

SRM VALLIAMMAI ENGINEERING COLLEGE

(An Autonomous Institution)

S.R.M Nagar, Kattankulathur – 603 203

Department of Electronics and Communication Engineering



Laboratory Manual

EC3764– MICROWAVE AND OPTICAL COMMUNICATION LABORATORY

Regulation - 2023

Semester/Branch : **VII semester ECE**

Academic Year : **2026 - 2027 (ODD SEMESTER)**

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SRM VALLIAMMAI ENGINEERING COLLEGE

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SRM Nagar, Kattankulathur – 603 203

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

VISION OF THE INSTITUTE

Educate to excel in social transformation

MISSION OF THE INSTITUTE

- ❖ To contribute to the development of human resources in the form of professional engineers and managers of international excellence and competence with high motivation and dynamism, who besides serving as ideal citizen of our country will contribute substantially to the economic development and advancement in their chosen areas of specialization.
- ❖ To build the institution with international reputation in education in several areas at several levels with specific emphasis to promote higher education and research through strong institute-industry interaction and consultancy.

VISION OF THE DEPARTMENT

To excel in the field of electronics and communication engineering and to develop highly competent technocrats with global intellectual qualities.

MISSION OF THE DEPARTMENT

M1: To train the students with the state-of-art technologies and to develop innovative solutions to cater to the societal needs.

M2: To orient the students towards global career with universal moral values and professional ethics.



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(An Autonomous Institution)

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PROGRAM OUTCOMES

- 1. Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
- 2. Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
- 3. Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
- 4. Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
- 5. Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
- 6. The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
- 7. Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
- 8. Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

9. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

11. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PROGRAM SPECIFIC OUTCOME (PSOs)

1. Ability to solve societal problems by applying knowledge acquired in the core domain.
2. Ability to apply technologies like VLSI, Embedded and Wireless Communications to meet the industrial requirements.

SYLLABUS

EC3764 MICROWAVE AND OPTICAL COMMUNICATION

L T P C

LABORATORY

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OBJECTIVES:

- To study the microwave passive & active devices, tubes and network analysis.
- To acquire the insights of microwave transmission using microwave bench setup.
- To apply the scattering matrix for the analysis of different microwave passive components.
- To understand the characteristics and measurements in optical fiber.
- To realize the working principle of optical source, detector and fibers.
- To explore the building blocks of fiber optic communication link.

LIST OF EXPERIMENTS

Microwave Experiments

1. Gunn diode characteristics
2. Reflex Klystron mode characteristics
3. Microwave parameters measurement using test bench - VSWR, Frequency, Wavelength, Attenuation.
4. S-parameter Measurement of microwave components- Isolator, Circulator and Magic Tee.
5. Characterization of Directional Coupler.
6. Radiation Pattern measurement of Horn Antenna / Parabolic Reflector Antenna.
7. Microwave measurements using a Vector Network Analyzer
 - a. Return loss b. VSWR c. Impedance

Optical Communication Experiments

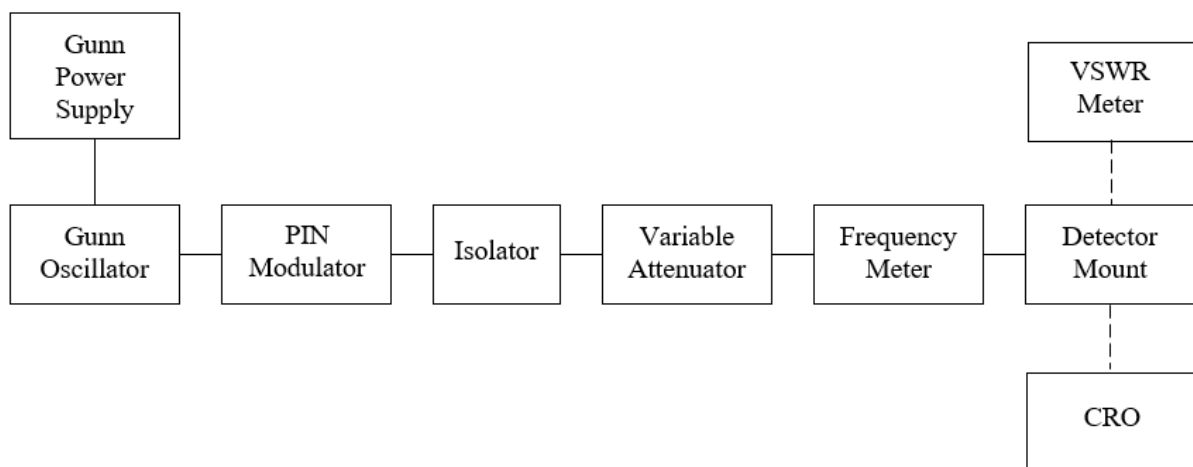
1. Numerical Aperture determination for Fiber.
2. Measurement of attenuation, bending and connector loss.
3. Mode Characteristics of Fiber.
4. DC Characteristics of LED and PIN Photo diode.
5. Fiber optic Analog and Digital Link- frequency response (analog) and eye diagram (Digital)

TOPIC BEYOND THE SYLLABUS EXPERIMENT

1. Voice communication by using microwave test bench

Total: 45 Periods

BLOCK DIAGRAM :



TABULATION :

OUTPUT POWER AND FREQUENCY

GUNN BIAS (V)	POWER (dB)	FREQUENCY (GHz)

V-I CHARACTERISTICS

GUNN BIAS (V)	CURRENT (mA)

EXPT 1 : GUNN DIODE CHARACTERISTICS

AIM :

To generate the microwave signal using Gunn diode and determine the following characteristics of Gunn diode.

- a) V-I characteristics of Gunn diode
- b) Output power and frequency as a function of bias voltage.

EQUIPMENTS REQUIRED :

Gunn Power Supply, Gunn Oscillator, PIN Modulator, Isolator, Variable Attenuator, Frequency Meter, Detector Mount, Waveguide Stands, VSWR Meter, CRO, Cables and Accessories.

THEORY :

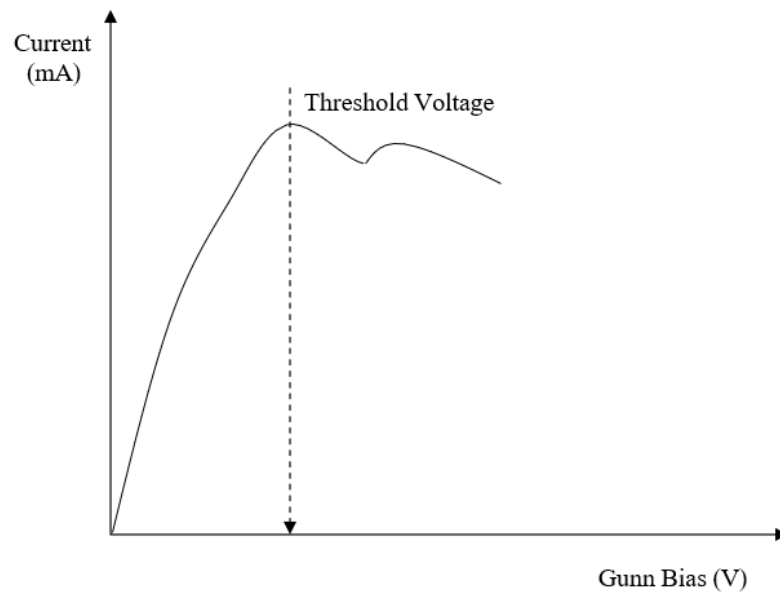
The Gunn oscillator is based on negative differential conductivity effect in bulk semiconductors, which has two conduction bands minima separated by an energy gap. A disturbance at the cathode gives rise to high field region, which travels towards the anode. When this high field domain reaches the anode, it disappears and another domain is formed at the cathode and starts moving towards anode and so on. The time required for domain to travel from cathode to anode (transit time) gives oscillation frequency.

In a Gunn oscillator, the Gunn diode is placed in a resonant cavity. In this case the oscillation frequency is determined by cavity dimension then by diode itself.

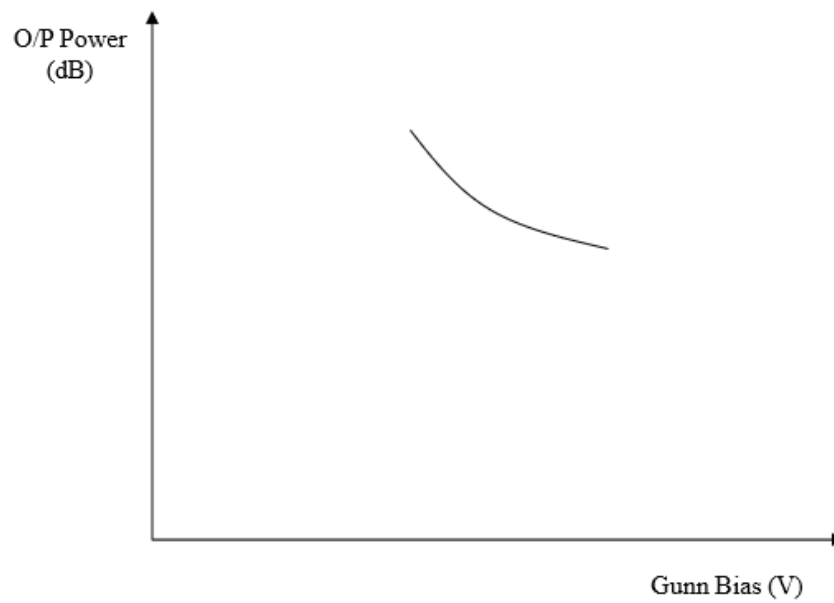
Although Gunn oscillator can be amplitude modulated with the bias voltage. We have used separate PIN modulator through PIN diode for square wave modulation.

A measure of the square wave modulation capability is the modulation depth i.e. the output ratio between, 'ON' and 'OFF' state.

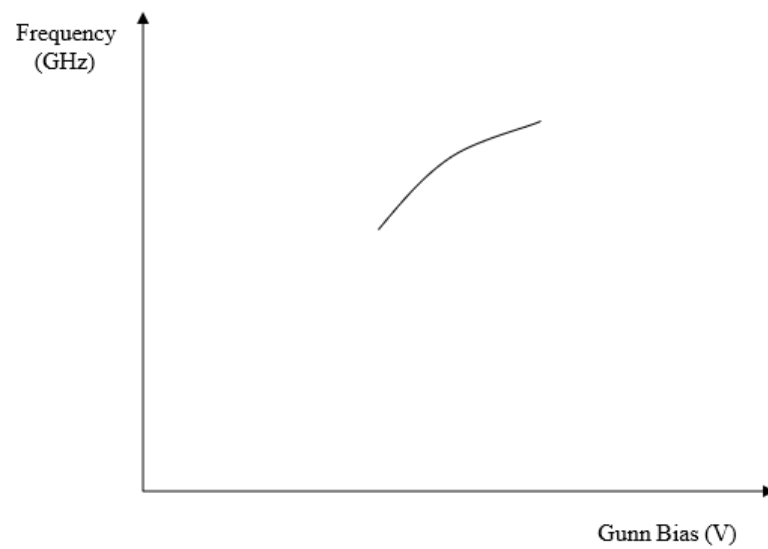
MODEL GRAPH :



OUTPUT POWER vs. GUNN BIAS



FREQUENCY vs. GUNN BIAS



PROCEDURE :

A) V-I CHARACTERISTICS OF GUNN DIODE

1. Set the components and equipment as shown in figure.
2. Before switching ON the power supply keep the control knobs of Gunn power supply as below.
Gunn bias and PIN bias knob – Fully anticlockwise
Meter switch – Voltage position.
Selector switch – INT position
Mod Frequency knob – Any position.
3. Initially set the variable attenuator for maximum attenuation.
4. Rotate the knob of frequency meter at maximum position.
5. Set the micrometer of Gunn oscillator for required frequency of operation.
6. Switch ON the Gunn power supply, CRO and cooling fan.
7. Rotate PIN bias knob to around maximum position
8. Increase the Gunn bias voltage control knob up to 7 volts.
9. Measure the Gunn diode current corresponding to the various voltage controlled by Gunn bias knob through the panel meter and meter switch.
10. Plot the voltage and current reading on the graph.
11. Measure the threshold voltage which, corresponds to maximum current.

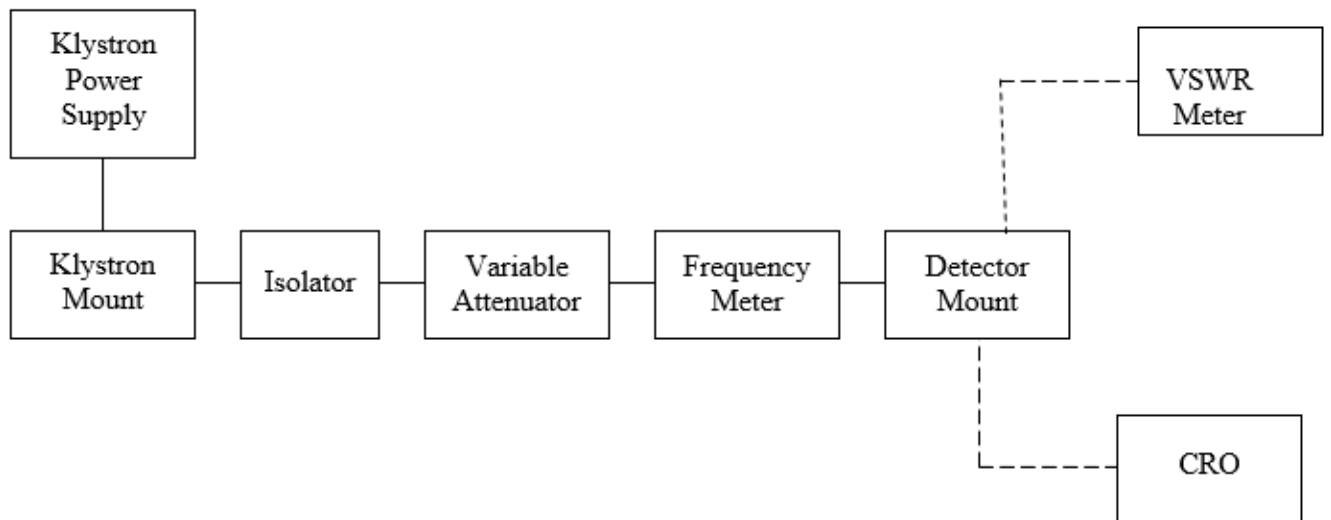
B) OUTPUT POWER AND FREQUENCY AS A FUNCTION OF BIAS VOLTAGE

1. Set the components and equipment as shown in figure.
2. Before switching ON the power supply keep the control knobs of Gunn power supply as below.
Gunn bias and PIN bias knob – Fully anticlockwise
Meter switch – Voltage position.
Selector switch – INT position
Mod Frequency knob – Any position.

RESULT :

Thus the characteristics of Gunn diode are studied and the V-I characteristics, Output power and Frequency as a function of Gunn bias voltage are also plotted.

BLOCK DIAGRAM :



TABULATION :

REPELLER VOLTAGE (V)	POWER (W)	FREQUENCY (GHz)	TUNING RANGE

EXPT 2 : REFLEX KLYSTRON MODE CHARACTERISTICS

AIM :

To study the characteristics of the reflex klystron and to determine its electronic tuning range.

