ECE 301 - Lecture #1

Signals and Systems

What is a signal?

Function of one or more independent variables

We will usually call the independent variable "time"

$x(t)$: signal

What is a system?

Transformation of input signals that result in output signals

What are the concepts?

- Time and Frequency

Description of Variations

Information Content of the signal

- Linear and Time Invariant Systems

(LTI Systems)

* Linearity

- Additivity

$$x_1(t) \longrightarrow \boxed{S} \longrightarrow y_1(t)$$

$$x_2(t) \longrightarrow \boxed{S} \longrightarrow y_2(t)$$

$$x_1(t)+x_2(t) \longrightarrow \boxed{S} \longrightarrow y_1(t)+y_2(t)$$

That has to apply for any choice of $x_1(t)$ and $x_2(t)$

- Homogeneous system

$$x(t) \longrightarrow \boxed{S} \longrightarrow y(t)$$

any complex number

$$a\,x(t) \longrightarrow \boxed{S} \longrightarrow a\,y(t)$$

A system is linear if it is additive and homogeneous.

Time Invariance

A system is time invariant if any shift to the input signal results in the same shift in the output signal

$y(t) = x(t-1)$ time invariant

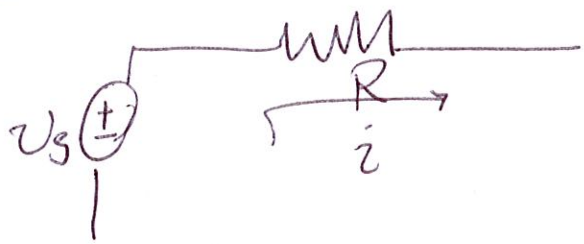
$y(t) = t\,x(t)$ time variant

Discrete-time and Continuous-time Signals

$x[n]$: n is an integer

$x(t)$: t is a real number

Energy and Power of Signals



* instantaneous power

$$p(t) = v(t)\, i(t) = \frac{1}{R} v^2(t)$$

Total energy over $t_1 \leq t \leq t_2$

$$\int_{t_1}^{t_2} p(t)\, dt = \int_{t_1}^{t_2} \frac{1}{R} v^2(t)\, dt$$

Average Power over $t_1 \le t \le t_2$

$$\frac{1}{t_2 - t_1} \int_{t_1}^{t_2} \frac{1}{R} v^2(t)\, dt$$

$n_1 \le n \le n_2$

Total energy over $t_1 \le t \le t_2$

CT: $$\int_{t_1}^{t_2} |x(t)|^2\, dt$$

DT: $$\sum_{n=n_1}^{n_2} |x[n]|^2$$

$n_1 \le n \le n_2$

Average Power over $t_1 \le t \le t_2$

CT: $$\frac{1}{t_2 - t_1} \int_{t_1}^{t_2} |x(t)|^2\, dt$$

DT: $$\frac{1}{n_2 - n_1 + 1} \sum_{n=n_1}^{n_2} |x[n]|^2$$

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$$E_\infty = \lim_{T \to \infty} \int_{-T}^{T} |x(t)|^2 \, dt = \int_{-\infty}^{\infty} |x(t)|^2 \, dt$$

DT: $$E_\infty = \lim_{N \to \infty} \sum_{n=-N}^{N} |x[n]|^2 = \sum_{n=-\infty}^{\infty} |x[n]|^2$$

$$P_\infty = \lim_{T \to \infty} \frac{1}{2T} \int_{-T}^{T} |x(t)|^2 \, dt$$

DT: $$\lim_{N \to \infty} \frac{1}{2N+1} \sum_{n=-N}^{N} |x[n]|^2$$