ELC5693-GENERAL COMMUNICATION THEORY
6B07112 Electronic and Electrical Engineering

№5 lecture

Methods and forms of Signal Representation

Dosbayev Zhandos Makhsutuly, senior lecturer
E-mail: zh.dosbayev@satbayev.university

Outline

Definitions

Complex number representation

Types of signal

Signal transforming

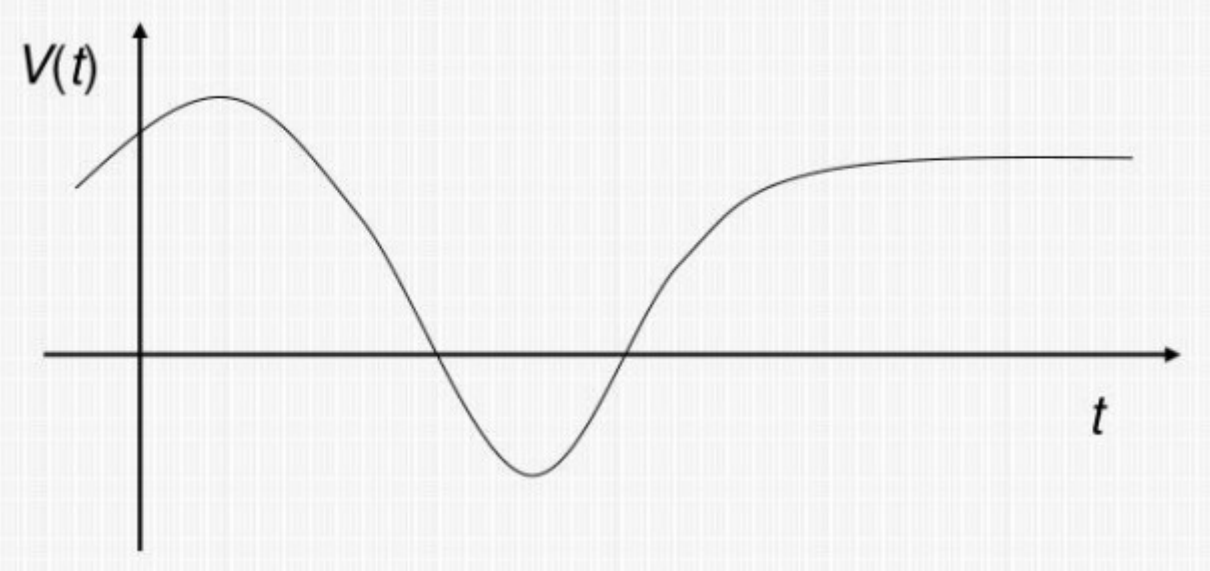
What is signal?

Sign -> Signal

- Traffic signal
- Flashing indicator light of a car
- Mobile network signal
- In the fields of communications, signal processing, and in electrical engineering more generally, a **signal** is any time-varying or spatial-varying quantity.

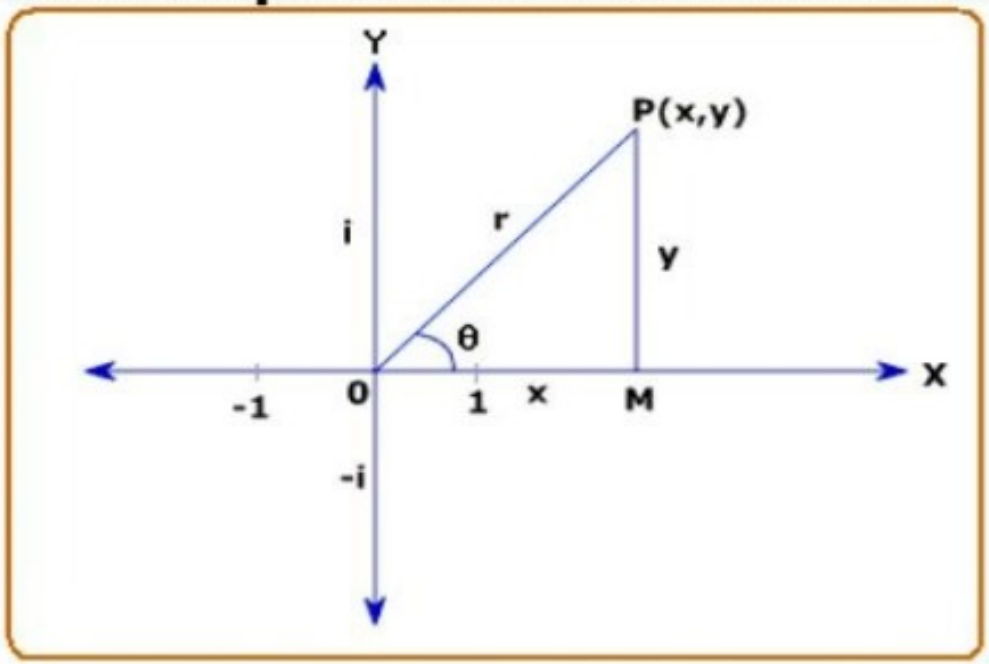
Signal

- "A signal is a function of independent variables that carry some information."
- e.g. A Voltage V(t) or a Current C(t) that depends on time



