CLASS TEST

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ELECTROMAGNETICS THEORY

ELECTRONICS ENGINEERING

Date of Test : 30/06/2025

ANSWER KEY

1.	(a)	7.	(d)	13.	(c)	19.	(d)	25.	(b)
2.	(d)	8.	(b)	14.	(b)	20.	(b)	26.	(c)
3.	(a)	9.	(d)	15.	(c)	21.	(d)	27.	(c)
4.	(c)	10.	(a)	16.	(d)	22.	(d)	28.	(a)
5.	(d)	11.	(d)	17.	(c)	23.	(d)	29.	(a)
6.	(b)	12.	(d)	18.	(b)	24.	(b)	30.	(d)

DETAILED EXPLANATIONS

1. (a)

For conductor to dielectric boundary

$$D_n = \rho_s$$
$$E_t = 0$$

2. (d)

$$\nabla \cdot \vec{E} = -\frac{\partial \vec{B}}{\partial t}$$

3. (a)

By using Maxwell's equations

$$\eta = \sqrt{\frac{\mu}{\in}} = \eta_o \sqrt{\frac{1}{\in_r}} = \frac{120\pi}{9}$$

$$H_o = \frac{E_o}{\eta} = \frac{10 \times 9}{120\pi} = 0.2387 \simeq 0.24$$

4. (c)

We know that,phase velocity, $v_p = \dfrac{c}{\cos\theta}$

$$\text{given, } \theta = 60°$$
$$c = 3 \times 10^8 \text{ m/sec}$$
$$v_p = \frac{3 \times 10^8}{\cos 60°} = 6 \times 10^8 \text{ m/sec}$$

5. (d)

The cutoff frequency of rectangular waveguide,

$$f_c = \frac{c}{2}\sqrt{\left(\frac{m}{a}\right)^2 + \left(\frac{n}{b}\right)^2}$$

For, TM_{11} mode, $m = 1$, $n = 1$.

$$\frac{m\pi}{a} = \frac{\pi}{4} \Rightarrow a = 4 \text{ cm}$$

$$\frac{n\pi}{b} = \frac{\pi}{3} \Rightarrow b = 3 \text{ cm}$$

For TE_{11},

$$f_c = \frac{3 \times 10^{10}}{2}\sqrt{\left(\frac{1}{4}\right)^2 + \left(\frac{1}{3}\right)^2} = \frac{3 \times 10^{10}}{2}\sqrt{\frac{25}{16 \times 9}}$$

$$f_c = 6.25 \text{ GHz}$$

6. (b)

We know that,

The dominant mode is TE_{11}. Therefore, the cutoff wavelength for circular waveguide for dominant mode propagation is,

$$\lambda_c \simeq 3.46 \times (\text{radius})$$
$$\lambda_c \simeq 3.46 \times 3$$
$$\lambda_c \simeq 10.38 \text{ cm}$$

7. (d)

Given, $$\vec{E} = 2e^{-j\frac{z}{\sqrt{3}}}\hat{a}_x + je^{-j\frac{z}{\sqrt{3}}}\hat{a}_y \text{ V/m}$$

Since x-component and y-component have unequal magnitudes, the given wave is elliptically polarized.
And y-component leads x-component by 90°, it is left hand elliptically polarized wave.

8. (b)

We know that, $$\nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$$

and $$\vec{D} = \epsilon_0 \vec{E} \quad \text{(or)} \quad \vec{E} = \frac{\vec{D}}{\epsilon_0} \text{ for free space}$$

$$-\frac{\partial \vec{B}}{\partial t} = \begin{vmatrix} \hat{a}_x & \hat{a}_y & \hat{a}_z \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ \frac{10}{\epsilon_0}\sin(2\pi t + 5z) & 0 & 0 \end{vmatrix}$$

$$= \frac{10}{\epsilon_0}\frac{\partial}{\partial z}[\sin(2\pi t + 5z)]\hat{a}_y$$

$$= \frac{50}{\epsilon_0}\cos(2\pi t + 5z)\hat{a}_y$$

∴ $$\vec{B} = -\frac{50}{\epsilon_0}\int \cos(2\pi t + 5z)\hat{a}_y\, dt$$

$$\vec{B} = \frac{-50}{2\pi \times \frac{10^{-9}}{36\pi}}\sin(2\pi t + 5z)\hat{a}_y$$

$$\vec{B} = -9 \times 10^{11}\sin(2\pi t + 5z)\hat{a}_y \text{ Tesla}$$

9. (d)

