2.2 Proposed Antenna Design

The proposed fractal antenna is based on the Sierpinski Gasket antenna. The difference is that instead of a triangular slot a circular slot is removed from the initial structure. The initiator and generator of the proposed compound fractal antenna is shown in Fig. 3(a) and Fig. 3(b) respectively.

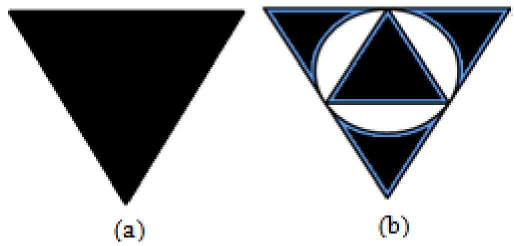

Figure 3: Proposed compound fractal antenna (a) Initiator (b) Generator.

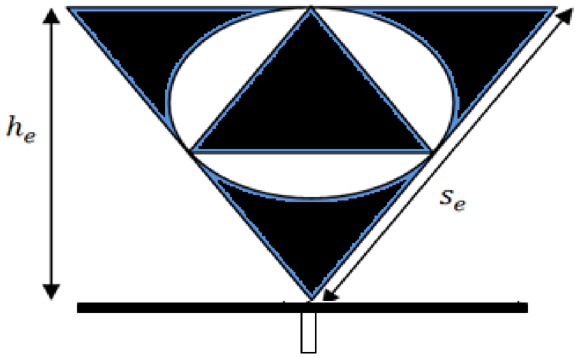

Figure 4: Geometry of proposed compound fractal antenna

Initially it starts with an equilateral triangle which is the initiator. Then a circle with a triangle is inscribed in the equilateral triangle and this circular part is removed, which forms the first iteration. The geometry of the proposed compound fractal antenna is shown in Fig.4. The substrate material is of thickness 1.6mm and with permittivity 4.4. The dimension of substrate is same, 60mmx60mm. The ground is also kept perpendicular to the patch and with the dimension 60mmx60mm. Similarly the effective side length (s_e) is 52.8mm.

The structure was fed through a 50 coaxial probe with an SMA connector on the bottom vertex of equilateral triangle. The structure of the proposed compound fractal antenna on the substrate is shown in Fig 5.

3. Simulated Results

The simulation has been performed using Ansoft HFSS. The radiating patch, the ground plane and all conductors are assumed to be perfect electric conductor. The simulation frequency range is from 0.1 GHz to 4 GHz. The simulated antenna structure is shown in Fig. 5.

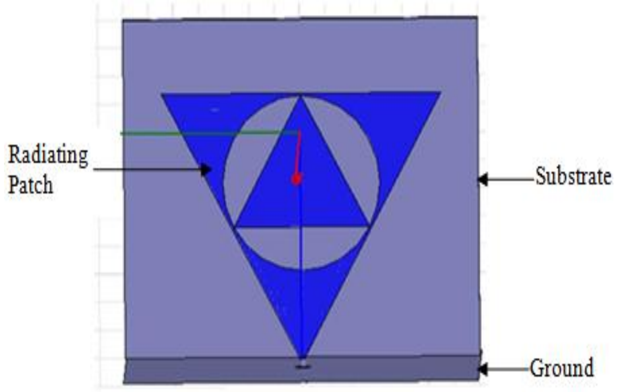

Figure 5: Structure of proposed compound fractal antenna on substrate FR4.

Fig. 6 shows the S_{11} for the first iteration of the Proposed Compound Fractal Antenna with respect to the frequency.

