MULTILAYERED COMPLIMENTARY QUASI-FRACTAL SIERPINSKI PATCH ANTENNA FOR WIRELESS TERMINALS

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ABSTRACT

In this work the fractal microstrip antenna with Sierpinski geometry with some variations have been analyzed. An attempt in this field is the Complimentary Sierpinski Microstrip Antenna (CSMA), which blends the benefits of the multiband characteristics of Sierpinski microstrip antenna and that of the complimentary antenna. The dual layered complementary arrangement has positive effects in respect to the resonance such that the frequencies, which were yet to achieve prominence in conventional fractal planar structures, are greatly emphasized. The developed technology is tested for a laboratory prototype antenna. The simulation results are in agreement with the experimental results.

INTRODUCTION

The wireless systems proliferation demands antennae catering to various frequencies. The antennae designer's goals for a wireless system are multifaceted due the system's properties. One such property is multiband operation of radiating systems. Designs are being experimented and realized in this area. The design of multiband antenna and in broader sense a frequency independent antenna has led to the discovery of the log spiral and log periodic antenna validating the Rumsey's principle [1]. An extension of the quest for multiband characteristics into the non-Euclidean domain has led to the fractal antennae [2]. Sierpinski prefractal structure is well documented [3, 4]. Hence, this work considers it's complimentary. The duality principle of electromagnetic gets reflected in its characteristics. It is seen that the lower frequencies are less prominent for single layer Sierpinski antenna. The log periodic character of Sierpinski fractal multiband antenna has been reported in [5][6]. The conventional Sierpinski fractal is not favorable structure for true multiband operation. The design reported herein merges the Babinet principle and the fractal geometry. The structure has been simulated in commercially available software package, Microwave Office 2000. The results show that the lower frequencies are equally emphasized, a proposition not true for the conventional Sierpinski geometry. Thus the complimentary Sierpinksi microstrip antenna design can be used efficiently for various wireless systems for true multiband operation. These structures can be used as wireless terminals in both indoor and outdoor environments.

QUASI-FRACTAL

These are a set of geometry, which was first classified by B.B.Mendelbrot [7]. These structures are recognized by their self-similar properties and fractional dimension. In the recent years the geometrical properties of self-similar and space filling nature has motivated antennae design engineers to adopt this geometry a viable alternative to meet the target of multiband operation. Fractional dimensions, self-similar and scaling properties, characterize these structures [8]. The structures that are studied as antenna are not the ones that are obtained after infinite iteration but those after finite iterations as desired by the designer. So these structures are called quasi-fractal antennae.

DESIGN

This novel design is amalgamation of the prefractal Sierpinski Microstrip Antennae (SMA) and the principles of complimentary antennae [9]. The middle layer is the normal Sierpisnki planar structure on a substrate with dielectric constant 2.4 and loss tangent of 0.0009. The thickness of the substrate is chosen to be 1.59 mm and the size is of 8cm×8cm. The top layer is laid over a substrate of the same specification as above. The complimentary structure is formed on the top layer. It is shown in Fig. 1 for the second iteration. A common feed with center conductor being 1.7mm in diameter feeds the Sierpinski planar and the complimentary structure. The sides of the initiator equitriangle are 6cms. Removing the central triangle of side length 3cms forms the first iteration. The scaling factor is to and the mass ratio is three. That removed portion forms the complimentary top layer. Similarly the second iteration of complimentary quasi-fractal Sierpinski microstrip antennae is formed. The antenna is better known as the Complimentary Sierpisnki Microstrip Antenna (CSMA). The complimentary patch is fed at its corner and the middle layer Sierprinski is fed at the center of the base.

