Broadband dual frequency microstrip antenna

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A new dual port microstrip antenna geometry for dual frequency operation is presented. The structure consists of the intersection of two circles of the same radius with their centres displaced by a small fraction of the wavelength. This antenna provides wide impedance bandwidth and excellent isolation between its ports. The gain of the antenna is comparable to that of a standard circular microstrip antenna operating at the same resonant frequency. A theoretical analysis for calculating the resonant frequencies of the two ports is also presented.

Introduction: Microstrip antennas have many advantages, such as low profile, light weight, conformal nature etc., over conventional radiating elements, and have attracted much attention in the past few years. Commonly used microstrip radiators are circular or rectangular patches. Radar and advanced communication applications, such as synthetic aperture radar (SAR), the global positioning system (GPS), and vehicular communication, require low profile antennas capable of dual frequency dual polarisation operation with sufficiently large bandwidth and good isolation between the ports. In the literature only a limited number of methods which are capable of dual frequency operation and have dual polarisation [1, 2] at the ports, are available. Most of these techniques provide a small impedance bandwidth that limits their fields of application.

This Letter proposes a new microstrip antenna geometry that provides two independent ports with orthogonal polarisation and gain comparable to that of a standard circular patch antenna. Corresponding to its two ports, the new structure resonates at two frequencies with large impedance bandwidths. Energy is coupled electromagnetically to these ports using two perpendicular microstrip feed lines. The new antenna offers excellent isolation between its ports which is essential in avoiding crosstalk. A formula for calculating the resonant frequencies of the two ports is also proposed.

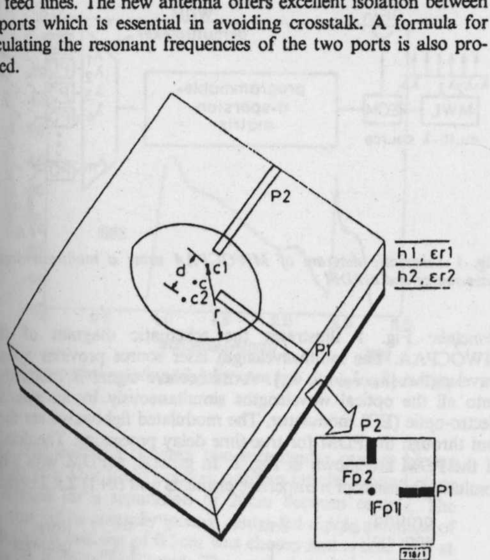

Fig. 1 *Geometry of proposed microstrip antenna with feeding technique*

Design and experimental details: The antenna geometry is defined by the intersection of two circles of the same radius r with centres $c1$ and $c2$ displaced by a small distance d and fed by proximity coupling using two 50Ω perpendicular microstrip lines as shown in Fig. 1.

The test antenna is fabricated on a substrate (RT/Duroid) with dielectric constant $\varepsilon_1 = 2.21$ and thickness $h_1 = 0.08$cm. The intersection of two circular patches of radius $r = 2$cm each with their centres displaced by a distance $d = 0.4*r$cm (optimised experimentally for maximum bandwidth and good isolation) is etched on the above substrate and fed as shown in Fig. 1. The microstrip feed lines are fabricated on a substrate of dielectric constant $\varepsilon_{r2} = 4.5$ and thickness $h_2 = 0.16$cm. The optimised feed locations are F_{P1} – 0.6cm and F_{P2} = 0.5cm.

