PC 481 FIBRE OPTICS LAB MANUAL

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CONTENT

Chapter 1

Measurement of light power in optical fibres

1.1 Purpose

The purpose of this exercise is to familiarize yourself with fibre optic measurements and measurement equipment.

1.2 Introduction

This exercise is intended to introduce basic concepts of measurement related to optical fibre networks.

1.3 Theory

$$P(dBm) = 10Log_{10}(\frac{Ps}{1mW}) \quad (1.1)$$

$$P(dB) = 10Log_{10}(\frac{P_A}{P_B}) \quad (1.2)$$

1.4 Procedure

1.4.1 Experimentation

Apparatus

- various meters
- various single mode cables
- various fibre light sources

Method

PROTECT EYES!!!!

• always keep sources capped unless in use
• never point at eyes (yours or anyone else's!)

PROTECT Equipment

• most pieces few to 10's of thousand dollars. (even used!)
• take your time
• don't move equipment unless absolutely necessary

Power is measured in three ways:

1. absolute, in Watts
2. relative, in dB (See Equation 1.2.)
3. absolute, in dBm (See Equation 1.1.)

This exercise will cover the following concepts:

1. Conversion between power units:

• dBm to W
• W to dBm

Note that difference in dBm = difference in dB

2. Comparing sources: Which is most dangerous?
3. Comparing meters: How consistent are they?

IN-LAB TASKS

IT1: Measure the power of a single source in dBm using a single meter, and convert it to mW. Do this with it connected properly and improperly so you can see the difference. Use the results to fill in Table 1.1. Demonstrate general results to the lab instructor.

IT2: Measure the power through a single cable with a single meter using 3 different sources to determine the power of each source. Note any indications about what class of laser each source represents. (If a source produces two wavelengths, measure both.) Use the results to fill in the dBm columns of Table 1.1. (You'll convert to mW later.) Demonstrate general results to the lab instructor.

IT3: Measure the power through a single cable with a single source with 3 different meters to see how well the meters agree. Repeat the measurement with the first meter after the others to see how consistent it is. Use the results to fill in the dBm columns of Table 1.3. (You'll convert to mW later.) Will the different powers of the different sources affect this? Explain.
Demonstrate general results to the lab instructor.

Analysis

Post-lab Discussion Questions

Q1: What is a class I laser? Do your power measurements agree for the ones which identify themselves as such?

Q2: What is the dB value of
1. 10 % loss?
2. 50 % loss?
3. 90 % loss?

Q3: What percentage of the input power is lost if the cable is improperly connected?

Q4: What is the advantage of measuring power in dB over mW?

Post-lab Tasks

T1: Fill in the conversions from dBm to mW in Tables 1.2 and 1.3.

Recap

By the end of this exercise, you should know how to :
- Connect optical fibre components properly.
- Measure optical power in

  - dBm
  - Watts

and convert between both units.

Summary

Item	Number	Received	Weight (%)
Pre-lab questions	0		0
In-lab questions	0		0
Post-lab questions	4		30
Pre-lab Tasks	0		0
In-lab Tasks	3		60
Post-lab Tasks	1		10

Source			
Meter			
Properly connected		Improperly connected	
dBm	mW	dBm	mW

Table 1.1: Power conversion

Meter				
Source	1550nm		1310nm	
	dBm	mW	dBm	mW

Table 1.3: Source variation

Source				
Meter	1550nm		1310nm	
	dBm	mW	dBm	mW

Table 1.4: Meter variation

Chapter II

2. Propagation of light. Numerical aperture in optical fibres

2.1 Purpose

The purpose of this experiment is to study propagation of light in optical fibres,   measure numerical (NA) of the fibre.

2.2 Introduction

Fibre optic cables are used in transmitting data in communication systems for making physical links among fixed points. Since it carries signal as light, optical fibres cannot pick up electromagnetic interference. The center of fibre is the core, which has a higher refractive index compare to the outer coating and this difference makes light to propagate through central core because of total internal reflection and is the means by which an optical signal is confined to the core of a fibre. In order a light to be guided through it must enter the core with an angle that is less than so called acceptance angle for the fibre. A ray entering the fibre with an angle greater than the acceptance angle will be lost in the cladding. The acceptance angle also called "numerical aperture". So, the numerical aperture (NA) is a measurement of the ability of an optical fibre to capture light.

