ANALYSIS AND DESIGN OF A DUAL-PORT COMPACT MICROSTRIP ANTENNA

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ABSTRACT: *A dual-port dual-polarized compact microstrip antenna for avoiding cross coupling between the two frequency bands is proposed and analyzed. This antenna offers channel isolation better than 25 dB, and is more compact compared to a conventional rectangular patch. Analytical equations for calculating the resonant frequencies at both ports are also presented. The theoretical calculations are verified using experimental results.* © 2002 John Wiley & Sons, Inc. Microwave Opt Technol Lett 32: 125–127, 2002.

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1. INTRODUCTION

Radar and advanced communication applications require low-profile antennas capable of dual-frequency dual-polarization operation and good isolation between the ports. Microstrip antennas of different geometries for dual polarization are available in the literature [1–3]. The severe problem with a dual-polarized satellite link is the cross coupling of cochannels, producing interference and crosstalk. These effects can be avoided using dual-port antennas, which provide excellent isolation between the ports. In this letter, we propose a compact dual-port microstrip antenna with an area reduction of ~ 65% compared to a rectangular microstrip antenna, and an isolation better than 25 dB between its ports. Analytical equations for calculating the resonant frequencies at both ports are derived.

2. ANTENNA DESIGN

The schematic diagram of the antenna is shown in Figure 1. The structure consists of an arrow-shaped patch with an intruding triangle of height W_{cd} and a protruding triangle of height W_{cp} with slanted lengths S_1 and S_2 etched on a dielectric substrate of thickness h_2 and dielectric const ${}_2$ fed by proximity coupling using two 50 Ω perpendicular microstrip lines etched on a substrate of thickness h_1 and dielectric constant ϵ_{r1}.

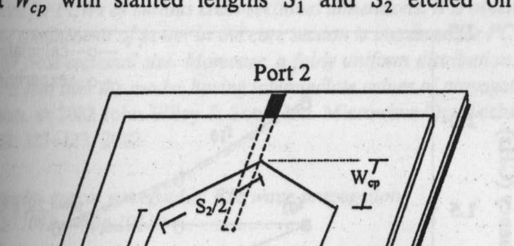

Figure 1 Geometry of the proposed dual-port microstrip antenna

A typical antenna structure of length $L = 0.04$ m, width $W = 0.06$ m, $W_{cd} = 0.01$ m, and $W_{cp} = 0.01$ m is etched on a substrate of thickness $h_1 = 0.0016$ m and $\varepsilon_{r1} = 4.28$. Two 50 Ω microstrip feedlines are fabricated on a similar substrate kept below the patch to provide electromagnetic coupling.

3. RESONANT FREQUENCY CALCULATION

The standard equations for computing the resonant frequency of a rectangular patch antenna are modified to take into account the effect of the intruding and protruding lengths W_{cd} and W_{cp}. The line extension factor and the effective resonating lengths of the two modes are obtained by the following empirical relations. Here, h used in the equations is the effective thickness $h = h_{\text{eff}}$ ($h_{\text{eff}} = h1 + h2$) and the dielectric constant $\varepsilon_r = \varepsilon_{r1} = \varepsilon_{r2}$.

For Port 2,

$$f_{10} = \frac{c}{2(S_{\text{eff}} + 2\Delta l_1)\sqrt{\varepsilon_1}} \tag{1}$$

$$\varepsilon_1 = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}(1 + 12h/W)^{-1/2} \tag{2}$$

$$\Delta l_1 = \frac{0.412h(\varepsilon_1 + 0.3)(W/h + 0.258)}{(\varepsilon_1 - 0.258)(W/h + 0.8)} \tag{3}$$

For Port 1,

$$f_{01} = \frac{c}{2(W_{\text{eff}} + 2\Delta l_2)\sqrt{\varepsilon_2}}$$

where ε_2 and Δl_2 are calculated by replacing W by S in Eqs. (2) and (3), respectively, with $S = (S_1 + S_2)/2$

S_{eff} and W_{eff} are calculated as follows.

