# A Dual-Band Star Chain Fractal CPW Antenna for LTE and RF Altimeter Systems

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***Abstract* - Long-Term Evolution (LTE) network is one of frequency band using in communication devices radio altimeter system which use in aircraft navigation system. These device requires versatile antenna ability. The work scheme of this antenna by using new designed fractal geometry to provide a "dual-band frequency" for both applications at 1.8 GHz and 4.3 GHz. Normally, the harmonic frequency is not match with the acquired frequency this problem can solve with Star Chain Fractal geometry that can shift the harmonic frequency by optimization the geometry parameter and the paper also using coplanar waveguide feed (CPW) to make an antenna be easily fabricated. The step-impedance matching technique on this paper improves both fundamental frequency and harmonic frequency return-loss performance. The optimization and simulation is based on a commercial software of "CST Microwave Simulation".**

***Keywords* — Fractal, Coplanar Waveguide Feed Antenna, Iteration, Long-term Evolution, Radio Altimeter, Dual-band.**

## 1. Introduction

The scheme of Aeronautical Communication System (ACS) is designed under safety and backup plan concept for passenger therefore the device in same system should be cross-work with each other to prevent malfunction of aircraft system which include communication system that is an essential system for aircraft [1] and especially on Unmanned Aerial Vehicle (UAV) which use radio altimeter with at least the bandwidth of 200 MHz [2] to define operating altitude and LTE network to transmit video data. So the versatile and integrated devices are also required.

Star Chain fractal geometry represents how to make antenna resonant at dual-band frequencies to make multi-function of antenna and versatility. Although shape is based on fractal hexagon shape allows designer to control antenna parameter [3]-[4], The CPW advantage is make an antenna integrated in microwave circuit or monolithic microwave integrated circuit (MMIC) easily [4]. The radiation pattern is improves by the CPW technique [5] as the advantage of coplanar waveguide feed.

This paper is represented of new shape antenna to operating in fundamental frequency at 1.8 GHz LTE and the overall length provide harmonic second frequency at 4.3 GHz radio altimeter by the characteristic of the Star Chain shape. The step-impedance technique use to make matching at resonant frequencies in other word is improves return loss ($S_{11}$). However, the antenna result is gain from optimization which based on these mentioned techniques.

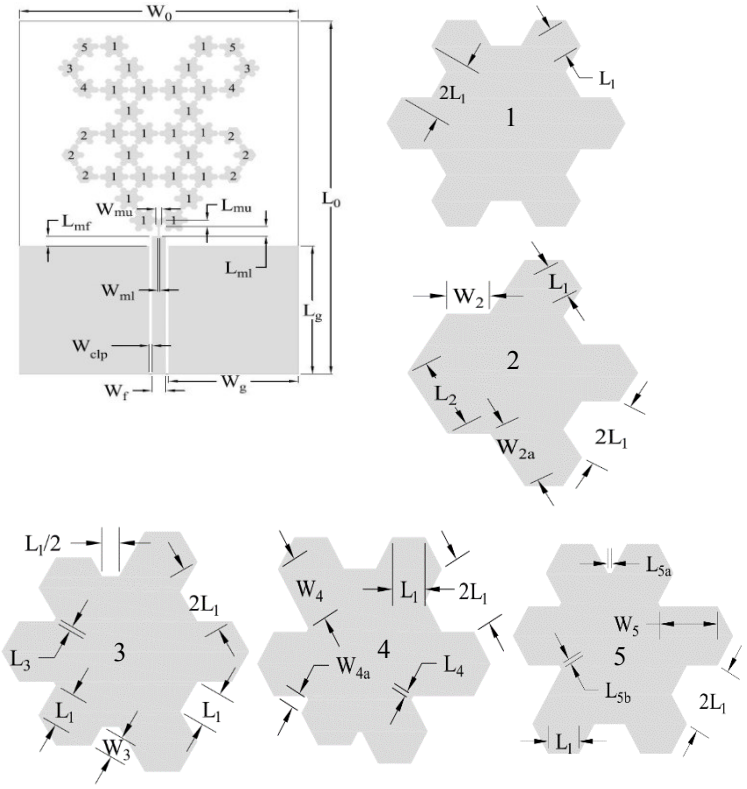



Fig.1.The Star Chain fractal geometry parameters

## 2. Antenna design

According to Fig.1, The Star Chain fractal geometry is presented by the proposed of designed antenna on epoxy resin (FR-4) which has metal thickness of 0.035 mm and dielectric constant is equal to 4.3. This antenna is designed as a quarter wavelength of fundamental frequency radiation patch with starts the initiator as a 1.6 mm hexagon shape, the 1st iteration on the middle length of old shape (0 iteration). The optimization via CST Microwave Simulation provides the antenna parameter as the following width, $W_2$ = 0.45 mm, $W_3$ = 0.25 mm, $W_4$ = $W_5$ = 0.746 mm, $W_{4a}$ = 0.169 mm, the step impedance matching has width and length $W_{ml}$, $W_{mu}$, $L_{ml}$, $L_{mu}$ as 0.2 mm, 0.6 mm, 1.2 mm, 0.8 mm, respectively. The coplanar waveguide feed is calculated by the formula to match with 50 Ω probe feeder with width $W_g$ = 14.065 mm, $W_f$ = 1.47 mm and $W_{clo}$ = 0.2 mm to reduce antenna length of

coplanar without ground antenna. These parameter length $L_1$ = 0.4 mm, $L_2$ = 0.857 mm, $L_3$ = 0.2 mm, $L_4$ = $L_{5a}$ = $L_{5b}$ = 0.05 mm on radiation patch can affect resonant frequency and shift to designed the antenna to operate at desired frequency that these parameter is optimized.

