Measurement of Cavity Q, Dielectric Constant

Aim: To learn the Q factor measurement and dielectric constant measurement at microwave frequencies.

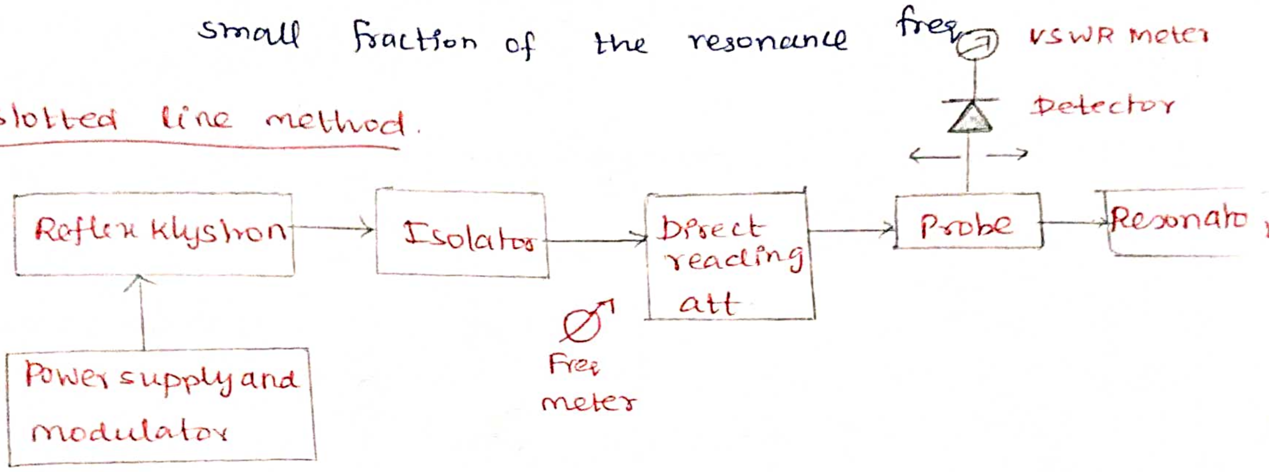
objective: To study the block diagrams & working procedure

① Cavity Q

High Q cavity - difficult to measure

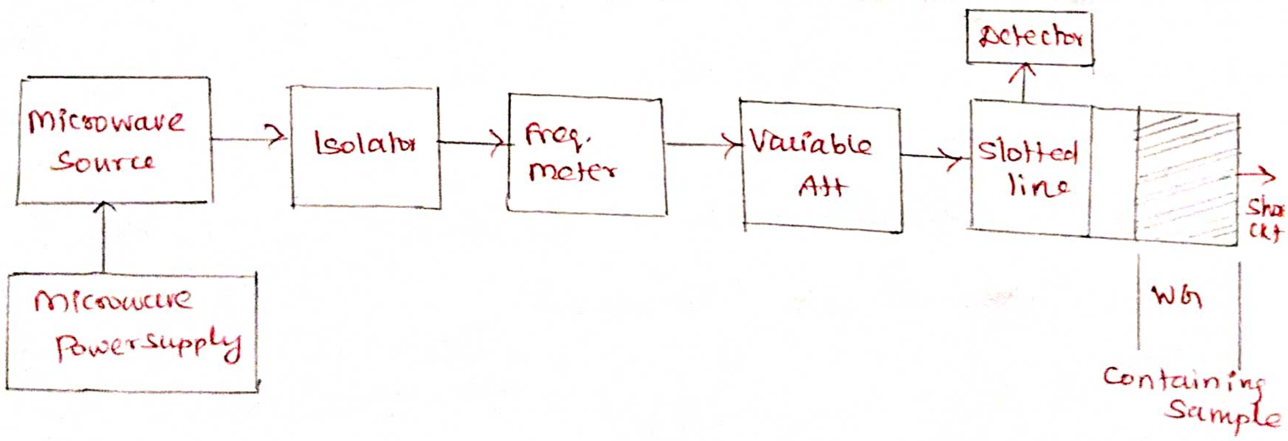
* Bcoz, 3dB BW of cavity response curve is very small fraction of the resonance freq.

Slotted line method.



* measured through pure VSWR measurements or through measurement of the shift in position of a standing wave minimum as the generator freq. is varied.

