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Dual Feed Φ-Shaped Patch Antenna For 5G Applications

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Abstract:

In wireless communications, microstrip antennas play a dominant role because of their light weight, small size, and the ease of fabrication. In this paper, a Dual Feed Φ-shaped patch antenna is proposed for 5G applications. The Dual Feed Φ-Shaped Patch Antenna has a resonant frequency of 3.5 GHz with return loss -21.2dB, gain 4.41 dB and directivity 4.682. The designed antenna uses FR4 material with overall size of 55x55x1.6 mm and it is designed and simulated by using HFSS. The results explain that the Dual Feed Φ-Shaped Patch Antenna has favorable characteristics for 5G applications.

Keywords: Microstrip Patch Antenna, 5G Technology, Return Loss, VSWR, Gain**.**

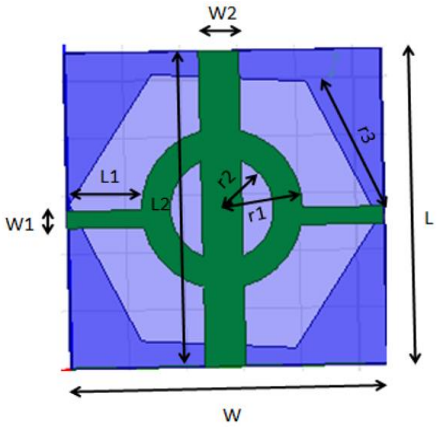
1. Introduction

In any wireless communication field antenna is the primary need. The microstrip patch antennas are widely used antennas because of their light weight, fabrication is easy, small size and can easily implement in any system [1-2]. The patch antenna provides high efficiency and its efficiency is based on the εr of the material used for that patch. The efficiency of the antenna increases when the material εr has low value. There are several methods to feed patch but the microstrip feed and coaxial feed are mostly used methods. A patch antenna is mounted on substrate and it consists of a rectangular, circular, triangular, or any patch of metal mounted over ground plane. Microstrip patch antenna are used for different applications such as mobile phones, satellites, radars, GPS, multiple input multiple output (MIMO), RFID and guidance of missiles. Narrow bandwidth is the main disadvantage of Microstrip patch antenna. To design any microstrip patch antenna many optimization techniques are used such as coplanar waveguide, proximity coupling and dual feed. Wide bandwidth antennas are used for a wide range of network frequencies which is more efficient for far field implementation. For a dual feed antenna, phase difference can be easily maintained. For example, if we want to design circularly polarized antenna with a 90-degree phase shift orthogonal feeds are used.

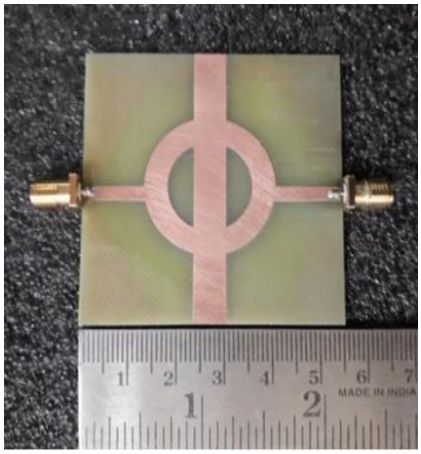
One of the most common issues in wireless communication is the orientation of receivers and transmitters. To overcome this issue, circularly polarized antennas are commonly used. These dual CP antennas have a compact design and are equipped with polarization characteristics. They are used in GPS and navigation satellites. 5G is faster and more advantageous compared to its predecessor. Its initial frequencies are between 3.3 and 3.8 GHz. A dual feed -shaped patch antenna is proposed for use in 5G.

2. Antenna Design:

The dual feed Φ-shaped patch antenna design is simulated by using HFSS software. Fig 1 and Fig 2 shows the Simulated and Fabricated front view and bottom view of Dual feed Φ shaped patch antenna. Its structure contains Hexagon which is placed in ground plane. The material used for dielectric substrate is FR4 epoxy. The dimensions (in mm) of antenna for designing are as follows: The Length and Width of the Ground plane are L = 55, W = 55. The radius of circle 1 and circle2 are r_1=14 and r2 = 9 respectively and the radius hexagon is r3=51.The Length and Width of pair of rectangular feeding lines are L_1 = 18 and W1 = 3.The Length and Width of vertical rectangle are L2 = 55 and W2= 7.

