Fiber Optics

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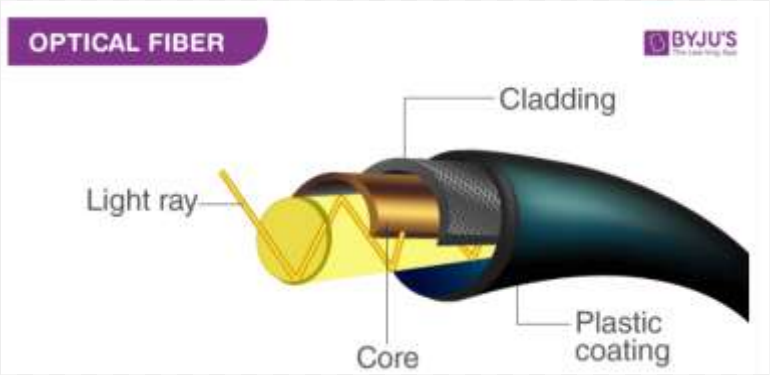
What is an Optical Fiber

Optical fiber is the technology associated with data transmission using light pulses travelling along with a long fiber which is usually made of plastic or glass.



- **Thin strands of pure glass**
- **Carry data over long distances**
- **At very high speeds**
- **Fiber can be bent or twisted**

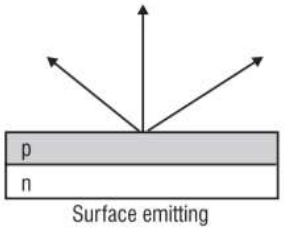
- **Types of Optical Fibres**
- **Step Index Fibers**
- **Graded Index Fiber**
- **Plastic Optical Fibers**
- **Glass Fibers**
- **Single-Mode Fibers**

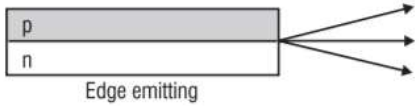
FIBER OPTIC SOURCES

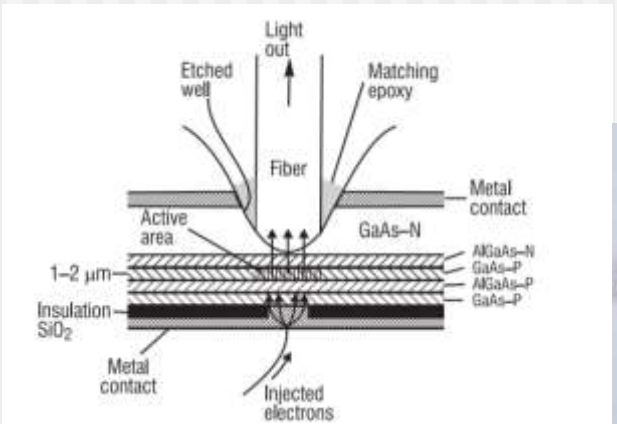
Two basic light sources are used for fiber optics: laser diodes (LD) and light-emitting diodes (LED).

LED Versus Laser

Characteristic	LED	Laser
Output power	Lower	Higher
Spectral width	Wider	Narrower
Numerical aperture	Larger	Smaller
Speed	Slower	Faster
Cost	Less	More
Ease of operation	Easier	More difficult



