Optical fibres

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Optical fibres

A thin flexible and transparent wire prepared for light propagation is called optical fibre. The optical fibre has been constructed for the following reasons:

1. The light wave cannot traverse long distance in air without any losses.

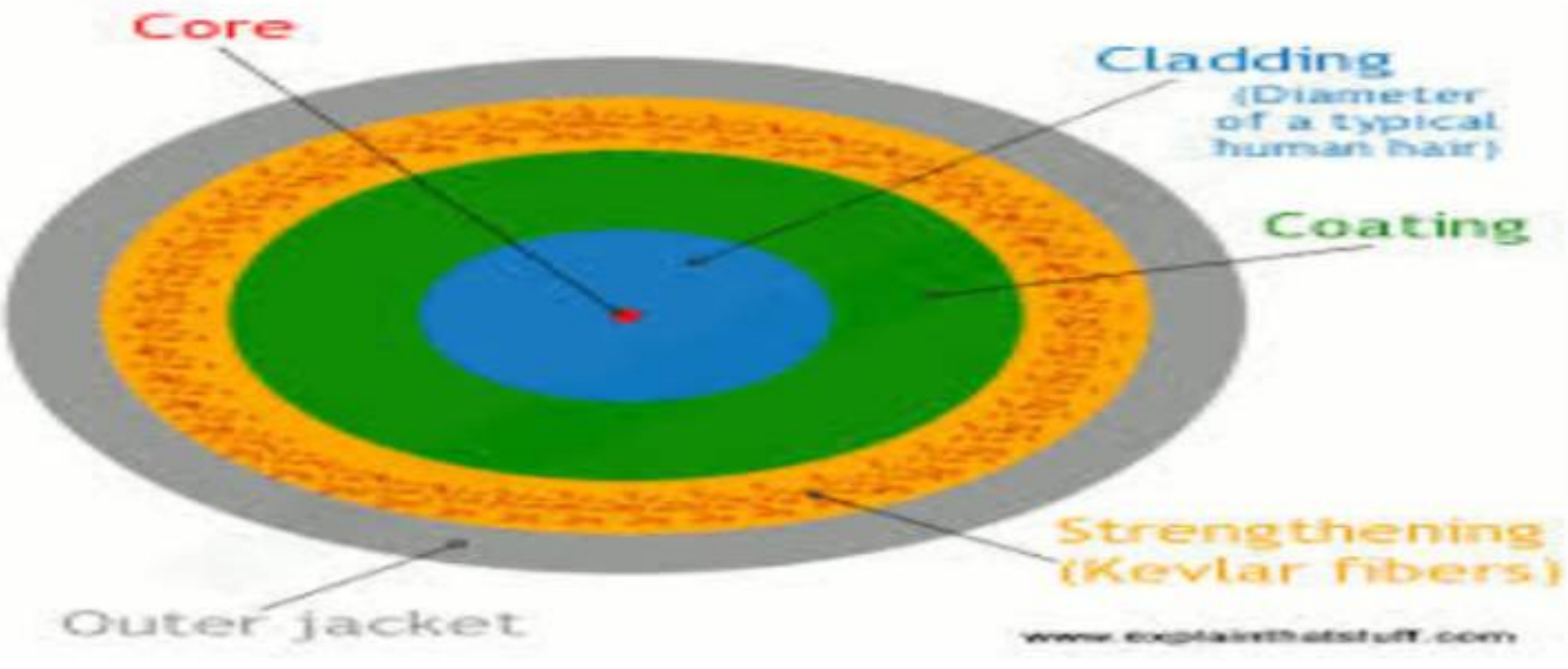
2. To make loss less light wave communication, the optical waves can be guided through optical fibre.

Important advantages of fiber optic communication

- Transmission loss is low.
- Fiber is lighter and less bulky than equivalent copper cable.
- More information can be carried by each fiber than by equivalent copper cables.
- There is complete electrical isolation between the sender and the receiver

STRUCTURE OF AN OPTICAL FIBER

The basic structure of an optical fiber consists of three parts; the core, the cladding, and the coating or buffer. The core is a cylindrical rod of dielectric material. Dielectric material conducts no electricity. Light propagates mainly along the core of the fiber. The core is generally made of glass.



