Data and Signals

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Note
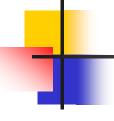
To be transmitted, data must be transformed to electromagnetic signals.

Note

Data can be analog or digital.
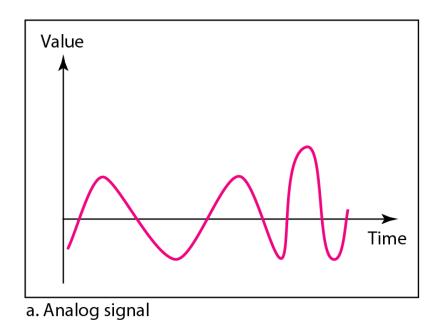Analog data are continuous and take continuous values.
Digital data have discrete states and take discrete values.

Note

Signals can be analog or digital. Analog signals can have an infinite number of values in a range; digital signals can have only a limited number of values.

Figure 1 *Comparison of analog and digital signals*
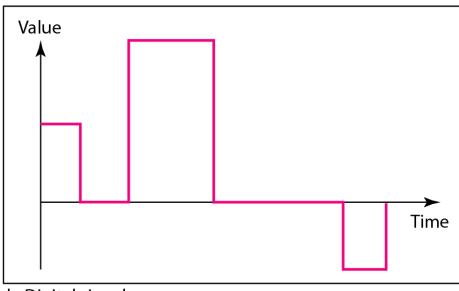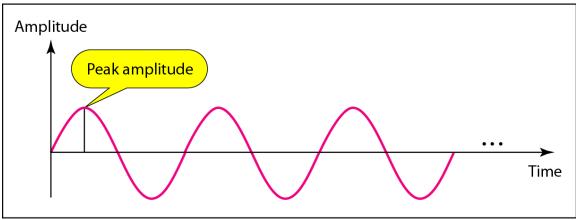
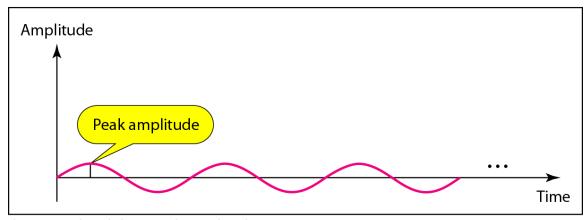

a. Analog signal

b. Digital signal

Figure 2 *Two signals with the same phase and frequency, but different amplitudes*
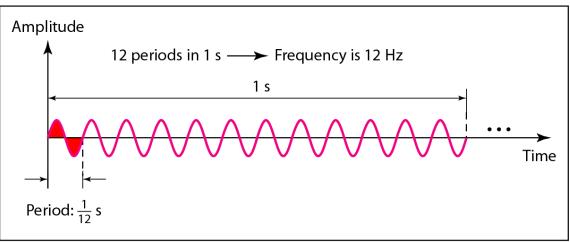

a. A signal with high peak amplitude

b. A signal with low peak amplitude

Frequency and period are the inverse of each other.

$$f = \frac{1}{T} \qquad \text{and} \qquad T = \frac{1}{f}$$

Figure 3 *Two signals with the same amplitude and phase, but different frequencies*

Amplitude

12 periods in 1 s ⟶ Frequency is 12 Hz

1 s

Time

Period: $\frac{1}{12}$ s

a. A signal with a frequency of 12 Hz

Amplitude

6 periods in 1 s ⟶ Frequency is 6 Hz

1 s

Time

T

Period: $\frac{1}{6}$ s

b. A signal with a frequency of 6 Hz

3.8
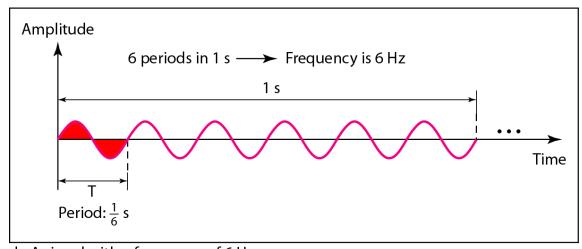
Table 1 *Units of period and frequency*

