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Bevel U-L Shaped Structures In A CPW Fed Printed Monopole Antenna

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Abstract

A new multiband planar antenna with a compact size is designed and developed for wireless applications. The proposed antenna is fabricated on an FR4 substrate with the thickness of 1.6 mm, relative permittivity of 4.3 and a loss tangent of 0.008. The overall size of the radiating element is 15.2 x 9.6 mm^2. It is evident that the reference antenna exhibits multiband characteristics for -15dB return loss impedance bandwidth is 19.35% (1.4 - 1.7 GHz) at 1.6 GHz, (2.6 - 3.2 GHz) at 3 GHz, (4.1 - 4.6 GHz) at 4.3 GHz, (5.3 - 5.9 GHz) at 5.7 GHz, (6.3 - 7 GHz) at 6.7 GHz, (7.5 - 7.7 GHz) at 7.6 GHz, (9 - 9.8 GHz) at 9.4 GHz. Good antenna performances such as radiation patterns and antenna gains over the operating bands have also been observed

Introduction

The rapid progress in wireless communication systems requires a continuing demand for low cost power efficient and small size system designs.The integration of different radio modules into the same piece of equipment has created a need for multiple band operation. A variety of studies have come up with different techniques to achieve multiband and wide band operations for printed antennas [1]-[5]. The presented antenna structures in the literature are lengthy one and cannot achieve high bandwidth in a limited space.

In this paper, a compact, multiband planar monopole antenna integrated with four resonators is proposed. A single integrated antenna with various band selective resonators can cover several different frequency bands. Some of the desired features for this type of antenna include multiband, moderate fractional impedance, bandwidth, compact size, simple impedance matching to the feed line and low profile.

Antenna Design

The geometry of the proposed antenna is illustrated in Figure 1. The proposed antenna is fabricated on an FR4 substrate with the thickness of 1.6 mm, relative permittivity of 4.3 and a loss tangent of0.008 as shown in Figure 2. The overall size of the radiating element is 15.2 x 9.6 mm^2. Here, four $\lambda_0/4$ length strips integrated with the monopole antennas and they can be treated as resonators.

Two parallel strip monopoles ‘a’ and ‘b’ are chosen for the design with a gap ‘G’. The longer monopole is operated close to $\lambda_0/4$ length corresponding to 7.4 GHz. The shorter monopole is operated at $\lambda_0/4$ length corresponding to 9.5 GHz. The gap between the monopole and the ground plane ischosen as 2 mm. Two beveled L shaped strips S_1 and S_2 of $\lambda_0/4$ length close to 5.7 GHz and 4.3 GHz is directly connected to the longer arm of the monopole as shown in Figure 3. Like this, one shorter beveled L shaped strip S_3, close to $\lambda_0/4$ at 9 GHz and beveled U shaped slotted strip US_4 close to $\lambda_0/4$ length at 2.8 GHz are directly connected to the shorter arm of the monopole.

A wide slot having dimension of 10.8 mm x 16 mm is placed in the ground plane. A Co-Planar Waveguide transmission line, which consists of signal strip thickness of 1.6mm and a gap distance of 0.4 mm between the single strip and the coplanar ground plane is used for feeding the antenna. All $\lambda_0/4$ length strips are excited at their fundamental resonant frequencies which are directly proportional to the dimensions of their lengths. In the process of integration of anantenna four $\lambda_0/4$ strips are combined as shown in Figure 3.

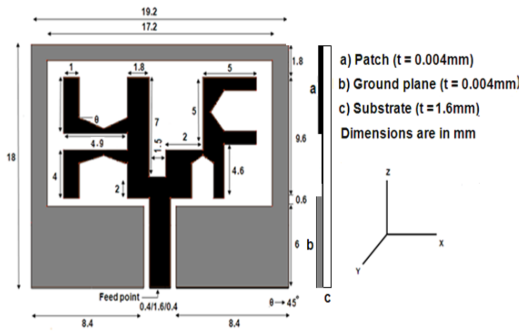

Figure 1: Geometry of The Proposed Antenna

It is to be noted that the four resonators are not independent but coupling with each other and integrates with the monopole antenna, to meet the multiband operation requirements.

