Design of broadband circular patch microstrip antenna with plus slot for WLAN and WiMAX Application

[1]Sarvesh Kumar Bhartiya, [2] Vinod Kumar Singh, [3]Rajeev Shankar Pathak

[1, 3]M.Tech Scholar, S.R.Group of Institutions, Jhansi, India
[2] Assistant professor, S. R. Group of Institutions, Jhansi, India
Email: Sarvesh.11289@gmail.com, singhvinod34@gmail.com,rajeevsp88@yahoo.com

Abstract: ***In this paper, the design and analysis of Circular microstrip patch antenna with Plus shape for the WLAN & WiMax application is presented. The operating frequency of antenna 4.7 GHz having circular shape. The antenna design consists of a single layer of substrate with thickness 1.6 mm having dielectric constant of 4.4.The simulation results of proposed slotted circular microstrip patch antenna have been obtained by IE3D Zealand Software. The effects of different parameters like return loss, radiation pattern are studied. The simulated result shows that the proposed antenna presents a bandwidth of 78.81%.***

Keywords: Return loss, Radiation Pattern, Antenna efficiency, Radiation Efficiency and plus slotted antenna.

I. INTRODUCTION

Microstrip antennas are getting popularity amongst the researchers due to its attractive features such as low profile, low cost, light weight, ease of fabrication and compatibility with microwave circuits.[1-4] However, despite of these several advantages, the microstrip antennas suffers from some disadvantages of narrow bandwidth and low efficiency. Various researches have been made to increase the bandwidth of Microstrip antennas, which includes increase of the substrate thickness, the use of a low dielectric constant, slotted patch antennas, introducing the parasitic elements either in coplanar or stacked configuration, the use of various impedance matching and feeding techniques [5-10].The dielectric constant of the substrate is closely related to the size and the bandwidth of the microstrip antenna. Low dielectric constant of the substrate produces larger bandwidth, while the high dielectric constant of the substrate results in smaller size of antenna. **[6--10]**

In the past few years researchers have tried various methods to enhance the bandwidth and it is observed that as the bandwidth is increased the efficiency and gain decreases. To obtain a larger bandwidth along with optimum gain and efficiency and maintaining the size of antenna is a major challenge to the researchers working with microstrip antennas these days [11-15].

In this paper a wide band plus slotted circular microstrip antenna with compact size is presented which have bandwidth of around 78.81%.The antenna is suitable for various mobile cellular communication systems such as WLAN and WiMax.

II. ANTENNA DESIGN

The proposed line-fed wide band circular plus slotted antenna is presented in Figure1. The ground plane has the dimensions of Lg× Wg and is printed on a substrate of thickness h = 1.6 mm and relative permittivity ε_r = 4.4. The optimized design parameters of the proposed patch antenna are shown in table 1. The circular plus slot is introduced on the patch with glass epoxy substrate provide bandwidth enhancement. There are different slots in designing the circular microstrip antenna, The slot is plus shape .The effect of changing The slot length and width are studied on parameters like gain, return loss, radiation efficiency, antenna efficiency etc .A Coaxial probe feed is used at different points by Changing the feed locations and their effect are seen on above parameters.

The bandwidth of antenna can be defined as the percentage of the frequency difference over the center frequency [5]. According to these definitions can be written in terms of equations as follows

$$BW(\%) = \left[\frac{f_H - f_L}{f_C}\right]100$$

Where f_H and f_L are the upper and lower cut off frequencies of the resonated band when its return loss reaches -10 dB and f_C is a centre frequency between f_H and f_L respectively.

Design Equation

Because of fringing effect electrically the patch of antenna looks larger than its physical dimensions.

