LABORATORY WORK BOOK

For Academic Session ______

Semester _______

OPTICAL FIBER COMMUNICATION

(TC-315)

For

TE (TC)

Name: ____________________

Roll Number: ____________________

Batch: ____________________

Department: ____________________

Year/Semester: ____________________

Department of Electronic Engineering
NED University of Engineering & Technology, Karachi

LABORATORY WORK BOOK

For The Course

TC-315 OPTICAL FIBER COMMUNICATION

Prepared By:

Danish Mahmood Khan (Sr. Laboratory Engineer)

Ms. Saba Ahmed (Assistant Professor)

Reviewed By

Dr. Muhammad Imran Aslam (Associate Professor)

Approved By:

Board of Studies of Department of Electronic Engineering

INTRODUCTION

Optical Fiber Communication Practical Workbook covers those practical that are very knowledgeable and quite beneficial in grasping the core objective of the subject. These practical solidify the theoretical and practical concepts that are very essential for the engineering students.

This work book comprise of practical covering the topics of Optical fiber Communication that are arranged on modern trainer boards. Above all this workbook contains a relevant theory about the Lab session.

CONTENTS

LAB SESSION 01

OBJECT

To study the basic structure and types of the optical fiber

EQUIPMENT

- Light Source
- Cable #3
- Cable #4
- Cable #5

THEORY

An optical fiber (or fibre) is a glass or plastic solid rode that carries light along its length with the help of the total internal reflection. It consists of core and cladding. The refractive index of the core is greater than the cladding. They can be either single mode or multi-mode fibers.

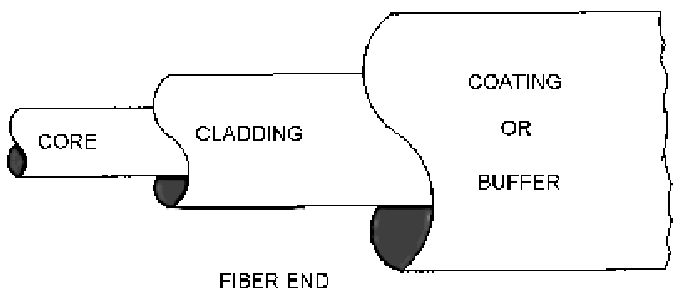

Figure 1.1: Optical Fiber

Multi-mode Fiber

Fiber with large core diameter (greater than 10 micrometers) may be analyzed by geometric optics. Such fiber is called multi-mode fiber, from the electromagnetic analysis. In a step-index multi-mode fiber, rays of light are guided along the fiber core by total internal reflection. Rays that meet the core-cladding boundary at a high angle (measured relative to a line normal to the boundary), greater than the critical angle for this boundary, are completely reflected. The critical angle (minimum angle for total internal reflection) is determined by the difference in index of refraction between the core and cladding materials. Rays that meet the boundary at a low angle are refracted from the core into the cladding, and do not convey light and hence information along the fiber. The critical angle determines the acceptance angle of the fiber, often reported as a numerical aperture. A high numerical aperture allows light to propagate down the fiber in rays both close to the axis and at various angles, allowing efficient coupling of light into the fiber. However, this high numerical aperture increases the amount of dispersion as rays at different angles have different path lengths and therefore take different times to traverse the fiber. A low numerical aperture may therefore be desirable.

In graded-index fiber, the index of refraction in the core decreases continuously between the axis and the cladding. This causes light rays to bend smoothly as they approach the cladding, rather than reflecting abruptly from the core-cladding boundary. The resulting curved paths reduce multi-path dispersion because high angle rays pass more through the lower-index periphery of the core, rather than the high-index center. The index profile is chosen to minimize the difference in axial propagation speeds of the various rays in the fiber. This ideal index profile is very close to a parabolic relationship between the index and the distance from the axis.

Single mode Fiber:

The most common type of single-mode fiber has a core diameter of 8–10 micrometers and is designed for use in the near infrared. The mode structure depends on the wavelength of the light used, so that this fiber actually supports a small number of additional modes at visible wavelengths. Multi-mode fiber, by comparison, is manufactured with core diameters as small as 50 micrometers and as large as hundreds of micrometres. The normalized frequency V for this fiber should be less than the first zero of the Bessel function J0 (approximately 2.405). Single mode fiber has the least dispersion and hence is used for longer distances.

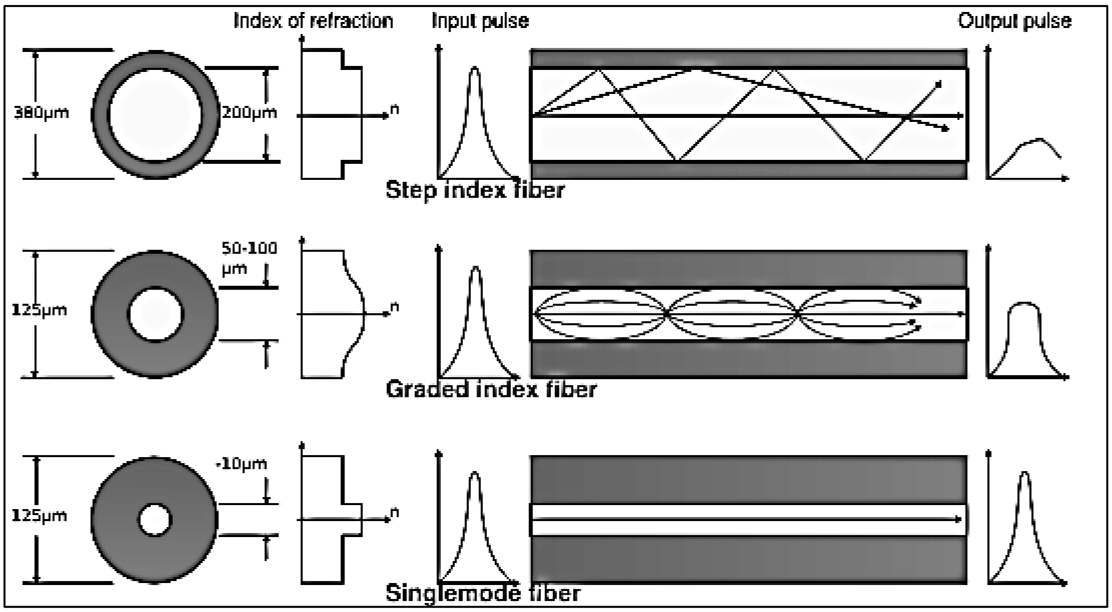

Figure 1.2: Step Index, Graded Index, Single Mode Fiber

PROCEDURE AND OBSERVATION

Connect the given optical fiber with the light source and observe the light patters and the diameter of the fiber.

Cable#3 is ____

Cable #4 is ____

Cable #5 is ____

RESULT

____

____

____

____

LAB SESSION 02

OBJECT

To measure the numerical aperture (NA) of the different cables provided

EQUIPMENT

- Provided optical cables
- Laser Source
- Measurement bench

THEORY

Numerical Aperture is defined as the light gathering capability of the fiber mathematically given by:

NA= Sin θA

Sin θA=

(D/2L) Where:

- L is the distance between the cable end and the measurement bench L=20mm
- D is the diameter of the acceptance cone

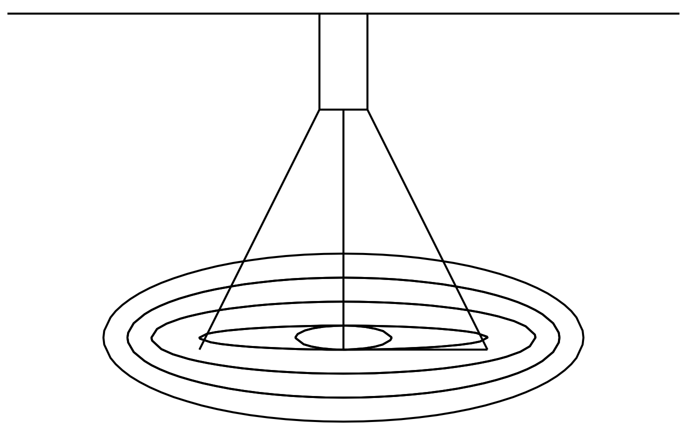

Figure 2.1: Numerical Aperture of a Fiber

PROCEDURE

- Insert one end of the cable into the laser source (660nm) and other end into the measuring bench
- Activate the laser source
- Evaluate the diameter of the lightened area
- As we move from cable 3 to cable 5 the brightness of the light point decreases as it is the function of the core diameter and the light become focused at single point

OBSERVATION

(Diameter of each circle is 2 mm)

Cable 3 (200/230) µm (step index multimode)

D = ____________________

NA = ____________________

Cable 4 (62.5/125) µm (graded index multimode)

D = ____________________

NA = ____________________

Cable 5 (09/125) µm (step index single mode)

D = ____________________

NA = ____________________

RESULT

It has been observed that as the diameter of the core decreases the NA also decreases as the light gathering capability is the function of core diameter.

LAB SESSION 03

OBJECT

To observe characteristic curve of the LED

EQUIPMENT

- Power supply psu or ps1
- Testing module MCM-40
- Multimeter
- Optical power meter

THEORY

The commonest optical sources are light-emitting diodes (LED) and laser diodes (LD). Both these diodes can be used to generate radiations at different wavelengths, corresponding to the windows where fibers show the minimum attenuation.

The LED is a particular diode which emits light through process of recombination of the electron-hole pairs due to a forward bias of the junction The optical power emitted is a function of the forward driving current .At present the LEDs in the 1st windows are made of gallium arsenide or of the ternary compound with aluminum (ALGaAs/GaAs), the LEDs in the 2nd e 3rd windows are made of indium gallium-arsenide-phosphide (InGaAsP/InP).

