Multi-band Slotted Bowtie Antenna for L, S and C band Applications

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***Abstract*-A multi-band slotted bowtie antenna for L, S and C band applications is presented. The proposed antenna has the configuration of 40 mm*58 mm*1.5 mm. The slots are etched on the bowtie antenna to obtain multi-band features. The number of slots and spacing between them is varied for parametric study. The designed is fabricated on FR4 material and the measured and simulated results are in good agreement with each other thus confirming the proposed antenna design. High Frequency Structural Simulator (HFSS) is used for simulating the antenna design.**

Keywords: Bowtie, parasitic, HFSS, Multi-band, slot

I. INTRODUCTION

With the advancement and growth of the electronic industry and devices, the demand for miniaturization along with multi-frequency features has become the need of the hour for the wireless communication systems. The antenna with light weight, compact size and high efficiency tops the priority list as a suitable candidate for the wireless applications [1-3]. A bowtie antenna with all the above attributes contributes a lot in wireless communication systems. Various studies have investigated the use of bowtie antenna [4-6]. In [7], a bowtie antenna has been designed for detecting the stroke in a human body. An antenna is placed on/near the human skin to detect any stroke. The antenna resonates at low frequencies due to increasing signal attenuation. Authors in [8] have designed a slotted bowtie antenna with tapered tuning stubs to characterize it. In [9], a circularly polarized bowtie antenna is designed for satellite and GPS applications where capacitive coupling four probe feeds are used to increase the impedance bandwidth. Similar antenna is designed in [10] for air-craft radar applications and X-band applications. The antenna resonates at dual frequencies when fed with CPW feed. The CPW feed antennas are advantageous in terms of unipolar structure, wide bandwidth and bidirectional radiation. In this paper, a slotted bowtie antenna with multi-band features for L, S and C band is proposed where the antenna is fed parasitically. The optimization of number of slots and its spacing with respect to each other is investigated.

The paper is organized as follows. Section II gives antenna design and parametric analysis. In section III, fabrication results are discussed. Section IV finally concludes the research.

II. ANTENNA DESIGN AND PARAMETRIC ANALYSIS

A bowtie antenna with length 58 mm and width 40 mm having no slot on the patch is shown in Fig. 1(a). The CPW feed line is 26 mm long and 2 mm wide. The ground is the back side of the substrate and in the form of a rectangle. When feed is applied, the antenna reverberates at tri-bands yielding frequencies in L band (1.9 GHz) and S band (2.8 GHz and 3.7 GHz) respectively as shown in Fig. 1(b).

The etching of slots on bowtie antenna helps in getting multi-band features in the antenna. Without increasing the size, the bowtie antenna is further etched upon with 10 slots keeping 0.8 mm spacing between them as in Fig. 2(a). When simulated, the slotted bowtie antenna yields multi-band frequencies instead of tri-band frequencies. The frequencies lie in L band (1.6 GHz and 1.8 GHz), S band (2.8 GHz) and C band (4.8 GHz, 5.6 GHz and 6.6 GHz) as shown in Fig. 2(b).

To parametrically analyze the antenna, two variations are worked upon. First, the variation in number of slots is done and then the spacing between them is varied. The slots are changed from 10 to 9, 8 and 7 respectively. When simulated individually, the results in Fig. 3(a) show that the variation in the number of slots does not introduce any new band but with the decrease of the number of slots, the frequency bands from 1-5 GHz show a shift of nearly 100 MHz towards right and in 5-6 GHz band, the splitting up of the band is observed with the decrease in bandwidth. Hence, the number of slots can be reduced to target specific frequency bands, thus making the proposed antenna as a reconfigurable.

Next, the antenna is characterized for three different spacing of 0.7 mm, 0.8 mm and 0.9 mm respectively (number of slots=10). When simulated for the above mentioned spacing, the antenna depicts the return loss as in Fig. 3(b). It can be seen that with gap of 0.8 mm, the antenna yields higher return loss and bandwidth as compared to other spacing.

