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Data Communication Part-2

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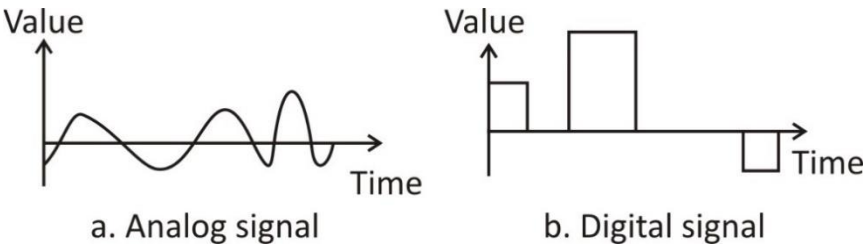
Analog and Digital Data :

The term analog refers to the information that is continuous; digital data refers to the information that hasthe discrete states. For example , theanalog clock that has hour , minutes and second hands gives information in continuous form; the movements of the hands are continuous . On the other hand , digital clock that reports the hours and the minutes will change suddenly from 9:05 to 9:06.

Digital data take on discrete values. For example , data are stored in the computer memory in the form of 0's and 1's .



a. Analog signal b. Digital signal

Periodic and Non periodic :

period : when a periodic signal completes a pattern within a measurable time frame, and repeats that pattern over the subsequent identical periods. The completion of the

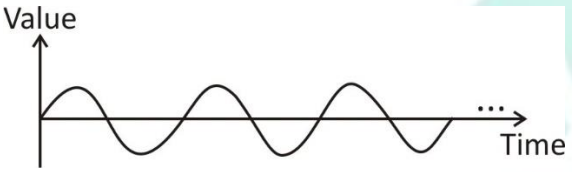
one full pattern is called **cycle** . A non-periodic signal are changes without exhibiting a pattern or cycle that repeats over the time .

Both digital and analog signals can be **periodic or non-periodic** . In data communications, we commonly use non-periodic digital signals and periodic analog signals.

Periodic Analog Signals:

SINE Wave:

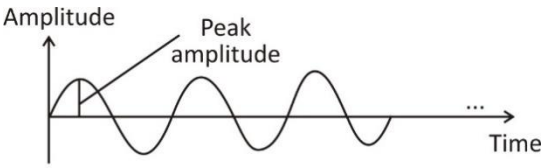
Most fundamental form of analog signal is **a Sine Wave**. when we visualize it as a simple oscillating cave , its change over the course of a cycle is smooth and consistent , a continuous, rolling flow.



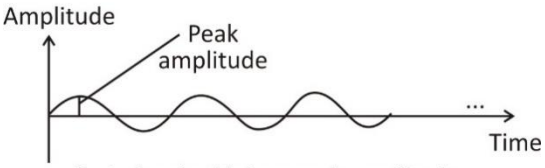
A sine wave can be represented by the three parameters: the peak amplitude , the frequency , and the phase . These three parameters fully describe a sine wave.

Peak Amplitude :

A peak amplitude of signal is the absolute value of its **highest intensity** , proportional to the energy it carrier. For electricity signals , peak amplitude is normally measured in volts .



a. A signal with high peak amplitude



b. A signal with low peak amplitude

Periodic And Frequency:

Period refers to the amount of time, in seconds , a signals needs to complete 1 cycle. **Frequency** refers to the number of periods in 1s. Period is the inverse of frequency, and frequency is the inverse of period.

f = **1/t;** **and t = 1/f;**

frequencyandperiodare the inverse of each other.

Period is formally expressed in seconds . Frequency is formally expressed in **Hertz(HZ)**.

