Topic 30:
Communicating Information

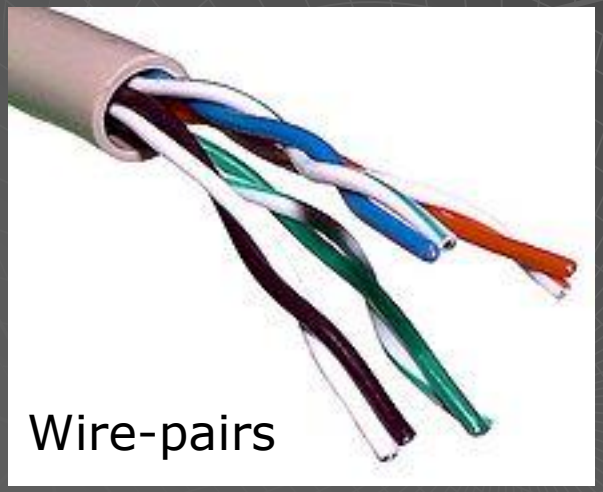
30.1 Principles of Modulation
30.2 Sidebands and bandwidth
30.3 Transmission of information by digital means
30.4 Different channels of communication
30.5 The mobile-phone network

30.4: Channels of Communication

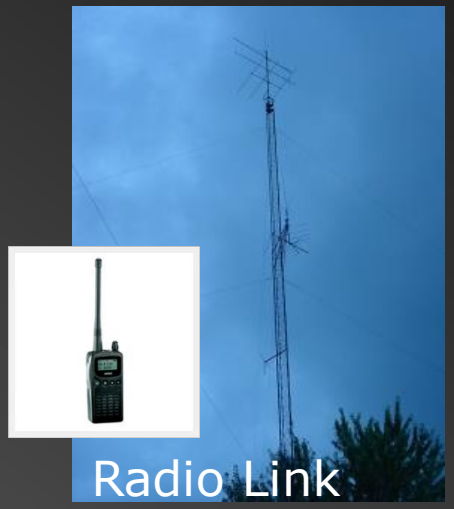
- Wire-pairs
- Coaxial cables
- Radio waves
- Microwaves
- Optic fibres

Channels of Communication

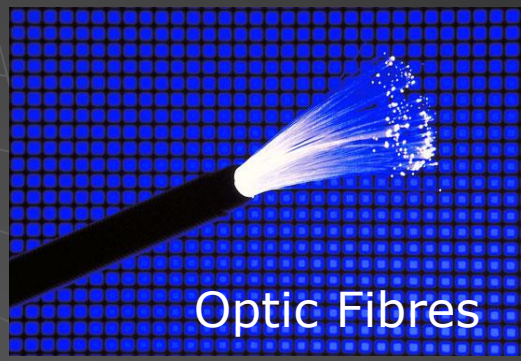
Channels of communication are the different means/media of transferring signals.


Wire-pairs

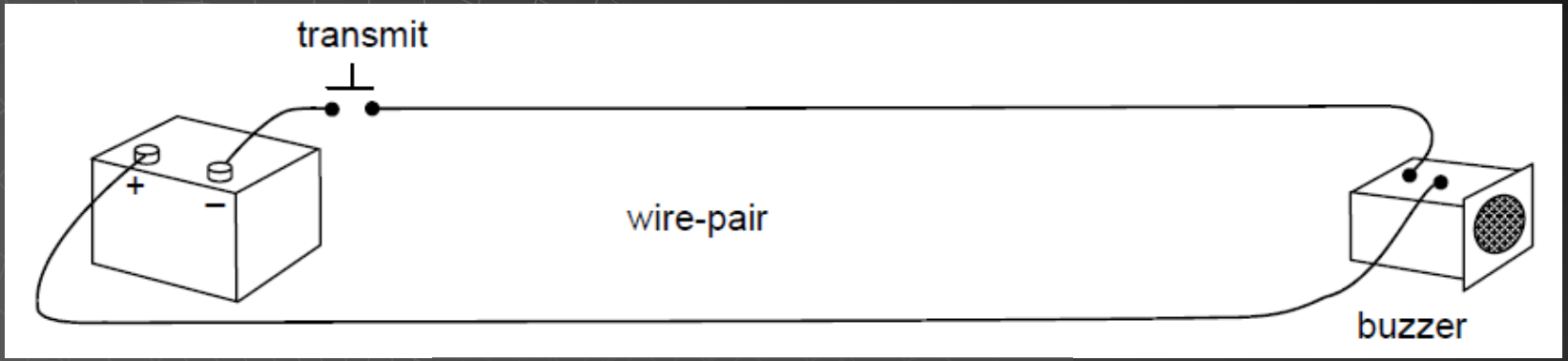

Coaxial Cables


Radio Link


Microwave Link


Optic Fibres

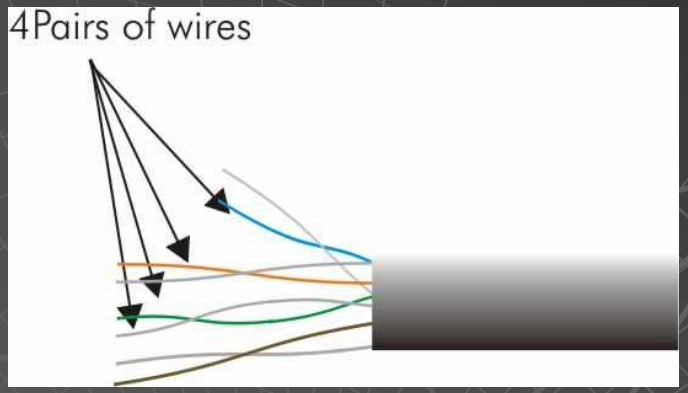
Wire-Pairs



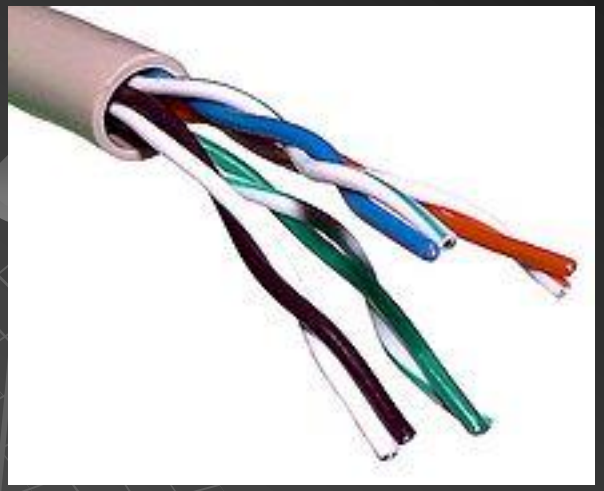
Morse Code Transmitter

- Consists of a pair of insulated copper wires
- Used mainly for very short distances with low frequencies. Examples:
  - Linking telephones to the nearest exchange
  - Linking door bell in a house to the switch outside
- High attenuation of the signal
  - energy is lost as heat in the resistance of the wires
  - as radiation since the wires act as aerials
- Easily pick up external interference that degrades the original signal

