

Digital Signal Processing

# Chap 1. Introduction

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# Course Outline

- Pre-requisites
  - Engineering Mathematics
  - Signals and Systems
- Course Homepage
  - Homepage: <http://portal.korea.ac.kr> → <http://mcl.korea.ac.kr>
- Questions
  - Ask questions any time, but preferably during the lectures
  - Office: Engineering Bldg, Rm 215
  - Tel: 02-3290-3217
  - Email: [changsukim@korea.ac.kr](mailto:changsukim@korea.ac.kr)

# Course Outline

- Assessment Methods
  - Assignments: 15%
  - Attendance & Quizzes: 15%
  - Mid-term Exam: 30%
  - Final Exam: 40%
- Textbook
  - A. V. Oppenheim and R. W. Schaffer, *Discrete-Time Signal Processing*, 3<sup>rd</sup> edition, Pearson, 2010.
- Reference
  - Sanjit K. Mitra, *Digital Signal Processing: A Computer-Based Approach*, McGraw Hill, 2006.

# Course Outline

Week	Topics	Events
1	Chap 1. Introduction	
2	Chap 2. Discrete-Time Signals and Systems	
3	Chap 2. Discrete-Time Signals and Systems	
4	Chap 2. Discrete-Time Signals and Systems	
5	Chap 3. Z-Transform	
6	Chap 3. Z-Transform	
7	Chap 3. Z-Transform	
8	NA	Mid exam (30 OCT 2013)
9	Chap 4. Sampling of Continuous-Time Signals	
10	Chap 5. Transform Analysis of LTI Systems	
11	Chap 5. Transform Analysis of LTI Systems	
12	Chap 6. Structures for Discrete-Time Systems	
13	Chap 7. Filter Design Techniques	
14	Chap 8. DFT	
15	Chap 9. Computation of DFT	
16	NA	Final exam (16 DEC 2013)

# DSP Systems (~2005)



iPod **mini**

A thousand songs.  
Five cool colors.



# DSP Systems (2006)



# DSP Systems (2007)



# DSP Systems (2008)



SLRCLUB Presents



**Nikon D90**





# DSP Systems (2009)



# DSP Systems (2013)



iPhone 5



Samsung GALAXY S4



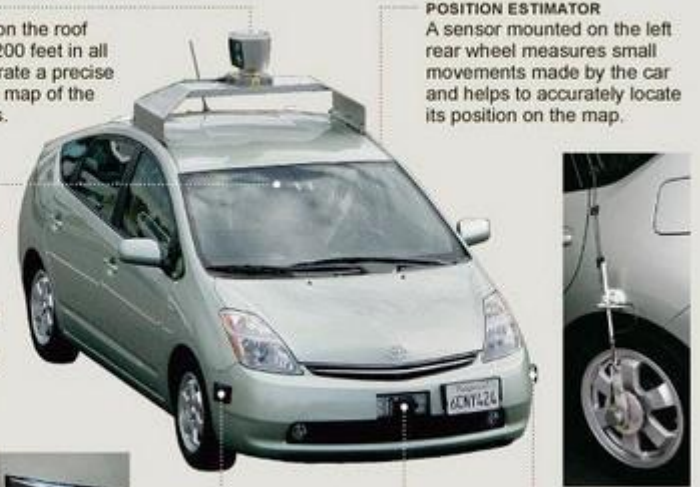
## Autonomous Driving

Google's modified Toyota Prius uses an array of sensors to navigate public roads without a human driver. Other components, not shown, include a GPS receiver and an inertial motion sensor.

**LIDAR**  
A rotating sensor on the roof scans more than 200 feet in all directions to generate a precise three-dimensional map of the car's surroundings.

**POSITION ESTIMATOR**  
A sensor mounted on the left rear wheel measures small movements made by the car and helps to accurately locate its position on the map.

**VIDEO CAMERA**  
A camera mounted near the rear-view mirror detects traffic lights and helps the car's onboard computers recognize moving obstacles like pedestrians and bicyclists.



**RADAR**  
Four standard automotive radar sensors, three in front and one in the rear, help determine the positions of distant objects.

