Introduction to DSP

Phan Duy Hùng

What is Digital Signal Processing?

What reasons for learning DSP ?

Signal, systems, and Signal Processing

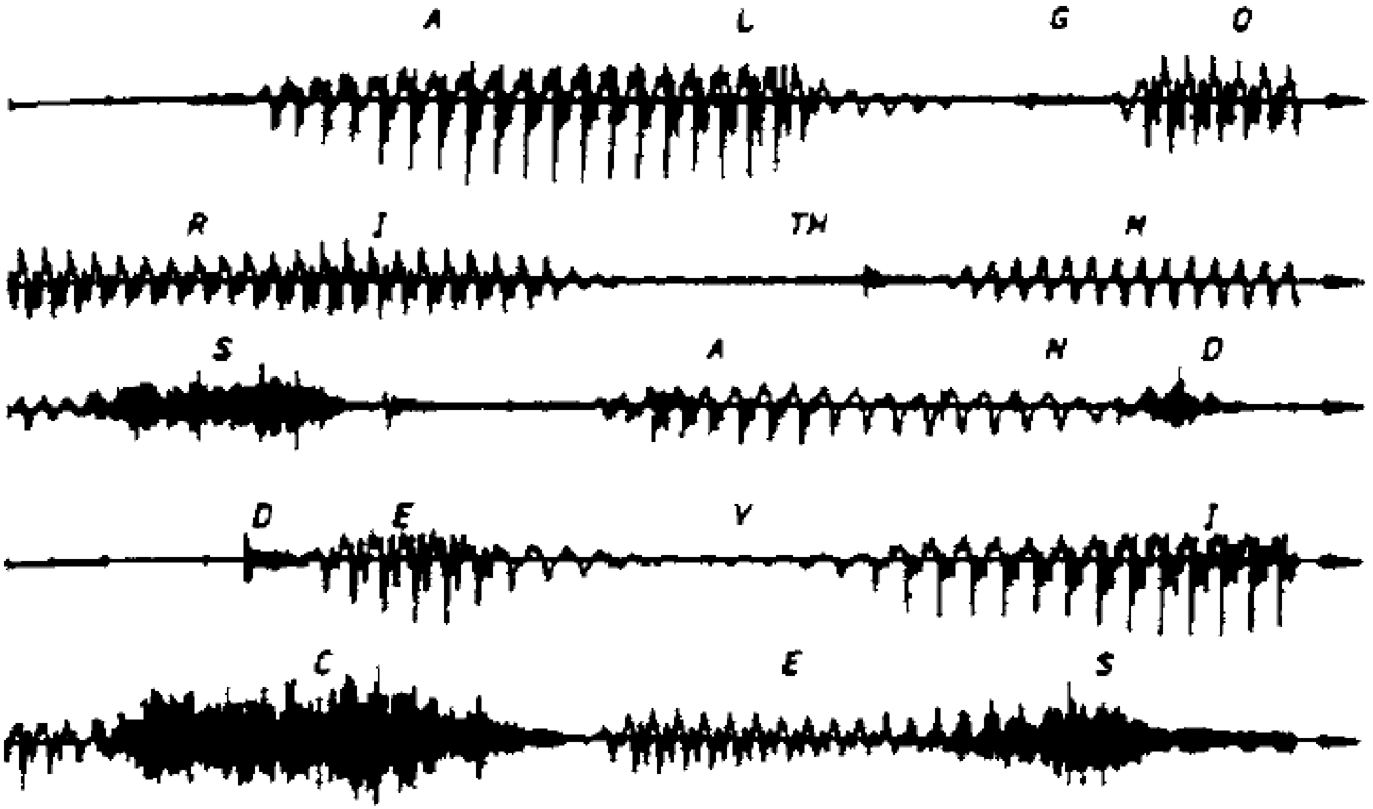

Figure 1.1.1 Example of speech signal

Basic Elements of a Digital Signal Processing System

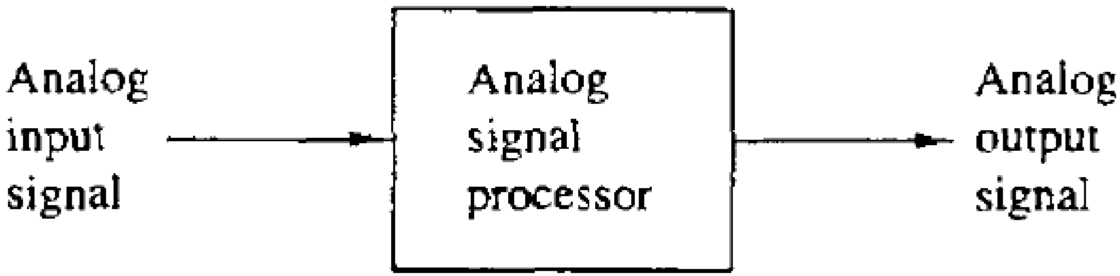

Figure 1.1.2 Analog signal processing

Advantages of Digital over Analog Signal Processing

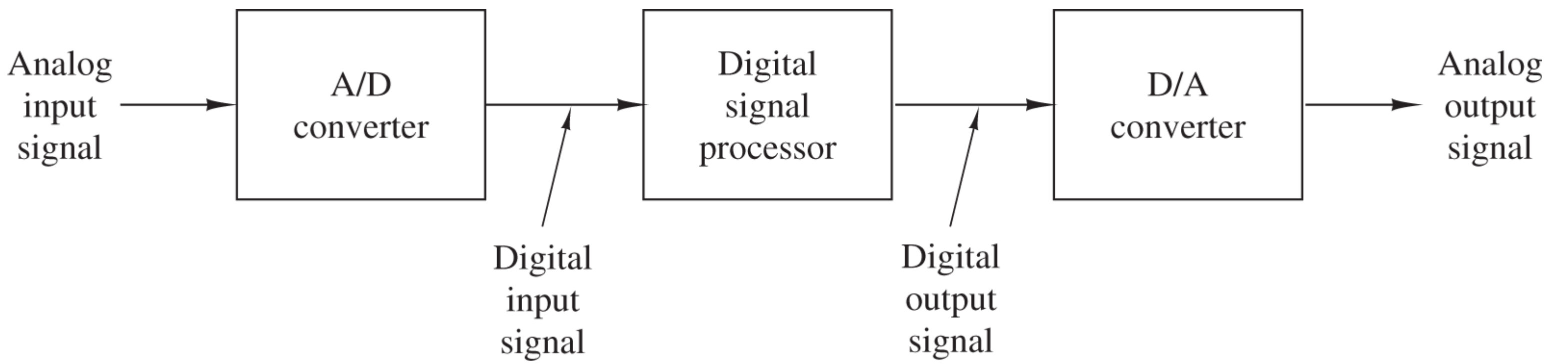

Figure 1.1.3 Block diagram of a digital signal processing system.

