ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24AUG1608

A Comparative Exploration of Microwave Antennas and Millimeter Antennas for Fifth Generation Communications and its Applications

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Abstract:- In wireless communications, microwave and millimeter antennas are emerging research areas. An antenna is quite important for modern communication system as the decorate of the air interface mainly depends on the antenna designs. With significant wireless evolution from 1G to 5G, technologies and network capabilities are also evolving to meet rapidly growing customer demands. These ever-increasing demands have grown alongside the broader technical achievements of the antenna design community. Comparative analysis of microwave and millimeter antenna with their gain, bandwidth, size, thickness, S-parameter and frequency is discussed in this paper.

Keywords:- *Millimeter Antenna, Microwave Antenna, Fifth-Generation (5G), Frequency Band, 5G Application.*

I. INTRODUCTION

It is increasing consumer demand daily to promote fifth-generation (5G) wireless communication development. Communication technology is used randomly everywhere, and fifth-generation (5G) communication is an excellent innovation in communication. The 5G is a mobile networking system that is supposed to provide more data capacity and speeds than the preceding fourth-generation (LTE) (Lin & Lin, 2017). 5G infrastructure has exceptionally low latency and dependability, enabling innovative technology in various industries (Alam et al., 2019). It is generally accept that 5G wireless network must address six issues that 4G needs to handle successfully: larger bandwidth, big data rate, low end-to end latency, enormous application connection, decreased cost, and dependable provisioning of quality of experience (Ruchi et al., 2021).

There are several types of antenna proposed for 5G operation. Large bandwidth in the mm-wave spectrum is necessary to meet large data requirements. In millimeter wave frequencies, bandwidths in the order of GHz are achievable, but more efforts are necessary to exploit this with other needs effectively. Significant improvements in other characteristics, as gain, tangent loss, polarization are urgently required since antenna representation for 5G might be directly dependent on the antennas operation.

We descant microwave and millimeter wave antennas in this study. Millimeter wave technology is essential to 5G communication technology. However, as consumer electronics evolve, there are various issues in mobile device antenna design (Lin & Lin, 2017). With higher integration, the space available to millimeter wave antennas array to achieve excellent acting, like broad bandwidth, low isolation, covered intense radiation and it is significantly smaller. Second, the electromagnetic environment of a mobile device is quite complex (Jilani et al., 2018). Now, those who are interested to research in antenna designing efficient and small antenna structure ,5G millimeter wave band ,particularly at 28 GHz, 38 GHz, and 72GHz making strong contenders for 5G mobile communication (Amrutha & Sudha, 2019). Microwave frequency is fundamental in 5G communication. A microwave antennas are a corporal transmission device that transmitted m signals between two or more address(Wang et al., 2020) . Microwave antennas are used randomly, especially electronic warfare, radio wave, radar communication.

II. LITERATURE REVIEW

- *Background*

Novel and substantial methods for designing antennas for different microwave and millimeter-wave applications have been tried in recent decades. Antenna miniaturization, array configuration, gain, and bandwidth are essential things in microwave and millimeter wave antennae.

- *Microwave Antenna*

Beam forming, tiny cell, multiple input multiple output (MIMO) and edge detection are vital technologies in paving the way for 5G deployment (Alam et al., 2019). MIMO and CR technology are used for 5G communication in sub-6 GHz frequencies. Fig.-1 is the footprint of the investigated multi-slotted antennas. The design under consideration consists of a rectangular immersed radiation. The radiation element is etched on the front side of a 1.5mmthickness and FR4 dielectric substrate of 4.6 and tangent loss 0.002 and the ground plane are also include and it is printed on the rear side of the double-sided substrate with side length LG. It generates a 3.83GHz frequency (Azim et al., 2021).

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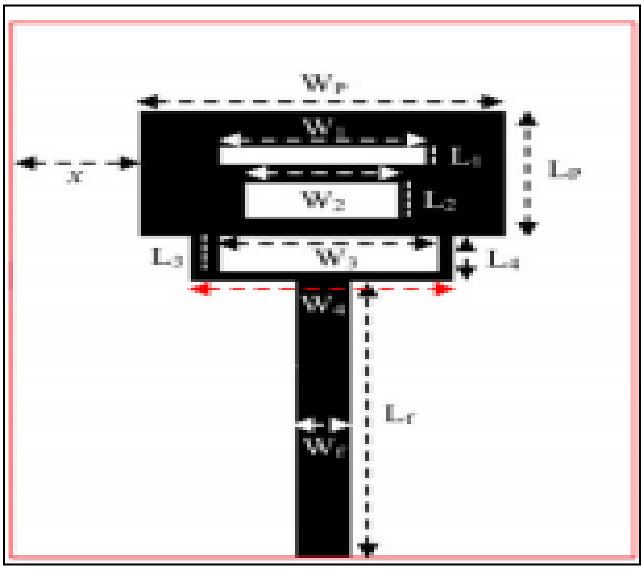

