LIST OF EXPERIMENTS

1. Reflex Klystron Characteristics
2. Gunn Diode Characteristics
3. Directional Coupler Characteristics
4. VSWR Measurement
5. Frequency and Wavelength Measurement
6. Circulator Characteristics
7. Scattering Parameters of Magic Tee
8. Impedance Measurement
9. Characterization of LED
10. Characterization of LASER
11. Intensity modulation of LASER output through an optical fiber
12. Measurement of data rate for digital optical link
13. Measurement of losses for analog optical link

EXPERIMENT-1

REFLEX KLYSTRON CHARACTERISTICS

AIM:

To verify the characteristics of Reflex Klystron tube and to determine the electronic tuning range.

APPARATUS:

1. Klystron Power Supply SKPS-610
2. Klystron Tube 2K-25 with Klystron MOLInt-XM-251
3. Isolator XI-621
4. Frequency Meter XF-710
5. Variable Attenuator XA-520
6. Detector Mount XD-451
7. Wave Guide Stand XU-535
8. VSWR Meter SW-215
9. Oscilloscope
10. BNC Cable

THEORY:

The Reflex Klystron makes the use of velocity modulation to transform continuous electron beam energy into microwave power. Electrons emitted from the cathode are accelerated and passed through the positive resonator towards negative reflector, which retards and, finally, reflects the electrons and the electron turn back through the resonator. Suppose an RF- Field exists between the resonator, the electrons traveling forward will be accelerated or retarded, as the voltage at the resonator changes in amplitude. The accelerated electrons leave the resonator at an increased velocity and the retarded electrons leave at the reduced velocity. The electrons leaving the resonator will need different time to return, due to change in velocities. As a result, returning electrons group together in bunches. As the electron bunches pass through resonator, they interact with voltage at the resonator grids. If the bunches passes the grid at such time that the electrons are slowed down by the voltage then energy will be delivered to the resonator and the Klystron will oscillate. Fig. 2 & 3 shows the relationship between output power, frequency and reflector voltages.

The frequency is primarily determined by the dimensions of the 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.

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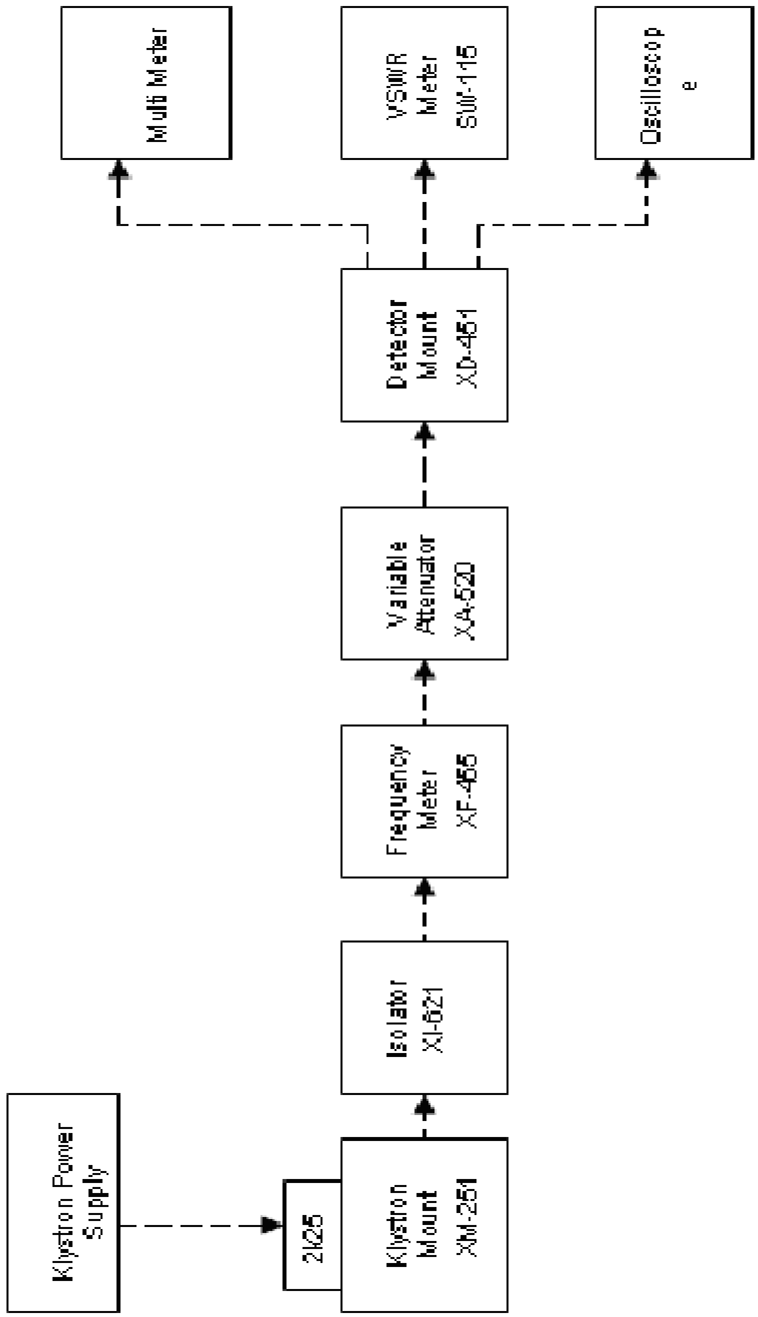

FIG. 1 SET UP FOR STUDY OF KLYSTRON TUBE

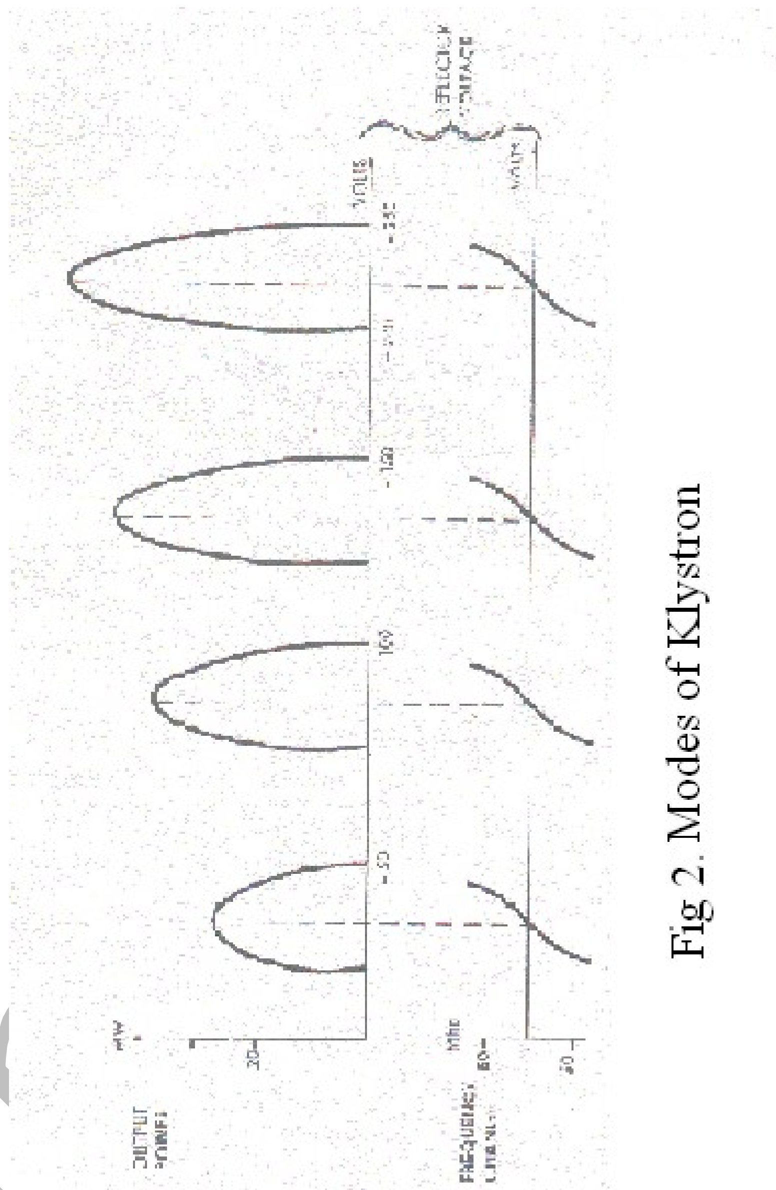

Fig 2. Modes of Klystron

PROCEDURE:

A) **Carrier Wave Operation**

1. Connect the components and equipment as shown in Fig.1.
2. Set the variable attenuator at the minimum position.
3. Set the Mod-switch of Klystron Power Supply at CW position, beam voltage control knob to fully anticlockwise and reflector voltage control knob to fully clock wise and the meter Switch to OFF position.
4. Rotate the knob of frequency meter at one side fully.
5. Connect the DC Microampere meter with detector.
6. Switch ON the Klystron Power Supply, VSWR Meter and Cooling Fan for the Klystron Tube.
7. Put on beam voltage switch and rotate the beam voltage knob clockwise slowly up to 300V meter reading and observe beam current position," the beam current should not increase more than 30mA.
8. Change the reflector voltage slowly and watch current meter. Set the voltage for maximum deflection in the meter.
9. Tune the plunger of klystron mount for the maximum output.
10. Rotate the knob of frequency meter slowly and stop at the position, where there is lowest output current on multimeter. Read directly the frequency meter between two horizontal line and vertical marker. If micrometer type frequency meter is used, read the micrometer reading and use the frequency chart.
11. Change the reflector voltage and read the current and frequency for each reflector voltage.

B) **Square Wave Operation**

1. Connect the equipment and components as shown in figure1.
2. Set micrometer of variable attenuator around some position.
3. Set the range switch of VSWR meter at 40dB position, input selector switch to crystal impedance.
4. Set Mod-Selector switch to AM-MOD position, beam voltage control knob to fully anticlockwise position.
5. Switch ON the klystron power supply, VSWR meter, cooling fan.
6. Switch ON the beam voltage switch and rotate the beam voltage knob clockwise up to 300V deflection in meter.

7. Keep the AM-MOD amplitude knob and AM-FRE knob at mid position.
8. Rotate the reflector voltage knob to get deflection in VSWR meter.
9. Rotate the AM-MOD amplitude knob to get maximum output in VSWR meter.
10. Maximize the deflection with frequency knob to get maximum output in VSWR meter.
11. If necessary, change the range switch of VSWR meter from 30dB to 50dB if the deflection in VSWR meter is out of scale or less than normal scale respectively. Further the output can be also reduced by variable attenuator for setting the output for any particular position. Find the oscillator frequency by frequency meter as described in the earlier set up.

C) <u>Mode Study on Oscilloscope</u>

1. Setup the components and equipments as shown in figure1.
2. Keep the position of variable attenuator at minimum attenuation position.
3. Set the mode selector switch to FM-MOD position, FM amplitude and FM frequency knob at mid position, keep beam voltage knob fully anticlockwise and reflector voltage knob to fully clockwise position and beam switch to OFF position.
4. Keep the time/division scale of oscilloscope around 100Hz frequency measurement and Volt/div to lower scale.
5. Switch on the Klystron Power Supply and Oscilloscope.
6. Switch ON beam voltage switch and set beam voltage to 300V by beam voltage control knob.
7. Keep amplitude knob of FM Modulator to maximum position and rotate the reflector voltage anticlockwise to get modes as shown in figure2. on the Oscilloscope. The horizontal axis represents reflector voltage and vertical axis represents output power.
8. By changing the reflector voltage and amplitude of FM modulation, any mode of Klystron Tube can be seen on Oscilloscope.

OBSERVATIONS:

Beam Voltage =

Repeller Voltage =

Tabular Form

S.No	Repeller Voltage	Frequency	PowerMeter reading(dBm)

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RESULT: The characteristics of Reflex Klystron has been studied and modes have been found.

EXPERIMENT-2

GUNN DIODE CHARACTERISTICS

AIM:

To verify the V-I characteristics of Gunn Diode.

APPARATUS:

1. Gunn Power Supply GS-610
2. Gunn Oscillator XG-11
3. Isolator XI-621
4. Frequency Meter XF-710
5. Matched Termination XL-400
6. Oscilloscope
7. BNC Cable

THEORY:

The Gunn Oscillator is based on negative differential conductivity effect in bulk semiconductors which has two conduction bands separated by an energy gap (greater than thermal energies). A disturbance at the cathode gives rise to high field region which travels towards the anode. When this field domain reaches the anode, it disappears and another domain is formed at the cathode and starts moving towards anode and so on. The time required for domain to travel from cathode to anode (transit time) gives oscillation frequency.

In a Gunn Oscillator, the Gunn diode is placed in a resonant cavity. The Oscillator frequency is determined by cavity dimensions.

Although Gunn Oscillator can be amplitude modulated with the bias voltage. We have used a PIN modulator for square wave modulation of the signal coming from Gunn diode.

A measure of the square wave modulation capability is the modulation depth i.e. the output ratio between ON and OFF state.

