*Channels of communication*

# Transfer of information

- A signal whether analogue or digital is transmitted and received using ***channels of communication***.
- This may be achieved in various ways using different channels of communication including

  **1.) Wire-pairs**

  **2.) Coaxial cables**

  **3.) Optic fibres**

  **4.) Radio links**

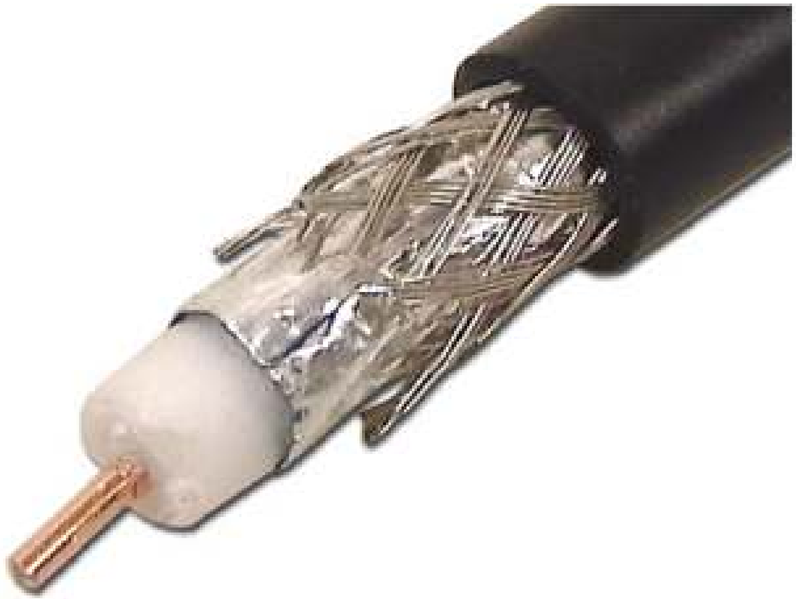
  **5.) Microwave links**

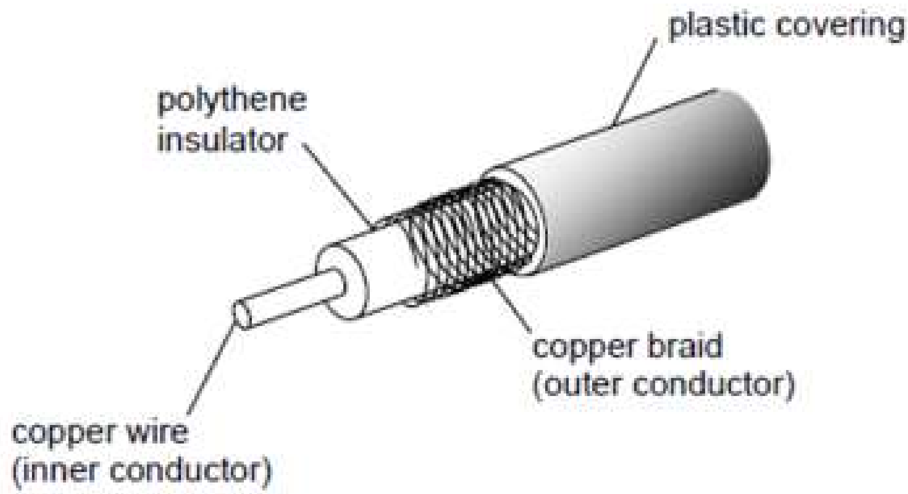
# 1.) Wire-pairs

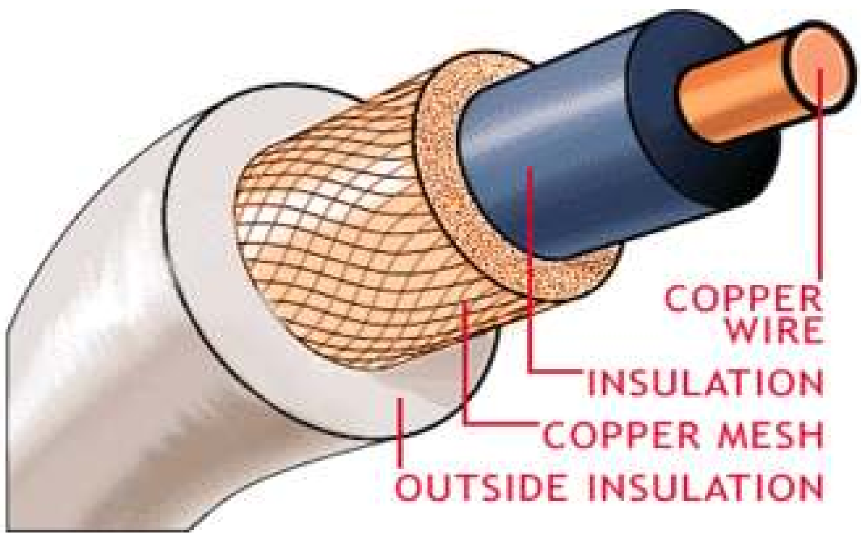
# 1.) Wire-pairs

- Wire-pairs provide a very simple link. In modern communications, wire-pairs are used mainly for very short distances with low frequencies. Example: linking a fixed telephone to a local exchange.
- If high frequency signals are transmitted along a pair of wires over an appreciable distance, repeated amplification must be provided at regular intervals.
- This is due to the very high attenuation of the signal. Energy is lost as heat in the resistance of the wires.
- A further problem is that the wires easily pick up external interference that degrades the original signal.
- 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 has extremely limited bandwidth.

