LABORATORY Manual

MICROWAVE LAB (ECE-513)

ECE-5th SEMESTER

ACADEMIC YEAR (2024-25)

Department of Electronics & Communication Enginerring

Department of Electrical Engineering

Model Institute of Engineering & Technology (Autonomous)

Kot Bhalwal, Jammu - 181122

www.mietjmu.in

Course Code	Course Name	Course Type	Cd	L	T	P	Marks		
							Sessional	Final Exam	Total
ECE-513	Microwave Lab	PCC	2	0	0	4	50	-	50

COURSE OUTCOMES

At the end of the course the student will be able to:	
CO1	Plot and understand the impact of change in reflector voltage on current and frequency in reflex klystron tube.
CO2	Evaluate the parameters (frequency, wavelength) of rectangular waveguide for a particular mode.
CO3	Calculate reflection coefficient and VSWR of electromagnetic field.
CO4	Verify the impedance measured using klystron tube with Smith Chart.
CO5	Determine attenuation using isolator and circulator

LIST OF EXPERIMENTS

S.No.	Title
1	Verify the characteristics of Reflex Klystron tube and to determine its electronic tuning range.
2	Determine the frequency and wavelength in Rectangular waveguide.
3	Determine the standing-wave ratio & reflection coefficient.
4	Measure unknown impedance with smith chart.
5	Verify the characteristics of Gunn diode.
6	Verify V-I Characteristics.
7	Determine output power & frequency as a function of voltage.
8	Calculate the coupling factor & directivity using a directional coupler.
9	To study the following Tees: - E-Plane H-Plane Magic Tee
10	To study the Isolator & Circulators.
11	Examine and Demonstrate the radiation pattern of Horn antenna.

ADDITIONAL WEB RESOURCES

1.	VLAB LINK: Microwave lab by IIT Delhi which gives hands-on experience to the students. eem-iitd.vlabs.ac.in/experiments.htm

LAB REPORT INSTRUCTIONS

- Provide specific title of the lab experiment.

- Theory: Provide a concise abstract (typically 100-200 words) that summarizes the purpose, methods, key findings, and significance of the experiment.
- Materials/ Equipment: List all materials, components, and equipment used in the experiment. Include specifications when applicable.
- Software/Simulation Tools:
- Experimental Procedure: Describe the step-by-step procedure for conducting the experiment. Be detailed and clear in your instructions. Include diagrams or schematics to illustrate the setup, connections, and component placement. Explain any variations or adjustments made to the standard procedure.
- Observation & Calculations/Analysis: Detail the data you collected during the experiment. Include descriptions of measurements and any calculations made. Use tables, charts, or graphs to present data clearly. Discuss any trends, patterns, or significant observations. Interpret the data in the context of the experiment's objectives. Ensure that all figures, tables, and equations are correctly labeled.
- Results: Summarize the key findings of the experiment. Present results in a clear and organized manner using tables and graphs. Include units of measurement and labels for data points.
- Conclusion: Provide a concise summary of the experiment's key points and outcomes.

GRADING AND ASSESSMENT

- **Continuous Evaluation**: 30 marks
- **Final Demo & Viva**: 10 marks
- **Attendance**: 10 marks
- **Lab Overall Marks**: 50 marks

COURSE POLICIES

- **Attendance**: Minimum 75% attendance is mandatory to appear in the final examination of the course.
- **Late Submissions**: Manuals and projects must be submitted by the specified timelines.

FACULTY INFORMATION

- **Office Hours**
  Monday (12:05 PM - 12:55 PM)
  Friday (12:05 PM - 12:55 PM)
- **Contact Information**
  satyendra.ece@mietjammu.in

EXPERIMENT 1: - Verify the characteristics of Reflex Klystron tube and to determine its electronic tuning range.

Aim: -To study the dependence of microwave power output and frequency of an X-band reflex Klystron (2K25) on the repeller voltage and to plot the mode diagrams.

Apparatus Required: -

(i) Reflex Klystron 2k25 (ii) Klystron supply

(iii) Klystron Mount (iv) Isolator

(v) Variable Attenuator (vi) Wave meter

(vii) Detector (viii) Slotted Line

(ix) VSWR Meter

Theory: - A reflex Klystron is a single cavity resonator Klystron. It is a low power microwave source delivering about 10 to 100 milli-watt output in the microwave frequency range of 1 to 30 GHZ with an efficiency of 30% maximum. Reflex klystrons as microwave sources have application as local oscillators in commercial, military radar, Doppler radar and in most of micro wave measurement systems.

Modes of operation: - In a reflex Klystron repeller voltage plays a key role in deciding the oscillating condition and the mode of operation. If the resonant frequency of the cavity and the beam voltage are kept constant, then the amplitude and frequency of oscillations obtained from the reflex Klystron vary with the repeller voltage. The different oscillating regions correspond to different transit time modes. Power and frequency Klystron is shown in the mode diagrams see Fig.1

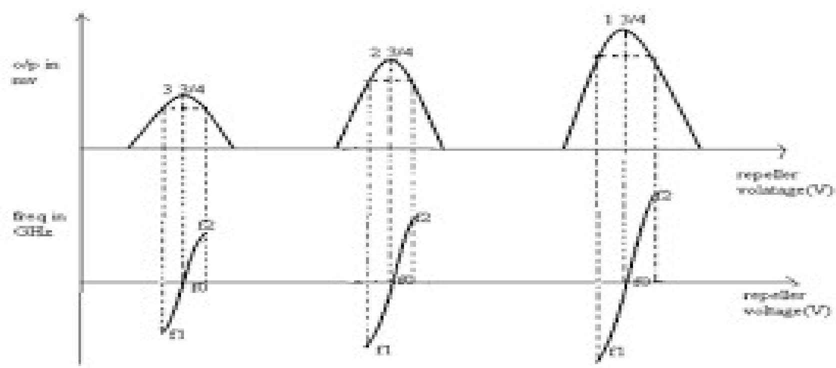


Fig.1- **Modes of a Typical Klystron Tube**

DISPLAY OF MODES:- The variation of the microwave power output of a klystron and the frequency of oscillations with reflector voltage can be displayed on the oscilloscope. V is varied. Through its operating range by means of an AC Voltage which is simultaneously applied to the horizontal deflecting plates. The microwave output of the Klystron is rectified by a crystal detector and is applied to vertical deflecting plates of CRT. The pattern obtained on the oscilloscope is a plot of power against reflector voltage. A wave meter in the microwave bench between the klystron and the detector will show a dip at the frequency of wave meter. Common on klystron source in Laboratories is 2k2.5 or 723 A/B which requires a beam voltage of 300 volts, beam current of 22 ma, reflector voltage up to 160 volts and the power output is 25 m watts.