For a transmission line terminated with short circuit at load end,

input impedance, $$Z_{in} = jZ_0 \tan \beta l$$

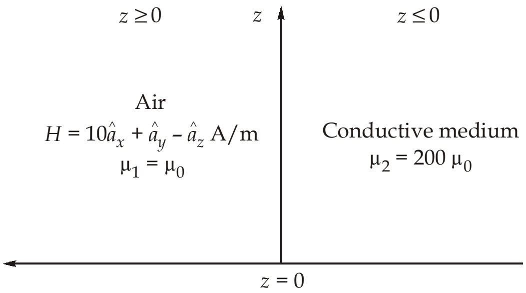
where, $$\beta = \frac{\omega}{v} = \frac{2.5\pi \times 10^7}{3 \times 10^8} = 0.262 \text{ rad/m}$$

∴ $$Z_{in} = j50 \tan(0.262 \times 2.5)$$
$$Z_{in} = j38.41\ \Omega$$

10. (a)

$$\vec{k} \cdot \vec{E} = 0$$
$$\vec{k} = 2\hat{a}_x - 4\hat{a}_y$$
$$\vec{k} \cdot \vec{E} = 2E_0 - 4 = 0$$
⇒ $$E_0 = \frac{4}{2} = 2$$

11. (d)



$$H_{1n} = -\hat{a}_z \;;\; H_{1t} = 10\hat{a}_x + \hat{a}_y$$

H_{2t} is tangential component in $Z \leq 0$.

Since,
$$H_{1t} = H_{2t} = 10\hat{a}_x + \hat{a}_y$$

$$H_{2n} = \frac{\mu_1}{\mu_2} H_{1n} \;(\because \text{ Normal components of } \vec{H} \text{ are discontinuous})$$

$$H_{2n} = \frac{1}{200}(-\hat{a}_z) = -0.005\hat{a}_z$$

$\therefore$
$$\vec{H}_2 = \vec{H}_{2n} + \vec{H}_{2t}$$

$$\vec{H}_2 = 10\hat{a}_x + \hat{a}_y - 0.005\hat{a}_z \text{ A/m}$$

$$\vec{B}_2 = \mu_2 H_2$$

$$= 200 \times 4\pi \times 10^{-7}\left[10\hat{a}_x + \hat{a}_y - 0.005\hat{a}_z\right]$$

$$\vec{B}_2 = 2.513\hat{a}_x + 0.2513\hat{a}_y - 0.00125\hat{a}_z \text{ mWb/m}^2$$

The angle made by $\vec{B}$ with the interface is

$$\tan\alpha = \frac{B_{2n}}{B_{2t}}$$

$$\alpha = \tan^{-1}\left(\frac{B_{2n}}{B_{2t}}\right) = \tan^{-1}\left(\frac{0.00125}{\sqrt{2.513^2 + 0.2513^2}}\right)$$

$$\alpha = 0.028°$$

12. (d)

Given,
$$\sigma = 5.8 \times 10^7 \text{ S/m},$$
$$\mu_r = 1, \in_r = 1$$

$$\text{Skin resistance, } R_s = \frac{1}{\sigma\delta} = \sqrt{\frac{\pi f \mu}{\sigma}}$$

$$R_s = \sqrt{\frac{\pi \times 10^8 \times 4\pi \times 10^{-7}}{5.8 \times 10^7}} = 2.60 \times 10^{-3}\,\Omega$$

13. (c)

Given, $\sigma = 0$, $\mu = 2\,\mu_0$, $\in\, = 10 \in_0$

$$J = 60\sin(10^9 t - \beta z)\hat{a}_x \text{ mA/m}^2$$

$$v_p = \frac{\omega}{\beta}$$

$$\frac{3\times10^8}{\sqrt{\mu_r \in_r}} = \frac{10^9}{\beta}$$

$$\frac{3\times10^8}{\sqrt{2\times10}} = \frac{10^9}{\beta} \Rightarrow \beta = 14.907 \text{ rad/m} \simeq 14.91 \text{ rad/m}$$

14. (b)

- Circular waveguide occupy more space for dominant mode.
- Machining the inner surface of a circular waveguide to create a specific taper or cross-section can increase manufacturing costs.
- The potential for mode dispersion in circular waveguides can cause signal distortion, particularly at higher frequencies.

