International Journal of Thin Film Science and Technology

Volume 2
Issue 3 *Sep. 2013*

Article 7

2013

# New Design of Hairpin-Koch Fractal Filter for Suppression of Spurious Band

Amer Basim Shaalan
*University of Baghdad – college of science – department of physics-Iraq-Baghdad*, nadirfadhil@yahoo.com

Nadir Fadhil Habubi
*Al_Mustasiriyah University, College of Education, Physics Department/ Baghdad/ Iraq.*, nadirfadhil@yahoo.com

Sami Salman Chiad
*Al_Mustasiriyah University, College of Education, Physics Department/ Baghdad/ Iraq.*, nadirfadhil@yahoo.com

Ziad Abdulahad Toma
*Al_Mustasiriyah University, College of Education, Physics Department/ Baghdad/ Iraq.*, nadirfadhil@yahoo.com

International Journal of Thin Films Science and Technology

http://dx.doi.org/10/12785/ijtfst/020307

# New Design of Hairpin-Koch Fractal Filter for Suppression of Spurious Band

**Amer Basim Shaalan [1], Nadir Fadhil Habubi [2] , Sami Salman Chiad [2], Ziad Abdulahad Toma [2]**

[1] *University of Baghdad – college of science – department of physics-Iraq-Baghdad*
[2] *Al_Mustasiriyah University, College of Education, Physics Department/ Baghdad/ Iraq.*

*E-mail: nadirfadhil@yahoo.com*

Received: 17 Jul. 2013, Revised: 26 Jul. 2013; Accepted: 13 Aug. 2013
Published online: 1 Sep. 2013

**Abstract:** The use of fractal geometries has significantly impacted many areas of science and engineering; one of which is microwave filters. Microstrip filters have been widely used in a variety of microwave circuits and systems, it has received much attention because of the advantages such as compact and simple structures, small sizes, easy fabrication and low cost, etc., and all these features are the requirement of the wireless communication systems.
The design of a hairpin-Koch filter has been proposed. This filter exhibits periodic frequency response. The spurious bands are being suppressed significantly through the implementation of Koch fractal on the micro strip coupled line.

**Keywords:** Hairpin-line, Koch fractal, band pass filter, spurious band.

## 1. Introduction

Harmonic filters are invaluable for removing unwanted higher-order harmonic signals from microwave multipliers and mixers in receiver designs, among other applications [1]. Although a variety of filter configurations have been developed to reduce the level of harmonic signals, the authors investigated two varieties of band pass filter designed for good harmonic suppression [2, 3]. Parallel coupled line sections were employed in both filter approaches. Micro strip filters are essential parts of the microwave system and play important role in many communication applications especially wireless and mobile communications [4, 5]. These are getting popular due their compact size, light weight, low cost and ease of fabrication [6]. One of the best methods to suppress spurious bands involve making optimum line structures by inserting periodic shapes, such as grooved, wiggly and inter-digitized lines into conventional coupled lines [7]. These periodic structures are used to create Bragg reflections to suppress the harmonics. In this work, a conventional hairpin-line is designed and simulated through moments method Ansoft software [8]. Subsequently, Koch fractal is applied to the conventional filter and spurious band is being suppressed successfully. Finally, the proposed filters are physically implemented on FR-4 ‘Glass/Epoxy’ PCB and the simulated results discussed.

## 2. Experimental

The starting shape of Koch Island is a square loop. Each of the four sides of the square is replaced by the generator. The generator is a straight segment divided into three segments, each segment is equal to one third (1/3) the length of the starting one. The middle one is removed from its place and connected with two other segments [9], this is shown in figure (1-a). These two segments are tuned to adjust the overall perimeter of the fractal length. Shape of fractal Koch is shown in figure (1-b)