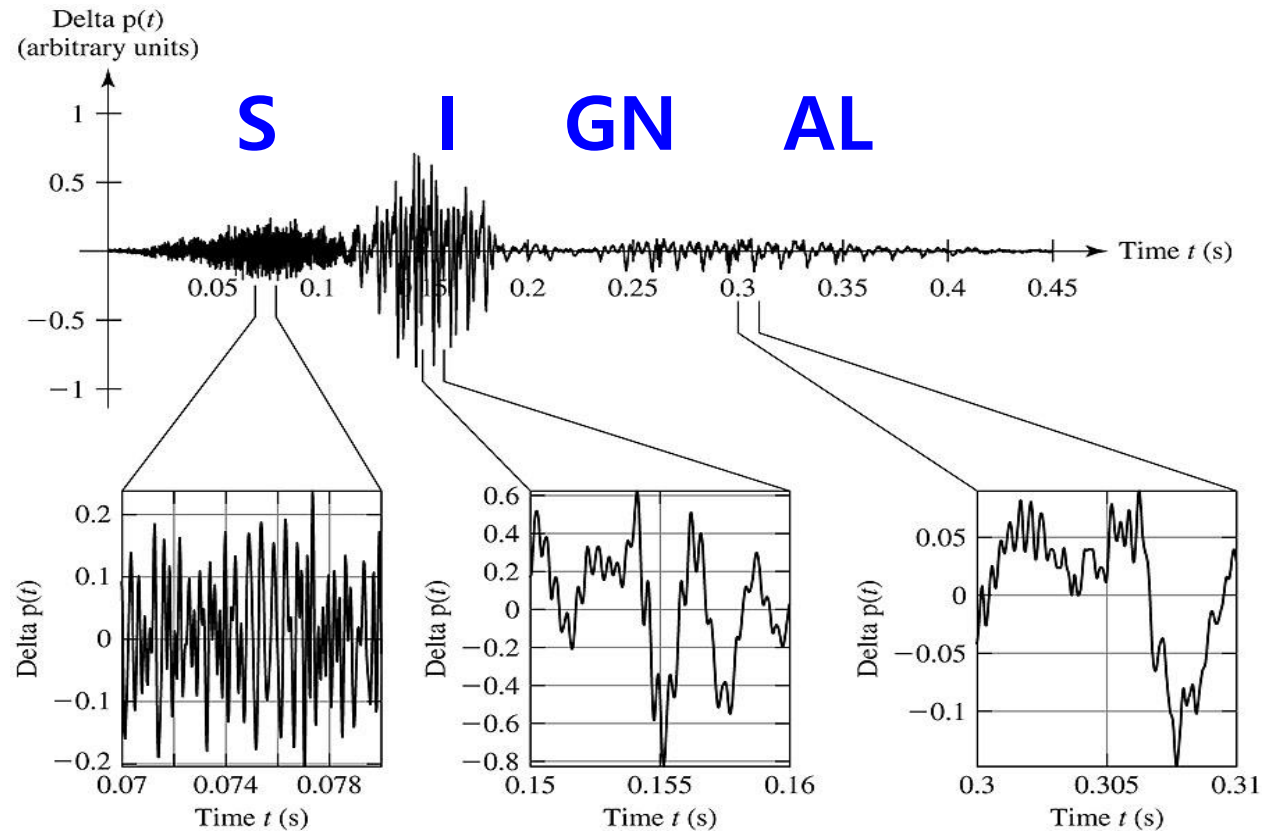


# DSP Systems (2014)



# Signals

- $s(t) = 1.05 t^2$
- $s(x, y) = 3x + 2xy + 10y^2$



# Systems and Signal Processing

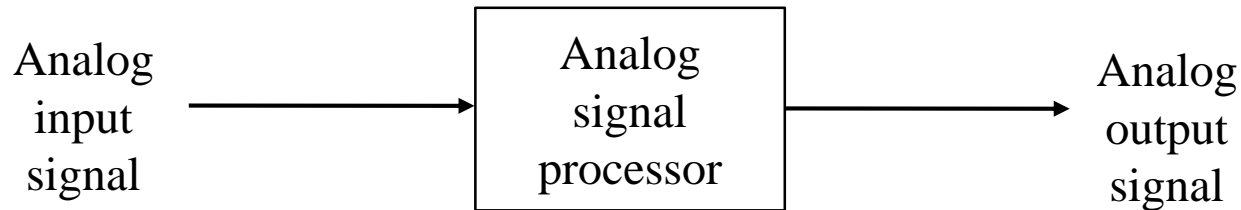
- A *system* performs an operation on a signal



