Code: AE72/AE120   Subject: MICROWAVE THEORY AND TECHNIQUES

AMIETE – ET (Current & New Scheme)

Time: 3 Hours   **December - 2017**   **Max. Marks: 100**

PLEASE WRITE YOUR ROLL NO. AT THE SPACE PROVIDED ON EACH PAGE IMMEDIATELY AFTER RECEIVING THE QUESTION PAPER.

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.**
- **The answer sheet for the Q.1 will be collected by the invigilator after 45 minutes of the commencement of the examination.**
- **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.   Microwave frequencies are normally regarded as those in the range of
    (A) 1 to 500 MHz   **(B)** 1000 to 10,000 GHz
    (C) 1 to 100 GHz   **(D)** 10 to 1000 GHz

b.   What ferrite device can be used instead of duplexer of isolate microwave transmitter and receiver when both are connected to the same antenna?
    (A) Isolator   **(B)** Magnetron
    (C) Simplex   **(D)** Circulator

c.   Klystron oscillators are most often used in the frequency range of
    (A) 300 to 3000 MHz   **(B)** 3000 to 30000 MHz
    (C) 30 to 30000 MHz   **(D)** 10 to 10000 MHz

d.   A magnetron is operated at a duty cycle of 0.001. It has a peak power output of 100 kilowatts. Its average power is
    (A) 10,000 watts   **(B)** 100 watts
    (C) 1,000 watts   **(D)** 1,000,000 watts

e.   Which of the following is used as a high power microwave oscillator?
    (A) Thyratron   **(B)** Magnetron
    (C) Klystron   **(D)** Reflex-klystron

f.   The velocity factor of a transmission line depends on
    (A) temperature
    (B) skin effect
    (C) relative permittivity of dielectric
    (D) None of these

g.   A loss less line of characteristic impedance Z_0 is terminated in pure reactance of $-jZ_0$ value. VSWR is
    (A) 10   **(B)** 2
    (C) 1   **(D)** Infinity

h. In a circular waveguide the dominant mode is
   (A) TE_{01} (B) TE_{11}
   (C) TE_{20} (D) TE_{21}

i. The reflection coefficient on a line is 0.2 ∠45°. The SWR is
   (A) 0.8   (B) 1.1
   (C) 1.2   (D) 1.5

j. Which of the following is not a microwave tube?
   (A) Travelling wave tube   (B) Cathode ray tube
   (C) Klystron   (D) Magnetron

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

Q.2 a. Prove that the input admittance of a lossless line at a distance '*l*' from the load is

$$Y_{in} = Y_o \left[\frac{Y_L + jY_o \tan \beta l}{Y_o + jY_L \tan \beta l} \right]$$

Where $Y_0 = 1/Z_0$ and $Y_L = 1/Z_L$. **(8)**

b. A distortion less line has $Z_0 = 60\Omega$, $\alpha = 20$mNp/m, u = 0.6c, where c is the speed of light in a vacuum. Find R, L, G, C and λ at 100 MHz. **(8)**

Q.3 a. In context of waveguide, explain the following terms:
   (i) Dominant and Degenerate modes.
   (ii) Cutoff frequency and cutoff wavelength
   (iii) TE^Z and TM^Z fields
   (iv) Propagation constant and intrinsic wave impedance. **(8)**

b. A rectangular waveguide with dimensions *a* = 2.5cm, b = 1cm is to be operated below 15.1GHz. How many TE and TM modes can the waveguide transmit if the guide is filled with a medium characterized by $\sigma = 0$, $\varepsilon = 4\varepsilon_0$, $\mu_r = 1$? Calculate the cutoff frequencies of the modes. **(8)**

Q.4 a. What are cavity resonators? Derive the equations for resonant frequencies for a rectangular and circular cavity resonator. **(8)**

b. Explain the TE and TM field patterns in a rectangular cavity. **(3)**

c A circular waveguide has radius of 3cms and is used as a resonator for TM 011 mode at 10GHz by placing two perfectly conducting plates at its two ends. Determine the minimum distance between the two end plates. **(5)**

Q.5 a. Explain the operation of E-H plane Tee junction. Why is a hybrid E-H plane Tee referred to as Magic Tee? Derive the scattering matrix for E-H plane Tee.
   (2+1+5)

b. The scattering parameters of a two port are given as: $S_{11} = 0 = S_{22}$, $S_{12} = 0.3+j0.4 = S_{21}$. Find the distance that the position of port 1 should be shifted to the left so that S_{12} and S_{21} will be real numbers, given $\beta = 34.3$ rad/m. **(8)**

Q.6 a. What are the limitations of conventional tubes at microwave frequencies? Explain how these limitations can be overcome. **(5)**

b. By means of Applegate diagram, explain the operation of a reflex klystron. Show that the theoretical efficiency of a reflex klystron is 22.78%. **(8)**

c. List the performance characteristics and applications of a typical reflex klystron. **(3)**

Q.7 a. How is bunching achieved in a cavity magnetron? Derive an expression for the cutoff magnetron flux density with reference to a cylindrical cavity magnetron. **(8)**

b. A four cavity klystron VA-628 has the following parameters:
  Bam voltage (v_0) = 14.5kV
  Beam Current (I_0) = 1.4A
  Operation frequency (f) = 10GHz
  DC electron charge density (ρ_0) = 10^{-8} c/m^3
  Velocity perturbations (V) = 10^5 m/sec.
Compute the
(i) DC electron velocity, (ii) the DC phase constant, (iii) the plasma frequency, and (iv) the reduced plasma frequency for R = 0.4. **(8)**

Q.8 a. Explain the following planar transmission lines:
(i) Microstrip Line
(ii) Parallel Strip Line
(iii) Coplanar Strip Line
(iv) Shielded Strip Line **(8)**

b. Describe briefly the fabrication steps for a monolithic microwave integrated circuit. **(8)**

Q.9 a. What is Gunn diode? Write the principle of operation with proper diagram. Describe the different modes of operation briefly. **(10)**

b. An IMPATT diode has a junction capacitance (C_j) of 0.5pF and package inductance (L_p) of 0.5nH. if the breakdown voltage is 100V and bias current is 100mA, determine the resonant frequency and efficiency. Assume the RF peak current as 0.8A and load resistance R_L as 2 Ohm. **(6)**