Design of Wideband Printed Monopole Antenna Using WIPL-D

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Abstract: For the purpose of wideband operations, a printed monopole antenna fed by a microstrip line is investigated. A single element is studied before using it to form a linear array or two-dimensional antenna array system. The antenna element has a single T-shaped radiator fed by a microstrip line. This design is found to be useful for the entire C-band frequency range centered at 6 GHz. The computed return loss is presented that shows a bandwidth of 77%, with a 50 Ω input impedance. The radiation pattern is as presented for the proposed antenna at 6 GHz exhibits very low cross polarization. The effect of varying the monopole dimensions on the antenna performance has also been studied. The single element design was analyzed using the WIPL-D software package, which is based on method of moment solution.

Keywords: Monopole antenna, WIPL-D.

1. Introduction

In applications where size, weight, cost, performance, ease of installation, and aerodynamic profile are constrains, low profile antennas like microstrip patch are required. Because microstrip antennas inherently have narrow bandwidths (BW) and, in general, are half-wavelength structures operating at the fundamental resonant mode [1], researchers have made efforts to overcome the problem of narrow BW, and various configurations have been presented to extend the BW [2-8], for example, by introducing slots in a microstrip patch configuration. Many researches are carried out in the field of microstrip elements and arrays for Synthetic Aperture Radar (SAR) applications [9-12], mainly to achieve antennas capable of matching various demands. To meet the requirements for the 2.4/5.2 GHz applications, some novel printed antennas are presented in [13-15]. This paper presents a wideband microstrip antenna with low cross-polarization for operation in the frequency range from 4 GHz to 9 GHz that achieves a bandwidth of 77%. The single element parameters are presented and discussed. This antenna element is to be used in the development of linear and two-dimensional antenna array systems. Computation of the return loss is presented using WIPL-D and verification using our developed finite difference time domain (FDTD) code is conducted.

2. Single Element Design

The basic topology for the single element of the proposed antenna array is based on the developed monopole antenna introduced by Johnson and Rahmat-Samii [2]; however, our design exhibits a microstrip fed line with different parameters for the bandwidth purposed at C-band operations. The structure of the microstrip-fed printed monopole antenna, shown in Fig. 1, is printed on a substrate of thickness h = 0.813 mm (32 mil) and relative permittivity ε_r = 3.38. The width of the monopole is denoted as *W1* and its length as *L1*. The parameter *L2* is defined as the distance from the ground plane to the monopole antenna. The truncated ground plane on the backside of the substrate, with an area of

22×11.5 mm^2, is used to match a 50 Ω feeding network. A 50 Ω microstrip line, used for feeding, with a length *L3*=11.5 mm and a width *W*=1.9 mm is used.

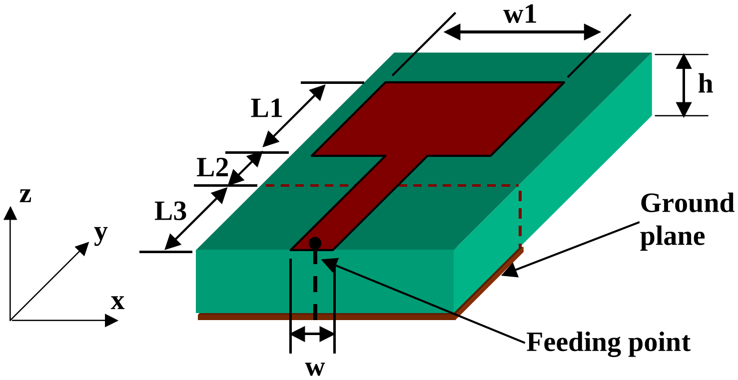

Fig. 1. Geometry of the proposed Tab monopole antenna.

