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Formulations for Hexagon Shaped Ultra Wide Band Antennas

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ABSTRACT
A hexagonal ultra wide antenna has been studied. First, the hexagon has been fed at one of its vertices and the effect of change in dimensions has been observed. An optimum bandwidth of 14 GHz has been obtained. Next, an equivalent circular ultra wide-band antenna is designed and current distribution at $TM_{11}$and TM_{21} mode is studied. Lastly frequency formulation for vertex-fed hexagonal antenna at $TM_{11}$and TM_{21} mode is presented. The frequencies calculated using the same closely agrees with the simulated results. Thus proposed formulations can be used to realize ultra-wide band hexagonal antenna from the desired frequency range.

Keywords
Ultra wide-band micro strip antenna, planar monopole antenna, hexagon ultra wide band antenna

1. INTRODUCTION
In wireless applications requiring higher data rates that involve pulse communication systems, larger bandwidth (BW) (in few GHz) is needed and in such applications printed ultra-wideband (UWB) antennas have become very popular due to their small size and low cost [1]. Many micro strip variations of UWB antenna using different patch shape like, rectangular, square, circular, triangular, etc. have been reported which gives BW in few GHz [1]. Most of the printed UWB antennas are fed using micro strip line or by using coplanar waveguide fed. By using different shapes for the patch and slot, ultra wideband antennas are realized [3 – 8]. The ultra-wide band response in these structures is realized due to higher BW at the individual mode. The use of different slots changes the frequencies and impedance at individual modes to realize further increase in BW. The use of multiple slots in a patch antenna and in the ground plane results in ultra-wide band response [9-15].Depending upon the slot position with respect to the excited modes, amount of fringing fields from the slotted patch area changes, which changes the patch radiating efficiency. In the previously reported paper [2], a hexagonal ultra-wide band antenna was studied and fabricated. First, the antenna was fed at the centre of the base of the hexagon. It yielded a bandwidth of around 14 GHz. The dimensions of the hexagon had also been varied by chopping it on two opposite sides. This reduced the bandwidth of the antenna. Next, the hexagon was fed at one of its vertices and it was observed that the bandwidth of the configuration remained the same. Further, the same configuration had been chopped and it was observed that its bandwidth reduced by 0.5 GHz. The hexagon was then fed by offsetting its position along the base. This configuration yielded an optimum bandwidth of 14.5 GHz. In this paper, formulations for the hexagonal UWB antenna have been presented. First, regular hexagonal UWB antenna is considered. Then an equivalent circular UWB antenna is simulated and its resonance curve is compared to that of the hexagonal UWB antenna. The current distributions at different modes for both configurations is studied. The formulas for CMSA given in [1] are then used for the hexagonal configuration. It is observed that the same formulas are not applicable as the error is very large. Hence, new formulas are proposed for hexagonal UWB antennas and it is observed that results show a low percentage error. All antennas have been initially analyzed using IE3D software [16] using glass epoxy substrate ($\varepsilon_r = 4.3$, h = 1.6 mm, tan δ = 0.02).

2. OFFSET BASE-FED HEXAGON UWB ANTENNA:
The offset base-fed hexagon UWB antenna is shown in Fig.1. The hexagon has a side-length of s = 8.25 mm and the gap between the patch and the ground plane is given by g = 0.5 mm. The dimensions of the ground plane are: L = 24 mm, W = 10 mm and the strip width, a, is 4 mm. The resonance curve and return loss plot for the optimized configuration are given in Fig.2 (a) and (b) respectively. It is observed that this configuration yields a bandwidth of 14.5 GHz [2].