Fig 1 Microwave Antenna

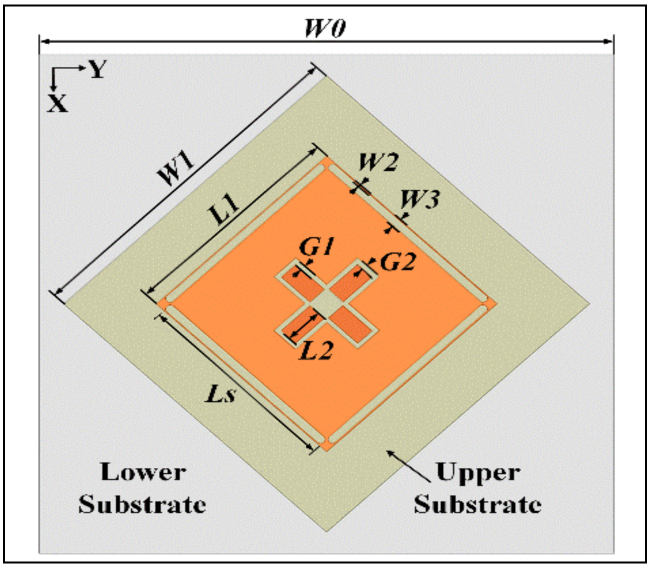

Fig 2 Microwave Antenna

In Fig. 2 is differential-fed polarized patch antenna. This antenna comprises two layers of F4B substrates, a square radiation patch and shaped feeding mechanisms. The permittivity of both substrates is 2.65mm, and tangent loss is 0.002. The upper layer thickness is 0.5 mm, while the lower layer thickness is 0.8 mm. The radiating patch is printed on the upper substrate's top layer, while the OCSIRs are printed on the lower substrate's bottom layer. It generates 3.8 GHz frequency (Li et al., 2020).

Fig.3 nobel multiband antenna. This antenna operates sub-6 GHz bands. This antenna consists of some element like T-shaped element, one monopole antenna and some passive element. All elements in top and the passive element are on the bottom. In this antenna FR-4 is used as substrate. This antennas permittivity εr=4.4 and tangent loss is 0.02 .It generates 2.8GHz frequency (Sekeljic et al., 2019).

