University of Technology

Department of Laser&Optoelectronics Engineering.

Final Examination 2011-2012

Subject: communication & propagation	***Class:*** *3rd year*
Division: Laser & Optoelectronics Eng.	***Time: 3 hours***
Examiner: T. Al-Zain	***Date:*** */ /2012*

Answer only five questions

Q 1: a) Determine the followings from the FM voltage:

$e = 12\,sin(18.84x10^8\,t + 6\,sin\,1250t)$. (1) Amplitude voltage, (2) f_c, f_m, (3) Modulation index and B.W, (4) total instantaneous value of the FM voltage equation. (6 Marks)

b) Calculate the total attenuation in dB and the attenuation coefficient if the load current equal to 20 % from the input current, where the line is matched with the load, the line long 2km, then write the propagation constant equation if the frequency (3 MHz). (6 Marks)

Q 2: Find the voltage reflection coefficient if $Z_L = (100 + j100)\,\Omega$, $Z_o = 50\,\Omega$ and current received at a distance 8m from the sending end, given that the applied voltage (100) v. (12 Marks)

Q 3: Find the intrinsic impedance (Z_o) and propagation constant γ of T.L. if $R = 60\,\Omega, L = 2\,mH, G = 80\,\mu sem, C = 0.1\,\mu F, \omega = 5\,k\,rad/sec.$ (12 Marks)

Q 4: For Maxwell's equation, find $\nabla xH = E(\sigma + j\omega\varepsilon)$, then by using this formula find the wave equation in a conducting medium. (12 Marks)

Q 5: A satellite at a distance 40000 Km from a point on the earth's surface radiates a power of 2W from an antenna with a gain of 17 dB in the direction of observer. Find the flux density (P_d) at the receiving point and the power received by an antenna in (dB) with an effective area σ =10 m^2 and path loss in (dB/km), the frequency (11 GHz), suppose $G_r = G_t$. (12 Marks)

Q 6: a) Find the equation of power flow and where the energy stored. (6 Marks)

b) Find the equation of total modulation depth for two signals V_1 and V_2 at the same time on the carrier V_c. (6 Marks)

$I_s = \frac{E_s}{Z_o} = \frac{100}{50} = 2$ Amp.

$I_{RS} = \frac{E_R}{Z_o} = \frac{1.351\angle -141.248^\circ}{50\angle 0} = 0.027\angle -141.248^\circ$

Q3: $Z_o = \sqrt{\frac{Z}{Y}}$, $Z = R + j\omega L = 60 + j5\times10^{3}\times 2\times10^{-3} = 60 + j10$

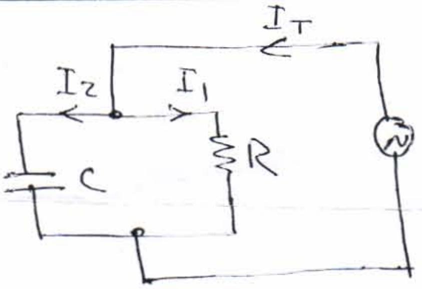
$Y = G + j\omega C = 80\times10^{-6} + 5\times10^{3}\times 0.1\times10^{-6} = 80\times10^{-6} + j5\times10^{-4}$

$Z_o = \sqrt{\frac{60+j10}{80\times10^{-6}+j5\times10^{-4}}} = \sqrt{\frac{60.83\angle 9.46}{5.06\times10^{-4}\angle 80.9}} = 346.7\angle -35.72^\circ$

$\gamma = \sqrt{(60.83\angle 9.46)(5.06\times10^{-4}\angle 80.9)} = 17.54\times10^{-2}\angle 45.18$

