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EMD HW-2

(1) $H = 0{,}2 \cdot \cos(wt - Bx) \cdot \vec{e_z}$

$P_{avg} = \frac{1}{2\eta}(E_0)^2 \cdot \vec{e_p}$

(a) $x+y=2$ side av. pow.

$E = (\vec{H} \times \vec{n}) \cdot \eta_0 \Rightarrow (0{,}2 \cdot \cos(wt - Bx) \cdot \vec{e_z} \times (\vec{e_x})) \cdot 120\pi$

$E = 75{,}398 \cdot \cos(wt - Bx) \cdot \vec{e_y}$

$P_{avg} = \frac{(75{,}398)^2}{240\pi} = 7{,}3411 \cdot \vec{e_x}$, $x+y=2$, $\frac{\vec{e_x} + \vec{e_y}}{2\sqrt{2}}$

$P = \frac{7{,}3411}{2\sqrt{2}} \cdot 10^{-2} = 2{,}595 \cdot 10^{-2}$ watt

(b) $\pi r^2 \Rightarrow 16 \cdot 10^{-4} \cdot \vec{e_x} \cdot 7{,}3411 = 0{,}0117$ watt

Scanned with CamScanner

2) $\vec{E} = 120\cos(10^9 t + 7x).\vec{e_z}$

a) $\beta = w.\sqrt{\mu.\varepsilon} \Rightarrow 7 = 10^9.\sqrt{\mu_0\varepsilon_0}.\sqrt{\varepsilon_r} \Rightarrow \varepsilon_r = \dfrac{49}{10^{18}.\mu_0\varepsilon_0} \rightarrow \frac{1}{c^2}$

$\varepsilon_r = \dfrac{49.c^2}{10^{18}} = \dfrac{49.9.10^{16}}{10^{18}} = \dfrac{441}{100} = \boxed{4{,}41 = \varepsilon_r}$

b) $\eta = \sqrt{\dfrac{\mu}{\varepsilon}} = \eta_0.\sqrt{\dfrac{\mu_r}{\varepsilon_r}} = \eta_0\sqrt{\dfrac{1}{\varepsilon_r}} = 120\pi\Omega.\sqrt{\dfrac{1}{4{,}41}} \cong \boxed{179{,}52\ \Omega}$

c) $V_p = \dfrac{w}{\beta} = \dfrac{10^9}{7} \cong 1{,}42.10^8\ m/sn$

d) $\vec{H} = \dfrac{1}{\eta}.(\vec{n}\times\vec{E}) = \dfrac{1}{179{,}52}.\ 120.\cos(10^9 t + 7x).(\vec{e_x}\times\vec{e_z})$

$\vec{H} = 0{,}668.\cos(10^9 t + 7x).\vec{e_y}$

e) $\mathcal{P} = \dfrac{1}{\mu_0}.\vec{E}\times\vec{H} = \dfrac{1}{4\pi.10^{-7}}.(120\cos(10^9 t+7x).\vec{e_z})\times(0{,}668.\cos(10^9 t+7x).\vec{e_y})$

$\mathcal{P} = 6{,}378.10^7\ \vec{e_x}\ .\cos^2(10^t + 7x)$

③ $\vec{H_i} = 5\cos(10^8 t - \beta z).\vec{e_x}$ $\quad \varepsilon = 2{,}65.\varepsilon_0,\ \mu = 5{,}5.\mu_0$

$\eta = \eta_0.\sqrt{\frac{5{,}5}{2{,}65}} = 120\Omega\pi.\sqrt{\frac{5{,}5}{2{,}65}} = 543{,}112$

$H \times n = \vec{e_x} \times \vec{e_z}$

So $E_i = 543{,}112.\ 5\cos(10^8 t - \beta z)(\vec{-e_y})$

$E_i = 2715{,}56.\cos(10^8 t - \beta z).(-\vec{e_y})$

$E_r = 488{,}80.\cos(10^8 t + \beta z).(-\vec{e_y})$

$E_t = 3204{,}36.\cos(10^8 t - \beta z).(-\vec{e_y})$

$\Gamma_{constant} = \frac{\eta_2 - \eta_1}{\eta_2 + \eta_1} = \frac{543{,}112 - 376{,}99}{543{,}112 + 376{,}99}$