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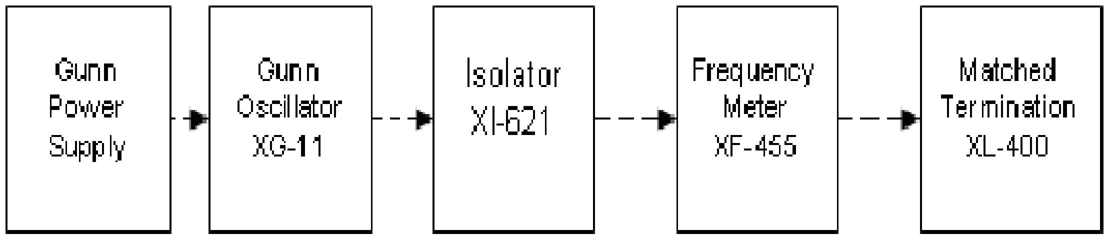

FIG.1 SETUP FOR THE STUDY OF
DC V-I CHARACTERISTICS OF GUNN OSCILLATOR

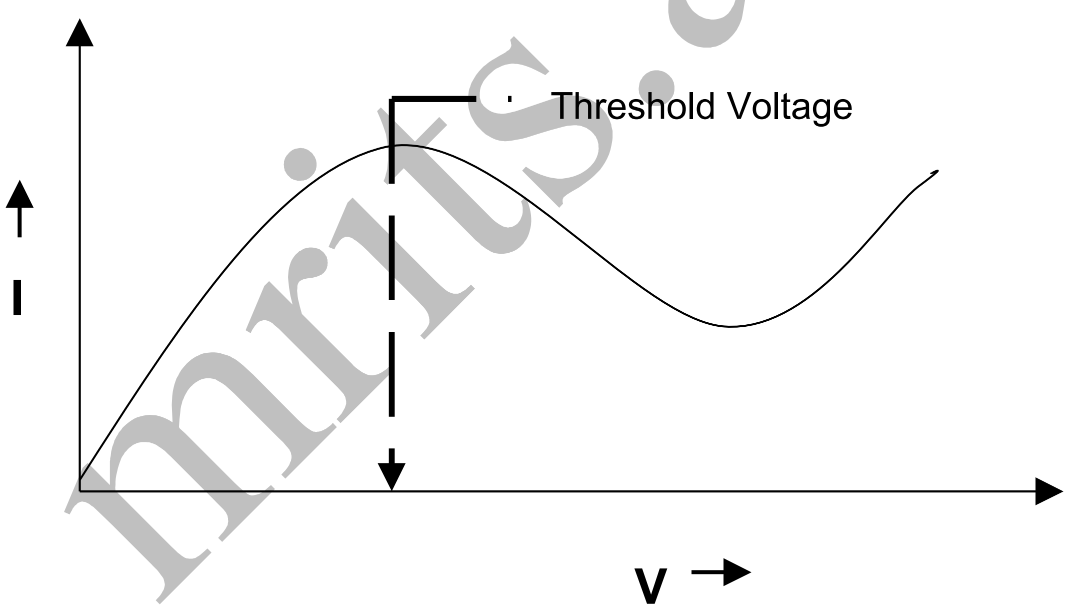

FIG 2. V-I CHARACTERISTICS OF GUNN OSCILLATOR

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PROCEDURE:

1. Set the components as shown in Fig.1.
2. Keep the control knobs of Gunn Power Supply as below:
   Meter Switch - OFF
   Gunn Bias Knob - Fully Anticlockwise
   PIN Bias Knob - Fully Anticlockwise
   PIN Mode Frequency - Any Position
3. Set the micrometer of Gunn Oscillator for required frequency of operation.
4. Switch ON the Gunn Power Supply.
5. Measure the Gunn Diode Current corresponding to the various Gunn bias voltage through the digital panel meter and meter switch. Do not exceed the bias voltage above 10V.
6. Plot the voltage and current readings on the graph.
7. Measure the threshold voltage which corresponds to maximum current.

Note: DO NOT KEEP GUNN BIAS KNOB POSITION AT THRESHOLD POSITION FOR MORE THAN 10-15 SECONDS. READING SHOLD BE OBTAINED AS FAST AS POSSIBLE, OTHERWISE DUE TO EXCESSIVE HEATING AND GUNN DIODE MAY BURN.

TABULAR FORM

S.No	Voltage	Current

RESULT: The Gunn diode characteristics have been observed and are drawn.

EXPERIMENT-3

DIRECTIONAL COUPLER CHARACTERISTICS

AIM:

To study the function of Multi Hole Directional coupler by finding the Coupling factor and Directivity of the coupler.

APPARATUS:

1. Klystron Power Supply SKPS-610(or Gunn Power Supply)
2. Klystron Tube 2K-25 with Klystron MOLInt-XM-2(or Gunn Diode)
3. Isolator XI-621
4. Frequency Meter XF-710
5. Variable Attenuator XA-520
6. Slotted LineSX-651
7. Tunable Probe SP-655
8. Detector Mount XD-451
9. Matched Termination XL-400
10. Multi Hole Directional Coupler XK-620
11. Wave Guide Stand XU-535
12. VSWR Meter SW-215
13. Oscilloscope
14. BNC Cable

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, the main arm and the auxiliary arm, electromagnetically coupled to each other refer to Fig.1.

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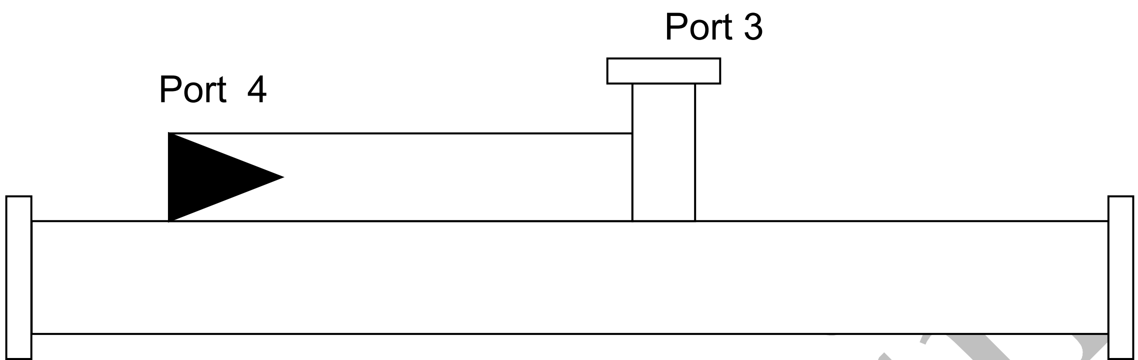

FIG.1 DIRECTIONAL COUPLER

The power entering in the main arm gets divided between ports 2 and 3 and almost no power in port 4. Power entering at port 2 is divided between port1 and 4. directional coupler parameters are determined by using

Coupling Factor C (dB)= 10 log $_{10}$ [P_1/P_3] when port 2 is terminated.

Isolation I (dB) = 10 log $_{10}$ [P_2/P_3] when port 1 is terminated.

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

Directivity (dB) = I-C=10 log $_{10}$ [P_2/P_1]

Main line VSWR is measured, looking into the main-line input terminal when the matched loads are placed at all other ports.

Auxiliary line VSWR is measured in the auxiliary line looking into the output terminal when the matched loads are placed on other terminals.

Main line insertion loss is the attenuation introduced in the transmission line by insertion loss of coupler, is defined as

Insertion Loss (dB) = 10 log $_{10}$ [P_1/P2]

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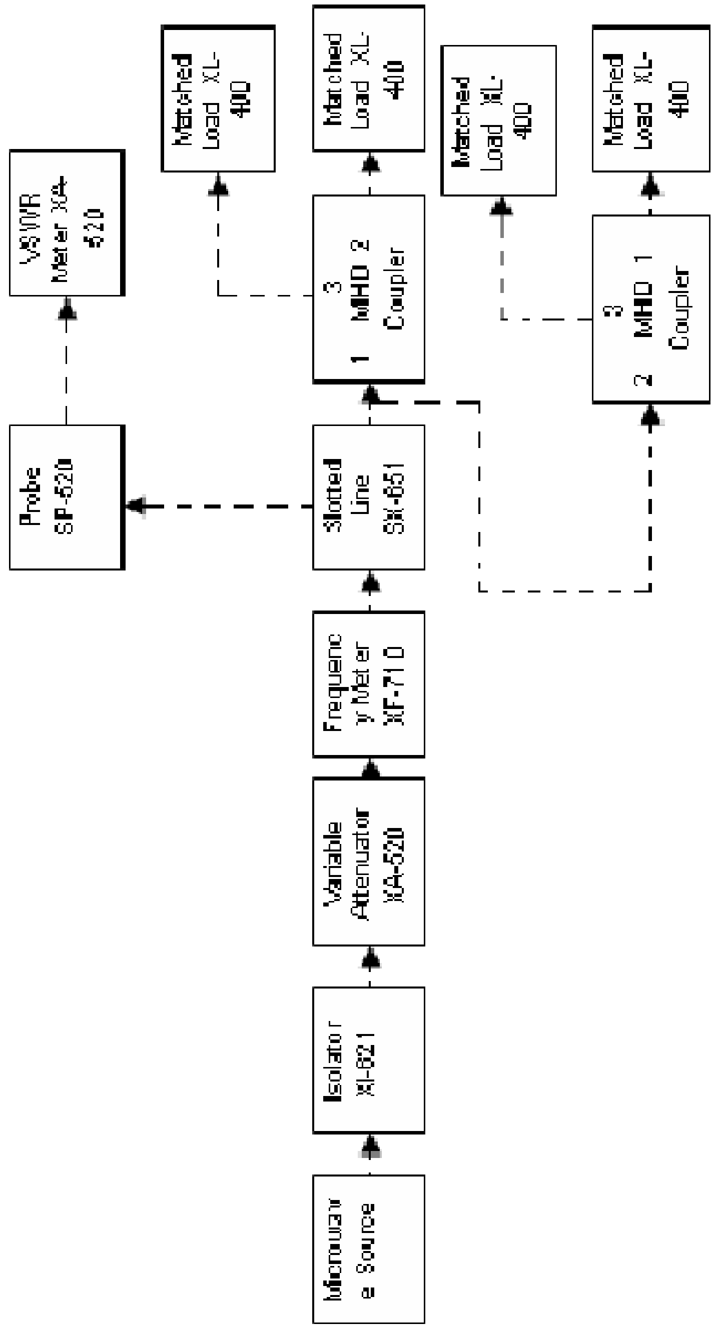

FIG 2 SETUP FOR MEASUREMENT OF VSWR OF MHD. COUPLER

PROCEDURE:

1. Set up the components and equipment as shown in figure2.
2. Energize the microwave source for particular frequency of operation.
3. Remove the multi hole directional coupler and connect the detector mount of the frequency meter. Tune the detector for maximum frequency.
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 reference level X
5. Insert the directional coupler as shown in figure 2 with detector to the auxiliary port 3 and matched termination to port2. Without changing the position of variable attenuator and gain control knob of VSWR meter.
6. Note down the reading on VSWR meter on the scale with the help of range-db switch if required. Let it be Y.
7. Calculate the Coupling factor which is given as X-Y=C (dB).
8. Now carefully disconnect the detector from the auxiliary port 3 and matched termination from port2 without disturbing the setup.
9. Connect the matched termination to port 3 and detector to port 2 and measure the reading on VSWR meter. Let it be Z.
10. Compute the Insertion Loss which is given as X-Z in dB.
11. Repeat the steps from 1 to 4.
12. Connect the directional coupler in 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.
13. Measure and note down the reading on VSWR meter. Let it be Y_d.
14. Compute the Isolation which is given as $X-Y_d$=I (dB).
15. Compute the directivity as $Y-Y_d$= I-C
16. Repeat the same for other frequencies.

OBSERVATIONS:

Beam Voltage =
Repeller Voltage =
Input Power at Port 1(X) =
Power at Port 2(Y) =
Power at port 3(Z) =
Input Power at port 2 (X) =
Power at port 3(Yd) =

CALCULATIONS:

Insertion Loss(X-Z) =
Coupling Factor(X-Y)=
Isolation(X-Yd) =
Directivity(Y-Yd) =

RESULT: Directional coupler characteristic parameters are obtained.

EXPERIMENT-4

VSWR MEASUREMENT

AIM:

To determine the Voltage Standing Wave Ratio and Reflection Coefficient of a waveguide.

