# Analog and Digital

Note

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

# ANALOG AND DIGITAL

- The term analog data refers to information that is continuous.
- The term digital data refers to information that has discrete states.
- Analog data take on continuous values.
- Digital data take on discrete values.

# Analog and Digital Data

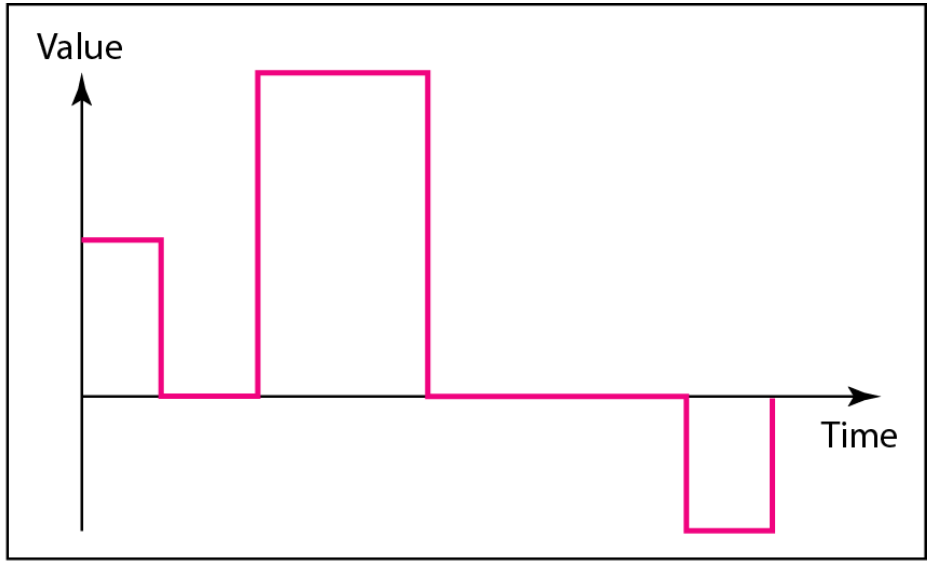
- Data can be analog or digital.
- Analog data are continuous and take continuous values.
- Digital data have discrete states and take discrete values.

# Analog and Digital Signals

- 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.

# Comparison of analog and digital signals


a. Analog signal

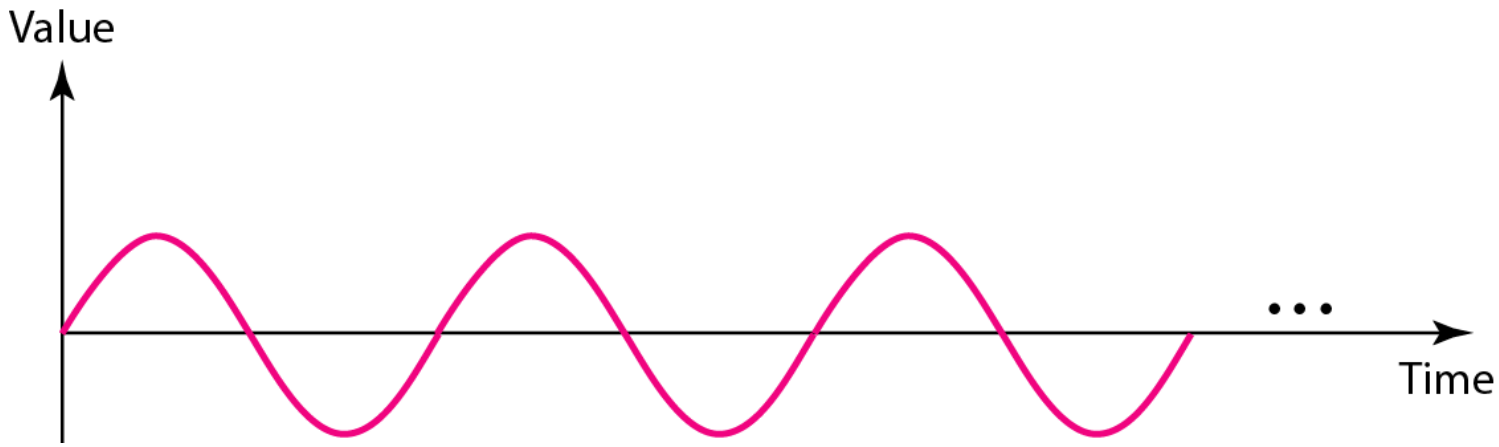



b. Digital signal

# ANALOG SIGNALS CHARACTERISTICS

- A periodic signal completes a pattern within a measurable time frame, called a period, and repeats that pattern over subsequent identical periods.
- The completion of one full pattern is called a cycle.
- A nonperiodic signal changes without exhibiting a pattern or cycle that repeats over time.

