FDTD ANALYSIS OF A SYMMETRIC T-STRIP FED WIDEBAND RECTANGULAR MICROSTRIP ANTENNA

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ABSTRACT: *A theoretical analysis of a symmetric T-shaped microstrip-fed rectangular microstrip antenna using the finite-difference time-domain (FDTD) method is presented in this paper. The resonant frequency, return loss, impedance bandwidth, and radiation patterns are predicted and are in good agreement with the measured results.* Microwave Opt Technol Lett 43: 332–334, 2004; DOI 10.1002/mop.20461

Key words: *microstrip antennas; bandwidth enhancement; T-strip feed; FDTD; electromagnetic coupling*

1. INTRODUCTION

Microstrip antennas are attractive due to their low cost, conformability, and ease of fabrication. However, the primary barrier to implementing these antennas in many applications are their limited

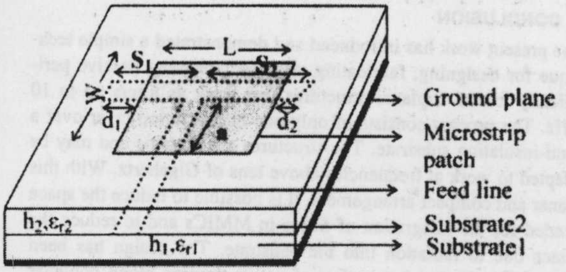

Figure 1 Geometry of the rectangular microstrip antenna with symmetric T-shaped feed

bandwidth. Several techniques have been proposed in the literature for widening the bandwidth. These include impedance matching [1, 2], use of thick substrates [3], and multiple resonators [4]. In all these cases, the bandwidth is found to be less than 10%. T-probe feeding has been applied to enhance the bandwidth up to 40%, but it increases the antenna size and volume [5]. Recently, a novel approach of exciting a patch antenna using symmetric T-shaped microstrip feed has been reported [6]. This feeding technique gives a 2:1 VSWR bandwidth of 23% and the structure is less complex.

This paper presents the theoretical investigations on the symmetric T-strip fed rectangular microstrip patch antenna. The finite-difference time-domain (FDTD) method is employed to analyze the antenna. The reflection and radiation characteristics of the antenna are studied.

2. ANTENNA GEOMETRY

The antenna is comprised of a rectangular microstrip patch of dimensions $L \times W$ fabricated on substrate of dielectric constant ε_{r2} and thickness h_2. The antenna is electromagnetically coupled with a 50Ω symmetric T-shaped feed line etched on another substrate of dielectric constant ε_{r1} and thickness h_1. The geometry of the antenna is shown in Figure 1.

3. THEORETICAL INVESTIGATIONS

The present antenna configuration is investigated using the FDTD method. A Gaussian pulse of half-width $T = 15$ ps and time delay $t_0 = 3T$ is applied at the source plane to ensure that its frequency contents covers the maximum frequency range of interest. The cell size is chosen so that an integral number of cells fit within the patch and the feed line substrate ($\Delta x = 1$ mm, $\Delta y = 1$ mm, and $\Delta z = 0.4$ mm). The time step $\Delta t = 1.159$ ps is used to satisfy the Courant Stability condition [7]. To reduce the number of time steps required for convergence an external source resistance of 50Ω is used [8].

The far-field pattern is calculated by using a sinusoid at a particular frequency as the source pulse and then the entire calculation is repeated. The sinusoid is allowed to reach steady state. The tangential E-fields are sampled from a planar area just above the patch surface. The far-field patterns corresponding to that frequency are calculated by taking the Fourier transform of the aperture fields sampled over a time of one period.

4. RESULTS AND DISCUSSION

At the experimentally optimized feed position, the return loss and radiation patterns are calculated numerically. Figure 2 shows the variation of the return loss with frequency of the antenna at the optimum position. A VSWR bandwidth of 23.23% in the operating band from 3.086 to 3.842 GHz is observed experimentally, while the calculation gives a bandwidth of 18.8% from 3.0544 to 3.6732 GHz. The variation of impedance bandwidth for different feed segment lengths S_1 and S_2 is also studied. The theoretical and experimental variations of impedance bandwidth for different feed segment lengths are plotted, as shown in Figure 3. The numerical results are verified with the experimental ones. The difference between the calculated and measured resonant frequency is 1.14%. The discrepancies may be due to the truncation effect of ground plane used in the calculation.

