Contrastive Parametric Analysis of Rectangular and Circular Microstrip Patch Antenna

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Abstract: **- The comparative analysis of the rectangular and circular patch antenna parameters is presented in this paper. To make it acceptable for various wireless applications the selected bandwidth is 10 GHz. HFSS is a software development tool which is used for design and the study of the performance of the presented antennas. The study gives the idea that the rectangular patch antenna exhibits higher return loss than the return loss of circular patch antenna whereas the rectangular patch antenna has an improved VSWR value of 1.18 than that of the circular patch with VSWR 1.27. Also the circular patch antenna offers about 8% higher radio bandwidth and nearly 2.0dB less side lobe power than that of the rectangular patch antenna. With rise in the dielectric constant of the substrate material there is a diminish structure of the patch antenna which leads to an accommodation in bandwidth, impedance and efficiency of the antenna. The simulated antennas are used in the field of 3G communications due to the resonance frequency. The delineate study about the dimensions such as width, length, feed point location, ground dimension for each patch antenna of different dielectric material are calculated and compared and the result shows about the contrastive analysis of different patch antenna performance parameter like VSWR, Reflection coefficient, Bandwidth, Impedance, Mismatch loss, Directivity, Gain and Field are analysed and compared. The paper includes the detailed analysis of various tables, graphs.**

***Index Terms*-Patch Antenna, Radiation Patterns, Resonant Frequency, VSWR**

I. INTRODUCTION

In the modern era antenna plays a vital role in the field of radio communication system. With no doubt it is known to be the electronic eye and ear of radio communication technique. An antenna is a transceiver device which can transmit and receive the microwave, radio and satellite signals. An antenna with high gain capability increases signal strength, whereas the receiving and transmitting is done by a low gain antenna over a wide range. The Microstrip patch antenna leads to a very innovative evolution in the world of miniaturization. It has a broad range of application in microwave systems such as radars, navigation, biomedical systems, mobile and satellite communications, missile systems, global positioning system for remote sensing etc. as it provides a compact size, small volume, light weight and can be easily fabricated on a printed circuit board. Microstrip patch antenna is a simple type of patch antenna with an easy fabrication technique by using a printed circuit board technology. It conveys microwave-frequency signals. The construction is based on a conducting microstrip disconnected from a ground plane by a dielectric layer known as the substrate.

The capacity to achieve broader range of frequencies is same as that of microstrip antenna which varies from 100 MHz to 100 GHz. Also the microstrip patch antennas have some major disadvantages as narrow bandwidth, lowgain and low power handling capability, low efficiency, large ohmic loss in the feed structure of arrays, poor end-fire radiator except tapered slot antennas. To overcome the mentioned disadvantages especially the narrow bandwidth which is 1-5%, several methods have been introduced that involves the modification of the patch shapes for wide band. Some feeding mechanisms for high gain and different types of slots and cuts can also be introduced. By increasing the thickness of the dielectric substrate the losses can be diminished. With increase in the photonic band gap structure the surface wave limitation (such as increased mutual coupling, poor efficiency etc.) can be overcome.

The design and simulation of both the rectangular and circular patch antenna is done by Software.

II. ANTENNA DESIGN

Rectangular Antenna Design:

The following equations (1),(2),(3),(4),(5) & (6) are used to determine the dimensions of a rectangular and circular patch antenna.

$$W = \frac{v_0}{2 f_r \sqrt{\frac{2}{\varepsilon_r + 1}}} \tag{1}$$

$$f_{eff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{W}\right]^{\frac{1}{2}} \tag{2}$$

$$\Delta L = 0.412h \frac{(\varepsilon_{reff} + 0.3)(\frac{W}{h} + 0.264)}{(\varepsilon_{reff} - 0.258)(\frac{W}{h} + 0.8)} \tag{3}$$

$$L_{eff} = L + 2\Delta L \quad (4)$$

$$L = \frac{v_0}{2 f_r \sqrt{\varepsilon_{eff}}} - 2\Delta L \quad (5)$$

Where W is the width of Patch,

v_0 is the free space velocity of light.

f_r is the resonant frequency.

