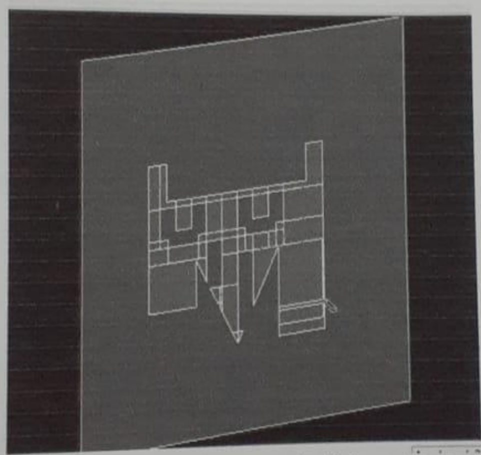

Fig. 2 :3D view of Proposed Geometry of irregular M shape slotted antenna on IE3D

III. Antenna Design

Fig.1 shows the geometry of the proposed ultra band MSA, The radiating rectangular patch,printed on a substrate of thickness h(1.6 mm) and dielectric constant $\varepsilon_r$is 4.4, the dielectric material thickness is 1.6mm thelength of both side, Lp=11.32mm , Wp=15.20mm and ground Lg=20.92mm, Wg=24.80mm . Which are oriented in orthogonal directions and have the feed point of irregular U slot polygon is X_f= 16.12 mm. and Y_f=6.5mm [4] [5].

IV. Experimental Results

To validate whether the design technique is applicable, the antenna has been simulated with IE3D Fig.3,Fig.4 and Fig. 5 shows the Return Loss Vs Frequency, VSWR versus frequency and smith chart respectively, the proposed irregular M shape slotted MSA. Fig.6, Fig.7, and Fig.8 shows the Return Loss Vs frequency of microstrip antenna by Vector analyzer, Gain Vs Elevation angle and 3D radiation Pattern respectively for theproposed slotted antenna.Fig.9, Fig. 11, Fig.12, Fig.13 shows 2D radiation pattern indicate greater main lobe, Directivity Vs Frequency of microstrip antenna, Gain (dBi) Vs Frequency, Efficiency (Antenna and Radiating) Vs Frequency respectively. From the simulation and hardware result we observe that the proposed slotted MSA is able to achieve the Return loss is -32 db,-31db respectively and the VSWR less than 2 for the slotted geometry. The outputresult by the Vector analyzer is shown in Fig.6 return loss (reflection coefficient) versus frequency ofthe proposed antenna. Since the feed point connected with the coaxial probe [6] . have good equal amplitudeand 90° phase shift, broadband LP radiation can be achieved. By using the thick air substrate, muchwider (71%)LP bandwidth obtained. The impedance matching of the antenna can be achieved by adjustment of the feed pointlocation, and the height between the radiator and the ground is (1.6mm) [8],[9].

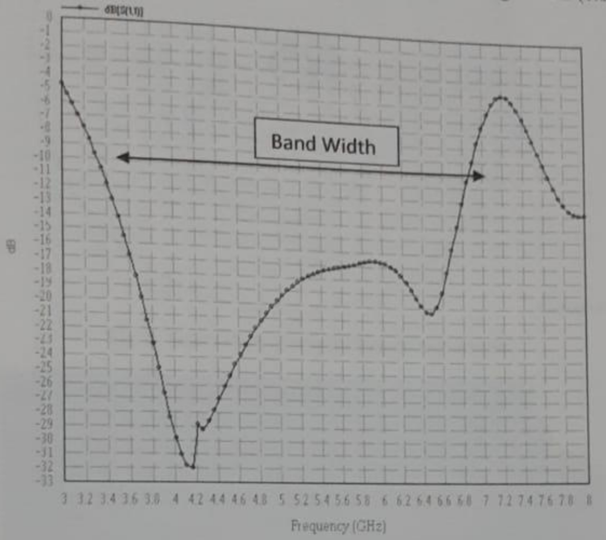

Fig. 3: S_{11} (Return Loss) Vs frequency of microstrip antenna

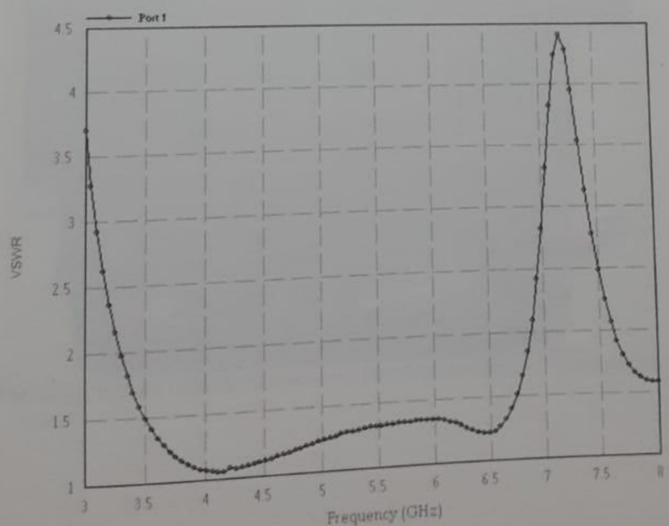

Fig. 4: Voltage standing wave ratio (vswr)Vs frequency

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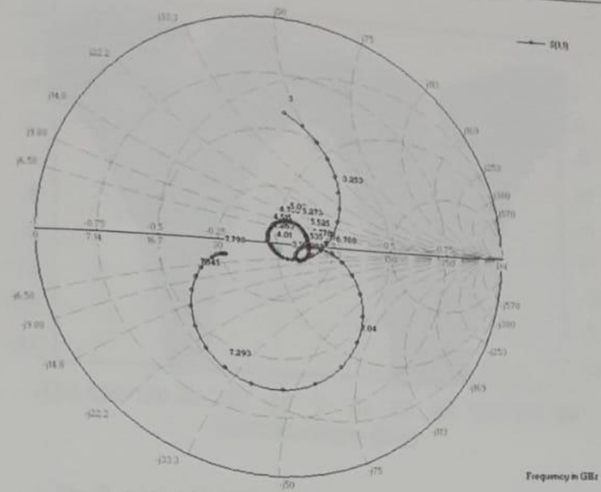

Fig. 5: Smith chart of proposed microstrip antenna

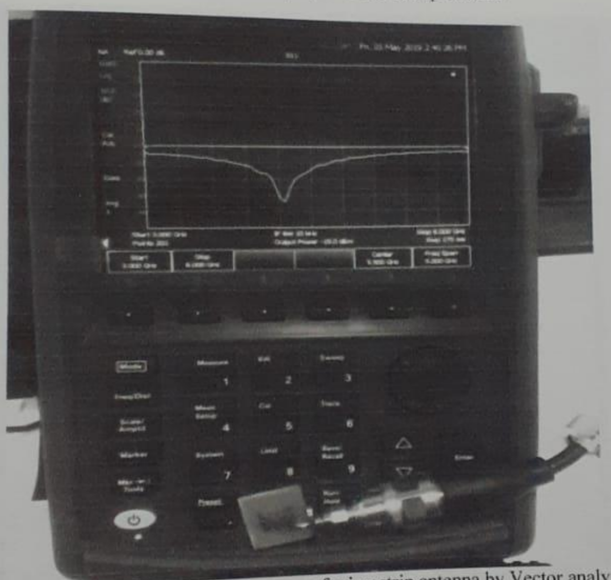

Fig. 6: S_{11} (Return Loss) Vs frequency of microstrip antenna by Vector analyzer

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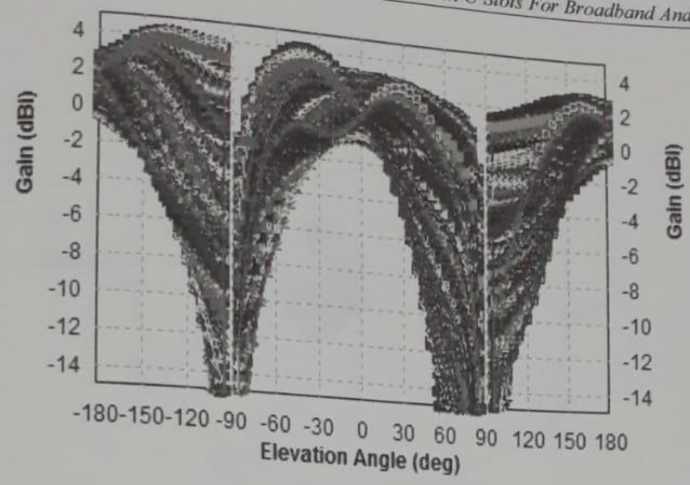