Classification of Signals

- Multichannel

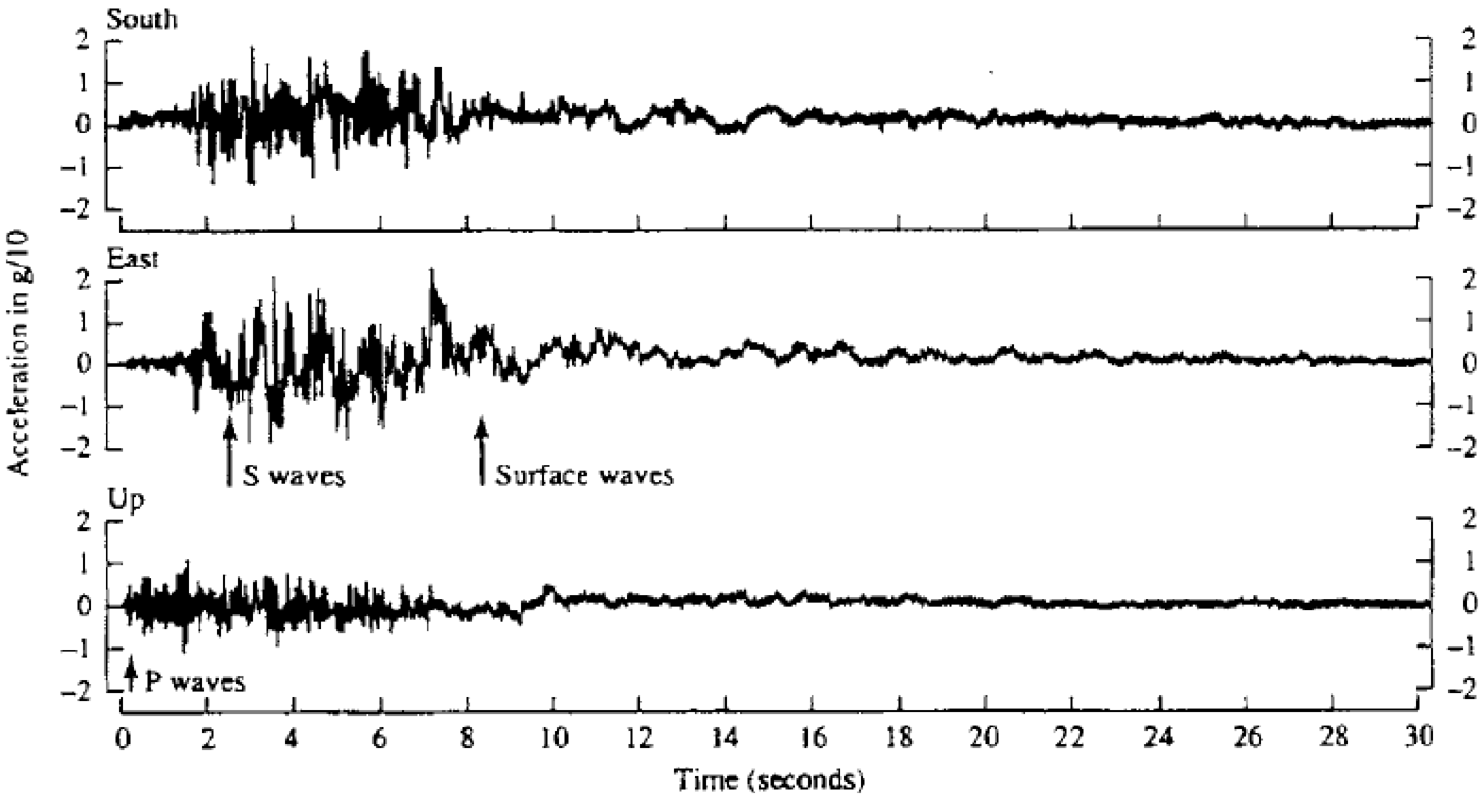

Figure 1.2.1 Three components of ground acceleration

Classification of Signals

- Multidimensional

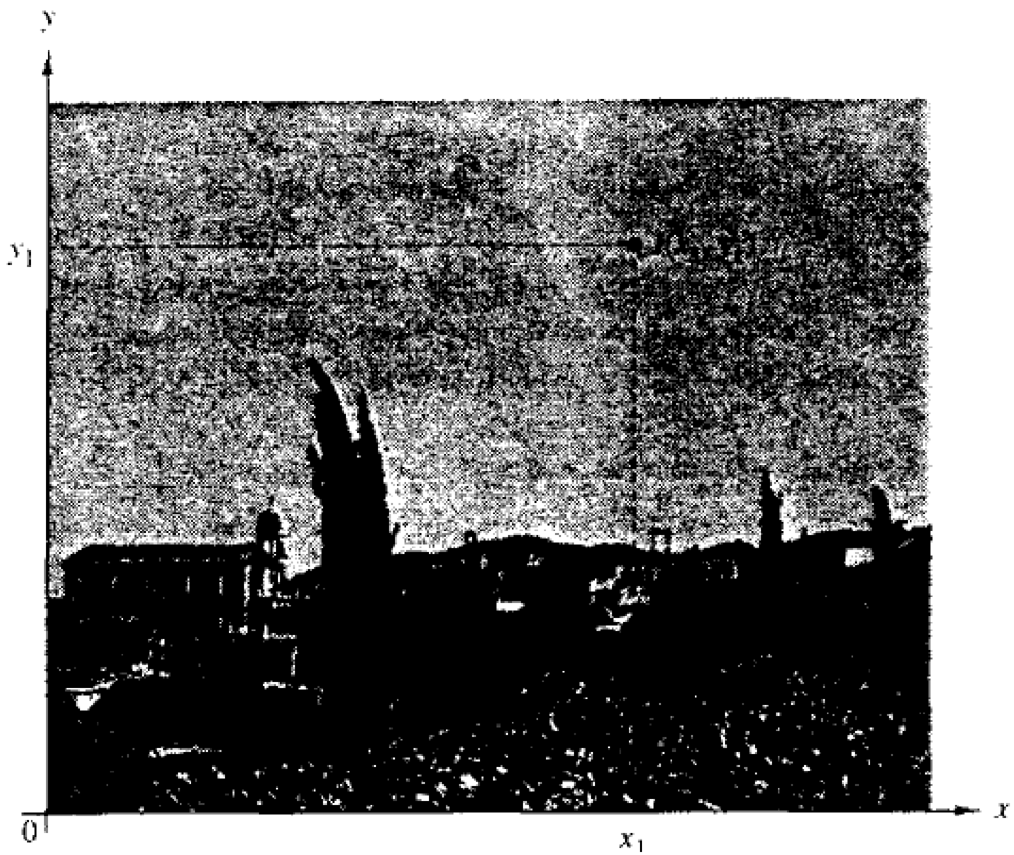

