Comparison of Rectangular and Circular Microstrip Fed Patch Antennas at 5.76 GHz

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Abstract. A Comparative study of rectangular and circular shape microstrip patch antennas at 5.76 GHz band is presented in this paper. Computer Simulation Technology (CST) microwave studio is used as the software environment to design and compare the performance of the antennas. Based on the results and analysis, it is found that rectangular patch antenna shows about 8 dB higher return loss then return loss of circular patch antenna. In addition, rectangular patch antenna has improved gain value of 7.499 dB then that of the circular patch with gain 7.114 dB. The radiation efficiency of both rectangular and circular shaped microstrip fed patch antennas is nearly the same.

Keywords: rectangular patch, circular patch, return loss, gain, bandwidth.

1 INTRODUCTION

In the era of modern world where communication has become indispensable, antennas are rightly to be said as electronic eyes and ears of the world due to their undeniable place in the communication technology. While, the revolution in antenna engineering leads the fast growing communication systems, Microstrip Patch Antennas have been one of the most innovative developments in the era of miniaturization. Microstrip Patch Antennas are increasingly finding their applications in a broad range of microwave systems from radars, telemetry, navigation, biomedical systems, mobile and satellite communications, missile systems, global positioning system (GPS) for remote sensing and etc. because of their light weight, low volume, low cost, low profile, ease of fabrication, conformability to mounting hosts and ability to be printed directly onto a circuit board.

The conventional structure of a Microstrip Patch antenna comprises of a metallic radiating patch element, embedded into a grounded dielectric substrate. The shape of the conducting patch can be of any geometrical form among which rectangular and circular are the most common. The rectangular and circular Microstrip patch antennas are used as simple and for the extensive and most demanding applications as they easily provide with feed line flexibility, multiple frequency operation, linear and circular polarizations, frequency agility, good bandwidth etc. A circular patch antenna fed by an aperture coupled microstrip line has been demonstrated in (Navarro 1991). In (Ripin 2012) a rectangular microstrip patch antenna with EBG structure has been presented. Rectangular and circular microstrip patch antenna can be employed for multi-frequency operation. A dual band circular patch antenna is presented in (Alabidi 2013) which is smaller than the conventional antenna for wideband application and a triple band capacitive-fed circular patch antenna with arc shaped slots that covers 2380–2508 MHz and 5100–6030 MHz is proposed in (Chen 2013). By introducing a twin-diamond shaped patch and a gap-coupled feed structure, a left-handed circularly polarized (LHCP) antenna has been obtained in (Xuehui 2013). Even six linear polarizations are also possible with a circular patch antenna using coaxial-fed at centre with 12 p-i-n diodes placed across a circular ring slot on the patch, as proposed in (Chang 2014).

Another reason for the popularity of the rectangular and circular patch antenna is their compatibility to array configurations. Rectangular and circular patches are very popular shapes for microstrip patch antenna array constructions. The design of a four by one (4×1) patch array microstrip rectangular antenna with microstrip line feeding based on quarter wave impedance matching technique and with centre frequency at 2.5GHz for WiMAX application has been presented in (Wahab 2010). In (Dundar 2012)1×4 rectangular microstrip array antennas have been designed at 16 GHz resonant frequency for Ku Band usage and for each antenna ,electrical parameters like S11 response, directivity, gain, radiation efficiency etc. are investigated for 26 array antennas in simulation media HFSS v12 by changing the feed line widths systematically.

However, Microstrip patch antennas have some major disadvantages as narrow bandwidth, low gain and low power handling capability. A narrow BW of approximately 1-5% is the most major limiting factor for the widespread applications of Microstrip Patch antennas. Therefore, to overcome those limitations several methods have been introduced which includes modification of the patch shapes for wide band (Islam 2009, Neyestanak 2008, Bhardwaj 2008, Angand 2007) different types of feeding mechanisms for high gain (Islam 2009, Gautam 2013) and introduction of different types of slots and cuts (Alishir 2013, Costanzo 2013).

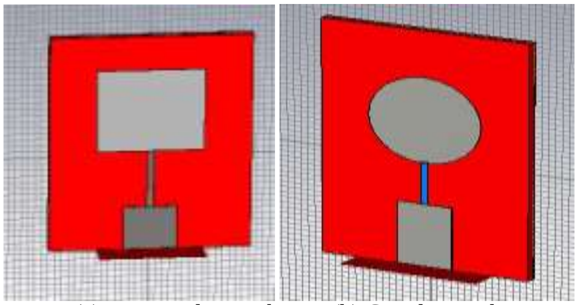
This paper work involves a comparative study of a rectangular and a circular patch antenna with line feed, both resonant at the frequency of 5.76 GHz. The comparison has been done on the simulated results obtained from the simulation software Computer Simulation Technology (CST) Microwave studio. The organization of the paper is as follows: section II shows the antenna design; the simulated results are discussed in Section III and finally section IV provides the conclusion of the presented study.

2 ANTENNA DESIGN

Both rectangular and circular shaped microstrip fed patch antennas were designed using computer simulation technology (CST) microwave studio software. The proposed antennas have been designed on the substrate roger RT5880 for a good dielectric constant of 3. The other parameters used to design two configurations antenna have been shown in Table 1. The software designed versions of both antennas are shown in the Figs. 1(a) and 1 (b).

