Modern Telecommunication Systems
Lecture 3

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Fiber Optic Cable

- A fiber-optic cable is thin glass or plastic cable that acts as a light “pipe.”
- Fiber cables have a circular cross section with a diameter of only a fraction of an inch.
- A light source is placed at the end of the fiber, and light passes through it and exits at the other end of the cable.
- Light propagates through the fiber based upon the laws of optics.

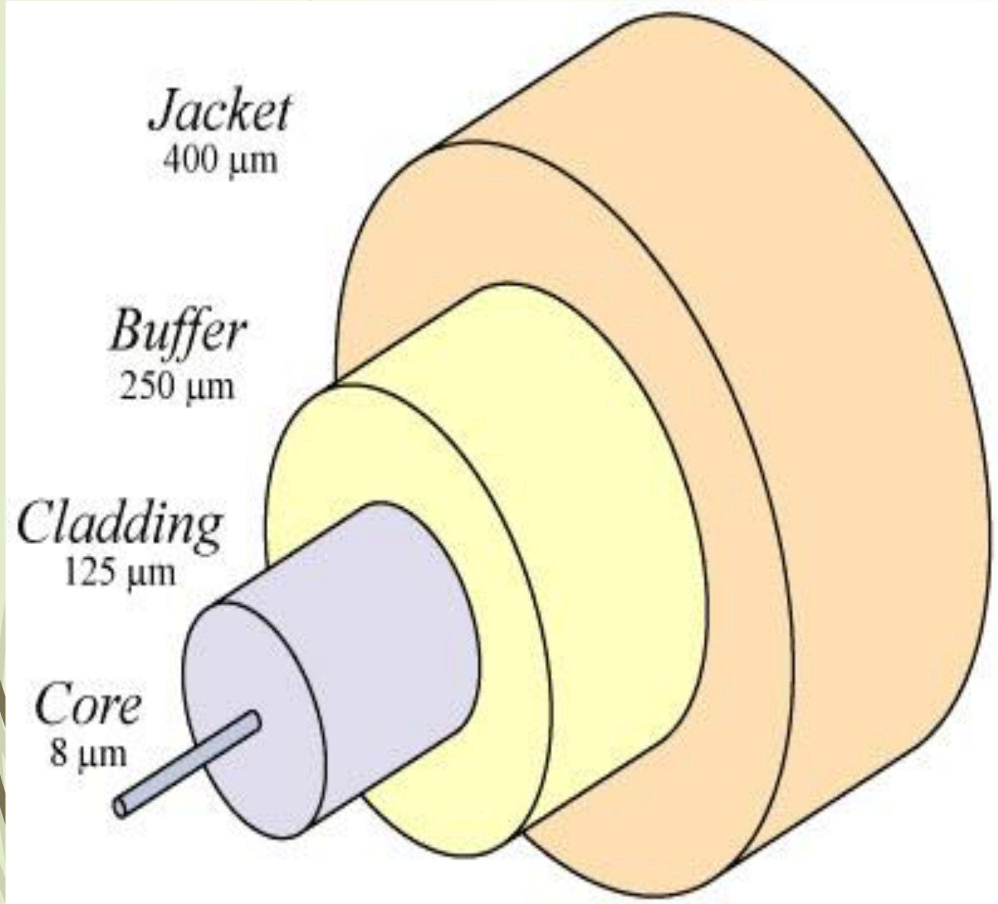
Fiber-Optic Cable Construction

- Fiber-optic cables come in a variety of sizes, shapes, and types.
- The portion of a fiber-optic cable that carries the light is made from either glass, sometimes called silica, or plastic.
- Plastic fiber-optic cables are less expensive and more flexible than glass, but the optical characteristics of glass are superior.
- The glass or plastic optical fiber is contained within an outer cladding.

