18PYB101J MODULE-5 LECTURE 15

- LOSSES IN FIBER OPTICS
- FIBRE OPTIC COMMUNICATION SYSTEM
- FIBRE OPTIC SENSORS

Losses in Fiber Optics

- **Attenuation**
- **Bend loss-micro, macro**
- **Absorption**
- **Dispersion-Intermodal, Intramodal**

Attenuation

- Attenuation means loss of light energy as the light pulse travels from one end of the cable to the other.
- It is also called as signal loss or fiber loss.
- It also decides the number of repeaters required between transmitter and receiver.
- Attenuation is directly proportional to the length of the cable.

Attenuation

- Attenuation is defined as the ratio of optical output power to the input power in the fiber of length L.

  $\alpha = 10 \log_{10} P_i/P_o$ [in db/km]

  where, P_i = Input Power

  P_o = Output Power, α is attenuation constant

Dispersion Loss

- As an optical signal travels along the fiber, it becomes increasingly distorted. This distortion is a sequence of intermodal and intramodal dispersion.

Two types of dispersion are:

1. Intermodal Dispersion:
   - Pulse broadening due to intermodal dispersion results from the propagation delay differences between modes within a multimode fiber.
2. Intramodal Dispersion:

It is the pulse spreading that occurs within a single mode.

- Material Dispersion
- Waveguide Dispersion

Dispersion Loss

- Material Dispersion:

  Also known as spectral dispersion or chromatic dispersion.

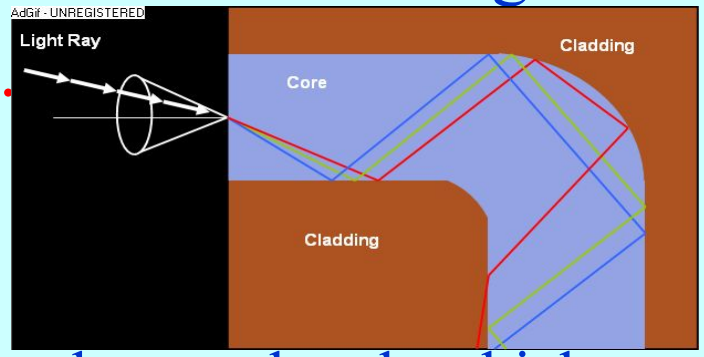
  Results because of variation due to Refractive Index of core as a function of wavelength, because of which pulse spreading occurs even when different wavelengths follow the same path.

- Waveguide Dispersion:

  Whenever any optical signal is passed through the optical fiber, practically 80% of optical power is confined to core & rest 20% optical power into cladding.

Bending losses

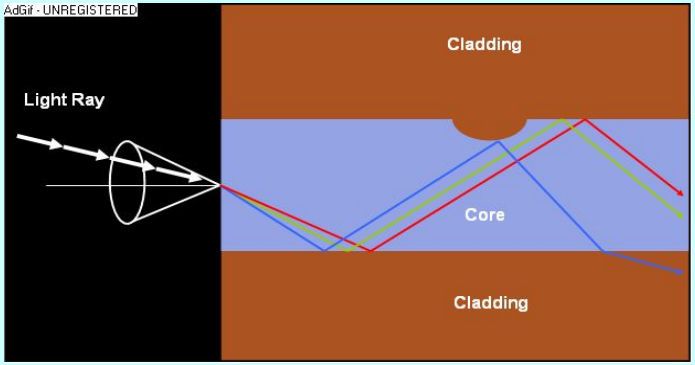
- The loss which exists when an optical fiber undergoes bending is called bending losses.



There are two types of bending

i) Macroscopic bending

Bending in which complete fiber undergoes bends which causes certain modes not to be reflected and therefore causes loss to the cladding.



ii) Microscopic Bending

Either the core or cladding undergoes slight bends at its surface. It causes light to be reflected at angles when there is no further reflection.

Absorption Loss

- Absorption of light energy due to heating of ion impurities results in dimming of light at the end of the fiber.