Wire-Pairs



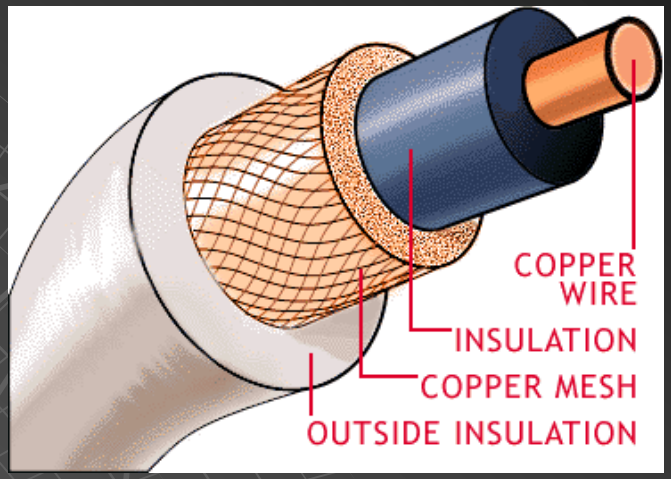
A cable of wire-pairs



- If several wire-pairs are arranged next to one another, they will pick up each other's signals.
- This effect is known as *cross-talk* or *cross-linking* and gives very poor security as it is easy to 'tap' a telephone conversation.
- The bandwidth of a pair of wires is only about 500 kHz.
- Consequently, as a means of carrying a large amount of information, it is extremely limited.

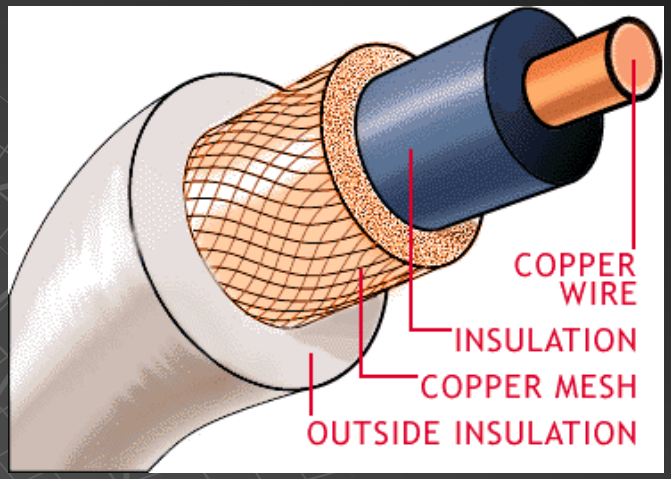
Coaxial Cable

Coaxial Cable



- Essentially, a pair of wires arranged so that one wire is shrouded by the other
- The signal is transmitted down the inner conductor and the outer conductor acts as the return wire and also shields the inner one from external interference.
- The outer conductor is usually connected to earth.

Coaxial Cable



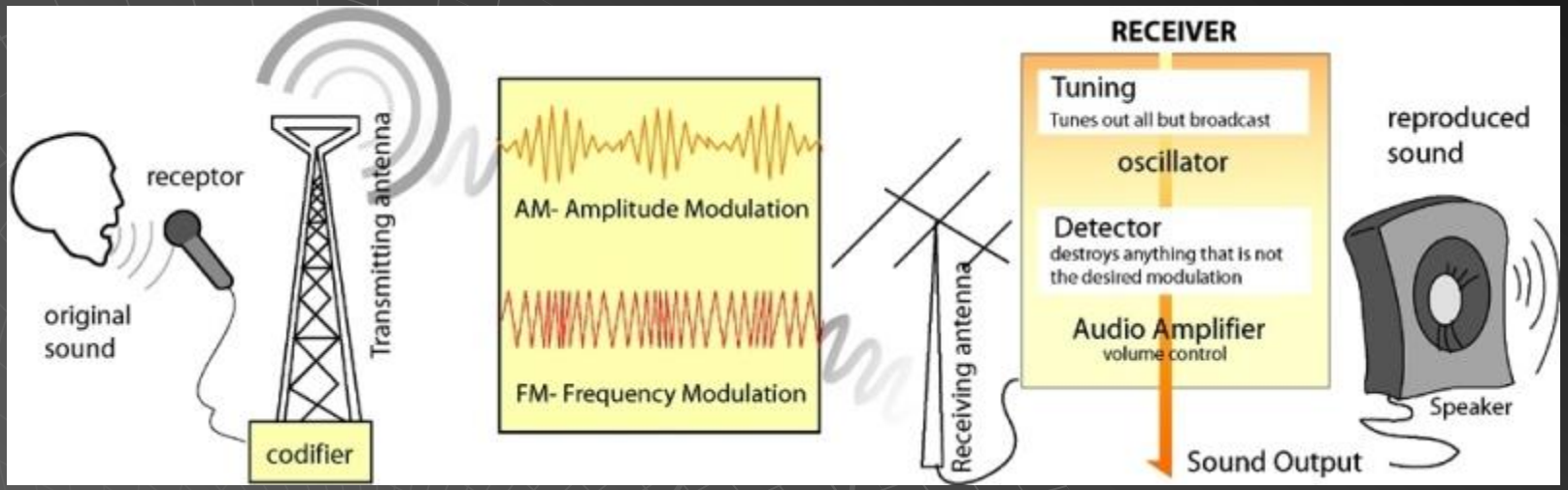
- More expensive than wire-pairs
- Less attenuation of the signal. This means that, for long distance communication, repeater amplifiers can be arranged further apart.
- Less prone to external interference, though not immune to it, so they do offer slightly greater security.
- The bandwidth of coaxial cable is about 50 MHz. It is capable of carrying much more information than a wire-pair.

