



μ W & FIBER OPTICS MANUAL EEC-751

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CONTENTS

1.	Syllabus for EEC-751 Lab.....	3
2.	Study and Evaluation Scheme.....	4
3.	List of Experiments.....	5
4.	Index.....	6
5.	Experiment No. 1.....	7
6.	Experiment No. 2.....	11
7.	Experiment No. 3.....	15
8.	Experiment No. 4.....	18
9.	Experiment No. 5.....	20
10.	Experiment No. 6.....	24
11.	Experiment No. 7.....	27
12.	Experiment No. 8.....	30
13.	Experiment No. 9.....	35
14.	Experiment No. 10.....	39
15.	Experiment No. 11.....	44

SYLLABUS FOR μ W & FIBER OPTICS

EEC -751: μ W & FIBER OPTICS

1. Study of Reflex Klystron Characteristics.
2. Measurement of guide wavelength and frequency of the signal in a rectangular Waveguide using slotted line carriage in a Micro wave Bench.
3. Measurement of impedance of an unknown load connected at the output end of the slotted line carriage in a Micro wave Bench
4. Determine the S-parameter of a Magic Tee.
5. Measurement of attenuation of an attenuator and isolation, insertion loss, cross coupling of a circulator.
6. Determine coupling coefficient, Insertion loss, Directivity and Isolation coefficient of Multi-Hole directional coupler.
7. Study of waveguide horn and its radiation pattern and determination of the beam width.
8. To setting up fiber optic analog link.
9. Study and measurement of losses in optical fiber.
10. Study and measurement of numerical aperture of optical fiber.
11. Study and measure characteristics of fiber optic LED's and photo detector

STUDY AND EVALUATION SCHEME

SESSIONAL EVALUATION:-

CLASS TEST : 10 MARKS

TEACHER'S ASSESMENT : 10 MARKS

EXTERNAL EXAM : 30 MARKS

TOTAL : 50 MARKS

LIST OF EXPERIMENTS

1. To study the Characteristics of Reflex Klystron tube.
2. Measurement of impedance of an unknown load connected at the output end of the slotted line carriage in a Micro wave Bench
3. Measurement of guide wavelength and frequency of the signal in a rectangular Waveguide using slotted line carriage in a Micro wave Bench.
4. To find the Scattering Parameters of Magic Tee
5. To measure coupling coefficient, Insertion loss & Directivity of a Directional coupler.
6. To study the Characteristics of circulator, isolator and hence measure insertion loss and isolation offered by these devices and also scattering parameters of circulator.
7. To measure the gain of a waveguide horn antenna.
8. To establish fiber optic analog link and to study the relationship between the input signal & received signal.
9. To measure propagation loss in plastic fiber and also to measure the bending loss
10. To study the VI characteristics of fiber optic LED'S. and Photo Detector
11. To measure the numerical aperture of the plastic fiber

Experiment No.-1

Objective:

To study the Characteristics of Reflex Klystron tube

Equipments required:

Klystron tube, Klystron power supply, Klystron mount, Isolator, Frequency Meter, Variable Attenuator, Detector mount, Wave guide stand, Cooling fan, VSWR meter, Cables and accessories.

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 traveling for-ward will be accelerated or retarded, as the voltage at the resonator changes in amplitude. The accelerated electrons leave the resonator at an increased velocity and the retarded electrons leave at the reduced velocity. The electrons leaving the resonator will need different time to return, due to change in velocities. As a result, returning electrons group together in bunches, as the electron bunches pass through resonator, they interact with voltage at resonator grids. If the bunches pass the grid at such a time that the electrons are slowed down by the voltage then energy will be delivered to the resonator; and Klystron will oscillate.

Procedure:

- (1) Set up the components and equipment as shown in fig.
- (2) Keep position of variable attenuator at minimum position.
- (3) Keep beam voltage knob fully anti-clock wise and repeller voltage to fully clockwise.
- (4) Switch on the Klystron power supply and oscilloscope.
- (5) Switch on beam voltage switch (HT) and set beam voltage to 300v by beam voltage control knob,
- (6) Keep amplifier knob of FM modulator to maximum position and rotate the reflector voltage anticlockwise to get modes.

(7) By changing the repeller voltage and amplitude of FM modulation, any mode of klystron tube can be seen on CRO.

Tabular FORM:

Mode No.	Repeller Voltage(V)	Amplitude (V)	Frequency (GHz)

Precautions:

- (1) Beam voltage in klystron power supply is first kept minimum and repeller voltage at maximum.
- (2) Power supply is kept in high-tension mode with am mode.
- (3) Now beam voltage is kept at high value.
- (4) Care should be taken to avoid microwave radiations.
- (5) Measurement bench is kept horizontal without any loose coupling.

Result:

The mode characteristics of Reflex Klystron are observed & plotted on the graph.

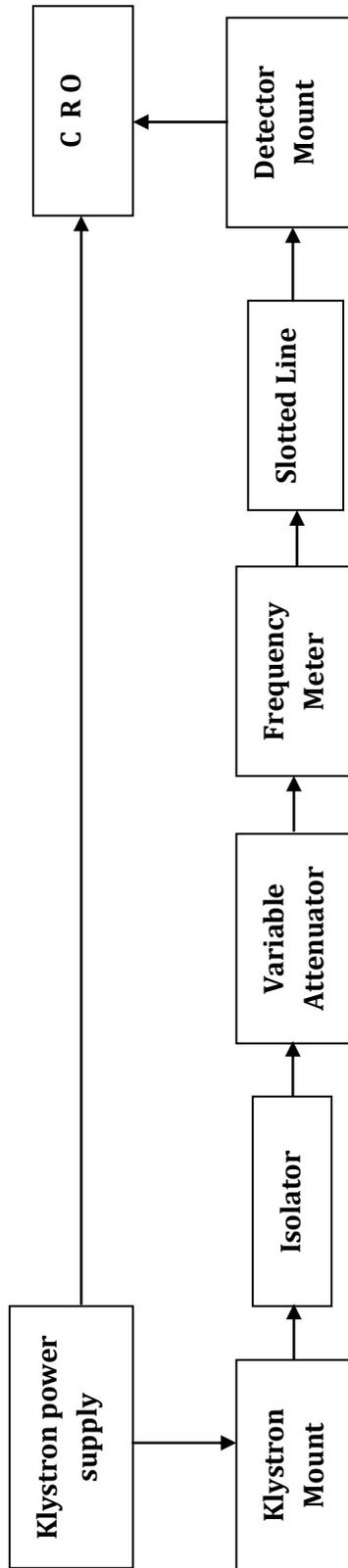


Figure: Bench setup for Klystron characteristics

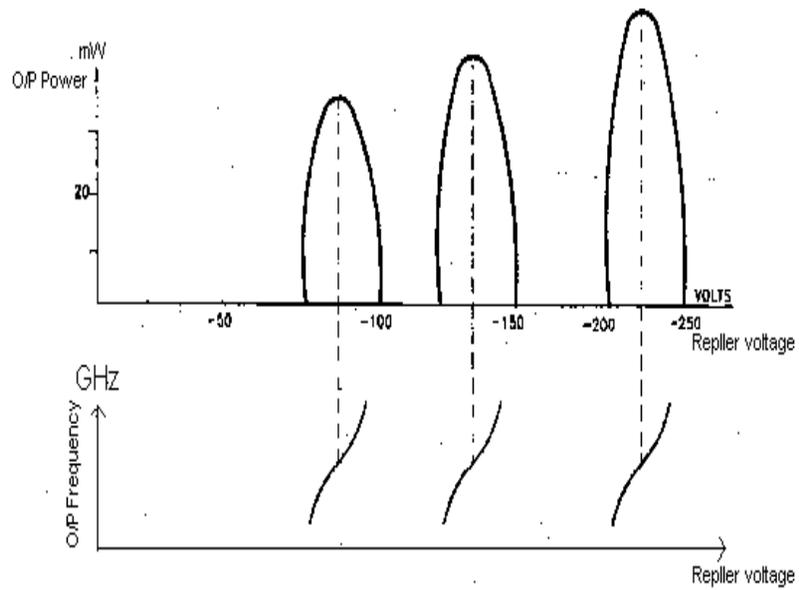


FIG. MODES OF 2K25

Experiment No.-2

Objective:

Measurement of impedance of an unknown load connected at the output end of the slotted line carriage in a Micro wave Bench

Equipment required:

Klystron Power Supply, Reflex Klystron Tube with Klystron Mount, Isolator, Frequency Meter, Variable Attenuator, Slotted Line, Tunable Probe, Detector Mount, Wave Guide Stands, VSWR Meter, Oscilloscope, Movable Short /Termination or any unknown load.

Theory:

The impedance at any point on a transmission line can be written in the form $R+jx$. For comparison SWR can be calculated

$$S = \frac{1 + |R|}{1 - |R|}$$

Where Reflection coefficient (R) = $\frac{Z - Z_0}{Z + Z_0}$

Z_0 = Characteristics impedance of wIg at operating frequency.

Z is the load impedance. The measurement is performed in following way.