The core is surrounded by a layer of material called the cladding. The cladding layer is made of a dielectric material . The index of refraction of the cladding material is less than that of the core material. The cladding is generally made of glass or plastic. The cladding performs the following functions:

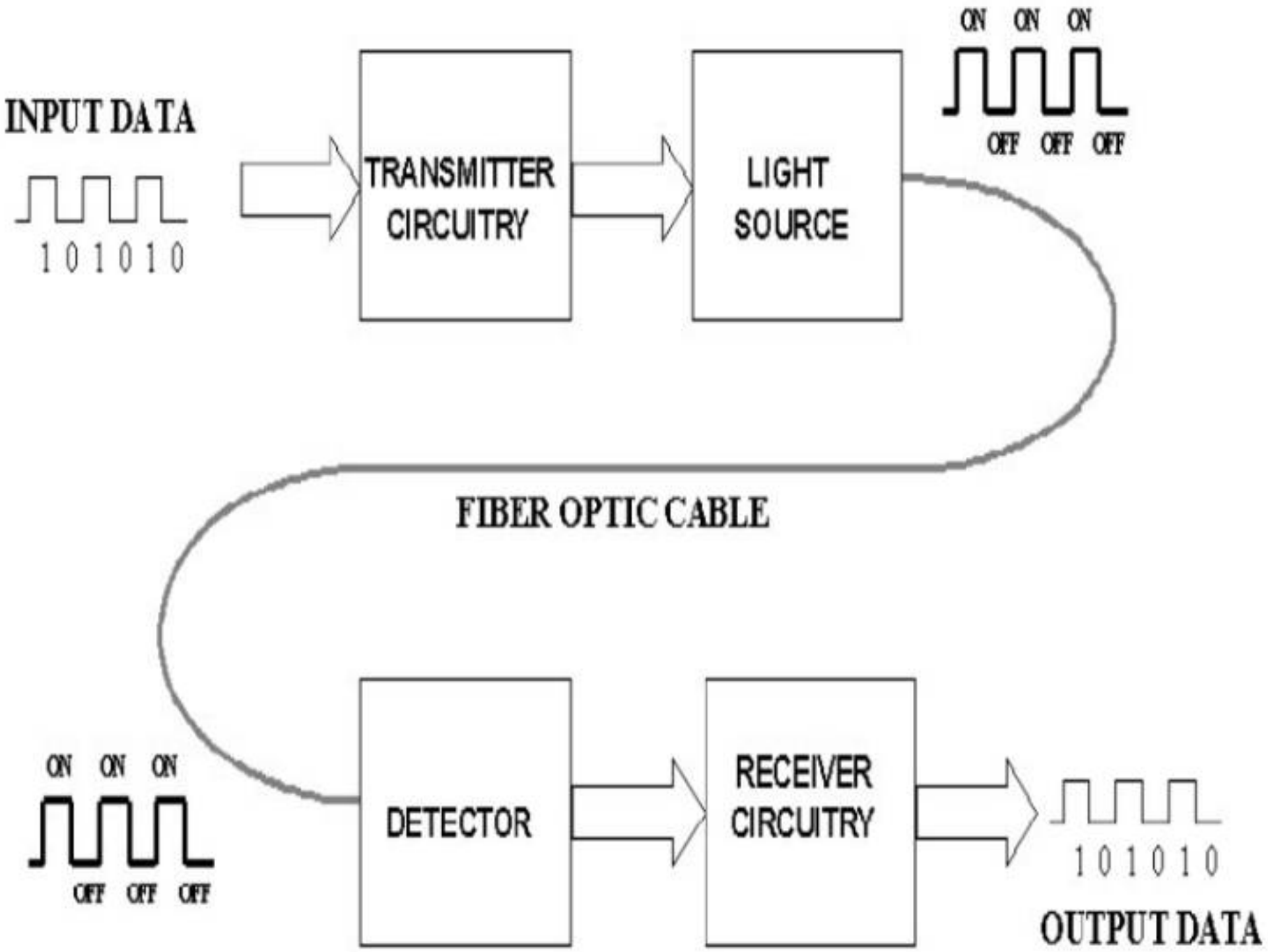
→Reduces loss of light from the core into the surrounding air