ε_{eff} is the effective dielectric constant.

h is the height of the substrate.

ΔL is the extension in length due to fringing effect.

L is the actual length of the patch. L_{eff} is the effective length of patch.

Circular Patch Antenna:

$$a = \frac{F}{\{1 + \frac{2h}{\varepsilon_r \pi F}[\ln(\frac{\pi F}{2h}) + 1.7726]\}^{\frac{1}{2}}} \quad (6)$$

Where $F = \frac{8.791 \times 10^9}{f_r \sqrt{\varepsilon_r}}$

The antenna is designed on a substrate named Roger RT/duroid 5880(tm) having dielectric constant 2.2. The other parametric configurations are described below. The proposed antenna is designed by using ANSYS Electronics version 17.1. The Figure 1 and Figure 2 shows the rectangular and circular microstrip patch antenna designed by HFSS. The design parameters dimensions are listed in Table 1.

TABLE 1.

Design Parameters Dimension

Parameter	Rectangular	Circular
Patch size	Length L=8.8mm width W=9.95mm	Radius, a=5.25mm
Substrate height, h	1.588mm	1.588mm
Patch thickness, M_f	0.05mm	0.05mm
Transmission line length, L_f	4.4mm	4.4mm
Transmission line width, W_f	1.2mm	1.2mm
Dielectric constant, ε_r	2.2	2.2

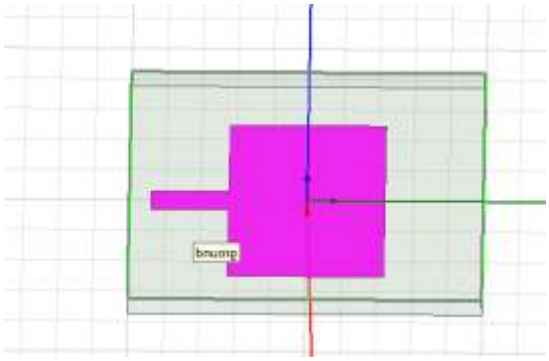


Figure 1. Rectangular Patch Antenna.

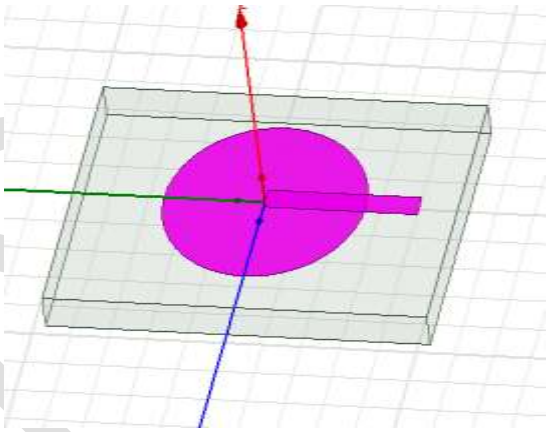


Figure 2. Circular Patch Antenna.

III. SIMULATION RESULTS ANALYSIS

The Figure 3(a) and Figure 3(b) shows the simulated resonant frequency of rectangular and circular microstrip patch is 9.3 GHz and 10.2 GHz respectively from the S11 plot.

vely from the S11 plot. The VSWR plots of rectangular and circular microstrip antennas are shown in Figure 4(a) and 4(b). The VSWR values are 1.219 and 1.0807 respectively. The Figure 5(a) and 5(b) shows the smith chart analysis of both the antennas. The 2D polar plot and 3D polar plot of radiation patterns are shown in Figure 6 and Figure 7.