Radio Link

Radio Link (1)

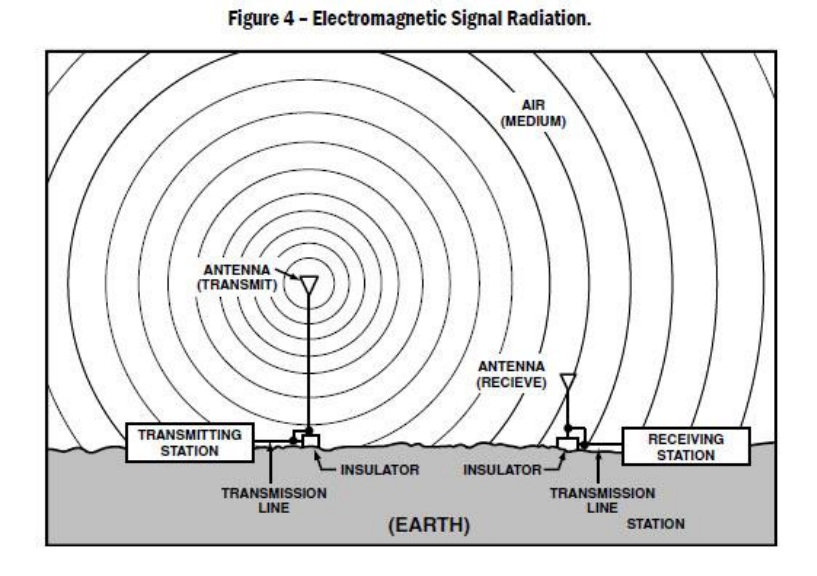
- Aerials are required for radio link.
- Energy is radiated from an aerial in the form of electromagnetic waves.
- These waves travel outwards from the aerial with the speed of light.
- Electromagnetic waves in the frequency range 30 kHz to 3 GHz are generally referred as radio waves.

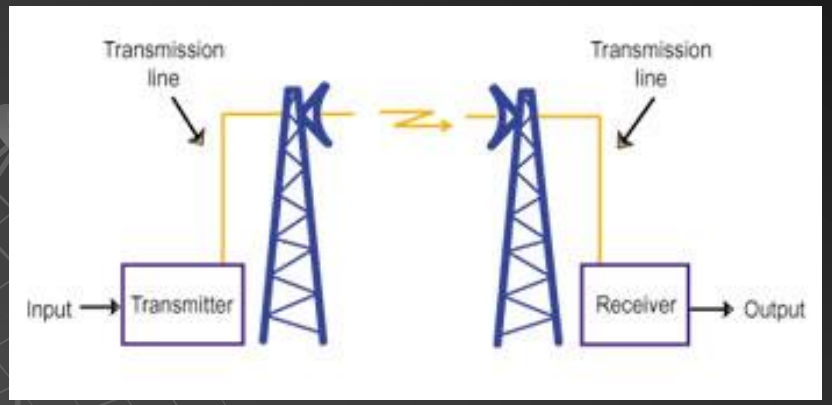
Radio Link (2)



- The first radio waves used for communication were of very low frequencies and very long wavelengths. The radio waves were switched on and off so that communication was by morse code.
- Later use of higher frequencies and the development of amplitude modulation (AM) enabled voice communication.
- Further development, including FM broadcasts and the use of different carrier frequencies, enabled higher-quality communication and also more radio stations to operate in the same area.

Radio Link (3)





- The choice of aerial for broadcasting determines whether the radio waves are emitted
  - in all directions (for broadcasting to a whole area)
  - or in one direction only (for point-to-point communication).
- Similarly, for the receiving of radio signals, the choice of aerial is determined by whether the signal is to be received from one direction or all directions.
- Aerials with dish reflectors enable the radio waves to be transmitted as parallel beams.

Radio Link (4)

type of wave	frequency	range
surface wave	below 3 MHz	up to 1000 km
sky wave	3 MHz → 30 MHz	worldwide by means of reflection from ionosphere and ground
space wave	greater than 30 MHz	line of sight – including satellite communication

Some Data on Frequencies and Ranges of Radio Waves

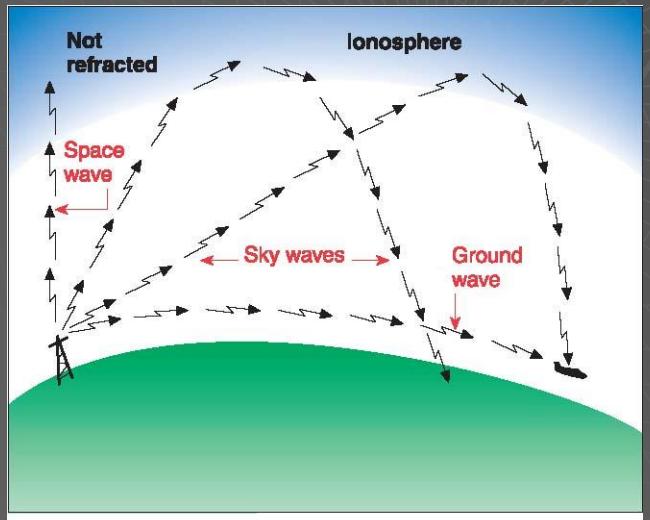


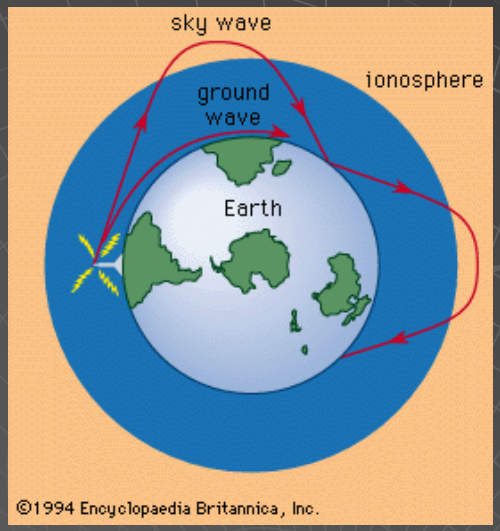
Figure 7-1. *Ground, space, and sky wave propagation.*

