CHAPTER 5

Experimental Setup
5.1 Introduction

A simple experimental setup for studying variation of the output power with the variation of refractive index of the medium (liquid) surrounding the core where the cladding is removed along the length of the fiber, is shown in the Fig (5.1).

![Experimental Setup](image)

One end of the optical fiber is terminated with a SMA connector and connected to a white light source. The other end of the fiber is also terminated with another SMA connector and coupled to a power meter. The length of the experimental fiber, viz., a plastic and glass fiber of length 2m and 20m respectively is used in the experimental setup. Along this length of the fiber, at its midpoint a known length of the plastic jacket and cladding is removed and this portion is dipped in an external guiding medium (liquid).
5.2 Apparatus Used

5.2.1 Source

The apparatus used is a Japanese make ANDO Electric Company white light source which has a halogen lamp as the light source. The modal number of this white light source is AQ1320. The device is also fitted with appropriate filter. An optical system condenses the light from the halogen lamp to be incident on the optical fiber. The halogen lamp is of 12V-50W capacity operating at wavelengths from 0.6 \( \mu \text{m} \) to 1.8 \( \mu \text{m} \).

By using appropriate good quality filters supplied by the company, various operating windows can be made use. Thus the wavelengths of 820nm, 850nm, 1300nm and 1550nm can be obtained from a single source. The spectral half wave width is less than 5nm. The output waveform is 270Hz chopped light providing good stability. The input electrical requirements of ANDO system is 220V A.C at 50Hz. The output from the source is taken through a flexible adopter, modal number AQ 1919 which can be connected to any fiber and a source.

5.2.2 Optical Chopper

The optical chopper permits high sensitivity power measurements when it is used in conjunction with power meter for measurements. The input side has a FC optical connector. The optical signal input at this
connector appears as a chopped optical signal at an optical connector on the output side of the same FC type. The optical power meter to be combined with this apparatus is limited to a chopped light. The insertion loss is less than 3dB and the input/output connectors are FC connectors.

The power meter used in the present setup is 3M-Photodyne INC with a 9V battery. The modal number of the power meter used is 17 XTA which has wavelength selections of 820nm, 850nm, 1300nm and 1550nm.

5.2.3 Programmable Monochromator

The programmable monochromator used in the apparatus is useful for various kinds of spectral measurements and photometry. It has a built-in diffraction grating as the dispersive element to permit high precision measurements. Wavelength setting can be made manually from the front panel. The apparatus comprises of a light receiving unit, a pulse motor for wavelength setting and its derived unit apart from the diffracting grating type monochromator. The spectral output to the input light is converted by the internal light receiving unit into an electrical signal which is displayed as the output. The light receiving unit is a silicon photodiode (or) a germanium photodiode which can be selected accordingly to the wavelength of operation from the front panel.
When combined with a halogen lamp light source and an optical power meter, the apparatus can be used to measure the optical loss characteristics of optical fibers and other optical devices. Some of the major specifications of the programmable monochromator are:

- **Spectral Width Range:** 0.6 - 1.8 μm
- **Resolution:** 1-20 nm, variable
- **Insertion Loss:** less than 3 dB
- **Wavelength Settings:** manual
- **Input Section:** bare fiber adopters and connector adopters
- **Output Section:** this can be connected to an optical power meter with a cord, with 6 pin connectors

All the above viz., white light source, optical chopper, programmable monochromator are all built-in in the ANDO white light source.

### 5.2.4 Chopped Light Power Meter

It consists of an optical power meter for chopped light (about 270 Hz rectangular modulation) in the power measurement ranges from 10 pW to 1 mW (from 80 to 0 dBm) in the 0.85 μm band and from 100 pW to 1 mW (-72 to 0 dBm) in the 1.3 μm band. The photoelectric converter sensor used is a silicon photodiode in the 0.85 μm band and a germanium photodiode in the
1.3 \mu m band. The display is a 4 digit display. The selection of power ranges is automatically accomplished. The power indication can be read in dBm and dB (reference) as well as in Watts. The apparatus is also provided with average function and range (hold) function. An analogue output corresponding to power level in each range can also be obtained. The major specifications of the chopped light power meter are:

- **Power Measurement Level**: 10pW to 1mW (-80 to 0dBm) in the range of 0.85 \mu m band and from 100pW to 1mW (-72 to 0dBm) in the 1.3 \mu m band.

- **Wavelength Range**: 0.6 to 1.1 \mu m (silicon sensor) in the 0.85 \mu m band; 1 to 1.7 \mu m (germanium sensor) in the 1.3 \mu m band.

