BANDWIDTH ENHANCEMENT OF A PRINTED WIDE SLOT ANTENNA FED BY A MICROSTRIPLINE WITH A FORK-LIKE TUNING STUB

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1. Introduction

Printed wide slot antennas have received much attention and have been used in radar and satellite communications applications due to their main advantage of wide bandwidth. Several studies on their characteristics have also been reported [1-4]. However, few efforts in further bandwidth enhancement of the printed wide slot antenna have been conducted. In this article, we propose a new design of printed wide slot antennas fed by a microstripline with a fork-like tuning stub (see Fig. 1). For such a design, a much wider impedance bandwidth (about 10 times) than that of a conventional microstripline-fed printed wide slot antenna can be obtained. Details of the proposed antenna design with the proposed feeding structure and obtained experimental results are presented and discussed.

2. Antenna design

The proposed antenna design is depicted in Fig. 1. The printed square slot has a side length of L and is printed on a microwave substrate. The printed slot is fed by a 50-Ω microstripline with a fork-like tuning stub, which is printed on the opposite side of the microwave substrate and placed symmetrically with respect to the centerline (y-axis) of the sqaure slot. The fork-like tuning stub consists of a straight section of length ℓ_2 and two branch sections of equal lengths ℓ_3, and the spacing between the centerlines of the two branch sections is ℓ_1. The widths of these sections are all the same and equal to that (w_f) of the 50-Ω microstripline. It is expected that with the proposed fork-like tuning stub, the coupling between the microstripline and the printed slot can be more effectively controlled [5], which is very helpful for improving the impedance characteristics. This behavior can lead to possible bandwidth enhancement of the printed wide slot antenna.

3. Results and discussion

Several design examples of the proposed design were constructed and studied. These design examples are all constructed on same microwave substrates of thickness 0.8 mm, relative permittivity 4.4, and size 110 mm × 110 mm. The side length of the square slot is 53.7 mm. Fig. 2 shows measured return loss of the typical design examples of antennas 1 and 2, whose parameters are: antenna 1: ℓ_1 = 10 mm, ℓ_2 = 2 mm, ℓ_3 = 20.6 mm; antenna 2: ℓ_1 = 15 mm, ℓ_2 = 2 mm, ℓ_3 = 15.9 mm. It is found that by tuning the spacing between the two branch sections and the length of the straight section of the fork-like tuning stub, the impedance locus can form a tight resonant loop around the center of the Smith chart. By further tuning the lengths of the two branch sections, the imaginary part of the input impedance can be compensated, which leads to good impedance matching over a very wide bandwidth. The results for a reference antenna constructed based on a corresponding conventional microstripline-fed printed slot antenna with a simple tuning stub (i.e., ℓ_1 = 0 in Fig. 1) are also shown for comparison. The parameters of the reference antenna are the same as those of antennas 1 and 2, except that the tuning stub length of the reference antenna is 28.0 mm in this study. From the results, it can be seen that the impedance bandwidth (determined by 1:1.5 VSWR) of antennas 1 and 2 reach 197 MHz and 1091 MHz, respectively, which are much greater than that (115 MHz) of the reference antenna. That is the obtained impedance bandwidth of the proposed design (antenna 2) can be nearly about 10 times that of the reference antenna. By comparing the results of antennas 1 and 2, it also suggests that there exists an optimal spacing between the two branch sections of the fork-like tuning stub. For antenna 2, the spacing selected is about one-third of the square slot's side length, which may be most effective in achieving more uniform field distribution in the square slot studied here.

Typical measured radiation patterns of the reference antenna, antenna 1, and antenna 2 are also plotted in Figs. 3 to 5, respectively. Results indicate that the frequencies within the wide impedance bandwidth of the proposed antennas have the same polarization planes and similar broadside radiation patterns. However, it should be noted that for the frequencies within the impedance bandwidth of antenna 2 larger than 2400 MHz, the radiation patterns are found to be tilted to a large angle, and the maximum antenna gain obtained is no longer in the broadside direction of the printed slot antenna. Also, the cross-polarization radiation, especially in the H-plane pattern, increases with increasing operating frequencies. In this case, in terms of the drop in on-axis gain less than 2 dB compared to that in the maximum radiation direction, the operating bandwidth of antenna 2 is still about 580 MHz (1821 to 2400 MHz), which is about 5 times that of the reference antenna. Antenna gains for frequencies within the operating bandwidth of antenna 2 are also measured, and the gain variations are observed to be less than 1.5 dBi, with a peak antenna gain of about 5.0 dBi.

