SRM VALLIAMMAI ENGINEERING COLLEGE

(An Autonomous Institution)

S.R.M Nagar, Kattankulathur – 603 203

Department of Electronics and Communication Engineering

Laboratory Manual

1906708 - ADVANCED COMMUNICATION LABORATORY

Regulation - 2019

Semester/Branch	**:**	**VII semester ECE**
Academic Year	**:**	**2022 - 23 (ODD SEMESTER)**
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(An Autonomous Institution)

SRM Nagar, Kattankulathur – 603 203

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

VISION OF THE INSTITUTE

Educate to excel in social transformation

MISSION OF THE INSTITUTE

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

VISION OF THE DEPARTMENT

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

MISSION OF THE DEPARTMENT

M1: To educate the students with the state of art technologies to compete internationally, able to produce creative solutions to the society`s needs, conscious to the universal moral values, adherent to the professional ethical code

M2: To encourage the students for professional and software development career

M3: To equip the students with strong foundations to enable them for continuing education and research.

PROGRAM OUTCOMES

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

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

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

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

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

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

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

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

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

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

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

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

PROGRAM SPECIFIC OUTCOME (PSOs)

PSO1: Ability to apply the acquired knowledge of basic skills, mathematical foundations, principles of electronics, modelling and design of electronics based systems in solving engineering Problems.

PSO2: Ability to understand and analyze the interdisciplinary problems for developing innovative sustained solutions with environmental concerns.

PSO3: Ability to update knowledge continuously in the tools like MATLAB, NS2, XILINIX and technologies like VLSI, Embedded, Wireless Communications to meet the industry requirements.

PSO4: Ability to manage effectively as part of a team with professional behaviour and ethics.

<u>Syllabus</u>

1906708 ADVANCED COMMUNICATION LABORATORY L T P C 0 0 4 2

OBJECTIVES:

The student should be made to:

- ❖ Understand the working principle of optical sources, detector, fibers.
- ❖ Develop a conventional optical communication link.
- ❖ Measure and analyse the BER, Pulse broadening.
- ❖ Capture an experimental approach to digital wireless communication.
- ❖ Realize the actual communication waveforms that will be sent and received across wireless channel.

LIST OF OPTICAL EXPERIMENTS

1. Measurement of connector, bending and fiber attenuation losses.
2. Calculation Numerical Aperture and Mode Characteristics of Fibers.
3. DC Characteristics of LED and PIN Photo diode.
4. Fiber optic Analog and Digital Link Characterization - frequency response (analog), eye diagram and BER (digital).

LIST OF WIRELESS COMMUNICATION EXPERIMENTS

5. Wireless Channel Simulation including fading and Doppler effects.
6. Simulation of Channel Estimation, Synchronization & Equalization techniques.
7. Analysing Impact of Pulse Shaping and Matched Filtering using Software Defined Radios.
8. OFDM Signal Transmission and Reception using Software Defined Radios

LIST OF MICROWAVE EXPERIMENTS

9. VSWR, Frequency, Wavelength and Impedance Measurement and Impedance Matching.
10. Characterization of Directional Couplers, Isolators, Circulators, E- Plane Tee, H- Plane Tee and Magic Tee.
11. Gunn Diode and Reflex Klystron Characteristics.
12. Microwave IC – Filter Characteristics.

TOPIC BEYOND THE SYLLABUS EXPERIMENT

1. Radiation Pattern Measurement of Parabolic Reflector Antenna.

Total: 60 Periods

OUTCOMES:

On completion of this lab course, the student would be able to

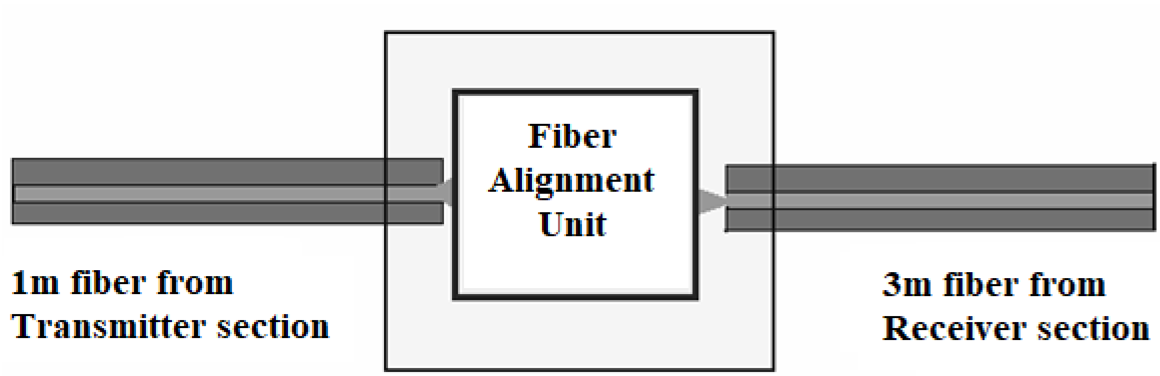
- Analyze the performance of simple optical link by measurement of losses and analyzing the mode characteristics of fiber.
- Investigate the characteristics of optical source and detectors.
- Examine the Eye Pattern, Pulse broadening of optical fiber and the impact on BER.
- Estimate the Wireless Channel Characteristics and analyse the performance of
- Wireless Communication System.
- Understand the intricacies in Microwave System design.

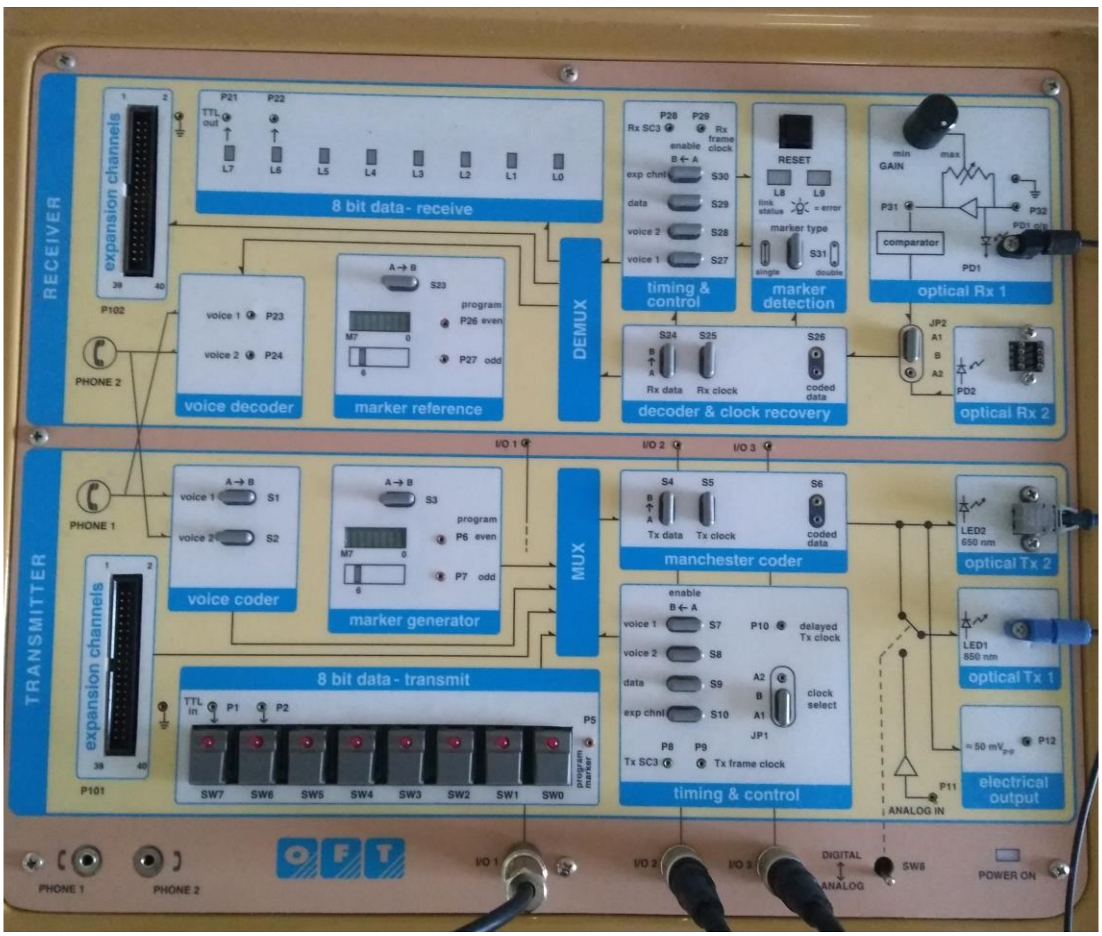
List of Experiments

OPTICAL

EXPERIMENTS

Connector Loss





Ex.No.: 1 MEASUREMENT OF CONNECTOR, BENDING AND FIBER ATTENUATION LOSSES

EX.NO: 1 (a) MEASUREMENT OF CONNECTOR LOSSES

AIM:

To measure the connector losses by using fiber alignment unit.

APPARATUS REQUIRED:

S.No.	Name of the Equipment's	Quantity
1	Benchmark Optic Fiber Trainer Kit	1
2	Two channel 20 MHz Oscilloscope	1
3	Function generator 1Hz – 10 MHz	1
4	1mm diameter of plastic optical fiber 1 meter	1
5	1mm diameter of plastic optical fiber 3 meter	1
6	Fiber alignment unit	1
7	BNC	2
8	Patch cords	Required

Pre-lab questions:

1. What is the speed of light?
2. List the advantages of optical fiber.
3. How the light is transmitted through the fiber?
4. Compare coaxial cable and fiber cable.
5. Name the sources used for the fiber optic communication?

THEORY:

The power emitted by a source needs to be launched into the optical fiber waveguide so that the modulated light generated by the transmitter can be transported through the fiber and delivered at the receiver end. Transmission of light over thousands of kilometer through optical fibers is possible only with the help of intermediate repeaters. Between successive repeaters, we need to connect a numbers of sections of fiber cables as well as a number of other optical components in between. The number of such joints or connectors depends on the distance between successive repeaters or the distance between the transmitter and the receiver in a repeaterless optical link. Even though technologically it is possible

OBSERVATION:

S.No	Length of the Fiber (l)	Input Voltage	Output Voltage
1	1 m – Before connecting fiber alignment unit		
2	1m + 3m = 4m – After connecting fiber alignment unit		

FORMULA:

$$\eta = -10log\left(\frac{V_4}{V_1}\right) - \alpha' \ (l_3 + l_1)$$

Where

$\eta - Coupling\ efficiency$

$\alpha' - attenuation\ constant\ in\ dB/m$

$l1 - length\ of\ 1m\ fiber\ optic\ cable$

$l3 - length\ of\ 3m\ fiber\ optic\ cable$

$V_1 - input\ voltage\ for\ 1m\ length\ fiber\ optic\ cable$

$V_4 - output\ voltage\ for\ 4m\ (1m + 3m)\ length\ fiber\ optic\ cable$

CALCULATION:

to fabricate single mode optical fibers of length around 200 km, such long fiber cables are not very convenient for transportation and installation. For field applications fiber cables of shorter lengths are generally used. The standard separation of 40-60 km between the repeaters requires multiple connections of fiber cables in between. Each fiber cable consists of a large number of fibers and each of the fibers from one cable is to be connected to the corresponding fiber of the subsequent cable. It should be borne in mind, that each such connection gives rise to an additional loss in the link. The loss encountered at each joint depends on a number of factors including the alignment of the fibers. Therefore, it is necessary to learn about various techniques for launching power from the source to the fiber and also from one fiber to another fiber.

PROCEDURE:

1. Connect the power supply cable to Optic fiber trainer kit.
2. Set the switch position to analog in the kit.
3. Ensure the jumper settings of switches S4 & S5 from post A to B in the Manchester coder and S6 is open.
4. Ensure the jumper settings of switches S24 & S25 from post A to B in the Decoder and clock recovery and S26 is open.
5. Similarly ensure the jumper setting of clock select JP1 from A1 to B in the Timing and control.
6. Switch ON the power supply for the kit and as well as switch ON the kit power.
7. Slightly unscrew the cap of optical transmitter Tx1 @ LED 1 850nm. Do not remove the cap from the connector. Once the cap is loosened, insert one end the 1mm diameter of plastic optical fiber 1 meter into the optical transmitter Tx1 @ LED 1 850nm cap. Now tighten the cap by screwing it back.
8. Ensure the jumper settings JP2 from B to A1 and A2 is open in the receiver section.
9. Insert other end of the optical fiber to the receiver part i.e., in optical Rx1 PD1 (Photo Detector 1). Slightly unscrew the cap of optical receiver Rx1 PD1. Once the cap is loosened, insert one end of the 1mm diameter of plastic optical fiber 1 meter into the optical receiver Rx1 PD1. Now tighten the cap by screwing it back.
10. Apply a 1 V P-P sine wave without any D.C. to I/O 3 BNC post in transmitter section
11. Connect the 3 pin patch cord between I/O 3 and I/O 2 in the receiver section and connect it in P11 post. (Analog IN, for feeding input signal to the Tx1).

12. Connect a 2 pin patch cord between P31 and I/O 1 in the receiver section.
13. Connect the transmitter section of I/O 2 and I/O 1 to oscilloscope channel 1 and channel 2 respectively.
14. Observe input sine wave signal at channel 1 and output sine wave signal at channel 2.
15. Note down the input and output amplitude of sine wave in the CRO.
16. Remove one end of 1m fiber from Rx1, insert one end of 3m fiber in Rx1 by step no.9.
17. Now connect the 1m fiber from Tx1 and 3m fiber from Rx1 by using fiber alignment unit.
18. Note down the input and output amplitude of sine wave in the CRO.

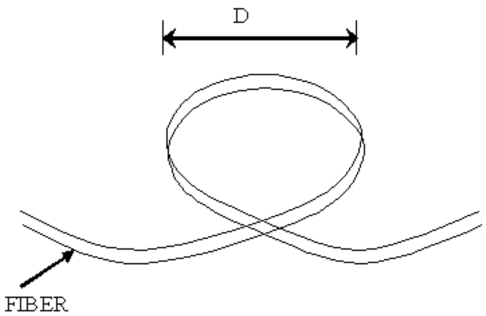
Post-lab questions:

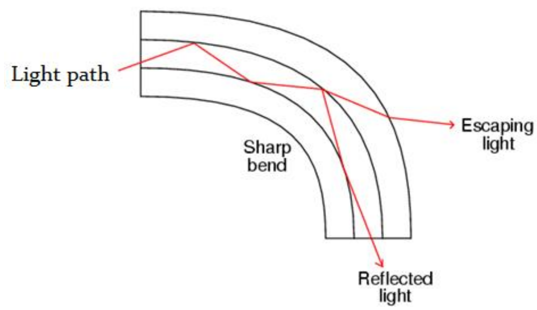
1. What are the basic types of fiber?
2. Define repeater.
3. Compare wired and wireless communication.
4. List the function of the driver circuit.
5. Why analog link is preferred for connector loss experiment?

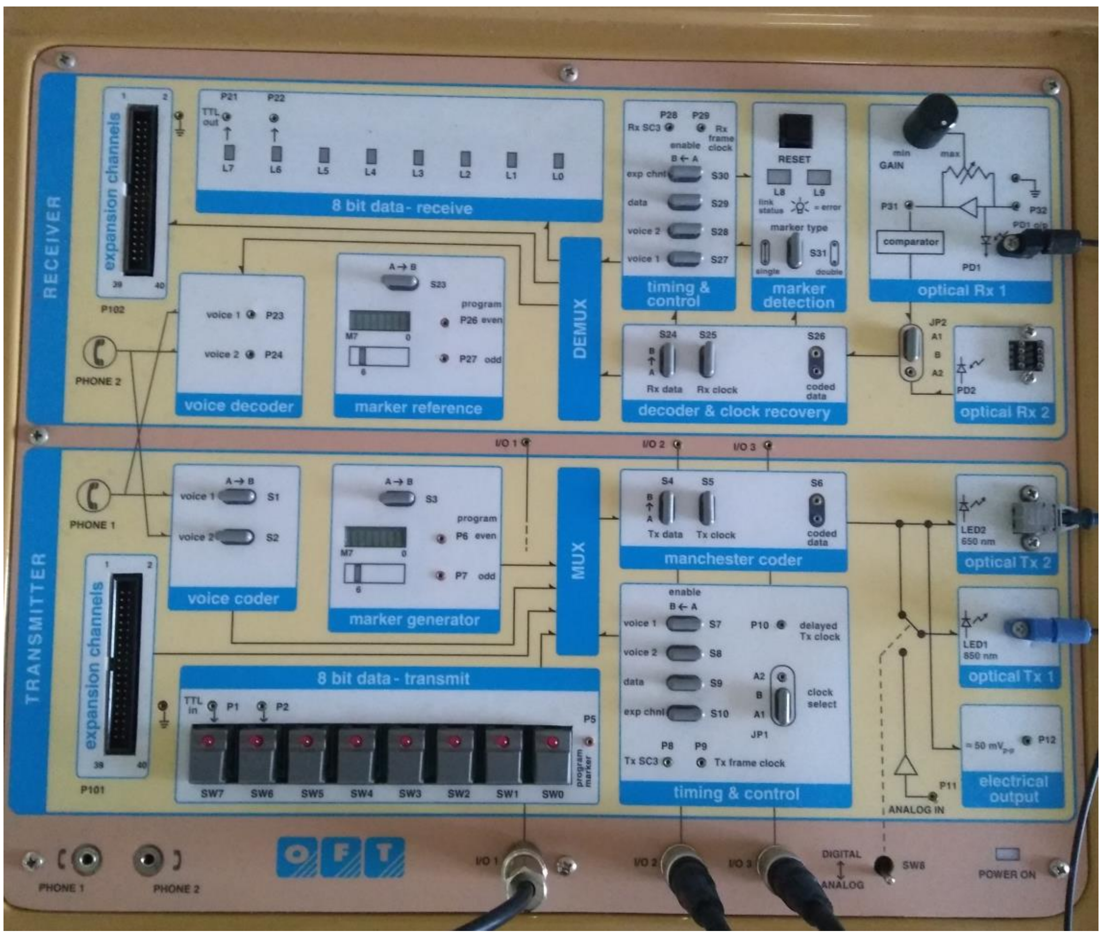
RESULT:

Thus the connector losses was measured using fiber alignment unit and the input and output voltages were noted.

Bending Loss:







Ex.No,: 1 (b) MEASUREMENT OF BENDING LOSSES

AIM:

To measure the bending losses by using optical fiber.

APPARATUS REQUIRED:

S.No.	Name of the Equipment's	Quantity
1	Benchmark Optic Fiber Trainer Kit	1
2	Two channel 20 MHz Oscilloscope	1
3	Function generator 1Hz – 10 MHz	1
4	1mm diameter of plastic optical fiber 1 meter	1
5	1mm diameter of plastic optical fiber 3 meter	1
6	BNC	2
7	Patch cords	Required

Pre lab questions:

1. What is linear scattering loss?
2. Define SBS and SRS.
3. Analyze the terms core and cladding.
4. Define radius of curvature.
5. Mention the significance of the core-cladding loss.

THEORY:

Additional loss in optical fibers may occur from bends in optical fibers. The bends in optical fibers can be classified in two categories:

(i) microscopic bends which have small radii of curvatures and comparable to fiber diameter and

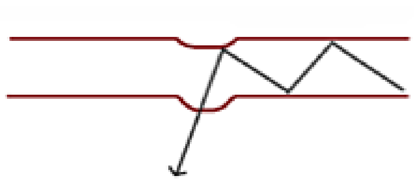
(ii) macroscopic bends which have radii of curvature much longer than the core diameter.

Both micro and macro bending can cause significant attenuation in optical fibers.

PROCEDURE:

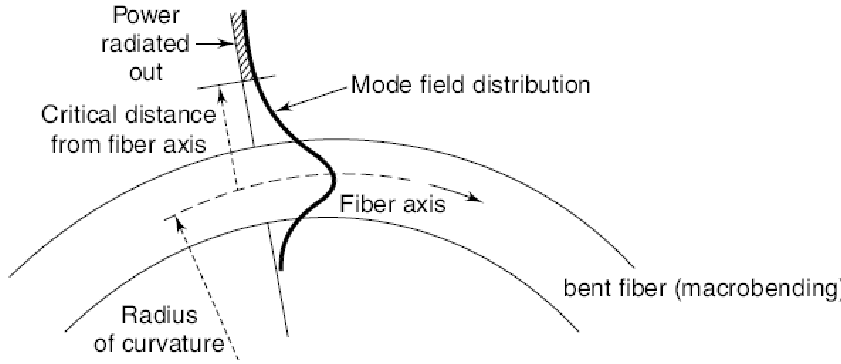
1. Connect the power supply cable to Optic fiber trainer kit.
2. Set the switch position to analog in the kit.
3. Ensure the jumper setting of clock select JP1 from A1 to B in the Timing and control also ensure the jumper settings of switches S4 & S5 from post A to B in the Manchester coder and S6 is open. (Transmitter section)

Microbending:



Light path

Macrobending:

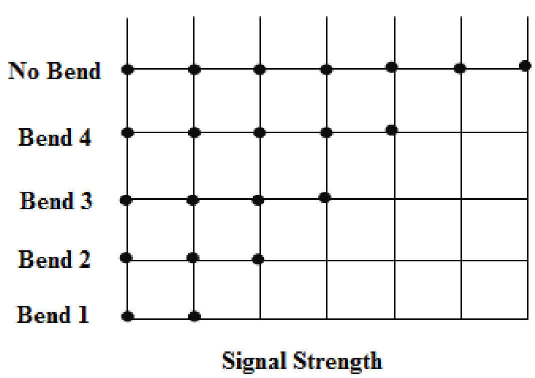


OBSERVATION:

Input signal (voltage) = 2V (before bending)

S.No	Bending (loop diameter in cm)	Output Voltage
1	6 cm	
2	5 cm	
3	4 cm	
4	3 cm	
5	2 cm	

BEND Vs SIGNAL STRENGTH

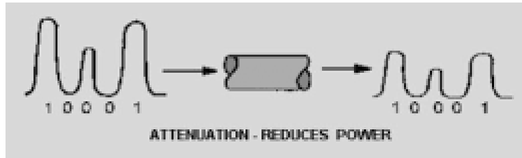


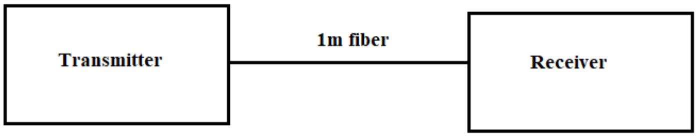
4. Similarly ensure the jumper settings of switches S24 & S25 from post A to B in the Decoder and clock recovery and S26 is open and the jumper settings JP2 from B to A1 and A2 should be in open. (Receiver section)
5. Switch ON the power supply for the kit and as well as switch ON the kit power.
6. Slightly unscrew the cap of optical transmitter Tx1 @ LED 1 850nm. Do not remove the cap from the connector. Once the cap is loosened, insert one end the 1mm diameter of plastic optical fiber 1 meter into the optical transmitter Tx1 @ LED 1 850nm cap. Now tighten the cap by screwing it back.
7. Insert other end of the optical fiber to the receiver part i.e., in optical Rx1 PD1. Slightly unscrew the cap of Rx1 PD1. Once the cap is loosened, insert one end of the 1mm diameter of plastic optical fiber 1 meter into the Rx1 PD1. Now tighten the cap by screwing it back.
8. Apply a 1 V P-P sine wave without any D.C. to I/O 3 BNC post in transmitter section
9. Connect the 3 pin patch cord between I/O 3 and I/O 2 in the receiver section and connect it in P11 post. (Analog IN, for feeding input signal to the Tx1).
10. Connect a 2 pin patch cord between P31 and I/O 1 in the receiver section.
11. Connect the transmitter section of I/O 2 and I/O 1 to oscilloscope channel 1 and channel 2 respectively.
12. Observe input sine wave signal at channel 1 and output sine wave signal at channel 2.
13. Note down the input and output amplitude of sine wave in the CRO.
14. Now bend the connected 1m fiber to form a loop from maximum diameter to minimum. Note down the input and output amplitude of sine wave in the CRO for the corresponding loop diameter. (Don’t reduce the loop diameter to less than 1cm).

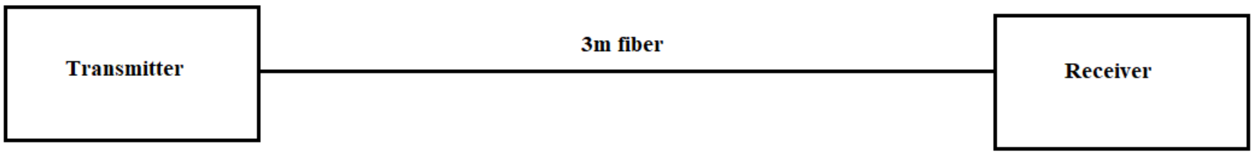
Post lab questions:

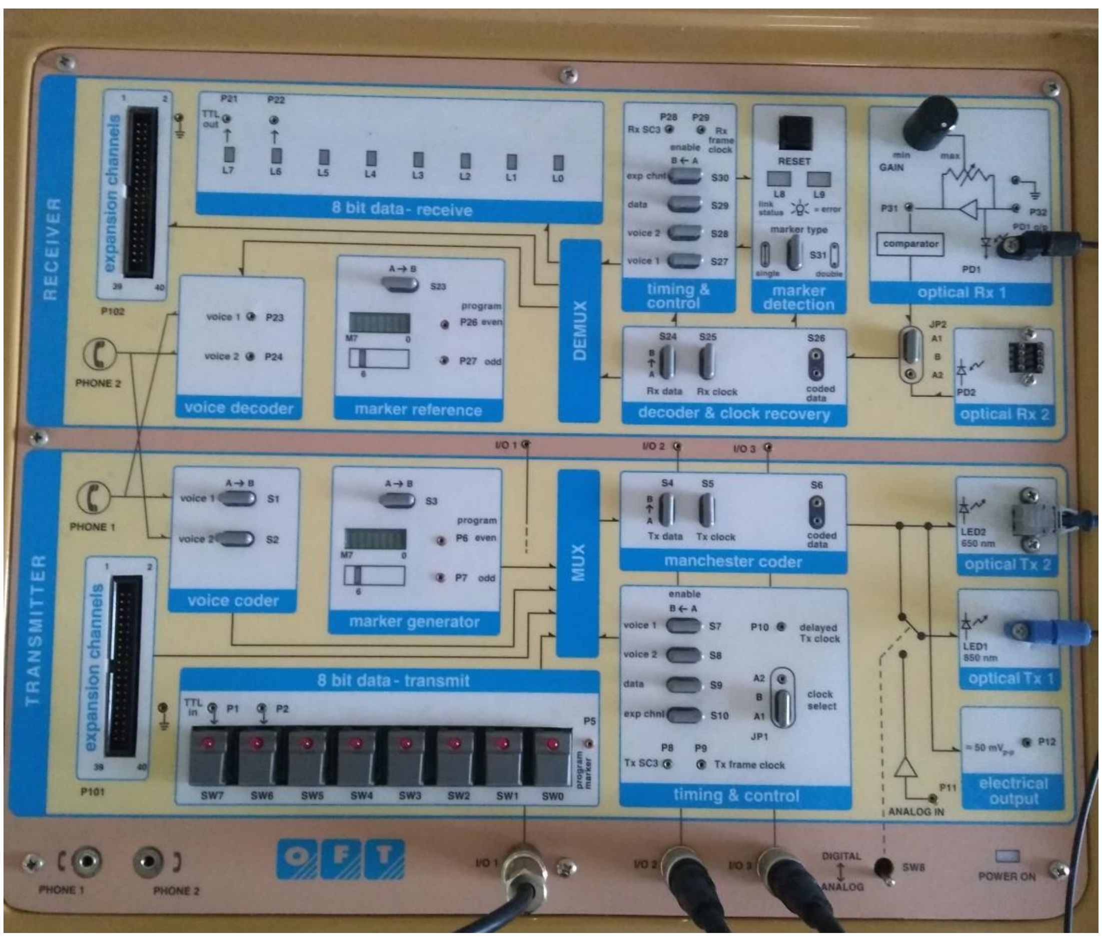
1. What is bending loss?
2. Mention the types of bending loss.
3. How to calculate the radius of curvature?
4. List the steps taken to minimize the micro bending losses.
5. Enumerate the standard formula for expressing the total power loss in an optical fiber.
6. **RESULT:**
7. Thus the bending losses was measured using fiber optic cable and the input, output voltages were noted.