There are two types of absorption:

1. Intrinsic Absorption:
   - Caused by the interaction with one or more components of the glass
   - Occurs when photon interacts with an electron in the valence band & excites it to a higher energy level near the UV region.

2. Extrinsic Absorption
   - Also called impurity absorption.
   - Results from the presence of transition metal ions like iron, chromium, cobalt, copper & from OH ions i.e. from water.

Fiber optic communication system

Introduction

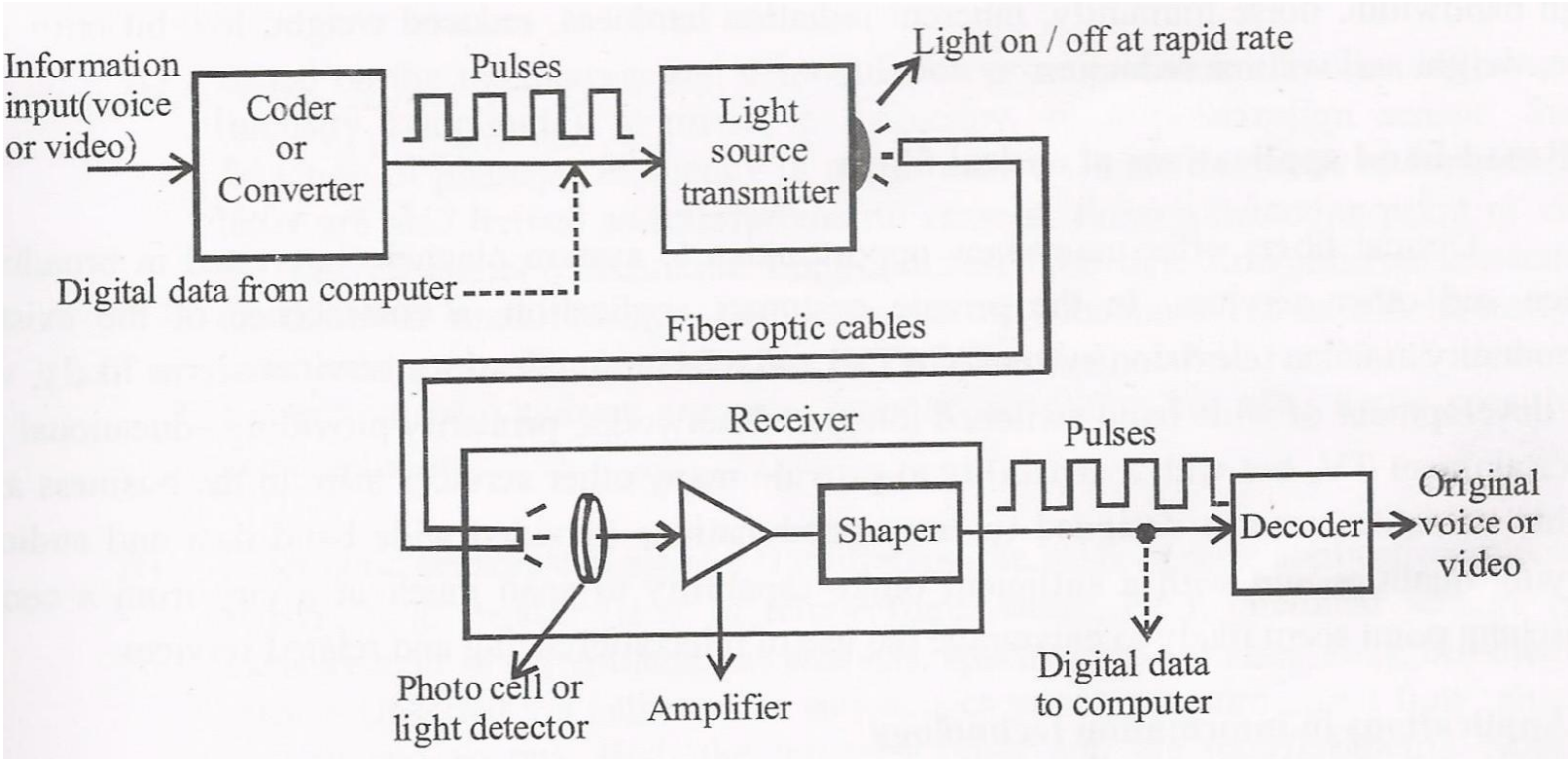
- In the early stages of development, fiber communication promised extremely high data rates, which would allow large masses of data to be transmitted quickly.
- It also had the potential for transmission over long distances without the need to amplify and retransmit along the way.
- Recent developments have exceeded the hope of those involved in the technology.

