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A New Miniaturized UWB CPW-Fed Slot Antenna With Tapering Feed Line

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Abstract *– A planar CPW-fed monopole slot antenna, with tapered feed line and H- shaped slot in ground plane is presented. The antenna has been printed on FR4 substrate with the dimension of 14mm×18mm×1mm. The experimental results demonstrate that the impedance bandwidth of proposed antenna ranges from 3.3 to 13 GHz for VSWR ≤ 2, and according to the simulation it has omnidirectional radiation pattern in H-plane and symmetrical in E-plane.*

Keywords*: Ultra wideband antennas, Coplanar waveguide, slot antennas*

ORIGINAL ARTICLE

INTRODUCTION

In modern wireless communication era there is an increase in the demand for systems, which are smaller in size and support high data rate providing high performance. After the release of Ultra Wideband (UWB) for unlicensed applications by the FCC, it has attracted more attention for use in wireless communication and sensing applications. For wireless applications, various antenna configurations including planar monopoles, slot antennas and dipoles have been suggested. Among them, Planar slot antennas combined with coplanar waveguide feed are more promising because of its simple structure, lower profile, easy fabrication, wide impedance bandwidth, less radiation loss, less dispersion and its easy integration with monolithic microwave integrated circuits (MMIC) [1].

In general, the wide bandwidth in CPW-fed slot antenna can be achieved by varying the dimensions of its structure which in turn will modify the impedance value. Several impedance tuning techniques are also reported in literature by varying the slot dimensions. These tuning techniques has been carried out in various slot geometries like bow-tie slots [2-4], wide rectangular slot [5-7], circular slot [8] and hexagonal slot [9]. The impedance tuning can also be performed using coupling mechanisms like inductive and capacitive coupled slots [10] and dielectric resonator coupling [11-12] and other techniques such as using photonic band gap (PGB) [13]. Even though large impedance bandwidths could be obtained using

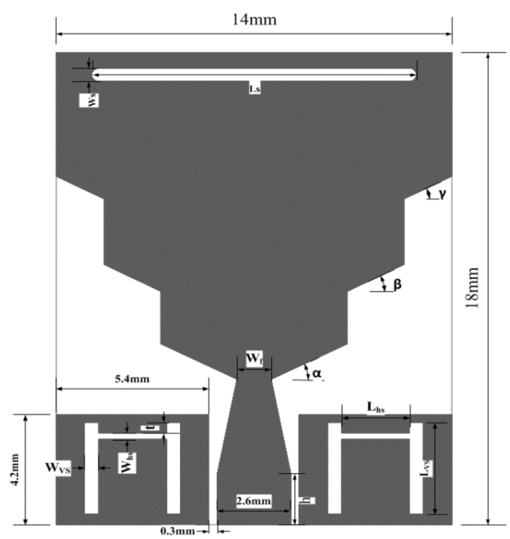

Fig. 1. Geometry of the proposed antenna

these techniques, they are quite complicated. In planar slot antennas two parameters affect the impedance bandwidth of the antenna, the slot width and the feed structure. The wider slot and the optimum feed structure results in more bandwidth and good impedance matching, respectively [14-18].

This letter proposes a simple and compact CPW planar UWB antenna. Due to the size of antenna the enhancement of the bandwidth is achieved by an H-shaped slot in ground plane and a tapering feed line. The design of the new antenna and its simulated and experimental results are presented.

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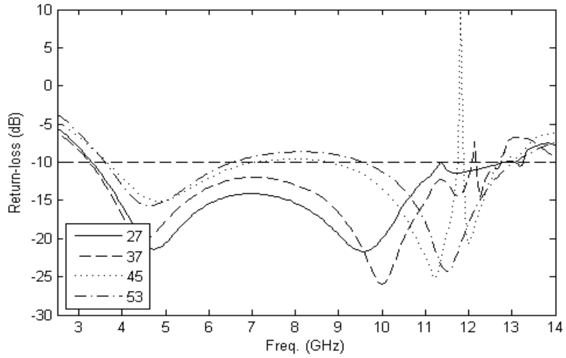

Fig. 2. Simulated return losses for different values of angels with fixed values of $\alpha = \beta = \gamma$ = 27,37,45,53

ANTENNA CONFIGURATION

The configuration of the proposed UWB printed monopole antenna structure is illustrated in Fig. 1. The antenna consists of three rectangular radiation patches that connect each other with taper steps and to the feed line. The ground plane introduced with two H-shaped slots to achieve a broad bandwidths. The H-slot comprises of two vertical arms of length L_{vs} and width W_{vs} and one horizontal arm of length L_{hs} and width W_{hs}.The feed line width is selected 2.6mm with the gap of 0.3mm and connects to the patch with 1.3mm width. This antenna was printed on FR4 substrate with the dielectric constant of 4.4 and the thickness of 1.6 mm which fed by a CPW transmission line. Simulations have been carried out using Ansoft HFSS.

ANTENNA DESIGN AND PARAMETRIC STUDY

One of the important parameters in design of proposed antenna is the angle of the tapering parts in the patch. Numerically the effect of tapering angle on the return loss is studied and simulation results are shown in Fig.2. According to the results, this study shows that, the optimized angles to reach the desired impedance bandwidth are equal for all three angles and it is 27°.

