

2022

PHYSICS

Paper : PHY 523

(Physics of Microwave)

Full Marks : 50

*The figures in the margin indicate full marks.**Candidates are required to give their answers in their own words as far as practicable.*Answer **any five** of the following.

1. (a) State and prove the Carline theorem in connection with a three port microwave circulator. Write the corresponding s-matrix.
(b) Define 'coupling factor' and 'directivity' of a microwave directional coupler.
(c) The Q - value of a microwave resonator changes from 1000 to 750 when it is coupled to a load circuitry. Find the Q - value of the load. 5+2+3
2. Starting from Maxwell's Electromagnetic equations find expressions for the different electric and magnetic field components for TE modes in a circular wave guide. 10
3. (a) Draw the schematic diagram of a cylindrical magnetron. Define 'Hull cut-off magnetic field'. Derive an expression for the 'Hull cut-off magnetic field' in terms of other relevant parameters.
(b) What is Read diode? With neat sketch briefly explain the electric field profile of a Read diode. 7+3
4. (a) A coaxial cylindrical wave guide of internal radius 'b' and central conductor of radius 'a' have air dielectric between them. Show by wave theory that the power transmitted through the wave guide is $\frac{1}{2}V_0I_0$ when a current of $I_0 e^{-j\omega t}$ is impressed on the central conductor.
(b) The dominant mode TE_{10} is propagated in a rectangular waveguide of dimensions $a = 2.25$ cm and $b = 1.00$ cm. Assume an air dielectric with a breakdown gradient of 3° kV/cm and a frequency of 10 GHz. There are no standing waves in the guide. Determine the maximum average power that can be carried by the guide. 6+4
5. (a) Show that the Q-factor of a cavity resonator can be expressed approximately by,

$$Q = [\omega\mu(\text{Volume})] / [2 R_S (\text{Surface area})]$$
 where R_S is the surface resistivity of the inner surface of the cavity, ω is the angular frequency and μ is the permeability.
(b) Explain with neat sketches the principle and construction of a gyrator.
(c) Write the transportation characteristics of a n-port circulator. Describe the structure and operation of a 4-port directional coupler type circulator. Write the s-matrix for this circulator. 3+2+5

Please Turn Over

6. (a) What are the advantages and disadvantages of a double stub matching over a single stub matching?
- (b) In a double stub matching assignment, the terminating impedance Z_L is $(100 + j 100) \Omega$, and the characteristic impedance Z_0 of the line and the stub is 50Ω . The first stub is placed at 0.40λ away from the load. The spacing between the two stubs is $3/8 \lambda$. Determine the length of the short circuited stubs when the matching is achieved. What terminations are forbidden for matching the line by the double stub device ?
7. (a) What are the dominant modes in a rectangular and circular waveguide? What do you mean by degenerate modes? Write down the degenerate mode for (i) a rectangular waveguide and (ii) a square waveguide.
- (b) Explain what do you mean by a cut-off frequency in a waveguide? What will happen if the frequency of input microwave is lower than the cut-off frequency?
- (c) An air filled circular waveguide of diameter 2 cm carries microwave of frequency of 10 GHz. Find the all-possible modes that can propagate. Then find (i) propagation constant, (ii) phase velocity, (iii) wavelength of wave within guide, (iv) characteristic impedance for all the modes.

(1+1+1)+2=5
