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Communication System

→ Transducers are the devices which convert one form of energy into another.
Eg: Loud speaker, Cameras, Human Eye, Brain

→ Strength of the sound is decided by amplitude.
→ Pitch of the sound is decided by frequency

Q. The pitch of the buzzing of mosquito is less than or much more than the roaring of lion? In terms of loudness?

Ans. The pitch of buzzing of mosquito is more, but it is less ~~loud~~, loud, because loudness does not depend on pitch.

→ The instantaneous position of a particle tells us the phase of the particle.

→ The process of changing some characteristics like amplitude, frequency, phase of a carrier by a signal is called modulation.
(modification, change)

It means that we modify the carrier with a signal & it is an important process of wireless communication.

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Need for Modulation :

① The original sound produced by microphone is weak and has a low frequency.

② Describes the height of the antenna needed

$$v = f\lambda$$

If the frequency of the signal is 20 KHz, length of the antenna comes out as 15 km.

$$3 \times 10^8 = 2 \times 10^4 \times \lambda$$

$$\Rightarrow \lambda = 15 \text{ km}.$$

If $f = 1$ MHz, $\lambda = 300$ m

If the frequency of the signal is raised to 1 MHz, the wave can be transmitted.

③

* Types of Modulation

$$e = E_m \sin(\omega t + \phi)$$

- e : Instantaneous value of modulated wave
- E_m : Maximum amplitude
- $\omega t + \phi$: Angular velocity

The 3 characteristics - amplitude, frequency & phase of carrier wave is changed in accordance with the instantaneous value of the signal.

Accordingly, modulation is of 3 types:

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The complete classification of modulation :

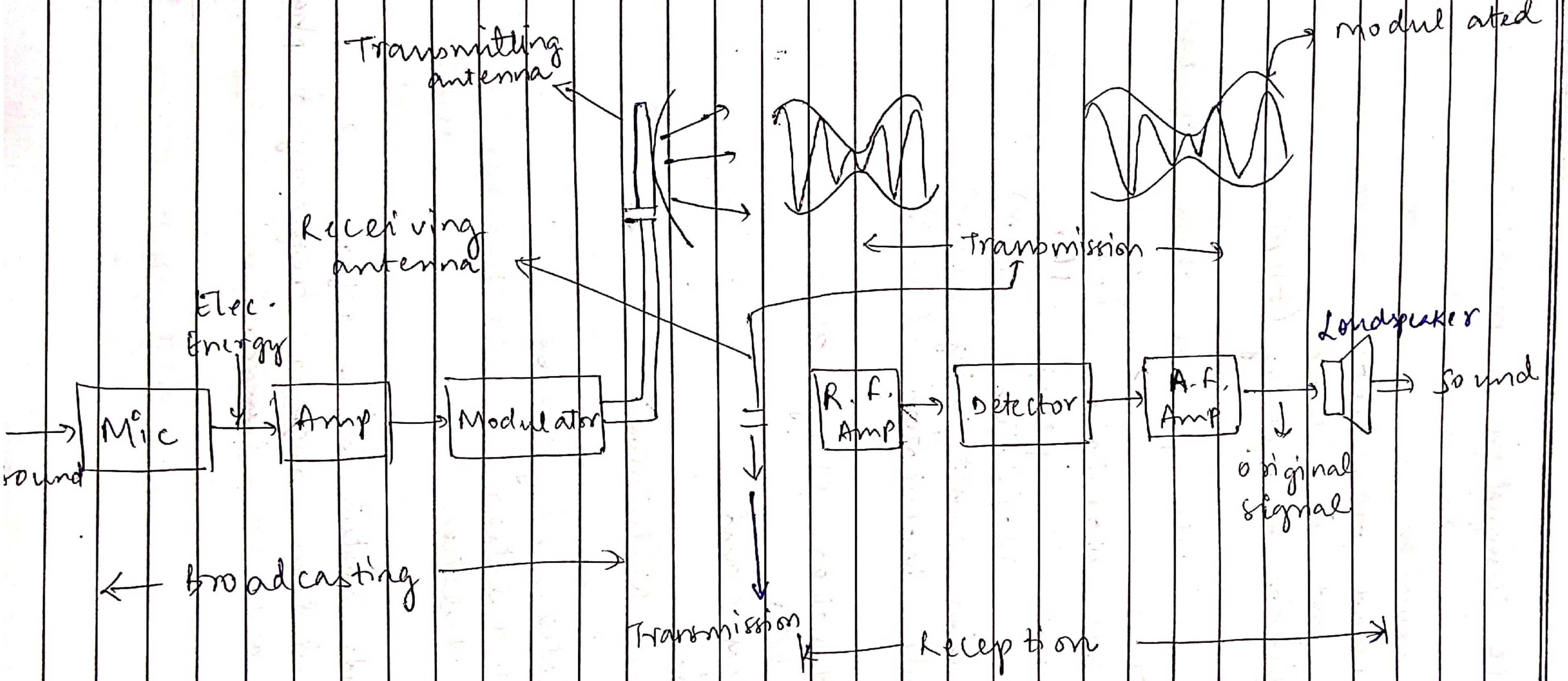
Amplitude Modulation
→ Single Sideband AM (SSBAM)
→ Double Sideband AM (DSBAM)
→ Frequency Division Multiplexing (FDM)