Figure 1.2.2 Example of a two dimensional signal

Classification of Signals

- Continuous-Time vs Discrete-Time Signals

- Continuous-Valued vs Discrete-Valued Signals

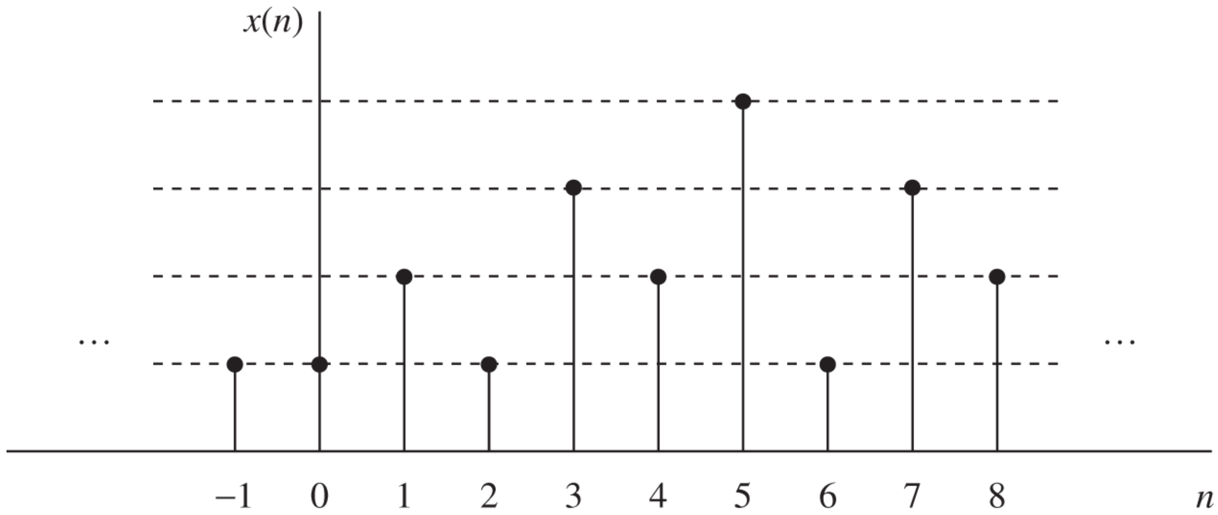

Figure 1.2.5 Digital signal with four different amplitude values.

