MARRI LAXMAN REDDY
INSTITUTE OF TECHNOLOGY AND MANAGEMENT
(AN AUTONOMOUS INSTITUTION)
(Approved by AICTE, New Delhi & Affiliated to JNTUH, Hyderabad)
Accredited by NBA and NAAC with 'A' Grade & Recognized Under Section2(f) & 12(B)of the UGC act,1956

R19-REGULATIONS
AY: 2025-26

Microwave and Optical Communication Lab

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

MARRI LAXMAN REDDY
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CERTIFICATE

This is to certify that this manual is a bonafide record of practical work in the **Microwave & Optical communication in First Semester of Fourth year B. Tech (ECE) programme** during the academic year **2025-26**. The book is prepared by Dr. I.Adum Babu Associate Professor, K Nagaraju, K.Sridhar Assistant Professors**,** Department of Electronics and Communication Engineering**.**

Signature of HOD Signature of Director Signature of Principal

PREFACE

It is one of the core areas of ECE and constitutes the largest applications in use today. Communication has entered into every part of today’s world. This Microwave & optical communication Lab is designed to help students understand the basic principles of communication techniques and microwave guides as well as giving them the insight on design, simulation and hardware implementation of circuits. The main aim is to provide hands-on experience to the students so that they are able to put theoretical concepts to practice. The content of this course consists of two parts, ‘Microwave’ and ‘Optical Communication’. Microwave is stressed upon as it is a key analysis of engineering design. Microwave bench set up is used for high frequency communication. Students will carry out design experiments as a part of the experiments list provided in this lab manual. Students will be given a specific design problem, which after completion they will verify using the components and hardwired implementation.

By,

Dr. I. Adum Babu
Assoc. Professor, Department of ECE
K. Nagaraju
K. Sridhar
Asst. Professors, Department of ECE

ACKNOWLEDGEMENT

It was really a good experience, working at Microwave and Optical Communications lab. We express our sincere thanks to Dr. N. Srinivas, Head of the Department of ECE, Marri Laxman Reddy Institute of technology & Management, for his concern towards us and gave us opportunity to prepare Microwave Engineering and Optical Communication laboratory manual. We are deeply indebted and gratefully acknowledge the constant support and valuable patronage of Dr. P. Sridhar, Director, Marri Laxman Reddy Institute of technology & Management. We are unboundedly grateful to him for timely corrections and scholarly guidance. We express our hearty thanks to Dr. R. Murali Prasad, Principal, Marri Laxman Reddy Institute of technology & Management, for giving us this wonderful opportunity for preparing the Microwave and Optical Communications laboratory manual.

At last, but not the least we would like to thank the entire ECE Department faculties those who had inspired and helped us to achieve my goal.

By,

Dr. I. Adum Babu

Assoc. Professor, Department of ECE

K Nagaraju

Asst. Professor, Department of ECE

K Sridhar

Asst. Professor, Department of ECE

GENERAL INSTRUCTIONS

1. Students should report to the concerned labs as per the timetable schedule.

2. Students who turn up late to the labs will in no case be permitted to perform the experiment scheduled for the day.

3. After completion of the experiment, certification of the concerned staff in-charge in the observation book is necessary.

4. Students should bring a notebook of about 100 pages and should enter the readings/observations into the notebook while performing the experiment.

5. The record of observations along with the detailed experimental procedure of the experiment.

6. Performed in the immediate last session should be submitted and certified by the staff member in-charge.

7. Not more than one student is permitted to perform the experiment on a setup.

8. When the experiment is completed, students should disconnect the setup made by them, and should return all the components/instruments taken for the purpose.

9. Any damage of the equipment or burnout of components will be viewed seriously by putting penalty.

10. Students should be present in the labs for the total scheduled duration.

11. Students are required to prepare thoroughly to perform the experiment before coming to Laboratory.

12. Procedure sheets/data sheets provided to the student’s should be maintained neatly and to be returned after the experiment.

SAFETY PRECAUTIONS

1. No horseplay or running is allowed in the labs.
2. No bare feet or open sandals are permitted.
3. Before energizing any equipment, check whether anyone is in a position to be injured by your actions.
4. Read the appropriate equipment instruction manual sections or consult with your instructor.
5. Before applying power or connecting unfamiliar equipment or instruments into any circuits.
6. Position all equipment on benches in a safe and stable manner.
7. Do not make circuit connections by hand while circuits are energized. This is especially.
8. Dangerous with high voltage and current circuits.

INSTITUTE VISION AND MISSION

VISION

To establish ideal academic institutions in the service of the nation, the world and the humanity by graduating talented engineers to be ethically strong, globally competent by conducting high quality research, developing breakthrough technologies, and disseminating and preserving technical knowledge.

MISSION

To fulfill the promised vision through the following strategic characteristics and aspirations:

1. **An atmosphere** that facilitates personal commitment to the educational success of students in an environment that **values diversity and community.**
2. Prudent and accountable **resource management**.
3. Undergraduate programs that integrate **global awareness, communication skills and Leadership and service** to meet society's needs;
4. Education and research **partnerships** with colleges, universities, and industries to graduate education and training that prepare students for **interdisciplinary engineering** research and advanced problem solving.
5. Highly **successful alumni** who contribute to the profession in the global society.

DEPARTMENT VISION, MISSION , PROGRAMME EDUCATIONAL OBJECTIVES AND SPECIFIC OUTCOMES

VISION

Imparting quality technical education through research, innovation and team work for a lasting technology development in the area of Electronics and Communication Engineering.

MISSION

To develop a strong centre of excellence for education and research with excellent infrastructure and well qualified faculties to instill in them a passion for knowledge.

PROGRAM EDUCATIONAL OBJECTIVES

Graduates of the program will

PEO 1: have successful **careers in Industry.**

PEO 2: show excellence in **higher studies/ Research.**

PEO 3: show good competency towards **Entrepreneurship.**

PROGRAM SPECIFIC OUTCOMES

PSO1: Analyze and design Analog and Digital circuits or systems for a given specification and function.

PSO2: Implement functional blocks of hardware designs for signal processing and Communication applications**.**

Program Outcomes (POs)

PO 1: An ability to apply knowledge of Science, Mathematics, Engineering & Computing fundamentals for the solutions of Complex Engineering problems.

PO 2: An ability to identify, formulates, research literature and analyze complex engineering problems using first principles of mathematics and engineering sciences.

PO 3: An ability to design solutions to complex process or program to meet desired needs

PO 4: Ability to use research-based knowledge and research methods including design of experiments to provide valid conclusions.

PO 5: An ability to use appropriate techniques, skills and tools necessary for computing practice.

PO 6: Ability to apply reasoning informed by the contextual knowledge to assess social issues, consequences & responsibilities relevant to the professional engineering practice.

PO 7: Ability to understand the impact of engineering solutions in a global, economic, environmental, and societal context with sustainability.

PO 8: An understanding of professional, ethical, social issues and responsibilities.

PO 9: An ability to function as an individual, and as a member or leader in diverse teams and in multidisciplinary settings.

PO 10: An ability to communicate effectively on complex engineering activities within the engineering community.

PO 11: Ability to demonstrate and understanding of the engineering and management principles as a member and leader in a team.

PO 12: Ability to engage in independent and lifelong learning in the context of technological change.

MICROWAVE & OPTICAL COMMUNICATION LAB

OBJECTIVES:

This Lab aims at:

- Defining the range of frequencies for operation in microwave engineering.
- Understand the functioning of microwave components
- Verify the various Characteristics of Active and Passive Microwave Devices Practically.
- Measure the characteristics optical devices.
- Measure the various parameters of the optical sources.

OUTCOMES:

Upon completion of the lab, student will be able to

CO1 – Study the characteristics of microwave sources

CO 2 -Estimate the guide wave length and free space wave length of a wave.

CO 3 -Analyse the characteristics of microwave devices.

CO 4 -Measure the various characteristics of different optical devices.

CO 5- Measure the different parameters of the optical sources.

EXPERIMENTS LEARNING OUTCOMES

EXP-1: REFLEX KLYSTRON CHARACTERISTICS

Objective:

To understand and analyze the concepts of klystron working, bench setup and its applications.

Outcome:

Able to design Reflex Klystron using source at using the same in real time applications.

EXP-2: Gunn Diode Characteristics

Objective:

To understand and acquire the knowledge about the concepts of gunn diode characteristics and its applications

Outcome:

Able to design Gunn Diode circuit and adept at using the same in real time applications.

EXP-3: Attenuation Measurement

Objective:

To understand and analyze the Measurement of attenuation in a waveguide.

Outcome:

Able to analyze the waveguides and find the attenuation measurement of a rectangular waveguide.

EXP-4: Directional Coupler Characteristics

Objective:

To provide an in-depth analysis of directional coupler using other wave guides and its many applications.

Outcome:

Practically understand how to design Directional coupler circuits using wave guides and adept at using the same in real time applications.

EXP-5: Scattering Parameters of Wave guide components

Objective:

To understand and identify the scattering parameters of a E-Plane Tee.

Outcome:

Able to analyze the waveguides and find the scattering parameters of a E-Plane Tee.

EXP-6: Frequency Measurement

Objective:

To understand and analyze the Measurement of Microwave Frequency.

Outcome:

Able to analyze the waveguides and find the Frequency measurement of a rectangular waveguide.

EXP-7: Impedance Measurement

Objective:

To understand and identify the impedance of a given load.

Outcome:

Able to design the waveguides and measure impedance of a given load.

EXP-8: VSWR Measurement

Objective:

To understand and analyze the concepts of VSWR Measurement and its applications.

Outcome:

Able to design VSWR Measurement and acquire the knowledge in practice.

EXP-9: Characterization of LED

Objective:

To study the relationship between the optical power output and dc forward current of LED

Outcome:

The optical power Vs forward current characteristics of 660 nm and 850 nm LEDs are observed.

EXP-10: Characterization of Laser Diode

Objective:

To find the characteristics of Optical Power (Po) of laser diode vs. Laser diode forward current (IF).

Outcome:

The optical power Vs forward current characteristics of the laser diode are observed.

EXP-11: Intensity modulation of Laser output through an optical fiber

Objective:

To study the following characteristics of intensity modulation of LASER output through optical fiber.

Outcome:

We studied the modulation characteristics of Laser.

EXP-12: Measurement of Data rate for Digital Optical link.

Objective:

Measure the data rate for the given data.

Outcome:

Able to design digital optical link and measure data rate.

EXP-13: Measurement of Numerical Aperture of fiber cable.

Objective:

To measure the numerical aperture of the plastic fibre.

Outcome:

Understand the procedure for finding numerical aperture of various optical fibers.

EXP-14: Measurement of losses for Optical link.

Objective:

To measure the bending losses of a fiber optic card.

Outcome:

Able to design analog optical link and measure the losses.

Department of Electronics & Communications Engineering

R22 B. Tech. ECE Syllabus

2270484: MICROWAVE AND OPTICAL COMMUNICATIONS LAB

B. Tech IV Year I Semester

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Note: Any **Twelve** of the following experiments

LIST OF EXPERIMENTS:

1. Analyse the Reflex Klystron Characteristics.
2. Analyse the Gunn diode Characteristics.
3. Attenuation Measurement.
4. Analyse the Directional Coupler Characteristics & Coupling, Directivity and Isolation Measurements.
5. Scattering parameters of wave guide components
6. Measurement of Frequency
7. Measurement of impedance
8. VSWR measurement, Low & High VSWR.
9. Characterization of LED.
10. Characterization of Laser Diode.
11. Intensity modulation of Laser output through an optical Fiber.
12. Measurement of Data rate for Digital Optical link.
13. Measurement of Numerical Aperture of Fiber cable.
14. Measurement of losses for Optical link.

LAB I/C **LAB FACULTY**

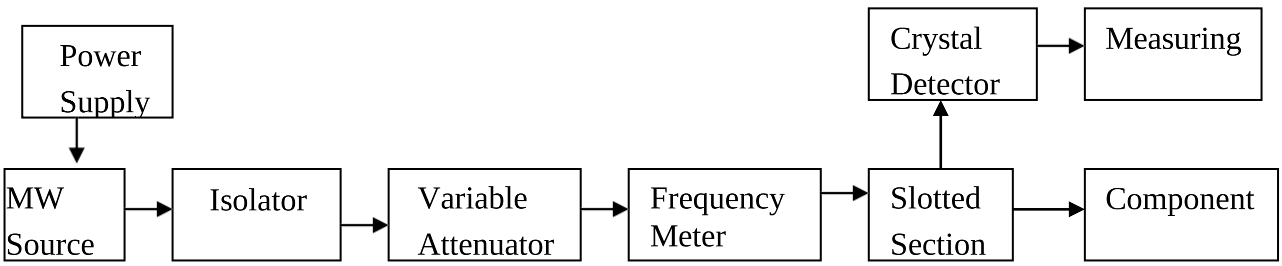
DESCRIPTION OF MICROWAVE BENCH

INTRODUCTION:

Electrical measurements encountered in the microwave region of the electromagnetic spectrum are discussed through microwave measurement techniques. This measurement technique is vastly different from that of the more conventional techniques. The methods are based on the wave character of high frequency currents rather than on the low frequency technique of direct determination of current or voltage. For example, the measurement of power flow in a system specifies the product of the electric and magnetic fields. Whereas the measurement of impedance determines their ratio. Thus, these two measurements indirectly describe the distribution of the electric field and magnetic fields in the system and provides its complete description. This is, in fact, the approach to most of the measurements carried out in the micro wave region of the spectrum.

Microwave Bench:

The micro wave test bench incorporates a range of instruments capable of allowing all types of measurements that are usually required for a microwave engineer. The bench is capable of being assembled or disassembled in a number of ways to suit individual experiments. A general block diagram of the test bench comprising its different units and ancillaries are shown bellow.



1. **Klystron Power Supply:**

Klystron Power Supply generates voltages required for driving the reflex Klystron tube like 2k25. It is stable, regulated and short circuit protected power supply. It has built on facility of square wave and saw tooth generators for amplitude and frequency modulation. The beam voltage ranges from 200V to 450V with maximum beam current.50mA. The provision is given to vary repeller voltage continuously from -270V DC to -10V.

2. **Gunn Power Supply:**

Gunn Power Supply comprises of an electronically regulated power supply and a square wave generator designed to operate the Gunn oscillator and PIN Modulator. The Supply Voltage ranges from 0 to 12V with a maximum current, 1A.