2.4 Theory

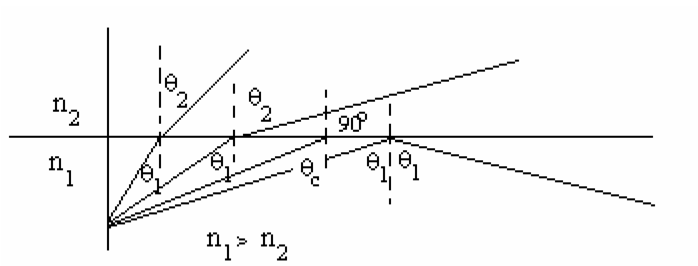
Propagation of light through the core of an optical fibre depends on materials of core, cladding and their refractive index difference. Snell's law explains the propagation of light along an optical fibre. This law explains relationship between angles of incident and transmission on the interface between two dielectric mediums:

$$n_1 \sin\alpha = n_2 \sin\beta$$

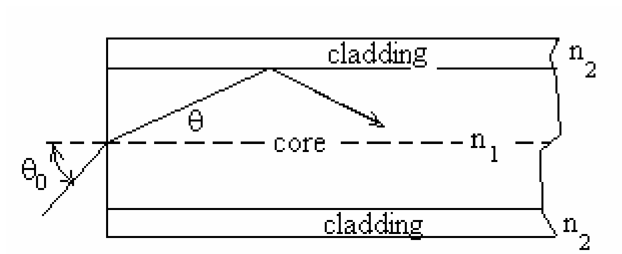
If the angle of incident is increased, there will be a point when angle of refraction will be equal to 90^0 which is referred to as critical angle. Therefore, Snell's law transforms to the relationship of critical angle, refractive index id core and cladding:

$$\sin \beta = \frac{n_2}{n_1}$$

If the angle of incident is increased slightly beyond the critical angle, refractive angle will also be increased beyond 90^0 level and 99.8% of incident light reflects towards n1 medium. So, light can propagate through a dielectric medium of refractive index n1 surrounded by a cladding dialectic material with n2 where n1>n2 in zigzag mode and for incident angle $\alpha > \beta$.



The speed of light traveling through a optical fibre with refractive index n=1.5 is calculated from n=c/v, where v is speed of light in the fibre and c-speed of light vacuum.



The acceptance angle can be calculated from refractive indices of the core and cladding using formula

$$\beta = \arcsin\left[\sqrt{n_1^2 - n_2^2}\right]$$

The numerical aperture of the fibre is equal to the sine of the fibre acceptance angle and it is given by:

$$NA = \left\lfloor \sqrt{n_1^2 - n_1^2} \right\rfloor$$

Pre-lab questions

1. Sketch numerical aperture for a step index fibre and graded index fibre.

2. What is a difference between half acceptance angle and glancing angle?

2.5 Procedure

2.5.1 Experiment

Apparatus

Optical fibre

Optical transmitter

Method

The experiment is carried in semi darkness. NA will be calculated by investigating the light leaving the fibre.

Equipment setup

a. Switch on the transmitter
b. Project the light output from the fibre on to the 5mm circle target

Measurement

In-lab Tasks

IT1: Determine the circle diameter R of the light and the distance L from the fibre to the screen. Calculate the acceptance angle and by taking the sine of the acceptance angle find the numeric aperture of the fibre. Repeat the measurement and calculate experiment uncertainties.

2.5.2 Analysis

Post lab questions and tasks

PT1: Tabulate your results and plot NA as a function of the distance L for each fibre and attach the plot.

PT2: Comment on the different factors influencing any inaccuracies you may find.

PT3: Compare and comment on your result by comparison with manufacturer value for the cable (SH4001 Super ESKA Polyethylene Jacketed Optical Fiber Cord)

2.6 Recap

By the end of this exercise, you should know how to:

- Measure speed of light and NA of optical fibre

2.7 Summary

Item	Number	Received	Weight (%)
Pre-lab questions	2		20
In-lab questions	0		0
Post-lab questions	1		10
Pre-lab Tasks	0		0
In-lab Tasks	1		50
Post-lab Tasks	1		20

Chapter III

3 Chromatic dispersion in optical fibers

3.1 Purpose

The purpose of this lab work is to learn dispersion, in particular chromatic dispersion in optical fibres.

3.2 Introduction

Fibre optic cables used in transmitting data in communication systems have distance limit due to Chromatic dispersion (CD). Therefore, CD is one of the basic characteristics of the fibre. It is caused by variation of the fibre index with the wavelength. CD happens because of difference colors of light traveling through the fibre at different speed. Since light colors travel in different velocities, some colors arrive at the end of the fibre in different times. This in turn provokes distortion of the optical system hence creates a distant limit for a given bite rate. CD is measured by comparing the time delay between the different wavelengths.

