Design and Analysis of Microstrip patch antenna for bandwidth enhancement and gain for pervasive wireless Communication

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Abstract: *A microstrip antenna is designed for C and S Band applications by using the concept of slot cutting. The corners of the exciting patch are truncated the antenna is designed on standard FR 4 substrate with operating frequency 4 GHz. The open stub is used to improve the impedance bandwidth. A 50 Ω probe feed line is used to excite the proposed antenna which behaves like a stub. The variation in the length of stub affects the reflection coefficient of the proposed antenna and hence it controls the return loss level as well as it improves the other parameters. The simulations of proposed antenna are done on IE3D tool and measure its characteristics.*

Key Words: *Microstrip patch antenna (MPA), microstrip feed Line, axial ratio, bandwidth.*

1. INTRODUCTION:

Microstrip antenna has been recognized as a separate entity in the field of microwave antenna because of its copious advantages such as low profile, low cast, small size, light weight, and ease of integration with other microwave components. Day by day wireless communication systems become more and more trendy, which results to develop an interest to work on improvement of antenna performances. As we already know that microstrip patch antenna is advantageous over conventional microwave antennas and therefore used in various fields such as mobile and satellite communication application, global positioning system applications, radar application and telemedicine application, missiles, aircraft, and handsets as well as in biomedical telemetry services [1]. There are many advantages of MPA over conventional microwave antenna such as thin profile, dual frequency, light weight, dual polarization, and easy fabrication etc. However antenna has it's inherently shortcomings such as, low gain, narrow impedance bandwidth and efficiency. Much rigorous research has been done in recent years to develop bandwidth enhancement as well as to improve other parameters. Many applications require wide bandwidth, which is not provided by the traditional microstrip antenna. Hence, severe efforts started among the scientific community to eradicate its inborn drawback of narrow bandwidth. There are several and illustrious methods to enhance the band width of the antennas including: the use of low dielectric substrate [2], the use of the substrate thickness, the use of different impedance matching and feeding techniques, the use of Multiple resonators, and the use of slot antenna geometry. For efficient results the accurate feeding is necessary and for that resistance as the function of feed location and frequency is possible accurately.

A. Designing of the Ground plane

The length (L_g) and width (W_g) can be expressed as

$$L_g = L + 6h \quad (1)$$

$$W_g = W + 6h \quad (2)$$

Where "h" represent the height of the dielectric constant of the substrate. "L" and "W" are the length and width (in mm) of the microstrip patch respectively.

W and L are calculated as

$$W = \frac{1}{2f_r\sqrt{\mu_0\varepsilon_0}}\sqrt{\frac{2}{\varepsilon_r+1}} \quad (3)$$

$$L = Le - 2\Delta L \quad (4)$$

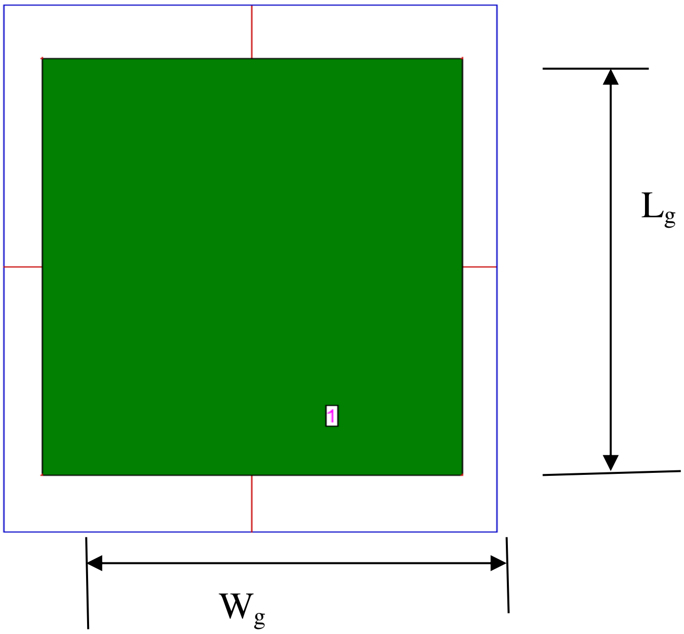

Figure 1. geometry of the ground plane of proposed antenna.

