Signal

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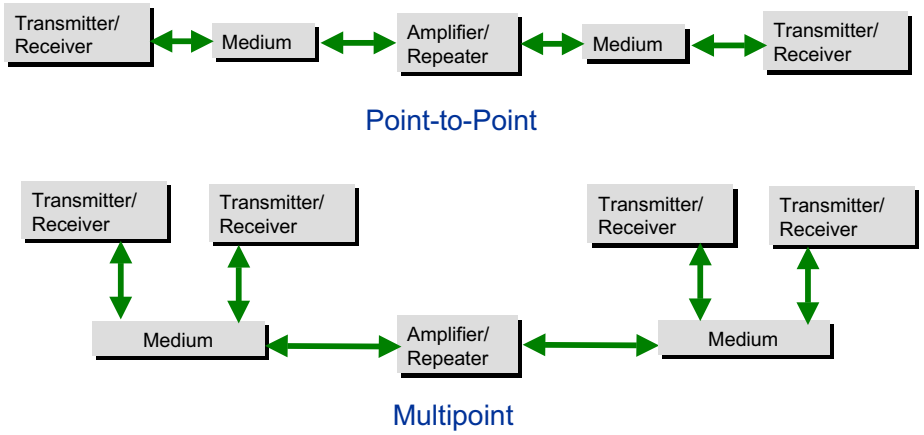
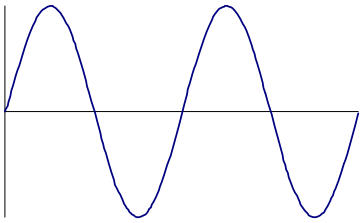
Transmission structure

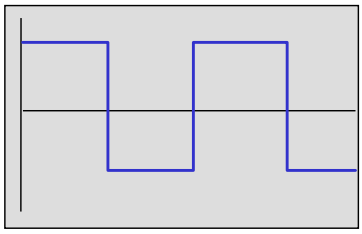


Data transmission occurs between transmitter and receiver over some transmission medium. The point-to-point configuration provides a direct link between two parties. There are only two parties sharing the medium. In a multipoint configuration, more than two parties share the same medium

Analog & Digital signal



- Analog

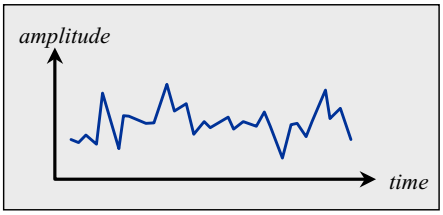


- Digital

Computers transmit data using digital signals, sequences of specified voltage levels. Graphically they are often represented as a square wave.

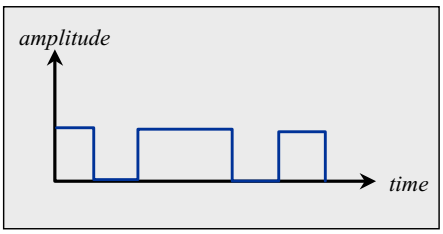
Computers sometimes communicate over telephone line using analog signals, which are formed by continuously varying voltage levels.

Time - Domain Signal



- **continuous**

$$\lim_{t \to a} s(t) = s(a) \quad \textit{for all of } a$$

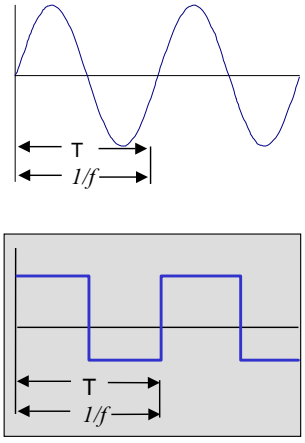


- **discrete**

$$\lim_{t \to a} s(t) = s(a) \quad \textit{for some of } a$$

The signal is a function of time. Horizontal axis represents time and the vertical axis represents the voltage level.

Periodic Signal



$s(t+T) = s(t)$ $-\infty < t < +\infty$

Components

- amplitude
- frequency
- phase

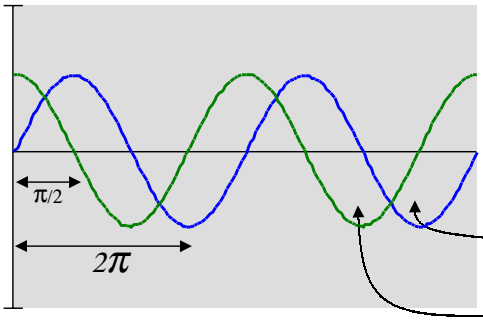
A signal *s(t)* is periodic if and only if

$$s(t+T) = s(t) \qquad -\infty < t < +\infty$$

where the constant T is the periodic of the signal, otherwise a signal is a periodic. Three important characteristics of a periodic signal are :

- *amplitude* the instantaneous value of a signal at any time measures in volts.
- *frequency* the number of repetitions of the period per second or the inverse of the period; it is expressed in cycles per second or Hertz (Hz).
- *phase* a measure of the relative position in time within a single period of a signal.

