

## UNDERSTANDING FIBRE OPTICS

### Introduction

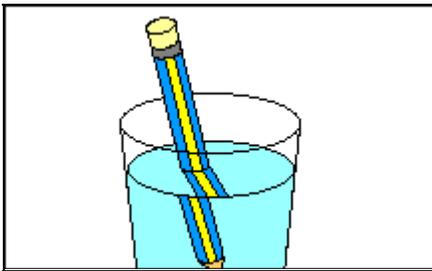
This article is part of the "Understanding CCTV Series" and is abstracts from STAM InSight - The Award Winning web based CCTV Program, which has many innovative CCTV tools for skill and productivity enhancement.

We all know fibre optics is the best transmission method but its workings are still a big mystery to many people. This article will demystify some of these issues and provide an overview, and explain the advantages and disadvantages of the fibre optics technology.

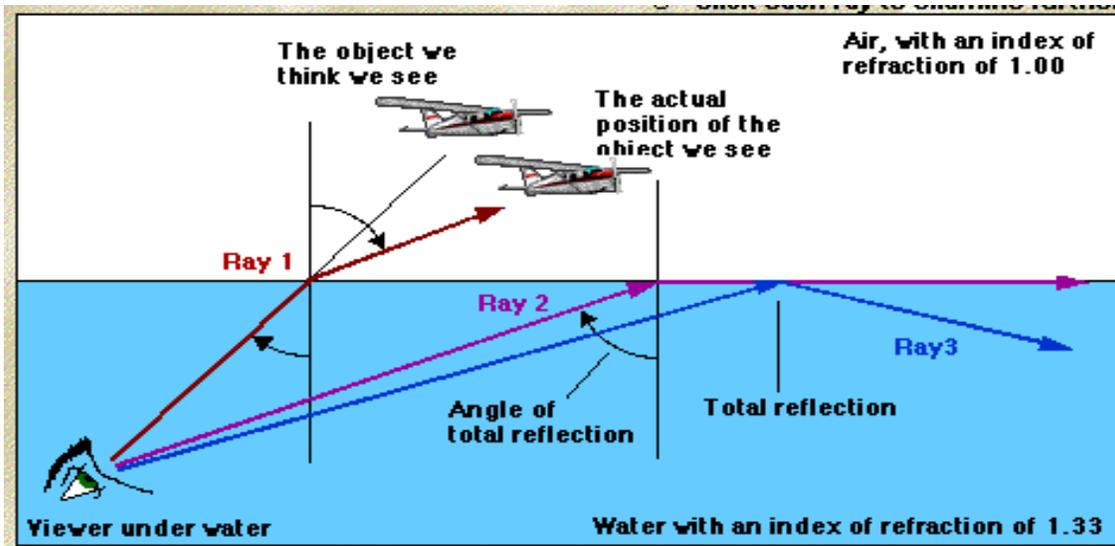
### What are fibre optics?

To put it simply, fibre optics is a technology whereby a signal like video, data or voice, is modulated on a light beam and sent down a glass tube over large distances, with very little attenuation and loss.

The principles of fibre optics are simple and easy to understand. All of us have seen the "broken straw" effect in a glass of water.