Reflex Klystron Oscillator:

At high frequencies, the performance of a conventional vacuum tube is impaired due to transit time effects, lead inductance and inter-electrode capacitance. Klystron is a microwave vacuum tube employing velocity modulation and transit time in achieving its normal operation. The reflex type known as reflex klystron, has been the most used source of microwave power in laboratory (fig.1).It consists of an electron gun producing collimated electron beam. The electron beam is accelerated towards the reflector (repellor) by a dc voltage V_0, while passing through the positive resonator grids. The velocity of the electrons in the beam will be

$$v_0 = \sqrt{\frac{2eVo}{m}}$$

e = electron charge

m = mass of the electron

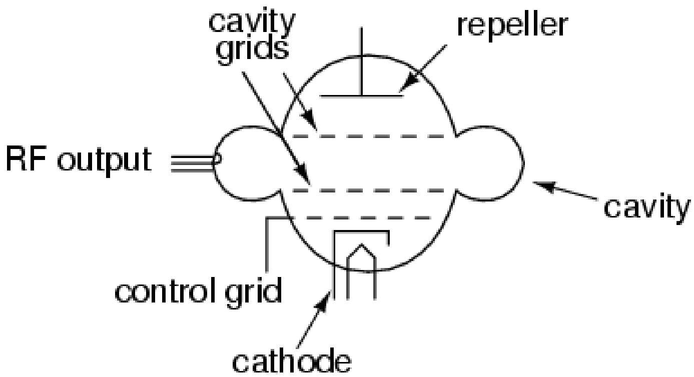


Fig: 1 Reflex Klystron Tube

The repeller, which is placed at a short distance from the resonator grids, is kept at negative potential with respect to cathode. And consequently, it retards and finally reflects the electrons which then turn back through the resonator grids.

Basic Theory of Operation:

To understand the operation of this device, assume that the resonator cavity is oscillating slightly, causing an AC potential, say $V_1\sin\omega t$ in addition to V_o, to appear across the cavity grids. These initial oscillations could be cause by any small disturbance in the electron beam. In the presence of the RF field, the electrons which traverse towards the repeller will acquire the velocity

$$V= \sqrt{\frac{2e(Vo \pm V1\sin wt)}{m}}$$

Thus, we have a velocity modulated beam traveling towards the repeller, having velocities between $V_o\sqrt{1+V_1/V_o}$ and $V_o\sqrt{1- V_1/V_o}$, i. e electrons leaving the cavity during the positive half cycle are accelerated while electrons leaving the cavity during negative half cycle are decelerated. Obviously, the electrons traversing towards the repeller with increased velocity.

i.e., faster ones shall penetrate farther into the region of the repeller field (called drift space) as compared to the electrons traversing towards the repeller with decreased velocity, i.e., slower ones. But the faster electrons, leaving the cavity take longer time to return to it and the faster electrons, therefore, catch up with slow ones. As a result, the resulting electrons group together in bunches. The bunching action is shown in Fig.2.

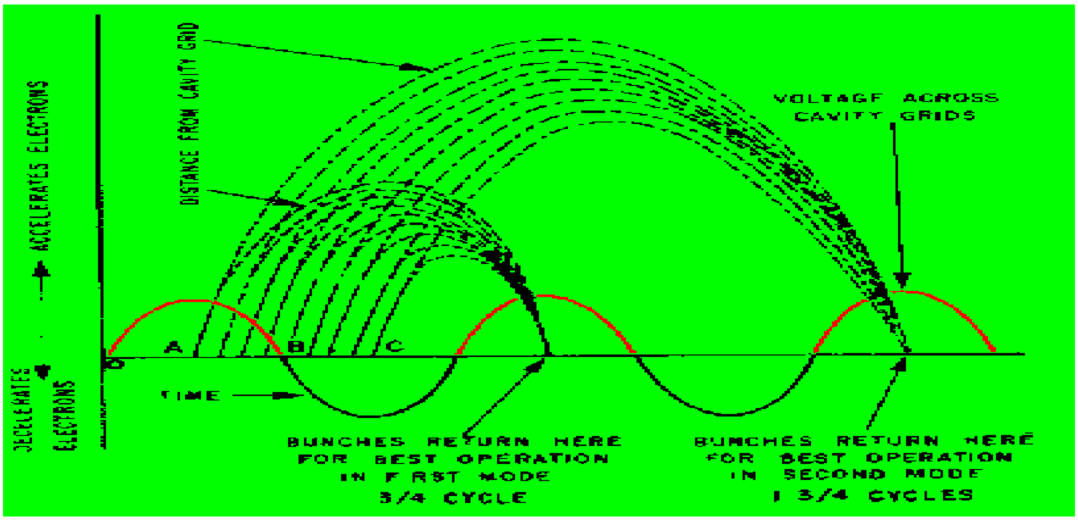


Fig 2: Bunching of Electrons in reflex Klystron Oscillator

As the electron bunches re cross the cavity, they interact with the voltage between the Cavity grids. If the bunches pass through the grids at the time when the grid potential is such that the electrons are severally decelerated, the decelerated electrons give up their energy and this energy reinforces oscillations within the cavity. Hence under these conditions, sustained oscillations are possible. The electrons having spent much of their energy are then collected by the positive cavity wall near the cathode. Thus, it is clear that in its normal operation the repeller electrode does not carry any current and indeed this electrode can severely be damaged by bombardment. To protect the repelled from such damage, the repeller voltage V_R is always applied before the accelerating voltage Vo.

Power Frequency Characteristics:

The cavities used in reflex klystrons do not have infinite Q, as such each mode of operation will be spread over a narrow range of repeller voltages. Fig.3 shows the variation of frequency and power output versus repeller voltages along with mode number. It should, however, be noted that repeller voltage - mode number correspondence is valid only at the center of mode (maximum power) of operation. That is, the repeller voltage needed for the calculations should measured only at the peak (top) of the mode. The variation in repeller voltage from the peak of the mode causes change in transit time, as a result the bunch is either not properly formed or starts de-bunching, thereby decreasing output power and also a slight change in frequency observed.

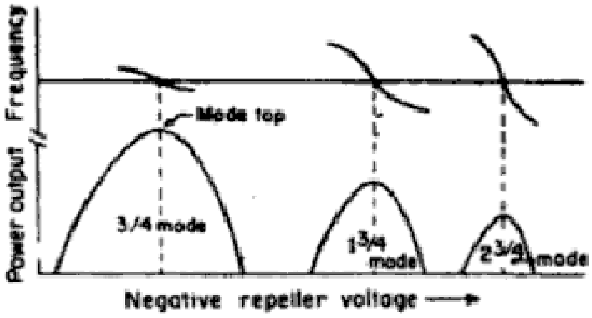


Fig:3 Typical Mode Curves of Reflex Klystron

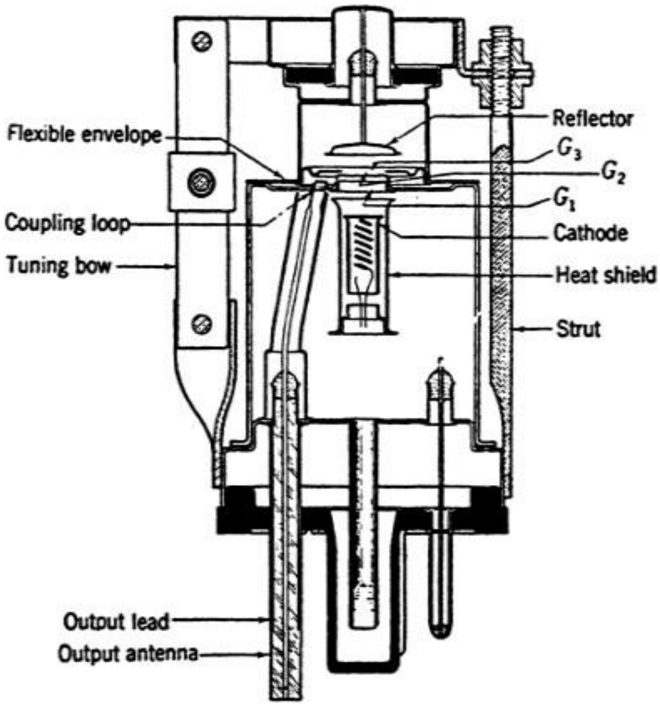


Fig 4: Cross Sectional View Of 2K25 Reflex Klystron

3.Gunn oscillator:

Gunn oscillator uti1izes Gunn diode which works on the principle that when a DC voltage is applied across a sample of n - type Gallium Arsenide; the current oscillates at microwave frequencies. This does not need high voltage as it is necessary for Klystrons and therefore solid state oscillators are now finding wide applications. Normally, they are capable of delivering 0.5 watt at 10GHz, but as the frequency of operation is increased the microwave output power gets considerably reduced.

Gunn oscillators can also be' used as modulated microwave sources. The modulation is generally provided by means of a PIN diode. PIN diode is a device whose resistance varies with the bias applied to it. When waveguide line is shunted with PIN diode and the diode is biased positively, it presents a very high impedance thereby not affecting the line appreciably. However, it is negatively biased, it offers a very low impedance, almost short- circuit thereby reflecting the microwave power incident on it. As impedance varies with bias, the signal is amplitude modulated as the bias varies. Since heavy-power is reflected during the negative biasing of PIN diode, so an isolator or an attenuator should invariably be used to isolate PIN diode and avoid overloading of the latter. Gunn oscillator can also be pulse –modulated, but it is accompanied by the frequency modulation and frequency modulation is not good, so separate PIN modulation is preferred.

4. Isolator:

This unattenuated device permits un attenuated transmission in one direction (forward direction) but provides very high attenuation in the reverse direction {backward direction). This is generally used between the source and rest of the set up to avoid overloading of the source due to reflected power.

5. Variable Attenuator:

The device that attenuates the signal is termed as attenuator. Attenuators are categorized into two categories namely, the fixed attenuators and variable attenuators. The attenuator used in the microwave set is of variable type. The variable attenuator consists of a strip of absorbing material which is arranged in such a way that its profusion into the guide is adjustable. Hence, the signal power to be fed to the microwave set up can be set at the desired level.

6. Frequency Meter:

It is basically a cavity resonator. The method of measuring frequency is to use a cavity where the size can be varied and it will resonate at a particular frequency for given size. Cavity is attached to a guide having been excited by a certain microwave source and is tuned to its resonant frequency. It sucks up some signal from the guide to maintain its stored energy. Thus if a power meter had been monitoring the signal power at the resonating condition of the cavity it will indicate a sharp dip. The tuning of the cavity is achieved by a micrometer screw and a curve of frequency versus screw setting is provided. The screw setting at which the power indication dip is noted and the frequency is read from the curve.

7. Slotted Section:

To sample the field with in a wave guide, a narrow longitudinal slot with ends tapered to provide smoother impedance transformation and thereby providing minimum mismatch, is milled on the top of broader dimension of wave guide. Such section is known as slotted wave guide section. The slot is generally so many wave lengths long to allow many minima of standing wave pattern to be covered. The slot location is such that its presence does not influence the field configurations to any great degree. On this Section a probe inserted with in a holder, is mounted on a movable carriage. The output is connected to detector and indicating meter. For detector tuning a tuning plunger is provided instead of a stub.

8. Matched Load:

The microwave components which absorb all power falling on them are matched loads. These consist of wave guide sections of definite length having tapered resistive power absorbing materials. The matched loads are essentially used to test components and circuits for maximum power transfer.

9. Short Circuit Termination:

Wave guide short circuit terminations provide standard reflection at any desired, precisely measurable positions. The basic idea behind it is to provide short circuit by changing reactance of the terminations.

8. VSWR meter:

Direct-reading VSWR meter is a low-noise tuned amplifier voltmeter calibrated in db and VSWR for use with square law detectors. A typical SWR meter has a standard tuned frequency of 100-Hz, which is of course adjustable over a range of about 5 to 10 per cent, for exact matching in the source modulation frequency. Clearly the source of power to be used while using SWR meter must be giving us a 1000-Hz square wave modulated output. The band width facilitates single frequency measurements by reducing noise while the widest setting accommodates a sweep rate fast enough for oscilloscope presentation. For precise attenuation measurements, a high accuracy 60 db attenuator is included with an expand offset feature that allows any 2 db range to be expanded to full scale for maximum resolution. Both crystal and bolometer may be used in conjunction with the SWR meter. There is provision for high (2,500-10,000 ohm) and low (50-200 ohm) impedance crystal inputs. This instrument is the basic piece of equipment in microwave measuring techniques and is used in measuring voltage peaks valleys, attenuation, gain and other parameters determined by the ratio of two signals.

9. Crystal Detector:

The simplest and the most sensitive detecting element is a microwave crystal. It is a nonlinear, non reciprocal device which rectifies the received signal and produces a current proportional to the power input. Since the current flowing through the crystal is proportional to the square of voltage, the crystal is rejoined to as a square law detector. The square law detection property of a crystal is valid at a low power level (<10 mw). However, at high and medium power level (>10 mw), the crystal gradually becomes a linear detector.

MICROWAVE COMPONENTS

A wave guide consists of a hollow metallic tube of a rectangular or circular shape used to guide an electromagnetic wave. Wave guides are used principally at frequencies in the microwave region. At frequency range x band from 8 to 12 GHz, for example, standard rectangular wave guide, RG - 52/U has an inner width 0.4 in and an inner length 0.9 in.

In wave guides the electric & magnetic fields are confined to the space within the guides. Thus, no power is lost through radiation, and even the dielectric loss is negligible, since the guides are normally air filled. However, there is some power loss as heat in the walls of the guides.

It is possible to propagate several modes of Electromagnetic waves within a wave guide. A given wave-guide has a definite cutoff frequency for each allowed mode and behaves as a high pass filter. The dominant mode in rectangular wave guides is TE_{1O} mode. It is advisable to choose the dimensions of a guide in such a way that for a given input signal only the energy of the dominant mode can be transmitted through the guide.

The cut off frequency for m, n^{th} mode

$$f_c = \frac{c}{2}\sqrt{\left(\frac{m}{a}\right)^2 + \left(\frac{n}{b}\right)^2}$$

The corresponding cut off wave length,

$$\lambda_c = \frac{2}{\sqrt{\left(\frac{m}{a}\right)^2 + \left(\frac{n}{b}\right)^2}}$$

Where c is velocity of light.

a is inner broader dimension of wave guide.

b is inner narrow dimension of wave guide & m, n indicate mode number.

The guide wave length, λg related to free space wave length & cut off wave length is

$$\frac{1}{\lambda_0^2} = \frac{1}{\lambda_g^2} + \frac{1}{\lambda_c^2}$$

Magic Tee Junction:

Wave guide junctions are used to split the line with proper consideration of the phase. The junctions that are widely encountered in microwave techniques are E - plane, H-Plane and Hybrid tees.