The unknown device is connected to the slotted line and the position of one minima's is determined. The unknown device is replaced by movable short to the slotted. Line. Two successive minima positions are noted. The twice of the difference between minima position will be guide wavelength. One of the minima is used as reference for Impedance measurement. Find the difference of reference minima and minima position obtained from unknown load. Let it be 'd'. Take a smith chart, taking '1' as center, draw a circle of radius equal to so. Mark a point on circumference of smith chart towards load side at a distance equal to d/λ_g . Join the center with this point. Find the point where it cut the drawn circle. The co-ordinates 'of this point will show the normalized impedance of load.

Procedure:

1. Set up the equipment's as shown in the figure.
2. Set the variable attenuator at minimum position.
3. Keep the control knobs of VSWR Meter as below
 - a. Range - 50db positions
 - b. Input Switch - Crystal Low Impedance
 - c. Meter Switch - Normal position
 - d. Gain (Coarse-Fine) - Mid position
4. Keep the Control. Knobs of Klystron power supply as below
 - a. Beam voltage switch - OFF
 - b. Mod switch - AM
 - c. Beam Voltage knob - Fully anticlockwise
 - d. Reflector Voltage - Fully clockwise
 - e. AM - Amplitude - Around fully clockwise
 - f. AM - Frequency knob - Around Mid position.
5. Switch 'ON' the Klystron power supply, VSWR Meter and cooling fan.
6. Switch 'ON' the Beam Voltage Switch position and set beam voltage at 300 V with help of beam voltage knob.
7. Adjust the reflector voltage knob to get some deflection in VSWR Meter.
8. Maximize the deflection with AM amplitude and frequency control knob of power supply.
9. Tune the plunger of Klystron Mount for Maximum deflection.
10. Tune the reflector voltage knob for maximum deflection.
11. Tune the probe for maximum deflection in VSWR meter.
12. Tune the frequency meter knob to get a 'dip' on the VSWR meter and note down the frequency directly from frequency meter.
13. Load end terminate with the device under test (DUT). Find VSWR of DUT using direct method or double minima method accordingly.
14. Note down the SWR S. also note down the minima position, let it be d.
15. Remove DUT and place moveable short at slotted line. The plunger of short should be at zero. (i.e. moveable short is used as short).
16. Note the position of two successive minima position. Let it be as d_1 and d_2 . Hence
$$\lambda_g = 2(d_1 - d_2)$$
17. calculate d/λ_g find out normalized impedance.

Observations:

Frequency of Excited Wave	Load VSWR	Position of minimum		Shift in minima $<\lambda/4=(d)$	Direction of shift towards load/generator
		Load	Short		
		d_1^l	d_1		
		d_2^l	d_2		

Calculations:

(A). Using formula:

The impedance can be calculated by using the following formula

$$Z_{in} = Z_o \{ [1-j S \tan (\pm 2\pi d/\lambda_g)] / [S-j \tan (\pm 2\pi d/\lambda_g)] \}$$

$$\text{Where } Z_o = \eta / \sqrt{1 - (\lambda_o^2 / \lambda_c^2)}$$

(+d) is for shift in minima towards load.

(-) is for shift in minima towards generator.

Precautions:

1. Keep the cooling fan towards the reflex Klystron.
2. Do not look into the transmitting Horn.
3. Do not apply ever repellar voltages as zero volts.

Result:

The unknown load impedance is calculated using formula and is verified.

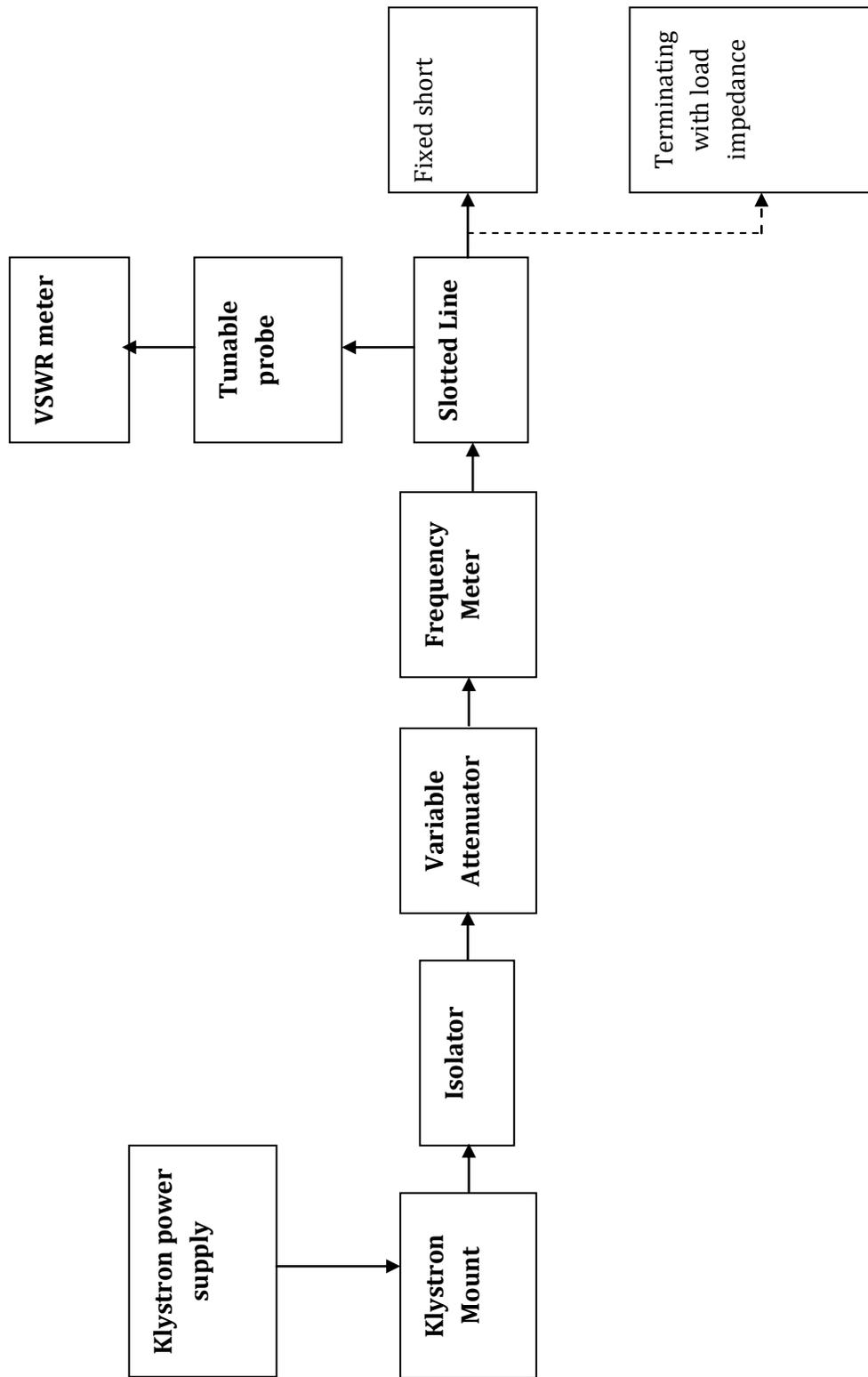


Figure: Bench setup for impedance measurement

Experiment-3

Aim:

Measurement of guide wavelength and frequency of the signal in a rectangular Waveguide using slotted line carriage in a Micro wave Bench.

Apparatus:

Gunn diode, Gunn oscillator, Isolator, PIN modulator, Frequency meter, Detector, CRO, Terminator

Theory:

For TE₁₀ mode in rectangular wave guide λ_0 , λ_g and λ_c are related as

$$(1/\lambda_0)^2 = (1/\lambda_g)^2 + (1/\lambda_c)^2.$$

Where λ_0 = free space wavelength

λ_g = guide wavelength.

λ_c = cutoff wavelength.

For TE₁₀ mode, $\lambda_c = 2a$, where a is broad dimension of wave-guide. The following relationship can be proved.

$$C = f \lambda.$$

Where, c is velocity of light & f is frequency.

Procedure:

1. Connect the circuit as per the block diagram.
2. Turn ON the gunn power supply & observe the square wave on CRO
3. Tune the frequency meter knob to get the dip on the CRO & note down the frequency directly from the frequency meter.
4. Move the probe to the MIN direction position, to get accurate reading; it is necessary to increase the scale range to higher position. Record the position.
5. Move the probe to next min position & record the corresponding frequencies.
6. Calculate the guided wavelength as twice the distance between two successive minimum positions obtained.
7. Calculate the guided wavelength by the following equation.
 - i. $\lambda_g = \lambda_f / [\sqrt{1 - (\lambda_f / \lambda_0)^2}]$
8. where λ_0 is the cutoff wavelength
9. Verify with frequency obtained by frequency meter.

Calculations:

$$(1/\lambda_0) = \sqrt{[(1/\lambda_g)^2 + (1/\lambda_c)^2]}$$

λ and 'f' is found from the above formula.

Precautions:

1. Care should be taken to avoid microwave radiation.
2. Loose coupling must be avoided.
3. Output signal is kept as high as possible.
4. Care should be taken while increasing distance on vernier scale.

