DESIGN OF ULTRA SMALL MICROSTRIP PATCH ANTENNA FOR WIRELESS COMMUNICATION APPLICATIONS

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DESIGN OF ULTRA SMALL MICROSTRIP PATCH ANTENNA FOR WIRELESS COMMUNICATION APPLICATIONS

A Thesis submitted in partial fulfillment of the requirements for the degree of

Bachelor of Technology in "Electrical Engineering"

By

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May-2013

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CERTIFICATE

This is to certify that the thesis entitled "**Design of ultra small microstrip patch antenna for wireless communication applications**", submitted by **Tanya Sharma (109EE0615) and Oshin Atal (109EE0530)** in partial fulfilment of the requirements for the award of **Bachelor of Technology** in **Electrical Engineering** during session 2012-2013 at National Institute of Technology, Rourkela is a bonafide record of research work carried out by them under my supervision and guidance.

The candidates have fulfilled all the prescribed requirements.

The Thesis which is based on candidates' own work, have not submitted elsewhere for a degree/diploma.

In my opinion, the thesis is of standard required for the award of a bachelor of technology degree in Electrical Engineering.

Place: Rourkela

Dept. of Electrical Engineering
National institute of Technology

Prof. Prasanna Kumar Sahu
Associate Professor

ACKNOWLEDGEMENT

We have been highly indebted in the preparation of this thesis to our supervisor, ***Prof. Prasanna Kumar Sahu*** whose patience and kindness, as well as his academic experience, has been invaluable to us. We could not have asked for a better role model, inspirational, supportive, and patient guide. His consistent support and unstinting guidance has always been an immense source of motivation and encouragement.

Our sincere thanks to *Ms. Sheeja K. L.* for her constant guidance and encouragement and providing us with all facilities and access to the resources vital to the completion of this project.

Last but not the least, big thanks to NIT Rourkela for providing us such a platform
where learning has known no boundaries.

Oshin Atal and Tanya Sharma

ABSTRACT

This paper presents a narrow band microstrip patch antenna for wireless communication. A microstrip patch antenna consists of a radiating patch on one side of a dielectric substrate and has a ground plane on the other side. The main radiator is a rectangular patch made up of copper. The advantages of this type of narrowband antennas are planar, smaller in size, simple structure, low in cost and easy to be fabricated, etc. thus attractive for wireless applications. Simulation of the antenna and subsequent adjustments of parameters gives apt values for the antenna to work efficiently at low cost. At the later stage, comparison between different antenna shapes has been provided and comparative study has been done in order to list the advantages of each shape and decide which shape is best suited for the desired wireless frequency of 1.7GHz. Also this work explores the performance enhancement of multiple patch antennas. Comparative studies between the array and individual unit have proved the betterment of results for wireless applications at 1.7GHz.

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CHAPTER **1.**

INTRODUCTION

1. INTRODUCTION

In order to design patch antenna we used CST microwave studio. It is a special tool for the simulation of high frequency components. It helps in the fast and accurate analysis of high frequency such as filter, antennas, planar and multi-layer structures and signal integrity (SI) and electromagnetic compatibility (EMC) effects.

Here, we used CST microwave studio to design antenna for wireless communication. We have to create compact or even electrically small antennas that are compatible with the modem technology. In order to design a patch antenna, we require:-

- Antenna tuning
- Voltage standing wave radio (VSWR) and return loss
- Bandwidth
- Gain and directivity
- Radiation pattern
- Diversity

Antenna shape

It consists of a radiating patch on one side of a dielectric substrate and has a ground plane on the other side. The patch consists of a conducting material like copper or gold. Microstrip patch antenna radiates because of the fringing fields between the patch edge and the ground plane. For a good antenna, a thick dielectric constant is desirable because it provides better efficiency, better radiation and larger bandwidth.

Familiarity with CST microwave studio

- Select the CST microwave studio.
- Define the unit that involves the dimension. Frequency and other parameters.
- Define the background material.
- Model the structure such as plates, cylinders, bricks, spheres, etc. using Boolean operators.
- Define the frequency range in GHz.
- Define the ports.
- Define boundary and symmetric conditions.
- Set field monitors.

Finally simulation is done. And while simulating we analyse the port modes and analyse s-parameter and field quantities.

1.1 Merits of Microstrip patch antennas

- Microstrip antennas are relatively inexpensive to manufacture and design because of the simple 2-dimensional physical geometry.
- Employed at UHF and higher frequencies because the size of the antenna is directly tied to the wavelength that the resonant frequency.
- Easy to print an array of patches on a single (large) substrate using lithographic techniques.
- Patch arrays can provide much higher gains than a single patch at little additional cost; matching and phase adjustment can be performed with printed microstrip feed structures, again in the same operations that form the radiating patches.

- The ability to create high gain arrays in a low-profile antenna is one reason that patch arrays are common on airplanes and in other military applications[1].
- Patch antennas can easily be designed to have vertical, horizontal, right hand circular (RHCP) or left hand circular (LHCP) polarizations, using multiple feed points, or a single feed-point with asymmetric patch structures[2].

1.2 Demerits of Microstrip Patch antennas

- Narrow bandwidth
- Low efficiency
- Poor polarization
- Low gain
- Extra radiation occurs from its feeds and junctions
- Excitation of surface waves
- Size of micro strip antenna comes in both advantages and disadvantages but there are Some applications where the size of microstrip antenna is too large to be used.

CHAPTER **2**

MOTIVATION

Wireless operations enable services, such as long-range communications, which are impractical or impossible to implement with the use of wires. The term is frequently used in the telecommunications industry to refer to telecommunications systems (e.g. radio transmitters and receivers, remote controls etc.) which use some type of energy (e.g. radio waves, acoustic energy, etc.) to transmit information without the use of wires. Information is passed on in this manner over both short and long distances.

Wireless networking (*e.g.*, the various types of unlicensed 2.4 GHz WiFi devices) is used for many purposes. Perhaps the most common use is to connect laptop users who commute from location to location. Another use is for mobile networks that connect via satellite. A wireless transmission method is a practical choice to network a LAN segment that must frequently alter locations. The following situations justify the use of wireless technology [3]:

- To cover a distance beyond the capabilities of typical cabling,
- To enable a backup communications link in case of normal network failure,
- To connect portable or temporary workstations,
- To overcome situations where normal cabling is tedious or financially impractical, or
- To remotely connect mobile users and networks.

Wireless communications can be via:

- Microwave communication, such as long-range line-of-sight via highly directional antennas, or short-range communication, light, visible and Infrared (IR) for example consumer IR devices such as remote controls or via Infrared Data Association (IrDA).
- Sonic, especially ultrasonic short range communication
- Electromagnetic induction and short range communication and power

- Wi-Fi technology
- Radio communication

Wireless communication includes various forms of fixed, mobile, and portable applications, such as two-way radios, cellular telephones, personal digital assistants (PDAs), and wireless networking. Other applications of radio *wireless technology* include GPS units, wireless computer mice, garage door openers, satellite television, broadcast television, keyboards and headsets, headphones, radio receivers, and cordless telephones

WIRELESS COMMUNICATION

IEEE **802.11** is a set of standards for implementing wireless local area network (WLAN) computer communication in the 2.4, 3.6, 5 and 60 GHz bands of frequency. They are implemented and maintained by the IEEE LAN/MAN Standards Committee. The 802.11a standard uses the same data link layer protocol and frame format as the original standard. It works in the 5 GHz band with a maximum net data rate of 54 Mb/s, plus error correction code, yielding realistic net achievable throughput in the mid-20 Mb/s.

Since the 2.4 GHz band is heavily used to the point of being overly crowded, using the relatively unused 5 GHz band gives 802.11a a significant advantage. In theory, 802.11a signals are absorbed more readily by walls and other solid objects in their path owing to their smaller wavelength. 802.11a also suffers from interference, however locally there may be fewer signals to interfere with, thus resulting in less interference and better throughput [4].

The Microstrip patch antennas are well known for their performance and their robust design, fabrication and their widespread usage. The advantages of the Microstrip patch antenna have overcome their de-merits such as light weight, easy to design etc., the applications are in the various fields such as in the medical applications, satellites and even in the military systems like in the aircrafts, missiles, rockets, etc. The usage of the Microstrip antennas are spreading in all the fields and areas and now they are gaining popularity in the commercial aspects due to the low cost of the substrate material and fabrication. It is also expected that due to the increasing usage of the patch antennas in the wide range it could take over the usage of the conventional antennas for the maximum applications. Microstrip patch antenna has many applications some of which are discussed as below:

Mobile and satellite communication application: Mobile communication needs small, low-cost, low profile antennas. Microstrip patch antenna has all these requirements and various types of microstrip antennas have been designed for use in mobile communication systems. For satellite communication circularly polarized radiation patterns are required and can be realized using either square or circular patch with one or two feed points.

Global Positioning System applications: Nowadays microstrip patch antennas with substrate providing high permittivity sintered material are being used for global positioning systems. These antennas are circularly polarized, compact and very expensive due to their positioning. It is expected that millions of GPS receivers will be used by the general population for land vehicles, maritime vessels and aircraft to find their position accurately.

Radio Frequency Identification (RFID): RFID uses in different areas like mobile communication, manufacturing, logistics, health care and transport. RFID system generally use frequencies between 30 Hz and 5.8 GHz depending on the applications. Basically RFID system is a transponder or tag and a transceiver or also reader.

Worldwide Interoperability for Microwave Access (WiMax): The IEEE 802.16 standard is also called WiMax. It reaches upto 30 mile radius theoretically and data rate of 70 Mbps.

MPA generates three resonant modes at 2.7, 3.3 and 5.3 GHz and is thus used in WiMax compliant communication equipment.

Radar Application: Radar is used for detecting moving targets example people and vehicles. It requires a low profile, light weight antenna subsystem, the microstrip antennas are the ideal choice. The fabrication technology is based on photolithography and enables the bulk production of microstrip antenna with repeatable performance at a lower cost in a lesser time as compared to the conventional antennas.

Rectenna Application: Rectenna is a special type of antenna, a rectifying antenna that is used to directly convert microwave energy to DC power. Rectenna is a concoction of four subsystems i.e. Antenna, post rectification filter, rectifier, ore rectification filter. In rectenna application, it is vital to design antennas with very high directive characteristics to satisfy the demands of long-distance links. Since the main aim of using the rectenna is to transfer DC power through wireless links for a long distance, it can only be accomplished by increasing the electrical size of the antenna.

Telemedicine Application: Antenna is operating at 2.45 GHz foe telemedicine application. The wearable microstrip antenna is used for Wireless Body Area Network (WBAN). The proposed antenna achieves a front to back ratio and gain as compared to the other antennas, as also the semi directional radiation pattern which is preferred over the omni-directional pattern to prevent undesired radiation to the user's body and satisfies the requirement for on-body and off-body applications. An antenna having a gain of 6.7 dB and a F/B ratio of 11.7 dB resonating at 2.45GHz is preferred for telemedicine applications.

Medicinal applications of patch: It is researched that in the treatment of malignant tumours. The microwave energy is the most effective way of inducing hyperthermia in the patient. The design of the particular radiator that is used for this purpose should possess light weight and easy in handling and also rugged. Only the patch radiator fulfils all these requirements. The initial patterns for the Microstrip radiator for inducing hyperthermia were based on the printed dipoles and annular rings which were designed based on S-band. Later the design was based on the circular microstrip disk at L-band. There is a simple operation that is included with the instrument; two coupled Microstrip lines are separated with a flexible separation that is used to measure the temperature inside the human body [5].

In this work, our objective was to design a rectangular and triangular microstrip patch array antennas operating at 1.7GHz for wireless applications. Its advantages over conventional rectangular and triangular single patch microstrip antennas operating at the same frequency was analyzed and discussed.

