COLLEGE OF ENGINEERING & TECHNOLOGY

Department: Electronics and Communications Engineering
Lecturer: Associate Prof. Dr. Hussein H. M. Ghouz
Course: Electromagnetic Wave Propagation (EM_II)
Course Code: EC442 — **Time: 2 Hours**
Date : Sat., Jan, 10, 2015 — **Total Marks:40**

Answer All Questions (Fall-2014/2015)

Use Illustrative Figures to Clearify Your Answer

Question No. 1: (12-Mark)

(a) Define the following:
Wave Propagation Factor – Standing Wave Ratio – Wave Impedance **(2-Mark)**

(b) Write down the complex instantaneous form of the different polarization type, assume a uniform plane wave propagating in a lossy medium along the x-direction **(2-Mark)**

(c) Derive an analytical form for both reflection coefficient and Brewster angle in case of a uniform plane wave having **E**-polarization. Assume the two media are lossless materials ($\varepsilon_1 \neq \varepsilon_2$, and $\mu_1 \neq \mu_2$) **(3-Mark)**

(d) A uniform plane wave having a perpendicular-polarization is obliquely incident from **region1** to **region2** at an angle θ_1. The constitutive parameters of the two regions are: $\varepsilon_1=\varepsilon_o$ & $\mu_1=\mu_o 150.0$ and $\varepsilon_2=\varepsilon_o$ & $\mu_2=\mu_o 200.0$ respectively. Compute the following:

1. The transmitted and reflected power densities ($P_{in}=15.0 w/m^2$) for the following values of incident angle θ_1: (i) $\theta_1=45^o$ (ii) $\theta_1=90^o$ (iii) $\theta_1=0^o$ **(3-Mark)**
2. If the wave propagates from **region2 to region1**, find the critical and Brewster angles **(2-Mark)**

Question No. 2: (14-Mark)

(a) Draw the equivalent circuit of an antenna in transmitting and receiving modes, then explain the physical meaning of each circuit elements **(3-Mark)**

(b) Sate the basic antenna parameters, and then explain only two of them **(2-Mark)**

(c) Define what is meant by antenna radiation problem? Explain in steps how to get the radiated fields (E & H) from an arbitrary antenna. **(3-Mark)**

(d) A ***transmitting antenna*** located on a tower having a height H_t of 20.0m, radiates magnetic field intensity in the free-space at far-zone given by:

$$\overline{\mathbf{H}}(\mathbf{r},\theta,\phi) = (4\pi / \mathbf{r}^2)\left(\sqrt{\cos(\theta-\pi/2)}\,\cos\,(\phi-\pi/2)\right)\mathbf{e}^{-\mathbf{j}\mathbf{k}\mathbf{r}}\,\mathbf{a}_\theta,\quad \text{Where, } 0 \leq \theta \leq \pi \text{ and } 0 \leq \varphi \leq \pi.$$

This antenna has the following parameters:

- Radiation resistance $R_r=85.0\Omega$
- Right Hand Circular polarization
- Peak power $P_t=2000.0$k watt
- Total Loss resistance $R_L=8.0\Omega$
- Operating frequency $f_o=2000$ MHz
- The feed line impedance $Z_o=50.0\ \Omega$

Compute the following antenna parameters:

1. Normalized radiation intensity $\mathbf{U_n}$ **(Θ, φ)** **(2-Mark)**
2. The directivity and efficiency (**D (Θ, φ)** & e_t) **(2-Mark)**
3. HPBW and FNBW in E and H planes **(2-Mark)**

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Question No. 3: (14-Mark)

(a) Classify the different types of wave, and then explain their communication scenarios **(2-Mark)**

(b) Assume, a receiving antenna is connected to a receiver circuit unit, having a noise temperature T_r of =120.0k°, through a lossless transmission line of length ℓ=1.0m and characteristic Z_o of 75Ω.This antenna is located on a tower having a height H_r of 30.0m, and a ground distance R of 2000.0m from the transmitting antenna given in **question No.2 (d)** to achieve a line of sight communication for a microwave link. The receiving antenna has a linear polarization (two components of electric filed), radiation resistance R_r of 80.0Ω, a loss resistance R_L of 5.0Ω, a noise temperature T_A of 100k°, and a maximum directivity D_o of 20.0 dB. Compute the following:

1. The free space loss in dB and the total system noise temperature **(2-Mark)**
2. The polarization loss factor **(2-Mark)**
3. The maximum power delivered to the receiver terminals **(2-Mark)**

(c) Referring to **question No. 1(c)**, assume a single dielectric-magnetic slab of a width **"d"** is inserted between the given two regions. This slab has relative permittivity and permeability ε_r and μ_r respectively. Find the following:

1. Find the condition on ε_r and μ_r to achieve total transmission (the wave is totally transmitted from the first region to the second region without reflection). Derive the wave impedance of the dielectric-magnetic slab in this case **(3-Mark)**
2. Derive the wave impedance of the dielectric-magnetic slab if the incident angle $\theta_1=0^o$. Find the width **d** and the ratio $\sqrt{\mu_r / \varepsilon_r}$ of the slab to achieve no reflection in the first region in this case. **(3-Mark)**

GoodLuck

$\varepsilon_o=8.854\text{x}10^{-12}$ $\mu_o= 4\pi\text{x}10^{-07}$

$$\alpha = \omega\sqrt{\frac{\mu\varepsilon'}{2}}\left(\sqrt{1+(\delta)^2}-1\right)^{1/2}$$

$$\beta = \omega\sqrt{\frac{\mu\varepsilon'}{2}}\left(\sqrt{1+(\delta)^2}+1\right)^{1/2}$$