Design of Double Folded Dipole Shape Multiband Antenna for mm-Wave Applications

[1]Ajeesh K, [1]Bijubal N B, [1]Aswanth Mohanan, [1]Adithya R B P, and [2]Sajith K, [2]Jobin Jose

[1]BTECH Student, [1]ECE Department, GEC Wayanad, Kerala-670644
[2]Assistant Professor in ECE Department, GEC Wayanad, Kerala-670644
[1]ajeesh77krish@gmail.com, [2]sajith.k@gecwyd.ac.in

Abstract : This paper presents a novel coplanar waveguide with Y shape-feed double folded dipole shape triple-band antenna for mm-wave 5G applications. Fundamentally co-planar waveguide fed is used in this antenna. The proposed antenna has a compact size of 8x4.6x0.6 mm^3. In this antenna, the material called FR-4 is used as a dielectric substrate having an epsilon value (dielectric constant) of 4.3 with a thickness of 0.6mm. This simulated antenna resonates at 32GHz, 40GHz, and 47GHz and it provides promising results such as the magnitude of reflection coefficients and VSWR are more suitable for mm-wave communication.

***Keywords*- Coplanar Waveguide CPW, Bandwidth, Gain, Radiation Pattern, millimeter wave, 5G applications.**

1 INTRODUCTION

The greatest changes happening around the world, along with technologies related to wireless and mobile communication are also changing. Although microwave spectrum offers a wide range of applications, those are becoming insufficient to accommodate the emerging data requirements of a new era. Fifth-generation (5G) communication which is expected to resolve these needs, offers a higher data transmission rate, ultra-low latency, and massive network capacity [1]. 5G network will be focused on millimeter-wave frequencies since it is the easiest way to get away from the over-crowded sub 6 GHz frequency region [2]. Because of the features like compact structure and low profile, micro size antennas are suited to achieve the requirements. Co-planar waveguide feeding (CPW-fed) techniques is considered to be good for 5G communication due to their low size, low cost, lightweight, and ease of installation.

A novel y feed double folded dipole multiband antenna (YDFDMA) is a micro-size or mm size antenna. It used CPW as a feedline, which is easy to fabricate with the cost-effective method. The CPW fed millimeter-wave antenna design is increased in all wireless communication fields, especially machine-to-machine communication and mm-wave-based BAN communication. S. Y. A. Fatah et al. proposed a UWB antenna for both microwave and millimeter-wave spectrum, covering (5.5-9.5) GHz and (55-95) GHz using Rogers 5880 as substrate [1]. Low complex uniplanar series fed antenna array along with asymmetrical slots for (24-27) GHz frequency is used for 5G applications is proposed in [2]. C. Han et al. [3] introduced a rectangle slot antenna that covers 28 GHz and 39GHz [3]. G. Ioannis et.al introduced a CPW fed antenna that effectively operated over an ultra-wide frequency range from 24GHz to 53GHz for future mm-wave based 5G mobile applications [4].

This paper is organized into four parts, part one gives the introduction and motivation of the CPW fed mm-wave antennas, and part 2 explains the antenna design and its geometrical structure. Part 3 provides the simulated antenna parametric results of the YDFDMA antenna. The last part 4 is the conclusion of the designed antenna.

2 DESIGN OF YDFDMA ANTENNA

A CPW-fed antenna is a combined structure of radiating patch, two grounds, and feedline that connects to patch and finally substrates on which these components are located on the same plane. A geometrical shape of YDFDMA is shown in Fig. 2.1 and Fig.2.2 shows the layered structure of the simulated antenna.

