LNMIIT/B. Tech/EC/PC/ECE /2017-18/Even/E

LNMIIT
The LNM Institute of Information Technology

Roll No-

The LNM Institute of Information Technology

Electronics and Communication Engineering Department

Microwave Engineering (ECE)

Date:07/05/2018

End Term- 2018

Time : 3 Hrs

Degree B.Tech

Programme -ECE

Class Size:199 R

Full Marks 100

	CO1	CO2	CO3	CO4	CO5
Questions	1,2,3	4,5,6,7a	7b,8	9	10
Marks	10+10+10	10+10+10+5	5+10	10	10
Marks/Max Marks (%)	30	35	15	10	10

Answer must be brief and to the point. Symbols have their usual meaning. All parts of the question must be answered in sequence. If necessary, make suitable assumptions and state the assumptions clearly.

Q1. a) Derive the bunching parameter for Reflex Klystron.

b) A reflex klystron is operated at 9 GHz with dc beam voltage 290 V for 1+3/4 mode, repeller space length 1mm, dc beam current 10 mA. The beam coupling coefficient is assumed to be 1. Calculate the repeller voltage, electronic efficiency and output power.

[4+(2+2+2)=10]

Q2. A travelling-wave tube (TWT) operates under the following parameters:

Beam Voltage: $V_0 = 3kV$
Beam Current: $I_0 = 30mA$
Characteristic Impedance of Helix: $Z_0 = 10\Omega$
Circuit length : $N = 50$
frequency: $f = 10GHz$

Determine

i) the gain parameter C
ii) the output power gain A_p in dB.
iii) all four propagation constants

b) Explain the Gunn-effect by two valley model theory

[2+2+4+2=10]

Q3. a) Explain the mechanism of Oscillation of Cavity Magnetron.

b) What is the need of strapping in Magnetron?

c) A pulsed cylindrical magnetron is operated with the following parameters

Anode Voltage=25kV
Anode Current=25A
Magnetic flux density = $0.34 Wb/m^2$

Cathode cylinder radius=5cm
Anode cylinder radius=10cm
Calculate

a) the angular frequency
b) the cut-off voltage
c) the cut-off magnetic flux density

[4+2+4=10]

Q4. a) Derive the mathematical expression for computing the input reactance of a lossless transmission line when the line is terminated into i) a short-circuit, ii) an open-circuit. Discuss how open-circuited and short-circuited transmission lines can be used to realize lumped components at microwave frequencies.

b) For a lossless transmission line whose characteristic impedance Z_0, phase constant β, and physical length L are known, derive the mathematical expressions for the ABCD parameters. (Hint: Start with transmission line equations, treat the transmission line as a two-port network, apply the definitions of ABCD parameters, and simplify the results.)

[5+5=10]

Q5. a) Using a suitable L-section impedance matching network, match a load impedance $ZL = 150 - j200\ \Omega$ to a 100 Ω generator at 3 GHz. Note that you should get TWO SOLUTIONS to this problem.

b) Using a single parallel short-circuited stub, match a load impedance $ZL = 60 - j80\ \Omega$ to a 50 Ω transmission line. Assume that the frequency of operation is 900 MHz. Also assume that the lossless transmission lines being used for impedance matching are operating in the TEM-mode.

[5+5=10]

Q6. a) A load of 100 Ω impedance is to be matched to a 50 Ω transmission line using a quarter-wave transmission line in between. What should be the numerical value of the characteristic impedance of the quarter-wave line?

b) A load impedance $ZL = 200 + j100\ \Omega$ is to be matched to a 40 Ω generator using a lossless transmission line in between. Calculate the required length and characteristic impedance of this lossless transmission line. Assume that the frequency of operation is 1 GHz. Also assume that the lossless transmission line being used for impedance matching is operating in the TEM-mode.