CHAPTER **3**

THEORY OF MICROSTRIP PATCH ANTENNA

3.1 Types of Microstrip patch antennas

1) **Half-wave rectangular antenna**:

The half-wave rectangular microstrip antenna has a virtual shorting plane along its centre. This may be replaced with a physical shorting plane to create a quarter-wavelength microstrip antenna. This is sometimes called a half-patch. The antenna only has a single radiation edge (equivalent slot) which lowers the directivity/gain of the antenna. The impedance bandwidth is slightly lower than a half-wavelength full patch as the coupling between radiating edges has been eliminated. The dielectric loading of a microstrip antenna affects both its radiation pattern and impedance bandwidth. As the dielectric constant of the substrate increases, the antenna bandwidth decreases which increases the Q factor of the antenna and therefore decreases the impedance bandwidth

2) **Planar Inverted F Antenna (PIFA)**

It is common in cellular phones with built-in antennas. It is increasingly used in the mobile phone market. The antenna is resonant at a quarter-wavelength (thus reducing the required space needed on the phone), and also typically has good SAR properties. This antenna resembles an inverted F, which explains the PIFA name. The Planar Inverted-F Antenna is popular because it has a low profile and an omnidirectional pattern. These antennas are derived from a quarter-wave half-patch antenna. The shorting plane of the half-patch is reduced in length which decreases the resonance frequency [6]. Often PIFA antennas have multiple branches to resonate at the various cellular bands. On some phones, grounded parasitic elements are used to enhance the radiation bandwidth characteristics.

3) **Folded Inverted Conformal Antenna**

The FICA placement on the handset board and its feeding mechanisms are similar to those used currently for the great majority of handsets with internal planar inverted F-antenna (PIFA) components. FICA structure is synthesised in order to sustain three resonant modes that better reuse the volume. The implementation of volume reuse allows spreading of the reactive electromagnetic energy associated with each resonant mode across the entire antenna volume. This results in FICA modes exhibiting a lower Q factor and a wider fractional bandwidth than the corresponding PIFA modes.

3.2 Feeding techniques and modelling of Microstrip patch antenna

A feed line is used to excite to radiate by direct or indirect contact. There are many different techniques of feeding and four most popular techniques are coaxial probe feed, microstrip line, aperture coupling and proximity coupling [6].

1) **Coaxial probe feeding**

Coaxial probe feeding is feeding method in which that the inner conductor of the coaxial is attached to the radiation patch of the antenna while the outer conductor is connected to the ground plane. Advantages of coaxial feeding is easy of fabrication, easy to match, low spurious radiation and its disadvantages is narrow bandwidth, difficult to model specially for thick substrate.

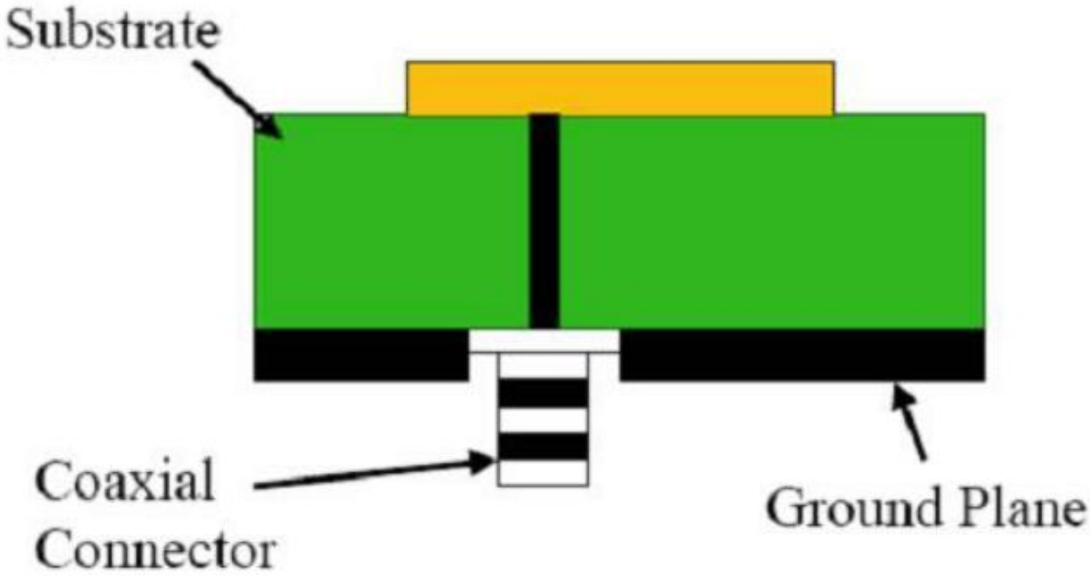

Fig 3.1: Coaxial feeding

2) Microstrip line feed

Microstrip line feed is one of the easier methods to fabricate as it is a just conducting strip connecting to the patch and therefore can be consider as extension of patch. It is simple to model and easy to match by controlling the inset position. However the disadvantage of this method is that as substrate thickness increases, surface wave and spurious feed radiation increases which limit the bandwidth.

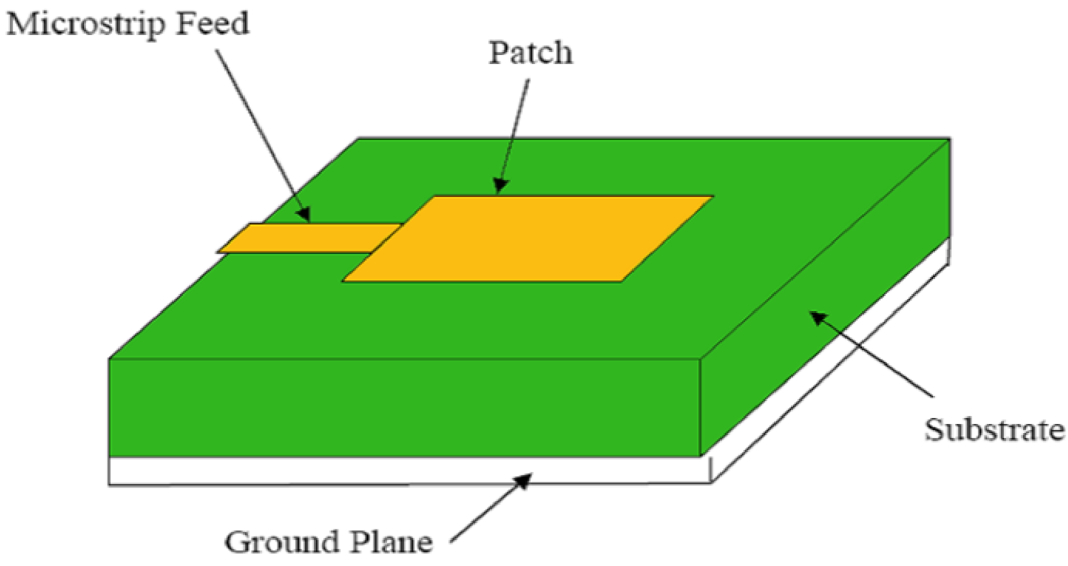

Fig3.2: Microstrip line feed

3) Aperture coupled feed

Aperture coupled feed consist of two different substrate separated by a ground plane. On the bottom side of lower substrate there is a microstrip feed line whose energy is coupled to the patch through a slot on the ground plane separating two substrates. This arrangement allows independent optimization of the feed mechanism and the radiating element. Normally top substrate uses a thick low dielectric constant substrate while for the bottom substrate; it is the high dielectric substrate. The ground plane, which is in the middle, isolates the feed from radiation element and minimizes interference of spurious radiation for pattern formation and polarization purity. Advantages is allows independent optimization of feed mechanism element

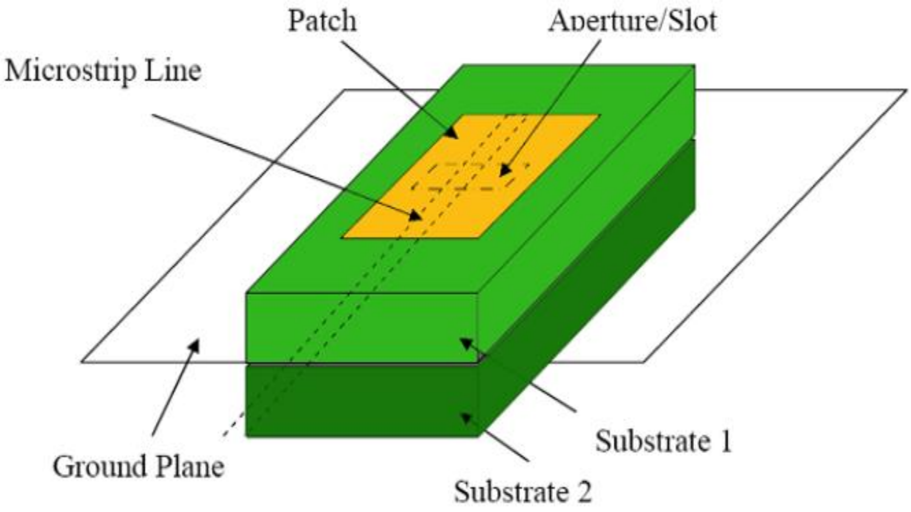

Fig 3.3: Aperture coupled feed

4) **Proximity Coupled Feed**

This type of feed technique is also known as the electromagnetic coupling scheme. In figure, two dielectric substrates are used so that two substrates are in between feed line and the radiating patch is on the top of the upper substrate. The merits of this feed technique are that it eliminates spurious feed radiation and provides very high bandwidth of about 13%, due to increase in the electrical thickness of the microstrip patch antenna. This scheme prrovides choice between two different dielectric media, one is patch and other is the feed line to optimize the individual performances.

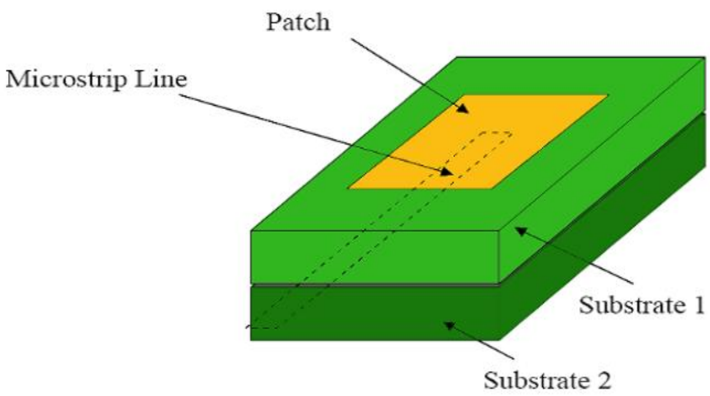

Fig: 3.4 Proximity coupled feed

3.3 Radiation fields

Radiation pattern

It is radiation properties of the antenna as a function of space coordinates. Radiation pattern is determined in a far field region and is depicted as a function of directional characteristics.

Isotropic, directional and Omni-directional patterns

Isotropic is a hypothetical lossless antenna having equal radiation in all directions. This expresses the directive property of actual antenna. Directional antenna is one having the property of radiating or receiving electromagnetic waves more effectively in some directions than in others. Omni-directional is defined as one having an essentially non-directional pattern in a given plane and a directional pattern in any orthogonal plane.

Principal pattern

E and H- plane are the principal patterns. E-plane is defined as the plane containing the electric-field vector and the direction of maximum radiation. H-plane is defined as the plane containing the magnetic-field vector and the direction of maximum radiation. For e.g.- the x-z plane (elevation plane, $\varphi=0$) is the principal E-plane and x-y plane (azimuthal plane, $\varphi= \pi/2$)) is the principal H-plane.

