جامعة الموصل / كلية الهندسة

قسم الهندسة الكهربائية

Subject Title: Microwaves

Subject Code: MIWA 411

Class 4: Electronic and communication

Instructor : Dr. Saad Wasmi Osman Luhaib

Course layout (15 Weeks)

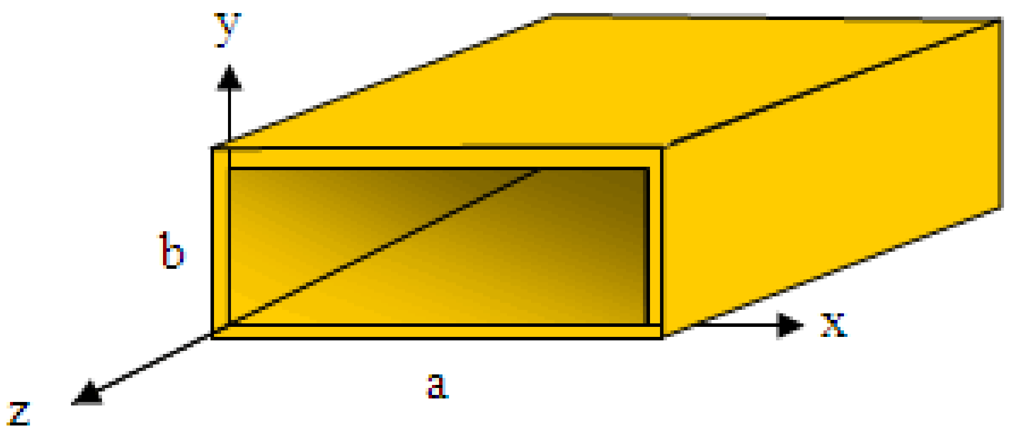
- Introduction to Microwave Engineering and Transmission line theory
- Rectangular and Circular waveguides
- Microwave Networks and Scattering Matrix
- Microwave Resonators
- Power divider, directional couplers
- Microwave Semiconductor Devices
- Microwave Amplifiers and Oscillators
- Microwave Tubes
- Ferrite devices

Books and References

1. D. M. Pozar, Microwave Engineering; 4th /edition, John Wiley & Sons Inc, 2012.
2. R. E. Collin, Foundations for Microwave Engineering; 2/e, Wiley-IEEE Press, 2000.
3. S. M. Liao, Microwave devices and Circuits; 3/e, Prentice Hall of India, 2004.

Rectangular Waveguide

- $\vec{E} = E_0 e^{\gamma_d z}$
- $\frac{\partial \vec{E}}{\partial z} = -\gamma_d \vec{E}$
- $\frac{\partial \vec{H}}{\partial z} = -\gamma_d \vec{H}$
- $\nabla \times \vec{\mathrm{E}} = -j\omega\mu\vec{H}$
- $\begin{vmatrix} a_x & a_y & a_z \\ \frac{\partial}{\partial z} & \frac{\partial}{\partial z} & \frac{\partial}{\partial z} \\ E_x & E_y & E_z \end{vmatrix} = -j\omega\mu\vec{H}$
- $\gamma = j\sqrt{\omega^2\mu_0\epsilon_0}$ when $\sigma = 0$ in free space , where $\gamma = j\omega\sqrt{\mu_0\epsilon_0}$



- Ex/A waveguide with rectangular cross section has dimensions of 7cmx3.5 cm. Assuming $\boldsymbol{TE_{10}}$ mode, good conductivity of the
walls, and the dielectric to be air compute. a- cutoff frequency, b-phase velocity of the wave at f=3.5 GHz, c- guided wavelength at same frequency, d- wave impedance

- Solution

- $f_c = \frac{c}{2a} = \frac{3\times10^8}{2*0.07} = 2.14\ GHz$

- $\nu_g = \frac{\omega}{\beta_g} = \frac{c}{\sqrt{1-\left(\frac{f_c}{f}\right)^2}} = \frac{3\times10^8}{\sqrt{1-\left(\frac{2.14}{3.5}\right)^2}} = 3.78\times10^8\,\frac{m}{s},\qquad \lambda_g = \frac{\nu_g}{f} = \frac{\lambda}{\sqrt{1-\left(\frac{f_c}{f}\right)^2}} = 10.8\ cm$

