A HYBRID COUPLED TRIPLE-FREQUENCY SLOT ANTENNA FED BY CPW

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1. Introduction

In recent years, the application of coplanar waveguide (CPW) as a feeding system on a printed slot antenna has become of increasing interest to many researchers [1-3]. This is firstly due to the printed slot antennas have a wider impedance bandwidth as compared to printed microstrip patch antennas. Secondly, printed slot antennas fed by coplanar waveguide have several advantages that include lower radiation losses, wider bandwidth, better impedance matching, and easier integration of solid-state devices. These papers show a CPW capacitively coupled dual-frequency slot antenna, which is composed of one slot loop antenna and one slot dipole antenna. A capacitively coupled slot loop antenna and a capacitively coupled slot dipole antenna decide the two resonant frequencies. For the sake of realizing the detail characteristics of the relatively printed slot antenna configuration, this paper presents a hybrid coupled slot antenna fed by CPW using a single layer substrate, which includes an inductively coupled slot dipole antenna and a capacitively coupled slot loop antenna.

In this article, we propose a simple design of a triple-frequency printed slot antenna with CPW feed. In applications, the proposed antenna consists of one capacitively coupled rectangular slot loop antenna and one inductively coupled rectangular slot dipole antenna, both antennas are coupled to each other and are excited by the CPW feed. The three resonant frequencies of the proposed antenna are decided by the dimensions of the two slot antennas. And, the three resonant frequencies have the same polarization planes. Designs of the proposed triple-frequency slot antenna are described and typical experimental results are demonstrated and discussed.

2. Antenna Design

Figure 1 shows the configuration of a triple-frequency printed slot antenna. The rectangular slot loop antenna has a dimension $L_1 \times W_1$, and has a width S_1. The rectangular slot dipole antenna has a length L_2, and has a width S_2. To simplify the design, the rectangular slot dipole antenna is placed in the center of the rectangular slot loop antenna. Both of them are hybrid coupled by a CPW feed. The characteristic impedance of the feeding CPW transmission line is 50Ω. By adjusting two widths of S_1 and S_2, it is found that the first three resonant frequencies of the proposed antenna can be excited with good impedance matching. Furthermore, the first two resonant frequencies are decided by the perimeter of the rectangular slot loop antenna, and the third resonant frequency is dependant the length L_2 of the rectangular slot dipole antenna.

3. Results and Discussion

A triple-frequency printed slot antenna operating at about *2.18GHz, 3.77GHz* and *5.44GHz* is designed and constructed. The proposed antenna is fabricated using inexpensive FR4 microwave substrate of thickness *1.6mm* and relatively permittivity *4.4*. For operating the first resonant frequency (about *2.18GHz*), we choose the rectangular slot loop antenna with the dimensions of $50.8mm \times 10.8mm$, and $S_1 = 1.8mm$. And, it is also found that the first and second resonant frequency of the proposed antenna are determined by the perimeter of the rectangular slot loop antenna, being about $1.05\lambda_{1g}$ and $1.84\lambda_{2g}$, respectively. Furthermore, for obtaining the third resonant frequency (about *5.77GHz*), the rectangular slot dipole antenna has dimensions $L_2 = 31.5mm$, $S_2 = 1mm$. It is also found that the third resonant frequency of the proposed antenna is controlled by the length of the rectangular slot dipole antenna, being about *0.73* λ_{3g}. It is also noted that λ_g is the wavelength in the slot, and is determined to be about *0.78* free-space wavelengths from [4] by considering the presence of different dielectric substrate on the two sides of the slot.

Figure 2 shows the measured return loss for the proposed print slot antenna. For comparison, the calculated (by IE3D^{TM} [5]) return loss is also expressed in Figure 2. From the results, the 10dB return-loss impedance bandwidths of the three resonant frequency are about *4.4%*(*2134~2231MHz*), *5.8%*(*3885~3664MHz*) and *10.3%*(*5746~5186MHz*), respectively. The antenna gains in the broadside direction are also measured for the proposed slot antenna, and *1.4dBi, 1.5dBi* and 5.5*dBi* gains are observed for the first, second and third resonant frequency, respectively. Figures 3, 4 and 5 show the measured E-plane and H-plane radiation pattern of the proposed antenna, respectively. All the three resonant frequencies have the same polarization planes, and broadside radiation patterns are also obtained. However, probably owing to the coupling effects of the rectangular slot loop and the rectangular dipole slot, the cross-polarization of the H-plane is very large at the second resonant frequency.

