SVR ENGINEERING COLLEGE

Approved by AICTE& Permanently Affiliated to JNTUA

Ayyalurmetta, Nandyal – 518503.Website: www.svrec.ac.in

Department of Electronics and Communication Engineering

MICROWAVE & OPTICAL COMMUNICATIONS LABORATORY

IVB.Tech (ECE) R15 I Semester

2020-21

STUDENT NAME	
ROLL NUMBER	
SECTION	

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Department of Electronics and Communication Engineering

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

CERTIFICATE

ACADEMIC YEAR: 2020-21

This is to certify that the bonafide record work done by Mr./Ms.____bearing H.T.No.__________________of IVB.Tech I Semester in the **MICROWAVE & OPTICAL COMMUNICATIONS LABORATORY.**

Faculty In-Charge **Head of the Department**

ECE DEPT VISION & MISSION PEOs and PSOs

ςισιον

To produce highly skilled, creative and competitive Electronics and Communication Engineers to meet the emerging needs of the society.

Μισσιον

- Impart core knowledge and necessary skills in Electronics and Communication Engineering through innovative teaching and learning.
- Inculcate critical thinking, ethics, lifelong learning and creativity needed for industry and society
- Cultivate the students with all-round competencies, for career, higher education and self-employability

I. PROGRAMME EDUCATIONAL OBJECTIVES (PEOS)

PEO1: Graduates apply their knowledge of mathematics and science to identify, analyze and solve problems in the field of Electronics and develop sophisticated communication systems.

PEO2: Graduates embody a commitment to professional ethics, diversity and social awareness in their professional career.

PEO3: Graduates exhibit a desire for life-long learning through technical training and professional activities.

II. PROGRAM SPECIFIC OUTCOMES (PSOS)

PSO1: Apply the fundamental concepts of electronics and communication engineering to design a variety of components and systems for applications including signal processing, image processing, communication, networking, embedded systems, VLSI and control system

PSO2: Select and apply cutting-edge engineering hardware and software tools to solve complex Electronics and Communication Engineering problems.

III. PROGRAMME OUTCOMES (PO'S)

1. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

2. Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

3. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

4. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

5. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

6. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

7. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

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

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

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

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

IV. COURSE OBJECTIVES

- To familiarize the students with basic Microwave communication systems.
- Integrate theory with experiments so that the students appreciate the knowledge gained from the theory course.
- Understand all types of Optical modulation / demodulation principles.

- Capable of Applying microwave Concepts/ Microwave components and test them.
- Able to design and analyze an optical fiber communications link

V. COURSE OUTCOMES

After the completion of the course students will be able to

Course Outcomes	Course Outcome statements	BTL
CO1	Understand different Optical modulation techniques & Laser receiver characteristics	L1
CO2	Analyze different modulation techniques using LED & LASER.	L3
CO3	Design and implement different modulation and demodulation techniques	L4
CO4	Observe the performance of system by plotting graphs & Measure Microwave devices &itscharacteristics.	L2
CO5	Observe the performance of system by plotting graphs & Measure Optical devices & its characteristics.	L5

VI. COURSE MAPPING WITH PO'S AND PEO'S

Course Title	P01	P02	P03	P04	P05	P06	P07	P08	P09	P010	P011	P012	PE01	PE02	PE03
Microwave & Optical communications Lab	3	3	3	2	3	3	2	3	3	3	3	3	2	3	3

V MAPPING OF COURSE OUTCOMES WITH PEO'S AND PO'S

Course Title	P01	P02	P03	P04	P05	P06	P07	P08	P09	P010	P011	P012	PE01	PE02	PE03
CO1	3	3	3	2	3	3	2	3	3	3	3	3	3	3	3
CO2	3	3	2	2	3	3	3	3	3	3	3	3	2	3	2
CO3	3	3	3	3	2	3	3	2	2	3	3	3	3	3	3
CO4	3	3	2	3	3	3	3	3	3	3	3	3	3	3	3
CO5	3	3	2	3	2	2	3	3	3	3	3	3	3	3	3

LABORATORY INSTRUCTIONS:

1. While entering the Laboratory, the students should follow the dress code. (Wearshoes and White apron, Female Students should tie their hair back).

2. The students should bring their observation book, record, calculator, necessarystationery items and graph sheets if any for the lab classes without which the students will not be allowed for doing the experiment.

3. All the Equipments and components should be handled with utmost care. Anybreakage or damage will be charged.

4. If any damage or breakage is noticed, it should be reported to the concerned incharge immediately.

5. The theoretical calculations and the updated register values should be noted down inthe observation book and should be corrected by the lab in-charge on the same day of the laboratory session.

6. Each experiment should be written in the record note book only after gettingsignature from the lab in-charge in the observation notebook.

7. Record book must be submitted in the successive lab session after completion ofexperiment.

8. 100% attendance should be maintained for the laboratory classes.

Precautions:

1. Check the connections before giving the supply
2. Observations should be done carefully.
3. Maintain some distance from test bench while taking readings.
4. All connections should be tightly connected with the help of screws.

LAB SYALLUBUS COPY

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B. Tech IV-ISem. (ECE)

15A04711 MICROWAVE & OPTICAL COMMUNICATIONS LABORATORY

Course Outcomes:

- Capable of Applying microwave Concepts/ Microwave components and test them
- Able to design and analyse an optical fiber communications link

Microwave Lab (PART – A) --- Any Seven (7) Experiments

1. Reflex Klystron Characteristics.
2. Gunn Diode Characteristics.
3. Attenuation Measurement.
4. Directional Coupler Characteristics.
5. VSWR Measurement.
6. Impedance Measurement.
7. Frequency and Wavelength measurements using slotted section.
8. Impedance Matching and Tuning
9. Scattering parameters of Magic Tee.
10. Radiation Pattern Measurement of horn Antennas (at least two antennas).

Optical Fiber Lab (PART – B) --- Any five (5) Experiments

1. Characterization of LED.
2. Characterization of Laser Diode.
3. Intensity modulation of Laser output through an optical fiber.
4. Measurement of Data rate for Digital Optical link.
5. Measurement of Numerical Aperture of the given fiber.
6. Measurement of losses for Analog Optical link.

INDEX

Microwave Lab (PART – A)

Experiment No.1 **Date:**

REFLEX KLYSTRON CHARACTERISTICS

AIM:

1) To study the mode characteristics of the reflex klystron.
2) To determine the mode numbers.

APPARATUS REQUIRED:

1. Klystron Power Supply with Cooling Fan --------------- 1No.
2. Reflex Klystron.. 1No.
3. Isolator.. 1No.
4. Frequency Meter.. 1No.
5. Variable Attenuator.. 1No.
6. Detector Mount________________________________1No.
7. Indicating Meter___1No.8. Oscilloscope with Probe -- 1No.
9. Waveguide Stands.. 3Nos.

THEORY:

The Reflex Klystron makes use of velocity modulation to transform a continuous electron beam into microwave power. Electron emitted from the cathode are accelerated and passed through the positive resonator towards negative reflector, which retards and, finally, reflects the electron; and the electron turns back through the resonator. Suppose an hf-field exists between the resonator, the electron travelling forward will be accelerated or retarded, as the voltage at the resonator changes in amplitude. The accelerated electrons leave the resonator at an increased velocity and the retarded electrons leave at the reduced velocity. The electrons leaving the resonator will need different time to return, due to change in velocities. As a result, returning electrons group together in bunches. As the electron bunches pass through resonator, they interact with voltage at resonator grids. If the bunches pass the grid at such time that the electrons are slowed down by the voltage, energy will be delivered to the resonator; and Klystron will oscillate. the schematic of a typical Klystron tube. the relationship between output power, frequency and reflector voltage. The frequency is primarily determined by the dimension of resonant cavity. Hence, by changing the volume of resonator, mechanical tuning range of Klystron is possible. Also, a small frequency change can be obtained by adjusting the reflector voltage. This is called Electronic Tuning Range. The same result can be obtained, if the modulation voltage is applied on the reflector voltage

CIRCUIT DIAGRAM:

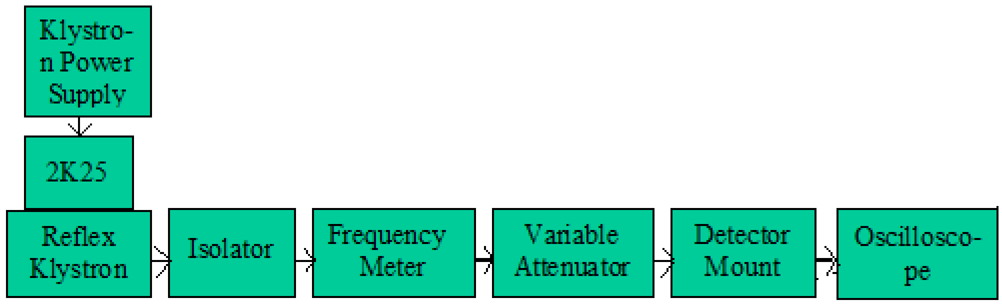


FIG: BENCH SET-UP FOR REFLEXIVE KLYSTRON CHARACTERISTICS

PROCUDURE:

1. Connect the components and equipments as shown in above figure.
2. Set the variable attenuator at minimum position (on 20mm).
3. After the completion of experiment, before going to switch off the mains keep all the knobs in minimum position (i.e.) as those are in rule 1.
4. 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.
5. Note the Modulation knob in — AM position
6. First switch on the cooling fan and Beam voltage knob is set near 270 volts (fixed)
7. Repeller voltage knob is to vary from 110v to 0v
8. Observe detector output on CRO to get square wave pulses .
9. Increase the Repeller voltage in steps of readings of and record the detector mount output in terms of voltage in the CRO by tuning the repellar voltage knob to have a dip in the output each time for each modes (3or 4 values until zero comes).
10. Plot the graph between Repellar voltage verses output voltage
11. The mode number is calculated by using the following formula.

$$\frac{V_2}{V_1} = \frac{n+1+3/4}{n+3/4}$$ (n----> mode number)

OBSERVATIONS:

Beam voltage = ---------- V
Beam current = --------- V

TABULAR COLUMN:

Sl. No.	Repellar voltage(V)	Output voltage(V)

CALCULATIONS:

For n_1:

$$\frac{v_2}{v_1} = \frac{n + 1 + \frac{3}{4}}{n + \frac{3}{4}}$$

n_1 = ________

For n_2:

n_2 = _______

For n_3:

n_3 = --------

EXPECTED GRAPH:

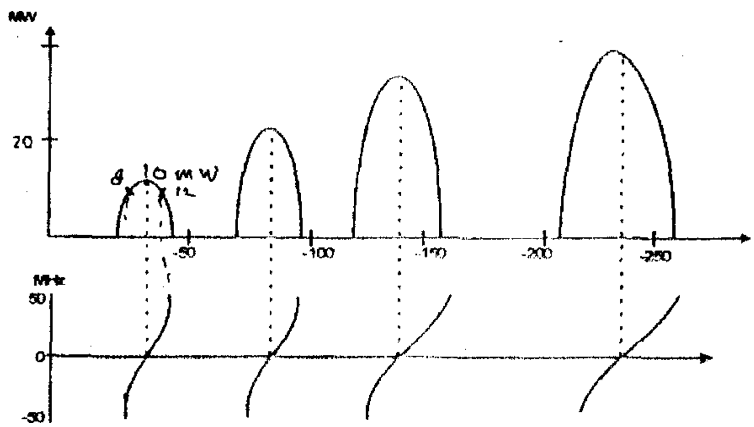


fig 4 Modes of 2K25

RESULT:

Hence the characteristics of the reflex – klystron has been studied. The tuning range of 1 2 3 modes is Observed.

PRECAUTIONS:

i. Keep all the knobs in minimum position before going to switch 'ON' the power supply of VSWR / Klystron power supplies. Note: For klystron power supply "HT" should be 'OFF' before switching 'ON' the main supply.
ii. Beam knob should be completely in anticlockwise direction and repeller voltage knob should be completely clockwise direction.
iii. Switch on the main supply and give some warm up time to get current / accurate reading. 5
iv. After the completion of experiment, before going to switch off the mains keep all the knobs in minimum position (i.e.) as those are in rule 1.
v. 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.
vi. Don't increase the repeller voltage more than -70V(i.e.) it should be between -70Vto - 270V.

VIVA QUESTIONS:

1. What is the operating principle of reflex klystron?
2. What are the applications of reflex klystron?
3. What is transit time?
4. What modes are generally used in a reflex klystron?
5. What is the operating frequency and power output of a reflex klystron?

Experiment No.2 **Date:**

GUNN DIODE CHARACTERISTICS

AIM:

To study Gunn Oscillator as a source of micro wave power and to study the V-I Chacteristics.

APPARATUS REQUIRD:

1. Gunn Power Supplywith Cooling Fan --------- 1No.
2. Gunn Oscillator 1No.
3. Isolator 1No.
4. Pin Modulator 1No.
5. Frequency Meter 1No.
6. Variable Attenuator -------------------------------- 1No.
7. Matchtermination 1No.
8. VSWR Meter 1No.
9. Waveguide Stands--------------------------------- 3No.

THEORY:

Semiconductors

Semiconductors are materials with electrical conductivity intermediate between that of a conductor and an insulator. In semiconducting materials thermal energy is enough to cause a number of electrons to release from valance band to conduction band, in which they are relatively free. Common semiconducting materials are silicon, germanium, gallium, arsenide etc.

Semiconductors are classified as;

Intrinsic semiconductors: Pure semiconducting materials like crystalline form of germanium and silicon, with equal concentration of electrons and holes.

Extrinsic semiconductors: Semiconducting material with the addition of suitable impurity atoms through doping.

Extrinsic semiconductors can be ***p-type*** or ***n-type*** depending on the impurities added to it. A p- type semiconductor is formed when adding pentavalent impurities like phosphorus, arsenic, antimony etc. to an intrinsic semiconductor. If the impurities added are trivalent atoms, we get the n- type semiconductor. Semiconductor diode is simply the combination of a p-type and an n-type material. It is formed by doping half of the silicon crystal with trivalent impurity (p-type) and the other half with pentavalent impurity (n-type). It has the characteristics of passing current in one direction only. If there is no voltage is applied across the junction, electrons will diffuse through the junction to p - side and holes will diffuse through the junction to n - side and they combine with each other. Thus the acceptor atom near the p - side and donor atom near n – side are left unutilized and is called the depletion layer. An electron field is generated by these uncovered charges which called the barrier potential. This opposes further diffusion of carriers and is known as depletion region

CIRCUIT DIAGRAM:

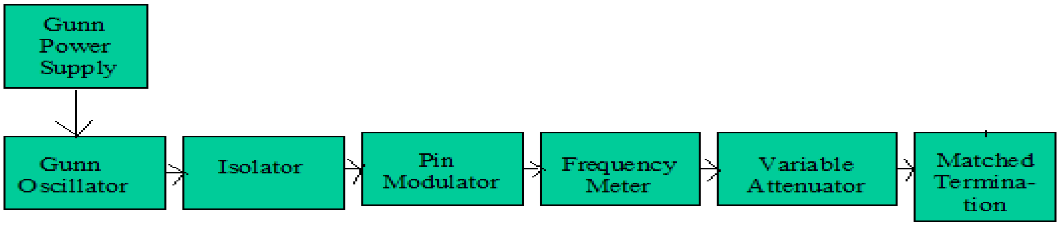


FIG: BENCH SET-UP FOR V-CHARACTERISTRICS OF GUNN DIODE

PROCEDURE:

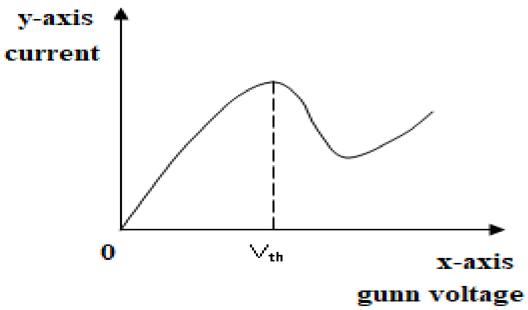
V-I characteristics:

1. Set the components as shown in above figure.
2. Keep the control knobs of Gunn power supply as below
   - Meter switch should be off
   - Gunn bias knob-fully anticlockwise
   - Pin bias knob (mod amp) – fully anticlockwise
   - Pin mode frequency – any position
3. Set the micrometer of Gunn oscillator for required frequency of operation.
4. Switch on the Gunn power supply.
5. Measure the Gunn diode current corresponding to various Gunn bias voltages throughthe digital panel meter and meter switch. 0.5 volts to 10 volts and note down the correspondingcurrent.
6. Plot the voltage and current reading on the graph and compare with expectedgraph.
7. Measure the threshold voltage which corresponds to maximum current.