Radiation pattern loss

The lobes are classified as major/ main, side, minor, and back lobes. A radiation lobe is basically a portion of the radiation pattern bounded by regions of relatively weak radiation intensity. A major lobe (main beam) is defined as the radiation lobe which contains the direction of maximum direction. A minor lobe is any lobe except a major lobe. A side lobe is adjacent to the main lobe and occupies the hemisphere in the direction of main beam. A back lobe is a radiation lobe whose axis makes an angle of approximately 180^0 with respect to the beam of an antenna.

Field regions

Far field region is defined as that region of the field of an antenna where the angular field distribution is essentially independent of the distance from the antenna. If the maximum linear dimension if an antenna is D, then the following 3 conditions must be satisfied to be in farfield region.

$$R > 2D^2/\lambda \quad ---- (1)$$

$$R >> D \quad ---- (2)$$

$$R >> \lambda \quad ---- (3)$$

Equation 1 and 2 ensures that power radiated in a given direction form distinct parts of the antenna are approximately parallel. This ensures the field in farfield region behaves like plane waves. Equation 3 ensures that these near fields are gone and we are left with radiating fields which fall off with distance as 1/R.

Directivity

It measures how directional an antenna's radiation pattern is. Antenna that radiates equally in all directions would have directionality equal to 0, and directivity if this type of antenna would be 1(0 dB). Directivity is a function of angle, however the angular variation is described by its radiation pattern.

Gain

It is closely related to the directivity, it takes into account the efficiency of the antenna as well as its directional capabilities. Absolute gain is defined as the ratio of the intensity, in a given direction, to the radiation intensity that would be obtained of the power accepted by the antenna.

Gain= 4π (radiation intensity/ total input power)

Efficiency

Radiation efficiency is a figure of merit for an antenna. It is a measure of the electrical losses that occur in the antenna. It is the ratio of total power radiated by an antenna to the net power accepted by the antenna from the connected transmitter. It is expressed in percentage.

VSWR (Voltage standing wave ratio)

It is a function of the reflection coefficient which describes the power reflected from the antenna. It is always a real and positive number for antennas. The smaller the VSWR, the better the antenna is matched to the transmission line and more power is delivered to the antenna. The minimum VSWR is 1.0. VSWR is determined from the voltage measured along a transmission line leading to an antenna. It is the ratio of the peak amplitude of a standing wave to the minimum amplitude of a standing wave.

3.4 Rectangular microstrip patch antenna

While designing aircraft, satellite and missile, spacecraft etc. the size, weight, ease of installation, cost and aerodynamic profile are the constraints, and low profile antennas are usually required. The microstrip patch antenna, conformable to planar and non-planar surfaces, simple and inexpensive to manufacture using modern printed-circuit technology. The patch shaped and mode, selected, is very versatile in terms of resonant frequency, polarization, pattern and impedance [7].

Polarization in antenna means the polarization of radiated fields produced by an antenna evaluated in the far field. And impedance relates the voltage to the current at the input to the antenna. Beside these, there are few disadvantages of microstrip antenna:-

- Low efficiency
- Low power
- Poor polarization purity
- Poor scan performance
- Very narrow frequency

In order to increase the efficiency and bandwidth, height of the substrate can be increased. As the height increases, surface waves are introduced which are desirable as they extract power from the total available for direct radiation. Surface waves travel within the substrate and are scattered at the bends. Microstrip antennas exhibit large electromagnetic signature at certain frequencies outside the operating band . Inorder to design antenna, substrate is used and the range of dielectric constant varies from $2.2 < \varepsilon_r < 12$. Sometimes thick substrate is used as it has dielectric constant in the lower end of the range which provides better efficiency, larger bandwidth and loose bound fields for radiation into space. And thin substrate with higher dielectric constants are desirable for microwave circuitry because they require tightly bound fields to minimize undesired radiation and coupling and lead to smaller element sizes [8].

SHAPES OF ANTENNA PATCH

The radiating patch can be square, rectangular, thin strip (dipole), circular, elliptical, triangular or any other configuration. Among these the square, rectangular, dipole, and circular are most common because of ease of analysis and fabrication, their attractive radiation characteristics and low cross-polarization radiation.

Dipoles are attractive as they inherently possess a large bandwidth and occupy less space. Linear and circular polarization can be achieved with either single elements or arrays of microstrip antennas.

We had designed a rectangular patch as we could easily analyse it using both the transmission line and cavity models which are most accurate for thin substrates. Transmission line model gives good physical insight, but is less accurate and is more difficult to model coupling. Cavity model is more accurate but very complex. A rectangular microstrip antenna can be represented as an array of two radiating narrow apertures (slots), each of width W and height H, separated by a distance L as we will see later. Due to transmission line, fringing effect is seen. As the dimensions of the patch are finite along the length and width, the fields at the edges of the patch undergo fringing i.e. the field exists outside the dielectric thus causing a change in the effective dielectric constant. It is a function of the dimensions of the patch and the height of the substrate.

Fringing = (length of the patch)/ (height of substrate)

In order to reduce fringing effect, L/H >> 1. It also influences the resonant frequency of antenna. As L/H >> 1 and ε_r >>1, the electric field lines concentrate mostly in the substrate. Fringing in this case makes the microstrip line look within electrically compared to its physical dimensions. As waves travel in the substrate and in air, and effective dielectric constant ε_{reff} is introduced to tackle the fringing.

The effective dielectric constant is the dielectric constant of uniform dielectric material so that line has identical characteristics, particularly propagation constant, as actual line of microstrip line. ε_{reff} is in a range of:

$$1 < \varepsilon_{reff} < \varepsilon_r$$

The value of ε_{reff} is closer to ε_r if, $\varepsilon_r >> 1$. ε_{reff} is also a function of frequency. For low frequency the effective dielectric constant is essentially constant. At low frequency, W/H>1

$$\varepsilon reff = (\varepsilon_r+1)/2 + (\varepsilon_r-1)/2\ [1+ 12(H/W)]^{-1/2}$$

CHAPTER **4**

DESIGN OF RECTANGULAR AND TRIANGULAR MICROSTRIP PATCH ANTENNA

4.1 Design of Rectangular patch antenna at 1.7GHz

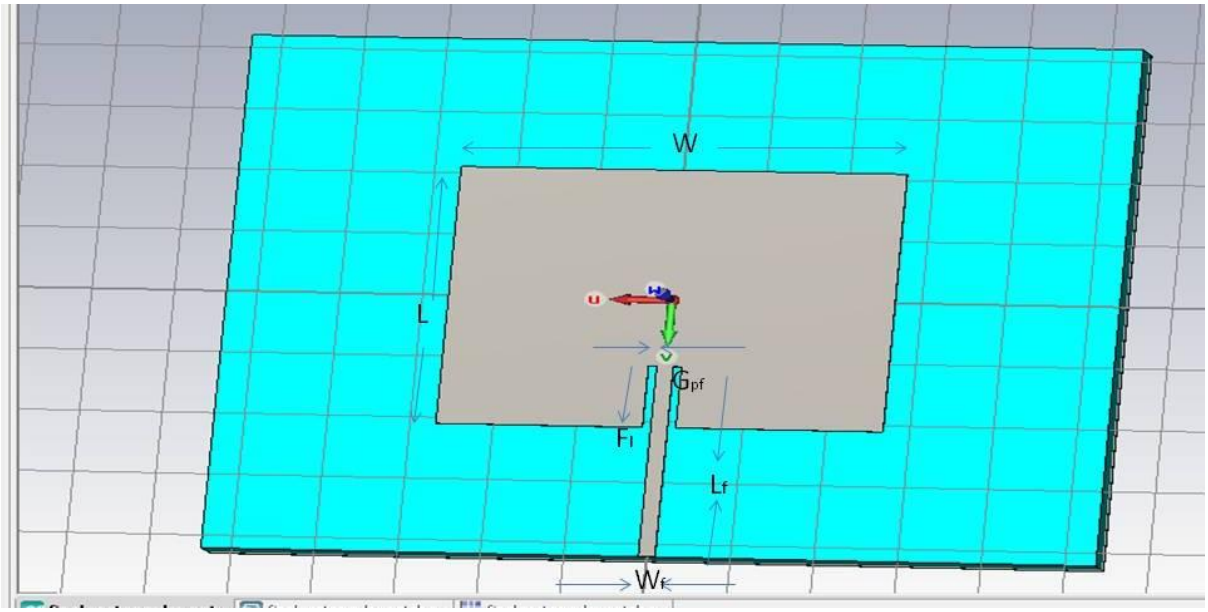

Fig 4.1: Design of rectangular patch antenna

Here the resonant frequency is 1.7GHz. The dimensions taken to design above the rectangular patch antenna are

L= 42.06 mm	**W**= 53.69 mm
$\mathbf{L_f}$= 31.03 mm	$\mathbf{W_f}$= 3 mm
$\mathbf{F_i}$= 10 mm	$\mathbf{G_{pf}}$= 1 mm
H= 4.5 mm	$\mathbf{m_t}$= 0.1 mm

Further we will calculated the return loss. From return loss we can determine whether the antenna is single band or multiband and also we can calculate bandwidth. The return loss plot can be seen from 1D result present in the navigation tree. Here return loss is at 0dB everywhere except at 1.6 GHz so it is a single band.

4.2 Results of Rectangular Patch Antenna at 1.7 GHz

The results of the simulation are shown below:

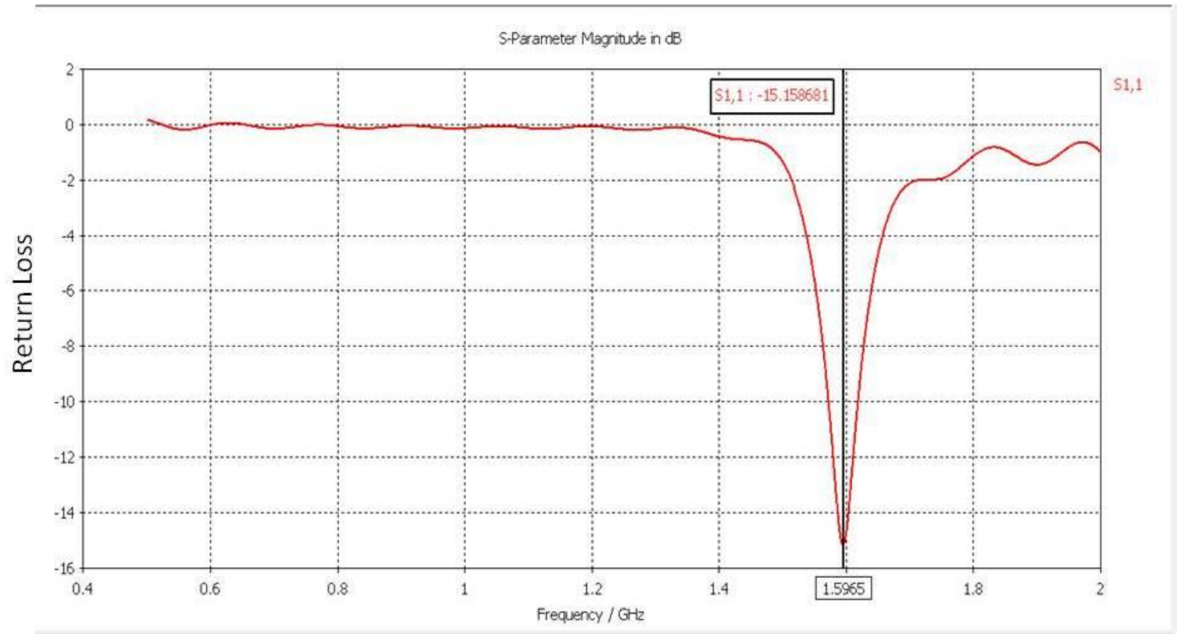

Fig4.2: Return loss at 1.7GHz

Bandwidth calculation

From graph after identifying -10dB line we get two points i.e. low and high frequency of band.

Here we get, low frequency= 1.5783GHz

high frequency =1.602GHz

Therefore bandwidth improvement= 1.49%

From this we can also judge whether it is narrow band or wide band.