Fiber-Optic Cable Construction

- The fiber, which is called the core, is usually surrounded by a protective cladding.
- In addition to protecting the fiber core from nicks and scratches, the cladding gives strength.
- Plastic-clad silica (PCS) cable is a glass core with a plastic cladding.
- Over the cladding is usually a plastic jacket similar to the outer insulation on an electrical cable.
- Fiber-optic cables are also available in flat ribbon form.

Fiber Optic Cable



Jacket: Fiber optic cable's jackets are available in different colors that can easily make us recognize the exact color of the cable.

Buffer: The main function of the buffer is to protect the fiber from damage

Cladding: The main function of the cladding is that it reflects the light back into the core

Core: The core of a fiber cable is a cylinder of plastic that runs all along the fiber cable's length, and offers protection

Types of Fiber-Optic Cables

- There are two ways of classifying fiber-optic cables.
  - The first method is by the index of refraction, which varies across the cross section of the cable.
  - The second method of classification is by mode, which refers to the various paths the light rays can take in passing through the fiber.

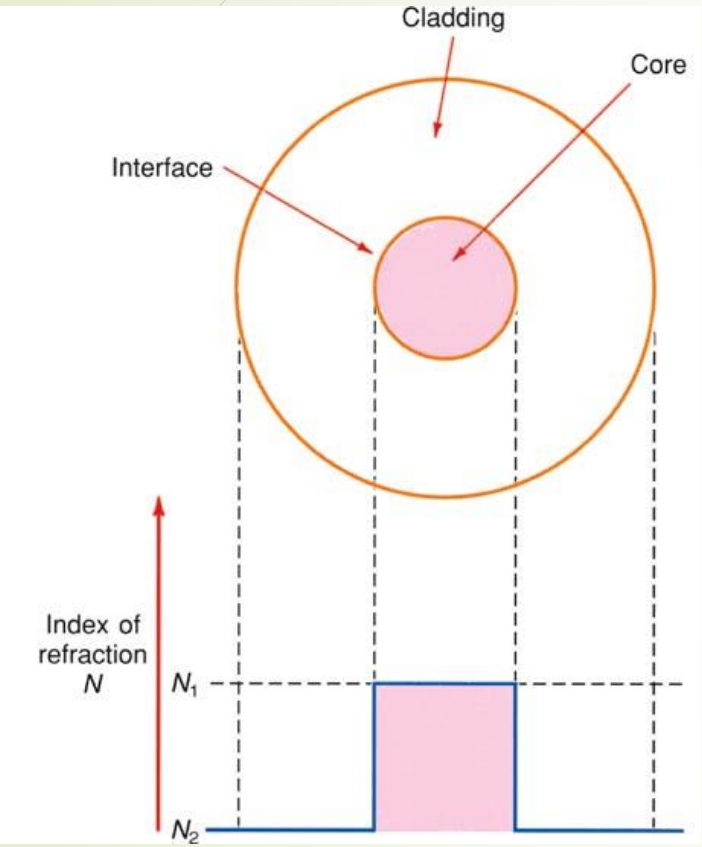
Types of Fiber-Optic Cables

- The two ways to define the index of refraction variation across a cable are the step index and the graded index.
  - Step Index Cables: For step index cables, refractive index of the cladding is lower than that of the core. Because of an abrupt index change at the core–cladding interface, such fibers are called step-index fibers.
  - Step index refers to the fact that there is a sharply defined step in the index of refraction at the core-cladding interface.

