Effect of Gap on the Koch Fractal Shaped End Coupled Microstrip Bandpass Filter

Gurpreet Kaur Kohli
Student of M.Tech ECE, KIET, Ghaziabad, India

Yashi Rajvanshi
Department of ECE, Vidya College of Engineering, Meerut, India

Mayank Khurana
Department of ECE, Vidya College of Engineering, Meerut, India

Pravesh Singh
Faculty Department of ECE, KIET, Ghaziabad, India

Abstract

In this paper the Koch Fractal shaped Microstrip End Coupled Half-wavelength Bandpass Filter is used to show the effect of space gap on the response with an center frequency of 2.02 Ghz . As the filters are the key elements of telecommunications and radar systems and are important items in the performance and cost of such system and the frequency bands development in microwave filter plays a major role in many RF or microwave applications.

Keywords - Fractal shaped Microstrip Filter, Half wavelength End Coupled Filter, RF Filters, Wavelength resonators and Centre frequency

1. Introduction

The fractal geometries such as Koch curve, Sierpinsky gasket, and Hilbert curve, etc. have been widely used to design several microwave devices, due to there which includes the reduction of resonant frequencies, smaller size and broadband width. In this paper we are using Koch fractal geometry, which named after the mathematician Helge von Koch, is a well known procedure which has been applied to miniaturize various conventional antennas. A fractal shape has two unique properties: space filling and self similarity. It can be used to filled a limited area as the order increases and occupies the same area regardless of the order. This is due to the space filling property. By self similarity, a portion of the fractal geometry always looks the same as that of the entire structure. As the Fractional Bandwidth increases the coupling must be increased and then the spacing between the lines of end coupled lines become very much small which is sometime impractical for the fabrication[8]. The End Coupled Filters are particularly suitable for printed circuit technology for planar formats as easily implemented and has the advantage of taking less space than a plain transmission line. The minimum width of gaps, like the minimum width of tracks, is limited by the resolution of the printing technology. To reduce insertion loss in the pass-band, the gaps are usually much smaller than the substrate height to enable tight coupling. The resonator lengths depend on the guide wavelength, coupling reactance and the gap capacitance. This configuration provides relatively narrow bandwidth. Since this structure is large, it is not a much preferred configuration. This type of filter has desirable advantages such as low-cost fabrication and easy integration [8].

2. End Coupled Filter

Fig 1.1 shows the end-coupled half-wavelength bandpass filters, which has open-end microstrip resonators of almost half-wavelength ($\lambda/2$) long at the midband frequency f_o of the bandpass filter. The resonators are coupled by means of gap capacitances between the resonator sections. The resonator length θ and the coupling gaps S between successive resonators are important design parameters.

Fig1.1 : General structure of end coupled microstrip bandpass filter.

This filter operates like the shunt-resonators type and the design equations are [3]:

$$\frac{J_{01}}{Y_0} = \sqrt{\frac{\pi}{2}\frac{FBW}{g_0 g_1}} \tag{1}$$

$$\frac{J_{j,j+1}}{Y_0} = \frac{\pi FBW}{2}\frac{1}{\sqrt{g_j g_{j+1}}} \text{ for j=1 to n-1} \tag{2}$$

$$\frac{J_{n,n+1}}{Y_0} = \sqrt{\frac{\pi}{2}\frac{FBW}{g_n g_{n+1}}} \tag{3}$$

Where g_o, g_1 ... g_n are the element of a ladder-type low pass prototype with a normalized cutoff Ω_c = 1 and FBW is the fractional bandwidth of bandpass filter. The $J_{j,j+1}$ are the characteristic admittances of J-inverters and Y_o is the characteristic admittance of the microstrip line.

Table1
Parameters of End Coupled Half- wavelength Resonator Bandpass Filter

S.No	Parameters	A	B	C	D
1	g_n	1.5963	1.0967	1.5963	1.0967
2	Z_0J_n	0.3137	0.1187	0.1187	0.3137
3	B_n	$6.96x10^{-3}$	$2.41x10^{-3}$	$2.41x10^{-3}$	$6.96x10^{-3}$
4	C_n	0.4520pF	0.1564pF	0.1564pF	0.4520pF
5	θ_n	2.72 rad	2.91 rad	2.72 rad	-

Assuming the capacitive gaps act as perfect, series-capacitance discontinuities of susceptance $B_{j,j+1}$ [2] .

$$\frac{B_{j,j+1}}{Y_0} = \frac{\frac{J_{j,j+1}}{Y_0}}{1-\left(\frac{J_{j,j+1}}{Y_0}\right)^2} \tag{4}$$

$$\theta_j = \pi - \frac{1}{2}\left[\tan^{-1}\left(\frac{2B_{j-1,j}}{Y_0}\right) + \tan^{-1}\left(\frac{2B_{j,j+1}}{Y_0}\right)\right] radians \tag{5}$$

