Performance Characterization of Radial Stub Microstrip Bow-Tie Antenna

[1]B.T.P.Madhav, [2]S.S.Mohan Reddy, [3]Neha Sharma, [3]J. Ravindranath Chowdary
[3]Bala Rama Pavithra, [3]K.N.V.S. Kishore, [3]G. Sriram, [3]B. Sachin Kumar
[1]Associate Professor, Department of ECE, K L University, Guntur DT, AP, India
[2]Associate Professor, Department of ECE, SRKR Engineering College, Bhimavaram, AP, India
[3]Project Students, Department of ECE, K L University, Guntur DT, AP, India

Abstract: **In this paper a novel radial stub feeding microstrip bow-tie antenna is designed to operate between C and X band and its performance characterization is presented. This antenna is having simple structure and topology over other stub loaded antennas. In addition the proposed antenna adjusts to the desired frequency easily. Antenna output parameters like radiation pattern, axial ratio, directive gain and quality factor are simulated and presented in this current work.**

Keywords: Radial Stub, Bow-Tie Antenna, Axial ratio, Directive gain, Quality factor.

I. INTRODUCTION:

In hybrid and monolithic circuits, the radial stub will be used in common. When low impedance levels are needed, the behavior of conventional stub degrades as a result of the excitation of higher order modes. In wide frequency band, the radial stub provides a low impedance level at a well specified insertion point. Ever since the radial stub theory was proposed, this topology has been used as a feeding structure for presenting a wide impedance band [1-2]. In this letter, we adopt this radial stub on the top layer to feed the antenna and additionally provide an improved resonance at the high frequency.

In the recent years the microstrip antennas have been used in engineering applications as well as in theoretical research. There are several reasons to choose microstrip antennas in the applications, which includes compact nature, low cost of fabrication, conformal structure etc. Bow-Tie antennas are becoming the attractive candidates for communication systems because of their compact nature compared to normal rectangular patch antennas. However in the literature fewer attempts have been made on the analysis of these models. The present paper deals with the design of bow-tie antenna using radial stub feeding and its performance characterization.

II. INPUT IMPEDANCE CALCULATION:

The electromagnetic field in the radial stub can be expressed in terms of radial line modes. Assuming that input port width w is very small compared to the wavelength, only TEM radial mode is excited with non negligible amplitude. Accordingly for ideal lossless radial stub, the input impedance is found to be

$$Z_{in} = -jZ_0(r_{ie})\cot(K_{rie}, K_{roe})$$

$$\cot(K_{rie}, K_{roe}) = \frac{N0(K_{rie})J1(K_{roe}) - J0(K_{rie})N1(K_{roe})}{J1(K_{rie})N1(K_{roe}) - N1(K_{rie})J1(K_{roe})}$$

$$Z_0(r_{ie}) = \frac{120\pi h}{rie\varphi\sqrt{\varepsilon_r}}$$

Where Ji and Ni are the Bessel and Neumann functions of ith order. Conductor and dielectric losses can be accounted by assuming a complex wave number: $k = \beta + j\alpha$, where

$$\alpha = \frac{Rs\sqrt{\varepsilon_r}}{120\pi} + \frac{\beta}{2}\tan(\delta)$$

Where Rs = conductor surface resistivity in ohm/square. Once Z_{in} has been computed, the scattering parameters of shunt connected single or double stubs can be calculated as considering the stub as a shunt load to the main line.

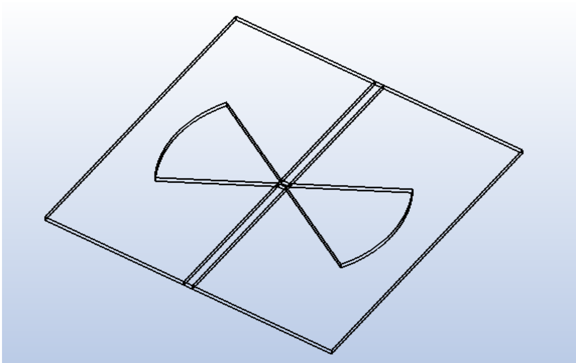

Figure 1 Radial Stub Microstrip Bowtie antenna

III. DESIGN CONSIDERATIONS OF BOWTIE ANTENNA:

From the figure 1, ‘a’ is the side length and ‘θ’ is the angle of the equilateral triangle. L1, L2, W1 and W2 are the dimensions of the matching network [3-4].

