Name : .....

Roll No. : .....

Invigilator's Signature : .....

CS/M.Tech (ECE)/SEM-1/MCE-104/2012-13

2012
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. Answer any *seven* questions. $7 \times 2 = 14$

   a) Write down the frequency ranges of each of the bands : S, X, C, Ku, K, and Ka 2

   b) Write down the continuity equation in generalized curvilinear system of coordinates and interpret it in the cylindrical system of coordinates. 2

   c) What is AC or RF resistance of a conductor ? 2

   d) How do you choose the length of an open-ended waveguide so that it behaves as a cavity resonator ? 2

   e) What is Faraday rotation in ferrites ? Enumerate its applications in microwave engineering. 2

   f) Explain why a fast-wave tube have a larger size than a slow-wave tube. 2

g) Give a comparison between the different modes of operation of IMPATT devices. 2

h) Explain why a double-drift-region (DDR) IMPATT gives a higher DC-to-RF conversion efficiency than its single-drift region (SDR) counterpart. 2

i) How do you characterize a lossless junction in terms of a scattering matrix, its complex conjugate and unitary matrix ? 2

j) Why is short electric (Hertzian) dipole a poor radiator ? What is the half-power bandwidth of the dipole ? 2

k) Why half-wave dipole is called a resonant antenna ? 2

l) How should one choose the thickness of a radome ? 2

2. a) Describe the different parts of a gyrotron explaining their functions. What is the role of relativistic electron bunching in the device ? 4 + 3

b) Derive the dispersion relation of the fast cyclotron wave on an electron beam and hence plot the beam-mode dispersion line and locate the operating point of the gyrotron on the waveguide-mode dispersion hyperbola with appropriate justification. 3 + 2 + 2

3. a) Describe the Kidley-Watkins-Hilson theory with reference to the Gunn effect. 5

b) Based on this theory, enumerate the three necessary criteria that must be satisfied by the band structure of a semiconductor in order for the latter to exhibit a negative resistance. 3

c) Describe in brief the various modes of operation of a Gunn diode. 6

4. a) Sketch the different structures and associated doping and electric field profiles of IMAPTT devices. 4

   b) Describe the operating principle of the Read diode. 6

   c) Give a comparison between IMPATT, TRAPATT and BARITT devices. 4

5. a) Explain Richard's transformation to convert lumped elements to transmission line sections and Kuroda's identities to separate filter elements by using transmission line sections. 4 + 3

   b) What is Wilkinson's power divider and what is its advantage over its lossless counterpart ? Carry out the even-odd-mode analysis of the power divider to derive its S-matrix. 3 + 4

6. a) What is an array of antennas ? What are the benefits of an array in relation to a single antenna ? 4

   b) What is meant by 'similar' elements of an array ? 2

   c) What is the array factor of an array ? 2

   d) Consider an array of two half-wave dipoles (elements 1 and 2) spaced 'd' apart and excited with currents of the same amplitude I_0 but a relative phase 'x' such that $I_1 = I_0$ and $I_2 = I_0\, e^{ix}$, the subscripts 1 and 2 referring to the elements. Derive the array factor of the array taking the phase centre of the element 1 as the origin (phase reference). 6

7. a) What are 'normal mode' and 'axial mode' helical antennas ? 4

b) Explain why an open-ended rectangular or circular waveguide is flared out to produce a 'horn' radiator. 6

c) How is it ensured that the field distribution at the horn aperture is a near-replica of the transverse field distribution of the waveguide mode ? 4

8. a) Deduce a relation between the curvature of a ray refracting through the troposphere and the variation of the refractive index of the troposphere with height and hence explain the significance of the definition of the modified refractive index of the troposphere with height, explain how the range of propagation is extended through duct propagation. 3 + 2 + 2

b) Considering the collisional effects obtain the condition for the maximum conductivity of an ionospheric layer. Ignoring collisional effects appreciate that the ionosphere behaves as a high-pass waveguide with a cutoff frequency equal to the electron plasma frequency. Deducing the secant law, develop the concept of the MUF and the skip distance with reference to sky-wave propagation and discuss how to measure them.

3 + 2 + 2