IJARSCT
ISSN (Online) 2581-9429
ISSN (Print) 2581-XXXX
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
IJARSCT
Impact Factor: 4.819
Volume 1, Issue 1, January 2021

Design and Analysis of Dual-Band Circular Patch Antenna for X-Band Applications with Enhanced Bandwidth

Pendli Pradeep and S. K. Satyanarayana
Assistant Professor, Department of Electronics and Communication Engineering
Sree Nidhi Institute of Science and Technology,
Affiliated to Jawaharlal Nehru Technological University, Hyderabad, Telangana, India

Abstract: *An antenna is a crucial component in the wireless communication system which converts electrical waves to EM waves and vice-versa which leads to revaluation in wireless communication technology. Due to this reason the experiment was performed on a simple circular patch antenna for better radiation along with wide transmission bandwidth. In this paper, a simple circular microstrip antenna structure is designed to operate at dual bands. The proposed antenna consists of a circular radiating patch, a 50-ohm feedline line, a quarter-wave impedance matching transmission line, and a ground plane. It meets significant requirements for large bandwidth, optimized gain, minimum reflections, and small size with high directivity and efficiency. This antenna contains FR4 Epoxy substrate material with permittivity 4.4 and size 36mm x 36mm x 1.67mm. ANSOFT HFSS simulator is used to analyze various parameters like return loss, VSWR, Impedance, and gain. The Resonant Frequency of the designed antenna is 8.77 GHz and 10.6 GHz. with minimum Return Loss of -52 dB and -21.66 dB respectively. It was also observed that 1.005 and 1.2 VSWR at 8.77 GHz and 10.6 GHz respectively.*

Keywords: Microstrip circular patch antenna, microstrip line feed, quarter wave impedance matching and HFSS

I. Introduction

An antenna is a heart of communication system. Even in single mobile it required many antennas if we use different frequency application required different antenna which leads to multiband antenna i.e. single antenna is capable to resonate at different frequencies. Now a day's antennas are designing with Metamaterials and Meta surface which have negative permittivity and permeability. A microstrip rectangular patch antenna or circular microstrip antenna contains conducting material and ground metal between them a dielectric material is placed. The dimensions of a patch shape are smaller than the ground plane and substrate material. Dimensions of a microstrip antenna generally depend on the operating frequency and value of the dielectric constant [1]. Patch antennas are used in many wireless applications. They have many advantages like light weight, low fabrication cost, linear and circular polarization are possible with simple feed and easy for fabrication. The limitation of this patch radiator is narrow Bandwidth, Somewhat small Gain and extraneous radiation from feed points and junctions. The betterment in these limitations is the challenging work [4]. The microstrip patch antenna can used for wireless communication systems and also used for more applications in various field of aeronautics, satellite and missile applications [3]. Metallic patch can be designed in any shape; various shapes are shown in below fig.1. The basic rectangular microstrip patch antenna is shown in fig.2.

Different kind of feeding methods are used in patch antenna designs. Microstrip line feeding process is illustrated in figure 3; the edge of the microstrip radiator is connected directly to a conducting microstrip feed. This feeding technique offers the advantage that the conducting radiator can have the opportunity of etched on same substrate providing a planar structure. The width of feed element is smaller than the patch antenna [6].

IJARSCT
ISSN (Online) 2581-9429
ISSN (Print) 2581-XXXX
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
Impact Factor: 4.819
Volume 1, Issue 1, January 2021

