Electromagnetic Waves IA-3

NAME: YASHVARDHAN SINGH
SEM/BRANCH: III RD - Electronics Engg. VLSI Design & Tech.
REG. No.: 230959136
ROLL NO.: 46
SIGN: yv

Q1.

(a) $\beta = \frac{2\pi}{\lambda} = \frac{2\pi \times 9375\times10^6 \times \sqrt{2.55}}{3\times10^8} = 313.54 \text{ rad/m}$

(b) $\lambda = \frac{c}{f\sqrt{\epsilon_r}} = \frac{3\times10^8}{9375\times10^6 \times \sqrt{2.55}} = 0.02 m$

(c) $v = \frac{c}{\sqrt{\epsilon_r}} = \frac{3\times10^8}{\sqrt{2.55}} = 187.867\times10^6 m/s$

(d) $\eta = \frac{\eta_0}{\epsilon_r} = \frac{377\Omega}{\sqrt{2.55}} = 236.086\,\Omega$

(e) $\vec{H} = \frac{\vec{E_0}}{\eta} = \frac{20}{236.086} = 0.0847 A/m$

Q2.

$\lambda_1 = 0.2 m \qquad \lambda_2 = 0.09 m$

$\mu_r = 1, \quad \epsilon_r = ?$

$\lambda_2 = \lambda_1/\sqrt{\epsilon_r} \Rightarrow \epsilon_r = \left(\frac{\lambda_1}{\lambda_2}\right)^2 = \left(\frac{0.2}{0.09}\right)^2 = 4.93$

$V_d = \frac{c}{\sqrt{\epsilon_r}} = \frac{3\times10^8}{\sqrt{4.93}} = 1.3511\times10^8 m/s$

Yashwardhan Singh
230959136
VLSI – 46

Q3. given:

$E = 10 \ V/m$

$\mu_r = 1$

$\varepsilon_r = 20$

$\sigma = 0.5 \ S/m$

to find:

amplitude of E at a distance of 10 cm inside the medium for frequencies of:

(a) 5 MHz:

$$\omega = 2\pi f = 3.1415 \times 10^7 \ rad/s$$

$$\frac{\sigma}{\omega \varepsilon_r \varepsilon_0} = 89.88$$

$$1 + \left(\frac{\sigma}{\omega \varepsilon_r \varepsilon_0}\right)^2 = 8079.427$$

$$\sqrt{8079.427 - 1} = 88.8856$$

$$\alpha = 3.1415 \times 10^7 \sqrt{\frac{4\pi \times 10^{-7} \times 20 \times 8.854 \times 10^{-12}}{2} \times \sqrt{88.88}}$$

$$\boxed{\alpha = 3.12411}$$

now, $E_z = E_0 e^{-\alpha z}$

$= 10 e^{-3.12411 \times 0.1}$

$= 7.316 \ V/m$ → for $f = 5 MHz$

$= 10 \times e^{-9.397 \times 0.1}$

$= 3.907 \ V/m$ → for $f = 50 MHz$ (calculation ahead)

$= 10 e^{-19.45 \times 0.1}$

$= 1.429 \ V/m$ → for $f = 500 MHz$ (calculation ahead)

Yashvardhan Singh
230959136
VLSI - 46

at 50 MHz,

$$\omega = 2\pi f = 3.1415 \times 10^8 \text{ rad/s}$$

$$\frac{\sigma}{\omega \varepsilon_r \varepsilon_0} = \frac{0.5}{3.1415 \times 10^7 \times 8.854 \times 10^{-12}} = 8.988$$

$$1 + \left(\frac{\sigma}{\omega \varepsilon_r \varepsilon_0}\right)^2 = 81.7842$$

$$\sqrt{1 + \left(\frac{\sigma}{\omega \varepsilon_r \varepsilon_0}\right)^2} = 9.0434$$

$$9.0434 - 1 = 8.0434$$

$$\alpha = 3.1415 \times 10^8 \sqrt{\frac{4\pi \times 10^{-7} \times 20 \times 8.854 \times 10^{-12}}{2} \times 8.0}$$

$$\alpha = 9.397$$

at 500 MHz,

$$\omega = 3.14159 \times 10^9 \text{ rad/s}$$

$$\frac{\sigma}{\omega \varepsilon_0 \varepsilon_r} = 0.8987$$

$$\left(\sqrt{1 + \left(\frac{\sigma}{\omega \varepsilon_0 \varepsilon_r}\right)^2}\right)^2 = 1.80779$$

$$\sqrt{1.80779} - 1 = 0.3445$$

$$\alpha = 19.45$$

final values for E:

1. at $f = 5$ MHz $\rightarrow$ 7.316 V/m
2. at $f = 50$ MHz $\rightarrow$ 3.907 V/m
3. at $f = 500$ MHz $\rightarrow$ 1.429 V/m

yashvardhan Singh
230959136
VLSI – 46

Q4] $E(z,t) = 0.2\cos(\omega t - 6.5z)\, a_x$ V/m

(a) $\lambda = \frac{2\pi}{k} = 0.967$ m

$v = f\lambda \Rightarrow f = \frac{3\times10^8}{0.967} = 310.37\times10^6$ Hz

$\omega = 2\pi f = 1949\times10^6$ rad/s

(b) at $z = 0$,

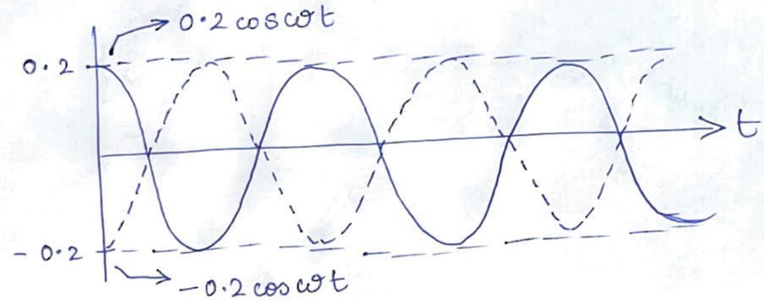
$E(z,t) = 0.2\cos\omega t$

at $z = \lambda/2$

$E(z,t) = 0.2\cos\omega t - 3.1427$

$= 0.2\cos(\omega t - \pi)$

$= -0.2\cos(\omega t)$



$H(z,t) = \frac{E(z,t)}{\eta} = 5.305\times10^{-4} \times \cos(\omega t - 6.5z)$

Q5] $\mu = 750\mu_0$
$\epsilon = 5\epsilon_0$
$\sigma = 10^{-6}$ S/m
$f = 10$ MHz

(a) $\sigma \neq 0 \neq \infty$
↳ not lossless or conducting.
$\sigma = 1\times10^{-6}$ S/m
$\because \tan\delta = \frac{\sigma}{\omega\epsilon} = 3.595\times10^{-4}$
$\therefore$ lossy.

(b) $\beta = 2\pi f\sqrt{\mu\epsilon} = 12.83$ rad/m

$\lambda = \frac{2\pi}{\beta} = 0.489$ m

(c) $k = \frac{2\pi}{\lambda} = \frac{\Delta\phi}{d} = 25.698°$

(d) $\eta = \sqrt{\frac{\mu_0\mu_r}{\epsilon_0\epsilon_r}} = 4614.0341\ \Omega$