Design of Double Band Circular Microstrip Patch Antenna for Wireless Applications in Ultra Wide Band (UWB)

Rajesh Kumar Nagar[1], Dr. Sudhir Agrawal[2]

Ph.D. Research Scholar, Department of ECE, Institute of Engineering & Technology (IET), SAGE University, Indore, 452020, Madhya Pradesh, India[1]

Professor & Dean Academics, Department of ECE, Institute of Engineering & Technology (IET), SAGE University, Indore, 452020, Madhya Pradesh, India[2]

Abstract

Antenna is a crucial component of communication. In today's communications devices, such as smart phones, which offer several applications and larger bandwidth, microstrip antennas are a better option than conventional antennas. The necessity for antennas that can transmit and receive at a quicker rate and with more than one frequency at once has arisen as a result of technology advancement. Due to the utilization of dual band antenna, this is achievable. The design of a microstrip rectangular patch antenna for dual band applications using two frequencies is presented in the study. The proposed antenna is based on circular shape pattern having the dimension of antenna is (LxWxH) 32 X 32 X 1.64 mm^3. The proposed antenna is based on circular shape pattern. The length of feed patch is 8mm and width is 2mm. Dimension of partial ground is 12mm X 3mm.The substrate material which is using in proposed antenna is FR4 material. S11or return loss is -19.96dB for the band-I and -23.51dB for the band-II. The bandwidth of proposed antenna is 890MHz, (5.26Hz – 4.3GHz) for the band-I and 2184 MHz, (7.87GHz – 5.69GHz) for the band-II. The VSWR value of band-I is 1.235 and for band-II is 1.142. The directivity of proposed antenna is 4.64 dBi for optimized band. As the VSWR, Return Loss, Gain are better than our reference paper we can also use our Dual Band antenna in Satellite Communications, Weather radar systems, Wi-Fi, ISM band, WiMAX, WLAN and Wireless applications.

Keywords – Circular Patch, FR4, Gain, Directivity, Return Loss, VSWR, CST.

1. Introduction

Today, the development of microstrip antennas for its planar applications is driven by the demand for small and inexpensive antennas. Tiny size, high-frequency operation, and various frequency capabilities. This antenna uses two bands of frequencies, and it can either operate on each band separately or concurrently. In this paper, slots are utilized for the same purpose. An antenna can be designed in a variety of ways to work for two frequencies. Dual band antennas have the advantage of being able to establish a reliable wireless connection in places that are frequently out of reach. Additionally, it can function as an energy-harvesting antenna. Microstrip antennas (MSA) are clearly necessary for WLAN/Wi-MAX application systems due to their properties of low cost and low profile.

2. Literature Survey

For microwave access and wireless applications, a compact dual-band MSA has been proposed. a more effective omnidirectional radiation pattern for the specified operating frequencies and a small antenna. At 5.2 GHz, it can be seen that the peak gain can exceed 3dBi [2]. For 2.4/5.2/5.8 GHz WLAN applications, a dual-band antenna with a small radiator is being developed. Wideband properties of this antenna are dependent on a number of factors, including the size of the U-slot and the probe-fed patch. This antenna is ideal for 2.3/2.5GHz WiMAX and 2.4/5.2 GHz WLAN applications and exhibits 37% impedance bandwidth and more than 90% antenna efficiency [3]. This study suggests a rectangular MSA to increase 2.4 GHz bandwidth for WLAN applications. Antenna bandwidth has been enhanced in this. This antenna was presented for use with WLAN and satellite [4].

In this study, a dual band L-shaped Microstrip patch antenna for WLAN systems is printed on a FR-4 substrate, achieving a frequency range of 5.1 GHz to 6.1 GHz with maximum gains of 8.4 and 7.1 dB in the lower and higher frequency bands, respectively [5]. For use with WLAN and Wi-MAX, a small rectangular patch antenna has been presented. This antenna is cost-effective, simple to use, and suited for Wi-MAX and WLAN applications across all frequency bands [6].