B. Designing of the slot

The dimensions of the given slot are as follows:

W = Patch's width
L = Patch's length
A= Length of outer exciting patch
B= Width of outer exciting patch
X= Length of inner exciting patch
Y= Width of inner exciting patch
a= Width of the cutting slot

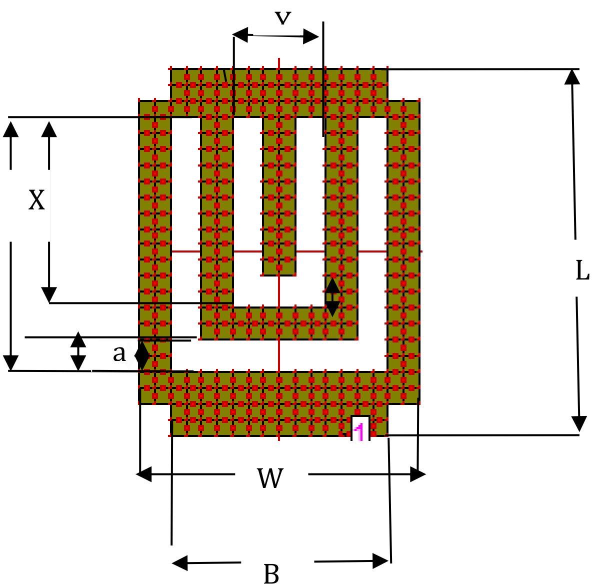

Figure 2.Top view of exciting patch

The Dimensions of the above slot are mentioned in the table 1

W	**17.43mm**
L	22.82mm
A	16mm
B	14mm
X	12mm
Y	06mm
A	02mm

The geometry of the proposed microstrip patch antenna is shown as in figure 3.

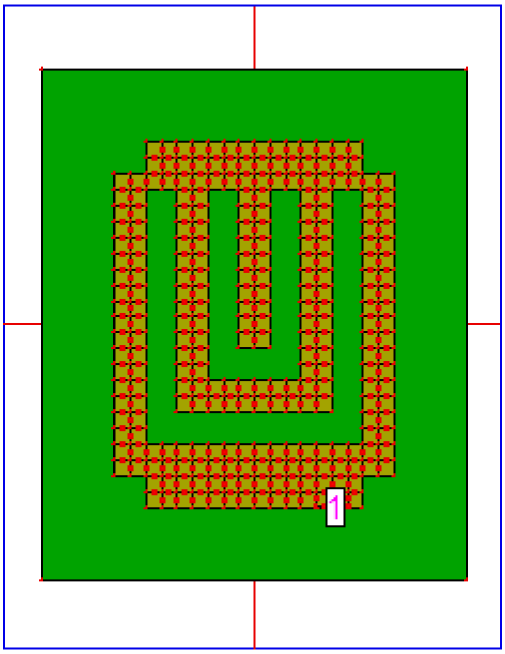

Figure 3. Geomtry of proposed antenna

Where, Le is the effective length and ΔL is the extended Length of the patch and are expressed in equation (5), (6) and (7).

$$L = \frac{c}{2f_o\sqrt{\varepsilon_{eff}}} \quad (5)$$

$$\Delta L = 0.412h\frac{(\varepsilon_{eff}+0.3)(\frac{w}{h}+0.2664)}{(\varepsilon_{eff}-0.258)(\frac{w}{h}+0.8)} \quad (6)$$

$$\varepsilon_{eff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\sqrt{\frac{1}{1+12\frac{h}{w}}} \quad (7)$$

Where "c" represents the speed of light in free space and "ε_{eff}" represents the effective dielectric constant of the substrate. The ground plane dimensions length "L_g" and width "W_g" are calculated as 33.57 mm and 40.029 mm respectively. The truncated corners are of dimension 3.92 mm*3.92 mm. Three dimensional view of proposed structure is shown in fig. 4.