The most significant parameters of LED are:

- Output wave length
- Output spectral width
- Output optical power: it ranges in some tens of µW, and depends on the forward driving current
- Frequency response

PROCEDURE

Optical power emitted by LEDs

- Power the module
- Disconnect the jumper j11-j13 and connect the jumper j12b, so that the circuit can be arranged as shown in fig 3.1. this configuration includes the LED at 660nm, forward polarized through the bias trimmer (p4)
- Measure the voltage v10 across the resistor of 10Ω connected in the series of LED (between TP15 and ground). the forward current if crossing the Led in expressed by the following formula:

  IF =v10 /10 [v10 in mv, If in ma]
- observe the intensity of the light emitted by the LED
- Power increase as current increase

Characteristic Curves of LEDs

- Disconnect the jumper j11-j12 and connect the jumper j13b, so that circuit can be arranged as shown in figure 3.2. this configuration includes the LED at 820nm, forward polarized through the bias trimmer (p4)

- Measure the voltage Vf across the LED (between TP14 and TP15) and the voltageV10 across the resistor of 10Ω connected in the series of LED (between TP15 and ground). the forward current if crossing the Led in expressed by the following formula:
  IF =v10 /10 [v10 in mv, If in ma]
- Connect the LED to optical power meter through cable3(200/230)
- Vary the BIAS trimmer P4 and measure Vf , V10 , IF and optical power Pout
- Plot the curve for the optical power of LED versus IF and of IF versus VF
- Change cable 3 with cable 4(50/125) and then with cable 5 (10/125) and observe the reading. of optical power

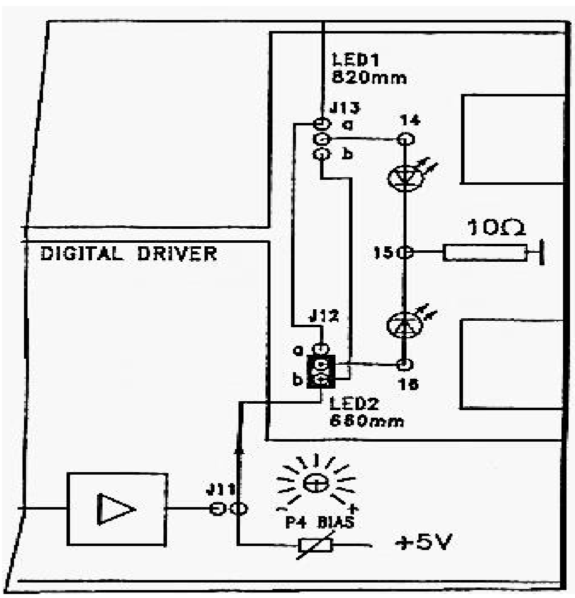

Figure 3.1: Connection Diagram

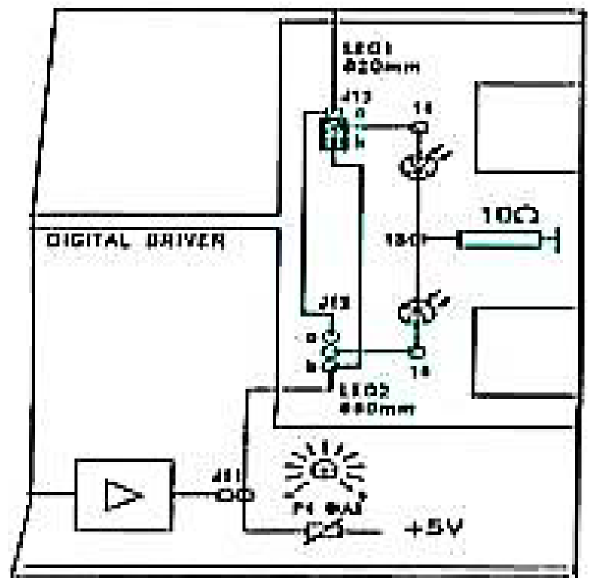

Figure 3.2: Connection Diagram

OBSERVATION

Sr No	Vf mV	V10 mV	IF =v10 /10 mA	Pout dBm

RESULT

- Characteristic curves of LED source is observed
- By changing the fiber optic cables it was observed that the optical power decreases as the Numerical Aperture of the cable decreases

LAB SESSION 04

OBJECT

To observe the attenuation & coupling loss in optical fiber

EQUIPMENT

- Power supply psu or ps1
- Testing module MCM-40
- Multimeter

THEORY

When the light crosses an absorbing medium, as in the case of optical fiber, the luminous energy decreases as distance increases. The loss in a fiber length (attenuation) is expressed by the ratio between the power entering one end of the fiber (PIN) and power coming out from the opposite end (Pout). Attenuation is normally measured in decibel:
Att (dB) = 10 log (Pout/Pin)

It can ranges from some db/m for plastic fiber, to fraction of db/km for glass fibers.

The attenuation of the light signal due to the fibers depends on the wave length and on the material which the fiber has been constructed with. In glass fiber the main causes of attenuation are the absorption losses and the scattering losses. Combining these losses lead to plotting the intrinsic attenuation curve like that shown in the fig 4.1 whereas the fig 4.2 shown the attenuation curve of a glass fiber.

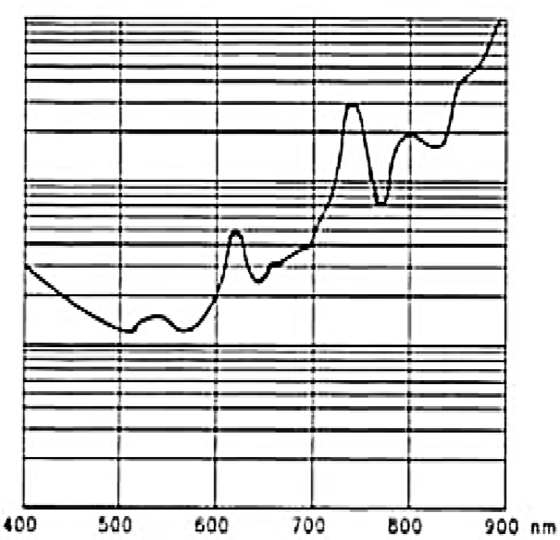

Figure 4.1: Typical attenuation curve of a plastic fiber

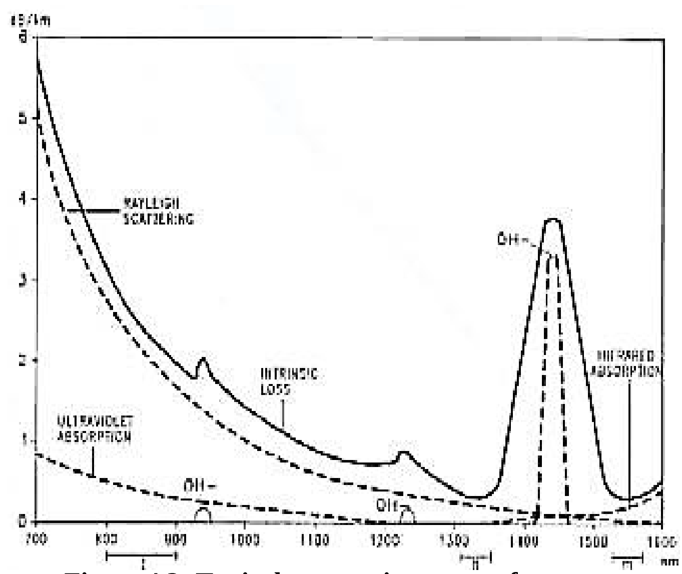

Figure 4.2: Typical attenuation curve of a single-mode glass fiber

Following losses leads to attenuation

Absorption loss: When the light photons have a certain value of energy, the atoms of glass of the core (SiO2) absorb a part of this energy. This phenomenon depends on wavelength and there are two different absorption zones, occurring in the infrared spectrum and in the ultra violet spectrum. Furthermore, during the chemical process of glass manufacturing, various metallic impurities are trapped in the core, among these impurities there are also some ions OH- which provoke absorption peaks at discrete value of wavelength.

Scattering loss: They are due to the granular structure (at microscopic level) of the material which the fiber is constructed with. This structure includes some scattering centers which are material point that scatter the radiation in all directions; even backwards this phenomenon is called Rayleigh scattering or material scattering.

Other losses: In an optical fiber link, other can be due to too narrow loops in the path of the optical cable (Bending losses), or to junction of more lengths of fiber. Of course they are not intrinsic losses of the fiber, but they depend on cable laying.

