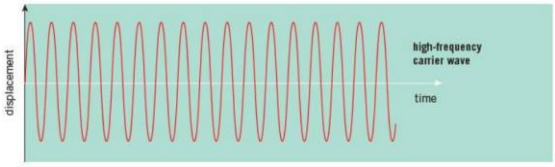
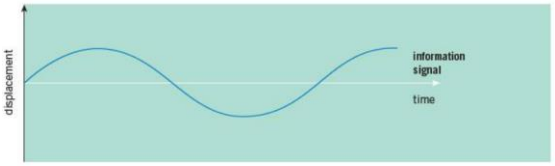
Communication

A. RADIO WAVES

- **Radio systems** start with sound passing into a microphone, the sound signal is converted into a radio signal and at the end, converted back into a sound signal.
- **The information signal** is transmitted with a **carrier wave**; higher frequency so shorter aerial required and different frequencies for different stations.
- The high-frequency wave has either its amplitude varied or its frequency varied so as to carry information, this called by **modulation**

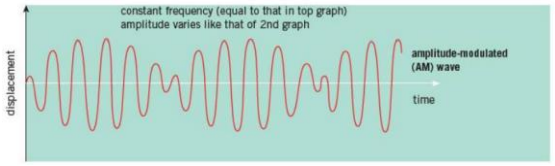




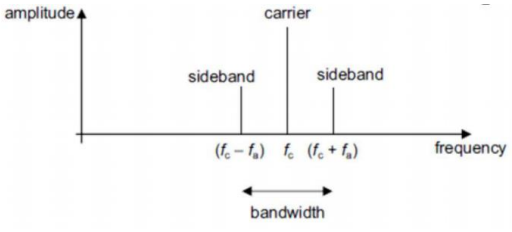
- **Advantages of Modulation over Direct:**
  - Shorter aerial required
  - Longer transmission range
  - Less attenuation
  - Allows more than one station in a region
  - Less distortion

B. AMPLITUDE MODULATION (AM)

- In **amplitude modulation (AM),** the carrier wave has constant frequency. The amplitude of the carrier wave is made to vary. These variations are in synchrony with the displacement of the information signal.
- The rate at which the carrier amplitude varies is equal to the frequency of the information signal.



- **An amplitude modulated wave consists of three components:**
  - Original carrier wave of frequency f_c and amplitude A_c
  - A wave of frequency $f_c - f_a$ and amplitude $\frac{A_a}{2}$
  - A wave of frequency $f_c + f_a$ and amplitude $\frac{A_a}{2}$

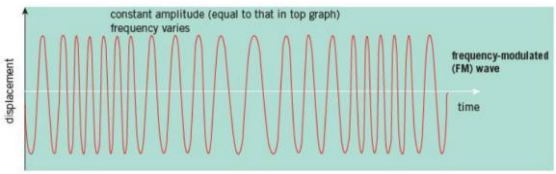


- The range of frequencies from the min to max in modulated carrier wave is called its **bandwidth.**

$$(f_c + f_a) - (f_c - f_a) = 2f_a$$

C. FREQUENCY MODULATION (FM)

- In **frequency modulation (FM),** the amplitude of the carrier wave remains constant. The frequency of the carrier wave is made to vary in synchrony with the displacement of the information signal.



- The rate at which the carrier wave frequency is made to vary is equal to the frequency of the information signal**.**

D. COMPARISON OF AM AND FM

Amplitude modulation:

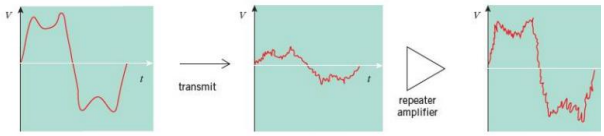
Pros	Cons
• Smaller bandwidth so more stations available in frequency range. • Greater area covered by one transmitter. • Cheaper radio sets.	• Requires a high power transmitter. • More electrical noise and interference.

Frequency modulation:

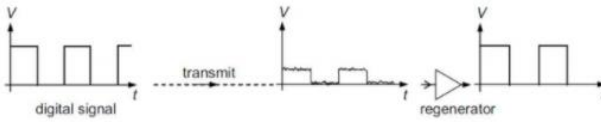
Pros	Cons
• Less electrical noise and interference. • Greater bandwidth produces better quality sound.	• Shorter range. • More complex circuitry. • More expensive.