This is the significance of return loss antenna

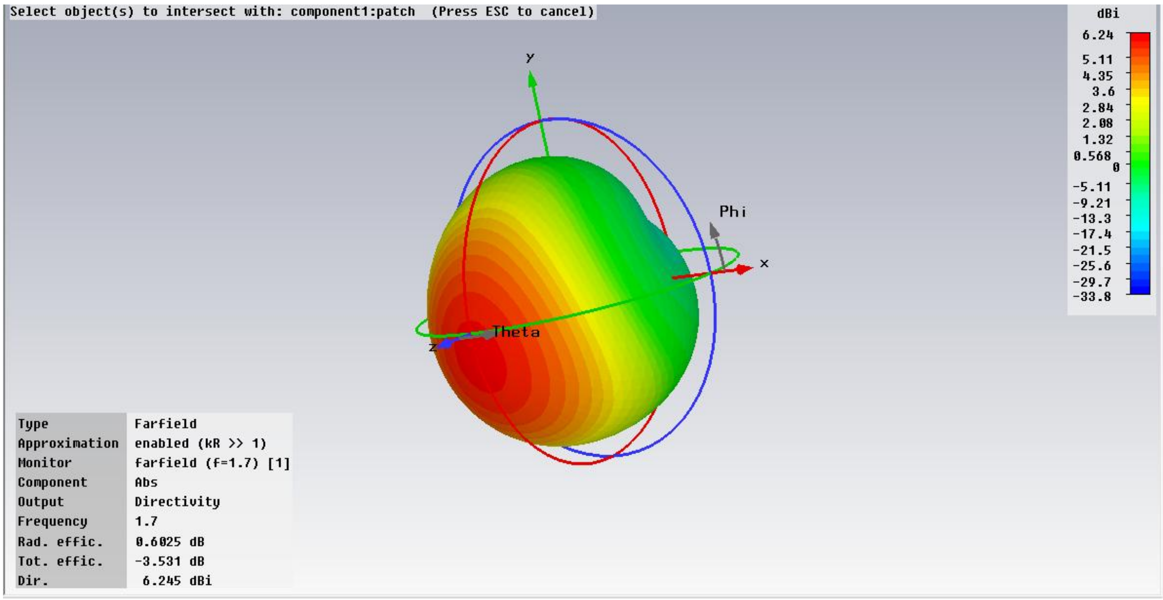

Fig4.3: 3D plot of gain at 1.7GHz

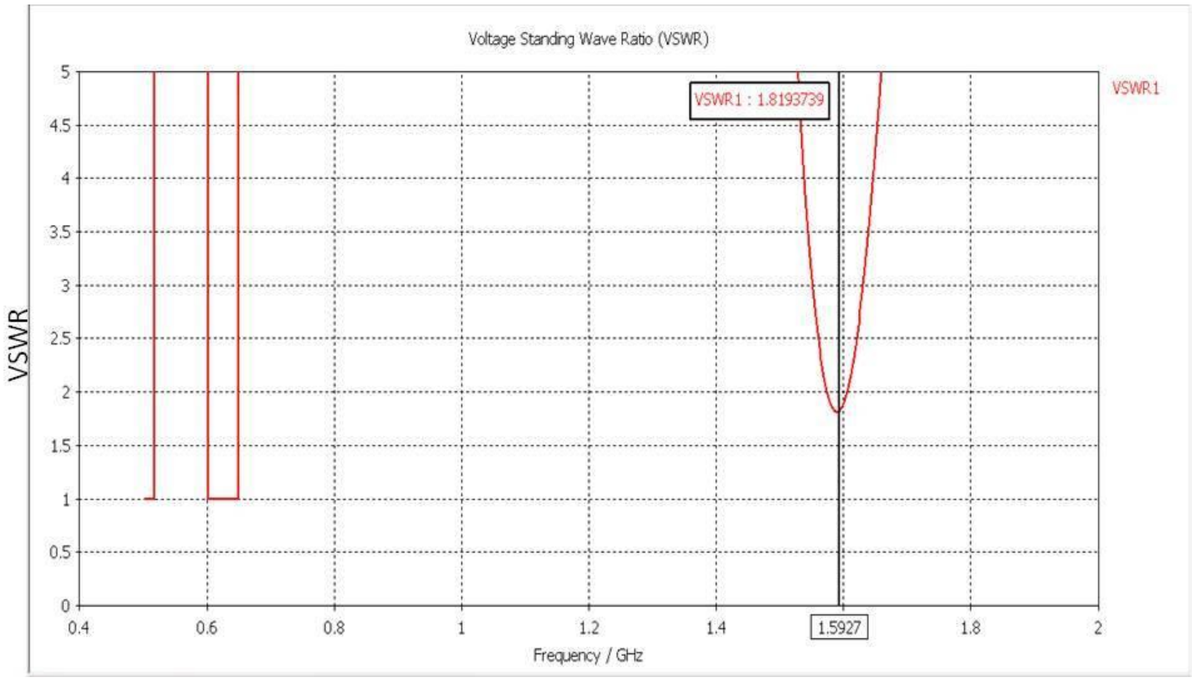

Fig4.4: VSWR at 1.7 GHz

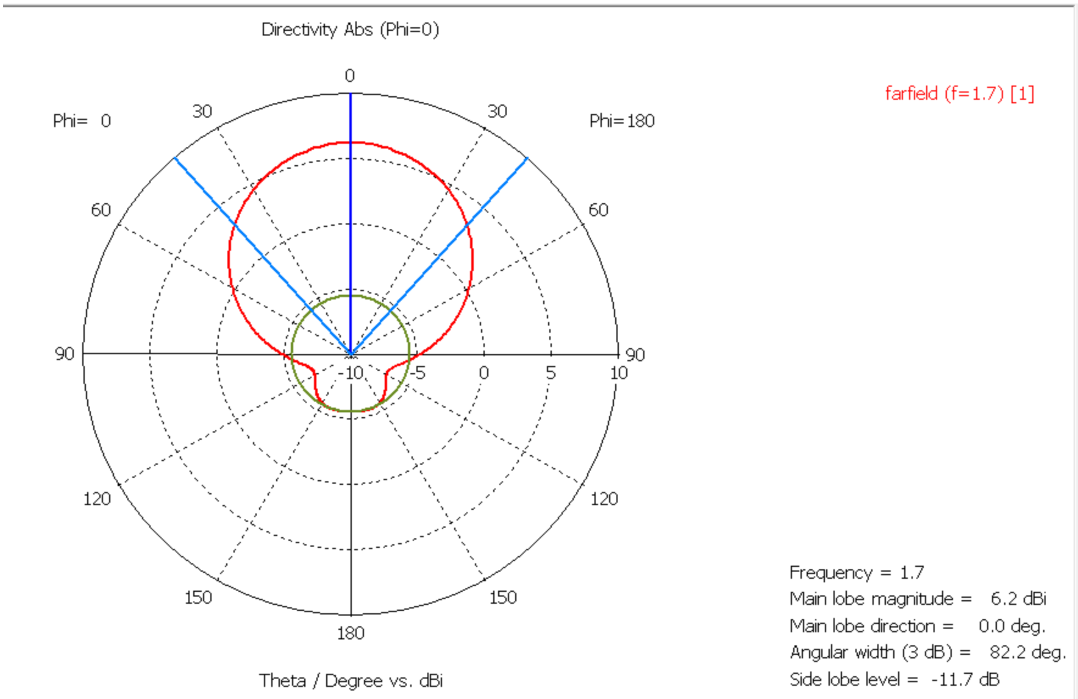

Fig4.5: E-plane at 1.7GHz

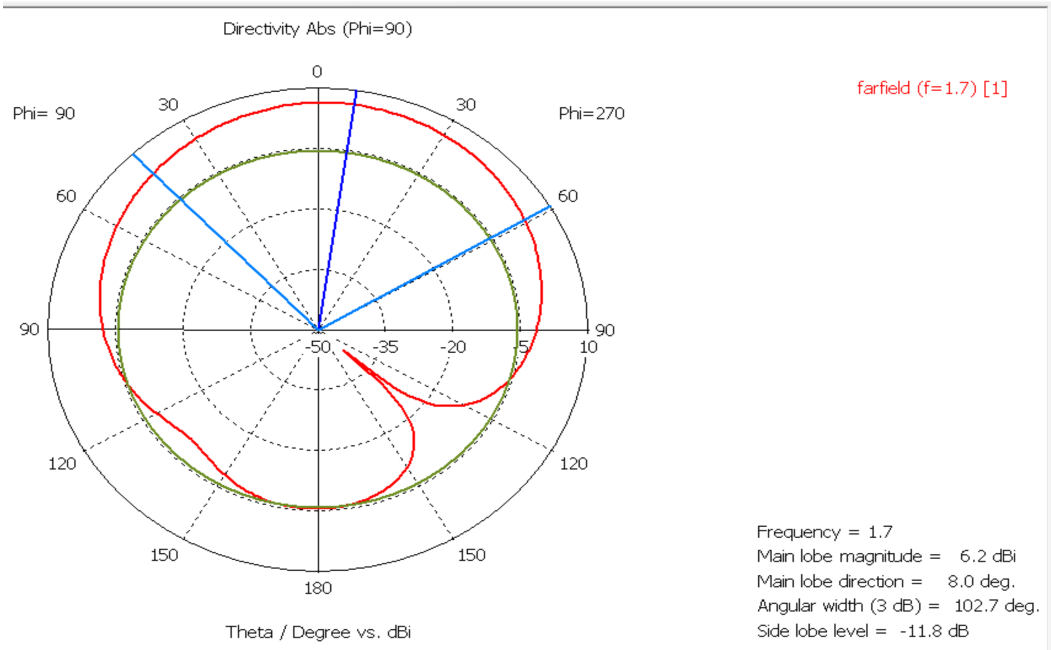

Fig 4.6: H-plane at 1.7GHz

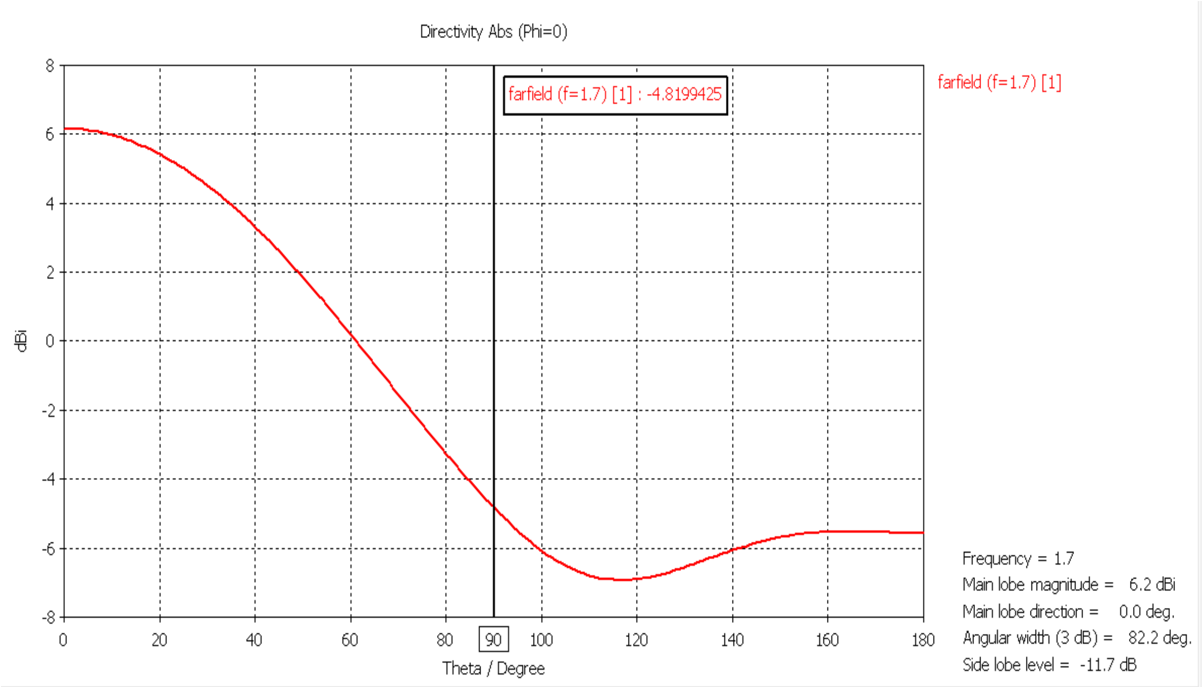

Fig4.7: Cartesian plot of directivity

4.3 Triangular patch antenna at 1.7GHz

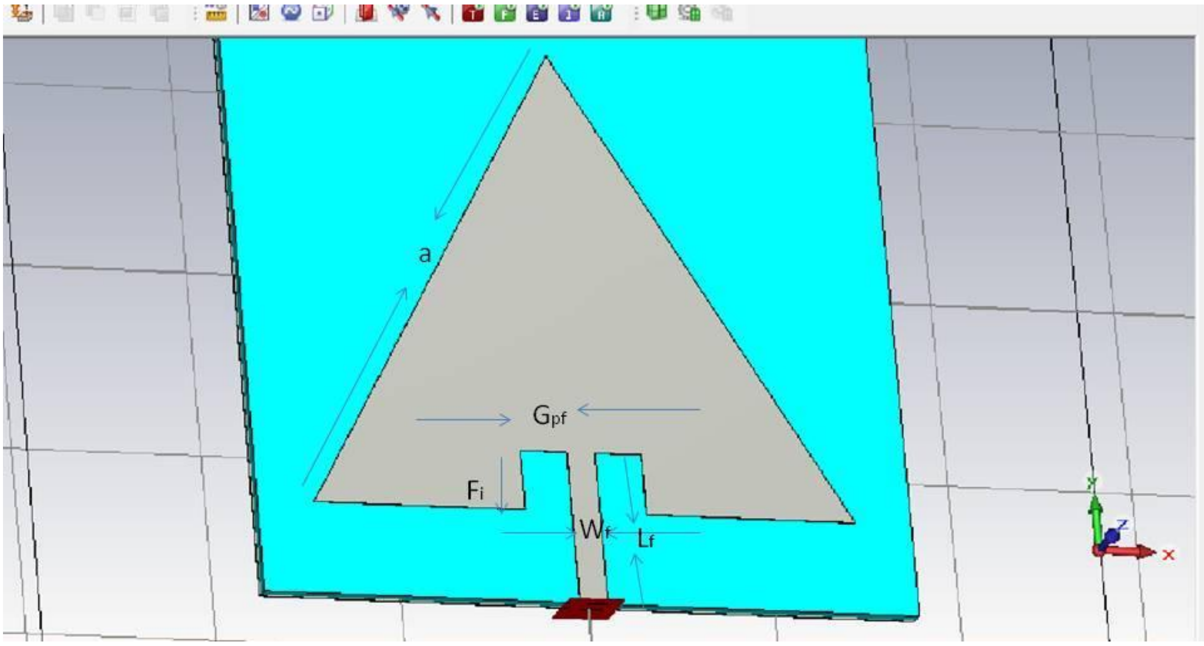

Fig4.8: Design of triangular patch antenna

We designed equilateral triangle with side 57.9mm. In order to calculate length of triangular side we have,

$$a = 2 \times c \div (3 \times f\sqrt{\varepsilon_r})$$

Where, c= speed of light

f= 2.5GHz

ε_r =4.4

therefore,

a=57.9mm

G_{pf}=1mm

W_f= 2 mm

