WIRELESS AND OPTICS LAB

VII Semester (   )

Image related to Lab (Department wise and lab wise)

Name of the Student :

Semester /Section :

USN :

Batch :

DAYANANDA SAGAR COLLEGE OF ENGINEERING

Accredited by National Assessment & Accreditation Council (NAAC) with 'A' Grade

(An Autonomous Institution affiliated to Visvesvaraya Technological University, Belagavi

&

ISO 9001:2008 Certified)

DEPARTMENT OF TELECOMMUNICATON ENGG

SHAVIGE MALLESWARA HILLS, KUMARASWAMY LAYOUT

BENGALURU-560078

Vision of the Institute

To impart quality technical education with a focus on research and innovation, emphasizing on development of sustainable and inclusive technology for the benefit of society.

Mission of the Institute

- ***To provide an environment that enhances creativity and innovation in pursuit of excellence.***
- ***To nurture teamwork in order to transform individuals as responsible leaders and entrepreneurs.***
- ***To train the students to the changing technical scenario and make them to understand the importance of sustainable and inclusive technologies.***

WIRELESS AND OPTICS LABORATORY MANUAL

VII Semester (17TE7DLWCO)

Name of the Student :

Semester /Section :

USN :

Batch :

DAYANANDA SAGAR COLLEGE OF ENGINEERING
(An Autonomous Institution affiliated to Visvesvaraya Technological University, Belagavi)
DEPARTMENT OF TELECOMMUNICATON ENGG
SHAVIGE MALLESWARA HILLS
KUMARASWAMY LAYOUT
BENGALURU-560078

VISION OF THE DEPARTMENT

- ***To disseminate quality technical education for achieving Academic Excellence through focused research encompassing Mobile, Sensor, and Telecommunication networks with a thrust on Space Communication and Telecommunication Standards***

MISSION OF THE DEPARTMENT

- ***By disseminating the knowledge of devices, systems, and technologies that are impacting the Telecommunication field.***

- ***By educating students towards multidisciplinary practices of Telecommunication industry and standards for a successful career.***

PROGRAMME EDUCATIONAL OBJECTIVES [PEOs]

Program Educational Objectve-1 (PEO1): Graduate contributes service to Telecommunication Engineering industry, government organizations, and society by applying skills acquired through formal technical education.

Program Educational Objectve-2 (PEO2): The graduate demonstrates ability to apply Scientific, Mathematical and Telecommunication Engineering knowledge for solving real life problems.

Program Educational Objectve-3 (PEO3): The graduate possess temperament of professional attitude, effective communication skills, and multidisciplinary approach to resolve Telecommunication domain specific challenges.

Program Educational Objectve-4 (PEO4): The graduate demonstrates continuous learning to update knowledge of emerging Telecommunication technologies through higher education, for sustainable career development to strengthen human values, with a focus on safety and environmental concern.

PROGRAMME SPECIFIC OUTCOMES [PSOs]

PSO1. To apply fundamental concepts of electrical and electronic circuits to analyze communication theory and systems.

PSO2. To design embedded system based solutions for realizing the real-time communication networks.

PSO3. To evaluate the core merits of signal processing and network protocols for telecommunication engineering standards, services and applications.

WIRELESS AND OPTICS LAB MANUAL

VII SEMESTER B. E (TCE)

Sub. Code:
Hrs/Week: 03
Total Hrs: 42

IA Marks : 50
Exam Hrs : 03
Exam Marks: 50

Course Objectives:

Course Outcomes:

COs	Wireless and Optics Lab : C	POs	Blooms Level
C4O8.1		P-01,2,3, 4,10,11	
C4O8.2		P-01,2,3, 4	
C4O8.3		P-01,2,3, 4	
C4O8.4		P-01,2,3, 4,10	
C4O8.5		P-01,2,3, 4,10,11	
C4O8.6		P-01,2,3, 4,10,11	

Syllabus:

List of Experiments

1. To determine the free space loss and the power received using Matlab program.
2. To write a Matlab program to calculate the link budget for satellite communication.
3. To write a Matlab program to calculate the Carrier to noise ratio for uplink and downlink and also the overall carrier to noise ratio.
4. To write a Matlab program to calculate the median path loss for Okumura model for outdoor propagation.
5. To write a Matlab program to calculate the median path loss for Hata model for outdoor propagation.
6. To set up an 850nm fiber optic analog link using Optic fiber trainer kit set up model. To set up a 650nm fiber optics digital link using Optic fiber trainer kit set up model.
7. Estimation of Attenuation loss, coupling loss, Numerical Aperture and radius of Curvature using Optic fiber trainer kit set up model.
8. To study the Time Division Multiplexing (TDM) with fiber communication system using Optic fiber trainer kit set up model.
9. To Study the R232 interface for PC Communication and voice interface in two optical fiber patch cards using Optic fiber trainer kit set up model.
10.

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WIRELESS AND OPTICS LAB

I - CYCLE

1. To determine the free space loss and the power received using Matlab program.
2. To write a Matlab program to calculate the link budget for satellite communication.
3. To write a Matlab program to calculate the link budget for satellite communication and also to calculate the Carrier to noise ratio for uplink and downlink and also the overall carrier to noise ratio.
4. To write a Matlab program to calculate the median path loss for Okumura model for outdoor propagation.
5. To write a Matlab program to calculate the median path loss for Hata model for outdoor propagation.

II – CYCLE

1. To set up an 850nm fiber optic analog link.
2. To set up a 650nm fiber optics digital link.
3. Estimation of Numerical Aperture and radius of Curvature
4. To study the Time Division Multiplexing (TDM) with fiber communication system.
5. To Study the R232 interface for PC Communication and voice interface in two optical fiber patch cards.
6. To generate and demodulate Quadrature Phase Shift Keying (QPSK) signal using MATLAB Program.

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DEPARTMENT OF TELECOMMUNICATON ENGG

DO's

1. Come prepared for the conduction of experiment to appreciate the concept.
2. Keep all the controls at minimum before switching ON
3. Submit your lab records before starting the experiment.
4. Check the correctness and terminals of the device/IC before connecting.
5. Follow the oral/written procedural instructions while conducting the experiment.
6. Take safety precautions while handling high voltage components and wear insulated footwear.
7. Switch off the power-supply in case of any malfunction of equipment/component and report the same to lab instructor.
8. Treat all the devices/equipments/components with due care and considerations.
9. Conduct the experiment by yourself, behave in a responsible manner at all the times and maintain silence.
10. Record the readings/outputs in observation book.
11. At the end of the experiment keep all equipments/devices/components in the original order.
12. At the end of the experiment keep the chairs/furniture in order.
13. Be regular to the lab.

DONT's

1. Do not use equipments/devices/components that you are unfamiliar with.
2. Do not switch on the power without proper circuit connection.
3. Do not use equipments/trainer kits unnecessarily.
4. Do not come late to the lab.
5. Do not wander in the lab.
6. Do not open any irrelevant websites on lab computer.
7. Do not upload/delete/alter any software on lab computer.

FREESPACE PROPAGATION – PATH LOSS MODEL

Aim:

To determine the free space loss and the power received using Matlab program.

Theory:

The free space path loss, also known as FSPL is the loss in signal strength that occurs when an electromagnetic wave travels over a line of sight path in free space. In these circumstances there are no obstacles that might cause the signal to be reflected refracted, or that might cause additional attenuation.

The free space path loss calculations only look at the loss of the path itself and do not contain any factors relating to the transmitter power, antenna gains or the receiver sensitivity levels.

To understand the reasons for the free space path loss, it is possible to imagine a signal spreading out from a transmitter. It will move away from the source spreading out in the form of a sphere. As it does so, the surface area of the sphere increases. As this will follow the law of the conservation of energy, as the surface area of the sphere increases, so the intensity of the signal must decrease.

