Multiband Sierpinski Fractal Patch Antenna

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Abstract The multiband behavior of the Sierpinski patch antenna is described in this paper, and a new technique to improve the multiband behavior from the point of view of the radiation patterns is introduced in this paper.

Introduction The use of fractal geometries is a new solution to design multiband antennas. The multiband behavior of the *Sierpinski monopole* has been presented and discussed, such monopole displayed a similar behavior over five bands from both the input return loss and the radiation patterns point of view [1-2]. The Sierpinski patch antenna has been analyzed using an *Iterative Network Model* [3] and the input impedance presented a log-periodic distribution tof the resonant frequencies with a log-period that is similar to the scale factor between the triangles. The next logical step is to explore the multiband behavior of the Sierpinski patch antenna from the point of view of the radiation patterns.

The traditional Sierpinski patch antenna The geometry of the traditional Sierpinski patch antenna is displayed in Fig.1.a, the gasket is constructed through four iterations, so four-scaled versions of the Sierpinski Gasket are found on the antenna (circle regions in Fig.1.a), where the smallest is a single triangle. There is a factor of two between scales, which means that the Sierpinski Gasket heights are 88.9, 44.5, 22.3 and 11.1 mm.

This particular shape has been chosen due to its similarity to the triangular patch antenna [4]. The triangular like shape appears at four different scales, then one could expect that a patch antenna with this fractal geometry would behave similarly to a triangular patch antenna but at four different bands.

From the point of view of the input impedance, the traditional patch antenna presents a multiband behavior. The input resistance and reactance of the traditional Sierpinski patch displayed in Fig.1.a is plotted in Fig.2. The patch is numerically analyzed using a MoM code, the ground plane is considered infinite and the patch is feed by a coaxial probe. The input impedance presents four resonant frequencies (1.17, 2.57, 5.42 and 11.17 GHz) corresponding to the four subgaskets that compose the Sierpinski patch, the four bands are log-periodically spaced by a factor of $\delta \approx 2$, which is exactly the characteristic scale factor that relates the several gasket sizes within the fractal shape.

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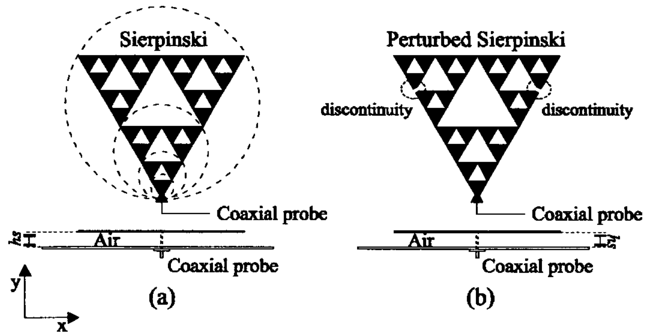

Fig.1. Geometry and configuration for the traditional and for the perturbed Sierpinski patch antennas. The separation between the ground plane and the patch surface is h_s=3 mm.

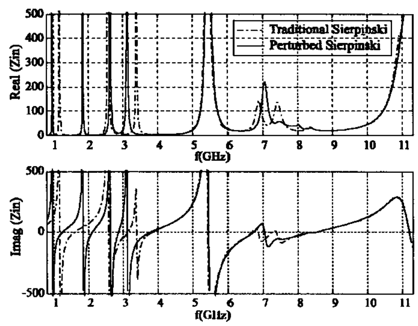

Fig.2. Input resistance and reactance for the traditional Sierpinski and for the perturbed Sierpinski patch antennas.

The problem is that from the second band to the forth one, the high order modes degrade the radiation patterns, which have a null at the broadside direction. The degradation of the radiation pattern is due to the fact that the high order modes of the Sierpinski patch have a resonant frequency similar to the resonant frequencies associated to the three smallest subgaskets with heights 44.5, 22.3 and 11.1 mm. The current density distributions for the four resonant frequencies are displayed in Fig.3. It is interesting to notice that at each band the current concentrates over a properly scaled substructure on the patch (circular regions in Fig.1), this region becomes smaller when the frequency is increased. However, for the second, third and fourth frequency bands related to the Sierpinski triangles with heights 44.5, 22.3 and 11.1 mm respectively, the high order modes associated to the Sierpinski gaskets of upper iterations can be observed in the current density distributions. The high order modes are responsible that the current density is distributed over a region that is bigger than the region corresponding at each subgasket. For instance, at the second band the current is high at the top junctions (dotted line) while the subgasket associated at this band is only 44.5 mm tall.

