MAHAVEER INSTITUTE OF SCIENCE & TECHNOLOGY

ESTD : 2001

Microwave and Digital Communications Lab

Department Of
Electronics and Communication Engineering

MICROWAVE ENGINEERING LAB

List of Experiments:

1.Reflex Klystron Characteristics.

2. Gunn diode characteristics.

3. Directional coupler characteristics.

4. VSWR Measurement.

5.Measurement of Waveguide Parameters.

6. Measurement of impedance measurement using reflex klystron.

7. Measurement of scattering parameters of magic tee.

8. Measurement of Scattering Parameters of Circulator.

9. Attenuation Measurement.

10. Measurement of Microwave Frequency

1. REFLEX KLYSTRON CHARACTERISTICS

AIM: To study the mode characteristics of the reflex klystron tube and to determine its Electronic tuning range.

EQUIPMENT REQUIRED:

1. Klystron power supply – {SKPS – 610 }
2. Klystron tube 2k-25 with klystron mount – {XM-251}
3. Isolator {X_1-625}
4. Frequency meter {XF-710}
5. Detector mount {XD-451}
6. Variable Attenuator {XA-520}
7. Wave guide stand {XU-535}
8. VSWR meter {SW-215}
9. Oscilloscope
10. BNC Cable

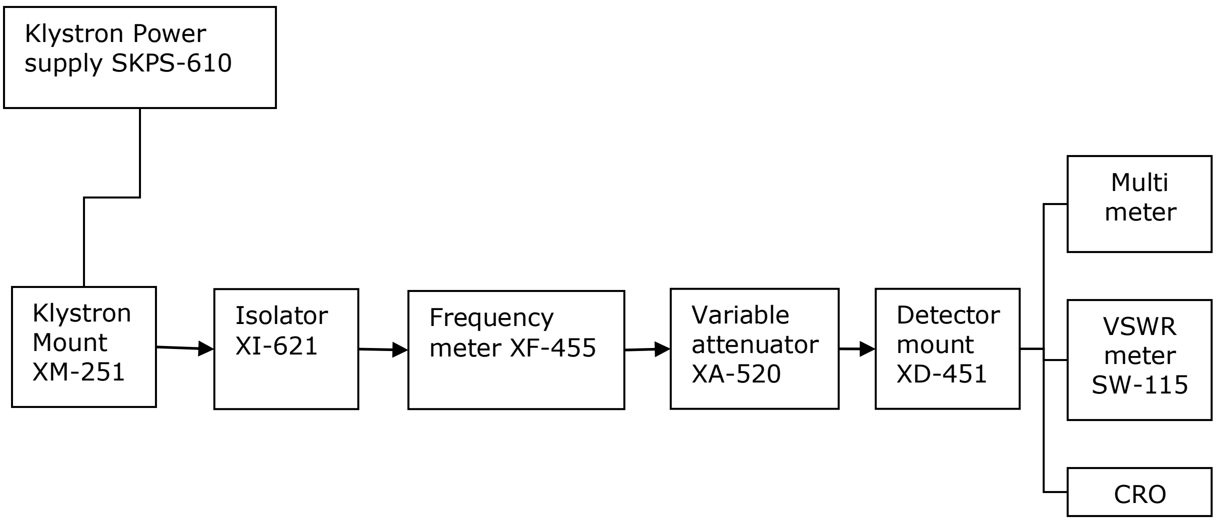
THEORY: The reflex klystron is a single cavity variable frequency microwave generator of low power and low efficiency. This is most widely used in applications where variable frequency is desired as

1. In radar receivers
2. Local oscillator in μw receivers
3. Signal source in micro wave generator of variable frequency
4. Portable micro wave links.
5. Pump oscillator in parametric amplifier

Voltage Characteristics: Oscillations can be obtained only for specific combinations of anode and repeller voltages that gives farable transit time.

Power Output Characteristics: The mode curves and frequency characteristics. The frequency of resonance of the cavity decides the frequency of oscillation. A variation in repeller voltages slightly changes the frequency.

BLOCK DIAGRAM:



EXPERIMENTAL PROCEDURE:

CARRIER WAVE OPERATION:

1. Connect the equipments and components as shown in the figure.
2. Set the variable attenuator at maximum Position.
3. Set the MOD switch of Klystron Power Supply at CW position, beam voltage control knob to fully anti clock wise and repeller voltage control knob to fully clock wise and meter switch to 'OFF' position.
4. Rotate the Knob of frequency meter at one side fully.
5. Connect the DC microampere meter at detector.
6. Switch "ON" the Klystron power supply, CRO and cooling fan for the Klystron tube..
7. Put the meter switch to beam voltage position and rotate the beam voltage knob clockwise slowly up to 300 Volts and observe the beam current on the meter by changing meter switch to beam current position. The beam current should not increase more than 30 mA.
8. Change the repeller voltage slowly and watch the current meter, set the maximum voltage on CRO.
9. Tune the plunger of klystron mount for the maximum output.
10. Rotate the knob of frequency meter slowly and stop at that position, where there is less output current on multimeter. Read directly the frequency meter between two horizontal line and vertical marker. If micrometer type frequency meter is used read the micrometer reading and find the frequency from its frequency calibration chart.
11. Change the repeller voltage and read the current and frequency for each repeller voltage.

B. SQUARE WAVE OPERATION:

1. Connect the equipments and components as shown in figure
2. Set Micrometer of variable attenuator around some Position**.**
3. Set the range switch of VSWR meter at 40 db position, input selector switch to crystal impedance position, meter switch to narrow position.
4. Set Mod-selector switch to AM-MOD position .beam voltage control knob to fully anti clockwise position.
5. Switch “ON” the klystron power Supply, VSWR meter, CRO and cooling fan.
6. Switch “ON” the beam voltage. Switch and rotate the beam voltage knob clockwise up to 300V in meter.
7. Keep the AM – MOD amplitude knob and AM – FREQ knob at the mid position.
8. Rotate the reflector voltage knob to get deflection in VSWR meter or square wave on CRO.
9. Rotate the AM – MOD amplitude knob to get the maximum output in VSWR meter or CRO.
10. Maximize the deflection with frequency knob to get the maximum output in VSWR meter or CRO.
11. If necessary, change the range switch of VSWR meter 30dB to 50dB if the deflection in VSWR meter is out of scale or less than normal scale respectively. Further the output can be also reduced by variable attenuator for setting the output for any particular position.

C. **MODE STUDY ON OSCILLOSCOPE**:

1. Set up the components and equipments as shown in Fig.
2. Keep position of variable attenuator at min attenuation position.
3. Set mode selector switch to FM-MOD position FM amplitude and FM frequency knob at mid position keep beam voltage knob to fully anti clock wise and reflector voltage knob to fully clockwise position and beam switch to ‘OFF’ position.
4. Keep the time/division scale of oscilloscope around 100 HZ frequency measurement and volt/div. to lower scale.
5. Switch ‘ON’ the klystron power supply and oscilloscope.
6. Change the meter switch of klystron power supply to Beam voltage position and set beam voltage to 300V by beam voltage control knob.
7. Keep amplitude knob of FM modulator to max. Position and rotate the reflector voltage anti clock wise to get the modes as shown in figure on the oscilloscope. The horizontal axis represents reflector voltage axis and vertical represents o/p power.
8. By changing the reflector voltage and amplitude of FM modulation in any mode of klystron tube can be seen on oscilloscope.

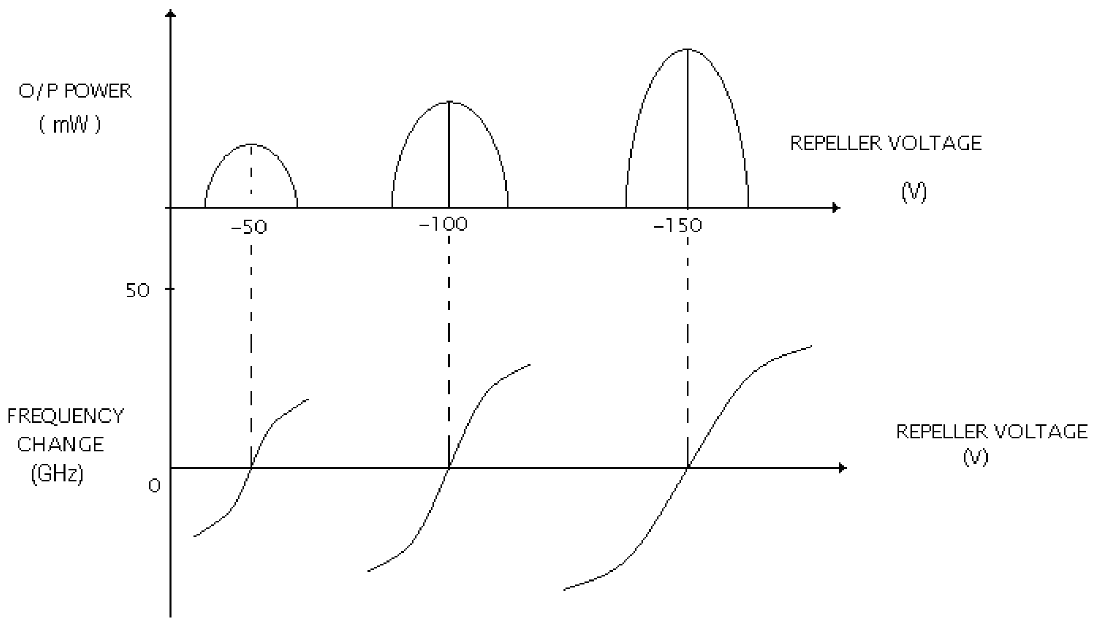
OBSERVATION TABLE:

Beam Voltage :…………V (Constant)

Beam Current :………….mA

Repeller Voltage (V)	Current (mA)	Power (mW)	Dip Frequency (GHz)

EXPECTED GRAPH:



RESULT:

2. GUNN DIODE CHARACTERISTICS

AIM: To study the V-I characteristics of Gunn diode.

EQUIPMENT REQUIRED:

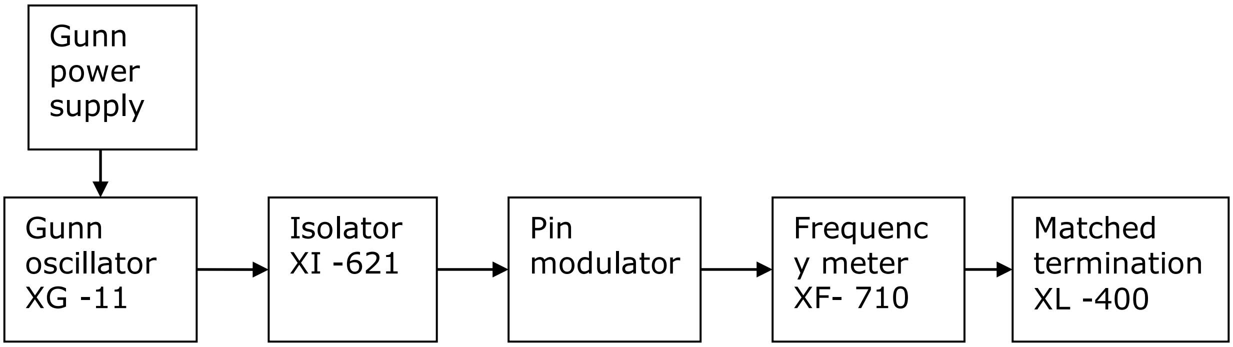
1. Gunn power supply
2. Gunn oscillator
3. PIN Modulator
4. Isolator
5. Frequency Meter
6. Variable attenuator
7. Slotted line
8. Detector mount and CRO.

THEORY:

Gunn diode oscillator normally consist of a resonant cavity, an arrangement for coupling diode to the cavity a circuit for biasing the diode and a mechanism to couple the RF power from cavity to external circuit load. A co-axial cavity or a rectangular wave guide cavity is commonly used.

The circuit using co-axial cavity has the Gunn diode at one end at one end of cavity along with the central conductor of the co-axial line. The O/P is taken using a inductively or capacitively coupled probe. The length of the cavity determines the frequency of oscillation. The location of the coupling loop or probe within the resonator determines the load impedance presented to the Gunn diode. Heat sink conducts away the heat due to power dissipation of the device.

BLOCK DIAGRAM



EXPERIMENTAL PROCEDURE:

Voltage-Current Characteristics:

1. Set the components and equipments as shown in Figure.
2. Initially set the variable attenuator for minimum attenuation.
3. Keep the control knobs of Gunn power supply as below

   Meter switch – “OFF”

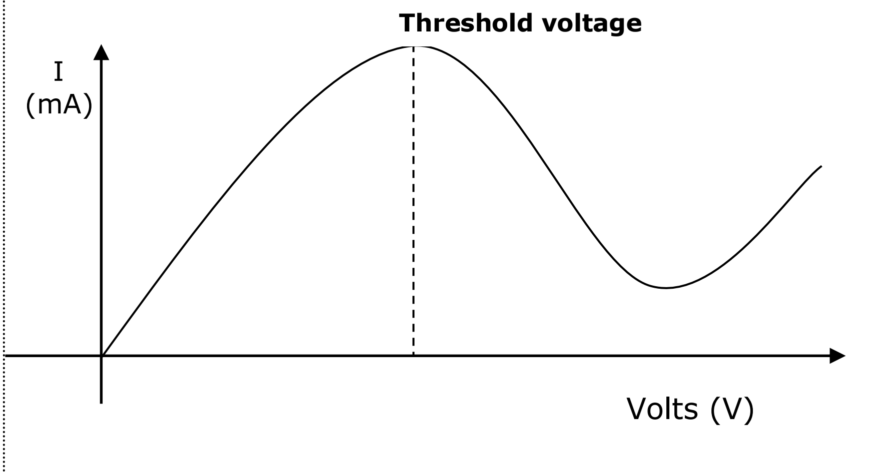
   Gunn bias knob – Fully anti clock wise

   PIN bias knob – Fully anti clock wise

   PIN mode frequency – any position
4. Set the micrometer of Gunn oscillator for required frequency of operation.
5. Switch “ON” the Gunn power supply.
6. Measure the Gunn diode current to corresponding to the various Gunn bias voltage through the digital panel meter and meter switch. Do not exceed the bias voltage above 10 volts.
7. Plot the voltage and current readings on the graph.
8. Measure the threshold voltage which corresponding to max current.