Attenuation losses









Ex.No,: 1(c) MEASUREMENT OF ATTENUATION LOSS

AIM:

To measure the Attenuation losses in a given fiber optic cable.

APPARATUS REQUIRED:

S.No.	Name of the Equipment's	Quantity
1	Benchmark Optic Fiber Trainer Kit	1
2	Two channel 20 MHz Oscilloscope	1
3	Function generator 1Hz – 10 MHz	1
4	1mm diameter of plastic optical fiber 1 meter	1
5	1mm diameter of plastic optical fiber 3 meter	1
6	BNC	2
7	Patch cords	Required

Pre-lab questions:

1. Outline the significance of attenuation in transmission of a signal.
2. How does the scattering loss occur?
3. State the reasons to opt for optical fiber communication.
4. Classify the mechanisms which cause absorption.
5. Write the two most important transmission characteristics of an optical fiber.

THEORY:

Attenuation or loss, in an optical fiber, primarily decides the maximum transmission distance (distance between the optical transmitter and the receiver) without using any repeater, which generally restores the signal at intermediate points in a long haul communication system. Extremely low loss of optical fibers (~1 dB / km) made fiber based optical communication more attractive as compared to conventional electrical communication systems based on metal cables which generally offer attenuation in the range of 3–5 dB / km. The attenuation or loss in an optical fiber is measured in terms of decibel (dB) in a way similar to that measured for any other communication channel. Ideally, when light travels through an optical fiber, the power decreases exponentially with the distance traversed by the light.

OBSERVATION:

S.No	Length of the Fiber (l)	Input Voltage	Output Voltage
1	1 m		
2	3 m		

FORMULA:

$$\frac{P_3}{P_1} = \left(\frac{V_3}{V_1}\right) = e\ (-\alpha\ (l_3 - l_1))$$

$\boldsymbol{Where}$

$\boldsymbol{P_1 - Optical\ received\ power\ from\ 1m\ fiber\ optic\ cable}$

$\boldsymbol{P_3 - Optical\ received\ power\ from\ 3m\ fiber\ optic\ cable}$

$\boldsymbol{\alpha - attenuation\ is\ in\ nepers/m}$

$\boldsymbol{l1 - length\ of\ 1m\ fiber\ optic\ cable}$

$\boldsymbol{l3 - length\ of\ 3m\ fiber\ optic\ cable}$

$\boldsymbol{V_1 - input\ voltage\ for\ 1m\ length\ fiber\ optic\ cable}$

$\boldsymbol{V_3 - output\ voltage\ for\ 3m\ length\ fiber\ optic\ cable}$

CALCULATION:

The Attenuation loss (α) =

PROCEDURE:

1. Connect the power supply cable to Optic fiber trainer kit.
2. Set the switch position to analog in the kit.
3. Ensure the jumper setting of clock select JP1 from A1 to B in the Timing and control also ensure the jumper settings of switches S4 & S5 from post A to B in the Manchester coder and S6 is open. (Transmitter section)
4. Similarly ensure the jumper settings of switches S24 & S25 from post A to B in the Decoder and clock recovery and S26 is open and the jumper settings JP2 from B to A1 and A2 should be in open. (Receiver section)
5. Switch ON the power supply for the kit and as well as switch ON the kit power.
6. Slightly unscrew the cap of optical transmitter Tx1 @ LED 1 850nm. Do not remove the cap from the connector. Once the cap is loosened, insert one end the 1mm diameter of plastic optical fiber 1 meter into the optical transmitter Tx1 @ LED 1 850nm cap. Now tighten the cap by screwing it back.
7. Insert other end of the optical fiber to the receiver part i.e., in optical Rx1 PD1 (Photo Detector 1). Slightly unscrew the cap of optical receiver Rx1 PD1. Once the cap is loosened, insert one end of the 1mm diameter of plastic optical fiber 1 meter into the optical receiver Rx1 PD1. Now tighten the cap by screwing it back.
8. Apply a 1 V P-P sine wave without any D.C. to I/O 3 BNC post in transmitter section
9. Connect the 3 pin patch cord between I/O 3 and I/O 2 in the receiver section and connect it in P11 post. (Analog IN, for feeding input signal to the Tx1).
10. Connect a 2 pin patch cord between P31 and I/O 1 in the receiver section.
11. Connect the transmitter section of I/O 2 and I/O 1 to oscilloscope channel 1 and channel 2 respectively.
12. Observe input sine wave signal at channel 1 and output sine wave signal at channel 2.
13. Note down the input and output amplitude of sine wave in the CRO.
14. Now disconnect existing 1m fiber and replace it by 3m fiber by step 6 & 7.
15. Note down the input and output amplitude of sine wave in the CRO.

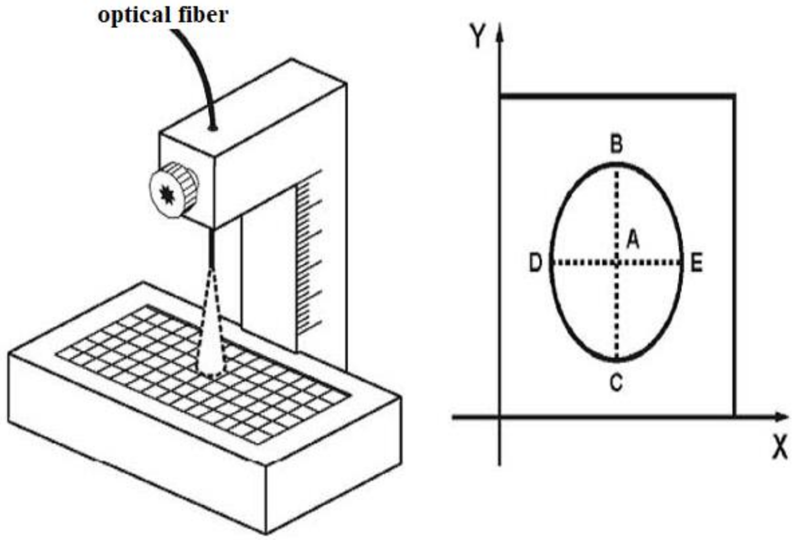
Post-lab questions:

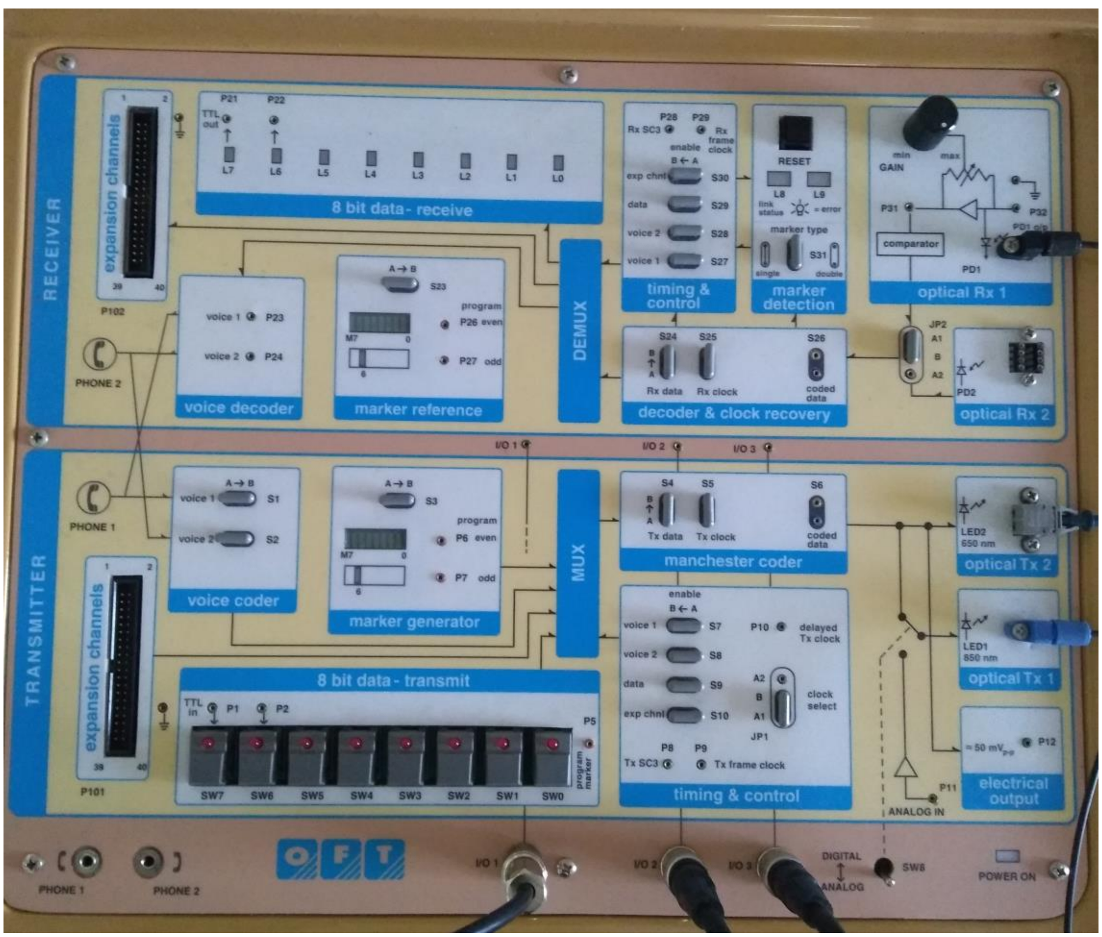
1. Identify the range of attenuation in a good quality single mode.
2. Write the unit of attenuation.
3. Compare attenuation and absorption loss.
4. Distinguish attenuation and bending loss.
5. Which limits the optical power transmission through the fiber?

RESULT:

Thus the attenuation losses was measured using 1m and 2m fiber optic cable and the input, output voltages were measured.

Numerical Aperture:





Ex.No.:2 NUMERICAL APERTURE AND MODE CHARACTERISTICS OF FIBERS

Ex.No.:2 (a) NUMERICAL APERTURE OF FIBER

AIM:

To measure the numerical aperture of the 1mm diameter of plastic optical fiber at 650 nm wavelength.

APPARATUS REQUIRED:

S.No.	Name of the Equipments	Quantity
1	Benchmark Optic Fiber Trainer Kit	1
3	1mm diameter of plastic optical fiber 1 meter	1
4	Numerical Aperture measurement unit	1
5	Steel Ruler	1

Pre-lab questions:

1. How optical source works in a communication system?
2. What is TIR?
3. Define refraction.
4. State Snell's law.
5. Mention the significance of numerical aperture in optical fiber.

THEORY:

Numerical aperture refers to the maximum angle at which the light incident on the fiber end is totally internally reflected and is transmitted properly along the fiber. The cone formed by the rotation of this angle along the axis of the fiber is the cone of acceptance of the fiber. The light ray should strike the fiber end within its cone of acceptance, else it is refracted out of the fiber core.

Consideration in Measurement:

1. It is very important that the optical source should be properly aligned with the cable and the distance from the launched point and the cable be properly selected to ensure that the maximum amount of optical power is transferred to the cable.
2. This experiment is best performed in a less illuminated room.

Observation:

d (mm)	x (mm)	NA
Average Numerical Aperture(NA)		

Formula:

$$x = (\frac{DE + BC}{4})$$

$$NA = Sin\theta = \frac{x}{\sqrt{d^2 + x^2}}$$

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

CALCULATION:

PROCEDURE:

1. Connect the power supply cable to Optic fiber trainer kit.
2. Ensure the jumper settings of switches S4, S5 & S6 from post A to B in the Manchester coder.
3. Ensure the jumper settings of switches S24, S25 & S26 from post A to B in the Decoder and clock recovery.
4. Similarly ensure the jumper setting of clock select JP1 from A1 to B in the Timing and control.
5. Switch ON the power supply for the kit and as well as switch ON the kit power.

6. Slightly unscrew the cap of optical transmitter 2 @ LED 2 650nm. Do not remove the cap from the connector. Once the cap is loosened, insert one end the 1mm diameter of plastic optical fiber 1 meter into the optical transmitter 2 @ LED 2 650nm cap. Now tighten the cap by screwing it back.
7. Insert other end of the optical fiber to the Numerical Aperture measurement unit. Adjust the fiber such that its cut face is perpendicular to the axis of the Fiber.
8. Keep the distance of about 2mm between the fiber tip and the horizontal screen. Gently tighten the screw and thus fix the fiber in the place.
9. Observe the illuminated circular patch of light on the screen.
10. Measure exactly the distance d and also the vertical and horizontal diameters BC and DE by the steel ruler.
11. Mean radius is calculated using the following formula $x = (\frac{DE+BC}{4})$
12. Find the numerical aperture of the fiber using the formula

$$NA = Sin\theta = \frac{x}{\sqrt{d^2+x^2}}$$

13. Repeat Step 10, 11 and 12 for 4mm, 6mm and 8mm to calculate the numerical aperture.

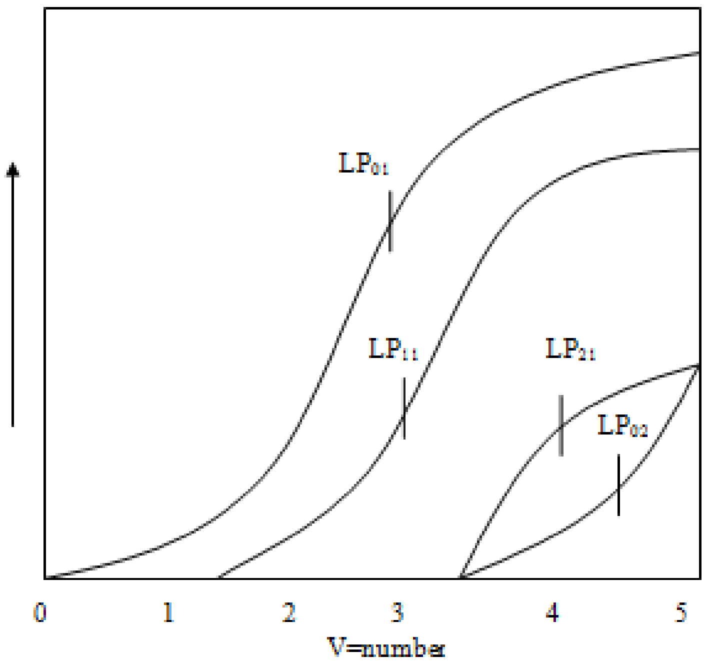
Post-lab questions:

1. Define acceptance angle for skew rays.
2. Recall the formula for NA.
3. Differentiate bound and unbound rays.
4. Which fiber have a large difference between the RI of the core and that of the cladding?
5. Write the range of Numerical aperture of a fiber.

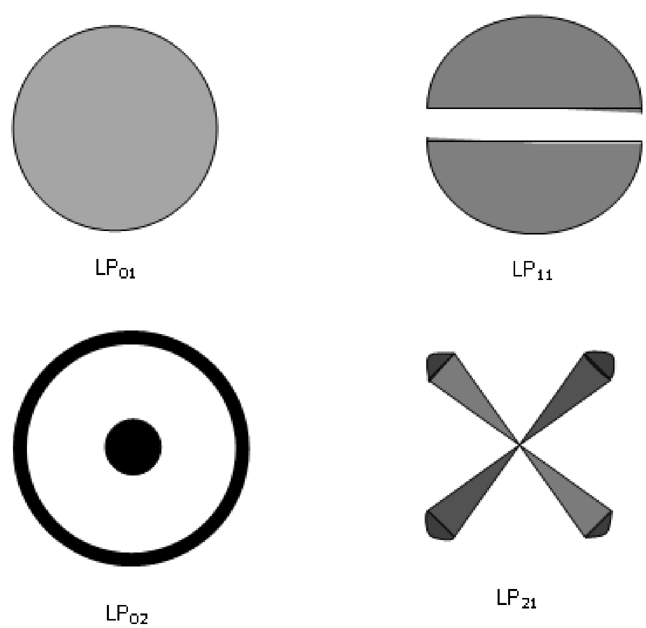
RESULT :

Thus the numerical aperture of 1mm diameter of plastic optical fiber at 650 nm wavelength was measured.

Lower Order Linearly Polarised Modes of Optical Fiber



Irradiance Pattern of Some Lower Order Linearly Polarized Mode



Ex.No.: 2 (b) MODE CHARACTERISTICS OF FIBER

AIM:

To observe the mode characteristics of fiber.

APPARATUS REQUIRED:

S.No.	Name of the Equipments	Specification	Quantity
1	Laser source (633nm-1mW)	2mW	1
2	Source to Fiber Coupler		1
3	Single Mode Fiber	SMF 9/125μm	1 meter
4	Fiber Holding Stand		1
5	Opaque Screen		1
6	Multimode Fiber	62.5/125μm	1meter

Pre lab questions:

1. What are TE modes?
2. Define Hybrid mode.
3. Devise the Maxwell's equations.
4. Mention the different types of modes in a fiber.
5. Illustrate weakly guiding approximation.

THEORY:

The central spot carries 95% of the intensity for laser beams with Gaussian profile. $I=I_0e^{-z(r/w)\ 2}$ Where e=2.718 beam of natural algorithm accepted definition of a radius of a Gaussian beam is the distance at which beam intensity has dropped to $/e^2=0.135$ times its peak value I_0. This radius called spot size. The spot diameter is W. Spot diameter (d) micron=focal length of the Lanes (f) mm X Laser Beam full divergence angle (DA) mrad.

In order to achieve maximum coupling efficiency, the fiber core diameter has to be bigger than the spot diameter.

$$NA_{rays} = \frac{\text{Laser Beam Diameter (B.D)}}{\text{2 X Lens Focal Length (f)}}$$

If $NA_{rays} \leq NA_{fiber}$ and spot diameter (w) ≤ fiber core diameter (d), then all of the laser light will be coupled into the fiber. 90% coupling efficiency into the single mode fiber from the Ne-Ne lasers is achievable. For beginners, coupling efficiency of 50% is considered to be a good result.

OBSERVATION:

Single mode Fiber:

a = 4.5μm (core radius)

NA = 0.11

$$V = \frac{2 \times \pi \times 4.5 \times 10^{-6} \times 0.11}{633 \times 10^{-9}}$$

V = 4.91

From figure only 4 LP modes propagate.

Total number of modes = $V^2/2$

No. of modes = 12

Multimode Fiber:

a = 31.25μm (core radius)

NA = 0.11

$$V = \frac{2 \times \pi \times 31.25 \times 10^{-6} \times 0.11}{633 \times 10^{-9}}$$

V = 34.12

Total number of modes = $V^2/2 = (34.12)^2/2$

No. of modes = 582.11

When V-number is less than 2.405, then only a single mode may propagate in the fiber wave-guide. This mode is HE_{11} mode or LP_{01} – Linearly Polarized mode. When V-number>2.405, other modes may propagate in the fiber. The first LP mode, which comes in at V=2.405, is the LP_{11} mode, the next lowest mode in the weakly guiding approximation.

When V is slightly greater than 2.405 i.e. V=4.91 then 4 Linearly Polarized modes will propagate through fiber.

LP_{02}: Degenerated twice: 2 modes, LP_{11}: 4 times degenerated: 4 modes

LP_{02}: Degenerated twice: 2 modes, LP_{21}: 4 times degenerated: 4 modes

Total 12 modes can propagate through fiber. This number is identical to that given by formula: $Ma=V^2/2=12$. The electromagnetic field distributions of these modes are as shown figure. We have a fiber with the proper V-number; varying the position and angle at which a tightly focused beam of the proper wavelengths is projected onto the fiber core can selectively launch these modes.

Operation Principle of Laser to Fiber Source Coupler

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

For small tilt angles, the resolution of the coupler Δz is determined by $\Delta z – f\Delta x /L$. where Δx is the resolution of the screws and L is the lever arm. For 80TPI (threads per inch) screws, a lens with 1mm focal length, and 20mm lever arm Δz = 1mm 2 micron/20mm = 0.1micron.

The number of modes propagating through the fiber depends on V-number. If the fiber whose V-number is less than 2.405, it allows to propagate single mode through it, so it is called as Single Mode Fiber. This time you will start with a fiber, which has V-number slightly greater than 2.405. Such a fiber is Multimode fiber, but the number of allowed modes is small enough so that they may be individually identified when the output of the fiber is examined.

PROCEDURE:

1. Keep Optical Bread board onto original and flat table surface, so that is will not toggle.
2. Fix the pre-fitted cylindrical head of the He-Ne laser source on to the surface of the breadboard from the bottom side with the help of Allen screws provided with it. Confirm the rigid ness of the mount.
3. Fix the laser to the fiber coupler mount on to the breadboard with the base plate orientation of it towards He-Ne laser exit.
4. Turn on the He-Ne laser and locate the beam spot on to the central portion of the laser-fiber coupling lens assembly by adjusting the vertical and horizontal travel arrangement provided with the mount. Tighten the screws of the vertical and horizontal slots.
5. Now look for the back reflection of the He-Ne spot from the rod lens of the coupler.

Irradiance Pattern of Some Lower Order Linearly Polarized Mode

1. Cylindrical laser head of the laser, adjust the back-reflected spot going back in exit hole by slowly moving the four screws provided for the laser mount.
2. Confirm the central alignment of the laser beam at the exit of the laser fiber coupler by putting a white card sheet and zooming the spot on to it. In case the spot is found off-center, adjust it to the center by slightly moving the screws of the laser mount.

3. Put the multimode optical patch cord on to the laser-fiber coupler exit and fix the other end of the fiber in the fiber holding stand by moving the grub screws provided with the holder.
4. You will see the bright laser-beam spot coming out of the fiber. Adjust the height of exit tip of the fiber to about 50mm. Min. from the white sheet of the paper.
5. Now you will see a bright round shape circular spot with laser speckle pattern on to the screen. If multimode pattern can be refined screws provided with laser-fiber coupler. Slightly adjusting or moving the screws on the laser mount can also view the change in pattern of this multimode spot.

Post-lab questions:

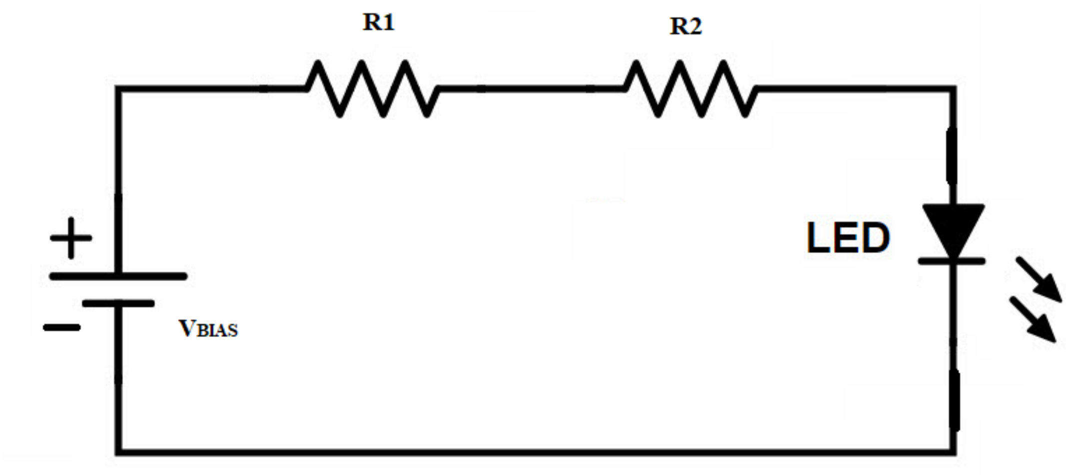
1. What are TM modes?
2. Write the expression for the total number of guided mode supported by the graded index fiber.
3. Define normalized frequency.
4. Why single mode fiber is widely used in telecommunications?
5. Enumerate the mode field diameter.

RESULT:

Thus the mode characteristics of fiber was observed.

LED

Circuit Diagram:



Observation:

S.No	Source Resistance (R_S) Ω	Voltage across resistor (V_S)	$I_f = V_S/R_S$	V_{LED} (V)	P_O (dBm)	P_O (μW)

Ex.No.: 3 DC CHARACTERISTICS OF LED AND PIN PHOTO DIODE

AIM:

To obtain the DC characteristics of LED and PIN photo diode

APPARATUS REQUIRED:

S.No	Name of the Equipment	Quantity
1.	LED module kit	1
2.	PIN photo diode kit	1
3.	Power supply Unit	1
4.	Fiber Optic cable	1 metre
5.	Power meter	1
6.	Multimeter	1
7.	Probe	Required

Pre-lab questions:

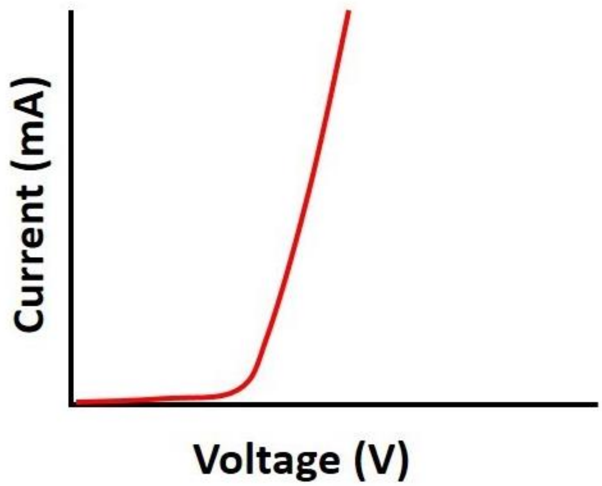
1. List the major components used in optical transmitter.
2. What is a transducer?
3. Mention the significant layers in the structure of PIN Photodiode.
4. Specify the modulation bandwidth of LED.
5. Define responsivity.

