

- 1) For a rectangular waveguide (WR-90) filled with dielectric material ($\epsilon_r=9$, $\mu_r=1$), operating in the dominant mode
 - a) find cut-off frequency
 - b) Determine the phase velocity and group velocity of the wave in the waveguide at a frequency of 3 GHz
 - c) Determine guided wavelength at 3 GHz
 - d) Determine the wave impedance in z direction
 - e) If wave is propagating with a frequency of $f = 1$ GHz, $f = 3$ GHz, and $f = 6$ GHz, what are the modes that can be excited within the waveguide.

2) A TE_{10} wave is excited at 4 GHz at $z = 0$ m in a rectangular waveguide with transverse dimensions 5 by 2.5 centimetres. The dielectric has a conductivity of 2×10^{-6} mho/m, and the permittivity and permeability are everywhere the same as for free space, Assume that the excitation is such that B_1 in equation equals $j1000$, Calculate the phase and group velocities, the power after 10m. Also, determine the fields as functions of the space coordinates and time.

$$E_y = -B_1 \sin\left(\frac{\pi x}{a}\right) e^{-j\bar{\beta}z}$$

3) Suppose that an air filled X-band is probed with a slotted section, and it is found that the distance between minima is 2 cm. the minima position does not shift when the actual load is replaced by a shorting plane. The standing wave ratio is 2. what is the load impedance and operating frequency.

4) If wave is launched at an angle of 60° in to a parallel plate waveguide

a) Find phase and group velocities

b) Find the cut-off frequency of TM_0 mode