Fractal stacked monopole with very wide bandwidth

C.T.P. Song, P.S. Hall, H. Ghafouri-Shiraz and D. Wake

A parallel feed stacked fractal antenna using the square Sierpinski and diamond Sierpinski carpet is introduced. The design achieves a good input impedance match throughout the passband (1–20GHz) but occasional slight mismatch occurs. Three different experimental results are shown and the measured gain of these antennas is generally > 0dBi. These antennas are suitable for applications in picocell environments for the operating bands of GSM, DECT and WLAN systems.

Introduction: Generated monopolar mode polarisation is of interest especially for applications in WLAN and HIPERLAN systems [1, 2]. The radiation properties and characteristics of monopole antennas mounted on a large ground plane make them highly suitable as base station antenna candidates for indoor and outdoor picocell applications. It would be advantageous for a communication infrastructure to be easily implemented for future systems while still being applicable to current systems. One such example of this infrastructure is the passive picocell system [3], where the optically delivered signal is converted to microwaves, allowing the antenna to serve as the final drop to the subscriber. These antennas are not only preferred because they are small, and lightweight, for easy installation, but they are also extremely wideband.

The fractal volume concept was introduced recently to improve the design flexibility of fractal antenna elements. However, a wideband match below VSWR < 2 is yet to be achieved [4]. In this Letter, we describe a novel stacked Sierpinski carpet fractal antenna. The feeding method of this fractal Sierpinski carpet antenna achieves a wideband match with a ratio of almost 20:1. To further demonstrate the design flexibility, two other variations of this approach are also presented experimentally: a diamond shaped Sierpinski carpet antenna element, and a square ratio Sierpinski carpet antenna element.

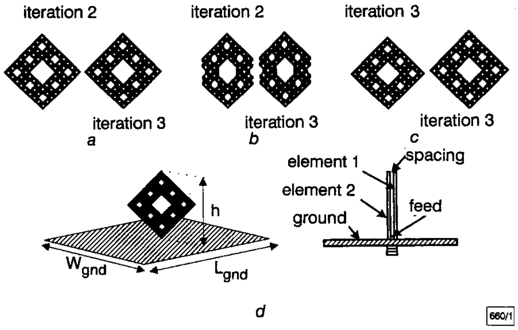

Fig. 1 *Antenna configuration of proposed wideband fractal stack monopoles*

Constituent elements of antennas:
a Antenna 1
b Antenna 2
c Antenna 3
d Mounting configuration of all antennas

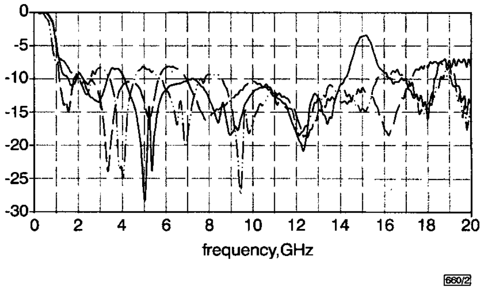

Fig. 2 *S_{11} performance of three-stack monopole*

——— antenna 1
– – – – antenna 2
— ·· — antenna 3

Antenna design: Antenna 1 is a combination of a second iterated and a third iterated square Sierpinski carpet element shown in Fig. 1*a*. Antenna 2 is a diamond Sierpinski carpet element (Fig. 1*b*) designed with its horizontal apex removed and iterated. The second iterated and third iterated elements of both antennas are combined and fed at their apexes. Antenna 3 is a combination of two elements of third iterated Sierpinski carpet antennas shown in Fig. 1*c*. These two elements are identical, and both are fed at their apexes, but one is scaled with respect to the other by a height ratio of 1.08. The heights, *h*, of these elements are 63 and 68mm; both elements shown in Fig. 1*a* and *b* are 54mm in height. The ground plane size is ~160mm and the element spacing is 1.5mm. All antennas are fed using the method shown in Fig. 1*d*.