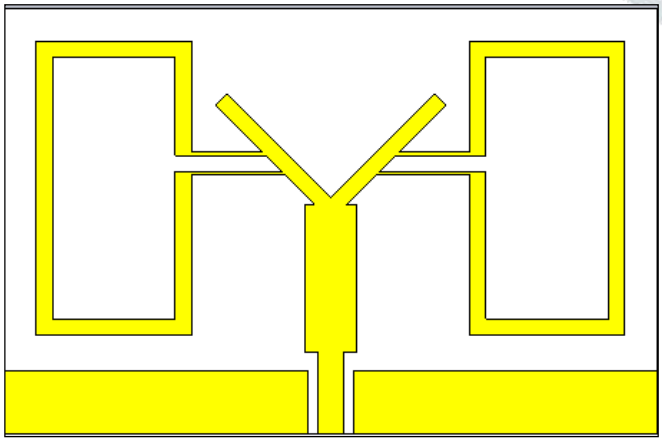

Fig.2.1. Geometrical shape of YDFDMA

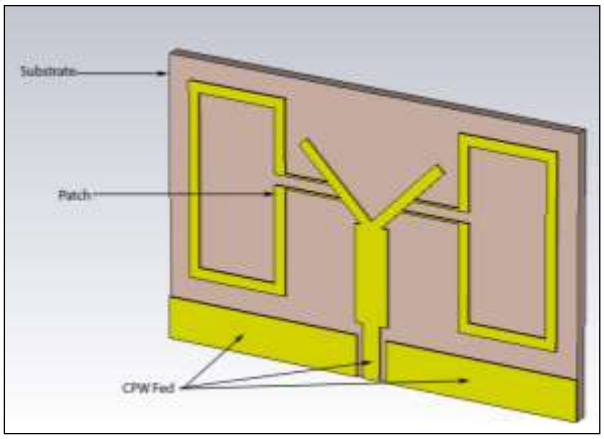

Fig. 2.2. 3D view of YDFDMA

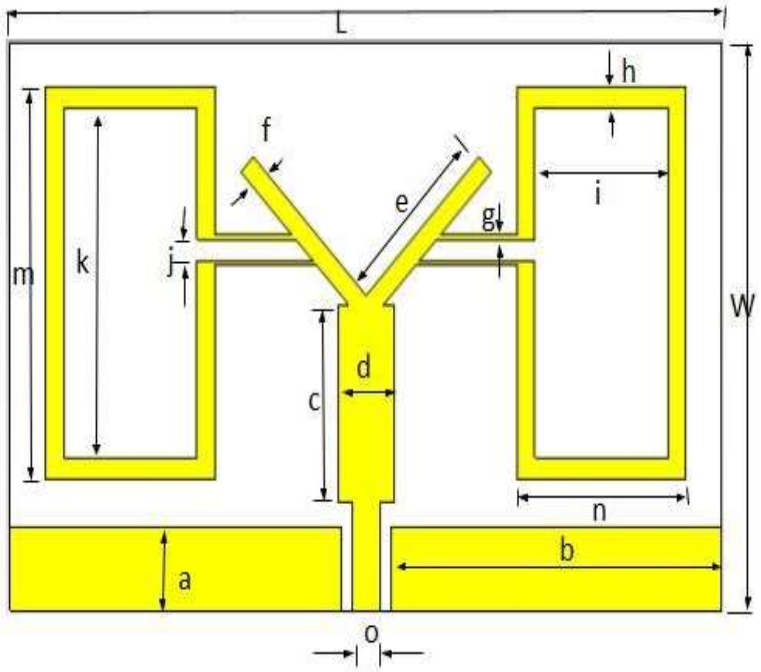

Fig.2.3. Dimension of YDFDMA.

Table.2.1.Dimension of YDFDMA

Antenna dimensions	Values (mm)	Antenna dimensions	Values (mm)
a	2.00	i	3.75
b	9.80	j	0.50
c	4.50	k	8.00
d	1.60	m	9.00
e	4.60	n	4.60
f	0.50	o	0.80
g	0.10	L	20.0
h	0.50	W	13.0

Fig. 2.3 illustrates the dimensions of YDFDMA and its parametric information is shown in Table. 2.1. The length 'L' and width 'W' of antenna is 20mmx13mm. The width of the CPW ground is 9.8mm and height is 2mm, the strip height is 6.5mm. The YDFDMA antenna design through time-domain solver, also the entire dimensions are in mm-scale.