Fig. 7: Gain Vs Elevation angle of microstrip antenna by IE3D

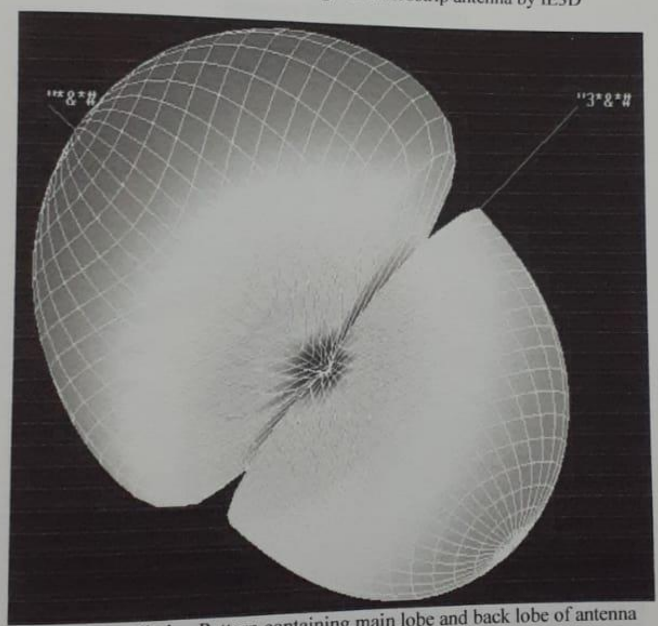

Fig. 8:3D radiation Pattern containing main lobe and back lobe of antenna

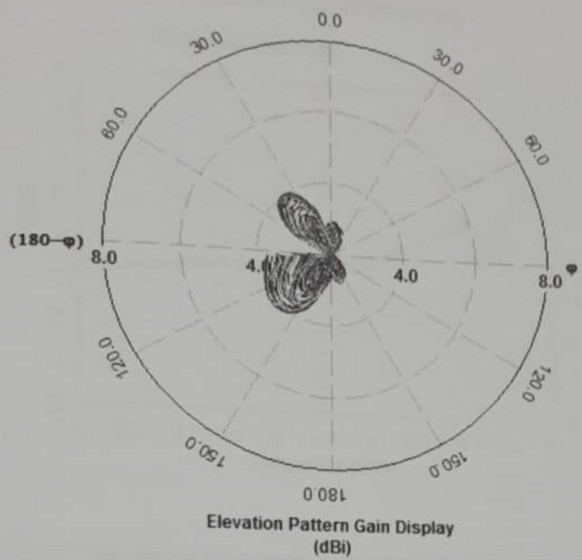

Fig. 9: 2D radiation pattern indicate greater main lobe in z direction

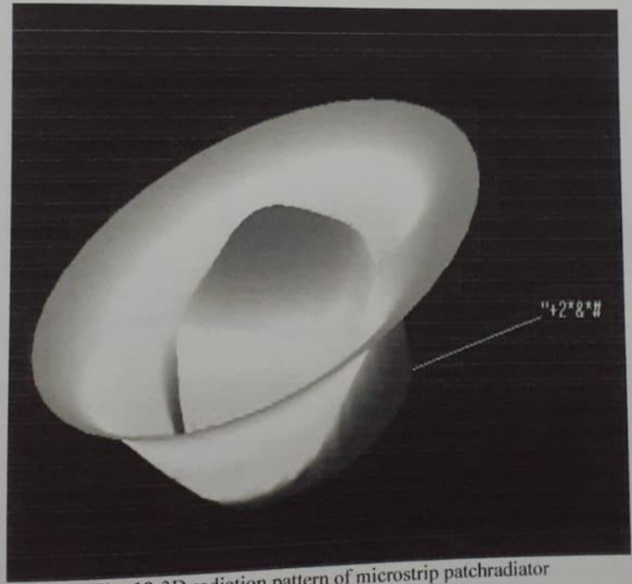

Fig. 10:3D radiation pattern of microstrip patchradiator

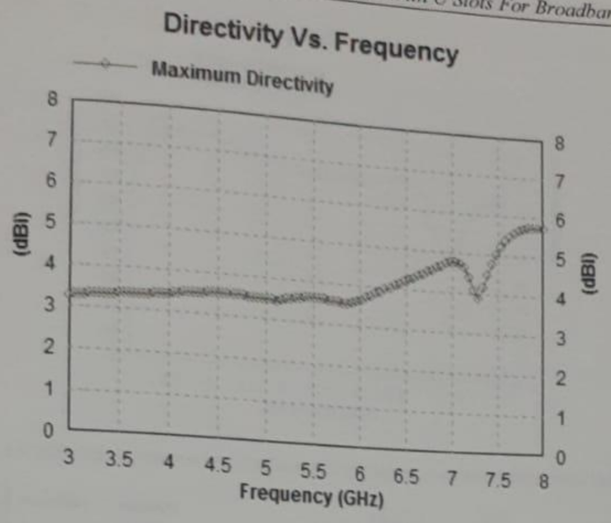

Fig. 11: Directivity Vs Frequency of microstrip antenna

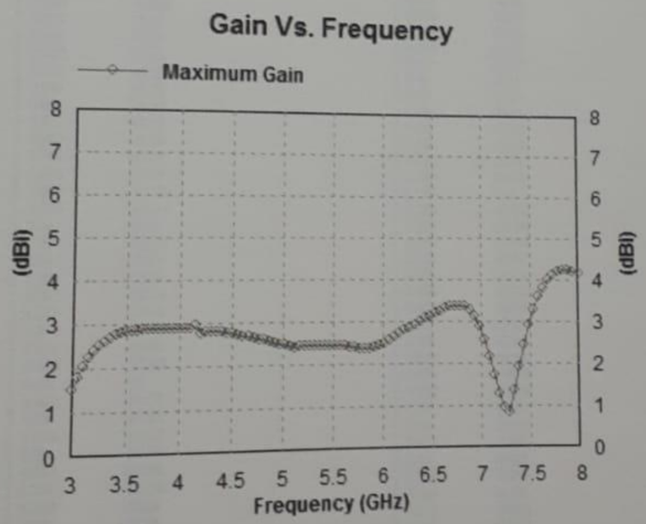

Fig. 12: Gain (dBi) Vs Frequency of microstrip patch radiator

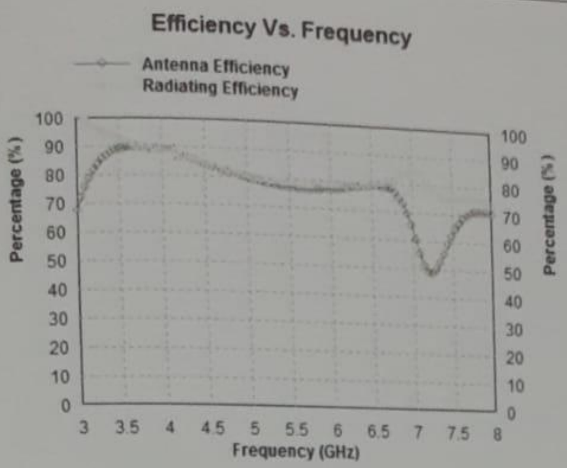

Fig. 13: Efficiency(Antenna and Radiating) Vs Frequency of microstrip patch radiator

