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A Novel Method to Improve Current Density in Multiband Triangular Fractal Antenna

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***Abstract*—In this paper modified feed for Sierpensiki gasket Fractal shaped is presented. Sierpensiki gasket structure is most widely used method in microstrip patch antenna design for multiband operation. But Sierpensiki gasket antenna suffers from the problem of reach of current density over complete fractal patch. In this paper a modified feeding structure is proposed for triangular shaped Sierpensiki gasket fractal patch antenna to have uniform current density throughout the fractal patch. The improvement is studied in terms of return loss and efficiency of antenna. Proposed feeding technique improves power flow throughout antenna so that it reaches small fractal as well as larger fractal structures. The simulated result shows agreement with the theoretical results.**

***Index Terms*—Sierpinsiki gasket, fractal, duroid, patch, current density.**

I. INTRODUCTION

Recent year's advancement in wireless field demands devices with small size and support to multimedia services. Antenna is always an important part of any wireless device. So it is always desirable to have small size antenna. Another requirement of antenna is ability of antenna to be embedded with PCB of wireless devices. For these requirements, Microstrip Patch antenna is proved to be best solution for Next generation wireless network devices. MSP antennas use to be small in size and at the same time if fed using CPW feed can be embedded with PCB of the devices.

Also with advancement in wireless technologies these devices needs to support multimedia applications. Multimedia applications like video conferencing, high definition video transfer, VoIP etc. demands high data rates and support for multiple technologies. As an example, in laptop it is desirable to have support for WiFi, Bluetooth, WiMAX and other PCS technologies support. But as antenna is frequency dependent device and different technologies work on different frequency, for the above mentioned requirement, multiple antennas are required. Another alternate for multiple technologies support by antenna is introduction of multiband antenna. Many techniques are introduced in literature for multiband operation of antenna as by cutting slot, using EBG structure, using Fractal shaped antennas etc.

To achieve multiband operation of antenna, fractal is proposed to be effective way. Fractal geometries are self-repeating complex shapes. Fractal shapes reduction technique is promising for next generation wireless device antenna design. Fractal antennas are most widely used antenna for multiband operation in Microstrip design. It has advantage of good efficiencies, good gains, compact size, Mechanical simplicity and robustness etc. Fractals are genuine multiband and broadband antennas. Fractal can be considered to be discrete radiating LC circuit. In Fractals different sized antennas are embedded in single antenna so as to produce resonance at multiple frequencies. Example of fractal shapes are Sierpinsiki gasket, Koch monopole etc. Fractal shapes are known to be space filling structure. Sierpinsiki gasket is most important and most used shape among fractal geometries. As lots of work has already been done in the field of sierpensiki gasket but it faces a problem that current density is not uniform throughout the patch [1].

In this paper Sierpeniski gasket shaped patch antenna is proposed for multiband operation of antenna. Traditionally proposed methods [2]–[6] uses modified ground plane to achieve uniform current distribution or coaxial feed at apex of antenna. But all these methods are not efficient ways to achieve uniform current density over Sierpinsiki gasket. These methods cause low efficiency of antenna radiation. Proposed work introduces modified coplanar waveguide (CPW) feed for improvement in current intensity over complete fractal patch. Proposed antenna performs well for four band of operation. Topology used in proposed structure is given below in next section.

II. TOPOLOGY

In this paper modified coplanar waveguide feed is used. When simple CPW feed is used, it just serves the purpose of producing fringing fields. But if structure is modified as shown in Fig. 1 below, ground planes also serve the purpose of inducing current densities in Sierpinsiki gasket patch. So, uniform current density can be achieved using proposed modified structure. In literature Sierpinsiki gasket monopole was presented with CPW feed. In proposed design Sierpinsiki gasket dipole with modified CPW feed is presented.

In this paper Triangular Fractal antenna Sierpinsiki gasket

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is presented with modified feed structure. Initially design is considered without proposed CPW fed. Simple Microstrip feed is used in structure shown in Fig. 1. But in proposed structure shown below in Fig. 1 modified CPW fed structure is proposed. Substrate used is Duroid having dielectric constant 2.5 and thickness of the substrate is 1.59 mm. Shape and geometry of Patch is Sierpensiki Gasket fractal. Initial generator for given shape is equilateral triangle with side length 40 mm. Overall dimensional length of patch is 40 mm and width is 69.28 mm. Microstrip line feed of width 4.5 mm is used to feed the patch.

