Optical Communication

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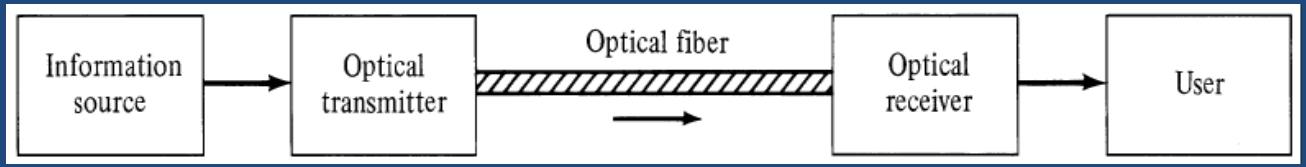
Unit – 6

OPTICAL SYSTEM DESIGN

Point to Point Links

The simplest transmission link is a point-to point line having a transmitter at one end and a receiver on the other, as shown below:



The design of an optical link involves many interrelated variables such as the fiber, source, and photodetector operating characteristics, so that the link design and analysis may require several iterations before they are working satisfactorily.

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➢The key system requirements needed in analyzing a link are:

1. The desired transmission distance
2. The data rate or channel bandwidth
3. The bit error rate (BER)

➢The major requirement to transfer the data from source to detector is to select the following components:

1. Light Source
2. Fiber Optic Cable
3. Detector

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1) Light Source :-

Selection of LED or laser diode optical source depends on the following factors:-

a) Emission wavelength
b) Output power
c) Number of emitting modes
d) Radiating area
e) Stability and Life time

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2. Fiber Optic Cable

Selection of the Multimode or single-mode optical fiber depends on the following factors:-

(a) Core size
(b) Core refractive-index profile
(c) Bandwidth or dispersion
(d) Attenuation
(e) Numerical aperture or mode-field diameter

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2. Photo detectors

Selection of the photo detectors depends on the following factors:-

a) Response time
b) Efficiency
c) Noise figure

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There area two analyses to ensure the desired system performance can be met.

1. Link power budget
2. Rise time budget

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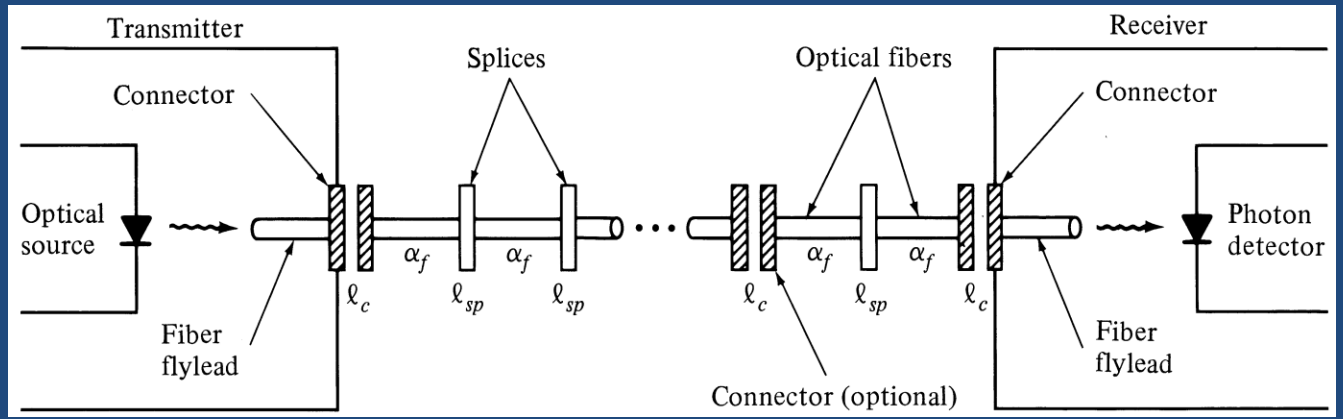
Link power budget

Link power budget determines whether the fiber optic link meets the attenuation requirements or amplifiers are needed to boost the power level.



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The link loss budget considers the total optical power loss P_T that allowed between the light source and detector.

The total power loss in the link is given by

$P_T = P_S - P_R$

$= 2Lc + \alpha L$ + System margin

Where,

P_S → optical power emerging from the end of a fiber

P_R → Receiver sensitivity

Lc → Connector loss

α → Fiber attenuation

L → Transmission distance

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Rise time budget

The rise time budget analysis is the convenient method for determining the dispersion limitation of an optical fiber link.