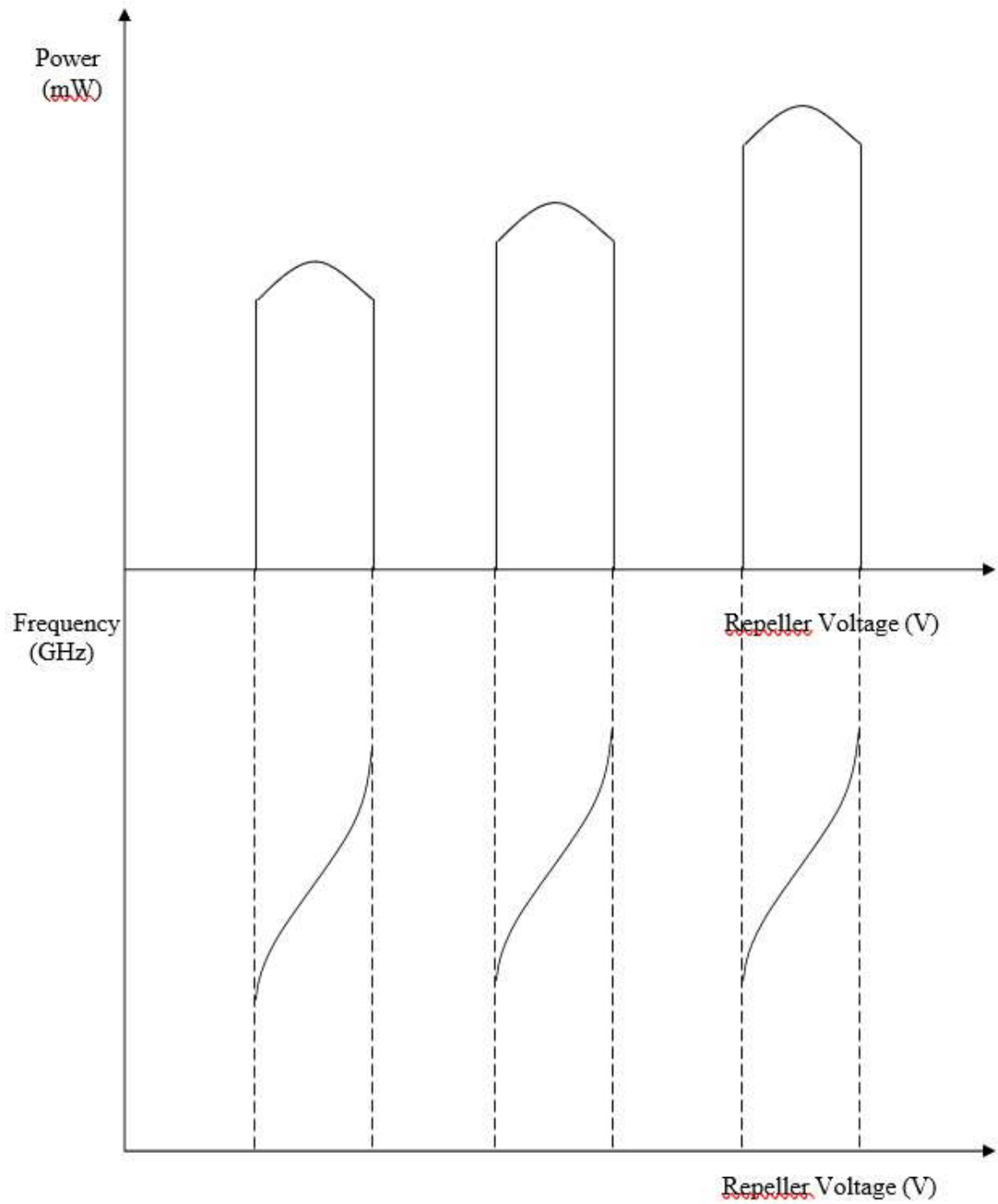
EQUIPMENTS REQUIRED :

Klystron Power Supply, Klystron Tube with Klystron Mount, Isolator, Variable Attenuator, Frequency Meter, Detector Mount, Waveguide Stands, VSWR Meter, CRO, Cables and Accessories.

THEORY :

The reflex klystron makes the use of velocity modulation to transform a continuous electron beam into microwave power. Electrons emitted from the cathode are accelerated and passed through the positive resonator towards negative reflector, which retards and finally reflects the electrons and the electrons turn back through resonator. Suppose an RF -field exists between the resonators the electrons traveling forward will be accelerated or retarded, as the voltage at the resonator changes in amplitude. The accelerated electrons leave the resonator at an increased velocity and the retarded electrons leave at the reduced velocity. The electrons leaving the resonator will need different time to return, due to change in velocities. As a result, returning electrons group together in bunches, As the electron bunches pass through resonator, they interact with voltage at resonator grids. If the bunches pass the grid at such a time that the electrons are slowed down by the voltage then energy will be delivered to the resonator; and klystron will oscillate. The frequency is primarily determined by the dimensions of resonant cavity. Hence, by changing the volume of resonator, mechanical tuning of klystron is possible, Also a small frequency change can be obtained by adjusting the reflector voltage. This is called electronic tuning.

MODEL GRAPH :



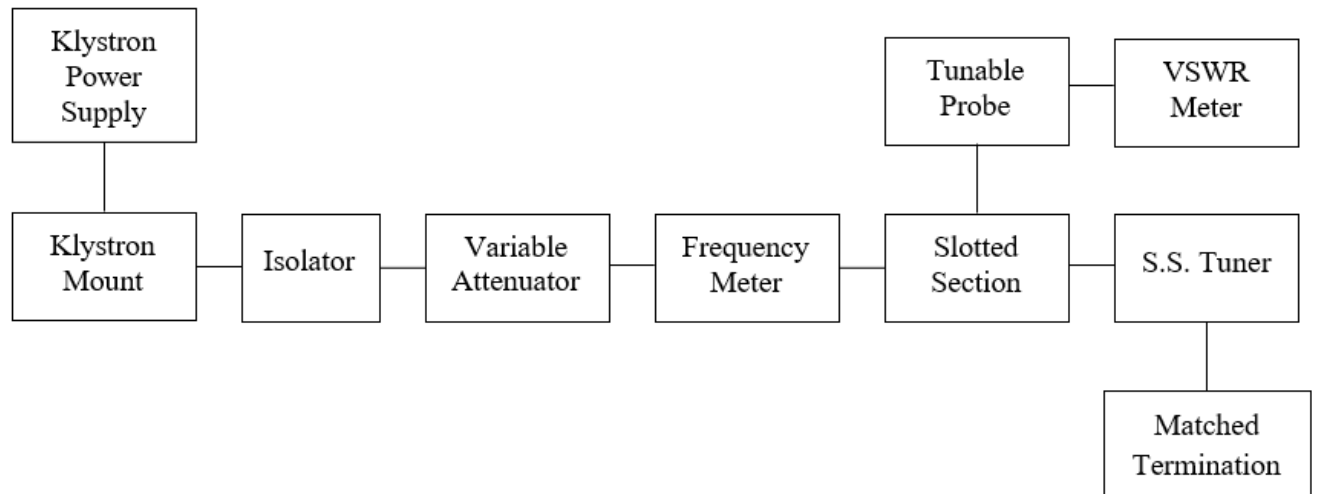
PROCEDURE :

1. Set the components and equipment as shown in figure.
2. Before switching ON the power supply keep the control knobs of Klystron power supply as below.
Meter switch – OFF position
Mod selector switch – AM position
AM Frequency & Amplitude - Mid position
Beam voltage – Fully anticlockwise
Reflector voltage – Fully clockwise
Standby switch – ON position
3. Keep the control knob of VSWR meter as below
Input switch – Low Impedance
SWR Range switch – 40dB
Meter switch – Normal
Gain (course & Fine) – Mid position.
4. Initially set the variable attenuator for maximum attenuation.
5. Rotate the knob of frequency meter at maximum position.
6. Switch 'ON' the Klystron power supply, VSWR meter and cooling fan.
7. Change the meter switch to beam voltage position and rotate beam voltage knob clockwise slowly up to 300V.
8. Rotate the reflector voltage knob to get any mode of klystron tube can be seen on an oscilloscope.
9. Take down the readings any three modes, Measure the frequency using frequency meter and corresponding reading of power at VSWR meter.

RESULT :

Thus the characteristics of reflex klystron are studied and its electronic tuning range is determined.

A) VSWR MEASUREMENT:



TABULATION :

REPELLER VOLTAGE :

FREQUENCY :

VERNIER SCALE READING (cm)	VSWR 'S'	REFLECTION COEFFICIENT = $S-1/S+1$

EXPT 3 : MICROWAVE PARAMETERS MEASUREMENT USING TEST BENCH - VSWR, FREQUENCY, WAVELENGTH, ATTENUATION.

AIM :

To measure the Voltage Standing Wave-Ratio, Frequency, Wavelength and Attenuation for matched load

EQUIPMENTS REQUIRED :

Klystron Power Supply, Klystron Tube with Klystron Mount, Gunn Power Supply, Gunn Oscillator, Isolator, Variable Attenuator, Frequency Meter, Slotted Section, Tunable Probe, S.S.Tuner, Matched Termination, Waveguide Stands, VSWR Meter, CRO, Cables and Accessories.

THEORY :

The electromagnetic field at any point of transmission line may be considered as the sum of two traveling waves: the 'Incident Wave' propagates from generator and the reflected wave propagates towards the generator. The reflected wave is set up by reflection of incident wave from a discontinuity on the line or from the load impedance. The magnitude and phase of reflected wave depends upon amplitude and phase of the reflecting impedance. The super position of two traveling waves, gives rise to standing wave along with the line. The maximum field strength is found where two waves are in phase and minimum where the two waves add in opposite phase. The distance between two successive minimum is half the guide wavelength on the line. The ratio of electrical field strength of reflected and incident wave is called reflection coefficient.

Hence VSWR denoted by S is

$$S = \frac{E_{\max}}{E_{\min}} = \frac{|E_I| + |E_r|}{|E_I| - |E_r|}$$

Where E_I – Incident Voltage E_r – Reflected Voltage

For dominant TE₁₀ mode in rectangular wave-guide λ_o , λ_g and λ_c are related as below.

$$(1/\lambda_o)^2 = (1/\lambda_g)^2 + (1/\lambda_c)^2$$

where λ_o is free space wavelength

λ_g is guide wavelength

λ_c is cut off wavelength

For TE₁₀ mode, $\lambda_c = 2a$ where 'a' is broad dimension of waveguide.

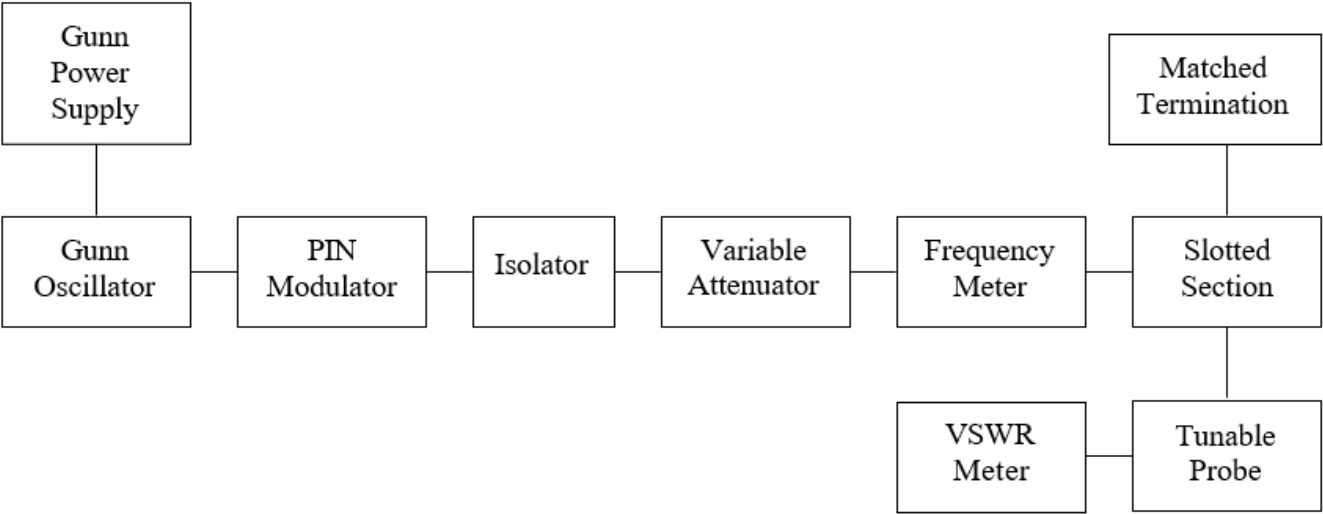
The following relationship can be proved

$c = f \lambda$ where c is velocity of light and f is frequency.

For an air filled hollow pipe waveguide. $\lambda_g = \lambda_o / \sqrt{1 - (\lambda_o / \lambda_c)^2}$

For TE_{mn} mode in rectangular waveguide. $\lambda_c = 2 / \sqrt{(m/a)^2 + (n/b)^2}$

B) FREQUENCY AND WAVELENGTH MEASUREMENT:



TABULATION :

FREQUENCY BY DIRECT METHOD :

INDIRECT METHOD :

REPELLER VOLTAGE (V)	POWER (W)	FREQUENCY (GHz)	TUNING RANGE

For dominant TE₁₀ mode we have,

$$\lambda_c = 2/\sqrt{[(1/a)^2 + (0/b)^2]} = 2a$$

$$\text{Thus, } \lambda_g = \lambda_o/\sqrt{[1-(\lambda_o/2a)^2]}, \lambda_g = 1/\sqrt{[(1/\lambda_o)^2-(1/2a)^2]} \quad 1/(\lambda_o^2) = 1/\sqrt{[(1/\lambda_g)^2 + (1/2a)^2]}$$

$$1/(\lambda_o^2) = 1/(\lambda_g^2) + (1/2a)^2$$

$$f = c/\lambda_o = c\sqrt{[(1/\lambda_g)^2 + (1/2a)^2]}$$

The wavelength λ_g can be measured as twice the distance between minima in the standard wave pattern.

The attenuators are two port bi-directional devices which attenuate power when inserted into the transmission line.

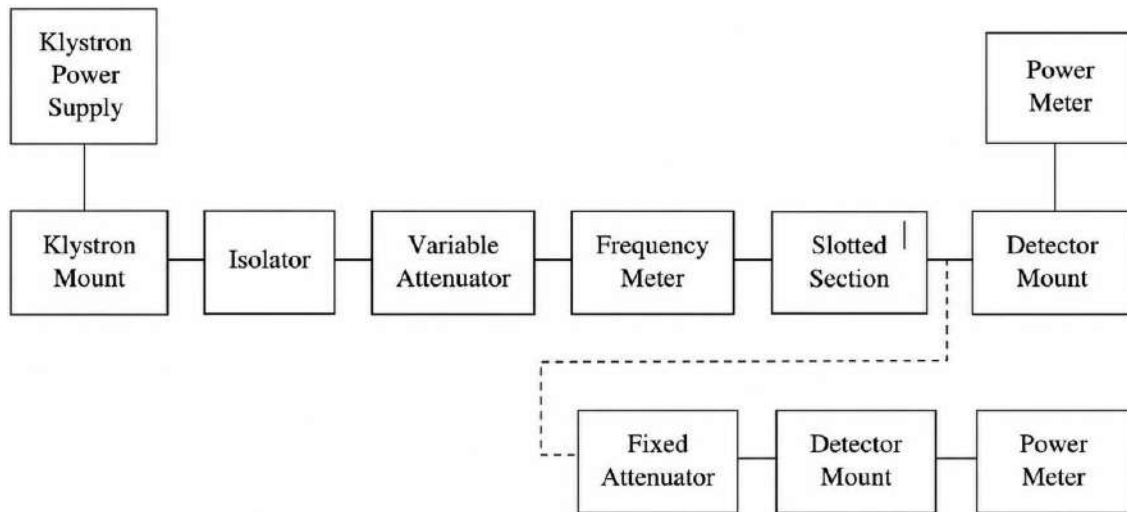
$$\text{Attenuation } A \text{ (dB)} = 10 \log_{10} (P_1/P_2)$$

Where P_1 – Power detected by the load without the attenuator in the line.

P_2 – Power detected by the load with attenuator in line.