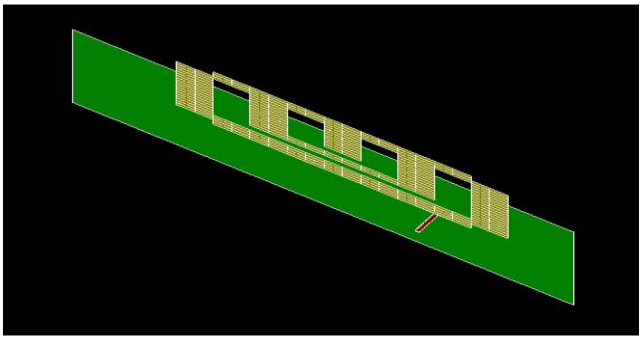

Figure 4. 3D view of proposed structure

2. DESIGN CONSIDERATION AND DISCUSSION OF RESULT:

The ground plane of dimension 26.43mm*31.82 mm*1.5 mm is used to fabricate the prototype.

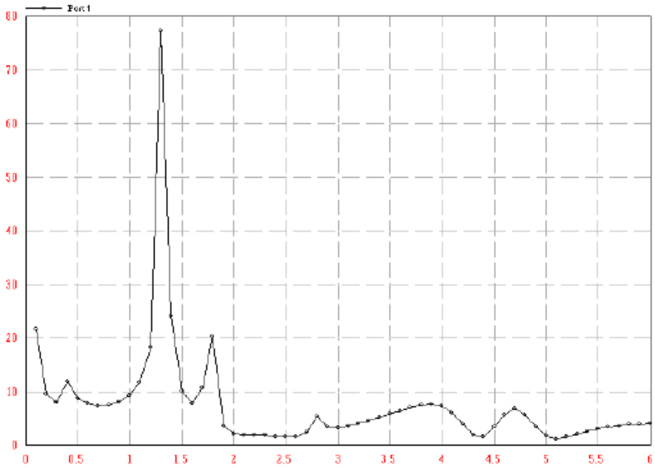

Figure 5. Simulated values of VSWR vs. Frequency

The variations in voltage standing wave ratio (VSWR) with respect to the Frequency are shown in Fig.5. The antenna VSWR is found to be 1.468, 1.841 and 1.554 at three resonance frequency 2.5 GHz, 4.3 GHz and 5.2 GHz which confirms low power reflection and enhance antenna performance. The return loss variations with respect to the Frequency are represented in Fig. 6 which shows an enhanced impedance bandwidth of 39.21% in range from 1.774 GHz to 1.554 GHz. The three resonances occur at frequency 2.5 GHz, 4.3GHz and 5.2 GHz. The directivity defines the maximum directional gain of an antenna in a particular direction and is found up to 5 dBi in the operating range of 5GHz to 5.2GHz as shown in fig. 7.

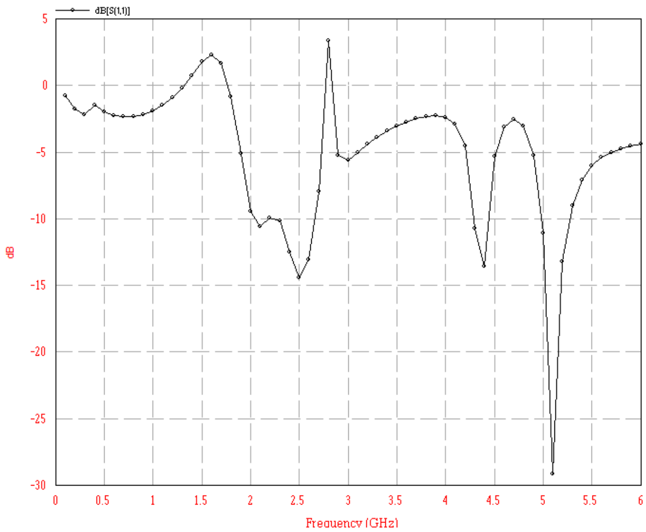

Figure 6. Simulated values of S11 vs. Frequency

The gain of the proposed antenna is found up to 5dB in the operating frequency range from 5 GHz to 5.2 GHz. The antenna efficiency of the proposed microstrip patch antenna is found up to 98 %.The maximum antenna efficiency for proposed structure is found to be 98% respectively as shown in figure 7.

