Topic 1.5- part 0
“LTI systems in time domain”

Senales y Sistemas

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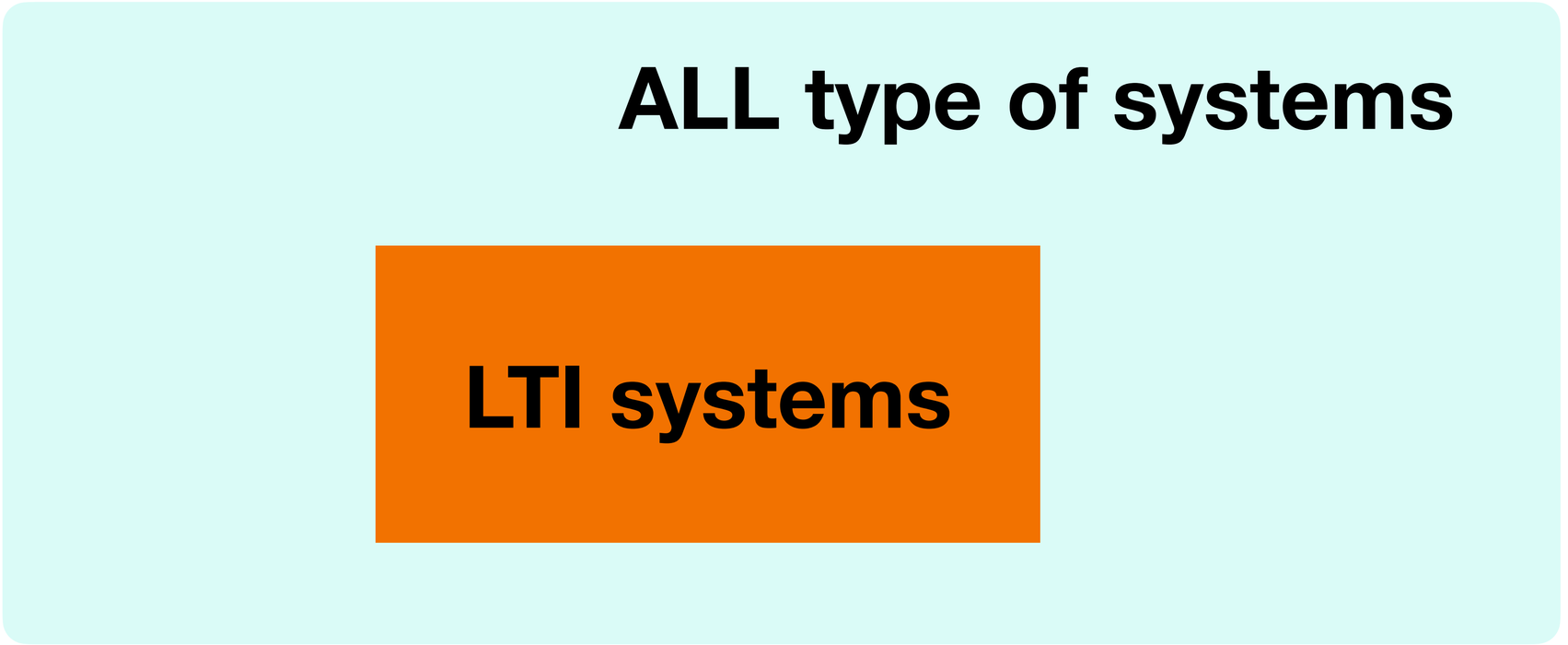
LTI systems

- We will focus on: LINEAR TIME INVARIANT (LTI) SYSTEMS
- LTI systems in time
- LTI systems in transformed domain (frequency domain etc.)



In this slides, WE WILL SEE:

HOW to express (IN the TIME DOMAIN) the output of:

1. LTI systems in (continuous) time

2. LTI systems in DISCRETE time

HOW to express (IN the TIME DOMAIN) the output of:

1. LTI systems in (continuous) time

HOW to express the output of LTI systems in TIME

Continuous Time - 2 WAYS:

- **CONVOLUTION INTEGRAL:**

$$y(t) = \int_{-\infty}^{+\infty} x(\tau)h(t-\tau)d\tau = \int_{-\infty}^{+\infty} x(t-\tau)h(\tau)d\tau$$

- **LINEAR DIFFERENTIAL EQUATIONS, WITH CONSTANT COEFFICIENTS AND NULL INITIAL CONDITIONS:**

$$\sum_{n=0}^{N} a_n \frac{d^n y(t)}{dt^n} = \sum_{m=0}^{M} b_m \frac{d^m x(t)}{dt^m}$$

(N) Initial conditions:

$$y(0) = \left.\frac{dy(t)}{dt}\right|_{t=0^-} = \ldots = \left.\frac{d^{N-1}y(t)}{dt^{N-1}}\right|_{t=0^-} = 0$$

HOW to express (IN the TIME DOMAIN)
the output of:

2. LTI systems in DISCRETE time

HOW to express the output of LTI systems in TIME

DISCRETE Time - THIS IS A SPOILER !!

- **CONVOLUTION SUM:**

$$y[n] = \sum_{k=-\infty}^{\infty} x[k]h[n-k] \qquad y[n] = x[n] * h[n]$$

- **LINEAR *DIFFERENCE* EQUATIONS, WITH CONSTANT COEFFICIENTS AND NULL INITIAL CONDITIONS:**

$$\sum_{i=0}^{L} b_i y[n-i] = \sum_{r=0}^{R} c_r x[n-r]$$

$n \geq 0$

$n = 0, 1, 2, 3...$

With L-INITIAL CONDITIONS (they are required)

$$y[-1], y[-2], ..., y[-L]$$

Linear Difference Equations

- A LTI systems in DT can be expressed using linear difference equations with constant coefficients. **(and null initial conditions)**

- Definition: $y[n] = \sum_{p=1}^{P} a_p y[n-p] + \sum_{m=0}^{M} b_m x[n-m]$

- They are ARMA (autoregressive-moving average) filters
- If all a_p=0 → FIR (FINITE IMPULSE RESPONSE) filters
- If all b_m=0 except b_0 → IIR (INFINITE IMPULSE RESPONSE) filters

Questions?