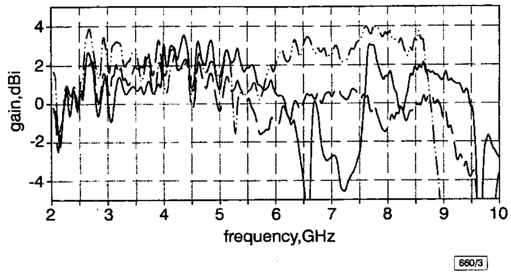

Fig. 3 *Gain of antennas 1–3 at 45° elevation*

——— antenna 1
– – – – antenna 2
— ·· — antenna 3

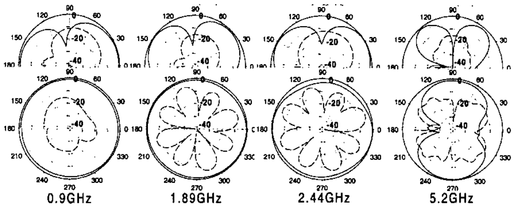

Fig. 4 *Polarisation plots of Sierpinski stack antenna: antenna 1 (square Sierpinski)*

——— co-polarisation
– – – – cross-polarisation

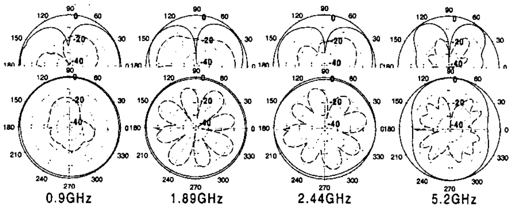

Fig. 5 *Polarisation plots of Sierpinski stack antenna: antenna 2 (diamond Sierpinski)*

——— co-polarisation
– – – – cross-polarisation

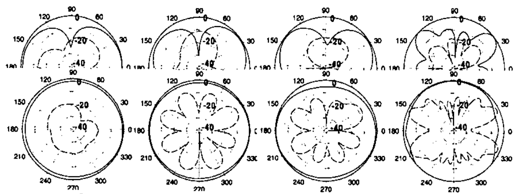

Fig. 6 *Polarisation plots of Sierpinski stack antenna: antenna 3 (square Sierpinski ratio)*

——— co-polarisation
– – – – cross-polarisation

Experimental result: The S_{11} performance of the three antennas is shown in Fig. 2. In general, a good match of –5dB is achieved throughout the passband from 1 to 20 GHz. However for VSWR < 2, some occasional slight mismatch is observed for all three antennas. The measured gain of these antennas is > 0dBi (Fig. 3). Note that the gain is measured at a 45° elevation from the azimuth of the antenna's ground plane. In Figs. 4 – 6, the plots correspond to operating bands of 0.9, 1.89, 2.44 and 5.9GHz from left to right, representing GSM, DECT, WLAN and HIPERLAN bands, respectively. The top row of each antenna shows the E-plane radiation while the bottom row shows the H-plane radiation. The radiation plots display good monopolar mode radiation. However, it is expected that when operating at higher frequencies, ripples along the plots are inevitable due to the fixed ground plane size. It was also observed that when operating at a higher frequency (5.2GHz), the H-plane shows an occurrence of a null in both the square and diamond stacked second and third iteration antennas. The lowest observed resonant match is much lower than that achievable with the actual height of the antenna. Both the second and third iteration combination antennas and the Sierpinski square ratio antenna show a good wideband match.

Conclusion: A wideband fractal Sierpinski antenna using a parallel feed technique has been presented. Also, a stacked fractal antenna using a square Sierpinski and diamond Sierpinski carpet with element height ratio has been presented. These designs achieved an approximate 20:1 match for a 50Ω feed port. The gain and radiation patterns are suitable for current application in the GSM, DECT, WLAN and HIPERLAN bands in indoor picocell environments.

