Multiband CPW Fed Y-Shaped Monopole Antenna Design for 5G Applications

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

[1]BTECH Student, [1]ECE Department, GEC Wayanad, Kerala-670644
[2]Assistant Professor in ECE Department, GEC Wayanad, Kerala-670644

***Abstract* :** A novel quad-band single-layered single patch Y-shape coplanar waveguide fed patch antenna is exhibited, for 5G communication and its application. 5G is the wireless technology (Fifth generation), which is meant to deliver data at a higher speed, low latency etc. The designed antenna has an overall dimension of 15x15x1.7mm^3 and used FR-4 having epsilon value 4.3 as a substrate with a thickness of 1.6mm. This designed antenna operates at resonating frequencies of 4GHz, 11GHz, 28GHz and 32GHz. simulated values of parameters such as return loss and VSWR shows that the designed antenna is more suitable for 5G communication purposes.

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

1 INTRODUCTION

Multiband antenna is the major component in wireless communication devices. The wireless communication is developing rapidly in recent days, the need for compact, low-profile and portable multiband antennas are also continuously increasing [1], [2]. Multiband microstrip patch antenna is widely used for wireless applications due to their advantages such as lightweight, low cost, low volume, high compatibility while using with integrated circuits and easy installation [3]. Coplanar waveguide (CPW) is used as feeding because of its many specialties such as easy integration with devices and also its less complex single metallic-layered structure. In this article, a novel y-shaped multiband monopole antenna (YSMMA) is presented. Only a single-layered substrate is used in the proposed work. The simulated YSMMA uses a coplanar waveguide feeding technique. While comparing to the rectangular antenna, this YSMMA offers a large number of services for the future 5G era and it also follows a radiation pattern similar to the omnidirectional pattern.

This article is organized into four parts, part 1 mentions the introduction of the designed antenna, part 2 talks about geometrical structure and its antenna design steps. Part 3 provides computer-generated results of various parameters of the designed antenna. Finally, part 4 covers the conclusion about the designed antenna.

2 DESIGN OF YSMMA

Conventional microstrip antenna includes a metallic radiating patch and feedline which is placed on top of a grounded dielectric substrate. Commonly used geometrical shapes for the radiating patch are circular and rectangular [4]. This antenna design involves two steps. First, creating a rectangular shaped radiating patch (stage-1 antenna). The second one involves removing a portion from the rectangular patch and creating a Y-Shaped patch. Fig.2.1 shows the structure of the YSMMA antenna (stage-2 antenna). The layered structure of the simulated antenna is mention in Fig.2.2.

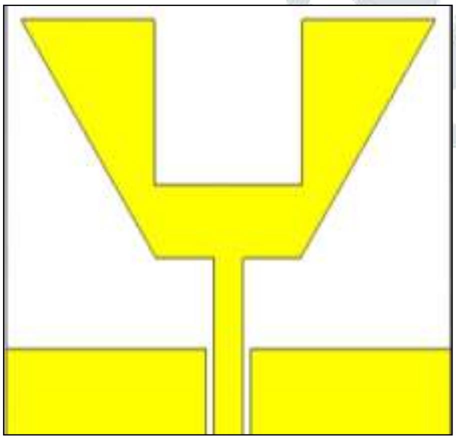

Fig. 2.1. Front view of CPW fed YSMMA

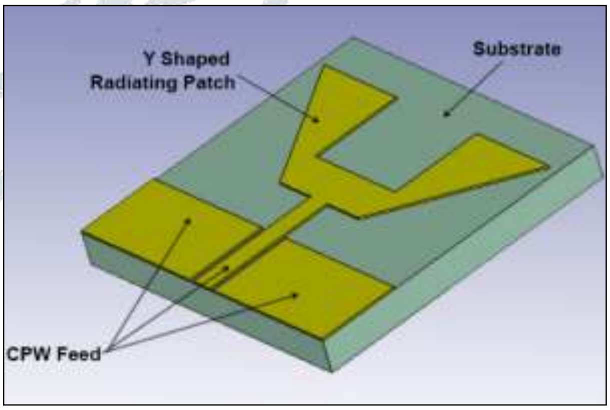

Fig.2.2. Perspective view of CPW fed YSMMA.

