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SIGNALS AND SYSTEMS

المذكرة الأولى

مدرس المقرر

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Textbook

- Luis F. Chaparro, *Signals and Systems Using MATLAB*, 2nd ed., Elsevier Inc., 2015.

- A.V. Oppenheim, A.S. Willsky with S. Hamid Nawab, *Signals and Systems*, 2nd edition, Prentice-Hall International, Inc, 1998.

References

- ✓ Richard Baraniuk, Signals and Systems, C o n n e x i o n s, Rice University, Houston, Texas, 2008.
- Steven T. Karris, *Signals and Systems with MATLAB Computing and Simulink Modeling*, 4th edition, Orchard Publications, 2008.
- ✓ Benoit Boulet, *Fundamentals of Signals and Systems*, Charles River Media, 2006.
- Zoher Z. Karu, *Signals and Systems Made Ridiculously Simple*, 4th Printing, ZiZi Press, 2001.
- Bernd Girod, Rudolf Rabenstein and Alexander Stenger, *Signals and Systems*, John Wiley & Sons, Ltd.2001.
- ✓ Hwei P. Hsu, *Schaum's Outline of Theory and Problems of Signals and Systems*, McGraw-Hill, 1995.

Evaluation Plan

	CE/ECE	
Quiz 1	5	
Test 1	20	
Quiz 2	5	
Test 2	20	
Final Exam	100	
Total	150	

Introduction

- The analysis of electrical signals is a fundamental problem for many engineers and scientists.
- Even if the immediate problem is not electrical, the basic parameters of interest are often changed into electrical signals by means of transducers.

Transducer

- It is device that converts energy from one form to another.
- It is an electronic device that converts the physical quantity into electrical signal and vice versa.
- Sensors are a type of transducers that converts physical quantity into electrical signal only.

Transducers

- Common transducers include:
- Accelerometers
- Load cells in mechanical work,
- ECG electrodes
- Blood pressure probes in biology and medicine
- pH and conductivity probes in chemistry.

Benefits of Electrical Signals

- The rewards for transforming physical parameters to electrical signals are great, as many instruments are available for the analysis of electrical signals in the time, frequency and modal domains.

1. Record the signal in electrical form
2. Process the signals
3. Analyze the signals

What is a Signal?

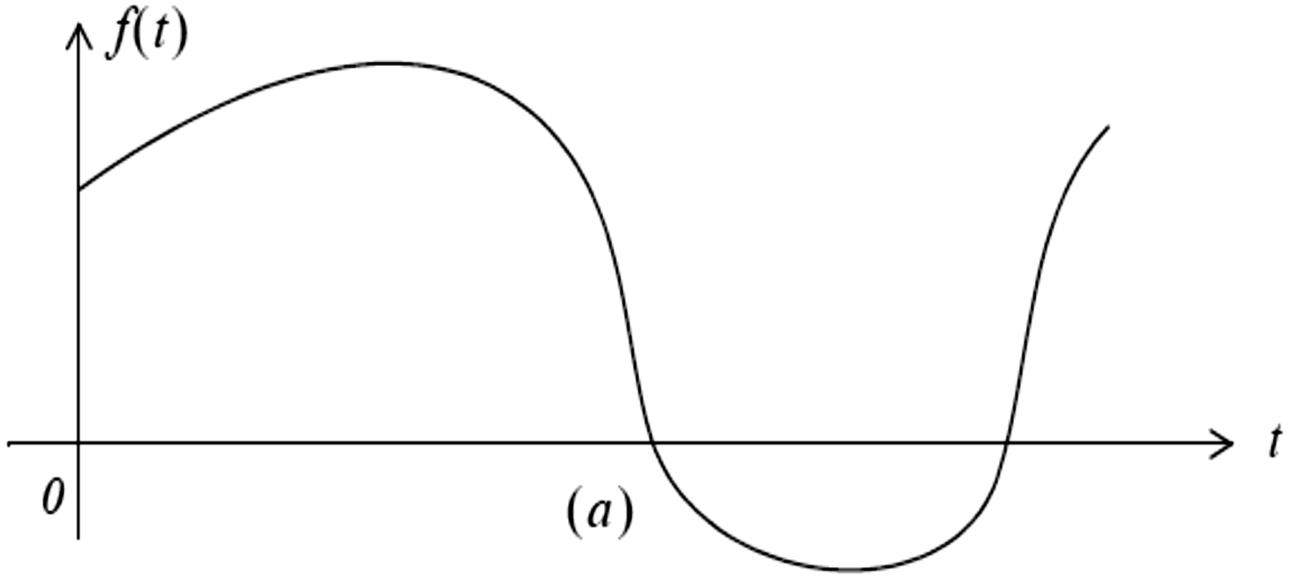
- Signal is a function that describes the time variation of a physical variable of a physical process.
- Signal is notion of any measurable quantity that is a function of one or more independent variables such as time or space.

Signals Examples

- Signals are everywhere!
- Voltages and currents are examples of electrical signals.
- The sound coming into your ears is a mechanical signal.
- The page of this note is a two-dimensional light signal on your retina.