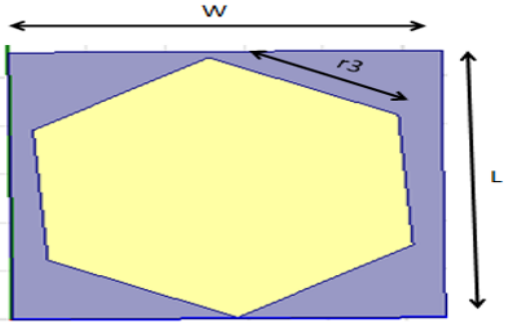


(a)

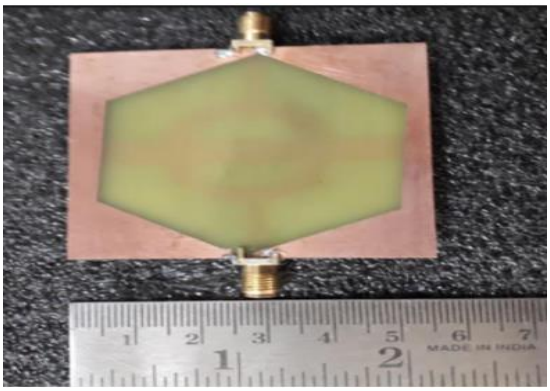


(b)

Figure 1. Front view of Dual Feed Φ-Shaped Patch Antenna (a) Simulated (b) Fabricated



(a)



(b)

Figure 2. Bottom View of Dual Feed Φ-shaped patch antenna (a) Simulated (b) Fabricated

The Equivalent circuit of the Dual feed Φ-shaped Patch Antenna is shown in Fig 3. It is a circuit model of dual port Φ-shaped patch antenna where Lf and Cf stands for microstrip feed inductance and static capacitance of antenna respectively. Ls and Cs stands for inductance and capacitance due to hexagonal slot in ground plane. The R, L, C are the Resistance, Inductance and Capacitor respectively.

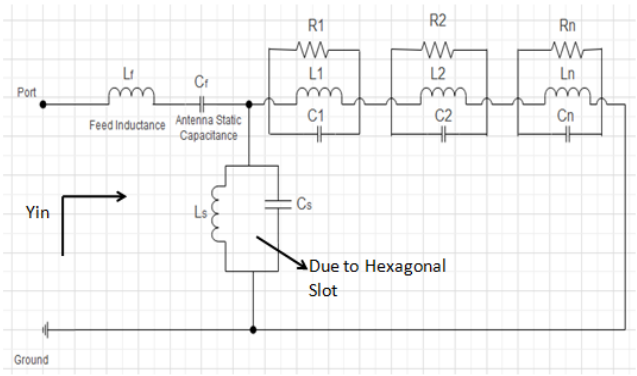


Figure 3. Equivalent circuit of Dual Feed Φ-Shaped Patch Antenna

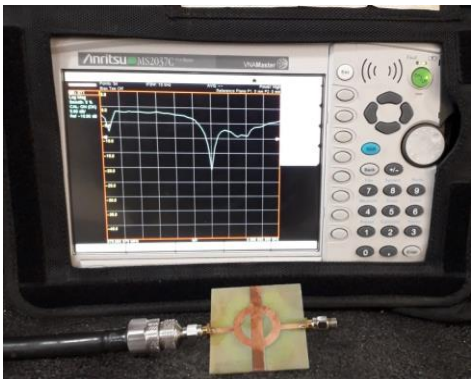


Figure 4. Measuring Return Loss for Dual Feed Φ-Shaped Patch Antenna

Fig 4 shows the Measuring Return Loss from Dual Feed Φ-Shaped Patch antenna connected to network Analyzer.

