



Study of Maria-Vaz Antenna Configuration

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ABSTRACT: The aim of this article is to design an antenna similar to the "Karchenko-Marconi-Emanuel Vaz Antenna", but planar using a fractal. To do this, the rings of a microstrip square configuration are folded at the junction and positioned parallel to each other. This study is based on the philosophy of matryoshka antennas, with some refinements. In particular, each ring is considered as a U-shaped antenna, and the frequency values of these two philosophies are compared with those of other commonly used methods. The execution of a FSS further clarifies the interest of the Maria Vaz Antenna. The theoretical study of the electric field employed in this case is simple and generalizable.

KEYWORDS: Antenna; fractal; frequency-selective surface; filosofia matryoshka; planar

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1. INTRODUCTION

A matryoshka-type planar antenna is described here and fitted as a three-in-a-fractal, which bears many similarities to others already studied by various authors. Antennas with the same resonant frequency but with a wider strip width and shorter length are used. This is theoretically correct, as the results are consistent with practice already verified with the Matryoshka antenna philosophy. Active elements, PIN diodes, and self-induction coils with associated geometries allow us to have three resonant frequencies: two related to the matryoshka philosophy, and the third can be activated or deactivated depending on the dipole geometry. A reconfigurable frequency-selective surface (FSS) using the matryoshka antenna philosophy is also described here. A self-induction coil was inserted into the horizontal arms of the dipoles, maintaining their resonance for Y polarization. PIN diodes inserted into the vertical arms of the dipoles control their respective resonance. The design procedures for each geometry, in addition to the PIN diode and RF, are described, along with the basic principles of self-induction. The expected results are discussed based on the analysis of the resonances of each geometry and the associated geometries, as well as the different polarization states of the PIN- (OFF-ON) diode. The results obtained in the calculations using the theoretical methods presented here agree well with those of other methods used in this particular antenna design and in their practical implementation. For a better understanding of how the fractal is constructed, combine Figure 3 with the Karchenko-Marconi-Emanuel Vaz Digital TV Antenna.

2. MATERIALS AND METHODS

Essentially, an FSS consists of conductive patches, or aperture elements, etched into a dielectric substrate, arranged in a plane of periodic structure, with the ability to filter electromagnetic waves as a function of frequency. As shown in Fig. 8, the frequency response of the FSS depends on the substrate characteristics, the geometry and periodicity of the unit cells, and the polarization of the incident wave. Because FSSs can pass or block electromagnetic waves in free space at different frequencies, they are also known as spatial filters.

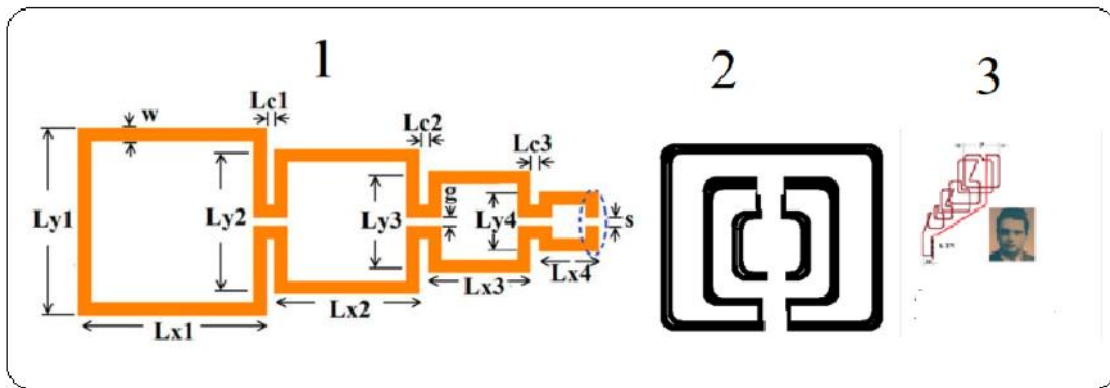


Fig. 1. Antenna with matryoshka philosophy; Fig. 2. Fractal cell for a planar antenna array; Fig. 3. Antenna Karchenko - Marconi - Emanuel Vaz;

The outline of a microstrip filter, with an open three-ring matryoshka geometry, is shown in Figure 8. The input and output microstrip lines are 2.8 mm wide (at a characteristic impedance of 50 Ohm). $W = 2.0$ mm and $g = s = 1.0$ mm are used.

This is a value very consistent with practice and various calculation methods, given that $\epsilon_{ref} = \frac{\epsilon_{refCPW} + 1}{2}$ and being ϵ_{refCPW} the value of the effective dielectric constant of a coplanar waveguide, CPW (coplanar waveguide), without the ground plane, with $s=10h$ and $W = S_y$. And using a program available at App CAD <http://www.hp.woodshot.com> it is calculated $\epsilon_{refPW} = 1,37$ e $\epsilon_{ref} = 1,185$

We'll maintain the same dielectric thickness from ring to ring. We'll position the openings facing the ground: these are the antenna feed points. See Figure 5.