- $Z_g = \frac{\omega\mu}{\beta_g} = \frac{\eta}{\sqrt{1-\left(\frac{f_c}{f}\right)^2}} = \frac{120\pi}{\sqrt{1-\left(\frac{2.14}{3.5}\right)^2}} = 151.65\pi\ \Omega$

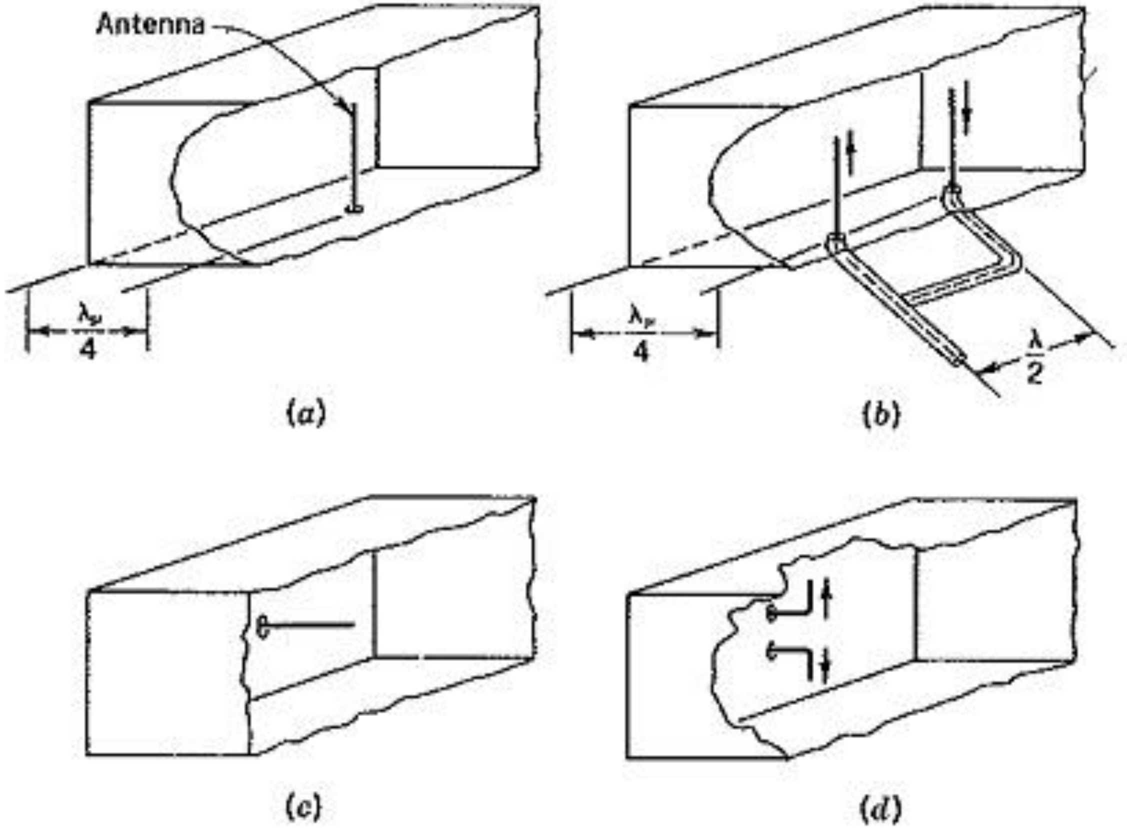
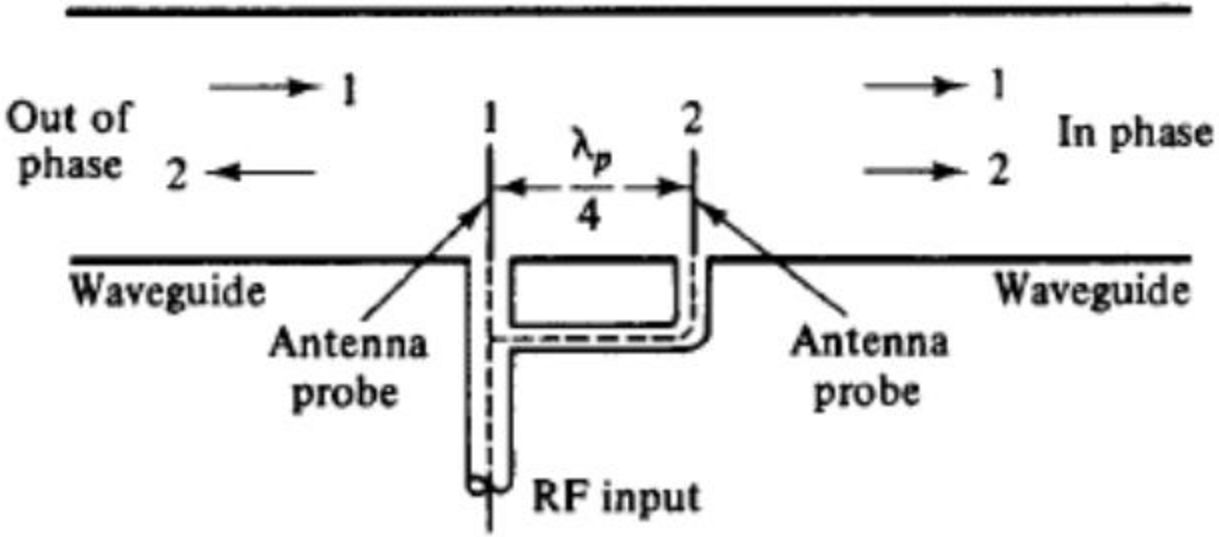