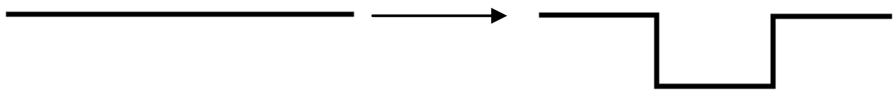

**Figure (1-a)**: The generator of Koch Island.

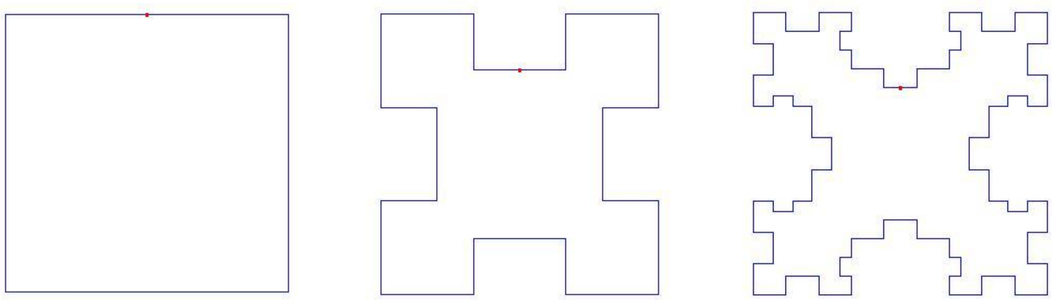

**Figure (1-b)**: Fractal Koch Island shape.

## 3. Results and Discussion

Hairpin filters are simple and compact in structures. They are obtained by folding parallel-coupled resonators of half-wavelength, in to a ‘U’ shape. Such resonators are the so-called Hairpin resonators.

For the 3rd order conventional Hairpin filter, the following are the design parameters: Band width, 20% at mid band frequency 1 GHz, dielectric constant, $\varepsilon_r = 4.4$, substrate thickness, h = 1.6 mm.

Ansoft software was used to design and simulate Hairpin-Koch filter, figure (2) shows the shape of zero, first and second iteration of the filter.

Center frequency is at 1GHz and bandwidth is 20%. The zero iteration of the filter has a large second harmonic of 5dBat 1.9 GHz. After Koch fractal implemented on the conventional design, the spurious band is considerably suppressed to -24 dB.

The simulated transmission coefficient ($s_{11}$) and reflection coefficient ($s_{21}$) for zero, first and second iteration are shown in figures (3, 4, 5) respectively.

