NOVEL SINGLE-FEED DUAL-BAND PLANAR INVERTED-F ANTENNA WITH A SLOT

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1. Introduction

Recently, the planar inverted-F antenna (PIFA) has received much attention in celluar phone communications because it has the merits such as compact (compared with wire antennas), efficiency (compared with microstrip antennas), and dual-polarization [1-6]. In addition, it was reported that the PIFA has low-absorption when it is in operation [7], because more radiation energy is directed away from the opposite postion of ground [5]. For multi-band operation, several designs have been presented by using L-shape spur line(s), or U-shaped slot [1-3]. Dual-band antenna was also designed using two radiation elements fed by dual feeds, and then some measures were taken to lessen mutal coupling between the elements [1,3,4].

In this paper, a novel single-feed PIFA with two shorting pins and a linear slot is proposed, operating at 800MHz and 1.9GHz bands. It is based on a single-band PIFA with no slot, whose bandwidth is as large as 12.6% by adding two shorting pins near the feed. The proposed design is examined through measurements of its return loss and radiation patterns. The antenna return loss was measured with an HP8510C network analyzer, and the radiation patterns were carried out with the antenna under test placed inside an anechoic chamber. Further, the finite-difference time-domain (FDTD) method was used to discuss resonant frequencies variation at different slot dimensions.

2. Antenna design

The geometry and dimensions of the proposed antenna are depicted in Fig.1. It is suspended on a finite conductive plane with area of $118 \times 50mm^2$, and fed by a 9mm-high coaxial line whose characteristic impedance is 50Ω. A linear line is cut in the patch grounded at s_1 and s_2, near the feed. The proposed antenna has almost the same size as a conventional PIFA operating 0.9GHz.

3. Results and discussions

Fig.2 show the measured return loss of the proposed PIFA within the frequency range of 0.7-2.0GHz. Two resonant frequencies are obtained at 0.85GHz and 1.87GHz. The bandwidths for the return loss, $s_{11} \leq -10dB$, are 7.2% at 0.8GHz band and 5.9% at 1.9GHz band. The return loss are less than -15dB in the two above frequency bands. We have found the two shorting pins, s_1 and s_2, are effective to obtain good matching in the both bands. In order to get better matching in the lower frequency band, we can adjust the position of s_1. The resonant frequencies are sensitive to the slots dimensions, especially to the slot length, d, which we will discuss later.

For validation ,the antenna return loss was also calculated with the FDTD method, and shown in Fig.2. A Gaussian-type excitation source was used in the simulations. The cell size was chosen as $1 \times 1 \times 1mm^3$. The timestep was 1.926 ps. Fig.2 shows that there is a good agreement between the measurements and the simulations, although the bandwith is much wider at the lower frequency band. The linear slot divides the patch to two different radiation elements, A and B (Fig.1b). By analyzing the simulated field distribution beneath the patch, we have found the main radiator is A at 0.86GHz, and becomes B at 1.9GHz. To further analyze effects of the slot dimensions on resonant frequencies, we calculated the return loss at different lengths and widths of the slot. It is well-known that the resonant frequency of a conventional single-band PIFA is determined by the patch size, namely, the wavelength is about four times the value, length plus width of the patch. Therefore, we have found that the lower resonant frequency of the proposed design is mainly determined by the patch size, and changes little with the changing slot dimensions. However, as the slot length is longer or the slot width is wider, the electric length is lengthen and then the lower frequency becomes lower accordingly. In addition, we found that the slot length has more effect on the higher resonant frequency than the slot width. When the slot length decreases from 37.9mm to 35.2mm, the higher frequency increases from 1.9GHz to 2.0GHz. At the same time, the lower frequency is reduced. The higher frequency also increases with the narrower width of the slot. Thus, we can choose different resonant frequencies by changing the length and width of the slot, which is useful for designing in practical application.

