COPLANAR WAVEGUIDE FED BOW-TIE SLOT ANTENNAS FOR WIDEBAND OPERATIONS

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ABSTRACT: *A bow-tie slot antenna with tapered connection to a 50Ω coplanar waveguide (CPW) feed line is introduced and its dimensional parameters have been studied for wideband operations in the X-band. A set of two element bow-tie slot antennas fed by one CPW is also introduced for wider bandwidth and improved gain. The configuration of one CPW feeding two elements of this antenna is simulated and it achieved 50% impedance bandwidth. Measurements of the return loss confirmed the simulation results for the single and the two element slot bow-tie designs.*

Keywords: Bow tie, wideband, coplanar waveguide, slot antennas, radar applications.

1. Introduction

Printed slot antennas fed by a coplanar waveguide (CPW) have many advantages over microstrip antennas. Besides small size, light weight, low cost, good performance, ease of fabrication and installation, and low profile, they exhibit wider bandwidth, lower dispersion and lower radiation loss than microstrip antennas besides the ease of being shunted with active and passive elements required for matching and gain improvement [1].

Bow-tie and bow-tie slot antennas are good candidates for wideband applications. A number of designs are introduced in [1-6] to demonstrate wide bandwidth capabilities that range from 17% to 40%. In this paper, a bow-tie slot antenna geometry with tapered feed line is studied and designed for wideband operation for radar applications. The related simulation and analysis are performed using the commercial computer software package, Momentum of Agilent Technologies, Advanced Design System (ADS), which is based on the method of moment (MoM) technique for layered media. The ADS simulator, Momentum, solves mixed potential integral equations (MPIE) using full wave Green's functions [7].

2. Element Geometry and Analysis

The geometry of the bow-tie slot antenna and its parameters are shown in Fig. 1. The tapering from the CPW to the bow-tie slot is to achieve better matching with a 50Ω feed line. The antenna is studied for 1.57 mm substrate with $\varepsilon_r = 2.2$ and the CPW feed line and slot widths are 3 and 0.25 mm, respectively, and its length is 18.5mm. The parameters of the antenna are the outer slot size W1 and L1, and L2, L3 and W2 that control the bow-tie flair angle and the tapering of the feed line. For the parametric study, W1, W2, L1, L2 and L3 are chosen to be 22.9, 1.25, 7.35, 0.95 and 2.25 mm, respectively, and only one parameter is changed at a time during the analysis. Figure 2 shows the effect of changing W1, where it is clear that increasing W1 shifts the operating band to a lower frequency range. As shown in Figures 3, 4 and 5, the parameters W2, L1 and L2 control the level of the return loss at the main resonance frequency.

Figure 6 shows the effect of changing L3. As L3 decreases, the resonance frequency shifts higher and the bandwidth increases. This behavior is due to the fact that when L3 decreases the bow-tie flair angle increases.

A prototype of the bow-tie slot antenna is fabricated and the return loss is measured using the HP 8510C vector network analyzer (VNA). The fabricated antenna has a finite ground plane truncated at 1 cm away from the bow-tie slot edge. The antenna with the connector is simulated using ADS Momentum and Fig. 7 shows a good agreement between the measured and simulated return loss of this fabricated antenna. According to the measured results, the finite ground plane bow-tie slot antenna has two operating frequency bands centered at 8.3 and 11.7 GHz with bandwidths 18% and 17.4%, respectively.

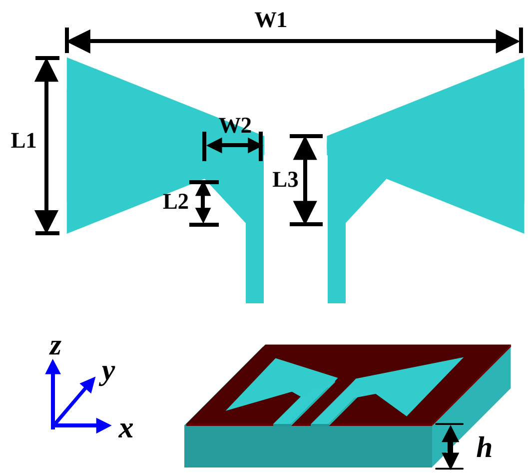

Fig. 1. Antenna geometry and parameters.