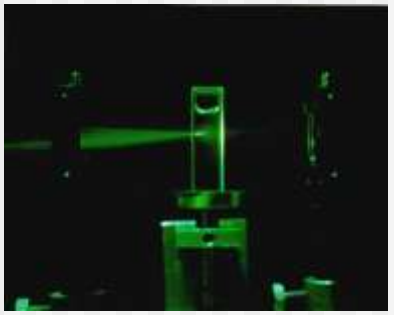




Coaxial Pigtail Fiber Dfb Laser Diode 1625nm Laser for Optical Transmitters

Sources of light

- Light emitting diodes
- Lasers



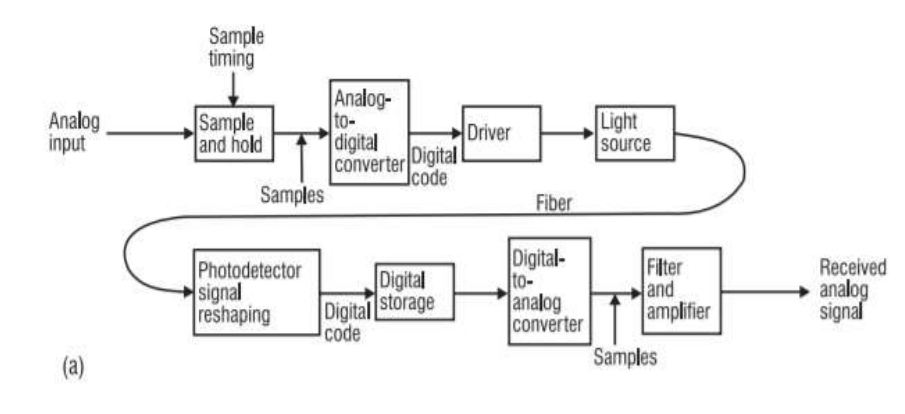
- Modulate electrical signals into optical signals
- Mostly modulate at 850nm, 1300nm and 1550 nm
- Lasers give high intensity, high frequency light
- LEDs are economical

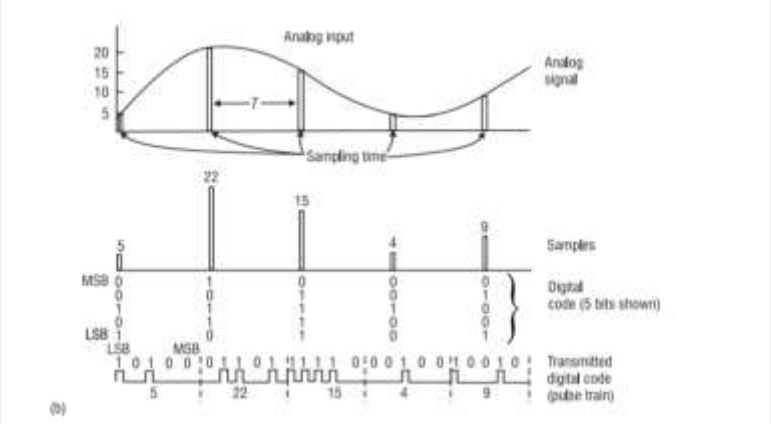
TRANSMISSION WINDOWS AND ANALOG SIGNAL COMMUNICATION

Window	Operating Wavelength
800 – 900 nm	850 nm
1250 – 1350 nm	1310 nm
1500 – 1600 nm	1550 nm

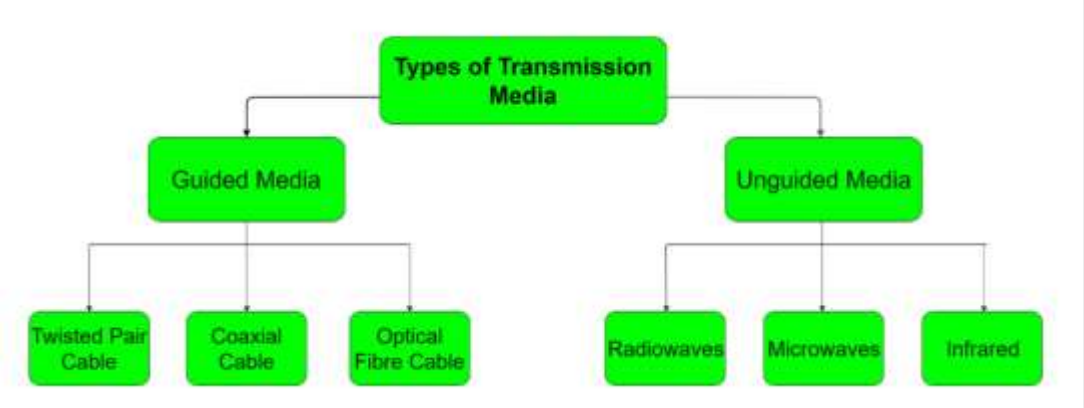
FIBER OPTIC LOSS CALCULATIONS

$$\text{Loss}_{\text{dB}} = 10 \log \frac{P_{\text{out}}}{P_{\text{in}}}$$





Transmission medium



Optical Fibre Cable –

- Advantages:

- Increased capacity and bandwidth
- Light weight
- Less signal attenuation
- Immunity to electromagnetic interference
- Resistance to corrosive materials

Physics of optical Cable

Ruggedised Simplex & Duplex Cable (With Tension Members)