3 RESULTS AND DISCUSSION

In this section, simulated results such as VSWR plot, return loss plot, 3D radiation plots, and polar (2D) plots of both magnetic and electric fields are discussed at each resonating frequencies of the YDFDMA Antenna is given below. Finally, the comparison between the referred antenna and YDFDMA is tabulated in the table.3.1.

3.1. Return Loss and VSWR

Return loss or Magnitude of reflection coefficient indicates how perfect the matching between the antenna and air or free space [5], [6]. From Fig. 3.1, it's observed that the RL value is less than -10dB in particularly three frequency bands. Each indicates the resonating frequencies of the YDFDMA. The return loss values for YDFDMA have 34dB at 32GHz, 22dB at 40GHz and 31dB at 47GHz.

VSWR shows the mismatch between the connector and the CPW fed or antenna [7], [8]. The bandwidth of resonating frequency can be determined from the return loss plot or VSWR plot. Fig.3.2 indicated the VSWR values at 32GHz, 40GHz, and 47GHz is 1.04, 1.16, and 1.06 respectively. Bandwidth values of 6.3GHz, 7.2GHz, and 10.5GHz are achieved at 32GHz, 40GHz, and 47GHz respectively.

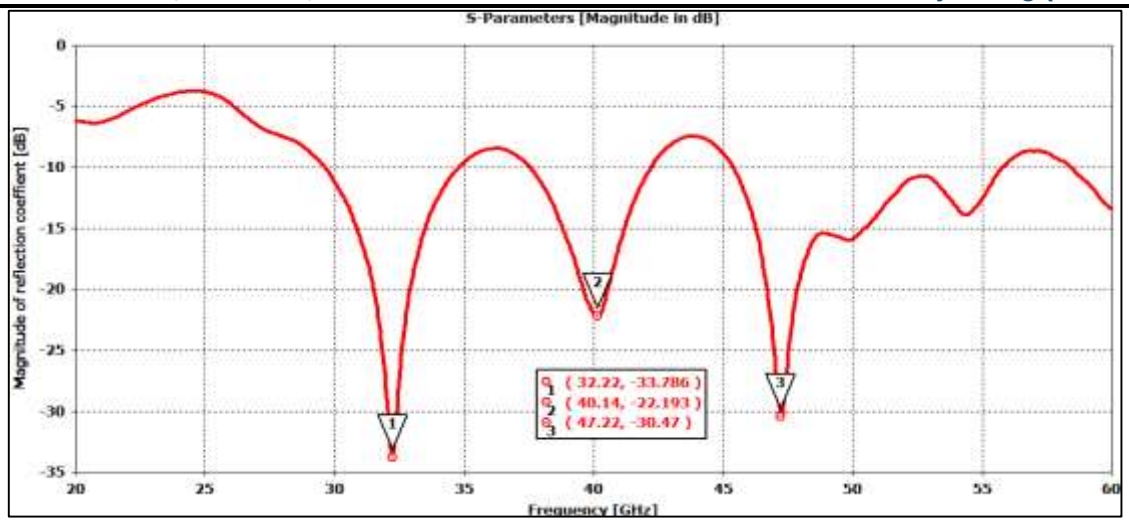

Fig. 3.1. Magnitude of RC versus Frequency plot of YDFDMA.

