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Design, Simulation and Performance Analysis of Circular Microstrip Patch Antenna for Circualr and Octagon Slots on the Patch

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ABSTRACT

This paper presents the Circular Microstrip Patch Antenna. The antenna is designed on FR-4 substrate with dielectric constant, =4.4 and height, h=1.6mm. Value of Loss Tangent = 0.002. The simulation tool used for the design is IE3D software. The patch used for antenna design is Circular Patch. The results are obtained for 1) Conventional Circular Microstrip Patch Antenna. 2) Circular slots on the patch. 3) Octagon slots on the patch.

Keywords: Circular Patch, Circular and Octagon Slots, FR-4 substrate, IE3D Simulator, Loss Tangent = 0.002.

I. INTRODUCTION

Wireless communication is a boon to mankind. It basically deals with information transmission over a distance without using wires, cables i.e. without any physical medium. There is no limit on distance for such type of communication. Devices employed for wireless communication are cell phones, GPS units, personal computers, laptops and satellite television [1].

The device which plays important role in wireless communication is Antenna. An antenna is basically a transducer that converts one form of signal into another. The need for antenna has increased to a great extent. Nowadays almost in all fields of research, antenna is used widely for smooth communication. They are used in space technology, aircrafts, mobile communication, missiles tracking, satellite broadcasting [2]. Type of antenna depends on the application. Due to the advancement in communication system, antenna requirements are also changing. A lot of research is going on to meet the antenna requirements. The antenna requirements which are in more demand are low cost, light weight, low profile capable to give high performance over a wide range of frequencies. The antenna type which fulfils these requirements are microstrip patch antennas [3][4]. The design of microstrip patch antenna consists of patch and ground plane separated by dielectric substrate. Patch and Ground plane are both conducting and the material used for it is mostly copper. The shape of the patch can be square, rectangular, circular, octagon, hexagon and many more. Depending upon the patch shape, antenna complexity varies [5]. Antenna design mostly depends on antenna dimensions. As the dimensions vary, the antenna parameters such as return loss, gain, directivity, current distribution, antenna & radiation efficiency and radiation patterns also vary. The simulation time required also depends on antenna design. There are four types of feeding techniques. They are Microstrip line feeding, Coaxial feeding, Aperture coupled feeding and

Proximity coupled feeding. Main advantage of coaxial feeding technique is that its practical use is easy. The feed point is determined by trial and error method in order to match the 50 ohms input impedance at feed on the patch. When impedance matching is achieved, more negative return loss and VSWR< 2 is obtained at design frequency [6][7]. In this paper technique used for feeding is coaxial feed. Point for feeding is kept constant for all the designs.

II.ANTENNA CALCULATIONS

2.1. Circular Patch Calculations

The actual radius of circular patch is given by:

$$a = \frac{F}{\left\{1+\frac{2h}{\pi\varepsilon_r F}\left[\ln\left(\frac{\pi F}{2h}\right)+1.7726\right]\right\}^{\frac{1}{2}}} \qquad (1)$$

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

(1) does not consider fringing effect. Since the patch becomes electrically larger due to fringing, patch radius changes and is referred as effective radius of patch, given by:

$$a_e=a\left\{1+\frac{2h}{\pi\varepsilon_r a\left[\ln\left(\frac{\pi a}{2h}\right)+1.7726\right]}\right\}^{\frac{1}{2}} \qquad (3)$$

Hence the resonant frequency, f_r , for the dominant mode TM_{110} is given by:

$$(f_r)_{110}=\frac{1.8412\upsilon_0}{2\pi a_e\sqrt{\varepsilon_r}} \qquad (4)$$

υ_0 is the free space speed of light.

2.2. Dimensions of Slots

Table 1. Design Dimensions

Antenna Design Circular Patch	Dimensions
Conventional Circular Patch	R = 22.7mm
Circular Slots (on Patch)	r = 1.5mm
Octagon slot (on Patch)	r =1.5mm

III.ANTENNA DESIGN

The following are the antenna designs, designed using dimensions given in the TABLE 1. There are total three antenna designs labelled as Fig.1 till Fig.3. The design frequency is 1.8GHz. By using (1) and (2), actual radius of circular patch is calculated and this radius is used in IE3D simulator to draw circular patch. IE3D simulator considers fringing effect and radius of patch increases which is referred as effective radius and is calculated by using (3).

