EE3140 Hour Exam 2, Fall 2013

There are 5 problems. All units are mks. Show your work for full credit.

1. A wave propagates between two parallel plates of infinite extent which are \( a = 20 \text{ cm} \) apart and perpendicular to the \( x \)-axis. The electric field of the wave is:

\[
E_x = E_1 \cos(40\pi x) e^{-jk_x z} \\
E_z = E_0 \sin(40\pi x) e^{-jk_x z}
\]

What mode is propagating? (6 points)

Transverse and longitudinal \( E \). Therefore, \( TM \) mode

\[
\frac{\lambda}{a} = 40\pi \Rightarrow m = 8
\]

mode = \( TM_8 \)

2. A load is measured to be \( Z_L = 50 + j50\Omega \) using \( 50\Omega \) cable. What is the reflection coefficient, \( \Gamma \)? (6 points)

\[
\Gamma_L = \frac{Z_L - Z_0}{Z_L + Z_0} = \frac{50 + j50 - 50}{50 + j50 + 50} = \frac{j50}{100 + j50} = \frac{j}{2 + j} = 0.447 \angle 63.4^\circ
\]

\[
\Gamma = 0.947 \angle 62.4^\circ
\]
3. A pulse generator having an internal resistance of 75Ω produces a pulse of amplitude 10V and duration 1μs with no transmission line connected. A 50Ω line, 400m long and open-circuited at the far end, is connected to the generator. In the spaces below, sketch the voltage reflection diagram and the voltage at z=400m, assuming that z = 0 is at the load and the phase velocity is 200m/μs (3 points each).
4. A 20Ω load is connected to a 50Ω line. Assuming single-stub tuning in order to create a match, what is the minimum distance from the load that the stub should be placed? Give your answer in wavelengths. (6 points)

\[ Z_{\text{in}} = \frac{20}{50} = 0.4 + j0 \]

1) \( \rho_{\text{at}} = 0.4 + j0 \)
2) \( \Gamma_{\text{at}} \rightarrow \gamma_{l,n} = 2.5 + j0 \)

Distance from load to stub = 0.009\( \lambda \)

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5. Consider a dielectric slab with \( \varepsilon_1 - 3\varepsilon_0 \) surrounded by air. What should the thickness be in order that only the \( TE_0 \) mode propagates for frequencies up to 200GHz? (6 points)

The \( n = 1 \) cut-off is at:

\[ f_c = \frac{n}{2d\sqrt{\varepsilon_0 (\varepsilon_1 - \varepsilon_0)}} \]

\[ 2d = \frac{3 \times 10^8}{200 \times 10^9 \sqrt{3-1}} \]

\[ 2d = 1.06 \times 10^{-3} \text{ m} \]
The Complete Smith Chart
Black Magic Design