Homework Set #2

ECE 6310 - Advanced Electromagnetic Fields

Balanis (2nd Edition): 3.2, 4.2, 4.22, 4.26
Balanis (2nd Edition): 5.4, 5.9, 5.21

Verify your solutions to 5.9 and 5.21 in HFSS (submit your plots and designs as part of your solution)

3.2. Verify that (3-28a) and (3-28b) are solutions to (3-26a).

4.2. Using Maxwell's equations, find the magnetic field components for the wave whose electric field is given in Example 4-1. Compare your answer with that obtained in the solution of Example 4-1.

4.22. Sea water is an important medium in communication between submerged submarines or between submerged submarines and receiving and transmitting stations located above the surface of the sea. Assuming the constitutive electrical parameters of the sea are $\sigma = 4$ S/m, $\varepsilon_r = 81$, $\mu_r = 1$, and $f = 10^4$ Hz, find the:

(a) Complex propagation constant (per meter).
(b) Phase velocity (meters per second).
(c) Wavelength (meters).
(d) Attenuation constant (Nepers per meter).
(e) Skin depth (meters).

4.26. In a source-free, free-space region, the complex magnetic field of a time-harmonic field is represented by

$$\mathbf{H} = \left[\hat{\mathbf{a}}_x(1+j) + \hat{\mathbf{a}}_z\sqrt{2}e^{j\pi/4}\right]\frac{E_0}{\eta_0}e^{-j\beta_0 y}$$

where E_0 is a constant and η_0 is the intrinsic impedance of free space. Determine the:

(a) Polarization of the wave (linear, circular, or elliptical). Justify your answer.
(b) Sense of rotation, if any.
(c) Corresponding electric field.

5.4. A vertical interface is formed by having free space to its left and a lossless dielectric medium to its right with $\varepsilon = 4\varepsilon_0$ and $\mu = \mu_0$, as shown in Figure P5-4. The incident electric field of a uniform plane wave traveling in the free-space medium and incident normally upon the interface has a value

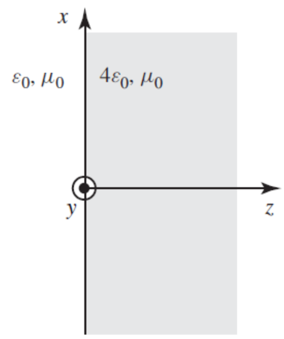

Figure P5-4

of 2×10^{-3} V/m right before it strikes the boundary. At a frequency of 3 GHz, find the:

(a) Reflection coefficient.
(b) SWR in the free-space medium.
(c) Positions (in meters) in the free-space medium where the electric field maxima and minima occur.
(d) Maximum and minimum values of the electric field in the free-space medium.

5.9. A uniform plane wave traveling in air is incident normally on a half space occupied by a lossless dielectric medium of relative permittivity of 4. The reflections can be eliminated by placing another dielectric slab, $\lambda_1/4$ thick, between the air and the original dielectric medium, as shown in Figure P5-9. To accomplish this, the intrinsic impedance η_1 of the slab must be equal to $\sqrt{\eta_0\eta_2}$ where η_0 and η_2 are, respectively, the intrinsic impedances of air and the original dielectric medium. Assuming that the relative permeabilities of all the media are unity, what should the relative permittivity of the dielectric slab be to accomplish this?

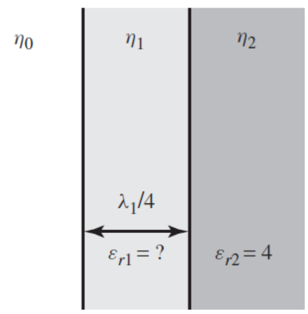

Figure P5-9

5.21. A uniform plane wave traveling in a lossless dielectric is incident normally on a flat interface formed by the presence of air. For ε_r's of 2.56, 4, 9, 16, 25, and 81:

(a) Determine the critical angles.

(b) Find the Brewster angles if the wave is of parallel polarization.

(c) Compare the critical and Brewster angles found in parts (a) and (b).

(d) Plot the magnitudes of the reflection coefficients for both perpendicular, $|\Gamma_\perp|$, and parallel, $|\Gamma_\parallel|$, polarizations versus incidence angle.

(e) Plot the phase (in degrees) of the reflection coefficients for both perpendicular and parallel polarizations versus incidence angle.