Frequency versus voltage characteristics:

5. At any one of these two frequencies set the Gunn biasing just above the threshold voltage V_o, and adjust the attenuator for suitable power level. Record frequency using the frequency meter.
6. Plot the frequency versus Gunn bias characteristics.

EXPECTED GRAPH:



TABULAR COLUMN:

Sl.No.	Gunn Voltage (V)	Current (mA)

CALCULATIONS:

Negative resistance region = $\frac{\Delta V}{\Delta I}$

$$= \frac{V_2 - V_1}{I_2 - I_1}$$

RESULT:

The V-I characteristics of Gunn diode has been observed. The threshold voltage is -56.25Ω.

PRECAUTIONS:

i. Do not keep Gunn bias knob position at the threshold position for more than 10-15 seconds
ii. Reading should be obtained as fast as possible otherwise due to excessive heat Gunn diode may burn
iii. Care should be taken such that the bias voltage should not exceed above 10V

VIVA QUESTIONS:

1. Why can't conventional tubes be used at microwave frequencies?
2. What is transit time?
3. What are the applications of Gunn diode characteristics?
4. What is velocity and current modulation in a reflex klystron?

Experiment No.3 **Date:**

ATTENUATION MEASUREMENT

AIM:

To study the substitution method for the measurement of attenuation and hence to determine the attenuation due to a component or device under test.

APPARATUS REQUIRED:

1. Klystron Power Supply with Cooling Fan ----------- 1No.
2. Klystron Tube .... 1No.
3. Isolator .... 1No.
4. Variable Attenuator .... 1No.
5. Frequency Meter .... 1No.
6. Slotted Line with Detector ---------------------------1No.
7. Tunable Probe with Detector------------------------- 1No.

9. Device under Test(SS tuner) ---------------------------1No.
10. Matched Termination --------------------------------- 1No.
11. Waveguide Stands________________________3Nos.

THEORY:

Attenuation is loss of power. During transit light pulse lose some of their photons thus reducing their amplitude. Attenuation for a fiber is usually specified in decibels per kilometer. For commercially available fibers, attenuation ranges from 1db/km for premium small core glass fibers to over 2000 dB/km for a large core plastic fiber. Loss is by definition negative decibels. In common usage, discussions of loss omit the negative sign. The basic measurement for loss in a fiber is made by taking the logarithmic ratio of the input power (P_i) to the output power (P_o).

$$\alpha\ (dB) = 10 \log_{10} P_i/P_0$$

where α is Loss in dB/meter.

Another impairment to the signal, besides attenuation is called dispersion. This effect limits the highest frequency that can transmitted through a certain length of fiber, and one of its causes (called ‘mode’ dispersion) results from the fact that there are different path lengths for each ray – those rays with larger values of angle of incidence travel less distance than those with smaller angle of incidence. Since the light in a fiber contains rays with all angels up to the critical angle, the time of arrival at the receiver of a short transmitted pulse will be spread over a time that is determined by the path lengths over which the individual rays travel, as the speed over a time that is determined by the path lengths over which the individual rays travel, as the speed of the light is the same in all directions. If the two short pulses are transmitted one after the other in quick succession, then the spreading of each pulse may cause the two to overlap at the receiver. Thus dispersion limits the frequency at which pulses can be detected, since the received could not be easily identified as having been generated from two separate pulses.

CIRCUIT DIAGRAM:

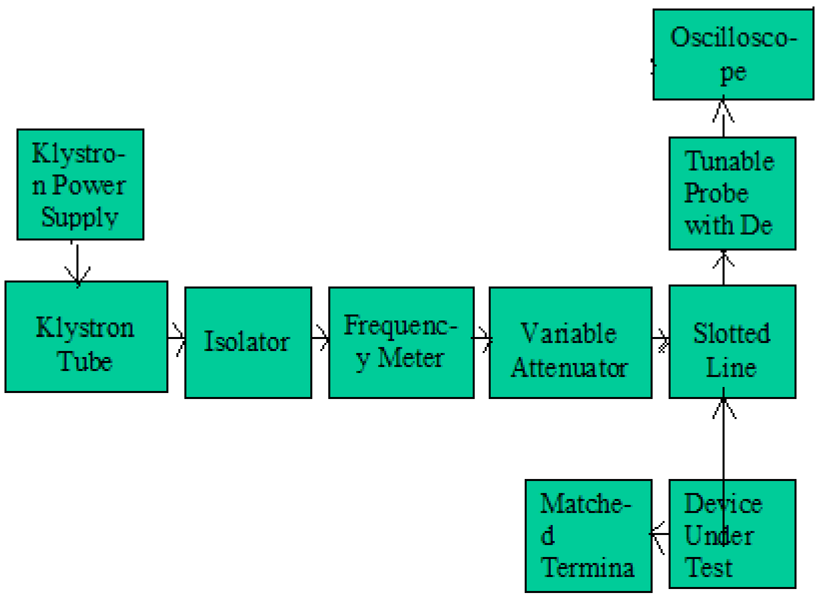


FIG: BENCH SET-UP FOR ATTENUATION MEASUREMENT

PROCEDURE:

1. Connect the components and equipments as shown in above figure.
2. Set the variable attenuator at minimum position.
3. Set the variable attenuator at minimum position (on 20mm).
4. After the completion of experiment, before going to switch off the mains keep all the knobs in minimum position (i.e.) as those are in rule 1.
5. 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.
6. Note the Modulation knob in — AM position
7. First switch on the cooling fan and Beam voltage knob is set near 270 volts (fixed)
8. Repeller voltage knob is to vary to near 70to90v
9. Observe output on CRO to get square wave pulses and to get maximum output voltages. Connect the probe to the Tunable Detector, SS-tuner and matched termination from the slotted section in the above setup.Set any reference level on the CRO with the help of variable attenuator and. Let it be V_1.
10. Carefully disconnect the detector mount the slotted line and detector mount to the other port of test variable attenuator to zero and record the reading of voltage on the CRO . Let it be V_2

test variable attenuator to zero and record the reading of voltage on the CRO. Let it be V_2

attenuator will be $10\log_{10}\frac{V_1}{V_2}$

In case of variable attenuator, change the attetunator reading and record the values in the CRO. Find out attenuation value for different readings.

CALCULATIONS:

Reference level in CRO input (V_1) =
CRO reading output using SS tuner V_2=

Attenuation = $10\log_{10}\frac{V_1}{V_2}$ =

2) For 10dB:
Reference level in CRO input (V_1) =
CRO reading output using SS tuner (V_2) =

Attenuation = $10\log_{10}\frac{V_1}{V_2}$ =

3) For 15dB:
Reference level in CRO input (V_1) =
CRO reading output using SS tuner (V_2) =

Attenuation = $10\log_{10}\frac{V_1}{V_2}$ =

RESULT:

Thus, various fixed attenuation measurement have been studied.

PRECAUTIONS:

i. Keep all the knobs in minimum position before going to switch ‘ON’ the power supply of VSWR / Klystron power supplies. Note: For klystron power supply “HT” should be ‘OFF’ before switching ‘ON’ the main supply.
ii. Beam knob should be completely in anticlockwise direction and repeller voltage knob should be completely clockwise direction.
iii. Switch on the main supply and give some warm up time to get current / accurate reading.
iv. After the completion of experiment, before going to switch off the mains keep all the knobs in minimum position (i.e.) as those are in rule 1.
v. 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.
vi. Don’t increase the repeller voltage more than -70V (i.e.) it should be between -70Vto - 270V.

VIVA QUESTIONS:

1. What is the microwave frequency range?
2. What is the range of wavelength of micro wave frequency?
3. Which is the band of frequency used usually in laboratory experiments?
4. What are the applications of attenuation measurement?

Experiment No.4 **Date:**

DIRECTIONAL COUPLER CHARACTERISTICS

AIM:

To measure the coupling factor and directivity and isolation of directional coupler.

APPARATUS REQUIRED:

1. Microwave sources with Cooling Fan ----------- 1No.
2. Isolator ------------ 1No.
3. Frequency Meter ------------ 1No.
4. Variable Attenuator ------------ 1No.
5. Slotted line Tunable Probe ------------ 1No.
6. Direction coupler ------------ 1No.
7. Detector Mount ------------ 1No.
8. Matched Termination ------------ 2No.
8. Cathode Ray Oscilloscope ------------ 1No.
9. C.R.O. Probe ------------ 1No.
10 Waveguide Stands ------------ 2Nos.

THEORY:

A directional coupler is a four-port microwave junction with the properties described below. With reference to Fig.1, which is schematic illustration or a directional coupler, the ideal directional coupler has the property that a wave incident in part 1 couples power into ports 2 and 3 but not into part 4. Similarly, power incident in part 4 couples into ports 2 and 3 but not into part 1. Thus ports 1 and 4 are uncoupled. For wave incident in port 2 or 3, the power also uncoupled. In addition, all four ports are matched. That is, if three ports are terminated in matched loads, the fourth port appears terminated –coupling and directivity. Let be the incident power in port 1 and left
in a matched load, and an incident wave in this port suffers no reflection. Directional couplers are widely used in impedance bridges for microwave measurements and for power monitoring. Since these devices are required to operate over a band of frequencies, it is not possible to obtain ideal performance over the whole frequency band. The performance of a directional coupler is measured by two pameters 1f P be the pled power in the forward direction in port 3. The coupling in decibels is then given by

CIRCUIT DIAGRAMS:

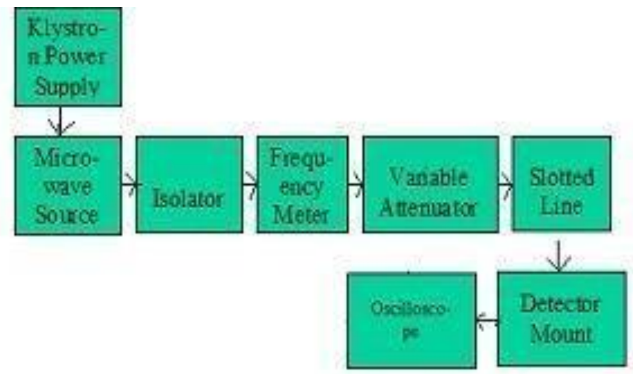


FIG: (a) BENCH SET-UP FOR DIRECTIONAL COUPLER CHARACTERISTICS

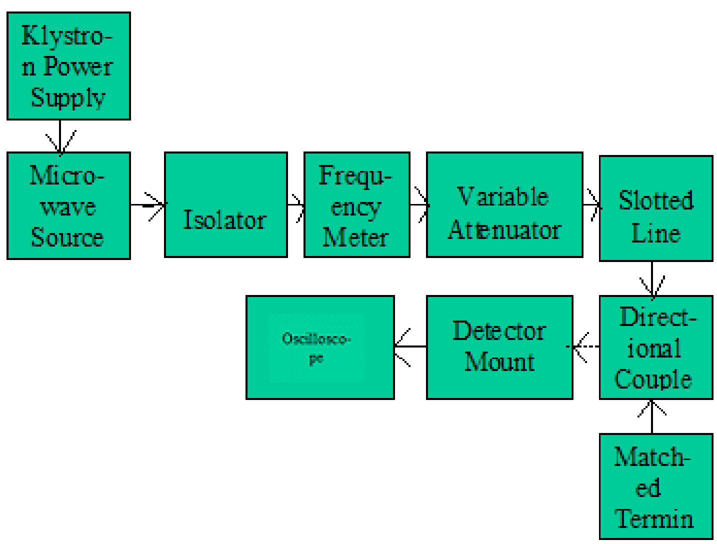
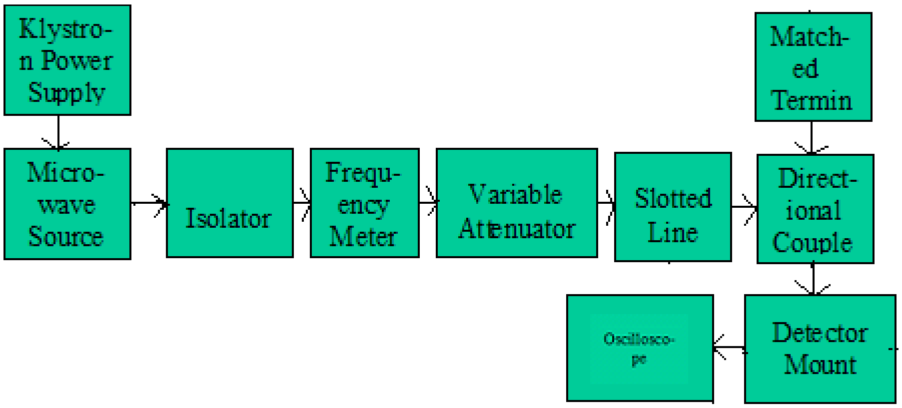


FIG: (b) BENCH SET-UP FOR DIRECTIONAL COUPLER CHARACTERISTICS



FIG(C): BENCH SET-UP FOR DIRECTIONAL COUPLER CHARACTERISTICS

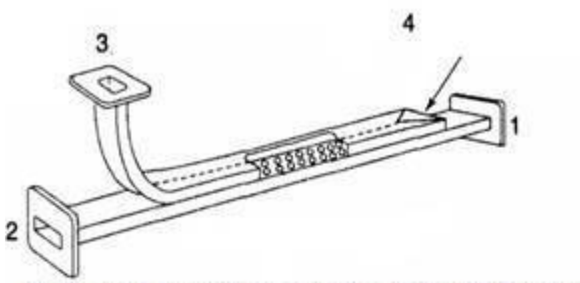


FIG: DIRECTIONAL COUPLER CHARACTERISTICS

<u>PROCEDURE</u>:

1. Connect the components and equipments as shown.
2. Set the variable attenuator at minimum position.
3. Connect the components and equipments as shown.
4. Set the variable attenuator at minimum position (on 20mm).
5. After the completion of experiment, before going to switch off the mains keep all the knobs in minimum position (i.e.) as those are in rule 1.
6. 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.
7. Note the Modulation knob in — AM position
8. First switch on the cooling fan and Beam voltage knob is set near 270 volts (fixed)
9. Repeller voltage knob is to near 70to90v
10. Observe detector mount output on CRO to get square wave pulses and note down the maximum output voltages.
11. Observe the above figure output for three steps i.e., V_1 for detector mount. V_2, V_3 and V_4

RESULT:

Hence we have measured the coupling factor and directivity and isolation of directional coupler.