⇒ The other modulation processes which use use in pulse modulation.
Pulse Amplitude Modulation (PAM)
Time Division Multiplexing (TDM)
Pulse Time Modulation (PTM)
Pulse Division Multiplexing (PDM)
Pulse Code Modulation (PCM)

Digital Modulation may be :
- Differential PCM,
- Adoptive PCM and
- Data Modulation
- Adoptive Data Modulation

The modulations may also be
- Analog Modulation
- Digital Modulation

⇒ The amplitude modulation is referred as linear Modulation; whereas frequency & phase modulation are non-linear.



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→ The broadcasting consist of microphone, amplifier, modulator and transmitting antenna.
→ For Reception consist of receiving antenna, R.F. Antenna, detector, A.F. amp. and the loudspeaker.

(A) Broadcasting
→ Microphone - It is a transducer which converts sound energy into electrical energy; and the speaker generates the sound of frequency b/w 20 Hz and 20 kHz, which is an audio freq.
→ Amplifier - used to amplify the signal of required strength.
The electrical signal obtained from mic is very weak, it is amplified to get reqd strength.
→ Modulator - The modulation of the signal occurs: a local oscillator generates high frequency waves called carrier waves. The signal modulates the carrier or the signal is superimposed on the carrier. The resultant waves are called modulated / radio waves

(B) Transmission
→ After broadcasting, the transmission starts. These radio waves travel in space with a speed 3×10^8 m/s, and reach the reception.

(C) Reception
→ The picking of these radio waves by radio receiver is called reception.
→ A radio receiver has following imp parts:
i) Receiving antenna - The radio waves induce an EMF on the antenna.

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ii) R.F. Amplifier - The radio waves lie in radio freq. range. The EMF induced is amplified at R.F. Amplifier.

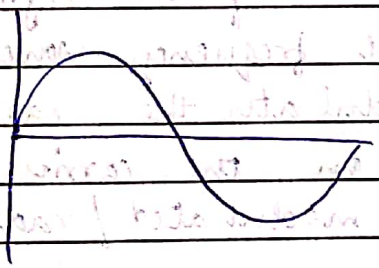
iii) Detector - The original signal is detected from the carrier by the detector circuit. The signal starts its forward journey while the carrier is grounded.

iv) A.F. Amplifier - The signal is in audio freq. range (20 Hz to 20 kHz).

v) Loudspeaker - final stage. The electric signal is again converted into the original sound signal which was produced in the broadcasting station.

→ Broadcasting means ~~out~~ to send out signal in all the directions.

→ (1)



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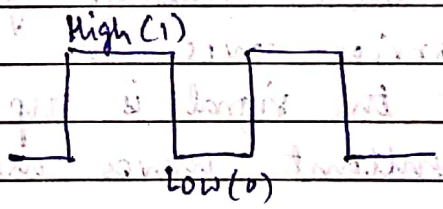

Analog form of broadcast signal in continuous variation.

Digital form of broadcast signal.

