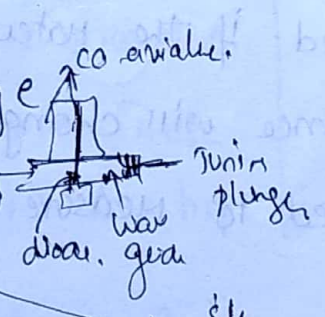
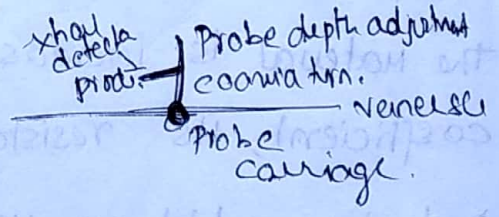
Microwave Measurements:- UNIT-5 note is in new note

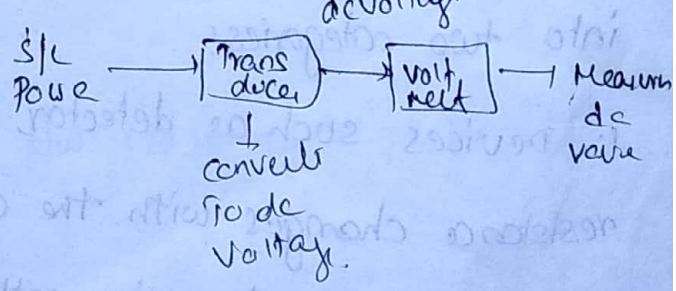
1. In low frequency ac ckts containing lumped elements such as voltage, current frequency & power.
2. impedance, powerfactor & phase angle can be calculated by using lumped elements.
3. At μwave frequencies the amplitude of voltage & currents on a transmission lines are the functions of distance & are not easily measured.
4. In lossless line, the power is independent of the location ∴ it is ~~convinces~~ convenient to measure power instead of voltage & current.
5. At μwave frequencies, most of the properties of devices and circuits are obtained from the measurment of s-parameters, frequency, phaseshift, VSWR, power & noise figure.
6. The vector network analyser, spectrum analyser, power meters are direct μwave measuring instruments. due to high cost in laboratory μwave measurement carried out by a 1KHz square wave.

Microwave Test Equipments:-

1. slotted line carriage
2. Tunable detector
3. power meter
4. spectrum analyser
5. VSWR meter







Power Measurements :-

→ Measurement of Microwave power plays an important role in Microwave engineering

→ It determines the o/p powers of generators & decides the functioning of transmitting & receiving systems.

$$\therefore P_{av} = I_{rms} \cdot V_{rms} \cdot \cos\phi$$

→ But at μwave it is impossible to specify and measure current & voltages because at μwave frequency circuit elements are distributed. This leads to various measurement techniques of μwave power.

→ Depending on power level, there are 3 different methods of measuring μwave power.

1. Measurement of very low power (<1mw);
2. Measurement of low power (<10mw);
3. Measurement of high power (10mw to 10w)

Principle:-

When μwave power is absorbed by a material the temperature of the material is increased. If the material has non-zero temperature coefficient, its resistance will change.

→ devices which are used to measure the power will divided into two categories:

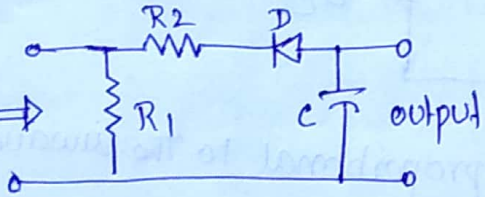
1. Devices such as detector, bolometers & thermocouples → whose resistance changes with the applied power. These devices used for measuring power in Microwatts.
2. calorimeters are not as sensitive but are capable of measuring power as high as hundreds of Kilowatts.

[disadvantage:-
1. unstable for small μwave power
2. accuracy = 5%.

→ Most uwave powa sources are sensitive to load impedance variations, & must be isolated from them. Klystron & Magnetrons will subject to output power & frequency variation if the load is Mismatched. so, An isolator is thus connected immediately after the power source.