As a result of this it is found that the signal decreases in a way that is inversely proportional to the square of the distance from the source of the radio signal

Free space path loss formula

The free space path loss formula or free space path loss equation is quite simple to use. Not only is the path loss proportional to the square of the distance between the transmitter and receiver, but the signal level is also proportional to the square of the frequency in use.

$$FSPL = (4\pi d/ \lambda)2 = (4\pi df/ c)2$$

FSPL is the Free space path loss,**d** is the distance of the receiver from the transmitter (metres),**λ** is the signal wavelength (metres),**f** is the signal frequency (Hertz),**c** is the speed of light in a vacuum (metres per second)

The free space path loss formula is applicable to situations where only the electromagnetic wave is present, i.e. for far field situations. It does not hold true for near field situations.

Decibel version of free space path loss equation

Most RF comparisons and measurements are performed in decibels. This gives an easy and consistent method to compare the signal levels present at various points. Accordingly it is very convenient to express the free space path loss formula, FSPL, in terms of decibels..

FSPL (dB) = 20 log10 (d) + 20 log10 (f) + 32.44

Where: **d** is the distance of the receiver from the transmitter (km) **f** is the signal frequency (MHz)

Affect of antenna gain on path loss equation

The equation above does not include any component for antenna gains. It is assumed that the antenna gain is unity for both the transmitter. In reality, though, all antennas will have a certain amount of gain and this will affect the overall affect. Any antenna gain will reduce the "loss" when compared to a unity gain system. The figures for antenna gain are relative to an isotropic source, i.e. an antenna that radiates equally in all directions.

FSPL (dB) = 20 log10 (d) + 20 log10 (f) + 32.44 -Gtx – Grx

Where: **Gtx**is the gain of the transmitter antenna relative to an isotropic source (dBi) **Grx**is the gain of the receiver antenna relative to an isotropic source (dBi)
The free space path loss equation or formula given above, is an essential tool that is required when making calculations for radio and wireless systems either manually or within applications such as wireless survey tools, etc. By using the free space path loss equation, it is possible to determine the signal strengths that may be expected in many scenarios. While the free space path loss formula is not fully applicable where there are other interactions, e.g. reflection, refraction, etc as are present in most real life applications, the equation can nevertheless be used to give an indication of what may be expected. It is obviously fully applicable to satellite systems where the paths conform closely to the totally free space scenarios

Power Received :

[Pr] = [Pt] + [Gt] + [Gr] – [FSPL]

Pr – Received power Pt – Transmitted power
Gt – Gain of the transmitting antenna Gr – Gain of the receiving antenna

Program:

```
clc;
close all;
clear all;
f=input('enter the frequency in Mhz: ');
L=300/f; %calculating wavelength
disp('thus the wavelength is: ');
L %displaying wavelength
d=input('enter the distance in km: ');
Gt=input('enter the transmitting antenna gain in db: ');
Gr=input('enter the receiving antenna gain in db: ');
Pt=input('enter the transmitted power in db: ');
ls=32.44+20*log10(d)+20*log10(f); %calculating path loss
disp(sprintf('%s %d %s','the path loss is:',ls,'db'));%displaying path loss
Pr=Pt+Gt+Gr-ls; %calculating recieved power in db
disp(sprintf('%s %d %s','therecieved power is:',Pr,'db'));
Pr=10^(Pr/10); %calculating recieved power in watts
```

```
disp(sprintf('%s %d %s','therecieved power is:',Pr,'watts'));
%displaying recieved power in watts.
```

Result: The program for power received by an antenna and path loss in Free space propagation was simulated successfully.

Experiment No: 2 Date: ___________

EXPERIMENT 2
LINK BUDGET EQUATION – SATELLITE COMMUNICATION

Aim :

To write a Matlab program to calculate the link budget for satellite communication.

Theory :

A link budget is an accounting of all the gains and losses in a transmission system. The link budget looks at the elements that will determine the signal strength arriving at the receiver. The link budget may include the following items:

Transmitter power.
Antenna gains (receiver and transmitter).
Antenna feeder losses (receiver and transmitter).
Path losses.
Receiver sensitivity (although this is not part of the actual link budget, it is necessary to know this to enable any pass fail criteria to be applied.

Where the losses may vary with time, e.g. fading, and allowance must be made within the link budget for this - often the worst case may be taken, or alternatively an acceptance of periods of increased bit error rate (for digital signals) or degraded signal to noise ratio for analogue systems.

Received power (dBm) = Transmitted power (dBm) + gains (db) - losses (dB)

The basic calculation to determine the link budget is quite straightforward. It is mainly a matter of accounting for all the different losses and gains between the transmitter and the receiver.

Losses = FSL + AML + RFL + PL + AA
FSL = Freespace loss AML = Antenna Misalignment loss
RFL=Receiver Feeder loss PL=Polarization Loss
AA = Atmospheric Absorption.

Carrier to Noise Ratio – Uplink

$CNR_u=EIRP_u+GTR_u-Loss_u+228.6$

Carrier to Noise Ratio – Uplink

$CNR_d=EIRP_d+GTR-Loss_d+228.6$

Overall Carrier to Noise Ratio

$CNR_{overall}=CNR_u X\ CNR_d/ (CNR_u+CNR_d)$

Program:

```
clc;
close all;
clear all;
pt=input('enter the input power in watts:');
Pt=10*log10(pt) %calculating transmitted power in db
gt=input('enter the transmitting antenna gain in db:');
gs=input('enter the recieving antenna gain in db:');
EIRP=Pt+gt %calculating EIRP
d=input('enter the distance in km:');
f=input('enter the frequency in mhz:');
fsl=32.4+20*log10(d)+20*log10(f) %calculating path loss
rfl=input('enter the reciever feeder loss in db:');
aa=input('enter the atmospheric absorption in db:');
aml=input('enter the antenna misalignment loss in db:');
pl=input('enter the polarization loss in db:');
losses=fsl+rfl+aa+aml+pl; %calculating total losses
disp(sprintf('%s %f %s','total loss',losses,'db'));
P=EIRP+gs-losses; %calculating power recieved
disp(sprintf('%s %f %s','Totalrecieved power =',P,'db'));
```

Result:

The Matlab program for calculating the link budget was simulated successfully.

Experiment No: 3 Date: ___________

CARRIER TO NOISE RATIO – SATELLITE COMMUNICATION

Aim :

To write a Matlab program to calculate the link budget for satellite communication and also to calculate the Carrier to noise ratio for uplink and downlink and also the overall carrier to noise ratio.

Theory :

A link budget is an accounting of all the gains and losses in a transmission system. The link budget looks at the elements that will determine the signal strength arriving at the receiver. The link budget may include the following items:

Transmitter power.
Antenna gains (receiver and transmitter).
Antenna feeder losses (receiver and transmitter).
Path losses.
Receiver sensitivity (although this is not part of the actual link budget, it is necessary to know this to enable any pass fail criteria to be applied.

Where the losses may vary with time, e.g. fading, and allowance must be made within the link budget for this - often the worst case may be taken, or alternatively an acceptance of periods of increased bit error rate (for digital signals) or degraded signal to noise ratio for analogue systems.

Received power (dBm) = Transmitted power (dBm) + gains (db) - losses (dB)

The basic calculation to determine the link budget is quite straightforward. It is mainly a matter of accounting for all the different losses and gains between the transmitter and the receiver.

Losses = FSL + AML + RFL + PL + AA

FSL = Freespace loss AML = Antenna Misalignment loss

RFL=Receiver Feeder loss PL=Polarization Loss

AA = Atmospheric Absorption.

