Compact ACS-Fed Koch Fractal Shape Antenna for Wideband Application

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***Abstract*—A compact Asymmetric coplanar strip (ACS) fed modified Koch fractal shape printed slot antenna. It suitable for Wireless, WiMax, WiBro and other important frequencies, is presented in this paper. Here, the operating frequencies of the triangle slot antenna are lowered by the Koch iteration technique resulting in compact antenna. The proposed antenna exhibits wideband frequency resonance. The simulated -10 dB bandwidth for this resonant frequency is 97.7 % ranging from 2.7 GHz to 7.88 GHz. The antenna is exhibits omnidirectional radiation pattern with < 3 dBi gain for entire bandwidth is presented. Also comparison of different antenna parameters are presented and discussed in this paper.**

Keywords- ACS Fed; Fractal Koch antenna; Microstrip Antenna; Wideband.

I. INTRODUCTION

Rapid progress in wireless communication promises to replace wired communication in the near future in which antenna plays a more important role. Microstrip patch antennas are widely used due to their inherent advantages of low profile, light weight, low cost [1-4] etc. The major limitation of microstrip antenna is narrow bandwidth. To overcome this limitation the patches are etched with slot like E-Shape [5], U-Shape [6], and Stack patch [7]. But using this type of shape the boundary condition and the cavity model are invalid for design and analysis.

Printed slot antennas are attractive because of their planar geometry and wide operating bands [8]. A coplanar waveguide (CPW) fed makes them more suitable for compact wireless communication devices owing to its features like uniplanar structure, easy fabrication and circuit integration [9]. Compact antennas can be designed using a meandered radiating structure and several antennas using this technique has been reported [10, 11].

Fractal antennas [12], have very good features like small size and multiband characteristics. Most fractal objects have self similar shape, with different scale [13,14]. The fractal shape carried out by applying the infinite number of iteration using multiple reduction copy machine (MRCM) algorithm [15]. In this paper, Asymmetric coplanar strip (ACS) feeding is employed for designing a compact fractal Koch shape antenna for wideband application.

In this paper, we proposed the modified fractal Koch antenna with triangle shape for wideband application. This is a simple model with ACS-Fed and miniaturization of the antenna structure is obtained. The modified Koch fractal shape is chosen as the radiating structure so as to excite lower frequencies within a smaller area. The Koch fractal shape antenna is operating in FCC approved UWB band but notches out the 5 GHz WLAN (4.65-6.4 GHz) frequencies to avoid interferences is reported earlier [16]. Proposed modified Koch fractal shape antenna employed for wideband operation covering 3.5/5.2/5.5/5.8 GHz WLAN and WiMax band and other important wireless frequencies. Using the ACS- Fed techniques, we observed the omnidirectional radiation pattern and gain throughout the operating band. The optimized dimensions of the tuning stub and ground, for wideband operation are also presented. This antenna is simulated using the CST microwave Studio Suit ™ 2010 based on the finite integration time domain (FITD) method.