1. Measurement of very low power (<1mw)

2 Methods 1. schottky barrier diode sensor



R_1, R_2 are biasing resistance, D is a schottky barrier diode, c: capacitor.

→ R/f i/p is applied to R_1 it passes through the resistance R_2. The diode detects the i/p power & converts the uwave power into heat energy.

→ The corresponding temp. rise provides a change in electrical parameters. These Parameters results in o/p current in low freq. circuit.

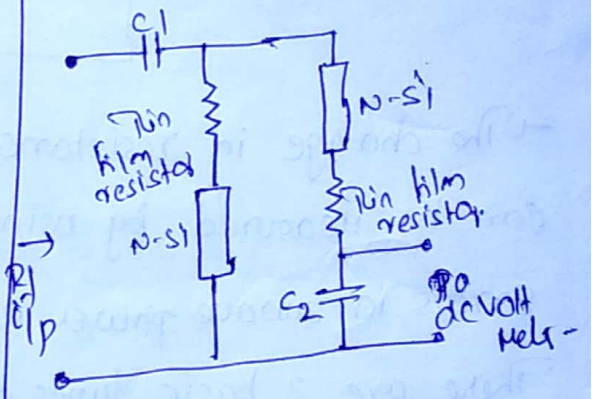
2. Measurement of low power (<10mw)

→ for measuring low power typically blw 1 to 10mw is performed using bolometers.

↓

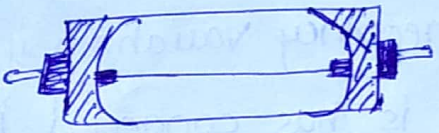
is a most commonly used detecting element in uwave freq. range. Bolometer is a temperature-sensitive elements when uwave power falls on it, its temperature rises which results in change

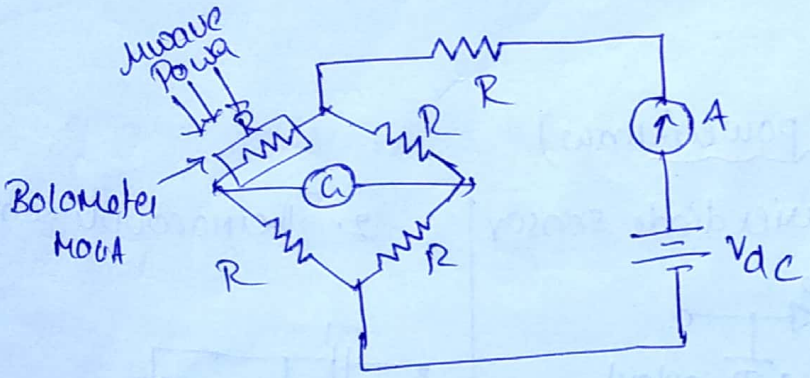
2. Thermocouple sensor.



① Thermocouple is a junction of 2 disimilar metals or semiconductors.

in resistance. The element with +ive temperature coefficient is used & the element used is <u>bauatteus</u>.





→ The change in resistance is proportional to the muave power which can be measured by using the Microwave bridge circuit.

Errors in muave power measurements:-

There are 3 basic types of errors 1. Instrumental error ← instability by biasing source.

