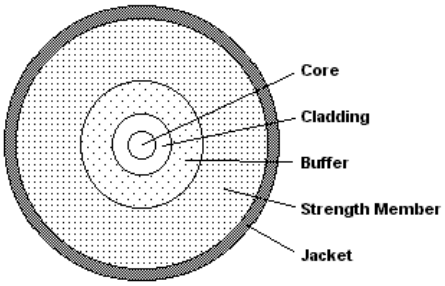
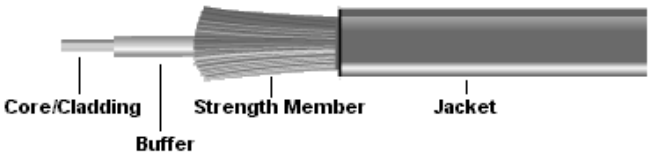
Fiber Optics Lesson Outline

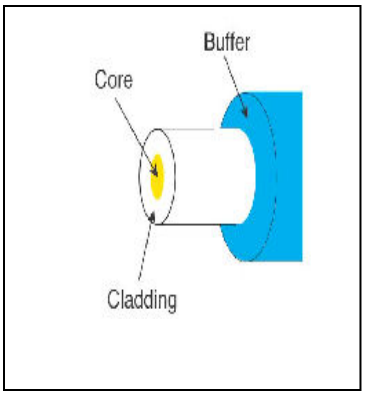
Fiber Optic Construction (from inside)





Core
- Higher index of refraction
- Smaller in single mode fiber than multimode fiber

Cladding
- Not stripped
- Lower index of refraction
- Traps light in the core
- Same diameter for single mode and multimode fiber



Buffer
- Resembles wire insulation
- Stripped for termination or splicing
- Primary buffer (acrylate)
- Secondary buffer (PVC)

Strength member
- Kevlar (aramid)
- Pull by strength member

Jacket
- Outermost layer
- Protects fiber from environment

Principle of operation

Total Internal Reflection
- Light confined in medium by a surrounding medium of lower index of refraction
- Only step-index multimode fiber works on this principle

Measurments

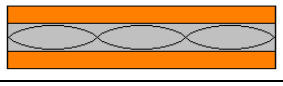
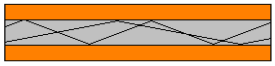
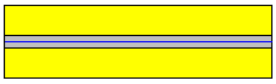
i.e. 62.5 / 125 = core diameter = 62.5 microns, outer diameter = 125 microns

Numeric Aperture

Also called “NA”

Highest angle that light can enter fiber and still be totally reflected

Modes

Graded index Multi mode	
Step index Multi mode	
Single mode	

Multimode
- Typical size: 62.5/125 (graded index)
- LEDs used for source

Use
- Short distance data networks

Step index
- Large core size
- Efficient coupling, Short low-speed data links

50/125
- Higher bandwidth
- more distance
- Gigabit networks
- OM3/4
  - Aqua color
  - Laser-optimized
    - More distance with gigabit networks using lasers

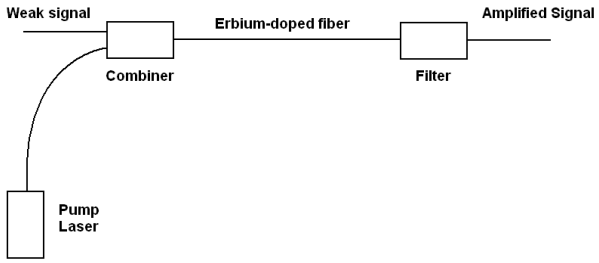
Graded index
- Light rays follow serpentine path near center of core
- LAN Fiber to the desk
- Most widely used in multimode datacom networks is 62.5/125

Plastic fiber
- Typically large core step index
- Consumer digital audio

Single-mode
- Light energy is propagated along core-cladding interface
- Typical size: 9/125
- Higher bit-rate/greater bandwidth
- Lower loss