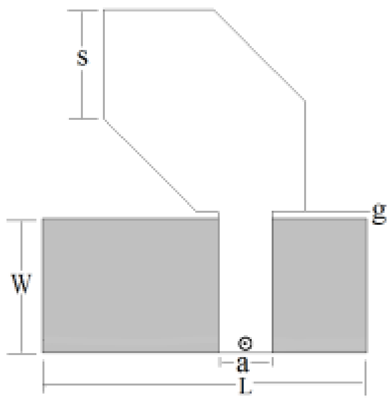

Fig.1: Offset base-fed hexagon UWB antenna [2]

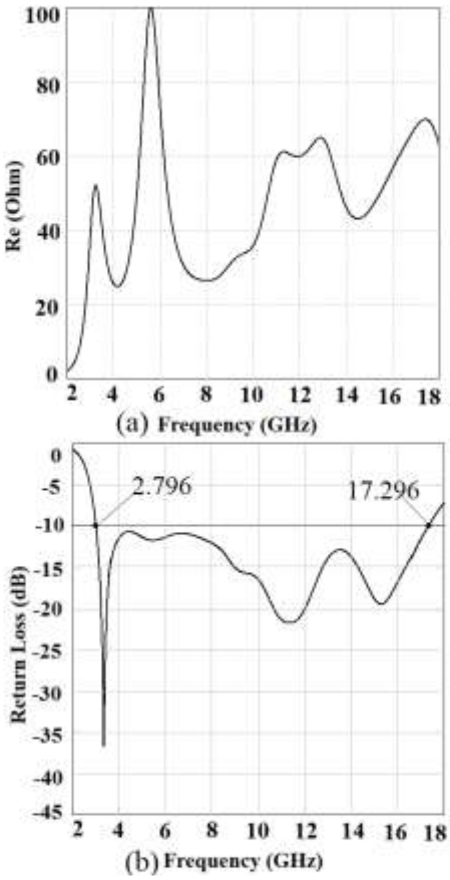

Fig.2: (a) resonance curve and (b) return loss plot for offset base-fed hexagon UWB antenna [2]

3. FORMULATIONS FOR HEXAGON UWB ANTENNA:

A center vertex fed hexagonal UWB antenna is shown in Fig.3 and it has similar dimensions as shown in Fig.1.The resonance curve graph is given in Fig.4 (a). The resonance curve shows various peaks at five different modes. The current distribution for the first two modes are given in Fig.4 (b) and (c) respectively.

