Compact Fractal Patch Microstrip Antenna Fed by Coplanar Waveguide for Long Term Evolution Communications

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Abstract - This paper proposes a new design of compact fractal patch microstrip antenna fed by coplanar waveguide to reduce the antenna dimension and to increase its bandwidth for Long Term Evolution application purposes. The results shown return loss of -23.45 dB and VSWR 1.144 can be achieved by controlling the height and the width of the fractal patch dimension. Bandwidth of the proposed antenna is 375 MHz which is equal to an increase of 200% compared to the conventional rectangular patch antenna and also the dimension of fractal patch antenna can be reduced until 66%.

Keywords—Coplanar Waveguide, Fractal Patch Microstrip Antenna, Bandwidth, Rectangular Patch Microstrip Antenna.

I. Introduction

The development of information technology is now growing rapidly, especially in wireless telecommunications. Data transfer speeds become an important requirement to make the telecom provider optimize the network in order to meet customer needs. The user side needs a receiver that can work for some diversed telecommunications systems, such as DCS at frequency band (1710 MHz -1885 MHz), PCS (1907 MHz -1912.5MHz), UMTS (1920 MHz – 2170 MHz),WLAN 2.4 GHz and LTE 2.3 GHz [1]. According to the Indonesian government regulate stated that the band frequency of 2300 MHz - 2400 MHz is used for broadband communication system such as Long Term Evolution [2].

Telecommunications devices are now becoming smaller and more compact, so it can be embedded to telecommunications equipment and one of these telecommunications devices is antenna. Microstrip antenna is one of many type of antennas that can be used for wireless communications, because this antenna has an advantages such as small size, compact and easy to be fabricated. However, this antenna has several disadvantages too including its narrow bandwidth and low gain. One way to overcome the narrow bandwidth is using fractal method and by using fractal method the dimensions of the antenna can be reduced and become more compact. There are several methods of fractal being developed based on its geometry, such as Hilbert [3], Sierpinski [4], Koch [5], and Minkowski [6-7].

In previous study done by [8], circular patch microstrip antenna using fractal method for LTE communication can be obtained bandwidth of 16.85%. The research conducted by [9] showed that the fractal method can be reduced the antenna size until 61.6%. In another study done by [10] has been successfully carried out optimization of bandwidth of 500 MHz at frequency of 7.51 GHz and of 350 MHz at frequency of 9.18 GHz.

From the above results of previous studies it can be concluded that the fractal method can reduce the dimension and increase the bandwidth of the proposed antenna. Therefore this paper proposed a new design of compact fractal patch microstrip antenna fed by coplanar waveguide to reduce dimension and to increase the bandwidth for Long Term Evolution application purposes.

II. Antenna Design

The proposed antenna is realized on one layer substrate with relative permittivity (***εr***) of 4.3, substrate thickness (***h***) of 1.6 mm and loss tangent (***tan δ***) of0.0265. The dimension of the rectangular patch antenna is given by below equations.

$$W = \frac{c}{2f\sqrt{\frac{\varepsilon r+1}{2}}} \quad (1)$$

$$L = L_{eff} - 2\Delta L \quad (2)$$

$$L_{eff} = \frac{c}{2f\sqrt{\varepsilon_{reff}}} \quad (3)$$

$$\varepsilon_{reff} = \frac{\varepsilon r+1}{2} + \frac{\varepsilon r-1}{2}[1+12\frac{h}{W}]^{-\frac{1}{2}} \quad (4)$$

$$\Delta L = 0{,}412.h\frac{(\varepsilon_{reff}+0.3)(\frac{W}{h}+0.264)}{(\varepsilon_{reff}-0.258)(\frac{W}{h}+0.8)} \quad (5)$$

In this research, the fractal iteration is done in two stages. At the first stage the fractal antenna is fed by microstrip line, while at the second stage is fed by coplanar waveguide or CPW. Using fractal method and together with coplanar waveguide fed line can enlarge the bandwidth of the proposed antenna. The dimension of fractal microstrip antenna is given by [11] and in this paper used deterministic fractal with Cohan Sinkowski modeling.

$$Lf = h\left(\frac{5}{3}\right)^{n} \quad (6)$$

Fig 1 shown the two stages process of the fractal antenna and in Fig 2 shown the fractal antenna at the modified design with $\boldsymbol{n}$ = 2.

