1. (a) Label ALL of the following on a blank Smith Chart:

Note: Smith Charts are provided at the end of this paper and are also available on course VISION page.

(i) Infinite impedance,

(1 mark)

(ii) Infinite admittance,

(1 mark)

(iii) Zero impedance,

(1 mark)

(iv) Zero admittance,

(1 mark)

(v) $g = 1$ circle,

(1 mark)

(vi) Location (or locations) defining no reflections, and

(1 mark)

(vii) Location (or locations) for a standing wave ratio of 2.

(1 mark)

Cont…/

/Cont…Q1

(b) In the transmission line circuit shown in Figure 1(b) below, all lines are lossless with $Z_0 = 75\ \Omega$.

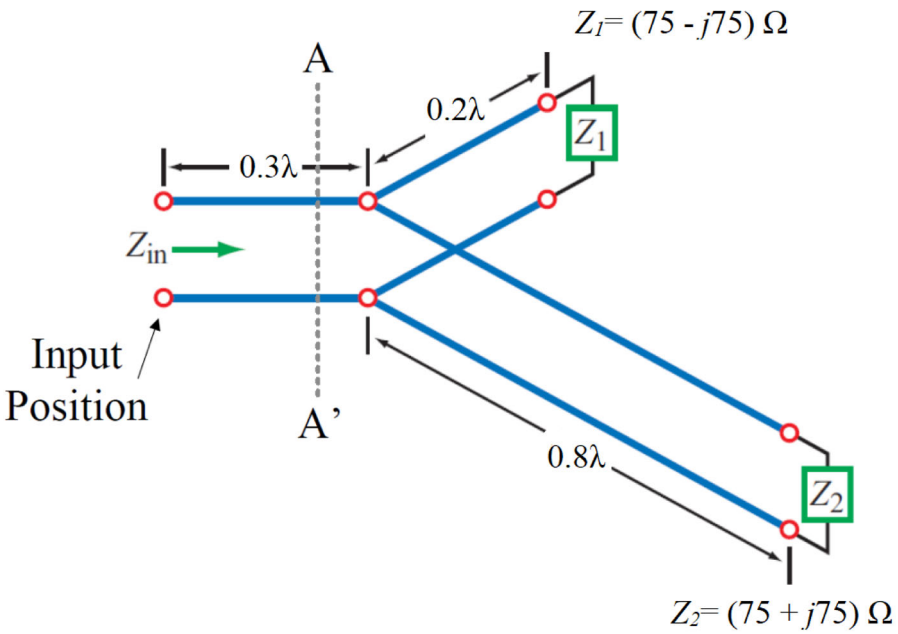

Figure 1(b)

(i) Using the Smith Chart, determine Z_{in}.

(8 marks)

(ii) Verify your above solution by using equations and calculations; i.e. NOT by using the Smith Chart.

(5 marks)

(iii) Now use the Smith Chart to obtain the impedance seen at the position AA' which is 0.25λ away from the input of the transmission line.

(5 marks)

2. Consider the transmission line circuit shown in Figure 2 below. The load is a capacitor of value C_L. All components and transmission lines are lossless. Operation angular frequency is ω.

Parameters: $C_L = 2$ pF; $L = 2$ nH; $Y_1 = 0.1$ S; $\omega = 2\pi\ 10^{-9}$ rad/s;
$Z_{01} = 25\ \Omega$; $Z_{02} = 50\ \Omega$.

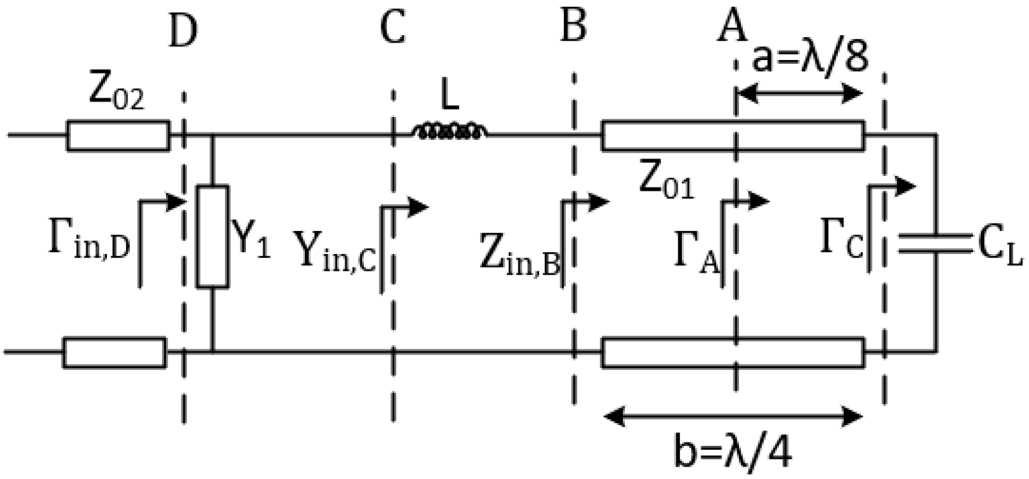

Figure 2

(a) Find the reflection coefficient Γ_C at the capacitor load C_L.

(4 marks)

(b) Find the reflection coefficient Γ_A at the distance $a = \lambda/8$ away from the load C_L.

(5 marks)

(c) Find the input impedance $Z_{in,B}$ at the observation point B defined in Figure 2.

(5 marks)

Cont…/

/Cont…Q2

(d) Find the input admittance $Y_{in,C}$ at the observation point C defined in Figure 2.

(5 marks)

(e) Find the reflection coefficient $\Gamma_{in,D}$ at the input point D defined in Figure 2.

(6 marks)

3. (a) Briefly define the basic operation of a 4-port directional coupler and provide the typical role and name of each port.

(2 marks)

(b) A four-port directional coupler has the following scattering matrix, which is defined using matched loads and the typical port notation.

$$S = \begin{bmatrix} 0.05\angle 45^o & 0.95\angle 30^o & 0.1\angle 90^o & 0.05\angle 60^o \\ 0.95\angle 30^o & 0.05\angle 45^o & 0.05\angle 60^o & 0.1\angle 90^o \\ 0.1\angle 90^o & 0.05\angle 60^o & 0.05\angle 45^o & 0.95\angle 30^o \\ 0.05\angle 60^o & 0.1\angle 90^o & 0.95\angle 30^o & 0.05\angle 45^o \end{bmatrix}$$

(i) Identify whether this is a lossless or a lossy coupler.

(3 marks)

Find the values in dB, making sure to report your calculations, for (ii) through (v) below:

(ii) The coupling,

(2 marks)

(iii) The isolation,

(2 marks)

(iv) The return loss,

(2 marks)

Cont…/

/Cont…Q3(b)

(v) The directivity, and

(2 marks)

(vi) The phase change for $1\,\text{Watt}$ of signal power from port 3 to port 4.

(2 marks)

(c) A signal with power of $2\ \text{mW}$ is supplied to the input of a 4-port $10\ \text{dB}$ directional coupler $(\text{C} = 10\ \text{dB})$. Assuming all ports are matched and assuming that the directivity is $25\ \text{dB}$ while the insertion loss is $0.6\ \text{dB}$, find the signal power levels in mW at the other three ports and determine the coupler's isolation in dB.

(10 marks)