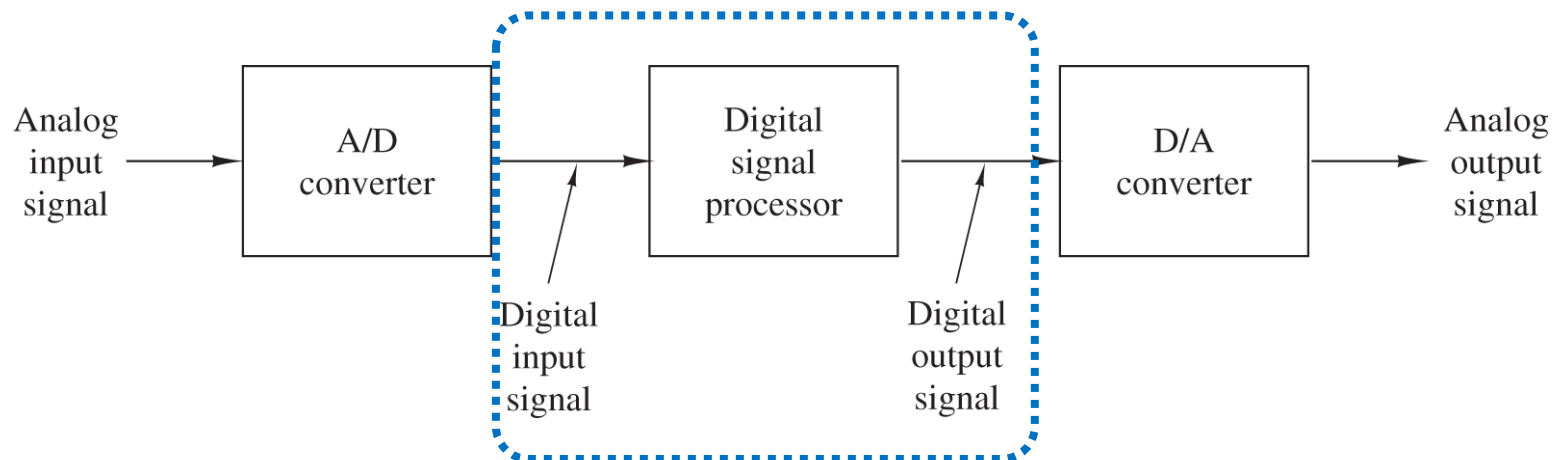
- Such operations are referred to as *Signal Processing*

# Analog Signal Processing vs. Digital Signal Processing

- Analog signal processing



- Digital signal processing



# Advantages of DSP over Analog Signal Processing

- Flexibility
- Accuracy
  - 16-bit, 32-bit, 64-bit digital computing
  - Extremely difficult to make accurate analog circuit components
- Easy storage and duplication
- Cost
  - Digital computing gets cheaper