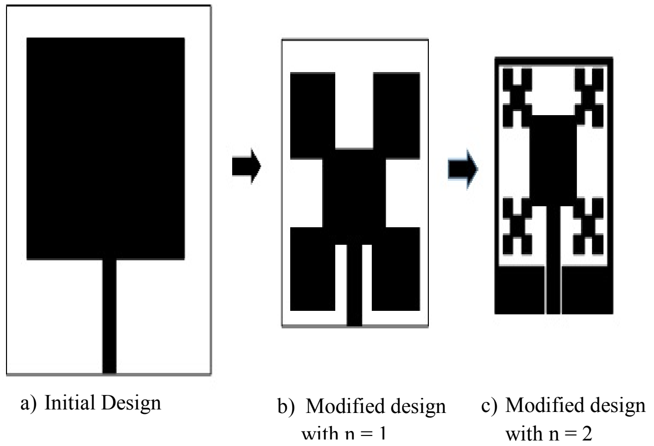

Fig 1 Fractal process on two stages

From Fig 2 below can be seen the dimension of A = 9.6 mm, B = 8.9 mm, Lg 1= 0.5 mm, Lg = 4 mm, Lz = 12 mm, Gs = 0.75 mm, Wz = 3 mm, L1= 11 mm, L2 = 11 mm and d = 10.4 mm. The dimension of the enclosure is 26.5 mm x 30 mm.

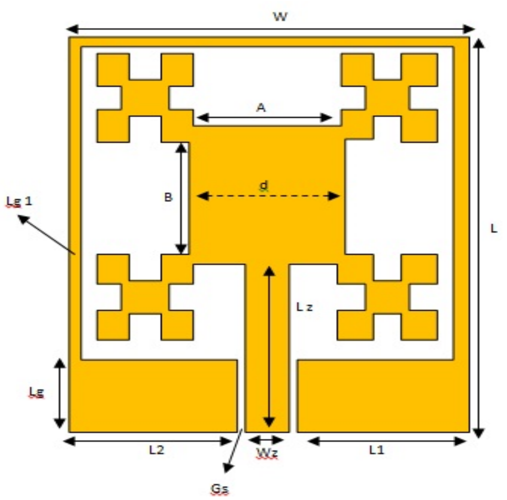

Fig 2 Fractal patch microstrip antenna with n = 2

The design of the proposed single fractal patch microstrip antenna can be seen in Fig 3 with the dimensions of A1= 2 mm, A2 = 2.5 mm, A3 = 2 mm, A4 = 2 mm, A5 = 2 mm, A6 = 2 mm, A7 = 2 mm and r = 3 mm.

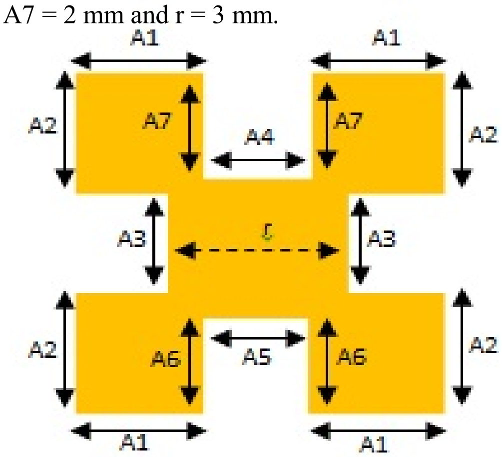

Fig 3 Design of single fractal patch antenna

III. Result And Discussion

After having several iterations, the best simulation results can be achieved by adjusting the dimension of the height and wide of the fractal patch antenna. The simulation results of return loss and VSWR from iteration process are shown in Fig 4 and Fig 5.

