FRACTAL STRIPLINE ANTENNA WITH COMBINED ELEMENTS

Gheorghe MORARIU, Mihai MIRON

"Transylvania" University, Brasov, Romania
(gheorghe.morariu@unitbv.ro, mihai.miron@unitbv.ro)

DOI: 10.19062/2247-3173.2016.18.1.38

Abstract: *The paper presents a model of fractal antenna having as resonance elements dipoles obtained by the combination of triangular and discoid surfaces. There are highlighted technical design features and experimental results (reflection coefficient, VSWR, gain). Covering a wide frequency band with a very satisfying gain and having reduced geometric dimensions, antenna is recommended in mobile telephony, digital television and multiservice.*

Keywords: *antenna, fractal, stripline, resonator*

1. INTRODUCTION

Considering the fractal geometrical structure as a combination of virtual capacitors and inductors, it is possible to create a system of resonators for more resonance frequencies which can be selected and corrected by particular fractal pattern, validating the idea that geometry is a core issue in the unique electromagnetic behavior determination of the independent frequency electromagnetic antennas [2].

The antenna contains fractal radiating elements obtained by combination the triangular and discoid surfaces, calculated for specific resonant frequencies.

The combination of butterfly dipoles with different angular opening in a linear and circular network forms a broadband radiant fractal structure (surface tip) with quasi-circularly polarization.

2. ANTENNA DESIGN

The reference resonant frequency of the resonant dipoles is calculated using the formula:

$$f_0 = \frac{c}{\sqrt{\varepsilon_r}}\frac{1}{\lambda}, \tag{1}$$

where $\varepsilon_r = 2.27$ and $c = 3 \cdot 10^8$m/s.

For a chosen wavelength $\lambda = 0.32$m, the resonant frequency is $f_0 = 0.624GH_z$.

Being a fractal structure, the antenna covers a frequency domain from $f_0/4$ to $2f_0$, so from $0.156GH_z$ to $1.248GH_z$.

Reference spectrum calculation. Considering V_i - angular variation of the phase in the direction of propagation for reception, θ the angle between direction of propagation for reception and antenna surface in the antenna sector ±β/2 where wave intensity module direction it is also considered constant, it follows that:

$$V_i = e^{j\theta} \cdot e^{j(\alpha+\gamma R_i)} \text{, where:} \tag{2}$$

$$\gamma = 2\pi / \lambda \text{ (dephasing coefficient);} \tag{3}$$

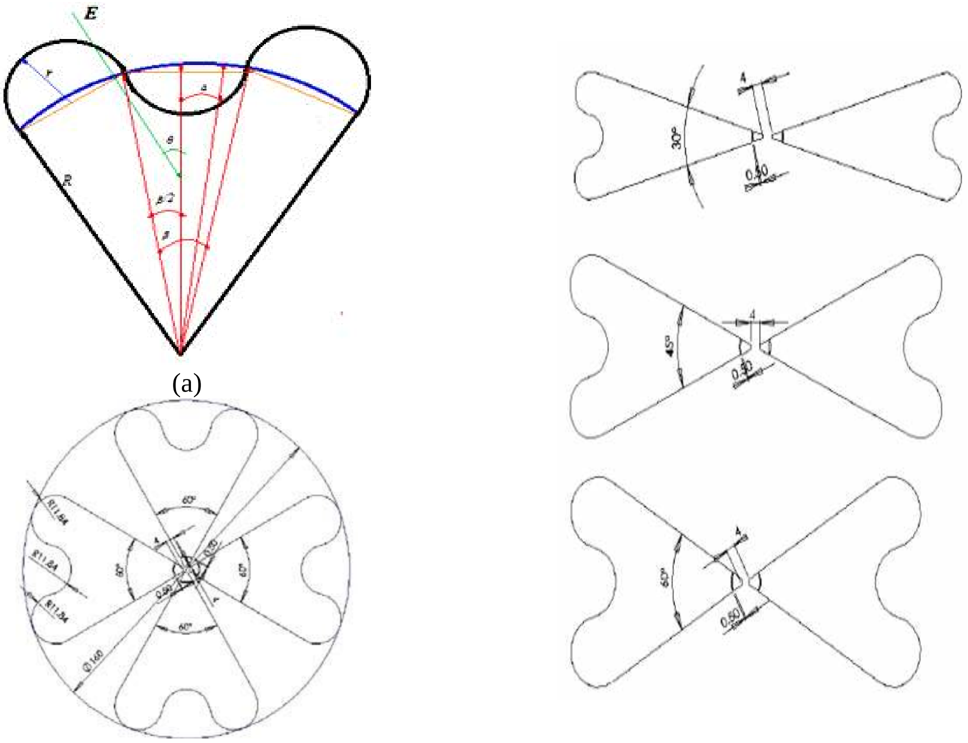
$$R_i = R\sqrt{1 \pm \sin(\beta)\cos(\varphi)}; \tag{4}$$