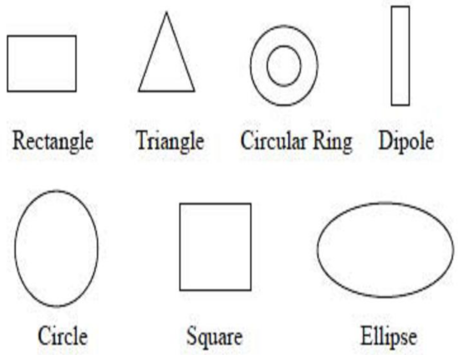

Figure 1: Shapes of various antenna patches

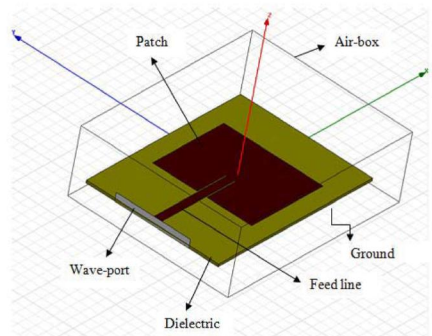

Figure 2: Structure of rectangular patch antenna

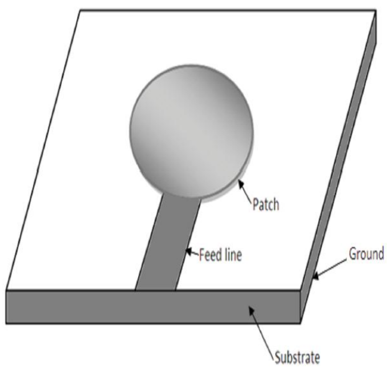

Figure 3: Structure of circular patch antenna

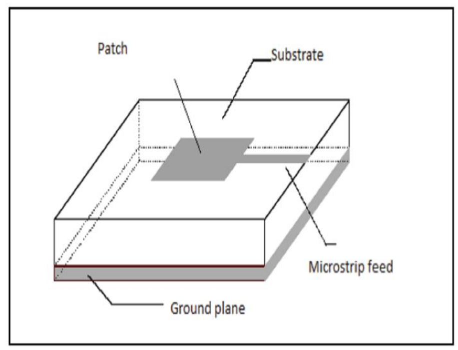

Figure 4: Structure of microstrip feed

In this article, initially a circular patch antenna design standard mathematical equations at the resonant frequency is given, a simple microstrip circular patch antenna with a 50 ohm microstrip line feed and quarter wave impedance matching transmission line is described in Section II. The antenna is working at dual bands for X band applications with minimum reflection coefficients. The simulation results are reported in the section III. Finally, section IV gives the apparent overview like conclusion, acknowledgement and followed by references

II. Proposed Antenna Design and Specifications

In section I, Microstrip patch antenna can be developed with any shape of radiating patch. To design a rectangular microstrip strip antenna various mathematical equations are expressed in literature. The advantage of circular patch antenna over a rectangular patch antenna, it requires only one parameter i.e. radius of the radiating patch. A basic structure of circular patch antenna is shown in figure 2. The circular patch antenna is developed using a substrate dielectric constant (εr), the resonating frequency (fr) and the height of the substrate medium (h). To calculate the radius 'a' of the patch, the following below equation are used.

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

where $$F = \frac{8.791X\,10^9}{f_r\sqrt{\varepsilon_r}} \quad (2)$$

Generally, substrate length (*L)* and width (*W)* are calculated using below expressions

$$L = 2 \times Circular\ Patch\ Diameter \quad (3)$$

$$W = 2 \times Circular\ Patch\ Diameter \quad (4)$$

IJARSCT

ISSN (Online) 2581-9429
ISSN (Print) 2581-XXXX

International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)

Impact Factor: 4.819

Volume 1, Issue 1, January 2021

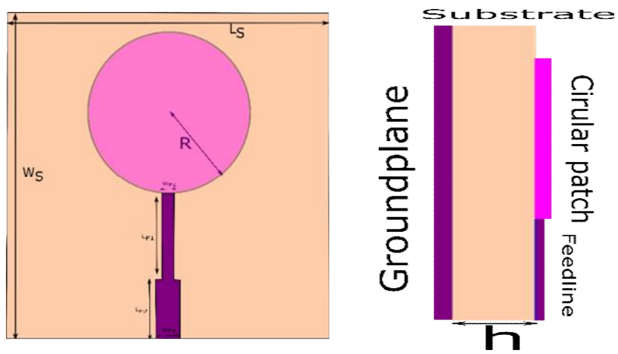

Figure 5: The proposed antenna a) Front View b) Side View

The proposed antenna values are shown in below table as well as few parameters are shown in the below table 1. In this design quarter wavelength transmission line is used between patch and transmission to reduce the reflection losses from antenna.

Table 1: Antenna Design Parameters

Parameter	Dimensions	Values(in mm)
Length of Substrate	L_S	36
Width of Substrate	W_S	36
Height of substrate	h	1.6
Loss tangent	tanȣ	0.02
Substrate	ε_r	4.4
Radius of patch	R	9
Length of Feedline1	L_{F1}	10
Width of Feedline1	W_{F1}	1.4
Length of Feedline2	L_{F2}	6.4
Width of Feedline2	W_{F2}	2.8

III. Results and Discussion

The graph in fig.6 illustrates the return loss characteristics of a designed antenna at various frequencies for X band applications. It is observed that the antenna has extremely good return loss (minimum) of -52 dB at 8.77 GHz frequency. It is also observed that the antenna is radiating at another frequency 10.6 GHz with return loss of -21.66 dB.