TABLE I. DESIGN PARAMETERS.

Parameter	Size	Material
Substrate length	80 mm	Duroid (ε_r= 2.2)
Substrate width	80 mm	Duroid (ε_r= 2.2)
Substrate height	1.59 mm	Duroid (ε_r= 2.2)
Patch length	40 mm	PEC
Patch width	69.28 mm	PEC
Patch triangle side length	40 mm	PEC
Microstrip feed line width	4.5 mm	PEC
Ground planes width	31.7 mm	PEC
Spacing b/w ground planes and feed line	Variable	-

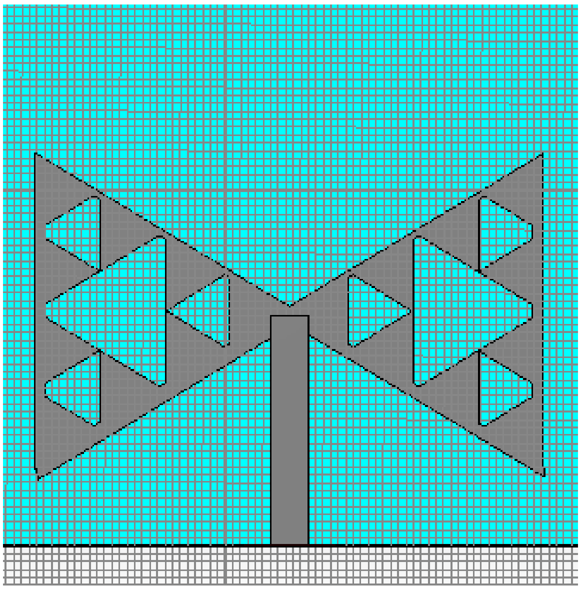

Fig. 1. Simple Sierpinsiki gasket fed with microstrip feed.

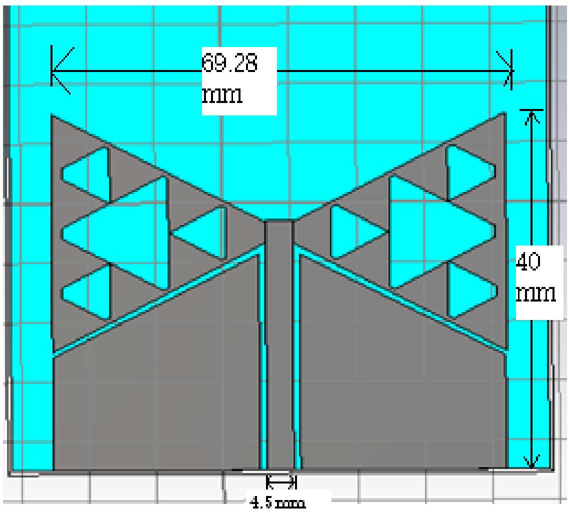

Fig. 2. Structure of proposed antenna.

Simulations are performed initially with different spacing between feed line and ground planes. The length of triangle is calculated according to resonant frequencies as given by formula in [7]:

$$s \cong \begin{cases} \frac{1}{\sqrt{3}}(0.3069 + 0.68\rho x)\frac{c}{f_r}(d^{-1})^n - \frac{t}{\sqrt{\epsilon_r}} & for\ n = 0, \\ 0.26\frac{c}{h}\delta^n, & for\ n > 0, \end{cases} \quad (1)$$

where n= no. of iteration, c=velocity of light, ϵ_r is dielectric constant of substrate i.e. ε_r= 2.2 for proposed design, f_r is resonant frequency, $\rho = d - 0.230735$ and x is one. h is the length of largest gasket i.e. largest triangle in Sierpinsiki gasket. δ is the scalar factor of the geometry which is 2 for proposed design.

III. RESULTS

Fig. 2 below shows return loss versus frequency graph. Fig. 3 shows s11 versus frequency graph for different values of spacing between ground planes and microstrip feed line. Optimum value of spacing is considered. The s11 versus frequency graph for optimum value of spacing is given in Fig. 4 below. Further results are given for optimum spacing considered. The -10 dB return loss (VSWR 2:1) impedance bandwidth is calculated for each band. Proposed antenna resonates at different frequencies shown below in table 1 with corresponding bandwidth at specific frequency.

