



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 × 2 = 10

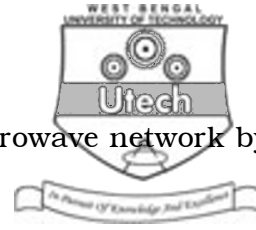
i) The Smith chart is a complex plane representing complex of

a) Load Impedance $z = r + jx$

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

c) Admittance $y = g + jb$

d) None of these.

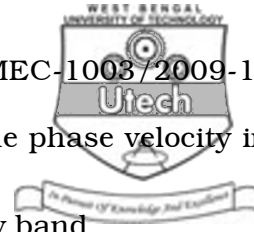


ii) Scattering matrix characterizes a microwave network by relating

- a) Terminal voltages and currents at specified reference planes
- b) Power levels at different 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) $\epsilon_r \left(\frac{10h}{W} \right)^{1/2}$
- b) $1/\epsilon_r \left(1 + \frac{10h}{W} \right)^{1/2}$
- c) $\frac{\epsilon_r - 1}{2} + \frac{\epsilon_r + 1}{2} \left(1 + \frac{10h}{W} \right)^{-1/2}$
- d) $\frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2} \left(1 + \frac{10h}{W} \right)^{-1/2}$.

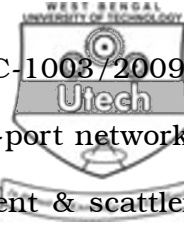


iv) In a hollow rectangular waveguide, the phase velocity in non-dispersive region of the frequency band

- 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 recommended range for x-band frequency does not include the frequencies close to its cut-off frequency. 3
3. a) Give a neat sketch of the transvers section of a micro-strip line. Show therein the electric 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 50Ω and a phase shift of 90° at 6 GHz. Given that the substrate thickness, $h = 1.03$ cm and the relative dielectric constant, $\epsilon_r = 2.5$. Assume a non-magnetic substrate. 7



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

$$\begin{bmatrix} 0 & 0.2 + j 0.3 \\ 0.2 + j 0.3 & 0 \end{bmatrix}$$

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 $\beta = 34.3$ radian/metre. 7

5. a) For a reflex klystron oscillator, establish the relationship 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 100Ω 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.
-