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SDARS Antenna

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***Abstract* – This paper examines the possibility for the design of a market-oriented antenna with circular polarization. The advantages of the suggested structure are cost-efficiency and simplicity of production compared to traditional ones (thick, high-epsilon antennas). The possibilities for its integration in GPS systems are also discussed.**

***Keywords* – Fractal Antenna, Circular polarization, SDARS, GPS**

I. Basic principles

SDARS (Satellite Digital Audio Radio Service) is currently operated by Sirius and XM radio. The system operates at 2.320-2.345 GHz (S-band) on Left Hand Circular Polarization (LHCP). The main engineering methods to achieve circular polarization are excitation of 2 modes in the printed resonator (H10 и H01). Some of the configurations shown on fig (1) are used for that purpose. In case 1a, the length of the patch is equal to its width. In the far field a linear polarization will be formed, sloped at 45 degrees. To ensure a circular polarization it is essential to provide a phase shift of 90 deg between these two orthogonal modes. Using non-exact resonant length of the sidewalls ensures this shift, so the L size is a bit longer than the resonant length and the W size is a bit shorter. This nearly square geometry gives +45 and -45 deg phase shift of the resonant modes and guarantees circular polarization in the far field zone of the antenna [1].

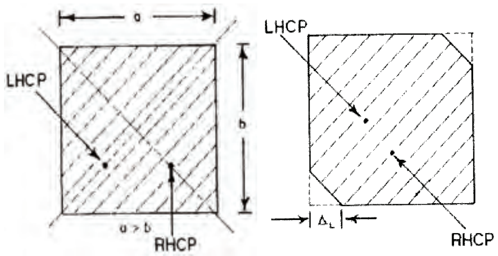

Fig. 1. Figure example

In case 1b, the circular polarization is created by two orthogonal modes, excited in the diagonals of the square. This effect (and 90 deg phase shift) can be explained with the reduction of distributed capacity on both sides of radiating edges. The tapered diagonal is characterized by much more inductive impedance. With variation of the area of the cut ΔS, the ratio E_x/E_y can be adjusted [3].

II. Fractal shapes

The use of a fractal structure is a basic way for reducing antenna size. Given the same frequency fractal antenna, size can be reduced up to less than 45% of the original size. On Fig2. a fractal Koch island form 0-th , fist and second order is presented. It is quite easy to see the change in the resonator size, with no change in the frequency. A reduction of 75% appears in fractals of second and third order. The second conclusion is that there is no size advantage from using higher order fractals (Higher than first order).[2].

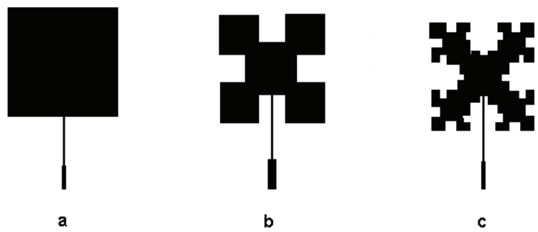

Fig. 2. Generation process of Koch island. (b, c – first and second order)

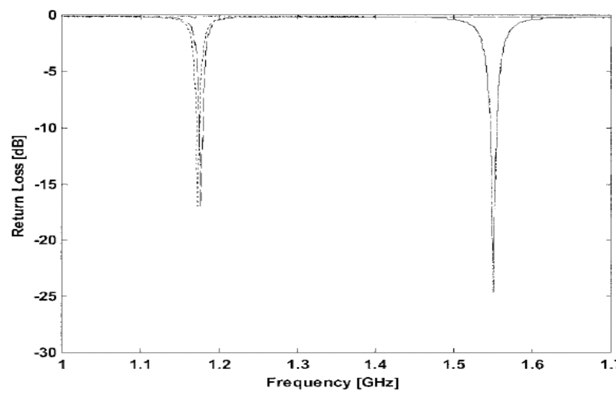

Fig. 3. Return loss of Koch island. (Solid line - 0 order, dashed lines – first and second order)

