Data Provided: Smith Chart (4 copies)

The University Of Sheffield.

DEPARTMENT OF ELECTRONIC AND ELECTRICAL ENGINEERING

Autumn Semester 2009-2010 (2 hours)

High Speed Electronic Circuit Design 6

Answer **THREE** questions. **No marks will be awarded for solutions to a fourth question.** Solutions will be considered in the order that they are presented in the answer book. Trial answers will be ignored if they are clearly crossed out. **The numbers given after each section of a question indicate the relative weighting of that section.**

1. a. Prove that the characteristic impedance of a lossless 0.25λ transmission line is given by $Z_o = \sqrt{Z_{in} Z_L}$. **(4)**

b. Calculate the inductance per unit length and the phase velocity for a lossless transmission line with a characteristic impedance of 50Ω and a capacitance of 67 pF/m. **(5)**

c. A lossless transmission line with an electrical length of 0.1λ and a real characteristic impedance of 75Ω is terminated with complex load impedance of 50+j20Ω. Find the input impedance, the reflection coefficient at a distance of 0.05λ from the load and the VSWR on the line. **(5)**

d. Using the appropriate transmission lines equations, show how the input impedance of a lossless transmission line can be made equivalent to a lumped capacitor or inductor when the line is terminated by a short or an open circuit load. **(6)**

2. a. Explain how the Smith chart can be used in the analyses of lossy transmission lines. **(4)**

b. A coaxial cable of a characteristic impedance Z_o=50Ω and a 5 cm length is terminated by a load impedance of Z_L=40+j35Ω. Find the input impedance of the line at a frequency of 1GHz assuming the guided wavelength is 77% of the free space wavelength. **(6)**

c. For a transmission line with Z_o=50Ω and terminated by Z_L=150-j50Ω, design a double stub matching network to match Z_L to Z_o. The 1st stub is located at the load, and the two stubs are separated by a distance of 0.125λ. The length of each stub should be $\leq$ 0.25λ. **(10)**

Note: Find one possible solution for each design.

3. **a.** Describe briefly what is meant by the transducer and the available power gains of a two port network. **(4)**

b. Explain with the aid of diagrams what is meant by the transmission matrix representation, ABCD, and why it is useful when analysing the cascade of two networks. **(4)**

c. A two port network is driven at both ports using $V_1 = 10\angle 0°$, $I_1 = 0.1\angle 30°$, $V_2 = 12\angle 90°$, $I_2 = 0.15\angle 120°$. Determine the incident and reflected voltages at both ports assuming a characteristic impedance of 50Ω for each port. **(4)**

d. Find the scattering parameters of the two ports network shown in Figure 1. The characteristic impedance of each port is 50Ω.

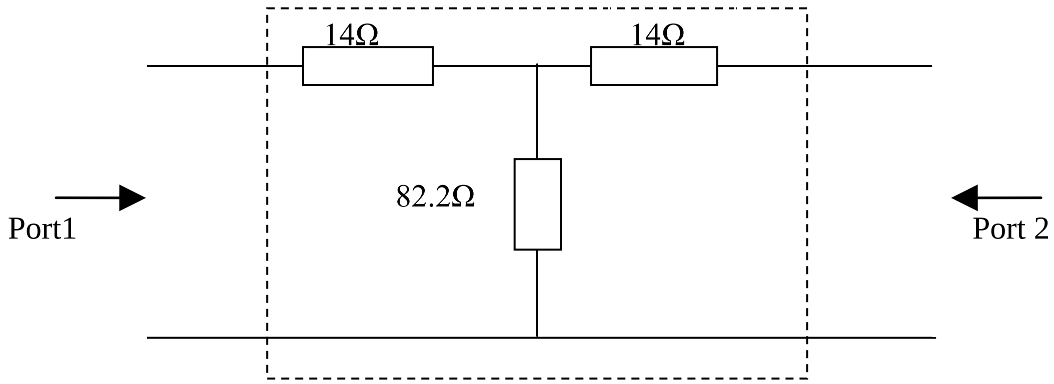

Figure 1 **(5)**

e. What value of gain/attenuation is provided from the above network? **(3)**

4. **a.** Explain briefly the required conditions to achieve an unconditionally stable amplifier operation. **(3)**

b. Explain why sometimes it is preferable to design an amplifier for less than the maximum obtainable gain? How this can be achieved? **(4)**

c. An amplifier has the following S parameters at 500 MHz; $S_{11} = 0.655\angle -57°$, $S_{21} = 10.5\angle 136°$, $S_{12} = 0.04\angle 47°$, $S_{22} = 0.79\angle -33°$. Determine whether the amplifier is unconditionally or conditionally stable. **(3)**

d. An amplifier has the following S-parameters that are measured at 6GHz with respect to a 50Ω reference characteristics impedance: $S_{11} = 0.655\angle -140°$, $S_{21} = 2.4\angle 50°$, $S_{12} = 0.0$, $S_{22} = 0.707\angle -83°$. Design the input and output matching networks of the amplifier so that an overall gain of 10dB is achieved. Plot and use constant gain circles for G_L=2dB and 3dB, and G_s=1dB and 0dB. **(10)**

You may find the following information useful:

The constant gain circles can be plotted using the following set of equations

$$C_S = \frac{g_S S_{11}^*}{1-(1-g_S)|S_{11}|^2}$$

$$r_S = \frac{\sqrt{1-g_S}\left(1-|S_{11}|^2\right)}{1-(1-g_S)|S_{11}|^2}$$

$$C_L = \frac{g_L S_{22}^*}{1-(1-g_L)|S_{22}|^2}$$

$$r_L = \frac{\sqrt{1-g_L}\left(1-|S_{22}|^2\right)}{1-(1-g_L)|S_{22}|^2}$$

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