Third lecture

Signals

Generally, the data usable to a person or application are not in a form that can be transmitted over a network. For example, a photograph must first be changed to a form that transmission media can accept.

The **data must be transformed to electromagnetic signals.** Both data and the signals that represent them can be either **analog or digital in form.**

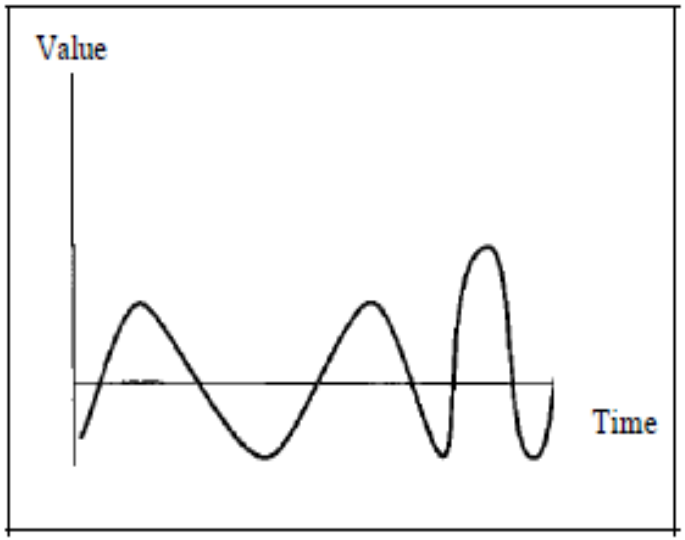
Analog and Digital Data

Analog data, such as the sounds made by a human voice, take on continuous values.

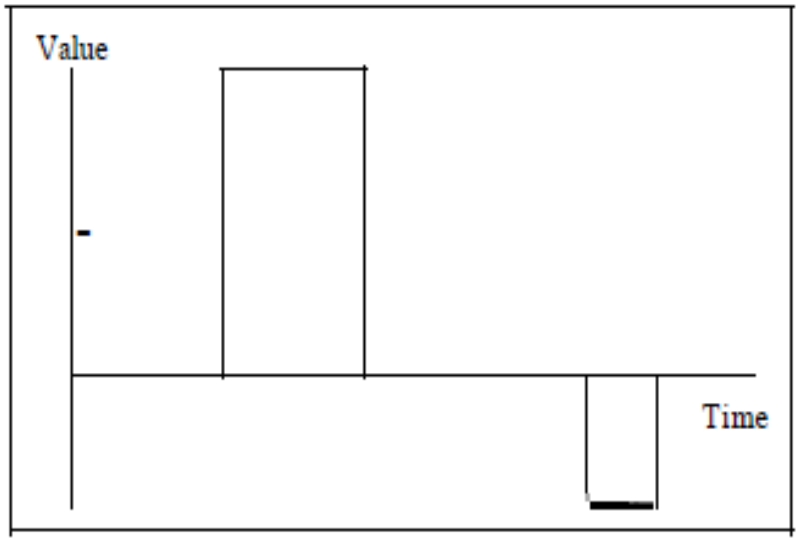
When someone speaks, an analog wave is created in the air. This can be captured by a microphone and converted to an analog signal or sampled and converted to a digital signal.

Digital data take on discrete values. For example, data are stored in computer memory in the form of Os and 1s. They can be converted to a digital signal or modulated into an analog signal for transmission across a medium.

Like the data they represent, signals can be either analog or digital. 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 O.



a. Analog signal



b. Digital signal

Periodic and Nonperiodic Signals

Both analog and digital signals can take one of two forms: *periodic or nonperiodic*

