Crown Square Microstrip Fractal Antenna

Amira Putri Binti Mohammad
Faculty of Electrical Engineering
Universiti Teknologi Mara Malaysia
40450 Shah Alam,Selangor, Malaysia
e-mail: mohammad.amiraputri@gmail.com

Abstract - **This paper presents the design of a crown square fractal antenna (CSFA) for wireless applications. This CSFA was fabricated on FR4 substrate with dielectric constant of ξr = 4.7 and thickness, h = 1.6 mm. All the design and simulation was carried out by using a commercial electromagnetic simulator, CST Microwave Studio. Measurements of the parameter of this antenna was carried out by using Vector Network Analyzer (VNA). It was observed that, both the measured and simulated values of the parameters of the antenna were close each other and compact size antenna was realized.**

Keywords: CSFA, Crown Square Fractal Antenna

I. INTRODUCTION

Antenna is a reciprocal device which is capable of radiating and receiving electromagnetic waves. It is used to interface a transmitter to free space or free space to a receiver. There are many type of antenna being used today such as dipoles, horns, and reflectors antenna. The choice of antenna used depends on the operating frequency.

Microstrip or patch antenna is widely used at microwave frequencies which consists of a patch of metallization on a grounded substrate, that is very thin with thickness, t where t $\ll \lambda_0$ and λ_0 is the free-space wavelength. The height, h of the patch is a small fraction of a wavelength where $h \ll \lambda_0$, and usually $0.003\lambda_0 \leq h \leq 0.05\lambda_0$) above a ground plane [1].

The microstrip antennas are usually used in the latest technology because of the antenna was compact, lightweight, and thin profile, which can be made conformal configuration [2]. Lightweight antenna provide low power handling capability and it can be used in low power transmitting and receiving applications. The feed line and matching networks can also be fabricated on the same substrate [2].

However, there are some limitations of microstrip antennas such as narrow bandwidth and complex feed structure. The bandwidth of the antenna depends on the dielectric constant, the thickness of the substrate and the resonant frequency [2].

Fractals were first defined by Benoit Mandelbrot in 1975 as a way to mathematically define structures whose dimension can not be limited to whole numbers [3]. Fractal antenna technology allowed us to design miniature antennas and integrate multiple telecommunication services into a single device [4].

Fractal concept has two properties, self similarity and space filling. The property of self similarity means that the fractal type becomes similar if we expand a portion of it infinitely. For space filling means that the size of fractal structure becomes large at the same area as the repetition number of times increases [5]. There are many fractal antenna pattern such as Sierpinski gasket, Bowtie and Hilbert curve.

This work, adopted second iteration CSFA design for the wireless application. The CSFA has been designed on FR4 substrate of ξr = 4.7 and h =1.6 mm with specification as indicated by Table 1. All the design and simulation were carried out by using CST Microwave Studio.

TABLE 1 :SPECIFICATION OF CSFA

Parameter	Specification
Centre Frequency	5.8 GHz
Return Loss	< -10 dB
VSWR	< 2
Input impedance	50 Ohms

II. METHODOLOGY

All the work involved in realizing CSFA is illustrated by Fig. 1. CST Microwave Studio was used in designing and simulation of CSFA. Then the layout of the antenna were generated and then followed by fabrication. The specification of substrate is shown by Table 2. All the measurements of the parameters of the antenna were carried out by using Vector Network Analyzer. The analysis was done to ensure the simulated and measured result satisfy CSFA specification.