A prototype, already ours, starting the calculation with a matryoshka antenna, gives us a good approximation for our fractal cell. Each cell is three-dimensional, very close to being square, because the third dimension is very small compared to the distance of the commonly measured external field points of interest. Thus, each fractal consists of three antennas radiating the resonance frequency controlled by varying the widths of the microstrip layer. The first, second, and third frequencies are graphed in Table 1. The third frequency results from the electrical action of the PIN diodes and induction coils to vary and stabilize the characteristic impedances. This study should be revisited by interested students at our universities and experimented with in microwave laboratories. We designed each ring as a slightly modified U-shaped dipole antenna. Similar studies have yielded good results in the laboratory; see the references. In our preliminary approach as a matryoshka antenna, the essential difference to our fractal is described by a frequency variation, by modifying the lengths of the microstrip of about ten percent, which corresponds on the substrate used by us to a variation of less than ten per hundred thousand, based on the calculations.

3. EMANUEL VAZ'S METHOD FOR THIN WIRES

In the Emanuel Vaz method, the electric field boundary condition equation is applied to the thin wire structure in an arbitrary way, which states that the total electric field vanishes on the surface of a perfectly conducting body. Practical antennas are made of very good conductors, so the perfect model condition can be used for the current behavior on the wire surface, represented by $r = r_s$, then:

$$E_t(r_s) = E_i(r_s) + E_s(r_s) = 0$$

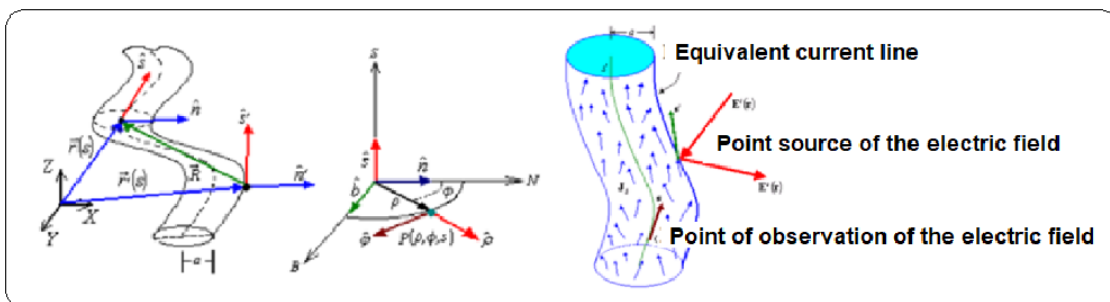


Fig. 4. Electric field at the surface thin irregularly shaped wire.

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$E_i(r_s)$, $E_s(r_s)$ are the impressed and scattered electric fields, respectively. At high frequencies, due to the skin effect, the current could be localized only at the surface of the wire. Considering Figure 4, the current is localized on the surface of the wire, and using the previous equation for the electric field at the surface of a thin, irregularly shaped wire, the calculations follow:

$$r(s) = x(s)\hat{i} + y(s)\hat{j} + z(s)\hat{k} \quad e \quad r'(s') = r(s') + an(s')$$

There is azimuthal independence, and the current distribution depends only on the arc length, and the very thin current filament $I_s(s')$ on the wire surface. The wire axis is represented by:

$$S(s) = \frac{dx(s)}{ds}\hat{i} + \frac{dy(s)}{ds}\hat{j} + \frac{dz(s)}{ds}\hat{k} \quad \wedge \quad S'(s') = \frac{dx'(s')}{ds'}\hat{i} + \frac{dy'(s')}{ds'}\hat{j} + \frac{dz'(s')}{ds'}\hat{k}$$

Geometry is also expressed by the difference vector $|r - r'|$, as:

$$R = |R| = |r - r'| = \sqrt{[x(s) - x'(s')]^2 + [y(s) - y'(s')]^2 + [z(s) - z'(s')]^2}$$

