MW & OC LAB MANUAL

Department of Electronics & Communication Engineering

VEMU INSTITUTE OF TECHNOLOGY::P.KOTHAKOTA

NEAR PAKALA, CHITTOOR-517112

(Approved by AICTE, New Delhi & Affiliated to JNTUA, Anantapuramu)

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Name:____

H.T.No:____

Year/Semester:____

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VEMU Institute of Technology
Dept. of Electronics and Communication Engineering

Vision of the institute

To be one of the premier institutes for professional education producing dynamic and vibrant force of technocrats with competent skills, innovative ideas and leadership qualities to serve the society with ethical and benevolent approach.

Mission of the institute

Mission_1: To create a learning environment with state-of-the art infrastructure, well equipped laboratories, research facilities and qualified senior faculty to impart high quality technical education.

Mission_2: To facilitate the learners to inculcate competent research skills and innovative ideas by Industry-Institute Interaction.

Mission_3: To develop hard work, honesty, leadership qualities and sense of direction in learners by providing value based education.

Vision of the department

To develop as a center of excellence in the Electronics and Communication Engineering field and produce graduates with Technical Skills, Competency, Quality, and Professional Ethics to meet the challenges of the Industry and evolving Society.

Mission of the department

Mission_1: To enrich Technical Skills of students through Effective Teaching and Learning practices to exchange ideas and dissemination of knowledge.

Mission_2: To enable students to develop skill sets through adequate facilities, training on core and multidisciplinary technologies and Competency Enhancement Programs.

Mission_3: To provide training, instill creative thinking and research attitude to the students through Industry-Institute Interaction along with Professional Ethics and values.

Programme Educational Objectives (PEOs)

PEO 1: To prepare the graduates to be able to plan, analyze and provide innovative ideas to investigate complex engineering problems of industry in the field of Electronics and Communication Engineering using contemporary design and simulation tools.

PEO-2: To provide students with solid fundamentals in core and multidisciplinary domain for successful implementation of engineering products and also to pursue higher studies.

PEO-3: To inculcate learners with professional and ethical attitude, effective communication skills, teamwork skills, and an ability to relate engineering issues to broader social context at work place

Programme Outcomes(Pos)

PO_1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO_2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO_3	**Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO_4	**Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO_5	**Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO_6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO_7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO_8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO_9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO_10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO_11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO_12	**Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Programme Specific Outcome(PSOs)

PSO_1	**Electronic System Design/Analysis:** Apply the fundamental concepts of Electronics and Communication Engineering to design and analysis of Electronics Systems for applications including Signal Processing, Communication & Networking, Embedded Systems, VLSI design and Control Systems.
PSO_2	**Software Tools:** Proficiency in specialized software tools and computer programming useful for the design and analysis of complex electronic systems to meet challenges in contemporary business environment.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY ANANTAPUR

B.Tech (ECE)– IV-I Sem **L T P C**

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(19A04701P) MICROWAVE AND OPTICAL COMMUNICATIONS LAB

Course Outcomes:

	Understand the mode characteristics of Reflex Klystron oscillator and negative resistance characteristics of Gunn Oscillator.
	Determine the Scattering matrix of given passive device experimentally and verify the same theoretically. Also determine numerical aperture and bending losses of a given optical fiber.
	Analyze the radiation characteristics to find the directivity and HPBW of a given antenna.
	Establish optical link between transmitter and receiver **experimentally** to find attenuation and signal strength of the received signal.

Note: All the experiments shall be conducted and there is no choice.

Microwave Engineering:

1. Set up the Full Microwave bench and know the importance of each block. Identify the pin configuration of Reflex Klystron with the help of its power supply cable connected from the power supply unit. Also identify the Microwave signal coupling from Klystron Oscillator to the waveguide.
2. Make use of the bench set up and conduct the experiment to find mode characteristics of Reflex Klystron: (i) Repeller voltage vs output power (ii) Repeller voltage vs Frequency.
3. Measurement of Frequency and wavelength of generated Microwave signal using Reflex Klystron oscillator.
4. Verify the negative resistance characteristics of Gunn oscillator using the Microwave bench set up with Gunn oscillator set up.
5. Find the Scattering matrix of E-plane, H-plane, and Magic Tees experimentally.
6. Make use of Microwave bench setup to find VSWR and impedance of an unknown load that is connected at the end of the bench set up. Make use of VSWR meter for the measurement of VSWR of a given load.
7. Determine directivity, insertion loss and coupling factor of a given Directional Coupler experimentally.
8. Making use of Microwave bench set up, find the radiation characteristics in both the planes and determine HPBW and directivity of a pyramidal horn antenna.

Optical Communication:

9. Conduct the experiment to draw the DC characteristics of LED and Photo diode.
10. Make use of Fiber optic kit to determine the **numerical aperture** and **bending losses** of a given optical fiber (transmission line).
11. Establish an optical link between transmitter and receiver and determine the signal strength at the receiver. Give the comments about the experiment by transmitting

    (i) **analog signal** (ii) **digital signal.**
12. Attenuation measurement in Fibers for various lengths.

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Dept. of Electronics and Communication Engineering

(19A04701P) MICROWAVE & OPTICAL COMMUNICATIONS LAB

LIST OF EXPERIMENTS TO BE CONDUCTED

Microwave Engineering:

1. Study of Microwave Components And Instruments
2. Reflex Klystron Characteristics.
3. Determination of Guide Wavelength And Frequency Measurement
4. Gunn Diode Characteristics.
5. Scattering parameters of Magic Tee
6. VSWR Measurement.
7. Directional Coupler Characteristics
8. Radiation Pattern Measurement of Horn Antenna.

Optical Communication:

9. DC characteristics of LED and Photo diode
10. Measurement of Numerical Aperture and bending losses of a given optical fibe.
11. Establish an optical link between transmitter and receiver and determine the signal strength at the receiver. Give the comments about the experiment by transmitting (i)analog signal (ii) digital signal
12. Attenuation measurement in Fibers for various lengths.

ADVANCED EXPERIMENTS

13. V I Characteristics of LASER Diode
14. S-Parameters of Circulator

CONTENTS

DOS & DON'TS IN LABORATORY

1. While entering the Laboratory, the students should follow the dress code (Wear shoes, White Apron & Female students should tie their hair back).
2. The students should bring their observation note book, practical manual, record note book, calculator, necessary stationary items and graph sheets if any for the lab classes without which the students will not be allowed for doing the practical.
3. All the equipments and components should be handled with utmost care. Any breakage/damage will be charged.
4. If any damage/breakage is noticed, it should be reported to the instructor immediately.
5. If a student notices any short circuits, improper wiring and unusual smells immediately the same thing is to be brought to the notice of technician/lab in charge.
6. At the end of practical class the apparatus should be returned to the lab technician and take back the indent slip.
7. Each experiment after completion should be written in the observation note book and should be corrected by the lab in charge on the same day of the practical class.
8. Each experiment should be written in the record note book only after getting signature from the lab in charge in the observation note book.
9. Record should be submitted in the successive lab session after completion of the experiment.
10. 100% attendance should be maintained for the practical classes.

SCHEME OF EVALUVATION

S NO	NAME OF EXPERIMENT	DATE	MARKS AWARDED				TOTAL (30M)
			Record (10M)	Observation (10M)	Viva voce (10M)	Attendance (10M)	
1	Set up the Full Microwave bench and know the importance of each block						
2	Reflex klystron characteristics						
3	Determination of Guide Wavelength and Frequency Measurement						
4	Gunn diode characteristics						
5	Scattering parameters of magic tee						
6	VSWR measurement						
7	Directional coupler characteristics						
8	Radiation Pattern Measurement of Horn Antenna						
9	DC characteristics of LED and Photo diode						
10	Measurement of Numerical Aperture and bending losses of a given optical fibe						
11	An optical link between transmitter and receiver Analog signal and Digital signal						
12	Attenuation measurement in Fibers for various lengths						
ADVANCED EXPERIMENTS							
13	V I Characteristics of LASER Diode						
14	S-Parameters of Circulator						

Signature of Lab In charge

Exp No:1 **Date:**

STUDY OF MICROWAVE COMPONENTS AND INSTRUMENTS

Aim: To become familiar with microwave components and instruments available in the laboratory.

Apparatus Used:

Klystron power supply, Gunn power supply, VSWR meter, power meter, Slotted section, Frequency/wave meter, RF Generator, Vector Network Analyzer.

Theory

Components/Devices:

Attenuator, circulator, Isolator, Waveguide twist, Magic Tee, E plane, H plane Tee, Directional coupler, Matched termination, PIN modulator, Crystal detector, Reflex klystron tube, Gunn diode, different types of antennas available.

LIST OF EQUIPMENTS AND DEVICES TO BE STUDIED:

Klystron Power Supply

1. Klystron tube
2. Isolator
3. Circulator
4. Attenuator
5. Direct reading frequency meter
6. Slotted line section with probe carriage
7. Crystal Detector
8. VSWR Meter
9. Different types of Antennas available
10. Magic tee
11. E and H Plane Tee
12. Matched Termination
13. Waveguide to coaxial adapter

INTRODUCTION:

A microwave test bench is an assembly of various microwave components, held together by Nuts & Bolts. It consists of a microwave source (Oscillator) at one end. The waves generated are led down by a wave guide through various components, so that the student can observe the propagation of waves, and their interaction and/or processing by various components.

- **Klystron Power Supply**

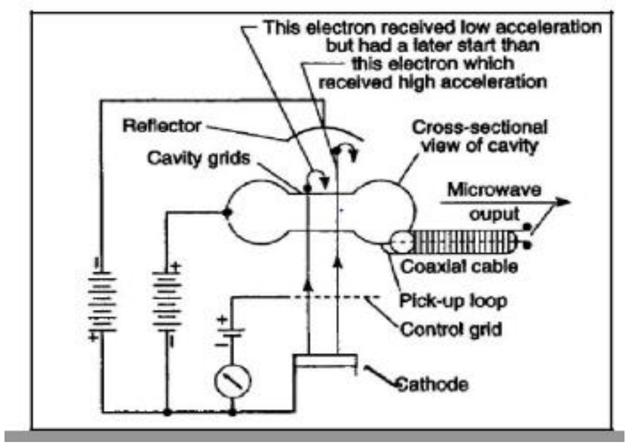
Klystron Power supply is a regulated power supply for operating low power klystron. Klystron power supply generates voltage required for driving the reflex klystron tubes like 2k25, 2k56, 2k22. It is absolutely stable, regulated and short circuit protected power supply. It has the facility to vary the Beam Voltage continuously and built in facility of square wave and saw tooth generators, for amplitude and frequency modulation.

- **Reflex Klystron (Klystron mount with tube)**

A waveguide of suitable length having octal base on the broad wall of the waveguide for mounting the klystron tube. It consists of movable short at one end of the waveguide to direct the microwave energy generated by the klystron tube. A small hole located exactly at the center of the broad wall of the waveguide is used to put the coupling pin of the tube as the electric field vector of EM energy is maximum at the center only. The maximum power transfer can be achieved by tuning of the movable plunger.

The Reflex Klystron

The reflex klystron, shown in Fig., employs a somewhat different stratagem to extract energy from an electron beam in the form of microwave oscillation. The anode of the klystron is a resonant cavity that contains perforated grids to permit accelerated electrons to pass through and continue their journey. Such electrons are not, however, subsequently collected by a positive electrode. Rather, they are deflected by a negatively polarized 'reflector' and are thereby caused to fall back into the cavity grids. The operational objective of the tube is to have such electrons return to the cavity grids at just the fight time to reinforce the electric oscillatory field appearing across these grids. When this situation exists, oscillations are excited and sustained in the cavity. Microwave power is coupled out of the cavity by means of a loop if coaxial cable is used, or simply through an appropriate aperture if a waveguide is used for delivering the power to the load. After the kinetic energy of the electrons has been given up to the oscillatory field of the cavity, the spent electrons fall back to the positive biased control grid where they are reflector with sufficient energy to pass through the cavity grids, thence to be collected by the control collected, thereby adding to control grid current. If the tube is not oscillating, a relatively high number of electrons are deflected by the retarding field of the grid. However, when oscillations are sustained in the cavity,the falling electrons yield most of their



energy to the oscillating electric field appearing across the cavity grids. Such electrons are subsequently collected by the cavity grids, which in this function behave as the plate of an ordinary diode. Inasmuch as the spent electrons do not fall into the positive field of the control grid, a profound dip in control-grid current accompanies the onset of oscillation within the cavity.

- **Isolator:**

The microwave test bench includes an attenuator, and an isolator. Both of these help to stop the reflected power from reaching the oscillator and pulling the frequency of the cavity and Gunn diode off tune when the load impedance is varied. An isolator is a two port device that transmits microwave or radio frequency power in one direction only**.** It is used to shield equipment on its input side, from the effects of conditions on its output side; for example, to prevent a microwave source being detuned by a mismatched load.Anideal isolator transmits all the power entering port 1 to port 2, while absorbing all the power entering port 2.

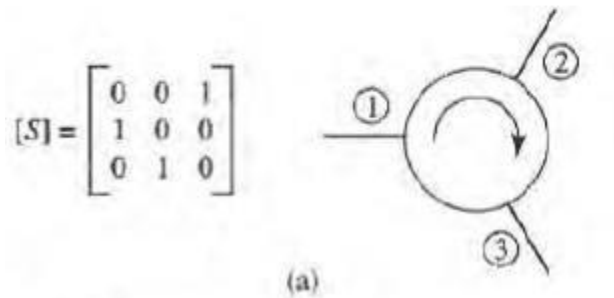
An isolator in a non-reciprocal device, with a non-symmetric matrix.

$$S = \begin{pmatrix} 0 & 0 \\ 1 & 0 \end{pmatrix}$$

To achieve non-reciprocity, an isolator must necessarily incorporate a non-reciprocal material. At microwave frequencies this material is invariably a ferrite which is biased by a static magnetic field. The ferrite is positioned within the isolator such that the microwave signal presents it with a rotating magnetic field, with the rotation axis aligned with the direction of the static bias field. The behavior of the ferrite depends on the sense of rotation with respect to the bias field, and hence is different for microwave signals travelling inopposite directions. Depending on the exact operating conditions, the signal travelling in one direction may either be phase-shifted, displaced from the ferrite or absorbed.

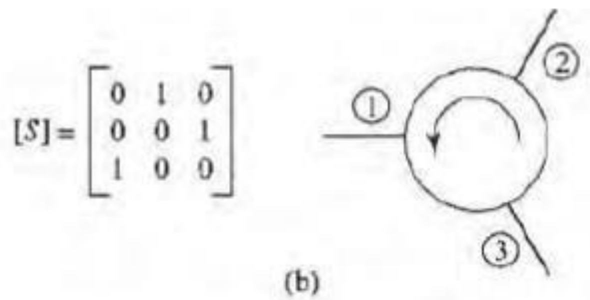
- **Circulator**

A circulator is a passive non-reciprocal three port device in which microwave or radio frequency power entering any port is transmitted to the next port in rotation only. There are two types of circulators and their [S] matrices i.e. Clockwise circulator and Counterclockwise circulator.



Clockwise Circulator

Counterclockwise Circulator



- **Attenuator:**

Attenuators are required to adjust the power flowing in a waveguide. Attenuators are of fixed, variable and rotary vane type, i.e.

Fixed: Any amount of fixed attenuation can be supplied between 3 to 40 dB. These attenuators are calibrated frequency band.

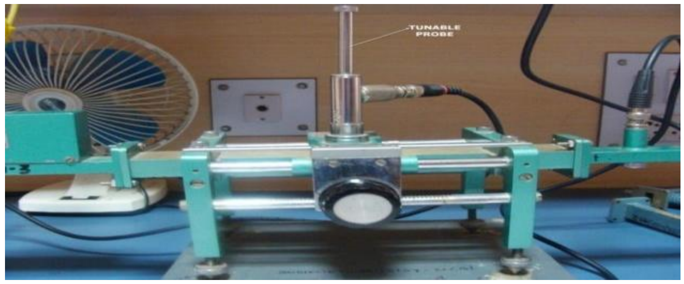
Variable: Variable attenuators provide a convenient means of adjusting power level very accurately.

