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Improvement of Circular Shaped Microstrip Patch Antenna Performances Using Triangular and Pentagonal Shaped Patches

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ABSTRACT : *A triangular and pentagonal shaped micristrip patch antenna with coaxial probe feed have been designed in this paper to increase the performances of a circular shaped microstrip parch antenna. FR4_epoxy substrate material with dielectric constant 4.4 is used to design the antenna. A comparative study have been made among the circular, triangular and pentagonal shaped patches. Among them, the pentagonal shaped patches gets the better performances whose return loss, bandwidth, gain, directivity and efficiency are -42.585dB, 200 MHz, 3.61dB, 5.48dB and 65.88% respectively. The return loss, bandwidth, gain, directivity and efficiency all are increased 11.80%, 4.987%, 35.71%, 21.78%, 11.47% respectively by pentagonal shaped patch compared with circular patch. The antenna has been designed using ansoft HFSS software to operate in the C-band having resonant frequency at 5 GHz.*
KEYWORDS: *Triangular & pentagonal patch, return loss, bandwidth, gain, efficiency, ansoft HFSS.*

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I. INTRODUCTION

Wireless communication processes are increasing day by day. Microstrip patch antenna that is used in wireless communication because of its remarkable advantages such as small profile, simple fabrication process, less manufacturing cost etc [1]. However it has many drawbacks. Small impedance bandwidth, low gain are the main problems of microstrip patch antenna [2]. To overcome this problem, many techniques have been used. A circularly polarized slotted rectangular compact microstrip patch antenna has been proposed in [3] for improvement of bandwidth. A partial ground plane, modified circular patch with jeans substrate textile material is proposed in [4]. This antenna is best suitable for body centric and C- band satellite communications because it covers the frequency range of 3.64 – 4.79 GHz. In paper [5], a hybrid fractural slot along with partial ground plane microstrip patch antenna is designed to improve the bandwidth. An inset feed microstrip antenna with elliptical patch is proposed for improvement the performances in [6]. Gain and bandwidth are improved using EBG substrate shown in [7]. To improve the bandwidth, a compact circularly polarized antenna is used in [8]. Stacked microstrip antenna is used in [9] to improve the performances.In paper [10], different shaped microstrip patch antenna such as rectangular, circular and elliptical shaped patches are used with coaxial probe feeding technology to compare among the patches. The dimensions of the antenna is 30 ×30 × 1.65 mm^3 where the elliptical shaped patches gets the better performances. This antenna is resonates as 5.00 GHz and its bandwidth, gain, directivity are 200 MHz, 2.96 dB, 4.66 dB respectively. In paper [11], a circular shaped microstrip patch antenna is designed and its performances is analyzed. The size of the antenna is 30 ×30 × 1.60 mm^3. It is resonated as 5.026 GHz and its return loss is -38.09 dB. The bandwidth, gain, directivity and efficiency of this antenna are 190.5 MHz, 2.66dB, 4.5dB and 59.1% respectively.

In this paper, a triangular and pentagonal shaped microstrip patch antenna have been designed to improve the performances of circular shaped microstrip patch antenna.

II. ANTENNA DESIGN AND DIMENSIONS

A triangular and pentagonal shaped patch antenna have been design in this paper that are shown in Fig. 1(a-b). Where **W** and **L** are used as the width and length of substrate material and ground. Firstly the radius of circular patch is calculated. Then three and five sides are used to create triangular and pentagonal patches. If the radius of circular shaped patch is "**a**" then the radius can be calculated as [11]

$$a=\frac{F}{\{1+\frac{2h}{\Pi\varepsilon_r F}\left[\ln\left(\frac{\Pi F}{2h}\right)+1.7726\right]\}^{1/2}} \quad \text{---------- (1)}$$

where, $F=\frac{8.791\times10^9}{f_r\sqrt{\varepsilon_r}}$ ---------- (2)

f_r = resonant frequency

ε_r = dielectric constant of substrate material

h= height of substrate material

Here FR4_epoxy substrate material is used whose dielectric constant is 4.4. In those design, coaxial probe feeding technology is used that is shown in Fig 1 (c). The radius of inner and outer cylinder are **d** and **D** where inner cylinder is used as 'pce' material and outer is as 'vacuum'. The position of inner and outer cylinder is used as (x,y) and the height of inner and outer cylinder is h_c. The antenna is designed using ansoft HFSS software. The overall dimensions of coaxial probe feed triangular and pentagonal shaped patches are shown in Table I.

