SLOTTED LINE MEASUREMENTS

Objective: To familiarize with the measurement technique using slotted line.

a) Measurement of standing wave distribution on a slotted line, with short circuit and open circuit termination.

b) Measurement of high VSWR by double minimum method.

List of Equipment:

1. Microwave source with square wave modulation
2. Variable attenuator
3. Crystal detector
4. VSWR Meter
5. Ferrite Isolator
6. Matched load

Theory:

a) **Standing Wave Distribution:** If a transmission lines is terminated in an independence not equal to its characteristic impedance, the termination is said to be 'not matched' to the line. Waves traveling down the line are partially or wholly reflected from the termination. Total reflection occurs when the terminal impedance is not dissipative, i.e. a short, open or reactive termination. Standing waves are the result of two wave trains of equal wavelength incident and reflected along the line in opposite directions.

b) **High VSWR by Double Minimum Method:** The voltage standing wave ratio of a transmission line terminated in a load is defined as,

$$VSWR = \frac{V_{max}}{V_{min}} \tag{1}$$

where V_{max} and V_{min} are the voltage at the maxima and minima of voltage standing wave distribution. When the VSWR is high (≥ 5), the standing wave pattern will have a high maxima and low minima. Since the square law characteristic of a crystal detector is limited to low power, an error is introduced if V_{max} is measured directly. This difficulty can be avoided by using the 'double minimum method' in which measurements are take on the standing wave pattern near the voltage minimum. The procedure consists of first finding the value of voltage minima. Next two positions about the position of V_{max} are found at which the output voltage is twice the minimum value. If the detector response is square law, VSWR is given by

$$VSWR = [1 + \frac{1}{\sin^2(\frac{\pi d}{\lambda_g})}]^{1/2} \qquad (2)$$

where λg is the guide wavelength and d is the distance between the two points where the voltage is $2V_{min}$.

Procedure:

A block diagram of the experimental set up is shown in figure 1. The square wave modulated Microwave source is used. The slotted line probe carriage carries an electric probe to sample the electric field inside the slotted line. The voltage induced in this probe is proportional to the probe depth. This voltage is applied to the crystal detector having square law response. The crystal output corresponding to the modulation frequency (generally 1 KHz) is fed to a VSWR meter which is essentially a tuned, amplifier.

Since the amplifier is linear, the meter response is linear on the linear scale, and hence the reading is proportional to power. On the 'VSWR reading scale' the scale is laid out so that if the pointer is set to full scale when the probe is at V_{max}, the VSWR may be read directly when the probe is moved to V_{min}.

Since the crystal has a square law characteristic only for small powers, the amplifier should be set at almost full gain so that as small a power as possible gives full scale reading on the meter.

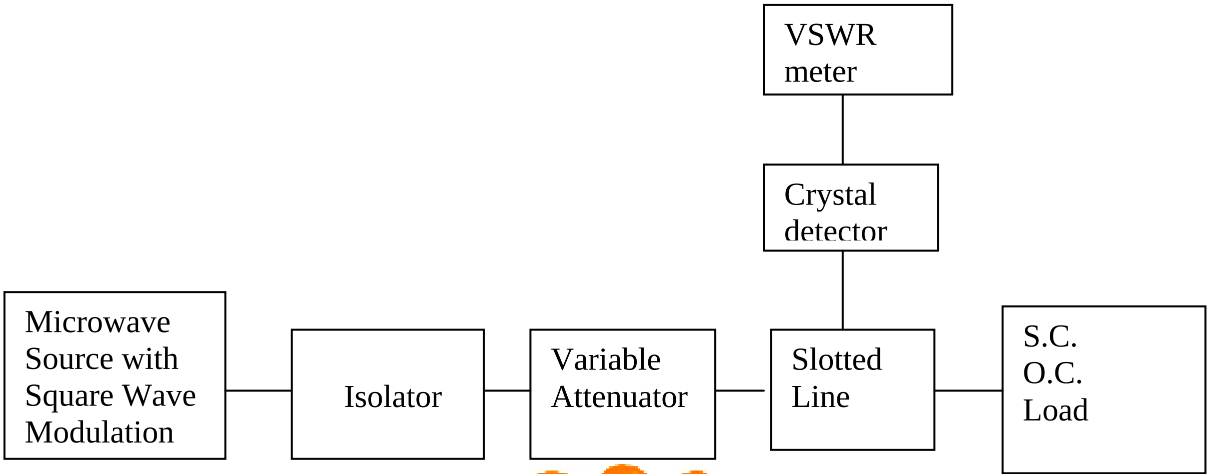

Figure 1. Experimental arrangment for measuring VSWR

(a) Measurement of standing wave distribution:

1. Energize the source and apply square wave modulation. First terminate the slotted line with a short-circuit termination. Move the slotted line probe to a position of voltage maximum in the standing pattern.
2. Tune the probe for maximum sensitivity by adjusting the tuning plunger on the slotted line. Adjust the probe.
3. Measure the standing wave pattern by moving the probe carriage along the slotted line section.
4. Repeat for open circuit termination.

(b) Measurement of high VSWR:

1. With the load connected to the end of the slotted line; located a position of v_{min} on the slotted line. Adjust the VSWR meter gain to some reference value say 3 db.
2. Move the probe along the slotted line on either side of v_{min} so that the reading is 3 db below the reference i.e. 0 db. Record the probe positions and obtain the distance between the two. Determine the VSWR using equation (2).

Discussions:

1. Why the slot is cut in the centre of the waveguide not off centre?

2. What types of errors are introduced in measurement due to finite probe depth and a slot in a waveguide?
3. Why detector is required to have a square law response? If it has response proportional to the cube of the input what correction you will need to apply.
4. If the excitation of the waveguide is changed to TE_{mn} mode, can we continue with this set up? What will be the effect of multimode in measurement?

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