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ELECTRONICS ENGINEERING

Objective Practice Sets

Microwave Engineering

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1 CHAPTER Introduction

Q.1 A square waveguide carries TE_{11} mode whose axial magnetic field is given by

$$H_z = H_0 \cos\frac{\pi x}{\sqrt{8}} \cos\frac{\pi y}{\sqrt{8}} \text{ A/m}$$

Where the waveguide dimensions are in centimeters. What is the cut-off frequency of the mode?

(a) 5 GHz (b) 7.5 GHz
(c) 6.5 GHz (d) 8 GHz

Q.2 Match **List-I** (Transmission system) with **List-II** (Mode) and select the correct answer using the codes given below the lists:

List-I	List-II
A. Rectangular waveguide	**1.** TE/TM
B. Circular waveguide	**2.** TEM
C. Coaxial Line	**3.** Quasi-TEM
D. Microstrip Line	

Codes :

	A	B	C	D
(a)	1	1	2	3
(b)	1	2	2	3
(c)	2	2	3	3
(d)	3	1	2	2

Q.3 In a hollow rectangular waveguide, the phase velocity

(a) Increases with increasing frequency.
(b) Decreases with decreasing frequency.
(c) Decreases with increasing frequency.
(d) Is independent of frequency.

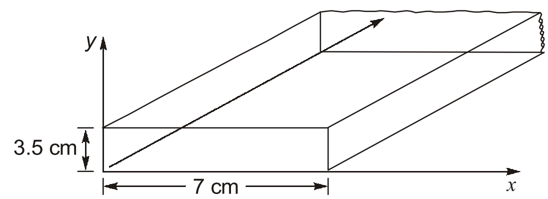
Q.4 A rectangular or a circular waveguide is

(a) A resonant circuit
(b) High-pass filter
(c) Low pass filter
(d) None of the above

Q.5 Typical microwave oven work on the frequency

(a) 1.225 GHz (b) 2.45 GHz
(c) 4.90 GHz (d) 9.80 GHz

Q.6 An air-filled rectangular waveguide of inside dimensions 7 × 3.5 cm operates in the dominant TE_{10} mode as shown in figure.



1. Find the cutoff frequency.
2. Determine the phase velocity of the wave in the guide at a frequency of 3.5 GHz

(a) 1.07 GHz, 3.78×10^8 m/s
(b) 2.14 GHz, 1.89×10^8 m/s
(c) 2.14 GHZ, 3.78×10^8 m/s
(d) 1.07 GHz, 1.89×10^8 m/s

Direction for Q. 7, 8 and 9

A lossless line has a characteristic impedance of 50 Ω and is terminated in a load resistance of 75 Ω. The line is energized by a generator which has an output impedance of 50 Ω and an open-circuit output voltage of 30 V(rms). The line is assumed to be 2.25 wavelengths long. Determine

Q.7 The input impedance

(a) 100 Ω (b) 33.33 Ω
(c) 66.67 Ω (d) 50 Ω

Q.8 The magnitude of the instantaneous load voltage.

(a) 0 V (b) 18 V
(c) 36 V (d) 42 V

Q.9 The instantaneous power delivered to the load is

(a) $\left(30\sqrt{2}\right)^2$ (b) $\frac{(36)^2}{75}$
(c) $\frac{(18)^2}{75}$ (d) $\frac{(42)^2}{75}$

Q.10 Consider the following statements about smith chart

1. The constant r and constant x circles all pass through the point ($G_r = 1$, $G_i = 0$).
2. The distance around the smith chart once is one-half wavelength ($\lambda/2$).

3. At a point of $Z_{min} = 1/\rho$, there is a V_{min} on the line while a point of $Z_{max} = \rho$, there is a V_{max} on the line.

(a) 1 only is correct (b) 2 only is correct
(c) 3 only is correct (d) 1, 2, 3 all are correct

Q.11 Guide wavelength (λ_g), cut-off wavelength (λ_c) and free space wavelength (λ_0) of a waveguide are related as

(a) $\frac{1}{\lambda_g^2} = \frac{1}{\lambda_0^2} - \frac{1}{\lambda_c^2}$ (b) $\frac{1}{\lambda_0^2} = \frac{1}{\lambda_g^2} - \frac{1}{\lambda_c^2}$

(c) $\frac{1}{\lambda_c^2} = \frac{1}{\lambda_0^2} + \frac{1}{\lambda_g^2}$ (d) $\frac{1}{\lambda_g} = \frac{1}{\lambda_0} + \frac{1}{\lambda_c}$

Q.12 A 75 Ω transmission line is first short terminated and the minima locations are noted. When the short is replaced by a resistive load R_L, the minima locations are not altered and the VSWR is measured to be 3.
What is the value of R_L?

(a) 25 Ω (b) 50 Ω
(c) 225 Ω (d) 250 Ω

Q.13 It is necessary to propagate a 10 GHz signal in a waveguide whose wall separation is 6 cm. What is the greatest number of half-waves of electric intensity which it will be possible to establish between two walls (i.e., what is the largest value of m)?

(a) 1 (b) 2
(c) 3 (d) 4

Q.14 In the question no -'13' calculate the guide wavelength for this mode of propagation.

(a) 2.27 cm (b) 4.54 cm
(c) 6.81 cm (d) 9.08 cm

Q.15 What is the formula for the cut off wavelength in a standard rectangular waveguide for the TM_{11} mode. Assume that standard rectangular waveguide has aspect ratio 2:1

(a) 0.447a (b) 1.341a
(c) 0.894a (d) 0.599a

Q.16 For some applications circular waveguides may be preferred to rectangular ones because of

(a) The smaller cross section needed at any frequency
(b) Lower attenuation
(c) Freedom from spurious modes
(d) Rotation of polarizations

Q.17 Which of the following antenna is best excited from a waveguide?