α - attenuation coefficient;

φ - the deviation angle (0 - 90^0) of the radius r of the half-disk resonator in relation to radius R of the fractal sector from dipole in its origin (position where R_i takes the maximum / minimum value) (Fig. 1(a));

$$R_i = R \pm r \tag{5}$$

β - angle of the fractal sector from dipole (30^0/3; 45^0/3; 60^0/3) (Fig. 1(a)).



(a) (b) (c)

FIG. 1. Fractal stripline antenna with combined elements: (a) Radiant fractal structure – combination of triangular and discoidal surfaces; (b) Central resonator scheme; (c) Butterfly dipoles diagram (λ / 2 = 170mm).

The total phase angle variation is

$$V_0 = \sum V_i , \tag{6}$$

$$V_0 = e^{j\theta} \sum e^{j(\alpha_n + \gamma R_i)} \Big|_{\alpha=0}^{\alpha=\pm\beta/2} \tag{7}$$

so that the wave received (E, H) has the expression:

$$E; H = |E; H| V_0 \tag{8}$$

From total angular phase variation expression (7) it is is observed that basic resonance spectrum covers a bandwidth of (± r / R)*f_0 for each dipole (approximately ± 20%).

In the case of considered central resonator - a compact disk-shaped element, field strength E_T is approximated by the following relationship [1], [2]:

$$E_T = E_0 \left(1 - \left(\frac{\omega \cdot r}{2c} \right)^2 \frac{1}{(1!)^2} + \left(\frac{\omega \cdot r}{2c} \right)^4 \frac{1}{(2!)^2} - \left(\frac{\omega \cdot r}{2c} \right)^6 \frac{1}{(3!)^2} + ... \right) \tag{9}$$

which becomes

$$E_T = E_0 \cdot e^{j\omega t} \cdot J_0 \frac{\omega \cdot r}{c}, \tag{10}$$

where: r - reference disc radius;
J_0 - zero-order Bessel function [7].

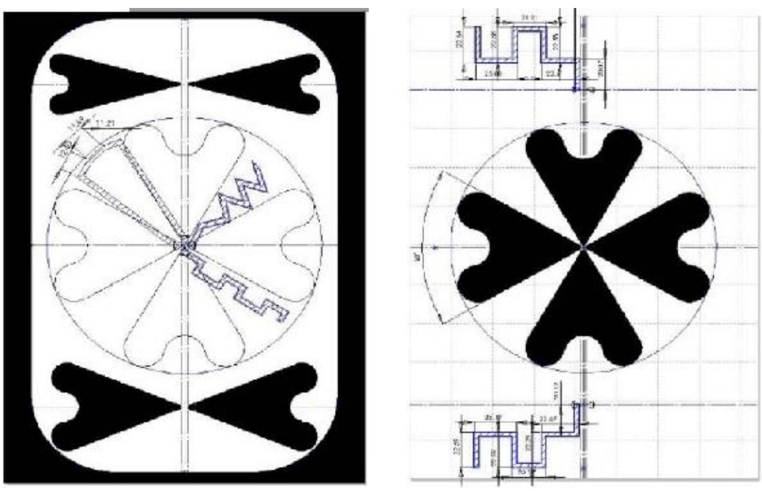
Take into consideration a disc radius r = 8cm, the calculated resonant frequency is 1.26GHz (ω·r/c = 2.4).

Technical realization of the antenna. Sizing and framing of antenna elements are presented below, in the figures 2 and 3.

