

A Compact W shape Snow Fractal Multiband Antenna for Wireless Applications

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Abstract. A novel compact W shape snow fractal multi-broadband planar antenna is proposed for mobile handsets in the paper. W shape two iteration fractal structure is combined with hexagonal monopole radiator, a nested concentric hexagon slot and coplanar waveguide (CPW) feed structure. The antenna can cover more than ten mobile applications in two broad-bands with -6dB bandwidth of 130.4% (0.51-2.42GHz) for UHF(606-806MHz), GSM900(880-960MHz), DCS1800(1710-1880MHz), TD-SCDMA(1880-2025MHz), WCDMA(1920-2170MHz), CDMA2000(825-880), LTE33-40(1900-2400MHz), LTE44(703-803MHz), WiFi, Bluetooth, and 11.49%(3.2-3.59GHz) for WiMAX wireless applications. The proposed antenna is fabricated on a 1.6 mm-thick FR4 substrate with dielectric constant of 4.4, and the size is 98*56mm². The good agreement between the measurement results and the simulation validates the proposed design approach and meets the requirements for various wireless applications.

Introduction

With the rapid development of mobile communication systems, miniaturized multiband planar antennas have been widely used in wireless mobile handsets because of its light weight, low profile, low cost, high manufacturing precision, easy to load, easy integration, etc. Resonance antennas, such as half-wave dipoles or quarter-wave monopoles are difficult to achieve multiband and miniaturization[1-2]. Therefore, asymmetric CPW-fed antenna are used to improve the bandwidth[3]. Meanwhile, CPW-fed is the most popular feeding structures adopted in recent literatures[4-6].

In order to better achieve the multiband and miniaturization, many technologies have been studied, such as coupling feed technology [7-9], slot loaded technology [10-11], loading matching network [12], loading printed distributed inductance technology [13] and fractal technology [14]. Especially, fractal design approach on controlling the current path and resonant mode on radiators with the fractal space-filling to increase the antenna electrical length and radiation efficiency is usually adopted. Fractal structure design approaches are known for their compact size, low profile and multiband response. In [15], proposed a monopole antenna with new hybrid dielectric resonator antenna (DRA) excited by new fractal structure, which provide a huge bandwidth ranging from 2 to 40GHz. In [16], proposed an antenna with square and Giuseppe Peano fractal geometries on two layers microstrip antenna which covered GPS, Hiper-Lan2, IEEE 802.11b/g applications. In [17], a multiband Minkowski fractal coplanar waveguide (CPW)-fed slot antenna loaded with a dielectric resonator for multiple wireless standards.

In this paper, a novel compact two iterations W-shape snow fractal microstrip antenna with a nested concentric hexagon slot structure for multi-broadband wireless applications is presented. The antenna covers more than ten mobile applications of UHF(606-806MHz), GSM900(880-960MHz), DCS1800(1710-1880MHz), TD-SCDMA(1880-2025MHz), WCDMA(1920-2170MHz), CDMA2000 (825-880), LTE33-40(1900-2400MHz), LTE44(703-803MHz), WiFi, Bluetooth and WiMAX.

Antenna structure and design procedure

a. Characteristics of Antenna Structure

The antenna is based on hexagonal snowflakes structure monopole radiator, and two isosceles triangles are digged on each edge of the hexagon to form a W shape. The same method is used to dig two smaller isosceles triangles on each remaining side to form W shape two iterations fractal structure. This will prolong the length of surface current on radiator, and will produce different frequency resonance points.



(a) no iteration (b) 1st iteration (c) 2nd iteration

Fig.1 stepwise iteration stages on each side of the radiator

The structure and dimensions of proposed multiband monopole antenna is shown in Fig.2 and Table 1. The antenna has two iterations W-shape fractal structure radiator with a concentric hexagon slot nested, a 50- Ω CPW feedline. The antenna is designed on FR4 substrate with height of 1.6mm, dielectric constant (ϵ_r) of 4.4 and loss tangent (δ) of 0.02.

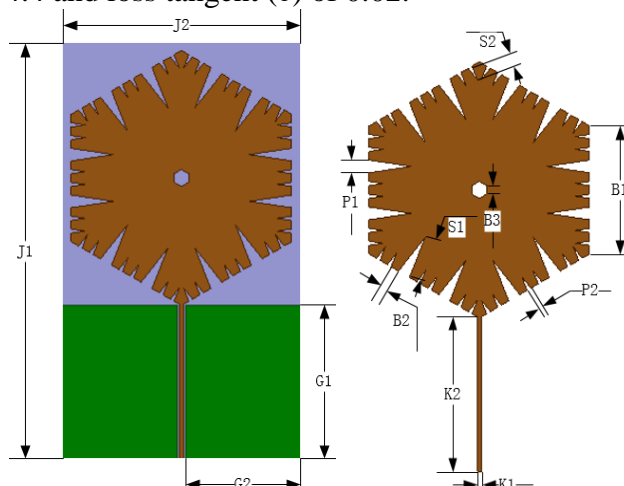


Fig.2. Layout of proposed antenna

Table 1. Dimensions of proposed antenna

Fractal Antenna Dimensions/Values(mm)							
J1	J2	G1	G2	K1	K2	B1	B2
98	56	36	27	1	36.3	30	2
B3	P1	P2	S1	S2			
2	3	1	10.1	3.4			

