EE361: ENGINEERING PROBABILITY AND STOCHASTIC PROCESSES

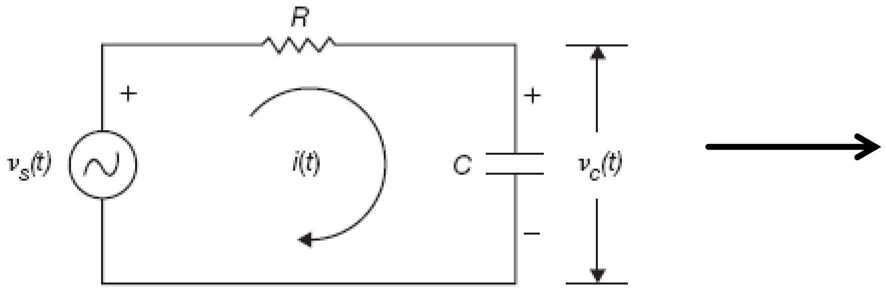
REVIEW SIGNALS AND SYSTEMS I

http://www.ee.unlv.edu/~b1morris/ee361

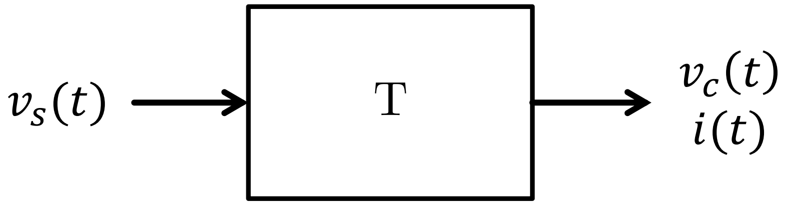
SIGNALS AND SYSTEMS I RECAP

- Signals – quantitative descriptions of physical phenomena
  - Represent a pattern of variation
- System – quantitative description of a physical process to transform an input signal to an output signal
  - The system is a "black box"
- E.g.

Physical system



Abstract system



SIGNALS

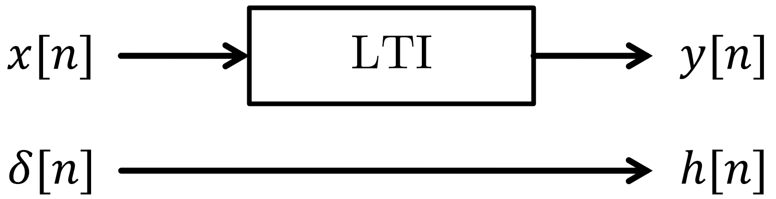
- This course deals with signals that are a function of one variable
  - Most often called “time”
- Continuous time (CT) signal
  - $x(t), \quad t \in \mathbb{R}$
  - Time is a real valued (e.g. 1.23 seconds)
- Discrete time (DT) signal
  - $x[n], \quad n \in \mathbb{Z}$
  - Time is discrete (e.g. 1 or 5)
    - Signal is a sequence and n is the location within the sequence

BASIC SYSTEM PROPERTIES

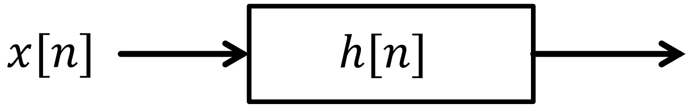
- Memoryless
  - Output does not depend on past/future values
- Invertible
  - Another system exists that accepts $y(t)$ as input and returns $x(t)$
- Causal
  - Output only depends on past or present values
  - Realizable system since it does not need future values
    - Implement non-causal systems with delays
- Stable
  - BIBO criterion: bounded input results in bounded output
- Linear
  - Given $T[x(t)] \rightarrow y(t)$
  - $ax_1(t) + bx_2(t) \rightarrow ay_1(t) + by_2(t)$
- Time Invariant
  - Time shift on input results in same time shift on output
  - $T[x(t - t_0)] \rightarrow y(t - t_0)$

LTI SYSTEM

- Linear and time-invariant systems



- Impulse response $h[n]$ completely specifies input/output relationship



$$
\begin{aligned}
y[n] &= x[n] * h[n] \\
&= \sum_{k=-\infty}^{\infty} x[k]h[n-k] \\
&= \sum_{k=-\infty}^{\infty} h[k]x[n-k]
\end{aligned}
$$

LTI PROPERTIES

- Memoryless
  - $h(t) = a\delta(t)$, where a is a constant
- Invertible

$$x[n] \longrightarrow \boxed{\;h[n]\;} \longrightarrow y[n] \longrightarrow \boxed{\;g[n]\;} \longrightarrow w[n] = x[n]$$

  - $h[n] * g[n] = \delta[n]$
- Causal
  - $h(t) = 0,\ \ t < 0$
  - Does not depend on future input – see convolution integral
- Stable
  - Absolutely integrable/summable
  - $\int_{-\infty}^{\infty} |h(\tau)| d\tau < \infty$

EIGEN PROPERTY

- Eigen function (signal) for an LTI system is a signal for which the output is the input times a (complex) constant

$$x_\lambda(t) \longrightarrow \boxed{h(t)} \longrightarrow y(t) = \lambda x_\lambda(t)$$

eigenvalue

- CT: $e^{st} \rightarrow H(s)e^{st}$
  - $H(s)$ – eigenvalue from Laplace Transform (system/transfer function)
- DT: $z^n \rightarrow H(z)z^n$
  - $H(z)$ - eigenvalue from Z-transform (system/transfer function)