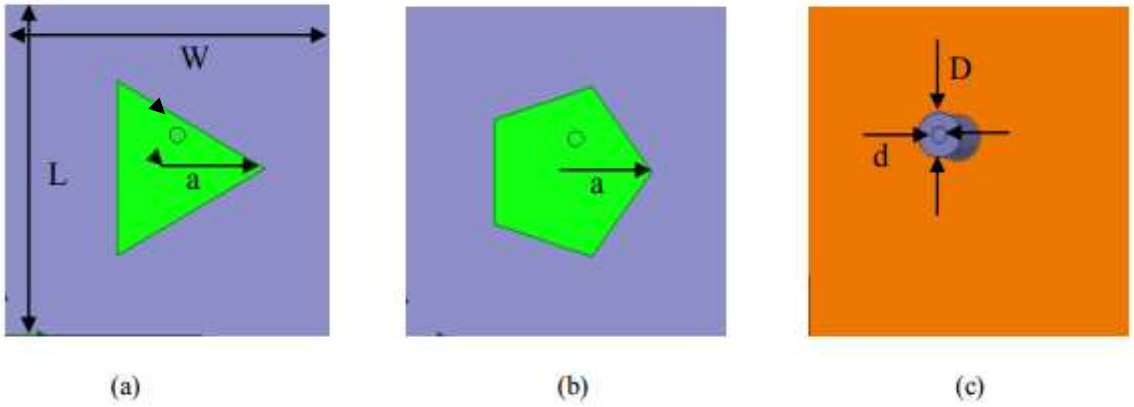


Fig.1: Geometry and dimension of proposed antenna (a) triangular (b) pentagonal patches (c) coaxial feed

Table I: Optimized dimension of proposed antenna

f_r= 5.00 GHz	ε_r= 4.4	h= 1.6 mm	W= 30 mm	L= 30 mm
a= 8.05 mm	(x,y)= (16mm, 18mm)	d= 0.7 mm	D= 2 mm	h_c= 7.9mm

III. RESULTS AND DISCUSSION

A triangular and pentagonal shaped microstrip patch antenna with coaxial probe feeding technology have been proposed whose performances are observed in terms of the return loss, bandwidth, gain, directivity, VSWR, efficiency etc. The performances are shown below—

A. Return loss & Bandwidth:

The return loss plot of coaxial probe feed triangular and pentagonal shaped microstrip patch antenna has been given in Fig. 2 (a-b). It has been observed that in Fig 2 (a), the return loss of triangular patch is -22.03dB which is resonated at 5.13 GHz and its bandwidth is 190 MHz (5.03-5.22 GHz). In Fig 2 (b), the return loss of pentagonal patch is -42.585dB which is resonated at 5.00 GHz and its bandwidth is 200 MHz (4.90-5.10 GHz). Here pentagonal patch gets the better results.

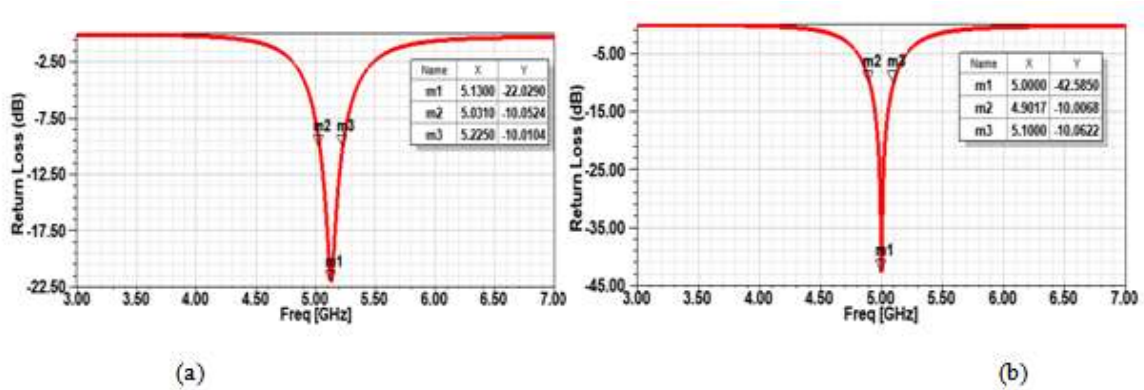


Fig. 2: Return loss of coaxial feed (a) triangular (b) pentagonal shaped microstrip antenna

B. Gain:

The gain plot of the coaxial probe feed triangular and pentagonal shaped microstrip patch antenna have been given in Fig. 3 (a-b). It has been observed that the gain of triangular and pentagonal patches are 3.36dB and 3.61dB respectively. Here pentagonal patch gets the better results.