# A color picture is a **three-channel, two-dimensional** signal

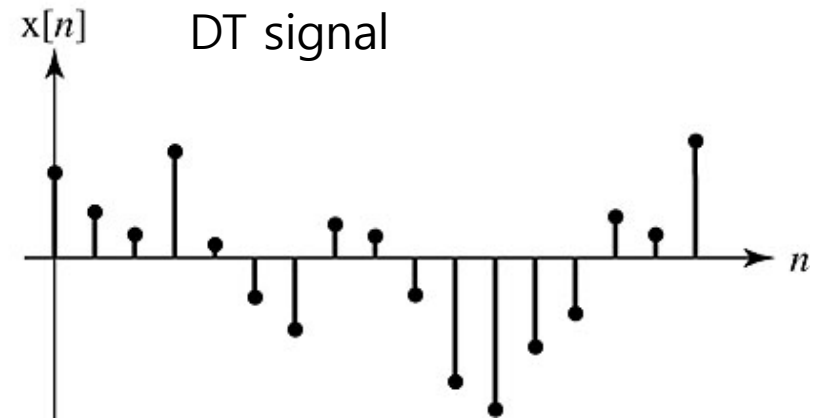
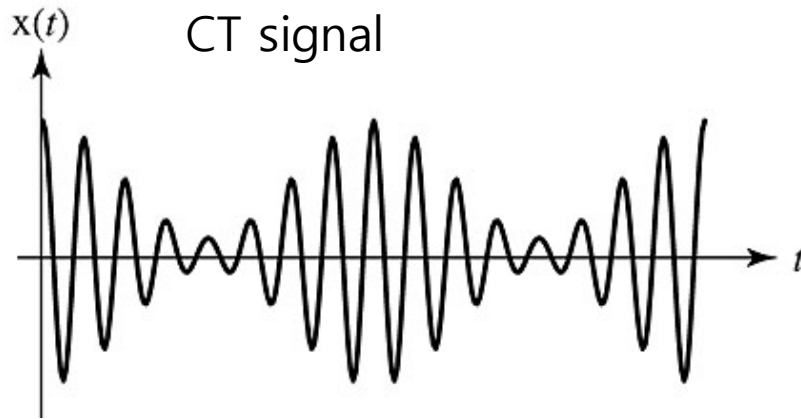
$$\mathbf{S}(x, y) = \begin{bmatrix} r(x, y) \\ g(x, y) \\ b(x, y) \end{bmatrix}$$



- In this work, we focus on single-channel, one-dimensional signals
- The single variable is called time

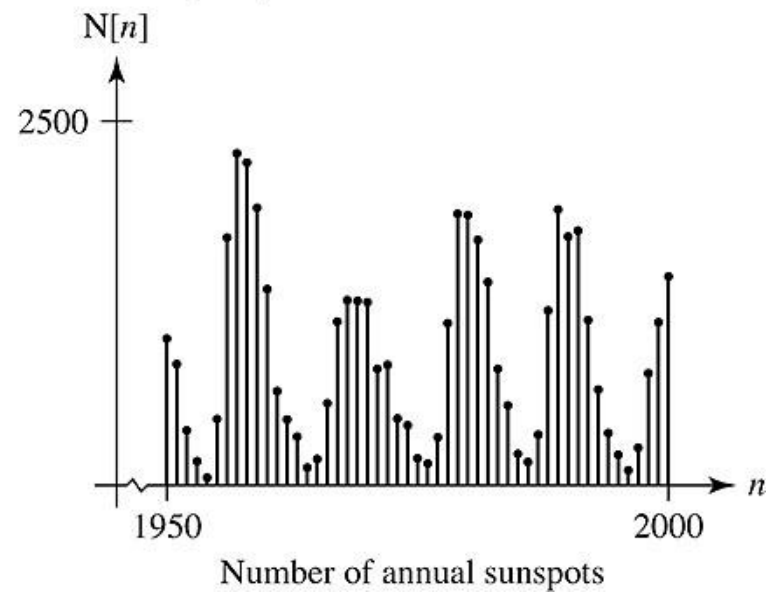
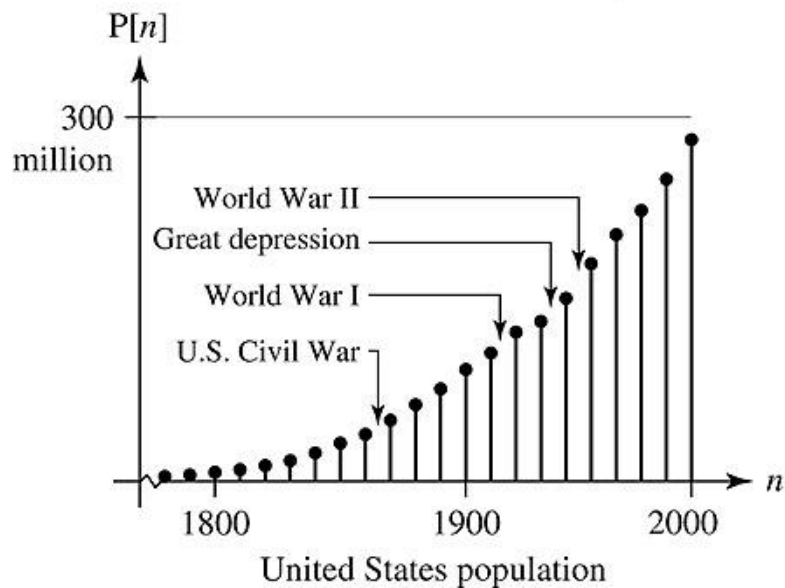
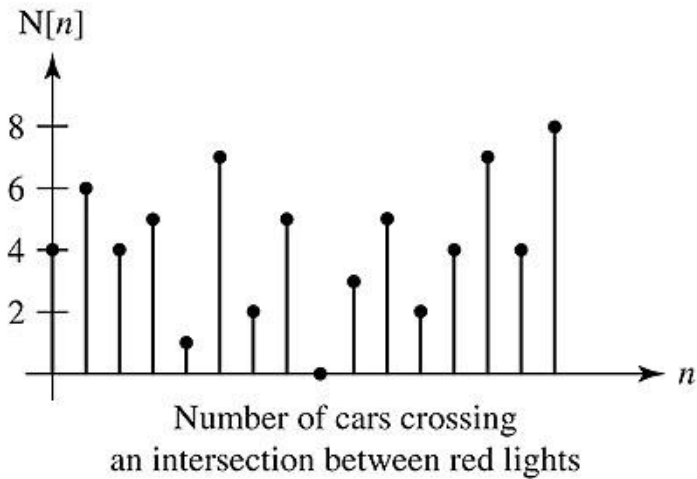