$\mathbf{n}(s)$ is the unit normal vector of the wire axis; as you can see, the curve representing the current filament is a curve parallel to the one representing the wire axis. Since the wire axis has an infinite collection of parallel curves, in practice, we selected the one that would facilitate the estimates. Applying the previous considerations, it is possible to obtain an expression for the electric field imprinted on the wire surface, known from the work of the "Emanuel-Idriss-II numerical integral formula: contribution to electronics", which gives us the value of the tangent electric field in a conducting wire of any thin section. Once all the previous equations are defined, the work is reduced to finding the vectors representing the axis and the parallel curves of the wire in question. The influence of the calculation inside or on the surface of a thin wire is given by introducing the expression for ρ as a function of ΔR into the calculations, as outlined in the article in ref. 6, but always very small, much more so here with the small dimensions of patch antennas:

$$\begin{aligned} \Delta R &= \rho^2 + a^2 - 2\rho a \cos(\Phi' - \Phi) \\ \bar{E} &= A \exp\left(j \operatorname{arctg} \frac{u_z u_y^2 - u_x u_z - u_z^2 + 2u_x u_y}{\frac{\mu v}{\omega}}\right) E_x + B \exp\left(j \operatorname{arctg} \frac{-u_z^2 - u_x u_y - u_z^2}{\frac{\mu v}{\omega}}\right) E_y + C \exp\left(j \operatorname{arctg} \frac{u_y u_z}{\frac{\mu v}{\omega}}\right) E_z \\ \underline{E}_t &= \rho \cos \Phi \hat{x} + \rho \sin \Phi \hat{y} = \sqrt{2} \sqrt{\left(\frac{\mu v}{\omega}\right)^2 + (u_y u_z)^2} \exp\left(j \operatorname{arctg} \frac{u_y u_z}{\frac{\mu v}{\omega}}\right) \\ u_y &= \begin{cases} 0 & \leftarrow |y| \leq ct \\ v\left(t - \frac{|y|}{c}\right) & \leftarrow |y| \geq ct \end{cases} \quad \wedge \quad u_z = \begin{cases} 0 & \leftarrow |z| \leq ct \\ v\left(t - \frac{|z|}{c}\right) & \leftarrow |z| \geq ct \end{cases} \\ \wedge \quad u_x &= \begin{cases} 0 & \leftarrow |x| \leq ct \\ v\left(t - \frac{|x|}{c}\right) & \leftarrow |x| \geq ct \end{cases} \end{aligned}$$

Pocklington, among others, with his own integral equation, addressed this problem based on Green's functions. However, here we revisit it, considering the microstrip as a wire, regardless of the charge distribution, at whatever frequency it may have. Recent studies have suggested that calculations should be considered as a waveguide, even when it comes to determining ϵ_{ref} . We addressed the problem using theoretical resources directly from the universities we attended.

Maria Vaz sent me a fractal to work on a patch antenna array, similar in base cell to that in Figure 5. It was a privilege to have Vaz's support. I call it the Maria-Vaz fractal; below I present the study based on the patch base cell of the antenna array for the widely used and easily tested case with narrow strips like the one outlined, with practically full use of Figure 2. This case is based on the foundations already studied with rigorous formulations, as presented in the references. This is already a bold move, but it required approval from our laboratories, where we conducted technical literature consultations. This is our example of an exact solution, after confirmation, for the array in Figure 6. We will study the electric field of each ring of the fractal cell and leave the problem-solving form.

The generation of FSS, frequency-selective surfaces that can be used, for example, on the doors of microwave equipment, as active filters, where they see inside but prevent microwave radiation from escaping to the outside, is a good example of the application of substrates with resonances in the GHz range. We also studied this case.

The PIN diode is a semiconductor device that operates as a variable resistor in RF and microwave applications. In general, two operating points of the PIN diode are considered, forward bias (low impedance) and reverse bias (high impedance), as illustrated in Figure 9. Although a more precise PIN diode model includes inductances, capacitances and resistances, as can be seen in Figure 9. In many applications a simplified model can be adopted, considering only the variable resistance.

Let us look at figure 6. There are M patch elements initially placed along the x-axis the array factor can be written as,

$$AF = \left[\sum_{m=1}^M I_{m1} \exp(j(m-1)Kd_x \sin\theta \cos\phi + \beta_x) \right]$$

The total array will be:

$$AF = \sum_{n=1}^N I_{1n} \left[\sum_{m=1}^M \exp(j(m-1)Kd_x \sin\theta \cos\phi + \beta_x) \right] \left[\exp(j(n-1)(Kd_y \sin\theta \cos\phi + \beta_y)) \right]$$

I_n is the excitation coefficient for patch m, d_x and β_x are the spacing and progressive phase shift between the elements along the x-axis.

