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Bandwidth Enhancement of Hexagonal Microstrip Patch Antenna by Ground Defect Technique

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Abstract- The Design of hexagonal patch is presented withsingle coaxial feed namelysimple hexagonalpatch,hexagonal patch with one triangular slot in ground for circular polarization. The circular polarization of two antennas are obtained with 1.31% axial ratio(AR) for simple hexagonal patch, 4.43% axial ratio hexagonal patch with slotted ground hexagonal patch antenna. The impedance band widths of these antennas are achieved as 1.85% for simple patch, 5.21% for slot ground patch. The feedlocation is optimized for the best impedance match to a 50Ω coaxial feed line. The average gain and radiation efficiency of antenna are also evaluated. Simulatedresults are verified experimentally

Index Terms-Microstrip antenna**,**hexagonalmicrostrip antenna, circularly polarized microstrip antenna, single coaxial feed.

I. INTRODUCTION

Circular polarization (CP) is more attractive due to increased number of applications in wireless communication, sensor system,global navigation satellite system and military. This is because circular polarization (CP) antenna does not require alignment of electric field vector at the receiving and transmitting end. Single feed allows a reduction in size, weight, complexity and RF power loss of any array feed. Circular polarization antennas are also useful as dual orthogonal feed power dividers but it is not suitable for present sensors [1-2] because large in size.

Regular geometrical shaped patches with a single feed point generally radiate linear polarization. In order to radiate circular polarization, it is necessary for two orthogonal modes with equal amplitude and in phase quadrature to be excited. A single patch antenna can be made to radiate as circular polarization if two orthogonal patch modes are simultaneously excited with equal amplitude and ±90 degree outphase with the sign determining the sense of rotation [1, 5]. This can be achieved by $45^o$from the x-axis coaxial feeding. We can improve the performance of antenna by introducing a parasitic element. The parasiticelements can be of two types, one is in horizontal plane and one in vertical plane. When the parasitic element is placed in horizontal plane with driven element, it increases the size of antenna but when placed in vertical over the feed driven patch, it reduces the size and becomes suitable for wireless communication system [6, 9].

So far circular polarization has been generated using various shapes i.e. triangular, circular and square. In this paper, hexagonal geometry of antenna of simple patch with circular polarization has been studied as against the modified slotted ground hexagonal patch antenna and parasitic hexagonal patch antenna.

II. DESIGN OF CIRCULAR MICROSTRIP ANTENNA (CMSA)

The resonance frequency of circular microstrip antenna can be designed using the equation

$$f_r = \frac{\chi_{mn} c}{2\pi a \sqrt{\varepsilon_r}} \quad \text{eq.....1}$$

Wheref_r ; resonance frequency Xmn=1.8411 for the dominant mode TM_{11}, c=velocity of light in free space, ε_r=relative permittivity of the substrate where as effective radius of circular microstrip antenna is given by

$$a_e = a\left\{1 - \frac{2h}{\pi a \varepsilon_r}\left(\ln\frac{\pi a}{2h} + 1.7726\right)\right\}^{1/2}$$

eq…..2

In the above expression, a is the actual radius of the circular patch antenna as shown in Figure 1, h isheight of the substrate and $\varepsilon_r$is relative permittivity of the substrate.

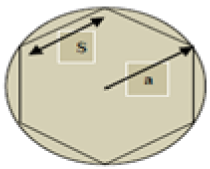


Fig. 1 Circular Microstrip Patch

III. HEXAGONAL MICROSTRIP ANTENNA (HMSA) DESIGN

Hexagonal microstrip patch antenna is one of the variousshapes capable for circular polarization[3,4].The design of hexagonal microstrip antenna can be done by using variation of static energy below hexagonal circular patch [5]. The relationship between the equivalent areas of circular and hexagonal patches in given [3, 4]

$$\pi a_e^2 = \frac{3\sqrt{3}}{2} S^2$$

………eq(3)

WhereSis side of hexagonal patch and a_e is effective radius of circular patch. The Figure 2 shows the top view of hexagonal microstrip patch.