Result:

Hence measured the frequency and waveguide parameters.

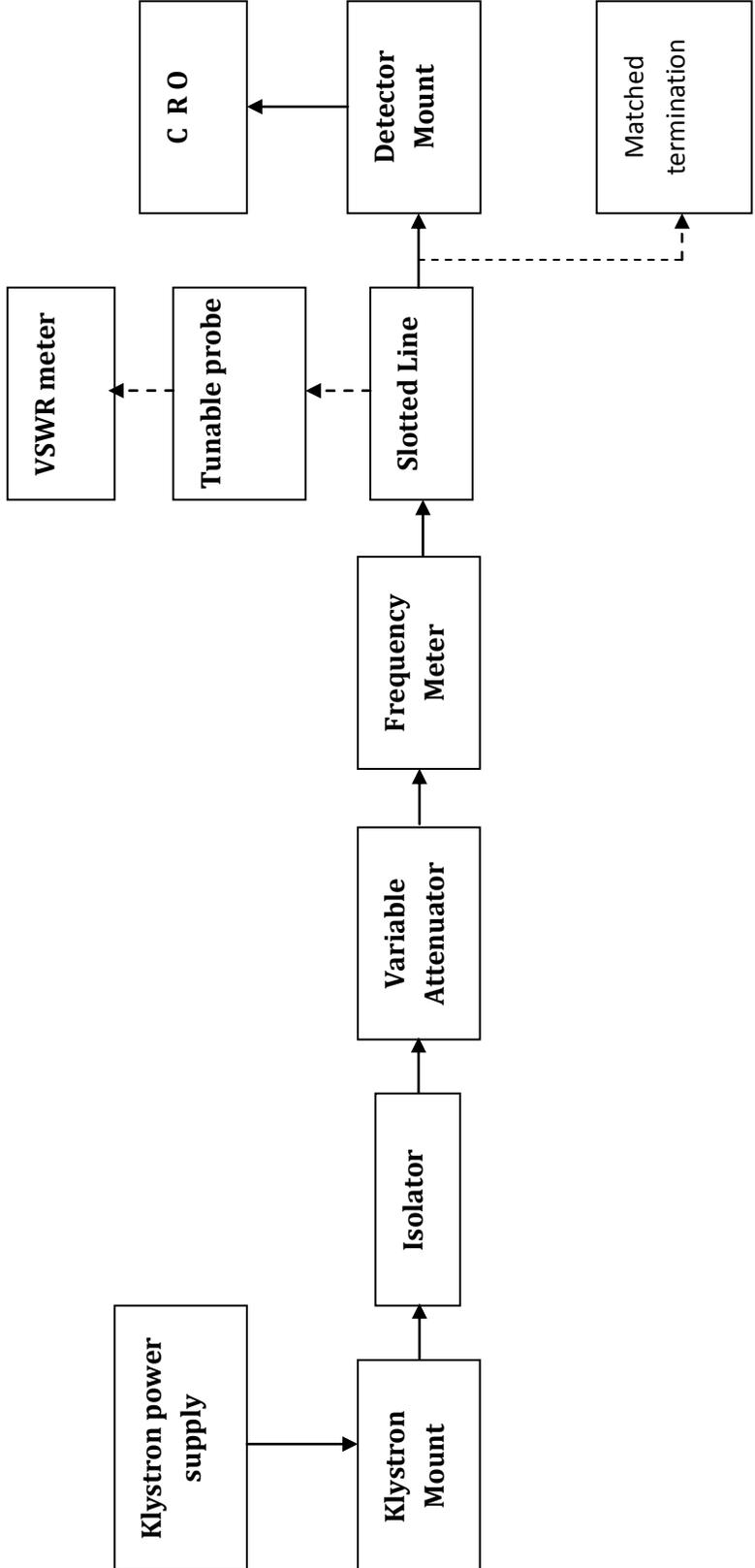


Figure: Bench setup for measurement of frequency & wave guide parameters

Experiment No.-4

Aim:

To find the Scattering Parameters of Magic Tee

Equipment required:

Klystron Tube 2K25, Klystron Power supply SKPS-610, Isolator, Variable attenuator, Frequency meter, Slotted line, Tunable probe, Magic tee, Matched terminations, Wave-guide stand, Detector mount, Oscilloscope, VSWR meter and accessories.

Theory:

The device magic Tee is a combination of the E and H plane tee , Arm 3 is the H- arm and arm 4 is the E-arm. If the power is fed, into arm 3 (H- arm) the electric field divides equally between arm 1 and 2 with the same phase, and no electric field exists in arm 4. 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 arm 1 and 2 simultaneously it is added in arm 3 (H-arm) and it is subtracted in E-arm, i. e. arm 4. The basic parameters to be measured for magic Tee are defined below.

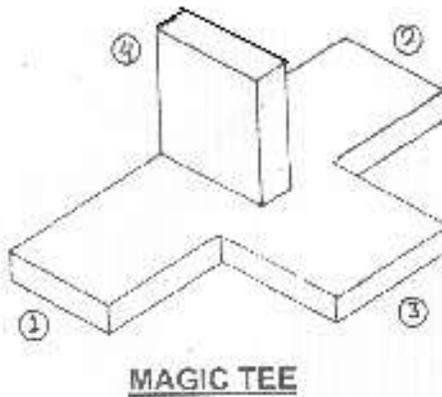
Procedure:

1. Initially arrange the bench set-up without magic Tee and set an input of certain value by using CRO.
2. Connect the magic tee device as shown in the set-up.
3. Energize the microwave source at a particular frequency of operation.
4. Calculate S_{12} , input to port 1 and measure output at port 2 by connecting the detector mount, remaining all ports are terminated with matched load.
5. Calculate S_1 by measuring the maximum and minimum voltage of the signal in the oscilloscope at port 1 by varying the slotted line. Hence,

$$S_1 = \sqrt{(V_{\max} / V_{\min})}$$

$$S_{11} = (S_1 - 1) / (S_1 + 1)$$

6. Repeat steps 4 & 5 for all the remaining three ports.



Observations:

$$S = \begin{vmatrix} S_{11} & S_{12} & S_{13} & S_{14} \\ S_{21} & S_{22} & S_{23} & S_{24} \\ S_{31} & S_{32} & S_{33} & S_{34} \\ S_{41} & S_{42} & S_{43} & S_{44} \end{vmatrix}$$

Precautions:

1. Keep the cooling fan towards the reflex Klystron.
2. Do not look into the transmitting Horn.
3. Do not apply ever repellar voltages as zero volts.

Result:

The scattering matrix of magic tee is found.

Experiment No.-5

Aim:

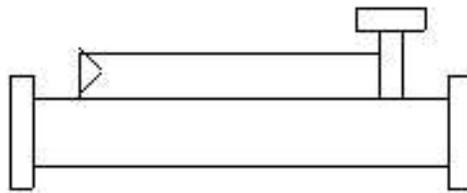
To measure coupling coefficient, Insertion loss & Directivity of a Directional coupler.

Apparatus required: -

Klystron tube, Klystron power supply, Klystron mount, Isolator, Cooling fan, Frequency Meter, Detector mount, Variable Attenuator, Wave guide stand, VSWR meter, MHD coupler, Matched Termination, Cables and accessories.

Theory:

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



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

$$\text{Coupling (db)} = 10 \log_{10} P_1 / P_4$$

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

$$\text{Insertion loss} = 10 \log_{10} P_1 / P_2.$$

The directivity of the coupler is a measure of separation between incident wave and the reflected wave. It is measured as the ratio of two power outputs from the auxiliary line when a given amount of power is successively applied to each terminal of the main line

with other port terminated by matched load. Hence Directivity is given by

$$D \text{ (db)} = 10 \log_{10} P_{4f} / P_{4r}$$

Where P_{4f} is the measured power at port 4 with equal amount of power is fed and P_{4r} to

Procedure: - Measurement of Coupling factor, Insertion loss & Directivity

- (1) Set the equipments as shown in fig.
- (2) Energize the microwave source for particular operation of frequency.
- (3) Remove the MHD coupler and connect the detector mount to the frequency meter. Tune the detector for max. Output.
- (4) Set any reference level of power on VSWR meter with the help of variable attenuator, gain control knob of VSWR meter and note down the reading (let it be X).
- (5) Insert the D.C as shown in fig. With detector mount to the auxiliary port 4 and matched termination to port 2. Without changing the position of variable attenuator and gain control knob of VSWR meter.
- (6) Note down the reading on VSWR meter (let it be Y) and calculate coupling factor using X & Y, which will be in db.
- (7) Now carefully disconnect the detector from the auxiliary port 4 and match termination From port2 without disturbing the setup.
- (8) Connect the matched termination to the aux. Port 4 and detector to port 2 and measure the reading on VSWR meter (let it be Z).
- (9) Compute insertion loss using X & Z in db.
- (10) Repeat the steps from 1 to 4.
- (11) Connect the D.C in the reverse direction i.e. port 2 to frequency meter side, matched termination to port1 and detector mount to port 4, without disturbing the position of the variable attenuator and gain control knob of VSWR meter.
- (12) Note down the reading and let it be Y_0 . Compute the directivity as $Y - Y_0$.

