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Ultra Wideband Antennas for Breast Cancer Detection

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Abstract:

Breast cancer is the most frequent cancer out of 100 different types of cancer detected in women globally, impacting 2.1 million every year and also records greatest number of causalities. Microwave breast imaging, which is nonintrusive and undisruptive to human, offers a promising alternative method when compared to earlier methods. Antenna plays a major role in microwave breast imaging process. A wide-ranging evaluation concerning the geometry, the frequency, the gain, the return loss and the materials adopted for the analysis and design of ultra wideband (UWB) antennas for breast cancer detection, is presented.
Keywords*: Microwave breast imaging, Ultra wide band antennas.*

I. INTRODUCTION

Statistical studies show that most of the women are getting affected by breast cancer and their number is increasing day by day all over world.Early diagnosis and screening helps to improve the survival rate. Majority of women are diagnosed at later stages due to weak health systems like ultra sound, MRI, mammography, etc and lack of awareness. Hyperthermia techniques using electromagnetic radiation have offered successful prop up for treatment [1]. Microwave Imaging is one of the imaging techniques and ultra-wide band detection methods used in medical applications to detect breast cancer. UWB detection works in the different frequency bands which corresponds ultra short radar pulses, a significant contrast appears between the relative dielectric permittivity and conductivity of healthy tissues and those of malignant tissues [2].Aggressive Research work is in progress in designing of microwave antenna especially for medical applications because different types of antennas are used across the world by different microwave medical imaging groups [3].The futuristic and anterior studies have shown that the implantable antennas can be used for both perception and restorative applications which are used to provide energy in cancer treatment using hyperthermia applications [4] and by providing health information in detail from the patient’s body to exterior devices [5].

In the medical field Antenna design plays a major role in microwave imaging for receiving the reflections from the scattered objects and for transmitting the signals. The various parameters that should be considered to design an antenna are size of the antenna, frequency of operation, reflection coefficient, gain, etc. Different types of antennas were designed to meet all the above mentioned requirements but still there are few problems in designing an efficient antenna. So designing an efficient antenna is the major research field especially in microwave imaging [6].

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II. Analysis of Different Types of Antennas

The following section presents different types of antennas designs which are used in microwave imaging applications especially in Breast cancer detection which can achieve few parameters of requirement. The antennas discussed below are designed using HFSS or CST software and their performance characteristics are tabulated.

1.Microstrip Patch Antenna:

Microstripor Patch Antennas are used more often due to its low cost, low profile and can be printed directly on the PCB. Different types of Patch Antennas have been proposed and their performances are compared. These antennas were designed with FR-4 substrate thickness of 1.6mm, Dielectric constant Range 4.2 - 4.4 and then simulated using HFSS. The Table below shows the performance of different patch Antennasin terms of frequency,gain and RC) [7].Stacked-patch antennas are traditionally designed using low permittivity materials [12] which are used in detecting breast cancer.

Table.No.01. Performance characteristics of different Micropatch antenna

Antenna	Frequency	Gain	Reflection Coefficient
Circular Micro Strip Patch Antenna	2.45GHz	3.2dB	-21.8dB
Rectangular Micro Strip Patch Antenna	2.45GHz	4.007dB	-12dB
Micro Strip Patch Antenna	6.3GHz		-16.4dB
Pentagon Patch Antenna	>2.2GHz	4dB	
Stacked patch antenna	4-9GHz		Up to 40dB

2.A Printed Log Periodic Tree Dipole Antenna (PLPTDA):

The printed log-periodic tree-fractal dipole antenna (PLPTDA) is an array of log-periodic tree-fractal dipoles with a microstrip feeding line. The proposed antenna is havingdimensions of 490 mm × 245 mm × 1.5 mm which is etched on a FR4 substrate with dielectric constant of 4.4 [8]. The performance characteristics of PLPTDA are analyzed using CST software and tabulated below

Table.No.02. Performance characteristics of PLPTA

Antenna	Frequency	Gain	VSWR
LPTDA LPT^1DA LPT^2DA	0.37-3.55GHz	4.0-7.0Db	<2

3.Bowtie Antenna:

The antenna was designed with substrate thickness of 1.59 mm with a gold-plated 17 µm-thick copper layer. The patch size of bow-tie is reduced by using substrate of high relative permittivity of 10.2. The performance of Bowtie is analyzed with IMDL (impedance matching dielectric layer) and without IMDL is results are given below after simulation using HFSS [9].

