ULTRA-WIDE BAND ANTENNA DESIGN TO IMPROVE DETECTION IN MICROWAVE IMAGING

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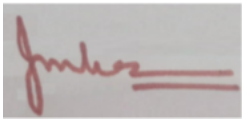

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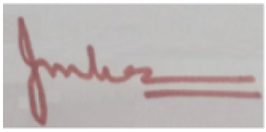

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DEDICATION

This thesis is out-and-out to my teachers, my parents and my loved ones. I take this opportunity to tanks my supervisor for continuously guiding me through the entire process, for encouraging me, and for mentoring me in the very best way possible. Though I had down times a few times, but the way my teachers and specially my supervisor lifted me at that time; is quite remarkable. For I am, an average student though, thanks everyone for bringing the best out of me. Thank you so much.

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I would like to grab on this opportunity to mention a few names who have been constant and predictable throughout this varying and. unpredictable nature of the research in self-processes. This journey would not have been possible without; First and foremost: My supervisor; who, have been a constant source of guidance; inspiration and most importantly he has taught me self-discipline and the techniques to manage the time properly and to avoid stress. Because, in the long run, meaning in life generally these qualities help a person a lot. He kept the entire process friendly and smooth.

Finally, I must thank my Parents for giving me the freedom to choose the life I always wanted to live. And they believe in me that I will get succeeded.

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ABSTRACT

In this research, a UWB antenna is designed for breast cancer detection. The technology on which it works is microwave imaging. The frequency range is between 1.5GHz-6.5GHz spectrum which meets the requirements of our application that is UWB antenna for tumour detection and other medical applications, especially for breast cancer detection. The material used for fabrication is Rogers TMM 3 and the tool in which the antenna design is simulated is FHSS. As to enhance the performance of the antenna several modification and techniques are used i.e. slot insertion and Bezier curve. This tends to improve the Gain, Return loss S11, Directivity and radiation pattern of the system. To increase the total gain of the system a symmetric array of size 2 x 5 of monopole pattern arrangement. This combination achieves better results in terms of the target parameters as compare to the previous work that runs on asymmetric array having hemispheric arrangement.

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ABBREVIATIONS

UWB	Ultra-wide band
MRI	Magnetic resonance imaging
PET	Positron Emission Tomography
DAS	Delay and sum
MIST	Microwave imaging via space-time
RWCB	Robust weighted Capon beam forming
MAMI	Multistate adaptive microwave imaging
GLRT	Generalized likelihood ratio test
RFID	Radio-frequency identification
MIMO	Multiple-Input Multiple-Output
BW	Bandwidth
SWR	Standing wave ratio
VNA	Vector Network Analyzer
NN	Network neutral
DF	Dissipation factor
SVM	support vector machine
SCR	Signal-to-cutter ratio

HFSS	High Frequency Simulation Software
SKMCH	Shaukat Khanum Memorial Cancer Hospital
SKMCH&RC	Shaukat Khanum Memorial Cancer Hospital And Research Centre

CHAPTER 1

INTRODUCTION

CHAPTER 1. INTRODUCTION

1. THESIS BACKGROUND/OVERVIEW

1.1. Breast Cancer:

Breast cancer is caused in females due to disorder in breast tissues. The symptoms perhaps include change in shape of the breast, drooping of breast may occur, redness on skin, fluid flow out of the nipple, yellowness of skin, and the patient can experience pain in bones and joints. In some cases, it can cause squatness of breath. Factor that lead to breast cancer includes lack of exercise, obesity, excessive use of ale, hormone replacement therapies can be cancerous, having no children or late children. Prior history of family where the victim had the issue inherited from her parent. Milk ducts and the lobules that stream milk to the ducts, are the often places which are susceptible to the development of cancer. Cancer that is due to ducts is called "Ductal Carcinomas", while the one which is caused by lobules is referred as "Lobular Carcinomas". In addition, there are about eighteen different types of breast tumours.

In women, nowadays, breast cancer is the second most common disease. Diagnosis of breast cancer at their early days as possible can vividly reduce the death rate. Around 1.7 million patients were diagnosed with breast cancer throughout the world in 2012. According to U.S. Breast Cancer Statistics, the maximum regular tumour that was detected amid American women is breast cancer. As of a report of 2017, among all the newly diagnosed cancers, at least 1 person among 3, tends to have breast cancer. In US according to a report of January 2018, the total count of breast cancer patients up till then was about a staggering 3.1 million. This comprises of the women who have been treated, and those who are still undergoing a treatment. It is forecasted that by the end of this year (2021) US women are expected to have an inundating number of offensive breast cancer. Also, it is expected that the number of newly diagnosed non-invasive breast cancer cases will touch some dangerous heights. [1].

The early diagnosis can help in saving a lot of lives. Biopsy is the technique that is used for the diagnosis of breast cancer, once identified. Further tests are done in order to verify; the cancer has expanded on a larger scale or is it just in the breast region. In developing countries or per say third world countries the surviving ratio, including the diagnosis and the treatment is very low. It is the prominent type of carcinoma in females according to international reports the chances of breast cancer are 100% more than that of a man.

Unluckily, in Asia, the highest rate of breast cancer is in Pakistan. The rate at which breast cancer in Pakistan is escalating is terrifying. One out of nine women diagnose with breast cancer. According to a report, it is likely that around 83000 breast cancer cases are reported each year. About 40,000 women die to the disease each year, in last 5 years around 1.1 million cases have been informed, 34,038 freshly identified cases and 16,232 demises in 2012 [2].

During the year 2016 at Shaukat Khanum Memorial Cancer Hospital and Research Centre (SKMCH&RC) Pakistan, a whole of 6,587 tumour cases have been recorded and the leading one amongst all type of cancers was breast cancer [3]. Just like other cancers, breast cancer also occurs due to the interaction of our environment and its effect on the genetics. Breast cancer causes illness to the breast cells or tissues, and these cells divide. Hence the cancer spreads out. There are many types of breast cancers, some of them are illustrated in the Figure 1.1.

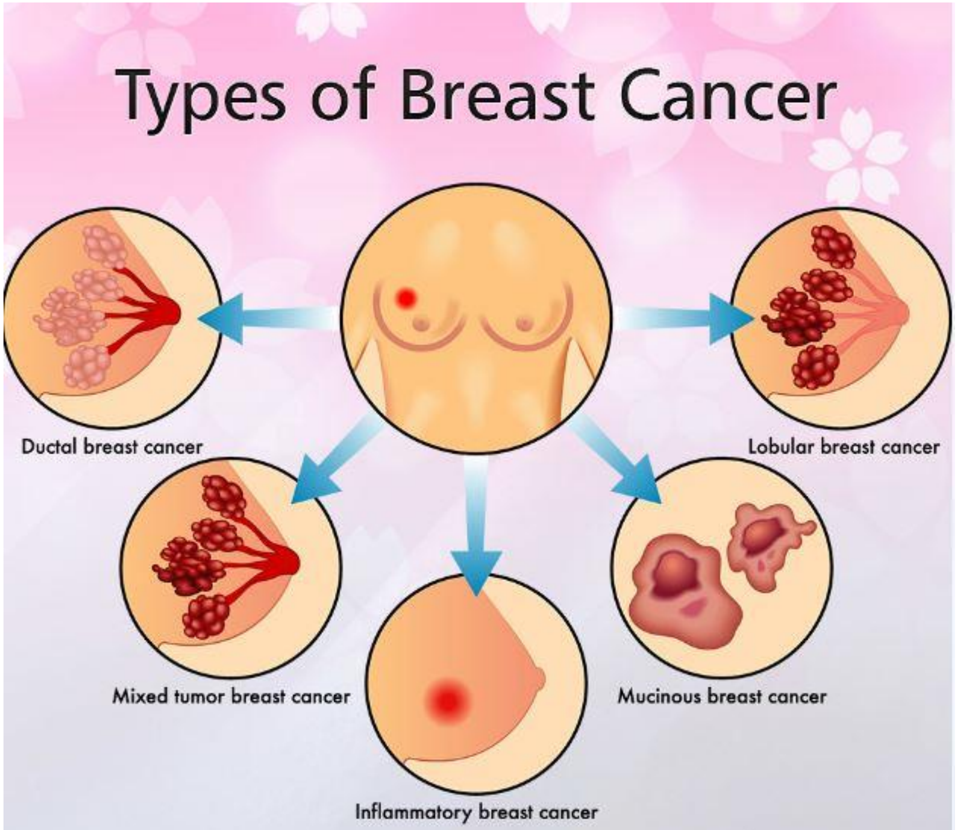


Figure 1.1 Different Types of breast cancer

1.2. Preventions:

In women breast cancer can be prevented by living a healthy lifestyle, exercise, avoid drinking and breast feeding the new born babies. The intake of fruits that are rich in citrus acid can dim the chances of breast cancer. In general, not only for breast cancer, but other diseases also, try to avoid the processed food. Reduced overweightness can be a barrier for breast cancer. It can also give other benefits: like reduces the chances of cardiac arrest and diabetes.

Pregnancy at early age can have a good effect on women when it comes to breast cancer. The women who impregnates at early age have less chances to have breast cancer latter in their life. The chances of breast cancer condense with the number of children a lady has.

1.3. Breast Cancer awareness:

For breast cancer awareness the symbol “Pink ribbon” is used as shown in Figure 1.2. It comprises of such events, fundraisers, and activities that are helpful to educate the masses about the decease. The symptoms, treatment and preventions are taught through different models. It is made sure that women follow the model. Those who reject or negate the model may be penalized according to the law. The main purpose of such arrangements is to teach.

Figure 1.2 Pink ribbon symbolisim for breast cancer awareness

1.4. Methods used for breast cancer detection:

Different techniques are used to detect breast cancer. The early detection is very crucial in order to treat it as soon as possible. Else, it can get late and a precious life can be lost. Following are the methods that are used to detect breast cancer, as shown in Figure 1.3.