Carrier to Noise Ratio – Uplink

$$CNR_u=EIRP_u+GTR_u-Loss_u+228.6$$

Carrier to Noise Ratio – Uplink

$$CNR_d=EIRP_d+GTR-Loss_d+228.6$$

Overall Carrier to Noise Ratio

$CNR_{overall}=CNR_u X\ CNR_d / (CNR_u+CNR_d)$

Program:

```
clc;
clear all;
close all;
EIRPu=input('Enter the uplink EIRP:');
EIRPd=input('Enter the downlink EIRP:');
GTRu=input('Enter the uplink G/T:');
GTRd=input('Enter the downlink G/T:');
fsl=32.4+20*log10(d)+20*log10(f) %calculating path loss
fsl=32.4+20*log10(d)+20*log10(f) %calculating path loss
RFLu=input('Enter the uplink RFL:');
RFLd=input('Enter the downlink RFL:');
AAu=input('Enter the uplink AA:');
AAd=input('Enter the downlink AA:');
AMLu=input('Enter the uplink AML:');
AMLd=input('Enter the downlink AML:');
Lossu=FSLu+RFLu+AAu+AMLu %calculating total losses in UPLINK
Lossd=FSLd+RFLd+AAd+AMLd %calculating total losses in DOWNLINK
CNRu=EIRPu+GTRu-Lossu+228.6; %calculating CNR of UPLINK
disp(sprintf('%s %f %s','total carrier to noise ratio for uplink is:',CNRu,'decilog'));
CNRd=EIRPd+GTRd-Lossd+228.6; %calculating CNR of DOWNLINK
disp(sprintf('%s %f %s','total carrier to noise ratio for downlink is:',CNRd,'decilog'));
CNRt=CNRu*CNRd/(CNRu+CNRd); %calculating total CNR
disp(sprintf('%s %f %s','total carrier to noise ratio is:',CNRt,'decilog'));
```

Result:

The program for power received by an antenna and path loss in Free space propagation was simulated successfully.

Experiment No: 4 Date: ___________

OUTDOOR PROPAGATION MODEL - OKUMURA MODEL

Aim:

To write a Matlab program to calculate the median path loss for Okumura model for outdoor propagation.

Theory:

The Okumura model for Urban Areas is a Radio propagation model that was built using the data collected in the city of Tokyo, Japan. The model is ideal for using in cities with many urban structures but not many tall blocking structures. The model served as a base for the Hata Model.

Okumura model was built into three modes. The ones for urban, suburban and open areas. The model for urban areas was built first and used as the base for others.

Coverage

Frequency = 150 MHz to 1920 MHz
Mobile Station Antenna Height: between 1 m and 10 m
Base station Antenna Height: between 30 m and 1000 m
Link distance: between 1 km and 100 km

Mathematical formulation

The Okumura model is formally expressed as:

$$L = L_{FSL} + A_{mu}(f, d) - G(t_{he}) - G(h_{re}) - G_{area} +$$

Where,

L = The median path loss. Unit: Decibel (dB)
L_{FSL} = The Free Space Loss. Unit: Decibel(dB)
$A_{mu}(f, d)$ = Median attenuation.Unit: Decibel(dB)
$G(h_{te})$= Mobile station antenna height gain factor= $20 \log (h_{te}/200)$ $1000m > h_{te} > 30m$
$G(h_{re})$= Base station antenna height gain factor = $10 \log (h_{re}/3m)$ $h_{re} \leq 3m$
$G(h_{re})$= Base station antenna height gain factor = $20 \log (h_{re}/3m)$ $10m > h_{re} > 3m$

G_{area} = Correction factor gain (such as type of environment, water surfaces, isolated obstacle etc.)

Okumura model does not provide a mean to measure the Free space loss. However, any standard method for calculating the free space loss can be used.

Program:

```
clc;
clear all;
close all;
fsl =32.4+20*log10(d)+20*log10(f) %calculating path loss
Amu (f, d) =input('enter the median attenuation value:');
G(the)=input('enter the Mobile station antenna height gain factor:');
G(hre)=input('enter the Base station antenna height gain factor:');
Garea =input('enter the Correction factor gain:');
L = fsl + Amu (f, d) - G(the)-G(hre)-Garea      ; %calculating median path loss
disp(sprintf('%s %f %s', 'the median path loss:',L,'dB'));
```

Result:

The program for Okumura Model – Outdoor Propagation was simulated successfully.

Experiment No: 5 Date: ____________

OUTDOOR PROPAGATION MODEL - HATA MODEL

Aim:

To write a Matlab program to calculate the median path loss for Hata model for outdoor propagation.

Theory:

In wireless communication, the Hata Model for Urban Areas, also known as the *Okumura-Hata model* for being a developed version of the Okumura Model, is the most widely used radio frequency propagation model for predicting the behaviour of cellular transmissions in built up areas. This model incorporates the graphical information from Okumura model and develops it further to realize the effects of diffraction, reflection and scattering caused by city structures. This model also has two more varieties for transmission in Suburban Areas and Open Areas.

Hata Model predicts the total path loss along a link of terrestrial microwave or other type of cellular communications.

This particular version of the Hata model is applicable to the radio propagation within urban areas.

This model is suited for both point-to-point and broadcast transmissions and it is based on extensive empirical measurements taken. PCS is another extension of the Hata model. The Walfisch and Bertoni Model is further advanced.

Coverage

Frequency, fc: 150 MHz to 1500 MHz

Mobile Station Antenna Height: between 1 m and 10 m = $\mathbf{h_{te}}$

Base station Antenna Height: between 30 m and 200 m = $\mathbf{h_{re}}$

Link distance: between 1 km and 20 km.

Mathematical formulation

Hata Model for Urban Areas is formulated as:

$$L_U = 69.55 + 26.16 \log f_c - 13.82 \log h_{te} - a(h_{re}) + [\, 44.9 - 6.55 \log h_{te}] \log d$$

For small or medium sized city,

$$a(h_{re}) = 0.8 + (1.1 \log f - 0.7)\, h_{re} - 1.56 \log f.$$

and for large cities,

$$a(h_{re}) = 8.29 (\log (1.54\, h_{re})^2 - 1.1\,, \qquad \text{if } f_c \le 300\text{MHz}$$

$$a(h_{re}) = 3.2\,(\log(11.75\,h_{re}))^2 - 4.97\,, \qquad \text{if } f_c \geq 300\text{MHz}$$ Where,

L_U = Path loss in Urban Areas (dB)

h_{te} = effective Height of base station Antenna (transmitter) (m)

h_{re} = Height of mobile station Antenna(Receiver) (m)

f= Frequency of Transmission (MHz).

$a(h_{re})$ = Antenna height correction factor

d= Distance between the base and mobile stations (km).

The term "small city" means a city where the mobile antenna height not more than 10 meters. i.e. $1 \leq h_{re} \leq 10$m

Program:

```
clc;
clear all;
close all;
f=input('enter the frequency of transmission in mhz:');
hte =input('enter the height of base station Antenna in meter:');
hre =input('enter the height of mobile station Antenna in meter:');
d=input('enter the distance between the base and mobile stations:');
n=input('enter 0 for small city and 1 for large city:');
if n==0
a(hre) =0.8+(1.1*log10(f)-0.7)* hre -1.56*log10(f);
else
if f >=150 && f<=200
a(hre) =8.29*(log10(1.54* hre))^ 2- 1.1;
else
if f ≥200 && f≤1500
a(hre) =3.2*(log10(11.75* hre))^ 2-4.97;
end;
end;
end;
Lu=69.55+26.26*log10(f)-13.82*log10(hre)-ch+(44.9-6.55*log10(hre))*log10(d);
```

```
disp(sprintf('%s %f %s','Path loss in Urban Areas=',Lu,'db'));
```

Result:

The program for Hata Model – Outdoor Propagation was simulated successfully.

Optical Fiber Communication

Fundamentals:

The principle of fiber optics needs to have an understanding of the basic principles of light and how it is propagated. Light is a type of energy called radiant energy that travels as electromagnetic rays. Radiant energy travels like waves produced in still water when a pebble is tossed into it. The waves radiant in every direction away from the point of where the pebble entered the water. Infrared, ultra violet and visible light is type of energy classified as light.
Different form of energy travel with larger or shorter waves and energy form the crest of one wave to the next, while frequency is a measure of the number of wave cycles performed in the space of one second.

Light rays bend or refract when they pass from one medium to another, which is caused by the slowing down of the rays at one edge of the beam at the cross over point. Because of the refraction, light can be reflect internally along a glass fiber and bounce along the inside, giving the signals a longer effective range.

Every optic fiber consists of three strands, each inside the other. The center one, the core 'core' is a special low loss grade of material that has a constant refractive index, i.e., its ability to bounce light along its length. The next one, the 'cladding' and the outer one the 'sheath' each have progressively lower refractive index which stop the light straying from center.
As transmission are unaffected by the electrical interference and do not weaken quickly, fiber optics are popular for long distances, especially as transmission speeds are those of light itself. These are systems capable of carrying over 4000 voice circuits per fiber and transmitting at rates in excess of 4 MBPS over stage length of at least 100 Km without repeaters or regenerators.