15. (c)

Given,
$$E = 30\cos(\omega t - z)\hat{a}_x \text{ V/m}$$
$$\mu = \mu_0, \in = 4\in_0$$

reflection coefficient, $\Gamma = \dfrac{\sqrt{\in_{r_1}} - \sqrt{\in_{r_2}}}{\sqrt{\in_{r_1}} + \sqrt{\in_{r_2}}}$

where, $\in_{r_1} = 1$ (for air)

$\in_{r_2} = 4$ (for medium)

$$\Gamma = \frac{1-\sqrt{4}}{1+\sqrt{4}} = \frac{1-2}{1+2} = \frac{-1}{3}$$

$$\Gamma = \frac{E_r}{E_i} \Rightarrow E_r = -\frac{1}{3}E_i$$

$$E_r = -10\cos(\omega t + z)\hat{a}_x \text{ V/m}$$

Since, reflected wave is in '–z' direction

$\therefore$ $H_r = \dfrac{E_r}{\eta}$; where, $\eta = 120\,\pi$

$$H_r = \frac{-10}{120\pi}\cos(\omega t + z)(-\hat{a}_y)$$

$\therefore$ $H_r = 26.53\cos(\omega t + z)\hat{a}_y$ mA/m

16. (d)

Given, Electric field phasor, $\vec{E} = 5e^{-0.2z}e^{-j0.2z}\hat{a}_x$ V/m

$$\alpha = \beta = 0.2.$$

Hence, the medium is a good conductor.

Intrinsic impedance, $\eta = (1+j)\dfrac{\alpha}{\sigma}$

$$\eta = (1+j)\frac{0.2}{4}$$
$$= (1+j)0.05$$

$$\eta = 0.0707 e^{j45°} = |\eta| e^{j\theta_\eta}$$

the average power density, $S_{av} = \dfrac{|E_0|^2}{2|\eta|} e^{-2\alpha z} \cos\theta_\eta \cdot \hat{a}_z$

$$S_{av} = \frac{25}{2 \times 0.0707} e^{-0.4z} \cos 45° \cdot \hat{a}_z$$

$$S_{av} = 125 e^{-0.4z} \hat{a}_z \text{ W/m}^2$$

17. (c)

Given, EM wave,

$$\vec{B} = 10^{-9} \cos\left[(\pi y) + (3\pi \times 10^8)t\right] \hat{a}_x$$

The wave travels in $-\hat{a}_y$ direction.

$$\beta = \pi \text{ m}^{-1} \quad \Rightarrow \quad \lambda = \frac{2\pi}{\beta} = \frac{2\pi}{\pi} = 2 \text{ m}$$

Wave velocity, $v = \dfrac{\omega}{\beta} = \dfrac{3\pi \times 10^8}{\pi}$

$$v = 3 \times 10^8 \text{ m/sec}$$

hence the medium is free space.

$$\vec{E} \times \mu_0 \vec{H} = -\hat{a}_y$$

$\therefore$ $\quad \vec{E} \times \hat{a}_x = -\hat{a}_y$

$\therefore$ $\vec{E}$ is in $-\hat{a}_z$ direction.

$$\frac{\vec{E}}{\vec{H}} = \eta \quad \Rightarrow \quad \vec{E} = \eta \frac{\vec{B}}{\mu_0} \quad \left(\because \vec{B} = \mu_0 \vec{H}\right)$$

$$\vec{E}_o = 120\pi \times \frac{10^{-9}}{4\pi \times 10^{-7}} = 0.3 \text{ V/m}$$

$\Rightarrow$ $\quad \vec{E} = 0.3 \cos\left[(\pi y) + (3\pi \times 10^8)t\right](-\hat{a}_z) \text{ V/m}$

$\Rightarrow$ $\quad \vec{E} = -0.3 \cos\left[(\pi y) + (3\pi \times 10^8)t\right] \hat{a}_z \text{ V/m}$

18. (b)

We know that,

Radiation resistance of an antenna,

$$R_r = 80\pi^2 \left(\frac{dl}{\lambda}\right)^2$$

$$= 80\pi^2 \left(\frac{1}{50}\right)^2 = 0.316\ \Omega$$

19. (d)

We know that, the distance between the adjacent voltage maxima and minima is equal to $\frac{\lambda}{4}$.