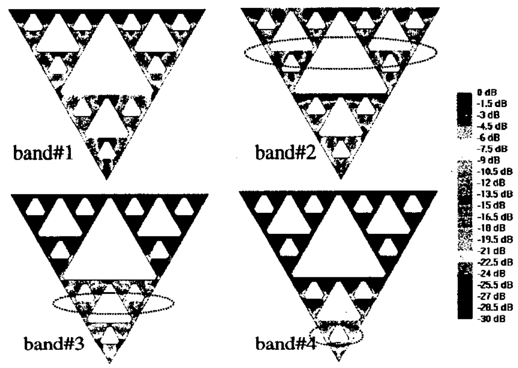

Fig.3. Current density distributions for the traditional Sierpinski patch.

The perturbed Sierpinski patch antenna In order to reduce the presence of the high order modes at the second band, the geometry of the Sierpinski patch antenna is modified like in Fig.1.b. The top junctions are broken because the density current at the second band is very high at these points (Fig.3), and this breaking force a minimum density current in these positions.

To analyze the influence of the breaking in the input and radiation parameters the perturbed patch is analyzed using a MoM code. The configuration and height of the patch is displayed in Fig.1.b, and is similar to the traditional Sierpinski patch.

The input resistance and reactance are plotted in Fig.2. The main differences are that a new band appears at 1.84 GHz (this resonant frequency is 1.91 times bigger than the first one) and the first resonance frequency (0.96 GHz) is 1.2 times smaller than the frequency of the traditional Sierpinski patch (1.17 GHz). The new band could be related to the resonant of the Sierpinski Gasket whose height is 44.5 mm, since the scale factor between the two frequencies is very close to 2, that is the scale factor between the heights of the two resonant triangles. The resonant frequency at 2.62 GHz must be connected to the high order mode of the tallest Sierpinski triangle.

To properly distinguish the real influence of the broken junctions on the patch radiation patterns, the main cuts ($\phi=0^o$ and $\phi=90^o$) are plotted in Fig.4 for the three resonant frequencies whose values ere 0.96, 1.84 and 2.62 GHz. The plots represent the total pattern with a 30 dB dynamic range. The patterns for the first and second resonant frequency are similar between them and both are broadside. It is interesting to notice that the pattern at 2.6 GHz has a null at broadside due to the presence of the high order mode of the 88.9 mm tall Sierpinski Gasket.

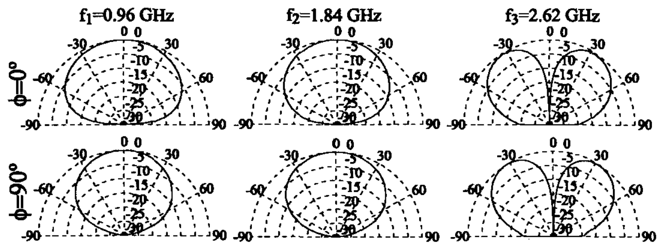

Fig.4. Total raditon pattern of the main cuts (ϕ=0° and ϕ=90°) for the perturbed Sierpinki patch antenna.

The breaking of the top junctions lends to a patch antenna that presents a broadside pattern at two bands, since the influence of the high order modes at the second band are suppressed. From the point of view of the radiation patterns, the multiband behavior of the Sierpinski patch antenna can be improved breaking the appropriate junctions.

Conclusions A new technique to improve the multiband behavior from the point of view of radiation patterns of the Sierpinski patch has been introduced. The technique suppresses the effects of the high order modes and a patch antenna with similar radiation patterns can be designed. Once the high order mode has been suppressed for the second band, the next step is to try eliminate it for the third and forth band breaking the appropriate junctions.

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