Table 1. List of Design Parameter

Parameter	Rectangular	Circular
Operating Frequency	5.76 GHz	5.76 GHz
Patch size	Width W= 16 mm Length L=13.3 mm	Radius, a= 8.17 mm
Subtract Height, h	1.454 mm	1.454mm
Patch Thickness, Mt	.035mm	0.035mm
Transmission Line Length, L_f	13.8 mm	20.1mm
Transmission Line Thickness	0.035mm	0.035mm
Dielectric Constant, ε_r	3	3



(a) Rectangular Patch (b) Circular Patch

Fig. 1. Structure of the proposed Rectangular Patch and Circular Patch Antennas.

3 SIMULATIONT RESULTS AND DISCUSSION

The return loss responses for both antenna cases are shown in the figs 2 and 3, respectively. Fig. 2 and Fig. 3 show that at the resonant frequency the minimum return loss value of the rectangular -27 dB, whereas for circular patch antenna the return loss has a minimum value of -19 dB at the resonant frequency specifying that a approximate 8 dB of better return loss value occurs for the rectangular patch antenna at the same resonant frequency. In case of -10 dB bandwidth (Fig. 4 and Fig. 5) consideration, the rectangular patch antenna and circular patch antenna shows the same bandwidth of 24 MHz.

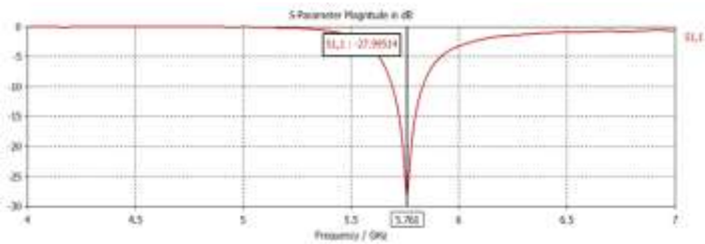


Fig. 2. Return loss response of Rectangular Patch Antenna

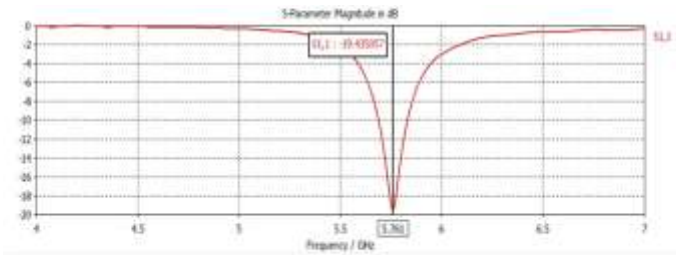


Fig. 3. Return loss response of Circular Patch Antenna

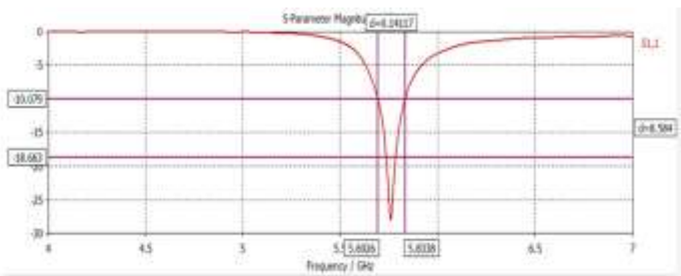


Fig. 4. Bandwidth calculation for Rectangular Patch Antenna

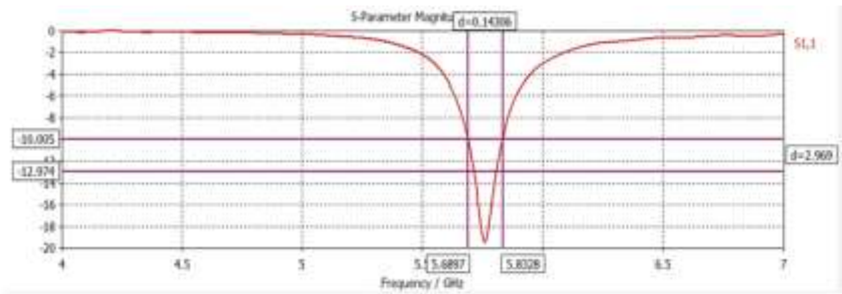


Fig. 5. Bandwidth calculation for Circular Patch Antenna

The 3-D radiation patterns and polar plot radiation patterns of the software designed both rectangular and circular path antennas are shown in the Figs. 6, 7 and 8 (a-b) respectively. From the 3-D radiation pattern it is noted that both antenna show directive radiation pattern. From the polar plot of radiation pattern (Figs. 8(a) and 8(b)) it can be seen that the directivity occurs with approximately same value for both rectangular and circular patch antenna. However, the 3dB angular beam width (i.e. HPBW) of circular patch antenna has a better value of 75.2 deg than the rectangular patch with 73.5 deg. beam width. Again the side lobe level for the circular patch is approximately same as rectangular patch. The circular patch antenna has a better radiation pattern when comparison is performed with circular patch antenna and rectangular patch antenna. From the radiation pattern plot (Fig. 6 and Fig. 7) gain of both antennas can be calculated. The rectangular patch antenna has a gain of 7.499 dBi while the gain of circular one is 7.114 dBi.