Complex number representation:

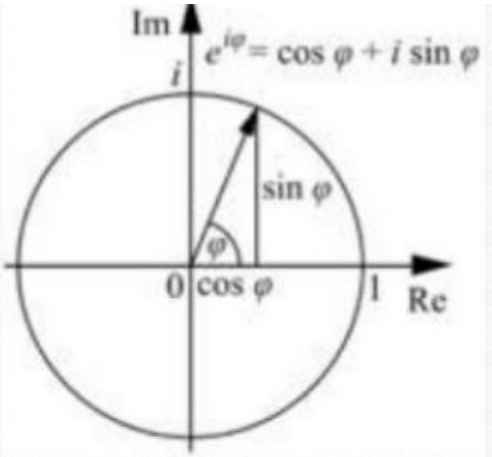
- Three ways to represent a complex number
- cartesian $z=x+iy$
- polar $z = r\angle\varphi$
- Exponential $z=r\,e^{i\varphi}$
- $r=\sqrt{x^2+y^2}$ *and* φ *in radians*



$$\varphi = \arg(z) = \begin{cases} \arctan\left(\frac{y}{x}\right) & \text{if } x > 0 \\ \arctan\left(\frac{y}{x}\right) + \pi & \text{if } x < 0 \text{ and } y \geq 0 \\ \arctan\left(\frac{y}{x}\right) - \pi & \text{if } x < 0 \text{ and } y < 0 \\ \frac{\pi}{2} & \text{if } x = 0 \text{ and } y > 0 \\ -\frac{\pi}{2} & \text{if } x = 0 \text{ and } y < 0 \\ \text{indeterminate} & \text{if } x = 0 \text{ and } y = 0. \end{cases}$$

Complex representation:

- **Euler's formula:** $e^{i\varphi} = \cos\varphi + i\sin\varphi$



Then $x = \cos\varphi$ and $y = \sin\varphi$

And $x = Re\{e^{i\varphi}\}$ and $y = Im\{e^{i\varphi}\}$

Let $\varphi = \omega t + \theta$

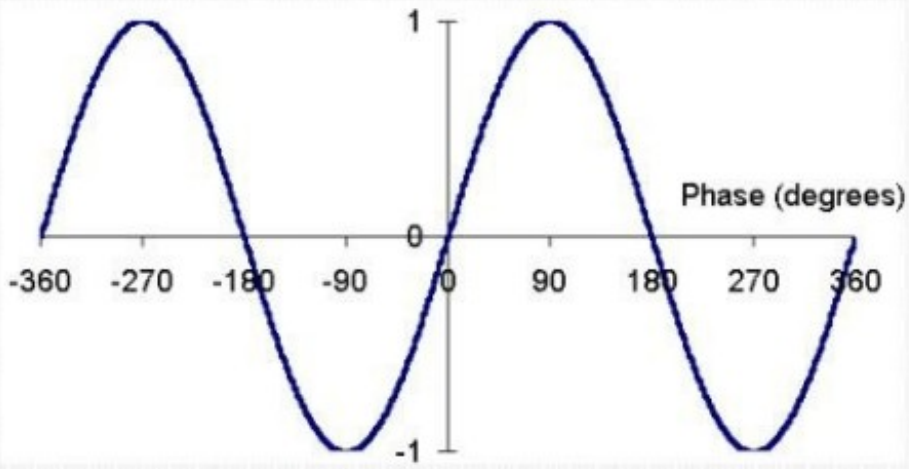
Then $x = Re\{e^{i\,\omega t+\theta}\} = \cos(\omega t+\theta)$

And $y = Im\{e^{i\,\omega t+\theta}\} = \sin(\omega t+\theta)$

$$y = \sin(\omega t+\theta) = Im\{e^{i(\omega t+\theta)}\}$$

How is a Signal Represented?

