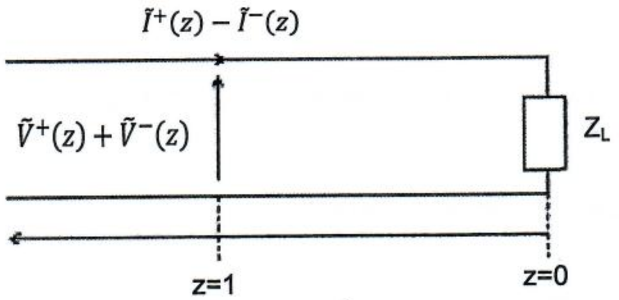
1. Consider the following **lossless** transmission line of characteristic impedance Z_0. The origin of the line is taken at the position of the load.



Where $\tilde{I}^+(z), \tilde{I}^-(z)$ are the position-dependent incident and reflected currents, and $\tilde{V}^+(z), \tilde{V}^-(z)$ the incident and reflected voltages. Z_L is the load impedance.

(a) Show that the voltage reflection coefficient at the load, Γ_L, is given by the relation

$$\Gamma_L = \frac{Z_L - Z_0}{Z_L + Z_0}$$

(5 marks)

(b) The transmission line is operating at a frequency of 20 GHz with a characteristic impedance Z_0 = 50 Ω. The load of the line is a resistance of 100 Ω itself in series with a capacitance of 3 pF.

(i) Calculate the reflection coefficient (magnitude and phase) and Voltage Standing Wave Ratio (VSWR) at the load.

(6 marks)

(ii) Using a Smith chart, determine the position of first voltage maximum from the load.

(6 marks)

/Cont...

/Cont…1.

(c) The following measurements of a transmission line of characteristic impedance $Z_0 = 50\ \Omega$ are provided:

The first voltage maximum is occurring at 5 cm from the load.

The voltage standing wave ratio is VSWR = 4

The distance between adjacent voltage maxima is 20 cm.

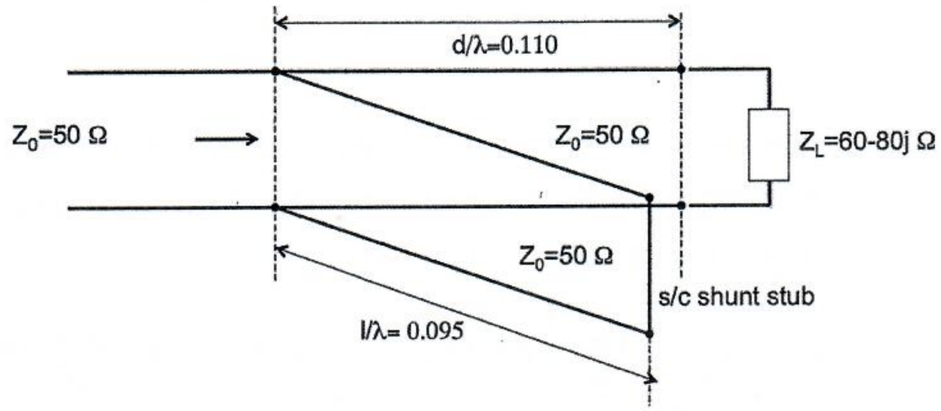
(i) Using a Smith chart, determine the value of the normalised load impedance, z_L, and deduce the load impedance, Z_L.

(4 marks)

(ii) Using the Smith chart, determine the magnitude of the voltage reflection coefficient

(4 marks)

2. Consider a load impedance Z_L = 60-j80 Ω connected to a transmission line of characteristic impedance Z_0 = 50 Ω. The circuit has been matched to the load using a single stub short-circuited (s/c) element of length 0.095λ and a transmission line of length 0.110λ according to the figure given below:



(a) By using a Smith chart, verify that the single-stub, short-circuited, shunt matching network is effectively matching this load to a 50 Ω impedance transmission line, in other words $Z_{in} = Z_0$.

Note: results are approximate.