# 2.) Coaxial cable



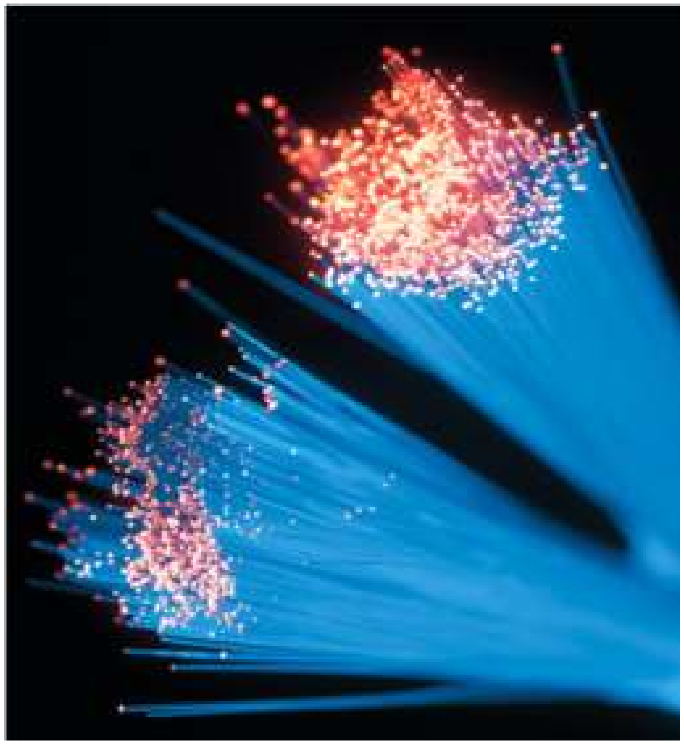


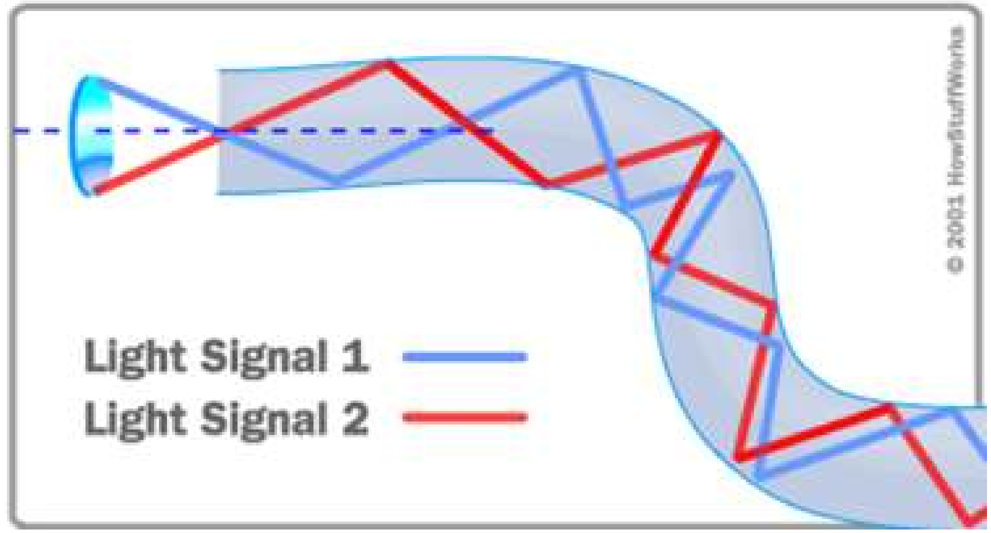



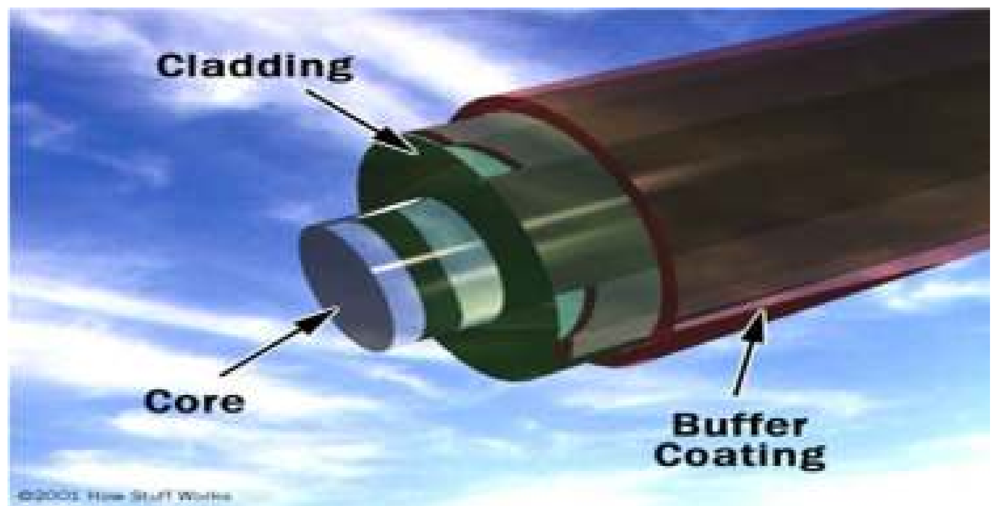
# 2.) Coaxial cables

- A coaxial cable consists of 2 wire conductors which are insulated
  - an inner metal conductor covered by an insulator
  - a second conductor(in the form of thin wire braid) that covers the first insulator
  - another protective layer of insulation covering the braided conductor
- Example: linking aerial to television, cable jack to amplifiers.
- 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 as the outer conductor is usually connected to earth.
- Coaxial cable causes less attenuation of the signal. This means that, for long distance communication, repeater amplifiers can be arranged further apart.
- Coaxial cables are less prone to external interference, though not immune to it, so they do offer slightly greater security compared to wire-pairs.
- The bandwidth of coaxial cables is about 50 MHz, hence much more information can be carried along a coaxial cable than along a wire-pairs.
- However, coaxial cables are more costly.

# 3.) Optic fibres





# 3.) Optic fibres

- An optic fibre consists of a fine strand of very pure glass(thinner than hair) surrounded by protective covering.
- Signal is in the form of series of pulses of light or infra-red radiation carrying digital data travel along the fibre as a result of total internal reflection.
- The radiated pulses are provided by lasers (light amplification by stimulated emission of radiation) and have very high frequencies of the order of $10^8$ MHz (i.e.$10^{14}$ Hz)
- In theory a single pulse need only last for $10^{-14}$ seconds; such high frequencies mean a large bandwidth. This would allow hundreds of thousands of individual telephone calls to share the same optic fibre.

- The advantages of transmission using optic fibres are indicated below.

  1.) Optic fibres have a wide bandwidth. This gives rise to a large transmission capacity simultaneously. Fewer links are required. Thus reduced calls cost.

  2.) Signal power losses in optic fibres are relatively small. This allows for longer uninterrupted distances between regenerator amplifiers and reduces the costs of installation.

  3.) The cost of optic fibre is much less than that of metal wire.

