# A Design of Dual Band Sierpinski Carpet Fractal Planar Inverted F Antenna (PIFA) for GSM 1800/1900, UMTS and HiperLAN Application

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## 1. Introduction

The Planar inverted-F antenna (PIFA) is currently in use as an embedded antenna in many radiotelephone handsets [1-8]. It is one of the most promising antenna types because it is small and has a low profile, making it suitable for mounting on portable equipments. The planar inverted-F antenna which is a type of microstrip antenna shows much promise in dealing with the shortfalls of the λ/4 monopole antenna in mobile communication applications [9]. The planar inverted-F antenna also has exhibited a reasonably high gain and possesses a bandwidth that is broad enough for mobile operation. [10-14]. However, PIFA have some drawbacks such as low efficiency, narrow bandwidth and inability to have a multi-band resonance. To enhance these shortcomings, especially narrow bandwidth, while meeting the miniaturization requirements of mobile devices, Fractal PIFA has been proposed, designed and presented in this work.

Fractal PIFAs can be used as an internal antenna solution and to produce a wideband frequency range [15-18]. The proposed designs are able to provide coverage at all desired frequency bands i.e. GSM 1800/1900, Universal Mobile Telephone System (UMTS) and High Performance Wireless Local Area Network (HiperLAN) application. In order to obtain a good fundamental antenna design, the initial studies were carried out theoretically, using CST Microwave Studio software.

## 2. Design Specification

A planar inverted-F antenna is generally a quarter-wave (λ/4) resonant structure achieved by short-circuiting its radiating patch to the antenna's ground plane using a shorting plate. They can resonance at a much smaller patch size for fixed operating frequency compared to the conventional patch antenna [19].

In order to start designing Sierpinski Carpet Fractal (SCF) antenna, a large square structure is created in the plane and divided into nine smaller congruent squares where the open central square is dropped out. The remaining eight square are divided into nine smaller congruent squares with again each central is dropped out. Figure 1 show the process of iteration for SCF antenna. The iteration for this process is up to third iteration. The ideal SCF antenna is obtained by iterating infinite number of times. [20- 21]

The calculation of the initial physical parameters of the SCF antenna pattern is presented here. This equation has been used to determine the all necessary dimensions of the micro strip patch antenna.

Patch width: $$W = \frac{1}{2f(\sqrt{\varepsilon_o \mu_o})}\sqrt{\frac{2}{\varepsilon_r + 1}} \quad (1)$$

Patch length extension: $$\Delta L = 0.142h \frac{(\varepsilon_{reff} + 0.3)\left(\frac{W}{h} + 0.264\right)}{(\varepsilon_{reff} + 0.258)\left(\frac{W}{h} + 0.8\right)} \quad (2)$$

Patch length: $$L = \left(\frac{1}{2f(\sqrt{\varepsilon_{reff}}\sqrt{\varepsilon_o \mu_o})}\right) - 2\Delta L \quad (3)$$

Effective patch length: $$Le = L + 2\Delta L \quad (4)$$

Combining PIFA element with fractal theory method, a novel dual band Sierpinski Carpet Fractal PIFA (SCF-PIFA) is proposed. The third order of SCF-PIFA was simulated to be printed over a thin Rogers RO4003 substrate of dielectric constant $\varepsilon_r$ = 3.38, and thickness, $h$ = 0.813mm. The final design can be summarized as the follow for the SCF-PIFA :

i. Patch Width ($L1$) = 27 mm and Patch Length ($L2$) = 27 mm
ii. PIFA height ($h$) = 8.0 mm
iii. Shorting Plate Width ($Ws$) = 5.0 mm
iv. Size of ground plane = 60 x 27 mm

# 3. Results and Discussions

SCF-PIFA effectively reduced the size element as compared to the printed microstrip transmission line feed Sierpinski Carpet antenna. Microstrip Sierpinski Carpet Antenna using Roger RO4003 substrate and the radiating patch is 108 x 108 mm and the ground plane size is 200 x 200 mm as shown in Figure 2(a). It is three times larger than SCF PIFA patch. Although, it produced a multiband frequency, SCF-PIFA produced a wider bandwidth and cover up most of the resonant frequency produced by printed Sierpinski Carpet antenna. The comparison result can be seen in Figure 3. The simulation software CST Microwave Studio was used to design parameters and the simulated return loss, impedance and VSWR result for SCF-PIFA are shown in Figure 6.

Figure 4 shows result for the matched resonance of the Sierpinski Carpet Fractal PIFA operate at GSM 1800/1900, UMTS and HiperLAN applications, and corresponding to good input impedance. Examining the result showed a good bandwidth and can be applying for mobile phone application. In Table 1 indicate the data result for the SCF-PIFA antenna.

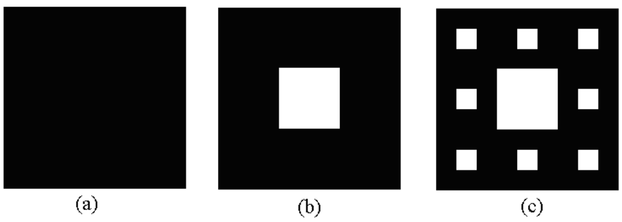
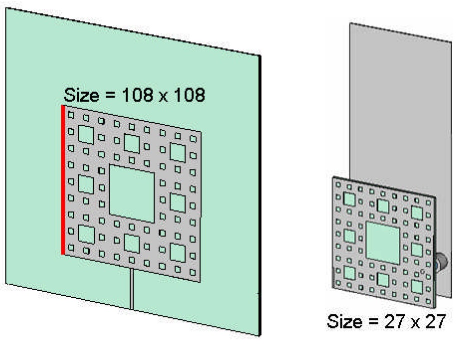



Figure 1 - Dimension for Microstrip Sierpinski Carpet Fractal antenna (a) First iteration (b) Second iteration (c) Third iteration




(a) (b)

Figure 2: Comparison size between printed line feed Sierpinski Carpet antenna and Sierpinski Fractal PIFA in millimeter.