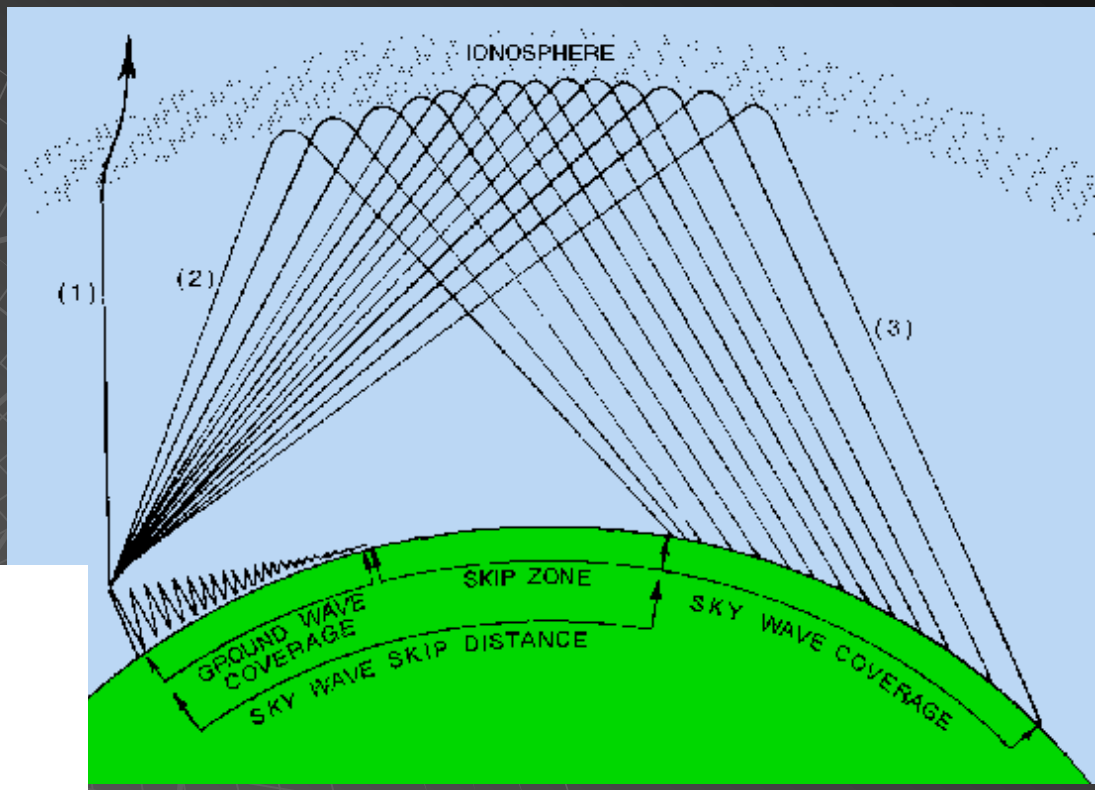
Surface waves: Waves that travel along the contour of the Earth by diffraction

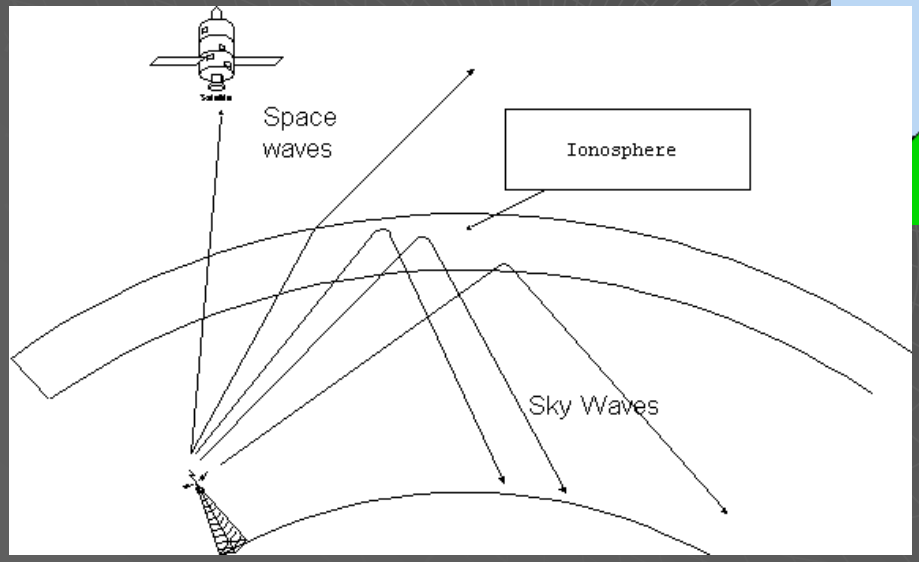
Sky waves: Waves that are reflected by the ionosphere

Space waves: Waves that are transmitted in a straight line (line-of-sight, LOS) from transmitter to receiver

Radio Link (5)







The three types of transmitting waves complement each other.

Skip zone is an area where the waves are not received.

Microwave Link

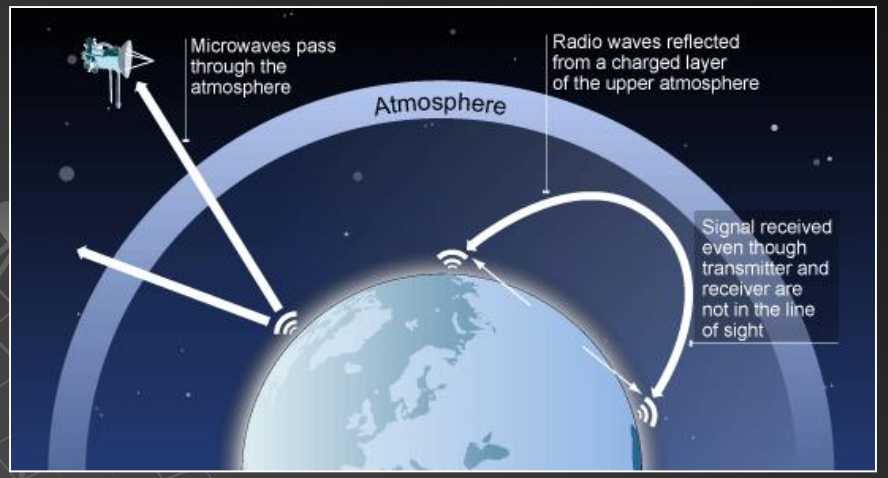
Microwave Link (1)

	frequency band	frequencies	wavelengths (in a vacuum)
LW radio	low frequencies LF	30 kHz → 300 kHz	10 km → 1 km
MW radio	medium frequencies MW	300 kHz → 3 MHz	1 km → 100 m
SW radio	high frequencies HF	3 MHz → 30 MHz	100 m → 10 m
FM radio	very high frequencies VHF	30 MHz → 300 MHz	10 m → 1 m
TV broadcast	ultra-high frequencies UHF	300 MHz → 3 GHz	1m → 10 cm
microwave/satellite	super-high frequencies SHF extra-high frequencies EHF	3 GHz → 30 GHz 30 GHz → 300 GHz	10 cm → 1 cm 1 cm → 1mm

The Frequency Bands used for Radio Communication

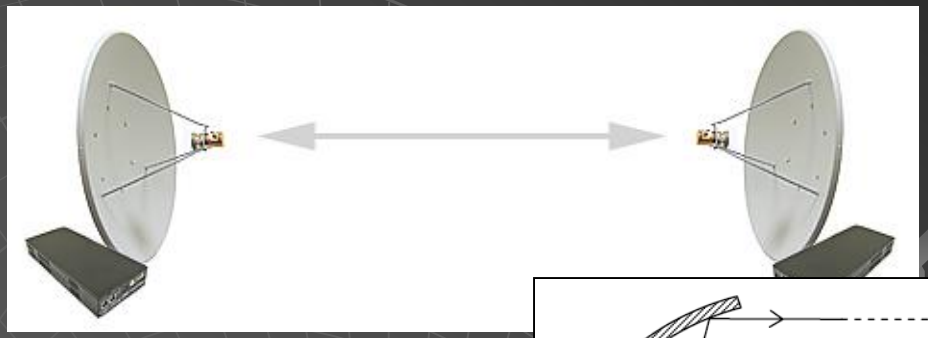
- Microwaves are radio waves in the SHF waveband from 3 GHz to 30 GHz.
- With such high frequencies, it has very short wavelengths of only a few centimetres.
- The wavelength of the radio waves determines the length of the aerial.
- For mobile phones, the aerial must be, for the sake of convenience, short and hence microwaves are suitable for its use.
- As the frequency of the carrier wave increases, the bandwidth also increases.