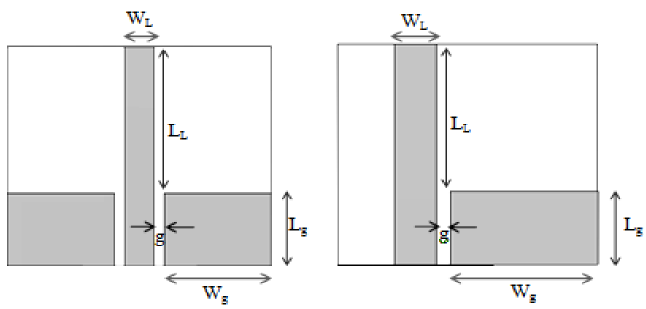


Fig. 1 a). Geometry of CPW-Fed Antenna

b). Geometry of ACS-Fed Antenna

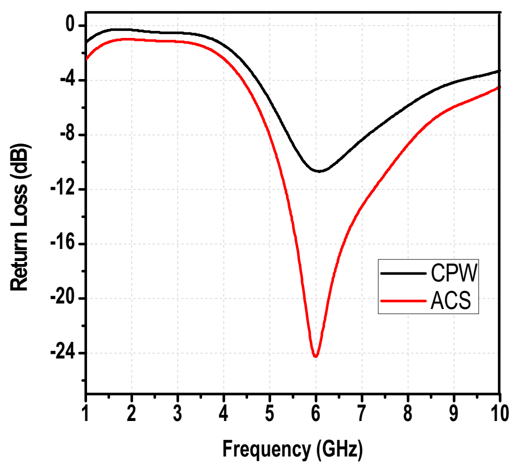


Fig. 2 Simulated Return Loss of ACS and CPW-Fed Antenna

II. Antenna Design

A. Asymmetric Coplaner Strip (ACS) Fed

In this antenna design a compact and effective feeding technique is employed. The ACS fed used for all the advantages of a uni-planar fed along with compactness [17]. This feeding mechanism is analogous to the coplanar wave guide fed expecting that the ACS fed has single lateral ground strip compared with twin lateral strip in the CPW feed. These antennas are simulated using CST microwave Studio Suit ™ 2010 and observed the return loss characteristics of both ACS and CPW feeding technique.

ACS and CPW feeding geometry is shown in fig. 1 (a) and (b) having the length (L_L= 10 mm) and width (W_L=5mm). The dimensions of ground plane of both the antenna are L_g=8.5 mm, *Wg=5 mm* and the gap (*g= 0.8 mm*) taken for good impedance matching [18].

The simulated return loss characteristics of ACS and CPW fed are shown in fig. 2. Both the antenna is radiated at 6 GHz frequency. Using the ACS feeding technique the antenna gain is ~ 2.1 dBi and for CPW feeding technique gain is ~ 2.3 dBi.

A compact ACS fed antenna having good return loss and gain is presented for single band operation. The aim of the design using ACS fed is miniaturized the antenna structure for easily housed within the space allocated in a wireless gadget.

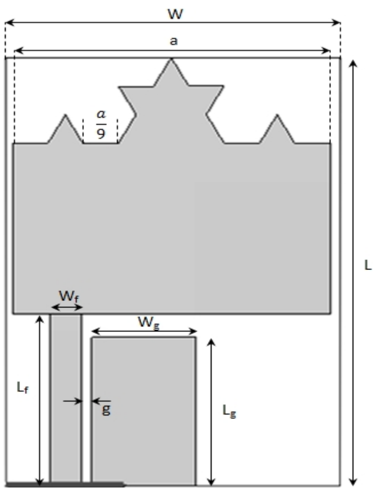


Fig. 3 Geometry of Proposed ACS-Fed Antenna

B. Prpposed ACS fed fractal shape antenna

The geometry of the proposed compact ACS feed Koch fractal shape patch antenna is described in fig 3. The basics of the antenna structure is chosen to be a rectangular patch has dimensions of width (*W= 25.5 mm*) and length (*L=37.5 mm*). It is constructed on a substrate with relative permittivity (ε_r) of 4.4 and thickness (h) of 1.6 mm. The ground size of this proposed antenna is W_g=8 *mm* and L_g=13 *mm* is fed by 50 Ω ACS fed technique, the length and width of ACS fed is W_f= 2.4 *mm*, L_f=10 *mm*, gap (*g=0.2 mm*). After iteration, the basic size of the equilateral triangle fractal shape is *a=24.3 mm*.

III. Antenna configuration

A. Effect of koch fractal geometry

Fig.4 shows the simulated return loss of the equilateral triangle size of modified Koch fractal antenna. As per expectation, the resonant frequency and the antenna return loss (-10 dB) is increased with increased the Koch fractal shape (*a*). It is observed that the Koch fractal geometry improves the matching of return loss at lower frequency along with the bandwidth enhacement of the patch antenna. The operational bandwidth shifted to 2.62-7.58 GHz to 2.9-8.46 GHz as a size increased of the fractal. Further inceased in the order of the shape causes only a minor reduction of the operating frequency. The following observation shows that the -10 dB return loss is good matching with *a=24.3 mm*.