3. Antenna Design

The geometry of the proposed structure is based on Circular Shape Microstrip Patch antenna. The general size of the structure is 32mm × 32mm × 1.64mm (L × W × H) and imprinted on

FR4, with an overall permittivity of 4.4, and a loss digression of 0.024. The antenna is taken care of by 50-Ω and 0.5W coaxial link or straightforward. CST microwave studio used to recreate the proposed plan.

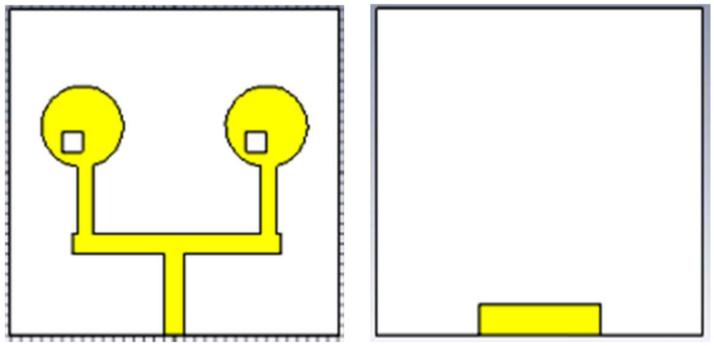

Figure 1: Top view and Bottom view of proposed antenna

Below table 1 is showing the necessary dimension and values for designing proposed antenna. This value is calculated by using standard formulas.

Table 1: Dimension for the proposed antenna design

Sr. No.	Parameter	Value
1	Frequency(fr)	4-8 GHz
2	Dielectric constant(εr)	4.4 / FR4
3	Metal Height	0.035mm
4	Substrate Height(h)	1.57 mm
5	Line Impedance	50 Ω - 70Ω
6	Antenna Length	32mm
7	Antenna Width	32mm
8	Tangent Loss	0.06
9	Feed patch length	8mm
10	Feed patch width	2mm
11	Feed patch height	0.035mm

The top and ground layer is made by lossy copper material and substrate is made by FR4 material which having 4.4 dielectric steady worth. The ordinary parts of the electric field at the two edges along the width are in inverse ways and in this manner out of stage since the patch is λ/2 long and consequently they drop each other in the broadside course.

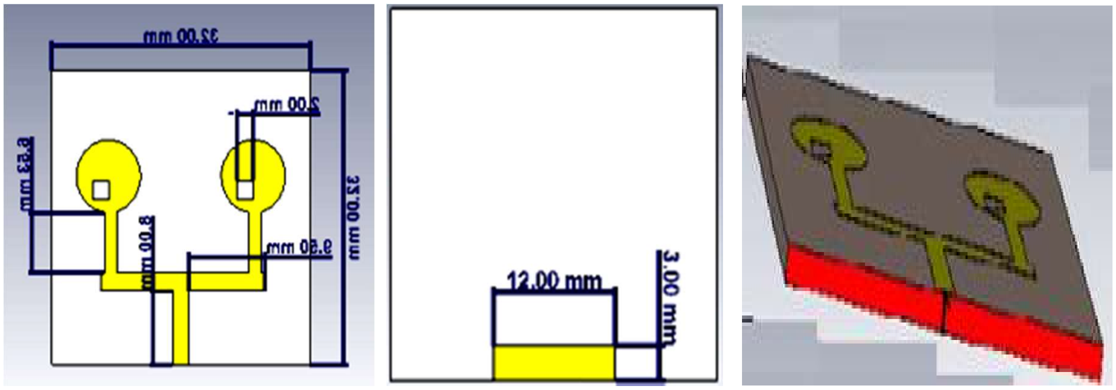

Figure 2: Dimension of circular MSPA and Side view in CST Studio

Figure 3 is showing CST view of proposed antenna; here it can be seen the antenna is designed according to Cartesian coordinate system as per the proposed design and Cartesian.