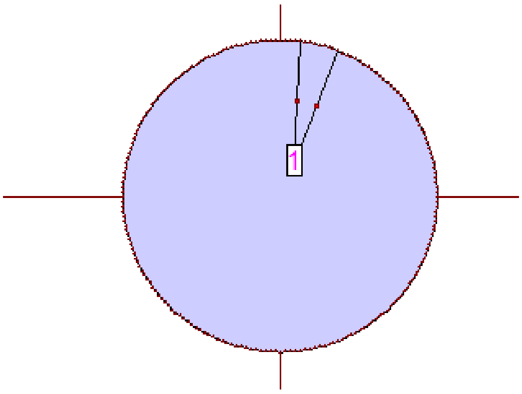

fig.1. conventional circular patch

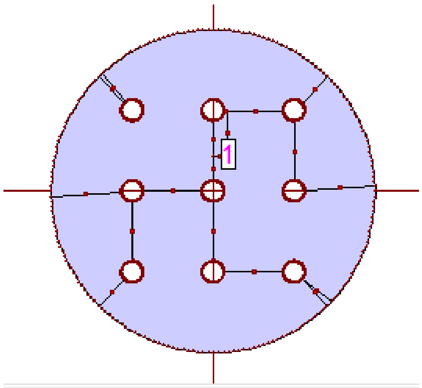

fig. 2. circular slots on the patch

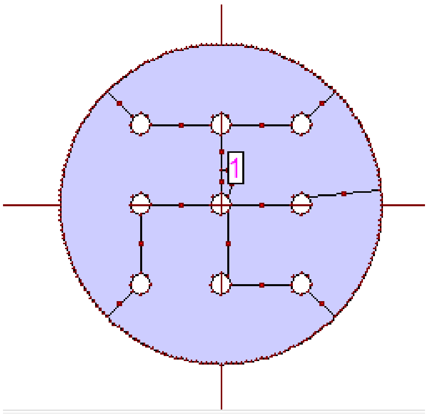

fig. 3. octagon slots on the patch

IV.SIMULATION AND RESULTS

The simulation results of antenna design consist of graphs of return loss vs. frequency and radiation patterns of the designed antennas. For all the designs, the operating frequency range is from 0.5 to 4GHz. This range is chosen depending upon the frequency in which antenna should operate. The other antenna parameters such as resonating frequency at which antenna radiates maximum, return loss, VSWR, radiation efficiency, antenna efficiency, gain, and directivity are tabulated in the TABLE 2. The feed point used is (2,5).