2. substitution error ← due to difference in heating element

3. Mount inefficiency error. ↓ impefect matching of impedance.

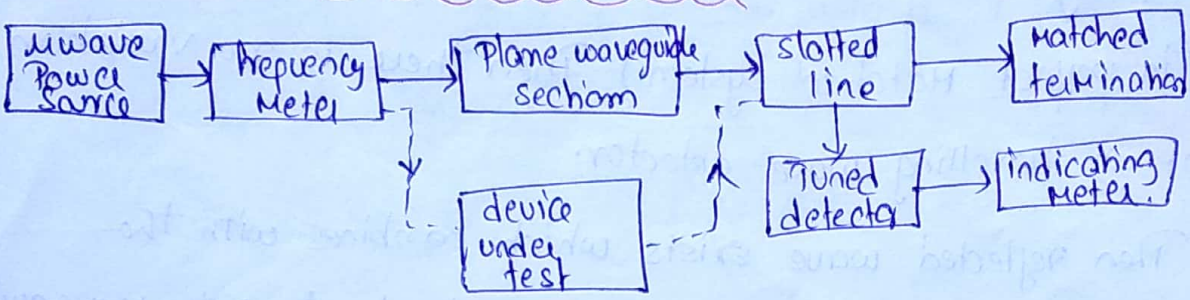
Attenuation Measurement:-

$$\alpha = 10\log_{10}\left(\frac{P_i}{P_o}\right)$$

P_i = input power to the device
P_o = output power from the device.

can be performed by 2-Methods 1. Direct or power ratio measuring Method
2. RF substitution Method.

1. Power ratio Measurement Method:-

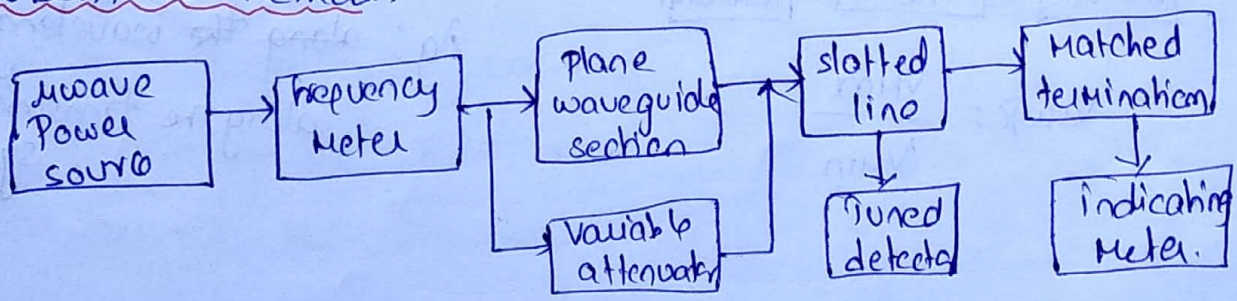


The direct Method involves Measuring power at two desired points i.e i/p power & o/p power with and without device of which attenuation is to be Measured.

→ It should be Measured under Matched conditions

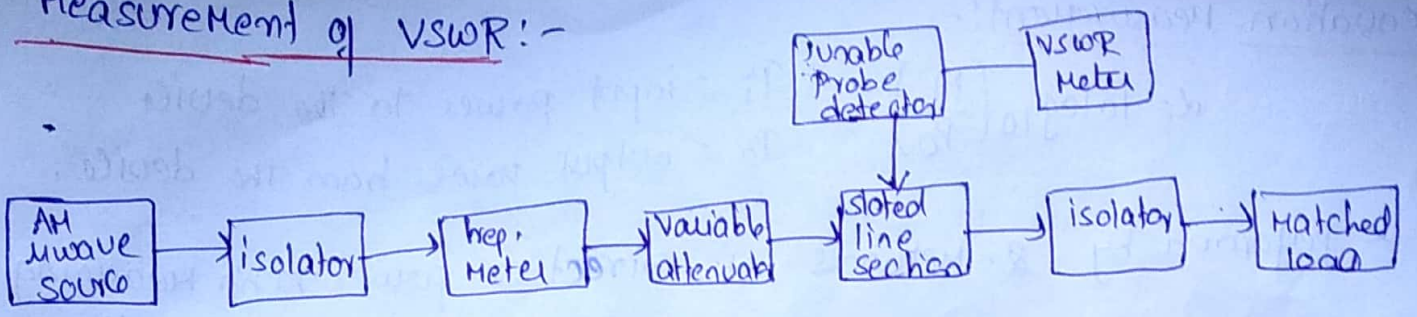
→ Power delivered to the load is Measured & Then power Measured with out load Then the ratio of second to the first power gives attenuation.

RF substitution Method:-



→ This Method is used when i/p power is low & device has high attenuation.

