Design of UWB Circular Antenna Array System for Microwave Imaging Radar

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Submitted to the faculty of Department of Electrical Engineering,
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in partial fulfillment for the requirements of B.E Degree in Electrical (Telecom) Engineering.

June 2022

In the name of ALLAH, the Most benevolent, the Most Courteous

CERTIFICATE OF CORRECTNESS AND APPROVAL

This is to officially state that the thesis work contained in this report

"UWB Circular Antenna Array System for Microwave Imaging Radar"

is carried out by

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under my supervision and that in my judgement, it is fully ample, in scope and excellence, for the degree of Bachelor of Electrical (Telecom.) Engineering in Military College of Signals, National University of Sciences and Technology (NUST), Islamabad.

Approved by

Supervisor

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Department of EE, MCS

Date: ___________

DECLARATION OF ORIGINALITY

We hereby declare that no portion of work presented in this thesis has been submitted in support of another award or qualification in either this institute or anywhere else.

ACKNOWLEDGEMENTS

We are appreciative towards our Creator Allah Subhana-Watala to have helped us during the process of authoring our thesis by putting innovative ideas in our mind and then improving them. Indeed, nothing could have been possible without Your inestimable aid and supervision. All the individuals who have helped us during our thesis did so because of Your will and no one is worthy of praise except You.

Our special gratitude for our supervisor, Dr Farooq Ahmed Bhatti, for aiding us with his vast knowledge during this complete process of thesis writing. He provided us a tension free environment which enabled us to complete our work in the best possible manner. He performed his role of a mentor in a perfect manner, and we could not have reached this stage without him. As a last point, we are all very thankful to our loving parents for fulfilling all our necessities that were required to reach this stage.

Plagiarism Certificate (Turnitin Report)

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ABSTRACT

“**Design of UWB Circular Antenna Array System for Microwave Imaging Radar**” is proposed in this report. The proposed antenna is structured for detection of cancerous cells in women breast. An array of 1x4 elements is designed, fabricated, and evaluated for the detection and diagnosis of the breast cancer tumor. The frequency range of the operation of the array is from 3.4 to 11 GHz. The return loss of the array is found to be less than -12 dB throughout the frequency band of operation 3.4 -11 GHz. Microwave Imaging techniques have used of the detection of breast cancer with the proposed antenna. The phantom developed by our colleague at MCS is tested using the same array over the complete frequency band and remarkably interesting results have been achieved. Similarly, the tumor in phantom has also been tested by the single element as well as using the developed array and very favorable results have been achieved throughout the band of operation from 3.4 -11 GHz.

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CHAPTER 1: INTRODUCTION

Antenna:

A device that converts electrical energy into electromagnetic energy and is also a transceiver is called an antenna. An antenna is a conductor who transmits and receives electromagnetic signals from surroundings. The main purpose of antenna is to communicate and share information between two and more devices. Antenna is widely used in medical field to detect and diagnose certain diseases. The applications of antenna for detection of breast cancer were proposed in beginning of 2000s. Slot antenna, ultrawide band and several other types of antennas have been proposed earlier for detection of such kind of disease, also mobile communication, satellite communication vehicular, airborne, communications, SIGINT (signal intelligence), and ISR (intelligence, surveillance, and reconnaissance) are applications of Antenna.

1.1. Types of antennas:

1.1.1. Wire Antenna:

Wire Antenna is simply a random wire suspended above the ground whose length is not related to the wavelength of antenna.
Examples: Dipole antenna, Monopole antenna, Helix antenna, Loop antenna
Applications of wire antenna are Automobiles, Spacecrafts, and communication in submarines.

Figure 1: Wire Antenna [2]

1.1.2. Microstrip Antennas:

Antenna fabricated on a circuit board is known as microstrip or internal antenna. Microstrip antennas use microwave frequencies and are very small in size.
Examples include circular shape, rectangular and sometimes novel.
Applications of antenna are mobile phones, cars, and air crafts.

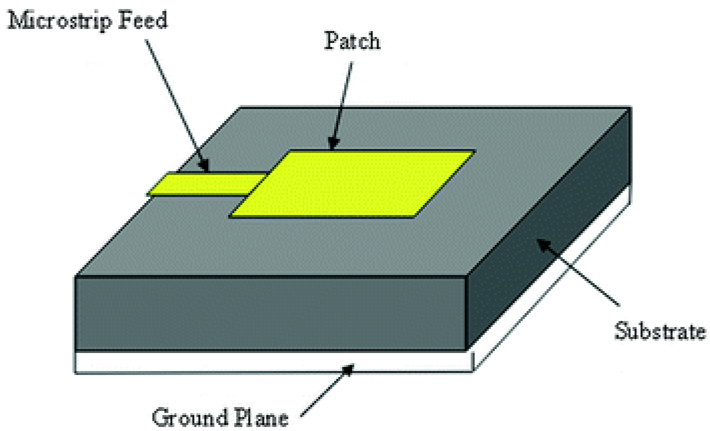


Figure 2: Microstrip antenna [2]

1.1.3. Aperture Antenna:

Aperture antennas are those who emit electromagnetic waves through an opening. These antennas are mostly used in acoustics megaphone and parabolic microphones.
Waveguide is an example of aperture antenna. When a transmission line's edge is ended with an opening, energy is radiated. It is an Aperture antenna because of this opening, which is an aperture.
Examples include Waveguide and Horn Antenna.
Applications of Aperture Antenna are Flush-mounted applications, aircraft, space craft.


Figure 3: Aperture Antenna [2]

1.1.4. Array Antenna:

Multiple connected antennas acting as a single antenna is known as an array antenna. The individual units are connected to single transceiver by feedlines that feed power in a specific relationship.
Examples include Yagi-Uda antenna, Micro strip patch array, Aperture array, Slotted wave guide array.
Usually used when high gain is required.

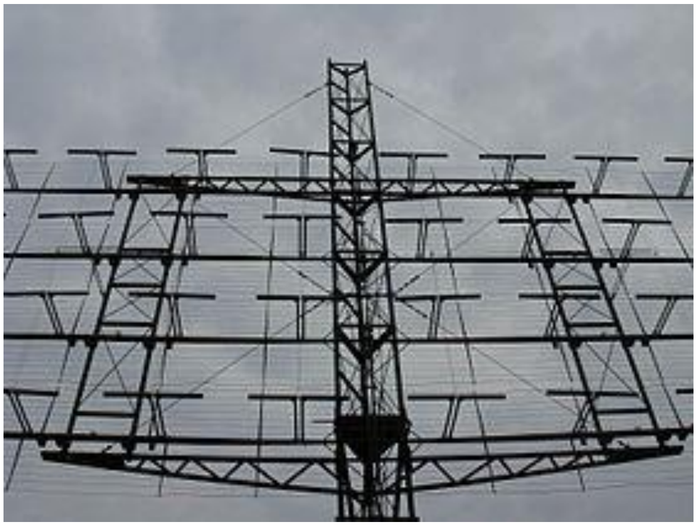


Figure 4: Array Antenna [2]

1.2. Antenna Parameters:

Antenna parameters are the essentials that are used in selecting an antenna for a required application. There are two types of antenna parameters: Radiation parameters and Network Parameters. Radiation parameters describe the functioning of antenna as it transmits and receives radio waves while Network parameters shows the behavior of antennas interconnect to which antenna is connected to.

1.2.1. Radiation Parameter:

Radiation Parameter include Gain Efficiency, Radiation Pattern, Return Loss, and Directivity.

1.2.1a. Gain Efficiency:

Gain is the strength of radiated signal in a specified direction, for isotropic antennas the gain is found constant in all directions. High gain means good strength of signals in a specified direction.

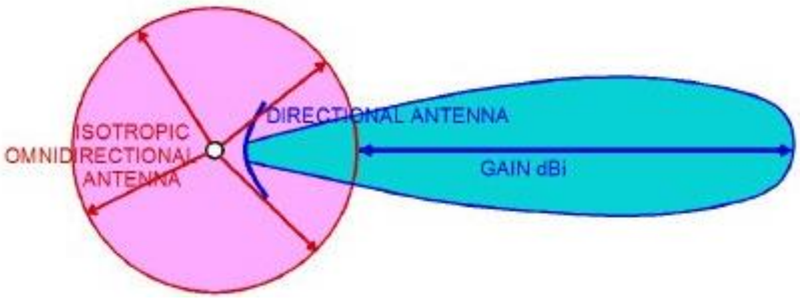


Figure 5: Gain [5]

1.2.1b. Radiation Pattern:

Radiation Pattern of an antenna is its directional (angular) dependence of the strength of radio waves from the antenna or other source. Types of radiation pattern includes Pencil beam pattern and Fan beam pattern.

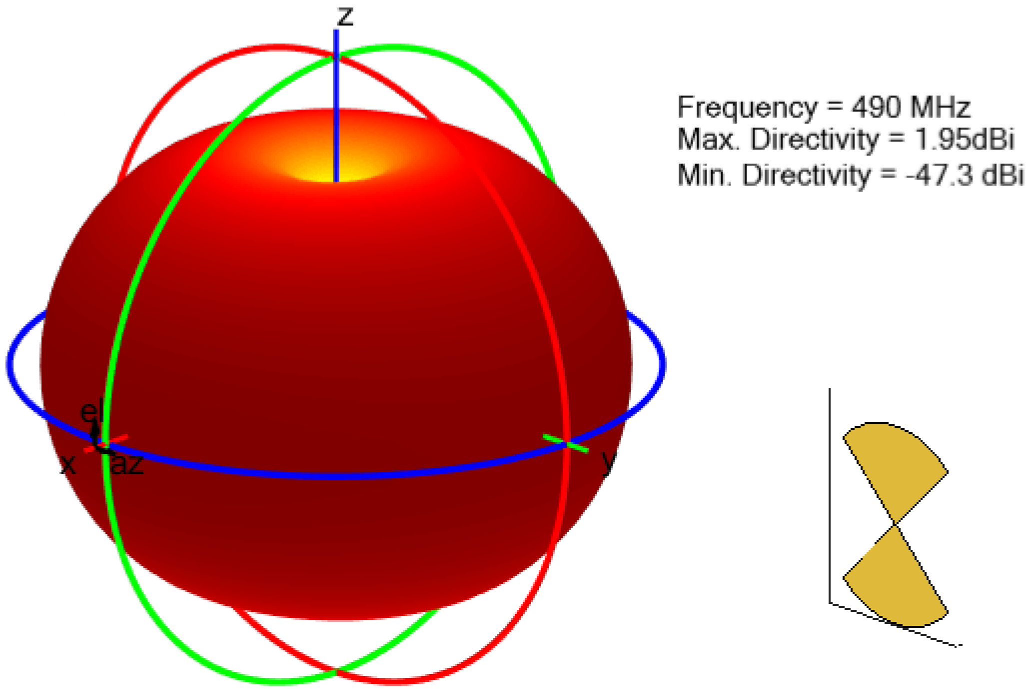


Figure 6: Radiation Pattern [5]

1.2.1c. Return loss:

Return loss is the degree of energy of signals relative to the discontinuity in transmission line or optical cable. The mismatch is caused between transmission line or connected to the line. For an antenna, the minimum return loss needed is -10db and a return loss less than this is always preferred.

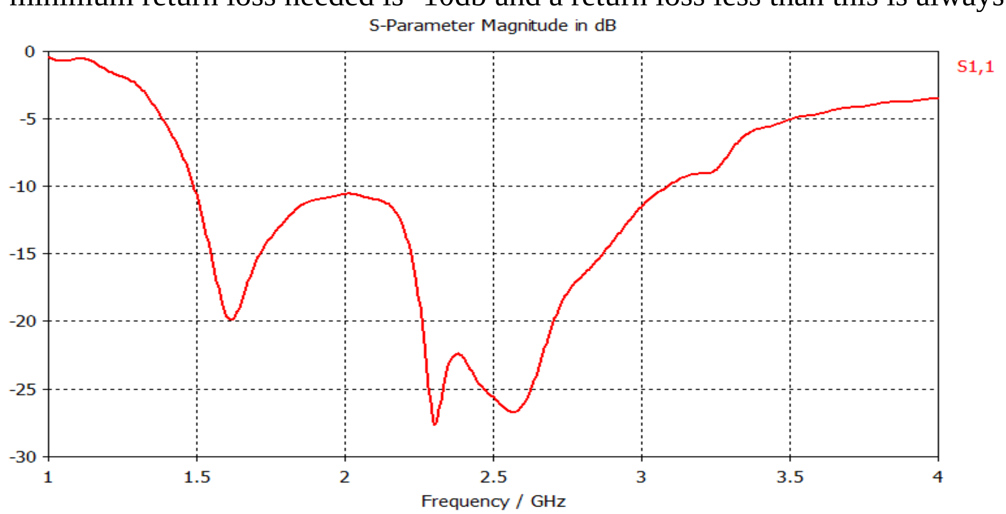


Figure 7: Return Loss [5]

1.2.1d. Directivity:

Antenna radiation strength in a particular direction is called directivity. Higher directivity means strong radiated beam that will travel further and is expressed in dB. It is mostly the ratio of radiated beam intensity in one direction to the radiation intensity averaged in all other directions.

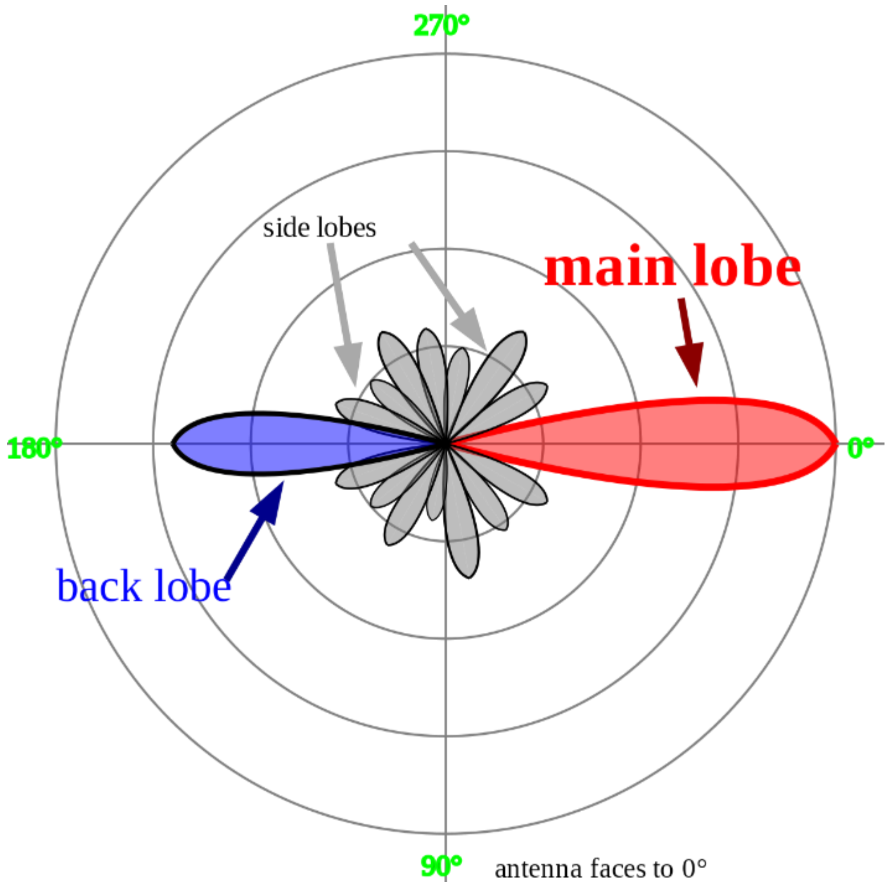


Figure 8: Directivity [2]

1.2.1e. Bandwidth:

The operating range of frequency on which an antenna operates is called the bandwidth of antenna. Bandwidth of an antenna is calculated in terms of Fractional bandwidth (FBW). In FBW we subtract the lowest operating frequency with highest operating frequency followed by division with center frequency. Bandwidth of antenna is related to the length of antenna and with antennas structure.