1.1 Conventional Circular Patch Antenna

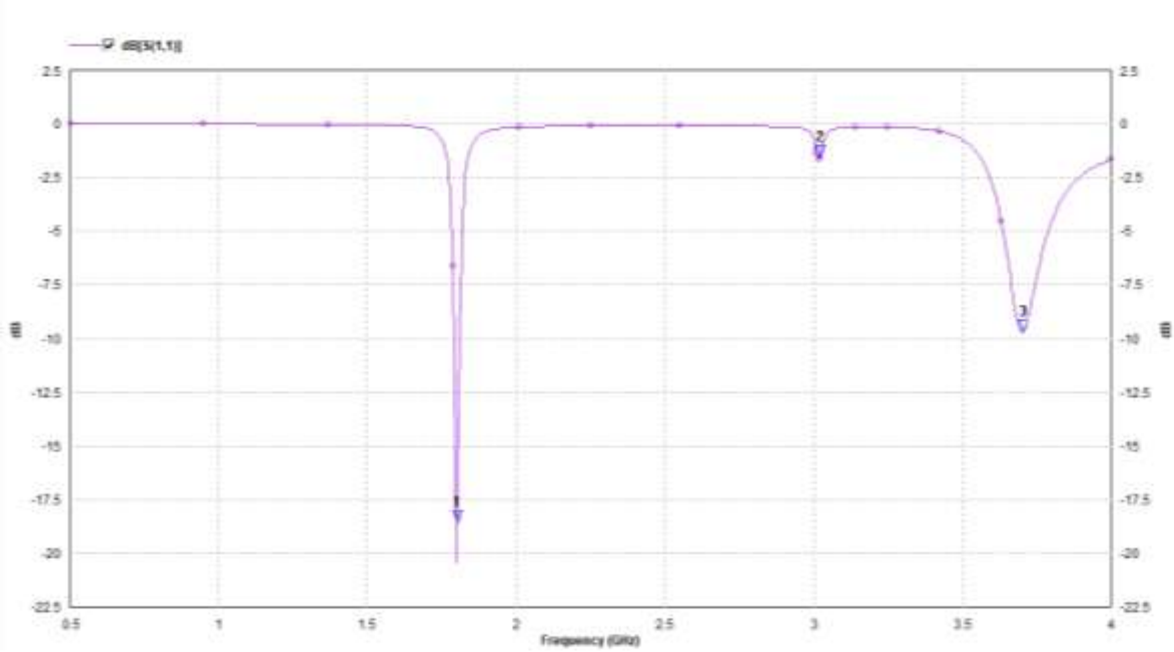

fig.4. return loss vs frequency

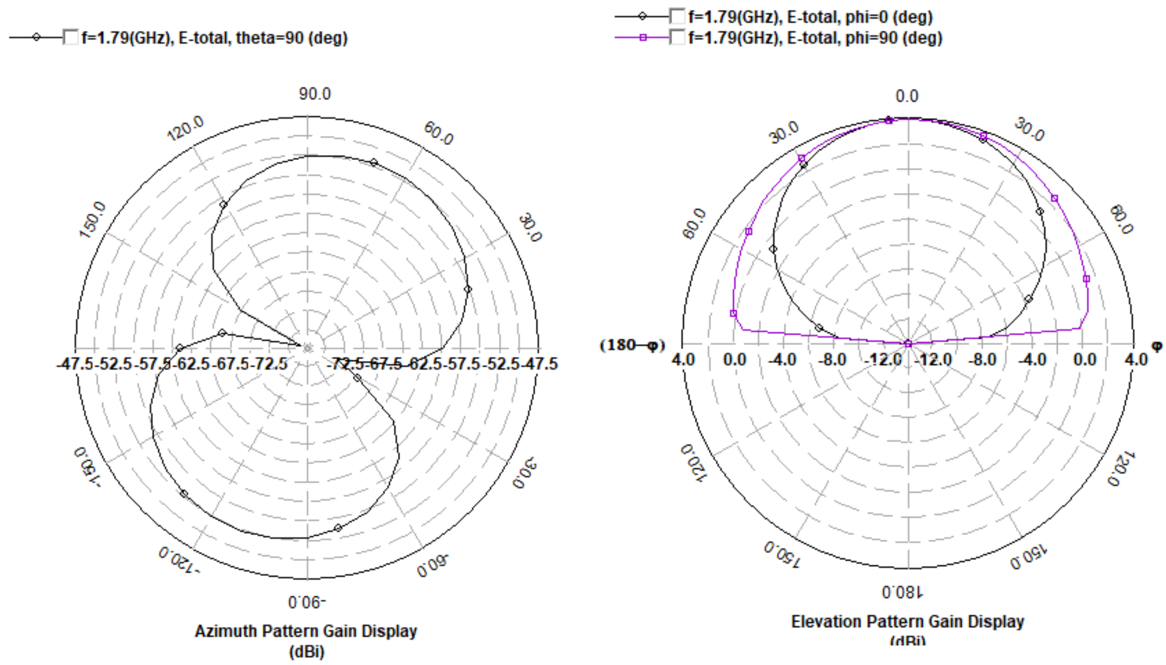

fig.5. radiation pattern XY (azimuth pattern), YZ and XZ (elevation pattern) plane