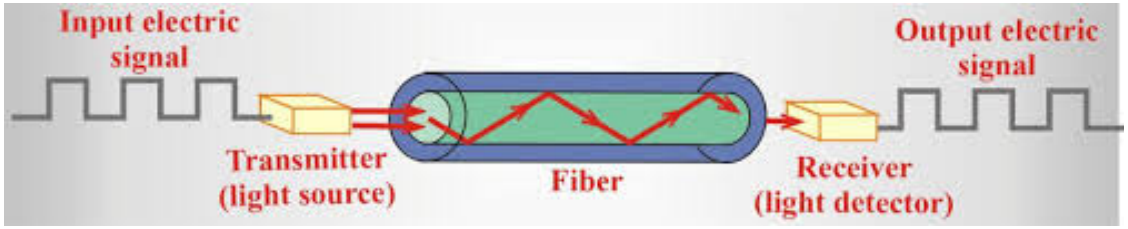
Basic model

- The bandwidth of the fiber optic communication system, which determines the maximum data rate, depends on the major components of the system.
- Fig. shows the block diagram of fiber optic communication system.
- The information signal to be transmitted may be voice, video or computer data.
- The first step is to convert the information into a form compatible with the communications medium.
- This is usually done by converting continuous analog signals such as voice and video (TV) signals into a series of digital pulses.
- An Analog – to – Digital (A/D) converter is used for this purpose. Computer data is already in the digital form.

- These digital pulses are then used to flash a powerful light source (i.e.) off and on very rapidly.
- In a simple low – cost system that transmits over short distances, the light source is usually a light emitting diode (LED).
- This is a semiconductor device that puts out a low – intensity red light beam. Other colours are also used.
- Infrared beams like those used in TV remote controls are also used in transmission.
- Another commonly used light source is the solid state laser.
- This is also a semiconductor device that generates an extremely intense single frequency light beam.

Fiber optic communication system





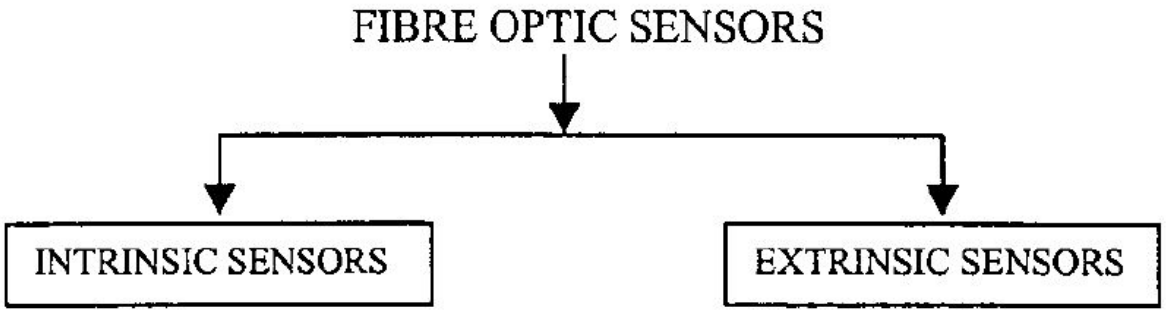
- The light beam pulses are then fed into a fiber – optic cable where they are transmitted over long distances.
- At the receiving end, a light sensitive device known as a photocell or light detector is used to detect the light pulses.
- This photocell or photo detector converts the light pulses into an electrical signal.
- The electrical pulses are amplified and reshaped back into digital form.
- They are fed to a decoder, such as a Digital – to – Analog converter (D/A), where the original voice or video is recovered.

