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Fractal Aperture Antenna for Wi-Fi Application

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ABSTRACT

A new model of fractal geometry for microstrip patch antenna is presented in this paper. The current fractal structure is implemented on patch aperture by placing slots in a systematic order. A commercial substrate material of RT-duroid is chosen with dielectric constant of 2.2 and loss tangent of 0.009. The dimension of the patch aperture is 56.7X42.9 mm. The simulated results show that the antenna is resonating at 2.6 GHz and 2.8 GHz, which comes under Wi-Fi application and a very good performance, is observed with respect to impedance bandwidth return loss, field distributions and radiation pattern.

Introduction

In the study of antennas, fractal antenna theory is a relatively new area. However, fractal antennas and its superset fractal electrodynamics is a hotbed of research activity. In the research journals, we see reports of active research covering such diverse areas of fractal electrodynamics as the study of scattering from fractal surfaces i.e. a signature of the surface is imprinted within the scattered field to the study of the radiation from lightening. A fractal is a rough or fragmented geometric shape that can be subdivided in parts, each of which is (at least approximately) a reduced-size copy of the whole. Fractals are generally self-similar and independent of scale [1-2]. There are many mathematical structures that are fractals; e.g. Sierpinski's gasket, Cantor's comb, von Koch's snowflake, the Mandelbrot set, the Lorenz attractor, et al. Fractals also describe many real-world objects, such as clouds, mountains, turbulence, and coastlines that do not correspond to simple geometric shapes [3].

Fractal antenna theory is built, as is the case with conventional antenna theory, on classic electromagnetic theory. Fractal antenna theory uses a modern (fractal) geometry that is a natural extension of Euclidian geometry. The effects of electromagnetic waves on fractal bodies have been intensively studied in recent years. Different from Euclidean geometries, fractal geometries have two common properties, space-filling and self-similarity. Self similar objects look roughly the same at any scale [4-5]. Thus, in an antenna with fractal shape, similar surface current distributions are obtained for different frequencies. The space filling property, when applied to an antenna element, leads to an increase of the electrical length. The more convoluted and longer surface currents result in lowering the antenna resonant frequency for a given overall extension of resonator. Therefore, given a desired resonance frequency, the physical size of the whole structure can be reduced [6].

Antenna Model and Dimensions: Figure 1 shows the fractal aperture antenna with multiple number of slots in a systematic manner. The current model is designed and simulated using commercial EM Simulator HFSS. HFSS can link field data between multiple HFSS models to capture the entire behaviour of the Antenna system from transmitter to receiver. The applications of HFSS are Antenna systems, advanced package co-design for single and multi-chip integration, On-chip passives and High-speed packages and interconnect. The dimensions of the antenna includes 56.7X42.9X1.6 mm. Feed location along Y-axis at 14.3 mm and feed length of 11.9 mm with coaxial inner radius of 1.19 mm and outer radius of 4 mm.

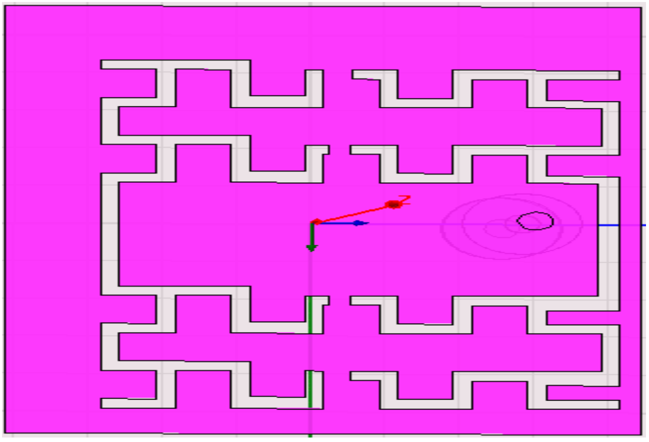

Figure 1. Fractal Antenna Model

Results and Analysis:

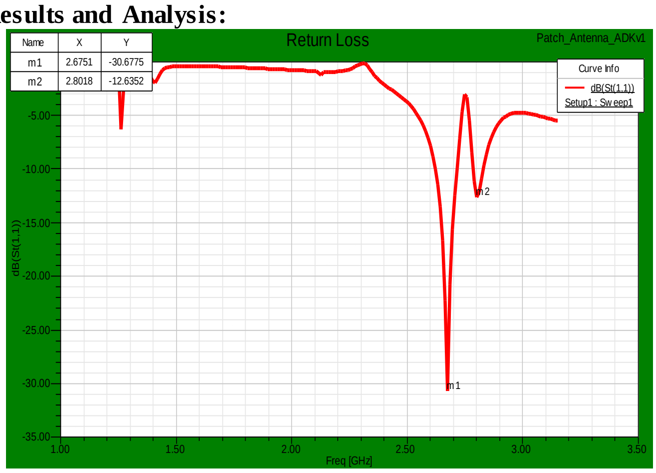

Figure 2. Return loss Vs Frequency

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The proposed antenna is resonating at dual band with return loss of -30.67, -12.63 dB at 2.6 and 2.8 GHz. Gain of more than 7 dB is obtained at resonating frequencies.

