LABORATORY MANUAL

FOR

SEVENTH SEMESTER B.TECH -KTU

COMMUNICATION SYSTEMS LAB (OPTICAL & MICROWAVE)

(EC431)

DEPARTMENT OF ELECTRONICS AND COMMUNICATION

ILAHIA COLLEGE OF ENGINEERING AND TECHNOLOGY

MULAVOOR P. O, MUVATTUPUZHA

(AFFILIATED TO KTU)

VISION

To nurture the talents of electronics and communication engineers, making them highly competent for growth of the society.

MISSION

- To deliver excellence in teaching - learning process.
- Promote safe, orderly, caring and supportive environment to learners.
- Development of skilled engineers to perform innovative Research for betterment of the society.
- To encourage industry - institute interaction, career advancement, innovation and entrepreneurship development.

PROGRAM EDUCATIONAL OUTCOME (PEO)

PEO1: To acquire a strong foundation in mathematics and scientific fundamentals, to develop an ability to analyze various functional elements of different disciplines of electronics and communication engineering.

PEO2: Develop technical competence to move in pace with rapid changes in technology.

PEO3: Equip learners to strengthen knowledge and soft skills for carrier advancement.

PEO4: Adhere to ethics to contribute for betterment of the society.

PROGRAM SPECIFIC OUTCOMES (PSO)

PSO1. To understand principles and applications of various electronic components/devices and circuits.

PSO2. Enable learners to solve complex problems using modern hardware and software tools.

SYLLABUS

COURSE CODE	COURSE NAME	L-T-P-C	YEAR OF INTRODUCTION
EC431	COMMUNICATION SYSTEMS LAB (OPTICAL & MICROWAVE)	0-0-3-1	2016

Prerequisite: EC403 Microwave & Radar Engineering, EC405 Optical Communication

Course objectives:

- To provide practical experience in design, testing, and analysis of few electronic devices and circuits used for microwave and optical communication engineering.

List of Experiments

Microwave Experiments: (Minimum Six experiments are mandatory)

1. GUNN diode characteristics.
2. Reflex Klystron Mode Characteristics.
3. VSWR and Frequency measurement.
4. Verify the relation between Guide wave length, free space wave length and cut off wave length for rectangular wave guide.
5. Measurement of E-plane and H-plane characteristics.
6. Directional Coupler Characteristics.
7. Unknown load impedance measurement using smith chart and verification using transmission line equation.
8. Measurement of dielectric constant for given solid dielectric cell.
9. Antenna Pattern Measurement.
10. Study of Vector Network Analyser

Optical Experiments: (Minimum Six Experiments are mandatory)

1. Measurement of Numerical Aperture of a fiber, after preparing the fiber ends.
2. Study of losses in Optical fiber
3. Setting up of Fiber optic Digital link.
4. Preparation of a Splice joint and measurement of the splice loss.
5. Power vs Current (P-I) characteristics and measure slope efficiency of Laser Diode.
6. Voltage vs Current (V-I) characteristics of Laser Diode.
7. Power vs Current (P-I) characteristics and measure slope efficiency of LED.
8. Voltage vs Current (V-I) characteristics of LED.
9. Characteristics of Photodiode and measure the responsivity.
10. Characteristics of Avalanche Photo Diode (APD) and measure the responsivity.
11. Measurement of fiber characteristics, fiber damage and splice loss/connector loss by OTDR.

COURSE OUTCOMES

The student will be able to

C407. 1	Students will understand Radiation Pattern Measurements of horn antenna.
C407. 2	Students will be able to understand the Reflex Klystron and Gunn Diode Characteristics.
C407. 3	Students will be able to measure the frequency, wavelength, VSWR and reflection coefficient of a microwave signal.
C407. 4	Students will able to understand dc characteristics of optical sources and measurements of optical fiber parameters and losses.

MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES

PO **CO**	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO10**	**PO11**	**PO12**	**PSO 1**	**PSO 2**
C407. 1	**3**	**-**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**2**	**-**
C407. 2	**3**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**2**	**-**
C407. 3	**3**	**-**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**2**	**-**
C407. 4	**3**	**-**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**2**	**-**
C407	**3**	**-**	**0.75**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**2**	**-**

LIST OF EXPERIMENTS

MICROWAVE EXPERIMENTS:

1. Verify the relation between Guide wave length, free space wave length and cut off wave length for rectangular wave guide.
2. VSWR and Frequency measurement.
3. Reflex Klystron Mode Characteristics.
4. GUNN diode characteristics.
5. Directional Coupler Characteristics.
6. Antenna Pattern Measurement.

OPTICAL EXPERIMENTS:

7. Measurement of Numerical Aperture of a fiber, after preparing the fiber ends.
8. Study of losses in Optical fiber.
9. Power vs Current (P-I) characteristics and measure slope efficiency of Laser Diode.
10. Voltage vs Current (V-I) characteristics of Laser Diode.
11. Voltage vs Current (V-I) characteristics of LED.
12. Power vs Current (P-I) characteristics and measure slope efficiency of LED.

INDUX

CYCLE: 01

MICROWAVE EXPERIMENTS

EXPT.NO:1 **DATE:**

FAMILIARISATION OF MICROWAVE COMPONENTS

AIM:

To familiarize various microwave components that are used in communication lab.

THEORY:

A microwave bench is an experimental setup consist of various microwave instruments such as waveguides, waveguide Tee, frequency meter, variable attenuator, horn antenna, power supply for the microwave source, VSWR meter etc. Brief details of instruments are given below:

WAVEGUIDES

A hollow metallic tube of uniform cross-section for transmitting electromagnetic waves by successive reflections from the inner walls of the tube is called as a Waveguide.

RECTANGULAR WAVE GUIDE

Wave guides are manufactured to the highest mechanical and electrical standards and mechanical tolerances. L and S band wave guides are fabricated by precision brazing of brass-plates and all other wave guides are in extrusion quality. W.G. sections of specified length can be supplied with flanges, painted outside and silver or gold plated in side.

SPECIFICATIONS X Band

EIA No. : WR - 90

Frequency: 8.2 - 12.4 GHZ

Width: 2.286cm

Height : 1.1016cm

Width: 2.54 cm

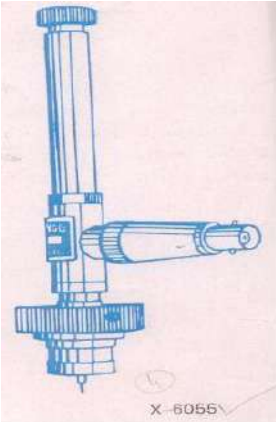
Height: 1.27cm ± Tol. (μm) : 7.6

Material: Brass/Copper.

TUNABLE PROBE

Model 6055 Tunable probe is designed for use with model 6051 slotted sections. These are meant for exploring the energy of the EF in a suitably fabricated section of wave guide. The depth of penetration into a wave guide - section is adjustable by the knob of the probe. The tip pick up the RF power from the line and this power is rectified by crystal detector, which is then fed to the VSWR meter or indicating instrument.

Model No. : X6055 /Freq (GHz): 8.2 - 12.4 /output Connector: BNC (F) /Detector: IN23.



WAVE GUIDE DETECTOR MOUNT (TUNABLE)

Model 4051 Tunable Detector Mount is simple and easy to use instrument for detecting microwave power thr' a suitable detector. It consists of a detector crystal mounted in a section of a Wave guide and shorting plunger for matching purpose. The output from the crystal may be fed to an indicating instrument. In K and R bands detector mounts the plunger is driven by a micrometer.

Model No. : X - 4051

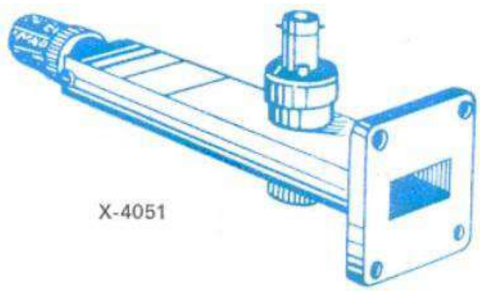
Freq. Range (GHz) : 8.2 - 12.4 O/P

Connector : BNC (F) Wave guide

type (WR-) : 90

Flange Type (UG/U): 39

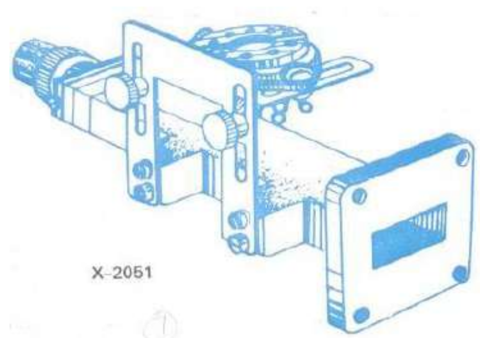
Detectors: IN23



KLYSTRON MOUNT

Model 2051 Klystron mounts are meant for mounting corresponding Klystrons such as 2K25, 723A/B, 726A or RK - 5976 etc. These consists of a section of wave guide flanged on one end and terminated with a movable short on the other end. An octal base with cable is provided for Klystron.

Model No. : X – 2051/ Freq. Range (GHz) 8.2 - 12.4/ WG Type (WR-) : 90 Flange Type (UG-/U): 39



CIRCULATORS

Model 6021 and 6022 are T and Y types of three port circulators respectively. These are precisely machined and assembled to get the desired specifications. Circulators are matched three port devices and these are meant for allowing Microwave energy to flow in clockwise direction with negligible loss but almost no transmission in the anti-clockwise direction.

Model No. : X - 6021

Frequency Range (GHz) : 8.6 - 10.6 or 10.2 - 12.2

Min. Isolation (dB): 20 Max. Insertion Loss (dB): 0.4 Max.

VSWR : 1.20

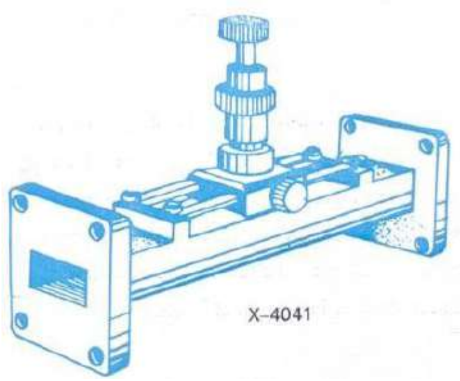
X-6021

X-6022

SLIDE SCREW TUNERS

Model 4041 slide screw tuners are used for matching purposes by changing the penetration and position of a screw in the slot provided in the centre of the wave guide. This consists of a section of wave guide flanged on both ends and a thin slot is provided in the broad wall of the Wave guide. A carriage carrying the screw is provided over the slot. A VSWR up to 20 can be tuned to a value less than 1.02 at certain frequency.

Model No. : X – 4041/ Freq. Range (GHz): 8.2 - 12.4/WG Type (WR-): 90 Flange type (UG/U) : 39



X-4041

MULTIHOLE DIRECTIONAL COUPLERS

Model 6000 series Multihole directional couplers are useful for sampling a part of Microwave energy for monitoring purposes and for measuring reflections and impedance. This consists of a section of Wave guide with addition of a second parallel section of wave guide thus making it a four port network. However the fourth port is terminated with a matched load. These two parallel sections are coupled to each other through many holes, almost to give uniform coupling; minimum frequency sensitivity and high directivity. These are available in 3, 6, 10, 20 and 40dB coupling.

Model No. : X - 6003

Frequency Range (GHz): 8.2 - 12.4

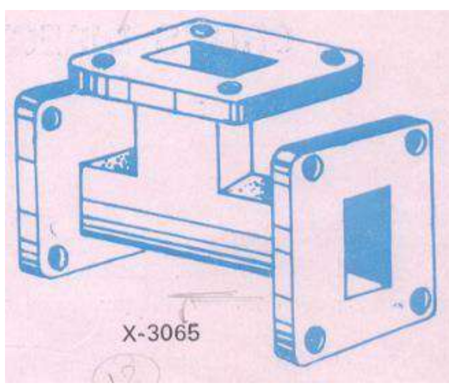
Coupling (dB) : 3,10,20,40 Directivity (dB)

: 35

Wave guide type (WR-): 90 Flange type (UG/U) : 39

E PLANE TEE

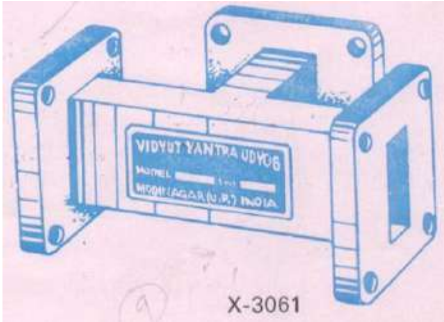
Model 3061 E - plane tee are series type T - junction and consists of three section of wave guide joined together in order to divide or compare power levels. The signal entering the first port of this T - junction will be equally dividing at second and third ports of the same magnitude but in opp. phase Model No. : X - 3061 Frequency Range (Ghz) : 8.2 - 12.4 WG Type (WR-) : 90 Flange Type (UG/U) : 39



H - PLANT TEE

Model 3065 H - Plane Tee are shunt type T - junction for use in conjunction with VSWR meters, frequency - meters and other detector devices. Like in E-plane tee, the signal fed through first port of H - plane Tee will be equally divided in magnitude at second and third ports but in same phase.

