PARAMETRIC STUDY OF A RING-PATCH

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INTRODUCTION

The structure of the ring-patch has been introduced recently for L-band aeronautical satellite communications (1) (2). It was associated with a classical circular patch. The two antennas were independenly fed in order to achieve a diplexing radiating element. Low mutual coupling was measured, because of the great difference of the size of the two antennas.

Cavity modelization was used to calculate the resonant frequencies of the different modes (3) (4). Theoretical and experimental results about the input impedance for the TM_{11} mode were presented in (4). But no radiation pattern was given for that mode.

In this paper, an experimental parametric study of a ring-patch is exposed and discussed. It shows the effect of the ring ratio on the radiation characteristics of the TM_{11} mode. The following parameters were measured versus the ring ratio : main plane patterns, cross polarization level in H - plane, quality factor and isolation between two probes feeding the ring patch.

THE BREADBOARDS

All the breadboards were milled in a brass material. The circular disk and the shielding ring are all in one block. The height of the ring patch is constant and equal to 6 mm. All the breadboards were designed to resonate around 2 GHz for the fundamental TM_{11}, mode. The ring ratio (inner diameter to the outer diameter - b/a) takes the values of 0, 0.15, 0.2, 0.3, 0.4, 0.5. The disk thickness is 1 mm in order to achieve a good flatness accuracy.

All the breadboards are fed by only one coaxial probe of a fifty ohms characteristic impedance, except specific cases.

RADIATION PATTERNS

The figures 1 and 2 depict the variation of the radiation patterns in the E- and H-planes. A ring ratio of 0 corresponds to a circular disk. It can be observed that the E plane beam width decreases rapidly compared to the H-plane beam width, when the shielding ring increases from 0 to 0.5. These results may have been guessed. As a matter of fact, keeping the resonant frequency constant, the actual surface of the ring patch grows up by 60 % for a ring ratio from 0 to 0.5. The radiation is assumed to be generated by radiating edges. Destructive interferences can be observed in the visible space, when the length between the edges is greater than a half wave length.

The figure 3 gives the cross polarization level in the H-plane, which has been measured. The parameter is the colatitude angle. Increase of the linear cross polarization versus the ring ratio can be observed. Higher order modes and asymetric excitation may explain those results.

CIRCUIT CHARACTERISTICS

For each breadboard the equivalent RLC parallel resonant circuit has been deduced. The quality factor has been calculated from that circuit. The figure 4 gives the variation of this parameter as a function of the ring ratio b/a. This curve seems to indicate that no remarkable change appears in the frequency bandwidth of the ring patch when the ring ratio increases. When fed by two coaxial probes in order to generate circular polarization, the transmission coefficient between the two ports has been measured at two different frequencies. As a common fact, the probes offer a serie inductance. The ring patch can be then matched to a frequency (matching frequency) different from the resonant frequency, defined at the maximum of the input resistance without adding any element. See figure 5.

The figure 6 gives the transmission coefficient between the two probes versus the ring ratio, at those two frequencies. It can be seen that, isolation between the two ports degrades when the ring ratio increases, and that a better isolation is achieved at the resonant frequency. Coupling level were measured below - 20 dB. These two facts confirm that higher order modes are excited. When the ring ratio increases. Out of the resonance, this spurious excitation gets worse and degradates the isolation between the two ports.

CONCLUSION

As a result, increasing the ring ratio from 0 to 0.5, leads to a patch directivity from 8 dBi to 10.5 dBi. These figures include energy in the sidelobes and in the cross polarization radiation. They are valid only for the TM_{11}, mode. Frequency bandwidth does not seem to be strongly related to the ring ratio.

When circular polarization has to be generated with a ring patch with air as a dielectric spacer, cross polarization purity may degrade off axis as the ring ratio increases.

REFERENCES

(1) "Microstrip array for aeronautical satellite communications"
SHIOKAWA WATANABE YASUNAGA GOTO CHATANI ABE
Denshi Tsushin Gakkai Gyutsu Kenkyu Hokoku.
(1986) 86 N° 132 pp 23-27.

(2) "Phased array antenna for aeronautical satellite communication"
M. YASANUGA-F. WATANABE
T. SHIOKAWA-M. YAMADA
ICAP 87 page 47 - 50.

(3) "Ring patch antennas for dual frequency use"
N. GOTO K. KANETA
1987 IEEE AP-S pp 944-947.

