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17/ENG04/071
ELECT /ELECT

QUESTION 4

a) In reference $\frac{\partial^2 E_y}{\partial x^2} = (j\omega\mu\sigma - \omega^2\mu\varepsilon) = \gamma^2 E_y$

$$\frac{\partial^2 E_y}{\partial x^2} = \gamma^2 E_y$$

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

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

$$\frac{\partial^2 E_y}{\partial x^2} = j\omega\mu\sigma E_y = \gamma^2 E_y$$

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

we then $\gamma = \sqrt{\frac{\omega\mu\sigma}{2}} + j\sqrt{\frac{\omega\mu\sigma}{2}}$

~~$\therefore E_y = E_0 e^{-\sqrt{\frac{\omega\mu\sigma}{2}}} e^{-\sqrt{\frac{\omega\mu\sigma}{2}}x}$~~

$\alpha = \sqrt{\frac{\omega\mu\sigma}{2}}$ and $\beta = \sqrt{\frac{\omega\mu\sigma}{2}}$

$$\therefore E_y = E_0 e^{-\sqrt{\frac{\omega\mu\sigma}{2}}x} \cdot e^{-j\sqrt{\frac{\omega\mu\sigma}{2}}x}$$

$$= E_y = E_0 e^{-x/\delta} \cdot e^{-jx/\delta}$$

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 flow along the surface of a material. At

$$\delta = \sqrt{\frac{2}{\omega\mu\sigma}} \qquad \omega = 2\pi f$$

$$\delta = \sqrt{\frac{\pi}{\pi \pi f \mu \sigma}} = \sqrt{\frac{1}{\pi f \mu \sigma}}$$

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

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

$\mu_r = 1$

$\mu_0 = 1.257 \times 10^{-6}$

$\mu = \mu_0 \times \mu_r$

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

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

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

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

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

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

QUESTION 7

(a) $a = 3mm$, $b = 10mm$, $\varepsilon_0 = 8.85 \times 10^{-12} f/m$, $\mu_0 = 1.257 \times 10^{-6} H/m$

$a = 0.03m$ $b = 0.01m$

capacitance per metor

$$C = \frac{2\pi\varepsilon_0}{\log_e b/a}$$

$$C = \frac{2\pi \times 8.85 \times 10^{-12}}{\log_e \frac{0.01}{0.003}}$$

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

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

Scanned with CamScanner

(b) L - inductance parameter

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

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

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

$$l = 2.90 \times 10^{-7} \; H/m$$

(c) The characteristic impedance

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

$$Z_0 = \sqrt{\frac{2.90 \times 10^{-7}}{5.84 \times 10^{-11}}}$$

$$Z_0 = 86.90\Omega$$

(d) Phase velocity $V_p$

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

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

$$V_p = 2\,996645634$$

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