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Sierpinski Carpet Patterned Rectangular Dielectric Resonator Antenna for X-Band Application Using Teflon

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Abstract—This paper presents a wideband Sierpinski carpet fractal patterned rectangular Dielectric Resonator Antenna (DRA) operating in the X-band, which is characterized by dielectric waveguide model method (DWM). In order to decrease the cost of the DRA the low-cost teflon is used as the material. A prototype is realized to validate the results of the simulation. The paper provides a comparison between conventional rectangular DRA and fractal shaped rectangular DRAs of the first and the second iterations. The antenna design methodology is discussed along with its resonance and radiation characteristics. The validity of the obtained results is proved by the close match of the experimental and simulation results. The measurements on prototype show impedance bandwidth of 48% covering the entire X-band with similar radiation pattern throughout the band with a gain of 7.5 dBi over 9.0–11.5 GHz.

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1. INTRODUCTION

Present and future wireless communication systems need antennas capable of supporting higher data rates and increased user densities. The researchers have renewed interest in the development of wideband and multiband antennas, including multiple antennas, usually with the same characteristics, that are physically separated from each other. This is beneficial for the mobile communication industry since it allows multiple users to share a limited communication spectrum and avoid co-channel interference.

Due to their small size, planar microstrip antennas are the common choice as radiators in mobile communication devices. Ohmic and surface wave losses increase with frequency in case of the microstrip antenna. Besides, they are inherently narrowband. On the other hand, dielectric resonator antenna (DRA) proposed in 1983 [1], has several advantages like low ohmic loss (due to the absence of conductors), low cost, small size and wider bandwidth when compared to microstrip antennas [2]. Its resonant frequency is a function of size, shape and material permittivity.

Traditional mono-modal DRAs were not suitable for wideband application due to their bandwidth limits. The major problem of DRA in comparison to microstrip antenna is its lower gain. Therefore, engineered configurations had been proposed to enhance their gain [3] and bandwidth [4–7].

Drilling off a tunnel in a rectangular DRA reduces the Q-factor and hence improves the impedance bandwidth [8]. Coulibaly et al. achieved broadband using microstrip-fed dielectric resonator antenna for X-band [9]. This antenna suffers from periodic mismatch, particularly at high frequency end. However, the air-gap introduced due to the tunnel adversely affects the resonant frequency and impedance characteristics [10–13], when the volume of the dielectric is low in X-band frequencies and above. Also, air gaps usually produce undesired effects on the antenna characteristic impedance [14]. Use of liquids has been suggested to avoid air-gap losses [15].

Broadband antennas have also been obtained by exploiting the self-similarity property of fractal geometry [16]. Authors have reported preliminary findings of using fractal geometry in DRA [17, 18] for extending the bandwidth. Simulated study on modifying the boundary of rectangular DRA using fractal concept has also been reported for WiMAX application [19].

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