A parametric study has been performed on this antenna using WIPL-D software package. The effect of changing the value of *W1* is addressed in Fig. 2, at a constant value of *L1* = 5 mm and *L2* = 2 mm. Figure 2 shows the shift in the frequency range when the value of *W1* was 7.8 mm until it was increased to 12 mm, as our target is to cover the C-band. By shifting the frequency lower, we set the width of the antenna to be 12 mm and tried to address the effect of changing the height of the antenna (*L1*) at a constant value of *L2* = 2 mm. Figure 3 shows the effect of changing the height of the monopole antenna. It can be clearly seen that changing the height of the antenna with width equal to 12 mm has shifted the frequency to the desired band. In our design we are trying not to maximize the size of the antenna and thus the values we selected for the width and height of our final design were 12 mm and 11.5 mm, respectively. By fixing the values of the height and width of the antenna as indicated, we tried to study the effect of changing the value of *L2* and its effect on increasing the bandwidth in order to obtain wideband characteristics. Figure 4 shows the effect of changing the value of *L2*, where it can be seen that the bandwidth has significantly increased thereby achieving a bandwidth of 77% in the C-band rang.

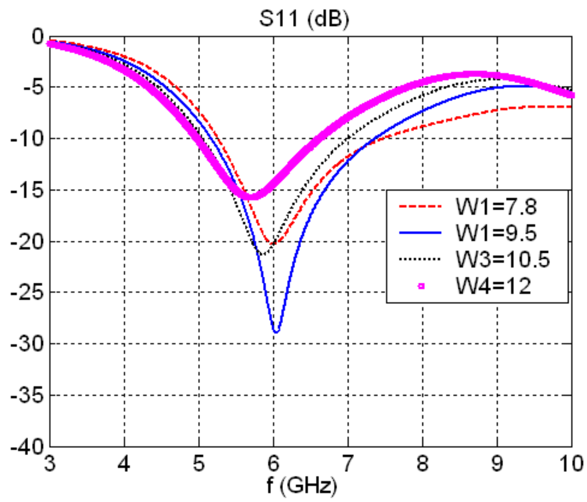

Fig. 2. The effect of changing *W1* on the return loss at *L1* = 5 mm and *L2* = 2 mm.

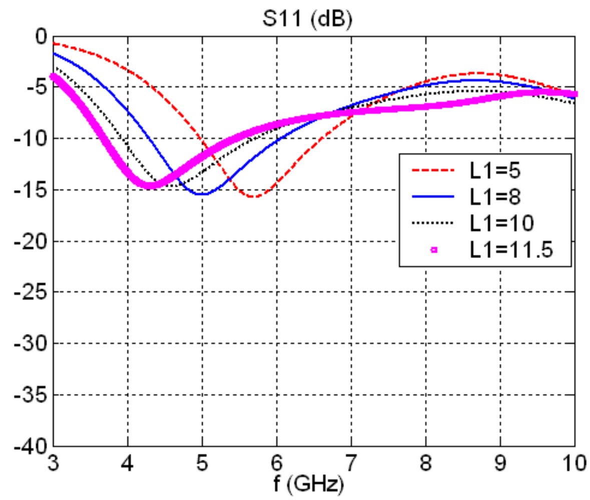

Fig. 3. The effect of changing *L1* on the return loss at *W1*= 12 mm and *L2*= 2 mm.

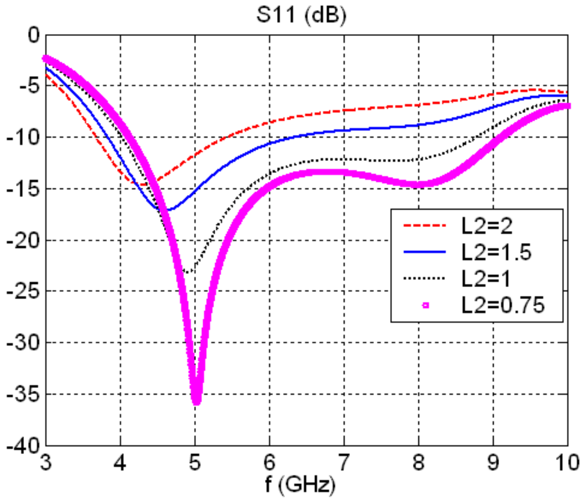

Fig. 4. The effect of changing *L2* on the return loss at *W1*= 12 mm and *L1*= 11.5 mm.