Advantages of Optical communication:

The properties of fiber are exceedingly varied owing to the wide application are and tailoring of those properties to different applications leaving apart the limitation of attenuation (Light becomes dimmer as it travels along the fiber), optical fibers have various advantages over copper wires apart from resistance and temperature. The most relevant among them are:

- **Very small cross talk:** Very little light escapes from the fiber is absorbed through the cladding, which provides good cross talk features.
- **Large bandwidth:** A single mode fiber provides several ten-fold GHz x Kms of a graded index fiber. This quantity is measured as the product of the bandwidth and unrepeated distance.
- **Low Loss:** The loss of an optical fiber is below 0.5 dB/Km, allowing unrepeated links of 60 Kms. By comparison loss of coaxial cable is around 20 dB/Km.

- **Bandwidth upgradability:** The transmission rate can be upgraded up to one order of magnitude, while utilizing the existing optical fiber.
- **Photonic**: As fibers are not electronic they do not generate sparks and can be used in flammable or explosive environments.
- **Availability of material:** Copper is limited and must be mined whereas silica is available in abundance.
- **Small size:** Outer diameter of strand is approximately 0.1 mm, which means fewer cables are necessary leading to reduced duct volume.
- **Lightweight and physical flexibility:** The weight of the finished cable fiber is 10 to 30 % less than that of a copper cable. Owing to its physical flexibility, the cable can be easily bent and be installed along with existing conduit.
- **Electro magnetically Robust and Oxidation free**: Optical fiber is free from the electromagnetic induction and does not rust as in case of metals. As a consequence optical fibers can endure adverse environments such as at the bottom of an ocean.

Optical Fiber Trainer's Kit

The Benchmark Optical Fiber Trainer - OFT - is the base-line for every fiber optic laboratory. It demonstrates state-of-the-art concepts in fiber optic communications. It provides for easy experimentation and effectively bridges the gap between a leading-edge technology and currently available technical training tools. As the concepts demonstrated are no different from those encountered in real-life systems, it can provide significant insights, of direct relevance, to the student and practicing engineers alike. In addition, it can serve as a ready-made communications platform for photo typing and in applications calling for fibre optic capabilities.

Features

Eleven usable 64 kbps channels User definable frame marker (two alternating 8-bit markers - can be set to CCITT compatible)

On-board two digitized voice channels, one 8-bit data channel and several user-expansion channels:

Demonstrates fully operational integrated voice/data fibre-optic communication link

- RS - 232C communications module optional - demonstrates computer communications over fibre
- Time Division Multiplexing of voice, data & user-defined data streams
- Modular design enables configuration with user-defined modules
- Wide scope for experimentation through use of external circuitry interfaced to kit
- Comprehensive manual describes wide range of experiments - can form basis of courses
- Ready -to -use kit comes complete with accessories

Optical	
Wavelengths	650nm and 850nm
FWHM spectral width	100nm
Fibre	1000 micron plastic fibre (1m, 3m and 20m lengths included)
Max link length	30m for 650nm optical digital link
	5m for 850nm link
Max data rate	2 Mbits/sec (NRZ)

Experiment No: 6 Date: ___________

Analog communication link using optical fiber

Aim: To set up an 850nm fiber optic analog link.

Components required: OPTICAL FIBER TRAINER KIT, Oscilloscope, function generator- 1Hz to 10MHZ.

Introduction: The experiment is designed to familiarize the user with OFT. An analog fiber optic link is to be set up in this experiment.. The detector is a simple PIN detector.

The LED Optical power output is directly proportional to the current driving the LED. Similarly for the PIN diode the current is proportional to the amount of light falling on the detector. Thus even though the LED and the PIN DIODE are non-linear devices the current in the PIN diode are non-linear devices the current in the PIN diode is directly proportional to the driving current of the LED. This makes the optical communication system a linear system.

The fiber used in optical fiber trainer kit is Multimode Plastic fiber with 1000µm core diameter. unlike its glass-glass and plastic coated silica fiber counterparts this fiber has very high attenuation. It is useful mainly for short links such as in local area networks especially where there could be serious EMI problems. While the loss in plastic fiber is high for all wavelength regions, the loss at 850nm is much higher than at 650nm.

Procedure:

1. Set the switch SW8 to the analog position. Switch the power on.
2. Feed a 1Vp_p (peak to peak) sinusoidal signal at 1KHz from a function generator to the analog in post P11 using the following procedure.

i) Connect a BNC-BNC Cable from the function generator to the BNC socket I/01

ii) Connect the signal post I/02 to the analog IN Post P11 using a patch chord.

3. Connect one end of the 1m fiber to the LED Source LED1 in the optical Tx1 block.
4. Connect I/03 to P31 of optical receiver1 using a connecting wire or a patch chord.
5. Connect I/01 and I/02 using a connecting wire or a patch chord.

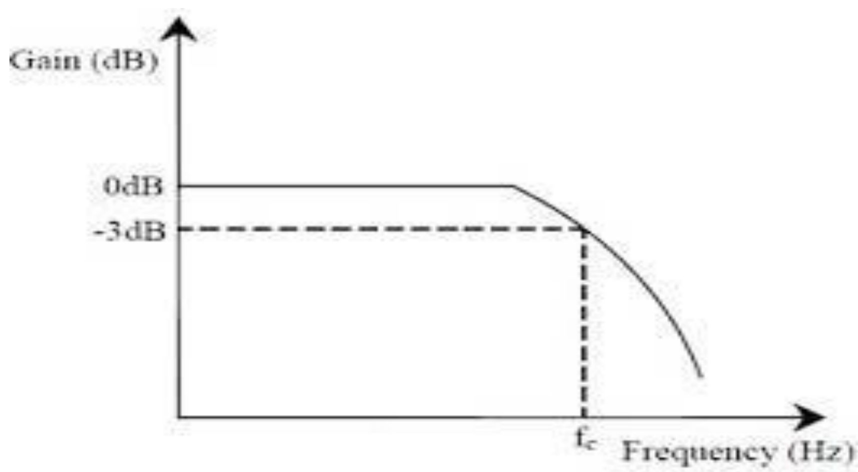
6. Connect a BNC-BNC cable from the I/02 to the CRO and assign that as the input signal and set the input frequency 1kHZ and 2Vp-p in the function generator.

7. Connect a BNC-BNC Cable from I/ 03 socket to CRO TO view the output signal.

8. Adjust gain knob in trainer kit such that no clipping of output wave forms takes place and does not disturb the gain throughout the experiment. Note down the output voltages and calculate the gain as per the tabular column.

Tabular column:

Freq(Hz)	Output voltage (Vo)	Gain =20 log($\frac{Vo}{Vi}$)



Filter Response

Calculation of attenuation loss and bending loss in analog link of 850nm :

Procedure:

1. Set up an fiber analog link as explained in the first experiment and note down the input voltage and output voltage values with a 1m fiber connected between optical reveicer1. Set the values 1Vp-p and 10KHz sinusoidal signal with zero dc.

2. Repeat the same for 3m fiber and note as per the tabular column.

3. Calculate attenuation loss as per the formula

$$\mathbf{(P3/P1) = \left(\frac{V3}{V1}\right) = exp(-\alpha\,(L3 - L1))}$$

Where α is attenuation in neper/m and P1 and P3 are received optical powers with 1m and 3m length fiber and calculate where α^1 is the fiber loss or the attenuation loss

$$\boldsymbol{\alpha^1\ (db/m) = 4.343\ \alpha\ (m^{-1})}$$

Tabular column:

Fiber length in m	Input		Output	
	Voltage (v)	Freq (Hz)	Voltage (v)	Freq (Hz)
1m				
3m				

Bending loss:

	500 cm Fiber	750cm Fiber
Diameter in cm	Voltage(v) loss	Voltage(v) loss
1cm		
2cm		
3cm		

To find critical radius of curvature: $\mathbf{R_c = (3n_1^2\lambda) / (4\pi\,(n_1^2 - n_2^2)^{3/2})}$

$$R_C = \frac{3n_1^2\lambda}{4\pi\,(n_1^2 - n_2^2)^{\frac{3}{2}}}$$

n_1= 1.46 for plastic and n_2 =1.458 for silica λ= 850nm

Experiment No: __7__________________ Date: ___________

DIGITAL COMMUNICATION LINK USING OPTICAL FIBER

Aim : To set up a 650nm digital link and to measure the maximum bit rate can be transmitted.