PROCEDURE

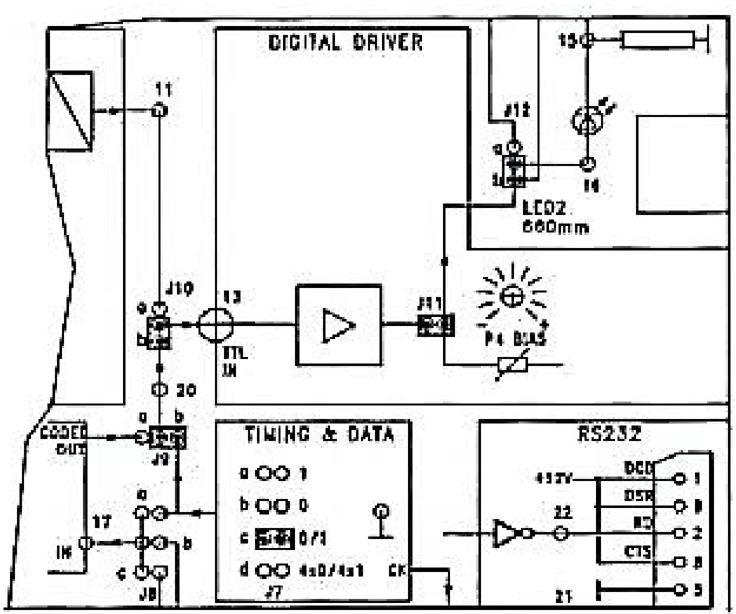

Figure 4.3: Connection Diagram

Attenuation of the fiber with increase in length

- Power the module
- Disconnect the jumper j13 and connect j7c-j9b-j10b-j11-j12b, so that the circuit can be arranged as it is shown in fig 4.3. This configuration includes the LED and the photodiode at 660 nm; moreover an alternating data signal (0/1) is applied to the input of the digital driver
- Connect the LED to the photodiode through the cable # 1,ST-St adapter and cable 6
- Set the bias trimmer (p4) to its intermediate position. connect j15b and observe the waveform in TP24 (voltage detected by the assembly “photodiode +Tran impedance amplifier”) on the oscilloscope
- Record the amplitude vout1 of the square wave detected
- Replace the cable # 1(plastic fiber of 1.5m) with the cable # 2(plastic fiber of 5 m) and

measure the new amplitude vout2 of the received signal, in TP24

- Calculate vout2/ vout1=___________________________________

Coupling and bending Losses

- Keep the same condition of the previous test (LED and photodiode at 660 nm connected through the cable # 2)
- Observe the waveform in TP24, on the oscilloscope
- Loose the fiber connector inserted in the ST-ST adapter and gradually move it away from the same adapter (and hence from the second ST connector inserted in the adapter)
- Note that the amplitude of the receive signal decrease as the connection is loosen, it also depends on the angle at which the connector of the source and of the detector are connected
- Bend the fiber and observe the wave form it will be observed that for sharp bends the wave form is more attenuated as the bending losses increases

Attenuation of the fiber as a function of wavelength

- Remove the jumper j12b and connect the j13b, in order to use the LED and the photodiode at 820nm
- Connect the LED 1 to the photodiode PD1 through the cable #1 (plastic fiber of 1.5m)
- Connect j15a and observe the waveform in TP23
- Record the amplitude vout3 of the square wave detected
- Replace the cable #1 (plastic fiber of 1.5 m) with the cable #2 (plastic fiber of 5 m) and measure the new amplitude vout4 of the signal received, in TP23

- Calculate vout4/ vout3 =___________________________________

<u>RESULT</u>

- It has been observed that the attenuation increases as the cable length increases
- The plastic fiber cable offer greater attenuation at 820nm then on 660nm

LAB SESSION 05

OBJECT

To analyze the operational characteristics and parameters of Photodiode used as photo detector in fiber optic system

EQUIPMENT

- Power supply psu or ps1
- Testing module MCM-40
- Oscilloscope

THEORY

Photo detector can transform an optical incident signal into an electric signal. The main requirements of a photo detector are:

- High sensitivity that is capacity of absorbing the maximum quantity of incident radiation
- High response rate, in order to detect very narrow light pluses
- Limited dimensions, low coast, reliability

The commonest photo detectors used in fiber optic system are the PN and PIN photodiode and avalanche photodiodes (APD).
The operating principle of photo diodes is based on a particular property of semiconductor: that is, a photon absorbed by the semiconductor generates an electron-hole pair, Applying a reverse bias to a PN junction generates a reverse current proportional to the incident light radiation. The performance of a photodiode can be improved if a slightly doped layer, called I (intrinsic), is sandwiched between P and N layers. These diodes are called PIN photodiodes after detector the signal are amplified by

- High impedance amplifier or
- Trans-impedance pre-amplifier

In the first case, the current (proportional to the light signal) generated by the photo detector crosses a resistor across which a voltage signal is developed, then this signal is amplified and in the trans-impedance pre-amplifier, the current is directly transformed into voltage, by effect of the feedback due to the resistance.

Hence vout = Ir .R

As regards sensitivity and noise, high impedance pre-amplifier offer better performance, whereas trans-impedance show a broader pass band.

PROCEDURE

- Power the module
- Disconnect the jumpers j11-j12 and connect the jumper j13b, so to produce the circuit of fig 5.1. The configuration includes the LED at 820 nm, forward biased with the BIAS trimmer (P4). Turn p4 completely to the right (maximum bias voltage)
- Connect the LED 1 and the photodiode PD! (820 nm) through the cable #3 (fiber 200/230)
- Connect a volt meter (or the DC oscilloscope) to TP23, where the voltage supplied by the detector is measured. Consider that the measured voltage is proportional to the current

generated by the photodiode.

- Now shift the fiber from the LED 1 (820 nm) to the LED 2 (660 nm) remove the jumper j13b and connect the jumper j12b
- Measure the new voltage at the output voltage of the detector (TP23)
- Disconnect the jumper J11-J13 and connect the jumper J12b,so that the circuit can be arranged as shown in fig 5.2
- Connect the LED 2 to the photodiode 660 nm (PD2), using the cable #2 (plastic fiber), the ST-ST adapter and the HP-ST connector
- Connect a voltmeter (or the DC oscilloscope) to TP24, where the voltage generated by the detector is measured. consider that the measured voltage is proportional to the current supplied by the photodiode
- Now move the fiber from the LED 2 (660 nm) to the LED 1 (820 nm).remove the jumper J12b and connect the jumper J13b
- Measure the new voltage at the output of the detector (TP24)

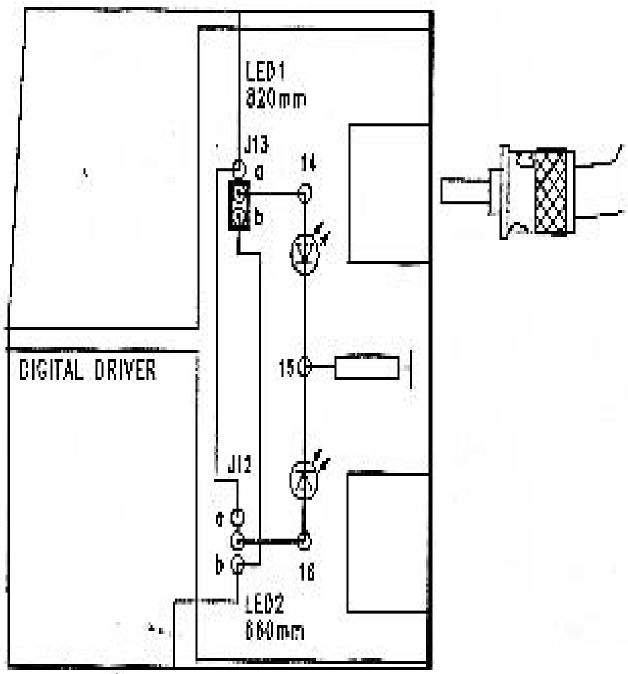

Figure 5.1: Connection Diagram

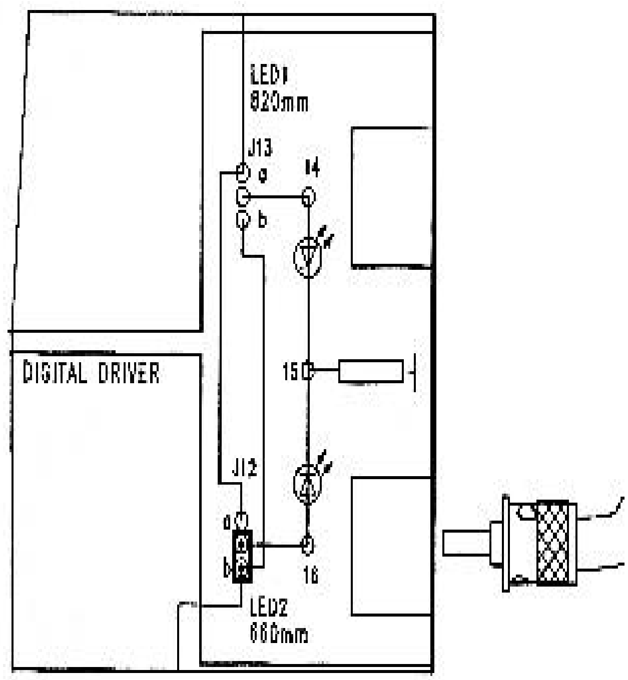

Figure 5.2: Connection Diagram

RESULT

- In the case when PD1 is connected with LED 2 the detected voltage is lower, because PD1 reaches its maximum sensitivity at 820nm
- In the case when PD2 is connected with LED 1 the detected voltage is lower (actually it coincides with the voltage measured without optical signal), because the photodiode PD2 reaches its maximum sensitivity at 660 nm and the attenuation of the fiber is higher at 820 nm than at 660 nm.

Therefore it can be concluded that that photo diode PD1 reaches its maximum sensitivity at 660 nm and PD2 at 820 nm.

LAB SESSION 06

OBJECT

To analyze the transmission characteristic of LED & laser source

EQUIPMENT

- Educational Panel
- Provided optical cables
- Oscilloscope

THEORY

The basic concept behind the optical transmitter is that it converts electrical input signals into modulated light for transmission over an optical fiber. The input signal determines the characteristics of the resulting modulated light, which may be turned on and off or may be linearly varied in intensity between two predetermined levels.
There are two commonly· used optical sources for generating the light pulses. These are light emitting diode (LED) and Laser Diode (LD). Laser diode with its version as injection-laser diode (ILD) is commonly employed. Both the sources funnel the light pulses into the fiber-optic medium where they transmit themselves down the fiber cable and are placed in very close proximity to the light emitting region to couple as much light as possible into the fiber.
The amount of light emitted by LED or ILD is required to be coupled with the fiber in the optical fiber system. The optical light, which is getting into optical fiber, is a function of a number of factors. These are the intensity of the optical source, the area of the light-emitting surface, the acceptance angle of the fiber, and the losses due to reflections and scattering.