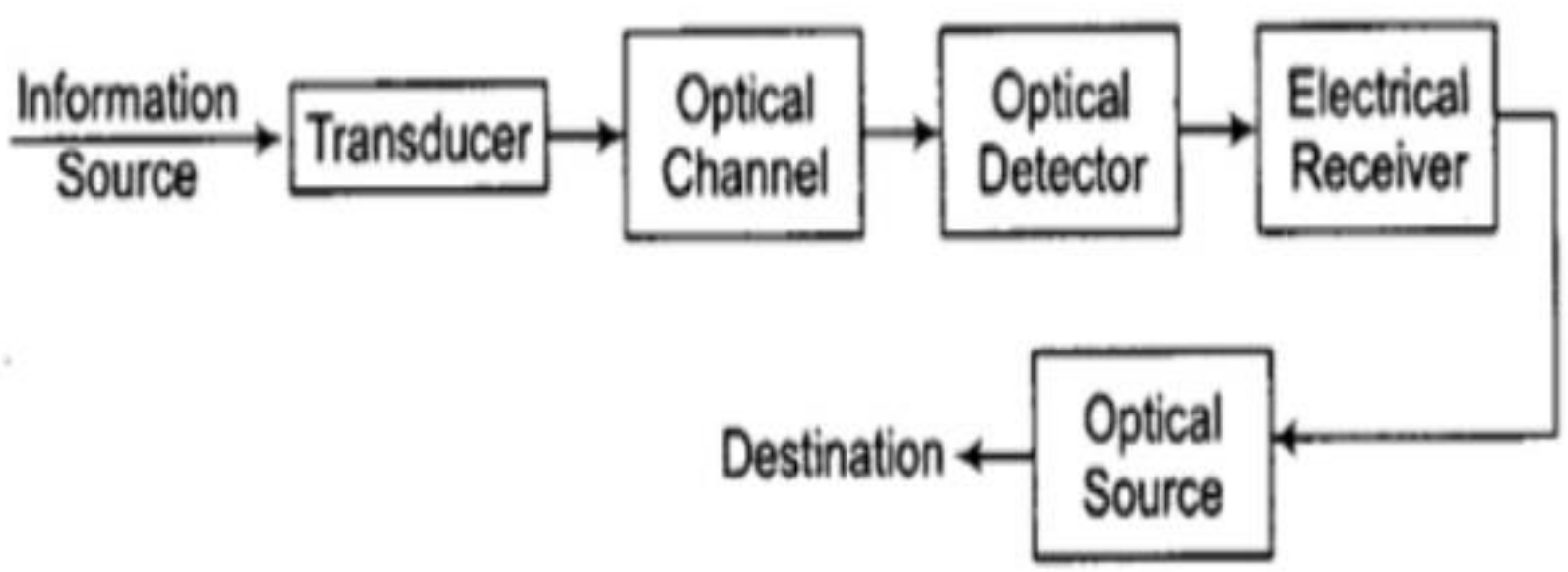
→ Reduces scattering loss at the surface of the core

For extra protection, the cladding is enclosed in an additional layer called the coating or buffer. The coating or buffer is a layer of material used to protect an optical fiber from physical damage. The material used for a buffer is a type of plastic.

Fiber optic communications

A fiber optic communication system generally consists of five elements: the encoder or modulator, the transmitter, the fiber, the detector, and the demodulator. Electrical input is first coded into a signal by the modulator, using signal processing techniques. The transmitter converts this electrical signal to an optical signal and launches it into the fiber. The signal experiences attenuation as it travels through the fiber, but it is amplified periodically by repeaters.





