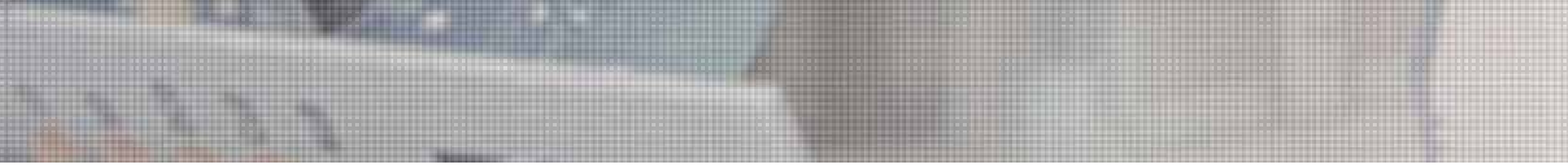
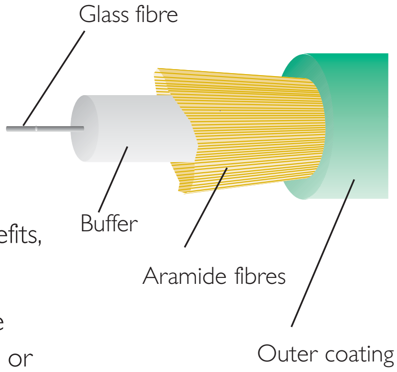


## Fibre Optic Communications

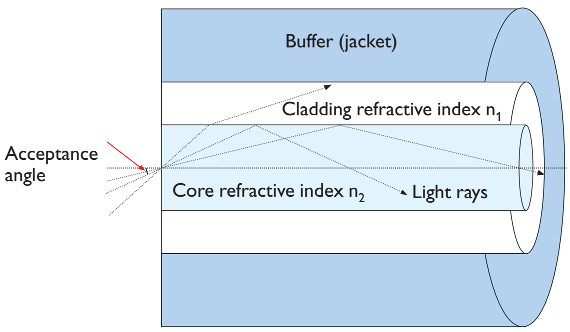
The greatest advantage of fibre cable is that it is completely insensitive to electrical and magnetic disturbances. It is therefore ideal for harsh industrial environments. It provides reliable transmission and has a very high data transfer capacity. Fibre cable can be used on specific sensitive sections of networks and be combined using a modem with, for example, 4-wire cable in a system. The investment to install a fibre network is still slightly higher than copper wire, but it offers many benefits, however the market is growing and prices are dropping.




The Westermo range of fibre products converts electrical signals to light, which are then transferred to the cable via a fibre optic transmitter with a light emitting diode or laser. It is possible to communicate over longer distances when using a laser and at higher speeds. However, laser diodes are more expensive components and for this reason light emitting diodes are in more widespread use. The receiver houses a photo-diode, which converts the light pulses back into electrical signals.

## Fibre cable

In principle, a fibre cable is made up of two types of glass with different refractive indices. The central part is known as the core and the surrounding part the cladding. When a light pulse enters the fibre, the pulse is reflected through the cable as the boundary between the two layers act like a mirror provided that the angle of incidence of the light entering the fibre is not too great.




The core and cladding of the fibre cable are enclosed by an outer sheath, whose sole task is to protect the fibre from external influences.

Selection of a cable depends on functions such as

- The material
- Singlemode or multimode
- Step or graded index
- Wave length of the transmitter

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## Material

The material used for the core and cladding differ on different types of fibre. The most common material used is glass. The glass used for these is extremely pure, silicon dioxide (silica). Other types of cable are PCS (Plastic-Clad Silica) with a core of glass and an outer cladding of plastic, or a plastic fibre cable with both the core and outer cladding of plastic.