$$f_r = \frac{c k_{mn}}{2\pi\sqrt{\varepsilon_r}}$$

$$f_r = \frac{2c\sqrt{m^2 + mn + n^2}}{3a\sqrt{\varepsilon_r}}$$

Where f_r is the resonance frequency, K_{mn} is the resonating modes, c is the velocity of light in free space, a is the side length of the bow-tie strip. When triangular resonator is surrounded by a perfect magnetic wall then this expression will be valid. The inner width is 1mm, outer width 18.8mm, arm length 17.1mm, gap port length 1mm, substrate thickness 1.58mm, substrate dimension along x-axis 40mm, substrate dimension along y-axis 60mm. the entire dimension of the antenna is of 60mmX40mmX1.6mm.

IV. RESULTS AND DISCUSSION:

In the proposed model RT-duroid substrate of dielectric constant 2.2 with height of 1.6 mm is taken. Figure 1 shows the return loss, smith chart, VSWR and directive gain curves for the proposed antenna. A return loss of less than -10 dB of -15.8 dB and VSWR of <2 of 1.4 is obtained at 8GHz from the current model. High directive gain of 18dB is attained from this model. Figure 3 shows the parameters of port admittance, port impedance, impedance matrix and quality factor of the antenna. From the port admittance curve, at resonating frequency the admittance of Real and imaginary parts of $5.2e^{-2}$ and $-1.2e^{-1}$ is obtained. For port impedance the intersection of real and imaginary parts at $-2.5e^{+1}$ is attained. At resonant frequency quality factor value of $3.52e^{+1}$ is attained. Henceforth, the radial stub is analyzed to be used for feeding and providing an additional resonance. In general, characteristic of the radial stub is represented by the effective dimension proposed by magnetic wall model [5-6], and effective angle and arc of a circle generated by effective dimension play important roles in deciding the high-frequency characteristic.