- **Direct reading frequency meter**

This Frequency Meter has convenient readout with high resolution is provided by long spiral dials. These dials have all frequency calibrations visible so you can tell at a glance the specific portion of each band you are measuring. Overall accuracy of these frequency meters is 0.17% and includes such variables as dial calibration. It is constructed from a cylindrical cavity resonator with a variable short circuit termination. Theshorting plunger is used to change the resonance frequency of the cavity bychanging the cavity length. DRF measures the frequency directly. It is particularly useful when measuring frequency differences of small changes. The cylindrical cavity forms a resonator that produces a suck-out in the frequency response of the unit. This you would turn the knob until a dip in the response is observed.

- **Slotted line section with probe carriage:**

The slotted line represented the basic instrument of microwave measurements. With its help it is possible to determine the VSWR, attenuation, phase and impedances. The position of carriage (probe) can be read from a scale with its vernier. The total travel of probe carriage is more than three time of half of guide wavelength. This system consists of a transmission line (waveguide), a traveling probe carriage and facility for attaching/detecting instruments.Theslot made in the center of the broad face do not radiate for any power of dominant mode. The precision built probe carriage having centimeters scale with a vernier reading of 0.1 mm least count is used to note the position of the probe. Additionally slotted section can be used to measure reflection coefficient and the return loss.



- **Crystal Detector:**

The crystal detector (Detector mount) can be used for the detection of microwave signal. RF choke is built into the crystal mounting to reduce leakage from BNC connector. Square law characteristics may be used with a high gain selective amplifier having a square law meter calibration. At low level of microwave power, the response of each detector approximate to square law characteristics and may be used with a high gain selective amplifier having a square law meter calibration.

- **VSWR Meter**

The VSWR meter or VSWR (voltage standing wave ratio) meter measures the standing wave ratio in a transmission line. The meter can be used to indicate the degree of mismatch between a transmission line and its load (usually a radio antenna), or evaluate the effectiveness of impedance matching efforts.

Ways to express VSWR

The reflection coefficient is what you'd read from a Smith chart. A reflection coefficient with magnitude of zero is a perfect match and a value of one is perfect reflection. The symbol for reflection coefficient is uppercase Greek letter gamma (Γ). Note that the reflection coefficient is a vector, so it includes an angle. Unlike VSWR, the reflection coefficient can distinguish between short and open circuits. A short circuit has a value of -1 (1 at an angle of 180 degrees), while an open circuit is one at an angle of 0 degrees. The **return loss** of a load is merely the magnitude of the reflection coefficient expressed in decibels. The correct equation for return lossis:

$$R.L. = -20\log\ |\Gamma|$$

Here are the equations that convert between VSWR, reflection coefficient and return loss:

$$\Gamma = \frac{VSWR - 1}{VSWR + 1} \qquad RL = -20\log\left[\frac{VSWR - 1}{VSWR + 1}\right]$$

$$VSWR = \frac{1 + \Gamma}{1 - \Gamma} \qquad RL = -20\log(\Gamma)$$

$$\Gamma = 10^{\frac{-RL}{20}} \qquad VSWR = \frac{1 + 10^{\frac{-RL}{20}}}{1 - 10^{\frac{-RL}{20}}}$$

Different types of Antennas available

<u>Conical Horn:</u>

It is also called as waveguide fed Conical Horn. The conical horn antenna is a practical microwave antenna, often used as a feed for communication / satellite dishes and radio telescopes. Although the axial symmetry makes it capable of handling any polarization of the exciting fundamental (TE11) mode, the pin-fed horn design provided here is for linearly polarization.

There are a number of permutations on the basic horn design which can serve to minimize the effects of diffractions, improve pattern symmetry and reduce the side lobe levels. These include corrugating the internal walls, curving the walls at the aperture, incorporating corrugations with the wall curvature at the aperture, and introducing higher order modes in the horn to reduce the field at the aperture edges. A lens is often placed across the aperture to compensate for phase error and thus narrow the beam width.

<u>Parabolic Dish:</u>

A parabolic antenna is an antenna that uses a parabolic reflector, a surface with the cross- sectional shape of a parabola, to direct the radio waves. The most common form is shaped like a dish and is popularly called a dish antenna or parabolic dish. The main advantage of a parabolic antenna is that it is highly directive; it functions analogously to a searchlight or flashlight reflector to direct the radio waves in a narrow beam, or receive radio waves from one particular direction only. Parabolic antennas have some of the highest gains that is they can produce the narrowest beam width angles, of any antenna type. They are used as high-gain antennas for point-to-point radio, television and data communications, and also for radiolocation (radar), on the UHF and microwave (SHF) parts of the electromagnetic spectrum. The relatively short wavelength of electromagnetic radiation at these frequencies allows reasonably sized reflectors to exhibit the desired highly directional response.

With the advent of TVRO and DBS satellite television dishes, parabolic antennas have become a ubiquitous feature of the modern landscape, not only in rural locales where CATV and terrestrial signals were limited or non-existent, but also in urban and suburban regions, where the aforementioned services compete with CATV and broadcast media. Extensive terrestrial microwave links, such as those between cell phone base stations, and wireless WAN/LAN applications have also proliferated this antenna type. Earlier applications included ground-based and airborne radar and radio astronomy.

Although the term dish antenna is often used for a parabolic antenna, it can connote a spherical antenna as well, which has a portion of spherical surface as the reflector shape.

TYPES OF PARABOLIC DISH:

Parabolic antennas are distinguished by their shapes:

Cylindrical - The reflector is curved in only one direction and flat in the other. The radio waves come to a focus not at a point but along a line. The feed is often a dipole antenna located along the focal line. It radiates a fan-shaped beam, narrow in the curved dimension, and wide in the un-curved dimension. The curved ends of the reflector are sometimes capped by flat plates, to prevent radiation out the ends, and this is called a pillbox antenna.

- Orange peel - Another type is very long and narrow, shaped like the letter "C". This is called an orange peel design, and radiates an even wider fan beam. It is often used for radar antennas.

Paraboloidal or dish - The reflector is shaped like a paraboloid. This is the most common type. It radiates a narrow pencil-shaped beam along the axis of the dish.

Shrouded dish - Sometimes a cylindrical metal shield is attached to the rim of the dish. The shroud shields the antenna from radiation from angles outside the main beam axis, reducing the side lobes. It is sometimes used to prevent interference in terrestrial microwave links, where several antennas using the same frequency are located close together. The shroud is coated inside with microwave absorbent material. Shrouds can reduce back lobe radiation by 10 dB.

They are also classified by the type of feed; how the radio waves are supplied to the antenna:

Axial or front feed - This is the most common type of feed, with the feed antenna located in front of the dish at the focus, on the beam axis. A disadvantage of this type is that the feed and its supports block some of the beam, which limits the aperture efficiency to only 55 - 60%.

Offset or off-axis feed - The reflector is an asymmetrical segment of a paraboloid, so the focus, and the feed antenna, is located to one side of the dish. The purpose of this design is to move the feed structure out of the beam path, so it doesn't block the beam. It is widely used in home satellite television dishes, which are small enough that the feed structure would otherwise block a significant percentage of the signal.

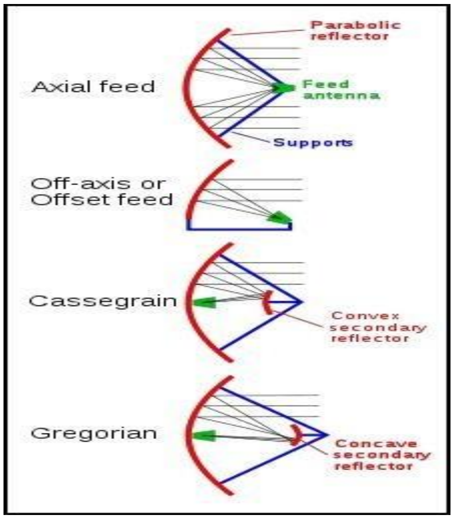


Figure (right) shows the main types of parabolic antenna feeds.

Cassegrain - In a Cassegrain antenna the feed is located on or behind the dish, and radiates forward, illuminating a convex hyperboloidal secondary reflector at the focus of the dish. The radio waves from the feed reflect back off the secondary reflector to the dish, which forms the main beam. An advantage of this configuration is that the feed, with its waveguides and "front end" electronics does not have to be suspended in front of the dish, so it is used for antennas with complicated or bulky feeds, such as large satellite communication antennas and radio telescopes. Aperture efficiency is on the order of 65 -70%.

Gregorian - Similar to the Cassegrain design except that the secondary reflector is concave, (ellipsoidal) in shape. Aperture efficiency over 70% can be achieved.

Gain:

The directive qualities of an antenna are measured by a dimensionless parameter called its gain, which is the ratio of the power received by the antenna from a source along its beam axis to the power received by a hypothetical isotropic antenna. The gain of a parabolic antenna is:

$$G = \frac{4\pi A}{\lambda^2} e_A = \frac{\pi^2 d^2}{\lambda^2} e_A$$

Where,

A is the area of the antenna aperture, that is, the mouth of the parabolic reflector

d is the diameter of the parabolic reflector

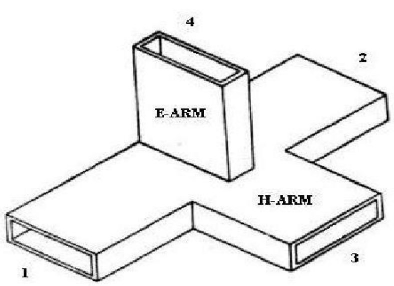
λ is the wavelength of the radio waves.

eA is a dimensionless parameter called the aperture efficiency. The aperture efficiency of typical parabolic antennas is 0.55 to 0.60.

- **<u>MagicTee:</u>**

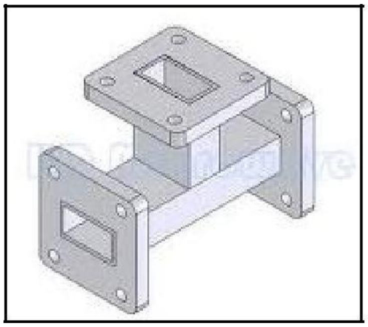
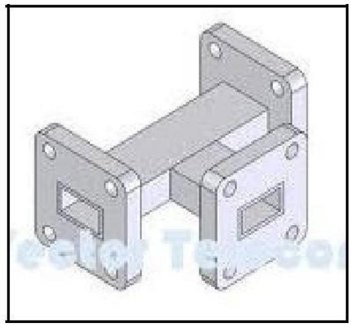
The magic tee is a combination of E and H plane tees. Arm 3 forms an H-plane tee with arms 1 and 2. Arm 4forms an E-plane tee with arms 1 and 2. Arms 1and 2 are sometimes called the side or collinear arms. Port 3 is called the H-plane port, and is also called the Sum port or the P-port (for parallel). Port 4 is the E-plane port, and is also called the (delta) port, difference port, or S-port (for Series).The name "magic tee" is derived from the way in which power is divided among the various ports. A signal injected into the H-plane port will be divided equally between ports 1 and 2, and will be inphase. A signal injected into the E-plane port will also be divided equally between ports 1 and 2, but will be 180 degrees out of phase. If signals are fed in through ports 1 and 2, they are added at the H-plane port and subtracted at the E-plane port. Thus, with the ports numbered as shown, and to within a phase factor, the full scattering matrix for an ideal magic tee is

$$S = \frac{1}{\sqrt{2}} \begin{pmatrix} 0 & 0 & 1 & -1 \\ 0 & 0 & 1 & 1 \\ 1 & 1 & 0 & 0 \\ -1 & 1 & 0 & 0 \end{pmatrix}$$



- **E and H Plane Tee**

In E Plane Tee the junction of the auxiliary arm is made on the broad wall of the main waveguide. And in H Plane Tee the junction of auxiliary arm is made on the narrow wall of the main waveguide.

E Plane Tee **H Plane Tee**

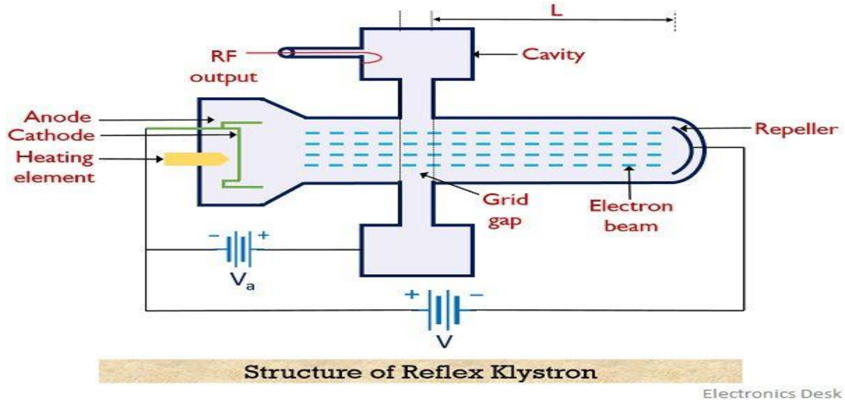
- **Matched Termination**

These are used for terminating the waveguide systems operating at low average power and are designed to absorb all the applied power assuring low SWR. Where a matched load is required as in the measurement of reflection, discontinuities of obstacle in waveguide systems, these components are used. These are also employed as a precise reference loads with tee junctions, directional couplers etc.

- **W/g Coaxial Adaptor:**

These adapters consist of a short section of waveguide with a probe transition coax **mounted on broad wall. It transforms waveguides impedance into** coaxial impedance. Power can be transmitted in either direction. Each adaptor covers 50% of the waveguide band.

pin configuration of Reflex Klystron:



Objectives:

1. Note relevant Technical specifications of the instruments.
2. Study position and functions of the front panel controls of the equipment.
3. Know basic principle of operation and functional block diagram of the instrument.
4. Facilities provided and limitations of the equipment if any.
5. Know initial settings of controls of the equipments before switching on the supply.
6. Precautions to be taken while carrying out the measurements.

Procedure:

(Separate sheet provided)

Observation: (Include your own Table relevant to theExperiment)

1. Identify the components/devices.
2. Study basic principle of operation of devices and components.
3. Know typical application of each component.
4. Identify the E field and H field mode patterns in these devices.

Results:

Conclusions:

Precautions:

1. Check the connections before switching on the kit.
2. Connections should be done properly.
3. Observation should be taken properly.

Exp no: 2 **Date:**

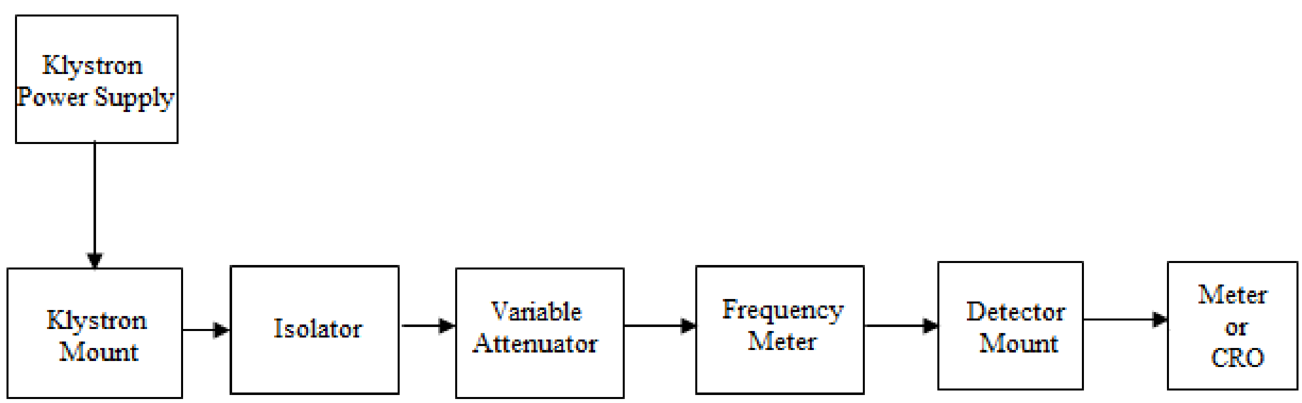
REFLEX KLYSTRON CHARACTERISTICS

Aim: To study mode characteristics of reflex klystron and hence to determine mode number, transit time electronic tuning range (ETR) and electronic tuning sensitivity (ETS).

