A Broadband Patch Antenna with Wide Slits

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Introduction

Broadband patch antennas with a thick air or foam substrate have been of considerable interest owing to their simple structure, easy fabrication, and good radiation characteristics over a wide operating bandwidth. However, when such broadband patch antennas are to be excited using a probe feed, achievable bandwidth is usually limited to be less than 10%, due to the large inductance associated with the longer probe in the thick substrate layer. To overcome this problem, there are usually some compensations or modifications to be introduced in the feed arrangement [1-3] or some slot loadings [4-6] to be added to the radiating patch. In this article we demonstrate a new and simple broadband design of a patch antenna with a pair of wide slits. The wide slits are inserted at the boundary of a circular patch (see Fig. 1) or at one of the radiating edges of a rectangular patch (see Fig. 2). The proposed broadband patch antenna can have similar wide impedance bandwidth and good radiation characteristics as those reported for a U-slotted patch antenna [4-6]. Details of the antenna design and experimental results are presented and discussed.

Antenna Design

Fig. 1 shows the geometry of a broadband circular patch antenna with a pair of wide slits. The circular radiating patch is supported by a conducting post of length h on top of the grounded substrate (feed substrate). The length h, which can be considered to be the air-substrate's thickness, should be much greater than the feed-substrate's thickness t. The circular patch is excited by a conducting post-microstrip line feed, and the feed position is along the circular patch's centerline or resonant direction with a distance d_p away from the patch boundary. Two identical wide slits of width w_1 and length ℓ are cut in the circular patch and placed in parallel with and symmetrically to the patch's centerline. The spacing of the two slits is S. By adjusting the slits' dimensions, w_1 and ℓ, and their spacing S, good impedance matching over a wide operating bandwidth can be obtained. The proposed design can also be applied to a

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rectangular patch antenna with a probe feed, as shown in Fig. 2, and similar good broadband characteristics are also obtained.

Experimental Results and Conclusions

Design examples of the proposed antennas shown in Figs. 1 and 2 have been implemented. Figs. 3-5 shows the measured return loss, radiation patterns and antenna gain for the antenna shown in Fig. 1. The 10-dB return loss impedance bandwidth is found to be as large as 460 MHz or about 26% referenced to the center frequency at 1768 MHz. In this case the air substrate's thickness is about 7% of the free-space wavelength of the center frequency. From the measured radiation patterns, it is also observed that good broadside radiation characteristics are obtained, and the cross-polarization radiation in the E plane is seen to be less than –20 dB. However, relatively larger cross-polarization radiation is seen in the H plane. As for the measured antenna gain, results show that a peak antenna gain of about 8.3 dBi is obtained, with the gain variations less than 1.5 dBi for frequencies within the impedance bandwidth. The measured return loss for a rectangular patch antenna with a pair of wide slits is presented in Fig. 6. In this case the impedance bandwidth is found to be about 408 MHz or about 25% with respect to the center frequency at 1644 MHz. Good radiation characteristics for frequencies within the impedance bandwidth is also observed and are similar to those observed for the circular patch antenna design. More results will be given in the presention.

References

[1] N. Herscovici, "A wide-band single-layer patch antenna," *IEEE Trans. Antennas Propagat.*, vol. 46, pp. 471-473, 1998.

[2] K. M. Luk, C. H. Lai and K. F. Lee, "Wideband L-probe-feed patch antenna with dual-band operation for GSM/PCS base stations," *Electron. Lett.*, vol. 35, pp. 1123-1124, 1999.

[3] T. W. Chiou and K. L. Wong, "Single-layer wideband probe-fed circularly polarized microstrip antenna," *Microwave Opt. Technol. Lett.*, vol. 25, April 5, 2000. (in press)

[4] K. M. Luk, Y. W. Lee, K. F. Tong and K. F. Lee, "Experimental studies of circular patches with slots," *IEE Proc.-Microw. Antennas Propag.*, vol. 144, pp. 421-424, 1997.

[5] T. Huynh and K. F. Lee, "Single-layer single-patch wideband microstrip antenna," *Electron. Lett.*, vol. 31, pp. 1310-1312, 1995.