UNITS of Periodic And Frequency :

Periodic		**Frequency**	
UNIT	**EQUIVALENT**	**UNIT**	**EQUIVALENT**
Seconds (S)	1s	Hertz(Hz)	1 Hz
Milliseconds (ms)	10^{-3} S	Kilohertz(kHz)	10^{3} Hz
Microseconds (us)	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

Example:

The power we use at home has a frequency of 60 Hz(50 Hz in Europe) . The period of this sine wave can be determine as follows :

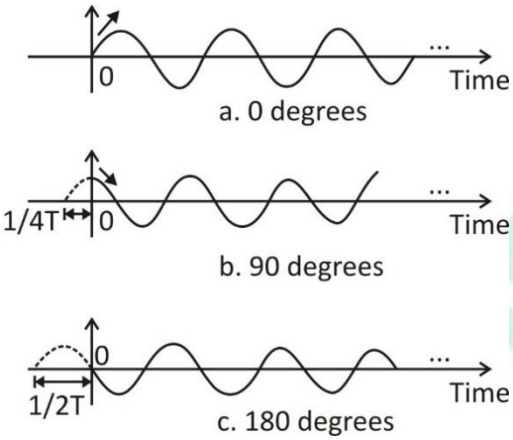
T = 1/f = 1/60 = 0.0166s = 0.0166 X 10^{3}ms = 16.6 ms.

This means that the period of the power for our light at home is 0.0166s. or 16.6 ms. Our eyes are not sensitive enough to distinguish there rapid changes in amplitudes .

PHASE:

The term phase , or phase shift , describe the position of the wave form relative to time 0 .

Phase is measured in degree or radians[360° is 2πrad; 1° is 2π/360 rad , and 1 rad is 360/(2π)]. A phase shift of 360° corresponds to the shift of a complete period; a phase shift 180° corresponds to a shift or one-half of a period ; and a phase shift of 90° corresponds to a sift of one-quarter of a period



Wavelength:

Wavelength is another characteristics of a signal travelling through a transmission medium. Wavelength binds the frequencyor theperiodof a simple sine wave to the propagation speed of the medium .

Wavelength = propagation speed / frequency = (propagation speed) X period

For example , in a vacuum , propagating speed of light is $3x10^8$ m/s . That speed is lower in air and morelower in cable .

The wavelength is normally measured in micrometers(microns) not in meters .

Bandwidth:

The range of frequency is contained in a composite signal is its bandwidth . The bandwidth is difference between two numbers . For example, if a composite signal contains frequencies between 2000 and 5000 , its bandwidth is 5000-2000 or 3000.

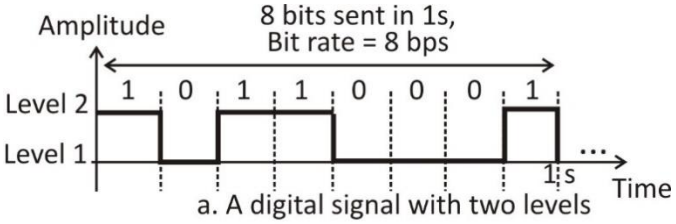
Example : If a period signal is decomposed into five sine waves with frequencies of 100, 300, 500, 700 and 900 Hz . what is its bandwidth ?

Sol: Let f_n be the highest frequency , f_i is the lowest frequency , and B the bandwidth . Then

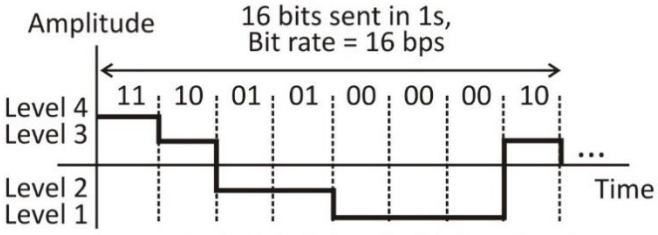
$B= f_n- f_i = 900-100 = 800$ Hz

Digital Signal :

Information can also be represented by a digital signal. For example , a 1 can be encoded as a positive voltage and a 0 as a negative voltage. A digital signal can have more than two level. In this case , we can send more than 1 bit for each level below figure shows two signals , one with two levels and other with four. We send 1 bit per level in part of the figure and 2 bit per level in part b of the figure . In general if a signal has Nlevels , each level needs $\log_2$Nbits. for this reason , we can send $\log_2 4$ = 2 bits in part b.



a. A digital signal with two levels



b. A digital signal with four levels

Example: A digital signal has eight levels . How many bits needed per level ?we calculated the number of bits from the following formulas . Each signal level represented by 3 bits.