The attenuators consist of a rectangular wave guide with a resistive vane inside it to absorb microwave power according to their position with respect to side wall of the wave-guide. As electric field is maximum at center in TE₁₀ mode, the attenuation will be maximum if the vane is placed at center of the wave-guide. Moving from center toward the side wall, attenuation decreases in the fixed attenuator, the vane position is fixed where as in variable attenuator, its position can be changed by help of micrometer or by other methods.

C) ATTENUATION MEASUREMENT



TABULATION :

REPELLER VOLTAGE :

P ₁ (dB)	P ₂ (dB)	Attenuation(dB)

PROCEDURE :**For VSWR Measurement:**

1. Set the components and equipment as shown in figure.
2. Before switching ON the power supply keep the control knobs of Klystron power supply as below.
Meter switch – OFF position
Mod selector switch – AM position
AM Frequency & Amplitude - Mid position
Beam voltage – Fully anticlockwise
Reflector voltage – Fully clockwise
Standby switch – ON position
3. Keep the control knob of VSWR meter as below
Input switch – Low Impedance
SWR Range switch – 40dB
Meter switch – Normal
Gain (course & Fine) – Mid position.
4. Initially set the variable attenuator for maximum attenuation.
5. Rotate the knob of frequency meter at maximum position.
6. Switch 'ON' the Klystron power supply, VSWR meter and cooling fan.
7. Turn the meter switch of power supply to beam voltage position and set the beam voltage at 300V with the help of beam voltage knob.
8. Adjust the reflector voltage to get some deflection in VSWR meter.
9. Maximize the deflection with AM amplitude and frequency control knob of power supply.
10. Tune the plunger of klystron mount for maximum deflection.
11. Tune the probe for maximum deflection in VSWR.
12. Tune the frequency meter knob to get dip on the VSWR scale, and note down the frequency directly from the frequency meter.
13. Keep the depth of pin of S.S.Tuner to around 3 – 4mm and lock it.
14. Move the probe along with slotted line to get maximum deflection.
15. Adjust VSWR meter gain control knob such that the meter indicates 1.0 on the normal upper SWR scale.
16. Move the probe to next minima point note down the SWR = S_0 on the scale. Also note down the probe position, let it be 'd'.
17. Calculate the Reflection Coefficient $|\rho| = \frac{S-1}{S+1}$

For Frequency and Wavelength Measurement

1. Set the components and equipment as shown in figure.
2. Before switching ON the power supply keep the control knobs of Gunn power supply as below.
Gunn bias and PIN bias knob – Fully anticlockwise
Meter switch – Voltage position.
Selector switch – INT position
Mod Frequency knob – Any position.
3. Keep the control knob of VSWR meter as below
Input switch – Low Impedance
SWR Range switch – 40dB
Meter switch – Normal
Gain (course & Fine) – Mid position.
4. Initially set the variable attenuator for maximum attenuation.
5. Rotate the knob of frequency meter at maximum position.
6. Set the micrometer of Gunn oscillator for required frequency of operation.
7. Switch ON the Gunn power supply, VSWR meter and cooling fan.
8. Rotate PIN bias knob to around maximum position
9. Increase the Gunn bias voltage control knob up to 7 volts.
10. Tune the micrometer of Gunn oscillator for maximum deflection in VSWR meter.
11. Tune the frequency meter knob to get a 'dip' on VSWR scale and note down the frequency directly from the frequency meter.
12. Replace the termination with movable short, and detune the frequency meter.
13. Move the probe along with slotted line, the deflection in VSWR meter will vary. Move the probe to a minimum deflection position. To get accurate reading, it is necessary to increase the VSWR range dB to higher position. Note and record the probe position.
14. Move the probe next minimum position and record the probe position again.
15. Calculate the guide wavelength as twice the distance between two successive minimum positions obtained as above.
16. Measure the wave-guide inner broad dimension 'a' which will be around 22.86mm for X-band.
17. Calculate the frequency by following equation. $f = c / \lambda_o = c \sqrt{[(1 / \lambda_g)^2 + (1/2a)^2]}$

For Attenuation Measurement:

1. Set up the components and equipments as shown in fig.\
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 maximum power on power meter.
4. Measure the power in power meter. Let it be P_1 .
5. Carefully disconnect the detector mount from the slotted line, without disturbing any position on the set up. Place any one microwave device (attenuator) in slotted line and detector mount to other port of device. Now measure the power in power meter. Let it be P_2
6. Compute insertion loss or attenuation will be $P_1 - P_2$ dB.

RESULT :

Thus the VSWR, Frequency, Wavelength and Attenuation is determined.

VSWR:

Frequency by direct method :

Frequency by indirect method:

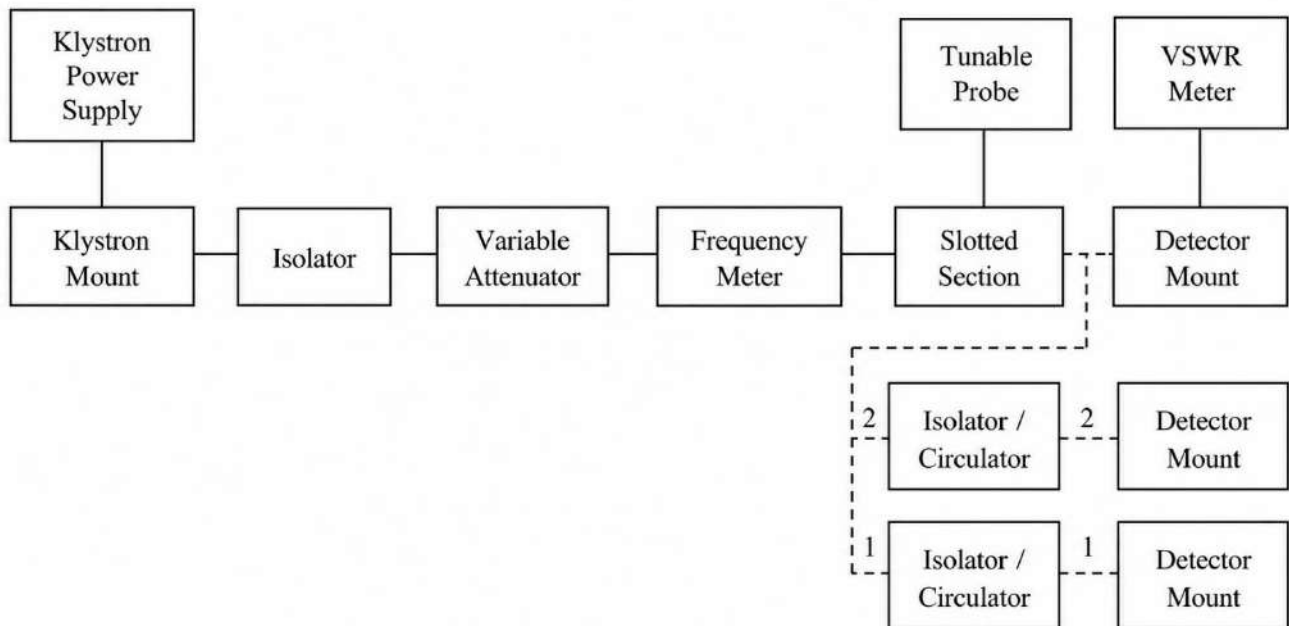
Free space wavelength (λ_0) :

Guide wavelength (λ_g) :

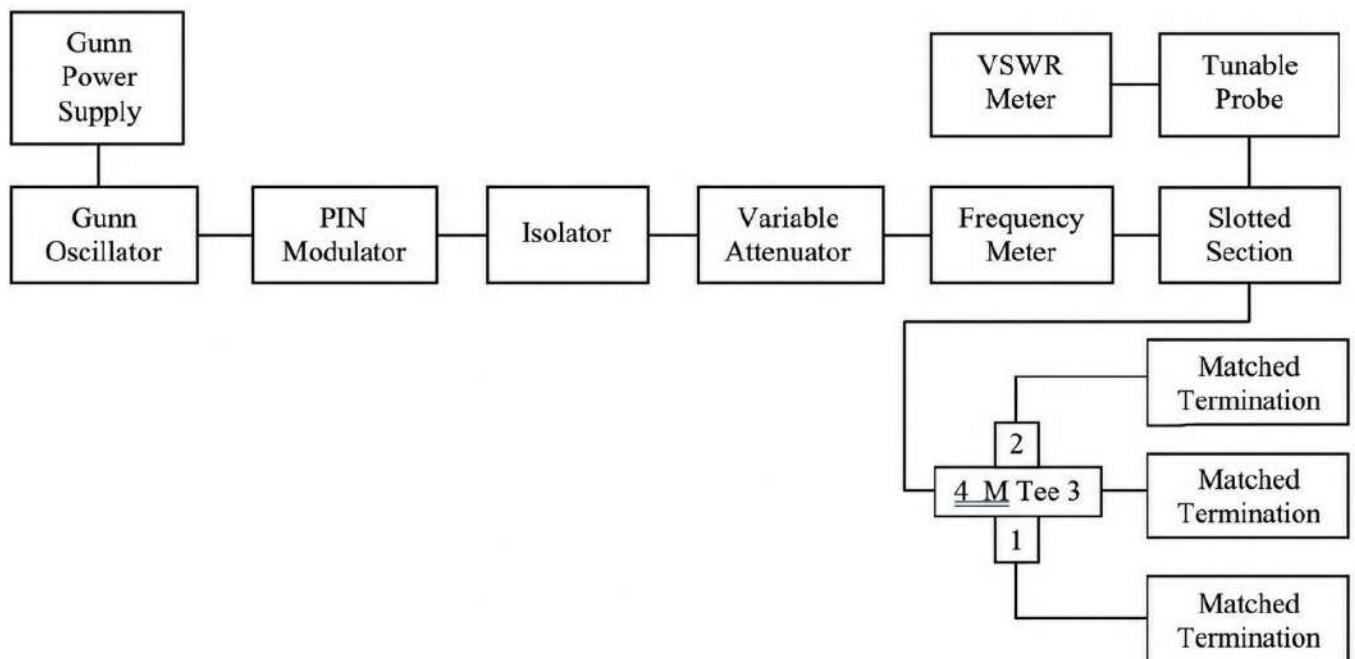
Attenuation (dB):

BLOCK DIAGRAM

FOR ISOLATOR AND CIRCULATOR



FOR MAGIC TEE



EXPT 4 : S-PARAMETER MEASUREMENT OF MICROWAVE COMPONENTS- ISOLATOR, CIRCULATOR AND MAGIC TEE

AIM :

To measure S-parameter of Isolator, Circulator and Magic Tee

EQUIPMENTS REQUIRED :

Microwave Source (Klystron or Gunn), Isolator, Variable Attenuator, Frequency Meter, Slotted Section, Tunable Probe, Isolator, Circulator, Detector Mount, Matched Termination, Waveguide Stands, VSWR Meter, CRO, Cables and Accessories.

THEORY :

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.

CIRCULATOR

The circulator is defined as a device with ports arranged such that energy entering a port is coupled to an adjacent port but not coupled to other ports. A wave incident on port 1 is coupled to port 2 only, a incident at port 2 is coupled to port 3 only and so on.

INSERTION LOSS

The ratio of power supplied by a source to the input port to the power detected by a detector in the coupling arm, i.e. output arm with other port terminated in the matched load, is defined as insertion loss or forward loss.

ISOLATION

Is the ratio of power fed to input arm to the power detected at not coupled port with other port terminated in the matched load.

MAGIC TEE

The device Magic Tee is a combination of E and H plane Tee. Arm 3, the H-arm forms an H plane Tee and arm 4, the E-arm forms an E plane Tee in combination with arm 1 and 2 a side or collinear arms. If power is fed into arm 3 (H-arm), the electric field divides equally between arm 1 and 2 in the same phase, and no electrical field exist in arm 4. Reciprocity demands no coupling in port 3 (H-arm). 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 from arm 1 and 2, it is added in arm 3 (H-arm) and it is subtracted in E-arm, i.e. arm 4.

A) ISOLATION

The isolation between E and H arms 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 arms 1 and 2 are terminated matched load.

TABULATION :

ISOLATOR

REPELLER VOLTAGE :

P1	PORT 2 (P2)	PORT 1 (P3)

CIRCULATOR

REPELLER VOLTAGE :

P1	PORT 2 (P2)	PORT 1 (P3)

Hence, Isolation = $10 \log_{10} (P_4/P_3)$

Similarly, isolation between other parts may also be defined.

B) COUPLING COEFFICIENT

It is defined as $C_{ij} = 10^{-\alpha/20}$

Where α = attenuation / isolation in dB where 'i' is input arm and 'j' is output arm.

Thus $\alpha = 10 \log_{10} (P_i/P_j)$

Where P_i is power delivered to arm i and P_j is power detected at j arm.

PROCEDURE :

For Isolator and Circulator

1. Set up the components and equipments as shown in fig.
2. Energize the microwave source for maximum output particular frequency of operation. Tune the detector mount for maximum output in the VSWR meter.
3. Set any reference level of power in VSWR meter with the help of variable attenuator and gain control knob of VSWR meter. Let it be P_1 .
4. Carefully remove the detector mount from slotted line without disturbing the position of set up. Insert the isolator / circulator between slotted line and detector mount. Keeping input port to slotted line and detector at its output port. A matched termination should be placed a third port in case of circulator.
5. Record the reading in the VSWR meter. If necessary change range-dB switch to high or lower position and taking 10dB change for one step change of switch position. Let it be P_2 . Compute insertion loss on $P_1 - P_2$.
6. 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 another port terminated by matched termination (in case circulator) after setting a reference level without isolator or circulator in the set up as described in insertion loss measurement. Let same P_1 level is set.
7. Record the reading of VSWR meter inserting the isolator or circulator as given step 7. Let it be P_3 .
8. Compute isolation as P_1-P_3 in dB.

MAGIC TEE

GUNN BIAS VOLTAGE :

ARM 1	ARM 2	ARM 3	ARM 4

For Magic Tee

A) VSWR MEASUREMENTS OF THE PORTS

1. Set up the components and equipments as shown in fig.
2. Keeping E arm towards slotted line and matched termination to other ports.
3. Energize the microwave source for particular frequency of operation and tune the detector mount for maximum output.
4. Measure the VSWR of E arm as described in measurement of SWR for low and medium value.
5. Connect other arm to slotted line and terminate the other port with matched termination. Measure the VSWR as above. Similarly, SWR of any port can be measured.