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Placing n of these arrays in the y -axis direction, plus a distance d_y and a phase difference β_y , in a rectangular array, we will have, according to Figure 6, for the array factor:

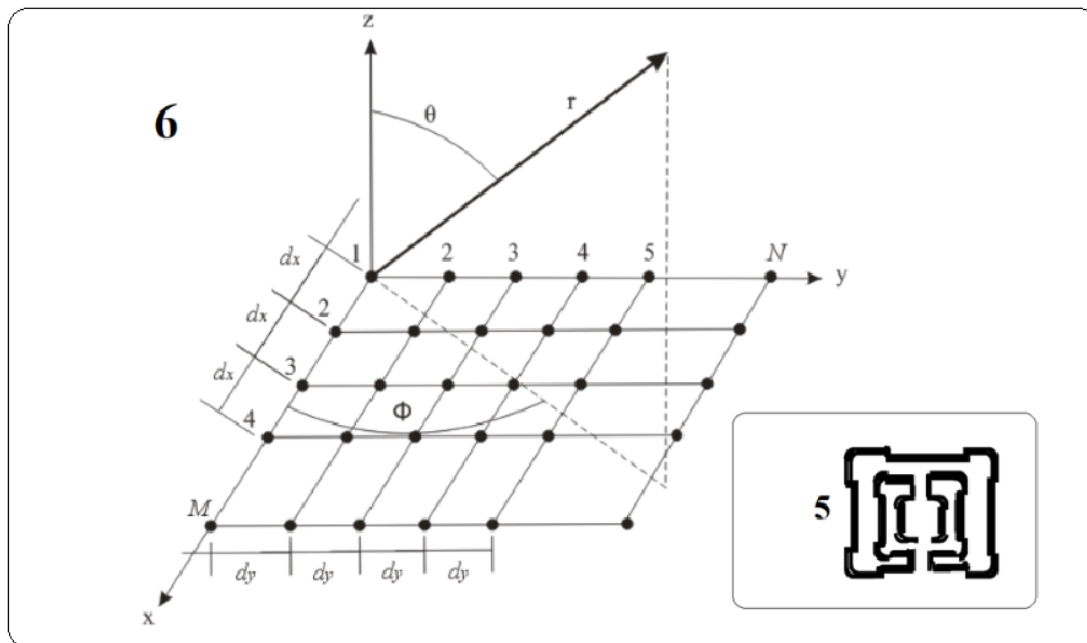


Fig. 5. Three-ring matryoshka fractal cell. Fig.6. three-dimensional fractal array in the case of the Maria-Vaz antennas

$$AF = I_0 \sum_{m=1}^M \exp(j(m-1)Kd_x \sin\theta \cos\phi + \beta_x) \left[\sum_{n=1}^N I_{1n} \exp(j(n-1)(Kd_y \sin\theta \cos\phi + \beta_y)) \right]$$

Note that any of these sums is formed by sums of sines and cosines of angles, in number of N or M .

$\psi_x = Kd_x \sin\theta \cos\phi + \beta_x$ and $\psi_y = Kd_y \sin\theta \cos\phi + \beta_y$, functions of only x or only y and θ . The parameter ϕ sweeps the entire space.

Here, in our notation, see ref 10, it is :

$$S + iS' = AF \therefore S = \frac{\sin \frac{nh}{2}}{\sin \frac{h}{2}} \cos \left(a + \frac{n-1}{2} h \right), S' = \frac{\sin \frac{nh}{2}}{\sin \frac{h}{2}} \sin \left(a + \frac{n-1}{2} h \right) \Rightarrow AF = \sqrt{S^2 + S'^2} = \frac{\sin \frac{nh}{2}}{\sin \frac{h}{2}}$$

In the case of isotropy, we have for an antenna in any $M \times N$ array:

$$AF_n(\theta, \phi) = \left\{ \frac{1}{M} \frac{\sin \frac{M\psi_x}{2}}{\sin \frac{\psi_x}{2}} \right\} \times \left\{ \frac{1}{N} \frac{\sin \frac{N\psi_x}{2}}{\sin \frac{\psi_x}{2}} \right\}$$

Note that $M \times N \times 3$ is the number of antennas in the three-dimensional fractal array. In the case of the Maria-Vaz antennas, we also have three steps on the z -axis. Therefore, although they are not possibly isotropic, they must at least have, for good conditions, equal coupling impedances, and of course, we can still induce isotropy with the width of the ribbons. See, Balanis, ANTENNA THEORY ANALYSIS AND DESIGN 3rd edition.

Therefore, reasoning similar to that presented for determining AF would lead to:

$$AF = \left\{ \frac{1}{M} \frac{\sin \frac{M\psi_x}{2}}{\sin \frac{\psi_x}{2}} \right\} \times \left\{ \frac{1}{N} \frac{\sin \frac{N\psi_x}{2}}{\sin \frac{\psi_x}{2}} \right\} \times \left\{ \frac{1}{3} \frac{\sin \frac{N\psi_x}{2}}{\sin \frac{\psi_x}{2}} \right\} \quad \text{Equation 1}$$

The presence of divisors M , N , and 3 in the last mathematical expression solves the problem of uniformizing the field value across the array cells. When the spacing between patch elements is greater than or equal to $\lambda/2$, there may be multiple maxima of equal amplitude. The main maximum is the main lobe, and the other maxima are secondary lobes.

There may be grating lobes in the xz and yz planes. The spacing between patch elements in the x and y directions, respectively, must be less than $\frac{\lambda}{2}$, that is, $d_x < \frac{\lambda}{2}$ and $d_y < \frac{\lambda}{2}$.

The array factor was obtained here, as the sources are isotropic. If the array contains identical elements, the total field can be obtained by multiplying the patterns similar to the linear array.

Let's consider the fractal Vaz, with its larger principal cell, where a potential difference V_0 is applied. A similar problem occurs in the following cells. This is a Dirichlet problem for the flat band shown in the figure 7. Let's determine the potential function, V , the electric field at a nearby point in space.

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Let us seek a solution to the problem using the method of subposition of the solutions provided by the separation of variables: $\exp(ax) \cos(ay)$, $\exp(ax) \sin(ay)$, $\exp(bx) \cos(ay)$, $\exp(bx) \sin(ay)$ for all constants a and b , and finally, $1, x, y, xy$.

After this potential calculation, we just have to add the values of the vector V caused by each of the rings.

Let us start by superimposing only solutions that satisfy the limiting conditions as much as possible, since we want $V \rightarrow V_0$, when $x \rightarrow +\infty$, in other words, the potential difference tends to zero when x tends to d . We will restrict ourselves to the superposition of solutions such that $\exp(ax) \cos(ay) + \exp(ax) \sin(ay) \leftarrow a > 0$. Since we want $y = 0$, then $V \neq 0$ we will have terms in $\exp(ax) \cos(ay)$. Since we also want $V \neq 0$ for all x and y . Since it is approximately the maximum of the potential difference. at $x = c, V \neq 0, y \approx \frac{d}{2}$ we have solutions in $\exp(ax) \sin(ay)$ ou $\exp(-ax) \sin(ay)$ with $a = \frac{\pi}{2} + 2n\pi$. We are therefore left with solutions of the type $\exp(ax) \sin(ay)$ or $\exp(-ax) \sin(ay)$ which we will show are solutions to the problem, which we can superimpose on:

$V = \sum_{-1}^1 B_n \exp(ax) \cos(ay) + \sum_{-1}^1 C_n \exp(ax) \sin(ay) + \sum_{-1}^1 D_n \exp(-ax) \sin(ay) + 1 + x + y + xy$ which will be the solutions that will interest us. No, manifestly possible with a finite sum, but it is with a Fourier series, a series of sines of V over $\left[3 \frac{V_0}{8}, 5 \frac{V_0}{8}\right]$, series of period $T = 2 \frac{V_0}{8}$, uniformly convergent on $\left[3 \frac{V_0}{8}, 5 \frac{V_0}{8}\right]$, because V is interval-monotonic and continuous.

These calculations are justified because, by increasing the absolute value by geometric series of constant ratio $\exp(-2\pi h)$, we see that the series and the partially derived series term by term first and second are absolutely and uniformly convergent for $x > h > 0$ for all y . This proves only the existence, but not the uniqueness, of the presented solution.

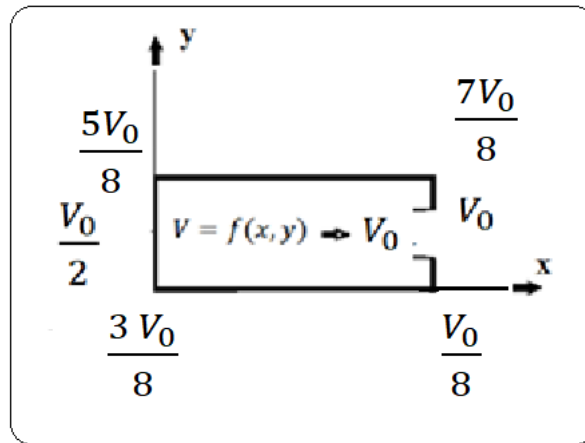


Fig. 7. Electric field distribution per fractal cell ring. Maria Vaz

This equation for V can be stated as follows:

$$V = [A \exp(ax) + B \exp(-ax)][C \cos(ay) + D \sin(ay)] + 1 + x + y + xy \quad \text{Equation 2}$$

Before describing a physical problem and forcing the constants appearing in the series to satisfy the predicted boundary conditions, let us consider the physical nature of the potential given by a simple choice of these constants. Choosing $A=0, C=0$ and $BD \neq 0$, we have: The potential cannot always rise and will have to be:

$$BD \exp(-ax) \sin(ay) + 1 = V \quad \text{Equation 3}$$

$$BD \sin\left(a \frac{c}{2}\right) + 1 + \frac{c}{2} = \frac{V_0}{2} \Big|_{x=0, y=\frac{c}{2}} \quad \text{Equation 4}$$

$$BD \sin(ac) + 1 = \frac{5V_0}{8} \Big|_{x=0, y=c} \quad \text{Equation 5}$$

Dividing equation 5 by equation 4 we have successively:

$$\frac{\sin(ac)}{\sin\left(a \frac{c}{2}\right)} = \cos\left(a \frac{c}{2}\right) = \frac{\frac{5V_0}{8} - 1}{\frac{V_0}{2} - 1}$$