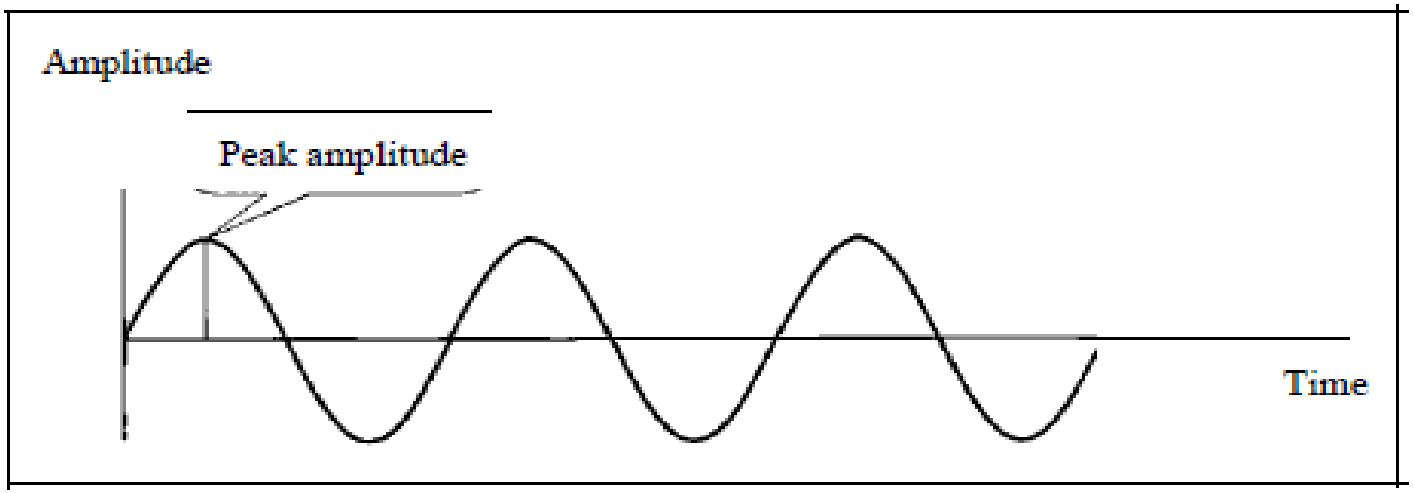
(sometimes refer to as *aperiodic, because the prefix a in Greek means "non").*

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 nonperiodic signal changes without exhibiting a pattern or cycle that repeats over time.

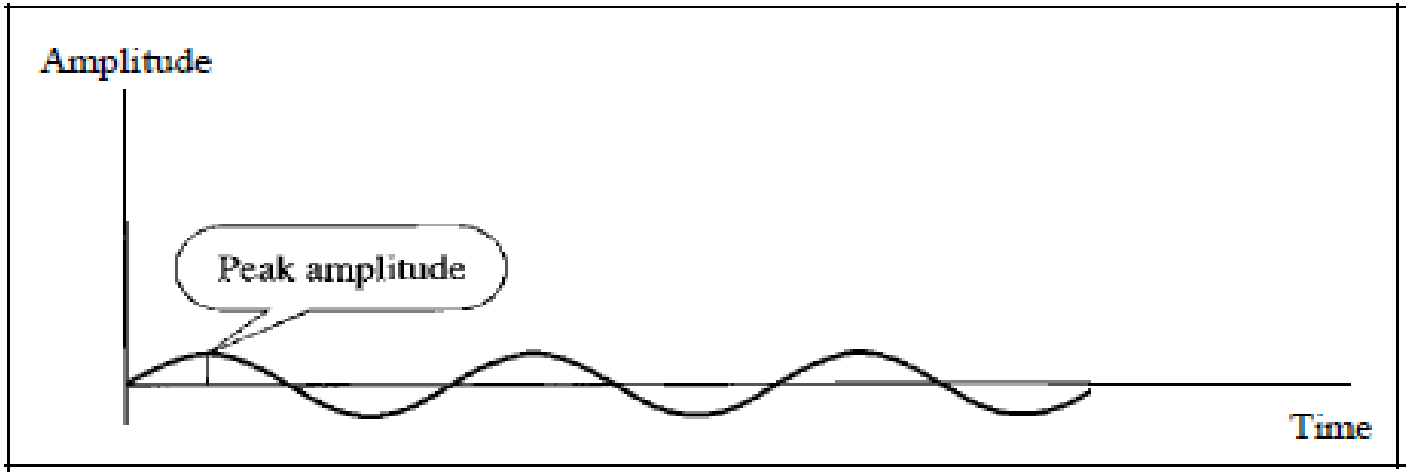
A sine wave can be represented by three parameters: the *peak amplitude, the frequency, and* the *phase*.