Note: Do not keep Gunn bias knob position at threshold position for more than 10-15 sec. readings should be obtained as fast as possible. Otherwise due to excessive heating Gunn diode may burn

EXPECTED GRAPH:



I-V CHARACTERISTICS OF GUNN OSCILLATOR

OBSERVATION TABLE:

Gunn bias voltage (v)	Gunn diode current (mA)

RESULT:

3. DIRECTIONAL COUPLER CHARACTERISTICS

AIM: To study the function of multi-hole directional coupler by measuring the following parameters.

1. The Coupling factor, Insertion Loss and Directivity of the Directional coupler

EQUIPMENT REQUIRED:

1. Microwave Source (Klystron or Gunn-Diode)
2. Isolator, Frequency Meter
3. Variable Attenuator
4. Slotted Line
5. Tunable Probe
6. Detector Mount Matched Termination
7. MHD Coupler
8. Waveguide Stand
9. Cables and Accessories
10. CRO.

THEORY:

A directional coupler is a device with which it is possible to measure the incident and reflected wave separately. It consist of two transmission lines the main arm and auxiliary arm, electromagnetically coupled to each other Refer to the Fig.1. The power entering, in the main-arm gets divided between port 2 and 3, and almost no power comes out in port (4) Power entering at port 2 is divided between port 1 and 4.

The coupling factor is defined as

Coupling (db) = 10 $\log_{10}$ [P1/P3] where port 2 is terminated, Isolation (dB) = 10 $\log_{10}$ [P2/P3] where P1 is matched.

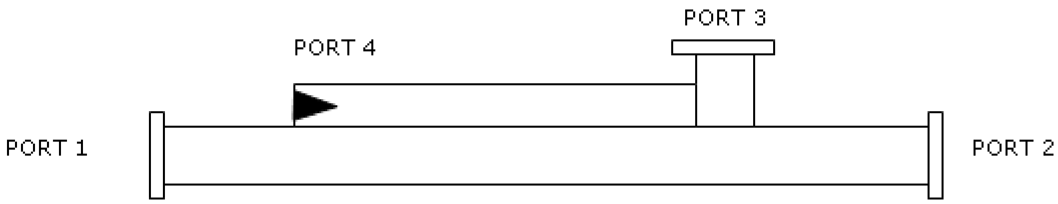


FIG. DIRECTIONAL COUPLER

With built-in termination and power entering at Port 1, the directivity of the coupler is a measure of separation between incident wave and the reflected wave. Directivity is measured indirectly as follows:

Hence Directivity D (db) = I-C = 10 $\log_{10}$ [P2/P1]

Main line VSWR is SWR measured, looking into the main-line input terminal when the matched loads are placed at all other ports.

Auxiliary live VSWR is SWR measured in the auxiliary line looking into the output terminal when the matched loads are placed on other terminals.

Main line insertion loss is the attenuation introduced in the transmission line by insertion of coupler, it is defined as:

Insertion Loss (dB) = 10 $\log_{10}$ [P1/P2]

BLOCKDIAGRAM:

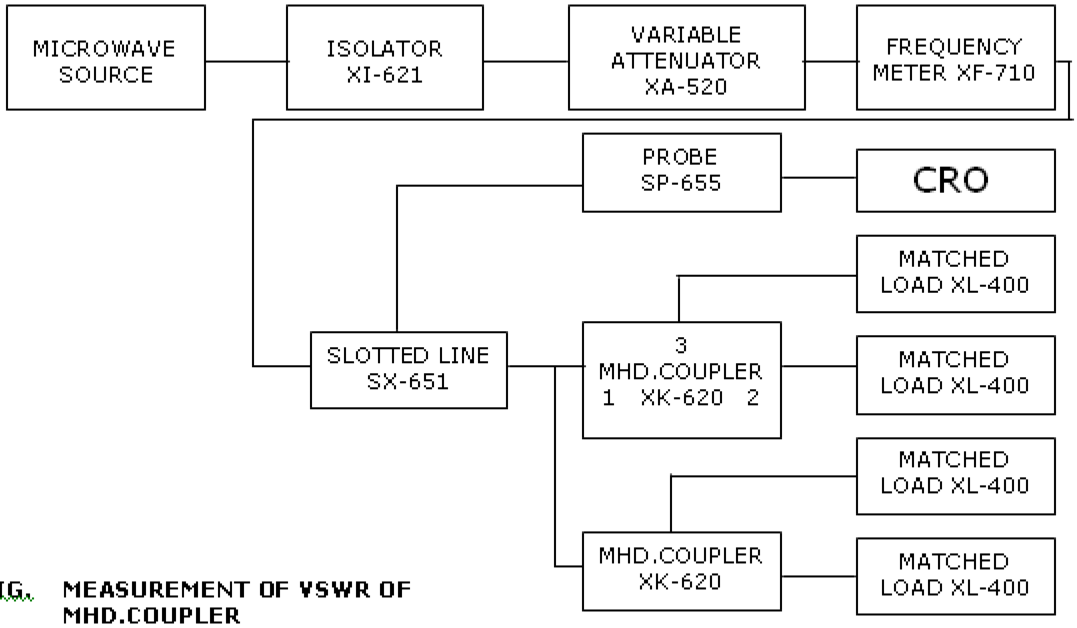


FIG. MEASUREMENT OF VSWR OF MHD.COUPLER

EXPERIMENTAL PROCEDURE:

1. Set up the equipments as shown in the Figure.
2. Energize the microwave source for particular operation of frequency .
3. Remove the multi hole directional coupler and connect the detector mount to the slotted section.
4. Set maximum amplitude in CRO with the help of variable attenuator, Let it be X.
5. Insert the directional coupler between the slotted line and detector mount. Keeping port 1 to slotted line, detector mount to the auxiliary port 3 and matched termination to port 2 without changing the position of variable attenuator.
6. Note down the amplitude using CRO, Let it be Y.
7. Calculate the Coupling factor X-Y in dB.
8. Now carefully disconnect the detector mount from the auxiliary port 3 and matched termination from port 2 , without disturbing the setup.
9. Connect the matched termination to the auxiliary port 3 and detector mount to port 2 and measure the amplitude on CRO, Let it be Z.
10. Compute Insertion Loss= X – Z in dB.
11. Repeat the steps from 1 to 4.
12. Connect the directional coupler in the reverse direction i.e., port 2 to slotted section, matched termination to port 1 and detector mount to port 3, without disturbing the position of the variable attenuator.
13. Measure and note down the amplitude using CRO, Let it be Y_0.
14. Compute the Directivity as $Y-Y_0$ in dB.