[2+8=10]

Q7. a) A tapered matching section has its profile dictated by $d\ ln\ (Z/\ Z0)\ /dz = Asin\ (\pi z/L)$. Calculate the constant A so that $Z(0) = Z0$ and $Z(L) = ZL$. L is the taper length, z is the variable

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co-ordinate along the length of the taper, Z (z) is the impedance at location z along the taper length, Z_L is the load impedance which needs to be matched to Z_o.

b) Consider a maximally-flat Low-Pass Filter whose 3-dB cutoff occurs at 900 MHz frequency. What would be the required order of the filter if, in the stop-band of the filter, it is necessary to have at least 15-dB attenuation at 1.1 GHz frequency?

[5+5=10]

Q8. a) Design a maximally-flat Low-Pass Filter with a 3-dB cutoff frequency of 2 GHz, impedance of 50 Ω, and at least 15 dB insertion loss at 3 GHz. Use the prototype beginning with a shunt element.

b) Design a 7-dB attenuator using balanced-T configuration. Assume that the input impedance and output impedance of the attenuator are 50 Ω each.

[5+5=10]

Q9. a) Name the five types of Microwave Resonators which are commonly being used nowadays.

b) Design a 3-dB quadrature hybrid coupler for operation at 2400 MHz. Use microstrip construction with RT/Duroid 5080 substrate material (thickness=60 mil, dielectric constant = 2.2).

c) Design a Wilkinson power divider for equal power division at 900 MHz. Use microstrip construction with RT/Duroid 5080 substrate material (thickness=10 mil, dielectric constant = 2.2).

[2+4+4=10]

Q10. a) Name at least ten components used in building microwave transmitters and receivers.

b) How is designing a Low Noise Amplifier (LNA) different from designing a High Power Amplifier (HPA)?

c) How does a Vector Network Analyzer (VNA) exploit the properties of a Directional Coupler, to measure S parameters?

d) What are the three main methods of measuring power at microwave frequencies?

e) A microwave HPA is being fed with -10 dBm power (as measured using a Directional Coupler plus Input Power Meter combination). The output power is measured through a 30-dB attenuator whose output is fed to the Output Power Meter. If the reading on the Output Power Meter is +31.76 dBm, calculate the gain of the HPA.

f) If the SNR at the input of a LNA is 10 dB and that at its output is 7 dB, what is the Noise Figure (NF) of the LNA? Which instrument would you use to measure Noise Figure?

g) What is the main purpose of using Spectrum Analyzer in a microwave lab?

h) Design a rat-race coupler for operation at 900 MHz. Use microstrip construction with RT/Duroid 5080 substrate material (thickness=10 mil, dielectric constant = 2.2). **[1+1+1+1+1+1+1+3=10]**

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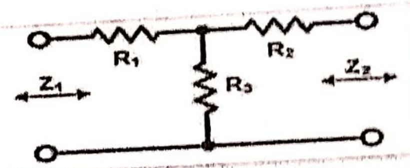
Formula Sheet



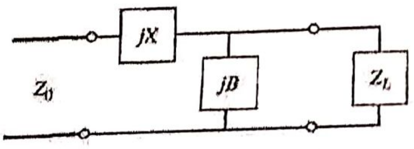
Balanced Tee (T) Attenuator

$$R_1 = \frac{Z_1 \cdot (k+1) - 2 \cdot \sqrt{k \cdot Z_1 \cdot Z_2}}{k-1} \; [\Omega]$$

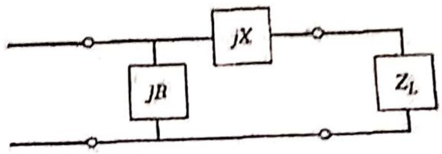
$$R_2 = \frac{Z_2 \cdot (k+1) - 2 \cdot \sqrt{k \cdot Z_1 \cdot Z_2}}{k-1} \; [\Omega]$$

$$R_3 = \frac{2 \cdot \sqrt{k \cdot Z_1 \cdot Z_2}}{k-1} \; [\Omega]$$

$$\Gamma(\theta) = \frac{1}{2}\int_{z=0}^{L} e^{-2j\beta z}\frac{d}{dz}\ln\left(\frac{Z}{Z_0}\right)dz.$$