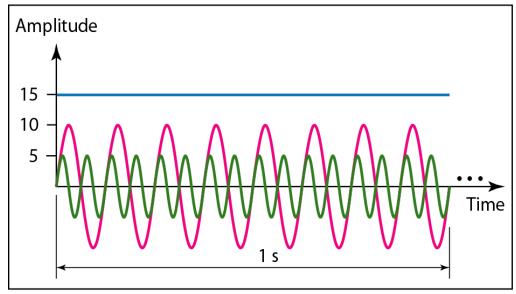| Unit	Equivalent	Unit	Equivalent
Seconds (s)	1 s	Hertz (Hz)	1 Hz
Milliseconds (ms)	10^{-3} s	Kilohertz (kHz)	10^3 Hz
Microseconds (μs)	10^{-6} s	Megahertz (MHz)	10^6 Hz
Nanoseconds (ns)	10^{-9} s	Gigahertz (GHz)	10^9 Hz
Picoseconds (ps)	10^{-12} s	Terahertz (THz)	10^{12} Hz

3.9

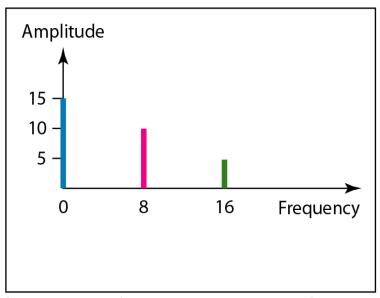**Frequency is the rate of change with respect to time.**

Change in a short span (فترة قصيرة) of time means high frequency.

Change over a long span of time means low frequency.

Figure 4 *The time domain and frequency domain of three sine waves*

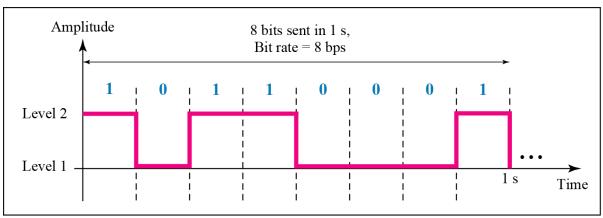a. Time-domain representation of three sine waves with frequencies 0, 8, and 16

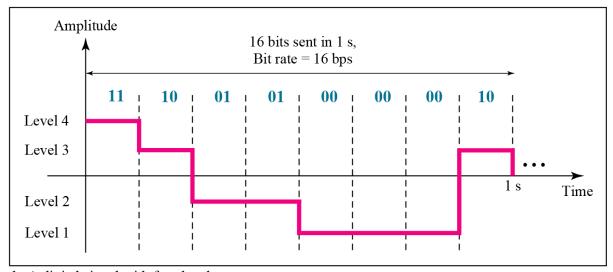b. Frequency-domain representation of the same three signals

DIGITAL SIGNALS

*In addition to being represented by an analog signal, information can also be represented by a **digital signal**. For example, a 1 can be encoded as a positive voltage and a 0 as zero voltage. A digital signal can have more than two levels. In this case, we can send more than 1 bit for each level.*

Figure 7 *Two digital signals: one with two signal levels and the other with four signal levels*

a. A digital signal with two levels

b. A digital signal with four levels

TRANSMISSION IMPAIRMENT (ضعف، تدهور)

Signals travel through transmission media, which are not perfect. The imperfection (خلل، عيب) causes signal impairment. This means that the signal at the beginning of the medium is not the same as the signal at the end of the medium. What is sent is not what is received. Three causes of impairment are **attenuation** **(اضمحلال)**, **distortion (تشويه)**, *and* **noise (ضجيج)**.