3. Parameters Of Dual Feed Φ-Shaped Patch Antenna:

The Dual Feed Φ-Shaped Patch Antenna is simulated in HFSS software. High Frequency Structure Simulator (HFSS) solves electromagnetic structures of high frequency applications and uses Finite Element Method (FEM). It is important tool for designing antenna and RF electronic circuit including transmission lines, filters and packaging. Desired results can be obtained through parametric analysis and optimization. The Dual Feed Φ-shaped Patch Antenna is resonating at 3.5 GHz frequency and this frequency is used for 5G application. $|S_{11}|$ <-10 dB is good for antenna design. The Return loss of Dual Feed Φ-Shaped Patch antenna resonates at 3.5GHz is equal to -21.2 dB and is shown in Fig 5. The Simulated and Fabricated values of Return Loss for Dual Feed Φ-Shaped Patch Antenna design is shown in Return Loss Plot.

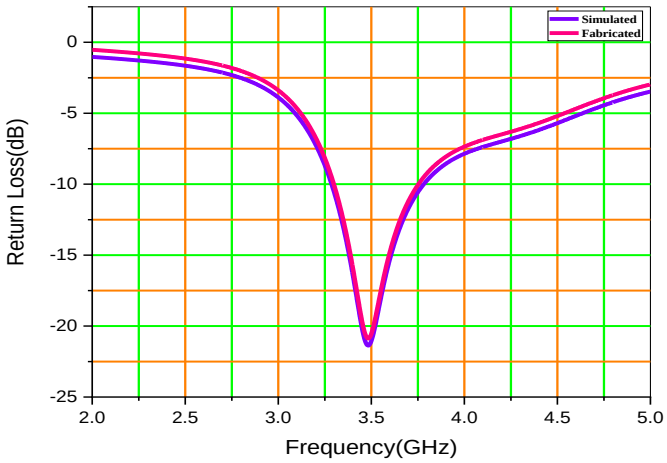


Figure 5. Simulated Vs Fabricated Return Loss for Dual feed Φ-shaped patch antenna

The S-parameters are related to the input-output relationship in an electrical system. In Figure6, we show the characteristics of the dual feed -shaped patch antenna which exhibits a high impedance bandwidth of 3.3 to 3.8 GHz.

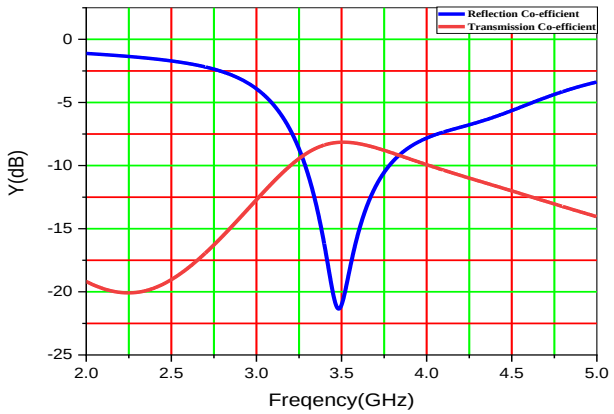
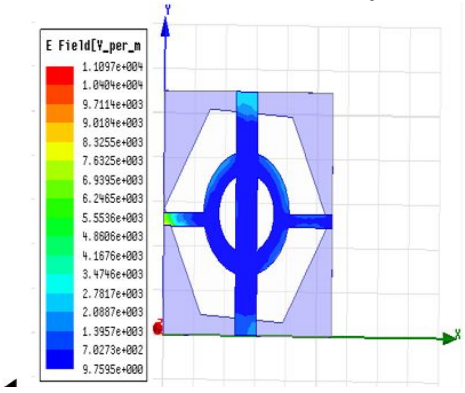
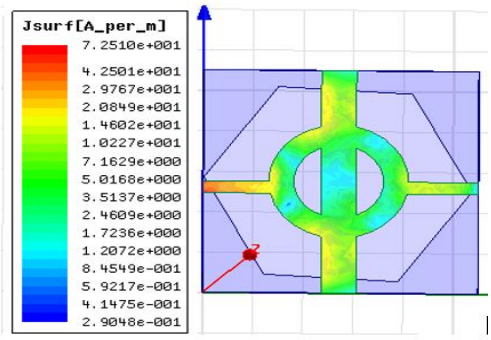


Figure 6 S Parameters for Dual Feed Φ-Shaped Patch Antenna



(a)

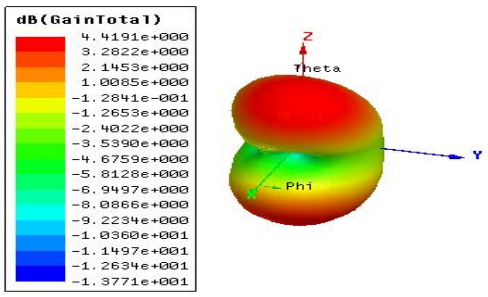


(b)