Peak Amplitude

The peak amplitude of a signal is the absolute value of its highest intensity, proportional to the energy it carries. For electric signals, peak amplitude is normally measured in *volts*.



a. A signal with high peak amplitude



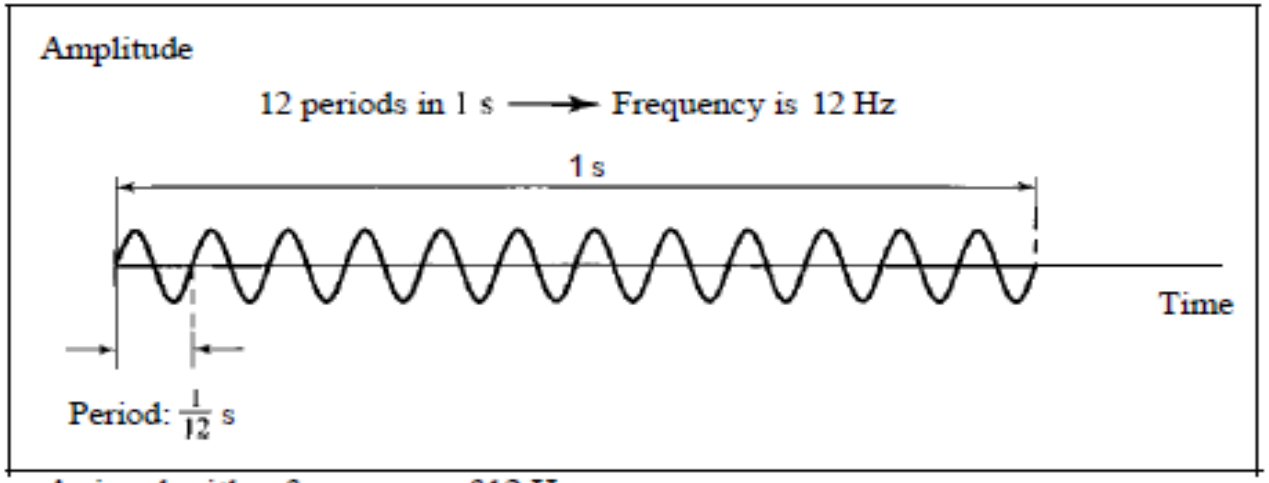
b. A signal with low peak amplitude

Period and Frequency

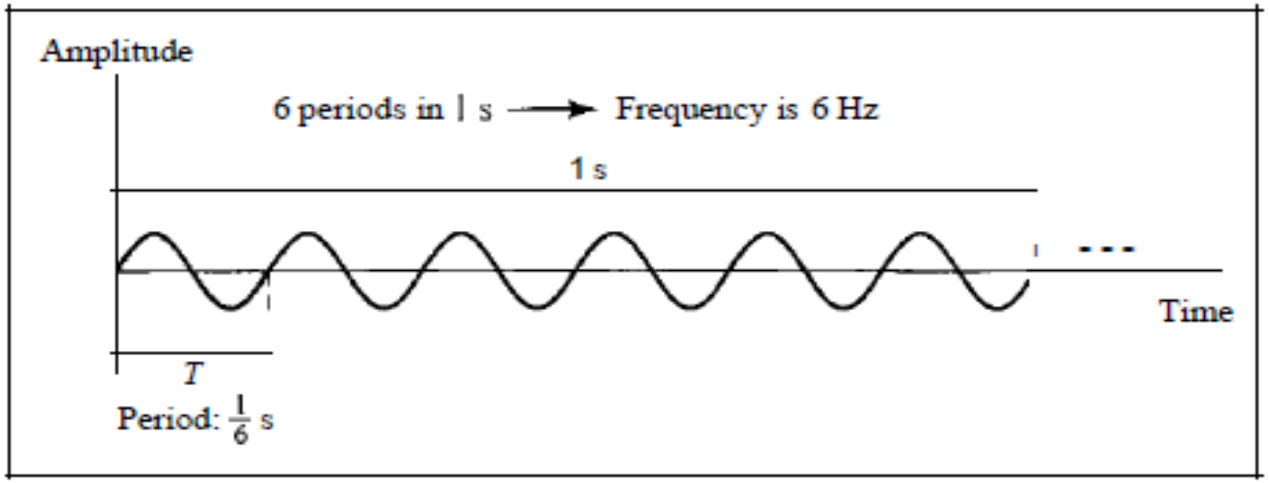
Period refers to the amount of time, in seconds, a signal needs to complete 1 cycle. Frequency refers to the number of periods in I s. Note that period and frequency are just one characteristic defined in two ways. Period is the inverse of frequency, and frequency