1.2 Circular Patch Antenna with Circular slot over the patch

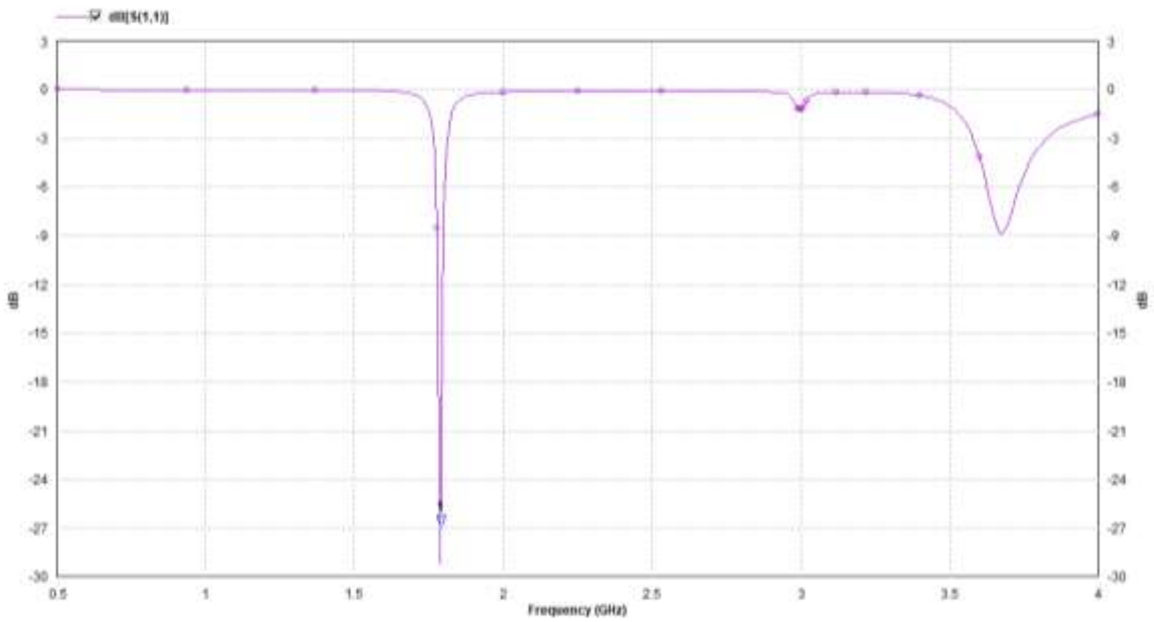

fig.6. return loss vs frequency

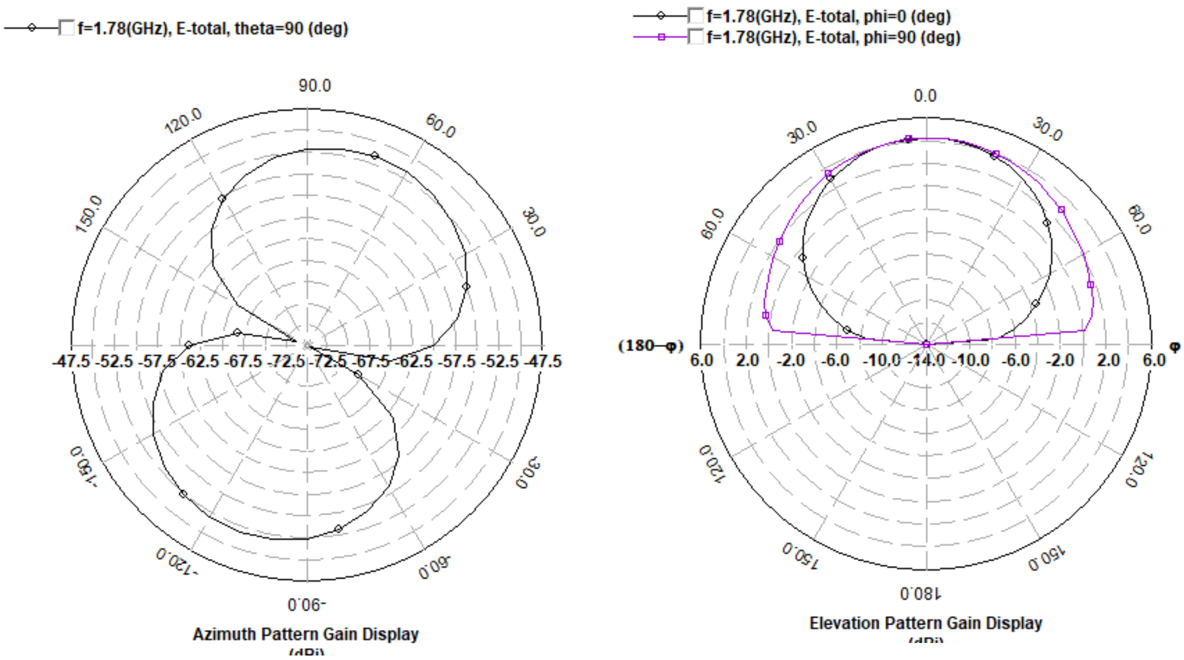

fig.7. radiation pattern XY (azimuth pattern), YZ and XZ (elevation pattern) plane

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1.3 Circular Patch Antenna with Octagon slot over the patch

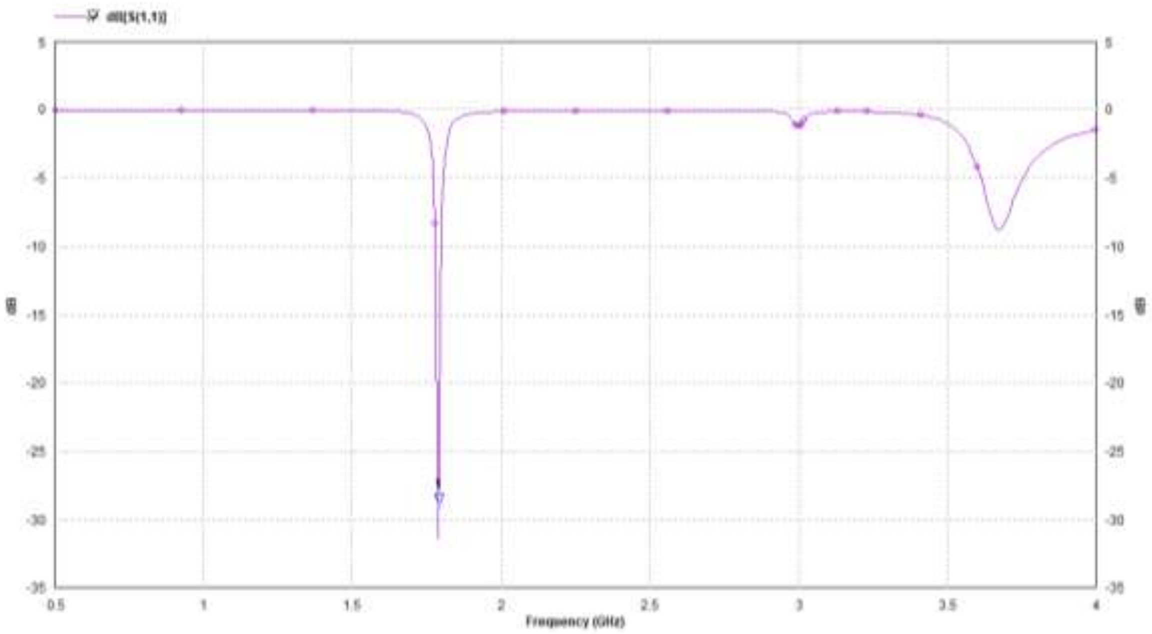

fig.8. return loss vs frequency

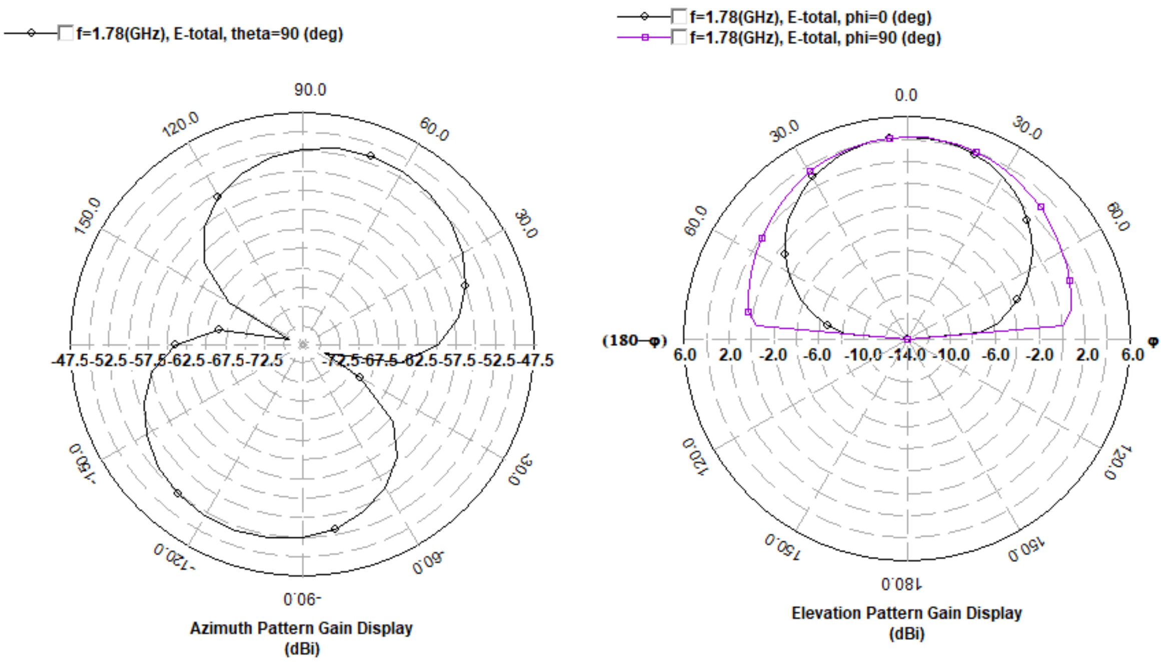

fig.9. radiation pattern XY (azimuth pattern), YZ and XZ (elevation pattern) plane

Table 2. Antenna Parameters

Antenna Design Circular Patch	Antenna Parameters						
	Frequency (GHz)	**Return Loss (dB)**	**VSWR**	**Radiation Efficiency** (%)	**Antenna Efficiency (%)**	**Gain (dBi)**	**Directivity (dBi)**
Conventional	1.80	-18.59	1.61	73.11	57.28	3.86	6.28
Circular Slots (Patch)	1.79	-27.03	1.81	71.94	61.89	4.20	6.29
Octagon Slots (Patch)	1.78	-29.03	1.7	72.24	61.73	4.19	6.29

V.CONCLUSION

The paper contains work done on Circular Microstrip Patch Antenna designed using Circular and Octagon slots. It is observed that all three antenna designs resonate at design frequency. When slots are made on the patch, the frequency at which antenna resonates either decreases or increases. Depending upon the shift, the electrical length of the antenna whether increased or decreased can be determined. The different slot shapes are used on the patch to observe change in Gain. Depending upon the slot shape on the patch, variation in the Gain is observed and is shown in TABLE 2. It is seen that compared to conventional circular patch antenna, circular and octagon slots on the patch has better return loss and gain. These parameters vary depending upon the position, size and type of slots.

VI. FUTURE WORK

To improve antenna parameters and to resonate antenna at different frequencies, different slot shapes on different patch shapes can be used. Further the use of Microstrip Techniques such as DGS, use of air gap between ground and substrate, arrays can be used while designing antenna to enhance antenna parameters.

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