FIGURE 10-15 Methods of exciting common modes in rectangular waveguides. (*a*) $TE_{1,0}$; (*b*) $TE_{2,0}$; (*c*) $TM_{1,1}$; (*d*) $TE_{1,1}$

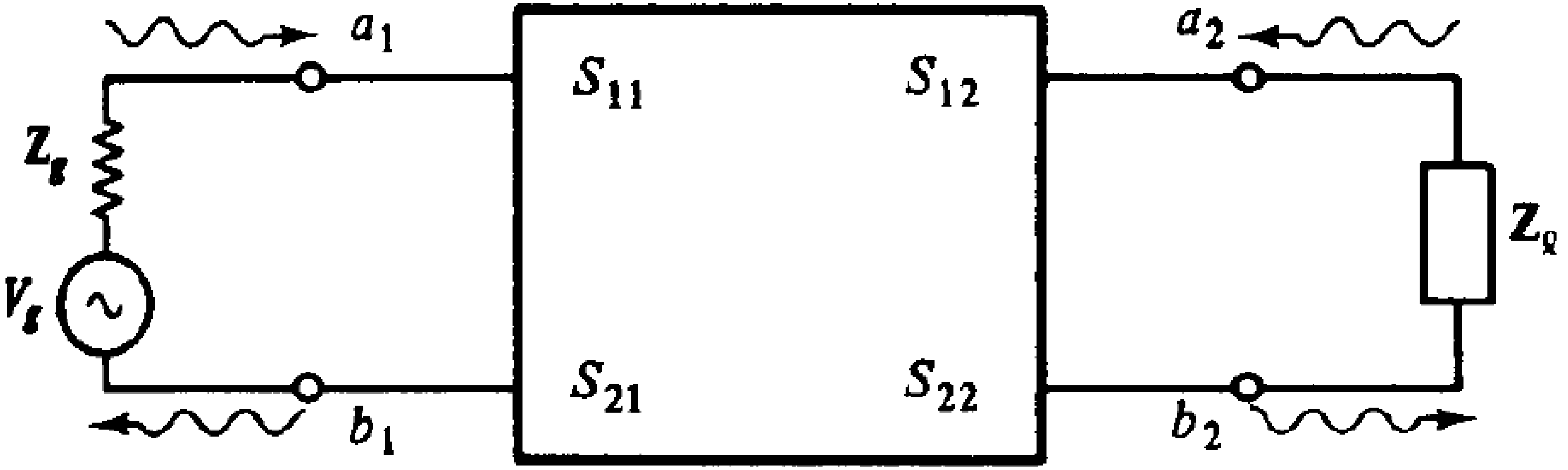


S-Parameter Theory

- new method of characterization is needed to overcome these problems. The logical variables to use at the microwave frequencies are traveling waves rather than total voltages and total currents. These are the *S* parameters, which are expressed as