Figure 9 *Attenuation*

Original

Attenuated

Amplified

Amplifier

Point 1

Transmission medium

Point 2

Point 3

3.15
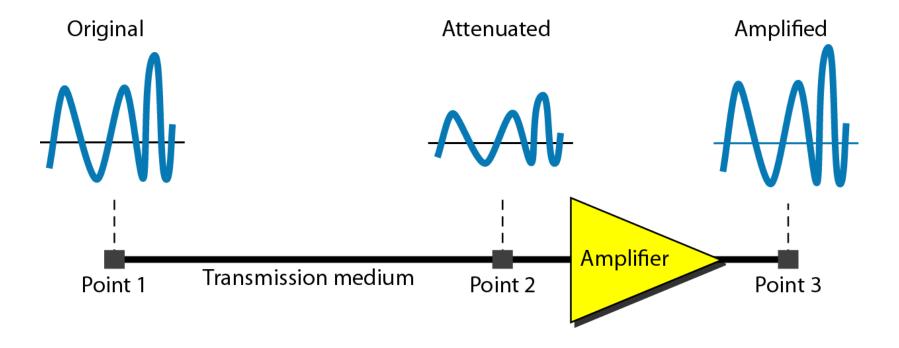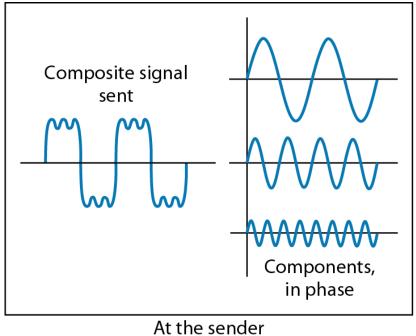
Figure 9 *Distortion*

Figure 10 *Noise*
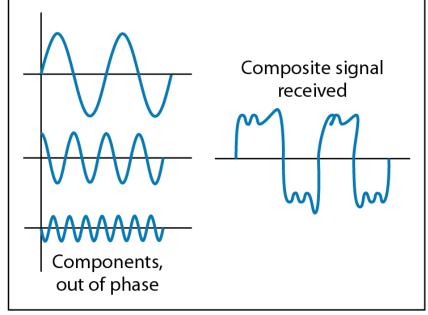
Example
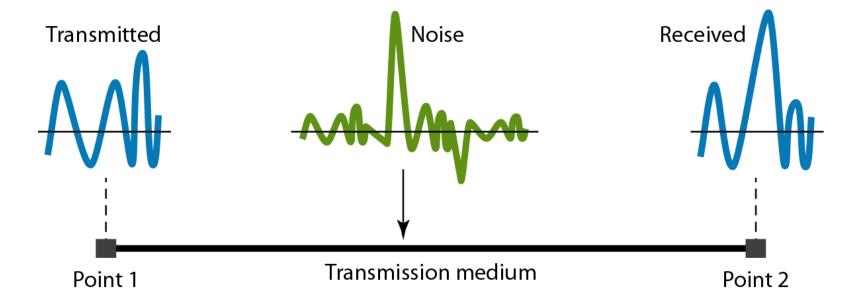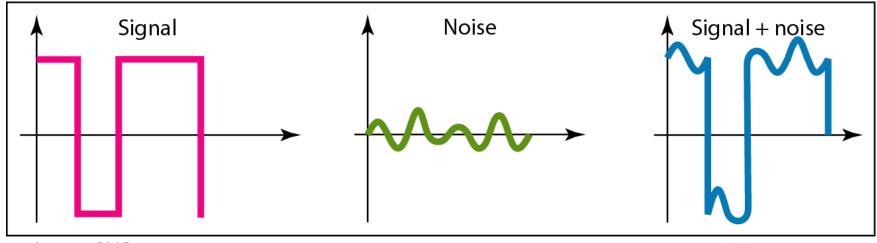
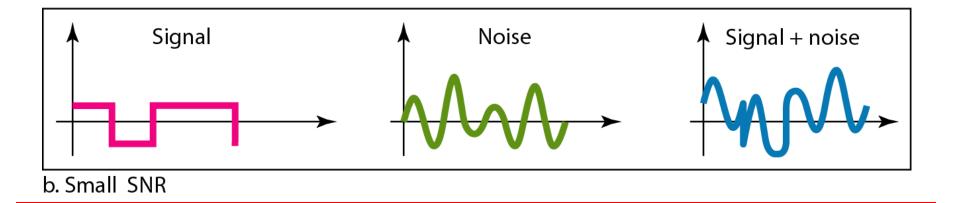*The power of a signal is 10 mW and the power of the noise is 1 μW; what are the values of SNR and SNR$_{dB}$?*