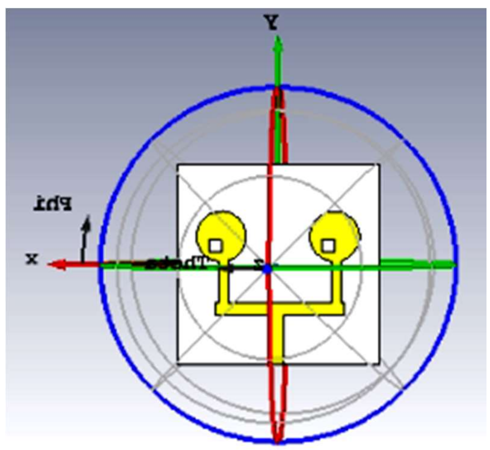

Figure 3: CST view of proposed circular MSPA

4. Simulation Results And Discussion

Proposed antenna is simulated in CST microwave studio, it is a specific apparatus for the quick and exact 3D EM reproduction of high frequency issues. Alongside an expansive application extend.

Figure 4 shows the Return Loss (S_{11}) parameters for the proposed antenna, value of S11or return loss is -19.96dB for the band-I at resonant frequency 4.7 GHz. And value of S11or return loss is -23.51dB for the band-II at resonant frequency 6.7 GHz.

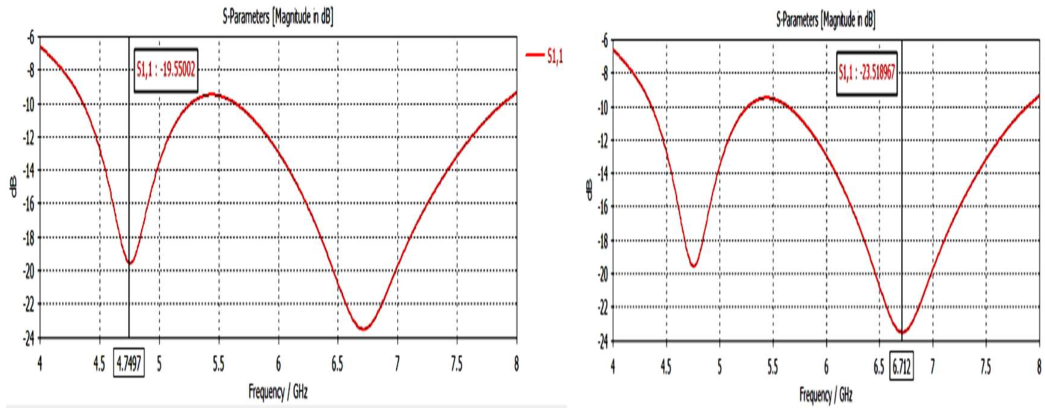

Figure 4: S11 or Return loss of band-I and band-II

The figure 5 shows the bandwidth of proposed antenna is 890MHz, (5.26Hz – 4.3GHz), for first band and the bandwidth of proposed antenna is 2184 MHz, (7.87GHz – 5.69GHz).

