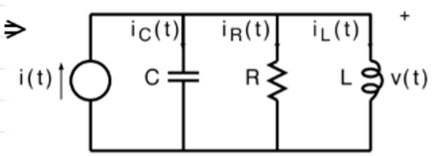
2023년 9월 21일 목요일 13:51

CM06 230921Th

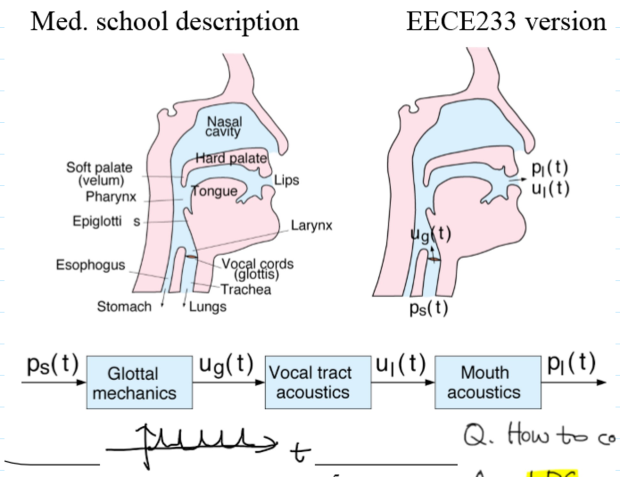
Announcements

1. 지난 강의 수정/보완 사항

(i)



(ii)



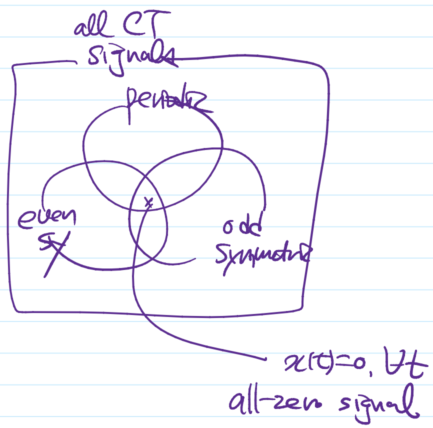
(ii)' VOCODER
- Segmentation
- decomposition
- Compression
- ENC (FEC)
- (TX)
- (RX)
- DEC
- decompress
- synthesis

(iii) 냉장고
- 열전달 : 기계
- motor, compressor, controller, HMI, comm. : 전자전기

(iv) periodic even-symmetric ∋ sin, periodic odd-symmetric ∋ cos.

$\cos\frac{2\pi t}{T}$

$\sin\frac{2\pi t}{T}$



2. HW and Quiz
   - Quiz #1 will be taken on ~~Thursday 28~~ Tuesday 26 in the beginning of the ~~8th~~ 7 classs meeting. It will take about 15-20 minutes.
   - HW03 will be assigned soon. Due will be next Tuesday. For details, check the PLMS class homepage.

3. 강의 자료
   - Handouts and annotated pdfs are downloadable from the non-PLMS class homepage at http://cisl.postech.ac.kr/class/eece233/schedule.htm.
   - Recorded CMs are available from cisl.postech YouTube channel. Please place clickable time stamps.

4. 출석
   - 출결상태에 대해 전자출결시스템(https://wpsc.postech.ac.kr/eams/login)을 확인하세요. 정정사유가 있는 학생은 증빙를 제출해 주세요.
   - 지난 CM#5는 지각없이 모두 출석으로 처리해 놓았습니다.

5. Overview (The numbers are the chapter numbers of the textbook)
   1. Signals and Systems

2. Linear Time-Invariant Systems
3. Fourier Series Representation of Periodic Signals
4. Continuous-time Fourier Transform
5. Discrete-time Fourier Transform
6. Time and Frequency Characterization of Signals and Systems
9. Laplace Transform
10. Z-transform
7. Sampling
8. Communication Systems

6. Review

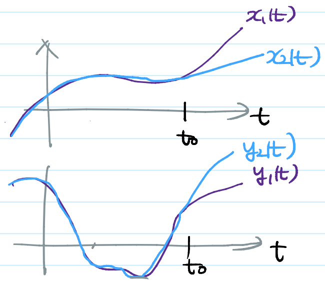
- Visualize and Simplify!!! ((V)), ((S)), ((G)), ...
- Stop and Think
- A classification of systems
    - a CT system: a (causal) LTI system
    - a DT system: a (causal) LTI system
    - a CT/DT converter: y[n] = x(nT), for all n; 'a uniform sampler with sampling rate T (Samples/s) = (S/s)'
    - a DT/CT converter: y(t) = \sum_n x[n]p(t-nT), forall t; 'a uniform interpolator with interpolation function p(t) and conversion rate T (Samples/s)'
    - etc.
- Description of the mapping rule of a system = Input/Output (I/O) relation
- How to roughly visualize an I/O relation?
    - a block diagam vs. a graph
- How to precisely describe an I/O relation?
    - examples
        - a differential equation for a CT system
            - a linear constant-coefficient differential equation (LCCDE)
        - a difference equation for a DT system
            - a linear constant-coefficient difference equation (LCCDE)
        - etc.
- A classification of CT systems with deterministic I/O relations
    - 표기법 x(t) -> y(t)
    - Def. A CT system is causal if ...
        - Examples
            - Use the definition to prove, or a block diagram to justify.
            - Find a counter-example to disprove.
                - x^2(t-1)의 의미
                - x^n: x raised to the power of n; x to the n
                - delay and advance vs. right- and left-shift of a graph of a signal
        - differential/difference equations with initial conditions, causality...
    - Def. A CT system is memoryless if ...
        - Lemma. A CT memoryless system is causal. The converse is not necessarilly true.
    - Def. A CT system is linear if ...
        - In the real-world, a system can be (approximately) linear only on a limited input range.
        - However, we design a (approximately) linear system because ...
        - Def. A CT system satisfies the ZIZO condition if ...
        - Lemma. If a CT system is linear, then it satisfies the ZIZO condition. The converse is not necessarily true. Its contrapositive is very useful.

