

Department of Electronic Engineering
EE 3109 Applied Electromagnetics

Assignment 1
Deadline: 13th Mar 2015

Question 1

(a) The Maxwell's equations can be formulated in terms of a vector potential $\vec{A}$, and a scalar potential V .

(i) Explain why we can define $\vec{A}$ such that $\vec{B} = \nabla \times \vec{A}$.

(ii) Explain why we can define V such that $\vec{E} = -\nabla V - \frac{\partial \vec{A}}{\partial t}$.

(iii) Explain what Lorentz gauge is and why it is useful in the formulation of the Maxwell's equations in terms of $\vec{A}$ and V . (10)

(b) In free space, the electric field of a uniform plane wave is given in phasor form:

$$\vec{E} = \hat{x}(30 - j20)e^{-j15z} \text{ V/m}$$

Find the frequency of the wave f , k , and $\vec{H}(z, t)$. (15)

Question 2

(a) In a low-loss dielectric medium (μ, ϵ, σ), the propagation constant can be approximated as:

$$\gamma \approx j\omega\sqrt{\mu\epsilon}\left(1 - j\frac{\sigma}{2\omega\epsilon}\right) \text{ m}^{-1},$$

where $\mu = \mu_0$ and $\epsilon = \epsilon_r\epsilon_0$.

Find the approximate expressions for α , β , η , and u_p in terms of μ_0 , ϵ_0 , ϵ_r , and σ . (10)

(b) An x-polarized 300MHz wave travels in the +z direction in a low-loss dielectric medium with $\mu_r = 1$, $\epsilon_r = 4$, and $\sigma = 4 \times 10^{-4} \text{ S/m}$. The phasor form of the electric field intensity is given by:

$$\vec{E} = \hat{x}60e^{-\gamma z} \text{ V/m}.$$

(i) Using the results in part (a), determine α , β , η , and u_p .

(ii) Write an expression for the $\vec{H}$ in phasor form.

(iii) Find the time-average Poynting Vector $\vec{P}_{av}$ in the medium. (15)

Question 3

- (a) The E-field of a uniform plane wave in free space is given in phasor form:

$$\vec{E} = \hat{y}3e^{j(\pi/4-25x)} + \hat{z}2e^{j(\pi/4-25x)} \text{ V/m.}$$

- (i) Describe the polarization of the wave.
- (ii) Find the corresponding H-field in phasor form.

(10)

- (b) Consider a uniform plane wave in a lossless dielectric having an E-field given by:

$$\vec{E}(t, z) = \hat{x}20\cos(\omega t - 50z) - \hat{y}10\sin(\omega t - 50z) \text{ V/m,}$$

and its phase velocity in the dielectric is $0.6c$.

- (i) Determine the frequency of the wave.
- (ii) Find the dielectric constant of the medium.
- (iii) Describe the polarization of the wave.
- (iv) Find the corresponding H-field.

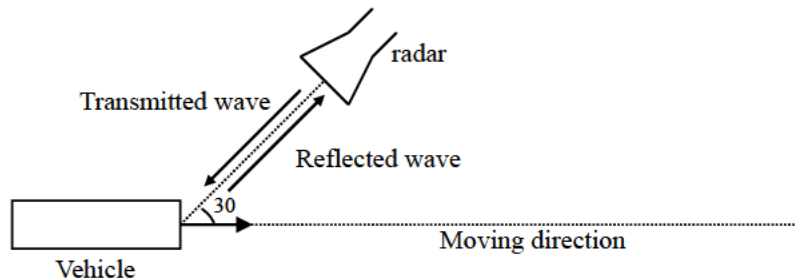
(15)

Question 4

A Doppler radar is used to determine the speed of a moving vehicle by measuring the frequency shift to the wave reflected from the vehicle.

- (a) Assuming that the reflecting surface of the vehicle can be represented by a perfectly conducting plane and the transmitted signal is a time-harmonic uniform plane wave of a frequency f incident obliquely on the reflecting surface with an angle of 30 degrees as shown in the following figure, find the relation between the frequency shift and the speed of the vehicle.

(15)



- (b) Determine the speed of the vehicle in (km/hr) if the frequency shift is 3 kHz and the frequency of the transmitting wave is 12 GHz.

(10)