Equipment and Component:

S.no	Apparatus	Range/Specification	Quantity
1	Klystron Power Supply	-	1
2	Klystron Mount	-	1
3	Isolator	-	1
4	Variable Attenuator	-	1
5	Frequency Meter	-	1
6	Detector Mount	-	1
7	Meter/CRO	30 MHz	1
8	Waveguide Stands	-	4
9	BNC Cables	-	1
10	Cooling Fan	-	1

Experimental Setup:



Theory

The Reflex Klystron is a microwave tube used as a microwave source in the lab. It makes use of velocity modulation to transform a continuous electron beam into microwave power. Its oscillation frequency can be varied over a wide band and it can be pulse and frequency modulated.

Electrons emitted from the cathode are accelerated by and pass through the positive resonator grid towards the reflector. The reflector is at a negative voltage with respect to cathode, and consequently it retard and finally reflects (reflex klystron) the electrons, which then turn back through the resonator grids: In case the klystron starts to oscillate, a hi-field exists between the resonator grids. The electron travelling through the grid will be either accelerated or retarded as the voltage changes in amplitude. Accelerated electrons leave the grid at an increased velocity and retarded electrons leave at a reduced velocity. Because of the difference in velocity the electrons leaving the grids will need different time to return (i.e., have different transit times).As a result of returning electron group together in bunches. This variation in velocity of the electrons is called velocity modulation.

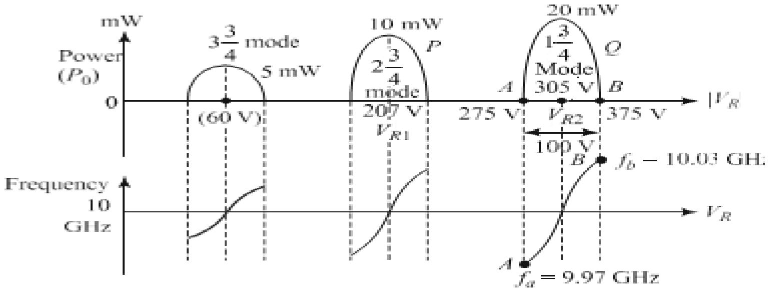


Fig.(B) Mode characteristics of reflex Klystron

As the electron bunches pass through the resonator grids, they interact with the voltage between the grids. If the bunches pass through the grids at a time such that the electrons are slowed down by the grid voltage energy will be delivered to the resonator and the klystron will oscillate. Strongest oscillation will occur when transit time in the reflector resonator region n + ¾ cycles of the resonator frequency, where 'n' an integer is including zero. If the bunches pass through the grids at a time such that the electrons are accelerated by the voltage, energy will be removed from the resonator and no oscillations will occur.

Procedure:

14. Connect the components and equipment as shown in fig. A
15. Keep the control knob of klystron power supply as below:

    Mode switch: AM

    Beam voltage knob: Fully anti-clockwise

    Repeller voltage knob: Fully clockwise

Meter switch: Beam Voltage/Beam Current/ Repeller Voltage: Beam current

Current Rotate the frequency meter at one side (NOTE: Rotate frequency meter very slowly).

Switch on the klystron power supply, V.S.W.R/CRO and cooling fan for the klystron tube. Wait for 1-2 minutes for the klystron to respond.

Cathode voltage knob at minimum position gives a beam voltage about 235V to 300V. Observe beam current on the meter by changing meter switch to beam current position. “The beam current should not be more than 30mA”. (Try to set Beam current at 20 mA by increasing/Decreasing beam voltage knob)

Now change the meter switch to repeller/reflector voltage position.

Decreasing the reflector/repeller voltage, record output power and frequency.

To measure frequency, switch the Mode-switch of klystron to AM mode and observe output on CRO display. Use AM amplitude, frequency controls and controls on Oscilloscope front panel try to get clear display on C.R.O. By rotating the frequency meter observe for dip in the output and note the corresponding frequency.

8. Put ‘ON’ the beam voltage switch and rotate the beam voltage knob clockwise in supply slowly and watch VSWR meter set the voltage for maximum deflection on the meter.

9. Change the repeller voltage slowly & watch the VSWR meter. Set the voltage for maximum deflection on the meter.

10. Rotate the knob of frequency meter slowly and stop at that position where there is lowest O/P on VSWR meter.

11. Read directly, the frequency meter between two horizontal fine marks.

12. Change the repeller voltage and read the power and frequency for each repeller voltage.

Mechanical and Electronic Tuning:

Mechanical tuning depends on changing the width of cavity i.e. the effective I capacitance and thus the resonant frequency of the klystron changes. The power output remains same with tuning. Electronic tuning refers to change in repeller voltage causing a change in output frequency. However, the power output also changes. A measure of electronic tuning is given by ‘Electronic tuning Sensitivity (ETS)’. This can be determined by taking the slope of the frequency characteristic of the modes.

Observation: (Include your own Table relevant to the Experiment)

S.No.	repeller voltage(volts)	output Voltage (mv)	Wavemeter reading Frequency(GHz)

CALCULATIONS:

Tuning range of 1 ¾ mode is

Po = 10(x/20) watts, where x is dB reading in VSWR meter. (Include sample calculations/Display/plot/typical graph)
By taking the values of repeller voltage we can calculate the the mode number

N1 = n + ¾ with V2 =
N2 = (n +1) + ¾ with V1 =
N1 & N2 are respective modes numbers.
ETS (Electronic Tuning Sensitivity) = f2 - f1 / V2 – V1 MHz / V

Precautions:

1. Check the connections before switching on the kit.
2. Keep all the knobs in minimum position before going to switch 'ON' the power supply of VSWR / Klystron power supplies.
3. Note: For klystron power supply "HT" should be 'OFF' before switching 'ON' the main supply.
4. Beam knob should be completely in anticlockwise direction and repeller voltage knob should be completely clockwise direction.
5. Switch on the main supply and give some warm up time to get current / accurate reading.
6. Connections should be done properly.
7. Don't see directly inside the waveguide.
8. After the completion of experiment, before leaving the bench switch off the mains keep all the knobs in minimum position (i.e.) as those are in rule 2.
9. If the main supply failed in the middle of the experiment, come to 1st condition (i.e.) keep all the knobs in minimum positions and switch off main switches.

10. Don’t increase the repeller voltage more than -70V (i.e.) it should be between -70Vto 270V.

Conclusion:

Viva Question:

1. Explain the operation of the reflex klystron tube.
2. What is the basic principle involved in microwave tubes.
3. What is the difference between velocity modulation and current density modulation?
4. What happens to the power output as the repeller voltage increases?
5. What are the various modes of operation in the reflex klystron?

Exp .No:3 **Date:**

DETERMINATION OF GUIDE WAVELENGTH AND FREQUENCY MEASUREMENT

AIM: To measure the frequency and wavelength of microwave oscillator and to demonstrate the relationship between frequency guide and space wavelength**.**

APPARATUS REQUIRED:

S.no	Apparatus	Range/Specification	Quantity
1	Klystron Power Supply	-	1
2	Klystron Mount	-	1
3	Isolator	-	1
4	Variable Attenuator	-	1
5	Frequency Meter	-	1
6	Detector Mount	-	1
7	Meter/CRO	30 MHz	1
8	Waveguide Stands	-	4
9	BNC Cables	-	1
10	Cooling Fan	-	1

THEORY:

It uses only a single re-entrant microwave cavity as a resonator. The electron beam emitted from the cathode is accelerated by the grid and passes through the cavity anode to the repeller space between the cavity anode and the repeller electrode. The feedback required to maintain oscillations within the cavity is obtained by reversing the electron beam emitted from cathode towards repeller electrode and sending it back through the cavity.

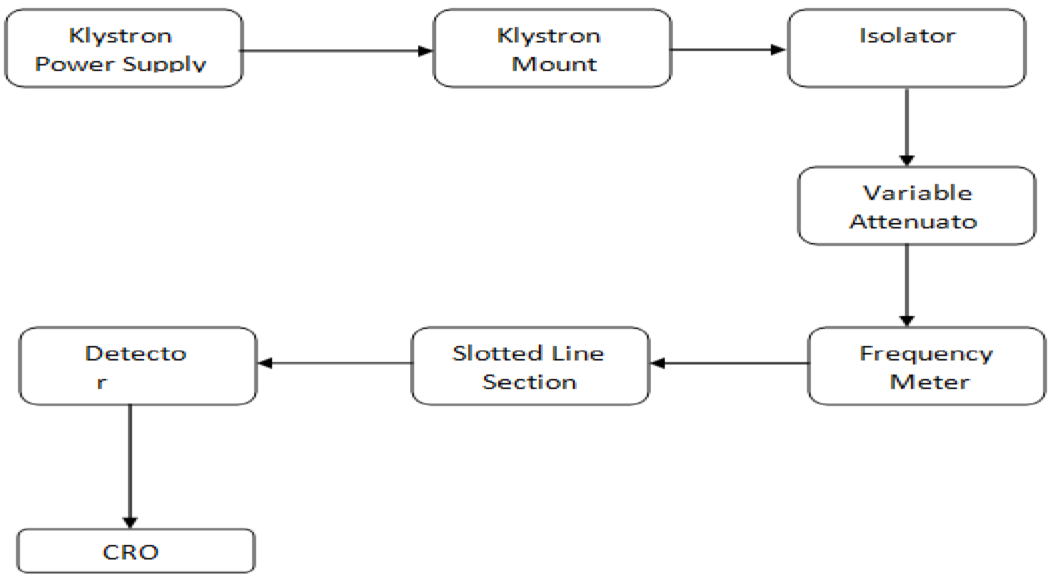
The electrons in the beam are velocity modulated before the beam passes through the cavity second time and will give up the energy to cavity to maintain oscillations. This type of klystron oscillator is called as a reflex klystron because of the reflex action of the electron beam. The physical design of the tube controls the no. of modes possible in practical applications. The bunched electrons in a reflex klystron can deliver maximum power to the cavity at any instant which corresponds to the positive peak of the RF cycle of the cavity oscillation. The power output of a reflex klystron is maximum, if the bunched electrons on return cross the cavity gap when the gap field is positive maximum.

PRECAUTIONS:

1. Before switch ON the power supply, ensure that all the knob are kept in minimum position.
2. Switch ON the power supply, set the beam voltage between 230V to 270V.

3. Set the beam current in the range of 17mAmps to 20 mAmps. Always the repller voltage having negative value it should be in the range of 160V to 200V.

BLOCK DIAGRAM:



FORMULAE:

1. $\lambda o = C/fo$ ($C = 3*10^8$m or$3*10^{10}$cm)
2. $\lambda g = 2(d1 \sim d2)$
3. $\lambda o'' = \lambda g*\lambda c/\sqrt{\lambda g^2+\lambda c^2}$
4. $\lambda c = 2a$ (a =2.3cm)
5. $fo'' = c/\lambda o''$ Slotted

PROCEDURE:

1. The connections are made as per the block diagram.
2. Before switching ON the klystron tube, check the beam voltage and repeller voltage are kept in minimum.
3. Switch ON the power supply and set the beam current as 17mA to23mA.

4. Then the frequency mater is tuned to get a dip in the CRO and the frequency reading from the meter is noted as „fo‟. The frequency meter is detuned after the reading is taken down.
5. The position of the slotted line section is varied to get the minimum point (zero output in the CRO). The position of the tunable probe is noted from the scale provided in the slotted line section as„d1‟.
6. The tunable probe is moved in the same direction as above and vary next minima is found and noted as „d2‟.
7. From the above values, find λO, λg, λo‟ and fo can be calculated using the equations.

TABULATION:

Beam Voltage: **Beam Current:**

RepellerVoltage:

Frequency of oscillation in GHz (fo)	**Position of minima**		**λo in cm**	**λg in cm**	**λo' in cm**	**fo' in GHz**
	d1 in cm	**d2 in cm**				

CALCULATIONS:

Result:

Conclusion:

Viva Questions:

.

1. How electronic tuning is achievable in klystron?
2. What changes occurs in the frequency due to the repeller voltage variation?
3. What is the maximum theoretical efficiency, frequency range of the reflex klystron?
4. How bunching is achieved in reflex klystron?
5. What is the advantage of reflex klystron over two cavity klystron?

Exp .No:4 **Date:**

GUNN DIODE CHARACTERISICS

Aim: To determine the characteristics of Gunn diode

Apparatus Required:

S.no	Apparatus	Range/Specification	Quantity
1	Gunn Power Supply	-	1
2	Gunn Oscillator	-	1
3	PIN Modulator	-	1
4	Variable Attenuator	-	1
5	Isolator	-	1
6	Detector Mount	-	1
7	Matched terminator	-	1
8	Waveguide Stands	-	4
9	BNC Cables	-	1
10	Cooling Fan	-	1

Theory:

Transferred electron devices operate with hot electrons whose energy is very much greater than the thermal energy. Transistors operate with warm electrons whose energy is not much than their thermal energy (0.026 ev) at room temperature, Gunn diode is an example of this kind. Gunn-Effect diodes are named after J.B.Gunn who in 1963 discovered periodic fluctuations of current passing through the n-type GaAs specimen when the applied voltage exceeded a certain critical value.

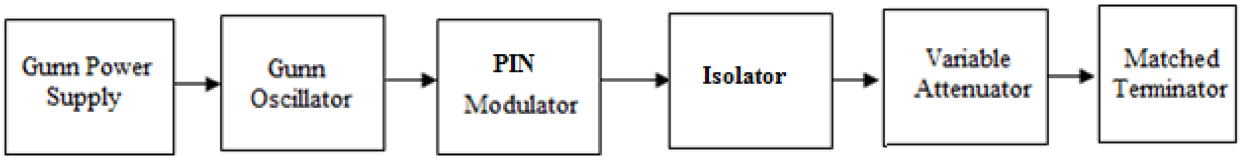
From Gunn's observations, the carrier drift velocity is linearly increased from zero to a maximum when the electric field is varied from zero to a threshold value. The Gunn's observations are in complete agreement with the Ridley-Watkin-Hilsum (RWH) theory.

There are two modes of negative resistance devices: 1.Voltage controlled mode 2.Current controlled mode. In the voltage controlled mode, the current density can be multi valued, whereas in the current controlled mode, the voltage can be multi valued. The negative resistance of the sample at a particular region is $\frac{dI}{dV} = \frac{dJ}{dE}$ = Negative resistance.

Applications:

1. Broadband linear amplifier
2. Fast combinational and sequential logic circuits.
3. As pump source in parametric amplifier.

Bench Set Up for Gunn Diode Characteristics



Procedure:

1. Connect the components as shown in the Bench setup.
2. Maintain some PIN bias voltage constantly.
3. Vary the Gunn biasing voltage from 0 to 5V in steps and note the Corresponding current on the panel meter of the power supply.
4. Observe the ammeter output and note the threshold voltage corresponding to where the output current starts decreasing.
5. Observe the ammeter reading and note down the valley voltage at which the current starts increasing again.
6. Plot the V-I Characteristics for the obtained values and determine threshold voltage (V_{th}).