b. Performance of Simulation

The simulation is conducted by Ansoft HFSS 15.0. Fig.3 illustrates the reflection loss (S_{11}) curves at different ground length.

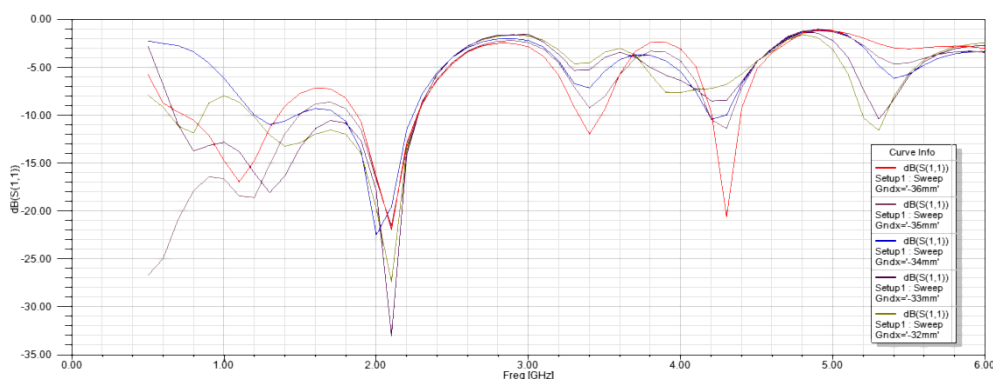


Fig.3. Combined simulated reflection loss of antenna

Fig.4 shows that the antenna can operate at four different wide frequency bands centered at 1.1GHz with -16.95dB reflection loss, 2.1GHz with -21.7dB reflection loss, 3.4GHz with -11.9dB reflection loss, and 4.3GHz with -20.5dB reflection loss. The simulated -10dB bandwidth for the first frequency band (0.74-1.37GHz) is 59.72%, the second band (1.87-2.27GHz) is 19.32%, the third band (3.33-3.48GHz) is 4.4% and the fourth band (4.20-4.39GHz) is 4.4%. The -6dB bandwidth for the first frequency band (0.51-2.42GHz) is 130.4%, the second band (3.2-3.59GHz) is 11.49%, and the third band (4.12-4.48GHz) is 8.4%. Fig.5 shows the voltage standing wave ratio (VSWR) curve of the antenna. These bands cover several commercial application bands of 2G, 3G, 4G-LTE, WiFi, Bluetooth and WiMAX, as given in Table 2 and Table 3.

