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Quad-Band EBG Integrated Monopole Fractal Antenna for Wearable Purpose

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Abstract—This paper is about fractal antenna used for wearable applications. This paper describes about the performance of antenna, based on fractal geometry, on body conditions, for wearable applications. We know that as the practical shape or size of the antenna varies, the electrical parameters also get disturbed and may change. That's why we discuss all the possible distractions for various conditions.

Keywords—*Antenna, Fractal Antenna, Wearable Antenna, On-Body Antenna*

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1. INTRODUCTION

As we all know that in today's world demands for new inventions and technologies have been arrived so rapidly that it becomes very important to transform old technologies into new versions. As we know it is a bit hard to carry an extra device with us everywhere so we implant antennas in our clothes. This makes antennas as wearable as well as easy to carry anywhere. As the demand for high radiation power is increases with small size conditions, thus we combine fractal geometry technology with antenna designing. This makes antenna of small size with the capability to radiate a high range of power also.

These types of antennas may widely used in military, police, medical and commercial applications. As the demand for wearable antennas are increasing, various standards are established for in-body, on-body and off-body antenna techniques. In the in-body antenna techniques antenna is inserted inside the body of a living beings. This technique is already in use for tracking locations of various animals in national parks, sanctuaries, for keeping information about various aqua life and many more.Whereas, off-body antennas are in usesince a long time for transmission and reception of information. Now a day a new technique called on-body antenna technique is being widely used.

For wearable purpose an antenna should be in small size and may be capable of transmitting and receiving a high range of radiated power. That's why we use fractal geometry technique for designing wearable antenna. Fractal technique is a kind of technique in which self-similarity geometry is being used instead of using arrays of antennas for high radiation power. For making operating frequency highly inefficient, the size of the antenna is made smaller than operating frequency. And as the stored reactive energy increases rapidly, radiation resistance of antenna decreases in the same proportion. For more efficiency fractal design is used.

Wearable antenna should be fabricated on such type of material which could easily compliment the characteristics of the antenna. The material for textile use must possess some qualities like low cost, highly comfortable, should be lossless and easily available in the market.

2. DESIGN CONSIDERATIONS

2.1. Fabric Characterization

Permittivity and loss tangent for semi solid materials can be determined by various techniques. Some of them are Cavity Perturbation method, Mom-segment method, Resonance method,Transmission line and Open Ended Coaxial Probe method.For denim jeans relative permittivity is 1.7 and loss tangent is 0.085 [1]. This characteristic is measured by using the open ended coaxial probe method.

To determine the actual dipole length of the antenna effective permittivity is required. By using close form method instead of conventional method, effective permittivity is measured [2].

$$\varepsilon_{eff} = 1 + \left(\frac{\varepsilon_r - 1}{2}\right)\frac{K_2}{K_1} \quad (1)$$

$$K_1 = K(k_1) / K'(k_1) \quad (2)$$

$$K_2 = K(k_2) / K'(k_2) \quad (3)$$

ε_r = relative permittivity of substrate.

When $l_{ed} > h$ and $l_{ed} >> s$, the values of k_1 and k_2 can be approximated by

$$k_1 = \frac{l_{ed}}{l_{ed} + 2s} \quad (4)$$

$$k_2 = e^{-\pi s}/_{(2h)} \quad (5)$$

l_{ed} = the dipole length estimation
s = the gap between dipole arm
h = the thickness of substrate

2.2. Antenna Design Consideration

To obtain fractal geometry, one starts with a rectangle of area A, called the zeroth iteration. The first iteration is constructed by adding a rectangle of halfthe area (A/2) to three sides of the first rectangle and cut out the rectangle of half the area from the same. As quad-band operation was required, the first iteration wasused as the radiating element. In order to tune the frequency to required bands, slight changes in dimensions were done to the first iteration. The dimension details of the monopole antenna are depicted in Fig. 1.The process is reused in the generation of higher iterations [3, 4]. In this work we take Zeroth iteration area as 90X57 mm^2.

