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A Novel Compact Planer Millimeter Wave Sensor for Breast Cancer Detection

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ABSTRACT
The present scenario, demands and requirement of highly compact ,low cost ,high rate devices, multifunctional devices is quite a challenge these days and it's a prominent tools for analyzing biological and physiological parameter of breast cancer cells in patients for diagnosis. These days many researchers working on the antenna to make device more compact ,low cost with improvised radiations and operated at high rate for the biomedical applications. In this research work the antenna size of 8mm * 8mm with height of 1 mm operating at frequency range 30 GHz-70 GHz .Millimeter wave technology based structure designed size of 2mm*2mm for antenna with thickness 1 mm which enhanced the gain and reflection coefficient of antenna which makes it approachable and suitable for many wireless biomedical applications.
The nondestructive examination of the tissue of an human body is possible with this microwave imaging because microwaves are non-ionizing and are less harmful while comparing with the existing techniques available in present. Microwave imaging can precisely pinpoint the location and size of the damaged cell tissue because the cancer cell is extremely small in the initial phase of breast cancer. Microwave frequency shall be used to detect the damaged tissue since their conductivity and permittivity values will vary while comparing the normal and healthy breast tissues infected cancer tissue. Patients don't experience any health problems during this cancer tissue detection procedure because the energy absorbed by the breast while using a Metamaterial based millimeter wave antenna .The analytical result obtained from HFSS studio and compared with the real time data. The gain of antenna increases from upto 12 db . The designed structure placed on the substrate which is made of roger 5880 with the microstrip patch which shows enhanced results in overall performance makes this suitable for many mobile applications etc and can be integrated with many communication devices....

Keywords: *Millimeter wave technology; FR4 ; Reflection coefficient (s11) ;Permeability μ ;Permittivity Ɛ.*

1. INTRODUCTION:

In today's increasing demands of compact and low cost ,high performance antenna in the area of biomedical and wireless on body/off body health application attracted attention of many researchers[4-7] .The wide band antenna required low profile , light weight ,high rate and maintaining large spectrum of frequencies and command overall performance .For wireless devices widely used microstrip antenna considered as a very suitable choice for modern devices due to its easy fabrication with any modified and variously designed patch ,offer low cost ,conformability with structure [10-15]. Millimeter antenna designed in such way it can be implemented with any kind of antenna .Due to its property this shows high negative reflection coefficient and element act as an highly radiated electromagnetic wave device[20-23].

In the initial stages of breast cancer, cancer or cysts, a breast exam every four minutes is an important step in diagnosis. Statistics in India show that a woman is diagnosed with breast cancer every four minutes. Early rapid screening gave the US a 90% survival rate compared to 60% for India. [1,2]Early diagnosis not only provides better treatment, but also provides faster treatment. For biopsy-based breast cancer methods for tissue analysis suffer high cost ,time consuming . So latest report on Microwave imaging metamaterial based biosensor replacing the factors affecting to treatment[5,6].

To overcome limitations in an antenna , several researchers used microwave imaging(antenna) for breast cancer detection, particularly in UWB frequency region for microwave imaging and it used in depth of penetration in tissue[8]. At this antenna's particular operating frequency, the electrical property values are changed based on the tissue samples from different human tissue and permittivity and conductivity of the malignant cells at 100 kHz are ranging from 2 × 103 to 6 ×103 and 2-4 mS/cm respectively[15]. Operating frequency of the antenna is inversely proportional to the size of the antenna. At low frequency the antenna size becomes larger so this research shows very compact portable antenna with wide range frequency[21][23][30].

In the research the relative permittivity (Ɛ)of normal tissue and malignant tissue values from 100 MHz to 900 MHz is 21 to 15 and 61 to 57 respectively[18]. For the same band of frequency the conductivity of the normal and malignant tissue values are 0.1-0.18 S/m and 0.79-1.8 S/m respectively[28] . The relative permittivity(Ɛ)of normal and malignant tissue values from 0.5 GHz to 30 GHz is 14-7.5 and 58-19 respectively[21]. For the same band of frequency the conductivity of the normal and malignant tissue values are 0.1-6 S/m and 1-35 S/m respectively[18].