# Continuous-Time vs Discrete-Time Signals



- DT signals often arise
  - by selecting values of an analog signal at discrete-time instants
  - by accumulating a variable over a period of time

# Examples of Discrete-Time Signals



# Continuous-Valued vs Discrete-Valued Signals

- A discrete-time signal having a set of discrete values is called a **digital signal**
- Digitization =  
    sampling (time) + quantization (value)

# Analog-to-Digital Conversion

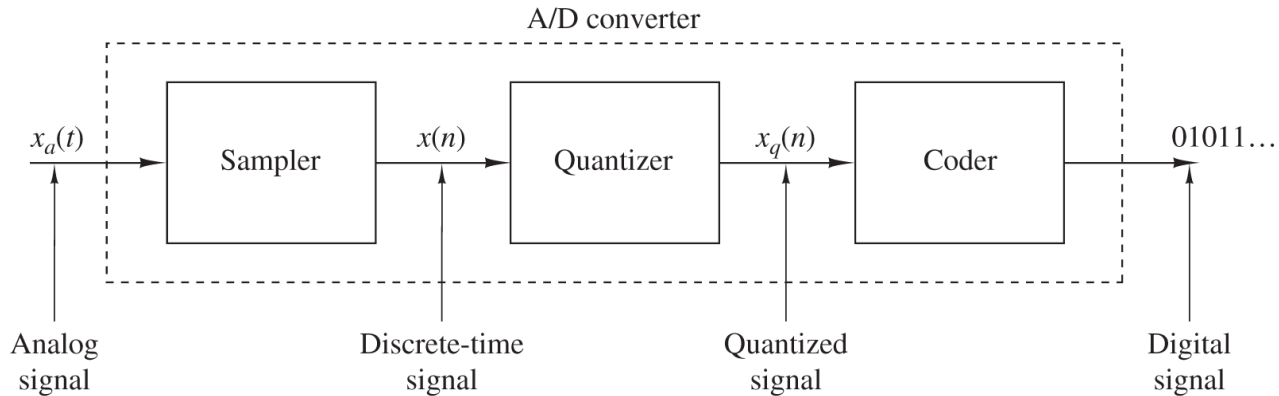


Figure 1.4.1 Basic parts of an analog-to-digital (A/D) converter.