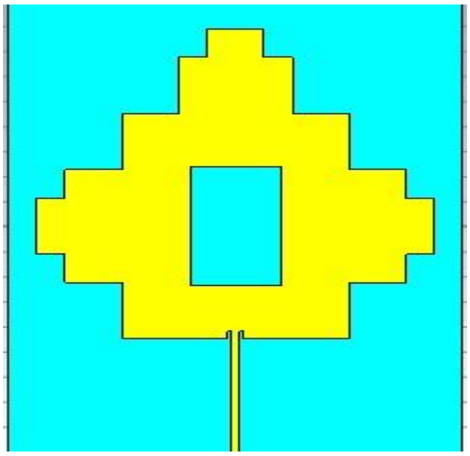

Fig. 1 Designof Fractal Antenna

The antenna is backed with a 3X3 EBG array of dimension 150X150 mm^2. The dimension of the unit cell is depicted inFig. 2. The substrate material used for EBG is also jean fabric.

The unit cells and the ground plane are made of copper sheets. The entire EBG structure acts as a band-reject filter at GSM-1800 MHz and ISM-2.45 GHz bands. This correspondsto the transmission coefficient response for the EBGobtained using the suspended line method.

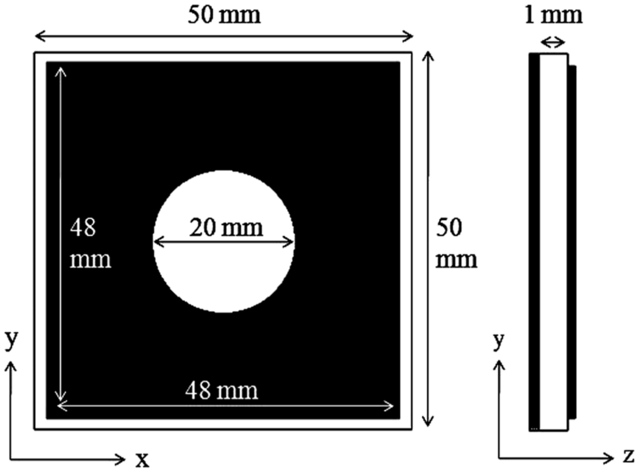

Fig. 2 Dimensions of EBG unit cell

3. RESULT

A thin foam layer of thickness 2 mm is placed between the antennaand the EBG array. This is done to prevent contact betweenthe antenna's edge connector and the EBG elements. Thefabricated prototype is tested using ENA Series E5070A 2portRF Network Analyser [5,6]. The S_{11} plot for this work is shown in Fig. 3.

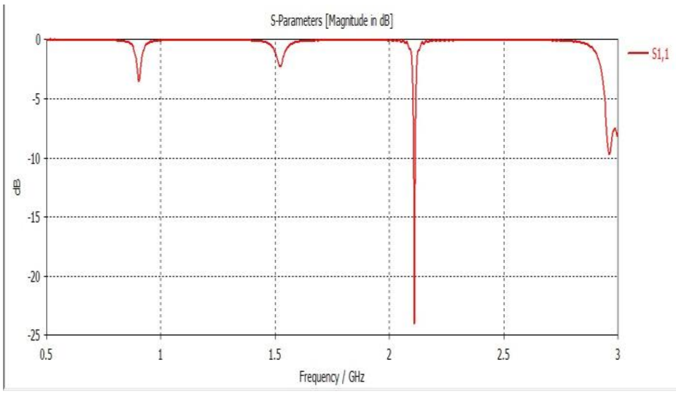

Fig. 3S_{11} Plot for Designed Antenna

CONCLUSION

In this paper we have studied about various conditions which wearable antenna has to be gone through. Thus by taking an overview of those conditions we can design a wearable fractal antenna with high accuracy and high safety.This paper gives us idea about the increase in radiation as the iteration of the antenna increases. So we can conclude that as we increase the iterations of the fractal geometry, the frequency use and the radiation range will increase.

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