→ Reasons for error in Comm^n system :

① Bandwidth

② Noise - unwanted signals

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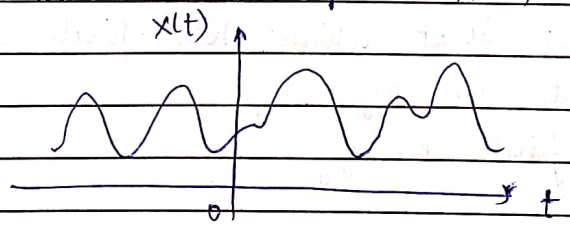
The bandwidth allowed to A.M. transmission is only 10 kHz.
Human ear requires a bandwidth of 15 KHz for complete satisfaction. ~~The to~~
The bandwidth allowed to F.M transmission is 200 kHz.

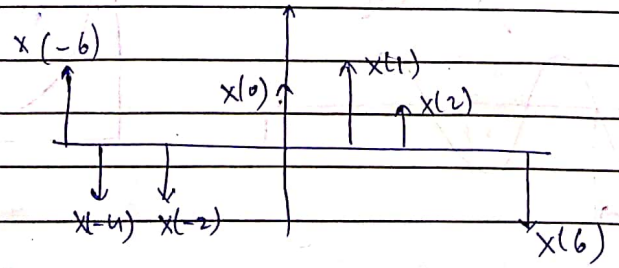
* Signal - Any signal may be a function of time, temperature, position, pressure & distance. A function ~~which consists of more~~ of one or more independent variables which contains some information is called a signal.
Eg: Voltage & Current are electrical signals, and are functions of time as independent variables.

Signals may be classified as :

(A) (1) Continuous Time Signal $x(t)$



(2) Discreet Time Signal



(B) Real & Complex signals
If value is a real no. → real signal
complex no. → complex

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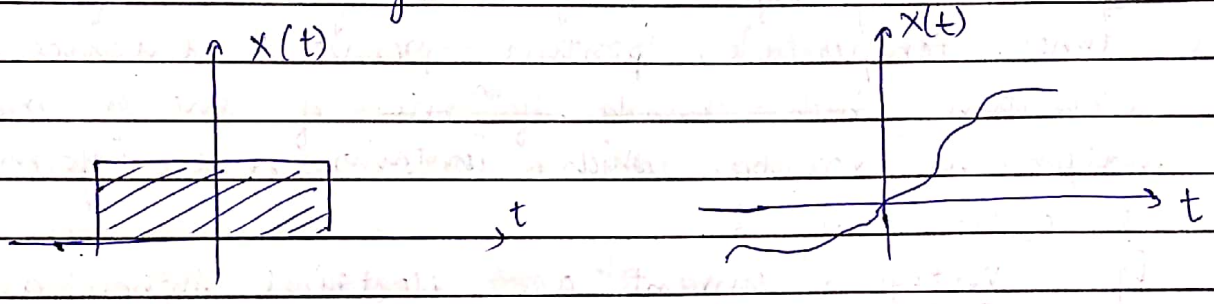
(C) Deterministic & Non-Deterministic :
Deterministic can be ~~spect~~ completely specified in time. It means we can determine the value of amplitude at a time.
Non-deterministic – irregular, instantaneous amplitude cannot be predicted.
Eg: Thermal noise

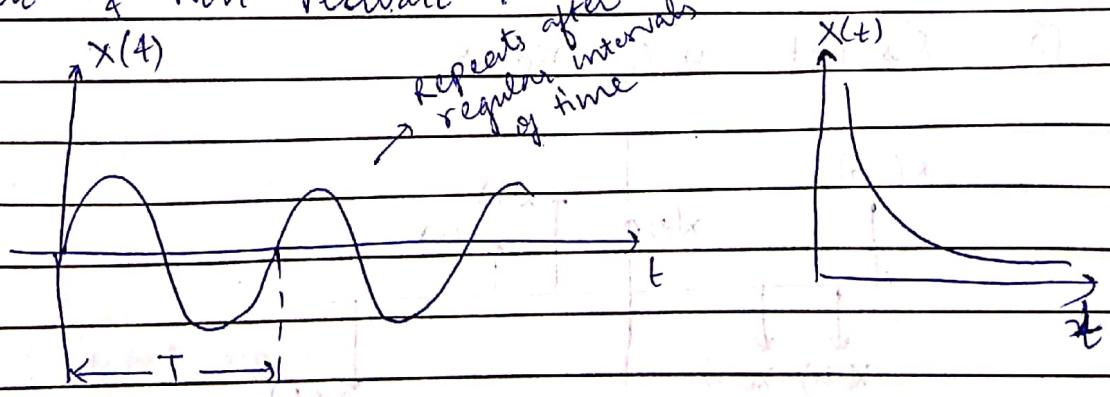
(D) Even & Odd signal :