THEORY:

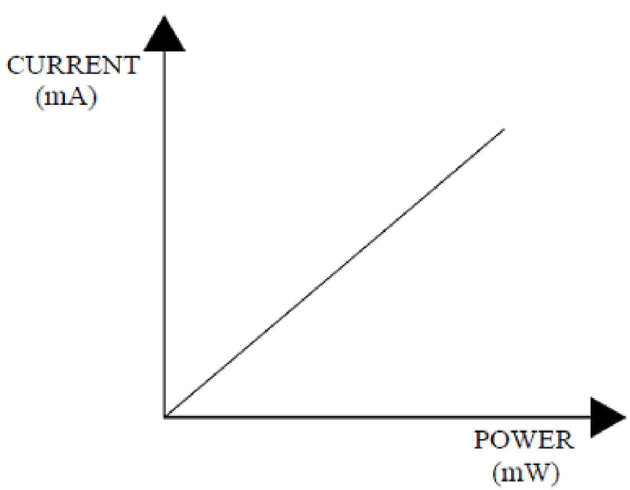
LED:

The transmitter of an optical fiber communication system consists of an optical source, optical interconnects and associated electronics necessary for modulation of the light output in accordance with the information or intelligence signal. An optical source is the key component of the optical transmitter unit. The purpose of an optical source is to convert an electrical signal reliably into optical radiation

VI Characteristics:



PI Characteristics:



(E/O conversion). There are a variety of optical sources that convert electrical energy to an optical signal (light). However, in view of the compatibility with the dimensions of an optical fiber, semiconductor optical sources are generally used in fiber optic communication system. There are two types of semiconductor optical source e.g. LightEmitting Diode (LED) and Injection Laser Diode (ILD) often referred to as Laser Diode (LD).

PIN Photo diode:

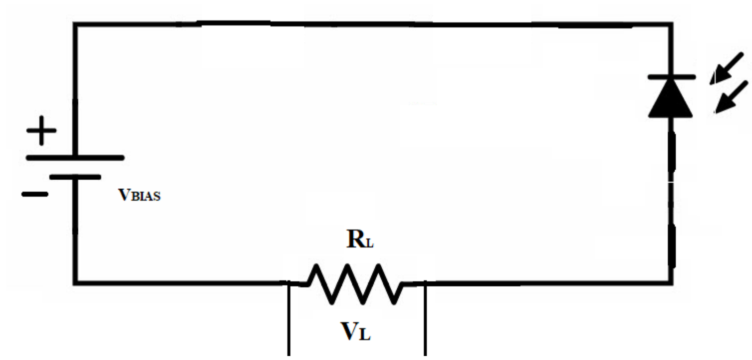
The function of a photodetector is to convert the received optical signal into its electrical counterpart. A photodetector is a key component of an optical receiver in an optical fiber communication system where the optical signal is converted to an electrical signal and subsequently processed by associated electronic circuits. The photodetector receives the transmitted optical pulses containing information (such as voice, video or computer data) impressed on it and converts it into an electrical signal that is supposed to be a replica of the original information signal. However, in practice the signal received by the receiver is generally weak and distorted depending on the nature of the channel (optical fiber in this case). The weak mutilated electrical signal extracted by the detector is further amplified and refined by subsequent stages of the receiver before being delivered at the output. From this application point of view, a photodetector is basically a transducer that converts a signal from optical domain to electrical domain. This process is known as Optical-to-Electrical (O/E) conversion. A reverse conversion from Electrical-to-Optical (E/O) domain is generally achieved in an optical fiber communication system by an optical source (e.g. light emitting diode or injection laser diode) at the transmitter end.

PROCEDURE for DC Characteristics of LED:

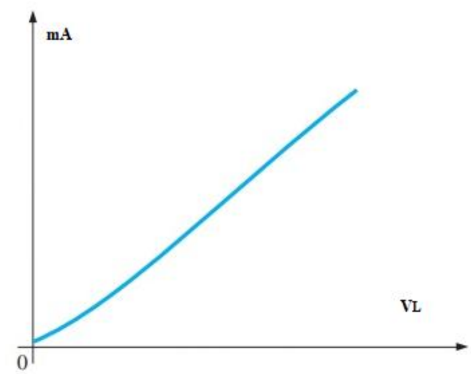
1. Connections are made as per circuit diagram.
2. Ensure that R_2 should be minimum and then switch ON the power supply.
3. Measure resistance value between R_1 & R_2 which is R_S, find the voltage acreoss the terminals V_S.
4. Measure the LED voltage V_{LED} across the diode.
5. Note down the power meter reading P which is dBm. Calculate P_O using the formula P_O=10^ (P/10) in mW.
6. Vary the R_2 value and repeat the step 4 to step 6 for different readings.
7. Plot the graph for the obtained readings.

PIN photo diode

Circuit Diagram:



VI Characteristics:



OBSERVATION:

Forward bias:

S.No	V_L (V)	$I_f=V_L/R_L$ (mA)	P_O (dBm)	P_O (μW)

PROCEDURE for DC Characteristics of PIN photo diode:

1. Connections are made as per the circuit diagram.
2. Ensure the minimum bias voltage and then switch ON the power supply.
3. Change the switch selection mode to forward bias condition.
4. Vary the input voltage V and note down the power meter readings for dBm. PO = 10^(P/10) in mW.
5. Compute IL using Ohms law.
6. Change the switch selection mode to reverse bias condition.
7. Repeat step 5 and step 6 and note down the readings.
8. Plot the graph for the obtained readings.

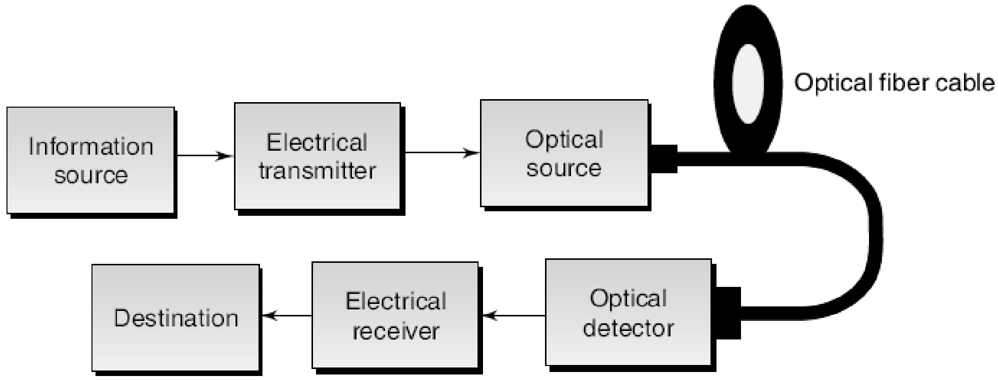
Post-lab questions:

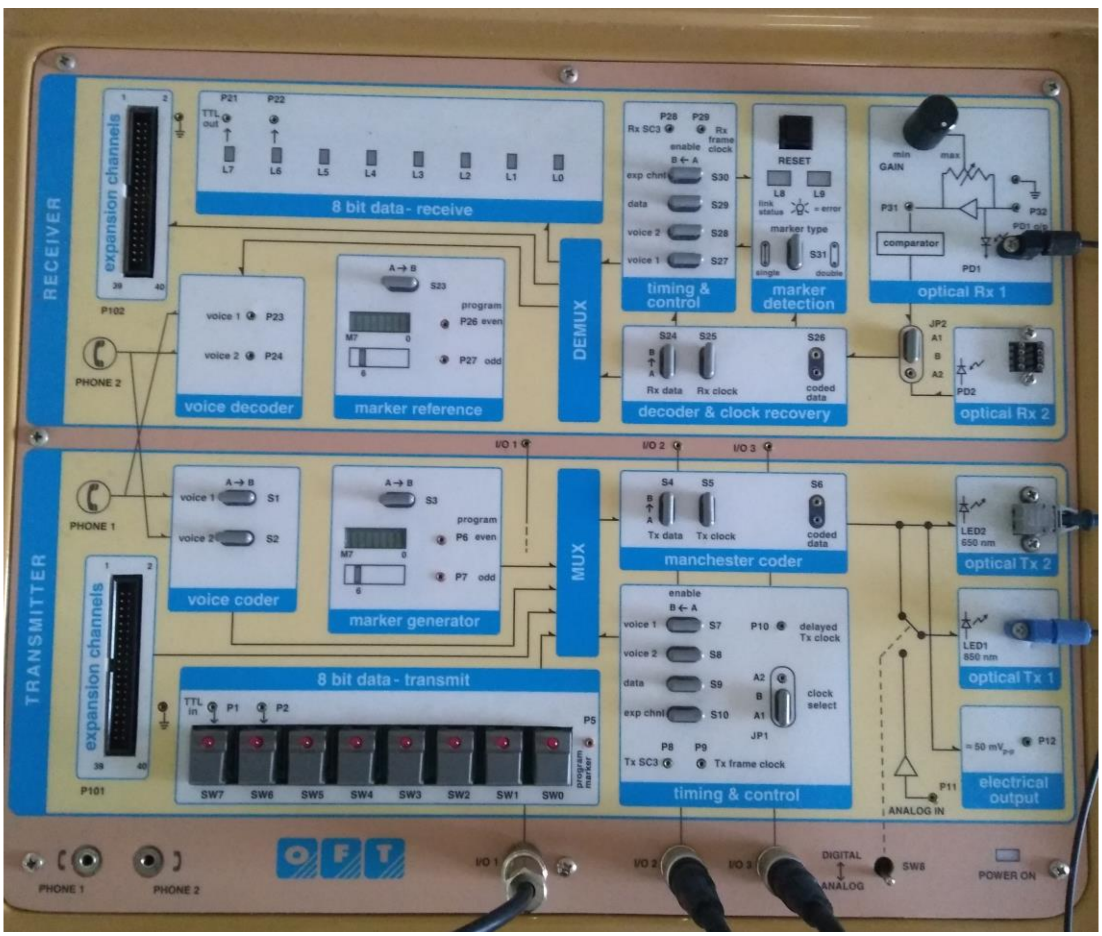
1. Give the advantages of LED.
2. How to compute internal quantum efficiency for LED.
3. Why carrier confinement is used in LED ?
4. What is radiance or brightness ?
5. Define photodiode dark current.

RESULT:

Thus the DC characteristics of LED and PIN photo diode was noted and the graph was plotted for the same.

Block diagram of an Optical Communication System:





Ex.No: 4 FIBER OPTIC ANALOG AND DIGITAL LINK CHARACTERIZATION - FREQUENCY RESPONSE (ANALOG), EYE DIAGRAM AND BER (DIGITAL).

Ex..No.: 4 (a) FIBER OPTIC ANALOG AND DIGITAL LINK CHARACTERIZATION - FREQUENCY RESPONSE (ANALOG),

AIM:

To obtain the frequency response for fiber optic analog link characterization and I/O data pattern observation for fiber optic digital link characterization using 850nm wavelength.

APPARATUS REQUIRED:

S.No.	Name of the Equipment’s	Quantity
1	Benchmark Optic Fiber Trainer Kit	1
2	Two channel 20 MHz Oscilloscope	1
3	Function generator 1Hz – 10 MHz	1
4	1mm diameter of plastic optical fiber 1 meter	1
5	Patch cords	Required
6	BNC	2

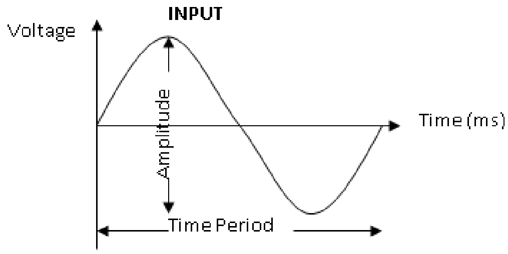
Pre Lab Questions:

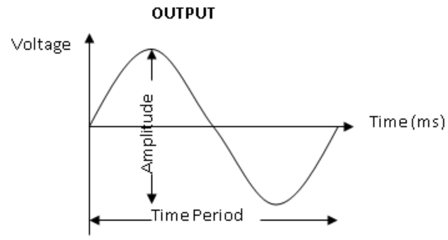
1. What is the function of an optical transmitter in an optical repeater?
2. Write the advantages of optical communication.
3. Write the functions of light sources.
4. What was the technique used in earlier communication?
5. Compare repeater and transponder.

THEORY:

Optical fiber has rapidly become the most popular medium for long distance transmission of data, voice and video signals. It has emerged today as the obvious choice in a variety of telecommunication applications, including the emerging Integrated Service Digital Networks (ISDN) and is spearheading the new information super-highways. At the same time, optical fibers are becoming increasingly popular in local and short-haul networks; thus optical fibers being used

Model graph: Fiber Optic Communication - Analog Link:





Observation:

<u>ANALOG LINK:</u>

Input voltage Vi = 1 V

S.No	Frequency (kHz)	V_o (V)	Gain = 20log(V_o/V_i) (dB)

in the transmission of signalling information for railways for communication between NC machines on a factory-floor, in a variety of local networks, and for communications within tanks, ships and aircraft.

ANALOG LINK & DIGITAL LINK:

Basically a fiber optic link contains three main elements, a transmitter, an optical fiber & a receiver. The transmitter module takes the input signal in electrical form & 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.

If the input is analog signal (sine wave) then the output is also an analog signal. If the input is digital signal like 0’s and 1’s, then the switches from SW0 to SW7 will ON for the respective data pattern. The output will be observed in receiver by glowing of the LED for the respective data input pattern.

TRANSMITTER:

Fiber optic transmitters are typically composed of an expansion channels, voice coder, marker generator, 8-bit data transmit, multiplexer, timing control, Manchester coder, electrical input section, optical TX1 @ LED1 850 nm and optical TX2 @ LED2 650nm.

TRANMISSION MEDIUM:

An optical fiber is a cylindrical dielectric waveguide that confines the electromagnetic energy in the form of light and guides it in a direction parallel to its axis. The transmission characteristics of the fiber depend on the structure of the fiber.

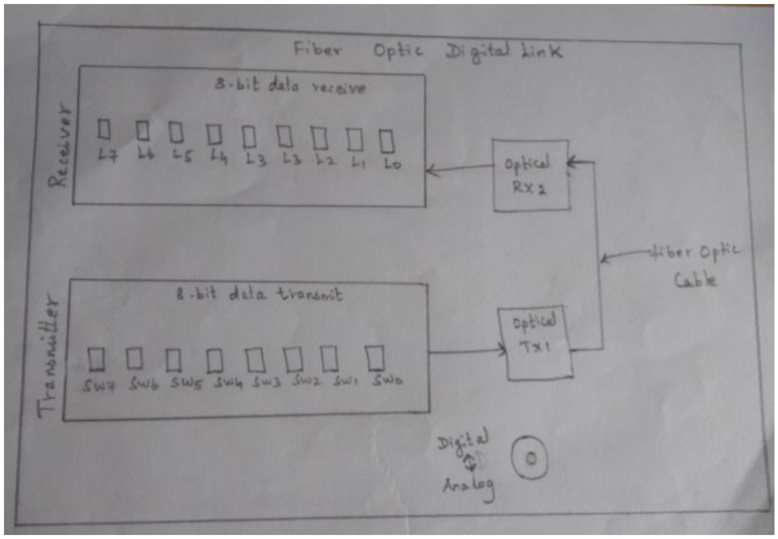
RECEIVER:

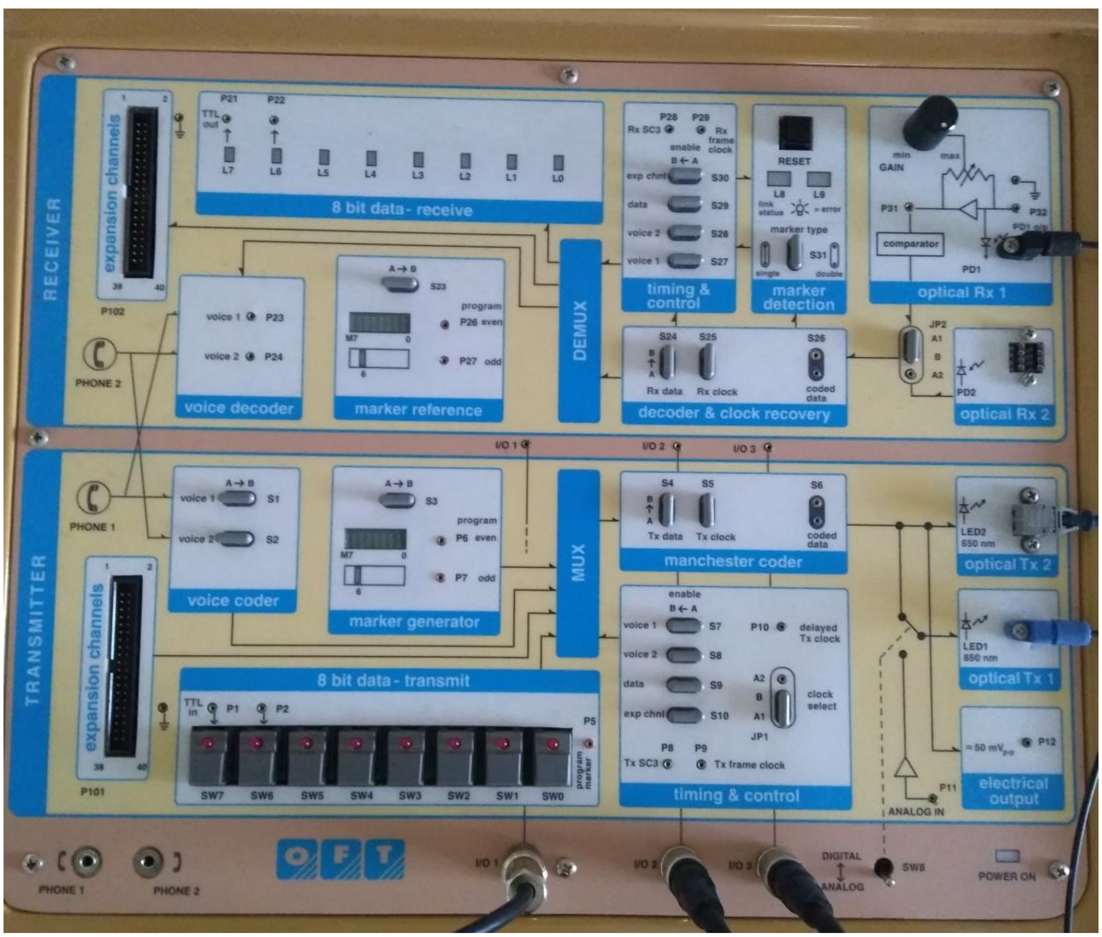
Fiber optic receivers are typically composed of an expansion channels, voice decoder, marker reference, 8-bit data receive, demultiplexer, timing control, marker detection, decoder & clock recovery, optical RX1 photo detector and optical RX2 photo detector.

PROCEDURE: FIBER OPTIC COMMUNICATION - ANALOG LINK:

1. Connect the power supply cable to Optic fiber trainer kit.
2. Set the switch position to analog in the kit.
3. Ensure the jumper settings of switches S4 & S5 from post A to B in the Manchester coder and S6 is opened.

Fiber Optic Communication Digital link:





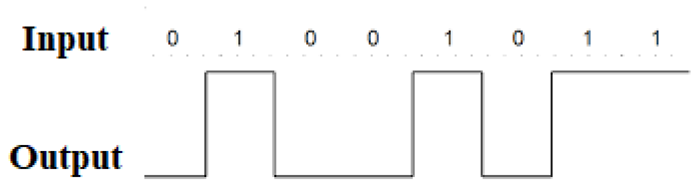
4. Ensure the jumper settings of switches S24, S25 & S26 from post A to B in the Decoder and clock recovery.
5. Similarly ensure the jumper setting of clock select JP1 from A1 to B in the Timing and control.
6. Switch ON the power supply for the kit and as well as switch ON the kit power.
7. Slightly unscrew the cap of optical transmitter Tx1 @ LED 1 850nm. Do not remove the cap from the connector. Once the cap is loosened, insert one end the 1mm diameter of plastic optical fiber 1 meter into the optical transmitter Tx1 @ LED 1 850nm cap. Now tighten the cap by screwing it back.
8. Insert other end of the optical fiber to the receiver part i.e., in optical Rx1 PD1 (Photo Detector 1). Slightly unscrew the cap of optical receiver Rx1 PD1. Once the cap is loosened, insert one end of the 1mm diameter of plastic optical fiber 1 meter into the optical receiver Rx1 PD1. Now tighten the cap by screwing it back.
9. Apply a 1 V P-P sine wave without any D.C. to I/O 3 BNC post in transmitter section
10. Connect the 3 pin patch cord between I/O 3 and I/O 2 in the receiver section and connect it in P11 post. (Analog IN, for feeding input signal to the Tx1).
11. Connect a 2 pin patch cord between P31 and I/O 1 in the receiver section.
12. Connect the transmitter section of I/O 2 and I/O 1 to oscilloscope channel 1 and channel 2 respectively.
13. Observe the input sine wave signal at channel 1 and output sine wave signal at channel 2.
14. Adjust the GAIN Knob from min to max which is in optical Rx1 such that no clipping take place.
15. Vary the input signal from 100 Hz to 5 MHz and measure the gain of the received signal.
16. Plot the frequency Vs gain and find out the lower cut-off frequency, upper cut-off frequency to calculate the bandwidth.

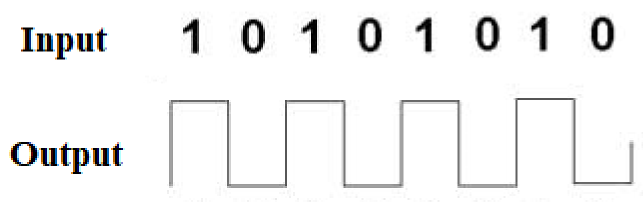
FIBER OPTIC COMMUNICATION – DIGITAL LINK:

1. Connect the power supply cable to Optic fiber trainer kit.
2. Set the switch position to digital in the kit.
3. Ensure the jumper settings of switches S4 & S5 from post A to B in the Manchester coder and S6 is opened.

Model Graph:

Fiber Optic Communication – Digital Link:





Observation:

<u>DIGITAL LINK:</u>

Input - Switch	Output - LED
Data pattern - 0 1 0 0 1 0 1 1 **Switch Conditions** SW6, SW3, SW1, SW0 – ON position SW7, SW5, SW4, SW2 – OFF position	**For the given Data pattern - 0 1 0 0 1 0 1 1** **LED Conditions** L6, L3, L1, L0 – indicates LED ON (glow) L7, L5, L4, L2 – indicates LED OFF
Data pattern - 1 0 1 0 1 0 1 0 **Switch Conditions** SW7, SW5, SW3, SW1 – ON position SW6, SW4, SW2, SW0 – OFF position	**For the given Data pattern - 1 0 1 0 1 0 1 0** **LED Conditions** L7, L5, L3, L1 – indicates LED ON (glow) L6, L4, L2, L0 - indicates LED OFF

4. . Ensure the jumper settings of switches S24, S25 & S26 from post A to B in the Decoder and clock recovery
5. Similarly ensure the jumper setting of clock select JP1 from A1 to B in the Timing and control.
6. Switch ON the power supply for the kit and as well as switch ON the kit power.
7. Slightly unscrew the cap of optical transmitter Tx1 @ LED 1, 850nm. Do not remove the cap from the connector. Once the cap is loosened, insert one end the 1mm diameter of plastic optical fiber 1 meter into the optical transmitter Tx1 @ LED 1, 850nm cap. Now tighten the cap by screwing it back.
8. Insert other end of the optical fiber to the receiver part i.e., in optical Rx1 PD1 (Photo Detector 1). Slightly unscrew the cap of optical receiver Rx1 PD1. Once the cap is loosened, insert one end of the 1mm diameter of plastic optical fiber 1 meter into the optical receiver Rx1 PD1. Now tighten the cap by screwing it back.
9. Choose any 8 bit data pattern and switch ON it respectively in the 8-bit data transmit block.
10. Observe output in the 8-bit data receiver block. LED's will glow for the corresponding applied input switches.

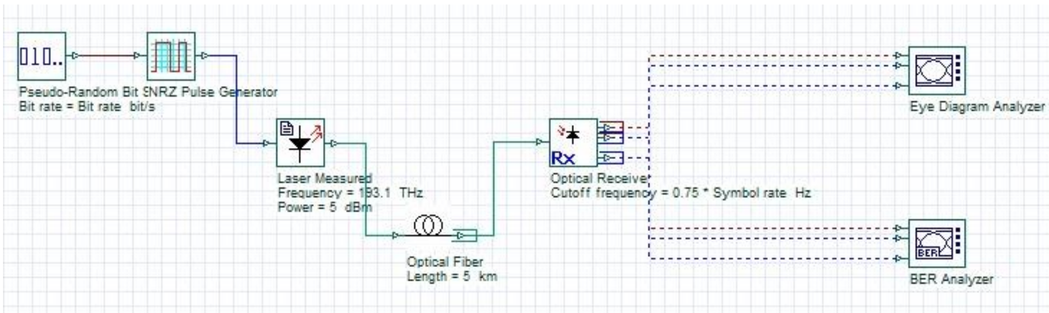
Post Lab Questions:

1. What is link?
2. Define node.
3. Give the difference between analog link and digital link.
4. Differentiate wired and wireless communication.
5. What is the function of an optical receiver in an optical repeater?

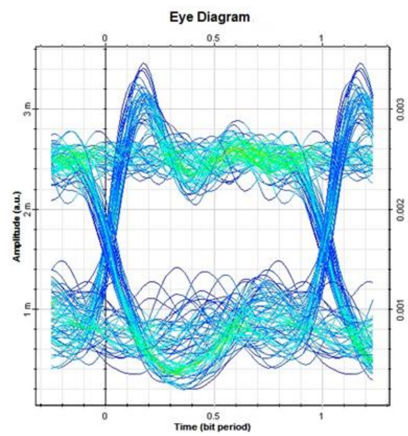
RESULT:

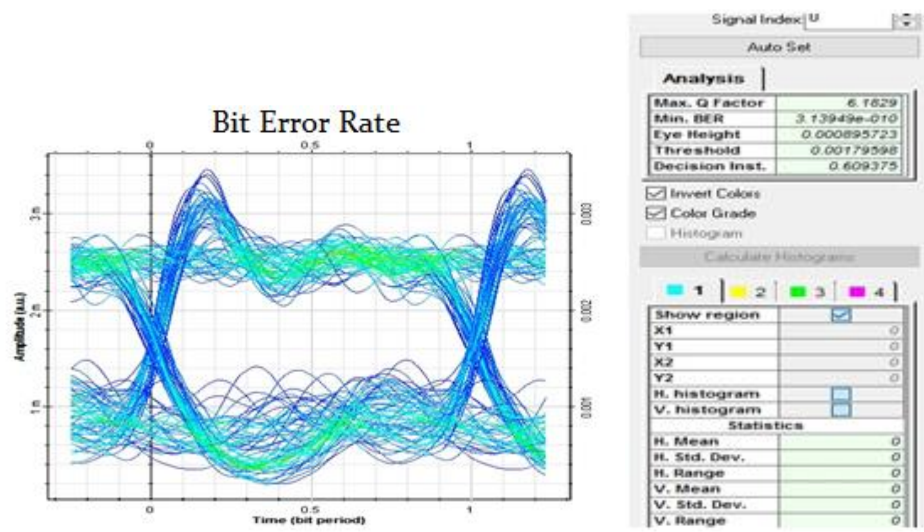
Thus the frequency response for fiber optic analog link characterization and I/O data pattern observation for fiber optic digital link characterization was verified by using 850nm wavelength.

