## Subject: MICROWAVE THEORY AND TECHNIQUES

**Time: 3 Hours** **DECEMBER 2010** **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.**
- **The answer sheet for the Q.1 will be collected by the invigilator after half an hour 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.**

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**Q.1 Choose the correct or the best alternative in the following: (2×10)**

a. A waveguide section in a microwave circuit will act as a:

**(A)** High pass filter **(B)** Low pass filter
**(C)** Band pass filter **(D)** Band stop filter

b. X-band microwave frequency range is defined as

**(A)** 8-12 GHz **(B)** 4-6 GHz
**(C)** 18-25 GHz **(D)** 1-2 GHz

c. The phase velocity $v_P$ and the group velocity $v_g$ in a waveguide, and velocity $c$ of light are related as follows

**(A)** $v_p + v_g = c$ **(B)** $v_p / v_g$ = a constant
**(C)** $v_p\, v_g = c^2$ **(D)** $v_p + v_g = c^2$

d. When a transmission line is terminated by its characteristic impedance it represents

**(A)** An infinite line **(B)** A mismatched line
**(C)** It is high VSWR line **(D)** It is a finite line

e. The dominant mode in a rectangular waveguide is

**(A)** $TE_{10}$ mode **(B)** $TM_{11}$ mode
**(C)** TEM mode **(D)** $TE_{11}$ mode

f. A magic T is a microwave junction having

**(A)** 4 ports **(B)** 6 ports
**(C)** 2 ports **(D)** 5 ports

g. In a microstrip line the propagating mode is

**(A)** a pure TEM mode **(B)** a quasi TEM mode
**(C)** a TE mode **(D)** a TM mode

h. In a Hybrid Ring (rat-race circuits), when a wave is fed into port 1, it will not appear at port 3 because the difference of phase shift for the waves travelling in the clockwise and anticlockwise directions is

**(A)** zero **(B)** $180^\circ$
**(C)** $360^\circ$ **(D)** $90^\circ$

i. A transmission line has characteristic impedance of 50 + j0.01 $\Omega$ and is terminated in a load impedance of 73-j42.5 $\Omega$.The VSWR is

**(A)** 0.38 **(B)** 0.4524
**(C)** 2.21 **(D)** 0.2262

j. An IMPATT diode has the following parameters:
Carrier drift velocity $v_d = 2\times10^7$ cm/s; Drift region length $L = 6\,\mu m$;
$V_{o\,max}$ = 100 V; $I_{max}$ = 200 mA; $\eta$ = 15; $V_{od}$ = 90 V. The resonant frequency in giga hertz is

**(A)** 1.667 GHz **(B)** 1.5 GHz
**(C)** 166.7 GHz **(D)** 16.67 GHz

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

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**Q.2** a. Why a conventional open wire line is not suitable for microwave transmission? Indicate the different types of transmission lines commonly used with mode of transmission used in each case. **(5)**

b. Write the characteristics of smith chart and describe the steps involved in determination of normalized impedance using smith chart. **(6)**

c. Find the input impedance of a line, given a line of characteristic impedance 100 $\Omega$ and $\frac{1}{3}\lambda$ long. If this line is terminated in a load which has an impedance 150+j60; what is its input impedance (use smith chart) **(5)**

**Q.3** a. Derive the wave equation for TM wave and obtain all the field components in a rectangular waveguide. **(10)**

b. An air filled rectangular waveguide of inside dimension 7×3.5 cms operates in the dominant $TE_{10}$ mode as shown in Fig.1.

Find (i) cut off frequency (ii) Determine phase velocity of the wave in the guide at a frequency of 3.5 GHz (iii) Determine the guide wave length at the same frequency. **(6)**

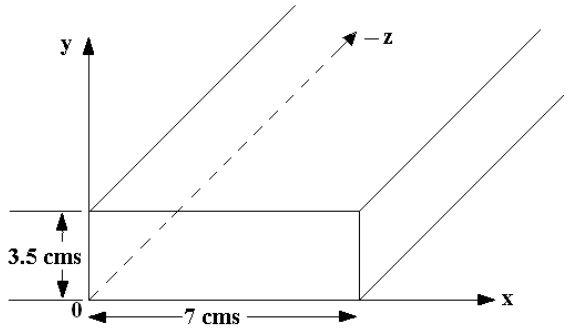

Fig.1

**Q.4** a. The impedance matrix of a certain dumped element network is given by $z = \begin{bmatrix} 4 & 2 \\ 2 & 4 \end{bmatrix}$. Determine the scattering matrix. **(6)**

b. Write a short note on the following with neat diagram.
(i) circulator (ii) isolator. **(3+3)**

c. Explain magic-T with neat diagram. Write S-matrix representation of it. **(4)**

**Q.5** a. What is transfer electron effect. Explain how this is used in solid-state device in generating micro wave oscillations. **(6)**

b. Explain Gunn effect and discuss the different modes of oscillations in Gunn diode. **(10)**

**Q.6** a. What are the high frequency limitations of vacuum tubes? How they overcome in microwave tubes. **(4)**

b. With the help of a neat diagram explain the principle of Reflex klystron. Illustrate velocity modulation with the help of Applet gate diagram and obtain an expression for output power and efficiency of it. **(8)**

c. An IMPATT diode has the following parameters:
(i) Carrier drift velocity $v_d = 4 \times 10^7$ cms/s;
(ii) Drift region length $L = 6\ \mu m$ .
(iii) Maximum operating voltage $V_{max} = 100$ V;
(iv) Maximum operating current $I_{0\,max} = 200$ mA;
(v) Efficiency $\eta = 15\%$;
(vi) Breakdown voltage $V_{bd} = 90$ Volts.
Compute (i) maximum CW output power in watts (ii) resonant frequency in giga hertz. **(4)**

**Q.7** a. Explain equations of electron motion in a cylindrical magnettron. **(6)**

b. A X band pulsed cylindrical magnettron has the following operating parameters:

Anode voltage $V_o$ = 26 kVolts; Beam current $I_o$ = 27 Amps; Mag. flux density $B_o$ =0.336 Watts/$m^2$; radius of cathode cylinder $a$ = 5 cms; Radius of vane edge to centre $b$ = 10 cms. Compute the following:
(i) The cyclotron angular frequency (ii) The cut off voltage for a fixed $B_o$. **(6)**

c. Explain forward wave crossed field amplifier with a diagram. **(4)**

**Q.8** a. A certain microstrip line has the following parameters:
(i) $\in_r$ (= relative dielectric constant of the board material) = 5.23
(ii) Height from the microstrip line to ground = 7 mils
(iii) Thickness of the microstrip line = 2.8 mils
(iv) Width of the microstrip line = 10 mils.
Calculate the characteristic impedance of the line. **(4)**

b. Explain microstrip line with diagrams. What are the losses associated with it? **(6)**

c. Write explanatory note on:
(i) Coplanar strip lines (ii) Shielded strip lines **(3+3)**

**Q.9** a. What are the fabrication steps involved in manufacturing of MMICs? **(6)**

b. Give a brief comparison between discrete circuit and integrated MIC. **(6)**

c. Write a short note on Hybrid Integrated Circuit fabrication **(4)**