Classification of Signals

- Deterministic vs Random Signals

Concept of Frequency

Continuous-Time Sinusoidal Signals
vs Discrete-Time

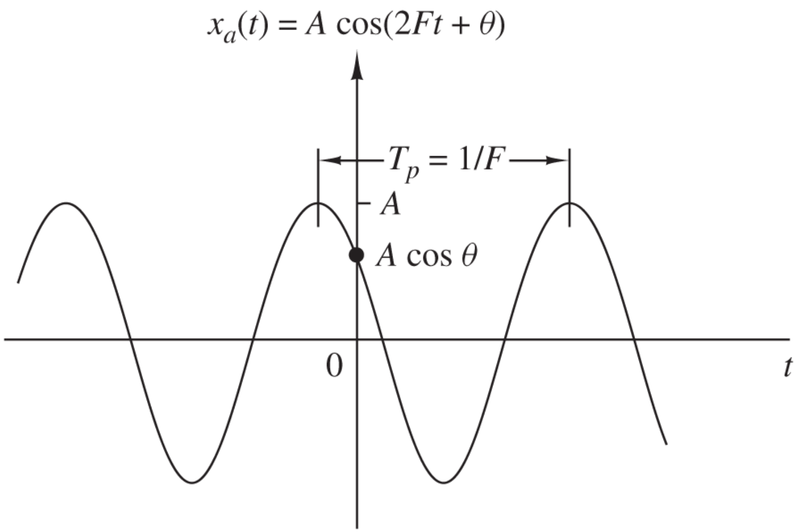

Figure 1.3.1 Example of an analog sinusoidal signal.

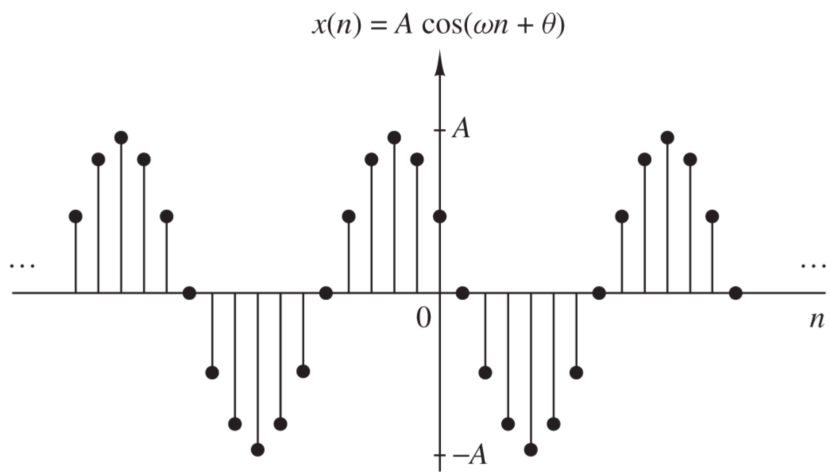

Figure 1.3.3 Example of a discrete-time sinusoidal signal ($\omega = \pi/6$ and $\theta = \pi/3$).

The highest rate of oscillation in a discrete-time sinusoid is attained when $\omega=\pi$ (or $\omega=-\pi$) or, equivalently, $f=1/2$ (or $f=-1/2$)

