

MICROWAVE ENGINEERING
(ECEN 3103)

Time Allotted : 2½ hrs

Full Marks : 60

Figures out of the right margin indicate full marks.

*Candidates are required to answer Group A and
any 4 (four) from Group B to E, taking one from each group.*

Candidates are required to give answer in their own words as far as practicable.

Group – A

1. Answer any twelve:

12 × 1 = 12

Choose the correct alternative for the following

- (i) A waveguide is a
 - (a) band pass filter
 - (b) high pass filter
 - (c) band stop filter
 - (d) low pass filter.
- (ii) In TE₁₀ mode of wave propagation in a rectangular waveguide, if the larger dimension of the waveguide is 2 cm, then the cut off wavelength for that mode is
 - (a) 40 cm
 - (b) 0.4 cm
 - (c) 4 cm
 - (d) 4 mm.
- (iii) If the reflection coefficient of a 2 port network is 0.5 then the return network loss in the network is
 - (a) 6.5 Db
 - (b) 0.15 dB
 - (c) 6.020 dB
 - (d) 10 dB.
- (iv) S parameters are expressed as a ratio of
 - (a) voltage and current
 - (b) impedance at different ports
 - (c) incident and the reflected voltage waves
 - (d) None of the mentioned.
- (v) A major disadvantage of klystron amplifier is
 - (a) low power gain
 - (b) low bandwidth
 - (c) high source power
 - (d) design complexity.
- (vi) Number of cavity in reflex klystron
 - (a) 2
 - (b) 4
 - (c) 1
 - (d) 3
- (vii) The total length of a rat-race junction is
 - (a) $31\lambda g/2$
 - (b) $31\lambda g/4$
 - (c) $2\lambda g/3$
 - (d) $1\lambda g/2$.
- (viii) For a two-port network the voltage reflection coefficient seen looking towards the load, Γ_S is
 - (a) $(Z_S - Z_0) / (Z_S + Z_0)$
 - (b) $(Z_S + Z_0) / (Z_S - Z_0)$
 - (c) $Z_S / (Z_S - Z_0)$
 - (d) $Z_0 / (Z_S - Z_0)$.

- (ix) The power loss of a maximally flat low-pass filter can be expressed as
 (a) $1 + \epsilon^2 \left(\frac{\omega}{\omega_c}\right)^{2N}$ (b) $1 + \epsilon^2 \left(\frac{\omega}{\omega_c}\right)^2$
 (c) $1 - \epsilon^2 \left(\frac{\omega}{\omega_c}\right)^{2N}$ (d) $1 + \epsilon^2 \left(\frac{\omega_c}{\omega}\right)^{2N}$.
- (x) The power gain of a two-port transducer network depends on
 (a) Independent of both the impedances (b) Z_s
 (c) Z_L and Z_s (d) Z_L .

Fill in the blanks with the correct word

- (xi) Ferrite isolators are ____ port microwave devices.
- (xii) For lossless propagation of EM waves through an unbounded dielectric, the propagation constant is ____.
- (xiii) With an increase in the operating frequency of a micro strip line, the effective dielectric constant of a microstrip line: _____.
- (xiv) The mode of propagation in a microstrip line is _____.
- (xv) A magic T-junction is a combination of _____.

Group - B

2. (a) Derive the expressions of field components due to TE mode in a rectangular waveguide. [[CO1](Analyse/IOCQ)]
 (b) Calculate the cut-off frequency of the following modes in a square waveguide 4 cm × 4 cm TE₁₀, TM₁₁ and TE₂₂. [[CO1](Analyse/IOCQ)]

7 + 5 = 12

3. (a) Prove that the group velocity (u_g) is related to the phase velocity (u_p) of the wave propagation by

$$u_p u_g = u^2$$

where u is the medium velocity—i.e., the velocity of the wave in the dielectric medium unbounded by the guide. [[CO1](Analyse/IOCQ)]

- (b) Evaluate and draw the surface current for dominant mode. [[CO1](Apply/HOCQ)]
 (c) An air-filled rectangular waveguide has cross-sectional dimensions $a = 6$ cm and $b = 3$ cm. Given that

$$E_z = 5 \sin \frac{2\pi x}{a} \sin \frac{3\pi y}{b} \cos(10^{12}t - \beta z) \text{ V/m}$$

Determine the mode of propagation and cut off frequency. Also find the intrinsic impedance. [[CO1](Apply/IOCQ)]

3 + 4 + 5 = 12

Group - C

4. (a) Explain following terms (a) E-plane Tee (b) H-plane Tee (c) Magic Tee. [[CO2](Remember/LOCQ)]

- (b) Draw a typical directional coupler and define directivity and coupling coefficient. [[CO2](Remember/LOCQ)]
6 + 6 = 12
5. (a) Explain that a three-port network cannot be simultaneously reciprocal, lossless and matched at all ports. [[CO3](Understand/LOCQ)]
- (b) A two-port network has the following S-Matrix
- $$\begin{bmatrix} 0.1\angle 0^\circ & 0.8\angle -45^\circ \\ 0.8\angle 45^\circ & 0.2\angle 0^\circ \end{bmatrix}$$
- (i) Determine whether the network is reciprocal or not.
- (ii) Determine whether the network is lossless or not.
- (iii) If port 1 is terminated with an open load, calculate the return loss at the port 2.
- (iv) If the port 2 is terminated with matched load, calculate the return loss at port 1. [[CO3](Analyse/IOCQ)]
6 + 6 = 12

Group - D

6. (a) Describe with a neat sketch the constructional details and principle of operation of a reflex klystron tube. [[CO4](Remember/LOCQ)]
- (b) Explain velocity modulation principle. [[CO4](Remember/LOCQ)]
8 + 4 = 12
7. (a) Discuss a cross field device used to generate high power in microwave frequency. [[CO4](Remember/LOCQ)]
- (b) Discuss Gunn oscillation mechanism in details. [[CO4](Remember/LOCQ)]
7 + 5 = 12

Group - E

8. (a) Design a low pass filter with cut off frequency of 200 MHz and attenuation of 50 dB at 250 MHz. The flatness of the filter response is not a design consideration. Design a filter that requires the least number of components. [[CO6](Create/HOCQ)]
- (b) Differentiate between Butterworth filter and Chebyshev filter. [[CO5](Analyse/IOCQ)]
9 + 3 = 12
9. (a) Define available power gain in a two-port amplifier operating in microwave frequency. [[CO5](Remember/HOCQ)]
- (b) Derive the expression of available power gain in a two-port amplifier operating in microwave frequency. [[CO5](Remember/LOCQ)]
3 + 9 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	53.13	30.21	16.67