Even signal shows symmetry in time domain & identical about origin.

(E) Power & Energy signal :
A Power signal is that which has finite average power and infinite energy.
In energy signal, finite energy

(F) Periodic & Non-Periodic :



(G) Analog & Digital signal

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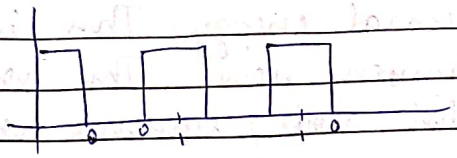
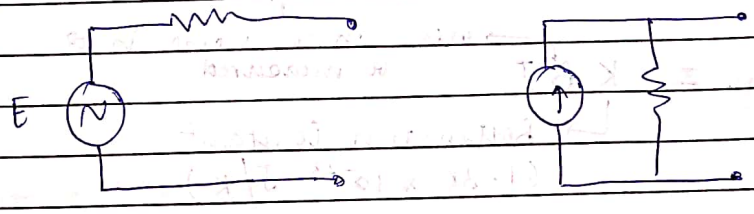
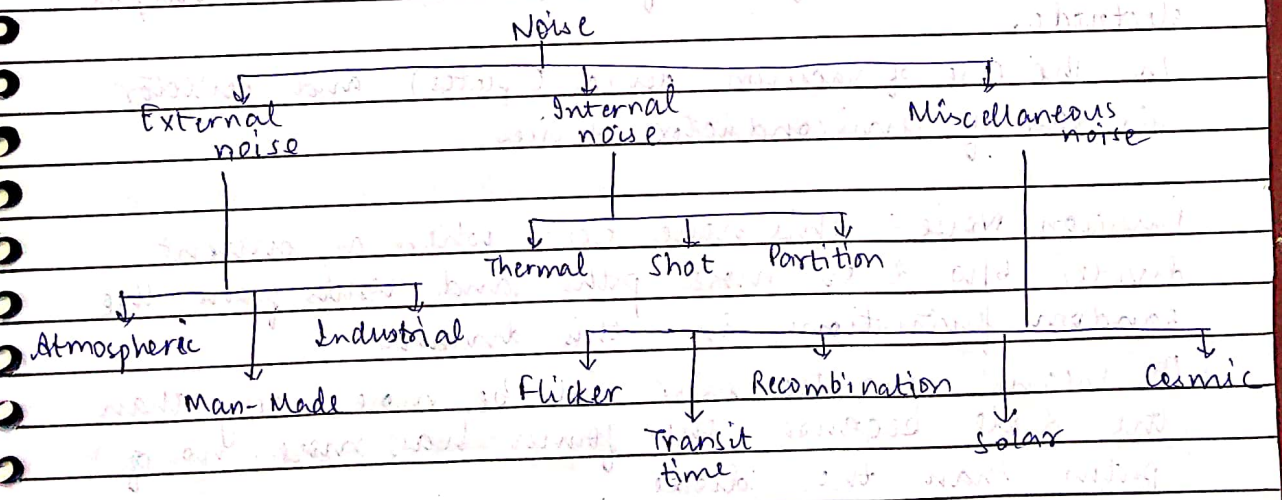


Digital

(H) Electrical signal – represented in form of voltage / current source.



* Types of Noises – Unwanted form of signal or energy that may interfere with the reception & reproduction of wanted signals.



Thermal Noise : In case of conductors, free e^- are always in random motion due to thermal energy. The average voltage resulting from this motion will be zero, but average power available is not zero, because

noise power results from thermal energy. This is known as thermal noise / johnson noise. This noise is also called agitation / white noise / resistance noise.