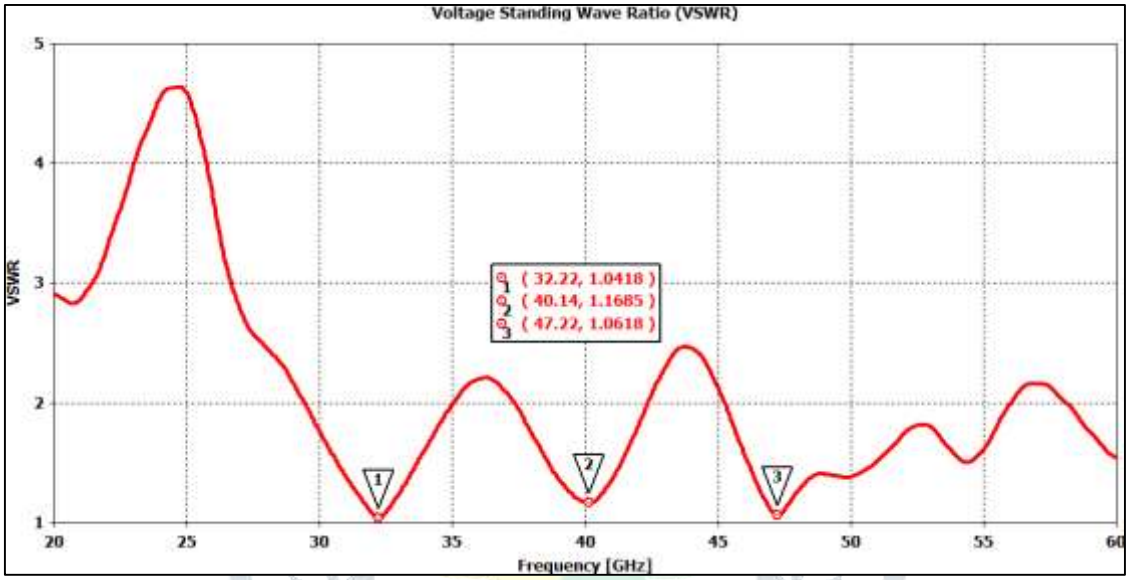

Fig.3.2. VSWR Versus Frequency Plot of YDFDMA.

3.2. Radiation pattern and E and H field pattern.

A radiation pattern is a pictorial representation of the radiation field as a function of direction (or as a function of space coordinates). It also shows how an antenna radiates [9]. Fig. (3.3-3.5) shows the directivity plot of YDFDMA at various resonating frequencies. The simulated antenna has a directivity value of 7.2dBi at 32GHz, 5.2dBi at 40GHz, and 5.8dBi at 47GHz. Fig. (3.6-3.8) shows the combined plot of both E and H field patterns at respective resonating frequencies. E field stands for electric field pattern (phi=90) and H field for azimuthal pattern (theta = 0) [10]. E-field pattern indicated the directional characteristics of YDFDMA, and H-field indicated the non-directional characteristics of YDFDMA.