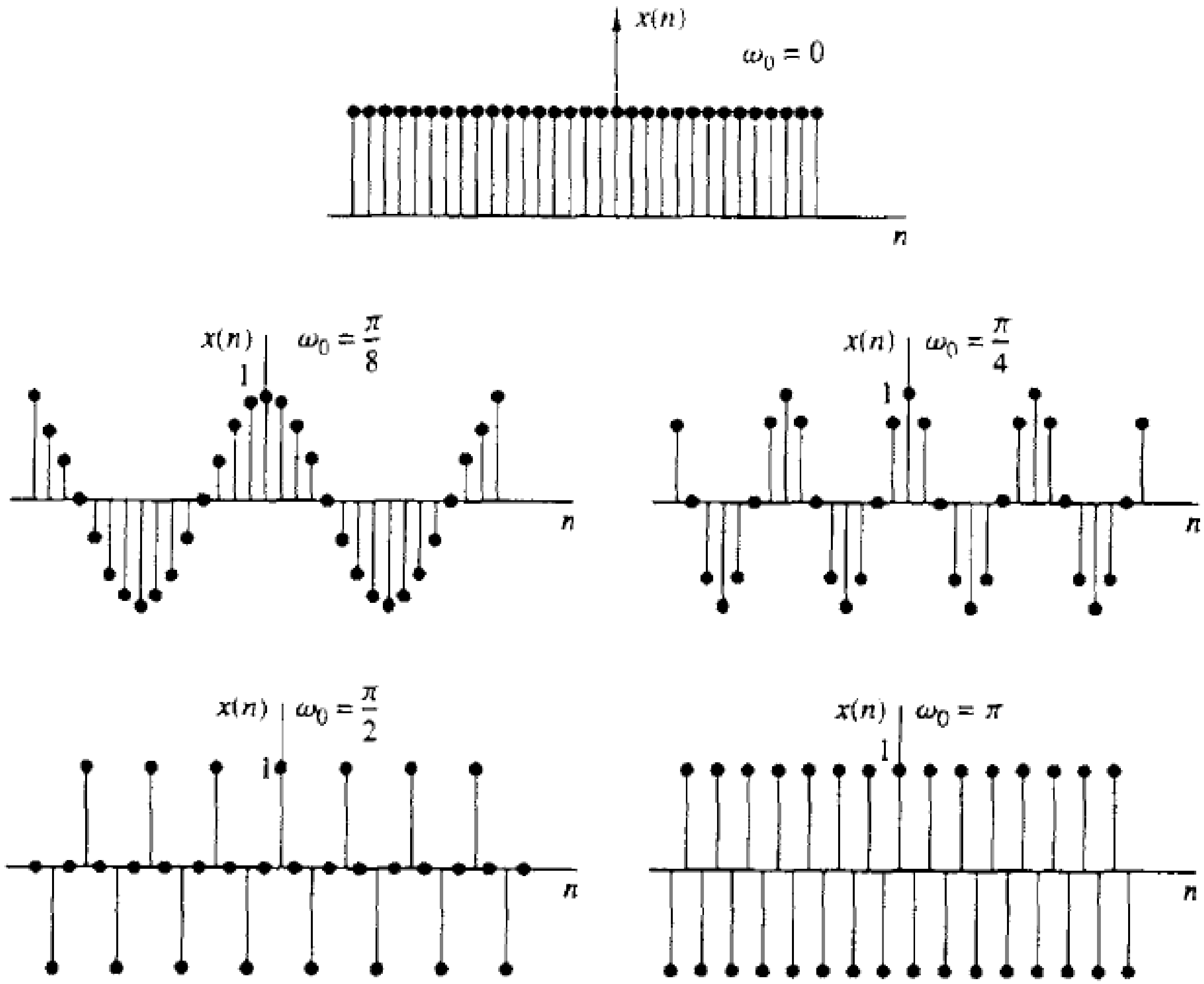

Figure 1.3.4 Signal $x(n)=\cos\omega_0 n$ for various values of the frequency ω_0

Analog-to-Digital and Digital-to-Analog Conversion

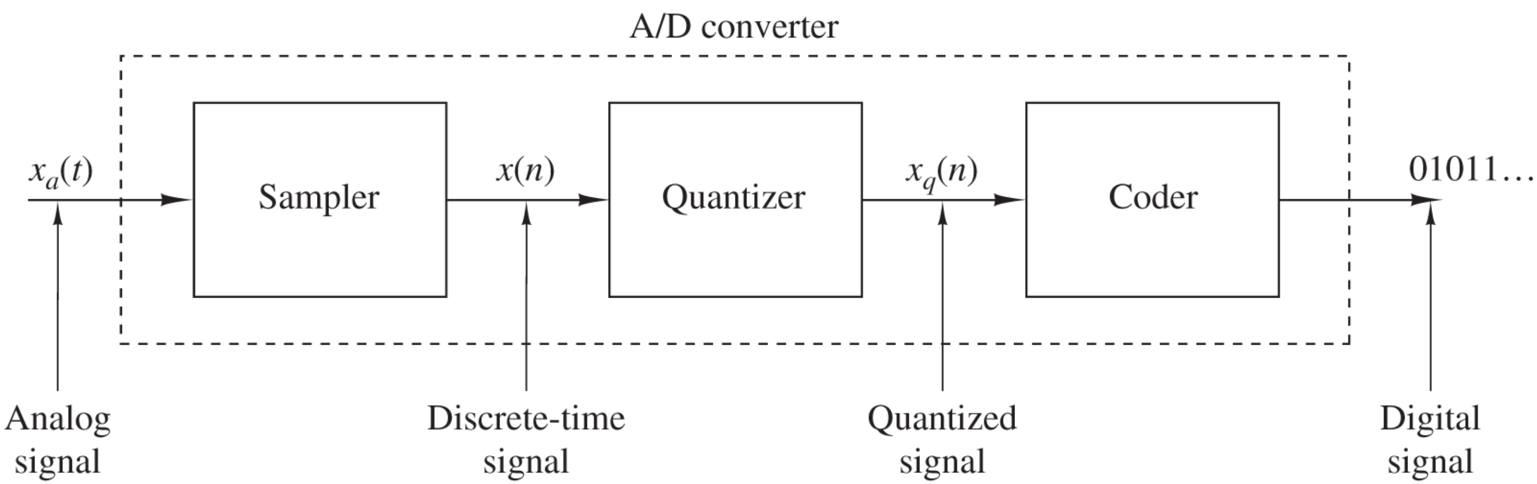

Figure 1.4.1 Basic parts of an analog-to-digital (A/D) converter.