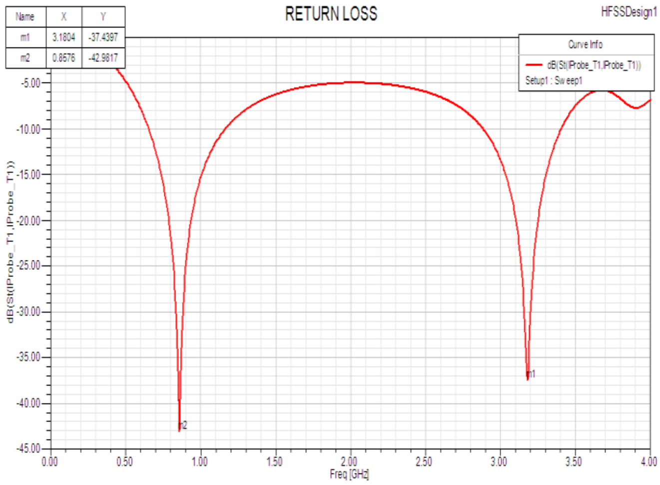

Figure 6: Simulated S_{11} for the first iteration of the Proposed Compound Fractal Antenna.

It can be seen from Fig. 6 that using a compound generator return losses lower than -10 dB are obtained. So two resonances are achieved from the first iteration. The first resonance are slightly lower at 0.86 GHz exhibits a return loss of -42.98 dB and the second resonance at 3.18 GHz exhibits a return loss of -37.43 dB.

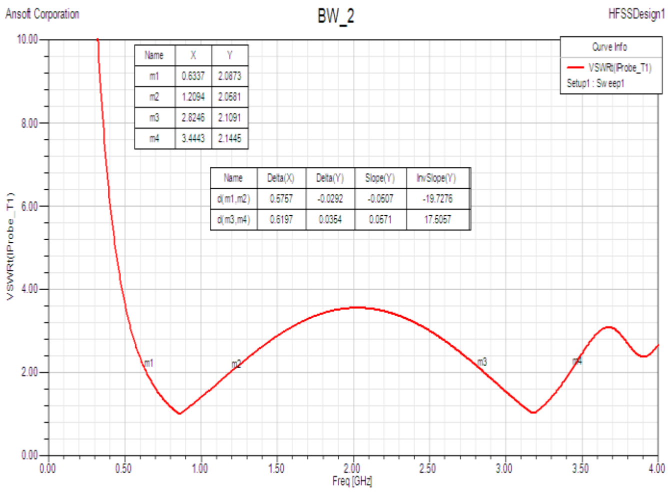

Figure 7: VSWR graph for measurement of Bandwidth for the first iteration of the Proposed Compound Fractal Antenna.

Fig. 7 shows the simulated voltage standing wave ratio (V SWR) with respect to the frequency of the proposed compound fractal antenna. It can be seen from Fig. 7 that the antenna impedance bandwidth extends from 0.63-1.20 GHz and 2.82-3.44 GHz with VSWR less than 2. The bandwidth obtained by the compound fractal antenna. for the resonant frequencies is shown in Table I.

Table 1: Resonant properties for the Proposed Compound Fractal Antenna.

Resonant Frequency	*Range Of Frequency*	*Bandwidth*	*Bandwidth %*
0.86 GHz	0.63-1.20 GHz	570 MHz	66.27 %
3.18 GHz	2.82-3.44 GHz	620 MHz	19.49 %

The far-field radiation characteristics of the proposed compound antenna for the resonant frequencies are shown in Fig. 8. The radiation pattern are obtained in two principal (x-y and y-z) planes.

