

Lab #4 Coupled Line Filter ECEn 464

Introduction: Coupled line filters are among the most practical filters used in real microwave circuits. This laboratory exercise demonstrates their flexibility in adapting to a range of frequencies. **Be sure to provide screen shots of the pertinent information and describe what you are doing in a systematic fashion.**

Laboratory objective: Become more familiar with the coupled line filter and its uses.

Laboratory exercises:

1. Internet search and discussion of coupled line filters.

Give a short (one or two paragraphs) synopsis of a scholarly paper that uses coupled line filters. The paper must have been published no earlier than Jan. 2002. Be sure to include a copy of the first page of the paper.

2. ADS Simulation of a coupled line filter:

Design a microstrip (relative permittivity=3.3 and thickness=30 mils) coupled line filter using a system impedance of $Z_0 = 50$ ohms with the following specifications:

- Lower 3 dB cutoff frequency: 5.9 GHz
- Upper 3 dB cutoff frequency: 6.1 GHz
- 10 dB rejection at 7.23 GHz
- Maximally flat frequency response

This will require choosing the proper filter order using the correct tables, determining the even and odd mode impedances for each section, and using line calc. to determine the spacing, widths, and lengths of each coupled line section.

Simulate your design and then tweak it to obtain the desired results.

Be sure to note and explain the pertinent behaviors.

Conclusion: Make some general observations about what you learned from ADS simulations coupled line filters.

Use these Equations to go from the values of g in the table to even and odd mode impedances.

$$Z_0 J_1 = \sqrt{\pi \Delta / 2 g_1}$$

$$Z_0 J_n = \frac{\pi \Delta}{2 \sqrt{g_{n-1} g_n}}$$

$$Z_0 J_{N+1} = \sqrt{\pi \Delta / 2 g_N g_{N+1}}$$

$$\Delta = (\omega_2 - \omega_1) / \omega_0, \quad \omega_0 = \sqrt{\omega_1 \omega_2}$$

$$Z_{0e} = Z_0 [1 + J Z_0 + (J Z_0)^2]$$

$$Z_{0o} = Z_0 [1 - J Z_0 + (J Z_0)^2]$$

Additional Helps:

1. To start, you need to convert the bandpass specifications to the lowpass specifications. Remember that you have two cutoff or corner frequencies ($f_1 = 5.9$ GHz and $f_2 = 6.1$ GHz) and two stopband frequencies (something unspecified at the lower end and 7.23 GHz). Since I have only specified the upper stopband frequencies, we will deal with $f_2 = 6.1$ GHz and $f_{s2} = 7.23$ GHz for our corner and stopband frequencies. Using these, compute the lowpass equivalent values using the lowpass-to-bandpass transformation (equation (2.66) in your notes).

$$\omega_c = \frac{1}{\Delta} \left(\frac{f_2}{f_0} - \frac{f_0}{f_2} \right)$$

$$\omega_s = \frac{1}{\Delta} \left(\frac{f_{s2}}{f_0} - \frac{f_0}{f_{s2}} \right)$$

- Note that I have used frequencies in Hz. Since they are ratios, I don't have to use frequency in radians (the scaling by 2π will cancel).
2. Next, you can look at the chart in the book showing attenuation versus normalized frequency for different filter orders (for Maximally Flat). Compute $|\omega_s/\omega_c| - 1$ from your computations in step 1 and select the filter order that gives 10 dB of attenuation at this value.
 3. Read off the values of g from your table (again for Maximally Flat) for this filter order. If your filter order is N , you have $N+1$ values. Compute the $N+1$ values of $Z_0 J_n$ using the equations on page 1. For $n = 1$, use the first equation, and for $n = N+1$, use the last equation. For all other values of n , use the middle equation.
 4. For each value of $Z_0 J_n$, compute Z_{0e} and Z_{0o} . These are called even and odd mode impedances. The coupled line sections require both values to be fully specified.
 5. In LineCalc, select MCLIN as the element (it defaults to MLIN) and set the substrate parameters and the frequency (to be f_0). You can now specify the even and odd mode impedances as well as the characteristic impedance (50 ohms) for each element and synthesize to find the width of the lines (both coupled lines are the same width) and the spacing between the lines for each of the $N+1$ coupled line filter elements (using the values you computed in Step 4). The sections are quarter wavelength ($E_{\text{Eff}} = 90$ degrees). Don't worry about specifying C_{dB} . Lay the filter out using these values. Use the MCFIL element from the Microstrip palette, as shown below. Note that the parameters W1 and W2 on this element represent the widths of the lines connected to ports 1 and 2, respectively. To be precise, you should set these properly. The circuit below is for different frequencies and for $N = 3$ (leading to 4 sections).

