DUAL-FREQUENCY AND BROADBAND OPERATIONS OF A COPLANAR WACEGUIDE-FED PRINTED SLOT ANTENNA

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1. Introduction

Dual-frequency operation is an important subject in printed antenna designs. Many related dual-frequency printed patch antennas have also been reported [1-3]. However, mainly due to the inherent narrow bandwidth characteristic of printed patch antennas, the two operating frequencies in these designs are also narrow-banded. To achieve broadband dual-frequency operations, the use of a printed slot antenna is very attractive. This is because printed slot antennas usually have a wider bandwidth as compared to printed patch antennas, and it is very possible that both the two operating bandwidths of dual-frequency printed slot antennas can have wider bandwidths, leading to broadband dual-frequency operation. However, it is noted that very few dual-frequency printed slot antennas have been reported in the open literature. One typical design in this topic is achieved by adding a special network of resonant stubs to a CPW-fed printed slot antenna to obtain simultaneous impedance matching of two separate operating frequencies [4]. In this article we demonstrate a new structure of a CPW-fed printed slot antenna for achieving dual-frequency operation. Good impedance matching of the proposed antenna can be obtained without an extra matching network, leading to a much simpler antenna structure than the recent design reported in [4]. Also, the proposed antenna can perform a wider operating bandwidth, compared to a simple CPW-fed printed slot antenna. Details of the dual-frequency and broadband operations of the proposed CPW-fed printed slot antenna are presented and discussed.

2. Antenna design

Fig. 1 shows the structure of the proposed CPW-fed printed slot antenna. An open-ring conducting strip is loaded in the printed slot of dimensions L × W. In this case the proposed antenna can be treated as two coupled printed slot antennas: one rectangular slot loop antenna and one rectangular slot antenna with dimensions $L_s \times W_s$. Both the two slot antennas are fed by a capacitively coupled CPW feed, which has a tuning stub of length t connected to the signal strip of the CPW. A pair of small tuning stubs of length b in parallel to the CPW's tuning stub is also introduced and connected to the two open ends of the open-ring strip. Good impedance of the first two operating frequencies of the present antenna can be achieved by choosing proper length of b and t. In addition, the first resonant frequency is determined by the perimeter (2L+2W) of the rectangular slot loop antenna, and the second resonant frequency is mainly dependent on the length L_s of the rectangular slot antenna. Adjusting the width of the conducting strip loaded in the printed slot, the dimensions of the rectangular slot loop antenna and the rectangular slot antenna on the proposed antenna will be changed. The frequency ratio of the two frequencies can thus be varied. In addition, by properly choosing a smaller width of the open-ring strip than that used for achieving dual-frequency operation, a bandwidth-enhanced printed slot antenna can be achieved.

3. Experimental results and discussion

In the experimental study, the proposed printed slot antennas are all printed on same microwave substrates of thickness 1.6 mm and relative permittivity 4.4 with a ground plane of dimensions 88 mm × 75 mm. A 50-Ω CPW is used for feeding the antenna. Fig. 2 shows typical results of the measured return loss for two prototypes (antennas 1 to 2) of different parameters. For antenna 1, it can be seen that the first resonant frequency occurs at 1647 MHz and the second resonant frequency is at 2417 MHz. In this case, the frequency ratio is about 1.46. For antenna 2, the perimeter of the rectangular slot loop is the size of that of antenna 1, but with a different length of L and W, and the first and second resonant frequencies are at 1606 and 1771 MHz, respectively. It is seen that the frequency ratio of antenna 2 is about 1.1, smaller than that of antenna 1. The bandwidths of antennas 1 and 2 are all observed to be about 7% to 20%, which are much wider than those of the conventional dual-frequency printed patch antennas [1-3]. Fig. 3 shows the measured radiation patterns of antenna 1. Both of the two resonant frequencies are of the same polarization planes and similar broadside radiation patterns. The antenna gains of the two frequencies of antenna 1 and 2 are also measured. The two frequencies of antenna 1 have a peak antenna gain of 4.2 dBi and 3.6 dBi, respectively; those of antenna 2 are 4.4 dBi and 3.4 dBi, respectively.

Broadband operation of the proposed antenna can be obtained by selecting a proper width of the loaded open-ring strip. Fig. 4 shows the measured return loss against frequency for a typical design with broadband operation. In this case, the obtained impedance bandwidth of the antenna is 506 MHz or about 30%. Typical measured radiation patterns are also presented in Fig. 5. Good radiation patterns are obtained, and the gain variations for frequencies within the impedance bandwidth are observed to be within 1dB.

4. Conclusion

A new CPW-fed printed slot antenna loaded by an open-ring conducting strip for dual-frequency and broadband operations has been proposed and experimentally studied. The propoed antenna is composed of one rectangular slot loop antenna and one rectangular slot antenna. The perimeter of the rectangular slot loop antenna and the length of the rectangular slot antenna determine the first and second resonant frequencies of the proposed antenna, respectively. The frequency ratios, up to about 1.46, of the two frequencies can be obtained. Moreover, by properly adjusting the width of the loaded open-ring strip, bandwidth enhancement of the proposed antenna can also be obtained. More detailed results will be discussed in the presentation.

