Microwave Engineering

- Cut off wave number in rectangular waveguide

$$k_c = \sqrt{\left(\frac{m\pi}{a}\right)^2 + \left(\frac{m\pi}{b}\right)^2} = \omega\sqrt{\mu\varepsilon}$$

- Cut-off wavelength

$$\lambda_c = \frac{1}{\sqrt{\left(\frac{m}{2a}\right)^2 + \left(\frac{n}{2b}\right)^2}}$$

- Cut-off frequency

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

- Propagation constant

$$\beta = \pm\,\omega\sqrt{\mu\varepsilon}\,\sqrt{1 - \left(\frac{f_c}{f}\right)^2}$$

- Phase velocity

$$v_p = \frac{c}{\sqrt{1 - \left(\frac{f_c}{f}\right)^2}}$$

- Waveguide wavelength

$$\lambda_g = \frac{\lambda}{\sqrt{1-\left(\frac{\lambda}{\lambda_c}\right)^2}}$$

λg

- Waveguide impedance

$$Z_{TE} = \frac{\omega\mu}{\beta} = \frac{\eta}{\sqrt{1-(\lambda_0/\lambda_c)^2}},$$

$$Z_{TM} = \frac{\beta}{\omega\mu} = \eta\sqrt{1-(\lambda_0/\lambda_c)^2}$$

- Power handling capacity

$$P_{max} = 27\left(\frac{E_d}{f_{max}}\right)\sqrt{1-(f_c/f)^2}\text{ watts}$$

- Attenuation

$$\propto = \frac{\text{Power loss / unit length}}{2(\text{Average power transmitted})}$$

- Microstrip line, Z_o $\quad Z_o = \frac{377}{\sqrt{\varepsilon_r}}.\frac{h}{w}$

- Velocity modulation in 2-cavity klystron

$$v_1 = v_0\left(1+\frac{V_1}{V_0}\sin\omega t_1\right)^{\frac{1}{2}}$$

- Optimum bunching occurs at

$$L_{max} = 3.682\frac{v_0 V_0}{\omega V_1}$$

- Bunching parameter X of a klystron

$$X = \frac{V_1}{2V_0}\theta_0$$

- Efficiency (η)

$$\eta = \frac{P_{out}}{P_{in}} = \frac{0.58 I_0 V_2}{I_0 V_0} = 0.58\frac{V_2}{V_0}$$

- For maximum transfer of energy

$$\left(\frac{V_1}{V_0}\right)_{max} = \frac{2\times 1.84}{2n\pi - \pi/2} = \frac{3.68}{\left(2n\pi - \frac{\pi}{2}\right)}$$

- Relation between Repeller voltage and Accelerating voltage in reflex klystron is $\frac{V_0}{(V_R - V_0)^2}$

$$= \frac{1}{8}.\frac{1}{\omega^2 s^2}\frac{e}{m}\left(2\pi n - \frac{\pi}{2}\right)^2$$

- Efficiency of Reflex klystron $\eta = \frac{2X' J_1(X')}{\left(2n\pi - \frac{\pi}{2}\right)}$ (Maximum 22.78%)
- Axial phase velocity in TWT $v_p = v_c\left(\frac{\text{Pitch}}{2\pi r}\right)$
- Hull's cut-off field (Magnetron)

$$B_c = \frac{\left(8V_0 \frac{m}{e}\right)^{\frac{1}{2}}}{b\left(1 - \frac{a^2}{b^2}\right)}$$

- Resonant frequency of rectangular cavity resonator

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

- Resonant frequencies of circular cavity resonator

$$f_r = \frac{1}{2\pi\sqrt{\mu\varepsilon}}\sqrt{\left(\frac{X_{np}}{a}\right)^2 + \left(\frac{q\pi}{d}\right)^2}$$

- Q of a Rectangular Cavity Resonator:

$$Q = \frac{\omega\mu\,(\text{vol})}{2\,Rs\,(\text{sur})}$$

- Measurement of High VSWR

$$\text{VSWR} = \frac{\lambda_g}{\pi(d_2 - d_1)}$$

- Skip distance $D_{ship} = 2h\sqrt{\left(\frac{f_{muf}}{f_c}\right)^2 - 1}$
- Critical frequency $f_c = \sqrt{N_{max}}$
- Maximum usable frequency

$$f_{mvf} = f_c\sqrt{1 + \left(\frac{D}{2h}\right)^2}$$

- Line of sight range

$$= \sqrt{2 \times \frac{4}{3} r}\left[\sqrt{h_t} + \sqrt{h_r}\right] = 4.12\left[\sqrt{h_t} + \sqrt{h_r}\right]\text{km}$$

- Friss equation, $P_r = P_t G_t G_r\left(\frac{\lambda}{4\pi d}\right)^2$