53 (EC 601) MWEN

2018

MICROWAVE ENGINEERING

Paper : EC 601

Full Marks : 100

Time : Three hours

The figures in the margin indicate full marks for the questions.

Answer ***any five*** *questions* : 5×20=100

1. *(a)* Starting from Maxwell's equation derive the electromagnetic field equations in rectangular waveguide for TE_{mn} mode.

   (b) A rectangular waveguide has cross-section $2.5 \times 5cm^2$. Determine the guide wavelength λ_g, phase velocity v_p, phase constant β at signal wavelength $4.5cm$ for the dominant mode.

   10+10

2. *(a)* Show that for a rectangular waveguide the free space wavelength λ of a wave is related to guide wavelength λg as

$\lambda = \frac{\lambda_g \lambda_c}{\sqrt{\lambda_g^2 + \lambda_c^2}}$, where λ_c is the cut-off wavelength.

(b) A rectangular waveguide has the following characteristics : $b = 1.5cm$, $a = 3.0cm$ $\mu_r = 1$ and $\epsilon_r = 2.25$.

(i) Calculate the cut-off wavelength and cut-off frequency for TE_{10}, TE_{20} and TM_{11} modes.

(ii) Calculated λ_g and z_o at $4.0GHz$.

8+12

3. *(a)* Derive an expression for the resonant cavity $(a \times b \times l)$ with $a > b > l$ and hence obtain the dominant mode of resonance.

(b) Define 'Q' factor of a cavity. Distinguish between 'loaded Q' and 'unloaded–Q' of the cavity.

(c) Describe critical coupling, overcoupling and undercoupling. Draw the variation of VSWR with coupling co-efficient.

7+6+7

4. *(a)* Discuss the working principle of a 'Magic-T'.

(b) Obtain the Scattering matrix equation of a 'Magic-T' by using necessary properties of the Scattering matrix.

(c) Explain why 'Scattering Matrix' representation of a Microwave network is preferred over z-matrix or y-matrix.

7+8+5

5. *(a)* Describe the ideal 'Directional Coupler'. Define 'Coupling' and 'Directivity' in the context of a directional coupler.

(b) Mention the practical shortcomings of a such a directional coupler. Discuss how these shortcomings can be overcome.

(c) Explain with neat sketch the working principle of Faraday Isolator.

6+4+10

6. *(a)* Explain the working principle of a Reflex Klystron Oscillator.

(b) Explain what is meant by 'velocity modulation' and how this phenomenon is used in the Operation of a Klystron tube.

(c) Draw the power *vs* repeller voltage and frequency *vs* repeller vortage characteristics of a Reflex Klystron. Explain qualitatively. 7+6+7

7. (a) Show that the group velocity v_g is related to the phase velocity v_p as

$$v_g = v_p\sqrt{1-(f_c/f)^2}$$

(b) A waveguide has a cross-section $1.5cm \times 0.8cm$. The medium inside the waveguide has $\sigma = 0$, $\mu = \mu_o$, $\epsilon = \epsilon_o$. The magnetic field component is given as

$$H_x = 2\sin\left(\frac{\pi x}{a}\right)\cos\left(\frac{3\pi y}{b}\right)\sin\left(\pi \times 10^{11}t - \beta z\right)$$

Determine :

(i) the mode of operation

(ii) the cut-off frequency

(iii) the phase constant β

(iv) the propagation constant γ

(v) the wave impedance Z_g. 6+14