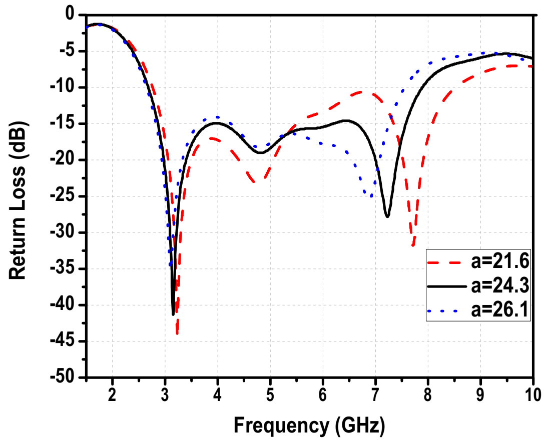


Fig. 4 Simulated Return Loss of antenna for different Koch fractal size.

B. Effect of Ground plane size

Fig. 5 shows the simulated return loss (-10 dB) performance of the antenna, using ACS-feed technique with changing the ground size width (W_g). The width (W_g) has a prominent effect on the wideband matching of the proposed fractal antenna. Although length (L_g) has almost negligible effect, therefore the length (L_g=13 *mm*) is fixed for these operation of wideband. It is observed that while we increased the width of the ground plane the, impedance bandwidth is not matching with the wideband application. The value of W_g=10 *mm* is a good matching with return loss.

C. Effect of Gap between line and ground plane

Fig. 6 shows the return loss of the simulated proposed fractal antenna with changing the gap (g) between line and ground plane. It is observed that while we increase the gap (g) of the Koch fractal shape antenna the simulated -10 dB return loss is good matching but the resonant frequency is shifted. Therefore the -10 dB return loss is matching in *g=0.8 mm*.

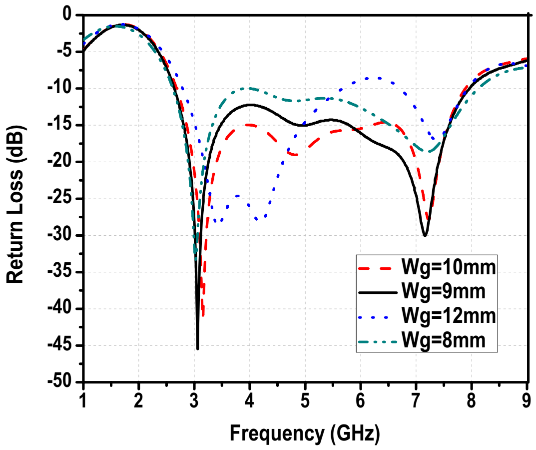


Fig. 5 Simulated Return Loss of ground plane width.

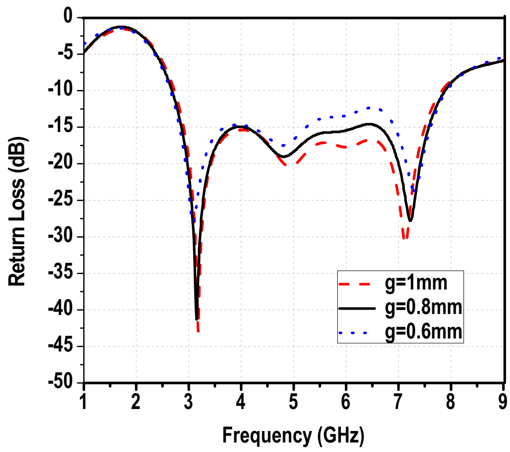


Fig. 6 Simulated Return Loss of gap of the antenna.

