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Wideband Slot Loaded Compact Monopole Antenna

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Abstract: A wideband slot loaded compact monopole antenna is proposed. Five slots with different shape are embedded on the modified radiating patch. The proposed antenna provides a wide usable fractional bandwidth of 122% (5.3– 21.8 GHz). The designed antenna is extremely compact with overall size of 13.5 mm X 9 mm X 1.6 mm with a 50Ω feed line. Measured and simulated reflection coefficients vs. frequency plots are provided.

Keywords: Monopole antenna, wireless personal area network, ultra-wideband, rectangular patch.

I. INTRODUCTION

Printed monopole antennas have received increasing attention in Ultra-wideband (UWB) applications since they exhibit very attractive merits such as wide impedance bandwidth, simple structure, and omni-directional radiation pattern. UWB technology has undergone many significant developments in recent years. However, there still remain many challenges in making this technology alive up to its full potential. The band allocation of UWB is 3.1-10.6 GHz as specified by the Federal Communication Commission (FCC). In the design of a UWB planar monopole antenna, the shape of the antenna patch, the ground plane, and the geometry of the ground plane slots are of great importance. The conventional methods include cutting a slot on the patch [1], [2], using conductor-backed plane [3], inserting a slit on the patch [4], [5], use of wing shaped patch [6] and use of vertical coupling strip [7]. Throughout the literature, various methods to achieve wideband along with the band-notched characteristics are proposed. The conventional methods include, cutting a slot on the patch or ground plane and by using conductor-backed plane [9].

This article presents a planar monopole antenna for wideband application with a compact dimension of 13.5 X 9 X 1.6 mm^3. The design employs modification of the rectangular patch and ground plane. Five slots with different shape are embedded on the modified radiating patch. The proposed antenna provides a wide usable fractional bandwidth of 122% (5.3– 21.8 GHz). Details of the proposed antenna structure and parametric studies are described in Section 2, and the measured results are discussed in Section 3.

II. ANTENNA GEOMETRY

The Fig. 1 is describing the proposed antenna configuration. We here have a modified rectangular patch area covering 6.75 x 7 mm^2. The ground is being proposed of a rectangular shape of 6 x 9 mm^2. The rectangular ground and bow tie patch is printed on the opposite sides of the dielectric substrate. Here we are using the inexpensive FR-4 glass epoxy dielectric constant of ε_r=4.4 of the dimension of 13.5x9x1.6 mm^3. The patch is being feed by a microstrip line of width 2mm and length of 7.5mm which provides a better impedance matching. The basic design of the antenna is being developed by introducing slots on the patch and ground plane. There are 5 slots on the patch. A beheaded star shaped slot is introduced at the upper edge of modified the rectangular patch. A 'V' shaped slot of width 0.6 mm is embedded just under the beheaded star shaped slot. Two inverted backless 'P' slots are drawn at the sides of the bow tie, the left one is of width of 0.7mm and of total length of 6.74mm and the right slot of width 0.4mm and the length of 6.74mm. A 'U' slot is being introduced under the 'V' slot that extends to the microstrip feed line. The point at which microstrip line is connected to the patch is 7.5mm high from ground plane. The edges are inclined at a slope like a ladder is kept with support by a wall. The ground plane is rectangular one, covering a 6 x 9 mm^2 area. The rectangular ground has 3 slots. There are 2 rectangular slots of width 0.7 mm and 0.4mm respectively making the 2 hands of the 'L' configuration. The circular slot of radius 0.4mm is being used as the pivot of the hands in the 'L' configuration. Fabricated prototype is shown in Fig. 2.

III. RESULTS AND DISCUSSIONS

Based on the design, some of the sensitive parameters have been studied numerically to investigate the influence of the introduced slots on both the patch and ground. The frequency response of the antenna strongly depends on the geometry of the radiating patch and the ground plane. So, to optimize the antenna performances, an extrusive parametric analysis has been performed with the presence of (a) Variation of angular arm; (b) 'U' type slot; (c) 'V' shaped slot introduction; (d) slots on the ground plane; and (e) beheaded star shape slot and inverted backless 'P'. At each time one of the parameters is being varied and simulated by the MoM-based software Ansoft designer.

Effect of Inclined Arm:

The work was started from a rectangular patch antenna. Two inclined arms are included in the lower side

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of the patch and its effect is summarized in Fig. 3. In this figure one can see that the reference antenna (without any modification) provides three bands 2.467 GHz (6.303- 8.77 GHz), 2.996 GHz (12.295- 15.291 GHz), and-