PROCEDURE

Checking the channel transmission speed

Both LED and LASER source are used with respective photodiode receivers, to consider the performance of the carrier out transmission channel in terms of speed.

- Use the following test generator :PLUSE 1,PULSE2 and DATA PATTERN, that are the three digital signal generators in particular:
- **PULSE1:** square-wave with adjustable duty cycle and frequency. When the duty cycle is minimum and frequency maximum, OUT 8 output provides a square-wave over 60Mb/s
- **PULSE 2:**square wave with fixed frequency and duty cycle of the 50% The OUT 9 output provides a square-wave of 2Kb/s
- **DATA PATTERN:** digital signal that can be selected 0, 1, 0/1 4x0/4x1. in the condition 0/1 (maximum bit rate)the OUT 10 output provides a square wave of 256 kb/s

850nm LED

- Use the DIGITAL DRIVER and LED SOURCE 1 sections
- Set the AN/DIG switch to DIG
- Connect the jumper between TP14 and ground.
- Connect the F.O OUT 1 output to the F.O IN 1 input with an optical cable “4”
- Set both AN/DIG switches to DIG
- With a BNC-BNC co-axial cable, connect the OUT 9 output of the PLUSE 2 to the IN 2 input of the DIGITAL DRIVER 1

- Connect the oscilloscope to Out 2 of the DIGITAL RECEIVER 1 and check that the signal is properly received
- Change the test generator PLUSE 2 with DATA PATTERN and check that the signal is properly received
- Change the test generator DATA PATTERN with PLUSE 1 and check that the signal is properly received. When the frequency is adjusted to the maximum and the duty-cycle to the minimum the characteristic of the received signal worsen because the channel does not allow so high speeds

1310nm LASER

- Use the section composing the TX 3
- Connect the F.O OUT 3 output to the F.O IN 3 input with an optical cable “4”
- Set the ON switch to LASER ON
- With a BNC –BNC coaxial, connect the OUT 9 output of the PLUSE 2 to the IN 4 input of TX 3
- Connect the oscilloscope to OUT 4 of RX 3 and check that the signal is not properly received: the channel does not allow the transmission of digital signal with low bit rates
- Change the test generator PLUSE 2 with the DATA PATTERN and check that the signal is properly received now: the channel enables the transmission of a signal with this bit rate (256kb/s)
- Change the test generator DATA PATTERN with PLUSE 1 and check that the signal is still properly received. Besides when the frequencies is adjusted to the maximum and the duty cycle to the minimum and the duty cycle to the minimum, the characteristic of the received signal are highly better in the last case where the channel uses the LED source
- Check that there are the same characteristic also with mono-mode fiber “5”that is used, in fact for high speed because it introduces very low modal dispersion

OBSERVATION

850nm LED source and 1310nm LASER source:

Wave form at Out 2 and Out 4 in case of:

PULSE2

DATA

PATTERN:

PLUSE1:

RESULT

LAB SESSION 07

OBJECT

- **To get familiar with digital communication systems**
- **To measure pre-bias current of the LED, Emitted power regulation and analyze waveforms of transmitted and received signals using different fiber**

EQUIPMENT

- Educational panel
- Tester
- Oscilloscope
- Optical power meter including the windows 1st /IInd 850/1310nm
- Provided optical cables

THEORY

Introduction to Digital Communication System

The Educational Panel contains three kinds of a digital communication system that are good for the transmission of TTL digital signals:

- 2 communication system with LED source, and
- 1 communication system with LASER source

Both these communication system are based on the same operating principal: the light signal to be transmitted undergoes an ON/OFF modulation.
Obviously they have different characteristics and performance indicating a different use.

Digital transmitter with LED TX1 TX2 source

TX1 and TX2 consists in two equal section

- DIGITAL DRIVER 1 (2) it constitutes the LED bias stage. There is a circuit that clip the TTL input signal and biased Led through the BIAS potentiometer
- LED SOURCE 1 (2) it constitutes the stag containing the luminous source with output of ST F.O OUT 1 (2) connector. A jumper on TP14 and 16 is present to carry out the bias current measurement

Digital receivers with detector RX1 and RX2

RX1 and RX2 consists in two equal section

- PIN PD DETECTOR 1 (2) constitutes the reception stag containing the PIN optical photodiode detector, with input of ST F.O IN 1 (2) connector. The photo detector current output is amplified by a trans impedance pre-amplifier (mounted in the same container of the photodiode) that provides a voltage output proportional to the input current
- DIGITAL RECEIVER 1 (2) constitutes the stag processing the signal of the last stag. in particular, there is a voltage limiter amplifier couples in a.c (operating on the switch threshold), a threshold comparator circuit providing a PECL signal (pseudo ECL) straight and negated (to increase the switching speed)and a current converting the PECL signal into TTL levels (0/5 v) that are provided across the output.

Digital transmitter with laser TX3 source

TX3 consists in two sections

- **DIGITAL LASER DRIVER** constitutes the laser basing stag. There is the converter circuit from TTL level in PECL (straight and negated component),the modulator and bias circuit with ON switch

- **LASER SOURCE** constitutes the stag containing the light source with ST F.O out 3 connector output. There is the photo diode of the APC for bias control

Digital receiver with avalanche detector RX3

RX consists in two sections

- **AVALANCHE PD DETECTOR** constitutes the reception stag containing the avalanche photo diode optical detector, with ST F.O IN 3 connector Input. The Photodiode is biased with constant current to reduce the influence of temperature. The output is amplified and sent to the next voltage stage
- **DIGITAL LASER RECEIVER** constitutes the stage processing the signal of the last stage. In particular there is a filter limiting the band of the output signal from the pre-amplifier, to limit the noise and so to increase the sensibility of the receiver. Then, there is a stage amplifying limiting and providing the signals to the separator stage with PECL output (straight and negated).At last, there is the converter stage of levels from the PECL to the TTL. Besides, there is a detection circuit for the input signal with signaling LED when the level is lower than the detection threshold