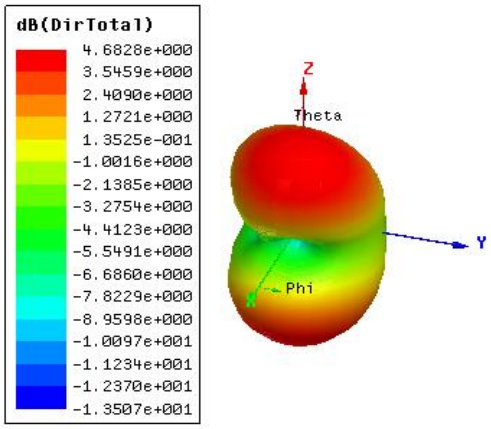
Figure 7. Current Flow at Resonant Frequency 3.5 GHz

(a) E-Field (b) J-Field

Gain is the fundamental parameter for an antenna and determines the performance of antenna through a direction to give a better picture of radiation pattern. The Dual Feed Φ-Shaped Patch Shaped Antenna has the gain of 4.41 dB which is shown in Fig 8(a). The Radiation Pattern is the mathematical or graphical representation of radiation properties of antenna. Directivity is the fundamental parameter for an antenna. It determines the direction of antenna radiation pattern. The Dual Feed Φ-Shaped Patch antenna has the directivity of 4.68dB which is shown in Fig 8(b).Full form of VSWR is voltage standing wave ratio. The VSWR shows the amount of relected power from the antenna. The VSWR is a positive real number for antennas. The antenna is matched to transmission line when VSWR value is small.The VSWR plot is shown in Fig 9. And it is less than 2 dB which is 1.51.The Simulated and Fabricated values of VSWR for Dual Feed Φ-Shaped Patch Antenna is plotted in Fig 9.



(a)



(b)

Figure 8 Dual Feed Φ-Shaped Patch Antenna

(a) Gain (b) Directivity

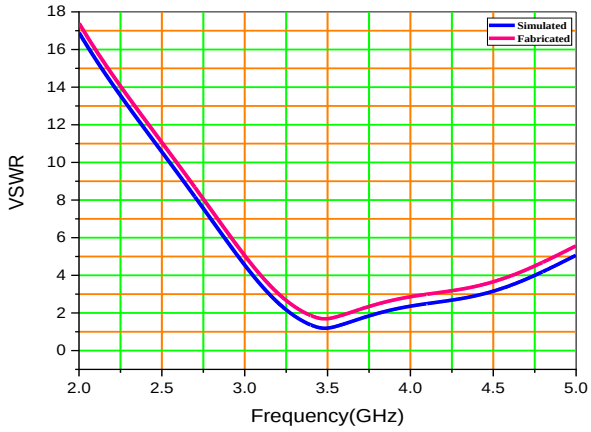
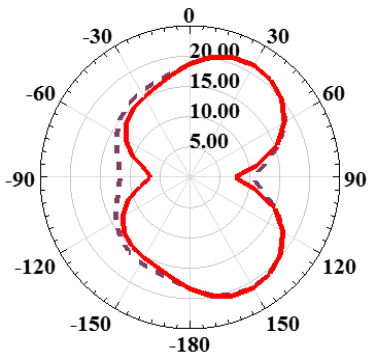


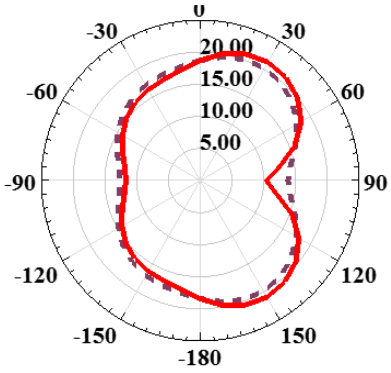
Figure 9. Simulated Vs Fabricated VSWR Graph for Dual Feed Φ-Shaped Patch Antenna