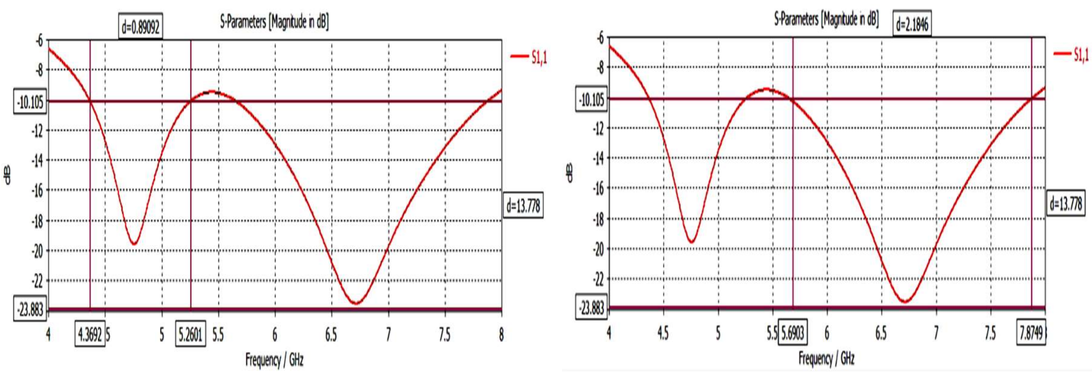

Figure 5: Bandwidth Plot for band-I and band-II

VSWR is a function of the reflection coefficient, which describes the power reflected from the antenna. The VSWR value of band-I is 1.235 and The VSWR value of band-II is 1.142 as shown in figure 6.

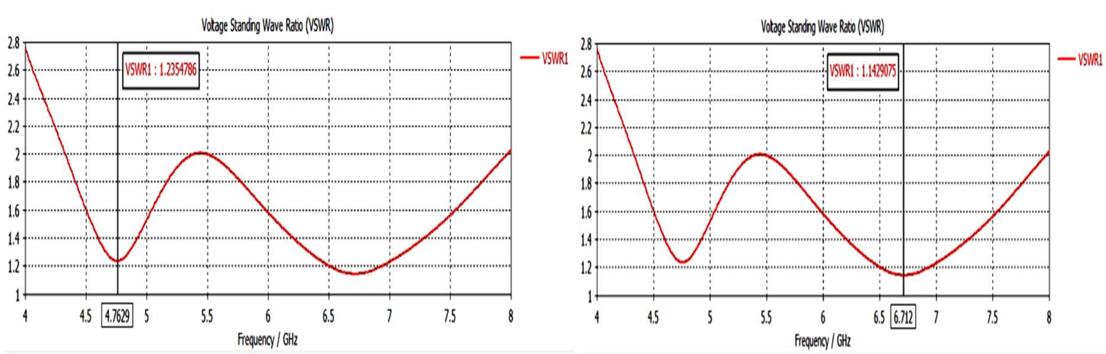

Figure 6: Simulated result of VSWR for band-I and band-II

Stimulated results is shown in figure 7 result of accepted power, power outgoing all ports power radiated and power stimulated. Stimulated power is 0.5W while power radiated is 0.49 so the antenna efficiency is more than 90%.

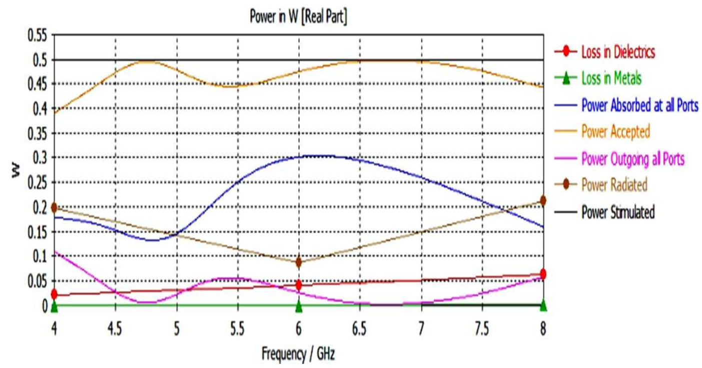

Figure 7: Power in different port for first band

Figure 8 is showing far field 2D radiation pattern. The directivity of proposed antenna is 4.64 dBi for optimized band and the 3D Radiation pattern of proposed antenna band is shown in the figure.

