Impedance Measurement

Aim:

To know the impedance measurement techniques at microwave frequencies

objective: To learn the concepts of measuring impedance

* Measurement of Impedance using .

Slotted line Method

* Reflection coefficient .

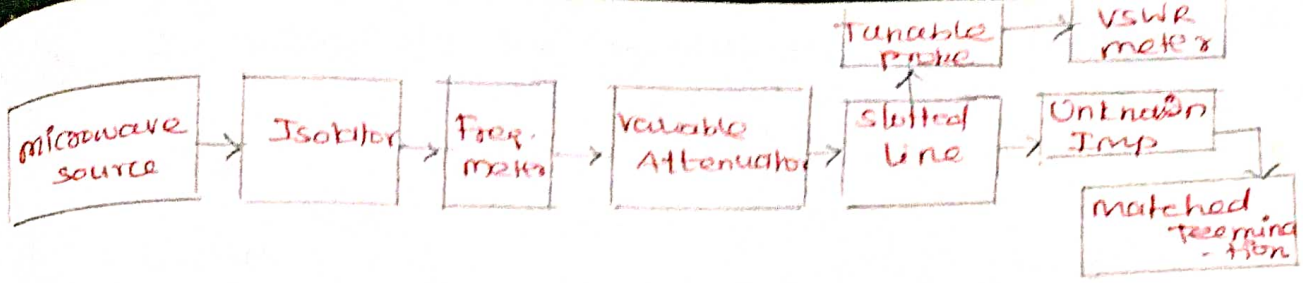
$$\Gamma_L = \frac{Z_L - Z_0}{Z_L + Z_0} \quad \rightarrow (1)$$

Z_0 - characteristic impedance of operating freq.

Z_L - Load impedance at any point.

Complex impedance $Z_L = Z_0 \frac{1+\Gamma_L}{1-\Gamma_L}$ $\rightarrow (2)$

$$\Gamma_L = \rho_L e^{j\phi_L} \quad \rightarrow (3)$$



Setup for impedance measurement

ρ_L - magnitude of Γ_L and

ϕ_L - phase of Γ_L

Measuring the phase of the complex reflection coeff. Γ_L (ϕ_L) from the distance of first voltage standing wave minimum d_{min} and the magnitude of Γ_L from VSWR.

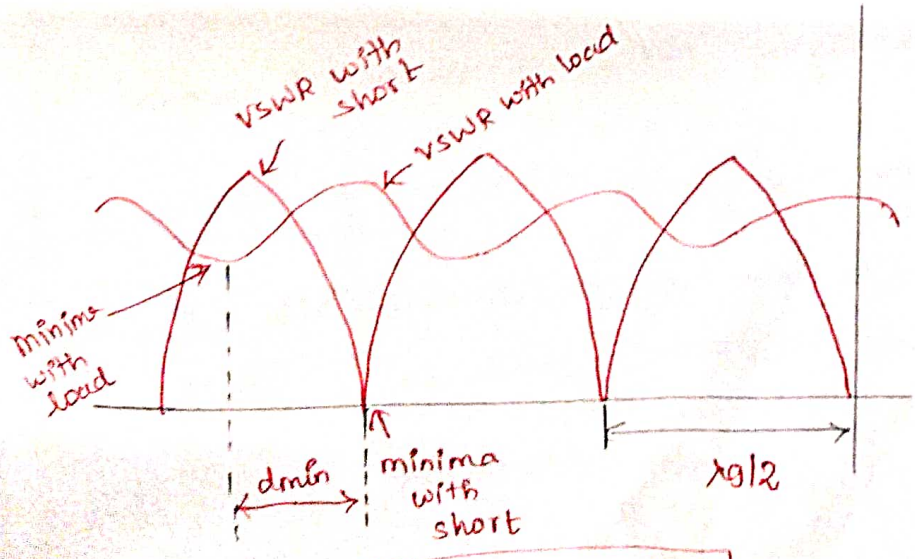
Magnitude from VSWR measurement

$$|\rho_L| = \frac{VSWR-1}{VSWR+1} \longrightarrow (4)$$

phase $\rho \rightarrow$ found from d_{min}.

Measurement steps:

1. Unknown device (load) connected to slotted line and SWR = S_0 and position of one minima is determined.
2. Then load is replaced by a movable short to the slotted line. Two successive minima positions are noted.



Determination of d_{min}

λg = 2 x distance b/w two successive minima = Guide wavelength

$= 2 d_{min}$

$= 2(d_1 - d_2)$ ⟶ (5)

(3) one of the minima is used as reference.
Find the difference b/w reference minima and minium position obtained from unknown load and namely as, 'dmin'

(4) If the minima is shifted to the left then the unknown load impedance is inductive

If it shifts to the right then → capacitive

(5) amount of shift is then converted in terms of wavelength.

Using smith chart, the normalized impedance calculated in terms of magnitude and phase.

(6) Take a smith chart taking '1' as center, draw a circle of radius equal to So. mark a point on circumference of chart towards load side at a distance equal to $\frac{d_{min}}{\lambda g}$

(7) Join the center with this point. Find the point where it cuts the drawn circle.

(8) This point shows the normalized impedance of load, Unknown impedance Z_L is then calculated from eqn (2)

* Measurement of Impedance using reflectometer

* Two directional couplers are used to sample the incident power Pi and reflected power Pr from Load.

* Unknown impedance is connected to the output port.

magnitude of the reflection coeff ρ can be obtained on reflectometer from which impedance calculated.

* Reflection coefficient of load

$$\Gamma_L = \sqrt{\frac{\text{Reflected power}}{\text{Incident power}}} = \sqrt{\frac{P_r}{P_i}}$$

* $VSWR = S = \frac{1+\Gamma_L}{1-\Gamma_L}$

* Known wave impedance is calculated by connecting a movable short instead of unknown impedance device.

Then, unknown imp

$$Z_L = Z_g \frac{1+\Gamma_L}{1-\Gamma_L}$$

Z_g - known wave impedance

Z_L - unknown (load) imp

Outcome:

Able to learn and apply Impedance measurement techniques for laboratory measurements using microwave setup.

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