To be transmitted, data must be transformed to electromagnetic signals. Transmission is the communication of data by the propagation and processing of signals.

❖ Analog & Digital Data

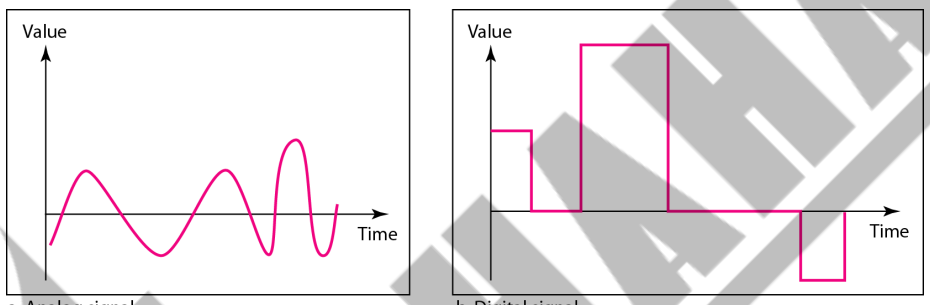
Data can be analog or digital. The term analog data refers to information that is continuous; digital data refers to information that has discrete states. Analog data take on continuous values. Digital data take on discrete values.

For example, voice and video are continuously varying patterns of intensity. Most data collected by sensors, such as temperature and pressure, are continuous valued. Digital data take on discrete values; examples are text and integers.

❖ Analog & Digital Signals

An **analog signal** is a continuously varying electromagnetic wave that may be propagated over a variety of media, depending on spectrum; examples are wire media, such as twisted pair and coaxial cable; fiber optic cable; and unguided media, such as atmosphere or space propagation. Analog signals can have an infinite number of values in a range.
An analog signal has infinitely many levels of intensity over a period of time. As the wave moves from value A to value B, it passes through and includes an infinite number of values along its path.

A **digital signal**, on the other hand, can have only a limited number of defined values. Although each value can be any number, it is often as simple as 1 and 0. Digital signals can have only a limited number of values.

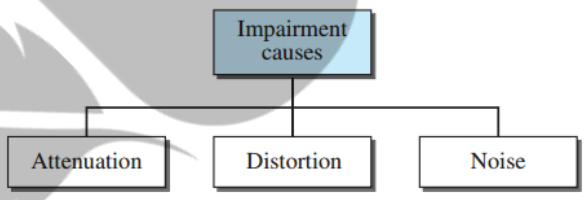


a. Analog signal b. Digital signal

❖ Periodic & Non-Periodic

Both analog and digital signals can take one of two forms: periodic or non-periodic (sometimes referred to as aperiodic; the prefix a in Greek means "non"). **In data communications, we commonly use periodic analog signals and non-periodic digital signals.** A **periodic signal** completes a pattern within a measurable time frame, called a period, and repeats that pattern over subsequent identical periods. The completion of one full pattern is called a cycle. A **non-periodic signal** changes without exhibiting a pattern or cycle that repeats over time.

❖ Transmission Impairments

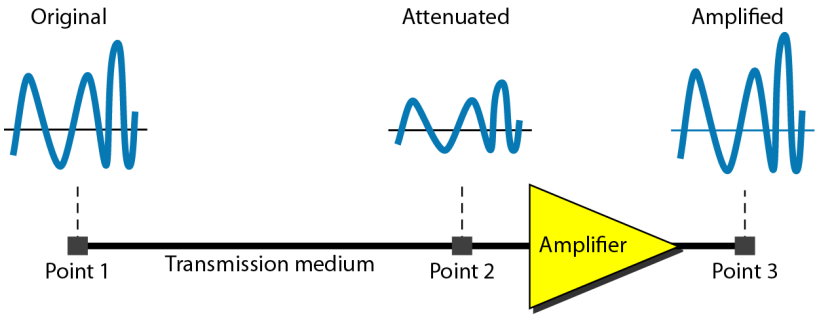


Signals travel through transmission media, which are not perfect. The imperfection causes signal impairment. This means that the signal at the beginning of the medium is not the same as the signal at the end of the medium. What is sent is not what is received. Three causes of impairment are attenuation, distortion, and noise