* An E-plane tee is designed by fastening a piece of a similar wave guide to the broader wall of a wave guide section. The fastened wave guide, also known as series arm is parallel to the plane of the electric field of the dominant TE_{10} mode in the main wave-guide.

* An H-plane tee is obtained by fastening the auxiliary wave guide perpendicular to the narrow arm of the main wave guide section. The auxiliary arm, also known as shunt arn should lie in the H - plane of the dominant TE_{10} mode in the main wave guide

*Hybrid tee is a combination of the E - plane tee and H plane tee. It has certain characteristics listed below:

1) If two waves of equal magnitude and the same phase are fed into port 1 and port 2, the output will be zero at E - arm and additive at H - arm.

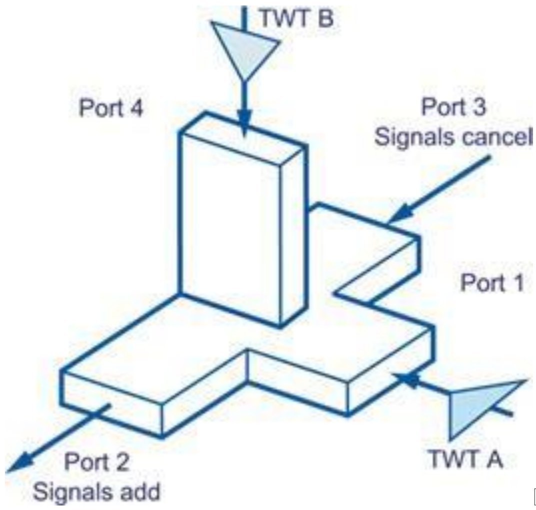
2) If a wave is fed into H - arm, it will be divided equally between port 1 & port 2 of the collinear arms and will not appear at E - arm.

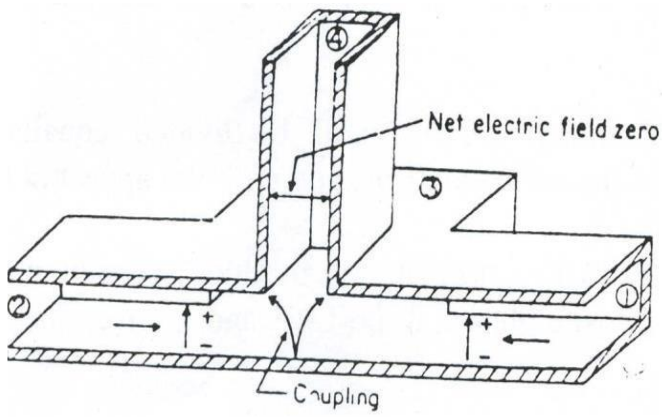
3) If a wave is fed into E - arm, it will produce an output of equal magnitude and opposite phase at port - 1 and port 2. The output at H - arm is zero.

4) If a wave is fed into one of the collinear arms at port 1 or port 2, it will not appear in the other collinear arm at port 2 or 1, because E - am1 causes a phase delay while the H - arm causes a phase advance.

The Scattering matrix of a Magic Tee is given as:

$$[S] = \frac{1}{\sqrt{2}}\begin{bmatrix} 0 & 0 & 1 & 1 \\ 0 & 0 & -1 & 1 \\ 1 & -1 & 0 & 0 \\ 1 & 1 & 0 & 0 \end{bmatrix}$$





(a) Magic Tee (b) Cut way rear view of a wave guide E-H Tee.

The hybrid tee can be used

1) In impedance bridges

2) As antenna duplexer

3) As Mixer

4) As modular, etc.

Directional Coupler (DC):

Directional coupler is a 4-port wave guide junction. It consists of a primary wave guide and a secondary wave guide connects together through apertures. These are uni directional devices. Directional couplers are required to satisfy (1) reciprocity (2) conservation of energy (3) all ports matched terminated. The characteristics of a **DC** can be expressed in terms of its:

1. **Coupling factor**: The ratio, in dB, of the power incident and the power coupled in auxiliary arm in forward direction.

$$C = 10\log_{10}\left(\frac{P_i}{P_c}\right) \text{ dB}$$

Where

P_i = Incident power

P_c = Coupled Power

2. **Directivity**: The ratio expressed in decibels, of the power coupled in the forward direction to the power coupled in the backward direction of the auxiliary arm with un used terminals matched terminated.

$$D = 10\log_{10}(P_c/P_r) \text{ dB}$$

Where P_r=Reverse Power
P_c = Coupled Power

3. Insertion loss: The Ratio, expressed in decibels, of the power incident to the power transmitted in the main line of the coupler when auxiliary arms are matched terminated.

$$I= 10 \log_{10} (Pi / P_{i1})$$

Where P_{i1} = Received power at the transmitted port

Isolation: The ratio, expressed in decibels of the power incident in the main arm to the backward power coupled in the auxiliary arm, with other ports matched terminated.

$$L= 10\log_{10} (Pi/P_r) \text{ dB}$$

For an ideal coupler D & I are infinite while C& L are Zero. Several types of directional couplers exist, such as a two-hole directional coupler, Schwinger directional coupler and Bethe - hole directional coupler. Directional couplers are very good power samplers.

Circulator:

A circulator is a passive microwave component which allows complete transmission from n to (n+ 1) port. Circulator can be constructed with the help of magic tees & gyrator or directional coupler with phase shifter or using ferrite material and so on. A ferrite type circulator employs ferrite material at the center of the junction. This ferrite post will be magnetized normal to the plane of the junction. Electromagnetic wave, which propagates through the ferrite material under goes phase change during its transverse. The phase change is dependent upon the intensity of the magnetic bias and the length of the ferrite rod. The bias & dimensions of the ferrite are so chosen, such that the wave moves unidirectional from n to (n+ 1) port.

The characteristics of the circulator:

1. **Insertion loss: The ratio of power input at port n to the power detected at Port n+1**

$$L= 10 \log_{10}(Pi/ P_r)$$

Where P_i = Incident power at port n

P_r = received power at port n+1

2. **Isolation: The ratio of power at port n to the power detected at port n-l.**

$$I=10 \log_{10}(Pi/ P_3)$$

Where P_i = Incident power at port n

P_3 = received power at port n-1

The scattering matrix of a three-port circulator

$$[S]= \begin{bmatrix} 0 & 0 & 1 \\ 1 & 0 & 0 \\ 0 & 1 & 0 \end{bmatrix}$$

Circulators can be used as (1) de coupling isolators (2) duplexers

FIRING OF THE REFLEX KLYSTRON:

To fire the klystron correctly, adopt the following procedure.

i) Set the cooling fan to blow air across the tube and turn on the filament voltage, and then wait for a few minutes.

ii) Set the attenuator at a suitable level, say at 3db value.

iii) Apply the repeller voltage to its maximum value, say - 250V.

iv) Set the MOD switch of klystron power supply to CW position, Beam Voltage control knob to fully anti clock wise and reflector voltage control knob to fully clock wise and the meter switch to OFF position.

v) Rotate the knob of frequency meter at one side fully.

vi) ON the klystron power supply, VSWR meter and cooling fan for the klystron tube.

vii) Put the meter switch to beam voltage position and rotate the beam voltage knob clockwise slowly up to 300V meter reading, and observe beam current on the meter by changing meter switch to Beam current position.

"The ***beam current should not increase more than 30 mA***"

viii) Adjust the repeller voltage to have maximum power output (micro ammeter current)

ix) If meter goes out of scale, increase attenuation to have suitable power level.

x) Also adjust the klystron mounting plunger for maximum power output and repeat step if desired.

For the best set-up, the attenuator. Must have maximum value corresponding to the peak in the output meter.

1. REFLEX KLYSTRON CHARACTERISTICS

AIM:

To study the mode Characteristics of a Reflex klystron tube and to calculate the electronic tuning range (ETR).

EQUIPMENT:

1. Regulated klystron power supply - 1 No
2. Reflex klystron with mount and cooling fan -1 No
3. Isolator -1 No
4. Variable attenuator -1 No
5. Frequency meter/wave meter -1 No
6. Waveguide detector mount with detector -1 No
7. VSWR meter or micro ammeter -1 No
8. Waveguide stands and accessories

BENCH SET-UP:

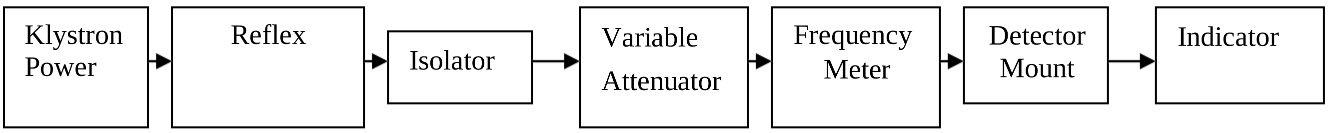


Fig:1

PROCEDURE:

(A) CARRIER WAVE OPERATOR

1) Assemble the equipment as shown in Fig.1 with VSWR meter as indicating meter.
2) Set the variable attenuator at the minimum position.
3) Set the MOD switch of klystron power supply to CW position, Beam Voltage control knob to fully anti clock wise and reflector voltage control knob to fully clock wise and the meter switch to OFF position.
4) Rotate the knob of frequency meter at one side fully.

5) ON the klystron power supply, VSWR meter and cooling fan for the klystron tube.

6) Put the meter switch to beam voltage position and rotate the beam voltage knob clockwise slowly up to 300V meter reading, and observe beam current on the meter by changing meter switch to Beam current position.

"The ***beam current should not increase more than 30 mA***"

7) Change the repeller voltage slowly and watch on the VSWR meter for maximum deflection in the meter. If no deflection is obtained, change the range of meter.

8) Tune the plunger of klystron mount for the maximum output.

9) Rotate the knob of frequency meter slowly and stop at that position, when there is less output on meter. Read directly the frequency between two horizontal line and vertical marker.

10)Change the repeller voltage and read the Power and frequency for each repeller voltage and plot the graph between frequency and voltage, Power and voltage.

(B) Mode Study on Oscilloscope:

1) Assemble the equipment as shown in Fig.1 with VSWR meter as indicating meter.

2) Set the variable attenuator at the minimum position.

3) Set the MOD switch of klystron power supply to FM-MOD/AM-Mod position, with FM/AM amplitude knob and FM/AM frequency knob at mid position, keep the Beam Voltage control knob to fully anti clock wise and reflector voltage control knob to fully clock wise and the meter switch to OFF position.

4) keep the time/div. scale of oscilloscope around 100 Hz frequency and Volt/Div. to lower scale.

5) ON the klystron power supply and cooling fan for the klystron tube.

6) Put the meter switch to beam voltage position and rotate the beam voltage knob clockwise slowly up to 300V meter reading, and observe beam current on the meter by changing meter switch to Beam current position.

"The beam current should not increase more than 30 mA"

7) Change the repeller voltage slowly and watch on the VSWR meter for maximum deflection in the meter. If no deflection is obtained, change the range of meter.

8) Tune the plunger of klystron mount for the maximum output.

9) Now remove the BMC cable from VSWR meter and connect it to CRO.

10) Keep amplitude knob of FM/AM modulator to maximum position.

11) Change the repeller voltage slowly and watch the amplitude of FM/AM modulation on the Oscilloscope, Note the amplitude of output wave.

12) Draw the graph between output power and repeller voltage.

MODEL GRAPH:

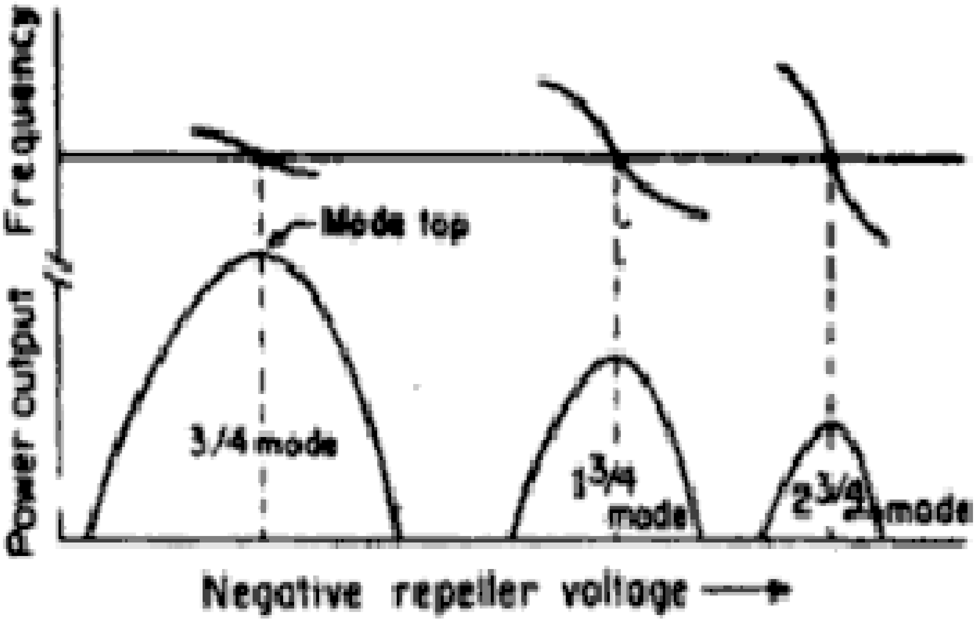


Fig.2: Typical mode curves for a reflex klystron

TABLE:

S. No	Repeller Voltage (In Volts)	CRO/VSWR meter reading (In V/dB)	Frequency meter reading (In Ghz)

Calculate **Electronic Tuning Range**, i.e., the frequency band from one end of the mode to Another, from the graph of V_R vs frequency

The formula for electronic Tuning range is given as

$$ETR = \frac{dV_R}{df}$$

Note: As the repeller voltage increases mode number decreases and power increases.

Inference:

1. Mode charts for Reflex Klystron are drawn.
2. The Electronic tuning range for_____________mode is___________

VIVA QUESTIONS:

1. How bunching takes place in a reflex klystron?
2. Why efficiency of the klystrons is low? Write the expression for it
3. What is the effect of cavity gap on electron bunching?
4. How are the electrons in the reflected beam collected in a reflex klystron?
5. Is some beam focusing arrangement needed in anode-reflector space?
6. What do you mean by velocity and density modulations? How do these differ from frequency and phase modulations?
7. Why is it necessary to cool the klystrons?
8. The two cavity Klystron uses what cavity as an output cavity?
9. What element of the reflex Klystron replaces the output cavity of a normal Klystron?
10. If the constant speed electrons in reflex klystrons remain in the repeller field for 1 ¾ cycle what is the mode of operation?

