EEE 451/551

HW #3

① Maxwell's two curl equations are given by

$$\nabla \times \bar{E} = -j\omega\mu \bar{H} \qquad \text{——— (1)}$$

$$\nabla \times \bar{H} = \bar{J}_i + \sigma \bar{E} + j\omega\epsilon \bar{E} \qquad \text{——— (2)}$$

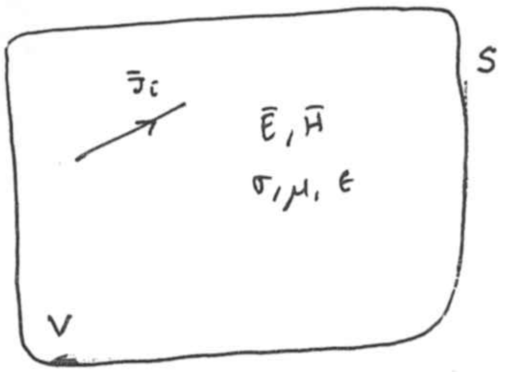
where J_i is the impressed source, ϵ and μ are complex quantities given by $\epsilon = \epsilon' - j\epsilon''$ and $\mu = \mu' - j\mu''$

using (1) and (2) derive the conservation of power given by

$$-\frac{1}{2}\int_V \bar{E}\cdot\bar{J}_i^{*}\, dv = \frac{1}{2}\oint_S (\bar{E}\times\bar{H}^{*})\cdot d\bar{s} + \frac{\sigma}{2}\int_V |\bar{E}|^2\, dv + \frac{\omega}{2}\int_V \left(\epsilon''|\bar{E}|^2 + \mu''|\bar{H}|^2\right) dv$$

$$+ j\frac{\omega}{2}\int_V \left(\mu'|\bar{H}|^2 - \epsilon'|\bar{E}|^2\right) dv$$

where V is the volume bounded by S as illustrated below.



Hint: start with $\bar{H}^{*}\cdot(\nabla\times\bar{E}) = ---.$

$\bar{E}\cdot(\nabla\times\bar{H}^{*}) = ---$

Then use a vector identity.

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(Continue)

(2) Consider a lossless parallel plate transmission line with a characteristic impedance Z_0. We want to play with its dimensions; however, we want to keep its characteristic impedance constant. Therefore,

(i) If the plate width w is kept constant, and the relative dielectric constant, ϵ_r, between the plates is doubled, how should the thickness, d, between the plates be changed?

(ii) How should w be changed for a given d if ϵ_r is doubled?

(iii) How should w be changed for a given ϵ_r if d is doubled?

(iv) Discuss the possible variations in the phase velocity after the changes specified in parts (i), (ii), (iii).

(3) A uniform transmission line is to be constructed using a dielectric medium with $\epsilon_r = 2.25$. Neglecting all losses,

(a) find the distance of separation for a 300 Ω two-wire line, where the radius of the conducting wires is 0.6 mm,

(b) find the inner radius of the outer conductor for a 75 Ω coaxial line, where the radius of the center conductor is 0.6 mm.

(4) (a) Consider a lossy transmission line which has a complex propagation constant γ and characteristic impedance Z_0. If $R/L = G/C$, then determine α, β, R_0 and X_0 where $Z_0 = R_0 + jX_0$. What is special about this line?

(b) The following characteristics have been measured on a lossy transmission line at 100 MHz: $Z_0 = 50\Omega$, $\alpha = 0.01\,\text{dB/m}$, $\beta = 0.8\pi$ rad/m. Determine R, L, G and C