PRECAUTIONS:

i. Keep all the knobs in minimum position before going to switch 'ON' the power supply of VSWR / Klystron power supplies. Note: For klystron power supply "HT" should be 'OFF' before switching 'ON' the main supply.
ii. Beam knob should be completely in anticlockwise direction and repeller voltage knob should be completely clockwise direction.
iii. Switch on the main supply and give some warm up time to get current / accurate reading.
iv. After the completion of experiment, before going to switch off the mains keep all the knobs in minimum position (i.e.) as those are in rule 1.
v. 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.
vi. Don't increase the repeller voltage more than -70V(i.e.) it should be between -70V to -270

VIVA QUESTIONS:

1. What is Directivity in a Coupler?

2. What are the applications of directional coupler characteristics?

3. What is the Difference between a 3-Port Coupler and 4-Port Coupler?

Experiment No.5 **Date:**

IMPEDANCE MEASUREMENT

AIM:

To study the method of measurement of Oscilloscope at the input of the component under test and hence to determine the input impedance.

APPARATUS REQUIRED:

1. Klystron Power Supply with Cooling Fan -- 1No.
2. Klystron Tube with Mount ------------ 1No.
3. Isolator ------------ 1No.
4. Variable Attenuator ------------ 1No.
5. Frequency Meter ------------ 1No.
6. Slotted Line Section ------------ 1No.
7. Matched termination ------------ 1No.
7. Unknown Load (SS tuner) ------------ 1No.
8. Cathode Ray Oscilloscope ------------- 1No.
9. C.R.O. Probe ------------ 1No.
10. Waveguide Stands ------------ 3Nos.

THEORY:

The opposition that a circuit offers to the flow of AC is called impedance. By measuring the voltage and current in an AC circuit and utilizing the following equation

$$Z=V/IZ=V/I$$

We can obtain the magnitude of circuit impedance. However, it is often desirable to separate impedance into resistive and reactive components. One instrument that is used to measure the separate resistive and reactive parts of impedance is the AC Bridge. The circuit of the general AC Bridge is shown in figure 1.
The configuration is similar to that of the Wheatstone bridge, yet distinct differences exist between the components. The AC Bridge has impedance arms, rather than resistance arms; instead of a battery and galvanometer, an AC signal source and null detector are used. If the signal voltage is in the audio range, a set of headphones may be used as the null detector; otherwise, a sensitive AC Voltmeter is used.
As in the Wheatstone bridge, at balance, no current flows through the detector. The voltage from a to c equals that from a to d, so that

$$I1Z1=I3Z3 \ (1)I1Z1=I3Z3 \ (1)$$

Similarly,

$$I2Z2=IxZx \ (2)I2Z2=IxZx \ (2)$$

It follows that for balanced conditions

$$Z1Z2=Z3Zx$$

CIRCUIT DIAGRAM:

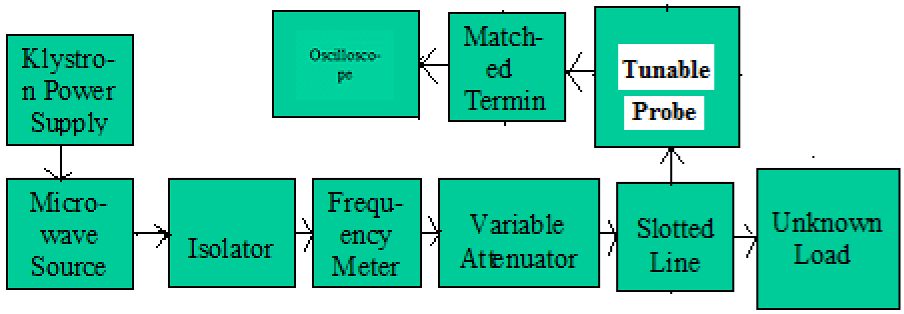


FIG: BENCH SET-UP FOR IMPEDANCE MEASUREMENT

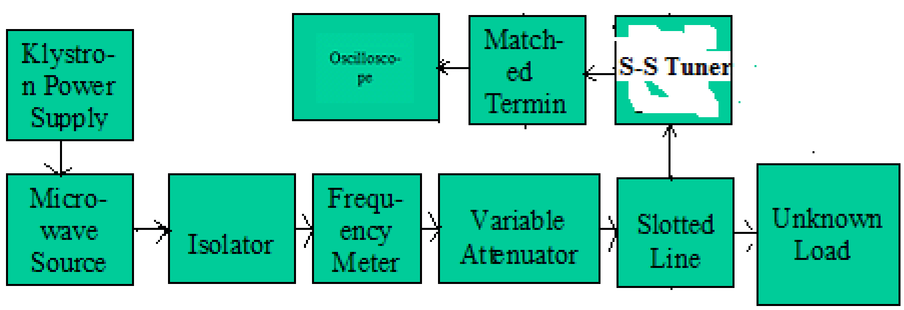


FIG: BENCH SET-UP FOR IMPEDANCE MEASUREMENT BOTH ARE SHORTED

PROCEDURE:

1. Connect the components and equipments as shown in above figure.
2. Set the variable attenuator at minimum position (on 20mm).
3. After the completion of experiment, before going to switch off the mains keep all the knobs in minimum position (i.e.) as those are in rule 1.
4. 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.
5. Note the Modulation knob in — AM position
6. First switch on the cooling fan and Beam voltage knob is set near 270 volts (fixed)
7. Repeller voltage knob is to near 70to90v
8. Connect the matched termination to get tunable probe for output (x1) and second SS-tuner and matched termination on CRO to get square wave pulses (x2)
9. After setting the mode in reflex klystron by precautions, move the probe of the slotted section to locate a point on the vernier scale of the slotted section corresponding to the voltage three minimas.

12. Note the position of 3 successive minimas positions Let it be as x1 x2 and x3.

Measure the CRO by taking 'Vmax' and 'Vmin' by moving the slotted line.

$$V.S.W.R. = \frac{V_{max}}{V_{min}}$$

The unknown impedance Z_L is calculated as

$$Z_L = \frac{1 - j[\tan(\beta.\Delta_L)(V.S.W.R.)]}{V.S.W.R. - j[\tan(\beta.\Delta_L)]}$$

$Z_{in} = Z_L.Z_0$

CALCULATIONS:

V_{min} = ---- V

V_{max} = -----V

$$VSWR = \frac{V_{Max}}{V_{Min}} = -----$$

Minimum positions matched termination short with SS tuner:

X_1 = ---------- cm.
X_2 = ---------- cm.

X_3 = ---------- cm.

X_2-X_1 = -------cm.

X_3-X_2 = --------cm.

$$X = \frac{X_2 - X_1 + X_3 - X_2}{2}$$ =---------cm.

λ g = 2 X d-------- = --------- cm.

Minima positions with short circuit:

X1-XS_1 = ----------cm.

X2-XS_2 = ----------cm.

X3-XS_3 = ----------cm.

X_1-XS_1 = ---------- cm.

Average Difference, $\Delta L = \dfrac{(X_1 - XS_1) - (X_2 - XS_2) + (X_3 - XS_3)}{3}$ =-----------cm.

Negative sign indicates towards generator

Or

Positive sign indicates towards Load

$\beta = \dfrac{2\pi}{\lambda g}$ =-----------

$\beta.\ \Delta_L$ = ...

$$Z_L = \frac{1 - j[\tan(\beta.\Delta_L)(V.S.W.R.)]}{V.S.W.R. - j[\tan(\beta.\Delta_L)]}$$

Z_L = -------- jΩ

Input Impedance, $Z_{in} = Z_o.\ Z_L$

$Z_o = 50\Omega$

Z_{in} = 50 X (________+_________J).

Z_{in} =...............................JΩ.

RESULT:

The unknown impedance has been determined using smith chart

PRECAUTIONS:

i. Keep all the knobs in minimum position before going to switch 'ON' the power supply of VSWR / Klystron power supplies. Note: For klystron power supply "HT" should be 'OFF' before switching 'ON' the main supply.
ii. Beam knob should be completely in anticlockwise direction and repeller voltage knob should be completely clockwise direction.
iii. Switch on the main supply and give some warm up time to get current / accurate reading.
iv. After the completion of experiment, before going to switch off the mains keep all the knobs in minimum position (i.e.) as those are in rule 1.
v. 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. vi. Don't increase the repeller voltage more than -70V(i.e.) it should be between -70Vto -270V.

VIVA QUESTIONS:

1. Which of the following is commonly used for mixing duplexing and impedance measurements?
2. Which of the following is used for impedance matching in a CRO?
3. What is the material of directional coupler?
4. What are the applications of impedance measurement?

Experiment No.6 **Date:**

FREQUENCY & WAVELENGTH MEASUREMENTS USING SLOTTED SECTION

AIM:

1) To measure the guide wave length.
2) To calculate the frequency of the microwave signal travelling in the bench set up.

APPARATUS REQUIRED:

1) Klystron Power Supply ---------------------- 1No
2) Reflex Klystron with Cooling Fan-----------1No.
3) Isolator...1No.
4) Variable Attenuator ---------------------------1No.
5) Detector Mount.....................................1No.
6) Indicating Meter ....1No.
7) Matched Termination -------------------------1No.
8) Frequency Meter....................................1No.
9) Slotted Section......................................1No.
10) Tunable Probe......................................1No.
11) Cathode RayOscilloscope----------------------1No.
12) C.R.O. Probe..1No.
13) Wave Guide Stands -----------------------------3Nos.

THEORY:

a) Standing Wave Distribution: If a transmission lines is terminated in an independence not equal to its characteristic impedance, the termination is said to be 'not matched' to the line. Waves traveling down the line are partially or wholly reflected from the termination. Total reflection occurs when the terminal impedance is not dissipative, i.e. a short, open or reactive termination. Standing waves are the result of two wave trains of equal wavelength incident and reflected along the line in opposite directions.

b) High VSWR by Double Minimum Method: The voltage standing wave ratio of

$$VSWR = \frac{V_{max}}{V_{min}}$$

where V_{max} and Vmin are the voltage at the maxima and minima of voltage standing wave distribution. When the VSWR is high (, the standing wave pattern will have a high maxima and low minima. Since the square law characteristic of a crystal detector is limited to low power, an error is introduced if ≥ 5)V_{max} is measured directly. This difficulty can be avoided by using the 'double minimum method' in which measurements are take on the standing wave pattern near the voltage minimum. The procedure consists of first finding the value of voltage minima. Next two positions about the position of Vmax are found at which the output voltage is twice the minimum value. If the detector response is square

$$VSWR = [1 + \frac{1}{sin^2(\frac{\pi d}{\lambda_g})}]^{\frac{1}{2}}$$

where λ_g is the guide wavelength and d is the distance between the two points
where the voltage is 2 $V_{min.}$
positions about the position of Vmax are found at which the output voltage is twice the minimum value. If the detector response is square

$$VSWR = [1 + \frac{1}{sin^2(\frac{\pi d}{\lambda_g})}]^{\frac{1}{2}}$$

where λ_g is the guide wavelength and d is the distance between the two points
where the voltage is 2 $V_{min.}$

CIRCUIT DIAGRAM:

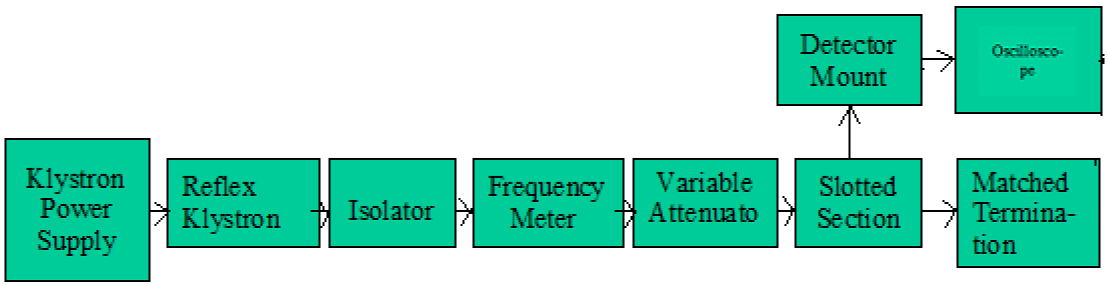


FIG: BENCH SET-UP FOR WAVE GUIDE PARAMETERS MEASUREMENT

PROCEDURE:

1. Connect the components and equipments as shown in above figure.
2. Set the variable attenuator at minimum position (on 20mm).
3. After the completion of experiment, before going to switch off the mains keep all the knobs in minimum position (i.e.) as those are in rule 1.
4. 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.
5. Note the Modulation knob in — AM position
6. First switch on the cooling fan and Beam voltage knob is set near 270 volts (fixed)
7. Repeller voltage knob is to near 70to90v
8. Connect the matched termination to get tunable probe for output and second SS-tuner and matched termination on CRO to get square wave pulses and note down the maximum output voltages
9. After setting the mode in reflex klystron by precautions, move the probe of the slotted section to locate a point on the vernier scale of the slotted section corresponding to the voltage two minimas.
10. Find the average distance between the consecutive minima. Calculate the guide wave length.
11. Calculate the cut-off wave length as
    λ_c = 2 X length of the broadwall of the wave guide.
12. Calculate the free space wave length(λ) as

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

7) Calculate the frequency (f) as $f = \frac{c}{\lambda}$

1^{st} Minima = ---------- + --------- cm.

2^{nd} Minima = --------- + --------- cm.

The guide wave length (λ_g) = 2X2^{nd} Minima - 1^{st} Minima

= 2X ----------- cm.

(λ_g) =....................... cm.

Cut-off wave length (λc) = 2Xa (where a= 2.286)

(λ_c) =................. cm.

The free space wave length is $\frac{1}{\lambda^2} = \frac{1}{\lambda g^2} + \frac{1}{\lambda c^2}$

λ =.................. c. m.

Frequency, $f = \frac{c}{\lambda}$ (where c =3X10^{10})

f =...............GHz.

RESULT:

Thus the frequency and wavelength of rectangular waveguide has been determined. Frequency = 9.6 GHz

PRECAUTIONS:

i. Keep all the knobs in minimum position before going to switch 'ON' the power supply of VSWR / Klystron power supplies. Note: For klystron power supply "HT" should be 'OFF' before switching 'ON' the main supply.
ii. Beam knob should be completely in anticlockwise direction and repeller voltage knob should be completely clockwise direction.
iii. Switch on the main supply and give some warm up time to get current / accurate reading.
iv. After the completion of experiment, before going to switch off the mains keep all the knobs in minimum position (i.e.) as those are in rule 1.
v. 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.
vi. Don't increase the repeller voltage more than -70 V(i.e.) it should be between -70V to -270V.

VIVA QUESTIONS:

1. .How is slotted line used to measure frequency and wavelength?
2. For what purpose is a slotted line is used?
3. Which of the following steps are carried out while measuring the impedance using slotted line?
4. What are the applications of frequency and wave length using slotted section?

Experiment No.7 **Date:**

SCATTERING PARAMETERS OF MAGIC TEE

AIM:

1) To study the operation of magic tee.
2) To estimate the s-parameters of the magic tee.

APPARATUS REQUIRED:

1) Klystron Power Supply--------------------------------1No.
2) Reflex Klystron Tube with Cooling Fan--------------1No.
3) Variable Attenuator..1No.
4) Slotted Line with Detector -----------------------------1No.
5) Voltage Standing Wave Ratio -------------------------1No.
6) Cathode Ray Oscilloscope with Probe ----------------1No.
7) Magic Tee...1No.
8) Tunable Probe..1No.
9) Magic Tee Stands..3Nos.