PRECAUTIONS:

1. Avoid loose connections.
2. Avoid Parallax errors.

RESULT:

4. VSWR MEASUREMENT

AIM: To determine the standing-wave ratio and reflection coefficient.

EQUIPMENT REQUIRED:

1. Klystron tube (2k25)
2. Klystron power supply (skps - 610)
3. VSWR meter (SW 115)
4. Klystron mount (XM – 251)
5. Isolator (XF 621)
6. Frequency meter (XF 710)
7. Variable attenuator (XA – 520)
8. Slotted line (X 565)
9. Wave guide stand (XU 535)
10. Movable short/termination XL 400
11. BNC CableS-S Tuner (XT – 441)
12.

THEORY:

Any mismatched load leads to reflected waves resulting in standing waves along the length of the line. The ratio of maximum to minimum voltage gives the VSWR. Hence minimum value of S is unity. If S<10 then VSWR is called low VSWR. If S>10 then VSWR is called high VSWR. The VSWR values more than 10 are very easily measured with this setup. It can be read off directly on the VSWR meter calibrated. The measurement involves simply adjusting the attenuator to give an adequate reading on the meter which is a D.C. mill volt meter. The probe on the slotted wave guide is moved t get maximum reading on the meter. The attenuation is now adjusted to get full scale reading. Next the probe on the slotted line is adjusted to get minimum, reading on the meter. The ratio of first reading to the second gives the VSWR. The meter itself can be calibrated in terms of VSWR. Double minimum method is used to measure VSWR greater than 10. In this method, the probe is inserted to a depth where the minimum can be read without difficulty. The probe is then moved to a point where the power is twice the minimum.

BLOCK DIAGRAM

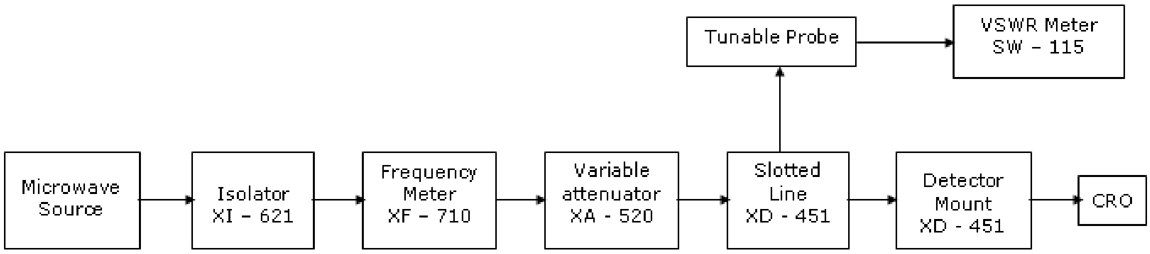


FIG: SET UP FOR LOW VSWR MEASUREMENT

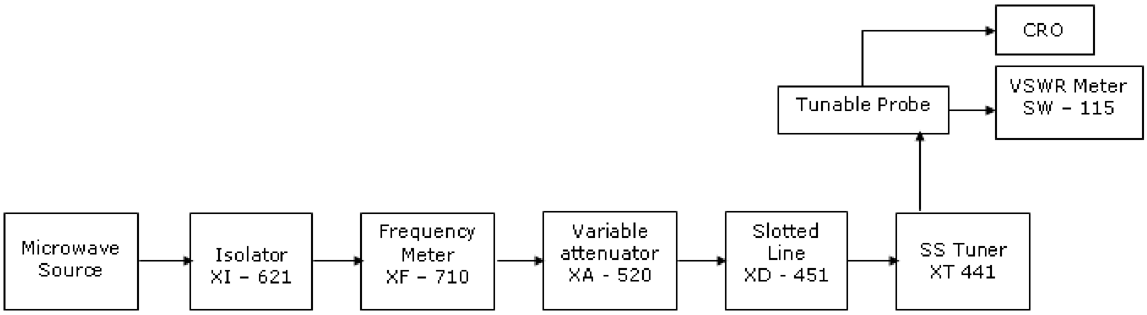


FIG: SET UP FOR HIGH VSWR MEASUREMENT

PROCEDURE:

1. Set up equipment as shown in figure.
2. Keep variable attenuator in minimum attenuation position.
3. Keep control knobs of VSWR meter as below

   Range dB = 40db / 50db

   Input switch = low impedance

   Meter switch = Normal

   Gain (coarse fine) = Mid position approximately
4. Keep control knobs of klystron power supply as below.

   Beam Voltage = OFF

   Mod-Switch = AM

   Beam Voltage Knob = fully anti clock wise

   Reflection voltage knob = fully clock wise

   AM-Amplitude knob = around fully clock wise

   AM frequency and amplitude knob = mid position
5. Switch ‘ON’ the klystron power supply, VSWR meter and cooling fan.
6. Switch ‘ON” the beam voltage switch position and set (down) beam voltage at 300V.
7. Rotate the reflector voltage knob to get deflection in VSWR meter.
8. Tune the O/P by turning the reflector voltage, amplitude and frequency of AM modulation.
9. Tune plunges of klystron mount and probe for maximum deflection in VSWR meter.

10. If required, change the range db-switch variable attenuator position and (given) gain control knob to get deflection in the scale of VSWR meter.
11. As your move probe along the slotted line, the deflection will change.

A. Measurement of low and medium VSWR:

1. Move the probe along the slotted line to get maximum deflection in VSWR meter.
2. Adjust the VSWR meter gain control knob or variable attenuator until the meter indicates 1.0 on normal VSWR scale.
3. Keep all the control knob as it is move the probe to next minimum position. Read the VSWR on scale.
4. Repeat the above step for change of S-S tuner probe depth and record the corresponding SWR.
5. If the VSWR is between 3.2 and 10, change the range 0dB switch to next higher position and read the VSWR on second VSWR scale of 3 to 10.

B. Measurement of High VSWR: (double minimum method)

1. Set the depth of S-S tuner slightly more for maximum VSWR.
2. Move the probe along with slotted line until a minimum is indicated.
3. Adjust the VSWR meter gain control knob and variable attenuator to obtain n a reading of 3db in the normal dB scale (0 to 10db) of VSWR meter.
4. Move the probe to the left on slotted line until full scale deflection is obtained on 0-10 db scale. Note and record the probe position on slotted line. Let it be d1.
5. Repeat the step 3 and then move the probe right along the slotted line until full scale deflection is obtained on 0-10db normal db scale. Let it be d2.
6. Replace S-S tuner and termination by movable short.
7. Measure distance between 2 successive minima positions of probe. Twice this distance is guide wave length λg.
8. Compute SWR from following equation

$$SWR = \frac{\lambda g}{\pi (d1 - d2)}$$

OBSERVATION TABLE:

LOW VSWR

VSWR = ________

HIGH VSWR

Beam Voltage (v)	x_1 (cm)	x_2 (cm)	x_1 (cm)	x_2 (cm)	Avg $(x_1-x_2) = x$ (cm)	$\lambda g=2x$ (cm)

$\lambda g = 6cm$

d1 (cm)	d2 (cm)	d1-d2 (cm)	VSWR = $\lambda g / \pi(d1-d2)$

RESULT: .