Solution

The values of SNR and SNR$_{dB}$ can be calculated as follows:

$$SNR = \frac{10,000 \; \mu W}{1 \; mW} = 10,000$$

$$SNR_{dB} = 10 \log_{10} 10,000 = 10 \log_{10} 10^4 = 40$$

Figure 11 *Two cases of SNR: a high SNR and a low SNR*

a. Large SNR

b. Small SNR

TRANSMISSION MODES

The transmission of binary data across a link can be accomplished in either parallel or serial mode. In parallel mode, multiple bits are sent with each clock tick. In serial mode, 1 bit is sent with each clock tick. While there is only one way to send parallel data, there are three subclasses of serial transmission: asynchronous, synchronous, and isochronous.
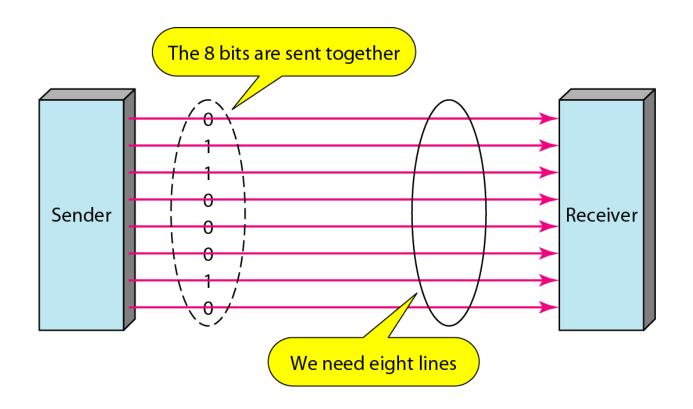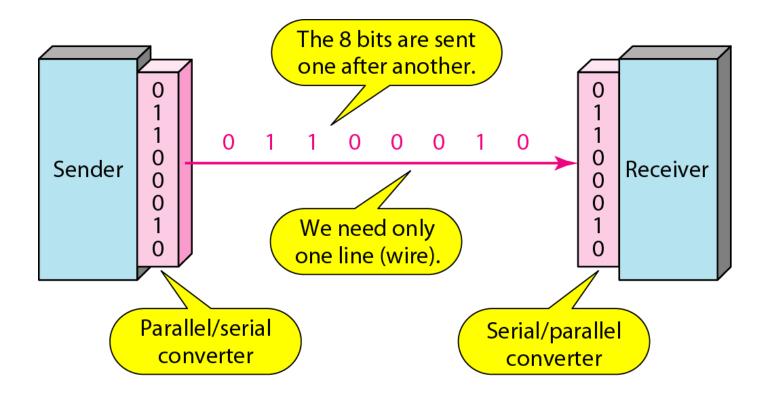
Figure 13 *Parallel transmission*