APPARATUS:

1. Klystron Power Supply SKPS-610
2. Klystron Tube 2K-25 with Klystron MOLInt-XM-2
3. Klystron Mount XM-25
4. Isolator XI-621
5. Frequency Meter XF-710
6. Variable Attenuator XA-520
7. Slotted Line SX-651
8. Tunable Probe XP-655
9. SS Tuner XT-441
10. Detector Mount XD-451
11. Wave Guide Stand XU-535
12. VSWR Meter SW-215
13. Oscilloscope
14. BNC Cable

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, give 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 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 is defined as ratio between maximum and minimum field strength along the line. VSWR is denoted by S and is given as

$$S = \frac{E_{max}}{E_{min}}$$

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

E_i= Incident Voltage

E_r= Reflected Voltage

Reflection Coeffecient, ρ is

$$\rho = \frac{E_r}{E_i} = \frac{Z_L-Z_0}{Z_L+Z_0}$$

Where Z_L is the load impedance, Z_0 is characteristics impedance. The above equation gives following equation.

$$\rho = \frac{S-1}{S+1}$$

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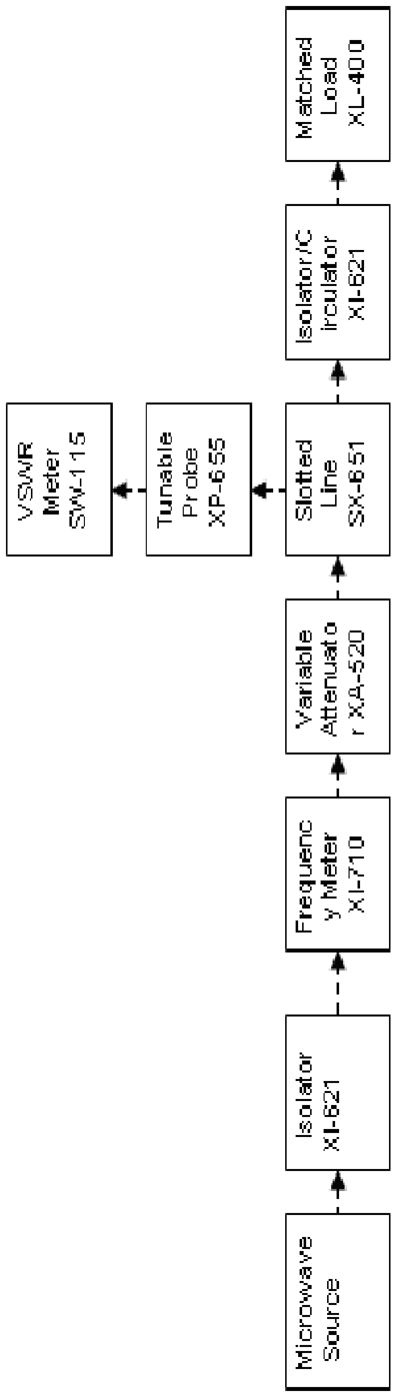
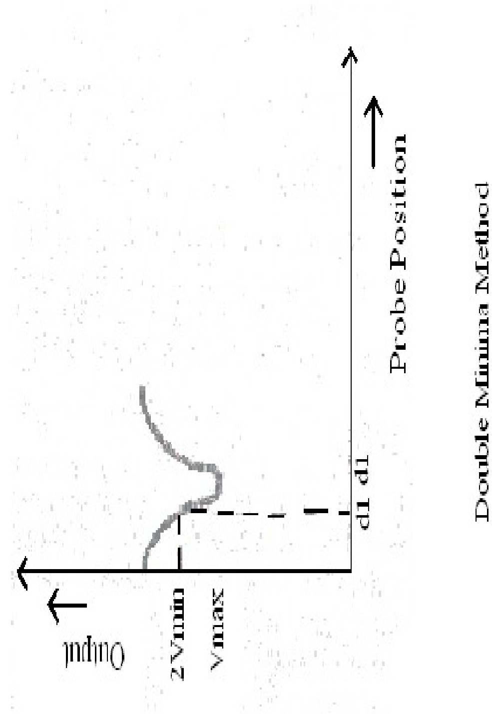
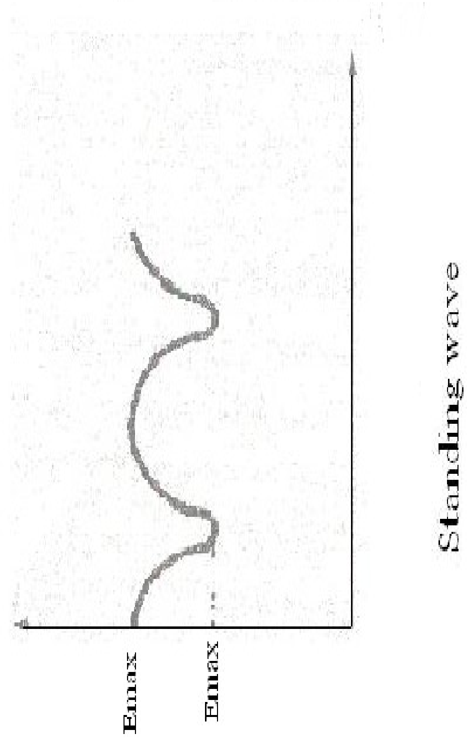


FIG1. SET UP FOR VSWR MEASUREMENT





PROCEDURE:

1. Set up the components and equipments as shown in figure.
2. Keep the variable attenuator in the minimum attenuation position.
3. Keep the control knobs of VSWR meter as below

Range dB	-	40 db/50db
Input Switch	-	Low Impedance
Meter Switch	-	Normal
Gain (Coarse- Fine)	-	Mid Position Approx.

4. Keep the control knobs of Klystron Power Supply as below

Beam Voltage	-	OFF
Mod- Switch	-	AM
Beam Voltage Knob	-	Fully Anticlockwise
Reflector Voltage Knob	-	Fully Clockwise
AM-Amplitude Knob	-	Around Fully Clockwise
AM- Frequency Knob	-	Mid position

5. Switch ON the Klystron Power Supply, VSWR meter and Cooling Fan.
6. Switch ON the Beam Voltage Switch position and set the beam voltage at 300V.
7. Rotate the reflector voltage knob to get deflection in VSWR meter.
8. Tune the output by turning the reflector voltage knob, amplitude and frequency of AM Modulation.
9. Tune the plunger of Klystron Mount and Probe for maximum deflection in VSWR meter.
10. If required, change the range db- switch variable attenuator position and gain control knob to get maximum deflection in the scale of VSWR meter.
11. As you move probe along the slotted line, the deflection in VSWR meter will change.

A. **Measurement of Low and Medium VSWR**

1. Move the probe along the slotted line to get maximum deflection in VSWR meter.
2. Adjust the VSWR meter gain control knob or variable attenuator until the meter indicates 1.0 on normal VSWR meter scale.
3. Keep all the control knobs as it is, move the probe to the next minimum position. Read the VSWR on scale.
4. Repeat the above step for change of SS Tuner probe depth and record the corresponding VSWR.

5. If the VSWR is between 3.2 and 10, change the range db switch to next higher position and read the VSWR on second VSWR scale of 3 to 10.

B. **Measurement of High VSWR(Double Minima Method)**

1. Set the depth of SS Tuner slightly more for maximum VSWR.
2. Move the probe along with slotted line until a minimum is indicated.
3. Adjust the VSWR meter gain control knob and variable attenuator to obtain a reading of 3db in the normal dB scale (0 to 10dB) of VSWR meter.
4. Move the probe to the left on the slotted line full scale deflection is obtained on 0-10dB scale. Note and record the probe position on slotted line. Let it be d_1.
5. Repeat the steps 3 and then move the probe right along the slotted line until full scale deflection is obtained on 0-10 dB in normal dB scale. Let it be d_2.
6. Replace the SS Tuner and termination by movable short.
7. Measure the distance between the successive minima positions of the probe. Twice this distance is guide wavelength λ_g.
8. Compute SWR from the following equation

$$SWR = \lambda_g/\pi\ (d_1-d_2)$$

OBSERVATIONS:

Beam Voltage =
Repeller Voltage =

Low VSWR

Reading on VSWR meter =

High VSWR

Position of first minima =
Position of second minima =
Distance between two minima=

CALCULATIONS:

$$VSWR\ (S) = \lambda_g/\pi\ (d_1-d_2)$$

$$\rho = \frac{S-1}{\ldots\ldots} =$$

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S+1

RESULT: Voltage standing wave ratio has been calculated by direct reading and double minima method.

EXPERIMENT-5

FREQUENCY AND WAVELENGTH MEASUREMENT

AIM:

To determine the frequency and wavelength in rectangular wave guide working in TE_{10} mode.

APPARATUS:

1. Klystron Power Supply SKPS-610
2. Klystron Tube 2K-25 with Klystron MOLInt-XM-2
3. Klystron Mount XM-25
4. Isolator XI-621
5. Frequency Meter XF-710
6. Variable Attenuator XA-520
7. Slotted Line SX-651
8. Tunable Probe XP-655
9. Detector Mount XD-451
10. Matched termination XL-400
11. Wave Guide Stand XU-535
12. Movable Short XT-481
13. VSWR Meter SW-215
14. Oscilloscope
15. BNC Cable

THEORY:

For dominant TE_{10} mode Rectangular waveguide λ_0, λc, λg are related as below

1 1 1

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$$\frac{}{\lambda^2_0} = \frac{}{\lambda^2_g} + \frac{}{\lambda^2_c}$$

Where λ_0 is free space wave length
λg is guide wavelength
λc is cut off wavelength

For TE $_{10}$ mode λ_c=2a where a is broader dimension of waveguide.

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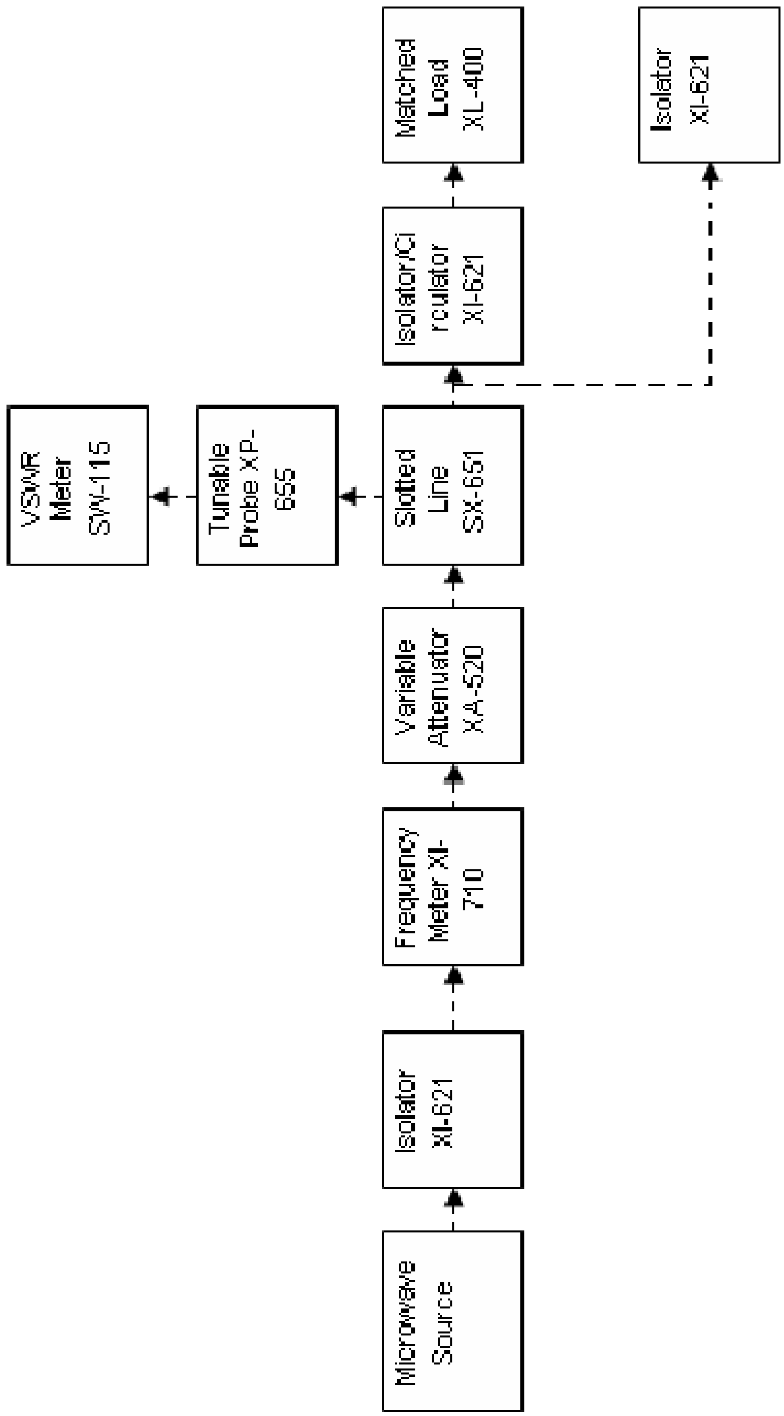

FIG. SETUP FOR FREQUENCY & WAVE-LENGTH MEASUREMENT

PROCEDURE:

1. Set up the components and equipment as shown in figure.
2. Set the variable attenuator at minimum attenuation position.
3. Keep the control knobs of VSWR Meter as below:

Range	-	50dB
Input Switch	-	Crystal low Impedance
Meter Switch	-	Normal Position
Gain(Coarse Fine)	-	Mid Position

4. Keep the control knobs Klystron Power Supply as below

Beam Voltage	-	OFF
Mod-Switch	-	AM
Beam Voltage Knob	-	Fully Anticlockwise
Reflector Voltage	-	Fully Clockwise
AM Amplitude Knob	-	Around Fully Clockwise
AM Frequency Knob	-	Around Mid Position

5. Switch ON the Klystron Power Supply, VSWR meter and Cooling fan.
6. Switch ON the beam voltage switch and set beam voltage at 300V with the help of beam voltage knob.
7. Adjust the reflector voltage to get some deflection in VSWR meter.
8. Maximize the deflection with AM amplitude and frequency control knob of power supply.
9. Tune the plunger of Klystron mount for maximum deflection in VSWR meter.
10. Tune the reflector voltage knob for maximum deflection.
11. Tune the probe for maximum deflection in VSWR meter.
12. Tune the frequency meter knob to get a dip on the VSWR scale and note down the frequency directly from frequency meter.
13. Replace the termination with movable short, and detune the frequency meter.
14. Move the probe along the slotted line. The deflection in VSWR meter will vary. Move the probe to a minimum deflection position, to get accurate reading. If necessary increase the VSWR meter range dB switch to higher position. Note and record the probe position.
15. Move the probe to next minimum position and record the probe position again.
16. Calculate the guide wavelength as twice the distance between two successive minimum positions obtained as above.
17. Measure the guide waveguide inner broad dimension ‘a’ which will be around 22.86mm for X-Band.
18. Calculate the frequency by following equation.