In transistors, the resistance noise depends on collector, base and emitter resistances.

Average noise power (P_n) $\propto$ Bandwidth (B)
$\propto$ Absolute Temperature (T)

$P_n = K B T$
- B → over which noise is to be measured
- K → Boltzmann Constant (1.38×10^{-23} J/K)

Shot noise: Occurs in all the active devices like vacuum diode, triode, transistor etc.
~~All the active~~ It occurs due to random variation in the arrival of no. of e^- (holes) at the output electrode.

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$$I_n^2 = 2 I_c B \left[1 - \frac{|\alpha|^2}{\alpha_0}\right]$$

I_c: collector current

α: common base short circuited current amplification factor

α_0: current amplification factor (low freq. value)

B: effective bandwidth.

Q. Two resistors of 20 and 30 kΩ are at room temperature. Calculate thermal noise voltage
(a) for each resistor.
(b) for both resistors in series
(c) both in parallel.
Bandwidth is 100 kHz and $KT = 4 \times 10^{-21}$ W/Hz

Ans: For 20 kΩ, $V_n^2 = 4RBKT$
$= 4 \times 20 \times 10^3 \times 10^5 \times 4 \times 10^{-21}$
$= 320 \times 10^{-13}$

Miscellaneous Noises:

Flicker Noise / Modulation Noise / Low frequency noise.
At low audio frequencies, a poorly understood form of noise is found in transistors, called flicker noise.
flicker noise $\propto$ emitter current
$\propto$ 1/ frequency
It can be ignored above 500 Hz, as the spectrum density increases as frequency decreases.

Transit Time / High Frequency Noise:
When the transit time of e^- crossing a junction in semiconductor devices is comparable with the periodic time of a signal, some of the carriers

may diffuse back to the emitter. This gives rise to a noise called as Transit time noise.
The spectrum density of this noise increases with the frequency, therefore is significant at high frequency.
The transit time of an e^- is the time taken by e^- to move from cathode to anode.
The transit time of an e^- in a diode is dependent on anode voltage, and is expressed as:

$$\tau = 3.3 \frac{d}{\sqrt{V}} \mu \text{ sec}$$

d : spacing b/w cathode and anode.

Generation / Recombination Noise:
In semiconductor devices, when a random generation or recombination of carriers occur, this gives rise to a noise current. The noise generated is known as recombination noise.

Solar Noise:
Along with other radiations, Sun emits a constant noise radiation due to high temp at its surface.

Cosmic Noise:
The distant stars have high temp, and they also radiate noise in the same manner as the sun.

~~Electrical Noise~~ (*) The solar and cosmic noise come under space or Terrestrial noises (b/w 10 MHz to 1.43 GHz)

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Electrical Noise / Humming

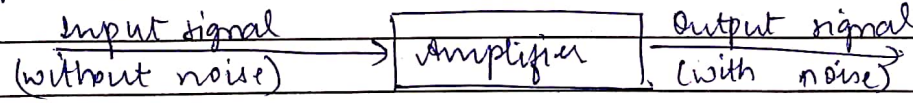
This is generated due to power line frequencies, which is 50 Hz in audio devices. The power frequencies contain its harmonics 100 Hz, 200 Hz ..... which causes noise.
Appropriate filters circuitry can reduce this noise.

Cross Talk

This is being observed Cross talk enters an audio equipment due to the presence of others circuits in the vicinity.

Generated Noise

This noise is generated in amplifiers. When the signal is entering an amplifier, this noise is produced.



The components of amplifiers - resistors, capacitors, transistors, etc. - generate this noise.
Types of generated noises:
a) Johnson Noise
b) White Noise
c) Pink Noise

Conducted Noise

Radiated Noise / General Noise / Ambient Noise:

These may be electrical / magnetic fields in the surroundings. Unwanted signals may radiate into the audio device & produce noise.

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Examples:
Human noise, transmitters, motors, rockets, fluorescent tubes

⇒ Harmful Effects of Noise: Hypertension, Fatigue

⇒ Noise may be reduced using regulated power supply. It can be reduced by sound absorbents, insulators.