➢ Attenuation

Attenuation means a loss of energy. When a signal, simple or composite, travels through a medium, it loses some of its energy in overcoming the resistance of the medium. That is why a wire carrying electric signals gets warm, if not hot, after a while. Some of the electrical energy in the signal is converted to heat. To compensate for this loss, amplifiers are used to amplify the signal. Attenuation introduces three considerations for the transmission engineer.

- ✓ A received signal must have sufficient strength so that the electronic circuitry in the receiver can detect and interpret the signal.
- ✓ The signal must maintain a level sufficiently higher than noise to be received without error.
- ✓ Attenuation is greater at higher frequencies, and this causes distortion.



Decibel

To show the loss or gain of energy the unit "decibel" is used.

$$dB = 10\log_{10}P_2/P_1$$

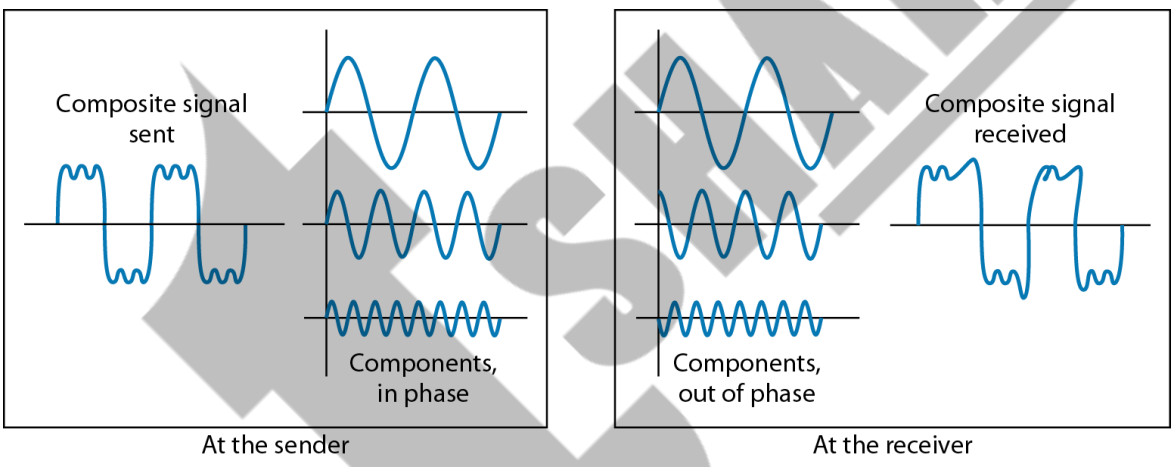
P_1 - input signal

P_2 - output signal

➢ Distortion

Distortion means that the signal changes its form or shape. Distortion occurs in composite signals. Each frequency component has its own propagation speed traveling through a medium. The different components therefore arrive with different delays at the receiver. That means that the signals have different phases at the receiver than they did at the source.

It does not occur when signals are transmitted through the air by means of antennas. Delay distortion is caused by the fact that the velocity of propagation of a signal through a cable is different for different frequencies.



➢ Noise

Noise is another cause of impairment. Several types of noise, such as thermal noise, induced noise, crosstalk, and impulse noise, may corrupt the signal.

Thermal noise is the random motion of electrons in a wire, which creates an extra signal not originally sent by the transmitter. **Induced noise** comes from sources such as motors and appliances. These devices act as a sending antenna, and the transmission medium acts as the receiving antenna. **Crosstalk** is the effect of one wire on the other. One wire acts as a sending antenna and the other as the receiving antenna. **Impulse noise** is a spike (a signal with high energy in a very short time) that comes from power lines, lightning, and so on.