

UNIVERSITY OF UTAH
DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

ECE 5320/6322

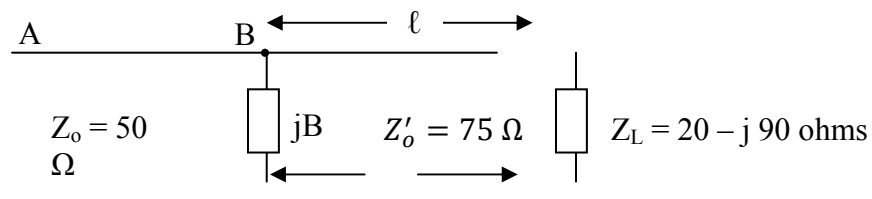
HOMEWORK #1-9

Fall 2014

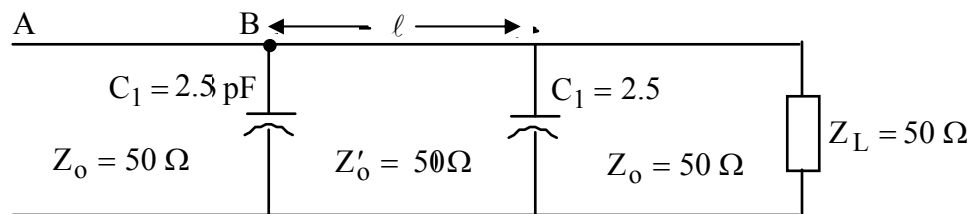
1. Using Eqs. 1.60 and 1.125, calculate the skin depth δ_s and surface resistance R_s of copper, aluminum, and gold at the microwave frequency of 8 GHz.

2. A 50Ω characteristic impedance microstripline is connected to a load of impedance $20 - j 90$ ohms. Calculate the following quantities for an input power of 0.3 W at a frequency of 8 GHz.
 - a. real and imaginary parts of the load impedance
 - b. SWR
 - c. the guide wavelength λ_g assuming that $\epsilon_{\text{effective}} = 2.5$
 - d. the maximum voltage anywhere on the microstripline
 - e. the maximum current anywhere on the microstripline
 - f. the distances of the voltage minima from the load
 - g. the power transmitted to the load
 - h. input impedance of the circuit given that the length of the microstrip-line is 1 cm

3. The load in Problem 2 can be matched to the transmission line by using a shunt susceptance jB (capacitive or inductive) that is suitably placed at a distance ℓ as shown in the following:



- a. Calculate the distance ℓ to obtain matching for section AB of the microstripline.
 - b. Calculate the susceptance jB and the value of inductance or capacitance that is needed at a frequency of 8 GHz.
4. a. Calculate the VSWR for section AB of a microwave circuit for which the equivalent circuit is as shown in the following:



It is given that the wavelength of microwaves on the circuit is 3.0 cms and length ℓ between two capacitances is 1.3 cm. The frequency of the signal is 8 GHz.

- b. What must the length ℓ be so that perfect matching is obtained for the signal input side or section AB of the circuit (VSWR = 1.0)?
5. Using Agilent ADS or any other software, calculate and plot the reflection coefficient S_{11} for the circuits designed in Problem 3 and Problem 4, **part b**, as a function of frequency for the frequency band 6.0 – 9.0 GHz in frequency steps ΔF of 0.03 GHz. Determine the frequency bands for which $S_{11} < 0.316$ (return loss of 10 dB). This corresponds to the frequency band for which $\text{SWR} < 2.0$.
6. An antenna of equivalent impedance $Z_a = 20 - j 90 \Omega$ is to be conjugate matched to a transistor amplifier of output impedance $Z_g = 50 + j 20 \Omega$. Design a circuit of topology shown either in Fig. 1a or 1b so that the input impedance

$$Z_{in} = Z_g^* = 50 - j 20 \text{ ohms}$$

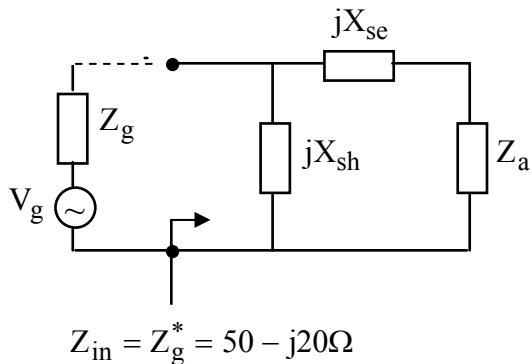


Fig. 1a

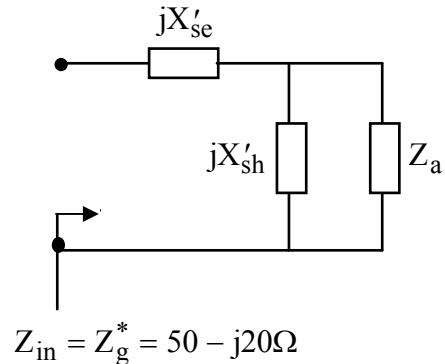


Fig. 1b

For an open-circuit voltage $V_g = 2$ V RMS, calculate the power delivered to the load i.e. the antenna.

7. Do Problem 3.19 of the Text.

Calculate the attenuation per unit length in dB/m for the stripline of Problem 3.19 of the Text at 4.0 GHz and at 6.0 GHz ($Z_0 = 100\Omega$). Include both the conductor and dielectric losses in your calculations. Compare the conductor and dielectric losses of this triplate stripline at 4.0 and 6.0 GHz. Note that the dielectric loss increases more rapidly than the conductor loss.

8. Do Problem 3.20 of the Text.

Calculate the attenuation per unit length of this microstripline at 4.0 and 6.0 GHz. The substrate thickness for this microstripline (as in Problem 3.20) is 0.51 mm. Compare the conductor and dielectric losses of this microstripline at 4.0 and 6.0 GHz.

9. Calculate the attenuation per unit length in dB/m of a $Z_0 = 50\Omega$ coaxial line of outer diameter $2b = 7/32$ " at 5 GHz. Assume the conductors to be made of copper

and assume (a) air-filled line and (b) a Teflon-filled line ($\epsilon_r = 2.08$, $\tan \delta = 4 \times 10^{-4}$).

- c. To what frequencies can the above coaxial lines of case a and b be used without exciting the higher-order modes such as TE and TM modes?
- d. Calculate the power handling capacity of the air-filled coaxial line of case a assuming that the breakdown field strength = 29000 V/cm.