Figure 14 *Serial transmission*

Transmission Media
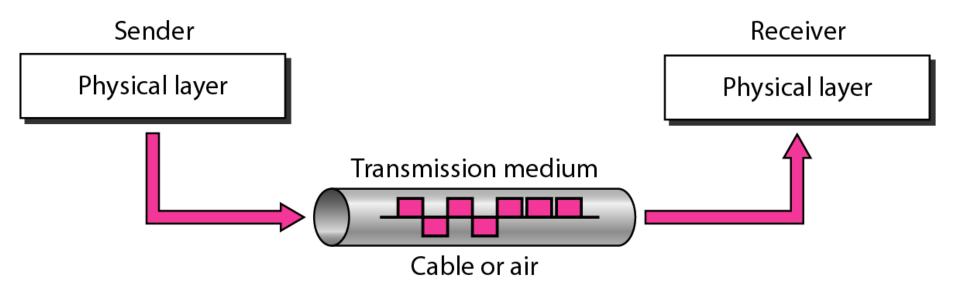
Figure 15 **Transmission medium and physical layer**
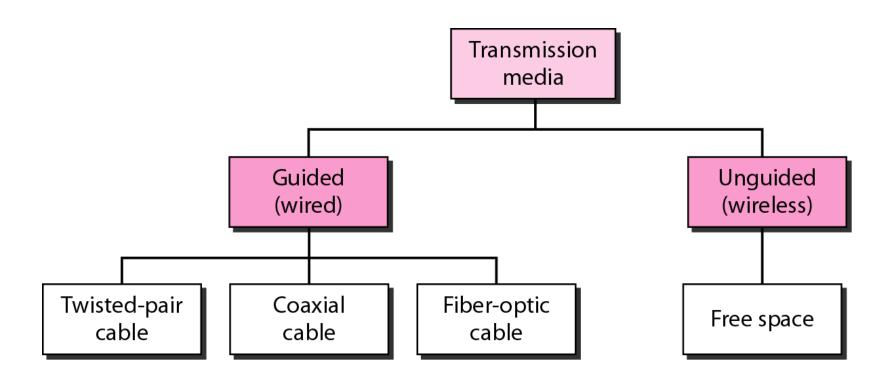
Figure 16 *Classes of transmission media*
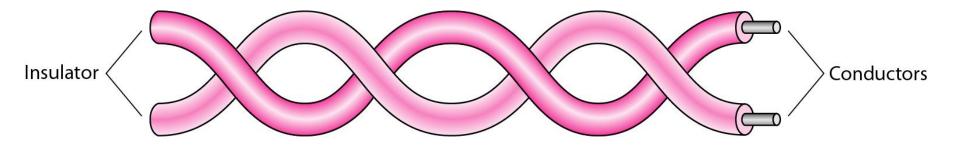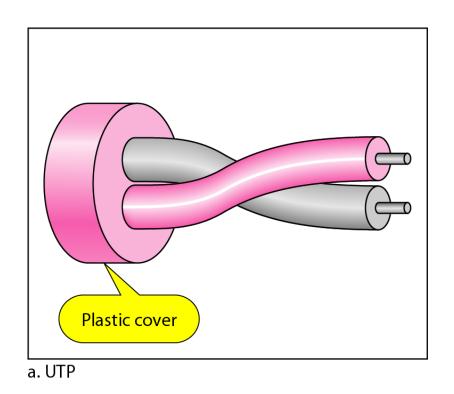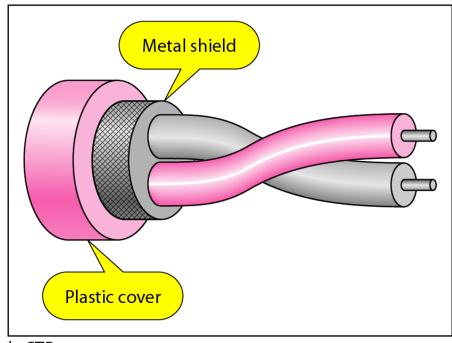
Figure 17 **Twisted-pair cable**