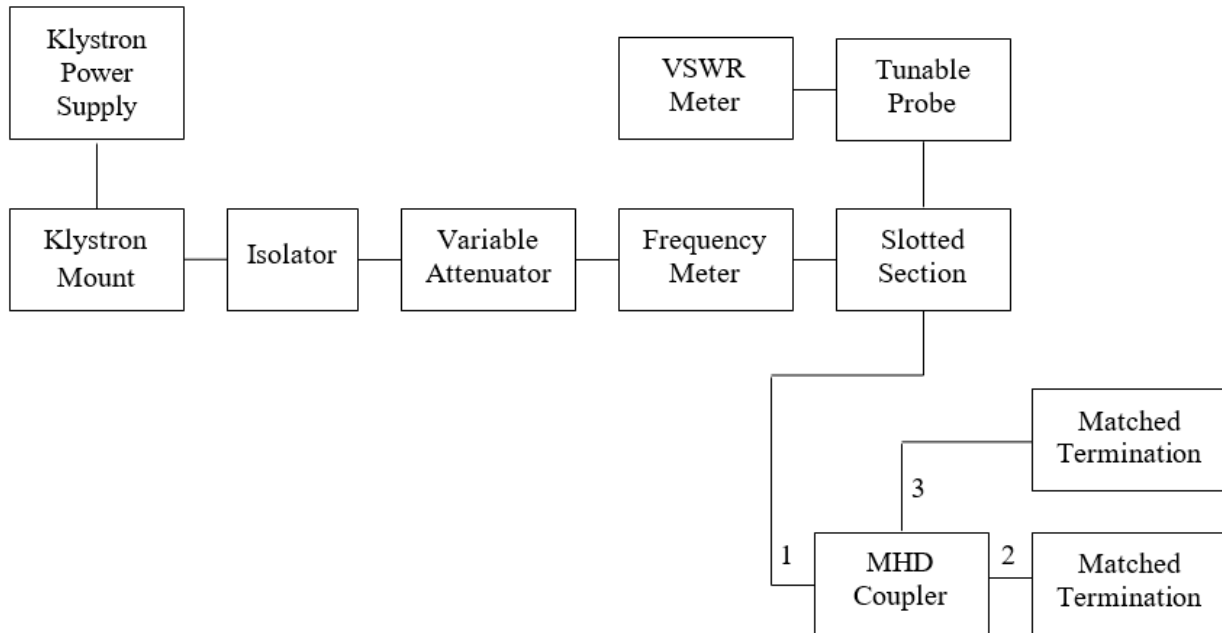
B) MEASUREMENT OF ISOLATION AND COUPLING COEFFICIENT

1. Remove the tunable probe and Magic Tee from the slotted line and connect the detector mount to slotted line.
2. Energize the microwave source for particular frequency of operation and tune the detector mount for maximum output.
3. With the help of variable attenuator and gain control knob of VSWR meter, set any power level in the VSWR meter and note down. Let it be P_3 .
4. Without disturbing the position of variable attenuator and gain control knob, carefully place the Magic Tee after slotted line keeping H arm connected to slotted line, detector to E arm and matched termination to arm 1 and 2. Note down the reading of VSWR meter. Let it be P_4 .
5. Determine the isolation between port 3 and 4 as $P_3 - P_4$ in dB.
6. Determine the coupling coefficient from equation given in the theory part.
7. The same experiment can be repeated for other port also.

RESULT :

Thus the S-parameters of Isolator, Circulator, and Magic Tee are calculated

BLOCK DIAGRAM :



EXPT 5 : CHARACTERIZATION OF DIRECTIONAL COUPLER

AIM :

To study the characteristics of Multi-Hole Directional coupler.

EQUIPMENTS REQUIRED :

Microwave Source (Klystron or Gunn), Isolator, Variable Attenuator, Frequency Meter, Slotted Section, Tunable Probe, MHD Coupler, Detector Mount, Matched Termination, Waveguide Stands, VSWR Meter, CRO, Cables and Accessories.

THEORY :

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

The Coupling factor is defined as

Coupling (dB) = $10 \log_{10}(P_1/P_3)$ where port 2 is matched P3

Isolation = $10 \log_{10}(P_2/P_3)$ where port 1 is matched P3

Directivity D (dB) = Isolation – Coupling = $10 \log_{10}$

Insertion Loss = $10 \log_{10}(P_1/P_2)$ when power is entering at port 1 P2

TABULATION :

REPELLER VOLTAGE :

ARM 1	ARM 2	ARM 3	ARM 4

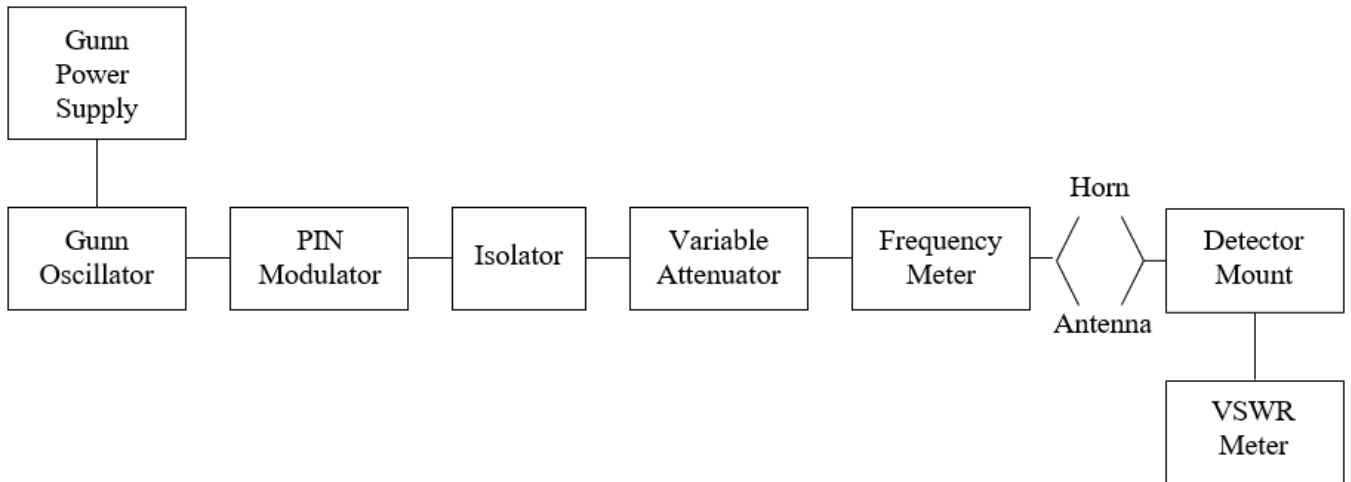
PROCEDURE :

1. Set up the equipments as shown in fig.
2. Energize the microwave source for particular frequency of operation using Klystron or Gunn Oscillator
3. Remove the multi-hole directional coupler and connect the detector mount to the frequency meter. Tune the detector for the maximum output.
4. Set any reference level of power on VSWR meter with the help of variable attenuator, gain control of VSWR meter, and note down the reading. (Reference level let it be X)
5. Insert the directional coupler with detector to the auxiliary port 3 and matched termination to port 2, without changing the position of variable attenuator and gain control of VSWR meter.
6. Note down the reading on VSWR meter on the scale with the help of range dB switch if required. (let it be Y)
7. Calculate coupling factor, which will be $X - Y$ in dB.
8. Now carefully disconnect the detector from the auxiliary port 3 and matched termination from port 2 without disturbing the set up.
9. Connect the matched to the auxiliary port 3 and match termination from port 2 without disturbing the set up.
10. Connect the matched termination to the auxiliary port 3 and detector to port 2 and measure the reading on VSWR meter. Suppose it is Z.
11. Compute insertion loss $X - Z$ in dB.
12. Connect the directional coupler in the reverse direction, i.e. port 2 to frequency meter side, matched termination to port 1 and detector mount to port 3, without disturbing the position of the variable attenuator and gain control knob of VSWR meter. Measure and note down the reading on VSWR meter, let it be Y_d .
13. Compute the directivity as $Y - Y_d$ and repeat the same for other frequencies.

RESULT :

Thus the characteristics of directional coupler is studied.

BLOCK DIAGRAM :



TABULATION :

GUNN BIAS VOLTAGE :

ZERO BIAS ATTENUATION : FREQUENCY :

DISTANCE BETWEEN TWO HORN ANTENNA :

ANGLE IN DEGREE	POWER IN dB	ATTENUATION IN dB

EXPT 6 : RADIATION PATTERN OF HORN ANTENNA

AIM :

To determine the radiation pattern of horn antenna and to measure the Half Power Beam Width (HPBW).

EQUIPMENTS REQUIRED :

Gunn Power Supply, Gunn Oscillator, PIN Modulator, Isolator, Variable Attenuator, Frequency Meter, Detector Mount, Two Horn Antenna, Turn Table, VSWR Meter, CRO, Cables and Accessories.

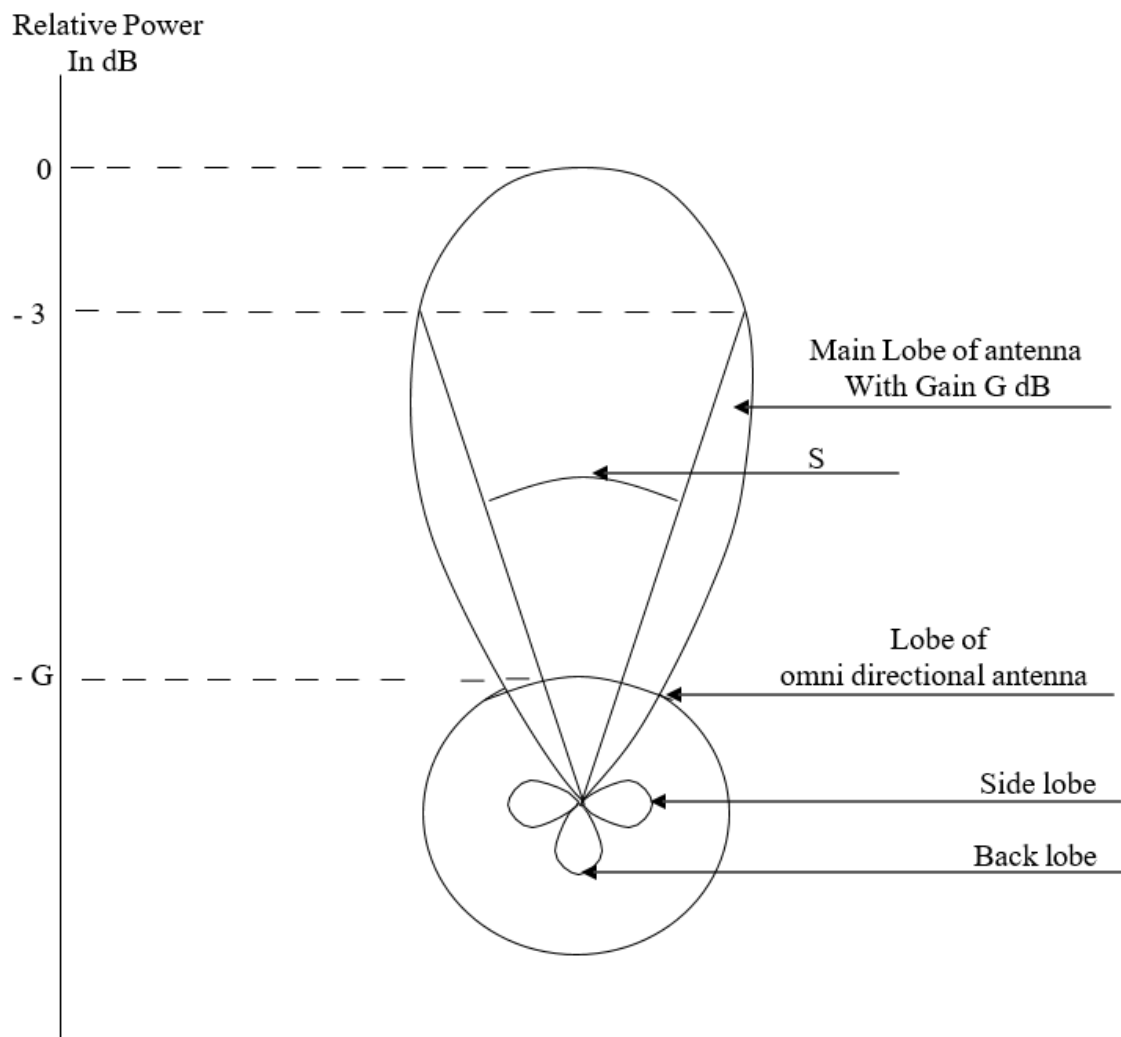
THEORY :

If a transmission line propagating energy is left open at one end, there will be radiation from this end. In case of a rectangular wave-guide this antenna presents a mismatch of about 2:1 and it radiates in many directions. The match will improve if the open wave-guide is a horn shape.

The radiation pattern of an antenna is a diagram of field strength or more often the power intensity as a function of the aspect angle at a constant distance from the radiating antenna. An antenna pattern is of course three-dimensional but for practical reasons it is normally presented as a two dimensional pattern in one or several planes. An antenna pattern consists of several lobes, the main lobe, side lobes and the back lobe. The major power is concentrated in the main lobe and it is required to keep the power in the side lobes and back lobe as low as possible. The power intensity at the maximum of the main lobe compared to the power intensity achieved from an imaginary omni-directional antenna (radiating equally in all directions) with the same power fed to the antenna is defined as gain of the antenna.

MODEL GRAPH :

ANTENNA RADIATION PATTERN



PROCEDURE :

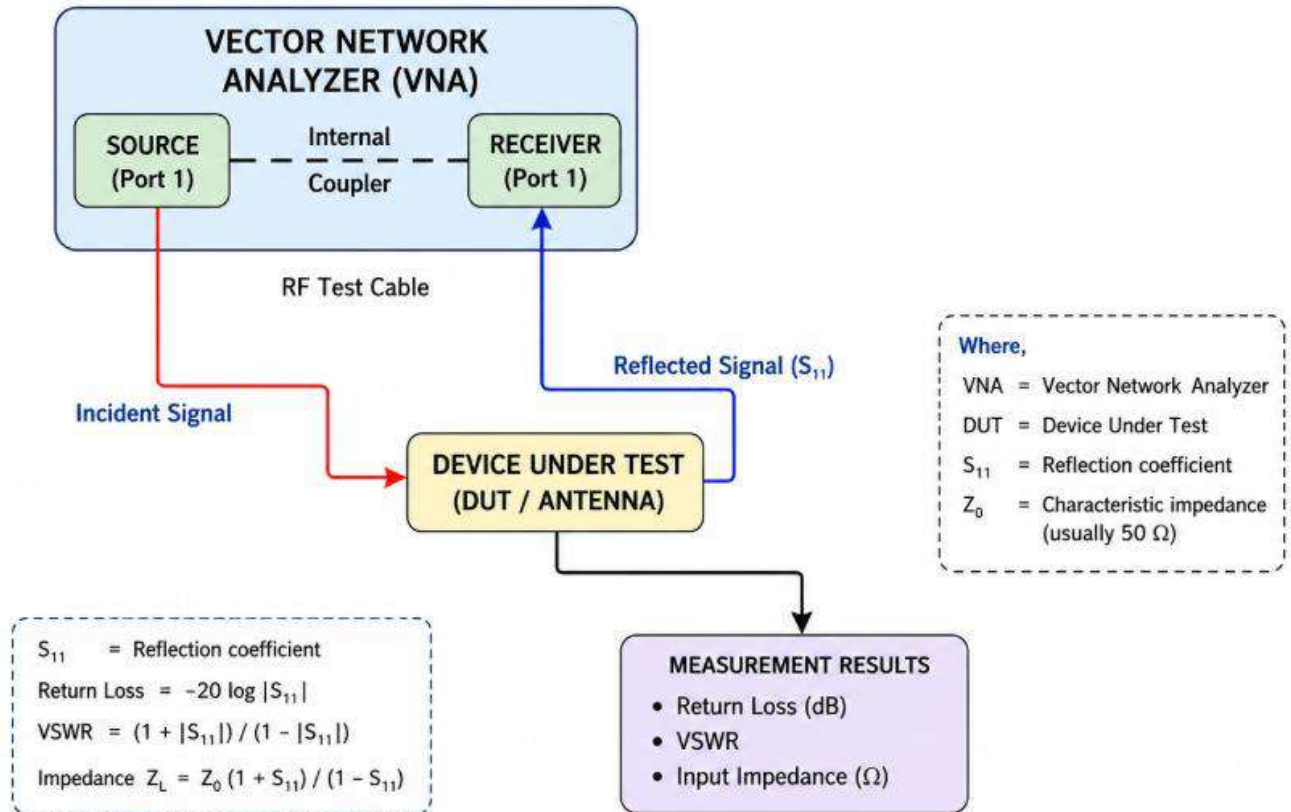
ANTENNA RADIATION PATTERN PLOTTING

1. Set the components and equipment as shown in figure. Keeping the axis of both antennas in same axis line.
2. Energize the Microwave source for maximum output at desired frequency with square wave modulation by tuning square wave amplitude and frequency of modulating signal of Gunn power supply and by tuning the detector.
3. Obtain full scale deflection (0dB) on normal dB scale (0 – 10dB) at any convenient range switch position of the VSWR meter by gain control knob of VSWR meter or by variable attenuator.
4. Turn the receiving horn to the left in 2 or 5 steps up to 40 – 50 and note the corresponding VSWR dB reading in normal dB range. When necessary change the range switches to next higher range and add 10dB to the observed value.
5. Repeat the above step but this time turns the receiving horn to the right and note down the readings.
6. Draw a relative power pattern i.e. output V/S angle.
7. From diagram determine 3dB-beam width of the horn antenna can be measured.