Observation and calculations: -

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

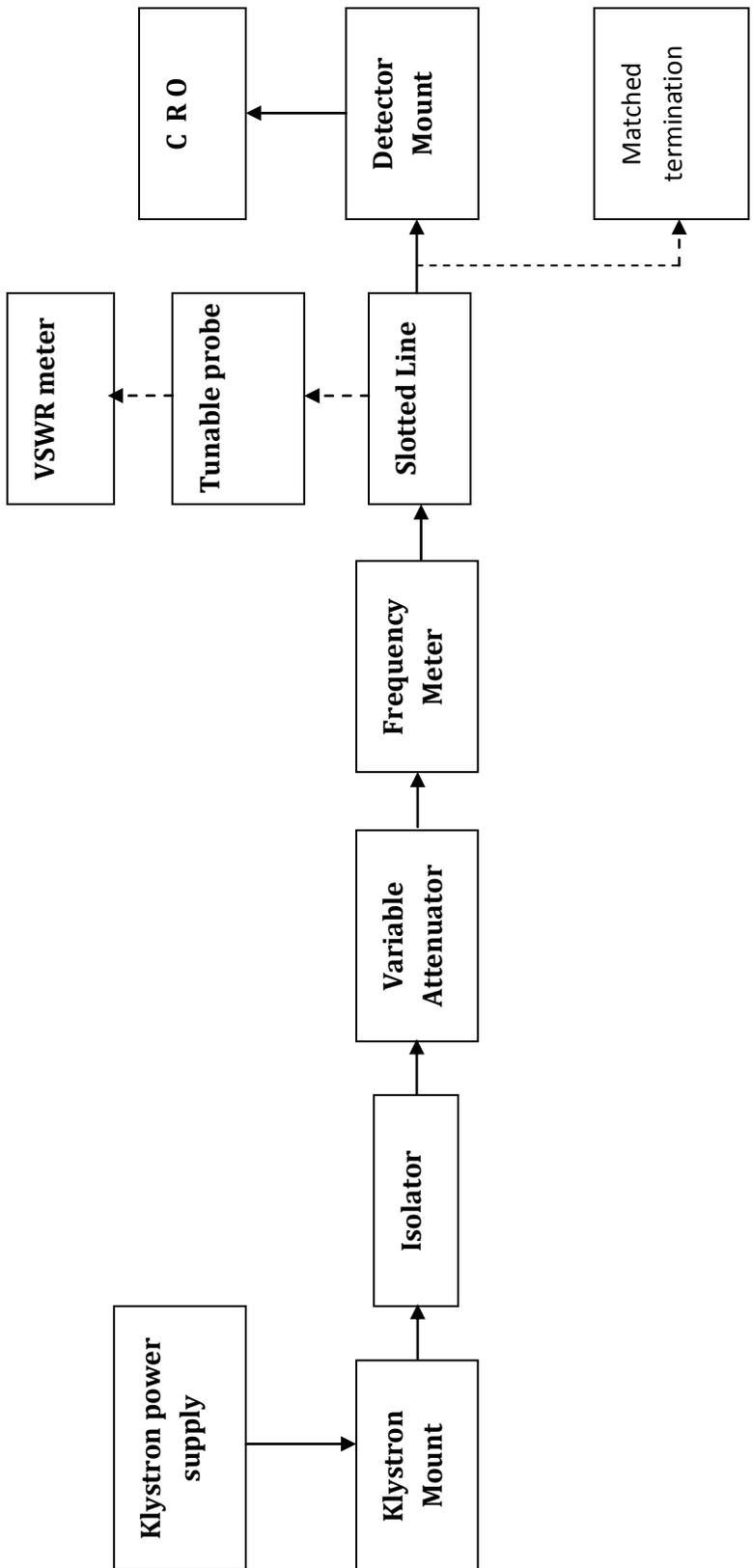
Result

The measured value for MHD coupler are

Coupling coefficient =

Insertion loss =

Directivity =



Experiment no.-6

Aim:

To study the Characteristics of circulator, isolator and hence measure insertion loss and isolation offered by these devices and also scattering parameters of circulator.

Equipment required:

Klystron Power Supply, Reflex Klystron Tube with Klystron Mount, Isolator, Frequency Meter, Variable Attenuator, Slotted Line, Tunable Probe, Detector Mount, Wave Guide Stands, VSWR Meter, Oscilloscope, Movable Short /Termination, circulator, isolator.

Theory:

Ferrites are non-metallic materials with magnetic properties. Ferrites have one more peculiar property, which is useful at microwave frequencies, i.e, and the non-reciprocal property. When two circular polarized waves one rotating clockwise and other anti-clockwise are made to propagate through ferrite, the material reacts differently to the two rotating fields, thereby presenting different effective permeability's to both the waves. Isolator and circulator are two microwave devices that make use of Faraday rotation principle.

Circulator

Circulator is multi-port device such that wave incident on nth port is coupled to (n+1)th port only. That is if power is incident in port 1, port 2 is coupled but not port 3.

Isolator

An isolator is a two - ports device that transfers energy from input to output with little attenuation and from output to input with very high attenuation. This is generally used between the source and rest of the setup to avoid over loading of the source due to reflected power

Insertion Loss

Insertion Loss is the ratio of power supplied by a source to the input arm, to the power detected by the detector in the coupled arm with all ports matched termination.

Isolation

Isolation is the ratio of power fed in arm 1 by a matched generator to the power detected in port 3 by detector with port 2 terminated in matched loads.

Procedure:

Measurement of Insertion loss and Isolation

1. Set up the components and equipment's as shown in fig. without the ferrite device i.e., directly connect detector with VSWR meter in order to measure input.
2. Keep the control knobs of VSWR Meter as below
 - a. Range - 50db positions
 - b. Input Switch - Crystal Low Impedance
 - c. Meter Switch - Normal position
 - d. Gain (Coarse-Fine) - Mid position
3. Keep the Control. Knobs of Klystron power supply as below
 - a. Beam voltage switch - OFF
 - b. Mod switch - AM
 - c. Beam Voltage knob - Fully anticlockwise
 - d. Reflector Voltage - Fully clockwise
 - e. AM - Amplitude - Around fully clockwise
 - f. AM - Frequency knob- Around Mid position.
4. Energize the microwave source for particular frequency of operation.
5. Set some reference reading in VSWR meter by adjusting the variable attenuator. Note this attenuator setting as (A1) dB.

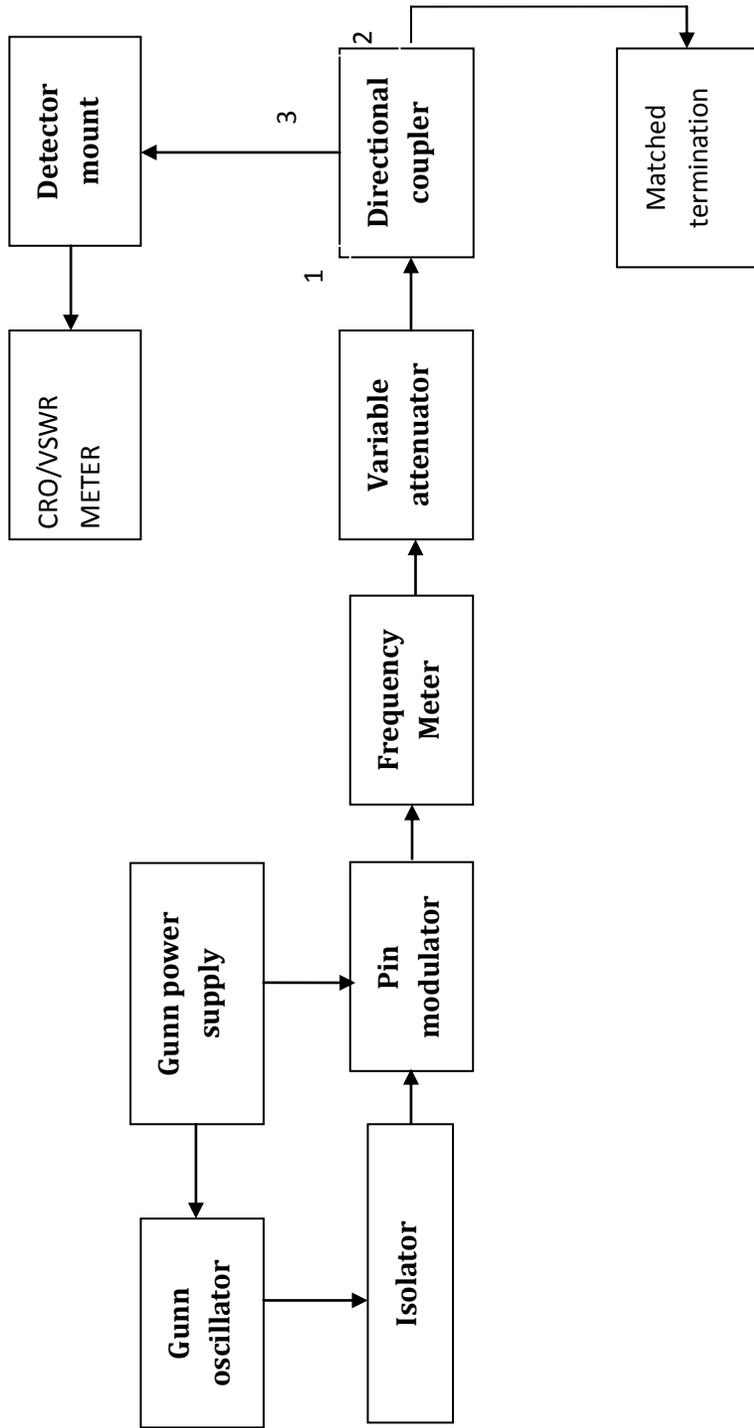


Figure: Bench setup for measurement of coupling losses

Experiment No.-7

Aim :

To measure the gain of a waveguide horn antenna.

