

## ENEE 381 Problem Set #6

Due May 10, 2004

One or two of these questions will be on the final examination.

- (1) A parallel plate waveguide with plate spacing of 10mm allows TM and TE waves to propagate provided they are above their cutoff frequency. Calculate the cutoff frequency of the  $TM_1$ ,  $TM_2$ ,  $TM_3$ ,  $TE_1$ ,  $TE_2$  and  $TE_3$  modes.
- (2) A waveguide is formed from two perfect conductors. The conductors are spaced by 50mm with a dielectric of  $\epsilon_r=2.25$ . For an operating frequency of 10GHz calculate  $\beta$ ,  $v_p$ ,  $v_g$ ,  $Z_z$ , and  $\lambda_g$  for the following modes:
  - (a) TEM mode
  - (b)  $TM_1$  mode
  - (c)  $TM_2$  mode.
- (3) For a rectangular waveguide with dimensions 50mm $\times$ 20mm calculate the cutoff frequencies for the  $TE_{10}$ ,  $TE_{20}$ ,  $TE_{2,2}$ ,  $TM_{11}$  and  $TM_{23}$  modes. How do these cutoff frequencies change if the waveguide is filled with a lossless dielectric with  $\epsilon_r=4$ ?
- (4) A rectangular waveguide of dimension 50mm $\times$ 20mm filled with air is being operated at 1.1 times its cutoff frequency for the  $TE_{10}$  mode. Calculate  $\beta$ ,  $Z_z$ ,  $v_p$ ,  $v_g$ , and  $\lambda_g$  for the mode.
- (5) A rectangular waveguide of dimension 20mm $\times$ 10mm is being operated at 1.2 times the cutoff frequency for the  $TM_{11}$  mode. Calculate  $\beta$ ,  $Z_z$ ,  $v_p$ ,  $v_g$ , and  $\lambda_g$  for the mode.
- (6) A rectangular waveguide of dimension 50mm $\times$ 20mm filled with air is being operated at 1.1 times its cutoff frequency for the  $TE_{10}$  mode. The TE wave reaches a section of the waveguide that is now completely filled with a lossless dielectric with  $\epsilon_r=3$ . Calculate the reflection coefficient in magnitude and phase, VSWR, and the fraction of the incident power that passes into the loaded waveguide section.
- (7) A waveguide of dimension 20mm $\times$ 10mm that is filled with air carries a  $TE_{10}$  mode at a frequency of 10GHz. The total power being transferred down the guide is 1W. What is the peak electric field amplitude in the waveguide?