5. IMPEDANCE MEASUREMENT USING REFLEX KLYSTRON

AIM: To measure an unknown impedance using the smith chart.

EQUIPMENT REQUIRED:

1. Klystron tube 2k25
2. Klystron power supply Skps-610
3. Klystron mount XM-251
4. Isolator XF 62
5. Frequency meter XF 710
6. Variable attenuator XA – 520
7. Slotted line XS 565
8. Tunable probe XP 655
9. VSWR meter
10. Wave guide stand SU 535
11. S-S tuner (XT 441)
12. Movable short/termination

THEORY:

The impedance at any point on a transmission line can be written in the form R+jx.

For comparison SWR can be calculated as

$$S = \frac{1+|R|}{1-|R|}$$ where reflection coefficient 'R'

Given as

$$R = \frac{Z - Z_0}{Z + Z_0}$$

Z_o = characteristics impedance of wave guide at operating frequency.

Z is the load impedance

The measurement is performed in the following way.

The unknown device is connected to the slotted line and the position of one minima is determined. The unknown device is replaced by movable short to the slotted line. Two successive minima portions are noted. The twice of the difference between minima position will be guide wave length. One of the minima is used as reference for impedance measurement. Find the difference of reference minima and minima position obtained from unknown load. Let it be 'd'. Take a smith chart, taking '1' as centre, draw a circle of radius equal to S. Mark a point on circumference of smith chart towards load side at a distance equal to d/λg.

Join the center with this point. Find the point where it cut the drawn circle. The co-ordinates of this point will show the normalized impedance of load.

BLOCK DIAGRAM

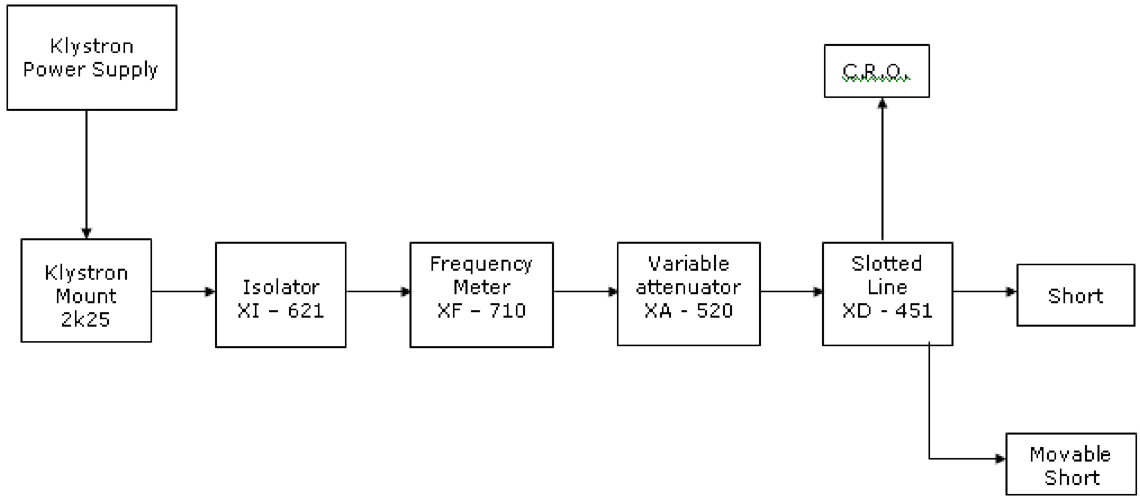


FIG: SET UP FOR IMPEDANCE MEASUREMENT

PROCEDURE:

1. Calculate a set of Vmin values for short or movable short as load.
2. Calculate a set of Vmin values for S-S Tuner + Matched termination as a load.

Note: Move more steps on S-S Tuner

3. From the above 2 steps calculate $d = d_1 \sim d_2$
4. With the same setup as in step 2 but with few numbers of turns (2 or 3). Calculate low VSWR.

Note: High VSWR can also be calculated but it results in a complex procedure.

5. Draw a VSWR circle on a smith chart.
6. Draw a line from center of circle to impedance value (d/λg) from which calculate admittance and Reactance ($Z = R \pm jx$)

OBSERVATION TABLE:

Load (short or movable short)					
x_1 (cm)	x_2 (cm)	x_1 (cm)	x_2 (cm)	x_1 (cm)	x_2 (cm)

x = _______

λg = ______

Load (S.S. Tuner + Matched Termination)

S.S Tuner + Matched Termination	Short or Movable Short

d1= , d2 =

d = d1 ~ d2 =

Z = d/λg =

RESULT;.

6. SCATTERING PARAMETERS OF MAGIC TEE

AIM: To Study the operation of Magic Tee and calculate Coupling Co-efficient and Isolation.

EQUIPMENT REQUIRED:

1. Microwave source : Klystron tube (2k25)
2. Isolator (XI-621)
3. Frequency meter (XF-710)
4. Variable Attenuator (XA-520)
5. Slotted line (SX-651)
6. Tunable probe (XP-655)
7. Detector Mount (XD-451)
8. Matched Termination (XL-400)
9. Magic Tee (XE-345/350)
10. Klystron Power Supply + Klystron Mount
11. Wave guide stands and accessories

THEORY:

The device Magic Tee is a combination of E and H plane Tee. Arm 3 is the H-arm and arm 4 is the E-arm. If the power is fed, into arm 3 (H-arm) the electric field divides equally between arm1 and 2 with the same phase and no electric field exists in the arm 4. If power is fed in arm 4 (E-arm) it divides equally into arm 1 and 2 but out of phase with no power to arm 3, further, if the power is fed in arm 1 and 2 simultaneously it is added in arm 3 (H-arm) and it is subtracted in E-arm i.e., arm 4.

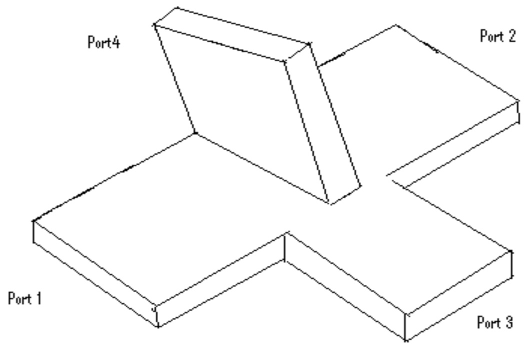


Fig: Magic Tee

A. Isolation:

The Isolation between E and H arm is defined as the ratio of the power supplied by the generator connected to the E-arm (port 4) to the power detected at H-arm (port 3) when side arm 1 and 2 terminated in matched load.

Isolation (dB) = $10 \log_{10} [P4/P3]$

Similarly, Isolation between other ports may be defined.