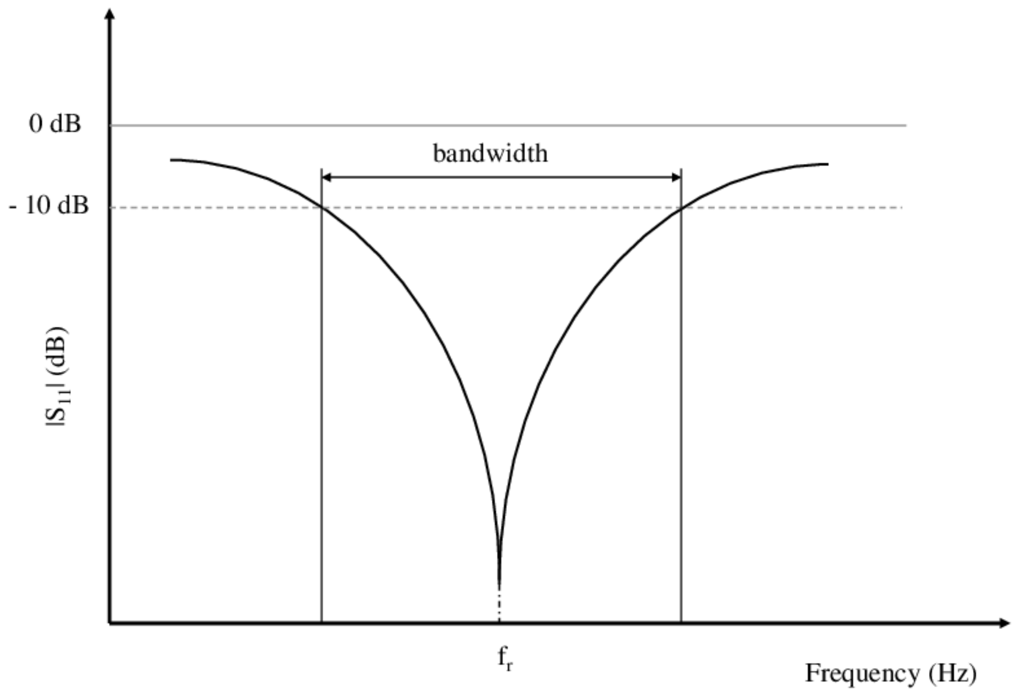


Figure 9: Bandwidth [5]

1.2.2. Network Parameters:

Network Parameters describe the behavior of antenna when it is connected to different devices. These parameters are used to determine appropriate matching network and interconnect needed to connect an antenna to a transmitter/receiver.

1.2.2a. Impedance Matching:

Impedance means the total opposition the circuit provides to the flow of current. It includes both resistance and reactance. Antenna impedance refers to the resistance and reactance shown at the terminals of antenna. For an antenna to operate in a satisfactory manner the impedance between feedline and antenna structure should be same e.g.: impedance is 50 ohms in most cases.

1.2.2b. Reflection Coefficient:

The ratio of the power of the direct signal reflected from the port to the total signal power minus the radiation loss is called the reflection coefficient.

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

1.3. Antenna Structural Elements:

Antenna Structural elements include the basic elements which are needed to make an antenna and run it. For microstrip antenna the basic units needed are as follows.

1.3.1. Substrate:

An insulator on which patch of antenna is placed in microstrip antenna is called a substrate. It provides electrical and mechanical strength to the structure of antenna. Different Substrate show diverse types of behavior when they are used in different environments, and it depends on Substrate itself. For example, the FR-4 substrate is only good for lower frequency like 1-4GHz while the Rogers RT Duriod is good for high frequencies like 30-60GHz. So, substrate is going to affect antenna performances therefore, the desired material should be used keeping the required results in mind.

1.3.2. Ground of an Antenna:

It is a conducting surface that is a part of antenna and is situated below substrate. It is mostly flat or horizontal in structure. The size and shape of antenna effects the antenna performance mostly in radiation characteristics and gain. To be ground plane the conductive surface must be the quarter of wavelength of radio waves in radius. We can increase the directivity and gain of antenna by working on its ground.

1.3.3. Antenna Patch:

A patch is a structure placed on a substrate that radiates the electromagnetic waves in outer surroundings. Patches comes in different random shapes like circle, square, dipole, rectangular, elliptical, and triangular. They can be novel also and their shape depends on the required antenna characteristics. For an array antenna multiple patches are placed on a single substrate followed by a single or multiple feedlines.

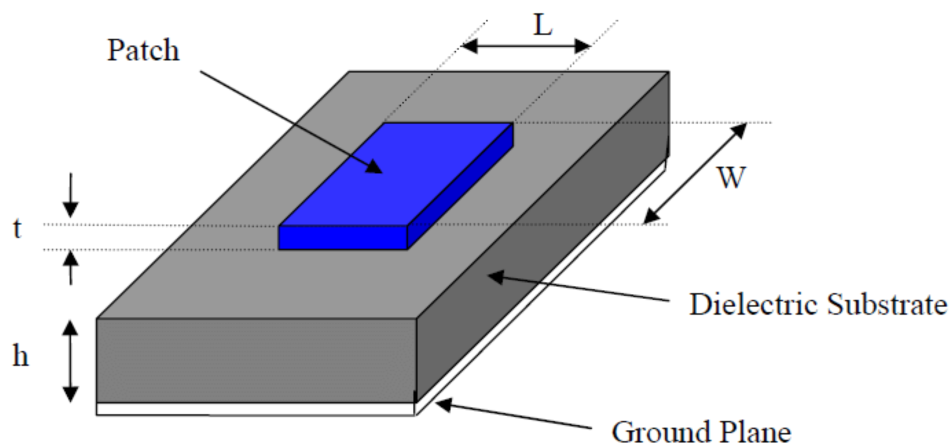


Figure 10: Antenna Patch [2]

1.3.4. Coaxial:

A coaxial cable is a type of cable in which the inner conductor is surrounded by an insulating layer surrounded by a conductive shield. Many products also have an insulated outer shell. The figure below shows a typical cable configuration. Electrical signals pass through the center conductor.

1.3.4a. Coaxial Probe Feed:

In this feeding method the inner side of coaxial connector to which coaxial cable is going to attach is soldered with radiating patch, while the outer side is connected to ground plane.

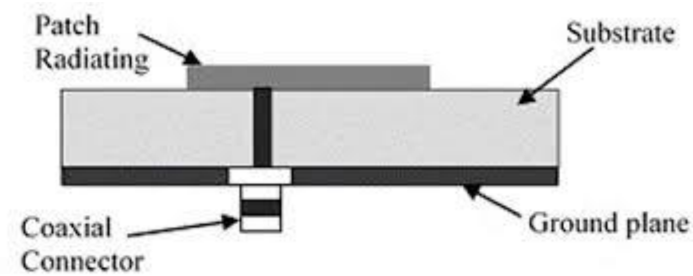


Figure 11: Coaxial Probe Feed [2]

1.3.4b. Aperture Coupling feed:

In this the ground plane is used to separate the radiating patch and microstrip feed line. Coupling between patch and feedline is done through a slot in ground plane. Usually, the coupling is done at the center to lower the cross polarization.

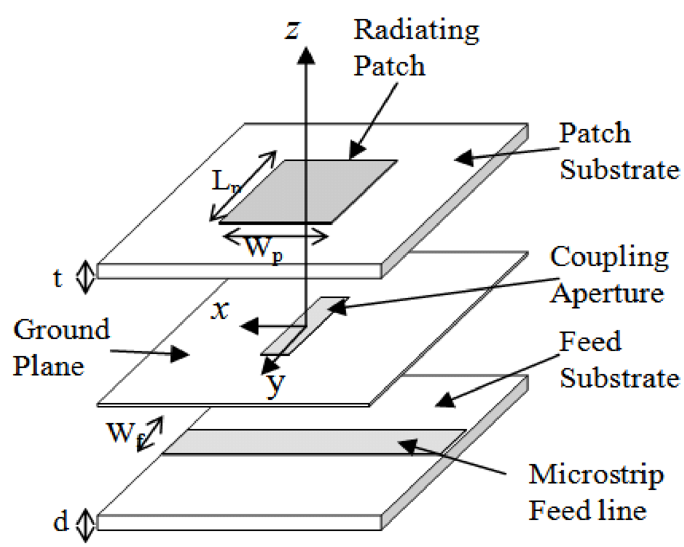


Figure 12: Aperture Feed line [8]

1.3.4c. Proximity Coupling Feed:

In these two dielectric substrates are used in a stacked position such that feedline passes in between them, and the radiating patch is on the top of upper substrate.

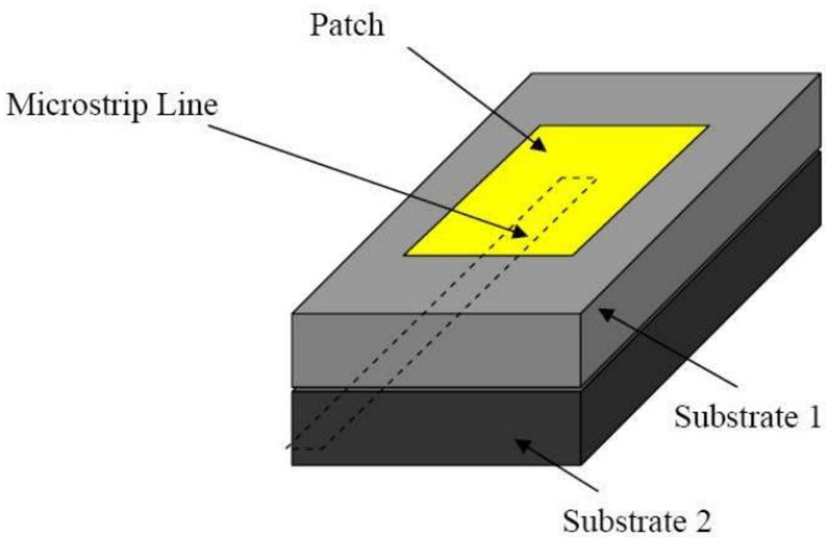


Figure 13: Proximity Feed

1.3.4d. Microstrip Line Feed:

In this a conducting strip is attached directly with the edge of microstrip patch. Thus, feed is etched on the substrate to provide planar structure.

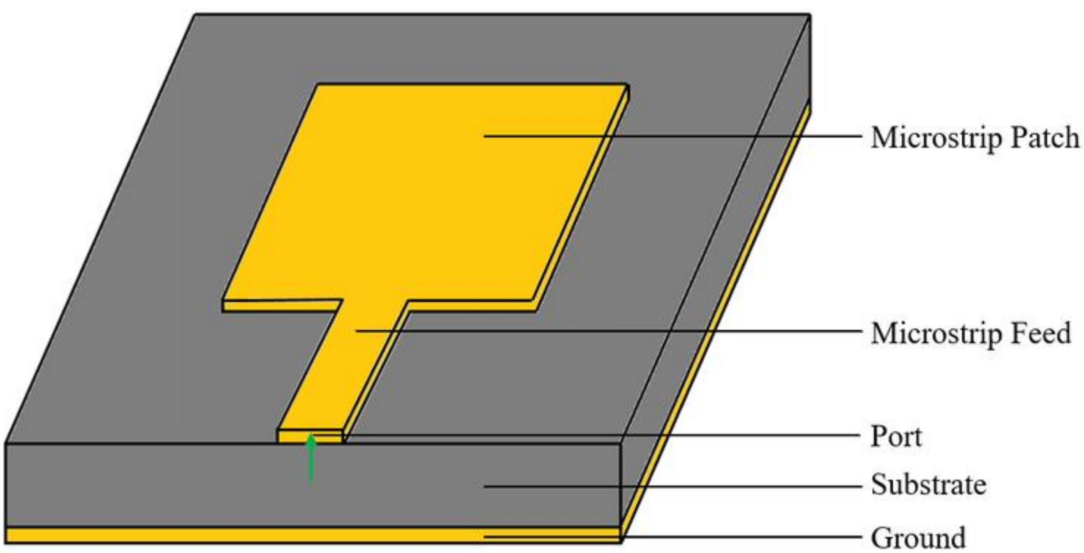


Figure 14: Microstrip Feed [7]

1.3.4e. Insert Feed:

In this the transmission and the Microstrip line feed are same, but feed is inserted into a radiating patch. It has good matching characteristics.

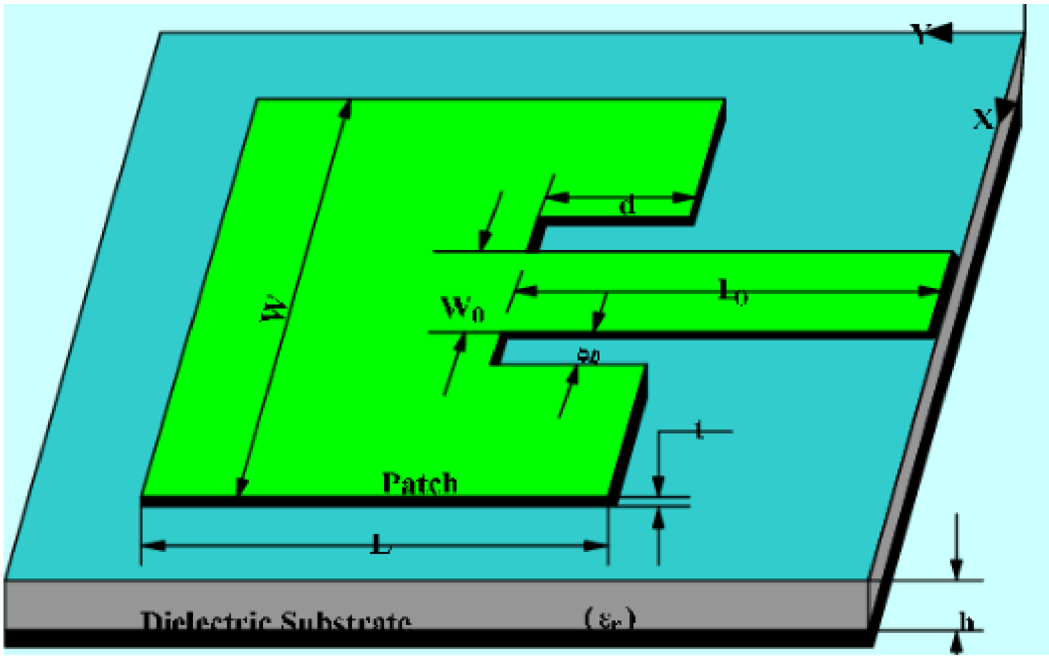


Figure 15: Insert Feed [7]

1.4. Problem Statement:

Breast cancer is the most common disease found in women these days and the number of deaths associated with it has increased due to unawareness and late diagnosis.
As time progresses the treatment of this disease and the probability of patients' life decreases. So, an early diagnosis is required to help the patient in treatment of this disease.

1.5. Proposed Solution:

The main solution considered is to early detect the malignant cancerous tissues in women and help them in treatment. For this purpose, an antenna is to be design that should help in detection of cancerous cells found in women. We propose an array antenna which will help the medical field in detecting the disease and helps them to treat it efficiently.

1.6 Relevant Sustainable Development Goals

Primary SDG: Industry, Innovation, and Infrastructure.

This project includes Development of a system based on UWB circular array antenna which can detect objects within the body and is innovation in medical field due to its use in Cancer detection.

Secondary SDG: Good health and Well-being.

Resulting system will be useful for the early detection of Cancer tumors which will help doctors in preventing the severity of the disease.

CHAPTER 2: Literature Review

In this Chapter we are going to go through some research papers to get a better understanding of breast cancer tumor detection and diagnosis and about the basic requirements from our antenna in the field of medical treatment.

RESEARCH PAPERS:

2.1. UWB Microwave Imaging System Including Circular Array Antenna

The design of an ultra wideband (UWB) microwave imaging system using a 12-element circular array antenna is described in this work. The small tapered slot antenna (TSA) components of the array operate in the 3.1-10.6 GHz frequency. The array elements are activated by two SP6T coaxial switches connected to a vector network analyzer (VNA) to achieve single or multiple static radar operation. A mechanical cylindrical scanning subsystem is also used to move the array. This electro-mechanical subsystem quickly scans marked objects in high resolution. This article explains why we use this visualization system. Also shown is a visualization of a circular plastic container filled with vegetable oil and a small diameter circular cylindrical target using a new image reconstruction algorithm.

2.1.1. Antenna Design:

In the proposed array, the antenna elements are compact size Tapered Slot Antennas (TSAs) featuring the 10dB return loss and constant radiation patterns (narrow in the E-plane and wide in the H-plane) across the band of 3.1-10.6GHz when radiating into air. Developed on Rogers-RT6010 substrate with εr=10.2 and thickness K=0.64mm, they are 36mmx36mm in size excluding a coaxial connector. Their design without and with the corrugations was reported in [The outer side of SMA (Sub Miniature version A) connector with nine vias were soldered to the front side of ground plane while the inner side was soldered with microstrip feed.