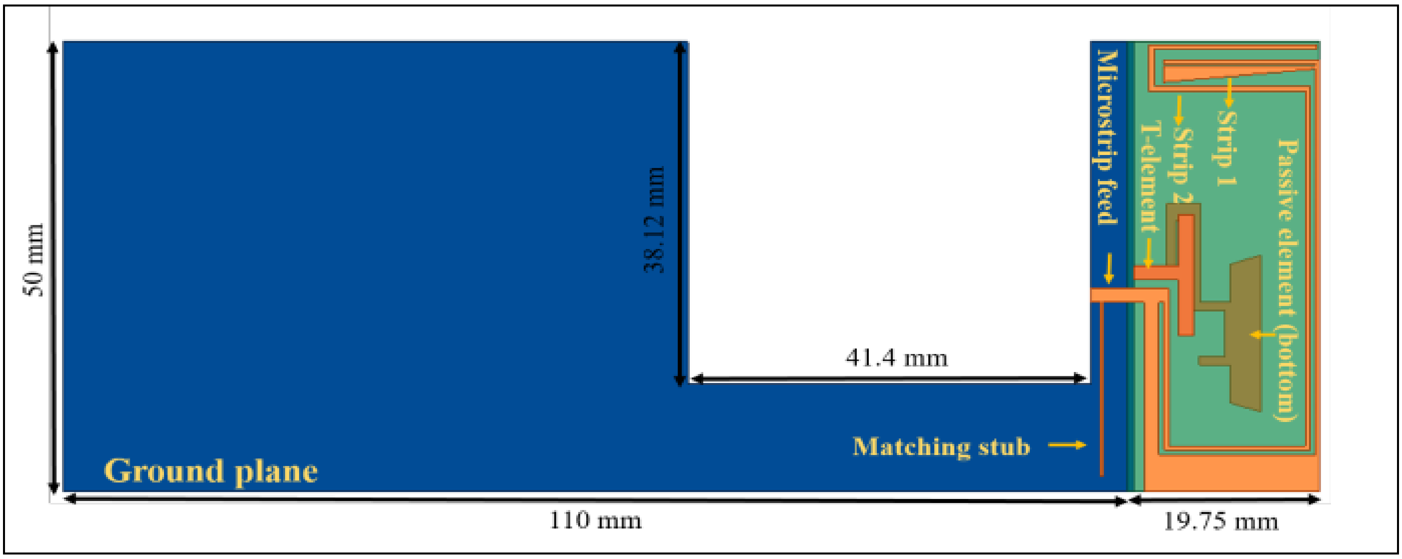

Fig 3 Microwave Antenna

Fig, 4 is the dual-polarization base station antenna. This antenna has an anti-interference capacity. Dual-polarized base station antenna contains three parts these are feed structure, reflector and central radiator. There is two crossed dipoles, both are include in primary radiator. There are two vertical substrate, in front side Γ-shaped feeding line and on back side rectangle patch.. Both are placed between radiator and reflector. In this antenna, measured bandwidth is 52.60% and average gain is 7.57dBi.Good radiation performance, dual polarization, high isolation and anti-interference capability is extra advantages (Wang et al., 2020).

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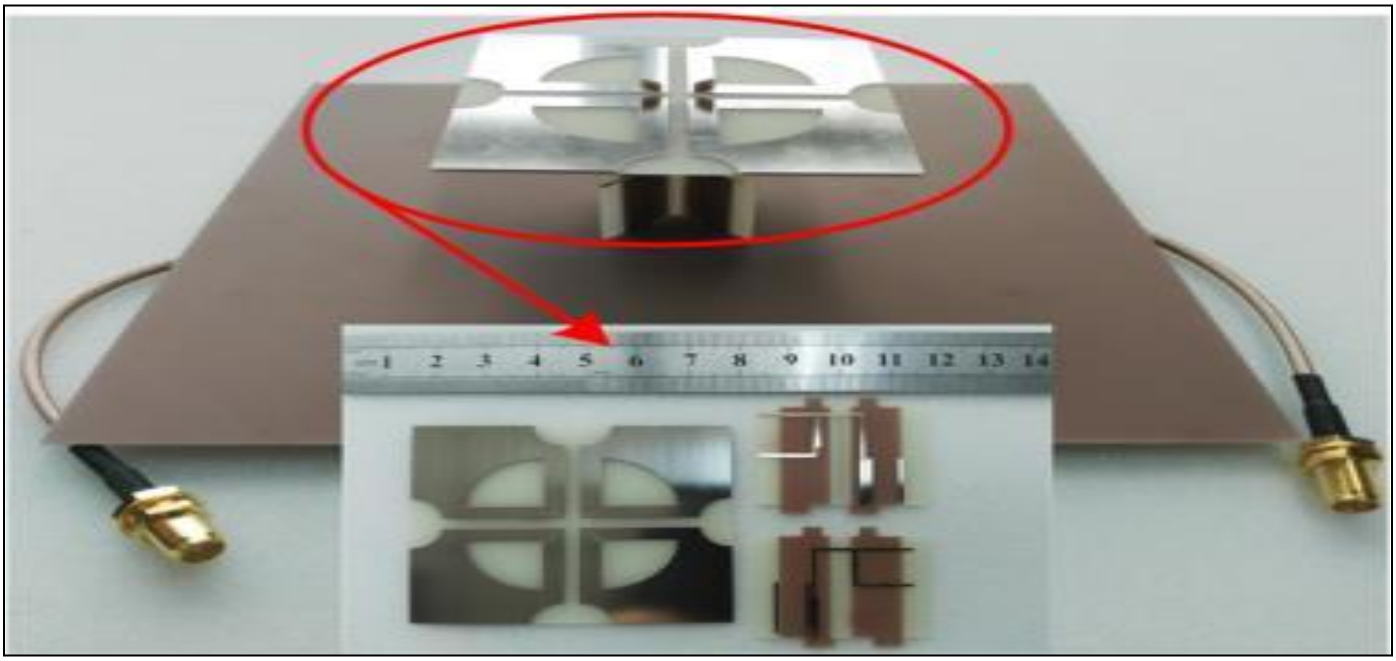

Fig 4 Microwave Antenna

In Fig.5 is a four-port MIMO antenna. This antenna consists of three select mode.The modes are (a) wide band antennas, (b) frequency tenable thin band antennas, (c) wide band antenna with frequency tenable band. Four port MIMO band antenna design for 5G application with sub 6-GHz.The frequency range is (2.51-4.21 GHz). The four-port MIMO antenna sensing range is (2.0-5.7) GHz. In the second mode of operation, it exhibits narrowband frequency tenability from 3.21- 4.00 GHz.In the third mode of operation, the band-notch frequency of the antenna is tenable from (3.3-4.0) GHz. Rogers RO-4350 substrates used in this antenna.