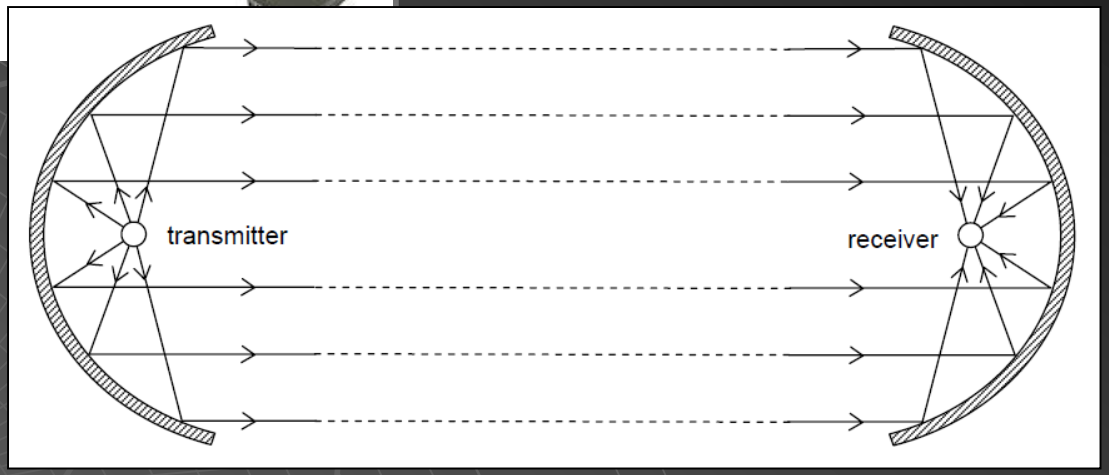
Microwave Link (2)



- The bandwidth of a microwave link is of the order of GHz. This large bandwidth means that the microwave beam has a large capacity for transmitting information.
- Microwaves are generally used for point-to-point communication where signals are transmitted directly from transmitter to receiver (space waves).
- For terrestrial use, the range of the transmissions is limited to line-of-sight and relay stations are used.
- For very long distance transmission, microwaves are transmitted beyond the atmosphere and sent back to Earth by communication satellites.

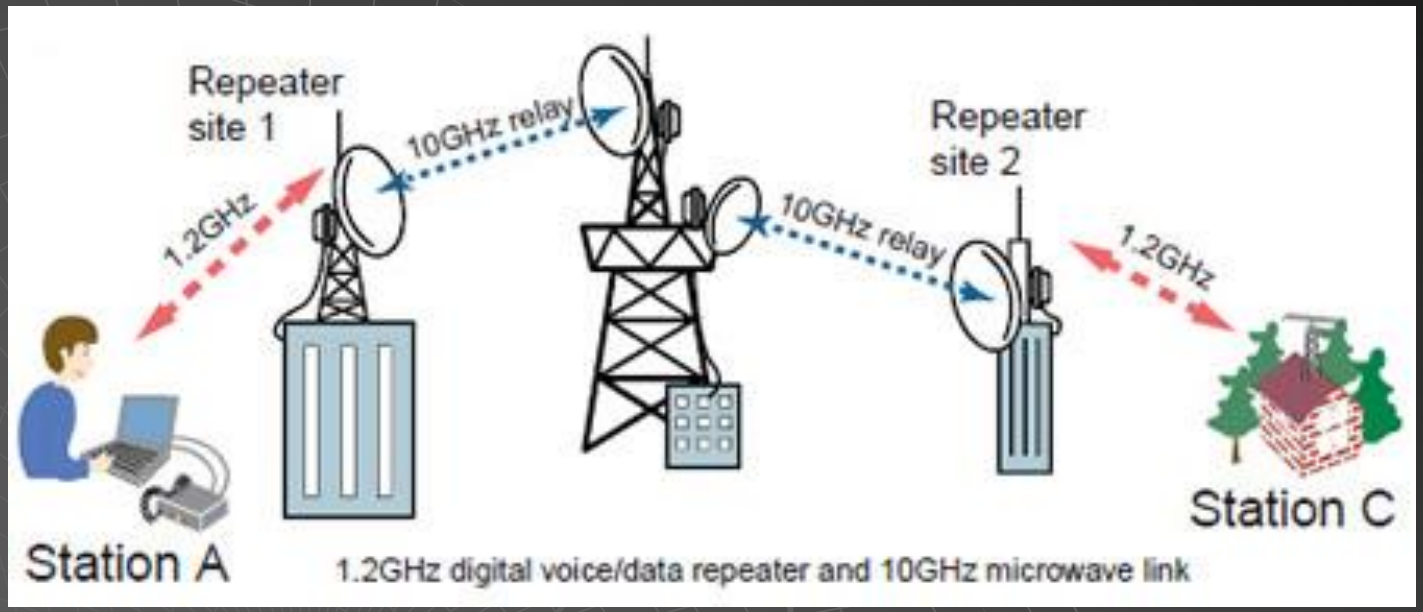
Microwave Link (3)





- The transmitting element is placed at the focus of a parabolic reflector.
- The parabolic reflector, reflects and focuses the wave power on to a receiving element.
- In this way, the wave power is radiated in a parallel beam.
- Note: The reflecting parabolic dish is not the aerial. The aerial is found at the focus of the reflecting dish.

