BIPOLAR DISK MICROSTRIP ANTENNA. THEORETICAL AND EXPERIMENTAL CONSIDERATIONS

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Abstract: The paper presents the main theoretical and practical aspects regarding wideband disk microstrip antenna construction. There are presented electromagnetically parameters of the antenna, their shape, physical dimensions and results of the experimental measurements. The material outlines specific characteristics of the bipolar disk microstrip antenna.

Keywords: antenna, microstrip, radiation.

1. INTRODUCTION

The microstrip antenna operation is based on the resonance principle at electromagnetic wave frequency from exposure field. This type of antenna can replace the voluminous and expensive antennas. The planar structure of the microstrip antenna permits to implement a variety of surfaces in different shapes.

The microstrip antennas are used in radar installation, in mobile and satellite communications systems, etc. In the same time the microstrip antennas can be part of the directional or non-directional array antennas that use phasing methods; the gain obtained are comparable with gain of parabolic reflector antennas.

2. ANTENNA ARCHITECTURE

From physical point of view the microstrip antenna contain an active plan made from resonant elements, dielectrically separated by a ground conductor plan [2].

The frontier radiation coefficient of the electromagnetic field is proportional to relative permittivity (ε_r) of the dielectric layer.

The radiant elements of a microstrip antenna can have different shapes: circular, elliptical, polygonal, ring. In the next there are presented a bipolar antenna with disk shape dipoles and symmetrically parallel slots (figure 1).

3. FIELD STRUCTURE AND RADIATION PROCESS

Take into consideration the small dimensions of the radiant elements, the antenna has a good efficiency of the high frequency electromagnetic radiation phenomenon.

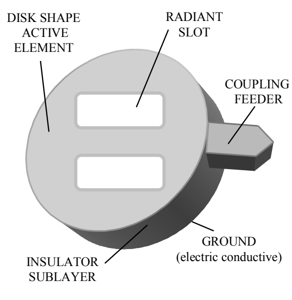

Fig.1. Panoramic view of the disk shape dipole

The main source of radiation is the frontier electric field disposed around the active elements and the frontier electric field of the two slots. The figure 2 shows the electric field distribution (E) generated by the radiant element.

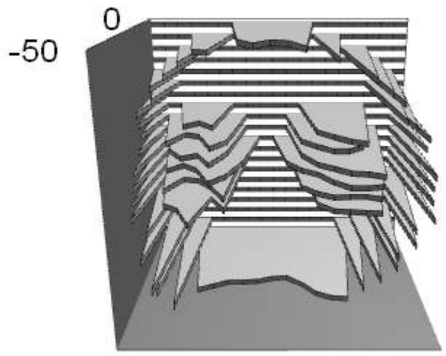

Fig.2. Spatial distribution of the E field

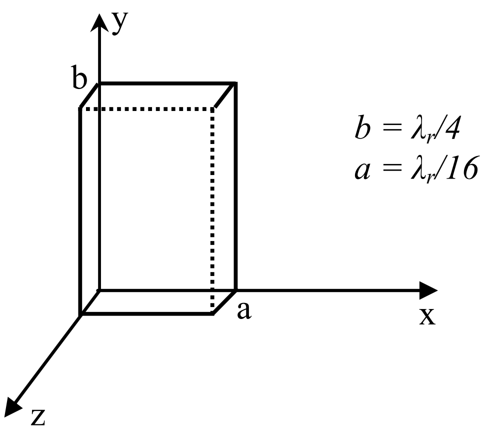

Fig.3. Model of plane resonant cavity

The dynamics of the electric field on the frontier of the two slots results from electromagnetic wave equation of plane resonant cavity (figure 3) [1].

Real wavelength in active element is

$$(1)\ \lambda_r = \frac{c}{\sqrt{\varepsilon_r} \cdot f}$$

where:

c is speed of light;
ε_r is relative permittivity;
f is frequency.

The electromagnetic wave equation of plane resonant cavity is (Balanis, 1997):

$$(2)\ \frac{\partial^2 H_z}{\partial x^2} + \frac{\partial^2 H_z}{\partial y^2} + \mu\varepsilon\omega^2 H_z = 0$$

Considering the conditions:

$E_z = 0,\ x = 0$ and $x = \lambda/16$;
$E_z = 0,\ y = 0$ and $y = \lambda/4$,

the result is:

$$(3)\ H_z = H_0 \cos\left(n\pi\frac{16x}{\lambda}\right)\cos\left(m\pi\frac{4y}{\lambda}\right)$$

$$(4)\ 0 \le x \le \frac{\lambda}{16},\ 0 \le y \le \frac{\lambda}{4}.$$

From equation (3) result the resonant specific pulsations of the different wave propagation mode (eq.5).

$$(5)\ \begin{aligned}\omega &= \frac{\pi}{\sqrt{\varepsilon\mu}}\sqrt{\frac{256n^2}{\lambda^2} + \frac{16m^2}{\lambda^2}} = \\ &= \frac{4\pi}{\sqrt{\varepsilon\mu} \cdot \lambda}\sqrt{16n^2 + m^2}\end{aligned}$$

Because the Oy axe is parallel with the diameter of the slots alignment, the H_{01} mode is dominant. So, n=0 and m=1.

$$(6)\ \omega_r = \frac{4\pi}{\lambda_r\sqrt{\varepsilon\mu}} = \frac{4\pi}{\lambda_r\sqrt{\varepsilon_r}\sqrt{\varepsilon_0\mu_0}} = \frac{4\pi \cdot c}{\lambda_r\sqrt{\varepsilon_r}}$$

For $\varepsilon_r \cong 3{,}3$ the resonant frequency is

$$(7)\ f_r = \frac{2c}{\lambda_r\sqrt{\varepsilon_r}} \cong 1{,}1GHz.$$

The resonant frequency of disk shape resonator is obtained by solving the equation (8):

$$(8)\ J_0\left(\frac{\omega \cdot r}{c}\right) = 0$$

where:
ω is pulsation;
r is radius of the disk;
J_0 is the zero order Bessel polynomial

The solutions of the polynomial are:
$x \cong 2{,}402$ for fundamental mode;
$x \cong 5{,}52$ for first order harmonic.