Block diagram of fibre optic communication

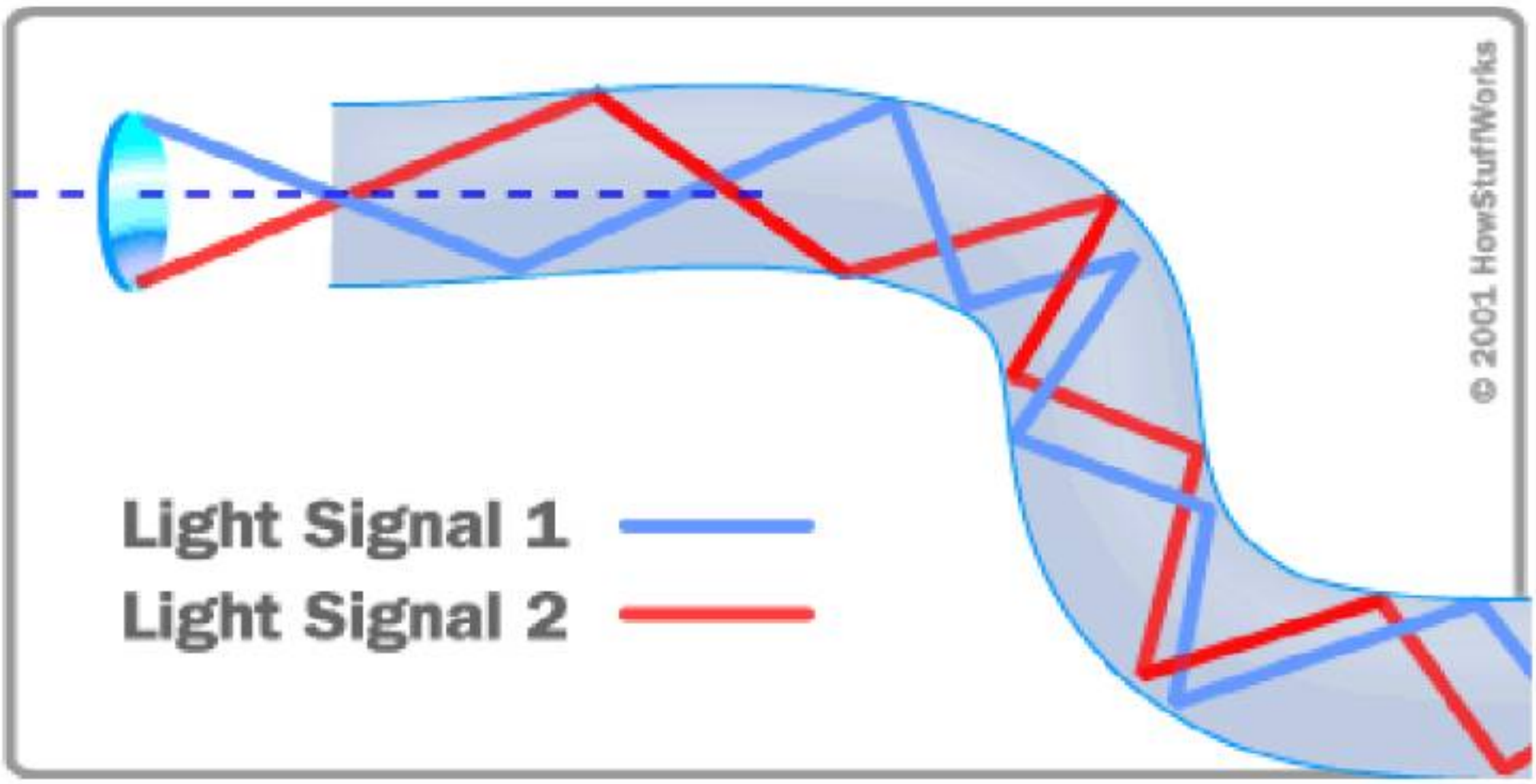
It is sent to the demodulator, which decodes it to obtain the original signal. Finally, the output is sent to the computer or to the handset of your telephone, where electrical signals cause the

speaker to vibrate, sending audio waves to your ear.

Principle of Propagation

The core and cladding are constructed from different compositions of glass, theoretically, light entering the core is confined to the boundaries of the core because it reflects back whenever it hits the cladding.

For total internal reflection to occur, the index of refraction of the core must be higher than that of the cladding, and the incidence angle is larger than the critical angle.