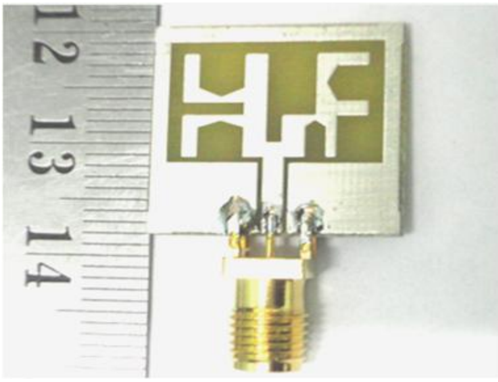

Figure 2: Fabricated bevel U-L shaped antenna

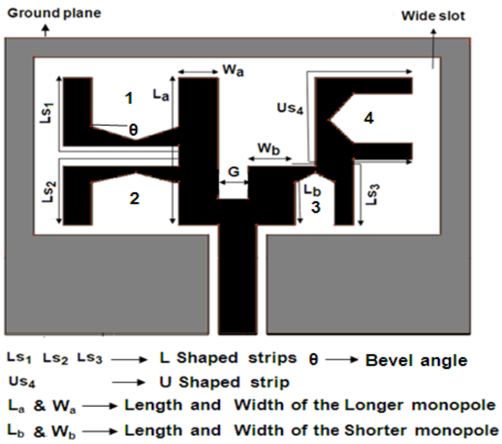

Figure 3: Parameters of bevel U-L shaped antenna

To improve the quality factor, the surface current must be distributed effectively into two or three dimensions throughout the antenna. The introduction of a bevel increases the bandwidth and control of this frequency is possible by adjusting the bevel angle. The resonator is based on the structure having at least one oscillating electromagnetic field. When the equivalent ‘L’ and ‘C’ of the respective resonators are installed into the antenna element, generates the multi resonance frequencies.

Return Loss

Figure 4 shows the simulated and measured return loss of the proposed antenna. In order to characterize the antenna, an Agilent 8757D scalar network analyzer is used to measure the Return loss of the antenna as shown in Figure 5. Many multibands are created after adding four resonators along with the monopole antennas. It is evident that the reference antenna exhibits multiband characteristics for -15dB return loss impedance bandwidth is 19.35% (1.4 - 1.7 GHz) at 1.6 GHz, 20.69% (2.6 - 3.2 GHz) at 3 GHz, 11.49% (4.1 - 4.6 GHz) at 4.3GHz,10.71% (5.3 - 5.9 GHz) at 5.7 GHz, 10.52% (6.3 - 7 GHz) at 6.7GHz, 26.31% (7.5 - 7.7 GHz) at 7.6 GHz, 8.51% (9 - 9.8 GHz) at

9.4 GHz. The slight deviation of simulated and measured results may be due to antenna fabrication inaccuracies and connector soldering. Figure 6 shows the measurement of return loss at 4.3GHz

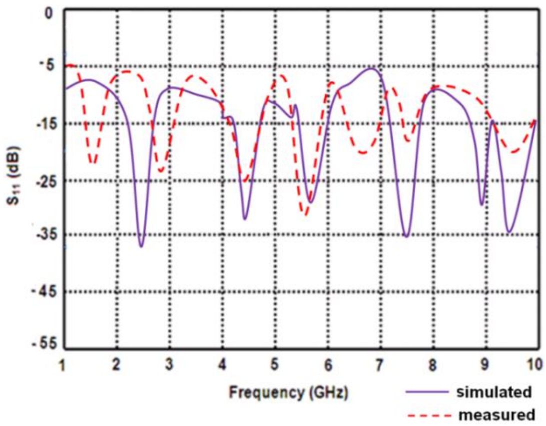

Figure 4: Return loss Characteristics of a bevel U-L shaped antenna

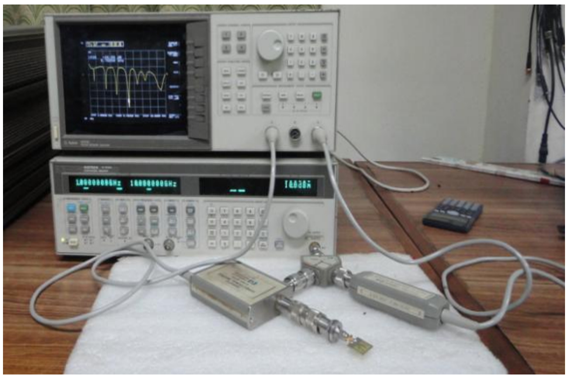

Figure 5: Return loss measurement using HP 8757D Scalar NW Analyzer for a bevel U-L shaped antenna

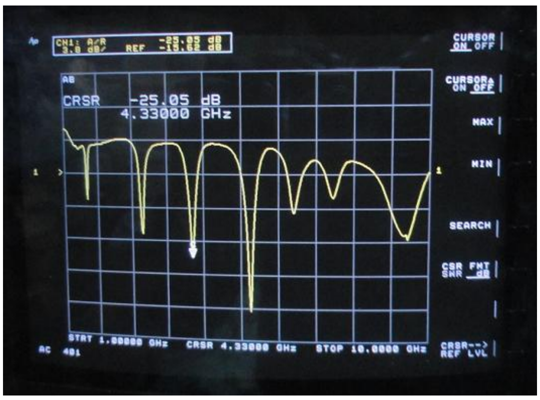

Figure 6: Measurement of Return Loss At4.3ghz

Current Distribution

The simulated current distribution for two different frequencies at 4.3 GHz and 7.4 GHz are given in Figures 6 (a) and 6 (b). At 4.3 GHz, the current distribution is maximum at the starting point and minimum at the ending point for all the resonators and monopole antennas. This shows that all sections of the antenna have monopole like characteristics.