Optical Fiber Communication Link:



OUTPUT:





Ex.No.: 4 (b) EYE DIAGRAM AND BER (DIGITAL)

AIM:

To analyze the Eye diagram and Bit Error Rate by using an optical receiver.

SOFTWARE USED:

Optisystem 14

MODULES REQUIRED:

- BER Analyzer
- Optical Fiber Cable
- Signal generator
- Pulse generator
- DFB laser
- Optical Receiver

Pre-lab questions:

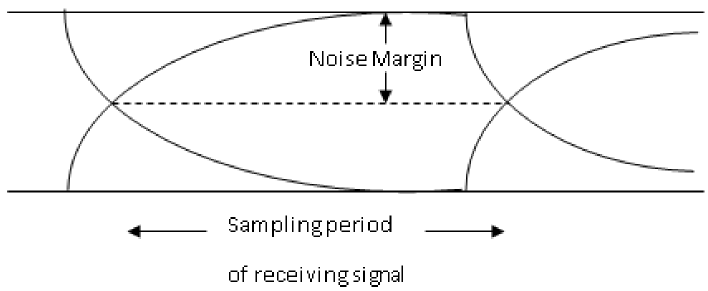
1. Define time jitter.
2. Write the fundamental concepts of a coherent light wave system.
3. What is mask testing?
4. How to define an eye contour.
5. Differentiate ASK, FSK and PSK.

THEORY:

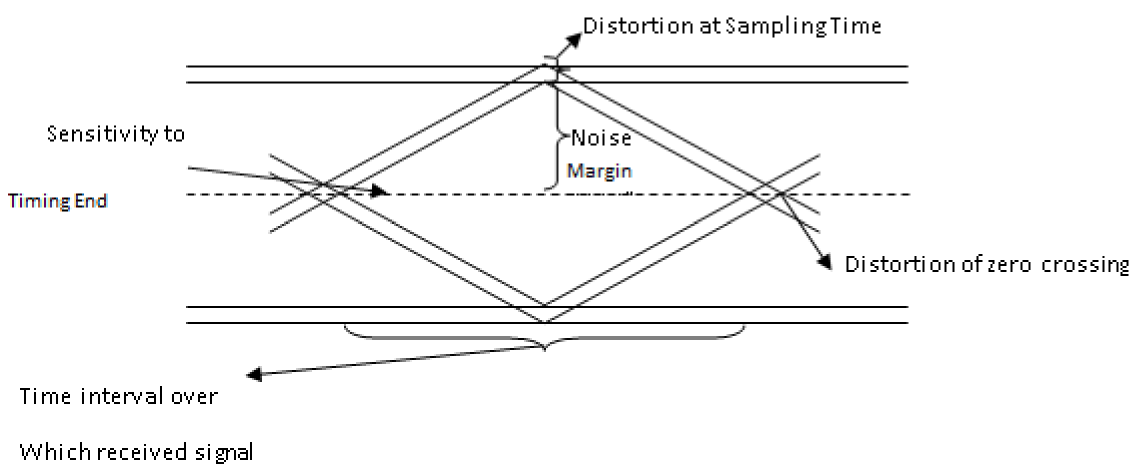
Eye diagrams are generated on a Bit Error Rate (BER) analyzer and are used to measure the reliability and performance of the communication system. It can be used to measure the quality of the transmission link. An eye diagram is a display showing overlapping of all the possible one-zero combination. Eye diagram is known as multi-valued displays, because each point in time axis has multiple voltage values. The width of the eye represents the pulse width or bit period. As the eye closes horizontally, it signifies that the bits are more closely together, increasing the possibility of ISI. The vertical aspect of the eye diagram shows how accurate the system can distinguish a bit 1 and 0. If the eye closes vertically, it signifies the system will not be able to distinguish 1's and 0's accurately.

MODEL GRAPH:

Eye Pattern



Interpretation of Eye Pattern



PROCEDURE:

1. Refer to Figure and make the following connections using Optisystem software.
2. Set the data rate of 2.5Gbps.
3. Simulate the optical communication link.
4. View the eye diagram and bit error rate value using either Eye diagram analyzer or BER analyzer.

Post-lab questions:

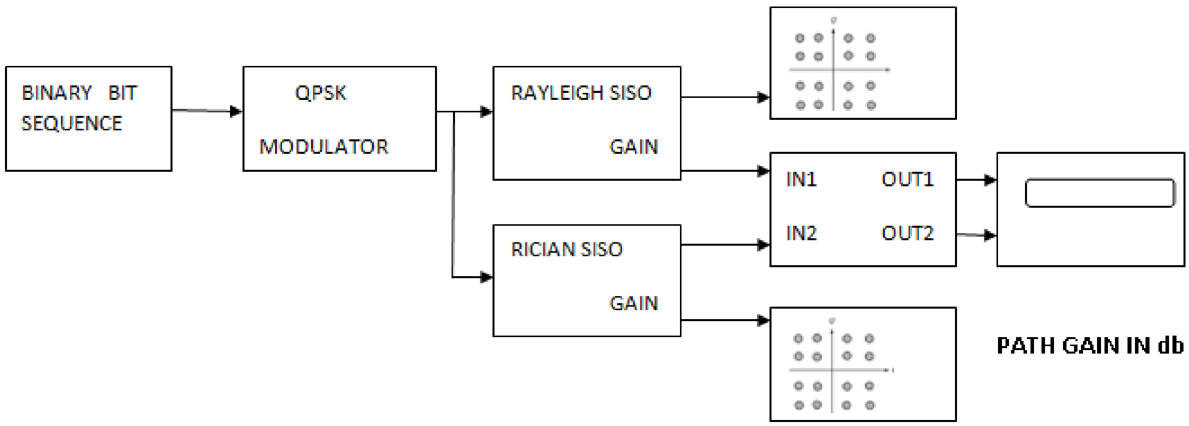
1. Mention the significance of eye pattern.
2. What is intersymbol interference?
3. How the performance of analog receiver and digital receiver is measured?
4. Devise a method to generate pseudorandom sequence.
5. Define noise margin.

RESULT:

Thus the Eye diagram and Bit Error Rate was analyzed by using an optical receiver.

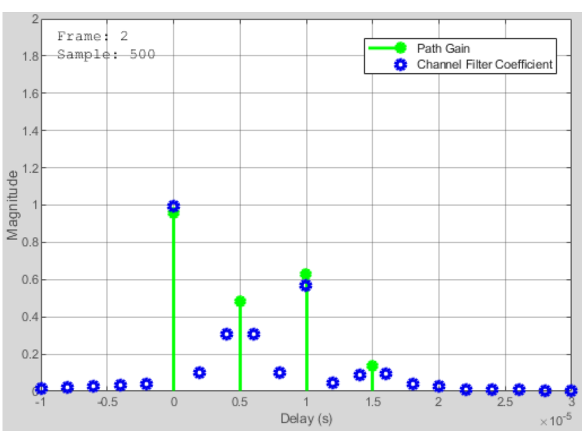
WIRELESS COMMUNICATION EXPERIMENTS

Block Diagram:

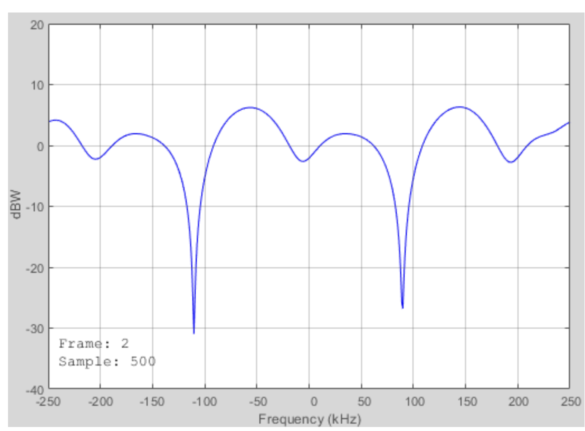


Simulation Outputs:

Impulse Response



Frequency Response



Ex.No.: 5 WIRELESS CHANNEL SIMULATION INCLUDING FADING AND DOPPLER EFFECTS

AIM:

To simulate the wireless channel including Rayleigh and Rician multipath fading channel system objects and Doppler shifts.

COMPONENTS REQUIRED:

- ❖ Personal computer
- ❖ MATLAB software

Pre Lab Questions:

1. Define fading.
2. What is diffraction and scattering?
3. How impulse response.is mentioned for the free space signal.
4. Mention the advantage of MATLAB in computation of wireless channel parameters.
5. Define Brewster angle.

THEORY:

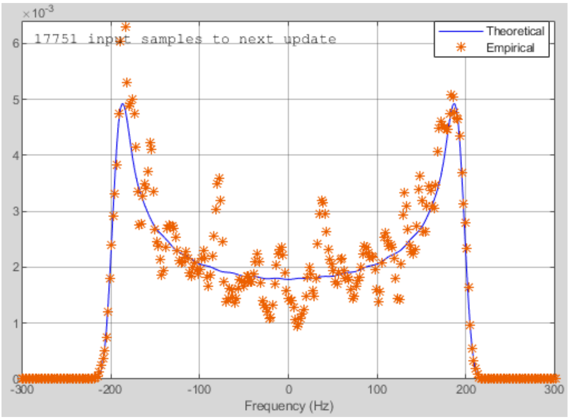
Fading:

Fading is used to describe the rapid fluctuations of the amplitudes, phases or multipath delays of a radio signal over a short period of time or travel distance, so that large-scale path loss effects may be ignored. Fading is caused by interference between two or more versions of the transmitted signal which arrive at the receiver at slightly different times. These waves called multipath waves, combine at the receiver antenna to give a resultant signal which can vary widely in amplitude and phase, depending on the distribution of the intensity and relative propagation time of the waves and the bandwidth of the transmitted signal.

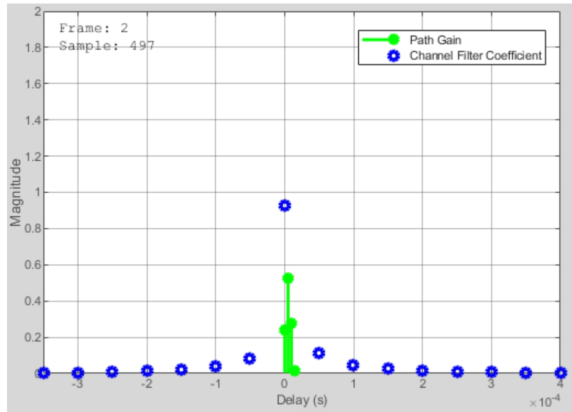
The three most important effects are

- ❖ Rapid changes in signal strength over a small travel distance or time interval.

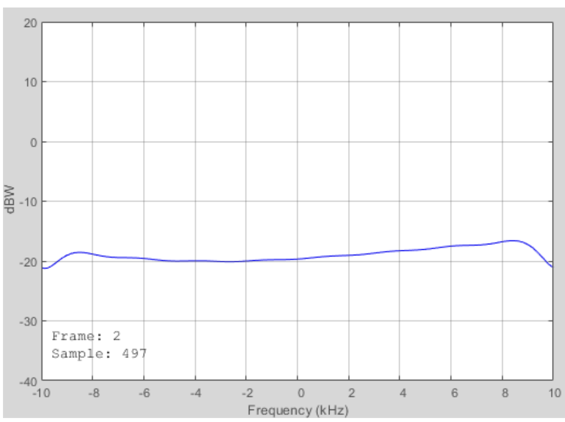
Doppler Spectrum



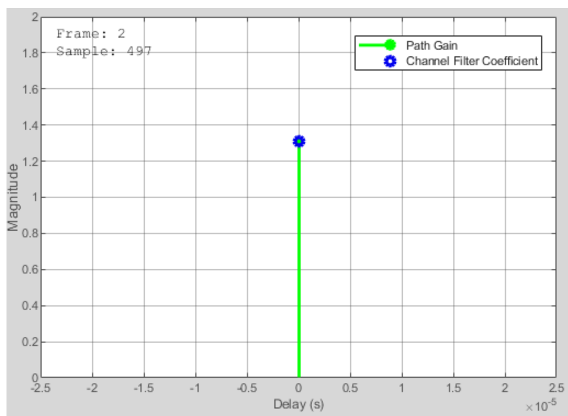
Impulse Response



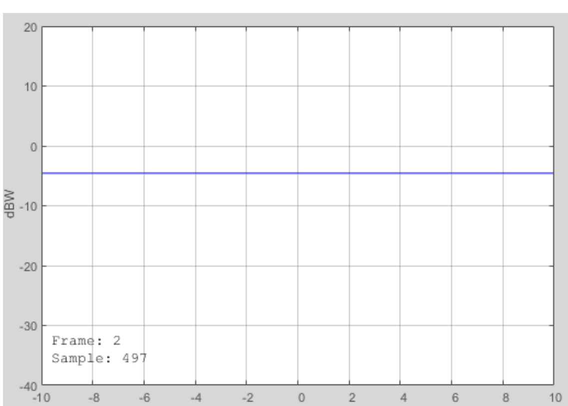
Frequency Response



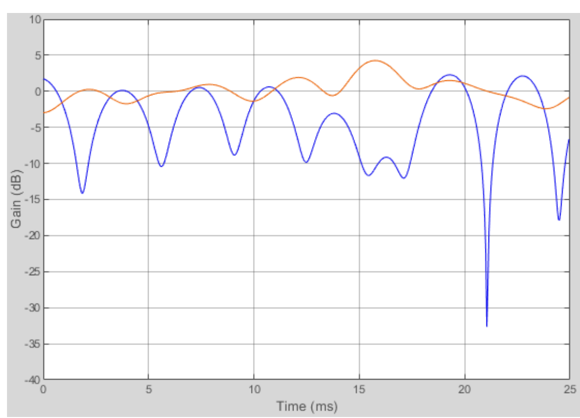
Impulse Response



Frequency Response



Multipath Gain



- ❖ Random frequency modulation due to varying Doppler shifts on different multipath signals.
- ❖ Time dispersion (echoes) caused by multipath propagation delays.

Doppler Effects:

Due to the relative motion between the mobile and base station each multipath wave experiences an apparent shift in frequency. The shift in received signal frequency due to motion is called Doppler Effect, and it is directly proportional to the velocity and direction of motion of the mobile with respect to the direction of arrival of the received multipath wave.

PROCEDURE:

Processing a signal using a fading channel involves the following steps:

1. Create a channel System object that describes the channel that you want to use. A channel object is a type of MATLAB variable that contains information about the channel, such as the maximum Doppler shift.
2. Adjust properties of the System object, if necessary, to tailor it to your needs. For example, you can change the path delays or average path gains.
3. Apply the channel System object to your signal using the step method, which generates random discrete path gains and filters the input signal. The characteristics of a channel can be shown with the built-in visualization support of the System object.

PROGRAM:

```
sampleRate500kHz = 500e3;    % Sample rate of 500K Hz
sampleRate20kHz  = 20e3;     % Sample rate of 20K Hz
maxDopplerShift  = 200;      % Maximum Doppler shift of diffuse components (Hz)
delayVector = (0:5:15)*1e-6; % Discrete delays of four-path channel (s)
gainVector  = [0 -3 -6 -9];  % Average path gains (dB)

KFactor = 10;            % Linear ratio of specular power to diffuse power
specDopplerShift = 100;  % Doppler shift of specular component (Hz)

% Configure a Rayleigh channel object
```

```
rayChan = comm.RayleighChannel( ...
    'SampleRate',          sampleRate500kHz, ...
    'PathDelays',          delayVector, ...
    'AveragePathGains',    gainVector, ...
    'MaximumDopplerShift', maxDopplerShift, ...
    'RandomStream',        'mt19937ar with seed', ...
    'Seed',                10, ...
    'PathGainsOutputPort', true);

% Configure a Rician channel object
ricChan = comm.RicianChannel( ...
    'SampleRate',              sampleRate500kHz, ...
    'PathDelays',              delayVector, ...
    'AveragePathGains',        gainVector, ...
    'KFactor',                 KFactor, ...
    'DirectPathDopplerShift',  specDopplerShift, ...
    'MaximumDopplerShift',     maxDopplerShift, ...
    'RandomStream',            'mt19937ar with seed', ...
    'Seed',                    100, ...
    'PathGainsOutputPort',     true);
qpskMod = comm.QPSKModulator( ...
    'BitInput',    true, ...
    'PhaseOffset', pi/4);

% Number of bits transmitted per frame is set to be 1000. For QPSK
% modulation, this corresponds to 500 symbols per frame.
bitsPerFrame = 1000;
msg = randi([0 1],bitsPerFrame,1);

% Modulate data for transmission over channel
modSignal = qpskMod(msg);
```

```
% Apply Rayleigh or Rician channel object on the modulated data
rayChan(modSignal);
ricChan(modSignal);

release(rayChan);
release(ricChan);

rayChan.Visualization = 'Impulse and frequency responses';
rayChan.SamplesToDisplay = '100%';

numFrames = 2;

for i = 1:numFrames % Display impulse and frequency responses for 2 frames
   % Create random data
   msg = randi([0 1],bitsPerFrame,1);
   % Modulate data
   modSignal = qpskMod(msg);
   % Filter data through channel and show channel responses
   rayChan(modSignal);
end

release(rayChan);
rayChan.Visualization = 'Doppler spectrum';
numFrames = 5000;

for i = 1:numFrames % Display Doppler spectrum from 5000 frame transmission
   msg = randi([0 1],bitsPerFrame,1);
   modSignal = qpskMod(msg);
   rayChan(modSignal);
end
```

Narrowband or Frequency-Flat Fading

```
release(rayChan);
rayChan.Visualization = 'Impulse and frequency responses';
rayChan.SampleRate = sampleRate20kHz;
rayChan.SamplesToDisplay = '25%';  % Display one of every four samples

numFrames = 2;

for i = 1:numFrames % Display impulse and frequency responses for 2 frames
    msg = randi([0 1],bitsPerFrame,1);
    modSignal = qpskMod(msg);
    rayChan(modSignal);
end
```

release(rayChan);

```
rayChan.PathDelays = 0;        % Single fading path with zero delay
rayChan.AveragePathGains = 0;  % Average path gain of 1 (0 dB)

for i = 1:numFrames % Display impulse and frequency responses for 2 frames
    msg = randi([0 1],bitsPerFrame,1);
    modSignal = qpskMod(msg);
    rayChan(modSignal);
end
```

release(rayChan);

```
rayChan.Visualization = 'Off'; % Turn off System object's visualization
ricChan.Visualization = 'Off'; % Turn off System object's visualization

% Same sample rate and delay profile for the Rayleigh and Rician objects
ricChan.SampleRate       = rayChan.SampleRate;
ricChan.PathDelays       = rayChan.PathDelays;
```

```
ricChan.AveragePathGains = rayChan.AveragePathGains;
% Configure a Time Scope System object to show path gain magnitude
gainScope = dsp.TimeScope( ...
    'SampleRate', rayChan.SampleRate, ...
    'TimeSpan',   bitsPerFrame/2/rayChan.SampleRate, ... % One frame span
    'Name',       'Multipath Gain', ...
    'ShowGrid',   true, ...
    'YLimits',    [-40 10], ...
    'YLabel',     'Gain (dB)');

% Compare the path gain outputs from both objects for one frame
msg = randi([0 1],bitsPerFrame,1);
modSignal = qpskMod(msg);
[~, rayPathGain] = rayChan(modSignal);
[~, ricPathGain] = ricChan(modSignal);
% Form the path gains as a two-channel input to the time scope
gainScope(10*log10(abs([rayPathGain, ricPathGain]).^2));
```

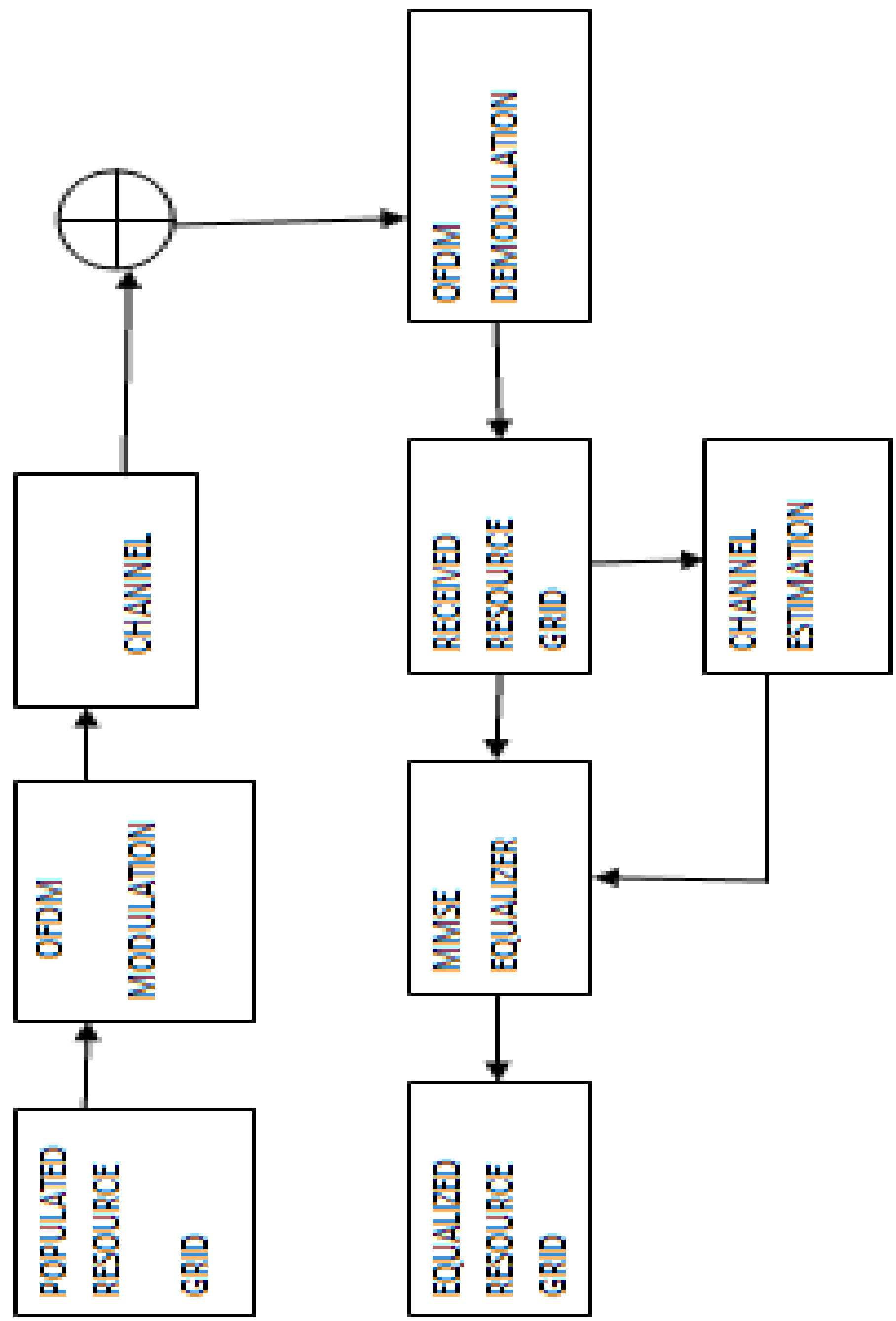
Post Lab Questions:

1. Differentiate slow fading and fast fading.
2. Define Doppler shift.
3. List the factors influencing small scale fading.
4. What are the important parameters of mobile multipath channels?
5. How frequency selective fading differs from flat fading ?

RESULT:

Thus the wireless channel including Rayleigh and Rician multipath fading channel system objects and Doppler shifts were simulated and the graphs are noted.

Block Diagram:



Ex.No.: 6 SIMULATION OF CHANNEL ESTIMATION, SYNCHRONIZATION AND EQUALIZATION TECHNIQUES

AIM:

To Simulate the Channel Estimation, Synchronization & Equalization techniques using MATLAB.

COMPONENTS REQUIRED:

- Personal computer
- MATLAB

Pre Lab Questions:

1. Compare simplex, duplex.
2. What is full duplex?
3. Give the advantages of wireless communication.
4. Define channel estimation.
5. Discuss about channel assignment in wireless communication.

THEORY:

Channel Estimation:

In digital wireless communication systems, information is transmitted through a radio channel. For conventional, coherent receivers, the effect of the channel on the transmitted signal must be estimated to recover the transmitted information. For example, with binary phase shift keying (BPSK), binary information is represented as +1 and −1 symbol values. The radio channel can apply a phase shift to the transmitted symbols, possibly inverting the symbol values. As long as the receiver can estimate what the channel did to the transmitted signal, it can accurately recover the information sent.

Channel estimation is a challenging problem in wireless communications. Transmitted signals are typically reflected and scattered, arriving at the receiver along multiple paths. When these paths have similar delays, they add either constructively or destructively, giving rise to fading. When these paths have very different delays, they appear as signal echoes. Due to the mobility of the transmitter, the receiver, or the scattering objects, the channel changes over time.