The measured far-field radiation patterns of this proposed design within the two operating bands are investigated at 0.86GHz and 1.9GHz (Fig.3 and Fig.4). Radiated fields, E_θ and E_Φ, in E and H planes have been taken into account respectively. At 0.86GHz, Fig.3 shows that the field component, E_Φ, has an omnidirectional pattern in H plane, and that E_θ has a near-omnidirectional pattern in E plane. At 1.9GHz, the cross-polarization increases in both E and H planes, and the patterns become proximately omnidirecational. It can be found in Fig.4 that in many degrees, in both E and H planes, the values of E_Φ is as much as that of E_θ. It means that the proposed antenna has almost dual-polarization performance at 1.9GHz. So it can receive electromagnetic wave with horizontal and vertical polarizations effectively at 1.9GHz, which is useful for portable terminals in wireless communications. In addition, the ground effects on radiation patterns seem not larger at the both frequencies due to small size of the ground plane (shown in Fig.3 and Fig.4).

Finally, the antenna gain is also investigated in this study. The measured gain is 2.3dBi at 0.86GHz and 3.8dBi at 1.9GHz. The gain at 1.9GHz is larger, which maybe the result of the larger ground effect than that at lower frequency, 0.86GHz.

4. Conclusions

In this paper, a novel dual-band PIFA with a linear slot has been investigated experimentally. It has wider bandwidth than that given in [1]. This compact low-profile antenna shows approximately omnidirectional radiation characteristics, good matching and gain, which are preferable for dual-band application in wireless communications. The two resonant frequencies can easily be adjusted by choosing the dimensions of the slot, and good impedance can be obtained in the two frequency bands by adjusting the positions of the two shorting pins.

In addition, the proposed antenna can be used for a triple-band antenna design by adding another linear slot. The details of two single-feed triple-band designs will be given at presentation.

References:

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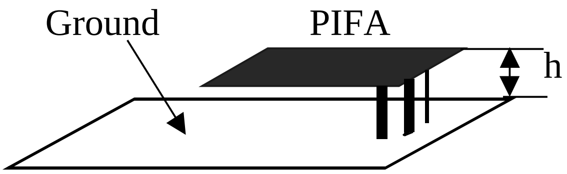
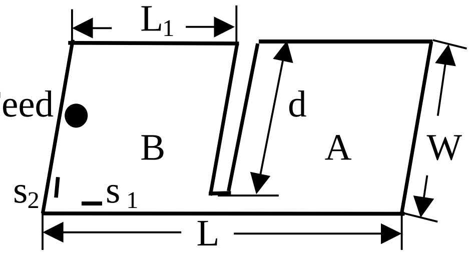


a. the antenna mounted on a finite ground



b. top view of the antenna

Fig.1 Geometry of the proposed design
(parameters:W=40mm, L=46.3mm, L_1=23mm, h=0.9mm, d=36mm)

