Answer

Subject - Radiation and Microwave Techniques.
(MTETC 102)

⇒ Que. 1 (a) For 8 marks

Given data $a = 1.07\ cm$
$b = 0.48\ cm$

$$f_c = \frac{c}{2\pi\sqrt{\epsilon_r}}\sqrt{\left(\frac{m\pi}{a}\right)^2 + \left(\frac{n\pi}{b}\right)^2} = 9.72\ GHz.$$

at 15 GHz, $K = 4\cancel{33}.1\ m^{-1}$

Prop. const^n for TE_{10} mode

$$\beta = \sqrt{\left(\frac{2\pi f\sqrt{\epsilon_r}}{c}\right)^2 - (\pi/a)^2} = \sqrt{K^2 - (\pi/a)^2}$$

$$= 345.1\ m^{-1}$$

attenuation due to dielectric loss

$$\alpha_d = \frac{K^2 \tan\delta}{2\beta} = 0.119\ Np/m = 1.03\ dB/m$$

surface Resistance of the copper wall is

$$\sigma = 5.8\times10^7\ S/m$$

$$R_s = \sqrt{\frac{\omega\mu_0}{2\sigma}} = 0.032\ \Omega$$

attenuation due to cond. loss.

$$\alpha_c = \frac{R_s}{a^3 b\beta k\eta}(2b\pi^2 + a^3k^2) = \cancel{0.50}$$
$$= 0.050\ Np/m = 0.434\ dB/m$$

Q 1st (b)

The scaler Helmholtz eq^n in cylindrical coordinate is given by

$$\frac{1}{r}\frac{\partial}{\partial r}\left(r\cdot\frac{\partial\psi}{\partial r}\right) + \frac{1}{r^2}\frac{\partial^2\psi}{\partial\phi^2} + \frac{\partial^2\psi}{\partial z^2} = \gamma^2\psi.$$

$$\psi = R(r)\,\Phi(\phi)\,Z(z)$$

$R(r)$ = a f^n of the r coordinate only.

$\Phi(\phi)$ = ϕ

$Z(z)$ = z

$$\frac{1}{rR}\frac{\partial}{\partial r}\left(r\cdot\frac{\partial R}{\partial r}\right)+\frac{1}{r^2\Phi}\frac{\partial^2\Phi}{\partial\phi^2}+\frac{1}{Z}\frac{\partial^2 Z}{\partial z^2}=\gamma^2$$

Since the sum of three independent term is constant. each of the three term is also equal to constant.

$$\frac{\partial^2 Z}{\partial z^2}=\gamma_g^2 Z \qquad \therefore \boxed{Z=A\cdot e^{-\gamma_g z}+B\cdot e^{\gamma_g z}}$$

γ_g = Prop. const^n of the guide

$$\frac{r}{R}\frac{\partial}{\partial r}\left(r\cdot\frac{\partial R}{\partial r}\right)+\frac{1}{\Phi}\frac{\partial^2\Phi}{\partial\phi^2}-(\gamma^2-\gamma_g^2)r^2=0$$

$$\therefore \frac{\partial^2\Phi}{\partial\phi^2}=-n^2\Phi$$

$$r\frac{\partial}{\partial r}\left(r\cdot\frac{\partial R}{\partial r}\right)+\left[(k_c r)^2-n^2\right]R=0 \qquad \boxed{\Phi=A_n\sin n\phi+B_n\cos n\phi}$$

$$\therefore \boxed{R=C_n J_n(k_c r)+N_n(k_c r)}$$

$$\Psi=\left[C_n\cdot J_n(k_c r)+N_n(k_c r)\right]\left[A_n\sin n\phi+B_n\cos n\phi\right]\cdot e^{\pm j\beta_g z}$$

Sol^n of boundary cond. $\Rightarrow$ $N_n=0$

and $A_n\sin n\phi+B_n\cos n\phi=\sqrt{A_n^2+B_n^2}\cos\left[n\phi+\tan^{-1}\frac{A_n}{B_n}\right]$

$=F_n\cdot\cos n\phi$.

$$\boxed{\Psi=\Psi_0 J_n(k_c r)\cos n\phi\cdot e^{-j\beta_g z}}$$

Additional

- diagram of cylindrical W/G. coordinate
- Bessel's E^n wave for $\cos(k_c r)$ and $\sin(k_c r)$
- Detail boundary condition.

Q 2nd

(a) $\bar{Z}_L = \frac{Z_L}{Z_0} = \frac{1+\Gamma_L}{1-\Gamma_L} = 1.643 + j\,01.23 = R + jX$

$X = L\omega = j\,1.23$

Inductance $L = 1.23/\omega$ $\quad f = 1000\,MHz.$

$= 195\,pH.$

(b) standing wave ratio

$\rho = 3$ and $\rho = 5.8$

(c) $\left|\frac{J_c}{J_d}\right| = \frac{\sigma}{\omega\epsilon} = 10$ $\quad \omega = \frac{\sigma}{10\epsilon}$

$f = \frac{\sigma}{2\pi \times 10\epsilon} = 0.44\,GHz.$

(d) Complex pointing theorem.

$P_{in} = \langle P_d \rangle + j2\omega\left[\langle W_m - W_e \rangle\right] + P_{tr}.$

- statement and Defination
- Proof.