Noise in Communication Systems

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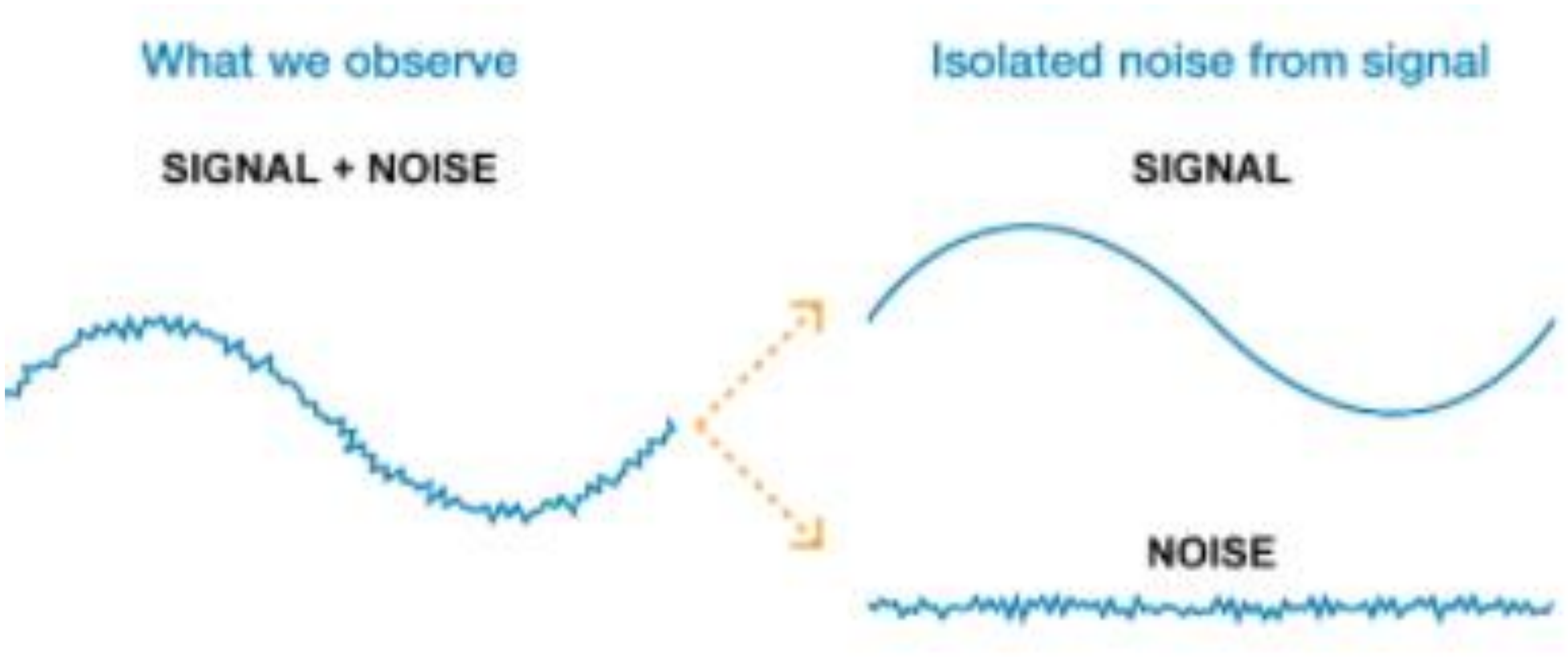
Noise in communication systems

What is noise?

- **Undesired signal which carries no information.**
- Noise is a general term which is used to describe an unwanted signal which affects a wanted signal.