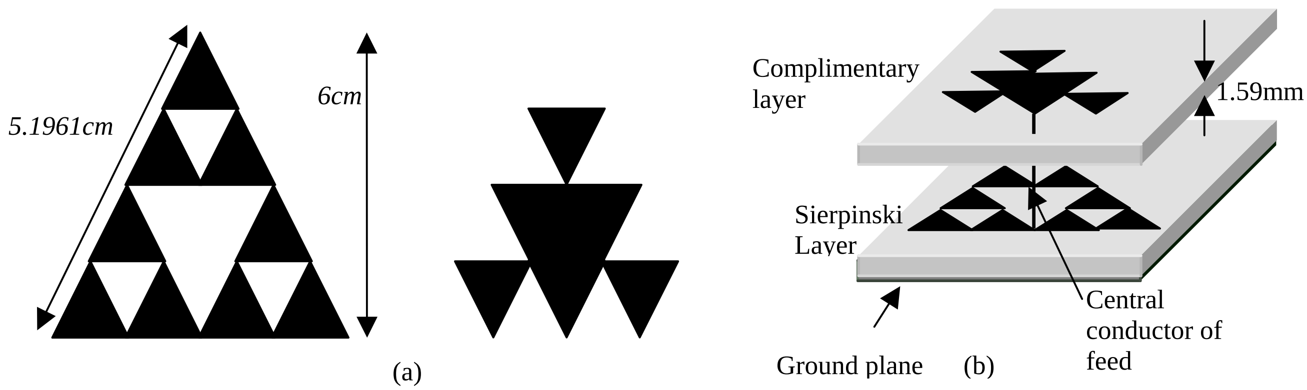

Fig. 1 (a) Sierpinksi Complimentary microstrip patch antenna (top- view) for second iteration and its complimentary (b) Sierpinksi Complimentary microstrip dual layer patch antenna for second iteration (side-view). The dielectric substrate has permittivity of 2.4 and loss tangent 0.0005.

RESULTS AND DISCUSSION

The antennae were analyzed for the simple single layered SMA for both first and second iterations the current distribution and return loss against frequncy are shown in Fig. 2 and 3 respectively. For the first iterations of the complimentary SMA the resonant frequencies observed are 4.3 GHz, 7 GHz, 8.3 GHz and 9.8 GHz respectively with the prominent frequencies being 4.3 GHz and 7 GHz. The current distribution is shown for 7GHz. The second iteration resonates at 3.1 GHz, 6.6,9.2 GHz as shown in Fig.3. It is seen that the lower resonant frequencies are less emphasised in case of the single layered structures of the Sierpisnki geometry. Thus the true multiband character is not so emphasised by this single layered design approach. The experiments were carried out using a HP8757C SNA

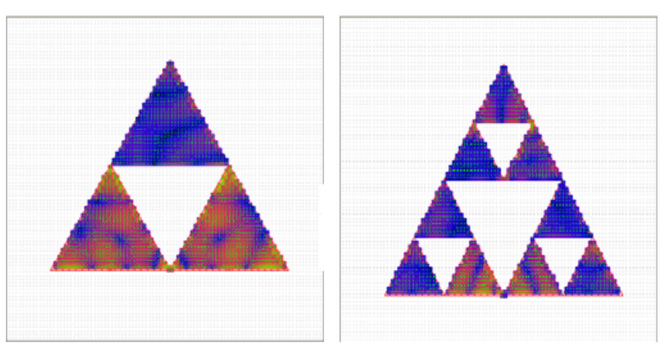

Fig. 2. Current distribution for base fed single layered SMA for first and second iterations.

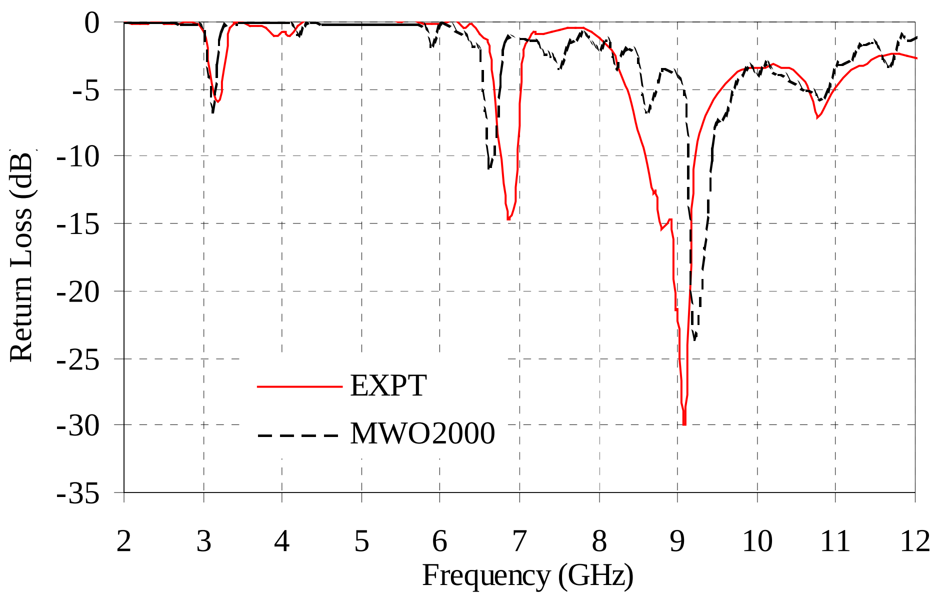

Fig. 3. Return loss pattern of Sierpinksi microstrip antenna for second iteration for side length of the generating triangle of 6 cm.