Features

- *Large core diameter and high numerical aperture provide highly efficient coupling to inexpensive visible LEDs*
- *Very easy to cut and terminate with low misalignment losses*

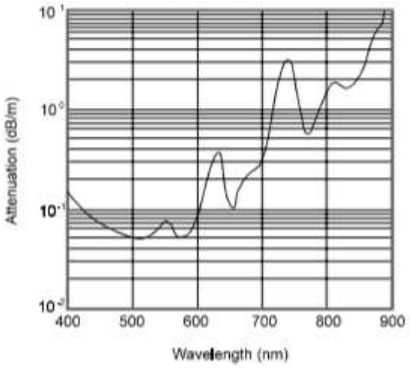
Applications

- *Transmission of data over short distances*
- *Image transmission*
- *Industrial sensors*
- *Illuminated signs and displays*

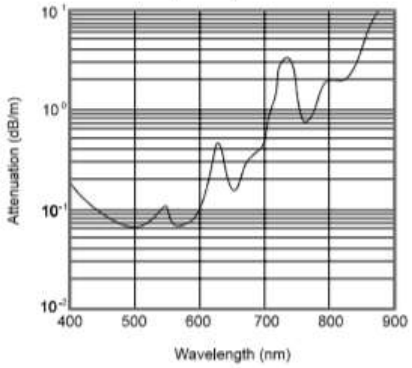
	Part No	Attenuation	Min. Bend Radius	No. of Cords	Fibre/Cable Diameter	Jacket Material
Sim	FDPF 4001 EHTT	-0.18dB/m	17mm	1	1000µ/5.0mm	PVC on PE, Kevlar Reinforced
Dup	FDPF 4002 EHTT	-0.18dB/m	17mm	2	1000µ/2.2mm	PVC on PE, Kevlar Reinforced