OPERATION OF KLYSTRON POWER SUPPLY

(i) Assemble test bench as shown in Fig 1

(ii) Before switch ON, check and adjust following settings:

a. Repeller voltage control knob is at mid position.
b. Beam voltage control knob is at minimum position (leftmost)

(iii) Switch on the klystron power supply and the cooling fan.

(iv) Set following voltages

a. Adjust the repeller voltage to 70 – 100 volts.
b. Set beam voltage to 270 volts.

(v) Switch to internal amplitude modulation.

(vi) Switch to beam current and observe the beam current. It should be around 5-30 ma.

(vii) Observe the detector output.

Adjust the frequency meters tuning head till you get a dip in the power output. This position corresponds to the frequency of the wave traveling in the Microwave bench. Note the micrometer reading and power output. Repeat the measurement at different values of the repeller voltage and plot a graph between the repeller voltage and the frequency is determined from the calibration chart.

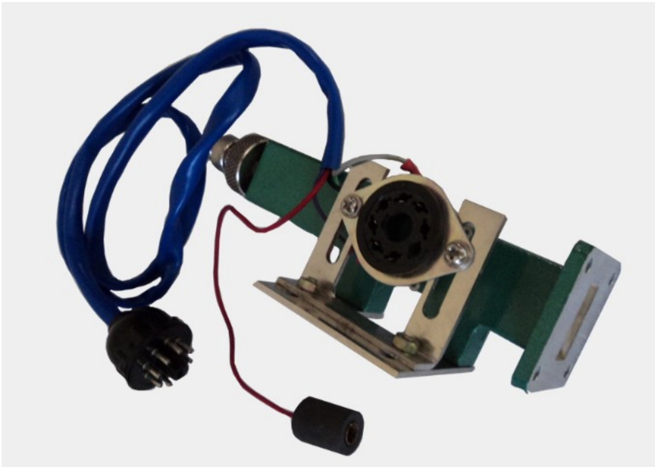


Figure: Klystron Mounts

Figure: Wave guide detector

Figure: Direct Read frequency meter

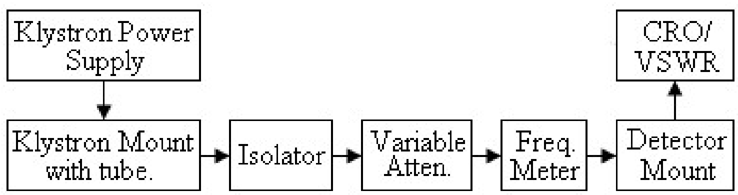


Fig.2- Block Diagram of Reflex Klystron Characteristics

Procedure: -

(i) Set up the components and equipment as shown in Fig.2

(ii) Switch ON klystron Power supply and check following:-
   a. Beam voltage is set near 270 volts.
   b. Repeller voltage is set near to 70 volts.
   c. Modulation is set to AM
   d. Keep Variable attenuator at min position

(iii) Keep the time / division scale of oscilloscope around 100Hz frequency measurement and validity to lower scale.

(iv) Observe detector output on CRO or in VSWR meter. Adjust following to get neat square wave pulses and maximum output.

(v) After getting maximum output about 1 volt on CRO, adjust variable attenuator and reduce output power to one fourth about 200 m volt.

(vi) Plot klystron modes by observing output for different values of repeller voltage -40V to -160 volt and tabulate results for the following:-
   a. Amplitude and frequency of AM
   b. Beam Voltage
   c. Repeller Voltage.

OBSERVATIONS:-

Tabulate the data as below:

Beam Voltage = 270 Volts (Fixed)

S.No	Repeller Voltage	Power Output	Frequency

		(db)	Dip mm	Corr Freq.

Observe above for values of repeller between 40 volts to 160 volts.

Plot as per fig 1.1

Precaution: - never keep repeller voltage zero.

Conclusion: -

Experiment 2: - Measurement of Frequency and Wavelength in rectangular waveguide.

Aim: -To measure frequency and wavelength of an X- band reflex Klystron (2k25) source or a Gunn Source.

Apparatus Required: -

(i) Reflex Klystron 2k25 (ii) Klystron supply

(iii) Klystron Mount (iv) Isolator

(v) Variable Attenuator (vi) Frequency meter

(vii) Detector (viii) Slotted Line and Probe

(ix) VSWR Meter (x) Shorting Plate

Theory: -

The wavelength is measured by measuring the distance between two consecutive minima's on slotted line scale. The distance between two minima's gives half wavelength. From the wavelength frequency is calculated by following formulae:-

$\lambda g = \lambda o / \sqrt{1-(\lambda o/\lambda c)^2}$

whereλo is free space wavelength

λc is cut off wavelength.

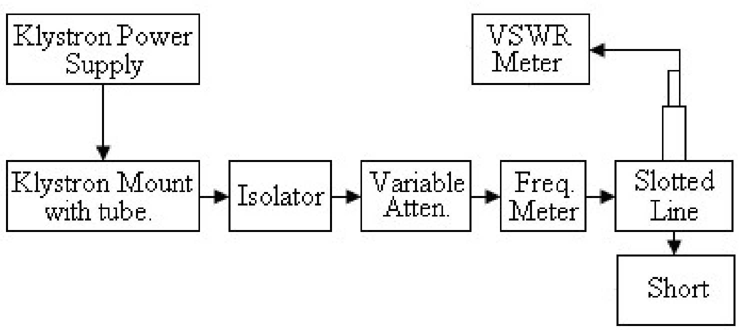


Fig.2 – Block Diagram for Measurement of Frequency and Wavelength

Fig.2 –Test Bench for Measurement of Frequency and Wavelength

Procedure: –

I. using slotted line

i. Assemble the equipment as shown in Fig.3 take care that all components are mechanically aligned and firmly screwed.
ii. Set up the klystron for maximum power output. Shot the slotted line at load end using a reflector or shorting plate.
iii. Tune tunable probe for maximum power.
iv. Move slotted line probe until you get a position of minimum signal power as observed on db scale of VSWR meter (red scale). Note down this reading. Let it be x.
v. Now move further probe on slotted line until you get the next minima ion line.

