Q: Why study signals & systems?

A: Fundamental to solving engineering problems

* Model the problem of interest as a "system" Often involves writing down the mathematical description of the input/output signals & their relationship.

* Analze the system: Usually involves the study of various possible signals associated with the system

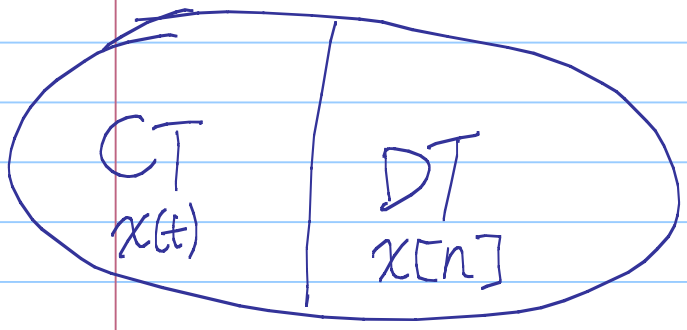
* Design a new system: Requires deciding a suitable system architecture as well as finding good system parameters.

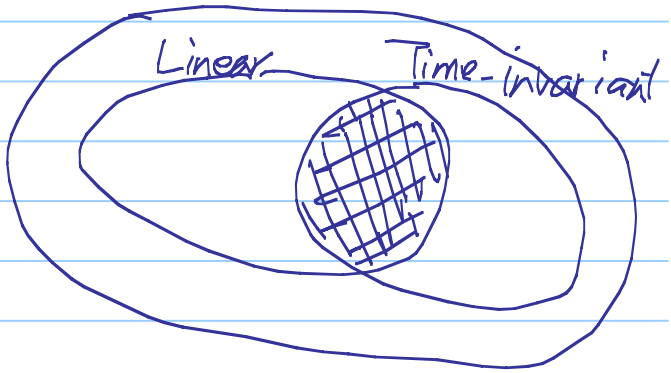
* Implement and test the system: Check the system & the input/output signals to see whether the performance is satisfactory.

* The scope of this course

Signals

Systems





① Signals vs. LTI systems.

② New Analytical Tools:

Fourier transform, Laplace transform

z-transform, convolution integral...

"Convolution sum" as in convolutional neural networks in machine learning.

③ Important applications:

Filters, AM/FM radios

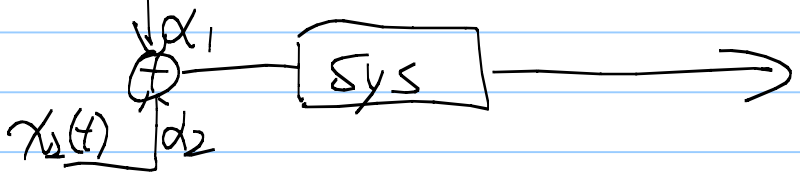
Quantization, sampling,

digital signal processing, etc.

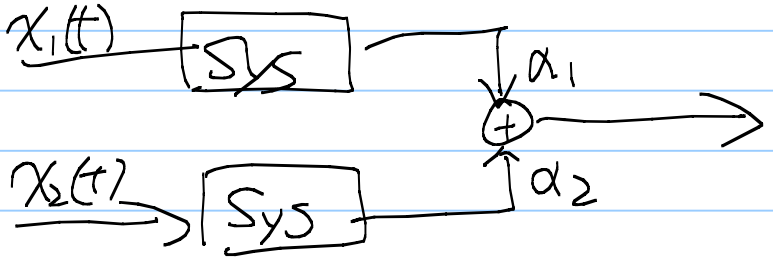
ECE 440, VIP Beyond-5G team, ECE544

Definition: We say a system is linear if the output of the following two configurations are always identical

Config #1. $x_1(t)$



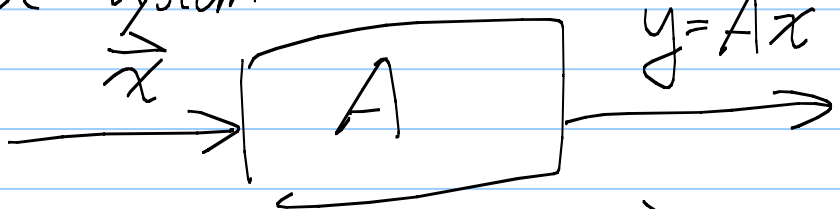
Config #2: $x_1(t)$



Q: How to check whether a system is linear or not?