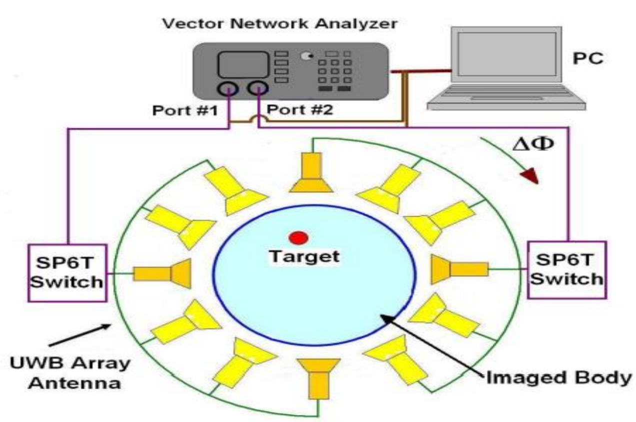


Figure 16: Antenna Design [10]

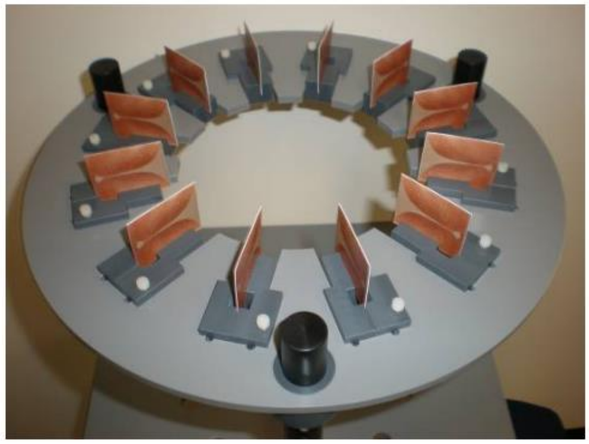


Figure 17: Fabricated view [10]

Imaging:

Here, two experiments are reported. One is with a single conducting target of 5mm diameter and the other one with an additional conducting target of 4mm diameter. The measurements are performed in the UWB of 3-12GHz. Fig.2a shows the imaging result for a 5mm diameter cylindrical target and Fig.2b shows the imaging result for two cylindrical targets one of 5mm diameter and the other of 4mm diameter.

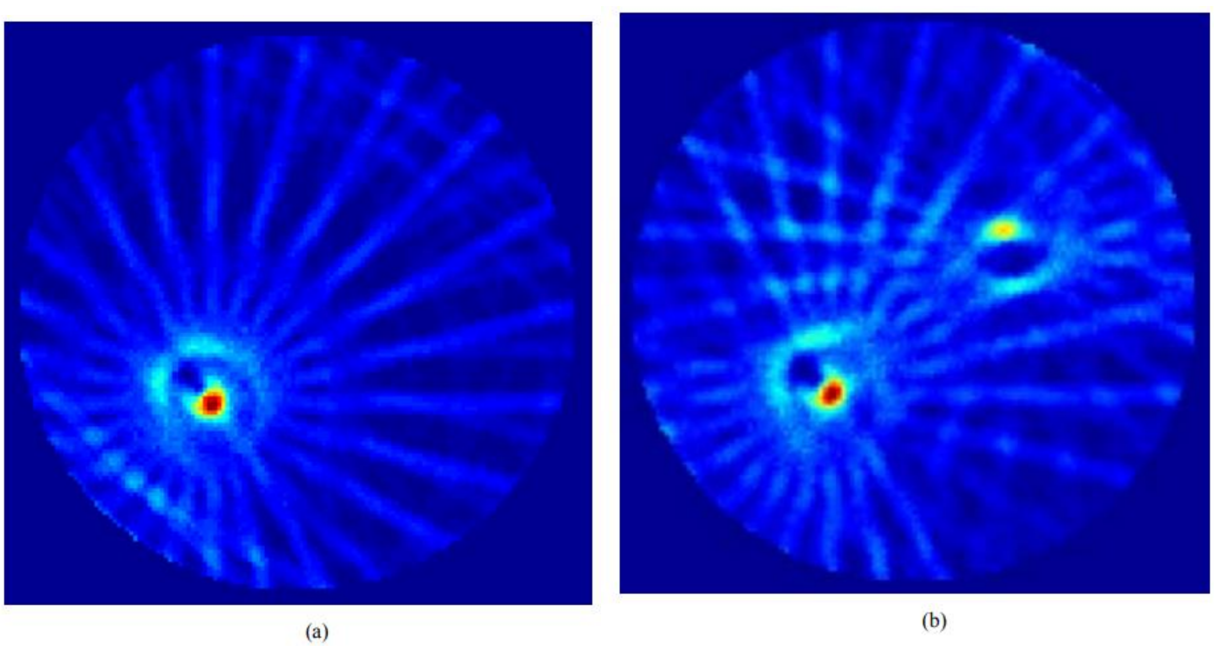


Figure 18: Resulting Image [10]

2.2. Flexible 16 Antenna Array for Microwave Breast Cancer Detection:

Radar based microwave imaging has been used for detection of breast cancer in recent times. Observing the dielectric difference of tissues or the change of densities between malignant and normal tissues is the main theory behind it. Single and Dual polarization based wireless ultra-wide band antennas were designed to detect the cancerous tissues using an inhomogeneous multilayer model of the human breast. This antenna operating frequency is to be 2 to 4GHz with S11 less than -10db.
Flexible material was used for best adaption and easy to wear in detecting the cancer. An individual antenna is 20 x 20 mm followed by 4x4 ultra-wide band antennas with single and dual polarization in a format like that of bra were designed. In addition, reflectors for the arrays were used to improve the penetration of propagated electromagnetic waves from antenna to breasts by factor 3.3 and 2.6, respectively.

2.2.1. Antenna Design:

A single and dual polarized antenna was designed with 20x20 mm antenna dimension and 4x4 ultra-wide antennas for array formation. Reflectors were added with the array antennas to improve the penetration of electromagnetic waves from antenna to skin. 0.05mm of Kapton polyimide was used as the flexible substrate with relative permittivity of 3.5. A coplanar waveguide transmission line was used as feed having 50-ohm impedance over 2 to 4GHz. Single and Dual polarized both antennas were designed to check the activity of cancerous cells. SMA connectors were also used in this antenna design.

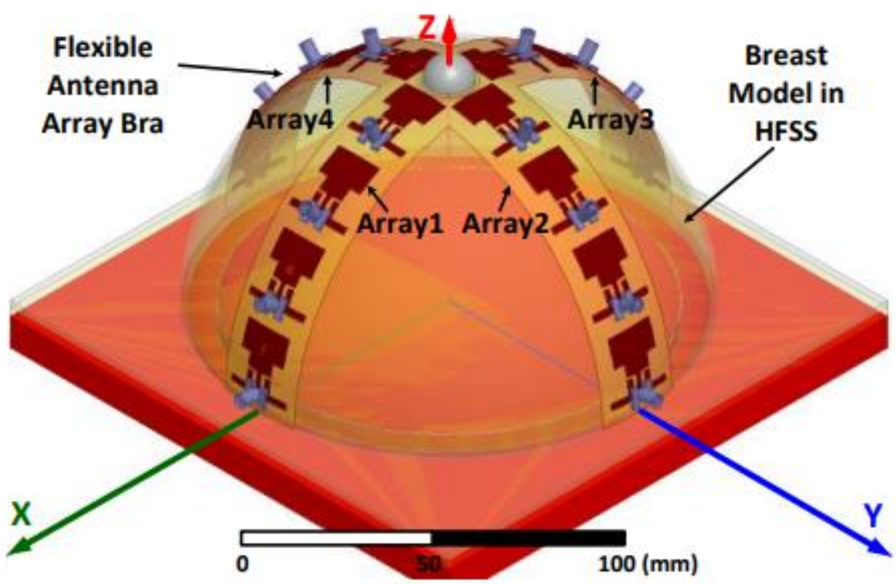


Figure 19: Antenna Design [12]

2.2.2. Results:

S11 results observed at various positions.

(a) Monopole antenna
(b) Single arm Spiral Antenna.

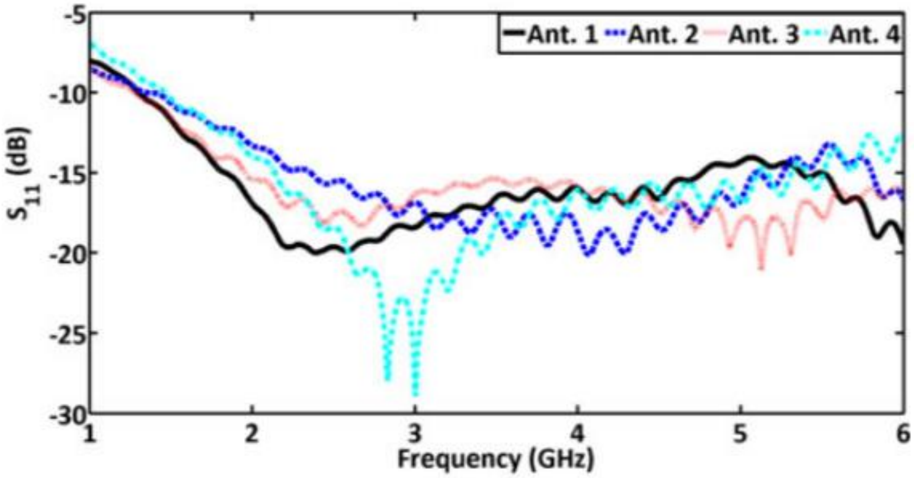
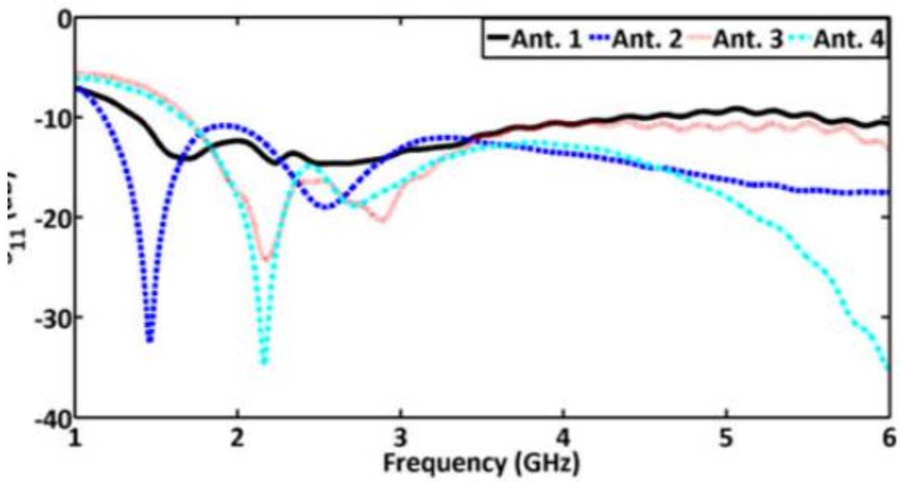


Figure 20: Monopole S11 [12]



(b)

Figure 21: Single arm Spiral S11 [12]

Induced Surface current for both single and dual polarized antenna was measured.

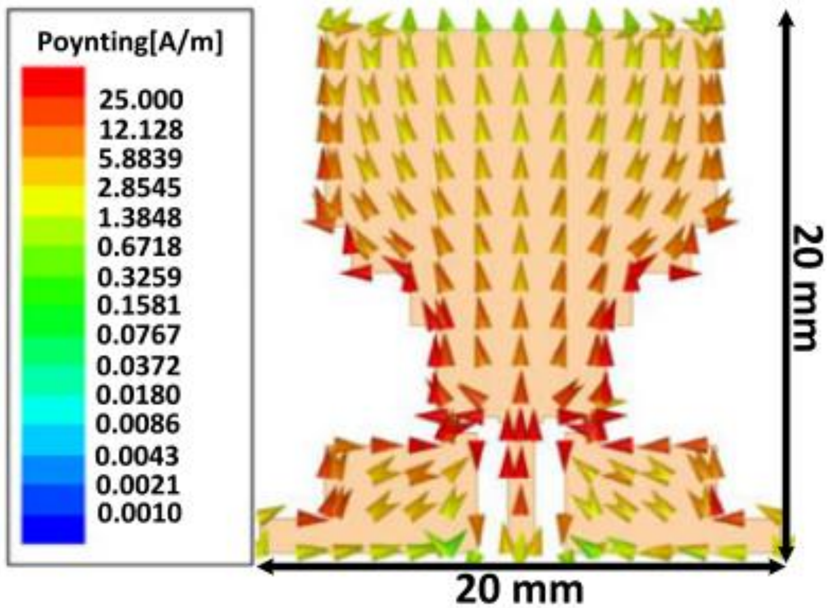


Figure 22: Single Polarized [12]

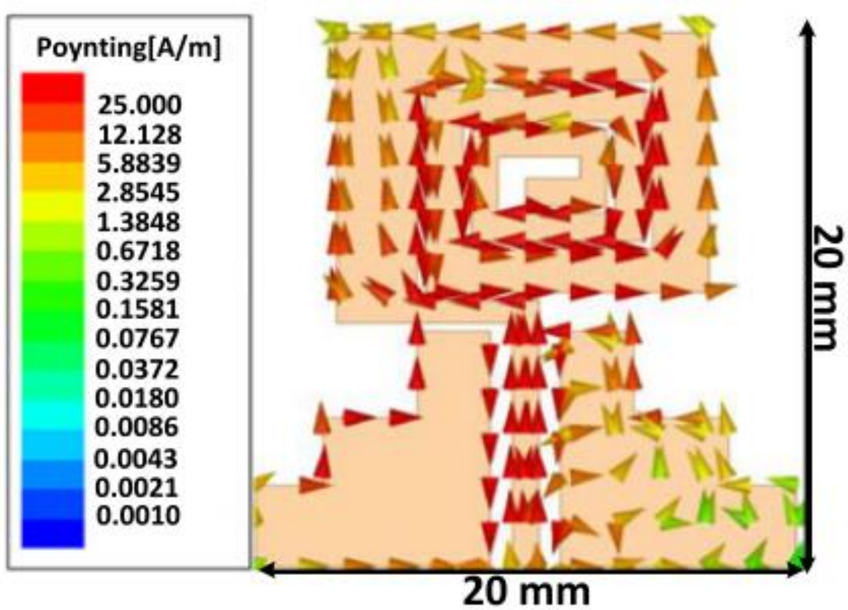


Figure 23: Dual Polarized [12]

2.3. 4 x 4 Pentagonal Patch Array Antenna for Breast Cancer Detection:

A 4x4 pentagonal array antenna using FR-4 as a substrate is designed to detect the presence of breast cancer. The reflection coefficient or S11 measured was -5db for frequency more than 2.2GHz.SMA connectors were used.

2.3.1. Antenna Design:

FR-4 substrate with 4x4 antenna array were used in addition with SMA connectors which are connected at the bottom of substrate. The inner and outer sides of SMA connectors are attached to upper and lower sides of FR-4.

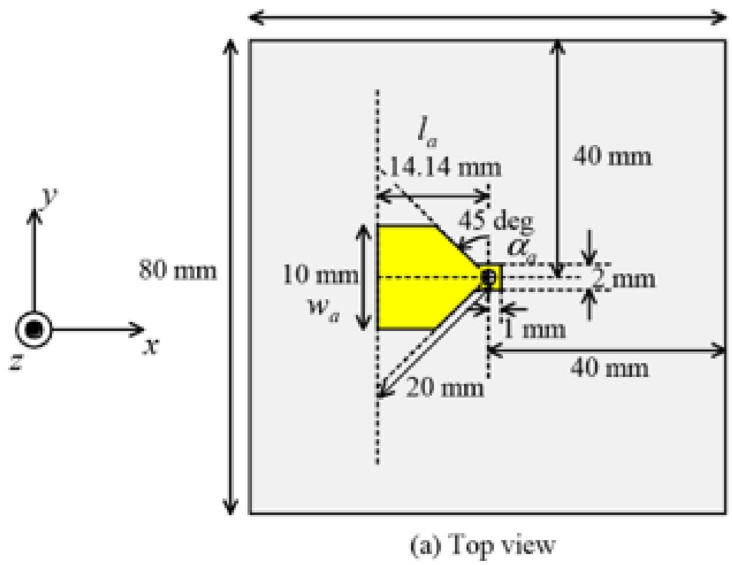


Figure 24: Antenna Design [11]

