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

DEPARTMENT OF ELECTRONIC AND ELECTRICAL ENGINEERING

Autumn Semester 2011-2012 (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 conjugate impedance matching. **(3)**

b. A lossless transmission line with a length of 5 cm and a characteristic impedance of 50Ω is terminated with a complex load impedance of (60-j20)Ω at a frequency of 1GHz. Use the required transmission line equations to calculate the reflection coefficient at the load, the input impedance, voltage standing wave ratio, and the input reflection coefficient. **(5)**

c. A load impedance of Z_L=50-j10Ω is to be matched to a 75Ω source using a lossless transmission line of characteristic impedance Z_o and length ℓ. Find the required Z_o (real) and ℓ. **(6)**

d. Consider a lossless transmission line that is terminated by a load impedance of Z_L. Show that the reflection coefficient at a distance *d* from the load can be expressed as $\Gamma_{(d)} = \Gamma e^{-j2\beta d}$, where Γ is the reflection coefficient at the load, and β is the phase constant. **(6)**

2. a. Explain briefly how the Smith chart can be used for admittance transformation. **(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=4+j0. Use the Smith chart to find the voltage standing wave ratio, 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=(140-j110)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 $\leq$ 0.25λ. **(10)**

Note: Find one possible solution for each design.

3. **a.** Explain the limitations of basic circuit theory in the design of high frequency electronic circuits. **(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 transmission parameters for the network shown in Figure 1

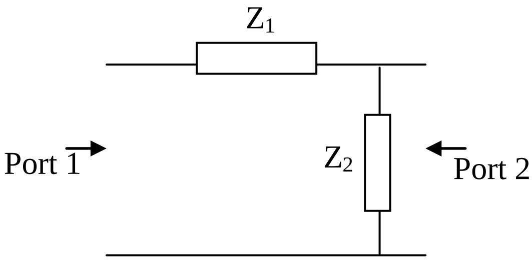

Figure 1

(4)

d. Determine the scattering parameters 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}).

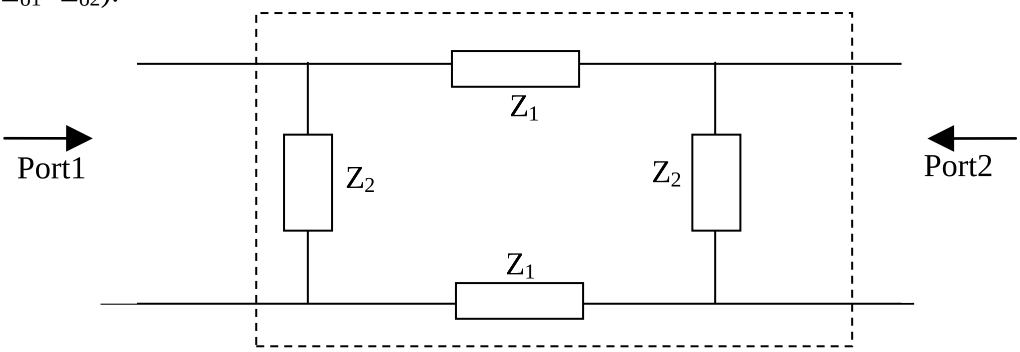

Figure 2

(8)

4. **a.** Explain the difference between conditional and unconditional stability. **(2)**

b. Explain briefly what is meant by constant gain circles. **(2)**

c. Consider a BJT with the following parameters: $S_{11} = 0.3\angle 30°$, $S_{21} = 2.5\angle\text{-}80°$, $S_{12} = 0.2\angle\text{-}60°$, $S_{22} = 0.2\angle\text{-}15°$. Determine whether the transistor is unconditionally stable, and design an amplifier with a power gain of 8 dB. In addition ensure that $\Gamma_{in} = \Gamma_s^*$, where Γ_{in} and Γ_s^* have their usual meaning. **(6)**

d. Design an amplifier to have a gain of 10dB at 6GHz using a transistor with the following S parameters (Z_o=50Ω): $S_{11} = 0.61\angle\text{-}70°$, $S_{21} = 2.24\angle 32°$, $S_{12} = 0$, $S_{22} = 0.72\angle\text{-}83°$. Plot, and use, constant gain circles for G_s=0.5dB, G_s=1.5dB, G_L=1.5dB, and G_L=2.5dB, where G_s and G_L have their usual meaning. **(10)**

You may find the following information useful:

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

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

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

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

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

$$C_{g_o} = \frac{g_o(S_{22}-\Delta S_{11}^*)^*}{1+g_o(|S_{22}|^2-|\Delta|^2)}$$

$$r_{g_o} = \frac{\sqrt{1-2Kg_o|S_{12}S_{21}|+g_o^2|S_{12}S_{21}|^2}}{\left|1+g_o(|S_{22}|^2-|\Delta|^2)\right|}$$

SKK