20 - Communication systems

Q-1) What are the different channels of communication?

① **Wire pairs :**

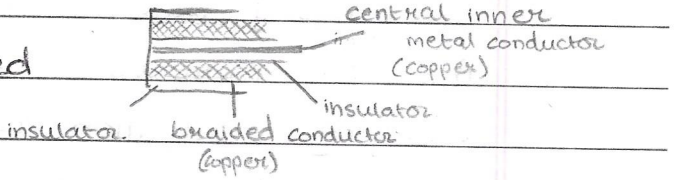
Link transmitter and reciever by means of 2 copper wires

Used for short distance communication at low frequency.

eg: Connect telephone to a socket.

eg : connect doorbell to switch outside the door.

② **Coaxial cables :**



An electrical signal is transmitted along the central inner conductor.

The wire braid is earthed and acts as a return for the signal and shields the inner conductor from external interference.

eg: connect aerial to TV receiver.

eg : mobile phones.

③ **Radio waves :**

A.C. in wire acts as an aerial. Energy is radiated from the aerial in the form of EM (radio) waves.

* A.M. and F.M. waves.

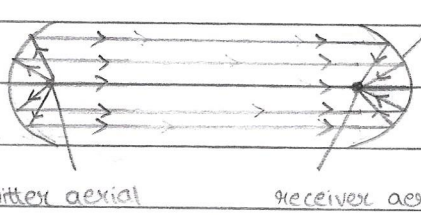
30 kHz – 3 GHz. eg: radio's

④ **Microwaves :**

Microwave (EM) waves are uses for point-to-point communication since their range of transmission is limited to line of sight.

eg: link ground station to a satellite.

Reflecting parabolic dishes are used so that the transmission is in the form of a parallel beam and then maximum wave power can be focused onto the receiver.



⑤ Optic fibres :

It consists of fine strands of very pure glass surrounded by a protective covering.

Pulses of light or infra-red radiation travel along the optic fibre as a result of total internal reflection, carrying information along the fibres.

- radiation pulses are provided by lasers and have a very high frequency.

* Infra-red rather than visible light is used because it has less attenuation ∴ fewer repeaters are required.

Q-2) What is modulation?

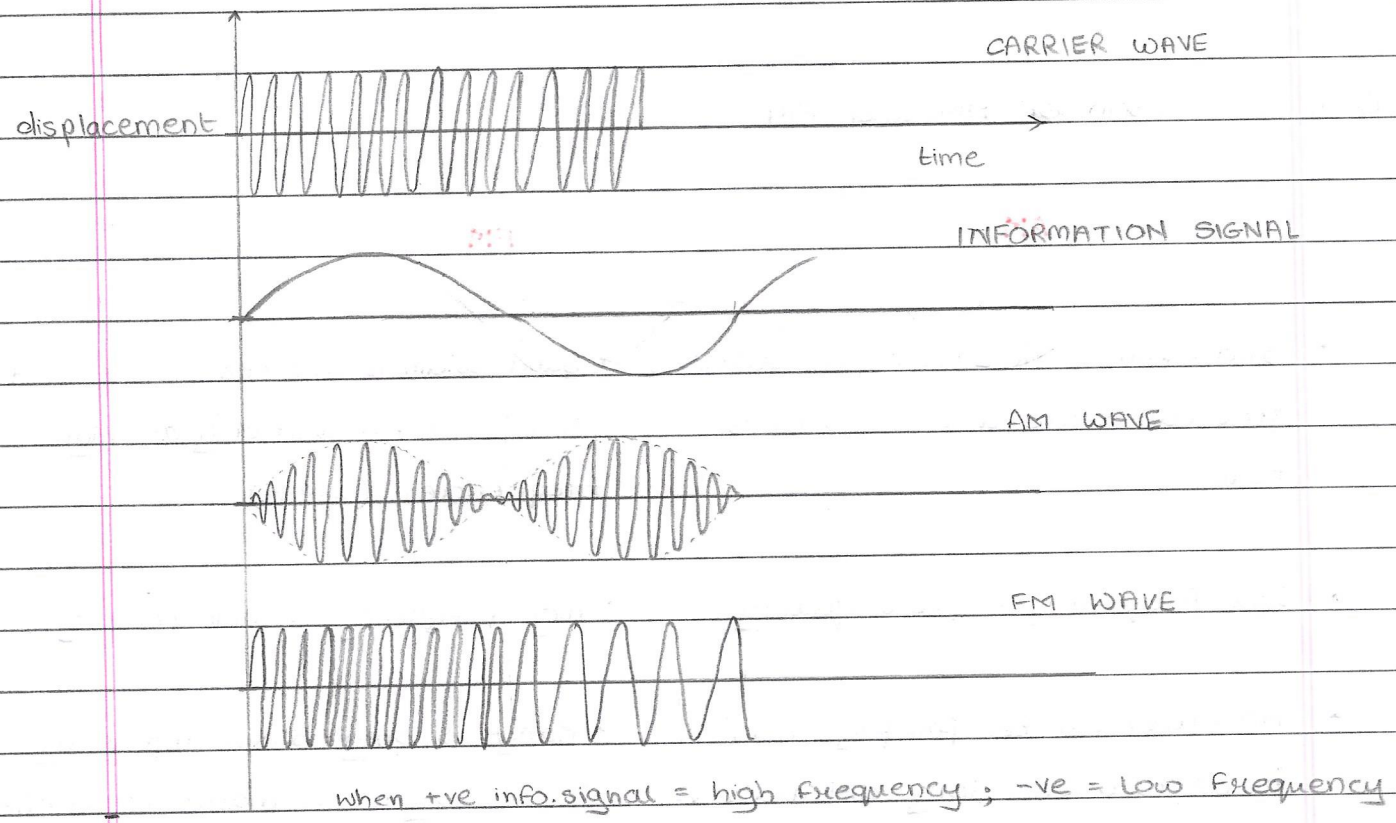
> In modulation, a high frequency wave, known as a carrier wave, has either its amplitude or frequency altered by the information signal (of low frequency) so as to carry information.