Real Time Applications:

- Bunching takes place in a reflex klystron
- Beam focusing arrangement needed
- Efficiency of the klystrons is low
- Two cavity Klystron uses cavity as an output cavity
- Velocity and density modulations

2. GUNN DIODE CHARACTERISTICS

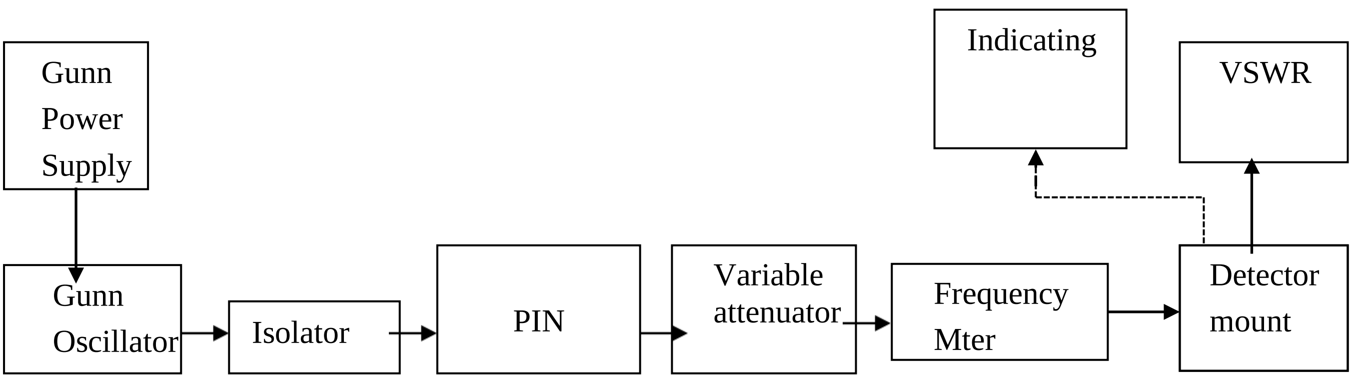
AIM:

To study Gunn oscillator as a source of microwave power and hence to study V-I characteristics of Gunn diode

EQUIPMENT:

1. Gunn oscillator -1No
2. Gunn oscillator power supply - 1 No
3. PIN diode modulator - 1 No
4. Ferrite isolator - 1 No
5. Frequency meter - 1 No
6. Attenuator - 1 No
7. Detector with tunable mount - 1 No
8. VSWR meter - 1 No
9. Cathode Ray Oscilloscope - - 1 No
10. Coaxial to waveguide adapter - 1 No
11. Cables and accessories

BENCH SET-UP:



PROCEDURE:

1. Set the equipment as shown in Fig. Taking due care for biasing PIN and Gunn diodes.
2. Initially set variable attenuator for minimum attenuation.
3. Keep the control knobs for gunn power supply as below Meter

    switch - OFF

    Gunn bias Knob - Fully anti-clock wise PIN bias

    Knob - Fully anti clock wise

    PIN mod Frequency - Any position

4. Set the Gunn oscillator micrometer tuning screw at suitable frequency say 9 GHz. Adjust attenuator for suitable power level.
5. Switch On the Gunn power supply.

(a)Voltage- Current Characteristics:

1. Turn the meter switch of Gunn Power supply to Voltage position.

2. Measure the Gunn diode current corresponding to various Voltages controlled by Gunn bias knob through the panel meter and meter switch. **Do not exceed the bias voltage above 10 volts.** Note the values in table 1.

3. Plot the voltage and current readings on the graph sheet that must be as shown in fig 5.1.

4. Measure the threshold voltage which corresponds to Maximum current.

NOTE: Do not keep Gunn bias knob position at threshold position for more than 8- 10 Seconds. Reading should be obtained as fast as possible. Otherwise, due to excessive Heating, Gunn diode may burn.

Tabular Column:

S.no	Voltage (in Volts)	Current (in mA)	Peak Voltage (From the graph)
1			
2			
3			
4			
5			

(B) Square Wave Modulation:

1. Keep the Meter switch to volt position and rotate Gunn bias voltage slowly so that panel meter of Gunn power supply reads 10 V.

2. Tune the PIN modulator bias voltage and frequency knob for maximum output on the Oscilloscope.

3. Coincide the bottom of the square wave in oscilloscope to some reference level and note the micrometer reading of variable attenuator.

4. Now with help of variable attenuator coincide the top of square wave to *SAME* reference level and note down the micrometer reading.

5. Connect VSWR meter to detector mount and note down the dB reading in VSWR meter for both the micrometer reading of the variable attenuator.

6. The difference of both db reading of VSWR meter gives the modulation depth of PIN modulator.

CALCULATIONS:

Micrometer reading when bottom of square wave coincides with reference (m1) = Corresponding reading of VSWR meter for m1 (P1) = Micrometer reading when top of square wave coincides with same reference (m2) = Corresponding reading of VSWR meter for m2 (P2) = Modulation depth of PIN modulator = (P2-P1)

MODEL GRAPH:

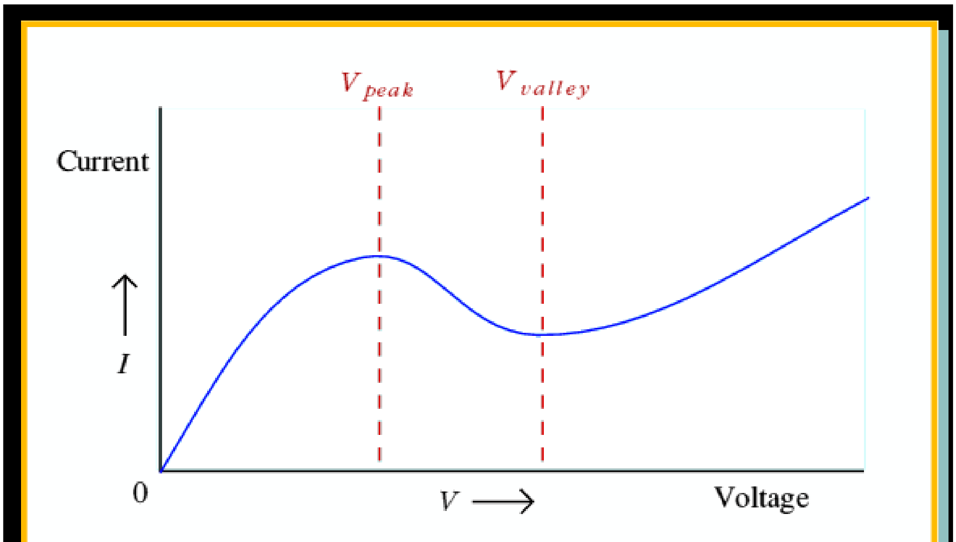


Figure 5.1 I/V curve of a Gunn diode.

Inferences:

The characteristics of Gunn diode are plotted and Modulation depth for PIN modulator is calculated.

VIVA QUESTION:

1. What are various modes of Gunn diode?
2. What is a PIN diode and how does it work as amplitude modulator?
3. Why are Gunn diode devices classified as voltage-controlled devices?
4. Compare and contrast Gunn diode oscillator with a reflex klystron Oscillator
5. Name some crystals from which Gunn diode may be manufactured.
6. Write the RWH criteria for negative resistance.
7. Write the criteria for classifying modes in gunn diode.
8. For LSA mode f*L >___________________?
9. For stable Amplification mode $n_0 * L =$ ________________________?
10. For delayed domain mode f* L lies between_________________________________?

Real Time Applications:

- Gunn diode can be operated in various modes.
- Gunn diode devices classified as voltage-controlled devices
- Efficiency of the gunn diode is high.
- Gunn diode may be manufactured from different crystals
- Velocity and density modulations

3. ATTENUATION MEASUREMENT

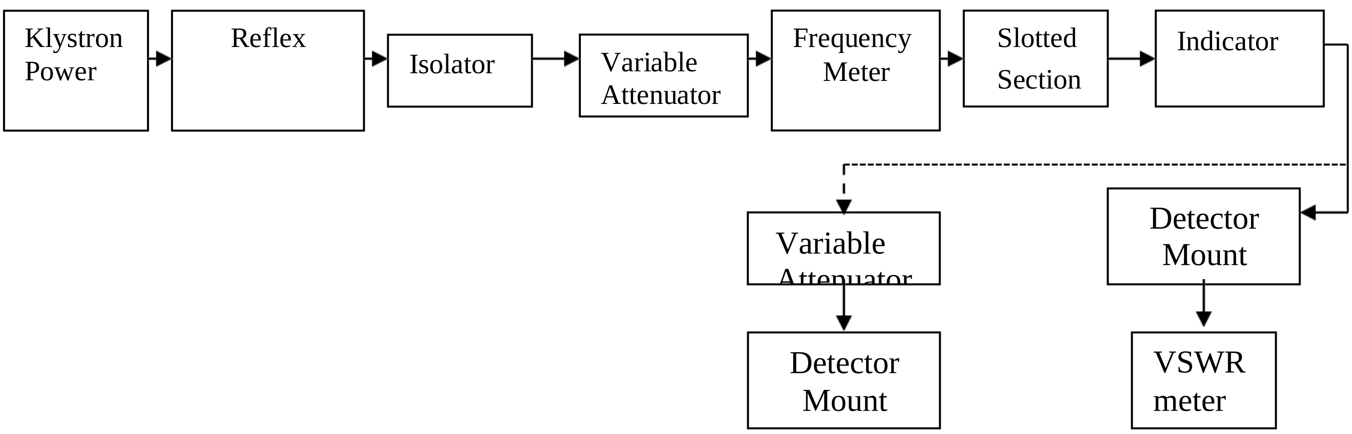
AIM:

To study the attenuator and to calculate the attenuation provided by variable attenuator.

EQUIPMENT:

1. Regulated klystron power supply -1No
2. Reflex klystron with mount and cooling fan -1 No
2. 3. Isolator -1 No
4. Variable attenuator -2 No
5. Frequency meter. -1 No
6. Slotted Line section -1 No
7. Tunable probe -1 No
8. Waveguide detector mount with detector -1 No
9. V SWR meter or micro ammeter - 1 No
10. C.R. O - 1 No
11. Waveguide stands and accessories

BENCH SET-UP:



Setup 1 Setup 2

Fig:1

THEORY:

The attenuator is a two-port bi-directional device which attenuates some power when inserted into the transmission line.

* Attenuation A(dB)= 10 log [P1/P2]

Where P1 =Power absorbed by load without attenuator in the line.

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

PROCEDURE:

For Insertion loss/ Attenuation measurement

3. Assemble the equipment as shown in setup 1.
4. Fire the reflex klystron by considering all the proper conditions.
5. Tune the detector mount for maximum deflection on VSWR meter [detector mount's output should be connected to VSWR meter]
6. Set any reference level on the VSWR meter with the help of variable attenuator and gain control knob of VSWR meter, Let it be P1.
7. Carefully disconnect the detector mount from the slotted line without disturbing any position of the setup. Place the test Variable attenuator to the slotted line and detector mount to other port of test variable attenuator.
8. Keep the micrometer reading of test attenuator to Zero and record the reading of VSWR meter let it be P2. Then the Insertion Loss of the test attenuator will be (P1- P2) dB.
9. Now change the micrometer reading and record the VSWR meter reading in table. Find out attenuation value for different position of micrometer reading and plot the graph.

TABLE:

Sl. No	Micrometer reading	VSWR meter reading P2 (dB)	Attenuation (P1-P2) dB
1.			
2.			
3.			
4			
5			
6			
7			

RESULT: Attenuation provided by variable attenuator is studied and calculated.

VIVA QUESTIONS:

1. What do you mean by attenuation?
2. What is an attenuator?
3. How does attenuator differ from an isolator?
4. How does a ferrite attenuator differ from a carbon pad?
5. Why absolute measurement of attenuation is essential?
6. Which type of waveguide attenuation have relatively high accuracy andgreater versatility and why?
7. What are various types of attenuators present in waveguide systems?
8. What is Flap attenuator?
9. What is Vane attenuator?
10. What are the various uses of attenuator? Real

Time Applications:

- Bunching takes place in a reflex klystron
- Beam focusing arrangement needed
- Efficiency of the klystrons is low
- Two cavity Klystron uses cavity as an output cavity
- Velocity and density modulations

4. DIRECTIONAL COUPLER CHARACTERISTICS

AIM:

To calculate the Isolation, coupling coefficients, and directivity.

EQUIPMENT:

1. Regulated klystron power supply - 1 No
2. Reflex klystron with mount and cooling fan -1 No
3. Isolator -1 No
4. Variable attenuator -1 No
5. Frequency meter/wave meter -1 No
6. Waveguide detector mount with detector -1 No
7. VSWR meter or micro ammeter -1 No
8. Matched Terminations - 3 No
9. Two-hole Directional Coupler - 1 No
10. Slotted section - 1 No
11. Waveguide stands and accessories

BENCH SET-UP:

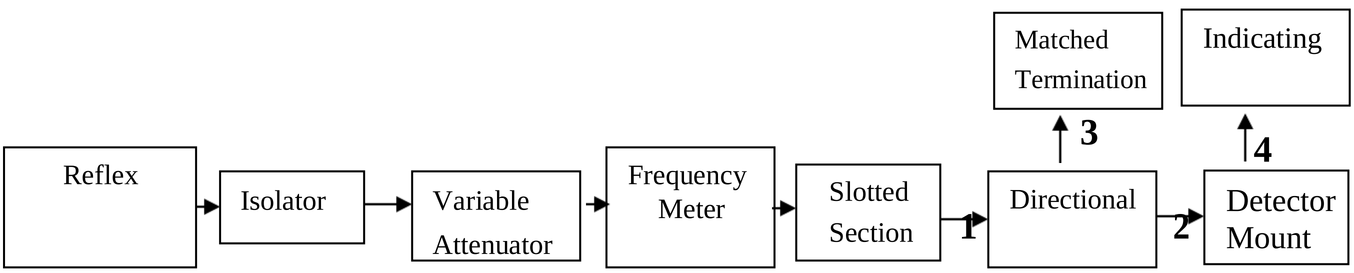


Fig: 1

PROCEDURE:

1) Assemble the set up as shown in fig. 1 by connecting mount detector initially instead of Directional Coupler.

2) By taking care about Reflex klystron, energize reflex klystron to obtain maximum power in the VSWR meter.