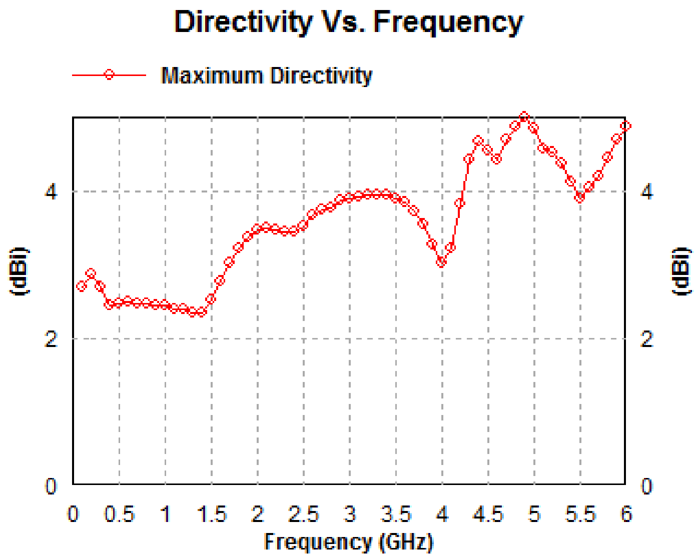

Figure 7. Simulated values of Directivity vs. Frequency

The smith chart of the praposed microstrip antenna is shown as in figure 9 at freuency 5.2GHz.