Radio Link (4)



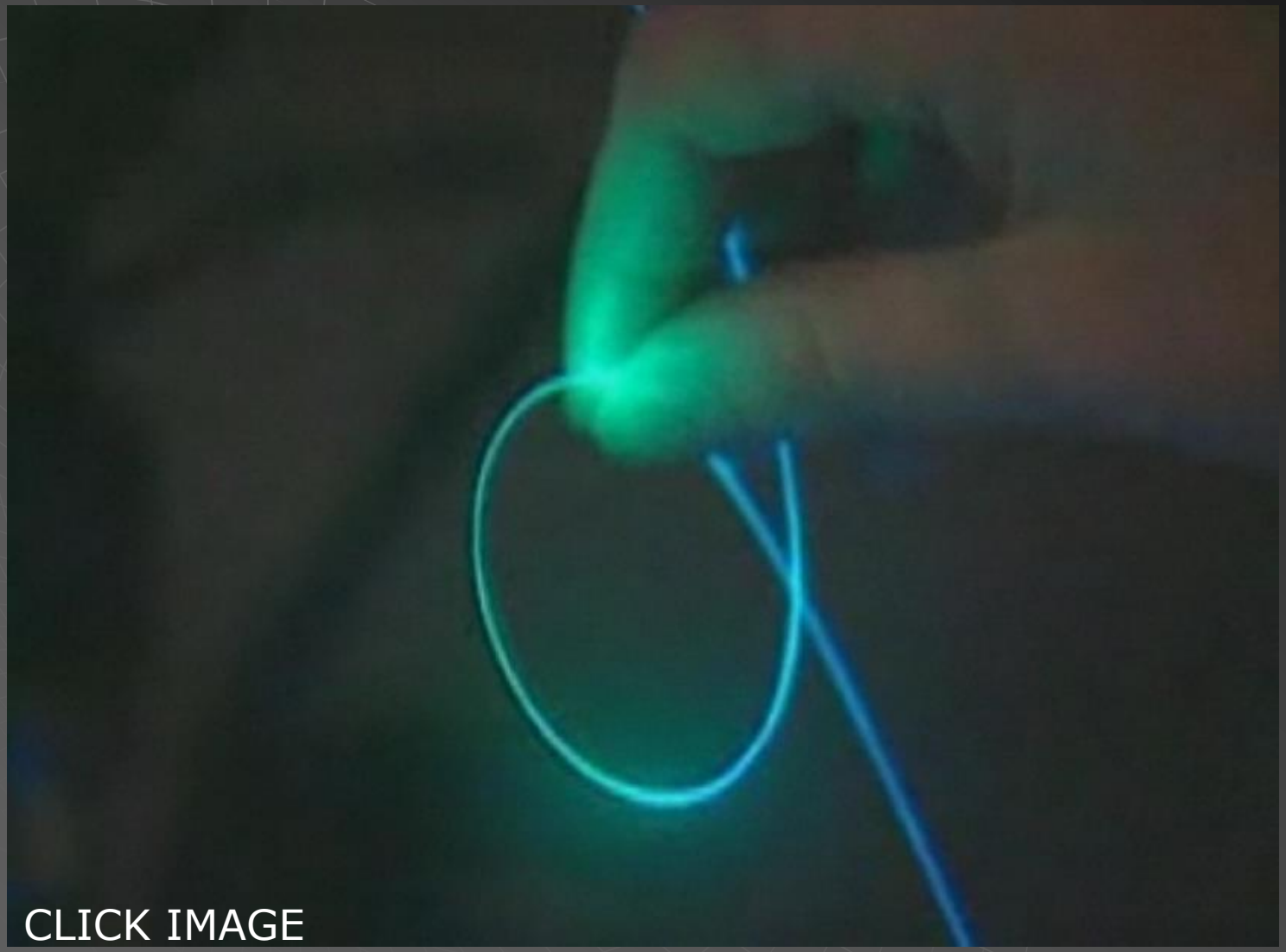
- The intensity of the waves will always be reduced (attenuated) as the distance from the transmitter increases.
- They need to be strengthen / amplified at regular distance.

Optic Fibres

Optic Fibres

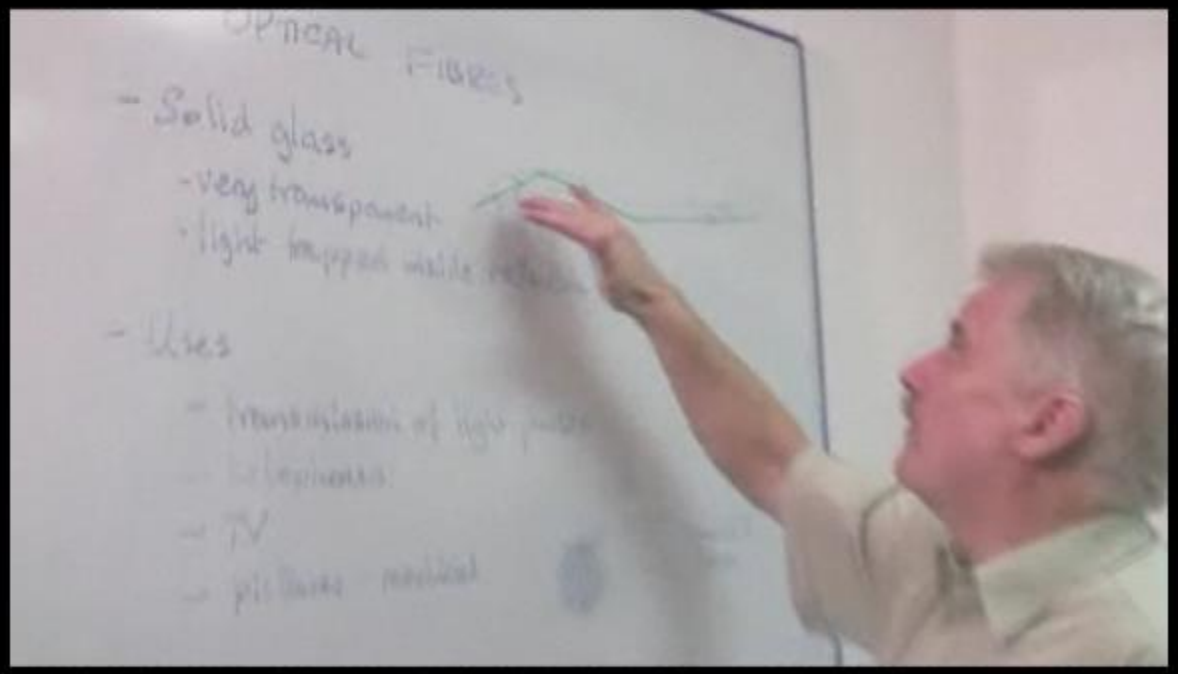
- Optic fibres are strands of optically pure glass as thin as a human hair that carry digital information over long distances