Freq[GHz]	dB[S(1,1)]
3	-4.818
3.051	-5.489
3.101	-6.219
3.152	-7.008
3.202	-7.857
3.253	-8.765
3.303	-9.732
3.354	-10.76
3.404	-11.85
3.455	-13.01
3.505	-14.23
3.556	-15.52
3.606	-16.89
3.657	-18.34
3.707	-19.88
3.758	-21.49
3.808	-23.18
3.859	-24.92
3.909	-26.69
3.96	-28.4
4.01	-29.92
4.061	-31.09
4.111	-31.84
4.162	-32.06
4.212	-28.87
4.263	-29.26
4.313	-28.66
4.364	-27.85
4.414	-27
4.465	-26.15
4.515	-25.32
4.566	-24.53
4.616	-23.78
4.667	-23.08
4.717	-22.43
4.768	-21.82
4.818	-21.25
4.869	-20.73
4.919	-20.25
4.97	-19.81
5.02	-19.4
5.374	-17.58
5.424	-17.45
5.475	-17.34
5.525	-17.25
5.576	-17.18
5.626	-17.11
5.677	-17.03
5.727	-16.94
5.778	-16.85
5.828	-16.76
5.879	-16.69
5.929	-16.67
5.98	-16.71
6.03	-16.82
6.081	-17.01
6.131	-17.29
6.182	-17.67
6.232	-18.14
6.283	-18.69
6.333	-19.3
6.384	-19.89
6.434	-20.34
6.485	-20.43
6.535	-19.94
6.586	-18.86
6.636	-17.35
6.687	-15.65
6.737	-13.9
6.788	-12.2
6.838	-10.57
6.889	-9.059
6.939	-7.674
6.99	-6.45
7.04	-5.431
7.091	-4.662
7.141	-4.185
7.192	-4.015
7.242	-4.136
7.293	-4.505
7.343	-5.067
7.394	-5.77
7.444	-6.573
7.495	-7.436
7.545	-8.334
7.596	-9.236
7.646	-10.11
7.697	-10.92
7.747	-11.63
7.798	-12.2
7.848	-12.62

Fig. 14:Data chart of S_{11} (Return Loss) Vs Frequency by simulation software

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Table no 1: Proposed antenna Design parameters for software and hardware

Design of Micro strip patch antenna	**Design on Software base antenna**	**Design on Hardware base antenna**
Name of Pattern	Irregular M shape	Irregular M shape
Frequency of Operation (GHz)	6.0	6.0
Dielectric constant of substrate	4.4	4.4
Loss tangent	.0012	.0012
Height of the dielectric substrate (mm)	Z=1.6mm	Z=1.6mm
Feeding method (Probe feed) mm	Point (x=16.12,y=6.5)	Point (x=16.12,y=6.5)
Width of the ground (W_g)	24.8mm	24.8mm
Length of the ground (L_g)	20.92mm	20.92mm
Width of the patch (W_p)	15.20mm	15.20mm
Length of the patch (L_p)	15.20mm	15.20mm

Table no 2: Measured result by IE3D software and hardware by network analyzer

Antenna Design	**Bandwidth (%)**	**Return Loss (dB)**
Software Based Design	71%	-32
Hardware Based Design	58%	-31

V. Conclusion

In this paper, a new design ofbroadband irregular slotted MSA with operating frequency6.0 GHz. The antenna has an output by using IE3D and compared with the experimental value. A thick air substrate is used in the present proposed design, and impedance matching is obtained through the irregular M shape radiating patch. The software result shows the bandwidth is achieve 71% and 58% which is usable for the C Band applications, resultsshows that the proposed antenna is able to achieve VSWR less than 2 and the return loss is -32.db.

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Design of irregular Diamond Shape Microstrip Patch Antenna with U slot to Enhance bandwidth for S band applications

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Abstract

Now a day's developing wireless communication systems (WCS), mobile communications, direct broad banding technique (DBT), wireless local area networks (WLANs) suggest that demand for Microstrip antennas and array will increase even further. In this paper the bandwidth of microstrip patch antenna is enhanced by using U slot technique and chooses a dielectric layer which is covered by copper material. Here two patches, one is radiating patch and second is ground are used to enhance the bandwidth and whole Geometry resonates at their operating frequency (6 GH$_z$) which is in the S band. Glass Epoxy material is used as dielectric between radiating patch and ground plane. The dimension of radiating element is adjusted to achieve desired resonant frequency. The coaxial probe feeding technique is used for its simplicity. Zeland IE3D simulation software used for antenna simulation and effects of physical parameters are investigated. These works obtains the efficiency, bandwidth directivity, and gain of microstrip antenna and can be increased by some changes in structure with cutting slot. The bandwidth is found as 57.85% and the return loss as -19.5dB which is higher as compare to conventional patch antenna.

Keywords: Bandwidths, Return loss, U slot Microstip patch Antenna, Efficiency, VSWR.

1. Introduction

The S band is covering frequencies from 2 to 6 GHz. Thus it crosses the conventional boundary between the UHF and SHF bands at 3.0 GHz. This frequency band is used by airport surveillance radar , weather radar, surface ship radar, and some satellites. The mini radar short-band ranges from 1.55 to 5.2 GHz. The S band also contains widely used for low power microwave devices such as wireless headphones, cordless phones, (Wi Fi), and microwave ovens (typically at 2.495 GHz). Printed microstrip patch antennas [1] are getting popular for modern communication system due to their features which includes small size, low cost and ease of fabrication. An extensive work on simple microstrip geometries including rectangular, circular and triangular shaped structures have been reported [2]. The advantages of patch antennas are that they radiate with moderately high gain in a direction perpendicular to the substrate and can be fabricated in a low cost material. Efficiency and Bandwidth of a Microstrip radiator depends upon many factors for as size, shape, substrate thickness, dielectric constant of substrate, feeding techniques and its location, etc. For good performance, a thick dielectric substrate having a low dielectric constant is desirable for higher bandwidth, better efficiency and better radiation [3-5]. Rectangular microstrip patch has been modified for some applications to other shapes. Irregular Diamond shape microstrip antenna has smaller size compared to the square for the high frequency range .At high frequency range, antenna size will very reduce. The small size is an important requirement for portable communication equipments [6-9]. Coaxial probe feed is used to feed the antenna. Thick substrate properties are used for improvement of proposed antenna. Zeland IE3d simulation software is used for output characteristics. IE3D simulation software used for electromagnetic analysis and design in the high frequency range.

2. Antenna designing and geometry

2.1 Resonance Frequency of Antenna

The resonance frequency f_{mn} depends on the patch size, cavity dimension, and the filling dielectric constant, as follows [9][10]:

$$f_{mn} = \frac{k_{mn}c}{2\pi\sqrt{\varepsilon_r}} \quad (1)$$

Where m = 0, 1, 2, and n = 0, 1, 2..., k_{mn} = wave number at m, n mode, c is the velocity of light, ε_r is the dielectric constant of substrate, and

187

$$k_{mn} = \sqrt{\left(\frac{m\pi}{W}\right)^2 + \left(\frac{n\pi}{L}\right)^2} \quad (2)$$

For TM_{01} mode, the length of non-radiating rectangular patch's edge at a certain resonance frequency and dielectric constant according to equation (1) becomes

$$L = \frac{c}{2f_r\sqrt{\varepsilon_r}} \quad (3)$$

$$W = \frac{c}{f_r}\sqrt{\frac{2}{\varepsilon_r + 1}} \quad (4)$$

Where f_r = resonance frequency at which the rectangular microstrip antennas are to be designed. The radiating edge W, patch width, is usually chosen such that it lies within the range L<W>2L, for efficient radiation. The ratio W/L = 1.5 gives good performance according to the side lobe appearances. In practice[18] the fringing effect causes the effective distance between the radiating edges of the patch to be slightly greater than L. Therefore, the actual value of the resonant frequency is slightly less than f_r. Taking into account the effect of fringing field, the effective dielectric constant for TM_{01} mode is derived using [15,16]

By using above equation we can find the value of actual length of the patch as,

$$L = \frac{c}{2f_r\sqrt{\varepsilon_{eff}}} - 2\Delta l \quad (5)$$

Where ε_{eff} = effective dielectric constant and Δl = line extension which is given as:

$$\varepsilon_{eff} = \frac{(\varepsilon_r + 1)}{2} + \frac{(\varepsilon_r + 1)}{2}\left[1 + 12\frac{h}{W}\right]^{-\frac{1}{2}} \quad (6)$$

$$\frac{\Delta l}{h} = 0.412\frac{(\varepsilon_{eff} + 0.3)\left(\frac{W}{h} + 0.264\right)}{(\varepsilon_{eff} - 0.258)\left(\frac{W}{h} + 0.8\right)} \quad (7)$$

2.2 Design of the Microstrip Antenna

A conventional microstrip antenna includes a ground plate, radiator unit and power unit. The substrate of L × W × h, the size of radiator slab L × W .The antenna dimensions calculated by microstrip theory [18]. Based on wireless communication standard, the band of the microstrip antenna should be lies between 3-6 GHz Simply taking the work frequency of the microstrip antenna as f = 6 GHz, we get the antenna length L_p = 11.32 mm, the antenna width W_p = 15.20 mm, by using Eq. (1-7) and conceder the finite ground length(L_p+6h), L_g = 20.92 mm and the ground width(W_p +6h), W_g = 24.80 mm, and the thickness of dielectric board h = 1.6 mm.

