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Study of Different Types of Noise and Its Effects in Communication Systems

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ABSTRACT

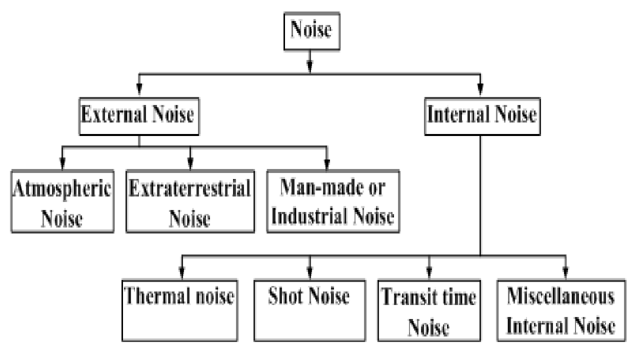
This paper represents the classification of noise and its effects. Electrical disturbances interfere with signals, producing noise. Noise can be defined as an unwanted signal that interferes with the communication or measurement of another signal. A noise itself is a signal that conveys information regarding the source of the noise. It is even present and limits the performance of communication and measurement systems.Therefore the removal of the effects of noise has been at the core of the theory and practice of communications and signal processing.

Keywords---- Noise quantities, Signal-to-Noise Ratio, Noise Figure, Noise Temperature.

I. INTRODUCTION

With reference to an electrical system, noise may be defined as any unwanted form of energy which tends to interfere with proper reception and reproduction of wanted signal. Many disturbances of an electrical nature produce noise in receivers, modifying the signal in an unwanted manner. In radio receivers, noise may produce hiss in the loudspeakers output. In television receivers 'snow' or 'confetti' (colored snow) becomes superimposed on the picture. In pulse communication systems, noise may produce unwanted pulses or perhaps cancel out the wanted ones. It may cause serious mathematical errors. Noise can limit the range of systems, for a given transmitted power. It affects the sensitivity of receivers, by placing a limit on the weakest signals that can be amplified. It may sometimes even force a reduction in the bandwidth of a system.

II. CLASSIFICATION OF NOISE



External noise cannot be reduced except by changing the location of the receiver or the entire system. Internal noise on the other hand can be easily evaluated mathematically and can be reduced to a great extent by proper design. As already said, because of the fact that internal noise can be reduced to a great extent, study of noise characteristics is a very important part of the communication engineering.

III. EXTERNAL NOISE

The noise whose sources are external to the receiver come under heading of external noise and include atmospheric noise and extraterrestrial noise and man-made or industrial noise.

3.1 Atmospheric Noise

Atmospheric noise or static is caused by lighting discharges in thunderstorms and other natural electrical disturbances occurring in the atmosphere. These electrical impulses are random in nature. Hence the energy is spread over the complete frequency spectrum used for radio communication.Atmospheric noise accordingly consists of spurious radio signals with components spread over a wide frequency range. It is propagated over the earth in the same way as the desired radio waves of the same frequencies, so that a given receiving point, the receiving antenna picks up not only the signal but also the static from all the thunderstorms, local or remote.The field strength of atmospheric noise varies approximately inversely with the frequency. Thus large atmospheric noise is generated in low and medium frequency (broadcast) bands while very little noise is generated in the VHF and UHF bands. Further VHF and UHF components of noise are limited to the line-of-sight (less than about 80 Km) propagation. For these two-reasons, the atmospheric noise becomes less severe at Frequencies exceeding about 30MHz.

3.2 Extraterrestrial Noise

There are numerous types of extraterrestrial noise or space noises depending on their sources. However, these may be put into following two subgroups.

Solar Noise: Thisis the electrical noise emanating from the sun. Under quite conditions, there is a steady radiation of noise from the sun. This results because sun is a large body at **a** very high temperature (exceeding 6000°C on the surface), and radiates electrical energy in the form of noise over a very wide frequency spectrum including the spectrum used for radio communication. The intensity produced by the sun varies with time. In fact, the sun has a repeating 11-Year noise cycle. During the peak of the cycle, the sun produces some amount of noise that causes tremendous radio signal interference, making many frequencies unusable for communications.