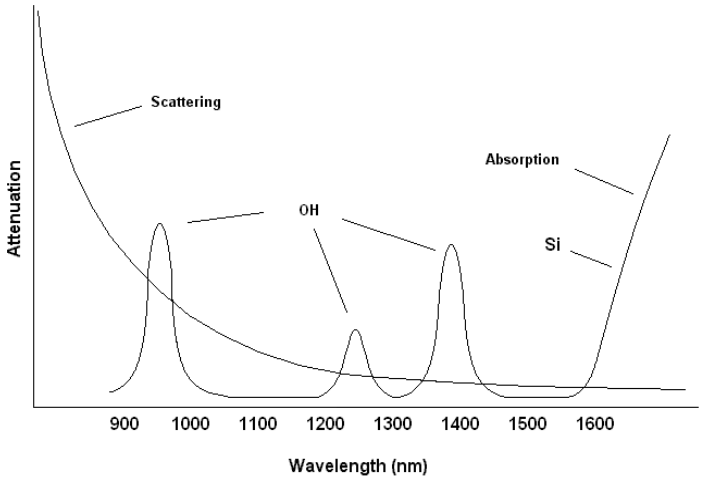
Use
- Long distance
- Telecom (telephone systems)
  - Outside plant
  - FTTx
- CATV

Erbium-doped fibers
- Used in stimulated-emission (non-electronic) **amplifiers**



Attenuation
- Scattering

Primary cause of attenuation
Greater at 850nm than at 1300nm



Cables

Jacket Colors

Yellow
- Single mode

Orange
- Multimode

Aqua
- OM3/OM4 Laser-optimized multimode

Hybrid

Combines multiple single mode and multi mode fibers into a single bundle

Composite

Combines fiber optic and copper

Tight buffer

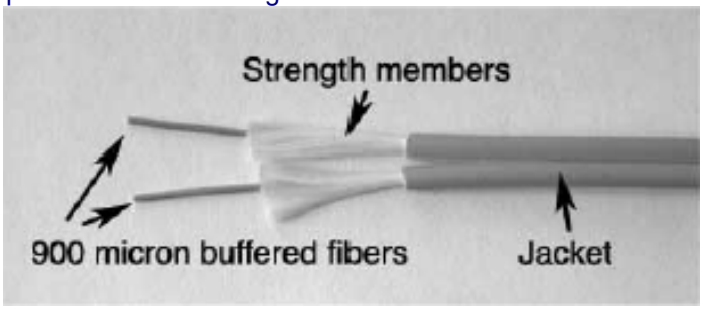
Buffer tightly adhered to fiber
Flexible
Easy termination

Simplex

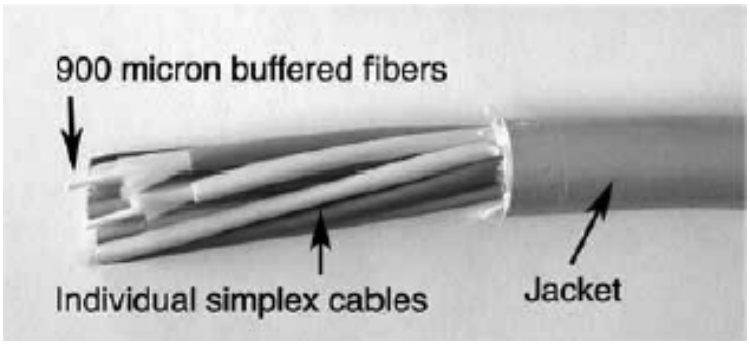
A single 900 micron diameter tight buffered cable with Kevlar and jacket.
Patch cords and backplanes

Zip cord

Two simplex cables bonded together



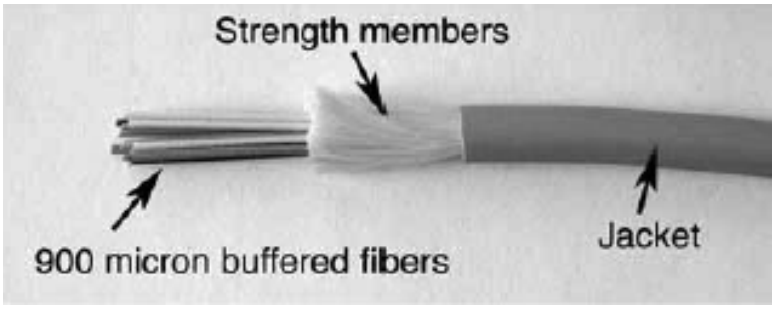
Breakout Cable



Several simplex cables bundled together
Suitable to run directly to computer backplane
Conduit riser and plenum runs

