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Design And Analysis Of Koch Fractal Wearable Antennas With Jean Substrate

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Abstract— This paper presents the design and development of Koch fractal dipole antenna for wearable applications at 5.25 GHz. Common jeans cotton is used as a flexible substrate material having a dielectric constant of 1.6 for the design and fabrication of the proposed antenna. Increasing the number of iterations increases the number of sections, which eventually results in 120% reduction in size. Size miniaturization is obtained using second iteration Koch geometry with the antenna bandwidth of 10%, and the return loss of −20.02 dB is achieved under the flat condition. The investigations are to characterize the antenna in flat condition.

Keywords — : *Fractal, wearable Antenna,*

I. INTRODUCTION

Wearable antenna bonds cloth into the communication system, making electronic devices less obtrusive. Recently, wearable antennas find profound applications: assistance to emergency services such as police, paramedics and fire fighters, military applications including soldier location tracking. In addition, it is used for image and video transmission for instant decentralized communications, access/identification systems by identifying individual peripheral devices, navigation support in the car or while walking, pulse rate monitoring, RFID applications, in sports, etc.

In supporting the increasing interest in antennas and propagation research for body communication systems, the IEEE 802.15 standardization group has been established to standardize applications intended for on-body, off-body or in-body communication. Body worn systems with new generation of clothing endowed with sensing, processing, actuation, communication, energy harvesting and storage abilities are emerging as a solution to the challenges of ubiquitous monitoring of people in applications such as health care, lifestyle, protection and safety . Wearable antennas designed for military applications should meet the following requirements: thin, lightweight, low maintenance, robust, conformal, easy integration into clothing and should not affect the movement of the soldier.

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Wearable antennas are realized using flexible substrate materials, and they are made up of textile and electro textile materials. Textile materials must be inexpensive, comfortable, lossless and easily available in the market. In four decades, many researchers have developed flexible wearable antennas using different textile materials such as flannel fabric, felt fabric, cotton. Gupta et al. reported electrical properties of different substrate materials such as jeans cotton, poly cotton, Shield It fabric and jean fabric, in the frequency range of 0.3–3 GHz.

The major challenge in the design of wearable antenna is the size reduction, especially one resonates at single or multiband frequencies. Self-similarity of the fractal geometry can be used for size reduction with multiband characteristics. Von Koch introduced the Koch geometry in 1904, and it can be designed using an iterative function system by a set of affine transformation. Fractal shaped dipole antennas with Koch curves are generally fed at the centre of the geometry. By increasing the fractal iteration, the length of the curve increases, reducing the resonant frequency of the antenna. These geometries have a large number of tips and corners, a fact that helps to improve antenna efficiency. Several other self-similar geometries, Sierpinski gaskets, Koch curves, Minkowski curves, Sierpinski carpets, are the fractal shapes widely used in antenna design to obtain multiband or broadband miniaturized antenna.

II. PROPOSED SYSTEM

The proposed project has second iteration Koch fractal antenna with Jean substrate material. Size miniaturization is obtained results in 120% reduction in size using second iteration Koch geometry. The return loss of −20.02 dB is achieved under the flat condition at frequency 5.25GHz. The Koch antenna is designed for the frequency band of 3GHz-6GHz. Maximum gain of 20.80dB is achieved using Koch antenna.

III. IFS FOR KOCH

The first iteration for the Koch curve consists of taking four copies of the unit horizontal line segment, each scaled by $\mathbf{r} = 1/3$. Two segments must be rotated by 60°, one counterclockwise an/d one clockwise in Figure . Along with the required translations, this yields the following IFS.

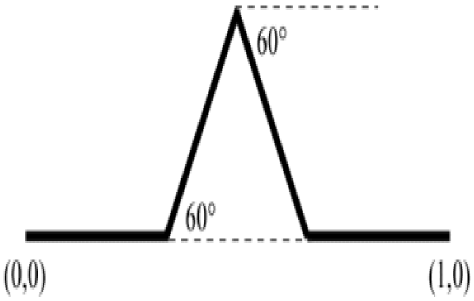


Figure 4.1 Counterclockwise and clockwise rotation

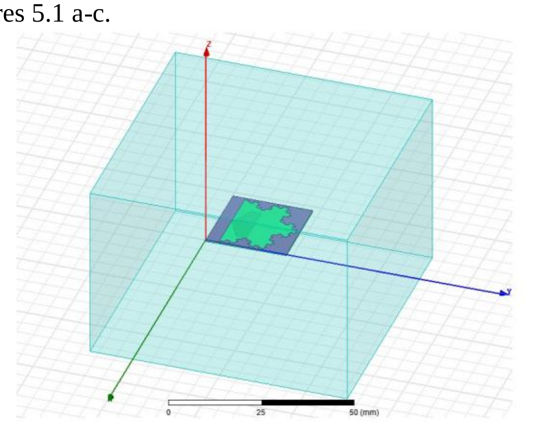
$$f1(x)=\begin{bmatrix}\frac{1}{3} & 0\\ 0 & \frac{1}{3}\end{bmatrix}x \quad scale\ by\ r$$