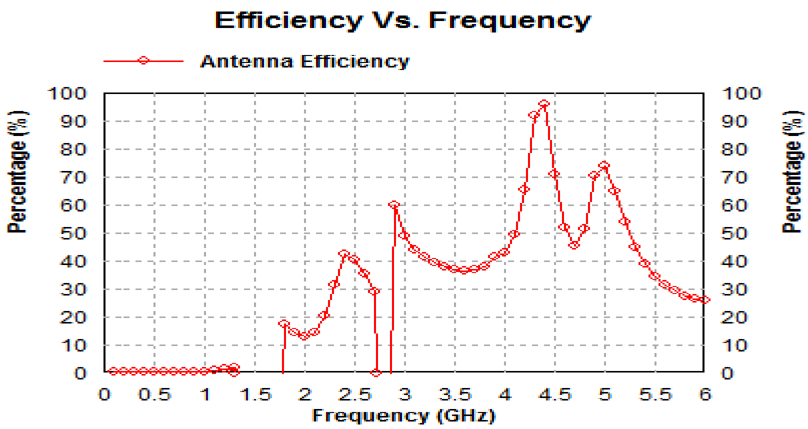

Figure 8. Simulated values of Efficiency vs. Frequency

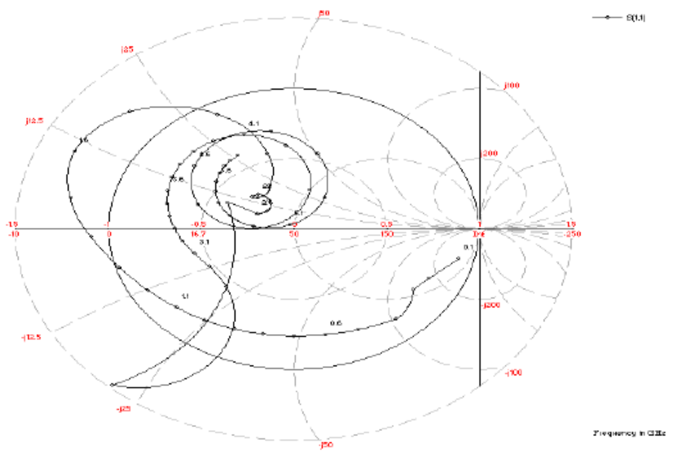

Figure 9. Smith chart of proposed antenna

The simulated values of axial ratio vs. frequency are shown as in figure 10. 2D pattern of the proposed microstrip antenna is shown in figure 11. The 3D view of proposed antenna is shown in figure 12.