A sine wave(periodic signal )



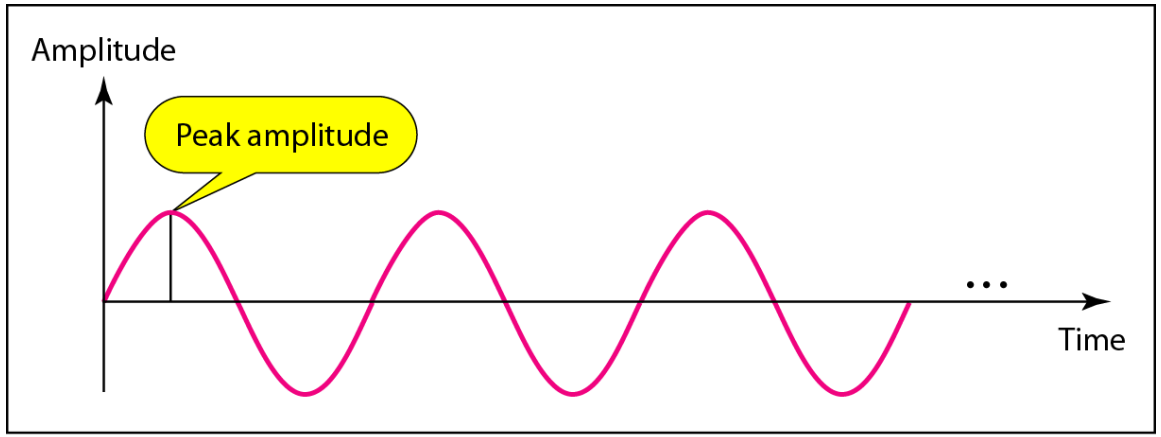
## A sine wave(periodic signal )

A sine wave can be represented by three parameters:

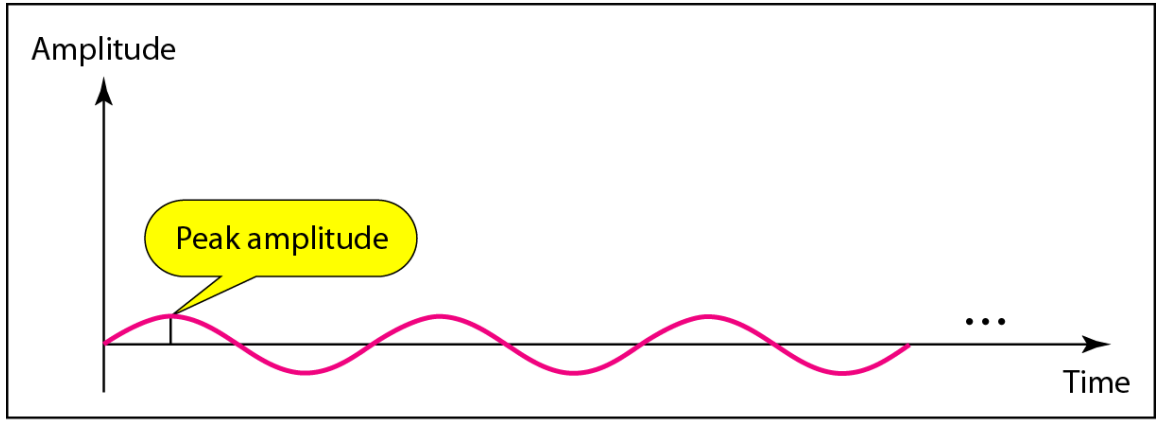
1. the peak amplitude
2. the frequency, and
3. the phase.

These three parameters fully describe a sine wave.