Cosmic noise: Distant stars are also suns and have high temperatures. These stars, therefore, radiate noise in the same way as our sun. The noise received from these distant stars is thermal noise (or black body noise) and is distributing almost uniformly over the entire sky. We also receive noise from the center of our own galaxy (The Milky Way) from other distant galaxies and from other virtual point sources such as quasars and pulsars.

3.3 Man-Made Noise (Industrial Noise)

By man-made noise or industrial- noise is meant the electrical noise produced by such sources as automobiles and aircraft ignition, electrical motors and switch gears, leakage from high voltage lines, fluorescent lights, and numerous other heavy electrical machines. Such noises are produced by the arc discharge taking place during operation of these machines. Such man-made noise is most intensive in industrial and densely populated areas. Man-made noise in such areas far exceeds all other sources of noise in the frequency range extending from about 1 MHz to 600 MHz

IV. INTERNAL NOISE

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. Again random noise power is proportional to the bandwidth over which it is measured.

4.1 Thermal Noise

Conductors contain a large number of freeelectrons and ionsstrongly bound by molecular forces. The ions vibrate randomly about their normal (average) positions, however, this vibration being a function of the temperature. Continuous collisions between the electrons and the vibrating ions take place. Thus there is a continuous transfer of energy between the ions and electrons. This is the source of resistance in a conductor. The movement of free electrons constitutes a current which is purely random in nature and over a long time averages zero. There is a random motion of the electrons which give rise to noise voltage called thermal noise.

Thus noise generated in any resistance due to random motion of electrons is called *thermal noise or white or Johnson noise.*

The analysis of thermal noise is based on the Kinetic theory. It shows that the temperature of particles is a way of expressing its internal kinetic energy. Thus *"Temperature"* of a body can be said to be equivalent to the statistical rms value of the velocity of motion of the particles in the body. At -273°C (or zero degree Kelvin) the kinetic energy of the particles of a body becomes zero .Thus we can relate the noise power generated by a resistor to be proportional to its absolute temperature. Noise power is also proportional to the bandwidth over which it is measured. Therefore

$P_n \propto TB$

$P_n = kTB$ ------ (1)

Where

Pn = Maximum noise power output of a resistor.

k = Boltzmann's constant= 1.38 x10-23 Joules / Kelvin.

T = Absolute temperature, K = 273+ ^{0}C

B = Bandwidth over which noise is measured.

From equation (1), an equivalent circuit can be drawn as shown in below figure

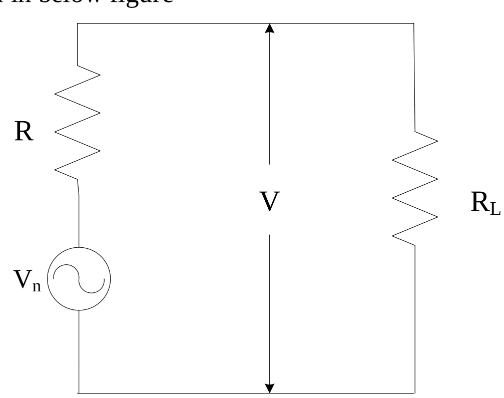


Figure 01: Resistance noise generator

Assume that R_L is noiseless and is receiving the maximum noise power generated by R; under this conditions of maximum power transfer, R_L must be equal to R. Then

$$P_n = \frac{V^2}{R_L} = \frac{V^2}{R} = \frac{(V_n/2)^2}{R} = \frac{V_n{}^2}{4R}$$

$$V_n{}^2 = 4RP_n = 4RkTB \text{ and } V_n = \sqrt{4RkTB}$$

4.2 Shot Noise

The most common type of noise is referred to as shot noise which is produced by the random arrival of 'electrons or holes at the output element, at the plate in a tube, or at the collector or drain in a transistor or amplifying device and appears as a randomly varying noise current superimposed on the output. Shot noise is also produced by the random movement of electrons or holes across a PN junction. Even through current flow is established by external bias voltages, there will still be some random movement of electrons or holes due to discontinuities in the device. An example of such a discontinuity is the contact between the copper lead and the semiconductor materials. The interface between the two creates a discontinuity that causes random movement of the current carriers.

4.3 Transit Time Noise

Another kind of noise that occurs in transistors is called transit time noise. Transit time is the duration of time that it takes for a current carrier such as a hole or current to move from the input to the output. The devices themselves are very tiny, so the distances involved are minimal. Yet the time it takes for the current carriers to move even a short distance is finite. At low frequencies this time is negligible. But when the frequency of operation is high and the signal being processed is the magnitude as the transit time, then problem can occur. The transit time shows up as a kind of random noise within the device, and this is directly proportional to the frequency of operation.

4.4 Miscellaneous Internal Noise

Flicker Noise: Flicker noise or modulation noise is the one appearing in transistors operating at low audio frequencies. Flicker noise is proportional to the emitter current and junction temperature. However, this noise is inversely proportional to the frequency. Hence it may be neglected at frequencies above about 500 Hz and it, Therefore, possess no serious problem.

Transistor Thermal Noise: Within the transistor, thermal noise is caused by the emitter, base and collector internal resistances. Out of these three regions, the base region contributes maximum thermal noise.

Partition Noise: Partition noise occurs whenever current has to divide between two or more paths, and results from the random fluctuations in the division. It would be expected, therefore, that a diode would be less noisy than a transistor (all other factors being equal) If the third electrode draws current (i.e.., the base current). It is for this reason that the inputs of microwave receivers are often taken directly to diode mixers.

V. 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, it can be expressed in terms of decibels.

$$\text{Signal-to-Noise Ratio} = 10 \log \frac{SignalPower}{NoisePower} = 10 \log \frac{P_s}{P_n}$$

VI. NOISE FIGURE

Noise Figure **F** is designed as the ratio of the signal-to-noise power supplied to the input terminals of a receiver or amplifier to the signal-to-noise power to the output or load resistor.The noise figure **F** also called the noise factorcan be computed with the expression

$$F = \frac{InputSignal - to - Noisepower}{OutputSignal - to - Noisepower}$$

In a practical receiver, the output signal-to-noise power will be lower than the input value, and so the noise figure will exceed 1. However, the noise figure will be 1 for an ideal receiver, which introduces no noise of its own. The noise figure may be expressed as an actual ratio or in decibels.

VII.

VII. NOISE TEMPERATURE

Noise temperature is employed extensively for antennas and low-noise microwave amplifiers. Not the least reason for its use is convenience, in that it is an additive like noise power. Another advantage of the use of noise temperature for low noise levels is that it shows a greater variation for any given noise-level change than does the noise figure, so changes are easier to grasp in their true perspective. The relation between noise figure and equvalent noise temperature is as follows:

$$F = 1 + (T_{eq} / T_0)$$

Where F = noise figure

$T_o = 17^0C = 290$ K

T_{eq} = equivalent noise temperature of the amplifier or receiver.

VIII. CONCLUSION

From the above study we conclude that the sources of noise are many, and vary from audio frequency acoustic noise emanating from moving, vibrating or colliding sources such as revolving machines, moving vehicles, computer fans, keyboard clicks, wind, rain, etc. to radio-frequency electromagnetic noise that can interfere with the transmission and reception of voice, image and data over the radio-frequency spectrum. This paper gives details information about types of noise and its effect. Therefore, noise reduction is important problem in applications such as cellular mobile communication, speech recognition, image processing, medical signal processing, radar, sonar, and in any application where the signals cannot be isolated from noise.

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