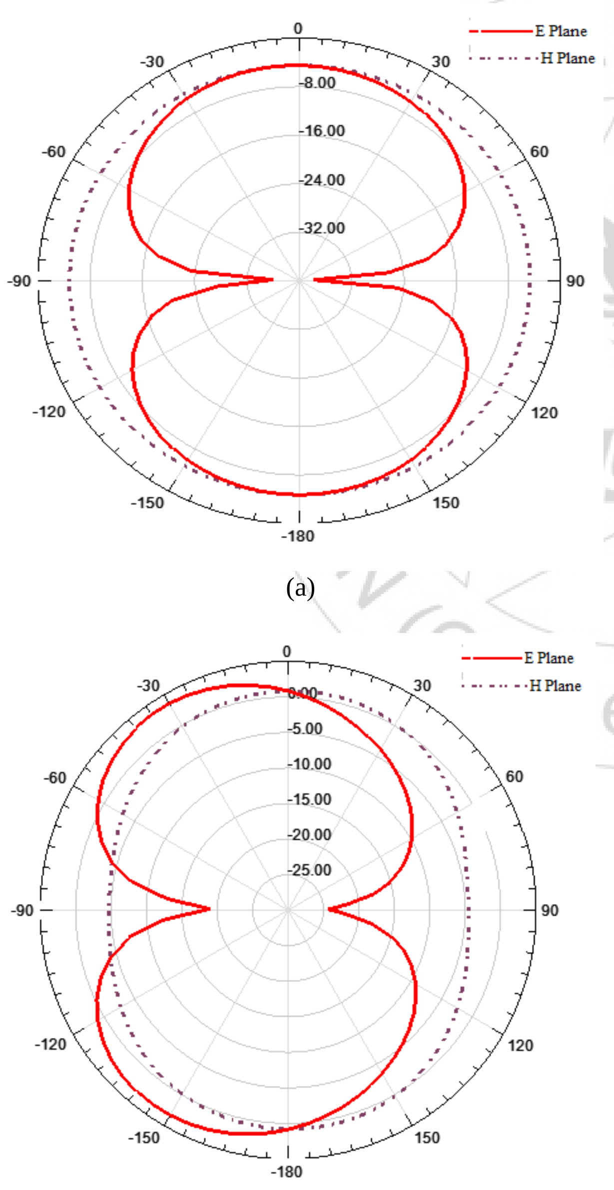

Figure 8: Radiation Patter for the first iteration of Proposed Compound antenna (a) 0.86 GHz (b) 3.18 GHz.

The radiation patterns are stable and in the considered bands this antenna exhibits nearly omni-directional radiation characteristic in the H-plane(y-z plane) and dipole like directional patterns in the E-plane (x-z plane). The E-plane radiation patterns over operating frequencies are roughly symmetric and have two main lobes.

4. Measured Results

The simulated design of proposed antenna is fabricated using FR4 substrate. The radiating patch is of copper material and ground is a simple copper sheet. The prototype is shown in Fig 9.

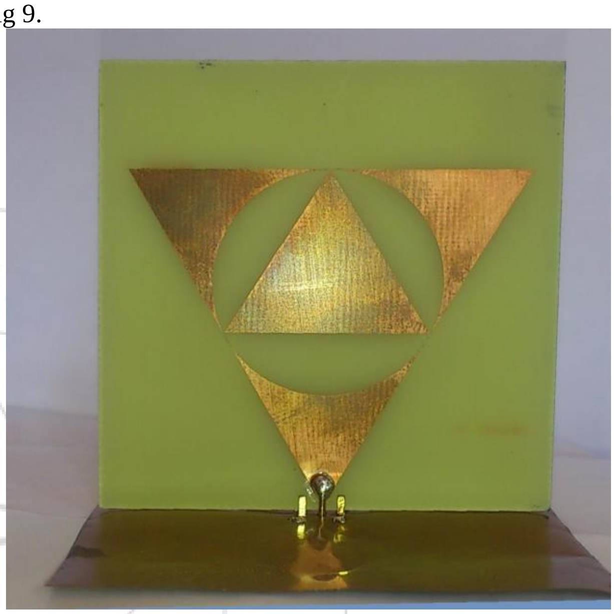

Figure 9: Photograph of the fabricated antenna.

The fabricated antenna is measured using Vector Network Analyzer. The Network Analyzer was calibrated before measuring the results. The measured results of Return Loss and VSWR are shown in Fig. 10 and Fig. 11 respectively.