Example: Consider a 2×2 matrix A.

& a system



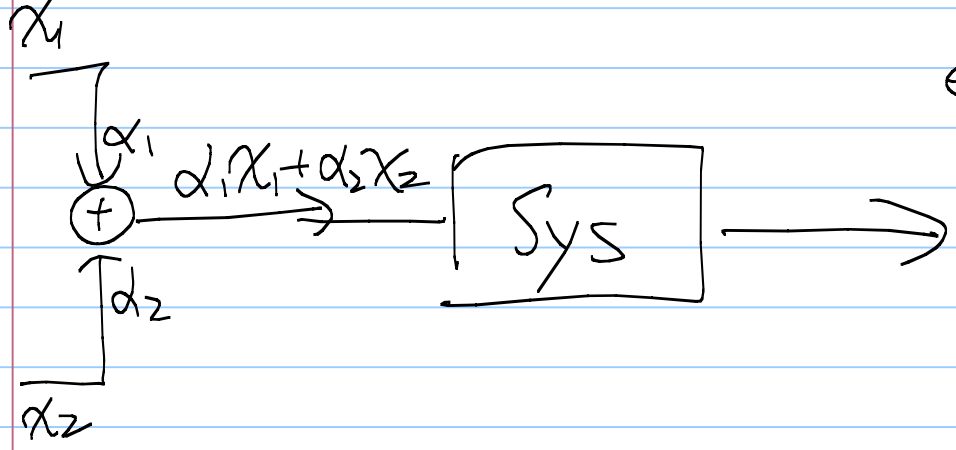
input $\vec{x} = \begin{pmatrix} x_1 \\ x_2 \end{pmatrix}$ output $\vec{y} = \begin{pmatrix} y_1 \\ y_2 \end{pmatrix} = A \begin{pmatrix} x_1 \\ x_2 \end{pmatrix}$

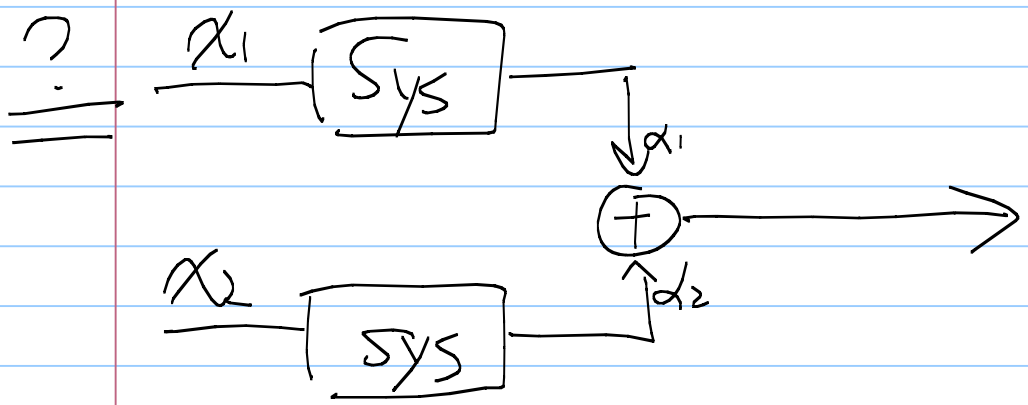
Q: Is such a system linear?

A: Step 1: Write down / draw the two configurations.

(do not assign any value to $\vec{x}_1$ & $\vec{x}_2$
We want to use $\vec{x}_1, \vec{x}_2$ to represent any signals; Do not assign any value to α_1, α_2, & we want to use α_1, α_2 to represent any combination

Step 2: Check whether the outputs are equal.

