QUAID-E-AWAM UNIVERSITY OF ENGINEERING SCIENCE & TECHNOLOGY, NAWABSHAH.
DEPARTMENT OF ELECTRONIC ENGINEERING
LASER AND FIBER OPTICS 05ES (2nd Term, Final Year)
*Lab Experiment # ……*

Name: ___________________________ Roll No: _____________ Date: ___________

# LOSSES IN OPTICAL FIBER

## PERFORMANCE OBJECTIVES

The objective of this experiment is to measure the losses in an optical fiber communication link:

1. To measure Attenuation at 850nm using two-fiber method.
2. To measure Attenuation at 650nm using two-fiber method.
3. To measure Bending Loss.
4. To measure Coupling Loss.

## HARDWARE REQUIREMENTS

- Module Kit: OFT Trainer
- Fiber Alignment Unit
- Fiber cables: 1m and 3m
- Power Supply module, Input: 220-240 V AC, 50Hz. Output: +5V DC.
- Power interface cable with DIN jacks at both ends.
- Two channel, 20MHz Oscilloscope.
- Function generator, 1Hz-10 MHz
- BNC-BNC cables.
- Regular patch cord.
- 3-plug patch cord.

## DISCUSSION

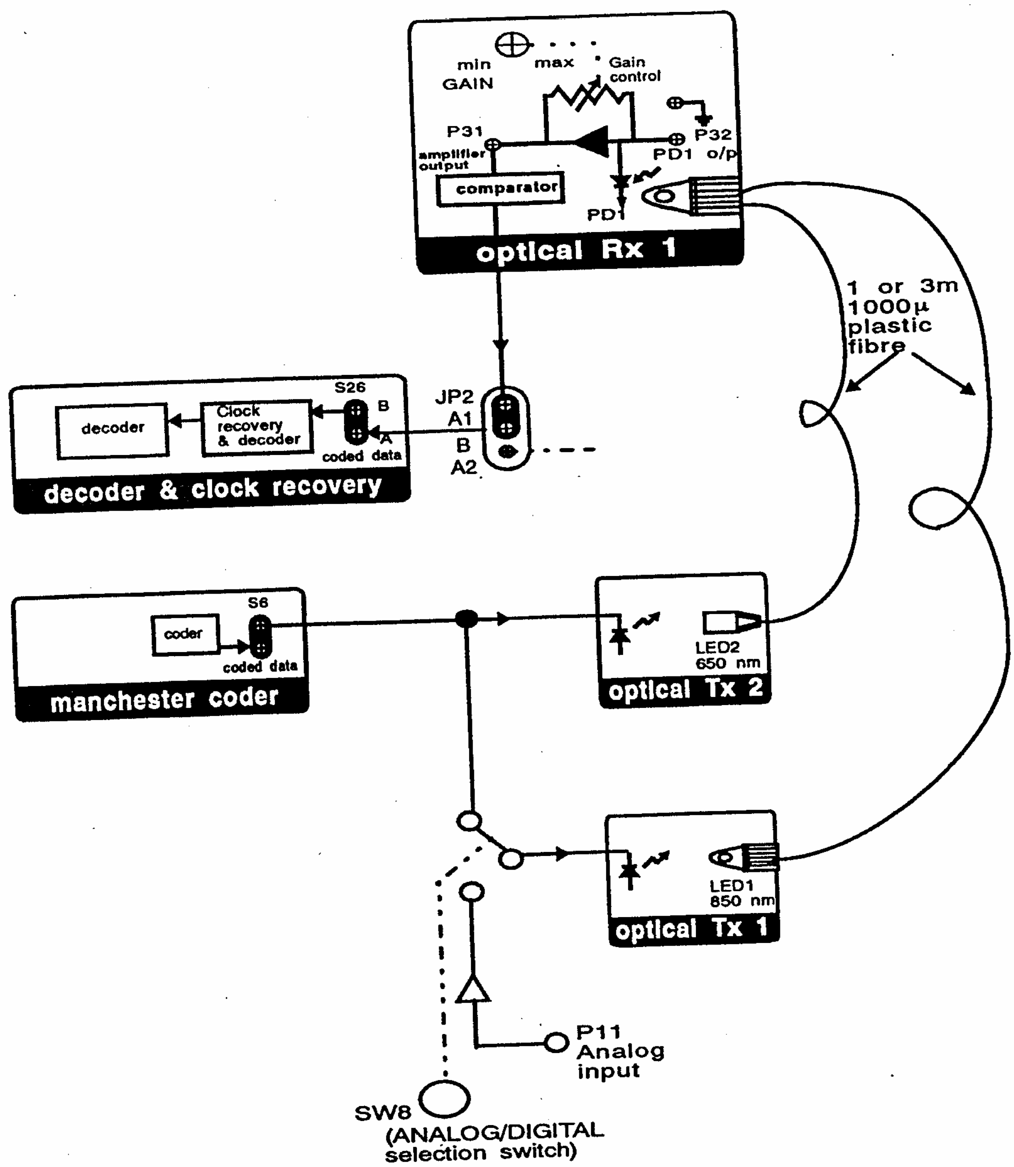
The fiber used in OFT is multimode plastic fiber with 1000µm core diameter. Unlike its Glass-Glass and Plastic Coated Silica fiber counterparts, this fiber has very high attenuation. It is useful mainly for short links such as in Local Area Networks, especially where there could be serious EMI problems. This fiber has been selected for the OFT because of ease of handling it affords.

While the loss in plastic fiber is high for all wavelength regions, the loss at 850nm is much higher than at 650nm.

Apart from the above propagation loss in a fiber, bending of fiber, connectors, splices and couplers may all contribute significantly to the losses in a fiber optic communication link.

An Optical Fiber is a circular waveguide. A small bend in a fiber will not significantly affect the propagation characteristics and therefore the losses in the fiber. However, if the fiber is bent with a radius of curvature smaller than a certain (usually about centimeter), the propagating signal may suffer significant bending losses.

Two optical fibers are joined using either a connector or a splice. The alignment of the cores of the two fibers is critical in both the situations, as even the minutest misalignment or gap between the fibers may cause significant coupling losses.




**PROCEDURE**

1. The OFT Trainer comes with a power supply module, operating at 220-240AC, 50Hz. The output of the power supply module is +5V DC (regulated) and is available through a DIN socket. A power-interface cable with DIN jacks at both ends is provided for connecting the power supply module to the OFT.
2. Connect one end of the power-interface cable to the power supply module, and the other end to the OFT.
3. Set the switch SW8 to the ANALOG position. Ensure that the shorting plug of the jumper JP2 is across the posts B & A1 (for PD1 selection). Remove the shorting plug from coded data links S6 in the Manchester coder block and S26 in the Decoder & clock recovery block.

**ATTENUATION AT 850nm**

4. Connect the 1m fiber and set up an analog link using LED1 in the Optical Tx1 block and detector PD1 in the Optical Rx1 block [850nm link]. Drive a 1Vp-p 10 KHz sinusoidal signal with zero d.c. at P11. Observe the signal at P31 on the oscilloscope. Use the BNC I/Os for feeding in and observing signals. Adjust the GAIN such that the received signal is not saturated. Do not disturb the level of the signal at the function generator or the gain setting throughout the rest of the experiment.
5. Note the peak value of the signal received at P31 and designate it as $V1$. Replace the 1m fiber by the 3m fiber between LED1 and PD1. Again note the peak value of the received signal and designate it as $V3$. if α is the attenuation in the fiber and $l1$and $l3$ are the exact length of the 1m and 3m fibers in meters respectively, we have

$$\frac{P3}{P1} = \frac{V3}{V1} = \exp[-\alpha(l3 - l1)]$$

Where α is in nepers/m, and $P1$ and $P3$ are the received optical power with 1m and 3m fibers respectively.

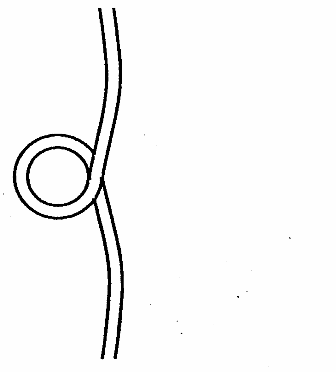
Compute α' in dB/m for 850 nm wavelength using α'= 4.343 α, where α is in nepers/m.

**ATTENUATION AT 650nm**

6. Now set up the 650nm link using LED2, detector PD1 and 1m fiber. Remove the shorting plugs from S6 and S26 and feed in a TTL signal of 10 KHz at post B of S6. Observe the signal at P31 on the oscilloscope. Adjust the GAIN such that the received signal is not saturated. Note the peak value of the signal received at P31 and designate it as $V1$. Replace the 1m fiber with the 3m fiber between LED2 and PD1. Again, without disturbing the GAIN, note the peak value of the received signal and designate it as $V3$. Compute α' in dB/m for a 650nm wavelength using the expression given in Step 5.