B. Coupling Factor:

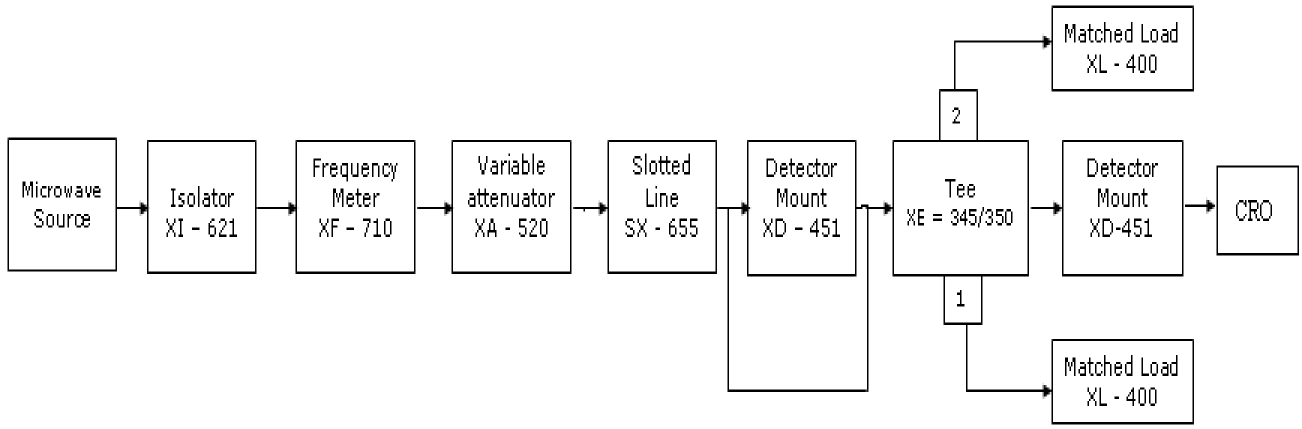
It is defined as Cij = $10 - \propto/20$

Where '$\propto$' is attenuation / isolation in dB when 'i' is input arm and 'j' is output arm.

Thus, $\propto = 10 \log_{10} [P4/P3]$

Where P3 is the power delivered to arm 'i' and P4 is power detected at 'j' arm.

BLOCK DIAGRAM:



EXPERIMENTAL PROCEDURE:

1. Setup the components and equipments as shown in figure.
2. Energize the microwave source for particular frequency of operation and tune the detector mount for maximum output.
3. With the help of variable frequency of operation and tune the detector mount for maximum output attenuator, set any reference in the CRO let it be V_3.
4. Without disturbing the position of the variable attenuator, carefully place the Magic Tee after the slotted line, keeping H-arm to slotted line, detector mount to E-arm and matched termination to Port-1 and Port-2.
5. Note down the amplitude using CRO, Let it be V_4.
6. Determine the Isolation between Port-3 and Port-4 as V_3-V_4.
7. Determine the coupling co-efficient from the equation given in theory part.
8. The same experiment may be repeated for other Ports also.

OBSERVATIONS:

Ports	Power (W)

Calculations:

Coupling Co-efficient:

$$\alpha = 10 \log \frac{Vi}{Vj}$$

Therefore $C = 10^{-\alpha/20}$

RESULT:

7. SCATTERING PARAMETERS OF CIRCULATOR

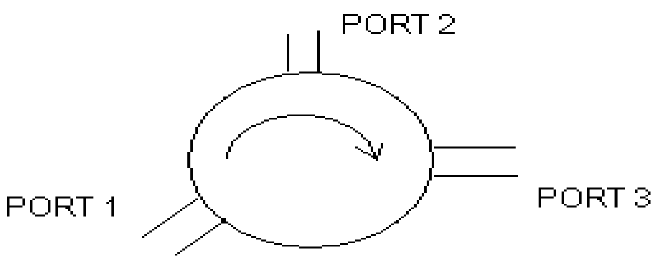
AIM: To study the Isolator and circulators and measure the Insertion Loss and Isolation of Circulator.

EQUIPMENT REQUIRED:

1. Microwave Source (Klystron or Gunn-Diode)
2. Isolator, Frequency Meter
3. Variable Attenuator
4. Slotted Line
5. Tunable Probe
6. Detector Mount Matched Termination
7. Circulator
8. Waveguide Stand
9. Cables and Accessories
10. VSWR Meter.

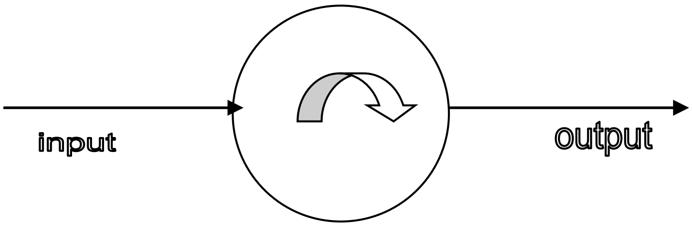
CIRCULATOR:

Circulator is defined as device with ports arranged such that energy entering a port is coupled to an adjacent port but not coupled to the other ports. This is depicted in figure circulator can have any number of ports.



ISOLATOR:

An Isolator is a two-port device that transfers energy from input to output with little attenuation and from output to input with very high attenuation.



The isolator, shown in Fig. can be derived from a three-port circulator by simply placing a matched load (reflection less termination) on one port.

The important circulator and isolator parameters are:

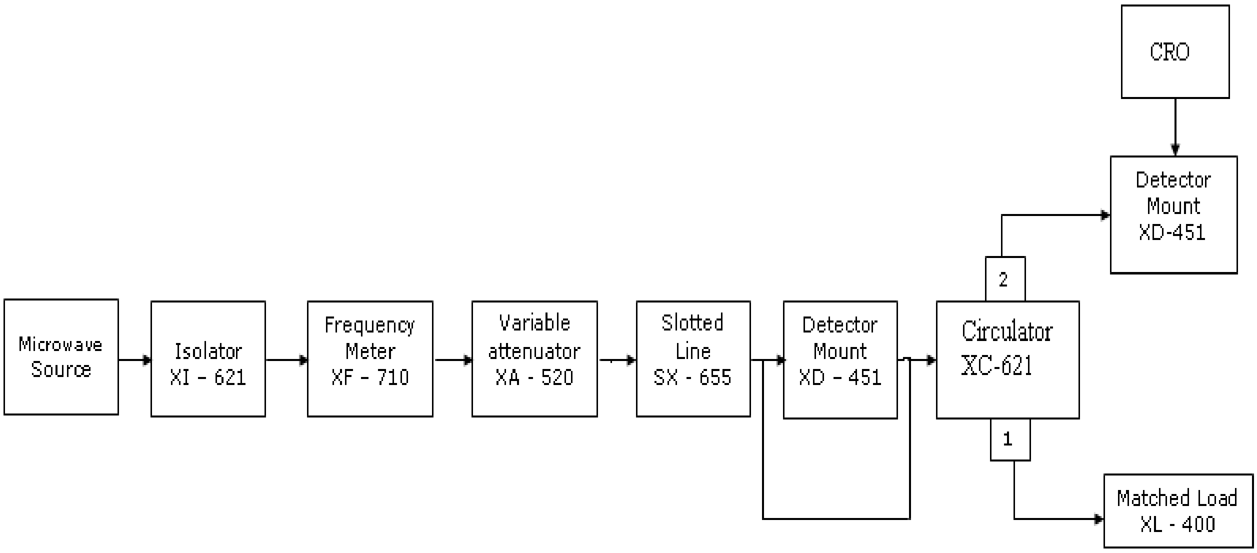
A. Insertion Loss

Insertion Loss is the ratio of power detected at the output port to the power supplied by source to the input port, measured with other orts terminated in the matched Load. It is expressed in dB.