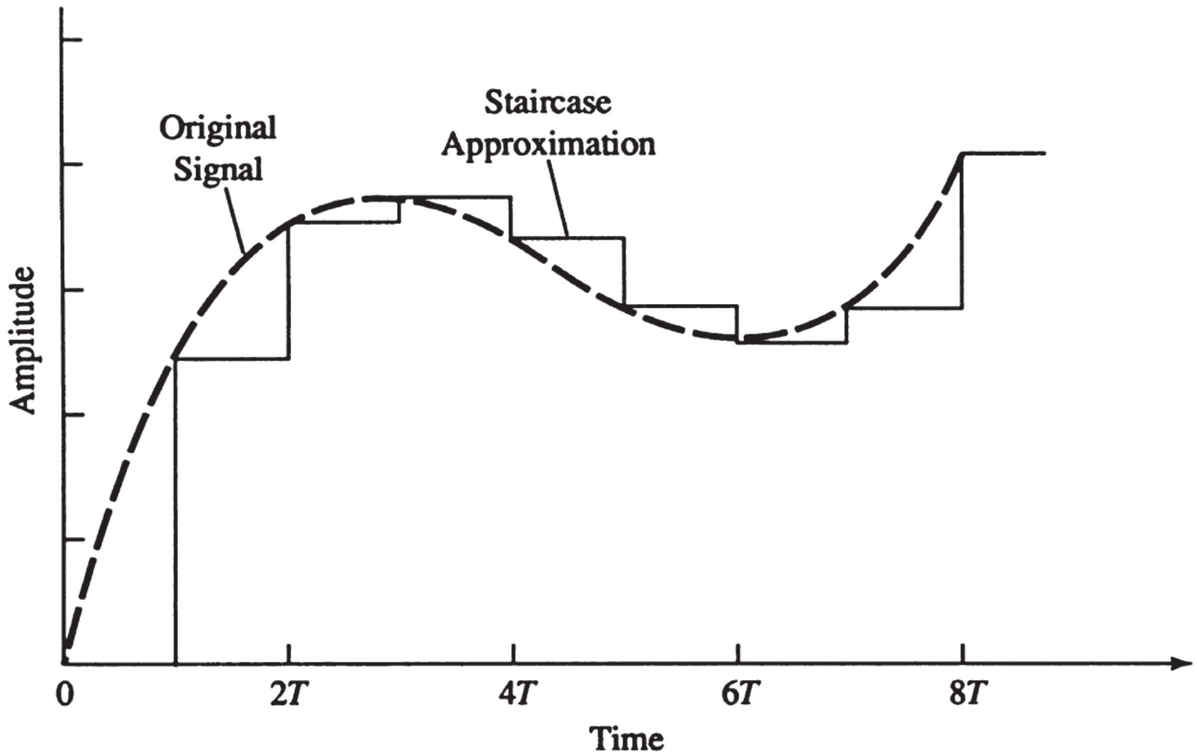

Figure 1.4.2 Zero-order hold digital-to-analog (D/A) conversion.

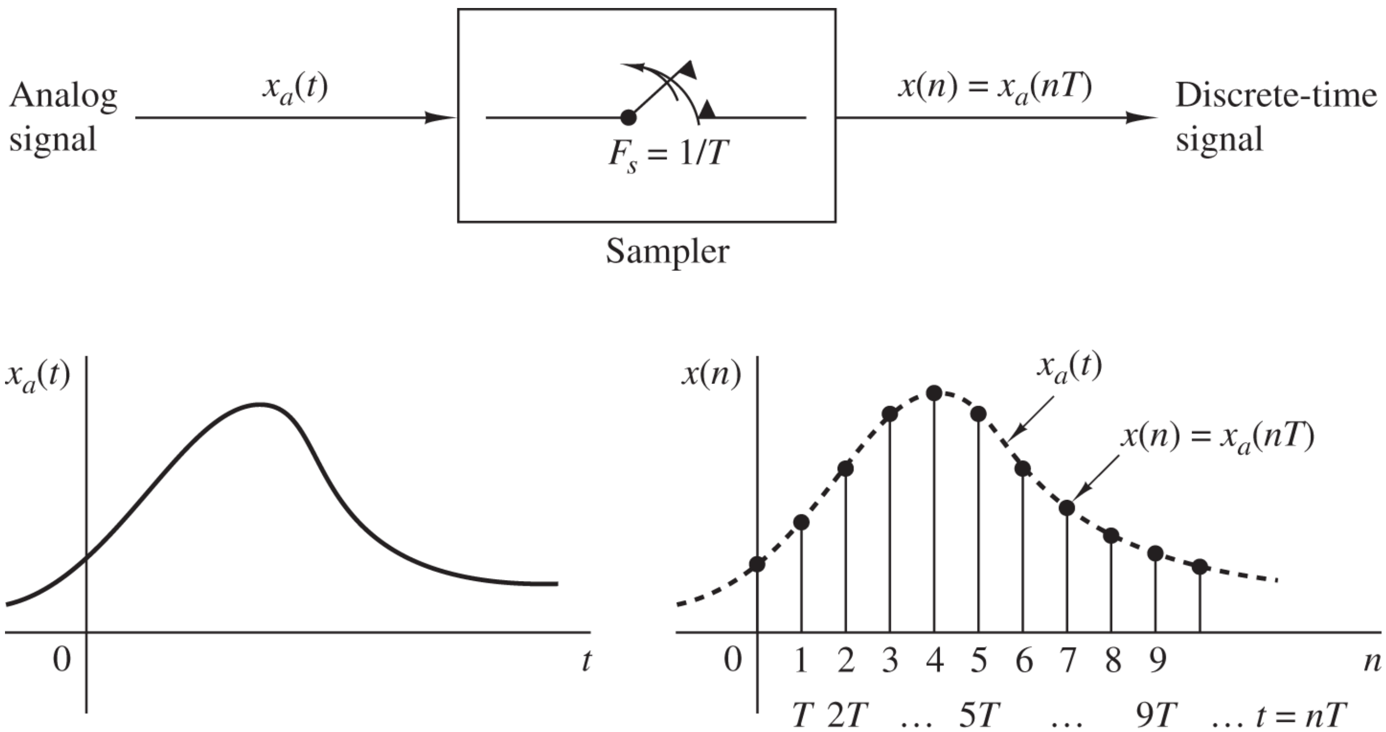

Figure 1.4.3 Periodic sampling of an analog signal.