Phase different



- signal out of phase by π/2 radians

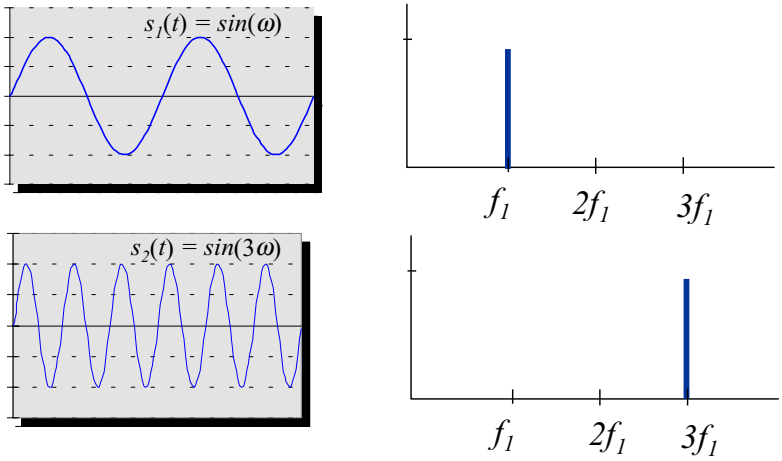
$s_1(t) = sin(\omega)$

$s_2(t) = sin(\omega+\pi/2)$

The figure shows two signals that are out of phase by π/2 radians (2π radians = 360° = 1 period). Thus we can express a sinusoid as

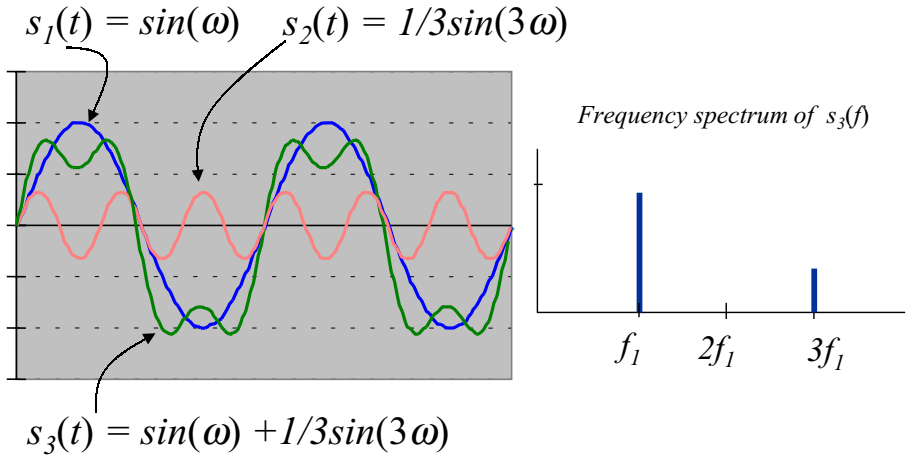
$$s(t) = A\ sin(\omega + \theta)\ ;\ \theta = phase\ shift$$

Frequency Domain Concept



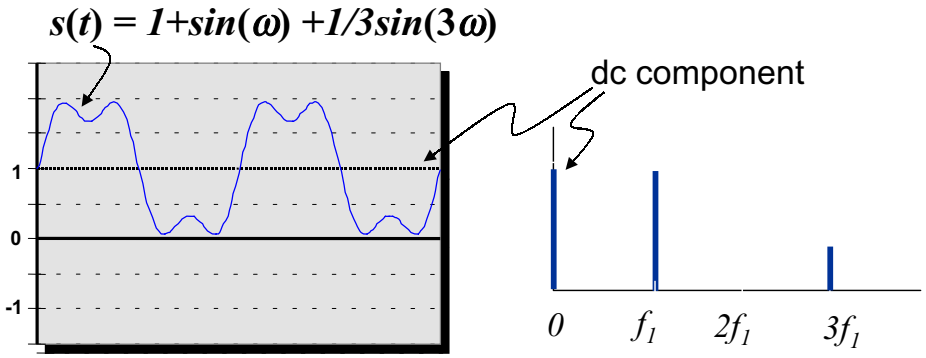
The signal is a function of time, but it can be also be expressed as a frequency.