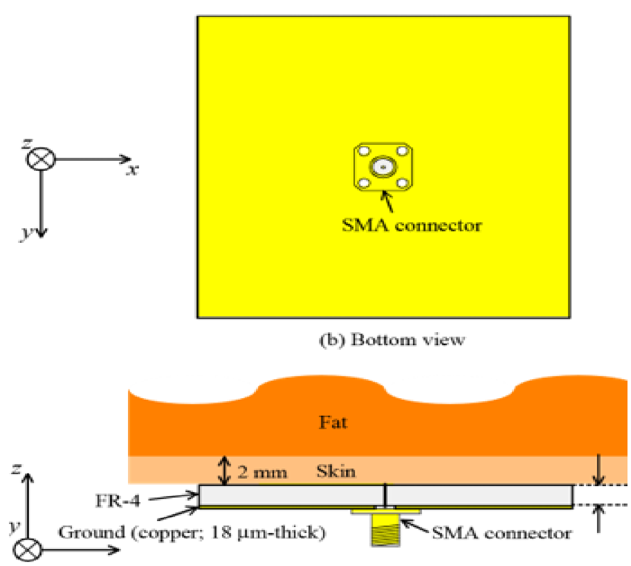
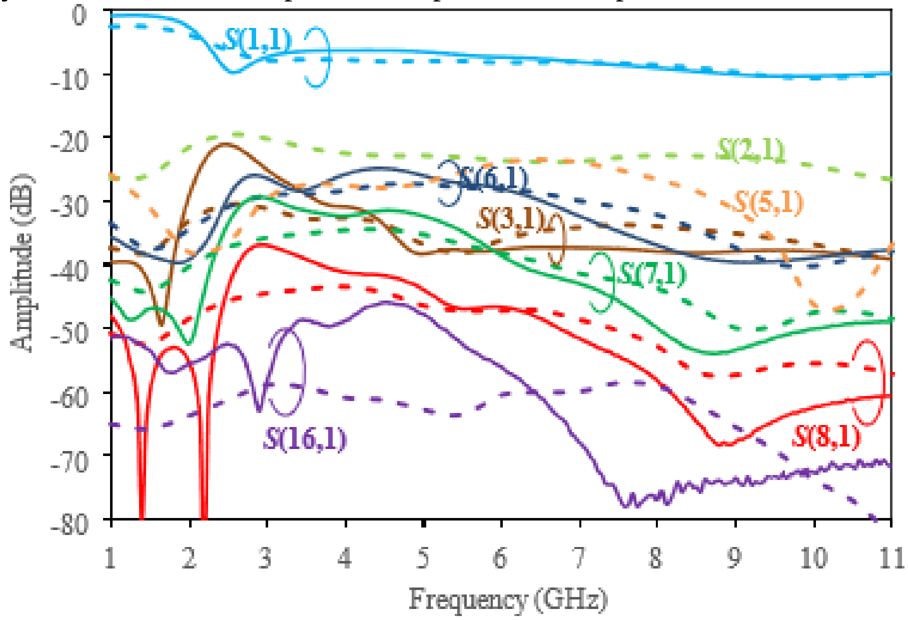


Figure 25: SMA connector [11]

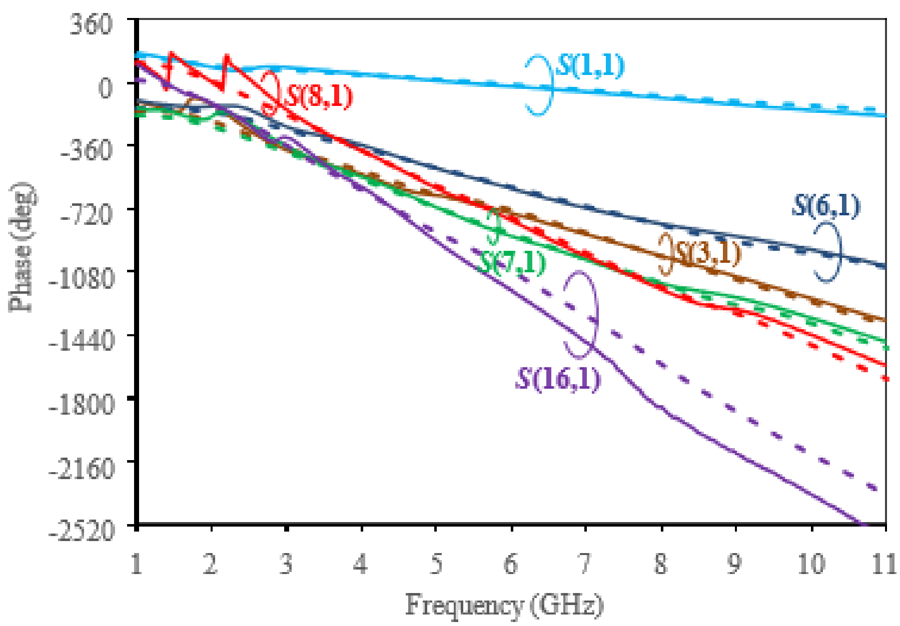
2.3.2. Results:

Frequency Characteristics of S parameters phase and Amplitude are shown.



(a) Amplitude

Figure 26: Amplitude Return loss [11]



(b) Phase

Figure 27: Phase Return loss [11]

Research Gap Analysis:

As in above papers a 16-element array were used to detect the cancerous cells along with 16 different feeds for each individual element which led to impedance mismatching, so we are going for 1x4 element with a single feed for each 4-element array and total 4 feeds for 16 element arrays. 1x4 element array is used independently to find S11, S22, S33, S44 results. The main idea to separately using 1x4 array to see the coupling results.

CHAPTER 3: ANTENNA DESIGN

Designing Antenna and discussing the basic antenna parameters and requirements needed for making of an Antenna.

3.1. Substrate Selection:

An insulator on which patch of microstrip antenna is placed is called substrate of an antenna. In addition of decreasing the size of antenna it also provides mechanical strength and electrical stability. For greater bandwidth, a thicker substrate is preferred, moreover the substrate selection depends on Loss tangent (tan (δ)) and Dielectric constant(ϵr).

3.1.1. Loss tangent (tan ((δ):

The angle between the resistive and reactive component of a system with permittivity is called loss tangent. It shows the dissipation of electrical energy due to different physical processes such as dielectric resonance and electrical conduction.

3.1.2. Dielectric constant (ϵr):

The ratio of electric permeability of material to the electric permeability in free space is called dielectric constant. Keeping these parameters in mind, we have chosen our substrate FR-4. F means Flame Retardant and 4 means fiber glass epoxies. Its versatile high-pressure thermoset plastic laminate grade with good strength to weight ratios. 4.3 is the dielectric constant for FR-4. Its highly desirable for frequencies lower than 4GHz.

3.2: FR-4 Data Sheet:

Table 2:FR-4 properties

Parameter	Value
Dielectric Constant	4.5
Height	1.5 mm
Loss Tangent	0.019
Conductor (copper) Thickness	0.035mm

3.3 Antenna Design:

The Antenna model was designed on software CST and was carefully observed and worked on to get the desired results depending on the requirements.
Each parameter of microstrip patch antenna has its own position and Dimension.

Table 3: Antenna Dimension

Parameter	**Dimensions**
Substrate (FR-4)	Length=29mm Width=29mm Height=1.6mm
Ground	Length=10.5mm Width=29mm Height=0.1mm
Feed	Length=4.8mm Radius =2.5mm Material= Teflon
Patch	Radius=9mm Height=0.1mm

3.4: Single Element Antenna:

Our antenna is novel in nature and is designed on CST. The first diagram shows the patch of the antenna, and the second diagram shows the ground with a coaxial feed.

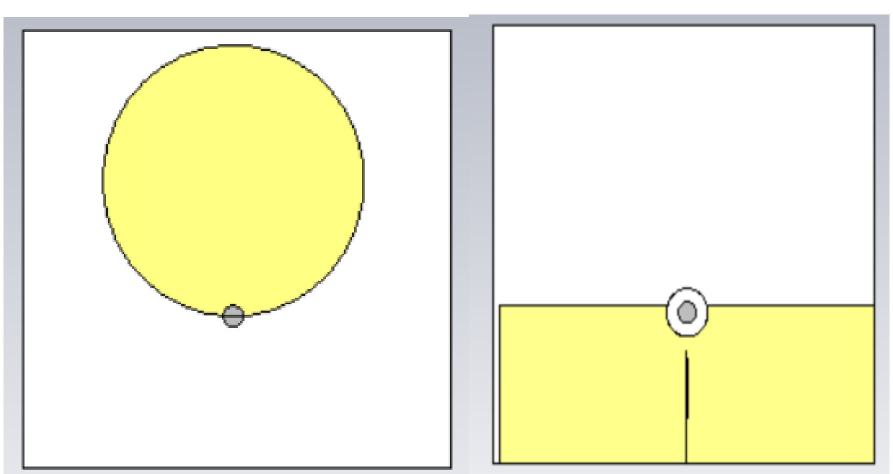


Figure 28: Antenna Design

3.5 Results of Single Element:

The results include S11-Plot, Gain Plot and Radiation Pattern of Antenna.

The S11 plot shows the operating frequency range from 3.44 to 11 GHz and above. Return loss is -12 dB throughout the band.

3.5.1. Return Loss:

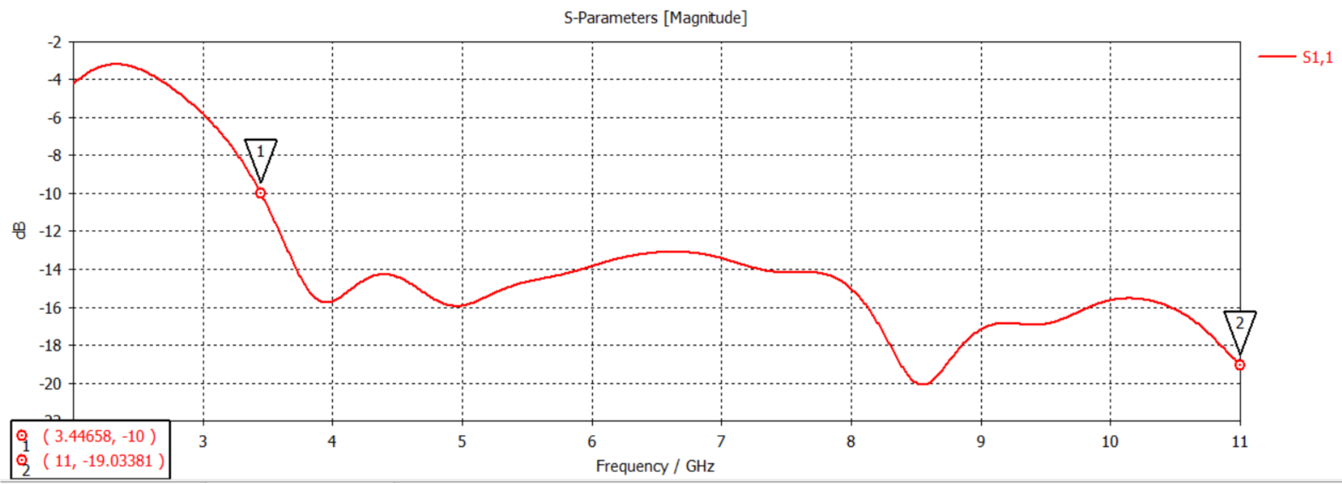


Figure 29: return loss

3.5.2. Gain Plot:

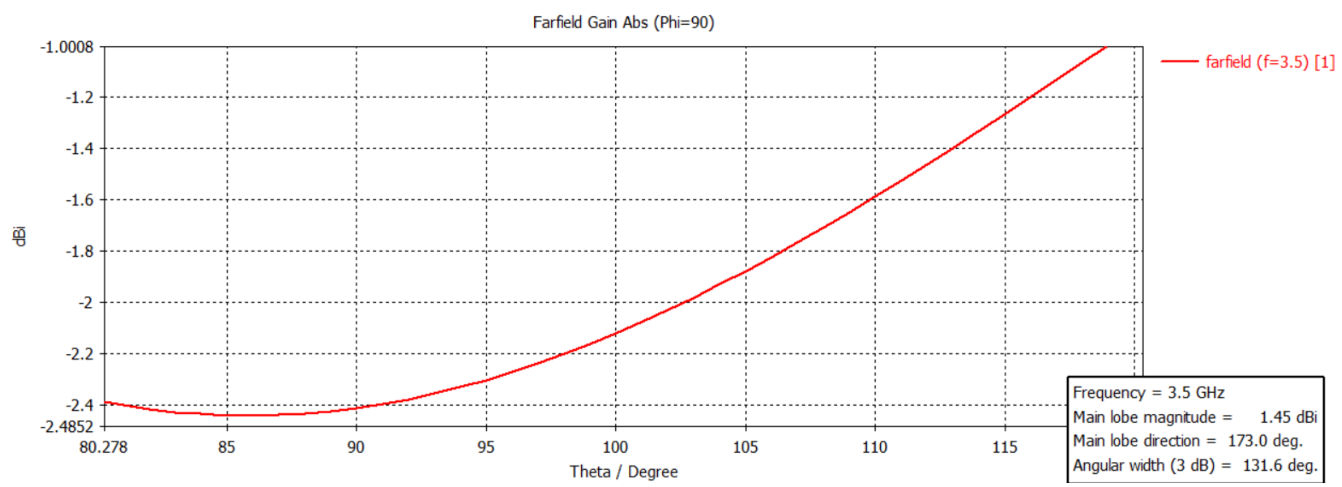


Figure 30: Gain Plot

3.5.3. Radiation Pattern:

The following figure shows the radiation pattern of the developed antenna at frequency of 3.5 GHz.

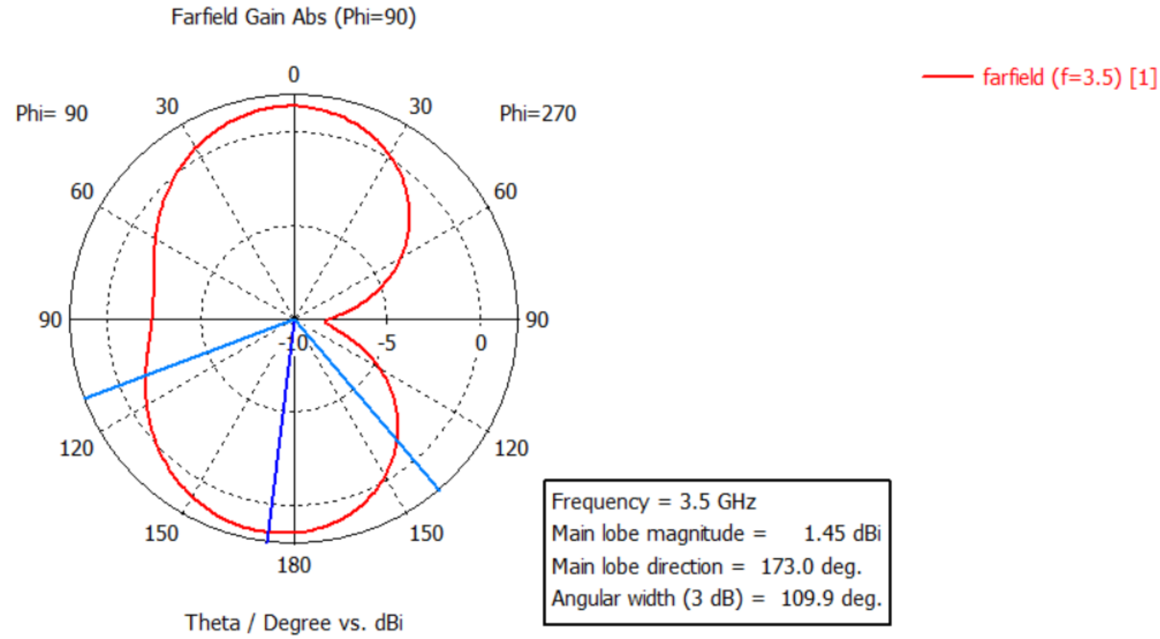


Figure 31: Radiation pattern

CHAPTER 4: ARRAY ANTENNA DESIGN

4.1. Array of Antenna:

Multiple elements of initial design were used together to form an array of antenna. A 4-element array is made using software CST having a single feed for every four-antenna array. In this regard we have four 1x4 antenna arrays.

4.2. Array Antenna Design:

The array antenna was designed using software CST in which we have four 1x4 antenna array elements.

In this we used coaxial feed also known as probe feed in which the inner conductor is soldered or connected to the patch of antenna while the outer side is connected to ground plane.

4.2.1. 1x4 Array Antenna Design:

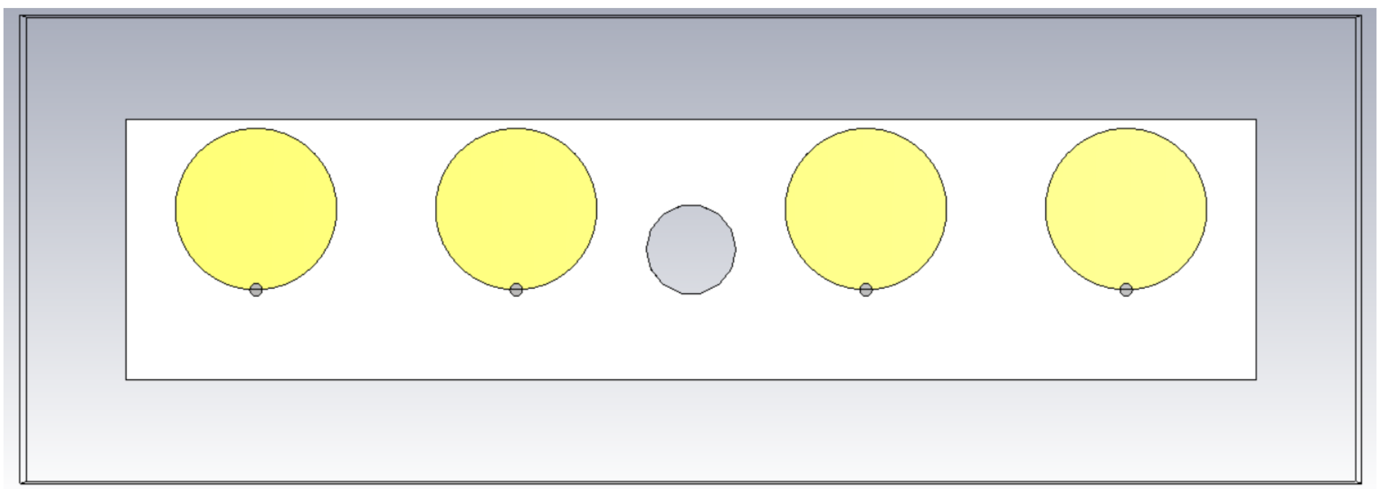


Figure 32: 1x4 array antenna design

4.2.2. Substrate:

The substrate is FR-4 which is very suitable for lower frequencies. The substrate data sheet is shown in chap 3. The substrate has a slot of 0.5 cm radius in the middle of the array. The whole array would be used for the detection of cancer tumors in women breasts.