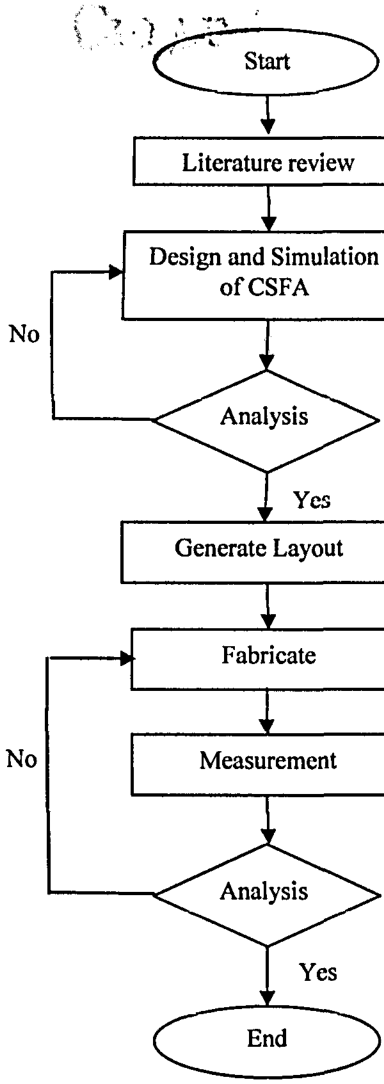


Figure 1. Work process

TABLE 2 :SPECIFICATION OF SUBSTRATE

Parameter	Specification
Substrate	FR4
Dielectric Constant	4.7
Substrate height	1.6 mm
Conductor thickness	0.035 mm

III. DESIGN

CSFA pattern was realized based on nearly square shape as indicated by Fig. 2(a) as the basic shape of fractal antenna and followed by iteration process. CSFA is represented in Fig. 2(b) and 2(c).

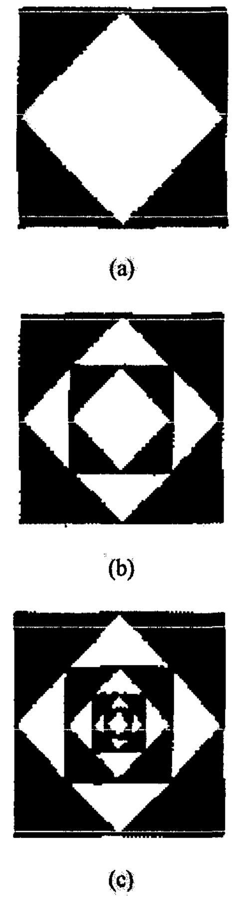


Figure 2. CSFA iteration

(a) Base (b) First (c) Second

Nearly square shape microstrip antenna has been designed on FR4 substrate of r = 4.7 and h =1.6 mm. The dimension of solid square is, b/a= 1.0526, where a = 29.82mm. The operating wavelength of the CSFA is indicated by Eq. (1) [8]:

$$\text{Wavelength, } \lambda = \frac{c}{f\sqrt{\varepsilon}} \qquad (1)$$

Where c = speed of light

f = frequency

ε = dielectric constant

CSFA was realized by having nearly square pattern and then followed by removing a nearly diamond from the first pattern. Then, the half size of nearly square from the first nearly square were added.

The design was completed by removing the nearly diamond pattern from the second nearly square as shown in Fig. 3, hence first iteration CSFA pattern was realized.

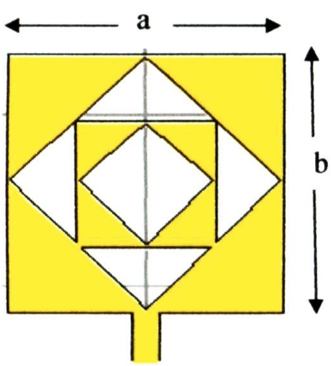
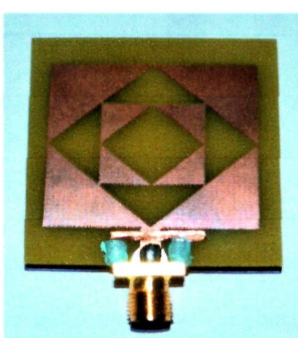


Figure 3. Simulated First Iteration CSFA

IV. RESULT AND DISCUSSION

The prototype CSFA was realized as shown by Fig. 4. The measurement of parameters of this CSFA was carried out by using Vector Network Analyzer. The return loss and voltage standing wave ratio (VSWR) for simulation and measured result is shown in Fig. 5 and Fig. 6 respectively. It is observed that the simulated centre frequency is 5.80 GHz while the measured centre frequency is 5.83 GHz. The two values are closed with each other.