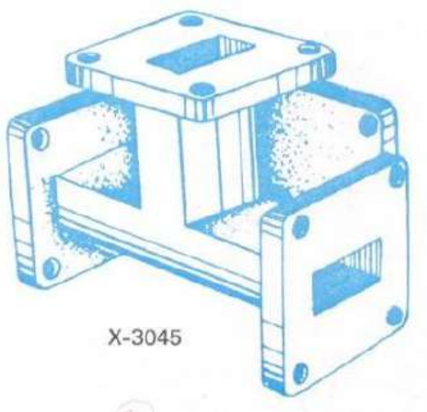
Model No. : X - 3065 Frequency Range (GHz) : 8.2 - 12.4 WG Type (WR-) : 90 Flange Type (UG-/U) : 39



MAGIC TEE

Model 3045 E - H Tee consists of a section of wave guide in both series and shunt wave guide arms, mounted at the exact midpoint of main arm. Both ends of the section of wave guide and both arms are flanged on their ends. These Tees are employed in balanced mixers, AFC circuits and impedance measurement circuits etc. This becomes a four terminal device where one terminal is isolated from the input terminal.

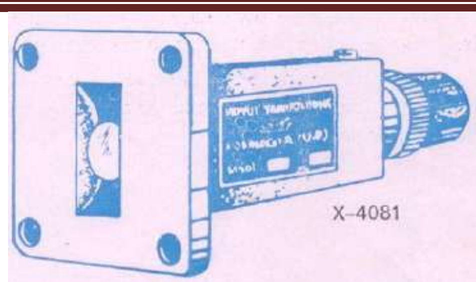
Model No. : X - 3045 Frequency Range (Ghz) : 8.2 - 12.4 WG Type (WR-) : 90 Flange Type (UR-/U) : 39



MOVABLE SHORT

Model 4081 movable shorts consists of a section of waveguide, flanged on one end and terminated with a movable shorting plunger on the other end. By means of this noncontacting type plunger, a reflection co-efficient of almost unity may be obtained.

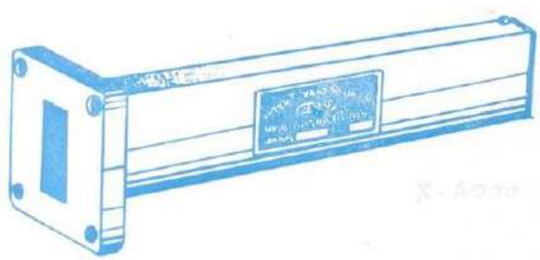
Model No. : X - 4081 Frequency Range (GHz) : 8.2 - 12.4 WG Type (WR-) : 90 Flange Type (UG-/U) : 39



MATCHED TERMINATION

Model 4000 are low power and non-reflective type of terminations. It consists of a small and highly dissapative taper flap mounted inside the centre of a section of wave guide. Matched Terminations are useful for USWR measurement of various waveguide components. These are also employed as dummy and as a precise reference loads with Tee junctions, directional couplers and other similar dividing devices.

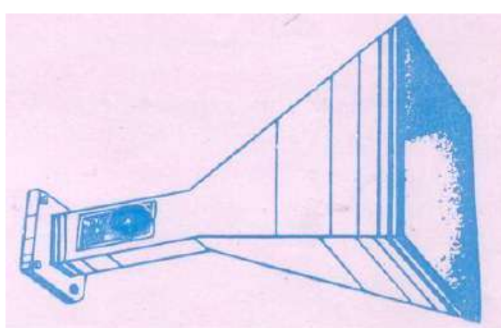
Model No. : X - 4000, Freq. Range (GHz) : 8.2 - 12.4 Max VSWR : 1.04 AV Power : 2W, WG Type (WR-) 90, Flange Type (UG-/U) : 39



PYRAMIDAL WAVEGUIDE HORN ANTENNA

Model 5041 pyramidal Wave guide Horn antenna consists of waveguide joined to pyramidal section fabricated from brass sheet. The pyramidal section shapes the energy to concentrate in a specified beam. Wave guide horns are used as feed horns as radiators for reflectors and lenses and as a pickup antenna for receiving microwave power.

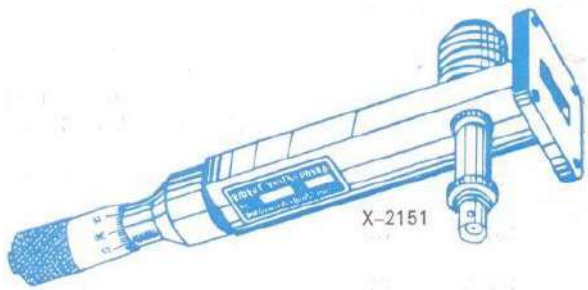
Model No. : X - 5041 Frequency Range (Ghz) : 8.2 - 12.4 Max VSWR : 1.20 WG Type (WR-) : 90
Flange Type (UG-/U) : 39



GUNN OSCILLATORS

Model 2151 Gunn Oscillators are solid state microwave energy generators. These consists of waveguide cavity flanged on one end and micrometer driven plunger fitted on the other end. A gunn-diode is mounted inside the Wave guide with BNC (F) connector for DC bias. Each Gunn oscillator is supplied with calibration certificate giving frequency VS micrometer reading.

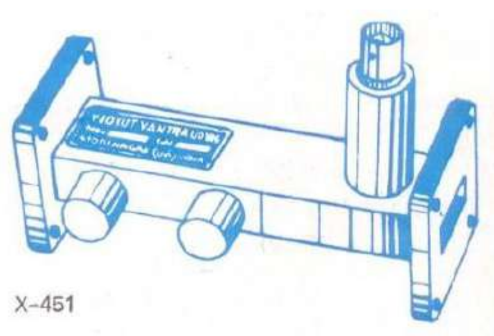
Model No. : X - 2152, Freq : 8.2 - 12.4 GHz, Min output power : 10 MW WG Type (WR-) : 90 Flange Type (UG-/U) : 39



PIN MODULATORS

Model 451 pin modulators are designed to modulate the cw output of Gunn Oscillators. It is operated by the square pulses derived from the UHF (F) connector of the Gunn power supply. This consists of a pin diode mounted inside a section of Wave guide flanged on its both end. A fixed attenuation vane is mounted inside at the input to protect the oscillator.

Model No. : X - 451 Frequency Range (GHz) : 8.3 - 12.4 Max RF Power : 1W WG Type (WR-) : 90 Flange Type (GHz) : 39



GUNN POWER SUPPLY

Model X-110 Gunn Power supply comprises of a regulated DC power supply and a square wave generator, designed to operate Gunn-Oscillator model 2151 or 2152, and pin modulators model 451 respectively. The DC voltage is variable from 0 - 10V. The front panel meter monitors the gunn voltage and the current drawn by the Gunn diode. The square wave of generator is variable from 0 - 10V in amplitude and 900 - 1100 Hz in frequency. The power supply has been so designed to protect Gunn diode from reverse voltage application over transient and low frequency oscillations by the negative resistance of the Gunn-diode.

SPECIFICATIONS

Amplifier Type: High gain tuned at one frequency

Frequency: 1000 Hz ± 2%

Sensitivity: 0.1 microvolt at 200 for full scale

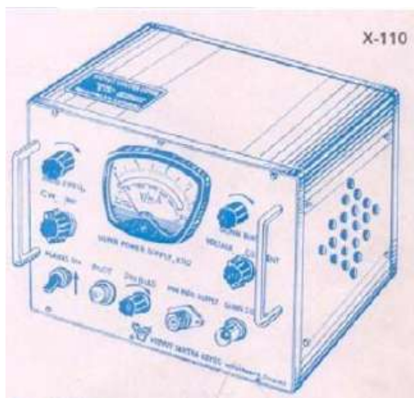
Band width: 25 - 30 cps

Range: 70dB min in 10 dB steps Scale

selector : Normal Expand Gain control :

'Coarse' & 'Fine' Mains power : 230V,

50Hz



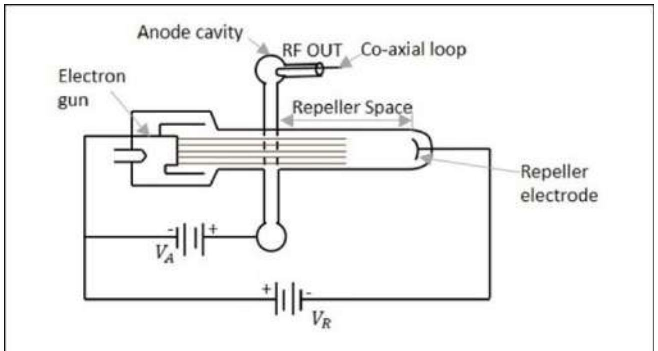
ISOLATORS

The three port circulators Model 6021 may be converted into isolators by terminating one of its port into matched load. These will work over the frequency range of circulators. These are well matched devices offering low forward insertion loss and high reverse isolation. Model No. : X - 6022 Frequency Range (GHz) : 8.6 -
or 10.2 - 12.2 Min Isolation (dB) : 20 Max Insertion Loss (dB) : 0.4 Max VSWR : 1.20

REFLEX KLYSTRON

This microwave generator is a Klystron that works on reflections and oscillations in a single cavity, which has a variable frequency. Reflex Klystron consists of an electron gun, a cathode filament, an anode cavity, and an electrode at the cathode potential. It provides low power and has low efficiency.

The electron gun emits the electron beam, which passes through the gap in the anode cavity. These electrons travel towards the Repeller electrode, which is at high negative potential. Due to the high negative field, the electrons repel back to the anode cavity. In their return journey, the electrons give more energy to the gap and these oscillations are sustained. The constructional details of this reflex klystron are as shown in the following figure. It is assumed that oscillations already exist in the tube and they are sustained by its operation. The electrons while passing through the anode cavity, gain some velocity.



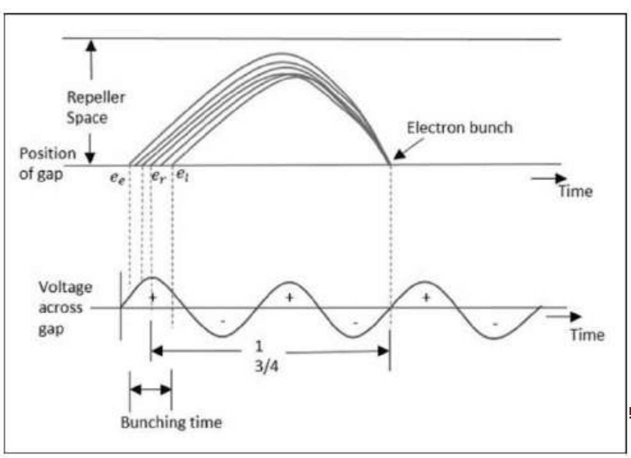
Constructional details of Reflex Klystron

The operation of Reflex Klystron is understood by some assumptions. The electron beam is accelerated towards the anode cavity.

Let us assume that a reference electron **er** crosses the anode cavity but has no extra velocity and it repels back after reaching the Repeller electrode, with the same velocity. Another electron, let's say **ee** which has started earlier than this reference electron, reaches the Repeller first, but returns slowly, reaching at the same time as the reference electron.

We have another electron, the late electron **el**, which starts later than both **er** and **ee**, however, it moves with greater velocity while returning back, reaching at the same time as **er** and **ee**.

Now, these three electrons, namely **er**, **ee** and **el** reach the gap at the same time, forming an **electron bunch**. This travel time is called as **transit time**, which should have an optimum value. The following figure illustrates this.



EXPT. NO: 1 **DATE:**

GUNN DIODE CHARACTERISTICS

AIM:

To study the V-I characteristics of Gunn Diode

COMPONENTS REQUIRED:

Gunn mount, Gunn Diode, Gunn diode power Supply, Isolator, variable Attenuator, Frequency meter, Power Detector and output indicating meter.