4.3. Array Antenna Dimensions:

As we switched our patch antenna to array antenna, we are going to have some different dimensions of antenna parameters.

Table 4: Array Antenna Dimension

Parameter	Dimensions
Substrate (FR-4)	Length=29mm Width=126mm Height=1.6mm
Ground	Length=10.5mm Width=116mm Height=0.1mm
Feed	Length=4.8mm Radius =2.5mm Material= Teflon
Patch	Radius=9mm Height=0.1mm

4.4. Results of 1x4Array Design:

We are going to see the CST results of whole 1x4 array antenna design.

4.4.1. Return loss:

The measured result of the developed antenna is shown in figure 33. This figure shows the return loss of single element as well as the 1x4 array elements. The S11, S22, S33, S44 of array elements are shown below. We see that the whole band and return loss is below -10 dB over all the frequency range of the band.

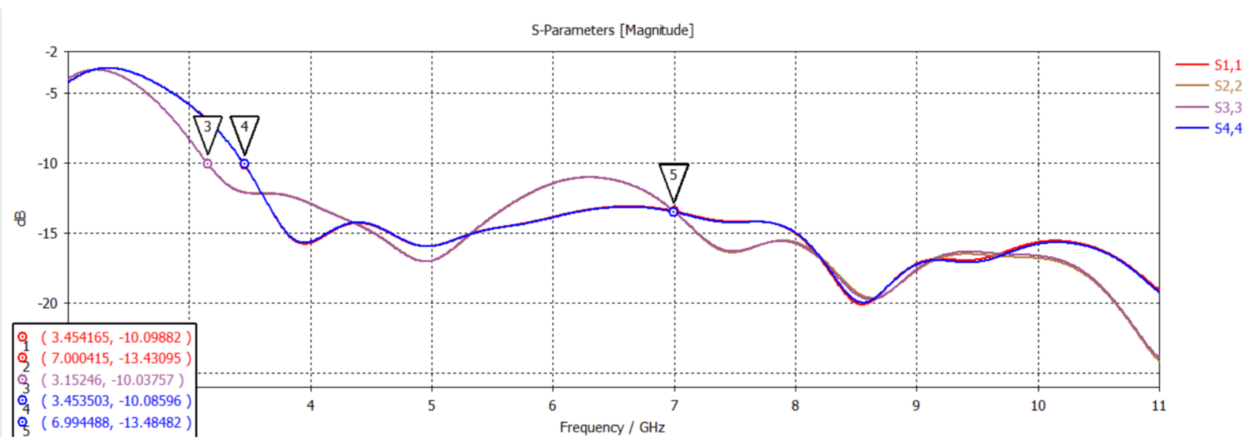


Figure 33: Return loss of 1x4 element array

4.4.2. Gain Plot:

The Gain Plot shows the gain of 1x4 element array.

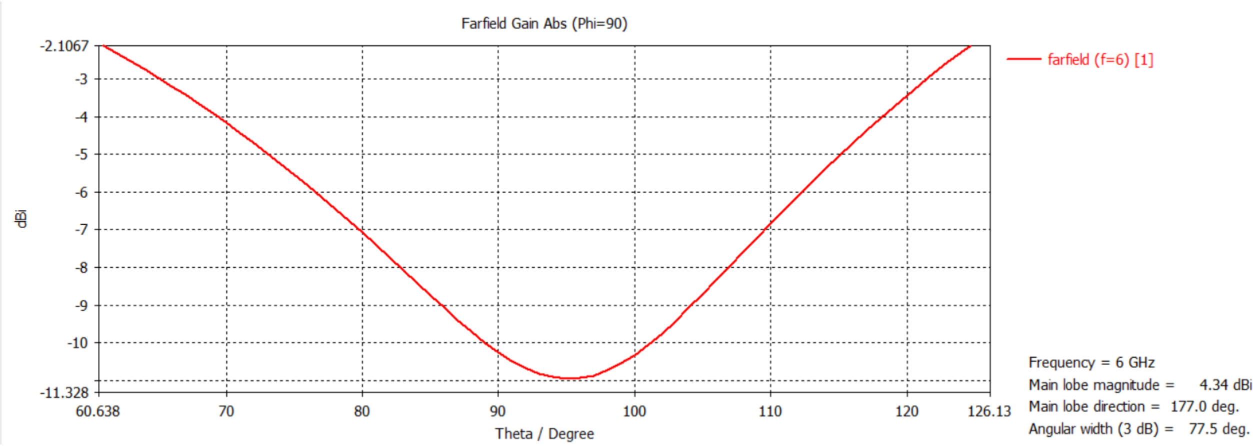


Figure 34: Gain Plot of 1x4 Array

4.4.3. Radiation Pattern:

The Radiation Pattern of 1x4 element array shows the radiated pattern in which antenna has chosen to radiate. It is the description of main lobes and side lobes of antenna. It also shows the Directivity of antenna.

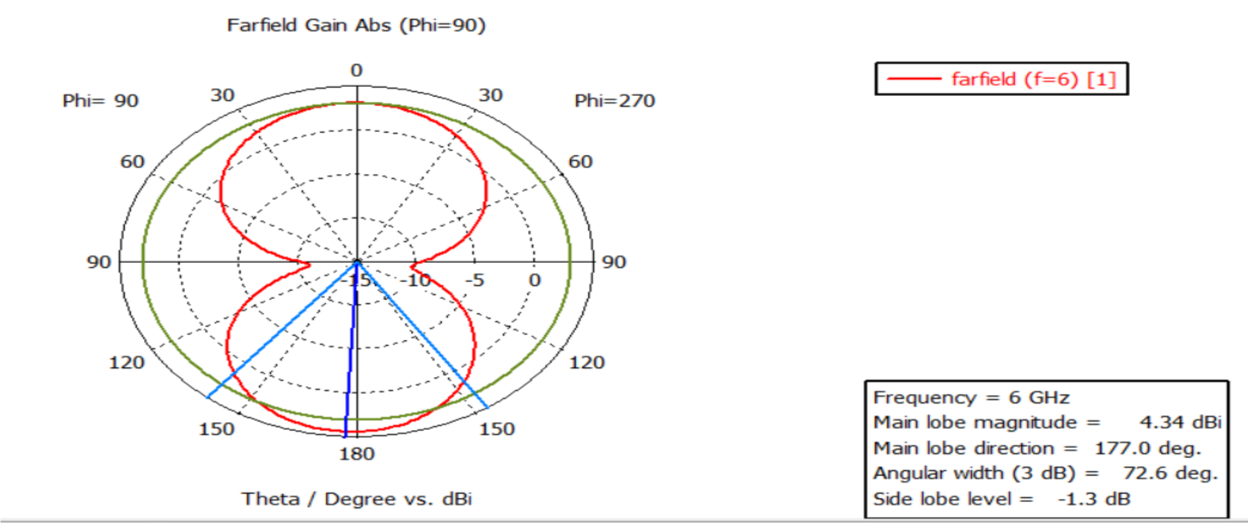


Figure 35: Radiation Pattern of 1x4 array

4.5. Simulation Results:

S11, S22, S33, S44 for each element are separately shown in the following figures:

4.5.1. S11:

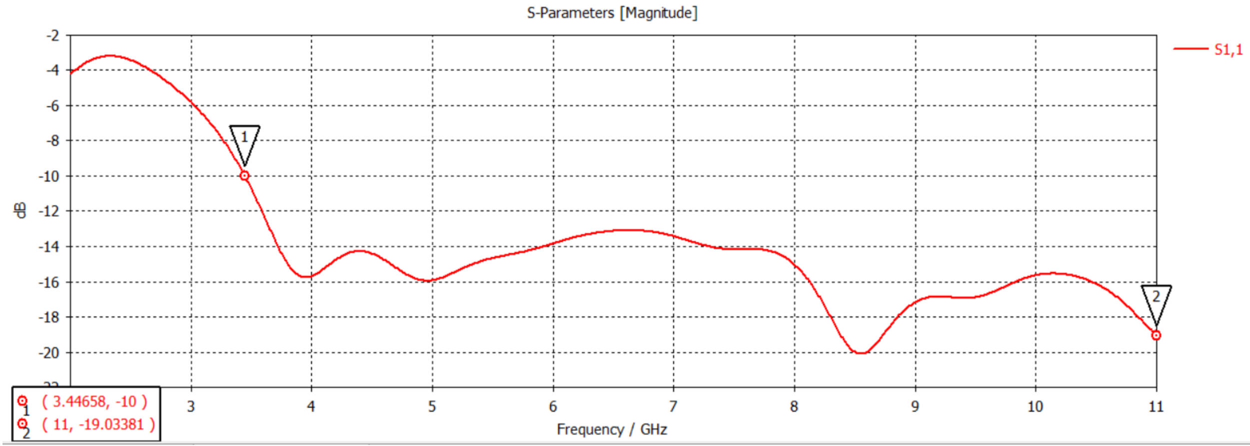


Figure 36(a): Return loss of first element

4.5.2. S22:

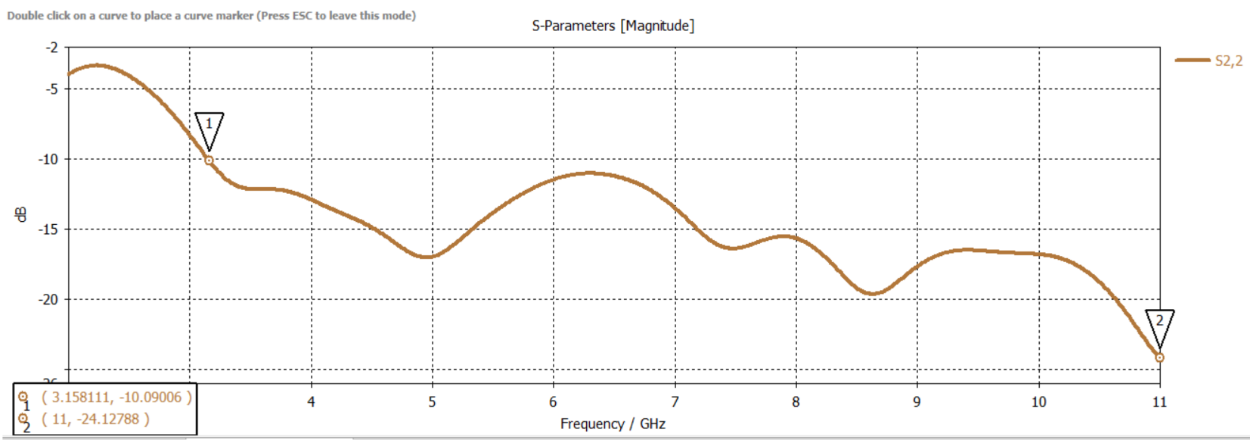


Figure 36(b): Return loss of second element

4.5.3. S33:

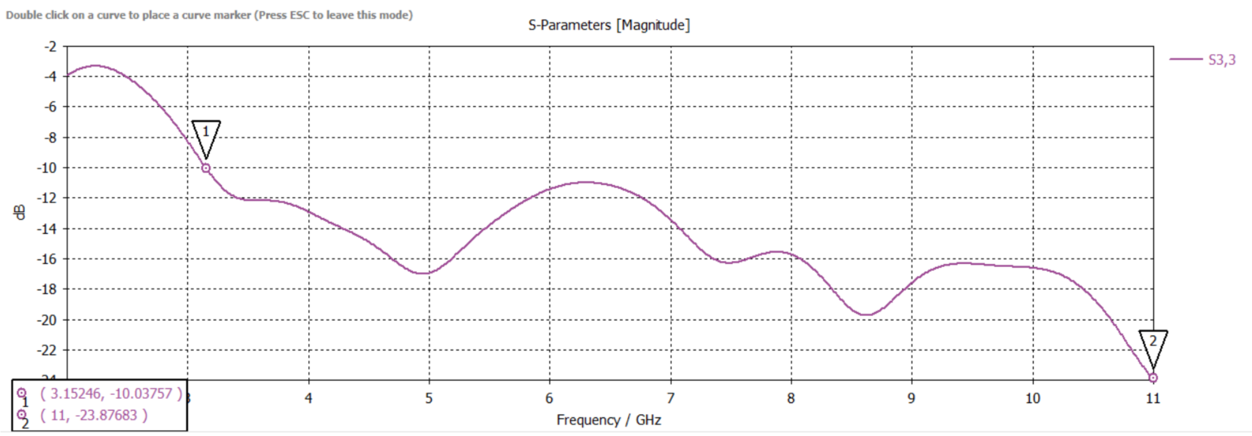


Figure 36(c): Return loss of third element

4.5.4. S44:

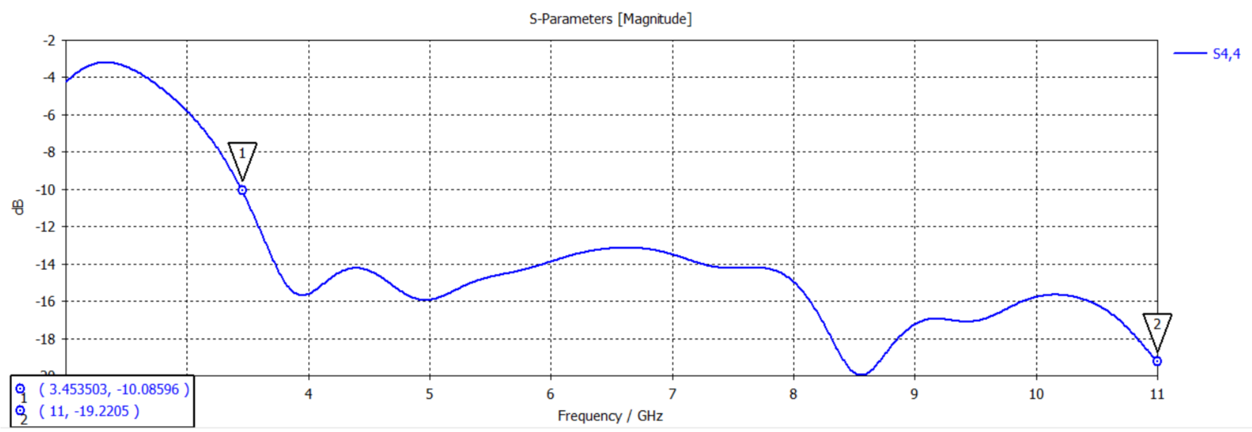


Figure 36(d): Return loss of fourth element

4.5 UWB Results:

The proposed antenna works on 3.4-11GHz frequency. Following are the radiation pattern and gain plot at various frequencies.

