

# Dual band Planar Fractal Dipole Antenna for RFID application

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## 1. Introduction

The technology of Radio Frequency Identification (RFID) was growth rapidly and expanding widely. The ability of detecting passive label within certain range of distance, basically upgrading the system in term of cost efficient and also low power consumption, thus give a benefits to various type of sectors, such as healthy sector, robotic as well as security sector. The good on antenna design is needed for RFID purposes in order to provide maximum abilities and capabilities of the system. Normally, antenna on this kind of application has to radiate at all direction. This is because to ensure that the label can be read at any location and direction. Therefore, the dipole antenna is proposed because its suit the criteria above and also easy to design[1,2].

Nowadays, there is an increasing demand on the small size of label. The geometrical Koch fractal technique was one the method that can be used to reduce the size of the antenna, on the same time does not affect much on the other type of performance. Fractal were first defined by Benoit Mandelbort in 1975 as a way of mathematically define structures whose dimension cannot be limited to whole numbers. Fractal antennas have shown the possibility to miniaturize antennas and to improve input matching [3]. Certain classes of fractal antennas can be configured to operate effectively at various frequency bands (multiband). Usually, the antenna can only operate one particular frequency. By designing multiple numbers of dipole arms at one surface, it can produce multiple number of operating frequency. This kind of technology of radio communication have grown rapidly and expanding widely in terms of RF circuit fabrication improvement and other miniaturization technologies which make portable radio equipment become smaller, cheaper and reliable. These trends will continue, indeed at greater pace over the next decade. In Ultra-High Frequency (UHF), it provides guarantee of longer distance communication, but have the disadvantage of much influenced and affected by material properties (effects of metal and lossy materials) as well as the presence of objects in the near field zone of the tag itself [2]. Hence, the challenging of the antenna design is a platform for UHF-Tag, which at the same time cost-effective and small sized. Small tag suffers higher demand nowadays. Short reading distances and the fact cost per tag is too high are the major reasons that passive RFID systems have not made their breakthrough yet [4]. One key to greater reading distances is the improvement of the antenna on the tags. Since a passive tag does not have its own power supply, it is important that the tag can absorb as much energy as it can from the radiated reader antenna. As a solution to minimize the antenna size while keeping high radiation efficiency is by implementing the fractal to the antenna. In designing a small antenna, effective length has to be large because the resonant frequency would be lower [5,6].

## 2. Design consideration

The dual-band dipole is printed on one side of the FR-4 substrate (dielectric constant,  $\epsilon_r = 4.5$ , thickness,  $h = 1.6$  mm and tangent loss,  $\delta = 0.019$ ), and consist of 3 design, which are straight dipole, first iteration dipole and partially second iteration dipole. In order to achieve dual-band operation, the dipoles are located on the same surface. Meaning that, one dipole is for 900 MHz and

another dipole is for 2.4 GHz operating frequency. The antenna is grounded through via wire. In second design, both dipoles are being applied with first iteration Koch, meanwhile another adding iteration for partially second iteration design. The purpose is to reduce the size of the antenna. The structure of the designed antenna is shown in Figure 1. The length of the dipole determine the resonant frequency, meanwhile the width is for matching and radiation resistance, where in this project 50  $\Omega$  coaxial probe is used. The value of width in this project is 1.2 mm.

### 3. Result and Discussion

Figure 2 shows the simulated and measured result of dual band printed dipole antenna at three different configurations. It shows that the three design of the antenna produce almost very similar in term of response and the minimum value of return loss. In this particular result two resonant frequencies are obtained which are at 900 MHz and 2.4 GHz. The resonant frequencies for 900 MHz is approximately at -15 dB while the resonant frequency at 2.4 GHz is between -12 and -16 dB. The percentage of size reduction is 11.43 % for design 2 and increase up to 16.72 % in design 3. This prove the size of the antenna is becomes smaller when Koch fractal technique is applied to the design. The performance of the antenna is also investigated in term of return loss value where the flare angle is changing from original 60<sup>0</sup>, to 30<sup>0</sup> and 45<sup>0</sup>. It is shown that the return loss is shifting due to the changing of antenna length and compare with 3 type of angles. The 60<sup>0</sup> give the best performances.