i.e., 9 cm – 3 cm = 6 cm = $\frac{\lambda}{4}$ (or) λ = 24 cm

given, the first voltage minima, l_{min} = 3 cm = $\frac{\lambda}{8}$

i.e., $$2\beta\, l_{min} = n\pi + \theta_\Gamma$$

$$\therefore \quad 2 \times \frac{2\pi}{\lambda} \times \frac{\lambda}{8} = \pi + \theta_\Gamma$$ (for first voltage minima, n = 1)

$$\therefore \quad \theta_\Gamma = -\frac{\pi}{2}$$

$$\therefore \quad |\Gamma| = \frac{SWR - 1}{SWR + 1} = \frac{3-1}{3+1} = \frac{2}{4} = 0.5$$

hence, $$\Gamma = |\Gamma| e^{+j\theta_\Gamma} = 0.5 e^{-j\frac{\pi}{2}} = -j\,0.5$$

$$\therefore \quad Z_L = Z_0\left[\frac{1+\Gamma}{1-\Gamma}\right] = 150\left[\frac{1-j0.5}{1+j0.5}\right] = (90 - j120)\Omega$$

20. (b)

Given, frequency, f = 37.5 MHz

length, l = 5 m

$$\text{wavelength, } \lambda = \frac{c}{f} = \frac{3\times 10^8}{37.5\times 10^6} = 8 \text{ m}$$

$$\therefore \quad \text{the length of lines, } l = \frac{5\lambda}{8}$$

$$\therefore \quad \text{input impedance, } Z_{in} = Z_0\left[\frac{Z_L + jZ_0 \tan\beta l}{Z_0 + jZ_L \tan\beta l}\right]$$

$$Z_{in} = 75\left[\frac{45 + j60 + j75\tan\left(\frac{2\pi}{\lambda}\cdot\frac{5\lambda}{8}\right)}{75 + j(45+j60)\tan\left(\frac{2\pi}{\lambda}\cdot\frac{5\lambda}{8}\right)}\right]$$

$$Z_{in} = 75\left[\frac{45 + j135}{15 + j45}\right] = 225\ \Omega$$

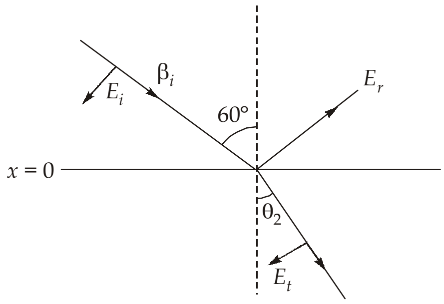
21. (d)

Given, incident electric field,

$$E_i = 50\left(\frac{\sqrt{3}}{2}\hat{a}_x - \frac{1}{2}\hat{a}_z\right)\cos\left[6\pi\times 10^9 t - 10\pi(x + \sqrt{3}z)\right]$$

The phase constant, $$\beta_i = 10\pi(x + \sqrt{3}z)$$

$$\beta_i = 20\pi\left(\frac{1}{2}\hat{a}_x + \frac{\sqrt{3}}{2}\hat{a}_z\right)$$



$$\frac{\sin\theta_1}{\sin\theta_2} = \sqrt{\frac{1.5\,\epsilon_0}{\epsilon_0}}$$

$$\Rightarrow \quad \sin\theta_2 = \sqrt{\frac{\epsilon_0}{1.5\,\epsilon_0}}\sin 60^\circ = \frac{1}{2}$$

$$\therefore \quad \theta_2 = 45^\circ$$

Since the electric field vector (which is perpendicular to β_i) is entirely in the plane of incidence. Thus, it is corresponds to parallel polarization.

Transmission coefficient for parallel polarization,

$$\tau = \frac{2\left(\frac{120\pi}{\sqrt{\epsilon_r}}\right)\cos\theta_1}{\left(\frac{120\pi}{\sqrt{\epsilon_r}}\right)\cos\theta_2 + 120\pi\cos\theta_1}$$

$$= \frac{2\left(\frac{120\pi}{\sqrt{1.5}}\right)\cos 60^\circ}{\left(\frac{120\pi}{\sqrt{1.5}}\right)\cos 45^\circ + 120\pi\cos 60^\circ}$$

$$\therefore \quad \tau = 0.758$$

$$\beta_t = 20\pi\sqrt{\epsilon_r}\left(\frac{1}{\sqrt{2}}\hat{a}_x + \frac{1}{\sqrt{2}}\hat{a}_z\right)$$

$$= 20\pi\sqrt{1.5}\left(\frac{1}{\sqrt{2}}\hat{a}_x + \frac{1}{\sqrt{2}}\hat{a}_z\right)$$

$$\beta_t = 10\sqrt{3}\pi(\hat{a}_x + \hat{a}_z)$$

$$\therefore \quad \frac{E_t}{E_i} = \tau \quad \Rightarrow \quad E_t = 0.758\,E_i$$

