

**M.TECH/ECE/1<sup>st</sup> SEM/ECEN 5103/2017**  
**ADVANCED MICROWAVE COMMUNICATION**  
**(ECEN 5103)**

**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) Travelling wave tubes are preferred in radar applications over magnetrons because they have
- (a) wider bandwidth  
(b) greater efficiency  
(c) lower noise  
(d) capacity to generate larger duty cycle.
- (ii) Which of the following microwave tubes uses an axial magnetic field and a radial electric field?
- (a) klystron amplifier  
(b) travelling wave tube  
(c) reflex klystron  
(d) magnetron.
- (iii) Insertion loss is defined by
- (a)  $IL = -20\log_{10} (1-|\Gamma|^2)$   
(b)  $IL = -10\log_{10} (1-|\Gamma|^2)$   
(c)  $IL = -10\log_{10} |\Gamma|$   
(d)  $IL = -10\log_{10} (1+|\Gamma|^2)$ .
- (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 phase  
(c) change in both magnitude and phase  
(d) no change.
- (v) The performance of an antenna is independent of frequency if the antenna geometry or profile can be completely specified in terms of angles. This is known as :
- (a) babinet's principle  
(b) rumsey's principle  
(c) booker's principle  
(d) fermat's principle.

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- (vi) The directivity of N-element broadside linear uniform array is inversely proportional to:
- (a) inter element spacing (d)  
(b) number of elements (N)  
(c) wavelength ( $\lambda$ )  
(d) array Length (L).
- (vii) Radiation resistance of an antenna depends upon:
- (a) operating wavelength  
(b) operating frequency  
(c) input power  
(d) none of these.
- (viii) If the angle between the two arms of a simple dipole is reduced from  $180^\circ$  to  $90^\circ$ . What happens to its radiation resistance
- (a) increases  
(b) decreases  
(c) remains the same  
(d) increases then decreases.
- (ix) The skip distance is
- (a) same for each layer  
(b) independent of the state of ionization  
(c) independent of frequency  
(d) independent of transmitted power.
- (x) In microwave communication links, path diversity and frequency diversity are adopted to overcome fading in the path due to
- (a) rain attenuation  
(b) polarization shifting  
(c) phase lagging  
(d) fog accumulation.

**Group - B**

2. (a) With suitable figure, describe the operating principle of a tunnel diode.
- (b) A shunt-mounted PIN diode in a TEM transmission line having characteristic impedance  $Z_0 = 50$  ohms can be represented by a shunt impedance  $Z = R + jX$ . Calculate the insertion loss and isolation at a frequency  $f_0 = 2$  GHz. The forward resistance  $R_f = 0.1 \Omega$  and capacitance  $C_j = 0.02$  pF.
- (c) Derive an expression for the junction capacitance of varactor diode.
- 4 + 4 + 4 = 12**
3. (a) Discuss why compound semiconductor MESFETs are preferred over Si MESFETs.
- (b) With the help of the small signal equivalent circuit of a MESFET explain qualitatively why they are useful in microwave applications compared to conventional JFET.

- (c) A GaAs MESFET has the following parameters :  
 $R_g = 2.8\Omega$ ;  $R_i = 2.45\Omega$ ;  $R_d = 500\Omega$ ;  $R_s = 2.45\Omega$ ;  $g_m = 54\text{mS}$  and  $C_{gs} = 0.5\text{pF}$   
 Calculate the cut-off frequency and the maximum operating frequency.  
**2 + 6 + (2 + 2) = 12**

**Group - C**

4. (a) A series reactance  $Z = jX$  is connected between two lines with different characteristic impedances  $Z_1$  and  $Z_2$ . Find the S-matrix of the junction.  
 (b) A rectangular waveguide resonator of cross-sectional dimensions  $2.3\text{ cm} \times 1\text{ cm}$  is filled with air. What should be the length of the resonator for  $\text{TE}_{101}$  mode resonance at 10 GHz? What is the next higher mode of resonance and the corresponding resonant frequency?  
**5 + 7 = 12**
5. (a) How can the low pass filter design procedure be used to design high pass, band pass and band stop filters?  
 (b) Design a two section air filled coaxial line binomial transformer to match the original line of characteristic impedance  $50\ \Omega$  to a  $100\ \Omega$  load. What bandwidth is obtained for  $\Gamma_m = 0.1$  for matching at 10 GHz?  
**6 + 6 = 12**

**Group - D**

6. (a) Explain the radiation mechanism of a rectangular microstrip patch antenna.  
 (b) A very thin half-wavelength slot is cut on an infinite, planar, very thin, perfectly conducting electric screen. Find its input impedance. (Assume it is radiating into free-space).  
**8 + 4 = 12**
7. (a) Explain the concept of pattern multiplication in linear antenna array using suitable pictorial representation.  
 (b) Explain the concept of separable excitation associated with planar array with rectangular grid.  
 (c) A uniform linear array is operating at 6 GHz and required to produce an end fire beam. If the array consists of 10 identical elements with an inter-element spacing of  $0.5\ \lambda$ , find out the progressive phase and array length.  
**3 + 5 + 4 = 12**

**Group - E**

8. (a) Derive the link budget equation for a microwave communication system.  
 (b) List a few common types of fading experienced in space wave communication. Provide a discussion on the causes of fading along with their possible mitigation techniques.  
**4 + 8 = 12**
9. (a) Calculate the value of frequency at which electro magnetic wave must propagate through E region with index of 0.6 and electron density of  $4.23 \times 10^4$  electron/ $\text{m}^3$ .  
 (b) Prove that line of sight distance is given by  $d = 3.75 (\sqrt{h_t} + \sqrt{h_r})$ .  
**4 + 8 = 12**