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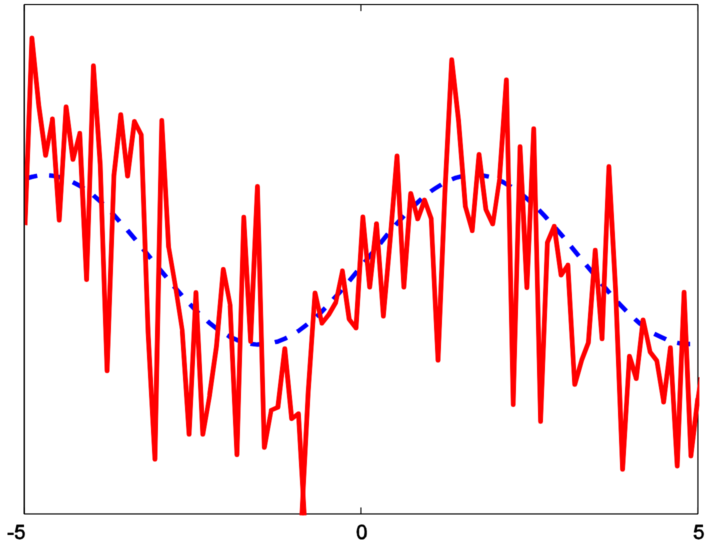
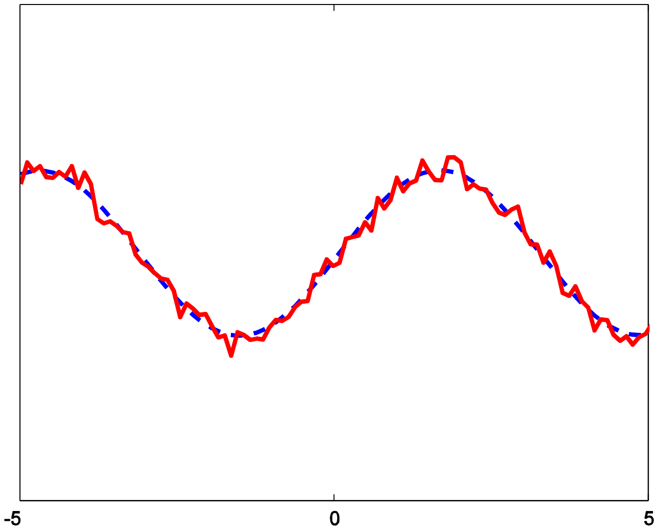
Noise in communication systems

Noise is an ever present part of all systems. Any receiver must contend with noise and the resulting degradation in the quality of the transmitted and received signal.





•If the noise level becomes high, the information cannot be recovered

•Even for lower noise levels, the quality of the information reception will be reduced. (think of bad cell phone reception)

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Noise in communication systems

- Noise is an ever present part of all systems. Any receiver must contend with noise and the resulting degradation in the quality of the transmitted and received signal.

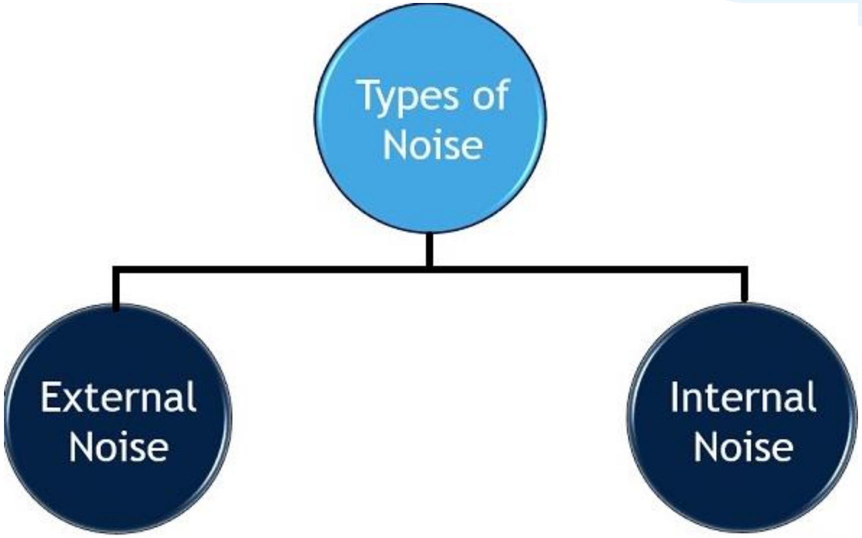
- In analog systems, noise deteriorates the quality of the received signal, e.g. the appearance of "snow" on the TV screen, or "static" sounds during an audio transmission.

- In digital communication systems, noise degrades the throughput because it requires retransmission of data packets or extra coding to recover the data in the presence of errors.