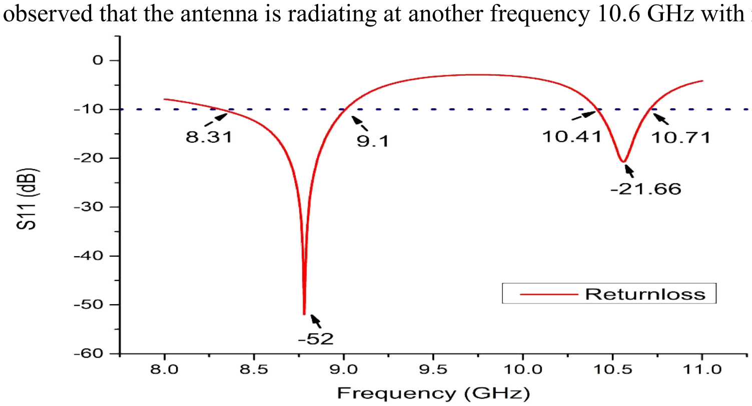

Figure 6: The Reflection coefficient of proposed antenna

DOI: 10.48175/IJARSCT-717

IJARSCT
ISSN (Online) 2581-9429
ISSN (Print) 2581-XXXX
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
Impact Factor: 4.819
Volume 1, Issue 1, January 2021

Fig.7 shows the VSWR values at varies frequencies for X band applications. The inference is made from the graph that the designed antenna has very minimum value of 1.005 at 8.77 GHz frequency (almost near to ideal VSWR value). The graph also shows VSWR value 1.2 at 10.06 GHz frequency.

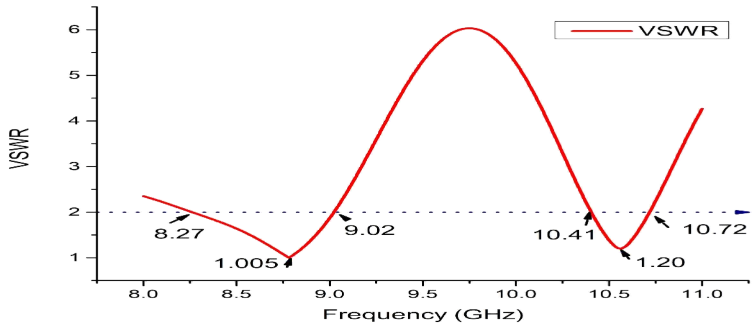

Figure 7: The proposed antenna VSWR plot

The smith chart in fig.8 shows antenna impedance, which gives the impedance, is equal to 0.924+0.055i. The real value is almost equal to 1 and its imaginary part is very small. So this indicates that, the designed antenna has perfect match between the characteristic impedance and the input impedance of an antenna.