RESULT :

Thus the radiation pattern is determined and the Half Power Beam Width are measured

BLOCK DIAGRAM



EXPT 7 : MICROWAVE MEASUREMENT USING VECTOR NETWORK ANALYZER

AIM :

To measure the Return Loss, Voltage Standing Wave Ratio (VSWR), and Input Impedance of a microwave device using a Vector Network Analyzer (VNA).

EQUIPMENTS REQUIRED :

Vector Network Analyzer, Calibration Kit, Device Under Test (DUT), RF Coaxial Cables, Adapter and Connectors.

THEORY :

A Vector Network Analyzer (VNA) measures the scattering parameters (S-parameters) of RF and microwave devices. It is used to determine return loss, VSWR, and impedance characteristics of the device under test.

Reflection Coefficient: $\Gamma = (Z_L - Z_0)/(Z_L + Z_0)$

Return Loss: $RL = -20 \log_{10}|\Gamma|$

VSWR = $(1 + |\Gamma|)/(1 - |\Gamma|)$

Input Impedance: $Z_L = Z_0[(1 + \Gamma)/(1 - \Gamma)]$

TABULATION:**RETURN LOSS AND VSWR MEASUREMENT:**

DUT	FREQUENCY (GHZ)	RETURN LOSS	VSWR
DIRECTIONAL COUPLER			
E-PLANE TEE			

IMPEDANCE MEASUREMENT:

DUT	FREQUENCY (GHZ)	RESISTANCE (Ω)	REACTANCE (Ω)	IMPEDANCE (Ω)
DIRECTIONAL COUPLER				
E-PLANE TEE				

PROCEDURE

A. VNA CALIBRATION

1. Switch ON the VNA and allow it to warm up.
2. Set the desired frequency range.
3. Connect the calibration kit.
4. Perform Open, Short, and Load calibration.
5. Save the calibration settings.

B. RETURN LOSS MEASUREMENT

1. Connect the DUT to Port 1 of the VNA.
2. Select the S11 parameter display.
3. Set the display format to Return Loss (dB).
4. Sweep over the required frequency range.
5. Record the return loss at the resonant frequency or frequencies of interest.

C. VSWR MEASUREMENT

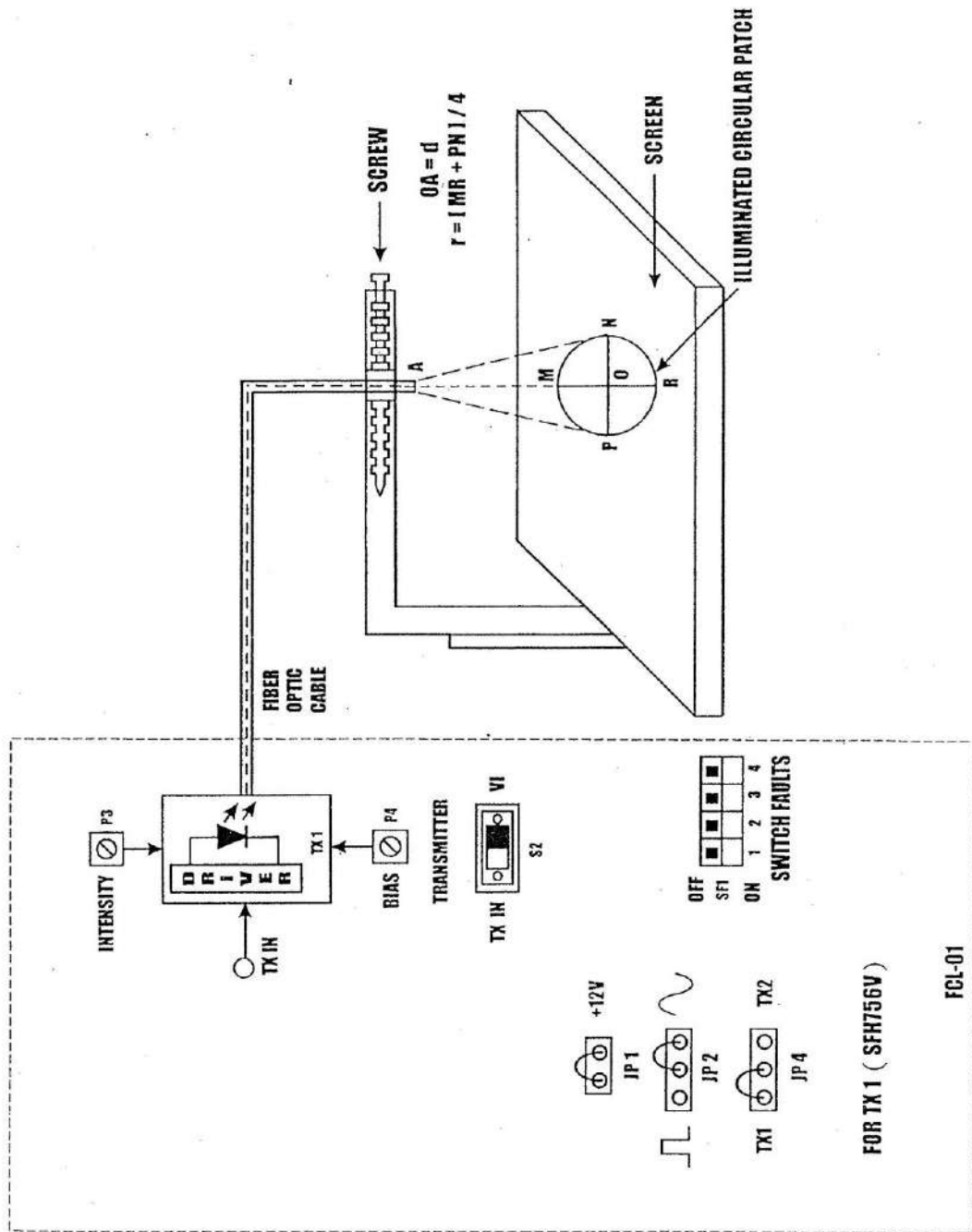
1. Using the same S11 measurement setup, select VSWR format.
2. Perform the frequency sweep.
3. Note the VSWR values at the desired frequencies.

D. IMPEDANCE MEASUREMENT

1. Select Smith Chart display on the VNA.
2. Observe the impedance point corresponding to the operating frequency.
3. Record the real and imaginary parts of the impedance.
4. Alternatively, use the marker function to directly read the impedance value.

RESULT:

Thus, the Return Loss, VSWR, and Input Impedance of the given microwave device were measured using a Vector Network Analyzer.



BLOCK DIAGRAM FOR NUMERICAL APERTURE MEASUREMENT

OPTICAL EXPERIMENTS

EXPT 1 : NUMERICAL APERTURE DETERMINATION FOR FIBER

AIM :

To measure the numerical aperture (NA) of the optical fiber

EQUIPMENTS REQUIRED :

Optical Trainer Kit (FCL-01), 1 Meter Fiber Cable, NA Measurement JIG, Ruler, Power Supply

THEORY :

Numerical aperture is a characteristic parameter of any given fiber's light gathering capability defined by the sine of half angle over which a fiber can accept light. It refers to the maximum angle at which the light incident on the fiber end is totally internally reflected and is transmitted properly along the fiber. The cone formed by the rotation of this angle along the axis of the fiber is the cone of acceptance of the fiber. The light ray should strike the fiber end within its cone of acceptance; else it is refracted out of the fiber core.

PROCEDURE:

1. Make connections as shown in fig. Connect the power supply cables with proper polarity to FCL-01 kit. While connecting this, ensure that the power supply is OFF.
2. Slightly unscrew the cap of LED SFH756V (660nm). Do not remove the cap from the connector. Once the cap is loosened, insert the fiber into the cap. Now tighten the cap by screwing it back.
3. Keep the jumpers JP1, JP2 & JP4 on FCL-01 as shown in fig.
4. Keep switch S2 in VI position on FCL-01.
5. Switch on the power supply.
6. Insert the other end of the fiber into the numerical aperture measurement jig. Hold the white sheet facing the fiber. Adjust the fiber such that its cut face is perpendicular to the axis of the fiber.
7. Keep the distance of about 10mm between the fiber tip and the screen. Gently tighten the screw and thus fix the fiber in the place.
8. Observe the bright red light spot on the screen by varying intensity pot P3 and bias pot P4.
9. Measure exactly the distance d and also the vertical and horizontal diameters MR and PN as indicated in the fig.
10. Mean radius is calculated using the formula $r = (MR + PN) / 4$.
11. Find the numerical aperture of the fiber using the formula.

TABULATION :

DISTANCE (d)	VERTICAL MR	HORIZONTAL PN	RADIUS $r = MR + PN / 4$

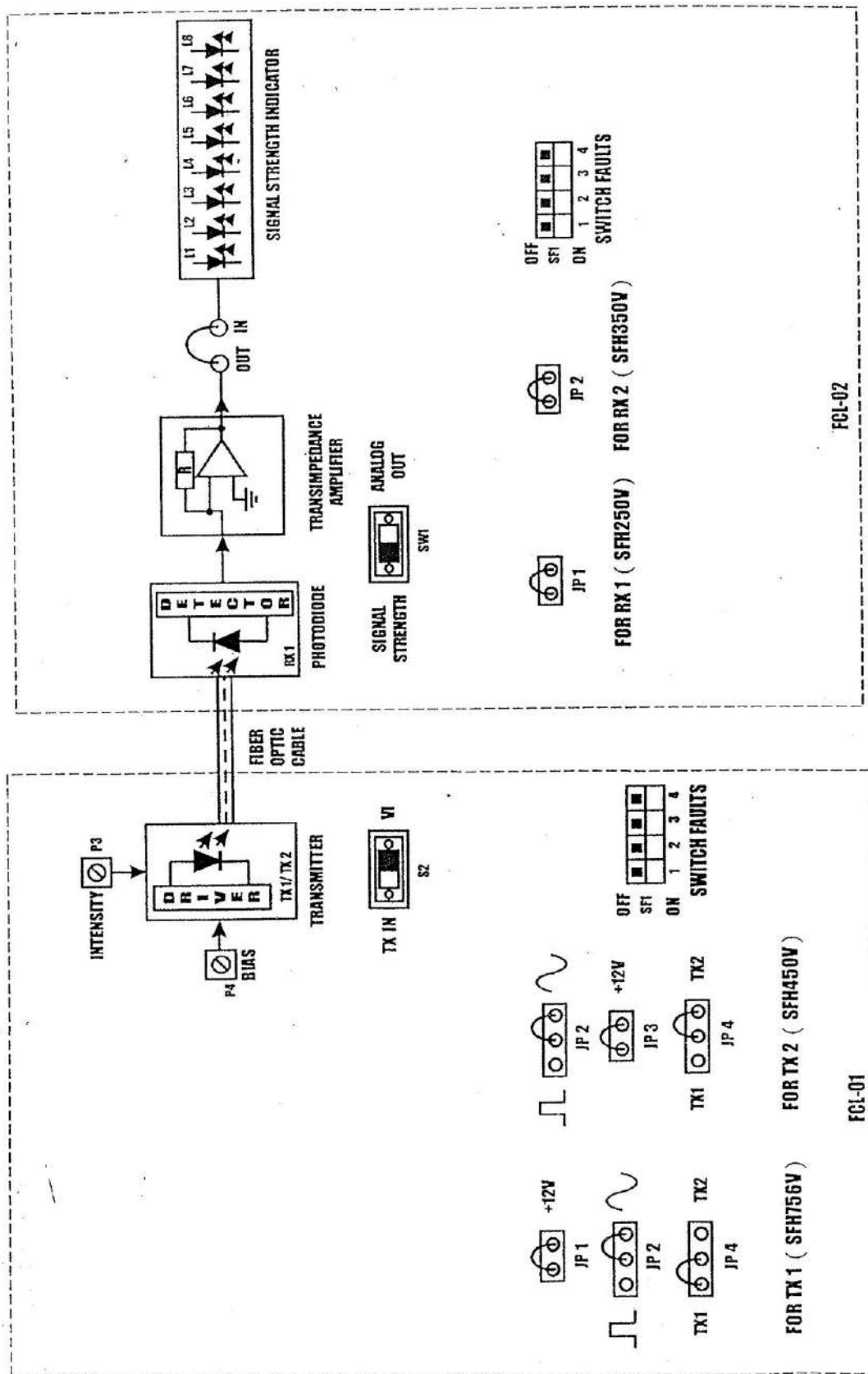
CALCULATION :

$$NA = \sin \theta_{\max} = r / \sqrt{d^2 + r^2}$$

Where $\theta_{\max}$ is the maximum angle at which the light incident is properly transmitted through the fiber.

RESULT:

Thus the numerical aperture of optical fiber is measured.



BLOCK DIAGRAM FOR MEASUREMENT OF FIBER OPTIC LOSSES

EXPT 2 : MEASUREMENT OF ATTENUATION, BENDING AND CONNECTOR LOSSES

AIM :

To measure the attenuation loss, bending loss and connector loss in the optical fiber.

EQUIPMENTS REQUIRED :

Optical Trainer Kit (FCL-01 & 02), 1 , 3 Meter & Connectorized Fiber Cable, Patch Chords, Power Supply, Function Generator and CRO

THEORY :

Optical fibers are available in different variety of materials. These materials are usually selected by taking into account their absorption characteristics for different wavelengths of light. In case of optical fiber, since the signal is transmitted in the form of light, which is completely different in nature as that of electrons, one has to consider the interaction of matter with the radiation to study the losses in fiber. Losses are introduced in fiber due to various reasons. As light propagates from one end of fiber to another end, part of it is absorbed in the material exhibiting absorption loss. Also part of the light is reflected back or in some other direction from the impurity particles present in the material contributing to the loss of the signal at the other end of the fiber. In general terms, it is known as propagation loss. Plastic fibers have higher loss of the order of 180 dB/Km. whenever the condition for angle of incidence of the incident light is violated, the losses are introduced due to refraction of light. This occurs when fiber is subjected to bending. Lower the radius of curvature more is the loss. Other losses are due to the coupling of fiber at LED & photo detector ends.

TABULATION :**ATTENUATION LOSS**

Length of the cable	Input Signal Amplitude (V)	Output Signal Amplitude (V)	Attenuation (dB/m)

CONNECTOR LOSS

P2 (1m fiber)	P1 (Connectorized fibers)	LOSS = P2 – P1

PROCEDURE :

A) MEASUREMENT OF ATTENUATION LOSS

1. Connect the power supply cables with proper polarity to optical transmitter and receiver kit while connecting this ensure that power supply is off.
2. Switch on the power supply feed about 2 vpp sinusoidal signal of 1 KHZ from the function generate to analog in of the optical transmitter kit.
3. Insert 1m fibre cable into cap of SFH 756 v (660 nm). Connect the other end of fibre to detector SFH 250 v (photo transistor detector)
4. Observe the detector signal at the port and out on oscilloscope.
5. Measure the peak value of received signal at analog out terminal let this value be v2
6. Now replace 1m by 3m fibre between same LED and detector.
7. Do not disturb any settings again take part peak voltage and let it be v
8. If α is the alternative of the fibre then.

$$(\text{db/ meter}) = 10/L1 - L2 \text{ LOG } V2/ V1$$

Where L1 – 3m fibre length for v1

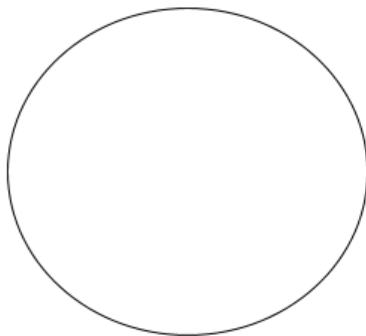
L2 = 1m fibre length for v2.