THEORY:

A directional coupler is a four-port microwave junction with the properties described below. With reference to Fig.1, which is schematic illustration or a directional coupler, the ideal directional coupler has the property that a wave incident in part 1 couples power into ports 2 and 3 but not into part 4. Similarly, power incident in part 4 couples into ports 2 and 3 but not into part 1. Thus ports 1 and 4 are uncoupled. For wave incident in port 2 or 3, the power also uncoupled. In addition, all four ports are matched. That is, if three ports are terminated in matched loads, the fourth port appears terminated –coupling and directivity. Let be the incident power in port 1 and left
in a matched load, and an incident wave in this port suffers no reflection. Directional couplers are widely used in impedance bridges for microwave measurements and for power monitoring. Since these devices are required to operate over a band of frequencies, it is not possible to obtain ideal performance over the whole frequency band. The performance of a directional coupler is measured by two pameters 1*f P* be the pled power in the forward direction in port 3. The coupling in decibels is then given by

$$C = 10 \log_{10} \frac{p_i}{p_f}$$

Ideally, the power coupled in the backward direction in arm 4 should be zero. The extent to which this is achieved is measured by the directivity D, which is defined as

$$D = 10 \log_{10} \frac{p_f}{p_b}$$

The directivity is a measure of how well the power can be coupled in the desired direction in the second waveguide.
A number of properties of the ideal directional coupler may be deduced from the symmetry and unitary properties of its scattering matrix.

The directional couplers are designed for a wide range of coupling factors, e.g., 3db, 10 db, 20db, 30db etc. The directivity of good coupler is about 30db. There is a great variety of ways of constructing directional couplers. A common type of directional coupler consists of two waveguides with suitable coupling apertures located in a common wall. With reference to Fig.1, sometimes, one of the ports, the port isolated from the input port, may be permanently match-terminated and therefore become inaccessible for any connections. A coupler is called a dual directional coupler when all four ports are accessible for connections.

CIRCUIT DIAGRAM:

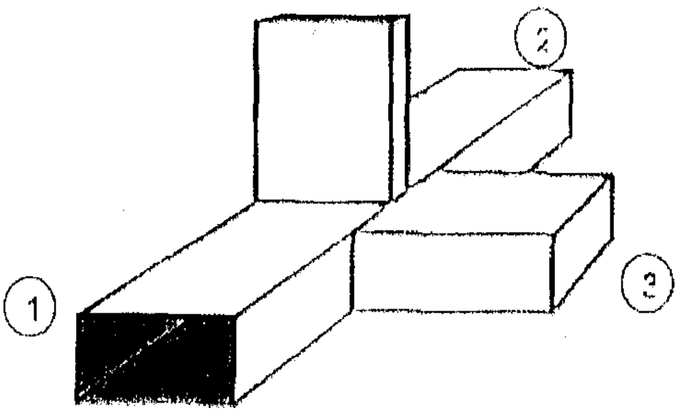


Fig: Magic Tee

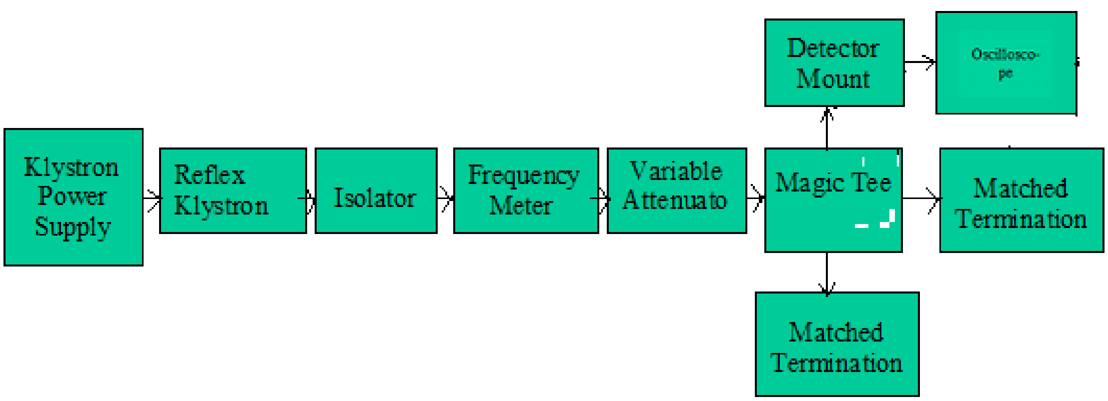


FIG: BENCH SET-UP FOR SCATTERING PARAMETERS OF THE MAGIC TEE

PROCEDURE:

1. Connect the components and equipments as shown.
2. Set the variable attenuator at minimum position.
3. Connect the components and equipments as shown.
4. Set the variable attenuator at minimum position (on 20mm).
5. After the completion of experiment, before going to switch off the mains keep all the knobs in minimum position (i.e.) as those are in rule 1.
6. 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.
7. Note the Modulation knob in — AM position
8. First switch on the cooling fan and Beam voltage knob is set near 270 volts (fixed)
9. Repeller voltage knob is to near 70to90v
10. Observe detector output on CRO to get square wave pulses and note down the maximum output voltages. Observe the output for four steps i.e., for Magic tee $S_{31} = \frac{\sqrt{V_1}}{\sqrt{V_3}}$.

CALCULATIONS:

: Calculate S_{31} by using the formula $S_{31} = \frac{\sqrt{V_1}}{\sqrt{V_3}}$.

Input port1&port3 is matched termination

V_1 = -------V
V_2 = -------V
V_3 = ------- V

S_{11} = ------- V
S_{12} = ------- V
S_{13} = ------- V

Input port2&port1 is matched termination

V_1 = -------V
V_2 = -------V
V_3 = ------- V

S_{21} = ------- V
S_{22} = ------- V
S_{23} = ------- V

Input port3&port2 is matched termination

V_1 = ------- V
V_2 = ------- V
V_3 = ------- V

S_{31} = ------- V
S_{32} = ------- V
S_{33} = ------- V

The S-matrix is

S = $\begin{bmatrix} & & \\ & & \\ & & \end{bmatrix}$

RESULT:

Thus, we have studied the functions of magic tee by measuring its parameters and compared with its properties.

PRECAUTIONS:

i. Keep all the knobs in minimum position before going to switch 'ON' the power supply of VSWR / Klystron power supplies. Note: For klystron power supply "HT" should be 'OFF' before switching 'ON' the main supply.
ii. Beam knob should be completely in anticlockwise direction and repeller voltage knob should be completely clockwise direction.
iii. Switch on the main supply and give some warm up time to get current / accurate reading.
iv. After the completion of experiment, before going to switch off the mains keep all the knobs in minimum position (i.e.) as those are in rule 1.
v. 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.
vi. Don't increase the repeller voltage more than -70V(i.e.) it should be between -70Vto - 270V.

VIVA QUESTIONS:

1. What are the features of magic tee?
2. For what purpose is a slotted line is used?
3. What is magic tee How many ports does it have?
4. What are the applications of scattering parameters of magic tee?

Optical Fiber Lab (PART – B)

Experiment No.1 **Date:**

MEASUREMENT OF LOSSES FOR AN ANALOG OPTICAL LINK

AIM:

To study various types of losses that occurs in optical fibers in 660n.m. and 850n.m. wave length.

APPARATUS REQUIRED:

1) Fiber Optic Cables (1mtr. & 5mtr.)..1 No.
2) Digital Multimeter..2 No.
3) 2105Adapters ....2 No.
4) Fiber Optic Analog Transmitter Kit (2105).................................1 No.
5) Fiber Optic Analog Receiver Kit (2105) ....1 No.

THEORY:

Attenuation or loss in optical fibers basically refers to the loss of power. During transit, light pulse loses some of their photons, thus reducing their amplitude. Attenuation for a fiber is usually specified in decibels per kilometer. The degree of attenuation depends on the wavelength of light transmitted.
Attenuation measures the reduction in signal strength by comparing the output power with input power. Measurements are made in decibels (dB). The basic measurement for loss is done by taking the logarithmic ratio of input power (P_i) to the output power (P_o).

Material absorption losses - It is a loss mechanism related to the material composition and fabrication process of the fiber which results in the dissipation of some of the transmitted optical power as heat in waveguide. The absorption of light may be intrinsic (caused by one or more major components of glass) or extrinsic (caused by impurities within the glass).

Linear scattering losses - Linear scattering mechanisms cause the transfer of some or all of the optical power contained within one propagating mode to be transferred linearly(proportionally) into a different mode. This process tends to result in attenuation of the transmitted light as the transfer may be to a leaky or radiation mode which does not continue to propagate within the fiber core, but is radiated from the fiber. It is mainly of two types:

a) Rayleigh scattering (b) Mie scattering

Bending loss

Radiative losses occur whenever an optical fiber undergoes a bend of finite radius of curvature. Fibers can be subjected to two types of bends:

a) Macroscopic bends (having radii that is large as compared with the fiber diameter)
b) Random microscopic bends of fiber axis

<u>CIRCUIT DIAGRAMS</u>:

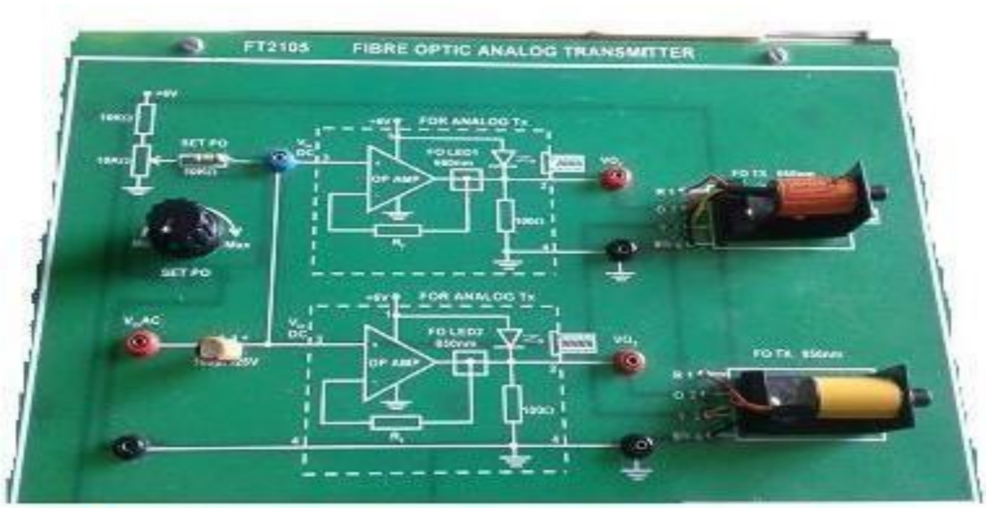


FIG: FIBER OPTIC ANALOG TRANSMITTER KIT

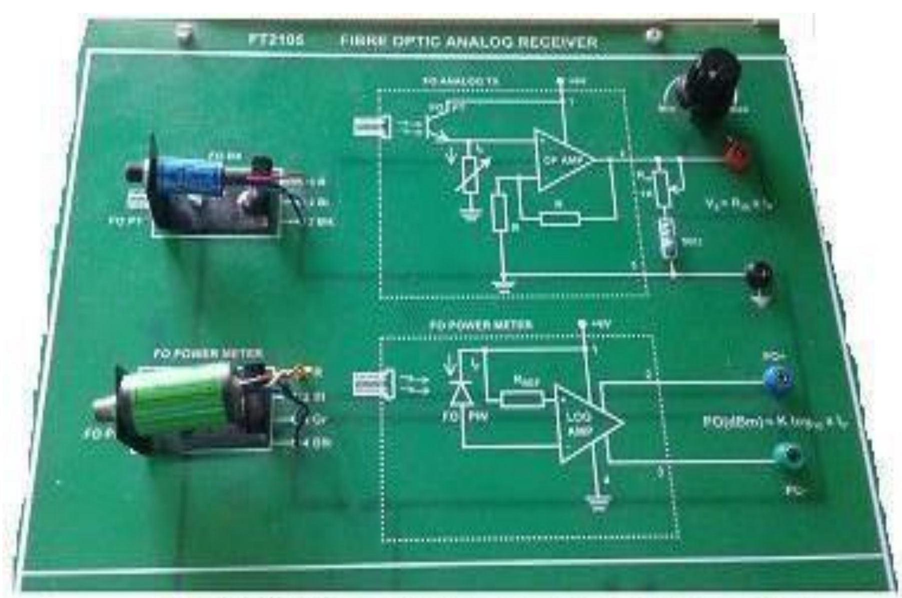


FIG: FIBER OPTIC ANALOG RECIVER KIT

PROCEDURE:

1) Connect one end of the cable1 to the LED1 port of the fiber optic Analog Transmitter and the other end to the fiber optic pin port (power meter port) of fiber optic analog receiver.
2) Set the digital multimeter to the 2000m.v. range. Connect the pair of wires marked optic analog receiver to the digital multimeter, red lead of the digital multimeter to P_{o+} back lead of the digital multimeter to P_{o-} terminals. Turn the digital multimeter on. The power meter is now ready for use.
3) Plug the alternate current mains for both units. Connect the optical fiber with patch card, cable1 securely, as shown, after releiving all twists and strains on the fiber. While connecting the cable please note that minimum force should be applied. At the same time ensure that the connector is not loosely coupled to the receptacle. After connecting the optical fiber cable properly, adjust set P_o knob to set power of L.E.D1 to a suitable value, say, -15.0 d. b. Note this as P_{o1}.
4) Wind one turn of the fiber on the mandrel as shown in exp.1 and note the new reading of power meter P_{o2}. Now the loss due to bending and strain on the plastic fiber is P_{o1}-P_{o2} d. b. For more accurate readout set the digital multimeter to the 200m.v. range and take the measurement. Typically the loss due to the strain and bending the fiber is 0.3 to 0.8 d. b.
5) Next remove the mandrel and relieve cable1 of all twists and strains. Note the reading P_{o1}. Repeat the measurement and with cable2 and note the reading P_{o2}. Use the in line SMA adapter and connect the two cables in series as shown. Note the measurement P_{o6}.
6) Repeat the entire experiment with LED2 at 850n.m. and tabulate it.

CALCULATIONS:

1meter (fiber optic cable)

Initial power	Without bending	1st bend	2rd bend	3rd bend	Average
P_0					
P_1					
P_2					

5meter (fiber optic cable)

Initial power	Without bending	1st bend	2rd bend	3rd bend	Average
P_0					
P_1					
P_2					

RESULT:

We have been studied various types of losses that occurs in optical fibers in 660n.m. and 850

VIVA QUESTIONS:

1. How is loss measured in a fiber optic system?
2. What are the different types of losses in optical fiber?
3. Which of the following loss occurs inside the fiber?
4. How is fiber optic cable measured
5. What are the applications of fiber optic losses?

Experiment No.2 **Date:**

CHARACTERIZATION OF LED

AIM:

To study the characterization of LED.

APPARATUS REQUIRED:

1) Fiber Optic Analog Transmitter Trainer Kit (2105)	------------	1No.
2) Fiber Optic Analog Receiver Trainer Kit (2105)	-------------	1No.
3) Digital Multimeter	------------	2No.
4) 2105 Adapters	-------------	2No.
5) Fiber Optic Cables 1mtr. & 2 mtr.	-------------	2No

THEORY:

Light Emitting Diode (LED):

A Light Emitting Diode (LED) is a semiconductor diode that emits light when an electric current is applied in forward direction of the device as in simple LED circuit. The effect is a form of electroluminescence where incoherent and narrow-spectrum light is emitted from the p-n junction.

For optical communication systems requiring bit rates less than approximately 100-200 Mb/s together with multimode fiber-coupled optical power in tens of microwatts, semiconductor light-emitting diodes (LEDs) are usually the best light source choice. LEDs require less complex drive circuitry than laser diodes since no thermal or optical stabilization circuits are needed and they can be fabricated less expensively with higher yields.