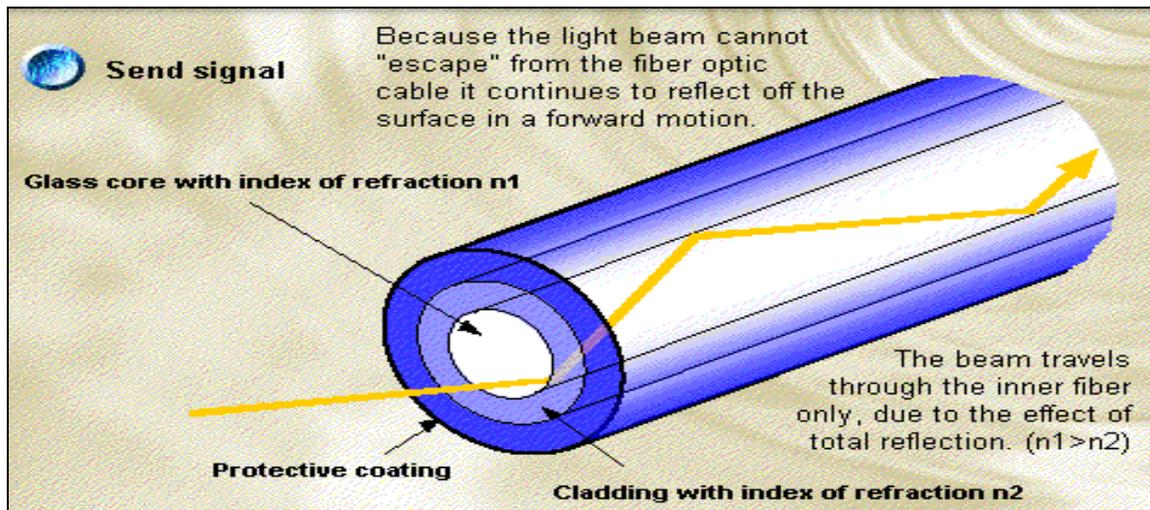


When light travels from air to a denser medium, like glass for example, the light slows down by a factor equal to the optical index of the material and this slow down in speed results in the bending of the light beam. This phenomenon is seen in our daily life on a regular basis. The beautiful colours in a diamond occur due to the same reason.



As shown in the example when we see an object from underwater, the object is not in the actual position as we think because light bends travelling from water to air. When this angle of entry is increased, there would come a stage when the light is reflected back into the same medium, as shown in ray 3. This angle is called the angle of Total Reflection. Fibre Optics uses this simple principle for transmission. The core of the fibre optics cable, which is made of glass, has a higher index of refraction than the index of the cladding, which covers this core. So when light is ejected into the glass core at the correct angle, it will reflect back from the surface and continue doing this in its forward travel. In other word the light cannot "escape" from the fibre optics cable.

It is easy to modulate any signal, whether it be video, data or voice, on to light and send it into a cable, where it can not escape and it has to travel in the forward direction. In the other word, this



light beam carries the signal through the glass core of the fibre optics cable.

### Components of a fibre optics system

The use of fibre optics is extensive, but the components used to make up a system are usually similar. These are:

1. Input Modulator: This modulates the incoming signal with a light beam
2. Light Emitting Device: This generates the light for modulation, which is in the infrared frequency range. The higher the frequency, larger the bandwidth of the signal.
3. Fibre Optics Cable: There is a range of cables, which are available to suit different
4. Applications
5. Light Receiving element: Which receives the light signal at the other end.
6. Output Demodulator: This separates the signal from the light beam.

All fibre optics systems use the above components. The specification of each component will vary depending on the application and use. For example an LED (Light Emitting Device) will be adequate for CCTV as the light source, but a LD (Laser Diode) is a must if higher bandwidths are required.

## Different types of fibre optics cable

There are 3 different types of fibre optics cable available. These are:

### 1. Step Index

This cable has a distinct index of refraction for the core and the cladding. It is the cheapest type of cable and causes deformation due to the various paths lengths of the light ray. This is called modal distortion.

### 2. Graded index or multimode

In order to equalise the path lengths and improve pulse response, the multimode cable was developed. The index of refraction of the core is varied in smooth fashion. This would mean the angle of reflection would vary, which helps in equalising the path lengths and reduce distortion.

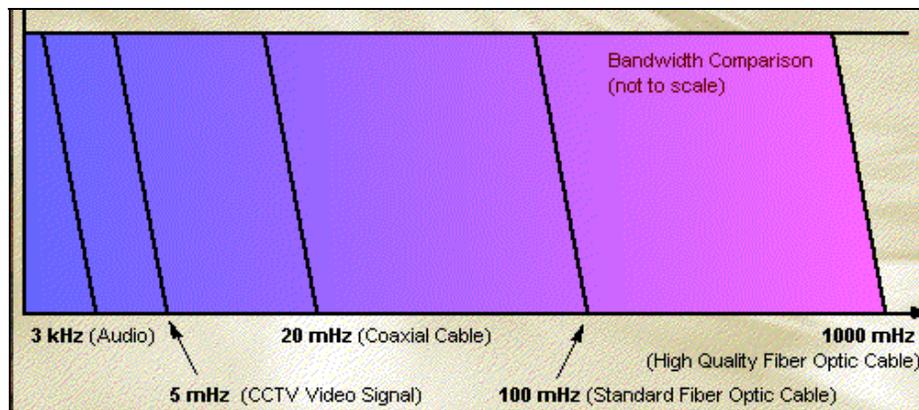
### 3. Single mode

The single mode has the best pulse response because the diameter of the core is very narrow and the light wave virtually goes straight. Obviously this the most expensive cable.