$f=c/\lambda$ where $c=3*10^8$ meter/sec.

19. Verify with frequency obtained by frequency meter.
20. Above experiment can be verified at different frequencies.

OBSERVATIONS:

Beam Voltage =
Repeller Voltage =
Frequency reading from frequency meter =
First voltage minima position (d1) =
Second voltage minima position (d2) =

CALCULATIONS:

$\lambda g = 2(d1\text{-}d2)$

$\lambda c = 2a$

$$\frac{1}{\lambda^2_0} = \frac{1}{\lambda^2_g} + \frac{1}{\lambda^2_c}$$

$\lambda_0 =$

$f = c/\lambda_0$

RESULT: The frequency and wave length in a rectangular waveguide working in TE_{10} mode has been and verified with direct reading.

EXPERIMENT-6

STUDY OF CIRCULATOR/ISOLATOR

AIM:

To verify the characteristics of isolator and circulators.

APPARATUS:

1. Klystron Power Supply SKPS-610
2. Klystron Tube 2K-25 with Klystron MOLInt-XM-2
3. Klystron Mount XM-25
4. Circulator XC-651
5. Isolator XI-621
6. Frequency Meter XF-710
7. Variable Attenuator XA-520
8. Slotted Line SX-651
9. Tunable Probe XP-655
10. Detector Mount XD-451
11. Matched termination XL-400
12. Wave Guide Stand XU-535
13. VSWR Meter SW-215
14. Oscilloscope
15. BNC Cable

THEORY:

Circulator is defined as device with ports arranged such that energy entering a port is coupled to an adjacent port but not coupled to the other ports. This is depicted in Fig.2 circulator can have any number of ports.

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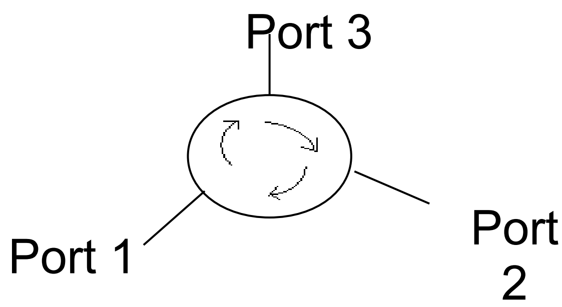

Fig. 2

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.

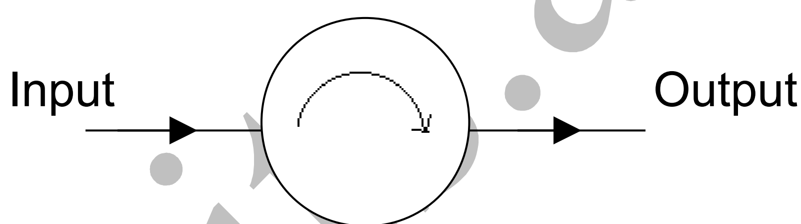

Fig.3

The isolator, shown in Fig.3 can be derived from a three-port circulator by simply placing a matched load (reflection less termination) on one port.
The important circulator and 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 d**B.**

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 in the line with all parts except the test port are matched.

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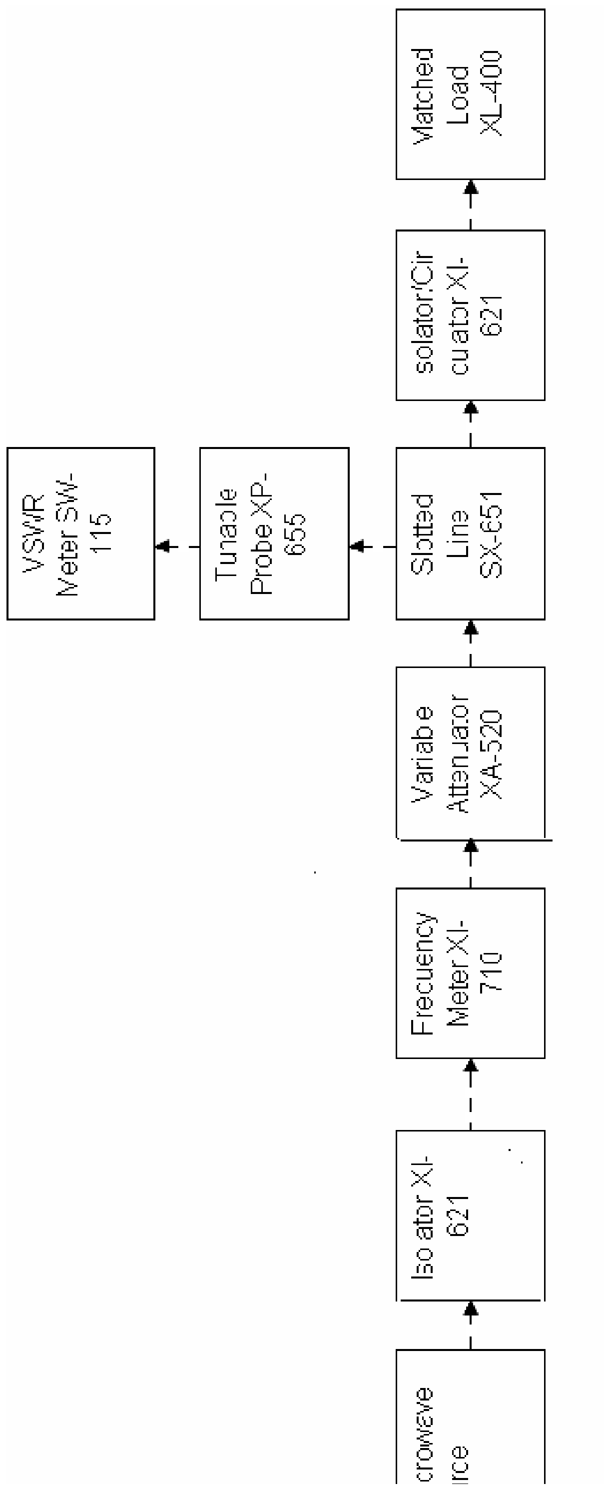

Fig. 1 MEASUREMENT OF VSWR OF ISOLATOR/CIRCULATOR

PROCEDURE:

C. **Measurement of input VSWR**

1. Set up the components and equipments as shown in Fig.1. With input port of isolator or circulator connected to the slotted line and matched loads on other ports.
2. Energize the microwave source for particular frequency of operation.
3. With the help of slotted line probe and VSWR meter find out VSWR of the isolator or circulator as described earlier for low and medium SWR measurements.
4. The above procedure can be repeated for other ports.

D. **Measurement of Insertion Loss and Isolation**

1. Remove the probe and isolator/ circulator from slotted line and connect the detector mount to the slotted section. The output of the detector mount should be connected with VSWR meter.
2. Energize the microwave source for maximum output for a particular frequency of operation. Tune the detector mount for maximum output in VSWR meter.
3. Set any reference level of power in VSWR meter the help of variable attenuator and gain control knob of VSWR meter. Let it be P1.
4. Carefully remove the detector mount from slotted line without disturbing the position of the setup. Insert the isolator or circulator between slotted line and detector mount.
5. Record the reading in the VSWR meter, if necessary change range switch to high or lower position, and read 10dB change for each step change of switch position. Let it be P2.
6. Compute insertion loss given as P1-P2 in dB.
7. For measurement of Isolation, the Isolator/ Circulator has to be connected in reverse i.e. output port to slotted line and detector to input port with other port terminated by matched termination.
8. Record the readings of VSWR meter after and let it be P3.
9. Compute isolation as P1-P3 in dB.
10. The same experiment can be done for other ports of circulator.
11. Repeat the above experiment for other frequency if needed.

OBSERVATIONS:

Beam voltage =

Repeller voltage =
Input power at port 1 =
Power at port 2 =
Power at port 3 =
Input power at port 2 =
Power at port 1 =
Power at port 3 =

RESULT: The characteristics of Circulator has been observed by applying input power at one of the ports and observing powers in other ports.

EXPERIMENT-7

SCATTERING MATRIX OF MAGIC TEE

AIM:

To obtain the scattering matrix of Magic Tee.

APPARATUS:

1. Microwave source
2. Isolator XI-621
3. Frequency Meter XF-710
4. Variable Attenuator XA-520
5. Slotted Line SX-651
6. Tunable Probe XP-655
7. Magic Tee XE-345/350
8. Detector Mount XD-451
9. Matched termination XL-400
10. Wave Guide Stand XU-535
11. VSWR Meter SW-215
12. Oscilloscope
13. BNC Cable

THEORY:

The device magic Tee is a combination of the E and H plane tee (Fig. 1), 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 arm with the same phase, and no electric field exist in arm 4. If power is fed in arm 4(E arm), it divides equally in to arm1 and arm2 but out of phase with no power to arm3 (H arm), 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. arm4.

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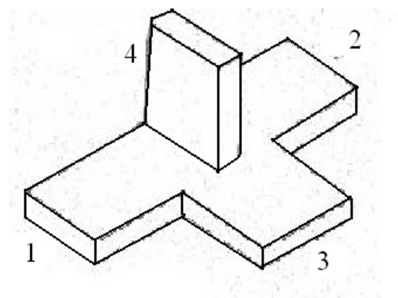

Fig.1 MAGIC TEE

The basic parameter to be measured for magic Tee is 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 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 (port4) to the power detected at H arm (port3) when side arm 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 $C_{ij}=10\text{-}\alpha/20$

Where is α 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.

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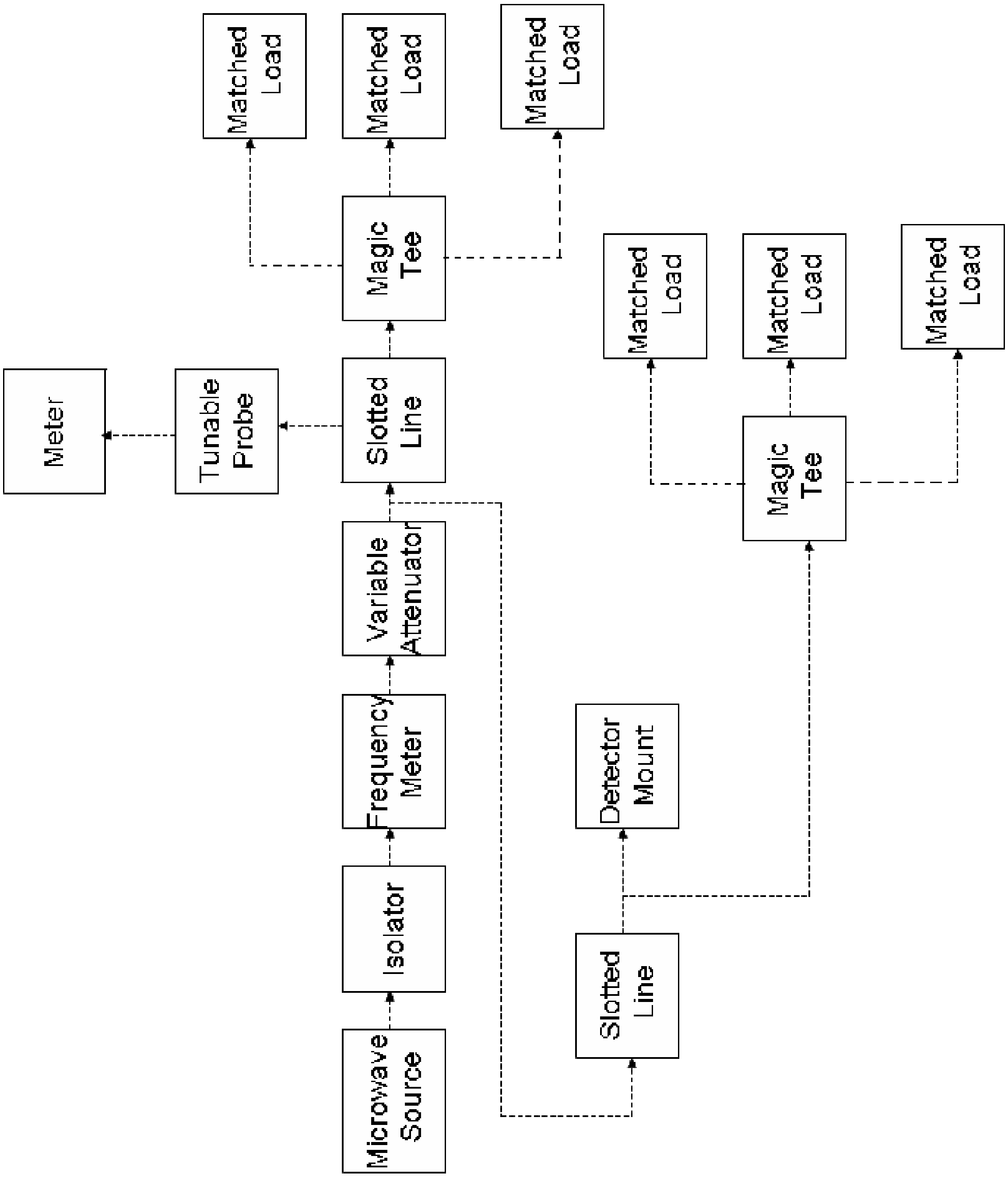

BLOCK SET UP FOR THE STUDY OF MAGIC TEE

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PROCEDURE:

1. **VSWR Measurement of the ports**

1. Set up the components and equipments as shown in Fig.2. Keeping E arm towards slotted line and matched termination to other ports.
2. Energize the microwave source for particular frequency of operation.
3. Measure the VSWR of E-arms as described in measurement of SWR for low and medium value.
4. Connect another arm to slotted line and terminate the other port with matched termination. Measure the VSWR as above. Similarly VSWR of any port can be measured.