To be useful in fiber transmission applications and LED must have a high radiance output, a fast emission response time and high quantum efficiency. To achieve a high radiance and a high quantum efficiency, the LED structure must provide a means of confining the charge carriers and the stimulated optical emission to the active region of the pn junction where radiative recombination takes place.

The two basic LED configurations being used for fiber optics are surface emitters and edge emitters.

Internal Quantum Efficiency:

The internal quantum efficiency η_{int} is an important parameter of an LED. It is defined as the fraction of the electron-hole pairs that recombine radiatively. If the radiative recombination rate is R_r and the non-radiative recombination rate isR_{nr}, then the internal quantum efficiency is the ratio is the ratio of the radaitive recombination rate to the total recombination rate. η_{int} is typically 50% in homojunction LEDs, but ranges from 60 to 80% in double-heterostructure LEDs.

Optical Power:

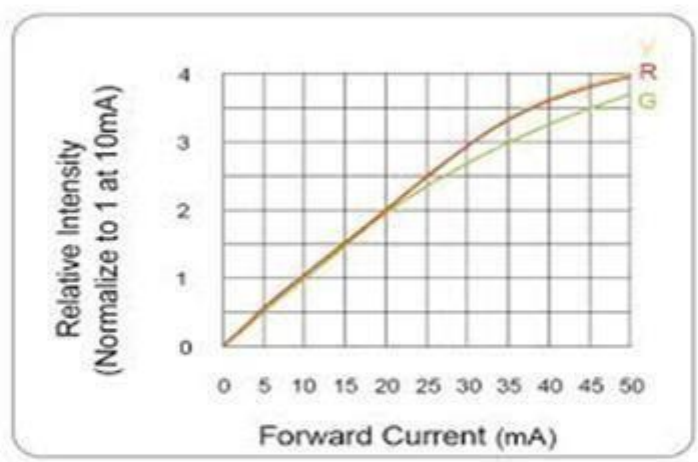
If the current injected into the LED is *I*, then the total number of recombinations per second is *I/q*, where *q* is the electron charge. Total number of radaiative recombinations is equal to $(\eta_{int} I/q)$. Since each photon has an energy *hν*, the optical power generated internally by the LED is: $P_{int} = (\eta_{int} I/q)(h\nu)$.

External Quantum Efficiency:

The external quantum efficiency $(\eta_{ext})$of a LED is defined as the ratio of the photons emitted from the LED to the number of internally generated photons. Due to reflection effects at the surface of the LED typical values of η_{out} are < 10%.

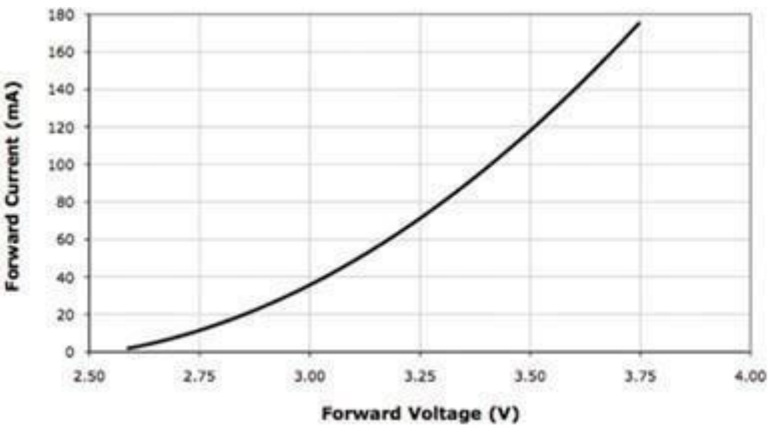
i) Light Intensity (Optical Power) vs. Current:

This is a very important characteristic of an LED. It was shown earlier that the optical power generated by an LED is directly proportional to the injected current *I* (current through the LED). However, in practice the characteristic is generally non-linear, especially at higher currents. The near-linear light output characteristic of an LED is exploited in small length fiber optic analog communication links, such as fiber optic closed-circuit TV.



ii) Junction Voltage vs. Current:

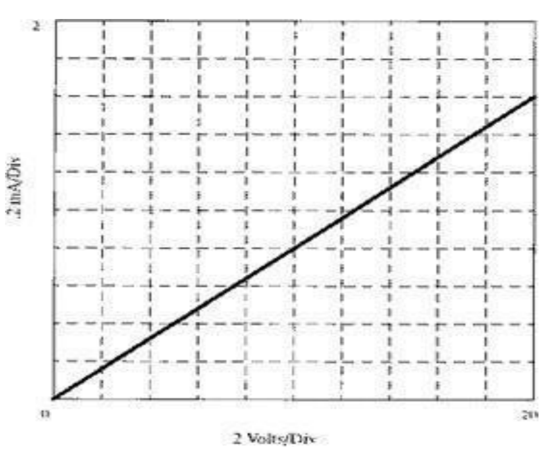
The junction voltage vs. current characteristic of an LED is similar to the V-I characteristics of diodes. However, there is one major difference. The knee voltage of a diode is related to the barrier potential of the material used in the device. Silicon diodes and bipolar junction transistors are very commonly used whose knee voltage or junction voltage is about 0.7 V. Very often it is wrongly assumed that other diodes also have the same junction voltage. In an LED, depending on the material used its junction voltage can be anywhere between 1.5 to 2.2 Volts.



Light Dependent Resistor (LDR):

An electrical current consists of the movement of electrons within a material. Good conductors have a large number of free electrons that can drift in a given direction under the action of a potential difference. Insulators with a high resistance have very few free electrons, and therefore it is hard to make the them move and hence a current to flow.An LDR or photoresistor is made any semiconductor material with a high resistance. It has a high resistance because there are very few electrons that are free and able to move - the vast majority of the electrons are locked into the crystal lattice and unable to move. Therefore in this state there is a high LDR resistance.As light falls on the semiconductor, the light photons are absorbed by the semiconductor lattice and some of their energy is transferred to the electrons. This gives some of them sufficient energy to break free from the crystal lattice so that they can then conduct electricity. This results in a lowering of the resistance of the semiconductor and hence the overall LDR resistance. The process is progressive, and as more light shines on the LDR semiconductor, so more electrons are released to conduct electricity and the resistance falls further.

Characteristics of LDR:



CIRCUIT DIAGRAMS:

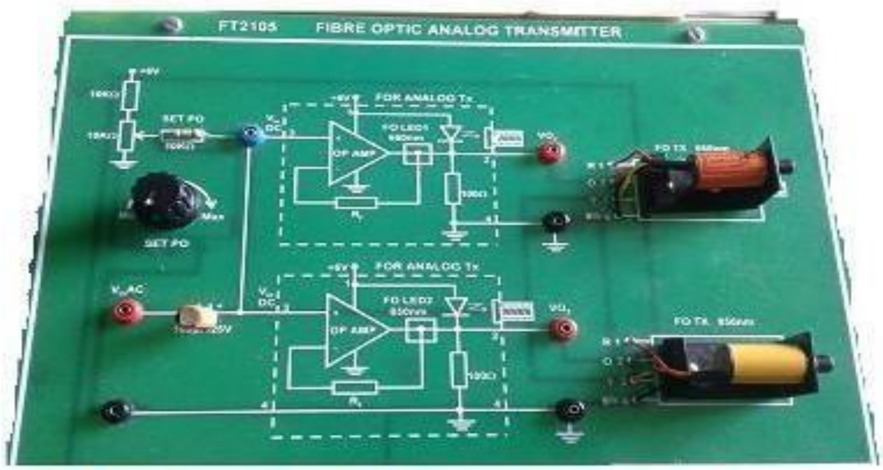


FIG: FIBER OPTIC ANALOG TRANSMITTER KIT

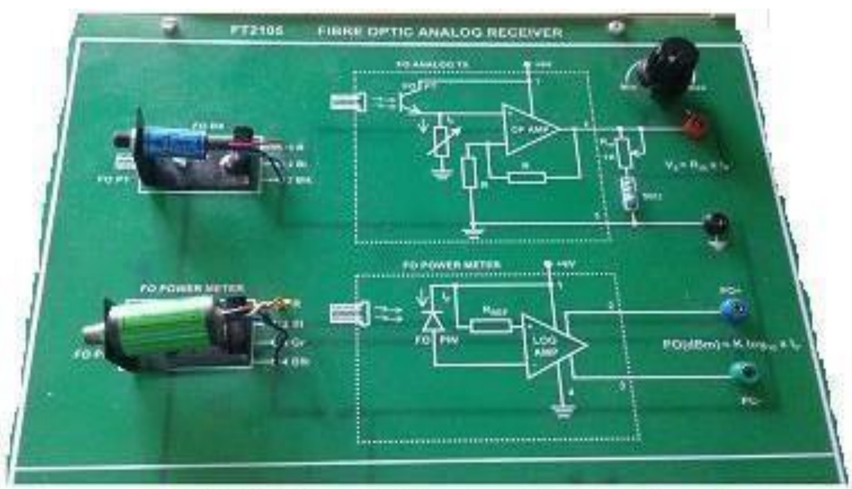


FIG: FIBER OPTIC ANALOG RECIVER KIT

PROCEDURE:

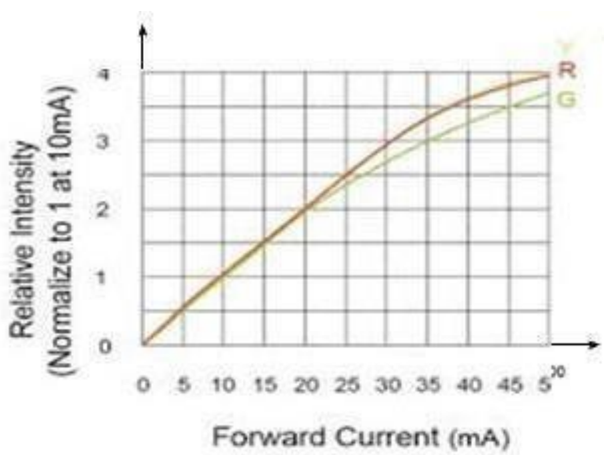
1) Connect one end of cable1 to the LED1 port of fiber optic Analog Transmitter and the other end of the fiber optic pin to power meter(PO) port of fiber optic analog Receiver.

$$P_o = \frac{(Reading)}{10} \text{ dB.}$$

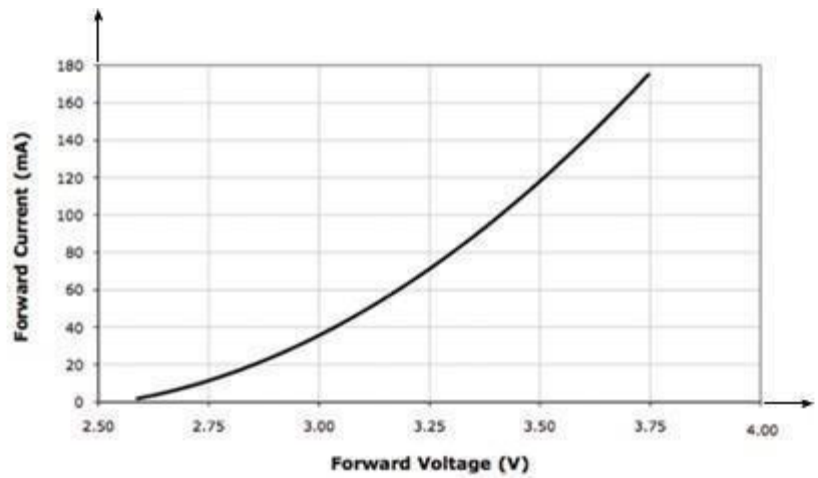
2) Set digital multimeter1 to the 2000mV range and connect the green wires marked P_o on the RX-unit to it. The power meter is ready for use.
3) Set digital multimeter2 to the 2000mV range and connect it between the V_{o1} and ground in the TX-unit.
   $I_{F1} = \frac{V_{o1}(mV)}{100}$ in mA.
4) Plug the alternate current mains for both units. Adjust the SET P_o knob on the TX-unit to the extreme anticlockwise position to reduce I_{F1} to 0. The reading on the power meter should be out of range.
5) Slowly turn the SET P_o knob clockwise to increase I_{F1}. The power meter should read -30.0 dB approximately. From here change I_{F1} in suitable steps and note the power meter readings, P_o. Record upto the extreme clockwise position.
6) Repeat the complete experiment for P_o LED2 and tabulate the readings for V_{o2} & P_o.

$$I_{F2} = \frac{V_{o2}}{50} \text{ in mA.}$$

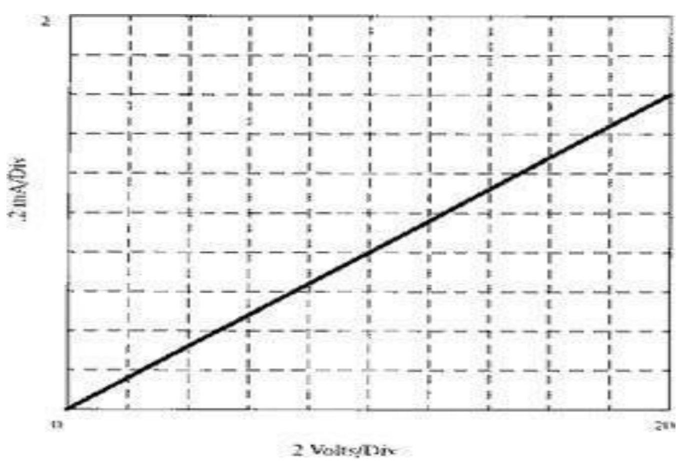
EXPECTED WAVE FORMS:



i) Light Intensity (Optical Power) vs. Current



ii) Junction Voltage vs. Current



I-V Characteristics of LDR

<u>FOR 660 N.M.</u>:

Sl.No.	**(V_o)**	$\frac{V_0}{100} = I_F$	**P_0**

FOR 850N.M.

Sl.No.	**(V_0)**	$\frac{V_0}{50}$ **= IF**	**P_0**

RESULT:

We have studied the characterization of LED and we have ploted the graph between forward voltages versus forward current.

VIVA QUESTIONS:

1. What are the characteristics of LEDs?
2. What are the different types of losses in optical fiber?
3. What are the IV characteristics of LED?
4. What are the applications of LED?

Experiment No.3 **Date:**

CHARACTERIZATION OF LASER DIODE

AIM:

To study the optical power (P_o) of a laser diode verses laser diode forward current (I_F).

APPARATUS REQUIRED:

1) Optical Fiber Modulator Trainer Kit (2107) ---------------- 1No.
2) Optical Fiber Demodulator Trainer Kit (2107) ---------------- 1No.
3) Digital Multimeters ---------------- 2No.
4) 2107 Adapters ---------------- 2No.
5) 2mtr.Cable ---------------- 1No.

THEORY:

Laser diodes and light emitting diodes have a number of elements in common with respect to their theory of operation. However the laser diode theory of operation incorporates more elements, taking in additional processes to provide the coherent light it produces.

While there are many different forms of laser diode, the basis of the laser diode theory of operation is very similar - the basic precepts remain the same, although there are a number of minor differences in the way they are implemented..