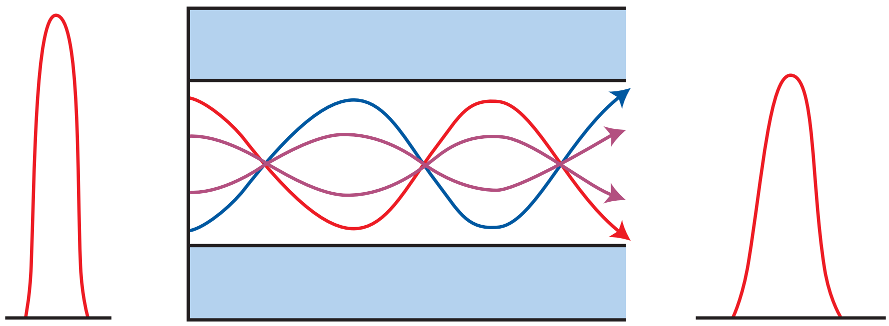
Glass cable gives the best performance, but is more complicated to terminate. Plastic fibre on the other hand is easier to terminate, but offers the worst performance.

## Attenuation in multimode fibre

Different thickness' of core material form different types of fibre cable. There are two main types that you should be aware of, these are multimode and singlemode fibre.

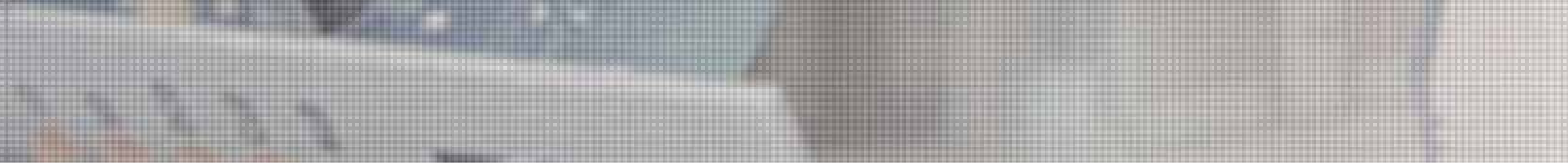
The most common dimension of multimode cable is a 62.5 µm core and 125 µm outer cladding (the cable is then designated 62.5/125).

The most common singlemode cable dimension is 9 µm core and 125 µm cladding (9/125).



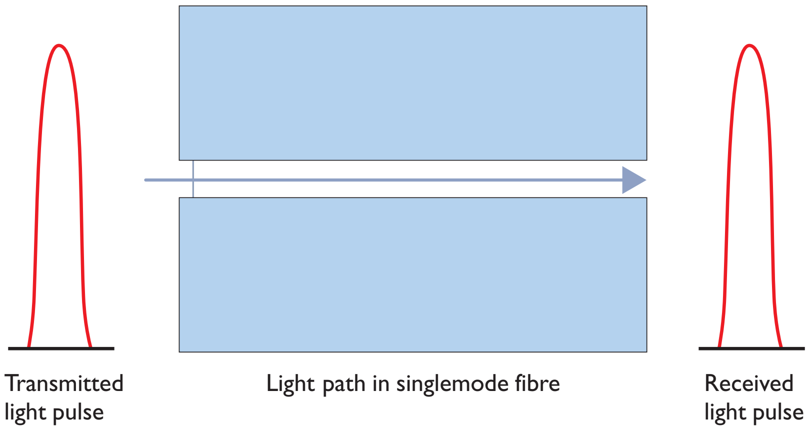

## Multimode

A multimode fibre has a dimension that affords space for several modes in a core. Multimode cables are available in two categories, these are graded index and step index. In a step index fibre, as modes reflect through the cable, some have to travel further than others and in doing so the light pulse will spread. This is one disadvantage which means the fibre has a lower bandwidth. The solution to this problem is graded index. In these cables the refractive index reduces gradually from the core's centre towards the cladding. This means that a light beam travelling mainly in the centre of the cable travels more slowly than those further out. The overall effect keeps the pulse together.