3) Adjust variable attenuator for reasonable power level say 30db. Record the power level. This is power level at the output of the slotted section and hence it is the input power, Pi to the Directional Coupler in the set up

4) Carefully remove the detector set up and insert the Directional Coupler as in the set up with port 3 terminated with matched load.

5) Determine power at port 2 in decibels by noting the change in the output level on the indicating meter, let it be P_2.

6) Interchange the positions of the detector set up and matched load and determine power in db by noting the change in output power level (with reference to level in step 3) at port 3, Let it be P_3

7) Repeat steps 4 to 7 for port 2 and port 3 also.

8) Calculate the Coupling factor, Isolation and Directivity using the formulas: Isolation i-j

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

Coupling coefficient $= 10 \log (P_i/P_j)$

Directivity =

Where Pi= power delivered from port i Pj=

power detected at j^{th} arm

10 Calculate all the input and output powers at all the ports.

11) By using the standard scattering matrix of a Directional Coupler, verify the scattering parameters theoretically and compare both practical and theoretical values.

12) Determine the frequency of the exciting wave using frequency meter.

RESULT:

The Isolation, coupling coefficients, and directivity are calculated.

VIVA QUESTIONS:

1. Which dimension of the waveguide determines the frequency range?
2. What is the primary Purpose of directional coupler?
3. In which direction maximum directivity of a directional coupler should be?
4. State the applications of directional coupler?
5. Give the examples of non-reciprocal devices.
6. How the performance of a directional coupler can be determined?
7. The distance between two holes in a directional coupler is____________________
8. What is the function of absorbent material in directional coupler?
9. What happens to reflected energy that enters a directional coupler that is designed to sample incident energy?
10. What will happen in waveguide when an impedance mismatch occurs?

Real Time Applications:

- Dimension of the waveguide determines the frequency range
- Maximum directivity of a directional coupler should be high.
- The performance of a directional coupler can be determined.
- Function of absorbent material in directional coupler.
- Reflected energy that enters a directional coupler that is designed to sample incident energy

5. SCATTERING PARAMETERS OF WAVE GUIDE COMPONENTS

AIM:

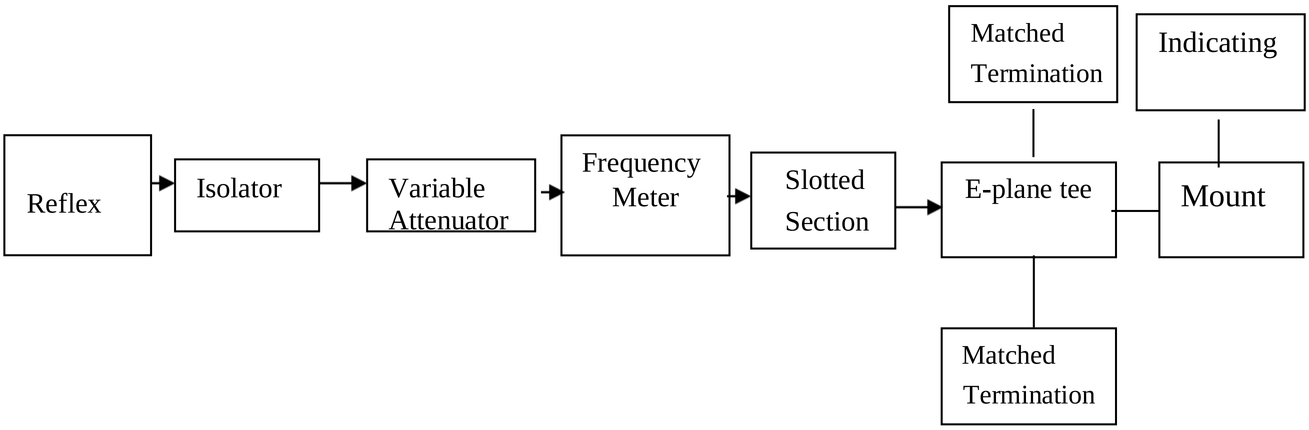
(a)To calculate the Isolation and coupling coefficients,

(b)To verify scattering parameters of a E-plane tee

EQUIPMENT:

1. Regulated klystron power supply - 1 No
2. Reflex klystron with mount and cooling fan -1 No
3. Isolator -1 No
4. Variable attenuator -1 No
5. Frequency meter/wave meter -1 No
6. Waveguide detector mounts with detector -1 No
7. VSWR meter or micro ammeter -1 No
8. Slotted Section -1 No
9. Matched Terminations - 3 No
10. Waveguide stands and accessories

BENCH SET-UP:



PROCEDURE:

1) Assemble the set up as shown in fig. 1by connecting mount detector initially instead of Magic tee.

2) By taking care about Reflex klystron, energize reflex klystron to obtain maximum power in the VSWR meter.

3) Adjust variable attenuator for reasonable power level say 30db. Record the power level. This is power level at the output of the slotted section and hence it is the input power, Pi to the magic tee in the set up

4) Carefully remove the detector set up and insert the magic tee as in the set up with port 3 and 4 terminated in matched loads.

5) Determine power at port 2 in decibels by noting the change in the output level on the indicating meter, Let it be P_2 .

6) Interchange the positions of the detector set up and matched load and determine power in db by noting the change in output power level(with reference to level in step 3) at port 3, Let it be P_3

7) Interchange the positions of the detector set up and matched load and determine power in db by noting the change in output power level (with reference to level in step 3) at port 4, let it be P_4

8) Repeat steps 4 to 7 for port 2, port 3 and port 4.

9) Calculate the Coupling factor, Isolation using the formulas: Isolation

$$i\text{-}j = 10 \log_{10} (P_j / P_i)$$

Coupling coefficient = $10 \log (P_i/P_j)$

Where Pi=power delivered from port i Pj= power detected at j^{th} arm

10) Calculate all the input and output powers at all the ports .

11) By using the standard scattering matrix of a magic tee, verify the scattering parameters.

12) Determine the frequency of the exciting wave using frequency meter.

RESULT:

The Isolation and coupling coefficients are calculated.

VIVA QUESTIONS:

1. If the power is applied at port 4 then the power is__________________________
2. If the power is applied at port 1 then the power is__________________________
3. If the power is applied at port 2 then the power is__________________________
4. If the power is applied at port 3 then the power is__________________________
5. Which field configurations is easy to produce in waveguide?
6. Write the applications of magic Tee.
7. Which term is used to identify various field configurations that can exist in a waveguide?
8. What is magic tee?
9. What is magic in magic tee?
10. Magic tee is combination of______

Real Time Applications:

- Dimension of the waveguide determines the frequency range
- Maximum directivity of a directional coupler should be high.
- The performance of a directional coupler can be determined.
- Function of absorbent material in directional coupler.
- Reflected energy that enters a directional coupler that is designed to sample incident energy

6. FREQUENCY MEASUREMENT

AIM:

To determine the frequency and wavelength in a rectangular waveguide working in TE10 mode

EQUIPMENTS:

1. Regulated klystron power supply -1 No
2. Reflex klystron with mount and cooling fan -1 No
3. Isolator -1 No
4. Variable attenuator -2 No
5. Frequency meter. -1 No
6. Slotted Line section -1 No
7. Tunable probe - 1 No
8. Waveguide detector mount with detector - 1 No
9. V SWR meter or micro ammeter - 1 No
10. C.R. O - 1 No
11. Waveguide stands and accessories

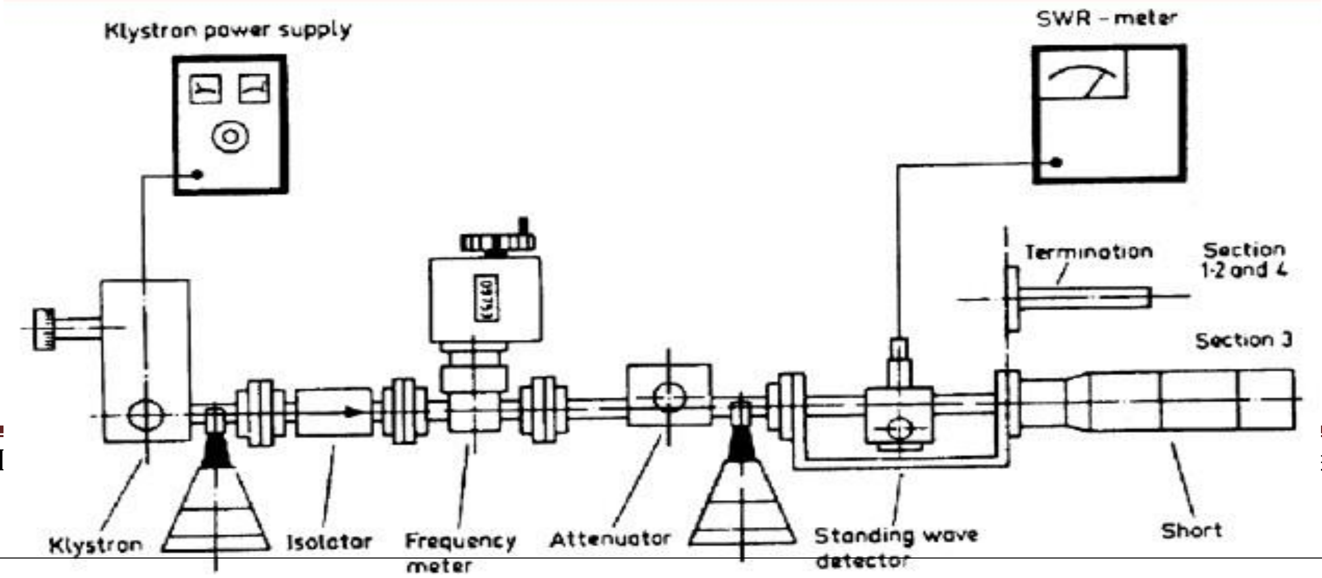
THEORY:

For dominant TE10 mode in rectangular waveguide λ0, λg, and λc are related as below:

$$\frac{1}{\lambda_o^2} = \frac{1}{\lambda_g^2} + \frac{1}{\lambda_c^2}$$

Where
λo is free space wavelength, λg is guide wavelength and λc is cutoff wavelength
For TE10 mode, λc = 2a, where a is broad dimension of waveguide.

BLOCK DIAGRAM:



PROCEDURE:

1. Set up the components and equipments as shown in Fig. 1.
2. Set the variable attenuator at maximum position.
3. Keep the control knobs of VSWR meter as below: Range db 50 db position Input Switch Crystal low Impedance Meter switch Normal position
Gain (Coarse & fine) Mid Position
4. Keep the control knobs of Klystron power supply as below: Meter switch 'Off'
Mod-switch AM
Beam Voltage knob fully anticlockwise Reflector Voltage Fully clockwise
AM-Amplitude knob around fully clockwise AM-Frequency knob Around Mid Position
5. Switch 'ON' the Klystron power supply, VSWR Meter and cooling fan.
6. Rotate the meter switch of power supply to beam voltage position and set beam voltage at 300 V with 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 VSWR meter.
12. Tune the frequency meter knob to get a 'dip' on the VSWR scale and note down the frequency directly from 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 position, 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 broad dimension 'a' which will be around 2.286cm for X- band.

18. Calculate the frequency by following equation:

$$f = \frac{c}{\lambda_o} = c\sqrt{\frac{1}{\lambda_g^2} + \frac{1}{\lambda_c^2}}$$ where $c = 3 \times 10^8$ meter/sec. i.e. velocity of light.

19. Verify with frequency obtained by frequency meter.
20. Above experiment can be verified at different frequencies.
21. Record the experimental results in a tabulated form as per format given below:

TABLE:

Guided wavelength measured λ_g	Calculated f_o	Phase velocity $(f_o \lambda_g) = v_p$	Group velocity $(f_o \lambda_o)^2 / f_o \lambda_g = v_g$	Remark

RESULT:

The frequency and wavelength in a rectangular waveguide working in TE10 mode is calculated.

VIVA QUESTIONS:

1. What is the function of frequency meter in microwave bench?
2. What is the technique for measuring the frequency?
3. What technique is used for measuring frequency accurately?
4. Compare and contrast Gunn diode oscillator with a reflex klystron Oscillator
5. Name some crystals from which Gunn diode may be manufactured.
6. Write the RWH criteria for negative resistance.
7. Write the criteria for classifying modes in gunn diode.
8. For LSA mode f*L >___________________?
9. For stable Amplification mode $n_0 * L =$ ________________________?
10. For delayed domain mode f* L lies between_________________________________?

Real Time Applications:

- Gunn diode can be operated in various modes.
- Gunn diode devices classified as voltage-controlled devices
- Efficiency of the gunn diode is high.
- Gunn diode may be manufactured from different crystals
- Velocity and density modulations.

7. IMPEDANCE MEASUREMENT

AIM:

To measure the unknown impedance of a given component.

EQUIPMENT:

1. Klystron Power Supply (SKPS-610)
2. Klystron Tube (2K-25) with Klystron Mount (XM-25),
3. Isolator (XI -621), Frequency Meter (XF- 710),
4. Variable Attenuator (XA-520),
5. Slotted line (XS 565),
6. Tunable probe (XP-655),
7. Detector Mount (XD-451),
8. Wave Guide Stand (XU-535),
9. VSWR Meter (SW-115),
10. Movable short/ Termination (XL 400) or any unknown load,
11. BNC -BNC Cable.

THEORY:

The unknown terminating impedance can be determined by measuring standing wave ratio & distance of a convenient maxima or minima from the load. Normally for distance measurement minima is used because it is more sharply defined. The unknown load admittances is given by the transmission equation as

$$Z_L^l \quad \frac{1 - jS\ TanQ.\ d_{min}}{S - j\ Tan\ Q.\ d_{min}}$$

Where, S = VSWR

dmin = distance of first minima from the load.

A screw projecting into the waveguide offers variation in the admittance with the insertion of the screw. The depth of screw, changes only the reactive part of the admittance, so if the line is matched, the load offered by the screw for a certain depth is

Y = 1 + j b

Where *b* is the susceptance due to the screw

The unknown impedance can also be determined by using Smith chart, once the VSWR and position of minima is known with the load.

