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

The University Of Sheffield.

DEPARTMENT OF ELECTRONIC AND ELECTRICAL ENGINEERING

Autumn Semester 2013-2014 (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 briefly what is meant by a matched transmission line, and what is the input impedance of this line. **(2)**

b. A lossless transmission line with a length of 2 cm and a characteristic impedance of 50Ω is terminated with a complex load impedance of (70-j30)Ω at a frequency of 2GHz. Use the required transmission line equations to calculate the input impedance, input reflection coefficient, voltage standing wave ratio, insertions and return losses. **(6)**

c. It is desired to use a section of a lossless 50Ω transmission line terminated in a short circuit to construct an equivalent inductance with a reactance of 25Ω. Assuming the guided wavelength is 75% of the free space wavelength at a frequency of 1 GHz. Determine the shortest possible line length that would exhibit the desired reactance at its input. **(5)**

d. Consider a lossless transmission line, which has a characteristic impedance of Z_o and terminated by a load impedance of Z_L. Show that the voltage reflection coefficient at the load is given by $\Gamma = (Z_L - Z_o)/(Z_L + Z_o)$. **(7)**

2. **a.** Explain the advantages of using the Smith Chart in network analysis. **(4)**

b. A lossy line with attenuation of 15 dB/m at 300 MHz, is terminated by a load with a normalized impedance of z=3+j1. Use the Smith chart to find the VSWR at a distance of 10cm from the load. **(6)**

c. For a transmission line with a characteristic impedance of Z_o=50Ω and terminated by a load impedance Z_L=(150-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.

Find one possible solution in which the length of each stub is ≤ 0.25λ. **(10)**

3. **a.** Explain with aid of a diagram the difference between the input reflection coefficient and the S_{11} scattering parameter in a two ports 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. Explain briefly the interaction of the incident and reflected waves in a two port network and how it can be represented using the scattering matrix. **(4)**

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

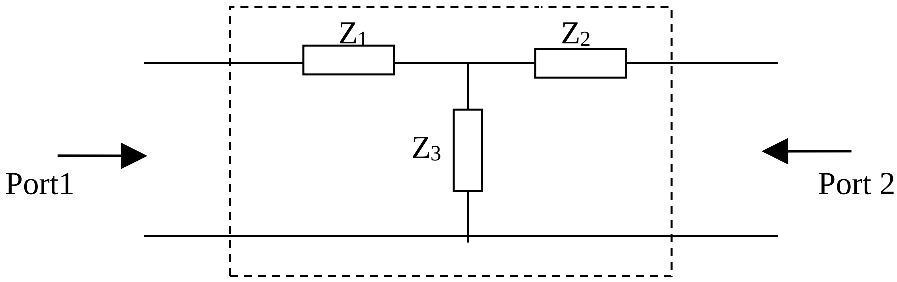

Figure 1 **(8)**

4. **a.** Explain briefly how an amplifier can be designed for a maximum gain. **(2)**

b. Explain with the aid of diagrams what is meant by the unconditional stability of an amplifier. **(4)**

c. Consider a two-port network with a characteristic impedance of Z_0 and with the following S parameters: $S_{11} = 0.1\angle 0°$, $S_{21} = 0.8\angle 90°$, $S_{12} = 0.8\angle 90°$, $S_{22} = 0.2\angle 0°$. What is the input reflection coefficient at port 1 when port 2 is terminated with a short circuit load? **(4)**

d. Design an amplifier to have a gain of 10dB at 6GHz using a transistor with the following S parameters (Z_0=50 Ω): $S_{11} = 0.61\angle$-170°, $S_{21} = 2.24\angle 32°$, S_{12} = 0., $S_{22} = 0.72\angle$-83°. Plot, and use, constant gain circles for G_s=0.5dB, G_s=1.5dB, G_L=1.5dB and G_L=2.5dB. **(10)**

You may find the following information useful:

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

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

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

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

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

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