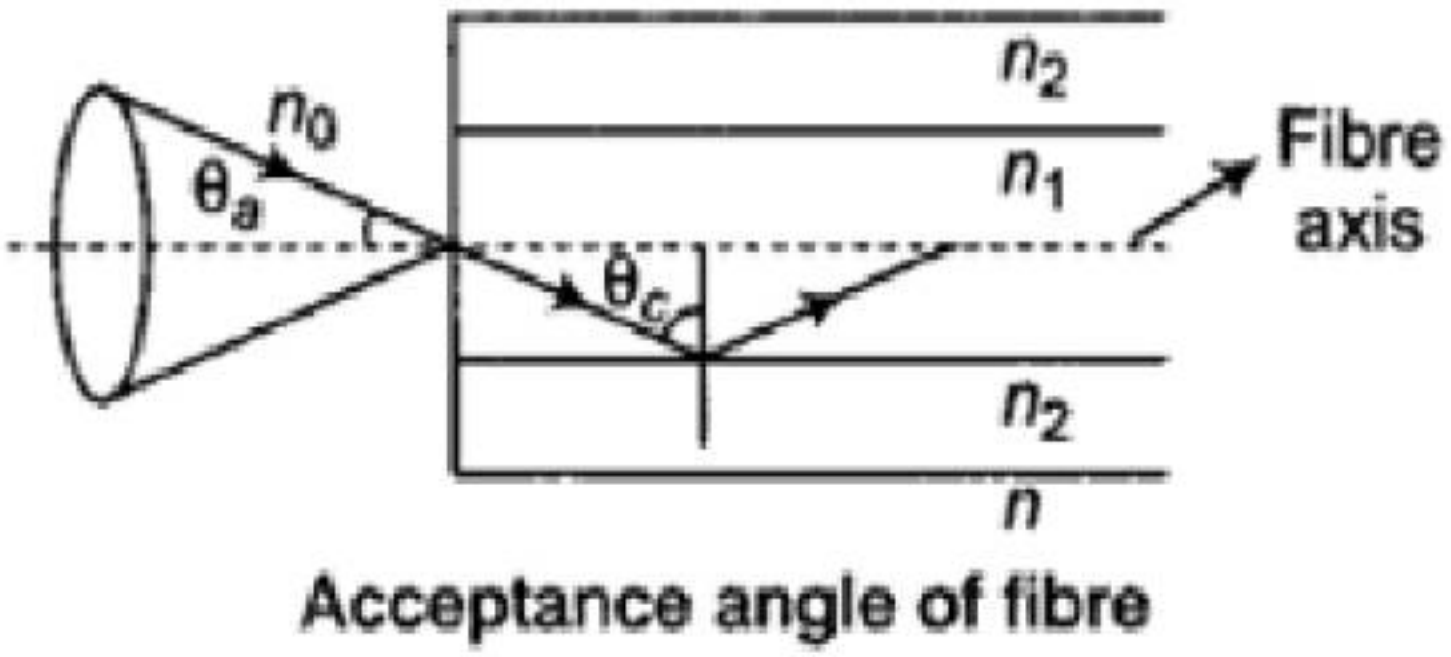


Optical fibres are cylindrical waveguides made of two concentric layers of very pure glass. The core (the interior layer) with refractive index n1 serves as the medium for light propagation, while the cladding (the exterior layer) has a lower refractive index n2 where n1 >n2 assuring that light rays are reflected back to the core.

Based on the principle of total internal reflection, only rays with incident angles greater than the critical angle, at the CLADDING-CORE interface, can be REFLECTED.

Acceptance Angle (θa)

Acceptance angle is the maximum angle to the fiber axis at which the light may enter in order to propagate.



Acceptance angle of fibre

n1, n2 = Refractive indices of core and cladding respectively

If angle of incidence to the fiber will be greater than θa, then total internal reflection will not take place in optical fiber and some information will be lossed.

Numerical Aperture (NA)

It is a measure of light collecting ability of fibre. It establishes the relationship between acceptance angle and refractive indexes of different medium involved.

n0 sin θa = n1sin(90 – θc) = n1cos θc

$$n_c \sin\theta_a = n_1\sqrt{1-\sin^2\theta_c}$$

$$n_0 \sin\theta_a = n_1\sqrt{1-\left(\frac{n_2}{n_1}\right)^2}$$

$$NA = n_0 \sin\theta_a = \left(n_1^2 - n_2^2\right)^{1/2}$$

Types Of Optical Fiber

Multi Mode :

(a) Step-index – Core and Cladding material has unif

orm but different refractive index.

(b) Graded Index – Core material has variable index

as a function of the radial distance from the center

Single Mode

–The core diameter is almost equal to the wave length of the emitted light so that it propagates along a single path.

Applications of optical fibers

Telephone transmission method uses fibre-optic cables. Optical fibres transmit energy in the form of light pulses. The technology is similar to that of the coaxial cable, except that the optical fibres can handle tens of thousands of conversations simultaneously.

Optical fibers can be used as sensors for the measurement mechanical force, pressure, electric field, electric current, magnetic field, temperature, nuclear radiations, density etc.

In computers, fibers are used to exchange the information between different terminals in a network.

The optical fibers are used in industrial automation, security alarm system and process control.

It is possible to study interior of the lungs and other parts of the body that can not be viewed directly (endoscopy).

The fiber optical system widely used in defence services because high privacy is maintained