III. Results

To form a circular polarization in a fractal antenna, a higher order fractal is used for changing corner capacity. Actually, in that case the capacity increases, in spite of the trend described in the case on Fig. 1b. By changing the fractal order and fractal dimension a proper axial ratio can be adjusted

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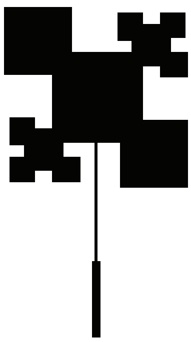

Fig. 3. Proposed design of Circular polarized fractal antenna

The main rule of thumb for producing circular polarization is the area affected of fractalization should be in some definite ratio to the area of initial patch. (Eq.1). In that ratio Q_0 is the quality factor of the patch antenna before fractal changes to be applied. Fractal dimension could be not only a integer number, but also a fraction. This will affect the fractal geometry and gives opportunity for "fine tuning" the shape on the desired frequency.In other words changing both - the fractal size and fractal dimension could be achieved the necessary distributed capacity with shape on proper size and resonating on proper frequency. Such procedure is presented on Fig. 4.

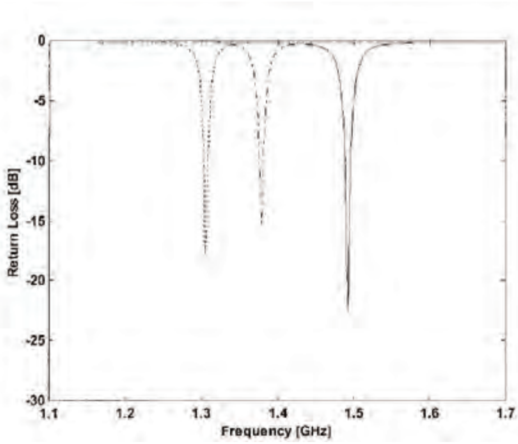

Fig. 4. Tuning of fractal shape by change of fractal dimension. (Solid line – 0.6, dashed lines 0.77 and 2.0)

The use of fractal shapes has one major disadvantage – the bandwidth became narrower with the increase of fractal order. In that exact application this will not be a problem, because SDARS and GPS signals are narrowband enough and antenna properties will not affect the system performance. Because of that reason matching with quarter wave transformer has been used also.

$$\frac{\Delta S}{S} = \frac{1}{2Q_0} \tag{1}$$

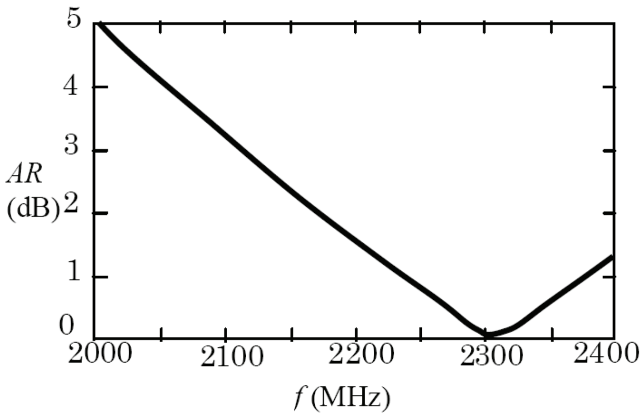

Fig. 4. Axial ratio of the Fractal CP antenna

The simulated axial ratio diagram is presented on Fig.4. Cross-polarization discrimination is maintained in sufficient levels in wide frequency range. Anyway this parameter depends on receiving direction and polarization purity became worse for direction different than main one. For proper functioning of the system it is essential no services to operate on the opposite polarization.

IV. CONCLUSION

In this paper, the Koch island microstrip patch antenna is proposed. Fractal shape is used in order to reduce antenna size and maintain dielectric permittivity in reasonable values. This patch antenna has a lower resonant frequency compared to the zero-th iteration patch, and this property contributes to the reduction in antenna size. Main advantage of proposed design is significant lower cost than the ordinary high-epsilon antennas and possibility for mass production from inexpensive substrates that can be found on the market. Additional advantage is the increase of antenna efficiency because of lowering the dielectric permittivity. There is also decrease in fringing fields and edge leaking of surface waves. This antenna is intended mainly for automotive industry.

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