Optic Fibres



CLICK IMAGE

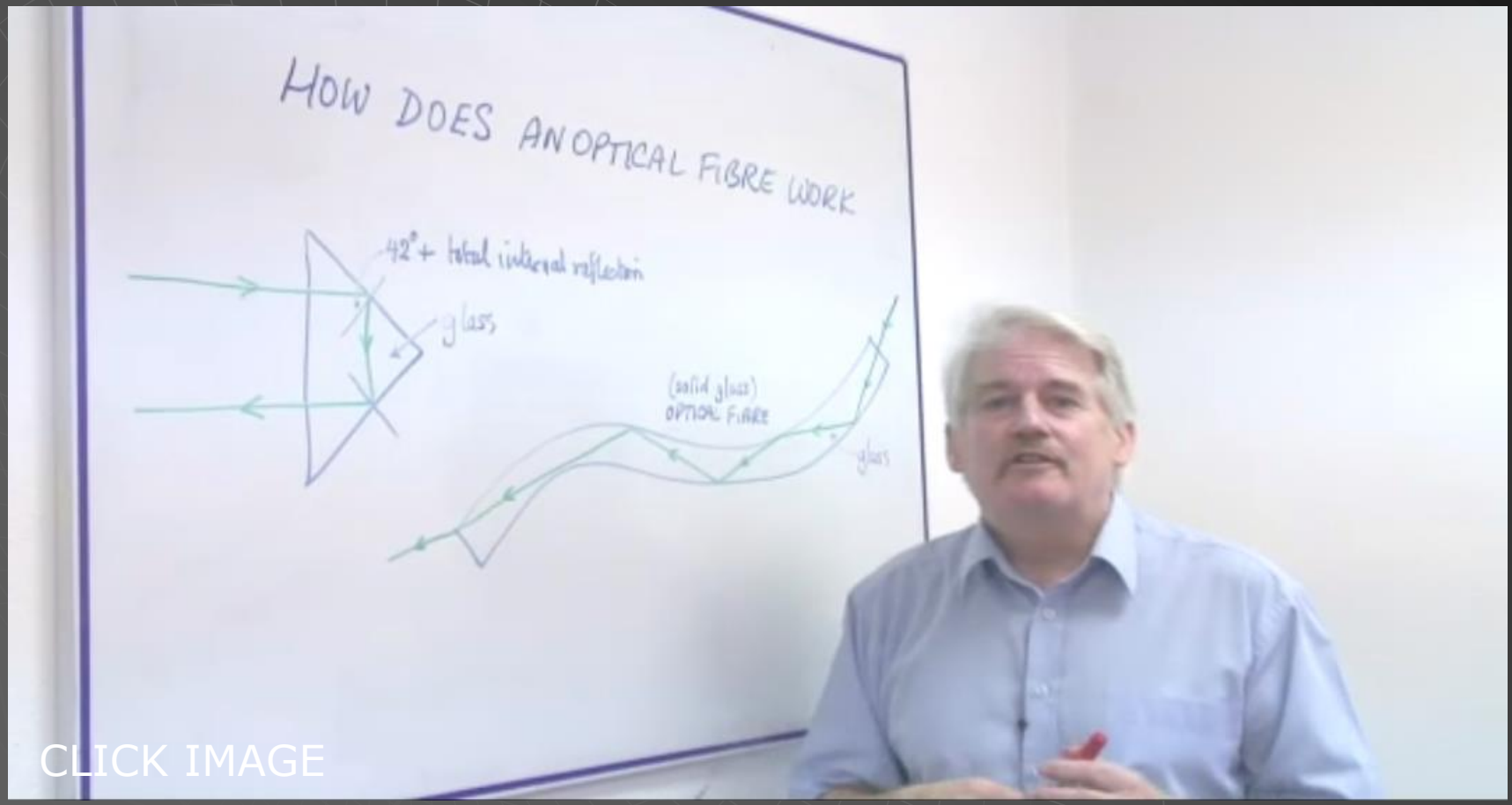
What are Optic Fibres



CLICK IMAGE

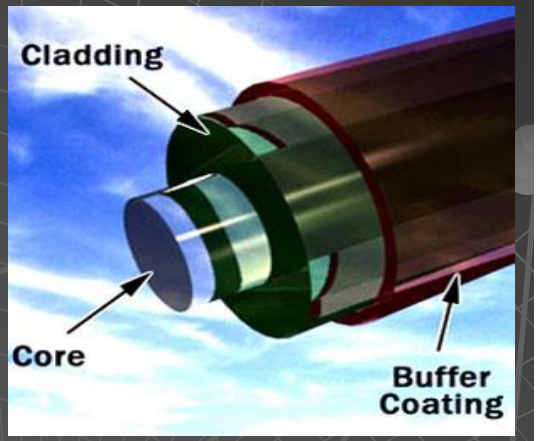
Optic fibres are solid glass.

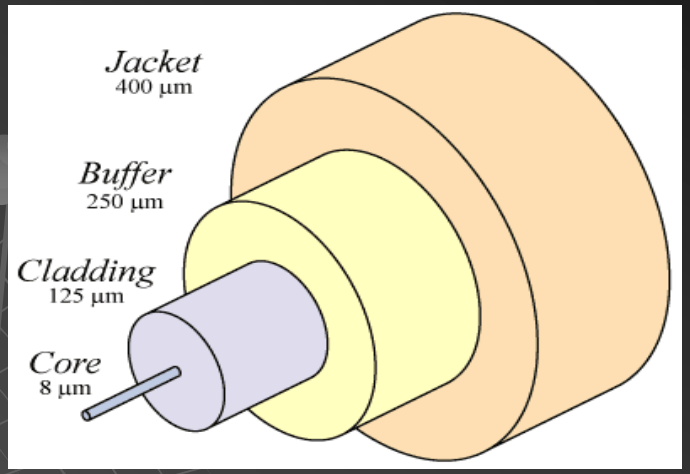
How Does Optic Fibre Work?



Optic fibres transmit optical pulses using the principle of total internal reflection.

Structure of an Optic Fibre



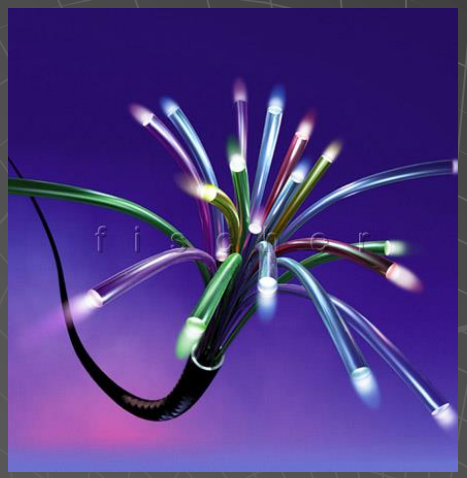


A single optical fibre, will have the following parts:

- **Core - Thin glass center of the fibre where the light travels**
- **Cladding – An outer optical material (glass of lesser density) surrounding the core**
- **Buffer coating - Plastic coating that protects the fibre from damage and moisture**

Hundreds or thousands of these optical fibres are arranged in bundles in optical cables. The bundles are protected by the cable's outer covering, called a jacket.