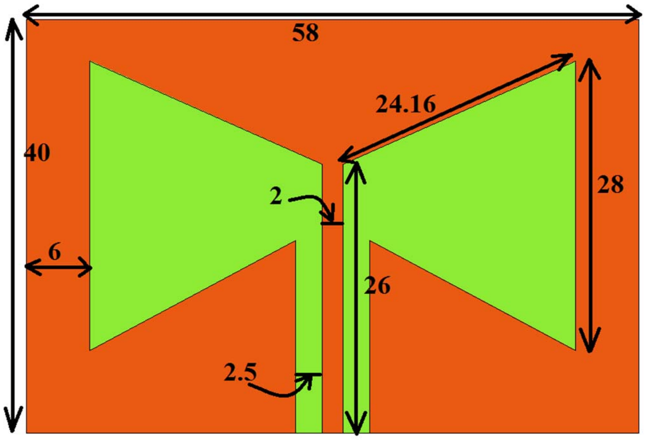


Fig. 1(a). Geometry of bowtie antenna without slot

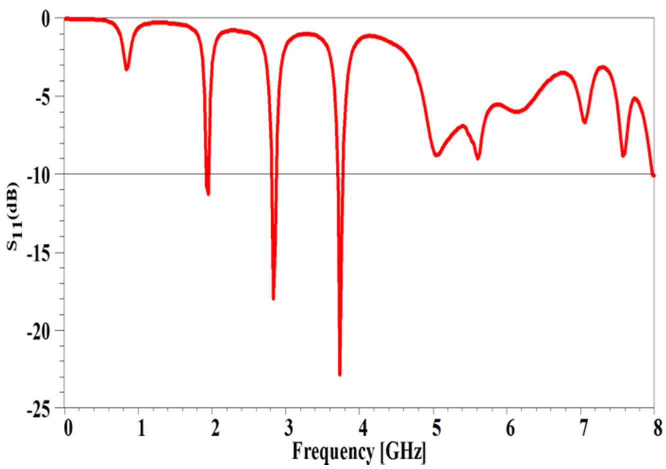


Fig. 1(b). Simulated reflection coefficient of bowtie antenna without slots

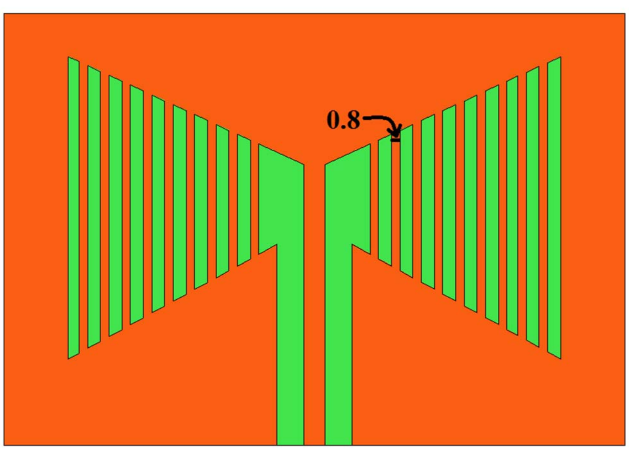


Fig. 2(a). Top layer of slotted bowtie antenna

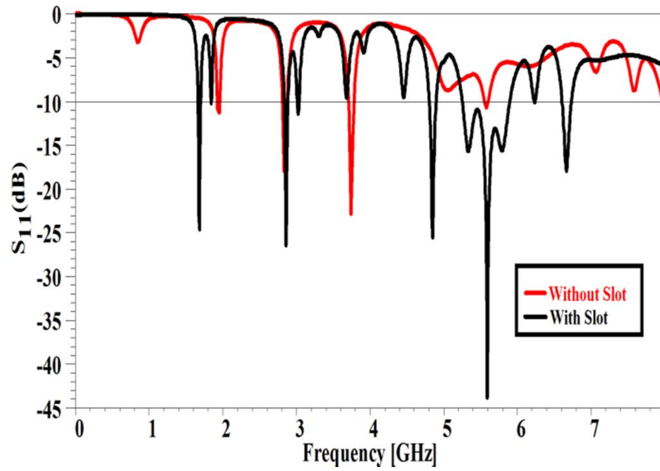


Fig. 2(b). Simulated reflection coefficient of slotted bowtie antenna

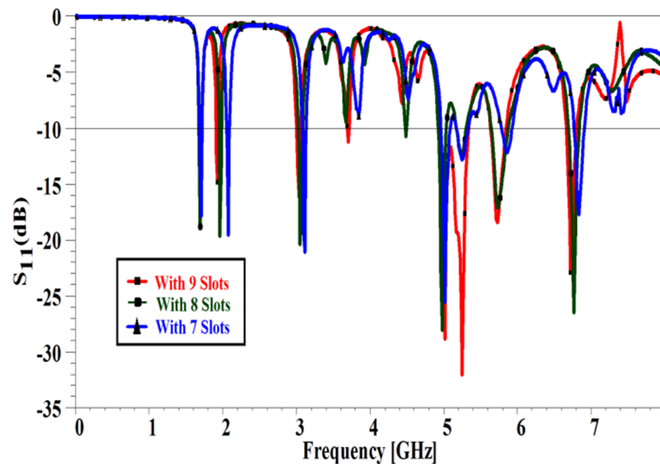


Fig. 3(a). Effect of varying number of slots on reflection coefficient

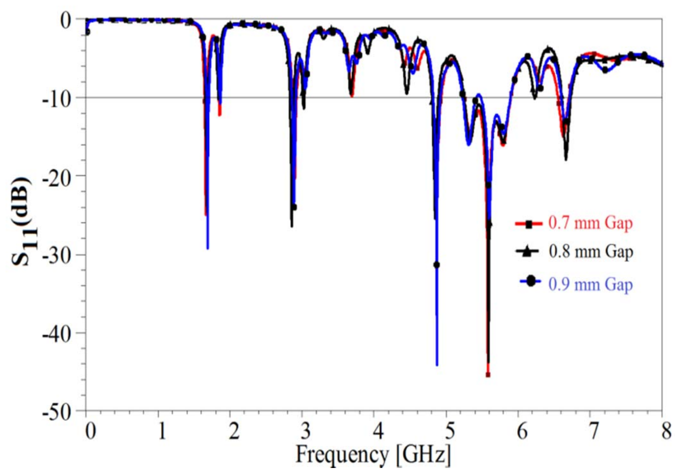


Fig. 3(b). Effect of varying slot spacing on reflection coefficient

III. EXPERIMENTAL RESULTS

Based on the above parametric analysis, an antenna with 10 slots and 0.8 mm spacing is fabricated as in Fig. 4(a). The structure uses easily available FR4 substrate with relative permittivity 4.4 and loss tangent 0.01.

The measured and simulated reflection coefficients are depicted in Fig. 4(b). It can be seen that multi-bands are obtained from the prototype antenna at 1.6 GHz, 2.8 GHz, 4.8 GHz, 5.6 GHz and 6.6 GHz respectively which are in good agreement with the simulation results; however at 1.8 GHz the practical antenna does not reverberates.

The measured and simulated radiation pattern at 1.6 GHz, 2.8 GHz and 5.6 GHz is illustrated in Fig. 5 to show the stability across the band. The surface current density distribution shown in Fig. 6 depicts that in L band (1.6 GHz) the antenna radiates more from shorter fins whereas as the frequency shifts to higher bands (S/C Band), the radiations are concentrated more at the outer fins of the slotted bowtie antenna.

