EE2025 Engineering Electromagnetics: July-Nov 2019

Tutorial 6: Waveguides

1. A section of a rectangular waveguide of cross-section 2 cm $\times$ 1.5 cm is to be used as a delay line in a radar at 10 GHz. What should be the length of the section to realize a delay of 10 nsec ?

2. (a) Derive an expression for the conductive loss in a rectangular waveguide for the fundamental mode.
   (b) In a 5 cm $\times$ 3 cm waveguide the TE_{10} mode is propagating at 10 GHz. The total power carried by the waveguide is 10 W. If the conductivity of the waveguide walls is 2 $\times 10^7 \mho/m$, find the attenuation constant of the waveguide in dB/m.

3. In an air-filled rectangular waveguide with a = 2.286 cm and b = 1.016 cm, the y component of the TE mode is given by

$$E_y = \sin(2\pi x/a)\cos(3\pi y/b)\sin(10\pi \times 10^{10}t - \beta z)V/m$$

   Find
   (a) the operating mode
   (b) the propagation constant γ
   (c) the intrinsic impedance η
   (d) Find the dielectric loss α_d of the mode when the waveguide is filled with water(Complex permittivity of water at 50 GHz is $\epsilon_0(16.40 - j26.31)$)

4. A frequency of 9.5 GHz is used to excite all possible modes in a hollow rectangular waveguide of dimensions 3 cm $\times$ 2 cm. The length of the waveguide is 100 m. Find the difference between time of arrivals of the fastest mode and the slowest mode.

5. A 240 degree phase shift is produced by a 4 GHz signal when traveling along a dielectric filled waveguide 3 cm long. If the cutoff frequency of the waveguide when air-filled is 10 GHz, calculate the relative permittivity of the dielectric.

6. For a square waveguide, show that attenuation α_c is minimum for TE_{10} mode when $f = 2.962 f_c$

7. A 4 cm square waveguide is filled with a dielectric with complex permittivity $\epsilon_c = 16\epsilon_o(1 - j10^{-4})$ and is excited with the TM_{21} mode. If the waveguide operates at 10 % above the cutoff frequency, calculate attenuation α_d. How far can the wave travel down the guide before its magnitude is reduced by 20 % ?