The coupling gaps sj, j+1 of the microstrip end coupled resonator filter are;

$$C_g^{j,j+1} = \frac{B_{j,j+1}}{\omega_0} \tag{6}$$

where ω0 = 2πf0 is the angular frequency at the midband. The physical lengths of resonators are given by

$$\ell_j = \frac{\lambda_{g0}}{2\pi}\theta_j - \Delta\ell_j^{e1} - \Delta\ell_j^{e2} \tag{7}$$

The effective lengths can then be found by

$$\Delta\ell_j^{e1} = \frac{\omega_0 C_p^{j-1,j}}{Y_0}\frac{\lambda_{g0}}{2\pi} \tag{8}$$

$$\Delta\ell_j^{e2} = \frac{\omega_0 C_p^{j,j+1}}{Y_0}\frac{\lambda_{g0}}{2\pi} \tag{9}$$

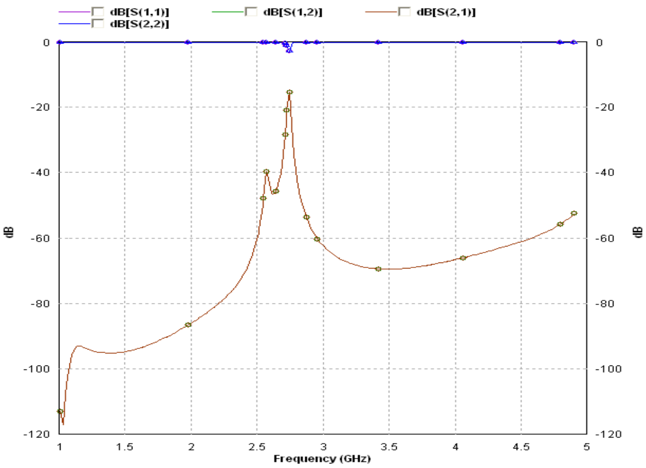
3. Filter Design

From the parameters given below the Fractal shaped End coupled micro strip band pass filter , with a 0.5dB equal-ripple pass band characteristic for 0th & Ist order is designed using IE3D with the center frequency of 2.45 GHz having a bandwidth of 10% and equal ripple in the pass-band of 0.5dB, with the FR4 substrate of dielectric constant 4.2 with thickness of 1.58mm for a third order Chebyshev filter.

Fig 1.2 :- Proposed Filter Design layout (1^{st} Order)

3.3.1 0^{th} Order Filter

Fig 1.3:- Layout of 0^{th} order with $S_{0,1} = S_{3,4}$= 0.437mm and $S_{1,2} = S_{2,3}$= 0.801 mm



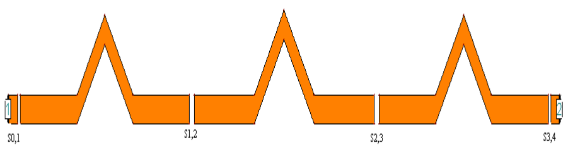


Fig 1.4:- Layout of 1st order with $S_{0,1} = S_{3,4}$= 0.437mm and $S_{1,2} = S_{2,3}$= 0.801 mm

3.3.1 1st Order Filter

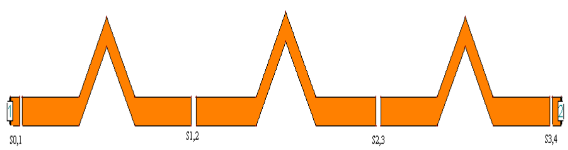


Fig 1.5:- Layout of 1st order with $S_{0,1} = S_{3,4}$= 0.437mm and $S_{1,2} = S_{2,3}$= 0.801 mm

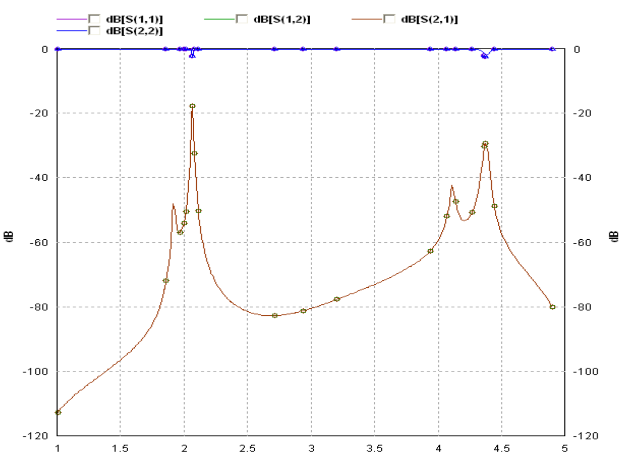


Fig 1.6:- Response of the Layout of 1st order with $S_{0,1} = S_{3,4}$= 0.437mm and $S_{1,2} = S_{2,3}$= 0.801 mm

4. Result and Analysis

The above responses using IE3D shows that the end-coupled line band-pass filter having an identical near pass-band region. for 1st order at 2.02GHz the Return Loss is 2.434db and Insertion loss is 18.83 and $S_{1,2} = S_{2,3}$= 0.801 mm .

5. Conclusion

This is observed from this analysis that the further symmetrical approach i.e. iterations tends to produce a more compact filter with less coupling effect in its realization when frequency increases and also this minimizes required space for realization and is suitable for integration within wireless system.

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