For ($L < W$),

$$\left.\begin{aligned} S_{\text{eff}} &= S_1 - (0.0001/L) + 0.01W \\ &\quad -0.68(W_{cd} - 0.01) - 0.03(W_{cp} - 0.01) \\ W_{\text{eff}} &= W + 0.58W_{cp} - 0.43W_{cd} \end{aligned}\right\} \quad \text{for } W_{cd}/W \le 0.5$$

$$\left.\begin{aligned} S_{\text{eff}} &= 0.5(S_1 + L) + 0.4W_{cd} - 0.175W - 0.03(W_{cp} - 0.01) \\ W_{\text{eff}} &= 0.78W + 0.025W_{cd} + 0.49W_{cp} \end{aligned}\right\} \quad \text{for } W_{cd}/W > 0.5.$$

For ($L \ge W$),

$$S_{\text{eff}} = S_1 + 2.3(L - 2W - 0.0046/L)W_{cd} + 0.00006/L - 0.1(W_{cp} - 0.01), \quad \text{for } W_{cd}/W < 1$$

$$W_{\text{eff}} = W + 0.58W_{cp} - 0.43W_{cd} + 0.0023(L - W)/W, \quad \text{for } W_{cd}/W \le 0.5$$

$$W_{\text{eff}} = 0.78W + 0.025W_{cd} + 0.49W_{cp} + 0.0025W_{cd}/W + 0.17(L - W - 0.01), \quad \text{for } W_{cd}/W > 0.5.$$

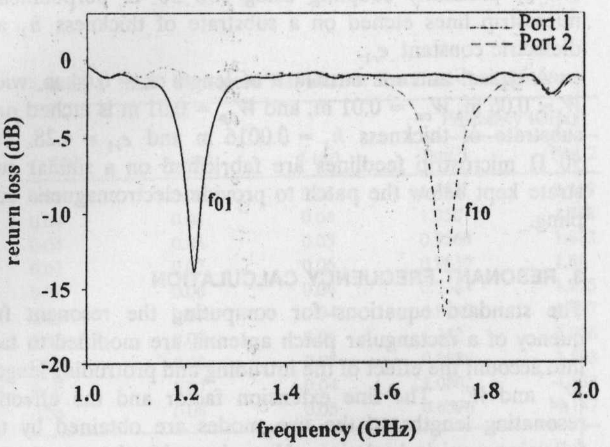

Figure 2 Measured return loss against frequency for two ports

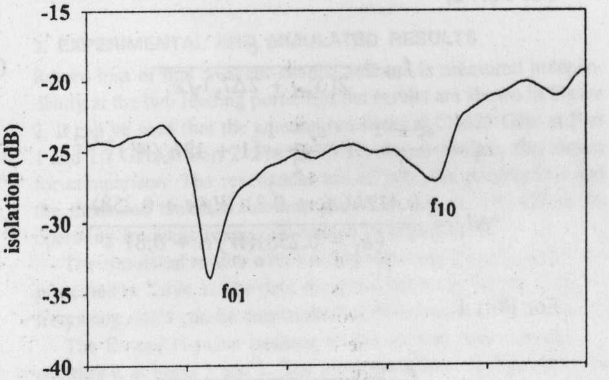

Figure 3 Measured isolation between ports 1 and 2

4. EXPERIMENTAL AND THEORETICAL RESULTS

The measured return loss against frequency for the two ports are shown in Figure 2. Figure 3 shows the isolation between the two ports, and Figure 4 shows their transmission characteristics. From these figures, it is clear that the isolation between the ports is better than 25 dB, which implies very small cross coupling. The *E*-plane and *H*-plane patterns for the frequencies 1.2175 and 1.7175 GHz are shown in Figure 5. The cross-polar performance for both frequencies is found to be better than 20 dB.

