



## Attenuation-Limited Fiber Length

### Objective

Calculate the attenuation-limited fiber length based on the power budget equation. Simulate the resulting system and verify that it meets performance objectives.

### Theory

The power budget equation states that the power budget in a transmission system must equal the sum of all power losses plus the power margin. The power budget is the difference between the transmitter output power and the receiver sensitivity in dBm. The equation is thus

$$P_T - S_R = AL_F + L_C + L_A + M$$

where

- $P_T$  = transmitter output power (dBm)
- $S_R$  = receiver sensitivity (dBm)
- $A$  = fiber attenuation (dB/km)
- $L_F$  = fiber length (km)
- $L_C$  = coupling loss (dB)
- $L_A$  = additional known losses (dB)
- $M$  = power margin (dB)

In this exercise, all parameters in the above equation are given except the fiber length, which must be determined.

The receiver sensitivity is defined here to be the minimum power required in order to achieve a BER of  $10^{-9}$ , which corresponds to a Q factor of 6. The receiver sensitivity depends on the bit rate. The fiber attenuation depends on the operating wavelength.



## Pre-lab Calculations

Using the power budget equation above and the parameters listed below, determine the attenuation-limited fiber length.

Transmitter output power	0 dBm
Operating wavelength	1550 nm
Bit rate	2.5 Gb/s
Receiver sensitivity	-30 dBm
Fiber attenuation	0.19 dB/km
Number of connectors	2
Loss per connector	0.5 dB
Additional known losses	0 dB
Power margin	6 dB

## Layout

The system has been created using OptiSystem and exported as an OptiPerformer file. There are two versions; one for 2.5 Gb/s and one for 10Gb/s. Work with the 2.5 Gb/s first. An optical attenuator has been used to represent the connector loss and the system margin. When you open up the OptiPerformer file, there will be a list of parameters that you can adjust. They are located near the bottom right hand corner. Adjust the parameters according to the above table. Also, the dispersion and nonlinear effects in the fiber have been disabled.

To set the receiver sensitivity to -30 dBm for 2.5GB/s, make sure the thermal noise parameter in the receiver is set to  $8.97e-24$  W/Hz.

The necessary visualizer components to have been placed in the OptiPerformer file to obtain the necessary data from the simulation.



## Simulation

1. Run the simulation and record the following data:

- Optical power levels (dBm)
  - Both ends of fiber
  - Receiver input
- BER analysis
  - BER
  - Q factor
  - Eye diagram

2. Set the fiber length to 125% of the value calculated in the pre-lab and repeat the simulation and data recording.

## Analysis and Report

Compare the results of the simulations and your pre-lab calculations and record your observations and explanations of differences in your lab report.

Your report should contain:

- Cover page
  - Title of the lab
  - Course name and number
  - Your name
- Pre-lab calculations
- Screen shots of layout and results, including eye diagrams
- Summary table listing for each simulation
  - Fiber length in km
  - Received power in dBm
  - Q factor
  - BER

Written summary of your observations