(a) Horn (b) Discone
(c) Helical (d) Biconical

Q.18 Standard mismatching in microwave circuits have SWR from:

(a) 0.5 : 1 to 2 : 1 (b) 1 : 0 to 2 : 1
(c) 1.2 : 1 to 2 : 1 (d) 1 : 33 to 2 : 1

Q.19 Waveguides are considered superior to coaxial lines in the range

(a) 30 MHz to 1 GHz
(b) 1 GHz to 3 GHz
(c) 3 GHz to 100 GHz
(d) 100 GHz to150 GHz

Q.20 The following waveguide tuning component is not easily adjustable

(a) Stub (b) Iris
(c) Screw (d) Plunger

Q.21 Which of the following is not true about the properties of TEM modes in a lossless medium.

(a) Its cutoff frequency is zero
(b) Its propagation constant is the constant in an unbounded dielectric
(c) Its phase velocity is the velocity of light in an unbounded dielectric
(d) None of these

Q.22 A rectangular waveguide is designed to propagate the dominant mode TE_{10} at a frequency of 5 GHz. The cut off frequency is 0.8 of signal frequency. The ratio of the guide height to width is 2. The dimensions of the guide are

(a) 3.75 cm, 1.875 cm
(b) 4 cm, 2 cm
(c) 8 cm, 4 cm
(d) 2.54 cm, 1.27 cm

Q.23 The guide wavelength is measured by short-circuiting a waveguide and shifting the tunable probe along the slotted line to locate the voltage minima. If the shorting plate is replaced by a matched load, then

(a) it would improve the accuracy of the measurement.
(b) the guide wavelength cannot be measured.
(c) it will give less accurate result, as no reflected wave is present.
(d) it will change the value of the guide wavelength

Explanations Introduction

1. (b)

$$\lambda_c = \frac{2a}{\sqrt{m^2+n^2}}$$

$$= \frac{2a}{\sqrt{\left(\frac{1}{\sqrt{8}}\right)^2+\left(\frac{1}{\sqrt{8}}\right)^2}} = 4 \text{ cm}$$

$$\therefore \quad f_c = \frac{c}{\lambda_c} = \frac{3\times10^8}{4\times10^{-2}} = 7.5 \text{ GHz}$$

2. (a)

Microstrip line $\to$ Quasi-TEM

Coaxial line $\to$ TEM

3. (c)

$$\text{Phase velocity} = \frac{c}{\sqrt{1-\left(\frac{f}{f_c}\right)^2}} = \frac{c}{1-\left(\frac{\lambda_c}{\lambda}\right)^2}$$

4. (b)

RWG : below certain cutoff frequencies it doesn't work, so we can say it acts like high pass filter.

5. (b)

Microwave oven : 2.45 GHz

6. (c)

$$f_c = \frac{c}{2a} = \frac{3\times10^8}{2\times7\times10^{-2}} = 2.14 \text{ GHz}$$

$$V_p = \frac{c}{\sqrt{1-\left(\frac{f_c}{f}\right)^2}} = \frac{3\times10^8}{\sqrt{1-\left(\frac{2.14}{3.5}\right)^2}}$$

$$= 3.78\times10^8 \text{ m/sec}$$

7. (b)

$$z_{in} = \frac{(50)^2}{75} = 33.33\ \Omega$$

8. (c)

$$\text{Reflection coefficient } \Gamma = \frac{z_L - z_0}{z_L + z_0} = \frac{75-50}{75+50}$$

then the instantaneous voltage at load

$$V = V^+ e^{-j\beta l}(1+\Gamma) \quad (\because l = 0)$$

$$= 30(1+0.2) = 36 \text{ V}$$

9. (b)

Instantaneous power delivered to load is

$$P = \frac{(36)^2}{75} = 17.28 \text{ W}$$

11. (a)

$$\frac{1}{\lambda^2} = \frac{1}{\lambda_g^2} + \frac{1}{\lambda_c^2}$$

12. (c)

$$\text{VSWR} = 3 = \frac{1+|\Gamma|}{1-|\Gamma|}$$

$$\Rightarrow \quad |\Gamma| = 0.5 = \frac{z_L - z_0}{z_L + z_0} \quad z_0 = 75\ \Omega$$

$$\therefore \quad z_L = 225\ \Omega$$

13. (c)

when $m = 1$, $\lambda = \frac{2\times6}{1} = 12$ cm ✓

when $m = 2$, $\lambda = \frac{2\times6}{2} = 6$ cm ✓

when $m = 3$, $\lambda = \frac{2\times6}{3} = 4$ cm ✓

when $m = 4$, $\lambda = \frac{2\times6}{4} = 3$ cm ×

for 10 GHz $\lambda = \frac{3\times10^8}{10\times10^9} = 3$ cm

$\therefore$ $m = 4$ is not allowed

14. (b)

$$\lambda_g = \frac{\lambda}{\sqrt{1-\left(\frac{\lambda}{\lambda_c}\right)^2}} = \frac{3}{\sqrt{1-\left(\frac{3}{4}\right)^2}} = 4.54 \text{ cm}$$

15. (c)

For aspect ratio 2 : 1 $\Rightarrow$ $b = a/2$

$$\therefore \quad \lambda_0 = \frac{2}{\sqrt{\left(\frac{m}{a}\right)^2+\left(\frac{n}{b}\right)^2}} = \frac{2a}{\sqrt{m^2+4n^2}}$$

here $m = n = 1$

$$\therefore \quad \lambda_0 = \frac{2a}{\sqrt{5}} = 0.894 \text{ a}$$