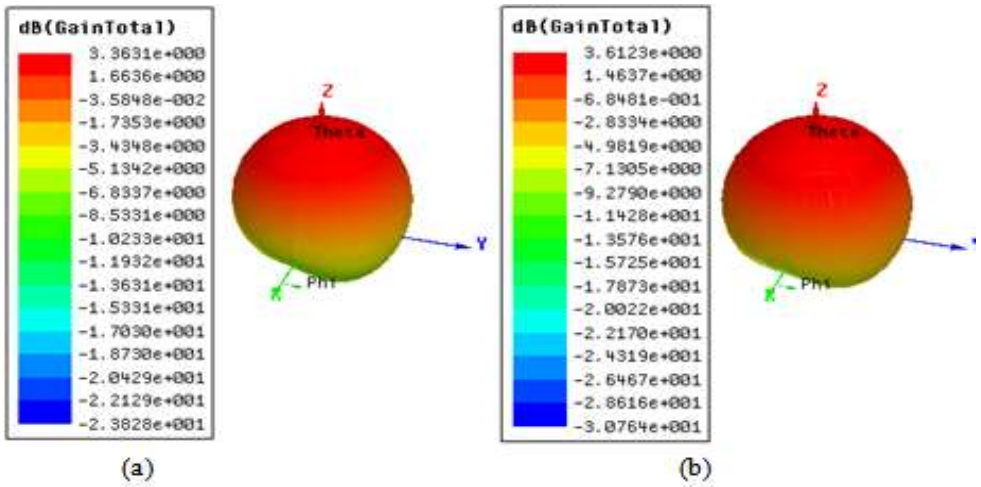


Fig. 3: Gain of coaxial feed (a) triangular(b) pentagonal microstrip antenna

C. Directivity

The directivity plot of the coaxial probe feed triangular and pentagonal shaped microstrip patch antenna have been given in Fig. 4 (a-b). It has been observed from Fig.4 (a-b) that the directivity of triangular and pentagonal patches are 5.13dB and 5.48dB respectively. Here pentagonal patch gets the better results.

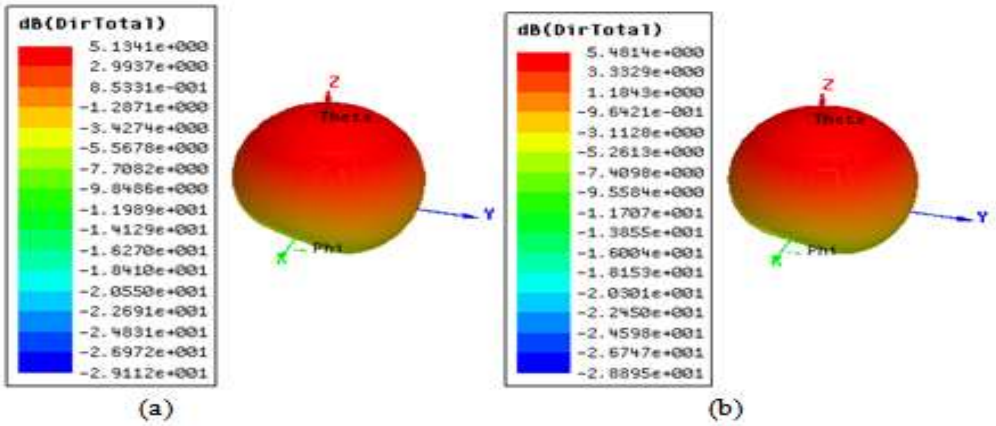
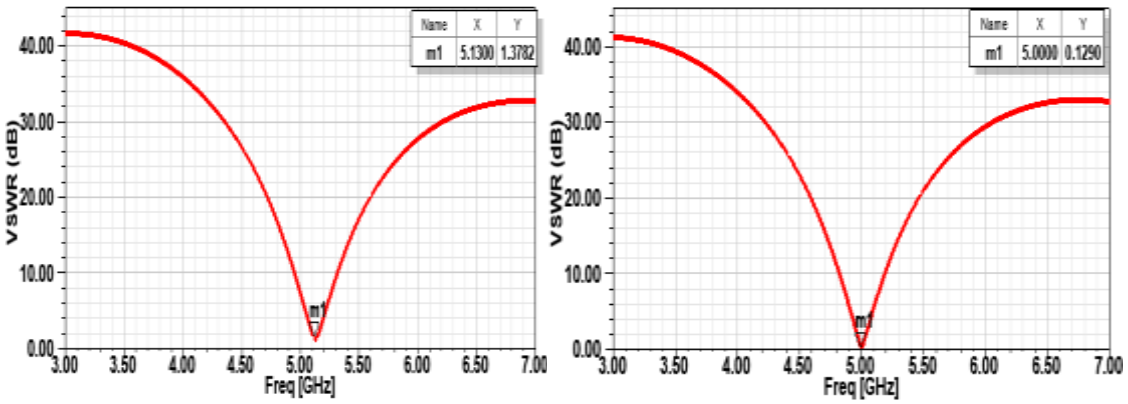