Observations & Conclusion: -

Experiment 3: Determine the standing-wave ratio & reflection coefficient

Aim: -To study the standing, wave pattern in a waveguide at x band and to measure VSWR of low, medium and high magnitudes.

Apparatus Required:-

(i) Reflex Klystron 2k25 (ii) Klystron supply

(iii) Klystron Mount (iv) Isolator

(v) Variable Attenuator (vi) Wave meter

(vii) Detector (viii) Slotted Line

(ix) VSWR Meter (x) CRO

Theory: -

Slotted line is a transmission line with a slot cut longitudinally in the centre of waveguide Standing waves are formed due to mismatch between source and load. The incident signals entering from source end and the reflected signals coming from opposite load side combine to form minima and maxima are minima is so calibrated that it directly reads as VSWR.

Fig.5- Test Bench for Measurement of VSWR

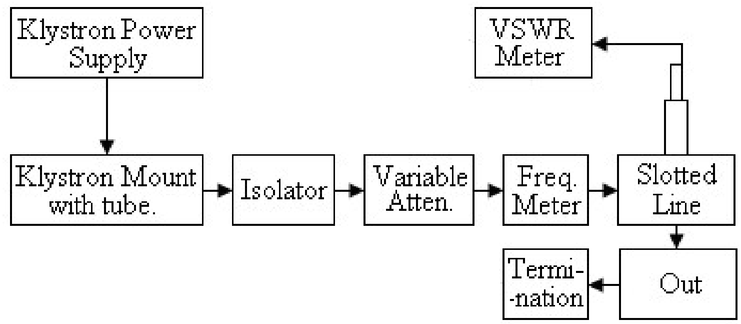


Fig.6- Block Diagram for Measurement of VSWR

Procedure: -

1. Assemble equipment as shown in Fig 6.Take care that all the components are mechanically aligned and firmly screwed.
2. Set up the klystron for maximum power output.
3. Put the probe on a standing wave minimum, increase the sensitivity of the amplifier to nearly maximum, and adjust the probe depth to the minimum sensitivity. Measure the output frequency of the klystron.

For measurement of low and medium VSWR

1. Let the slotted section be connected directly to a matched termination. Move the probe carriage and calculate the VSRW by noting the maximum and minimum output readings (For a matched condition, the square root of the maximum to the minimum reading should be less than or equal to 1.1)
2. Insert the element under test Move the probe in the slotted line to a voltage maximum Adjust the gain control on the VSWR meter so that the pointer on the output meter is set exactly to full scale on the VSWR scale Move the probe in the slotted line to a voltage minimum and note the reading on the output scale. This value is directly the voltage standing, wave ratio (VSWR).
3. In case VSWR is a greater than 2, voltage minimum become too small for accurate reading on the range as the voltage maximum In such a case measure the voltage minimum on two separate ranges of amplifier sensitivity such that both the values are read accurately near half scale of the indicating meter. The VSWR. Can be computed from the actual value of maxima and minima.

For High Standing Wave Ratio

1. Move the probe slowly in the direction of the minimum and reach a point giving full scale deflection. Plot a graph between power output and probe position. Determine x the distance between the double minimum power points from the graph.

2. Compute the value of wave length in free space from the expression $\lambda = c/f$ where c is the velocity of electromagnetic waves in free space and f is the frequency in the waveguide from the expression

$$\lambda g = \lambda 0 / \sqrt{1 - (\lambda 0 / 2a)^2}$$

where a is the larger internal dimension of the waveguide (here a = 22.86 mm)

3. Compute the value of the VSWR by the expression

$$VSWR = \lambda / (\pi * \Delta X)$$

where a is the larger internal dimension of the waveguide (here a = 22.86 mm)

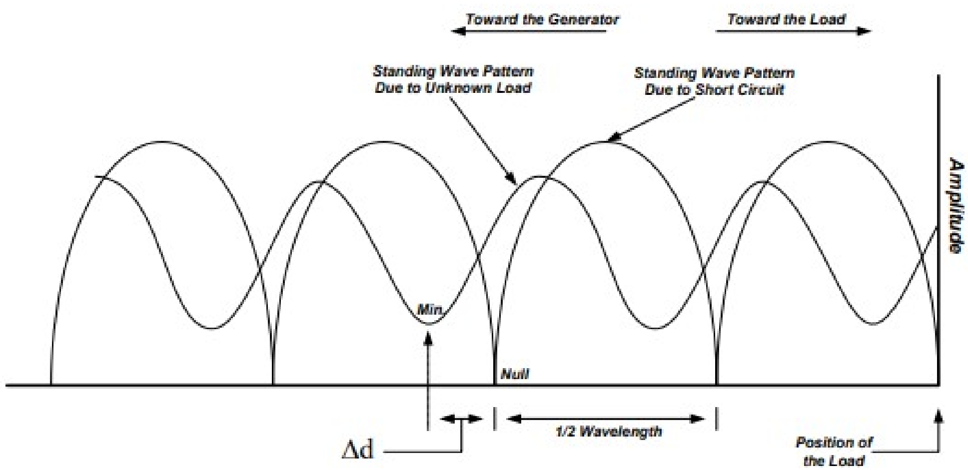
Precaution: - never keep repeller voltage zero.

Observations & conclusion

Experiment 4: Measure unknown impedance with smith chart.

Aim: Calculation of unknown load impedance using smith chart

Theory: In this exercise, you will use your knowledge of the nature of standing waves and your slotted line measurement skills developed in Lab 3 to determine the impedance of a line mistermnation. A mistermination occurs whenever a line is terminated with a load impedance that is unequal in value to the line's characteristic impedance.
The load impedance can be determined two ways, either mathematically or through the use of the Smith Chart. For this experiment, you will utilize both of these methods and compare the results.
Plot the curve:



1. Calculate $Q/\lambda g$

2. Take a smith chart taking '1' as a center and draw a circle of radius equal to the VSWR value (constant VSWR circle).

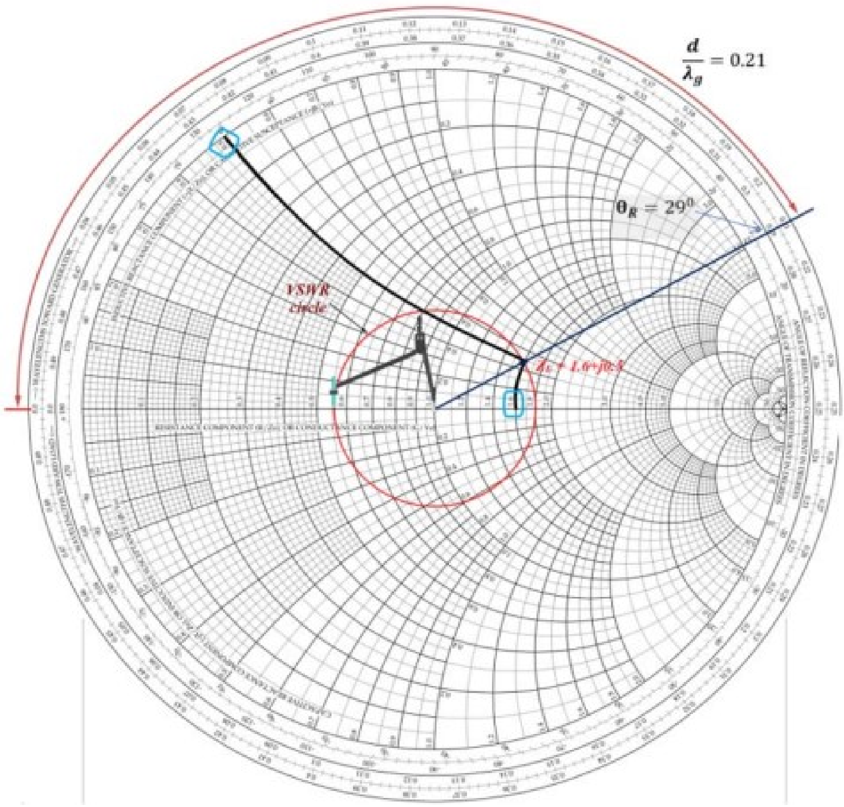
3. Make a point on circumference of chart towards load side (if 'Q' is positive) or towards generator side (if 'Q' is negative) at a distance equal to " $Q/\lambda g$"

4. Join the center with this point.

5. Find the point where it cut the drawn circle. The coordination of this point will show the normalized impedance of load.

6. Multiply normalized load impedance with the calculated characteristics impedance to obtain the value of unknown load impedance.

Smith Chart:



Observation: By plotting the normalized load impedance on a Smith Chart, the input impedance as a function of line length can be found. The Smith Chart also provides the value of the reflection coefficient, power delivered to load, as well as the voltage standing wave ratio (VSWR). Distance measurements are given in terms of wavelengths.

Conclusion:

Experiment 5: - Verify the V-I characteristics of Gunn diode.

Aim: Study I-V Characteristics of Gunn diode in X-band.

Equipment's: Gunn power supply, Gunn oscillator, Isolator, PIN modulator, Frequency meter, Variable attenuator, Detector with tunable mount, Waveguide stands, SWR meter, Matched load terminations, Cables and Accessories.

THEORY: GUNN Diodes (Transferred ElectronDevice) Gunn diodes are negative resistance devices which are normally used as low power oscillator at microwave frequencies in transmitter and also as local oscillator in receiver front ends. J B Gunn (1963) discovered microwave oscillation in Gallium arsenide (GaAs), Indium phosphide (InP) and cadmium telluride (CdTe). These are semiconductors having a closely spaced energy valley in the conduction band as shown in Fig. 1.1(a) for GaAs. When a dc voltage is applied across the material, an electric field is established across it. At low Efield in the material, most of the electrons will be located in the lower energy central valley.

At higher E-field, most of the electrons will be transferred in to the high-energy satellite L and X valleys where the effective electron mass is larger and hence electron mobility is lower than that in the low energy valley. Since the conductivity is directly proportional to the mobility, the conductivity and hence the current decreases with an increase in Efield or voltage in an intermediate range, beyond a threshold value Vth as shown in Fig. 1.1(c). This is called the transferred electron effect and the device is also called 'Transfer Electron Device (TED) or Gunn diode'. Thus the material behaves as negative resistance device over a range of applied voltages and can be used in microwave oscillators.

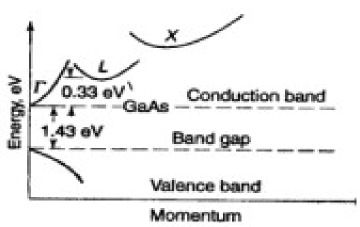


Fig 1.1(a) Multi-valley conduction band energies of GaAs

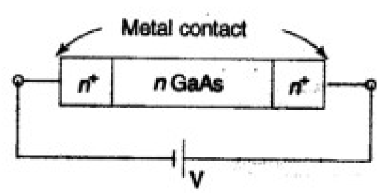


Fig 1.1(b) Gunn Diode configuration

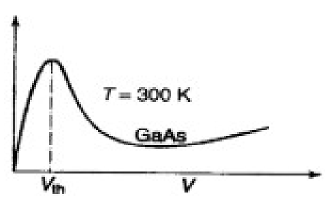


Fig 1.1(c) Current-voltage characteristics of GaAs

Gunn Oscillator: In a Gunn Oscillator, the Gunn Diode is placed in a resonant cavity. In this case the oscillation frequency is determined by cavity dimension than by the diode itself. Although Gun Oscillator can be amplitude-modulated with the bias voltage, we have used separate PIN modulator through PIN diode for square wave modulation.

PROCEDURE:

1. Set the components and equipment as shown in the Fig. 1.3.

2. Initially set the variable attenuator for maximum attenuation.

3. Keep the control knob of Gunn Power Supply as below:

Meter Switch - 'OFF'

Gunn bias knob - Fully anticlockwise

Pin bias knob - Fully anticlockwise

Pin Mod Frequency - Any Position

4. Keep the control knob of VSWR meter as below:

Meter Switch - Normal

Input Switch - Low Impedance
Range dB Switch - 40 dB

Gain Control Knob - Fully clockwise.

5. Set the micrometer of Gunn Oscillator for required frequency of operation.

6. 'ON' the Gunn Power Supply, VSWR meter and Cooling fan.