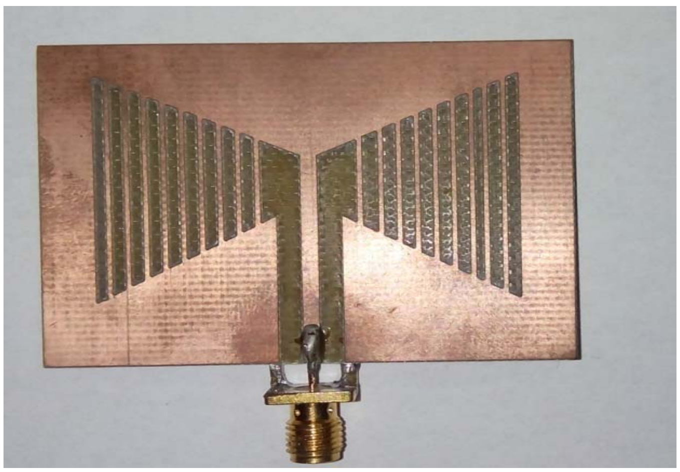


Fig. 4(a). Fabricated bowtie antenna with 10 slots and 0.8 mm spacing

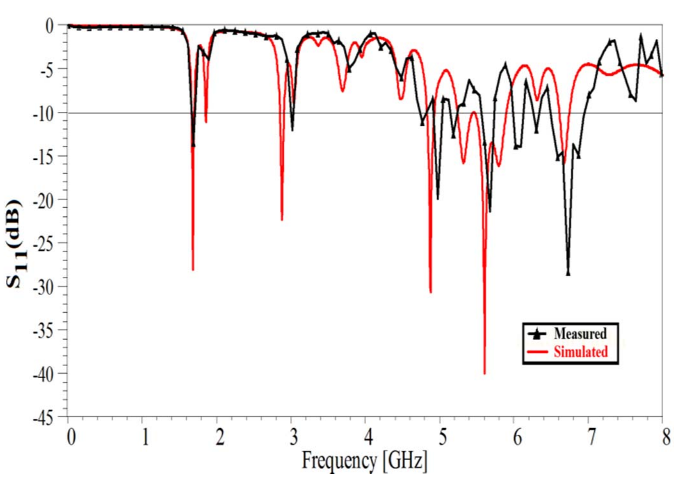


Fig. 4(b). Measured Vs simulated reflection coefficient of slotted bowtie antenna