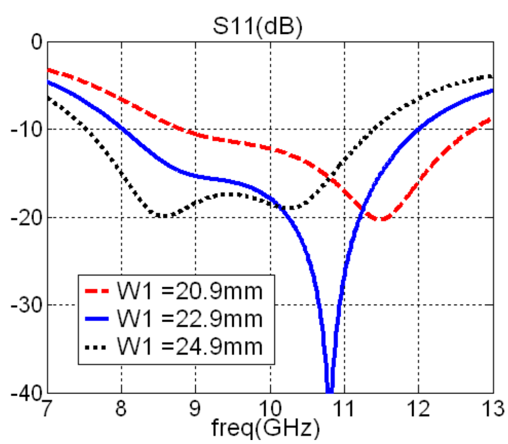

Fig. 2. The effect of changing W1.

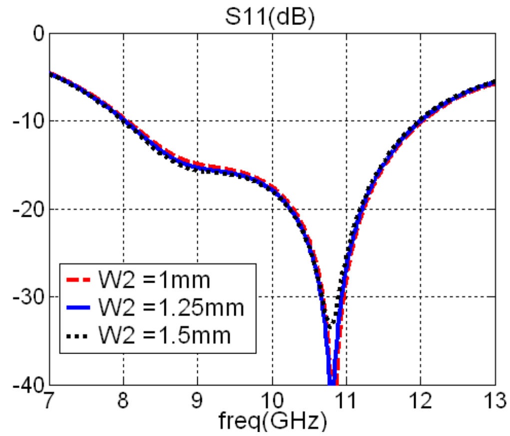

Fig. 3. The effect of changing W2.

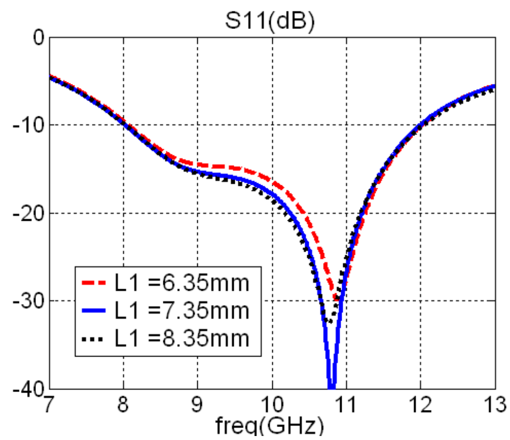

Fig. 4. The effect of changing L1.

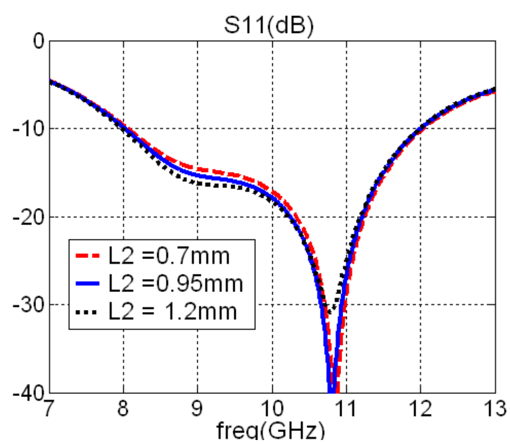

Fig. 5. The effect of changing L2.

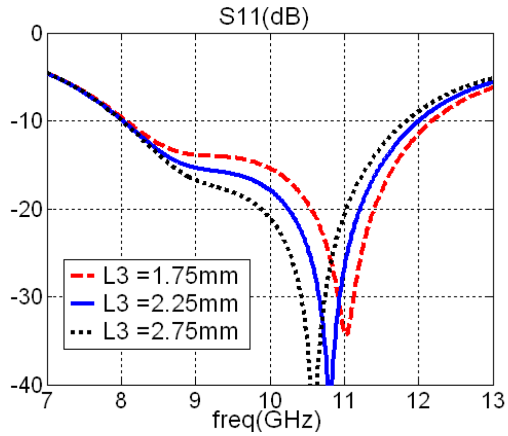

Fig. 6. The effect of changing L3.