Set-up for Gunn diode:

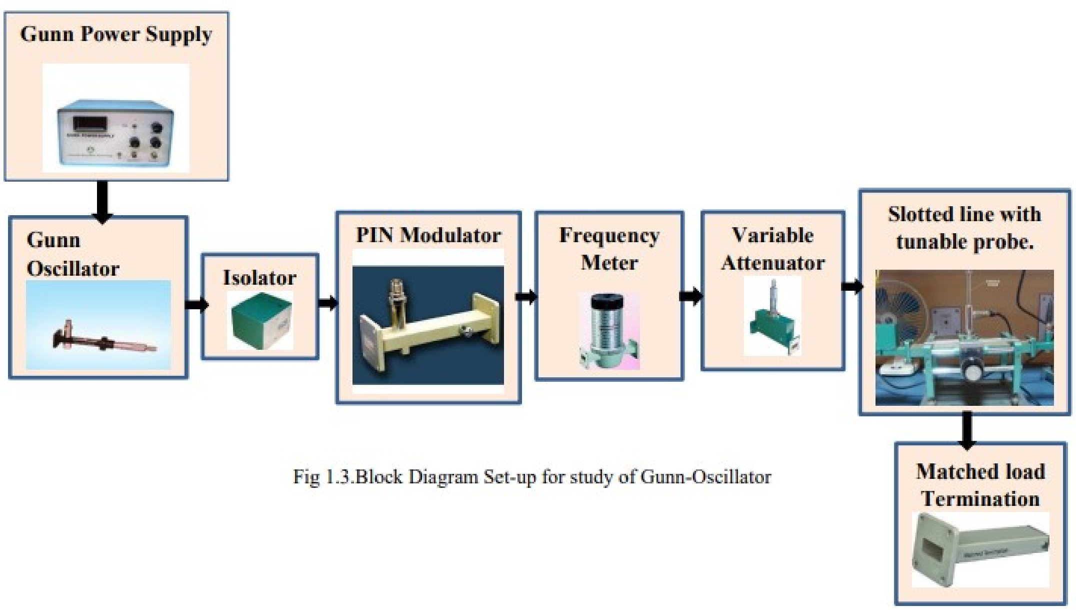


Fig 1.3.Block Diagram Set-up for study of Gunn-Oscillator

Experiment No. 7: Determine output power & frequency as a function of voltage.

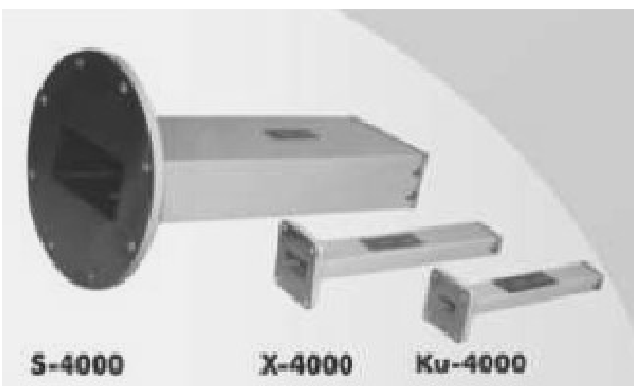
Aim:-Determine output power & frequency as a function of voltage.

Apparatus required: -

(i) Klystron along with a cooling blower and the power supply
(ii) Standing wave amplifier (VSWR meter)
(iii) Magic tee
(iv) Terminations -2 nos.
(v) X band microwave bench

Theory: -

The device "Magic Tee" is a combination of the E and H Plane Tee.Arm3,the H arm forms an H Plane Tee and Arm4 ,the E Plane tee in combination with Arm1 and 2 as side or collinear arms. If the power is fed into Arm3 (H arm), the electric field divides equally between Arm1 and 2 with the same phase and no electric field exists in the Arm4 (E arm).Reciprocity demands no coupling in port 3 (H arm) if power is fed in Arm4 (E arm), it divides equally into Arms1 and 2 , but out of phase with no power to Arm3.Further , if power is fed from Arms1 and 2 , it is added in Arm3 (Harm) and it is subtracted in E arm i.e. Arm4.



Matched Terminations **Magic Tee**

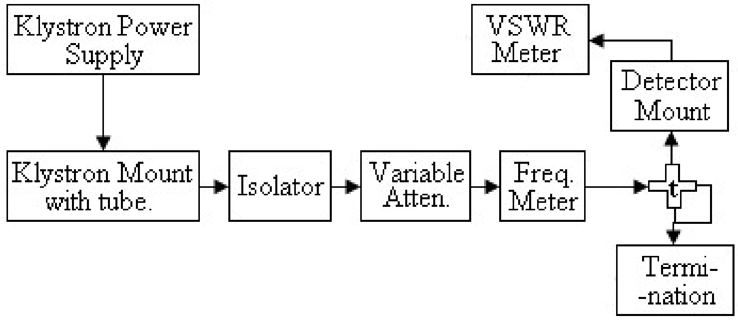


Fig.11 – **Block Diagram for Measurement of Magic Tee**

Procedure: -

1. Assemble equipment as shown in Fig 11. Take care that all the components are mechanically aligned and firmly screwed.
2. Set up the Klystron for maximum power output.
3. Connect BNC output of tunable probe into VSWR meter.
4. Connect the magic Tee as shown Fig. 11.

A) Measure of coupling port 1 to port 4 ort 1 input power from source. Port 2,3 terminated measure power at port 1. Let it be P1 Connect magic tee, then measure again power at port 3. Let it be P2
Coupling = P1-P2 db

B) Repeat above for coupling between port 1 and port 2 this should be same as that between port 1 and port 4.

C) Measure insertion loss between port 1 and port 3. By terminating port 2 and port 4
Loss = P2 - P1

Conclusion:-

Experiment 8: Calculate the coupling factor & directivity using a directional coupler.
Aim: -To measure coupling factor and directivity of a waveguide directional coupler and to determine scattering parameters.

Apparatus Required: -

(i) Gunn Oscillator (ii) Gunn Power Supply

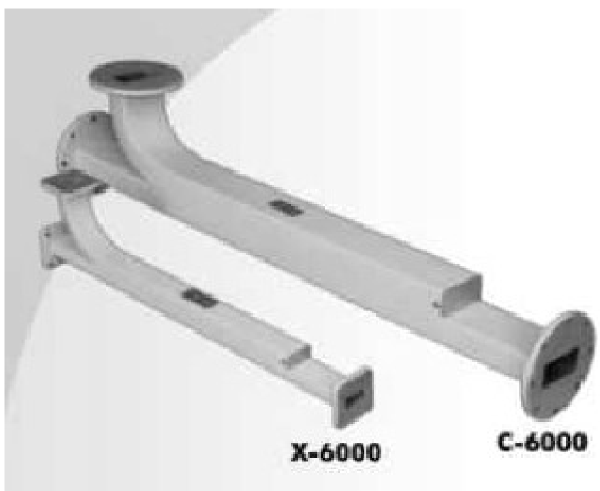
(iii) Directional Coupler (iv) Isolator

(v) Variable Attenuator (vi) Frequency meter

(vii) Detector (viii) Termination -2 nos.