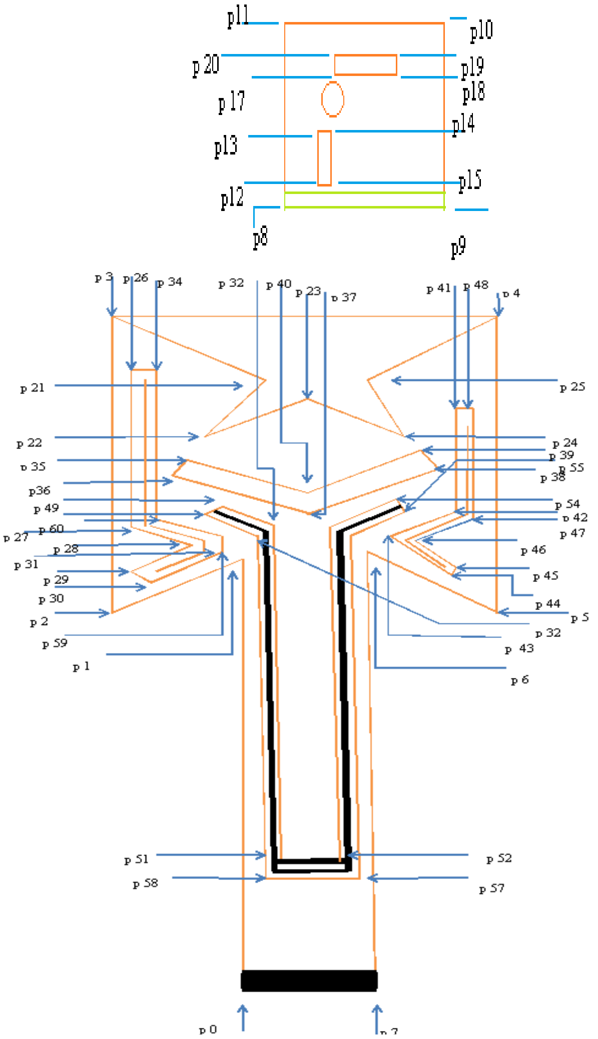

Fig. 1 Configurations of the proposed antenna along with co-ordinate points.

Ground: P8(0, 0); P9(9, 0); P10(9, 6); P11(0, 6); P12(3.3 , 0.39); P13(3.3, 3.89); P14(3.7; 3.89); P15(3.7, 0.39); P 16(3.4, 4.6); P17(3.07, 5.15); P18(5.81, 5.15); P19(5.81, 5.85); P20(3.07, 5.85).

Patch: P0(3.5, 0); P1(3.5, 7.5); P2(1, 6.75); P3(1, 13.5); P4(8, 13.5); P5(8, 6.75); P6(5.5, 7.5); P7(5.5, 0).

Voids: P3(1, 13.5); P21(3.5, 12); P22(3, 10.75); P23(4.5, 11.5); P24(6, 10 .75); P25(5.5, 12); P26(1.65, 12.35); P 27(1.65, 8.78); P28(2.42, 8.42); P29(1.20, 7.72); P30(1.56, 7.11); P31(3.69, 8. 34); P32(3.69, 8.61); P33(2.34, 9.22); P34(2.34, 12.35); P35(2.84, 10.59); P36(2.61, 10.08); P 37(4.5, 9.17); P38(6.39, 10.04); P39(6.13, 10.59); P40(4.5, 9.80); P41(6.8, 11.2); P42(6.8, 9.12); P43(5.72, 8.5); P61(5.7, 8.4); P44(7.4, 7.4); P45(7.58, 7.73); P 46(6.40, 8.45); P47 (7.2, 8.9), P48(7.2, 11.2); P49(2.96, 9.56); P50(4.07, 9.04); P51(4.06, 2.07); P52(4.92, 2.07); P53(4.92, 9.04); P54(6.03, 9.59); P 55(6.09, 9.46); P56(5.07, 8.95); P57(5.07, 1.39); P58(3.92, 1.92); P59(3.92, 8.95); P 60(2.90, 9.46).

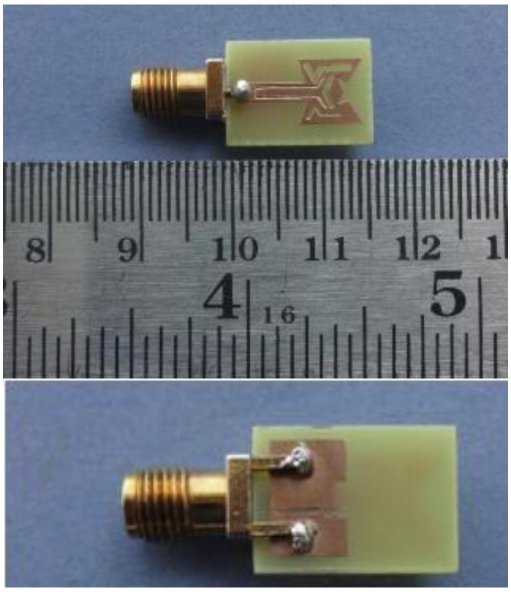

Fig. 2 Prototype of the fabricated antenna.

3.347 GHz(18.637- 21.984 GHz). Due to modification the lower cut off is not changing though the band width has increased 7.767 GHz(6.606- 14.373 GHZ). The return loss at the middle band increases.