It is clearly proved in resarch that the permittivity of the normal tissue as well as malignant tissue values are decreased while increasing the frequency & vice a versa. The conductivity is just opposite to permittivity(Ɛ), i.e. while increasing frequency of operation over the normal and malignant tissue the conductivity values are increased[18].

(Microwave Imaging) MI is a new technique to locate and size tumors. It uses reflected electromagnetic waves in an amount that propagates in the direction of the tumor and is determined by the difference in permeability and permeability of benign and malignant tissues. Two types of microwave photography are currently used. The first is microwave tomography , which uses an inverse scatter algorithm to image the affected area. The process is time consuming and difficult due to the time required to manufacture the product .Ground radar-based methods are the easiest and most reliable way to locate breast cancer cells. In this process, the difference between the dielectric properties of malignant and benign tissue is considered an important point in terms of image formation. During this procedure, electromagnetic waves are shot, recalled, and processed by special software called Focus Algorithm to create an image of the affected area and locate the cyst[11,12,13].

The electrical properties of malignant and normal tissues in the system determine the efficiency of the system. In t he previous study, the breast was accepted as a homogen eous tissue and the ratio of benign and malignant tissue was found to be 5:1. In a recent study, it was determined that the prices changed only by 10%. Another important fact to be reported in previous studies is tissue loss. The human body can tolerate tissue loss of 4dB/cm at 6 GHz[20,21].

The conclusion drawn from all previous findings is that t he physical risk must be high in order to close the minute gap, while the low frequency is necessary to reduce the t issue in the body. These problems are alleviated by instal ling body surface radios operating in the low AB frequen cy bands to provide high performance and low loss.
Medical Procedures is the result of Jack's first work in br eaking waves in 1960. H. Raymond developed the theory of wave refraction, which distinguishes many objects th at use electricity from charge explosion and reflection[14 ,15].

At a later stage, Uno et al. , Luk and Lueng, Mongia et al ., Tie Jun Cuiand and Mikhinev et al. He completed his work by studying dielectrics and scattering and memory methods. These studies open the door to new methods fo r image restoration with dielectric resonators. BAVA (Ba lanced Antipodal Vivaldi Antennas and Arrays, Slot Ant ennas and Arrays, TWTLTA (Traveling Wave Tapered a nd Loaded Transmission Line Antennas), many designs of metamaterial based millimeterwave patch antennas have been proposed in th e literature so far.[21,22] It is a good and effective altern ative.Many researchers have proposed various mmWave antenna designs for medical applications, such as L-shaped, H-shaped,

cube and ring-shaped.

This article presents a new type of base station antenna with partial ground structure operating in the lower Euro pean frequency band.[27] In this design, high gain and el ectrical efficiency are important in order to use the anten na designed as a breast cancer screening unit. The antenn a sensor in this new study broadcasts the microwave sign al to the target tissue, simulating the reflected signal back scattered from the target tissue and transmits the data to t he computer system.[18]

Compared to existing wireless technologies such as 4G or Wi-Fi, millimeter wave communications "provide several gigahertz of unlicensed bandwidth, more than 200 times that allocated to modern Wi-Fi and cellular networks." 5G millimeter wave design provides high bandwidth, transmission speed and low latency, which is suitable for use in large-scale biomedical applications such as breast cancer detection ,defected tissue removal ,neural applications etc. However, 5G millimeter wave applications need to be affordable and affordable for existing IoT users due to new challenges such as power consumption and power consumption.

Table.1 comparison with related work

Papers	**Patch Size (mm)**	**Resonance Frequency (GHz)**	**Return Loss (dB)**	**Gain (dB)**	**Band-width (GHz)**
[3]	1.3×1.2	28,38	-40,-18	3.75, 5.06	3.34,1.39
[15]	1.3×1.83	28,38	-35,-20	5.8, 5.5	0.7,0.38
THIS WORK	2*2	24,36,54	-36,-15	6.9, 7.4	2.05

designed microstrip millimeter wave antenna

This designed antenna has a micro sized structure in the shape of rectangle of sized 2mm *2mm etched with roger 5880 substrate of 8mm* 8mm and attached to a 1mm rectangular feeding line which provide current to the device and the plain ground of the size 8mm*8mm.This antenna provide high reflection coefficient at high frequency. This antenna gives multiple operating frequency 40-60GHz .reflection coefficient at 40GHz is -25 dbi and -15 dbi at 30GHz. This millimeter wave patch structure embedded antenna increases impedance of the system and dive high gain rate overall.