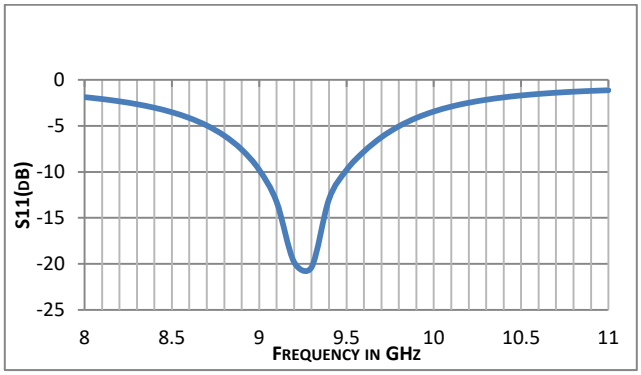


Figure 3(a). S_{11}-Parameter Plot of Rectangular Patch Antenna

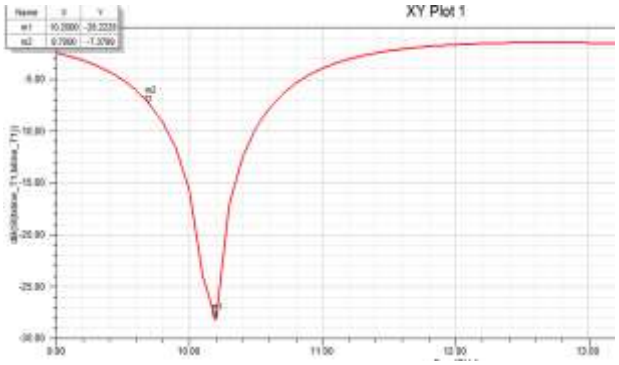


Figure 3(b). S11-Parameter Plot of Circular Patch Antenna

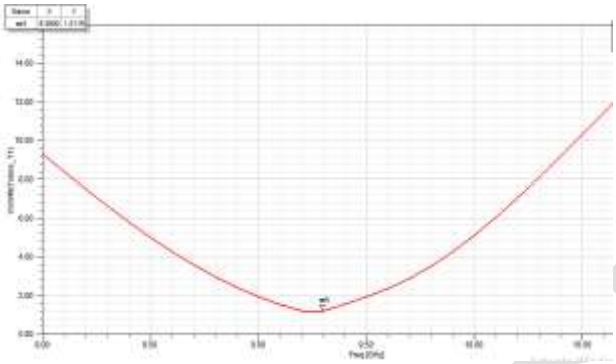


Figure 4(a). VSWR Plot of Rectangular Patch Antenna

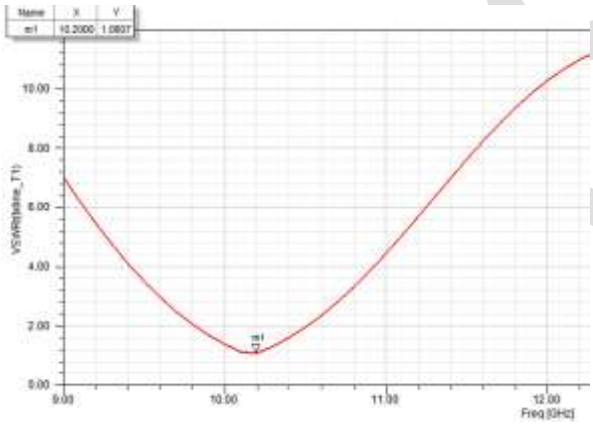


Figure 4(b). VSWR Plot of Circular Patch Antenna

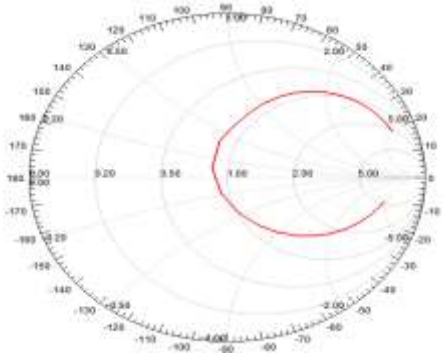


Figure 5(a). Smith Chart of Rectangular Patch Antenna

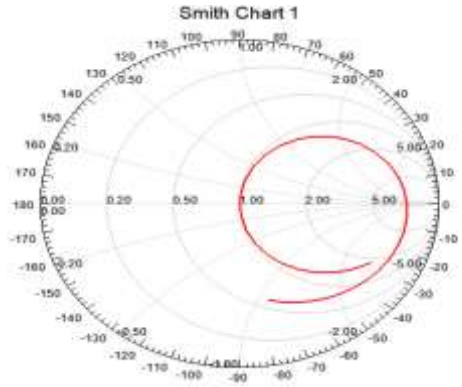


Figure 5(b). Smith Chart of Circular Patch Antenna

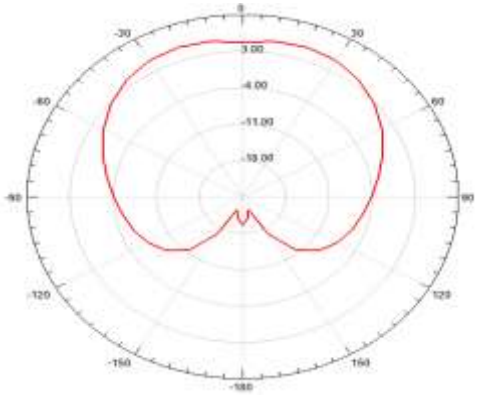


Figure 6(a). Polar Plot of Radiation Pattern of Rectangular Patch Antenna

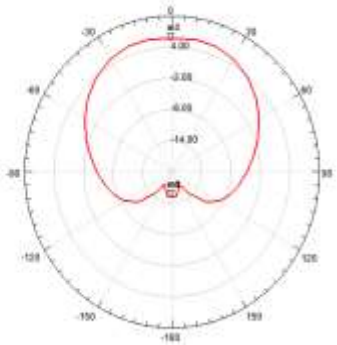
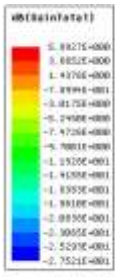


Figure 6(b). Polar Plot of Radiation Pattern of Circular Patch Antenna



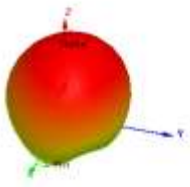


Figure 7 (a). 3D Radiation of rectangular patch antenna

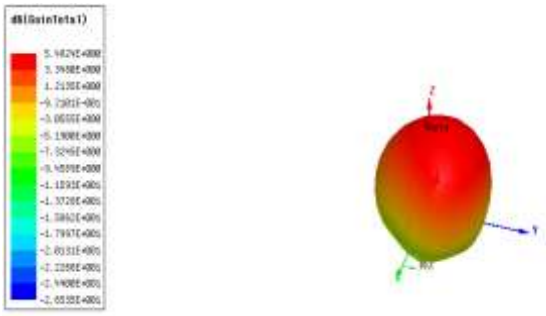


Figure 7(b). 3D Radiation of Circular Patch Antenna.

The different parametric comparison of rectangular and circular patch antenna is listed in Table2.

TABLE 2.
Comparison of Performance Parameters

Parameters	Rectangular	Circular
Return Loss	-20.3714 dB	-28.2228 dB
VSWR	1.219	1.0807
Resonant Frequency	9.3 GHz	10.2 GHz
Directivity	4.6834 dB	5.6199 dB
Gain	4.5863 dB	5.5783 dB
Side Lobe Level	-19.5642 dB	-15.2924 dB

IV. CONCLUSION

The comparison study of both the rectangular and circular patch antenna has been carried out by the help of HFSS software tool. Both the antenna shows good result in accordance with the return loss, VSWR, gain and radiation efficiency. It is most applicable in the field of satellite communication, RADAR etc. From the prospective of return loss, gain, VSWR rectangular antenna shows better performance than circular patch antenna and according to the bandwidth, radiation pattern, side lobe levels and smith chart (impedance matching) circular patch antenna is better than rectangular patch antenna.

The above theory and simulation signifies that the directivity of circular patch antenna is more as compare to the rectangular patch antenna for a given parameter. That's why the circular patch antenna is more popular and can be efficiently used as coparing to other microstrip antenna i.e. rectangular patch antenna.

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AUTHOR'S DETAILS

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