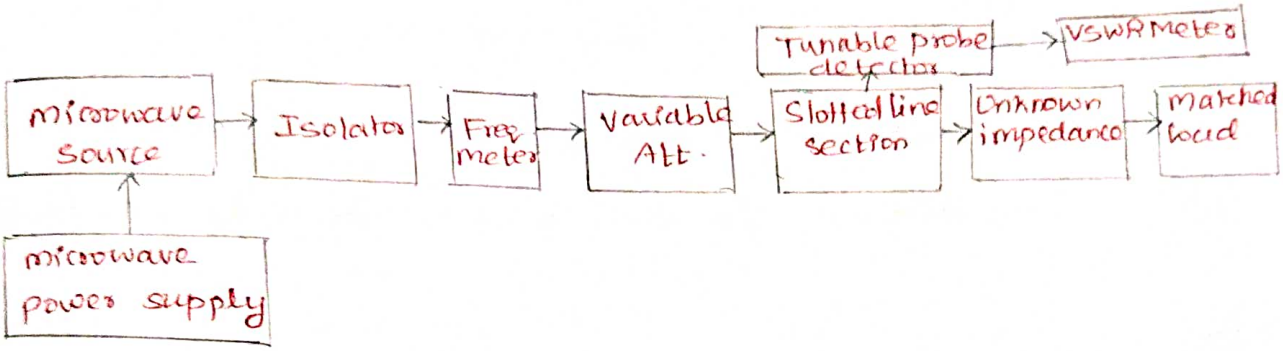
VSWR Measurements

Aim: To know the measurement method of VSWR and magnitude of voltage Reflection coefficient using slotted line.

objective: To learn slotted line method for VSWR

* **Slotted line method**

* VSWR and Γ are used for measurement of load impedance
* Determines the degree of impedance matching.



VSWR:

$$S = \frac{V_{max}}{V_{min}} = \frac{1+\Gamma}{1-\Gamma}$$

Reflection coefficient

$$\Gamma = \frac{P_{reflected}}{P_{incident}}$$

1) Low VSWR ($S < 20$)

- directly on the VSWR meter

* variable att ⇒ 10dB ; microwave source set to required freq. 1KHz modulation adjust for maximum reading on 30dB scale
* Probe on the slotted line is moved to get minimum reading on the meter (V_{max})
* Attenuation is adjusted - full scale reading ; Probe on slotted line adjusted to minimum reading (V_{min})
* $\frac{V_{max}}{V_{min}}$ gives VSWR.

Possible Sources of Error in measurements

i) V_{max} and V_{min} may not be measured in the square-law region of the crystal detector

ii) The probe thickness and depth of penetration may produce reflections in the line and also distortion in the field

iii) When VSWR < 1.05 the associated VSWR of connector produces significant error in VSWR measurement. Very good low VSWR (<1.01) connector should be used for very low VSWR.

iv) Any harmonics and spurious signals from the source may be tuned by the probe to cause measurement error.

v) A residual VSWR of slotted line arises due to mismatch impedance b/w the slotted hole and the main line.

ii) High VSWR (S > 20)

* double minimum method
* EM wave - considered as sum of two traveling waves - Incident wave which propagates from generator & Reflected wave - towards generator
* standing wave - superposition of two.
* maximum field strength - In phase waves
  minimum - opposite waves
* Distance b/w two successive minimum or maximums is half the guide wavelength on the line

Reflection Coefficient - Ratio of electrical field strength of reflected and incident wave (ρ) is,

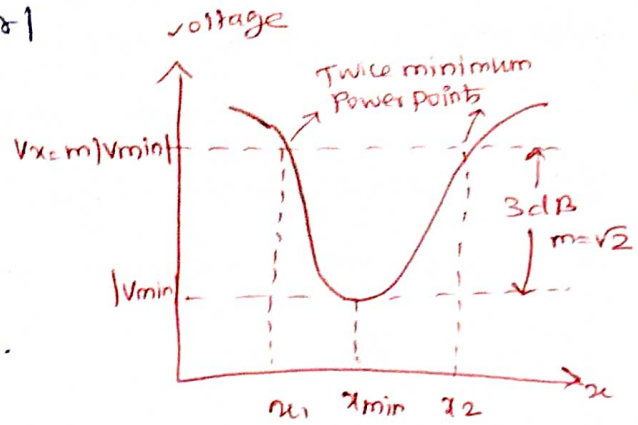
$$\Gamma = \frac{E_r}{E_i} = \frac{Z - Z_0}{Z + Z_0}$$

$$|\Gamma| = \frac{S-1}{S+1}$$

Incident voltage – E_I

Reflected voltage – E_r

VSWR : $$S = \frac{E_{max}}{E_{min}} = \frac{|E_I| + |E_r|}{|E_I| - |E_r|}$$



Double minima method

* Probe is inserted to a depth where minimum can be read
* Probe then moved to a point where power is twice the minimum.
  → Let this position (x_1)
* moved to twice the power point on other side of minimum (x_2)

$$P_{min} \propto V_{min}^2$$

$$2 P_{min} \propto V_x^2$$

$$\Rightarrow \frac{1}{2} = \frac{V_{min}^2}{V_{x2}}$$

$$V_x^2 = 2 V_{min}^2$$

$$V_x = \sqrt{2}\, V_{min}$$

Guide wavelength

$$\lambda_g = \frac{\lambda_0}{\sqrt{1 - \left(\frac{\lambda_0}{\lambda_c}\right)^2}}$$

Cutoff λ

$$\lambda_c = 2a$$

Free space λ

$$\lambda_0 = \frac{c}{f}$$

High VSWR :-

$$S = \frac{\lambda_g}{\pi(x_1 - x_2)}$$

Outcome :

Able to learn the VSWR measurement techniques and

Apply in microwave measurement experiments

—x— x—