The University Of Sheffield.

Data Provided: Smith Chart (3 copies), Useful equations are given at the end of the paper

DEPARTMENT OF ELECTRONIC AND ELECTRICAL ENGINEERING

Autumn Semester 2012-2013 (2 hours)

High Speed Electronic Circuit Design

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 and define briefly what is meant by return losses. **(2)**

b. A lossless transmission line with a length of 10 cm and a characteristic impedance of 50Ω is terminated with a complex load impedance of (90+j20)Ω at a frequency of 3GHz. Use the required transmission line equations to calculate the input impedance, input reflection coefficient, voltage standing wave ratio, and insertion losses. **(5)**

c. 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)**

d. Show that the voltage standing wave ratio along a transmission line is given by VSWR= $(1+\rho)/(1-\rho)$, where ρ is the magnitude of the reflection coefficient. **(7)**

2. **a.** Explain how impedance matching can be achieved using a single stub. **(4)**

b. An unknown load impedance is connected to a 0.1λ long 50Ω lossless transmission line. The VSWR and phase of the reflection coefficient measured at the input of the line are 5 and 40° respectively. Determine the input and load impedances by using the Smith Chart provided. **(6)**

c. For a transmission line with a characteristic impedance of Z_o=50Ω and terminated by a load impedance Z_L=(100+j40)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. Find one possible solution in which the length of each stub is $\leq 0.25\lambda$. **(10)**

3. a. Explain and define briefly what Signal Flow Diagrams analysis are used to represent, and what are the two basic components of any SFD. **(4)**

b. Explain briefly the difference between the available power gain and the transducer power gain. **(4)**

c. Calculate the transmission (ABCD) parameters of the network shown in Figure 1.

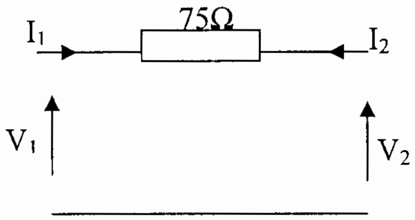

Figure 1

(4)

d. Determine the scattering parameters, S_{ij} (i,j=1 or 2), of the two-port network shown in Figure 2. Assume the characteristic impedances for the input and output ports are equal ($Z_{o1}=Z_{o2}$).

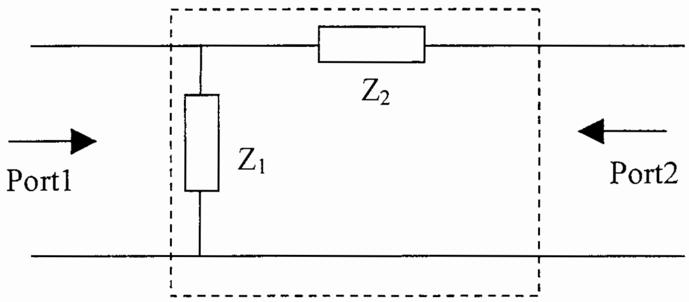

Figure 2 **(8)**

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

b. A microwave transistor has the following S parameters at 10GHz: $S_{11} = 0.45\angle 150°$, $S_{21} = 2.05\angle 10°$, $S_{12} = 0.01\angle -10°$, $S_{22} = 0.4\angle -150°$. The source and load impedances are Z_g=20 Ω and Z_L=30 Ω, respectively. Compute the available power gain, transducer power gain, and the operating power gain when a 50Ω reference impedance is assumed. **(6)**

c. An amplifier has the following scattering and noise parameters

F GHz	S_{11}	S_{21}	S_{12}	S_{22}
6	$0.6\angle -60°$	$2\angle 81°$	0	$0.7\angle -60°$

Z_o=50Ω R_N=20Ω NF_{min}=2dB Γ_{opt}=$0.62\angle 100°$

Design an amplifier having a 2.5dB noise figure with the maximum gain that is compatible with this noise figure using noise figure and constant gain circles on the Smith chart provided. **(10)**

You may find the following information useful:

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

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

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

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

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

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

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

SKK