# Two signals with the same phase and frequency, but different amplitudes




a. A signal with high peak amplitude



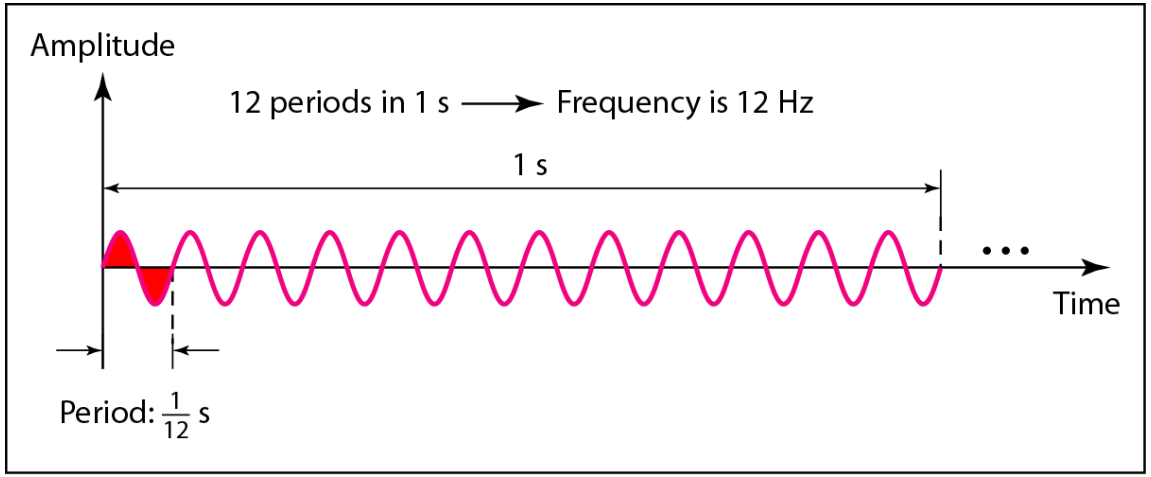

b. A signal with low peak amplitude

Note

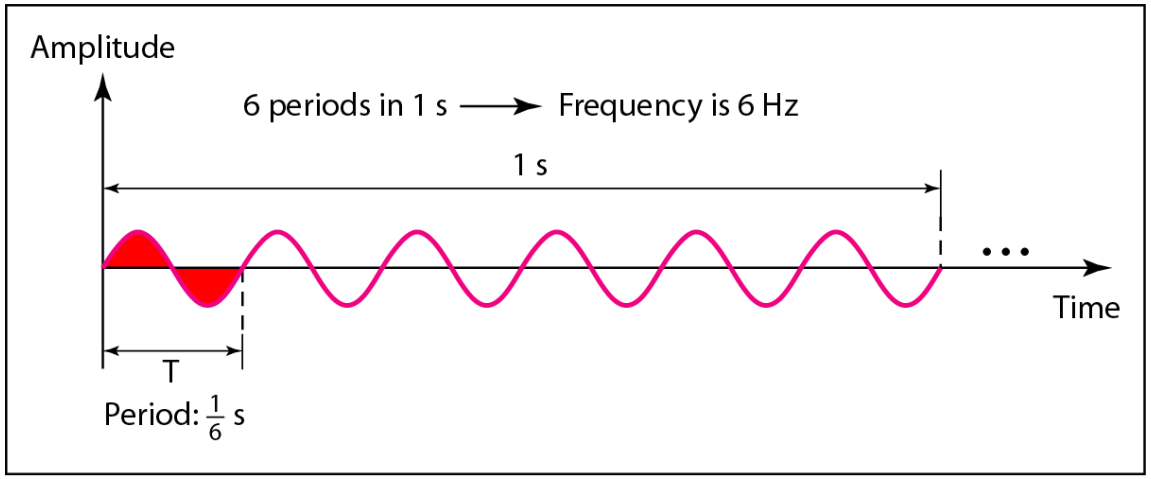
Frequency and period are the inverse of each other.

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

# Two signals with the same amplitude and phase, but different frequencies




a. A signal with a frequency of 12 Hz




b. A signal with a frequency of 6 Hz

## 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 |

# Example

The power we use at home has a frequency of 60 Hz. The period of this sine wave can be determined as follows:

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$$T = \frac{1}{f} = \frac{1}{60} = 0.0166\ \text{s} = 0.0166 \times 10^3\ \text{ms} = 16.6\ \text{ms}$$

# Example

The period of a signal is 100 ms. What is its frequency in kilohertz?