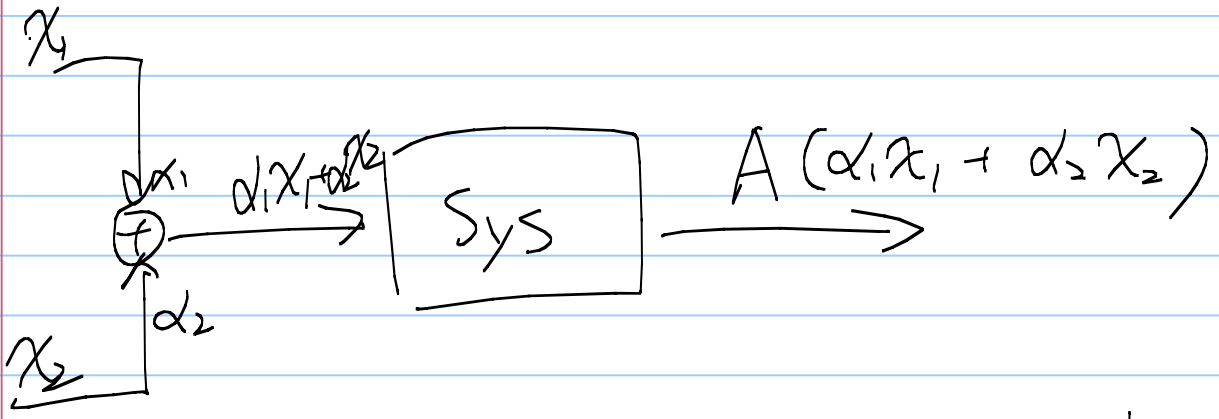




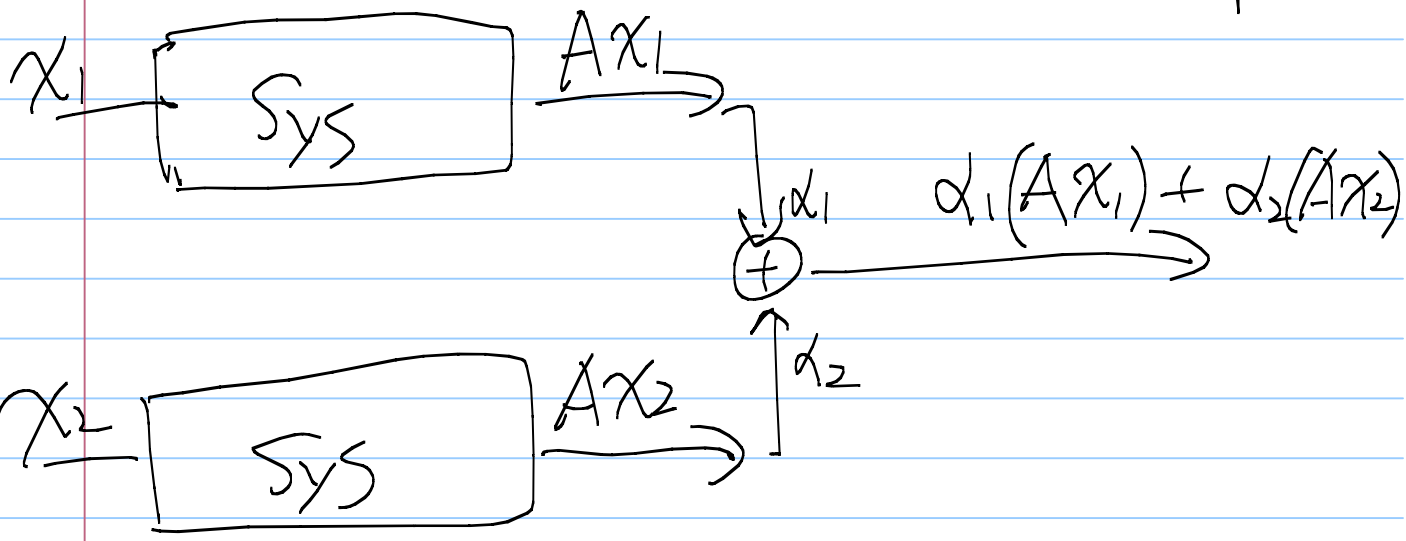
If equal, then the sys is linear. If not, $\Rightarrow$ non-linear.

In our example:

Top (combining the input)



Bottom (combining the output) ||

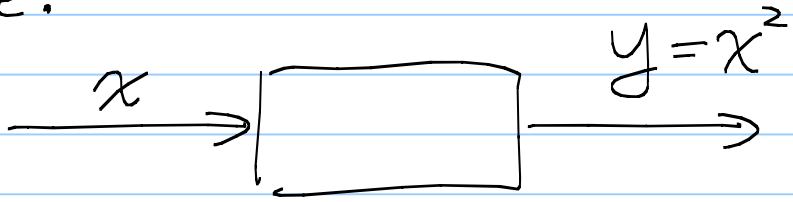


Ans: Linear.

