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DEPT: Elect/Elect

QUESTION 4

a) In reference $\frac{d^2 E_y}{dx^2} = (j\omega\mu_0\epsilon_0 - \omega^2\mu_0\epsilon_0) = \gamma^2 E_y$

$$\frac{d^2 E_y}{dx^2} = \gamma^2 E_y$$

$$\gamma = \alpha + j\beta$$

$$E_y = E_0 e^{-\gamma x} = E_0 e^{-\alpha x} e^{-j\beta x}$$

$$\frac{d^2 E_y}{dx^2} = j\omega\mu_0\epsilon_0 E_y = \gamma^2 E_y$$

from $\sqrt{2} = 1 + j$

we then $\gamma^2 = \frac{j\omega\mu_0\epsilon_0}{2} + j\frac{j\omega\mu_0\epsilon_0}{2}$

$\therefore E_y = E_0 e^{-\frac{\sqrt{j\omega\mu_0\epsilon_0}}{2} x} e^{-\frac{j\sqrt{j\omega\mu_0\epsilon_0}}{2} x}$

$$\alpha = \frac{\sqrt{j\omega\mu_0\epsilon_0}}{2} \quad \text{and} \quad \beta = \frac{j\sqrt{j\omega\mu_0\epsilon_0}}{2}$$

$$\therefore E_y = E_0 e^{-\frac{\sqrt{j\omega\mu_0\epsilon_0}}{2} x} \cdot e^{-\frac{j\sqrt{j\omega\mu_0\epsilon_0}}{2} x}$$
$$= E_y = E_0 e^{-x/\delta} \cdot e^{-jx/\delta}$$

The amplitude of the wave decreases rapidly and exponentially as it passes through a conducting medium by a factor of $e^{-x/\delta}$

(b) Skin depth is a measure of how closely electric current flows along the surface of a material. At

$$\delta = \frac{2}{\sqrt{j\omega\mu_0\epsilon_0}} \quad \omega = 2\pi f$$

$$\delta = \sqrt{\frac{Z}{Z \times f \mu \epsilon}} = \sqrt{\frac{1}{\pi f \mu \epsilon}}$$

(c) $f = 10 \text{ MHz} = 1 \times 10^7 \text{ Hz}$

$$\delta = 5.8 \times 10^7 \text{ s/m}$$

$$N_r = 1$$

$$N_o = 1.257 \times 10^{-6}$$

$$\mu = \mu_o \times \mu_r$$

$$= 1 \times 1.257 \times 10^{-6}$$

$$= 1.257 \times 10^{-6}$$

$$= 1.257 \times 10^{-6}$$

$$\delta = \text{Skin depth} = \sqrt{\frac{1}{\pi f \mu \epsilon}}$$

$$= \sqrt{\frac{1}{\pi \times 1 \times 10^7 \times 1.257 \times 10^{-6} \times 5.8 \times 10^7}}$$

$$\delta = 2.09 \times 10^{-6} \text{ m}$$

QUESTION 7

(a) $a = 3 \text{ mm}$, $b = 10 \text{ mm}$, $\epsilon_o = 8.85 \times 10^{-12} \text{ f/m}$, $\mu_o = 1.257 \times 10^{-6} \text{ H/m}$

$$a = 0.03 \text{ m} \quad b = 0.01 \text{ m}$$

capacitance per meter

$$C = \frac{2\pi \epsilon_o}{\log_e \frac{b}{a}}$$

$$C = \frac{2\pi \times 8.85 \times 10^{-12}}{\log_e \frac{0.01}{0.03}}$$

$$= \frac{2\pi \times 8.85 \times 10^{-12}}{\log_e 28.03}$$

$$C = 3.84 \times 10^{-11} \text{ f/m}$$

(b) L-inductance parameter

$$L = \frac{\mu_0}{2\pi} \log_e \frac{b}{a}$$

$$L = \frac{1.257 \times 10^{-6}}{2\pi} \log_e \frac{0.01}{0.003}$$

$$= \frac{1.257 \times 10^{-6}}{2\pi} \log_e 28.03$$

$$L = 2.90 \times 10^{-7} \text{ H/m}$$

(c) The characteristic impedance

$$Z_0 = \sqrt{\frac{L}{C}}$$

$$Z_0 = \sqrt{\frac{2.90 \times 10^{-7}}{3.84 \times 10^{-11}}}$$

$$Z_0 = 86.90 \Omega$$

(d) Phase velocity V_p

$$V_p = \frac{1}{\sqrt{LC}}$$

$$V_p = \frac{1}{\sqrt{(2.90 \times 10^{-7}) \times (3.84 \times 10^{-11})}}$$

$$V_p = 299664563.4$$

$$= 29.10 \times 10^7 \text{ V}$$