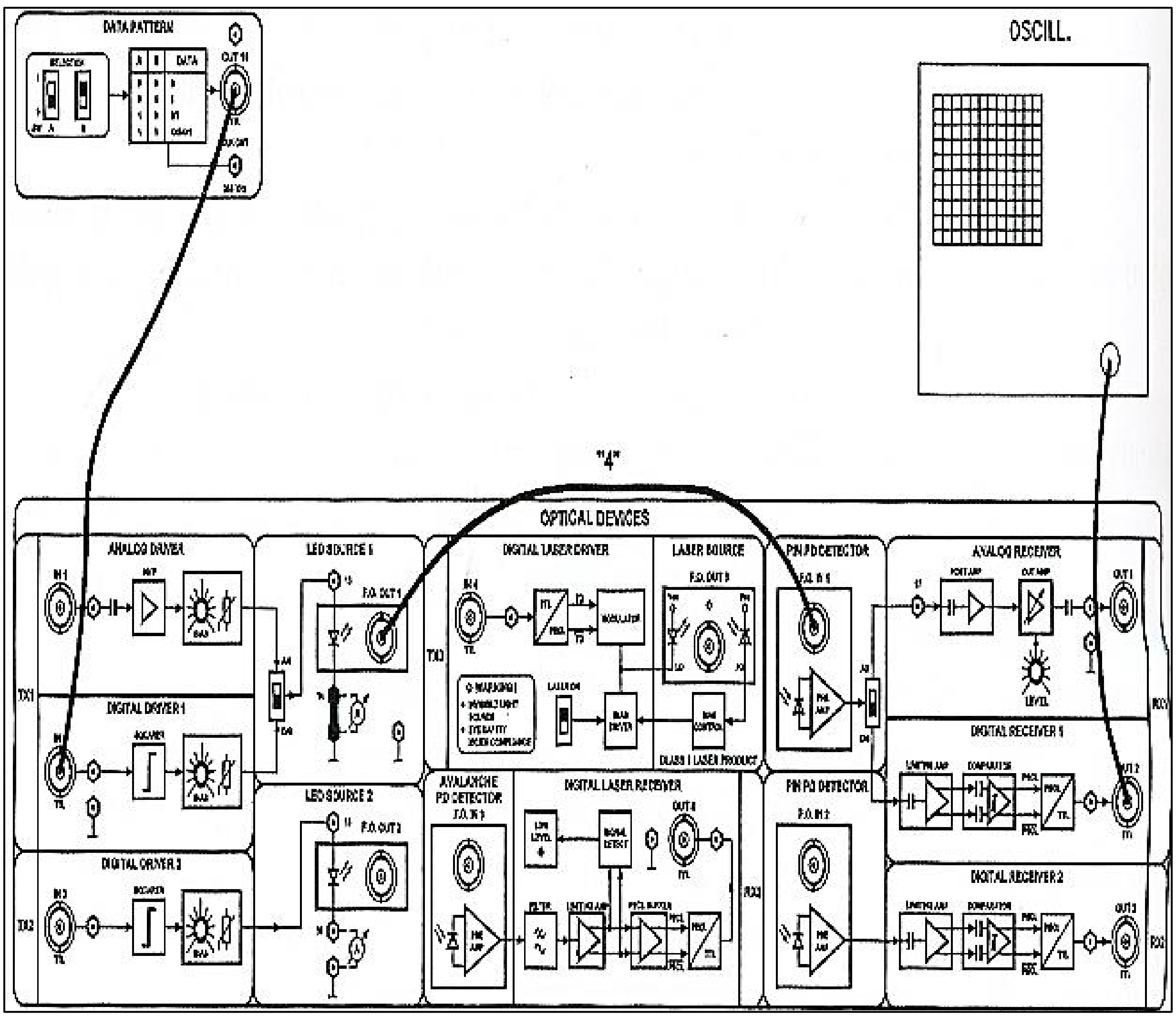

Figure 7.1: Connection Diagram

PROCEDURE

Pre-bias current of the LED

- Power the panel with the provide power supply use the DIGITAL DRIVER 1 and LED SOURCE 1 sections
- Use the DIGITAL DRIVER 1 and LED SOURCE 1 section
- Disconnect any jumper between TP14 and ground and insert a tester configured as ammeter (range in mA)
- Set the AN/DIG switch to DIG
- In this configuration, this 850 nm LED is used directly biased via the BIAS potentiometer.
- Adjust the BIAS potentiometer to the minimum
- In these conditions, there is no input signal (0v to IN2)
- Inside the receptacle, see that the LED, although being driven by a low level signal, is not completely off. Besides, the emitter intensity depends on the position of the BIAS potentiometer
- In these conditions, there is pre-bias current even if the digital driving signal is to zero, so the LED is always lightly on.
- Check that, adjusting the BIAS potentiometer from the minimum to the maximum, the pre bias current changes from about 40 to 80 ma
- Set the AN/Dig switch to AN
- Now, check that the pre-biasing range is between 10mA to 80mA about, attesting that a higher range is necessary for the analog signal in respect to the digital signal operation

Emitted power regulation

- Set the AN/DIG switch to DIG
- With a BNC-BNC coaxial cable, connect the OUT 10 output of the DATA PATTERN to the IN 2 input of the DIGITAL DRIVER 1
- Set the switches SW A to 0 and SW b to 1, so to drive the circuit with a signal fixed to +5V (logical Level 1)
- Via the fiber with identifier “4” (62.5/125) connect the source (F.O ‘OUT 1) to the optical power meter, and turn it on
- On the meter, select the wave length of 850 nm and the reading in dBm
- Check that direct current If flowing across the LED depend on the BIAS potentiometer regulation and so does the maximum optical power emitted by the LED, too

Wave form of the transmitted signal

- Set the SW A switches to 1 and SW B to 0, so to drive the TTL circuit with a 0/1 alternated data signal
- Connect the oscilloscope to the test point of the IN 2 input and to TP13
- Check that in TP13 there is a voltage over the LED threshold (over the BIAS regulation
- With the power meter, Check that the emitted power follows the same variation law, too

Wave from of the received signal

- Set up the circuit as in fig 7.1
- In this configuration the LED and the 850nm PIN photodiode are used

- Set the AN/DIG switch to DIG in the transmission section and to AN in the reception section
- Via the fiber with identifier “4” (62.5/125) connect the source (F.O OUT 1) to the F.O IN 1 input of the PIN photodiode detector
- Connect the oscilloscope to TP13 to TP17
- Check the Wave from of the transmitted and the received signal, i.e. of TP13 (voltage across the LED) , TP17 (voltage detected together with the “photodiode
- + trans-impedance amplifier unit), OUT 3 (received TTL signal, TTL signal, after the reception AN/DIG switch is set to DIG).

Wave form

Use of different kind of fiber

- Remove, now the 62.5/125 fiber (cable “4”) and connect the 200/230 fiber (cable “3”)
- Turn the BIAS potentiometer completely rightward (maximum bias current)
- Examine the Wave-form in TP17
- The signal amplitude is null in respect to the last case, as detector receive a too high optical power and is in saturation. This is due to the fact that the power inserted into fiber by the source in higher with the 200/230 fiber (cable “3”) as this has a higher numerical opening although the 200/230 fiber has a higher attenuation than the 62.5/125 one, this is scarcely affecting due to the short cable length.
- Reducing the emitted optical power BIAS control or lightly setting the fiber further from the detector or the LED, you can see that the detected signal take the right, shapes beside the amplitudes is superior than that with the 62.5/125 fiber.
- Repeat the last measurement using the mono mode 9/125 fiber cable “5” The optical power at the fiber output is very low, practically negligible due to the very small numerical opening mono mode fiber. for this reasons, the reception is impossible. There is only the BIAS voltage.
- Repeat the last measurement using the plastic fiber (cable”1” 1.5 m) the plastic fiber attenuation at 850nm is higher than the one of the glass fiber, and so the received signal (TP17) has smaller amplitude.
- Change the 1.5m plastic fiber with the 5-m one (cable “2”) as the fiber is longer, the optical signal is attenuated more.

RESULT

LAB SESSION 08

OBJECT:

To carry out transmission of an audio signal using fiber optics as a backbone

EQUIPMENT

- Educational panel
- provided optical cables
- Co-axial cables with BNC connector

THEORY

A fiber-optic cable provides a pipeline that can carry large amounts of information. Copper wires or copper coaxial cable carry modulated electrical signals but only a limited amount of information, due to the inherent characteristics of copper cable. Free-space transmission, such as radio and TV signals, provides information transmission to many people, but this transmissions scheme cannot offer private channels. Also, the free-space spectrum is becoming a costly commodity with access governed by the FCC. Fiber-optic transmission offers high bandwidth and data rates, but it does not add to the crowded free space spectrum.

PROCEDURE

- Power the panel with the provided power supply
- Connect OUT 6 port of Test Generator module to IN 1 port of Analog driver section
- Make sure the switch is at AN position in Analog driver section
- Join POINT 14 of LED Source 1 with ground
- Connect F.O.OUT 1 port to F.O.IN 1 port of Pin PD detector using provided fiber cable
- Set switch to AN position
- Connect Analog Receiver OUT 1 port to Audio IN of Speaker 1 or Speaker 2

RESULT

LAB SESSION 09

OBJECT

To become familiar with different types of multiplexing techniques

EQUIPMENT

- Educational Trainer Board
- Cables

THEORY

Wavelength Division Multiplexing

WDM enables the utilization of a significant portion of the available fiber bandwidth by allowing many independent signals to be transmitted simultaneously on one fiber, with each signal located at a different wavelength. Routing and detection of these signals can be accomplished independently, with the wavelength determining the communication path by acting as the signature address of the origin, destination or routing. Components are therefore required that are wavelength selective, allowing for the transmission, recovery, or routing of specific wavelengths.
In a simple WDM system, each laser must emit light at a different wavelength, with all the lasers light multiplexed together onto a single optical fiber. After being transmitted through a high-bandwidth optical fiber, the combined optical signals must be demultiplexed at the receiving end by distributing the total optical power to each output port and then requiring that each receiver selectively recover only one wavelength by using a tunable optical filter. Each laser is modulated at a given speed, and the total aggregate capacity being transmitted along the high-bandwidth fiber is the sum total of the bit rates of the individual lasers. An example of the system capacity enhancement is the situation in which ten 2.5-Gbps signals can be transmitted on one fiber, producing a system capacity of 25 Gbps. This wavelength-parallelism circumvents the problem of typical optoelectronic devices, which do not have bandwidths exceeding a few gigahertze unless they are exotic and expensive. The speed requirements for the individual optoelectronic components are, therefore, relaxed, even though a significant amount of total fiber bandwidth is still being utilized.

Subcarrier Multiplexing

Another method conceptually related to WDM is subcarrier multiplexing (SCM). Instead of directly modulating a ~terahertz optical carrier wave with ~100s Mbps baseband data, the baseband data are impressed on a ~gigahertz subcarrier wave that is subsequently impressed on the THz optical carrier. Figure 3 illustrates the situation in which each channel is located at a different subcarrier frequency, thereby occupying a different portion of the spectrum surrounding the optical carrier. SCM is similar to commercial radio, in which many stations are placed at different RF (Radio Frequency) such that a radio receiver can tune its filter to the appropriate subcarrier RF. The multiplexing and demultiplexing of the SCM channels is accomplished electronically, not optically. The obvious advantage of cost-conscious users is that several channels can share the same expensive optical components; electrical components are typically less expensive than optical ones. Just as with TDM, SCM is limited in maximum subcarrier frequencies and data rates by the available bandwidth of the electrical and optical components.

Therefore, SCM must be used in conjunction with WDM if we want to utilize any significant fraction of the fiber bandwidth, but it can be used effectively for lower-speed, lower-cost multiuser systems.