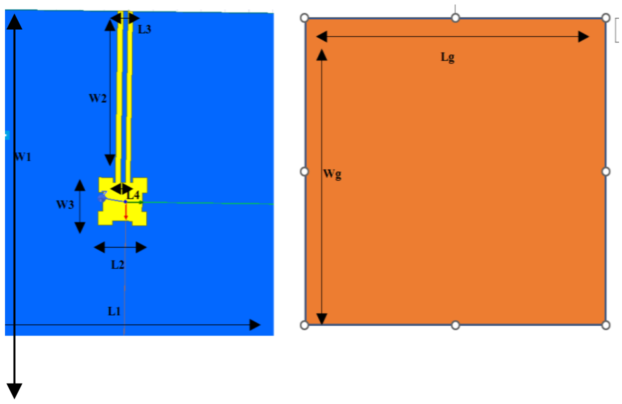


fig.1 2D structure of millimeter wave antenna

Table 1.Dimensions of millimeter wave antenna structure

Parameters	Description	Value (mm)
L1	Length of Substrate	8
W1	Width of patch Substrate	8
H	Height of patch Substrate	1
L3	Length of Patch	0.4
W3	Width of Patch	0.4
L4	Gap between the feed line	0.1
W2	Width of patch Feed line	3.6
L2	Length of patch Feed line	2
Wg	Width of plain Ground	8
Lg	Length of plain Ground	8

theoritical representation of antenna

This microstrip antenna analyzed by this equations and calculated by patch width and length .according to their operating frequency the patch structure are designed.

Width (W):

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

Length(L)

$$\Delta L = 0.412h\frac{(\varepsilon_{reff}+0.33)\left(\frac{W}{h}+0.264\right)}{(\varepsilon_{reff}-0.258)\left(\frac{W}{h}+0.8\right)} \quad (2)$$

$\Delta L = L_{eff} - W$ (3)

$$\epsilon_{re} = \frac{\epsilon_r+1}{2} + \frac{\epsilon_r-1}{2}\left[1+10\times\frac{h}{w}\right]^{-\frac{1}{2}} \quad (4)$$

Where ϵ_{re} is the effective dielectric constant

$$F=\frac{2\pi w f_o\sqrt{\epsilon_r}}{c} \quad (5)$$

This work shows 3D architecture of millimeter antenna patch with wave port helps current to travel on the surface through patch.

Dimensions of compact square shaped patch are chosen accordin this research paper is a combination of patch and rectangular me proper selection of antenna structures dimensions i.e. length (Ld) antenna response can be attained . Q-factor of millimeter design de structure. This MSA antenna used lowest order mode of Rectang frequency for this specific mode can be calculated with the follow

$$k_x\tan(k_x Ld|2) = \sqrt{(\varepsilon_r-1)k_o^2 - k_x^2}$$

(6)

Where

$$k_o = \frac{2\pi}{\lambda_o} = \frac{2\pi f_o}{c}, \quad k_y = \frac{\pi}{Wd} \text{ and } k_x^2 + k_y^2 + k_z^2 = \varepsilon_r k_o^2$$

