

**RF & MICROWAVE ENGINEERING
(ECEN 4101)**

Time Allotted : 3 hrs

Full Marks : 70

Figures out of the right margin indicate full marks.

*Candidates are required to answer Group A and
any 5 (five) from Group B to E, taking at least one from each group.*

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

**Group - A
(Multiple Choice Type Questions)**

1. Choose the correct alternative for the following: **10 × 1 = 10**
- (i) A TE₁₀ rectangular waveguide is to be designed for operation over 25-35 GHz and the band centre is 1.5 times the cutoff frequency. The dimension of broad side is
 (a) 15 mm (b) 10 mm
 (c) 9 mm (d) 7.5 mm.
- (ii) The Q factor measures
 (a) frequency selectivity (b) insertion loss
 (c) impedance bandwidth (d) electromagnetic coupling.
- (iii) Assertion (A): TWT uses a focusing mechanism to prevent the electron beam from spreading.
 Reason (R): In a TWT the electron beam has to travel a much longer distance than in Klystron.
 (a) Both A and R are correct but R is not correct explanation of A
 (b) Both A and R are correct and R is correct explanation of A
 (c) A is wrong but R is correct
 (d) A is correct but R is wrong.
- (iv) Phase velocity (v_p) in a rectangular waveguide
 (a) $>c$ (b) $<c$
 (c) $=c$ (d) 0.8 m/s.
 c =velocity of light
- (v) Spacing between holes in a two hole directional coupler is
 (a) $\lambda_g/4$ (b) $\lambda_g/32$
 (c) $\lambda_g/12$ (d) $\lambda_g/16$.
- (vi) Magic Tee is a
 (a) 2 port network (b) 3 port network
 (c) 5 port network (d) 4 port network.

- (vii) An evanescent mode occurs when
 (a) a wave is attenuated rather than propagate
 (b) the propagation constant is purely imaginary
 (c) $m=n=0$, so all field components are vanished
 (d) the wave frequency is same as cut off frequency.
- (viii) In a Klystron, velocity modulation takes place in the
 (a) drift tube (b) collector
 (c) catcher cavity resonator (d) input cavity resonator.
- (ix) Which of the following is used for its negative resistance characteristics?
 (a) Point-contact diode (b) Schottky diode
 (c) IMPATT diode (d) Varactor diode.
- (x) To make a device unconditionally stable, stability circles must be
 (a) completely outside of Smith Chart
 (b) totally within the Smith Chart
 (c) completely outside or inside Smith Chart
 (d) partly outside or inside Smith Chart.

Group - B

2. (a) Draw field configuration for TE₁₁ mode.
 (b) Find out total average power transmitted across the cross section of a rectangular waveguide for TE₁₀ mode.
 (c) An air field rectangular waveguide operates at 40 GHz. If the cut-off frequency of TE₁₂ mode is 25 GHz, calculate the wavelength, phase constant, phase velocity and intrinsic impedance of this mode.
- 3 + 4 + 5 = 12**
3. (a) What is meant by the quality factor of a cavity resonator? Show that unloaded, loaded and external Q of a cavity are related by the equation

$$\frac{1}{Q_{Loaded}} = \frac{1}{Q_{Unloaded}} + \frac{1}{Q_{External}}$$
- (b) Determine the length of a rectangular waveguide cavity that will operate at 10 GHz in the TE₁₀₁ mode, provided, $a = 22.86$ mm and $b = 10.16$ mm. Calculate the Q of the cavity if it is made of copper. The conductivity of copper is $\sigma = 5.8 \times 10^7$ S/m.

6 + 6 = 12

Group - C

4. (a) Derive the S matrix for symmetrical directional coupler.

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6 + 6 = 12

Group - C

4. (a) Derive the S matrix for symmetrical directional coupler.

- (b) A directional coupler of 10 dB coupling and 40 dB directivity produces a transmission loss of 1 dB. For an input power of 10 mW at the input port of main arm, determine the power at the other ports when matched terminated.

7 + 5 = 12

5. (a) Propose an experimental setup through which Directional Coupler can be characterized.
- (b) What do you mean by impedance matching? Why impedance matching is necessary? Design an impedance matching network using quarter wave transmission line.

4 + 8 = 12

Group - D

6. (a) Define following filter parameters: (i) Insertion Loss (ii) Return Loss and (iii) Group delay. Briefly explain their physical significance.
- (b) Design a maximally flat low pass composite filter with a cut-off frequency 5 GHz, impedance 50 Ω and 15 dB insertion loss at 7 GHz.

5 + 7 = 12

7. (a) Describe working principle of a Magnetron oscillator with a proper diagram.
- (b) A two cavity Klystron operates at 5GHz with a dc beam voltage of 10 KV and 2 mm cavity gap. For a given input RF voltage, the magnitude of the gap voltage is 100 V. Calculate the transit time, the transit angle at the cavity gap and the velocity of the electron leaving the gap.

7 + 5 = 12

Group - E

8. (a) What is Gunn effect? Describe the RWH theory to explain Gunn effect.
- (b) Perform small signal analysis of MESFET. Based on analysis results comment on its characteristics.

6 + 6 = 12

9. (a) Illustrate and describe the operating principle of Travelling Wave Tube.
- (b) "Reflex Klystron is a velocity modulated device"- justify the statement with relevant (i) illustration (ii) mathematical expressions and (iii) explanations.

6 + 6 = 12