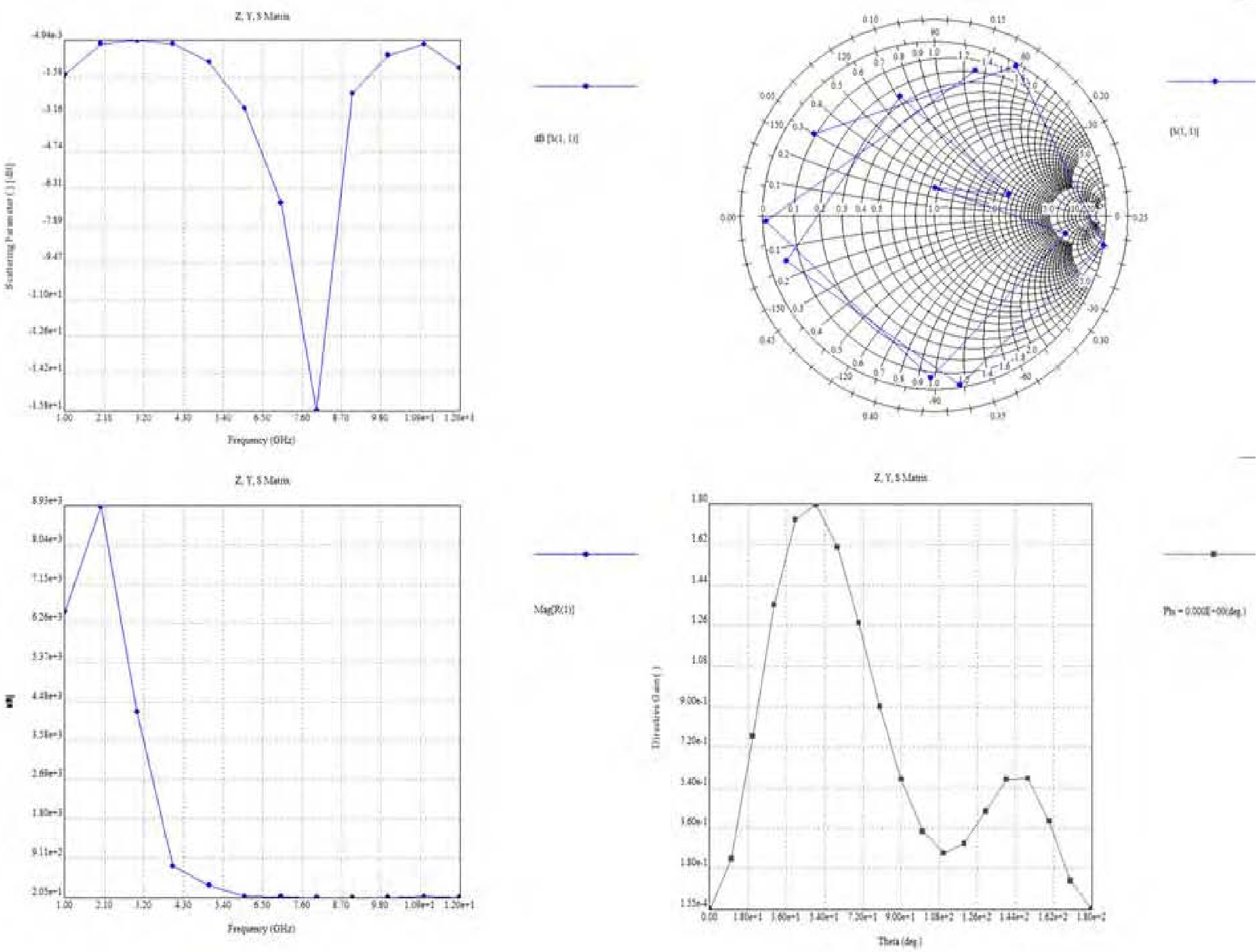

Figure 2, (a) Return loss, (b) Smith Chart, (c) VSWR, (d) Directive gain

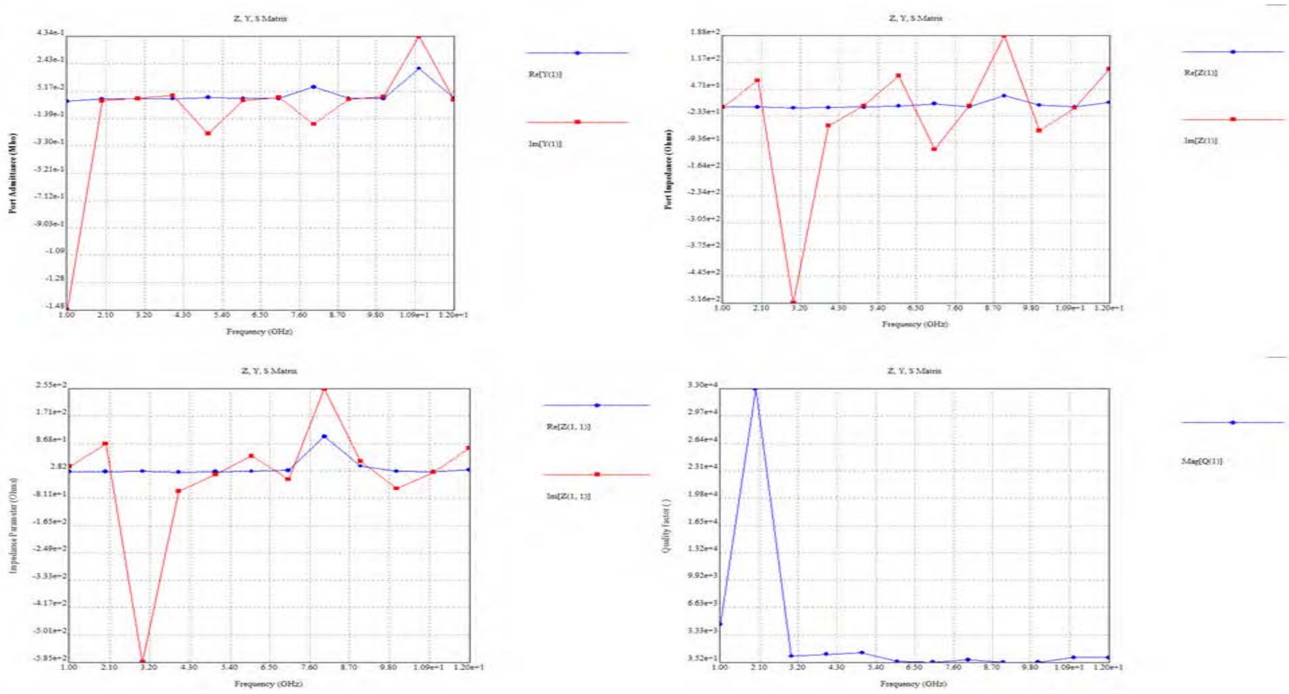

Figure 3, (a) Port Admittance, (b) Port Impedance, (c) Impedance Matrix, (d) Quality Factor

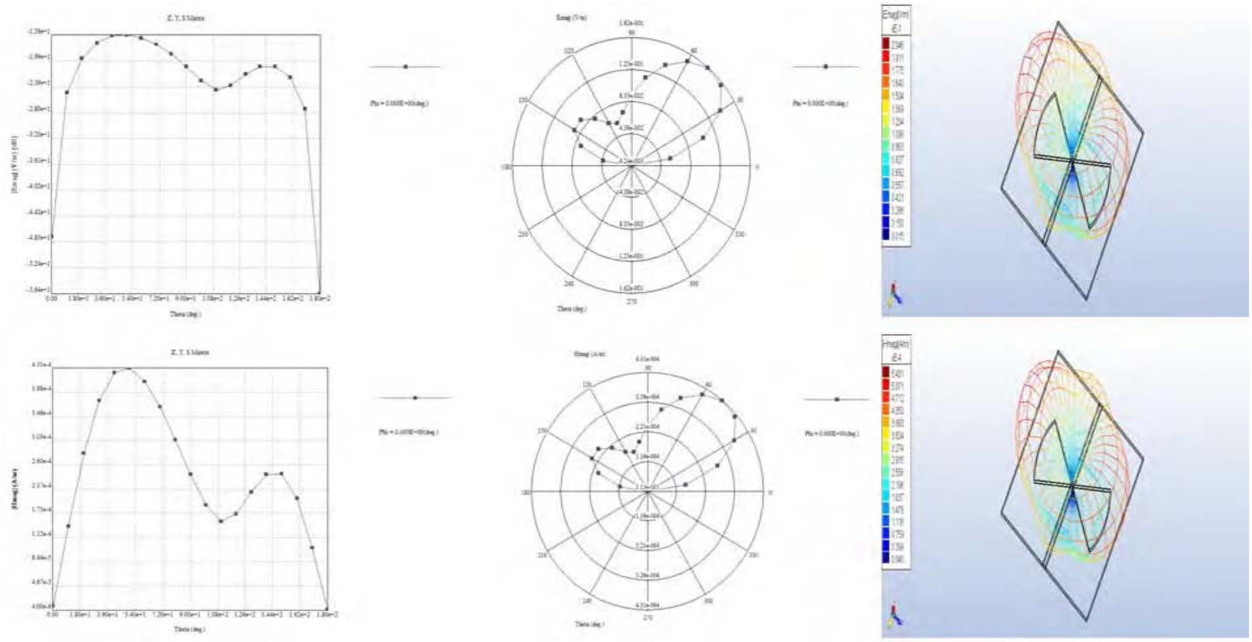

Figure 4, (a) Radiation Pattern in E-Plane, (b) Radiation Pattern in H-Plane

For each mode, there are two orthogonal planes in the far field region. One designated as E-plane and the other designated as H-plane. The far zone electric field lies in the E-plane and the far zone magnetic field lies in the H-plane. The patterns in these planes are referred to as the E and H plane patterns respectively.