Introduction: The OFT trainer kit can be used to set up two fiber optic digital links one at wavelengths of 650nm and other at 850nm. LED1--850nm LED2---650nm.

PD1 in the optical rx1 block is a PIN detector which gives a current proportional to the optical power falling on the detector. The received signal is amplified and converted to a TTL signal using a comparator. The gain control plays a crucial role in this conversion.PD2 in the optical receiver block is another receiver which directly gives out TTL Signals.

Equipments required: OPTICAL FIBER TRAINER KIT, Oscilloscope, function generator- 1Hz to 10MHZ.

Procedure:

I. Set the switch SW8 to the digital position. Switch the power on.

II. Connect a 1m optical fiber between LED2 650nm optical tx2 and the PIN detector1. Feed a 5Vp-p square wave signal at 10kHz from the function generator using the following procedure.

- Connect a BNC-BNC Cable from the function generator to the BNC socket I/01

III. Connect I/03 to P31 of optical receiver1 using a connecting wire or a patch chord.

IV. Connect I/01 and I/02 using a connecting wire or a patch chord.

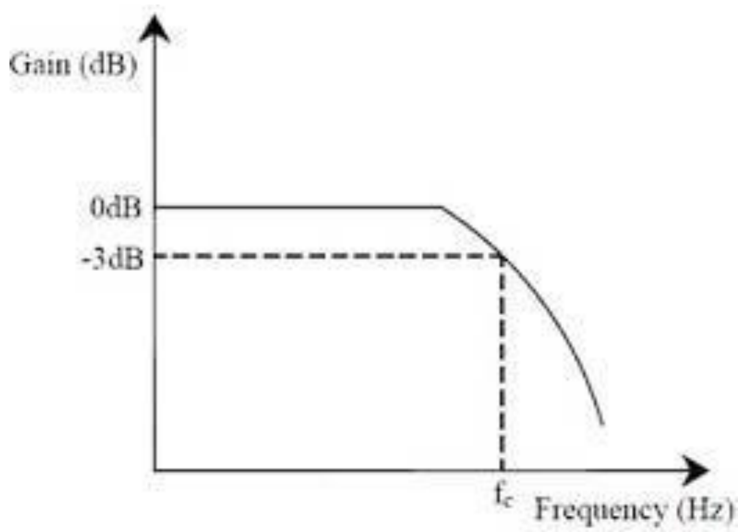
V. Connect a BNC-BNC cable from the I/02 to the CRO and assign that as the input signal and set the input frequency 10kHZ and 5Vp-p in the function generator.

VI. Connect a BNC-BNC Cable from I / 03 socket to CRO TO view the output signal.

VII. Adjust gain knob in trainer kit such that no clipping of output wave forms takes place and does not disturb the gain throughout the experiment. Note down the output voltages and calculate the gain as per the tabular column.

Tabular column:

Freq(Hz)	Output voltage (Vo)	Gain =20log Vo/Vi



Filter Response

Coupling loss:

1. Connect one end of the 1m fiber to LED 2 and the other end to the detector PD1.
2. Drive the LED with a 10kHz TTL Signal and note down asV1 and disconnect the fiber from the detector.
3. Take the 3m fiber and connect one end to the detector PD1 The optical signal can be seen emerging from the other end of the 1m fiber.

4. Bring the free ends of the 2 fibers using the possible and align them as shown in fiber alignment unit. Note down as V4.

5. Calculate the coupling loss using the formula

$$\eta = -10 \log\left\{\frac{V4}{V1}\right\} - \alpha^{I} (L_3 + L_1)$$

$$\eta = -10 \log\left\{\frac{V4}{V1}\right\} - \alpha^{I} (L_3 + L_1)$$

Experiment No: __8___________________ Date: ___________

ESTIMATION OF NUMERICAL APERTURE AND RADIUS OF CURVATURE

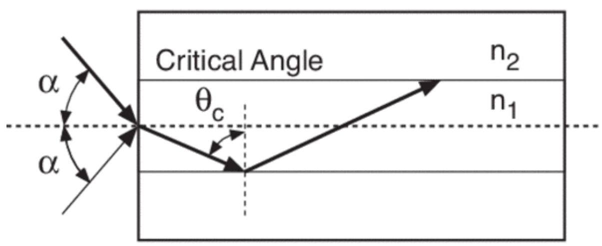
Numerical aperture of a fiber is a measure of the acceptance angle of light in the fiber. Light which is launched at angles does not get coupled to propagating modes in the fiber and therefore does not reach the receiver at the other end of the fiber.

Procedure:

1. To set up an 650nm digital link with 1m fiber. Drive a 5Vp-p square wave signal of 10KHz

   Insert the other end of fiber into numerical aperture measurement unit and adjust the fiber such that its tip is 0.5cm, 1cm from the screen and calculate the numerical aperture using the formula.

Numerical Aperture



$$NA = \sin\alpha = \sqrt{n_1^2 - n_2^2}$$

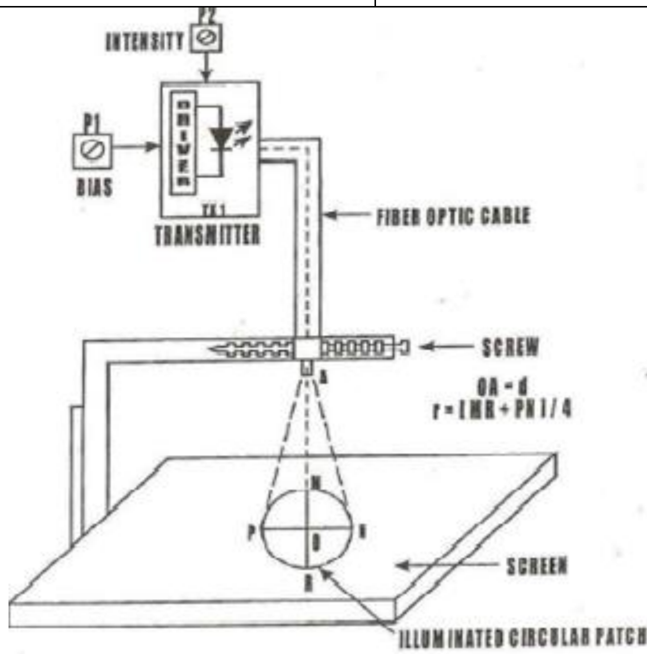
Full Acceptance Angle = 2α

$$\text{Numerical aperture} = \sin\boldsymbol{\theta} = \frac{X}{(d^2 + x^2)^{1/2}}$$