Spectral Attenuation

1000µ Polymer

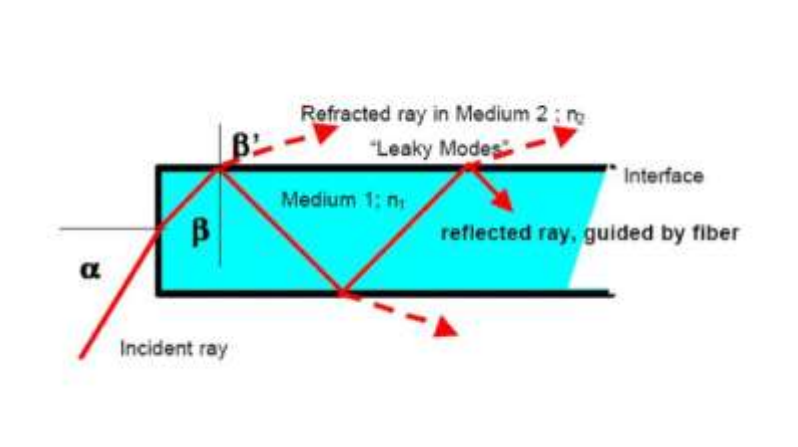


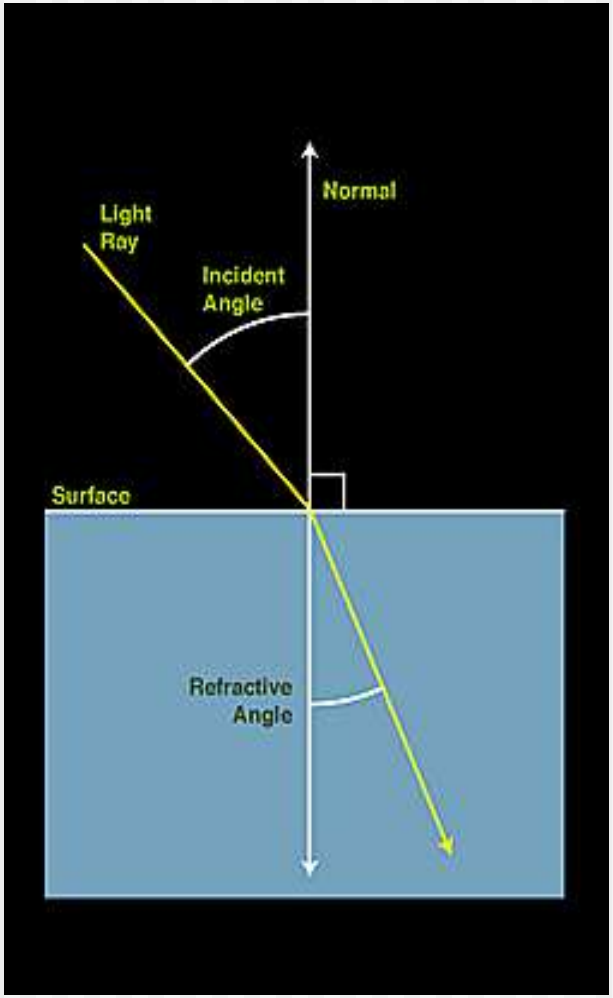
500µ Polymer



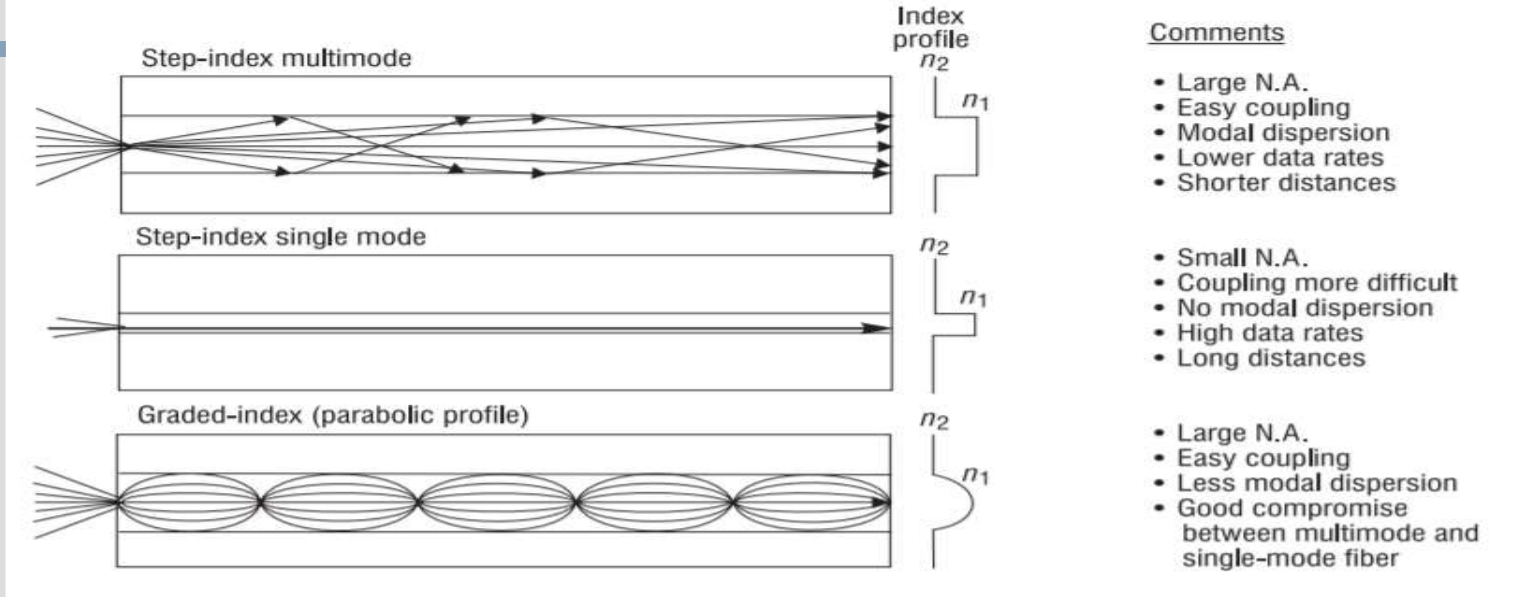
Refraction of light

- Speed of light changes as it across the boundary of two media
- Angles w.r.t normal