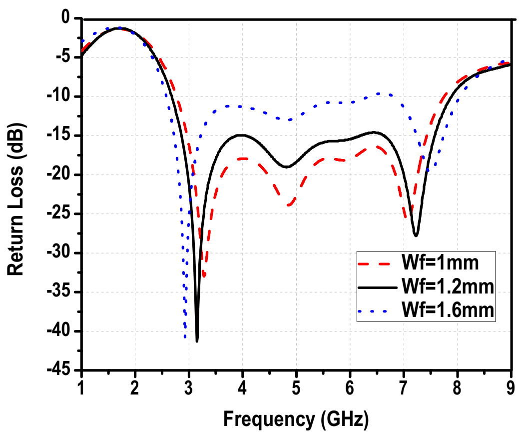


Fig. 7 Simulated Return Loss of ACS fed line.

D. Effect of ACS fed line

Fig. 7 shows the return loss of simulated proposed antenna with effect of ACS-fed line width (W_f). It is observed that, while increase the width of the ACS-fed line the impedance bandwidth is increased at certain limit. Therefore the value of width is good matching with $W_f=1.2$ *mm.*

IV. Results and Discussion

A. Return Loss (S_{11}) Characteristics

Fig. 8 shows the return loss characteristics of the proposed modified Koch fractal antenna for wideband application. It is printed on FR4 substrate with relative permittivity (ε_r) of *4.4* and the thickness of the patch is 1.6 mm. The simulation result is obtained from CST microwave Studio Suit ™ 2010. The dimension of the Koch size is chosen *a=24.1 mm* for the proposed wideband application geometry. The -10 dB impedance bandwidth of the antenna is from 2.7 GHz to 7.88 GHz with resonance at 3.24 GHz, 4.79 GHz and 7.23 GHz. The entire bandwidth covers the WLAN/WiMax and other important wireless application bands.

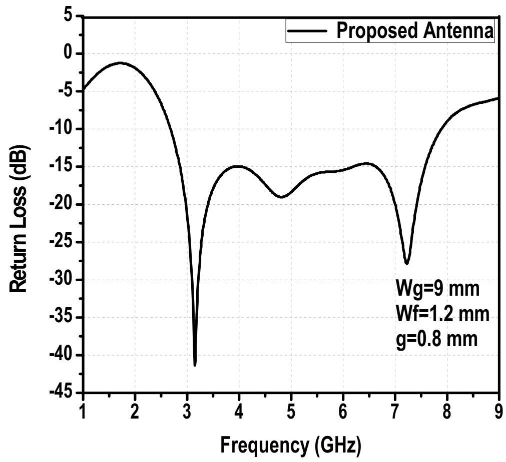


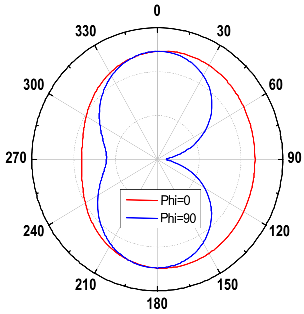
Fig. 8 Simulated Return Loss of Proposed fractal shape Antenna

B. Radiation Pattern Characteristics

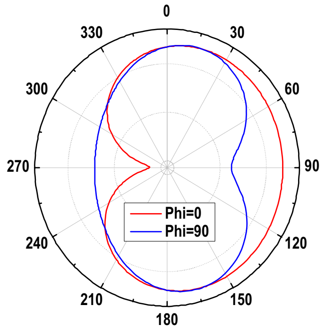
Radiation pattern characteristics of proposed ACS fed Koch fractal antenna is shown in Fig. 9 at 3.24 GHz, 4.79 GHz and 7.23 GHz in the broad side direction at V=0° and V=90°. In addition, very monopole like radiation pattern with omnidirectional radiation is observed. The 3 dB beamwidth at these three frequencies are 91.8°, 78.6° and 88.4° are obtained.