## Sampling

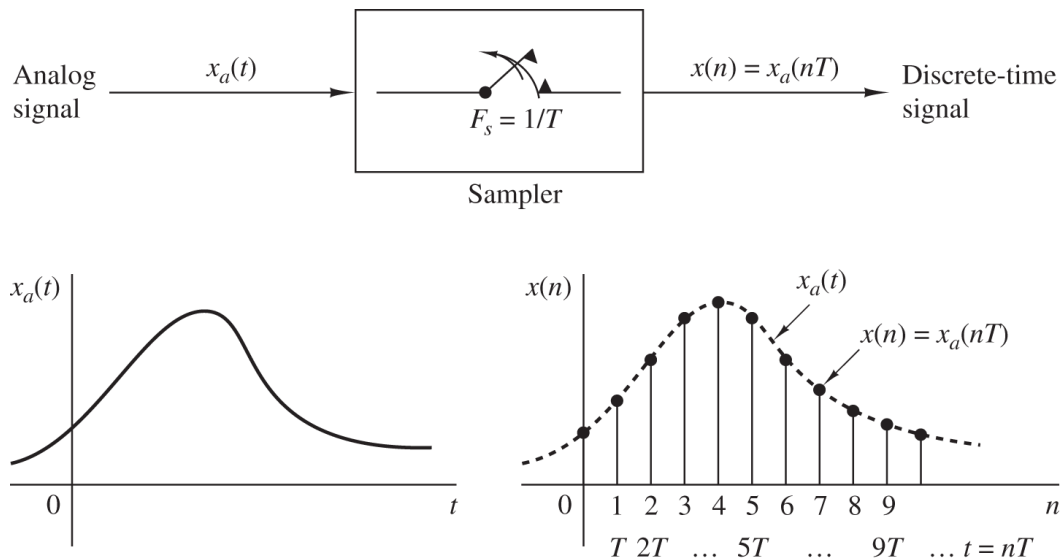
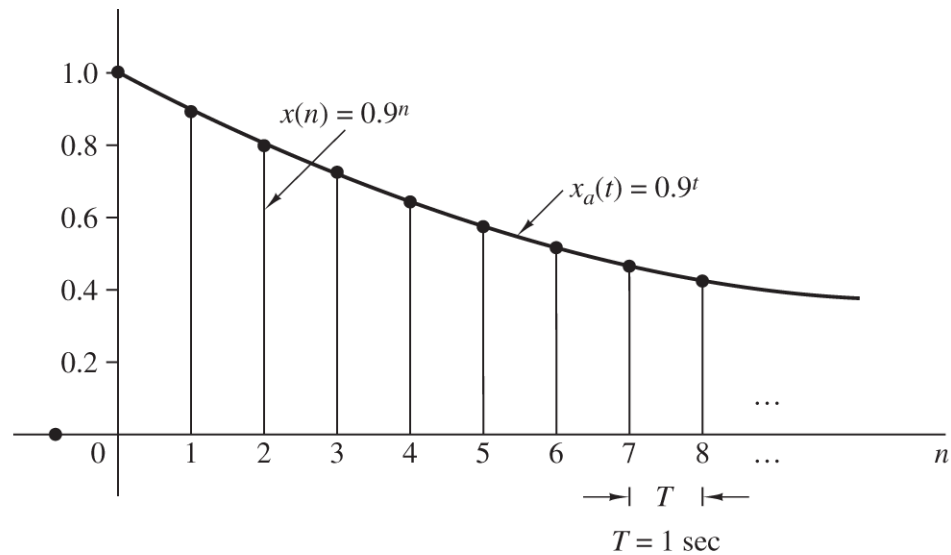


Figure 1.4.3 Periodic sampling of an analog signal.