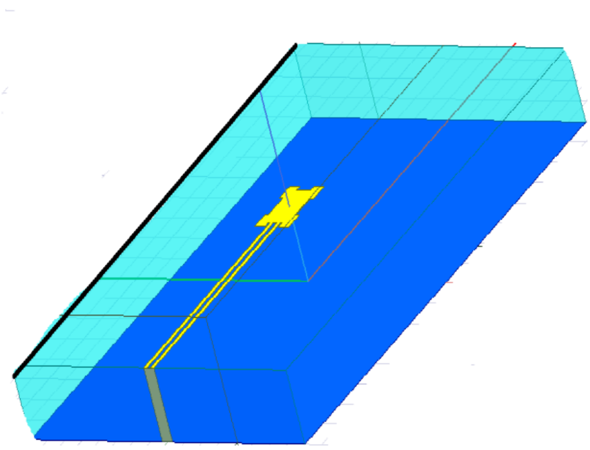
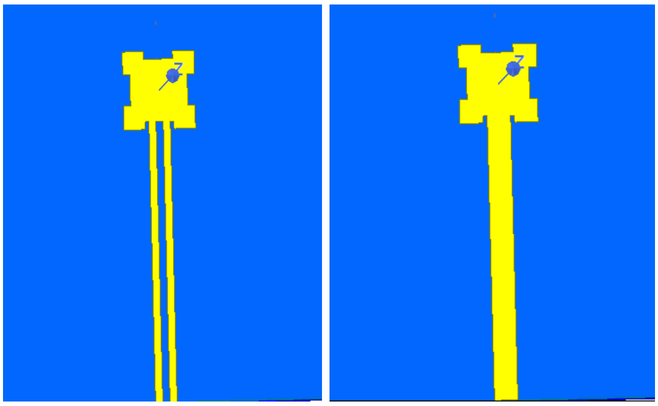


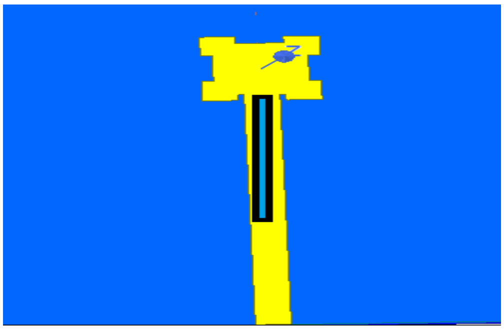
fig.2 shows 3d structure of antenna with wave port

Variation in the top of patch

This figure 3 shows variation in feed line of antenna structure w high band width and less conductor loss.



(b)



(c)

Fig3 a) slotted feed line with patch b) full rectangular feed c) ha

Fig .4 shows variation in reflection coefficient with differe high reflection coefficient -36db at 38GHz and -15 db at 54 (frequency. This compact design which operated on high fr small damaged tissue in human body .this antenna can im which makes detecting easier for breast cancer patient.

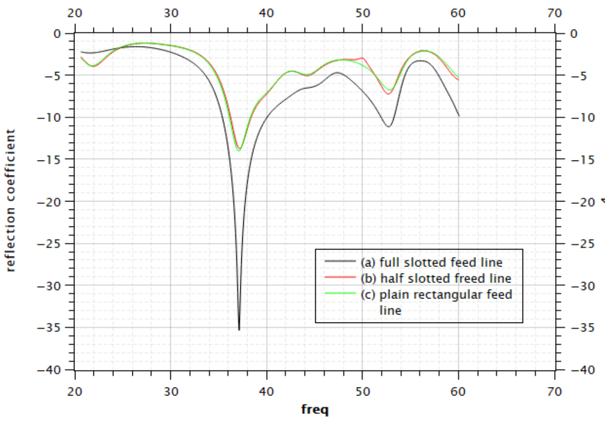
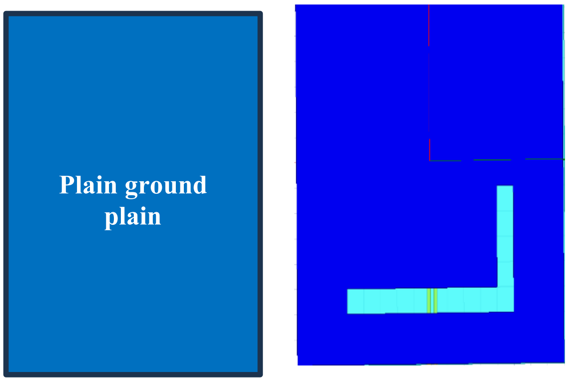


fig.4 shows reflection coefficient of variation in feed line

This high reflection shows high absorption of radiation signal scattered

Due to metamaterial surface with millimeter wave antenna.

Variation in ground plain



(b)

Fig .4 a,b shows variation in ground plain with slot

Figure 4 shows a variation in ground plain with making L shape and H shape so it shows variation in overall performance and antenna parameters . Due to full ground the bandwidth increases and reflection coefficient also increarse.

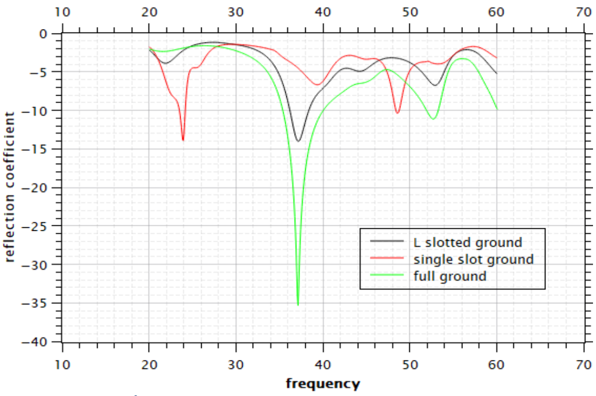


Fig.5 Reflection coefficient with variation in ground plain

Table -2 Antenna perametre with 5G slotted and plain ground

Antenna	5G Antenna with plain ground		5G antenna with Slotted ground	5G antenna with slotted feed line
Resonant frequency (GHz)	38	54	24 ,38,54	38
Return loss S1,1 (dB)	-35	-12	-15,-15,-10	-15

Electric and magnetic field

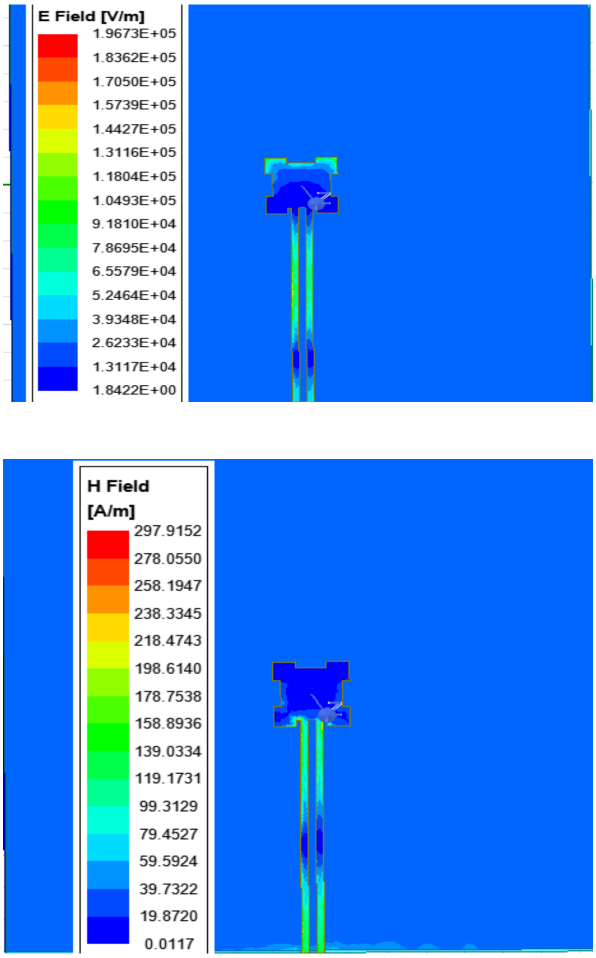


Fig 6 current transmission on the surface

This figure 6 shows electric and magnetic field variation on the surface and current travel at the surface.

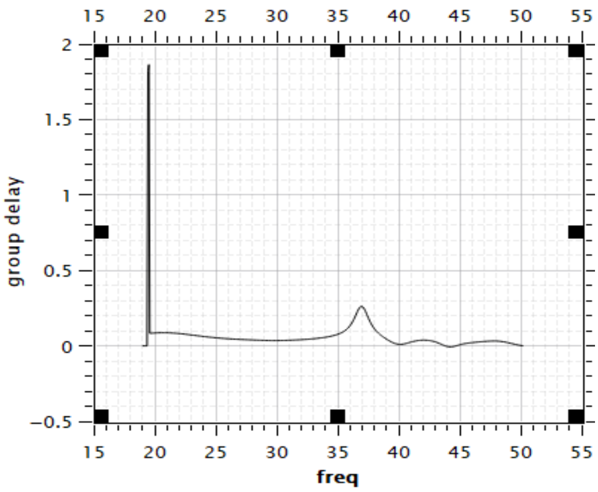


Fig.7 Group delay of antenna

Radiation pattern

This figures shows radiation pattern of gain electric field and co-polarization and cross polarization graph of antenna at operating frequency.

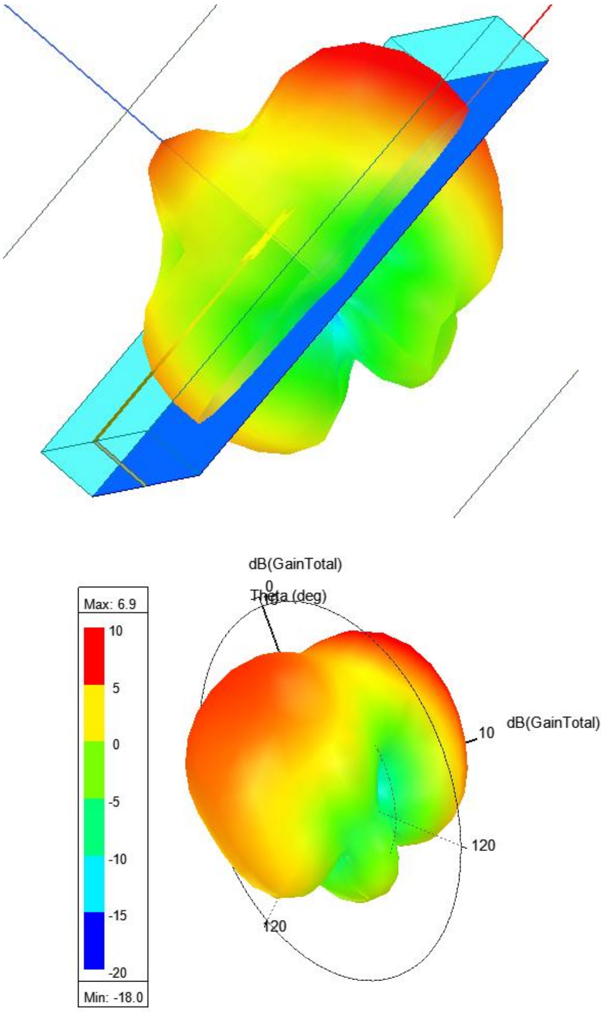
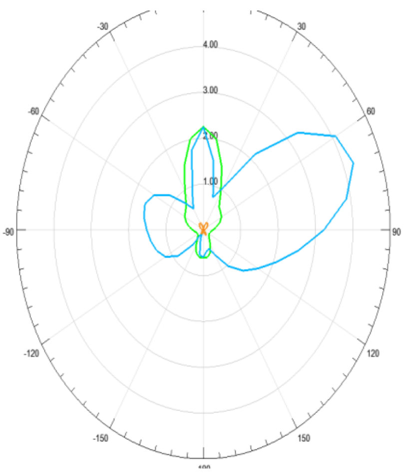
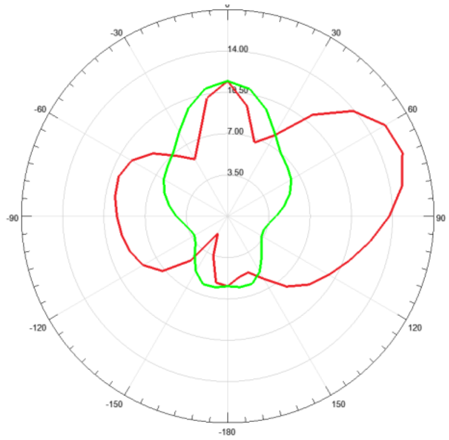


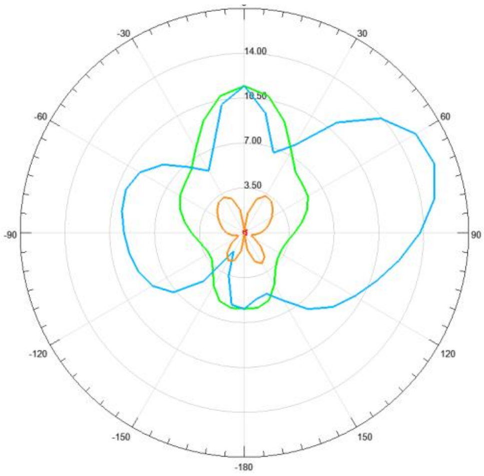
Fig.8 Gain pattern radiation on the surface of antenna



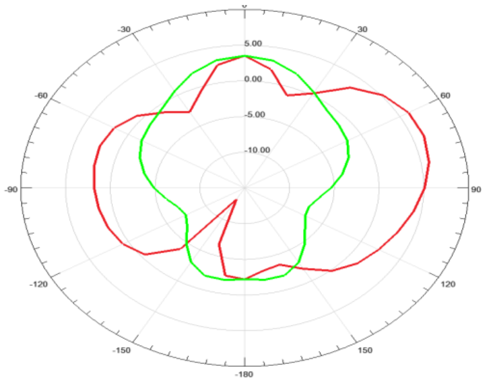
(a)



(b)



(c)



(d)

Figure 9 shows radiation pattern of millimeter wave antenna which operated at 34 GHz fig a ,b shows gain radiations and c, d shows electric field radiation at ϴ=0,90 andΦ-0,90

The single-layer MSA antenna had a straightforward design but suffered from narrow IBM, AR, and bulkiness. In this design the sequential-phase fed CP patch array ,consisting of a single-layer substrate and 2*2 patch array ,achieved high gain but suffered from the sequential-phase design complexity and bulkiness.

Table-4 comparison of various antenna present for millimeter wave technology

Paper	Type of Antenna	Dimensions of Antenna (Length x Width x thickness)	Substrate Material	Operating Bands (GHz)	Gain (dB)
This work	Millimeter microstrip antenna	2mm x 2mm	Roger	38-54GHz	8
\[26]	Conformal slot array antenna	h = 0.254mm	Rogers58 8 0	34.25 - 35.75	12
[27]	Conformal antenna array with switching network	(31 x 46.4)mm2 x 127µm	RT/ DUROID 5880	61	18.8
[28]	Conformal antenna array	(25 x 20 x 0.127) mm3	Polytetrafluoroethylene	58.8	17.2
[29]	Microstrip Arrary Antenna	3.05 x 0.2 x 0.2 mm3	RO4003C RO 5880	22-32	12.5
[30]	PET based Flexible antenna	(16 x 16) mm2 x 135µm	PET	20-40	7.44
[31]	Wideband mm-wave tapered dielectric rod antenna	10 x 20 x 25 mm3	copper	50-75	14.5d B
[32]	Mm -wave Conformal antenna	(11 x 12) mm2 x 100µm	Rogers ULTRALAM 3850	26 - 40	11.35
[33]	mm wave tapered antennas based on Spoof SPP	19.2 x 12.5 x 12.5 mm3	copper	50-75 50-70	16.06 -19.3 20.1- 23.9
[34]	Single layer CP wave antenna	h = 0.508mm	Rogers 4350B	28-34	20.3 – 21.9

TABLE.3 Review of metamaterial with this work

conclusion

In this research a simple millimetre wave microstrip patch antenna is designed for early breast cancer detection and IOT wireless communication. This millimetre wave antenna is compact and light weighted which make it very useful for handheld devices .The antenna radiating patch reaches dual-band and multi band which used in biomedical applications .This micro Millimetre wave patch antenna gives dual frequency at 38GHz and 54GHz frequencies & all of these bands are used in wide band applications. This millimetre wave Antenna gives a Gain of 6.9dB for 38GHz and 7.4dB for 54GHz respectively. This gives reflection coefficient of -35 dbi at 38 GHz so analysing with results it can achieve high Gain by using array and metamaterial . This antenna has high Gain with this operating frequency and high , high Bandwidth, high Radiation efficiency and directivity which makes it suitable for many wireless networks and 5G communication it can directly implement on portable devices and many compact devices with easy implemented technique..

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