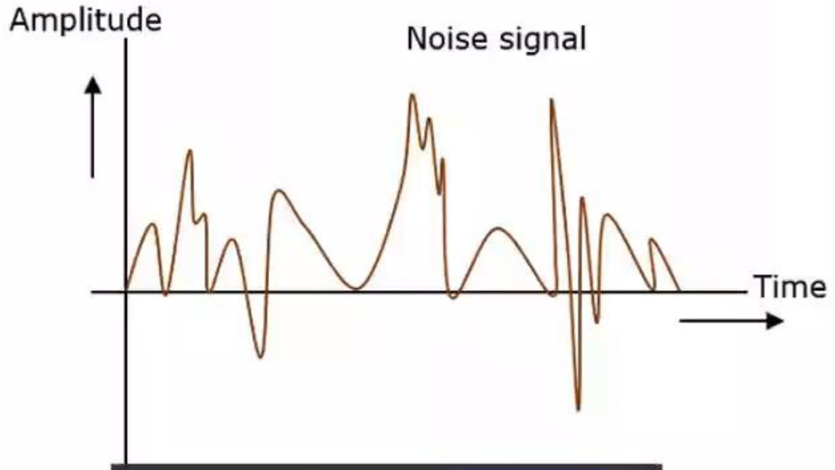
In any communication system, during the transmission of the signal, or while receiving the signal, some unwanted signal gets introduced into the communication, making it unpleasant for the receiver, questioning the quality of the communication. Such a disturbance is called as **Noise**.

What is Noise?

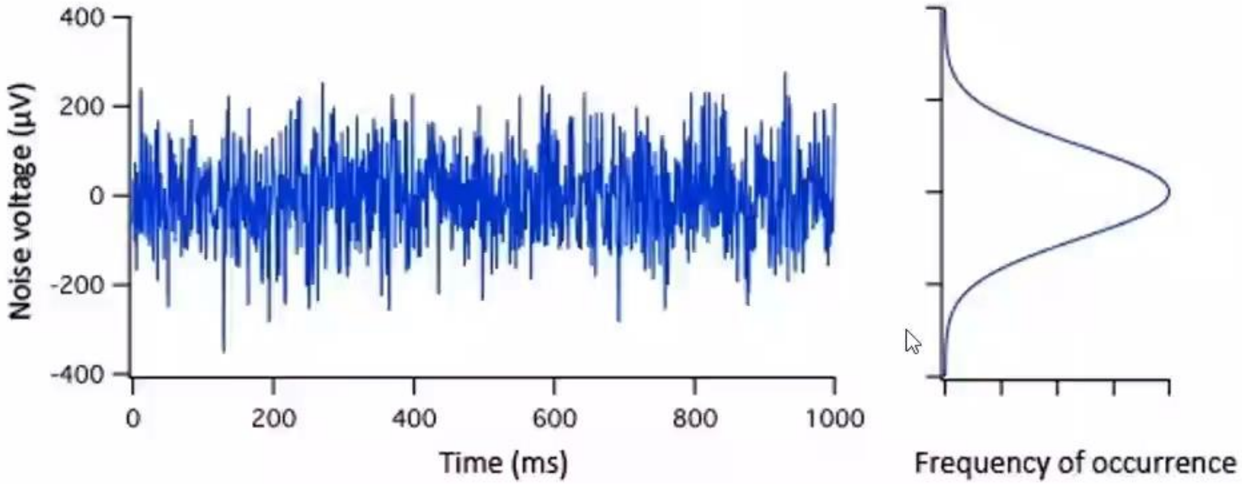
Noise is an **unwanted signal** which interferes with the original message signal and corrupts the parameters of the message signal. This alteration in the communication process, leads to the message getting altered. It is most likely to be entered at the channel or the receiver.
The noise signal can be understood by taking a look at the following example.



Hence, it is understood that noise is some signal which has no pattern and no constant frequency or amplitude. It is quite random and unpredictable. Measures are usually taken to reduce it, though it can’t be completely eliminated.

Most common examples of noise are :

- “Hiss” sound in radio receivers
- “Buzz” sound amidst telephonic conversations
- “Flicker” in television receivers etc.



Types of Noise

The classification of noise is done depending upon the type of source, the effect it shows or the relation it has with the receiver etc.

There are two main ways of which noise gets produced. One is through some external source while the other is created by the internal source, within the receiver section.

External Source

This noise is produced by the external sources which may occur in the medium or channel of communication, usually. This noise can't be completely eliminated. The best way is to avoid the noise from affecting the signal.

Examples :

Most common examples of this type of noise are:

- Atmospheric Noise (due to irregularities in the atmosphere).
- Extra-terrestrial noise such as solar noise and cosmic noise.
- Industrial noise.
- AWGN

Internal Source

This noise is produced by the receiver components while functioning. The components in the circuits, due to continuous functioning, may produce a few types of noise. This noise is quantifiable. A proper receiver design may lower the effect of this internal noise.

Examples :

Most common examples of this type of noise are:

- Thermal agitation noise (Johnson noise or Electrical noise)
- Shot noise (due to the random movement of electrons and holes)
- Transit-time noise (during the transition)
- Miscellaneous noise is another type of noise which includes flicker, resistance effect, and mixer generated noise, etc.

Atmospheric noise

It is radio noise caused by natural atmospheric processes, primarily lightning discharges in thunderstorms. It is mainly caused by cloud-to-ground flashes as the current is much stronger than that of cloud-to-cloud flashes. On a worldwide scale, 3.5 million lightning flashes occur daily. This are about 40 lightning flashes per second.

The sum of all these lightning flashes results in atmospheric noise. It can be observed, with a radio receiver, in the form of a combination of white noise (coming from distant thunderstorms) and impulse noise (coming from a near thunderstorm). The power-sum varies with seasons and nearness of thunderstorm centers.

Although lightning has a broad-spectrum emission, its noise power increases with decreasing frequency. Therefore, it is seen at very low frequency and low frequency, atmospheric noise often dominates, while at high frequency, man-made noise dominates in urban areas.

Consequently, it mainly affects long-range navigation systems (maritime radio), terrestrial radio broadcasting stations (LW, MW, and SW) and to a considerably lesser extent, FM and TV reception.

Extraterrestrial Noise

It is safe to say that there are almost as many types of space noise as there are sources.

For convenience, a division into two subgroups will suffice.

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, again there are two types. 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 6OOO°C on the surface).

It therefore radiates over a very broad frequency spectrum which includes the frequencies we use for communications. However, the sun is a constantly changing star which undergoes cycles of peak activity from which electrical disturbances erupt, such as corona flares and sunspots. Even though the additional noise produced comes from a limited portion of the sun's surface, it may still be Orders of magnitude greater than that received during periods of quiet sun.

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. The noise received is called *thermal* (or *black-body)* noise and is distributed fairly uniformly over the entire sky.

We also receive noise from the center of our own galaxy (the Milky ~ Way), from other galaxies, and from other virtual point sources such as "quasars" and "pulsars." This *galactic* noise is very intense, but it comes from sources which are only points in the sky. Two of the strongest sources, which were also two of the earliest discovered, are Cassiopeia A and Cygnus A. Note that it is inadvisable to refer to the previous statements as "noise" sources when talking with radio astronomers!

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.

Fluorescent lights are another powerful source of such noise and therefore should not be used where sensitive receiver reception or testing is being conducted. The noise is produced by the arc discharge present in all these operations, and under these circumstances it is not surprising that this noise should be most intense in industrial and densely populated areas.

AWGN

In signal processing, **White Noise** is a random signal having equal intensity at different frequencies, giving it a constant power spectral density. The term is used, with this or similar meanings, in many scientific and technical disciplines, including physics, acoustical engineering, telecommunications, and statistical forecasting. White noise refers to a statistical model for signals and signal sources, rather than to any specific signal. White noise draws its name from white light, although light that appears white generally does not have a flat power spectral density over the visible band.

In discrete time, white noise is a discrete signal whose samples are regarded as a sequence of serially uncorrelated random variables with zero mean and finite variance; a single realization of white noise is a random shock. Depending on the context, one may also require that the samples be independent and have identical probability distribution (in other words independent and identically distributed random variables are the simplest representation of white noise). ***In particular, if each sample has a normal distribution with zero mean, the signal is said to be Additive White Gaussian Noise (AWGN).***

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Thermal-Agitation 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.

In thermodynamics, kinetic theory shows that the temperature of a particle is away of expressing its internal kinetic energy. Thus the "temperature" of a body is the statistical root mean square (rms) value of the velocity of motion of the particles in the body. As the theory states, the kinetic energy of these particles becomes approximately zero (Le., their motion ceases) at the temperature of absolute zero, which is 0 K (kelvins, formerly called degrees Kelvin) and very nearly equals -273°C. 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.

Shot Noise

Thermal agitation is by no means the only source of noise in receivers.

The mm 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* is *the arrival of electrons* (or holes) *at the output electrode* of an amplifying device an 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 meta sheet. Hence the name *shot* noise.

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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. The minute currents induced in the input of the device by random fluctuations in the output current become of great importance at such frequencies and create random noise (frequency distortion).

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. From above 500 Hz up to about fab/5, transistor noise remains relatively constant, so that an equivalent input resistance for shot and thermal noise may be freely used.

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 transconductance* of mixers is much lower than the transconductance of amplifiers. Second, if *image frequency rejection* is inadequate, as often happens a shortwave frequencies, noise associated with the image frequency will also be accepted.

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Signal-to-Noise Ratio (SNR) is the **ratio of the signal power to the noise power**. The higher the value of SNR, the greater will be the quality of the received output.

Signal to Noise Ratio.

Noise is usually expressed as a power because the received signal is also expressed in terms of power. By Knowing the signal to noise powers the signal to noise ratio can be computed. Rather than express the signal to noise ratio as simply a number, you will usually see it expressed in terms of decibels.

$$Signal\ TO\ Noise\ Ratio = 10\log\frac{Signal\ power}{Noise\ Power} = 10\log\frac{P_s}{P_n}$$

A receiver has an input signal power of l.2μW. The noise power is 0.80μW. The signal to noise ratio is

Signal to Noise Ratio = 10 Log (1.2/0.8)

= 10 log 1.5

= 10 (0.176)

= 1.76 dB

Noise Figure

Noise Figure **F** is designed as the ratio of the signal-to-noise power at the input to the signal to noise power at the output.

The device under consideration can be the entire receiver or a single amplifier stage. The noise figure **F** also called the **noise factor** can be computed with the expression

F = Signal to Noise power Input/Signal to noise power output

You can express the noise figure as a number, more often you will see it expressed in decibels.

It describes the performance of a device.