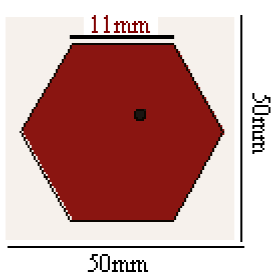


Fig 2

IV.ANTENNA CONFIGURATION

1. Simple hexagonal microstrip patch

Hexagonal microstrippatch antenna is designed on substrateFR4 with dielectric constant ε_r=4.3, thickness h=1.53mm and substrate size 50mm x 50 mm.The side length of hexagonal patch antenna has been calculated using the above expression eq(3) and obtained to be 11mm for the central frequency f_o =3.5GHz is show in Figure 2.To obtain the circular polarization, we optimized the feed location from the center of patch to an angle of 45°from x-axis. The feed position is optimized by 3D software HFSS.These parameters are common for all the mentioned structures in this paper.

2. Slotted ground hexagonal patch antenna

Second design a single triangular slot in cut out in ground plane with size length of slot is 11mm and 7.778 mm and side length of driven patch is 11mm, Top view of structure show in figure 4.This antenna is simulated by adjusting the feed position and length of triangular slot in ground. The center frequency of antenna is shifted towards higher frequency 3.84 GHz with the improvement in bandwidth.

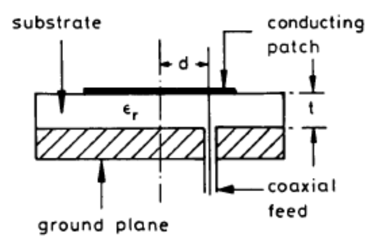
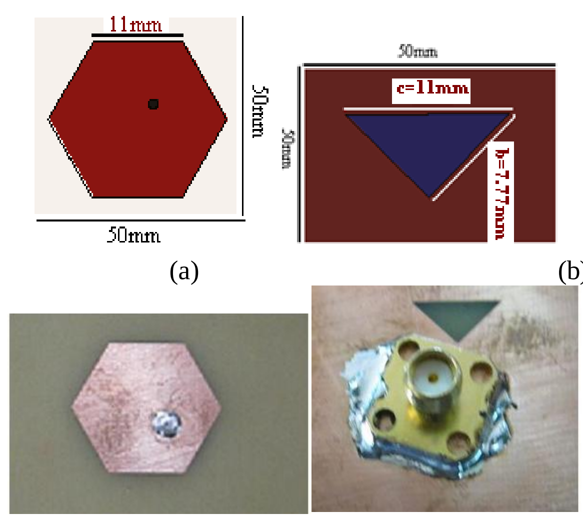


Fig. 3 Side view simple hexagonal microstrip patch



(c) (d)

Fig(4) Top view of simulated (a)hexagonal patch(b)Triangular slot in ground Fabricated(c)Simple patch(d)Triangular slot in ground

V. **SIMULATED RESULTS AND DISCUSSION**

1. Impedance Bandwidth

We designed the simple hexagonal patch at central frequency f_o= 3.5GHz and optimized the feed location at d=2.96mm from the center of patch. We obtained an impedance bandwidth of 64.4MHz from 3.45 GHz to 3.52 GHz at VSWR 2:1with 1.85 % bandwidth as shown in Figure 6.In the second, a single triangular slot is cut out in ground plane and its size and feed location are optimized. The optimum feed location is obtained d=4.19mm and size length of slot triangular is obtained 11 mm and 7.778 mm. The impedance bandwidth obtained 200.5MHz from 3.74GHz to3.94GHz at VSWR 2:1 with corresponds to 5.2% for the corresponding central frequency of 3.84GHz. This bandwidth is 3.36 % more in comparison to simple hexagonal patch. The optimized dimension of hexagonal patched are tabulated in Table -1 .It is observed that the impedance bandwidth increases and central frequency shifts towards higher frequency for ground slotted patch against the simple patch antenna it is show in figure(5)

S No	Types of patch	Feed point(mm)	Impedance bandwidth (MHz)	Axial bandwidth(MHz)	Avg Gain (dB)	Eff. η %	f_o GHz
1	Simple	2.96	64.4	45.80	6.0	94	3.50
2	Slotted	4.18	200.5	170	6.5	83	3.84

Table 1 Optimum dimension of simple hexagonal microstrip patch,slotted ground hexagonal microstrip patch.