In Fig. 4 the current distribution for the CSMA for both iterations are shown. The return loss plot is given in Fig. 6 for both first and second iterations CSMA. It is observed that the frequencies that were not well established in the single layered SMA has been emphasized in the dual layered complimentary SMA. Thus this shows a true multiband operation. It is further proclaimed that the Babinet's principle holds true for these structures in claiming that the lower frequencies are equally well prominent and thus the antennae can radiate efficiently for the wide frequency ranges hopping from one band to the other.

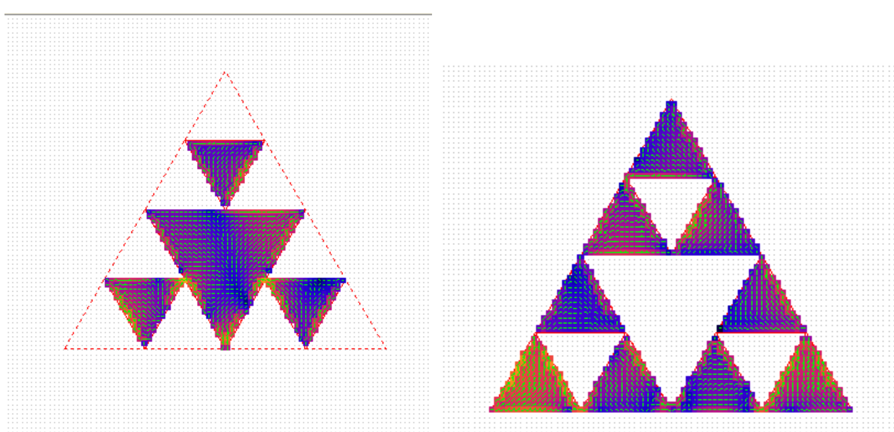

Fig. 4. Current distribution dual layered complimentary SMA for second iteration.

It is seen from Fig. 5 that the dual layer is resonant at 2.5,4.9,8.4 GHz. One can also observe a shift towards the lower end for complimentary structures.

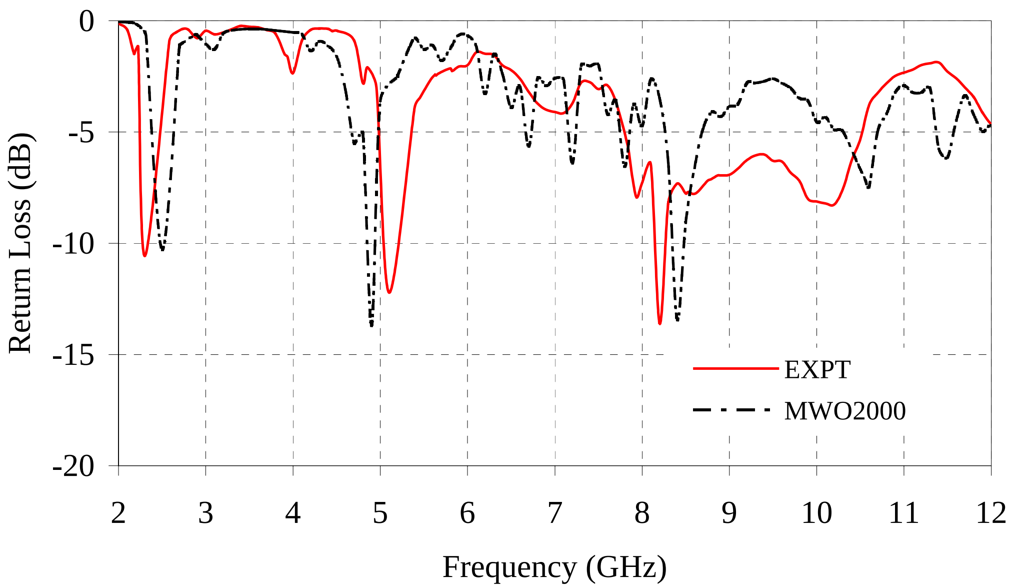

Fig. 5. Return loss pattern of Complimentary Sierpinksi dual layer microstrip antenna second iteration. The lower frequencies that were not emphasized by the conventional Sierpisnki fractal antenna have gained prominence.

CONCLUSION

The design modification to the single layered SMA has resulted in improvement in return loss for all resonances. Thus we can emphatically proclaim that this is a true multiband antenna. The improved design using the principles of complimentary antenna has made the claim of fractal antennas, of being multiband, more emphatic. For wireless systems such antennas are useful, as equal prominence for all frequencies is desired.

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