C. Surface Current Distribution

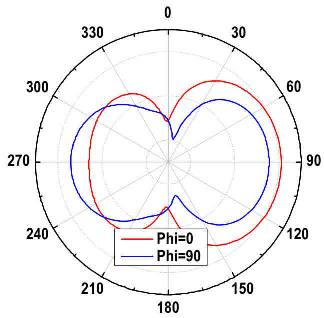
The excited surface current distribution of the modified Koch fractal shape patch antenna, obtained from the CST microwave Studio Suit ™ 2010. Fig. 10 shows the surface current distribution at 3.24 GHz, 4.79 GHz and 7.23 GHz. It is clear that all these three frequencies have very similar surface current distributions on ACS fed patch. This characteristic agrees with the radiation patterns characteristics of all frequencies shown in Fig 4. Moreover, it has also been found that in this design the surface current on the ACS-fed patch is strong and dominates the main radiation performance of the antenna. This results in a very linear polarization pattern and also agrees with the simulated radiation pattern results.



(a)



(b)

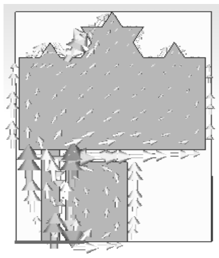


(c)

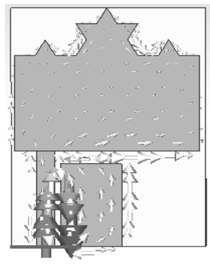
Fig. 9 Simulated Radiation pattern at (a) 3.16 GHz (b) 4.79 GHz (c) 7.23 GHz

D. Antenna Performance (Gain and Total Efficiency)

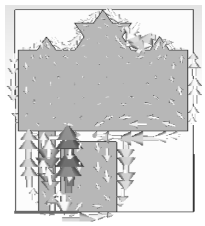
When the antenna is used for wideband application frequency, the impedance mismatch must be taken in to account for defining its characteristics. Especially, while calculating antenna gain and the efficiency of the antenna, ACS-fed technique is used to compute the gain and total efficiency of the proposed antenna as shown in Fig. 11 and Fig. 12. The maximum realized gain at the range of 3-6 dBi is obtained for the antenna and the total efficiency is ~90% for entire bandwidth.



(a)



(b)



(c)

Fig. 10 Surface Current Distribution at (a) 3.16 GHz (b) 4.79 GHz (c) 7.23 GHz

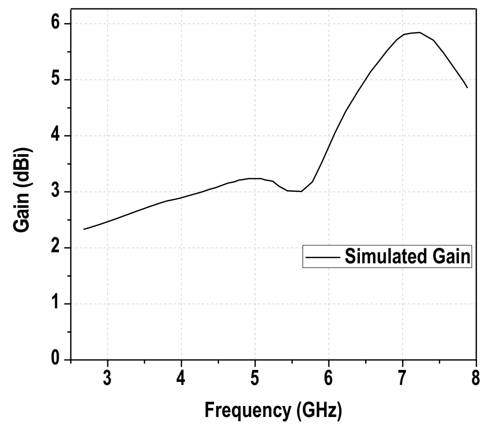


Fig. 11 Gain of Proposed fractal shape antenna

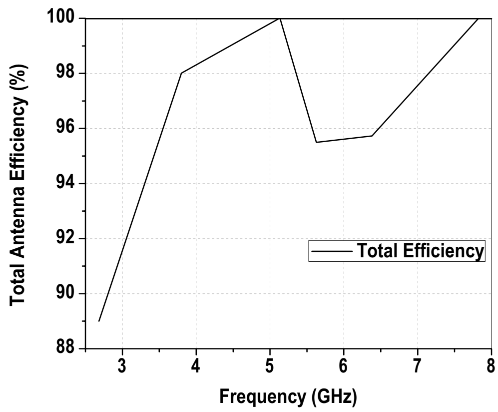


Fig. 12 Total Efficiency of Proposed fractal shape antenna

V. CONCLUSION

A compact modified Koch fractal microstrip patch antenna for wideband application is designed and discussed. The miniaturized is achieved by using the ACS-fed and Koch fractal geometry. The effects of the various geometrical parameters on the Antenna performance are studied. Simulated results show the antenna is suitable for the WLAN/WiMax and other important frequencies. The un-planar design, simple feeding technique and compactness make are easy for integration of the antenna into circuit boards.

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