⇔

$$a \frac{c}{2} = \cos^{-1}\left(\frac{\frac{5V_0}{8} - 1}{\frac{V_0}{2} - 1}\right) + 2m\pi$$

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⇔

$$a = \frac{2}{c} \left[\cos^{-1} \left(\frac{\frac{5V_0}{8} - 1}{\frac{V_0}{2} - 1} \right) + 2m\pi \right] \quad \text{Equation 6}$$

$$BD \exp[-a d] \sin \left(\frac{ac}{2} \right) + 1 = V_0$$

∴

$$BD = \frac{V_0 - 1}{\exp \left[-\frac{2}{c} \left[\cos^{-1} \left(\frac{\frac{5V_0}{8} - 1}{\frac{V_0}{2} - 1} \right) + 2m\pi \right] d \right] \sin \left(\cos^{-1} \left(\frac{\frac{5V_0}{8} - 1}{\frac{V_0}{2} - 1} \right) + 2m\pi \right)}$$

Note that V_0 is a constant as well as c and d well chosen from the problem.

From equation 2 and the last one we have

$$V = \frac{V_0 - 1}{\exp[-a d] \sin \left(\frac{a}{2} c \right)} \exp[-ax] \sin[ay] + 1 \quad \text{Equation 7}$$

Considering expression 8 of the definition of $\sinh(ax)$ we can write equation 4.

$$\sinh(ax) = \frac{1}{2} (\exp(ax) - \exp(-ax)) \quad \text{Equation 8}$$

$$V = \frac{V_0 - 1}{\exp[-a d] \sin \left(\frac{a}{2} c \right)} [\exp[ax] - 2 \sinh[ax]] \times \sin[ay] + 1 \quad \text{Equation 9}$$

Of course, for each value of V_0 , we have infinite field values satisfying this condition. By adding both sides of the equations, we can also obtain a solution to the problem from this sum. This is an ideal of the solutions to the problem solved by the differential equation that we already said has a solution. Since this is a solution of equation 2 as well, we still let the designation be V . The subscript in V_{0m} indicates that this amplitude factor will have a different value for each different value of m .

$$V = \sum_{m=1}^{+\infty} \{V_{0m} [\exp[ax] - 2 \sinh[ax]] \times \sin[ay] + 1\} \quad \text{Equation 10}$$

Comparing equation 9 with equation 10 we get:

$$V_{0m} = \frac{V_0 - 1}{\exp[-a d] \sin \left(\frac{a}{2} c \right)} \quad \text{Equation 11}$$

$$V_{0m} = \frac{V_0 - 1}{\exp \left\{ \frac{2}{c} \left[\cos^{-1} \left(\frac{\frac{5V_0}{8} - 1 - c}{\frac{V_0}{2} - 1 - \frac{c}{2}} \right) + 2m\pi \right] d \right\} \sin \left\{ \left[\cos^{-1} \left(\frac{\frac{5V_0}{8} - 1 - c}{\frac{V_0}{2} - 1 - \frac{c}{2}} \right) + 2m\pi \right] \right\}} \quad \text{Equation 12}$$

We must consider the three rings of the Maria-Vaz antenna, and this equation (13) gives us the electric field for one ring. Depending on the dimensions of the other two rings and their feed position, they create compound fields.

Note that these dipoles are fed with voltages that are: $\left(V_0, \frac{V_0}{2}, \frac{V_0}{4} \right)$.

The calculation of the electromagnetic field due to the three rings of the fractal antenna at a point in space is obtained using the array factor, as already indicated. In the case of the U-shaped fractal antennas considered here, which is our current approximation of the matryoshka fractal antenna theory, it is given for far fields by what is known as $E(z) = \frac{V_0}{z_0} \exp(-\beta z)$. We relied on cutting-edge works such as "FSS Analysis with U-Shaped Metallization Layer Geometry" and [Planar Printed Structures Based on Matryoshka Geometries: A Review](#) which we cite in our references. But our own work involved rigorously determining the electric field through an analytical process near of the antenna. We then have the following expression for the electric potential field of a Maria-Vaz antenna ring