Measurement of VSWR:-



* VSWR & voltage reflection coefficient are used for the measurement of load impedance by slotted line.

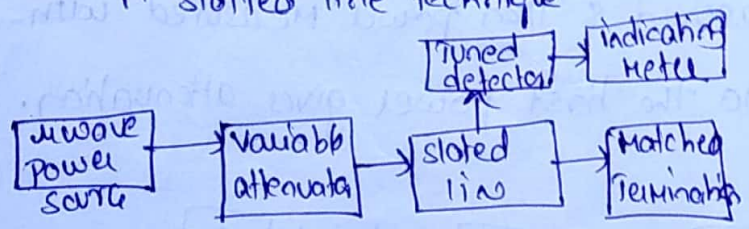
→ If $Z_0 = Z_L$ (in perfect Matched system) Then there is no variation in the output of travelling wave detector.

If $Z_0 \neq Z_L$ Then reflected wave exists which combines with the incident wave to create standing wave along the length of the waveguide.

$$VSWR = \frac{V_{MAX}}{V_{MIN}}$$

There are two commonly used Methods 1. slotted line technique
2. double MINIMUM Method.

1. slotted line technique



$$VSWR = \frac{V_{MAX}}{V_{MIN}}$$

2. double MINIMUM Method.

$$SWR = \frac{\lambda g}{\lambda (d_2 - d_1)}$$

λg : ~~along the~~ wavelength along the transmission system.