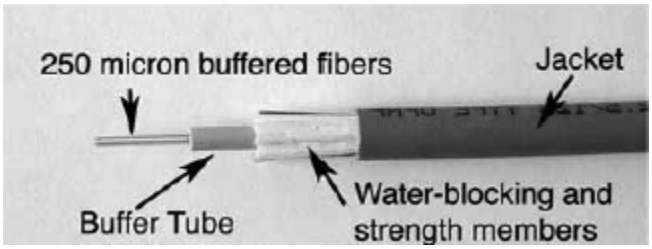
Distribution / Tightpack

Several **900 micron** tight buffer fibers bundled together



Short dry conduit runs & Terminated in junction boxes

Loose tube



Contains bundles of **250 micron fibers** loosely packed in buffer tubes
Outside plant trunking
Filled and Blocked
Often filled with **water-repellant gel** or wrapped with water-repellant paper
Resistant to water damage
Terminating
Breakout kit (fan out kit)

Armored

Rodent resistance
Suitable for direct burial

Aerial/Self-support

Built-in messenger cable & Long-term tension loads

Ribbon

High density / high fiber count
small size / diameter
low cost
Used for metropolitan and long distance

Considerations

- Installation
- Environment

Cable Designations

- **OF** – Optical Fiber
- **N** – Non-conductive
- **C** – Conductive
  - Must be grounded
- **P** – Plenum
  - May be used in air handling areas
- **R** – Riser
  - Vertical runs

Specifying Cable

- Considerations
  - Installation
    - Indoor
      - Tyhpe of building
    - Outdoor
  - Environment
    - Compliance with NEC and local electrical codes
      - Fiber optic cable for use inside a building must be rated to meet the NEC Article 770.5 or equivalent flammability requirements.

Installation

- Minimum installation bend radius (under pulling tension)
  - 20 times cable diameter
- Minimum long-term bend radius
  - 10 times cable diameter

Pulling long lengths of cable

- lubricate
- pull from center to ends
  - Feed cable into center vault and pull both ends to end vaults.
- use breakaway swivel or monitor tension

Cable Ties

- Applied hand tight

Link loss budget analysis

- Performed during the design phase
- Ensures cable plant is properly installed
- Provides a pass/fail loss value
- Ensures intended communication system will work
- Includes expected loss of all cable, connectors and splices, including connectors at the ends of the cables

Connectors

- Not used for permanent joints

Requirements

- High mechanical strength
- Low loss
- Low reflectance

Standards

- TIA-568
  - Standard for premises cabling
  - Any connector standardized by a FOCIS document conforms to TIA-568

Terminating methods

- Epoxy polish
  - Oldest terminating method
  - Factory Pigtails
- Anaerobic Adhesive
  - Fast cure time

- Less Polishing
- Can cure before fiber gets through the connector

- Pre-polish Connector
  - No need to polish
  - Quick
  - Higher estimated loss due to internal splice along with connector loss

Ferrule finishes

- Air gap
- PC (Physical Contact)
  - Reduces reflectance
  - Types of PC finishes
    - Flat PC
    - Round PC
    - Angled PC
      - APC (Angled Physical Contact)
      - Angled at 8 degrees to minimize back reflections
      - Least Reflectance

Connector Colors

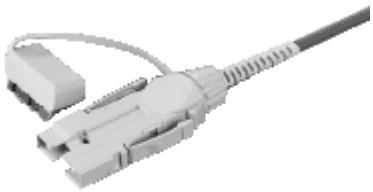
- Blue
  - Single mode
- Beige
  - Multimode
- Green
  - Angled Physical Contact (APC)

Connector styles

- MU
  - Small form factor connector
  - Used outside U.S. (Japan)

- ESCON

- FDDI



- **ST**

Deutch 1000 (obsolete)

FC

Biconic (obsolete)

D4

SMA

SC (most common for new multimode installations)

MPO (MT)