To adapt the resonant elements to the feeder were used line sections with length

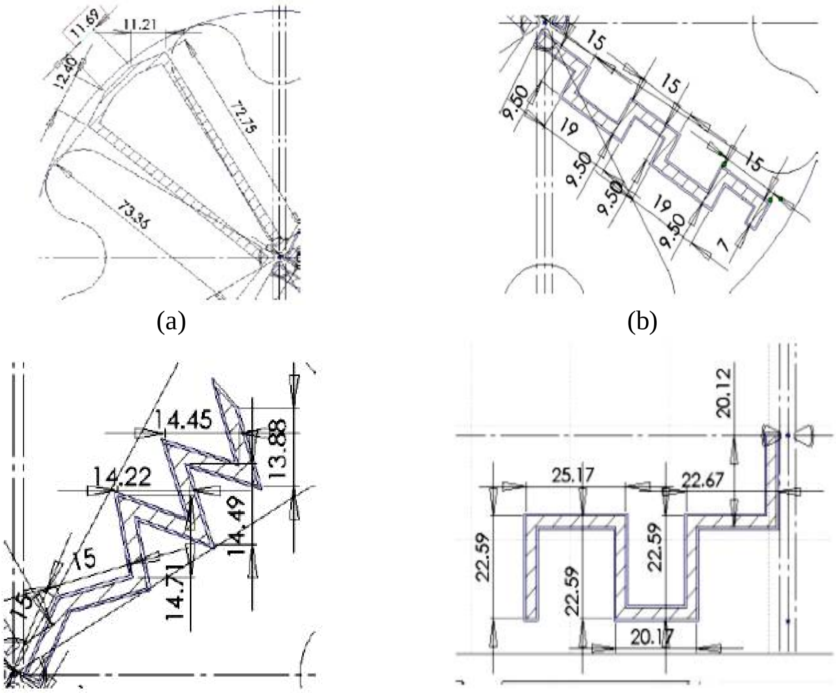
$$L = n \cdot \lambda + \frac{\lambda}{4}, \tag{11}$$

where n = 0, 1, 2.



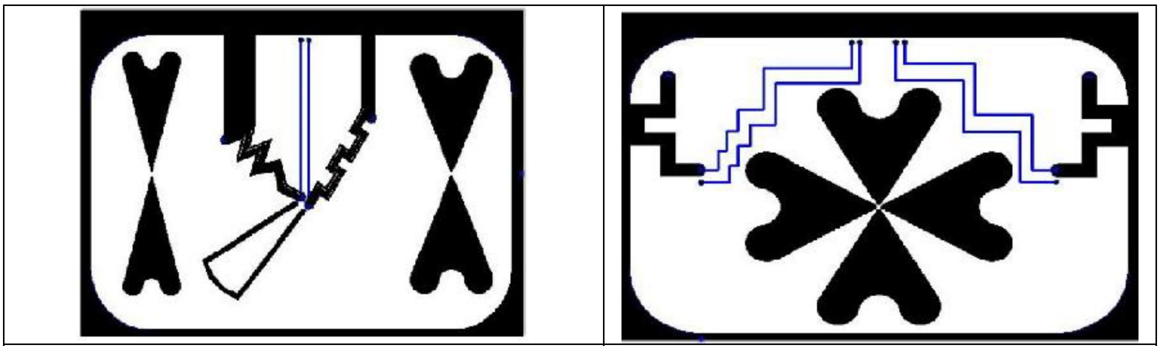
(a) (b)

FIG. 2. Fractal stripline antenna with combined elements – framing of elements: (a) frontal view; (b) rear view.



(a) (b) (c) (d)

FIG. 3. Fractal stripline antenna with combined elements:
(a) Element of adaptation - phasing line; (b) Element of adaptation (1) to a radiating element with opening of 60º; (c) Element of adaptation (2) to a radiating element with opening of 60º; (d) Element of adaptation to a radiating element with opening of 45º.



(a) (b)

FIG. 4. Fractal stripline antenna with combined elements – final implementation: (a) frontal view; (b) rear view.

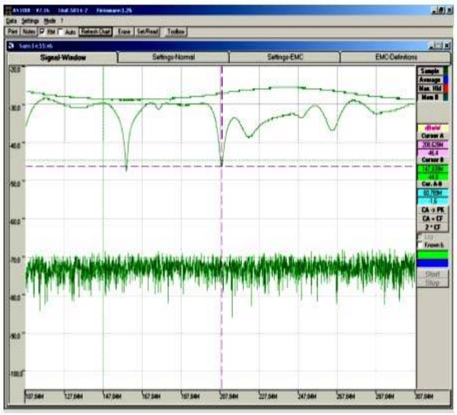
3. EXPERIMENTAL RESULTS

Data on electrical measurements obtained from experiments are presented in sequential order as follows: reflection coefficient variation, standing wave ratio variation, reception diagram with afferent frequency bands, directivity diagrams and antenna gain.

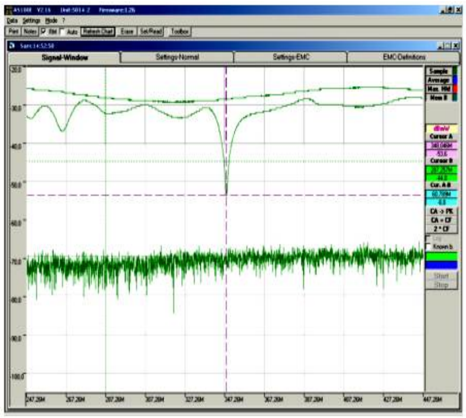
According to the reflection coefficient diagram, Γ=1 for a signal domain from (-27) to (-30)dB, and Γ=0 for a signal domain from (-70) to (-80)dB.