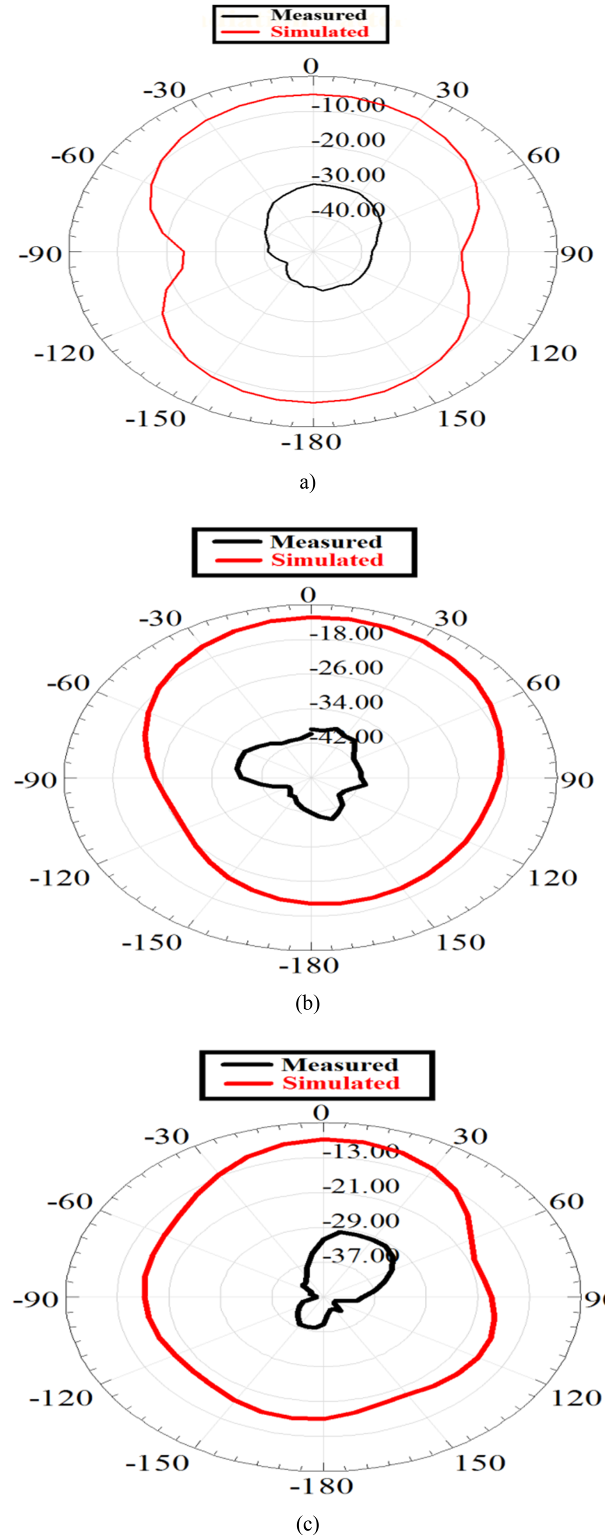
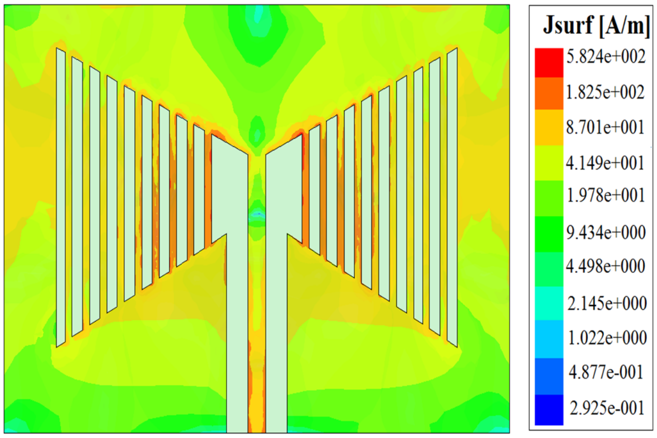
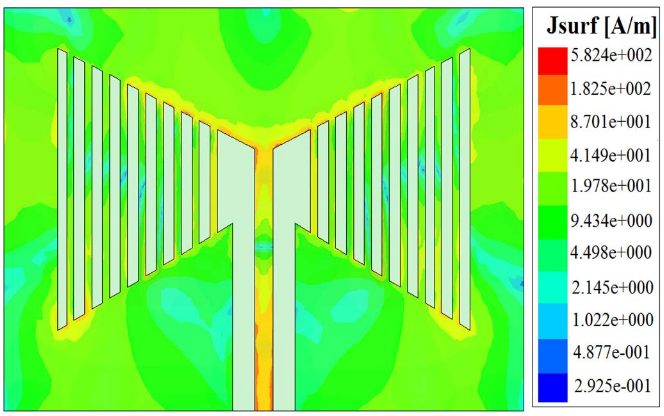


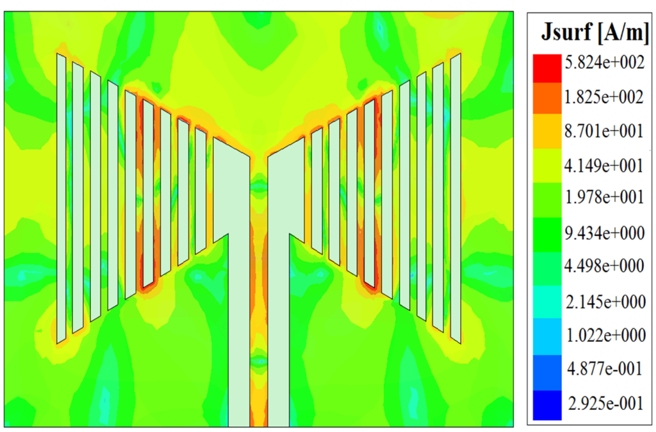
Fig. 5. Measured and simulated radiation pattern at a) 1.6 GHz b) 2.8 GHz c) 5.6 GHz