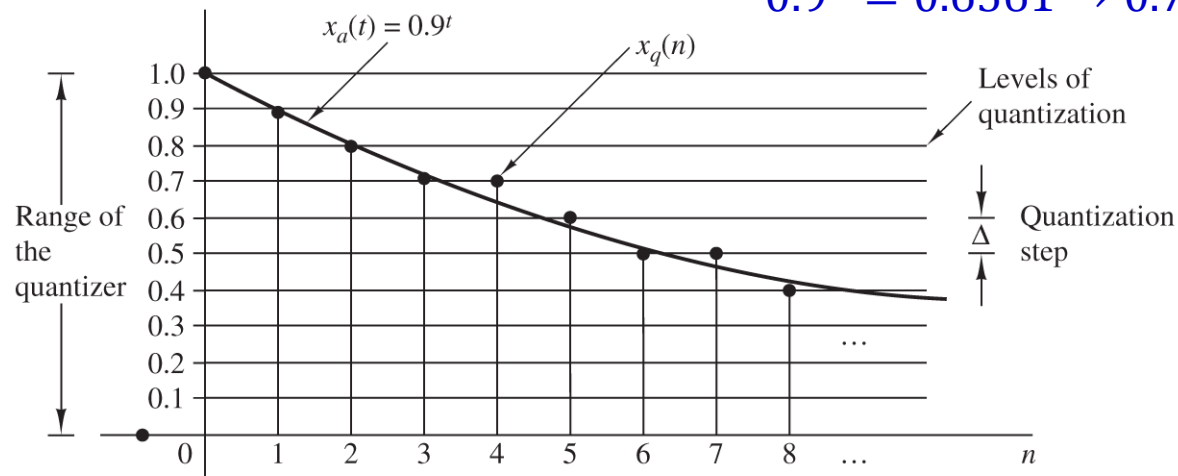
# Analog-to-Digital Conversion

## Quantization



(a)

$$0.9^4 = 0.6561 \rightarrow 0.7$$



(b)

Figure 1.4.7 Illustration of quantization.

# Digital-to-Analog Conversion

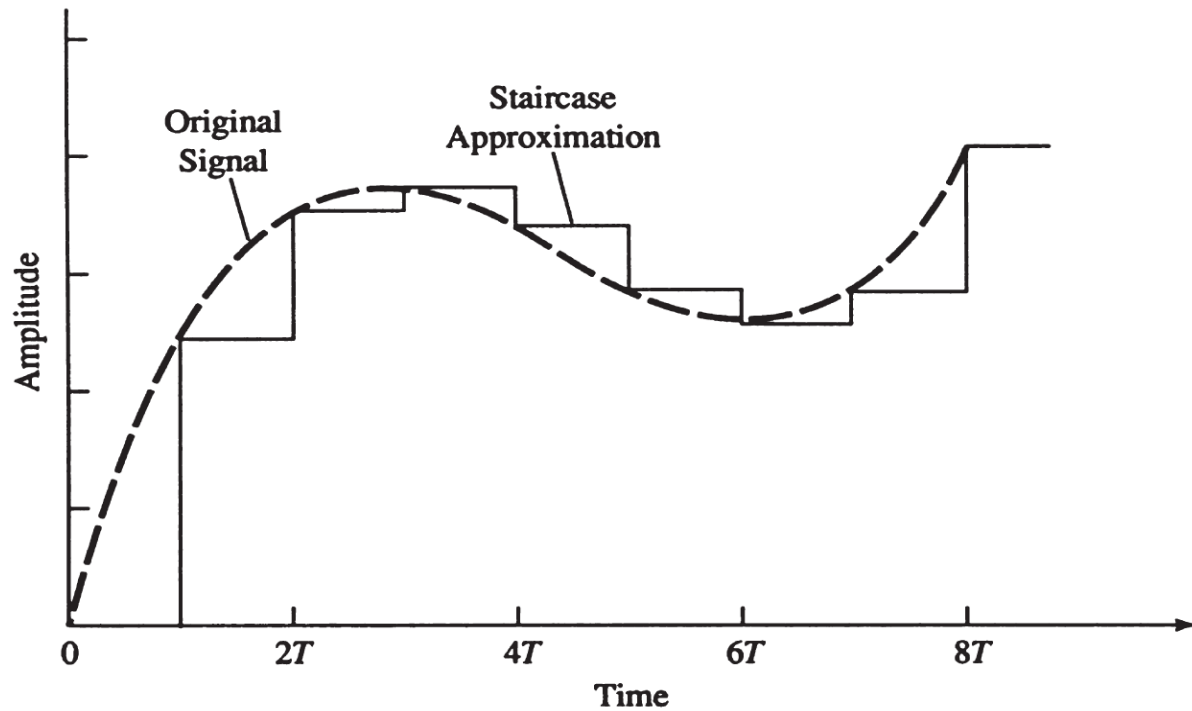


Figure 1.4.2 Zero-order hold digital-to-analog (D/A) conversion.