2.3 Simulation and Result Analysis

Now find the value of return loss on feeding point (10.46mm, 4.8mm) , the basic Geometry of proposed antenna shown in Fig.1 , and simulate the proposed antenna with EM simulator IE3D .All formulas taken by references, then run on operating frequency 6 GHz and evaluates maximum (return loss) reflection coefficient S_{11} with high bandwidth and also find VSWR which is less than 2.

After theoretical analysis we find the reflection coefficient -20.32 dB where simulated and measured result are -20.32dB and -22.75 dB at the resonance frequency 4.5 GHz, 4.5 GHz, respectively which shown in Fig.3 and fig 6., and the VSWR is less than 2 for all resonant frequency as shown in Fig.4 .

BW = f2-f1 / (f2+f1/2) = 7.8-4.3/6.05 = 57.85 %

Fig.5, Fig.7, Fig.8 indicate the Smith chart of proposed microstrip antenna, 3D radiation Pattern and 2D radiation pattern of the proposed geometry by software analysis respectively.Fig.9, Fig.10, Fig.11propesed the Gain (dBi) Vs Frequency, Directivity Vs Frequency and Efficiency (Antenna and Radiating) respectively.

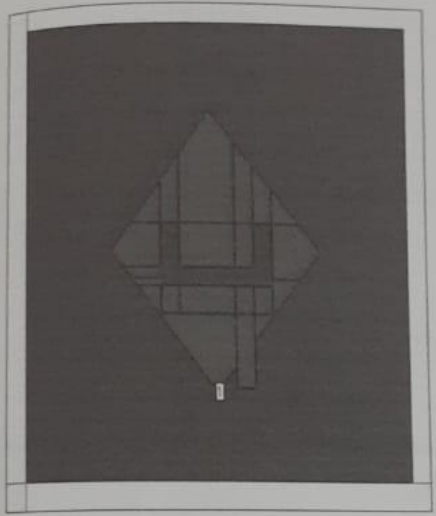

Fig. 1: Proposed Geometry of irregular Diamond slotted antenna on IE3D

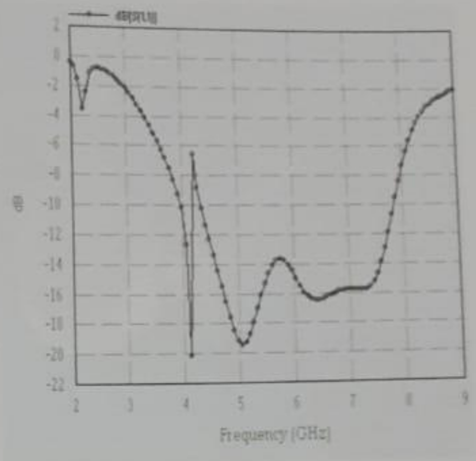

Fig. 3: S_{11} (Return Loss) Vs frequency of microstrip antenna

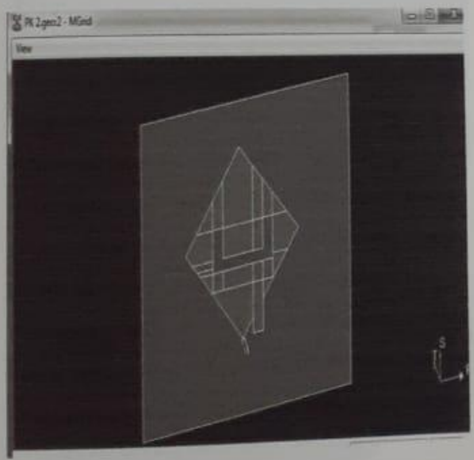

Fig. 2: 3D Geometry of irregular Diamond slotted antenna on IE3D

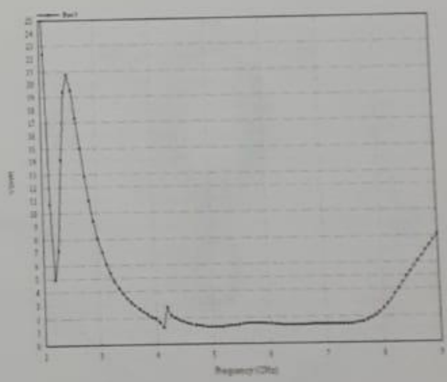

Fig. 4: Voltage standing wave ratio (vswr) Vs frequency

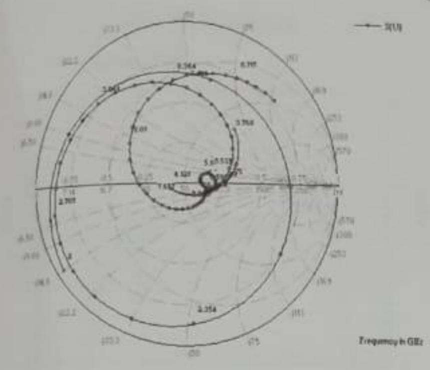

Fig. 5: Smith chart of proposed microstrip antenna

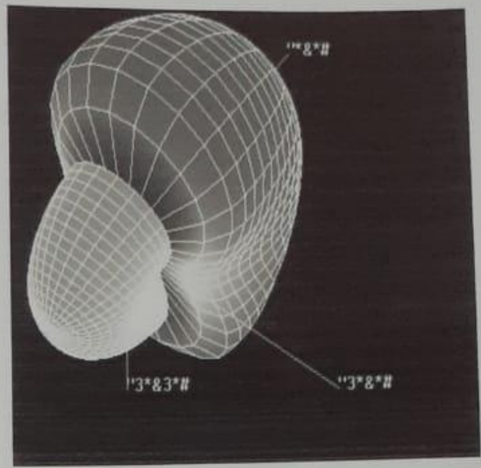

Fig. 7: 3D radiation Pattern containing main lobe and back lobe of antenna

Fig. 6: S_{11} (Return Loss) Vs frequency of microstrip antenna on Vector analyzer

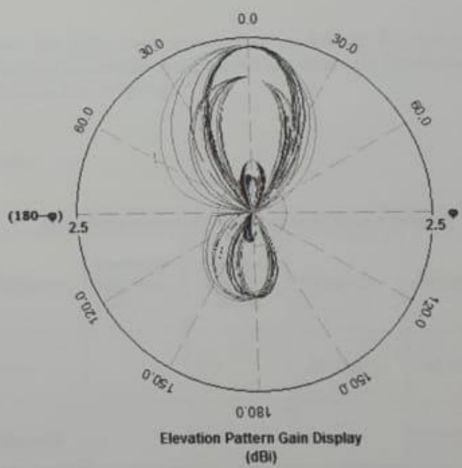

Fig. 8: 2D radiation pattern indicate greater main lobe in z direction

190

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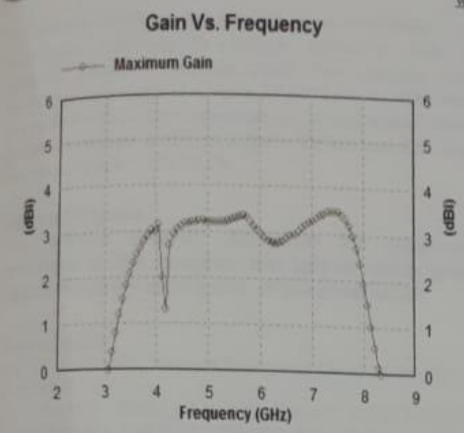

Fig. 9: Gain (dBi) Vs Frequency of microstrip patch radiator

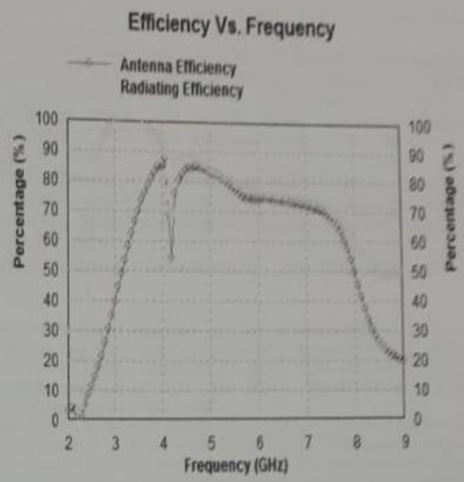

Fig. 11: Efficiency (Antenna and Radiating) Vs Frequency of microstrip patch radiator

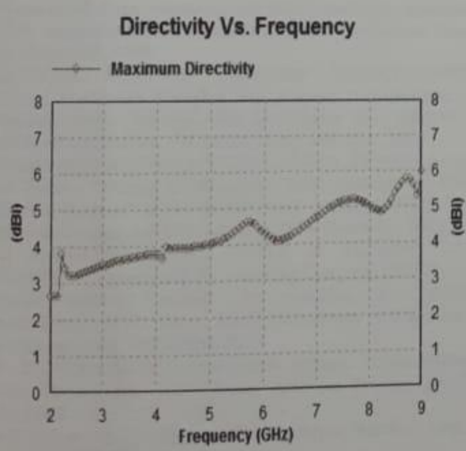

Fig. 10: Directivity Vs Frequency of microstrip antenna

Here the table contain reflection coefficient S_{11} (return loss) and bandwidth by simulated and hardware analysis as shown below in "table.1".

