EE2011 Engineering Electromagnetics - Part CXD
Tutorial 8

Q1*

A uniform plane wave in air with $\mathbf{E}_i(z) = \hat{\mathbf{x}}10\,e^{-j6z}$ is incident normally on an interface at $z = 0$ with a medium having a dielectric constant of 2.56 and relative permeability $\mu_r = 1$. Find the following:

(i) Instantaneous expressions for $\mathbf{E}_r(z,t)$, $\mathbf{H}_r(z,t)$, $\mathbf{E}_t(z,t)$ and $\mathbf{H}_t(z,t)$.

(ii) The expression for the time-average Poynting vectors in air $\mathbf{S}_{av_1}$ and in the dielectric medium $\mathbf{S}_{av_2}$.

Q2*

A uniform plane wave in air is partially reflected from the surface of a lossless material whose intrinsic impedance η_u is unknown. A measurement of the electric field in front of the interface yields a 1.5 m spacing between successive minima, with the first minimum occurring 0.75 m from the interface. A standing wave ratio of 5 is measured. What is η_u?

Q3

A uniform plane wave $(\mathbf{E}_i, \mathbf{H}_i)$ with a frequency of 3 GHz travels in the +z direction in a lossless medium with $\varepsilon_{r1} = 4$ and $\mu_{r1} = 1$. The electric field is polarized in the *x*-direction. The wave impinges normally on another lossless medium in region 2, $z > 0$, where $\varepsilon_{r2} = 9$ and $\mu_{r2} = 1$. The amplitude of the incident electric field is 100 V/m. Write phasor and instantaneous expressions for:

(i) $\mathbf{E}_1$ and $\mathbf{H}_1$ of the total wave in medium 1.

(ii) $\mathbf{E}_2$ and $\mathbf{H}_2$ of the total wave in medium 2.

(iii) Draw the standing wave patterns for the electric and magnetic fields.
Indicate the values and positions (in mm) of maxima and minima in both media.

Q4

(See next page)

***** Questions to be discussed in the class.

The electric field of a uniform plane wave in a lossless nonmagnetic medium characterized by $\varepsilon_r = 16$ for $z < 0$ is given by

$$\mathbf{E}(z,t) = 10\cos(\omega t - 100z)\,\hat{\mathbf{x}} + 20\cos(\omega t - 100z + \pi/3)\,\hat{\mathbf{y}} .$$

This wave is incident on a lossless medium characterized by $\mu_r = 12$ and $\varepsilon_r = 6$ for $z > 0$.

(i) Find expressions for the instantaneous reflected and transmitted electric field intensities.

(ii) Find the average power density at $z = 4$ m.

For Q1 and Q2, which will be discussed in the tutorial class, the final solutions are given as follows. The full version of solutions will be distributed in due time.

Q1.

(i)

$$\mathbf{E}_r(z,t) = -\hat{\mathbf{x}}2.25\cos(1.8\times 10^9 t + 6z) \quad \text{V/m}$$

$$\mathbf{H}_r(z,t) = \hat{\mathbf{y}}0.0060\cos(1.8\times 10^9 t + 6z) \quad \text{A/m}$$

$$\mathbf{E}_t(z,t) = \hat{\mathbf{x}}7.75\cos(1.8\times 10^9 t - 9.6z) \quad \text{V/m}$$

$$\mathbf{H}_t(z,t) = \hat{\mathbf{y}}0.0325\cos(1.8\times 10^9 t - 9.6z) \quad \text{A/m}$$

(ii)

$\mathbf{S}_{av_1} = 0.126\hat{\mathbf{z}}$ W/m^2 $\qquad$ $\mathbf{S}_{av_2} = 0\,.\,1\,2\hat{\mathbf{z}}\,6 \quad {}^{2}$

Q2.

$$\eta_u = 5\eta_0 = 5\times 377 = 1885 \ \Omega$$

***** Questions to be discussed in the class.