The enlargement of L is given by eq. 1 shown below

$$\frac{\Delta l}{h} = 0.412\frac{(\varepsilon_{reff}+0.300)\left(\frac{W}{h}+0.264\right)}{(\varepsilon_{reff}-0.258)\left(\frac{W}{h}+0.813\right)} \quad (1)$$

Where the effective (relative) permittivity is given by eq. 2 shown below

$$\varepsilon_{reff} = \frac{\varepsilon_r+1}{2}+\frac{\varepsilon_r-1}{2}\left[1+12\frac{h}{W}\right]^{1/2} \quad (2)$$

This is related to the ratio of h/W. The larger the h/W, smaller the effective permittivity the effective length of the patch is given by

$$L = \frac{1}{2\,fr\sqrt{\varepsilon_{reff}}\sqrt{\mu_o\varepsilon_o}}-2\Delta l \quad (3)$$

$$f_{nm} = \frac{cK_{nm}}{2\pi a_e\sqrt{\varepsilon_r}} \quad (4)$$

Where $\mathbf{K_{nm}}$ the derivative of the Bessel function of

Order n & c is velocity of light. Since the dimension of the patch is treated a circular loop, the actual radius of the patch is given by (Balanis, 1982)

$$a = \frac{F}{\left\{1+\frac{2h}{\pi\varepsilon_r F}\left[\ln\left(\frac{\pi F}{2h}\right)+1.7726\right]\right\}^{1/2}} \quad (5)$$

$$F = \frac{8.791\times10^9}{f_r\sqrt{\varepsilon_r}} \quad (6)$$

Equation (6) does not take into consideration the fringing effect. Since fringing makes the patch electrically larger, the effective radius of patch is used and is given by (Balanis 1982)

$$a_e = a\left\{1+\frac{2h}{\pi\varepsilon_r a}\left[\ln\left(\frac{\pi a}{2h}\right)+1.7726\right]\right\}^{1/2} \quad (7)$$

Design Procedure

Step1: Using equation (4) to find out the resonant frequency

Step2: Calculate the effective permittivity using the equation (2)

Step3: Compute the extension of the length using

the equation (1)

Step4: Determine the length L by solving the equation for L giving the solution to design the antenna.

Table1. Dimensions of the Prescribed Antenna

Resonant Frequency(Fr)	4.7
Dielectric Constant (εr)	4.4
Radius of circular patch(a)	9 mm
Substrate Thickness(h)	1.6mm

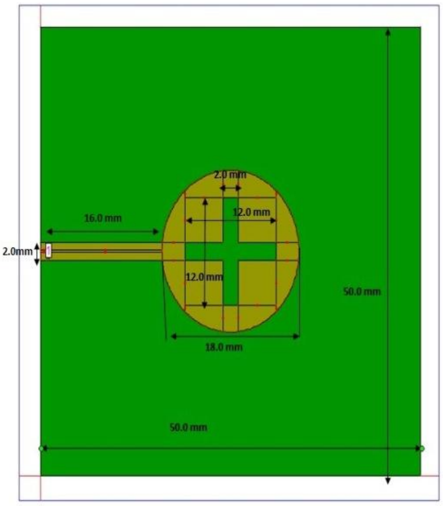

Figure 1: Top view of Proposed Antenna

III. RESULTS AND DISCUSSION

Figure 2 shows the variation of return loss versus frequency of proposed MSA. From this figure, it is clear that the proposed MSA resonates at 2.75 GHz and 3.88 GHz of frequency. The impedance bandwidth of proposed MSA is found to be 78.81%.

Table 2.Results of Proposed antenna design

Parameters	**Obtained Results**
Band Width	78.81%
Maximum Directivity at 3.75 GHz	6 dBi at 3.88 GHz
Maximum Antenna Efficiency	88% at 3.88 GHz