# 3.) Optic fibres

- Continue…

  4.) The diameter and weight of fibre optic cables is much less that that of metal cables. This implies easier handling and storage and smaller diameter means all rays have almost same path length.

  5.) Optic fibres have very high security since they do not radiate energy and thus there is negligible 'cross-talk' between fibres.

  6.) Optic fibres do not pick up electromagnetic interference. This means they can be used in electromagnetically 'noisy' environments, for example alongside electric railway lines.

  7.) Optic fibre is ideal for digital transmissions since the light is obtained from lasers that can be switched on and off very rapidly.

- Disadvantages:

  1.) High investment cost.

  2.) More fragile than copper wires.

  3.) Requires special skills **-** Optical fibres cannot be joined together as a easily as copper cable and requires additional training of personnel and expensive precision splicing and measurement equipment.

# 4.) Radio waves

- When radio was first developed, an electrical oscillation of a very low rate, a few kilohertz (the carrier wave) was linked to a long wire – the aerial.
- It then soon became possible to modulate the carrier wave (by AM or by FM) so that information could be sent at a much faster and higher rate. Different carrier frequencies allowed different radio stations to share the same air space (frequency multiplexing).
- Energy that is radiated from an aerial is in the form of electromagnetic waves and is propagated at the speed of light. If the frequency of the transmitted waves are somewhere in the range from 30 kHz to 3 GHz, then the waves are known as radio waves.
- The electromagnetic radiation that is emitted from a transmitting aerial can be arranged (by suitable choice of the aerial) to radiate in all directions (e.g. for national broadcasting).
- For point-to-point communications, the aerial can be arranged to radiate mostly in one direction. No matter what aerial is used, there is always energy loss and the power of the signal picked up by a receiving aerial is reduced as the distance between the transmitter and the receiving aerial is increased.

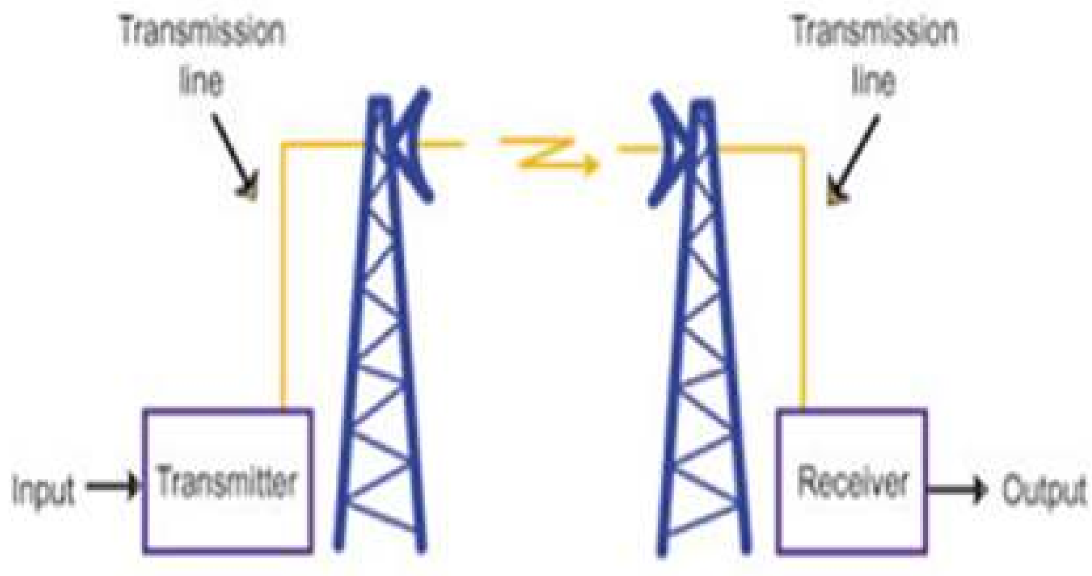
# 4.) Radio waves

- The actual distance any particular waves propagate is dependent on frequency, as illustrated in table below.