coordinates of edges of triangles are: (0, 25.07, 0.8), (-28.95, -25.07, 0.8) and (28.95, -25.07, 0.8)

height of substrate is 70mm and centroid of triangle is (0, 0, 0.8)

After this the simulation of the design was performed and following results were obtained.

4.4 Results of Triangular Patch Antenna at 1.7GHz

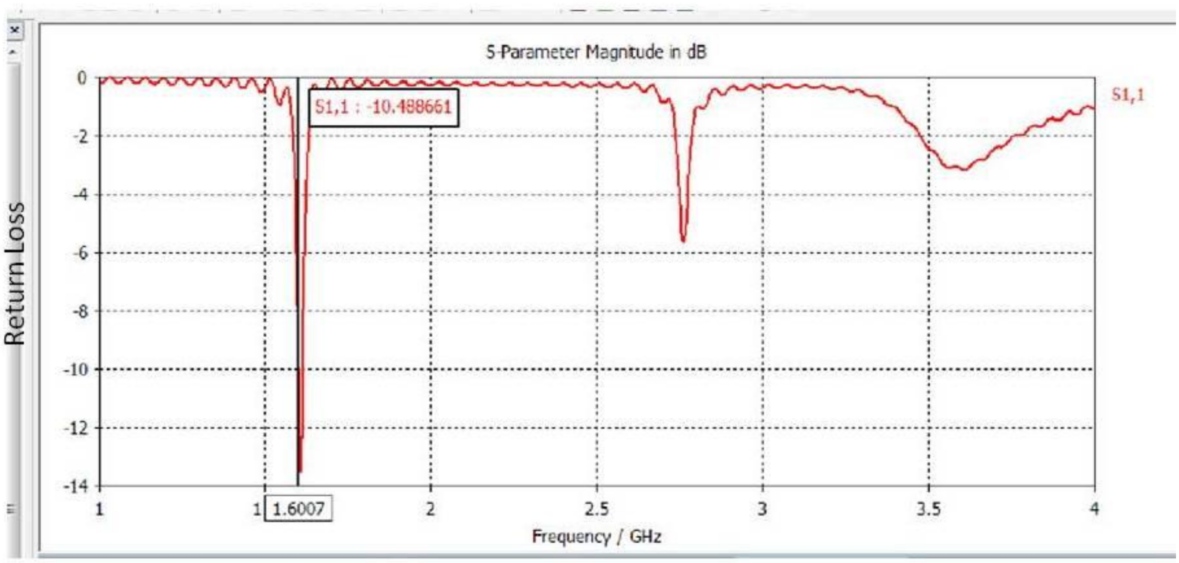

Fig4.9: return loss at 1.7GHz

From this figure we get that it is a single band showing resonant frequency at 1.6GHz.

From graph after identifying -10dB line we get two points i.e. low and high frequency of band.

Here we get, low frequency= 1.5973GHz

high frequency =1.6121GHz

Therefore bandwidth improvement= 0.92%

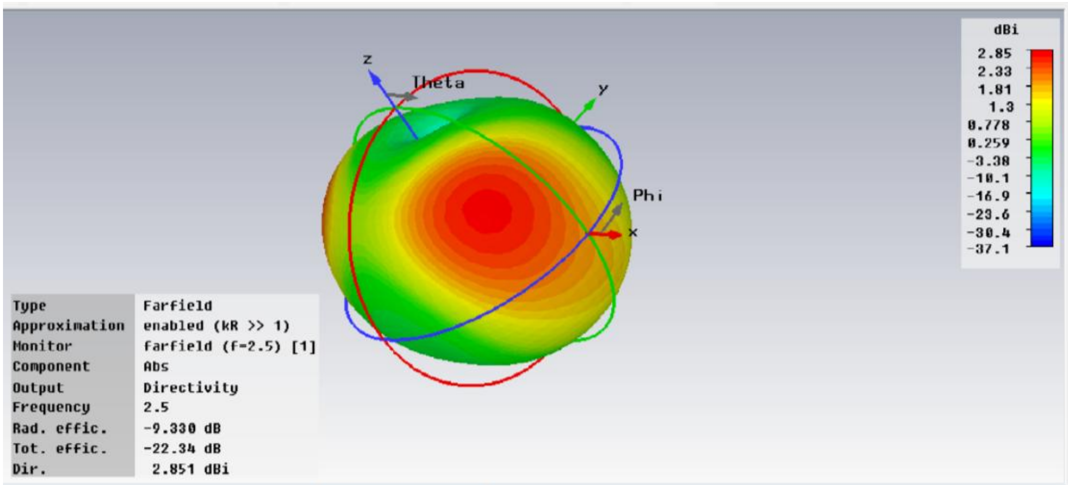

Fig4.10: 3D plot of gain at 1.7GHz

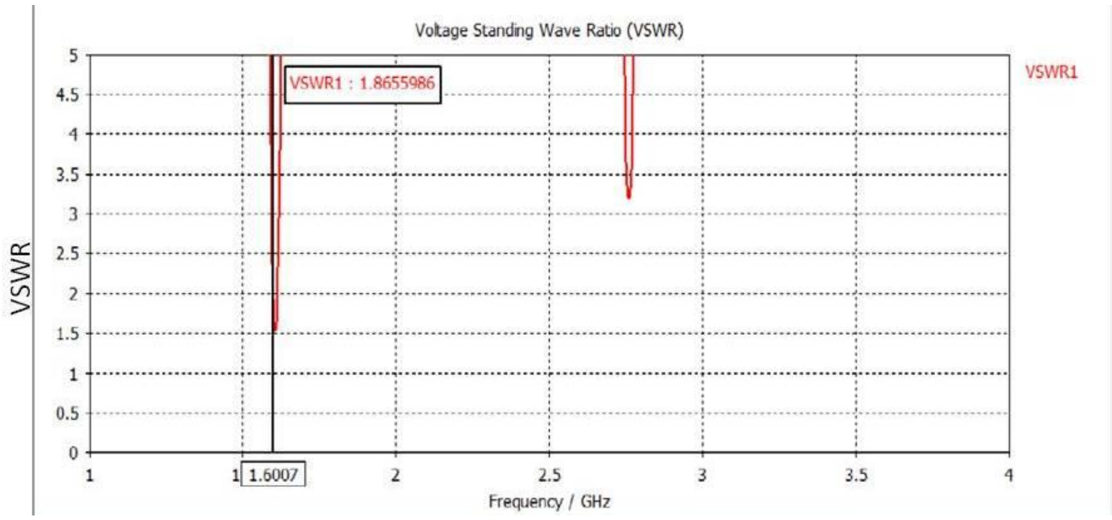

Fig4.11: VSWR at 1.7GHz

Here VSWR is 1.865 and it should be less than 2.