(ix) VSWR Meter or CRO

Theory: -A directional coupler is a four port waveguide junction. It consist of a primary waveguide 1-2 and a secondary there is free transmission of power, without reflection, between port 1 andj port 2 and there is no transmission of power between port 1 and port 3 or between port 2 and port 4 because no coupling exists between these two pairs of ports. The degree of coupling between port 1 and port 4 and between port 2 and port 3 depends on the structure of the coupler.



Directional Coupler

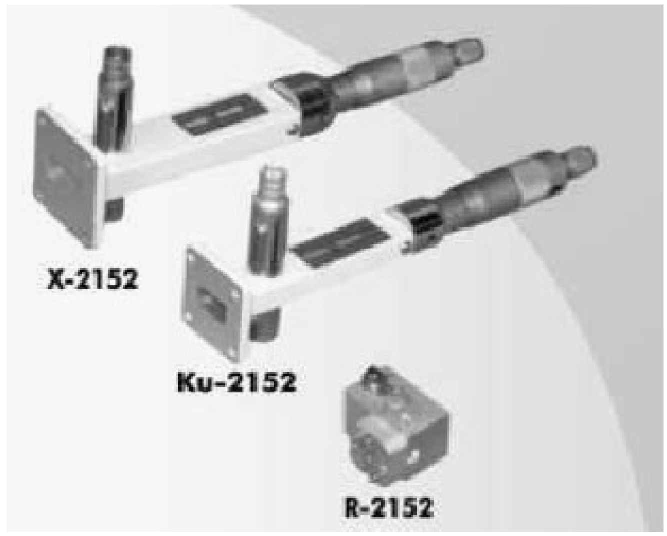
The characteristics of a directional coupler can be expressed in terms of its coupling fact ors and its directivity. Assuming that the wave is propagating from port 1 to port 2 in the primary line, the coupling factor and Directivity are defined respectively by :-

Coupling Factor (db) = 10 Log (P1 /P4)

Directivity (db) = 10 Log (P1/P3)

It should be noted that port 2, port 3 and port 4 are terminated in matched loads. The coupling factor is the measure of the ratio of power levels in the primary and secondary lines. The directivity is a measure of how well the forward traveling wave is isolated to the secondary wave guide. An ideal directional coupler should have infinite directivity. In other words, the power at port 3 has infinite directivity. In other words, the power at port 3 must be zero because port 2 and port 4 perfectly matched.

Actually well designed directional couplers have directivity above 30 db.



Gunn Oscillator

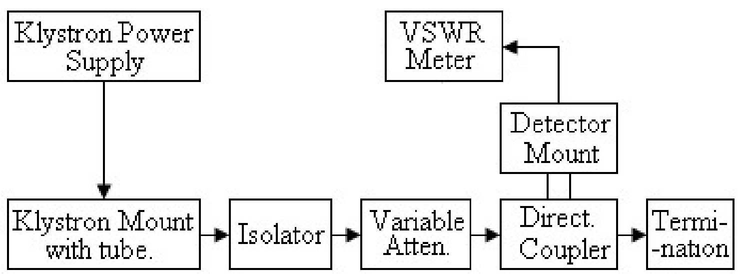


Fig.7 – **Block Diagram for Measurement of Directional Coupler**

Procedure: -

1. Arrange the experimental setup as shown in Fig.7 and switch on the Gunn power supply and tune Gunn Oscillator until you get a clear Square pulse in the range of min100 mill volts signal.

2. Fix the directional coupler in the power input at port 1 and arrange then detector in port 2 See the variable attenuator to get the full scale reading on the VSWR meter on 30 or 40 db scale. Note the reading.

3. Terminate the directional coupler in a matched arm. Since the output of the main arm is terminated, there will be no reflection. the power going from the auxiliary arm can be measured by the meter and the difference of the reading of main and auxiliary arm in db gives the value of the coupling factor in db. Do not change the setting of variable attenuator.

4. For directivity measurement, note down the reading of the meter in the above setting with the detector in the auxiliary arm. Reverse the direction of the power flow in the directional. Coupler (by physically reversing the directional coupler in microwave test bench.) The difference of the readings give the directivity of the directional coupler in db i.e. difference in level between port 1 and port3, while port 2 & 4 are terminated.

MEASUREMENT OF COUPLING					
S.NO.	Gunn Osc. Min position	CorrFreq (GHz)	Power (db) Port 1	Power (db) Port 4	Coupling P1 – P4 (db)

5. Determine the VSWRof the coupler at port 1, port 2, port 3, and port 4 (by reversing) with the help of the standing wave detector.

<u>OBSERVATIONS</u>:-

MEASUREMENT OF INSERTION LOSS (I L)					
S.NO.	Gunn Osc. Min Position	Corr. Freq (GHz)	Power (db) Port 1	Power (db) Port 2	I L P1- P2 (db)

MEASUREMENT OF DIRECTIVITY					
S.NO.	Gunn Osc. Min Position	Corr. Freq (GHz)	Power (db) Port 2	Power (db) Port 3	Directvity P2-P3 (db)

Conclusion:-

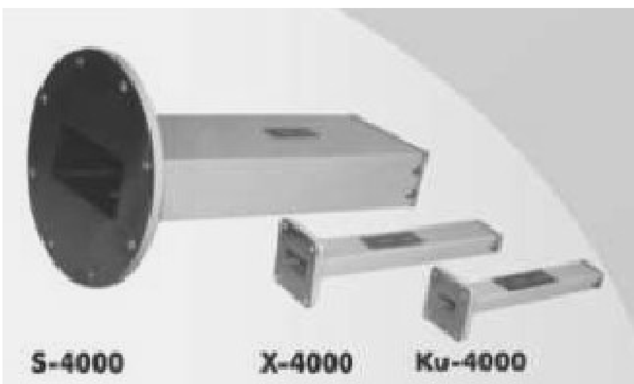
Experiment 9: To study the following Tees: -
E-Plane
H-Plane
Magic Tee

Aim:-To study division of power using magic tee.