TABLE 1
PERFORMANCE OF THE Sierpinski Fractal PIFA

| Resonant Frequency (GHz) | Bandwidth (GHz) |
|---|---|
| 2.00 | (1.6842 – 2.5439) = 0.8597 |
| 5.00 | (4.6842 – 5.2456) = 0.5614 |

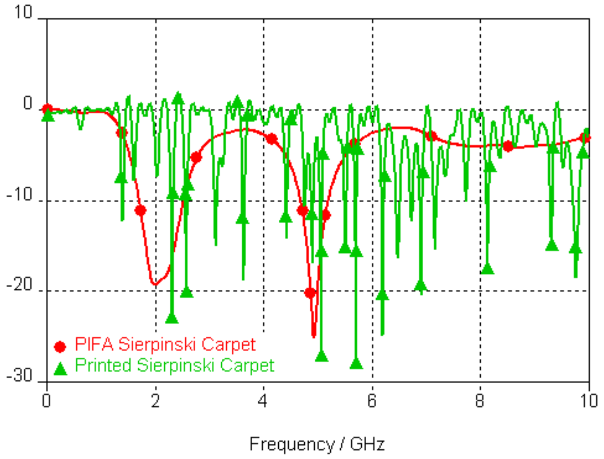
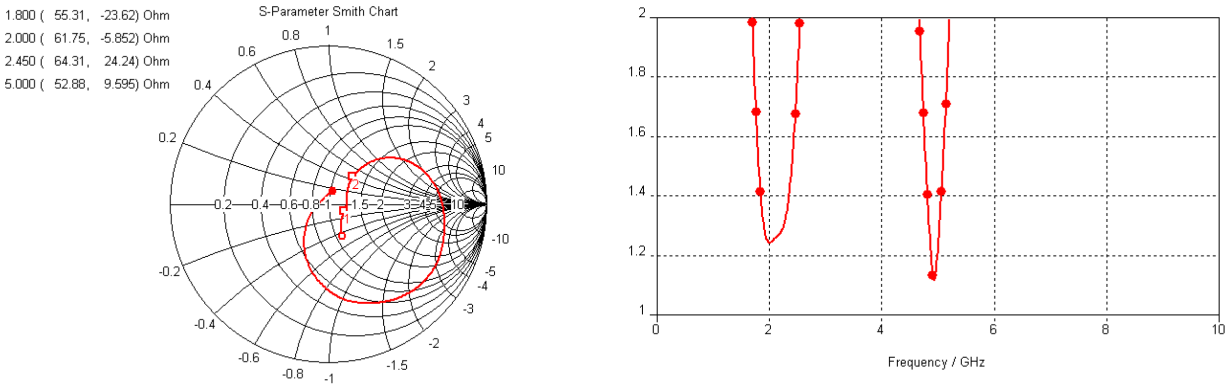



Figure 3: S11 result between printed line feed Sierpinski Carpet antenna and Sierpinski Fractal PIFA




(a) (b)

Figure 4: PIFA results (a:) Input Impedance, b:) Sierpinski Carpet Fractal PIFA VSWR)

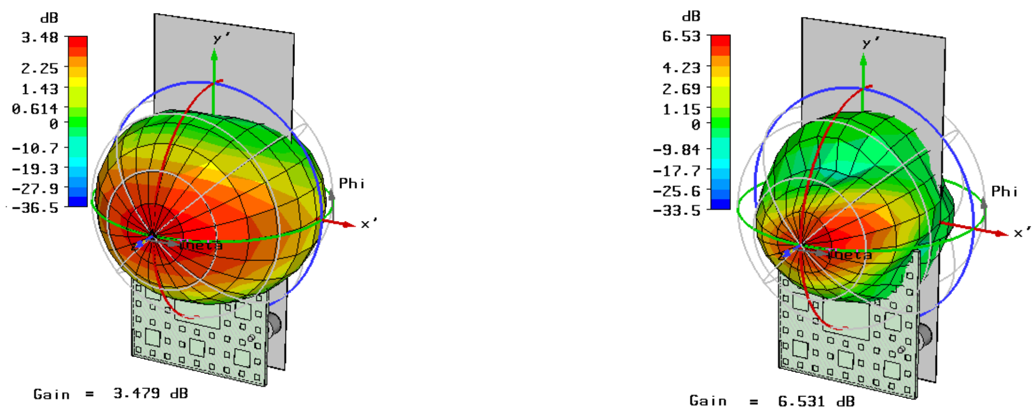



Figure 5: 3-D simulated radiation pattern result on Sierpinski Carpet Fractal PIFA and gain value a) 2.0GHz, gain = 3.479 b) 5.00GHz, gain = 6.531

From Figure 5, it is observed that the radiation pattern in the two planes is near omni-directional, thus, extremely suitable for applications in mobile communication devices.

## 4. Conclusion

In this paper, we have proposed a compact SCF-PIFA which has wide bandwidth for mobile phones operating in GSM1800/1900, UMTS and HiperLAN frequency bands. The accomplishment of acceptable bandwidth is definitely an important consideration for antenna design in mobile communications systems. As well matched impedance bandwidth must cover the entire required operating frequency range, as well as the VSWR equal to 2 or 1.5. The radiation pattern result shows an omni directional radiation, which can radiate equally in all direction. This entail that the antenna is suitable for application in wireless communication, especially in the desired domain.

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