Insulator

Conductors
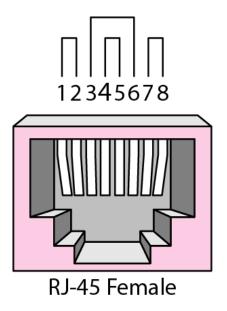
Figure 18 **UTP and STP cables**

a. UTP

b. STP

7.27

Figure 19 *UTP connector*

RJ-45 Female
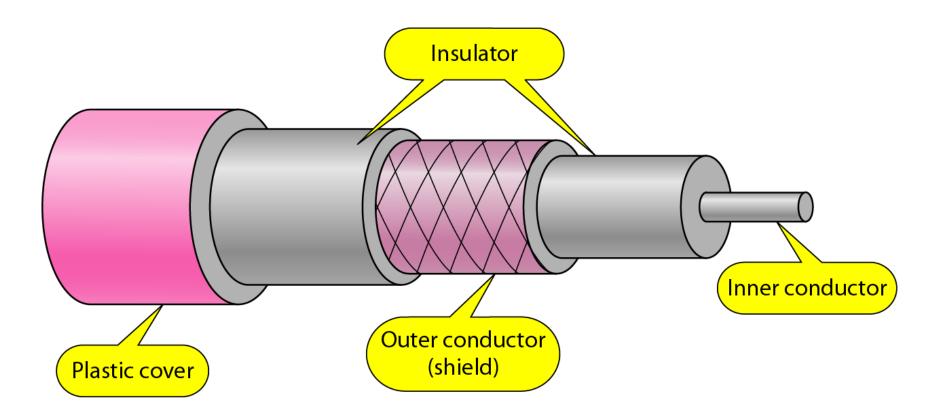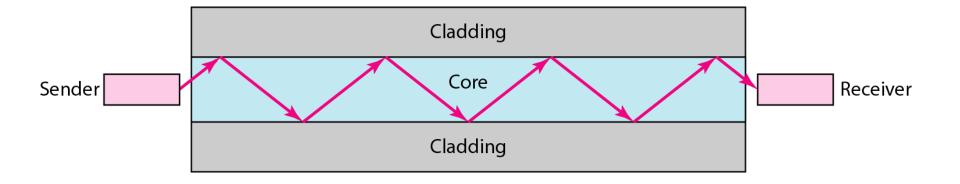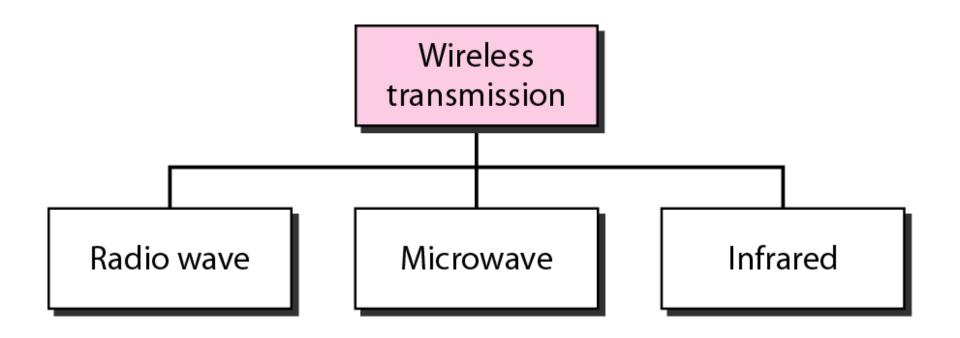
RJ-45 Male

7.28
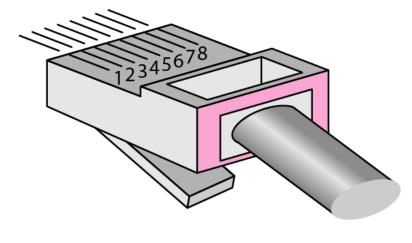
Figure 20 *Coaxial cable*

Figure 21 **Optical fiber**

Wireless transmission

Radio waves are used for multicast (متعدد البث) communications, such as radio and television.

Note

Microwaves are used for unicast (البث الاحادي) communication such as cellular telephones, satellite networks,
and wireless LANs.

> **Note**
>
> *Infrared (اشغة تحت الحمراء) signals can be used for short-range communication in a closed area using line-of-sight propagation.*