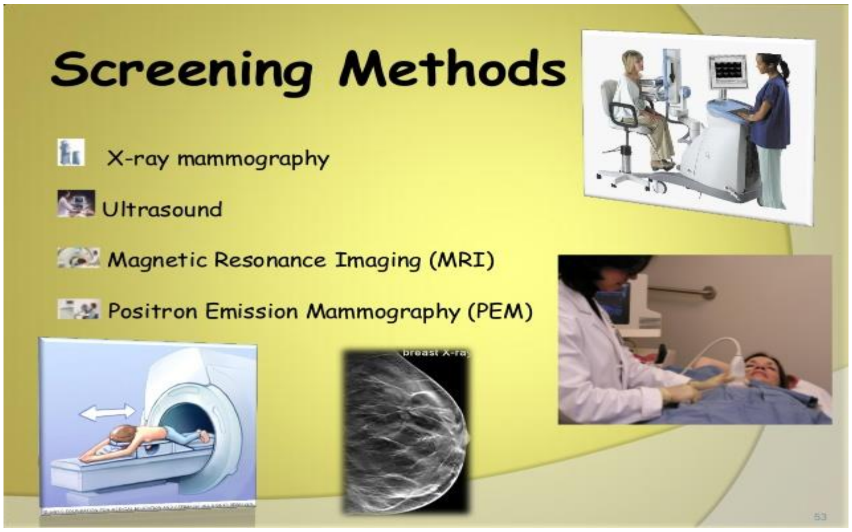


Figure 1.3 Different Types of Screening Methods

- **Breast screening**
- **X-Ray**
- **Ultrasound**
- **MRI**
- **PET**
- **Microwave**

1.4.1. Breast Screening:

Breast screening is a technique of finding a breast cancer when it is too minor to see or feel. Incumbent methods for breast screening are listed in the image given below. Those methods are commonly used for primary breast cancer findings. Microwave waves are used in a non-invasive breast screening technique and this method is safe for humans. In future, it can be used as an alternative of other techniques used for breast screening. [4,5].

1.4.2. X-Ray:

It involves a “Mammogram”, which is basically an X-Ray of the breast (‘Mammography’, as shown in the Figure 1.4, is the process in which the human breast is diagnosed and screened by using low-energy X-ray). It is usually used for timely breast malignance diagnosis. However, it has several limitations. Several available reports discourse the threats of contact to emissions [6].

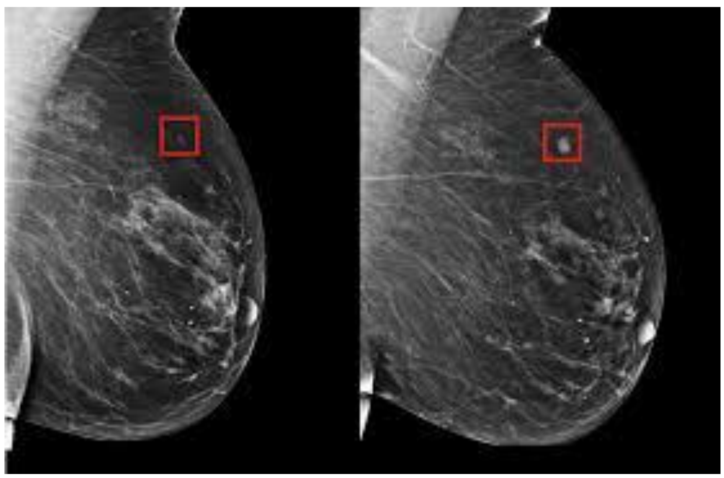


Figure 1.4 X-ray Mammography

1.4.3. Problem with X-Rays:

The breast screening with the help of X-Rays can induce more harms to the women who are in their 40s. The X-Ray mammography upshots about 20% of false positives in women in their 40s.The false positive results can have harmful effects on the patient that include overtreatment, pointless, and every now and then it can lead to invasive surgical treatment which results not only in expenditure, but also can prompt psychological tension. Further, during the breast inspection X-ray mammography prerequisites compression of the breast to lie as plane as possible, this can origin patient discomfort [7]. In mammogram images the fatty tissues appear black, while the cancer tissues appear white. Therefore, in dense breast it is often difficult to distinguish between the diseased and healthy tissues. [8].

1.4.4. Ultrasound:

In Ultrasound internal body structure is examined by using sound waves. It uses frequencies above 20 kHz for operation. Ultrasound pulsations are sent by means of a transducer placed on the skin surface, and this produces ultrasound images. It is a painless and safe method from radiation exposure. [9]. Figure 1.5 shows the ultrasound mammography in detail. The one to the right is infested breast while the other one is healthy.

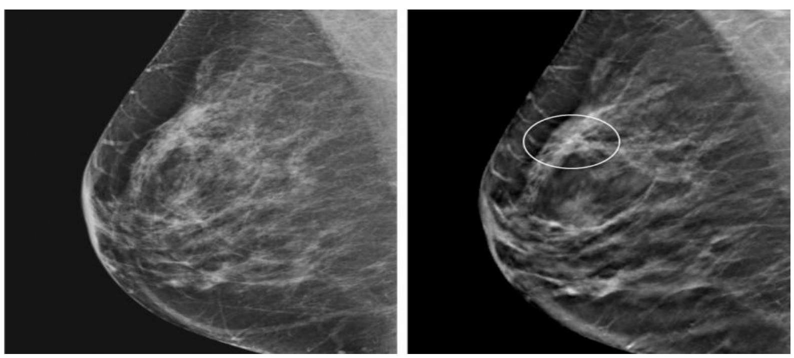


Figure 1.5 Ultra Sound Mamography

1.4.4.1. Problem with Ultrasound:

Ultrasound does not distinguish between malignant and benign tumour because of low resolution (A benign tumour is self-limiting and grows slowly. The cells of a malignant, or cancerous, tumour produce daughter cells which can be uncontrollable). Moreover, if mammogram results are sceptical than ultrasound is used as secondary method to check tumours.

1.4.5. MRI:

MRI stands for “Magnetic resonance imaging”. MRI uses radio waves and strong magnetic fields to foster internal images of the body. In this method different type of tissues are examined by amount of energy absorption. Throughout the examination of soft tissue like breast, a distinctive kind of liquid is injected to provide improved images. Typically, MRI is used for many other purposes**.** MRI Mammography results are shown in Figure 1.6.

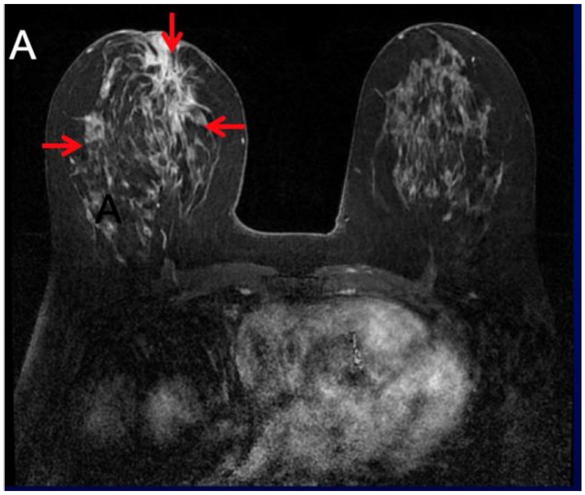


Figure 1.6 Magnetic resonance imaging Mamography

1.4.5.1. Problem with MRI:

MRI is first of all a very expensive technique. It is suitable for brain tumor detection and other terminal diseases. Secondly, the problem with MRI is that its reports takes a long time to be generated. that why MRI is not feasible for early breast tumor detection.

1.4.6. PET:

PET stands for “positron emission tomography”. Figure 1.7 shows the results of PET mammography. A mixture of radioactive ingredients is vaccinated in the patient with glucose or glycoprotein in PET. The cancerous cells grow much quicker than the normal cells for the reason that they devour nutrients. Positrons are emitted, when the cancer cells consume nutrients. PET is able to consider cancer in the very initial phases by spotting those positrons. nothing like X-ray, CT scan (Computerized tomography scan), and MRI because PET is better in capturing the minute detail-movement of molecules.

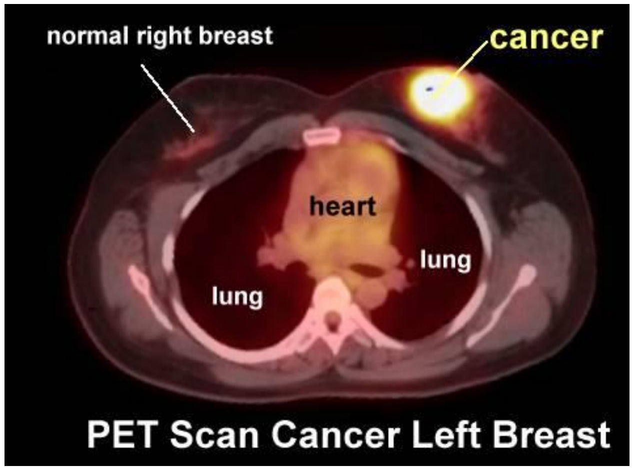


Figure 1.7 PET Mamography

1.4.6.1. Problem with PET:

The limitation of PET is its low resolution than other methods, especially when high accuracy & reliability is desirable.

1.4.7. Microwave:

The restrictions described in detailed section 1.1 regarding the existing diagnostic imaging methods used for screening motivate the researchers to develop alternative imaging methods. Scattering wave or reflected waves is used in microwave imaging, which helps in differentiation between the normal and effected tissues of breast. Due to the difference in dielectric properties of healthy and infected tissues, it is possible for microwave breast imaging to distinguish between them. The initial experiments performed in [10-12]. Microwave imaging is capable of detecting a tumour up to a small size, in a less time and low cost as compare to other incumbent technologies in the market. [13].

In Radar based imaging methods focusing algorithm is used for the generation of 3D images of breast. These images are created with the help of reflected signals from the breast. Some of the renowned algorithms used for microwave image recreation are: the delay and sum (DAS) [14], microwave imaging by means of space-time, also known as (MIST) [15], robust weighted Capon beam forming (RWCB) [16], multistate adaptive microwave imaging (MAMI) [17], and generalized likelihood ratio test (GLRT) [18]. Pre-processing is executed to acquire a tumour reaction, prior to applying the focusing algorithm. Pre-processing may comprise the extracting tumour reaction, recompense tissue harms, or outspread. It is essential to extract tumour response during pre-processing because it is likely to have not only the desire signal but also the direct signal received from the transmitting antenna, skin reflection and antenna coupling in the received signal.