'Figure 4. Prototype of CSFA

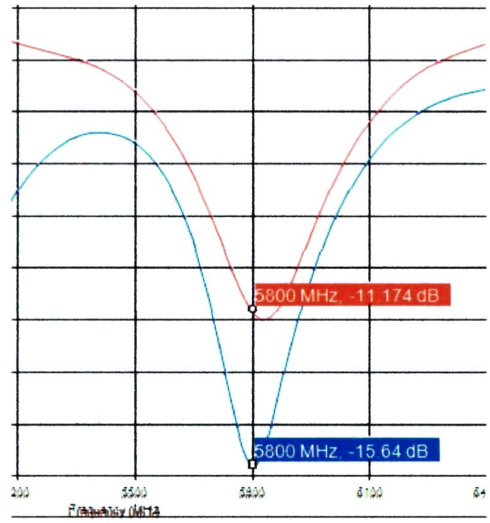


Figure 5. Return loss of CSFA

The value of simulated return loss of CSFA at frequency 5.8 GHz is -15.64 dB while for the measured return loss is -11.174 dB at frequency 5.8 GHz. Both the values are lower than -10 dB and it is acceptable as the value of the return loss meet the specification of CSFA. Both value indicate good matching.

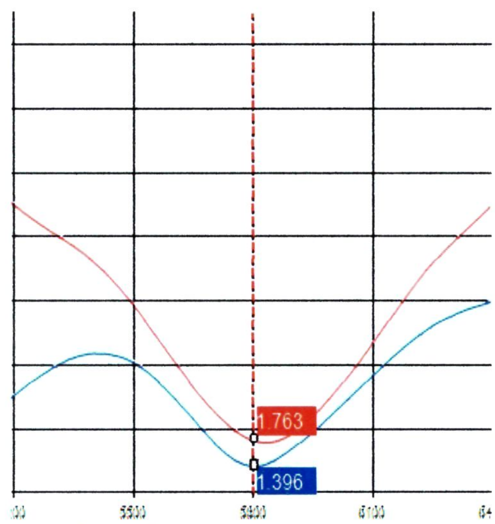


Figure 6. VSWR of CSFA

At 5.8 GHz as the centre of frequency of CSFA , the value of VSWR for the simulated is 1.396 while measured VSWR is 1.763. In order to be ideal CSFA , the value must below than 2. Both of the result was below than 2 means the design was approximately ideal.

The 3-D and 2-D radiation pattern has been simulated for the first iteration of CSFAis shown in Fig. 7 and Fig. 8 respectively. The maximum gain at 5.80 GHz is 1.518dBi.

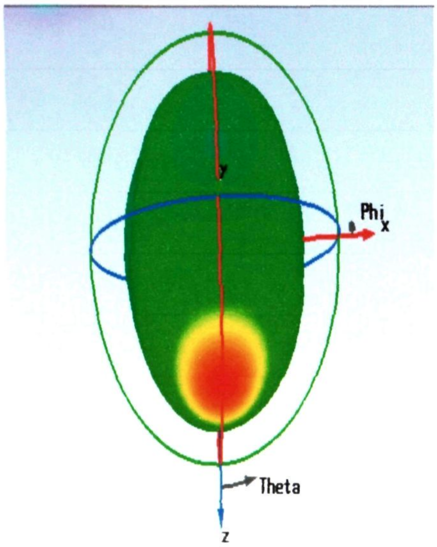


Figure 7. 3D radiation pattern of CSFA

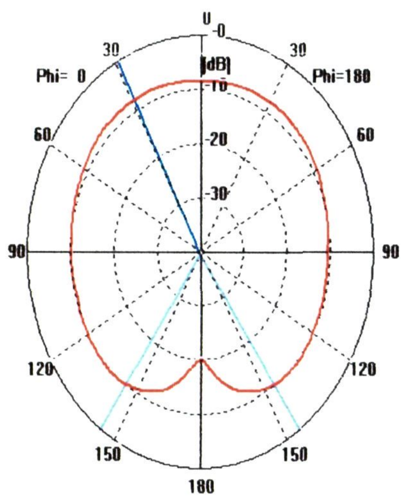


Figure 8. 2D radiation pattern of CSFA

The CSFA pattern indicates omni-directional radiation pattern. Omni-directional antenna radiation pattern provide excellent gain across all elevation angles but can also manipulated for more focused requirements. The measured value of line impedance at 5.8 GHz is 51.562 Ω was shown in Fig. 9.