EXPERIMENTAL SET UP:

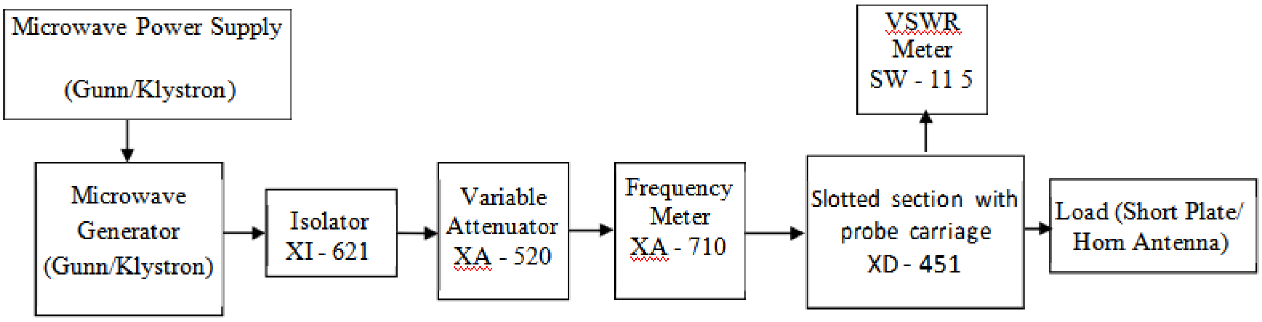


Fig .6.1 Experimental set up for Impedance Measurement

Procedure:

1. Set up the equipment's as shown in Fig.6.1.
2. Keep variable attenuator at maximum position.
3. Keep the Control knobs of VSWR meter as below:

   Range dB ---40dB/50dB

   Input Switch---------------------------------------Impedance Low

   Meter Switch--------------------------------------Normal

   Gain (Coarse-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 approximately

1. ON' the Klystron Power Supply, VSWR Meter and Cooling Fan.
2. Turn the Meter Switch of Klystron Power Supply to beam voltage position and set the beam voltage between 240V to 300V.
3. Assemble the components with detector as load.
4. Move the probe carriage to the position of voltage maximum and adjust detector tuning for peak meter reading when attenuator is set to suitable level.
5. Measure VSWR when load end is terminated with a matched load. If it is greater than 1.02, reduce it to this value by adjusting probe depth and stub length or with tuning section.
6. Terminate the line with load (horn) and measure load VSWR and Guide wavelength λg
7. Note down the position of voltage minimum (d3).

8. Remove the horn carefully and terminate the line in a short circuit. Record the position of minimum (shift <λg /4) towards generator end (d4).
9. Calculate shift in minimum of load from reference plane d = d4 - d3 in wavelength units (d / λg).
10. Calculate the load impedance using below formula:

$$Z_L = y \cdot Z'_L \textbf{ Ohms,}$$

Where y is Free Space Impedance i.e., 377 Ω or 120π

$$Z'_L \quad \frac{1 - jS\,Tan Q.\,d_{min}}{S - j\,Tan\,Q.\,d_{min}}$$

CALCULATIONS:

S (VSWR Value of the Horn Antenna) =1

d_1 =__cm

d_2 =_____cm

$\lambda_g = 2(d_1 - d_2) =$ ____ cm

$\beta = 2/\lambda_g =$ ______

d_3 =___cm

d_4 =_____cm

$d_{min} = d_4 - d_3 =$______cm

$Z'_L \quad \frac{1-jS\ TanQ.d_{min}}{S-j\,Tan\ Q.d_{min}} =$ ________ Ω

$Z_L = y \cdot Z'_L =$ ________**ohms**

Result: Hence we observed the impedance of a given load

Viva Questions:

1. What is impedance?

2. Why impedance matching is required?

3. What happens impedance mismatched condition?

4. What are the techniques used to measure impedance?

5. What are the differences in between single and double stub?

8. VSWR MEASUREMENT

AIM:

To determine the standing-wave ratio and reflection coefficient.

EQUIPMENT:

1. Regulated klystron power supply - 1 No
2. Reflex klystron with mount and cooling fan -1 No
3. Isolator -1 No
4. Variable attenuator -1 No
5. Frequency meter/wave meter -1 No
6. Waveguide detector mount with detector -1 No
7. VSWR meter or micro ammeter -1 No
8. Waveguidestandsandaccessories - 1No
9. BNC cables
10. S-S Tuner.

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 presence of two traveling waves gives rise to standing wave along the line. The maximum field strength is found where two waves are in phase and minimum where they are in opposite phase. The distance between two successive minimum (or maximum) is half the guided wave-length 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 ratio between maximum and minimum field strength along the line. Hence VSWR is

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

Where $|E_I|$ and $|E_R|$ are respectively the amplitudes of the incident and reflected electric field strengths. Standing wave ratio is frequently expressed in decibels

$$\text{VSWR (db)} = 20 \log_{10} \frac{E_{max}}{E_{min}}.$$

Further, the ratio of the reflected to the incident electric field intensities is defined as reflection coefficient, i.e.,

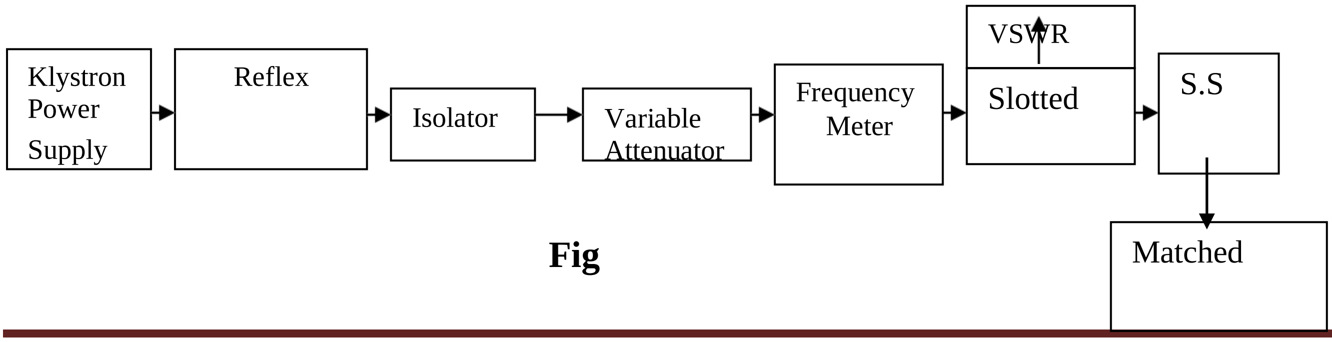
$$\Gamma_R = \frac{E_R}{E_I} = \frac{Z_L - Z_0}{Z_L + Z_0}.$$

Where *ZL* is the load impedance and Z0 is the characteristic impedance. Hence, VSWR can be expressed in terms of reflection coefficient as follows:

$$S = \frac{1 + \Gamma_R}{1 - \Gamma_R}.$$

when *E* max = *E* min , i.e., there is no reflection [*E R* = 0], the resulting VSWR=1.00, this is the requirement of a 'matched circuit'. In other words, under given ideal conditions, the VSWR of a matched load is 1.00. Under extreme mismatch conditions, *E* min =0, i.e., total reflection, [*E R* = *E I*], the resulting VSWR =∞. However, in most of the cases, VSWR is greater than 1.00. It is not rare to obtain VSWR as low as 1.02 in well-designed set-up having matched components.

BENCH SET-UP:



Fig

PROCEDURE:

1. Equipments are set up as shown in Fig.
2. Variable attenuator is kept at maximum position.
3. Control knobs of VSWR meter are kept as below:

Range db - 40 db/50 db

Input switch - Impedance low Meter

switch - Normal

Gain (Coarse-Fine) - Mid position approx.

4. The control knobs of Klystron power supply are kept as below: Meter switch - 'OFF'

Mode switch - 'AM'

Beam voltage knob - Fully Anticlockwise Reflector voltage knob - Fully clockwise

AM frequency & amplitude knob Mid position

5. Klystron power supply, VSWR meter and cooling fan are switched ON.

6. Meter switch of Klystron power supply is switched to Beam voltage position and beam voltage is set at 300 V.

7. Reflector voltage knob is rotated to get deflection in the VSWR meter.

8. Output is tuned by tuning the reflector voltage, amplitude and frequency of AM modulation.

9. The plunger of Klystron mount is tuned for maximum deflection. The probe of the slotted waveguide can also be tuned for maximum deflection.

10. The db range switch, gain control knob of the VSWR meter can also be adjusted along with the variable attenuator of the set up to get deflection in the VSWR meter if found necessary.

11. If the probe is moved along the slotted line, the deflection will be changing.

A) Measurement of Low and Medium VSWR (VSWR<10)

1. The probe is moved along the slotted line for maximum deflection in the VSWR meter.

2. The gain control knob of the VSWR meter or the variable attenuator is adjusted until the meter indicates 1.00 on normal SWR scale (0- ∞).

3. Keeping all control knobs as it is, the probe is adjusted for minimum position on the SWR reading. The VSWR meter reading is recorded (SWR meter reading at the minimum, when the maximum is set for 1.00, gives directly the VSWR)

4. The above step is repeated by moving the probe along the slotted line in the same direction for more number of minimum position and the corresponding VSWR readings are recorded.

5. If the VSWR is between 3.20 and 10.00, the range db switch is changed to next higher position and the VSWR reading is taken by the VSWR scale of 3.00 to 10.00.

6.This way the table 2.1 is completed for the unknown load at different frequencies by repeating the above steps 1 to 5.

Table: Low and medium VSWR measurements

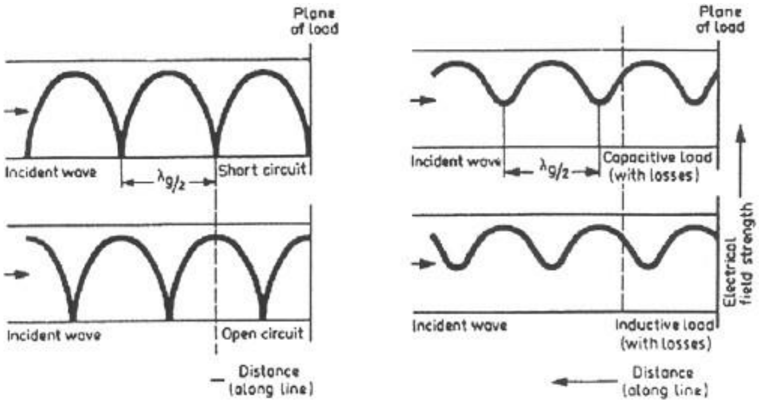
SI. No.	VSWR (dB)	Frequency (GHz)
1. 2. 3. 4.		

B) Measurement of High VSWR:

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

$$SWR = \lambda g / \prod (d2-d1)$$

MODEL GRAPH:



RESULT:

The standing-wave ratio and reflection coefficient is determined.

Viva Questions

1. How bunching takes place in a reflex klystron?
2. Why efficiency of the klystrons is low? Write the expression for it
3. What is the effect of cavity gap on electron bunching?
4. How are the electrons in the reflected beam collected in a reflex klystron?
5. Name some crystals from which Gunn diode may be manufactured. 6.Write the RWH criteria for negative resistance.

7.Write the criteria for classifying modes in gunn diode. 8.What is the primary Purpose of directional coupler?

9.In which direction maximum directivity of a directional coupler should be? 10.State the applications of directional coupler?

Real Time Applications:

- Dimension of the waveguide determines the frequency range
- Maximum directivity of a directional coupler should be high.
- The performance of a directional coupler can be determined.
- Function of absorbent material in directional coupler.
- Reflected energy that enters a directional coupler that is designed to sample incident energy

9. CHARACTERIZATION OF LED

AIM:

a) To plot the volt-ampere characteristics of a LED.

b) To determine the cut-in voltage, dynamic & static forward bias resistance.

EQUIPMENT:

1. Semiconductor trainer module containing bread board
2. LED CQ124
3. 1KΩ - resistor – 1no.
4. Voltmeter (0-30V)
5. Ammeter (0-200mA)

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.

Different technologies employed in chip fabrication lead to significant variation in parameters for various emitter diodes. All the emitters distinguish themselves in offering high output power coupled in to the important peak wavelength of emission, conversion efficiency, to be useful in fiber transmission applications as LED must have a high radiance output. Fast emission response time and high quantum efficiency, its radiance is a measure of optical power radiated into unit solid angle per unit area of the emitting light source. High radiances are necessary to couple sufficiently high optical power levels into a fiber.

EXPERIMENTAL SET UP:

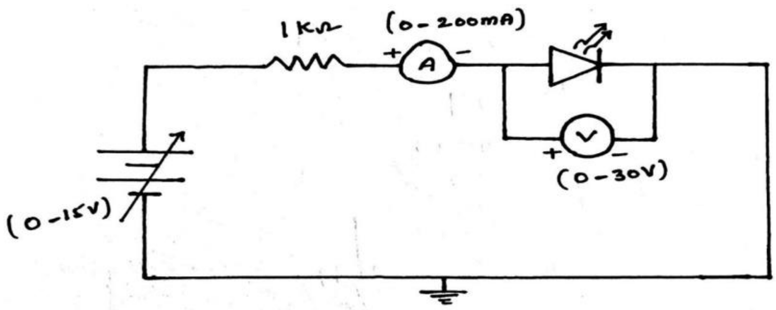


Fig.1.1 Circuit diagram to obtain V-I characteristics of LED

MODEL GRAPH:

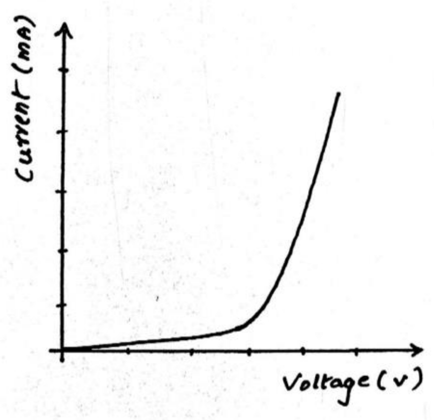


Fig.1.2 V-I characteristics of LED

PROCEDURE:

1. Connect the equipment as shown in Fig.1.1
2. Use CQ124 LED and make it forward bias connection.
3. Increases the voltage applied to diode gradually in steps and note the ammeter andvoltmeter readings and plot is drawn

Table1.1 Tabular column to note down the Voltages and Currents:

Sno	Voltage(V)	Current (mA)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		

PRECAUTIONS:

1. Do not connect the ammeter across the supply (or) to diode.
2. Do not connect the voltmeter in series with the diode.
3. Select the meters of proper range which are somewhat greater than required ratings.