1.5. Problem statement:

"To design an improved UWB antenna for breast cancer detection through microwave imaging using monopole planner array having high gain, low back propagation, lesser side lobes and low manufacturing cost".

1.6. Problem Description:

The key issue is to design such antenna that operate in spectrum of UWB frequency band as well as low-weight, low cost that meets the criteria of simplicity and solidity. The other challenge that is to determine the number of antenna element while designing an antenna array from which we reduce the cost of the system [19].

Our major focus of design parameter would be to improve S11 parameters, gain and directivity particularly for breast cancer detection application. To improve the directional properties, a reflector will be used and positioned behind the antenna, resulting in reduced back propagation of radiation.

1.7. Microwave antenna:

It is a physical device that uses “Microwave signals or waves” for transmission. Microwave signals are electromagnetic signals of very small wavelength (1m-1mm), with frequency range between 300 MHZ to 300 GHZ. Microwaves have very minute wavelength as compare to radio waves that were used in previous microwave technologies.

1.8. Working of Microwave Antenna:

The electricity in transmitter antenna causes the electrons to vibrate which produces radio signals. These signals travel through air with the speed of light. Upon reaching the receiver antenna they make the electrons of antenna vibrate. Microwaves are similar to radio waves but have very smaller wavelength.

1.9. Types of Microwave antennas:

Some of the different antenna types are discussed according to shape, architecture and applications. Subsequent are few types.

- Micro strip patch antenna
- Horn antenna
- Parabolic antenna
- Plasma antenna
- MIMO antenna

1.9.1. Micro strip patch antenna:

They are often called "Patch antennas". They have operating frequency range from 100 MHZ-100 GHZ. It has a simple structure in which a radiating patch is connected or mounted on a Di-electric substrate, while the other side is having a plane ground as shown in Figure 1.8. The patching material is made up of a conductor for example: Gold, copper or any metal. These antennas are widely used due to its low cost, less weight and easy operation. They are manufactured in a large number, are used in communication systems, paging, cellular system, and GPS etc.

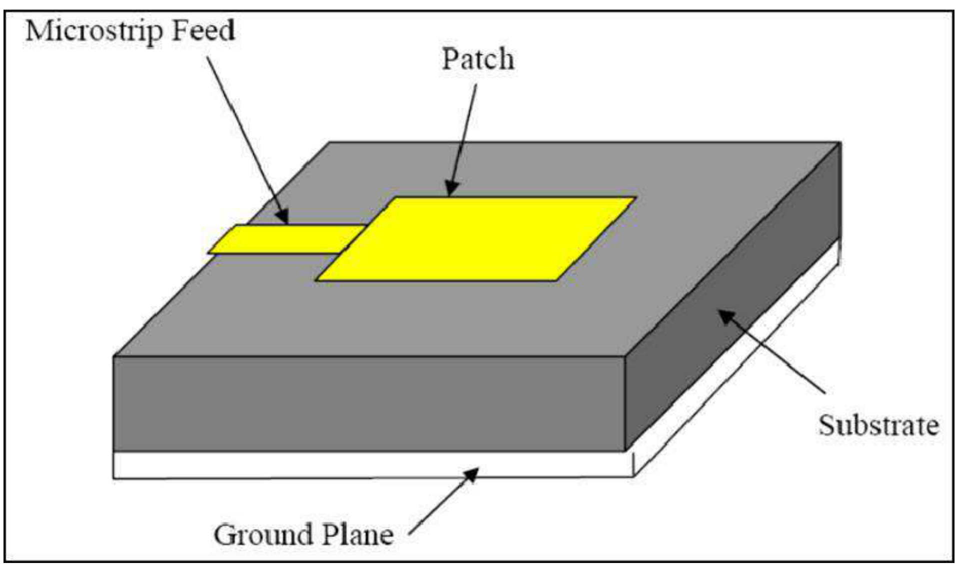


Figure 1.8 Micro Strip Patch Antenna

1.9.2. Horn antenna:

This antenna is commonly known as "Horn antenna", because it has a megaphone like shape. It is also known as "Microwave horn antenna". These antennas operate at high frequencies (way above 300 MHZ). These antennas have a waveguide which is wide at the outer side. These antennas are capable of computing the gain of other antennas, hence are used for calibrating and finding the directivity of other antennas. Horn antennas have a gain of 25dB, and have high bandwidth (B.W), Average directivity and most notably a low standing-wave-ratio (SWR). Figure 1.9 shows the structure of horn antenna.

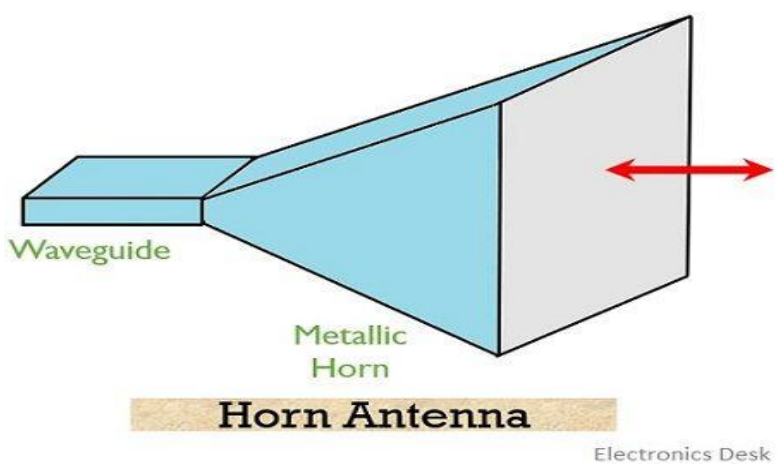


Figure 1.9 Horn Antenna

1.9.3. Parabolic antenna:

Parabolic antenna has a curved shape, like that of a dish as shown in the Figure 1.10. As it has a parabolic shape Therefore sometime called Dish antenna or parabolic antenna. The main advantage of such antennas is that they have a high directionality. As these antennas have high directivity. So, they are used for point-to-point communication in hilly areas. In mountainous regions dish antennas are used at sender and receiver end; Microwave signals are used as medium of transmission. Parabolic antennas are used in radar systems and used to communicate with ships and airplanes.

Figure 1.10 Parabolic antenna

1.9.4. Plasma antenna:

This 90 GHZ antenna uses plasma in place of metal as development element. Gas is used for conduction, instead of a metal. During the transmission and reception process the gas ionizes. Basically “plasma antennas” are radio antennas, having a high frequency cut-off; Means they can operate on high frequencies as well as low frequencies. They are used in 4G, High speed digital communication, RFID, Radar systems, and electronic intelligence. The Figure 1.11 shows the complete assembly of plasma antenna.

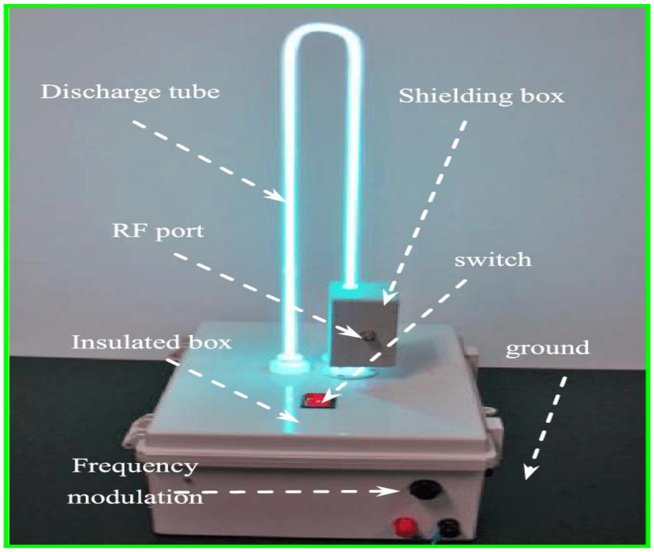


Figure 1.11 Plasma antenna

1.9.5. MIMO antenna:

It is one of the smartest antenna, in this MIMO (multiple input multiple output) are used on both the ends to enhance the performance of the communication. The MIMO antenna has basically 2 primary advantages: Firstly, it has high directivity, and secondly, it increases the capacity of the system. They are used in mesh systems and RFID systems.

The above designated antennas perform a vital part in the areas of wireless communication, radar, satellite, and radio communication. Figure 1.12 shows the concept of MIMO antenna.

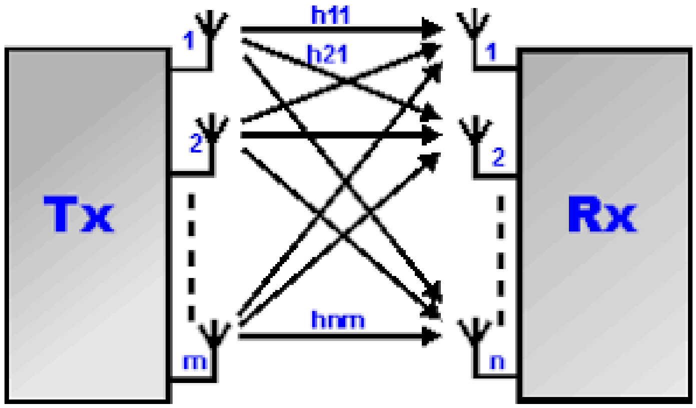


Figure 1.12 MIMO antenna

1.10. Solution to the problem:

For UWB application a MIMO array antenna is proposed which can detect breast cancer using microwave imaging. The intention is to design such an antenna that accomplishes UWB band. Also, the aim is to optimize the output of the antenna having 2x5 pattern for microwave imaging. Moreover, the designed antenna is having relatively improved S11 parameters, gain, and directivity and have reduced back radiation than the previously designed antenna.

1.11. Thesis Organization:

The thesis comprises of 5 chapters, mainly. The first chapter is an introductory chapter, followed by detailed review. After this methodology is discussed, results are evaluated and compared to other techniques in chapter 4; so, that the validity of the results can be guaranteed. In chapter 5, the thesis is wrapped up with a conclusion and future work.