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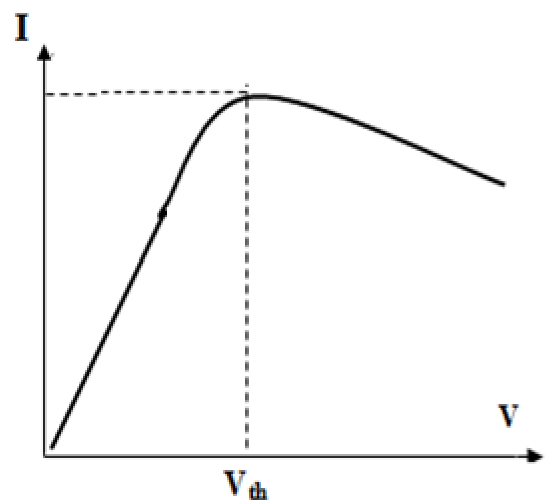
Tabular Column:

$V_{th} =$

S.no	VOLTAGE(V)	CURRENT (mA)

Model Graph:



V-I Characteristics of Gunn Diode

Precautions:

1. The bias is kept course and the fine control knobs of the power meter are kept in the minimum position before the meter is switched on.
2. The attenuator position should not be disturbed after adjusting for maximum power output.
3. Loose connection between the components should be avoided.

.

Result:

Conclusion:

Viva Questions:

1. What are the different modes of Gunn diode?
2. What is Gunn Effect?
3. What are the applications of Gunn Diode?
4. Explain LSA Mode.
5. Explain the purpose of PIN modulator.

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Exp .No: 5 **Date:**

SCATTERING PARAMETERS OF MAGIC TEE

Aim: To determine the scattering parameters of Magic Tee.

Apparatus Required:

S.no	Apparatus	Range/Specification	Quantity
1	Klystron Power Supply	-	1
2	Klystron Mount	-	1
3	Isolator	-	1
4	Variable Attenuator	-	1
5	VSWR Meter	-	1
6	Meter/CRO	30 MHz	1
7	Waveguide Stands	-	4
8	BNC Cables	-	1
9	Cooling Fan	-	1
10	Matched terminator	-	1
11	Magic Tee	-	1
12	Detector mount	-	1

Theory:

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

The basic parameters to be measured for magic Tee are defined as follows:

Input VSWR:

Value of VSWR corresponding to each port as a load to the line while other ports are terminated in matched load.

Isolation:

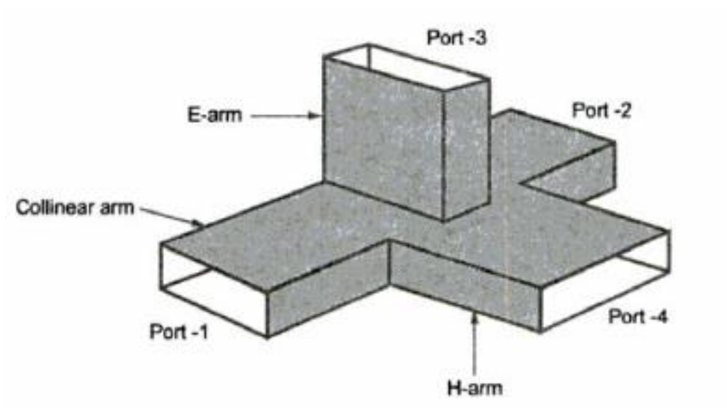
The isolation between E and H arms is defined as the ratio of the power supplied by the generator connected to the E arm to the power detected at H-arm when side arms 1 and 2 terminate in matched load. Isolation (dB) = 10 $\log_{10} [p_4/p_3]$

Similarly isolation between other ports may also be defined. Coupling Factor- It is defined as $C_{ij} = (10 - \alpha) / 20$.Where α is attenuation / isolation in dB. When i is input and j is output arm

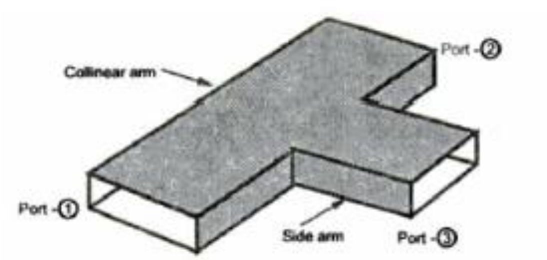
Thus $\alpha = 10 \log_{10} [p_4/p_3]$. Where p_3 is the power delivered into arm 'i' and p_4 is power detected at 'j' arm.

<u>Magic TEE Diagram:</u>

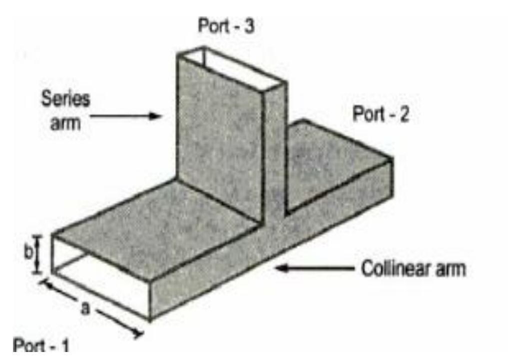
Bench Set Up For Scattering Parameters of Magic Tee:



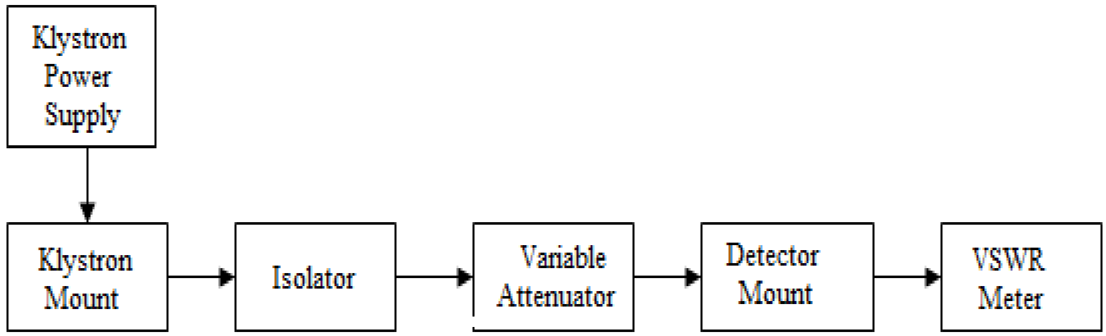
<u>H-PLANE TEE</u>



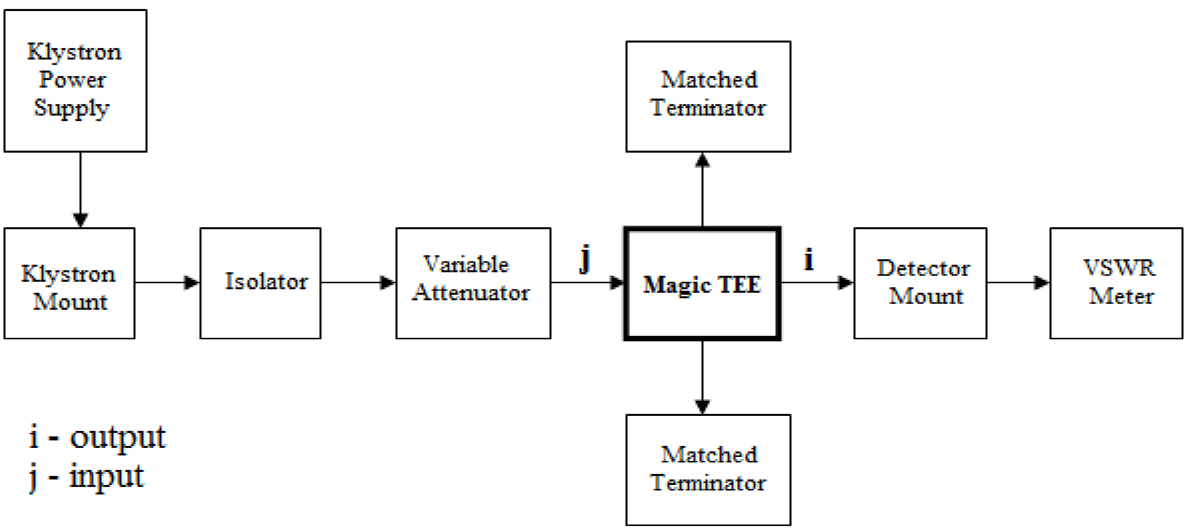
<u>E-PLANE TEE</u>



Bench Set – Up 1: To Keep the Attenuation (VSWR) Meter at 0 dB



Bench Set – Up 2: To Measure Non Diagonal Elements



<u>Procedure</u>:

1. Assemble the components as shown in bench setup 1.
2. Switch on the Klystron in internal mode with proper precautions and necessary cooling system.
3. Adjust the gain of VSWR meter reading to get 0dB attenuation.
4. Again assemble the components as shown in bench setup 2 without disturbing the Klystron source.

To Calculate Non-Diagonal Elements of S – Matrix:

1. Feed the input at E-port (port 4) of Magic Tee and measure the output at port 2. The value obtained in the VSWR meter is the power coupled to E-port to collinear port.
2. The value obtained in the VSWR meter = X_{dB} = 20 log S_{ij}
3. $\therefore$ S_{ij} = Antilog (X/20)

   Example to Calculate S_{24} Non-diagonal Element:

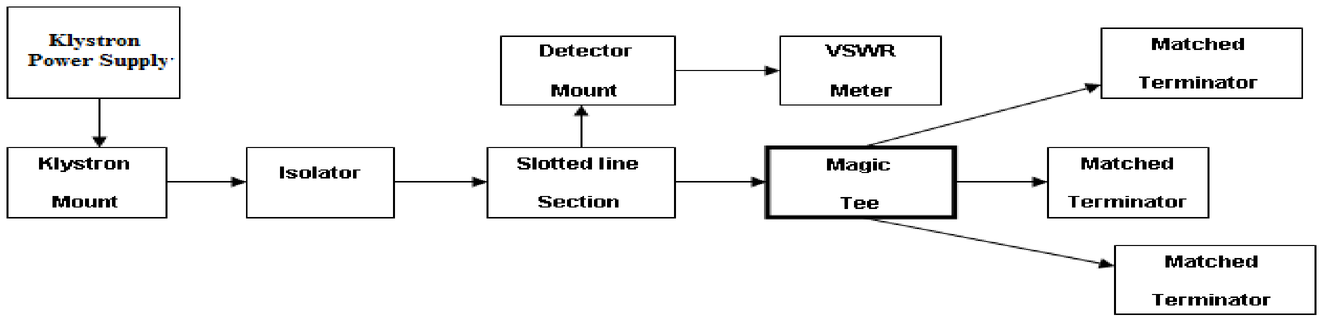
   - Input fed to PORT 4
   - Output Measured at PORT 2 = X_{dB}

     i.e., 20 log S_{24} = X_{dB}

4. Repeat the same procedure for the remaining non-diagonal elements.

S-element	I/P & O/P Port	VSWR meter reading(X dB)	S=Antilog(X/20)

Bench Set - Up 3: To Measure Diagonal Elements



Procedure to Calculate Diagonal Elements:

1. If the ports are perfectly matched, then the reading obtained on the VSWR meter is 0dB.
2. Slowly move the probe on the slotted line section and see whether any deflection is getting on the meter.
3. If
   a. There is no deflection, then the corresponding diagonal element value is zero.
   b. Otherwise, repeat the same procedure followed in diagonal elements calculation.

S-element	I/P & O/P Port	VSWR meter reading (X dB)	S_{ij}
S_{11}	I/P – Port1 O/P- Port1		$\mathbf{S_{11}}$ **=**
S_{22}	I/P – Port2 O/P- Port2		$\mathbf{S_{22}}$ **=**
S_{33}	I/P – Port3 O/P- Port3		$\mathbf{S_{33}}$ **=**
S_{44}	I/P – Port4 O/P- Port4		$\mathbf{S_{44}}$ **=**

Precautions:

1. Loose connections between the components should be avoided.
2. The Magic Tee must be handled carefully while inserting in to the circuit.

.

Result:

Conclusion:

Viva Questions:

1. What are the properties of magic tee?
2. What is the isolation between E and H arm?
3. What is isolation in magic tee?
4. What is H plane tee?
5. What is the difference between E plane and H plane?

Exp .No: 6 **Date:**

VSWR MEASUREMENT

Aim: To measure the VSWR by using direct method and double minima method.

Apparatus Required:

S.no	Apparatus	Range/Specification	Quantity
1	Klystron Power Supply	-	1
2	Klystron Mount	-	1
3	Isolator	-	1
4	Variable Attenuator	-	1
5	Frequency Meter	-	1
6	Meter/CRO	30 MHz	1
7	Waveguide Stands	-	4
8	BNC Cables	-	1
9	Cooling Fan	-	1
10	Slotted Line Section	-	1
11	Tunable Probe Detector	-	1

Theory:

The magnitude of the standing waves can be measured in terms of standing wave ratios. The ratio of V_{max} and V_{min} is the voltage standing wave ratio (or) VSWR, denoted by S;

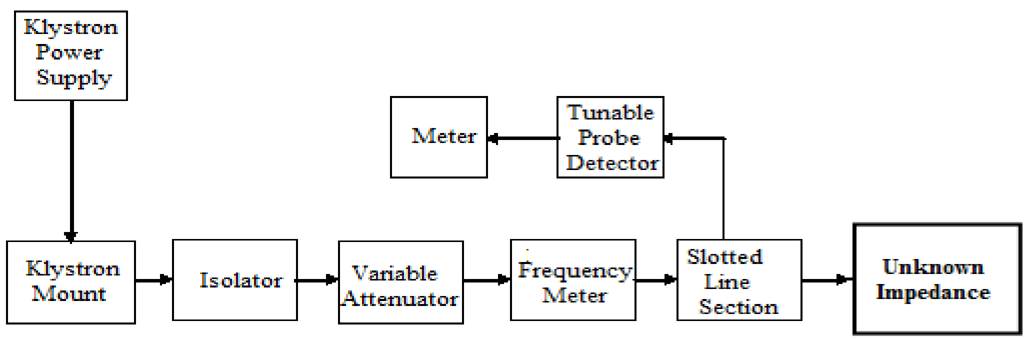
$$S = \frac{|V_{max}|}{|V_{min}|}$$ which allows to take values in the range $1 \leq S \leq \infty$.

The value of S can be measured experimentally by using a slotted line. Its value depends on the degree of mismatch at the load i.e. on the reflection coefficient. Value of VSWR not exceeding 10 are very easily measured with the set up and can be read off directly on the VSWR meter calibrated.

The measurement basically consists of simply adjusting the Attenuator to give an adequate reading on the meter, which is a DC Milli Volt Meter. The probe on the slotted wave is moved to get maximum reading on the meter. The attenuation is now adjusted to get full scale reading and this full scale reading is noted down. Next the probe on the slotted line is adjusted to get minimum reading on the meter (corresponding to V_{min}). The ratio of the first reading on the meter to the second gives the VSWR (Voltage Standing Wave Ratio).

Bench Set Up For VSWR Measurement

Bench Set-Up 1: Low VSWR Measurement

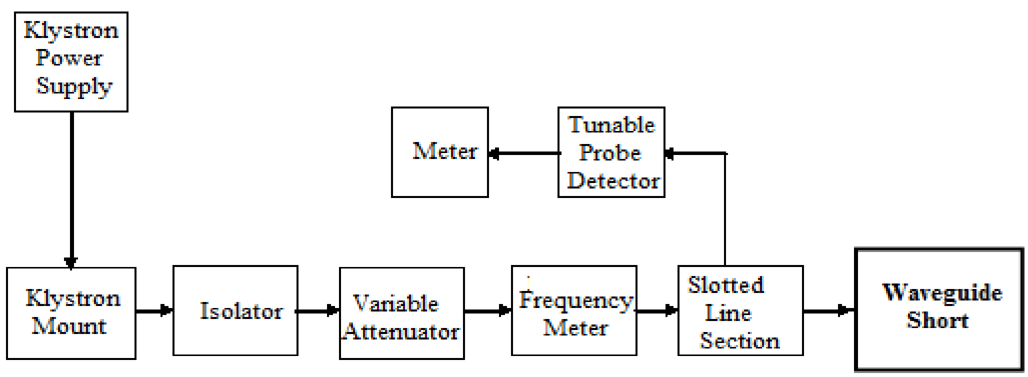


Procedure:

For Low VSWR Measurement:

1. The components are arranged as shown in the bench set-up1.
2. The probe is moved along the slotted line section to get a maximum deflection in the VSWR meter and adjust the meter to read 1.0 on the scale.
3. The probe is moved along the slotted line section and stop at where a minimum deflection is shown. The VSWR meter reading directly gives the values of low VSWR.