## 3. Simulation and Measured result

Following the antenna design process and optimization process, the harmonic frequency is also depend on shape number 2 in Fig. 1 which can shift the harmonic frequency.

Fig. 2 - 3 shows the comparison between XZ and YZ plane at 1.8 GHz and 4.3 GHz. The measured result and simulation result is quite agree with common fractal shape that is the Omni-directional radiation pattern in electric field plane (XZ - plane). The effect of top loop shape on Star chain fractal geometry makes the radiation on magnetic field plane (YZ - plane) is not symmetry as shown in Fig. 3.

Simulation graph of return loss is shown on Fig. 4 which can describe how the harmonic frequency of Star Chain fractal geometry can occur by the top loop of geometry in Fig. 5b no response of harmonic frequency in usable range.

Simulation result of return loss resonant with the fundamental frequency at 1.8 GHz with a 400 MHz but in the measured result has perform bandwidth 1100 MHz from (1500 MHz - 2600 MHz) and (1.6287 GHz - 2.0387 GHz) for simulation result. At 4.3 GHz harmonic frequency in measured result the frequency has shifted down approximately 100 MHz which has bandwidth from (3900 MHz - 4450 MHz) and for simulation result with resonant cover bandwidth from (4.0654 GHz - 4.5237 GHz). The overview of measured result is the operating frequency shift down approximately 100 MHz due to the substrate material is eliminated by milling machine in fabrication method which change the dielectric of substrate.

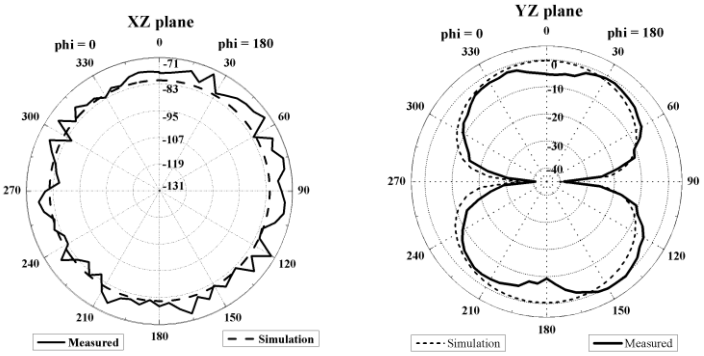



Fig. 2. Comparison between measured and simulation of E-plane and H-plane radiation pattern at 1.8 GHz.

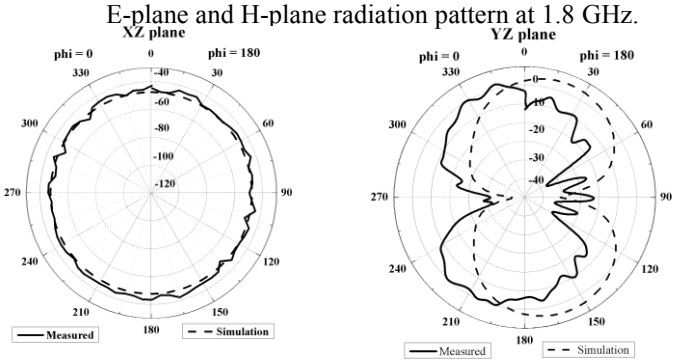



Fig. 3. Comparison between measured and simulation of E-plane and H-plane radiation pattern at 4.3 GHz.

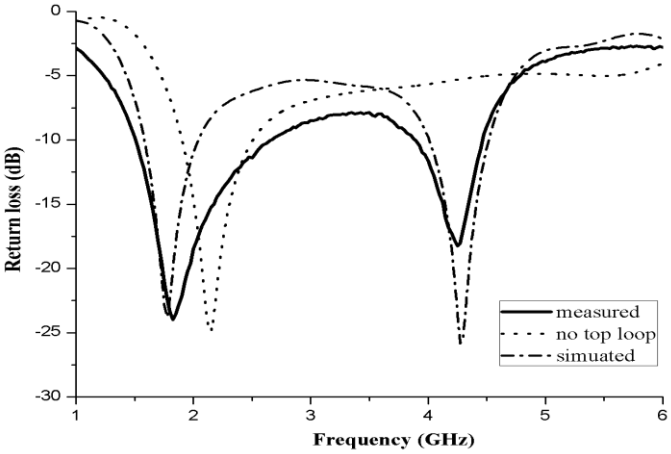
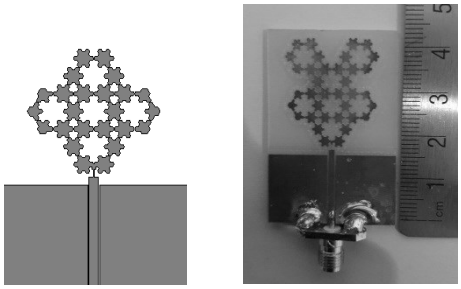



Fig. 4. The comparison of return loss



(a) (b)

Fig. 5. The Star Chain shape antenna
(a) No top loop (b) Prototype

## 4. Conclusion

The proposed of dual-band fractal coplanar waveguide feed antenna uses epoxy resin (FR-4) area of 45 mm ($L_0$) x 30 mm ($W_0$) which is shown on the paper that represent the technique of fractal geometry as Star Chain shape antenna for operating dual-band frequencies at 1.8 GHz with a 1100 MHz bandwidth (1500 MHz - 2600 MHz) for LTE frequency band and the control the harmonic frequency to shift to the altimeter frequency band at 4.3 GHz with a 550 MHz bandwidth (3900 MHz - 4450 MHz) with is illustrated in Fig. 4 which is cover in RF altimeter and LTE operating bandwidth frequency.

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