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Fractal - Shaped Microstrip End Coupled-Line Bandpass Filter

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Abstract— ***This paper presents a new compact fractal shape low insertion microstrip bandpass filter.The development of the frequency bands in microwave filter, play an important role in many RF or microwave applications. Filters are an essential part of wireless communications, networking ,radar ,imaging, and positioning systems. There has been a particularly marked growth in the cellular communications industry in recent years. This has contributed to both very demanding performance specifications for filters and the commercial pressures for low cost, high volume and quick delivery. Through an investigation into and a subsequent implementation of filter theory, the RF filter design of End Half-wavelength Resonators Bandpass Filters is simulate in this paper .The proposed filter is designed at center frequency of 2.45 GHz for 4.4 permittivity and having insertion loss greater than 30db for the range between 2.5 GHz to 4 GHz. The design and simulation are performed using 3D full wave electromagnetic simulator IE3D***

Keywords— ***Fractal shaped Microstrip Bandpass Filter , End Coupled Filter, RF Filters, Wavelength resonators and Centre frequency***

I. INTRODUCTION

It is particularly suitable for planar formats, is easily implemented with printed circuit technology and has the advantage of taking up no more space than a plain transmission line would. The limitation of this topology is that performance (particularly insertion loss) deteriorates with increasing fractional bandwidth, and acceptable results are not obtained with a Q less than about 5. A further difficulty with producing low-Q designs is that the gap width is required to be smaller for wider fractional bandwidths. 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. Traditionally, microstrip coupled line filters have been used to achieve narrow fractional bandwidth bandpass filters (BPFs) due to their relatively weak coupling [1-5]. This type of filter has desirable advantages such as low-cost fabrication and easy integration. However, despite these advantages, this type of filter has some problems, such as a large second harmonic. This parasitic second harmonic contributes to an asymmetric passband shape and degrades the upper band skirt properties. In addition, a large second harmonic signal can degrade the performance of other system components such as mixers. The large second harmonic is generated by the large difference between the even- and odd-mode effective dielectric constants of the microstrip coupled lines. The phase velocity for each mode is significantly different due to the inhomogeneous characteristics of the microstrip structure.

II. END COUPLED FILTER

Figure 1.1 illustrates the end-coupled half-wavelength bandpass filters, where each open-end microstrip resonators is 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. The gap could be imagined as a J-inverter in this case, these J-inverters tend to reflect high impedance levels to the end of the $\lambda/2$ resonators[9-10].

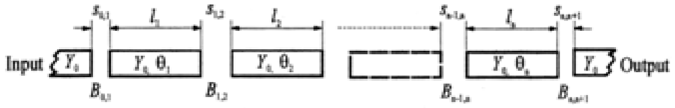

Fig1.1 : General structure of end coupled microstrip bandpass filter.

Hence, the filter operates like the shunt-resonators type and the design equations are [2]

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

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

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

where g_o, g_1 ... g_n are the element of a ladder-type lowpass prototype with a normalized cutoff $\Omega_c = 1$ 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. Assuming the capacitive gaps act as perfect, series- capacitance discontinuities of susceptance $B_{j,\ j+1}$ are: [2]

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

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

where the $B_{j,j+1}$ and are evaluated at $f_{0.}$ The second term on the right-hand side of (1,2,3) indicates the absorption of the negative electrical lengths of the J-Inverters associated with the jth half-wavelength resonator[6-8].

Table1 Parameters of End Coupled Half- wavelength Resonators Bandpass Filter

S.No	Parameters	Section1	Section2	Section3	Section4
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	-

The coupling gaps $s_{j,\ j+1}$ of the microstrip end coupled resonator filter are;

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

where $\omega_0 = 2\pi f_0$ 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

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

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

III. FILTER DESIGN

Fractal shaped End coupled microstrip bandpass filter , with a 0.5dB equal-ripple passband characteristic for Ist order. For the the center frequency of 2.45 GHz, bandwidth of 10% and equal ripple in the pass-band of 0.5dB, design a band-pass filter for the ISM band. The FR4 substrate of dielectric constant 4.2 with thickness of 1.58mm for a third order Chebyshev filter.