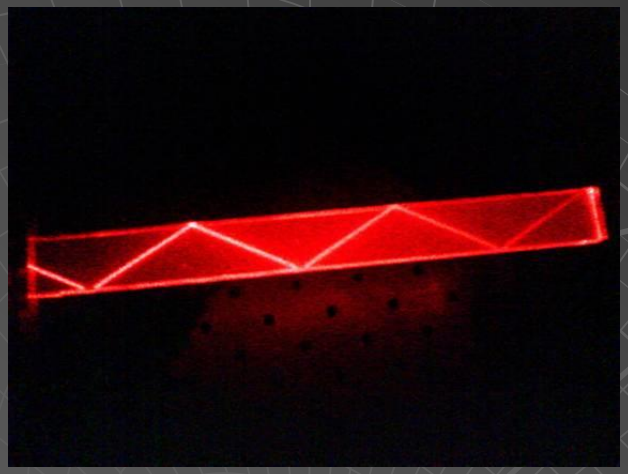
Transmitting Optical Pulses

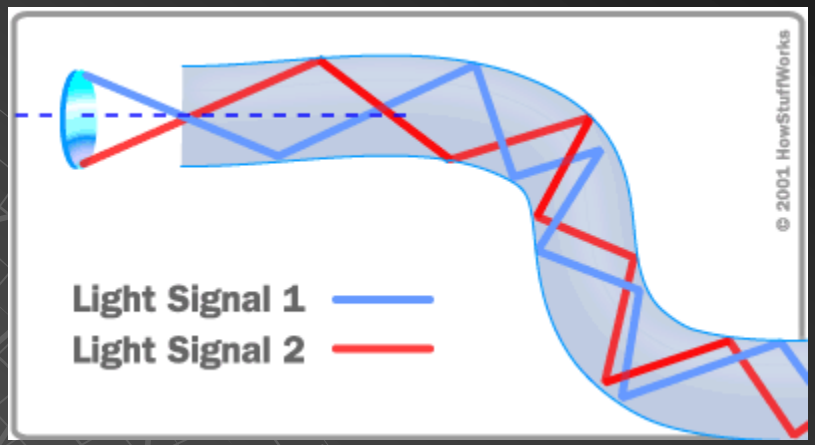


One single optic fibre can transmitter as much data as a bundle of coaxial wires

- Optic fibres carry digital information in the form of pulses of light or infra-red radiation.
- These pulses are provided by lasers and the light produced has very high frequencies of the order of 10^8 MHz.
- In theory, a bit or individual light wave could last for only 10^{-14} s. This would allow hundreds of thousands of individual information, telephone calls for example, to share the same optic fibre.
- However, present technology does not allow control at such high frequencies. The duration of a bit is governed by how fast the laser providing light to the fibre can be switched on and off. This is, at present, of the order of GHz but is increasing as technology develops.

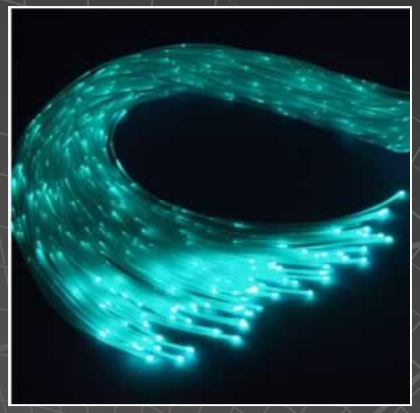
Transmitting Optical Pulses

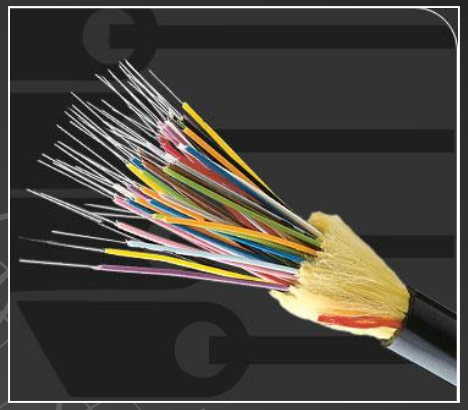




- Pulses of light or infra-red radiation travel along the fibre as a result of **total internal reflection**.
- As there is **no loss of energy** in total internal reflection, the light impulses can travel great distances.
- However, some of the light signal **do degrade** within the fibre, mostly due to **impurities in the glass**.

Advantages of Optic Fibres





- **Large bandwidth, giving rise to large transmission capacity**
- **Much lower cost than metal wires**
- **Diameter and weight of cable is much less than metal cable, hence easier handling and storage**
- **Much less signal attenuation, so far fewer regenerator amplifiers are required, reducing the cost of installation**
- **Do not pick up electromagnetic interference, so very high security and negligible cross-talk**
- **Can be laid alongside existing routes such as electric railway lines and power lines.**

Optic Fibre: May 2008 Q12

(a) Optic fibre transmission has, in some instances, replaced transmission using co-axial cables and wire pairs.

Optic fibres have negligible cross-talk and are less noisy than co-axial cables.

Explain what is meant by

(i) cross-talk, [2]

(ii) noise. [2]

(b) An optic fibre has a signal attenuation of 0.20 dB km–1.

The input signal to the optic fibre has a power of 26 mW. The receiver at the output of the fibre has a noise power of 6.5 μW.

Calculate the maximum uninterrupted length of optic fibre given that the signal-to-noise ratio at the receiver must not be less than 30 dB. [5]

Solution: May 2008 Q12

(a) (i) picking up of signal in one cable — M1
from a second (nearby) cable — A1

(ii) <u>random</u> (unwanted) signal / power — B1
that masks / added to / interferes with / distorts transmitted signal — B1
*(allow this mark in **(i)** or **(ii)**)*

(b) if P is power at receiver,
$30 = 10\lg(P / (6.5 \times 10^{-6})$ — C1
$P = 6.5 \times 10^{-3}$ W — C1
loss along cable $= 10\lg(\{26 \times 10^{-3}\} / \{6.5 \times 10^{-3}\})$ — C1
$= 6.0$ dB — C1
length $= 6.0 / 0.2 = 30$ km — A1

Channels: Nov 2008 Q9

Different frequencies and wavelengths are used in different channels of communication.

Suggest why

(a) infra-red radiation rather than visible light is usually used with optic fibres, [2]

(b) the base stations in mobile phone networks operate on UHF, [2]

(c) for satellite communication, frequencies of the order of GHz are used, with the uplink having a different frequency to the downlink. [2]

Solution: Nov 2008 Q9

(a)	IR has less attenuation (per unit length)			B1
	fewer (repeater) amplifiers / longer <u>uninterrupted</u> length			B1
(b)	*either*	limited range		B1
		(so) cells do not overlap (appreciably)		B1
	or	short wavelength	(B1)	
		so convenient length aerial (on mobile phone)	(B1)	
(c)	large bandwidth / large information carrying capacity			B1
	different so that uplink signal not swamped by downlink			B1