This is α for peak wavelength of 660 nm.

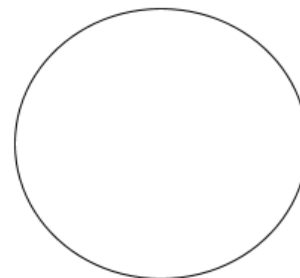
TABULATION :
BENDING LOSS

BENDING (SIZE)	SIGNAL STRENGTH
NO BEND BEND @ 1 BEND @ 2 BEND @ 3 BEND @ 4	

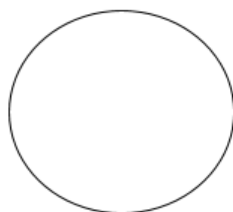
BEND@1



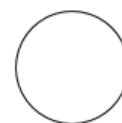
BEND@2



BEND@3



BEND@4



B) MEASUREMENT OF BENDING LOSS

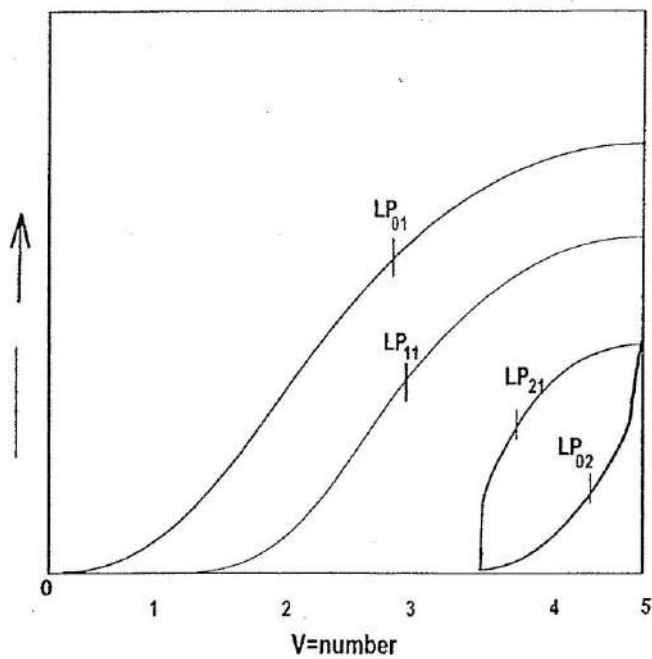
1. Keep the connections with 1 meter fiber as per the above procedure.
2. Adjust the transmitter power so that the SIGNAL STRENGTH reading is 8. Now take the portion of the fiber and loop it to match the bends as shown in fig. As you match each bends write down the reading from signal strength indicator. Don't bend the fiber too tightly or it may not come back to shape.
3. Measure the loss for a number of different bends.

C) MEASUREMENT OF CONNECTOR LOSS

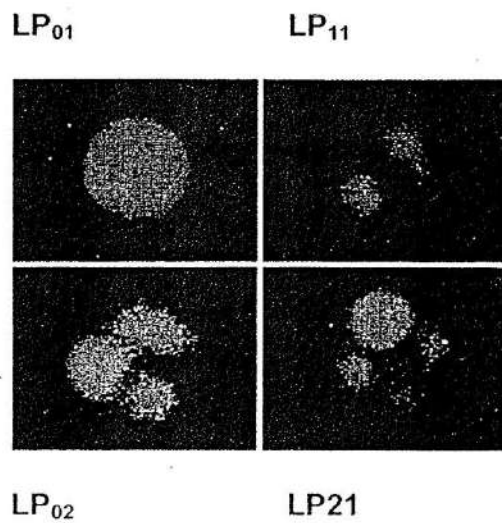
1. Keep the connections with 1 meter fiber as per the above procedure.
2. Adjust the transmitter power so that the SIGNAL STRENGTH reading is 8.
3. Remove the 1 meter fiber and insert 0.5 meter connectorized fibers through connecting sleeve. What reading you get on the signal strength? Now take your loss from this measurement, say 7dB and subtract it from 8dB. Your connector loss is then $8\text{dB} - 7\text{dB} = 1\text{dB}$ this is actual connector loss.

RESULT :

Thus the losses in optical fiber are measured.



LOW ORDER LINEARLY POLARIZE MODES OF AN OPTICAL FIBER



IRRADIANCE PATTERN OF SOME LOW ORDER LINEARLY POLARISED MODE

EXPT 3 : MODE CHARACTERISTICS OF OPTICAL FIBER

AIM :

To study the mode characteristics of fiber optic cable and observe the lower order Linearly Polarized (LP) modes.

EQUIPMENTS REQUIRED :

LASER Source (633 nm – 1mW), Source to Fiber Coupler, Single Mode Fiber, Fiber Holding Stand, Opaque Screen

THEORY :

The central spot carries 95% of the intensity for laser beams with Gaussian profile. $I = I_0 e^{-2(r/w)^2}$ where $e = 2.718$ is the base of the natural logarithm. An accepted definition of a radius of a Gaussian beam is the distance at which the beam intensity has dropped to $1/e^2 = 0.135$ times its peak value I_0 . This radius is called spot size. The spot diameter is w .

Spot Diameter (d) micron = Focal length of the Lens (f) mm x Laser beam full divergence angle (DA) mrad. In order to achieve maximum coupling efficiency, the fiber core diameter has to be bigger than the spot diameter.

NA rays = Laser Beam Diameter (B.D.) = 2 x Lens Focal Length (f)

The source coupler is comprised of two base plates. One of the base plates contains a focusing lens and a female connector receptacle. The other base plate is attached onto the laser. An O-ring is sandwiched between the base plates. Threaded screws interconnect the two base plates. A screw driver to alter the angular orientation of one base plate relative to the other can then adjust the screws.

The number of modes propagating through the fiber depends on V-number. If the fiber whose V-number is less than 2.045, it allows to propagate single mode through it, so it is called as Single Mode fiber. For a Multimode fiber, V-number is slightly greater than

2.045 but the number of allowed modes is small enough so that they may be individually identified when the output of the fiber is examined.

When $V < 2.045$, then only a single mode may propagate in the fiber waveguide.

This mode is HE₁₁ mode or LP₀₁ – Linearly Polarized mode.

When $V > 2.045$, other modes may propagate, when V is slightly greater than 2.045 i.e. $V = 4.91$ then 4 Linearly Polarized modes will propagate through fiber.

PROCEDURE :

1. Keep optical bread board onto original and flat table surface, so that it will not toggle.
2. Fix the pre-fitted cylindrical head of the He-Ne laser source on to the surface of the bread board from the bottom side with the help of Allen screws provided with it. Confirm the rigidity of the mount.

OBSERVATION & CALCULATION :

Parameter of given fiber are,

$$A = 4.5\mu\text{m (core radius),}$$

$$N.A=0.11, \lambda = 633\text{nm}$$

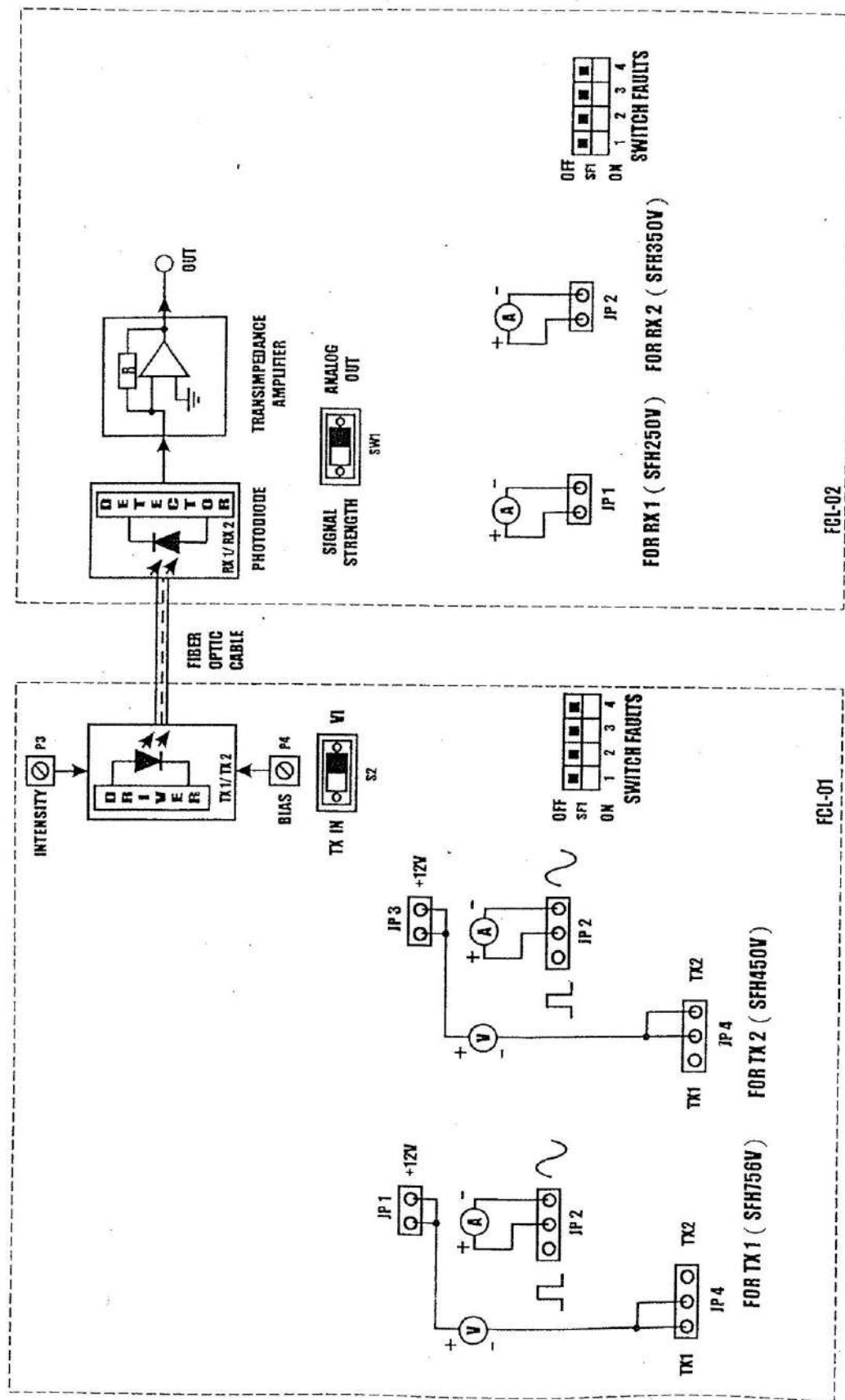
$$V = 2 \pi \times A \times N.A / \lambda$$

$$\text{Total number of modes} = V^2 / 2$$

3. Fix the laser to the fiber coupler mount on to the bread board with base plate orientation of it towards He-Ne laser exit.
4. Turn on the He-Ne laser and locate the beam spot on the central portion of the laser-fiber coupling lens assembly by adjusting the vertical and horizontal travel arrangement provided with the mount. Tighten the screws of the vertical and horizontal slots.
5. Now look for the back reflection of the He-Ne laser spot from the rod lens of the coupler. In case if you found the back spot, away from the exit of the cylindrical laser head of the laser, adjust the back-reflected spot going back in exit hole by slowly moving the four screws provided for the laser mount.
6. Confirm the central alignment of the laser beam at the exit of the laser fiber coupler by putting a white card sheet and zooming the spot on to it. In case the spot is found of center, adjust it to the center by slightly moving the screws of the laser mount.
7. Put the multimode optical patch cord on to the laser fiber coupler exit and fix the other end of the fiber in the fiber holding stand by moving the grub screws provided with the holder.
8. Notice the bright laser beam spot coming out of the fiber. Adjust the height of exit tip of the fiber to about 50mm. Min. from the white sheet of the paper.
9. Observe the bright round shape circular spot with laser speckle pattern on to the screen. Multimode pattern can be refined by screws provided with laser-fiber coupler. Slightly adjusting or moving the screws on the laser mount, view the change in pattern of this multimode spot.
10. After observing the multimode pattern, change multimode fiber optic patch cord with single mode fiber patch cord.
11. For single mode patch cord, the blur pattern of the various single mode patterns will appear on the screen. That is, single circular two lobes, three lobes and four lobes patterns can be very well observed by slightly adjusting the Allen screws of the laser-fiber coupler.

RESULT :

Thus the mode characteristics of fiber optic cable are studied.



BLOCK DIAGRAM FOR CHARACTERISTICS OF FIBER OPTIC LED'S AND DETECTORS

EXPT 4 : DC CHARACTERISTICS OF LED AND PIN PHOTODIODE

AIM :

To determine the characteristics of fiber optic LED and Photodiode.

EQUIPMENTS REQUIRED :

Optical Trainer Kit (FCL-01 & 02), Optical Fiber Cable (1m), Patch chords, Jumper to crocodile wires, Power supply, Volt meter & Ammeter

THEORY :

In optical fiber communication system, electrical signal is first converted into optical signal with the help of E / O conversion device as LED. After this optical signal is transmitted through optical fiber, it is retrieved in its original electrical form with the help of O / E conversion device as photo detector. The most significant features of LEDs, which are used for optical communication include high modulation rate capability, high radiance, high reliability and emission wavelengths restricted to the near infrared spectral regions of low attenuation in fibers.

Photo detectors usually come in variety of forms like photo conductive, photovoltaic, transistor type output and diode type output. Here also characteristics to be taken into account are response time of the detector, which puts the limitation on the operating frequency, wavelength sensitivity and responsivity.