Network for z_L inside the 1+jx circle



Network for z_L outside the 1+jx circle

z_L/z_0

$$Z_0 = jX + \frac{1}{jB + 1/(R_L + jX_L)}$$

$$B(XR_L - X_L Z_0) = R_L - Z_0$$

$$X(1 - BX_L) = BZ_0 R_L - X_L$$

$$B = \frac{X_L \pm \sqrt{R_L/Z_0}\sqrt{R_L^2 + X_L^2 - Z_0 R_L}}{R_L^2 + X_L^2}$$

$$X = \frac{1}{B} + \frac{X_L Z_0}{R_L} - \frac{Z_0}{BR_L}$$

$$\frac{1}{Z_0} = jB + \frac{1}{R_L + j(X + X_L)}$$

$$BZ_0(X + X_L) = Z_0 - R_L$$

$$(X + X_L) = BZ_0 R_L$$

$$X = \pm\sqrt{R_L(Z_0 - R_L)} - X_L$$

$$B = \pm\frac{\sqrt{(Z_0 - R_L)/R_L}}{Z_0}$$

Positive X implies an inductor and negative X implies a capacitor
Positive B implies an capacitor and negative B implies a inductor

$$\epsilon_e = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2}\frac{1}{\sqrt{1 + 12d/W}}$$

$$Z_0 = \begin{cases} \frac{60}{\sqrt{\epsilon_e}}\ln\left(\frac{8d}{W} + \frac{W}{4d}\right) & \text{for } W/d \le 1 \\ \frac{120\pi}{\sqrt{\epsilon_e}\,[W/d + 1.393 + 0.667\ln(W/d + 1.444)]} & \text{for } W/d \ge 1 \end{cases}$$

$$\frac{W}{d} = \begin{cases} \frac{8e^A}{e^{2A} - 2} & \text{for } W/d \le 2 \\ \frac{2}{\pi}\left[B - 1 - \ln(2B - 1) + \frac{\epsilon_r - 1}{2\epsilon_r}\left(\ln(B-1) + 0.39 - \frac{0.61}{\epsilon_r}\right)\right] & \text{for } W/d \ge 2 \end{cases}$$

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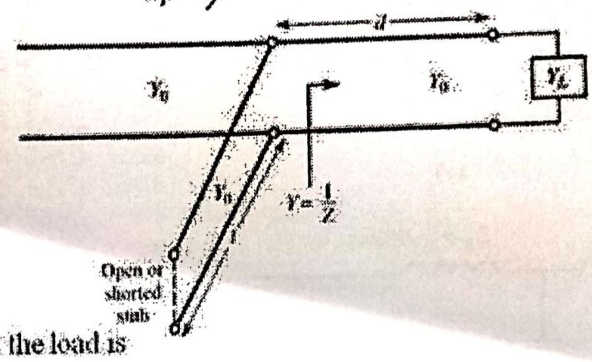
$$A = \frac{Z_0}{60}\sqrt{\frac{\epsilon_r + 1}{2}} + \frac{\epsilon_r - 1}{\epsilon_r + 1}\left(0.23 + \frac{0.11}{\epsilon_r}\right) \qquad B = \frac{377\pi}{2Z_0\sqrt{\epsilon_r}}$$



Shunt Stub

Load impedance $Z_L = \frac{1}{Y_L} = R_L + jX_L$

The impedance Z down a length d from the load is

$$Z = Z_0\frac{(R_L + jX_L) + jZ_0 t}{Z_0 + j(R_L + jX_L)t}, \text{ where } t = \tan\beta d$$

$$Y = \frac{1}{Z} = G + jB$$

$$G = \frac{R_L(1+t^2)}{R_L^2 + (X_L + Z_0 t)^2} \qquad B = \frac{R_L^2 t - (Z_0 - X_L t)(X_L + Z_0 t)}{Z_0[R_L^2 + (X_L + Z_0 t)^2]}$$

d is chosen to satisfy $G = Y_0 = 1/Z_0$

$$\Rightarrow \quad t = \begin{cases} \dfrac{X_L \pm \sqrt{R_L[(Z_0 - R_L)^2 + X_L^2]/Z_0}}{R_L - Z_0}, & R_L \neq Z_0 \\[2ex] \dfrac{-X_L}{2Z_0}, & R_L = Z_0 \end{cases}$$