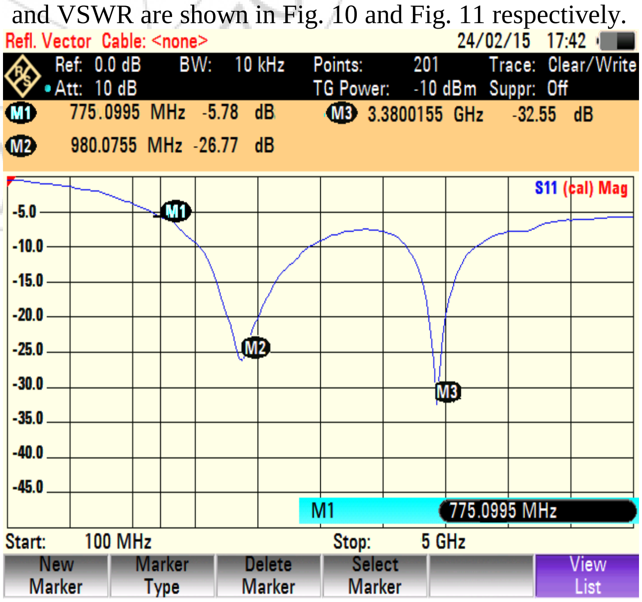

Figure 10: Measured return loss of the fabricated antenna.

Return losses lower than -10dB is achieved which indicates multiple bands. The multiple resonances are achieved at 0.98GHz and 3.38GHz. But compared to the simulated return loss there has been a slight frequency shift.

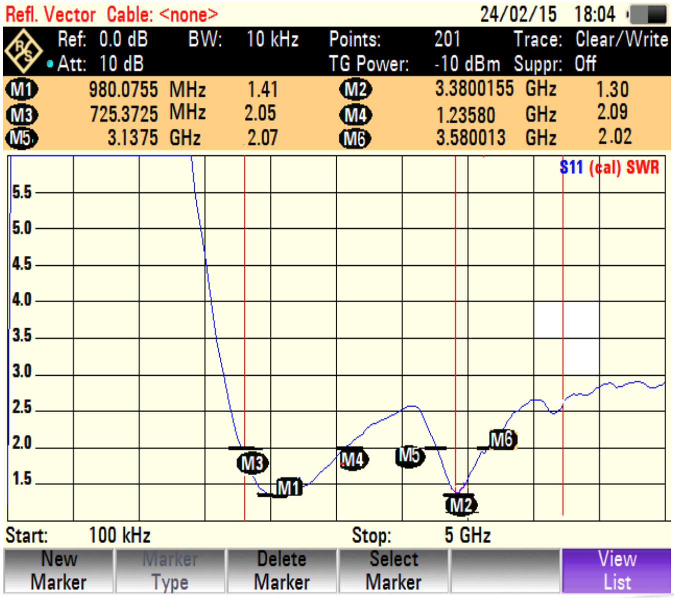

Figure 11: Measured VSWR of the fabricated antenna.

VSWR values lower than 2 are achieved. The values are close to 1 which indicates good matching. The impedance bandwidth obtained by measuring the fabricated antenna is shown in Table II.

Table 2: Resonant properties for the Proposed Compound Fractal Antenna

Resonant Frequency	*Range Of Frequency*	*Bandwidth*	*Bandwidth %*
0.98 GHz	0.72-1.23 GHz	510 MHz	58.16 %
3.38 GHz	3.137-3.58 GHz	443 MHz	13.10 %

5. Conclusion

A novel compound fractal antenna has been designed, simulated and fabricated. The measured antenna shows that the antenna is capable of operating over multiple bands. As the iteration increases the number of resonant frequency increases. The proposed antenna behaves as an multiband antenna. With the addition of a compound generator in the fractal geometry, very good impedance matching and improvement in bandwidth has be attained. Bandwidth of 510MHz and 443MHz has been obtained from the fabricated antenna. The measured results are in good agreement with the simulated results.

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