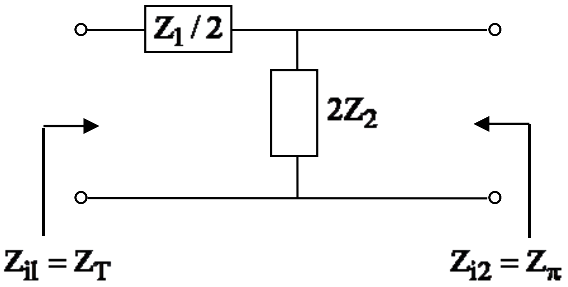
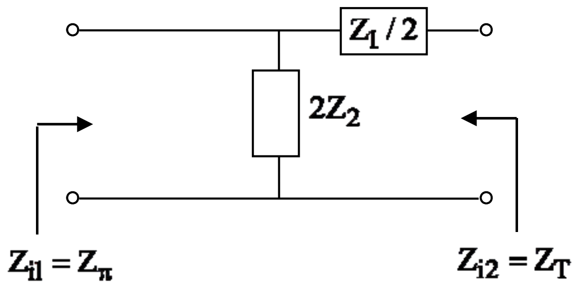
UNIVERSITY OF UTAH
ELECTRICAL AND COMPUTER ENGINEERING DEPARTMENT

ECE 5320/6322 HOMEWORK PROBLEMS 13-20 Fall 2014

13. a. Using the procedure discussed in Section 4.4 of the Text, write ABCD parameters for the bisected (half section) T- and π-filters sketched below:



Bisected (half section T-filter)



Bisected (half section π-filter)

b. Using the expressions 8.27a and 8.2b of the Text, calculate Z_{i1} and Z_{i2} for these half-section circuits and show that these are the same as Z_{iT} and $Z_{i\pi}$ given in Table 8.1 for full-section T and π networks, respectively.

14. Redesign the 0.5 db equal-ripple low-pass filter on page 8-15 of the Chapter 8 Class Notes by using the capacitive input configuration of Fig. 8.25(a) rather than the inductive input configuration of Fig. 8.25(b). For this circuit:

a. Calculate the values of the various capacitances and inductances for a cutoff frequency f_c = 3 GHz.

b. Using ADS software, calculate S_{21} and S_{11} as a function of frequency for the frequency band 1-8 GHz in frequency steps Δf = 0.04 GHz.

c. How does S_{21} calculated for part b compare with that given in Fig. (a) on page 8-21 of the Chapter 8 Class Notes where the inductive input configuration of Fig. 8.25(b) is used instead of the capacitive input configuration used here?

d. Calculate the lengths of the various segments in the stepped impedance microstrip version of this filter using $Z_{o\ell} = 15\Omega$ for capacitances and $Z_{oh} = 120\Omega$ for inductances. Use the approach given in Section 8.6 of the Text and on page 8-25 of the Notes.

e. Calculate and compare S_{21} for the microstrip version of the filter in part d with that of the lumped-element version of the filter in part b. Explain differences, if any.

15. a. Using the transformation relationships given in Table 8.6 of the Text or on page 8-24 of the Class Notes, transform the N = 5, 0.2 dB equal-ripple low-pass filter designed on page 8-15 of the Notes into a band-pass filter with a bandwidth of 10 percent and center band frequency of 4 GHz.

b. Calculate the values of inductances and capacitances needed for this circuit. Combine series inductances and capacitances and draw the final circuit for this band-pass filter.

c. Using ADS software, calculate S_{21} and S_{11} as a function of frequency for the frequency band 2-6 GHz in frequency steps $\Delta f = 0.04$ GHz.

d. Is it possible to explain the attenuation of this band-pass filter for frequencies below and above the passband in terms of the attenuation curves given in Fig. 8.27a of the Text?

16. Select a rectangular waveguide capable of propagating pulsed power of 300 KW at 5 GHz (suggest WR 187).

a. List in ascending order the frequencies of five lowest-order modes of the waveguide.

b. What is the recommended frequency band of operation for the TE_{10} mode for the selected waveguide?

c. What is the guide wavelength λ_g and the wave impedance Z_{TE} in this waveguide at 5 GHz?

d. Assuming the waveguide to be air-filled and the material of the waveguide to be aluminum, calculate the attenuation per unit length in dB/m for this waveguide. Calculate the power loss in this waveguide for a propagation length of 10 feet.

e. Calculate the maximum electric field in the waveguide to ascertain that this is indeed less than the breakdown field strength in dry air i.e. 29000 V/cm.

f. Calculate the pulsed power that will result in air breakdown in the waveguide. This is the maximum power rating for this waveguide at 5 GHz.

17. a. Using Equation 3.96 for attenuation α_c due to conductor losses for the TE_{10} mode in a rectangular waveguide, derive an expression for the frequency for which α_c is minimum.

    b. Calculate the frequency and the minimum attenuation for the TE_{10} mode of a WR-90 waveguide. Assume the material of the waveguide to be aluminum (see pages 27 and 18 of the Text for R_s) and the waveguide to be air-filled.

18. Calculate the magnitude of $\vec{E}$ at the open end of a WR-187 waveguide to which an input power of 100 KW is fed at a frequency of 5 GHz. The SWR in this waveguide is measured to be 1.8 and the position of the voltage minimum is 2 cm from the open end.

19. Select a cylindrical waveguide capable of propagating pulsed power of 200 KW at 5 GHz over a distance of 10 feet (suggest WC 240).

    a. List in ascending order the frequencies of the five lowest-order modes of the waveguide.

    b. What is the recommended frequency band of operation for the TE_{11} mode in this waveguide?

    c. What is the guide wavelength λ_g and the wave impedance Z_{TE} in this waveguide at 5 GHz?

    d. Assuming the waveguide to be air-filled and the material of the waveguide to be aluminum, calculate the attenuation per unit length in dB/m and the total power lost in this waveguide of length 10 feet. Compare the total attenuation in dB for this cylindrical waveguide with that obtained for the rectangular waveguide of Prob. 15 part d.

e. Calculate the maximum electric field in this waveguide to ascertain that this is indeed less than the breakdown field strength in air, i.e. 29000 V/cm.

f. Calculate the maximum power rating for this waveguide at 5 GHz.

20. The attenuation constant α_c for the TE_{nm} modes of a cylindrical waveguide in nepers/m is given by

$$\alpha_c = \frac{R_s}{a\eta_\varepsilon} \frac{1}{\left(1 - f_c^2 / f^2\right)^{1/2}} \left(\frac{f_c^2}{f^2} + \frac{n^2}{p_{nm}'^2 - n^2} \right) \qquad \frac{Np}{m}$$

a. Calculate the attenuation in dB/m for an air-filled WC 150 waveguide made of copper for the TE_{11} and TE_{01} modes at a frequency of 50 GHz. Note that the attenuation for the TE_{01} mode is considerably smaller than the TE_{11} mode.

b. Calculate the attenuation for the above two modes at f = 90 GHz. Show that the attenuation for the TE_{11} mode increases with frequency while that for the TE_{01} mode decreases with frequency in going from 50 to 90 GHz.