$$\therefore \quad E_t = 0.758\times 50\left(\frac{1}{\sqrt{2}}\hat{a}_x - \frac{1}{\sqrt{2}}\hat{a}_z\right)\cos\left(6\pi\times 10^9 t - 10\sqrt{3}\pi(x+z)\right)$$

$$= 37.9\left(\frac{1}{\sqrt{2}}\hat{a}_x - \frac{1}{\sqrt{2}}\hat{a}_z\right)\cos\left[6\pi\times 10^9 t - 10\sqrt{3}\pi(x+z)\right]$$

$$E_t = 26.79(\hat{a}_x - \hat{a}_z)\cos\left[6\pi\times 10^9 t - 10\sqrt{3}\pi(x+z)\right]\text{V/m}$$

22. (d)

Since $a > b$, the dominant mode is TE_{10}.

If free space, $$f_c = \frac{c}{2a} = \frac{3\times10^8}{2\times0.05} = 3\,\text{GHz}$$

intrinsic impedance, $$\eta_1 = \frac{\eta_0}{\sqrt{1-\left(\frac{f_c}{f}\right)^2}}$$

$$\eta_1 = \frac{377}{\sqrt{1-\left(\frac{3}{9}\right)^2}} = 399.87\,\Omega$$

In dielectric medium, $$f_c = \frac{c}{2a\sqrt{\epsilon_r}} = \frac{3\times10^8}{2\times0.05\times\sqrt{4}} = 1.5\,\text{GHz}$$

intrinsic impedance, $$\eta_2 = \frac{\eta}{\sqrt{1-\left(\frac{f_c}{f}\right)^2}}$$

$$\eta_2 = \frac{377/\sqrt{4}}{\sqrt{1-\left(\frac{1.5}{9}\right)^2}} = 191.175\,\Omega$$

$\therefore$ reflection coefficient, $$\Gamma = \frac{\eta_2-\eta_1}{\eta_2+\eta_1}$$

$$\Gamma = \frac{191.175-399.87}{191.175+399.87} = -0.353$$

$\therefore$ standing wave ratio, $$S = \frac{1+|\Gamma|}{1-|\Gamma|}$$

$\therefore$ $$S = \frac{1+0.353}{1-0.353} = 2.091$$

23. (d)

For FNBW, $U(\theta) = 0$ (or) $U(\theta)_{\theta=\theta_n} = 0$

i.e., $\cos^2(\theta_n)\cos^2(3\theta_n) = 0$

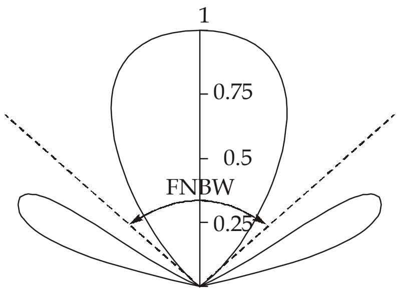
This leads to two solutions for θ_n;

$$\cos\theta_n = 0 \Rightarrow \theta_n = \cos^{-1}0 = \frac{\pi}{2}\text{rad} = 90^\circ$$

$$\cos 3\theta_n = 0 \Rightarrow 3\theta_n = \cos^{-1}0 = \frac{\pi}{2}\text{rad}$$

$$\Rightarrow \theta_n = \frac{90^\circ}{3} = 30^\circ$$

The one with the smallest value leads to the FNBW.



because of the symmetry pattern,

$$\text{the FNBW} = 2\theta_n = 2 \times 30° = 60°$$

24. **(b)**

$$P_{\text{rad}} = \int P_{\text{avg}} \cdot dS$$

$$= \frac{1}{2\eta}\int |E_\phi|^2 \, dS$$

$$= \frac{(0.1)^2 \times 10^6}{2 \times 120\pi \times (2\pi)^2}\int\int \frac{\cos^4\theta}{r^2} \cdot r^2 \sin\theta \, d\theta \, d\phi$$

$$= \frac{(0.1)^2 \times 10^6}{8 \times 120 \times \pi^3} \times 2\pi \int \cos^4\theta(-\cos\theta)\, d\theta$$

$$= \frac{0.01 \times 10^6}{4 \times 120 \times \pi^2} \times \left(-\frac{\cos^5\theta}{5}\right)_0^\pi$$

$$= \frac{10^4}{480\pi^2} \times \left(\frac{2}{5}\right) = 0.844 \text{ W}$$

25. **(b)**

Given, $E = 10\cos(3\pi \times 10^7 t - 0.2\pi x)\hat{a}_z$ V/m

$\therefore$ $\beta = 0.2\pi \Rightarrow \frac{2\pi}{\lambda} = 0.2\pi \Rightarrow \lambda = 10$ m