B. Isolation

Isolation is the ratio of power applied to the output to that measured at the input. This ratio is expressed in db. The isolation of a circulator is measured with the third port terminated in a matched load.

BLOCK DIAGRAM:



EXPERIMENTAL PROCEDURE:

Measurement of insertion

1. Remove the isolator or circulator from slotted line and connect the detector mount to the slotted section. The output of the detector mount should be connected with CRO.
2. Energize the microwave source for maximum output for a particular frequency of operation. Tune the detector mount for maximum output in the CRO.
3. Set any reference level of output in CRO with the help of variable attenuator, Let it be V_1.
4. Carefully remove the detector mount from slotted line without disturbing the position of the set up. Insert the isolator/circulator between slotted line and detector mount. Keep input port to slotted line and detector its output port. A matched termination should be placed at third port in case of Circulator.
5. Record the output in CRO, Let it be V_2.
6. Compute Insertion loss given as V_1-V_2 in db.

Measurement of Isolation:

7. For measurement of isolation, the isolator or circulator has to be connected in reverse i.e. output port to slotted line and detector to input port with other port terminated by matched termination (for circulator).
8. Record the output of CRO and let it be V_3.
9. Compute Isolation as V_1-V_3 in db.
10. The same experiment can be done for other ports of circulator.
11. Repeat the above experiment for other frequency if needed.

PRECAUTIONS:

1. Avoid loose connections.
2. Avoid Parallax errors.

RESULT:

8. ATTENUATION MEASUREMENT

AIM: To study insertion loss and attenuation measurement of attenuator.

EQUIPMENT REQUIRED:

1. Microwave source Klystron tube (2k25)
2. Isolator (xI-621)
3. Frequency meter (xF-710)
4. Variable attenuator (XA-520)
5. Slotted line (XS-651)
6. Tunable probe (XP-655)
7. Detector mount (XD-451)
8. Matched termination (XL-400)
9. Test attenuator
   a) Fixed
   b) Variable
10. Klystron power supply & Klystron mount
11. Cooling fan
12. BNC-BNC cable
13. VSWR or CRO

THEORY:

The attenuator is a two port bidirectional device which attenuates some power when inserted into a transmission line.

Attenuation A (dB) = 10 log (P1/P2)

Where P1 = Power detected by the load without the attenuator in the line

P2 = Power detected by the load with the attenuator in the line.

BLOCK DIAGRAM

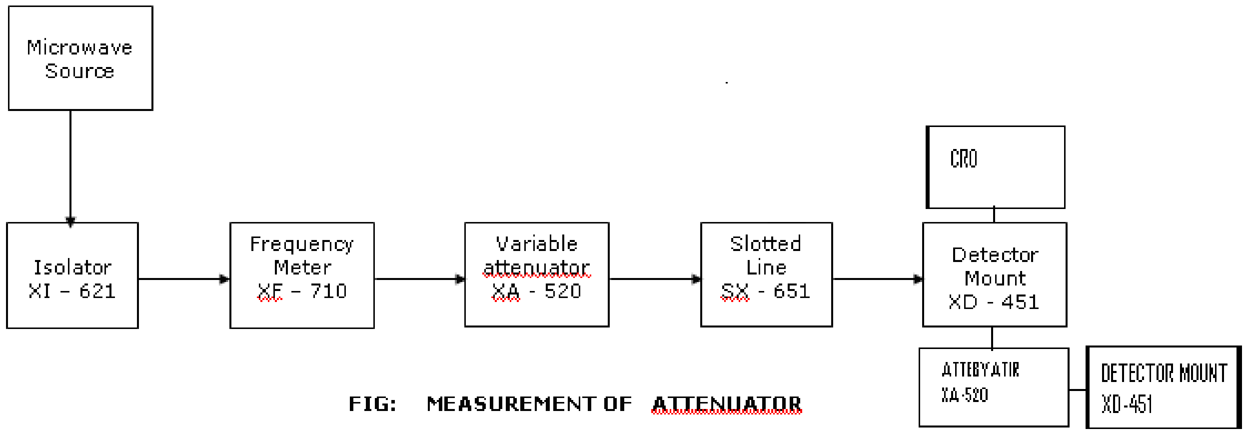


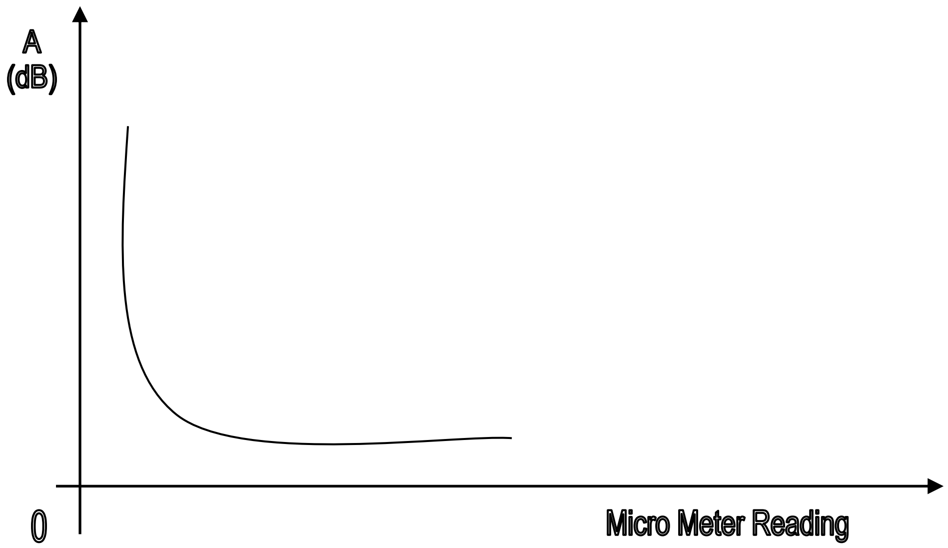
FIG: MEASUREMENT OF ATTENUATOR

PROCEDURE:

1. Connect the equipments as shown in the above figure.
2. Energize the microwave source for maximum power at any frequency of operation
3. Connect the detector mount to the slotted line and tune the detector mount also for max deflection on VSWR or on CRO
4. Set any reference level on the VSWR meter or on CRO with the help of variable attenuator. Let it be P1.
5. Carefully disconnect the detector mount from the slotted line without disturbing any position on the setup place the test variable attenuator to the slotted line and detector mount to O/P port of test variable attenuator. Keep the micrometer reading of text variable attenuator to zero and record the readings of VSWR meter or on CRO. Let it to be P2. Then the insertion loss of test attenuator will be P1-P2 db.
6. For measurement of attenuation of fixed and variable attenuator. Place the test attenuator to the slotted line and detector mount at the other port of test attenuator. Record the reading of VSWR meter or on CRO. Let it be P3 then the attenuation value of variable attenuator for particular position of micrometer reading of will be P1-P3 db.
7. In case the variable attenuator change the micro meter reading and record the VSWR meter or CRO reading. Find out attenuation value for different position of micrometer reading and plot a graph.
8. Now change the operating frequency and all steps should be repeated for finding frequency sensitivity of fixed and variable attenuator.