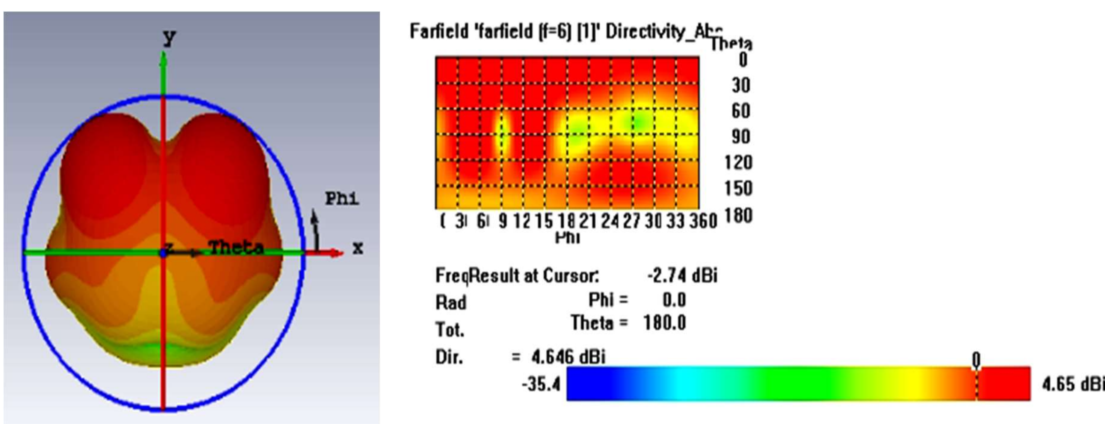

Figure 8: 3D Radiation pattern and Directivity 2D plot of proposed antenna

Analysis has been made for various antenna parameters like return loss, resonant frequency, gain, directivity, bandwidth and VSWR. Another crucial factor in the antenna is current dispersion. At the conclusion of the patch and the beginning of the patch, the voltage should be positive. Figure 9 shows the surface current of proposed antenna, the electric and magnetic field of proposed antenna is also showing, here electric field represents by blue dots while magnetic field represents by green dots.

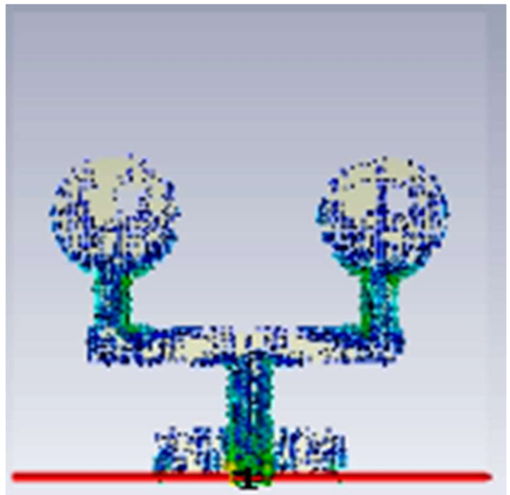

Figure 9: Surface current of proposed antenna

5. Result Summary

The proposed antenna is analyzed using CST Studio suit. Table 2 shows the simulated results of return loss, VSWR, Gain, Directivity, Resonant Frequency and Bandwidth.

Table 2: Simulation Result summary of designed circular antenna

Sr No.	Parameter	Proposed design (band-I)	Proposed design (band-II)
1	S11 or Return loss	-19.55 dB	-23.51 dB
2	Band Width	890 MHz	2184 MHz
3	VSWR	1.23	1.14
4	Resonant Frequency	4.7 GHz	6.7
5	Design type	Circular	
6	Dimension	32 X 32 X 1.6 mm^3	
7	No of band	2	
8	Directivity	4.64 dBi	
9	Gain	4.3 dBi	

6. Conclusion

A new structure based on the circular patch antenna for wireless communication in ultra wide band (UWB) is proposed. Return Loss (S_{11}) parameters for the proposed antenna, which represents antenna band of frequency for which the antenna designed is optimized i.e. frequencies ranging from 4 GHz to 8 GHz with S11or return loss is -19.96dB for the band-I at resonant frequency 4.7 GHz and value of S11or return loss is -23.51dB for the band-II at resonant frequency 6.7 GHz. Bandwidth of proposed antenna is 890MHz, (5.26Hz – 4.3GHz), for first band-I and 2184 MHz, (7.87GHz – 5.69GHz) for the band-II. VSWR value of band-I is 1.235 and The VSWR value of band-II is 1.142. The directivity of proposed antenna is 4.64 dBi for optimized band. Accepted power, power outgoing all ports power radiated and power stimulated. Stimulated power is 0.5W while power radiated is 0.49 so the antenna efficiency is more than 90%.