Ref.PPT Prof. Ali M. Niknejad U.C. Berkeley

Types of Noise

In a communication system, there are two main types of noises:



The electrical noise that is introduced in the transmitting medium is termed external noise.

The noise introduced by the components in the transmitter and receiver is known as internal noise.

Types of Noise

1. External Noise

External noise may be classified as :

1.1 Man-made noise(Industrial noise):

• **Produced by *electromagnetic waves* generated by things like electric motors, power lines, engine ignition system etc.**

1.2 Atmospheric noise:

• **caused by naturally occurring disturbances in the earth's atmosphere due to, e.g. lightning, etc.**

1.3 Extra-terrestrial Noise: **Extraterrestrial Noise exist on the basis of their originating source. They are subdivided into**

i) Solar Noise

ii) Cosmic Noise

Types of Noise

2. Internal Noise

Internal noise is produced by electronic circuits.

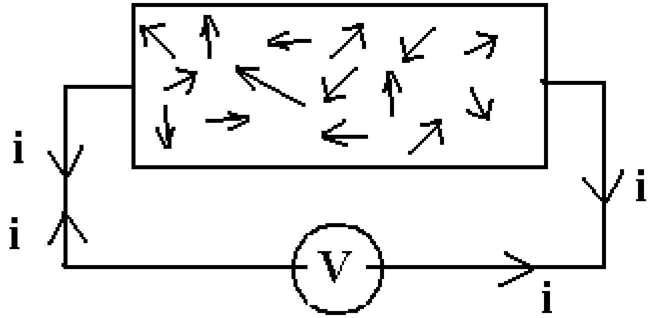
There are two types of internal noise:

- **2.1.Thermal noise**
- **2.2. Shot noise**

Types of Noise

2.1 Thermal Noise (*Johnson* noise)

Thermal noise is generated in a resistive component due to the *rapid and random motion of electrons and atoms* inside the component.



This motion increases with increasing temperature (hence, "thermal").

This random motion of electrons produces an unpredictable component in a current passing through a resistor (hence, "noise").

It is sometimes referred to as *Johnson* noise, after its discoverer.

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2.2 Shot Noise

Shot noise exists in all active devices, especially in *transistors*.

It is caused by *random variations in the arrival rate* of electrons or holes at the output of the device.

Signal-to-Noise Ratio

FIG. 1: Whether noise is a nuisance or a signal may depend on whom you ask. (Cartoon by Rand Kruback. Used with permission of Agilent Technologies.)

Signal-to-Noise Ratio

Signal-to-Noise Ratio (SNR or S/N) provides a comparison of noise and signal powers at the same point. It is defined as

$$\frac{S}{N} = \frac{V_s}{V_n} \quad \text{or} \quad \frac{S}{N} = \frac{P_s}{P_n}$$

where V_s = signal voltage
V_n = noise voltage
P_s = signal power
P_n = noise power

and in decibel form (which is usually convenient) as

$$SNR(dB) = 10 \log_{10} \frac{P_S}{P_N}$$

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Signal-to-Noise Ratio

Assume, e.g., that the signal voltage is 1.2 μV and the noise is 0.3 μV. The *S/N* ratio is 1.2/0.3 = 4. Most *S/N* ratios are expressed in terms of power rather than voltage. For example, if the signal power is 5 μW and the power is 125 nW, the *S/N* ratio is $5 \times 10^{-6}/125 \times 10^{-9} = 40$.

The preceding *S/N* values can be converted to decibels as follows:

$$\text{For voltage: dB} = 20 \log \frac{S}{N} = 20 \log 4 = 20(0.602) = 12 \text{ dB}$$

$$\text{For power: dB} = 10 \log \frac{S}{N} = 10 \log 40 = 10(1.602) = 16 \text{ dB}$$

Ref: Electronics communication by Frenzel.

Limits of communication systems

Noise **imposes a limit on the rate of information transmission**
Noise is unavoidable**.**

Why is noise unavoidable?
• **At any temperature above absolute zero, thermal energy causes microscopic particles to exhibit random motion. The random motion of charged particles such as electrons generates random currents or voltages called** ***thermal noise*****.**

• ***Thermal noise exists in every communication system*****.**

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Thank You