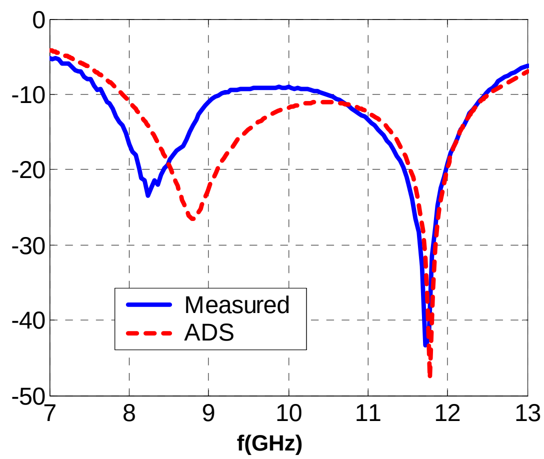

Fig. 7. Comparison between the measurement results and ADS results for the modified bow-tie slot antenna.

3. Two Elements with One CPW Feed

The study of the CPW-to-CPW transition between two different lines and the effect of deformed feed line in [8] is used here to connect the two bow-tie slot antennas with one CPW. Two Elements of the bow-tie slot antenna with W1, W2, L1, L2 and L3 chosen to be 22.9, 1.25, 7.35, 0.95 and 2.25 mm, respectively, over a substrate of 1.57 mm thickness and ε_r = 2.2, is simulated. The return loss for this combination is shown in Fig. 8. The design provides wider bandwidth over the single element as the antenna operates from 8.7 to 14.5 GHz with approximately 50% bandwidth. The feeding mechanism is similar to that in Fig. 9; however, the center-to-center distance between the two antennas is 26.72 mm and the single element feed line is kept at 18.5 mm. Another combination of two bow-tie slot antennas is designed for a substrate of ε_r = 3.38 and 60 mil height, connected to one CPW feed line as shown in Fig. 9. This design is fabricated and measured, and the picture of the antenna and the comparison between the measured and computed return loss are shown in Fig. 10. According to the measurements, this configuration operates from 7.1 to 10.7 GHz with 40% bandwidth, with a good agreement between simulation and measurements results.

The radiation pattern of the last design is calculated using ADS Momentum at 10 GHz. Figures 11 and 12 show the radiation patterns in the x-z and y-z, respectively, for this antenna. In y-z plane there is no Eϕ because of the symmetry of the antenna. The cross polarization level is less than -40 dB in the z-direction. The calculated gain and directivity of this antenna are 7.12 dB and 8.268 dB, respectively, and the resulting efficiency is 77%.

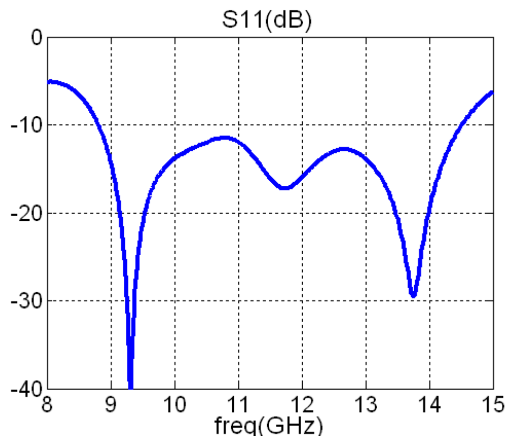

Fig. 8. Return loss of two bow-tie slot antennas connected to one CPW on a substrate with 1.57 mm height and ε_r = 2.2.

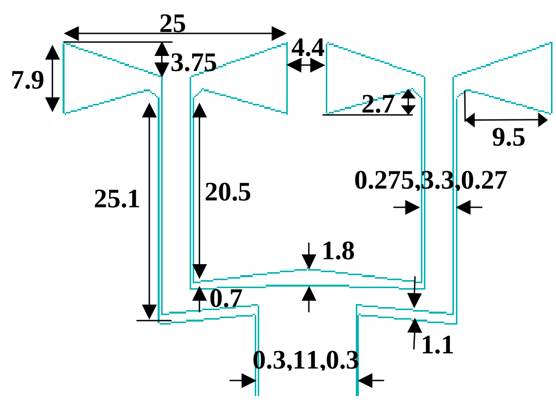

Fig. 9. Geometry and dimensions in mm of the two bow-tie slot antennas fed by one CPW.