The Radiation Patterns for Dual Feed Φ-Shaped Patch Antenna is shown in Fig 10 which shows when Theta(θ) is not varying and Phi(Φ) is varying. Phi values are Φ = 0, 30 , Φ = 30, 60, Φ = 60, 90, Φ = 90, 120, Φ = 120, 150 and Φ = 150, 180. The difference between the upper cut-off frequency and lower cut-off frequency gives bandwidth. The mathematical expression for bandwidth is

$BW = (F_H - F_L)/F_C X\ 100$



(a)


0
-30
30
20.00
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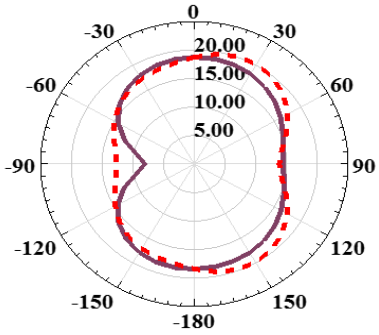
60
-90
90
-120
120
-150
150
-180

(b)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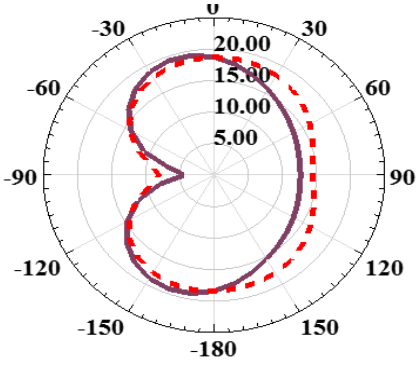
(c)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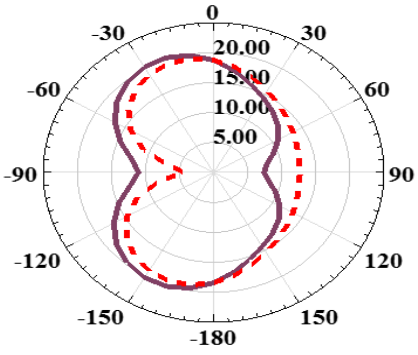
(d)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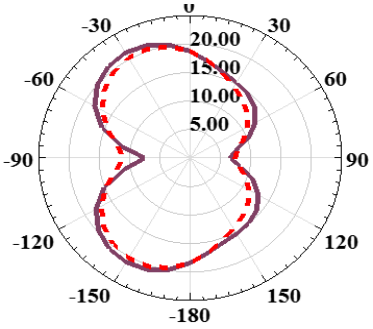
(e)



(f)

Figure 10 Radiation Patterns for Dual Feed Φ-Shaped Patch Antenna when θ is not varying for (a) Φ = 0, 30 (b) Φ = 30, 60 (c) Φ = 60, 90 (d) Φ = 90, 120 (e) Φ = 120, 150 (f) Φ = 150, 180

The characteristics of the dual feed -shaped patch antenna are compared with those of the reference antennas. It provides a gain level of 4.41 dBat the resonant frequency of 3.5 GHz. Comparison of design characteristics with referenced antennas

Table 1. Comparison of design characteristics with referenced antennas

Reference	[12]	[13]	[14]	This Work
Substrate Material	FR4	FR4	FR4	FR4
Shape of Patch	Square	Slotted Square	Elliptical	Φ-Shaped
Resonant Frequency (GHz)	2.23	2.27	5	3.5
Gain (dB)	3.5	3	2.35	4.41
Return Loss (dB)	-14	-10.53	-10.23	-21.2
Size (mm)	28x 28	28 x 28	35 x 30	55 x 55

4. Conclusion:

Dual feed Φ- Shaped patch antenna is designed by using HFSS software. The microstrip Patch Antennas are widely used antennas because of its light weight, cost is low and easy to fabricate. The dielectric substrate used is FR4 Epoxy. The return loss of dual feed Φ-shaped patch antenna below -10 dB is -21.2 dB. The Dual Feed Φ-Shaped Patch Antenna exhibits an impedance bandwidth of 3.3-3.8 GHz. The VSWR and Gain of Dual Feed Φ-Shaped Patch Antenna is 1.51 and 4.41 dB respectively. The Dual Feed Φ-Shaped Patch Antenna is suitable for 5G applications. 5G operates at frequencies of about 28 GHz and 39 GHz. The initial frequencies of 5G are below 6GHz i.e., 3.3-3.8 GHz.

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