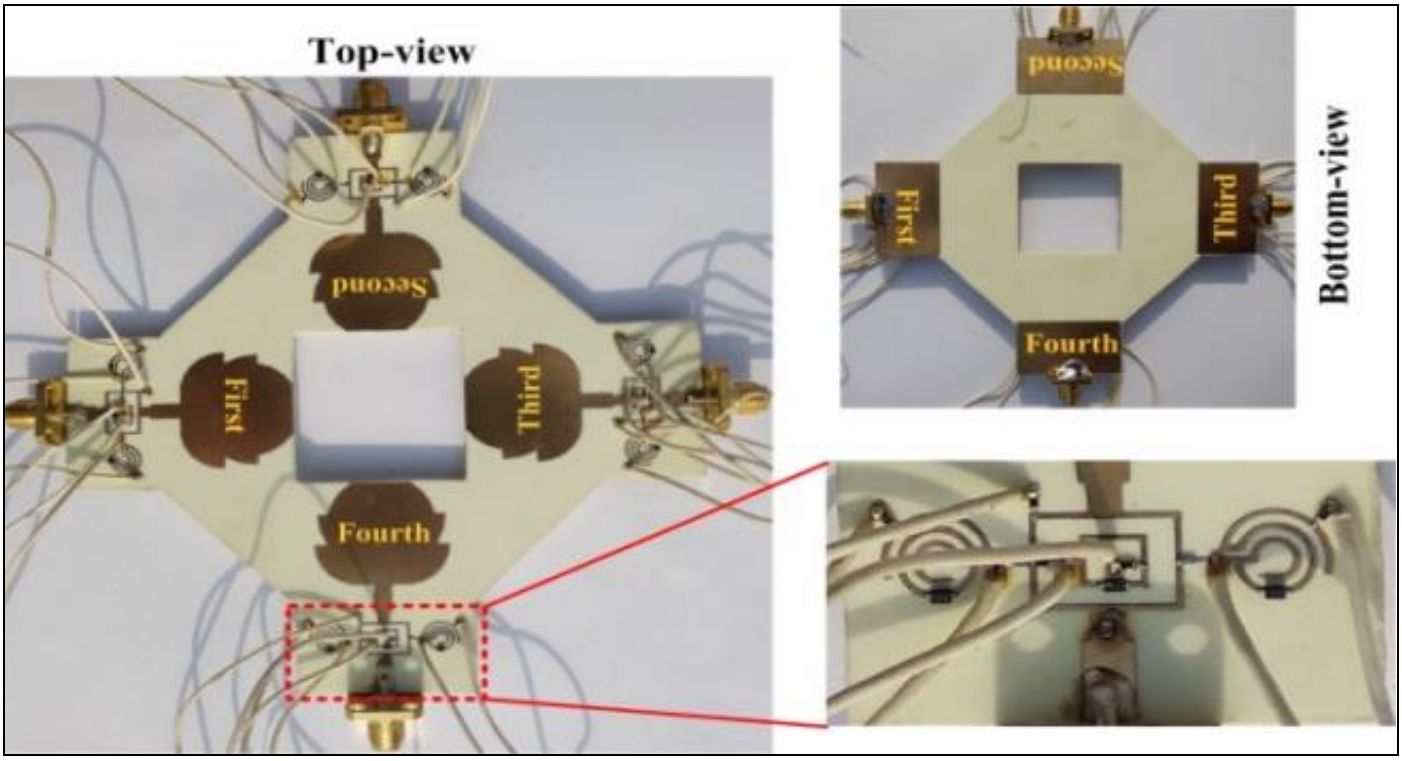

Fig 5 Microwave Antenna

Fig. 6 is a Folk-shaped dipole Microwave antenna. This antenna support (3400-3800) MHz with a combination of LTE band. FR-4 Di-electric metals are used as substrates. Folk-shaped dipole antennas permittivity 4.40 Folk-shaped tangent loss is 0.02. This antennas simulated gain is 3.5GHz, and the elements are orthogonal. This antenna's transmit power array is allocated to each antenna, and Signal to noise ratio (SNR) is 20dB.