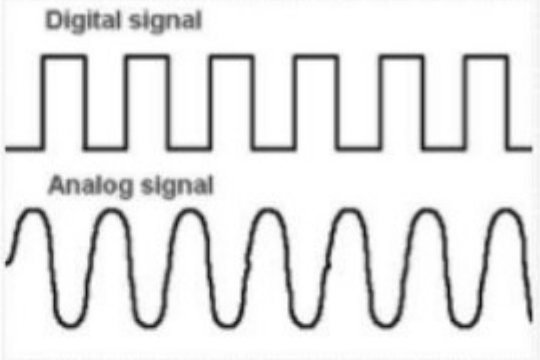
- Mathematically, signals are represented as a function of one or more **independent variables**.
- Below signal depends on independent variable t with parameters A, ω and θ.
- $s = A\,Sin(\omega t+\theta) = A\,Im\{e^{j(\omega t+\theta)}\}$

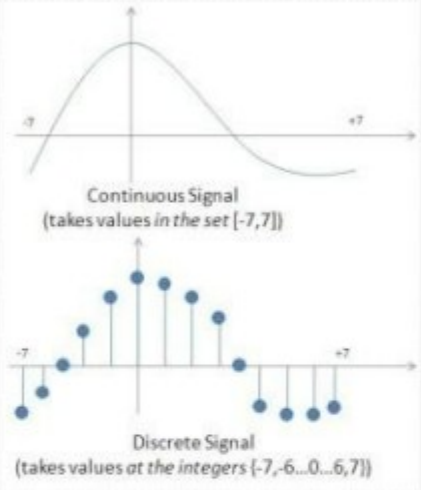


A=Amplitude real
ω =angular frequency
θ =phase
Sin(~)=function

Types of Signal:

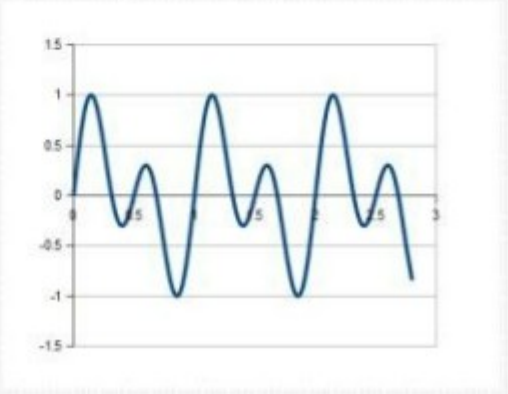
Analog and digital signals





Continuous and Discrete-Time Signals

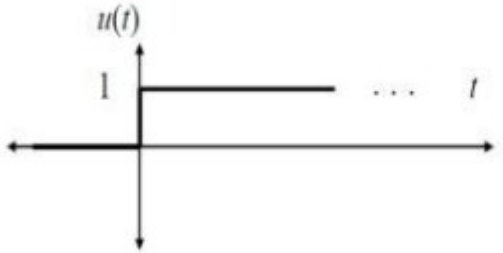
Periodic aperiodic Signal

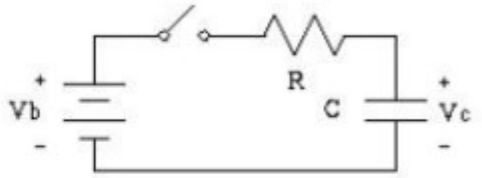


Types of Signal (contd.)

- Unit Step Function u(t)

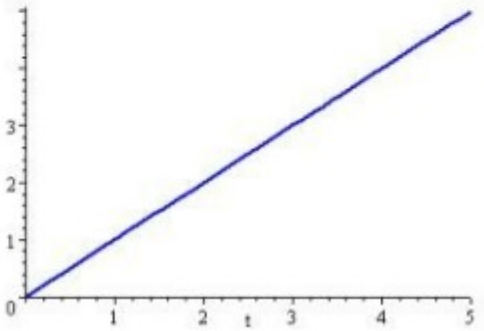
$$u(t) = \begin{cases} 1, t \geq 0 \\ 0, t < 0 \end{cases}$$





- Ramp function r(t)

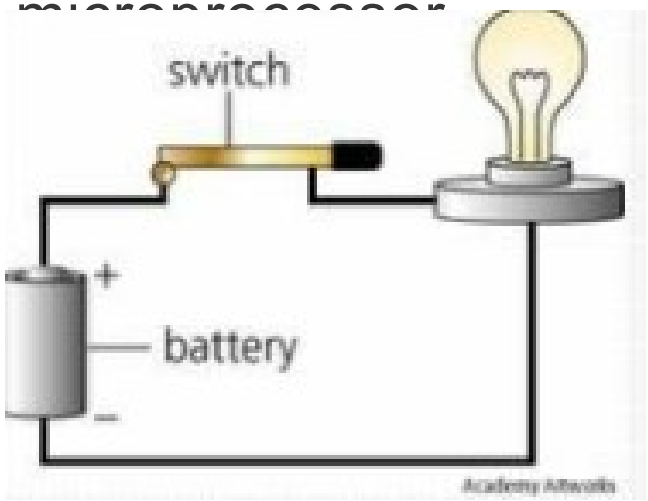
$$r(t) = \begin{cases} t, t \geq 0 \\ 0, t < 0 \end{cases}$$

