

MICROWAVE ENGINEERING
(ECEN 3103)

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) The dominant TM mode in a rectangular waveguide is
(a) TM_{21} (b) TM_{12} (c) TM_{11} (d) TM_{32} .
 - (ii) In certain applications, circular waveguides are preferred to rectangular waveguides because of
(a) lower attenuation (b) small cross section
(c) freedom of spurious mode (d) none of these.
 - (iii) In microwave frequencies, a cavity may be considered as a
(a) low-pass filter (b) band-pass filter
(c) high-pass filter (d) band-stop filter.
 - (iv) If only the position of the port of a network is changed, then its scattering parameter undergoes a
(a) Change in magnitude
(b) Change in the phase
(c) Change in both magnitude and phase
(d) No change.
 - (v) The total length of a rat-race junction is
(a) $3\lambda_g/2$ (b) $3\lambda_g/4$ (c) $2\lambda_g/3$ (d) $\lambda_g/2$.

- (vi) For S matrix to be unitary, the circuit should be
(a) reciprocal (b) lossless
(c) matched (d) none of the above.
- (vii) If the reflection coefficient of a 2 port network is 0.25 then the return network loss in the network is
(a) 12.05 dB (b) 0.15Db (c) 20dB (d)10dB.
- (viii) Ferrite isolators are ___ port microwave devices.
(a) Two (b)Three (c) Four (d) both (a) and (b).
- (ix) Transducer power gain of a two port network is dependent on:
(a) Z_S and Z_L (b) Z_S
(c) Z_L (d) Independent of both the impedances.
- (x) One of the reasons why vacuum tubes eventually fail at microwave frequencies is that their
(a) noise figure increases
(b) transit time becomes too short
(c) shunt capacitive reactance become too large
(d) series inductive reactance become too small

Group - B

2. (a) A rectangular waveguide has width $a = 22.86$ mm and height $b = 10.16$ mm.
(i) Calculate the cut-off frequency and cut-off wavelength of the first four modes.
(ii) If the waveguide is operated at a frequency of 20 GHz, then identify the propagating modes. In addition, determine the degenerate modes.
- (b) For a rectangular waveguide, prove that $\frac{1}{\lambda_g^2} = \frac{1}{\lambda^2} - \frac{1}{\lambda_c^2}$.
6 + 6 = 12
3. (a) Find the expression for average power for dominant mode inside an air filled rectangular waveguide.
(b) Prove that $\frac{1}{Q_L} = \frac{1}{Q_0} + \frac{1}{Q_{ext}}$
 Q_L, Q_0, Q_{ext} are loaded, unloaded and external Q factor for cavity resonator.
(c) What do mean by degenerate mode of a rectangular waveguide?
6 + 4 + 2 = 12

Group - C

4. (a) Prove that for a reciprocal lossless N port network, the impedance matrix is purely imaginary.

(b) Describe the operating principle of a rat race coupler.

5 + 7 = 12

5. (a) Derive the S matrix for symmetric directional coupler.

(b) 'A three port network cannot be simultaneously lossless, reciprocal and matched at all ports'- Give a justification of the statement.

8 + 4 = 12

Group - D

6. (a) Explain the amplification procedure for Travelling wave Tube device with a suitable diagram.

(b) Explain oscillation mechanism of a Gunn diode.

6 + 6 = 12

7. (a) Describe the design procedure of a single-stage transistor amplifier for maximum gain.

(b) Explain the working principle of reflex klystron as an amplifier with a suitable diagram.

6 + 6 = 12

Group - E

8. (a) Describe the operating principle of a TRAPATT diode.

(b) Explain the operating principle of GaAs/Si HEMT. Briefly describe small signal model of GaAs/Si HEMT.

6 + 6 = 12

9. (a) Design a prototype for low pass Butterworth filter of the order $N=5$. The cut off frequency is 5GHz and the input resistance $R_0= 20 \Omega$.

The filter parameters are given as

$g_0=0.6180, g_1= 1.6180, g_2 =2.000, g_3=1.6180, g_4= 0.6180, g_5= 1.000$.

(b) What do you mean by conditional stability of an amplifier?

10 + 2 = 12

| Department & Section | Submission Link |
|----------------------|---|
| ECE A | https://classroom.google.com/w/MTQzNjQ1NDY0OTUx/tc/MjY1MTg2MTk0OTk3 |
| ECE B | https://classroom.google.com/u/1/w/MjE2NjIwODc1MjI5/tc/Mjc0NzlwMjk3MTY0 |
| ECE C | https://classroom.google.com/w/MTE4NDk5ODAwODA1/tc/MjY0OTkyNjgxNDE1 |