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C.T.P. Song, P.S. Hall and H. Ghafouri-Shiraz (*School of Electrical and Electronic Engineering, University of Birmingham, Edgbaston, Birmingham B15 2TT, United Kingdom*)

E-mail: songp@ee-wp.bham.ac.uk

D. Wake (*BT Laboratories, Martlesham Heath, Ipswich, Suffolk, IP5 3RE, United Kingdom*)

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Low-cost antenna of series-fed printed strip dipoles

F. Tefiku and C.A. Grimes

A newly developed antenna comprising series-fed printed strip dipoles is described. The effect of substrate permittivity on the radiation properties of the antenna is investigated, using an analysis model based on the general concept of the equivalent radius of cylindrical antennas. An antenna with a gain of > 9dB and VSWR ≤ 1.5 over the frequency range 1.8–2.2GHz is presented.

Introduction: Printed strip dipoles are widely used as the radiating elements in low-cost base stations for commercial communication systems. Arrays of series-fed printed strip dipoles can be fabricated as easily as a single strip dipole. The properties of a dual-frequency antenna consisting of two-printed strip dipoles have been presented [1]. In this Letter we report on the effect of the dielectric substrate on the radiation characteristics of series-fed printed strip dipoles and present a series-fed array antenna of four-printed strip dipoles featuring broadband operation. The antenna is matched to the feed line (VSWR ≤ 1.5), and has a gain of > 9dB over the frequency range 1.8 – 2.2GHz. This simple, easily manufactured antenna is well suited for the base station antennas of public mobile communication systems. Results from an equivalent analysis model that transforms printed conductors to coated circular conductors [2] and uses the usual method of moments for wire antennas closely correspond to experimental results.

Antenna structure and design: Fig. 1 shows a schematic diagram of the array antenna. Four strip dipoles have their arms printed on the two sides of an electrically thin dielectric substrate. The strip dipoles are connected through parallel feed lines of characteristic impedance Z_C. The dipoles are closely spaced and a direct connection between them is employed for endfire radiation. Resonances on the feeder line may be excited due to reflections, and are characterised by rapid changes in the antenna characteristics over a narrow frequency range. It is necessary to exactly predict the positions where these resonances occur, and if possible to move them from the frequency range of interest.

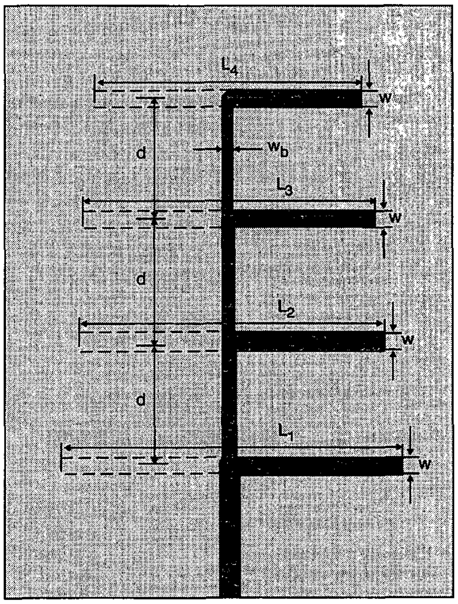

Fig. 1 *Configuration of series-fed array of four printed strip dipoles*

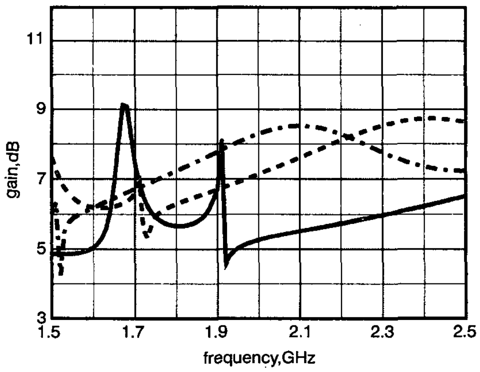

Fig. 2 *Calculated gain of analysed antenna for different values of permittivity*

——— $\varepsilon_r = 1.0$
– – – – $\varepsilon_r = 2.2$
– · – · – $\varepsilon_r = 3.2$

The proposed antenna has a simple configuration, but a large number of analysis parameters. It is printed on a finite dielectric substrate and represents a three-dimensional composite structure