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Design and Analysis of End- Coupler, Half Wavelength Resonator Microstrip Line Band Pass Filter

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Abstract: There is an increasing demand for microwave system in modern communication system due to low cost, compact size and high accuracy. In this paper, design and synthesis of the fifth order end-coupler microstrip line band pass filter has been describe by method of moments, where FR4 material is used with dielectric constant 4.4 at 6GHz frequency. The analytic result obtained through IE3D software and thoroughly discussed.

Keywords: Band Pass Filter, Microstrip, L-C element,Microwave Filter, End-Coupler Configuration.

I. INTRODUCTION

Microstrip line is the most popular type of transmission line because it can easily miniaturized and integrated with both active and passive microwave devices and also provide many advantages like low cost, compact size, light weight and low insertion loss. Conventional filter structures like equal ripple and Butterworth low pass filters are requirement of special fabrication methods. Conventional low frequency techniques for fabrication does not fit at these frequencies due to the very high losses associated. The design and synthesis are performed using 3D full wave method of moment based electromagnetic simulator IE3D.

In present work, the fifth order end-coupler, half wavelength resonator band pass filter has been designed in microstrip configuration with the help of IE3D software and physically implemented on top of the FR/4 substrate using conventional fabrication process.

II. FILTER DESIGN

The design of band pass filters involves two main steps. The first one is to select an appropriate band pass prototype and then find an appropriate microstrip realization that approximates the lumped element filter. The choice of the type of response, including pass band ripple and the number of reactive elements will depend on the required specifications. The element values of the low pass prototype filters, which are usually normalized to make a source impedance g_0=1 and a cutoff frequency Ω_c= 1.0, are then transformed to the L-C elements for the desired cutoff frequency and the desired source impedance, which is normally 50 ohms for microstrip filters. For proposed design work, chebyshev approximation is assumed which exhibits the equal ripple pass-band and maximally flat stop-band. The general structure and half wavelength resonators end-coupler bandpass microstrip line filter is displayed in figure 1.

The general configuration of an end-coupled microstrip bandpass filter is illustrated in Figure 1, where each open-end microstrip resonator is approximately a half guided wavelength long at the midband frequency $f0$ of the bandpass filter. The coupling from one resonator to the other is through the gap between the two adjacent open ends, and hence is capacitive.

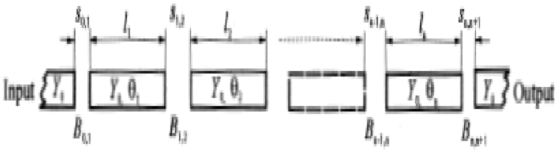

Figure 1. Basic Structure

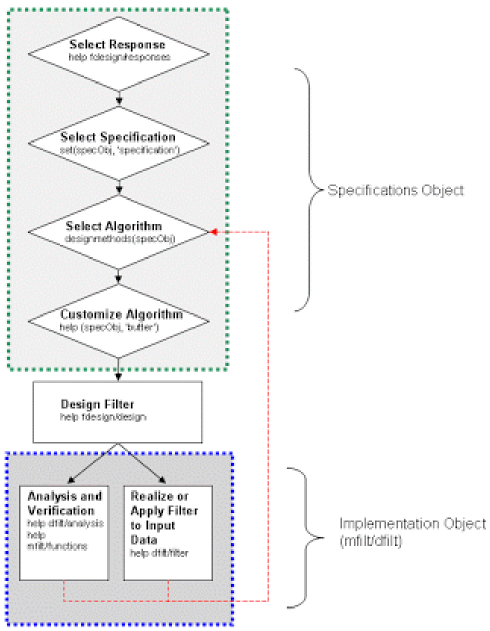

Figure 2. Flow diagram to design the filter

III. DESIGN PROCEDURE

Fifth order band pass filter have been designed in microstrip configuration with the following specification. Centre frequency f_c = 6 GHz, with spacing

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Dielectric permittivity ε_r = 4.4
Substrate thickness =1.6 mm
Loss tangent, tanδ = 0.02
Pass Band ripple = 0.1dB
Input/Output load impedance Z_o = 50 Ω
Pass band ripple = 0.1dB
Normalized cutoff frequency Ω_c = 1
FBW=0.028
Guided wavelength=27.196 mm