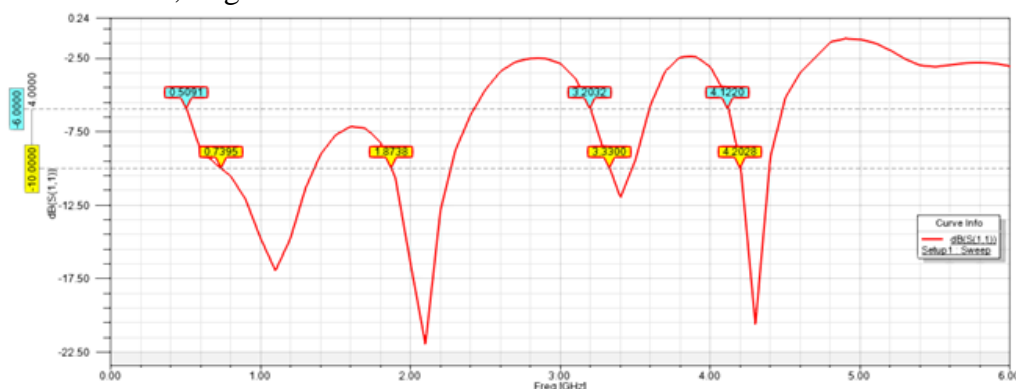


Fig.4. Simulated return loss (S_{11}) of proposed antenna

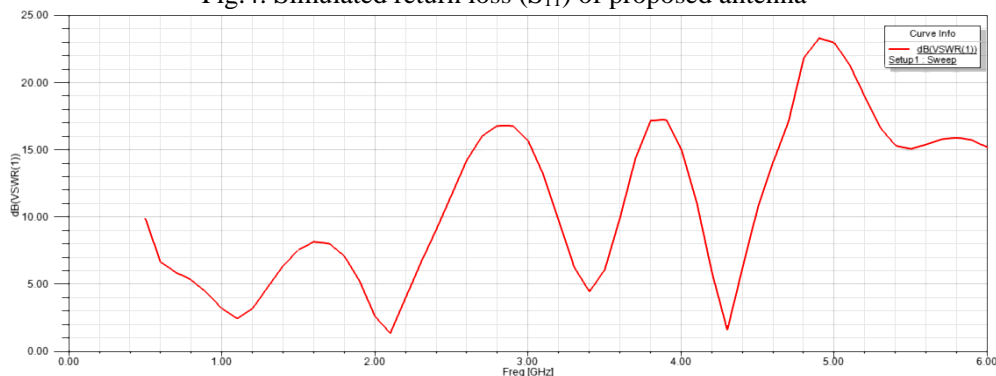


Fig.5. Simulated VSWR of proposed antenna

Table 2. -10dB frequency bands covered by antenna

Band No.	-10dB Bandwidth	Covered Commercial Bands
1	0.74-1.37GHz (59.72%)	GSM900(880-960MHz), CDMA2000(825-880,885-960MHz)
2	1.87-2.27GHz (19.32%)	TD-SCDMA(1880-2025MHz),WCDMA(1920-2170MHz), LTE33-37(1900-2025MHz)
3	3.33-3.48GHz (4.4%)	WiMAX(3.3-3.48GHz)

Table 3. -6dB frequency bands covered by antenna

Band No.	-6dB Bandwidth	Covered Commercial Bands
1	0.51-2.42GHz (130.4%)	UHF(606-806MHz),GSM900(880-960MHz), DCS1800(1710-1880MHz),TD-SCDMA(1880-2025MHz,2300- 2400MHz supplementary),WCDMA(1920-2170MHz,1755-1880MHz Supplementary),CDMA2000(825-880,885-960MHz Supplementary), LTE33-40(1900-2400MHz), LTE44(703-803MHz), WiFi, Bluetooth
2	3.2-3.59GHz (11.49%)	WiMAX(3.3-3.48GHz)

The surface current amplitude distribution on radiator of the proposed antenna that work at the center frequency of 1.1GHz, 2.1GHz, 3.4GHz, and 4.3GHz, respectively, are shown in Fig.6(a)-(d). For 1.1GHz frequency, the current is more concentrated at the bottom of the radiator, as shown in Fig.6(a). With the frequency increase, the outer edges of the radiator has more current. While for 4.3GHz frequency, the current is relatively maximum at all edges of the radiator, as shown in Fig.6(d).

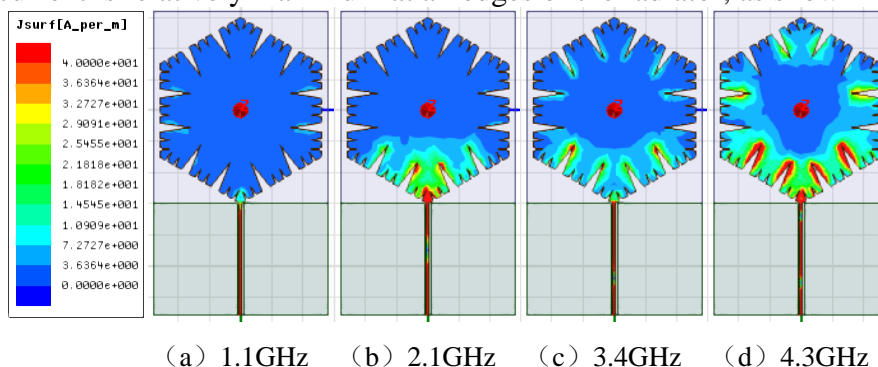


Fig.6 Current amplitude distribution at different center frequencies

The simulated E-plane and H-plane radiation patterns of proposed antenna at the center frequencies of 1.1GHz, 2.1GHz, 3.4GHz and 4.3GHz are shown in Fig.7(a)-(d). It can be seen that E-plane and H-plane patterns are close to omnidirectional at all bands.