The formula used for voltage standing wave ratio is:

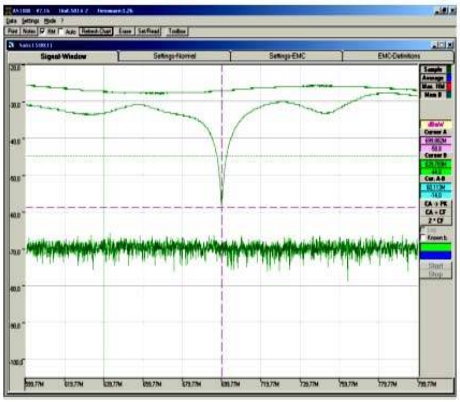
$$VSWR = \frac{1+|r_n|}{1-|r_n|}, \text{ where } r_n = 1, 2, 3. \quad (12)$$



(a)



(b)



(c)

$$U1 = Ur \cdot 10^{\frac{r1}{20}} [mV] = 0.2236 \cdot 10^{\frac{-30}{20}} = 0.2236 \cdot 0,031 = 0.007 [mV]$$

$$U0 = Ur \cdot 10^{\frac{r0}{20}} [mV] = 0.2236 \cdot 10^{\frac{-75}{20}} = 0.2236 \cdot 0.00017 = 0.000039 [mV]$$

$$\Delta U_r = U1 - U0 = 0.00697$$

$$x = \frac{\Delta U_r}{100} (mV/div) = 0.0000697 (mV/div)$$

$$U_{banda1} = Ur \cdot 10^{\frac{dBvf}{20}} = 0.2236 \cdot 10^{\frac{-46.4}{20}} = 0.2236 \cdot 0.004 = 0.00107$$

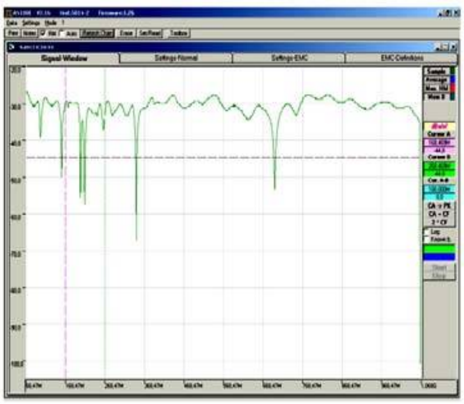
$$k = \frac{U_{banda1} - U0}{x} = \frac{0,00107 - 0,000039}{0,0000697} = 14.92$$

(d)

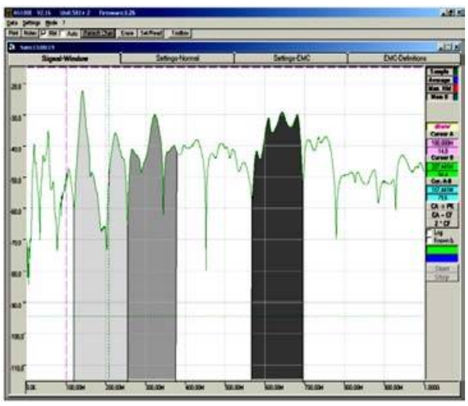
FIG. 5. Reflection coefficient variation: (a) 107-307MHz;
(b) 247.2-447.2MHz; (c) 599.7-799.7MHz; (d) The calculation procedure (Γ=k/100).

Table 1 - Reflection coefficient variation and standing wave ratio.

	Frequency band #1 f_1 = 208,628MHz	Frequency band #2 f_2 = 348,046MHz	Frequency band #3 f_3 = 699,892MHz
Γ - reflection coefficient (k/100)	0.1492	0.06269	0.026839
VSWR - voltage standing wave ratio	1.3507	1.1429	1.0585



(a)



(b)

FIG. 6. VSWR variation (a) and reception diagram with afferent frequency bands (b).