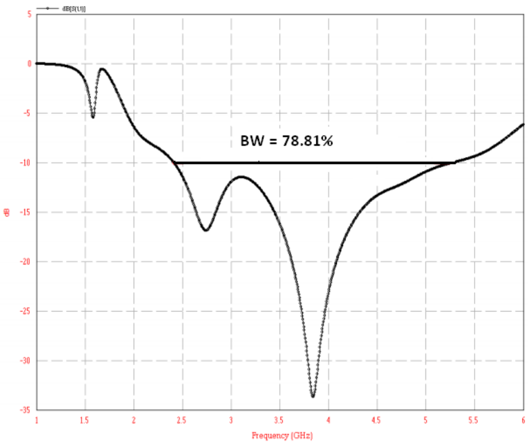

Figure 2: S11 parameter of Proposed Antenna

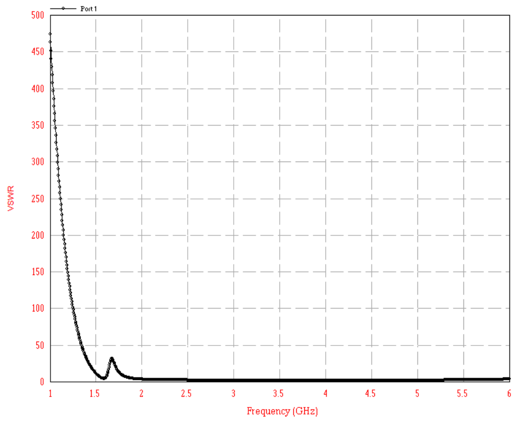

Figure 3: VSWR of Proposed Antenna

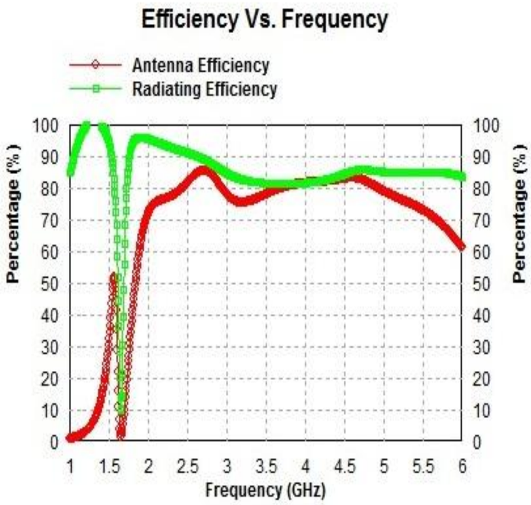

Figure 4: Efficiency plot of proposed Antenna

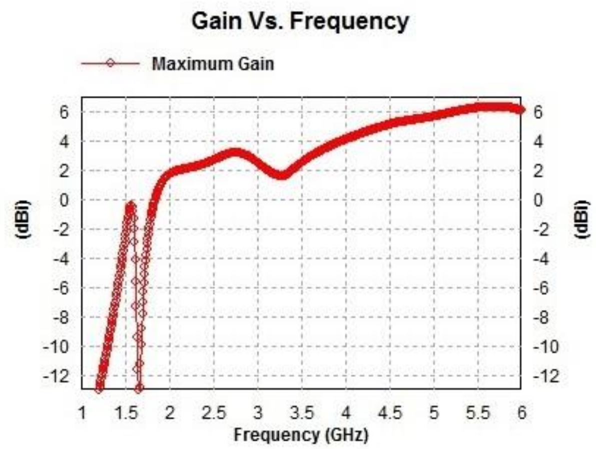

Figure 5: Gain Vs Frequency plot of proposed Antenna

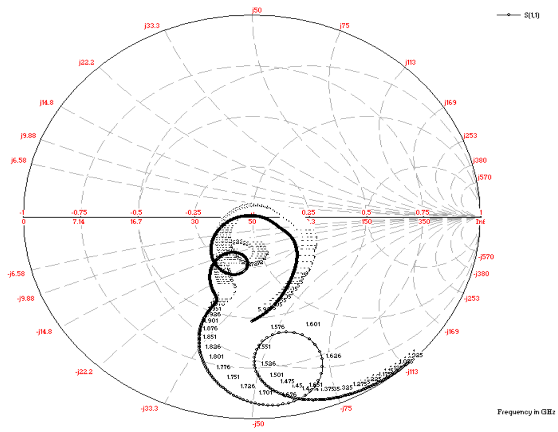

Figure 6: Smith chart of Proposed Antenna

IV. CONCLUSION

The proposed designed antenna is suitable for broad band application. The simulated result shows that the proposed antenna presents a bandwidth of 78.81%which is shown in fig 2. Fig4 presents the maximum radiation efficiency 88%. The maximum achievable gain of the antenna is 6 .dBi shown in fig 5.The developed line feed wide band compact microstrip antenna is suitable for WLAN and WiMax applications.

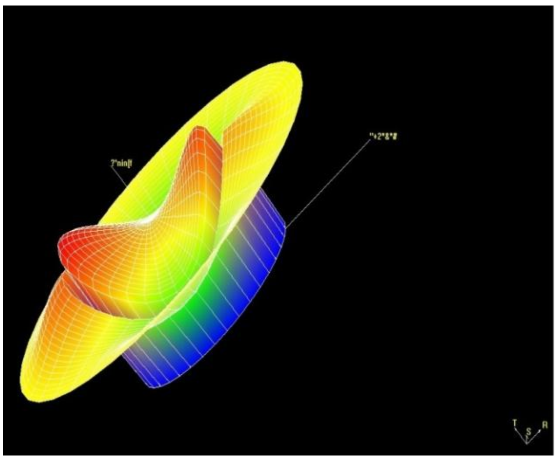

Figure 7: 3D Radiation Pattern of Proposed Antenna

REFERENCES

[1] Girish Kumar and K.P. Ray, Broadband Microstrip antennas, Norwood: Artech House 2003.

[2] I. J. Bahl and P. Bhartia, Microstrip Antennas, Artech House, Dedham, MA, 1980

[3] Stutzman, W.L. and Thiele, G.A., Antenna Theory and Design, John Wiley & Sons, Inc, 1998

[4] Balanis, C.A., Antenna Theory: Analysis and Design, John Wiley & Sons, Inc, 1997.

[5] E.O. Hammerstad, "Equations for Microstrip Circuit Design,"Proc. Fifth European Micro-wave Conf., pp. 268–272, September 1975.

[6] Amit A. Deshmukh, Ameya Kadam and K. P. Ray, "Broadband Proximity Fed Modified E-shaped Microstrip Antenna," Proc. IEEE, Vol. 978-1, 2011.

[7] M. T. Islam, M. N. Shakib and N. Misran, "Broadband E-H shaped microstrip patch antenna for wireless systems," Progress In Electromagnetics Research, PIER 98, pp. 163-173, 2009.

[8] Vinod Kumar Singh , Zakir Ali, Shahanaz Ayub, Ashutosh Kumar Singh, "A wide band Compact Microstrip Antenna for GPS/DCS/PCS/WLAN Applications", a book chapter in the book entitled "Intelligent Computing, Networking, and Informatics", (Book ISBN: 978-81-322-1664-3) Chapter 113, pp: 183–204 in Springer

[9] Ansari, J. A. and R. B. Ram, "Broadband stacked U-slot microstrip patch antenna, "Progress In Electromagnetic Research Letters, Vol. 4, 17-24, 2008.

[10] Vinod Kumar Singh, Zakir Ali, Ashutosh Kumar Singh, Shahanaz Ayub "Dual Band Microstrip Antenna for UMTS/WLAN/WIMAX Applications" IEEE Proc.Communication Systems and Network Technologies (CSNT-2013), Print ISBN: 978-0-7695-4958-3/13, pp-47 – 50, April-2013, Gwalior, India

[11] Nagraj Kulkarni, S. N. Mulgi, and S. K. Satnoor "Design and Development of Triple Band Tunable Microstrip Antenna" Microwave and Optical Technology Letters Vol. 54, No. 3, pp 614-617March 2012.

[12] Avisankar Roy and Sunandan Bhunia, "Compact Broad Band Dual Frequency Slot Loaded Microslot Patch antenna with Defecting Ground Plane for WI-MAX and WLAN", IJSCE, ISSN: 2231-2307, Vol.1, Issue-6, January -2012.

[13] Saurabh Jain, Vinod Kumar Singh, Shahanaz Ayub, "Bandwidth and Gain Optimization of a Wide Band Gap Coupled Patch Antenna", IJESRT, ISSN: 2277-9655, March 2013.

[14] Vinod Kumar Singh, Zakir Ali, A. K. Singh, Shahanaz Ayub "Dual band triangular slotted stacked microstrip antenna for wireless applications" Central European Journal of Engineering (CEJE), Springer ISSN: 1896 1541Volume 3, Issue 2, pp 221-225 June, 2013.

[15] Stuti Srivastava, Vinod Kumar Singh, Zakir Ali, Ashutosh Kumar Singh,"Duo Triangle Shaped Microstrip Patch Antenna Analysis for WiMAX lower band Application" Procedia Technology Elsevier 10 pp-554 – 563, 2013

◈◈◈