$$V = \sum_{m=1}^{+\infty} \frac{V_0 - 1}{\exp \left\{ \frac{2}{c} \left[\cos^{-1} \left(\frac{\frac{5V_0}{8} - 1 - c}{\frac{V_0}{2} - 1 - \frac{c}{2}} \right) + 2m\pi \right] d \right\} \sin \left\{ \left[\cos^{-1} \left(\frac{\frac{5V_0}{8} - 1 - c}{\frac{V_0}{2} - 1 - \frac{c}{2}} \right) + 2m\pi \right] \right\}} \times \left\{ \exp \left[\frac{2}{c} \left[\cos^{-1} \left(\frac{\frac{5V_0}{8} - 1 - c}{\frac{V_0}{2} - 1 - \frac{c}{2}} \right) + 2m\pi \right] x \right] - 2 \sinh \left[\frac{2}{c} \left[\cos^{-1} \left(\frac{\frac{5V_0}{8} - 1 - c}{\frac{V_0}{2} - 1 - \frac{c}{2}} \right) + 2m\pi \right] x \right] \right\} \times \sin \left\{ \frac{2}{c} \left[\cos^{-1} \left(\frac{\frac{5V_0}{8} - 1 - c}{\frac{V_0}{2} - 1 - \frac{c}{2}} \right) + 2m\pi \right] y \right\}$$

Equation 13

The electric field will be practically the sum, at each point, of the fields produced by the three rings of each fractal cell. It is well known that this field decreases significantly with increasing distance from the antenna, But it is an important parameter in an FSS. Let's record an iterative process of resolving the potential spectrum in a FORTRAN program, see ref 18.