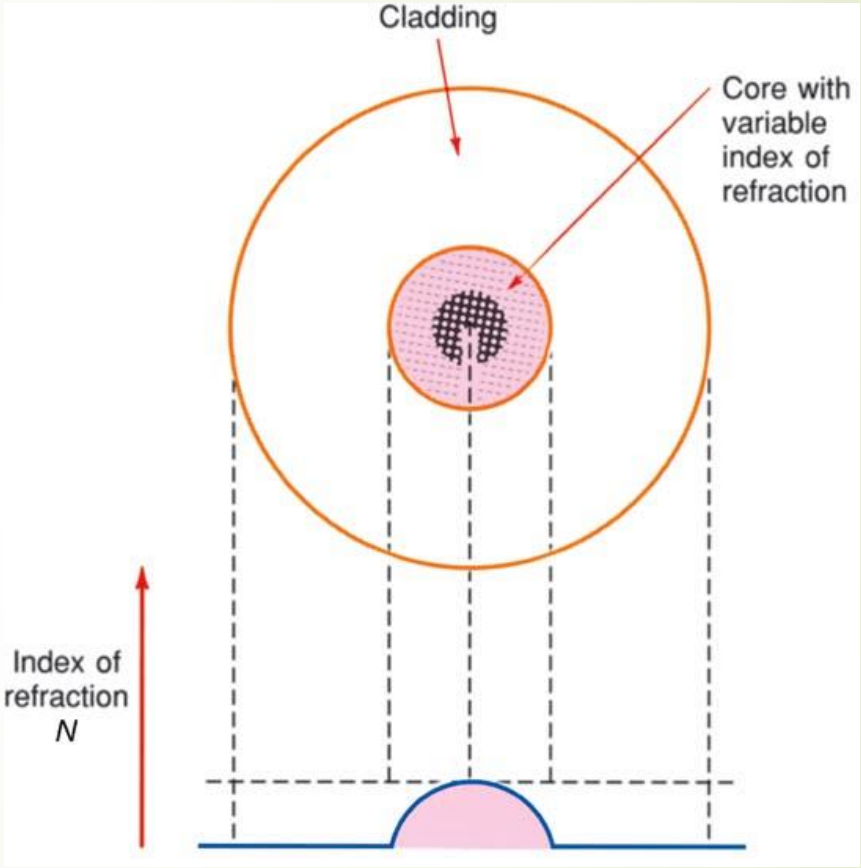
Types of Fiber-Optic Cables

- Graded Index: With the graded index cable, the index of refraction of the core is not constant. It varies smoothly and continuously over the diameter of the core.
- The refractive index of the core in graded-index fibers decreases gradually from its maximum value n1 at the core center to its minimum value n2 at the core–cladding interface.

Types of Fiber-Optic Cables



A step index cable cross section.



Graded index cable cross section.

Types of Fiber-Optic Cables: Cable Mode

- Mode refers to the number of paths for light rays in the cable.
- There are two classifications: single mode and multimode.
  - Single Mode: In single mode, light follows a single path through the core. Single-mode fiber is so small in diameter that rays of light can reflect internally through one layer only. Interfaces with single-mode optics use lasers as light sources.
  - Compared with multimode fiber, single-mode fiber has higher bandwidth and can carry signals for longer distances.

Types of Fiber-Optic Cables: Cable Mode

- Multimode: In multimode, the light takes many paths.
- Multimode fiber is large enough in diameter to allow rays of light to reflect internally.
- Interfaces with multimode optics typically use LEDs as light sources. LEDs are not coherent sources.
- They spray varying wavelengths of light into the multimode fiber, which reflects the light at different angles. Light rays travel in jagged lines through a multimode fiber, causing signal dispersion.
- Together these factors limit the transmission distance of multimode fiber compared with single-mode fiber.