The total system rise time is the square root of sum of squares of the rise times from each contributor ti to the pulse rise time degradation.

There are four elements that may reduce the system speed.

1. Transmitter rise time
2. Group velocity dispersion
3. Modal dispersion rise time
4. Receiver rise time

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Line Coding in Optical Links

Line coding is used as set of rules for arranging the signal symbols in a particular pattern.

Necessity of Line Coding:

1. To minimize errors that are produced from channel interference effect by introducing redundancy into the data stream.
2. Any degree of error free transmission of digital data must be achieved depending on the amount of introduced redundancy.
3. A tradeoff must be made between timing and noise bandwidth in the case of selecting a particular line code.

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4. Format of the transmitted optical signal must be considered.

5. It also needs to have an inherent error detecting capability.

There are three types of codes normally used for transmission purpose.

1. NRZ codes
2. RZ codes
3. Block codes

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Merits of line coding:

1. Offers large BW.
2. They are less affected due to temperature variations.
3. Error monitoring functions is provided in coding.

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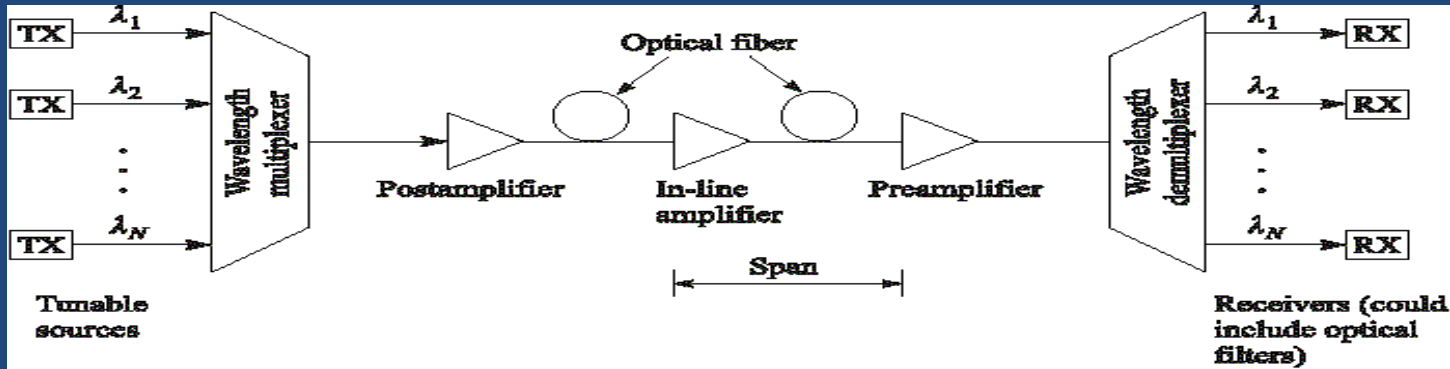
Wavelength Division Multiplexing(WDM)

Underlying principles of any communication system is to transmit number of signals through a channel simultaneously.

Optical signals of different wavelengths can be transmitted along a fiber simultaneously through Wavelength division multiplexing(WDM).



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Features of WDM

1. Upgradation in the capacity in the fiber network.

2. Any type of signal can be sent simultaneously and independently over the same fiber.

3. Wavelength sensitive optical routing devices in designing communication networks and switches are having importance.

Types of WDM

1. Unidirectional WDM
2. Bidirectional WDM

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Attenuation Measurement

Attenuation of optical power in a fiber waveguide is due to

1. Absorption
2. Scattering mechanism
3. Waveguide defects

There are three basic methods are available for determining attenuation in fibers.