$x^{(n)}$

x^n

$x : \mathbb{R} \to \mathbb{R}$

$x(t) = \sin \frac{2\pi t}{T}$



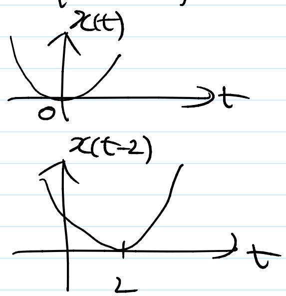
" t_0 까지는 입력의 과거가 같으면 출력의 과거도 같다. "

$\forall t \le t_0$ 또는
$\forall t < t_0$

[illegible]!

$x^2(t-2)$

$= \{x(t-2)\}^2$



Def. If $x_1(t) \to y_1(t)$, then
$x_2(t) \to y_2(t)$

$a x_1(t) + b x_2(t) \to a y_1(t) + b y_2(t)$

조건명제 conditional statement.
역 converse
이 inverse
대우 contrapositive

$x_2(t) \to y_2(t)$

$a x_1(t) + b x_2(t) \to a y_1(t) + b y_2(t)$

역 inverse
대우 contrapositive

7. Preview
    - Proposition. more than 2 signals
    - Def. A CT system satisfies the initial rest condition if ...
    - Theorem. Given a CT linear system, it is causal iff it satisfies the initial rest condition.
  - Def. A CT system is time-invariant if ...
    - Lemma. If a CT system is memoryless, then it is TI.
    - Theorem. If the input to a CT TI system is periodic, then its output is also periodic with the same period.
  - Def. Impulse response of a DT LTI system
  - Def. the convolution sum(mation)
    - Theorem. y[n] = x[n]*h[n]
      - Interpretations
        - delayed weighted sum of inputs vs.
        - delayed weighted sum of impulse responses

□ Causal — signal / system

Def. A CT signal $x(t)$ is causal if $x(t) = x(t)u(t)$, $\forall t$

Def. A CT system is causal if $x_1(t) \to y_1(t)$ & $x_2(t) \to y_2(t)$ & $x_1(t) = x_2(t)$, $\forall t \le t_0$

then $y_1(t) = y_2(t)$, $\forall t \le t_0$.

□ Def. A DT system is linear if $x_1[n] \to y_1[n]$ & $x_2[n] \to y_2[n]$ then $a x_1[n] + b x_2[n] \to a y_1[n] + b y_2[n]$.

$a_1 \quad a_2 \quad a_1 \quad a_2$

Proposition. A DT system is linear iff $x_k[n] \to y_k[n]$ for $k \in K$ — a countable set (finite / infinite)

$\Rightarrow \sum_{k \in K} a_k x_k[n] \to \sum_{k \in K} a_k y_k[n]$

$\sum_{k=1}^{2}$ $\quad K = \{1, 2\}$

$K = \mathbb{N}$ $\quad \sum_{k=1}^{\infty}$

the index set of Σ

$y_k[n] = \mathcal{L}(x_k[n])$, $\forall k$.

$(y_k[n])_{n=-\infty}^{\infty}$

$(y_k[n])_{n \in \mathbb{Z}}$

cf) 함수의 연속 at $x = x_0$: $f(x_0) = \lim_{x \to x_0} f(x)$

(연속함수

$f(\lim_{x \to x_0} x) =$

$\lim_{x \to x_0} x = x_0$

PROPERTIES OF LINEAR SYSTEMS

Proposition. (superposision of more than 2 signals)

If $\quad x_k[n] \to y_k[,n]$

then $\quad \boxed{\sum_k a_k x_k[n] \to \sum_k a_k y_k[n]}$.

If $x_k[n] \rightarrow y_k[n]$

then $\boxed{\sum_k a_k x_k[n] \rightarrow \sum_k a_k y_k[n]}$.

This property seems to be almost trivial now, but it is one of the most important ones used in EECE233.

Q How to handle nonlinearity?
A. affine ≈ linear. (0) $y=ax+b$
- linearize. '선형화'
- Volterra series
- Busgang's theorem, etc

Properties of Linear Systems (Continued)

Def. A CT system has the initial rest property if ZI until t_0 implies ZO until t_0, i.e.,

$$x(t)=0 \quad \text{for } t \le t_0 \quad \rightarrow \quad y(t)=0 \quad \text{for } t \le t_0 \qquad (*).$$

Theorem. A linear system is causal if and only if it satisfies the conditions of initial rest: (both necessary and sufficient)

"Proof"

a) Suppose a CT L system is causal. Show that (*) holds.

b) Suppose a CT L system has (*) hold. Show that the system is causal.

$(y_k[n])_{n\in\mathbb{Z}}$

$$\mathcal{L}\left(\sum_k a_k x_k[n]\right) = \sum_k \mathcal{L}\left(a_k x_k[n]\right) = \sum_k a_k \mathcal{L}\left(x_k[n]\right) = \sum_k a_k y_k[n]$$

uivalent

$$f\left(\lim_{x\to x_0} x\right) = \lim_{x\to x_0} f(x)$$

$$\lim_{x\to x_0} x = x_0$$