Number of bits per level represented by $\log_2 8 = 3$.

Bit Rate:

Bit rate (instead of frequency) - is used to describe the digital signals. The bit rate is the number of bit sent in 1's , expressed in bit per second(bps).

Example:

Assume that we need to download text documents at the rate of 100 pages per second .What is required bit rate of the channel?

Sol: A page is an average of 24 lines with 80 characters in each line . If we assume that one character requires 8 bits , then the bit rate is

100 X 24 X 80 X8 = 1536000bps = 1.536 Mbps .

Bit Length:

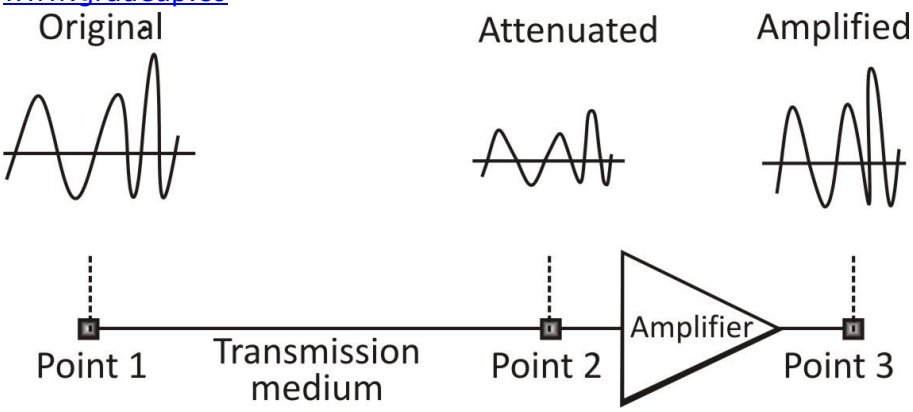
It is defines as the distance one cycle occupies on the transmission medium.

Bit length = propagation speed X bit duration

Transmission Impairment:

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 medium .



DECIBEL:

To show that signal has lost or gained strength, engineers use the unit of the decibel. The decibel (db) measures the relative strengths of two signals or one signal at two different point.

$$db = 10\log_{10} p_2/ p_1$$

variable P_1 and P_2 are the powers of a signal at point 1 and 2 . some engineering book define the decibel in terms of voltage instead of power. Power is proportional to the square of the voltage , the formula is $dB = 20 \log_{10}(v_2/v_1)$. In this text , we expressed dB in terms of power .

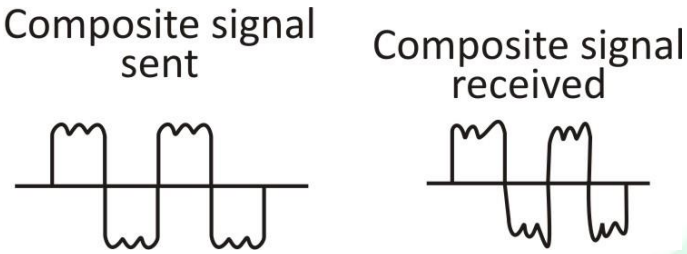
Example:

A signal travels through an amplifier, and its power is increased 10 times .This means that the $P_2 = 10P_1$. In this case the amplification i.e. gain of power can be calculated as follows

$$10\log_{10} p_2/ p_1 = 10\log_{10} 10p_1/ p_1 = 1 \text{ dB}.$$

Distortion :

Distortion means that a signal changes its shape orform. Distortion mostly occur in a composite signal made of different frequencies. Each signal component has its own propagation speed through mediumthat is why its own delay in arriving at the final destination.



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