4. Conclusions

The simple triple-frequency hybrid coupled coplanar waveguide-fed printed slot antenna has been presented and experimentally studied. This antenna is constructed by the rectangular slot loop antenna and the rectangular slot antenna. The first two resonant frequencies are mainly controlled by the perimeter of the rectangular slot loop antenna, and the third resonant frequency is determined by the length of the rectangular slot dipole antenna. The three operating frequencies of the presented printed slot antenna are of same polarization planes and have similar radiation characteristics.

References

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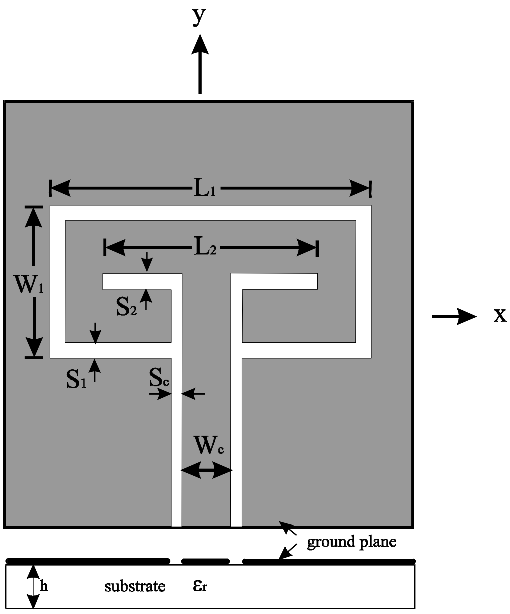

Fig.1 Geometry of the proposed triple-frequency printed slot antenna.

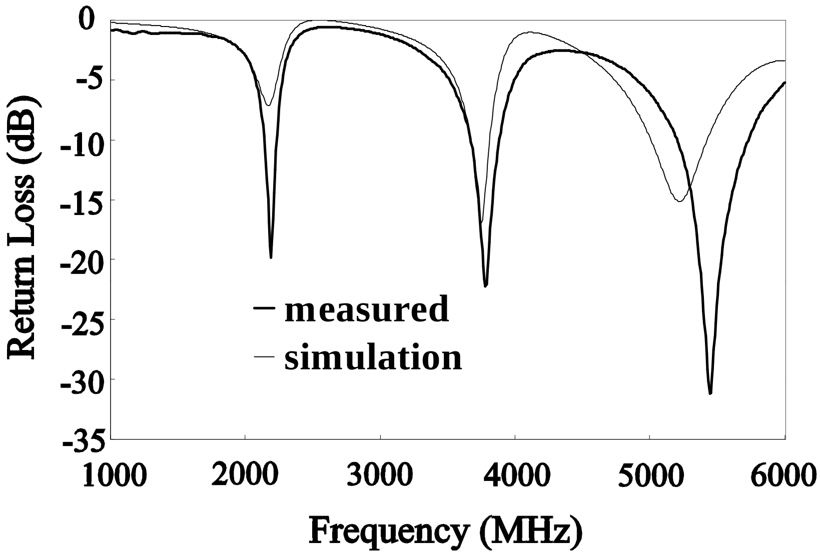

Fig. 2 Measured and calculated return loss against frequency for the proposed triple-frequency printed slot antenna; $h = 1.6mm$, $\varepsilon_r = 4.4$, $L_1 = 50.8mm$, $W_1 = 10.8mm$, $S_1 = 1.8mm$, $L_2 = 31.5mm$, $S_2 = 1mm$, $W_c = 6.4mm$, $S_c = 0.5mm$, ground-plane size = 70mm$\times$35 mm.