(8 marks)

(b) Using a Smith chart, show that there is another matching solution which uses a transmission line of length d = 0.260λ and a single stub, short-circuited, shunt matching network of length l = 0.405λ.

(8 marks)

/Cont...

/Cont…2.

(c) Assuming that the load is matched at 2 GHz and that the load consists of a resistor and capacitor in series.

(i) Calculate the values of the resistance and capacitance.

(3 marks)

(ii) The magnitudes of the input reflection coefficient, $|\Gamma_{in}|$, for these two matching networks as a function of frequencies ranging from 1 to 3 GHz can be given as below.

	First matching network	Second matching network
f = 1 GHz	0.95	0.78
f = 2 GHz	0	0
f = 3 GHz	0.8	0.45

(A) Plot on the same graph, $|\Gamma_{in}|$ as a function of f for both matching networks.

(2 marks)

(B) Which matching network would you choose? Justify your answer.

(3 marks)

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

(i) Infinite impedance,

(ii) Infinite admittance,

(iii) zero impedance,

(iv) zero admittance,

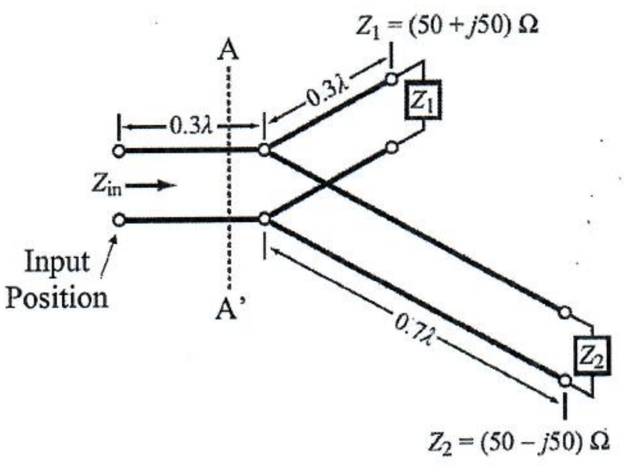
(v) g = 1 circle,

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

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

(7 marks)

(b) See the transmission line circuit show in the Figure below. All lines are lossless with $Z_0 = 50\ \Omega$. Note: Part (a) is not needed for parts (b), (c), and (d).



Using the Smith Chart, determine Z_{in}.

(8 marks)

/Cont...

/cont…3.

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

(5 marks)

(d) Now use the Smith Chart to develop an equivalent circuit by placing a complex load at the position AA' which is 0.75λ away from the input of the transmission line.

(5 marks)

4. (a) Draw the circuit diagram for an equal-split Branch line hybrid coupler. You can use basic transmission line sections as well. This coupler is to connect to other transmission lines which have a characteristic impedance of 75 Ohms.

(1 mark)

(b) Make sure to include and clearly label the following on your circuit:

(i) The important transmission line impedances,

(1 mark)

(ii) The isolated and the through ports,

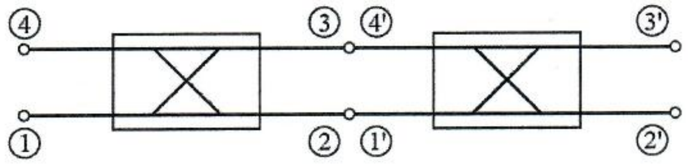
(1 mark)

(iii) Any critical lengths.

(2 marks)

The following question parts are not related to parts (a) through (b).

(c) Two identical 90 degree hybrid couplers, both with a coupling value C = 8.34 dB, are connected as shown below. You can consider the input voltage at port 1, on the left side, to be $V_1^+ = 1\ V \angle 0°$.



(i) Find the resulting output voltage amplitudes and phases at ports 2 and 3 (between the couplers), relative to the given input voltage V_1^+.

(10 marks)

/Cont...

/Cont…4(c)

(ii) Find the resulting output voltages at ports 2′ and 3′ (at the end of the second coupler), relative to the given input voltage V_1^+.

(10 marks)

END OF PAPER