CHAPTER 2

LITERATURE REVIEW

CHAPTER 2. LITERATURE REVIEW

In this chapter different “breast screening” techniques are discussed and their pros and cons are conversed. Mainly 2 types of methods are adopted: X-rays and Microwaves. In medical field, X-rays can be magnificently replaced by microwave imaging techniques for the breast cancer detection. Since X-rays can have dangerous effects on the human body. Therefore, microwaves are the best alternative option. Apart from x-rays and microwave, there are some other methods too. Like, PET. They don’t have any harm to the human torso, apparently. But it has a limitation: PET has low resolution; MRI is another method but it is very expensive. Thus, it not used often due to its high cost.

Ultrasound has its own limitations: It cannot differentiate between the bad and a good tissue. Therefore, there is chance of a mistake. Perhaps it may occur that, we target a kind tissue instead of a malignant one and can lead to a trouble. Due to all these limitations, microwave is the best option to be considered in this scenario. Basically, there are 2 methods of microwave imaging. As discussed, below.

In Microwave tomography, for breast diagnostic image a specific method is used which is called “inverse scattering”. Scattering signal from different objects are used in inverse scattering for the creation of the map of, conductivity and permittivity. However, the calculation process is thorny and difficult, that’s why inverse problem has delays. Also, iterative image reconstruction algorithms are usually required to obtain a solution for non-linear inverse scattering problem. In general, to unravel and attain a meaningful solution for the above problems a proper regulation is required. [20, 21]

Because of these advantages of UWB MIMO, the proposed configuration below plays a vital role in solving many problems. Reflected wave from objects is used for the recreation of image in Radar based microwave imaging. When microwaves transmit the signal to internal breast with tumour it uses the replication that upsurges due to dissimilarity in the electrical dielectric properties of healthy and disease-ridden breast tissues [22]. This same method was initially proposed for military applications but now is implemented to the human body too. It was design by Hagness in Wisconsin University, and Benjamin in Bristol University [23].

Recently, an experimental based 3D phantom, using 3D printing technology, has been developed by University of Bristol and Goethe University of Frankfurt that is almost close to the standard breast phantom. [23]. additionally, for breast health scrutiny, the research team of McGill university has performed a medical study of microwave radar in time domain. [24]. presently breast cancer is the second most prominent cancer amongst women, especially in women who are above forty, or in their forties. X-rays breast screening technique is one of the renowned techniques now a days but there is a problem with it: It has about 20 percent false detection rate, which is alarming. [25]. Micro-strip antenna can be the best contender in microwave imaging, since it is compressed but the delinquent with it is that it has a narrow Bandwidth (B.W). Due to this, we need to work on other techniques which can surge the bandwidth up to 70 percent [26]. In one of the breast screening method, that is microwave based, the spatial distribution of a scatter object is rebuilt by scrutinizing the backscattered signals using different image rebuilding methods [27]. The key objective of UWB radar imaging is to regulate whether the tumour exists or not; If exists it has to spot it accurately and in the meantime process the backscattered signals effectively [28]. A UWB system for microwave imaging is designed that uses a monopole antenna. This antenna operates in frequency rage 1.416-10 GHZ band. The main aim is to somehow increase the bandwidth which is the main issue in breast screening. Secondly, an effort is put upon the fact that the tumour has to be detected as early as possible. Some bandwidth enlargement techniques are introduced. (The insertion slot and partial ground plans) [29].

Traditional breast screening techniques like: MRI, Resonance imaging and ultrasound etc. are already available but the problem with them: firstly, most importantly it needs trained doctors who are able to operate the system. Secondly, they are expensive. These methods cannot be implemented easily. So, for this a new method is proposed by the name of “Vector Network Analyzer” or (VNA). This uses frequencies in between the range of 1GHZ to 10GHZ. This study proves that the more the antenna is nearer to the tumour cell; the more it is easy to detect cancer. At 8.8 GHZ the signal scatters more as on other frequencies in the range mentioned above [30]. Ahmad, et.al used bode plots to calculate the size of the detected tumour. The transfer function of the received UWB pulse is analysed and then incorporated with bode plots the size is determined. [31].

By subtraction and average method: Firstly, the received UWB pulses are attuned and then passed through an oscilloscope in real time. Image is built through delay and sum beam forming algorithm. Average method is better than subtraction method. [32]. Methods like VNA and subtraction methods can be only used in clinics/hospitals, in the supervision of doctors and trained staff. A new method that is user friendly and can be used at home is proposed. Breast phantasm is placed in between two homemade antennas; one antenna transmits while the other receives. This UWB and Network neutral (NN) based system detects cancer (If any). This system is robust and performs better than any other homemade system that too at low cost.2 types of breast phantoms are used: Homogenous and heterogeneous. This system can screen 100 percent, 82.62 percent and 90.69 percent breast cancer when heterogeneous phantasm used. Similarly, with homogeneous phantasm it can screen 100 percent, 89.06 percent and 83.96 percent respectively [33].

In [34], a wearable antenna is proposed. The system works on multistate time-domain pulsed radar. The setup consists of a bra which has 16 elastic antennas embedded to it. The wearable prototype was given to healthy volunteers for a span of 28 days to check the results; the result came to be better than that of table-based prototype. Also, this technique is easy to be used, cost effective and doesn't need any hospital or doctors.

An infrared based breast screening device that is non-contact and non-invasive, is proposed. A linear support vector machine (SVM) differentiates between a good and bad tissue, based on its feature vector (FV). The system is FPGA based and can scan up to 79.06 percent and 88.57 percent, respectively. The system is easy to use and can be connected with the smart phone for notifications [35]. Antenna array formation is one of the significant parameters that have to be kept in mind while designing an antenna. Within last decade multistate radar systems have been proposed from time to time. Antenna array configuration has direct effect on the image quality, performance and Signal-to-cutter ratio (SCR). Therefore, antenna array configuration should be heed upon when designing an antenna [36].

In [37] the design of breast imaging has been proposed using two antenna arrays, for both arrays same antenna design has been used. Each array have the combination of two antennas and two arrays have different polarization manner. For the received signal accuracy two different configuration has been used one is co-polarization and the other is cross polarization. The operating frequency of antenna element is between 3.1 to 10 GHz. From the results it is clear that the co-polarization is detecting tumors away from the wall chest, and cross polarization detecting tumors close to the chest wall. 1n [38] an UWB antenna has been presented with 4x4 array pattern for microwave breast imaging. The antenna element is designed of a monopole slot antenna having miniaturized size. In design of antenna Duroid RT substrate has been used with relative permittivity of 10.2. Homogenous and inhomogeneous models of breast phantoms having glandular phantoms have been used for the measurements. In [39] an integrated system has been proposed for microwave imaging system. CMOS technology is used with pair of patch antennas and formed a planner array. Roger RO4003c substrate is used having permittivity of 3.55.

CHAPTER 3

METHODOLOGY

CHAPTER 3. METHODOLOGY

In the proposed methodology a monopole antenna is designed with ultra-wide bandwidth (UWB) operating in between 1.5GHZ to 6.5GHz. The reason of selection this specific bandwidth is to consider the breast tissues parameters, because for human body we need below 10GHz frequency which can easily penetrate from human body [40]. The greater the bandwidth the greater will be the resolution but sides lobes are generated if we increase bandwidth beyond certain limits, the more the sides lobes the more reflection will be generated which will not produce accurate results, therefor we limit the bandwidth. The element antenna design is taken from a previous work which was proposed for breast cancer detection, but we have made improvement to the previous design which was generating side lobes in the system and degrades the total efficiency of the system [41]. We made some special changes in the design of the antenna to make it suitable for breast cancer detection application. The new designed antenna is fed by 50 Ω micro strip line. The length (L) and width (W) of the antenna is 45mm and 85mm respectively. Exaction port is wave port. Boundary of the designed antenna is perfect E plan. As far it goes for the other parameters i.e. radius, feed etc. are mentioned in the table below.

Table 1: Antenna Parameters

Parameters		
Variable	**Dimensions**	**Unit**
L_Spline	33	mm
W_Spline	17	mm
I_feed	45	mm
h	0.794	mm
W_feed	0.7	mm
W	45	mm
L	85	mm
rad	6	mm
Rad1	4	mm
1_gnd	48	mm
Cut_x	8	mm
Cut_y	5	mm
wp	25	mm
Ip	33	mm
H_prt	10	mm

The material used for manufacture of antenna is Rogers TMM 3. It has a permittivity of 3.27, dielectric loss is 0.002 and thickness of 0.794mm. Speaking of Rogers; they are basically printed circuit boards manufactured by the company called "Rogers", that's why are famously known by the very name. There are various other materials that are used for antenna fabrication, the famous substance that is used after Rogers for fabrication is called FR-4. These materials have a lower dielectric constant of 4.5 than the "Rogers", which has a dielectric constant of 6.5 to 11. Rogers have an edge of being able to perform at higher frequency, FR-4 are unable to do so. There is more signal loss in FR-4 materials because of high dissipation factor (Df). Rogers have less temperature variations than FR-4. The use of Rogers yields better results as compare to FR-4.

3.1. Proposed Antenna Design:

The used technique for antenna designing in Figure 13 is called "Quadratic Bezier Spline" The crux of the whole mechanism is that we have eight points (Po-P7). Po is the point at which antenna is provided with a 50 Ω micro strip line and is at point (0, 0). We have made few changes in the design and arrangement of points (i.e., Po-P7). In [34] the very same technique is used to form the outline of the antenna or Quadratic Bezier Spline. The points (P1, P2 and P3) are at the same axis, and its mirror image yields the point (P5, P6 and P7). As far as the only point remaining (P4), it is fixed at x=0 and is positioned along Y-axis. There is "Virtual point" between each control point; this gives us eight virtual points in total (PV0-PV7). By connecting all these points produces the "Bezier Curve". However, in the new proposed design, the point Po and P4 are same as the aforementioned. However, the points (P1, P2 and P3) are on different X and Y coordinates. And, their mirror image gives us the points (P5, P6 and P7). There are virtual points in between the control points. As the control points are at different coordinates, the virtual points also change; by connecting these points gives us a modified curve that is enhanced in terms of output and shape. The total length (Edge) of Bezier Curve is 114.31mm.