Apparatus required :

Microwave source, Frequency meter, Isolator, Variable attenuator, Detector mount, Two horn antenna, Turn table, VSWR meter and Accessories.

Theory:

If a transmission line propagating energy is left open at one end, there will be radiation from this end. In case of a rectangular waveguide this antenna presents a mismatch of about 2 : 1 and it radiates in many directions. The match will improve if the open waveguide is a horn shape. The radiation pattern of an antenna is a diagram of field strength or more often the power intensity as a function of the aspect angle at a constant distance from the radiating antenna. The power intensity at the maximum of the main lobe compared to the power intensity achieved from an imaginary Omni directional antenna (radiating equally in all direction) with the same power fed to the antenna is defined as in gain of the antenna.

3 db Beam Width

The angle between the two points on a main lobe where the power intensity is half the maximum power intensity. When measuring an antenna pattern, it is normally most interesting to plot the pattern far from the antenna.

Far field pattern is achieved at a minimum distance of $2D$ (for rectangular Horn Antenna)

$$\lambda_0$$

where D is size of the broad wall of horn aperture in free space wave length.

It is also very important to avoid disturbing reflection. Antenna measurement are normally made at outdoor rangers or in so called anechoic chambers made of absorbing materials.

Antenna measurements are mostly made with unknown antenna as receiver. There are several methods to measure the gain of antenna. One method is to compare the unknown antenna with a standard gain antenna with known gain. An another method is to use two identical antennas, as transmitter and other as receiver from following formula the gain can be calculated.

$$P_r = \frac{P_t \lambda_0 G_1 G_2}{(4 \pi S)}$$

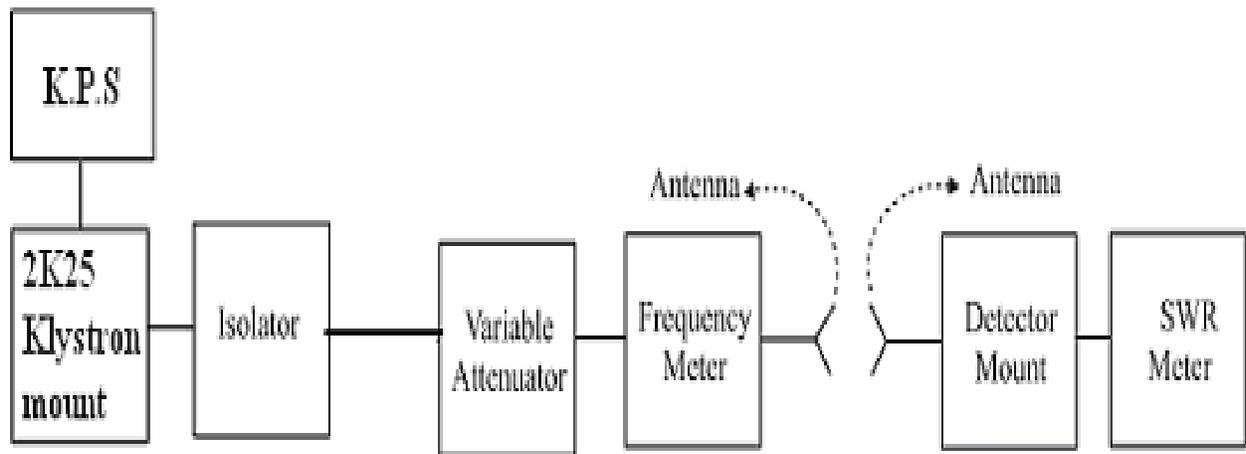
Where P_t = Transmitted Power ,

P_r = Received Power,

G_1, G_2 = Gain of transmitting & receiving antenna

λ_0 = free space wavelength

Block diagram:



Procedure: -

GAIN MEASUREMENT

1. Set up the equipments as shown in Fig. Both horns should be in line.
2. Keep the range db switch of VSWR meter at 50 db position with gain control full.
3. Energize the Gunn Oscillator for maximum output at desired frequency with modulating amplitude and frequency of Gunn Power Supply and by tuning of detector.
4. Obtain full scale deflection in VSWR meter with variable attenuator.
5. Replace the transmitting horn by detector mount and change the appropriate range db position to get the deflection on Scale (do not touch the gain control knob). Note and record the range db position and deflection of VSWR meter.
6. Calculate the difference in db between the power measured in step 4 and 5.

7. Convert G into db in above example

$$G \text{ db} = -10 \log 318 = -15.02 \text{ db}$$

8. The same set up can be used for other frequency of operation.

Precautions:-

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

Experiment No.-8

Aim:

To establish fiber optic analog link and to study the relationship between the input signal & received signal.

Equipment required

Link-A kit, 1 Meter Fiber cable, 20 MHz Dual Channel Oscilloscope, Power supply

THEORY

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

TRANSMITTER

Fiber optic transmitters are typically composed of a buffer, driver and optical source. The buffer electronics provides both an electrical connection and isolation between the transmitter and the electrical system supplying the data. The driver electronics provides electrical power to the optical source in a fashion that duplicates the pattern of data being fed to the transmitter. Finally the optical source (LED) converts the electrical current to light energy with the same pattern. The LED SFH756V supplied with the kit operates inside the visible light spectrum. Its optical output is centered at near visible wavelength of 660 nm. The emission spectrum is broad, so a dark red glow can usually be seen when the LED is on. The LED SFH450V supplied with the kit operates outside the visible light spectrum. Its optical output is centered at near infrared wavelength of 950 nm.

RECEIVER

The function of the receiver is to convert the optical energy into electrical form, which is then conditioned to reproduce the transmitted electrical signal in its original form. The detector

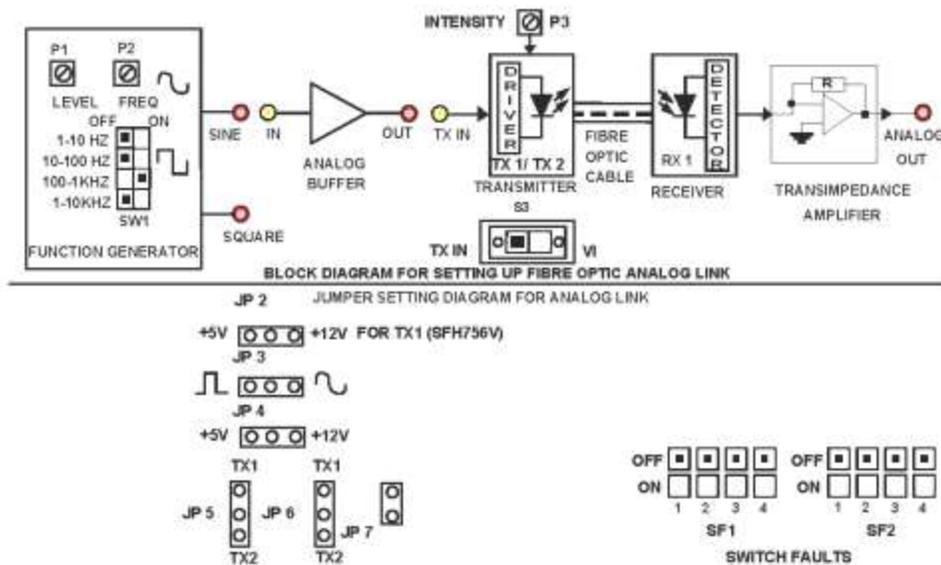
SFH250V used in the kit has a diode type output. The parameters usually considered in the case of detector are its responsivity at peak wavelength and response time. SFH250V has responsivity of about 4 μA per 10 μW of incident optical energy at 950 nm and it has rise and fall time of 0.01 μsec . PIN photodiode is normally reverse biased. When optical signal falls on the diode, reverse current starts to flow, thus diode acts as closed switch and in the absence of light intensity; it acts as an open switch. Since PIN diode usually has low responsivity, a trans impedance amplifier is used to convert this reverse current into voltage. This voltage is then amplified with the help of another amplifier circuit. This voltage is the duplication of the transmitted electrical signal.