Apparatus required:-

(vi) Klystron along with a cooling blower and the power supply
(vii) Standing wave amplifier (VSWR meter)
(viii) Magic tee
(ix) Terminations -2 nos.
(x) X band microwave bench

Theory:-The device "Magic Tee" is a combination of the E and H Plane Tee.Arm3,the H arm forms an H Plane Tee and Arm4 ,the E Plane tee in combination with Arm1 and 2 as side or collinear arms. If the power is fed into Arm3 (H arm), the electric field divides equally between Arm1 and 2 with the same phase and no electric field exists in the Arm4 (E arm).Reciprocity demands no coupling in port 3 (H arm) if power is fed in Arm4 (E arm), it divides equally into Arms1 and 2 , but out of phase with no power to Arm3.Further , if power is fed from Arms1 and 2 , it is added in Arm3 (Harm) and it is subtracted in E arm i.e. Arm4.



Matched Terminations **Magic Tee**

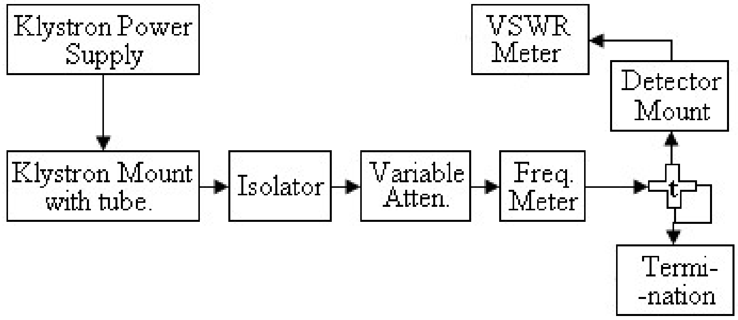


Fig.11 – **Block Diagram for Measurement of Magic Tee**

Procedure: -

5. Assemble equipment as shown in Fig 11. Take care that all the components are mechanically aligned and firmly screwed.
6. Set up the Klystron for maximum power output.
7. Connect BNC output of tunable probe into VSWR meter.
8. Connect the magic Tee as shown Fig. 11.

D) Measure of coupling port 1 to port 4 ort 1 input power from source. Port 2,3 terminated measure power at port 1. Let it be P1 Connect magic tee, then measure again power at port 3. Let it be P2
Coupling = P1-P2 db

E) Repeat above for coupling between port 1 and port 2 this should be same as that between port 1 and port 4.

F) Measure insertion loss between port 1 and port 3. By terminating port 2 and port 4
Loss = P2 - P1

Experiment 10: - Study of isolators & circulators

Aim: -

1. To measure insertion loss of attenuators or device.
2. To calibrate 0-20 db wave guide attenuator.
3. To determine forward and backward attenuation offered by a Ferrite waveguide isolator.
4. To calculate S parameters.

Apparatus required: -

(i) Reflex Klystron 2k25 (ii) Klystron supply

(iii) Klystron Mount (iv) Isolator

(v) Variable Attenuator (vi) Attenuator

(vii) Detector (viii) VSWR Meter or CRO

Theory: The usual method of reducing attenuation of the power level in a waveguide is to introduce a dielectric slab coated with an absorbing material. Slab attenuators have been built with a maximum attenuation of 90 db. Calibration is not independent of frequency. Another type of precision variable attenuator makes use of a circular waveguide section and the resistive vane is rotated in the circular guide section about the axis of the guide As the vane is rotated, a component of the E field induces current in the vane and attenuation increases. Maximum attenuation occurs when the vane is parallel with the E field. If Pl is the input power to the attenuator and p2 is the output power and the attenuator is terminated in matched load, the attenuator in db is;

Attenuation = log (p1/p2)

Attenuators are normally reciprocal so that

Reflection coefficients at the input and output port are identical.

Thus for reciprocal attenuator.

S11=S22= {VSWR -1}/{VSWR+1}

Where S11 and S22 are Reflection coefficients at input and output

Unidirectional ferrite isolator: An isolator is a two port non reciprocal component that allows a wave incident on port 1 to be transmitted to port 2 but does not allow the wave incident on port 2 to be transmitted to port 1. One import a application of an isolator is to prevent power being, reflected back from a mismatched load.

A common type of isolator, is based on FARADAY ROTATION. When an electromagnetic wave travels through a ferrite material in a direction parallel to the applied magnetic field, the coefficients are;

S21 = 1

S12 = S11=S22=0

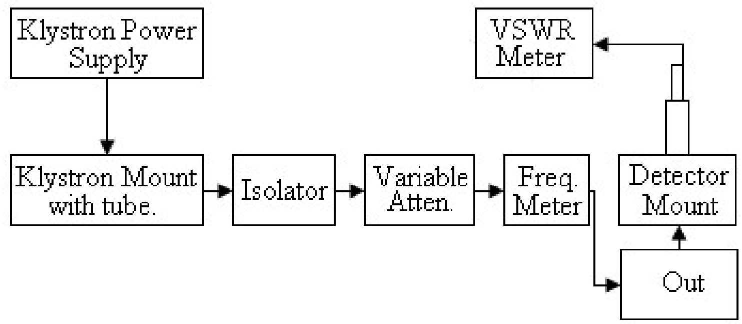


Fig.10 – **Block Diagram for Measurement of Attenuators and Isolators**

Procedure: -

Calibrating Attenuator:

1. Arrange microwave bench as shown.
2. Switch on klystron and VSWR meter.
3. Set the attenuator setting so that you get reading in VSWR meter.
4. Take the micrometer reading as reference.
5. Calibrate the micrometer in db by noting down various readings of attenuation in db as micrometer position and plotting these values in chart.

Measuring Isolation:

1. Change the set up for isolator study.
2. Arrange the isolator after Calibrated attenuator.
3. Measure the forward attenuation of the isolator.
4. Reverse the isolator direction and measure the attenuation.
5. Also determine following:

   a) Frequency of operation

   b) Input and output VSWR of attenuator / isolator

Let it be V1 and V2

c) Calculate S parameters.

Thus S11 = {V1-1}/{V1+ 1}   S22 = {V2-1} /V2+1}

Conclusion:-

Experiment No. 11: Examine and Demonstrate the radiation pattern of Horn antenna.
Aim: - To plot the radiation pattern of Horn antenna in E/H plane.

Apparatus Required: -

(i) Reflex Klystron 2k25 (ii) Klystron supply

(iii) Klystron Mount (iv) Isolator

(v) Variable Attenuator (vi) Horn Antenna – 2 nos.