2. Measurement of Isolation and coupling factor

12. Remove the tunable probe and Magic tee from the slotted line and connect the detector mount to slotted line.
13. Energize the microwave source for maximum output for a particular frequency of operation and tune the detector mount for maximum output in VSWR meter.
14. With the help of variable attenuator and gain control knob of VSWR meter, set any power level in the VSWR meter and note down the reading. Let it be P3.
15. Without disturbing the position of variable attenuator and gain control knob, carefully place the Magic Tee after the slotted line keeping H-arm connected to slotted line, detector to E-arm and matched termination to arm1 and 2. Note down the reading of VSWR meter. Let it be P4.
16. Determine the isolation between port 3 and 4 as P_3-P_4 in dB.
17. Determine the coupling coefficient from the equation $C_{ij}=10-\alpha/20$

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

    $\alpha= 10\log_{10} (P_4/P_3)$

    Where P_3 is power delivered to arm I and
    P_4 is power detected at arm j
18. The same experiment may be repeated for other ports also.
19. Repeat the above experiment for other frequencies.

OBSERVATIONS:

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Beam voltage	=
Repeller voltage	=
Input power at port 3	=
Power at port 4	=
Power at port 1	=
Power at port 2	=
Input power at port 4	=
Power at port 3	=
Power at port 1	=
Power at port 2	=
Input power at port 1	=
Power at port 2	=
Power at port 3	=
Power at port 4	=
Input power at port 2	=
Power at port 1	=
Power at port 3	=
Power at port 4	=

RESULT: Magic Tee Characteristics are observed by giving input to different ports and by seeing outputs at other ports. By using those values Scattering Matrix has been formed.

EXPERIMENT 8

IMPEDANCE MEASUREMENT

AIM:

To measure an unknown Impedance of the waveguide using the smith chart.

APPARATUS:

1. Microwave source
2. Isolator XI-621
3. Frequency Meter XF-710
4. Variable Attenuator XA-520
5. Slotted Line SX-651
6. Tunable Probe XP-655
7. Detector Mount XD-451
8. Matched termination XL-400
9. Wave Guide Stand XU-535
10. SS Tuner XT-441
11. Movable Short XT-481
12. VSWR Meter SW-215
13. Oscilloscope
14. BNC Cable

THEORY:

The Impedance at any point on a transmission line can be written in the form of R+jX. For comparison SWR can be calculated as

S=1+1R1
………

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1-1R1

Where Reflection Coefficient R= Z-Z_0
……..
Z+Z_0

Z_0 isCharacteristic Impedance of waveguide at operating frequency.

Z is load Impedance.

The measurement is performed in the following way. The known device is connected to the slotted line and the position of one minima is recognized. The unknown is device is replaced by movable short to the slotted line. Two successive minima positions are noted. The twice of the differences 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 S0. Mark a point on circumference of Smith Chart towards load side at a distance equal to D/λg. Join the center with this point. Find the point where it cut the drawn circle. The coordinates of this point will show the normalized impedance of the load.

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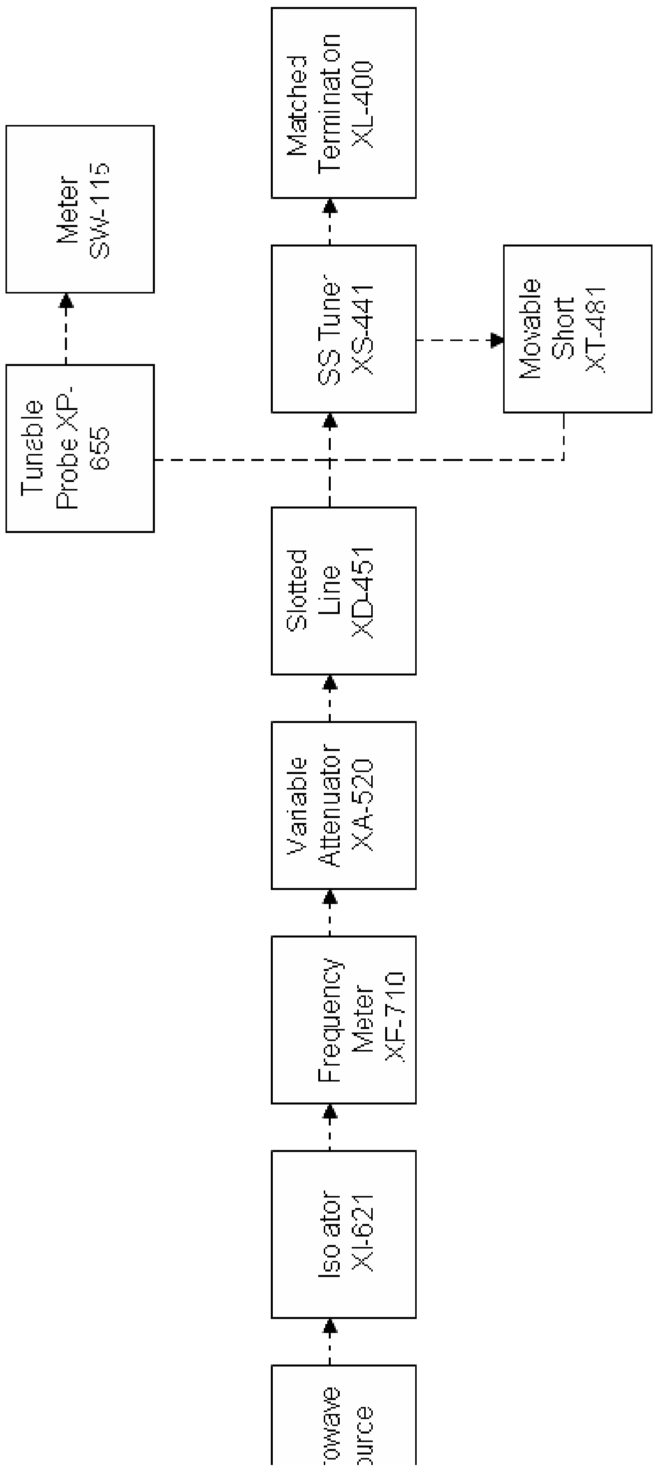

FIG. SETUP FOR IMPEDANCE MEASUREMENT

PROCEDURE:

1. Set up the components and equipments as shown in figure.
2. Set the variable attenuator at the minimum position.
3. Keep the control knobs of VSWR meter as below

Range dB	-	50db
Input Switch	-	Crystal Low Impedance
Meter Switch	-	Normal
Gain (Coarse- Fine)	-	Mid Position Approx.

4. Keep the control knobs of Klystron Power Supply as below

Beam Voltage	-	OFF
Mod- Switch	-	AM
Beam Voltage Knob	-	Fully Anticlockwise
Reflector Voltage Knob	-	Fully Clockwise
AM-Amplitude Knob	-	Around Fully Clockwise
AM- Frequency Knob	-	Mid position

5. Switch ON the Klystron Power supply, VSWR and Cooling fan.
6. Switch ON the beam voltage switch position and set beam voltage at 300V with the 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 VSWR meter and note down the frequency directly from frequency meter.
13. Keep the depth of pin of SS Tuner to around 3 to 4 mm and lock it.
14. Move the probe along the slotted line to get maximum deflection.
15. Adjust VSWR meter gain control knob and variable attenuator until the meter indicates 1 on the normal dB SWR scale.
16. Move the probe to next minima position and note down the SWR S0 on the scale, also note down the probe position, let it be D.
17. Remove the SS Tuner and matched termination and place movable short at the slotted line. The plunger of short should be at zero.
18. Note the position of two successive minima position. Let it be as d1 and d2. Hence $\lambda g=2(d1-d2)$.
19. Calculate $d/\lambda g$.

20. Find out the normalized impedance as described in the theory section.
21. Repeat the same experiment for the other frequency if required.

OBSERVATION:

Beam voltage =
Repeller voltage =
First voltage minima position (d1) =
Second voltage minima position (d2) =

$\lambda g=2(d1-d2)=$

$d/\lambda g=$

Normalized impedance from smith chart =

RESULT: The unknown Impedance of the waveguide is found by using the smith chart.

EXPERIMENT-9

CHARACTERIZATION OF LED

AIM:

To study the relationship between the LED dc forward current and the LED optical power output and determines the linearity of the device at 660mm as well as 850nm. The conversion efficiencies of the two LEDs will also be compared.

APPARATUS:

1. Fiber Optic Analog Transmitter Kit
2. Fiber Optic Analog Receiver Kit
3. Multimeters
4. Patch Chords
5. Optical Fiber Cable

THEORY:

LEDs and Laser diodes are commonly used sources in optical communication systems, whether the system transmits digital or analog signals. In the case of analog transmission, direct intensity modulation of the optical source is possible, provided the optical output from the source can be varied linearly as a function of the modulating electrical signal amplitude. LEDs have a linear optical output with relation to the forward current over a certain region operation. It may be mentioned that in many low-cost, short-haul and small bandwidth applications, LEDs at 660nm, 850nm and 1300nm are popular. While direct intensity modulation is simple to realize, higher performance is achieved by fm modulating the base-band signal prior to intensity modulation.

The relationship between an LED optical output Po and the LED forward current I_F is given by $Po=K.I_F$ (over a limited range), where K is a constant.

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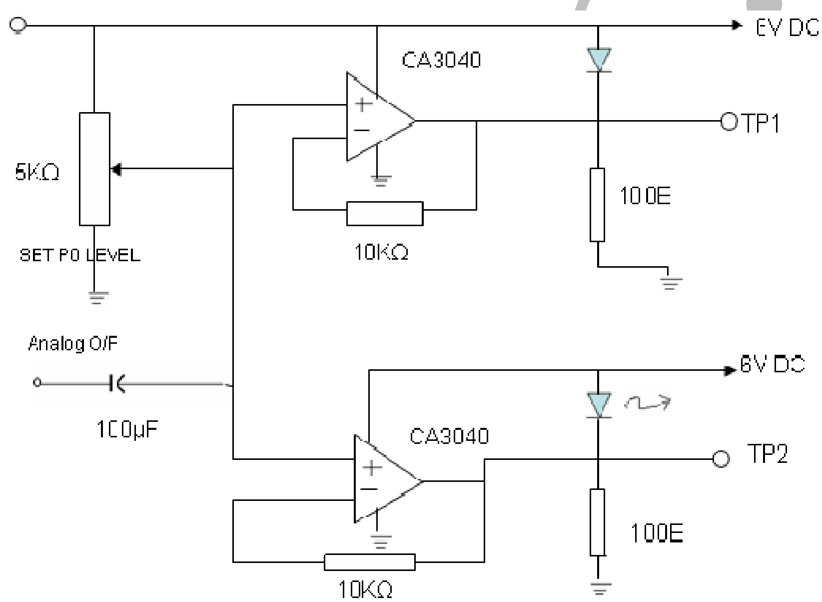
Circuit Diagrams:

FIBER OPTIC ANALOG TRASMITTER



Fiber Optic Analog Receiver

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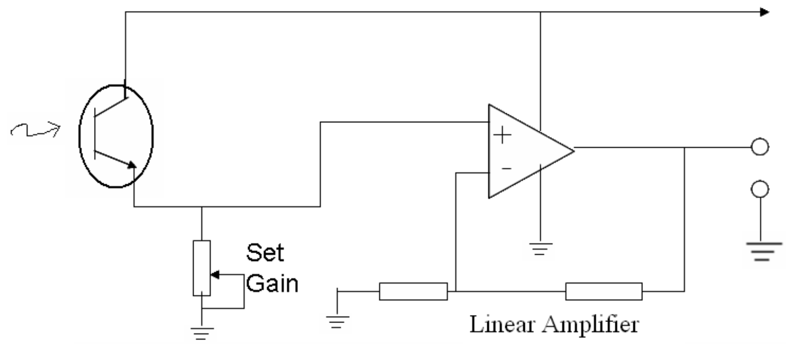
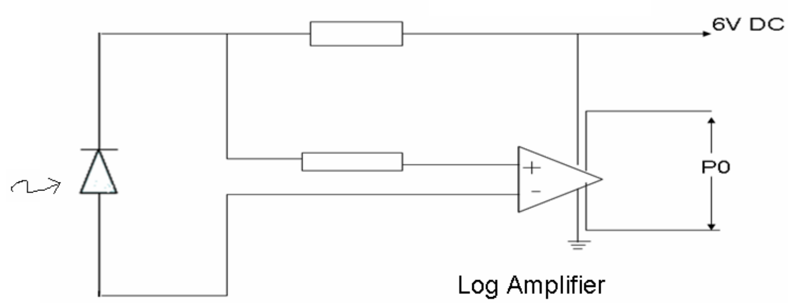
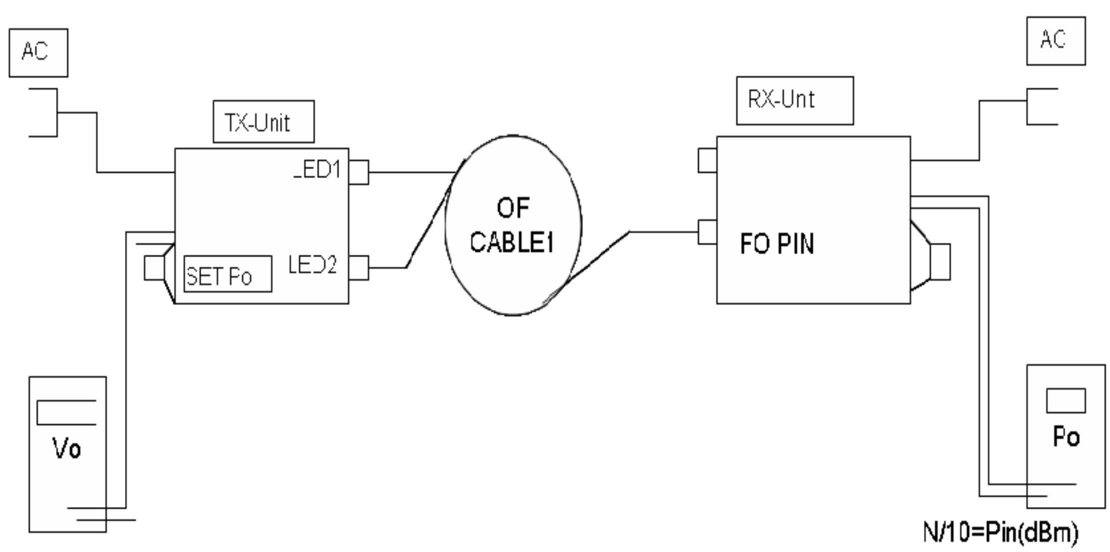






BLOCK SETUP FOR LED CHARACTERISATION

PROCEDURE:

1. The Block set up for led characterization is shown in above Fig..
2. Connect one end of Cable1 to the LED1 port of PHY 148 TX and the other end to the **FO PIN** (power meter) port of PHY149-RX.
3. Set DMM1 to the 200mV range and connect the marked Po on the RX unit to it. The powermeter is ready for use. **Po= (Reading)/10 dBM.**
4. Set DMM2 to the 200.0mV range and connect it beween the **(Vo1)** and ground in the TX unit.**If1= Vo1 (mV)/100** in ma.
5. Plug the AC mains for both units. Adjust the SET **Po** knob on the TX unit the extreme anticlockwise positions to reduce I_{11} to 0. The reading on the power meter should be out of range
6. Slowly turn the **SET P0** know clockwise to increase $I_{!!}$ in suitable steps and note the power meter readings. Po. Record up to the extreme clockwise positions.
7. Repeat the complete experiment for **PO LED2** and tabulate the readings for **Vo2** & Po. **If 2-Vo2(mV)/50** in ma. Apply the correction of **2.2.dB** discussed in Experiment for the 850nm **LED.**

Table of Readings for 660nm

S.No.	Vo1(mV)	If1= Vo1 (mV)/10(ma)	Po(dBm)
1			
2			
3			
4			
5			
6			

Tabe of Readings for 850nm

S.No.	Vo1(mV)	If1= Vo1 (mV)/10(mA)	Po(dBm)	Po(dBm) Corrected
1				
2				
3				
4				
5				
6				

RESULT: LED characteristics has been observed & its characteristic curves are obtained.

EXPERIMENT-10

CHARACTERIZATION OF LASER DIODE

AIM:

The aim of the experiment is to study the operations of the Automatic Current Control (ACC) of the Automatic Power Control (APC) modes

APPARATUS:

1. Laser diode Kit
2. Multimeters
3. Connecting wires
4. Patch Chord

5. Fiber Optic Cable

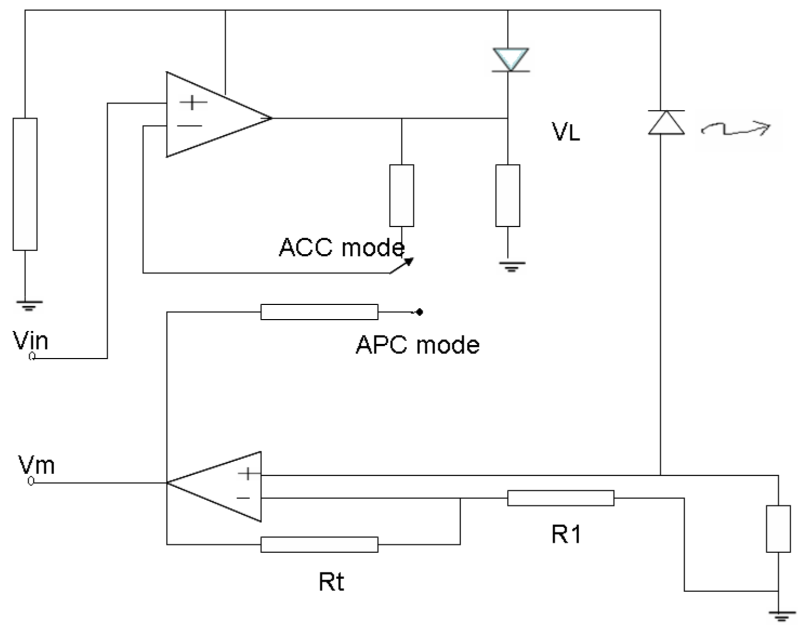
THEORY:

Laser diodes are commonly used as sources in optical communication systems, whether the system transmits digital or analog signals. A Laser diode has a built-in photo detector, which one can employ to monitor the optical intensity of the laser at a specified forward current. This device is also effectively utilized in designing an optical negative control feed back loop, to stabilize the optical power of a laser in the steep lasing region. The electronic circuit scheme that employs the monitor photodiode to provide a negative feedback for stabilization of optical power is known as the automatic power control mode (APC). If a closed loop employs current control alone to set optical power then this mode is called the automatic current control mode (ACC). The disadvantage of ACC is that the optical power output may not be stable at a given current due to the fact that small shifts in the lasing characteristics occur with temperature changes and aging. The disadvantage of the APC is that the optical feedback loop may cause oscillations, if not designed properly.

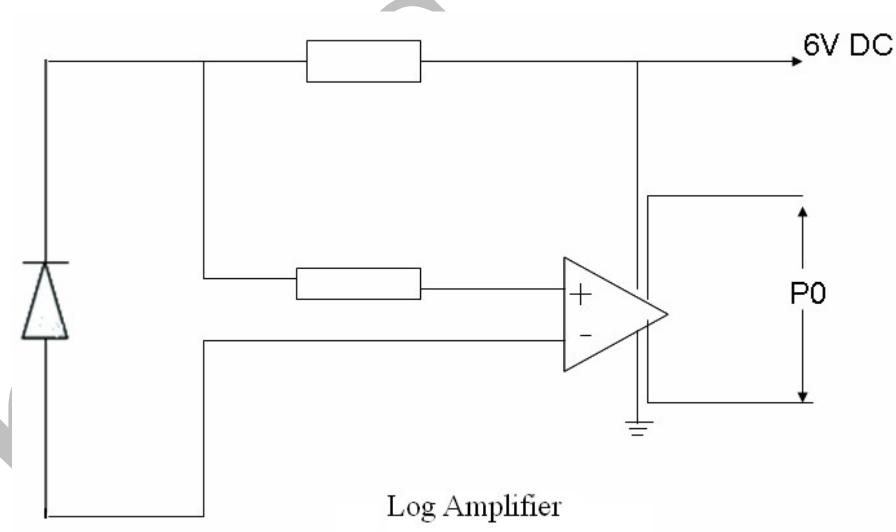
The basic operations of the ACC and APC schemes have already been discussed in Expl. In the ACC mode the feedback to the laser driver is derived from the load current I_F Vo tracks the V_{ref} (or V_{in} dc). As already noted, this may not ensure constant optical power for a given V_{ref}, if shits in laser threshold occur due to change in temperature an ageing. On the other hand the APC circuit derives its feedback from the monitor photocurrent, I_M which is proportional Po. Here V_m tracks V_{ref}, we get a constant optical power output, irrespective of changes in temperature and ageing.

Circuit Diagrams:

Laser diode Transmitter



Laser diode Receiver



Log Amplifier

PROCEDURE:

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1. Connect the 2-meter PMMA FO cable1 Po port of PHY-TX and Couple the laser to the power meter on the RX unit.
2. Set DMM1 to the 200mV range and connect it between (Vm) and ground terminal on the TX unit.
3. Set DMM2to the 2000mV range and connect it between (VL) and ground terminal on the TX unit.
4. Set DMM3 to the 200mV range and connect it between (P0) terminals on the RX unit. Turn it on. The power meter is ready for use. Po= (Reading) 10 dBm
5. Plug the AC mains. Adjust the SET I_f knob to the extreme anticlockwise position.
6. Set the ACC/APC select switch to ACC Mode. Slowly turn the SET I_f knob clockwise to increase Po the suitable value. Note the readings PO1 and VL (V_L=V_{ref} in the ACC Mode when system gain in unity) readings. Next switch to the APC Mode and note Po2 and the Vm readings (V_m=V_{ref} in the APC mode for system gain = unity Record up to the extreme clockwise positions.

Table of Readings ACC an APC Opeartions /PMMA MODE

S.No.	ACC V_L=V_{ref}(mV)	MODE P_o(dBm)	APC V_m=V_{ref}(mV)	MODE P_o(dBm)
1				
2				
3				
4				
5				
6				

RESULT: The operation of LASER in APC &ACC Mode have been obtained and its characteristic curves have been drawn.

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EXPERIMENT11

LASER DOIDE LINEAR INTENSITY MODULATION SYSTEM

A1M:

The aim of the experiment is to study the following ac characteristics of an intensity modulation laser and fiber optics system:

(i) V_{in} (ac) Vs V_{out} (ac) for fixed carrier Power P_o and signal frequency F_0

(ii) V_{in} Max Vs P_o for known distortion the V_{out} at fixed F_o

APPARATUS:

1. Laser diode transmitter kit
2. Patch cords
3. Fiber optic cable
4. Signal generator(0-1MHz)
5. Multimeter

THEORY:

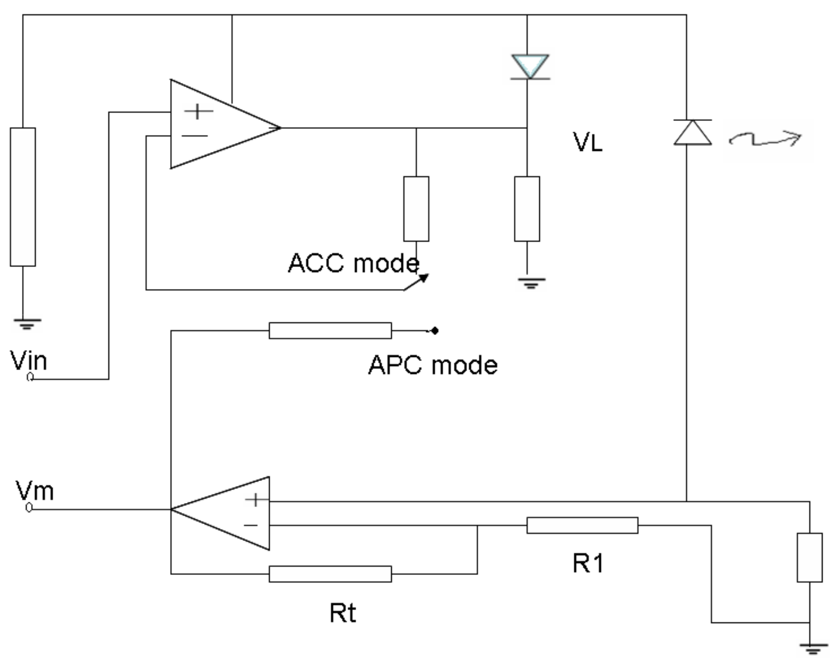
The intensity modulation / demodulation system is realized using the PHY-159 TX Module and the PHY-158 RX unit linked through an optical fiber. We use the 2-meter PMMA fiber cable.

The Laser carrier power, Po is set by adjusting the SET I_F knob in the middle laser. Selection of optimum carrier power is essential to minimize distortion. Limiting depth of modulation also ensure distortion free transmission. We bandwidth of the system in the present case is limited by the photo detector. We should operate in the APC mode to obtain optical output proportional to the modulation signal V_{in}. We will however operate in the ACC mode too.