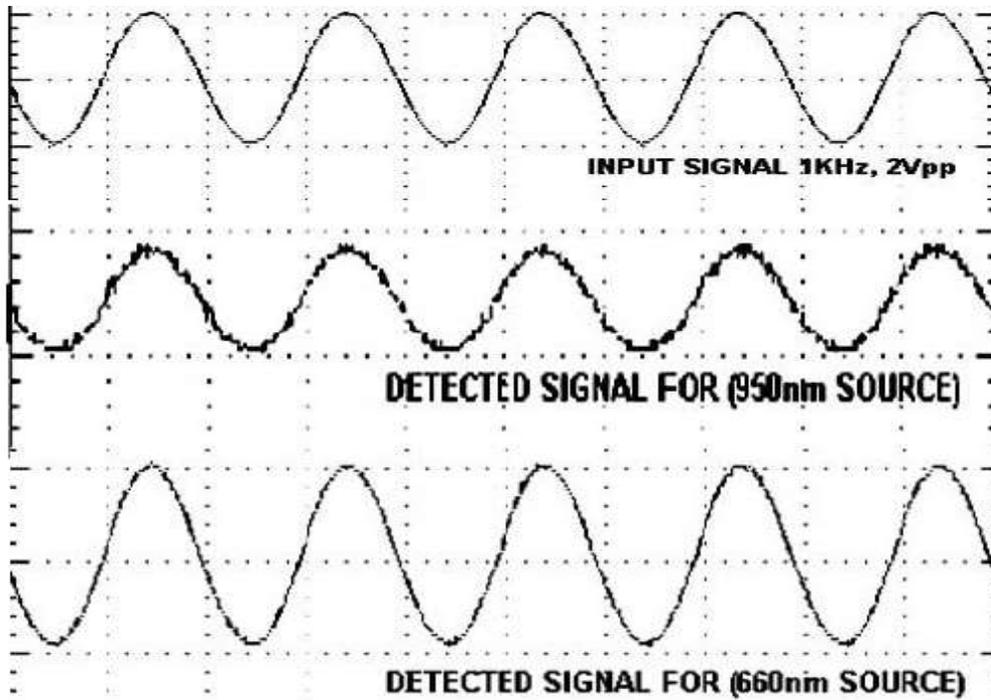
Procedure

1. Slightly unscrew the cap of LED SFH 756V TX1 (660 nm) from kit. Do not remove the cap from the connector. Once the cap is loosened, insert the fiber into the cap and assure that the fiber is properly fixed. Now tight the cap by screwing it back. Keep INTENSITY pot P3 at minimum position i.e. fully anticlockwise.
2. Make the connections and jumper settings as shown in Fig. Connect the power supply cables with proper polarity to kit. While connecting this, ensure that the power supply is OFF.
3. Switch on the Power supply.
4. Select the frequency range of Function Generator with the help of Range Selection Switch SW1, frequency can be varied with pot P2. adjust the voltage LEVEL of the sine wave with pot P1 as per following setting
FREQUENCY: 1 KHz, LEVEL: 2V p-p
5. Connect SINE post of the Function Generator section to IN post of Analog Buffer Section.
6. Connect OUT post of the Analog Buffer Section to TX IN post of TRANSMITTER.
7. Connect the other end of the fiber to detector SFH 250V (RX 1) in kit very carefully.
8. Check the output signal of the Analog Buffer at its OUT post in Kit. It should be same as that of the applied input signal.

9. Observe the output signal from the detector at ANALOG OUT post on CRO by adjusting INTENSITY (Optical Power Control) Pot P3 in kit and you should get the reproduction of the original transmitted signal
10. To measure the analog bandwidth of the link, connect the external Signal Generator with 2Vp-p sine wave to IN post of Analog Buffer Section and vary the frequency of the input signal from 100 Hz onwards. Measure the amplitude of the received signal for each frequency reading.
11. Plot a graph of gain / Frequency. Measure the frequency range for which the response is flat.

Repeat the procedure 1 to 11 for IR LED 450V (950nm) TX2.





Observations:

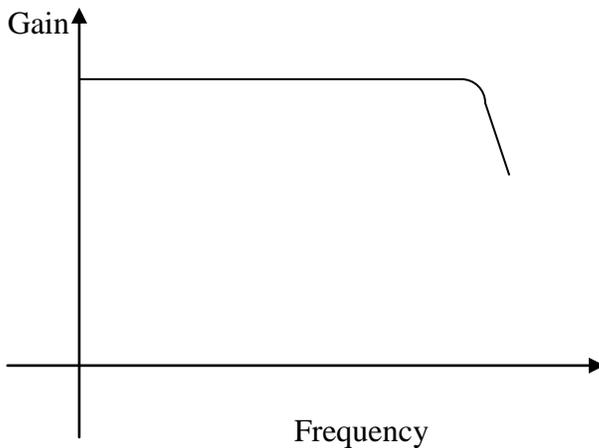
Frequency (Hz)

I/P Signal amplitude (Volts)

Output signal amplitude (Volts)

$$\text{Gain} = 20 \log (V_o / V_i) \text{ (dB)}$$

Model graph



Precautions:

It is very important that the optical sources 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.

Result:

On optical fiber link is established. The frequency response is observed. A graph is drawn between gains in (dB) Vs frequency in Hz.

Experiment No.-9

Aim:

To measure propagation loss in plastic fiber and also to measure the bending loss

Equipment required:

Link-A kit, 20 MHz Dual Trace Oscilloscope, 1 & 3 Meter Fiber cable, Power supply.

Theory:

Optical fibers are available in different variety of materials. These materials are usually selected by taking into account their absorption characteristics for different wavelengths of light. In case of optical fiber, since the signal is transmitted in the form of light, which is completely different in nature as that of electrons, one has to consider the interaction of matter with the radiation to study the losses in fiber. Losses are introduced in fiber due to various reasons. As light propagates from one end of fiber to another end, part of it is absorbed in the material exhibiting absorption loss. Also part of the light is reflected back or in some other directions from the impurity particles present in the material contributing to the loss of the signal at the other end of the fiber. In general terms it is known as propagation loss. Plastic fibers have higher loss of the order of 180 dB/Km. whenever the condition for angle of incidence of the incident light is violated the losses are introduced due to refraction of light. This occurs when fiber is subjected to bending. Lower the radius of curvature more is the loss. Another loss are due to the coupling of fiber at LED and photo detector ends.

Procedure:

1. Slightly unscrew the cap of LED SFH 756V TX1 (660 nm) from kit. Do not remove the cap from the connector. Once the cap is loosened, insert the fiber into the cap and assure that the fiber is properly fixed. Now tight the cap by screwing it back. Keep INTENSITY pot P3 at minimum position i.e. fully anticlockwise.
2. Make the connections and Jumper settings as shown in block diagram Connect the power supply cables with proper polarity to kit. While connecting this, ensure that the power supply is OFF.

3. Set the sine wave with 1 KHz, 2V p-p amplitude and connect it to IN post of analog buffer.
4. Connect the other end of the fiber to detector SFH 250V (RX 1) in kit very carefully Keep all the switch faults in OFF position.
5. Switch on the power supply.
6. Observe the output signal from the detector at ANALOG OUT post on CRO by adjusting INTENSITY (Optical Power Control) Pot P3 in kit and you should get the reproduction of the original transmitted signal. Mark this amplitude level as V1.
7. Now replace 1-meter fiber by 3-meter fiber without disturbing any of the previous settings. Measure the amplitude level at the receiver side again. You will notice that it is less than the previous one. Mark this as V2.
8. If alpha is the attenuation of the fiber then we have, $P1/P2=V1/V2=e^{-\alpha(L1+L2)}$ where alpha = nepers / meter L1 = fiber length for V1 L2 = fiber length for V2 This alpha is for the wavelength of 950 nm. To get the alpha for 660 nm wavelengths proceed as follows.
9. Repeat the above steps and replacing SFH 450V(950nm) by SFH 756V(660nm).
10. Make the Jumper settings as shown in the fig.
11. Compare the values of alpha and find out the wavelength, which has less attenuation in the fiber.

Measurement of bending losses

1. Repeat all the steps from 1 to 11 as above.
2. Bend the fiber in a loop as shown in block diagram Measure the amplitude of the received signal.
3. Keep reducing the diameter to about 2 cm & take corresponding output voltage readings. (Do not reduce loop diameter less than 2 cm.)
4. Plot a graph of the received signal amplitude versus the loop diameter.