- Both the light sources at the sending end and the light detectors on the receiving end must be capable of operating at the same data rate.
- The circuitry that drives the light source and the circuitry that amplifies and processes the detected light must both have suitable high-frequency response.
- The fiber itself must not distort the high-speed light pulses used in the data transmission.

- In very long transmission systems, repeater units must be used along the way.
- Since the light is greatly attenuated when it travels over long distances, at some point it may be too weak to be received reliably.
- To overcome this problem, special relay stations are used to pick up light beam, convert it back into electrical pulses that are amplified and then retransmit the pulses on another beam.
- Several stages of repeaters may be needed over very long distances.
- But despite the attenuation problem, the loss is less than the loss that occurs with the electric cables.

FIBRE OPTIC SENSORS

- **Sensor** is a transducer which is used to convert one physical variable into another
- Fibre optic sensors are fibre based devices for sensing some quantity, typically temperature mechanical strain, but sometimes also displacements, vibrations, pressure, acceleration or concentrations of chemical species.

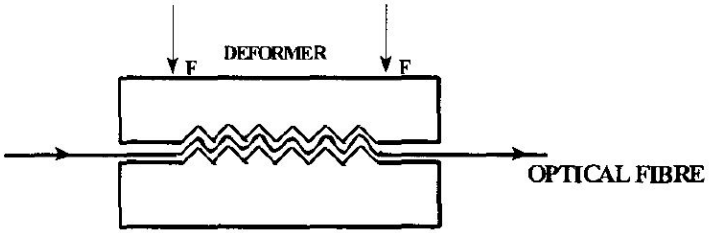


Introduction

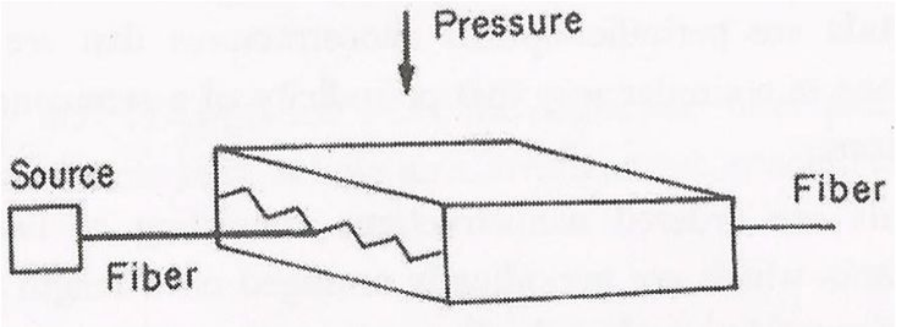
- Fiber Optic Sensor Classifications
  - Sensing region: Intrinsic vs. Extrinsic
    - Intrinsic fiber optic sensor has a sensing region within the fiber and light never goes out of the fiber.
    - In extrinsic sensors, light has to leave the fiber and reach the sensing region outside and then comes back to the fiber.

DISPLACEMENT SENSOR (Intrinsic)

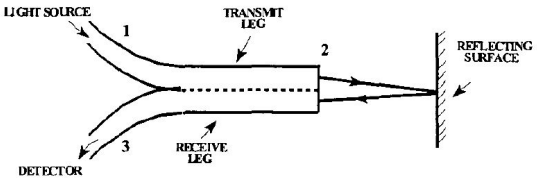
- Optical fiber placed between a pair of ridged plates which impart a periodic perturbation to the fiber.



- The quantity to be measured acts directly on the fiber to modify the radiation passing through it.
- The plates induce micro bend losses due to displacement
- The intensity of the light output varies
- By measuring the change in intensity, displacement is measured.



POSITION SENSOR (Extrinsic)



- It consists of two fibers, one to transmit light from source to object and other to collect light from the object.
- The quantity to be measured acts indirectly on the fiber to modify the radiation.
- Change in the position of the object will result in changes in the amount of light collected by the detector.
- By recording the change in intensity, the position is estimated.