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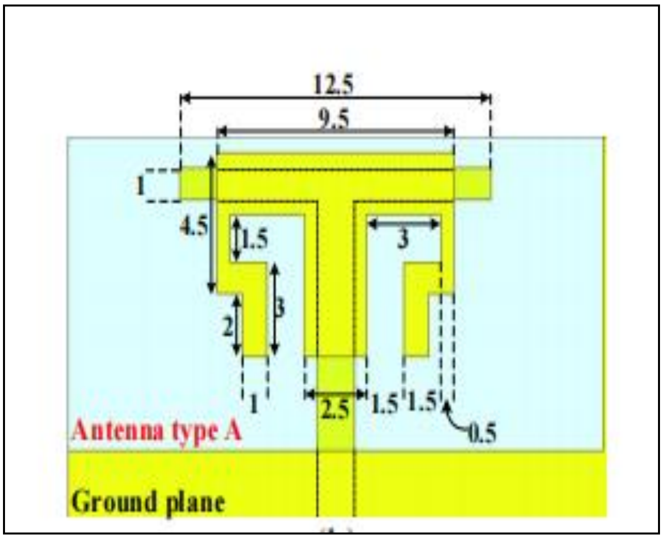

Fig 6 Microwave Antenna

In Fig.7 antenna is L-shaped open slot antenna. This antenna is designed as a sub-6GHz band. L-shaped antenna covered unlicensed LTE 46(5150-5925 MHz). This antenna dielectric substrate is FR-4 with dimensions 130*100*0.8 mm3. L-shaped open slot antenna's permittivity is 4.40 and the tangent loss is 0.02. This antennas simulated gain is 5.5GHz.

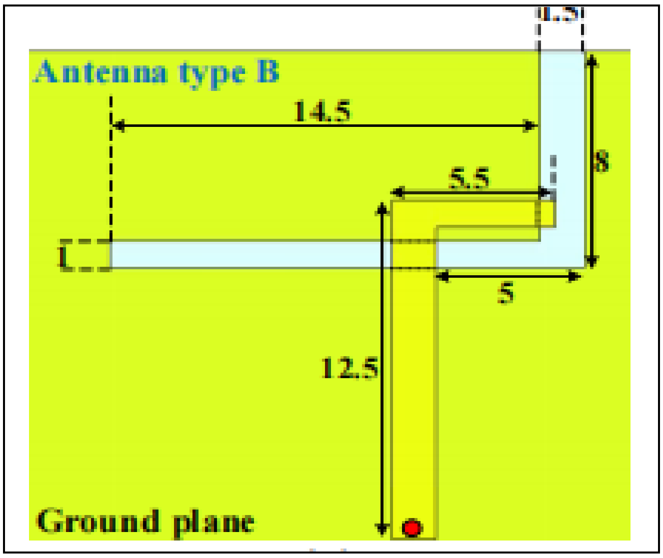

Fig 7 Microwave Antenna

Table 1 Microwave Antennas Different Parameter

Microwave antenna	Substrate	Operating frequency	Thickness	Tangent loss
Footprint investigated multi-slotted antenna	FR4	3.83GHz	1.5mm	0.02
Differential-fed polarized patch antenna	F4B	3.80GHz	1.3mm	0.002
Nobel multi band antenna	FR4	2.8GHz	1.6mm	0.02
Dual-polarization base station antenna	FR4	3.4-3.6GHz	-	-
Four-port MIMO antenna	Rogers RO-4350	2.50-4.20GHz	1.6mm	0.0009
Folk-shaped dipole Microwave antenna	FR-4	3.5GHz	1.524mm	0.02
L-shaped open slot antenna	FR-4	5.5GHz	0.8mm	0.02

- *Millimeter wave Antennas*

The Fig.8 is a 5G millimeter wave antenna. This antenna is single band antenna that operates 28GHz.The antenna has an inverted C shape, and its substrate uses Rogers RT 5880. Rogers RT 5880 is used for high frequency and FR-4 as a substrate for low frequency. In 28GHz frequency, FR-4 is lossy, but Rogers RT 5880 operates at high frequency. This antenna configuration is based on a Rogers RT5880 substrate and 2.20 is permittivity. This antenna 0.508 mm thin and a tangent loss is 0.0022. This antenna's simulated reflection co-efficient is -23.09 dB. 1.98GHz is impedance bandwidth, where the observed reflection co-efficient is -16.95 dB with an impedance bandwidth of 1.232 GHz (27.356-28.588 GHz).The gain of this antenna at 28GHz is 7.4dB (Ruchi et al., 2021).