THEORY:

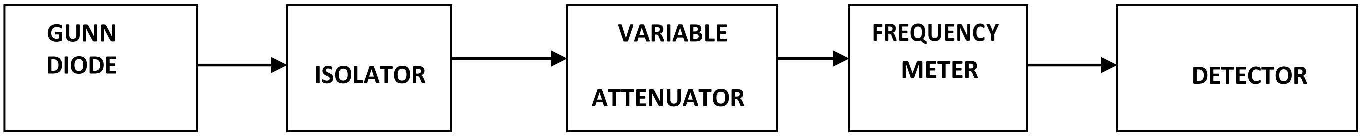
The Gunn Oscillator is based on negative differential conductivity effect in bulk semiconductors which has two conduction bands minima separated by an energy gap (greater than thermal agitational energies). A distribution at the cathode gives rise to high field region which travels towards the node. When this high field domains 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. The Oscillation frequency is determined by cavity dimension than by diode itself.

PROCEDURE:

1. Arrange the bench setup as shown in figure.
2. Set gunn bias at minimum position
3. Switch on the gunn power supply.
4. Connect the gunn output probe.
5. Slowly increase the gunn bias and current is measured for different voltages using meter available in the power supply.
6. Vary voltage from 0V to 10V(do not exceed beyond 10v).
7. Decrease the gunn bias to the minimum positon
8. Disconnect gunn bias chord from the unit.
9. Plot the V-I characteristics.

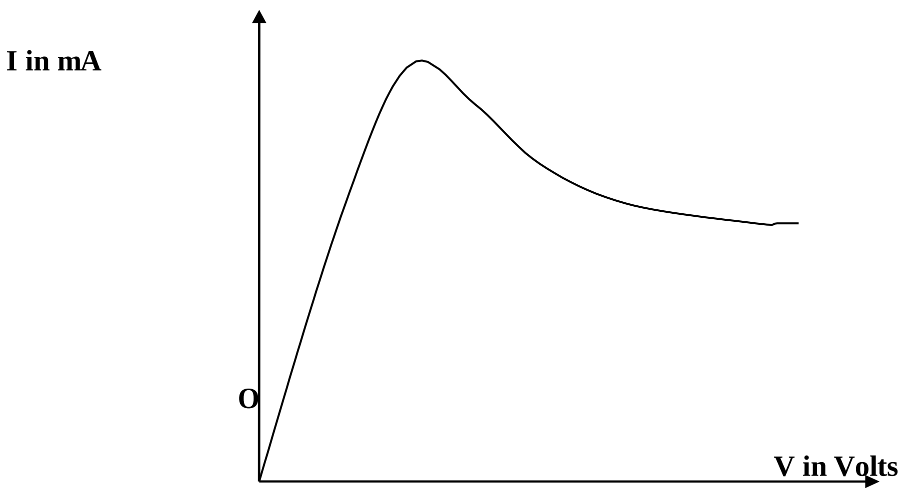
BENCH SETUP DIAGRAM OF GUNN DIODE CHARACTERISTICS:



TABULAR COLUMN:

Sl. No.	GUNN BIAS VOLTAGE (V in Volts)	OUTPUT CURRENT (I in mA)

EXPECTED GRAPH:



RESULT:

EXPT. NO: 2 **DATE:**

REFLEX KLYSTRON MODE CHARACTERISTICS

AIM:

To plot the characteristics of $1\frac{3}{4}$, $2\frac{3}{4}$, $3\frac{3}{4}$ and modes of a given reflex klystron microwave source.

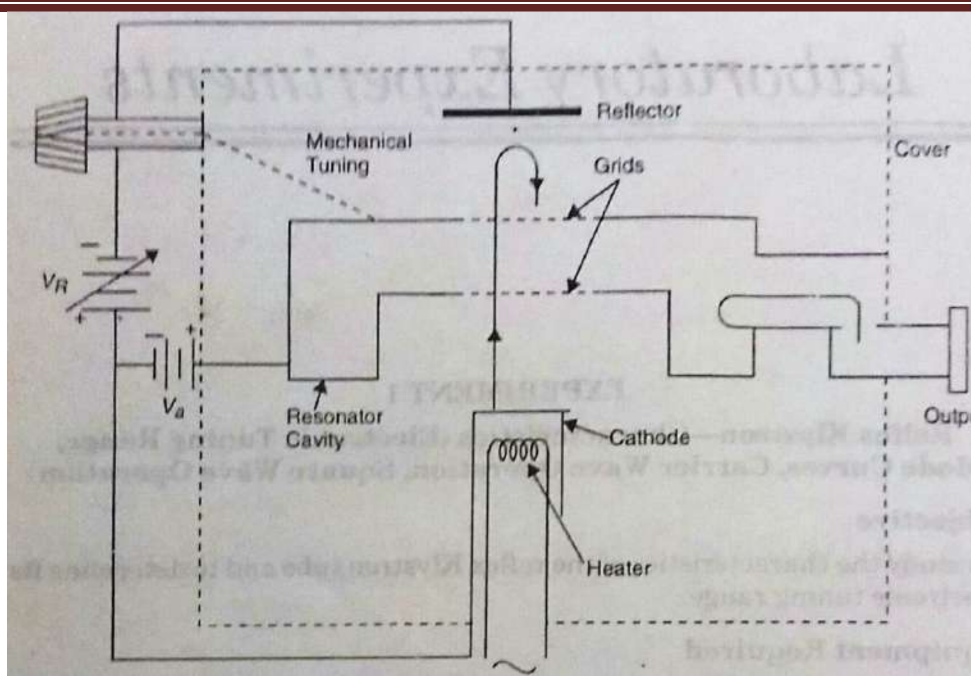
COMPONENTS REQUIRED:

Klystron Power Supply, Klystron Mount, Reflex klystron, Isolator, Variable Attenuator**,** Frequency meter, Power Detector and output indicating meter.

THEORY:

The Reflex Klystron makes use of velocity modulation to transform a continuous electron beam into microwave power. Electron emitted from the cathode is accelerate and passed through the positive resonator towards negative reflector, which retards and, finally, reflects the electron; and the electron turns back through the resonator. Suppose an hf-field exists between resonator, the electron travelling 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. 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 the resonator, they interact with voltage at resonator grids. If the bunches pass the grid at such time that the electrons are slowed down by the voltage, energy will be delivered to the resonator, and Klystron will oscillate. Below diagram shows the schematic of a typical Klystron tube.

The frequency is primarily determined by the dimension of resonant cavity. Hence, by changing the volume of resonator, mechanical tuning range of Klystron is possible. Also, a small frequency change can be obtained by adjusting the reflector voltage. This is called Electronic Tuning Range.



PROCEDURE:

Initial Setting

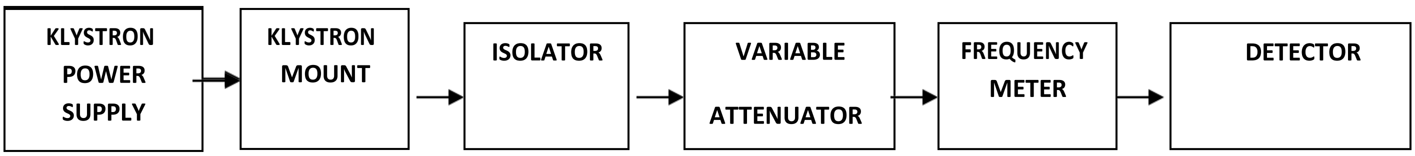
Before switch ON, Set repeller voltage at maximum value beam current at minimum value.

Measurement Setting

1. After power ON, set beam current at 20– 22mA.
2. Set attenuator at minimum to have maximum output current in ammeter.
3. Slowly reduce the repeller voltage to get the $1\frac{3}{4}$ mode.
4. Once the mode is obtained, measure the ammeter reading and frequency corresponds to each repeller voltage.
5. For measuring the frequency, tune the frequency meter till getting a dip in ammeter and note the value corresponds to the dip.

6. Repeat the procedure for 1 ¾ ,2 3/4 and 3 3/4 and modes of a given reflex klystron Microwave source.

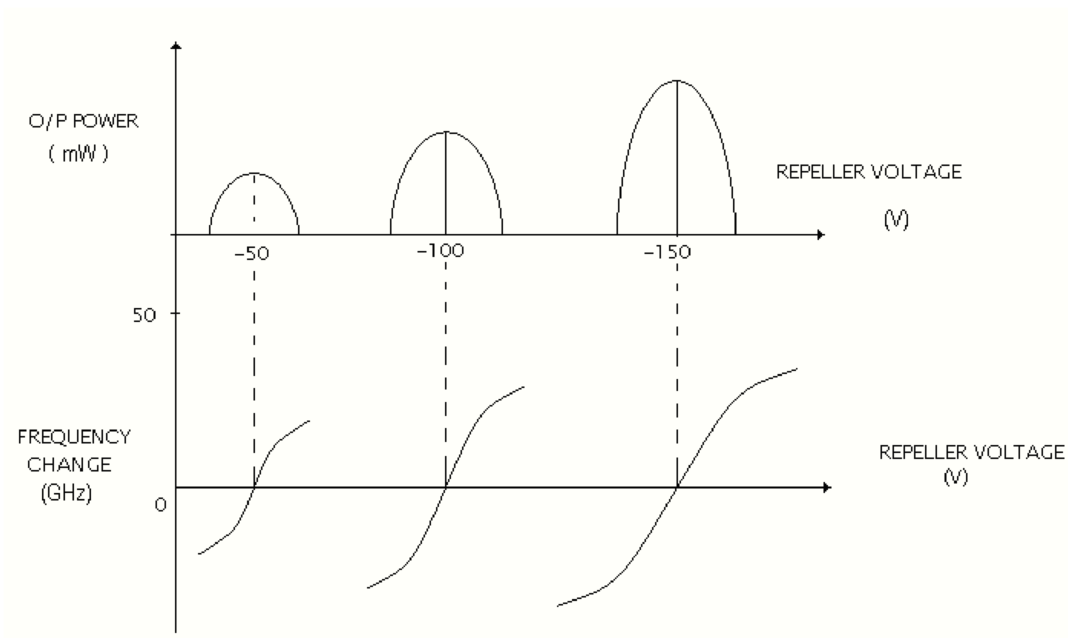
BENCH SETUP DIAGRAM OF REFLEX KLYSTRON OSCILLATOR:



TABULAR COLUMN:

SI. No.	REPELLER VOLTAGE in Volts	CURRENT in mA	OUTPUT POWER in mwatts

EXPECTED GRAPH:



RESULT:

EXPT. NO: 3 **DATE:**

VSWR AND FREQUENCY MEASUREMENT

AIM:

To measure the VSWR and calibrate the frequency meter.

COMPONENTS REQUIRED:

Klystron Power Supply, Klystron Mount Reflex klystron, Isolator, Variable Attenuator, Frequency meter, Power Detector and output indicating meter.

THEORY:

The electromagnetic field at any point of transmission line, may be considered as the sum of two travelling waves: the 'Incident Wave' propagates from the 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 presence of two travelling waves, gives rise to standing wave alongwith the line. The maximum field strength is found where two waves are in phase and minimum where the two waves adds in opposite phase. The distance between two successive minimum (or maximum) is half the guide wavelength on the line. The ratio of electrical field strength of reflected and incident wave is called reflection coefficient.

The voltage standing wave ratio (VSWR) is defined as the ratio between maximum and minimum field strength along the line.

Hence VSWR, S = $\frac{E_{max}}{E_{min}} = \frac{|E_1| + |E_r|}{|E_1| - |E_r|}$

PROCEDURE:

Initial Setting

Before switch ON, Set repeller voltage at maximum value beam current at minimum value.

Measurement setting for VSWR

1. Set up the equipment as shown in the figure.

2. Keep the variable attenuator at maximum position.
3. Keep the control knob of VSWR meter as shown below Range db –
   40 db/50 db
   Input Switch – Impedance Low Meter
   Switch – Normal
   Gain (Course-fine) – Mid position approximately
4. Keep the control knobs of Klystron Power Supply as below Meter Switch
   – 'OFF'
   Mod Switch – 'AM'
   Beam Voltage Knob – Fully anti-clockwise Reflector
   voltage knob – fully clockwise
   AM Frequency and amplitude knob – Mid position
5. 'ON' the Klystron Power Supply, VSWR meter and Cooling Fan.
6. Turn the Meter Switch of Klystron Power Supply to beam voltage position and set the beam voltage at 300V.
7. Rotate the reflector knob to get deflection in VSWR meter.
8. Tune the output by tuning the reflector voltage, amplitude and frequency of AM modulation.
9. Tune for maximum deflection by tuning the plunger of Klystron Mount. Also tune for maximum deflection by tuning the probe.
10. If necessary change db-switch, variable attenuator position and gain control knob to get deflection in the scale of VSWR meter.
11. Move the probe along with slotted line to get maximum deflection in VSWR Meter.
12. Adjust the VSWR meter gain control knob or variable attenuator until the meter indicates 1.0 on normal SWR Scale ($0 - \infty$).
13. Keep all the control knob as it is, move the probe to next minimum position.
    Read the VSWR on scale and record it.
14. Repeat the above step for change of S-S. Tuner probe depth and record the corresponding SWR.
15. If the VSWR is between 3.2 and 10, change the range dB switch to next higher position and read the VSWR on second VSWR scale is 3 to 10.