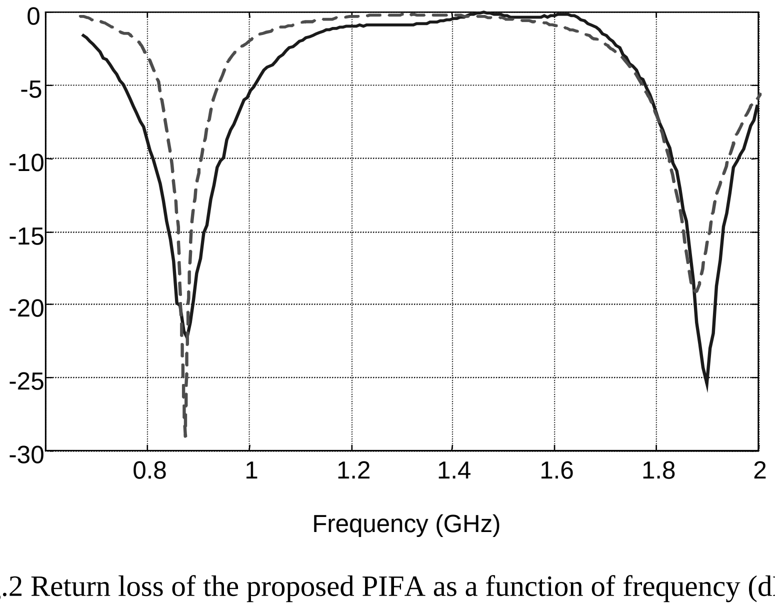
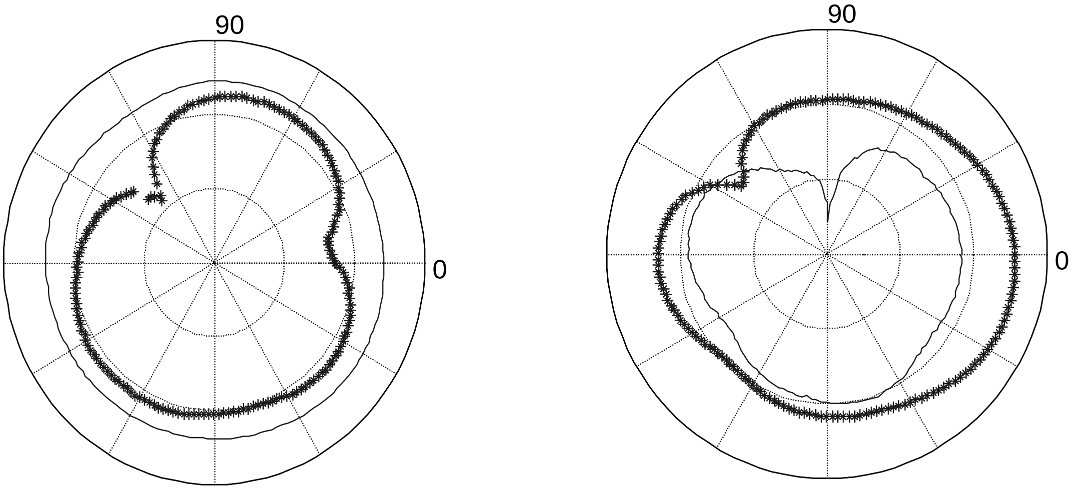


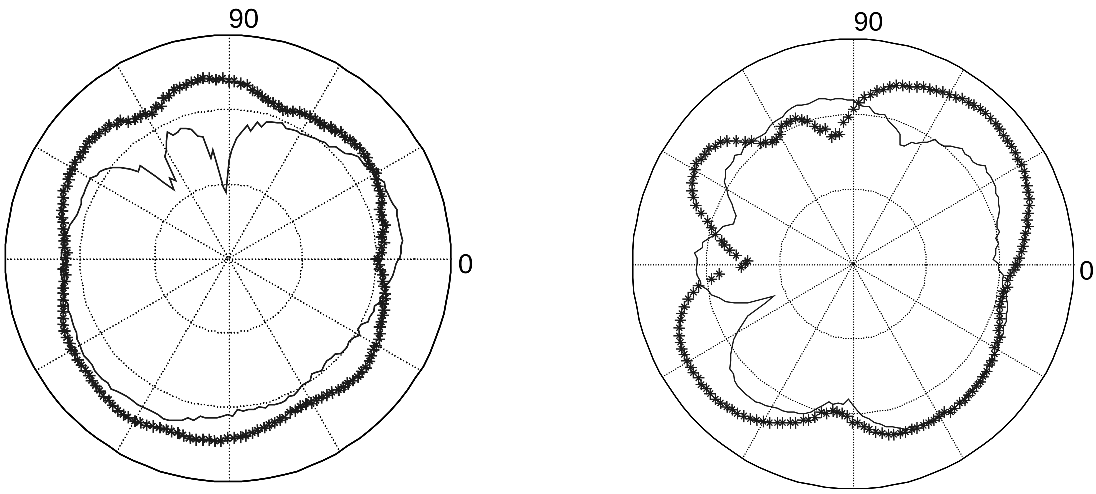
Fig.2 Return loss of the proposed PIFA as a function of frequency (dB)
(solid line: simulated results; dashed line: measured results)



a. in H plane

b. in E plane

Fig.3 Measured radiation patterns at 0.86GHz (__ Ephi, ** Etheta, Ref=10dB, div=20dB)



a. in H plane

b. in E plane

Fig.4 Measured radiation patterns at 1.9GHz (__ Ephi, ** Etheta, Ref=10dB, div=20dB)