Mode of propagation



DISPERSION

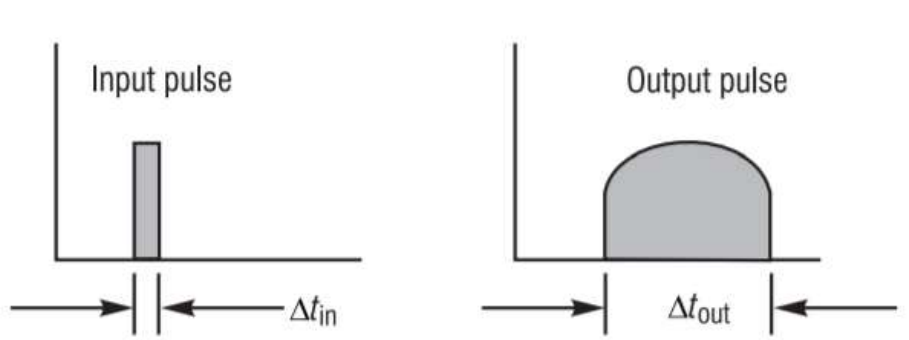


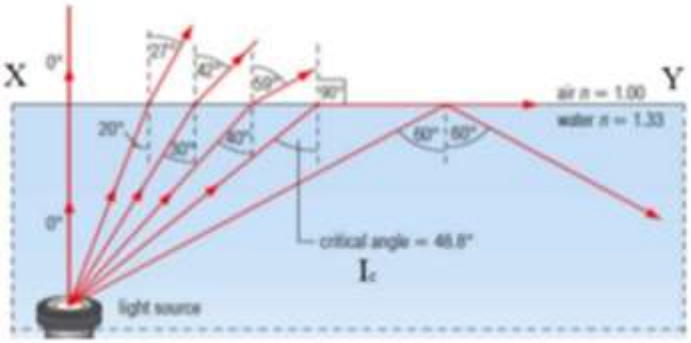
Figure 8-3 *Pulse broadening caused by dispersion*

Principle and Working

Characteristics of Optical Fibre:

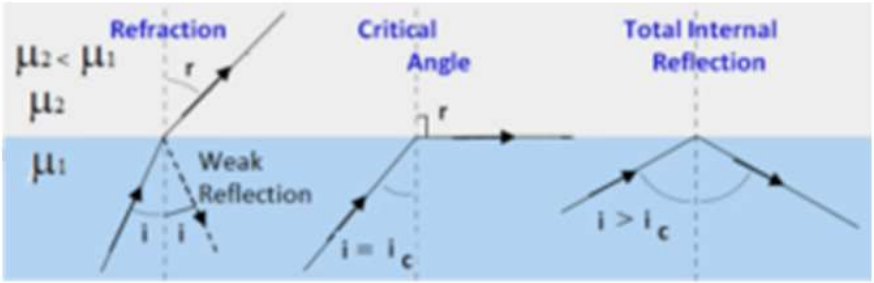
- It has a large bandwidth. The optical frequency of 2×10^{14} Hz can be used and hence the system has higher bandwidth. Thus optical fibres have greater information-carrying capacity due to greater bandwidth.
- In optical fibre system transmission losses are as low as 0.1 db/km.
- Optical fibres are of small size and have lightweight as compared to electrical cables. They are flexible and very high tensile strength. Thus they can be twisted and bent easily.
- Optical fibres provide a high degree of signal security as it is confined to the inside of fibre and cannot be tapped and tempered easily. Thus it satisfies the need for security which is required in banking and defence.
- Optical fibre communication is free from electromagnetic interference.
- Fibre optic fibres do not carry high voltages or current. Hence, they are safer than electrical cables.

Total Internal Reflection of Light and its Explanation:



Analytical Treatment of Optical Fibres

Critical Angle:



Snell'S Law

$$\frac{\sin i}{\sin r} = \frac{\mu_2}{\mu_1}$$

At the start of the total internal reflection, $i = i_c$ and $r = 90°$

$$\frac{\sin i_c}{\sin 90°} = \frac{\mu_2}{\mu_1}$$

$$\therefore \sin i_c = \frac{\mu_2}{\mu_1} \times 1$$

$$\therefore i_c = \sin^{-1}\left(\frac{\mu_2}{\mu_1}\right)$$

$$\text{Now, } \cos i_c = \sqrt{1 - \sin^2 i_c}$$

$$\therefore \cos i_c = \sqrt{1 - \left(\frac{\mu_2}{\mu_1}\right)^2}$$

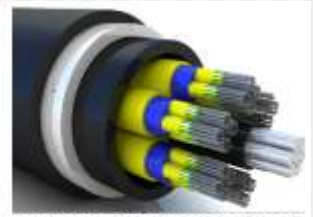
$$\therefore \cos i_c = \sqrt{\left(\frac{\mu_1^2 - \mu_2^2}{\mu_1^2}\right)}$$

$$\therefore \cos i_c = \frac{\sqrt{\mu_1^2 - \mu_2^2}}{\mu_1}$$

Fiber Optic vs. DSL Internet: How they work plus pros and cons

What is fibre-optics?