Measurement setting for frequency calibration

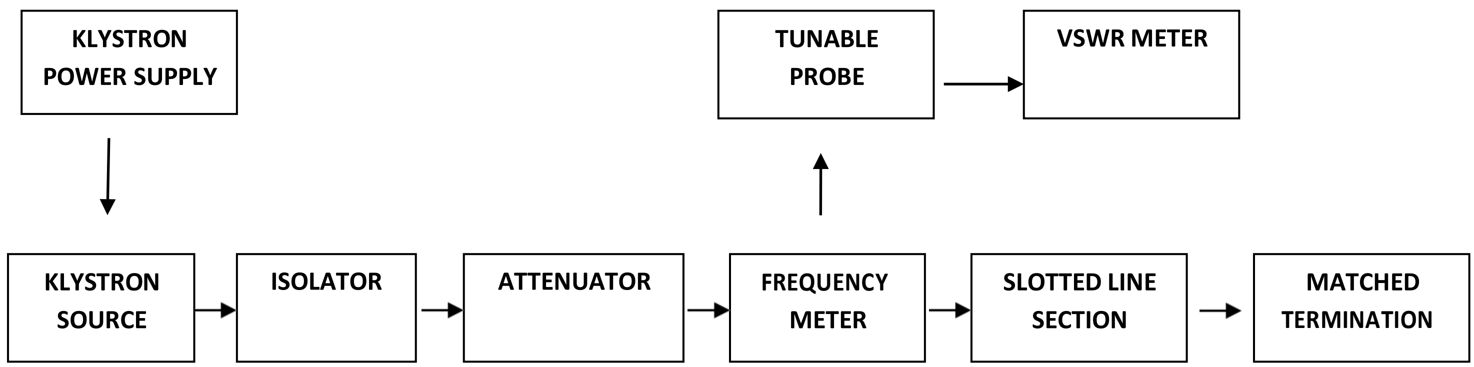
1. Operate klystron in $1^{3/4}$ mode.

2. At each point on this mode, observe dip in the direct frequency meter and note down the value in GHz.

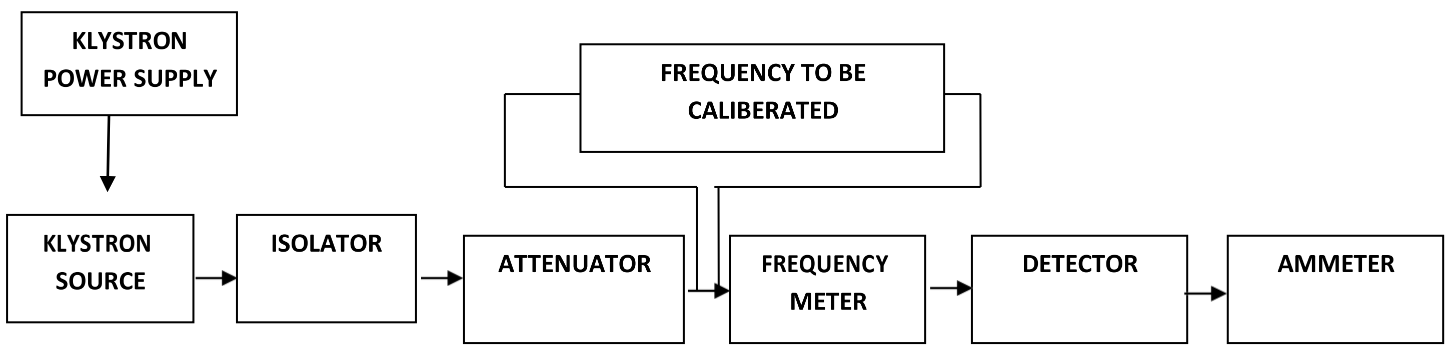
3. Detune the direct frequency meter.

4. Note down the indirect frequency meter reading corresponding to the dip in the same.

BENCH SETUP FOR MEASURING VSWR:



BENCH SETUP FOR FREQUENCY METER CALIBRATION:



TABULAR COLUMN:

SI.NO	REPELLER VOLTAGE in Volt	FREQUENCY (Direct)	FREQUENCY (Indirect)

RESULT:

EXPT. NO: 4 **DATE:**

VERIFICATION OF WAVELENGTH EQUATION FOR RECTANGULAR WAVEGUIDE

AIM:

To verify the relation between guide wavelength , free space wavelength and cutoff wavelength for rectangular waveguide

$$\frac{1}{\lambda_o^2} = \frac{1}{\lambda g^2} + \frac{1}{\lambda c^2}$$

COMPONENTS REQUIRED:

Klystron power supply ,klystron source with mount,isolator,attenuator,frequency meter,slotted line section with tunable probe,match termination,movable short,ammeter

THEORY:

For dominant TE_{10} mode in rectangular waveguide λ_o, λg, λc are related as below

$$\frac{1}{\lambda_o^2} = \frac{1}{\lambda g^2} + \frac{1}{\lambda c^2}$$

λ_o=free space wavelength

λg=guide wavelength

λc=cutoff wavelength

for TE_{10} mode λc=2a where a is broad dimension of waveguide. The following relationship can be proved

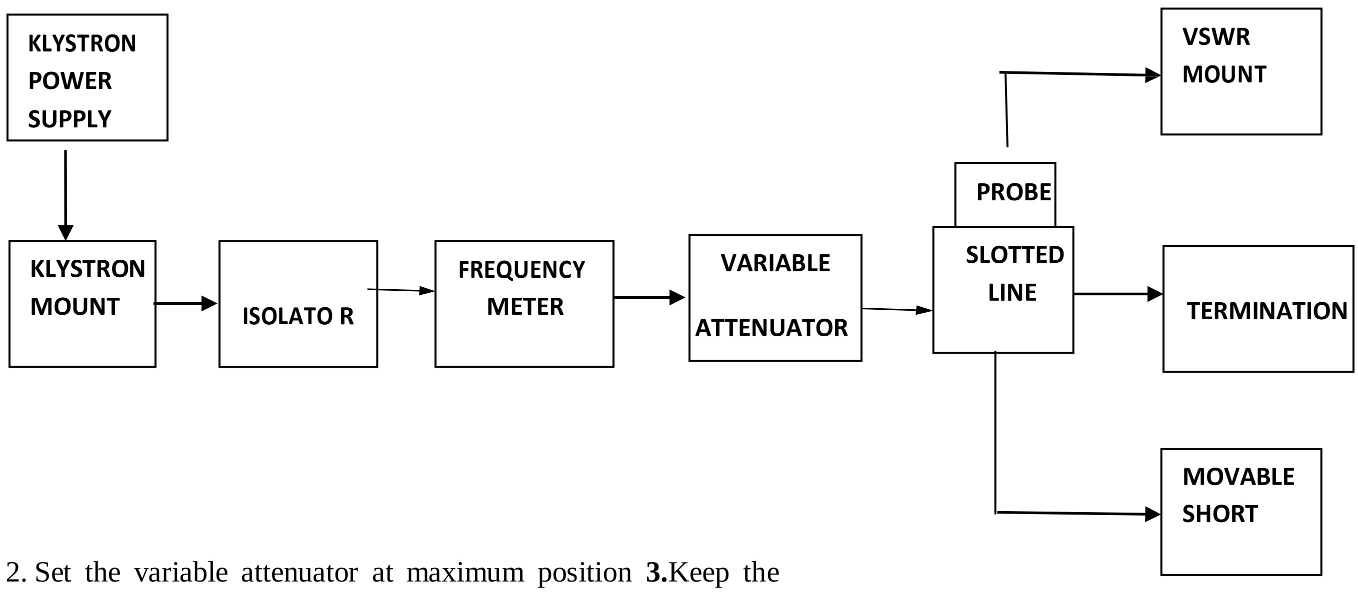
$$c = f\lambda$$

where c is the velocity of light and f is frequency

PROCEDURE:

1. Set up the components as shown in figure

SETUP FOR FREQUENCY AND WAVELENGTH MEASUREMENT:



2. Set the variable attenuator at maximum position **3.**Keep the control knobs of VSWR meter as below: Range db - 50db position

Input switch - Crystal low impedence

Meter switch - Normal position

Gain(coarse and fine) - mid position

4. Keep the control knobs of Klystron power supply as below: Meter Switch - 'OFF'

Mod Switch - AM

Beam Voltage Knob - Fully anti-clockwise

Reflector Voltage - Fully clockwise

AM-Amplitude knob - Around fully clockwise AM-

Frequency knob - Around Mid position

5. 'ON 'the klystron power supply, VSWR meter and cooling fan

6. Turn the meter switch of Power supply to beam voltage position and set beam voltage at 300V with

the help of beam voltage knob

7. Adjust the reflector voltage to get some deflection in VSWR Meter

8. Maximize the deflection with AM amplitude and frequency control knob of power supply

9. Tune the plunger of Klystron Mount for maximum deflection.

10. Tune the reflector voltage knob for maximum deflection.

11. Tune the probe for maximum deflection in the VSWR Meter.

12. Tune the frequency meter knob to get the ‘dip’ on the VSWR scale and note down the frequency directly from the Frequency meter.

13. Replace the termination with movable short, and detune the frequency meter.

14. Move probe along with the slotted line, the deflection in VSWR meter will vary. Move the probe to a minimum deflection postion,to get accurate reading, it is necessary to increase the VSWR meter range db switch to higher position .Note and record the probe position.

15. Move the probe to next minimum position and record the probe position again.

16. Calculate the guide wavelength as twice the distance between two successive minimum positions obtained as above.

17. Measure the waveguide inner board dimension ‘a’ which will be around 22.86mm for X-band.

18. Calculate the frequency by following equation:

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

where $c=3\times10^8$ meter/sec., i.e., velocity of light.

19. Verify the frequency obtained by frequency meter.

20. Above experiment can be verified at different frequencies.

OBSERVATIONS AND CALCULATIONS:

RESULTS:

EXPT. NO: 5 **DATE:**

DIRECTIONAL COUPLER CHARACTERISTICS

AIM:

To measure the coupling coefficient and directivity of the given directional coupler.

COMPONENTS REQUIRED:

Klystron power supply,klystron source,isolator,variable attenuator,frequency meter,directional coupler detector,ammeter

THEORY:

A directional coupler is a useful hybrid waveguide joint, which coules power in an auxiliary waveguide arm in one direction. It is a four-port device but one of the ports is terminated into a matched load. Ref figure 1.

Characteristics of a Directional Coupler

An ideal directional coupler has the following characteristics

If power is fed into port (1) the power is coupled in ports (2) and (3) i.e., power flows in the forward direction of the auxiliary arm port (3) but no power couples in port (4) i.e., in backward direction similarly power fed in (2) couples into ports (1) and (4) and not in (3).

) All the four ports are matched, i.e. if three of them are terminated in matched loads, the fourth is automatically terminated in a matched load.

i) If power couples in reverse direction, power fed in (1) appears in ports (2) and (4) and nothing in (3), then such type of coupler is known as backward directional coupler. The conclusion is that in the auxiliary section the power is coupled in only one direction.

We will measure (i) coupling coefficient as a function of frequency, (ii) directivity as a function of frequency.These parameters are defined as follows:

(i) Coupling: Coupling coefficient is the ratio of power supplied to the main line input (P1) to the power output (PAO) at the auxiliary line output. The coupling coefficient C is usually expressed in decibels as a positive number.

C = 10 log10 (P1/PAO) Db C

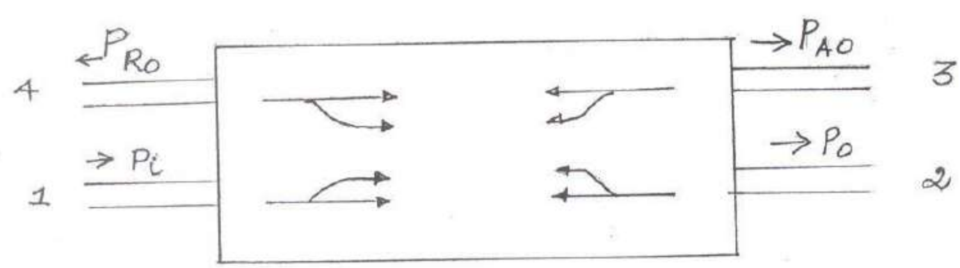
=20 log10 (V1/V2) dB

(ii) Directivity: The directivity D is a measure of the discrimination property of a directional coupler between the waves traveling in the two directions in the main line. It is measured as the ratio of the two power outputs from the auxiliary line when a given amount of power is successively applied to each terminal of the main line. The other terminals or ports of the coupler not in use in the particular measurement are assumed to be terminated in matched loads.