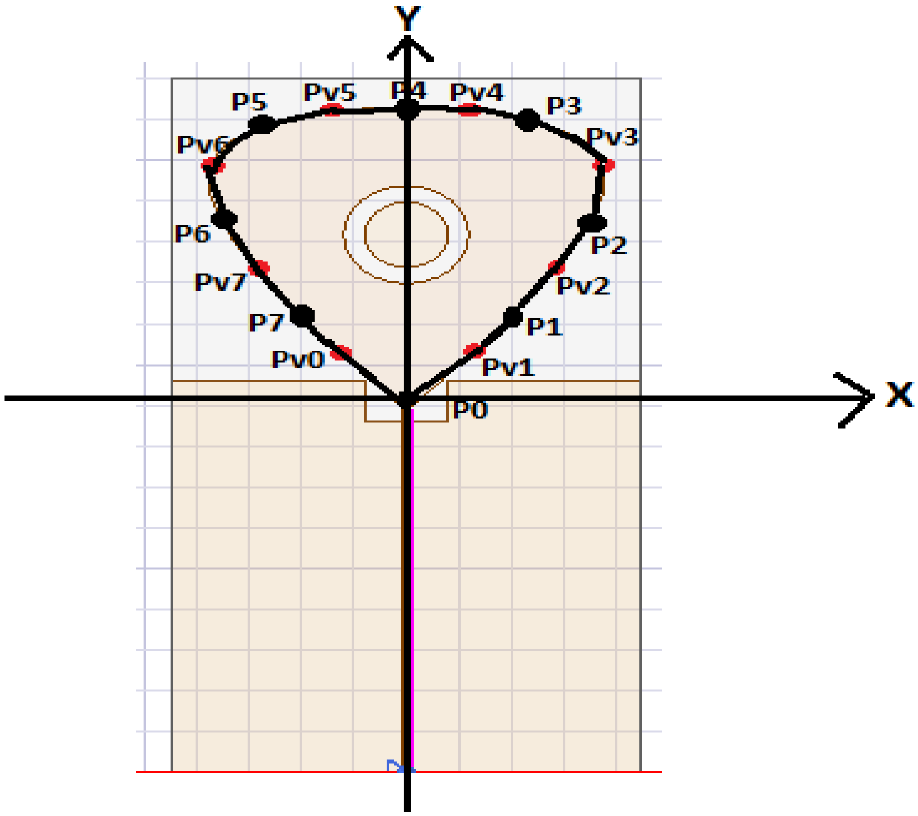


Figure 3.1 Bezier spline Formation and its points

3.2. Antenna Geometry:

The proposed antenna has the dielectric permittivity r =3.27 and thickness =0.794 and is printed on a dielectric substance as mentioned above. The proposed antenna has large radius of 6mm and small radius of 4mm, and the torus is infused into it with a partial ground plane, which is place in a slot (8mm x 5mm) and printed on the substrate. A 50 Ω micro strip line is given to the feed, which has a length of 44.593mm and a thickness of 0.7mm. This is to be noted that, when we change the dimensions of the slot, this influences the shape of antenna. Wave port of the antenna is λ/8. Wave port dimension is 10mm x 25mm. The software used for simulation and designing is FHSS.

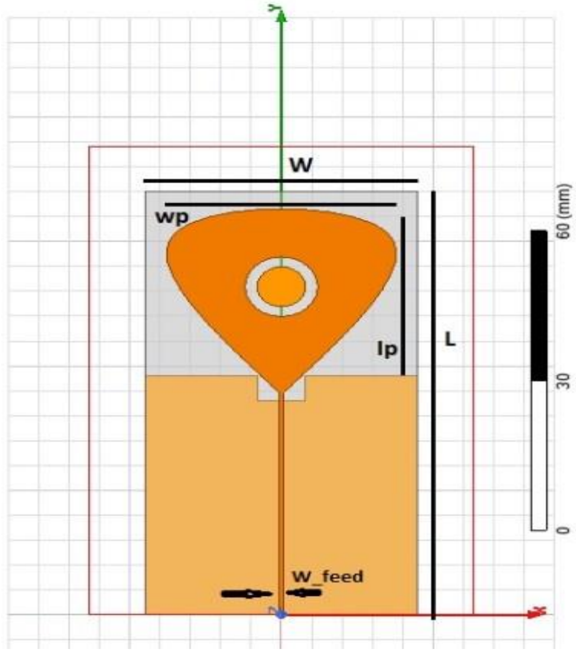


Figure 3.2 Top View of UWB Antenna

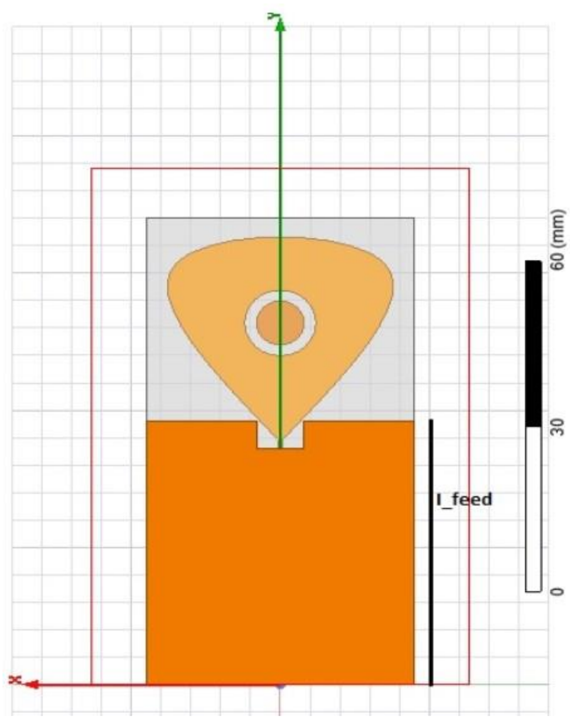


Figure 3.3 Bottom View of UWB Antenna

3.3. Array Design:

For such particular application, our aim is minimize the number of elements within the array to make the system simple and cost effective. Therefore, we have used the Ideal Side Lobe (ISL) formula to get the minimum number of antenna for the array design, which is expressed in “(1)”.

$$ISL = -20 \log10 NE \qquad (1)$$

NE describe the minimum number of elements for array. The number of transmitting and receiving antennas for array can be comprehend from the below equation.

$$NE = NTx \,.\, NRx \qquad (2)$$

In the above formula NTx is the number of transmitter elements and the NRx is the number of receiving elements. To find the total number of antenna N in the array we have the equation N = NTx + NRx

By solving equation (1) we need 20dB for ISL, the total number of elements will be $NE = 10^{20/20} = 10$, and from the equation (2) the combination of the elements will be 2x5. So from above equation for the improvement of S11 parameters we choose 2x5 symetric array for our system.

For experemental point of view we have tested different type of arrays during simulation like 2x2, 2x3, 2x4, 4x4 etc but the results of 2x5 array was more improved as compare to the other arrays.

3.4. Mechinisim:

The proposed antenna is composed of 2 x 5 MIMO array setup. Meanining that, the main antenna has numerous small antennas mounted on it. Some of them are receiving antennas, whilst the other performs the transmission. This antenna works the same as radar i.e. the transmitting antenna propagates microwave signals through the breast that is to be scanned.

These rays passes through the fatty tissues and ultimately hits the “Gladular tissues” that are present in the breast. Now there are two possibilities to this: Number one is; If there is a defective or cancerous tissue, Construtive or distructive interference is caused and an image is formed through the receiver into the imaging unit. The Second possibility is if there is no deceased tissue in between the Gladular tissues, the waves passes through the tissues unchanged and no interferance is shown in the image produced. Since we can have 2 types of images, the one that has interference in it are the cancerous one, while the other are healthy.

It is worth of concen that the cancer is mostly found in the Glandualr area of breast as seen in the Figure 3.4 that are present on the outerside away from the nipples. It is advised to keep the distance between the antennas large (1mm x 11mm in this setup), this gives us efficient coverage, meaning the glandular tissues can be targeted more accurately. Furthermore, if the distance is kept small; Let’s say:1mm x 3mm or 1mm x 5mm; this will only target the center region, that is: the area closer to the nipples where the chances of cancer cells is very very less. A better would be to keep suficent gap between antenna elements as to acheive good results. The Basic architecture of Microwave based breast screening system is given below in the Figure 3.5.