Fiber optic Internet is an Internet connection that transfers data fully or partially via fiber optic cables. "Fiber" refers to the thin glass wires inside the larger protective cable. "Optic" refers to the way the type of data transferred – light signals. So, an Internet connection using fiber optic cables is an Internet connection in which data is delivered in light signals via small, flexible glass wires.



Pictured above is a 3-D rendering a fiber optic cable. Note the smaller bundles of cables inside the larger cable. These smaller strands (fibers) transmit data via light signals.

What is DSL?

DSL is an Internet connection delivered via telephone lines. The abbreviation stands for "Direct Subscriber Line."

Speed and reliability

Fiber optic networks can deliver speeds up to 1 Gpbs (1000 Mbps), whereas DSL speeds typically top out around 6 Mbps

The speeds that fiber optics can deliver are ideal for virtually anything you do online, including:
Downloading music and videos
Streaming TV and movies
Playing real-time multiplayer games online
Connecting many devices, such as computers, mobile devices, smart TVs, at once

While higher DSL speeds can perform some of those tasks, albeit slower than fiber optics can, DSL connections are more ideal for basic online activities, such as:
Browsing the Web
Sending and receiving emails
Sending and receiving pictures
Downloading e-books

You likely recognize this wire. DSL is delivered by telephone wire. A telephone cord then runs from the phone jack to your router. From there, you can connect your computers and other devices wirelessly or by cable.

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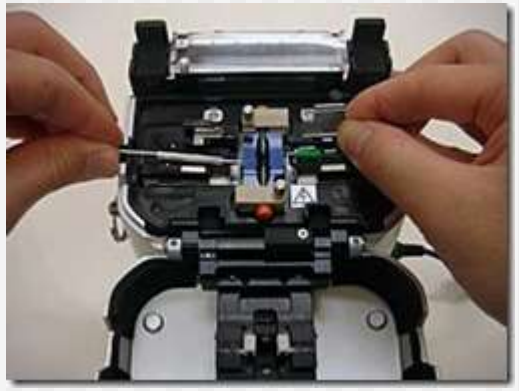
FUSION SPLICING

There are two types of fiber splicing – ***mechanical splicing*** and ***fusion splicing***.



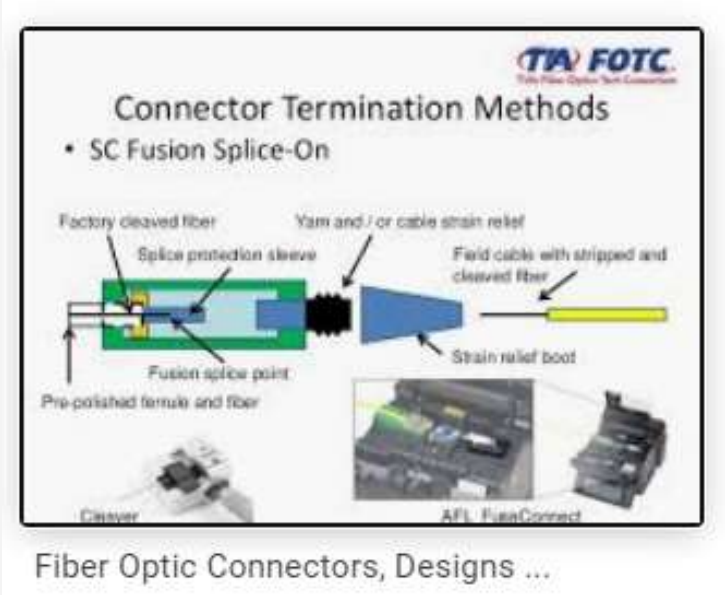
Alignment

CORE ALIGNMENT The two fibers are illuminated from two directions, 90 degrees apart with multiple camera

CLAD ALIGNMENT The fibers sit in a holder or V-groove and are lined up "physically", based on the outer diameter of the fiber's cladding.

HAND HELD A revolution in splicing came about with the introduction of battery powered handheld fusion splicers.