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

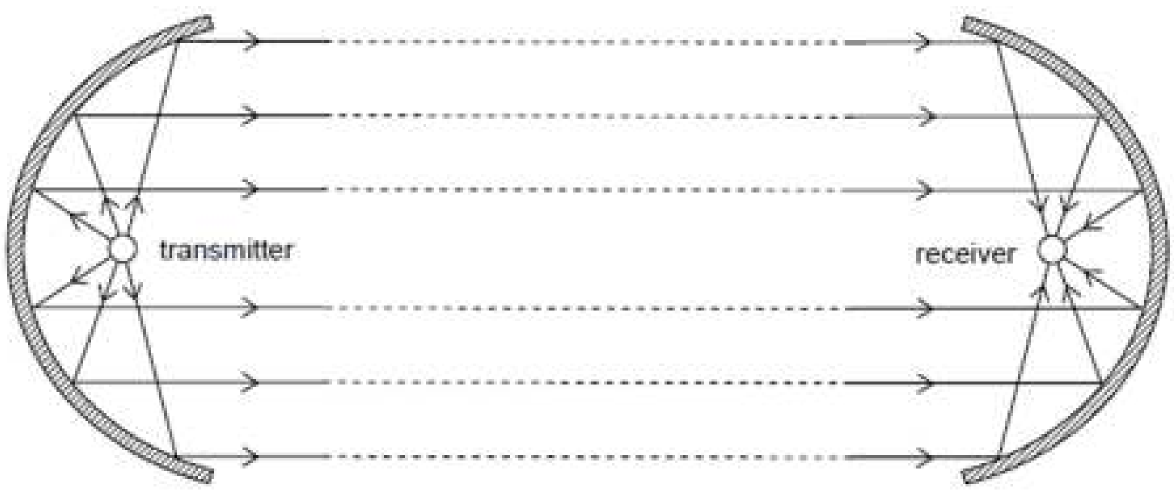
- ***Surface waves*** have low frequencies and follow the Earth's surface.
- ***Sky waves***, which are mostly high frequency waves, are reflected by the ionosphere and the Earth.
- ***Space waves*** are waves with frequencies above 30 MHz and not reflected by the ionosphere. They can only be used for 'line of sight'(i.e. straight) communication but their range can be extended by a satellite link.

# 5.) Microwave link



# 5.) Microwave Link

- Microwaves are also electromagnetic waves but they are in the range of 3 GHz to 300 GHz and are generally used for point to point communications as the range of transmissions is limited to line of sight.
- For long distance transmission, many repeater stations are required.
- Reflecting parabolic dishes are used so that the transmission is in the form of a parallel beam and so that as much wave power as possible can be focused onto the receiving aerial.
- The reflecting parabolic dishes at the transmitter or the receiver are not the aerials. The aerial is found at the focus of the transmitting or reflecting dish.
- The bandwidth of a microwave link is of the order of 1 GHz which means that the microwave beam has a large capacity for transmitting information.



# Channels of Communication using EM spectrum

- As a means of communicating from a single transmitter over a large area, the AM broadcasts on the LW and MW are relatively cheap and technically simple.
- In modern communication, considerable use is made of the VHF and UHF wavebands for mobile phones, walkie-talkie radio etc.
- This is due to the fact that, at these frequencies, the wavelength is relatively small and hence the aerial can be made conveniently short.
- The part of the electromagnetic spectrum used for communication is shown below.

| | 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<br>extra-high frequencies EHF | 3 GHz → 30 GHz<br>30 GHz → 300 GHz | 10 cm → 1 cm<br>1 cm → 1mm |

- <u>The bandwidth of a communication link increases as the frequency of the carrier wave increases.</u>