1. Cut-back Technique
2. Insertion-Loss method
3. Optical Time Domain Reflectometer (OTDR)

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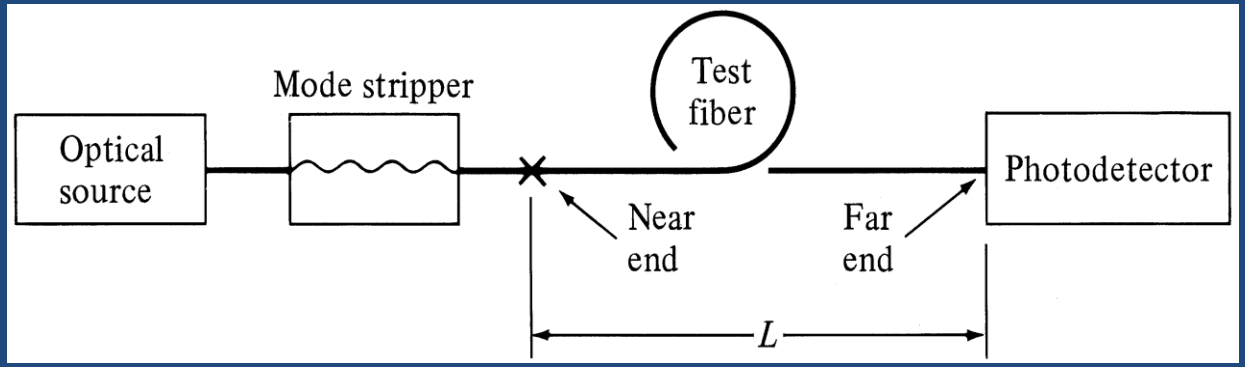
Cut-Back Technique



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Cut-Back Technique

It is a destructive method requiring access to both ends of the fiber.

To find transmission loss , the optical power is first measured at the output of the fiber.

Then , without disturbing the input condition, the fiber is cut off a few meters from the source, and the power at this near end is measured.

Average loss α in decibels per kilometer is given by

$$\alpha = (10/L) \text{ Log } (P_N/P_F)$$

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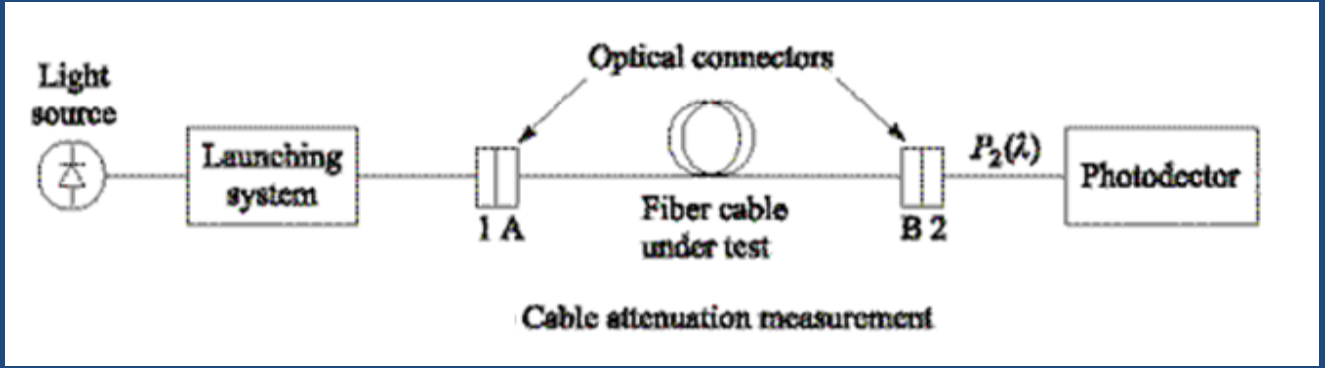
Insertion Loss method

For cables with connectors one cannot use cut back technique.

It is less accurate method than the cut back method.

This method is a non-destructive method.



Cable attenuation measurement

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Insertion Loss method

To carryout the attenuation tests, the connector of the short-length launching fiber is attached to the connectors of the receiving system and the launch-power level P1 is recorded.

Next, the cable assembly to be tested is connected between the launching and receiving systems, and the received power level P2 is recorded.

$$A = 10 \log (P1 / P2)$$

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OTDR (Optical Time Domain Reflectometer)

It is a fiber optic tester. It is also called as Optical RADAR.

It provides information regarding local losses and reflective elements.

It is mainly used to find the place of fault in an optical fiber.

OTDR uses the effects of Rayleigh scattering and Fresnel reflection.

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OTDR (Optical Time Domain Reflectometer)

Rayleigh scattering occurs when the light travelling down the fiber encounters small materials variations and discontinuities in the refractive index.

Fresnel reflections occur when the light encounters abrupt variations in the material properties that are caused by a break or air gaps or connectors.

