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Analysis and Design of Triple Band Compact Microstrip Patch Antenna with Fractal Elements for Wireless Applications

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Abstract

This paper presents the design of triple band compact microstrip patch antenna with fractal elements. The antenna has been designed on FR4 substrate with thickness 1.6mm, dielectric constant 4.4 and resonant frequency of antenna is 3.2GHz. Gain of antenna is improved by addition of fractal elements to the nine corners of the nonagon patch. Introduction of fractal elements improved the gain from 1.24dB to 7.96dB and miniaturization takes place due to the decrease in resonant frequency from 3.38GHz to 2.88GHz on increasing the iteration number. The three iterations of antenna is designed and simulated by using HFSS V13 software and the designed antennas covers the frequency bands of WLAN, WiMax and other wireless applications which comes under the frequency ranges of S-band, C-band and X-band.

Keywords: HFSS; fractal elements; WLAN; nonagon patch.

1. Introduction

There is a large demand of antennas which can operate on multi-frequency bands due to their major role in the field of wireless communication system [1]. According to the large demand of compact antenna the microstrip antenna gain momentum due to its many attractive features such as low-profile, low cost, light weight, ease of installation etc [2]. In modern communication system there is a need of multiband, wideband and compact antenna which can be fulfilled by designing the microstrip antenna and fractal antenna which has all the features of wireless communication systems [5]. Large number of techniques has been proposed to design the different types of antennas for wireless applications [2]. Different shapes of antennas has been designed for different wireless applications which can be operate in the frequency band of the desired applications of antenna, WLAN antennas are designed to

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operate in the frequency range of 2.4-2.48GHz, 5.15-5.35GHz and 5.75-5.82GHz and WiMax antennas are designed to operate in the frequency range of 2.5-2.69GHz, 3.5GHz and 3.4-3.6GHz [4].

Fractal antennas concept was put forwarded in 1995 by Nathan Cohen. The space-filling and self similarity properties of fractal antennas are used to achieve wideband and multiband characteristics and can be used for various wireless applications [6]. The elements of fractal antenna allow it to have different resonances. The discontinuities in the shape of fractal antenna increase the radiation property and bandwidth [7]. Many different shapes of fractal antenna have been designed so far such as sierpinski carpet fractal antenna [8], Koch- curves and sierpinski gasket [9]. In this work the design of polygon shape microstrip patch antenna witch fractal elements has been designed and various parameters such as return loss, VSWR and gain are simulated by using the HFSS V13 software.

2. Antenna Design and Configuration

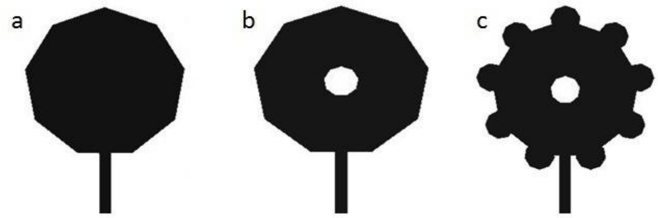

Figure 1: (a) 0th (b) 1st and (c) 2nd iteration of proposed antenna

The three iterations of designed antenna called nonagon antenna are shown in Figure 1. The resonant frequency of designed antenna is 3.2GHz and antenna consists of line feed, polygon patch and the small fractal elements which are printed on the one side of substrate. The small fractal elements are attached on the patch and the technique of adding the fractal element on the patch is shown in Figure 2. Proposed antenna is simulated on FR4 epoxy substrate with thickness 1.6mm and the relative permittivity of 4.4 by using the HFSS version 13 software. Radius of patch element is calculated by using equation (1) to (4) and is found to be 12.6mm. The schematic diagram of proposed antenna is shown in Figure 3 and its parametric values are given in Table 1.

$$a = F\left\{1 + \frac{2h}{\pi F \varepsilon_r}\left[\ln\left(\frac{\pi F}{2h}\right) + 1.7726\right]\right\}^{-\frac{1}{2}} \tag{1}$$

Where F can be calculated by using

$$F = \frac{8.791\,X\,10^9}{f_r\sqrt{\varepsilon_r}} \tag{2}$$

$$f_r = \frac{1.8412c}{2\pi a_e\sqrt{\varepsilon_r}} \tag{3}$$

The effective radius of antenna is calculated by the equation given by:

$$a_e = a\left\{1 + \frac{2h}{\pi a \varepsilon_r}\left[\ln\left(\frac{\pi a}{2h}\right) + 1.7726\right]\right\}^{\frac{1}{2}} \tag{4}$$