MT-RJ

Optijack

LC

Splicing

Permanent joint between two fibers

Requirements (same as connectors)

- High mechanical strength
- Low loss
- Low reflectance

Fusion splicing

- Lowest loss
- Least back reflection
- Should not be used in manholes

Mass fusion splicing

- Used for ribbon cable

Cleaning

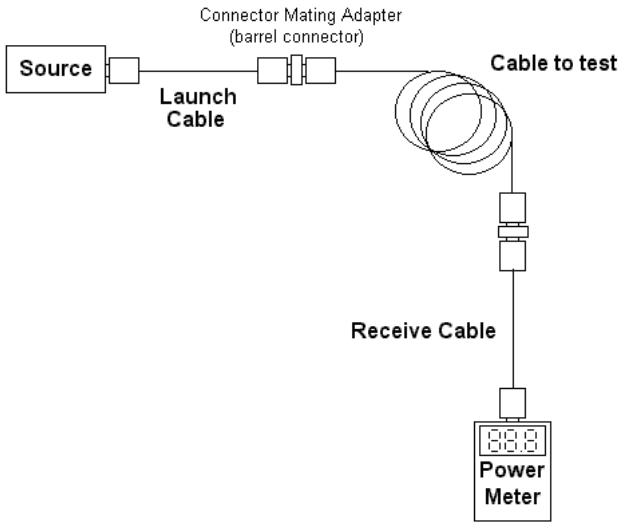
Use lint-free pads and isopropyl alcohol

Testing

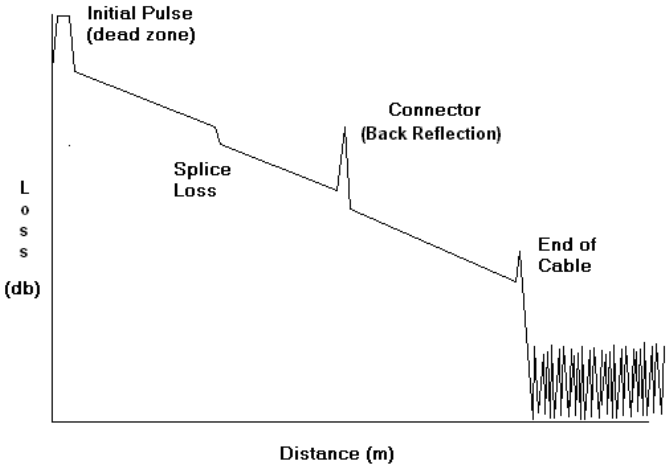
Light Source / Power meter (LSPM or OLTS)

Source/receive power test

Measures insertion loss
Reference cables chosen for low loss
Match fiber mode (fiber type) and wavelength
    Use single mode reference cables to test a single mode cables
    Use 1300 nm to test a cable that will be used at 1300 nm.
Performed before plant acceptance
    To ensure the plant is within the loss budget
Cannot be performed by OTDR



Visual Fault Locater
    Visible laser
    Continuity
    Fiber tracing
    Fault locating close to end of cable
Visual Fiber Tracer (continuity checker)
    Incandescent light or LED
    Continuity and polarity (TX to RX, RX to TX)
Optical Loss Test Kit
    Optical loss
Fiber Optic talk set
    Communication
Microscope
    Connector faults
    Increases danger to eye from high-power light sources
OTDR (Optical Time-domain Reflectometer)
    Similar principles to radar
    Fault locating
    Splice loss
    Length
    Cannot test for transmitter to receiver power loss



Safety

- Eye protection
  - Always wear when working with fiber optics
  - Protects from fiber scraps, shards, etc.
    - Most common danger when working with fiber optics
- Material Data Safety Sheets (MSDS)
  - Information on safe handling and disposal

Measurements

- **Fiber size**
  - Microns (μ)
- **Bandwidth**
  - Megahertz (MHz)
- **Wavelength**
  - Nanometers (nm)
- **Jacket outside diameter**
  - Millimeters (mm) or Inches (in)
- **Power**
  - dBm (absolute power referenced to 1mw)
- **Loss**
  - decibels (dB)
- **Cable length**
  - Feet or Meters