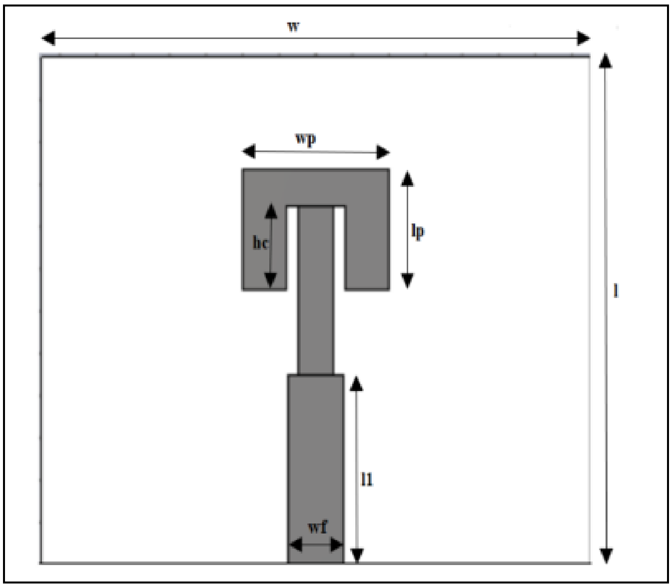

Fig 8 Millimeter Antenna

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The Fig.9 is a microstrip patch antenna that works at frequencies of 28GHz and 38GHz. As shown in Fig.9, The frequency bands 28GHz and 38GHz are significant contenders for mobile communication. Roger RT 5880 was utilized as a high-frequency substrate. Rogers RT 5880 is a high-frequency circuit material packed with PTFE composite laminates for high-reliability, aerospace, and defense applications. An inverted C-shape patch antenna is used in 28GHz patch antennas. The frequency range of the patch antenna is 26.1- 29.9 GHz and gains 7.2 DBi

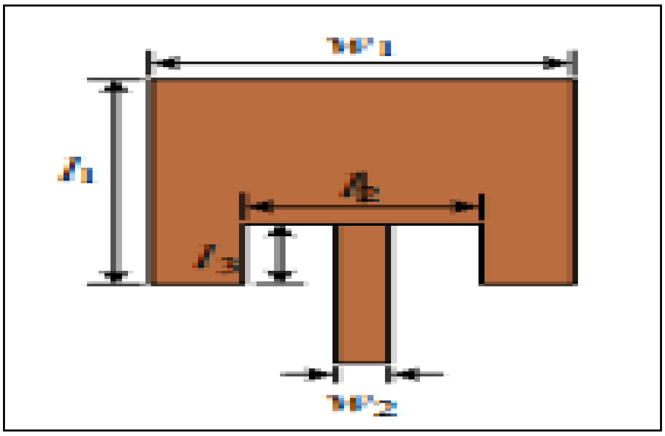

Fig 9 Millimeter Antenna

Fig. 10 is a Quasi-yogi antenna, first published in 1928. The quasi-yogi antenna improves the frequency spectrum of 26.1GHz-29.9GHz. The quasi-yogi antenna was used in 5G mobile device communication. The quasi antennas gain is 8.4dB. However, a quasi-yogi antenna may also be seen in microwave antennas (Thakur, 2018).

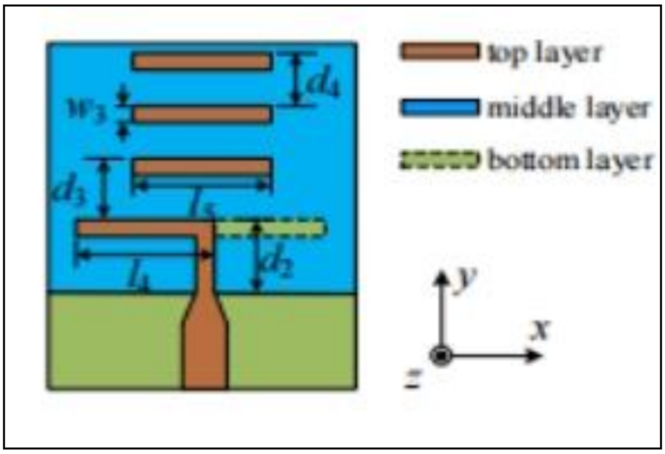

Fig 10 Millimeter Antenna

Fig. 11 is a phase array antenna. Phase array is used as point-to-point communication, base stations and mobile handsets. The phase array antenna covers the frequency range of 25GHz (low frequency) to 40GHz (high frequency) (Kumar et al., 2020). The phased array antenna is built on a dipole antenna with two base holes. Its arm comprises two circles, with a spacing of 0.6mm between them from the center. The S-parameter of phased array antennas is affected by several factors. If its arm circular value decreases, then optimize the S-parameter value is 37GHz.