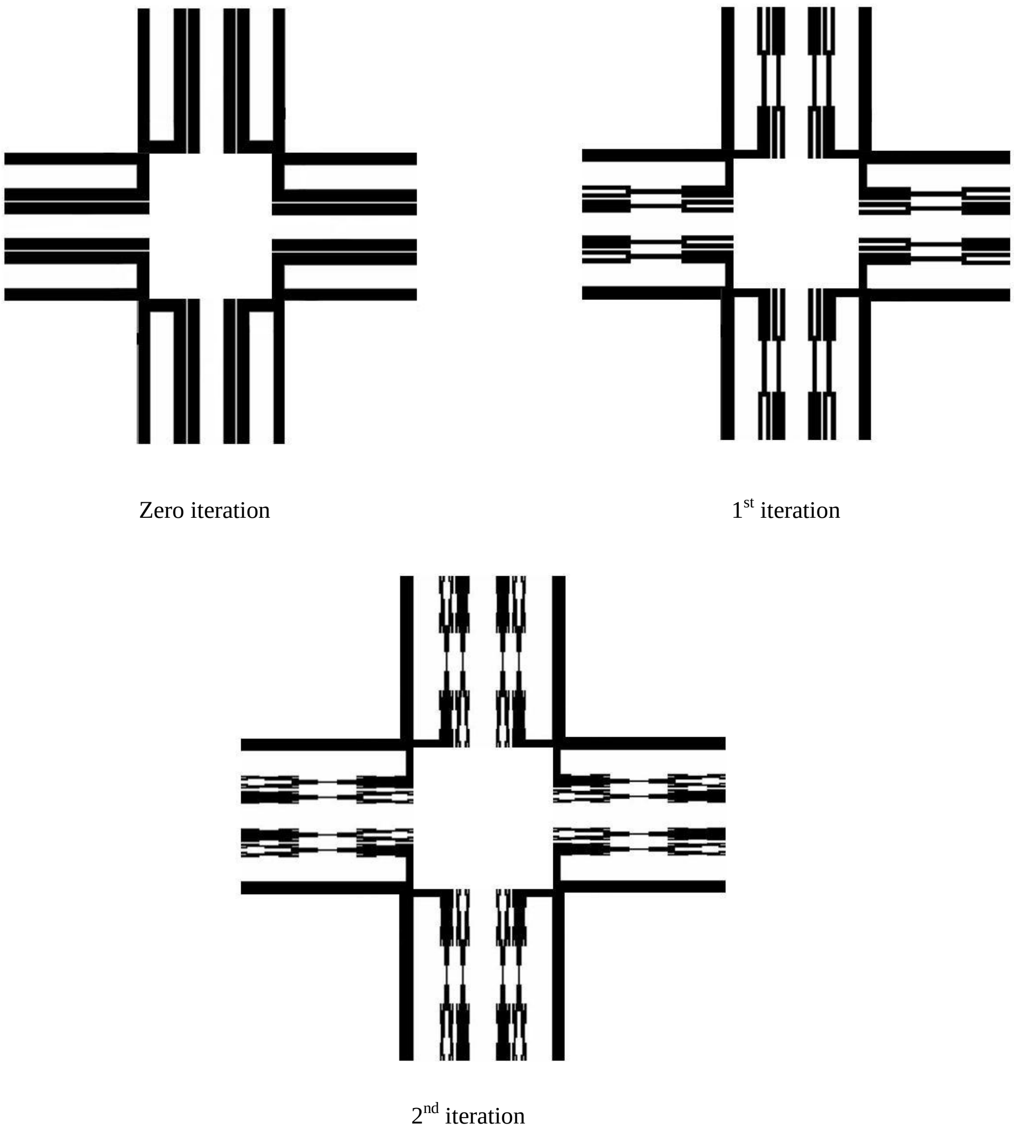


**Figure 2:** Hairpin-Koch filter shape.

**4.**

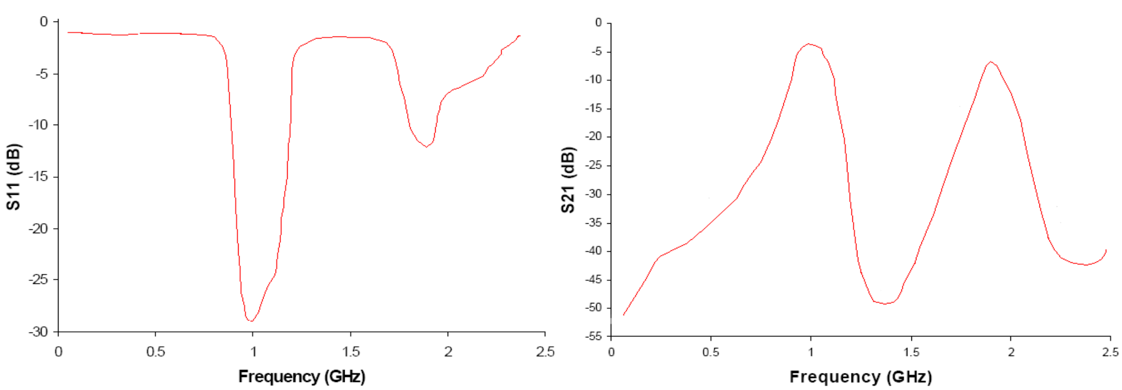


**Figure 3:** Transmission and Reflection coefficients for zero iteration.

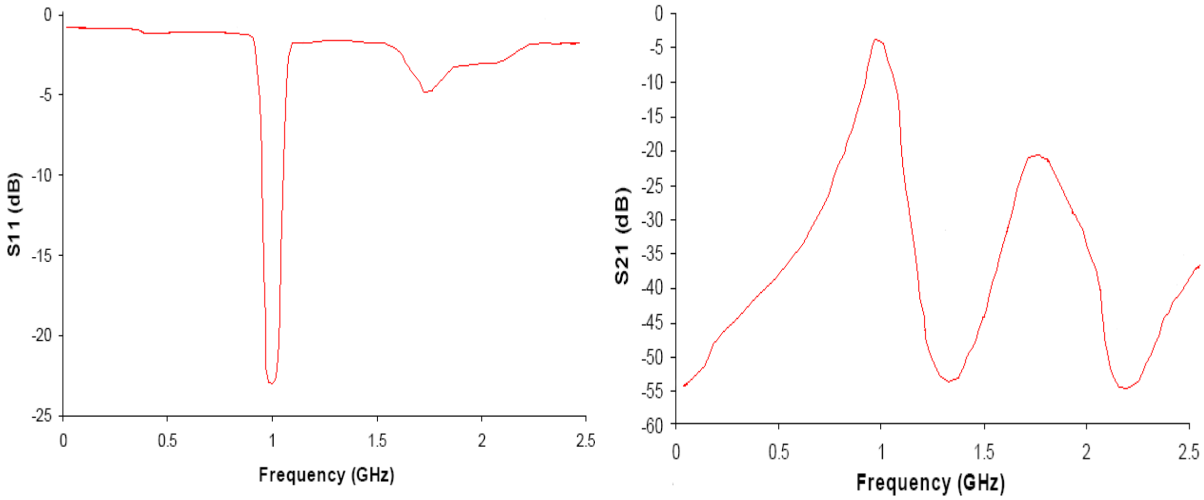


**Figure 4:** Transmission and Reflection coefficients for 1st iteration.

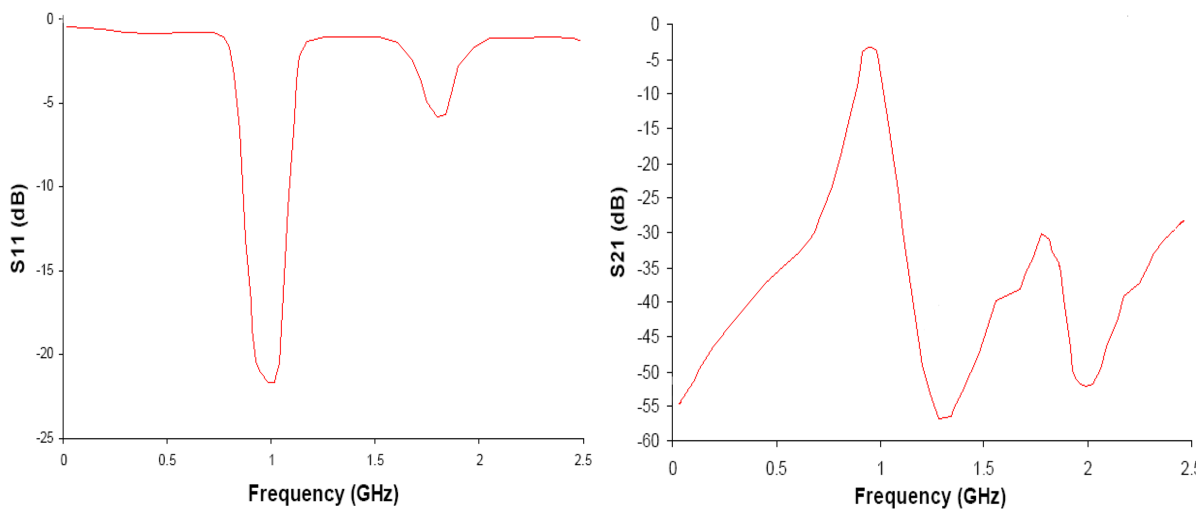


**Figure 5:** Transmission and Reflection coefficients for 2nd iteration.

## 4. Conclusions

In the present work, Hairpin-Koch filter has been proposed and simulated using Ansoft code. It was found that the unwanted harmonics can be suppressed using fractal geometry. The suppression can be up to -29 dB for the $2^{nd}$ iteration. This method can be applied to other microstrip structures facing harmonic problems. It could be a solution for RF systems that required reduction in harmonic components.

## References

[1] C. W Tang and M. G. Chen, “A microstrip ultra-wideband Band pass filter with cascaded broadband band pass and band stop filters,” IEEE Trans. Microw. Theory Tech., **55**, 2412‐2417, (2007).