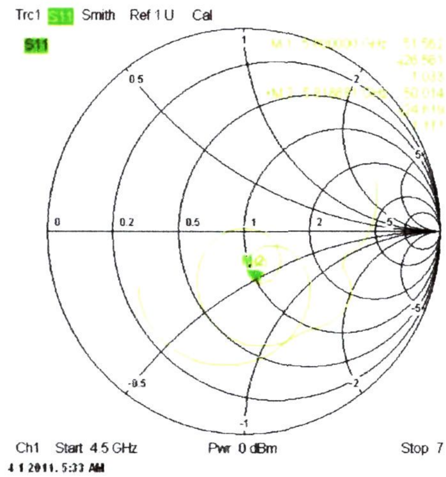


Figure 9. Measured line impedance of CSFA

TABLE 3. SPECIFICATION, SIMULATED AND MEASURED OF CSFA

Parameter	**Specification**	**Simulation**	**Measurement**
Return loss	< -10 dB	-15.64 dB	-11.174 dB
VSWR	< 2	1.763	1.396
Input impedance	50 Ω	49.62 Ω	51.562 Ω

Table 3 highlights the simulated and measured values of all the parameter of the CSFA. There was slight discrepancy between the simulated and measured values but all the values meet specification. The discrepancy maybe due to many reasons such as error in fabrication process, the value of dielectric constant, ξr, the height of substrate and parasitic losses or coaxial cable losses.

CONCLUSION

In this work, CSFA was successfully designed, simulated, analyzed, and fabricated. A prototype CSFA was realized and it is very small and compact. All the parameters, return loss, S_{11} and the VSWR meet the requirement of the specification. The 2-D and 3-D radiation pattern of the CSFA shows an omni-directional pattern and resonance frequency at 5.8 GHz. The CSFA can be used for an unlicensed wireless applications.

FUTURE WORKS

This work can be further improved by increasing the number of iterations of the CSFA. The gap between the diamond pattern and the nearly square pattern of the design can be further explored to improve the performance of this CSFA.

ACKNOWLEDGMENT

The author would like to thank Mrs Kamariah Binti Ismail, Faculty of Electrical Engineering, University Teknologi MARA for the guidance and support.

REFERENCES

[1] Balanis, C. A., Antenna Theory, Analysis Design, 3rd ed., John Wiley & Sons, Inc., 2005.

[2] P. B. Ramesh Garg, Inder Bahl, Apisak Ittipiboon., Microstrip Antenna Design Handbook, 2nd ed., Artech House, 2000, pp 1-1.

[3] Carles Puente Baliarda, Member, IEEE, Jordi Romeu, Member, IEEE, and Angel Cardama, Member, IEEE, "The Koch Monopole: A Small Fractal Antenna", 11 November 2000.

[4] Noor Asniza Murad, Mazlina Esa, Mohd Fairus Mohd Yusoff and Siti Hajar Aminah Ali, "Hilbert Curve Fractal Antenna for RFID Application", 2006 International RF And Microwave Conference Proceedings, 12 – 14 September 2006, Putrajaya, Malaysia.

[5] Seung-sik Lee, Jung-Nam Lee, Sang-Sung Choi, Jong-Kweon Park, "The Design of Fractal Antenna for UWB Applications", The 2009 International Symposium on Antennas and Propagation (ISAP 2009), 20 - 23 October 2009, Bangkok, Thailand.

[6] P. Dehkhoda, A. Tavakoli, "A Crown Square Microstrip Fractal Antenna",Electrical Engineering Department Amirkabir Univenity of Technology,Tehran,Iran.

[7] Wang Yong, Liu. Shaobin "A New Modified Crown Square Fractal Antenna", Nanjing University of Aeronautics & Astronautics, Nanjing 210016 China.

[8] John L.Vokalis, Antenna Engineering Handbook, 4th ed., McGraw-Hill Book Company, pp 1-5.

[9] Y. Song, Y.-C. Jiao, G. Zhao, And F.-S. Zhang, "Multiband CPW-FED Triangle-Shaped Monopole Antenna For Wireless Applications", Progress In Electromagnetics Research, PIER 70, 329–336, 2007.

[10] J. Ghalibafan , *Student member, IEEE,* F. H. Kashani, "A Circularly Polarized Fractal Microstrip Antenna for RFID Applications", IEEE International Symposium on Radio-Frequency Integration Technology, 2009.