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# MICROWAVE ENGINEERING

## Paper–ECE–407 E, Opt. (II)

*Time allowed : 3 hours]* *[Maximum marks : 100*

***Note :*** *Attempt any five questions by selecting at least one question from each section.*

## Section–I

**1.** (a) Why transmission line resonators are not used at microwave frequencies, give at least two reasons ? 3

(b) Draw and explain the distribution of E and H fields w.r.t. length of the cavity for quarter-wave and half-wave coaxial cavity. 2+2=4

(c) How dielectric constant of a solid is measured by using waveguide method, explain with necessary expressions and diagram ? 8

(d) A cavity resonator is constructed from a section of waveguide of dimensions, width 'a', height

'b' and length 'L' by closing off ends of it with copper plates. Show that if cavity is to resonante in $TE_{101}$ mode, the frequency of resonance is : $f_0 = c/2L[\sqrt{1+(L/a)^2}]$ ? 5

2. (a) Derive expressions for unloaded quality factor of rectangular cavity. 8

(b) What do you mean by insertion loss and explain the method to measure it ? 7

(c) Calculate incident microwave power using calorimeter wattmeter method if mass of water is 100gm and rise in temperature is 100° C. 2

(d) Determine attenuation measured by attenuator if reading of power meter is 10mW, when attenuator is present and 20mW when attenuator is absent ? 3

## Section–II

3. (a) Derive expressions for power required to bunch the electron beam for two cavity klystron amplifier. 5

(b) A two cavity klystron amplifier operates under following parametric characteristics; $V_0 = 1000$ Volts, $R_0 = 40$ KΩ, $I_0 = 25$ mA, f = 3 GHz, Gap Spacing (d) = 1mm, Spacing between two cavities (L) = 4 cm and effective shunt impedance ($R_{sh}$) = 30 KΩ, then by neglecting beam loading calculate :

(i) Input gap voltage to give maximum output

(ii) Voltage Gain

(iii) Efficiency of Amplifier

(iv) Beam Loading Conductance 4×2=8

(c) Derive expressions for beam current density for multi-cavity klystron amplifier. 7

4. (a) Explain following in context to cylindrical magnetron :

(i) Strapping

(ii) Frequency Pushing

(iii) Frequency Pulling

(iv) Conditions for sustained oscillations

4×2=8

(b) Derive expressions for axial electric field in helix TWT and calculate circuit equation. 6

(c) A TWT operates under following parametric conditions :

Beam Voltage ($V_0$) = 3KV, Beam Current ($I_0$) = 30 mA, $Z_0$ = 10Ω, Circuit Length (N) = 50, Frequency (f) = 10GHz then calculate following:

(i) Gain parameter

(ii) Output Power Gain

(iii) All four Propagation Constant 2×2=6

## Section–III

5. (a) Explain the operation of a Precision Rotary Attenuator using suitable diagrams of each of its sectional plates and calculate the value of output electric field and its S-matrix. 7

(b) Prove that sum of products of each term of any one row or column of S-matrix multiplied by its complex conjugate is unity. 6

(c) In a two port matched network give the values of following losses in terms of S-parameters :

(i) Insertion Loss

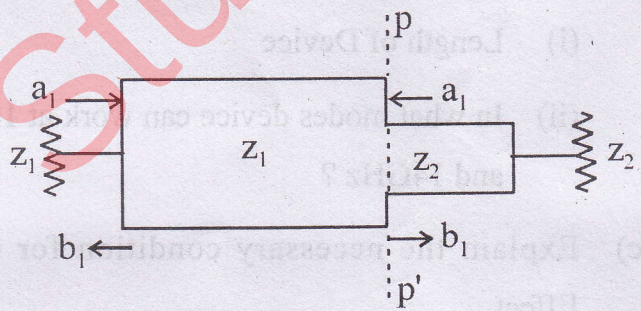
(ii) Transmission Loss

(iii) Reflection Loss

(iv) Return Loss 4

(d) How circulator can be constructed using Two Hole Directional Coupler, explain ? 3

6. (a) Two transmission lines of characteristic impedances $Z_1$ and $Z_2$ are joined at plane PP' (shown below) then express S-parameters in terms of impedances when each line is matched Terminated. 8



(b) Explain the operation of Magic-Tee and solve its S-matrix for numerical values of S-parameter when port-3 & port-4 are perfectly matched. 3+4=7

(c) In a H-plane tee junction, compute power delivered to the loads of 40Ω and 60Ω connected to arms 1 and 2 when a 10m W power is delivered to matched port 3. 5

## Section–IV

7. (a) Explain high field domain formation in GUNN diode and describe its properties. 10

(b) A GUNN diode is working in transit time modes at 12GHz. The domain of charges move at $10^7$ cm/sec speed. Calculate :

(i) Length of Device

(ii) In what modes device can work at 10GHz and 14GHz ? 6

(c) Explain the necessary condition for Gunn Effect. 4

8. (a) Compare the physical structures of IMPATT and TRAPATT diodes. 7

(b) If a TRAPATT diode has doping concentration $(N_A) = 2 \times 10^{15}$ $cm^{-3}$ and current density of 20 $KA/cm^2$ then calculate Avalanche zone velocity. 5

(c) Explain principle of operation of BARITT diode. 8