[2] J. T. Kuo, S. P. Chen and M. Jiang, “Parallel-Coupled Microstrip Filters With Over-Coupled End Stages for Suppression of Spurious Responses,” IEEE Microwave and Wireless Components Letters, **13** (10), 440-442, (2003).

[3] J. Sor, Y. Qian, and T. Itoh, “Miniature low-loss CPW periodic structures for filter applications”, IEEE Trans. Microwave Theory Tech., **49**, 2336–2341, (2001).

[4] D. Xiao, J. and Y. Li, “Novel trapezoidal planar dual-mode bandpass filter using one single patch resonator”, Microwave and Optical Technology Letters, **48** (11), 42–2145, (2006).

[5] J. Xiao, Y. Li., “Novel compact microstrip square ring bandpass filters”, Journal of Electromagnetic Waves and Applications, **20** (13), 1817‐1826, (2006).

[6] G. Hong Jia Shen and M. J. Lancaster, “Microstrip Filters For RF/Microwave Application”, John Wiley & Sons Inc, (2001).

[7] I. K Kim, N. Kingsley and M. Morton,“Fractal-shaped microstrip coupled-line band pass filters for suppression of second harmonic” Transactions on Microwave Theory and Techniques, **53** (9), 2943-2948, (2005).

[8] Ansoft HFSS software, http://ansoft.com.

[9] R. E Kutter., “Fractal Antenna Design”, B. Sc. Honor Thesis, BEE, University of Dayton., (1996).