$$f2(x)=\begin{bmatrix}1/6 & -\sqrt{3}/6\\ \sqrt{3}/6 & 1/6\end{bmatrix}x+\begin{bmatrix}\frac{1}{3}\\ 0\end{bmatrix} \quad scale\ by\ r, rotate\ by\ 60^{\circ}$$

$$f3(x)=\begin{bmatrix}1/6 & \sqrt{3}/6\\ -\sqrt{3}/6 & 1/6\end{bmatrix}x+\begin{bmatrix}\frac{1}{2}\\ \sqrt{3}/6\end{bmatrix} \quad scale\ by\ r, rotate\ by\ -60^{\circ}$$

$$f4(x)=\begin{bmatrix}\frac{1}{3} & 0\\ 0 & \frac{1}{3}\end{bmatrix}x+\begin{bmatrix}\frac{2}{3}\\ 0\end{bmatrix} \quad scale\ by\ r$$

For the design of Koch antenna , Jean cloth(Roger RT Duroid) is considered as substrate and Copper is used for Koch structure. This layout of the Koch antenna is drawn using HFSS software. The overall area of the wearable Koch antenna is reduced to 26mm from 220mm.The Koch antenna is designed for the frequency band of 3GHz-6GHz.The original layout view and rotated layout view are shown in figures 5.1 a-c.



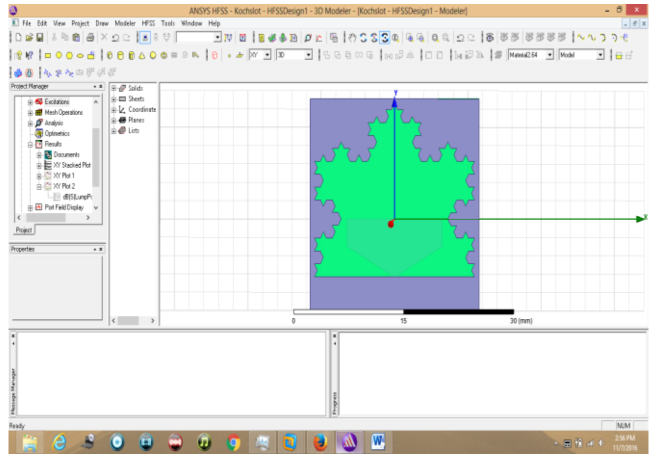


Figure 5.1 Design of Koch fractal antenna

Antenna Dimension	Koch fractal II iteration dipole
Length (mm)	26
frequency (GHz)	6
Return loss (dB)	−20.02
length reduction	120%

Feed Line

The trapizoidal shape feed line is used for the designed antenna.

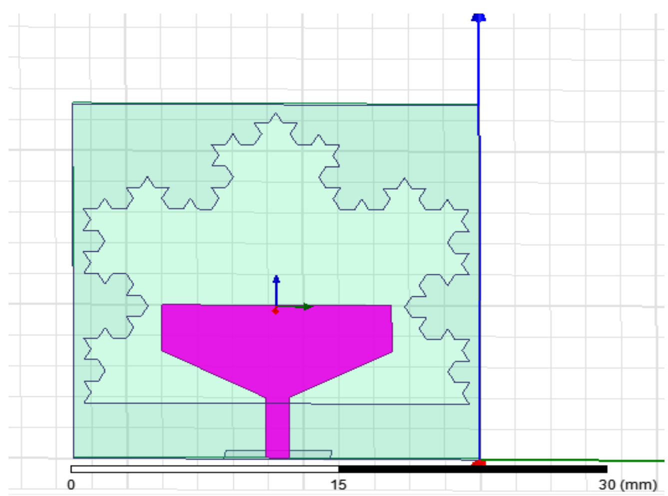
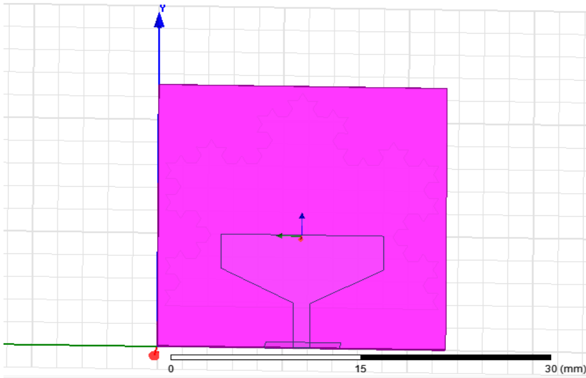


Figure 5.2 Feed Line

Ground

The cotton is considered as ground plane which is shown in figure 5.3.