Fig. 4: Directivity of coaxial feed (a) triangular (b) pentagonal microstrip antenna

D. VSWR

The Voltage Standing Wave Ratio (VSWR) of triangular and pentagonal patches are 1.38dB and 0.13dB respectively those are shown in Fig 5 (a-b). As pentagonal shaped patches gets the lower value of VSWR, its performance is better.

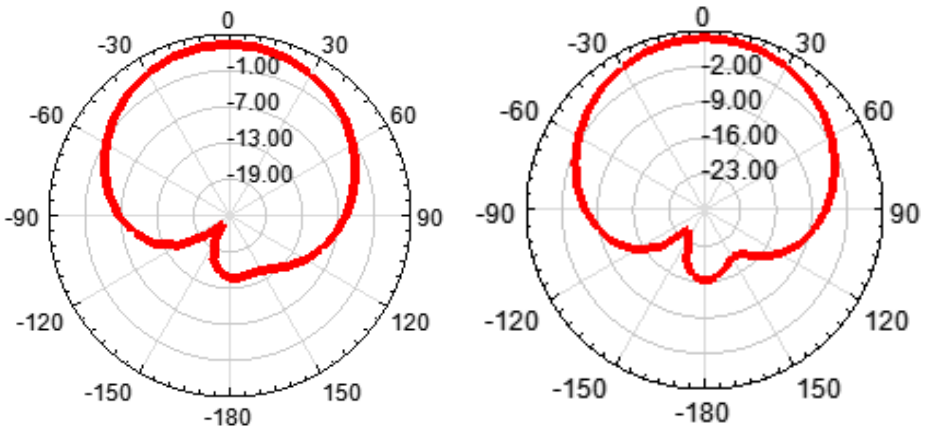


(a) (b)

Fig. 5: VSWR of coaxial feed (a) triangular (b) pentagonal microstrip antenna

E. Radiation pattern

The 2D radiation pattern of the coaxial probe feed triangular and pentagonal shaped patch antenna has been given in Fig. 6 (a-b).



(a) (b)

Fig. 6: 2D Radiation plot of coaxial feed (a) triangular (b) pentagonal microstrip antenna

Now a comparative report have been created among the circular [11], triangular and pentagonal patches those are shown in Table II. From the table, it is shown that, the pentagonal shaped patch gets the better performances than triangular and Ref. [11]. The return loss of pentagonal patch is -42.585dB which is better than circular [11] and triangular patches and it is resonated at 5 GHz that is exactly matched than others. The bandwidth, gain, and directivity of pentagonal patches are 200 MHz, 3.61dB and 5.48dB respectively. The efficiency calculated by the ratio of gain and directivity is 65.88%. From Table II, it is also seen that, the return loss, bandwidth, gain, directivityand eficiency are 11.80%, 4.987%, 35.71%, 21.78% and 11.47% greater than the Ref. [11].

Table II: Comparative results

Parameters	Circular Patch, Ref. [11]	Triangular Patch	Pentagonal Patch	Parameters increased by Pentagonal Patch compared with Ref. [11]
Resonance peak (GHz)	5.026	5.13	5.00	exactly matched
Return loss (dB)	-38.09	-22.03	-42.585	11.80%
Bandwidth (MHz)	190.5	190	200	4.987%
Gain (dB)	2.66	3.36	3.61	35.71%
Directivity (dB)	4.5	5.13	5.48	21.78%
Efficiency (%)	59.1%	65.49%	65.88%	11.47%

IV. CONCLUSIONS

A coaxial probe feed triangular and pentagonal shaped microstrip patch antenna have been designed in this paper and compared with circular patch [11]. Among them, the pentagonal shaped patches gets the better performances. The return loss, bandwidth, gain, directivity and efficiency all are increased 11.80%, 4.987%, 35.71%, 21.78%, 11.47% respectively by pentagonal shaped patch. The performances can be increased more by using various techniques. The antenna can be used in C-band applications.

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