F=3.5 GHz:

The radiation pattern and gain plot at 3.5 GHz is shown below:

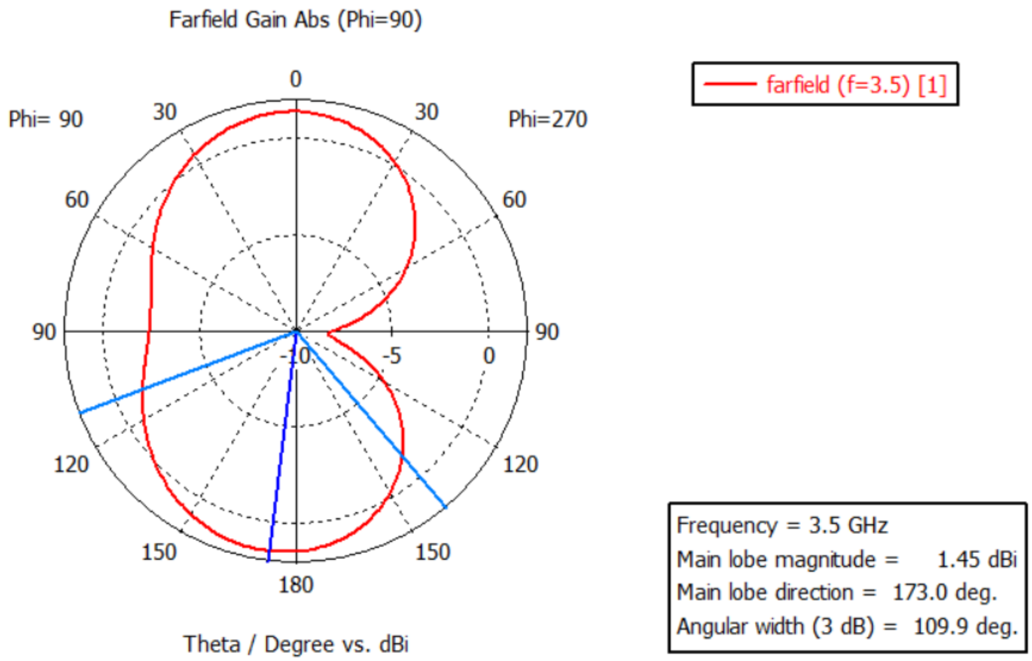


Figure 37(a): Radiation Pattern at 3.5 GHz

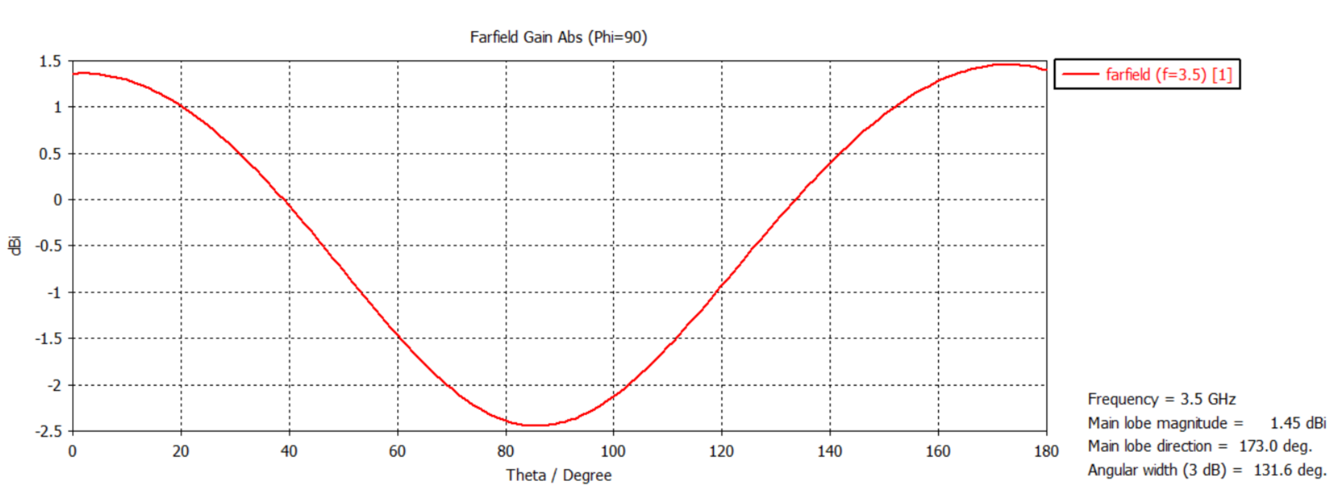


Figure 37(b): Gain Plot at 3.5 GHz

F=4GHz:

The radiation pattern and gain plot at 4 GHz is shown below:

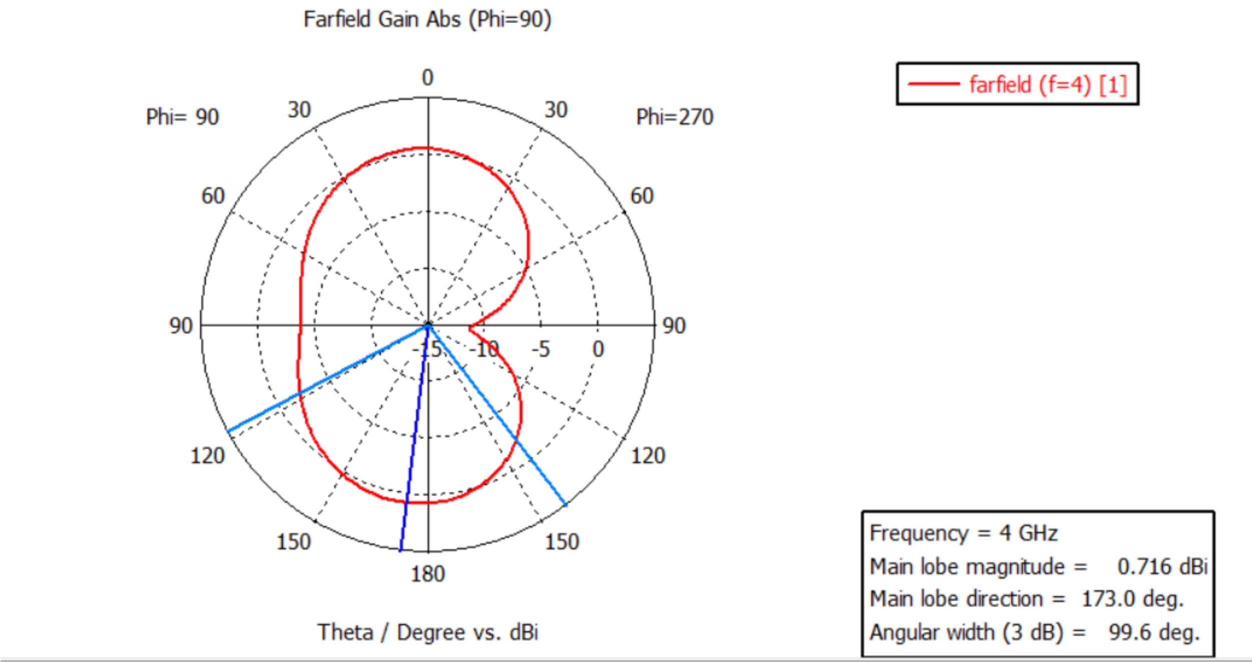


Figure 38: Radiation Pattern at 4 GHz

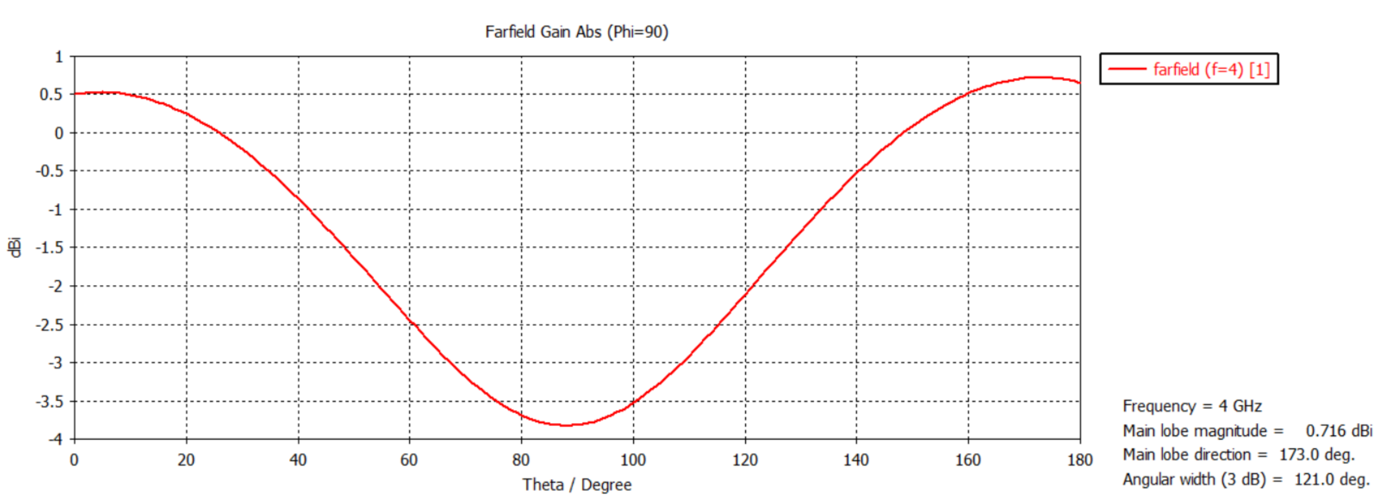


Figure 39: Gain Plot at 4 GHz

F=5GHz:

The radiation pattern and gain plot at 5 GHz is shown below:

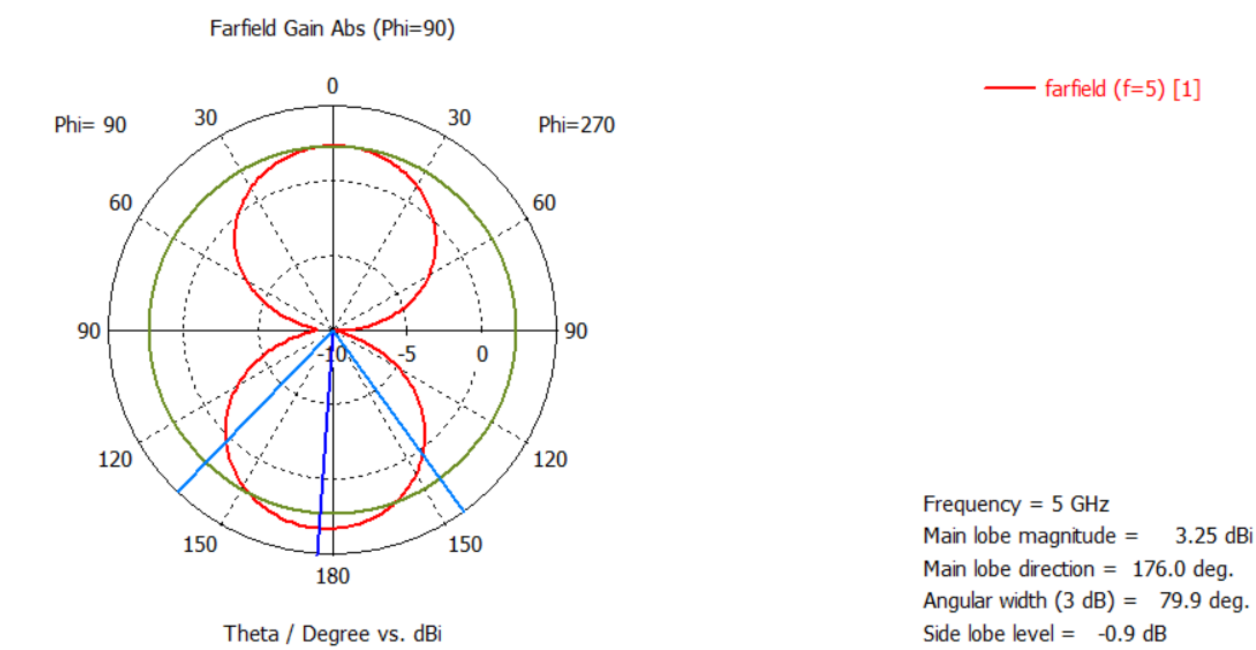


Figure 40: Radiation Pattern at 5 GHz

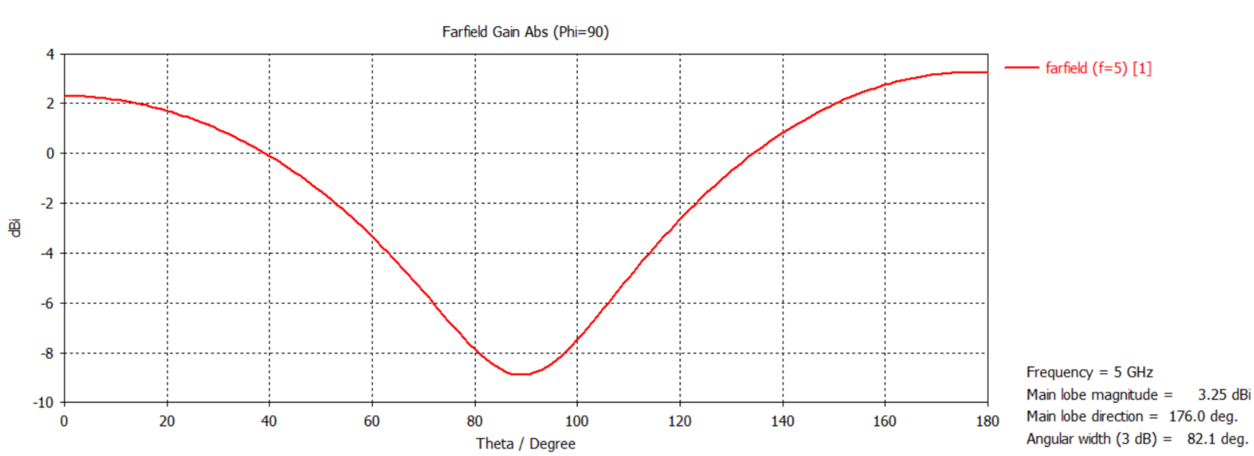


Figure 41: Gain Plot at 5 GHz

F=6GHz:

The radiation pattern and gain plot at 6 GHz is shown below:

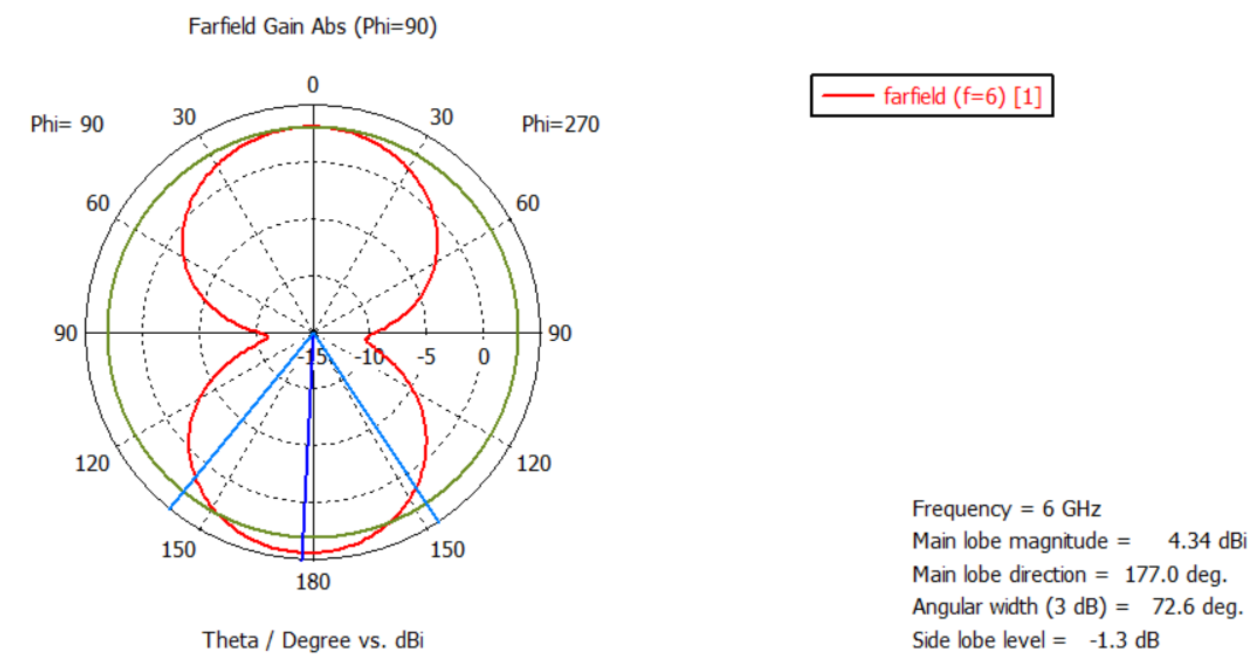


Figure 42: Radiation Pattern at 6 GHz

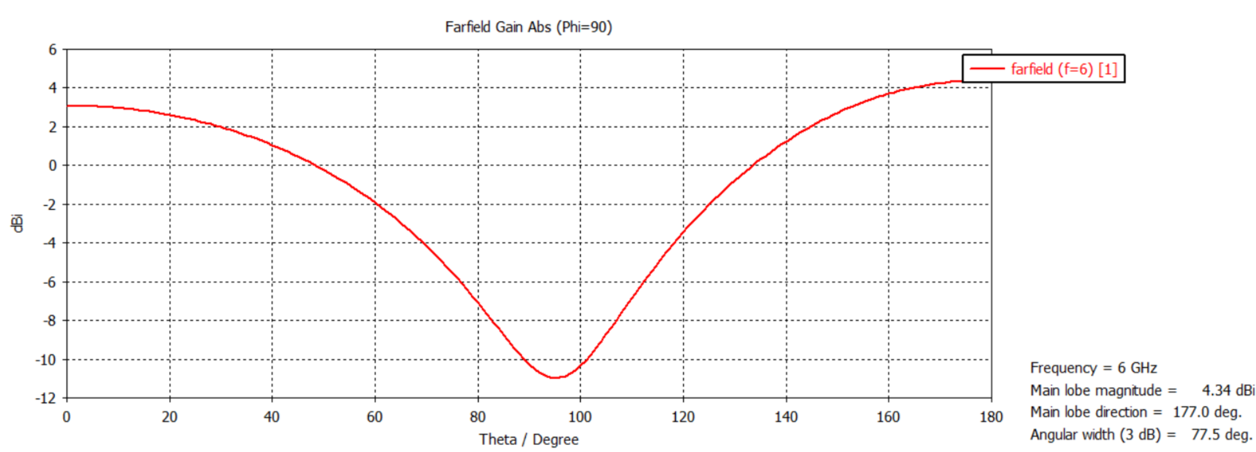


Figure 43: Gain Plot at 6 GHz

F=7GHz:

The radiation pattern and gain plot at 7 GHz is shown below:

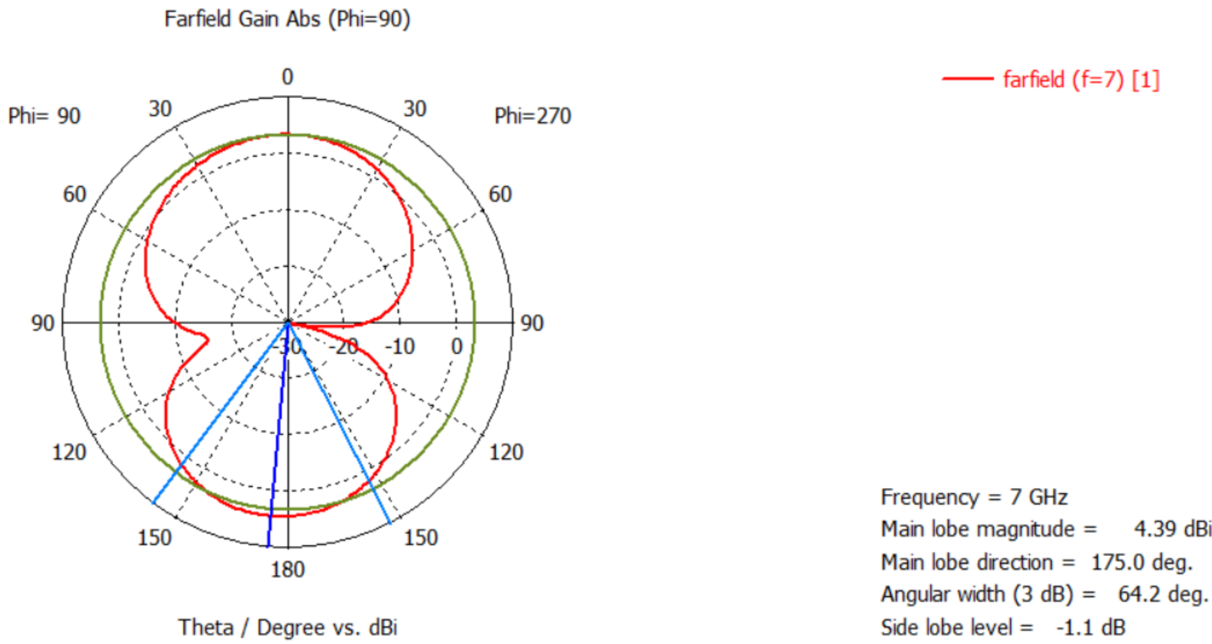


Figure 44: Radiation Pattern at 7GHz

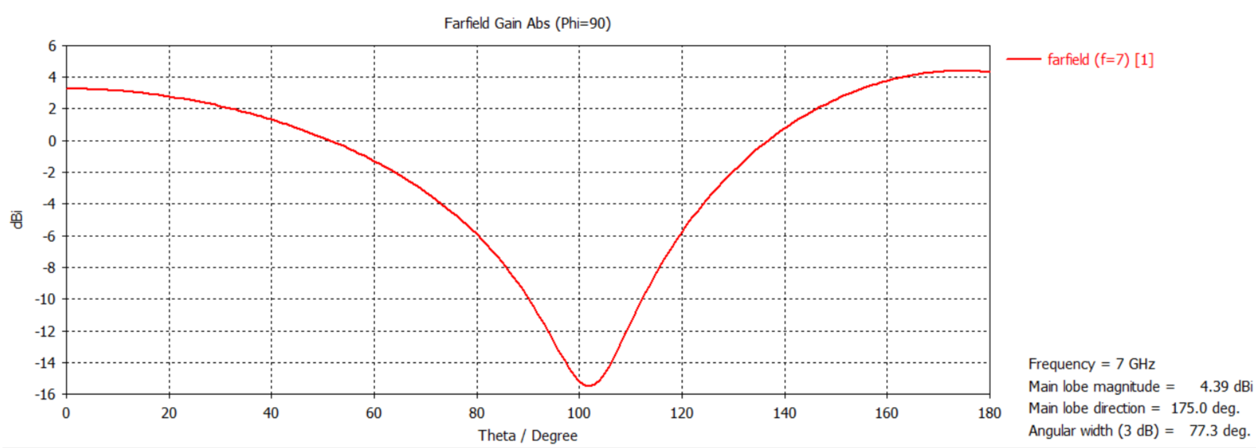


Figure 45: Gain Plot at 7 GHz

F=8GHz:

The radiation pattern and gain plot at 8 GHz is shown below:

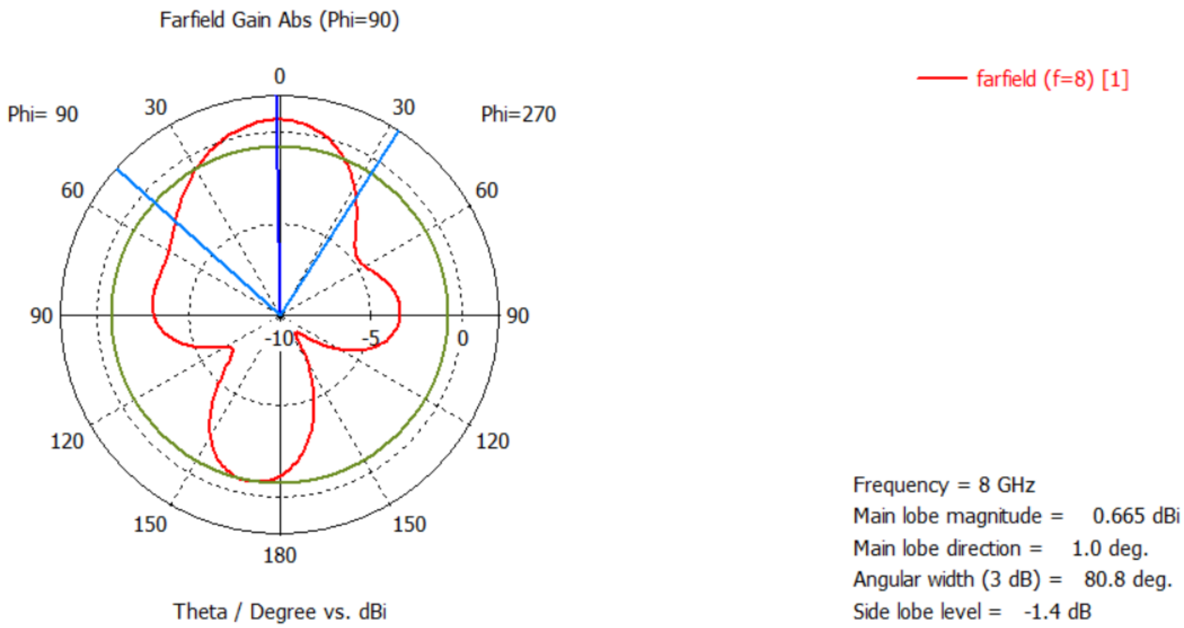


Figure 46: Radiation Pattern at 8 GHz

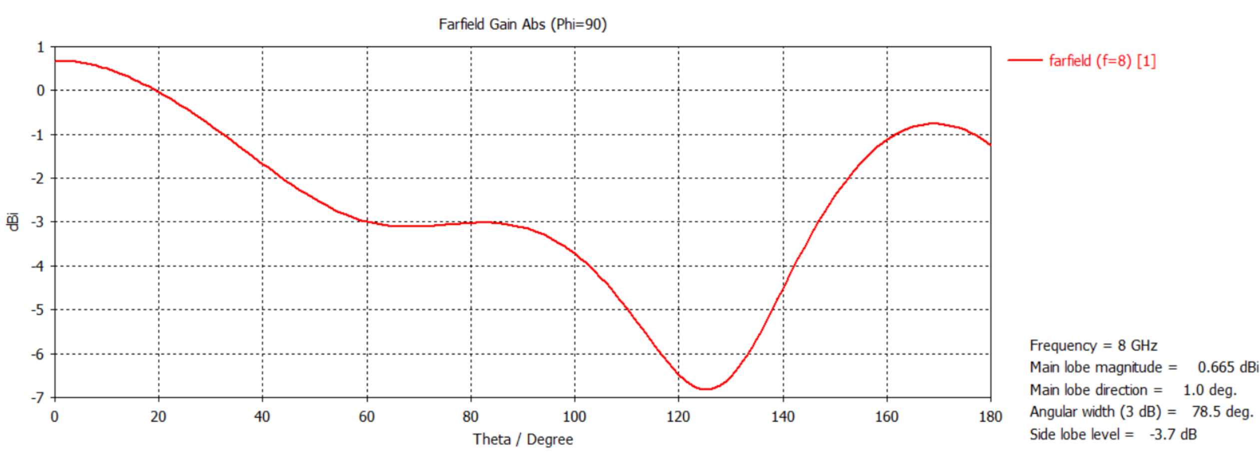


Figure 47: Gain Plot at 8 GHz

F=9GHz:

The radiation pattern and gain plot at 9 GHz is shown below:

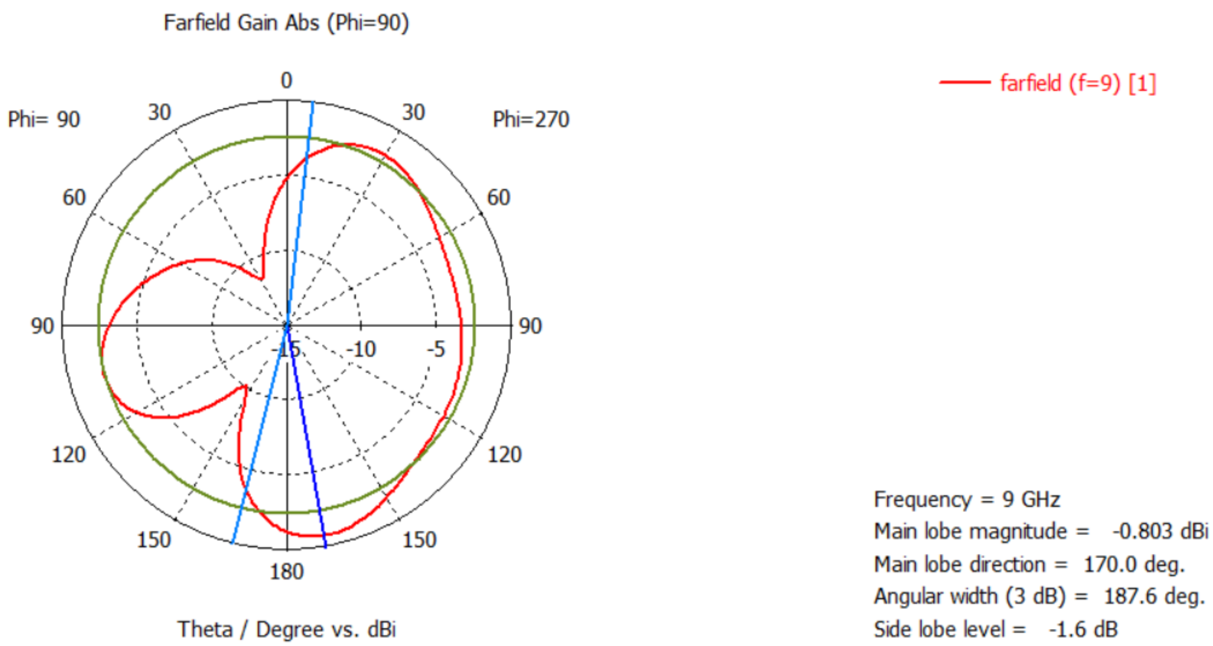


Figure 48: Radiation Pattern at 9 GHz

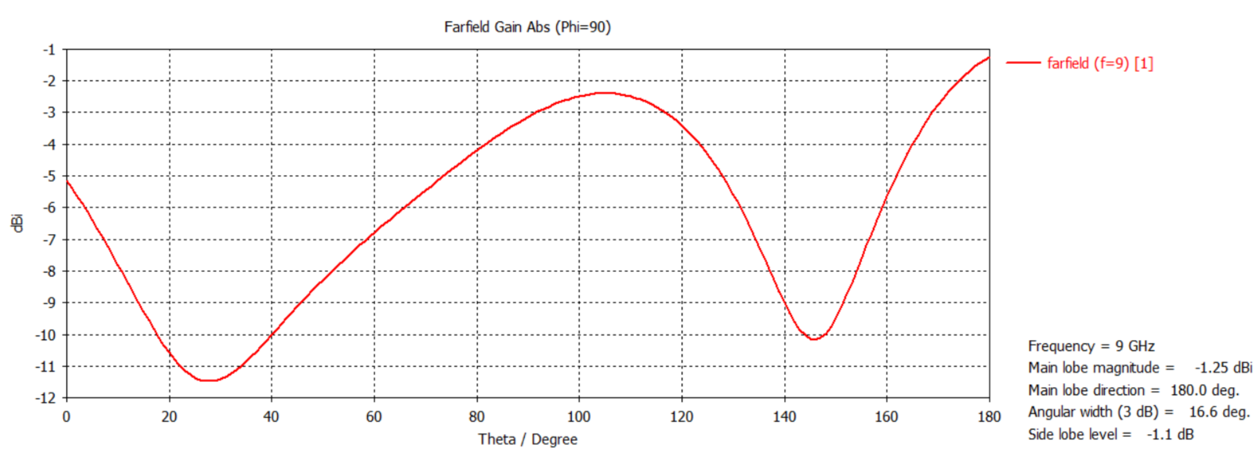


Figure 49: Gain Plot at 9 GHz

F=10GHz:

The radiation pattern and gain plot at 10 GHz is shown below:

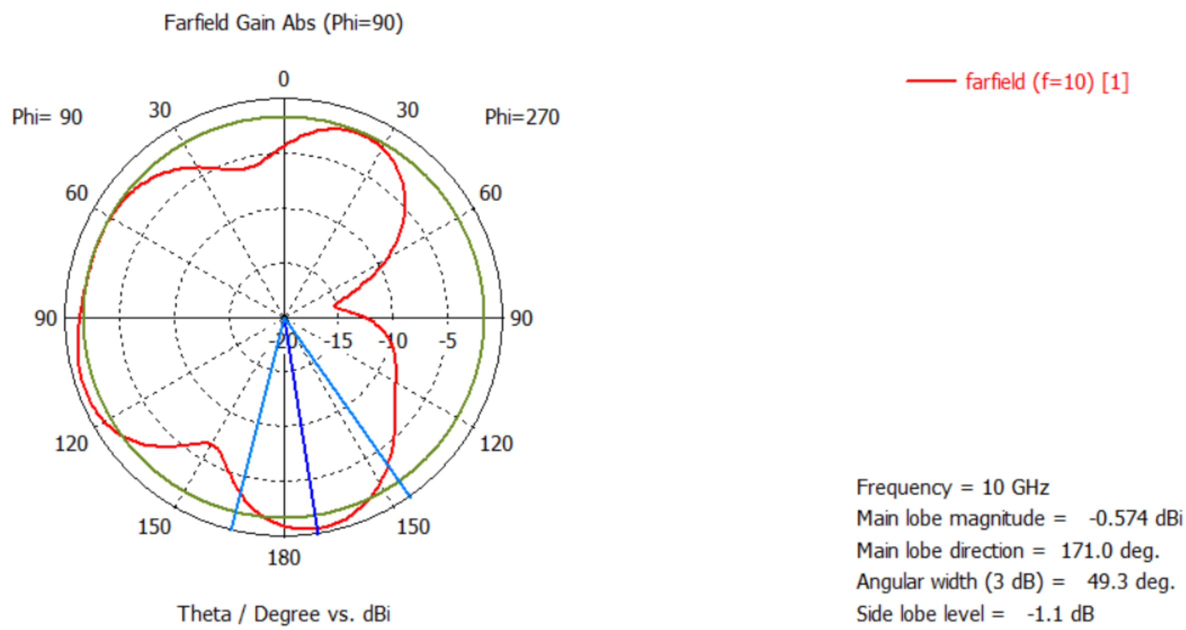


Figure 50: Radiation Pattern at 10 GHz

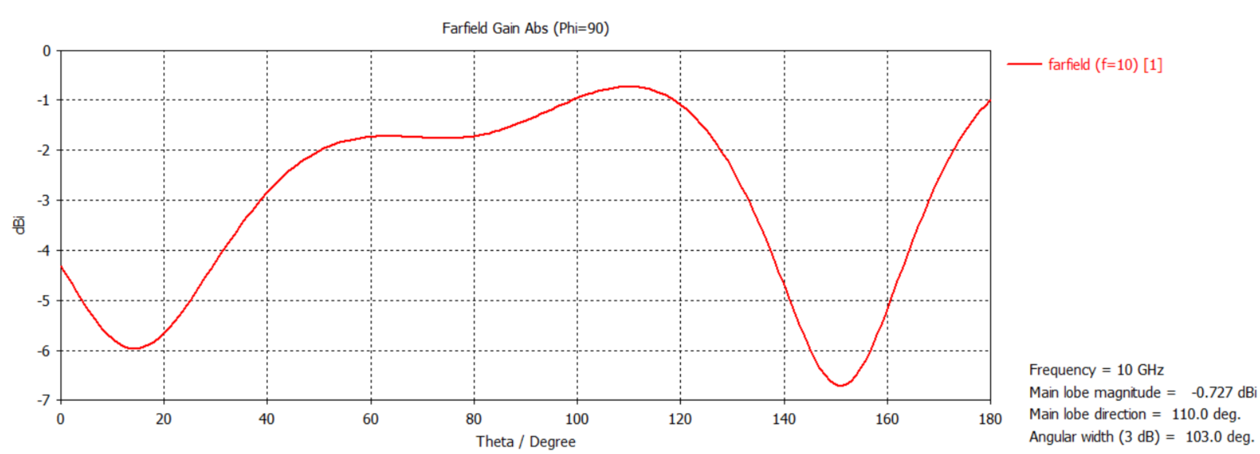


Figure 51: Gain Plot at 10 GHz

F=11GHz:

The radiation pattern and gain plot at 11 GHz is shown below:

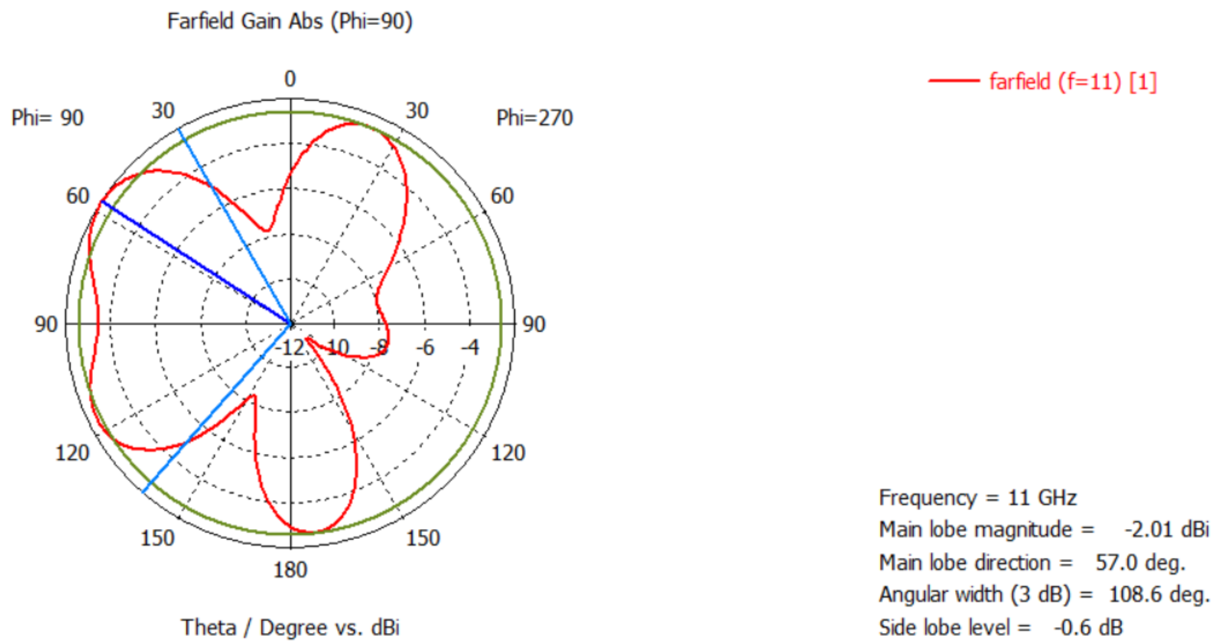


Figure 52: Radiation Pattern at 11 GHz

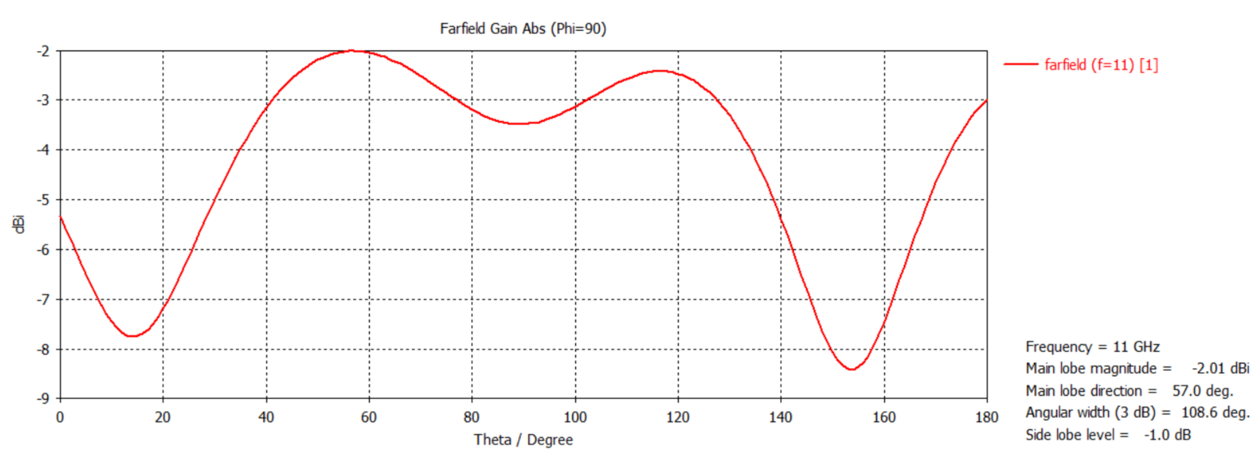


Figure 53: Gain Plot at 11 GHz

4.6. Hardware:

Figure 54: Front View of Fabricated Antenna

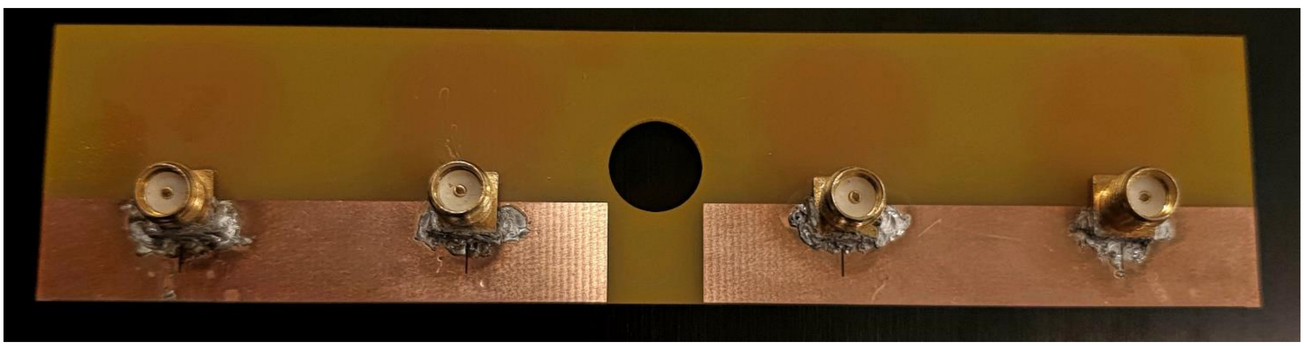


Figure 55: Back View of Fabricated Antenna

4.7 Hardware Results:

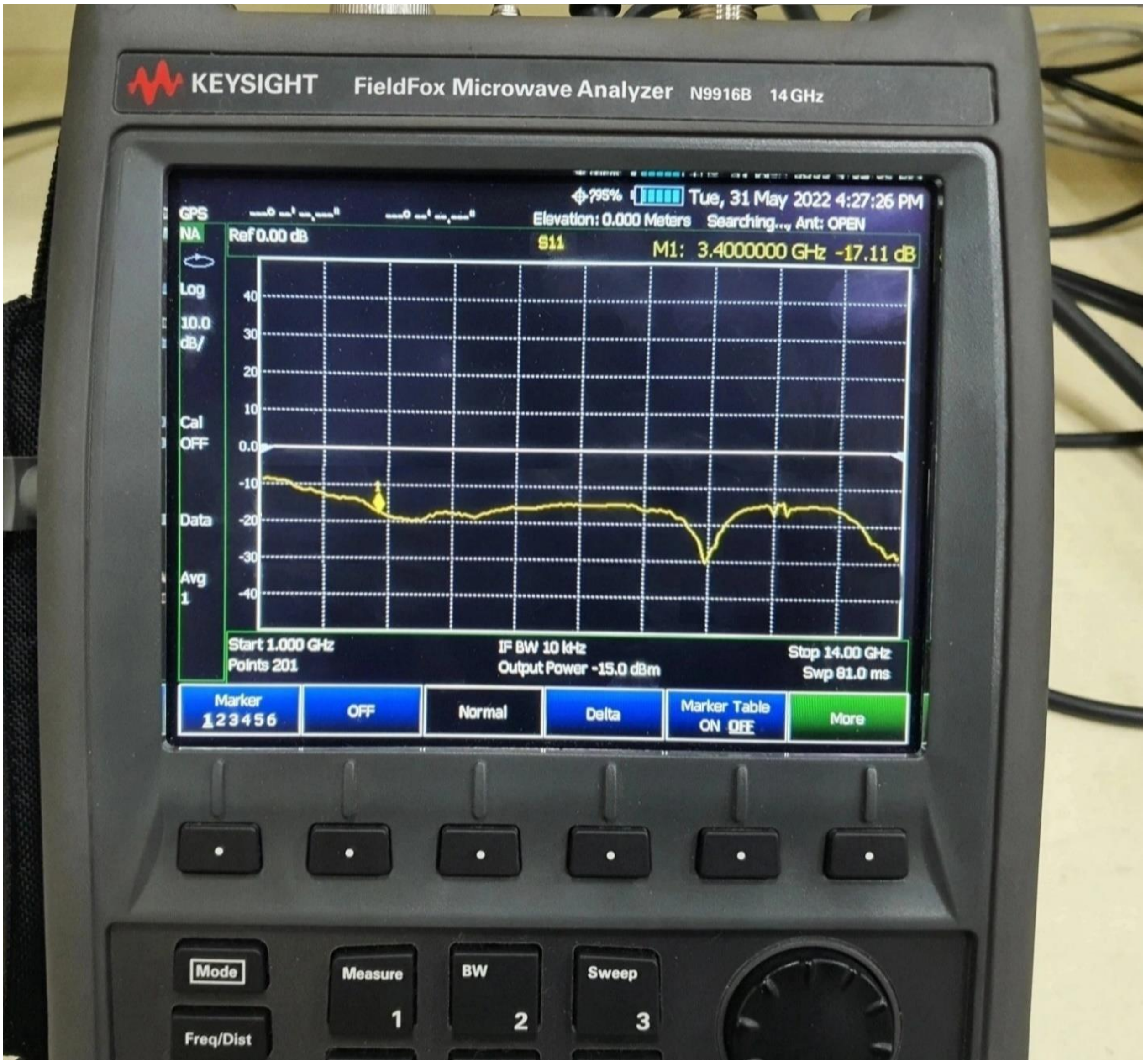


Figure 56: Results of Fabricated Antenna

For better and accurate results, we got our antenna fabricated from Smart PCBs, Islamabad so that these results are close to the simulated results on CST.

CHAPTER 5: MICROWAVE IMAGING

In the following paragraphs, we will discuss about some concrete steps for finding the tumor in the phantom. Following figure 57 depicts the overall experimental configuration for measuring the reflected signal. The VNA is employed in the experimental analysis to determine S11 from the breast phantom.

Figure 57: Real Time Measurement of S11 using VNA

The UWB antenna is centered above the phantom during the measurement process. By measuring its impedance at various frequencies between 3.4 and 11 GHz, we find that this UWB antenna can successfully receive and transmit signals in those ranges.
The UWB antenna, which is connected to the VNA's end terminal, can be used to both receive and transmit the electromagnetic wave. The VNA has a frequency range of 2-to-14 GHz. The UWB antenna sends out a microwave signal that illuminates the ghost. The reflected signal is collected by the same antenna that was used to transmit data at frequencies between 3.4 and 11 GHz (S11).

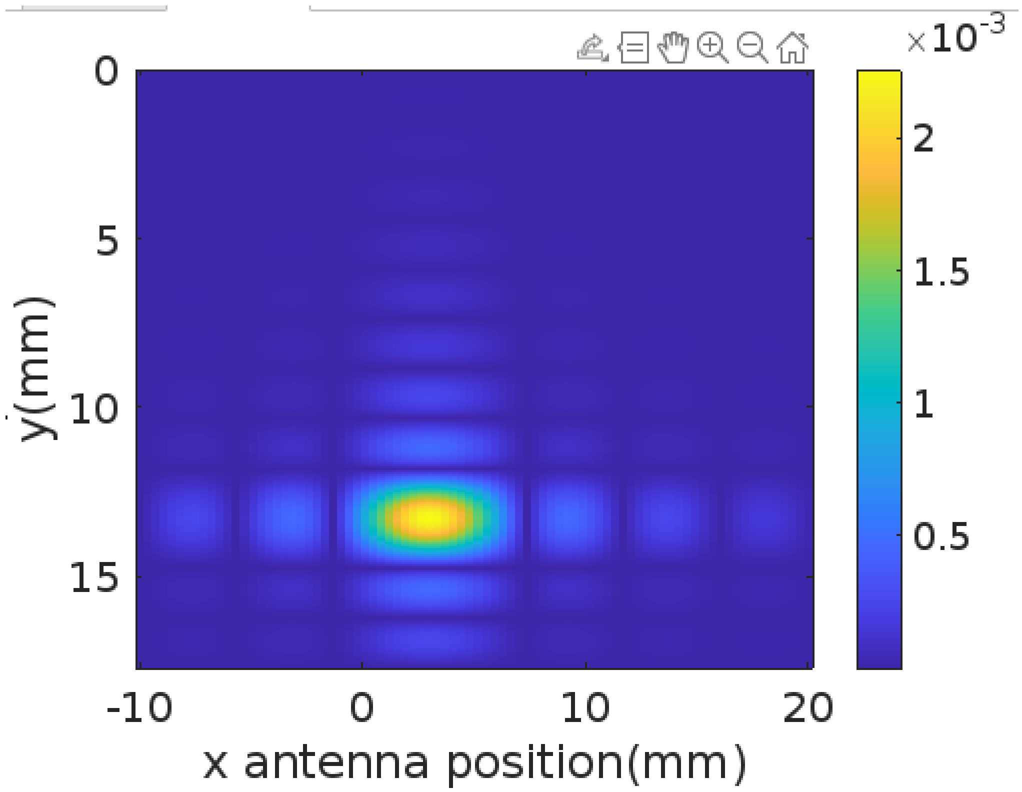


Figure 58: Reconstructed image with a tumor at the depth of 13mm

The Y-axis in the above diagram shows the depth of the tumor in millimeters(mm) and the X-axis shows the position of the antenna in millimeters(mm). First, we used the antenna of frequency 9GHz and the tumor was placed at the depth of 13mm, and the antenna was located at the surface of the phantom. It was placed just at the surface so that the microwaves could be scattered in the breast phantom completely.

CHAPTER 6: FUTURE WORK AND CONCLUSIONS

6.1: Future Work:

As there has been many devices made for detection of breast cancer, but they all work only on a greater stage of the cancer which is harmful for the human body. So, our antenna has the advantage of detecting the tumor which is on exceedingly early stage and not harmful for the body yet. It will help the doctors to cure the patient as soon as possible. The results we achieved can be improved by using better substrates, by using more patches and using micro-ports.

6.2: Conclusions:

In our project, 1x4 patch array antenna is proposed whose operating frequency range is from 3.4 to 11 GHz. Smaller size patch antenna can be converted into antenna arrays by combining more than one element. The advantage of making array is that it provides scattered signal information more precisely hence which results in better detection of the tumor. As there are many types of antennas like dipole, horn etc., but patch antenna has been given priority due to its light weight, small structure, ease in fabrication and low cost. The designed patch antenna finds its major use in medical field for detection of breast cancer tumor at its exceedingly early stage. Several research papers based on recent techniques like Mammography, MRI, BSE, Microwave Imaging have been reviewed but we prefer to detect the breast cancer tumor by the varying dielectric properties of tissues due to its harmless factor.

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