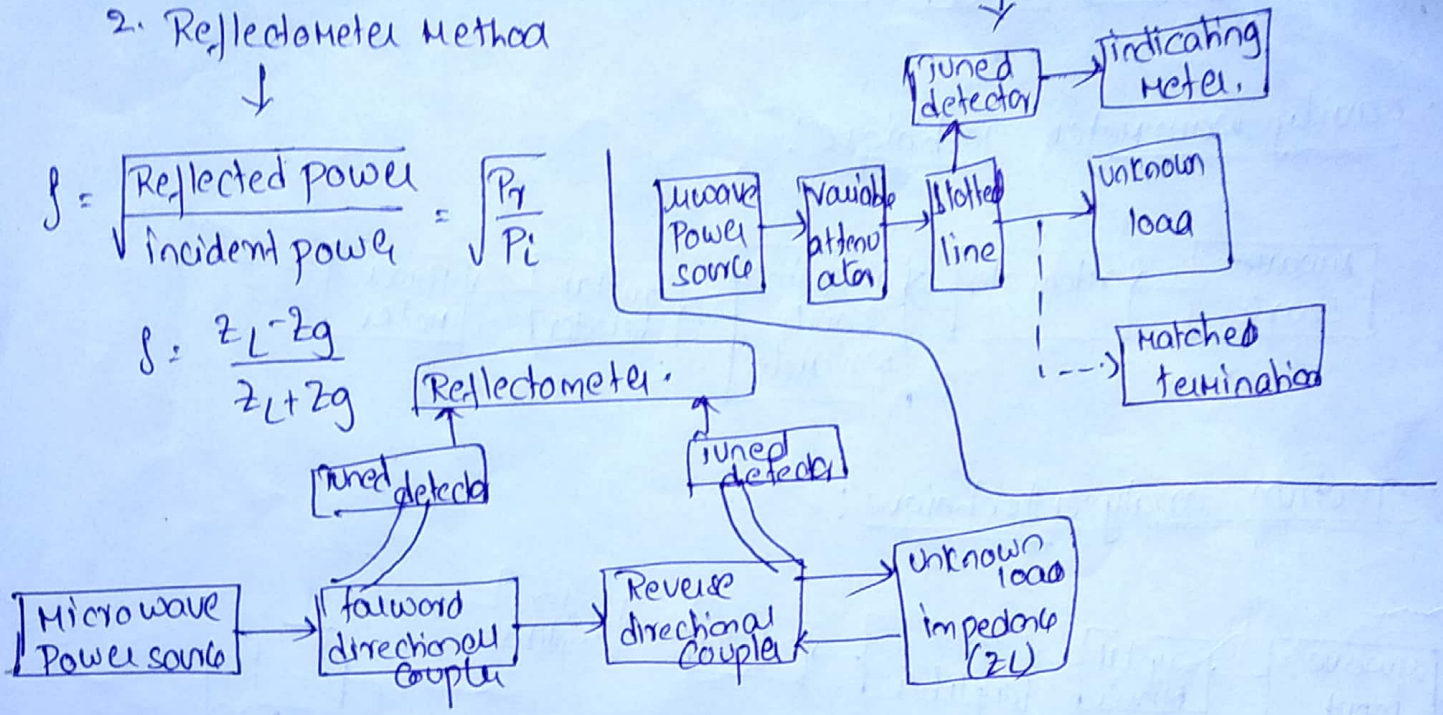
Impedance Measurement:-

Methods used to measure the impedance at μwave frequency are

1. slotted line Method
2. Reflectometer Method

$$\rho = \sqrt{\frac{\text{Reflected power}}{\text{incident power}}} = \sqrt{\frac{P_r}{P_i}}$$

$$\rho = \frac{Z_L - Z_0}{Z_L + Z_0}$$

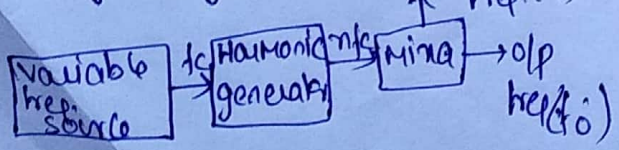


Frequency Measurement:-

There are two techniques to measure Microwave frequency

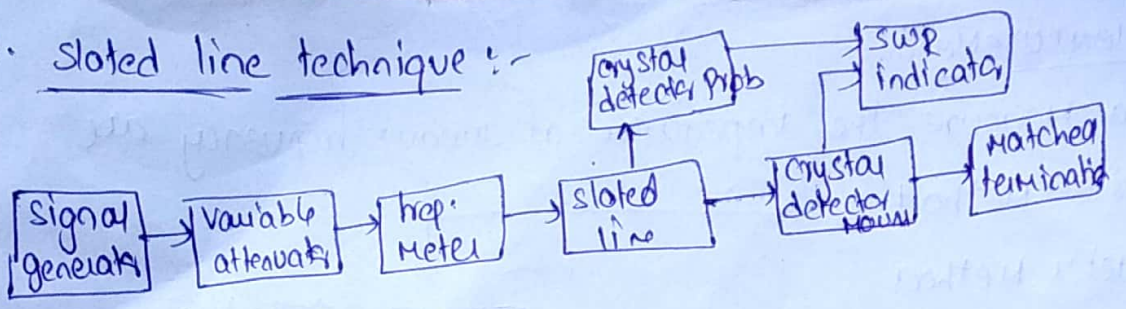
1. Mechanical technique → a) slotted line technique
2. Electronic technique → b) cavity wavemeter technique (or) Resonant cavity technique
   c) spectrum Analyzer Method

Principle:- electronic technique is based on the comparision of unknown Microwave frequency with a harmonic of known frequency by a frequency heterodyne system.

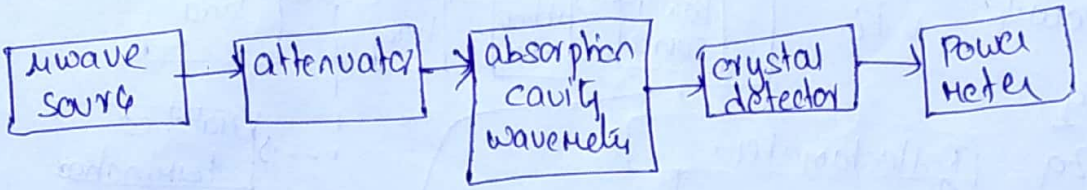


$$f = nf_c - f_0$$

1. Slotted line technique :-



2. cavity wavemeter Technique :



3. Spectrum analyser technique :-