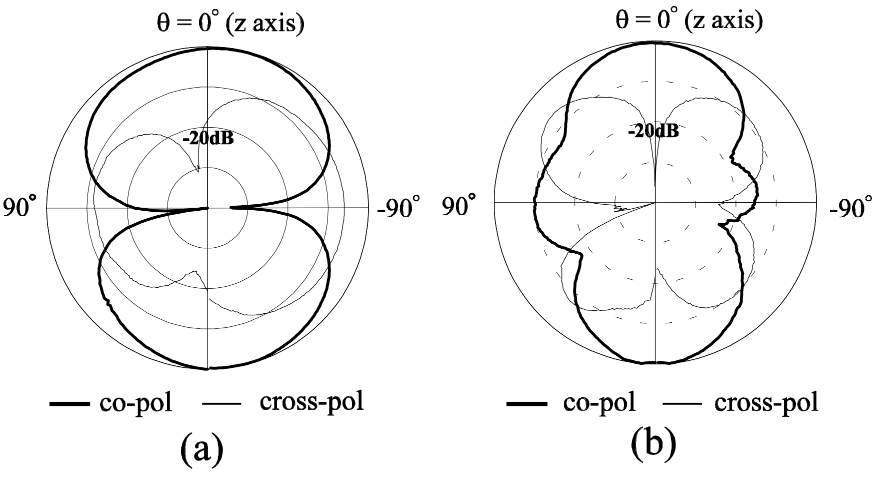

Fig. 3 Measured radiation patterns in two principal planes at *2180 MHz* for antenna studied in Fig. 2. (a) E-plane (y-z plane). (b) H-plane (x-z plane).

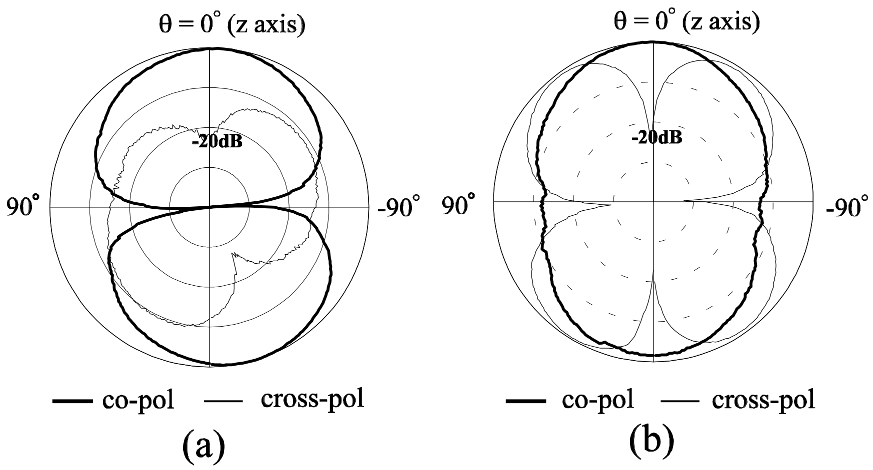

Fig. 4 Measured radiation patterns in two principal planes at *3770 MHz* for antenna studied in Fig. 2. (a) E-plane (y-z plane). (b) H-plane (x-z plane).

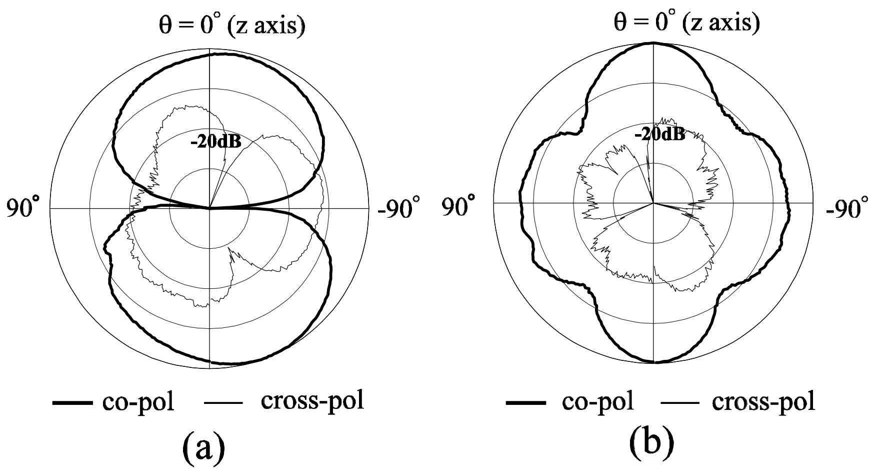

Fig. 5 Measured radiation patterns in two principal planes at *5440 MHz* for antenna studied in Fig. 2. (a) E-plane (y-z plane). (b) H-plane (x-z plane).