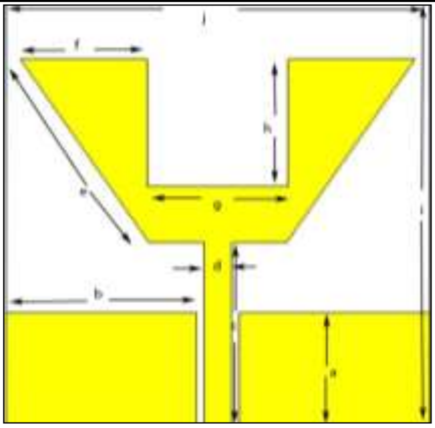

Fig.2.3.Dimensions of YSMMA.

Table.2.1. Dimension of YSMMA.

Antenna Dimension	Values (mm)	Antenna Dimension	Values (mm)
a	4.00	f	4.5
b	6.75	g	5.00
c	6.50	h	4.50
d	1.00	i	15.0
e	7.94	j	15.0

The substrates/dielectrics are commonly used in antennas to improve their electrical and mechanical stability. They are also useful to reduce the size and producing displacement current (time varying electric field) which causes the production of magnetic fields.FR-4 is used as substrate due to its low cost and its various characteristics like the ability to show good dielectric qualities in both humid and dry conditions and retaining its high mechanical values. Dimensions of the simulated antenna structure are shown in Fig.2.3 and Table 2.1.

3 RESULTS AND DISCUSSION

In this section, results such as return loss plot, VSWR plot, 3D radiation plots and polar (2D) plot of both electric and magnetic fields are discussed at each resonating frequencies. Bandwidth at each resonating frequencies can be obtained from the VSWR plot or reflection coefficient plot [5].

3.1. Return Loss

Return loss can be interpreted along with devices matching and it measures how well a device is matched [6], [9]. Return loss values for resonating frequency of stage-1 antenna are 12dB for 6.2GHz, 18dB for 11.3GHz and 17dB for 32.3GHz. The designed antenna has 13dB at 4GHz, 43dB at 11GHz, 14dB at 28GHz and 17dB at 32GHz. Relation between the magnitude of reflection coefficient and frequency is showed in Fig.3.1, and red and green curves correspond to stage-1 antenna and Y-shape patch antenna.

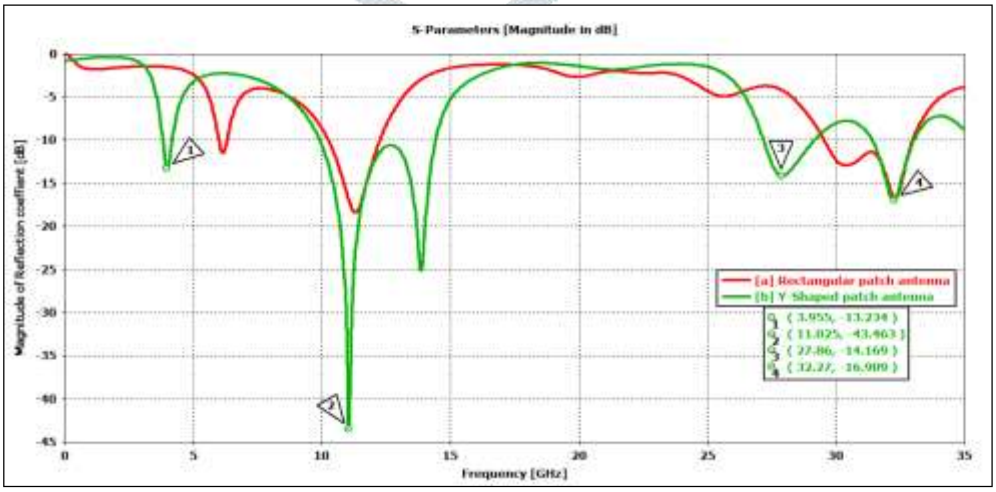

Fig. 3.1. Return loss Vs frequency plot of YSMMA.

3.2. VSWR

Voltage standing wave ratio indicates the amount of mismatch between antenna and connector (feedline connecting to antenna) [7], [10]. The VSWR values are 1.55 at 4GHz, 1.01 at 11GHz, 1.48 at 28GHz and 1.33 at 32GHz. Bandwidth measured from simulated results are as follows, 0.41GHz BW at 4GHz, 4.61GHz BW at 11GHz, 2.19GHz BW at 28GHz and 1.79GHz BW at 32GHz. VSWR is plotted in Fig.3.2, red and green curves correspond to stage1 antenna and Y-shaped patch antenna.