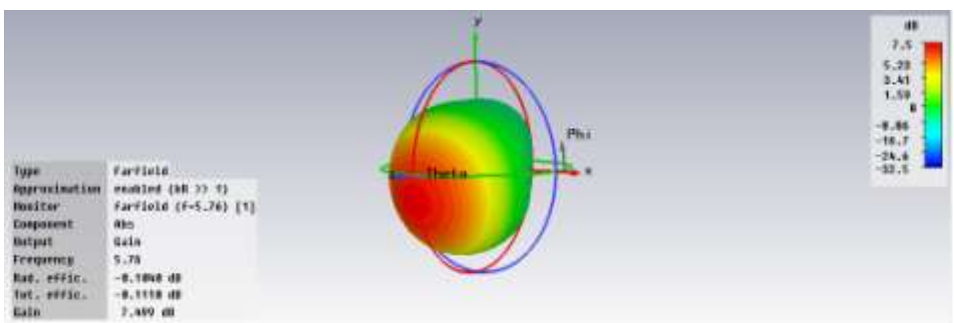


Fig. 6. 3D Radiation pattern for Rectangular Patch Antenna

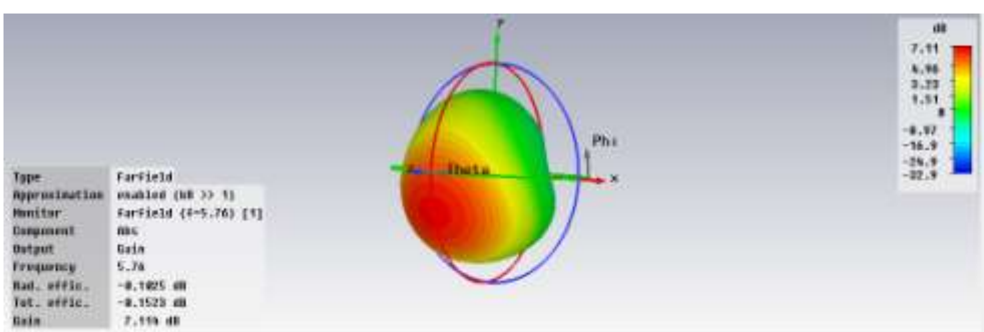
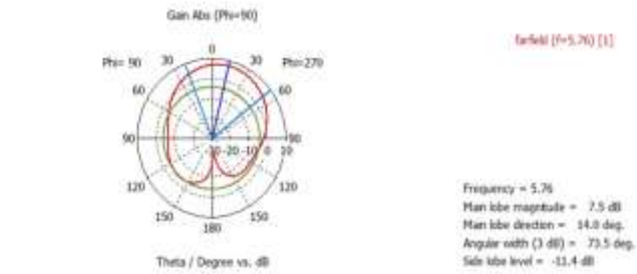
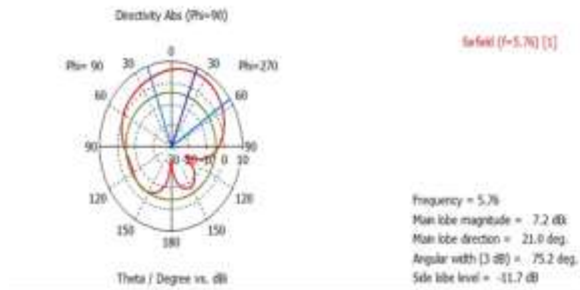


Fig. 7. 3D Radiation pattern for Circular Patch Antenna



(a)



(b)

Fig. 8. (a) Polar plot of radiation pattern of Rectangular Patch antenna (b) Polar plot radiation of Rectangular Patch antenna

The overall comparison of different performance parameters of rectangular and circular patch antennas have been summarized in table II. From perspective of return loss, rectangular antenna shows superiority over the circular one and when bandwidth and side lobe levels are considered both rectangular and circular patch antenna shows same performance. In addition, both the antennas exhibit same radiation efficiency and total radiation efficiency and nearly same directivity which make them compatible for similar applications.

Table 2. Comparison of Performance Parameters

Parameter	**Rectangular**	**Circular**
Return Loss	-27 dB	-19 dB
Bandwidth	14 MHz	14 MHz
Directivity	7.06dBi	7.21 dBi
HPBW	73.5 deg	75.2 deg
Side Lobe Level	-11.4 dB	-11.7 dB
Gain	7.499 dB	7.114 dB
Radiation Efficiency	97%	97%
Total Efficiency	97%	96%

4 CONCLUSION

Comparison between a rectangular patch antenna and a circular patch antenna using the simulation results obtained from CST Microwave studio has been carried out. Both the antenna configurations show quite good results on perspective of return loss, gain and radiation efficiency, for 5.725-5.825 GHz band application and can be used for same application of wireless communications. However, from the perspective of return loss and gain the rectangular patch configuration shows better performance.

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