Program:

```
enb.NDLRB = 15;                 % Number of resource blocks
enb.CellRefP = 1;               % One transmit antenna port
enb.NCellID = 10;               % Cell ID
enb.CyclicPrefix = 'Normal';    % Normal cyclic prefix
enb.DuplexMode = 'FDD';         % FDD
SNRdB = 22;             % Desired SNR in dB
SNR = 10^(SNRdB/20);    % Linear SNR
rng('default');         % Configure random number generators

cfg.Seed = 1;                  % Channel seed
cfg.NRxAnts = 1;               % 1 receive antenna
cfg.DelayProfile = 'EVA';      % EVA delay spread
cfg.DopplerFreq = 120;         % 120Hz Doppler frequency
cfg.MIMOCorrelation = 'Low';   % Low (no) MIMO correlation
cfg.InitTime = 0;              % Initialize at time zero
cfg.NTerms = 16;               % Oscillators used in fading model
cfg.ModelType = 'GMEDS';       % Rayleigh fading model type
cfg.InitPhase = 'Random';      % Random initial phases
cfg.NormalizePathGains = 'On'; % Normalize delay profile power
cfg.NormalizeTxAnts = 'On';    % Normalize for transmit antennas

cec.PilotAverage = 'UserDefined'; % Pilot averaging method
cec.FreqWindow = 9;               % Frequency averaging window in REs
cec.TimeWindow = 9;               % Time averaging window in REs

gridsize = lteDLResourceGridSize(enb);
K = gridsize(1);    % Number of subcarriers
L = gridsize(2);    % Number of OFDM symbols in one subframe
P = gridsize(3);    % Number of transmit antenna ports
```

```
txGrid = [];

% Number of bits needed is size of resource grid (K*L*P) * number of bits
% per symbol (2 for QPSK)
numberOfBits = K*L*P*2;

% Create random bit stream
inputBits = randi([0 1], numberOfBits, 1);

% Modulate input bits
inputSym = lteSymbolModulate(inputBits,'QPSK');

% For all subframes within the frame
for sf = 0:10

    % Set subframe number
    enb.NSubframe = mod(sf,10);

    % Generate empty subframe
    subframe = lteDLResourceGrid(enb);

    % Map input symbols to grid
    subframe(:) = inputSym;

    % Generate synchronizing signals
    pssSym = ltePSS(enb);
    sssSym = lteSSS(enb);
    pssInd = ltePSSIndices(enb);
    sssInd = lteSSSIndices(enb);
```

```
    % Map synchronizing signals to the grid
    subframe(pssInd) = pssSym;
    subframe(sssInd) = sssSym;

    % Generate cell specific reference signal symbols and indices
    cellRsSym = lteCellRS(enb);
    cellRsInd = lteCellRSIndices(enb);
    % Map cell specific reference signal to grid
    subframe(cellRsInd) = cellRsSym;

    % Append subframe to grid to be transmitted
    txGrid = [txGrid subframe]; %#ok

end

[txWaveform,info] = lteOFDMModulate(enb,txGrid);
txGrid = txGrid(:,1:140);

cfg.SamplingRate = info.SamplingRate;

% Pass data through the fading channel model
rxWaveform = lteFadingChannel(cfg,txWaveform);

% Calculate noise gain
N0 = 1/(sqrt(2.0*enb.CellRefP*double(info.Nfft))*SNR);

% Create additive white Gaussian noise
noise = N0*complex(randn(size(rxWaveform)),randn(size(rxWaveform)));

% Add noise to the received time domain waveform
rxWaveform = rxWaveform + noise;
```

```
offset = lteDLFrameOffset(enb,rxWaveform);
rxWaveform = rxWaveform(1+offset:end,:);

rxGrid = lteOFDMDemodulate(enb,rxWaveform);

enb.NSubframe = 0;
[estChannel, noiseEst] = lteDLChannelEstimate(enb,cec,rxGrid);
eqGrid = lteEqualizeMMSE(rxGrid, estChannel, noiseEst);
% Calculate error between transmitted and equalized grid
eqError = txGrid - eqGrid;
rxError = txGrid - rxGrid;

% Compute EVM across all input values
% EVM of pre-equalized receive signal
EVM = comm.EVM;
EVM.AveragingDimensions = [1 2];
preEqualisedEVM = EVM(txGrid,rxGrid);
fprintf('Percentage RMS EVM of Pre-Equalized signal: %0.3f%%\n', ...
    preEqualisedEVM);
% EVM of post-equalized receive signal
postEqualisedEVM = EVM(txGrid,eqGrid);
fprintf('Percentage RMS EVM of Post-Equalized signal: %0.3f%%\n', ...
    postEqualisedEVM);
% Plot the received and equalized resource grids
hDownlinkEstimationEqualizationResults(rxGrid, eqGrid);
```

Synchronization:

Synchronization is the process by which a receiver node determines the correct instants of time at which to sample the incoming signal. Carrier synchronization is the process by which a receiver adapts the frequency and phase of its local carrier oscillator with those of the received signal.

Equalization:

Equalization is the reversal of distortion incurred by a signal transmitted through a channel. Equalizers are used to render the frequency response—for instance of a telephone line—flat from end-to-end. When a channel has been equalized the frequency domain attributes of the signal at the input are faithfully reproduced at the output. Telephones, DSL lines and television cables use equalizers to prepare data signals for transmission.

Equalizers are critical to the successful operation of electronic systems such as analog broadcast television. In this application the actual waveform of the transmitted signal must be preserved, not just its frequency content. Equalizing filters must cancel out any group delay and phase delay between different frequency components.

PROCEDURE:

The example generates a frame worth of data on one antenna port. As no transport channel is created in this example the data is random bits, QPSK modulated and mapped to every symbol in a subframe. A cell specific reference signal and primary and secondary synchronization signals are created and mapped to the subframe. 10 subframes are individually generated to create a frame. The frame is OFDM modulated, passed through an Extended Vehicular A Model (EVA5) fading channel, additive white Gaussian noise added and demodulated. MMSE equalization using channel and noise estimation is applied and finally the received and equalized resource grids are plotted.

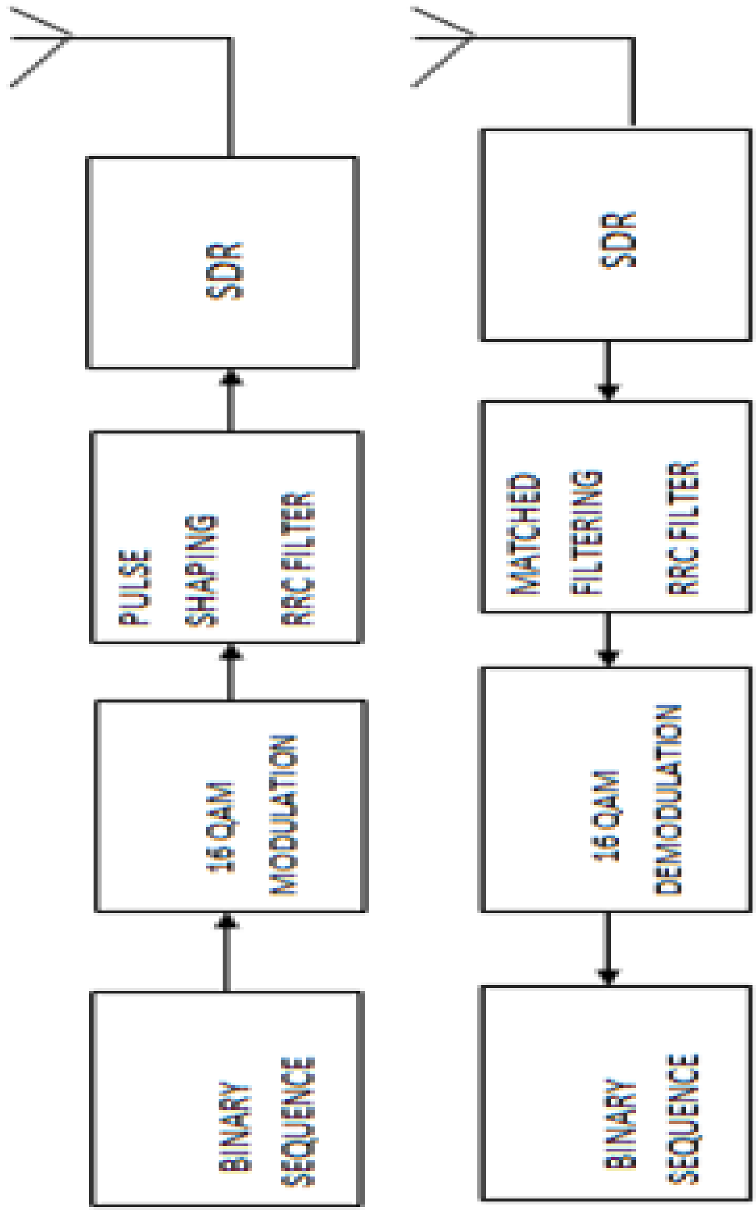
Post Lab Questions:

1. Define synchronization.
2. Outline the features of equalization.
3. List the different types of channel models.
4. Give the main idea of equalization in the time domain and frequency domain.
5. What is linear equalizer and mention the types of linear equalizer.

Result:

Thus the Simulation of Channel Estimation, Synchronization & Equalization techniques was done using MATLAB and the output was verified.

Block Diagram:



Ex. No. 7 ANALYSING IMPACT OF PULSE SHAPING AND MATCHED FILTERING USING SOFTWARE DEFINED RADIOS

AIM:

To analyse the impact of pulse shaping and matched filtering by using SDR.

COMPONENTS REQUIRED:

- ❖ Personal computer
- ❖ MATLAB software
- ❖ SDR hardware

Pre Lab Questions:

1. Enumerate the concept of pulse shaping.
2. Mention the types of pulse code modulations.
3. What is filter?
4. List the types of filter.
5. Define SDR.

THEORY:

Pulse shaping:

Pulse shaping is the process of changing the waveform of transmitted pulses. Its purpose is to make the transmitted signal better suited to its purpose or the communication channel, typically by limiting the effective bandwidth of the transmission. By filtering the transmitted pulses this way, the intersymbol interference caused by the channel can be kept in control. In RF communication, pulse shaping is essential for making the signal fit in its frequency band.

Typically pulse shaping occurs after line coding and modulation.

Examples of pulse shaping filters that are commonly found in communication systems are:

- ❖ Sinc shaped filter
- ❖ Raised-cosine filter
- ❖ Gaussian filter

PROGRAM:

```
M = 16; % Modulation order
k = log2(M); % Number of bits per symbol
numBits = 3e5; % Number of bits to process
sps = 4; % Number of samples per symbol (oversampling factor)
filtlen = 10; % Filter length in symbols
rolloff = 0.25; % Filter rolloff factor
rrcFilter = rcosdesign(rolloff,filtlen,sps);
fvtool(rrcFilter,'Analysis','Impulse')
rng default; % Use default random number generator
dataIn = randi([0 1],numBits,1); % Generate vector of binary data
dataInMatrix = reshape(dataIn,length(dataIn)/k,k); % Reshape data into binary 4-tuples
dataSymbolsIn = bi2de(dataInMatrix); % Convert to integers
dataMod = qammod(dataSymbolsIn,M);
txFiltSignal = upfirdn(dataMod,rrcFilter,sps,1);
EbNo = 10;
snr = EbNo + 10*log10(k) - 10*log10(sps);
rxSignal = awgn(txFiltSignal,snr,'measured');
rxFiltSignal = upfirdn(rxSignal,rrcFilter,1,sps); % Downsample and filter
rxFiltSignal = rxFiltSignal(filtlen + 1:end - filtlen); % Account for delay
dataSymbolsOut = qamdemod(rxFiltSignal,M);
dataOutMatrix = de2bi(dataSymbolsOut,k);
dataOut = dataOutMatrix(:); % Return data in column vector
[numErrors,ber] = biterr(dataIn,dataOut);
fprintf('\nFor an EbNo setting of %3.1f dB, the bit error rate is %5.2e, based on %d errors.\n', ...
    EbNo,ber,numErrors)

%Visualize Filter Effects
EbNo = 20;
snr = EbNo + 10*log10(k) - 10*log10(sps);
rxSignal = awgn(txFiltSignal,snr,'measured');
```

```
rxFiltSignal = upfirdn(rxSignal,rrcFilter,1,sps); % Downsample and filter
rxFiltSignal = rxFiltSignal(filtlen + 1:end - filtlen); % Account for delay

eyediagram(txFiltSignal(1:2000),sps*2);
eyediagram(rxSignal(1:2000),sps*2);
eyediagram(rxFiltSignal(1:2000),2);

scatplot = scatterplot(sqrt(sps)*...
    rxSignal(1:sps*5e3),...
    sps,0,'g.');
hold on;
scatterplot(rxFiltSignal(1:5e3),1,0,'kx',scatplot);
title('Received Signal, Before and After Filtering');
legend('Before Filtering','After Filtering');
axis([-5 5 -5 5]); % Set axis ranges
hold off;
```

Matched Filter:

A matched filter is obtained by correlating a known delayed signal, or *template*, with an unknown signal to detect the presence of the template in the unknown signal. This is equivalent to convolving the unknown signal with a conjugated time-reversed version of the template. The matched filter is the optimal linear filter for maximizing the signal-to-noise ratio (SNR) in the presence of additive stochastic noise.

Matched filters are commonly used in radar, in which a known signal is sent out, and the reflected signal is examined for common elements of the out-going signal. Pulse compression is an example of matched filtering. It is so called because impulse response is matched to input pulse signals. Two-dimensional matched filters are commonly used in image processing, e.g., to improve SNR for X-ray. Matched filtering is a demodulation technique with LTI (linear time invariant) filters to maximize SNR. It was originally also known as a North filter.

Software Defined Radio:

Software-defined radio (SDR) is a radio communication system where components that have been traditionally implemented in hardware such as mixers , filters, amplifiers, modulators, demodulators, etc., are instead implemented by means of software on a personal computer or embedded system. While the concept of SDR is not new, the rapidly evolving capabilities of digital electronics render practical many processes which were once only theoretically possible.

A basic SDR system may consist of a personal computer equipped with a sound card, or other analog-to-digital converter, preceded by some form of RF front end. Significant amounts of signal processing are handed over to the general-purpose processor, rather than being done in special-purpose hardware (electronic circuits). Such a design produces a radio which can receive and transmit widely different radio protocols (sometimes referred to as waveforms) based solely on the software used.

Software radios have significant utility for the military and cell phone services, both of which must serve a wide variety of changing radio protocols in real time.

In the long term, software-defined radios are expected by proponents like the SDR Forum (now The Wireless Innovation Forum) to become the dominant technology in radio communications. SDRs, along with software defined antennas are the enablers of the cognitive radio.

A software-defined radio can be flexible enough to avoid the "limited spectrum" assumptions of designers of previous kinds of radios, in one or more ways including.

- Spread spectrum and ultra wideband techniques allow several transmitters to transmit in the same place on the same frequency with very little interference, typically combined with one or more error detection and correction techniques to fix all the errors caused by that interference.
- Software defined antennas adaptively "lock onto" a directional signal, so that receivers can better reject interference from other directions, allowing it to detect fainter transmissions.
- Cognitive radio techniques: each radio measures the spectrum in use and communicates that information to other cooperating radios, so that transmitters can avoid mutual interference by selecting unused frequencies. Alternatively, each radio connects to a geolocation database to obtain information about the spectrum occupancy in its location and, flexibly, adjusts its operating frequency and/or transmit power not to cause interference to other wireless services.

- Dynamic transmitter power adjustment, based on information communicated from the receivers, lowering transmit power to the minimum necessary, reducing the near-far problem and reducing interference to others, and extending battery life in portable equipment.
- Wireless mesh network where every added radio increases total capacity and reduces the power required at any one node. Each node transmits using only enough power needed for the message to hop to the nearest node in that direction, reducing the near-far problem and reducing interference to others.

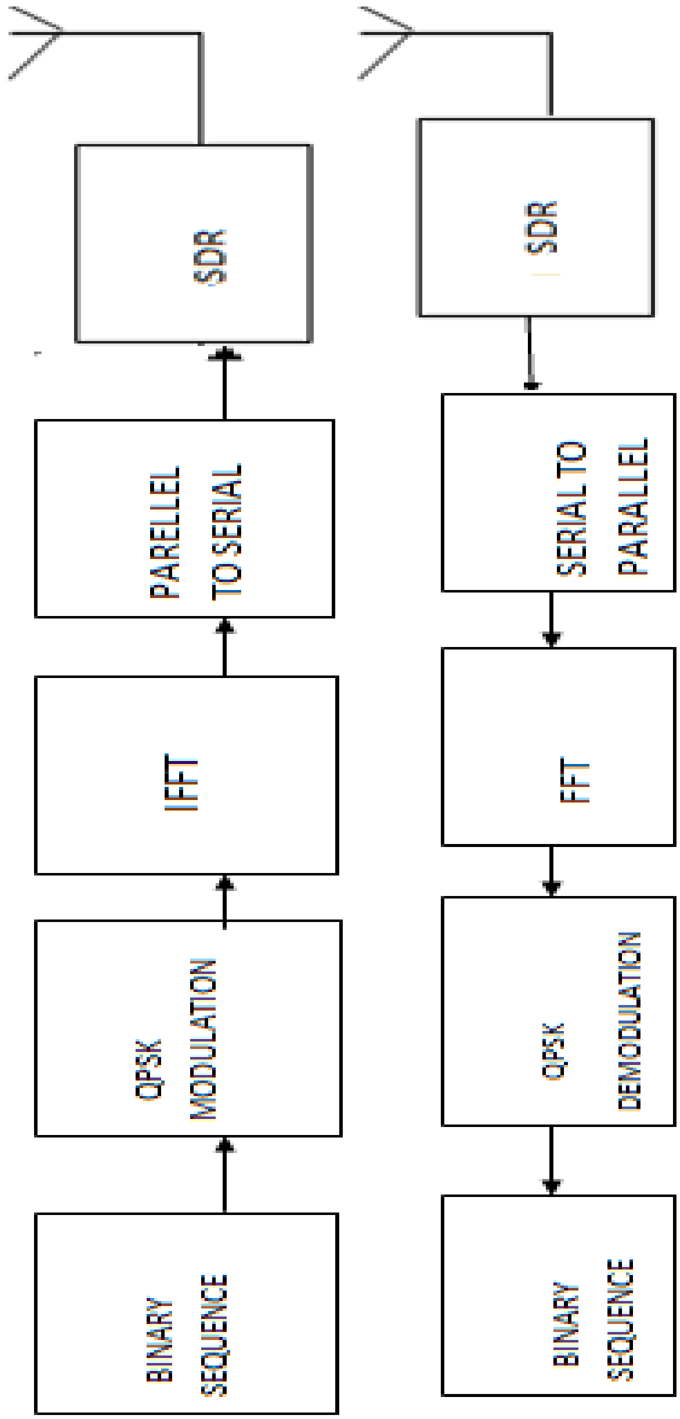
Post Lab Questions:

1. Is SDR compatible with standards in wireless communication?
2. What is the advantage of SDR?
3. Outline the significance of ISI in wireless communication.
4. Define ICI.
5. Mention the advantages of PRBS.

Result:

Thus the impact of Pulse Shaping and Matched Filtering was analyzed using Software Defined Radios and its outputs were verified.

Block Diagram:



Ex.No.: 8 OFDM SIGNAL TRANSMISSION AND RECEPTION USING SOFTWARE DEFINED RADIO

AIM:

To transmit and receive the OFDM signal using SDR.

COMPONENTS REQUIRED

- Personal computer
- MATLAB software
- SDR

Pre Lab Questions:

1. What are the main requirements of the modulation technique in a communication?
2. Why OFDM is preferred in a wireless communication?
3. State the advantages of OFDM.
4. What is PAPR in OFDM?
5. What are the steps involved in transmission in the wireless communication link?

THEORY:

Implementation of OFDM in actual hardware using Software Defined Radio (SDR) concepts and verification of its performance with different channel estimation methods in various propagation environments have been almost unexplored. The great flexibility feature of SDR systems facilitates the implementation and experimentation of OFDM systems with less cost and effort, compared to the implementation of the whole system in hardware. In this paper, a customized SDR testbed has been developed based on the GNU radio software platform and version-2 Universal Software Radio Peripheral (USRP2) devices to evaluate the practical error performance of OFDM-based systems in both Gaussian and Rician propagation environments. Three different channel interpolation techniques, namely linear interpolation, second-ordered interpolation and cubic spline interpolation, and a blind SNR estimation algorithm have been implemented in our testbed.. The experimental OFDM system on the developed SDR testbed performs very close to the simulated OFDM system, thus the developed testbed can be used to verify advanced signal processing techniques in OFDM systems in various realistic channels by simply developing software, without the need for otherwise complicated hardware developments.

PROGRAM

```
%==========================================================================
====
% The mfile investigates the generation, transmission and reception of
% the OFDM signal without channel noise or HPA effect
%==========================================================================
====
clear all
clc
close
%   ---------------
%   A: Setting Parameters
%   ---------------
M = 4;                          %   QPSK signal constellation
no_of_data_points = 64;         %   have 64 data points
block_size = 8;                 %   size of each ofdm block
cp_len = ceil(0.1*block_size);  %   length of cyclic prefix
no_of_ifft_points = block_size;           %   8 points for the FFT/IFFT
no_of_fft_points = block_size;
%   --------------------------------------------
%   B:  %   +++++   TRANSMITTER    +++++
%   --------------------------------------------
%   1.  Generate 1 x 64 vector of data points phase representations
data_source = randsrc(1, no_of_data_points, 0:M-1);
figure(1)
stem(data_source); grid on; xlabel('data points'); ylabel('transmitted data phase representation')
title('Transmitted Data "O"')
%   2.  Perform QPSK modulation
qpsk_modulated_data = pskmod(data_source, M);
scatterplot(qpsk_modulated_data);title('qpsk modulated transmitted data')
%   3.  Do IFFT on each block
```

```
%   Make the serial stream a matrix where each column represents a pre-OFDM
%   block (w/o cyclic prefixing)
%   First: Find out the number of colums that will exist after reshaping
num_cols=length(qpsk_modulated_data)/block_size;
data_matrix = reshape(qpsk_modulated_data, block_size, num_cols);
%   Second: Create empty matix to put the IFFT'd data
cp_start = block_size-cp_len;
cp_end = block_size;
%   Third: Operate columnwise & do CP
for i=1:num_cols,
   ifft_data_matrix(:,i) = ifft((data_matrix(:,i)),no_of_ifft_points);
   %   Compute and append Cyclic Prefix
   for j=1:cp_len,
      actual_cp(j,i) = ifft_data_matrix(j+cp_start,i);
   end
   %   Append the CP to the existing block to create the actual OFDM block
   ifft_data(:,i) = vertcat(actual_cp(:,i),ifft_data_matrix(:,i));
end
%   4.  Convert to serial stream for transmission
[rows_ifft_data cols_ifft_data]=size(ifft_data);
len_ofdm_data = rows_ifft_data*cols_ifft_data;
%   Actual OFDM signal to be transmitted
ofdm_signal = reshape(ifft_data, 1, len_ofdm_data);
figure(3)
plot(real(ofdm_signal)); xlabel('Time'); ylabel('Amplitude');
title('OFDM Signal');grid on;
%   ------------------------------------------
%   E:  %   +++++   RECEIVER    +++++
%   ------------------------------------------
%   1.  Pass the ofdm signal through the channel
recvd_signal = ofdm_signal;
```

```
%   4.  Convert Data back to "parallel" form to perform FFT
recvd_signal_matrix = reshape(recvd_signal,rows_ifft_data, cols_ifft_data);
%   5.  Remove CP
recvd_signal_matrix(1:cp_len,:)=[];
%   6.  Perform FFT
for i=1:cols_ifft_data,
   %   FFT
   fft_data_matrix(:,i) = fft(recvd_signal_matrix(:,i),no_of_fft_points);
end
%   7.  Convert to serial stream
recvd_serial_data = reshape(fft_data_matrix, 1,(block_size*num_cols));
%   8.  Demodulate the data
qpsk_demodulated_data = pskdemod(recvd_serial_data,M);
scatterplot(qpsk_modulated_data);title('qpsk modulated received data')
figure(5)
stem(qpsk_demodulated_data,'rx');
grid on;xlabel('data points');ylabel('received data phase representation');title('Received Data "X"')
```

Post Lab Questions:

1. Mention the purpose of FFT and IFFT in OFDM.
2. Define Carson’s rule.
3. Define Guard interval.
4. What is meant by data field in OFDM?
5. Brief about windowing in OFDM.

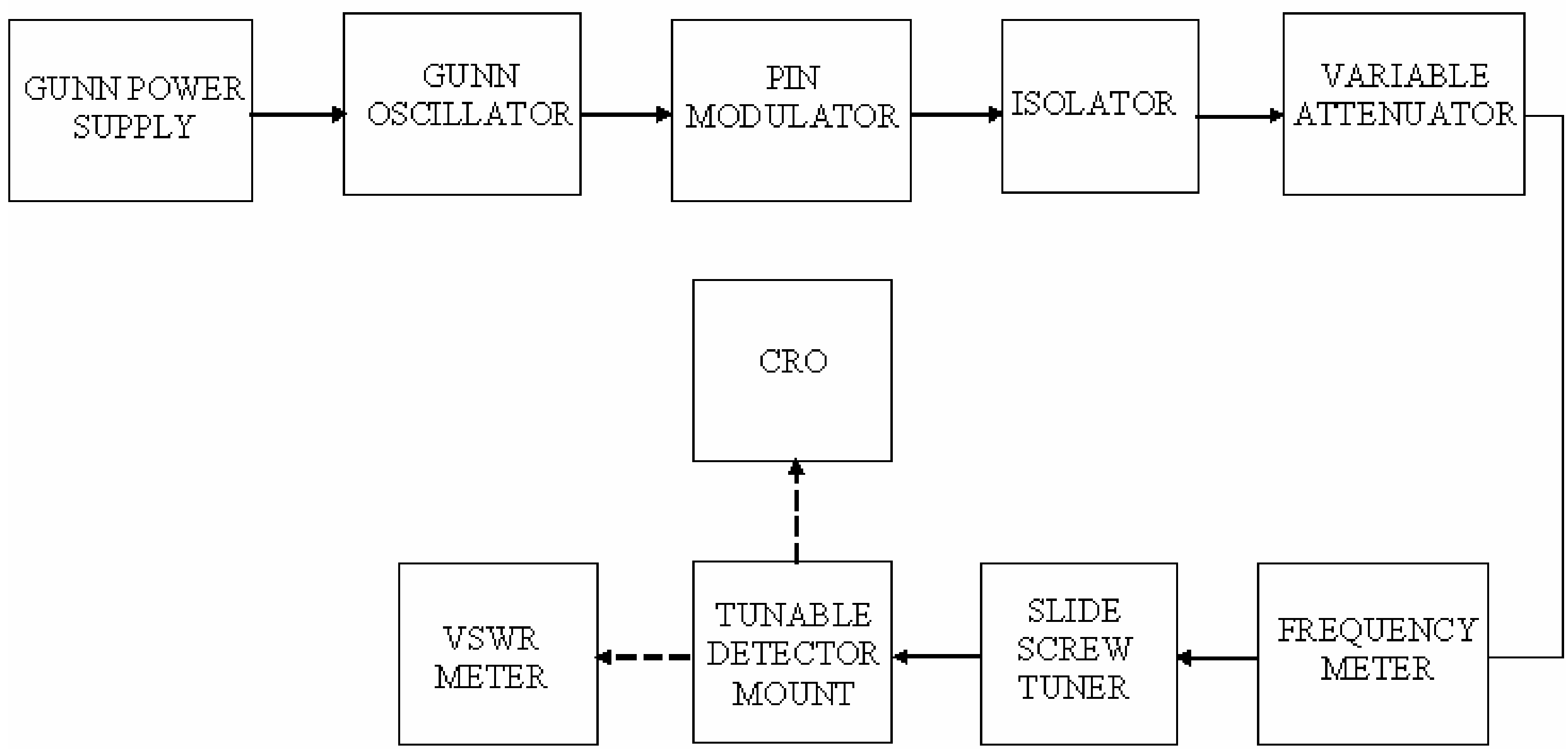
Result:

Thus the OFDM signal transmission and reception was done using SDR.