D = 10 log10 (PA0/Pd) db D =

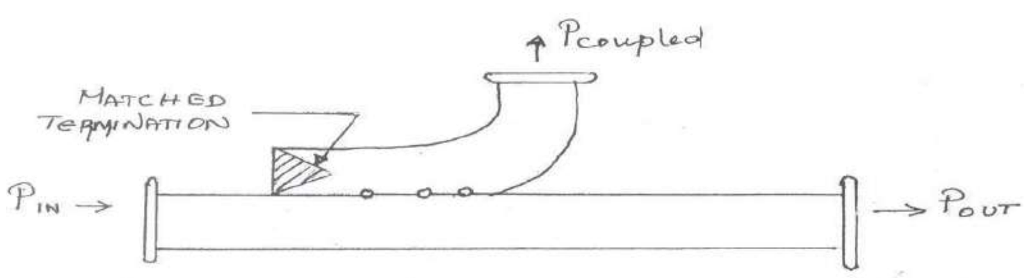
20 log (V3/V4) db

DIRECTIONAL COUPLER AS A FOUR – PORT DEVICE



DIRECTIONAL COUPLER AS A THREE – PORT DEVICE :

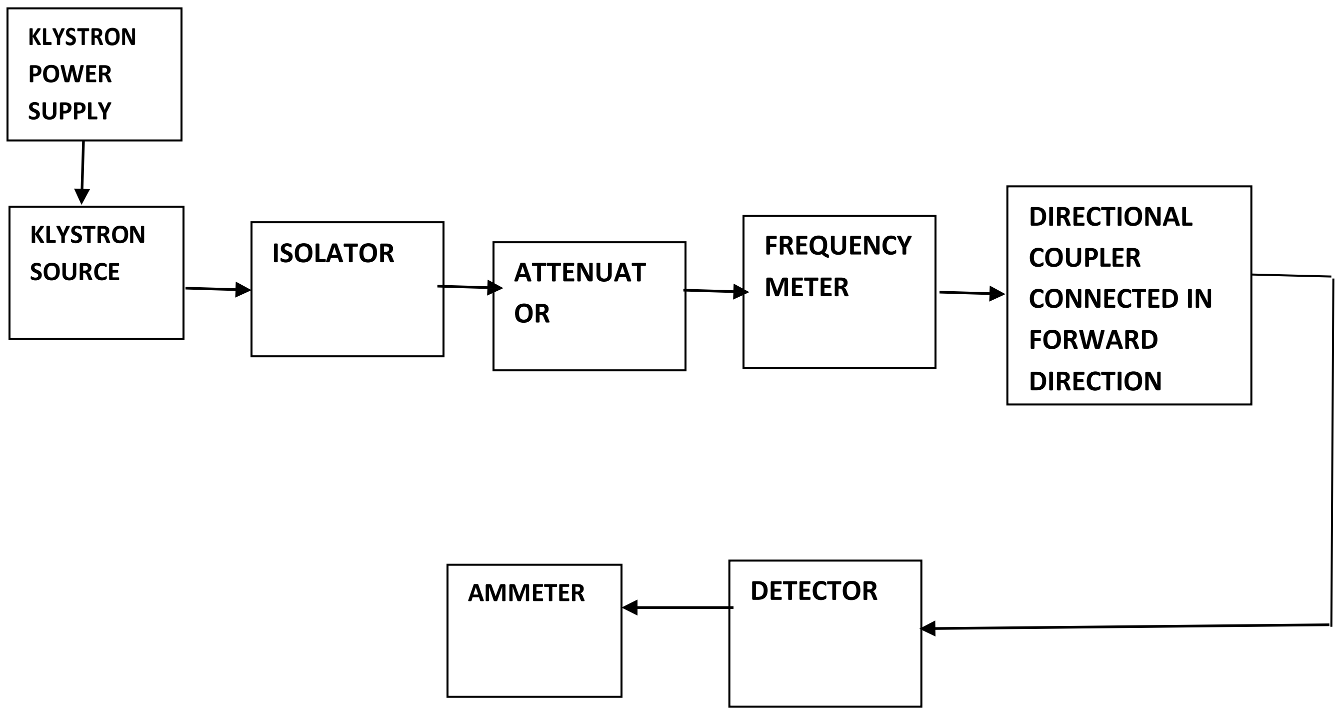
UNDEIRECTIONAL COUPLER



PROCEDURE:

1. Setup the components and equipments as shown in the figure SETUP FOR

MEASURING COUPLING COEFFICIENT



2. Energize the microwave source as per the switch on procedure

3. Remove the directional coupler and connect the detectors to the frequency meter .Tune the detector for maximum output and note it as p1.

4. Insert the directional coupler as shown in 1st figure with detector to the auxiliary port3 and matched termination to port2.Note the ammeter reading from port3 and name it as p2

5. Compute coupling coefficient

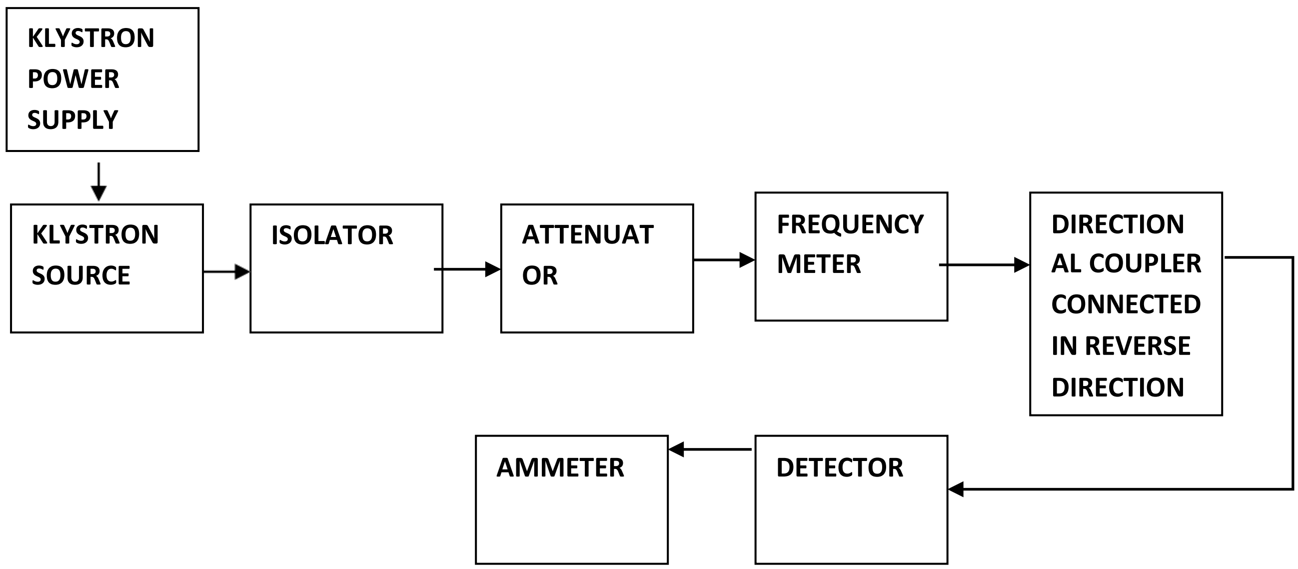
C=10 log(p1/p2)

6. Connect the directional couplernin the reverse direction as in the second figure.that is port2 to frequency meter,match termination to port1 and detector mount to port3.Note the ammeter reading as p3.

7. Compute directivity

D=p1/p3.

SETUP FOR MEASURING DIRECTIVITY



OBSERVATIONS AND CLCULATIONS:

RESULT

EXPT. NO: 6 **DATE:**

ANTENNA PATTERN MEASUREMENT

AIM:

To plot the radiation pattern of the waveguide horn antenna and to measure the half power beam width.

COMPONENTS REQUIRED:

Microwave source , klystron power supply , isolator ,variable attenuator , detector ,transmitting horn antenna ,receiving horn antenna ,ammeter.

THEORY:

In microwave communication, the transmission and reception of microwave signal through free space, is a must. Antenna act as an impedance transformer between the free space and some in this communication. The fundamental antenna parameters are field patterns, directivity, beam width and gain. A waveguide may behave as an antenna if its open end is matched to free space intrinsic impedance. Such an antenna will have shapes like that of horn and are called as horn antenna.

Radiation pattern:

The radiation pattern of an antenna is a diagram of electric field strength. Here, the directional characteristics of an antenna would ideally be shown as a three dimensional graph in which, for each direction, the radius from a central point is proportional to the power density at a given distance. For practical reasons, the radiation pattern is normally shown by two dimensional graphs which show a section or sections of the three-dimensional pattern. The radiation pattern of an antenna is a 3D graphical representation of the radiation properties of the antenna as a function of position (usually in spherical coordinates). If we imagine an antenna placed at the origin of a sphered coordinate system, its radiation pattern is given by measurement of the electric field over surface of a sphere of radius r. For a fixed r, electric field only a function of Θ and Φ. So we can write E (Θ, Φ). 3-D radiation patterns are difficult to draw and visualize in a 2D plane like on a piece of paper. So usually, they are drawn in two principal 2-D plane & which are orthogonal to each other (E & H planes). E-plane (H-plane) is usually the plane in which there are maximum electric (magnetic) fields for a linearly polarized antenna.

3-db Beam width:

3-db Beam width often used as a measure of the directivity of an antenna. It is the angle (HPBW) between the two points on the main lobe at which the radiated power density is half the maximum. The gain is generally the higher if the beam width is narrow and the side lobes are small, so that the power is sent in the desired direction. An antenna which has these entire characteristics will also generally be an efficient receiver of radiation.

Far field pattern:

The radiation pattern differs when measured close to the antenna and at a distance. It is usually the latter condition which is of interest, referred to as the ‘far field’. For practical purposes and in the case of a simple horn antenna, the far

field may be taken to start at a distance

$2D \,/\lambda 0$

from the horn, where D is its

layer dimension at the opening and λ_0 is the free space wavelength . Radiation measured is easily disturbed by reflection from the ground and other object. These problems are avoided as far as possible in practice by using clear areas out of doors, or by using 'anechoic chamber' rooms having walls specially designed to absorb radiation

Horn antenna:

A horn antenna or microwave horn is an antenna that consists of a flaring metal waveguide shaped like a horn to direct radio wave in a beam. Horns are widely used as antenna at UHF and microwave frequencies , above 300MHz.They are used as field antennas (called feed horns) for larger antenna structure such as parabolic antennas , as standard calibration antennas to measure the gain of other antennas, and as a directive antenna for each devices as radar guns, automatic door openers, and microwave radiometers. Their advantage is moderate directivity, low standing wave ratio (SWR), broad bandwidth, and simple construction and adjustment.

An advantage of horn antennas is that since they have no resonant elements, they can operate over a wide range of frequencies, a wide band width. The usual bandwidth for horn antennas are typically the order of 10:1 and can be up to 20:1 (for completely allowing it to operate from 1GHz to 20GHz). The input impedance is slowly varying over this wide frequency range, allowing low voltage standing wave ratio (VSWR) over bandwidth. The gain of horn antennas ranges up to 25dBi with 10-20 dBi being typical

The several type of horns include

-Sectoral E-plane horn

-Sectoral H-plane horn

-Pyramidal horn

-Conical horn

Sectoral horns can be produced if the flaring is done in one direction. If the flaring is done in the direction of electric field vector, then it is termed as electrical E- plane horn. If the flaring is in the direction of magnetic field vector, then it is termed as electrical H-plane horn. Pyramidal horn flares out in both directions. Here the flaring is done along both walls of the rectangular waveguide. h is the height of E plane and 'w' is the width in H plane.

.

By flaring the walls of a circular waveguide, a conical horn is produced. This EM wave leaving the horn is no longer plane but spherical. Also the radiated beam is not directive.