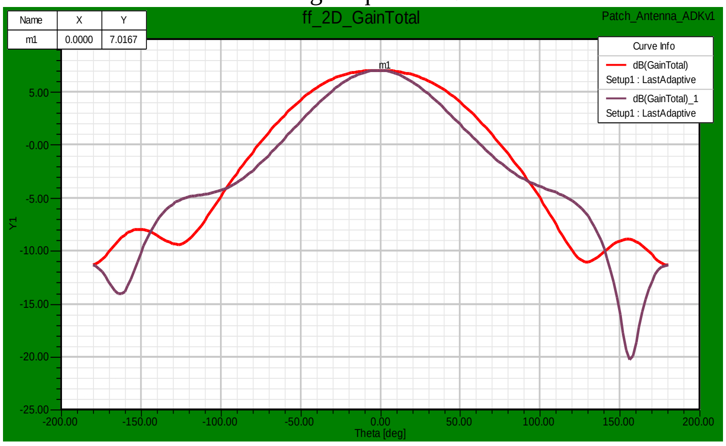

Figure 3. Gain Curve

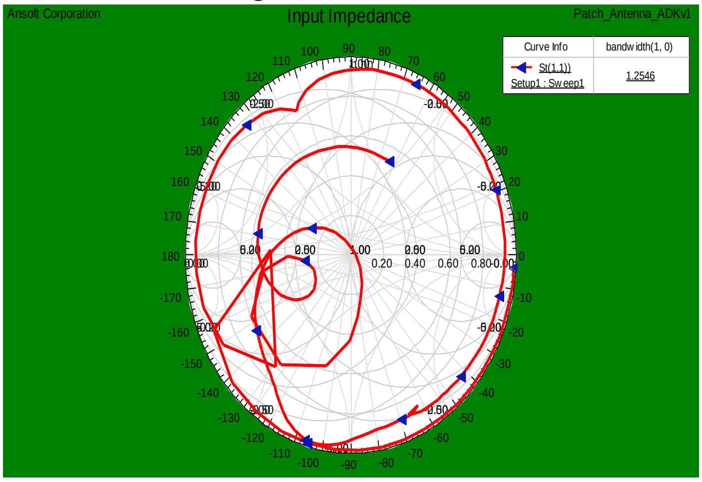

Figure 4 Input Impedance smith chart

Input impedance smith chart is shown in figure 4. Bandwidth of 0.75% is attained from the current model. Figure 5 and 6 shows the E-Field, H-Field and Current distribution of the proposed model at both the resonating frequencies 2.6 and 2.8 GHz.

$$E_\theta(r,\theta,\phi) = -2wh\left(\frac{E_0}{\eta_0}\right)\cos\phi(1-T^{TM}(\theta))\cos\left(k_x\frac{L}{2}\right)\mathrm{sinc}\left(k_y\frac{w}{2}\right)\mathrm{tanc}(k_{z1}h)$$

$$E_\phi(r,\theta,\phi) = 2wh\left(\frac{E_0}{\eta_0}\right)(\cos\theta\sin\phi)(1-T^{TE}(\theta))\cos\left(k_x\frac{L}{2}\right)\mathrm{sinc}\left(k_y\frac{w}{2}\right)\mathrm{tanc}(k_{z1}h)$$

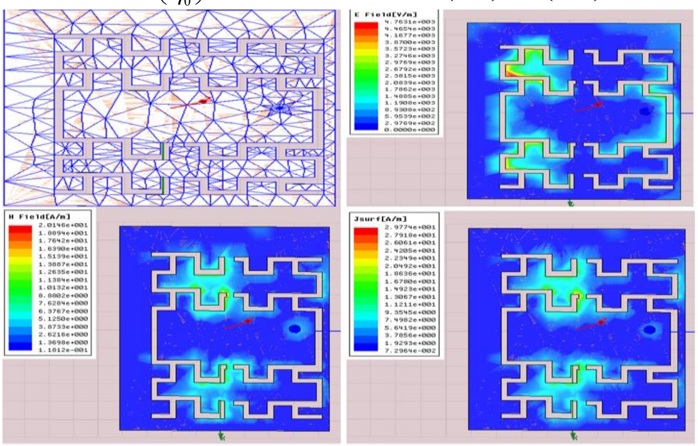

Figure 5 a)FEM Based Mesh Generation b) E-Field Distribution
c) H-Field distribution d) Current Distribution at 2.6 GHz