is the inverse of period, as the following formula as show.

F=1/T and T=1/F



a. A signal with a frequency of 12 Hz



b. A signal with a frequency of 6 Hz

Period is formally expressed in seconds. Frequency is formally expressed in Hertz (Hz),

Unit	*Equivalent*	*Unit*	*Equivalent*
Seconds (s)	1 s	Hertz (Hz)	1 Hz
Milliseconds (ms)	10^{-3} s	Kilohertz (kHz)	10^{3} Hz
Microseconds (μs)	10-6 s	Megahertz (MHz)	10^{6} Hz
Nanoseconds (ns)	10^{-9} s	Gigahertz (GHz)	10^{9} Hz
Picoseconds (ps)	10^{-12} s	Terahertz (THz)	10^{12} Hz

Phase

The term phase describes the position of the waveform relative to time O. If we think of the wave as something that can be shifted backward or forward along the time axis, phase describes the amount of that shift. It indicates the status of the first cycle.

the phase is in terms of shift or offset. We can say that

1. A sine wave with a phase of 0° is not shifted.
2. A sine wave with a phase of 90° is shifted to the left by ¼ cycle.
3. A sine wave with a phase of 180° is shifted to the left by ½ cycle.

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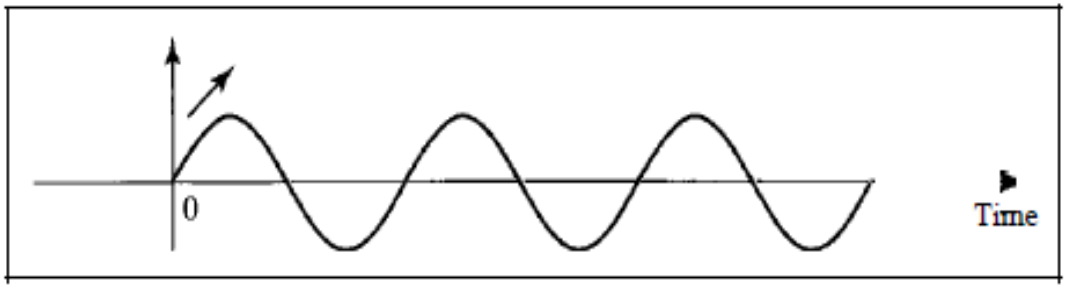
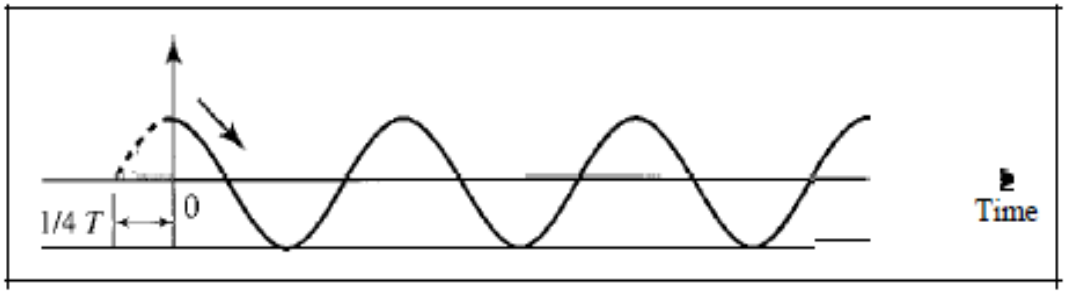
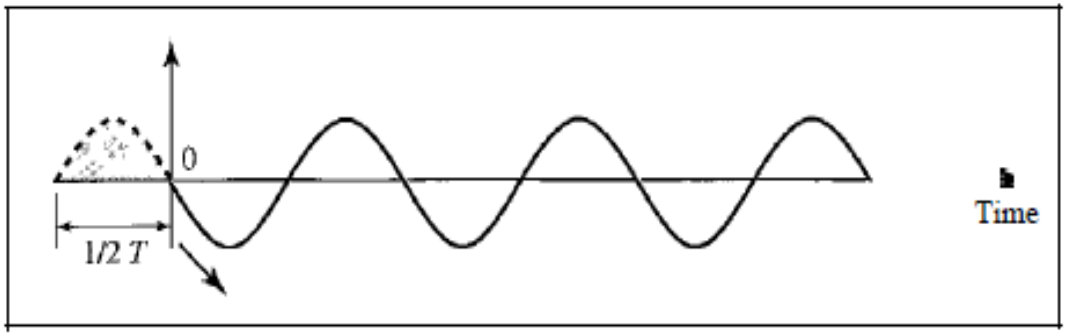


