A simple design of broadband higher frequency microstrip patch antenna for K band application

Pushpendra Singh[1], Swati Singh[2]

[1](EC Department/ Amity University Rajasthan, India)
[2](EC Department/ CSJM University Kanpur, U.P. India)

Abstract-*This paper presents a simple design of crossed taper shaped higher frequency antenna which can be used in K band. The proposed antenna design is simulated by computer simulation technology microwave studio simulator. The goal of this paper is to optimize the performance of the microstrip patch antenna at the higher frequency band. The proposed antenna geometry provides the desired bandwidth, gain and the radiation pattern. The antenna is fabricated using FR-4 substrate and parameters like return loss, VSWR, surface current distribution and input impedance are measured.*

Keywords*: proposed antenna geometry, radiation pattern, surface current distribution, VSWR, efficiency;*

1. INTRODUCTION

In the resent year ago, first widely used satellite and radar technology was developed for many application related to military purpose [1]. During a half a century later, there is a much wider satellite, radar and astronomical application. Satellite and radar is needed for weather forecast, airport traffic control and automotive applications. Radar technology has a major importance on a mass production basis [2, 3, 4, 5]. Signal processing components which make it possible to detect even low power signals in much application area where more RF energy was needed. Low power and light weighted components are major requirements in saving the costs [6, 7, 8, 9, 10]. Nowadays, microstrip patch antenna has become very popular and is widely used in K band of applications. Microstrip antenna provided the better various features such as high gain, low cost and high performance [11, 12, 13]. The major characteristic of the microstrip antenna is that they are robust and reliable in nature such type antenna has the simple design geometry [14, 15].

This paper presents the crossed taper shaped antenna geometry which provides much improved antenna performance in term of impendence bandwidth and radiation performance. The proposed antenna design and performance presented in the next section.

This paper is divided in 4 sections. I section presents introduction and II shows the proposed antenna design. Simulation results and discussion detail are shown in III section, while IV section presents the paper conclusion.

2. ANTENNA DESIGN

The proposed antenna geometry has finite ground plane with the dimensional 7 × 10 mm. The antenna design consists the patch of PEC material deposited on the FR-4 substrate (ε = 4.4), has a thickness of 1.59mm. The substrate and the ground dimensional is 7 × 10 mm shown in fig -1. The geometry of the patch in form of the crossed taper which has the major width and length 3mm, 9mm respectively and the feed dimensional is 5 x 0.8mm. The geometry is simulated using the finite element method based Computer Simulation Technology microwave studio.

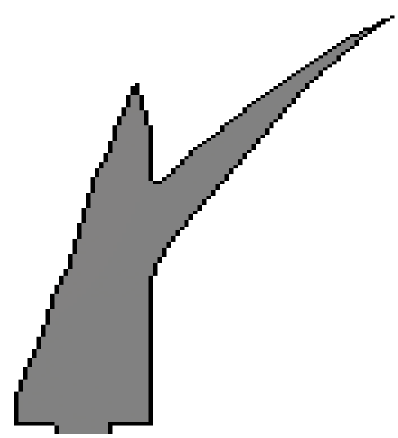
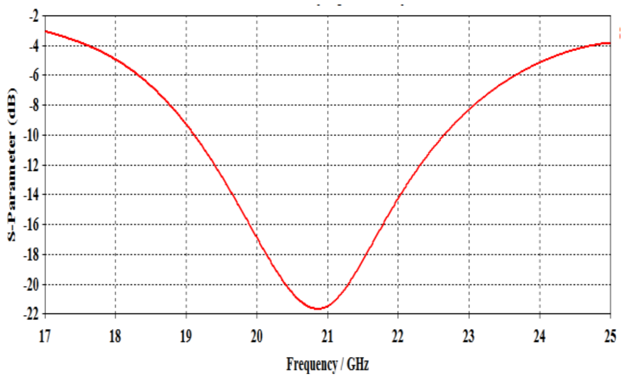


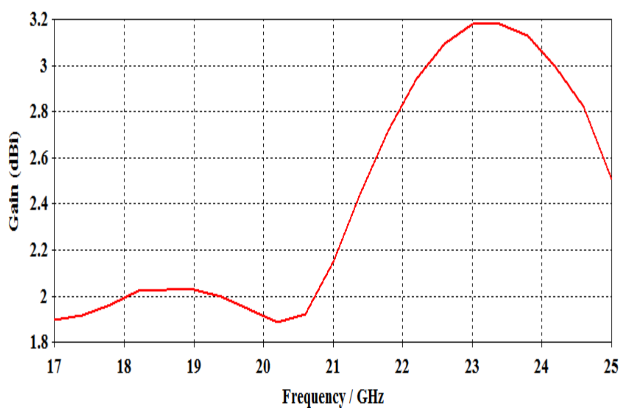
Fig -1: Front view proposed antenna design.

International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056
Volume: 03 Issue: 02 | Feb-2016 www.irjet.net p-ISSN: 2395-0072

3. SIMULATED RESULTS



(a)

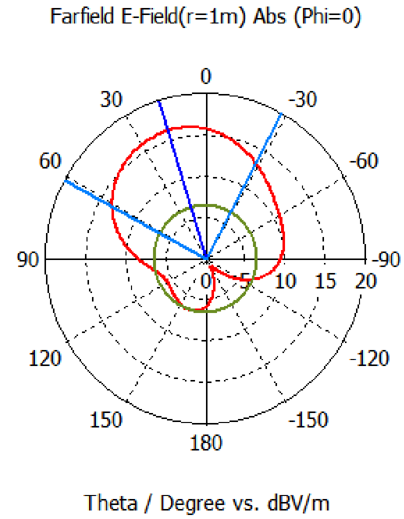


(b)

Fig -2: (a) Variation of reflection coefficient (S11) as a function of frequency (b) Variation of gain with frequency.

The return loss is studied with respect to frequency variation is shown in the fig -2(a). By using the CST software that is seen from the antenna resonates at a single resonant frequency *fr* is equal to 20.88GHz with a impendence bandwidth 3.5GHz (19.1GHz - 22.6GHz). It is found that the simulated values are shown is below -10dB nearly -22dB that the antenna has a good performance (less than -10dB) in satellite and radar communication technology (K band).

The maximum gain provided by the proposed antenna 3.2dBi at the 23GHz frequency. The gain is rapidly decrease after the 19GHz frequency and it's get the minimum value (1.9dBi) nearly resonant frequency (20.88GHz). It is ranging toward the high value after it shown in fig -2 (b).



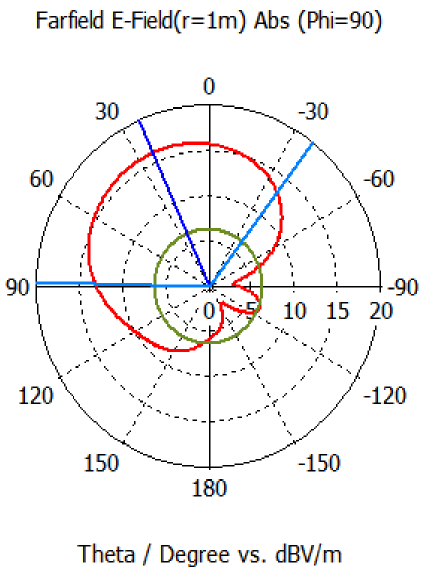


Fig -3: Variation of E and H plane elevation patterns at resonant frequency.

2D radiation pattern of E and H plane of the proposed antenna with respect to their resonant frequency is shown in fig -3. E plane radiation pattern is bends across nearly 20^0 with the normal of the patch geometry while the H plane pattern, the major lobe tilts across the 24^0 and a small minor lobe is just opposite to it. This result shows that the radiation is bidirectional nature shown in figure. Such performance of the antenna's characteristic is better than the other conventional antenna. The 3D view, of the gain pattern is shown in Fig: 4. the red spot shows that the gain is maximum nearly 2.079dBi on the top view.

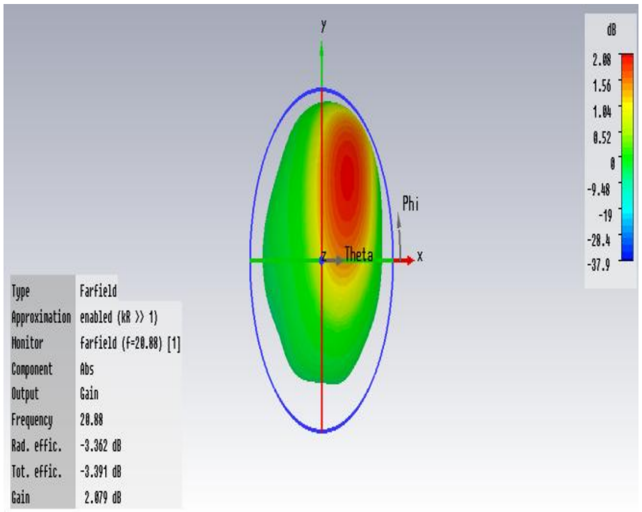
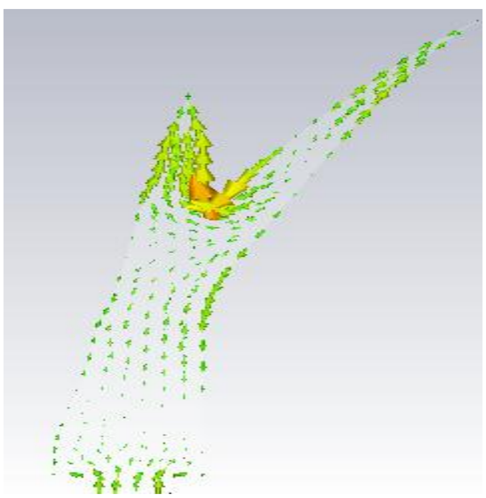
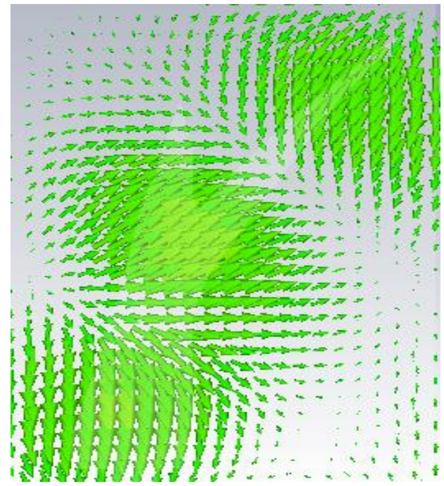


Fig -4: 3D view , the gain of proposed antenna at resonant frequencies 20.88GHz.



(a)



(b)

Fig -5: Current distribution in patch (a) and ground plane (b) of the proposed antenna at resonant frequencies.

The current distribution profile of the proposed antenna geometry on the patch geometry and the ground plane at resonant frequency (20.88GHz) is depicting in fig -5. The current distribution on the patch is maximum at the crossed taper's junction and is also at the taper's edge which is generally shown by the red spot. Such distribution of current is maximum across the one diagonal of ground plane. By deep examine the current profile is also maximum at the feed junction shown in fig -5 (a).

The variation of the VSWR with respect to the frequency is shown in fig -6. the antenna geometry offers the minimum VSWR value nearly 1 at the resonant frequency. The lower value of the VSWR provides the good impendence matching [16, 17, 18].

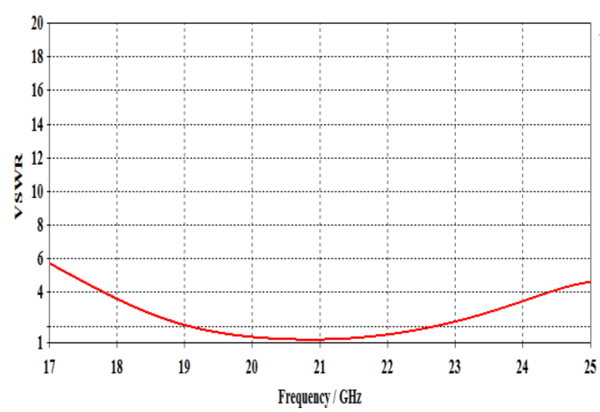


Fig -6: VSWR Plot/ Frequency.

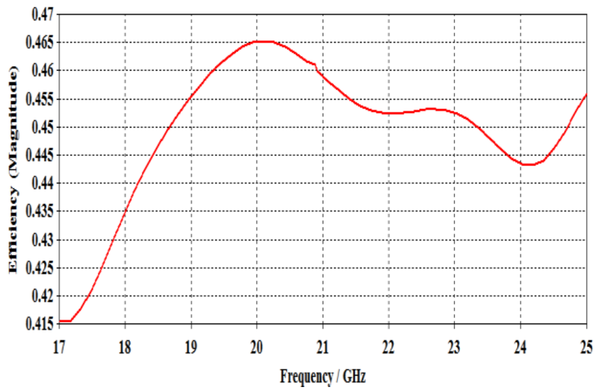


Fig -7: Variation of the efficiency with frequency.

The proposed antenna offers the maximum efficiency 46.5% at the 20GHz frequency. At the resonance frequency, its value 46% is shown in fig -7.

CONCLUSION

The crossed taper based higher frequency broad band micro strip patch antenna's structure provides broader bandwidth 3.5GHz (19.1- 22.6) GHz, desired VSWR nearly 1 and maximum gain (3.2dBi). Reducing cost and improving the proposed antenna performance is important in the field of satellite and radar communication. The proposed antenna may be useful in K band applications. The antenna performance further may improve use the several methods like stacked patches, defected ground, use of active devices. Here, such proposed antenna design that could have several times improved radiation performance compare to the other conventional antenna.

REFERENCE

[1] J.W. Weedon, W. Payne, and G. Rebeiz, "Mems-switched reconfigurable antennas," In Antennas and Propagation Society International Symposium, IEEE, vol. 3, 2001, pp. 654 –665.