Fresnel reflection is 10,000 times greater than Rayleigh scattering in terms of reflected power.

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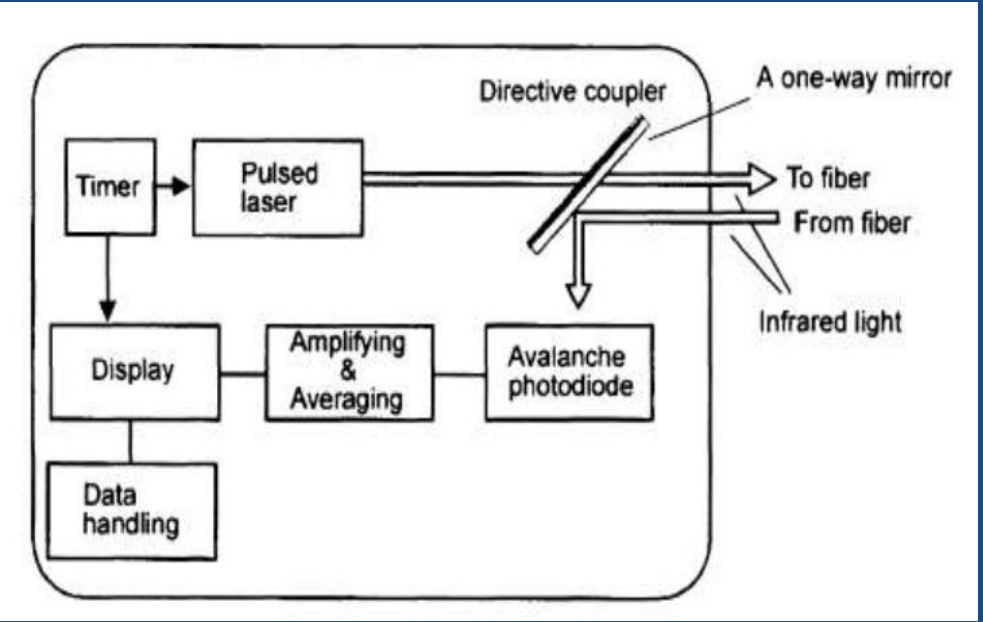
OTDR (Optical Time Domain Reflectometer)



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EYE PATTERN

Simple but powerful measurement method for assessing the data handling capability of a digital transmission system.

- The eye pattern measurements are done in time domain.

- Also allow the effect of waveform distortion to be immediately shown on the oscilloscope.

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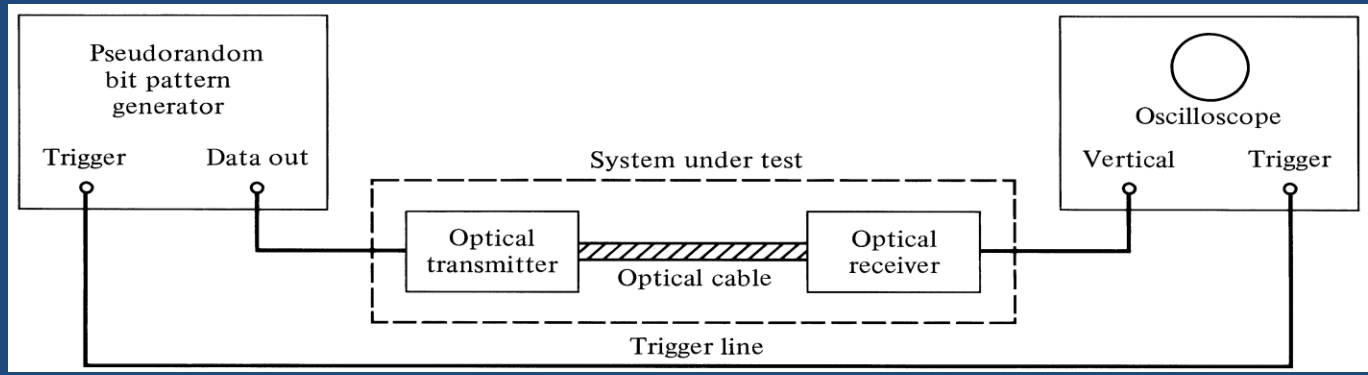

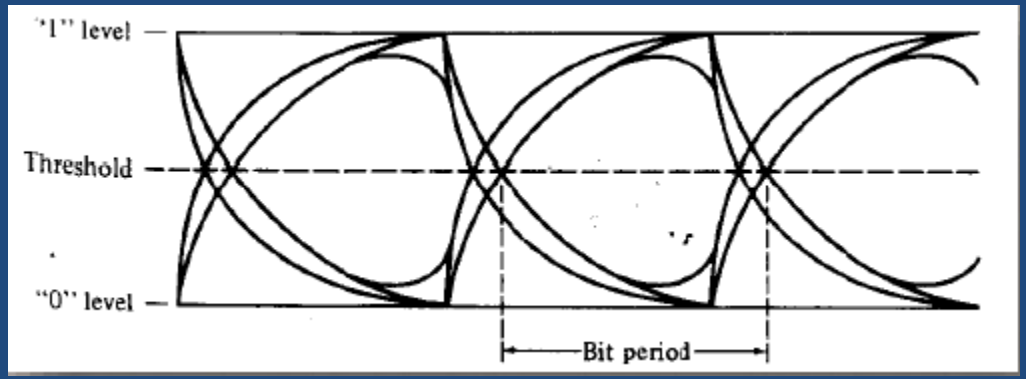

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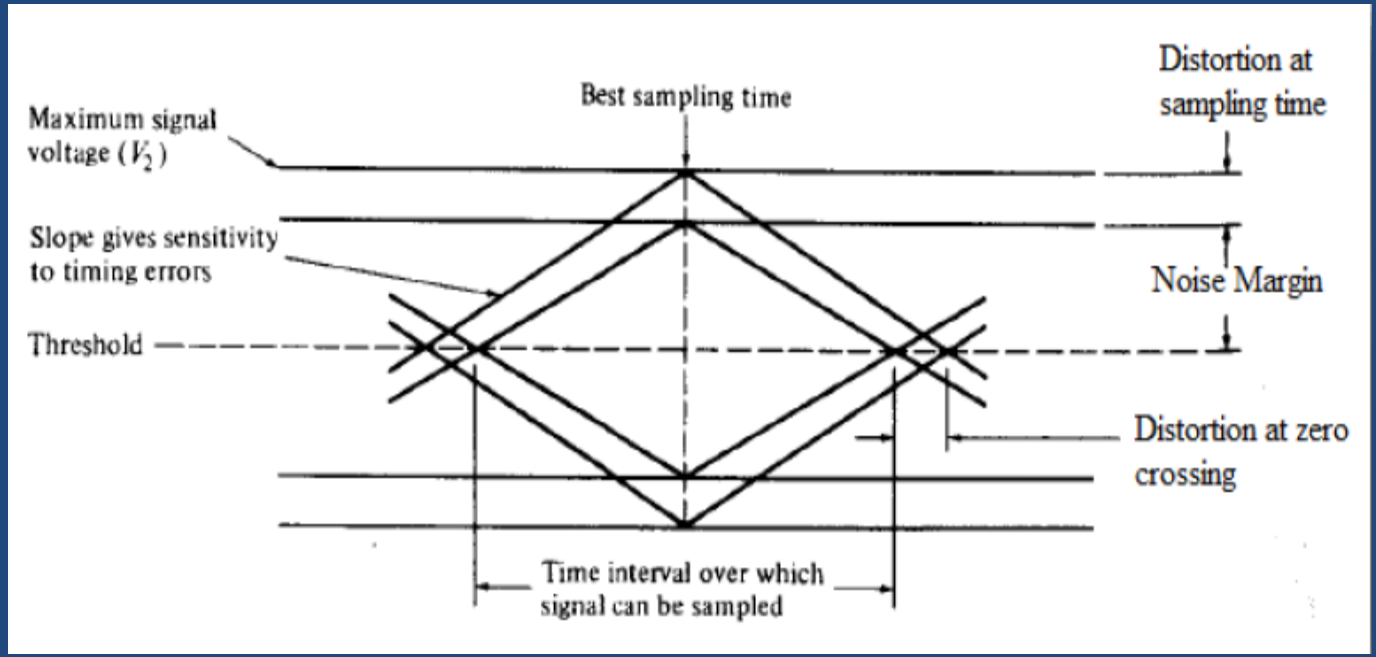
SIMPLIFIED EYE PATTERN



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Thank you