A New CPW-Fed Slot Antenna for Ultra-Wide Band Application

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Abstract

A new design of a coplanar waveguide (CPW)-fed folded slot antenna is presented which is suitable for ultra-wide band application. Antenna impedance and bandwidth are studied as function of slot parameters, substrate dielectric constant, and substrate thickness. Wideband operation is achieved by designing an adjacent semicircular slot to a folded slot antenna. A prototype antenna was fabricated on RO4003 (ε_r = 3.38, substrate thickness = 1.5 mm) and measured for VSWR characteristics. The antenna can operate in the 4.1-7.7 GHz frequency range and has a bandwidth of 61% within 2:1 VSWR.

1. Introduction

Recently there has been considerable interest on antennas for ultra-wide band application. CPW-fed slots are one of the most popular kinds of antennas since they can be easily integrated with microwave integrated circuits (MICs) and monolithic microwave integrated circuits (MMICs) [1-4]. Conventional slots have higher input resistance at resonance which makes it difficult to match them with 50Ω lines. It has been shown that folded slots provide a better solution [5]. In this paper we propose a CPW-fed slot antenna suitable for ultra-wide band application. The proposed antenna was designed and developed by studying and understanding an existing triple slot antenna.

2. Antenna Geometry

A photograph of the proposed antenna is shown in Fig. 1. The slot antenna is printed on RO4003 with dielectric constant of 3.38. The substrate measures 230 mm by 150 mm by 1.5 mm. The slot antenna is on one side of the substrate while the other side does not contain any metal. There is a T-shaped tuning stub at the end of the coplanar waveguide. The length of this tuning stub determines the operating bandwidth of the antenna. After running a few simulations, the optimum radius of the semi-circular slot was found to be *R = 10 mm*. Two additional small rectangular slots were added at both ends of the semi-circular slot. These new slots further enhance the bandwidth of the proposed radiator.

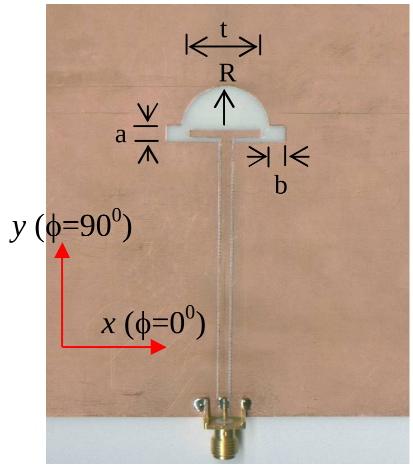
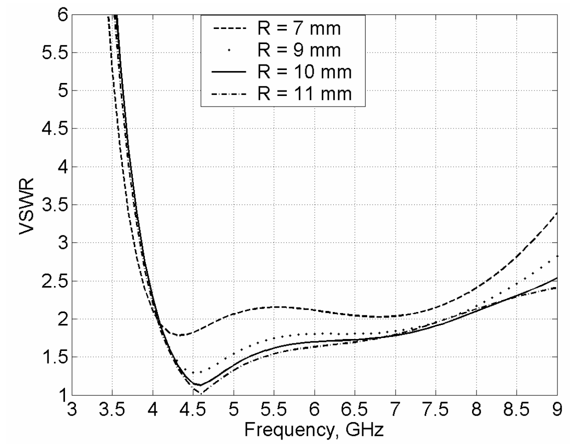
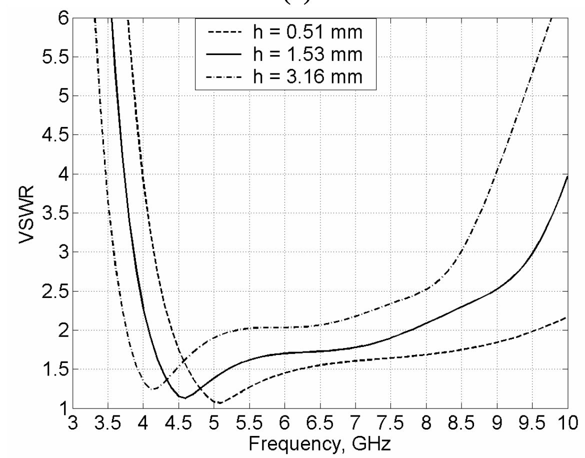


Figure 1: Photograph of CPW-fed wide-band slot antenna (R = 10 mm, h = 1.5 mm, t = 13 mm, a = 5 mm, and b = 2.5 mm).

Antenna design was conducted using IE3D, a full-wave Method of Moments (MoM) based solver. In order to reduce computation time, an infinite ground plane was assumed and the slot antenna was replaced by an equivalent magnetic current source. This antenna can easily provide an operating bandwidth of 4.1 to 7.7 GHz (61%). The radius of the semi-circular slot is varied and corresponding VSWR plots are shown in Fig. 2(a). As the radius increases the VSWR curves' dips go lower indicating better impedance match. We choose R = 10 mm in our design. Then the substrate thickness (h) was changed and VSWR are plotted in Fig. 2(b). With increasing substrate thickness, the VSWR performance degrades.



(a)



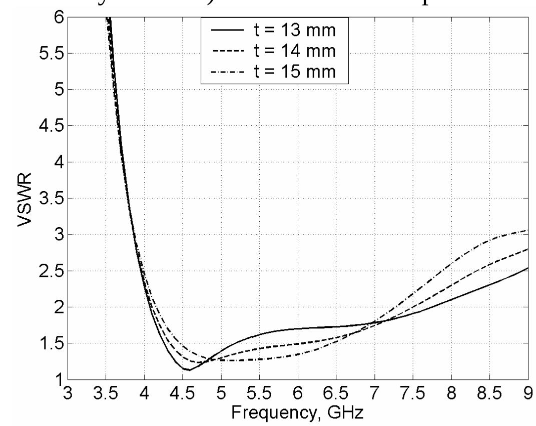
(b)

Figure 2: Computed VSWR with (a) circle radius and (b) substrate thickness as parameters.

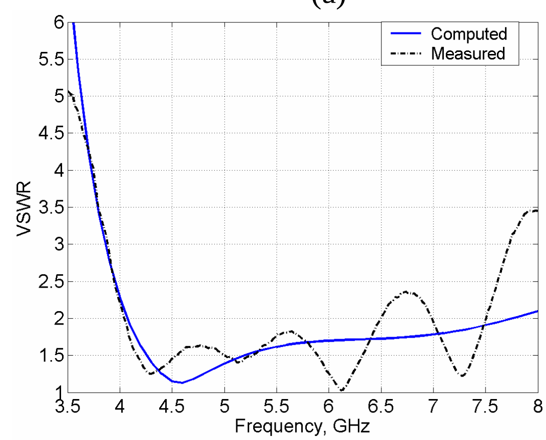
As h = 1.5 mm gives good VSWR data and due to its availability, we take this height as our design value. We then proceed to see the effect of the length of the T-shaped end part of the CPW feed in Fig. 3(a). From the figure, it is evident that a length (t) of 13 mm gives optimum performance.

3. Results

We fabricated the slot antenna as shown in Fig. 1 and a comparative representation of the computed and measured VSWR is shown in Fig. 3(b). The fabricated antenna was tested using an Agilent 8719 ES vector network analyzer. The measured and computed VSWR bandwidths agree well in the desired frequency band. The measured VSWR response shows some ripples especially at the higher frequencies, which may have resulted from finite substrate size (230 mm by 150 mm) and fabrication imperfections.



(a)



(b)

Figure 3: (a) Computed VSWR with varying tuning stub length and (b) computed and measured VSWR characteristics (R = 10 mm, h = 1.5 mm).

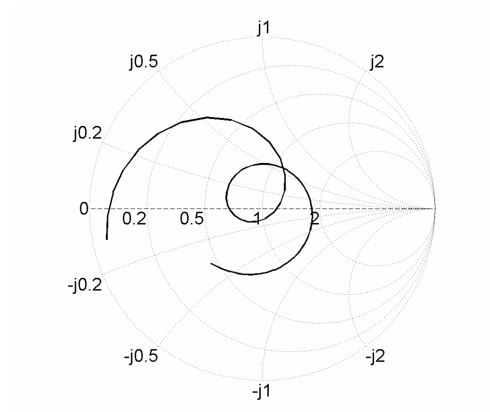


Figure 4: Input impedance of the slot antenna (R = 10 mm, h = 1.5 mm, t = 13 mm).

Further optimization results demonstrate that a bandwidth of more than an octave (4.4-9.5 GHz) can be easily achieved [see Fig. 2 (b)]. Computed input impedance for the wideband slot antenna with R = 10 mm, h = 1.5 mm, t = 13 mm is plotted in Fig. 4. The loop around the center of the Smith chart clearly indicates a good impedance match. Computed peak gain over the operating frequency band is shown in Fig. 5. Gain is almost flat over the band of interest.

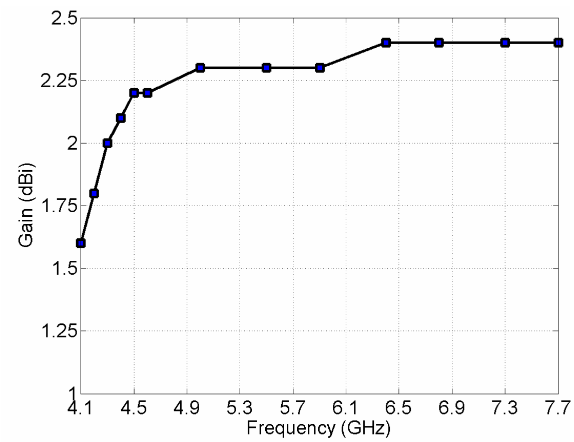
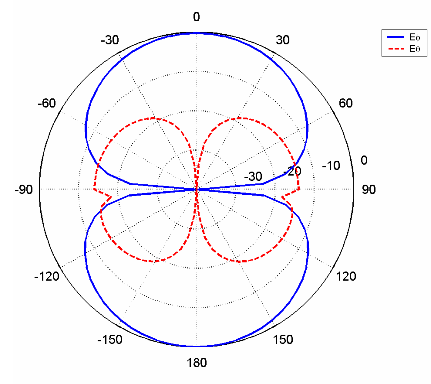


Figure 5: Computed gain as a function of the operating frequency (R = 10 mm, h = 1.5 mm, t = 13 mm).

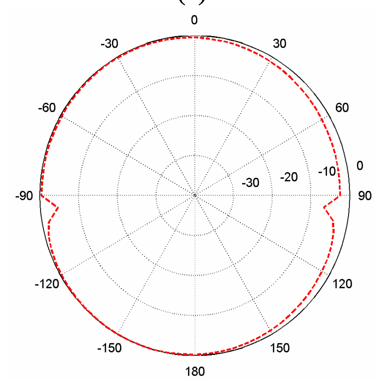
Normalized gain patterns are presented in Fig. 6, 7 and 8 at two different frequencies for both φ = 0º and φ = 90º planes. These figures depict that this antenna unlike the types proposed in [3] has much less cross-polarization levels at the high end of the band. Computed electric field distributions at 5, 6 and 7 GHz are plotted in Fig. 9. At higher frequency, fields decrease over the semi-circular slot region.

4. Conclusion

A new printed CPW-fed slot antenna is proposed. This is an ultra wide band antenna and has very less cross polarization over the operating frequency band. The gain is almost flat over this band of interest. The feeding technique is such that the input impedance is well matched and ensures very large impedance bandwidth from 4.1 GHz to 7.7 GHz (61%) when geometric parameters are well optimized.



(a)



(b)

Figure 6: Computed normalized radiation patterns (R = 10 mm, h = 1.5 mm, t = 13 mm) at 5 GHz, (a) $\phi = 0^0$ and (b) $\phi = 90^0$.

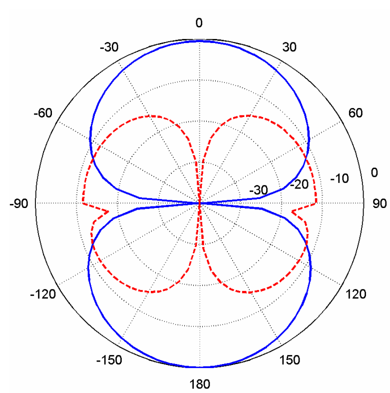


Figure 7: Computed normalized radiation patterns (R = 10 mm, h = 1.5 mm, t = 13 mm) at 7 GHz, $\phi = 0^0$.

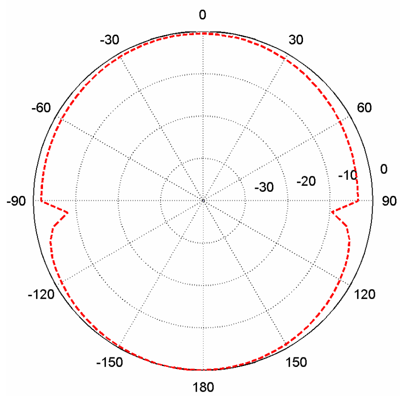
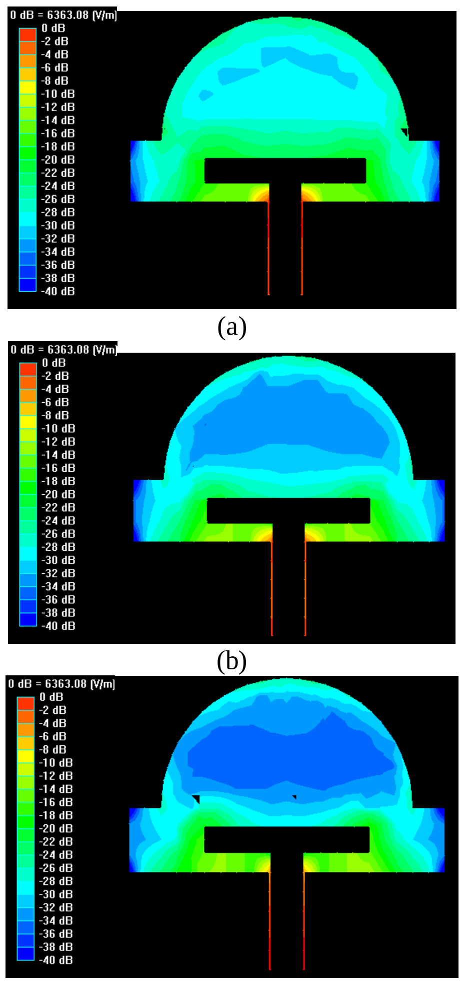


Figure 8: Computed normalized radiation patterns (R = 10 mm, h = 1.5 mm, t = 13 mm) at 7 GHz, $\phi = 90^0$.



(a)

(b)

(c)

Figure 9: Computed electric field distributions for the proposed antenna (R = 10 mm, h = 1.5 mm, t = 13 mm) at (a) 5 GHz, (b) 6 GHz and (c) 7 GHz.

5. References

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