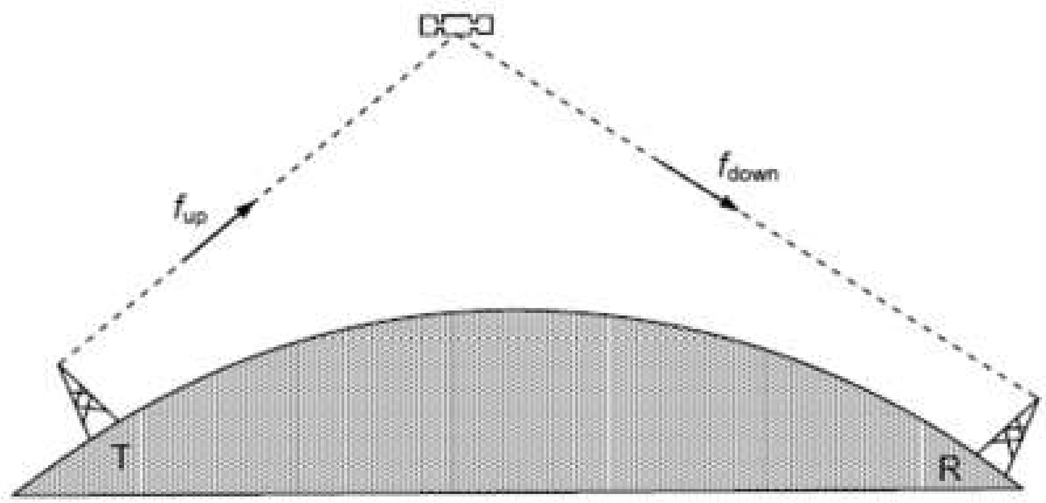
# *Satellite communication*

# Satellite Communication

- Although long distance communication using radio waves is possible on the MW waveband (as surface waves) and the SW waveband (as sky waves), for modern communication systems, there are some disadvantages:
  1.) Long distance communication using sky waves is unreliable as it depends on reflection from layers of ions in the upper atmosphere which vary in height and density. This gives rise to variable quality of signal.
  2.) Surface waves are also unreliable because there is poor reception in hilly areas.
  3.) The wavebands available on MW and SW are already crowded.
  4.) The bandwidths that are available are narrow and completely unable to carry large amounts of information.

- Satellite communication enables more wavebands to be made available and at much higher frequencies, thus giving rise to a much greater data carrying capacity.

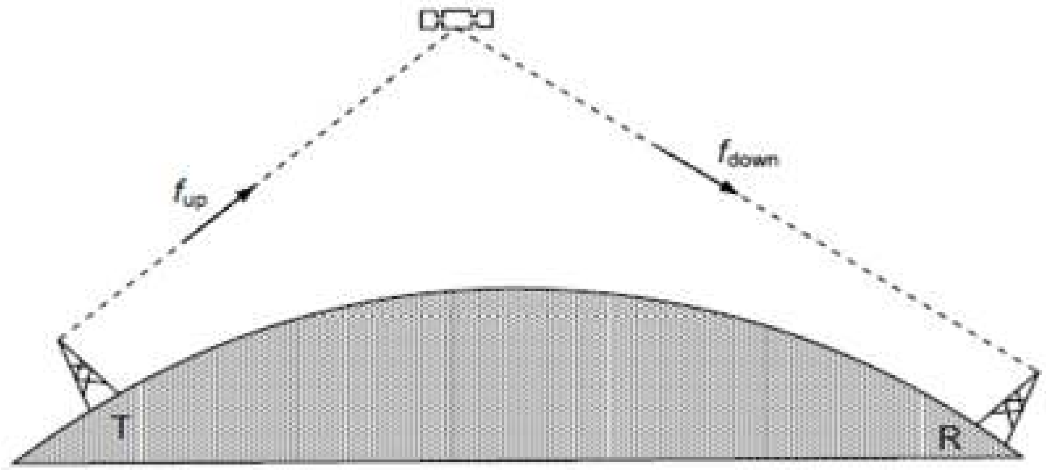
# Basic principle of satellite communications




**<u>Procedure</u>**

1) ***A carrier wave of frequency $f_{up}$ is sent from a transmitter T on Earth to a satellite***
2) ***The satellite receives the signal greatly attenuated***
3) ***The signal is amplified***
4) ***The carrier frequency is changed to a lower frequency $f_{down}$***
5) ***The carrier wave of $f_{down}$ is then directed back to a receiver R on Earth***

# Basic principle of satellite communications




- The 'uplink' and 'downlink' carrier frequencies $f_{up}$ and $f_{down}$ respectively are different so that the very low power signals received from Earth are not swamped by(i.e. can be distinguished from) the high power signal that is transmitted back to Earth
- Some typical values of uplink/downlink are 6/4 GHz(6/4 GHz band), 14/11 GHz and 30/20 GHz
- We are going to see the 2 kinds of satellites namely:

**1.) Geostationary Satellite**

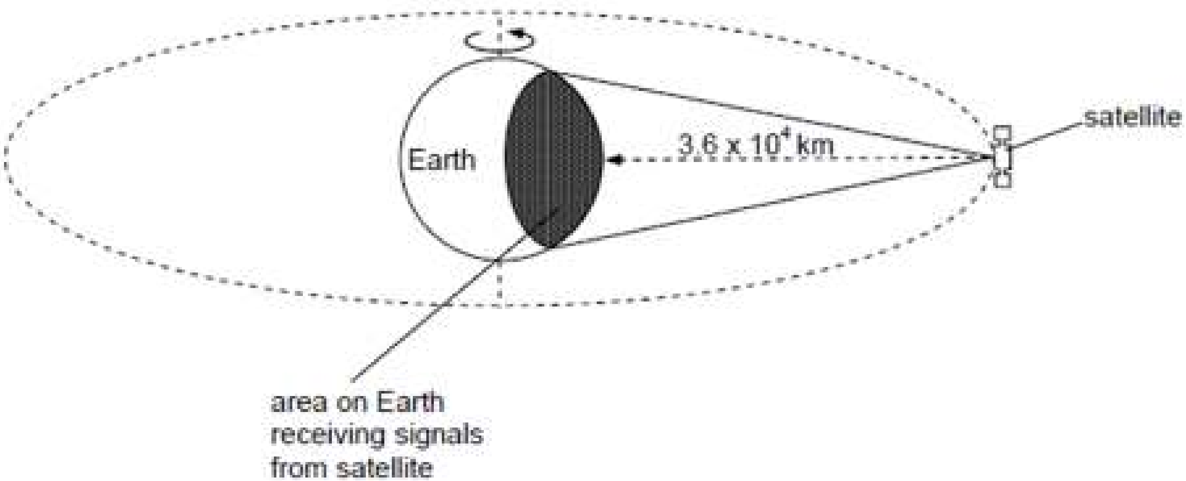
**2.) Polar Satellite.**

# Geostationary Satellite

- The communication satellite may be in **geostationary orbit** which means that the satellite is above the equator, orbits the Earth with a period of 24 hours at a height of 3.6 x $10^4$ km above the Earth's surface and in the same direction as the rotation of the Earth which is from west to east.
- From the viewpoint of a person on Earth, the satellite remains above the same point on the Earth's surface.
- The transmitting aerial and the receiving aerial on Earth both have large parabolic reflectors
- Advantage of geostationary satellites is that these aerials can be in fixed positions and hence the satellite does not need to be tracked.
- This also means that a geostationary satellite can have a permanent link with a transmitting ground station hence maintaining communications with any point on the Earth's surface that can receive the signal from the satellite.
- A number of satellites with overlapping areas allows for long distance communications removing the need for long distance submarine cables
- Geostationary satellite is used for television broadcasting (allowing for 'live' events in one country to be viewed by another), telephone communication, & weather monitoring.

# Geostationary Satellite

- There are problems with geostationary satellites.
- Geostationary satellites are in equatorial orbits which means that *communication in polar regions (north & south) may not be possible because a satellite will not be in line-of-sight.*
- The height of the orbit may also pose a problem as between the transmission and receipt of the signal, the wave must travel at least twice the distance between the satellite and Earth i.e. $7.2 \times 10^4$ km for which the time to travel is 0.24 seconds. Hence, longer time delay.
- This delay may be increased where several satellites were involved and would not be acceptable for telephone conversation.
- To avoid these problems, geostationary satellites may be used in conjunction with optic fibres.



# Polar Satellite

- Polar orbits are relatively low with a period of rotation of the order of 90 minutes.
- Such satellites will, as a result of the rotation of the Earth, at some time each day orbit above every point on the Earth's surface.
- For a satellite having a period of 90 minutes, each orbit crosses the Equator 23° to the west of the previous orbit.
- It is not possible to have continuous communication links with one such satellite because, from Earth, the satellite appears to move rapidly across the sky and, for part of the time, is below the horizon.
- Polar orbiting satellites are used for communications, for monitoring the state of the Earth's surface, weather forecasting, spying etc.

# Polar Satellite

- Polar orbiting satellites are used for communication since they are in low orbits, resulting in short time delays between transmission and receipt of a signal.
- Furthermore, total global coverage is possible. However, a network of such satellites is required in order to maintain continuous links.
- The satellites must be tracked and the link switched from one satellite to another.
- Geostationary satellites have the advantage that they do not need to be tracked.