INTRODUCTION

Fibre optics behave quite different to metal cables. The concept of information transmission is the same though. We need to take a "carrier" signal, identify a signal parameter we can modulate, modulate it with the desired information and…that's it.

Let's take the transmission of a TV signal in a Cable TV network as an example. We take a "carrier" which is a more or less sinusoidal wave of a certain frequency, modulate the amplitude of this carrier with a TV signal which we normally call video and send it through a coaxial cable. Coaxial cables are good to deliver "carriers" with frequencies up to few hundred MHz. The bigger the amount of information we need to transmit using a certain carrier the bigger the bandwidth the modulated carrier will occupy. Cable TV networks can offer several tens of TV channels occupying a bandwidth of hundreds of MHz.

The higher the frequency of a carrier the higher the bandwidth we can use to modulate it with information and the higher its capacity to transmit information. So, those carriers with high frequencies will be more capable of transmitting information.

There is a very high frequency type of carrier, the light. Figure 1 describes how frequency spectrum is distributed in the various bands and applications and where the light frequencies are located.

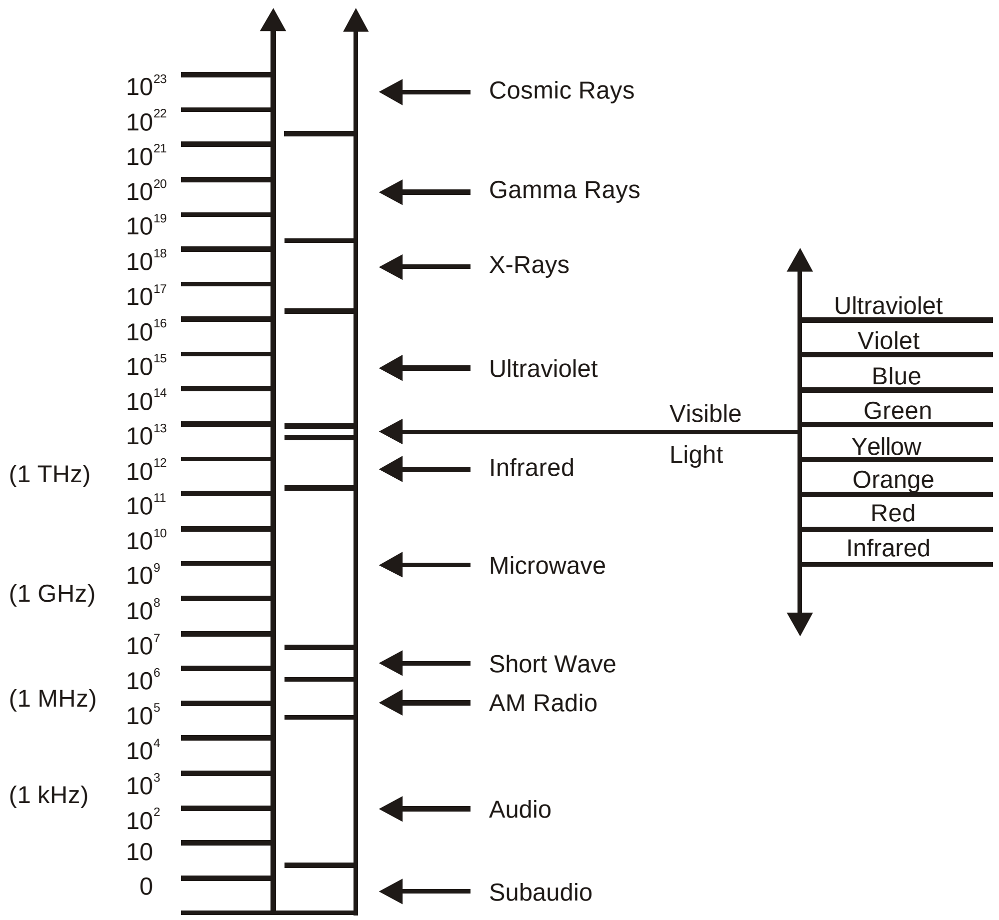

FIGURE 1

Light frequency is very high, tens of TeraHertz. There is another parameter related to the frequency which is widely used when talking about light, the wavelength. The higher the frequency of a carrier the lower the wavelength. Figure 2 expands the part of the spectrum occupied by the light and is already marked in wavelength units.