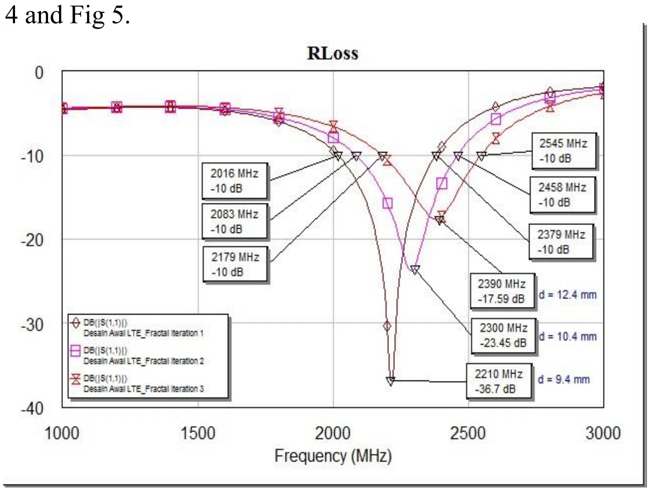

Fig 4 Simulation result of return loss

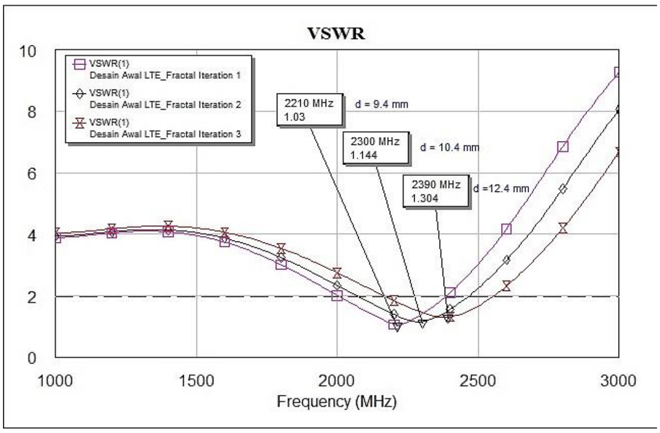

Fig 5 Simulation result of VSWR

The overall iterations can be summarized into Table 1 and Table 2 as follows.

TABLE 1 ITERATIONS OF THE FRACTAL ANTENNA

Iteration	Parameter		
	A	*B*	*d*
First	8.6 mm	9.9 mm	9.4 mm
Second	9.6 mm	8.9 mm	10.4 mm
Third	10.6 mm	8.5 mm	12.4 mm

TABLE 2 SIMULATION RESULTS

Iteration	Parameter			Frequency
	Return Loss	*VSWR*	*Bandwidth*	
First	-38.60 dB	1.024	362 MHz	2200 MHz
Second	-23.45 dB	1.144	375 MHz	2300 MHz
Third	-17.53 dB	1.306	366 MHz	2390 MHz

After having several iterations by adjusting A and B, from Table 1 and Table 2 it can be seen return loss of -23.45 dB and VSWR of 1.144 at frequency of 2300 MHz can be obtained when the dimension of ***d*** is 10.4 mm. With this condition the bandwidth can be increased into 375 MHz. Using fractal method, the dimension of the proposed antenna can be reduced until 66% compared to the first design of rectangular microstrip antenna. The comparison of the dimension of the rectangular patch antenna and the proposed antenna after the second process with ***n*** = 2 can be seen in Fig 6 and Table 3.

