IJSRD - International Journal for Scientific Research & Development| Vol. 4, Issue 09, 2016 | ISSN (online): 2321-0613

A Microstrip Teeth-Like Patch Slot Antenna for Defense and Satellite Applications

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Abstract— Micro strip antennas are used as integrated antennas in wireless devices such as mobile phones, and also employed in Satellite communications. The Microstrip Patch Antenna (MPA) finds immense applications [17] in mobile and satellite communication, Global Positioning System, Radio Frequency Identification (RFID), WiMax, RADAR, Rectenna, telemedicine applications, etc. The advantages of MPA are low weight, low profile, both linear and circular polarization, easy feeding. The main disadvantage of MPA is its low bandwidth [17].A Microstrip Teeth-Like Patch Slot Antenna is proposed, designed, fabricated and tested. The proposed antenna operates in the desired C-Band and maintains its radiation characteristics in it. The antenna gain and directivity vary as 2-4 dB and 5.5-6.5 dBi respectively. The proposed antenna can find applications in Defense Applications, Satellite Applications (6.425-6.725 GHz i.e., the Uplink frequencies for MEASAT etc.).

Key words: Defense and Satellite Applications, Microstrip Teeth-Like Patch Slot Antenna

I. INTRODUCTION

A. *Microstrip Patch Antennas {MPA)*

The Microstrip Patch Antenna(MPA) basically consists of a dielectric substrate sandwiched between two metallic plates on both the sides. These metallic plates consist of the radiating patch on one side (top) and the ground plane on the other side. The schematic diagram of the MPA is indicated in fig. 1 [2], [32].

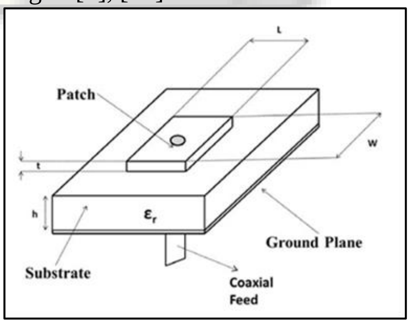

Fig. 1: Micro Strip Antenna

The Patch as well as the ground plane is usually made up of conducting material like copper. The patch element as well as feed line is usually made over the sub-strate by removing undesirable copper cladding. The patch can be made of any shape, but for the ease of analysis usually the patch is made square, rectangular, circular, triangular, and elliptical or any other known geometrical shapes. The parameters of the MPA are L, W, h, t. Generally L lies in the range $0.33330\ \lambda 0 < L < 0.5\lambda 0$, where $\lambda 0$ denotes the free space wavelength. The metallic patch is chosen to be very thin such that $t <<< \lambda 0$, where t denotes the thickness of the metallic patch. The height of the dielectric substrate h lies in the range $0.003\lambda 0 < h < 0.05\lambda 0$. Usually the relative electrical permittivity of the substrate generally has a value lying between $2.2 < er < 12$.

The MPA can be fed by many techniques like microstrip line feed, coaxial feed, aperture coupling, proximity coupling. There are many techniques available for the analysis of the MPA like Transmission line model

II. ANTENNA DESIGN

The Microstrip Patch Antenna is designed using FR-4 substrate having dielectric constant $E= 4.3$, thickness h=1.5mm and having dimensions as 30 x 45 mm^2 Microstrip patch has dimensions 15 x 22.5 mm2. Teeth-like slots are cut in the patch with the dimensions L1 = 15 mm, L2= 5 mm as shown in the diagram. The width of the slots is d = 0.5 mm and the gap between the vertical slots segments i.e., g = 1.5 mm. The Microstrip Patch Antenna is fed by the coaxial cable at a distance 'sv' from one of the edges, sv = 3.5mm. The ground plane dimensions are 30 x 45 mm^2. The thickness of the metal sheet is taken as mt = 0.018mm. The antenna structure is depicted in fig. 2.1.

