AMIETE – ET (NEW SCHEME) - Code: AE72

Subject: MICROWAVE THEORY AND TECHNIQUES

JUNE 2010

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 the best alternative in the following: **(2×10)**

a. If the spacing between the transmission lines is smaller than the wavelength of the transmitted signal, the transmission line must be analysed as_____.

(A) a coaxial transmission line **(B)** a waveguide
(C) a twisted pair **(D)** a two open wire line

b. In a standing wave pattern of the voltage wave, the distance between any two successive maxima of minima is_____.

(A) one wavelength **(B)** one fourth wavelength
(C) one half wavelength **(D)** n wavelength

c. The dominant mode in a particular wave guide is the mode having _____ cut-off frequency.

(A) lowest **(B)** low
(C) high **(D)** highest

d. The tunnel diode is a _____ resistance semiconductor p-n junction diode.

(A) nil **(B)** positive
(C) negative **(D)** high resistance

e. A parametric device is one that uses_____.

(A) linear reactance **(B)** time invariant reactance
(C) non linear reactance **(D)** time varying resistance

f. In practice, the electronic efficiency of a Klystron amplifier is in the range of_____.

(A) 60 to 65% **(B)** 0 to 15%
(C) 85 to 100% **(D)** 15 to 30%

g. The crossed-field (CFA) is used in space communication because the CFA is characterised by_____.

(A) moderate power and BW
(B) high efficiency and saturated amplification
(C) small size and low weight
(D) all given in **(A)**, **(B)** & **(C)**.

h. The parameters of a rectangular micro stripe are w = 10 mils and t = 2.8 mils. On transformation in to a circular conductor, the d, the diameter of the wire over ground is

(A) 7.236 mils **(B)** 6.7 mils
(C) 10 mils **(D)** 2.8 mils

i. The packaging density of a typical monolithic microwave IC (MMIC) is _____ compared to conventional ICs.

(A) the same **(B)** quite low
(C) quite high **(D)** high

j. In free space the propagation-delay time is_____.

(A) 3.333 ns/m **(B)** 3.333 $\mu s/m$
(C) 3.333 ms/m **(D)** 3.333 s/m

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

Q.2 a. Express the propagation constant in terms of the transmission line parameters R, L, G and C. **(2)**

b. Derive the following expressions for transmission line:
(i) attenuation constant (ii) phase constant
(iii) characteristic impedance (iv) phase velocity **(6)**

c. Show that for air insulated conductors, the phase velocity is approximately equal to velocity of light in vacuum. **(2)**

d. A transmission line has the following per unit length parameters: $L = 0.2\ \mu H/m$, $C = 300\ pf/m$, $R = 5\Omega/m$ and $G = 0.01 s/m$. Calculate the propagation constant and characteristic impedance of this line at 500 MHz Recalculate these quantities in the absence of loss (R=G=0). **(6)**

Q.3 a. Derive the total solution of the Helmholtz equation in rectangular coordinates **(8)**

b. Explain the methods of exciting various modes in rectangular waveguides. **(3)**

c. An air-filled rectangular waveguide of inside dimensions $7 \times 3.5\ cm$ operates in the dominant TE_{10} mode. Determine:
(i) the cut-off frequency
(ii) find the phase velocity in the guide at frequency of 4GHz
(iii) find the guided wavelength λ_g at the same frequency **(5)**

Q.4 a. Derive the S-matrix of a directional coupler. Also reduce the S-matrix in the terms of p, the transmission factor and q, the coupling factor. **(6)**

b. A 2 W power source is connected to the input of a directional coupler with C = 20 dB, D = 25 dB, and an insertion loss of 0.7 dB. Find the output powers (in dBm) at the through, coupled, and isolated ports. Assume all ports are to be matched. **(6)**

c. Explain briefly Faraday-rotation isolator. **(4)**

Q.5 a. Draw the equivalent circuit for a parametric amplifier. Clearly mark all the parameters and list out the two properties of a parametric up-converter. **(4)**

b. Explain the J-E characteristics of Gunn diode. **(5)**

c. Explain each term for parametric up-converter:
(i) Power gain (ii) Noise figure and (iii) Bandwidth
and calculate the same for the following given parameters

Ratio of output frequency over signal frequency: $f_o/f_s = 25$
Figure of merit: $\gamma Q = 10$
Factor of merit figure: $\gamma = 0.4$
Diode temperature: $Td = 350^\circ K$

(4+3)

Q.6 a. Explain the operating principle of Helix Travelling wavetubes. **(4)**

b. Explain the limitations of conventional vacuum tubes and how it can be overcome? **(6)**

c. What do you mean by velocity modulation in Klystron and derive the expression for it? **(6)**

Q.7 a. List the three types of magnetrons. **(3)**

b. Give the Hull cut-off voltage and Hull cut-off magnetic flux density for a linear magnetron. **(7)**

c. A linear magnetron has the following operating parameters:
Anode voltage: $V_0 = 20\,kV$
Anode current: $I_0 = 17A$
Magnetic flux density: $B_0 = 0.01 wb/m^2$

Distance between cathode and anode: d = 6 cm
Compute
(i) The Hull cut-off voltage for a fixed B_0.
(ii) The Hull cut-off magnetic flux density for a fixed V_0 **(6)**

Q.8 a. Explain the difference between microstripline and stripline **(4)**

b. List the parameters namely Inductance, L, Capacitance, C, Characteristic impedance Z_0 & phase velocity, ϑ_p for a lossless parallel strip line. **(8)**

c. A gold parallel strip line has the following parameters:
Relative dielectric constant of polyethylene: $\varepsilon_{rd} = 2.25$
Strip width: w = 25 mm
Separation distance: d = 5 mm
Calculate the
(i) Characteristic impedance of the strip line

(ii) Strip-line capacitance
(iii) Strip-line inductance
(iv) Phase velocity. **(4)**

Q.9 a. List the advantages of MMIC circuits over discrete circuits. **(3)**

b. List the basic characteristics required for ideal substrate materials. **(3)**

c. Describe a thin film planar resistor and express the resistance in terms of its parameters. **(5)**

d. Explain the planar capacitor film development in MMICs. **(5)**