$\gamma = 0.175\angle 45.18$

Q4: from the RC cct. $I_1 = \frac{V}{R}$



$I_2 = \frac{\partial Q}{\partial t} = C\frac{\partial V}{\partial t}$, where $Q = CV$,
Q is the charge capacitor,
I_1 = conduction current,
I_2 = displacement current. The current does not flow in the capacitor, $J_1 = \frac{I_1}{A}$, where A = cross section area of the wire, J_1 = conduction current density.
$\therefore J_1 = \sigma E$, where σ = conductivity of the medium.
$C = \epsilon\frac{S}{h}$, Where S = Cross section area of plates of capacitor, h = distance between plates,
ϵ = permittivity $(8.85\times10^{-12}\,F/m)$, But $E = \frac{V}{h}$
$\therefore I_2 = \frac{\epsilon S \cancel{h}}{\cancel{h}}\frac{dE}{dt}$, $J_2 = \frac{I_2}{S} = \frac{\epsilon \cancel{S}}{\cancel{S}}\frac{\partial E}{\partial t} = \epsilon\frac{\partial E}{\partial t}$.
But $D = \epsilon E$, where D = electric flux density,
$\therefore J_{total} = J_1 + J_2 = \sigma E + \epsilon\frac{\partial E}{\partial t} = \sigma E + \frac{\partial D}{\partial t}$,
$D = e^{j\omega t}$, $\frac{\partial D}{\partial t} = j\omega e^{j\omega t} = j\omega D$, $\therefore \nabla\times H = \sigma E + j\omega D =$
$= \sigma E + j\omega\epsilon E = E(\sigma + j\omega\epsilon)$

① — $\frac{\text{تخزين}}{(3)}$

أجوبة النموذج الثاني

Q1: a. from the equation $e = A \sin(\omega_c t + \frac{\Delta\omega}{\omega_m} \sin \omega_m t)$

(1) The amplitude voltage $= \underline{12\ volt}$.

(2) $f_c = \frac{\omega_c}{2\pi} = \frac{18.84 \times 10^8}{2\pi} = \underline{300}\ MHZ$

$f_m = \frac{\omega_m}{2\pi} = \frac{1250}{2\pi} = \underline{199}\ HZ$

(3) $m_f = \underline{6}$, $\therefore 1 < m_f < 20$, $B.W = 2(\Delta f + f_m)$,

$\Delta f = m_f * f_m = 6 \times 199 = 1194\ HZ$,

$\therefore BW = 2(1194 + 119) = 2786 = 2.786\ KHZ$

(4) $e = A \sin\theta(t)$, Where A = amplitude voltage

$\theta(t)$ = phase angle (rad.), $\therefore e = A \sin(\omega_c t + m_f \sin \omega_m t)$

B. $N = -\ln\left|\frac{I_L}{I_{in}}\right| = -\ln\left|\frac{20}{100}\right| = 3.9$ neper $* 8.686 = 33.875$ dB

$\alpha = \frac{N}{x} = \frac{3.9}{2 \times 10^3} = 0.002$

$\beta = \frac{2\pi}{\lambda}$, $\lambda = \frac{c}{f} = \frac{3 \times 10^8}{3 \times 10^6} = 0.01\ m$

$\therefore \beta = \frac{2\pi}{0.01} = 628\ rad/sec.$,

$\therefore \gamma = \alpha + j\beta = 0.002 + j628$

Q2: $\Gamma = \frac{Z_L - Z_0}{Z_L + Z_0} = \frac{(100 + j100) - 50}{100 + j100 + 50} = \frac{(50 + j100)}{(150 + j100)} = \frac{111.8 \angle 63.43}{180.28 \angle 33.69}$

$\Gamma = 0.62 \angle 29.74^\circ$, $\alpha = \gamma \cos\theta$, $\beta = \gamma \sin\theta$

$\alpha = 0.62 \cos 29.74 = 0.538$ | $\alpha_8 = 0.538 \times 8 = 4.304$ neper

$\beta = 0.62 \sin 29.74 = 0.308$ | $\beta_8 = 0.308 \times 8 = 2.464$ rad.

$e^{\alpha + j\beta} = \frac{E_s}{E_R}$, $e^{4.304} \angle 2.464 = \frac{100}{E_R}$, $E_R = \frac{100}{73.995 \angle 2.464}$

$E_R = 1.351 \angle -2.464\ rad. = 1.351 \angle -141.248^\circ$

from Ampen's law $\oint H.dl = I_T = \int_s J_T \cdot ds = \int_s (J_c + J_D) \cdot ds =$ (3)

$= \int_s [\sigma E + \frac{\partial D}{\partial t}] \cdot ds$. By application of Stocks theorem the Maxwell equations in differential form $\nabla \times H = J_c + \frac{\partial D}{\partial t}$