Bench Set-Up 2: High VSWR Measurement



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Procedure for High VSWR Measurement:

1. The components are arranged as shown in the bench set-up2.
2. The probe is inserted to depth where the minima can be read without difficulty and then moved to a point where the power is twice the minima power. This point is denoted by $\mathbf{D_{m1}}$. The probe is then moved to the twice the power point on other side of the minima and corresponding point is noted as $\mathbf{d_{m2}}$.
3. λg is calculated by replacing unknown impedance with wave guide short.

$$\text{Then High VSWR} = \frac{\lambda g}{\pi(d_{m1} \sim d_{m2})}$$

λg=2x Distance between successive minima

Calculations:

Low VSWR:

V_{max}=

V_{min}=

VSWR=V_{max}/V_{min}

VSWR=

High VSWR:

Readings :

First minima (d1) = __________ cm.

Second minima (d2) = _________ cm.

Guide wave length (λg_1) **= 2 X (Distance between successive minima)**

= 2 X (d1~d2)

= 2 X (   )

= _______ cm.

3dB (left) d_{m1} = ____________ cm.

3dB (left) d_{m2} = ____________ cm.

$$\text{VSWR} = \frac{\lambda g}{\pi\left(d_{m1} \sim d_{m2}\right)} =$$

Precautions:

1. Beam voltage should be minimum and repeller voltage should be normal before switch ON/OFF the Klystron Power Supply.

Result:

The Low and high VSWR are measured.

Low VSWR=

High VSWR=

Conclusion:

Viva Questions:

1. What is a directional coupler?

2. List the types of directional coupler.

3. Draw a basic directional coupler?

4. List the performance of a directional coupler.

5. Define the directivity `D' of a directional coupler.

Exp .No: 7 Date:

Directional Coupler

AIM:-To measure coupling coefficient, Insertion loss &Directivity of a Directional coupler.

APPARATUS REQUIRED: -

S.no	Apparatus	Range/Specification	Quantity
1	Klystron Power Supply	-	1
2	Klystron Mount	-	1
	Isolator	-	1
4	Variable Attenuator	-	1
5	Frequency Meter	-	1
6	Detector Mount	-	1
7	Meter/CRO	30 MHz	1
8	Waveguide Stands	-	4
9	BNC Cables	-	1
10	Cooling Fan	-	1
11	Directional coupler	-	1
12	Matched Terminator	-	1

Directional Coupler Diagram:

THEORY:-

A directional coupler is a device with which it is possible to measure the incident and reflected wave separately. It consist of two transmission lines, main arm and auxiliary arm, electro magnetically coupled to each other. The diagram is given below. The power entering in port 1 in the main arm divides between port 2 and port 4 almost no power comes out of port 3. Power entering in port 2 is divided between port 1 and 3.

Assuming power is entering from port 1, then The coupling factor is defined as

Coupling (db) = 10 log 10 P1 / P4

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

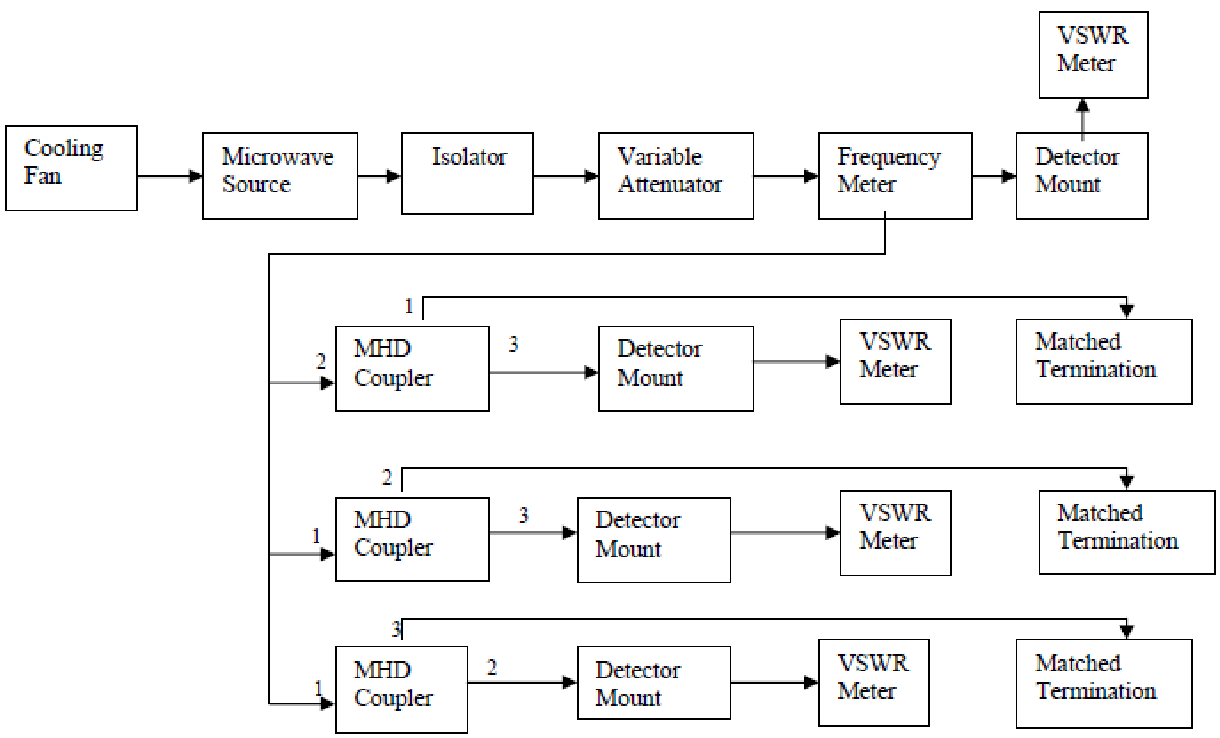
Insertion loss = 10 log 10 P1 / P2.

The directivity of the coupler is a measure of separation between incident wave and the reflected wave. It is measured as the ratio of two power outputs from the auxiliary line when a given amount of power is successively applied to each terminal of the main line with other port terminated by matched load. Hence Directivity is given by

D (db) = 10 log 10 P4f/ P4r

here P4f and P4r are the measured powers at port 4 with equal amount of power is fed to port 1 and 2 respectively.

BLOCKDIAGRAM:-



PROCEDURE:-Measurement of Coupling factor, Insertion loss &Directivity .

(1) Set the equipments as shown in fig.

(2) Energize the microwave source for particular operation of frequency.

(3) Remove the MHD coupler and connect the detector mount to the frequency meter. Tune the detector for max. Output.

(4) Set any reference level of power on VSWR meter with the help of variable attenuator, gain control knob of VSWR meter and note down the reading

(5) (let it be X).

(6) Insert the D.C as shown in fig. With detector mount to the auxiliary port 4 and matched termination to port 2. Without changing the position of variable attenuator and gain control knob of VSWR meter.

(7) Note down the reading on VSWR meter (let it be Y) and calculate coupling factor using X &Y, which will be in db.

(8) Now carefully disconnect the detector from the auxiliary port 4 and match termination from port2 without disturbing the setup.

(9) Connect the matched termination to the aux. Port 4 and detector to port 2 and measure the reading on VSWR meter (let it be Z).

(10) Compute insertion loss using X & Z in db.

(11) Repeat the steps from 1 to 4.

(12) Connect the D.C in the reverse direction i.e. port 2 to frequency meter side, matched termination to port1 and detector mount to port 4, without disturbing the position of the variable attenuator and gain control knob of VSWR meter.

(13) Note down the reading and let it be Y0 .Compute the directivity as Y- Y0.

(14) Repeat the same for other frequency.

OBSERVATIONANDCALCULATIONS:-

Calculate D, C and I using the equations as given above.

The measured values for MHD coupler are

Coupling coefficient =

Insertion loss =

Directivity =

PRECAUTIONS:- .

1. Use fan to keep the Klystron temperature low.
2. Ensure tight connections of the apparatus
3. Avoid cross connections of the threads.
4. Use stabilized power supply.

RESULT:-

Conclusion:

Viva Questions:-

1. What is directional coupler?
2. What is Insertion loss?
3. In a two hole directional coupler, what is the distance between two holes?
4. Name a few other types of directional couplers?
5. How many holes can be there in a Directional coupler?

.

Exp .No: 8 **Date:**

HORN ANTENNA

AIM:

To find the radiation pattern of the horn antenna using appropriate tools.

APPARATUS REQUIRED:

S.no	Apparatus	Range/Specification	Quantity
1	Klystron Power Supply	-	1
2	Klystron Mount	-	1
3	Three port circulator with M.T	-	1
4	Variable Attenuator	-	1
5	Frequency Meter	-	1
6	Meter/CRO and Horn antenna.	30 MHz	1
7	Waveguide Stands	-	4
8	BNC Cables	-	1
9	Cooling Fan	-	1
10	Slotted Line Section	-	1
11	Tunable Probe Detector	-	1

THEORY:

The transmitted power (Pt) of an antenna of gain (G) and the receiving power (Pr) of an antenna of gain (G) are related by the equation.

$$Pr/Pt = (\lambda 0 / 4\pi s)^2 \, G1G2$$

S - Distance separation between two antennas, Xo - free space wavelength.

If two similar antennas are being used then G1=G2=G then the equation reduces to

$$Pr/Pt = (\lambda / 4\pi s)^2 \, G2$$

λo is calculated using formula.

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

λg is the successive minima's separation distance "Smin".

The minimum distance of Separation between two antennas is given by Smin= $2d^2/\lambda o$, where d= 9.6 cm the large dimension of transmitting antenna.

PROCEDURE:

1. Before connecting the two antennas, connect the waveguide detector mount directly to the slotted line.

2. Switch "ON" the power supply and obtain oscillations.

3. Adjust the variable attenuator and tune the waveguide detector mount to get maximum voltage.

4. Note down the frequency of oscillation using the frequency meter.

5. Find the distance of separation between successive minima in the slotted line to calculated λg and λo.

6. Connect the two horn antenna H 1& H 2 between the slotted line & waveguide detector.

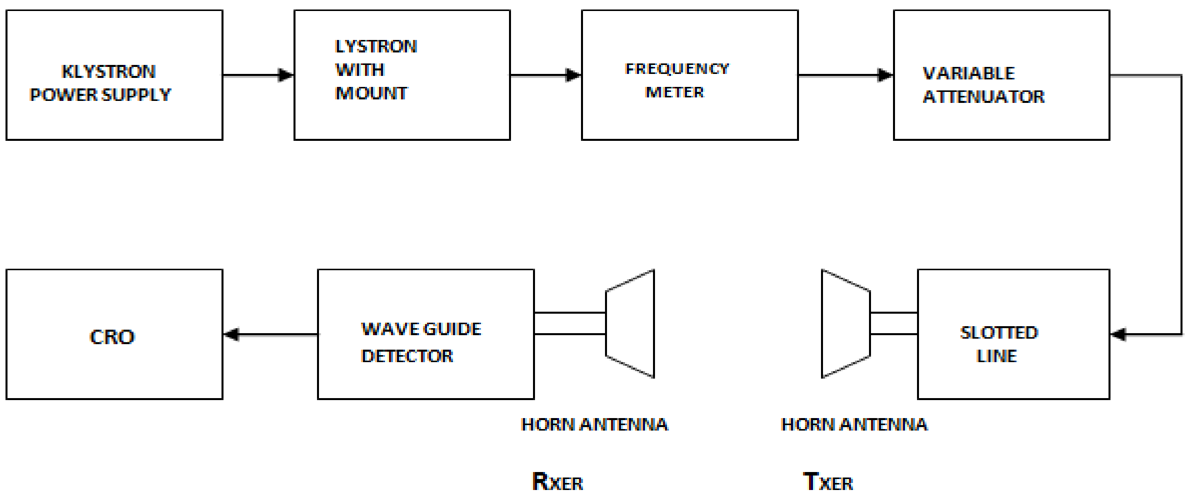
7. Keep the distance between two horns greater then Smin So that antenna under test is in the far field of transmitting antenna & note down the distance of separation „S" between two horns.

8. Note down the corresponding voltage reading VR in the CR0 connected to the Waveguide detector mount without any tuning.

9. Repeat the experiment for different values of separation between two horns.

10. Calculated the gain using the formula gain in dB = l0log10 $(VR/VT*4\pi S/\lambda o)$

BLOCK DIAGRAM:



FORMULAE

- Gain in dB = 10log (Vout/Vin)

TABULATION: Input voltage: Half power beam width of Horn antenna:

E – Plane Horn			H – Plane Horn		
Angle in degree	Amplitude in volts	Gain in dB	Angle in degree	Amplitude in volts	Gain in dB

.

PRECAUTIONS:

1. Before switch ON the power supply, ensure that all the knob are kept in minimum position.
2. Switch ON the power supply, set the beam voltage between 230V to270V.
3. Set the beam current in the range of 17mAmps to 20 mAmps. Always the repller voltage having negative value it should be in the range of 150V to200V.

CALCULATIONS:

Result:

Conclusion:

Viva Questions:

1. What is horn antenna & its applications ?
2. What is the directivity of horn antenna ?
3. How many types of horn antenna are there ?
4. What is the impedance of horn antenna ?
5. What are the characteristics of horn antenna ?

Exp .No: 9 **Date:**

DC CHARACTERISTICS OF LED AND PIN PHOTO DIODE

AIM:

To find the DC characteristics of LED source and PIN photo diode

APPARATUS REQUIRED:

S.No	APPARATUS	QTY
1.	OFT Power Supply	1
2.	Digital Multimeter	1
3.	LED Module	1
4.	Power Meter	1

PROCEDURE:

FOR LED CHARACTERISTICS:

1. Connect the OFT power supply to the module
2. Measure the voltage V1 across the resistor R1 and calculate the current through LED If which is If =V1/180 for 850nmPF
3. Now measure the voltage VLED across the LED and note down
4. Measure the optical power output of LED
5. Calculate the power output in mW
6. Turn the potentiometer in clockwise direction slightly towards the maximum till you get the convenient reading
7. Draw the graph

FOR PHOTO DIODE CHARACTERISTICS:

1. Put 1M ohm resistor across VL.
2. Connector ST Connector end of the patch cord supplied with the module to the power source.
3. Set the power source in CW mode and to give maximum output power.
4. Slightly unscrew the black colored cap of the PD to loosen it.