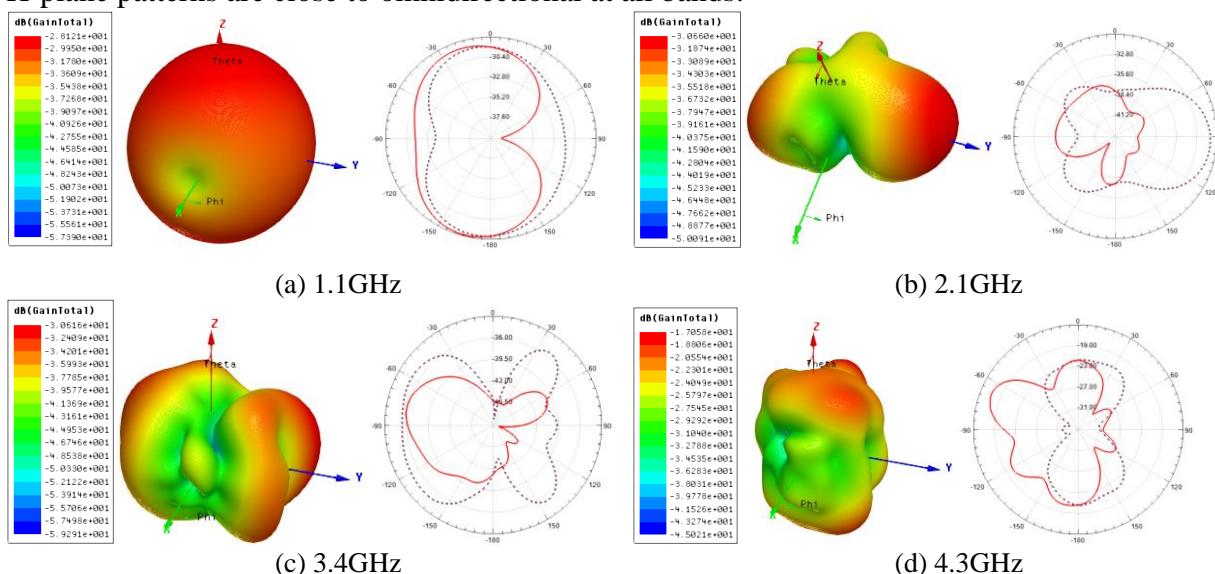


Fig.7. E- and H- plane radiation patterns at different center frequencies

Fabrication and measured results

To verify the mult-broadband performance of the planar antenna, a prototype antenna is fabricated and measured. The antenna is built on 1.6mm thick FR4 substrate with loss tangent=0.02 and 30 μ m copper on both sides. Fig.8(a) shows the front and back views of the antenna. The antenna is tested by antenna measurement system of PNA3621, as shown in Fig.8(b).

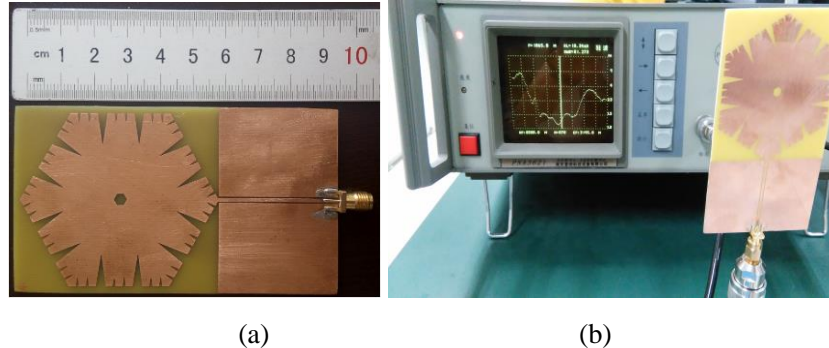


Fig.8 (a) Fabricated prototype antenna and (b)Testing scenario

The measured reflection loss (S_{11}) and Voltage Standing Wave Ratio (VSWR) have better agreement with the simulated results, as shown in Fig.9. This makes the antenna compatible for mobile communications applications.

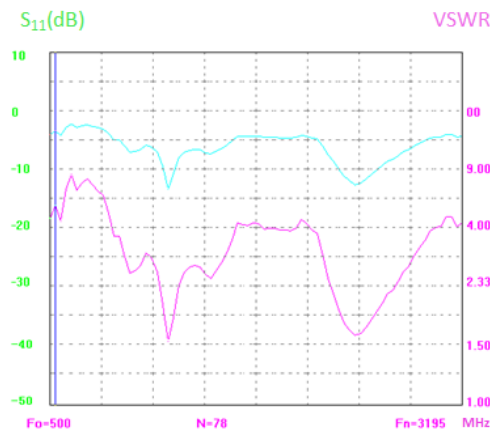


Fig.9. Measured S_{11} and VSWR curves

Conclusions

A W-shape structure snow fractal multiband planar antenna is developed for GSM900, DCS1800, TD-SCDMA, WCDMA, CDMA2000, LTE, Bluetooth and WiMAX applications. The better agreement between the measurement results and the simulation validates the proposed antenna meet the requirements for various wireless applications.

Acknowledgements

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