Calculations

For 1 mt cable

Input voltage (V_1) = 1 Volt

Output voltage(V_2) =

Frequency = 1KHz

For 3mt cable

Input voltage (V_1) = 1 Volt

Output voltage(V_2) =

Frequency = 1KHz

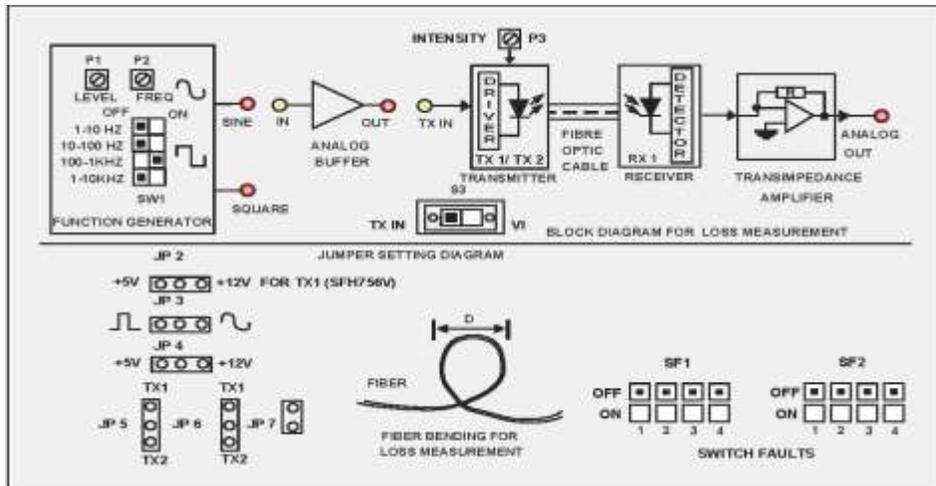
Attenuation loss

$V_1 / V_2 = \exp [-\alpha (l_1 + l_2)]$; $l_1 = 1 \text{ mt}$; $l_2 = 3\text{mt}$; $\alpha =$ nepers / mt

Observations

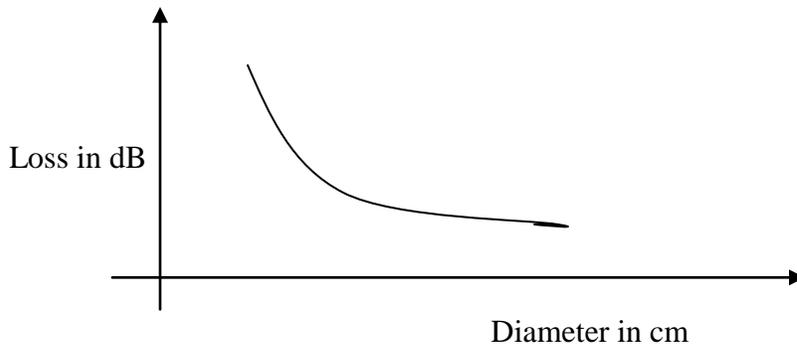
Input voltage (V_1) = 1 Volt

S.No	Diameter (cm)	Out put Voltage (volts)	Loss in dB = $-20 \log_{10}$ (V_0 / V_i)



BLOCK DIAGRAM FOR LOSS MEASUREMENT

MODEL GRAPH



Precautions

It is very important that the optical sources 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.

Result

The attenuation factor α is found. The bending loss is calculated for different diameters of curvature. It is observed that bending loss is less as diameter increases.

Experiment No.10

Aim:

To study the VI characteristics of fiber optic LED'S. and Photo Detector

Equipment required

Link-A kit, 20 MHz Dual Trace Oscilloscope, 1 & 3 Meter Fiber cable, Power supply, Voltmeter, Current meter, Jumper Connecting Wires-4.

Theory

In optical fiber communication system, electrical signal is first converted into optical signal with the help of E/O conversion device as LED. After this optical signal is transmitted through optical fiber, it is retrieved in its original electrical form with the help O/E conversion device as photo detector.

Different technologies employed in chip fabrication lead to significant variation in parameters for the various emitter diodes. All the emitters distinguish themselves in offering high output power coupled into the plastic fiber. Data sheets for LEDs usually specify electrical and optical characteristics, out of which are important peak wavelength of emission, conversion efficiency (usually specified in terms of power launched in optical fiber for specified forward current), optical rise and fall times which put the limitation on operating frequency, maximum forward current through LED and typical forward voltage across LED.

Photo detectors usually come in variety of forms like photoconductive, photovoltaic, transistor type output and diode type output. Here also characteristics to be taken into account are response time of the detector, which puts the imitation on the operating frequency, wavelength sensitivity and responsivity.

Procedure

(A) Characteristics of Fiber Optic LED

1. Make the jumper and switch settings as shown in the jumper diagram. Keep pot P4 in fully clockwise position.
2. Connect the ammeter with the jumper connecting wires (provided along with the kit) in jumpers JP3 as shown in the diagram.

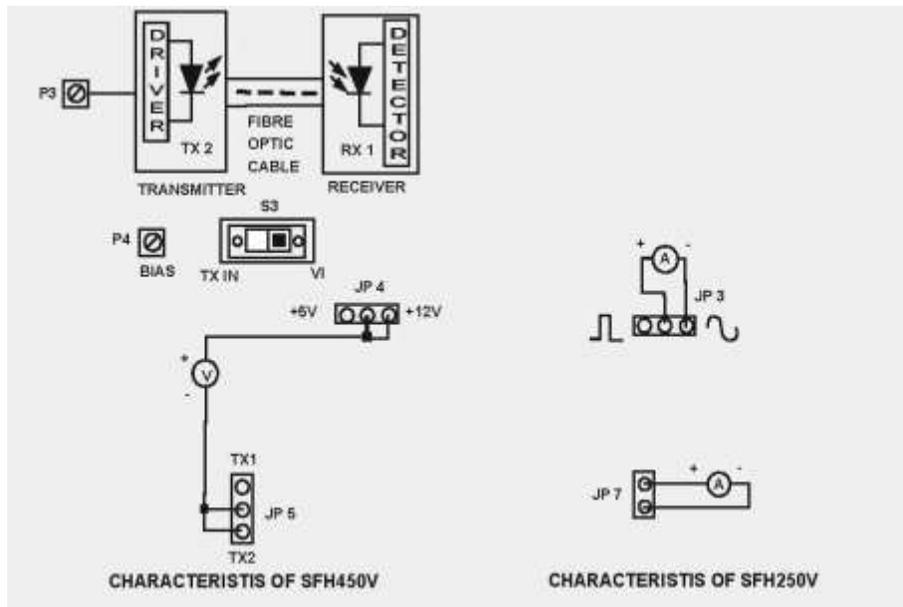
3. Connect the voltmeter with the jumper wires to JP5 and JP2 at positions as shown in the diagram.
4. Switch on the power supply. Keep the potentiometer P3 in its minimum position (fully anticlockwise position), P4 is used to control biasing voltage of the LED. To get the VI characteristics of LED, rotate P3 slowly and measure forward current and corresponding forward voltage of the LED, Take number of such readings for forward voltage, forward current & optical power. Keep SW towards VI position.
5. For each reading taken above, find out the power, which is product of I and V. This is the electrical power supplied to the LED. Data sheets for the LED specifies optical power coupled into plastic fiber when forward current was 10 micro A as 200microW. This means that the electrical power at 10mA current is converted into 200 micro W of optical energy. Hence the efficiency of the LED comes out to be approx. 1.15%.
6. With this efficiency assumed, find out optical power coupled into plastic optical fiber for each of the reading in step 4. Plot the graph of forward current v/s output optical power of the LED.
7. Repeat the above procedure by using SFH 450V (950 nm) LED.