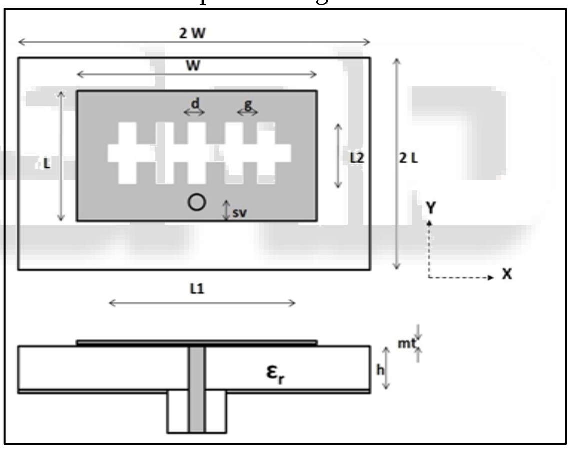

Fig. 2: Antenna Design

The various parameters of the design are tabulated in the table 1.

Parameter	Value(mm)
L	15
w	22.5
h	1.5
L_1	15
L_2	5
s_v	3.5
d	0.5
g	1.5
mt i.e., thickness of the copper cladd	0.018

Table 1: List of parameters for antenna design 1

A. *Simulation results*

The $S_{11\ parameter}$ of the basic Microstrip patch antenna and that with proposed slot is shown in the fig. 2.2. As clear from fig. 2.2, with the proposed slot in the Microstrip patch antenna, it introduces additional band (near the higher order mode of the basic patch without slot) in the 8_{11} parameter of the basic Microstrip patch antenna. The introduction of a new band causes the widening of the S11 parameters of the basic Microstrip patch antenna near 6-7 GHz. The fundamental frequency of the antenna shifts in the lower frequency range with the introduction of the slot, as expected due to the lengthening of the current Path.

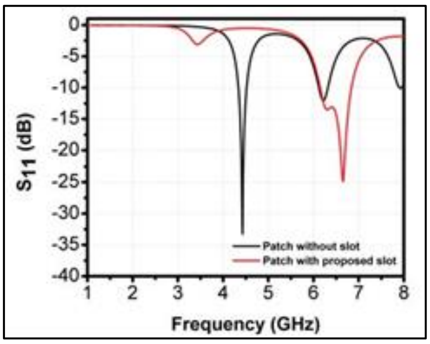

Fig. 2.2: Return Loss (8_{11}) comparison of the Microstrip patch antenna with and without proposed slot.

The position of the slot feed 'sv' is optimized to give the best obtainable impedance matching in the desired band (6-7 GHz). Other parameters like Ll, L2, d, g are also optimized to obtain best results. Fig. 2.3 shows the Gain and Directivity variation in the obtained band. The gain of the antenna varies as around 2.25 dB to 3.6 dB and the Directivity vary as around 5.25 dBi to 7 dBi. Fig. 2.4 shows the radiation patterns of the designed antenna in the 6.497 GHz center frequency at different planes.

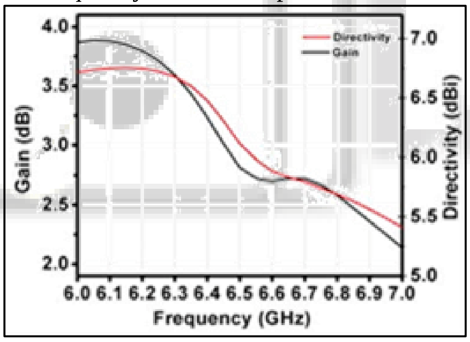

Fig. 2.3: Gain and Directivity variation in the 6-7 GHz band.

Fig. 2.4 shows the radiation patterns of the designed antenna in the 6.497 GHz center frequency at different planes.

Fig. 2.5 And Fig. 2.6 shows the parametric variation of the parameter 'd' and 'g' respectively. The parameter 'g' represents the gap between the vertical slots and the parameter 'd' represents the width of the slots. As 'd' is increased, the 8_{11}parameter shifts in the higher frequency range. As 'g' is increased, the 811 parameter shifts in the lower frequencies. The values g = l.5mm and d= 0.5mm was selected to be the best and adopted.