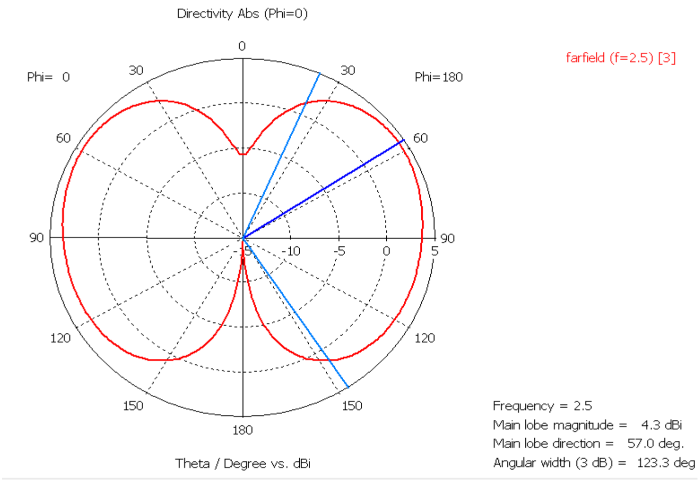

Fig4.12: E-plane at 1.7GHZ

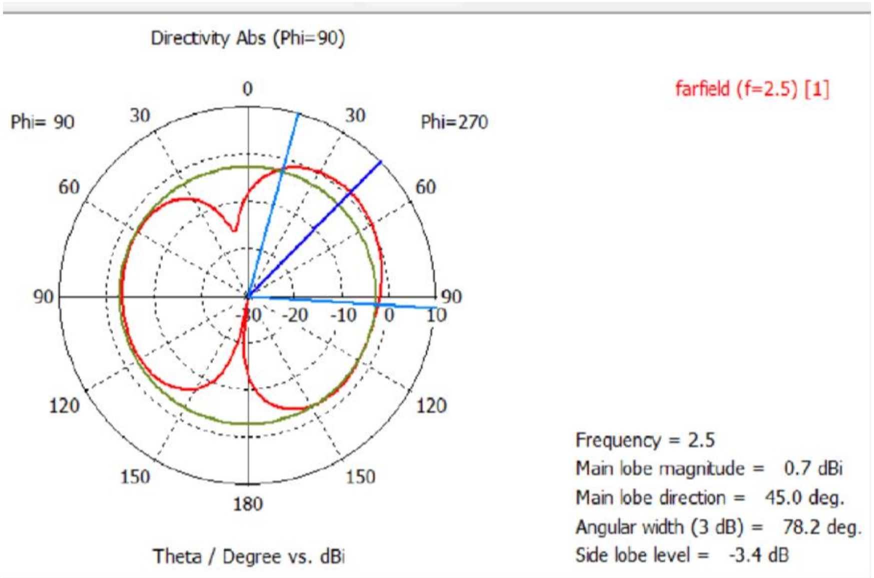

Fig4.13: H-plane at 1.7GHz

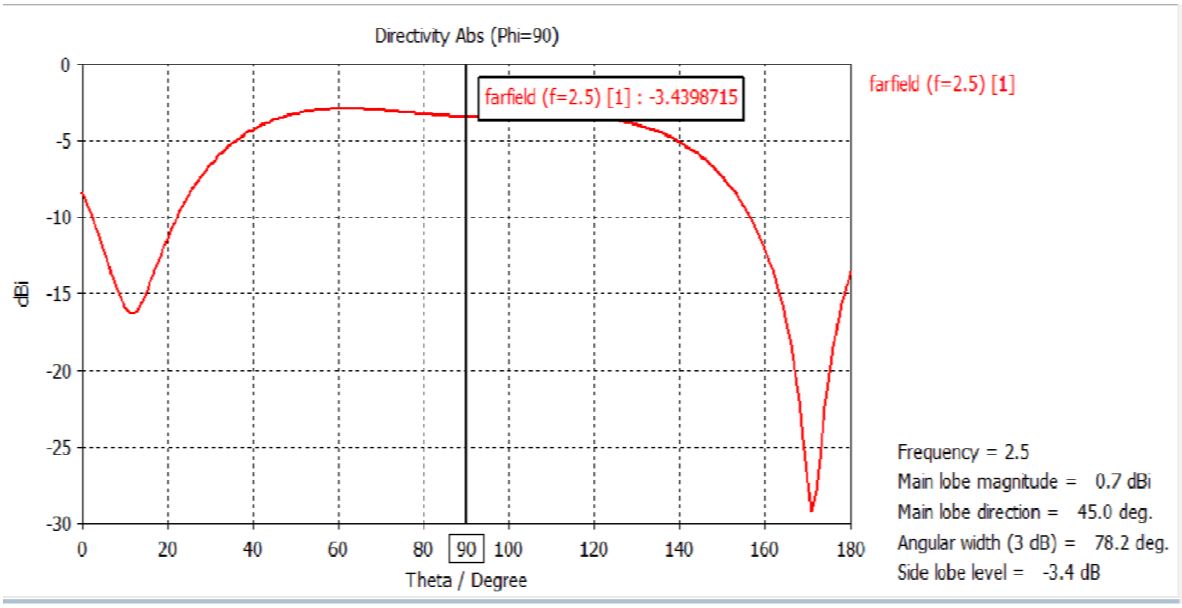

Fig4.14: Cartesian plot of directivity

4.5 COMPARISON OF RECTANGULAR AND TRIANGULAR PATCH

SINGLE PATCH ANTENNA	RESONANT FREQUENCY	RETURN LOSS	VSWR	BANDWIDTH IMPROVEMENT (%)	DIRECTIVITY
RECTANGULAR PATCH ANTENNA	1.6 GHz	-15 dB	1.42	1.49%	6.245dBi
TRIANGULAR PATCH ANTENNA	1.6 GHz	-13 dB	1.86	0.92%	2.456 dBi

The triangular patch antenna configuration is chosen because it has the advantage of occupying less metalized area on substrate than other existing configurations rectangular and circular geometries are most commonly used, Its dimension that tends to be small can make the overall dimension of the antenna very small too.

- Resonant frequency of both antennas is 1.6 GHz; these are suitable for ISM and WLAN.
- Rectangular patch antenna:- low profile, light weight antennas, most suitable for aerospace and mobile applications.

- Triangular patch antenna is smaller in size compared to rectangular .Directivity of rectangular patch antenna is higher than triangular patch antenna.

CHAPTER 5

DESIGN OF RECTANGULAR AND TRIANGULAR LINEAR ARRAY ANTENNA AND COMPARISON OF RESUTLS

5.1) Rectangular array antenna

In certain applications, desired antenna may be achieved with a single microstrip antenna. However, as in the case of microwave antenna, characteristics such as high gain, beam scanning, or directivity are achieved only when discrete radiators are combined to form arrays. A linear array consists of elements located finite distances apart along a straight line [9].

Design of linear 2×1 array

In order to make fair comparison, the same substrate used in single element(ε_r=4.4 and thickness h=1.6mm) is used in the 2×1 array. Here we took frequency 1.7GHz in order to determine the length and width of rectangle.

$$L = c \div (2 \times f_r \sqrt{\varepsilon})$$

Substituting all the values we get L= 42 mm

$$W = (c \div 2 \times F_r)\sqrt{(2/(\varepsilon\ + 1))}$$

Substituting, we get W= 53mm

Finally we get simulate the following design.

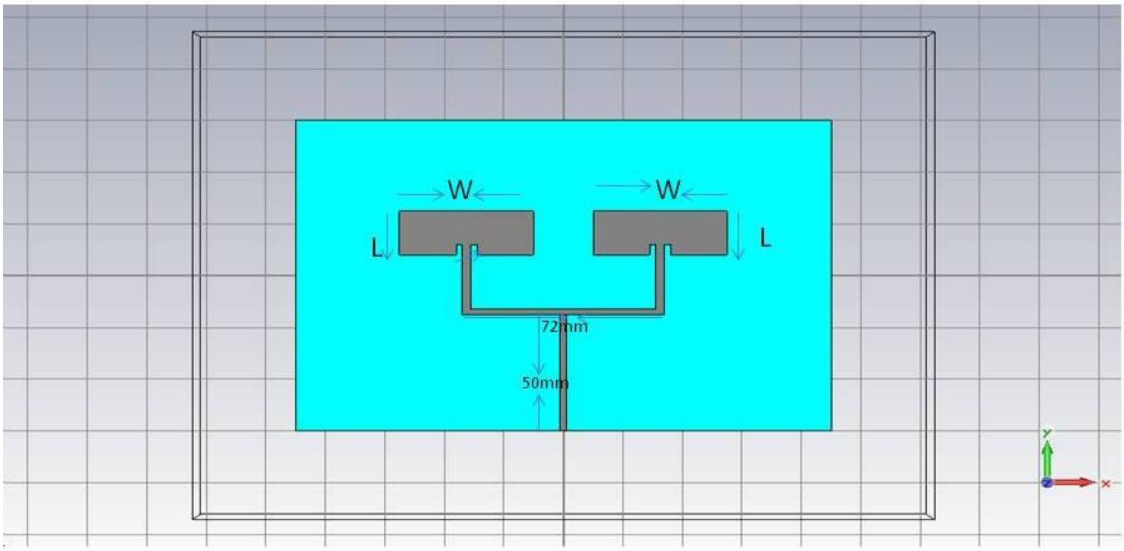

Fig5.1: Design of rectangular array patch antenna

After the simulation of the above design we get the following results.

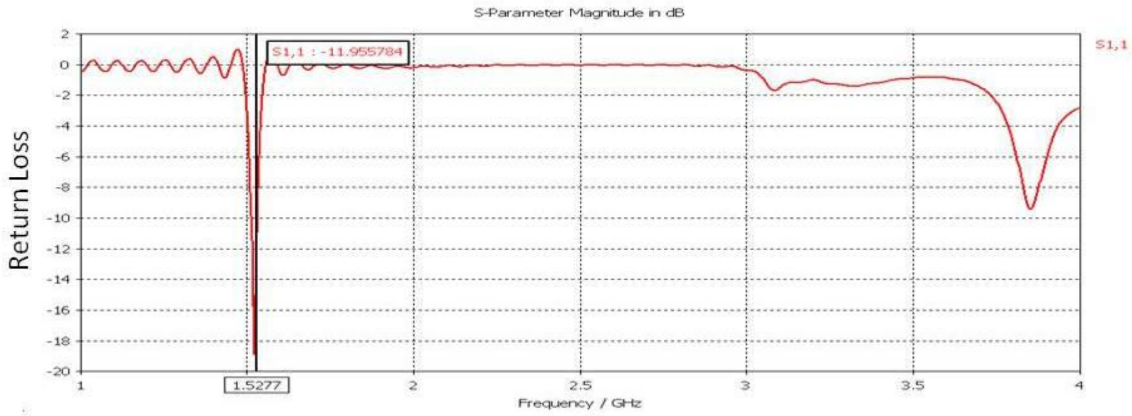

Fig5.2: Return loss

From return loss we get the improvement in bandwidth,

high frequency (f_1) = 1.5277 GHz

Low frequency (f_2) = 1.5100 GHz

Therefore, bandwidth = $(f_1-f_2)/\sqrt{f_1 f_2} \times 100\%$

= 1.165%

We got return loss = -19 dB resonating at 1.525 GHz

Further we get VSWR, 3D radiation pattern, Cartesian and polar plots.