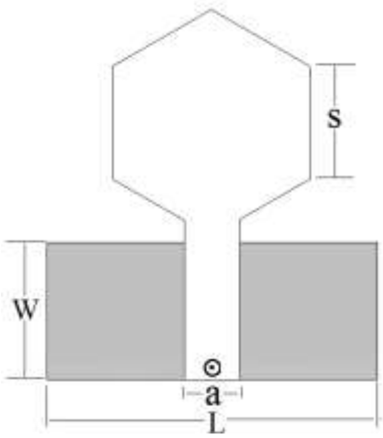

Fig.3: Vertex-fed hexagonal UWB antenna

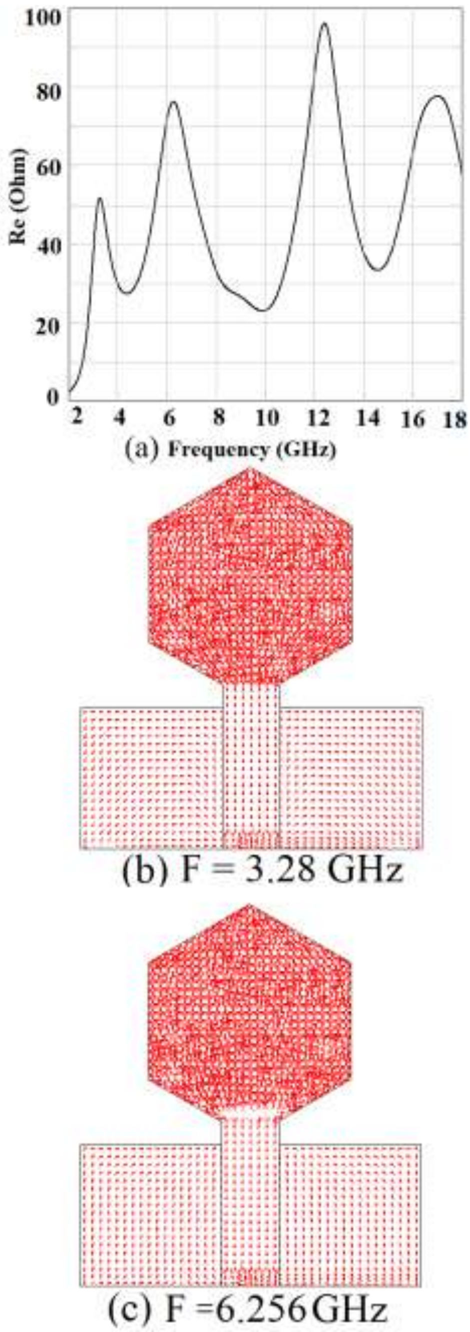

Fig.4: (a) resonance curve and current distributions at (b) TM_{11} and (c) TM_{21} mode for Vertex-fed hexagonal configuration

An equivalent circular UWB antenna is designed and current distribution at various frequencies is studied as shown in Fig.5 (a), (b) and (c) respectively. The circle has radius of r = 7.5 mm and the gap between the patch and the ground plane is given by 0.5 mm. The dimensions of the ground plane are: L = 24 mm, W = 10 mm and the strip width, a, is 4 mm. The resonance frequency plot is given in Fig.6. From the current distributions for both configurations it can be observed that the same modal distributions are obtained. Hence, using the resonance frequency formulas for CMSAs given in (1) we calculate the frequencies for the hexagonal side length s varying from 6.25 mm to 10.25 mm. It can be observed from the error plots shown in Fig.7 (a) and (b) that these formulas are not applicable for hexagonal UWB antennas. Hence we propose new formulas for hexagonal UWB antennas by studying the current distribution at various modes.

$$f_o = \frac{K_{mn}\, c}{2\Pi r_e \sqrt{\varepsilon_r}} \qquad (1)$$

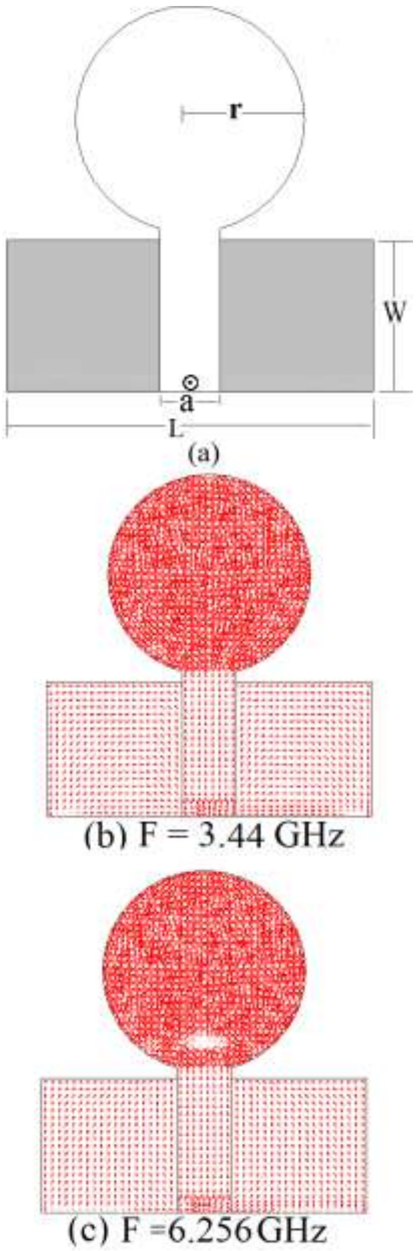

Fig.5: (a) Geometry of equivalent circular UWB antenna and current distributions at (b) TM_{11} and (c) TM_{21} mode for circular UWB antenna