## Advantages of fibre optics

Fibre Optics signal transmission offers many advantages over existing metallic links. Some of these are:

### Large bandwidth



Fibre optics offers very high bandwidths as compared to copper wire. The bandwidth of a fibre optics cable is between 100 MHz to 1000 MHz as compared to a copper wire, which can handle only 3 to 20 MHz. This large bandwidth allows many applications and uses of fibre optics. For example a video signal has a bandwidth of 5 MHz. It is therefore possible to send up to 20 - 200 video signals on a signal fibre optics cable. This is impossible with a copper wire. In fact by using digital compression techniques you could modulate up to 500 - 1000 video signals on a single cable.

### No interference

Unlike coaxial cable, which uses electric currents, fibre optics uses light making it immune to any type of interference

- **No EMI interference** - As light is the medium of transmission, fibre optics cable does not pick up Electro Magnetic Interference (EMI). EMI is the biggest source of problems with co-axial cable. Double images, moving lines, horizontal bands and picture snow in a video picture are due to EMI. All these are eliminated with the use of fibre optics.

- **No ground loop currents** - Ground loop current is caused when the two ends of the cable are not grounded to the same potential. This difference in potential causes a current, which is usually seen as moving lines on a video picture. Fibre optics does not use electricity and therefore ground loop currents are impossible.
- **No power interference** - Voltage has no effect on light beam. It is therefore irrelevant whether the fibre optics passes next to 240VAC or 10000 VAC, or close to a powerful transmitter. This has no effect on the light beam in the fibre optics cable.
- **Immune to lightning** - Even lightning that hits a centimetre away from a fibre optical cable cannot induce any voltage in it.

Fibre optics cables are very small and low in weight. It is therefore much easier to lay fibre optics cable compared to metallic cable, which can be heavy and bulky.

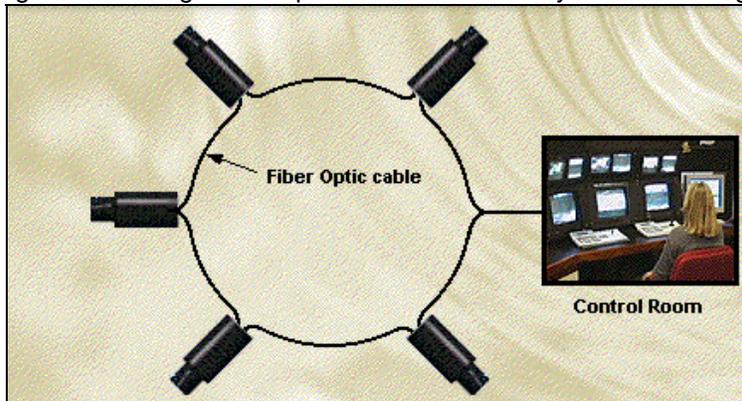
### Security of information

It is impossible to tap into a fibre optics cable without physically intercepting the signal, in which case it is detectable at the receiving end.

## Disadvantages of fibre optics

### 1. Cost of fibre optics cable.

Fibre optics is still quite expensive as compared to the copper wire, though the prices are coming down rapidly. This disadvantage could be made into an advantage by using innovative cabling and installation methods. In co-axial cable, a single cable has to be run from the camera point to the control room. As fibre optics has large bandwidths, it is possible to multiplex many video signals on a single fibre optics cable and thereby reduce cabling and installation cost. For



example in the Ring Method, a single fibre optics cable is run all over the site and the cameras are connected to this cable and the video signals are multiplexed at different frequencies.

### 2. Termination

Termination of fibre optics cable is complex and requires special tools, better precision of workmanship and is more

time consuming and therefore more expensive. Fibre optics cable has a very small diameter and requires specialised tools to align the cables correctly and then join them. The glass in the fibre optics core has to be grounded flat first to ensure correct alignment for proper and smooth termination. This looks complex, but many tools are available to ensure that the termination etc. can be achieved more easily.

### 3. Cable laying

The centre core of a fibre optics cable is made of glass. Extra precaution is required during cabling. Stretching of cable should be avoided as the glass core may crack. Also the cable bending is a major problem. Sharp bends could crack the cable but also the light beam bouncing of the glass core may not handle the bend and the light beam may 'escape out' of the core. Most cable manufacturers provide permissible bending angles.

There is no denying that the advantages definitely outweigh the disadvantages. There are more benefits into using fibre optics. It is because of these facts the usage of fibre optics is growing daily.

**About the author**

Jayant Kapatker is an international authority on CCTV and is the brain behind STAM InSight The Award Winning CCTV Program. This interactive multimedia contains over 14 hours of CCTV content. This series of articles have been based upon the subjects covered in the STAM CCTV – A complete review web based training course. For more information visit: [www.stamweb.com](http://www.stamweb.com) or email: [sales@stamweb.com](mailto:sales@stamweb.com)