COLLEGE OF ENGINEERING & TECHNOLOGY

Department: Electronics and Communications Engineering
Lecturer: Associate Prof. Dr. Hussein H. M. Ghouz
Course: Electromagnetic Wave Propagation
Course Code: EC442

Additional Problems

P.1 Drive the wave equation of general time dependence uniform plane wave propagating in a general medium along the z-direction, then; find the phasor form and the instantaneous form solutions of the both electric field and magnetic field

P.2 In P.1, assume a free-space medium, and time-harmonic dependence, find the wave parameters

P.3 Drive the wave equation of time-harmonic uniform plane wave propagating in a general medium along the x-direction, then; find the phasor form and instantaneous form solutions of both electric field and magnetic field

P.4 In P.3, assume a good conductor medium, find the wave parameters

P.5 A linearly polarized uniform plane wave (y-polarized) is propagating in the free space region along the forward z-direction. This wave has maximum electric field E_{y10}=10.0 v/m, and frequency F_0=1 GHz. Compute the following:

1. The phasor and instantaneous forms of the electric field
2. The propagation factor, intrinsic impedance, and phase velocity

P.6 In P.5, assume low loss dielectric medium, find the wave parameters

P.7 In P.5, assume a good conductor medium, find the wave parameters

P.8 The electric field intensity of a plane wave propagating in a low loss dielectric material is given by:

$$E(x) = [(e^{-j(5\pi/4)z}\,\mathbf{a_x} - je^{-j(5\pi/4)z}\,\mathbf{a_y}]\,e^{-0.5x}$$

What is the polarization type of this wave and its propagation factor?

P.9 In P.8, if $\varepsilon_r' = 4.7$ and $\delta = 0.025$, find the following:

1. The instantaneous form of the electric field
2. The wave impedance η and frequency f_o

P.10 A time-Harmonic magnetic flux density is given as $\overline{B} = B_o \cos(2\pi \times 10^8 t - 10\pi z) a_z$ in lossless material with properties ε_r =2.2 and μ_r=150. Assume there is no source in the material. Using Maxwell's equations find the following:

1. The electric field intensity in the material
2. The electric flux density in the material
3. The wave parameters inside the material

P.11 A linearly polarized uniform plane wave (y-polarized) propagating in the free space region along the forward z-direction, having maximum electric field E_{y10}=10.0 v/m, and frequency F_0=1 GHz, is normally incident on ideal dielectric region of a complex permittivity $\varepsilon = \varepsilon_o 6.8$ and permeability $\mu_2=\mu_o$. Compute the following:

1. The phasor and instantaneous forms of the electric field in each region
2. The propagation factor, intrinsic impedance, and phase velocity in region
3. The reflected and transmitted power densities
4. The voltage standing wave ratio
5. The instantaneous form of voltage standing wave, then, plot it

P.12 A linearly polarized uniform plane wave (x-polarized) propagating in the free space region along the forward z-direction is normally incident on a low loss dielectric region of permittivity ε_2 and permeability $\mu_2=\mu_o$. Assume the maximum incident electric field is E^+_{y01}, and the wave frequency is F_0 in GHz. Derive an analytical expressions for reflection and transmission coefficients

P.13 In part-(a), assume, the maximum electric field E^+_{y01}=20.0 v/m, frequency F_0=5.0 GHz, and $\varepsilon_2 = \varepsilon_o 10.0(1\text{-}j0.01)$. Compute the following:

1. The reflected and transmitted power densities
2. The standing wave ratio
3. The instantaneous form of standing wave, then, plot it

P.14 A linearly polarized uniform plane wave (y-polarized) propagating in the free space region along the forward z-direction, having maximum electric field E_{y10}=10.0 v/m, and frequency F_0=1 GHz, is normally incident on a lossy dielectric region of a complex permittivity $\varepsilon = \varepsilon_o(6.8\text{-}j0.068)$ and permeability $\mu_2=\mu_o$. Compute the following:

1. The phasor and instantaneous forms of the electric field in each region
2. The propagation factor, intrinsic impedance, and phase velocity in region
3. The reflected and transmitted power densities
4. The voltage standing wave ratio
5. The instantaneous form of voltage standing wave, then, plot it

P.15 A single lossless dielectric slab of a thickness "**d**" and permittivity "$\boldsymbol{\varepsilon_2}$" is inserted between two regions. The first region is the free-space and the second one is a lossless dielectric material of permittivity $\boldsymbol{\varepsilon_3}=\varepsilon_o 4.7$. A uniform plane wave, propagating in x-direction and polarized in y-direction, is normally incident on the first region. Assume a total transmission is achieved; find the following dielectric slab parameters:

1. The thickness **d**
2. The dielectric constant $\boldsymbol{\varepsilon_r}$
3. The wave impedance $\boldsymbol{\eta_w}$

P.16 A single lossless dielectric slab of a thickness "**d**" and permittivity "$\boldsymbol{\varepsilon_2}$" is inserted between two regions. The first region is the free space and the second one is a lossless dielectric material of permittivity "$\boldsymbol{\varepsilon_3}$". A uniform plane wave propagating in y-direction and polarized in z-direction is normally incident on the first region. Derive an analytical expression for the total reflection coefficient and the phasor form of standing wave in the first region. What is thickness of the dielectric slab to achieve total transmission?

P.17 Two lossless dielectric slabs of thickness "$\mathbf{d_1}$" and "$\mathbf{d_2}$" are inserted between two regions respectively. The first region is the free space and the second one is a lossless dielectric material having ε_r =4.4. A uniform plane wave, propagating in y-direction and polarized in z-direction (**E^+_z=10.0 V/m & f_o=3.0 GHz**), is normally incident on the first region. Assume that the first dielectric slab has a dielectric constant $\boldsymbol{\varepsilon_r}$=2.5. Derive an analytical expression for the wave impedance of the **second dielectric slab** $\mathbf{Z_{w2}}$. What are the thickness $\mathbf{d_2}$ and the dielectric constant ε_r of the **second slab** to achieve no reflection at the **first slab** independent on its thickness $\mathbf{d_1}$? Find the maximum and minimum values of the standing wave in first region in this case, and then plot it

P.18 Derive an analytical expression for both transmission and reflection coefficients in case of an oblique uniform plane wave having **H**-polarization. Assume the two general media are lossless materials ($\varepsilon_1 \neq \varepsilon 2$, and $\mu_1 \neq \mu_2$)

P.19 Derive an analytical expression for both critical and Brewster angles in case of uniform plane wave having **H**-polarization. Assume the two general media are lossless materials ($\varepsilon_1 \neq \varepsilon 2$, and $\mu_1 \neq \mu_2$). State existence conditions of these angles.

P.20 A uniform plane wave, having **H**-polarization, is obliquely incident from dielectric-1 to dielectric-2 with incident angle $\boldsymbol{\theta_1}$. The constitutive parameters of the two dielectric regions are: $\varepsilon_1=6.8\varepsilon_o$ & $\mu_1=100.0\mu_o$ and $\varepsilon_2=2.2\varepsilon_o$ & $\mu_2=150.0\mu_o$ respectively. Compute the following:

1. The critical and Brewster angles. Justify your answer
2. The transmitted and reflected power densities if $\mathbf{P_{inc}}$=20.0w/m^2 and $\boldsymbol{\theta_1}$=27.67^o
3. The transmitted and reflected power densities if $\mathbf{P_{inc}}$=20.0w/m^2 and $\boldsymbol{\theta_1}$=90^o