ROLL NO. ___________________

**Code: AE72** **Subject: MICROWAVE THEORY AND TECHNIQUES**

## AMIETE – ET (NEW SCHEME)

**Time: 3 Hours** **JUNE 2012** **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.**

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

a. The input impedance of a transmission line having finite length equal to '$\ell$' is given by

**(A)** $z_{in} = z_o \left\{ \dfrac{z_R \cosh\gamma\ell + z_o \sinh\gamma\ell}{z_o \cosh\gamma\ell + z_R \sinh\gamma\ell} \right\}$ **(B)** $z_{in} = z_o \left\{ \dfrac{z_o \cosh\gamma\ell + z_R \sinh\gamma\ell}{z_R \cosh\gamma\ell + z_o \sinh\gamma\ell} \right\}$

**(C)** $z_{in} = z_o \left\{ \dfrac{z_R \sinh\gamma\ell + z_o \cosh\gamma\ell}{z_R \cosh\gamma\ell + z_o \sinh\gamma\ell} \right\}$ **(D)** $z_{in} = z_o \{ z_R \tanh\gamma\ell + z_o \coth\gamma\ell \}$

b. The primary constants of a transmission line/km are $R = 6\,\Omega, G = 0.25\,\mu\Omega,$ $L = 2.2\,mH, C = 0.005\,\mu F, f = 1000\,Hz$, the characteristic impedance is

**(A)** 138.86 – j67.86Ω **(B)** 67.86 – j13.8Ω
**(C)** 678.86 – j138.12Ω **(D)** 13.86 – j67.86Ω

c. The [S] matrix of an ideal precision attenuator is

**(A)** $\begin{bmatrix} 0 & \sin^2\theta \\ \sin^2\theta & 0 \end{bmatrix}$ **(B)** $\begin{bmatrix} 1 & \sin^2\theta \\ \sin^2\theta & 1 \end{bmatrix}$

**(C)** $\begin{bmatrix} \sin^2\theta & 0 \\ 0 & \sin^2\theta \end{bmatrix}$ **(D)** $\begin{bmatrix} \sin^2\theta & 1 \\ 1 & \sin^2\theta \end{bmatrix}$

d. Travelling wave tube amplifier is based on the principle of

**(A)** electron beam interaction with slow wave structure
**(B)** electron beam interaction with static magnetic field
**(C)** electron beam interaction with time varying magnetic field
**(D)** electron motion

e. Crossed field tubes derive their names from the fact that

**(A)** There is no relationship between AC magnetic and AC electric field
**(B)** AC magnetic field and AC electric field are horizontal to each other
**(C)** AC magnetic field and AC electric field are perpendicular to each other
**(D)** DC electric field and DC magnetic field are perpendicular to each other

f. A waveguide termination having VSWR of 101 is used to dissipate 100 watts of power. The reflected power is

**(A)** 0.2246 W **(B)** 0.2268 W
**(C)** 0.3368 W **(D)** 0.3346 W

g. A pulsed cylindrical magnetron is operated with the following parameters
Anode voltage = 25 KV, Beam current = 25 A, Magnetic density = 0.34 $\mathrm{Wb}/\mathrm{m}^2$,
Radius of cathode cylinder = 5 cm, Radius of anode cylinder = 10 cm, the cut off magnetic flux density is

**(A)** 142.2 $\mathrm{mWb}/\mathrm{m}^2$ **(B)** 142.2 $\mathrm{Wb}/\mathrm{m}^2$
**(C)** 142.2 $\mathrm{mWb}/\mathrm{m}$ **(D)** 142.2 $\mathrm{Wb}/\mathrm{m}$

h. The drift velocity of electrons is $2\times10^{7}$ cm/s through the active region of length $10\times10^{-4}$ cm. Calculate the natural frequency of the diode

**(A)** 30 MHz **(B)** 30 GHz
**(C)** 20 GHz **(D)** 30 kHz

i. The characteristic impedance of microstrip lines can be expressed as $\left[\text{for } W/h \le 1\right]$

**(A)** $z_o = \frac{60}{\sqrt{\epsilon_{eff}}}\log_e\left[\frac{8h}{\omega}+\frac{w}{4h}\right]$ **(B)** $z_o = \frac{\sqrt{\epsilon_{eff}}}{60}\log_e\left[\frac{8h}{\omega}+\frac{w}{4h}\right]$