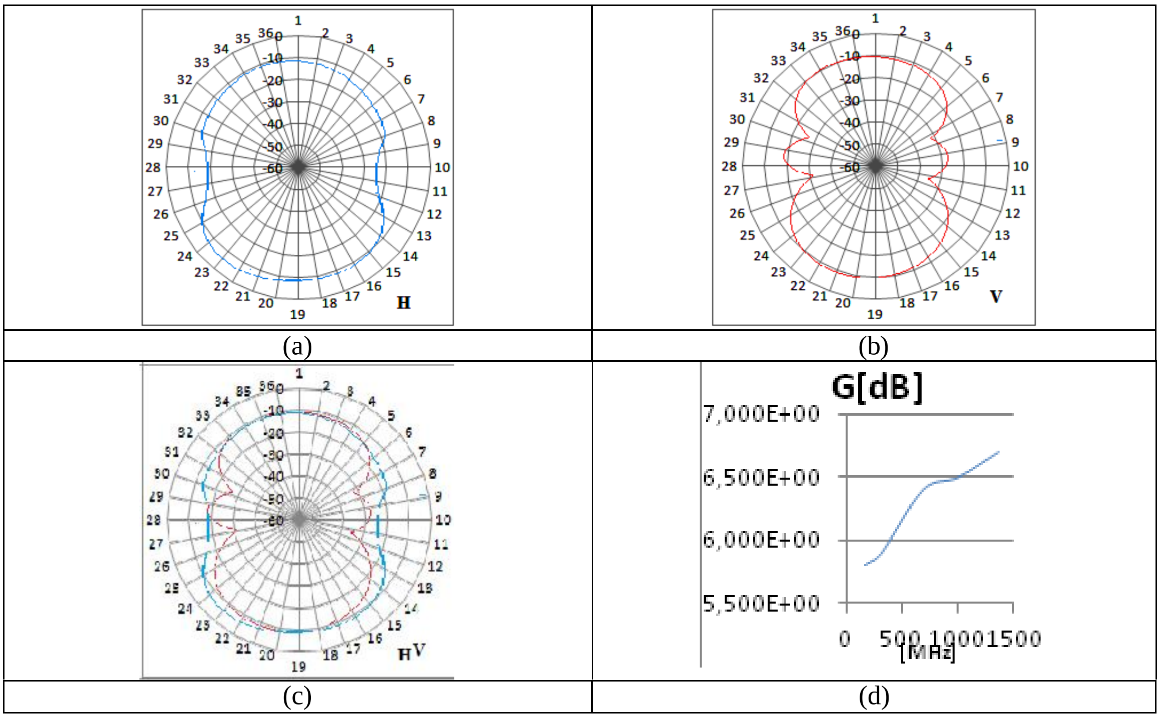


FIG. 7. Fractal stripline antenna with combined elements: (a) Directivity diagram - horizontal polarization; (b) Directivity diagram - vertical polarization; (c) Directivity diagram; (d) Antenna gain.

CONCLUSIONS

Fractal stripline antenna with combined elements at issue belonging to the class of fractal antennas (theoretically independent of frequency antennas) operate in 140MHz - 2.2GHz frequency band with a 6.5dB medium gain.

Note that the standing wave ratio and reflection coefficient decreases with increasing the frequency.

This fractal antenna operates in circular and vertical / horizontal polarization with small differences. Due assessment results, fractal stripline antenna with combined elements can be used in base stations of mobile telephony systems, in RFID systems and wherever it is necessary a microwave broadband communication.

REFERENCES

[1] S. Best, *A Comparison of the Resonant Properties of Small Space-Filling Fractal Antennas*, IEEE Antennas and Wireless Propagation Letters 2 (1), p. 197–200, 2003;

[2] Morariu, G., Alexandru, M., Miron, M., Romanca, M., Machedon-Pisu, M., Dobrescu, A. *Experiment-supported Study on the Bipolar Disk Microstrip Antenna*, DAAAM International Vienna, Austria, Annals of DAAAM & Proceedings, 2009;

[3] R. Kumar and P. Malathi, *On the Design of CPW- Fed Ultra Wideband Triangular Wheel Shape Fractal Antenna*, IJMOT, vol. 5 no. 2, p. 89-93, 2010;

[4] R. Kumar, K. K. Sawant, *On the Design of Circular Fractal Antenna with UShape Slot in CPW-Feed*, Wireless Engineering and Technology, no.1, p. 81-87, 2010;

[5] J. Pourahmadazar, C. Ghobadi, J. Nourinia, *Novel Modified Pythagorean Tree Fractal Monopole Antennas for UWB Applications*, New York, IEEE, 10.1109/LAWP.2011.2154354, 2011;

[6] R. Kumar and Prem Narayan Chaubey, *On the Design of Tree-type Ultra Wideband Fractal Antenna for DS-CDMA System*, Journal of Microwaves, Optoelectronics and Electromagnetic Applications, Vol. 11, no.1, p. 107-121, 2012;

[7] Morariu, G., Miron M., *Fractal Sector Stripline Antenna with Disks*, Review of the Air Force Academy, vol. XII, no. 3(27), 2014.