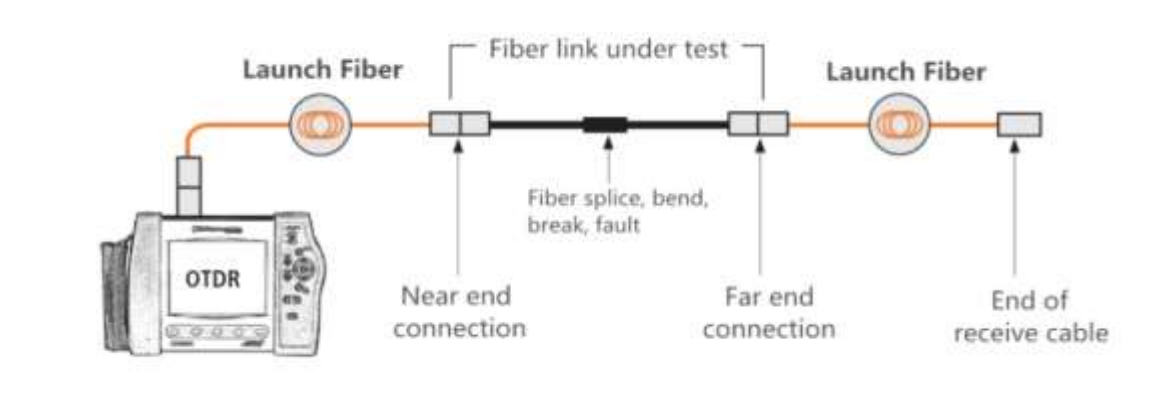
Splices and Connectors



Fiber Optic Connectors, Designs ...

Testing of Fiber

OTDR testing methods have become indispensable to building, certifying, maintaining and troubleshooting fiber optic systems.