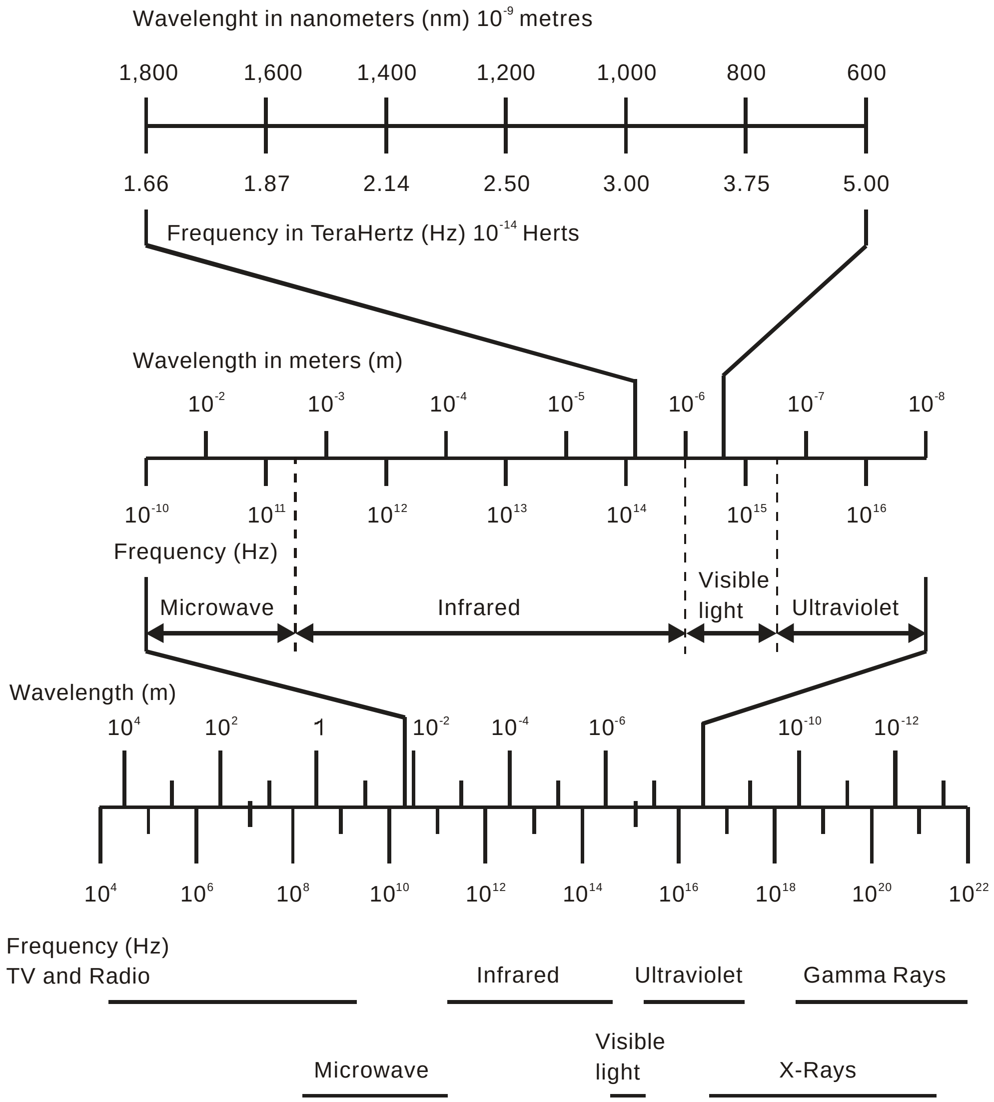

FIGURE 2

ADVANTAGES OF FIBRE OPTICS

As said before light frequency is so high (or wavelength so small) that is great to transmit information but how well does it travel from one place to another? We know the electrical signals travel pretty well in metal cables but nothing compares to light in optical fibre. If we have to list the most outstanding advantages of using light as a carrier and optical fibres as transmission channels these may be some of them:

- Great bandwidth available to transmit information. You can easily use many GHz of bandwidth limitations being mostly related to electronics in the transmitters and the receivers.
- Low attenuation of the light travelling through optical fibres. Light can travel many kilometres in an optical fibre with little attenuation and without using amplifiers/repeaters or having them spaced a lot more than amplifiers in coaxial cables for example.
- Immunity to interference's. Optical fibres are made of glass not of any metal which makes them immune to any kind of electromagnetic interference.
- Galvanic isolation. Since they are not metallic they don't establish electrical contact between emitter and receiver nor create any capacitance along the length of the cable.

VISIBLE AND INVISIBLE LIGHT

Human eye is sensible to light with wavelengths from 350 nm to 750 nm. We will perceive different colours depending on the wavelength of the ligh within that range, say red around 600 nm or violet around 400 nm . The portion of the spectrum below the visible is called ultraviolet and the one above infrared.

Ultraviolet	0,6 to 400 nm
Visible	400 to 700 nm
Infrared	700 to 1600 nm

OPTICAL FIBRES

Optical fibres are basically made of Silica. As shown in figure 3 the optical fibres have a 'core' and a 'cladding'. The light travels and is actually confined inside the core but the cladding is necessary to keep the light in the inner cylinder, the core. This core/cladding structure is very fragile and must be protected using other materials depending on the application before it is ready to be used as a finished fibre optics cable.

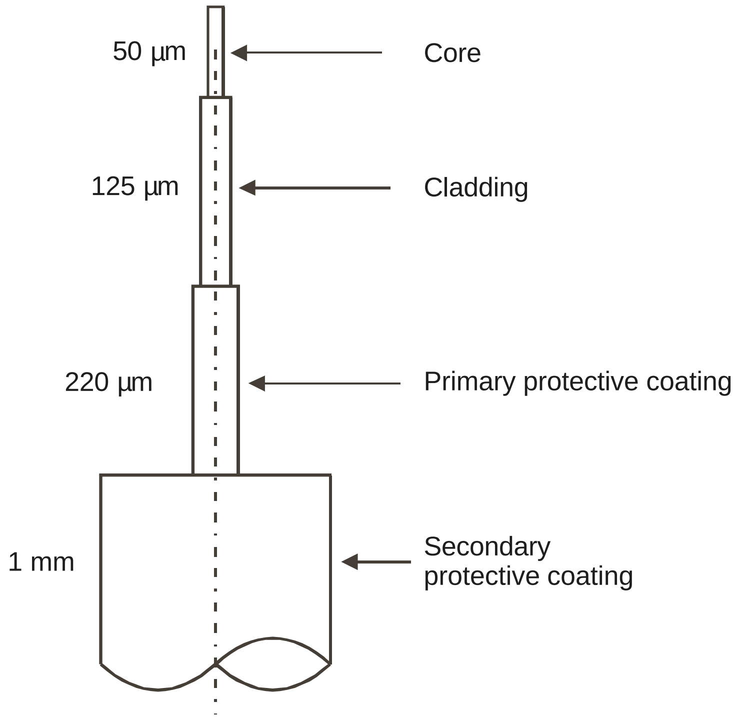

FIGURE 3

The diameter of the core is very small, just a few µm in most of the optical fibres used for telecommunications, while the cladding is several times bigger. Core and cladding diameters are used to classify different types of optical fibres. So if we have a 5/125 µm optical fibre it means the core diameter is 5 µm and the cladding diameter is 125 µm.