Note:1. For measuring frequency sensitivity of variable attenuator the position of micrometer reading of the variable attenuator should be same for all frequencies of operation.

EXPECTED GRAPH:



OBSERVATION TABLE:

Micrometer reading	P1 (dB)	P2 (dB)	Attenuation = P1-P2 (dB)

RESULT:

9. MEASUREMENT OF FREQUENCY AND WAVELENGTH

AIM: To determine the frequency and wavelength in a rectangular wave guide working in TE_{10} mode.

EQUIPMENT REQUIRED:

1. Klystron tube
2. Klystron power supply 5kps – 610
3. Klystron mount XM-251
4. Isolator XI-621
5. Frequency meter XF-710
6. Variable attenuator XA-520
7. Slotted section XS-651
8. Tunable probe XP-655
9. VSWR meter SW-115
10. Wave guide stand XU-535
11. Movable Short XT-481
12. Matched termination XL-400

THEORY:

The cut-off frequency relationship shows that the physical size of the wave guide will determine the propagation of the particular modes of specific orders determined by values of m and n. The minimum cut-off frequency is obtained for a rectangular wave guide having dimension a>b, for values of m=1, n=0, i.e. TE_{10} mode is the dominant mode since for TM_{mn} modes, n#0 or n#0 the lowest-order mode possible is TE_{10}, called the dominant mode in a rectangular wave guide for a>b.

For dominant TE_{10} mode rectangular wave guide λo, λg and λc are related as below.

$1/\lambda o^2 = 1/\lambda g^2 + 1/\lambda c^2$

Where λo is free space wave length

λg is guide wave length

λc is cut off wave length

For TE_{10} mode λc – 2a where ‘a’ is broad dimension of wave guide.

BLOCK DIAGRAM

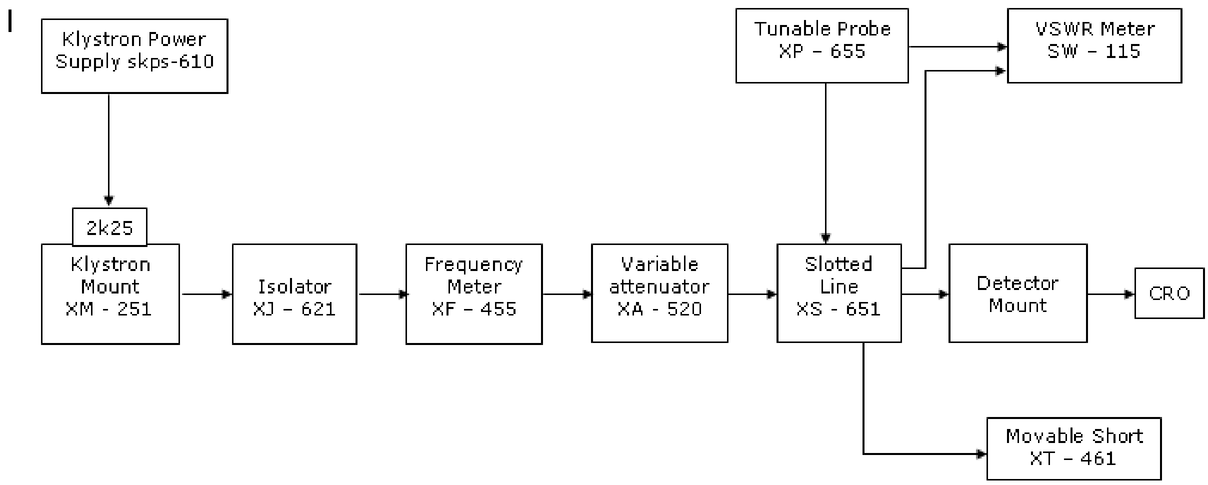


FIG: SET UP FOR FREQUENCY AND WAVELENGTH MEASUREMENT

PROCEDURE:

1. Set up the components and equipments as shown in figure.
2. Set up variable attenuator at minimum attenuation position.
3. Keep the control knobs of klystron power supply as below:

   Beam voltage – OFF

   Mod-switch – AM

   Beam voltage knob – Fully anti clock wise

   Repeller voltage – Fully clock wise

   AM – Amplitude knob – Around fully clock wise

   AM – Frequency knob – Around mid position
4. Switch ‘ON’ the klystron power supply, CRO and cooling fan switch.
5. Switch ’ON’ the beam voltage switch and set beam voltage at 300V with help of beam voltage knob.
6. Adjust the repeller voltage to get the maximum amplitude in CRO
7. Maximize the amplitude with AM amplitude and frequency control knob of power supply.
8. Tune the plunger of klystron mount for maximum Amplitude.
9. Tune the repeller voltage knob for maximum Amplitude.
10. Tune the frequency meter knob to get a ‘dip’ on the CRO and note down the frequency from frequency meter.
11. Replace the termination with movable short, and detune the frequency meter.

12. Move the probe along with slotted line. The amplitude in CRO will vary .Note and record the probe position , Let it be d1.
13. Move the probe to next minimum position and record the probe position again, Let it be d2.
14. Calculate the guide wave length as twice the distance between two successive minimum position obtained as above.
15. Measure the wave guide inner board dimension 'a' which will be around 22.86mm for x-band.
16. Calculate the frequency by following equation.

$$f = \frac{c}{\lambda} = \sqrt{\left(\frac{1}{\lambda^2{}_g} + \frac{1}{\lambda_c{}^2}\right)}$$

Where C = $3x10^8$ meter/sec. i.e. velocity of light.

17. Verify with frequency obtained by frequency modes
18. Above experiment can be verified at different frequencies.

$f_o = C/\lambda o$ => C => $3x10^8$ m/s (i.e., velocity of light)

$1/\lambda o^2 = 1/\lambda g^2 + 1/\lambda c^2$

$$\lambda_0 = \frac{\lambda_g \lambda_c}{\lambda_g{}^2 + \lambda_c{}^2}$$

$\lambda g = 2x\ \Delta d$

For TE_{10} mode => $\lambda c = 2a$

a → wave guide inner broad dimension

a = 2.286cm" (given in manual)

$\lambda c = 4.6cm$

OBSERVATION TABLE:

Beam voltage(v)	Beam current (mA)	Repeller voltage(v)	fo (using freq meter) (GHZ)	d1 (cm)	d2 (cm)	d3 (cm)	d4 (cm)	Δd1= d2-d1 (cm)	Δd2= d3-d2 (cm)	Δd3= d4 - d3	Δd=(Δd1+Δd2+ Δd3)/3	λg=2 x Δd	λo (cm)	fo (HZ)

RESULT: