Unit-5 Noise

Syllabus : Classification of noise, Sources of noise, Noise figure and Noise temperature, Noise bandwidth, Noise figure measurement, Noise in analog modulation, Figure of merit for various AM and FM, Effect of noise on AM &FM receivers.

Important questions:

1. Define shot Noise.
2. Write down the classification of Noise, and sources of noise
3. What are the various sources of Noise, How noise affects the overall performance of the communication system?
4. Write short note on

    I. Noise in AM.
    II. Noise figure
    III. Noise band width
    IV. Noise temperature
    V. Noise in FM

5. Determine figure of merit in FM
6. Discuss White noise and its power spectrum. Which frequency component does it have?

NOISE

Noise is unwanted signal that affects wanted signal

Noise may be defined as any unwanted introduction of energy tending to interfere with the proper reception and reproduction of transmitted signal. Many disturbances of an electrical nature produce noise in receivers, Modifying the signal in an unwanted manner. Example:

- **Hiss** sound in radio receivers
- **Buzz** sound amidst of telephone conversations
- **Flicker** in television receivers, etc.

Affect of noise

- Degrades system performance (Analog and digital)
- Receiver cannot distinguish signal from noise
- Efficiency of communication system reduces
- Noise limits the operating range of the systems
- Noise indirectly places a limit on the weakest signal that can be amplified by an amplifier. The oscillator in the mixer circuit may limit its frequency because of noise. A system's operation depends on the operation of its circuits. Noise limits the smallest signal that a receiver is capable of processing.
- Noise affects the sensitivity of receivers
- Sensitivity is the minimum amount of input signal necessary to obtain the specified quality output. Noise affects the sensitivity of a receiver system, which eventually affects the output.

Noise classification:

- ☐ **External Noise**
  - Manmade and natural resources
  - Sources over which we have no control
  - Examples are Motors, generators, atmospheric sources.
- ☐ **Internal Noise**
  - It is due to random movement of electrons in electronic circuits
  - Major sources are resistors, diodes, transistors etc.
  - Thermal noise or Johnson noise and shot noise are examples.

Sources of noise: External

1. Atmospheric Noise - Due to irregularities in the atmosphere. Static is caused by lightning discharges in thunderstorms and other natural electric disturbances occurring in the atmosphere. It originates in the form of amplitude modulated impulses, and because such processes are random in nature, it is spread over most of the RF spectrum normally used for broadcasting. Atmospheric, noise becomes less severe at frequencies above about 30 MHz.

2. Extraterrestrial Noise- such as **solar noise** and **cosmic noise.**

2.1 Solar noise The sun radiates so many things our way that we should not be too surprised to find that noise is noticeable among them. Under **normal "quiet" conditions, there is a constant noise radiation from the sun, simply**

because it is a large body at a very high temperature (over 6000°C on the surface). It therefore radiates over a very broad frequency spectrum which includes the frequencies we use for communications**.** The additional noise produced comes from a limited portion of the sun's surface due to consistently changing electrical activities in it.

2.2 Cosmic noise: Since distant stars are also suns and have high temperatures, they radiate RF noise in the same manner as our sun, and what they lack in nearness they nearly make up in numbers which in combination can become significant.

C. Industrial Noise - Between the frequencies of 1 to 600 MHz (in urban, suburban and other industrial areas the intensity of noise made by humans easily outstrips that created by any other source, internal or external to the receiver, Under this heading, sources such as auto mobile and aircraft ignition, electric motors and switching equipment, leakage from high-voltage lines and a multitude of other heavy electric machines are all included.

Source of Noise: Internal

Under the heading of internal noise, we discuss noise created by any of the active or passive devices found in receivers. Such noise is generally random, impossible to treat on an individual voltage basis, but easy to observe and describe statistically. Because the noise is randomly distributed over the entire radio spectrum there is, on the average, as much of it at one frequency as at any other. **Random noise power is proportional to the bandwidth over which it is measured.**

A. **Thermal noise/ white noise/ Johnson noise or fluctuation noise:**

The noise generated in a resistance or the resistive component is random and is referred to as thermal, agitation, white or Johnson noise. It is due to the rapid and random motion of the molecules (atoms and electrons) inside the component itself due to increase in temperature. This noise is zero at absolute zero degree Kelvin and generated **when temperature rises, also called thermal noise.**

This is also called Johnson noise who invented it. Thermal noise also referred as **'White noise'** since it has uniform spectral density across the EM Spectrum.

It becomes apparent that the noise generated by a resistor is proportional to its absolute temperature, in addition to being proportional to the bandwidth over which the noise is to be measured. Therefore Thermal noise power can be calculated using formula:

$$Pn \propto T\delta f = kT\delta f$$

$$Vn = \sqrt{4kT\,\partial f}$$

Where k = Boltzmann's constant = 1.38 x 10-23 J(joules)/K the appropriate proportionality constant .

in this case T = absolute temperature, **K = 273 + °C**

∂f = bandwidth of interest

P_n = maximum noise power output of a resistor

∞ = varies directly V_n =Noise Voltage

B. Shot noise: It is electronic noise that occurs when there are finite number of particles that carry energy such as electrons. The most important of all the other sources is the shot effect, which leads to shot noise in all amplifying devices and virtually all active devices. It is caused by random variations in the arrival of electrons (or holes) at the output terminal of an amplifying device and appears as a randomly varying noise current superimposed on the output. When amplified, it is supposed to sound as though a shower of lead shot were falling on a metal sheet. Hence the name shot noise.

In bipolar transistors, this is mainly a result of the random drift of the discrete current carriers across the junctions. The paths taken are random and therefore unequal. So that although, the average collector current is constant, minute variations nevertheless occur.

Shot noise behaves in a similar manner to thermal agitation noise, apart from the fact that it has a different source. It has uniform spectral density like thermal noise

Shot noise formulas for a diode is:

$$\boldsymbol{in = \sqrt{2eip\partial f}}$$

where i_n = rms shot noise current

e = charge of an electron= 1.6 x 10^{-19}

i_P = direct diode current ∂f= bandwidth of system

C. Transit Time Noise: If the time taken by an electron to travel from the emitter to the collector of a transistor becomes significant to the period of the signal being amplified, i.e., at frequencies in the upper VHF range and beyond, the so called transit time effect takes place, and the noise input admittance of the transistor increases. Once this high-frequency noise makes its presence felt, it goes on increasing with frequency.

D **Miscellaneous Noise**

Flicker: At low audio frequencies, a poorly understood form of noise called flicker or modulation noise is found in transistors. It is proportional to emitter current and junction temperature, but since it is inversely proportional to frequency, it may be completely ignored above about 500 Hz. It is no longer very serious.

Resistance Thermal noise: sometimes called resistance noise, it also present in transistors. It is due to the base, emitter; and collector. internal resistances, and in most circumstances the base resistance makes the largest contribution.

Noise in mixers: Mixers (nonlinear amplifying circuits) are much noisier than amplifiers using identical devices, except at microwave frequencies, where the situation is rather complex. This high value of noise in mixers is caused by two separate effects. First, conversion trans-conductance of mixers is much lower than the trans-conductance of amplifiers. Second, if image frequency rejection is inadequate, as often happens at shortwave frequencies, noise associated with the image frequency will also be accepted.