There are three main processes in semiconductors that are associated with light:

- ***Light absorption:*** Absorption occurs when light enters a semiconductor and its energy is transferred to the semiconductor to generate additional free electrons and holes. This effect is widely used and enables devices like to photo-detectors and solar cells to operate.
- ***Spontaneous emission:*** The second effect known as spontaneous emission occurs in LEDs. The light produced in this manner is what is termed incoherent. In other words the frequency and phase are random, although the light is situated in a given part of the spectrum.
- ***Stimulated emission:*** Stimulated emission is different. A light photon entering the semiconductor lattice will strike an electron and release energy in the form of another light photon. The way in which this occurs releases this new photon of identical wavelength and phase. In this way the light that is generated is said to be coherent

:

CIRCUIT DIAGRAMS:

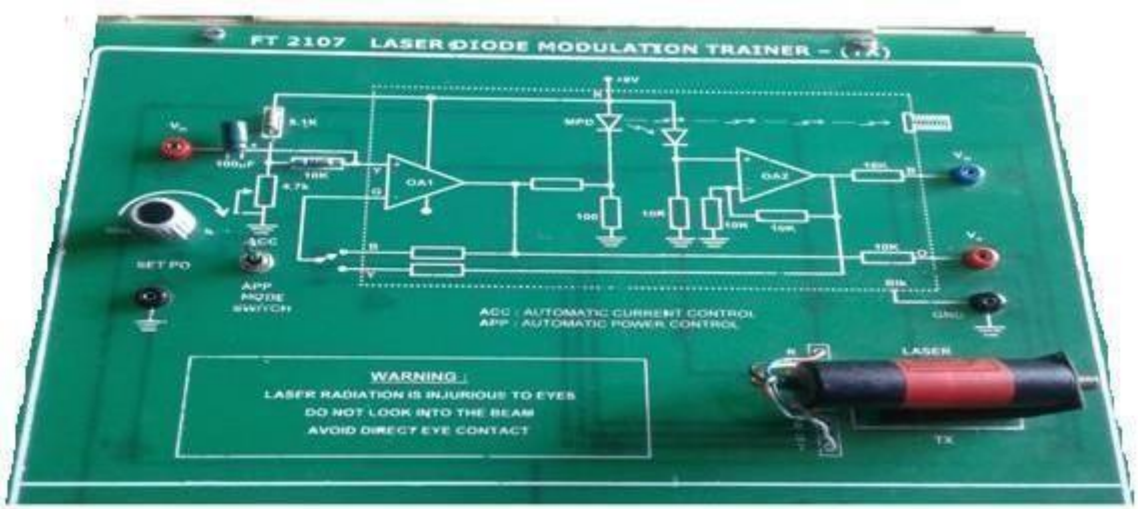


FIG: LASER DIODE MODULATION TRANSMITTER KIT

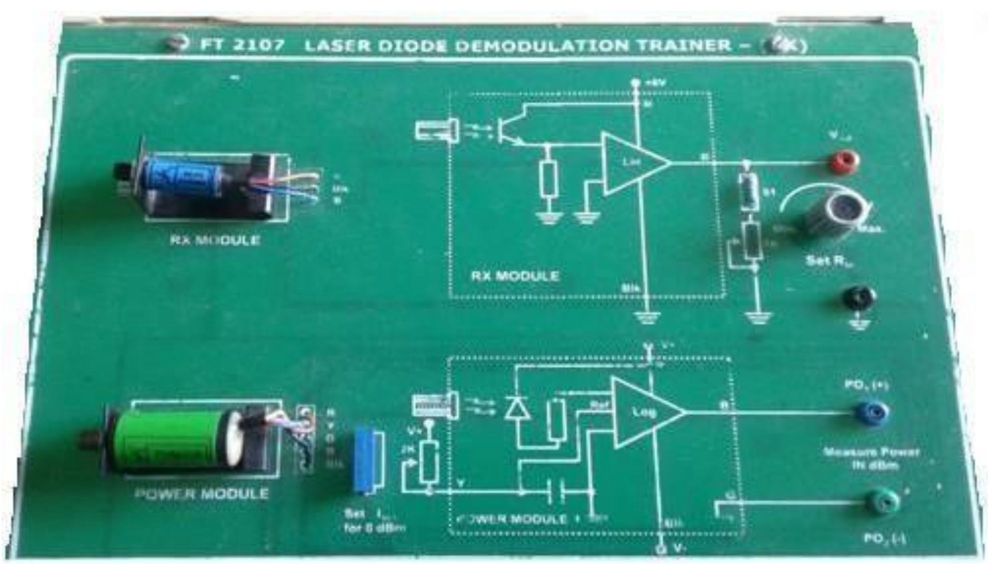


FIG: LASER DIODE DEMODULATION RECEIVER KIT

PROCEDURE:

1) Connect the 2-meter PMMA fiber optic cable1 to TX unit of TNS20EL and couple the laser light to the power meter on the RX unit as shown. Select ACC mode of operation.
2) Set digital multimeter1 to the 2000mV range. On the RX side connect the green wires marked P_o to it on. The power meter is now ready for use.

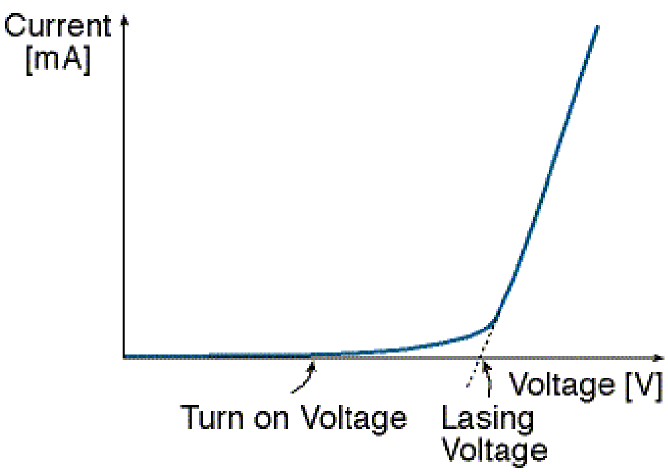
$$P_o = \frac{(Reading)}{10}\ dB.$$

3) Set digital multimeter2 to the 2000mV range and connect it between the red wire and ground (Black wire) on the TX unit.

$$I_F = \frac{Vo}{50}$$

4) Adjust the set I_f the TX knob to the extreme anticlockwise position to reduce I_F to 0.. The power meter reading will normally be below -40dBm. or out of range
5) Slowly turn the set I_f knob clockwise to increase I_F and P_o readings. Take closer readings prior to and above the laser threshold. Plot the graph P_o verses I_F current,I_F (mA) on x-axis and power(P_odB) on y-axis.

EXPECTED WAVE FORMS:



TABULAR COLUMN:

Sl.No.	**(V_0)**	**$I_F = \frac{V_0}{50}$**	**P_0**

RESULT:

We have been studied the characterization of laser diode and we have observed the graph between voltage versus current.

VIVA QUESTIONS:

1. What are characteristic of laser?
2. What is LED application and characteristics?
3. What are the applications of laser diode?

Experiment No.4 **Date:**

MEASUREMENT OF DATA RATE FOR DIGITAL OPTICAL LINK

AIM:

To study the following encoding methods used in optical fiber digital transmission.

1) Non Return to Zero Inverted Coding (NRZI).
2) Bi-Phase Coding.
3) Manchester Coding.

APPARATUS REQUIRED:

1) 2106 Transmitter Trainer Kit ---------------- 1No.
2) 2106 Receiver Trainer Kit ---------------- 1No.
3) Cathode Ray Oscilloscope ---------------- 1No.
4) Patch Chords ---------------- Few Nos.

CIRCUIT DIAGRAMS:

FIG: FIBER OPTIC DIGITAL TRANSMITTER KIT

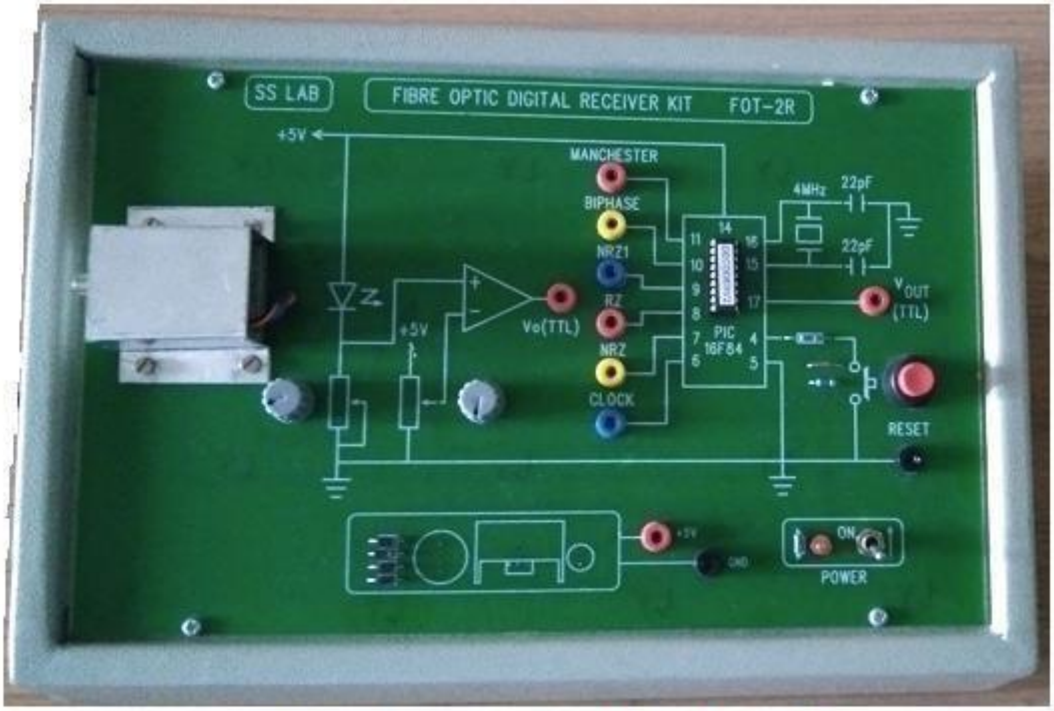


FIG: FIBER OPTIC DIGITAL RECEIVER KIT

PROCEDURE:

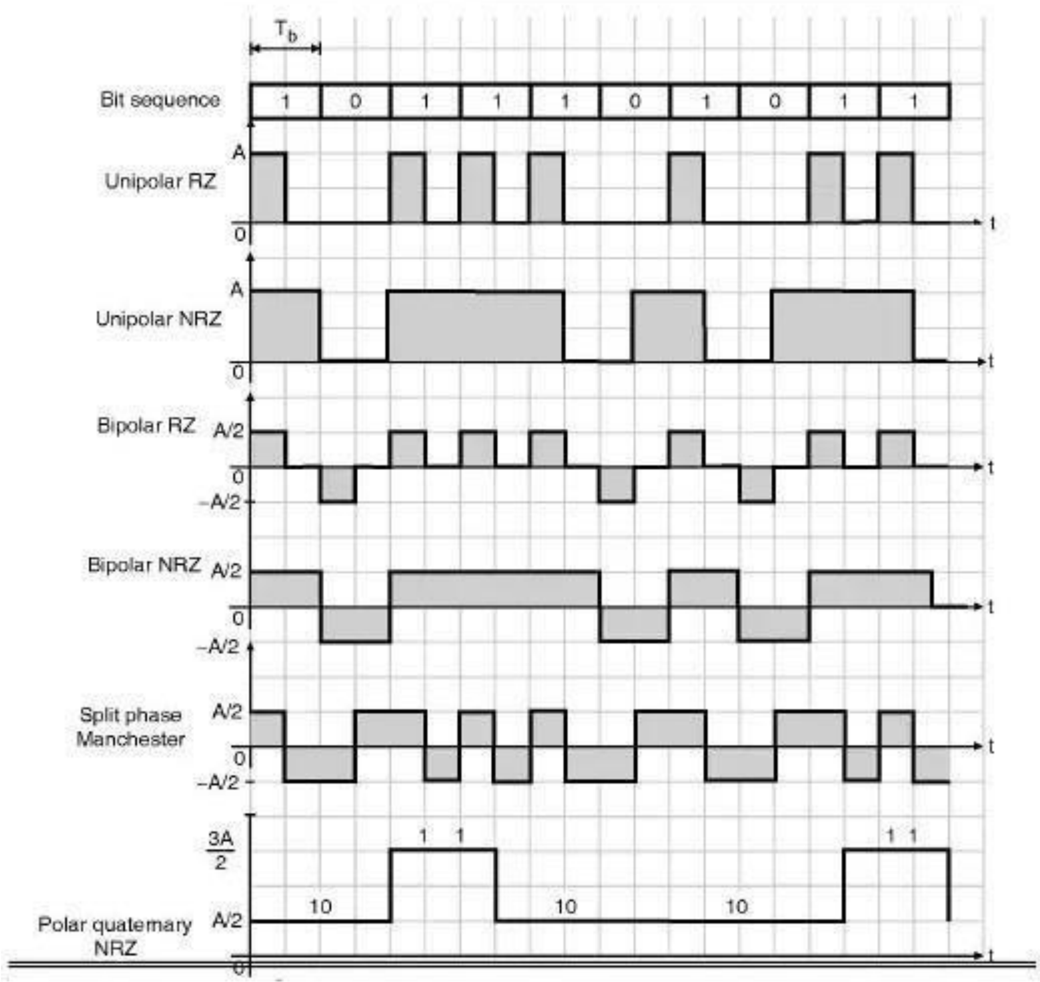
1) Connect one end of cable1 to the LED port of the FT 2106-TX and the other end to the fiber optic port of FT 2106-RX. While connecting the cable please note that minimum force should be applied. At the same time ensure that the connector is not loosely coupled the receptacle.
2) Connect NRZ encoder output to V_{in} on the TX side. Also connect it to Ch1 of a dual trace oscilloscope. Connect V_o on the RX side to Channel2 of the oscilloscope.
3) Set Rin to 200Ω using a digital multimeter to measure the resistance.
4) Now turn the power on for the TX and RX units. The NRZ waveform should appear on channel1. It should be a 5 kHz square wave.
5) Adjust Rth until the waveform on channel2, is almost identical to the NRZ.
6) Next connect V_o to NRZ input of the decoder on the RX side and connect the oscilloscope channel2 to $V_{out.}$ Reset both the TX and RX systems once. Observe the decoded V_{out} and compare with the NRZ encoder output. Read the serial code 1100 (this is repeated cyclically).
7) Repeat step6 for other waveforms one after the other, connecting the appropriate jumper on the TX and RX sides and resetting the system each time. The oscilloscope probes shall remain on the NRZ output (as this is the base band test signal for other codes) and $V_{out.}$ Match the received signals with the expected waveforms.

EXPECTED WAVE FORMS:

The bit sequence 1 0 1 1 1 0 1 0 1 1 is to be transmitted using following formats :

1. Unipolar RZ and NRZ
2. Bipolar RZ and NRZ
3. Split-phase Manchester
4. Polar quaternary NRZ.

Draw all the waveforms.



1) The DHM20B modules require external 5v DC power supply, digital signal generator and a PMMA patch chord terminated with SMA connectors.
2) The LED current when on is approximately 33m.a. when of it is 0m.a.
3) 5th diagram sets the threshold detection level for the internal comparator in the receiver.
4) Using this the rise time and fall time distortions may be suitably selected. Rin sets receiver gain and bandwidth.

RESULT:

We have studied the following encoding methods used in optical fiber digital transmission.

1) Non Return to Zero Inverted Coding (NRZI).
2) Bi-Phase Coding.
3) Manchester Coding.

VIVA QUESTIONS:

1. What is optical digital link?

Ans. An optical link is a telecommunications link that consists of a single end-to-end optical circuit. A cable of optical fibers, possibly concatenated into a dark fiber link, is the simplest form of an optical link. Other forms of optical links include free-space optical telecommunication links.

