Rectangular Cavity

TE_{zmnp} modes:

$$F_z = A_{mnp} \cos k_x x \cos k_y y \sin k_z z$$

$$k_x = \frac{m\pi}{a} \qquad m = 0, 1, 2, \ldots$$

$$k_y = \frac{n\pi}{b} \qquad n = 0, 1, 2, \ldots \qquad \text{except for } m = n = 0$$

$$k_z = \frac{p\pi}{c} \qquad p = 1, 2, 3, \ldots$$

TM_{zmnp} modes:

$$A_z = B_{mnp} \sin k_x x \sin k_y y \cos k_z z$$

$$k_x = \frac{m\pi}{a} \qquad m = 1, 2, \ldots$$

$$k_y = \frac{n\pi}{b} \qquad n = 1, 2, \ldots$$

$$k_z = \frac{p\pi}{c} \qquad p = 0, 1, 2, \ldots$$

Dispersion relation:

$$k_x^2 + k_y^2 + k_z^2 = \omega^2 \mu\varepsilon$$

$$\omega = \frac{1}{\sqrt{\mu\varepsilon}} \sqrt{k_x^2 + k_y^2 + k_z^2} = \frac{1}{\sqrt{\mu\varepsilon}} \sqrt{\left(\frac{m\pi}{a}\right)^2 + \left(\frac{n\pi}{b}\right)^2 + \left(\frac{p\pi}{c}\right)^2}$$

$$f = \frac{1}{2\sqrt{\mu\varepsilon}} \sqrt{\left(\frac{m}{a}\right)^2 + \left(\frac{n}{b}\right)^2 + \left(\frac{p}{c}\right)^2}$$

$\uparrow$

resonant frequency for TE_{zmnp} and TM_{zmnp} modes, denoted as $(f_r)_{mnp}$.

Quality factor:

$$Q = \omega \frac{\text{stored energy}}{\text{dissipated power}} = \omega \frac{W_e + W_m}{P_d} = \omega \frac{W}{P_d}$$

$$= \omega \frac{2W_e}{P_d} = \omega \frac{2W_m}{P_d}$$

For a perfect cavity, $Q \to \infty$