B. Effects of addition of vertical slot segments

Fig. 2.7 shows various slot segments in the designed Microstrip Patch antenna. As clearly indicated there is a horizontal slot segment having length Ll and other vertical slots are placed having length L2. There are 5 vertical slot segments, one in the center and 2 pairs on each side. The effect of addition of these segments is indicated in the Fig. 2.8. Fig. 2.8 is obtained by stepwise adding the vertical slot.

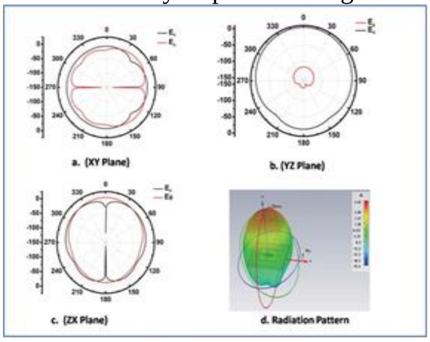

Fig. 2.4: Radiation patterns at fc = 6.497 GHz for different radiation, fc is the Center frequency of the obtained band.

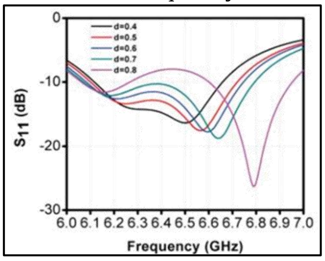

Fig. 2.5: Effect of'd' variation in S_{11} Segments to the horizontal slot segment and the corresponding changes in the $8_{11parameters}$ is plotted.

As indicated in Fig 2.8, the horizontal slot segment introduces a band in the S_{11} parameter. As the center-positioned vertical slot is added to the horizontal slot, the change is unnoticeable. The addition of pairs of vertical slot-pairs in the design shifts the band introduces towards the lower frequency as clearly depicted. This effect is accounted to the principle that as the slot length is increased (by increasing the number of slots i.e. Vertical slots), the resonant frequency decreases. Thus by adding more vertical slot segments, the two bands move closer to each other and the bandwidth enhancement is obtained thereby. The addition of further slot-pairs (3rd slot-pair) leads to saturation in the improvement in the return loss , hence we end up with adding only having 5 vertical slot segments thereby achieving the best results possible.

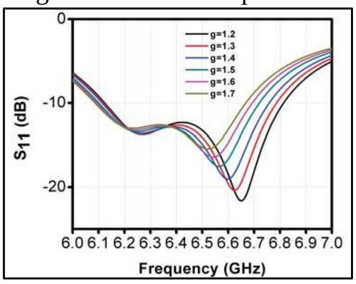

Fig. 2.6: Effect of 'g' variation in 811

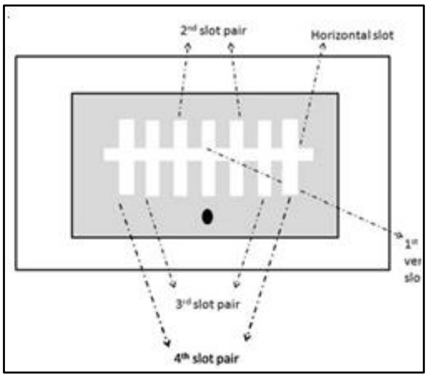

Fig. 2.7: Showing various slot segments

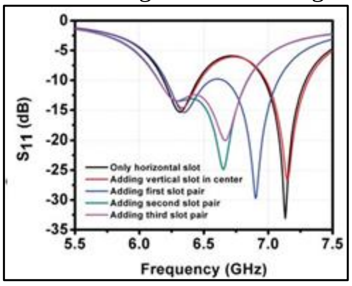

Fig. 2.8: Effect of addition of ther Vertical slots in the design

C. *Measurement Results*

The proposed antenna was fabricated using LPKF PCB prototyping machine. Later the antenna was tested using Agilent Vector Network Analyzer. The measured S-parameter has a striking resemblance with the simulated S-parameter as shown in fig. 2.10. The fabricated antenna is shown in fig. 2.9.