2. What are the important specifications of an optical fiber *?

Ans. Optical specifications of particular concern are attenuation and bandwidth, which are currently Specified at two operating wavelengths for each fiber type. Performance is specified at 850 and 1,300 nm for multimode fiber and 1,310 and 1,550 nm for single mode.

3. What are the two main causes of losses in signals of an optical fiber?

Ans. There are two main causes of intrinsic attenuation. One is light absorption and the other one is scattering. Light absorption is a major cause of losses in optical fiber during optical transmission. The light is absorbed in the fiber by the materials of fiber optic

4. What are the applications of measurement of data rate for digital optical link?

Ans.Typical bit rates used in modern optical transmission systems are 2.5 Gbit/s and 10 Gbit/s. With WDM, several optical channels are combined, in the optical domain, into a single optical beam, which is launched into the transmission fiber.

Experiment No.5 **Date:**

INTENSITY MODULATION OF LASER OUTPUT THROUGH AN OPTICAL FIBER

AIM:

To study the following alternate current characteristics of an intensity modulation laser and fiber optics.

1) $V_{in\,(ac)}$ verses $V_{out(ac)}$ for fixed carrier power P_o and signal frequency, F_o

APPARATUS REQUIRED:

1) Laser Diode Modulator & Demodulator Trainer Kit (2107) ------1No.
2) Optical Fiber Cable (1mtr.) --1No.
3) Digital Multimeter..2No.
4) Adapters..2No.
5) Cathode Ray Oscilloscope..1No.
6) Function Generator..1No.
7) Patch Chords..Few Nos.

THEORY:

Optical fibers are fine transparent glass or plastic fibers which can propagate light. They work under the principle of total internal reflection from diametrically opposite walls. In this way light can be taken anywhere because fibers have enough flexibility. This property makes them suitable for data communication, design of fine endoscopes, micro sized microscopes etc. An optic fiber consists of a core that is surrounded by a cladding which are normally made of silica glass or plastic. The core transmits an optical signal while the cladding guides the light within the core. Since light is guided through the fiber it is sometimes called an optical wave guide. The basic construction of an optic fiber is shown in figure (1).

In order to understand the propagation of light through an optical fibre, consider the figure (2). Consider a light ray (i) entering the core at a point A , travelling through the core until it reaches the core cladding boundary at point B. As long as the light ray intersects the core-cladding boundary at a small angles, the ray will be reflected back in to the core to travel on to point C where the process of reflection is repeated .ie., total internal reflection takes place. Total internal reflection occurs only when the angle of incidence is greater than the critical angle. If a ray enters an optic fiber at a steep angle(ii), when this ray intersects the core-cladding boundary, the angle of intersection is too large. So, reflection back in to the core does not take place and the light ray is lost in the cladding. This means that to be guided through an optic fibre, a light ray must enter the core with an angle less than a particular angle called the acceptance angle of the fibre. A ray which enters the fiber with an angle greater than the acceptance angle will be lost in the cladding.

CIRCUIT DIAGRAMS:

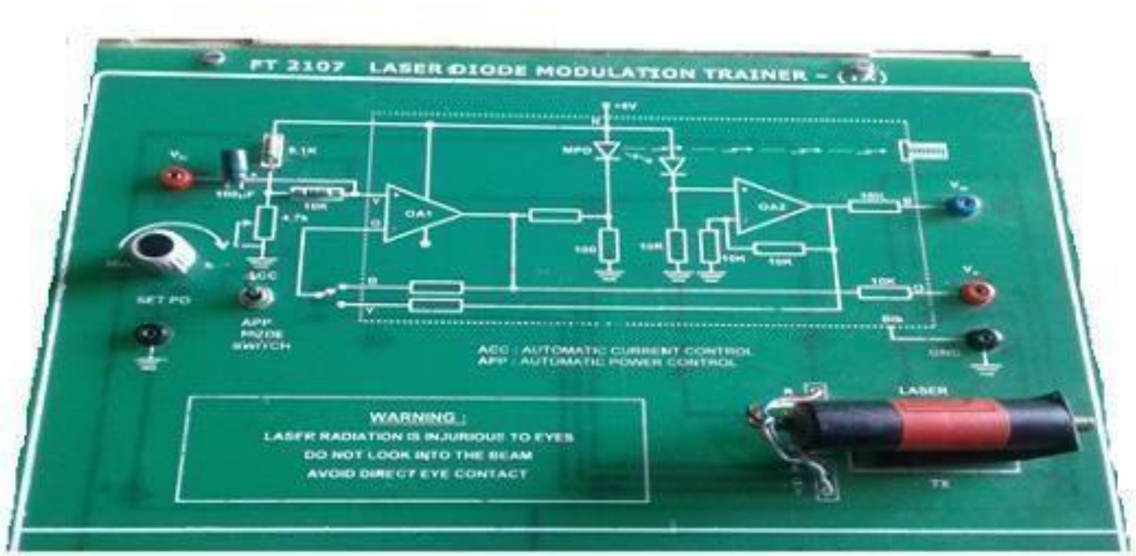


FIG: INTENSITY MODULATION TRANSMITTER KIT

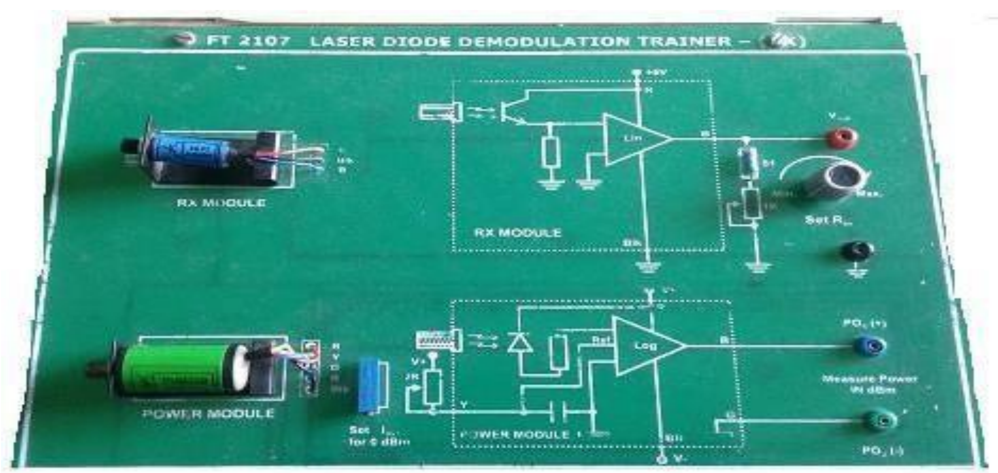


FIG: INTENSITY MODULATION RECEIVER KIT

PROCEDURE:

1) Connect one end of the PMMA fiber optic cable (cable1) to the laser port on the TX Unit. The other end is first connected to fiber optic PIN (on RX Unit) to set the carrier power level of the laser. Then it is removed and given to fiber opticPT (RX Unit) to study the response of the IM system.
2) Set digital multimeter to the 2000mV range. Connect the wires marked P_o to it. The power meter is now ready for use.

$$P_o = \frac{(\mathrm{Re}\,ading)}{10d.b.m.}$$

3) Plug the alternate current mains for both systems.
4) With the PMMA fiber optic cable connected to the power meter, adjust the set P_o knob to set the optical carrier power P_o to a suitable level say, -13dBm. Next disconnect the cable from the power meter and connect to fiber optic PT.
5) Set R_{in} suitably to get $V_{out} = V_{in}$ or a known gain. The system gain is now set. Next, vary V_{in} in suitable values from 10mV to 1000mV p-p and note the values of V_{out}. Tabulate and plot a graph V_{out} verses V_{in} .

EXPECTED GRAPH:

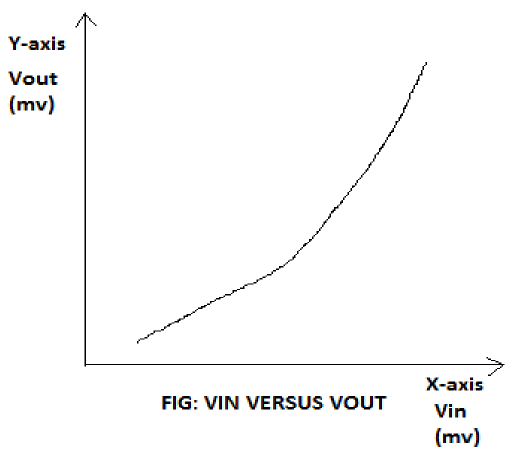


FIG: VIN VERSUS VOUT

TABULAR COLUMN:

Sl.No.	V_{in}(mV.p-p)	V_{OUT}(mV.p-p)	$G = \frac{V_0}{V_{IN}}$

RESULT:

We have studied the intensity modulation of laser output through an optical fiber and we have plotted the graph between Vinput versus Voutput.

VIVA QUESTIONS:

1. What is intensity in optical fiber?

Ans.Intensity (Amplitude) Sensors. In this case, the signal to be measured (the measured), intensity. (amplitude) modulates the light carried by an optical fiber. For this. Class of sensors a normalized modulation index (m) can be defined

2. Which modulation is used in optical fiber communication?

Ans. Fiber-optic telecommunication systems use pulse-code modulation. Information is transmitted as a series of pulses.

3. What are the important specifications of an optical fiber *?

Ans. Is a measurement tool for assessing data handling ability of optical digital communication system

4. What are the applications of intensity modulation of output through optic fiber?

Ans. Intensity Modulation Fiber-Optic Sensors. Intensity modulation is one of the simplest to measure because it only requires a photodetector to measure the light intensity ..... A photo detector is used to measure the intensity of the light transmitted through the fiber or reflected back to the input

BEYOND THE SYLLABUS EXPERIMENTS

Experiment No.1 **Date:**

SCATTERING PARAMETERS OF THE CIRCULATOR

AIM: 1) To study the operation of a ferrite based circulator.
2) To determine the s-parameters of the circulator.

APPARATUS REQUIRED:

1) Klystron Power Supply ------------------------------1No.
2) Reflex Klystron with Cooling Fan ------------------1No.
3) Isolator..1No.
4) Variable Attenuator...1No.
5) Frequency Meter...1No.
6) Matched Termination --------------------------------1No.
7) Tunable Probe with Detector------------------------1No.
8) Circulator...1No.
9) Cathode Ray Oscilloscope with Probe -------------- 1No.
10) Waveguide Stands...3Nos.

THEORY:

A microwave circulator is a multiport waveguide junction in which the wave can flow only from nth port to $(n+1)^{th}$ port in one direction. Please refer the figure given below.Although there is no restriction on the number of ports, four port microwave circulatoris the most common.

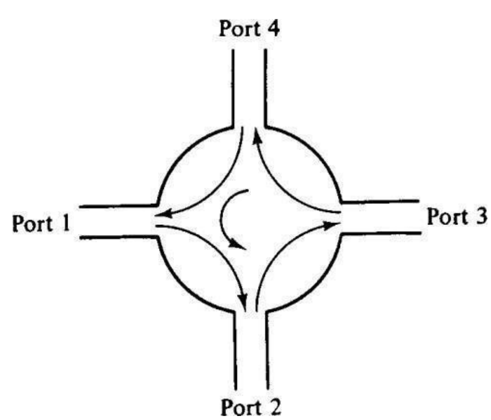


Fig 4.4: Four port Microwave Circulator

Many types of microwave circulators are in use today. However, their principles of operation remain the same. Figure given below shows a four port circulator constructed of two magic tees and a phase shifter. The phase shifter produces a phase shift of 180^o.

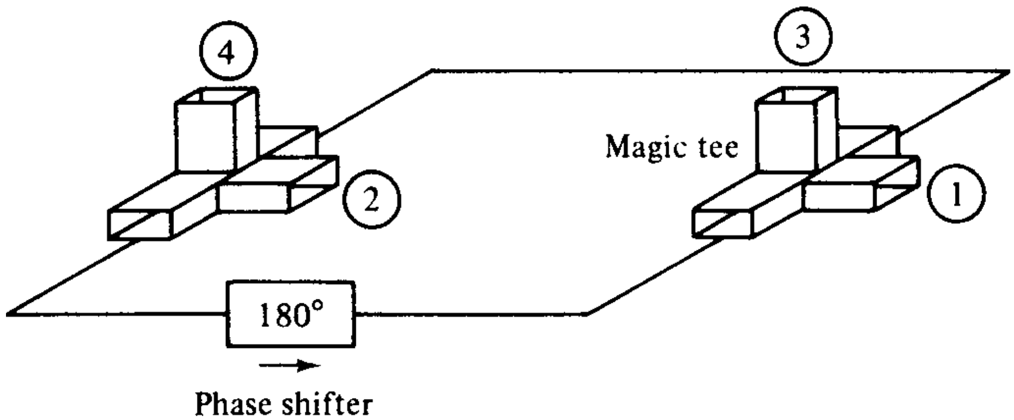


Fig 4.5: Circulator using 2 magic tees and one gyrator

Input from port 1: Gets splitted in two H-arms and enters the second magic Tee from right side path and left side path in phase, both gets cancelled in port 4 and gets added in port 2. Therefore output is available only from port 2.

Input from port 2: Gets splitted in two H-arms and enters the second magic Tee from right side path with 180^o phase shift and left side path with zero phase shift.Both the signals gets cancelled in port 2 and gets added in port 4. Therefore output is available only from port 4.

Input from port 4: Gets splitted in two E-arms and enters the second magic Tee from both the sides with in phase due to the gyrator. the signals gets cancelled in port 3 and gets added in port 1. Therefore output is available only from port 1.

Circulator using ferrite

Faraday rotation circulator consists of a piece of circular waveguide capable of carrying wave in the dominant mode TE_{11} with transitions to a standard rectangular guide which can carry TE_{10} at both the ends. The transition ports 1, 2 and two rectangular side ports 3 and 4 place with their broader wall along the length of the waveguide are twisted through 45^o. A thin ferrite rod is placed inside the circular waveguide supported by polyfoam and the waveguide is surrounded by a permanent magnet which produce dc magnetic field in the ferrite rod as shown below.

CIRCUIT DIAGRAM:

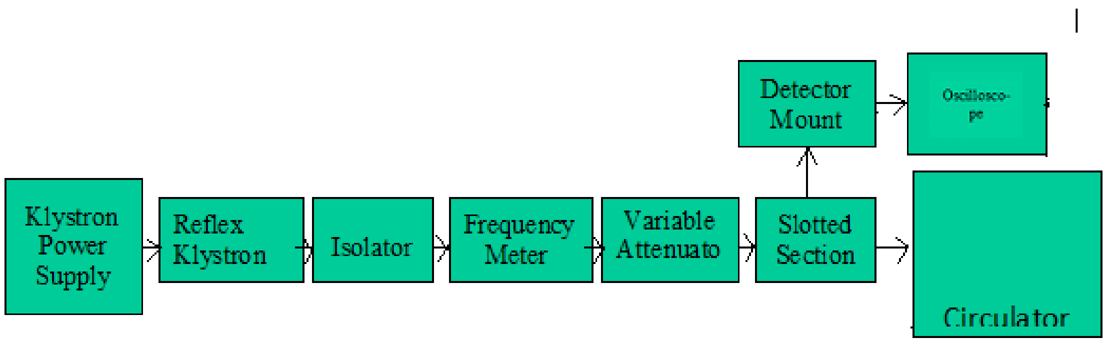


FIG: SCATTERING PARAMETERS OF THE CIRCULATOR

PROCEDURE:

1) Adjustments are made such that the microwave bench is perfectly horizontal and in the C.R.O.
2) Before switching on the klystron power supply, rotate the beam voltage knob full in clockwise direction, switch on the cooling fan.
3) After switching on the reflex klystron power supply, keep the beam voltage and the beam current at 220v and 16m.a. respectively.
4) By adjusting the modulation voltage and observe the wave form in the C.RO. (once the perfect square wave is observed in the C.R.O., it is said that a particular mode has been obtained for the reflex klystron.)
5) Connect the port-1 of the circulator to the input, i.e., to the frequency meter and the port-2 to the indicating meter and the port-3 to the matched termination.
6) Note down the signals at port-1 and port-2.
7) Calculate the scattering parameter S_{12} by using the following formula

   $$S_{12} = \frac{\sqrt{V_2}}{\sqrt{V_1}}$$

8) Repeat the above procedure from point (5) to point(7) and calculate the remaining parameters by properly connecting the circulator.