a. 0 degrees



b. 90 degrees



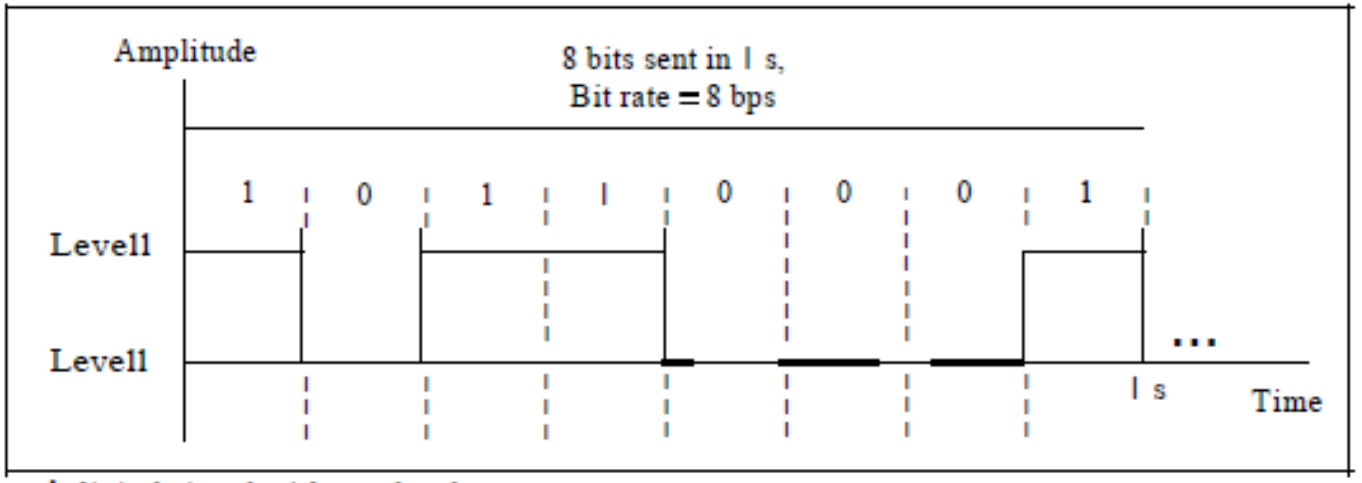
c. 180 degrees

DIGITAL SIGNALS

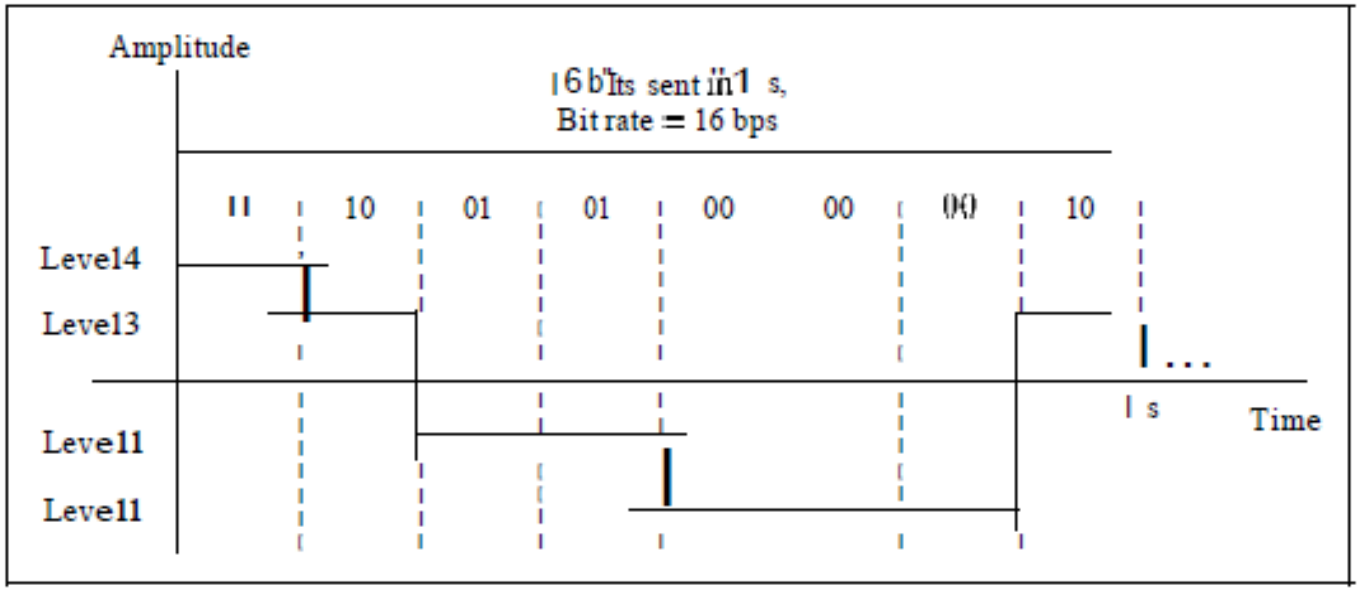
In addition to being represented by an analog signal, information can also be represented

by a digital signal. For example, a I can be encoded as a positive voltage and a 0

as zero voltage. A digital signal can have more than two levels. In this case, we can send more than 1 bit for each level.



a. A digital signal with two levels



b. A digital signal with four levels

We send 1 bit per level in part a of the figure and 2 bits per level in part b of the

figure. In general, if a signal has *L levels, each level needs* ***log2L*** *bits.*

Bit Rate

Most digital signals are nonperiodic, and thus period and frequency are not appropriate

characteristics. Another *term-bit rate (instead of frequency)-is used to describe*

digital signals. The bit rate is the number of bits sent in Is, expressed in bits per

second (bps).

Transmission of Digital Signals

We can transmit a digital signal by using one of two different approaches: baseband transmission or broadband transmission

Baseband Transmission

Baseband transmission means sending a digital signal over a channel without changing the digital signal to an analog signal.