Table 1

Different parameter of the antenna on IE3D and Analyzer				
Parameter	**Operating frequency (GHz)**	**Resonance frequency (GHz)**	**Hardware**	**Simulated**
Return loss	6	4.5	-22.75 (dB)	-20.32 (dB)
Bandwidth	6	4.5	41.50%	57.85%

Conclusions

In this paper, the design of broadband irregular single U slotted microstrip radiator with operating frequency 6.0 GHz. The antenna has an output by using IE3D simulation software and verify with the hardware result. A glass epoxy substrate is used in the present proposed design, and impedance matching by coaxial connector with the irregular Diamond radiating patch. The software result shows the bandwidth is achieve 57.85% and 41.50% which is usable for the S Band applications, results shows that the proposed antenna is able to achieve VSWR less than 2 and the return loss is -22.75.db.

Acknowledgment

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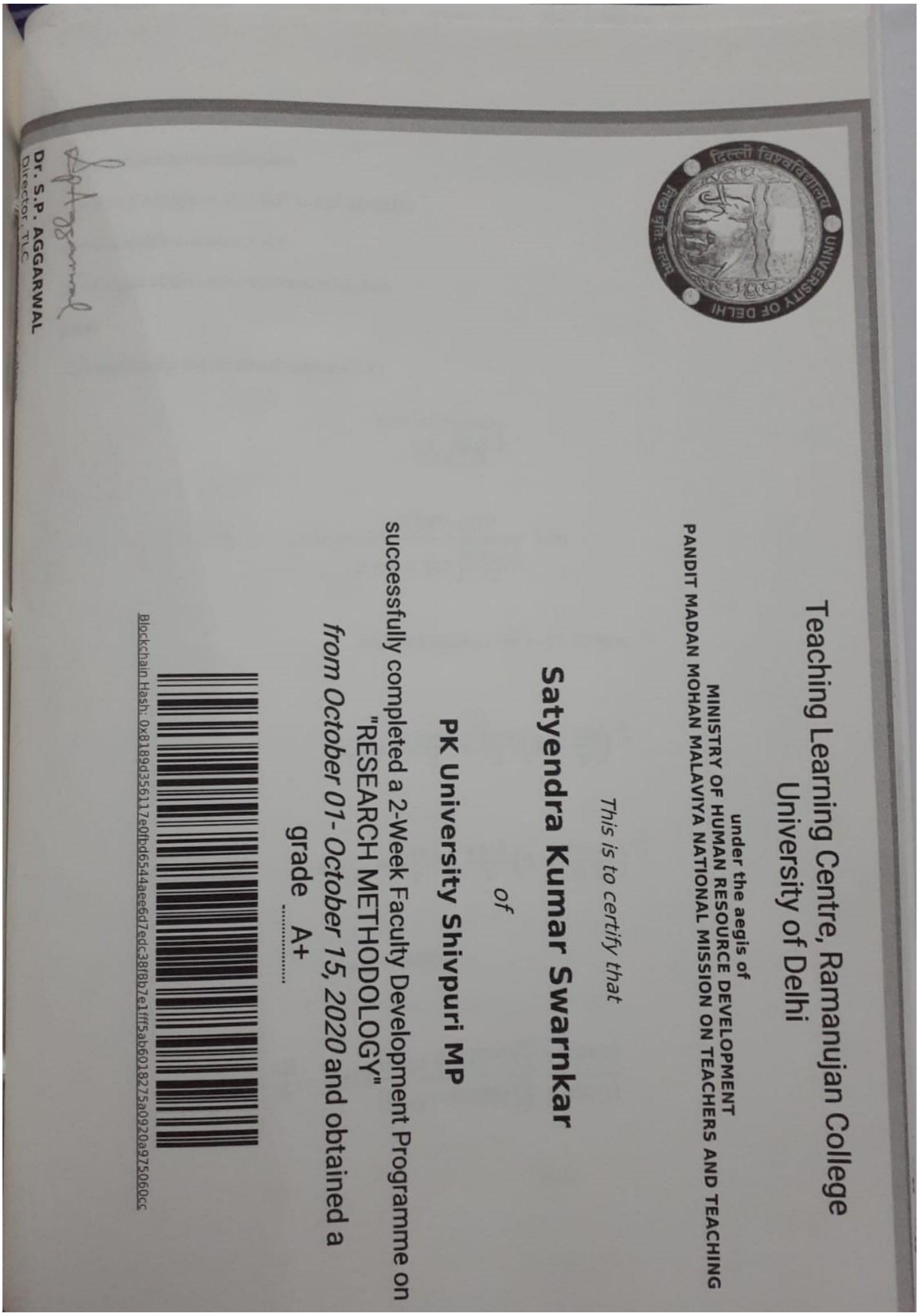

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"RESEARCH METHODOLOGY"
from October 01- October 15, 2020 and obtained a
grade A+

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Dr. S.P. AGGARWAL
Director, TLC

CALCULATION FOR (W) AND (L)

All quantities are in millimeter

C = Speed of light = $3 \times 10^8 \times 10^3$ mm/sec

ε_r = Dielectric constant = 4.4

h = Height of dielectric material =1.6 mm

First

Calculation for the width of antenna (W)

$$w = \frac{c}{2f_o\sqrt{\frac{\varepsilon_r + 1}{2}}}$$

$$w = \frac{3 \times 10^8 \times 10^3}{2 \times 6 \times 10^9\sqrt{\frac{4.4 + 1}{2}}}\ mm$$

Width of antenna $w = 15.20\ mm$

$$\varepsilon_{reff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left(1 + \frac{12h}{W}\right)^{-\frac{1}{2}}$$

$$\varepsilon_{reff} = \frac{4.4+1}{2} + \frac{4.4-1}{2}\left(1 + \frac{12\times1.6}{15.20}\right)^{-\frac{1}{2}}$$

$$\varepsilon_{reff} = 3.889$$

$$\frac{\Delta l}{h} = 0.412\frac{\left(\varepsilon_{reff} + 0.300\right)\left(\frac{w}{h} + 0.262\right)}{\left(\varepsilon_{reff} - 0.258\right)\left(\frac{w}{h} + 0.813\right)}$$

$$\Delta l = h \times 0.412 \frac{\left(\varepsilon_{reff} + 0.300\right)\left(\frac{w}{h} + 0.262\right)}{\left(\varepsilon_{reff} - 0.258\right)\left(\frac{w}{h} + 0.813\right)}$$

$$\Delta l = 1.6 \times 0.412 \frac{(3.889 + 0.300)\left(\frac{15.20}{1.6} + 0.262\right)}{(3.889 - 0.258)\left(\frac{15.20}{1.6} + 0.813\right)}$$

$$\Delta l = 0.721\, mm$$

$$2\Delta l = 1.44\, mm$$

Second

Calculation for the length of antenna (L)

$$\mathrm{L} = \frac{\mathrm{c}}{2f_0\sqrt{\varepsilon_{reff}}} - 2\Delta L$$

$$\mathrm{L} = \frac{3 \times 10^8 \times 10^3}{2 \times 6 \times 10^9\sqrt{3.889}} - 1.44$$

$$\mathrm{L} = 11.32 \text{ mm}$$

Where

$$\mathrm{L} = \mathrm{L}_p = \text{length of patch} = 11.32 \text{ mm}$$

$$\mathrm{W} = \mathrm{W}_p = \text{width of patch} = 15.20 \text{ mm}$$

13/09/2021.