References

[1]. Pozar, and M. David, "Microstrip antennas", Proceedings of the IEEE, vol. 80(1), pp. 79– 91, Jan1992.

[2]. Dharmendra Rishishwar, "Rectangular Microstrip Dual Patch Antenna to Enhance Bandwidth at 2.4 GHz for WLAN Applications," International Journal of Advanced Research in Computer Science & Technology Vol.1 Oct.2013.

[3]. E. Wang, "A Novel Dual-Band patch Antenna for WLAN Communication ," Progress In Electromagnetics Research C, Vol. 6, 93-102, 2009.

[4]. Arvind kumar Singh, "Compact Wide Band Microstrip Line Feed MSA for Wireless Application," International Journal of Computer Science& Engg Technology Vol.3 April. 2012 for global positioning system (GPS)," Electron. Lett., vol. 37, no. 22,pp. 1321–1322, 2001.

[5]. Princy Gupta ,"Design and study of planar invertedf antenna for Mobile devices Covering LTE/WLAN Applications ,"Progress In Science and Engineering Research Journal Vol.2 May.2014.

[6]. Balanis, C.A., 2005: Antenna Theory: Analysis and Design, John Wiley & Sons, Inc., 2 nd Edition, 1136 pp, ISBN: 978-0471592686.

[7]. Balanis, C.A., 2005: Antenna Theory: Analysis and Design, John Wiley & Sons, Inc., 2 nd Edition, 1136 pp, ISBN: 978-0471592686.

[8]. Thomas S. Laverghetta, Microwave Materials and Fabrication Techniques, Artech Inc. USA, 1985.

[9]. Alaziz, W.A., 2011: Design and development of multi-band microstrip rectangular fractal antenna for wireless applications, M.Sc. thesis, University of Sumer, Rifai, Iraq, DOI: 10.13140/RG.2.2.21507.45606.

[10]. Li, P., Liang, J., & Chen, X. (2006). Study of printed elliptical/circular slot antennas for ultrawideband applications. IEEE Transactions on antennas and Propagation, 54(6), 1670-1675.

[11]. K. S. Ryu and A. A. Kishk, "UWB Antenna with Single or Dual Band-Notches for Lower WLAN Band and Upper WLAN Band", IEEE Transactions on Antennas and Propagation, vol. 57, no. 12, pp. 3942-3950, 2009.

[12]. Praveen Kumar Rao, KM Jyoti Singh, Rajan Mishra "A Circular Shaped Microstrip patch Antenna for Bluetooth/Wi-Fi/UWB/X-band Applications" 2018 International Conference on Power Energy, Environment and Intelligent Control (PEEIC) G. L. Bajaj Inst. of Technology and Management Greater Noida, U. P., India, Apr 13-14, 2018, 978-1-5386-2341-1/18/$31.00 ©2018 IEEE, pp 638-641.

[13]. Tahsin Ferdous Ara Nayna, A. K. M. Baki, Feroz Ahmed "Comparative Study of Rectangular and Circular Microstrip Patch Antennas in X Band" International Conference on Electrical Engineering and Information & Communication Technology (ICEEICT) 2014, 978-1-4799-4819-2/14/$31.00 ©2014 IEEE.

[14]. Som Pal Gangwar, Kapil Gangwar, Arun Kumar "A Compact Microstrip Patch Antenna with Five Circular Slots for Wideband Applications" 2018 3rd International Conference on Microwave and Photonics (ICMAP 2018), 9-11 February, 2018,

[15]. R. Sharma et al., "Prototype of Slotted Microstrip Patch Antenna for Multiband Application", International Journal of Engineering & Technology, 1199-1201, 2018.