Types of Fiber-Optic Cables

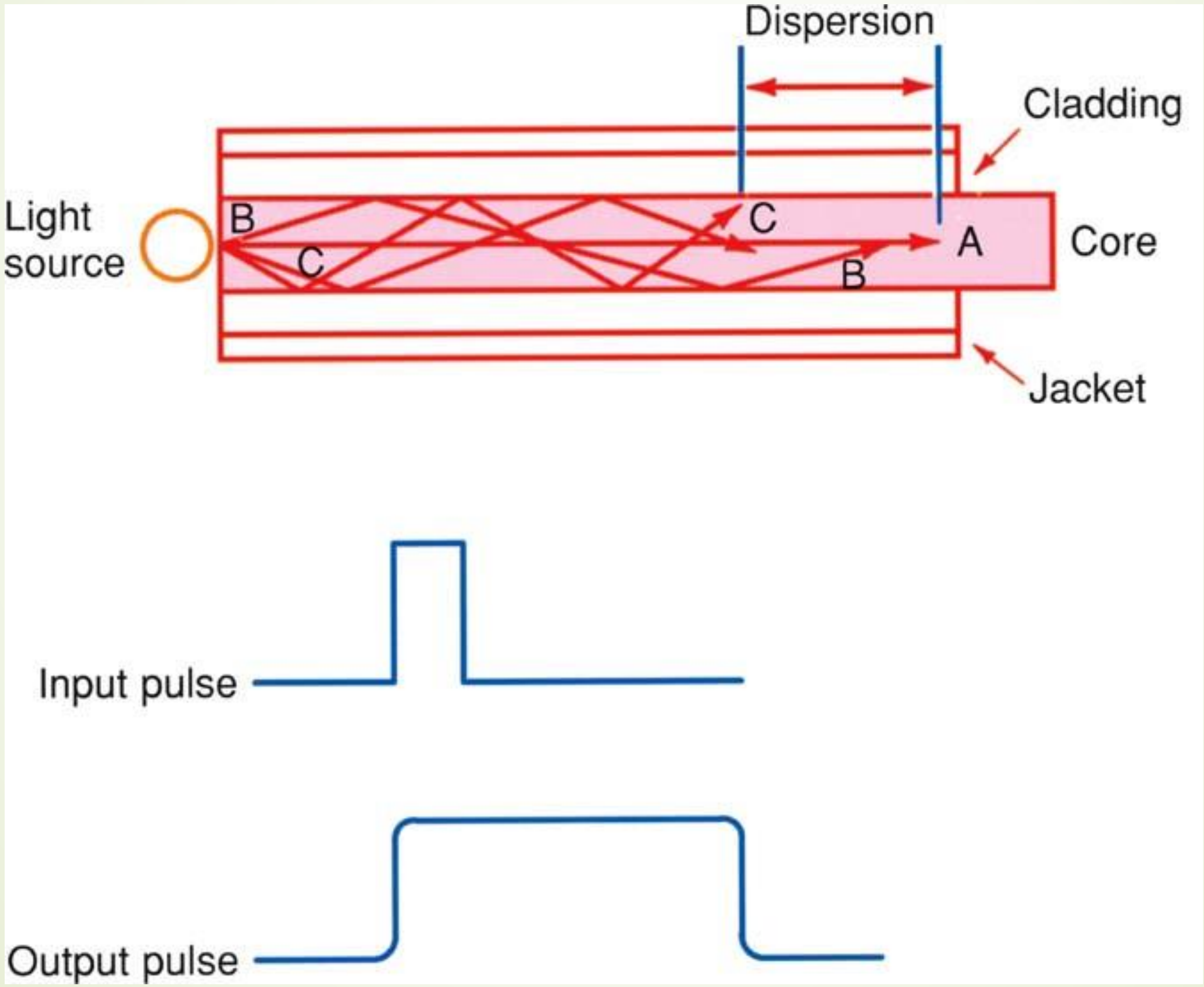
- In practice, there are three commonly used types of fiber-optic cables:

1. Multimode step index
2. Single-mode step index
3. Multimode graded index

Multimode Step Index Cable

- The multimode step index fiber cable is probably the most common and widely used type.
- It is the easiest to make and therefore the least expensive.
- It is widely used for short to medium distances at relatively low pulse frequencies.
- The main advantage of a multimode stepped index fiber is its large size.

