

611 - Microwave Engineering Supplementary Notes

Example

This is to demonstrate the propagation constant and attenuation in a rectangular waveguide (TE₁₀ Mode).

Let $a=2.0$ cm $b=1.0$ cm,

- a) find cut-off frequency
- b) propagation constant at 12.0 GHz
- c) attenuation constant at 4.0 GHz.
- d) attenuation over a distance of 2.0 cm
- e) guide wavelength at 12.0 GHz.

Given

$$i := \sqrt{-1}$$

$$f1 := 12 \cdot 10^9 \text{ Hz} \quad f2 := 4.0 \cdot 10^9 \text{ Hz}$$

$$a := 0.02 \text{ m} \quad b := 0.01 \text{ m} \quad \mu_0 := 4 \cdot \pi \cdot 10^{-7} \text{ H/m} \quad \epsilon_{\text{pso}} := 8.854 \cdot 10^{-12} \text{ F/m}$$

$$\text{dist} := 0.02 \text{ m}$$

a) Cut-off frequency is given by

$$f_c := \frac{1}{2 \cdot a \cdot \sqrt{\mu_0 \cdot \epsilon_{\text{pso}}}} \quad f_c = 7.495 \cdot 10^9 \text{ Hz}$$

b) Propagation constant at 12.0 GHz

$$k_c := \frac{\pi}{a} \quad k_c = 157.08 \text{ m}^{-1}$$

$$k_0 := 2 \cdot \pi \cdot f1 \cdot \sqrt{\mu_0 \cdot \epsilon_{\text{pso}}} \quad \text{m}^{-1} \quad k_0 = 251.499 \text{ m}^{-1}$$

$$\beta := \sqrt{k_0^2 - k_c^2} \quad \text{m}^{-1} \quad \beta = 196.412 \text{ m}^{-1}$$

c) Attenuation constant at 4.0 GHz

$$k_{02} := 2 \cdot \pi \cdot f2 \cdot \sqrt{\mu_0 \cdot \epsilon_{\text{pso}}} \quad \text{m}^{-1} \quad k_{02} = 83.833 \text{ m}^{-1}$$

$$\alpha := \sqrt{k_c^2 - k_{02}^2} \quad \text{m}^{-1} \quad \alpha = 132.838 \text{ m}^{-1}$$

d) Power attenuation over a distance of 2.0 cm is given by

$$P_{\text{attenuated}} := e^{-2 \cdot \alpha \cdot \text{dist}}$$

$$P_{\text{attenuated}} = 0.005$$

e) Guide wavelength

$$\lambda_{\text{guide}} := \frac{2 \cdot \pi}{\beta} \quad \lambda_{\text{guide}} = 0.032$$