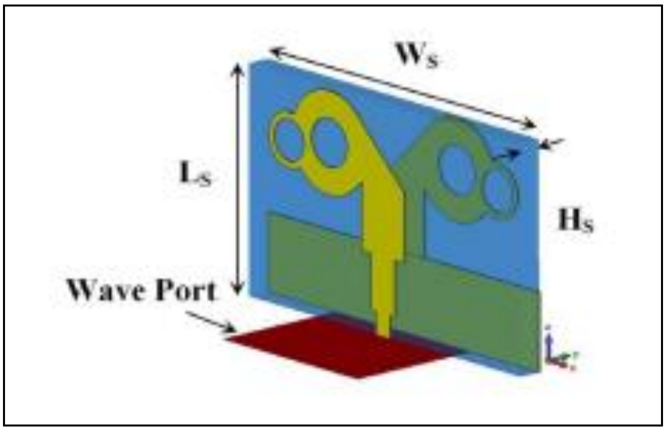

Fig 11 Millimeter Antenna

The Fig.12 is a filtering antenna array. The multi-layered print circuit board technique creates the filtering antennas array. The antenna array comprises three substrate layer, two prepared layers and four metal layer. An open-ended cavity produces vertical polarization (VP). To provide the filtering function, the small circuit feed through acts as a immoral wall, dividing the close-ended depth into the two resonant depths. A dipole antenna provides horizontal polarization (HP). The polarization of the filter antenna array may range from 24.25 to 29.5GHz, and the isolation is 15.00 dB.VP's average gain greater than 8.6 dB, whereas HP's is greater than 8.7 dB. At 27.5 GHz, the simulated beam scanning radiation (Thakur, 2018).

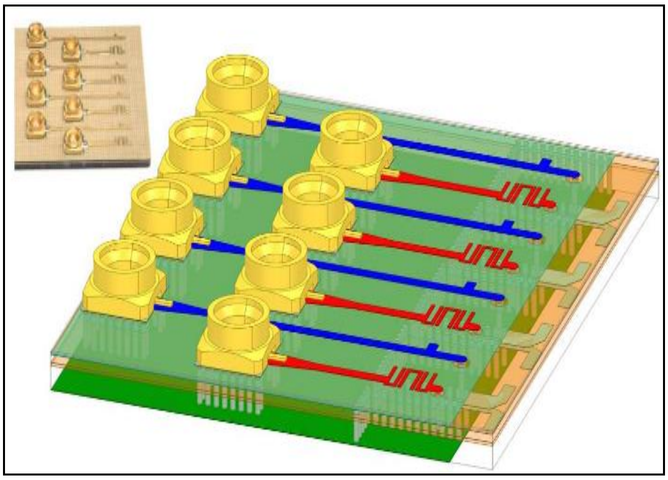

Fig 12 Millimeter Antenna

Fig.13 is a triple-band millimeter wave antenna. In this antenna Rogers RT 5880 is used as a substrate. Triple band millimeter wave antenna permittivity is 2.20 and its thickness is 0.508mm.U-structured and rectangular patch is major part in this antenna. In triple-band antennae, different shapes cover different frequencies. Inverted U-shaped operate 28GHz, rectangular E-shaped operate 39GHz and antennas top to bottom operate 4.7GHz.The antenna size is 30*26*0.543mm (Ruchi et al., 2022)