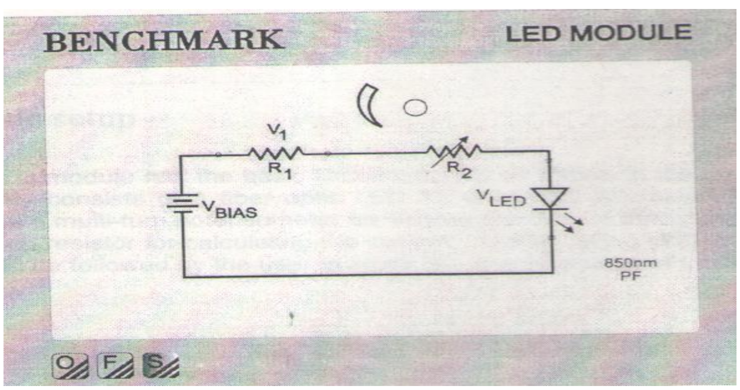
5. Vary the optical power P from -18 dBm approx in steps of 5dBm. Tabulate the readings as shown Iz=VL/1x106

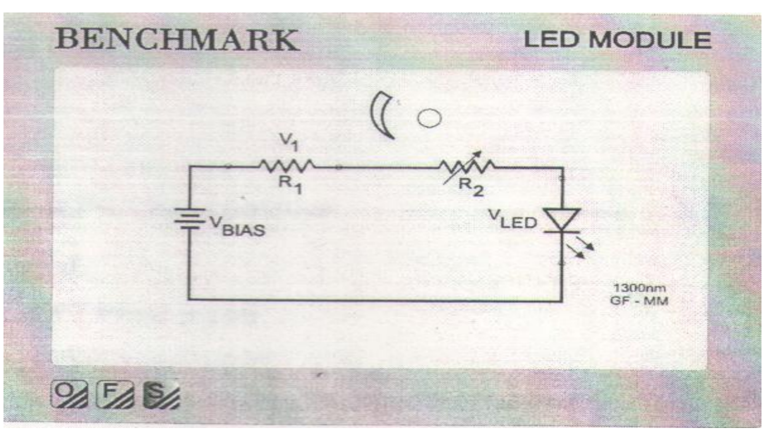
6. Plot the graph P vsL.

FORWARD BIAS AND REVERSE BIAS:

1. Put 10K ohm resistor across VL.
2. Adjust the potentiometer and fix the bias voltage at10V
3. Connector ST connector end of the patch cord supplied with the module to the power source
4. Set the power source in CW mode and to give maximum output power
5. Slightly unscrew the black colored cap of the PD to loosen it.
6. Slightly unscrew the black colored cap of the PD to loosen it.
7. Vary the optical power P from -18 dBm approx in steps of 5dBm. Tabulate the readings as shown Iz=VL/1x106
8. Plot the graph P vsL.

CIRCUIT DIAGRAM:





MODEL GRAPH:

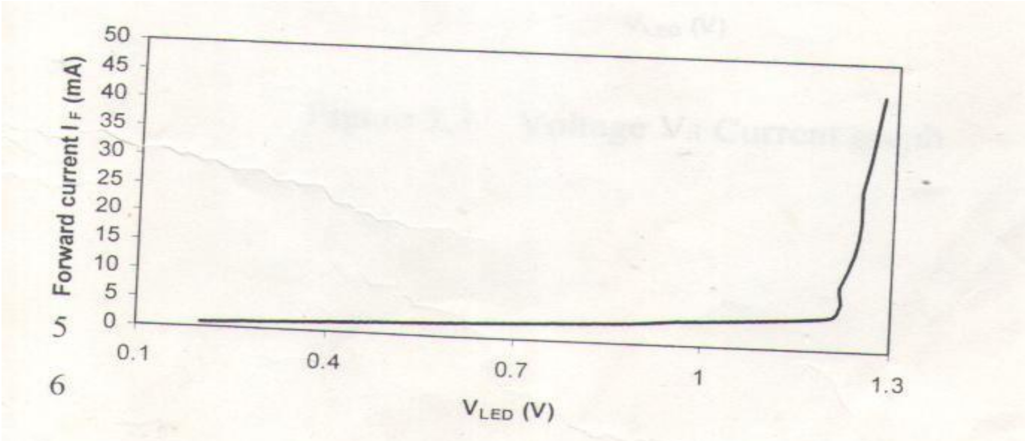
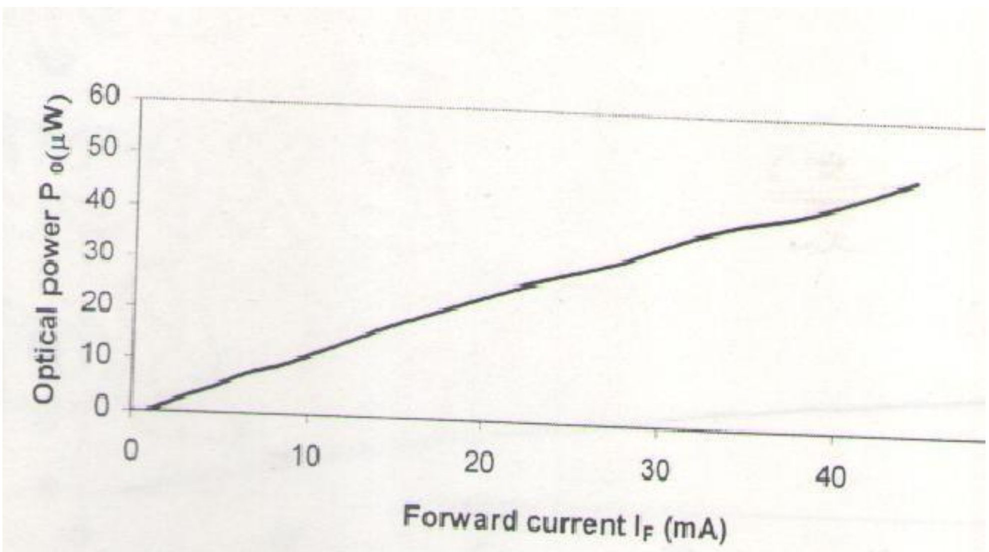
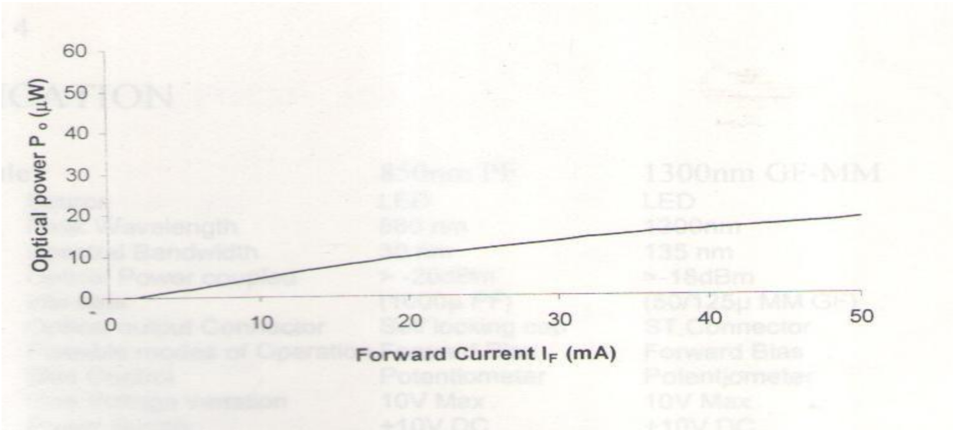


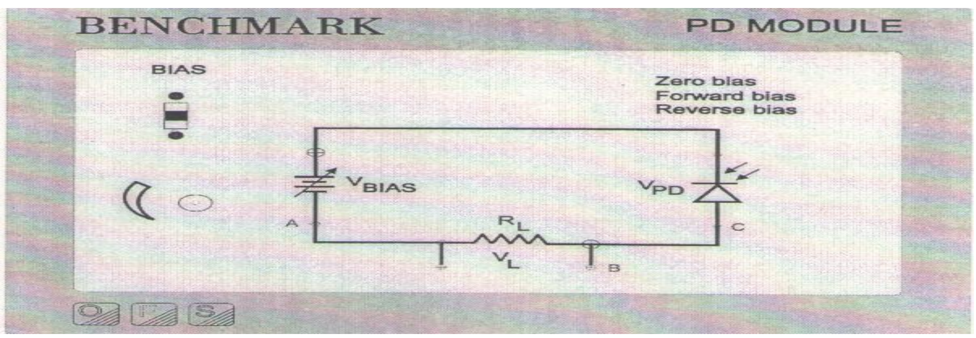
Figure 3.1 Voltage Vs Current graph

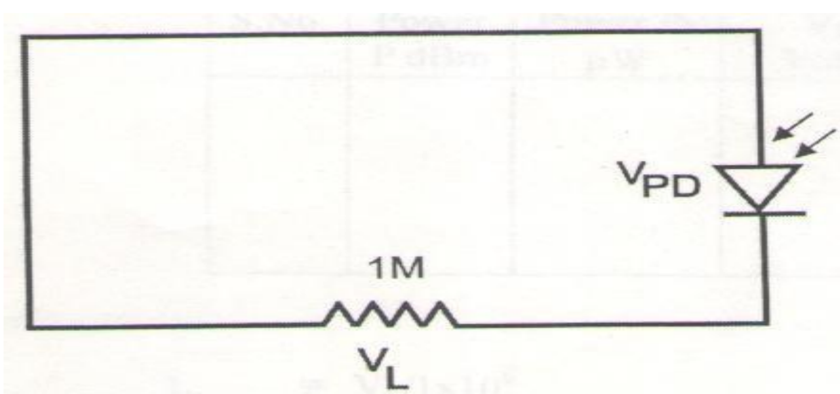


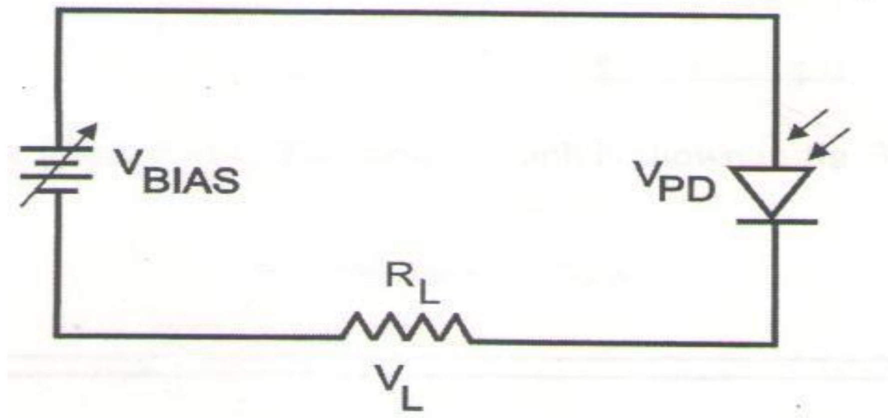
800 nm

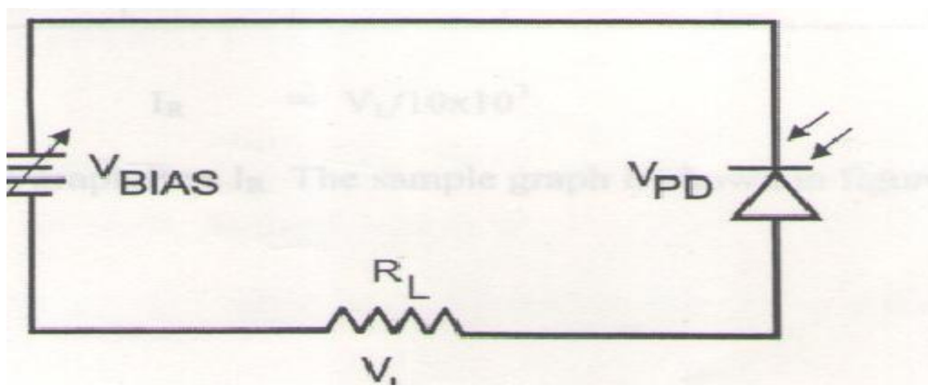


CIRCUIT DIAGRAM:









TABULATION [LED Module]:

S.No	V1(V)	If	VLED	P dBm	P0 mW

TABULATION [PHOTO DIODE MODULE] .

S.No	Power P (dBm)	Power P0 (μW)	VL(Volts)	Iz(μA)

TABULATION [PHOTO DIODE MODULE] Forward Bias:

S.No	Power P (dBm)	Power P0 (μW)	VL(Volts)	Iz(μA)

.

TABULATION [PHOTO DIODE MODULE] Reverse Bias:

S.No	Power P (dBm)	Power P0 (μW)	VL(Volts)	Iz(μA)

Result:

Conclusion:

.

Viva Questions:

.

1. What are the characteristics of laser diode?

2. What wave length is a diode laser?

3. What is Fabry Perot laser diode?

4. What is definition of laser diode?

5. Applications of Laser Diode?

.

Exp .No: 10 **Date:**

MEASUREMENT OF NUMERICAL APERTURE

Aim: To calculate the Numerical Aperture and bending losses of given optical fiber.

Apparatus Required:

S.no	Apparatus	Range/Specification	Quantity
1	Fiber Optic Trainer Kit		1
2	CRO	30 MHz	1
3	Function Generator	5 MHz	1
4	Optical Fiber Cable	1 Meter& 3Meter	1
5	Numerical Aperture measurement Kit	-	1
6	Scale	1 Cm	1
7	Power Supply	-	1
8	Connecting Wires	As per required	

Theory:

Numerical Aperture gives the relationship between the acceptance angle and the refractive indices of the three media involved namely the Core, Cladding and air.

A light ray incident on the fiber core at an angle θ, to the fiber axis is less than the acceptance angle for the fiber θ_a then the Numerical aperture is defined as the Sine of half of the angle of fibers

The ray enters the fiber from a medium of refractive index medium (air) of refractive index n_o and the fiber core has a refractive index n_1 which is slightly greater than the cladding refractive index n_2.

Assuming the entrance face at the fiber core to be normal to the axis, then considering the refraction at the air-core interface and using Snell's law given by:

$$n_o \text{ Sin } \theta_1 = n_1 \text{ Sin } \theta_2$$

$$n_o \text{ Sin } \theta_1 = n_1 \text{ Cos } \emptyset \qquad (\emptyset = \frac{\pi}{2} - \theta_2)$$

$$n_o \text{ Sin } \theta_1 = n_1 (1 - \text{Sin}^2\emptyset)^{1/2} \qquad (\text{Sin}^2\emptyset + \text{Cos}^2\emptyset = 1)$$

$$n_o \text{ Sin } \theta\, a = (n_1^2 - n_2^2)^{1/2}$$

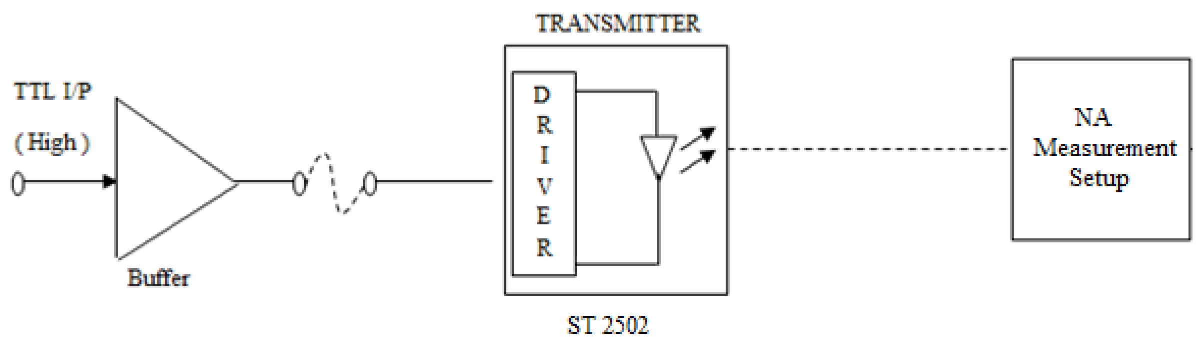
$$NA = (n_1^2 - n_2^2)^{1/2}$$

The Numerical aperture may also be given in terms of the relative refractive index difference Δ between the core and the cladding is defined as

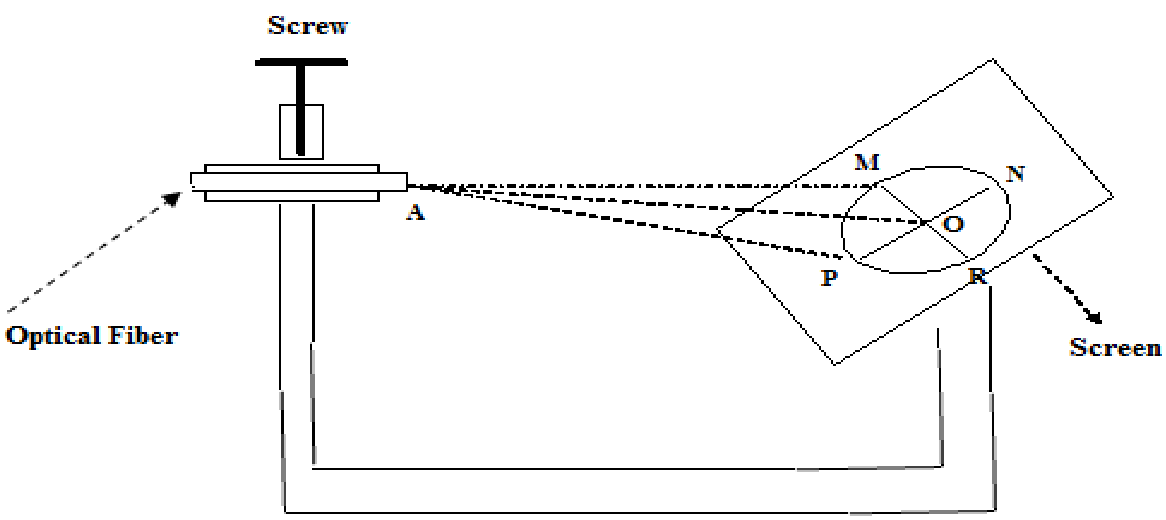
$$\Delta = \frac{n_1^2 - n_2^2}{2 n_1^2} \simeq \frac{n_1 - n_2}{n_1}$$

$$\therefore NA = n_1 (2\Delta)^{1/2}$$

Block Diagram of Digital Link Set-Up:



NA Measurement Setup



Procedure:

1) Connect the power supply to the board, frequency generator 1 KHz Sine wave to input of emitter circuit. Adjust its amplitude to 5 V_{p-p} .
2) Connect one end of fiber cable to output socket of the emitter - 1 circuit and other end to the Numerical aperture kit.