Optical Receivers and Transmitter

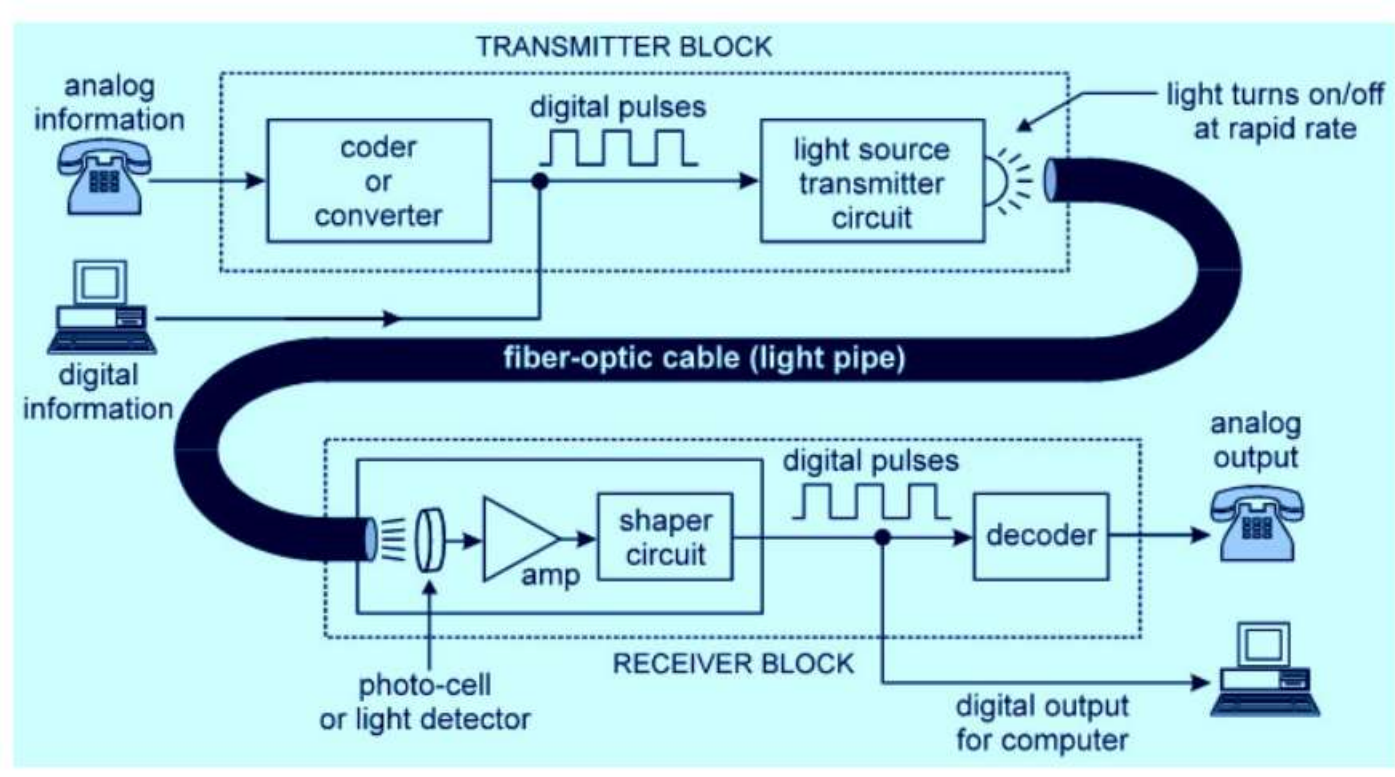
Receiver

High-Speed Optical Transmitters with Phase Modulators

		Key Specifications[a]		
Item #		**MX10C**	**MX10C-LB**	**MX10C-1310**
Max Bit Rate (Digital)		12.5 Gb/s		
Analog Bandwidth (Small Signal)		7 GHz		
Modulator Bandwidth (-3 dB)		10 GHz		
Integrated Laser[b]	**Laser Type**	C-Band Tunable	L-Band Tunable	1310 Fixed-Wavelength
	Wavelength Range	1527.6 - 1565.5 nm	1570.0 - 1608.8 nm	1310 nm (Typical)
	Frequency Range	191.50 - 196.25 THz	186.35 THz - 190.95 THz	-
	Intrinsic Linewidth	10 kHz (Typical) 15 kHz (Max)		2 MHz (Typical) 3 MHz (Max)

Specification of Transmitter

Optical fibre communication process



Characteristics of Fabre Optic Communication

Bandwidth – Single laser light dispersion means that a good amount of signal can be transmitted (Information being transferred in bits) per second which results in high bandwidth for long distances.
Smaller diameter – The diameter of Optical fiber cable is about 300 micrometers in diameter.
Light-weight – The Optical fiber cable is light in weight compared to the copper cable.
Long-distance signal transmission – Since the laser light doesn't disperse, it can be easily transmitted over long distances.
Low attenuation – The fiber is made of glass and laser is traveling through it, the signal transmitted has only 0.2 dB/km loss.
Transmission security – Optical encryption and no presence of the electromagnetic signal make the data secure over optical fiber.

Applications of Optical Fibre

Optical fiber communication is mainly used in the telecommunication industry which uses the optical fiber for:

- Telephone Signals transmission.
- Internet Communication.
- Cable Television Signal transmission.

Opotical Fiber Impact on IoT (Internet of Things)

Fast Transmission Media - The future will be IOT and all of our devices and things will be connected to the internet, which needs good communication and high speed. The only transmission media that supports such a requirement is Optical Fiber. The future needs IOT and IOT need Optical fiber for best communication that could help reach Wireless data speed up to 100 Gbps speed, making communications and large size data transfer in seconds.

Data Security – Security in IoT is the main concern when we think of large amount of data to be transferred between billions of devices connected together. Hacking of data from communication media is possible unless it is Optical fiber. The optical fibers are very difficult to hack and hacking them without being detected is like next to impossible. So again, an optical fiber can help secure the data and transfer it at very high speed.

No data loss due to interference - The optical fiber cables can be installed anywhere (even underwater or at high-temperature areas) and don't have any electromagnetic interference resulting in no data loss due to interference.

Optical Standards

Optical cable:

Selected standards and recommendations
Below there is a summary of selected standards for fiber optics.

ISO/IEC standards:

IEC 60793 parameters of optical fibers and and cables:
- **IEC 60793-2-10 - applicable to multimode optical fiber types A1a, A1b, and A1d**
- **IEC 60793-2-50 - applicable to single-mode 9/125 optical fiber types B1.1, B1.2, B1.3, B2, B4, B5**

IEC 60794-2 - requirements for indoor cables
IEC 60794-3 - requirements for outdoor cables
ISO/IEC 11801 - specifies general-purpose telecommunication cabling systems (structured cabling), including several classes of optical fiber interconnections (OM1 - OM4, with specified minimum modal bandwidth at 850 nm, and OS1, with attenuation max 1 dB/km)

Thank You