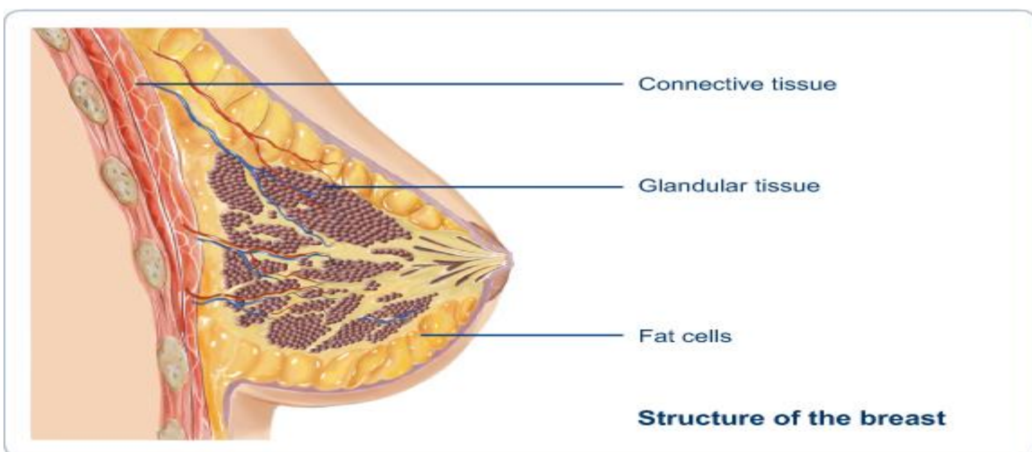


Figure 3.4 Structure of breast

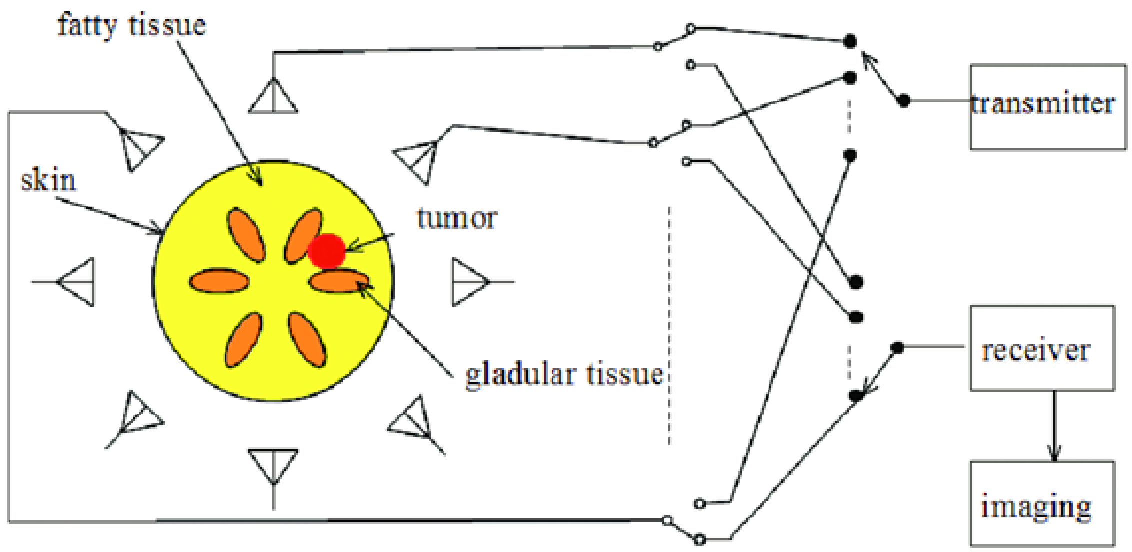


Figure 3.5 Basic Mechinisim of Microwave Mamography

CHAPTER 4

EVALUATION

CHAPTER 4. EVALUATION

This chapter comprises of the results. The results are compared with previous work. The results that we have compared are superior in terms of Gain, Return loss, Radiation pattern and cost from the previous work.

In [41] a microwave-based breast screening method is discussed. The spectrum used is between 1.416 - 9.367 GHz. A monopole antenna is fed by 50 Ω micro strip line, Moreover, several bandwidth enhancement techniques are used according to the need of application i.e. Tumour detection. A simple breast model is designed and simulated in CST software, the setup works on a six-monopole antenna array pattern in circular form and finally an algorithm is presented that helps in detection of small tumours (up to r=5mm).

In [42] a medical application based UWB antenna is presented, it uses 2 x 5 array pattern. This antenna has a good fractional bandwidth but the main issue is the ripples in S11 parameter, for this particular application the antenna response should be only on one single frequency, the signal response of more than one frequency response will provide poor results while image processing due to scattering and reflection of different frequency responses will not be possible.

4.1. Contribution:

In this research a UWB microwave MIMO antenna with 2 x 5 array pattern is presented. The basic antenna geometry is taken from the previously proposed work [41] but we have modified design to improve the performance of antenna parameter i.e. side lobe, gain, directivity, back propagation and return loss. Following modification have been made.

- Modification in the dimensions of insertion slot
- Radius of the inner circles of the antenna
- Arrangement of “Bezier Curve”
- Position of Bezier Curve
- Feed of antenna

Array pattern in previous work was in circular manner, while the array pattern that we have used is in planner form. Such array pattern gives us relatively high gains and directivity and also lower manufacturing cost. The results obtain after these modifications are far more superior; as shown below.

4.2. Return Loss S11:

Figure 4.1 shows the return loss S11 of the antenna presented in [41]. The operating frequency ranges from 1.416 to 9.367GHz. It can be seen that there is a frequency dip at 5.2 GHZ, which gives -34dB return loss but the drawback is the continuous ripples in the adjacent frequency band. This results in an inaccurate detection of tumor which results false detection. Also, to cater the extra ripples a filter is needed, which results in an escalation of cost. Furthermore, this makes the system slow and hard to implement. To achieve an accurate a high roll off factor is needed; meaning we have to need almost infinite values to produce good results. This makes the system intolerant, and finally a thermal effect is induced into the system.

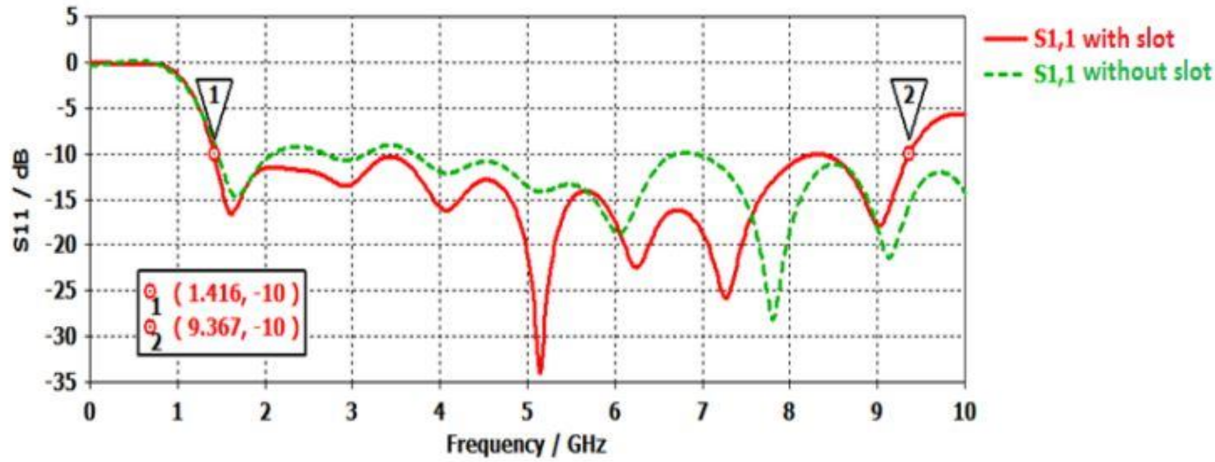


Figure 4.1 Return Loss S11 of Paper [41]

Figure 4.2 depicts a frequency dip at 3.8GHZ and gives us a return loss of -30dB. The operating frequency ranges from 3 to 14GHz. As we can see this graph produces ripples to adjacent frequency band. As this graph has fewer ripples but this antenna will also provide inaccurate measurement due to ripples.

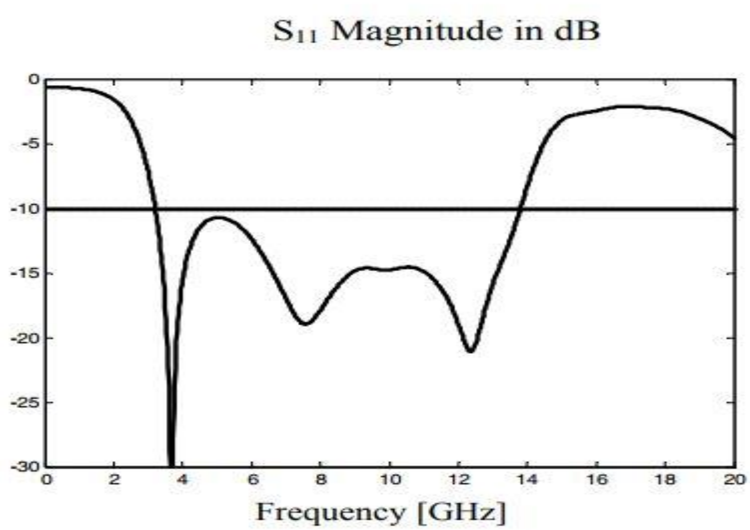


Figure 4.2 Return Loss of Paper [42]

Figure 4.3 shows the proposed antenna's return loss S11.There is a return loss at 3.404GHz of -31dB. The operating frequency ranges from 1.5GHZ to 6.5GHz. The sweep is from 1GHz to 15GHz. Delta S is 0.002GHz. Sweep type is fast. No design optimizer has been used in simulation. Now if we analyse all the three graphs (4.1, 4.2 and 4.3), it is clear that the proposed system has better results than the system depicted in the Figure 4.2 but, it has produced better results from the Figure 4.1. The advantage of the proposed system is that it gives us response at only single frequency, which yields to accurate results and less uncertainty. There is no need of expensive filters, easy to implement and finally reliable.

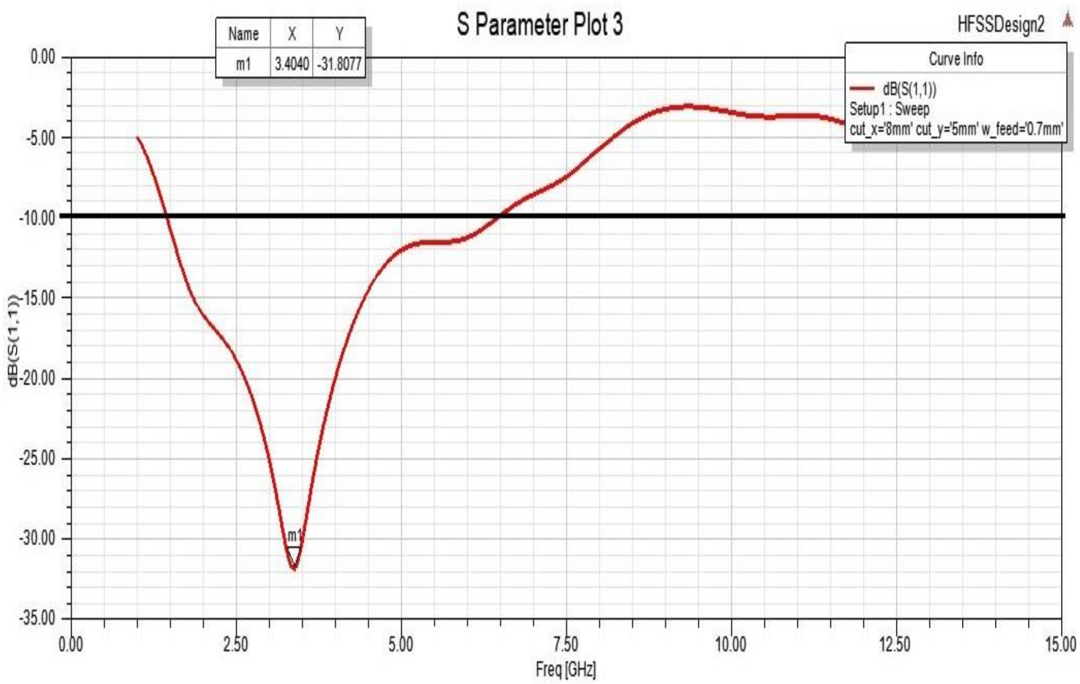


Figure 4.3 Return Loss of Proposed Antenna

4.3. Radiation Pattern (Single element antenna):

Figure 4.4 illustrates the radiation pattern of single element antenna. The frequencies used are 2GHZ, 4GHZ, 6GHZ and 10GHZ in E and H Planes. The antenna behaviour is dipole in the E plane, and omnidirectional in the H plane. The maximum gain that we have is 3.06dB, 2.77dB, 4.37dB and 5.5dB at frequencies of 2, 4, 6 and 10GHZ respectively.