E. ANALOGUE AND DIGITAL SIGNALS

- An information signal that has the same variations with time as the information itself is known as an **analogue signal.**
- **Noise** is not just unwanted sound, but any unwanted random signal that adds to the signal that is being transmitted.



- A **digital signal** consists of a series of 'highs' and 'lows' with no values between the 'highs' and the 'lows'.
- Digital signals are made up of only highs and lows so even though they get noisy during transmission, regenerator amplifiers reproduce the original digital signal and hence 'filter out' the noise.



E. ANALOGUE TO DIGITAL CONVERSION

Process:

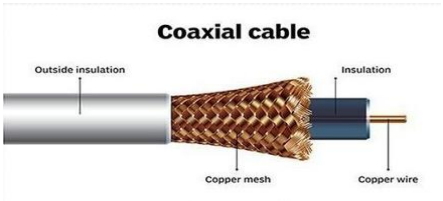
analog sound waves are converted to digital format and vice versa.

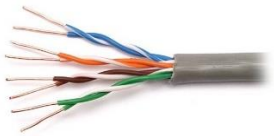
- an **Analogue to Digital Convertor (ADC):** Any device which can convert continuous natural sound waves into a digital format.
- ADCs are used together with analogue sensors (microphone).
- an **Digital to Analogue Convertor (DAC):** Any device which can convert a digital audio signal into a continuous natural sound waves.

- The digital signal is written in binary which has base 2 and each digit of a binary is called **bit**.
- Binary number only consist of 0 and 1 where 'high' voltage is represented by 1 and 'low' voltage by 0.

F. CHANNELS OF COMMUNICATION

- **Wire Pairs** (linking a land telephone to the local exchange)
- **Coaxial Cable** (connecting an aerial to a television)



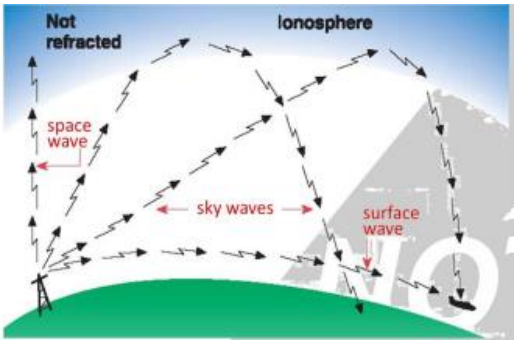


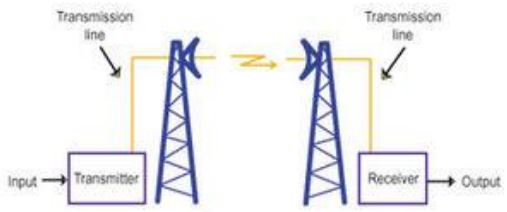
- **Comparison:**

Coaxial cable	Wire-pairs
Higher bandwidth	Low bandwidth
Highly secured	Have low velocity
Little cross-talk	Sometimes suffer from cross-talk
Less electrical interference and noise	There is noise and interference
Signal less attenuating	Signal attenuated greatly

C. RADIO AND MICROWAVE LINKS

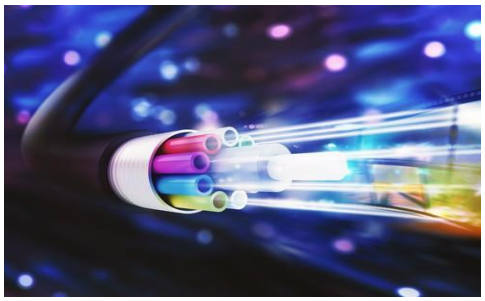
- Both are electromagnetic waves with wide range of frequencies.
- Security is achieved only by encoding the information.
- Their mode of use and range depend on frequency.





- **Surface waves:** travel close to the surface of the earth and diffract around it due to long wavelengths.
- **Sky waves travel in** the atmosphere in straight lines, reflecting back and forth between the ionosphere and Earth's surface hence can go a long distance.
- **Space waves** have a higher frequency so pass through the ionosphere and transmit in the line-of-sight.
- **Microwave**, with 3GHz – 30GHz frequency range generally used for point-to-point communication.
- **Reflecting parabolic dishes** used so that the transmission is in the form of a parallel beam and as much power as possible can be focused on the receiving aerial.

