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 constant \( \varepsilon_r \). 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 \( \varepsilon_r = 4.28 \). 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 \( h = h_1 + h_2 \) and the dielectric constant \( \varepsilon_r = \varepsilon_r \).

For Port 1,

\[
\begin{align*}
S_{eff} & = S_1 - \left( \frac{0.0001}{L} \right) + 0.01W - 0.68(W_{cd} - 0.01) - 0.03(W_{cp} - 0.01) \\
W_{eff} & = W + 0.58W_{cp} - 0.43W_{cd} \\
\text{for } W_{cd}/W & \leq 0.5 \\
S_{eff} & = 0.5(S_1 + L) + 0.4W_{cd} - 0.175W - 0.03(W_{cp} - 0.01) \\
W_{eff} & = 0.78W + 0.025W_{cd} + 0.49W_{cp} \\
\text{for } W_{cd}/W & > 0.5.
\end{align*}
\]

For Port 2,

\[
\begin{align*}
S_{eff} & = S_1 + 2.3(L - 2W - 0.0046/L)W_{cd} + 0.00006/L - 0.1(W_{cp} - 0.01), \\
W_{eff} & = W + 0.58W_{cp} - 0.43W_{cd} + 0.0023(L - W)/W, \\
\text{for } W_{cd}/W & < 1 \\
W_{eff} & = 0.78W + 0.025W_{cd} + 0.49W_{cp} + 0.0025W_{cd}/W \\
& + 0.17(L - W - 0.01), \\
\text{for } W_{cd}/W & > 0.5.
\end{align*}
\]
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.

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

REFERENCES


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