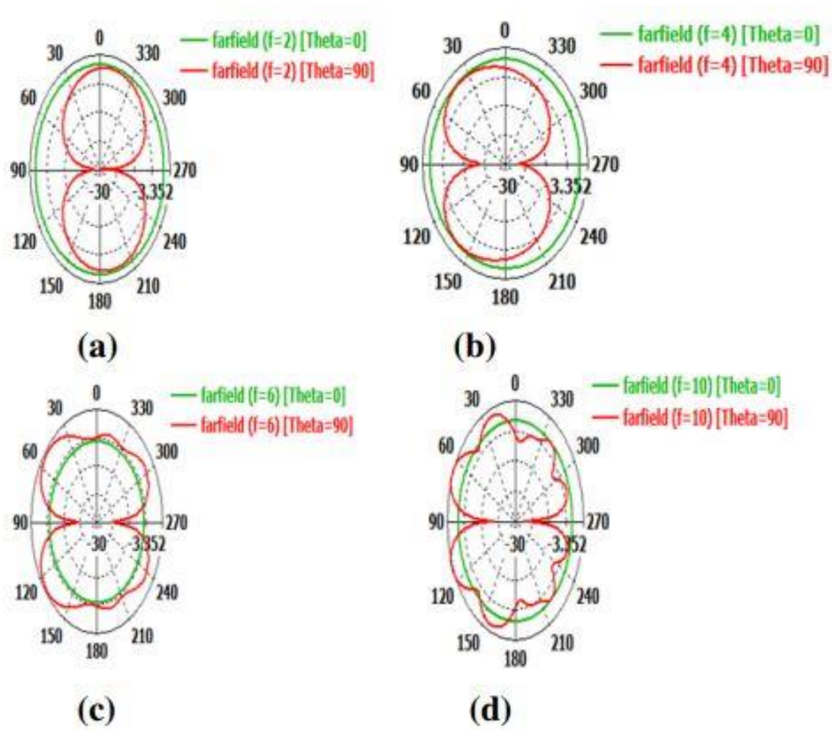


Figure 4.4 Radiation Pattern of Paper [41]

The Figure 4.5 shows the antenna radiation at frequencies 2, 4 and 6 GHz. The proposed antenna gain is 22dB, 20dB and 15dB respectively in E plan. It is to be noted that the value of ϕ is fixed at 0 degree while the value of θ varies from 0-360 degree. As we can see from the proposed antenna radiation gain is better as compare to the previously designed antenna. The proposed antenna gain is 19dB greater than previously propose antenna at 2GHz, similarly at 4GHz, 18dB gain improved and at 6GHz, 11.6 dB gain improved. The highest gain of proposed antenna is 22dB for 2 GHz with very small amount of side lobes.

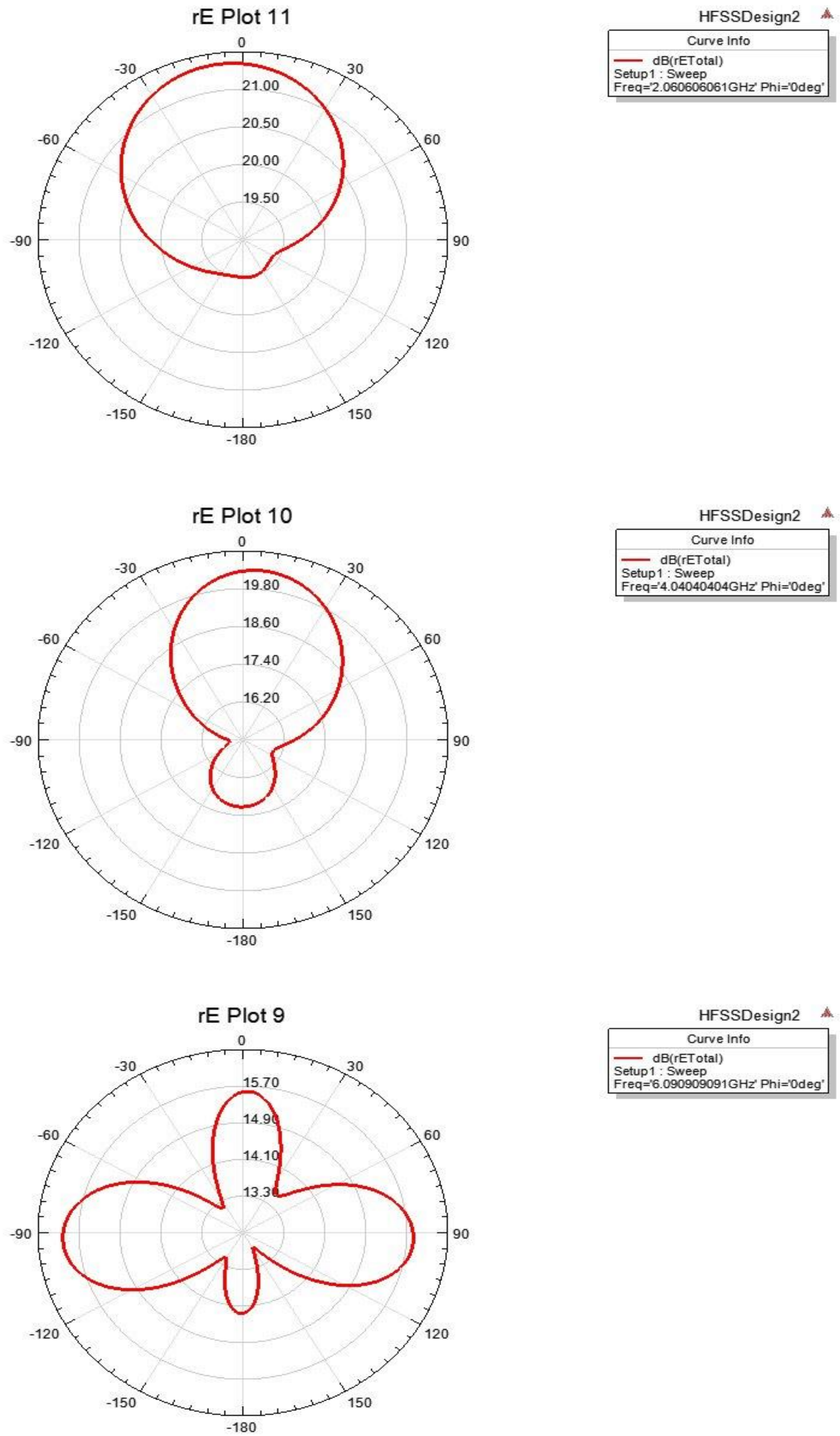
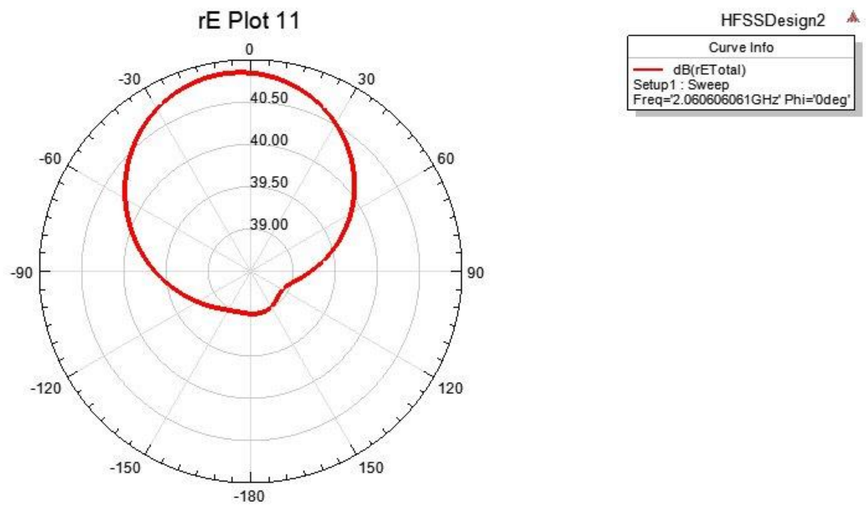
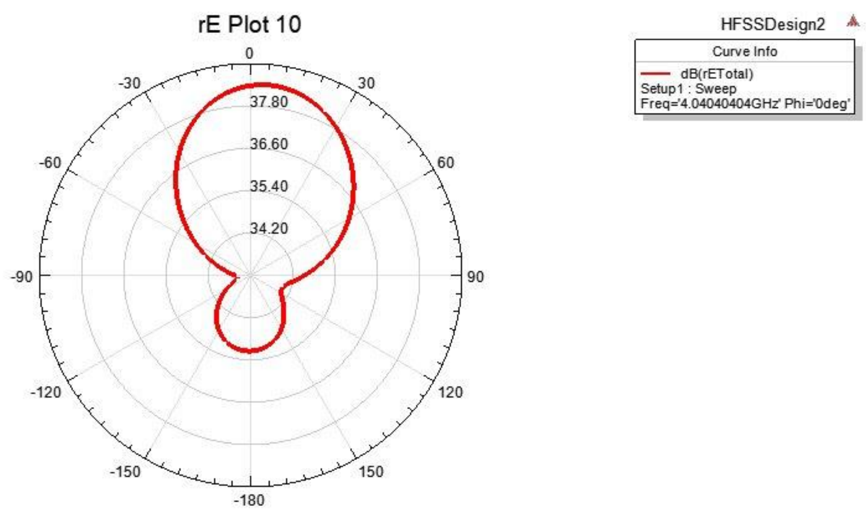


Figure 4.5 Proposed antenna radiation pattern

4.4. Array Radiation pattern:

Figure 4.6 shows the radiation pattern at frequencies 2, 4, 6GHZ. We have a gain of 41dB, 38dB and 31dB respectively. The value of ϕ is fixed at 0 degree while the value of **θ** varies from 0-360 degree. The difference of radiation gain is due to the proposed array configuration of 2 x 5 symmetric array pattern. In order to achieve better results in terms of gain, it is pivotal to use the array in symmetric order.