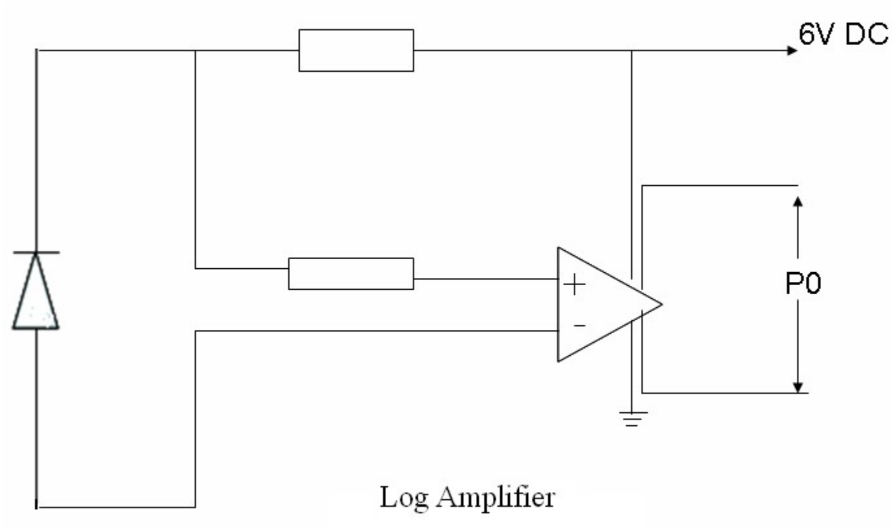
An ideal IM transmission system will have the relationship V_{out}=G.V_{in}, where G is a factor dependents on the LD conversion efficiency, loss in the optical transmission path and the laser photo detector conversion efficiency. Distortion results from the LD being biased in the non-linear region. Bandwidth is limited by the slowest device in the system; in this case it is the phototransistor. Speed can be increased by using a PIN diode, which is inherently a faster device.

Circuit Diagram:

Laser diode Transmitter



Laser diode Receiver



PROCEDURE:

1. Connect one end of the PMMA FO cable to the laser port Po on the TX unit. The other end is first connect to RX unit to set the carrier power level of the laser.
2. Set DMM to the 2000mV range and it connect the marked Po terminals on the RX unit. The power meter is now ready for use. Po= (Reading)/10dBm.
3. Set the carrier power level (Po) to a suitable value say-15dBm by suing DMM.
4. On the TX unit connect V_{in} to a function generator (10Hz to 500kHz: sine wave output 2Vp-p). Give the function generator output to CH1.
5. On the RX unit side, connect V_{out} to CH2 of the dual trace oscilloscope.
6. Plug the AC mains for both systems.
7. With the PMMA FO cable connected to the power meter, adjust the Set I_F knob t set the optical carrier power Po to suitable level say,-20dBm. Next disconnect the cable from the power meter and disconnect to FO PT.
8. Set signal frequency 2 KHz and amplitude 10-50mV respectively. Observe the transmitted and received signals on the oscilloscope. Set R_{in} suitably to get

---

V_{out}=V_{in}. The system gain is now equal to unity. Next, vary V_{in}, suitable values from the 10mVto 2000mVp-p and note the values of V_{out}. Tabulate and plot the graph V_{out} Vs V_{in}.

Table of readings: Vout Vs Vin:

Frequency =2 kHz; Carrier level Po=-15dBm Initial Gain= unity

S.No	V_{in}(mVp-p)	V_{out}(mVp-p)	G=Vo/V_{in}
1.			
2.			
3.			
4.			

The gain is constant at low frequency signals, and fall at high frequency signals.

9. Set signal frequency 2 KHz and Po to,-20dBm. Disconnect V_{in} before Po measurement. Set V_{in} to its maximum value for distortion free V_{out}. Note the value of V_{in} and V_{out}. Repeat this for other values of Po and record change in gain of any. You may additionally observer the waveforms in the oscilloscope do coupled position too.

Table of readings: V_{in} max Vs Po

Frequency =2 kHz: Initial Gain = Unity

S.No	P_o(dBm)	V_{in} max(mVp-p)	V_{out}(mVp-p)	G=V_o/V_{in}
1.				
2.				
3.				
4.				

10. The experiment can be repeated for other settings of gain.

RESULT: The AC character tics of intensity modulation of LASER diode has been observed and studied.

EXPERIMENT12

MEASUREMENT OF DATA RATE FOR DIGITAL OPTICAL LINK

A1M:

To verify a simple fiber optic digital link for transmission of a serial train of pulses. We will use the NRZ output from the encoder Microcontroller as the pulse train. We will use the test point Vo to study the received waveform.

APPARATUS:

1. Digital Transmitter kit
2. Digital Receiver kit
3. Patch Chords
4. Fiber Optic Cable
5. Multimeter

THEORY:

Most of the fiber optic communication systems in operation today employ digital transmission methods. Hence a food understanding of a simple fiber optic digital transmission system assumes great importance. Important parameters of a fiber optic digital transmission system that specify its performance are:

a) System Bandwidth (limited by various types of dispersions)
b) System Loss Budget (which determines the maximum distance)
c) System Bit Error Rate (BER equivalent to s/n ratio in an analog system)
d) Transmitter Power
e) Receiver Sensitivity

Selection of wavelength, fiber type, source type, detector type and coding scheme depends on a specific requirement.

One of the important design considerations, after a link requirement has been specified, is the power budgeting (or loss budget).

The simplest equation for loss budget (in decibels) is

$$Po - Pi = \sum Losses + M$$

Where Po is the optical output from the transmitter, Pi is the minimum optical power needed to be incident on the detector to realize the desired BER (signal to noise ratio),∑Losses is the total the optical losses in the path and M is the margin. Po depends solely on the selected source type. While a laser source will be able to couple higher power in to a fiber, low-cost LED will couple lower power in to the same fiber. Pi depends on the type of detector selected for the system. The detector's sensitivity, its bandwidth and its BER are related.

∑Losses represent all the losses in the optical path. These include i) Source-fiber coupling loss. (ii) Loss in fiber. (iii) Losses at splices and connector junctions and (iv) fiber-detector coupling loss. The parameter M has to be large enough to ensure the required BER at all times. In other words there should be no degradation in transmission due to variations in Po, Pi and ∑Losses. M should not be too high to drive the receiver to saturation. This necessitates optimum choice of M.

In the present experiment we shall use the hybrid fiber optic digital transmission modules along with a PMMA cable with SMA terminations. The signal to be transmitted shall be derived from the NRZ output of the line encoder.

CIRCUIT DIAGRAMS:

FIBER OPTIC DIGITAL TRANSMISMITTER

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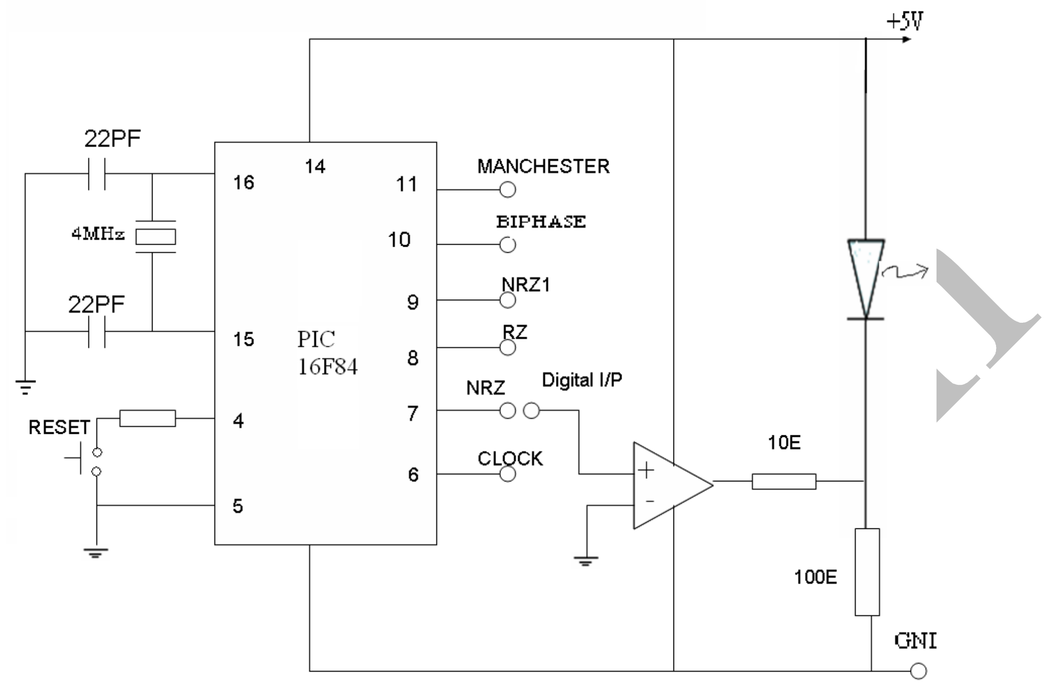
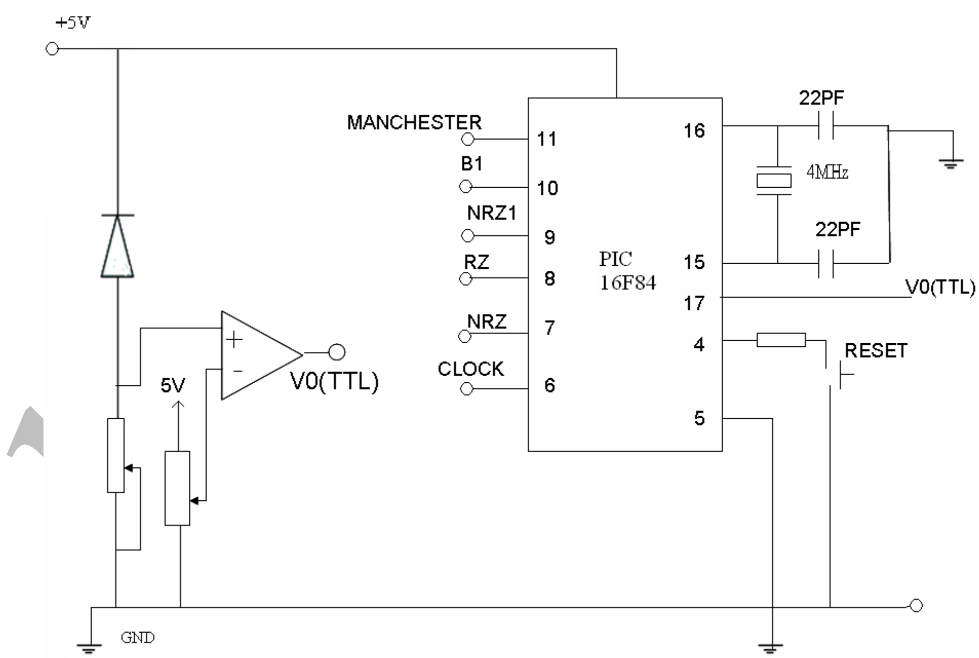
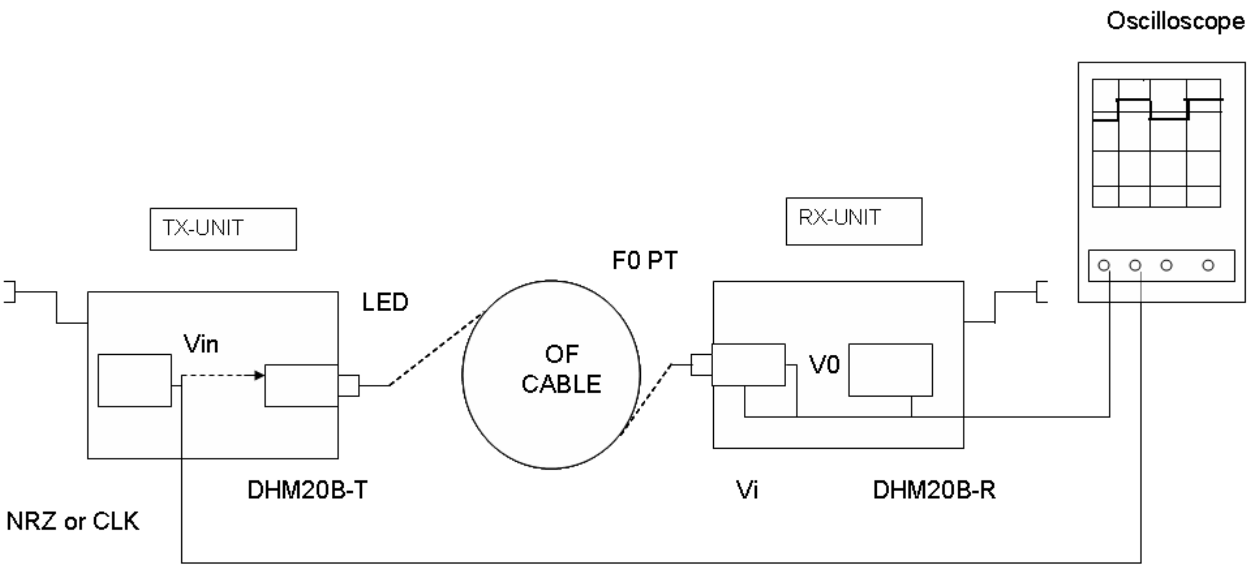


FIBER OPTIC DIGITAL RECEIVER





BLOCK SET-UP FOR F0 DIGITAL LINK

PROCEDURE:

1. The schematic diagram of an optical fiber digital link is shown in Fig.1
2. Connect one end of Cable 1 to the LED port of the PHY-146 TX and the other end to the FO PT port of PHY-147 RX. While connecting the cable please note that minimum force should be applied. At the same time ensure that the connectors not loosely coupled to the receptacle.
3. Connect NRZ encoder output to V_{in} on the TX side. Also connect it to Ch1 of a dual trace oscilloscope. Connect Vo on the RX side to Ch2 of the oscilloscope.
4. Set R_{in} to 200 ohms using a DMM to measure the resistance.
5. Now turn the power on for the TX and RX units. The NRZA waveform should appear on Ch1. It should be a 5Kz square wave. In case the waveform, does not appear, reset the Encode Microcontroller once.
6. Next, adjust R_{th} until the waveform on Ch2, is almost identical to the input. The digital link is now operation. Draw the transmitted and received waveforms.

