UTA PhD Diagnosis Exam (Spring 2013)

Electromagnetics

Instructions:
• Verify that your exam contains 7 pages (including the cover sheet).
• Please be sure to use blank paper to write your answers. If more space is needed, please ask the instructor for extra paper. DO NOT WRITE ON THE BACK OF A SHEET!
• The point values listed on this exam serve only as a guideline. The Dept reserves the right to make modifications to the weighting of the problems.
• Calculator is okay.

I Choose to work on Problems ____ and _____ (Choose only 2 from the 3 problems).

<table>
<thead>
<tr>
<th>Problem</th>
<th>Possible Points</th>
<th>Scores</th>
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<tbody>
<tr>
<td>1</td>
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<td>Total Score (Choose 2 Problems)</td>
<td>100</td>
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</tbody>
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1. The electric field of a uniform plane wave propagating in a lossless medium is given by

\[ \mathbf{E}(z,t) = -\hat{x}5 \cos \left( 2\pi \times 10^9 t - \frac{40\pi z}{3} \right) - \hat{y}3 \sin \left( 2\pi \times 10^9 t - \frac{40\pi z}{3} + \frac{\pi}{2} \right) \]

(a) Determine the associated magnetic field intensity, \( \mathbf{H}(z,t) \).
(b) Determine the time-average Poynting vector.
(c) Determine the polarization of the wave and the dielectric constant of the medium.
2. This problem addresses TM mode propagation in a parallel plate waveguide with thickness $a$, as indicated in the figure below. Assume the metal plates are infinite in extent, i.e., in the $y$ and $z$ directions. The magnetic field in the guide is $H_y(x, z) = A \cos(20x)e^{-j24.2z}$, where $x$ and $z$ are in meters. Assuming the waveguide is filled with air and operation is in the fundamental mode:

a) Find the operating frequency.
b) Find the dimension of the waveguide, i.e., $a$ in the figure below.
c) Find the cutoff frequency of the waveguide for this mode.
3. A wave is propagating from Medium 1 normally onto the surface with Medium 2, as shown in the figure below. Medium 1 is free space (intrinsic impedance of $120\pi$ or $377\Omega$), medium 2 has relative permittivity of 4, and medium 3 has relative permittivity of 8.

a) Find the impedance seen by the incident wave at point $x = -3.75$ cm, for a frequency of 2.5 GHz.

b) At what frequency will the total reflection looking into Medium 1 go to 0? Demonstrate mathematically.