VE216 Recitation Class 1

ZHU Yilun

UM-SJTU Joint Institute

VE216 SU20 Teaching Group

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Overview

1. Introduction
   - RC Arrangement
   - General Advice
2. Chapter 1: Signals and Systems
   - Signal Characteristics
   - Singularity Functions
   - Transformation of Signals
   - Preview: Systems
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RC Arrangement

Time	Join Through
Monday 16:00 - 17:30	Zoom ID: 537 259 5052

For zoom RC:

- you may need to join twice, due to 40-min limit
- I will join only 5 min before class starts, due to 40-min limit
- If you have questions, I prefer:
  Raise hand, then speak $>$ public message $>$ private message

For TA's job:

- ZHU Yilun - RC
- CHEN Ling, LI Zhipeng, YUAN Shuai - all the other staff, including Homework, Quiz, Lab, ...
- Please contact by email, rather than via Wechat

General Advice

- To me, this course seems like an (Applied) Math course, therefore:
  - Don't get lost in Math, think about physical meaning
  - Live with ambiguousness, don't treat it as a "Theoretical" Math course
- The course "Signals and Systems" on MIT Open Courseware by Prof. Alan V. Oppenheim's is highly recommended
  - Personally, recommend Video Lecture $>$ Textbook
- This course is inspiring because it provides a different view
  - When I first study this course, the application to *Communication Systems* is really fascinating to me.
  - After working as TA and reviewed all the contents again, I realized that this course is full of brilliant ideas.
  - I hope, at least, tell you the points that attracted me most
- Ever think of why this course is titled "Signals and Systems"?

Even and Odd

Theorem (Even and odd components)

$$x(t) = x_e(t) + x_o(t)$$

$$x_e(t) = \frac{1}{2}[x(t) + x(-t)], x_o(t) = \frac{1}{2}[x(t) - x(-t)]$$

Energy and Power

- Do not cram. Remember with the help of graph. (Eg.: power consumed by a resistor)
- Average value:

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

- Energy (remember the square):

$$E = \int_{-\infty}^{\infty} |x(t)|^2 dt$$

- Average power:

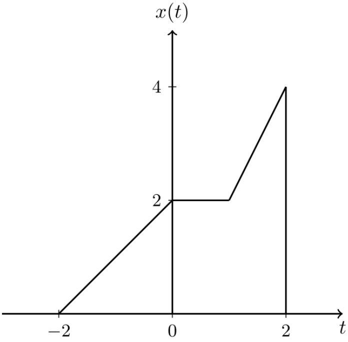
$$P = \lim_{T \to \infty} \frac{1}{2T} \int_{-T}^{T} |x(t)|^2 dt$$

- Energy Signal, Power Signal

Singularity Functions

- Unit Step Function: $u(t)$
  - $\delta(t) = \frac{d}{dt}u(t)$
- Rectangle Function:
  - $rect(t)$
  - $rect(t) = rect(-t)$
  - $rect(\frac{t-t_0}{T})$ is centered at t_0 and with width T
- Skill: Using these functions to represent piecewise functions — Q4,9

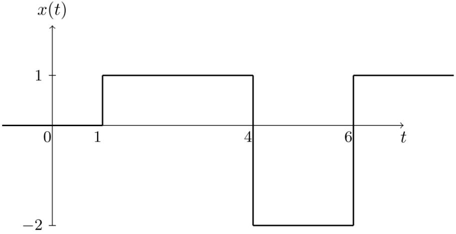
Exercise: Q4(a)



(a) Find a mathematical representation for $x(t)$.

Exercise: Q9

9. [4!] Consider the signal illustrated below.



(a) Express the signal $x(t)$ using a sum of step functions.

(b) Find the derivative of the signal and carefully sketch it.

Singularity Functions

- Unit Impulse Function: $\delta(t)$
  - sampling property — function

$$x(t)\delta(t-t_0) = x(t_0)\delta(t-t_0)$$

  - sifting property — number

$$\int_{-\infty}^{\infty} x(t)\delta(t-t_0)dt = x(t_0)$$

  - scaling property (prove : using area)

$$\delta(at) = \frac{1}{|a|}\delta(t)$$

Exercise

13. [6!] Let $s(t) = (\frac{t-1}{2})^2 rect(\frac{t-1}{2})$

    (a) Make a sketch of s(t).

    (b) Evaluate $\int_{-\infty}^{\infty} s(t)x(t)dt$, where $x(t) = \delta(t-\frac{1}{2}) + \delta(t-2) - \delta(3t-4)$.

Transformation of Signals

Theorem (Time transformation)

1) $x(\frac{t-t_0}{w})$ 2) $x(at-b)$

For Graph:

1) First scale according to w, then shift according to t_0
2) First time-delay by b, then time-scale by a

Wait... The word "Transformation" sounds familiar?
Yes. Transformation of signals is performed by systems!

Think about the physical meaning: There are two systems, one can shift the time, another can scale the time. Different sequence of connection requires different specification of (w, t_0, a, b) to reach the same effect.

Transformation of Signals

Theorem (Amplitude transformation)

1) Reversal $y(t) = -x(t)$
2) Scaling $y(t) = ax(t)$
3) Shifting $y(t) = x(t) + b$

General Transformation

- "Time" transformation: $y(t) = x(g(t))$
- "Amplitude" transformation: $y(t) = h(x(t))$

Consider:

- 1) $y(t) = x(t)$
- 2) $y(t) = x(\sin(t))$
- 3) $y(t) = \cos(x(t))$
- 4) $y(t) = \int_{-\infty}^{t/2} x(\tau)d\tau$

Question:

Think about whether the system that perform such transformation are: "linear, stable; time-invariant, causal, memoryless" in general.

We will come back to these after going through the system properties.

Preview: Systems

- Transform the input signal to the output signal
- Understand the system in terms of input-output relation
- const. system $y(t) = 0$ vs. "non-causal" $y(t) = x(t+1) - x(t+1)$?

- Question from class: Is a system casual if "x(t)" is non-casual?

- Digression: physical meaning of knowing $x(t)$, e.g.: $x(t) = \sin(t)$?

Summary

- Singularity functions
- Connection between signals and systems
- 2nd RC will focus on system properties

The End