4. Conclusions

A microstripline-fed printed wide slot antenna with a fork-like tuning stub for bandwidth enhancement has been demonstrated. Several design examples have been successfully implemented. Experimental results show that for the parameters studied here, the impedance bandwidth (1:1.5 VSWR) of the proposed antenna can reach nearly about 1.1 GHz, which is about 10 times that (115 MHz) of a corresponding conventional microstripline-fed printed wide slot antenna. More experimental results will be given in the presentation.

5. References

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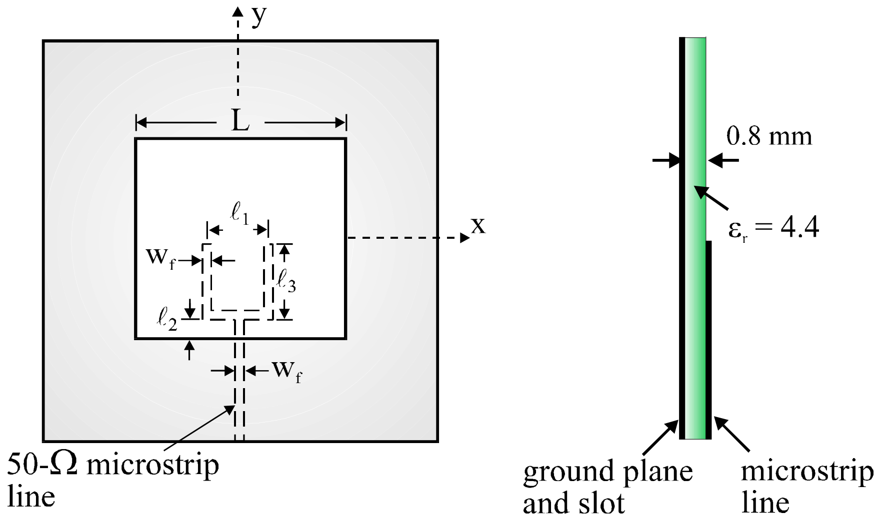


Fig. 1 Geometry of a printed wide slot antenna fed by a microstripline with a fork-like tuning stub.

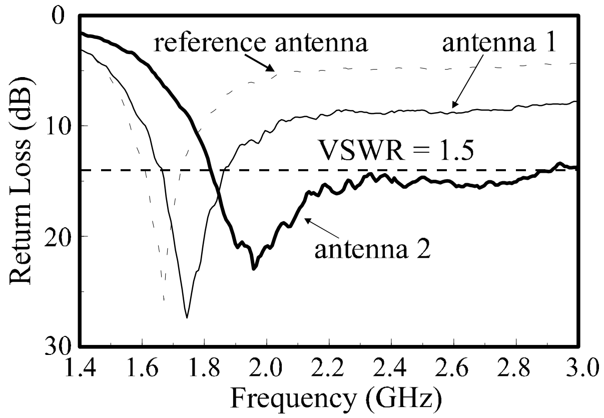


Fig. 2 Measured return loss against frequency for proposed antennas and reference antenna ($\ell_1 = 0$).