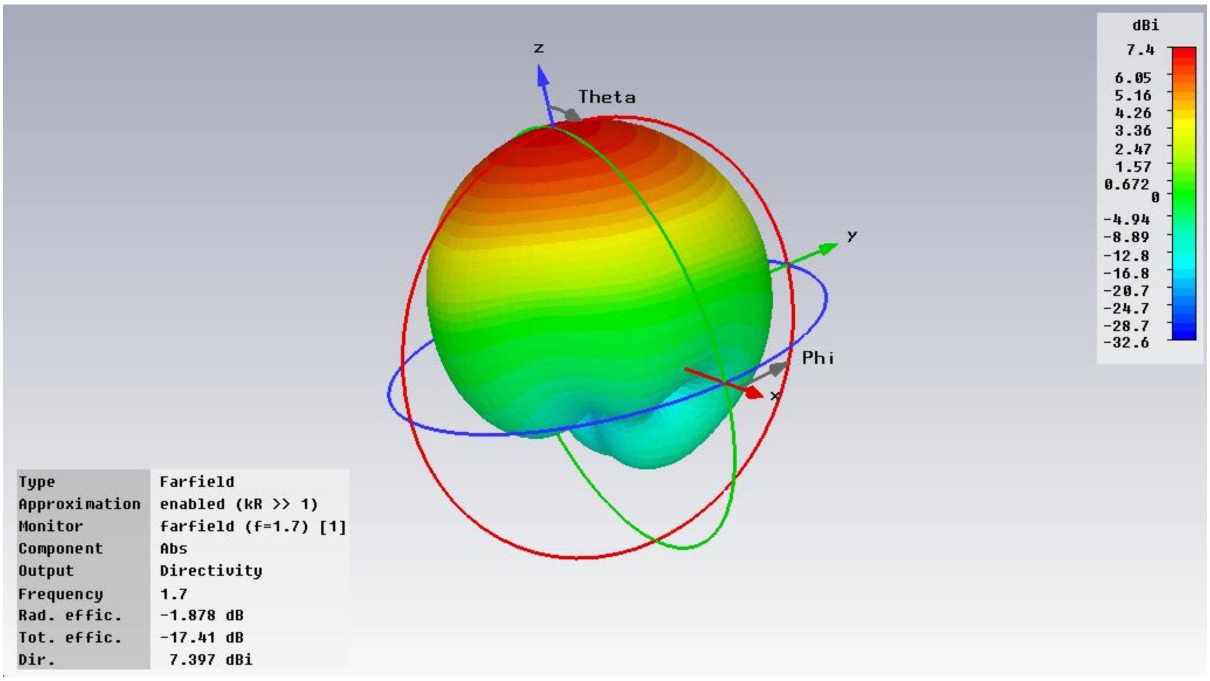

Fig5.3: 3D plot of gain

From above 3D plot we get directivity is 7.397 dBi

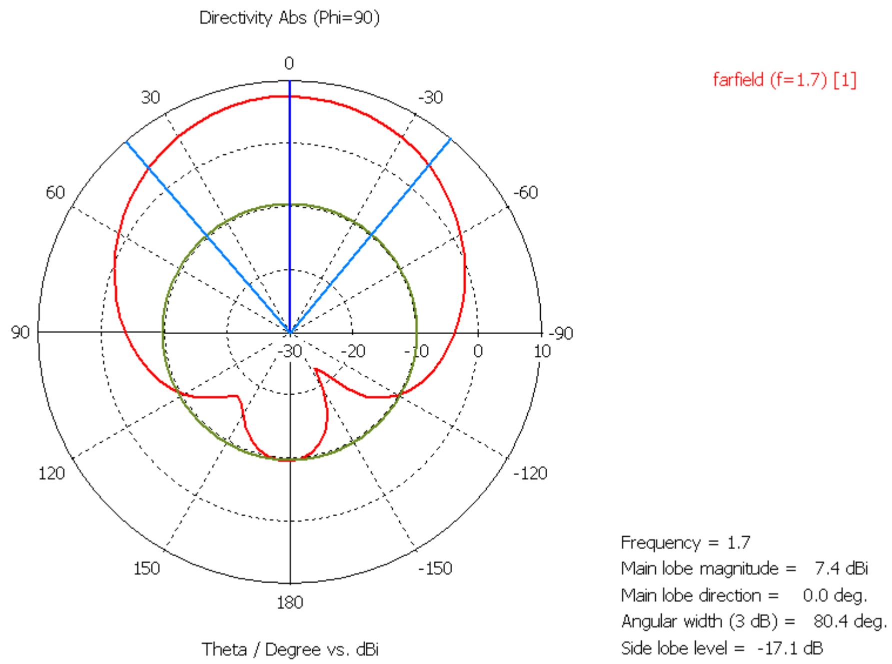

Fig5.4: H-plane at 1.5 GHz

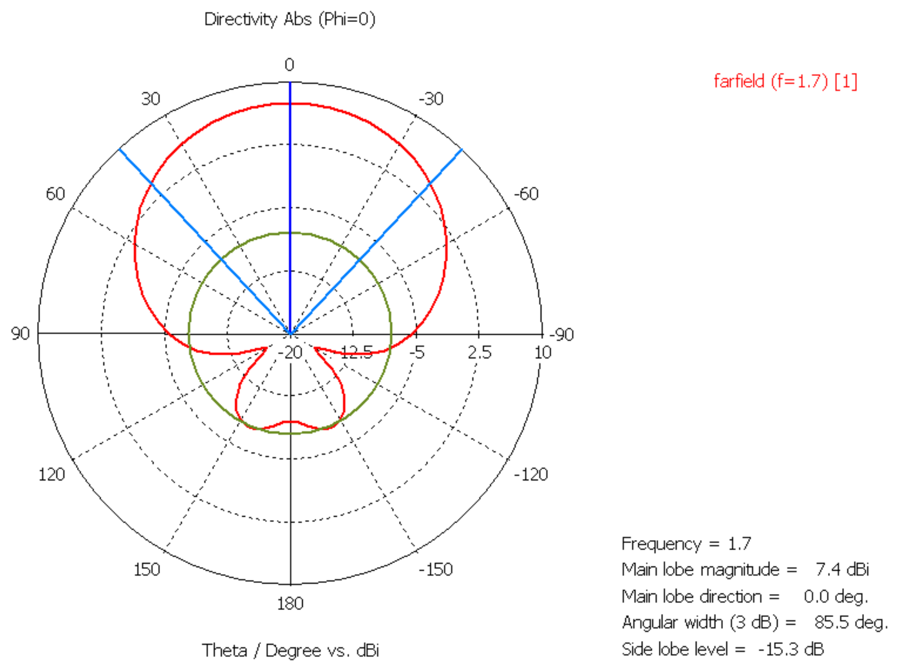

Fig5.5: E-plane at 1.5 GHz

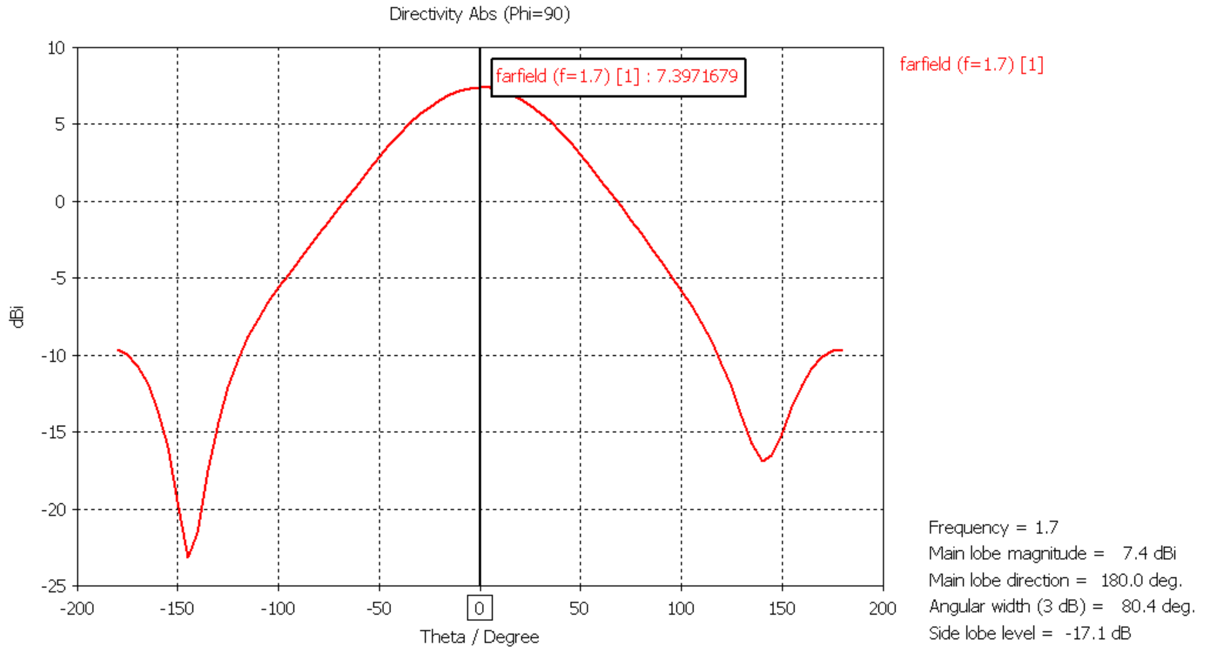

Fig5.6: Cartesian plot of directivity

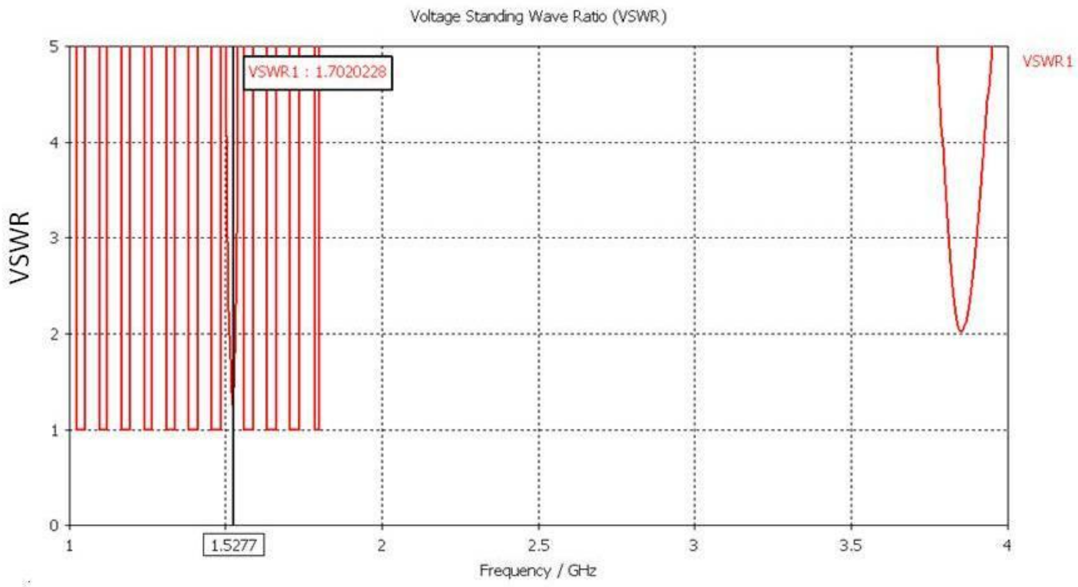

Fig5.7: VSWR at 1.5 GHz

5.2 Triangular array antenna

In order to design 2×1 element, we took 1.8GHz frequency and we got side of the triangular patch.

$$a= 2\times c\ (3\times f\sqrt{\varepsilon_r})$$

Substituting all the values we get a= 52mm.

The resulting 2×1 array is as follows:

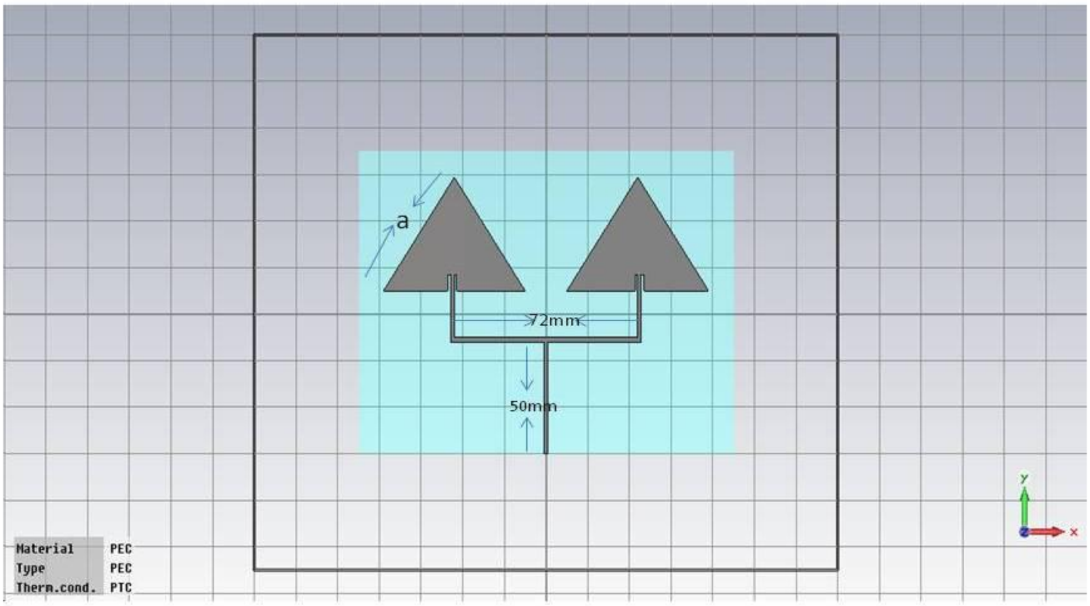

Fig5.8: Design of 2×1 array element.