**(C)** $z_o = \frac{60}{\sqrt{\epsilon_{eff}}}\log_e\left[\frac{w}{8h}+\frac{4h}{w}\right]$ **(D)** $z_o = \frac{60}{\sqrt{\epsilon_{eff}}}\log_{10}\left[\frac{w}{8h}+\frac{4h}{w}\right]$

j. In a directional coupler if all ports are completely matched, then

**(A)** $S_{11}=S_{22}=S_{33}=S_{44}=3/2$ **(B)** $S_{11}=S_{22}=S_{33}=S_{44}=\frac{1}{\sqrt{2}}$

**(C)** $S_{11}=S_{22}=S_{33}=S_{44}=1/2$ **(D)** $S_{11}=S_{22}=S_{33}=S_{44}=0$

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

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**Q.2** a. Derive an Expression for voltage and current of a open wire transmission line of length $\ell$. Also prove that $Z_o = \sqrt{Z_{oc} Z_{sc}}$ . **(10)**

b. The characteristic impedance of a certain line is $710\angle 14^\circ\,\Omega$ and the propagation constant is $0.007 + j0.028/\text{km}$. The line is terminated in a $300\,\Omega$ resistor. Calculate the input impedance of the line, if its length is 100 km. **(6)**

**Q.3** a. With the help of wave equation of $\vec{E}$ & $\vec{H}$ field, show that TEM wave cannot exist inside the waveguide. **(4)**

b. A rectangular waveguide has inner dimensions of $6\,\text{cm} \times 4\,\text{cm}$. When the waveguide is terminated in an unknown load impedance, the distance measured between a node and next antinode is found to be 4.55 cm, for the dominant mode. Find the frequency of the transmitted wave signal. **(4)**

c. Derive the wave equation for TE and TM wave and obtain all the field components in a cylindrical waveguide. **(8)**

**Q.4** a. Derive S-matirx of a magic tee and rat race circuit. **(8)**

b. A magic Tee is terminated at collinear ports 1 & 2 and difference port 4 by impedances of reflection coefficients $r_1 = 0.5, r_2 = 0.6$, $r_4 = 0.8$ respectively. If 1W power is fed at port-3, calculate the power reflected at port-3, and power transmitted at other three ports. **(8)**

**Q.5** a. Explain in detail the semiconductor structure of PIN diode and discuss how PIN diode can be used as switch with equivalent circuits. **(12)**

b. An IMPATT diode with nominal frequency 10 GHz has $C_j = 0.5\,\text{pf}, L_p = 0.5\,\text{nH}$ and $C_p = 0.3\,\text{pf}$ at breakdown bias of 80V and bias current of 80 mA. The RF peak current is 0.65A for $R_d = -2\Omega$. Find the resonant frequency of oscillation. **(4)**

**Q.6** a. Explain the operation of Reflex Klystron in detail with neat diagram. **(8)**

b. A two cavity klystron amplifier is tuned at 3 GHz. The drift space length is 2 cm, beam current 25 mA. The catcher voltage is 0.3 times the bean voltage. It is assumed that the gap length of the cavity is very less than the drift space, so that the input and output voltages are in phase $(\beta = 1)$. Compute

(i) power output and efficiency for $N = 5\frac{1}{4}$

(ii) beam voltage, input voltage and output voltage for maximum power output for $N = 5\frac{1}{4}$ mode. **(8)**

**Q.7** a. Derive an expressions for cut-off magnetic field and voltage of magnetron oscillator. **(5)**

b. Explain with neat diagram the operation of backward and cross field oscillator. **(6)**

c. A pulsed cylindrical magnetron is operated with the following parameters
Anode voltage = 25 kV, Beam current = 25A, Magnetic density = 0.34 $Wb/m^2$,
Radius of cylinder = 5 cm, Radius of anode cylinder = 10 cm
Calculate the angular frequency, cut-off voltage, magnetic flux density. **(5)**

**Q.8** a. A microstrip line is composed of zero thickness copper conductors on a substrate having $\in_r = 8.4$, $\tan\delta = 0.0005$ and thickness 2.4 mm, if the line width is 1mm and operated at 10 GHz. Calculate
(i) The characteristic impedance
(ii) The attenuation due to conductor loss and dielectric loss. **(8)**

b. Explain different losses in microstrip lines. **(8)**

**Q.9** a. Give the properties of substrate materials, conductor materials and dielectric materials for monolithic microwave integrated circuits. **(8)**

b. Write short notes on

(i) DC sputtering
(ii) Hybrid IC fabrication. **(8)**