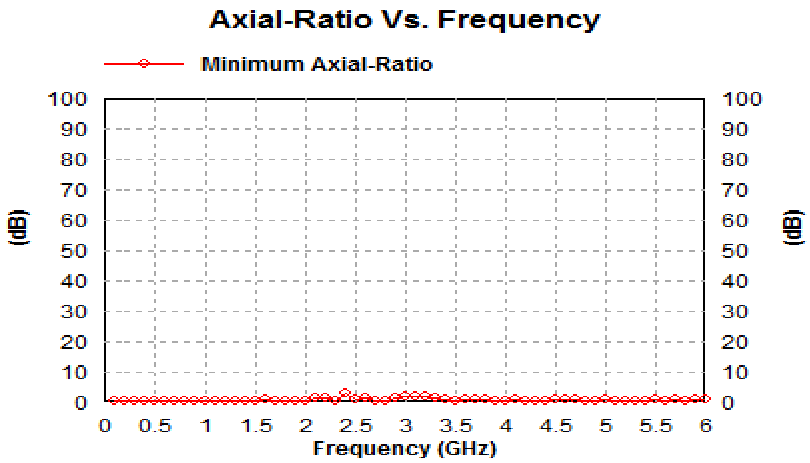

Figure 10. simulated value of axial-ratio Vs. Frequency

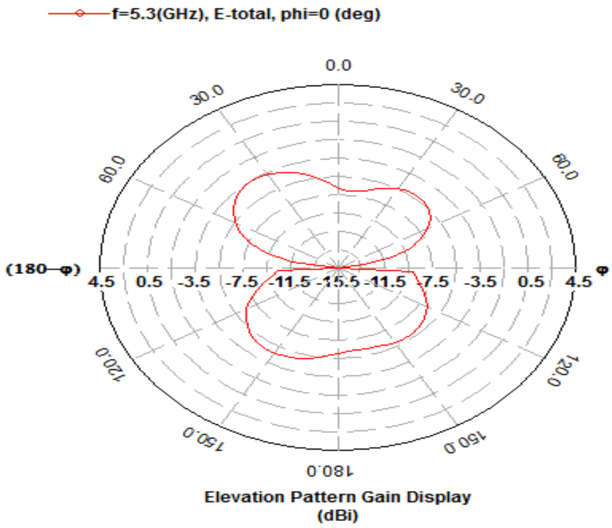

Figure 11. 2D pattern of proposed antenna at 5.2 GHz

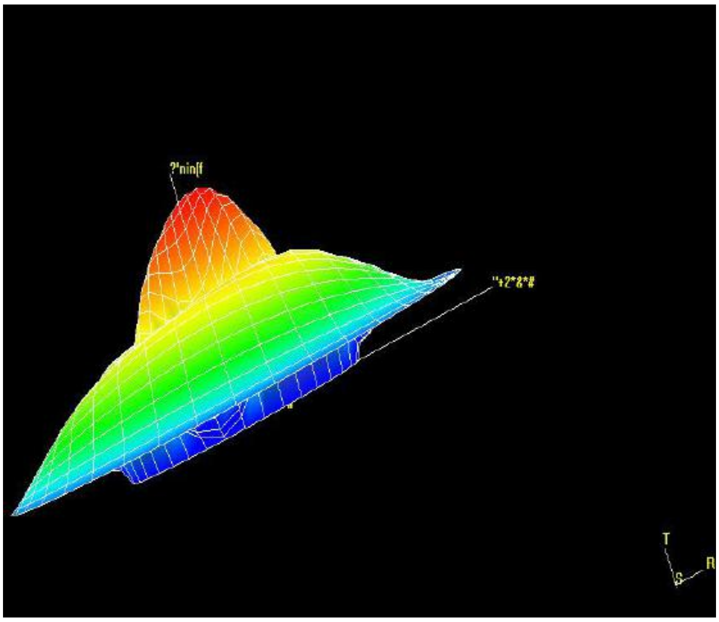

Figure 12. 3D view of proposed antenna.

3. CONCLUSION:

The Microstrip-probe-fed antenna with with cutting slot is proposed. An impedance bandwidth of 39.21% in range from 5 GHz to 5.2 GHz has been achieved. The three resonances occur at frequency 2.5 GHz, 4.3GHz and 5.2 GHz which covers S band and C band partially. The gain of proposed antenna is found as 5 dB at 5GHz frequency. The directivity of 5 dBi is achieved in impedance bandwidth. VSWR is found to be 1.468, 1.814 and 1.554 at three resonance frequency 2.5 GHz, 4.3GHz and 5.2 GHz. The antenna efficiency of proposed antenna is found to be 98%. Thus proposed structure is suitable for "S" band and "C" band applications.

REFERENCES:

1. J.-S. Hong, E.P. McErlean, and B. Karyamapudi, "Eighteen-pole superconducting CQ filter for future wireless applications", IEE Proc Microwave Antennas Propagate 1 53 (2006), 205–211.
2. C. Li, Q. Zhang, Q. Meng, L. Sun, J. Huang, Y. Wang, X. Zhang, A. He, H. Li, Y. He, and S. Luo, "A high-performance ultra-narrow bandpass HTS filter and its application in a wind-profiler radar system", Supercond Sci Technol 19 (2006), S398–S402.
3. Mahrukh khan, "Characteristics Mode Analysis of a class of Empirical Design Techniques for Probe-Fed, U-slot Microstrip Patch Antennas", IEEE transaction on antenna and propagation, volume issue 2016[doi 10.1109_TAP 2016.2556705].
4. H. Wang, X. B. Huang, and D. G. Fang, "A Single Layer wideband U-slot Microstrip Patch Antenna Array", IEEE antenna and wireless propagation letters, vol.7, 2008.
5. Kin-Fai Tong, Kwai-Man Luk, Senior Member, Kai-Fong Lee, and Richard Q. Lee, "A Broad-Band U-slot Rectangular Patch Antenna on microwave substrate",IEEE transactions on antennas and propagation, vol. 48, no. 6, June 2000.
6. Steven Weigand, Greg H. Huff, Kankan H. Pan, and Jennifer T. Bernhard, "Analysis and Design of Broad Band single-layer Rectangular U-slot microstrip Patch Antenna", IEEE transactions on antennas and propagation, vol.51, no. 3, march 2003.
7. G. F. Khodaei, J. Nourinia, and C. Ghobadi, "A practical miniaturized U-slot patch antenna with enhanced bandwidth", Progress In Electromagnetics Research B, Vol. 3, 47–62, 2008.
8. M.Koohestani, M. Golpour, "*U-shaped microstrip patch antenna with novel parasitic tuning stubs for ulta wideband applications*", IET Microw. Antennas Propag., vol. 4, no. 7, pp. 938–946, 2010.
9. Sandra Costanzo and Antonio Costanzo, "*Modified U-slot patch antenna with reduced cross-polarization",* IEEE Antennas Propag. Mag., vol. 57, no. 3, pp. 71–80, June 2015.
10. J. A. Ansari and B. R. Ram, "*Analysis of Broad-Band U-Slot Microstrip Patch Antenna*, "Microwave and Optical Technology Letters, vol. 50, no. 4, pp. 1069–1073, April 2008.