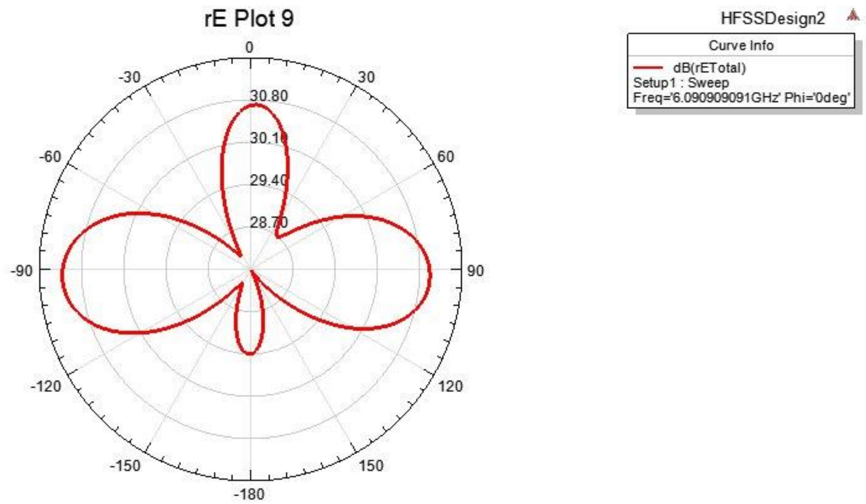


Figure 4.6 Proposed array radiation pattern

4.5. Gain plot (Single element antenna):

The Figure 4.7 shows the gain of single proposed antenna which is 2.55dB at 2.484 GHz. The proposed antenna is giving an improved gain at a single frequency.

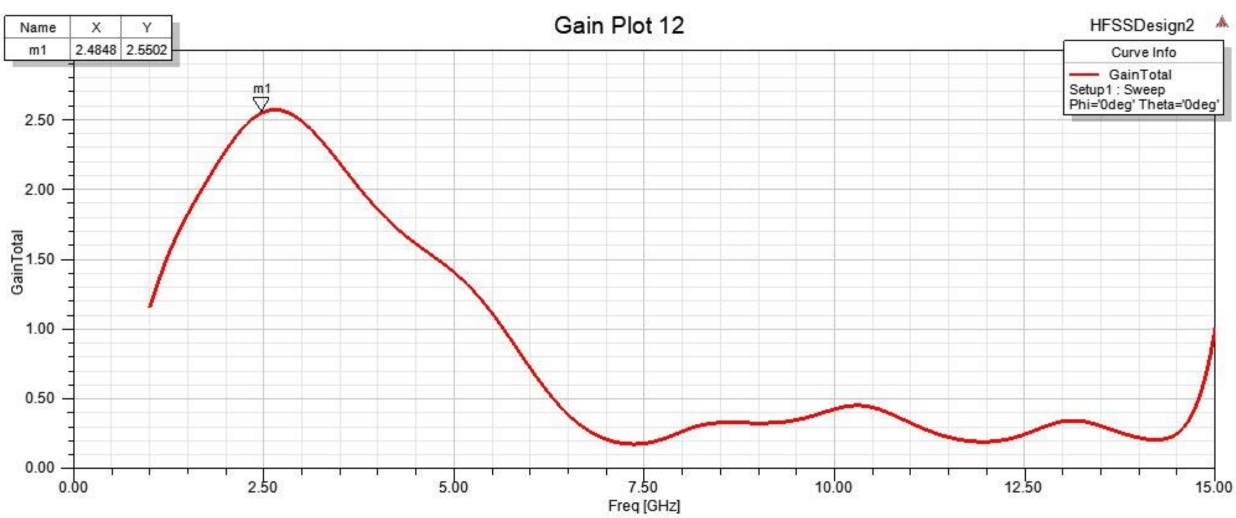


Figure 4.7 Single proposed antenna gain

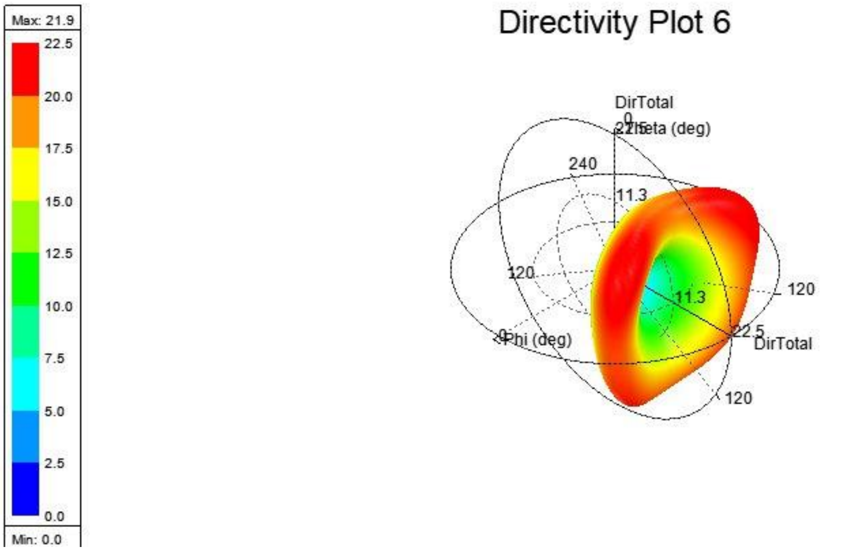
4.6. Gain Plot (Array):

Figure 4.8 shows the gain of a proposed 2 x 5 array which is 21.5 dB at the frequency 2.48GHZ. The better results are attained due to the modification in the geometry of the design antenna, for this, we can say that if the antenna is designed as per the specification and by utilizing modern materials and better modelling techniques.

Figure 4.8 Gain Plot of Proposed Antenna

4.7. Directional Gain (Array):

Figure 4.9 shows the directional gain of the antenna. At 6GHz the maximum directivity is 22.5 and **θ** revolves from 0-360 degree and ϕ=130. We can set the directivity of lobes by manipulating the value of "Inter gap between the arrays" to detect tumors in breast tissues i.e. glandular region. In the graph shown below the gap is 1mm x 11mm between the cells of array in X direction. Meaning that the lobes protrude outwardly and the goal is to target the Glandular region of the breast. In case we want to target the area closer to the centre region, for this we have to decrease the gap.



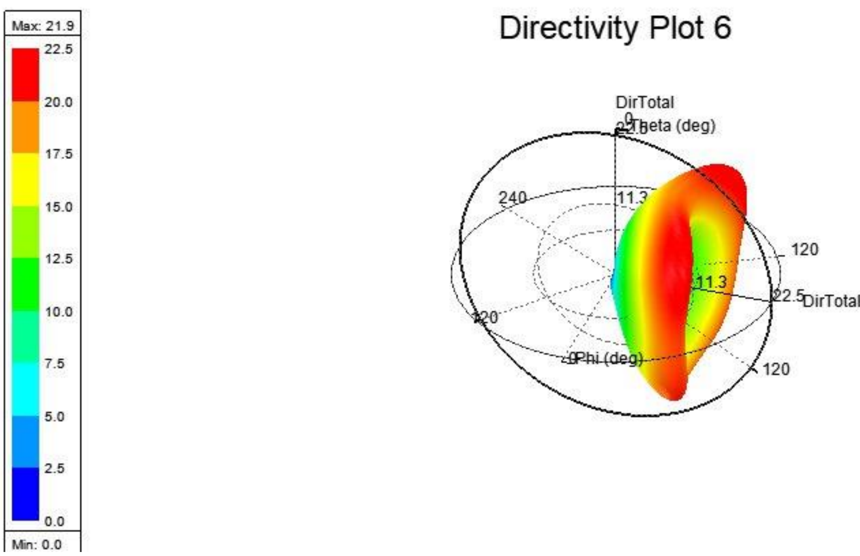


Figure 4.9 Directivity Gain of Array

CHAPTER 5

CONCLUSIONS AND FUTURE WORK

CHAPTER 5. CONCLUSIONS AND FUTURE WORK

5.1. Conclusion:

The soul motive of my research was to improve the Return loss S11 parameters, radiation pattern, gain, and directivity. For this purpose, a 2 x 5 UWB antenna array is designed. The material used for fabrication of antenna is Rogers TMM 3 and the software used for simulations is FHSS. For the sake of comparison, two recent papers are consulted. In order to improve the results from the previous work, changes have been introduced into the designing of the antenna i.e. design of "QUADRATIC BEZIER CURVE", so that the overall performance is enhanced, Secondly, the insertion slot is narrowed. The reason of doing so is to improve the return loss. Moreover, the array that is used in this proposed antenna is a "Symmetric array" instead of "Asymmetric array", the purpose is to increase the gain. Furthermore, some changes have been made to the radius of the concentric circles that are present in the antenna.

After these modifications, the results that were produced were compared briefly with other works, and they performed outstandingly, far more enhanced and excellent in terms of Gain, Return loss, directivity and radiation pattern.

5.2. Future work

In future it is highly prompted to implement the work done in this thesis on different focusing algorithms like DAS, MIST, RWCB, MAMI and GLRT techniques, using a breast model with having at least 5mm tumour. The antenna can be fabricated and could be verified in the field trials for proving the results.

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