**BENDING LOSS**

7. Set up the 850nm analog link using the 1m fiber. Drive a 1Vp-p sinusoidal signal of 10 KHz with zero d.c. at P11 and observe the received signal at P31 on the oscilloscope. Now bend the fiber in a loop as shown in figure. Reduce the diameter of the loop slowly and observe the reduction of the received signal at P31. Keep reducing the diameter of the loop to about 2 cm and plot the amplitude of the received signal versus the diameter of the loop. [Do not reduce the loop diameter to less than 1 cm].



Bending the Optical Fibre

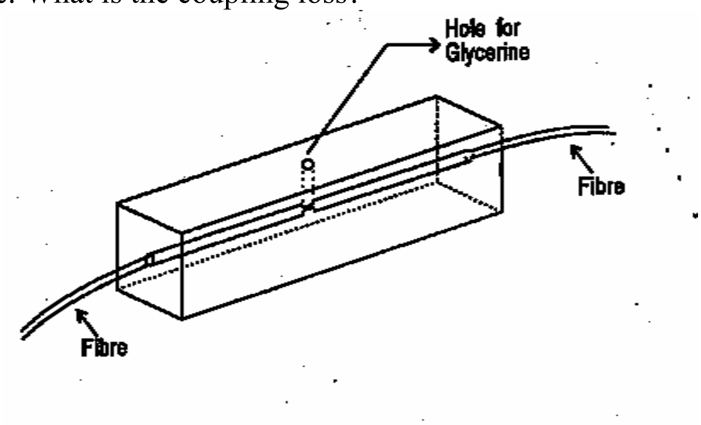
**COUPLING LOSS**

8. Connect one end of the 1m fiber to LED2 and the other end to the detector PD1. Drive the LED with a 10 KHz TTL signal at post B of S6. Note the peak signal received signal at P31 and designate it as *V*4 [ensure that the GAIN is low to prevent saturation]. Now disconnect the fiber from the detector. 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. Bring the free ends of the two fibers as close as possible and align from as shown in figure using the Fiber Alignment Unit. Observe that the received signal at P31 varies as the free ends of the fibers are brought closer and moved apart. Note the received signal level with the best possible alignment and designate it as *V*4. Using the attenuation constant value obtained in Step 5, compute the coupling loss associated with the above coupling of the two fibers using.

$$\eta = -10 \log \left(\frac{V4}{V1}\right) - \alpha' \left(l3 + l1\right)$$

Where α' is attenuation constant in dB/m at 650nm and η is the coupling loss in dB.

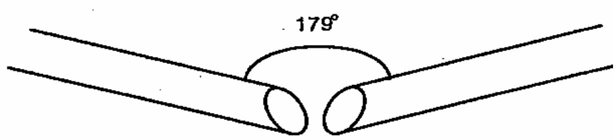
Now move the two fibers a bit apart in the Fiber Alignment Unit and note the decrease in the output voltage. What is the coupling loss?




**Fibre Alignment Using The Fibre Aligning Unit**

9. With the two ends of the fiber are aligned as close as possible, place a drop of glycerine/isopropylene through the hole provided in the Fiber Alignment Unit so as to cover the fiber ends. Note that the received signal now increases. Compute the coupling loss in the presence of an index matching fluid like glycerin. Why does the index matching fluid affect the coupling loss?

Now try aligning the two fibers without using the Fiber Alignment Unit. How well are you able to align the fibers? Estimate the losses as the two fibers are offset laterally and also when the two fibers are at an angle as shown in figure.




**Fibres at an angle**

## OBSERVATIONS

1. Compute the attenuation (α) and attenuation constant (α') of fibers at 850nm.
2. Compute the attenuation (α) and attenuation constant (α') of fibers at 650nm.
3. Compute the Coupling loss of two fibers.
4. Compute the coupling loss in the presence of an index matching fluid like glycerin.
5. BENDING LOSS**:**

Reduce the diameter of the loop slowly and observe the reduction of the received signal at P31. Keep reducing the diameter of the loop to about 2 cm and plot the amplitude of the received signal versus the diameter of the loop. [Do not reduce the loop diameter to less than 1 cm].

| S. NO. | Diameter of the Loop<br>cm | Amplitude of the received signal |
|---|---|---|
| | | |
| | | |
| | | |
| | | |

## REVIEW QUESTIONS

1. Define Attenuation?

_______________________________________________

_______________________________________________

2. Define Bending Loss?

_______________________________________________

_______________________________________________

3. Define Coupling Loss?

_______________________________________________

_______________________________________________

4. Why does the index matching fluid affect the coupling loss?

_______________________________________________

_______________________________________________

5. Define Power margin of a fiber optic link.

_______________________________________________

_______________________________________________

6. Derive the expressions used in Steps 5 & 8.

_______________________________________________

_______________________________________________