After the simulation we get the following results:

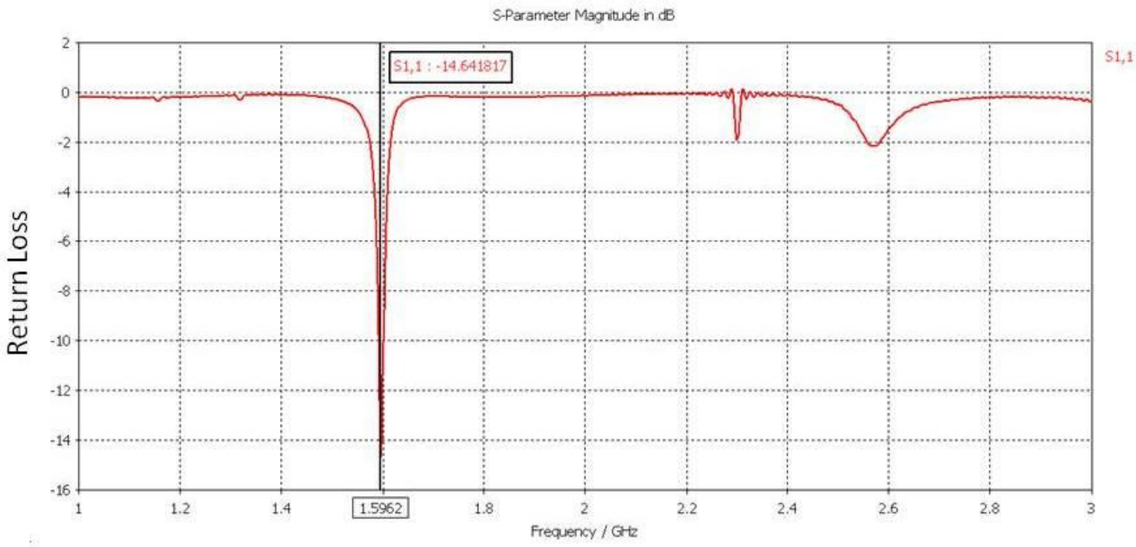

FIG 5.9: Return loss at 1.59 GHz.

Further we got VSWR, 3D, Cartesian and polar plot.

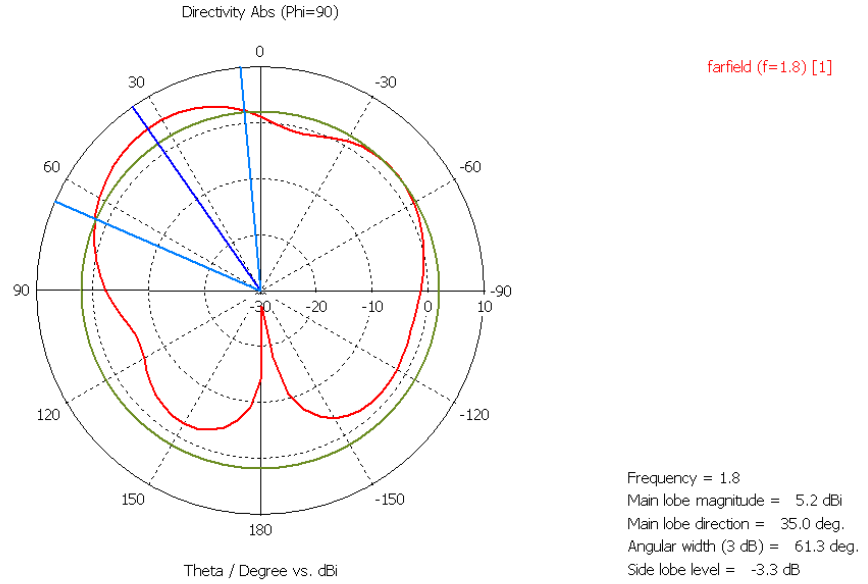

Fig5.10: H-plane at 1.59 GHz.

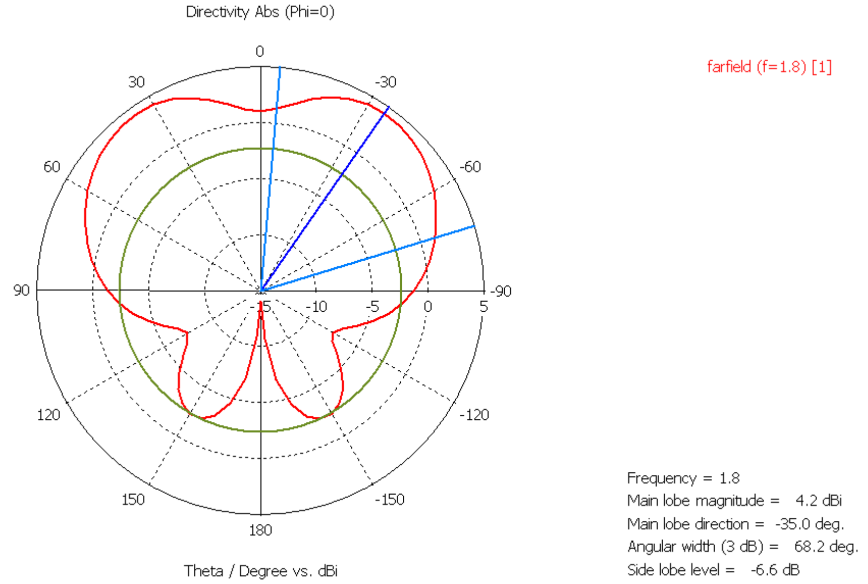

Fig5.11: E-plane at 1.59GHz.

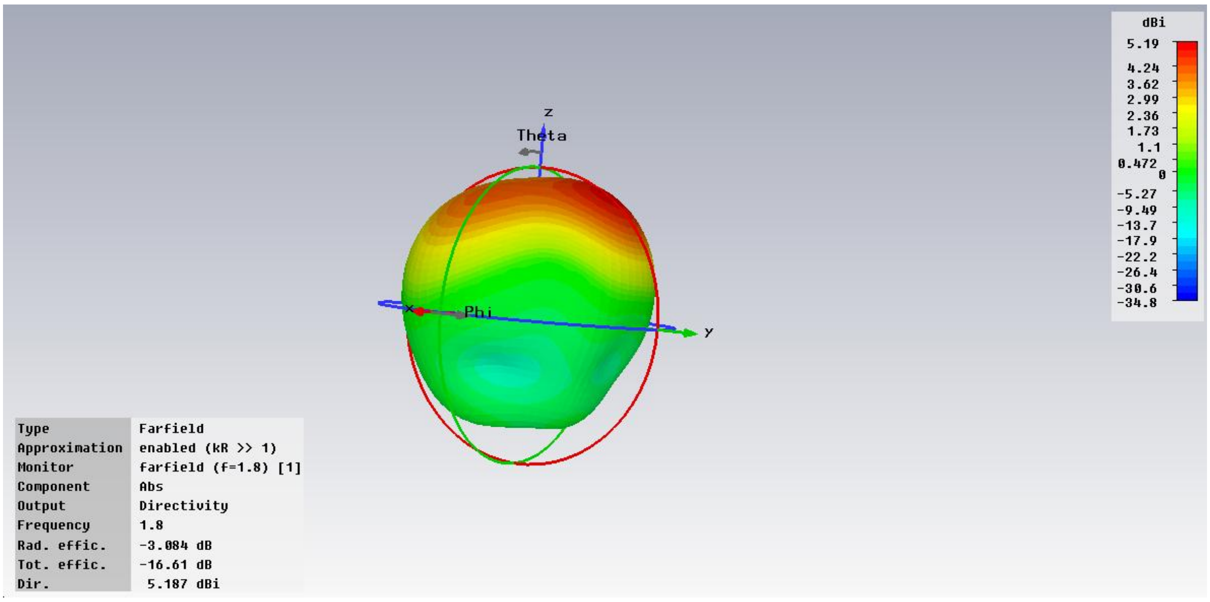

Fig5.12: 3D plot of gain at 1.50GHz

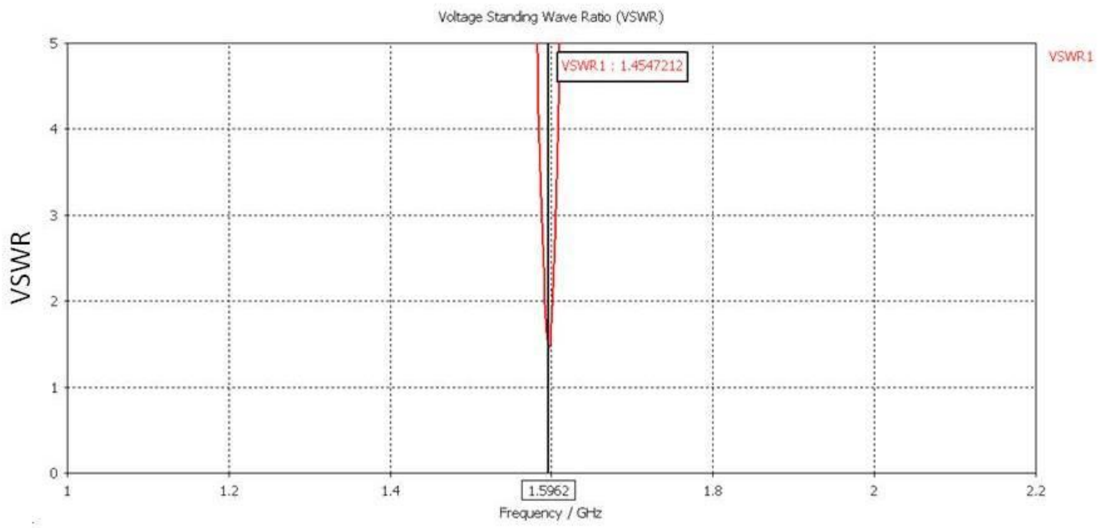

Fig5.13: VSWR at 1.59GHz

5.3) Comparison between rectangular and triangular array patch antenna

ARRAY PATCH ANTENNA	**RESONANT FREQUENCY**	**RETURN LOSS**	**VSWR**	**BANDWIDTH IMPROVEMENT (%)**	**DIRECTIVITY**
RECTANGULAR PATCH ARRAY ANTENNA	1.5277 GHz	-19 Db	1.720	1.165%	7.397dBi
TRIANGULAR PATCH ARRAY ANTENNA	1.5692 GHz	-15 dB	1.454	1.17%	5.187 dBi

From the results it is observed that the directivity of rectangular array antenna is better than triangular array antenna and the directivity of rectangular array antenna is better than rectangular patch antenna. İncreasing the number of elements increases the directivity. Hence rectangular patch array antenna is preferred as it has maximum directivity and efficiency among the antennas studied.

CHAPTER **6**

CONCLUSION

6. Conclusion

The size of triangular shaped antenna is smaller but it is very difficult and time taking to make the same, so we do not prefer this patch antenna. Because of directivity and wide radiation pattern we prefer rectangular patch antenna.

In the case of arrays, directivity and radiation pattern improves with the increase in number of elements and thus array is better than single element. On comparison between rectangular and triangular shapes it can be concluded that the rectangular array antenna is the most efficient of the simulated antennas.

6.1 Future work

Inorder to improve the directivity we can add more patches of antenna. So further we can design 4×1 and 8×1 to improve the directivity.

In future other different type of feed techniques can be used to calculate the overall performance of the antenna. Extensively and exclusively focusing on the area of different design methods especially in enhancing the impedance bandwidth and the efficiency.

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