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Solution

First we change 100 ms to seconds, and then we calculate the frequency from the period (1 Hz = $10^{-3}$ kHz).

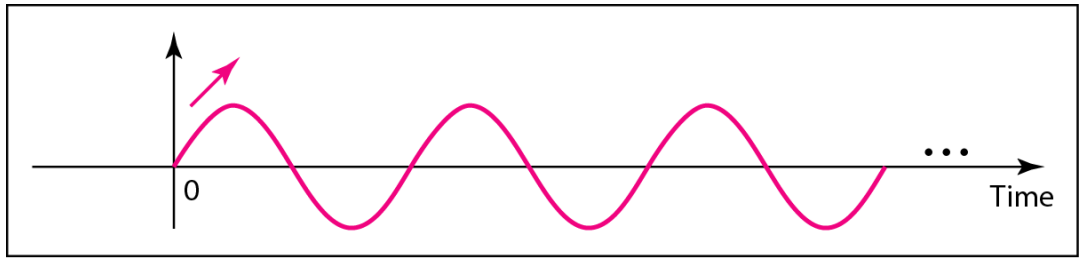
$$100 \text{ ms} = 100 \times 10^{-3} \text{ s} = 10^{-1} \text{ s}$$

$$f = \frac{1}{T} = \frac{1}{10^{-1}} \text{ Hz} = 10 \text{ Hz} = 10 \times 10^{-3} \text{ kHz} = 10^{-2} \text{ kHz}$$

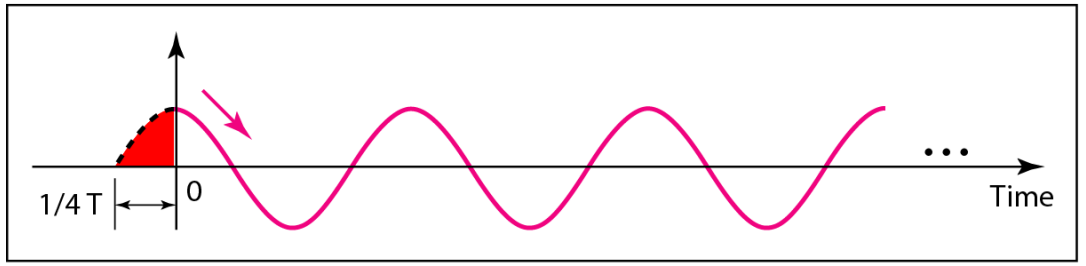
Note

Phase describes the position of the waveform relative to time 0.

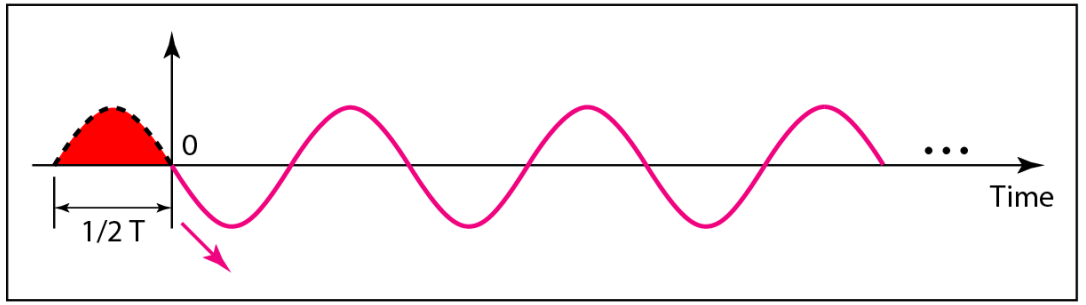
Figure Three sine waves with the same amplitude and frequency, but different phases




a. 0 degrees




b. 90 degrees




c. 180 degrees

# Example

A sine wave is offset 1/6 cycle with respect to time 0. What is its phase in degrees and radians?

Solution

We know that 1 complete cycle is 360°. Therefore, 1/6 cycle is

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$$\frac{1}{6} \times 360 = 60° = 60 \times \frac{2\pi}{360} \text{ rad} = \frac{\pi}{3} \text{ rad} = 1.046 \text{ rad}$$