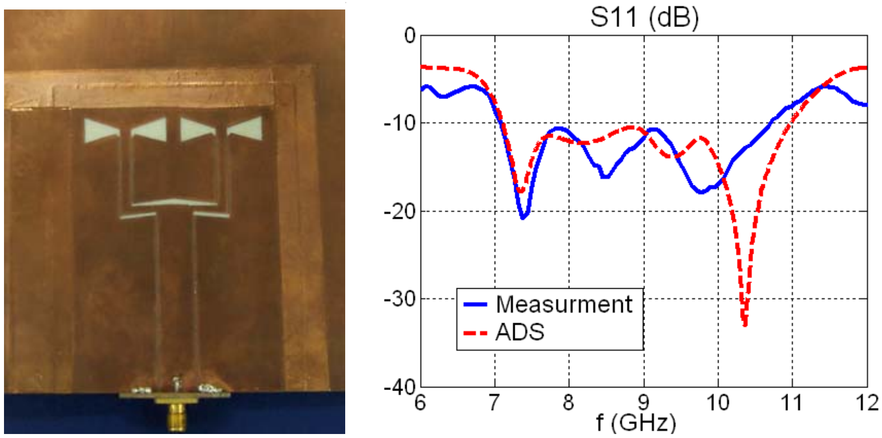

Fig. 10. Comparison between the measured and ADS return loss for the two bow-tie slot antennas fed by one CPW shown in Fig. 9.

4. Conclusion

A one-element bow-tie slot antenna fed by a 50 Ω coplanar waveguide is designed for the X-band operation. The measurements of this antenna show two operating bands centered at 8.3 and 11.7 GHz with bandwidths 18% and 17.4%, respectively. An array combination of two of these antennas fed by one CPW achieved 50% bandwidth from 8.7 to 14.5 GHz. A similar antenna is designed and fabricated with a different substrate board that operates from 7.2 to 10.7 GHz with 40% bandwidth.

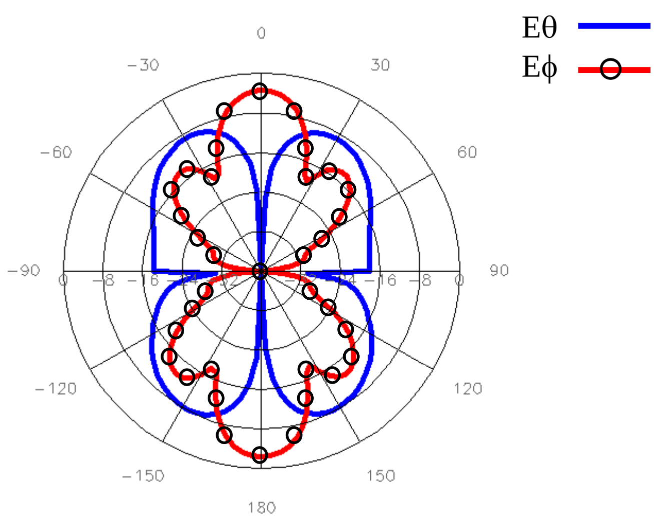

Fig. 11. Far field pattern at in the x-z plane at 10 GHz.

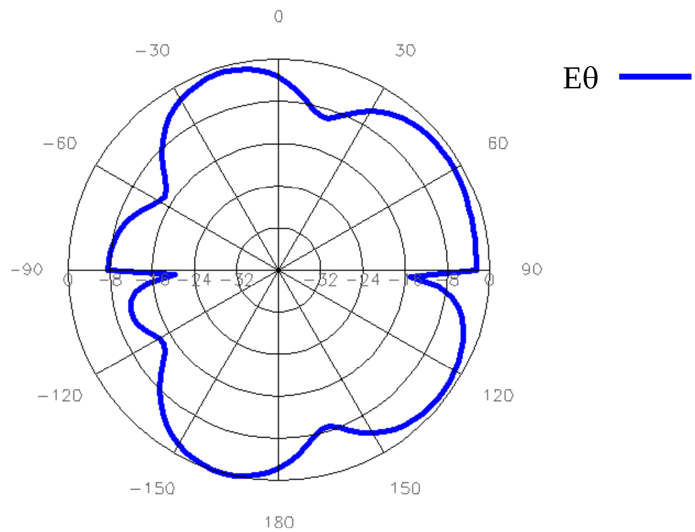

Fig. 12. Far field pattern at in the y-z plane at 10 GHz.

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