The formulae for approximate beam width of horn antenna are given by,

$$\theta_E = \frac{56\lambda_0}{h}$$ and

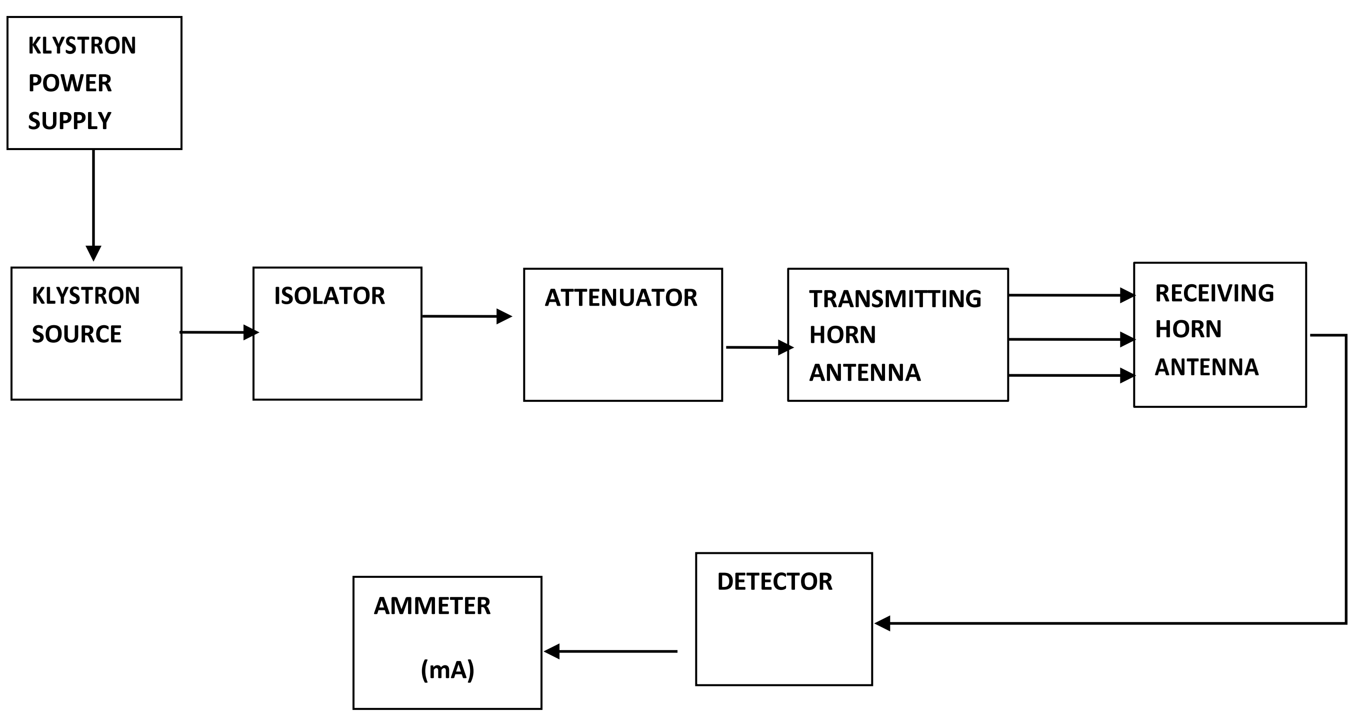
$$\theta_H = \frac{67\lambda_0}{w}$$

Since θ_E *and* θ_H are half power bandwidth in E and H directions. Directivity of horn is given by,

$$D = \frac{4.5\,A}{\lambda^2}$$

PROCEDURE:

1. Setup the equipment as shown in figure. Keep the axis of both antenna in same line.



2. Energize the klystron for maximum output and obtain maximum reading in Ammeter.

3. Tune the receiving point to the left in 2 degree or 5 degree steps and note the corresponding ammeter reading and angle of rotation to the left (φ).

4. Tune the receiving point to the left until the ammeter reading become zero.

5. Repeat the above step, but this time turn the receiving antenna to the right and note down the readings.

6. Plot a relative power pattern and obtain half power beam width.

OBSERVATION:

φ(degrees)	Radiated power(µw)

RESULT:

CYCLE: 02

OPTICAL EXPERIMENTS

EXPT NO: 7 **DATE:**

TO MEASURE THE NUMERICAL APERTURE OF A GIVEN OPTICAL FIBER

OBJECTIVE:

To measure the numerical aperture of a given optical fiber at 650 nm

HARDWARE REQUIRED:

Optical fiber Numerical Aperture measurement Kit

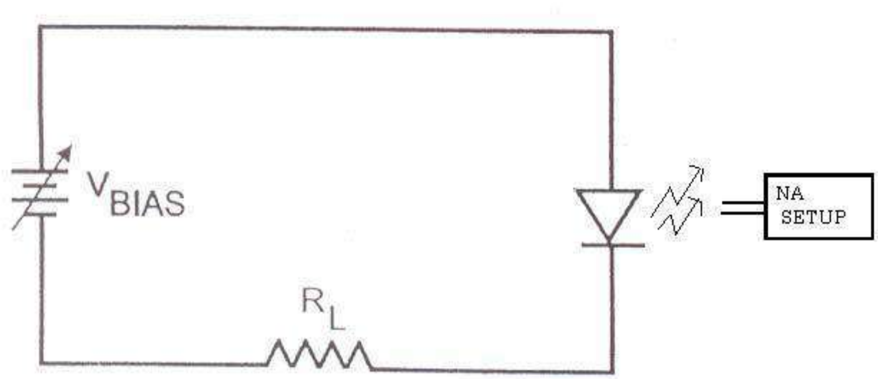
INTRODUCTION:

Numerical aperture (NA) of a fiber is a measure of the acceptance angle of light in the fiber. Light which is launched at angles greater than this maximum acceptable angle does not get coupled to propagating modes in the fiber and therefore does not reach the receiver at the other end of the fiber. The Numerical aperture is useful in the computation of optical power coupled from an optical source to the fiber, from the fiber to a photo detector and between two fibers.

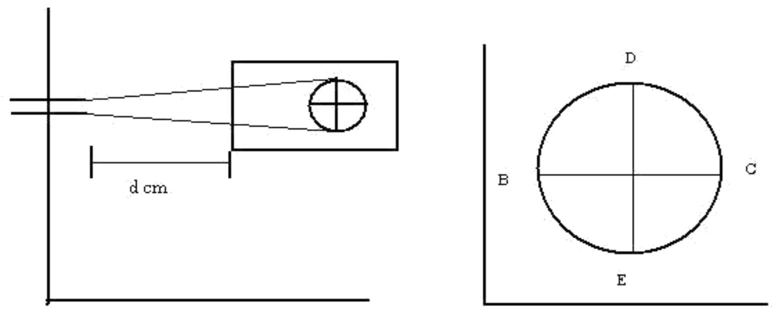
PRELAB QUESTIONS

1. Define angle of acceptance
2. If the angle of acceptance is 30 degree, what is the value of numerical aperture.
3. What is the formula for numerical aperture.
4. What is lens coupling and butt coupling
5. How to relate snell’ s law with Numerical Aperture.

DIAGRAM



TABULATION:



PROCEDURE:

1. Insert one end of the fiber into the numerical aperture measurement kit as shown in the figure. Adjust the fiber such that its tip is 10 mm from the screen
2. Gently tighten the screw to hold the fiber firmly in the place.
3. Connect the other end of the fiber to the LED Source through a connector. The fiber will project a circular patch of red light onto the screen. Let **d** be the distance between the fiber tip and the screen. Now measure the diameter of the circular patch of red light in two perpendicular directions (BC and DE in figure). The mean radius of the circular patch is given by

$$\mathbf{X = (DE + BC)/4}$$

4. Carefully measure the distance **d** between the tip of the fiber and the illuminated screen (OA) as shown in figure. The Numerical aperture of the fiber is given by

$$\mathbf{NA = \sin\theta = X/(d^2 + X^2)^{1/2}}$$

5. Repeat steps 1 to 4 for different values of **d,** compute the average value of Numerical aperture.

S.No	Measured diameter		Calculated average radius	Distance d (cm)	NA= Sin θ = $X/(d^2 + X^2)^{1/2}$
	d1 (cm)	d2(cm)	$\frac{d1 + d2}{4}$		

Average Numerical Aperture:

RESULT:

Thus the numerical aperture of an fiber optic cable is determined.

EXPT NO: 8 **DATE:**

MEASUREMENT OF PROPAGATION LOSS AND BENDING LOSS IN OPTICAL FIBER

OBJECTIVE:

To measure the propagation loss and bending loss in an optical fiber.

HARDWARE REQUIREMENT:

Kit(Fiber link-D)
1m, 3m Fiber Cable
Link Patch cords
Power supply

INTRODUCTION:

Optical fibers are available in different variety of materials. These materials are usually selected by taking into account their absorption characteristics of different wavelengths of light. 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. It is known as Propagation loss.Though the fibers are good at bending, each time the fiber is bent, a little light is lost. This experiment will measure how much of this light is lost for different sizes of bends.

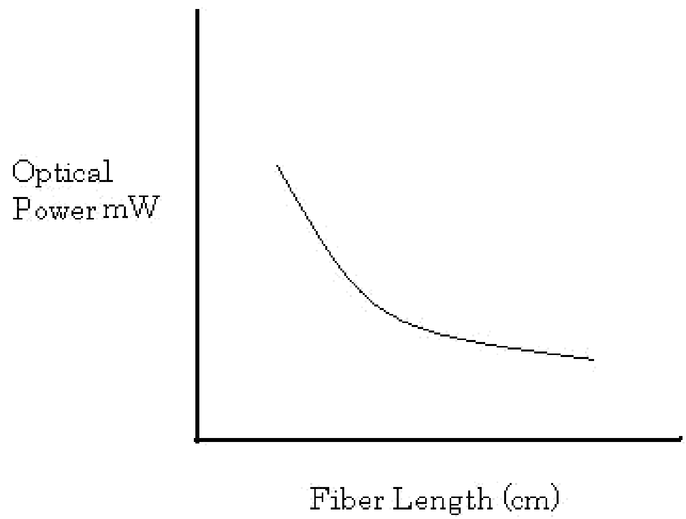
FORMULA:

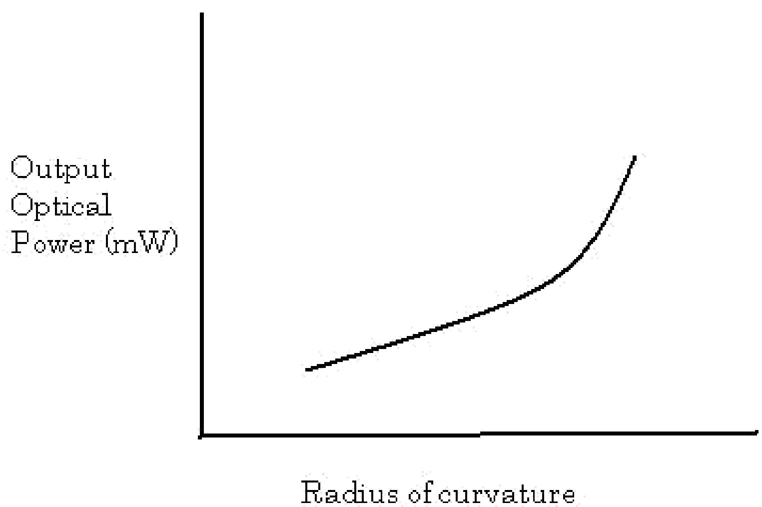
Propagation loss- Attenuation in dB/m

$$\alpha = \ln(P_{o1}/P_{o2}) /(l_2-l_1)$$

Where
P_{o1}---- Output power level (μw) at the end of the fiber of length l_1 (m)
P_{02} ---- Output power level (μw) at the end of the fiber of length l_2 (m)

MODEL GRAPH





PROCEDURE FOR PROPAGATION LOSS

1. Connect the power supply cables with proper polarity to kit. While connecting this, ensure that the power supply is OFF.
2. Connect the AMP O/P as a constant signal to the TX I/P using a patch cord.
3. You will measure the light output using SIGNAL STRENGTH section of the kit. The loss will be more for a longer piece of fiber. In order to measure the loss in the fiber you first need a reference of how much light goes into the fiber from the Light transmitter, You will use the short piece of fiber to measure this reference.

4. Switch on the power supply. Connect the short piece of fiber between the TX and RX of the kit. Adjust the transmitter level until the signal strength reads 6, this will

be your reference value. Now connect the long piece of fiber instead of the short piece. What reading do you get? Loss in optical fiber system is usually measured in dB. Loss of fiber itself is measured in dB/meter.

5. Subtract the length of the short fiber from the length of the long fiber to get the difference in the fiber lengths (4m-1m). The extra length of 3 m is what created the extra loss you measured. Then take the signal strength reading you obtained for the loss of the long fiber directly from the power meter.