3.3 Theory

Dispersion does not weaken the signal, it blurs it. CD measures in the unit of picoseconds per nm per km. Total CD dispersion Δt is calculated by multiplying CD by the range of wavelength generated by the light source and the fibre length:

Δt =chromatic dispersion (ps/nm-km) x $\Delta\lambda$ (nm) x distance (km)

In case of single mode fibres, it is possible to distinguish two dispersion components: material and waveguide dispersion. Material dispersion is a wavelength dependence of the fibre material refractive index. Waveguide dispersion depends on fibre geometry and refractive index profile. Last component is referred to as profile dispersion.

Pre-lab questions

1. What is dispersion and difference between chromatic and polarization mode once?

2. What determines the range of wavelength over which meaningful data is obtained for calculation of the chromatic dispersion curve?

3.5 Procedure

3.5.1 Experiment

Apparatus

Chromatic Dispersion Measurement System, FD440, GN Nettest,

Fibre link.

Measurement of the test fibre proceeds as follows. The COMMS up-link fibre is selected from the cable- normally a "dark" fibre within the test cable. The selected up-link fibre is connected between both units of the FD440. The Transmitter Unit "Locked" LED should illuminate. No, dim or intermittent illumination indicates that the reference fibre loss is too high (e.g. bad splices or connections, or fibre too long). The test fibre itself is now connected to the system and the light power coupling is maximised or checked using the software key f7. The measurement is initiated by a softkey f2, and after entering the fibre length and other details, takes place under total computer control. At the end of the measurement, the computer presents and stores the data.

Basic Operating Procedure.

The FD440 system consists of a transmitter and receiver, one placed at each end of the fibre span. A dedicated laptop is used to control the receiver. Two fibres connect the units: one is the fibre under test, and the other is the communications ("COMM") fibre used to synchronize the operation. Choose a spare (dark) fibre for the COMMs fibre.

Preparations at the lab include:

1) Creating the likely needed test files (containing all test parameters)
2) Establishing a reference measurement for all these test files (see above)
Field measurement procedures include:
1) Connecting the TEST and COMM fibres
2) Select the most suitable test file according to requirements.
3) Verify the optical connection using the power bar
4) Hit the Measure button (F2)
5) Enter the length of the fibre under test
6) Await the test result

Measurement

In-lab Tasks

IT1: Measure CD, Relative Attenuation.

3.5.2 Analysis

Post lab questions and tasks

PT: Analyze the obtained results and measurements and instrument uncertainties.

PT: Comment on source bandwidth and Chromatic Dispersion

3.6 Summary

Item	Number	Received	Weight (%)
Pre-lab questions	2		30
In-lab questions	0		0
Post-lab questions	0		0
Pre-lab Tasks	0		0
In-lab Tasks	1		40
Post-lab Tasks	2		30

References and bibliography:

1. Hetch, J., “Understanding Fibre Optics,” 2008
2. FD440 system manual

Chapter IV

4. Wavelength measurement and optical grating filter

4.1 Purpose

The purpose of this lab is to study Spectral Characteristics of traveling light in optical fibres and filtration of signal by grating based optical filter.

4.2 Introduction

Bandwidth determines a capacity of optical fibre. Grating filter allows separating signals after multiplexing. Diffraction grating filters are used to demultiplex optical signal.

4.3 Theory

As learned in Optics (PC237), Grating Diffraction is a result of the wave nature of light. As shown in Figure 1, when two light beams featured by λ_1 and λ_2 incident at the same angle θi the reflected light beams will appear at θ_d because of the difference of wavelengths

$$\Lambda(\sin\theta_i - \sin\theta_d) = m\lambda \qquad (1)$$

Here Λ- the grating period, m- the order of the diffraction and λ- the wavelength. Usually, m=1 is what we are interested in. In the lab, the red, green and violet lasers as λ_1, λ_2 and λ_3 being around 0.63µm, 0.52 and 0.41 µm respectively will be used. With the notations θ_d^R and θ_d^G for the reflected angles for red and green lasers, Equation (1) can be written Equation (2) and (3) as shown below

$$\Lambda(\sin\theta_i - \sin\theta_d^R) = m\lambda_1 \qquad (2)$$

$$\Lambda(\sin\theta_i - \sin\theta_d^G) = m\lambda_2 \qquad (3)$$

Measuring incident and reflected angles by the distances of three spots on ceiling, we can determine $\sin\theta_d^R$ and $\sin\theta_d^G$, and then calculate what the wavelength of the green lased λ_2 is. Similarly, the wavelength of the violet laser λ_3 can be determined also. Take a comparison of your data with the wavelengths listed above.