5. References

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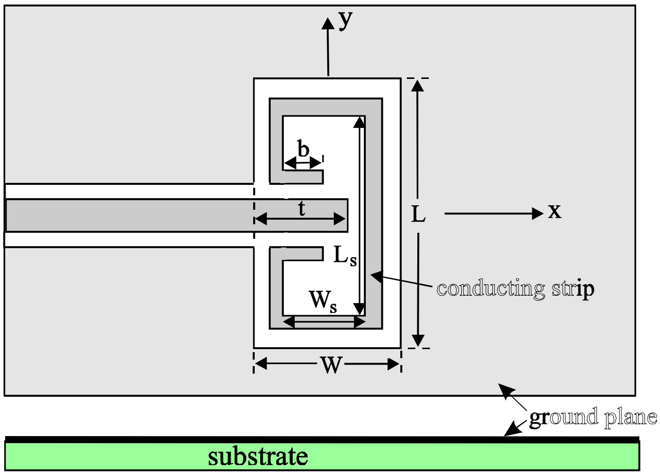

Fig. 1 Geometry of the proposed CPW-fed printed slot antenna.

printed slot antenna.

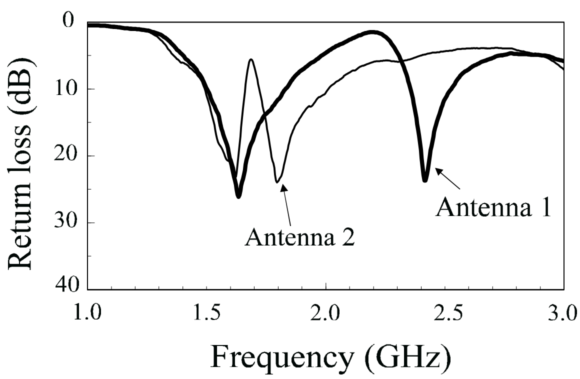

Fig. 2 Measured return loss for the proposed antenna. Antenna 1 parameters: L × W = 44.9×19.8 mm^2, $L_s \times W_s$ = 34.3×9.2 mm^2, t = 12.9 mm, b = 3.5 mm. Antenna 2 parameters: L × W = 49.9×14.8 mm^2, $L_s \times W_s$ = 41.7×6.6 mm^2, t = 10.5 mm, b = 6.2 mm.

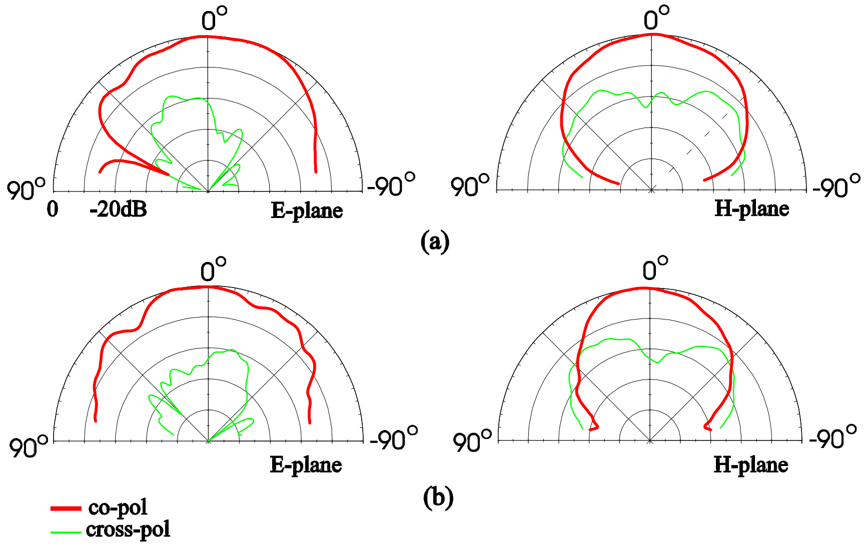

Fig. 3 Measured E-plane (x-z plane) and H-plane (y-z plane) radiation patterns for antenna 1 studied in Fig. 2. (a) f =1647 MHz. (b) f = 2417 MHz.

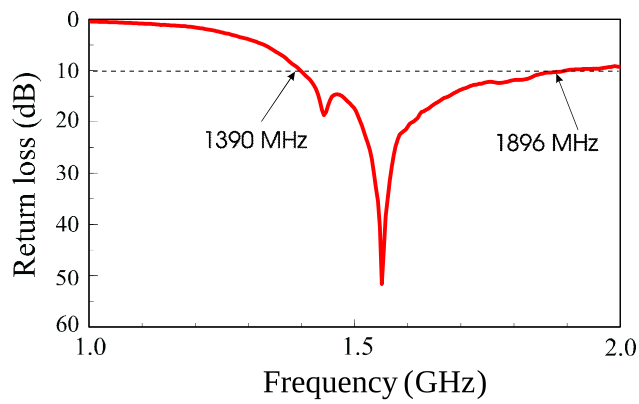

Fig. 4 Measured return loss against frequency for broadband operation.

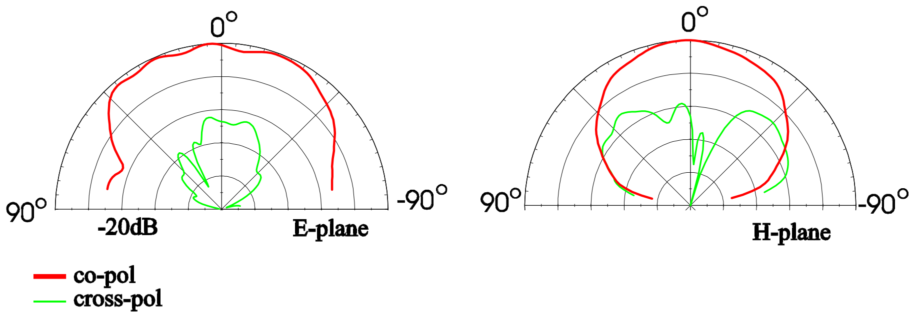

Fig. 5 Measured E-plane and H-plane radiation patterns for antenna studied in Fig. 4 with f = 1800 MHz.