### Attenuation in singlemode fibre

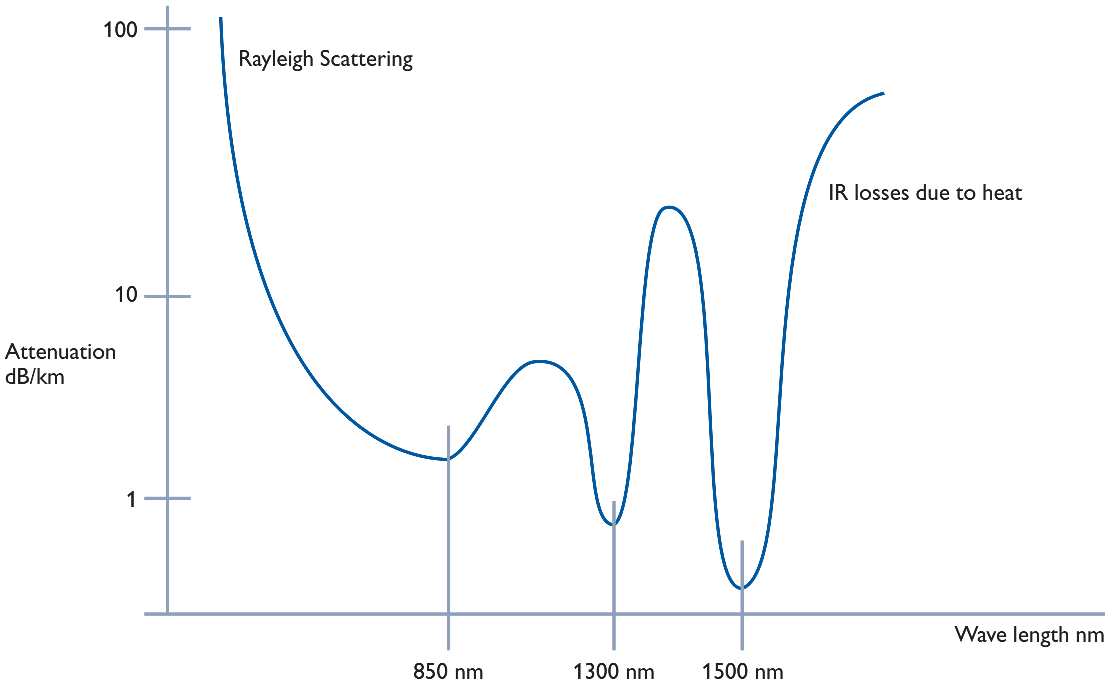
A singlemode fibre has such a fine core that it can only support one mode, which means that the transmitted light pulse is not distorted whilst travelling through the cable.




### Wave length

The attenuation in a cable is also dependent on the wavelength of the light produced by the transmitter. Wavelengths with low attenuation are 820 nm, 1300 nm and 1550 nm. Singlemode fibres will only effectively propagate the higher frequencies.

**Light Attenuation in Glass Fibre at different wavelengths**




Summary of fibre types

| Material | Type | Core/Outer casing | Attenuation (dB/km) | Field of application |
|---|---|---|---|---|
| **Plastic** | Multimode Step index | 200-600/450-1000 um | 330-1000 | Simple installation Short distances |
| **Glass (silicon) core plastic** | Multimode Step index | 200-600/350-900 um | 4-15 | Low cost, Short distances |
| **Glass** | Multimode Step index | 50-400/125-440 um | 4-15 | Low cost, Short distances |
| **Glass** | Multimode Graded index | 30-100/100-140 um | 2-10 | Medium cost Medium distance |
| **Glass** | Singelmode | 3-10/50-125 um | 0,4-5 | High cost Long distances |