To

The Head

Electronics & Communication

Department

BIET Jhansi

Subject :- Regarding Testing of antenna for my P.hD work.

Sir

This is Kind Information/request to you that, I had tested my antenna in your research Lab at Electronics & Communication Department BIET Jhansi. I am thankfull for your kind support.

Thanking you.

With regards

Er. Satyendra kumar Swarnkar

Research Scholar. P.K. University

9415067554

He had tested his Antenna in research Lab. of EC Deptt, BIET Jhansi.

13/09/2021

HEAD

Electronics & Communication Engineering Department

BIET JHANSI

P.K.University

Ref. No. PKU/2017/06/29/RO – STUD/08 Dated 29/06/17

To,

Satyendra Kumar Swarnkar,

Course Work Certificate

Dear Student,

This is to certify that **Satyendra Kumar Swarnkar.** (Reg.No. **PH16EGG002EC**) son/daughter of Mr. /Ms. **Asha Ram Swarnkar**, student of Ph.D. (EC& E) has successfully passed the course work examination with 'A' grade from P.K.University, Karera, Shivpuri.

Registrar

Village - Thanara, Distt. Shivpuri (M.P.)
Conatct : 7241115081, 7241115082, 7241115083, www.pkuniversity.org / www.pkuniversity.edu.in

P.K. UNIVERSITY

SHIVPURI (M.P.)

Established Under UGC Act 2F, 1956

Ref. No. PKU/2018/03/14/RO-STUD/08 Date 13/03/18

Certificate

To,

SATYENDRA KUMAR SWARNKAR

Enrollment No. 161595604566

Sub.: Registration for Ph.D. Degree

Dear Student,

This is certify that **SATYENDRA KUMAR SWARNKAR S/o ASHA RAM SWARNKAR** is registered for Ph.D. programme in the **Faculty of Engineering and Technology for the Branch of Electronics and Communication** at PK. University with registration number PH16EGG002EC and the topic ... **"BANDWIDTH ENHANCEMENT OF MICROSTRIP ANTENNA USING U-SLOT, STACKING AND DEFECTED GROUND TECHNIQUES FOR S AND C-BAND APPLICATIONS** "has been approved by the RDC held on 11/11/2017 for further research work that will be governed by the academic regulations of the University.

With kind regards

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TO WHOM IT MAY CONCERN

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Ref. No. RC/PKU/21/08 Date: 04/08/2021

To,

Mr. Satyendra Kumar Swarnkar,
Research Scholar,
Residence: S/o Asha Ram Swarnkar,720
Datia gate Bahar, Pathoriya Jhansi
Pin Code : 284002 U.P.

Subject: Letter of Pre Ph.D Viva-Voice.

Respected Sir,

Research Cell in P.K.University, Shivpuri offers research programmes leading to the award of the Ph.D. degree. The award of this degree is in recognition of high academic achievements, independent research and application of knowledge to the solution of technical and scientific problems in the various disciplines. The research program provides the candidates an enabling research experience during their stay in the University thus helping them to enter their professional life with right perspective and knowledge related to their respective fields of specialization.

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Research Cell

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Head, R & D Cell

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IEEE TRANSACTIONS ON ANTENNAS AND PROPAGATION, VOL. 62, NO. 9, SEPTEMBER 2014

Single-Layer Single-Patch Four-Band Asymmetrical U-Slot Patch Antenna

Shuo Liu, Shi-Shan Qi, Wen Wu, and Da-Gang Fang

***Abstract*—A single-layer single-patch four-band U-slot patch antenna, with linear polarization, is proposed for WiMax and WLAN systems. Using this antenna, impedance bandwidths ($|S_{11}| < -10$ dB) of 2.1%, 3.3%, 7.1% and 5.0% were achieved at central frequencies 3.35 GHz, 3.70 GHz, 5.20 GHz and 5.80 GHz, with gains of 7.6 dBi, 8.6 dBi, 8.5 dBi and 9.0 dBi, respectively. This antenna was made by cutting four asymmetrical U-slots in the patch. This structure has the following advantages: (1) the feed is simple, (2) the antenna has single-layer, (3) the structure of the antenna is simple, (4) the asymmetry of the U-slot arm provides one more degree of freedom in the design, (5) the antenna is inexpensive. The design guideline for the proposed antenna is given and the acceptability of the design is verified by other scenarios. The simulated and measured results are in good agreement**

***Index Terms*—Linear polarization, single-layer, single-patch, U-slot, four-band.**

I. Introduction

U-slot patch antennas, with linear polarization performance for communication, mobile phone Bluetooth, GPS navigation, WLAN and WiMax systems, have been introduced recently in [1]–[6]. Most of these designs can provide only one or two bands. However, with increasing number of information services, single-frequency antennas no longer meet the current market demands. A multi-band multi-function, simple structure and low cost antenna is what is needed for modern communications. Several solutions are available for such an antenna, including microstrip feed structure, multi-layer stacked patch structure and single-layer multi-slot patch structure. Among these, the single-layer multi-slot multi-band patch antenna, with its advantages of high gain, band isolation, simple structure and ease of integration on planar or non-planar surfaces, is credited with the best performance-to-cost ratio.

The concept of multi-band communication, multifunction application and miniaturization has been proposed many years ago. The advantage of multi-band system is that, when there is interference in one band system, the other can still work normally. Another typical advantage is that it can form complementary function. Multi-band slot patch antenna is also useful when one has to simultaneously deal with uplink and downlink data in satellite communications. It has great potential in modern communication systems.

During the past decade, multi-band performances at different bands were integrated into one antenna by employing multilayer, cutting slots in the patch [7]. In [8], a five-band linear polarization antenna was achieved by cutting five open-ended slots in the printed substrate. However, the peak reflection coefficient between the second and the third bands was only -8 dB. Besides, the useless signals interfered with the application bands. In [9], a compact multi-band antenna, combining a planar monopole, a novel T-shaped element and a parasitic element, has been presented. The peak gains of the antenna in lower and higher bands are 2.5 dBi and 1.5 dBi, respectively. To realize dual-band performance, which is applied in downlink and uplink satellite communications, a new dual-layer slotted patch antenna has been introduced in [10]. The size of the antenna is 100 mm × 100 mm and the peak gains in lower and higher bands are 3.5 dBi and 4.2 dBi respectively. In [11], a multi-band microstrip patch antenna has been obtained by using multiple stacked structures. The peak gains in different bands range from 6.9 dBi to 9.2 dBi. However, the dimension of the antenna is 220 mm × 180 mm × 14 mm. The large size antenna is not preferred in the applications of modern communication systems.

U-slot patch antennas are widely used in the past in wireless systems. A compact U-shaped open-end slot patch antenna is used in 3G or 4G mobile communication system, including GSM, WCDMA application bands [12]. In [13]–[15], a single-layer single-band coaxial probe feed U-slot antenna has been used in WLAN and WiMax systems. The advantages of the U-slot structure are that linear polarization and circular polarization radiation can be obtained by simply changing the length of the U-slot arm, and the wideband performance can be easily achieved simultaneously. Recently, a new approach to achieve dual-band and tri-band performances, by cutting U-slots in the patch, has been introduced in [16]–[18] where the band-notch appears at the resonant frequency of the slot. However, the working bands of the antenna do not quite match with the bands in the practical applications.

This communication presents a miniaturized, low cost, four-band linear polarization U-slots patch antenna that was made by cutting four asymmetrical U-slots in the patch. The working frequency bands were WiMax (3.3–3.8 GHz) and WLAN (5.150–5.250, 5.250–5.350, 5.725–5.825 GHz). Three of these U-slots were used to introduce band-notches at specific frequency points. From both simulation and experimental studies, it is found that the proposed antenna can simultaneously achieve multi-band performance, high gains, reduction in size and better band isolation. Details of the proposed antenna and its performance are given in the next two parts.

II. Antenna Design

A. Antenna Configuration

The geometry of the proposed four-band linear polarization asymmetrical U-slot patch antenna is shown in Fig. 1. The four-band higher gain performances were achieved by cutting four asymmetrical U-slots in a single layer patch. A square copper plate, measuring $L = 50$ mm along its edge, was used as the ground plane under the patch. The coaxial probe was directly connected to the patch and air was used as the substrate. The inner and outer diameters of the SMA connector were 0.6 mm and 2.0 mm, respectively. The commercial electromagnetic software HFSS was used for simulation. The final optimized parameters of the antenna are listed in Table I.