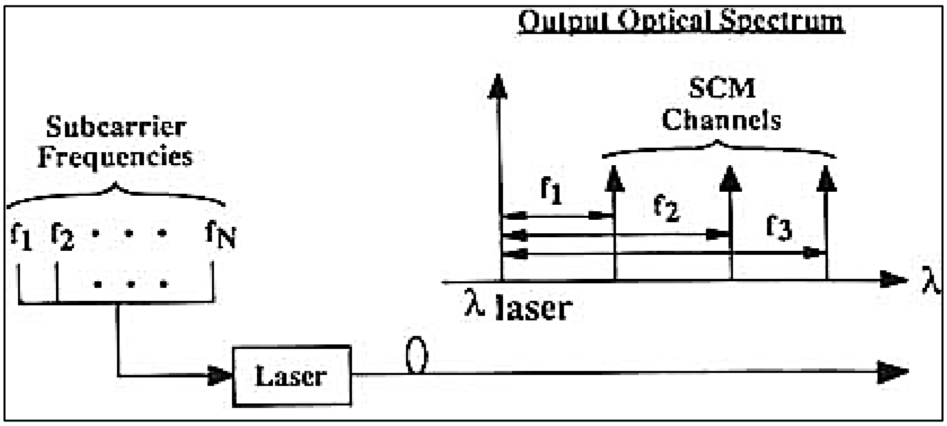

Figure 9.1: Frequency spectrum of several SCM channels transmitted from a single laser

OBSERVATION

Compare the SCM and WDM schemes used in the trainer and state in what circumstances you prefer each

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RESULT

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LAB SESSION 10

OBJECT: -

To carry out transmission of multiplexed digital data over fiber optics

EQUIPMENT:-

- Educational panel
- provided optical cables
- Co-axial cables with BNC connector
- Digital data source

THEORY:-

As fiber is best suited to digital transmission, many low-rate digital signals can be time division multiplexed (TDM) using electronic parallel-to-serial converters. Several low rate signals are combined into a single high-speed channel for transmission and then reconstructed or broken out at the receiving end.
Although high-speed TDM devices are available for aggregate data rates of 10-40 Gbps for telecommunications applications, affordable components, e.g.TDM ICs, fiber optic transceivers and test equipment, are currently limited to 2.5 Gbps. TDM can also be done in several stages, e.g. programmable logic devices (PLDs) can be used to combine many low-rate signals. Over-sampling using a common clock is required when the signals are asynchronous.
Wavelength division multiplexing (WDM) is used to transmit more than one high-speed digital data stream on a single optical fiber. Different wavelengths of light, i.e. different colors propagate in a single fiber without interfering as shown in figure. The devices that do the optical combining and separation are referred to as WDMs. These are passive optical devices that typically employ optical filters or gratings.

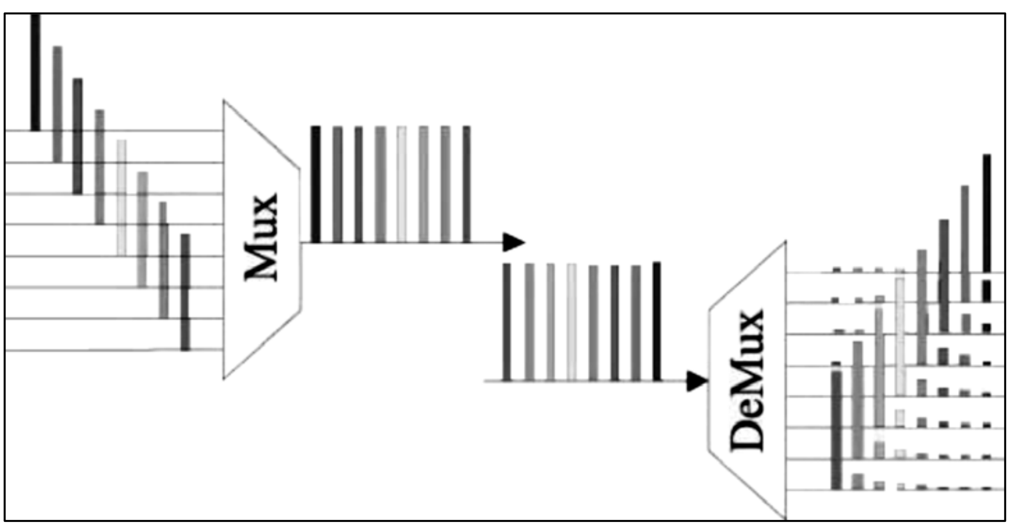

Figure 10.1: MUX and DE-MUX

PROCEDURE

- Power the panel with the provided power supply
- Connect Data multiplexer's 8 data pins with any digital data source (8 ON-OFF switches circuit over breadboard) with 5V.
- Connect OUT 5 TTL port to IN 1 port of Analog Driver module
- Make sure the switch is at AN position in Analog driver section
- Join POINT 14 of LED Source 1 with ground
- Connect F.O.OUT 1 port to F.O.IN 1 port of Pin PD detector using provided fiber cable
- Set switch to AN position
- Connect Analog Receiver OUT 1 port to IN 5 TTL of Data De-multiplexer section

RESULT

LAB SESSION 11

OBJECT

To carry out an audio and video communication system consisting of: audio and video source; audio video multiplexer and de-multiplexer; analog transmitter and receiver on optical fiber and loud speaker

EQUIPMENT

- Educational panel
- Oscilloscope
- Tester
- provided optical cables

THEORY

The optical fiber transmission system used in this experiment is suitable for analog communication its frequency response range from 50Hz to 6MHz about, and so it is proper for video signal transmission .The electrical signal linearly modulated in intensity the optical power emitted by the source. In this case we speak of Intensity Modulation (IM)

The analog signal is applied to an amplifier via ac coupling that eliminates the continuous component. The transmission LED is biased in the central zone of the characteristics "output optical power /driving current ", and is then driven by the amplified analog signal.

This changes the driving current is continuum, and consequently a modulation will be obtained with intensity equal to the optical power emitted by the LED

The reception optical detector consists in a PIN photodiode. The photodiode current output is amplified by a Trans impedance amplifier, providing a voltage output. Next amplifier stages adjust the amplitude of the received signal.

To carry out a complete video +audio communication system there are a video signal generator , an audio generator, an audio+ video multiplexer , an audio +video de- multiplexer, and audio amplifier on the panel.

The audio and video multiplex is carried out by adding the video to the audio sub carrier that is 5.5- MHz carrier frequency modulated by the audio signal.

PROCEDURE

- Power the panel with the provided power supply
- Use the AUDIO/VIDEO section of MODULATORS

VIDEO

- With a BNC-BNC cable, connect OUT 7 output of the VIDEO generator to the VIDEO IN input
- Turn ON all switches SW-1-2-3 and the command of the FM MOD
- Connect the oscilloscope to the input and examine the video signal with the range of gray

Waveform

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- Change SW-1-2-3 and see how the bar signal changes

AUIDO

- See the signal across TP11, a sine signal with amplitude of about 100mVpp and frequency of about 5.5 MHz : it is the sub carrier frequency of the FM modulator used to transmit the audio signal overlaid to the video

BASE BAND

- Note when the signal in BB OUT activates or note the FM MOD: there is the video signal with the audio sub carrier at 5.5 MHz overlaid

AUDIO VIDEO TRANSMISSION AND RECEPTION

- Use the ANALOG Driver and LED source 1
- Set the AN/DIG switch to AN
- Remove the jumper from TP14 and ground and connect an AM meter in between.
- Adjust the bias potentiometer to obtain a current of 60mA
- Reinsert the jumper.
- With a BNC-BNC coaxial cable connect the AUDIO OUT 6 to the AUDIO in 2 of the AUDIO/VIDEO MODULATOR
- with a BNC-BNC cable, connect OUT 7 output of the VIDEO generator to the VIDEO IN input of the AUDIO/VIDEO MODULATOR
- With a BNC-BNC coaxial cable connect the BB OUT of the AUDIO/VIDEO MODULATOR to the IN1 input of the analog driver
- Observe the Wave form at the input of analog driver

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- With the optical fiber #4 connect the source F.O out 1 to F O IN1 of the PIN photodiode detector
- Set The AN/DIG switch to AN in the receiver side too
- With a BNC-BNC coaxial cable connect the OUT 1 of the analog receiver to BB IN of the AUDIO/VIDEO DEMODULATOR
- With a BNC-BNC coaxial cable connect the AUDIO OUT 2 to the AUDIO IN of the speaker 2
- With a BNC-BNC coaxial cable connect the VIDEO OUT to the VIDEO IN input of the color TV monitor and turn the power on of the TV
- Adjust the level of BB OUT by level 2 to get 1Vpp
- Observe the received signal at TP 17, AUDIO OUT, and VIDEO OUT. Wave Forms:

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<u>RESULT</u>

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LAB SESSION 12

OBJECT

To carry out an optical Multiplexing of AUDIO/VIDEO /DATA communication system

EQUIPMENT

- Educational panel
- Oscilloscope
- Provided optical cables

THEORY

OPTICAL MULTIPLEXING

- The optical multiplexing rises from the need to transfer more optical information, even of different coding and bit-rate properties, on the same transmission mean: the optical fiber from this there is the need of a higher efficiency on the use of the available mean that is possible with an optical signal of different optical length into the same fiber

WDM CHARACTERSTIC

The used technique is known as WDM (Wavelength Division Multiplexing) and the typical characteristic are:

- Use of the band at low attenuation 1200-1600nm
- Capacity to carry some tens of Gb/s of the signal WDM channel
- Number of channels multiplexed in the order of hundreds
- The component used in this technique are the WDM, as seen in the last chapter that are passive component in our educational panel, WDM are used at the two channels 850 and 1310nm.

DWDM CHARACTERSTIC

- The most recent technology applied to optical cables is known as DWDM (Dense Wavelength Multiplexing) inside a single fiber the light generally travel decomposed into different “colors” i.e. different wave length these are the three frequency ranges called also windows
- The DWDM is a particular fiber different from the one we are used to conceive, where even thousands of windows are possible it is covered by a very thin layer of material with different reflection indexes to prevent interferences and in a second time many are packed to create an optical cable.
- The DWDM technology enables to send up to 80 different signals to a signal optical cable, each characterized by a different wave length. The DWDM so, are ideal solution to create high speed infrastructure: they case besides the transmission of multimedia signal (i.e audio visual contents) and enable the access to internet at very high speed.
- The first standard that have been defined and used by the manufacturers to carry out DWDM include 8 channel, but actually they pass to 16, 32 and 40 channels.