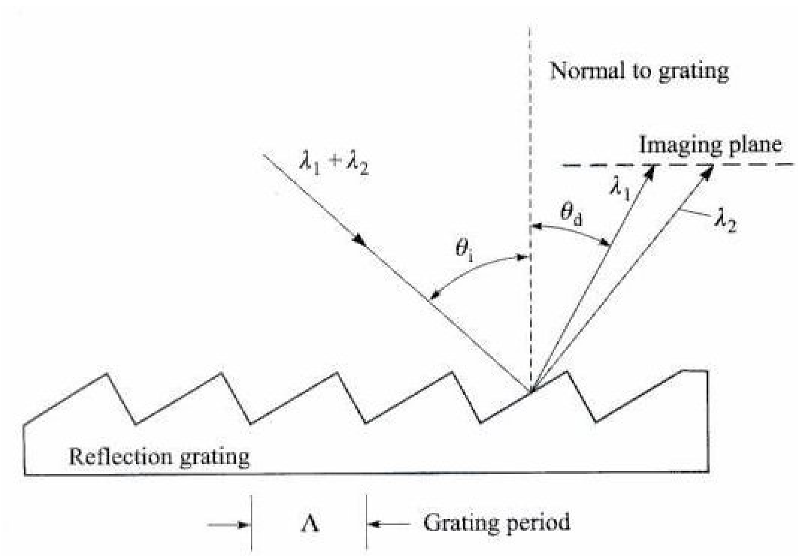


Figure 1 Grating diffraction

Grating filter are the device popularly used for demultiplexing for WDM system.

Pre-lab questions

1. What is difference between spectral width, bandwidth, relative and fractional bandwidth?

4.4 Procedure

4.4.1 Experiment

Apparatus

OSA, LD, Power supply and ammeter.

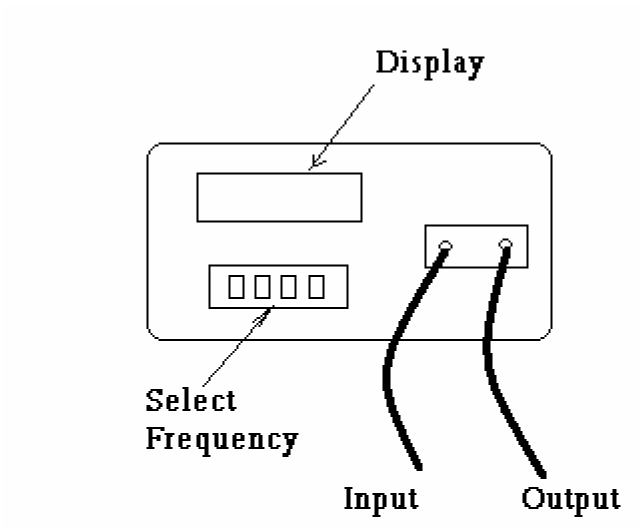


Figure 3 Grating Filter

Grating Diffraction

In the lab, the input of the grating filter is connected with an output terminal of either a broadband (~40nm) or narrowband (~20nm) laser source centered at 1560nm roughly, and the output of the grating filter is connected to the spectrum. Changing the frequency by selecting frequency of the grating filter, you will see the narrowed-band of the filtered signal on the spectrum. You will use the grating filter to find what the bandwidths of the two sources are.

Method

Caution: The ends of all optical fibres must be cleaned with acetone and a lint free cloth every time before coupling with any of the instruments

Equipment setup and measurement

Part C Grating Diffraction

IT1: Turn on two lasers: red and green. Project the grating diffraction pattern on the ceiling. Measure the space between red spots and between green spots, also the distance from grating to the spots on the ceiling.

IT:2 Determine the wavelength of green and read lasers respectively based on Equation (1). Remember the period of the grating can be directly determined from the parameter (1200 lines/mm) of the grating.

Part A Grating filter

IT:3 Test two laser sources, broadband and narrowband, around 1560nm respectively. Connect them one by one to the OSA, and measure the wavelengths for each of them. Determine roughly the bandwidths and the centered wavelengths.