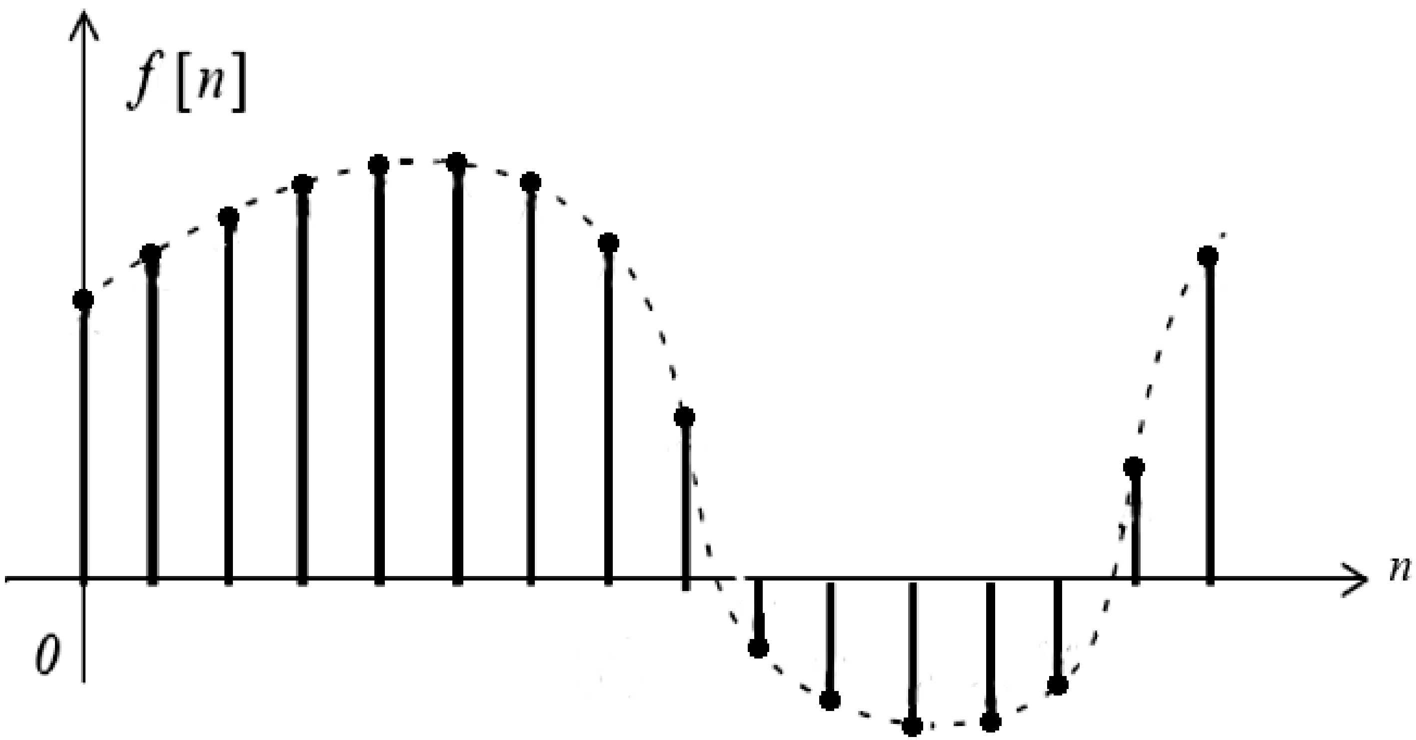
Continuous-time Signal

- A *continuous-time signal* is one that is present for all instants in time or space, such as an oscillating voltage signal or a photograph from a camera.



Discrete-time Signal

- A *discrete-time signal* is only present at discrete points in time or space and is often samples of a continuous-time process.

