

Iwatt Enobong udo ~~hatt~~
181 Eng 04/080
Electrical / Electronics
EEE 316 (4)

$$a) \text{ From ; } \frac{\partial^2 E_y}{\partial x^2} = (j\omega M\sigma - \omega^2 M\epsilon) E_y$$

$$\text{we have } \rightarrow \frac{\partial^2 E_y}{\partial x^2} = \gamma^2 E_y$$

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

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

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

$$\text{or } \gamma^2 = j\omega M\sigma$$

$$\gamma = \sqrt{j\omega M\sigma} = \alpha + j\beta$$

$$\text{from } * \frac{1+j}{\sqrt{2}}$$

$$\rightarrow \text{we have; } \gamma = \sqrt{\frac{\omega M\sigma}{2}} + j\sqrt{\frac{\omega M\sigma}{2}}$$

$$\rightarrow \alpha \equiv \sqrt{\frac{\omega M\sigma}{2}} \quad \text{and} \quad \beta \equiv \sqrt{\frac{\omega M\sigma}{2}}$$

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

$$\therefore \text{we have; } \rightarrow E_y = E_0 e^{-\frac{x}{\delta}} e^{-j\frac{x}{\delta}}$$

This shows that the amplitude of the wave decreases exponentially as it penetrates a conducting medium by a factor $e^{-\frac{x}{\delta}}$.

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b) Skin depth " δ " is defined as the depth of penetration of a wave inside a conductor

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

$$\text{and } \omega = 2\pi f$$

$$\therefore \delta = \sqrt{\frac{2}{2\pi f \mu \sigma}} = \sqrt{\frac{1}{\pi f \mu \sigma}}$$

$$\therefore \delta = \sqrt{\frac{2}{\omega \mu \sigma}} \quad \text{or} \quad \sqrt{\frac{1}{\pi f \mu \sigma}}$$

c) $f = 10 \text{ MHz} \approx 1 \times 10^7 \text{ Hz}$
 $\sigma = 5.8 \times 10^7 \text{ S/m}$, $\mu_r = 1$, $\mu_0 = 1.257 \times 10^{-6}$

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

$$\mu = \mu_r \times \mu_0 = 1 \times 1.257 \times 10^{-6} \\ = 1.257 \times 10^{-6}$$

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

$$\delta = 2.09 \times 10^{-5} \text{ m} \dots$$

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$$b \approx 10 \text{ mm}, \quad a = 3 \text{ mm}, \quad \epsilon_0 = 8.85 \times 10^{-12} \text{ F/m}$$

$\approx 0.01 \text{ m} \quad \approx 0.003 \text{ m} \quad \mu_0 = 1.257 \times 10^{-6} \text{ H/m}$

(a)

Capacitance per meter, C

$$C = \frac{2\pi \epsilon_0}{\log_e \frac{b}{a}}$$

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

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

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

(b)

Inductance per meter, L

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

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

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

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

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Characteristic impedance, Z_0

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

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

$$Z_0 = 86.90 \Omega //$$

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Phase Velocity, V_p

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

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

$$V_p = \cancel{8.98 \times 10^{16} \text{ V}}$$

$$V_p = 299664563.4$$

$$\approx 29.10 \times 10^7 \text{ V} //$$