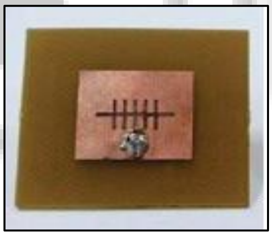

Fig. 2.9: The fabricated antenna

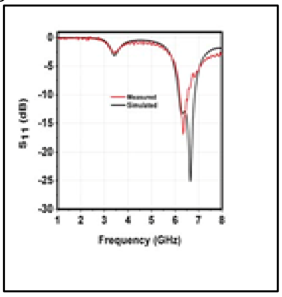

Fig. 2.10: The measured S-parameter has a striking resemblance with the simulated S-parameter.

The least variation in the measured and simulated results could be attributed to the use of low-frequency SMA connectors employed and the imperfections in the incorporation of the Coaxial feed through SMA connectors. However still the measured and the simulated results of the proposed design are quite satisfactorily matching in agreement with each other thereby verification of the proposed design has been done.

III. Conclusion

The Microstrip Tapered Tooth-Like slot antenna is designed which operates in the C-band, having a Gain of 2-4 dB in the desired band and an impedance bandwidth of 13%. The Antenna can find usage in the C-band applications like the Defense applications, Satellite applications (6.425-6.725 GHz i.e., the Uplink frequencies for MEASAT etc).

References

[1] A. AzARI, A new super wideband fractal microstrip antenna, IEEE Transaction on Antennas and Propagation, 59 (2011), pp. 1724-1727.
[2] C. BALANIS, Antenna theory analysis and design, John Wiley and Sons Inc., Wiley, 2005.
[3] S. BHAVSAR AND P. B. SINGH, Electromagnetic band gap structures in- corporated in antenna array: A review, International Journal of Computer Technology and Electronics Engineering (IJCTEE),
[4] H. CHOO AND H. LING, Design of multiband microstrip antennas using a genetic algorithm, IEEE MICROWAVE AND WIRELESS COMPONENTS LETTERS, 12 (2002), pp. 345-347.
[5] B. G. ET AL, Miniaturization of sot antennas using slit and strip loading, IEEE TRANSACTION ON ANTENNAS AND PROPAGATION, 59 (2011), pp. 3922-3927.
[6] B.-Q. L. ET AL, Uniplanar ebg structure with improved compact and wide- band characteristics, Electronic letters, 44 (2008), pp. 1362-1363.
[7] H. ET AL, An microstrip antenna array formed by microstrip line fed tooth- like-slot patches, IEEE TRANSACTION ON ANTENNAS AND PROPA-GATION, 55 (2007), pp. 1210-1214.
[8] I. S. ET AL, Microstrip patch antenna and its applications: A survey, Int. J. Comp. Tech. Appl., 2 (2011), pp. 1595-1599.
[9] K. F. L. ET AL., Dual- and multiband u-slot patch antennas, IEEE ANTEN- NAS AND WIRELESS PROPAGATION LETTERS, 7 (2008), pp. 645-647.
[10] K. L. ET AL, Design of a wideband microstrip bowtie patch antenna, IEE Proc.-Microw. Antennas Propag, 145 (1998), pp. 137-140.
[11] L. Y. ET AL., A novel compact electromagnetic-bandgap (ebg) structure and its applications for microwave circuits, IEEE TRANSACTIONS ON MI-CROWAVE THEORY AND TECHNIQUES, 53 (2005), pp. 183-190.
[12] W. C. L. ET AL., Triple-frequency meandered monopole antenna with shorted parasitic strips for wireless application, IET Microwaves Antennas and Propagation, 3 (2008), pp. 1110-1117.
[13] F. YANG AND Y. R. SAMII, Electromagnetic band gap structures in antenna engineering, Cambridge University Press, Cambridge, 2009.