phase velocity, $v_p = \frac{\omega}{\beta} = \frac{3\pi \times 10^7}{0.2\pi} = 1.5 \times 10^8$ m/s

$$v_p = \frac{3 \times 10^8}{\sqrt{\epsilon_r}} = 1.5 \times 10^8$$

the refractive index, $\sqrt{\epsilon_r} = \frac{3}{1.5} = 2$

magnetic field vector, $H = \frac{E}{\eta}$

where, $\eta = \frac{120\pi}{\sqrt{\epsilon_r}} = 60\pi$

$\therefore$ $H = \frac{10}{60\pi}\cos(3\pi \times 10^7 t - 0.2\pi x)(-\hat{a}_y)$

$$H = -0.053\cos(3\pi \times 10^7 t - 0.2\pi x)\,\hat{a}_y$$

26. **(c)**

According to boundary conditions for electric field,

$$E_{t_1} = E_{t_2}$$

i.e. tangential component is continuous.

$$D_{n_1} - D_{n_2} = -\rho_s$$

If region is charge free, $\rho_s = 0$

Then, $$D_{n_1} = D_{n_2}$$

i.e. normal component of flux density is continuous across the charge free boundary.

In case of perfect conductor $E_{t_2} = 0$ since electric field does not exist inside a perfect conductor but in case of finite conductivity it can't be zero, so statement 3 is wrong.

27. **(c)**

$$\text{For TM}_{11}\text{ mode, } f_c = \frac{c}{2}\sqrt{\left(\frac{1}{a}\right)^2 + \left(\frac{1}{b}\right)^2}$$

$$\Rightarrow \quad 12 \times 10^9 = \frac{3\times10^{10}}{2}\sqrt{\left(\frac{1}{a}\right)^2 + \left(\frac{1}{b}\right)^2} \quad \text{...(i)}$$

For TE_{03} mode, $$f_c = \frac{c}{2}\sqrt{0 + \left(\frac{3}{b}\right)^2}$$

$$12 \times 10^9 = \frac{3\times10^{10}}{2}\sqrt{\frac{9}{b^2}}$$

$$\therefore \quad b = 3.75 \text{ cm}$$

from equation (i),

$$12 \times 10^9 = 1.5\times10^{10}\sqrt{\left(\frac{1}{a}\right)^2 + \left(\frac{1}{3.75}\right)^2}$$

$$\Rightarrow \quad a = 1.32 \text{ cm}$$

Since $a < b$, the dominant mode is TE_{01}. (TM_{01} an TM_{11} mode does not exist in rectangular waveguide)

28. **(a)**

We know that,

For a waveguide,

$$\text{group velocity, } v_g = v\sqrt{1 - \left(\frac{f_c}{f}\right)^2}$$

$$\therefore \quad \frac{v_g}{v} = \sqrt{1 - \left(\frac{f_c}{f}\right)^2} = \sqrt{1 - \left(\frac{f_c}{1.2 f_c}\right)^2} = 0.55$$

29. (a)

For a distortionless transmission line,

$$Z_0 = \sqrt{\frac{R}{G}} \quad \text{...(i)}$$

and $$\alpha = \sqrt{RG} \quad \text{...(ii)}$$

From equations (i) and (ii), $$\alpha = \frac{R}{Z_0} = \frac{0.5}{100} = 0.005 \text{ Np/m}$$

30. (d)

Given, $$VSWR = 3$$

$$|\Gamma| = \frac{VSWR - 1}{VSWR + 1} = \frac{3-1}{3+1} = \frac{2}{4} = \frac{1}{2} = 0.5$$

Since, the load is purely resistive, $\theta_\Gamma = 0$ or π

for $\theta_\Gamma = 0 \Rightarrow \Gamma = 0.5 \Rightarrow Z_L = Z_0\left(\frac{1+\Gamma}{1-\Gamma}\right) = 50\left(\frac{1+0.5}{1-0.5}\right)$

$\therefore$ $$Z_L = 150\ \Omega$$

for $\theta_\Gamma = \pi \Rightarrow \Gamma = -0.5 \Rightarrow Z_L = Z_0\left(\frac{1+\Gamma}{1-\Gamma}\right) = 50\left(\frac{1-0.5}{1+0.5}\right)$

$\therefore$ $$Z_L = 16.67\ \Omega$$

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