TABLE II. FREQUENCY OF RESONANCE AND CORRESPONDING BANDWIDTH AT RESONATING FREQUENCY.

Frequency	Bandwidth
1.57 GHz.	451 MHz.
4.31 GHz.	460 MHz.
5.31 GHz.	170 MHz.
7.37	670 MHz.

The power density at different frequency for both antennas is given in Fig. 3 and Fig. 4. Power density at frequency 4.31 GHz and 7.37 GHz is shown which implies that power density is uniformly distributed over complete Sierpinsiki patch. Also proposed antenna maintains good radiation pattern with gain as it has uniform power density over complete patch.

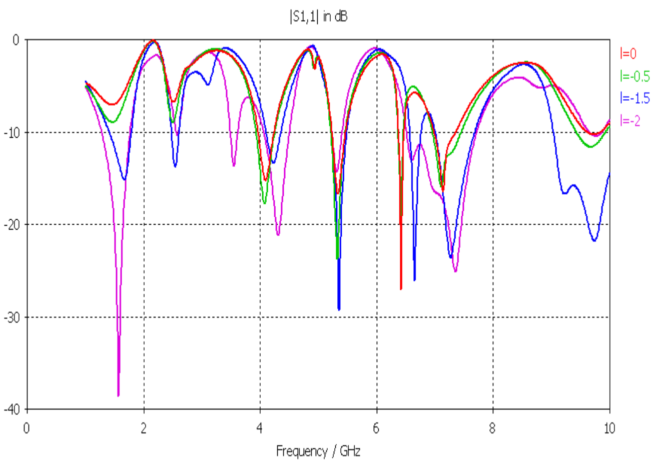

Fig. 3. S11 plot versus frequency for proposed antenna.

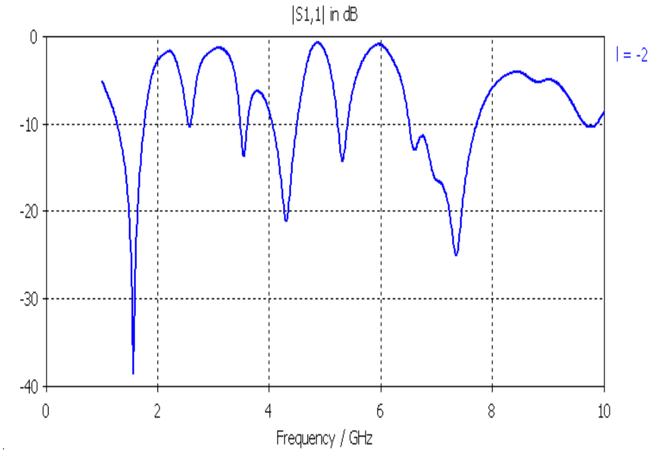

Fig. 4. s11 versus frequency for optimum spacing.

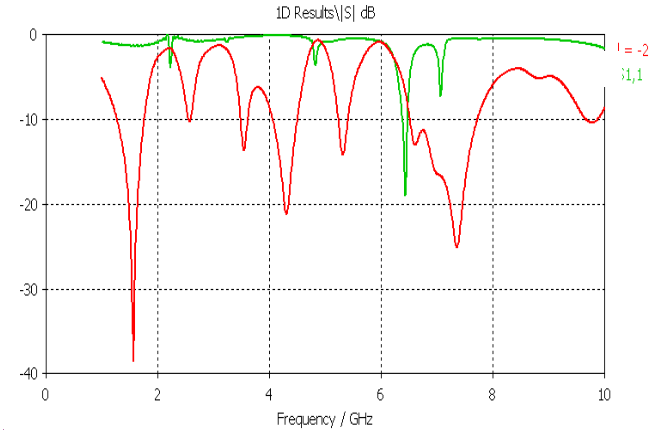

Fig. 5. Comparison of s11 for simple sierpinsiki gasket structure and proposed design.

Power is radiated through small triangle at larger frequency as $f_r=f(1/length)$ i.e. frequency of resonance is inversely proportional to length. While for radiation of power at higher frequencies is caused by smaller triangle. This is shown in Fig. 6 and Fig. 7 that power flow at 4.31 GHz. is due to larger triangle radiation and while at 7.31 GHz.