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

d= the distance from tip of the fiber till the white screen

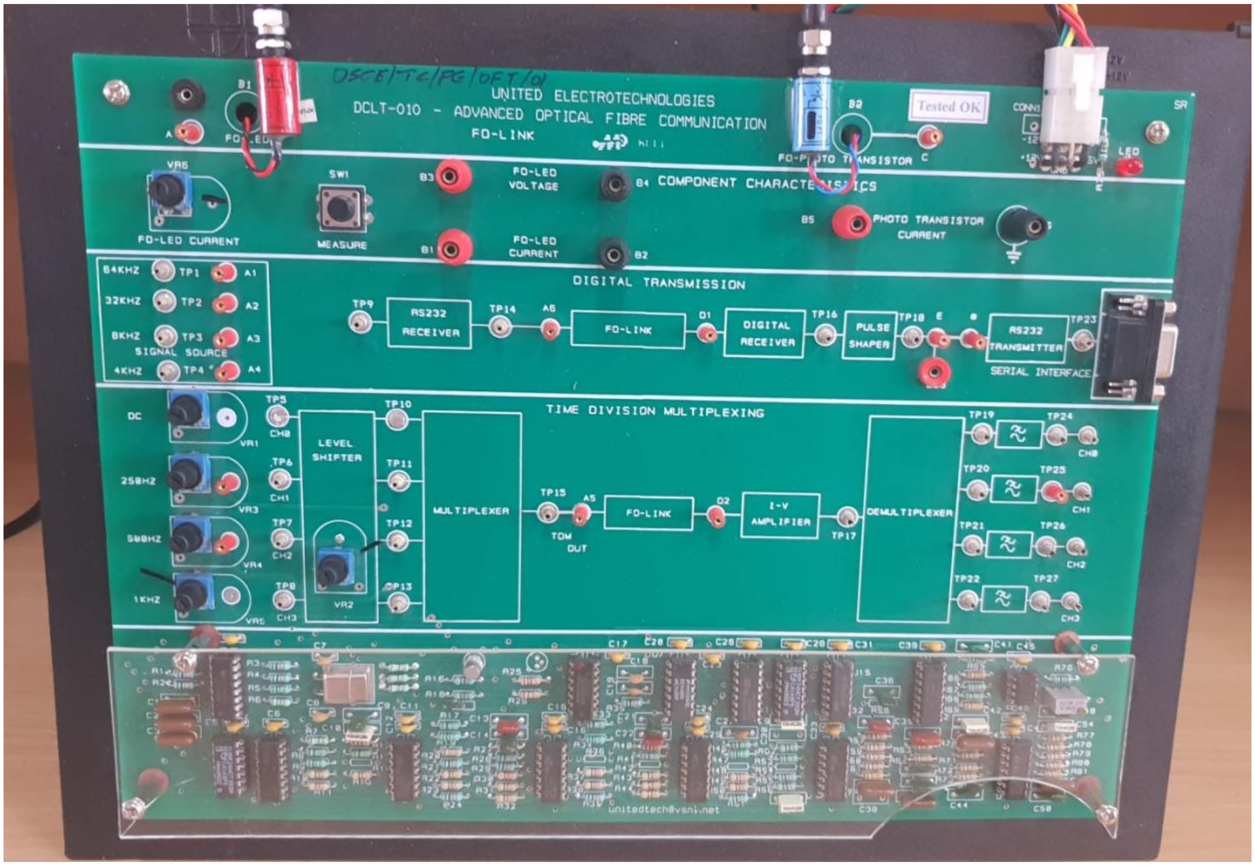
d distance from tip of fiber to base plate	X mean radius	Numerical aperture



<u>To find critical radius of curvature</u>:

$$R_C = \frac{3n_1^{\ 2}\ \boldsymbol{\lambda}}{(\ \mathbf{4\pi}\ (n_1^{\ 2} - n_2^{\ 2})^{3/2})}$$

n_1= 1.46 and n_2 =1.458 for plastic



DCLT 010 Fiber optic Communication trainer

Simplex Fiber Optic cable:

Core Material : PMMA(Polymethyl methacylate)

Cladding Material : Flourinated polymer

Fiber Structure : Step index type

Core/Cladding Diameter : 960 micron/1000 microns

Core Refractive Index : 1.492

Cladding Refractive index : 1.405 to 1.417

Numerical Aperture : 0.5 (typical)

Acceptance Angle : 55 to 60 degrees

Attenuation at 660 nm : Typically 0.3 dB per meter

Jacket Material : Polythene (black) , 2.2 mm OD

Fiber optic LED

Material : GaAlAs

Wavelength : 660 nm

Spectral Line width : 45 nm

Termination : SMA (905), gold plated

Analog signals : 250 Hz, 500 Hz, 1 KHz sinusoidal signals.

All amplitude variable from 0 to 5V

Digital signals : 64 KHz, 32 KHz, 16 KHz & 8 KHz signals

DC : Adjustable over 0 to 5 Volts.

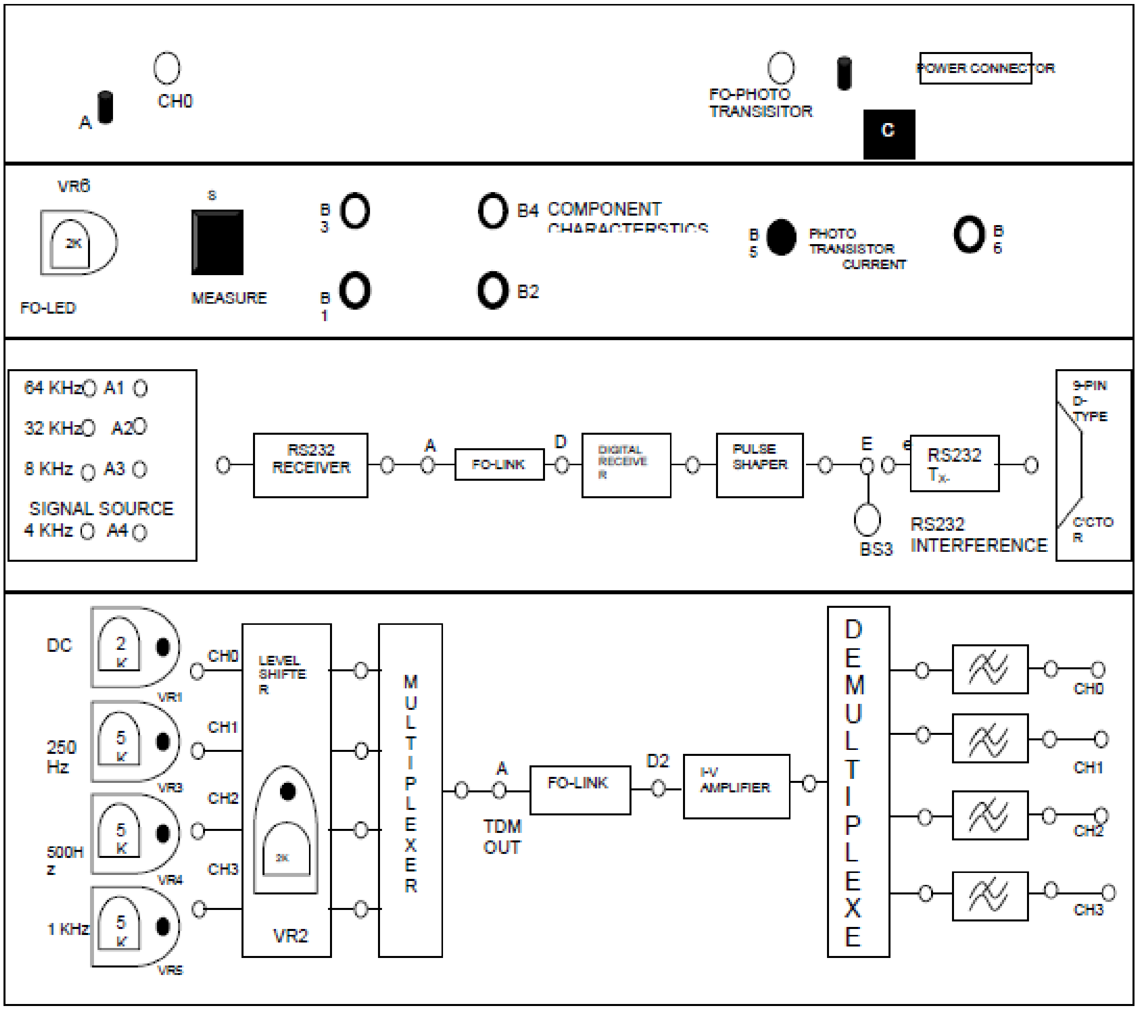
Power supply : AC 230 V to DC ±12 V, 5 V

Simplex cable with PMMA Fibre and SMA connections:

The simplex cable with PMMA fibre finds application for short distance analogue and digital signal transmission. The step index fibre has a large area of cross section and a high numerical aperture, facilitating easy coupling with transmitting and receiving devices. The light is guided along a fibre of one millimeter approximately to distance of a few tens of meters. The other main applications of PMMA fibres are in sensors, light guides and displays.

