EE3140 Hour Exam 2, Fall 2019

There are 4 problems. All units are mks. Show your work for full credit.

1. A wave propagates between two parallel conducting plates of infinite extent which are $a = 10 \text{ cm}$ apart and perpendicular to the x-axis. The electric field of the wave is:

$$E_x = E_1 \cos(40\pi x)e^{-jk_z z}$$

$$E_z = E_o \sin(40\pi x)e^{-jk_z z}$$

What mode, including number, is propagating? (for example, $TE_1$) (8 points)

Solution: $\nabla \times \vec{E}$ produces only $H_y$ term and longitudinal electric field ($E_z$ term); therefore, $TM_m$. Next, $\frac{m\pi}{a} = 40\pi \rightarrow m = 4$

mode = $TM_4$

2. A load is measured to be $Z_L = 100 + j50\Omega$ using $50\Omega$ cable. What is the percent power that is reflected from this load? (4 points) What is the VSWR? (4 points)

Soln: percent power reflected = $|\Gamma_L|^2 = \frac{|Z_L - Z_o|}{Z_L + Z_o}^2 = 0.2 \rightarrow 20\%$

VSWR = $\frac{1 + |\Gamma_L|}{1 - |\Gamma_L|} = 2.6$

percent power reflected = 20\%

VSWR = 2.6
3. A uniform plane wave, traveling in the z-direction, with normal incidence to a dielectric interface has a total electric field, $|E_{y\,\text{total}}|$, as shown in the figure below.

(a) Given that the left-hand side (medium 1) is free space, find the relative permittivity of the medium 2. (4 points)

Soln: $|E_{y\,\text{total}}| = |(1 + R_1 e^{2jkz})|$. At $z=0$, this is $|1 + R_1|:

$$1 + \frac{1 - \sqrt{\epsilon_r}}{1 + \sqrt{\epsilon_r}} = \frac{2}{3}.$$ 

Therefore, $\epsilon_r = 4$

(b) Find the wavelength of the wave in medium 1. (4 points)

Soln: $\lambda_1/2 = (4.5 - 1.5) = 3m \rightarrow \lambda_1 = 6m$

4. Consider a dielectric slab with $\epsilon_1 = 5\epsilon_o$ surrounded by air. What should the thickness be in order that only the $TE_0$ mode propagates for frequencies up to 200GHz? (8 points)

Soln: $f_c = \frac{n}{2d\sqrt{\mu_o(\epsilon_1 - \epsilon_o)}} \rightarrow 2d = \frac{3 \times 10^8}{200 \times 10^9 \sqrt{4}} = 7.5 \times 10^{-4} m$