* Amplitude modulation (AM)

The amplitude of the carrier wave is made to vary in accordance with displacement of the information signal. It's frequency remains constant.

* Frequency modulation (FM)

The frequency of the carrier wave is varied in accordance with displacement of the information signal. It's amplitude remains constant.



Need for modulation:

- allows more than to
~~only~~ one radio station ~~can~~ operate within the region
- less distortion / less attenuation.
- shorter aerial will be required

3) Side bands and band width?

. Bandwidth is the range of frequencies occupied by the Amplitude-modulated (AM) waveform.

> When a carrier wave of frequency f_c is Amplitude-modulated by a frequency f_s by the information signal, it contains 2 other frequencies:

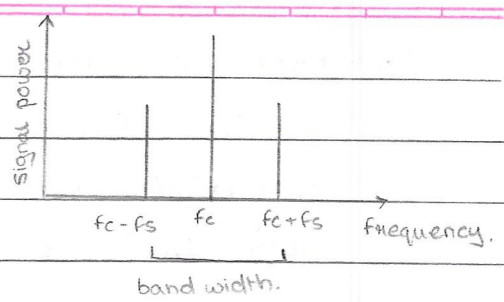
upper sideband : $f_c + f_s$

lower sideband : $f_c - f_s$.

Bandwidth = upper - lower band.

$(Fc + Fs) - (Fc - Fs)$

$= \underline{2Fs}$



Q-4) Comparison of AM and FM.

AM	FM
* Band width is 9kHz ∴ no. of stations that can share a wave band is more.	* Band width is 200 kHz ∴ less no. of stations. FM is used only at high frequencies (1 MHz)
* Low frequency ∴ poor quality	* High frequency ∴ high quality
* AM waves can be propagated / broadcasted over long distances ∴ one transmitter can serve a large area.	* Range is only 30km and is by line of sight ∴ many transmitters and repeaters are required for a large area.
* Interference will add-on to displacement of AM and will appear as noise in the output.	* Interference is not picked up by the reciever since it doesn't alter the frequency
* AM transmitters and receivers are electronically simpler and cheaper.	

Q-5) Radio-wave Frequencies.

> EM waves within 30kHz - 3GHz are radio waves.

Type of wave	Frequency	Range.
surface wave	below 3MHz.	up-to 1000 km
sky wave	3 - 30 MHz.	worldwide by means of reflection from ionosphere and ground
space wave	greater than 30MHz.	line of sight - including satellite communication.

Communication type	frequency band	frequency range	wavelength in air
LW radio	Low (LF)	30kHz → 300kHz	10km → 1 km
MW radio	medium (MF)	300kHz → 3MHz	1 km → 100m
SW radio	High (HF)	3MHz → 30MHz	100 m → 10m
FM radio	Very-high (VHF)	30MHz → 300 MHz	10m → 1m
TV and mobiles	Ultra-high (UHF)	300 MHz → 3GHz	1m → 10cm
microwave	Super-high (SHF)	3GHz → 30GHz	10cm → 1cm
satellite	Extra-high (EHF)	30GHz → 300GHz.	1cm → 1mm

Q-6) What is noise?

> Noise is the unwanted random power that adds itself to the signal being transmitted

Sources of noise:

- thermal vibrations of the atoms of the material through which the signal is passing.

- Induced voltages from magnetic fields caused by currents.
- Radio signals emitted by mobile phones nearby.

Q-7) What are analogue and digital signals?

> Analogue signal is a signal that varies continuously over a range of values.

> Digital signal is a signal that is composed of high and low voltages (1 and 0)

Advantages of Digital signals:

① They can be transmitted over long distances with regenerating amplifiers that filter out noise.
↳ In case of analogue, the small fluctuations in amplitude produced by noise are also amplified.