IT4: Connect respectively the output of two laser sources to input of the grating filter, and connect the output of the grating to the spectrum. Adjust the selected frequency for the grating filter, starting from 1560nm with an increment 1 nm. Measure the level vs. wavelength for the laser sources. Read out the center frequency by tuning marker. Calculate the relative bandwidth and fractional bandwidth for the two sources.

PT1: Compare the spectrum of LD and broadband source.

Post lab questions

PT: Comment on spectral characteristics of these light sources

4.5 Summary

Item	Number	Received	Weight (%)
Pre-lab questions	1		20
In-lab questions	0		0
Post-lab questions	0		0
Pre-lab Tasks	0		0
In-lab Tasks	5		70
Post-lab Tasks	1		10

Chapter V

5. Source of Light in optical fibres

5.1 Purpose

The purpose of this lab is to study optical properties of LASER diode and light emitting diode

5.2 Introduction

Light emitting diode (LED) and Diode Laser (DL) are major source of light traveling in optical fibres. Both of these sources are of semiconductor nature. In order to understand physical phenomena in optical fibres it is necessary to know the source of the light and its properties.

5.3 Theory

The working principle of LD and LED is different. LED based on recombination of electron – hole pair in –p-n junction and when it happens the free electron may lose quantum of energy to fill the available hole. This energy is radiated as light with wavelength depending on the size of the energy gap. The formula of energy versus wavelength is:

$$E = \frac{1.24}{\lambda(\mu m)}$$

E is the photon energy in eV. This means that material of LED determines the wavelength of light emitted. The LED output power is proportional to the current.

DL has pair of mirrors in addition to what LED has. These mirrors power the light from a recombination of electron –hole pair. The region between the mirrors, as a cavity acts like Fibre Perot resonator. When the distance between the mirrors is a multiply of half wavelength, the light will reinforce itself.

The formula of wavelength and cavity distance dependence is:

$$Cavity = \frac{\lambda m}{2n}$$

m-arbitrary integer; n-refractive index of the medium.

P-V characteristic curves of the devices allow determining threshold current, slope efficiency.

Light distribution of LED

Axial and radial distributions of radiation for a LED are shown in Figure 1. The axial illuminated power is inversely to square of distance between LED and the sensor

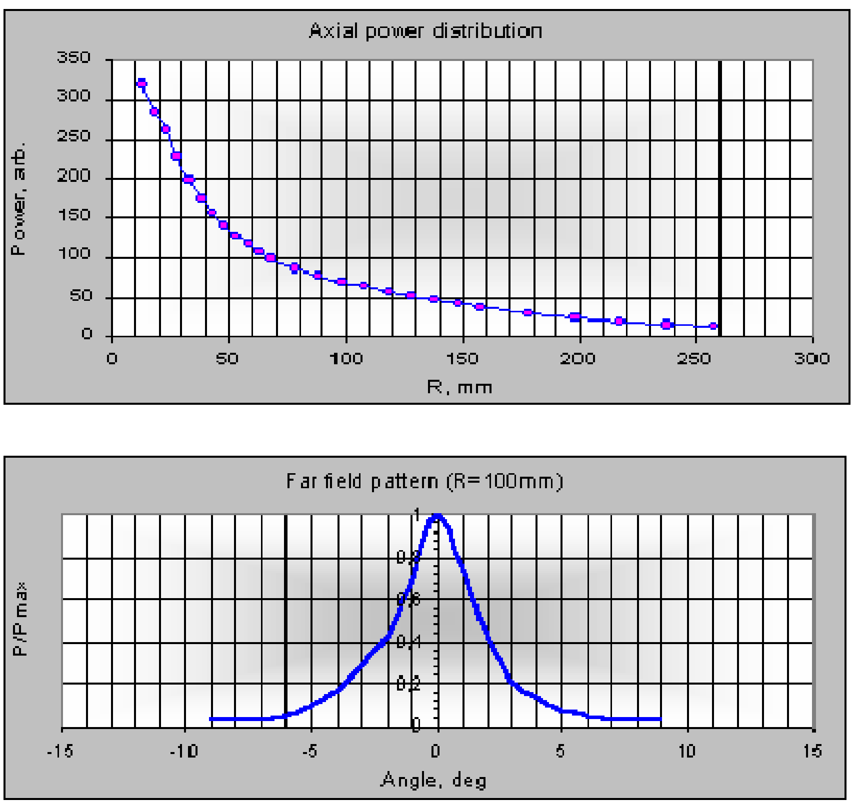


Figure 1. Axial and radial distribution of radiation for a LED.

The radial one is distributed as Gaussian function, as expected for most light sources.

Pre-lab questions

1. What is difference between Fabry - Perot and Distributed Feedback Lasers?

2. P-V characteristics for LED (PB series 1310T/1310R) and red LD are different. Although, both LED and LD have maximum values of applied voltages above which they will be damaged. Never take a chance to test the maximum values! What is maximum value for both of them?

5.5. Procedure

5.5.1 Experiment

Apparatus

LED

Photodiode

Oscilloscope and OSA

Method

Experiment setup and Measurement

Part I Distribution of radiation

IT1: Insert a white LED into two holes on a mount section. Be careful of positive and Negative pins for LED. Turn on the power for LED. Connect the sensor to power supply and to Oscilloscope. Measure an axial distribution. Move the sensor toward to LED by step of 2.5 cm. Measure radial distribution with the same steps.

Part II P-V Characteristics

IT2: Apply power and measure the voltage cross LED and resistor connecting red LED and resistors when emitted light from darkness to shining as shown in Figure 2.

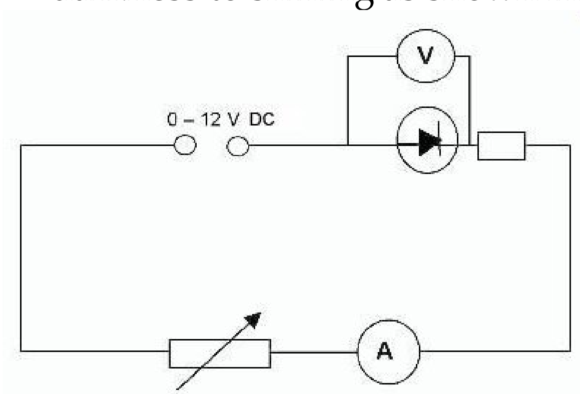


Figure 2 LED –P-V curve measurement circuit

IT3: Apply power and measure LD P-V characteristic as shown in Figure 3

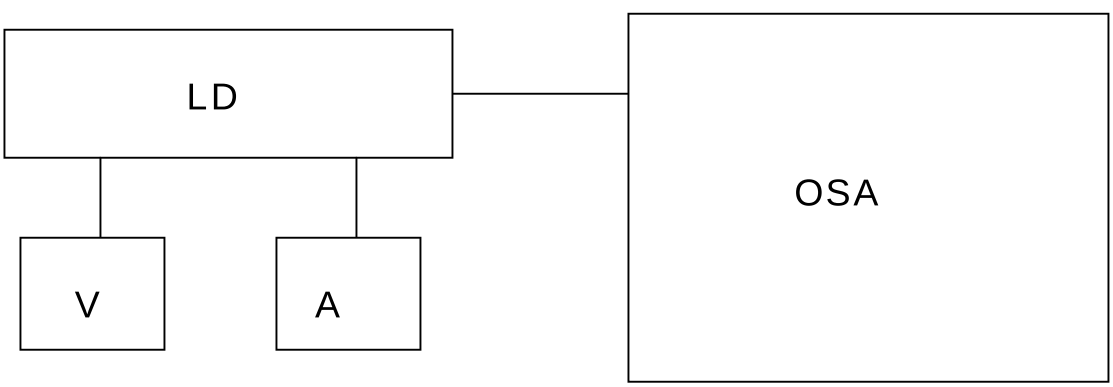


Figure 3 LD P-V curve measurement block diagram

Post lab questions and tasks

PQ1: What is the difference between LED and LD regarding to P-V characteristics.

PQ2: What is the difference between LED and LD regarding to wavelength distribution?

5.6 Summary

Item	Number	Received	Weight (%)
Pre-lab questions	2		20
In-lab questions	0		0
Post-lab questions	2		10
Pre-lab Tasks	0		0
In-lab Tasks	3		70
Post-lab Tasks	0		0

Chapter VI

Fibre Couplers

6.1 Purpose

The purpose for experimentation with fibre couplers is to understand the structure of a common three port fibre coupler as well as to be able to measure the characteristics of these couplers. Also, it is important to learn some of the applications of the couplers, mainly with relevance to optical networking, such that the couplers are often used as multiplexers (MUX) and de-multiplexers (DeMUX)

6.2 Theory

One of the most widely used components is the fibre coupler. The coupler allows two or more optical signals to be combined into one signal. The coupler can also be used to split the signals apart again. The fused coupler is the most common of the fibre couplers and the principle behind the fused couplers is that when two or more fibre cores are brought to within a wavelength apart some of the light in one core will leak into the other core or cores. The amount of coupling, or power transfer, between the cores is dependent upon the distance at which the core are apart, as well as the interaction length. Also, the coupling properties are very dependent upon wavelength I that operation of a coupler at 1310nm will distinctly vary in relation to a 1550nm wavelength. This experimentation will only cover couplers, which operate at the same wavelengths. In this case the amplitude of the signal has been combined or split, and a network built with couplers of this sort usually employs Time Division Multiplexing (TDM) for signal processing. In the fused fibre technology, two fibres are twisted then fused together to produce a fibre coupler. The amount of twists and the length of the fusion will determine coupling characteristics of the device, such that the coupling ratio can be between 0 ! 100% . This is a transmission device in that light travels from an input port to an output port on the opposite side of the device, with little reflection back from the input port. Since the main function of the fibre coupler is to transfer light power from one port to another, the key parameters are the coupling ratio, insertion loss, spectral response, and directivity. The 3-port coupler is a 50/50 coupler at 1550nm. The 50/50 means that half of the signal will be directed to each output port. The 4-port coupler is also a 50/50 coupler and will split the signal from the incoming ports 1 or 4 to the outgoing ports 2 and 3. The transfer of light power across ports is not a perfect process and there are considerable losses that occur in the coupling region. This is a major contributing factor in the device's insertion loss figure.

6.3 Procedure

6.3.1 Preparation

Pre-lab Questions

PQ1: Directivity is defined as 10 log (Pa/Pb). How would you compute this knowing Pa in dBm and Pb in dBm?

6.3.2 Experimentation

Apparatus

- 4-port coupler
- power meter
- patch cord
- 1310nm, 1550nm laser source

Method

1. Record the power level, Pa, of the source at 1550nm in Table 5.1.

2. Send a signal into one input port of the 4-port coupler.

3. Measure the output power P1 from output port 1, P2 from output port 2, and Pb, the other input port, respectively. Fill in the dB column of Table 5.1.

4. Determine the directivity of this coupler. (This is also referred to as near-end crosstalk.)

5. Feed the input into the other input port and repeat the measurements.

6. Repeat with a 1310nm signal.

In-lab Tasks

IT1: Explain general results to the lab instructor:
• power distribution from each input port between output ports
• variation with wavelength
• directivity

6.3.3 Analysis

• For both wavelengths, calculate the power, in watts,
– of the source going into input port a of the coupler
– of the source going into input port b of the coupler
– out of output port 1
- out of output port 2

• Determine the coupling ratio at both wavelengths, for both inputs.

- Determine how much signal is lost in the coupler for both inputs at both wavelengths, in mW and dBm.

Post-lab Discussion Questions

Q1: Summarize the information above, to describe the coupling ratios and internal losses at both wavelengths

Post-lab Tasks

IT1: Fill in the mW and % columns in Table 5.1.

6.4 Recap

By the end of this exercise, you should know how to :

- measure coupling coefficients
- measure near-end crosstalk

6.5 Summary

Item	Number	Received	Weight (%)
Pre-lab questions	1		10
In-lab questions	0		0
Post-lab questions	1		10
Pre-lab Tasks	0		0
In-lab Tasks	1		60
Post-lab Tasks	1		20

Template

Source						
Meter						
	1550nm			1310nm		
	Source power, dBm=			Source power, dBm=		
	dBm	mW	%	dBm	mW	%
Pa- P1						
Pa- P2						
Pa- P3						
loss						
Pb- P1						
Pb- P1						
Pb- P1						
loss						

Table 5.1: Coupling data

Chapter VII

Insertion Loss

7.1 Purpose

The purpose of the this experimentation is to practice taking measurements of insertion loss.

7.2 Theory

Insertion loss is the loss of transmitted light power when optical devices are inserted into the light path. An example of this would be the use of a patch cord, a fibre connector, imperfections in the fibre itself such as a bad splice, or an unclean fibre end. The total loss of light energy in the system is called the insertion loss.
Light traveling in the core of the fibre remains within the core due to the refractive index ratio of the core and cladding. This is due to the total internal reflection (TIR) relation. If the angle of the propagating light wave reflecting off of the cladding back into the core becomes less than the TIR angle, often called the critical angle, some of the light will escape into the cladding, and thus reduce the optical power of the signal.