② Dielectric constant



Dielectric constant $\epsilon_r = \frac{\epsilon}{\epsilon_0}$

ϵ_0 - Dielectric constant permittivity in free space

$\epsilon_r = \epsilon_r' + j\epsilon_r''$ due to presence of non-zero conductivity

ϵ' = Ability of dielectric to store energy

ϵ'' = measure of dissipation of energy in medium or loss factor

Also, relative dielectric constant

$$\varepsilon_r = \varepsilon'(1 - j\tan\delta)$$

Loss tangent : $\tan\delta = \frac{\varepsilon_r'}{\varepsilon_r''}$

measure of energy loss in the form of heat when a wave is propagated thro' the material.

Types:

waveguide method

cavity perturbation method.

Outcome : Able to understand the measurement setup for Q and dielectric constant.

—x— x—

Measurement of Scattering Parameters of a Network

Aim:

To learn the microwave setup measurement of S parameter for two-port Network.

objective : To study the procedure for S-parameters

S-parameters of a 2-port Network:

Scattering parameters are the ratios of the outgoing waves to the incident waves.

Steps:

1) Connect a source to the port 'm' and matched load to the port 'n'. These two ports are connected to a N/W analyser via two directional couplers.

2) Terminating all other ports in matched loads → so that at all other ports the amplitudes of incident waves are zero.

3) Network analyzer indicates S_{nm} amp & phase.

* Many cases, only the amplitude of S_{nm} is needed

S-parameters of a Magic Tee

Measurement of S_{ii}

Diagonal elements are determined from the slotted line measurement of VSWR, S_i at the corresponding port with other ports matched.

$$S_{ii} = \frac{S_i - 1}{S_i + 1}$$

Measurement of S_{ij} $(i \neq j)$:

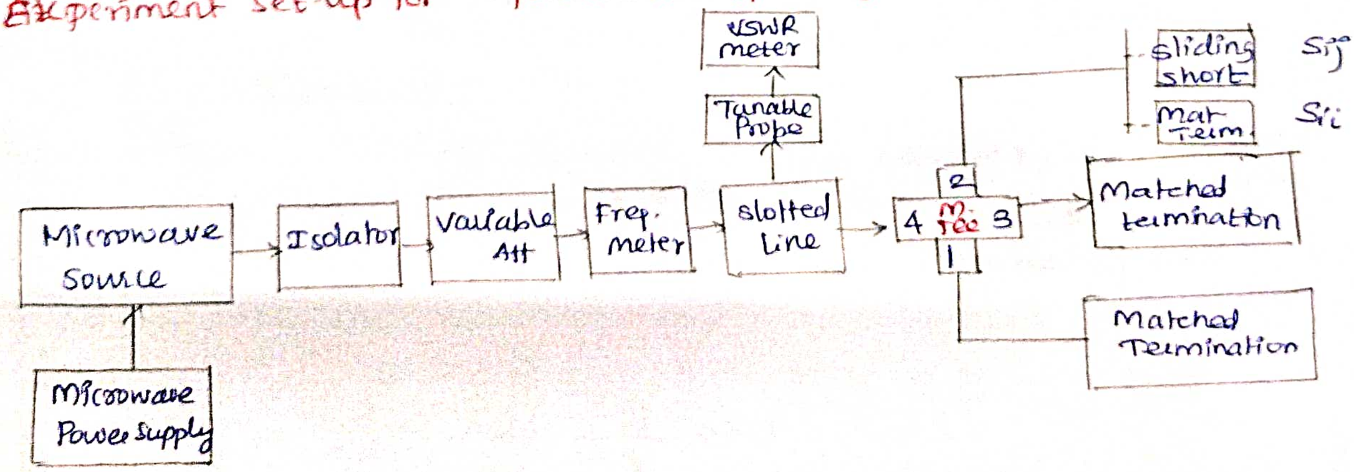
Ex: To measure S_{12}, ports 3 and 4 are match terminated and Port 2 is terminated in a short ckt plunger when the input is fed at port 1.

Isolation: Isolation b/w E and H arm is defined as the ratio of the power supplied by the generator connected to E-arm (port 4) to the power detected at H arm (port 3) when all other ports terminated with matched load (1 & 2)

Hence,

$$\text{Isolation} = 10 \log_{10} \frac{P_4}{P_3}$$

Experiment set-up for S-parameters of Magic Tee



Coupling coefficient

$$C_{ij} = 10^{-\alpha/20}$$

α = Attenuation / isolation in dB

$$\alpha = 10 \log_{10} \left[\frac{P_i}{P_j} \right]$$

P_i - Power delivered to arm i

P_j - Power detected at j arm

Outcome :

Able to apply the S-parameter measurement techniques of microwave passive devices in laboratories.

—x—x—