First determine the value of the prototype elements to realize the specifications. Also we have taken the

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

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

$$\frac{B_{j,j+1}}{Y_0} = \frac{\frac{J_{j,j+1}}{Y_0}}{1 - \left(\frac{J_{j,j+1}}{Y_0}\right)^2} \tag{3}$$

$$\theta_j = \pi - \frac{1}{2}\left[\tan^{-1}\left(\frac{2B_{j-1,j}}{Y_0}\right) + \tan^{-1}\left(\frac{2B_{j,j+1}}{Y_0}\right)\right] \text{radians} \tag{4}$$

To determined as to obtain the series capacitance by this formula:-

$$C_g^{j,j+1} = \frac{B_{j,j+1}}{\omega_0} \tag{5}$$

The physical lengths of resonators are given by

$$l_j = \frac{\lambda_{g0}}{2\pi}\theta_j - \Delta l_j^{e1} - \Delta l_j^{e2} \tag{6}$$

The effective lengths can then be found by

$$\Delta l_j^{e1} = \frac{\omega_0 C_p^{j-1,j}}{Y_0}\frac{\lambda_{g0}}{2\pi} \tag{7}$$

$$\Delta l_j^{e2} = \frac{\omega_0 C_p^{j,j+1}}{Y_0}\frac{\lambda_{g0}}{2\pi} \tag{8}$$

Similarly all other values of lengths of transmission lines are calculated.

In order to verify the validity of above expression in millimeter wave regime, a simulation study was performed using IE3D. To get exact response, an optimization was performed using software. The Chebyshev response that exhibits the equal ripple pass band and maximally flat stop band have been selected. The filters were designed using the conventional procedure given in [1] & [2]. The designed filters are shown in figure 3.

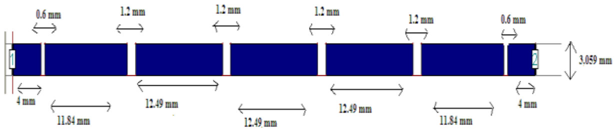

Figure 3. Fifth order band pass filter

IV. SIMULATED RESULT

The proposed filter is composed of fifth ordererd-coupler bandpass filter. The feed line is designed 50 ohm all geometric dimensions and figure 4 shows simulated results of the proposed microstrip band pass filter. For the simulation purpose we have used method of moment based full-wave EM solver IE3D.

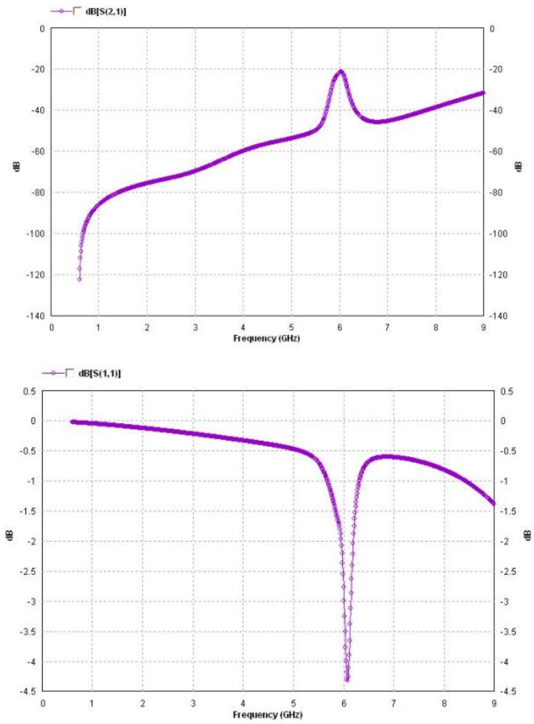

Figure 4. Full-Wave EM Simulated Performance of the End-Coupler Band Pass Filter.
(a)Insertion Loss (b) Return Loss

V. RESULT & CONCLUSION

In this paper study of band pass filter based on end-coupler topology is presented. Fifth order End-Coupler Band Pass Filter is design and synthesis. As per the expectation, for higher order filters sharp cut-off has been found. The value of S_{11} is 6.075,-4.30123 and S_{21} is 6.015,-21.7046. In future same design can be modified using fractal technology to get miniaturized dimensions.

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