MICROWAVE

EXPERIMENTS

BLOCK DIAGRAM:



Ex. No. : 9a VSWR AND IMPEDANCE MEASUREMENT AND IMPEDANCE MATCHING

AIM:

To determine the VSWR, Impedance Measurement and Impedance Matching.

COMPONENTS REQUIRED:

i. Gunn Power Supply
ii. Gunn Oscillator
iii. PIN Modulator
iv. Isolator
v. Variable Attenuator
vi. Frequency Meter
vii. Slide Screw Tuner
viii. Tunable Detector Mount
ix. VSWR Meter, CRO
x. Bayonet Neill Concelman(BNC) Connector
xi. Threaded Neill Concelman(TNC) Connector
xii. Cooling Fan
xiii. Waveguide Stand, Screw & Net

Pre Lab Questions:

1. What are all the microwave frequencies?
2. Define VSWR.
3. What is the function of frequency meter?
4. Is the microwave frequency is harmful to human beings?
5. Is the characteristic impedance of the sampler line section important?

THEORY:

The electromagnetic field at any point of transmission line, may be considered as the sum of two traveling waves the ‘Incident Wave, which Propagates from the source to the load and the reflected wave which propagates towards the generator. The reflected wave is set up by reflection of incident wave from a discontinuity in the line or from the load impedance. The superposition of the two traveling waves, gives rise to a standing wave along the line. The maximum field strength is found where the waves are in phase and minimum where the two waves add in opposite phase. The distance

OBSERVATION:

Frequency of Oscillation = ________GHz.

No. of Threads	VSWR (S)	Reflection Co-efficient K=(S-1)/(S+1)

between two successive minimum (or maximum) is half the guide wavelength on the line. The ratio of electrical field strength of reflected and incident wave is called reflection coefficient.

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

Hence VSWR denoted by S is as follows

$$S = E_{max}/E_{min}$$

$$= \{|E_i| + |E_r|\}/\{|E_i| - |E_r|\}$$

Where E_i = Incident Voltage

E_r = Reflected Voltage

Reflection Coefficient, ρ is

$$\rho = E_r/E_i = (Z_L - Z_O) / (Z_L + Z_O)$$

Where Z_L is the load impedance, Z_o is characteristics impedance.

The reflection coefficient in terms of VSWR (S)

$$(\rho) = (S-1)/(S+1)$$

INITIAL SETUP IN VSWR METER:

1. Set input selector switch in 200 Ohms.
2. Keep meter selector in Normal.
3. Select the range as 50dB or 40dB or 30dB and then vary the gain knob (fine and coarse) to get minimum attenuation. (VSWR = 1).

PROCEDURE:

1. Setup the equipment as shown in block diagram.
2. Keep the control knobs of Gunn power supply (GPS) as below.

Meter Switch	– off
Gunn bias knob	– Fully anticlockwise
PIN Mod. Amp knob	– Mid position
PIN Mod. Freq.knob	– Mid position

3. SwitchON the Gunn power supply, VSWR meter and Cooling fan. Set Gunn bias Voltage at 7.5V.
4. Tune the frequency meter to get a 'dip' on the CRO. Measure the operating frequency using frequency meter and detune the frequency meter.
5. Then remove the CRO and connect the VSWR meter to Tunable Detector mount.
6. If necessary change the range dB-switch, Variable attenuator position and gain control knob to get deflection in the scale of VSWR meter.
7. Adjust the VSWR meter gain control knob or variable attenuator until the meter indicates 1.0 on normal VSWR Scale.
8. Set the depth of S.S Tuner to around 3-4 mm. Read the VSWR on scale and record it.
9. Repeat the above step for change of S.S. Tuner probe depth and record the corresponding SWR.
10. If the reading at the minimum is lower than 3 on the top scale, set RANGE Switch to next higher range and read the indication on the second SWR or (3 to 10) scale of SWR.
11. If the range switch is changed by two steps used top SWR scale, however all indication on this scale must be multiplied by 10.
12. Using the formula, K=S-1/S+1, find the reflection co-efficient.

Post Lab Questions:

1. Does VSWR vary with line length?
2. Can the magnitude of the reflection coefficient (ρ) be greater than 1?
3. Can VSWR be negative?
4. Is there a minimum length of transmission line required on either side of the VSWR meter for valid readings?
5. What is an acceptable VSWR?

RESULT:

Thus the VSWR, Impedance Measurement and Impedance Matching were determined.

Ex. No. : 9b FREQUENCY AND WAVELENGTH MEASUREMENT

AIM :

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

COMPONENTS REQUIRED:

i. Klystron power Supply
ii. Klystron tube with mount
iii. Isolator
iv. Frequency Meter
v. Variable Attenuator
vi. Detector Mount
vii. CRO
viii. Bayonet Neill Concelman(BNC) Connector
ix. Cooling Fan
x. Waveguide Stand, Screw & Net

THEORY:

For dominant TE10 mode in rectangular waveguide λ_0, λg and λc are related as below

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

Where, λ_0 = free space wavelength

λ_g = guide wavelength

λ_c = cutoff wavelength

CALCULATION:

Guided Wavelength λ_g = 2d = cm.

Cut off Wavelength λ_c = 2a = cm.

Where a = 22.8 mm (Broader Dimension of the rectangular waveguide)

$$\lambda = [\, (1/\lambda g)2+(1/\lambda c)2 \,]^{-1/2} \text{ cm}$$

$$f = c/\lambda \text{ GHz.}$$

OBSERVATION:

Frequency (GHz)	Successive V_{min} or V_{max} Position (cm)	Successive Difference (cm)
	d1=	d2 - d1
	d2=	d3 - d2
	d3=	Avg (d) =

For TE_{10} mode , λc = 2a,

a = broader dimension of waveguide

INITIAL ADJUSTMENTS:

1. Keep the variable attenuator in the minimum attenuation position.
2. Keep the control knob of klystron power supply as below, before switching ON the device.

   Beam voltage = OFF

   Mod-switch = AM

   Beam voltage knob = Fully anticlockwise

   Repeller voltage knob = Fully anticlockwise

   AM frequency & Amplitude knob = mid position

   FM frequency & Amplitude knob = minimum position

PROCEDURE:

1. Set the components as shown in Block diagram.
2. Keep the control Knobs of klystron Power supply as mentioned in the basic set up.
3. Switch ON the Klystron power supply and set the beam voltage at 250 volts.
4. Adjust the repeller Voltage (120V) to get maximum output in CRO.
5. Tune the frequency meter knob to get a dip on CRO and note down the frequency of oscillation directly. Detune the frequency meter.
6. Move the probe along the slotted line to a minimum output voltage.
7. Record the probe position and let it be d1.
8. Move the probe to a next minimum position and note it as d2.
9. Calculate the Wavelength and Frequency.
10. Verify the calculated Frequency with the Frequency obtained from Frequency meter.

Post Lab Questions:

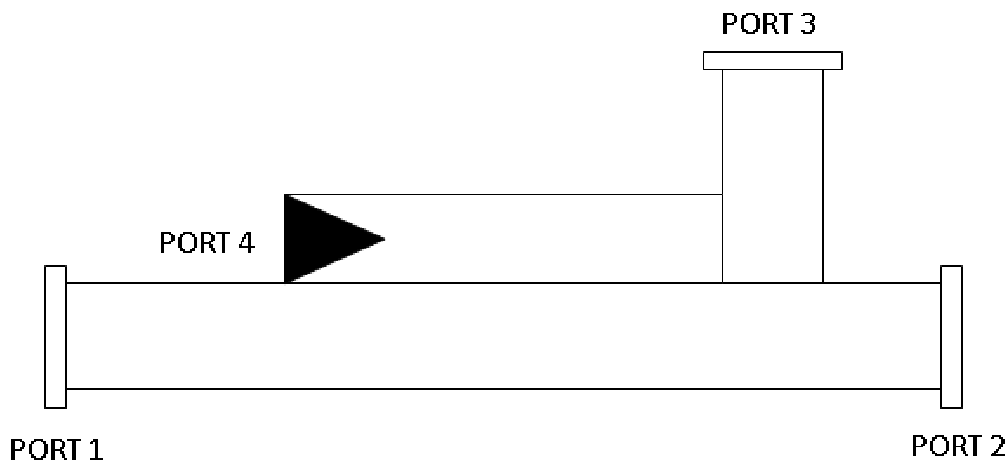
1. Give the frequency range for X, J, S- band.
2. What is an isolator?
3. Why TE_{01} cannot be considered as the dominant mode in rectangular waveguide?
4. Why S-matrix is used in microwave analysis?
5. What are standing waves?
6. What is a dominant mode?

RESULT:

Thus the Frequency and Wavelength in a rectangular Waveguide was determined.

Frequency = GHz , Wavelength = cm.

DIRECTIONAL COUPLER:



Ex. No. 10(a) : CHARACTERIZATION OF DIRECTIONAL COUPLERS

AIM:

To characterise the directional coupler.

COMPONENTS REQUIRED:

i. Gunn Power Supply
ii. Gunn Oscillator
iii. PIN Modulator
iv. Isolator
v. Variable Attenuator
vi. Frequency Meter
vii. Multihole Directional Coupler
viii. Tunable Detector Mount
ix. Matched Termination
x. VSWR Meter, CRO
xi. Bayonet Neill Concelman(BNC) Connector
xii. Threaded Neill Concelman(TNC) Connector
xiii. Cooling Fan
xiv. Waveguide Stand, Screw & Net

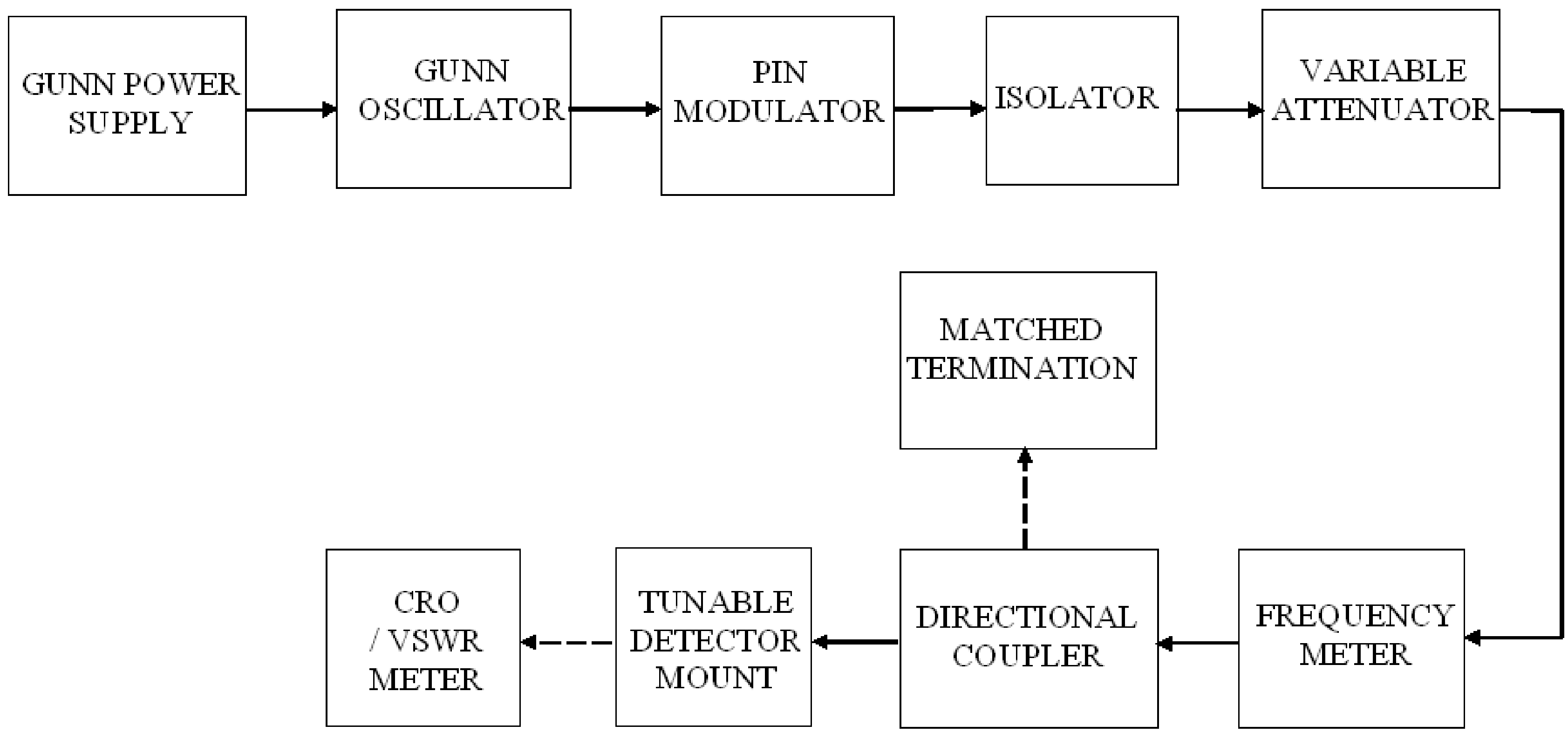
Pre Lab Questions:

1. Why Gunn oscillator is chosen?
2. Explain impedance matching.
3. What is meant by directional coupler?
4. Define waveguide.
5. What is insertion loss?

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 the main arm and auxiliary arm, electromagnetically coupled to each

BLOCK DIAGRAM:



other. The power entering, in the main-arm gets divided between port 2 and 3, and almost no power comes out in port (4) Power entering at port (2) is divided between port (1) and (4)

The coupling factor is defined as

Coupling (dB) = 10 $\log_{10} [P_1/P_3]$ where port 2 is terminated.

Isolation (dB) = 10 $\log_{10} [P_2/P_3]$ where P_1 is matched.

With built-in termination and power entering at Port 1, the directivity of the coupler is a measure of separation between incident wave and the reflected wave. Directivity is measured indirectly as follows:

Hence Directivity D (dB) = Isolation – Coupling

= 10 $\log_{10} [P_2/P_1]$

Insertion loss = 10 $\log_{10} [P_1/P_2]$

INITIAL SETUP IN VSWR METER:

1. Set input selector switch in 200 Ohms.
2. Keep meter selector in Normal.
3. Select the range as 50db or 40db or 30db and then vary the gain knob (fine and coarse) to get minimum attenuation. (VSWR = 1).

PROCEDURE:

1. Setup the equipments as shown in block diagram.
2. Keep the control knobs of Gunn power supply (GPS) as below.

   Meter Switch – off

   Gunn bias knob – Fully anticlockwise

   PIN Mod. Amp knob – Mid position

   PIN Mod. Freq. knob – Mid position
3. SwitchON the Gunn power supply, VSWR meter and Cooling fan. Set Gunn bias Voltage at 7.5V.
4. Tune the frequency meter to get a ‘dip’ on the CRO. Measure the operating frequency using frequency meter and detune the frequency meter.
5. Then remove the CRO and connect the VSWR meter to Tunable Detector mount.
6. Remove the multihole directional coupler and connect the detector mount of the frequency meter.

7. 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 (reference level let X)
8. Insert the directional coupler as shown in block diagram with detector to the auxiliary port 3 and matched termination to port 2. (Without changing the position of variable attenuator and gain control knob of VSWR meter).
9. Note down the reading on VSWR meter on the scale with the help of range-dB switch if required. (Let it be Y).
10. Calculate coupling factor which will be X–Y=C(dB)
11. Now carefully disconnect the detector from the auxiliary port 3 and match termination from port 2 without disturbing the set-up.
12. Connect the matched termination to the auxiliary port 3 and detector to port 2 and measure the reading on VSWR meter. Suppose it is Z.
13. Compute insertion loss X–Z in dB.
14. Connect the directional coupler in the reverse direction. i.e. port 2 to frequency meter side. Matched termination to port 1 and detector mount to port 3. (Without disturbing the position of variable attenuator and gain control knob of VSWR meter.)
15. Measure and note down the reading on VSWR meter. Let it be Y_d. $X–Y_d$ gives Isolation I (dB).
16. Compute the directivity as $Y–Y_d = I – C$

OBSERVATION:

Frequency of Oscillation = GHz.

X	=	dB (Without Directional Coupler)
Z	=	dB (I/p at port 1, o/p at port 2, Terminate at port 3)
Y	=	dB (I/p at port 1, o/p at port 3, Terminate at port 2)
Y_d	=	dB (I/p at port 2, o/p at port 3, Terminate at port 1)

Coupling Factor,	C = X–Y	=	dB
Insertion loss,	= X–Z	=	dB
Isolation	$I = X–Y_d$	=	dB
Directivity	$D = Y–Y_d$	=	dB

Post Lab Questions:

1. What is the primary purpose of a directional coupler?
2. How far apart are the two holes in a simple directional coupler?
3. What is the purpose of the absorbent material in a directional coupler?
4. In a directional coupler that is designed to sample the incident energy, what happens to the two portions of the wavefront when they arrive at the pickup probe?
5. What happens to reflected energy that enters a directional coupler that is designed to sample incident energy?

RESULT:

Thus the Directional coupler was characterized and the following measurement was done.

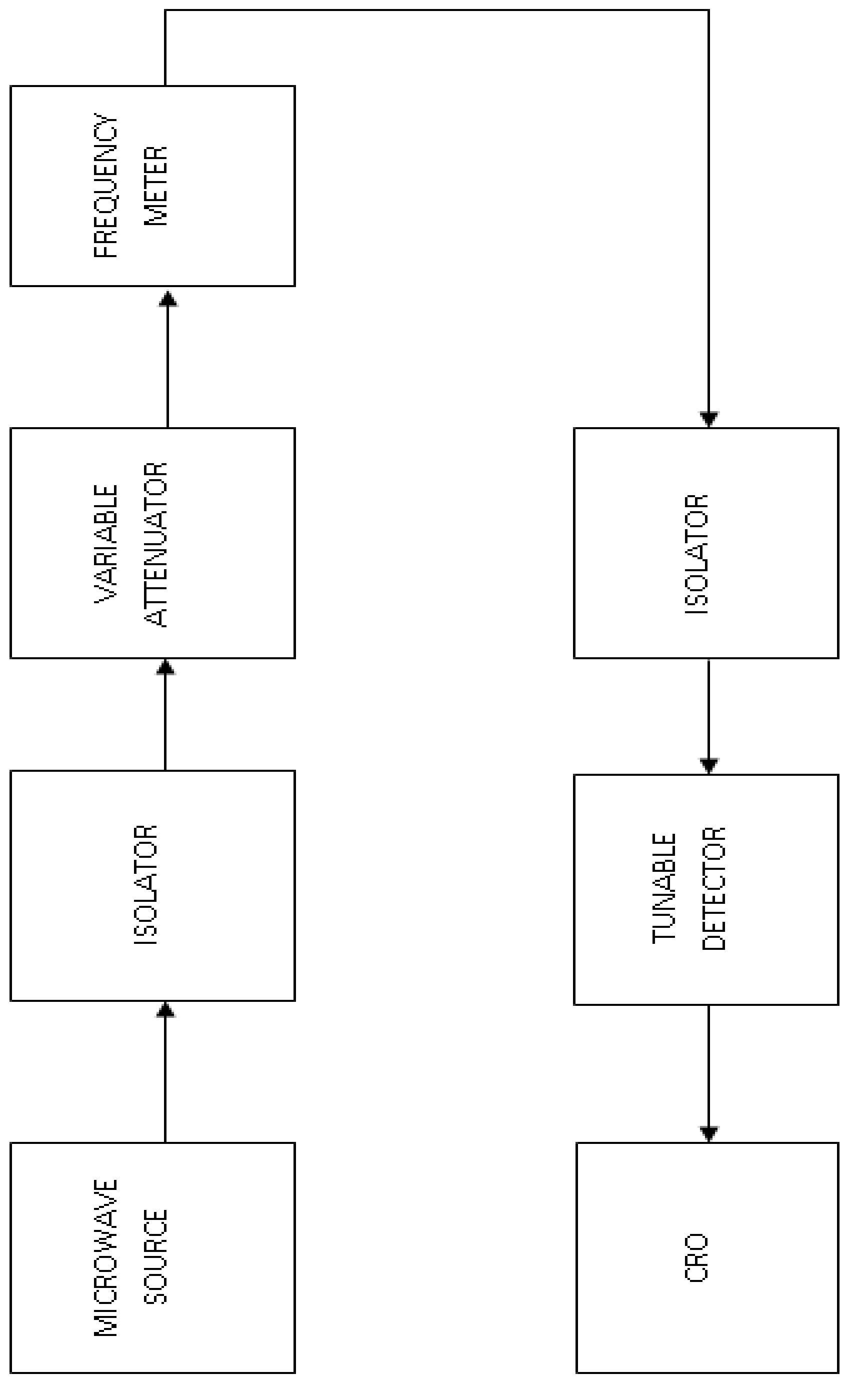
Coupling Factor, C = dB

Insertion loss, IL = dB

Isolation I = dB

Directivity D = dB

BLOCK DIAGRAM:



Ex. No. 10 (b) : ISOLATOR

AIM:

To measure the S–parameter of isolators.

COMPONENTS REQUIRED:

1. Microwave source (Gunn, Klystron)
2. Isolator
3. Frequency Meter
4. Variable Attenuator
5. Detector Mount
6. CRO / VSWR
7. Bayonet Neill Concelman(BNC) Connector
8. Cooling Fan
9. Waveguide Stand, Screw & Net

Pre Lab Questions:

1. Mention the different types of parameters which is used to analyse the microwave devices.
2. Define Isolator.
3. State Klystron working principle.
4. Define input VSWR.
5. What is the use of S-parameter?

THEORY:

ISOLATOR:

An isolator is a two-port device that transfers energy from input to output with little attenuation and from output to input with very high attenuation

The isolator can be derived form a three-port circulator by simply placing a matched load (reflection less termination) on one port.

The important isolator parameters are:

A. **Insertion loss:**

Insertion loss is the ratio of power detected at the output port to the power supplied by source to the input port, measured with other ports terminated in the matched load. It is expressed in dB.

READINGS:

PORT 1 (Volts)	PORT 2 (Volts)	S-PARAMETER
		S_{21} =
		S_{12} =

The S matrix of Isolator

$$S = \begin{bmatrix} S_{11} & S_{12} \\ S_{21} & S_{22} \end{bmatrix}$$

B. Isolation:

Isolation is the ratio of power applied to the output to that measured at the input. This ratio is expressed in dB. The isolation of a circulator is measured with the third port terminated in a matched load.

C. Input VSWR:

The input VSWR of an isolator or circulator is the ratio of voltage maximum to voltage minimum of the standing wave existing is the line with all parts except the test port are matched

PROCEDURE:

1. Set the components as shown in the block diagram,
2. Keep the control knob of microwave power supply as mentioned in the basic setup.
3. Switch on the power supply and energize the microwave source. Get the maximum output in CRO without connecting the Isolator. Measure the voltage using CRO.
4. Tune the frequency meter knob to get a dip in CRO and note down the frequency of oscillation directly. Detune the frequency meter.

5. Connect the Isolator in forward direction i.e. port 1 at input side(Frequency meter) and port 2 at output side (Tunable Detector) measure the input and output voltage using CRO.
6. Now connect the isolator in reverse direction i.e. Port 1 at output side and port 2 at input side and measure the output voltage using CRO.

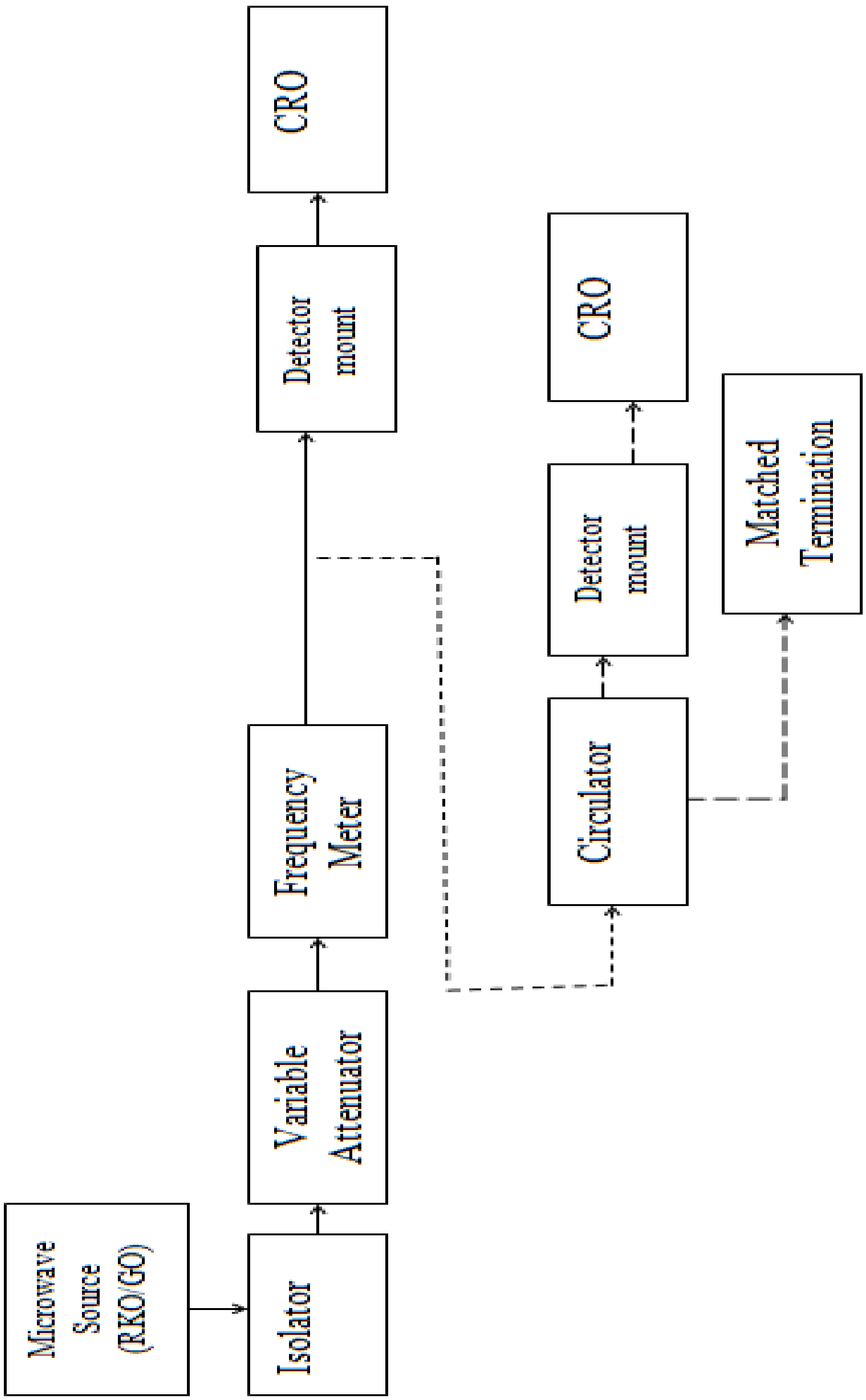
Post Lab Questions:

1. What are the reasons that low frequency parameters cannot be measured in microwaves?
2. What is S matrix and write the S matrix of N port network?
3. What is meant by hybrid coupler?
4. Compare z parameters and ABCD parameters with S-parameters.
5. State the properties of S matrix.

RESULT:

Thus the S-parameters of isolators were measured.

Block Diagram:



Ex.No. : 10 (c) CIRCULATOR

AIM :

To find the S-parameters of Circulator.

COMPONENT REQUIRED:

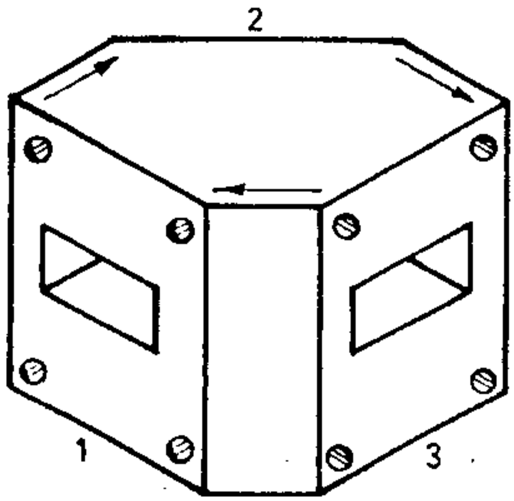
i. Microwave Source (RKO/GO)
ii. Isolator
iii. Variable Attenuator
iv. Frequency meter
v. detector mount
vi. VSWR meter
vii. Circulator and
viii. Matched Terminations-2.

Pre Lab Questions:

1. How does a microwave circulator work?
2. What is the purpose of a circulator?
3. What is the difference between isolator and circulator?
4. What is the use of isolator in microwave?
5. Define reflection amplifier.

THEORY:

The circulator is a multi port junction that permits transmission in certain ways. The wave incident at nth port can be coupled to $(n+1)^{th}$ port only.



Y-JUNCTION CIRCULATOR

READINGS:

PORT 1 (Volts)	PORT 2 (Volts)	PORT 3 (Volts)	S-PARAMETER
			S_{12}=
			S_{13}=
			S_{21}=
			S_{23}=
			S_{31}=
			S_{32}=

The S matrix of circulator

$$S = \begin{bmatrix} S_{11} & S_{12} & S_{13} \\ S_{21} & S_{22} & S_{23} \\ S_{31} & S_{32} & S_{33} \end{bmatrix}$$

PROCEDURE:

1. Set the components as shown in the block diagram,
2. Keep the control knob of microwave power supply as mentioned in the basic setup.
3. Switch on the power supply and energize the microwave source. Get the maximum output in CRO without connecting the circulator. Measure the voltage using CRO.
4. Tune the frequency meter knob to get a dip in CRO and note down the frequency of oscillation directly. Detune the frequency meter.
5. Connect the port 1 of circulator at input side (Frequency meter) and port 2 at output side (Tunable Detector) and port 3 is at matched termination. Measure the output voltage using CRO.
6. Similarly measure the output voltage by interchanging the ports.

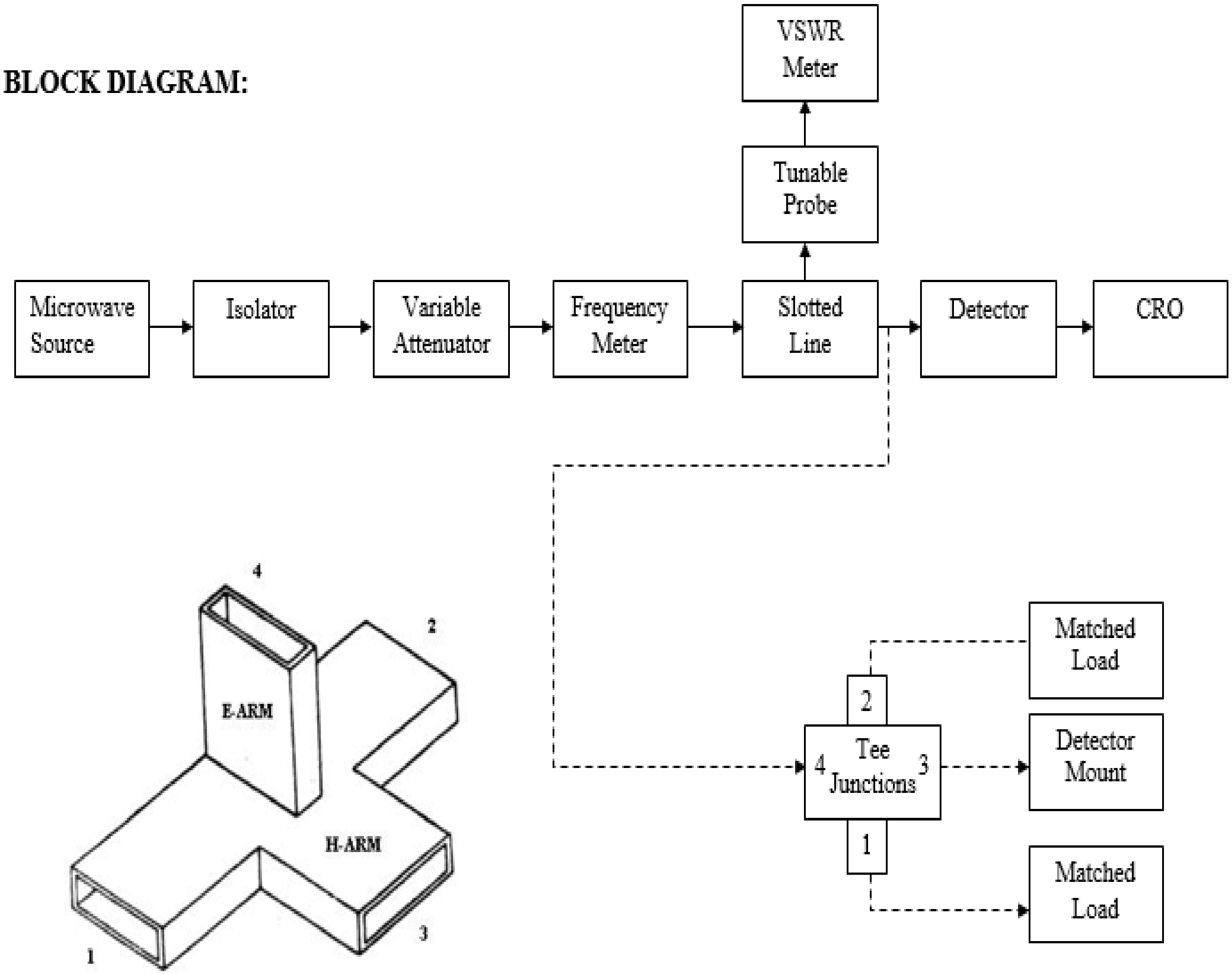
Post Lab Questions:

1. Define nonferrite circulators.
2. How are microwave measurements different from low frequency measurements?
3. Define ferrite circulators.
4. Write the scattering matrix for an ideal three-port circulator.
5. How ports are available in the circulator and mention its uses.

RESULT:

Thus the S-parameters of circulator were found and its values are noted.

BLOCK DIAGRAM:



Ex.No. : 10 (d) E-plane, H-plane and Magic Tee

AIM :

To measure the S-matrix of E-plane, H-plane and Magic Tee.

COMPONENTS REQUIRED:

i. Microwave source (Gunn, Klystron)
ii. Isolator
iii. Frequency Meter
iv. Variable Attenuator
v. Slotted line section with tunable probe
vi. E-plane Tee, H-plane tee, Magic tee
vii. Detector Mount
viii. CRO / VSWR
ix. Bayonet Neill Concelman (BNC) Connector
x. Cooling Fan
xi. Waveguide Stand, Screw & Net

THEORY:

The device magic tee is a combination of the E and H plane Tee. Arm 3, the H-arm forms an H-plane Tee and arm 4, E-arm forms an E-plane Tee combination of arm1 and 2 as side of collinear arms. If the power is fed in arm3 (H-arm), the electric field divides equally between arm 1 and 2 with the same phase and no electric field exits in arm4. If power is fed in arm 4 (E-arm), it divides equally in to arm 1 and 2 but out of phase with no power to arm 3, further , if the power is fed in arm1 and 2 simultaneously it is added in arm 3(H-arm) and it is subtracted in E-arm i.e. arm 4

READINGS for E-Plane Tee:

TABLE-1

Input voltage at	Output voltage at		
	Port 1	Port 2	Port 3
Port 1			
Port 2			
Port 3			

READINGS for H-Plane Tee:

TABLE-2

Input voltage at	Output voltage at		
	Port 1	Port 2	Port 3
Port 1			
Port 2			
Port 3			

READINGS for Magic Tee:

TABLE-3

Input voltage at	Output voltage at			
	Port 1	Port 2	Port 3	Port 4
Port 1				
Port 2				
Port 3				
Port 4				

The basic parameters to be measured for magic Tee are defined below.

A. Input VSWR:

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

B. Isolation:

The isolation between E and H arms is defined as the ratio of the power supplied by the generator connected to the E-arm (port 4) to the power detected at H-arm (port 3) when side arms 1 and 2 terminated in matched load

Hence Isolation (dB) = $10 \log_{10} [P_4/P_3]$

Similarly, Isolation between other parts may also be defined.

C. Coupling Factor:

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

Where α is attenuation / isolation in dB when i is input arm and j is output arm.

Thus $\alpha = 10 \log_{10} [P_4/P_3]$

Where P_3 is the power delivered to arm i and P_4 is power detected at j arm.

The S matrix of Magic Tee

$$S = \begin{bmatrix} S_{11} & S_{12} & S_{13} & S_{14} \\ S_{21} & S_{22} & S_{23} & S_{24} \\ S_{31} & S_{32} & S_{33} & S_{34} \\ S_{44} & S_{42} & S_{43} & S_{44} \end{bmatrix}$$

The S matrix of E-Plane and H-Plane Tee

$$S = \begin{bmatrix} S_{11} & S_{12} & S_{13} \\ S_{21} & S_{22} & S_{23} \\ S_{31} & S_{32} & S_{33} \end{bmatrix}$$

PROCEDURE:

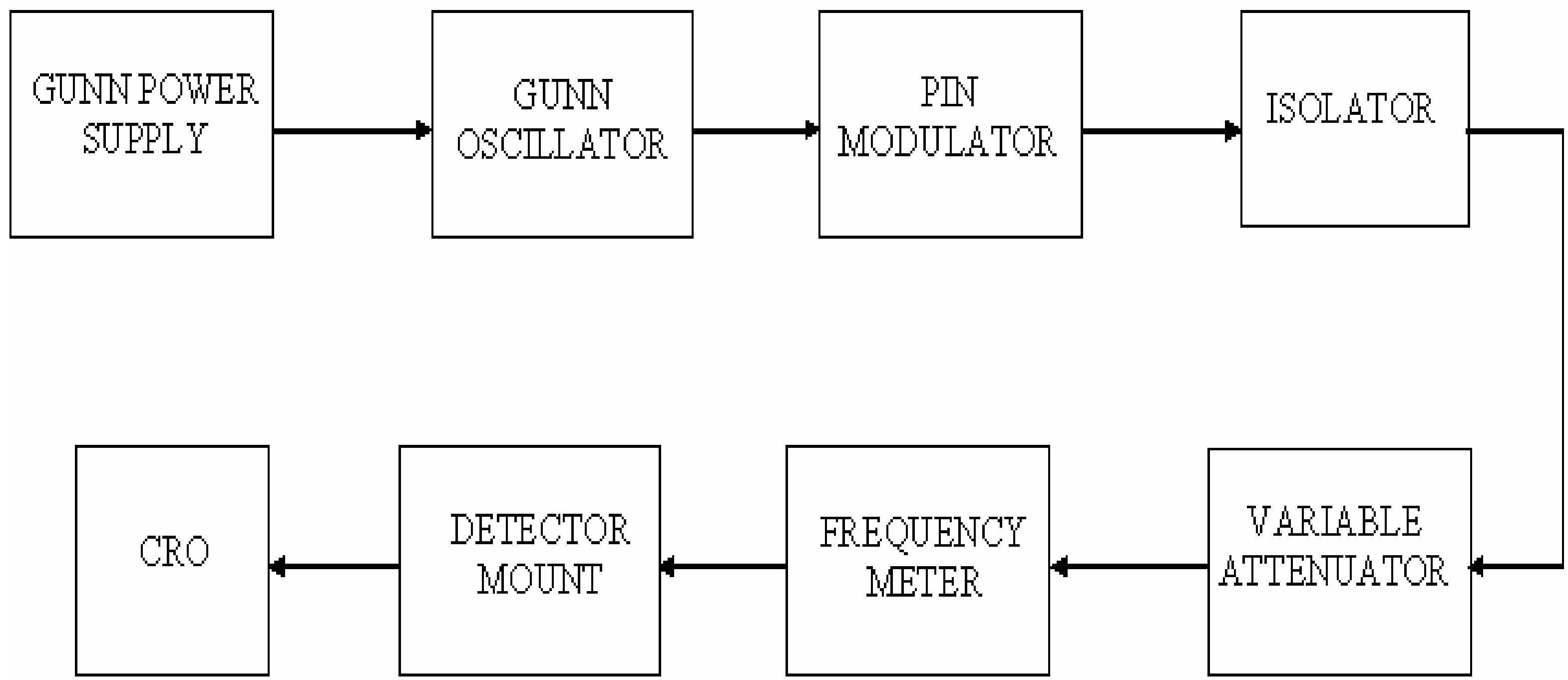
A. Measurement of Isolation and coupling factor:

1. Remove the tunable probe and Magic tee from the slotted line and connect the detector mount to slotted line.
2. Energize the microwave source for particular frequency of operation and tune the detector mount for maximum output.
3. With the help of variable attenuator and gain control knob of VSWR meter, set any power level in the VSWR meter and note down. Let it be P_3.
4. Without disturbing the position of variable attenuator and gain control knob, carefully place the magic tee after slotted line keeping H-arm connected to slotted line, detector to E-arm and matched termination to arm 1 and 2. Note down the reading of VSWR meter let it be P4.
5. Determine the isolation between port 3 and 4 as P_3–P_4 in dB.
6. Determine the coupling coefficient from equation given in the theory part.
7. The same experiment may be repeated for other ports also.
8. Repeat the above experiment for other frequencies.

RESULT:

Thus the S-parameters of E-plane, H-plane and magic Tee was measured.

BLOCK DIAGRAM:



Ex.No. 11 (a) GUNN DIODE CHARACTERISTICS

AIM :

To determine the characteristics of Gunn Diode.

COMPONENTS REQUIRED:

i. Gunn power Supply
ii. Gunn oscillator
iii. PIN modulator
iv. Isolator
v. Frequency Meter
vi. Variable Attenuator
vii. Detector Mount
viii. CRO
ix. Bayonet Neill Concelman(BNC) Connector
x. Threaded Neill Concelman(TNC) Connector
xi. Cooling Fan
xii. Waveguide Stand, Screw & Net

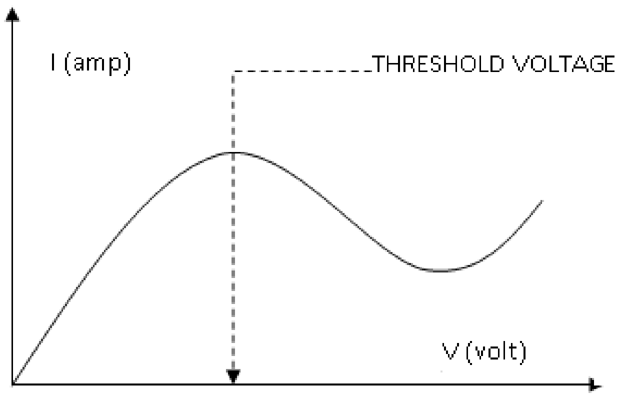
Pre Lab Questions:

1. Define Gunn Effect.
2. What is the necessary condition for an IMPATT to produce oscillations?
3. List the differences between microwave transistor and TED devices.
4. What are the advantages and disadvantages of parametric amplifier?
5. What is meant by avalanche transit time device?

THEORY:

Gunn diodes are negative resistance device which are normally used as low power oscillator at microwave frequencies in transmitter and as local oscillator in receiver front end. J.B. Gunn in 1963 discovered microwave oscillation. At low electric field in the material most of the electron will be located in the lower central valley. At high electric field most of the electron will be transferred in to the higher frequency satellite L and X valleys.

MODEL GRAPH:



OBSERVATION:

S.No	Voltage (V)	Current (mA)

PROCEDURE:

1. Set the components as shown in block diagram.
2. Keep the control knobs of Gunn power supply (GPS) as below.

   Meter Switch – off

   Gunn bias knob – Fully anticlockwise

   PIN Mod. Amp knob – Mid position

   PIN Mod. Freq.knob – Mid position
3. SwitchON the Gunn power supply, VSWR meter and Cooling fan. Set Gunn bias Voltage at 7.5V.
4. Set the micrometer of Gunn oscillator for required frequency of operation.
5. Measure the operating frequency using frequency meter.
6. Measure the Gunn Diode Current corresponding to the various Gunn bias voltage. Do not exceed the bias voltage above 10 volts.
7. Plot the voltage Vs Current and measure the threshold voltage which corresponds to maximum current.

NOTE:

Do not keep gun bias knob position at **threshold position** for more than **10-15 seconds** reading should be obtained as fast as possible. Otherwise due to excessive heating, **Gunn diode** may **burn**

Post Lab Questions:

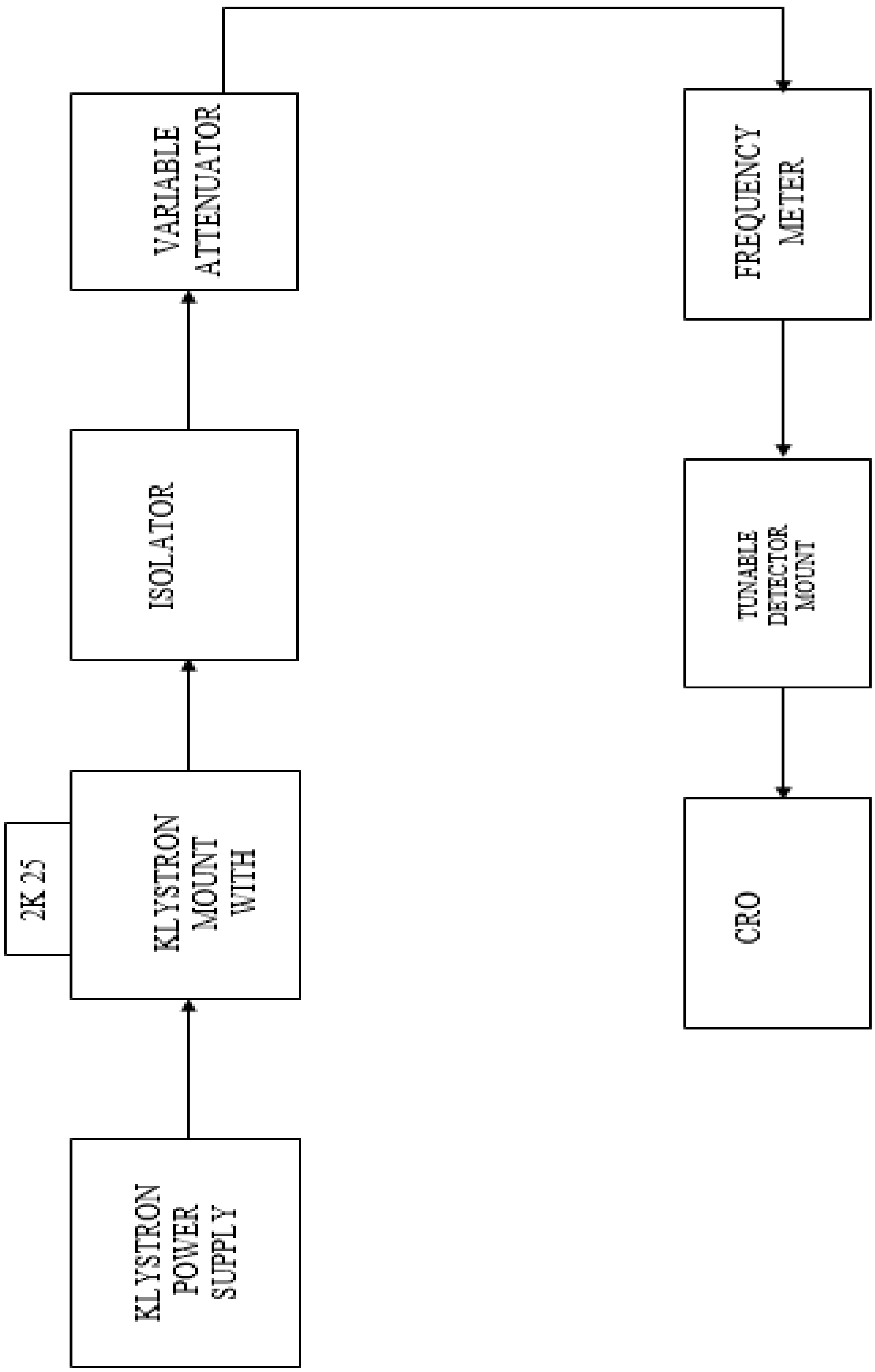
1. Define Attenuation.
2. What are the types of attenuator?
3. What is negative resistance in Gunn diode?
4. Name the semiconductor used in Gunn diode.
5. What is transferred electron effect?

RESULT:

Thus the characteristics of Gunn Diode was determined.

Threshold voltage, V_{th} = **Volts**

BLOCK DIAGRAM:



Ex.No. 11 (b) MODE CHARACTERISTICS OF REFLEX KLYSTRON

AIM :

To Study the Mode characteristics of the reflex klystron tube

COMPONENTS REQUIRED:

i. Klystron power Supply
ii. Klystron tube with mount
iii. Isolator
iv. Frequency Meter
v. Variable Attenuator
vi. Detector Mount
vii. CRO
viii. Bayonet Neill Concelman(BNC) Connector
ix. Cooling Fan
x. Waveguide Stand, Screw & Net

Pre Lab Questions:

1. Define velocity modulation.
2. How modes of oscillation observed in reflex klystron?
3. State the principle of operation of klystron.
4. Compare reflex klystron with two cavity klystron.
5. What is electron bunching?

THEORY:

The Reflex Klystron makes the use of velocity modulation to transform a continuous electron beam into microwave power. Electrons emitted from the cathode are accelerated & passed through the positive resonator towards negative reflector, which retards and, finally, reflects the electrons and the electrons turn back through the resonator. Suppose an RF-field exists between the resonators, the electrons travelling forward will be accelerated of retarded, as the voltage at the resonator changes in amplitude. The accelerated electrons leave at the reduced velocity. The electrons

OBSERVATION:

Beam Voltage:________V

Beam Current:________mA

S.No.	Negative Repeller Voltage (V)	Frequency (GHz)	Output Voltage (mV)

leaving the resonator will need different time to return, due to change in velocities. As a result, returning electrons group together in bunches, As the electron bunches pass through resonator, they interact with voltage at resonator grids. If the bunches pass the grid at such a time that the electrons are slowed down by the voltage then energy will be delivered to the resonator; and Klystron will oscillate.

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

INITIAL ADJUSTMENTS:

1. Keep the variable attenuator in the minimum attenuation position.
2. Keep the control knob of klystron power supply as below, before switching ON the device.

   Beam voltage = OFF

   Mod-switch = AM

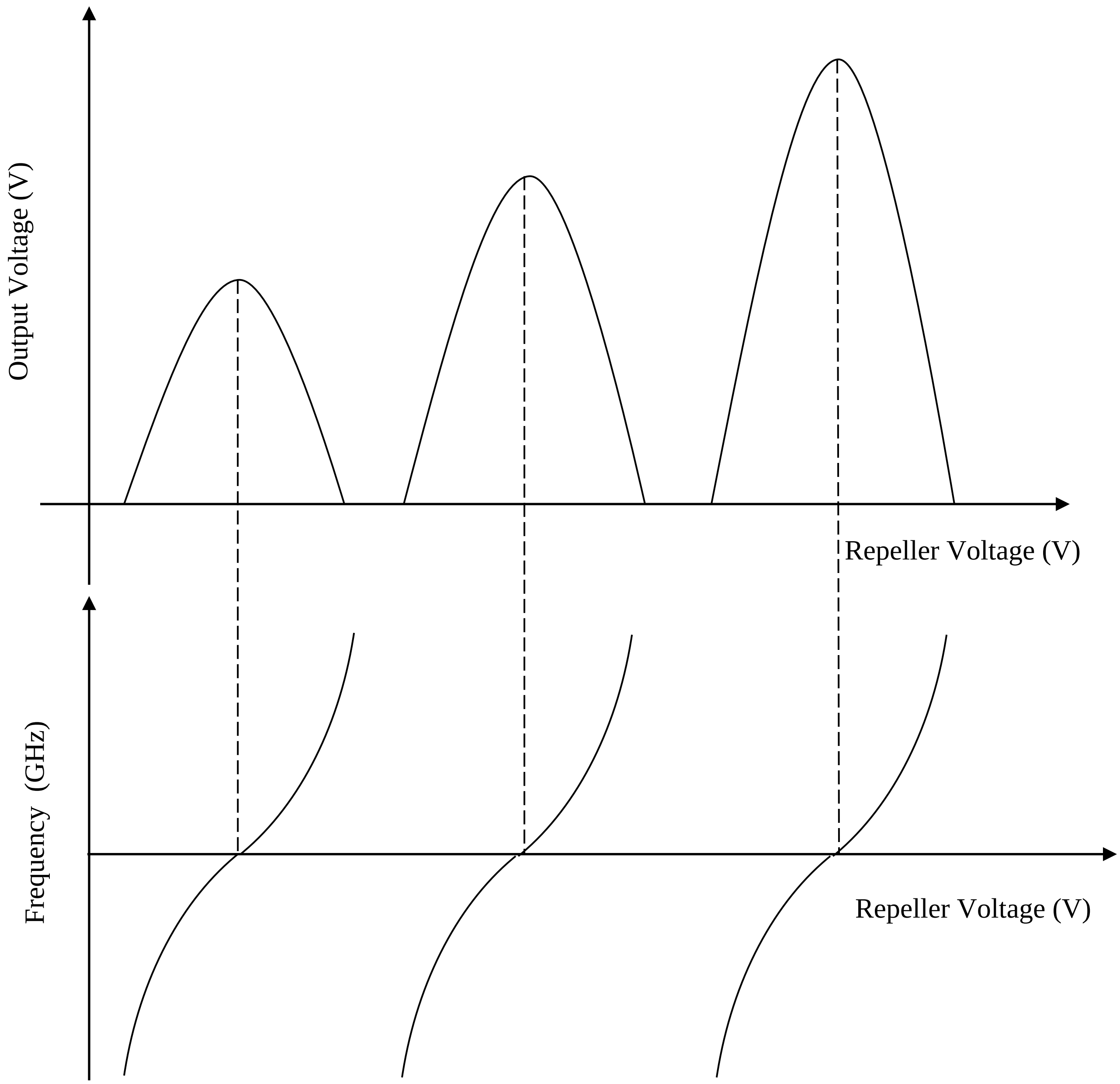
   Beam voltage knob = Fully anticlockwise

   Repeller voltage knob = Fully anticlockwise

   AM frequency & Amplitude knob = mid position

   FM frequency & Amplitude knob = minimum position

MODEL GRAPH:



Output Voltage (V)
Repeller Voltage (V)
Frequency (GHz)
Repeller Voltage (V)

PROCEDURE:

1. Connect the components as shown in Block diagram.
2. Keep the control Knobs of klystron Power supply as mentioned in the basic set up.
3. Switch ON the Klystron power supply and set the beam voltage at 250 volts.
4. Check & measure the beam current whether it is less than 30mA.
5. By changing repeller Voltage from –10V to –180V to get maximum output in CRO and measure the corresponding output voltage.
6. Tune the frequency meter to get a dip on CRO and note down the corresponding frequency of oscillation directly. Detune the frequency meter.
7. Get two readings below and above the mode.
8. Plot the Negative repeller voltage Vs ouput voltage readings on the graph.