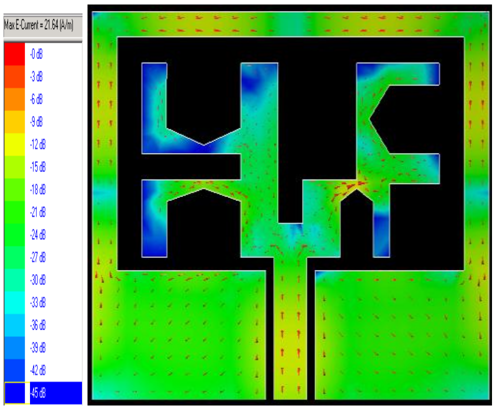

Figure 6(a): Surface Current Distribution at 4.3GHz

At 7.4 GHz, a wide slot in the ground plane disturb the surface current distribution. Maximum current flow is noticed on the upper edge of the ground plane and moderate current flow is observed in the lower part of the ground plane. This confirms that a part of the ground plane act as a radiating element. Strong current is observed in the feed line also.

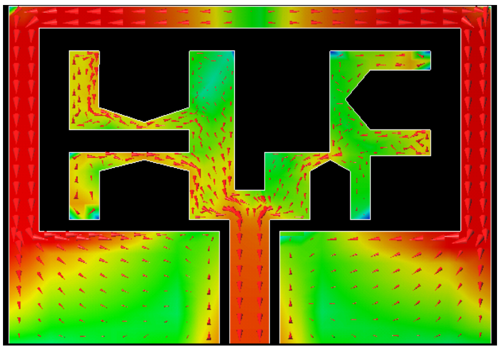

Figure 6(b): Surface Current Distribution at 7.4GHz

Radiation Pattern

Figures 7(a) and 7(b) show the simulated radiation patterns taken at 4.3 GHz and 7.4 GHz. At 4.3 GHz, in the E-plane, the maximum radiation is in the horizontal direction and it shows monopole like pattern. At 7.4 GHz, the radiation pattern looks like a dipole pattern and it is tilted due to non uniform current distribution in the ground plane. The H-plane at 4.3 GHz and 7.4 GHz shows a distorted omnidirectional pattern.

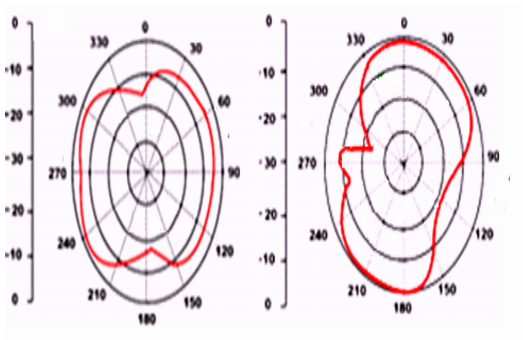

Figure 7 (a): Radiation pattern at 4.3 GHz and 7.4 GHz E-plane (XZ)

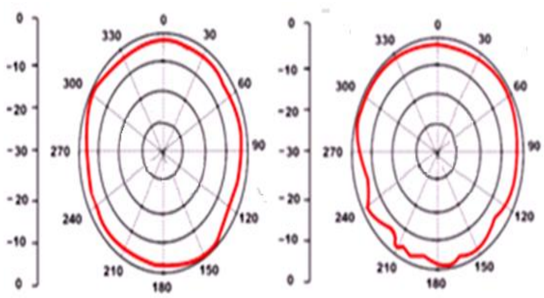

Figure 7 (b): Radiation pattern at 4.3 GHz and 7.4 GHz H-plane (XY)

GAIN

The simulated gain characteristics of a bevel U-L shaped antenna is shown in Figure 8. The gain varies from 0-3.8 dBi for the lower frequency ranges and 1.8-3 dBi for the middle frequency ranges whereas for the upper frequency range it varies from 1.8-2.8 dBi. Peak gain is about 3.8 dBi at 3 GHz.

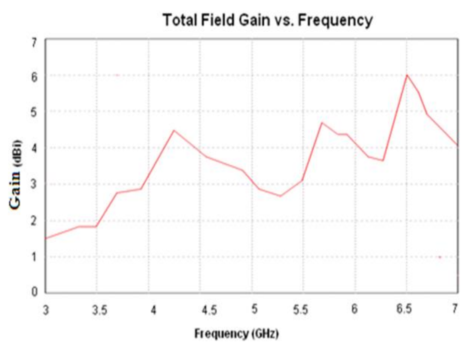

Figure 8: Gain Characteristic of a bevel U-L shaped antenna

Conclusion

A novel design of CPW fed integrated resonator antenna with multi band characteristics is proposed. The radiating element size is 15.2 x 9.6 mm^2. Peak gain is about 3.8 dBi at 3GHz. The -15dB return loss bandwidth is 1.4-1.7 GHz (19.35%), 2.6 - 3.2 GHz (20.69%) 4.1 - 4.6 GHz (11.49%) , 5.3-5.9 GHz (10.71%), 6.3 – 7 GHz (10.52%), 7.5 - 7.7 GHz (26.31%), 9 - 9.8 GHz (8.51%). Besides its multiband characteristics, the proposed antenna remains compact, making it a good candidate for wireless communication applications

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