Specification of simplex cable:

1. Core Material: PMMA (Polymethyl methacylate)
2. Cladding Material: Fluorinated polymer
3. Fibre Structure : Step index type
4. Core/Cladding Diameter: 960 micron/1000 microns
5. Core Refractive Index: 1.492
6. Cladding Refractive Index: 1.405 to 1.417
7. **Numerical Aperture: 0.5 (typical)**
8. Acceptance Angle: 55 to 60 degrees
9. **Attenuation (660nm): 0.3 dB/mtr**
10. Jacket Material: Polythene (black): 2.2 mm OD



DCLT 010 Fiber optic Communication trainer

Experiment No: __9____________________ Date: ___________

TIME DIVISION MULTIPLEXING

Aim: To study the Time Division Multiplexing (TDM) with fiber communication system.
Equipment required: OPTICAL FIBER TRAINER KIT, Oscilloscope, function generator- 1Hz to 10MHZ.

Introduction:
The fiber optic communication system supports Time division Multiplexing, where three different frequency analog signals are multiplexed to get the TDM o/p.
Since the signals are Bipolar and the optical source can respond to only unipolar signals, they are first level shifted in a DC level shifter where the bipolar signals are converted to unipolar. The TDM signal is then intensity modulated and then conveyed on the optical fiber. At the receiver end, a photo detector detects the signal from the light falling on it in the form of current.
A Current-Voltage (I-V) Amplifier converts the current signals to voltage and amplifies them. This is then fed to a De-multiplexer where the individual signals are obtained.

Experimental procedure:

- Connect TDM (A5) to FO-LED (A)
- Connect Photo Transistor output (C) to the input of the I-V Amplifier (D2)
- Terminate the fiber optic cable both at the source and the detector.
- Adjust the amplitudes of all sources DC, 250 Hz, 500 Hz and 1 KHz to minimum.

Observations:

- Observe the waveforms at TDM out (A5) and I-V Amplifier input (D2)
- It can be observed that (D2) duplicating (A5), except FO reduced amplitude and rounding off rise times.
- Observe the de-multiplexed waveform at the output of De-multiplexer. The De-multiplexer output will be Sample and Hold version of input source.
- Observe the reconstructed signal at the output of Low Pass Filters at CH0, CH1,
- CH2 andCH3.

6.6 Experimental setup:

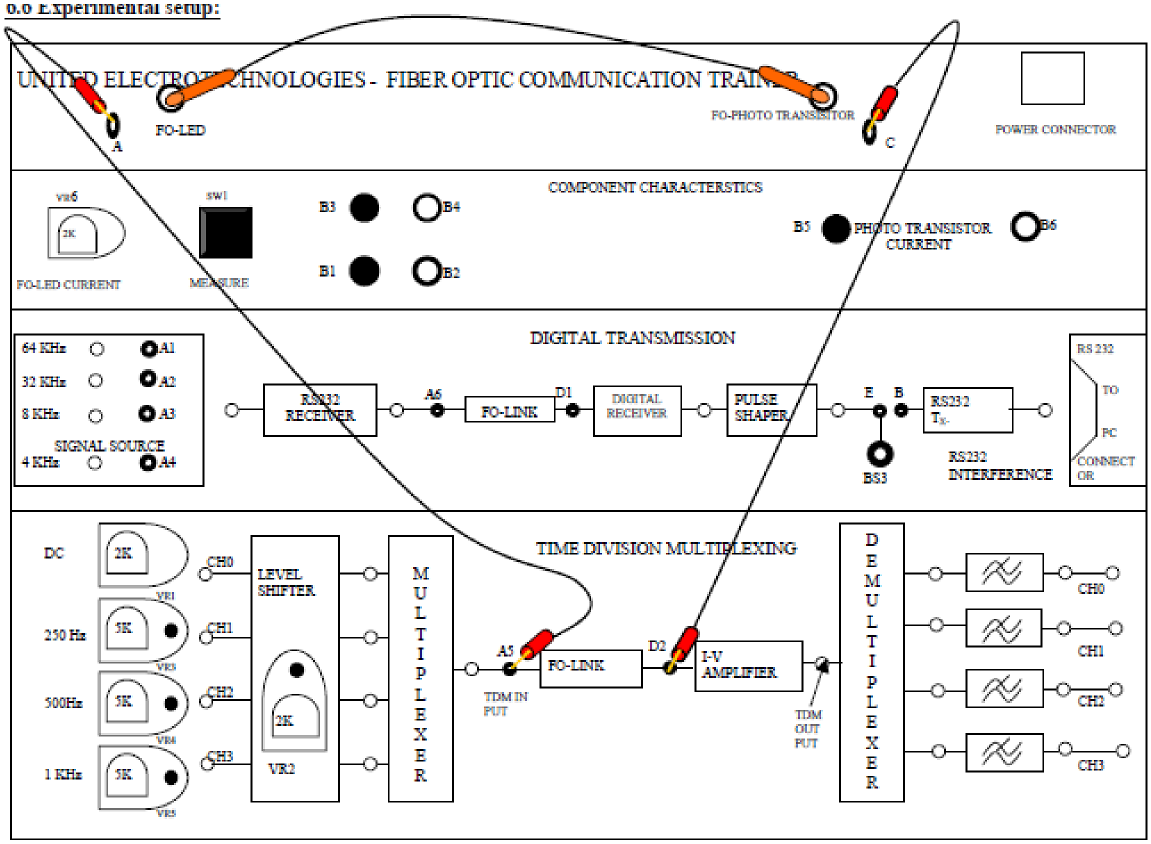
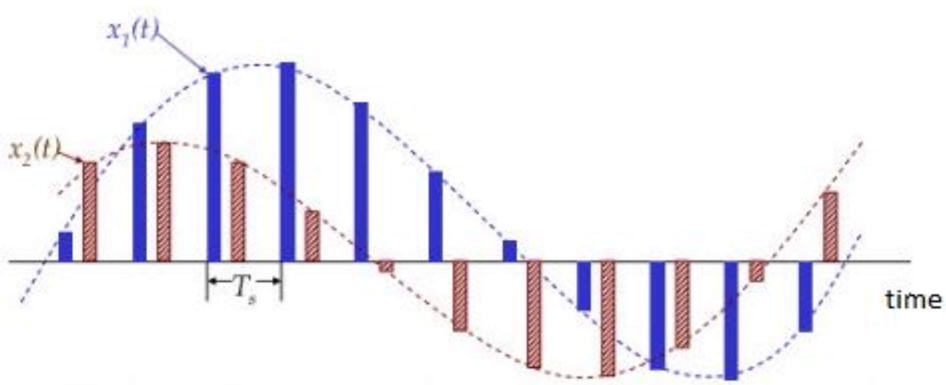


Fig: Optical fiber kit connections: Time division Multiplexing of Analog signals

Waveforms:



Experiment No: __10_____ Date: __________

RS 232 INTERFACE FOR PC COMMUNICATION AND AUDIO INTERFACE

Aim: To Study the R232 interface for PC Communication and voice interface in two optical fibre patch cards

Equipment Required: optical fiber trainer kit, voice interface & fibre optic tester

Introduction: Optical transmission techniques and optical fibers themselves have found application within the data processing equipment. Their low loss, low radiation properties provide obvious advantages in these applications. The communication with a PC on a fiber optic communication is accomplished with a serial communication software provided. Once the PC mode is executed, the data typed in the Transmit window will be converted to RS232 format. The RS232 levels through the com2 port will be then converted to TTL levels in the RS232 to TTL converter block and then fed to the FO-LED driver circuit for intensity modulation.

The converted optical signal is then conveyed through the Fiber optic cable to be received at the Photo Detector. The Photo Detector detects the TTl signals from the light variations and then converted to RS232 format in the RS232 converter block and then conveyed through the RS232 cable to the PC where the typed data is displayed on the Display window of the PC.

Experimental procedure for RS232 Interface:

· Terminate RS232 cable from PC to RS232 interface connector.

