**Optical Fiber Communications**

**Assignment one**

**Attempt all the Question**

**Submission Date:17.01.2022. Time: 6:59am.**

# Question 1

In a step-index fiber in the ray approximation, the ray propagating along the axis of the fiber has the shortest route, while the ray incident at the critical angle has the longest route. Determine the difference in travel time (in ns/km) for the modes defined by those two rays for a fiber with ncore = 1.5 and ncladding = 1.485 [10 Marks]

**solution**

* **Reasoning:  
  If a ray propagating along the axis of the fiber travels a distance d, then a ray incident at the critical angle θc travels a distance L = d/sinθc.  
  The respective travel times are td = dncore/c and tL = dncore/(sinθcc).**
* **Details of the calculation:  
  sinθc = ncladding/ncore. θc = 81.9 deg.  
  For d = 1000 m we have td = 5000 ns and tL =5050.51 ns.  
  The difference in travel time is therefore 50.51 ns/km.**

Solution:

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# Question 2

Optical power launched into fiber at transmitter end is 150 μW. The power at the end of 10 km length of the link working in first windows is – 38.2 dBm. Another system of same length working in second window is 47.5 μW. Same length system working in third window has 50 % launched power. Calculate fiber attenuation for each case and mention wavelength of operation. [10 Marks]

Solution

### Solution : Given data:

P(0) = 150 µW

z= 10 km

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z = 10 km

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Attenuation in 1st window:

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Attenuation in 2nd window:

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Attenuation in 3rd window:

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Wavelength in 1st window is 850 nm. Wavelength in 2nd window is 1300 nm. Wavelength in 3rd window is 1550 nm.

# Question 3

A transmitter has an output power of 0.1 mW. It is used with a fiber having NA= 0.25, attenuation of 6 dB/km and length 0.5 km. The link contains two connectors of 2 dB average loss. The receiver has a minimum acceptable power (sensitivity) of – 35 dBm. The designer has allowed a 4 dB margin. Calculate the link power budget. [10 Marks]

**SOLUTION**

Source power Ps= 0.1 mW

Ps= -10dBm

Since NA = 0.25

Coupling loss = -10log (NA2) = -10log (0.252) = 12 dB

Fiber loss = αfx Llf= (6dB/km) (0.5km)

lf= 3 dBConnector loss = 2 (2 dB) lc= 4 dB

Design margin Pm= 4 dB

∴Actual output power Pout = Source power– (Σ Losses)

Pout= 10dBm– [12 dB + 3 + 4 + 4]

Pout=-33 dB

Since receiver sensitivity given is–35 dBm.

i.e. Pmin=-35 dBm

As Pout> Pmin, the system will perform adequately over the system operating life.

# Question 4

When a mean optical power is lunched into an 8 km length of fiber is 12 µW, the mean optical power at the fiber output is 3 µW. Determine - 1) Overall signal attenuation in dB. 2) The overall signal attenuation for a 10 km optical link using the same fiber with splices at 1 km intervals, each giving an attenuation of 1dB. [10 Marks]

Solution:

(1) Part

The overall signal attenuation in decibels through the fiber is

\large dB=10log_{10}\frac{P_{in}}{P_{out}}

Given, input power = 120 μW; output power= 3μW; length of an optical fiber=8 km

so putting all these values in above formula, we get

\large =10log_{10}\frac{120\mu W}{3\mu W}

\large =10log _{10}40 =16.0 dB

Overall signal attenuation is 16.0dB for this optical fiber. Joining the two fiber cables together is known by the connectors and splicers. In this part, there are no connectors. So, no signal loss due to the connectors.

By calculating the signal attenuation per kilometer for the same fiber may be obtained by the formula;

In the first part, we found overall signal attenuation dB=16.0 dB

so now divide it by the L i.e. 8 Km. we will get attenuation per unit length, and it will be

=2.0 dB/km

=20 dB

To understand this part of the attenuation problem, we have to observe this picture carefully. Here the total length of optical fiber is 10 km and at every kilometer, there is a splice. So, count the total number of splices, are these will be nine or more. Just check how these are nine? Because this is the only important part of this problem.

The optical fiber has nine splices with an attenuation of 1 dB. So, loss due to all nine splices will be 9 dB. Hence the overall signal attenuation for the optical fiber is

= 20 dB + 9 dB = 29dB

From the second part, we have seen the attenuation per unit kilometer is 2 dB. Here, the optical fiber is the same and length is 10 km is given. By this way, the total attenuation will be 20 dB. Also, 9 dB due to splices that is additional.

* As attenuation leads to a loss of power along the fiber, the output power is significantly less than the couples power. Let the couples optical power is p(0) e. at origin (z = 0).

Then the power at distance z is given by,

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where, αp is fiber attenuation constant (per km).

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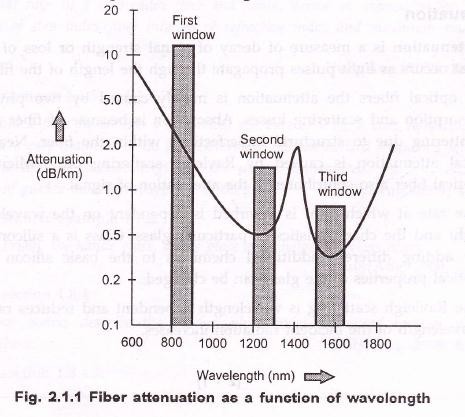
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This parameter is known as fiber loss or fiber attenuation

* Attenuation is also a function of Optical fiber wavelength as a function of wavelength is shown in Fig. 2.1.1.



**Example 2.1.1**: A low loss fiber has average loss of 3 dB/km at 900 nm. Compute the length over which –

1. a) Power decreases by 50 % b) Power decreases by 75 %.

Solution :             α = 3 dB/km

1. a) Power decreases by 50 %.

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α is given by,

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                                                         z = **1 km                                                                  … Ans.**

1. b)https://benchpartner.com/bp-content/uploads/2021/11/image308-76R4uTDObWy.png

Since power decrease by 75 %.

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https://benchpartner.com/bp-content/uploads/2021/11/image313-cxsc0IPTOOH.png                                                          z = **2 km                                                                  … Ans.**

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**Example 2.1.2 :**For a 30 km long fiber attenuation 0.8 dB/km at 1300nm. If a 200 µwatt power is launched into the fiber, find the output power.

**Solution**:                                    z = 30 km

α = 0.8 dB/km P(0) = 200 µW

Attenuation in optical fiber is given by,

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**Example 2.1.3**: When mean optical power launched into an 8 km length of fiber is 12 µW, the mean optical power at the fiber output is 3 µW.

Determine –

* Overall signal attenuation in
* The overall signal attenuation for a 10 km optical link using the same fiber with splices at 1 km intervals, each giving an attenuation of 1 dB.

**Solution**: **Given**:       z = 8 km

P(0) = 120 µW P(z) = 3 µW

* Overall attenuation is given by,

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* Overall attenuation for 10 km,

Attenuation per km  Attenuation in 10 km link https://benchpartner.com/bp-content/uploads/2021/11/image321-u9oixByfKrR.gif= 2.00 x 10 = 20 dB

In 10 km link there will be 9 splices at 1 km interval. Each splice introducing attenuation of 1 dB.

Total attenuation = 20 dB + 9 dB = **29 dB**

**Example 2.1.4**: A continuous 12 km long optical fiber link has a loss of 1.5 dB/km.

1. What is the minimum optical power level that must be launched into the fiber to maintain as optical power level of 3 µW at the receiving end?
2. What is the required input power if the fiber has a loss of 5 dB/km?

### [July/Aug.-2007, 6 Marks]

**Solution : Given data**: z = 12 km

α = 1.5 dB/km P(0) = 0.3 µW

1. Attenuation in optical fiber is given by,

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https://benchpartner.com/bp-content/uploads/2021/11/image326-asgh-V9xNaX.png

                     = 1.80

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Optical power output = **4.76 x 10-9 W                                                                                 … Ans.**

1. Input power = ? P(0)

When                          α = 2.5 dB/km

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   P(0) = 4.76 µW

Input power= **4.76 µW                                                                          … Ans.**

**Example 2.1.5**: Optical power launched into fiber at transmitter end is 150 µW. The power at the end of 10 km length of the link working in first windows is – 38.2 dBm. Another system of same length working in second window is 47.5 µW. Same length system working in third window has 50 % launched power. Calculate fiber attenuation for each case and mention wavelength of operation.                                                                                                                **[Jan./Feb.-2009, 4 Marks]**

### Solution : Given data:

P(0) = 150 µW

z= 10 km

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z = 10 km

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Wavelength in 1st window is 850 nm. Wavelength in 2nd window is 1300 nm. Wavelength in 3rd window is 1550 nm.

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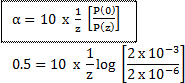
**Example 2.1.6**: The input power to an optical fiber is 2 mW while the power measured at the output end is 2 µW. If the fiber attenuation is 0.5 dB/km, calculate the length of the fiber.

### [July/Aug.-2006, 6 Marks]

**Solution : Given :**P(0) = 2 mwatt = 2 x 10-3 watt

P(z) = 2 µwatt = 2 x 10-6 watt α = 0.5 dB/km

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### Did you find this

# Question 5

An optical communication link is designed to transmit data over a (single mode) optical fiber of 100 km, with fiber loss of 0.2 dB/km, six splices with 0.05 dB per splice loss, and two connectors with 0.2 dB per connector. The receiver sensitivity is 20 μW. What is the minimum transmitter power (express in both mW and dBm)? [10 Marks]

End

Sensitivity: Public