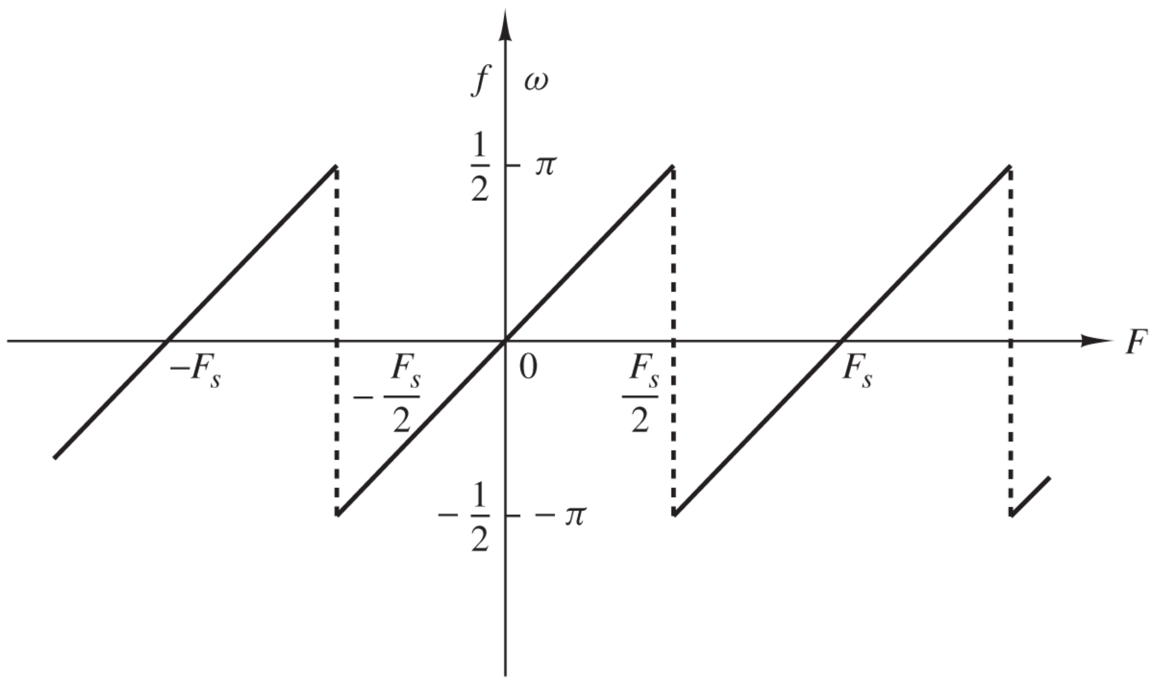

Figure 1.4.4 Relationship between the continuous-time and discrete-time frequency variables in the case of periodic sampling.

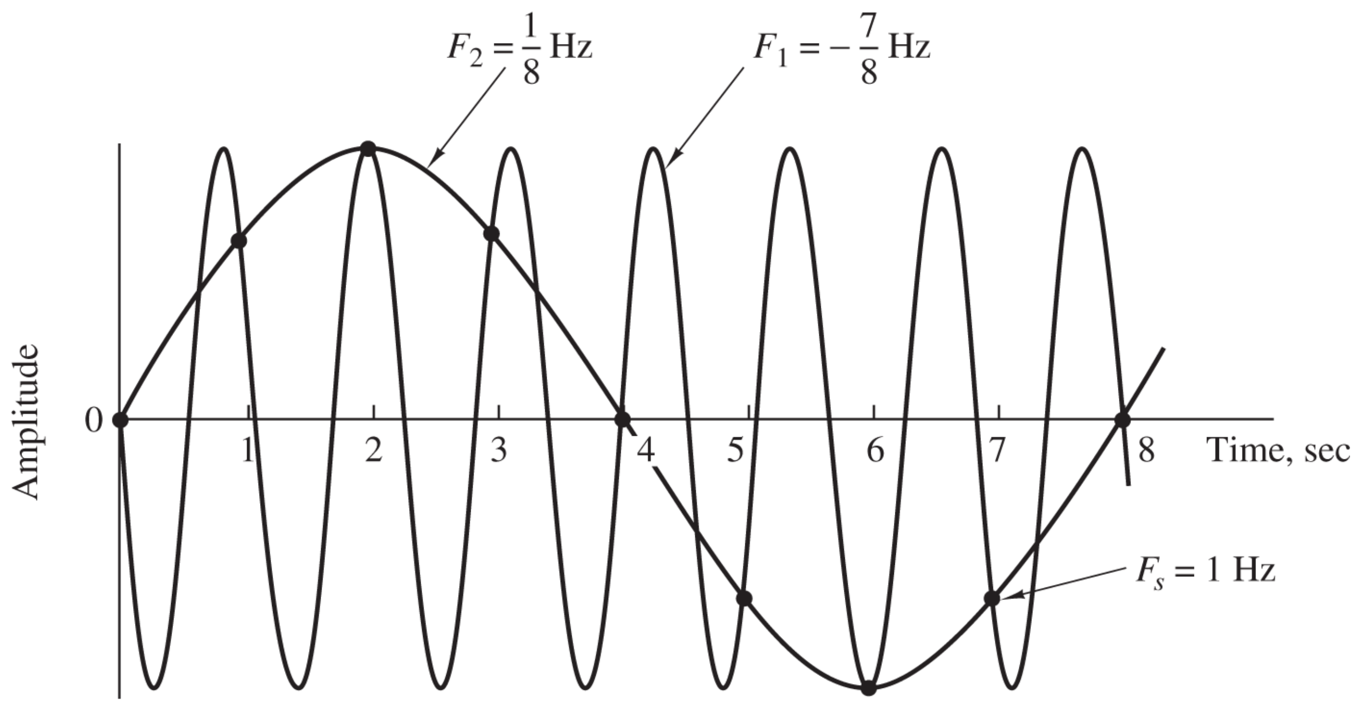

Figure 1.4.5 Illustration of aliasing.

The Sampling Thoerem

If the highest frequency contained in an analog signal $x_a(t)$ is $F_{max} = B$ and the signal is sampled at a rate $F_s > 2F_{max} = 2B$, then $x_a(t)$ can be exactly recovered from its sample values using the interpolation function:

$$g(t) = \frac{\sin 2\pi Bt}{2\pi Bt}$$

Thus $x_a(t)$ can be expressed as:

$$x_a(t) = \sum_{-\infty}^{\infty} x_a\left(\frac{n}{F_s}\right) g\left(t - \frac{n}{F_s}\right)$$

Where $x_a(n/F_s) = x_a(nT) = x(n)$ are the samples of $x_a(t)$.

