Name : .....

Roll No. : .....

Invigilator's Signature : .....

CS/M.Tech(ECE)/SEM-1/MCE-104/2010-11

2010-11

ADVANCED MICROWAVE COMMUNICATION ENGINEERING

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 Question No. 1 and any *four* from the rest.

1. Choose the correct alternatives for the following with a brief justification : $7 \times 2 = 14$

   i) In an ideal magic tee, port numbers 1 and 2 represent collinear arms, 3 and 4 represent *E*-arm and *H*-arm respectively. Some of the conditions relating to the coefficients of scattering matrix of tee are given below :

      I. $S_{13} = S_{23}$

      II. $S_{14} = S_{24}$

      III. $S_{12} = 0$

      IV. $S_{34} = 0$.

   Of these :

   a) I, II and III are correct

   b) I, II and IV are correct

   c) II, III and IV are correct

   d) I, III and IV are correct.

ii) A ship-to-ship communication system is plagued due to fading of signal. The best method to combat the situation seems to be the use of

a) highly directional antennas

b) ultra wide-band antennas

c) frequency diversity

d) space diversity.

iii) If a wave of critical frequency 30 MHz is departing at an angle of 60°, then the MUF is given to be

a) 60 MHz b) 15 MHz

c) 10 MHz d) 30 MHz.

iv) The effective dielectric constant, ε_{eff} of a micro-strip line is equal to

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

v) The scattering matrix of a 3-port circulator with clock-wise rotation from port 1-2-3 is

a) $\begin{bmatrix} 0 & 0 & 1 \\ 1 & 0 & 0 \\ 0 & 1 & 0 \end{bmatrix}$

b) $\begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$

c) $\begin{bmatrix} 1 & 0 & 1 \\ 0 & 0 & 0 \\ 1 & 0 & 1 \end{bmatrix}$

d) $\begin{bmatrix} 1 & 1 & 1 \\ 1 & 0 & 1 \\ 1 & 1 & 1 \end{bmatrix}$

vi) A half wave dipole used at a frequency of 300 MHz has a length of

a) 10 metres b) 3 metres

c) 1 metre d) 50 cm.

vii) The gain of an isotropic antenna is

a) 3 dB b) 0 dB

c) 10 dB d) 90 dB.

2. a) Obtain the relations :

$T_{11} = 1 / S_{21}$, $T_{12} = -S_{22} / S_{21}$,

$T_{21} = S_{11} / S_{21}$ and $T_{22} = S_{12} - (S_{11} S_{22}) / S_{21}$.

where , T's and S's are the coefficients of T-matrix and S-matrix respectively of a microwave network. 7

b) Establish the condition that is a must to construct a three-port network, which is really lossless and reciprocal, yet that could be matched in all ports together. 7

3. a) Explain the working principle of Wilkinson power divider. Mention its merits and demerits as a device in the microwave circuits and systems. 5 + 2

b) Obtain the required length and impedance of a quarter-wave transformer that will match a 100 Ω load to a 50 Ω air-filled coaxial line at 10 GHz. 7

4. a) Define and explain what are meant by power gain and effective radiated power of an antenna. 7

b) A half-wave dipole antenna is capable of radiating 1 kW and has a power gain of 2·15 dB in respect of an isotropic antenna. Find out the amount of power required to be fed to the isotropic radiator to match the field strength of the half-wave dipole. 7

5. a) Develop the theory of coupled line using even-mode and odd-mode analysis for planar structures. 7

b) A 20 dB, single-section, coupled line directional coupler using strip-line is to be designed. Assume that a copper-clad substrate with 0·158 cm ground plane separation and $\varepsilon_r = 2{\cdot}56$, is available. The line of $Z_0 = 50\ \Omega$ is used and the operating centre frequency is 3 GHz. Calculate the coupling coefficient and the even-mode and odd-mode characteristic impedances. In obtaining the values of W/b and S/b, what steps one has to take ? If $W/b = 0{\cdot}72$ and $S/b = 0{\cdot}34$, find the width and the separation of the coupled lines. 4 + 2 + 1

6. a) Explain the working principle of Gunn oscillators. 3

b) State and explain what is meant by Tunnel diodes. What is the negative resistance that a tunnel diode provides ? Explain how this is useful in generating oscillations. 4

c) Discuss the principle of negative resistance in IMPATT diode. 4

d) A tunnel diode has the following characteristics : Negative resistance = 26 Ω, Series resistance = 1 Ω. Junction capacitance = 5 nF. Calculate : (i) resistive cut-off frequency and (ii) when the diode is used as amplifier with a load of 24 Ω in parallel the gain of the amplifier. 3

7. a) In connection with space wave propagation, explain what is meant by Radio Horizon. How does it differ from the Optical Horizon ? 4 + 3

b) A terrestrial microwave link consists of repeaters at 40 km intervals. Calculate the minimum heights of the transmitting and receiving antennas above ground level to ensure line-of-sight condition. Assume suitable data if required. 7

8. Write short notes on any *two* of the following : 2 × 7

a) Friis transmission formula

b) Effects of atmospheric precipitations of RF propagation

c) Duct propagation : its causes and significances in microwave propagation

d) Log-periodic wire antennas in UHF signals : its merits and demerits.