

## Experiment - 2: Measurement of Numerical Aperture of Optical Fiber

**Date: - 24/01/25**

- 1. Aim:** To measure the numerical aperture of the plastic fiber using 660 nm wavelength LED.
- 2. Requirements:** Function Generator, CRO, Experimental Kit, 1 Meter Fiber Cable, Probes, Fiber holding fixture, Power Supply, Connecting links.

### 3. Pre Experiment Exercise:

#### Brief Theory

One of the primary parameters of a fiber is its *Numerical Aperture*. This parameter is used in equations describing the coupling losses of the source light entering the fiber, connector and splice losses, and other system performance equations.

Consider a ray, internal to the fiber as shown above, that is incident on the core-cladding interface at exactly the critical angle. If we extend this ray back through the fiber-air interface at the input by applying Snell's law, it will have an angle of incidence given by  $\theta_{max}$ . All incident rays with angles less than  $\theta_{max}$  will have a core-cladding angle of incidence greater than the critical incident angle and will be guided down the fiber. All input rays with angles greater than  $\theta_{max}$  will intercept the core-cladding interface at an angle less than the critical incident angle, will be partially transmitted through the interface, and hence will suffer some loss at each reflection. They will soon be attenuated into insignificance if the fiber is relatively long.

The maximum angle  $\theta_{max}$  is given by:

$$\theta_{max} = \sin^{-1} \left( \sqrt{n_1^2 - n_2^2} \right) \approx \sin^{-1} \left( n_1 \sqrt{2\Delta} \right)$$

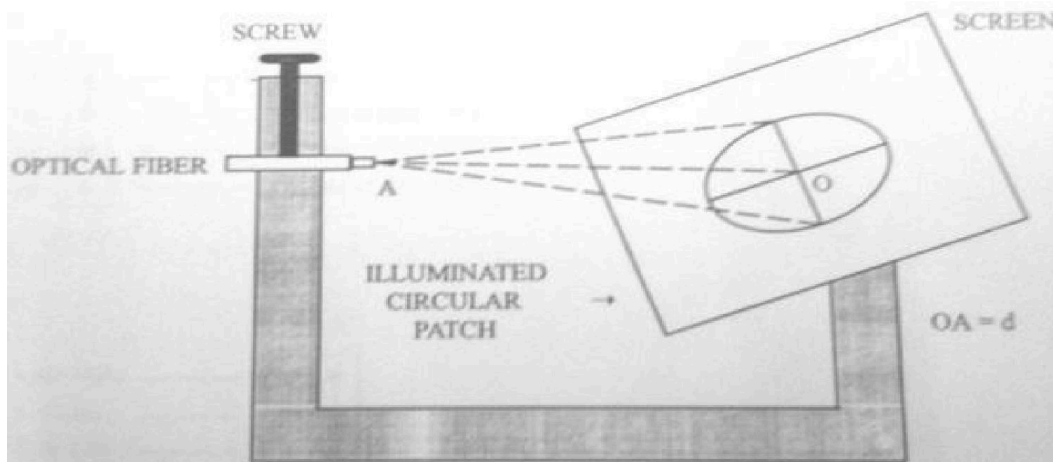
The Numerical Aperture of the fiber is the sine of this maximum input angle and is given by:

$$NA = \sin \theta_{max} = \sqrt{n_1^2 - n_2^2} \approx n_1 \sqrt{2\Delta}$$

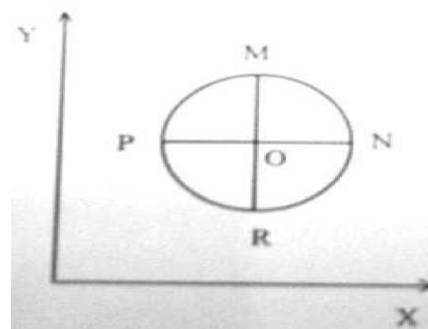
Considerations in NA measurement:

1. It is very important that the optical source should be properly aligned with the cable & the distance from the launched points and the cable be properly selected to ensure that the maximum amount of optical power is transferred to the cable.
2. This experiment is the best performed in a *less illuminated room*.

#### 4. Laboratory Exercise:



Setup for measurement of Numerical Aperture:



#### Procedure

1. Slightly unscrew the cap of LED SFH756V. Do not remove the cap from the connector.
2. Once the cap is loosened, insert the fiber into the cap. Now tighten the cap by screwing it back.
3. Connect the power cord to the kit & switch on the power supply. Apply TTL high input to the LED from EXT-TTL terminal.
4. Insert the other end of the fiber into the numerical aperture measurement jig. Hold the graph sheet facing the fiber in the place.
5. Now observe the illuminated circular patch of light on the screen (room should be less illuminated).
6. Measure exactly the distance  $d$  and also the vertical and horizontal diameter  $MR$  and  $PN$  as indicated in the figure.
7. Mean radius is calculated using the following formula  $r = (MR + PN)/4$
8. Find the numerical aperture of the fiber using the formula

$$NA = \sin \theta = \frac{r}{\sqrt{(r^2 + d^2)}}$$



**Observations:** Perform observations for values of  $d = 5\text{mm}$ ,  $10\text{mm}$ ,  $15\text{mm}$  and  $20\text{mm}$

d (mm)	MR	PN	$r = (MR + PN) / 4$	NA	$\theta$
5	5.5	5.5	2.75	0.4819	28.81
10	9.5	9.5	4.75	0.4290	25.40
15	14	14	7	0.4288	25.39

Average Numerical Aperture: **0.4465**

### 5. Conclusion/Comments:

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### 6. Questions

1. Find the core radius necessary for single mode operation at  $1320\text{ nm}$  of a step index fiber with  $n_1=1.480$  and  $n_2=1.478$ . What are the numerical aperture and maximum acceptance angle of this fiber?
2. Calculate the numerical apertures of (a) a plastic step-index fiber having a core refractive index of  $n_1=1.60$  and a cladding index of  $n_2=1.49$ , (b) a step index fiber having a silica core ( $n_1=1.458$ ) and a silicone resin cladding ( $n_2=1.405$ )
3. Explain the significance of the V- number.
4. Draw the refractive index profile of a graded index fiber and show with a neat diagram transmission of light through this fiber. Explain how GRIN fiber has transmission bit rate much higher than multitude Step index fiber.

## OCN 2

### Pre-test:

trade trade trade projet study trade trade trade

Virtual Labs

Physical Sciences > Basics of Physics > Experiments

Aim

Theory

Pretest

Procedure

Simulation

Posttest

References

Feedback

Measurement of Numerical aperture of optical fibre

1. The core of the optical fiber is having ----- refractive index as compared to cladding:  
☒ a. greater  
☐ b. smaller  
☐ c. same  
☐ d. NOT

2. For the light to propagate in optical fiber the correct relation between angle of incidence and the half acceptance angle is:  
☒ a.  $\alpha < \alpha_{max}$   
☐ b.  $\alpha > \alpha_{max}$   
☐ c.  $\alpha = \alpha_{max}$   
☐ d. none of these

3. The Numerical Aperture depends on:  
☐ a. Material of Core  
☐ b. Material of Cladding  
☐ c. Outer medium (air)  
☒ d. All of the above

4. Propagation of the signal in optical fiber is based on:  
☒ a. Total Internal Reflection  
☐ b. Reflection  
☐ c. Diffraction  
☐ d. Scattering

Submit Quiz

4 out of 4

### Plastic- fiber:

bop-iitk.vlabs.ac.in says

Percentage Error = 0%

OK

Select Cable : Fibre Cable

20mm

Distance of Screen (L) in mm

Reset

Message

```
>>Diameter (D) = 5.554mm
>>Diameter (D) = 6.666mm
>>Diameter (D) = 7.776mm
>>Diameter (D) = 8.888mm
>>Diameter (D) = 9.998mm
>>Diameter (D) = 11.11mm
>>Diameter (D) = 12.22mm
>>Diameter (D) = 13.332mm
>>Diameter (D) = 14.442mm
>>Diameter (D) = 15.554mm
>>Diameter (D) = 16.664mm
>>Percentage Error = 0%
>>Percentage Error = 0%
>>Percentage Error = 0%
>>Diameter (D) = 17.776mm
>>Diameter (D) = 18.886mm
>>Diameter (D) = 19.998mm
>>Diameter (D) = 21.108mm
>>Diameter (D) = 22.22mm
>>
```

Datatable

Sr No.	Distance of screen (L) in mm	Diameter (D) in mm
1.	5	5.554
2.	10	11.11
3.	15	16.664
4.	20	22.22

Final Numerical Aperture : 0.485

Draw Graph

Distance (L) in mm

Diameter (D) in mm

Verify

Glass-fiber:

bop-iitk.vlabs.ac.in says

Percentage Error = 0%

OK

Select Cable : Glass Cable

20mm

Distance of Screen (L) in mm

Reset

Message

```
>>Diameter (D) = 11.418mm
>>Diameter (D) = 13.324mm
>>Diameter (D) = 15.224mm
>>Diameter (D) = 17.126mm
>>Diameter (D) = 19.028mm
>>Diameter (D) = 20.932mm
>>Diameter (D) = 19.028mm
>>Diameter (D) = 17.126mm
>>Diameter (D) = 19.028mm
>>Diameter (D) = 20.932mm
>>Diameter (D) = 22.834mm
>>Diameter (D) = 24.738mm
>>Diameter (D) = 26.644mm
>>Diameter (D) = 28.544mm
>>Diameter (D) = 30.446mm
>>Diameter (D) = 32.35mm
>>Diameter (D) = 34.252mm
>>Diameter (D) = 36.154mm
>>Diameter (D) = 38.058mm
>>
```

Datatable

Sr No.	Distance of screen (L) in mm	Diameter (D) in mm
1.	5	9.514
2.	10	19.028
3.	15	28.544
4.	20	38.058

Draw Graph

Verify

Final Numerical Aperture : 0.689

Post test:

Virtual Labs

Measurement of Numerical aperture of optical fibre

Aim

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References

Feedback

1. The value of Numerical aperture of the single mode step index optical fiber is nearly:

☒ a. 0.2

☐ b. 2.0

☐ c. 20

☐ d. 200

2. Diameter of the spot on the screen ----- as the distance between the outlet of the optical fiber and the screen increases.

☒ a. Increases

☐ b. Decreases

☐ c. Remains constant

☐ d. none of these

3. As the difference between the refractive indices of the core and cladding of Optical fibre increases the Numerical Aperture:

☒ a. Increases

☐ b. Decreases

☐ c. Remains constant

☐ d. none of these

4. If any signal falls on the inlet of the optical fiber at an angle outside the acceptance cone then the signal:

☐ a. Cannot enter into the optical fiber

☒ b. Can enter but cannot propagate through the fiber

☐ c. Can enter and travel through the cladding of the optical Fiber

☐ d. none of these

Submit Quiz

4 out of 4

Practical Output:

