ATTENUATION IN OPTICAL FIBER

A fiber could be terminated in different ways. For instance, a fiber connector can be thread onto the end of the fiber. The connector and the fiber are glued together with epoxy. The end of the fiber is then polished to the best possible surface. The advantage of these fiber connectors is that they can be easily connected and disconnected.
The attenuation coeficient is strongly dependent on the wavelenght. The attenuation at different wavelengths can be measured by using different sources light.

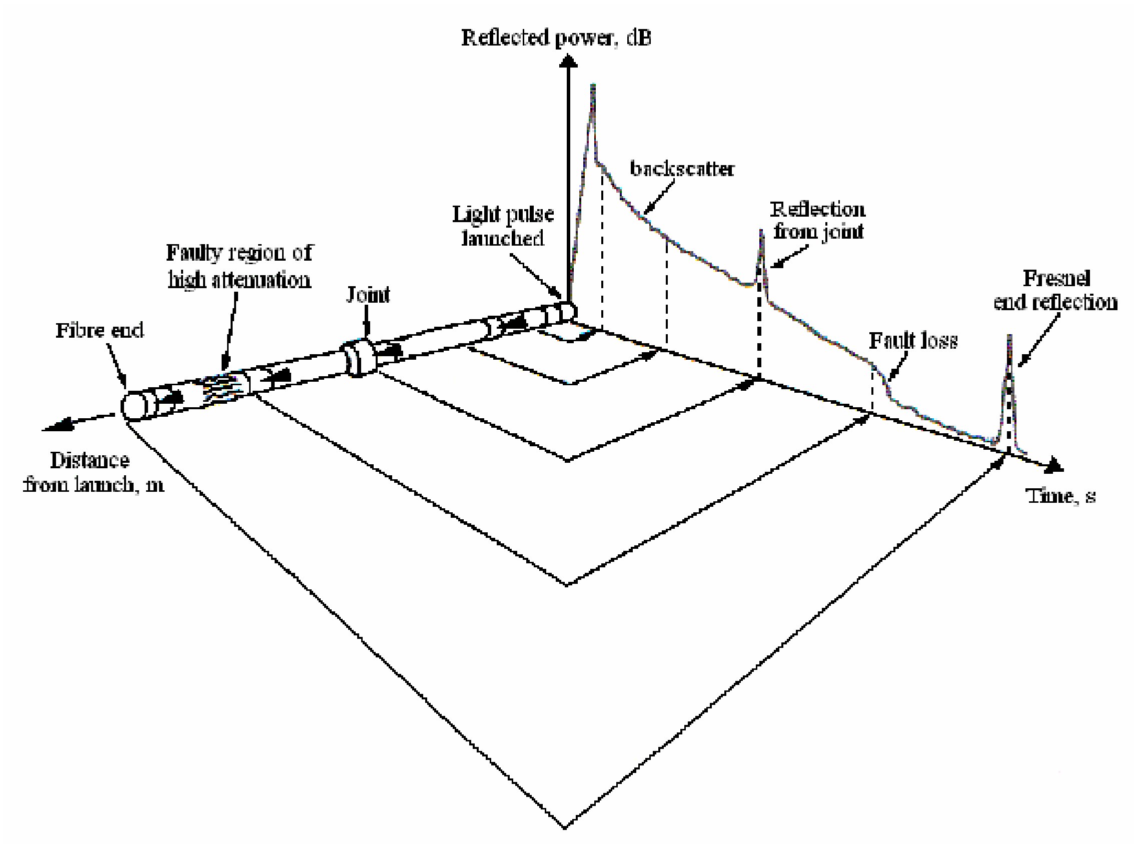
Optical Time Domain Reflectometer OTDR

Attenuation in the fiber as well as losses in specific fiber connectors may be measured by using the optical time domain reflectometry (OTDR) method. Needing only one end of the fiber to be accessed is an advantage of this technique.
A short laser pulse is sent to one end of the fiber. Time dependence of the reflected light is thereby studied. Rayleigh scattering attenuates the light transmitted in a fiber. Light is scattered in all directions, including backwards. A small fraction of the light intensity in a specific point of the fiber will always be backscattered.

If the fiber is excited with a short laser pulse, the backscattered light that reaches the entrance will have time dependence. The light detected at time t is reflected in a point at distance L from the entrance of the fiber.

The detected intensity exponentially falls as a function of time and attenuation are determined. If the intensity scale is logarithmic, the graph will be a straight line and the slope of the curve equals the attenuation.

A typical spectra with attenuation in the fiber is shown in the following figure.
Reflection in the connectors, losses in the splices and Fresnel reflection at the end of the fiber can also be observed.



Attenuation measurement using optical time domain reflectometer.

Material:

OTDR
Cabled multimode graded-index fiber 1200m length
Cabled multimode graded-index fiber 200 m length
Cabled singlemode fiber 2000 m length
Fiber optic adaptor

<u>Measurement of the 1200m length fiber</u>

- Insert one of the end of the cabled fiber (1200 m) in the OTDR.
- Let the other end of the fiber be unconnected.
- From the slope of the trace, measure the attenuation in the fiber:

L1 (m)	L2 (m)	Power level 1 (dB)	Power level 2 (dB)

Attenuation in the fiber in dB/m:

- From the Fresnel reflection, calculate the length of the fiber:

Measurement of the 200m length fiber

- Insert one of the ends of the cabled fiber (200 m) in the OTDR.
- Let the other end of the fiber be unconnected.
- From the slope of the trace, measure the attenuation in the fiber
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L1 (m)	L2 (m)	Power level 1 (dB)	Power level 2 (dB)

Attenuation in the fiber in dB/m:

- From the Fresnel reflection, calculate the length of the fiber:

Measurement of the 2000m length fiber

- Insert one of the ends of the cabled fiber (2000 m) in the OTDR.
- Let the other end of the fiber be unconnected.
- From the slope of the trace, measure the attenuation in the fiber
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L1 (m)	L2 (m)	Power level 1 (dB)	Power level 2 (dB)

Attenuation in the fiber in dB/m:

- From the Fresnel reflection, calculate the length of the fiber:

Measurement of the 2000 m, 1200 m and 200 m length fiber

- Insert one of the ends of the cabled fiber (2000 m) in the OTDR.
- Connect the other end of the 2000 m fiber with the cabled fiber (1200 m) by using the fiber optic adaptor
- Connect the other end of the 1200 m fiber with the cabled fiber (200 m) by using the fiber optic adaptor
- Let the other end of the cabled fiber (200 m) be unconnected
- From the reflection at the connectors, determine their positions:

- From the Fresnel reflection, calculate the length of the full set of the two cabled fibers:

Measurement of the attenuation with the insertion method

Material:

Laser He-Ne wavelength 632.8 nm
Semiconductor laser 1310 nm
Semiconductor laser 1550 nm
Coupling laser-fiber
2 Short multimode graded-index fibers
Cabled multimode graded-index fiber 1200m length
Cabled singlemode fiber 2000 m length
Fiber optic adaptor
Optical power meter

- Couple the light from the laser in the short fiber
- Measure the optical power received by the optical power meter
- Connect the two short fibers with the optic adaptor
- Measure the optical power received by the optic fiber power meter
- Couple the light from the laser in the cabled fiber (1200 or 2000 m)
- Measure the optical power received by the optical power meter

Wavelength	Power with short fiber (dBm)	Power with two short fibers (dBm)	Fiber optic adaptor attenuation (dB)	Power with multimode fiber (1200 m) (dBm)	Attenuation multimode fiber (dB/km)	Power with singlemode fiber (2000 m) (dBm)	Attenuation singlemode fiber (dB/km)
632.8 nm							
1310 nm							
1550 nm							

Macrobending losses

Radiative losses occur whenever an optical fiber undergoes a bend of finite radius of curvature. Macrobending losses occur when radius of curvature are large compared with the fiber diameter.

Losses are depending on the radius of curvature as it follows:

$$\alpha = \frac{P\left(r = R_i\right)\left(\mu W\right)}{P\left(r = \infty\right)\left(\mu W\right)} = e^{Rc/r}$$

We are determining the value of the constant Rc

Material:

Laser He-Ne wavelength 632.8 nm
Coupling laser-fiber
Short multimode graded-index fiber
Bending cylinders of different radius
Optical power meter

- Couple the light from the laser in the short fiber
- Measure the power received by the optical power meter when r = ∞
- Bend the short fiber by using different bending cylinders
- Measure the power received by the optical power meter when r = Ri
- Calculate the value of Rc for each measurement

$$R_C = r\ln\left(\alpha\right)$$

Radius	P(r=∞)	P(r=Ri)	α	Rc
R1=				
R2=				
R3=				
R4=				