· Connect (A6) to FO-LED (A)

· Connect photo transistor output (C) to digital receiver

· Connect the pulse shaper output (E) to RS232 Transmitter input (B)

-Observe the transmission of data from PC to PC through Optical fibers

Experimental Procedure for Audio Interface:

1. The DCLT-010 main card and the Voice interface cards are used for this expt.
2. Connect the microphone to Audio IN connector on the voice interface card

3. Connect the speaker to the audio OUT connector on the voice interface card
4. The analog signal output from Audio gain amplifier (Point “S1”) is connected to the Input of the FO led source (POINT “A”)
5. Connect the FO LED source output to the FO-PHOTO TRANSISTOR
6. Connect the signal output from the Photo Transistor (POINT “C”) to the low pass filter circuit of the I-V amplifier (POINT “D2”)
7. Connect the low pass filter output CH1 from DCLT010 main board to the to the Audio Output (POINT “S2”) of Voice interface card
8. The voice signal input from the microphone is converted into analog and then transmitted through the Fiber Optic cable and reconstructed back with and connected to Speaker.

Observations:

1. Observe the Voice performance at the speaker output in voice interface card
2. It can be observed that by varying the pot “VR1” in voice interface card volume of the voice can be controlled
3. It can be observed that by varying the pot “VR6” the intensity of the voice passing through fibre optic cables can be observed
4. Repeat the experiments for the 5mts and also 6mts cable and observe the performance for coupling losses and bending losses in Fiber optic communication.

6.7 Experimental Set-up:

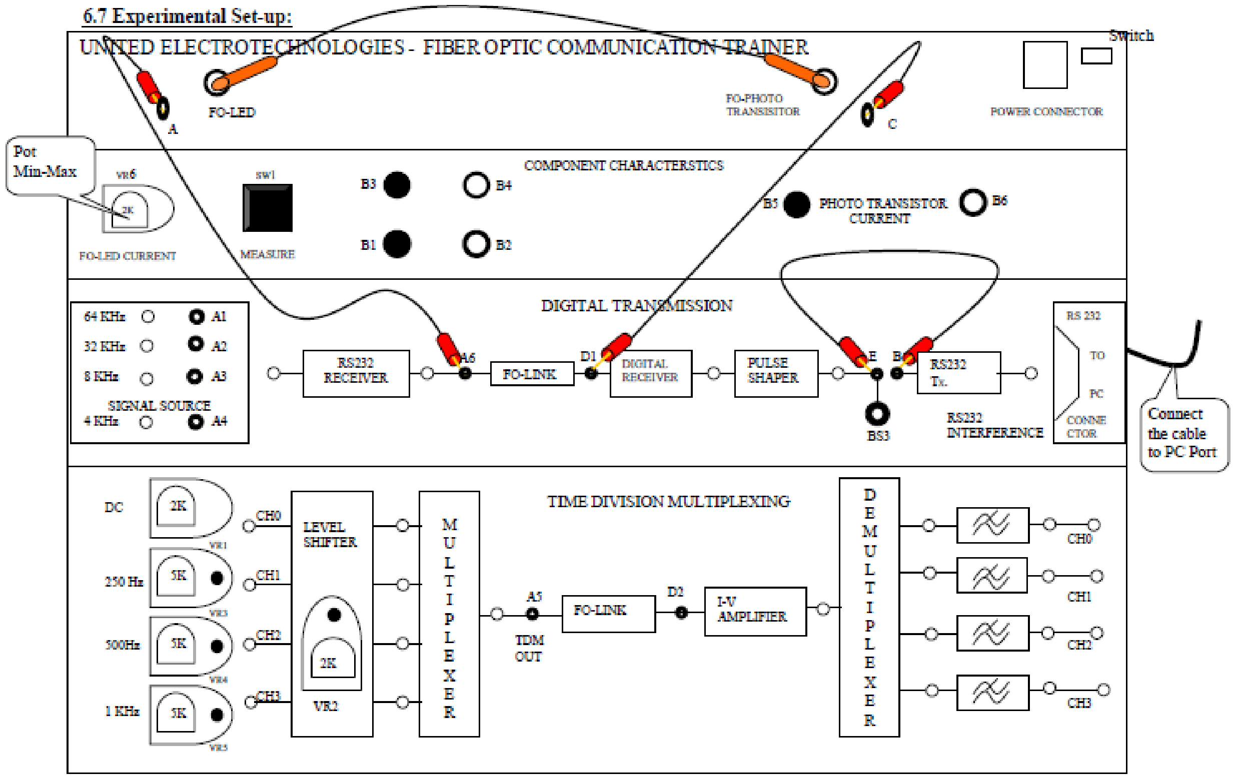
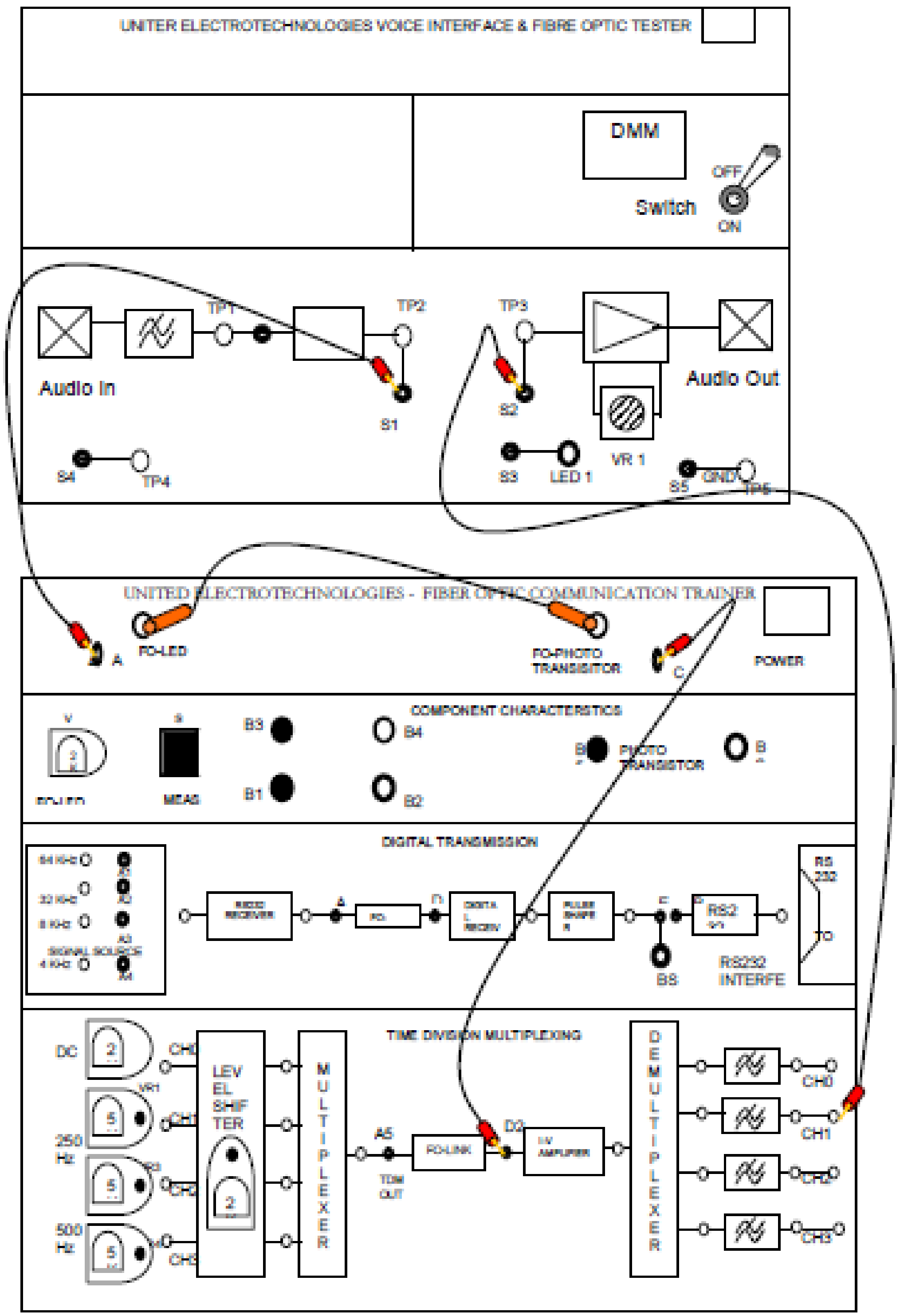


Fig: Optical fiber kit connections: RS-232 interface for PC communication



Voice Interface