Q: Are all sys linear?

Ans: No.

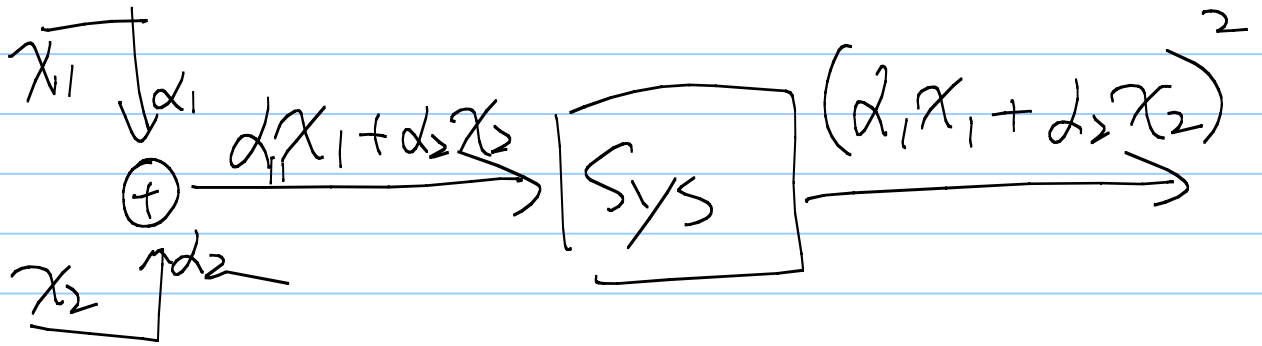
Example:

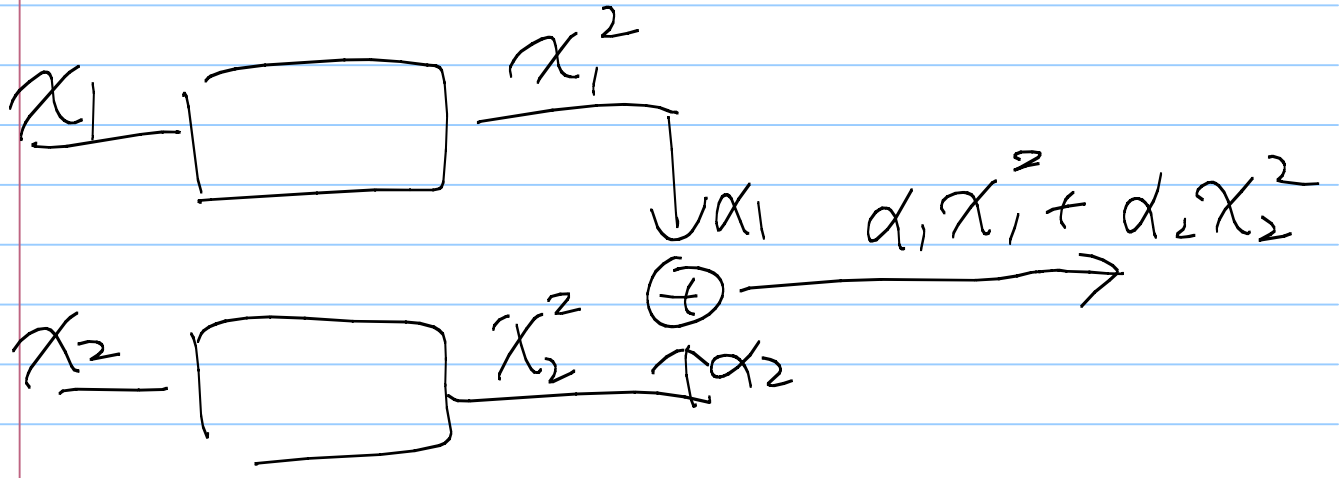


Q: Show that such a sys is non-linear.

Ans: Step 1: Write down the two configurations.

Step 2:





$\neq \Rightarrow$ Non-linear.