TABULATION :

LED CHARACTERISTICS

Vf (V)	If (mA)	Pi (mW)	Po (μW)

PHOTO DIODE CHARACTERISTICS

Ip (μA)	R (mA)

Vf = Forward voltage of LED, If = Forward current of LED

Pi = V * I (Electrical power), Po = Pi * 1.15% (Optical power of LED)

Vo = Output voltage of Photo diode,

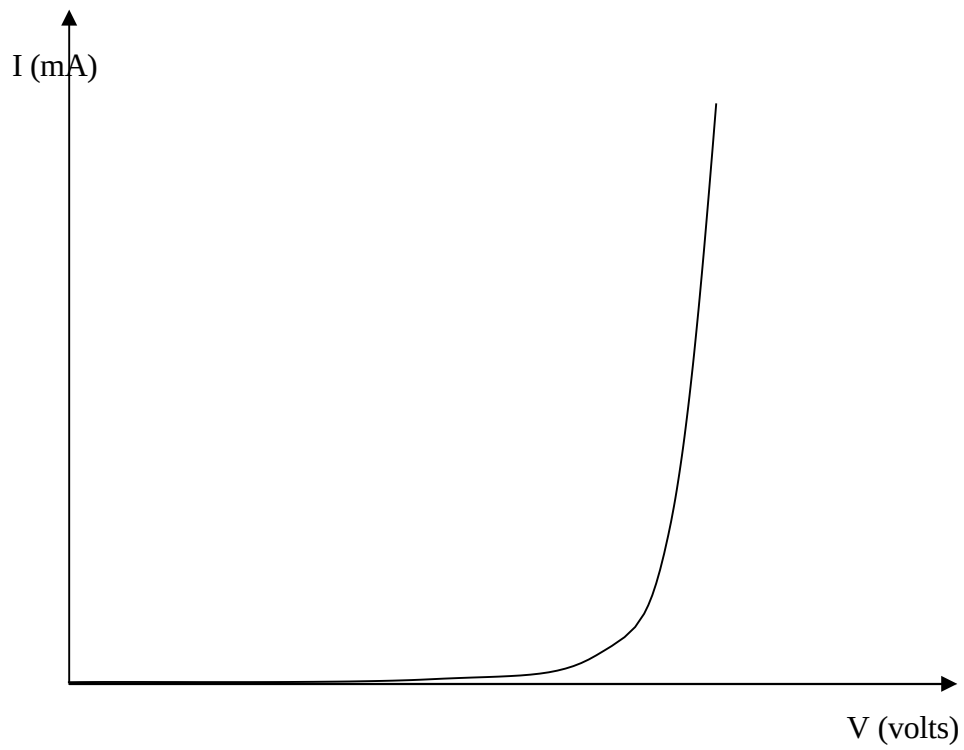
Ip = Output current of Photo diode R = Ip / Po (Responsivity)

PROCEDURE :

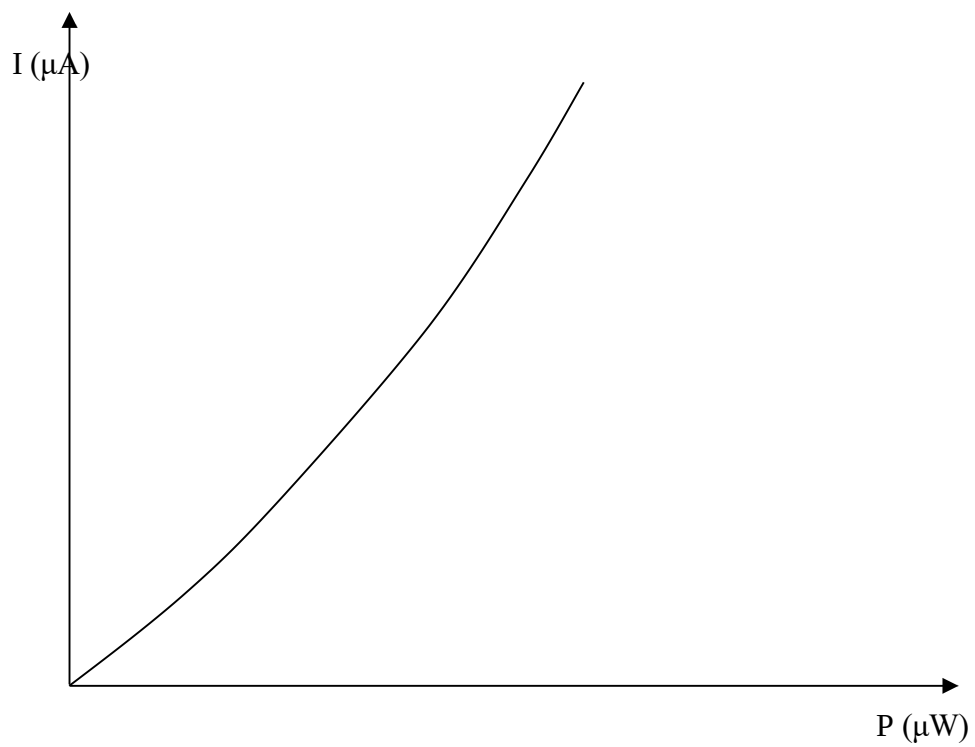
1. Make connections as shown in fig. Connect the power supply with proper polarity to FCL-01 & FCL-02 kits. While connecting this, ensure that the power supply is OFF.
2. Slightly unscrew the cap of LED SHF756V (660nm). Do not remove the cap from the connector. Once the cap is loosened, insert the 1-meter fiber into the cap. Now tighten the cap by screwing it back.
3. Slightly unscrew the cap of Photo Diode SFH250V. Do not remove the cap from the connector. Once the cap is loosened, insert the other end of fiber into the cap. Now tighten the cap by screwing it back.
4. Keep the jumpers JP1, JP2, JP3 & JP4 on FCL-01 as shown in fig.
5. Keep the jumpers JP1 & JP2 on FCL-02 as shown in fig.
6. Keep the switch S2 in VI position on FCL-01.
7. Connect Volt meter and Ammeter as per the polarities.
8. Switch on the power supply.
9. Keep the potentiometer P3 in its maximum position (anti-clockwise). P3 is used to control current flowing through the LED.
10. Keep the potentiometer P4 in its fully clockwise. P4 is used to control bias voltage of the LED.
11. To get the VI characteristics of LED, rotate P3 slowly and measure forward current and corresponding forward voltage. Take number of such readings for various current values and plot VI characteristics graph for the LED.
12. For each reading taken above, find out the power, which is product of V and I. This is the electrical power supplied to the LED.
13. Plot the graph of forward current v/s output optical power of the LED.

MODEL GRAPH :

VI CHARACTERISTICS



PI CHARACTERISTICS



14. Similarly measure the current at the detector.
15. Plot the graph of receiver current v/s output optical power of the LED.
16. Perform the above procedure again for all the combinations of Transmitter and Receiver.
17. Calculate the responsivity of the detector

$$R = I_p / P_o \text{ (A/W)} = \text{Photo current in } \mu\text{A} / \text{Optical power in } \mu\text{W}$$

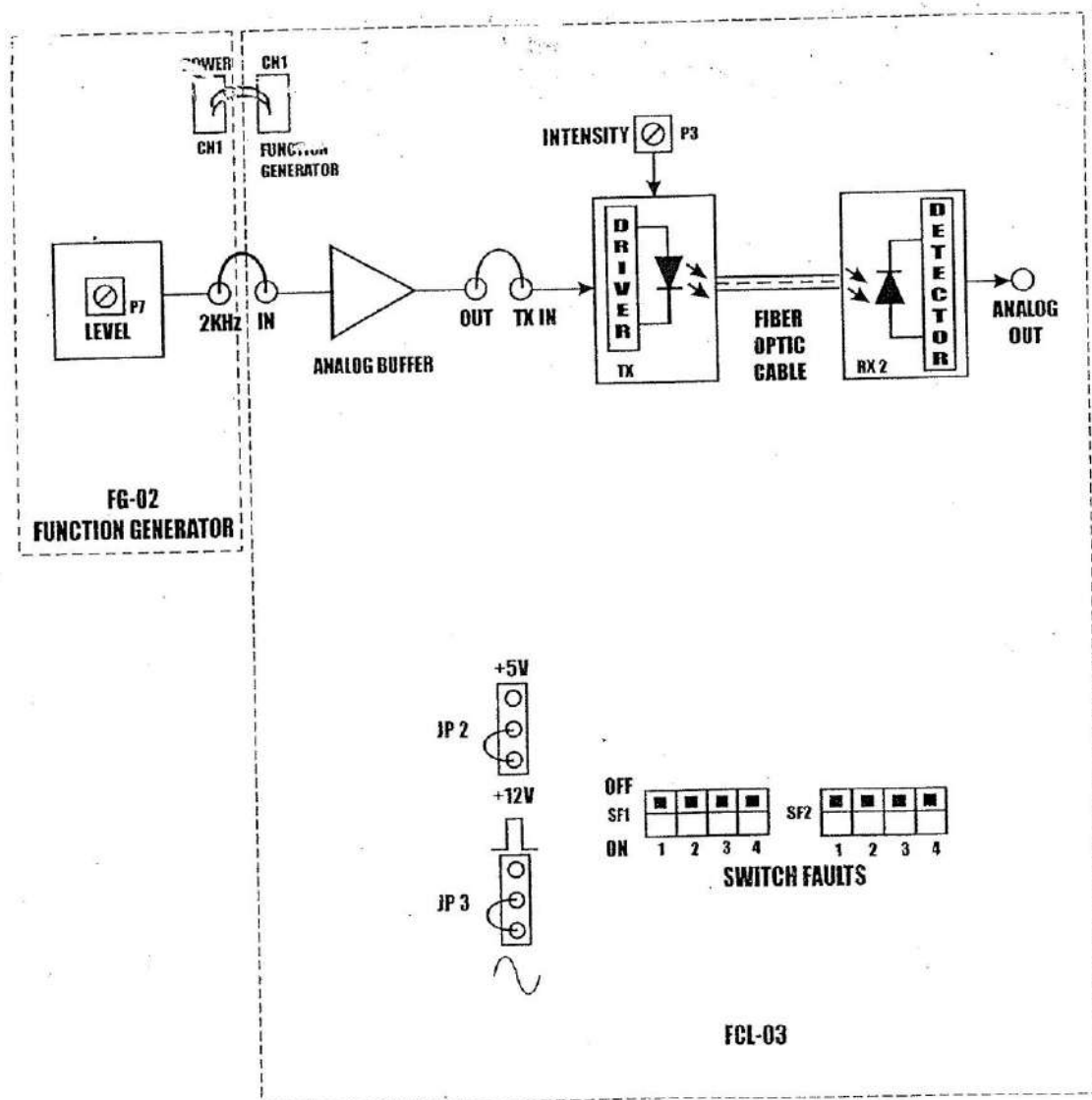
$$\text{Quantum efficiency } (\eta) = (I_p / q) / (P_o / hf)$$

$$q = 1.60218 \times 10^{-19} \text{ C}, \quad h = 6.6356 \times 10^{-34} \text{ J.s},$$

$$f = c / \lambda = (3 \times 10^8 \text{ m/s}) / 850\text{nm} \text{ or } \eta = R \cdot hf / q, R = \text{Responsivity}$$

RESULT :

Thus the characteristics of fiber optic LED and Photodiode are studied.



BLOCK DIAGRAM FOR FIBER OPTIC ANALOG LINK

EXPT 5: SETTING UP A FIBER OPTIC ANALOG & DIGITAL LINK

AIM :

To establish an optical transmission using analog and digital link.

EQUIPMENTS REQUIRED :

Optical Trainer Kit (FCL-03), Function Generator (FG-02), 1 Meter Fiber Cable, Patch Chords, Power Supply, CRO

THEORY :

Fiber optic links can be used for transmission of digital as well as analog signals. Basically, a fiber optic link contains three main elements, a transmitter, an optical fiber and a receiver. The transmitter module takes the input signal in electrical form and then transforms it into optical (light) energy containing the same information. The optical fiber is the medium, which carries this energy to the receiver. At the receiver, light is converted back into electrical form with the same pattern as originally fed to the transmitter.

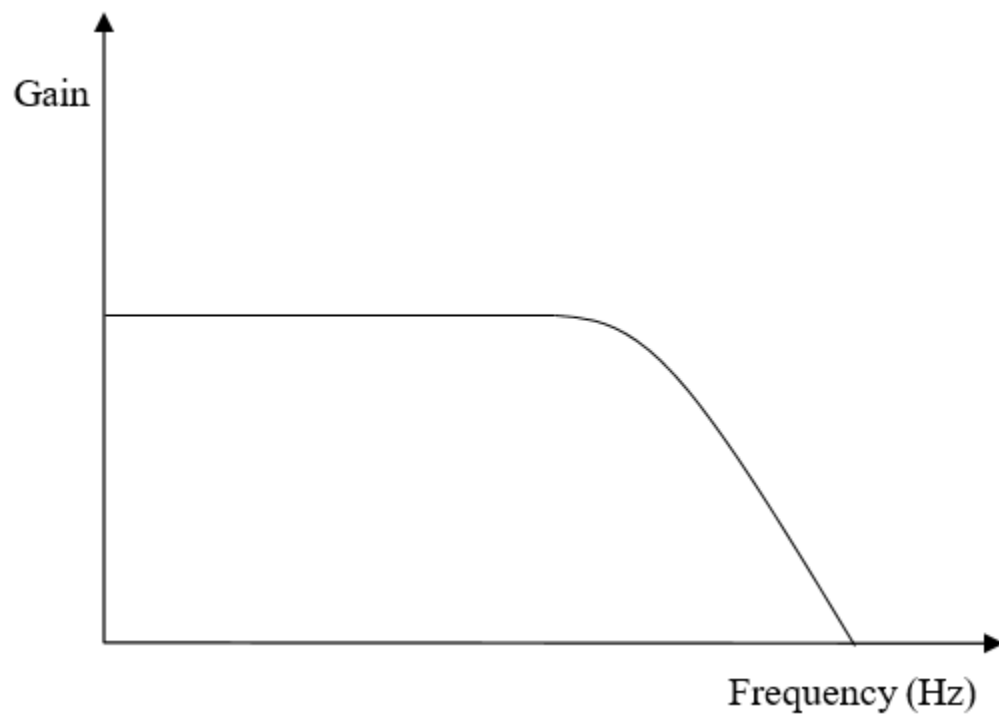
PROCEDURE :

ANALOG LINK

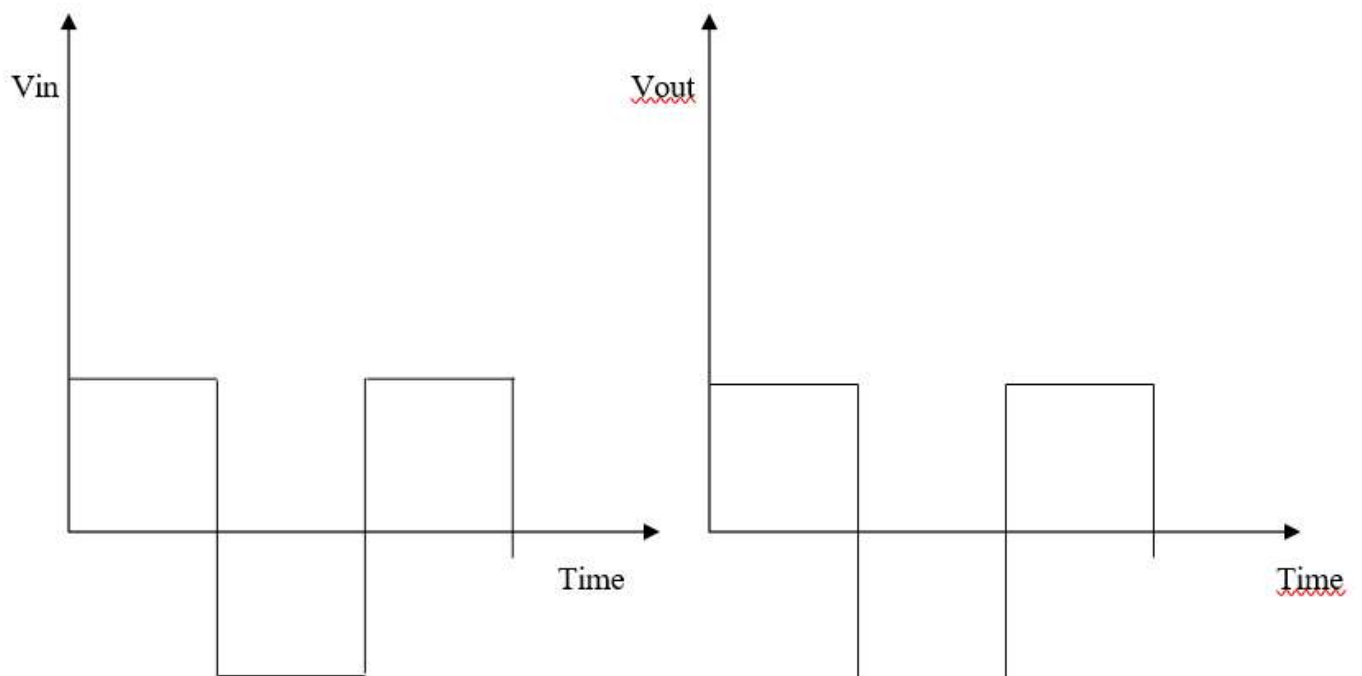
1. Make the connection as shown in fig. Connect the power supply cables with proper polarity to FCL-03 kit. While connecting this, ensure that the power supply is OFF.
2. Connect function generator FG-02 to FCL-03 using power cable.