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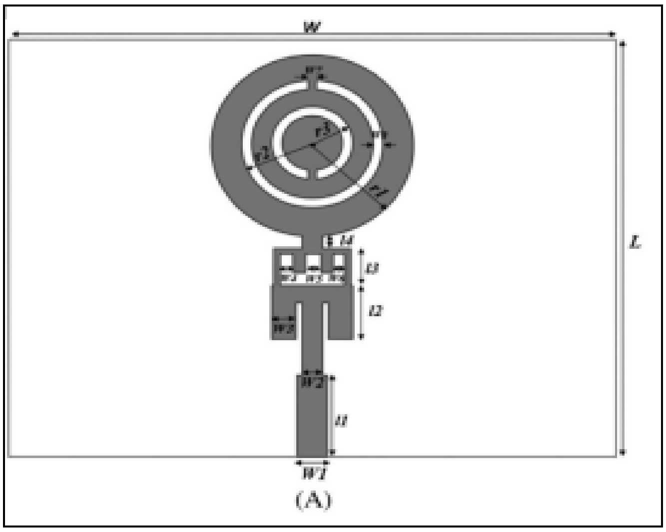

Fig 13 Millimeter Antenna

The Fig.-14 is a dual-band circular microchip patch antenna. This antenna's resonating frequency is 28GHz and 45GHz with 1.3GHz and 1 GHz bandwidth. This dual-band antenna's efficiency is 86.5% at 28GHz and 95.3% at 45GHz.The return loss at 28GHz is -40dB, and the maximum gain 7.6 dB on the other hand, the return loss at 45 GHz in -14dB, and the maximum gain is 7.21 dB. In this dual-band circular antenna design with (lossy) Rogers RT 5880 (lossy) substrate, the dielectric constant is 2.20 and tangent loss is 0.013 (Wang et al., 2020).

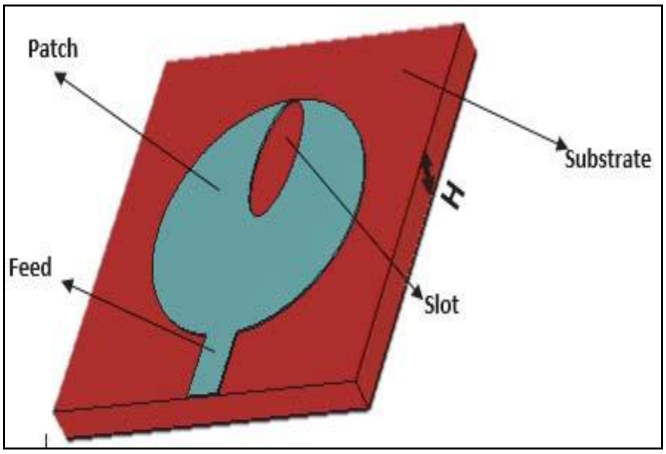

Fig 14 Millimeter Antenna

Table 2 Millimeter wave Antennas Different Parameter

Millimeter wave antenna	Substrate	Thickness	Operating frequency	Tangent loss
Inverted C shaped antenna	Rogers RT 5880	0.508mm	28GHz	0.0022
Quasi-yogi antenna	FR4	1.5mm	26.1-29.9 GHz	0.0027
Filtering antenna array	RT/Duroid 5880,FR4, RO3003	0.8mm	24.25-29.6GHz	0.0029
Dual band Circular micro patch antenna	Rogers RT5880 (lossy)	2mm	28 GHz,45GHz	0.013
Triple band millimeter wave antenna	Rogers RT 5880	0.508mm	28GHz,39GHz,4.7GHz	0.0009

- *Gaussian Process Regression*

Gaussian process called stochastic process. New samples can be predicted in this function and algorithms are

$Y(x^*) = \mu + r^T R^{-1} (y - I\mu)$……...…………………………..(1)

Where.

I is a n x1 vectors of ones and μ is the predictive distribution value.

$R_{i,j}$ = cross (x_i, x_j) is a co-relation function with i, j =1,2,3……n and r= [corr (x^*, x_1) ,r= [corr (x^*, x_2)….,(x^*, x_n).

- *Kriging Regression*

Kriging regression algorithms is used for antennas wide design.

$\zeta (S_0) = \sum_{k=0}^{P} \beta_k q (S_0)$…………………………………..…(2)

Where β_k are the linear regression coefficient and P is the number of variable and $\zeta (S_0)$ is the predicted value where s_o is input.

III. CONCLUSION

Antennas are a significant and essential part of wireless communication. Fifth-generation (5G) antennas play a significant role in modern communication .In modern communication fifth generation (5G) application increasing day by day. Microwave and millimeter wave antennas are used in wireless and mobile application .Microwave antennas has some special features and a millimeter wave antenna has some different features. Both antennas frequency range is different. In this work, with individual figures, microwave and millimeter wave antennas characteristics, behavior, bandwidth, gain, resonant frequency, and parameters are explained.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24AUG1608

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