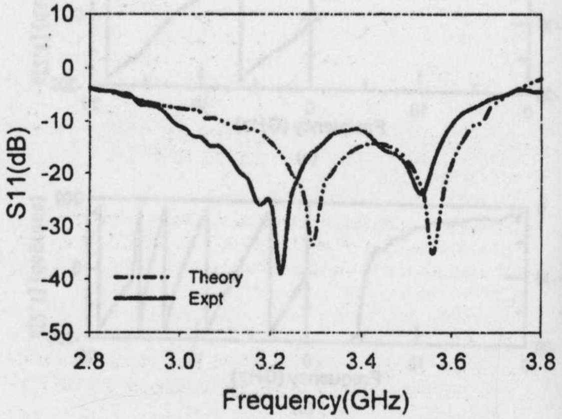

Figure 2 Variation of return loss with frequency ($\varepsilon_{r1} = \varepsilon_{r2} = 4.28$, $h_1 = h_2 = 0.16$ cm, $L \times W = 4 \times 2$ cm^2, $S_1 = S_2 = 3$ cm, $d_1 = 1.2$ cm, $d_2 = 1$ cm, $a = 0.9$ cm)

The E- and H-plane radiation patterns of the antenna are calculated and compared with the measured radiation patterns. Figure 4 shows the E- and H-plane radiation patterns of the antenna at the resonant frequency. The 3-dB beam width of the antenna in the E-plane and H-plane are 110°, 68°, and 113°, 80° according to the experiment and theory, respectively. The cross-polarization level is found to be better than −35 dB in the principal planes according to both theory and experiment. All the above radiation characteristics are highly suitable for large bandwidth applications.

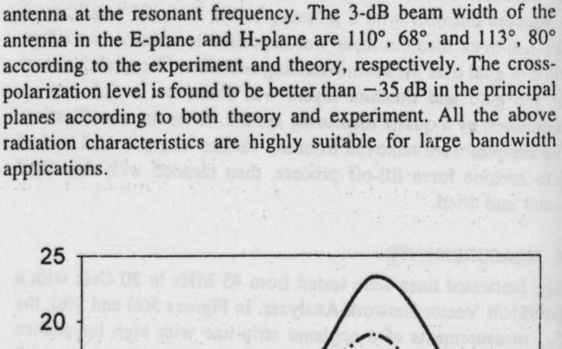

Figure 3 Variation of % bandwidth with feed segment length S_2 ($\varepsilon_{r1} = \varepsilon_{r2} = 4.28$, $h_1 = h_2 = 0.16$ cm)

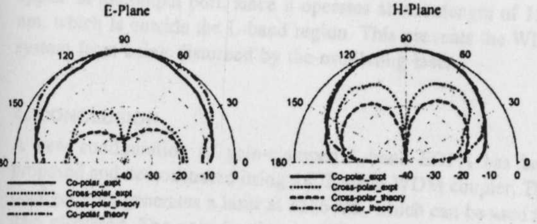

Figure 4 Radiation patterns of the antenna at resonant frequency ($\varepsilon_{r1} = \varepsilon_{r2} = 4.28$, $h_1 = h_2 = 0.16$ cm, $L \times W = 4 \times 2$ cm^2, $S_1 = S_2 = 3$ cm, $d_1 = 1.2$ cm, $d_2 = 1$ cm, $a = 0.9$ cm)

4. CONCLUSION

A time-domain analysis of a T-strip-fed rectangular microstrip patch has been performed. Good agreement between the theoretical and experimental results has been obtained. The proposed antenna is compact with reduced feeding complexity for bandwidth enhancement, and may find applications in wireless communication and Bluetooth technology.

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