B. Working Mechanism and Design Guideline

The strategy was to first design a U-slot patch antenna with broadband, and then introduce the second U-slot to produce a notch at the central frequency, so that the total band can be divided into two sub-bands. Thereafter, the third and the fourth U-slots were introduced to produce two notches at the central frequencies of the two sub-bands so that the sub-bands can be divided into four bands as required.

The central frequencies of the four bands required are $f_1 = 3.30$ GHz, $f_2 = 3.70$ GHz, $f_3 = 5.20$ GHz and $f_4 = 5.80$ GHz. The notch frequencies were expected to be located at the centers between two adjacent frequencies. They were 3.5 GHz, 4.45 GHz and 5.5 GHz. The

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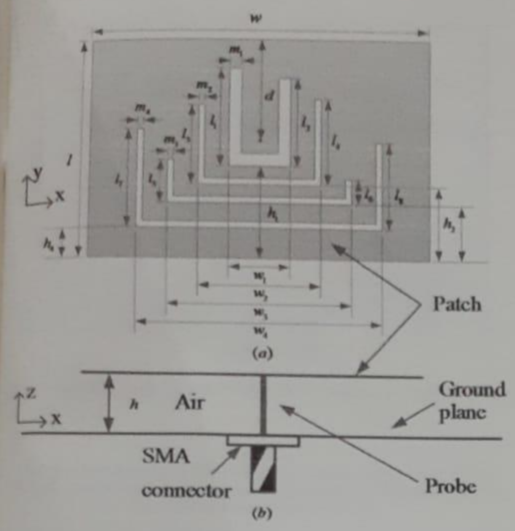

Fig. 1. Geometry of the four-band patch antenna. (a) patch with four U-slots, (b) cross-sectional view.

TABLE I
OPTIMIZED DIMENSIONS OF THE ANTENNA (UNIT: mm)

Parameter	Value	Parameter	Value
l_1	16	w_2	18
l_2	15	w_3	22.5
l_3	9.5	w_4	26
l_4	10	h_1	7
l_5	4.5	h_2	5
l_6	2	h_3	3
l_7	10.8	h_4	1
l_8	10	w	38
m_1	1.6	l	27.5
m_2	1	d	15.5
m_3	1	h	5
m_4	1	W_g	50
w_1	14.2	L_g	50

central notch frequency 4.45 GHz was actually the central frequency of the broadband, and the two side notch frequencies were actually the central frequencies of two sub-bands.

Against this background, the guidelines for designing the antenna can be summarized as follows.

First Step: A conventional asymmetric broadband U-slot patch antenna, with parameters w, l, h, l_1, l_2, m_1 and w_1 was designed first by using the following approximate formulas [6].

$$w = \frac{c}{2f_r}\sqrt{\frac{2}{\varepsilon_r + 1}} \quad (1)$$

$$l = \frac{c}{2f_r\sqrt{\varepsilon_r}} - 2\Delta l \quad (2)$$

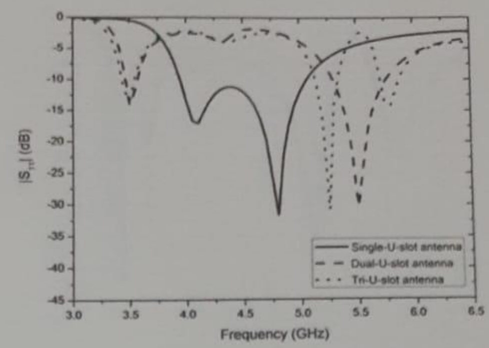

Fig. 2. Simulated reflection coefficients of single-U-slot, dual-U-slot and tri-U-slot antennas.

$$\varepsilon_{\text{reff}} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{w}\right]^{-1/2} \quad (3)$$

$$\Delta l = 0.412h\frac{(\varepsilon_{\text{reff}} + 0.3)\left(\frac{w}{h} + 0.264\right)}{(\varepsilon_{\text{reff}} - 0.258)\left(\frac{w}{h} + 0.8\right)} \quad (4)$$

$$w_1 = \frac{c}{\sqrt{\varepsilon_{\text{reff}}}f_2} - 2(l + 2\Delta l - m_1) \quad (5)$$

$$m_1 = \frac{\lambda_r(\text{air})}{60} \quad (6)$$

$$\frac{l_1}{w} \geq 0.3, \frac{l_2}{w} \geq 0.3 \text{ and } \frac{l_1}{w_1} \geq 0.75, \frac{l_2}{w_1} \geq 0.75 \quad (7)$$

$$h \geq 0.06\frac{\lambda_r(\text{air})}{\sqrt{\varepsilon_r}} \quad (8)$$

where $f_r = 4.45$ GHz was the central frequency of the broadband.

The U-slot was composed of two parallel vertical rectangular slots and a horizontal rectangular slot, which were cut in the patch to achieve broadband performance. Through calculation and optimization, a broadband U-slot antenna was achieved as shown in Figs. 2 and 3, wherein the results of dual-U-slot antenna and tri-U-slot antenna are also presented for later comparison. The dimensions from the formulas with symmetrical arms were used as the initial guess. Taking the required central frequency and the wide 10 dB return loss bandwidth as the objectives, the optimization was carried out by fine-tuning the dimensions, especially l_1 and l_2, by using the commercial software HFSS. The dimensions for this single-U-slot antenna are listed in Table III.

Second Step: The second slot was introduced to generate the notch at the central frequency 4.45 GHz of the broadband single-U-slot antenna. The total length of this slot was chosen to be approximately half the wavelength of the respective notch frequency 4.45 GHz and it was found that the location of this slot was insensitive to the notch frequency [16]–[18]. The final total length is shown in Table II. The optimization was carried out for fine-tuning the dimensions by using the commercial software HFSS. The dimensions for this dual-U-slot antenna are shown in Table III and the performances in Figs. 2 and 3.

Third Step: The third slot was introduced to generate the notch at the central frequency 5.5 GHz of higher sub-band of the dual-U-slot antenna. The total length of this slot was chosen to be approximately half the wavelength of the respective notch frequency 5.5 GHz. The optimization was carried out for fine-tuning the dimensions by using the commercial software HFSS. The dimensions of this tri-U-slot antenna are shown in Table III and the performances in Figs. 2 and 3. The final total length is listed in Table II.

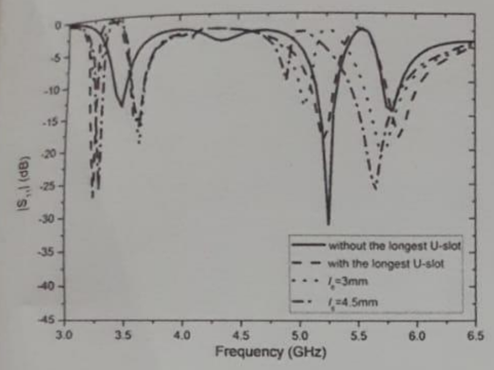

Fig. 11. Effect of the longest U-slot and simulated reflection coefficients on different l_6.

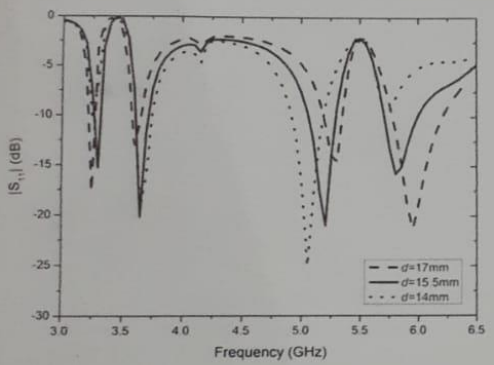

Fig. 12. Simulated reflection coefficients for the d.

the current distribution seriously and resulted only in an asymmetrical U-slot.

B. Effect of d

Fig. 12 shows the relationship between the parameter d and higher frequency shift. It can be seen that the notch-band (5.50 GHz) is not sensitive to parameter d, unlike the adjacent match-bands, which are seriously affected. On the contrary, the first notch-band (3.37 GHz) and the match-band (3.30 GHz) move slightly toward the higher frequency simultaneously. This is because the length of the longest U-slot ($l_7 + l_8 + w_4 - 2m_4$) determines the positions of the first and second frequency bands, and the variation in parameter d generates slight mismatch between the first and second frequency bands.