The contributions to the far fields are from the magnetic surface current densities on the side walls containing the radiating edges [7-8]. The directions of the magnetic currents that the E-plane is the y-z plane (Φ=90º) and the H-plane is the x-z plane (Φ=0º). For the TM_{10} mode, the E-plane is the x-z plane (Φ=0º) and the H-plane is the y-z plane (Φ=90º). Figure 4 shows the radiation pattern of the antenna in E-Plane and H-Plane.

$$E_{\theta}(r,\theta,\phi) = -2wh\left(\frac{E_0}{\eta_0}\right)\cos\phi(1 - T^{TM}(\theta))\cos\left(k_x\frac{L}{2}\right)\sin c\left(k_y\frac{w}{2}\right)\tan c(k_{z1}h)$$

$$E_{\phi}(r,\theta,\phi) = 2wh\left(\frac{E_0}{\eta_0}\right)(\cos\theta\sin\phi)(1 - T^{TE}(\theta))\cos\left(k_x\frac{L}{2}\right)\sin c\left(k_y\frac{w}{2}\right)\tan c(k_{z1}h)$$

V. CONCLUSION:

Radial stub loaded microstrip bowtie antenna is designed to operate between C and X band. The antenna output parameters are presented in this paper. This antenna is providing good bandwidth with low cross polarization levels and relatively high gain in the frequency band of operation. Furthermore it produces and endfire radiation pattern with good front to back ratio of more than 10dB. The desired return loss can be obtained as long as the radial stub matching is perfect. The Perfect impedance matching is achieved with radial stub feeding and the results show the applicability of this antenna in the desired frequency band applications.

ACKNOWLEDGEMENTS:

Authors like to express their gratitude towards department of ECE, Management of K L University and SRKR Engineering College for their support and encouragement during this work. Madhav likes to express his special thanks to Sri Koneru Satyanarayana garu, President, KLU and Dr. Srihari Rao garu, VC, KLU for providing Excellent R&D facilities to carry out this work.

REFERENCES:

[1] Roberto Sorrentino, Luca Ruselli, “A New Simple and Accurate Formula for Microstrip Radial Stub”, IEEE Microwave and guided wave Letters, Vol 2, No 12, 1992, pp 1-3.

[2] P. H. Rao, V. F. Fusco, and R. Cahill, “Linearly polarised radial stub fed high performance wideband slot antenna,” Electron. Lett., vol. 37, no. 6, pp. 335–336, Mar. 2007.

[3] P. H. Rao, V. F. Fusco, and R. Cahill, “Linearly polarised radial stub fed high performance wideband slot antenna,” Electron. Lett., vol. 37, no. 6, pp. 335–337, Mar. 2001.

[4] Z. Guiping, A.A Kishk, A.B Yakovlev and A.W Glisson,"A Broadbandprinted bow-tie antenna with a simplified feed”, IEEE Antennas and Propagation society International Symposium, vol 4, 2004, pp 4024-4027.

[5] Y-D Lin, and S-N Tsai, “Analysis and design of broadband-coupled striplines-fed bow-tie antennas,” IEEE Trans. Antennas and Propagat vol. 46, no. 3, pp. 459-560, March 1998.

[6] L. G. Maloratsky, “Reviewing the basics of microstrip lines,” *Microwave & RF.* pp. 79-88, March 2000.
[7] Kai Fong Lee, Kwai Man Luk, ‘Microstrip patch Antennas”, ICP, 2011.
[8] B.T.P.Madhav, VGKM Pisipati1, et all, “Liquid Crystal Bow-Tie Microstrip antenna for Wireless Communication Applications”, Journal of Engineering Science and Technology Review, ISSN: 1791-2377, 4 (2) (2011) 131-134.