- **Resolution**: 0.1 to 1% (or) 0.01 dB

- **Display**: 4 digit digital

- **Output**: analog output approximately 0 to 2v (corresponding to the power level in each range)

- **Interface**: an IEC standard interface can be installed as optional

- **Processing function**: relative dB display function, average function

- **Power requirements**: AC 230v at 50Hz, 6VA approximately. Also usable with a dedicated external battery.
5.3 Experimental Arrangement

5.3.1 Preparation of the Fiber

The experimental setup consists of a known length (20m) of multimode glass optical fiber, one end of which is connected to source through a connector. The other end of the fiber is connected to the power meter through another connector. About the mid point of the fiber length, some known portion of the external jacketing, polymer coating and cladding is removed. The external plastic jacketing is first removed carefully. Care is also taken in removing the polymer coating without damaging the core and the cladding material. The method used in the present work for removing the polymer coating is to dip the experimental fiber in wide mouth beaker containing benzene and heating up to 70°C. Sufficient care is taken in heating benzene so that the temperature of the liquid does not go beyond 70°C since the boiling point of benzene is around 80°C. The fiber is maintained in benzene at 70°C for 3-4 minutes and then taken out. It is then cooled to room temperature. The acrylic coating peels off without any external intervention leaving the core and cladding material. The fiber is then taken out of the beaker, gently washed in distilled water and allowed to dry for 30 minutes.

The fiber whose polymer coating is thus removed is now slowly dipped into the hydrogen fluoride solution to etch out a cladding material.
leaving the only core material. This is confirmed by measuring the diameter of the core and comparing it with the standard diameter mentioned in literature. Further confirmation is obtained in injecting light at one end of the fiber and observing a major portion of the light coming out of the fiber at the etched portion. A small amount of light also comes out at the output end of the fiber. The removal of the cladding over plastic fiber is relatively simpler compared to multimode glass fiber. After the removal of plastic jacket, the fiber is gently washed in distilled water and allowed to dry for about 30 minutes and dipped in Proponal (or) Dichloromethane for the removal of cladding material. The two types of fibers namely, plastic fiber and glass fiber so prepared are ready for connectorization and experimental work.

5.3.2 Connectorization:

After the removal of cladding at the center of the fiber of an optical fiber, the fiber ends have to be prepared for connectorization so as to make the connector losses as small as possible. The connector losses can be made small provided the fiber ends are prepared well. As a first step the fiber ends are to be cut with a diamond cutter. Care has to be taken in cutting the fiber ends straight with no angular cutting taking place. The external jacketing and acrylic coating are carefully removed at the ends with the
help of cleaver. The cleaver used is CT 03 supplied by ERRICSON FUJI KURA LIMITED, Tokyo, Japan.

The two ends of the fiber are then polished on a rough grain surface and then on a smooth grain surface to give a glassy and silver finish at its cross sectional ends. The cross sectional ends were then checked with the help of interferometric microscope to see that the end surface of the fiber is flat. The fiber ends are then inserted into appropriate connectors positioned properly and glued for permanent fixing. The fiber thus made is ready for experimental work. One end of this fiber is connected to the source while the other end is connected to power meter.

A wide mouth beaker was taken and covered completely with a back material so that no outside light enters the beaker during the experimental work. The fiber which is prepared earlier is placed at the center of the wide mouth beaker taking care to see that the sensing length of the fiber is at the center of the beaker without touching the bottom of the beaker. The ends of the fiber are then fixed with fiber holders on either side taking care to see that no pressure is applied on the fiber. Before beginning the experiment, the bare plastic fiber of 2m length (without taking away the plastic jacket, acrylic coating and cladding) is connected to the source at one end and the other end is connected to a power meter. The source is switched ON at a given wavelength and the reading of the power meter at the second end of the fiber is noted. This reading in the power meter may be taken as the
power launched into the fiber. The fiber so prepared earlier with connectors and in which cladding is removed at the center is connected to the source at one end and the other end is connected to power meter. The readings of the power meter are noted. This reading is the power through the fiber without plastic jacketing and cladding in air.

5.4 Variables Used in the Experiment:

The variables used in the experiment are:

a. Fibers: Plastic optical fiber and Multimode Glass fiber at different core/cladding diameters.

b. Operating wavelengths: 820nm, 850nm, 1300nm and 1550nm.

c. Guiding medium: sugar solution of various concentrations

5.4.1 Optical Fibers Used:

The experimental work was carried out with the following optical fibers with different core/cladding diameters as indicated below:

- Multi Mode Plastic fiber with 200/230 \( \mu \text{m} \)
- Multi Mode Glass fiber with 62.5/125 \( \mu \text{m} \)
5.4.2 Length of Optical Fiber/Length of Core

Exposed:

The following lengths of optical fibers with different exposed surfaces to the guiding medium were used:

- A plastic fiber of 2m length with core exposed to a surface length of 1, 2, 3cm.
- A multimode glass fiber of 20m length with core exposed to a surface length of 1, 2, 3cm.

5.4.3 Operating Wavelengths:

- Plastic fiber operating at 820nm, 850nm.
- Glass fiber operating at 1300nm, 1550nm.

5.4.4 Guiding Liquids:

The following guiding liquids namely pure water and sugar solutions of varying concentrations were selected for the experimental work. These liquids were selected as they represent the desirable extremes of refractive indices of 1.33 to 1.45.
5.4.5 Determination of Refractive Index:

The Abbes refractometer is used in the study of refractive index of liquid. At each concentration of the sugar solution, the refractive index is noted with Abbe's refractometer. The results are presented in the following graph shown in Fig 5.2. This enables the determination of refractive index for any known concentration of the liquid.
Fig. 5.2 Graph Showing Variation of R.I with Concentration of Sugar Solution
CHAPTER 6

Experimental Results