Return Loss

The s-parameter is calculated using HFSS and the return loss value from the figure 5.4 is -20.02 dB at the frequency 5.25GHz .This shows that this value is very low and all the signals are transmitted in the forward direction.3 dimension and 2 dimension views are shown in figures 5.4a ,5.4b.

Figure 5.4 (a) Return loss plot for 2nd iteration of Koch Antenna

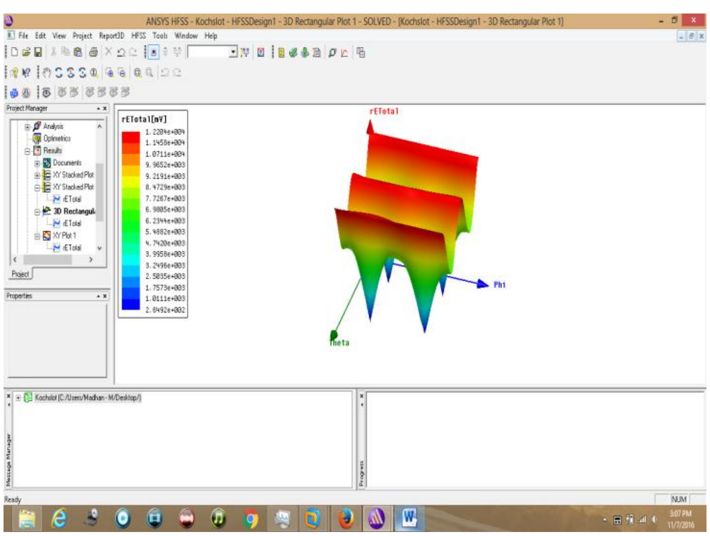


Figure 5.4 (b) Return loss 3D plot

FAR FIELD

It can be seen from the figure 5.5 that the far field distribution of the antenna is symmetric about 0 degree on either side of the Koch antenna and gain is 20.80dB at 3GHz-6GHz .The polar plot for the same is also given in figure 5.6.

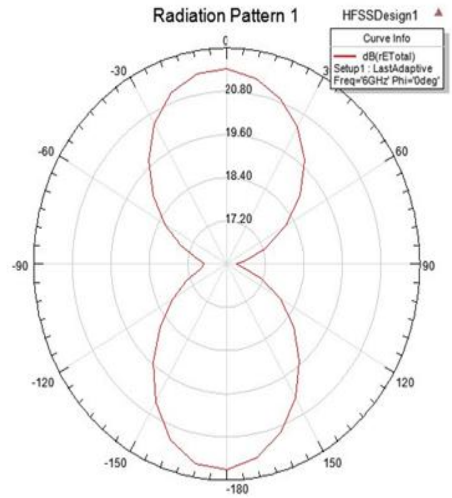


Figure 5.5 Far field 2D pattern in xy plane

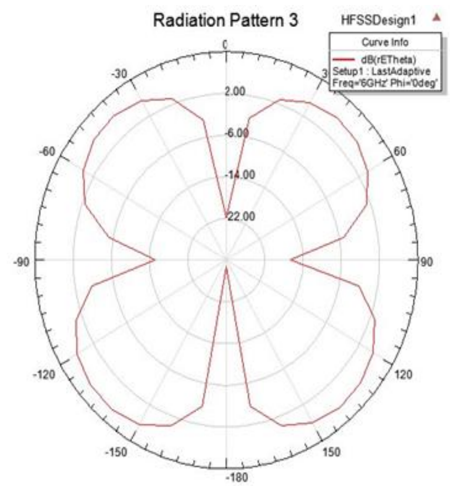


Figure 5.6 Polar plot

IV. CONCLUSION

A flexible wearable Koch fractal dipole antenna is constructed using fractal geometry for 6 GHz band of operation with jean substrate material. The initial design is started by using a single element equation of dipole antenna with scaling factor of 1/3. In this design, the highest iteration is Koch second iteration, and the overall simulated result is verified with the measured one under flat condition. The reflection coefficient of the antenna is changed and a significant shift in resonant frequency designed 6 GHz with Jean (Roger RT duroid). The above study shows that the antenna can be operated at VHF band suitable for military application. The main contribution of this design is 120% reduction in size compared to the conventional antenna.

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