3) Keep the white screen facing the fiber such that its face is perpendicular to axis of the fiber.

4) Keep the white screen with four concentric circles (10, 15, 20 & 25 mm) distance to make red spot fall on it.

5) Note down the distance of screen from the fiber end and note down the diameter 'W' of the spot.

6) Calculate the Numerical aperture from the formula: NA = $\frac{W}{\sqrt{4L^2 + W^2}}$ = Sin θ_{max}

7) Tabulate the various distances and diameters of circles made on white screen and calculate the Numerical Aperture from the formula.

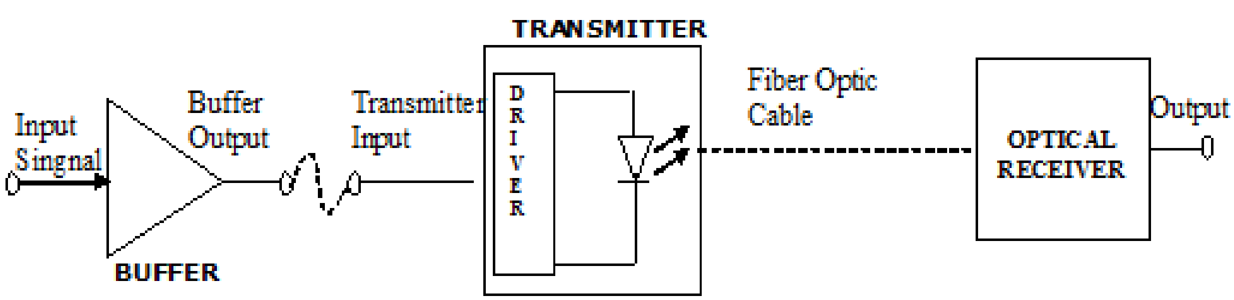
Calculations:

$$\frac{W}{\sqrt{4L^2 + W^2}}$$

Tabular Column:

L (mm)	W (mm)	NA = $\frac{W}{\sqrt{4L^2 + W^2}}$	θ_A = Sin^{-1} (NA)

Block Diagram Of Analog Link Set-Up:



Jumper setting diagram:

Procedure:

1. Connect the power supply cables to the fiber optic analog link trainer.
2. Connect the signal generator between input and the ground pins of the emitter circuit.
3. Set the Signal generator in Sine wave mode and select the frequency of 1 KHz and amplitude 2 V (peak to peak).
4. Connect the 1 M Optical Fiber Cable (L_1) between emitter and detector circuits.
5. Switch on the power supplies and Signal generator.
6. Observe the waveform at output of the detector circuit and note down its amplitude as reading V_1.
7. Switch OFF the power supplies and connect 2 M Optical Fiber Cable (L_2) between emitter and detector circuit.
8. Now switch ON the power supplies.
9. Observe the waveforms at the output of the detector circuit and note down its amplitude as reading V_2.
10. Now, calculate the Propagation Loss as $\gamma = \frac{\ln(V2 / V1)}{L1 + L2}$
11. Repeat step 4, by bending the cable around the mandrel rod for around one or two turns and note down the output reading as V_2'.
12. Calculate the bending loss by the formula given in step 10.

Tabular column: **V in =** .

S.no	Distance (cm)	Losses (V2)	$\gamma = \frac{\ln(V2 / V1)}{L1 + L2}$
1			
2			
3			
4			
5			

Result:

Conclusion:

Viva Questions:

1. What is the unit of numerical aperture?

2. What is the significance of numerical aperture?

3. What is the formula for numerical aperture?

4. What is bending loss in optical fiber?

5. What is the unit of measurement of the optical attenuation per unit length?

.

Exp .No: 11 **Date:**

SETTING UP OF ANALOG & DIGITAL OPTICAL LINK

Aim: To study the Analog Signal transmission for 660nm LED Source and measure the Data rate of Digital Optical link.

Apparatus Required:

S.no	Apparatus	Range/Specification	Quantity
1	Fiber Optics Analog Link kit	-	1
2	CRO	30 MHz	1
3	Function Generator	5 MHz	1
4	Fiber Cable	1 Meter	1
6	Power Supply	-	1
7	Fiber Optic Digital Link		1
8	Connecting Wires	As per required	

Theory:

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

TRANSMITTER:

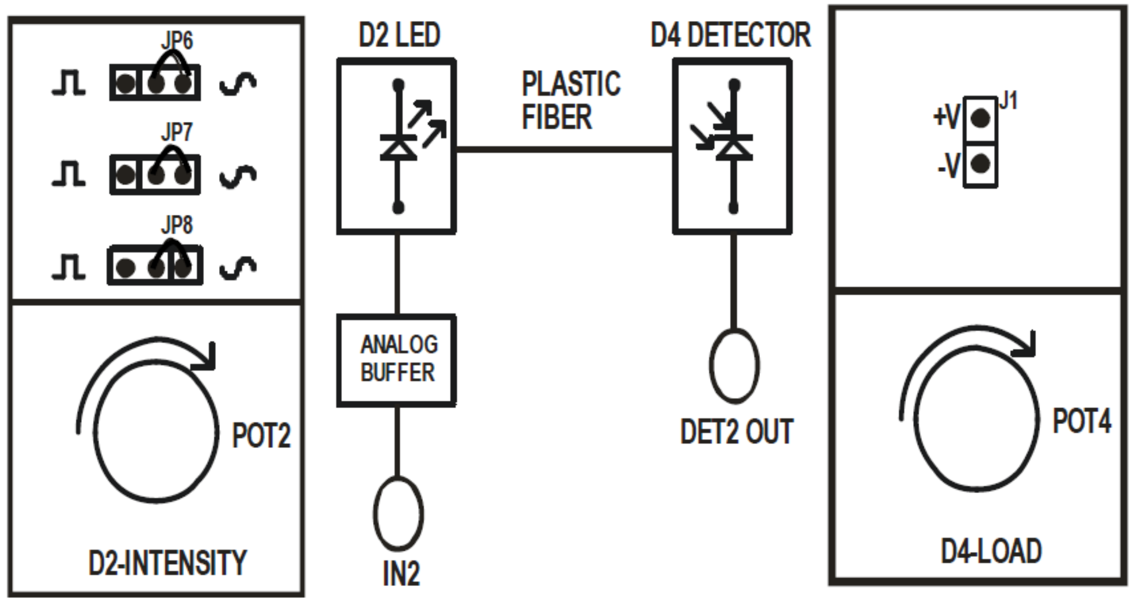
Fiber optic transmitters are typically composed of a buffer, driver and optical source. The buffer electronics provides both an electrical connection and isolation between the transmitter and the electrical system supplying the data. The driver electronics provides electrical power to the optical source in a fashion that duplicates the pattern of data being fed to the transmitter. Finally the optical source (LED) converts the electrical current to light energy with the same pattern.

RECEIVER:

The function of the receiver is to convert the optical energy into electrical form which is then conditioned to reproduce the transmitted electrical signal in its original form. The detector SFH250V used in the kit has a diode type output. The parameters usually considered in the case of detector are it's responsively at peak wavelength and response time.

SFH250V has responsivity of about 4 mA per 10 mW of incident optical energy at 950 nm and it has rise and fall time of 0.01 m sec. PIN photodiode is normally reverse biased.

Block Diagram Of Analog Link Set-Up:



Procedure:

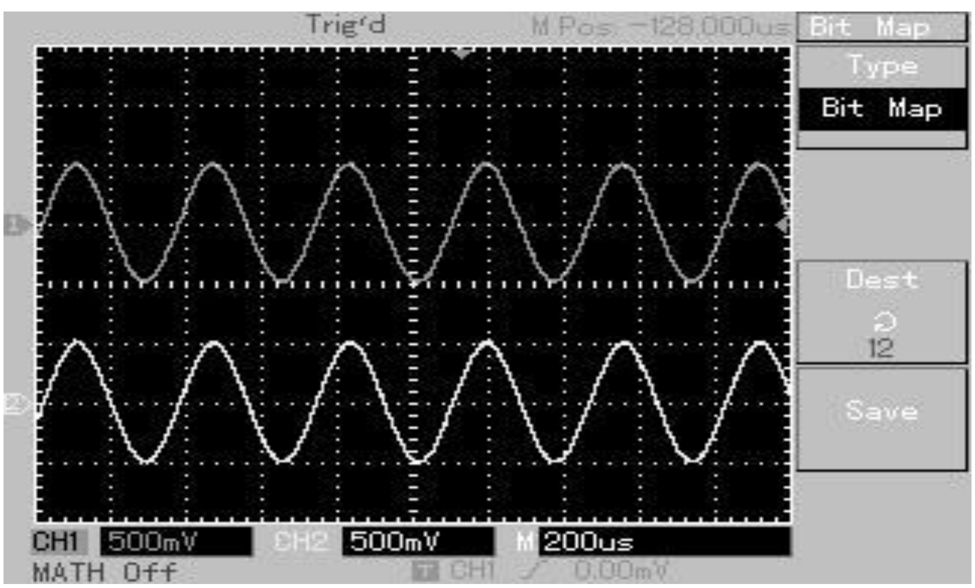
1. Refer to fig and carry out the connections
2. Keep Intensity Control pot POT2 fully anticlockwise
3. Keep jumper JP6, JP7 and JP8 to analog mode.
4. Make sure that the power supply of FOL-M-GPis off.
5. Apply 1Vp-p sine wave of frequency 1 KHz from function generator to the IN2 post of analog buffer.
6. Connect Optical O/P of LED D2 to photo transistor D4 using 1 meter plastic fiber patch chord provided.
7. Vary the Intensity control Pot POT2and observe the detected signal at DET2 OUT post.
8. Go on increasing the Function Generator sine wave frequency in steps of 1 KHz and observe the Detected Signal.
9. Note down the Frequency for the Function Generator sine wave at which the Detected Signal O/P. to get the undistorted detected signal adjust load using POT4.

.

Calculations:

Tabular column:

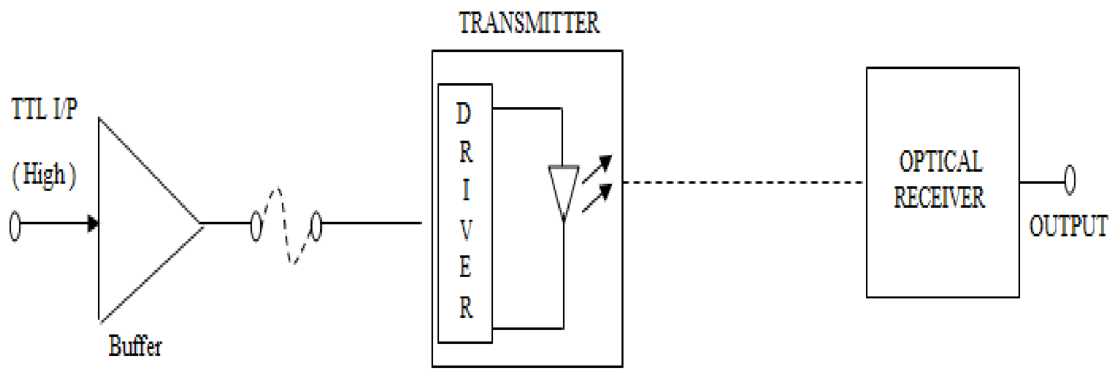
OBSERVATIONS:



CH1 : input signal from Function generator

CH2: detected signal through fiber optic link

Block Diagram of Digital Link Set-Up:



Procedure:

1) Connect the power chord with the fiber optic digital link and Switch ON.
2) Feed the TTL Square signal from the function generator to the input of the emitter circuit.
3) Also connect Channel 1 of CRO to emitter input.
4) Connect a half meter optical fiber cable to the output of the emitter circuit.
5) Connect the other end of the fiber cable to the input of the detector circuit.
6) Connect channel 2 of the CRO to the detector output.
7) Set the frequency of the TTL signal to 50 Hz; adjust the duty cycle of the input waveform to 25%.
8) Note down the ON time and OFF time of the output waveform by observing the output of the CRO and calculate its duty cycle.
9) Now vary the frequency of the input signal in steps of 100 Hz till 200 KHz and calculate the corresponding Duty cycle.
10) Repeat 'Step 9' by setting the duty cycle for the input waveform to 50 % & 75%.
11) Duty Cycle = $\frac{ON\ time}{ON\ time + OFF\ time}$

Tabular Column:

.

Frequency (Hz)	Output for 25% Duty Cycle			Output for 50% Duty Cycle			Output for 75% Duty Cycle		
	ON Time	OFF Time	Duty Cycle	ON Time	OFF Time	Duty Cycle	ON Time	OFF Time	Duty Cycle

Result:

Conclusion:

Viva Questions:

1. What is analog link in optical fiber?

2. Is fiber optic analog or digital?

3. How is a digital signal transmitted?

4.What is digital link in optical fiber?

5. What is the difference between analog and digital?

.

Exp .No: 12 **Date:**

ATTENUATION MEASUREMENT

AIM: To measure the attenuation losses in the given optical fiber.