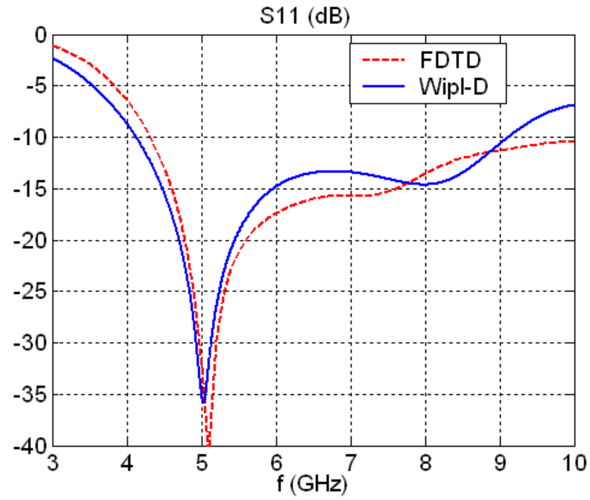

Fig. 5. FDTD verification for WIPL-D results at *W1*= 12 mm, *L1*= 11.5 mm and *L2*= 0.75 mm.

Figure 5 shows the return loss achieved for *W1* = 12 mm, *L3* = 11.5 mm and *L2* = 0.75 mm using the commercial software WIPL-D and our implemented FDTD code. Good agreement between the two techniques is achieved, while the small shift in the return loss obtained using the FDTD is due to the possible effect of using *W1* = 12.1 mm, instead of 12 mm because of the FDTD descretization, and due to the basic differences between these two simulation techniques.

The radiation pattern for this printed monopole antenna is shown in Fig. 6, where the pattern is nearly omni-directional. The antenna pattern shows very low cross polarization levels in the x-z and x-y planes and with no cross-polarized field in the y-z plane. The gain of this antenna across the C-band is found to be between 1.33 dB and 2 dB as shown in Fig. 7.