V. Conclusion

This communication presents the simple geometry of a single-layer single-patch four-band patch antenna. This antenna has four asymmetrical U-slots and is fed by a coaxial probe. The antenna can be easily designed to operate at 3.35 GHz, 3.70 GHz, 5.20 GHz and 5.80 GHz, which are WiMax and WLAN bands at S and C bands. The antenna provides impedance bandwidths of 2.1%, 3.3%, 7.1% and 5% at four different application bands. The peak gains are 7.6 dBi, 8.6 dBi, 8.5 dBi and 9.0 dBi. Tests of similar scenarios indicate that the proposed guidelines work well and may always give the expected results. When higher gain is needed, the proposed antenna can be used to form an array for achieving the required gain. The cross polarization levels of E-plane and H-plane are less than −10 dB in all the four bands, which are acceptable to most of the applications.

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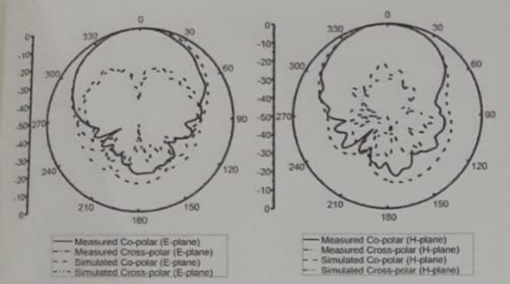

Fig. 5. Measured and simulated normalized radiation patterns of the antenna at 3.35 GHz.

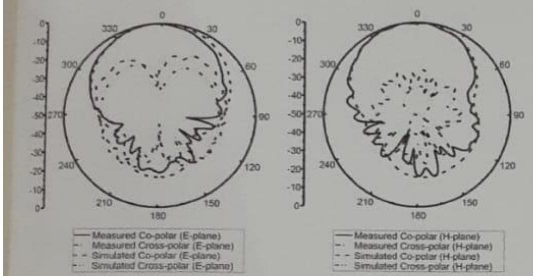

Fig. 6. Measured and simulated normalized radiation patterns of the antenna at 3.70 GHz.

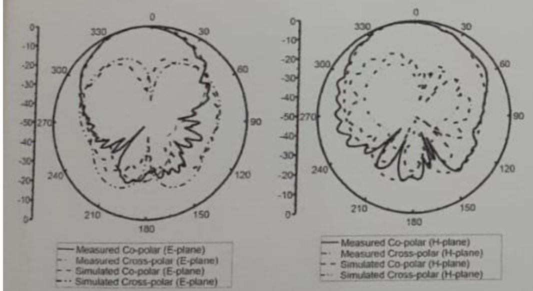

Fig. 7. Measured and simulated normalized radiation patterns of the antenna at 5.20 GHz.

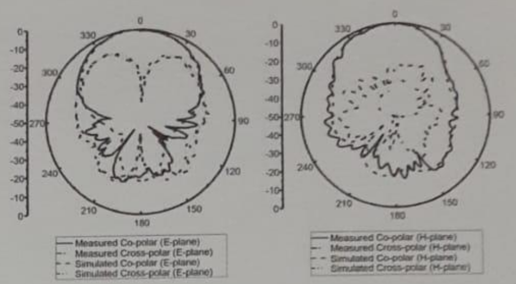

Fig. 8. Measured and simulated normalized radiation patterns of the antenna at 5.80 GHz.

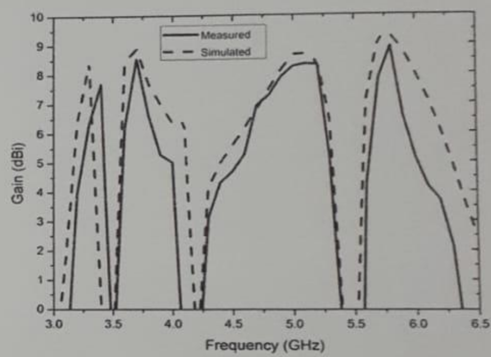

Fig. 9. Measured and simulated gains of the antenna.

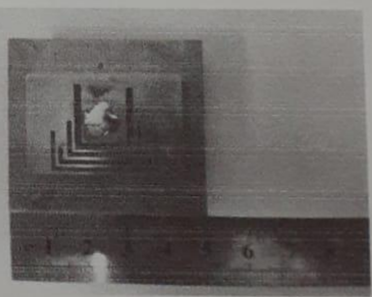

Fig. 10. Photograph of the four-band antenna prototype.

and 8.37 dBi. With increase in the dimension of the ground, the gains of the antenna increase in the four bands. However, these gains show no significant change when the dimension of the ground increases up to about 50 mm. This size was chosen for our design. Fig. 10 shows the photograph of the antenna.

IV. Parametric Studies and Discussion

A. *Effect of the Longest U-Slot and l_6*

To verify the guidelines of the antenna design, the longest U-slot $(l_7 + l_8 + w_4 - 2m_4)$ was selected for the parametric study. Fig. 11 shows that the introduction of the fourth U-slot in the patch resulted in a notch centered at about 3.5 GHz. The total length of the longest U-slot $(l_7 + l_8 + w_4 - 2m_4)$ is 44.8 mm, which is consistent with the analysis in Section II. Owing to the limited adjustable space of width w_3, an asymmetrical topology was employed to fine-tune the total length of the U-slot. In this design, l_6 was taken as the variable for the asymmetrical slot. As shown in Fig. 11, by fine-tuning l_6, desired frequency points can be obtained. Fortunately, the fine-tuning of l_6 did not affect

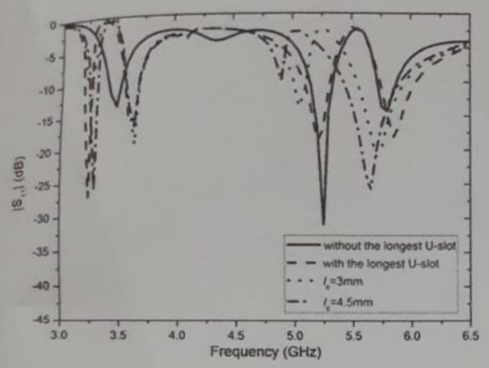

Fig. 11. Effect of the longest U-slot and simulated reflection coefficients on different l_6.

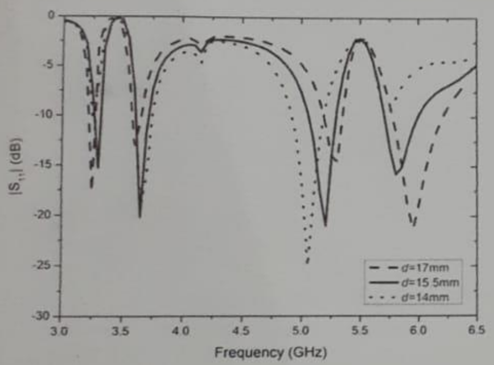

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Fig. 12 shows the relationship between the parameter d and higher frequency shift. It can be seen that the notch-band (5.50 GHz) is not sensitive to parameter d, unlike the adjacent match-bands, which are seriously affected. On the contrary, the first notch-band (3.37 GHz) and the match-band (3.30 GHz) move slightly toward the higher frequency simultaneously. This is because the length of the longest U-slot ($l_7 + l_8 + w_4 - 2m_4$) determines the positions of the first and second frequency bands, and the variation in parameter d generates slight mismatch between the first and second frequency bands.

V. Conclusion

This communication presents the simple geometry of a single-layer single-patch four-band patch antenna. This antenna has four asymmetrical U-slots and is fed by a coaxial probe. The antenna can be easily designed to operate at 3.35 GHz, 3.70 GHz, 5.20 GHz and 5.80 GHz, which are WiMax and WLAN bands at S and C bands. The antenna provides impedance bandwidths of 2.1%, 3.3%, 7.1% and 5% at four different application bands. The peak gains are 7.6 dBi, 8.6 dBi, 8.5 dBi and 9.0 dBi. Tests of similar scenarios indicate that the proposed guidelines work well and may always give the expected results. When higher gain is needed, the proposed antenna can be used to form an array for achieving the required gain. The cross polarization levels of E-plane and H-plane are less than −10 dB in all the four bands, which are acceptable to most of the applications.

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