DATA TRANSMISSION

For data transmission the data is encoded using BI phase Mark and BI phase space and Manchester coding these coding are illustrated in fig 12.1

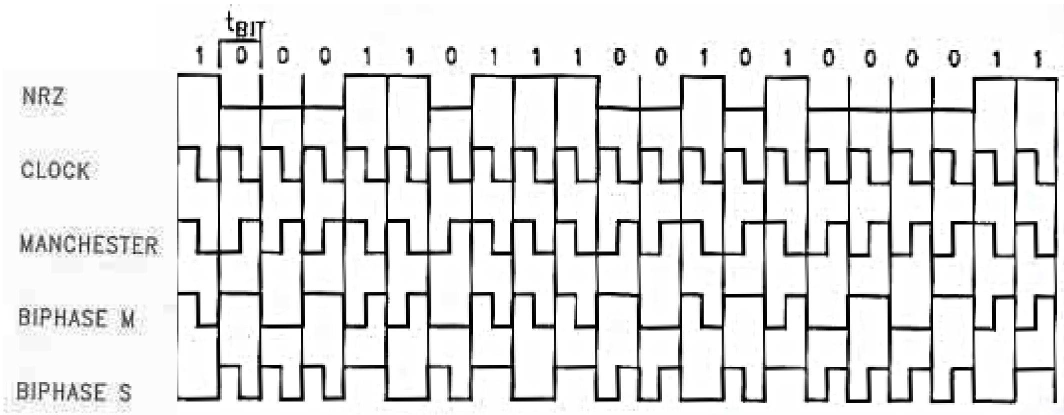

Figure 12.1: MUX and DE-MUX

PROCEDURE

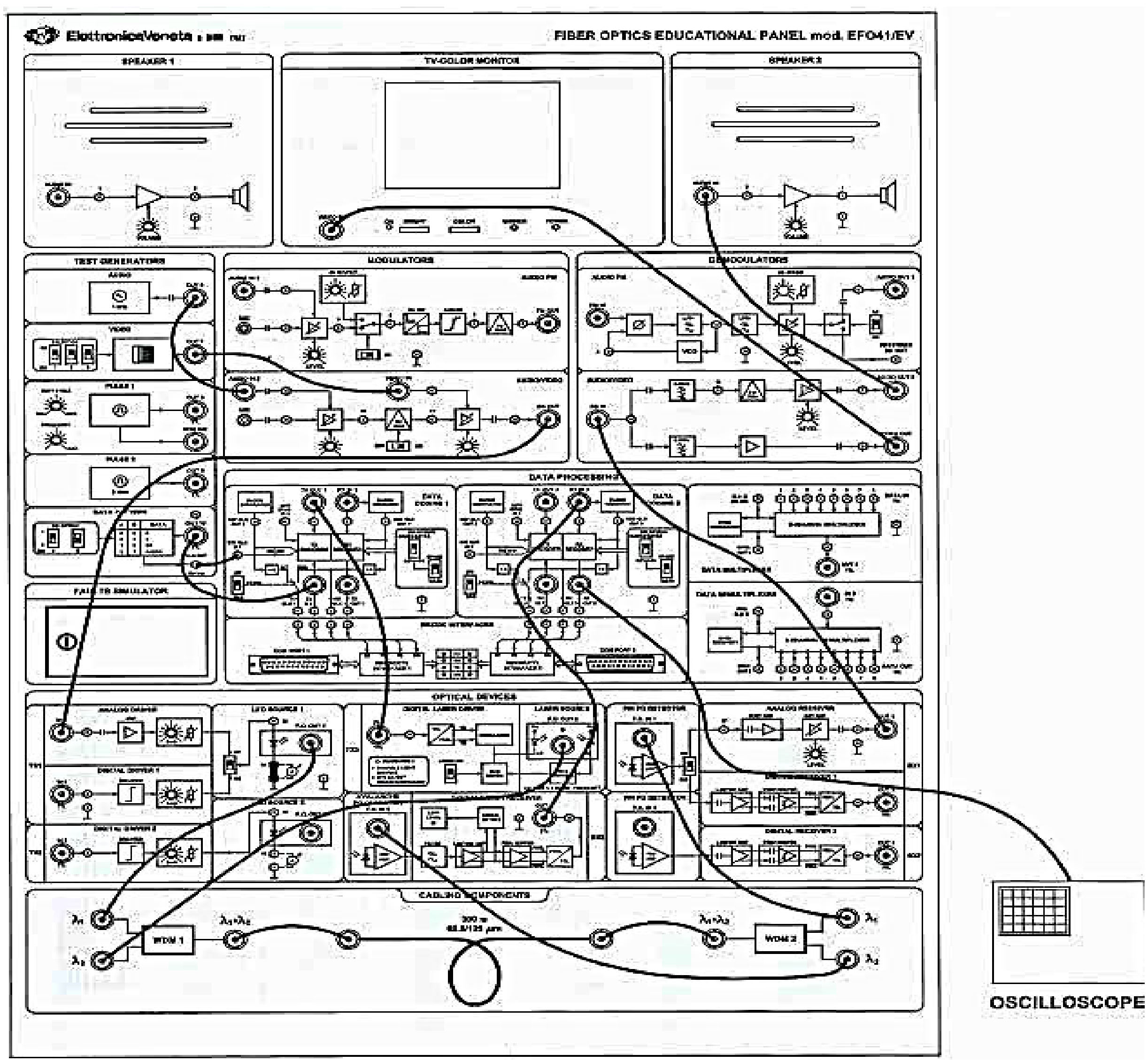

Figure 12.2: Connection Diagram

- Power the panel with the provided power supply
- Use the sections:
- TEST GENERATOR AUDIO , VIDEO ,DATA PATTERN MODULATOR :AUDIO
- /VIDEO
- DEMODULATOR :AUDIO/VIDEO
- DATA PROCESSING :DATA CODING 1(2)
- OPTICAL DEVICES :ANALOG DRIVER ,DIGITAL LASER DRIVER ,LED SOURCE 1,LASER SOURCE ,AVALANCHE PD DETECTOR , DIGITAL LASER RECEIVER ,PIN PD DETECTOR 1.ANALOG RECEIVER
- CABLE COMPONENET :WDM 1(2)
- Carry out the wiring a in fig 12.2(operation diagram as in fig 12.3A)
- Check the proper operation of the DATA transmission with the oscilloscope and ADUIO/VIDEO /DATA information
- Try to slowly disconnect a fiber of a secondary connection and check the loss of the single concerned information
- Carry out a wiring to invert the transmission direction to a single source letting the position of the other unaltered (operation diagram as in fig 12.3B)

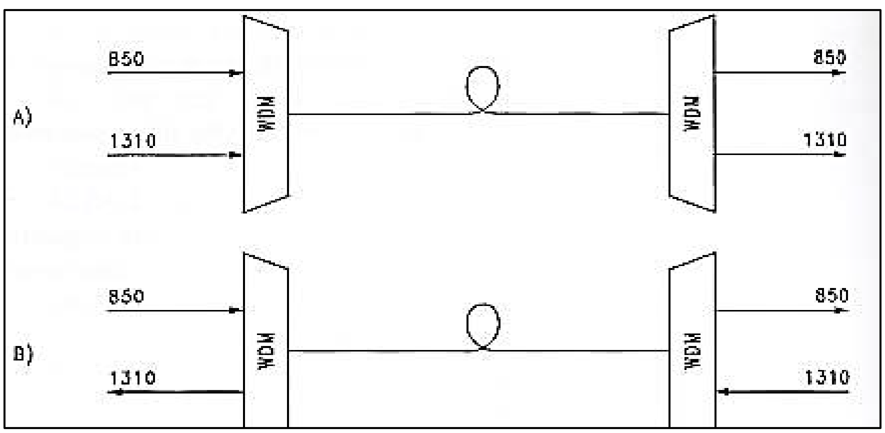

Figure 12.3: Operation Diagram

OBSERVATIONS

Observed wave Form at Video IN, Audio IN, BB OUT, TX IN 1, TX OUT 1, RX IN 2, RX OUT2, BB IN, AUDIO OUT 2, VIDEO OUT 2 are as follows:
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RESULT

Multiplexed audio /Video and digital data are received correctly using WDM couplers but the strength of the signal is weak as the system includes a 300 m long cable.

LAB SESSION 13

OBJECT

To connect two PCs over fiber optics using Ethernet-Fiber media converter

EQUIPMENT

- Fast Ethernet-Fiber Media Converters
- Personal Computers
- Ethernet Cables
- Optical cables

THEORY

Media converter is a simple networking device that makes it possible to connect two dissimilar media types such as twisted pair with fiber optic cabling. Fiber media converters are important in interconnecting fiber optic cabling-based systems with existing copper-based, structured cabling systems. They are also used in metropolitan area network (MAN) access and data transport services to enterprise customers.

Fiber media converters support many different data communication protocols including Ethernet, Fast Ethernet, Gigabit Ethernet, T1/E1/J1, DS3/E3, as well as multiple cabling types such as coax, twisted pair, multi-mode and single-mode fiber optics. Media converter types range from small standalone devices and PC card converters to high port-density chassis systems that offer many advanced features for network management.

Fiber media converters can connect different local area network (LAN) media, modifying duplex and speed settings. Switching media converters can connect legacy 10BASE-T network segments to more recent 100BASE-TX or 100BASE-FX Fast Ethernet infrastructure. For example, existing half-duplex hubs can be connected to 100BASE-TX Fast Ethernet network segments over 100BASE-FX fiber.

Key Features

The media converters have the following key features:

- **LEDs for unit and port status**

LED	State	Color	Description
PWR	ON	Green	Power is applied to the media converter.
LNK	ON	Green	A link has been established on the port.
ACT	ON	Green	Data is being received on the port.
FOX	ON OFF	Green	The port is operating in full-duplex mode. The port is operating in half-duplex mode.
M/LON	ON OFF	Green	The Missinglink feature is activated on the media converter. The Missinglink feature is disabled and

Table 13.1: LEDs' description

MDI/MDI-X button

The RJ-45 port on the media converter features an MDI/MDI-X button. You can use this button to configure the twisted pair port on the media converter as either MDI or MDI-X. This feature allows you to use a straight-through cable regardless of the type of end-node connected to the port.