MODEL GRAPH :

ANALOG LINK :



DIGITAL LINK :



3. Switch on the power supply.
4. Keep the jumpers JP2 & JP3 on FCL-03 as shown in fig.
5. Connect the 2 KHz, 2Vpp signal from FG-02 as a constant signal to the IN post of Analog Buffer on FCL-03.
6. Connect the output of Analog Buffer post OUT to post TX IN.
7. Slightly unscrew the cap of LED SFH756V (660nm). Do not remove the cap from the connector. Once the cap is loosened, insert the fiber into the cap. Now tighten the cap by screwing it back.
8. Now rotate the optical power control pot P3 in FCL-03 in anticlockwise direction. This ensures minimum current flow through LED.
9. Slightly unscrew the cap of RX2 Photo Diode SFH250V. Do not remove the cap from the connector. Once the cap is loosened, insert the other end of fiber into the cap. Now tighten the cap by screwing it back.
10. Observe the output signal from the detector at ANALOG OUT post on Oscilloscope by adjusting optical power control pot P3 in clockwise direction and you should get the reproduction of the original transmitted signal.
11. To measure the analog bandwidth of the link, keep the same connections and vary the frequency of the input signal from 100Hz onwards. Measure the amplitude of the received signal for each frequency reading.
12. Plot a graph of Gain/Frequency. Measure the frequency range for which the response is flat.

TABULATION :

INPUT VOLTAGE

FREQUENCY (KHz)	OUTPUT VOLTAGE (V)	GAIN (V_o/V_i)

DIGITAL LINK

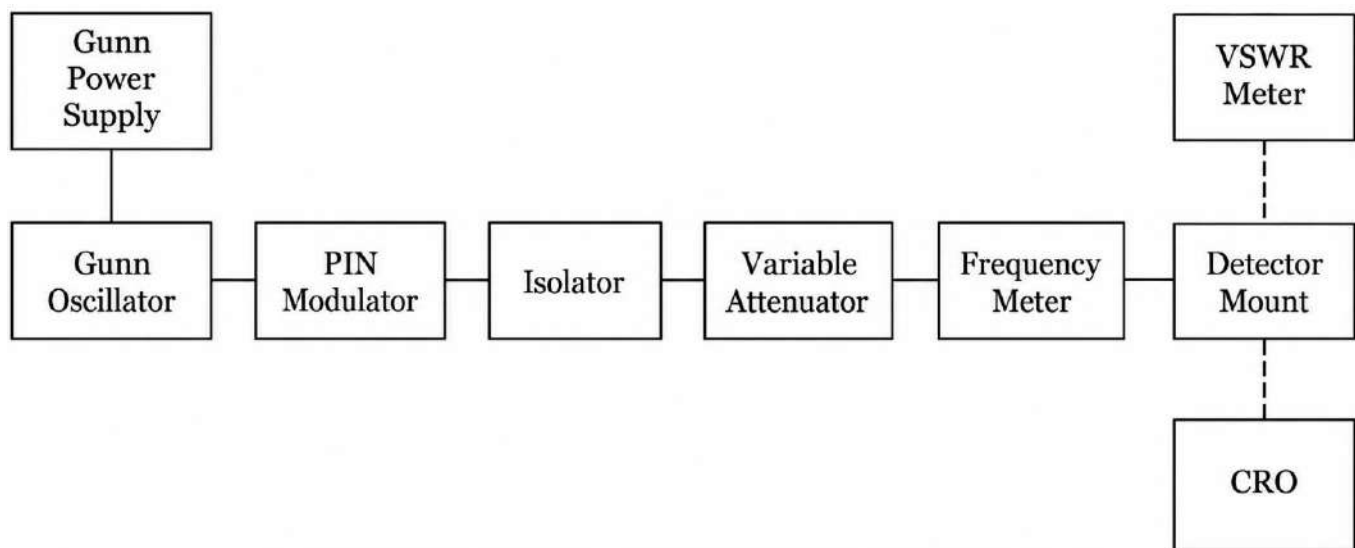
1. Switch on the power supply.
2. Keep the jumpers JP2 & JP3 on FCL-03 as shown in fig.
3. Connect the TTL signal from FG-02 as a constant signal to the IN post of Digital Buffer on FCL – 03.
4. Connect the output of Digital Buffer post OUT to post TX IN.
5. Slightly unscrew the cap of LED SFH756V (660nm). Do not remove the cap from the connector. Once the cap is loosened, insert the fiber into the cap. Now tighten the cap by screwing it back.
6. Slightly unscrew the cap of RX1 Photo Transistor with TTL logic output SFH551V. Do not remove the cap from the connector. Once the cap is loosened, insert the other end of fiber in to the cap. Now tighten the cap by screwing it back.
7. Observe the output signal from the detector at TTL OUT post on Oscilloscope you should get the reproduction of the original transmitted signal.
8. To measure the digital bandwidth of the link, keep the same connections and vary the frequency of the input signal from 100Hz onwards. Observe the variation in duty cycle of the received signal for each frequency reading and determine the maximum bit rate that can be transmitted on the digital link.

TABULATION :

FREQUENCY (Hz)	INPUT		OUTPUT	
	T _{ON}	T _{OFF}	T _{ON}	T _{OFF}

RESULT :

Thus the fiber optic analog and digital links are established.



VOICE COMMUNICATION BY USING MICROWAVE TEST BENCH

AIM :

To study the voice communication by using Microwave test bench

EQUIPMENTS REQUIRED :

Gunn Power Supply, Gunn Oscillator, PIN Modulator, Isolator, Variable Attenuator, Frequency Meter, Detector Mount, Waveguide Stands, VSWR Meter, CRO, Mic, Headphone, Cables and Accessories.

PROCEDURE:

1. Setup the common structure of the test bench.
2. Connect the mic in audio input of Gunn power supply socket (KPS – front panel, GPS – rear panel)
3. Select audio mode from GPS mode select switch.
4. Connect the detector output to SWR meter.
5. Select audio mode from SWR mode select switch.
6. Connect a headphone in audio output socket in SWR meter.
7. Select Headphone / Output switch at Headphone position from rear panel in SWR meter.
8. Tune the controls for maximum speaker output from headphone.
9. Now you can observe the audio signal strength is changing by variable attenuator or DIP produced by moving frequency meter etc.

RESULT :

Thus the voice communications by using Microwave are studied.

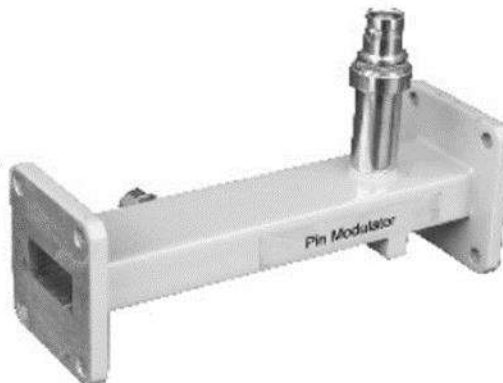
IDENTIFICATION OF MICROWAVE COMPONENTS



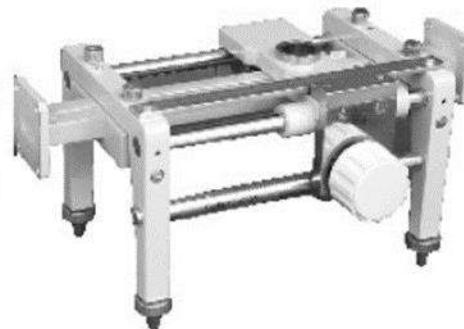
Gunn Oscillator (10 MW) - NV201



Isolator - NV204



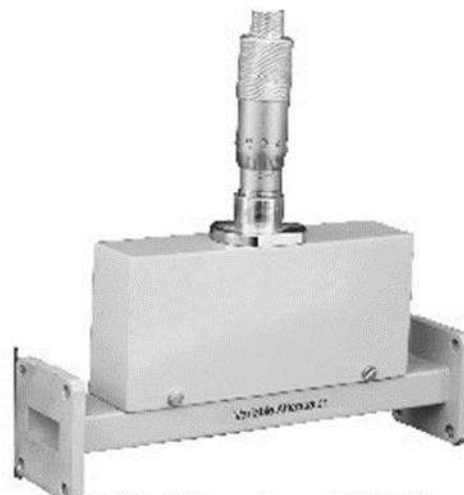
PIN Modulator - NV202



Slotted Section - NV207



Frequency Meter - NV205



Variable Attenuator - NV206



Detector Mount – NV209



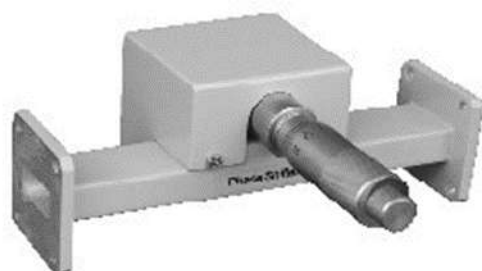
Tunable Probe – NV208



Klystron Mount – NV203



Coaxial Adapter – NV225



Phase Shifter – NV238



C. D. Coupler 20dB – NV229



E Plane Bend – NV232



E Plane Tee – NV221



Fixed Attenuator – NV217



Matched Termination – NV212



Magic Tee – NV223



T-Circulator – NV230



Multi hole Directional Coupler (10dB) – NV228



SS Tuner – NV220



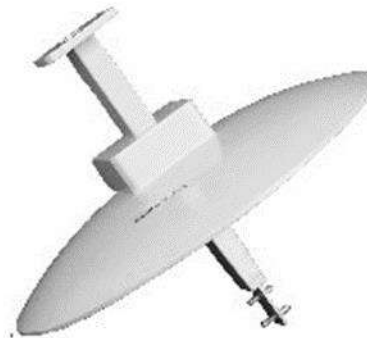
Precision movable short – NV235



Slotted Antenna Broad Wall – NV241



Slotted Antenna Narrow Wall – NV242



Parabolic Antenna – NV247



Waveguide Cavity – NV234



Waveguide Twist – NV216



Dielectric Antenna – NV243



H Plane Sectorial Horn – NV245



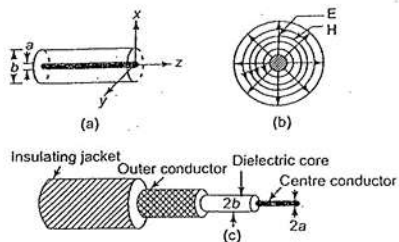
**Pickup Horn –
NV240**



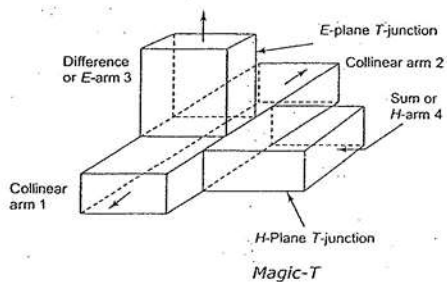
**Pyramidal Horn –
NV246**



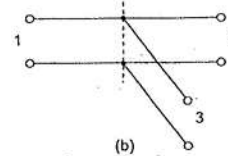
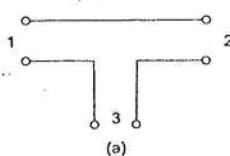
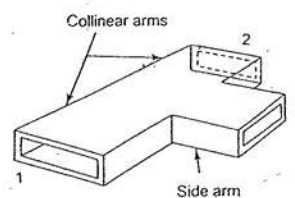
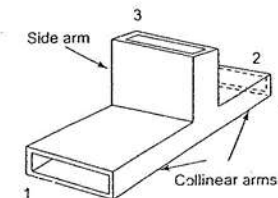
**Standard Gain Horn –
NV239**



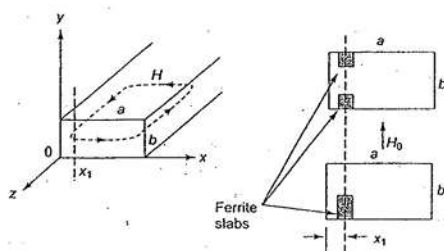
Coaxial lines and TEM wave fields



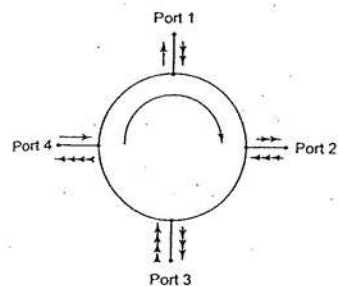
Magic-T



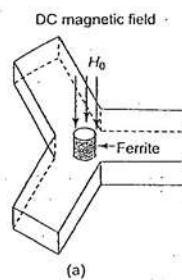
Waveguide tees (a) E-Tee or Series-T (b) H-Tee or Shunt-T



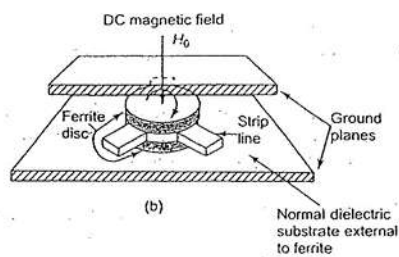
Waveguide isolator



Schematic diagram of a four-port circulator

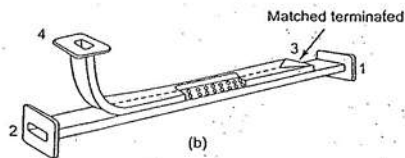
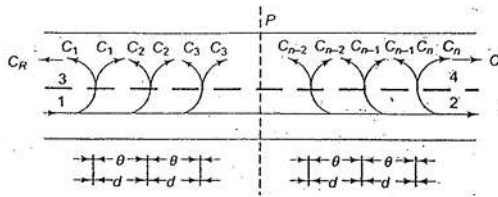
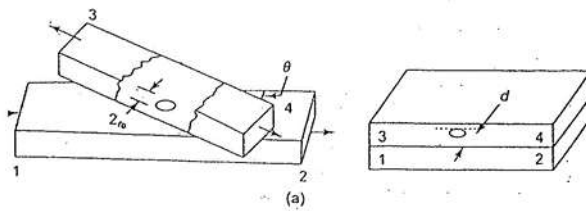


(a)

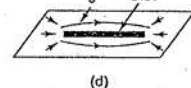
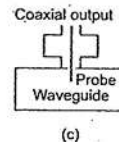
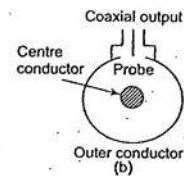
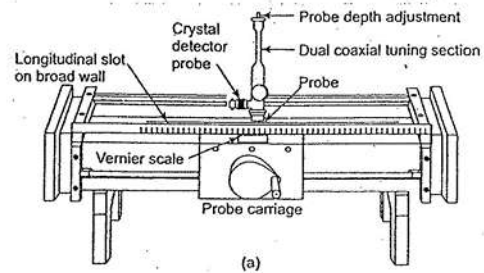


(b)

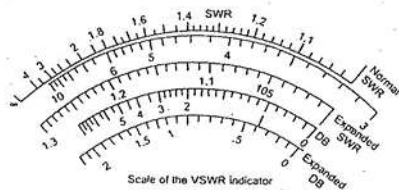
Three-port circulator: (a) waveguide type (b) stripline type



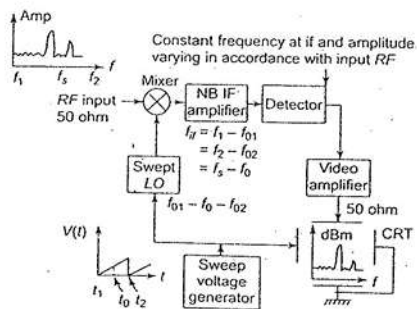
Waveguide directional couplers: (a) Bethe-hole coupler
(b) Multihole coupler



(a) Slotted line carriage and schematic diagram
(b) Cross-section of a coaxial slotted line
(c) Cross-section of rectangular waveguide slotted
(d) Longitudinal slot and electric wall currents



VSWR meter (Courtesy: Hewlett Packard)



Basic block diagram of a spectrum analyser