Multimode Step Index Cable



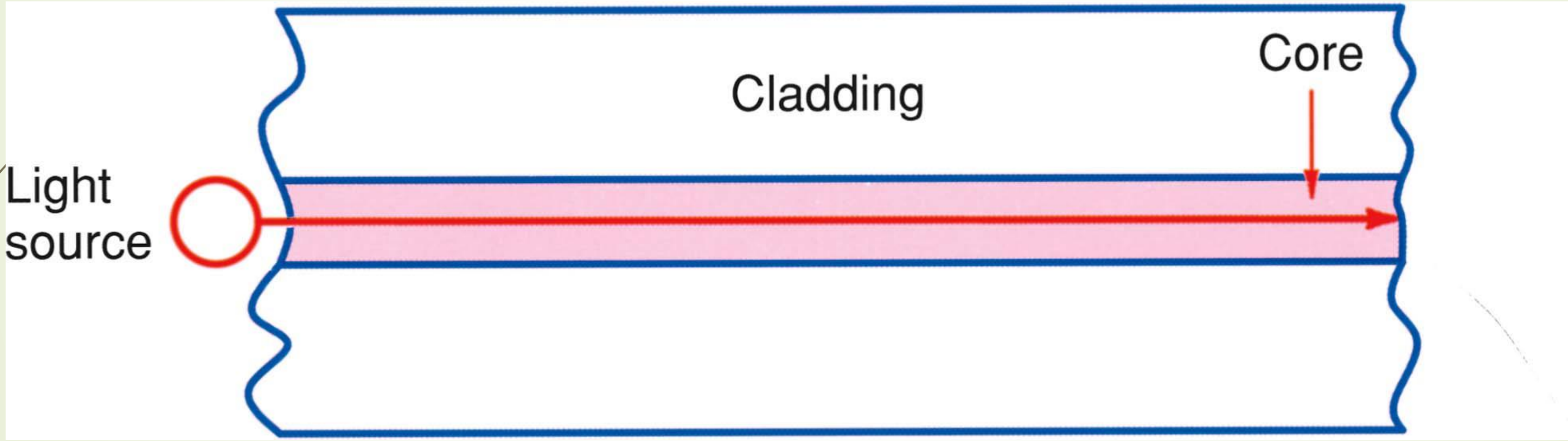
Single-Mode Step Index Cable

- A single-mode or mono mode step index fiber cable eliminates modal dispersion by making the core so small that the total number of modes or paths through the core is minimized.
- Typical core sizes are 2 to 15 μm.
- The pulse repetition rate can be high and the maximum amount of information can be carried in this type cable.
- They are preferred for long-distance transmission and maximum information content.

Single-Mode Step Index Cable

- This type of cable is extremely small, difficult to make, and therefore very expensive.
- It is also more difficult to handle.
- Splicing and making interconnections are more difficult.
- For proper operation, an expensive, super-intense light source such as a laser must be used.