$\therefore \nabla \times H = \epsilon \frac{\partial E}{\partial t} + \sigma E$, $\nabla \times \nabla \times H = \epsilon \frac{\partial}{\partial t}(\nabla \times E) + \sigma(\nabla \times E)$

$\nabla \times \nabla \times H = \epsilon \frac{\partial}{\partial t}\left(-\mu \frac{\partial H}{\partial t} + \sigma\left(-\mu \frac{\partial H}{\partial t}\right)\right) = -\mu\epsilon \frac{\partial^2 H}{\partial t^2} - \mu\sigma \frac{\partial H}{\partial t}$

$\nabla(\overbrace{\cancel{\nabla \cdot H}}^{=0}) - \nabla^2 H = -\nabla^2 H$, $\therefore \nabla^2 H - \underbrace{\mu\sigma \frac{\partial H}{\partial t}}_{} - \mu\epsilon \frac{\partial^2 H}{\partial t^2} = 0$

Damping factor, the wave is exponential decay.

Q5: ~~Path loss~~ $\cancel{L_A = \alpha_K \cdot r = \frac{0.01 \times 40.000 \times 10^3}{10^3} = 400\,dB}$

$P_r = \frac{P_t \cdot G_t \cdot G_r \cdot \lambda^2}{(4\pi r)^2}$, $L_{A\,dB} = 10 \log \frac{P_t}{P_r}$,

$\frac{P_t}{P_r} = \frac{(4\pi r)^2}{G_t \cdot G_r \cdot \lambda^2}$, $\underline{17\,dB = 50.1}$, $\lambda = \frac{3 \times 10^8}{11 \times 10^9} = 2.727\,cm.$

(1) $P_d = \frac{P_t \cdot G_t}{4\pi r^2} = \frac{2 \times 50.1}{4\pi (4 \times 10^7)^2} = 4.97 \times 10^{-15}\,W/m^2 = \underline{-143\,dB\,W/m^2}$

(2) $P_r = P_d \cdot \sigma = 4.97 \times 10^{-15} \times 10 = 4.97 \times 10^{-14}\,W$

$P_{r\,(dB)} = \underline{-133\,dBW}$.

$\therefore L_{A\,dB} = 10 \log \frac{P_t}{P_r} = 20 \log\left(\frac{4\pi \times 4 \times 10^7}{2.727 \times 10^{-2}}\right) - 50.1 - 50.1 = 105.1\,dB$

Path loss)

1

Q5: a. ① Energy stored in the electric and magnetic fields. ② The energy in the electro-magnetic field flow from Tx to Rx.

The rate of power flow $\nabla \cdot E \times H = H \cdot \nabla \times E - E \cdot \nabla \times H$

$$\nabla \times E = -\frac{\partial B}{\partial t}, \quad \nabla \times H = \frac{\partial D}{\partial t} + \sigma E$$

$$\therefore \nabla \cdot E \times H = -H \frac{\partial B}{\partial t} - E\left(\frac{\partial D}{\partial t} + \sigma E\right), \text{ But } -H\frac{\partial B}{\partial t} =$$

$$= -\frac{\mu}{2} \frac{\partial H^2}{\partial t}, \quad E\left(\frac{\partial D}{\partial t} + \sigma E\right) = \frac{\epsilon}{2} \frac{\partial E^2}{\partial t} + \sigma E^2,$$

$$\therefore \nabla \cdot E \times H = -\frac{\partial}{\partial t}\left\{\underbrace{\frac{\mu}{2} H^2}_{(1)} + \underbrace{\frac{\epsilon}{2} E^2}_{(2)}\right\} - \underbrace{\sigma E^2}_{(3)}$$

(1) Power density stored in magnetic field,
(2) Power density stored in electric field,
(3) Joulian Loss power due to flow of conduction current.

B. The total $m_T = \sqrt{\frac{B_1^2}{A_c^2} + \frac{B_2^2}{A_c^2}}$ Where B_1, B_2 are the max. amplitude of the information Signals V_1 and V_2, A_c amplitude of the Carrier.

$\therefore m_T = \sqrt{m_1^2 + m_2^2}$ Where m_1, m_2 represented the modulation depth of two Signals.
