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Resonance Frequencies of Compact Microstrip Antenna — Source link

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Resonance frequencies of compact microstrip antenna

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A simple technique for calculating the resonance frequencies of a compact arrow-shaped microstrip antenna is presented and discussed. The accuracy of the method is validated by experimental results.

Introduction: The arrow shaped microstrip antenna, which produces dual frequency dual polarisation operation with considerable size reduction compared to conventional patches has been reported [1]. These antennas provide greater area reduction and improved gain compared to drum shaped patches [2]. Prediction of the resonance frequency of drum shaped patches [3] and circular patches for broadband operation [4] are available in the literature. In this Letter, we propose empirical formulas for calculating the resonance frequencies of the arrow shaped microstrip antenna. These antennas can be employed for obtaining dual frequency with the same polarisation, bandwidth enhancement, circular polarisation etc. by varying its different parameters or by introducing slots. The proposed design equations provide an easier and simple way of predicting the resonant frequencies of these patches.

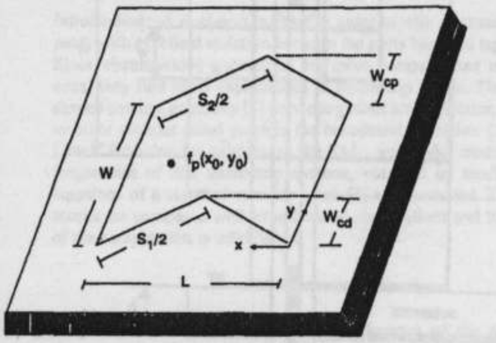

Fig. 1 *Geometry of arrow shaped microstrip antenna*

Frequency calculation: The schematic diagram of the antenna is shown in Fig. 1. The structure consists of an arrow shaped patch with an intruding triangle of height W_{cd} and protruding triangle of height W_{cp} with slanted lengths S_1 and S_2 etched on a dielectric substrate of thickness h and dielectric constant ε_r.

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: for the TM_{10} mode

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

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

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

for the TM_{01} mode

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

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

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

For $(L < W)$

$$\left.\begin{aligned} S_{eff} &= S_1 - (0.001/L) + 0.01W \\ &\quad - 0.68(W_{cd} - 0.01) - 0.03(W_{cp} - 0.01) \\ W_{eff} &= W + 0.58W_{cp} - 0.43W_{cd} \end{aligned}\right\} \text{ for } W_{cd}/W \le 0.5$$

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

For $(L >= W)$

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

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

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

Comparison of theory and experiment: The theoretical variation of the two resonant frequencies f_{10} and f_{01} with L for different values of W_{cd} and W_{cp} are given in Fig. 2. The experimental curves are also given to validate the computation. To further check the validity, the antennas were fabricated on substrates with different dielectric constants and thickness. The results are shown in Fig. 3. In all these cases the theoretical results are in good agreement with experimental values with maximum error < 2%.

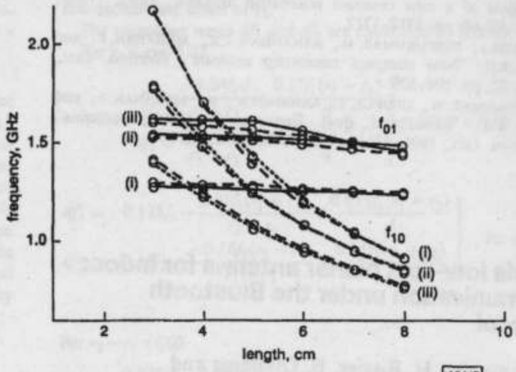

Fig. 2 *Variation of TM_{10} and TM_{01} mode frequencies with length L for different W_{cp} and W_{cd} (W = 5 cm)*

—O— calculated
- -O- - measured
(i) $W_{cd} = 1$, $W_{cp} = 2$
(ii) $W_{cd} = 2$, $W_{cp} = 1$
(iii) $W_{cd} = 3$, $W_{cp} = 1$

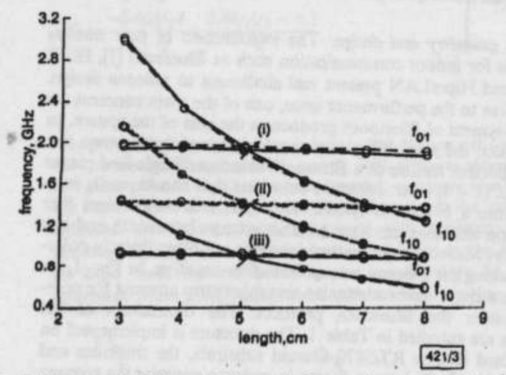

Fig. 3 *Variation of TM_{10} and TM_{01} mode frequencies with length L for different ε_r and h values*

—O— calculated
- -O- - measured
(i) $\varepsilon_r = 2.2$, $h = 0.08$
(ii) $\varepsilon_r = 4.28$, $h = 0.16$
(iii) $\varepsilon_r = 10.2$, $h = 0.066$

Conclusion: A simple and accurate technique to determine the resonance frequencies of the dominant modes of a compact arrow shaped patch antenna is presented. The method is validated by experimental results and the percentage error is found to be < 2%. This method of frequency prediction is less time consuming than the expensive simulation software.

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