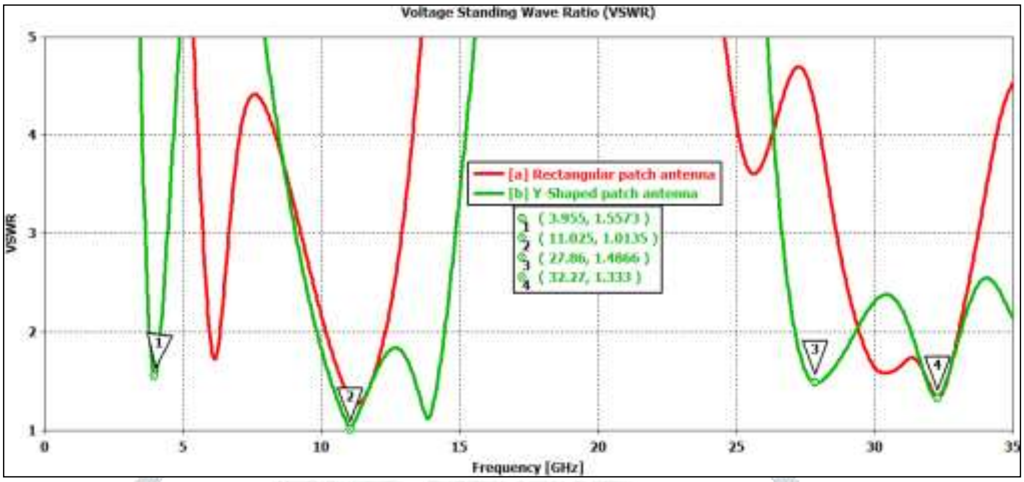

Fig. 3.2. VSWR plot of YSMMA.

3.2. Antenna Gain and Field pattern

A radiation pattern is a graphical representation that shows how energy radiates from an antenna or a source [8]. Fig(3.3-3.6) shows the directivity of the designed YSMMA. This antenna shows the directivity values of 2.1dBi at 4GHz, 3.5dBi at 11GHz, 6dBi at 28GHz and 8.2dBi at 32GHz. Both E and H field is graphical representation 2D polar plot of antennas field distributions at farfield. E field or electric field and H field or magnetic field can be derived from radiation pattern, [11], [12]. Fig (3.7-3.10) shows combined magnetic field and electric field polar plots of resonating frequencies of CPW fed YSMMA antenna.

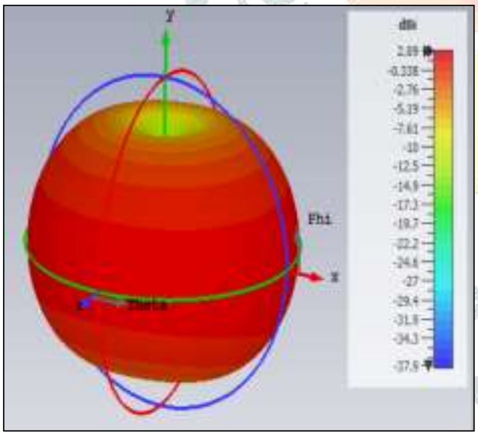

Fig. 3.3. Directivity plot at 4GHz.

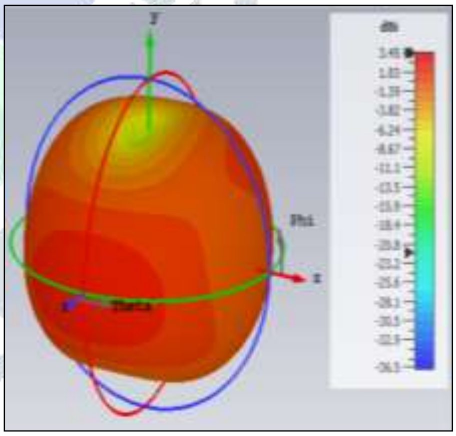

Fig. 3.4. Directivity plot at 11GHz.

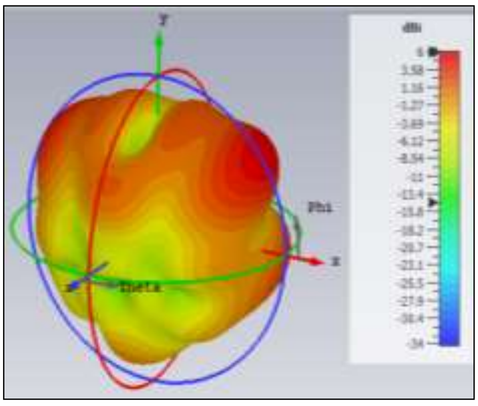

Fig. 3.5. Directivity plot at 28GHz.