Link Test/MissingLink ™ button

For performing a link test and activates the Missing Link feature which notifies end-nodes of connection failures.

The link test is a fast and easy way for you to test the connections between the ports on the media converter and the nodes that are connected to the ports. If a network problem occurs, you can perform a link test to determine which port is experiencing a problem, and be able to focus on the port and end-node where the problem resides.

The MissingLink feature enables the fiber optic ports on the media converter to pass the "Link" status of their connections to each other. When the media converter detects a problem with one of the ports, such as the loss of connection to an end-node, the media converter shuts down the connection to the other port, thus notifying the node that the connection has been lost.

Auto-negotiation Button

The auto-negotiation button, located on the front panel, disables the auto- negotiation feature (IEEE 802.3u) of the media converter. The media converter uses auto-negotiation to determine the duplex mode of the ports

lOOBase-TX twisted pair port operates in half- or full-duplex mode

lOOBase-FX fiber optic port operates in half- or full-duplex mode

External AC/DC power adapter

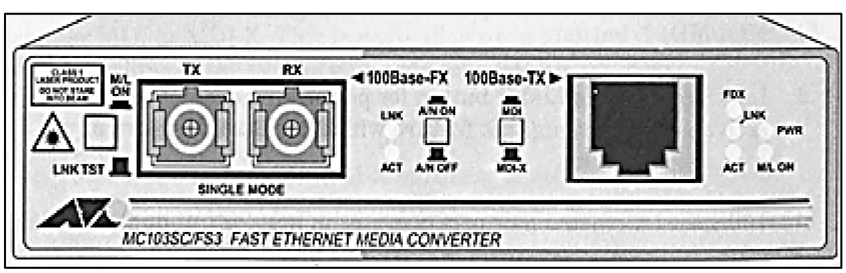

Figure 13.1: Fast Ethernet-Fiber Media Converter

<u>PROCEDURE</u>

Loop back test

To check hardware reliability of the media converter, perform the following procedure:

- Power OFF the media converter by unplugging the power adapter from the wall outlet and from the back of the unit

- Connect the RJ-45 twisted pair port to a 100Base port on the end-node and power ON the end-node
- Set the MDI/MDI-X button as follows:
    - If you are connecting a workstation to the 100Base port, set the MDII MDI-X button to the MDI-X (OUT) position. MDI-X is the default position
    - If you are connecting a hub or a switch to the 100Base port, set the MDI/MDI -X switch to the MDI (IN) position
- Using a tested and good fiber patch cable, attach the matching ends of the fiber cable to the transmit (TX) and receive (RX) connectors of the media converter.
- Set the media converter to the LNK TST(OUT) position.
- Power ON the media converter.
- Verify that the LNK LED on both the twisted pair and fiber optic ports are green.
    - If the LEDs are green, the unit is working properly and there is a problem elsewhere on the segment
    - If the LEDs are OFF there is a problem with the hardware or the attached fiber

Practical

- Power OFF the media converter by unplugging the power adapter from the wall outlet and from the back of the unit
- Connect the RJ-45 twisted pair port to a 100Base port on the end-node of media converter 1 and other end with the LAN card on PC1. Similarly connect media converter 2 with PC2
- Set the MDI/MDI-X button as follows:
    - If you are connecting a workstation to the 100Base port, set the MDII MDI-X button to the MDI-X (OUT) position. MDI-X is the default position
    - If you are connecting a hub or a switch to the 100Base port, set the MDI/MDI -X switch to the MDI (IN) position
- Using a tested and good fiber patch cable, attach TX port of convertor 1 to the RX port of convertor 2 and vice versa
- Power ON the media converters
- Ping PC 1 from PC 2

RESULT

LAB SESSION 14

OBJECT

To carry out cabling of a 2 floor building with fiber optic backbone

EQUIPMENT

- Modulo DL TC74-MC
- HUB Mod. TC74-DH
- SWITCH Mod. TC74-DS
- Media Converter
- Patch cables
- Fiber optics cables with ST connectors

THEORY

A backbone network or network backbone is a part of computer network infrastructure that interconnects various pieces of network, providing a path for the exchange of information between different LANs or subnet works. A backbone can tie together diverse networks in the same building, in different buildings in a campus environment, or over wide areas. Normally, the backbone's capacity is greater than the networks connected to it.

A large corporation that has many locations may have a backbone network that ties all of the locations together, for example, if a server cluster needs to be accessed by different departments of a company that are located at different geographical locations. The pieces of the network connections (for example: Ethernet, wireless, Optical fiber) that bring these departments together is often mentioned as network backbone.

A common misconception is that it is difficult to design a fiber-optic system. There are simple calculations to be made using information from the fiber optic product datasheet. When designing a fiber-optic system it is necessary to know the number and type of signals to be sent through the fiber as well as the transmission distance or required optical budget. We also need to know the transmission distance or required optical budget.

Backbones are the bearing elements of the cabling and they are necessary to connect among them:

- Different buildings with the building where campus star point is installed
- Different floor distributors with thee building start point

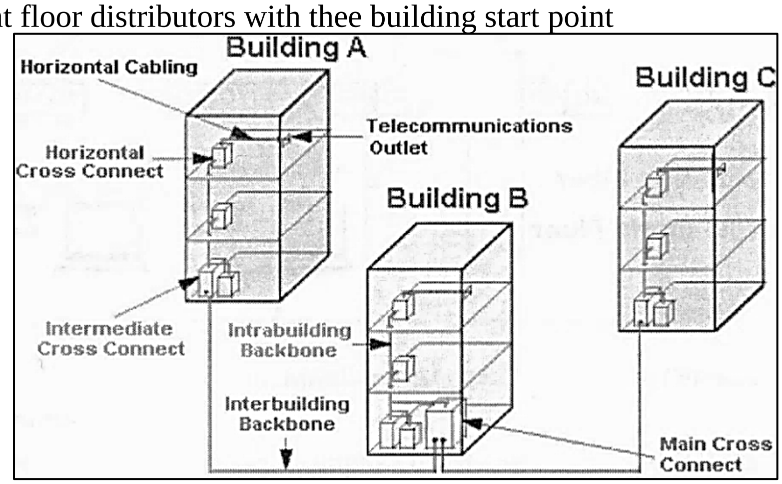

Figure 14.1: Building-Building connection using Fiber optics as backbone

PROCEDURE

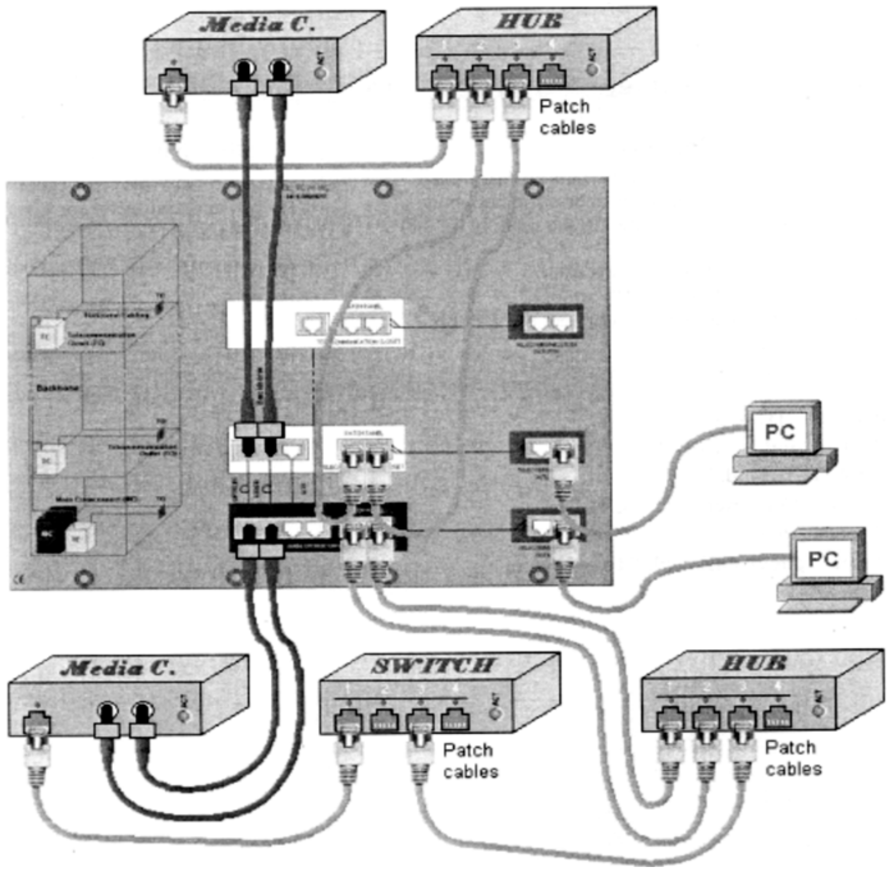

Figure 14.2: Connection Diagram

- Connect all devices as shown in figure 2
- Connect the two computers and start, on both of them, the network communication program which is used for the experiment
- Set the computer PC1 to operate as a server with:
  Local Address = PC 1
  Local Port = 1000
- Push the Listen button.
- Set the_ computer PC2 to operate as a PC1 client with:
  Remote Address = PC 1
  Remote Port = 1000
- Push the Connect button
  * When the button 'Connect' is pushed PC2 connects to the server PC 1.If the program doesn't show error messages the connection is right and the networks is operating
- Send a file from the computer Client PC2 to the server PC 1
- Check the right data transmission

RESULT