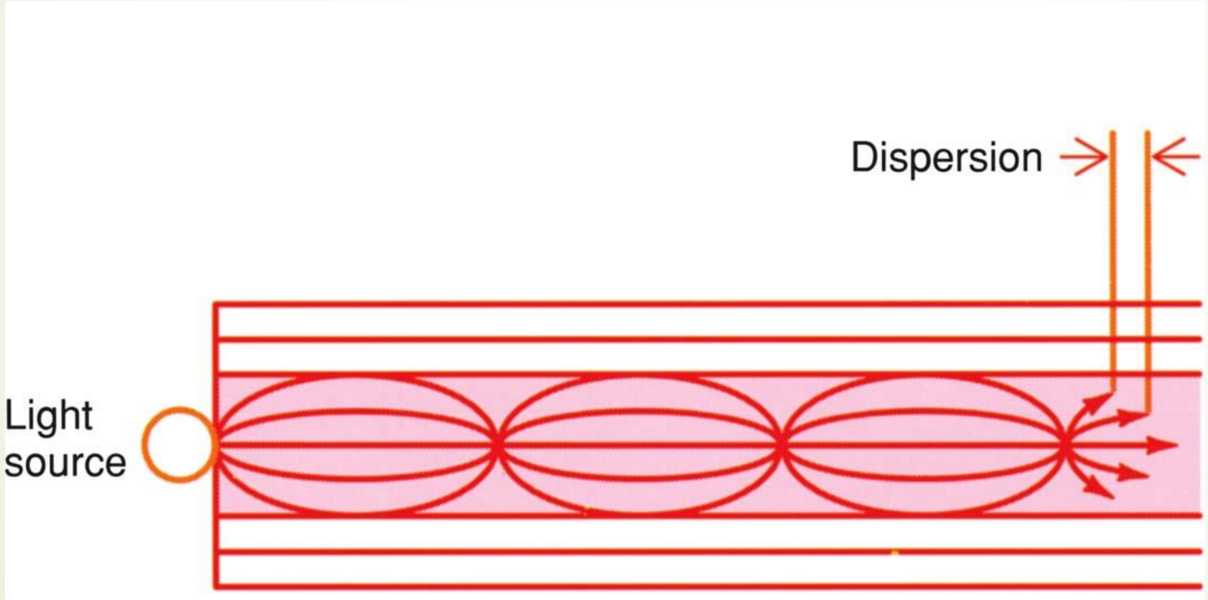
Single-Mode Step Index Cable



Multimode Graded Index Cable

- Multimode graded index fiber cables have several modes, or paths, of transmission through the cable, but they are much more orderly and predictable.
- These cables can be used at very high pulse rates and a considerable amount of information can be carried.
- This type of cable is much wider in diameter, with core sizes in the 50- to 100-μm range.
- It is easier to splice and interconnect, and cheaper, less intense light sources can be used.

Multimode Graded Index Cable



A multimode graded index cable.

Fiber-Optic Cable Specifications

- The most important specifications of a fiber-optic cable are:
  - Size
  - Attenuation
  - Bandwidth

Fiber-Optic Cable Specifications: Cable Size

- Fiber-optic cable comes in a variety of sizes and configurations.
- Size is normally specified as the diameter of the core, and cladding is given in micrometers (μm).
- Cables come in two common varieties, simplex and duplex.
- Simplex cable is a single-fiber core cable.
- In a common duplex cable, two cables are combined within a single outer cladding.

Fiber-Optic Cable Specifications: Attenuation

- The most important specification of a fiber-optic cable is its attenuation.
- Attenuation refers to the loss of light energy as the light pulse travels from one end of the cable to the other.
  - Absorption refers to how light energy is converted to heat in the core material because of the impurity of the glass or plastic.
  - Scattering refers to the light lost due to light waves entering at the wrong angle and being lost in the cladding because of refraction.

Fiber-Optic Cable Specifications: Bandwidth

- The bandwidth of a fiber-optic cable determines the maximum speed of the data pulses the cable can handle.
- The bandwidth is normally stated in terms of megahertz-kilometers (MHz-km).
- A common 62.5/125-μm cable has a bandwidth in the 100- to 300-MHz·km range.
- As the length of the cable is increased, the bandwidth decreases in proportion.

Fiber-Optic Cable Specifications: Frequency Range

- Most fiber-optic cable operates over a relatively wide light frequency range, although it is normally optimized for a narrow range of light frequencies.
- The most commonly used light frequencies are 850, 1310, and 1550 nm.

Cables and Connectors

- Cabling of fibers is necessary to protect them from deterioration during transportation and installation.
- Cable design depends on the type of application.
- For some applications it may be enough to buffer the fiber by placing it inside a plastic jacket.

Cables and Connectors

- For others the cable must be made mechanically strong by using strengthening elements such as steel rods.
- A light-duty cable is made by surrounding the fiber by a buffer jacket of hard plastic. Heavy-duty cables use steel or a strong polymer such as Kevlar to provide the mechanical strength

Cables and Connectors

- Connectors are needed to use optical fibers in an actual communication system.
- They can be divided into two categories.
- Fiber splice: A permanent joint between two fibers is known as a fiber splice, and a detachable connection between them is realized by using a fiber connector.
- Connectors: Connectors are used to link fiber cable with the transmitter (or the receiver), while splices are used to join fiber segments (usually 5–10 km long).