CALCULATIONS:

By using this formula we have to substitute $S_{12} = \frac{\sqrt{V_2}}{\sqrt{V_1}}$

Input port1&port3 is matched termination

V_1 = -------V
V_2 = -------V
V_3 = ------- V

S_{11} = ------- V
S_{12} = ------- V
S_{13} = ------- V

Input port2&port1 is matched termination

V_1 = -------V
V_2 = -------V
V_3 = ------- V

S_{21} = ------- V
S_{22} = ------- V
S_{23} = ------- V

Input port3&port2 is matched termination

V_1 = -------V
V_2 = -------V
V_3 = ------- V

S_{31} = ------- V
S_{32} = ------- V
S_{33} = ------- V

RESULT:

$$S = \begin{bmatrix} 0 & 0.35 & 0.612 \\ 0.612 & 0 & 0.35 \\ 0.35 & 0.6 & 0 \end{bmatrix}$$

We have studied the scattering parameters of the circulator.

VIVA QUESTIONS:

1. Why do we use scattering parameters?

Ans. S (scattering) parameters are used **to characterize electrical networks using matched impedances**. Here, scattering refers to the way traveling currents or voltages are affected when they meet a discontinuity in a transmission line.

2. What are the properties of scattering parameters?

Ans. Properties of [S] Matrix

[S] is always a square matrix of order nxn. $[S]_{n\times n}$.

[S] is a symmetric matrix. i.e., $S_{ij}=S_{ji}$.

[S] is a unitary matrix. i.e., $[S][S]^*=I$.

The sum of the products of each term of any row or column multiplied by the complex conjugate of the corresponding terms of any other row or column is zero.

3. How do you find scattering parameters?

Ans. The relationships between the two-port S parameters and the common network parameters are given in Table 2.3**.** 1. It is interesting to note that $S_{21}/S_{12}=z_{21}/z_{12}=y_{21}/y_{12}=h_{21}/h_{12}$.

2.3. 3 Two-Port S Parameters

Experiment No.2 **Date:**

CHARACTERISTICS OF E-PLANE AND H-PLANE TEE

AIM: To find the characteristics of given E-plane and H-plane

COMPONENTS REQUIRED:

1) Klystron Power Supply -------------------------------1No.
2) Reflex Klystron tube with Cooling Fan --------------1No.
3) Isolator ....1No.
4) Variable Attenuator ....1No.
5) Frequency Meter ....1No.
6) Matched Termination ---------------------------------1No.
7) Tunable Probe with Detector -------------------------1No.
8) Cathode Ray Oscilloscope with Probe ---------------1No.
9) Detector mounts____________________________1No.
10) Magic Tee ....1No.
11) Waveguide Stands ....3Nos.

THEORY:

In E-plane tee, axis of the side arm is parallel to the E field, the same is shown in the figure-1.As shown in figure, this **E-plane tee** type is perfectly matched using screw or capacitive or inductive windows at junction. As there is no reflection, diagonal S parameters of scattering matrix will be zero. Hence S11, S22 and S33 are zero. For matched junction, S matrix will be as depicted in the figure-1 in equation-(1). When the waves are fed into port-3(side arm), the waves at port-1 and port-2 of collinear arms will be of same magnitude but opposite in the phase. Hence ,S13 = -S23 Equation-(1) is for the perfectly matched junction, but in practice it will be poorly matched. S matrix when collinear arms are symmetric about the side arm is mentioned in equation-(2). Here, |S13| = |S23| and S11 = S22.

CIRCUIT DIAGRAM:

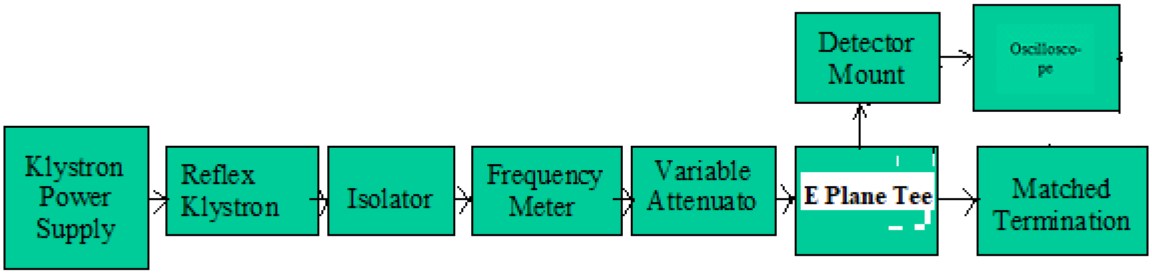
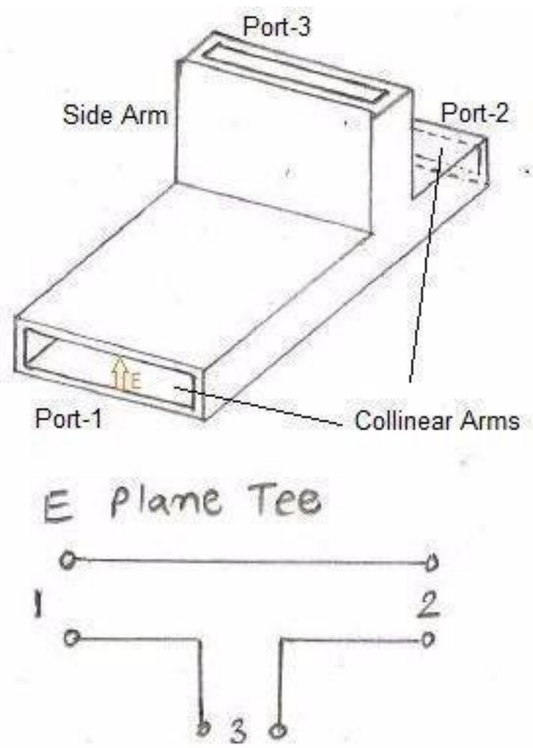
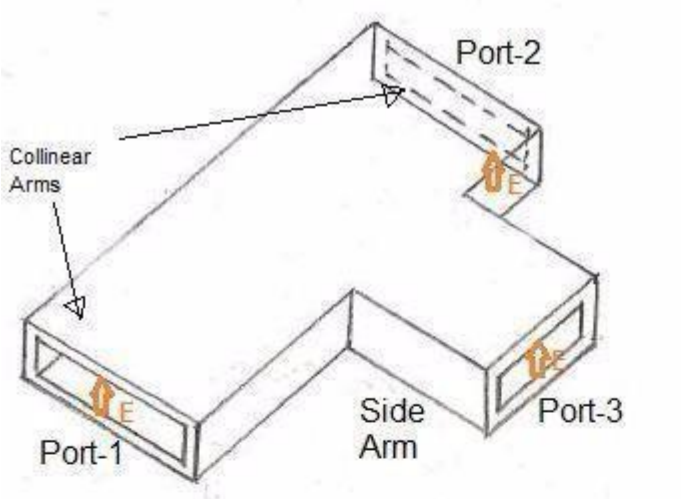


FIG: CHARACTERISTICS OF H&E-PLANE TEE

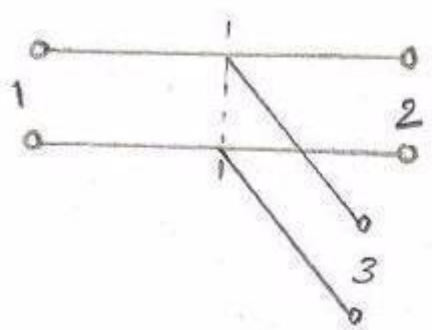


$$\begin{bmatrix} 0 & S12 & S13 \\ S21 & 0 & S23 \\ S31 & S32 & 0 \end{bmatrix} \quad \text{--- (1)}$$

$$\begin{bmatrix} S11 & S12 & S13 \\ S12 & S11 & -S13 \\ S13 & -S13 & S33 \end{bmatrix} \quad \text{--- (2)}$$



H Plane Tee



In H-plane tee, axis of the side arm is parallel to the H field, the same is shown in the above figure

In **H plane tee**, when two inputs are fed into port-1 and port-2 of the arms(collinear), output at port-3 will be in phase and also additive in nature. On the other side, if input is fed at port-3, the waves get split equally into port-1 and port-2 with in-phase and will have same magnitude. These properties of H-plane tee is used in waveguide power combiner and power divider.
S matrix of H-plane tee is same as mentioned for E-plane tee. The same is mentioned equation-(1) and equation-(2) in figure-1 except here S13 = S23.

As they are poor in providing good match, tuning screw is used to adjust the reactance of the system to obtain perfect impedance match.

PROCEDURE:

1) Adjustments are made such that the microwave engine is perfectly horizontal and C.R.O
2) Before switching on klystron power supply, rotate the beam voltage knob fully in anticlockwise direction and rotate the repeller voltage knob fully in clockwise direction, switch on the cooling fan.
3) After switching on the klystron power supply, keep the beam voltage and the beam current at 240v and 16ma. respectively.
4) Connect the port3 to the output and port2 to the Detector mount, port1 is connected to the matched termination.
5) Calculate S_{31} by using the formula

   $S_{31} = \frac{\sqrt{V_1}}{\sqrt{V_3}}$.
6) Repeat the above procedure for measuring the other parameters of E-Plane Tee & H-Plane Tee.

CALCULATIONS:

By using this formula we have to substitute $S_{12} = \frac{\sqrt{V_2}}{\sqrt{V_1}}$

Input port1&port3 is matched termination

V_1 = -------V
V_2 = -------V
V_3 = ------- V

S_{11} = ------- V
S_{12} = ------- V
S_{13} = ------- V

Input port2&port1 is matched termination

V_1 = -------V
V_2 = -------V
V_3 = ------- V

S_{21} = ------- V
S_{22} = ------- V
S_{23} = ------- V

Input port3&port2 is matched termination

V_1 = ------- V
V_2 = ------- V
V_3 = ------- V

S_{31} = ------- V
S_{32} = ------- V
S_{33} = ------- V

RESULT:

$$S = \begin{bmatrix} 0 & 0.3 & 0.6 \\ 0.6 & 0 & 0.3 \\ 0.3 & 0.6 & 0 \end{bmatrix}$$

We have studied the Characteristics of E-Plane and H-Plane Tee is verified.

VIVA QUESTIONS:

1. How are E and H plane tees used?

Ans. The E-plane and H-plane are reference planes for linearly polarized waveguides, antennas and other microwave devices..... In microwave circuits, a waveguide with three independent ports is called a TEE junction. The output of E-Plane Tee is 180° out of phase where the output of H-plane Tee is in phase.

2. What are the properties of scattering parameters?

Ans. Properties of [S] Matrix

[S] is always a square matrix of order nxn. [S]n×n.

[S] is a symmetric matrix. i.e., Sij=Sji.

[S] is a unitary matrix. i.e., [S][S]∗=I.

The sum of the products of each term of any row or column multiplied by the complex conjugate of the corresponding terms of any other row or column is zero. i.e.,

3. Why is H-plane called 3 db splitter?

Ans. H plane Tee is so called because the axis of side arm is parallel to planes of H-field of main transmission line. As all three arms of H plane tee lay in the plane of magnetic field,the magnetic field divide itself in arms this is thus the current junction.

4. How H-plane & E-plane tee are formed?

Ans. H-Plane Tee junction is formed by attaching a simple waveguide to a rectangular waveguide which already has two ports. The arms of rectangular waveguides make two ports called collinear ports i.e., Port1 and Port2, while the new one, Port3 is called as Side arm or H-arm. This H-plane Tee is also called as Shunt Tee.

STUDY OF MICROWAVE COMPONENTS

AIM:

To study the microwave components.

RECTANGULAR WAVEGUIDE:

Waveguides are manufactured to the highest mechanical and electrical standards and mechanical tolerance to meet internal specifications, L and S band waveguides are fabricated by precision brazing of brast plate and all other waveguides are in extrusion quality. Waveguide sections of specified length can be supplied with flinges, painted outside and silver or gold plated inside.

VARIABLE ATTENUATOR:

Model 5020 is a simple and conveniently variable type set level attenuators to provide at least 20db of continuously variable attenuation. These consist of a movable lossy vane inside the section of a waveguide by means of a micrometer. The configuration of lossy vane is so designed to obtain the low VSWR characteristics over the entire frequency band. These are meant for adjusting power levels and isolating a source and load.

FREQUENCY METER MICROMETER TYPE:

Model 4055 are absorption type cavity wavemeter called frequency meter. These are made of tunable resonant cavity of particular size. The cavity is connected to the source of energy through a section of waveguide. The cavity absorbs some power at resonance, which is indicated as a sip in the output power. The tuning of the cavity is achieved by means of a plunger connected to a Microcontroller. The readings of the micrometer at resonance gives frequency from the calibration chart, provided calibration is normally provided at 200Mhz internals.

TUNABLE PROBE:

Model 6055 tunable probes are designed for use with model 6051 slotted sections. These are meant for exploring the energy of the electric field in a suitable fabricated section of the waveguide. The depth of penetration into a waveguide section is adjustable by knob of the probe. The tip picks up the RF power from the line and this power is rectified by crystal detector, which is then fed to the VSWR meter or indicating instrument.

WAVEGUIDE DETECTOR MOUNT:

Model 4051 tunable detector mounts are simple and easy to use instruments for detecting microwave power through a suitable detector. It consists of a detector crystal mounted in a section of waveguide and a shorting plunging for matching purpose. The output of the crystal may be fed to and indicating instrument. In K and R band detector mounts, the plunger is driven by a micrometer.

THREE PORT FERRITE CIRCULATOR:

Model 6021 and 6022 are T and Y type of the three port ferrite circulators respectively. These are precisely machined and matched three port devices and these are meant for allowing microwave energy to flow in clockwise direction with negligible loss but almost no transmission in anticlockwise direction.

Purpose and for measuring reflections and impedance. These consist of a section of waveguide thus making it a four-part network. However, the fourth port is terminated with a matched load. These two parallel sections are coupled to each other through many holes almost to give uniform coupling minimum frequency sensitivity and high directivity. These are available in 3,6,10,20 and 40 db couplings.

E-PLANE BEND:

Model 7071 E-plane bends are fabricated from a section of waveguide to provide one 90° ± 1 bend in E-plane. The cross section of bent waveguide is kept throughout uniform to give VSWR less than 1.05 or 1.08 or 1.02 over the entire frequency band. Bends other than 90° can also be fabricated.

RESULT:

Thus the various microwave components were studied

VIVA QUESTIONS:

1. What is the frequency range of microwave?

Ans. Microwave frequencies range between 10^9 Hz (1 GHz) to 1000 GHz with respective wavelengths of 30 to 0.03 cm. Within this spectral domain are a number of communication systems applications that are important in both the military and civilian sectors

2. What is the difference between e-plane tee and H-plane tee?

Ans. E-Plane Tee: This is also known as series tee. It is connected in series with a branch or section of main waveguide transmission line .....H-Plane Tee: This is also known as shunt tee. It is connected in shunt with a branch or section of main waveguide transmission line.

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