Broadband Transmission (Using Modulation)

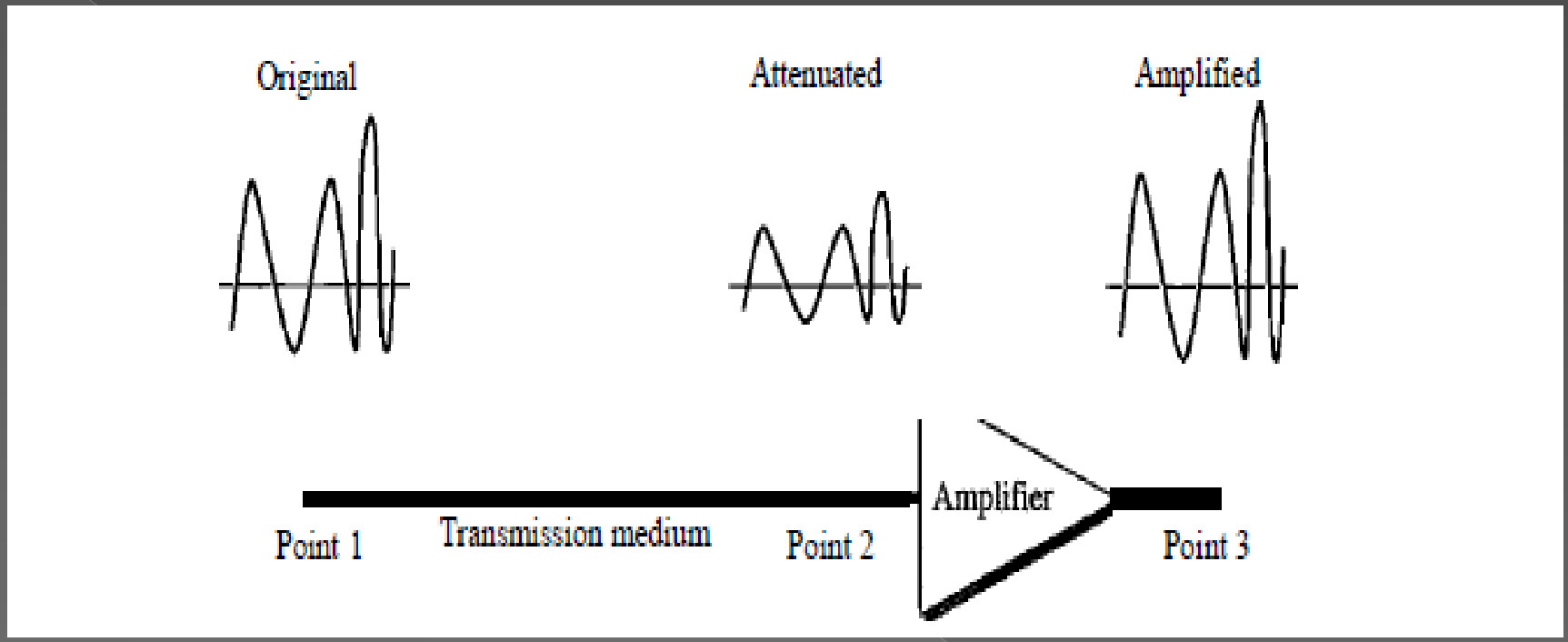
Broadband transmission or modulation means changing the digital signal to an analog signal for transmission