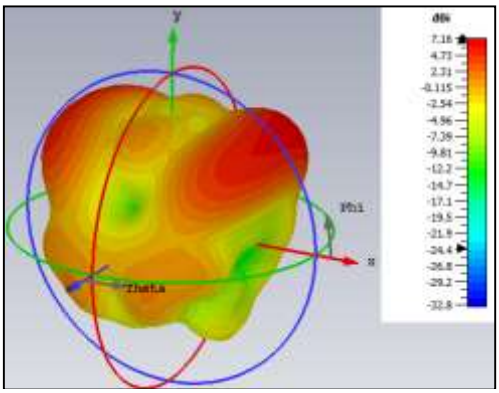

Fig.3.3. Directivity plot at 32GHz

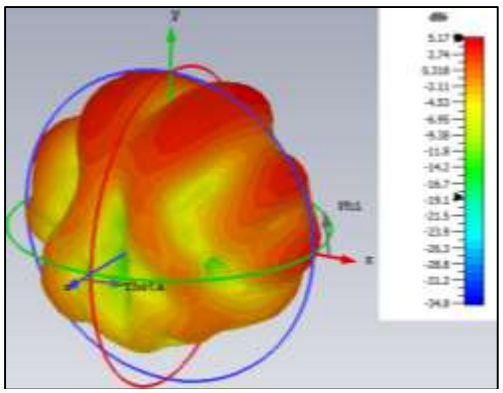

Fig.3.4. Directivity plot at 40GHz

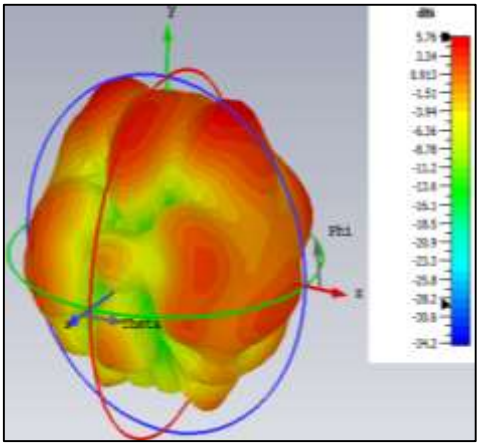

Fig.3.5. Directivity plot at 14GHz

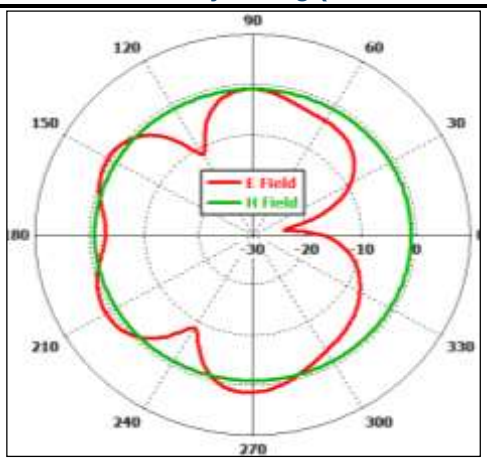

Fig.3.6. Electric and magnetic plot at 32GHz

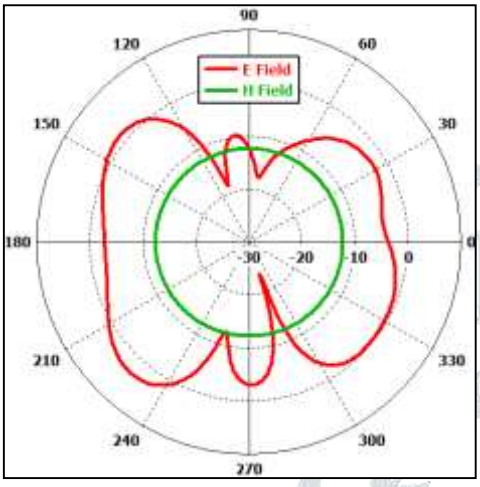

Fig.3.7. Electric and Magnetic plotat 40GHz

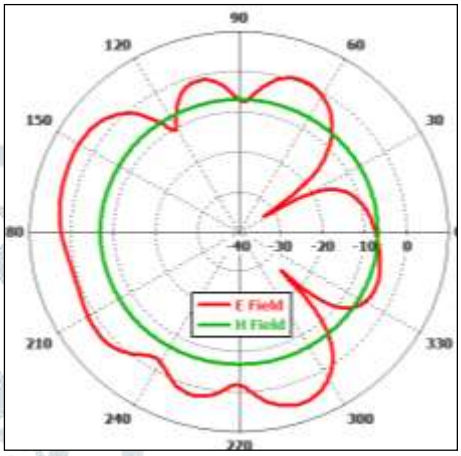

Fig.3.8. Electric and magnetic plot at 47GHz

Table 3.1. Comparision of designed and reference antenna.

Ref. literature	Dimension (mm^3)	Number of Bands	BW (GHz)	Substartes
[3]Han et.al	22	Double	7.1, 3.2	FR-4
[9] Sajith et.al	640	Doble	0.05, 0.1	Teflon
[11] Lee et.al	790	Single	0.012	FR-4
Prop. Ant.	22	Trible	6.3, 7.2, 10.5	FR-4

4 CONCULSION

The CPW based Y-feed double folded dipole shape multiband antenna for mm-wave applications have been presented. The designed antenna has high gain and sufficient operating bandwidth for 5G applications. The designed antenna has a compact size of 156mm3 and low-profile in nature. The standard result of RL and VSWR makes this antenna the best candidate for the machine-to-machine communication and 5G applications.

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