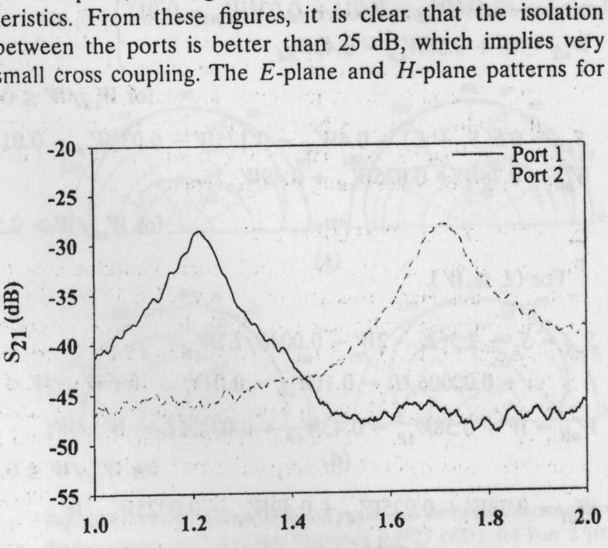

Figure 4 Measured transmission characteristics against frequency at two ports

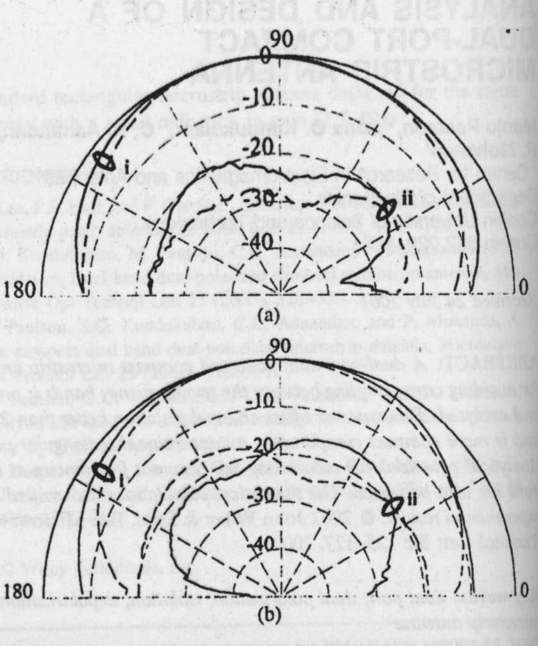

Figure 5 *E*-plane and *H*-plane radiation patterns. (a) Port 1 frequency (f_{01} = 1.2175 GHz). (b) Port 2 frequency (f_{10} = 1.7175 GHz). i) Copolarization. ii) Cross polarization. —— *E*-plane, - - - - *H*-plane

The theoretical variation of the two resonant frequencies at port 1 (f_{01}) and port 2 (f_{10}) with L for different heights h and permittivities ε_r are shown in Figure 6. The experimental curves are also given in the same figure to validate the computation. In all of these cases, the theoretical results are in good agreement with experimental values, with a maximum error of less than 2%.

5. CONCLUSION

A compact dual-port antenna for avoiding channel cross coupling in satellite communication is presented. The proposed antenna offers a greater size reduction compared to a standard rectangular patch and improved performance characteristics compared to the other compact patches. Analytical

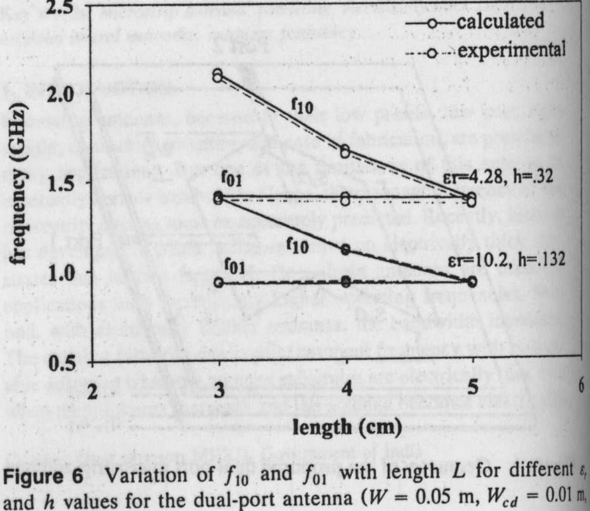

Figure 6 Variation of f_{10} and f_{01} with length L for different ε_r and h values for the dual-port antenna (W = 0.05 m, W_{cd} = 0.01 m, W_{cp} = 0.01 m)

equations developed here will be helpful in designing an antenna with different frequency ratios for different applications.

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