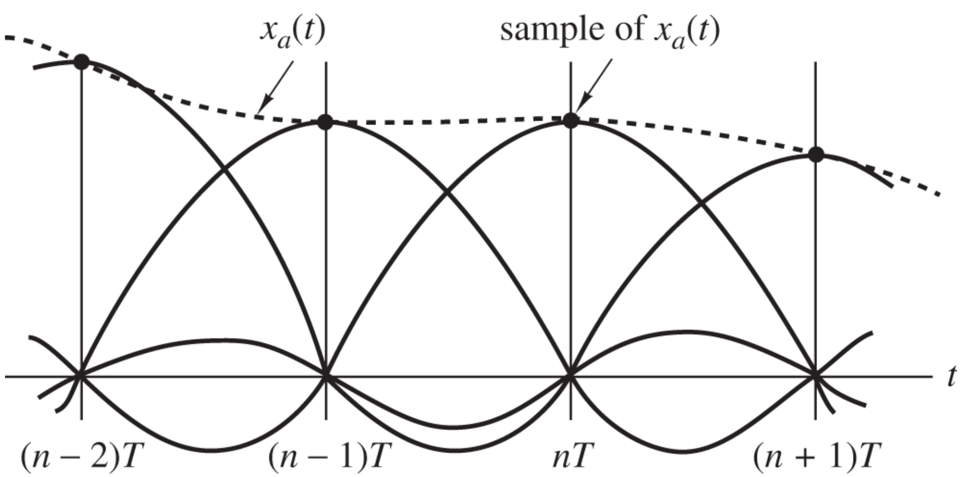

Figure 1.4.6 Ideal D/A conversion (interpolation).

Quantization of Continuous-Amplitude Signals

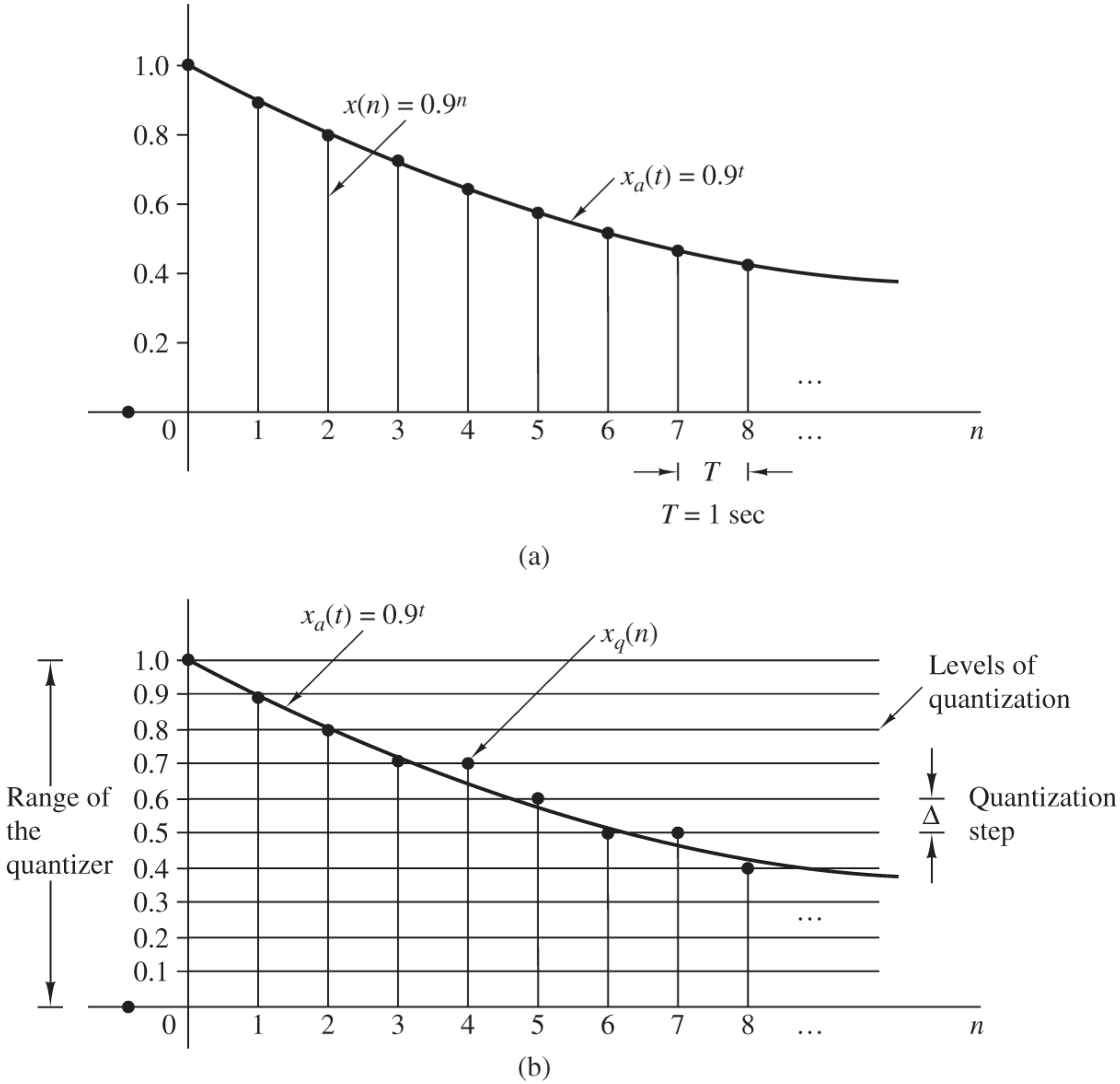

Figure 1.4.7 Illustration of quantization.

Coding of quantized samples