CALCULATIONS:

Cut in voltage=______Volts

Static Resistance = $\frac{V}{I}$= _______ KΩ

Dynamic Resistance = $\frac{\Delta V}{\Delta I}$= _______KΩ

Result: The V-I characteristics of LED are plotted

Model Viva Questions:

1. What is the basic principle of LED?
2. LED is coherent or non-coherent? Explain.
3. Which type of materials are used for the manufacture of LEDs?
4. What are direct and indirect materials, between them which one is used for LED
5. What is the difference between LED and Laser?
6. What is the difference between recombination process of direct and indirect materials.
7. What is the frequency and wavelength of the LED used in your experiment?
8. Define threshold voltage for LED?
9. Give the applications and advantages of LED?

10. CHARACTERIZATION OF LASER DIODE.

AIM:

To study V-I Characteristic of Laser Diode.
To study P-I Characteristic of Laser Diode.

EQUIPMENT:

1. Link – E Fiber Optic Trainer Kit.
2. Glass Fiber Cable with ST connector: 1 No.
3. Patch cords.
4. Voltmeter. (1 No)
5. Ammeter. (1 No)
6. Power Supply.

THEORY:

To obtain a laser action in a semiconductor, the medium should be prepared in a forma p-n junction diode with highly degenerate p- type and n-type region, in this way the inverse is produced in the junction region. this can be achieved by forward biasing the junction. when the junction Is forward biased with a voltage that is nearly equal to the energy gap voltage, electron and holes are injected across the junction in sufficient number to create a population inversion in a narrow zone called the active region.

The amount of population inversion, and hence the gain is determined by the current flowing in the laser diode. At low current values the losses offset lasing action. In this case the radiation exists due to spontaneous emission which increases linearly with the drive current. Beyond a critical value of the current (the threshold value), the lasing commences and the radiative out pout increases rapidly with increasing current, as shown in fig 2.1.

Experimental set up:

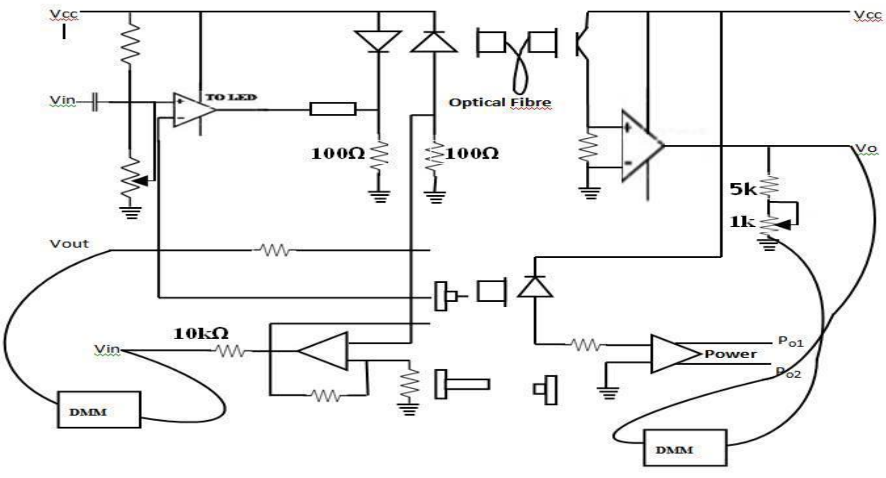
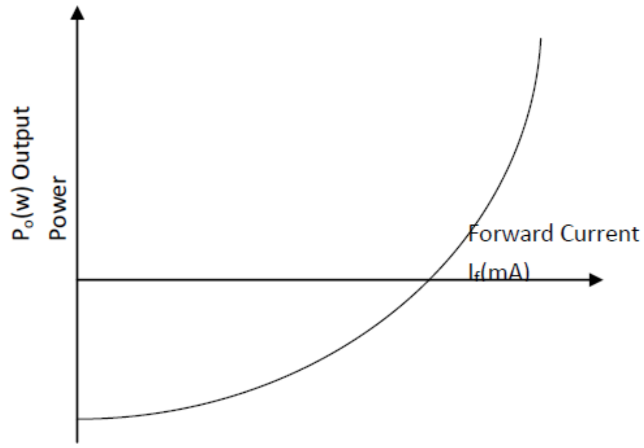


Fig.2.1 Link - E set up to study VI characteristics of LASER

MODEL GRAPH:



TABULAR COLUMN:

S.NO	Forward voltage (V_f)	Forward current (I_f)	Output reading(V)	P_0= reading/10 (mw)

RESULT: The V-I and P-I Characteristics of laser diode are observed and plotted**.**

Model Viva Questions:

1.Define Laser diode.

2.What are the essential components of laser?

3.Why we use the laser diode in optical communication rather than the other types of laser?

4. Explain the relation between the injection current and temperature and output power

5. Discuss the operation of the laser diode with constant wavelength operation.

6. Why the wavelength increased with increase temperature?

11. INTENSITY MODULATION OF LASER OUTPUT THROUGH AN OPTICAL FIBER

AIM:

To obtain Intensity Modulation of the Digital Signal, transmit it over a fiber optic cable and demodulate the same at the receiver end to retrieve the original signal.

EQUIPMENT:

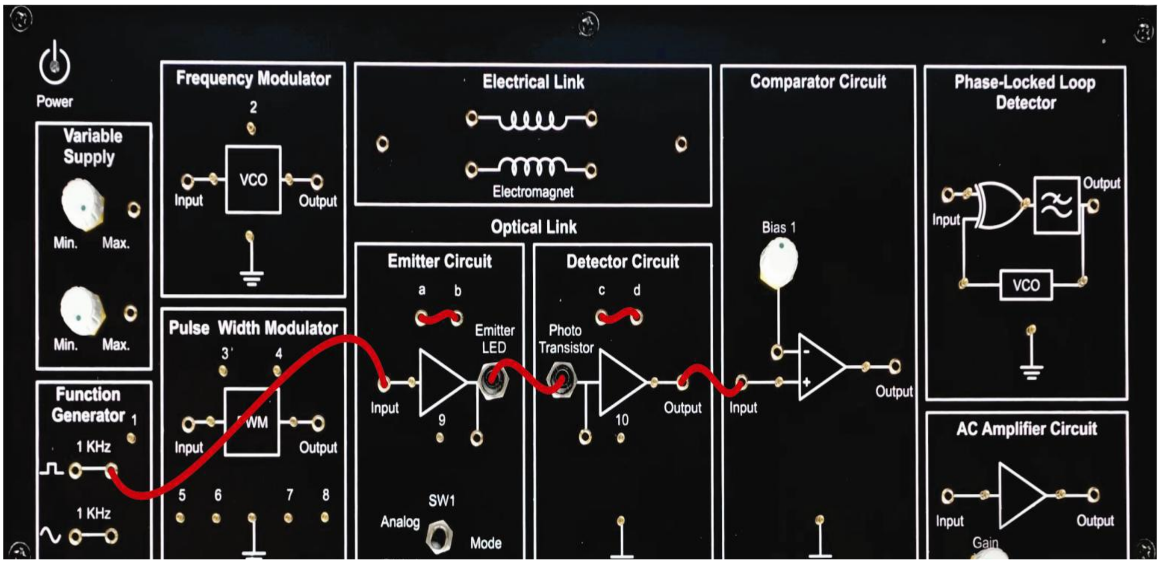
1. Intensity modulation of laser trainer kit
2. Optical Fiber cable
3. Digital Oscilloscope with necessary connecting probe

PROCEDURE:

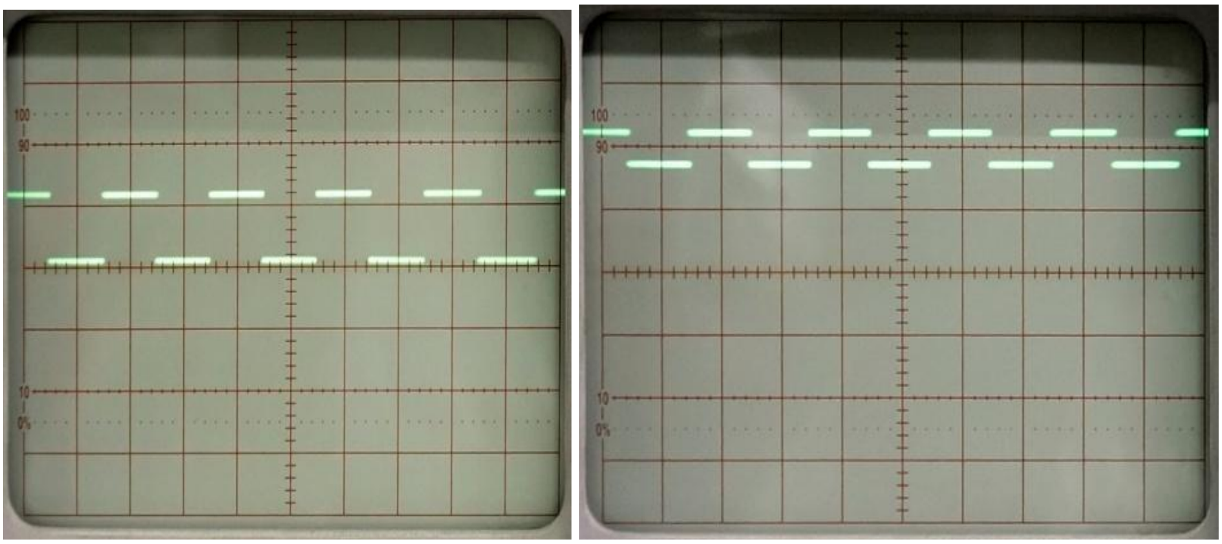
1. Connect the Tech Book Power Supply with mains cord to Tech Book Board
2. Make the connections as shown in the figure
   (i). Connect the 1 KHz square wave from Function Generator to emitter input.
   (ii) Connect the fiber optic cable between emitter output and detector input.
   (iii) Connect the detector output to comparator input.
3. Put the mode switch SW1 to Digital to drive the emitter in Digital mode. This ensures that signal applied to the driver input cause the emitter LED to switch quickly between 'On' & 'Off' states.
4. Switch 'On' the Power Supply of TechBook and Oscilloscope.
5. Examine the input to emitter on an Oscilloscope this 1 KHz square wave is now being used to amplitude modulates emitter LED.
6. Examine the output of detector. This should carry a smaller version of original 1 KHz square wave illustrating that the modulated light beam has been reconverted into an electrical signal.
7. Monitor inputs of comparator and slowly adjust the comparator bias potentiometer until the DC level on the negative input lies mid-way between the high & low level of the signal on the positive input. This DC level is comparator's threshold level.
8. Examine the output of comparator. Note that the original digital modulating signal has been reconstructed at the receiver.
9. Once again carefully flex the fiber optic cable; we can see that there is no change in output on bending the fiber. The output amplitude is now independent of the bend radius of the cable and that of length of cable, provided that detector output signal is large enough to cross the comparator threshold level. This illustrates one of the advantages of amplitude modulation of a light beam by digital rather than analog means. Also, non-linear ties within the emitter LED & phototransistor causing distortion of the signal at the receiver output are the disadvantages associated with amplitude modulating a light source by analog means. Linearity is not a problem if the light beam is switched 'On' & 'Off 'with a digital signal, since the detector output is simply squared up by a comparator circuit. To overcome problems associated with

amplitude modulation of a light beam by analog means, analog signals are often used to vary or modulate some characteristic of a digital signal (e.g. frequency or pulse width.). The digital signal being used to switch the light beam 'On' & 'Off' The next two experiments illustrate how an analog signal can be used to modulate two specific characteristics of a digital signal.

CIRCUIT DIAGRAM:



MODEL GRAPH:



S NO	Parameter	Amplitude	Time
1	Input signal		
2	Modulated signal		
3	Demodulated signal		

RESULT: Hence observed modulated output of the laser diode.

Model Viva Questions:

1. What is intensity modulation in optical fiber communication.
2. What is intensity in optical fiber.
3. What is the principle of working of laser explain optical fiber?
4. What type of material is used in the detector for regions 800 900 nm?
5. What is intensity modulation with direct detection?
6. What is direct detection?

12. MEASUREMENT OF DATA RATE FOR DIGITAL OPTICAL LINK

AIM:

The objective of this experiment is to learn to set up 650nm and 850nm digital links, and to measure the maximum bit rates supportable on these links.

EQUIPMENT:

1. OFT
2. Two channel 20MHz oscilloscope
3. Function generator (1Hz-10Hz)

THEORY:

The OFT can be used to set up two fiber optic digital links, one at wavelength of 650nm and the other at 850nm.LED1, in the optical Tx1 block, isan 850nmLED, and LED2, in the optical Tx2 block, is a 650nm LED.PD1, in the optical Rx1 block, is a PIN detector which gives a current proportional to the Optical power falling on the detector. The received signal is amplified and converted to a TTL signal using a comparator. The gain conversion plays a crucial role in this conversion.PD2, in the optical Rx2 block, is another receiver which directly gives out a TTL signal. Both the PIN detectors can receive 650nm as well as 850 nm signals, through their sensitivity is lower at 650nm.

PROCEDURE:

1.Connect the Tech Book Power Supply with mains cord to Tech Book Board

2. Make the connections as shown in next figure

(i). Connect the 1 KHz square wave from Function Generator to emitter input.

(ii) Connect the fiber optic cable between emitter output and detector input.

(iii) Connect the detector output to comparator input.

3. Put the mode switch SW1 to Digital to drive the emitter in Digital mode. This ensures that signal applied to the driver input cause the emitter LED to switch quickly between ‘On’ & ‘Off’ states.

4. Switch ‘On’ the Power Supply of Tech Book and Oscilloscope.

5. Examine the input to emitter on an Oscilloscope this 1 KHz square wave is now being used to amplitude modulates emitter LED.

6. Examine the output of detector. This should carry a smaller version of original 1 KHz square wave illustrating that the modulated light beam has been reconverted into an electrical signal.

7. Monitor inputs of comparator and slowly adjust the comparator bias potentiometer until the DC level on the negative input lies mid-way between the high & low level of the signal on the positive input. This DC level is comparator's threshold level.