(vii) Detector (viii) VSWR Meter or CRO

Theory: - The term radiation pattern refers simply to a graph of the radiation power supplied by the antenna to some detecting device plotted against angular position of the antenna. When it is rotated in a uniform plane polarized electromagnetic field. The horn antenna is a common form of microwave antenna physically the horn is simply a tapered section of waveguide providing a transition between a waveguide and free space. Although antennas do not provide a perfect match with rectangular waveguide propagating in a TE 10 mode, the radiated waveform is linearly polarized.

Radiation patterns and other characteristics are dependent on the horn length and the dimensions of the horn aperture, a and b for a pyramidal horn with a small flare angle, the gain is Approximately:

Gain of Horn $=10\ (a * b) / \lambda$

Half Power beam width in E plane $= 51\ \lambda / b$ deg

Half power Beam width in H plane $=70\ \lambda / a$ deg

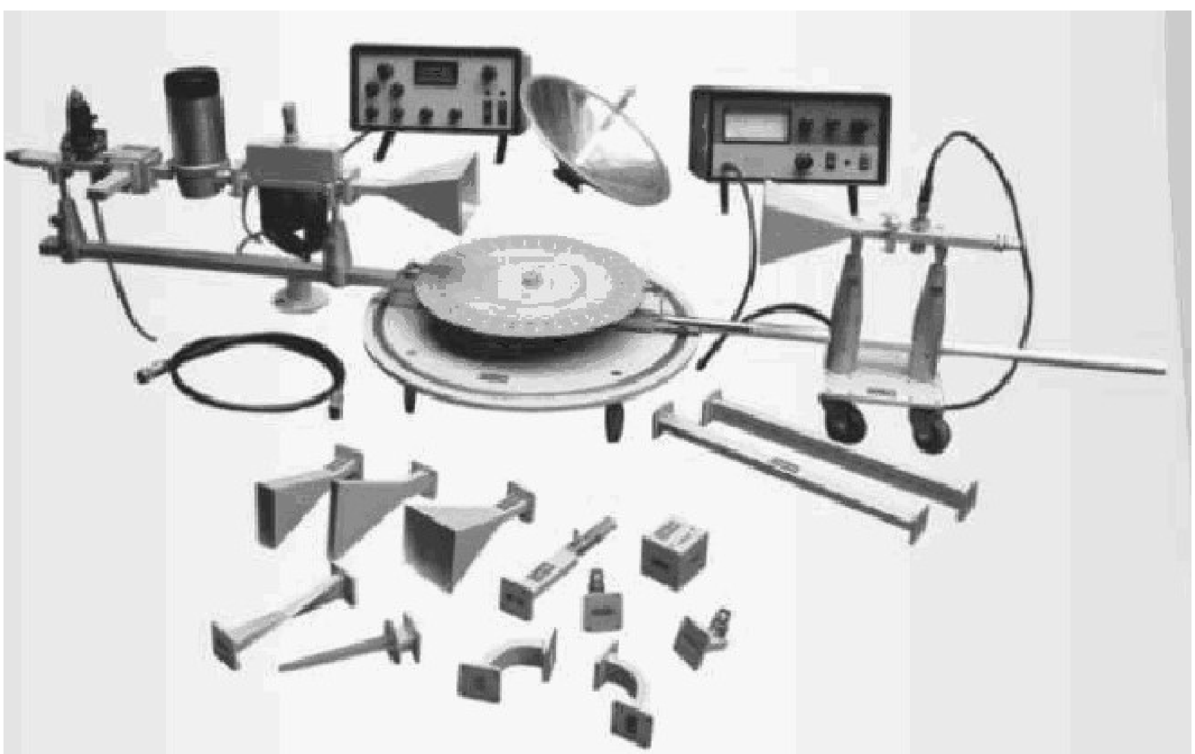


Fig.8 - **Test Bench for Plotting of Radiation Pattern of Antenna**

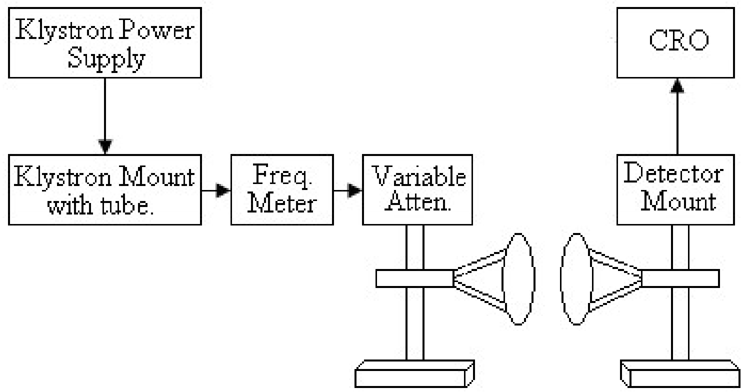


Fig.9 – **Block Diagram for Plotting of Radiation Pattern of Antenna**

Procedure: -

1. Arrange the experimental set up in the sequence shown: Fig 9. For B procedure A receiving horn followed by a waveguide crystal detector (tunable) on the elevated mobile stand which can move axially as well as along an angular all round the horn radiator. Klystron is connected to the supply and the detector output is connected to the VSWR meter.
2. Switch on the klystron as per instructions discussed in the experiment 1.
3. The horn is allowed to radiate towards an empty space. Remove all metallic objects from the vicinity of measurements the detector is kept at a distance from the aperture of the horn radiator.
4. The Crystal detector is rotated in angular fashion on both sides of the axis and the normalized intensity output in db below the intensity measured along the axis is recorded at different angles.
5. The measurements are repeated at different distance and with different horn angles in the H and E planes.
6. The radiation pattern is plotted on a polar graph.
7. Measure the variation of the intensity with distance along the axis of the horn radiator.
8. Measure the frequency of the radiation by the wave meter.

For Turn Table

System Details: -System consists of one fixed arm carrying transmitter, components and horn antenna and one rotatable arm carrying a Horn antenna and detector to measure relative signal power.

Some anteena parameters

Following parameters can be measured to approximate values:

1 3 db beam width: One can measure directly from polar plots plotted above.2

2 6 antenna gain ; this can also be measured by following substitution method

(a) Use a standard Horn Antenna Gain 16 db.

(b) Use two tripod stands as shown aside .

(c) Measure output on VSWR Meter using Standard Horn Antenna Let it

(d) Replace the standard horn antenna with unknown antenna whose gain is to be measured. Let it be y db.

(e) From above Gain of antenna can be calculate = 16db + (x-y) db.

Horn Antenna **Tripod Stand**

Results:-

The amplitude first increases as angle increases but after the angle 189, the amplitude starts decreasing.

Conclusion:-