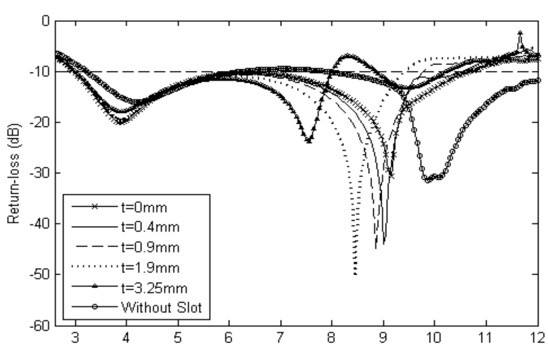

Fig. 3. Horizontal arm position effect with fixed value of L_{hs}= 2.4mm

The slotted ground plane is introduced as an effective part of the proposed antenna to alter the input impedance characteristics. Fig. 3 shows the Return-loss results for different positions of horizontal arm with fixed value of L_{hs}=2.4mm. As shown, the position of this arm moves the second resonance from 9.2 GHz to 7.6 GHz. Fig. 4 shows different results of the distances between two vertical arms with fixed value of t=0.4mm. Although it seems L_{hs}= 2.8mm gives better result but at least it causes a notch.

A slot is added in patch to add another resonance to satisfy the desired bandwidth. As it's presented in Fig.5, this notch causes a resonance around 7.85GHz but this notch can cause some filtering effects before its resonance that is controlled by the position of notch and a technique that is introduced as tapering feed line. Fig.5 shows the Return-loss diagram of different position of slot and the effects of tapering feed line in each position.

As it's illustrated in Fig.6 and 7, tapering feed line technique has an important effect beyond controlling return-loss around 7GHz and it would be its action in low frequencies. In this technique, there are two important factors to reach the required frequencies, the width of the connection point between feed line and patch, and the tapering angle. Fig 6 shows different results of the width of W_f with the fixed value of h= 0.8mm and Fig 7 shows

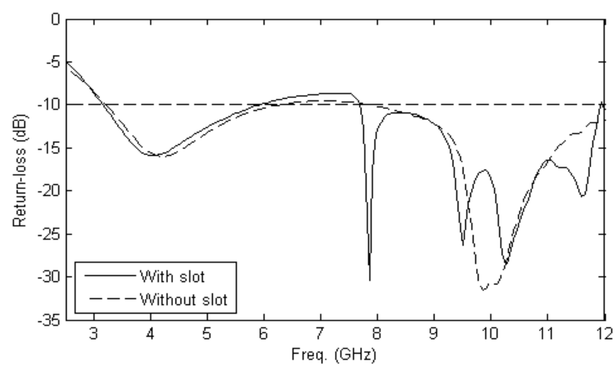

Fig. 5. Patch slot effect on return-loss

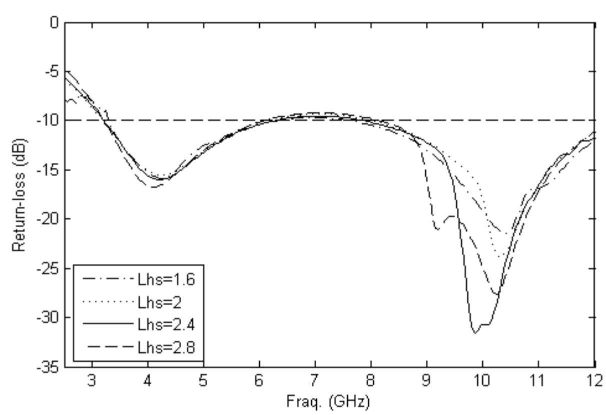

Fig. 4. Vertical arms distance effect with fixed value of t= 0.4mm

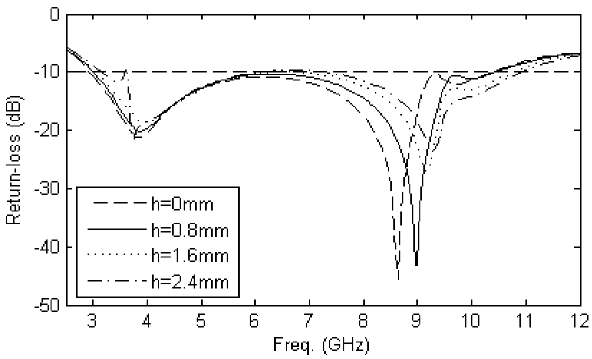

Fig. 6. Angle of tapered feed line effects with the fixed value of W_f = 1.3mm

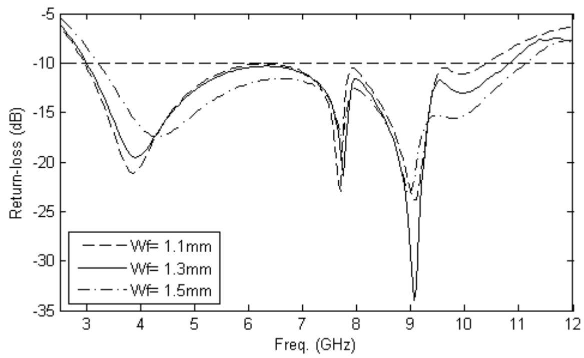

Fig. 7. The effect of the connection width of feed line and radiation patch with the fixed value of h= 0.8mm

the effect of different values of h in return-loss with fixed value of W_f= 1.3mm.

MEASUREMENT RESULTS AND DISCUSSION

Fig. 8 presents the photograph of a released printed monopole antenna on an FR-4 substrate with the SMA connector. Fig. 9 shows the measured and simulated return- loss characteristics of the proposed antenna. The fabricated antenna satisfies the 10 dB return loss requirement from 3.3 to 13.1 GHz. It's clear that there is a discrepancy between the measured data and simulated results. The reason of these differences can be interpreted as the effect of plate of the connector that works as ground plane for antenna. Also to confirm the accurate return loss characteristics for the designed antenna, it is recommended that the manufacturing and measurement process be performed carefully. The proposed antenna has been tested in the Antenna Lab of Iran Telecommunication Research Center (ITRC).

Fig. 10 shows the simulated radiation patterns including the co-polarization and cross-polarization in the H- (x–z plane) and E-planes (x–y plane). It can be seen that the radiation patterns in the x–z plane are Omni-directional for the three frequencies.

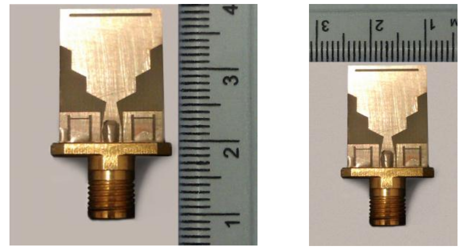

Fig. 8. Photogragh of proposed antenna

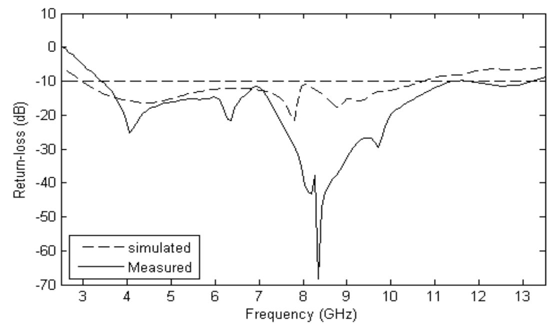

Fig. 9. Measured and simulated of the proposed antenna

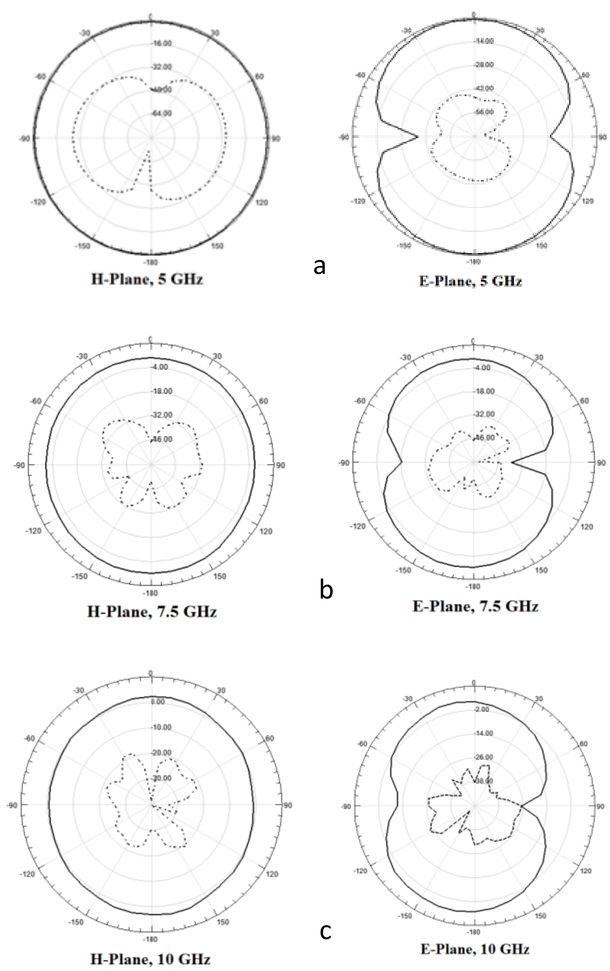

Fig. 10. E and H plane radiation pattern

CONCLUSION

In this paper, a novel compact planar monopole antenna with tapering feed line has been proposed for UWB applications. The feed gap distance, the angle of three tapered steps in the patch, the angle of tapered feed line, the sizes of the slots on the radiating patch and the slots on the truncated ground plane to obtain the wide bandwidth; have been optimized by parametric analysis. A parametric study was performed that demonstrated wideband characteristics can be achieved for the small antenna with the appropriate choice of the parameter. The designed antenna has a simple configuration and is easy to fabricate and satisfies the 10 dB return loss requirement and provides good monopole-like radiation patterns. Experimental results show that the proposed antenna could be a good candidate for UWB applications.

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