8. Examine the output of comparator. Note that the original digital modulating signal has been

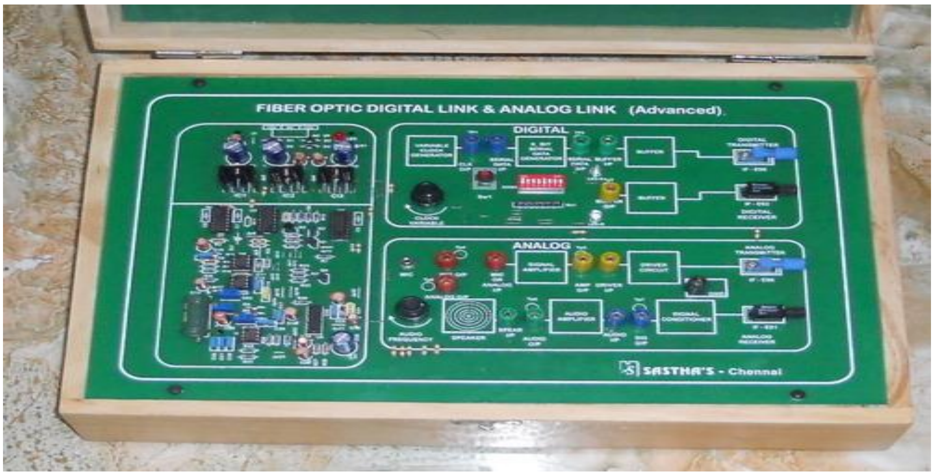
reconstructed at the receiver.

9. Change the frequency of square wave inputto10 KHz. Observe the received output on the Oscilloscope.

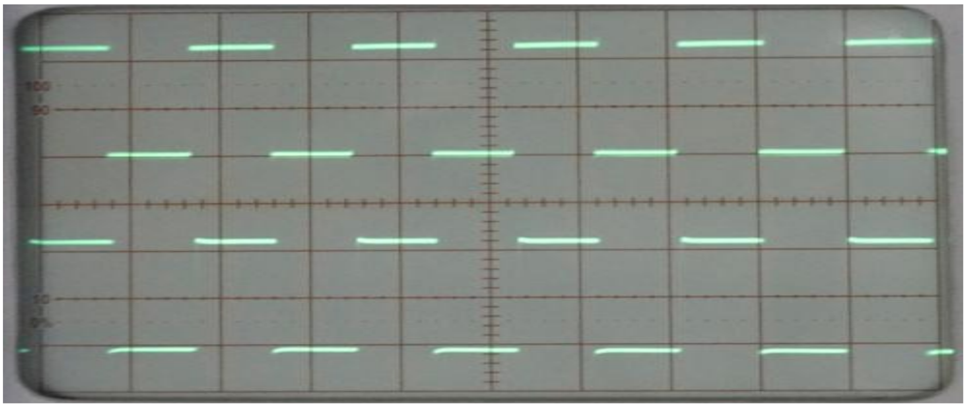
10. Vary the frequency of the TTL input observing the output each time. The comparator bias potentiometer can be adjusted, if required.

11. Note the frequency at which the output is distorted or has become zero. The bit rate supported by the link is twice the frequency reading corresponding to zero/ distorted output in bits per second.

CIRCUIT DIAGRAM:



MODEL GRAPH:



CALCULATIONS:

Square wave input: Amplitude (A) =

Frequency (f) =

Data rate = 2*f

------- bits/ sec

RESULT:

Hence, we calculated data rate for various frequencies using digital optical link setup.

Model Viva Questions:

1. What is meant by data rate?
2. What is the unit of bit rate?
3. What is data rate in optical communication?
4. How is optical signal measured?
5. What is channel data rate?
6. What are the two traffic channels and its data rate?

13. MEASUREMENT OF NUMERICAL APERTURE OF FIBER CABLE

AIM:

To estimate the Numerical Aperture of the 1mm diameter plastic fibre at 650 nm.

EQUIPMENT:

1.OFT Trainer Kit

2. Numerical Aperture Measurement Unit
3. 1mm diameter 1m fiber

THEORY:

Numerical aperture of the fiber is a measure of the acceptance angle oflight 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 other end of the fiber. The NA is useful in the computation of optical power coupled from an optical source to the fiber, from fiber to a photo detector, and between two fibers.

PROCEDURE:

SETUP:

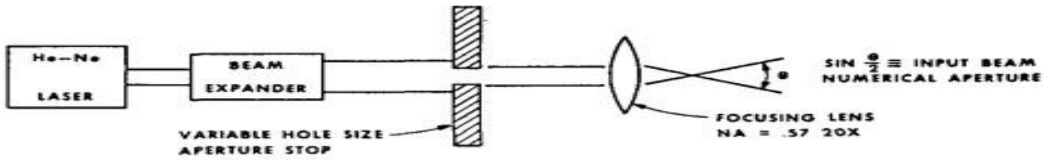
1. The interfaces used in the experiment are summarized in Table. Identify them on OFT kit with the layout diagram. The block diagram is shown in fig. ensure that the shorting plugs of Tx data shorting link S4, coded data shorting link S6, and Tx clock shorting link S5 in the Manchester coder block are in position. Also ensure that the shorting plug of clock select jumper JP1 is across the posts B&A1. A TTL signal from the multiplexer should now be driving LED2 in optical Tx2 block. This experiment is best performed in a less illuminated room.
2. Ensure that the cut planes of the 1m plastic fiber are perpendicular to the axis of the fiber. If required, prepare 1m of plastic fiber as per the instructions in appendix A.
3. Insert one end of fiber in to NA measurement unit as shown in figure. adjust the fibre such that its tip is 10mm from the screen.
4. Gently tighten the screw to hold the fiber firmly in place.
5. Connect the other end of the fiber to LED2 through the simplex connector. The fiber will project a circular patch of red light on to the screen. Now measure the diameter of the circular patch of red light in two perpendicular directions (BC and DE in Fig). the mean radius of the circular patch is given by

$$X = (DE + BC)/4$$

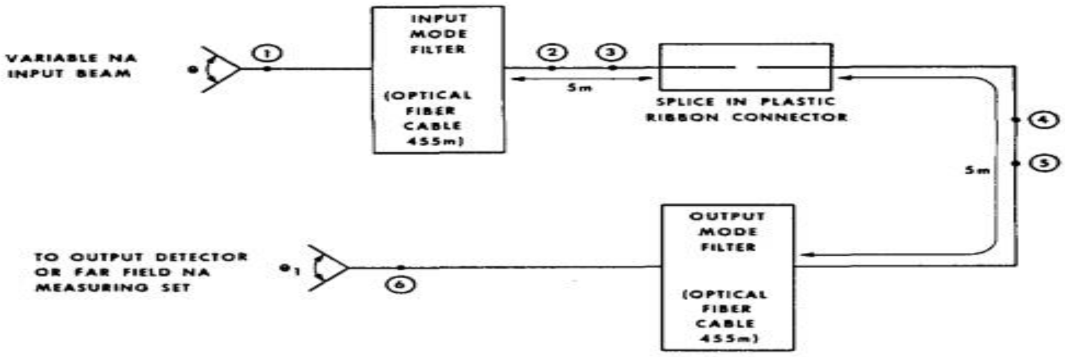
6. Carefully measure the distance d between the tip of the fiber and the illuminated screen (OA in Fig). The Numerical Aperture of the fiber is given by

$$NA = \sin(\Theta) = X / (\sqrt{(d2+X2)}$$

7. Repeat steps 3 to 6 for different values of d. compute the average value of Numerical aperture



(a)



(b)

TABULAR COLUMN:

S.No	Diameter W	Distance D	NA
1			
2			
3			

RESULT:

Hence calculated NA for various diameter and distance.

Model Viva Questions:

1. What is numerical aperture in fiber?
2. What is the importance of numerical aperture in optical fiber?
3. How do you find the numerical aperture of an optical fibre?
4. What is the formula of numerical aperture?
5. Which type of optical fiber is used in numerical aperture experiment?
6. Is numerical aperture dimensionless?

14. MEASUREMENT OF LOSSES FOR OPTICAL LINK

AIM:

The objective of this experiment is to measure the losses in an optical fiber communication link. The experiment not only enables one to determine the propagation loss in the fiber, but also to get a feel for bending and coupling losses.

EQUIPMENT:

1. OFT.
2. Two channel, 20MHZ Oscilloscope.
3. Function generator, 1HZ-10 MHZ.
4. Fiber alignment unit

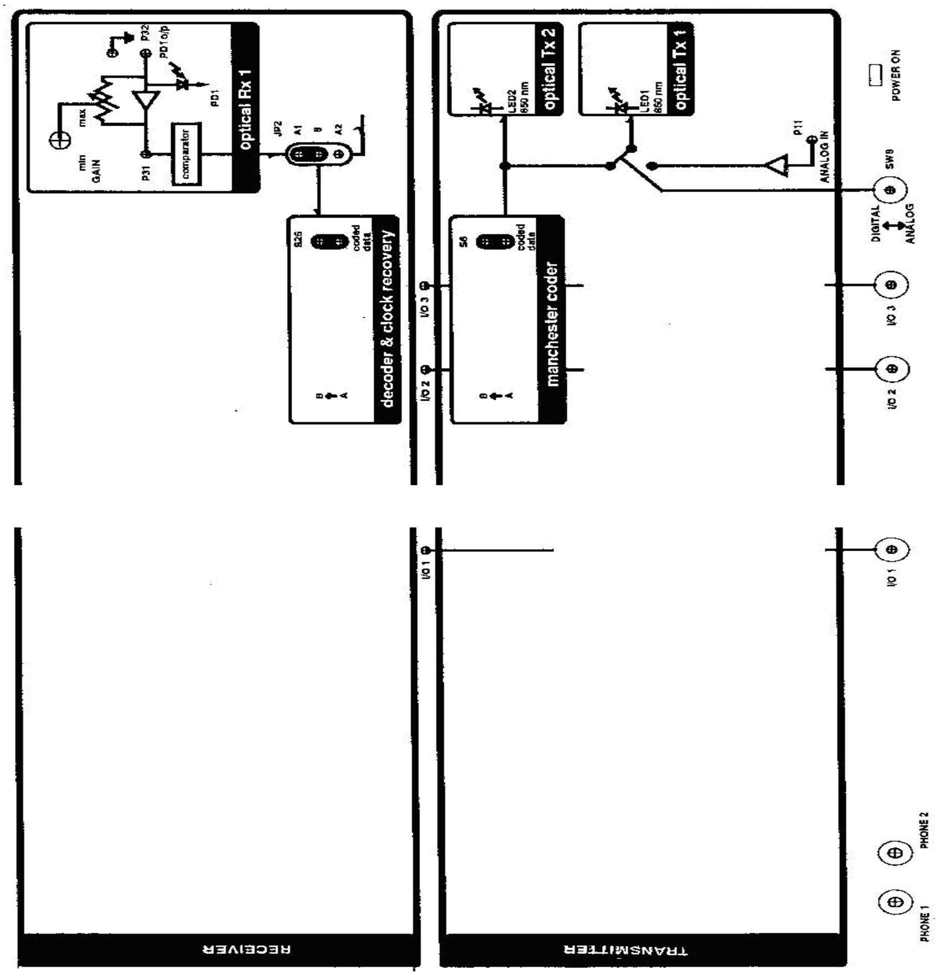
THEORY:

S.NO.	Identification Name	Function	Location
1	SW8	Analog/Digital selection switch should be set to ANALOG position.	
2	LED1 850nm	850nm LED	Optical Tx1 Block
3	LED2 650nm	650nm LED	Optical Tx2 Block
4	PD1	PIN Detector	Optical Rx1Block
5	JP2	PD1/PD2 Receiver Select Posts B & A1 should be shorted	
6	GAIN	GAIN Control Potentiometer	Optical Rx1Block
7	P11 ANALOG IN	Analog IN	
8	P31	PIN Detector signal after gain	Optical Rx1Block
9	I/O1,I/O2,I/O3	Input/output BNCs and posts for feeding in and observing signals	

10	S6 coded data	Manchester Coded Data Shorting link. Post A: Coded output Post B: Input to Tx1/Tx2/Electrical Post A & B should be shorted.	Manchester Coder Block
11	S26 coded data	Received Manchester Coded Data shorting link Post A: Receiver output (Rx1/Rx2) Post B: Input to decoder and clock recovery block Post A&B should be shorted	Decoder & Clock Recover Block

Table: Interface Details.

BLOCK DIAGRAM:



PROCEDURE:

1. Set the switch SW8 to the ANALOG position. Ensure that the shorting plug of the jumper JP2 is across the posts B& A1 (for PD1). Remove the shorting plugs from coded data shorting links. S6 in the Manchester coder block and S26 in the Decoder& clock recovery block.

Attenuation at 850 nm:

2. Take the 1m fiber and setup and analog link using LED1 in the Optical Tx1 block and detector PD1 in the Optical Rx1 block [850nm link]. Drive a 1V p-p 10 KHz sinusoidal signal with zero d.c. at P11. Observe the signal at P31 on the oscilloscope. Use the BNC I/Os for feeding in and observing signals. Adjust the GAIN such that the received signal is not saturated. Do not disturb the level of the signal at the function generator or the gain setting throughout the rest of the experiment.3. Note the peak value of the signal received at P31 and designated it as V1. Replace the 1m fiber by the 3m fiber between LED1 and PD1. Again note the peak value of the received signal and designate it as V3. If α is the attenuation in the fiber and I1 and I3 are the exact length of the 1m and 3m fibers in meters respectively, we have

$$\frac{P_3}{P_1} = \frac{V_3}{V_1} = \exp[-\alpha(I_3 - I_1]$$

Where α is in nepers/m, and P1 and P3 are the received optical power with
1m and 3m fiber respectively. Compute α in dB/m for 850nm wavelength using α'=4.343α where α is in nepers/m.

Attenuation at 650nm:

3. Now setup the 650nm link using LED2, detector PD1 and the 1m fiber. Remove the shorting plugs from S6 and S26 and feed in a TTL signal of 10 KHz at post B of S6. Observe the signal at P31 on the oscilloscope. Adjust the GAIN such that the received signal is not saturated. Note the peak value of the 1m fiber with the 3m fiber between LED2 and PD1. Again without disturbing the GAIN, note the peak value of the received signal and designate it as V3. Compute α' in dB/m for a 650nm wavelength using the expressions given Step3.

Bending Loss:

4. Set up the 850nm analog link using the 1m fiber. Drive 1Vp-p sinusoidal signal of 10 KHz with zero d.c. at P11 are observe the received signal at P31 on the oscilloscope. Now bend the fiber in a loop as shown in Figure. Reduce the diameter of the loop slowly and observe the reduction of the received signal at P31. Keep reducing the diameter of the loop to about 2 cm and plot the amplitude of the received sign versus the diameter of the loop. (Do not reduce the loop diameter to less than 1cm.)

RESULT:

Various losses in an optical fiber communication link are measured.

VIVA QUESTIONS:

1. What are the losses in optical fiber?
2. How do you measure the loss factor in optical Fiber communication?
3. What is the optical connector loss?
4. How many types of bending losses are there?
5. How are optical losses calculated?
6. How is total link loss calculated?
7. What is dB loss in cable?
8. Which cable length has highest attenuation?