Apparatus Required:

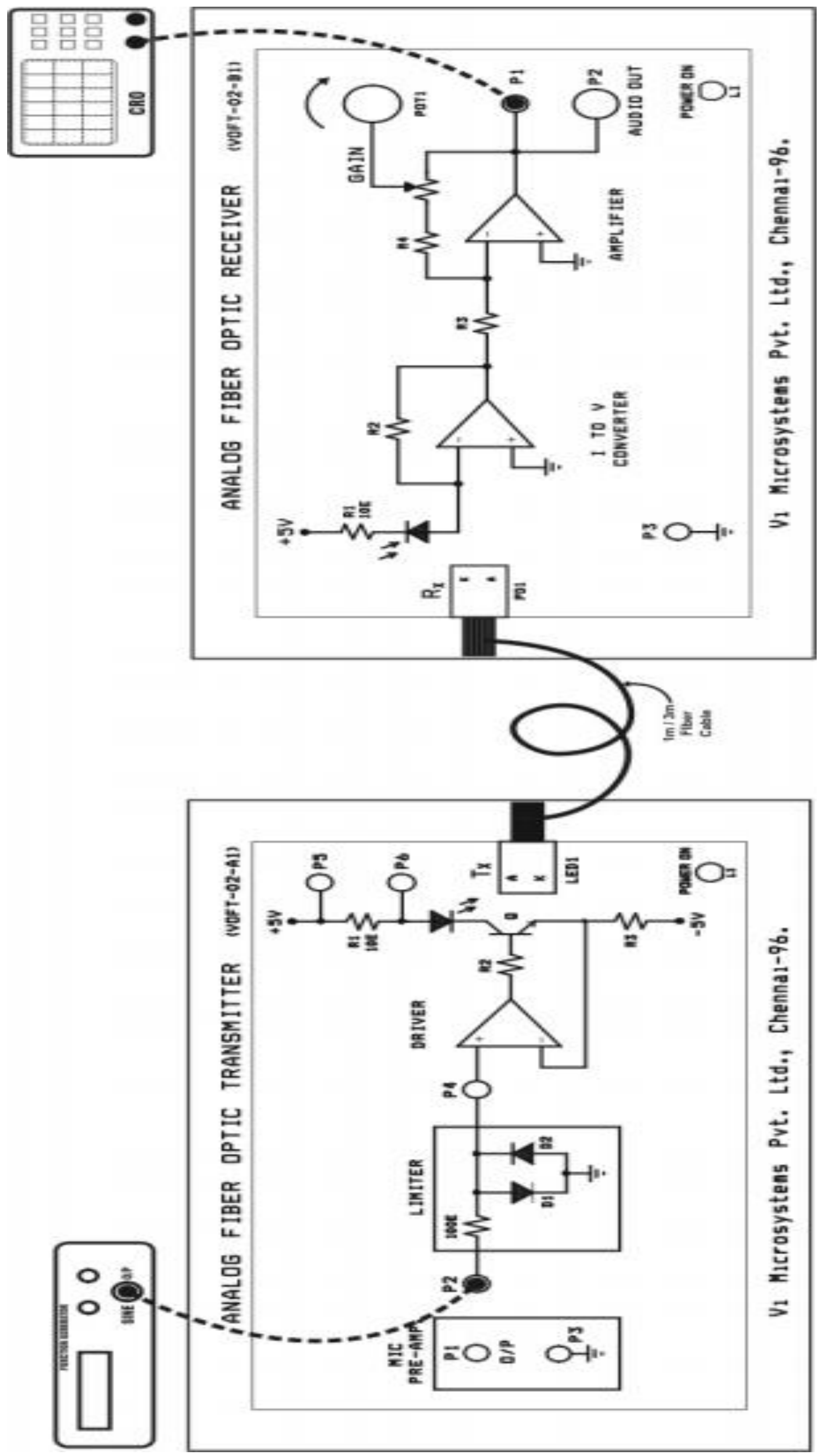
S.no	Apparatus	Range/Specification	Quantity
1	Analog (Tx & Rx) kit	-	1
2	CRO	120MHz	1
3	Function Generator	5 MHz	1
4	Fiber Cable	1 Meter & 3 Meter	1
5	Power Supply	-	1
6	Connecting Wires	As per required	

THEORY:

Measure the light power before it is directed into an optical fiber and then measure it again as it emerge from the fiber, would you expect to get same power of course not, the power coming out of the fiber should be less than the power entering it, that's called attenuation.

In fiber - optic communication, attenuation is the decrease in light power or intensity during light propagation along an optical fiber. Here the light loss caused by the violation of total internal reflection concept during installation or manufacturing called bending loss and the light delays its power while propagating through the fiber called propagation loss.

CONNECTION DIAGRAM:



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TABULATION:

S.NO.	Cable length (M)	Frequency (KHz)	I/P Voltage (volts in Vpp)	O/P Voltage (volts in Vpp)

Note:1m output voltage is V_1 and 3m is output voltage is V_2

PROCEDURE

1. Establish the analog link as suggest in experiment shown in figure with

   inputsignalamplitudeandfrequencyof1Vppand1KHzrespectively.

2. ConnecttheoutputofVOFT-02-B1(TestPointP1)tothechannel1ofoscilloscopeusingBNC-SP7cableandkeepfibercablelengthof1mbetweentransmitterandreceiver.

3. TurnthegaincontrolPOTatthereceiverandsetoutputamplitudelevelto5Vpp, let us say it V_1. Now replace 1m fiber cable by 3m fiber cable withoutaltering any other settings (receiver gain (or) input voltage).Measure the outputvoltage level for 3m fiber cable, let us say it V_2. The difference between the two readings is the extra loss in lost one due to the extra length of the fiber.

4. Determine the attenuation loss 'a' for 1m fiber in dB/m, $a=-10\log_{10}(\frac{V2}{})$

.

RESULT:

Conclusion:

Viva questions:

1. What are the main applications of optical fibre ?

2. What are the types opf attenuation measurement?

3. What is DB km?

4. What is the principle of OTDR?

5. What is the cause of attenuation?

Advanced experiment

Exp .No: 13 **Date:**

MEASUREMENT OF S-PARAMETERS OF CIRCULATOR CHARACTERISTICS

Aim: To study the S-Parameters of Circulator

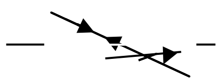
Apparatus Required:

S.no	Apparatus	Range/Specification	Quantity
1	Klystron Power Supply	-	1
2	Klystron Mount	-	1
3	Isolator	-	1
4	Variable Attenuator	-	1
5	VSWR Meter	-	1
6	Meter/CRO	30 MHz	1
7	Waveguide Stands	-	4
8	BNC Cables	-	1
9	Cooling Fan	-	1
10	Matched terminator	-	1
11	Circulator	-	1
12	Detector mount	-	1

THEORY:

CIRCULATOR:

Circulator is defined as device with ports arranged such that energy entering a port is coupled to an adjacent port but not coupled to the other ports. This is depicted in fig. 7 circulator can have any number of ports.



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S- Parameters:

The analysis and behavior of microwave circuits by considering the traveling waves at the selected reference planes results in the use of reflection (or) scattering coefficients.

The electromagnetic fields at each of the terminal planes can be written in terms of the normalized voltage and current. The total voltage and current are the sum of the incident and reflected waves. If M_1 represents the wave admittance for the dominant mode the total voltages and currents become.

$$V_1 = V_1^i + V_1^r$$

$$I_1 = M_1 (V_1^i - V_1^r)$$

$$I_1^i = M_1 V_1^i$$

In these equations the electric and magnetic fields are vector quantities and are a function of time. The coefficients V and I are therefore complex quantities for simplicity voltage coefficients can be written as

$$a = V_1^i \quad \text{and} \quad b = V_1^r$$

Total voltage and current become

$$V_1 = a + b \quad ; \quad I_1 = M_1 (a - b)$$

$$b_{12} = S_{12} a_2$$

$$b_{22} = S_{22} a_2$$

$$b_{N2} = S_{N2} a_2$$

In general, if excited by the mth arm these are

$$b_{1m} = S_{1m} a_m$$

$$b_{Nm} = S_{Nm} a_m$$

The constants which relates the incident and reflected waves. S_{Nm} are called scattering coefficients. It can be shown that in the case of transmission lines filled with ordinary substances, reciprocity conditions require that $S_{mm} = S_{mn}$.

The total signal reflected from the microwave circuit is obtained by summing the partial waves in the particular arm.

$$b_1 = \sum_{m=1}^{N} b_{1m}$$

$$b_N = \sum_{m=1}^{N} b_{Nm}$$

For the four terminal case (N = 2)

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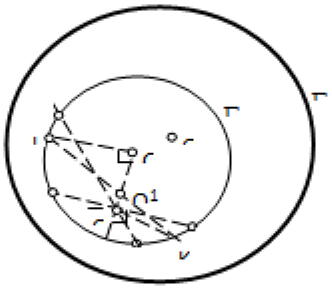


Alternate graphical method of

$b_1 = b_{11} + b_{12}$

$b_2 = b_{21} + b_{22}$

Since $b_{Nm} = S_{Nm} a_m$

$b_{11} = S_{11} a_1$

$b_{12} = S_{12} a_2$

$b_{21} = S_{12} a_1$ $b_{22} = S_{22} a_2$

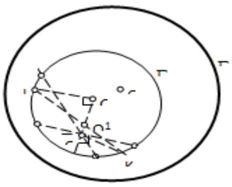
∴ The above equations become

$b_1 = S_{11} a_1 + S_{12} + S_{12} a_2$

$b_{21} = S_{12} a_1 + S_{22} a_2$

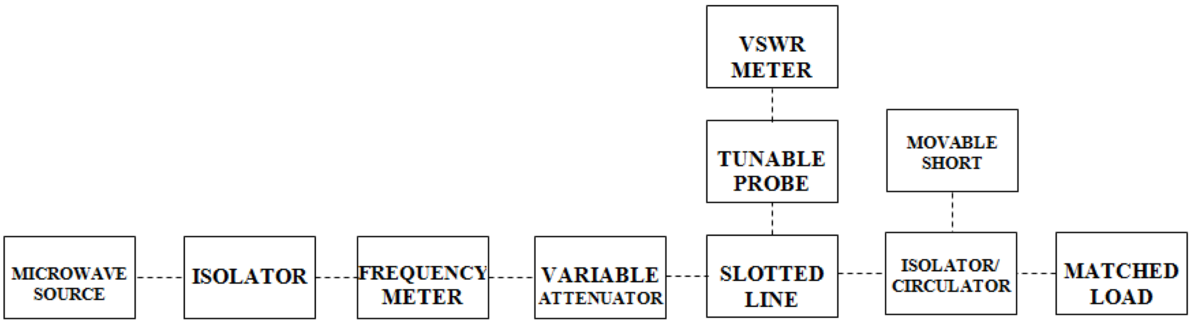
A shorting plunger terminates the output terminals of the unknown network and the corresponding input impedances are measured on the input side; because of the presence of losses in an arbitrary network, it is necessary to use more complicated graphical procedure for interpretation of the data. This method is powerful, equally useful for loss less and lossy networks and can be extended to certain classes of non uniform transmission lines.

$$|S_{12}| = |S_{21}| = R^1\left(1 - |S_{22}|^2\right)$$



Alternate graphical method of

BENCH SETUP FOR CIRCULATOR:



PROCEDURE:

1. Setup the equipment as shown in fig.
2. Energize the microwave source for a particular frequency of operation.
3. Now, keep the shorting plunger at the termination end and it is at zero position find the λ_g and V_{min} position.
4. Connect the port 1 of Circulator to the slotted line and matched loads on the other ports.
5. Now, keep the probe position at maximum and set VSWR = 1 by tuning the frequency of the AM signal and tunable probe.
6. Move the probe along slotted line to the minimum position take the direct VSWR on the VSWR scale and find V_{min} position on the slotted line and this minimum position is reference V_{min}.
7. Remove the matched load at port 2 and connect the shorting plunger with zero position.
8. Take the readings of VSWR and V_{min} positions for every $\lambda_g/16$ distance of plunger.
9. Note down the readings in tabular column and make the same procedure for other ports to get the S-parameters.

To find S-parameters follow the procedure given in the Graphical representation of S-parameters

Calculations:

$$V_{min} = \qquad \lambda_g = \qquad S_{21} \begin{pmatrix} S_{11} & S_{12} & S_{13} \\ S_{22} & S_{23} & \\ S_{31} & S_{32} & S_{33} \end{pmatrix}$$

Port 1 input

Port 2 with movable short

Port 3 matched

Tabular column:

.

OBSERVATIONS:

V_{min}	VSWR	λ_g position
		0
		$\lambda_g/16$
		-
		-
		$8\lambda_g/16$

Result:

Conclusion:

Viva Questions:

1. How are S parameters measured?
2. What do S parameters mean?
3. What is S parameter s21?
4. What is S parameter in microwave?
5. What is the purpose of a circulator?

Exp .No: 14 **Date:**

INTENSITY MODULATION OF LASER OUTPUT THROUGH AN OPTICAL FIBER

Aim: To determine the AC characteristics of an intensity modulation for LASER and Fiber optic system.

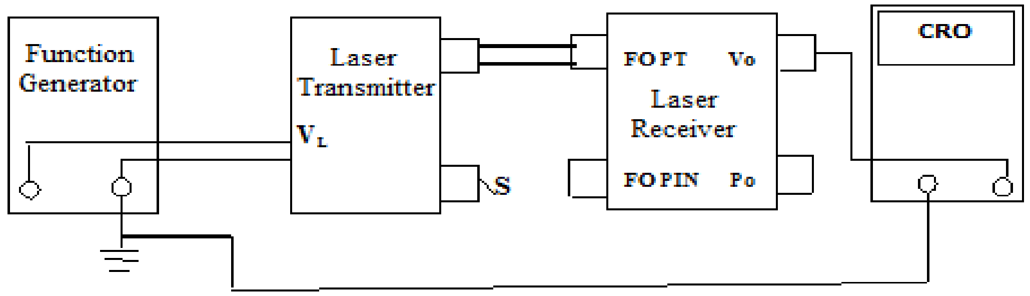
Apparatus Required:

S.no	Apparatus	Range/Specification	Quantity
1	Transmitter Module	-	1
2	Receiver Module	-	1
3	Power Supply	-	1
4	Optical Fiber cable	1 Meter	1
5	CRO	30MHz	1
6	CRO Probes	-	2
7	Connecting wires	As per Required	

Theory:

The intensity modulation / demodulation system is realized using PHY- 159 transmitter module and the PHY -158 receiver unit linked through an optical fiber. We use PMMA FIBER cable. The laser carrier power P_o is set by adjusting the 'set I_f' knob in the middle. Laser selection of optimum carrier power is essential to minimize distortion. Limiting the depth of modulation also ensures distortion free transmission. Bandwidth of the system in the present case is limited by the photo detector. We should operate in the APC mode to obtain optical output proportional to the modulating signal V_{in}. We will however operate in the APC mode too. An ideal IM transmission system will have the relationship $V_{out} = G. V_{in}$ where G is a factor depends on the LCD conversion efficiency

Experimental Set-Up:



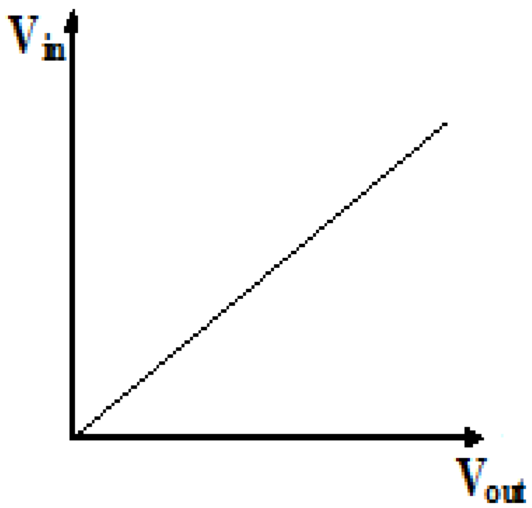
Procedure:

1. Connect the fiber optic cable, input signal and output as shown in the experimental set-up.
2. Set the signal frequency and amplitude to 2 KHz(mid band frequency)and 100mV respectively.
3. Adjust the **IF** Knob to get output of 100mV(i.e., 0dB gain)
4. Slowly vary the input amplitude to 1000mV insteps of 100mV And note down the corresponding output amplitude
5. Tabulate and plot a graph V_{out} Vs V_{in}.

Tabular Column:

V_{in} (V)	V_{out} (V)	Gain= V_{out}/V_{in}

Model Graph:



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Result:

Conclusion:

Viva Questions:

1. What are the types of optical fibers?
2. What are different types of fibers?
3. What is the principle of optical Fiber?
4. Which light is used in optical Fiber?
5. How is optical Fiber made?