The University Of Sheffield.

Data Provided: Smith Chart (4 copies), Useful equations are given at the end of the paper

DEPARTMENT OF ELECTRONIC AND ELECTRICAL ENGINEERING

Autumn Semester 2010-2011 (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. Explain briefly the difference between the lumped and distributed representations of a circuit element. **(4)**

b. A lossless coaxial transmission line with a length of 1 cm and a characteristic impedance of 50Ω is terminated with a complex load impedance of (37.5+j75)Ω. If the frequency is 3GHz, find the reflection coefficient at the load, the input impedance, the return loss and insertion loss of the line. **(5)**

c. Prove that the distance between any two successive maxima and minima of the voltage standing wave is 0.25λ. **(6)**

d. A lossless transmission line is terminated with a 200 Ω load. If the voltage standing wave ratio (VSWR) is 1.5, find the two possible values for the characteresitic impedance of the line. **(5)**

2. a. Explain how impedance matching can be achieved using a single stub. **(5)**

b. A lossy transmission line is terminated by a load impedance of Z_L=(70+j20)Ω. Find the input impedance when the line has a characteristic impedance of Z_o=50Ω, a length of 15 cm, and an attenuation of 18 dB/m at 300 MHz. **(5)**

c. For a transmission line with Z_o=50Ω and terminated by Z_L=(100+j30)Ω, 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 ≤ 0.25λ. **(10)**

Note: Find one possible solution for each design.

3. a. Explain with the aid of diagrams what is meant by the ABCD network representation and what is used for. **(4)**

b. Explain the difference between the input reflection coefficient and the S_{11} scattering parameter in a two ports network. **(4)**

c. Find the ABCD parameters for the series and shunt loads shown in Figure 1.

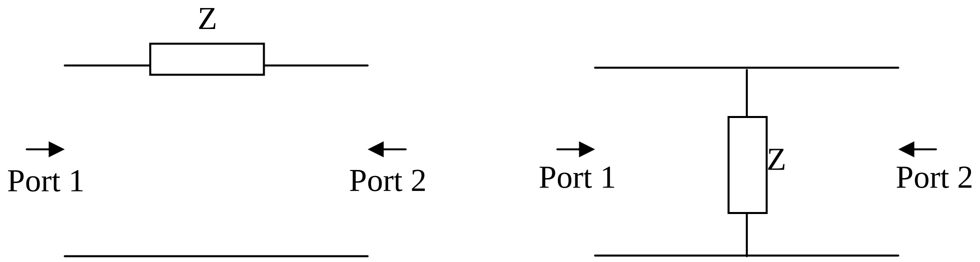

Figure 1

(4)

d. Find the scattering parameters of the two ports network shown in Figure 2. The characteristic impedance of each port is Z_0.

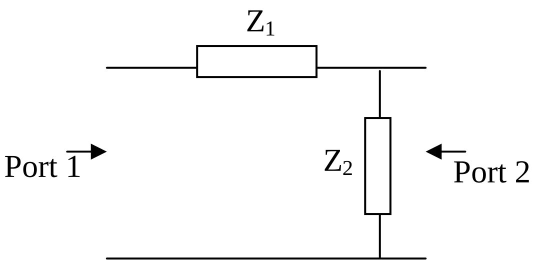

Figure 2

(8)

4. **a.** Outline the required steps to design an amplifier for a specific power gain when a unilateral assumption is not valid. **(4)**

b. A matched 3 dB attenuator is characterised by the following S-parameters: $S_{11} = 0$, $S_{21} = 0.707\angle 0°$, $S_{12} = 0.707\angle 0°$, $S_{22} = 0$. The input side of the attenuator is connected to a source impedance of Z_s=50Ω. The output side is connected to a load of Z_L=50Ω. Calculate the available power gain, the transducer power gain and the operating power gain. How do these gains change if the load is changed to 25Ω? **(6)**

c. An amplifier has the following scattering and noise parameters

F [GHz]	S_{11}	S_{21}	S_{12}	S_{22}
4.0	$0.6\angle{-60°}$	$1.9\angle 81°$	$0.05\angle 26°$	$0.5\angle{-60°}$

Z_o=50Ω R_N=20Ω NF_{min}=1.6dB $\Gamma_{opt} = 0.62\angle 100°$

Design an amplifier having a 2 dB noise figure with the maximum gain that is compatible with this noise figure. **(10)**

You may find the following information useful:

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

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

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

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

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

$$C_{NF} = \frac{\Gamma_{opt}}{(N+1)}$$

$$r_{NF} = \frac{\sqrt{N(N+1-|\Gamma_{opt}|^2)}}{(N+1)}$$

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