[6] K. L. Wong and W. H. Hsu, "Broadband triangular microstrip antenna with U-shaped slot," *Electron. Lett.*, vol. 33, pp. 2085-2087, 1997.

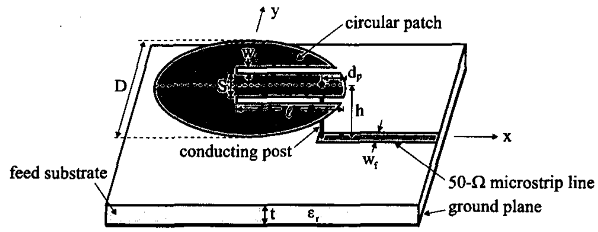

Fig. 1 Geometry of a broadband circular patch antenna with wide slits and a conducting post-microstrip line feed.

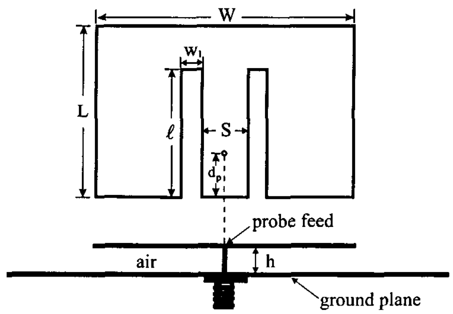

Fig. 2 Geometry of a broadband rectangular patch antenna with wide slits and a probe feed.

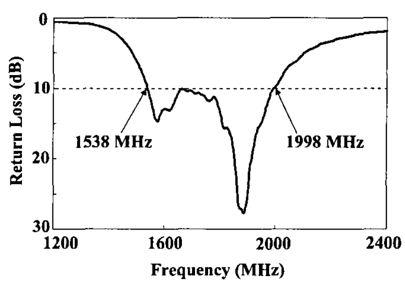

Fig. 3 Measured return loss against frequency for antenna shown in Fig. 1; $h = 12$ mm, $t = 0.8$ mm, $D = 76$ mm, $\ell = 47.8$ mm, $w_l = 5$ mm, $d_p = 16.8$ mm, ground-plane size = 150 mm × 150 mm.

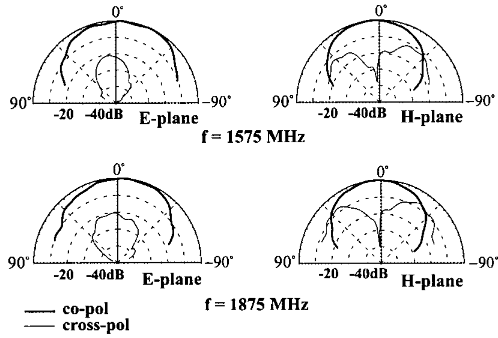

Fig. 4 Measured E-plane (x-z plane) and H-plane (y-z plane) radiation patterns; antenna parameters are given in Fig. 3.

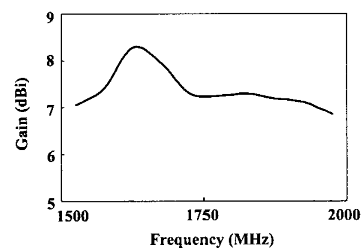

Fig. 5 Measured antenna gain in the broadside direction; antenna parameters are given in Fig. 3.

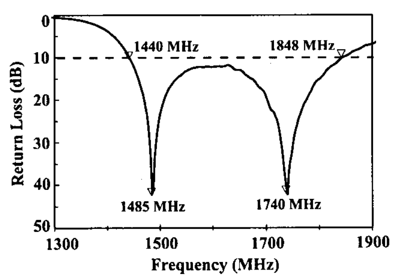

Fig. 6 Measured return loss against frequency for antenna shown in Fig. 2; $h = 14.3$ mm, $W = 105$ mm, $\ell = 47$ mm, $w_1 = 6.3$ mm, $S = 15.3$ mm, $d_p = 10$ mm, ground-plane size = 150 mm × 150 mm.