$g_0 = 1.0000$
$g_1 = 1.5963$
$g_2 = 1.0967$
$g_3 = 1.5963$
$g_4 = 1.0000$

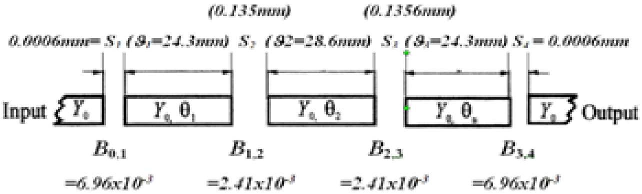

Fig1.2 :- Layout of a three-pole microstrip end-coupled band-pass filter

A. Designed Filter

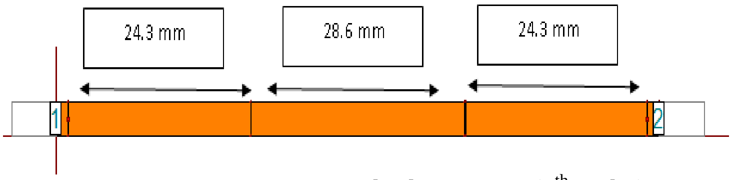

Fig 1.3 :- Proposed Filter Design (0^{th} Order)

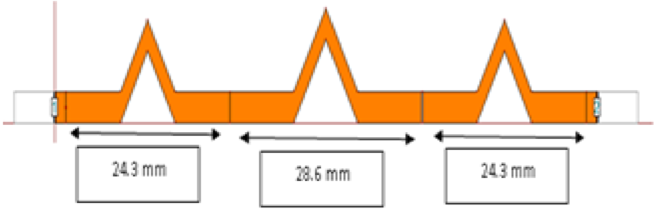

Fig 1.3 :- Proposed Filter Design (1^{st} Order)

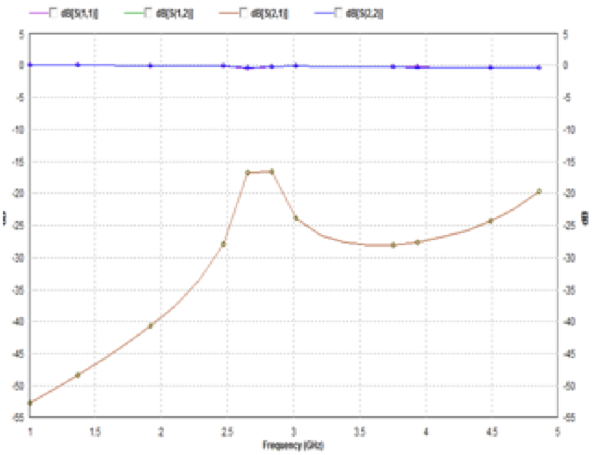

Fig 1.4: Amplitude response for end coupled microstrip bandpass filter (0^{th} order)

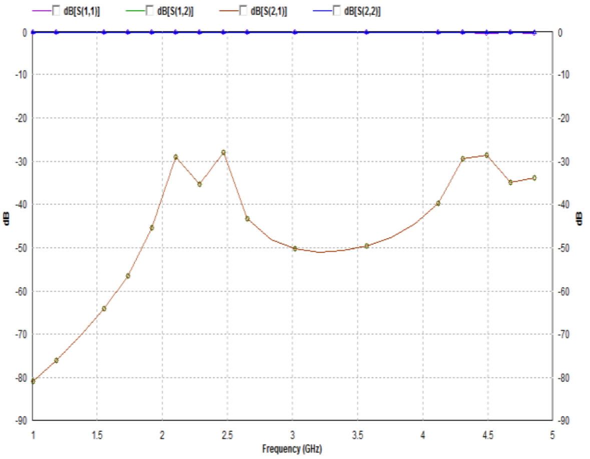

Fig 1.4: Response for Fractal shaped end coupled microstrip bandpass filter (1^{st} order)

V. CONCLUSION

In this paper, Fractal shaped end coupled microstrip filter have been proposed and investigated using IE3D . filter is designed at center frequency of 2.45 GHz for 4.4 permittivity and having insertion loss greater than 30 db for the range between 2.5 GHz to 4 GHz.

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