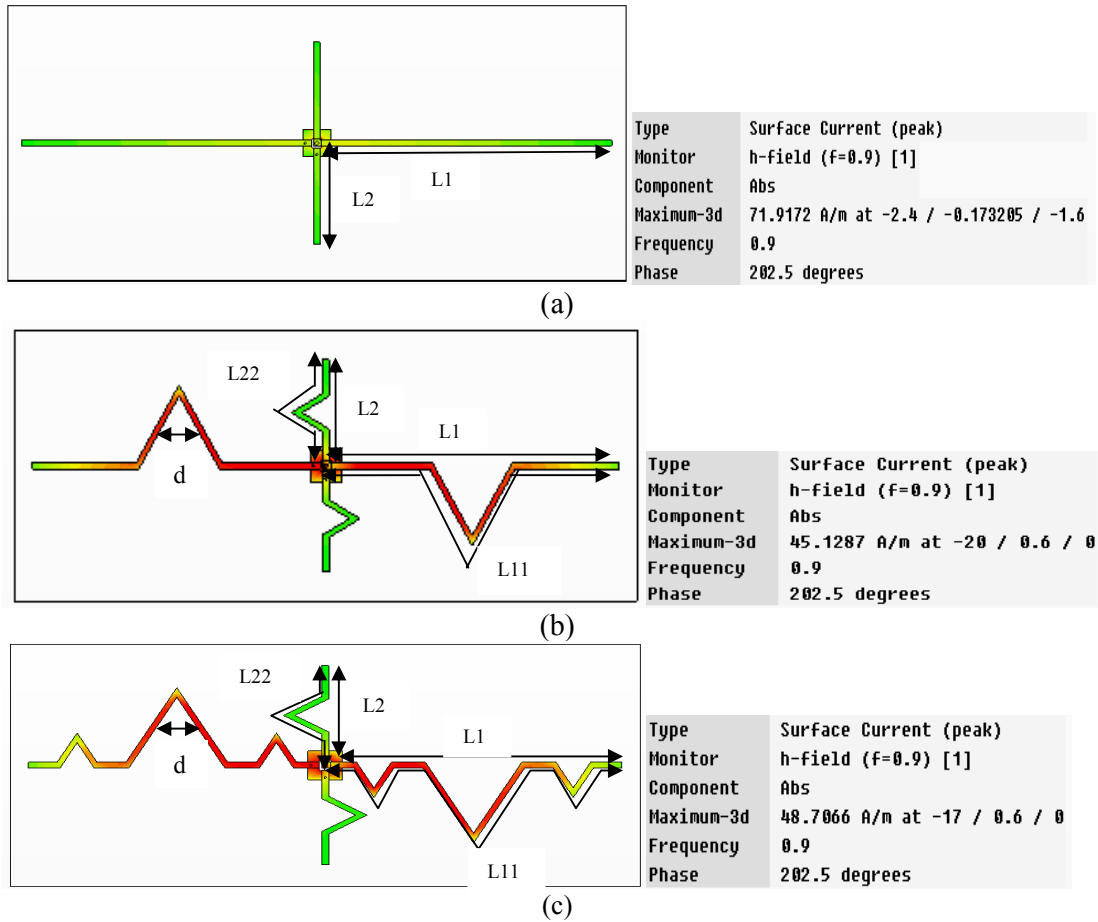
Figure 3 shows the radiation pattern for E-Plane and H-Plane at 900 MHz and 2.4 GHz frequency. From the graph, it shown that the E-Plane and H-Plane is difference for each particular frequency, where the E-Plane for 900 MHz is in 8-shaped, but this 8-shaped is happen at H-Plane at 2.4 GHz. Similar the omni-directional shaped, where it is reciprocal to each other. All of these happen because of the orientation of the antenna design, thus produced different radiation pattern view for both operating frequency.

### 4. Conclusion

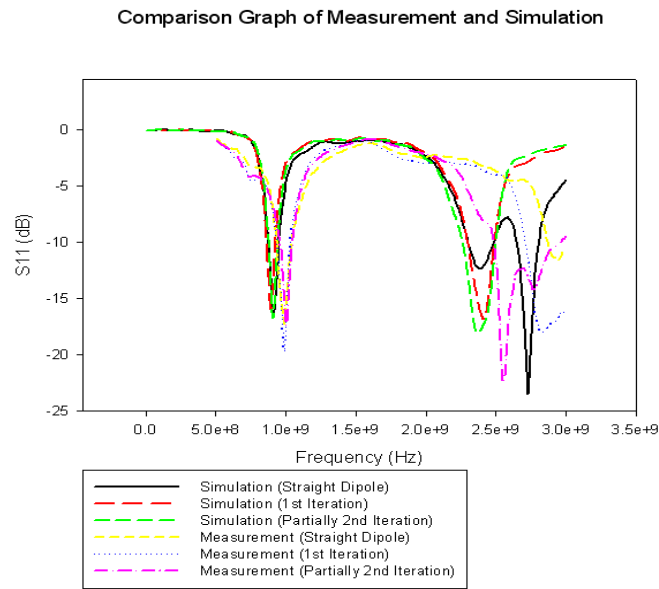
In this paper, three type of dual band fractal antenna is presented. It consist of straight dipole, first iteration dipole and partially second iteration dipole. The antenna resonates at 0.9 GHz and 2.4 GHz, with a return loss below than -10 dB. The performances of each antenna design have been analyzed and investigated. The size reduction for the first iteration is 11% while for partially second iteration the size reduction is 16%. The designed antenna is used as a passive dipole tag when integrated with ASIC microchip for both operating frequencies. The test of the reading distance shows that the antenna can be used as a tag for RFID systems.

