

**ECE3065**  
**HW4**  
**Due by Tuesday, 26. March 2013**

1. The dimensions of an X-band WR90 rectangular waveguide used for the feed of airport radars are  $a=0.9$  in and  $b=0.4$  in. Assuming free space within the waveguide, determine in GHz the cutoff frequencies in ascending order of the first 10  $TE_z$  and/or  $TM_z$  modes.
2. A rectangular air-filled waveguide WR510 used for cellular communication base stations has a cross-section of 5.1in x 2.55in.
  - (a) Calculate the cutoff wavelength  $\lambda_{oc}$  and the cutoff frequency  $f_{co}$  for the dominant TE mode.
  - (b) Determine the propagation constant and the transverse-wave impedance for this mode at  $f=10$  GHz.
  - (c) How close are the values of (b) to the TEM values.
3. Repeat the analysis of Problem (2) for the dominant TM mode.
4. If the amplitude of the  $H_x$  field for the dominant TE mode of Problem (2) is 10A/m, derive expressions for the spatial distributions of the EM components of this mode.
5. The inside dimensions of an X-band WR-75 waveguide are  $a=0.75$  in and  $b=0.375$  in. Assume that the waveguide is air-filled and operates in the dominant  $TE_{10}$  mode, and that it is used for a Meteorological Sensor feed. The air will break down when the maximum electric field intensity is  $2 \times 10^6$  V/m (common when lightning occurs nearby). Find the maximum power that can be transmitted at  $f=12$  GHz in the waveguide before the sensor gets destroyed (air breakdown occurs).
6. What is the Conductor and the Dielectric Loss for the Waveguide of Problem (5) if the dielectric filling is Teflon, the Conductors are made from Copper and the frequency is 12 GHz.

Teflon:  $\tan\delta=\epsilon''/\epsilon'=5 \times 10^{-4}$  (@ 12 GHz),  $\epsilon_r=2.1$   
Copper (Cu):  $\sigma=5.8 \times 10^7$  S/m
7. Assume a parallel-plate ideal plane transmission line filled with air and having a plate separation of  $a=15$ mm.
  - (a) Write an expression for the cutoff frequency and the modal characteristic impedance of the  $TE_n$  modes.
  - (b) Repeat the same for the  $TM_n$  modes.
  - (c) How many higher-order TE modes would propagate if the structure was excited by an incident wave with frequency 33 GHz?
8. Calculate the attenuation in decibels per meter for a  $TM_1$  wave between copper planes 1.5cm apart with air dielectric. Frequency is 12 GHz. For the same frequency and spacing, a glass dielectric with  $\epsilon_r=4$  and  $\epsilon''/\epsilon'=2 \times 10^{-3}$  is introduced. Calculate the attenuation from both dielectric and conductor losses. [HINT: Do not ignore the effect of the glass filling to the cutoff frequency!]