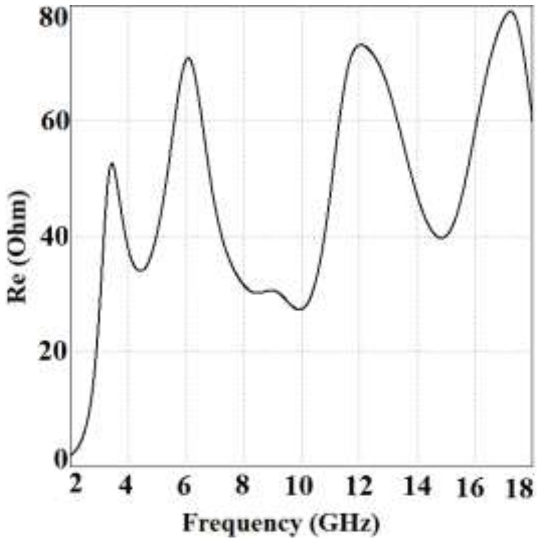

Fig.6: Resonance curve for circular UWB antenna

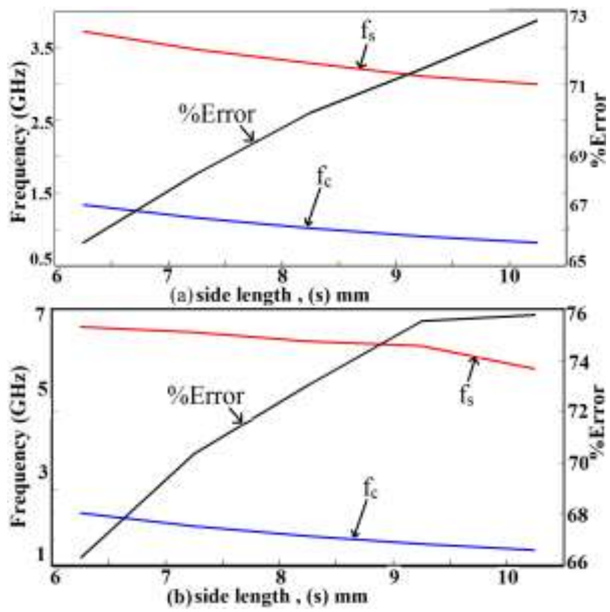

Fig.7: % error plots for (a) TM_{11} and (b) TM_{21} mode for vertex-fed hexagonal UWB antenna

In the vertex-fed hexagonal UWB antenna currents varies mainly along the side length of the patch for both TM_{11} and TM_{21} mode, hence variation along patch side length is considered as seen from Fig. 4 (b) and (c) and given in equation (2) and (3) respectively. The half wavelength frequencies in each of the cases are calculated by using equation (4) for m = 1 and n = 1 and for m =2 and n=1.Also % error is calculated by using equation (5). As shown in Figs. 8(a, b) more accurate prediction in resonant length/frequency, formulation with around 5% error is obtained. In each of the cases closer agreement between simulated and calculated values is obtained.

For TM_{11} mode,

$$S_e = \frac{s}{3} \tag{2}$$

For TM_{21} mode,

$$S_e = \frac{s}{3} + \frac{s}{5} \tag{3}$$

$$f_c = \frac{c\ K_{mn}}{2\Pi S_e \sqrt{\varepsilon_r}}$$

(4)

$$E = \left(\frac{f_{ie3d} - f_c}{f_{ie3d}} \right) x\,100 \tag{5}$$

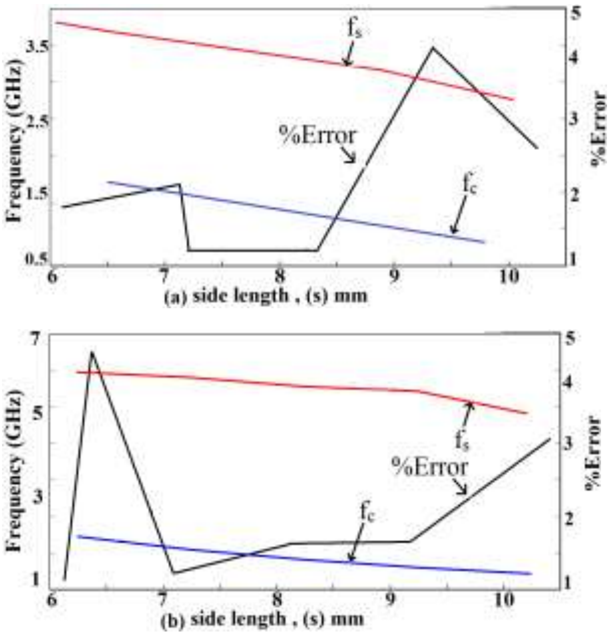

Fig. 8 Frequencies and % error plots for (a) TM_{11} and (b) TM_{21} mode for vertex-fed hexagonal UWB antenna

Thus proposed formulations for TM_{11} and TM_{21} mode in vertex-fed hexagonal UWB antenna can be used to design from desired frequency range.