7. Next remove the oscilloscope probe from Vo and connect to Vi to observe the waveform at the output of the detector. Note the amplitude and shape of this waveform, vis-à-vis the transmitted waveform. Change R_{in} to change the gain of the detector and note the amplitude and shape at Vi. When R_{in} is decreased the amplitude of Vi reduces, but there is a reduction in distortion as well.

8. Repeat the experiment by setting R_{in} to some other value and then adjusting R_{th} to obtain the received waveform as close to the transmitted one. In each case draw the transmitted and received waveforms.

RESULT: A simple fiber optic digital link for transmission of a serial train of pulses train is verified.

EXPERIMENT13

MEASUREMENT OF LOSSES FOR ANALOG OPTICAL LINK

A1M:

To obtain various types of loses that occur in optical fibers and measures losses in dB of two optical fiber patch cords at two wavelengths, namely **660nm** and **850nm**. The Coefficients of attenuation per meter at these wavelengths are to be computed from the results.

APPARATUS:

1. Digital Transmitter kit
2. Digital Receiver kit
3. Patch Chords
4. Fiber Optic Cable
5. Multimeter

THEORY:

Attenuation in an optical fiber is a result of number of effects. We will confine our study to measurement of attenuation in two cables (Cable1 and Cable2) employing an SMA-SMA In –line – adapter. We will also compute loss per meter of fiber in dB. We will also study the spectral response of the fiber at 2 wave lengths, 660nm and 850nm.

The optical power at a distance, L in an optical fiber is given by $P_L=P_O\ 10^{(-aL/10)b}$ where **Po** is the launched power and α is the attenuation coefficient in decibels per unit length. The typical attenuation coefficient value for the fiber under consideration here is 0.3dB per meter at wavelength of 660nm. Loss in fibers expressed in decibels is given by **-10log (Po/P_F)** where, **Po** is the launched power and **P_F** is power at the far end of the fiber. Typical at connector junction may vary from 0.3dB to 0.6dB.

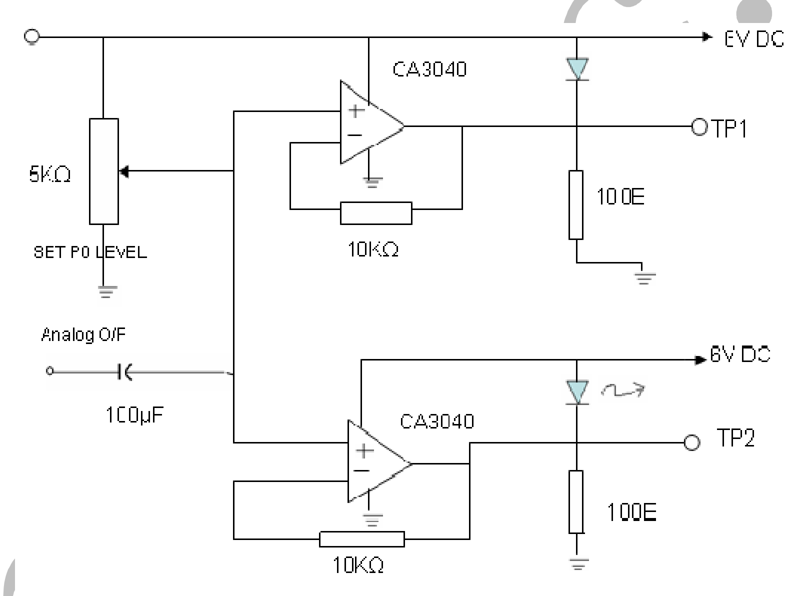
Losses in fibers occur at **fiber-fiber** joints or splices due to axial displacement, angular displacement, separation (air core), mismatch of cores diameters, mismatch of numerical apertures, improper cleaving and cleaning at the ends.
The loss equation for a simple Fibreoptic link is given as

Pin (dBm)-Pout(dBm)= $L_{J1} + L_{FIB11} + L_{J2} + L_{FIB12} + L_{J3}$**(dB)**

Where, L_{J1} (dB) is the loss at the LED-connector junction, L_{FIB11} (dB) is the loss in cable1, L_{J2} (dB) is the insertion loss at a splice or in-line adapter, L_{FIB12} (dB) is the loss in cable2 and L_{J3} (dB) is the lost at the connector-detector junction.

Circuit Diagrams:

FIBER OPTIC ANALOG TRASMITTER



Fiber Optic Analog Receiver

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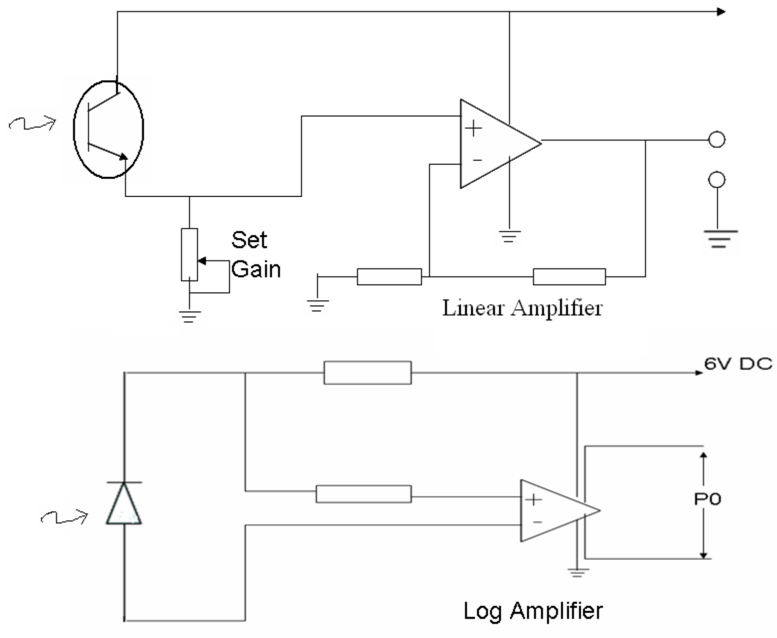

PROCEDURE

1. The schematic diagram for analog transmitter and receiver kits are shown in Fig. 1 & 2.

2. Connect one end of **Cable1** to the **LED1** port of the PHY 148-**TX** and the other end to the FOPIN port (power meter) of PHY-149-**RX** unit.

3. Set the DMM to the 2000mV range. Turn the DMM on. The Power meter is now ready for use.

4. Plug the AC mains for both units. Connect the Patch chord, Cable1 securely, as shown, after relieving all twists and strains on the fiber. <u>While connecting the cable please note that minimum force should be applied. At the same time ensure that connector is not loosely coupled to the receptacle</u>**.** After connecting he

optical fiber cable properly, adjust **SET Po** know to set power to LED1 to a suitable value, say, - 15.0dBm (the DMM will read 150mV). Note this as P_{01}.

5. Wind one turn of the fiber on the mandrel, as shown in experiment1 and note that new reading of the power meter P_{02}. Now that loss due to bending and strain on the plastic id **P_{01}-P_{02} dB.** For more accurate readout set the DMM to the 200.0mV range and take the measurement. Typically the loss due to the strain and bending the fiber is 0.3 to 0.8dB.

6. Next remove the mandrel and relieve **Cable1** of all twists and strains. Note the reading P_{01}. Repeat the measurement with Cable2 (meters) and note the reading P_{02}. Use the in-line SMA adapter and connect the two cables in series as shown. Note the measurement P_{03}.

Loss in Cable1 P_{03}- P_{02}- Lila Loss in Cable2= P_{03}- P_{01}- L_{ila}

Assuming a loss of 1.0dB in the in-line adapter (Lila=1.0db). We obtain the loss in each cable. The difference in the losses in the two cables will be equal to the loss in 4 meters of fiber (assuming that the losses at connector junctions are the same for both the cables). The experiment may be repeated in the higher sensitivity range of 200.0mV. The experiment may be repeated in the higher for other Po setting such as -15dBm,-20dBm,-25dBm etc.

Table of Readings for 660nm.

S.No	P_{01} (dBm)	P_{02} (dBm)	P_{03} (dBm)	Loss in Cable1 (dB)	Loss in Cable2 (dB)	Loss in 4 meters (dB)	Loss per (dB) at 660nm
1	-15.0						
2	-20.0						

3	-25.0						
4							

7. Repeat the entire experiment with LED2 at 850nm and tabulate in

Table of Readings for 850nm.

S.No	P_{01} (dBm)	P_{02} (dBm)	P_{03} (dBm)	Loss in Cable1 (dB)	Loss in Cable2 (dB)	Loss in 4 meters (dB)	Loss per (dB) at 850nm
1	-15.0						
2	-20.0						
3	-25.0						
4							

RESULT: The various types of losses that occur in optical fiber at two wave lengths have been computed.

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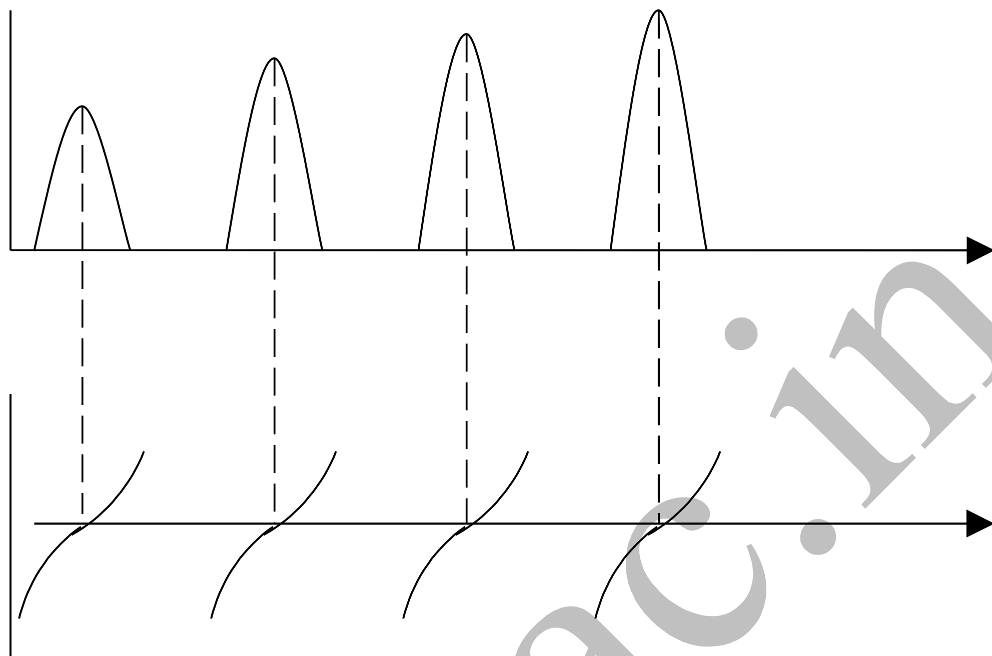

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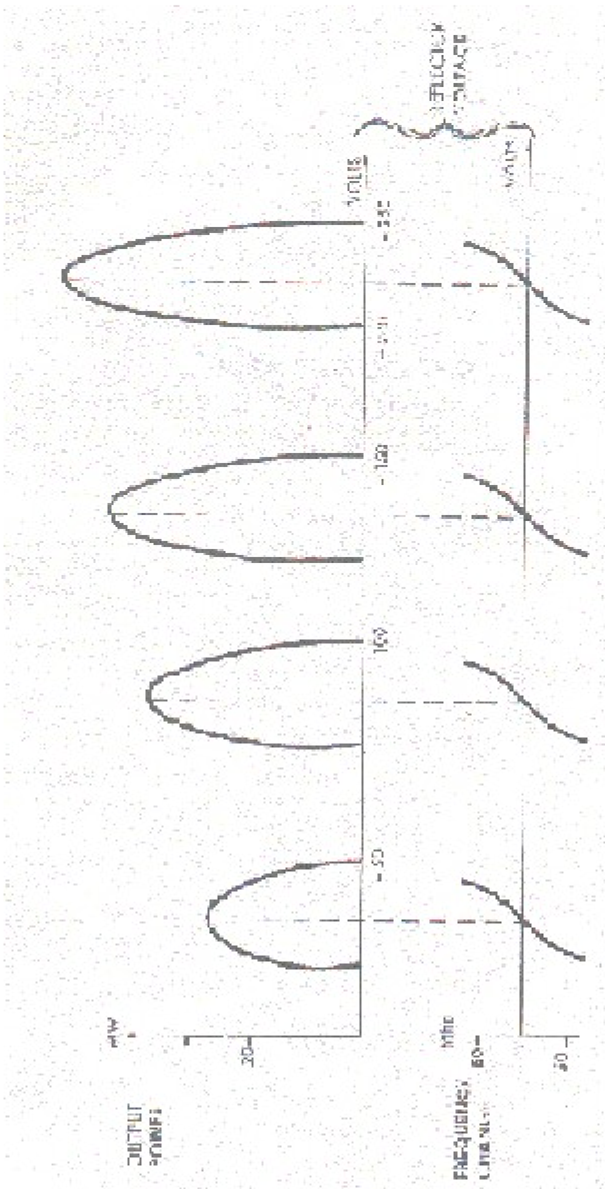

Fig 2. Modes of Klystron