The properties of every type of fibre will depend on different factors but most important are the core and cladding composition and diameters.

The two most important properties used to classify the optical fibres are attenuation and dispersion.

Attenuation indicates how much optical power is lost in the optical fibre and is normally expressed in terms of dB/km.

Dispersion describes how the optical fibre 'deforms' the light pulses travelling through the fibre and is one of the most important factors limiting the bandwidth.

ATTENUATION

Attenuation depends on the fibre composition and construction but also on the wavelength just in the same way attenuation in a coaxial cable depends on the frequency.

If we measure the attenuation of an optical fibre as a function of the light wavelength we obtain a quite interesting graphic, figure 4, which sets the basics for wavelength selection in all fibre optic communications.

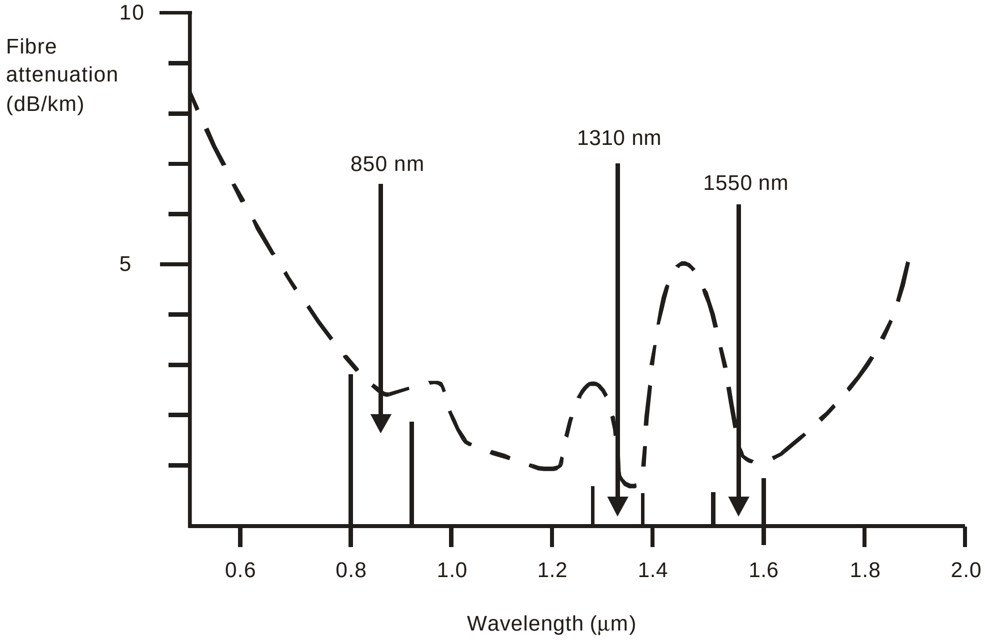

FIGURE 4

Looking at the graphic we can see why not all wavelengths are used for distance transmission of light in practical fibre optics communications. These are the most common:

850 nm	1st attenuation minimum
1310 nm	2nd attenuation minimum
1550 nm	3rd attenuation minimum

None of these wavelengths are visible but infrared because the attenuation at lower wavelengths would be unacceptably high for long distance applications.

DISPERSION

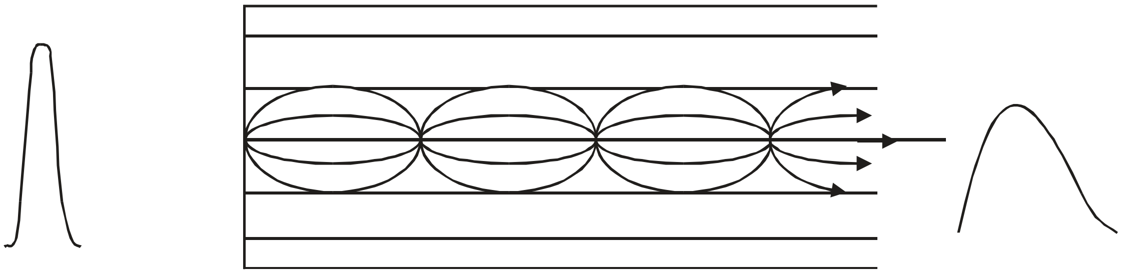

FIGURE 5

The bigger the dispersion in an optical fibre the lower the bandwidth available. If we want to transmit big amounts of information we need to use optical fibres not only with low attenuation but with low dispersion as well.