TRANSMISSION IMPAIRMENT

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

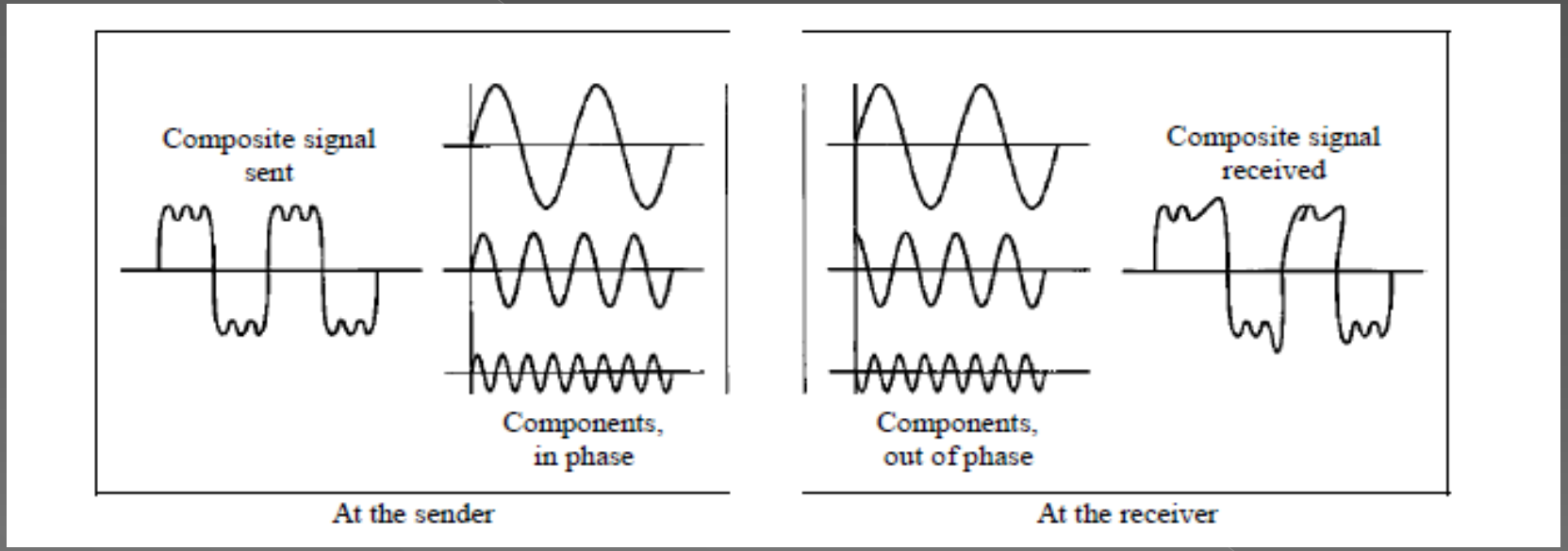
Attenuation

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.


Original
Attenuated
Amplified
Amplifier
Point 1
Transmission medium
Point 2
Point 3

Distortion

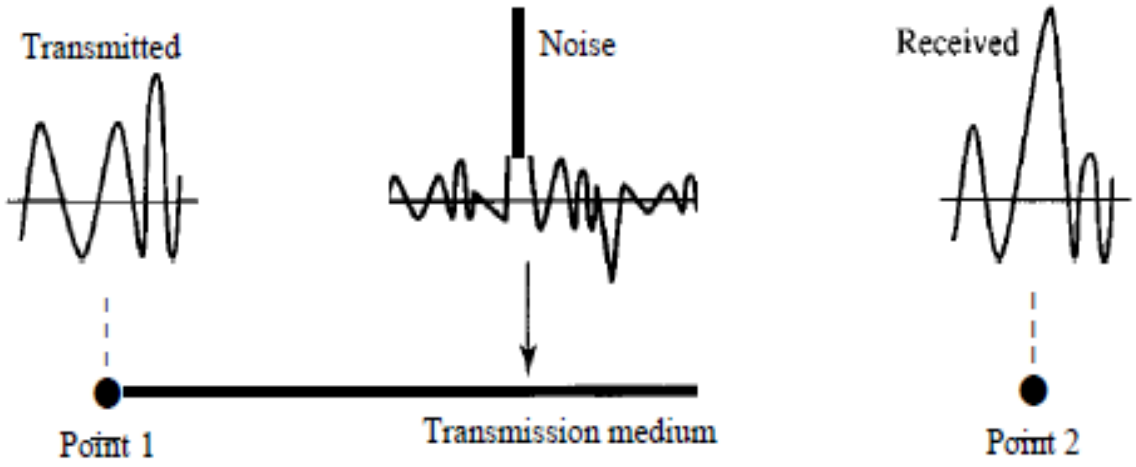
Distortion means that the signal changes its form or shape. Distortion can occur in a composite signal made of different frequencies.


Composite signal
sent
Components,
in phase
At the sender
Composite signal
received
Components,
out of phase
At the receiver

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.


Transmitted
Noise
Received
Point 1
Transmission medium
Point 2

Write a report on signal to noise ratio SNR