4. CONCLUSIONs

The reported hexagonal UWB antenna is discussed. By studying the surface current distributions at TM_{11} and TM_{21} mode, frequency formulations is presented. The frequencies calculated using them closely agrees with the simulated results. The proposed formulations can be used to design hexagonal UWB patch from desired lower cutoff frequency.

5. REFERENCES

[1] Kumar, G. and Ray, K. P. 2003. Broadband Microstrip Antenna

[2] Amit A. Deshmukh, Ami. A. Desai, S. A. Shaikh, K. Lele, S B. Nagarbowdi, N. V. Phatak, S. Agrawal, "Analysis of Hexagon Shaped Ultra Wide Band Antennas", Proceedings of ICCT-2015, 25th and 26th September 2015, Mumbai, India, (IJCA – ICCT-2015, No. 6, pp. 15 – 18,September2015,http://www.ijcaonline.org/proceedings/icct2015/number6/22673-1578, ISBN : 973-93-80888-64-4.

[3] Cengizham, M. D., Sibel, C. and Gonca, C. 2013. An Octagonal Shaped Ultra Wide Band Antenna With Reduced RCS , second International Japan-Egypt conference on electronics, Communications and Computers (JEC-ECC)

[4] Li, C., Zhang, Y., Li, Y., Wang, S. and Liao, X. 2011. Volcano Smoke Planar Ultra-Wide Band Antenna, International Conference on Electronic & Mechanical Engineering and Information Technology

[5] Chen, Y., Wei, H. and Zhenqi, K. 2008. Multiple Stopbands Ultra Wide Band Antenna , ICMMT Proceedings

[6] Yuan, Y., and Zhenghe, F. 2006. A Novel Band-Notched Ultra-Wideband Microstrip-Line Fed Wide-Slot Antenna , Proceedings of Asia-Pacific Microwave Conference

[7] Begaud, X. Ultra Wideband Wide Slot Antenna with Band-Rejection Characteristics.

[8] L. H. Weng, Y. C. Guo, X. W. Shi and X. Q. Chen, "An overview on defected ground structures", Progress in Electromagnetic Research B, vol. 7, 2008.

[9] J. Liang, C. C. Chiau, X.D. Chen, and C.G. Parini, "Study of a printed circular disc monopole antenna for UWB systems", IEEE Trans. Antennas & Propagation, vol. 53, 2005, pp. 3500 –3504.

[10] K. P. Ray and Y. Ranga, "Printed rectangular monopole antennas", IEEE Antenna Propag Soc Int Symp, 2006, pp. 1693–1696.

[11] P. Li, J. Liang, and X. Chen, "Study of printed elliptical/ circular slot antennas for ultra wideband applications, IEEE Trans. Antennas & Propagation, vol. 54, 2006, pp. 1670–1675.

[12] J. P. Zhang, Y.S. Xu, and W.D. Wang, "Ultra wideband microstrip fed planar elliptical dipole antenna", Electron Letters, vol. 42, 2006, pp. 144–145.

[13] K. L. Wong and Y.F. Lin, "Stripline-fed printed triangular monopole", Electron Letters, vol. 33, 1997, pp. 1428–1429.

[14] J. R. Verbiest and G. A. E. Vandenbosch, "Small-size planar triangular monopole antenna for UWB WBAN applications", Electron Letters, 42, 2006, pp. 566–567.

[15] Tao Hong, Shu-Xi Gong, Wen Jiang, and Ying Liu, "A novel monopole antenna for ultra-wide band application", Microwave And Optical Technology Letters Vol. 52, No. 12, December 2010, pp. 2694 – 2696.