Table.No.03. Performance characteristics of Bowtie Antenna

Antenna	Frequency	Gain	Reflection Coefficient
Bowtie Antenna with IMDL	2.65GHz-3.5GHz	>6.0dBi	-10dB
Bowtie Antenna with Removed IMDL	2.65GHz-3.5GHz	6.0dBi	-10dB

4.Balanced Antipodal Vivaldi Antennas (BAVA):

Theground and patch thickness for designing antenna at 0.035 mm with dimensions of the antenna are 75 mm x 100 mm x3 mm and with relative permittivity 2.94.Antenna was analyzed in free space and with director of high permittivity is not very insightful at lower frequencies, but results in higher directivity as the frequency increases [10].The Performance of BAVA is analyzed by simulation in HFSS and results are given below

Table.No.04. Performance characteristics of BAVA

Antenna	Frequency	Gain	Reflection Coefficient
BAVA,BAVA With Director	0.5GHz-4GHz	Same for both	<-10dB

5.Notched Antipodal Vivaldi Antenna:

The antenna is designed with dimensions 78×21.5 mm^2 with FR4 dielectric material of 1.6mm thickness and relative permittivity of 4.3.The Performance of Notched Antipodal Vivaldi Antenna is analyzed in different frequency ranges by simulation in HFSS and results are given below [1].

Table.No.05. Performance characteristics of Notched Antipodal Vivaldi Antenna

Antenna	Frequency	Gain	Reflection Coefficient
Notched Antipodal Vivaldi Antenna	1-2GHz 2-5GHz 5GHz 10GHz	6.8dB- 9.8dB 9.8dB 5dB 11dB	>-10dB >-10dB >-10dB >-10dB

6.Hemispherical Antenna Array:

The proposed antenna is designed using FDTD technique where two stacked patches was kept the same dimension, ground plane was substantially reduced to 23x29mm^2.The cavity has planar dimensions of and is 17-mm long to absorb back radiations and to avoid resonances.The antenna array designed is flexible 4x4 monopole single arm spiral UWB with dimensions 20x20 mm^2 which is miniature in size, very flexible and very economic [13].

Table.No.06. Performance characteristics of Hemispherical Antenna Array

Antenna	Frequency	Gain	Reflection Coefficient
Hemispherical Antenna Array	4.5GHz-10GHz	8.7dB	<-17dB

7.Flexible 4x4 Monopole Single Arm Spiral UWB:

The proposed antenna is designed to operate in the frequency range of 2GHz - 4GHz with S_{11} is equal or less than -10dB.The antenna array designed is flexible 4x4 monopole single arm spiral UWB with dimensions 20x20 mm^2.The antenna designed is miniature in size, very flexible and very economic [14].

Table.No.07. Performance characteristics of 4X4 Monopole Antenna

Antenna	Frequency	Gain	Reflection Coefficient
Flexible Monopole Antenna Array	2GHz-4GHz	9.8dB	<-10dB

8.Modified Compact Vivaldi Antenna:

The proposed antennas have beendesigned to operate in a frequency range of 2–4 GHz with reflection coefficient S_{11} below -10dB which have good impedance matching in different positions with different curvature around the breast. Dimensions of miniaturized flexible antennas are 20 mm × 20 mm, furthermore, two flexible 4×4UWB antenna arrays with reflector are designed which shows some improved results [15].

Table.No.08. Performance characteristics of Modified compact Vivaldi Antenna

Antenna	Frequency	Gain	Reflection Coefficient
Compact VivaldiAntenna	2GHz-4GHz	10.6	<-10dB

III. Conclusion

A comprehensive review of antennas used for detection of breast cancer has been carried out with their investigation on geometries, materials, resonant frequency, gain and return loss. Although, having different restrictions like type of antenna, design parameters, resources, etc are considered to achieve high performance antennas but still it can be considered as a generalized optimization problem which always leads to new innovation.We believe that the above tabulated performance characteristics of different antennas pave the way for future research oriented to the making of complete breast cancer detection antennas

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