(a)



(b)



(c)

Fig. 6. Surface current density a) 1.6 GHz b) 2.8 GHz c) 5.6 GHz

IV. CONCLUSION

A multi-band parasitic slotted bowtie antenna for GPS (1.6 GHz), Wi-MAX (2.8 GHz), WLAN (4.8/5.6 GHz) and WPAN (6.6 GHz) applications is presented. The slots etched on the bowtie antenna resulted into multi-band features thus introducing C band frequencies (4.8/5.6/6.6 GHz). Also, the L band is splitted into sub-bands thus resulting into higher bandwidth. Increasing/Decreasing the number of the slots of the bowtie antenna yields the reconfigurable property of the antenna. The measured and simulated results are in good agreement with each other hence justifying the proposed antenna design. Consequently, the proposed antenna marks its significance for multi-band operations in wireless applications.

REFERENCES

[1] H. Liu, H. Jiang, X. Guan, J. Lei and S. Li, “Single feed slotted bowtie antenna for triband applications”, IEEE Antennas and Wireless Propagation Letters, vol. 12, pp. 1658-1661, 2013.

[2] S. J. Wu and T. G. Ma, “A wideband Slotted Bowtie Antenna with Reconfigurable CPW-to-Slotline Transition for Pattern Diversity”, IEEE Transactions on Antennas and Propagation vol. 56, no. 2, pp 327-334, 2008.

[3] Q. Zhang, L. Si, Y. Ming, Y. Liu and X. Lv, “Design of a coplanar bowtie antenna for WLAN and Wi-max applications”, 3rd Asia pacific Conference on Antennas and Propagation China, pp. 284-283, 2014.

[4] A. Mehndipour, K. Aghdham, R. Dana and A. Sebak, “Modified Slot Bowtie Antenna for UWB Applications”, Microwave Opto Technology Letters, vol. 50, pp. 429-432, 2008.

[5] K.M. Shams, M. Ali and H.S. Hwang, “A Planar Inductively Coupled Bowtie Slot antenna for WLAN Applications”, vol. 20, pp. 861-871, 2012.

[6] N. Hassaine, L. Merad, S. M. Meriah and F. T. Bendimerad, “UWB Bowtie Slot Antenna for Breast Cancer Detection”, International Journal of Medical, Health, Biomedical, Bioengineering and Pharmaceutical Engineering vol. 6, no. 11, 2012.

[7] X. Li, M. Jalilvand, J. Yan, L. Zwirello and T. Zwick, “A multi-band slotted bowtie antenna for Stroke Detection”, IEEE International conference on ultra wideband, pp 439-442, 2012.

[8] A. A. Eldek, A.Z. Elsherbeni and C.E. Smith, “Characteristic of Slotted Bowtie Antenna with Tapered Tuning Stubs for Wideband Operation”, Progress in Electromagnetics Research, vol. no. 49, pp 53-69, 2004.

[9] S. Fu, Q. Kong and S. Fang, “Broadband circularly polarized microstrip antenna with coplanar parasitic ring slot patch for L-band satellite system applications”, IEEE Antenna and wireless Propagation Letters, vol. 13, pp 943-946, 2014.

[10] H. Liu, S. Li, J. Lei and F. Qin,“Dual-band bowtie slot antenna fed by coplanar waveguide”, IET Letters, vol. 50, no. 19, pp 1338-1340, 2014.