Frequency components



The figure shows two different signals which have different frequencies and its additional frequency components. The spectrum of a signal is the range of frequencies that it contains. For the $s_3(t)$, the spectrum extends, from f_1 to $3f_1$.

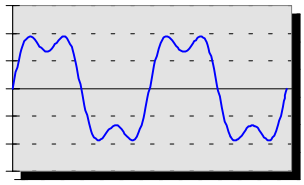
dc components



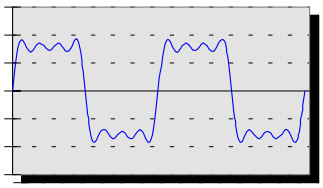
A component of zero frequency is a direct current (dc) With a dc component it has a frequency term at f=0. Each frequency component is also call a *harmonics.*

Fourier series

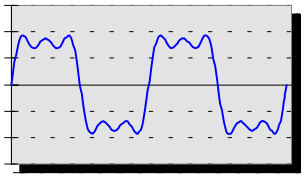
- $s(t) = 0.5a_2 + \sum_{i=1}^{\infty} [a_i cos(2\pi it/T)] + b_i cos(2\pi it/T)]$



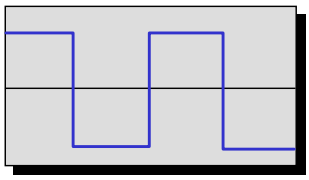
1 and 3 harmonics



1,3,5 and 7 harmonics



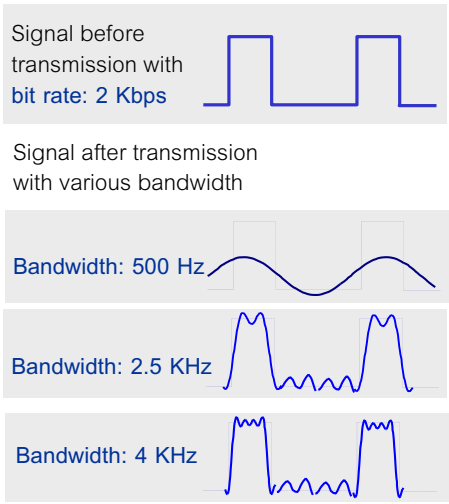
1,3 and 5 harmonics



whole harmonics

Jean Baptise Fourier developed a theory stating that any periodic function can be expressed as an infinite sum of sinusoidal function of varying amplitude, frequency, and phase shift. The sum is called a *Fourier Series*.

Data rate and Bandwidth



- **Transmission medium has a limited bandwidth**
- **Digital signal has infinite bandwidth**
- **Selection of transmission medium relies on the cost of investment and the quality of transmitted signal.**

The nature of transmission medium will limit the bandwidth that can be transmitted. The greater bandwidth of medium, the greater the cost. Economic and practical reason dictate the medium type. On the other hand, limiting bandwidth creates signal distortions. The more limited the bandwidth, the greater the distortion and the potential for error of the receiving signal.

Fourier's applications

- **Why a person's voice never sound exactly the same over the phone?**
- **How to block certain frequencies while allowing other?**
- **How a television can receive as many as 100 channels?**

Human speech has frequencies in range 20 Hz-20 kHz. The telephone can transmit signals between approximately 300 Hz and 3300 Hz. The original signal loses its very low and high frequency components.

Fourier's results are used in defining filter to block certain frequencies while allowing others to pass. Application of filter e.g. an equalizer attached to a stereo can be adjusted to bring out certain tones in music.

Signal can be grouped or multiplexed and transmitted together. Each TV channel is assigned a certain range of frequencies, and a signal defining the sound and pictures is created using frequencies within that range. Selecting channel simply allows frequencies within a certain range to pass.

Broadband Transmission

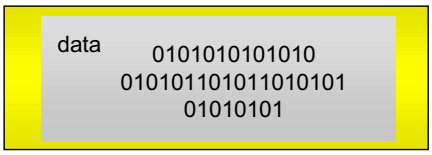
- **Multiple channels**
- **Normally use FDM**

Guard bands separate channel

A broadband transmission is an analog communication strategy in which multiple communication channels are used simultaneous. The data in a broadband transmissions modulated into frequency bands, or channels, and is transmitted in these channels.

Guards bands which are small bands of unused frequencies, are allocated between data channels. These provide a buffer against interference due to signals from one channel drifting into a neighboring one.

Baseband Transmission



- **Dedicated whole channel bandwidth for transmission**

A baseband connection is one that uses digital signals, which are sent over wires without modulation. Binary values are sent directly as pulses of different voltages levels rather than being transmitted with a carrier signal. It is possible to transmit multiple signals using multiplexing scheme.