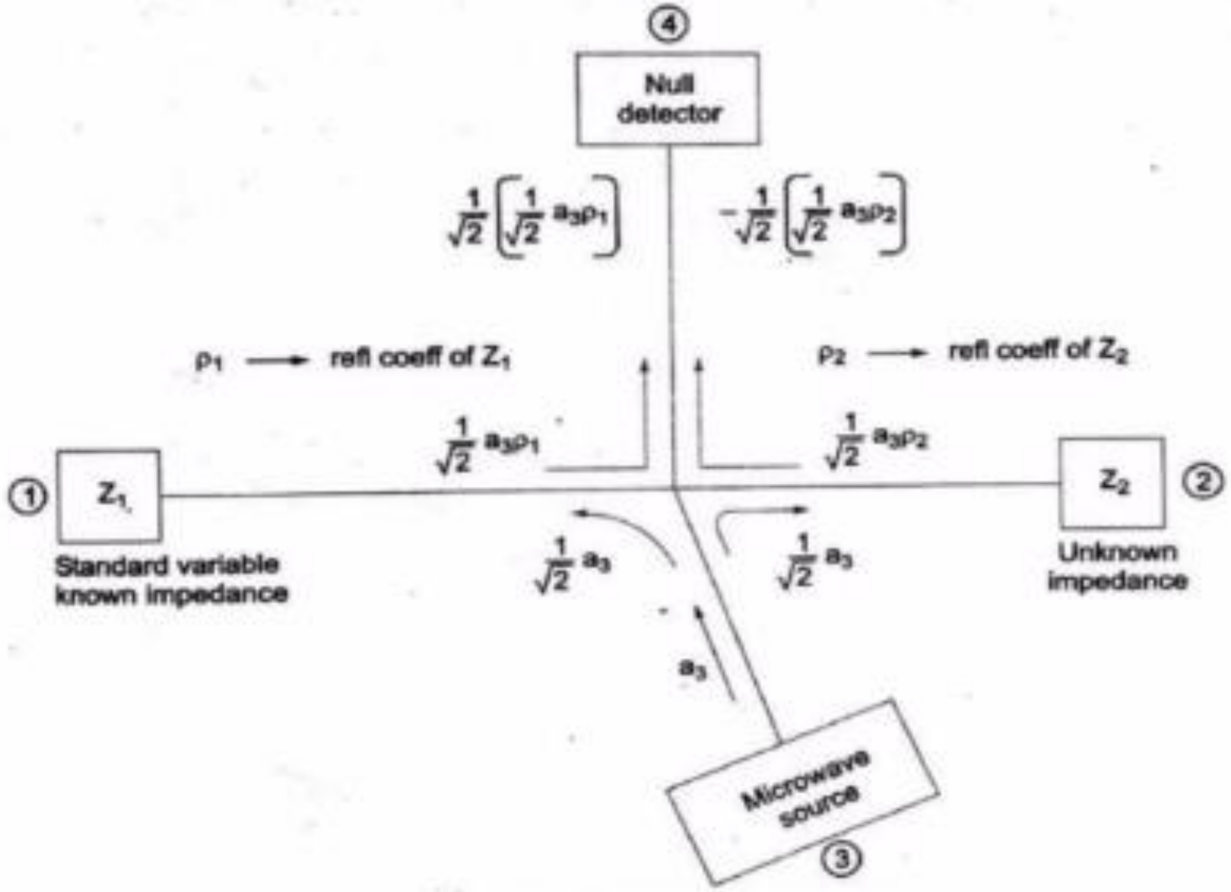
$$b_1 = S_{11}a_1 + S_{12}a_2$$

$$b_2 = S_{21}a_1 + S_{22}a_2$$

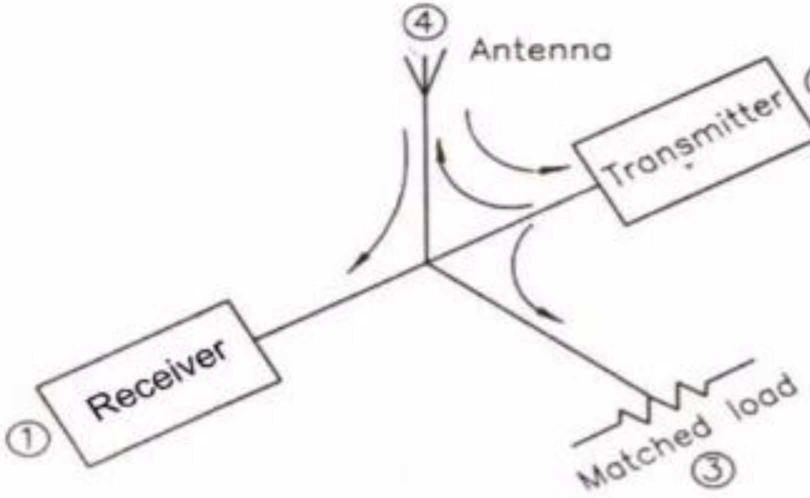


Applications

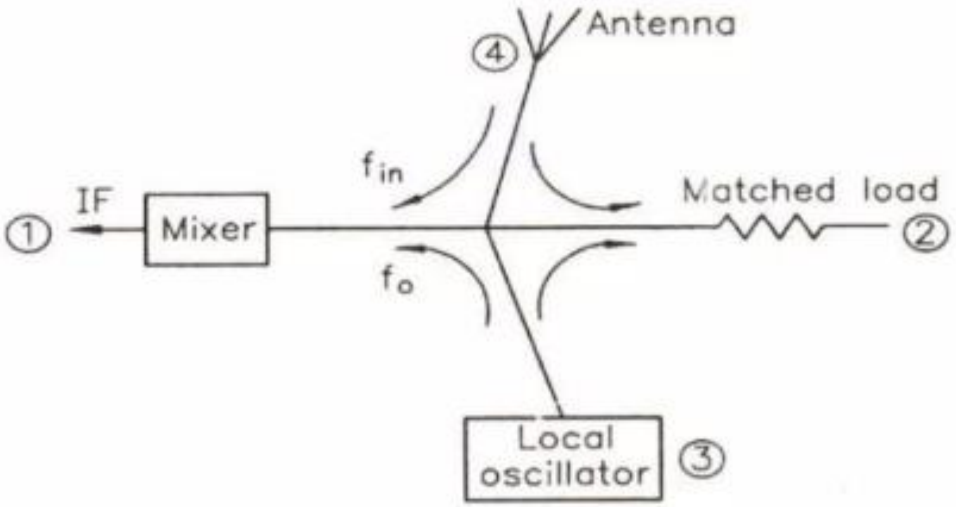
1. Measurement of Impedance



2. Magic Tee as a Duplexer