PROCEDURE FOR BENDING LOSS

1. Connect the power supply cables with proper polarity to kit. While connecting this, ensure that the power supply is OFF.
2. Connect the AMP O/P as a constant signal to the TX I/P using a patch cord.You will measure the light output using SIGNAL STRENGTH section of the kit.
3. Switch on the power supply. Connect the long piece of fiber between the TX and RX of the kit so there are no sharp bends in the fiber between them
4. Adjust the transmitter level until the signal strength reads 6, this will be your reference value. Now take the portion of the fiber and loop it into the spindle and note the signal strength from the power meter, which give the optical signal power in dBW/m.
5. Repeat it for various diameters of the spindle and for various numbers of bend on the spindle and measure the corresponding signal strength from the optical power meter.

TABULATION:

Sl. No	Length of the optical fiber cable m	Optical Power Signal Strength mW	Propagation Loss

Radius of the Spindle Vs Signal Strength:

S No	Radius of spindle	Signal Strength in mW
1		
2		
3		
4		

RESULT:

Thus the propagation loss in fiber optic cable is measured.

EXPT. NO .9 **DATE:**

V-I CHARACTERISTICS OF LASER DIODE.

OBJECTIVE:

To study the V-I characteristics of LASER diode.

HARDWARE REQUIRED

1. OFT power supply (OFT power supply can be used for LD module)
2. A digital multi-meter
3. Benchmark LD unit
4. Benchmark LD drive module with its accessories
5. Benchmark Fiber Optic Power meter with ST adaptor
6. Mounting Posts

INTRODUCTION

A **laser diode** is a laser where the active medium is a semiconductor similar to that found in a light-emitting diode. The most common and practical type of laser diode is formed from a p-n junction and powered by injected electric current. These devices are sometimes referred to as *injection laser diodes* to distinguish them from (optically) *pumped laser diodes*, which are more easily manufactured in the laboratory.

A laser diode, like many other semiconductor devices, is formed by doping a very thin layer on the surface of a crystal wafer. The crystal is doped to produce an n-type region and a p-type region, one above the other, resulting in a *p-n* junction, or diode.

When an electron and a hole are present in the same region, they may recombine or "annihilate" with the result being spontaneous emission — i.e., the electron may re-occupy the energy state of the hole, emitting a photon with energy equal to the difference between the electron and hole states involved. (In a conventional semiconductor junction diode, the energy released from the recombination of electrons and holes is carried away as phonons, i.e., lattice vibrations, rather than as photons.) Spontaneous emission gives the laser diode below lasing threshold similar properties to an LED. Spontaneous emission is necessary to initiate laser oscillation, but it is one among several sources of inefficiency once the laser is oscillating.

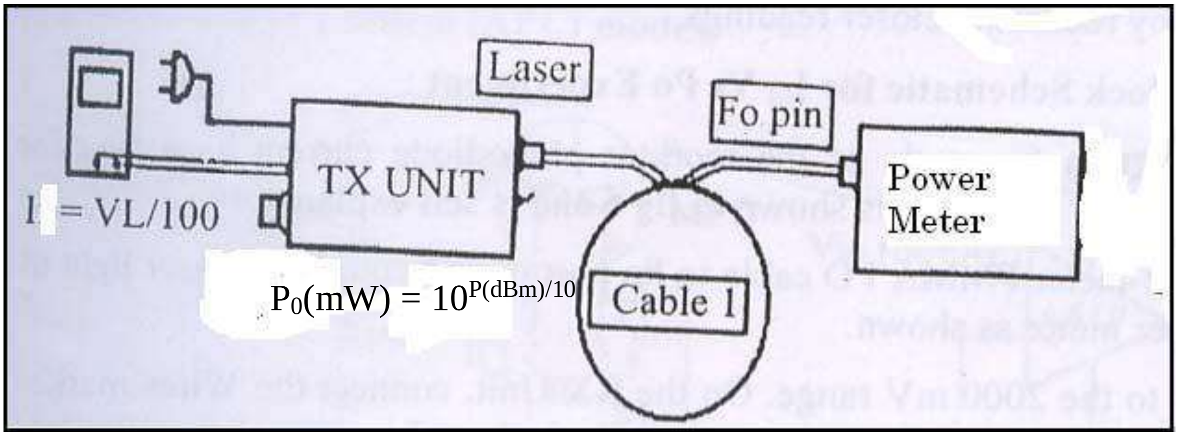
In the absence of stimulated emission (e.g., lasing) conditions, electrons and holes may coexist in proximity to one another, without recombining, for a certain time, termed the "upper-state lifetime" or "recombination time" (about a nanosecond for typical diode laser materials), before they recombine. Then a nearby photon with energy equal to the recombination energy can cause recombination by stimulated emission. This generates another photon of the same frequency, travelling in the same direction, with the same polarization and phase as the first photon. This means that stimulated emission causes gain in an optical wave (of the correct wavelength) in the injection region, and the gain increases as the number of electrons and holes injected across the junction increases. The spontaneous and stimulated emission processes are vastly more efficient in direct bandgap semiconductors than in indirect bandgap semiconductors; therefore silicon is not a common material for laser diodes.

As in other lasers, the gain region is surrounded with an optical cavity to form a laser. In the simplest form of laser diode, an optical waveguide is made on that crystal surface, such that the light is confined to a relatively narrow line. The two ends of the crystal are cleaved to form perfectly smooth, parallel edges, forming a Fabry-Perot resonator. Photons emitted into a mode of the waveguide will travel along the waveguide and be reflected several times from each end face before they are emitted. As a light wave passes through the cavity, it is amplified by stimulated emission, but light is also lost due to absorption and by incomplete reflection from the end facets. Finally, if there is more amplification than loss, the diode begins to "lase".

PRECAUTION

Avoid direct eye or skin exposure to laser beam while setting up the system or conducting experiments. Always view only the reflected rays while setting up the system or while conducting experiments**.**

Laser Diode (LD) module Setup



EXPERIMENT

PROCEDURE

1. Setup the LD module as shown in the figure.
2. Keep the potentiometer at the minimum position. Turn ON the power to the module.
3. Now without changing any voltage or the multi-turn post position, measure the optical power output P of the LD.

   Calculate the power in mW which is given as

4. Increase the current through LD by turning the multi-turn pot clockwise direction slightly towards the maximum till you get a convenient reading V_1 and repeat the steps 2 to 5 and tabulate them as shown below.
5. Repeat step 4 till multi-run pot reaches its maximum position and plot the graph for V_{LD} V_S I_{LD} and I_{LD} V_S P_0.
6. The threshold current of the LD can be found out from the P-I characteristics graph. Note down the current from the P-I graph at which there is a sharp rise in the optical output power. This is the threshold current of the LD.

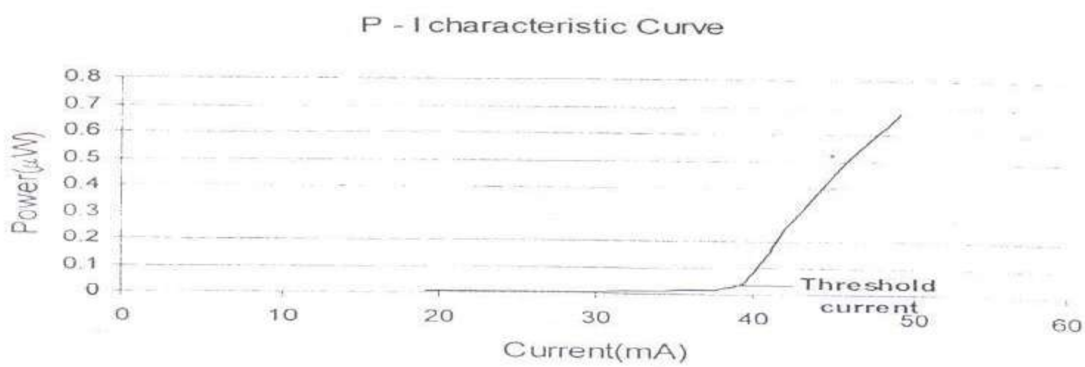
TABULATION

VI Characteristics

Voltage	Current in mA

Figure 1 P-I characteristics curve

MODEL GRAPH



RESULT :

The P-I characteristics of a Laser Diode were studied and plotted

EXPT. NO .10 **DATE:**

P-I CHARACTERISTICS OF LASER DIODE.

OBJECTIVE:

To study the P-I characteristics of LASER diode.

HARDWARE REQUIRED

1. OFT power supply (OFT power supply can be used for LD module)
2. A digital multi-meter
3. Benchmark LD unit
4. Benchmark LD drive module with its accessories
5. Benchmark Fiber Optic Power meter with ST adaptor
6. Mounting Posts

INTRODUCTION

A **laser diode** is a laser where the active medium is a semiconductor similar to that found in a light-emitting diode. The most common and practical type of laser diode is formed from a p-n junction and powered by injected electric current. These devices are sometimes referred to as *injection laser diodes* to distinguish them from (optically) *pumped laser diodes*, which are more easily manufactured in the laboratory.

A laser diode, like many other semiconductor devices, is formed by doping a very thin layer on the surface of a crystal wafer. The crystal is doped to produce an n-type region and a p-type region, one above the other, resulting in a *p-n* junction, or diode.

When an electron and a hole are present in the same region, they may recombine or "annihilate" with the result being spontaneous emission — i.e., the electron may re-occupy the energy state of the hole, emitting a photon with energy equal to the difference between the electron and hole states involved. (In a conventional semiconductor junction diode, the energy released from the recombination of electrons and holes is carried away as phonons, i.e., lattice vibrations, rather than as photons.) Spontaneous emission gives the laser diode below lasing threshold similar properties to an LED. Spontaneous emission is necessary to initiate laser oscillation, but it is one among several sources of inefficiency once the laser is oscillating.

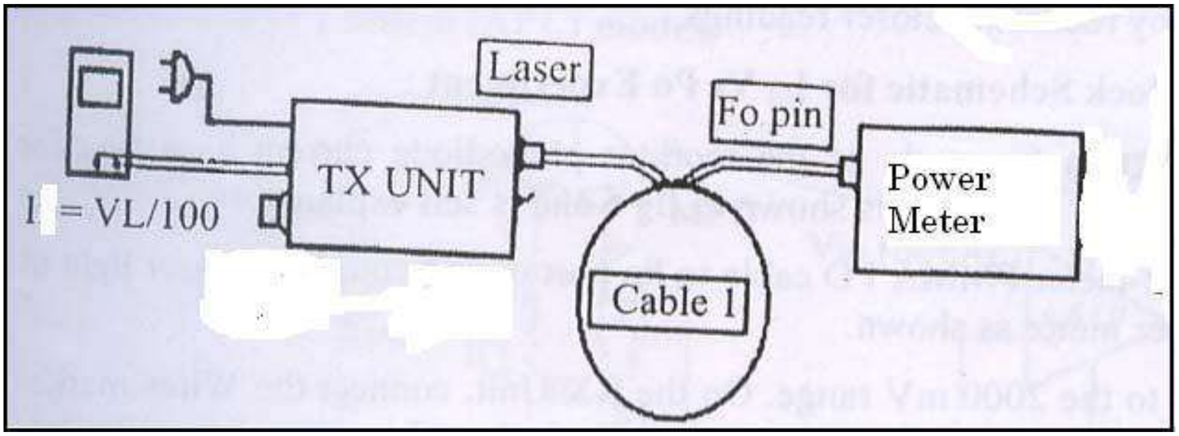
In the absence of stimulated emission (e.g., lasing) conditions, electrons and holes may coexist in proximity to one another, without recombining, for a certain time, termed the "upper-state lifetime" or "recombination time" (about a nanosecond for typical diode laser materials), before they recombine. Then a nearby photon with energy equal to the recombination energy can cause recombination by stimulated emission. This generates another photon of the same frequency, travelling in the same direction, with the same polarization and phase as the first photon. This means that stimulated emission causes gain in an optical wave (of the correct wavelength) in the injection region, and the gain increases as the number of electrons and holes injected across the junction increases. The spontaneous and stimulated emission processes are vastly more efficient in direct bandgap semiconductors than in indirect bandgap semiconductors; therefore silicon is not a common material for laser diodes.

As in other lasers, the gain region is surrounded with an optical cavity to form a laser. In the simplest form of laser diode, an optical waveguide is made on that crystal surface, such that the light is confined to a relatively narrow line. The two ends of the crystal are cleaved to form perfectly smooth, parallel edges, forming a Fabry-Perot resonator. Photons emitted into a mode of the waveguide will travel along the waveguide and be reflected several times from each end face before they are emitted. As a light wave passes through the cavity, it is amplified by stimulated emission, but light is also lost due to absorption and by incomplete reflection from the end facets. Finally, if there is more amplification than loss, the diode begins to "lase".