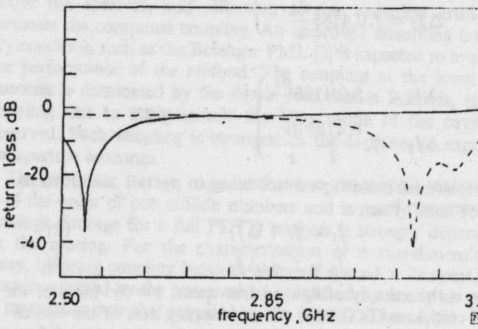

Fig. 2 *Variation of return loss with frequency*

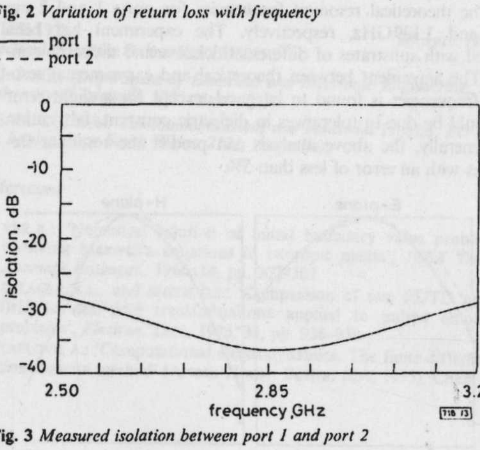

Fig. 3 *Measured isolation between port 1 and port 2*

Results: The antenna resonates at two frequencies, 2.635 and 3.05GHz for ports 1 and 2, respectively. The variation in return loss with frequency is given in Fig. 2. The 2:1 VSWR bandwidths corresponding to ports 1 and 2 are 3 and 5.3%, respectively. These values are somewhat higher than the bandwidth of a conventional circular microstrip patch antenna [3]. The frequency separation between the resonances is found to increase with *d*. The radiation from the antenna is linearly polarised and the polarisations of the two ports are orthogonal to each other. Fig. 3 clearly shows that the antenna offers an isolation better than 30dB between the ports in the operating frequency range (2.595 – 3.13GHz). The E and H-plane radiation patterns for ports 1 and 2 are shown in Fig. 4. The 3dB beam widths along the E-plane are 96.3 and 101.6° for ports 1 and 2, respectively. The corresponding beam widths along the H-plane are 65.9 and 94.5°. The cross-polar levels are found to be better than 25dB for these ports. The gain of the new antenna is found to be nearly equal (with a difference of < 0.5dB) to that of a corresponding standard circular microstrip patch operating at the same frequencies.

Theoretical analysis: The two resonant frequencies of the present antenna configuration can be calculated using the following procedure, as given in [4].

The TM_{11} mode resonant frequency of a circular microstrip patch antenna of radius r fabricated on a substrate of dielectric constant ε_r and thickness h is given as

$$f_r = \frac{1.841c}{2\pi r_e\sqrt{\varepsilon_r}} \quad (1)$$

where r_e is

$$r_e = r\left[1 + \frac{2h}{\pi r \varepsilon_r}\left(\ln\frac{\pi r}{2h} + 1.7726\right)\right]^{\frac{1}{2}}$$

Now the two frequency offset values are suitably modified as

$$\left.\begin{aligned}\Delta f_1 &= -f_r\frac{0.4185}{2}\frac{ds}{s}\\ \Delta f_2 &= f_r 0.4185\frac{ds}{s}\end{aligned}\right\}\quad \text{for } \varepsilon_r < 4.5$$

and

$$\left.\begin{aligned}\Delta f_1 &= -f_r 0.4185\frac{ds}{s}\\ \Delta f_2 &= f_r\frac{0.4185}{2}\frac{ds}{s}\end{aligned}\right\}\quad \text{for } \varepsilon_r \geq 4.5$$

The resonant frequencies corresponding to ports 1 and 2, respectively, are given by

$$f_1 = f_r + \Delta f_1 \qquad (2)$$

$$f_2 = f_r + \Delta f_2 \qquad (3)$$

where c is the velocity of light in free space, $s = \pi r^2$ (area of the original circle) and $(s - \Delta s)$ is the overlapping area of the two circles. The theoretical resonant frequencies for ports 1 and 2 are 2.609 and 3.129GHz, respectively. The experiment has been repeated with substrates of different thickness and dielectric constant. The agreement between theoretical and experimental resonance frequencies is found to be good, except for a slight error that could be due to tolerances in dielectric constant, fabrication etc. Generally, the above analysis can predict the resonant frequencies with an error of less than 5%.

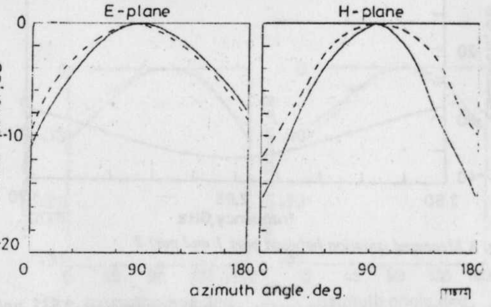

Fig. 4 *E-plane and H-plane radiation patterns of the antenna at the centre frequencies of the two ports*

——— port 1
- - - - port 2

Conclusion: A novel dual port broad-band microstrip antenna resonating at two frequencies and providing orthogonal polarisations with very good isolation between the two ports is reported. The gain of the antenna is comparable to that of a standard circular patch microstrip antenna. This antenna may find application in systems where dual frequency operation with large bandwidth is required.

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