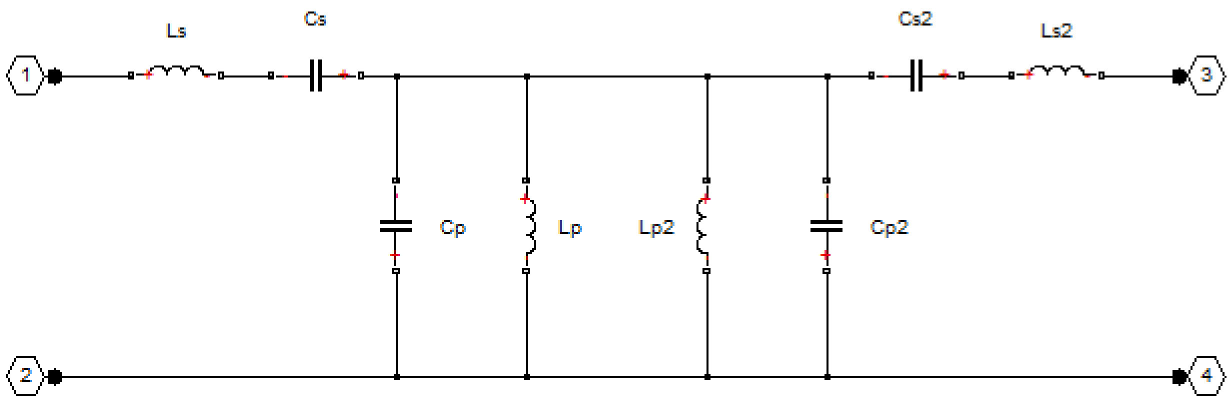
Post Lab Questions:

1. How the modes are observed in the reflex klystron?
2. What is transit time ?
3. Mention the significance of the repeller in the reflex klystron.
4. List the application of klystron.
5. Interpret the advantage of reflex klystron.

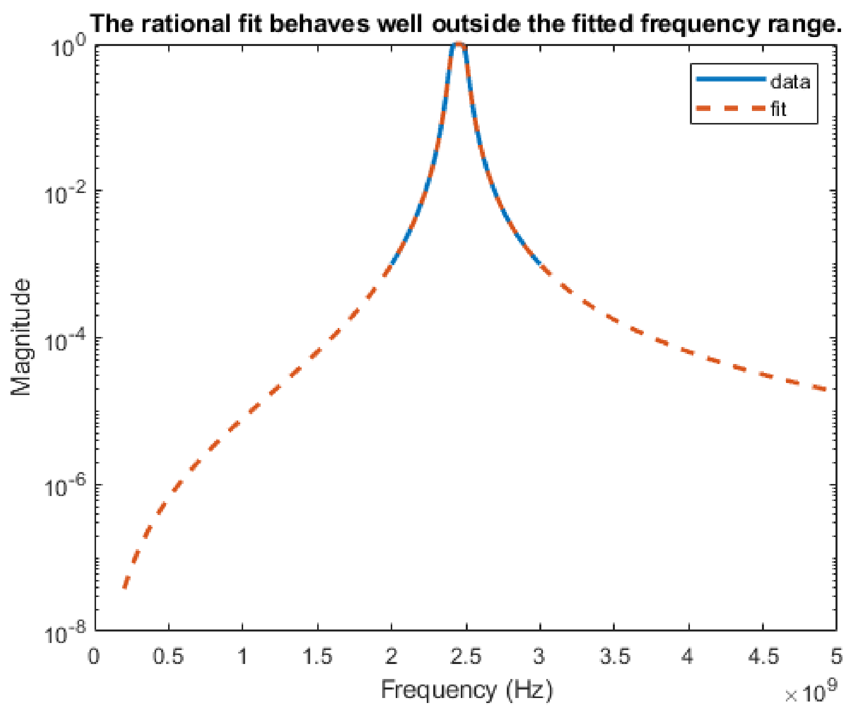
RESULT:

Thus the mode characteristics of Reflex Klystron was studied.

FILTER DESIGN :



FREQUENCY RESPONSE OF BANDPASS FILTER



Ex. No. 12 MICROWAVE FILTER CHARACTERISTICS

AIM:

To construct and obtain the characteristics of the RF bandpass filter with the lower 3 dB cutoff frequency of 2.4 GHz and an upper 3 dB cutoff frequency of 2.5 GHz.

COMPONENTS REQUIRED:

- Personal computer
- MATLAB software

Pre Lab Questions:

1. What is a RF filter?
2. Classify the types of filter.
3. Mention the need to find the 3dB cutoff frequency for the filter.
4. List the applications of the RF Filter
5. What are the advantages of the RF filter design.

THEORY:

Filters are used in many areas of electronics. One of the main areas where they are used is within the radio frequency or RF domain.

RF filters are used to remove or accept signals that fall in certain areas of the radio spectrum.

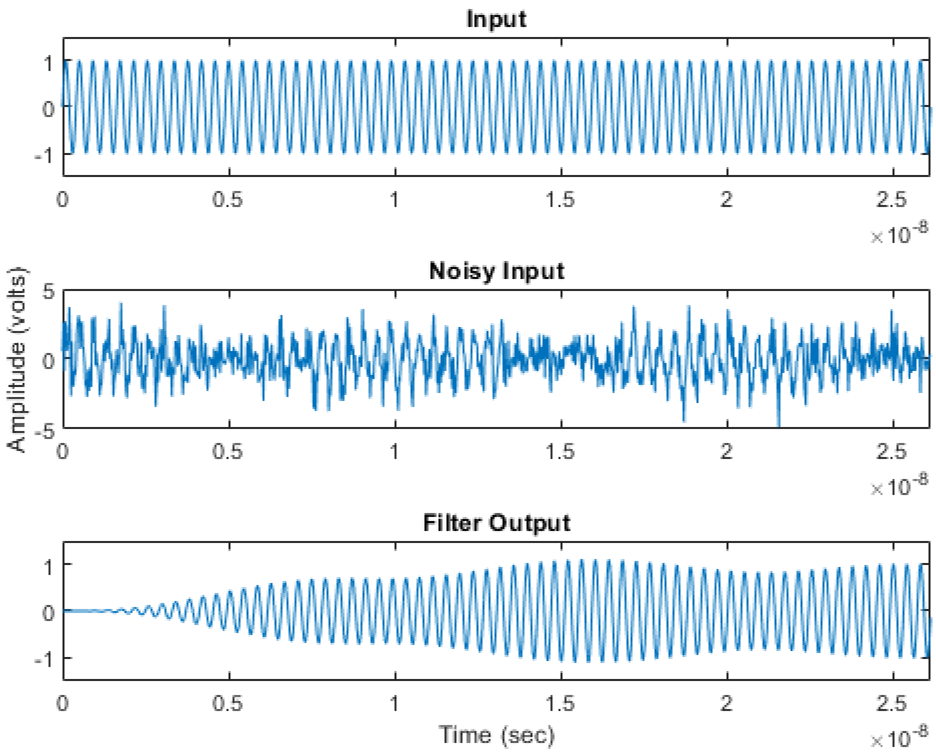
There are many different instances where they can be used - the list of applications is almost infinite. They are sued within radio receivers to provide the selectivity, as well as only enabling the right band of frequencies to enter the latter parts of the set. They are used within transmitters to ensure that unwanted or spurious signals are not transmitted. RF filters are used to ensure that the required mix products from mixers are passed on to the next stages.

The cut off frequency of the filter is defined as the point at which the output level from the filter falls to 50% (-3 dB) of the in band level, assuming a constant input level. The cut off frequency is sometimes referred to as the half power or -3 dB frequency.

The stop band of the filter is essentially the band of frequencies that is rejected by the filter. It is taken as starting at the point where the filter reaches its required level of rejection.

he band pass RF filter only allows through signals within certain frequencies. Above and below the cut-off frequencies, the signals will be attenuated and within the accepted band of radio frequencies, signals will be passed through.

TIME DOMAIN RESPONSE OF BANDPASS FILTER



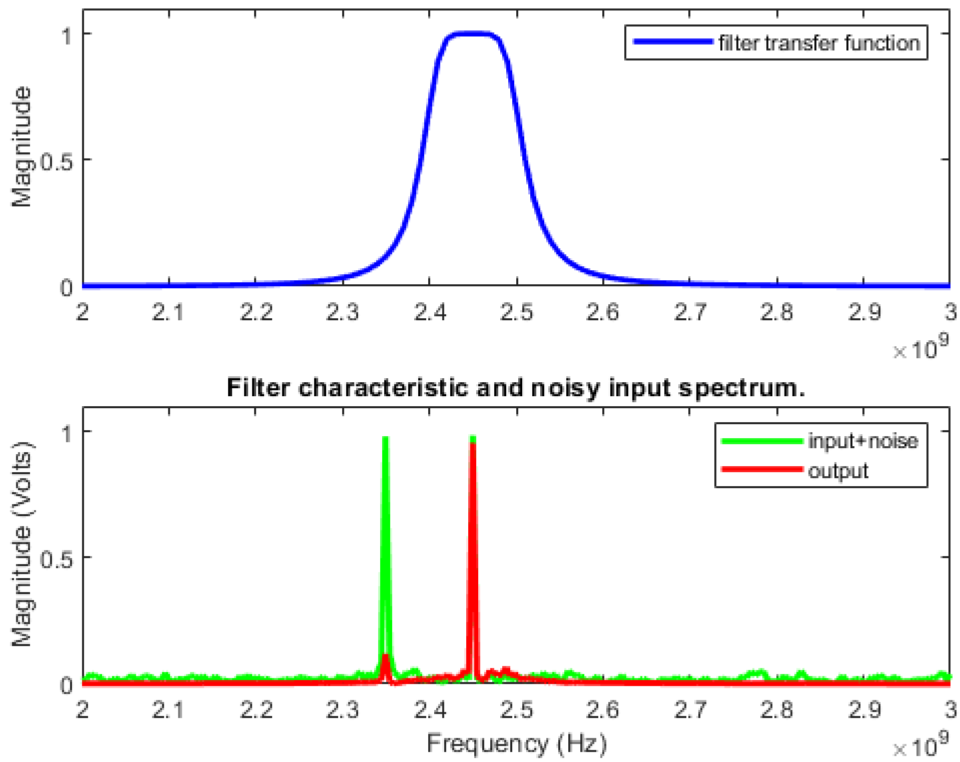
PROCEDURE:

1. Choose inductance and capacitance values using the classic image parameter design method.
2. Use rfckt.seriesrlc, rfckt.shuntrlc, and rfckt.cascade objects to programmatically construct a Butterworth circuit as a 2-port network.
3. Use analyze to extract the S-parameters of the 2-port network over a wide frequency range.
4. Use s2tf function to compute the voltage transfer function from the input to the output.
5. Use rationalfit function to generate rational fits that capture the ideal RC circuit to a very high degree of accuracy.
6. Create a noisy input voltage waveform.
7. Use timeresp function to compute the transient response to a noisy input voltage waveform.

PROGRAM :

```
Ro = 50;
f1C = 2400e6;
f2C = 2500e6;

Ls = (Ro / (pi*(f2C - f1C)))/2;
Cs = 2*(f2C - f1C)/(4*pi*Ro*f2C*f1C);

Lp = 2*Ro*(f2C - f1C)/(4*pi*f2C*f1C);
Cp = (1/(pi*Ro*(f2C - f1C)))/2;
Seg1 = rfckt.seriesrlc('L',Ls,'C',Cs);
Seg2 = rfckt.shuntrlc('L',Lp,'C',Cp);
Seg3 = rfckt.shuntrlc('L',Lp,'C',Cp);
Seg4 = rfckt.seriesrlc('L',Ls,'C',Cs);

cktBPF = rfckt.cascade('Ckts',{Seg1,Seg2,Seg3,Seg4});
freq = linspace(2e9,3e9,101);
analyze(cktBPF,freq);
sparams = cktBPF.AnalyzedResult.S_Parameters;
tf = s2tf(sparams);
fit = rationalfit(freq,tf);
widerFreqs = linspace(2e8,5e9,1001);
resp = freqresp(fit,widerFreqs);

figure
semilogy(freq,abs(tf),widerFreqs,abs(resp),'--','LineWidth',2)
xlabel('Frequency (Hz)')
ylabel('Magnitude')
legend('data','fit')
title('The rational fit behaves well outside the fitted frequency range.')
fCenter = 2.45e9;
fBlocker = 2.35e9;
```

FREQUENCY DOMAIN RESPONSE OF BANDPASS FILTER



```
period = 1/fCenter;
sampleTime = period/16;
signalLen = 8192;
t = (0:signalLen-1)'*sampleTime; % 256 periods

input = sin(2*pi*fCenter*t);     % Clean input signal
rng('default')
noise = randn(size(t)) + sin(2*pi*fBlocker*t);
noisyInput = input + noise;      % Noisy input signal

% Time domain response
xmax = t(end)/8;
figure
subplot(3,1,1)
plot(t,input)
axis([0 xmax -1.5 1.5])
title('Input')

subplot(3,1,2)
plot(t,noisyInput)
axis([0 xmax floor(min(noisyInput)) ceil(max(noisyInput))])
title('Noisy Input')
ylabel('Amplitude (volts)')

subplot(3,1,3)
plot(t,output)
axis([0 xmax -1.5 1.5])
title('Filter Output')
xlabel('Time (sec)')
%Frequency domain response
NFFT = 2^nextpow2(signalLen); % Next power of 2 from length of y
Y = fft(noisyInput,NFFT)/signalLen;
samplingFreq = 1/sampleTime;
f = samplingFreq/2*linspace(0,1,NFFT/2+1)';
O = fft(output,NFFT)/signalLen;

figure
subplot(2,1,1)
plot(freq,abs(tf),'b','LineWidth',2)
axis([freq(1) freq(end) 0 1.1])
legend('filter transfer function')
ylabel('Magnitude')
subplot(2,1,2)
plot(f,2*abs(Y(1:NFFT/2+1)),'g',f,2*abs(O(1:NFFT/2+1)),'r','LineWidth',2)
```

```
axis([freq(1) freq(end) 0 1.1])

legend('input+noise','output')
title('Filter characteristic and noisy input spectrum.')
xlabel('Frequency (Hz)')
ylabel('Magnitude (Volts)')
```

Post Lab Questions:

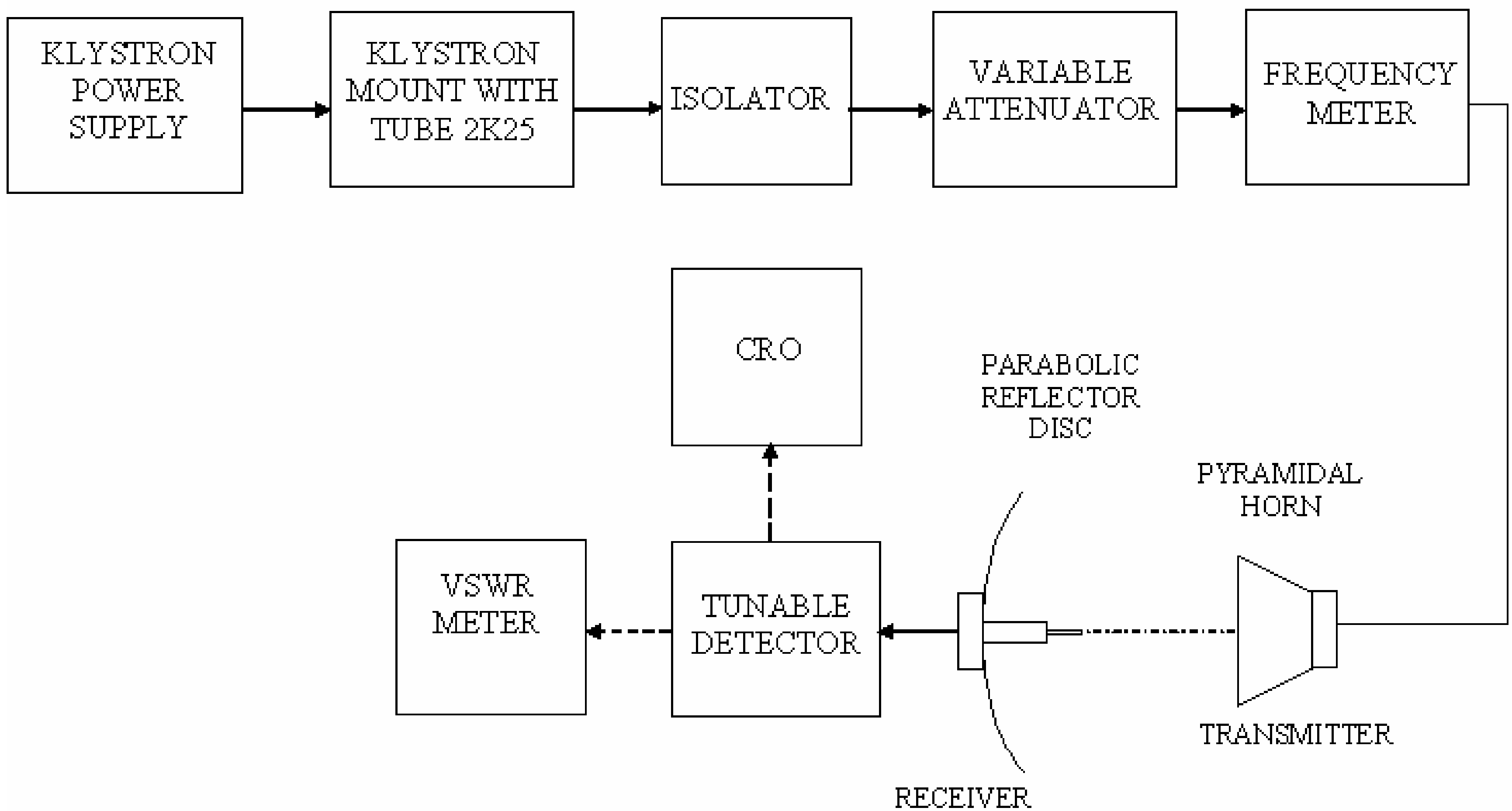
6. What is quality factor?
7. Compare narrowband and wideband filter
8. How to construct a bandpass filter using a low pass filter and high pass filter?
9. Mention the importance of bandpass filter in communication.
10. Distinguish between passive filter and active filter.

RESULT :

Thus the characteristic response of the RF Bandpass filter was obtained for the proposed cutoff frequency.

TOPIC BEYOND THE SYLLABUS EXPERIMENT

BLOCK DIAGRAM:



Ex.No. : 13 RADIATION PATTERN MEASUREMENT OF PARABOLIC REFLECTOR ANTENNA

AIM:

To measure the radiation pattern of a Parabolic Reflector antenna.

COMPONENTS REQUIRED:

i. Klystron Power Supply
ii. Klystron Mount with Tube 2K25
iii. Isolator
iv. Variable Attenuator
v. Frequency Meter
vi. One Horn Antenna
vii. Parabolic Reflector
viii. Tunable Detector Mount
ix. VSWR Meter, CRO
x. Bayonet Neill Concelman (BNC) Connector
xi. Cooling Fan
xii. Radiation pattern Twin Table
xiii. Waveguide Stand, Screw & Net

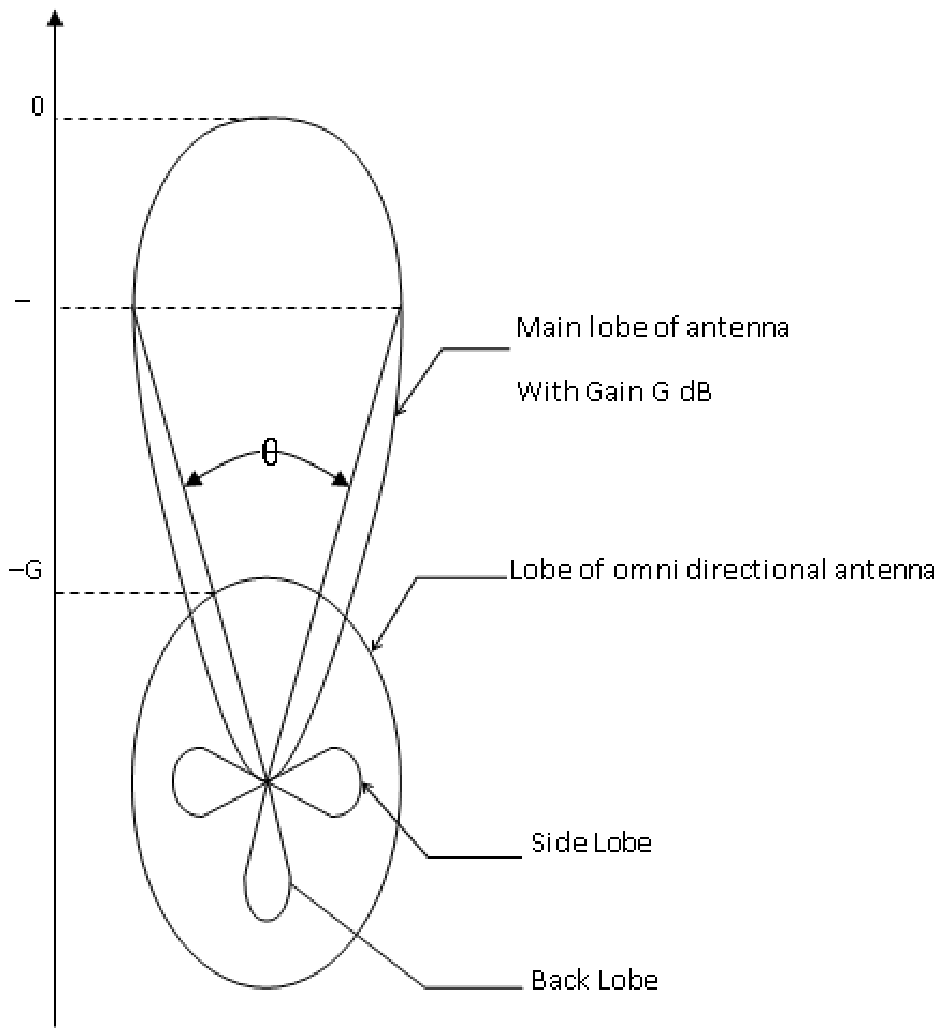
Pre Lab Questions:

1. Define antenna.
2. What is dipole antenna?
3. Mention the importance of radiation pattern.
4. What is parabolic reflector?
5. Why antenna is needed in wireless communication?

THEORY:

To improve the overall radiation characteristic of the reflector antenna, the parabolic structure is frequently used. Basically a parabola is a locus of a point which moves in such a way that the distance if the point from fixed point called focus plus the distance from the straight line called directrix is constant. When the beam of parallel rays is incident on a Parabolic reflector, then the radiations focus at a focal point. This principle is used in the receiving antenna.

MODEL GRAPH: (Polar port)



INITIAL SETUP IN VSWR METER:

1. Set input selector switch in 200 Ohms.
2. Keep meter selector in Normal.
3. Select the range as 50db or 40db or 30db and then vary the gain knob (fine and coarse) to get minimum attenuation. (VSWR = 1).

INITIAL ADJUSTMENTS IN KLYSTRON POWER SUPPLY:

1. Keep the variable attenuator in the minimum attenuation position.
2. Keep the control knob of klystron power supply as below, before switching ON the device.

Beam voltage	=	OFF
Mod-switch	=	AM
Beam voltage knob	=	Fully anticlockwise
Repeller voltage knob	=	Fully clockwise
AM freq. & Amp. Knob	=	Around mid position
FM freq. & Amp. Knob	=	minimum position

PROCEDURE:

1. Set the components as shown in Block diagram.
2. Keep the control Knobs of klystron Power supply as mentioned in the basic set up.
3. Replace the transmitting horn by detector mount or keep the transmitting and receiving antenna at close position.
4. Switch ON the VSWR meter, CRO, cooling fan & Klystron power supply and set the beam voltage at 250 volts.
5. Adjust the repeller Voltage (120V) to get maximum output in CRO.
6. Tune the frequency meter knob to get a ‘dip’ on CRO and note down the frequency of oscillation directly. Detune the frequency meter.
7. Using the formula $\mathbf{r = 2D^2/\lambda_o}$, Calculate the distance between antennas and keeping the axis of antennas in same line.
8. Then remove the CRO and connect the VSWR meter to Tunable Detector mount.
9. Obtain full scale deflection (0dB) on normal dB scale (0-10dB) and change the appropriate range dB position to get the deflection on scale (do not touch the gain control knob)
10. Note the range dB position and deflection of VSWR meter.

OBSERVATION:

Operating Frequency = GHz.

Right			Left		
Angle θ (Degree)	**Power (dB)**	**Relative Power (dB)**	**Angle θ (Degree)**	**Power (dB)**	**Relative Power (dB)**

CALCULATION:

$\lambda_o = C/f =$

$r = 2D^2/\lambda_o =$ cm

FORMULA:

$\mathbf{r \geq 2D^2/\lambda_o}$, $\lambda_o = C/f$ (for rectangular horn antenna)

Where

r– Distance between transmitter and receiver horn antenna.

D– Size of the broad wall of horn antenna.(10.1 cm)

λ_o– Free space wavelength. $C = 3\times10^8$ m/s. (Velocity of light)

f – Frequency of oscillation in GHz.

11. Tune the receiving parabolic reflector to the left in 10^0 steps up to 40^0 and note down the corresponding VSWR dB reading in the normal dB range. (When necessary, change the range switch to next higher range and add 10dB to observed value.)
12. Repeat the above step but this time turn the receiving parabolic reflector to the right and note down the readings.
    Plot a relative power pattern i.e. Output vs. angle.
13. From the diagram determine 3dB–width (beam width) of the Parabolic Reflector.

Post Lab Questions:

1. Define front to back Ratio.
2. Give the relation between gain & directivity.
3. Name the types of parabolic reflectors.
4. Define radiation resistance.
5. Write the applications of parabolic reflectors.

RESULT:

Thus the radiation pattern of the parabolic reflector antenna was measured.

HPBW =