7.3 Procedure

7.3.1 Preparation

Pre-lab Questions

PQ1: In order for the calculations below to work, should power be measured in mW or dBm? Explain.

7.3.2 Experimentation

Apparatus

- 2 patch cords
- patch cord adapter (connector)
- power meter
- 1550nm laser source

Method

1. Measure the output power (PA) of the 1550nm-laser diode or laser source with a power meter through one patch cord to be used as a reference. The reference patch cord should then be marked, for this will be the used as the reference to measure the loss of other devices and cords. (See Figure B.1). Repeat with a 1310nm source.

2. Repeat the above, though this time use another patch cord of a defined length and measure the output power again (PB).

3. Connect the two patch cords together via the provided adapter and take the power output (Ptotal) reading of the system. (See Figure B.2).

4. The overall loss should be noted such the Ptotal = PA + PB + P(adapter).

5. Now that the power loss of the separate components of the system is known we are able to determine the loss due to other components used in the system if the original references are used.

6. Replace the second patch cord with cord 3 and measure the insertion loss.

7. Replace the second patch cord with cord 4 and measure the insertion loss.

In-lab Tasks

IT1: Fill in the dBm columns of Table 2.1. (You'll fill in the mW columns later.) Demonstate general results to the lab instructor.

In-lab Questions

IQ1: Can you ever determine the insertion loss of the adapter itself? Explain.

7.3.3 Analysis

Post-lab Discussion Questions

Q1: If a device has an insertion loss of 3 dB, what percentage of the input power is being absorbed by the device?

Post-lab Tasks

T1: Fill in the mW columns of Table 2.1.

7.4 Recap

By the end of this exercise, you should know how to :

- Measure the insertion loss of any component in a fibre optic system.

7.5 Summary

Item	Number	Received	Weight (%)
Pre-lab questions	1		10
In-lab questions	1		20
Post-lab questions	1		10
Pre-lab Tasks	0		0
In-lab Tasks	1		40
Post-lab Tasks	1		20

7.6 Template

Source				
Meter				
Cord	1550nm		1310nm	
	dBm	mW	dBm	mW
1				
2				
Series				
3				
4				

Table 2.1: Cable variation

Chapter VIII

8. Measuring refraction index in fibre optics.

8.1 Purpose

The purpose of this experiment is to learn propagation of light in optical fibres and measure refractive index of the fibre

8.2Introduction

Refraction, change of direction of light, confines traveling light within the optical fibre. Without refraction, light waves would pass in straight lines through transparent substances without any change of direction, so leaves a fibre. This bending depends on the velocity of the wave through different mediums. Knowing the velocity, refractive index can be calculated.

8.3Theory

Propagation of light through the core of an optical fibre depends on materials of core, cladding and their refractive index difference. The speed of light traveling through an optical fibre and refractive index has following dependence

$$n = \frac{c}{\upsilon},$$

where v is speed of light in the fibre and c-speed of light vacuum.

Pre-lab questions

1. A refracted wave occurs when a wave passes from one medium into another medium. What determines the angle of refraction?

8.4 Procedure

8.4.1 Experiment

Apparatus

Set of three optical fibres of 10mm, 20m and 40m

Oscilloscope

Transmitter and receiver block

Method

Equipment setup

a. Turn on the oscilloscope
b. Connect the probe of channel 1 to the test point marked "Reference" on the transmitter and receiver block (TRB)
c. Connect the probe of channel 2 to the "Delay" test point on the TRB
d. Turn the power on
e. Select a fibre and insert one end of it in LED D3 unit and another to D8 detector.

Calibration

The calibration will be done with 15cm of optical fibre installed for distance 0. You should get calibration pulse as a reference pulse for subsequent measurements. Get the peak of second signal coincide with the peak of first signal using "Calibration delay knob" in TRB.

Measurement

In-lab Tasks

IT1: For different length optical fibres measure delay time and calculate speed of light. Write down the result for all three fibres and calculate uncertainties of the experiment.

Post lab questions and tasks

PT: Compare and comment on your result by comparison with manufacturer value for the cable (SH4001 Super ESKA Polyethylene Jacketed Optical Fibre Cord)

8.4 Recap

By the end of this exercise, you should know how to:
- Measure speed of light and determine n of optical fibres

8.5 Summary

Item	Number	Received	Weight (%)
Pre-lab questions	1		0
In-lab questions	0		0
Post-lab questions	0		0
Pre-lab Tasks	0		0
In-lab Tasks	1		60
Post-lab Tasks	1		20