FORTRAN PROGRAM

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1  DIMENSION A (17, 17),B(17,17)
2  DO 6I=2,17
3  DO 5J= 1,17
4  A(I,J)=0
5  CONTINUE
6  CONTINUE
7  DO 9J 2,16
8  A(I,J)=100.
9  CONTINUE
10 A(I,I)=50.
11 A(I,J) = 50
12 DO 16I= 2,16
13 DO 15J= 2.16
14 A(I,J) =(A(I,J-1)+ A(I-I,J)+ A(I,J+1)+ A(I+I,J))/4.
15 CONTINUE
16 CONTINUE
17 DO 23I=2.16
18 DO 22J=2,16
19 DO C=(A(I,J-1)+A((I-I,J)+A(I,J+1)+A(I+I,J)))/4
20 B(I,J)=A(I,J)-C
21 IF (ABS(B(I,J).00001.GT.0.) GO TO 12
22 CONTINUE
23 CONTINUE
24 24 WRITE (6,25((A(I,J), J=1,17), I=1.17)
25 FORMAT (1H0, 17F7.2)
26 STOP
27 END

```

Programs for iteration solutions are given in Chapter 24 of Boast, W. B.: Vector Fields, Harper Publishers, Incorporated, New York, (1964) and in Chapter 2 and Appendix of Silvester P. Modern Electromagnetic Fields, Prentice-Hall, Inc. Englewood Cliffs, (1968).

4. EXPERIMENTS AND CONCLUSIONS

Figure 8 shows a fractal cell using a 0.97 mm thick FR4 substrate with $\epsilon_r = 4.4$ and $\tan\delta = 0.02$. A unit cell with size $W_x = W_y = 24.0$ mm, $L_1 = 22.0$ mm, $L_{c1} = L_{c2} = 2.25$ mm, $L_2 = 14.5$ mm, $L_3 = 7.0$ mm, $w = 1.5$ mm, and $g = s = 1.0$ mm. The simulation and experimental results of the three rings of the Maria-Vaz antenna for vertical and horizontal polarizations are shown in Table 1. The experimental results could only be measured from 1 GHz. upwards. There was good overall agreement between the simulation and experimental results. Significant improvements are obtained by treating the Maria-Vaz configuration here as a half-wave dipole: an excellent estimation calculation process. The PIN diode model BAR 64-03W manufactured by Infineon Technologies, fixed RF 4310LC-132KEB with $1.3\mu H$ was used. With this technique we ensured the three resonance frequencies.

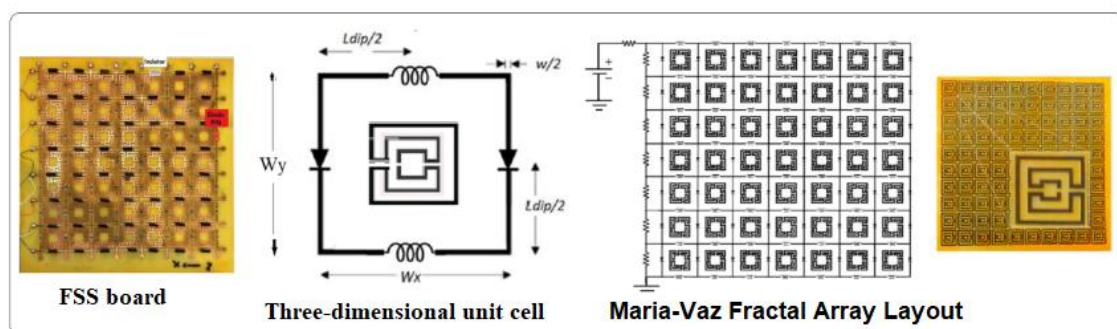


Fig. 8. Maria-Vaz fractal antenna arrays

Self-induction coils are key circuit components in many electronic designs, from power and voltage conversion circuits to high-frequency RF and microwave circuits. In addition to their inductance, in RF and microwave applications, performance parameters

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such as DC resistance (DCR), quality factor (Q), and self-resonant frequency (SRF) may be more relevant. See References 1 and 2.

When comparing the calculations for the planar fractal U-shaped antenna using the technical data available to me and the matryoshka, I found that commercial calculation processes such as the Wave Concept Iterative Procedure (WCIP) and the commercial computer program ANSYS® (Designer™), based on the Method of Moments, were closer to my estimate regarding the resonance frequency, considering the ring as a half-wave dipole. Therefore, I ended up directing my estimates from Table 1 toward the calculation of each ring as a half-wave dipole. This was my final requirement—the resonance frequency estimates—taking the Maria-Vaz antenna as a half-wave dipole. Work by my distinguished colleagues gave the Method of Moments a 17.39% error and the WCIP a 15.76% error in the U-shaped antenna estimates, while with the half-wave dipole antenna, the results were 9.33% and 9.68%, respectively.

The resonance frequency is very important. The Maria-Vaz Antenna, in this particular case, is a half-wave dipole in each ring.

Table 1. Simulation and experimental results of the three rings of the Maria-Vaz antenna for vertical and horizontal polarizations in an FSS.

Numerical results of resonance frequencies			
	$l_{x1}= 2 \text{ mm}$	$l_{x2}= 6 \text{ mm}$	$l_{x3}= 10\text{mm}$
Frq 1, WCIP GHz	9.41	6.62	4.66
Frq 1, MoM GHz	9.46	6.57	4.65
Frq 1, Estim. Ghz	9.86	6.29	4.59
Frq 2, WCIP GHz	-	12.23	10.64
Frq 2 MoM GHz	-	12.44	10.78
Frq 2 Estim. GHz	-	12.54	11.78

The form of microstrip antennas particularly those of the half-wave dipole philosophy that we use in this paper allow the calculation of the parameters of an antenna configuration using the array factor, particularly of the far field which as shown in figure 9 is given approximately, as it depends on many factors, by $E(z) = \frac{V_0}{Z_0} \exp(-\beta z)$, for each ring. The Maria-Vaz antenna was the fractal planar shape most similar to the Kharshenko-Marconi-Emanuel Vaz digital antenna developed in an article in QSP magazine cited in reference 7.

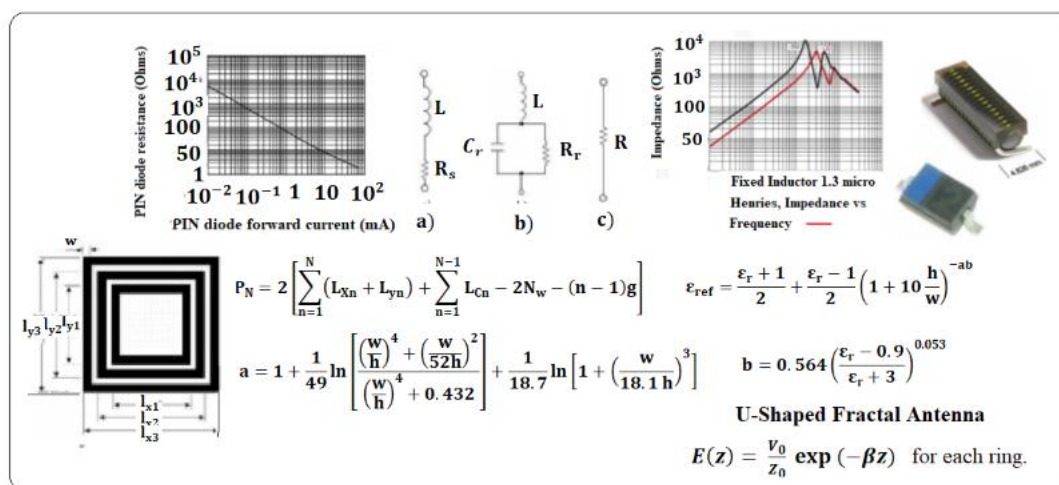


Fig. 9. Calculation of the parameters of an antenna configuration using the array factor, particularly of the far field

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