Singlemode fibres have very low dispersion by comparison to **multimode** fibres. Singlemode fibres will be ideal for high bandwidth, long distance transmission but they will be the most difficult to produce and the most expensive.

9/125 Typical single mode 1310 / 1550 nm
50/125 Typical multimode 850 / 1310 nm

SPLICING AND CONNECTORS

The purpose of a fibre optics connector will be to transfer as much light as possible from one fibre end to another. In this sense we may think fibre optics behave more like water pipes than copper cables.

Splicing of two fibre ends yields to the minimum leak of light in the junction but it is something rigid which does not allow for any flexibility or “connectability” needed in some cases where the fibres have to be connected to different places in different moments in time.

Connectors will use properties of light and its interaction with different materials to minimise the leaks.

CONNECTORS IN OPTICAL POWER METERS

Optical Power Meters will need to have a connector for they will have to measure light power coming out from different fibres every time. These measuring instruments use a photodector as a light sensing device which has a relatively wide sensing area, larger than the section of a fibre in any case.

FIGURE 6

Ones the connector of the fibre under test and the connector of the power meter come together the fibre is physically placed in such a way that the maximum amount of light goes to the photodetector. Because of the wider area of this light sensor and also due to the directivity of the fibre which illuminates the photodetector like a lantern it is not necessary to have physical contact between the fibre end in the connector and the surface to the sensing device. This gives some flexibility to the connection problem.

CONNECTORS IN LIGHT SOURCES

Things happen differently on the light source side. Light sources use a light emitting device which can be typically a laser diode or a light emitting diode (LED). These devices have to feed the light inside the narrow fibre 'tube' which is a difficult business, so difficult that most of the light sources are made with a 'pig tail' which is a piece of fibre assembled by the manufacturer of the light source with the purpose of optimising the light coupling. The pig tail is then assembled to the connector of the light source.

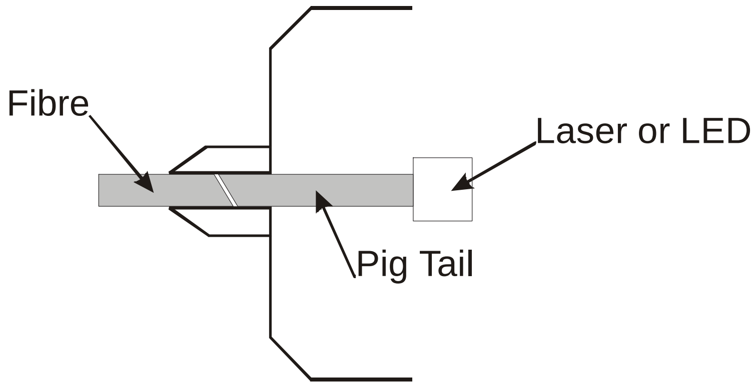

FIGURE 7

When the connector of the fibre under test and the connector of the light source come together the fibre will physically enter in contact with the end of the pig tail. The fibres can be finished in two different ways giving name to two types of connector assemblies, the PC and the APC.

PC stands for Physical Contact and means that both fibre ends are cut straight and touch each other.

APC stands for Angled Physical Contact and means that the fibre ends are not cut straight but with a certain angle and also touch each other.

Connecting PC and APC connectors can result in the destruction of the fibre ends. To avoid accidental cross connection of PC to APC and viceversa, APC connectors normally have green body or come with a green cap. On the contrary PC connectors have a red body or have a red cap.