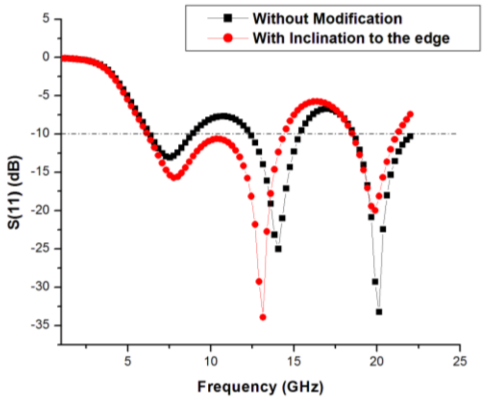

Fig. 3 Reflection coefficient characteristics.

Introduction of ‘U’, ‘V’ slot and ‘P’ slot:
From the Fig. 4 one can see that red lined graph is plotted for the ‘U’, ‘V’ slot and the black one is after introducing inverted backless ‘P’ slot to the existing antenna. Hence, the impedance matching improves with this modification.

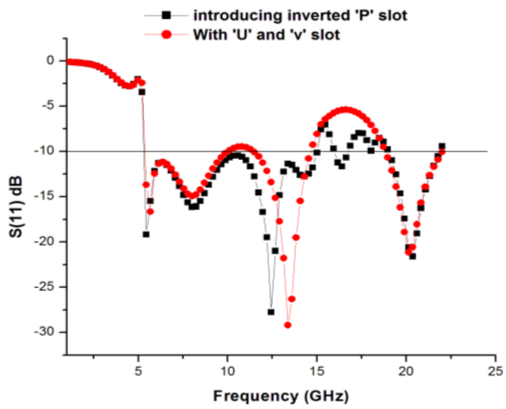

Fig. 4 Reflection coefficient characteristics introducing ‘U’, ‘V’ and ‘P’ slots

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Introduction of beheaded star slot:

Introducing the beheaded star slot one can see an improvement in the reflection coefficient of Fig. 5.

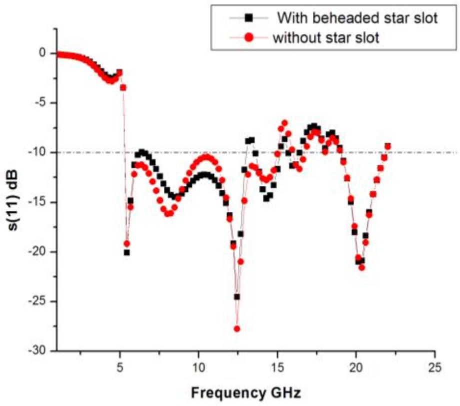

Fig. 5 Reflection coefficient characteristics introducing beheaded star slot

Introduction of the ground slots:

In the Fig. 6 one can see that by introducing the ground slots the upper cut off is increased slightly.

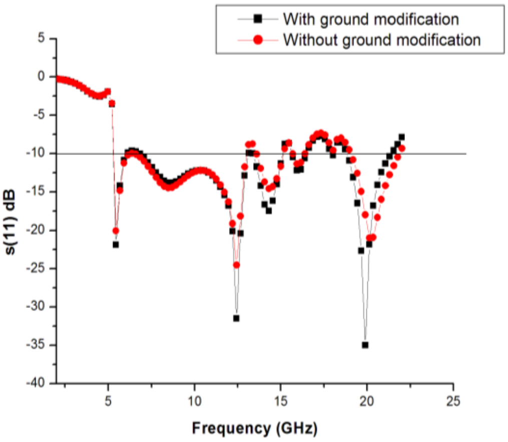

Fig.6 Reflection coefficient characteristics introducing ground slots

Measured Results:

With these parametric study different parameters of the proposed antenna is finalised, fabricated and measured using vector network analyser. The measured reflection coefficient is in good agreement with the simulated one. The antenna provides a wide impedance bandwidth of 16.5 GHz (5.3- 21.8 GHz).

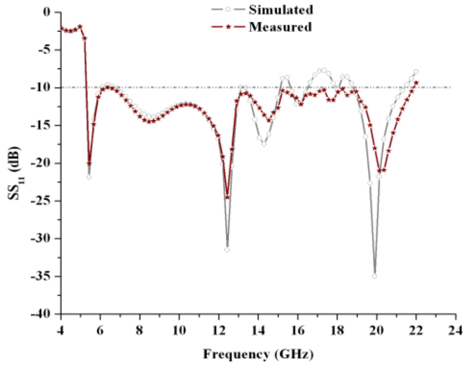

Fig.7 Simulated and measured reflection coefficient characteristic

IV. CONCLUSION

A small wideband monopole antenna is designed and fabricated. Antenna shows variable and wide impedance bandwidth achieved by inserting slots of different width, shape and length. Placing the 'U' type slot extending through the microstrip line up to 2 mm, the lower cut off reduces. The small slotted monopole antenna offers a very wide impedance bandwidth.

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