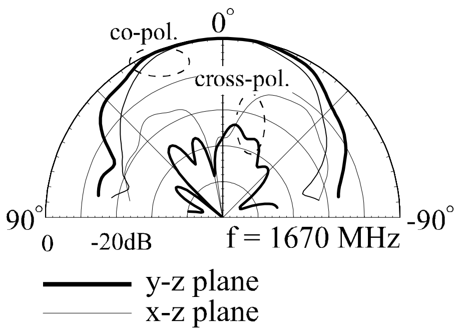
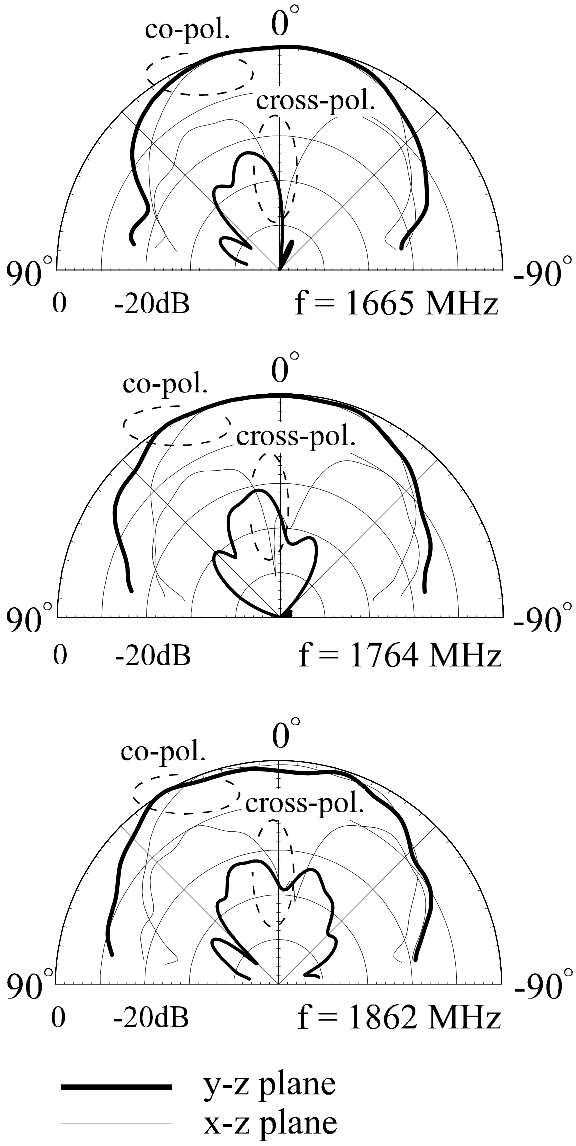


Fig. 3 Measured radiation patterns for the reference antenna.



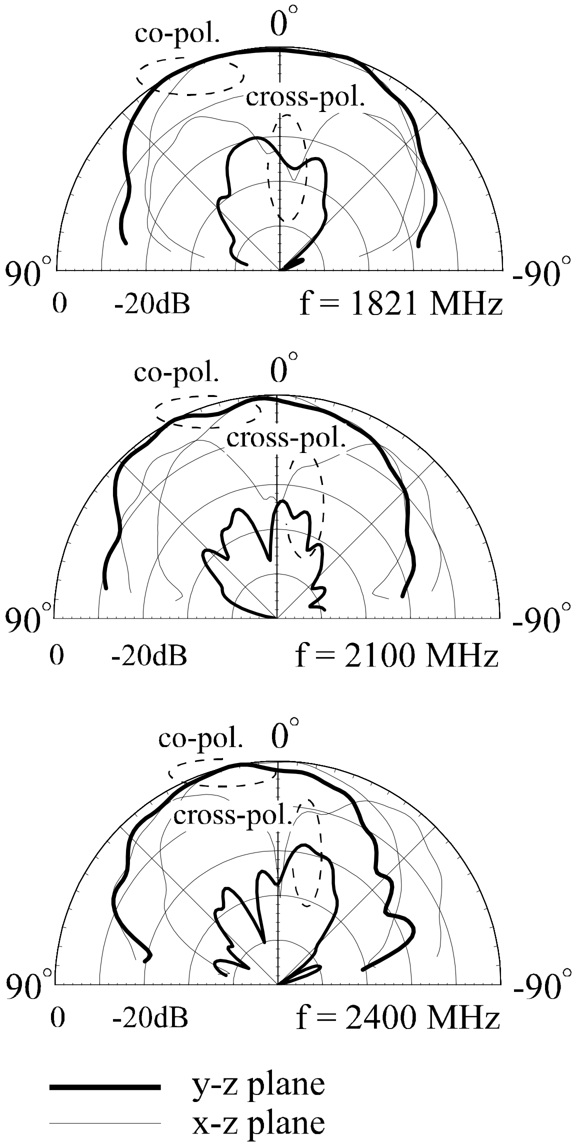


Fig. 4 Measured radiation patterns for antenna 1.

Fig. 5 Measured radiation patterns for antenna 2.