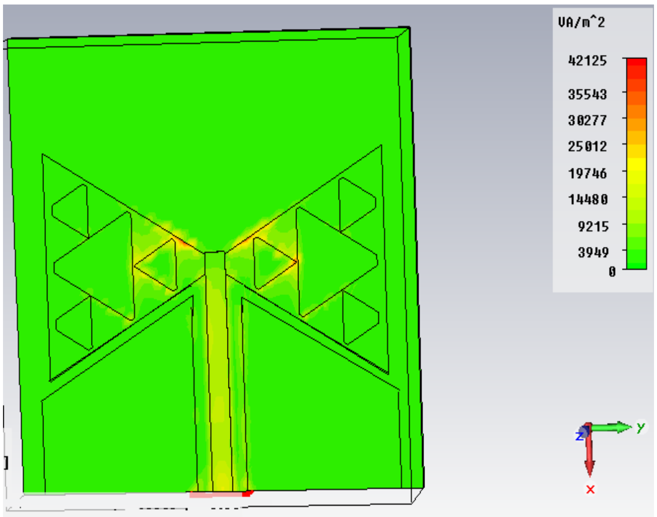

Fig. 6. Power flow at f=7.37 GHz.

Resonant frequency only smaller triangle radiates. So proposed antenna behaves like multiband antenna. Each band in proposed multiband antenna has wide bandwidth which is always advantageous. Further smith chart analysis shows that impedance at input of feed is 50.78 ohm at resonance so proper matching is achieved with 50 ohm connector and transmission line.

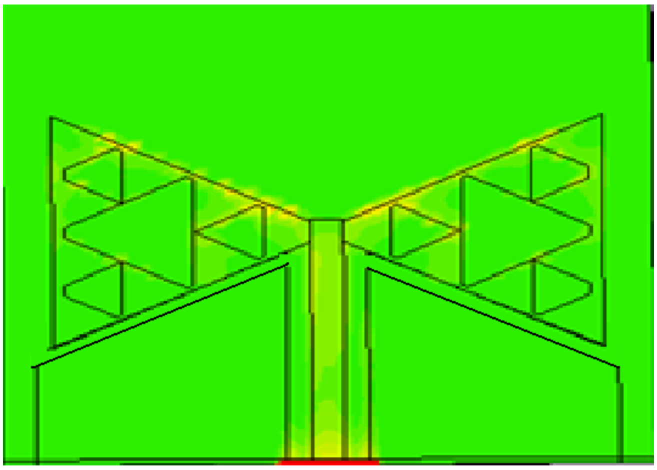

Fig. 7. Power flow at f=4.31 GHz.

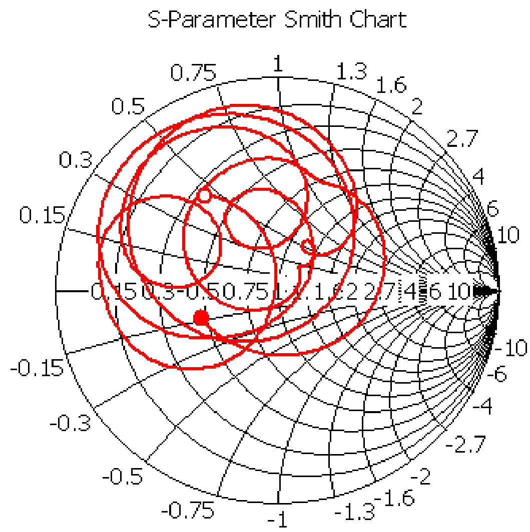

Fig. 8. Smith chart for the optimum design.

IV. CONCLUSIONS

The paper reports the novel design method to feed Sierpinsiki gasket shaped fractal antennas. In comparison to traditional simple design propose design ensures power reaches to even a smallest unit of fractal. The results explore the design of proposed structure with Sierpinsiki gasket design with 40 mm length of generator equilateral triangle. Further optimized value of space between feed and ground planes is considered for best results. Since improvement of current density affects the efficiency of radiation in antenna, introduced design maintain the simplicity of Sierpinsiki gasket otherwise producing good results without modifying basic sierpinsiki gasket fractals. For which mathematical modeling is present in literature. As Sierpensiki gasket structure is not modified mathematical equations proposed in [7] are still valid for proposed design.

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