(B) Characteristics of detector

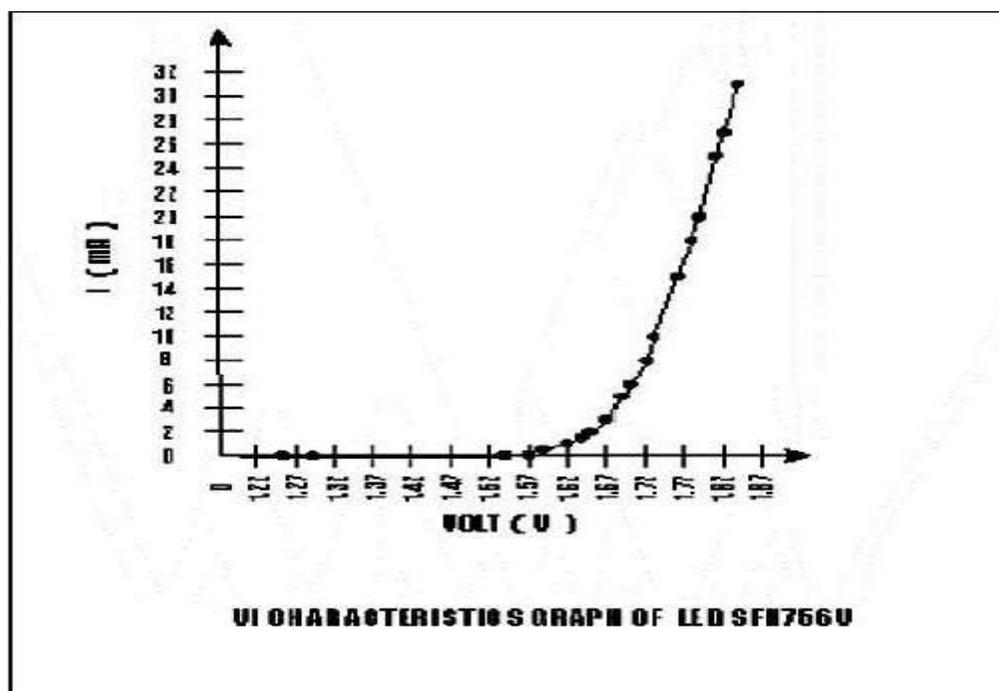
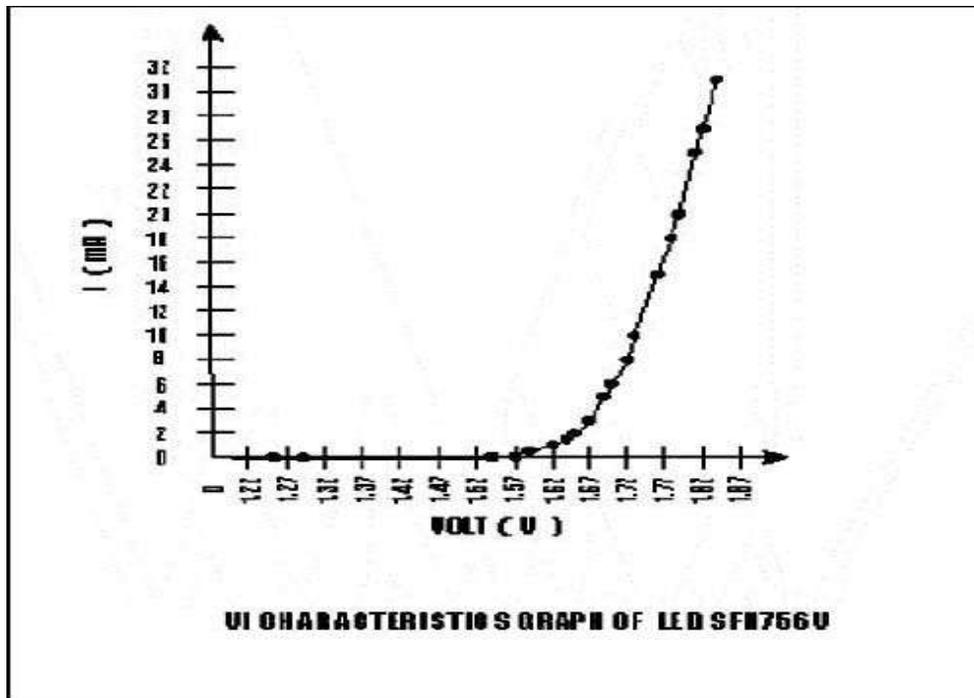
1. Make the jumper and switch settings as shown in the jumper diagram. Keep pot P4 in fully clockwise position.
2. Connect the ammeter with the jumper connecting wires (provided along with the kit) in jumpers JP7 as shown in the diagram.
3. Connect 1Meter Fiber between TX1 & RX1.
4. Measure the current flowing through Detector (RX1) SFH250V at corresponding optical power output (Normally in u A) as per the table.
5. We can observe that as incident optical power on detector increases, current flowing through the detector increases.

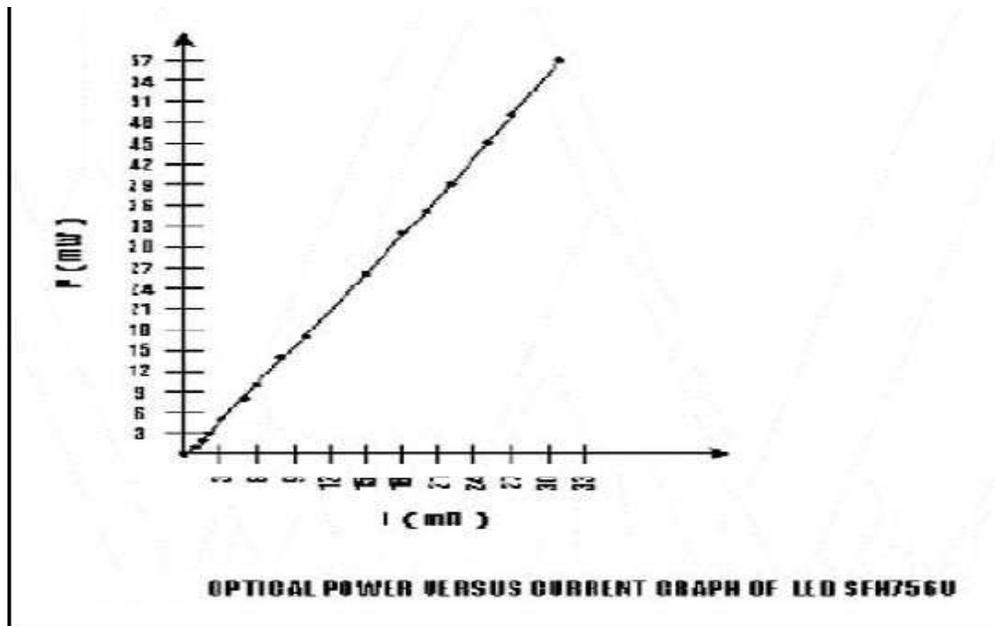
Observations

Sl.No	Forward Voltage of LED (V)	Forward Current of LED (mA)	Electrical Power $P_i = V * I$	Optical power of LED $P_o = P_i * 1.15\%$	Output current (μA)



BLOCK DIAGRAM FOR CHARACTERISTICS OF LED & DETECTOR





Precautions

It is very important that the optical sources 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.

Result:

The characteristics of LED & DETECTOR are found.

Experiment No.-11

Aim:

To measure the numerical aperture of the plastic fiber

Equipment required

Link-A kit, 1 Meter Fiber cable, NA JIG, Steel Ruler, Power supply

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 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.

Considerations in na measurement

1. It is very important that the optical source should be properly aligned with the cable and distance from the launched point and the cable is properly selected to ensure that the maximum amount of optical power is transferred to the cable.

This experiment is best performed in a less illuminated room.

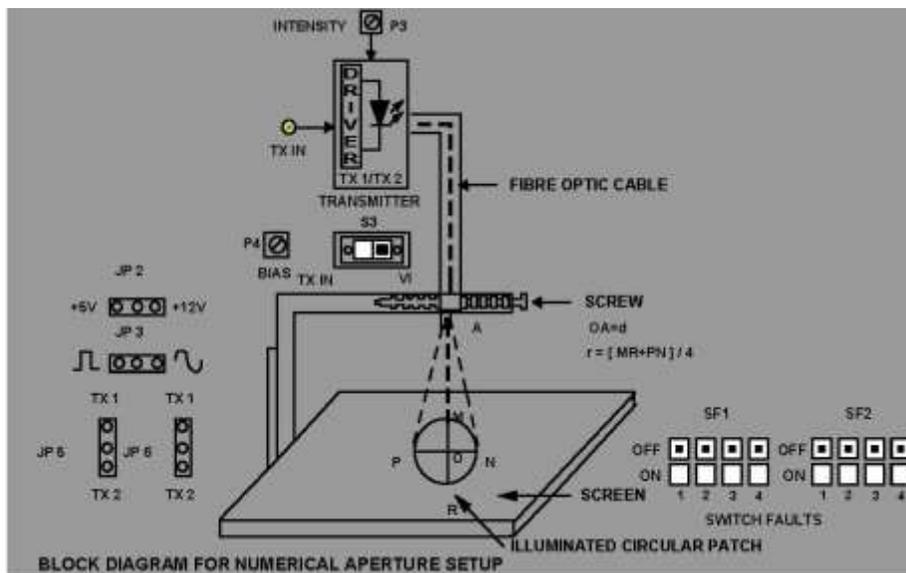
Procedure

1. Slightly unscrew the cap of LED SFH756V (660 nm). Do not remove the cap from the connector. Once the cap is loosened, insert the fiber into the cap. Now tight the cap by screwing it back. Keep Jumpers JP2 towards +5V position, JP3 towards sine position, JP5 & JP6 towards TX1 position.
2. Connect the power supply cables with proper polarity to kit. While connecting this, ensure that the power supply is OFF. Do not apply any TTL signal from Function Generator. Make the connections as shown in block diagram.
3. Keep Pot P3 fully Clockwise Position and P4 fully anticlockwise position.
4. Switch on the power supply.
5. Insert the other end of the fiber into the numerical aperture measurement jig. Hold the white sheet facing the fiber. Adjust the fiber such that its cut face is perpendicular to the axis of the fiber.

6. Keep the distance of about 10 mm between the fiber tip and the screen. Gently tighten the screw and thus fix the fiber in the place.
7. Now adjust Pot P4 fully Clockwise Position and observe the illuminated circular patch of light on the screen.
8. Measure exactly the distance d and also the vertical and horizontal diameters MR and PN indicated in the block diagram.
9. Mean radius is calculated using the following formula. $r = (MR + PN) / 4$
10. Find the numerical aperture of the fiber using the formula. NA =

$$\sin\theta_{\max} = r / \sqrt{d^2 + r^2}$$

Where θ_{\max} is the maximum angle at which the light incident is properly transmitted through the fiber



BLOCK DIAGRAM FOR NUMERICAL APERTURE SET UP

Observations

Sl.No	Distance between source and center of circular patch AO = d cm	Vertical Diameter MR cm	Horizontal diameter PN cm

Calculations

Mean radius $r = (MR+PN) / 4$

Numerical Aperture $NA = \sin\theta_{\max} = r / \sqrt{d^2 + r^2}$

Precautions

It is very important that the optical sources 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.

Result

The Numerical Aperture of the optical fiber is found.