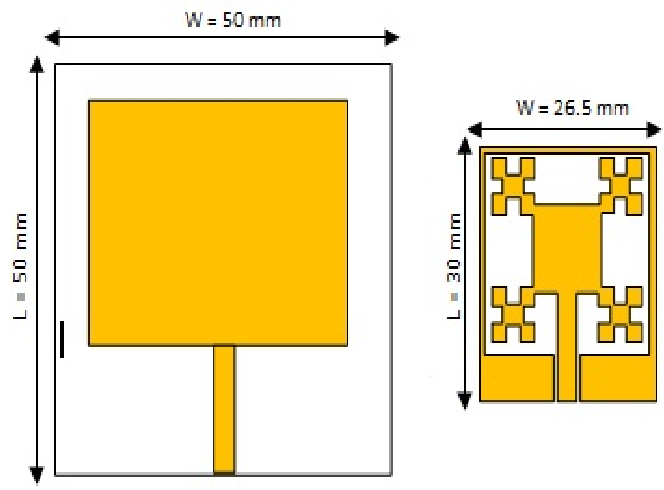

Fig 6 Comparison of the dimension of the antenna

TABLE 3 DIMENSION OF ANTENNA

Microstrip Antenna	Dimension of Enclosure
Rectangular Design	50 mm x 50 mm
Fractal Design	26.5 mm x 30 mm

Fig 7 below shown the comparison of the simulation results between the patch rectangular and the fractal patch antenna and Table 4 shown the comparison results of return loss and bandwidth.

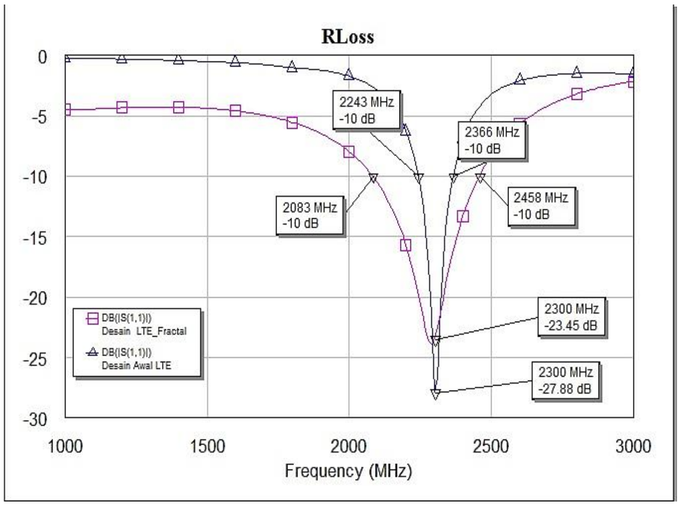

Fig 7 Comparison of simulation results

TABLE 4 SIMULATION RESULT

Microstrip Patch	Parameter		Frequency
	Return Loss	*Bandwidth*	
Rectangular Design	-27.88 dB	123 MHz	2300 MHz
Fractal Design	-23.45 dB	375 MHz	2300 MHz

From Table 4 it can be seen that using fractal method and coplanar waveguide fed line, the bandwidth of the proposed antenna can be increased until 200% at frequency 2300 MHz compared with the rectangular design microstrip antenna. Therefore it can be concluded that fractal method succeeds to reduce the dimension of the patch antenna and increased the bandwidth of the antenna.

From the above results shown that this paper proposed a new design of fractal method with Cohan Sinkowski modeling. This proposed antenna only use one substrate but can be increased the bandwidth until 200% compared with the previous study done by [8], using two substrates can be obtained bandwidth of 16.85%.

Beside that, the dimension of the proposed antenna can be reduced until 66% compared with the research conducted by [9] can be reduced the antenna size until 61.6%.

IV. CONCLUSION

A new design of compact fractal patch microstrip antenna is eventually well proposed. The best value of return loss, VSWR and bandwidth can be obtained by adjusting the dimension of height and wide of the fractal patch antenna. The impedance bandwidth of the proposed microstrip antenna is 375 MHz (2083 MHz – 2458 MHz). The dimension of the proposed antenna can be reduced up to 66% compared with the rectangular patch microstrip antenna design. Beside that the fractal method also succeeds to increase the bandwidth of the proposed antenna until 200% from 123 MHz to 375 MHz.

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