$\Gamma_{constant} = \frac{166{,}122}{920{,}103} = 0{,}18$

$H_r = \frac{488{,}80}{376{,}99}.\cos(10^8 t + \beta z).(-\vec{e_x})$

$H_t = \frac{3204{,}36}{543{,}112}.\cos(10^8 t - \beta z).\vec{e_x}$

④ $E = 50\sin(\omega t - 5x).\vec{e_y}$ $(\mu = 4\mu_0, \varepsilon = \varepsilon_0) \Rightarrow (\mu = \mu_0, \varepsilon = 4\varepsilon_0, \sigma = 0{,}1)$

In lossless medium

$v_p = \frac{1}{2\sqrt{\mu\varepsilon}} = \frac{c}{2}$, $\lambda = \frac{2\pi}{\beta} = 0{,}4\pi = \lambda$, $f = \frac{v_p}{\lambda} \Rightarrow \frac{1{,}5.10^8}{0{,}4.\pi} = 1{,}19.10^8$

So $\omega = 2.\pi.\,1{,}19.10^8$ and $\eta_1 = 2.120\pi = 240\pi\,\Omega$ (μ_0)

$\Rightarrow$ Medium 2

$\mu_0 = 4\pi 10^{-7}$
$\varepsilon_0 = \frac{10^{-9}}{36\pi}$

$$\eta_2 = \sqrt{\frac{j\omega\mu_2}{\sigma + j\omega\varepsilon_2}} = \sqrt{\frac{j.\,2{,}38\pi.10^8.\,\mu_0}{0{,}1 + j\,2{,}38\pi.10^8.4\varepsilon_0}}$$

$$\eta_2 = \sqrt{\frac{j.\,2{,}38\pi.10.4.\pi.}{0{,}1 + j.2{,}38\pi.\frac{10^{-1}}{36\pi}.4}} = \sqrt{\frac{234{,}896j}{0{,}1 + 0{,}02644.j}}$$

$(0{,}1 - 0{,}02644j)$

$$\eta_2 = \sqrt{\frac{(234{,}896j)\,[0{,}1 - 0{,}02644j]}{0{,}01 + 0{,}00069}} \Rightarrow \eta_2 = \sqrt{\frac{23{,}4896j + 6{,}21158}{0{,}01069}}$$

$$\eta_2 = \sqrt{2197{,}3.j + 581{,}064}$$

$$\eta_2 = \sqrt{581{,}064}.\sqrt{1 + 3{,}78j} \rightarrow \sqrt{581{,}064}.\sqrt{15{,}288}.\,e^{j\frac{5\pi}{24}} = 3{,}909.(1 + 0{,}768j)$$

arctan$(3{,}78) = 75{,}18$ so $\eta_2 = 24{,}105.\,3{,}909.(1 + 0{,}768j)$

$\eta_2 = 94{,}226 + 72{,}366j$

$$\Gamma = \frac{94{,}226 + 72{,}366j - 753{,}982}{94{,}226 + 72{,}366j + 753{,}982}$$

$$\Gamma = \frac{72{,}366j - 659{,}756}{72{,}366j + 848{,}208}$$ ... bored

$$\Gamma = \frac{(-659{,}756 + 72{,}366j).(848{,}208 - 72{,}366j)}{5236{,}837 + 719456{,}81} = -0{,}76497 + 0{,}1505j$$

$\Rightarrow |\Gamma| \angle 168{,}87$

$\Gamma \Rightarrow 0{,}60783 \angle 168{,}87$

$Z = \Gamma + 1 = 0{,}23533 + 0{,}1505j \Rightarrow Z = 0{,}078 \angle 32.6$

Volt. wave ratio

$$\Rightarrow \frac{1 + 0{,}6078}{1 - 0{,}6078} = \frac{1{,}6078}{0{,}3922} = 4{,}0994$$

(b) E_r and H_r

$\hookrightarrow \left|\frac{E_i}{\Gamma}\right| = |E_r|$ $\qquad E_r = 82{,}264 . \sin(\omega t + 5x - 168{,}87) . \vec{e_y}$

$-\vec{e_x} \times \vec{e_y} = (-\vec{e_z})$

$|H| = \left|\frac{E_r}{\eta}\right| \Rightarrow$ $\qquad H_r = 0{,}1091 . \sin(\omega t + 5x - 168{,}87) . (-\vec{e_z})$