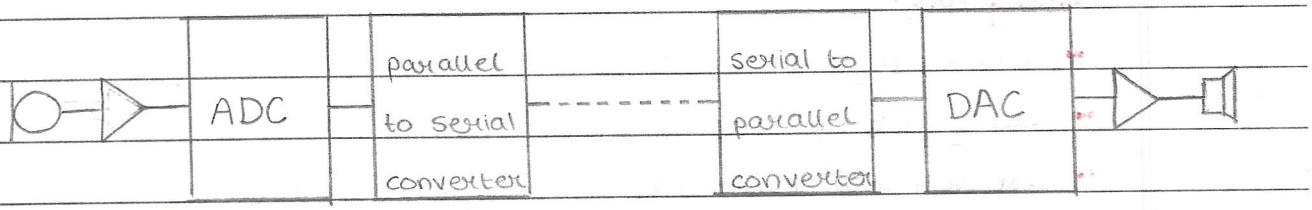
② Extra information in the form of extra bits can be added to the transmissions. These extra bits are a code for the receiving system to check for error and correct them before the signal is finally reproduced.

③ They are more reliable and cheaper.

④ They are easier to encrypt for secure transmission of data.

⑤ They are compatible with modern technology.

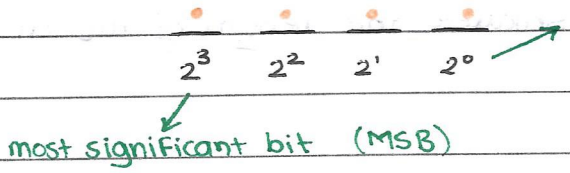
Q-8) Digital transmission system.



* In the analogue-to-digital-converter (ADC), the analogue voltage is sampled at regular time intervals. This is known as the sampling frequency/rate.
The value is then converted to a digital (binary) number.

* Sampling is the measurement of the analogue signal at regular time intervals.

Binary code:



* Parallel to serial converter takes the simultaneous bits of a number and transmits them, one after the other, down a single line.

The recovered signal can be improved by:

* Increasing the no. of bits reduces step height so smaller changes in amplitude can be detected.
* Increasing sampling frequency reduces step width, so more details of the signal can be recovered.

→ This allows the reproduction of the signal to be more exact.

Q-9) Comparison of the channels of communication

> Wire pairs:

- cause high attenuation
- easily pick up noise
- suffer from cross-talk and have low security
- have limited band-width.

> Coaxial cables

- more costly
- causes less attenuation
- less noise & cross-talk and are more secure
- have larger band-width.

> Radio and microwave links

* wavelength of radio-waves determines the length of the aerial.
  ↳ Shorter the wavelength, smaller the length of the aerial.
- have large band-width
- repeaters are required.

> Optic fibres

- have large bandwidth ∴ carries more information.
- cheaper than metal wires
- much less attenuation ∴ less repeaters / regenerator amplifiers required.
- Dont pick up EM interference and negligible cross-talk ∴ high security.

Q-10) Communication satellites.

- In sky waves, communication depends on reflection from layers of ions in the upper atmosphere.
  These layers of ions often vary in density, giving rise to a variable quality of signal.
- Only a few frequencies in the MW and SW bands are available.

Satellite communication uses higher frequencies, which have a higher bandwidth and can carry more information.
It provides a stronger signal than is obtained by reflection from the ionosphere.

The uplink (Fup) and downlink (Fdown) frequencies are different so that the low power signal recieved from the earth is not swamped by the high power signal transmitted back to earth.

Typical Fup/Fdown values:

6/4 GHz, 14/11 GHz, 30/20 GHz.

Geostationary satellites * pg 10 for exact definition.

↳ the satellite is in orbit above the equator with the same period as the Earth and appears to be fixed.

- no need to be tracked
- time delay
- uses: weather monitoring, telephone communication, TV transmission
- they are in communication with transmitter & receiver at all times (continuous communication)

Polar satellites

↳ they have low orbits and pass over the poles.

- less time delay
- whole of the Earth can be covered
- needs to be tracked
- more no. of satellites required for continuous communication.
- uses: weather forecasting, GPS, studying Earth's surface (eg: monitoring crop growth, melting of polar ice caps.)

Q-11) What is attenuation?

> Attenuation is the gradual decrease in the power of a signal the further it travels.

Causes of energy loss:
- power lost as heating of wire (I^2R loss)
- in optic fibres, power is lost due to absorption in impurities in glass and scattering due to imperfection.
- EM waves lose power in air due to absorption and scattering.

$$dB = 10 \log \frac{P_2}{P_1}$$ → amplification

$$-dB = 10 \log \frac{P_2}{P_1}$$ → attenuation. → to ignore -ve sign

OR $$dB = 10 \log \frac{P_1}{P_2}$$

Signal-to-noise Ratio:

$$dB = 10 \log \frac{P_{signal}}{P_{noise}}$$