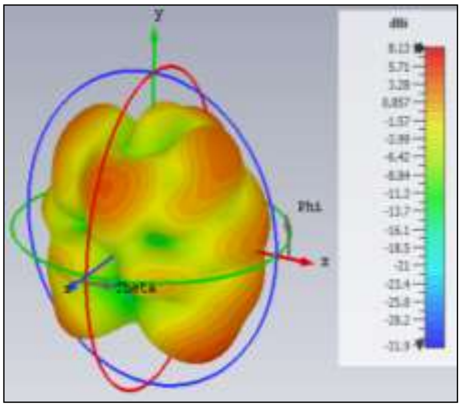

Fig. 3.6. Directivity plotat 32GHz.

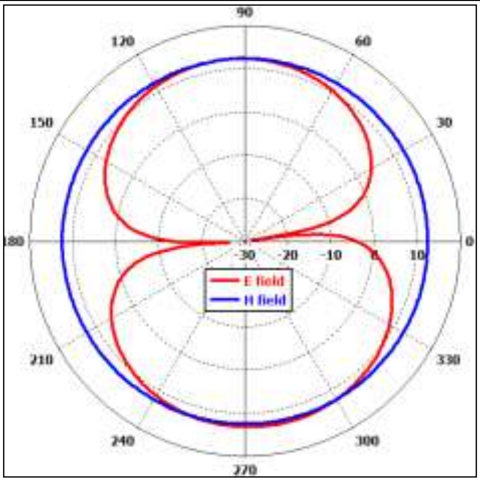

Fig. 3.7. Electric and Magnetic plot at 4GHz.

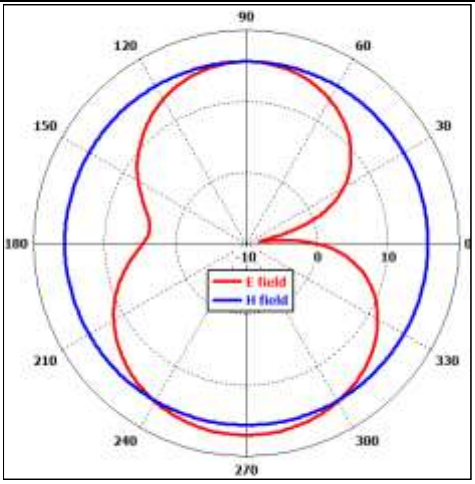

Fig. 3.8. Electric and Magnetic plot at 11GHz.

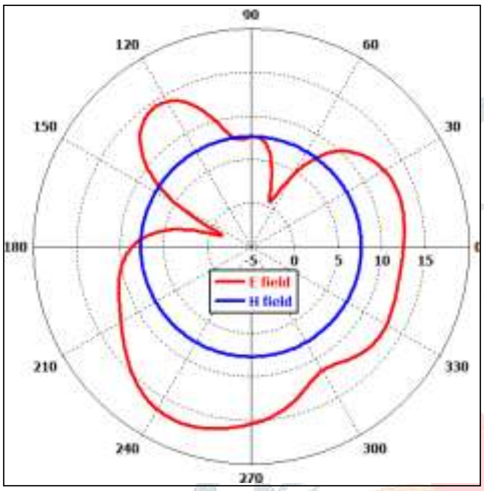

Fig. 3.9. Electric and Magnetic plot at 28GHz.

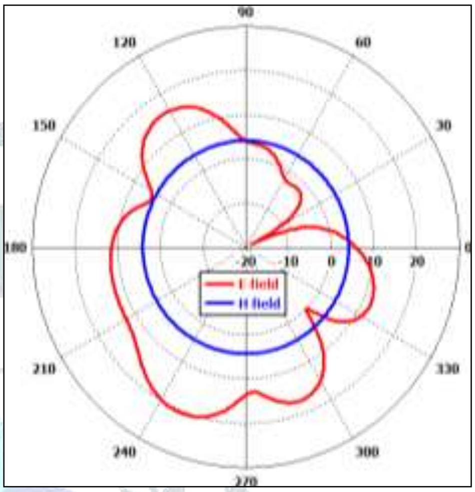

Fig. 3.10. Electric and Magnetic plot at 32GHz.

4 CONCLUSION

A novel coplanar waveguide fed YSMMA has been designed. The designed antenna provides better gain and adequate bandwidth for 5G applications. The omnidirectional pattern obtained in the first resonance (3.9GHz) of the antenna means that the simulated antenna is a monopole. The antenna is designed with an overall volume of 383 mm^3. The designed antenna shows better RL and VSWR values, which are very suitable for both IoT and 5G applications and also for multi-band communication applications.

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