(4) Properties of Centrally shorted Circular Patch
Microstrip Antennas' YiYu LIN L. SHAFAI
IEEE-AP-S June 6-10 1988 Syracuse p 700 - 703

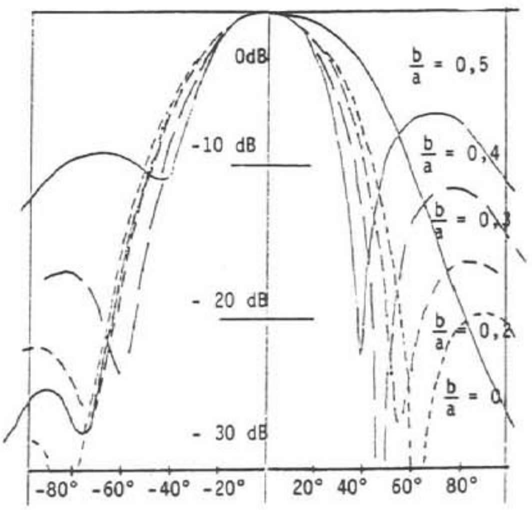

FIGURE 1: E-PLANE PATTERN

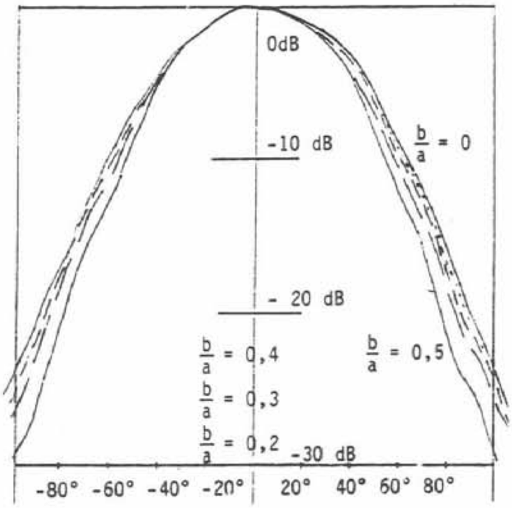

FIGURE 2: H-PLANE PATTERN

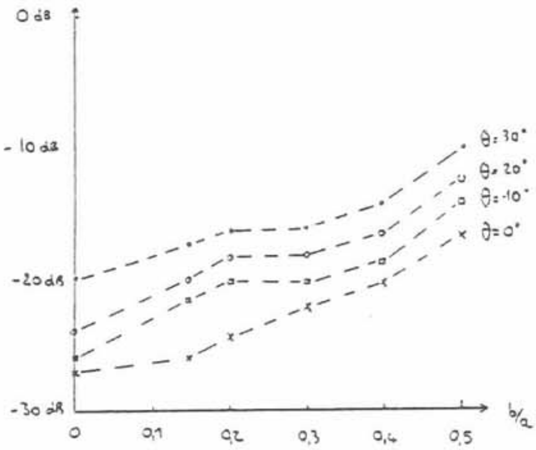

FIGURE 3: CROSS POLARIZATION LEVEL

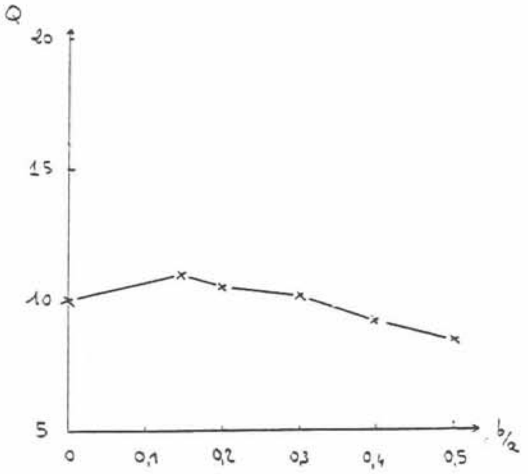

FIGURE 4: VARIATION OF THE Q-FACTOR

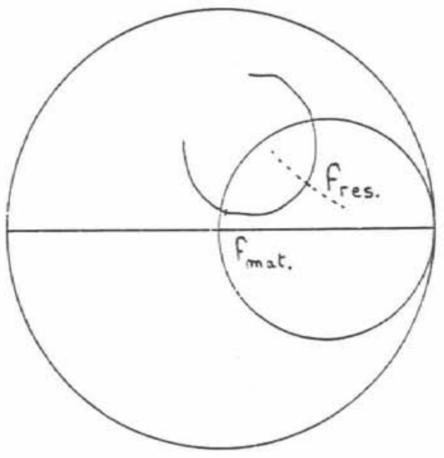

FIGURE 5: RESONANT AND MATCHING FREQUENCIES

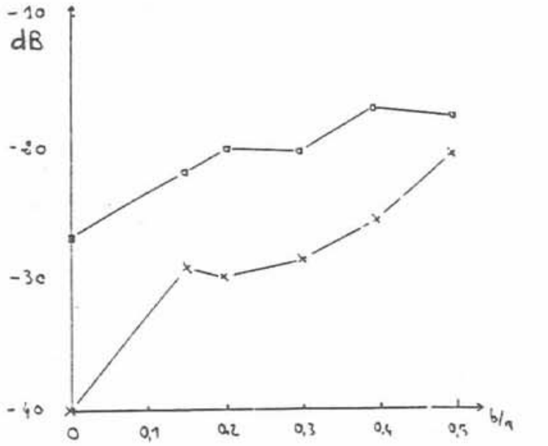

FIGURE 6 : ISOLATION BETWEEN THE TWO PROBES AT THE TWO PREVIOUS FREQUENCIES