H. OPTIC FIBERS



- Thin, flexible glass rods surrounded by a protective covering. Used to carry digital info and transmitted with infra-red radiation along the fiber as a result of **total internal reflection**.
- **Advantages:**
  - Large bandwidth, carry more information.
  - Low attenuation of signal, fewer regenerator amplifier required.
  - Low cost.
  - Smaller diameter than metal cable, less weight, easier handling/storage.
  - High security/no crosstalk low noise/no electromagnetic interference.

I. SATELLITE

- **Carrier wave** is sent from a transmitter on earth to satellite.
- Satellite receives the greatly attenuated signal.
- The signal is amplified and the carrier wave's frequency is changed to a lower value.
- Carrier wave sent back to earth.
- The different frequencies prevent swamping of uplink signal.
- Satellite communication enables more wavebands to be made at higher frequency so that much greater data-carrying capacity.

Geostationary satellites and Polar satellites

Polar Satellites	Geostationary Satellites
Not always in the same position relative to earth	Remains in fixed position above point on equator
Cannot be used for continuous comm.	Can be used for continuous comm.
Used for remote sensing	Continuously monitor climatic change
Travels from pole to pole with a shorter period	Satellite rotates with the same period as earth
Satellite passes over every area on earth	Cover only one third of the earth's surface
At smaller height above the earth and can detect objects of smaller detail	In equatorial orbit, from west to east with period of 24 hours
Difficult to track down the satellite	Easy to track down the satellite
Smaller delay times	Large delay time

J. SIGNAL ATTENUATION

- **Attenuation:**
  - The gradual decrease in power of a signal when it travels along medium such as wire, air, or fiber.
  - The further it travels, the more power it losses.

$$number\ of\ bels = \log\left(\frac{P_{out}}{P_{in}}\right)$$

- **Note:**
  - 1 bel = 10 decibels.
  - If $P_{out} > P_{in}$ the dB number is positive and there has been amplification.
  - if $P_{out} < P_{in}$ the number of dB is negative and there is attenuation.

- In a transmission line such as cable, the amount of attenuation is dependent on the length of the line and is calculated with

$$\text{Attenuation per unit length } (\text{dB km}^{-1}) = \frac{1}{L}10log\left(\frac{P_2}{P_1}\right) = \frac{attenuation\ (dB)}{length\ of\ cable\ (km)}$$

- Signal must be distinguishable above the level of noise, and can be measured by,

$$\text{signal to noise ratio} = 10\log\frac{signal\ power}{noise\ power}$$

- **Note:** The signal attenuation, the power gain on amplification, and the signal-to-noise ratio, are all given as a ratio of powers.

K. EXERCISE

- Frequencies in the UHF range normally propagate by means of:
  a. Ground waves
  b. Sky waves
  c. Surface waves
  d. Space waves

Answer:

d. Space waves

Solution:

Owing to its high frequency (UHF) wave can neither travel along the trajectory of the ground nor can it get reflected by the ionosphere. The signals having UHF are propagated through line-of-sight communication, which is nothing but space wave propagation.

- Digital signals

(i) do not provide a continuous set of values,

(ii) represent values as discrete steps,

(iii) can utilize binary system, and

(iv) can utilize decimal as well as binary system.

Which of the above statements are true?

a. (i) and (ii) only
b. (ii) and (iii) only
c. (i), (ii) and (iii) but not (iv)
d. (i), (ii), (iii) and (iv).

Answer:

c. (i), (ii) and (iii) but not (iv)

Solution:

A digital signal uses the binary (0 and 1) system for transferring message signals. Such a system cannot utilise the decimal system (which corresponds to analogue signals). Digital signals represent discontinuous values.

- A signal is amplified by two amplifiers, A and B, connected in series. The input power to amplifier A is 17 μW. Amplifier A has gain of 20 dB. The output power from amplifier B is 0.26 W. Determine:
(a). the overall gain, in dB, of the two amplifiers,
(b). the gain of amplifier B

Solution:

$$\text{(a) Gain in } dB = 10\ log\left(\frac{0{,}26}{17 \times 10^{-6}}\right)$$

$$\text{Overall gain in } dB = 10 \times 4.1845 = 41.8\ dB$$

(b) With all in dB,

Total gain = gain in first stage (A) + gain in second stage (B)

$$41.8 = A + 20$$

$$A = 21.8dB = 22dB$$