[2] A. Rolland, N. T. Nguyen, R. Sauleau, C. Person, and L. Le Coq, " Smooth-walled light-weight –band shaped horn antennas in metallized foam," IEEE Trans. Antennas Propag., vol. 60(3), 2011, pp. 1245–1251.

[3] J.S. Kuo and K.L. Wong, "A compact microstrip antenna with meandering slots in the ground plane," Microwave and Optical Technology Letters, vol. 29(2), 2001, pp. 95–97.

[4] H. Wang, X. Huang, and D. Fang, "A single layer wideband u-slot microstrip patch antenna array," Antennas and Wireless Propagation Letters, IEEE, vol. (7), 2008, pp. 9 –12.

[5] O. Noori, J. Chebil and Et.al, "Design and Analysis of Triple- Band Microstrip Patch Antenna with h- shaped Slots," International Conference on Computer and Communication Engineering, Kuala Lumpur, Malaysia 3-5 July 2012.

[6] S. H. Chang and W. J. Liao, " A broadband LTE/WWAN antenna design for tablet PC," IEEE Trans. Antennas Propag., vol. 60(9), 2012, pp. 4354 – 4359.

[7] S. Steshenko, A. A. Kirilenko, A. V. Boriskin, M. Zhadobov, and R. Sauleau, " Plane radiation patterns of rectangular waveguide aperture with a corrugated flange," In Proc. Int. Math. Methods Electromagn. Theory Conf., Kharkov, Ukraine, 2012, pp. 476 –479.

[8] P. Singh, K. Ray and S. Rawat, " Design of Nature Inspired Broadband Microstrip Patch Antenna for Satellite Communication," Seventh World Congress on Nature and Biologically Inspired Computing (NaBIC2015), Dec.1-3, 2015.

[9] K. L. Wong and T. W. Weng, "Small-size triple-wideband LTE/WWAN tablet device antenna," IEEE Antennas Wireless Propag. Lett.,vol. 12, 2013, pp. 1516–1519.

[10] S. Toshniwal , S. Sharma, S. Rawat, P. Singh, and K. Ray, " Compact Design of Rectangular PatchAntenna with Symmetrical U slots on Partial Ground for UWB Applications**,"** Congress on (IBICA 2015), Dec.1-3, 2015

[11] K. L. Wong and L. Y. Chen, "Small-size LTE/WWAN tablet device antenna with two hybrid feeds," IEEE Trans. Antennas Propag., Vol. 62(6), 2014 , pp. 2926–2934.

[12] A. Bath, A. Thakur, J. Sharma, Prof. B. Prasad, Design of a rectangular Patch Antenna, International Journal of Electrical and

Electroncs Engineering (IJEEE), vol. 1(1), 2014, pp. 1-6.

[13] S. Rawat, and K.K. Sharma, Annular ring microstrip patch antenna with finite ground plane for ultra -wideband applications, International Journal of Microwave and Wireless Technologies, 2015, pp. 179-184.

[14] K. L. Wong, H. J. Jiang, and T. W. Weng, Small-size planar LTE/WWAN antenna and antenna array formed by the same for tablet computer application, Microwave Opt. Technol. Lett., vol. 55, 2013, pp. 1928-1934.

[15] A. Rolland, A. V. Boriskin, C. Person, L. Le Coq, and R. Sauleau, " Lens-corrected axis-symmetrical shaped horn antenna in metalized foam with improved bandwidth," IEEE Antennas Wireless Propag. Lett., vol. 11(1), 2012, pp. 57–60.

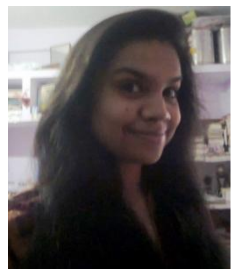
[16] M. Puri, S.S. Dhanik, P.K. Mishra, H. Khubchandani, "Design and Simulation of Double Ridged Horn Antenna Operating For UWB Application," IEEE India Conference (2013)

[17] M. R. Ahsan, M.T. Islam, M.H. Ullah, " A simple design of planar microstrip antenna on composite substrate for Ku/K band satellite applications," International Journal of Communications Systems, 2015, pp. DOI: 10.1002/dac.2970.

[18] R. Samii, M. Kovita, H. Rajagopalan, " Nature-Inspired Optimization Technique in Communication Antenna Design, "Proceeding of the IEEE, vol. 100 (7), 2012, pp. 2132-2144.

BIOGRAPHY

Pushpendra Singh did B. Sc. in Physics and M. Sc. in Electronic from CSJM University Kanpur. Presently he is pursuing Ph.D. in the field of Signal Processing System from Amity University, Rajasthan. His research interest includes Microwave devices.



Swati Singh did the Bachelor of Science and Master of Science in electronic from CSJM University Kanpur. Presently, she is pursuing the M. Tech. in field of Microwave device. Her research interest also includes in VLSI.