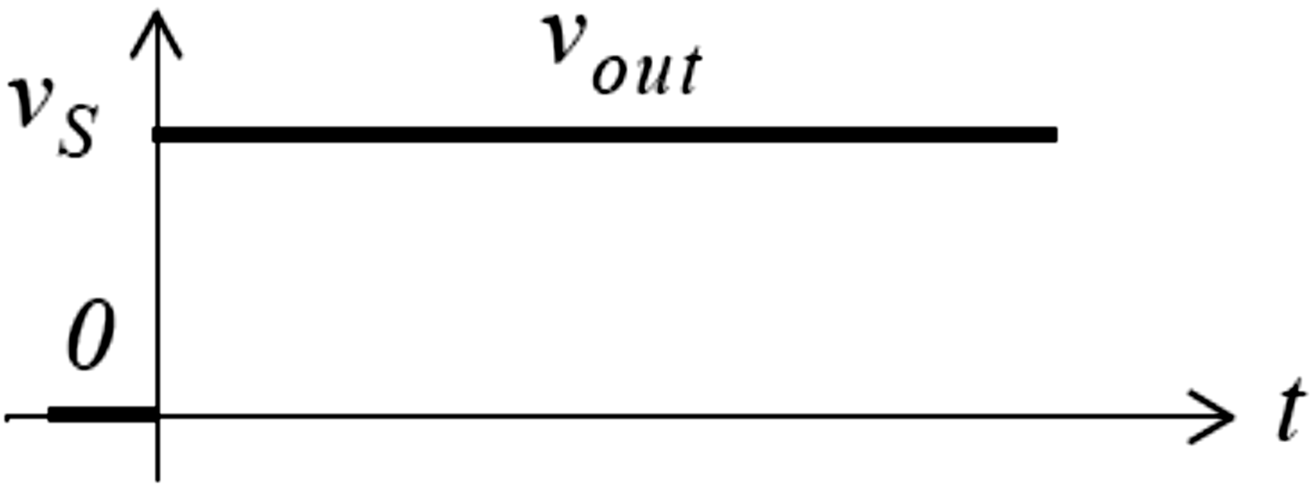


Examples of Discrete-time Signal

- The daily closing stock market average is a signal that changes only at discrete points in time (at the close of each day).
- A computer image composed of pixels is also a discrete time signal. (0: black, 255: white)
- Often, discrete-time signals are sampled versions of continuous-time signals, as is the case for the music recorded on compact discs or a photograph scanned into a computer.

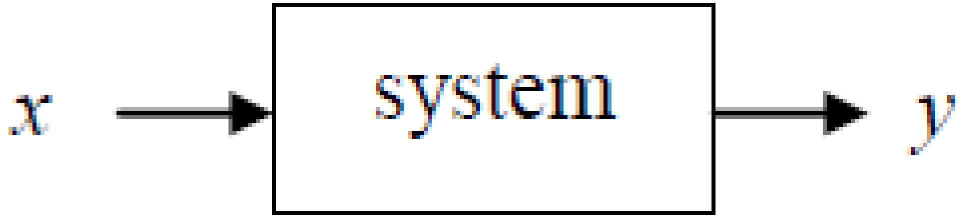
Discontinuous Signal

- A function is said to be *discontinuous* if it exhibits points of discontinuity,
- that is, the function jumps from one value to another without taking on any intermediate values.



What is a System?

- In general, a system is an abstraction of anything that takes an input signal, operates on it, and produces an output signal.
- In other words, a system establishes a relationship between its input and its output.



Examples of a System

- An automobile,
- where the input might be the position of the accelerator and the output the speed of the car.
- A camera,
- where the input is the light entering the lens and the output is a photograph.
- Systems that operate on continuous-time signals are known as CT systems, and
- Systems that operate on discrete-time signals are known as DT systems.

Linear System

- A system is considered to be linear if the following conditions are met:

1. when x(t) = 0 $\rightarrow$ y(t) = 0

2.

$$x_1(t) \longrightarrow \boxed{\text{System}} \longrightarrow y_1(t) \quad \text{and} \quad x_2(t) \longrightarrow \boxed{\text{System}} \longrightarrow y_2(t)$$

$$\text{Linearity} \Rightarrow Ax_1(t) + Bx_2(t) \longrightarrow \boxed{\text{Linear system}} \longrightarrow Ay_1(t) + By_2(t)$$

A, B = any complex constants

Linear System

- Also, for a linear system any linear operation on its input signal produces an output signal modified by the same linear operation.
- For example, a system that takes the absolute value of its input is not linear.
- An input of "2" produces an output of "2".
- However, an input of "–2" (multiply the original input by –1) does not produce an output of "–2".

Examples of a Linear System

- $y(t) = x(t)$

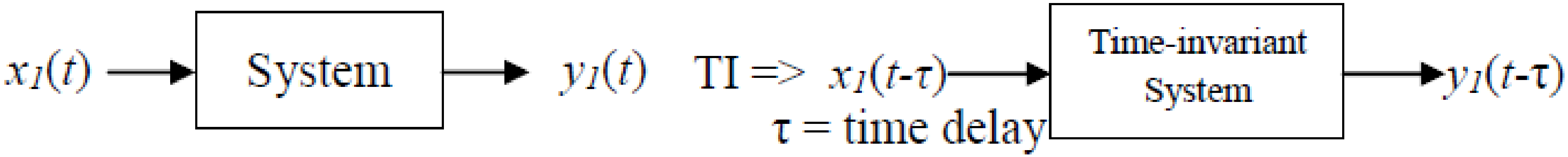
- $y(t) = x^2(t)$

Time Invariant System

- A *time-invariant* system is one that responds the same no matter at what time the input is presented.
- If input "*x*" produces output "*y*",
- then the input "*x*" presented 5 days later will produce the same output "*y*" exactly 5 days later. $y_2(t) = y_1(t - \tau)$
- In other words, delaying the input produces the corresponding delay in the output signal.

Time Invariant System

- Mathematically, this can be characterized as:
- Given



- Only a small percentage of the systems in the world are truly LTI.

Example of Time Invariant System

- $\mathrm{y}(t) = \sin x(t)$

- $\mathrm{y}[n] = n\, x[n]$