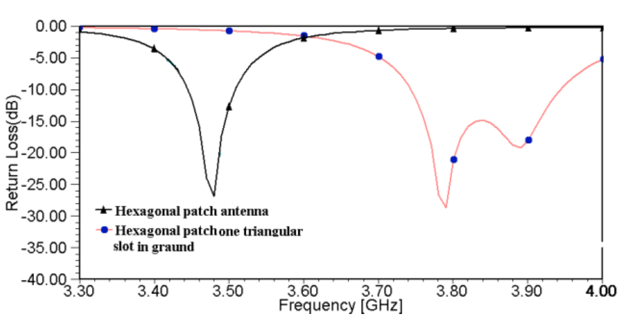


Fig.5 Simulated Return Loss(dB) of simple, slotted ground plane patch antenna

2.Experimental Impedance Bandwidth

Experimental impedance response of hexagonal with slotted ground is shown in figure 6. The impedance bandwidth obtained 214MHz from3.722GHz to3.936GHz at VSWR 2:1 with corresponds to 5.58% for the corresponding central frequency of 3.83GHz.center frequency slightly shift lower side due to connector ,soldering iron etc...

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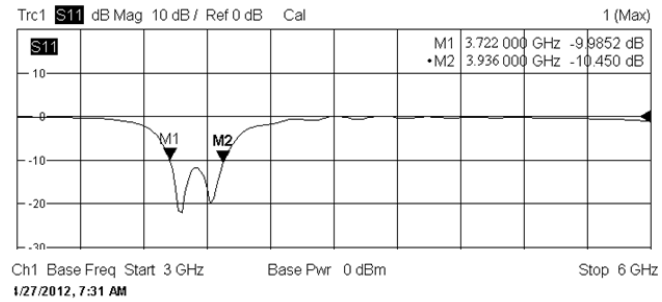


Fig 6 Experimental impedance response of ground slotted hexagonal

3. Axil Ratio

The purity of circular polarization is measured by axial ratio. Both circular polarized antennas are simulated for axial ratio.The simulated axial ratio bandwidth is calculated at 3 dB.The comparison of simulated axial ratios of both antennas are shown in Figure 7.It is observed from the simulated axial ratio for the simple hexagonal patch is achieved 45.8 MHz from frequency 3.44GHz to 3.49GHzat 3 dB axial ratio. This corresponds to 1.85 % axial bandwidth with center frequency of 3.47 GHz. For 2^{nd} antenna structure, the simulated axial ratio bandwidth is achieved 170MHz from frequency3.7641GHz to 3.9338GHz. This corresponds to 4.43% axial bandwidth at 3dB with center frequency3.84GHz.We observed that axial ratio bandwidth increase in case slotted ground patch antenna with comparison to simple hexagonal patch.

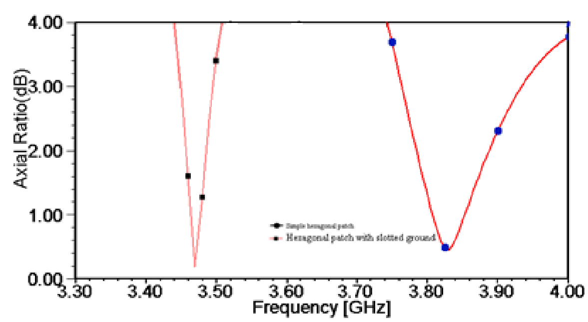


Fig. 7 Simulated axial ratio of simple, slotted ground plane patch antenna

4.Average Gain and Radiation Efficiency

The average gain of both antenna are also simulated. The average gain of the both antenna are: 6dB for simple hexagonal patch, 6.50dB for slotted antenna at center frequenct as shown in Figure 8. It is observed that the average gain increases for slotted ground patch antenna. The radiation efficiency of the both antenna has also been calculated and compared as shown in Figure 9. Radiation efficiency is obtained 94% for simple hexagonal patch, 83% for slotted ground antenna.

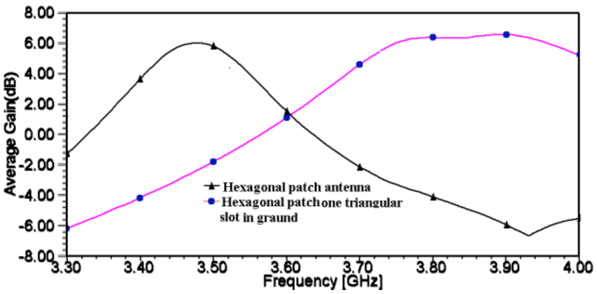


Fig. 8 Simulated average gain (dB) for simple hexagonalPatch, slotted ground hexagonal patch