The calculus of the disk radius:

$$(9)\ X = \frac{\omega \cdot r}{c} = 2{,}402;$$

$$(10)\ r \cong 1{,}12\frac{\lambda_r}{4}$$

The figures 4 to 9 present models and experimental results on disk microstrip antenna construction.

The change of the polarization planes are obtained by switching the radiant dipoles, (horizontal - vertical polarization) using two high frequency switches.

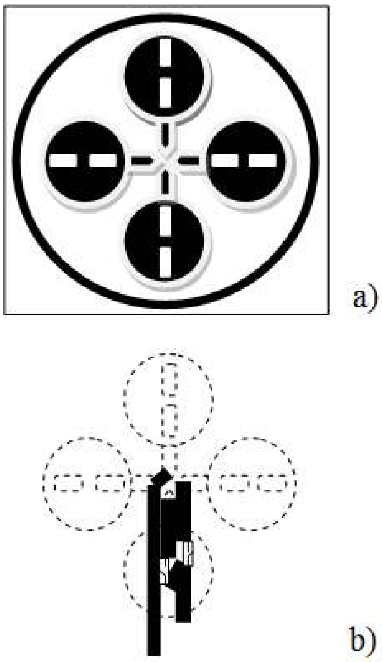

Fig.4. Microstrip antenna: a) front elevation; b) back plane

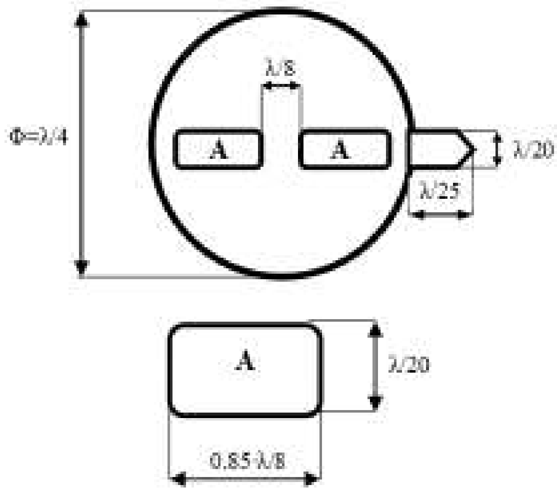

Fig.5. Microstrip antenna – design features

The separation of the two polarization planes is about 30dB, because the antenna is sensitive to circular polarization.

Fig.6. VSWR (S11) – 50Ω

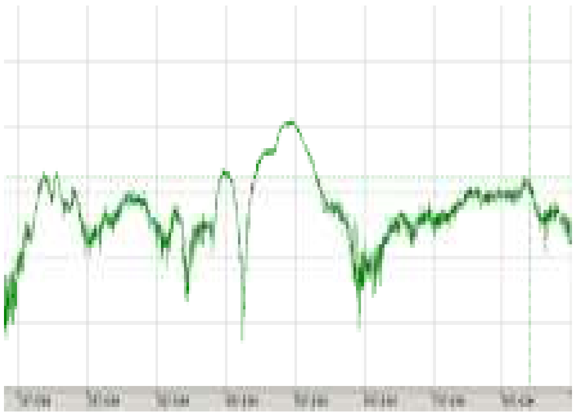

Fig.7. Free space receiver diagram

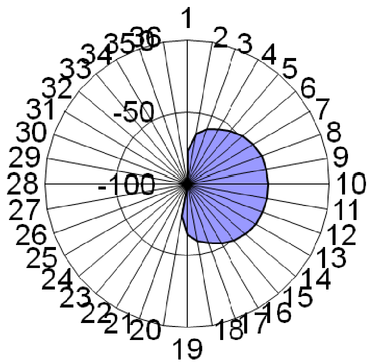

Fig.8. Antenna horizontal pattern diagram

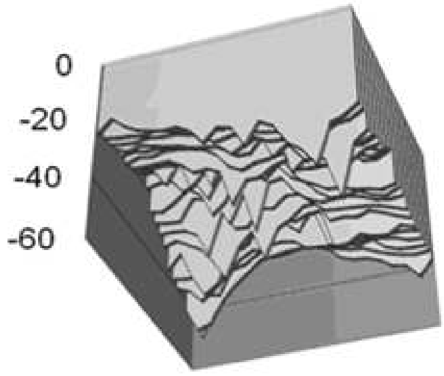

Fig.9. Spatial distribution of the electric field (E)

4. CONCLUSIONS

The presented microstrip antenna has a lot of advantages, such as: smaller size, low cost of production, easy to put in position, linear and circular polarization, feeder coupling simplicity.

Some drawbacks are: power losses in dielectric, limited gain, reduced directivity.

5. REFERENCES

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