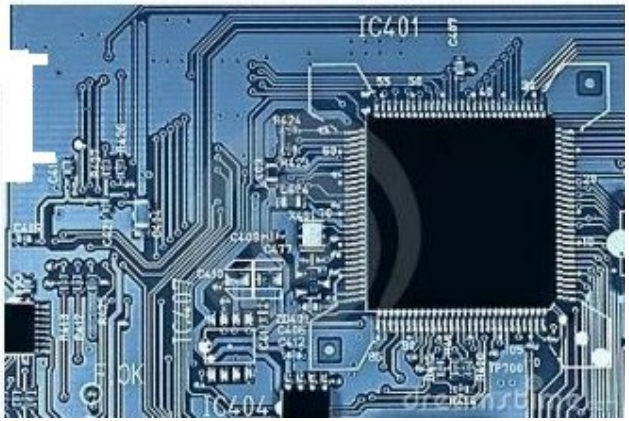


System:

- A **System** is any physical set of components that takes a signal and transforms it into another

- A system can be a simple one that turns a light ON/OFF. Or can be a complex one that does all the computation in a





Amplifier

- An **electronic amplifier** is a device for increasing the power of a signal.

- It does this by taking energy from a power supply and controlling the output to match the input signal shape but with a larger amplitude.
- There are various types of amplifier.

Time shifter

- A time shifter system shifts the function f(t) forward or backward by a specific time.

- The above system is a forward time shifter. It adds a delay (t_0) to the signal.

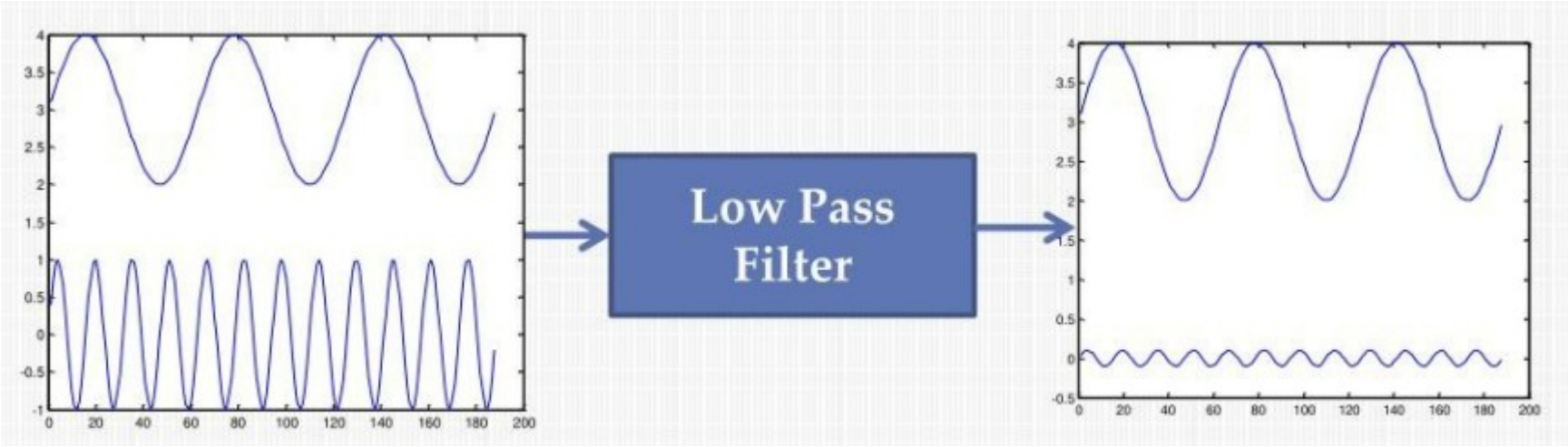
Sampler

- **Sampling** is the reduction of a continuous-time signal to a discrete-time signal

- The sampling frequency must be higher than the frequency of the signal to be sampled. {minimum twice as high)

Low Pass filter

- **A low-pass filter is a filter that passes low-frequency signals but attenuates (reduces the amplitude of) signals with frequencies higher than the cutoff frequency.**



High Pass filter

- **A high-pass filter (HPF) is a device that passes high frequencies and attenuates (i.e., reduces the amplitude of) frequencies lower than its cutoff frequency.**