### 5. Acknowledgement

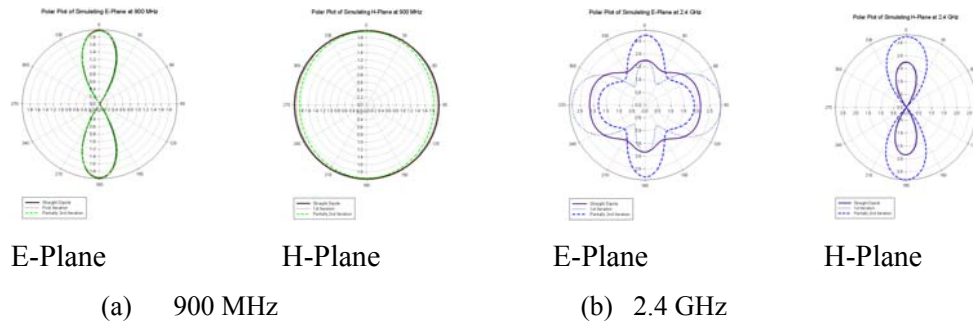
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**Figure 1.** The structure of the designed dual-band fractal antenna (a) straight (design 1) (b) 1<sup>st</sup> iteration (design 2) and (c) partially 2<sup>nd</sup> iteration (design 3)



**Figure 2.** The comparison of return loss graph between simulation and measurement



**Figure 4.** The polar plot of radiation pattern at 900 MHz (a) E-Plane (b) H-Plane

**Table 1.** The simulated results of dual-band fractal dipole antenna

Parameters	Straight	1 <sup>st</sup> Iteration	2 <sup>nd</sup> Iteration
L1/ L11 (mm)	61	55.5 / 70.1	50.8 / 79.6
L2 / L22(mm)	21	18.6 / 25.5	19.6 / 26.2
S11 (0.9 GHz)	-15.4 dB	-15.29 dB	-15.59 dB
S11 (2.4 GHz)	-12.25 dB	-16.61 dB	-17.59 dB
% Size Reduction	-	11.43 %	16.72%
Gain (0.9 GHz)	2.0 dBi	2.0 dBi	2.0 dBi
Gain (2.4 GHz)	1.8 dBi	1.8 dBi	2.8 dBi
% Bandwidth (0.9 GHz)	8.23 %	6.7 %	7.03 %
% Bandwidth (2.4 GHz)	7.33 %	7.9 %	10.09 %

## References

- [1] M. Abu and M. K. A. Rahim, “Triple-Band Printed Dipole Tag Antenna for RFID” *Progress In Electromagnetic Research C*, Vol. 9, pp 145 – 153, 2009
- [2] G. Monti, L. Catarinucci, and L. Tarricone, “Compact Microstrip Antenna for RFID Applications”, *Progress In Electromagnetic Research*, Vol. 8, pp 191 – 199, 2009
- [3] A. Ibrahim et al, Bi-band Fractal Antenna Design for RFID Applications at UHF, *Proc. ‘EuCAP 2006’*, France, 2006
- [4] J. S. Kim, W. Choi, G.-Y. Choi, C.-S. Pyo and J.-S. Chae, “Shorted Microstrip Patch Antenna Using Inductively Coupled Feed for UHF RFID Tag”, *ETRI Journal*, Vol. 30, Number 4, August 2008
- [5] X. Li, L. Yang, S. X. Gong, Y. J. Yang, and J. F. Liu, A Compact Folded Printed Dipole Antenna for UHF RFID Readers, *Progress In Electromagnetics Research*, Vol. 6, pp 47 – 54, 2009
- [6] Z. G. Fan, S. Qiao, J. T. Huangfu, and L. X. Ran, A Miniaturized Printed Dipole Antenna with V-Shaped Ground for 2.45 GHz RFID Readers, *Progress in Electromagnetics Research, PIER 71*, pp 149 – 158, 2007
- [7] Y. J. Wu, B. H. Sun, J. F. Li, and Q. Z. Liu, Triple Band Omni-Directional Antenna for WLAN Application, *Progress in Electromagnetic Research, PIER 76*, pp 477 – 484, 2007.