PRECAUTION

Laser radiation. Avoid direct eye or skin exposure to laser beam while setting up the system or conducting experiments. Always view only the reflected rays while setting up the system or while conducting experiments.

Laser Diode (LD) module Setup



PROCEDURE:

1. Setup the LD module as shown in the figure.
2. Keep the potentiometer at the minimum position. Turn ON the power to the module
3. Now without changing any voltage or the multi-turn post position, measure the optical power output P of the LD.
   Calculate the power in mW which is given as

$$P_0(mW) = 10^{P(dBm)/10}$$

4. Increase the current through LD by turning the multi-turn pot clockwise direction slightly towards the maximum till you get a convenient reading V_1 and repeat the steps 2 to 5 and tabulate them as shown below.
5. Repeat step 4 till multi-run pot reaches its maximum position and plot the graph for V_{LD} V_S I_{LD} and I_{LD} V_S P_0.
6. The threshold current of the LD can be found out from the P-I characteristics graph. Note down the current from the P-I graph at which there is a sharp rise in the optical output power. This is the threshold current of the LD

TABULATION:

PI characteristics

Current in mA	Power in mW

MODEL GRAPH

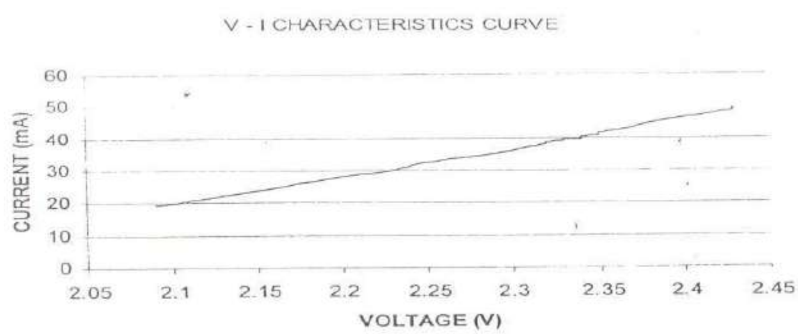


Figure 1. V-I characteristics curve

RESULT :

The P-I characteristics of a Laser Diode were studied and plotted

EXPT. NO: 11 **DATE:**

POWER VS CURRENT (P-I) CHARACTERISTICS OF LED.

OBJECTIVE

To study the Power Vs Current (P-I) characteristics of the given LED.

HARDWARE REQUIRED

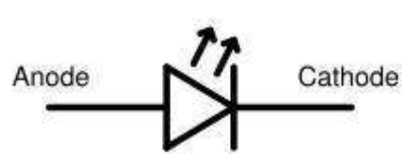
1. OFT Power Supply
2. A digital multi-meter
3. LED Module
4. Benchmark Fiber Optic Power Meter
5. Bare fiber adaptor-Plastic
6. 1.25m Plastic fiber

INTRODUCTION

A **light-emitting diode** (**LED**) is a semiconductor light source. LEDs are used as indicator lamps in many devices, and are increasingly used for lighting. Introduced as a practical electronic component in 1962, early LEDs emitted low-intensity red light, but modern versions are available across the visible, ultraviolet and infrared wavelengths, with very high brightness.

The LED is based on the semiconductor diode. When a diode is forward biased (switched on), electrons are able to recombine with holes within the device, releasing energy in the form of photons. This effect is called electroluminescence and the color of the light (corresponding to the energy of the photon) is determined by the energy gap of the semiconductor. An LED is usually small in area (less than 1 mm^2), and integrated optical components are used to shape its radiation pattern and assist in reflection.

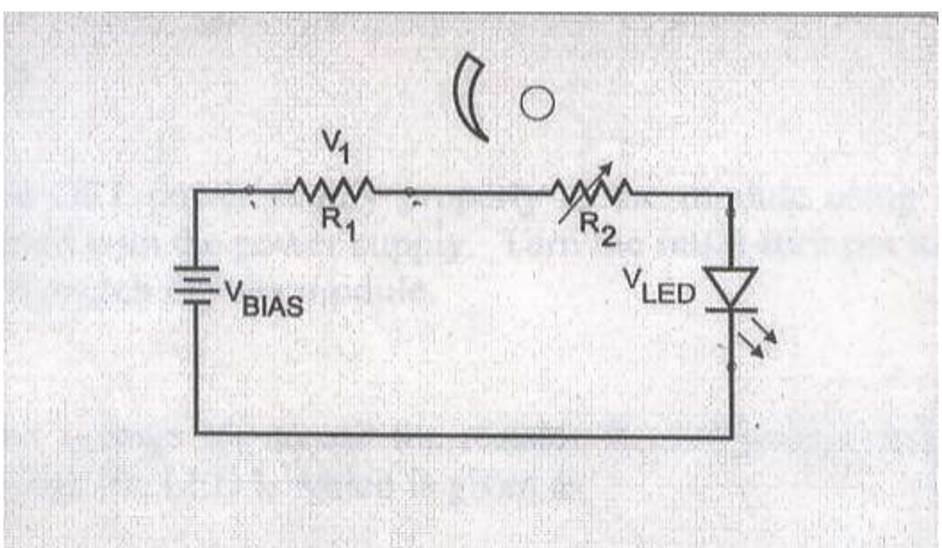
Symbol of LED



Like a normal diode, the LED consists of a chip of semiconducting material impregnated, or *doped*, with impurities to create a *p-n junction*. As in other diodes, current flows easily from the p-side, or anode, to the n-side, or cathode, but not in the reverse direction. Charge-carriers—electrons and holes—flow into the junction from electrodes with different voltages. When an electron meets a hole, it falls into a lower energy level, and releases energy in the form of a photon.The wavelength of the light emitted, and therefore its color, depends on the band gap energy of the materials forming the *p-n junction*. In silicon or germanium diodes, the electrons and holes recombine by a *non-radiative transition* which produces no optical emission, because these are indirect band gap materials. The materials used for the LED have a direct band gap with energies corresponding to near-infrared, visible or near-ultraviolet light.

LED development began with infrared and red devices made with gallium arsenide. Advances in materials science have made possible the production of devices with ever-shorter wavelengths, producing light in a variety of colors.LEDs must have a resistor in series to limit the current to a safe value, for quick testing purposes a 1kΩ resistor is suitable for most LEDs if your supply voltage is 12V or less.

LED Module Setup



PROCEDURE

Connect the OFT power supply properly to the module using the DIN-DIN cable provided with the power supply. Turn the multi-turn pot to its minimum position and switch ON the module.

1. Measure the voltage across the resistor R_1 (180 ohms and calculate the current through the LED l_f which is given as
   a. $1_f = V_1/180$
2. Now measure the voltage V_{LED} across the LED and note down.
3. Remove the dummy adaptor cap from the power meter PD exposing the large area photo-detector. Mount the bare fiber adaptor-plastic over the PD. Carefully hold the LED source very close to the photo-detector window perpendicular to it to couple all the optical power output P of the LED. Calculate the power in mW and note it down which is given as
   i. P_0 (mW) = $10^{P(dBm)/10}$
4. Turn the potentiometer clockwise direction slightly towards the maximum till you get a convenient reading V and repeat the steps 1 to 3 and tabulate.
5. Repeat step 4 till the potentiometer reaches its maximum position and plot the graph for V_{LED} V_S I_f and I_f V_S P_0). The graphs should be similar to the one shown in fig.1 and fig. 2 respectively.
6. Calculate the E-O conversion efficiency `η' of the LED from the plotted graph `I_f' V_S P_0 which is given as
   a. = P_0 / I_f
7. Unscrew the self locking cap in the LED without removing it completely and insert the 1.25 m plastic fiber into the cap. Now tighten the cap. Remove the ST adaptor from the power meter PD and mount the Bare fiber adaptor – plastic on to the PD. Insert the other end of the plastic fiber to this adaptor Repeat above experiment but the optical measurement with a plastic fiber and plastic fiber adaptor in Power meter, instead of measuring it was explained in step 3.

TABULATION

PI Characteristics

Current in mA	Power in mW

MODEL GRAPH

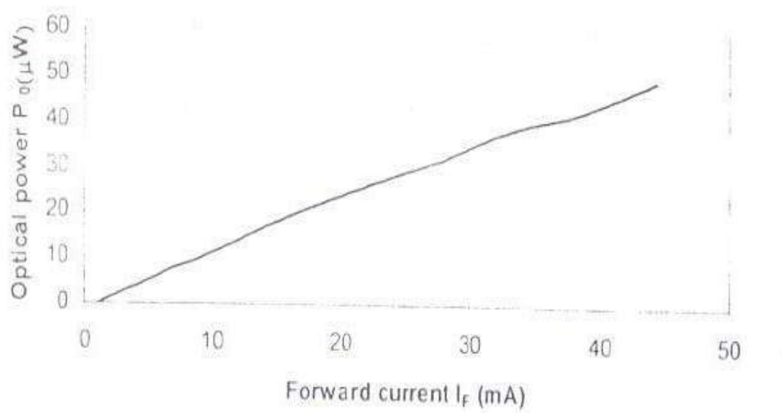


Figure 1. Power Vs Current graph

RESULT:

Thus the PI characteristics of LED has been studied and plotted.

EXPT. NO: 12 **DATE:**

VOLTAGE VS CURRENT (V-I) CHARACTERISTICS OF LED.

OBJECTIVE

To study the Voltage Vs Current (V-I) characteristics of the given LED.

HARDWARE REQUIRED

1. OFT Power Supply
2. A digital multi-meter
3. LED Module
4. Benchmark Fiber Optic Power Meter
5. Bare fiber adaptor-Plastic
6. 1.25m Plastic fiber

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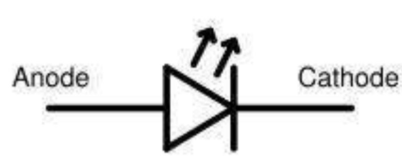
Symbol of LED



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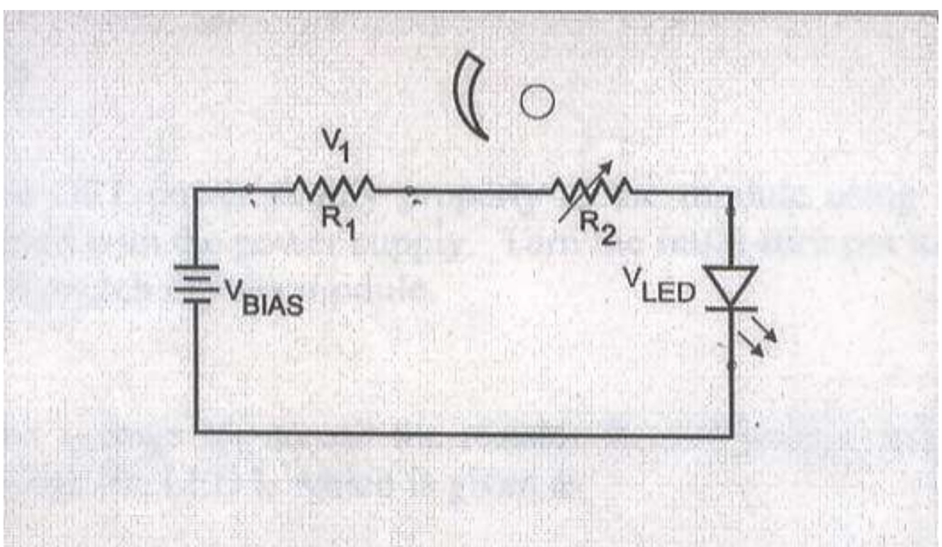
LED Module Setup



EXPERIMENT

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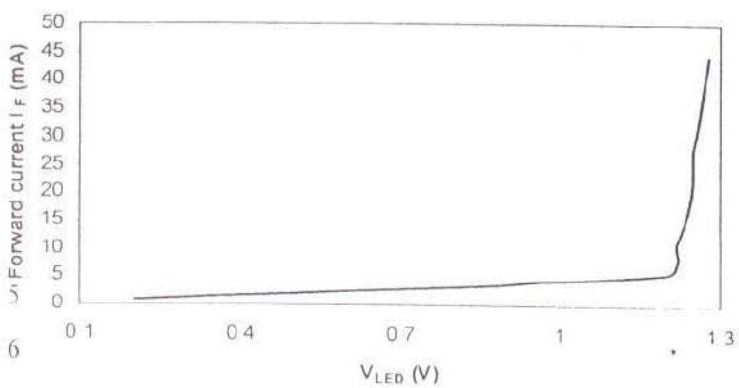
TABULATION

VI Characteristics

voltage	Current in mA

MODEL GRAPH



Voltage Vs Current graph

RESULT

Thus the VI characteristics of LED has been studied and plotted.