JUNE 2008

Code: AE20 **Subject: MICROWAVE THEORY & TECHNIQUES**
Time: 3 Hours **Max. Marks: 100**

NOTE: There are 9 Questions in all.

- **Question 1 is compulsory and carries 20 marks. Answer to Q. 1. must be written in the space provided for it in the answer book supplied and nowhere else.**
- **Out of the remaining EIGHT Questions answer any FIVE Questions. Each question carries 16 marks.**
- **Any required data not explicitly given, may be suitably assumed and stated.**

Q.1 Choose the correct or best alternative in the following: (2x10)

a. Which one of the following is a transferred electron device?

(A) BARITT diode **(B)** IMPATT diode
(C) GUNN diode **(D)** Step recovery diode

b. Most commonly used radar antenna is

(A) Yagi antenna **(B)** Rhombic antenna
(C) Parabolic reflector **(D)** None of the above

c. One of the following loss is not present in microstrip lines

(A) conduction loss **(B)** radiation loss
(C) dielectric loss **(D)** resistive loss

d. The reflection coefficient (ρ), related with load impedance (Z_L) and characteristic impedance (Z_O), is given by the following expression

(A) $\rho = \frac{Z_L + Z_O}{Z_L - Z_O}$ **(B)** $\rho = \frac{Z_O - Z_L}{Z_O + Z_L}$

(C) $\rho = \frac{Z_L - Z_O}{Z_L + Z_O}$ **(D)** $\rho = \frac{Z_O + Z_L}{Z_O - Z_L}$

e. Microwave components are specified by

(A) z-parameters **(B)** y-parameters
(C) s-parameters **(D)** h-parameters

f. A tunnel diode is a

(A) heavily doped p-n junction diode.
(B) ordinarily doped p-n junction diode.
(C) one side highly doped and other side lowly doped.
(D) bulk semiconductor device.

g. Operation of one of the following is not based on Faraday rotation

(A) circulators **(B)** gyrator
(C) phase shifter **(D)** isolator

h. Scattering parameters can be measured by a

(A) CRO **(B)** network analyzer
(C) spectrum analyzer **(D)** reflecto meter

i. One of the following selection is not required for the selection of MIC

(A) selection of substrate material **(B)** selection of conductor material
(C) selection of dielectric film **(D)** selection of soldering material

j. If frequency is 3 GHz to 30 GHz, then wavelength is of the order of

(A) centimetre **(B)** metre
(C) kilometre **(D)** hectametre

Answer any FIVE Questions out of EIGHT Questions.
Each question carries 16 marks.

Q.2 a. The terminating load of UHF transmission line with characteristic impedance $Z_o = 50\Omega$, working at 300 MHz is $50 + j50\Omega$. Calculate the VSWR and reflection coefficient. **(4)**

b. What are standing waves? Define VSWR. Express VSWR in terms of reflection coefficient (ρ). What do VSWR = 1 and VSWR = ∞ signify, with reference to the matching of the transmission line with the load. **(6)**

c. State Maxwell's equations in integral and differential forms. **(6)**

Q.3 a. A lossless parallel stripline has a conducting stripwidth w. The substrate dielectric separating the two conducting strips has a relative dielectric constant ϵ_{rd} of 6 (beryllia or beryllium oxide BeO) and a thickness d of 4 mm. Calculate

(i) The required width w of the conducting strip in order to have a characteristic impedance of 50Ω.

(ii) The strip-line capacitance.

(iii) The strip-line inductance.

(iv) The phase velocity of the wave in the parallel strip line. **(6)**

b. Enumerate the advantages and disadvantages of MICs. **(4)**

c. List the basic properties provided by ideal conductor, dielectric, and resistive materials used in MMICS. **(6)**

Q.4 a. Define Faraday rotation. **(4)**

b. Write a short note on posts and tuning screws. **(6)**

c. Derive the scattering matrix of a magic tee. **(6)**

Q.5 a. Two identical directional couplers are used in a waveguide to sample the incident and reflected powers. The output of the two couplers is found to be 2.5 mw and 0.15 mw. Find the value of VSWR in the waveguide. **(4)**

b. Describe how can the power of a microwave generator be measured using Bolometer. **(6)**

c. Describe a technique of measuring the phase shift provided by network. **(6)**

Q.6 a. Briefly explain the construction and operation of microwave transistors. Discuss its performance parameter. List out its performance characteristics and discuss. **(10)**

b. A typical n-type GaAs Gunn diode has the following parameters:

Threshold field $E_v = 2800\,V/cm$ Doping concentration $n_o = 2\times10^{14}\,cm^{-3}$ Applied field $E = 3200\,V/cm$ Operating frequency f = 10GHz
Device length L = 10 μm

(i) Compute the electron drift velocity.
(ii) Calculate the current density.
(iii) Estimate the negative electron mobility. **(6)**

Q.7 a. Show that the free space path loss is given by
L_{dB} = (32.5 + 20 log d + 20 log f) dB where d is the separation between Transmitter and Receiver and f is the frequency of operation. **(6)**

b. Write a short note on lens antenna. **(6)**

c. Calculate the beamwidth between first nulls and the beamwidth between half power points of a 3 metre paraboloid used in the S band at 3 GHz. Also determine the gain of the antenna. **(4)**

Q.8 a. Compare the waveguides with 2-wire transmission lines. **(6)**

b. Justify that a TEM wave (Transverse electric and magnetic) cannot propagate in a single conductor hollow waveguide. **(4)**

c. Design a rectangular metal waveguide to carry only the TE_{10} mode at a frequency of 5000 MHz. **(6)**

Q.9 a. By carrying out detailed mathematical analysis for reflex Klystron, obtain the expression for maximum power output. **(10)**

b. A reflex Klystron operates at the peak mode of n = 2 with beam voltage $V_o = 300V$. Beam current

I_0 = 20 mA, signal voltage $V_1 = 40V$. Determine

(i) the input power in watts

(ii) o/p power in watts

(iii) efficiency **(6)**