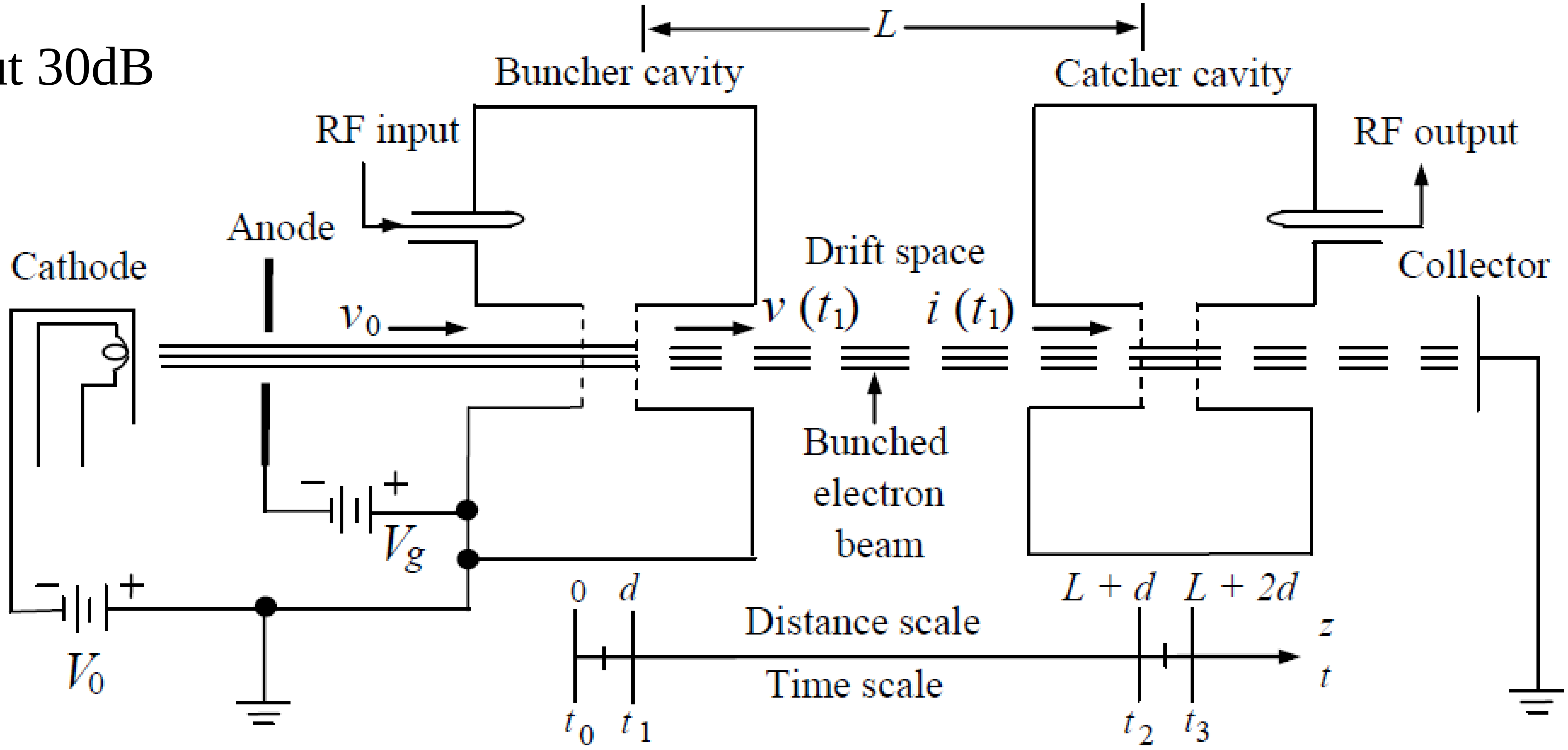


3. Magic Tee as a Mixer



Two Cavity Klystron

- Characteristics:-
- η ≈40%
- Output power:- continues wave up to 500 KW, pulsed power is up to 30MW at10 GHz.
- power gain about 30dB



- Gunn diodes can be made from the materials which consist of multiple, initially-empty, closely-spaced energy valleys in their conduction band like Gallium Arsenide (GaAs), Indium Phosphide (InP), Gallium Nitride (GaN), Cadmium Telluride (CdTe), Cadmium Sulfide (CdS), Indium Arsenide (InAs), Indium Antimonide (InSb) and Zinc Selenide (ZnSe).