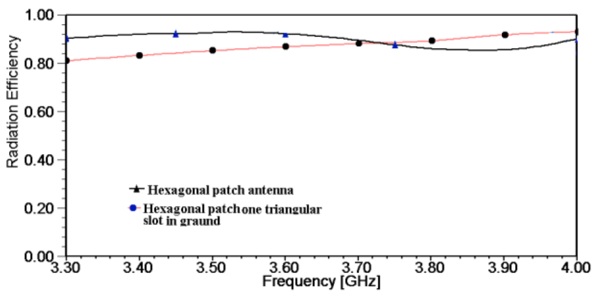


Figure 9 Simulated radiations Efficiency of Response of efficiency (η)

5. Radiation Patterns

These antennas are simulated in E and H –plane at center frequency. Figure 10 shows the E and H-plane radiation patterns of simple microstrip hexagonal patch at 3.47 GHz. The red color radiation pattern is in E-plane and black color is in H-plane. The slotted antenna radiation pattern is also simulated in E and H –plane at center frequency. Figure 11 shows the E and H-plane radiation patterns of slotted microstrip hexagonal patch at 3.8 GHz. The red color radiation pattern is in E-plane and black color is in H-plane. The back side of slotted patch antenna reduces in both E-plane and H-plane.

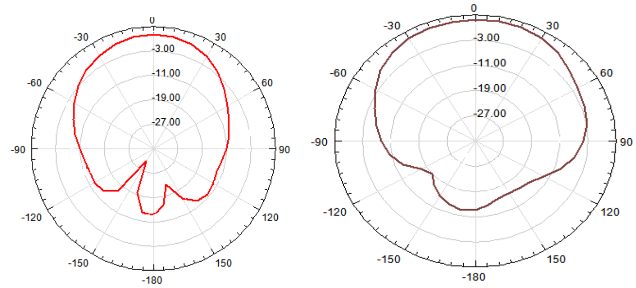


Fig. 10 Simulated radiation paterrn of simple patch (a)E-Plane (b)H-Plane at f=3.47GHz

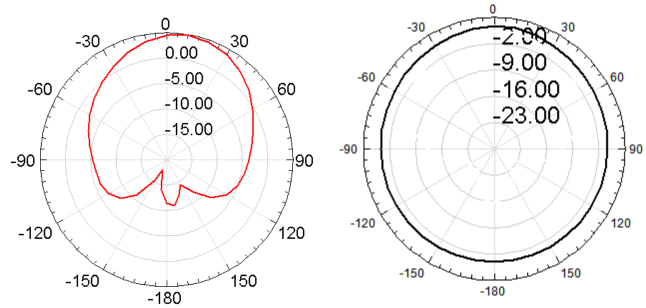
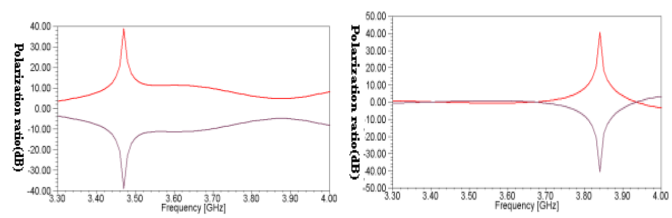


Fig. 11Simulated radiation pattern of slottedgroundpatch antenna(a) E-Plane (b)H-Plane at f=3.8GHz

6. Polarization Ratio

Theseantennas are simulated for the circular polarization rectangular plots. The CP plots for simple hexagonal, slotted ground hexagonal are shown in Figure 12. From the simulated results



(a) (b)

Fig.12, Simulated LHCP and RHCP for (a) simple (b) slotted antenna

VI .CONCLUSIONS

These antennas simple hexagonal patch, slotted ground antenna have been designed and simulated with respect to bandwidth, axial ratio, average gain and efficiency. The impedancebandwidth of slotted patch is achieved more in comparisons to simple hexagonal patch antenna. The average gain achieved in slotted hexagonal patch more than simple hexagonal patch antenna and radiation efficiency achieved more in simple patch against slotted patch antenna. The radiation pattern of E and H plane also studies it is observed the design of another circular polarization antenna with slotted is offer the better performance in term of bandwidth of purity of circular polarization and average gain .These antennas are very simple to design easy to fabrication with MIC/MMIC.

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