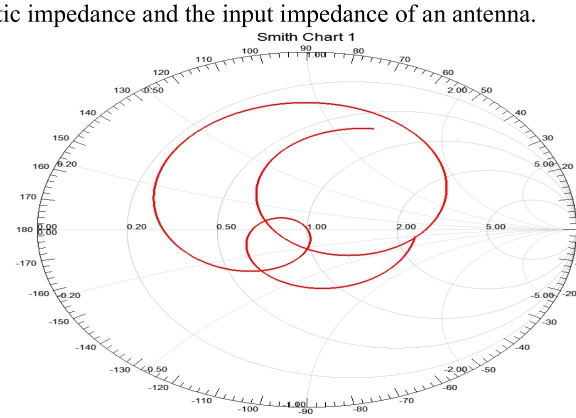

Figure 8: The proposed antenna Smith chart

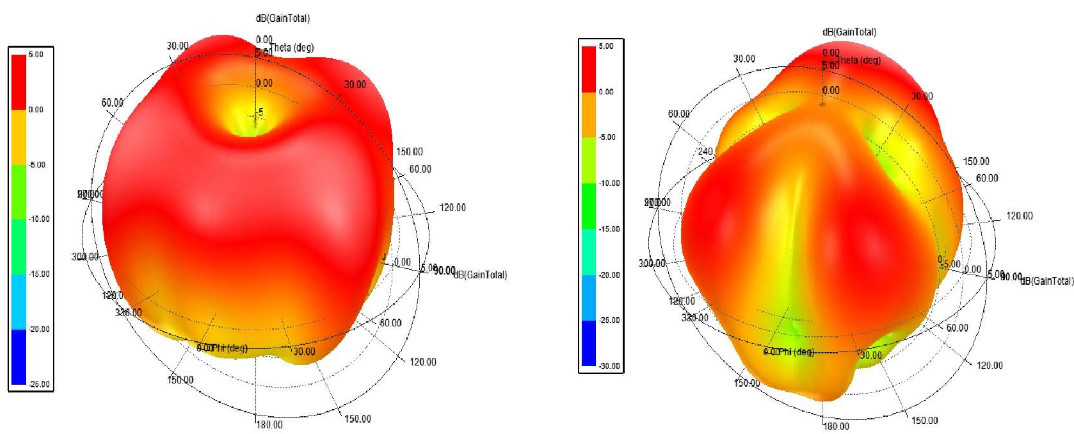

Figure 9: Radiation pattern in 3D polar plot a) at 8.77 GHz b) at 10.6 GHz

The radiation pattern of the designed antenna in 3D shown in fig.9 the gain of the antenna is found to be 5dB.

IV. Conclusion

This simple circular microstrip patch antenna gives minimum reflections at 8.77 GHz. It shows good radiation from antenna into free space without any reflection, this is the main advantage as compared with any other antenna. The antenna radiates at two different frequency bands so it can be used as multiband antenna for x-band applications. The designed antenna performs extremely well with minimum return loss of -52 dB at 8.77 GHz frequency. It is also found that the antenna also has a return loss of -21.66 dB at operating frequency of 10.6 GHz. The antenna is designed with small radius and substrate used is FR4, which has many advantages with low cost.

Acknowledgment

The authors would like to express sincere gratitude to the management of Sree Nidhi Institute of Science and Technology for their continuous support and encouragement in this work.

References

[1]. Vijayalaxmi S W, Dr. A Sreenivasan "“Design and Simulation of Ircular Microstrip Patch Antenna”, (ICIMIA 2017)978-1-5090-5960-7/17©2017 IEEE5.
[2]. Swagata B Sarkar, Design and Analysis of 5.2 GHz Rectangular Microstrip Patch Array Antenna using Split Ring Resonator, (ICSCN -2017), 978-1-5090-4740-6/17©2017 IEEE.
[3]. Manik Bhowmik1, Brij Bhushan Chowdhury2, Ratul De3, Circular Patch Antenna with modified Swastikashaped slot for Multiband Applications, (SPIN 20160) 978-1-4673-9197-9/16©2016 IEEE..
[4]. Namrata D. Mahajan, Kunal N. Dekate, Design and Simulation of Patch Antenna for3.51GHz S-Band and WiMAX Application”, (AEEICB16), 978-1-4673-9745-2 ©2016 IEEE.
[5]. Deepanshu Kaushal, T. Shanmuganatham, Danger Microstrip Patch Antenna for Fixed Satellite Applications, [ICETT] 2016 978-1-5090-3751-3/16 ©2016 IEEE
[6]. HoudaWerfelli, KhaoulaTayari, MondherChaoui, Mongi Lahiani, Hamadi Ghariani, Designof Rectangular Microstrip Patch Antenna, ATSIP’2016, 978-1-4673-8526-8/16©2016 IEEE
[7]. Shilpa K Jose, Dr.S.Suganthi, Rectangular Microstrip Antenna for WLAN Application, ICIIEC’15, 978-1-4799-6818-3/15© 2015 IEEE.
[8]. Shilpa K Jose, Dr. S. Suganthi, Rectangular Microstrip Antenna for WLAN Application, ICIIEC’15, 978-1-4799-6818-3/15© 2015 IEEE.
[9]. C.A. Balanis, “Antenna Theory Analysis and Design", Third Edition, Wiley, New Jersey, 2005.pagination Library, 2003 Edition.
[10]. Garg, Ramesh, Prakash Bhartia, Inder J. Bahl, and Apisak Ittipiboon. Microstrip antenna design handbook. Artech house, 2001.