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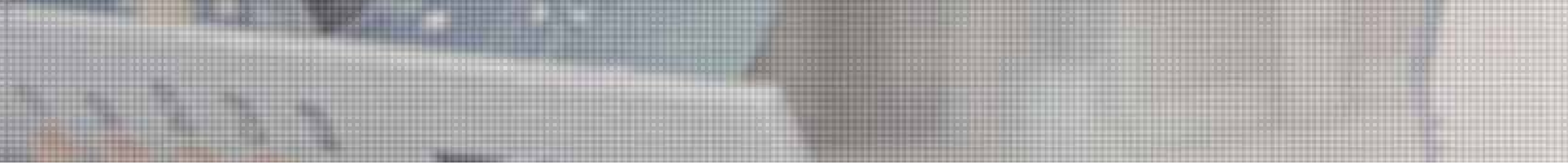
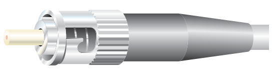
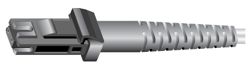


**Termination**

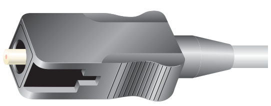
There are many different ways to terminate fibre cable. With glass fibre, multimode cable termination is the easiest to learn. One simple procedure called "crimp and cleave" is to crimp the connector on the fibre, this requires special pliers and then cleave the fibre carefully. Another more reliable procedure is to use an epoxy to bond the fibre into the connector; connectors are available with the adhesive already in the connector. The connector is then heated with the help of a special oven for around 1 minute; the fibre is inserted in the connector and is then allowed to cool. These two terminating methods both require equipment to prepare the fibre before mounting the connector and to polish the fibre after the cable is terminated. In systems where connection points are frequently changed the bonded fibre may be beneficial, as this gives a more durable termination. There is a large number of different fibre connectors available on the market, but primarily there are just four connectors that are used industrially, these are:



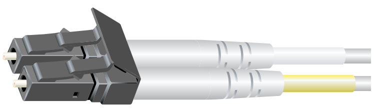
**ST** simplex connector used for multimode 2 km (1.24 mi)



**MTRJ** duplex connector used for multimode 2 km (1.24 mi) or singlemode 15/40 km (0.93/24.85 mi)



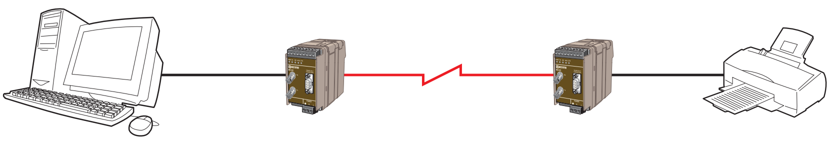
**SC** simplex connector used for multimode 2 km (1.24 mi) or singlemode 15/40 km (0.93/24.85 mi)



**LC** duplex connector used for singlemode 15/40/85 km (0.93/24.85/52.81 mi)

**Loss Budget Calculation**
The communication range of a system is dependent on the transmission output, the sensitivity of the receiver and the loss that arises in terminations and cable splices. In order to calculate this range a fibre budget is stated, which is the difference between the transmitter output power and receiver sensitivity, both these values have a typical value and a minimum level. We have chosen to document both these values for most products. We do this because there can be large variations in the manufacturers' specifications; this applies mainly to singlemode fibre.

**Example**
We connect two devices together using two MD-62s. Should we use multimode or singlemode fibre? Multimode cable has an attenuation of 3.2 dB/km at 820 nm whilst singlemode has an attenuation 0.5 dB/km at 1300 nm. The range in our example is 6 km (3.72 mi) with two splices in the cable, which both give an attenuation of 0.2 dB.



Option 1, Multimode cable
3.2 dB/km x 6 + 2 x 0.2 dB = 19.6 dB

Option 2, Singlemode cable
0.5 dB/km x 6 + 2 x 0.2 dB = 3.4 dB

According to the manual for the MD-62 the minimum fibre budget for:
Multimode cable 62.5/125 with a wave length of 820 nm 14.5 dB
Singlemode cable 9/125 with a wave length of 1300 nm 6.3 dB

In this example singlemode should be chosen.
This is an example of how the fibre budget is used to calculate the transmission distance, in our example we know the fibre budget from the manual for MD-62



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