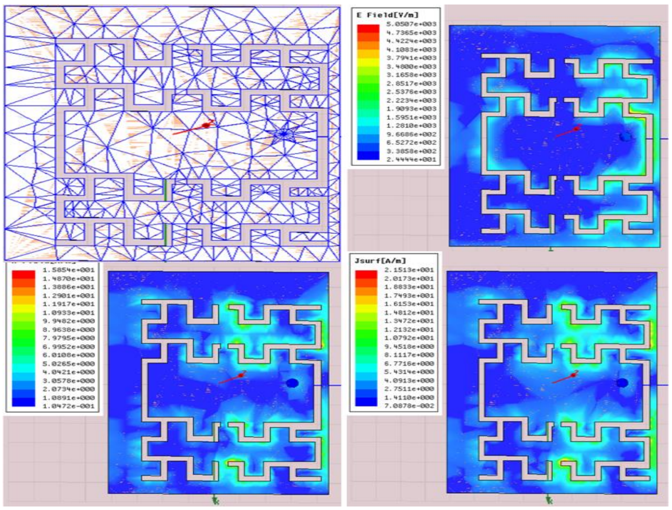

Figure 6 a)FEM Based Mesh Generation b) E-Field Distribution
c) H-Field distribution d) Current Distribution at 2.8 GHz

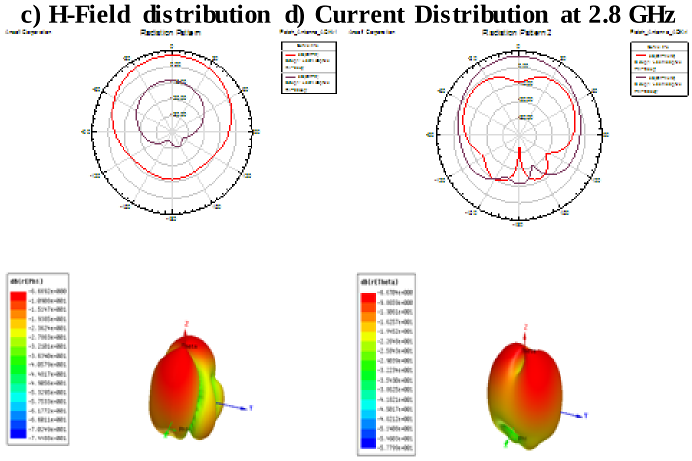

Figure 7 Radiation Pattern in XY plane and XZ plane at 2.6 GHz

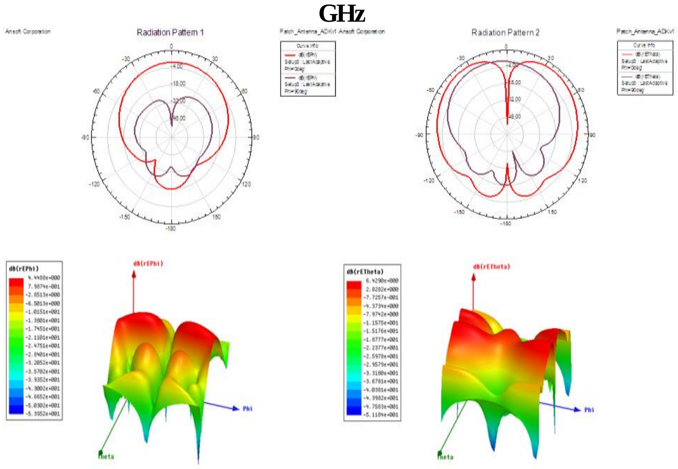

Figure 8 Radiation Pattern in XY plane and XZ plane at 2.8 GHz

For each mode, there are two orthogonal planes in the far field region. One designated as E-plane and the other designated as H-plane. The far zone electric field lies in the E-plane and the far zone magnetic field lies in the H-plane. The patterns in these planes are referred to as the E and H plane patterns respectively. Figure 7 and 8 shows the radiation pattern in XY and XZ plane.

Conclusion: Fractal aperture dual band antenna is designed and simulated results are presented in this paper. The current model is having equal spaced slots on the patch aperture with systematic distribution. This antenna is resonating at 2.6 and 2.8 GHz with gain of more than 7 dB and return loss less than -10 dB. Impedance matching of 50 ohms is attained at the port and bandwidth of 0.75% is obtained. The radiation pattern and field distributions are giving strong support towards the applicability of this antenna in the wireless communication applications.

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