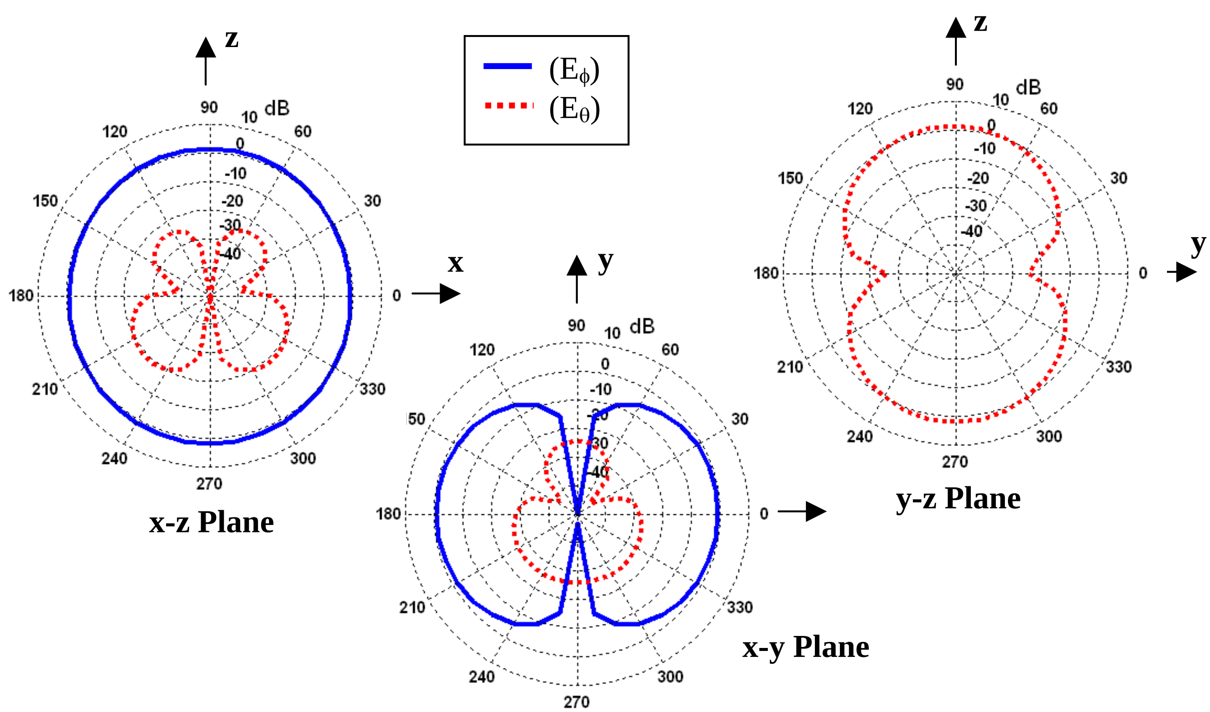

Fig. 6. Computed antenna patterns for the printed monopole antenna shown in Fig. 1.

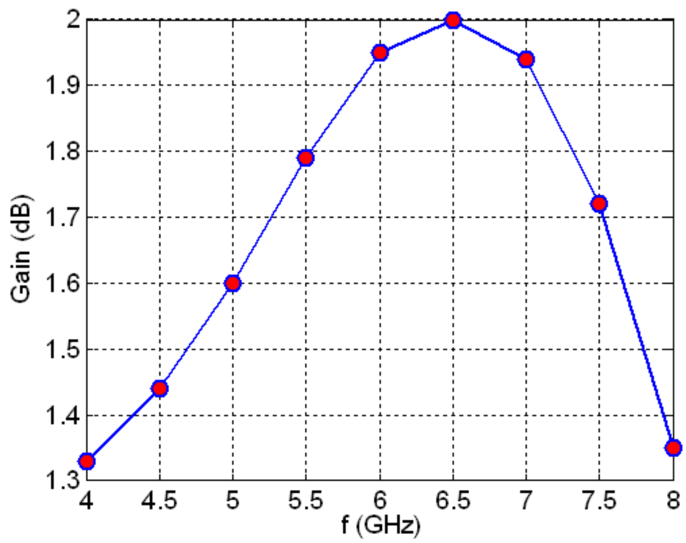

Fig. 7. Calculated gain over the entire C-band.

3. Array Configurations

The studied single element is to be introduced in a one-dimensional array or two-dimensional array configurations similar to those shown in Fig. 8 and Fig. 9, respectively. Antenna parameters and radiation patterns for an array of these elements will be presented.

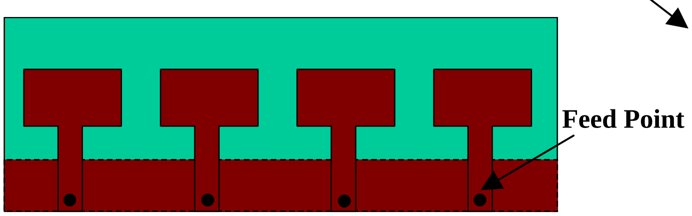

Fig. 8. Geometry of one-dimensional array.

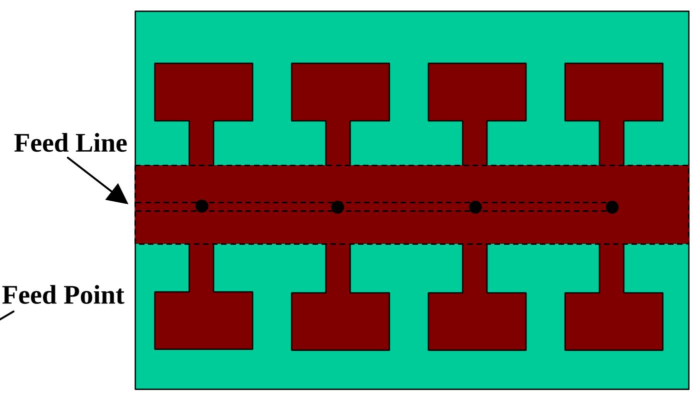

Fig. 9. Geometry of two-dimensional array.

4. Conclusion

A simple design of a printed monopole antenna fed by a microstrip line has been proposed for C-band operation. The computed results show that the antenna impedance bandwidth covers the entire range of the C-band. The main features of the antenna are its small size, simple design and the low cross polarization level.

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