ECE 671 – Assignment #3

Q1. Design a low-pass, maximally flat microwave filter with the cutoff frequency of 8GHz and at least 16dB attenuation at 13.6GHz as described below. The impedance is 50Ω. Assuming microstrip implementation of the filter on an RT/Duroid 5880 substrate having $\varepsilon_r = 2.2$, $d = 30\,mils$, and $\tan\delta = 0.001$, and with copper conductors of 34μm thick, designate the physical widths and lengths of the microstrip lines. Use ADS to plot the insertion loss versus frequency in each case (from DC to 40GHz).

a) Using only shunt stubs.

b) Using stepped-impedance lines. Assume the lowest and highest feasible characteristic impedances are 10Ω and 130Ω, respectively.

c) Repeat parts a) and b) by including the microstrip line discontinuities (steps and T-junctions) using the schematic simulation in ADS. Compare the results with those obtained in a) and b). (No optimization/tuning is required)

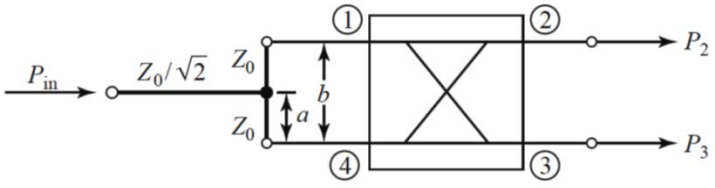
Q2. a) Design a three-section bandstop lumped-element filter with a 0.5dB equal-ripple response, a bandwidth of 10% centered at 3 GHz, and an impedance of 75Ω. What is the resulting attenuation at 3.1 GHz? Use ADS to plot the insertion loss versus frequency.

b) Re-simulate the circuit using non-ideal capacitors and inductors with Q-factors of 40 and 20, respectively. Compare the result with that of part a).

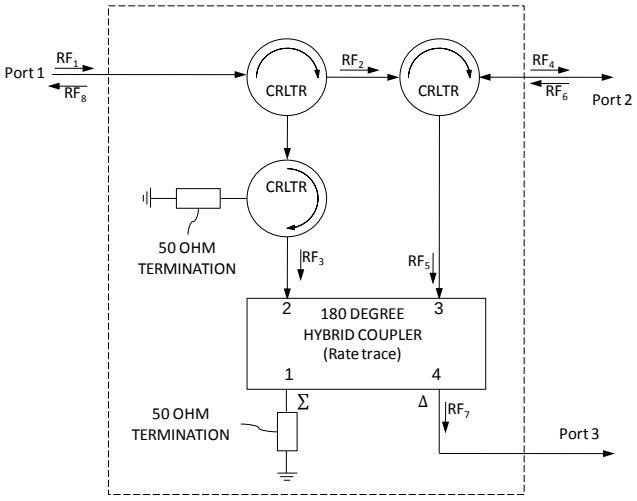
Q3. The Bailey unequal-split power divider uses a 90° hybrid coupler and a T-junction, as shown below. The power division ratio is controlled by adjusting the feed position, a, along the transmission line of length b that connects ports 1 and 4 of the hybrid. A quarter-wave transformer of impedance $Z_0/\sqrt{2}$ is used to match the input of the divider.

(a) For $b = \lambda/4$, show that the output power division ratio is given by $P_3/P_2 = \tan^2(\pi a/2b)$.

(b) Using a branch-line hybrid with $Z_0 = 50\Omega$, design a power divider with a division ratio of $P_3/P_2 = 0.5$, and plot the resulting input return loss and transmission coefficients versus frequency.

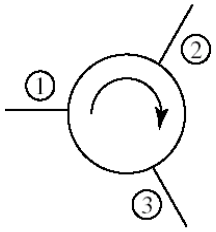


Q4. The following three circulators and an ideal four port 180 coupler are used to construct a three port microwave network as shown below:



Each circulator has the following scattering matrix:

$$[S] = \begin{bmatrix} 0 & 0.03 & 0.93 \\ 0.93 & 0 & 0.03 \\ 0.03 & 0.93 & 0 \end{bmatrix}$$



(a) Deduce the value of the ratio $\frac{RF_7}{RF_1}$ if the port 1 is used as source and port 2 and Port 3 are connected to 50 Ω.

(b) What is the functionality of the resulting three port network? (**Hint:** compare it with a single circulator).