Name : .....

Roll No. : .....

Invigilator's Signature : .....

CS/M.Tech(ECE)/SEM-1/MEC-1003/2009-10

2009

MICROWAVE AND MILLIMETER WAVE DEVICES & SYSTEMS

Time Allotted : 3 Hours | Full Marks : 70

The figures in the margin indicate full marks.

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

Answer questions 1 and any *four* from the rest.

1. Choose the correct answers for *all* of the following : $5 \times 2 = 10$

   i) The Smith chart is a complex plane representing complex of

      a) Load Impedance $z = r + jx$

      b) Reflection coefficient $\Gamma = |\Gamma| \angle \theta$

      c) Admittanc $y = g + j\,b$

      d) None of these.

ii) Scattering matrix characterizes a microwave network by relating

a) Terminal voltages and currents at specified reference planes

b) Power levels at diffierent ports

c) Incident and reflected signals normalized at terminal ports

d) Electric and magnetic fields at flanges of the ports of the network.

iii) The effective dielectric constant, ε_e of a micro-strip line having substrate thickness, h and strip width, W is

a) $\varepsilon_r \left(\frac{10h}{W} \right)^{1/2}$

b) $1/\varepsilon_r \left(1 + \frac{10h}{W} \right)^{1/2}$

c) $\frac{\varepsilon_r - 1}{2} + \frac{\varepsilon_r + 1}{2} \left(1 + \frac{10h}{W} \right)^{-1/2}$

d) $\frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2} \left(1 + \frac{10h}{W} \right)^{-1/2}$.

iv) In a hollow rectangular weveguide, the phase velocity in non-dispersive region of the frequency band

a) increases with increasing frequency

b) decreases with increasing frequency

c) is independent of frequency

d) depends on frequency band being used.

v) The atmospheric attenuation of the transmitted RF signal at millimetre-wave range varies with height, h. It

a) increases with h

b) decreases with h

c) remains constant with h

d) none of these.

2. a) Establish that the propagation constant of a lossless rectangular waveguide is a function of signal frequency. With the help of diagram, show how propagation constant depends on frequency. 5 + 2

b) Draw the $\omega - \beta$ plot of a rectangular waveguide. Show how the diagram can be used to determine the phase velocity and group velocity within the waveguide. 5

c) Explain why the recommeded range for *x*-band frequency does not include the frequencies closed to its cut-off frequency. 3

3. a) Give a neat sketch of the transvers section of a micro-strip line. Show therein the eletric field lines and magnetic field lines distribution. 4

b) Explain the concept behind the term *Effective Dielectric Constant* in respect of a microstrip lines. 4

c) Obtain the values of strip width and the length of microstrip line having a characteristic impedance of 50 Ω and a phase shift of 90° at 6 GHz. Given that the substrate thickness, h = 1·03 cm and the relative dielectric constant, ε_r = 2·5. Assume a non-magnetic substrate. 7

4. a) Define the transmission matrix of a two-port network in terms of input-output normalized incident & scattlered signals. 2

b) When two two-port networks are connected in cascade, obtain the overall scattering matrix of the combination in terms of scattering matrices of the individual. 6

c) The scattering matrix of a two-port network is given by

$$\begin{bmatrix} 0 & 0{\cdot}2 + j\,0{\cdot}3 \\ 0{\cdot}2 + j\,0{\cdot}3 & 0 \end{bmatrix}$$

Find the distance to which the reference plane of port 1 will be shifted so that S_{12} and S_{21} will be real numbers. It is given that $\beta = 34{\cdot}3$ radian/metre. 7

5. a) For a reflex klystron oscillator, establish the relatioship between the repeller voltage and mode number for a given beam voltage V_0 . 5

b) Explain with diagram, the construction and principle of working of a two cavity klystron amplifier. Explain the process of bunching using an "Applegate diagram". 6

c) A helix travelling wave tube operates at 4 GHz under a beam voltage, V_0 = 4 kV and a beam current I_0 = 20 mA. If the helix impedance Z_0 is 100 Ω and the circuit length N = 30, find the output power gain. 4

6. a) With the help of neat diagram, explain the operation of vane type variable attenuator. Give the merits and demerits of the passive component in comparison with a cut-off attenuator. 6

b) Give a precise diagram of a two-hole directional coupler and describe the working principle justifying its directional coupling process. Define and explain what is meant by the terms :

i) Coupling coefficient

ii) Directivity

iii) Isolation. 9

7. Write short notes on any *three* of the following : 3 × 5

a) Microstrip antennas

b) Millimetre wave radar

c) Magic Tee

d) IMPATT Devices

e) Design considerations of BWO for millimetre range

f) Multipath fading.