Connectors and Splicing

- Connectors are special mechanical assemblies that allow fiber-optic cables to be connected to one another.
- Most fiber-optic connectors either snap or twist together or screw together with threaded ends.
- Connectors ensure precise alignment of the cables to ensure maximum light transfer between cables.
- Dozens of different kinds of connectors are available for different applications. The two most common connector designations are **ST (bayonet connectors)** and **SMA.**

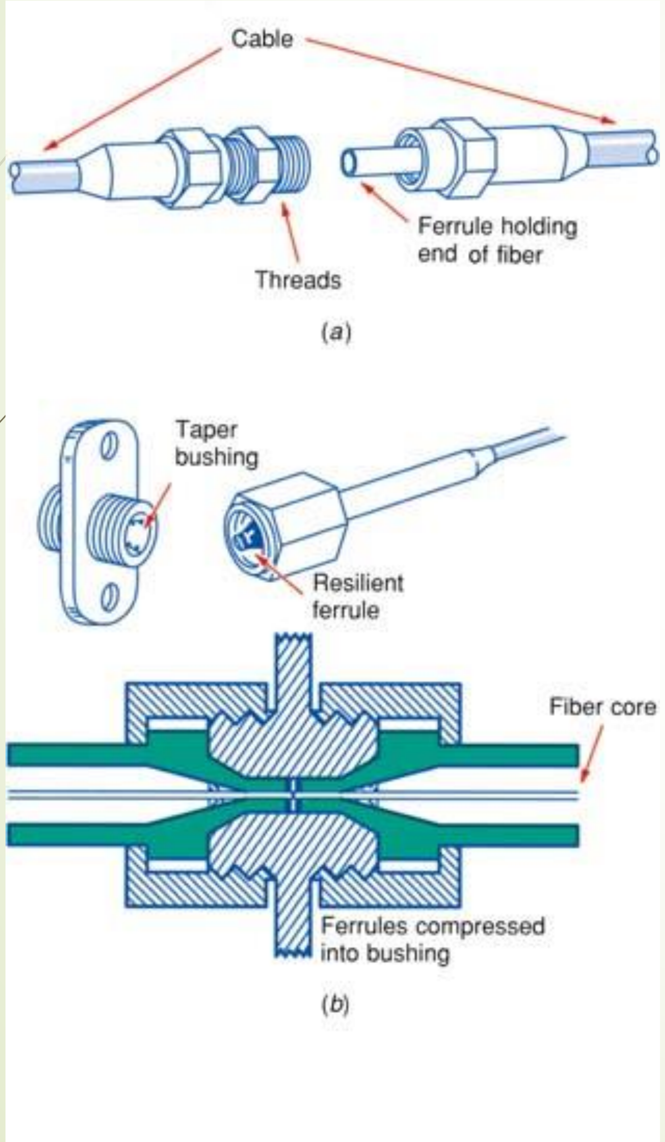
Connectors and Splicing

- When long fiber-optic cables are needed, two or more cables can be spliced together.
- A variety of connectors are available that provide a convenient way to splice cables and attach them to transmitters, receivers, and repeaters.

Connectors and Splicing

- Splicing fiber-optic cable means permanently attaching the end of one cable to another.
- This is usually done without a connector.
- The first step is to cut the cable, called cleaving the cable, so that it is perfectly square on the end.
- The two cables to be spliced are then permanently bonded together by heating them instantaneously to high temperatures so that they fuse or melt together.
- Special tools and machines must be used in cleaving and splicing to ensure clean cuts and perfect alignment.

Connectors and Splicing



Details of a fiber cable connector.

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