DATA COMMUNICATIONS AND NETWORKING

Data and Signals
Part 1

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BIT 2nd Year, 2nd Semester

Outline

- Analog and Digital
  - Analog Signals
  - Digital Signals
- Summary

ANALOG AND DIGITAL

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

➢ 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 on 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.

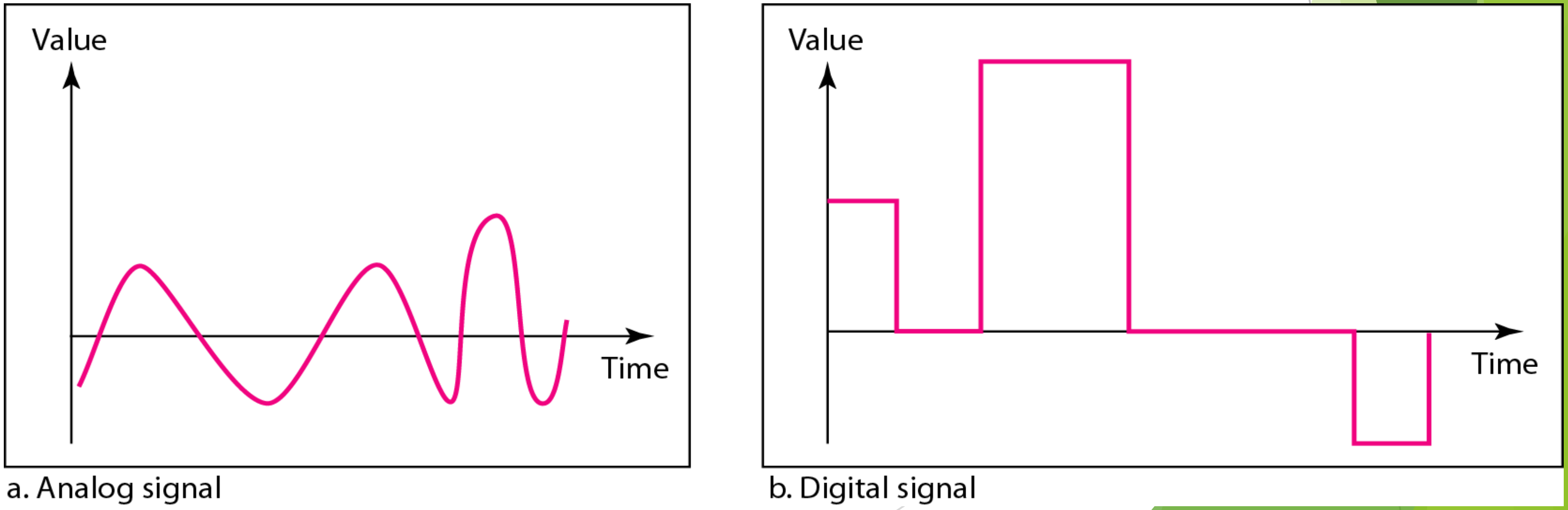


Figure 1. Comparison of analog and digital signals

ANALOG AND DIGITAL (continue…)

➢ Periodic and Nonperiodic Signals

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

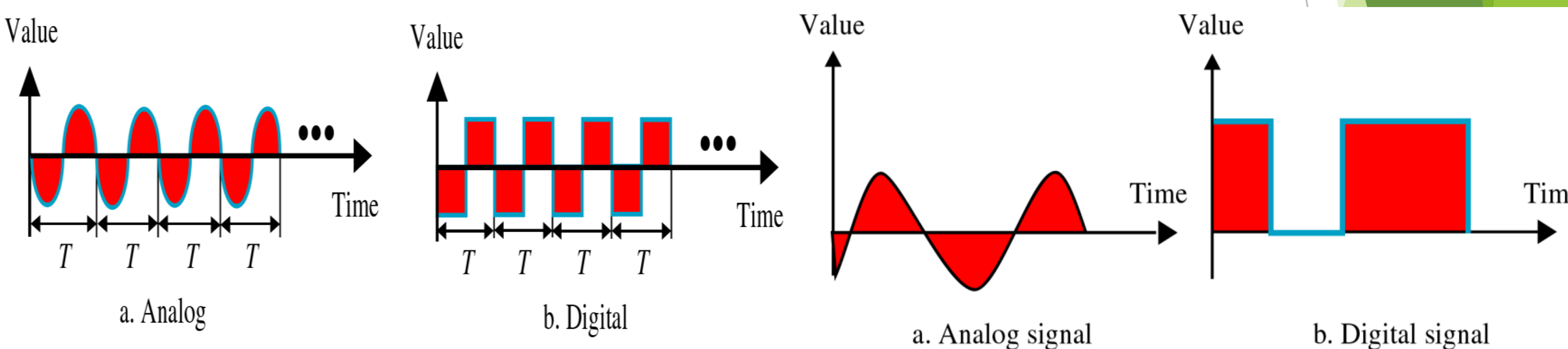


Figure 2. Periodic and Nonperiodic Signals

PERIODIC ANALOG SIGNALS

- Periodic analog signals can be classified as simple or composite.
- A simple periodic analog signal, a sine wave, cannot be decomposed into simpler signals.
- A composite periodic analog signal is composed of multiple sine waves

➢ Sine wave is described by:-

- Amplitude
- Period (frequency)
- phase

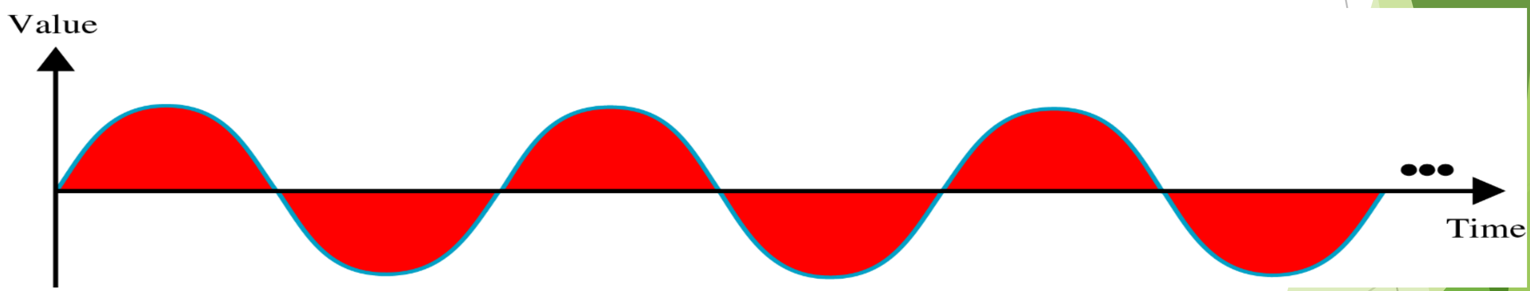


Figure 3. A sine wave

Peak Amplitude :- The peak amplitude of a signal is the absolute value of its highest intensity, proportional to the energy it carries. For electric signals, peak amplitude is normally measured in volts.

PERIODIC ANALOG SIGNALS(continue…)

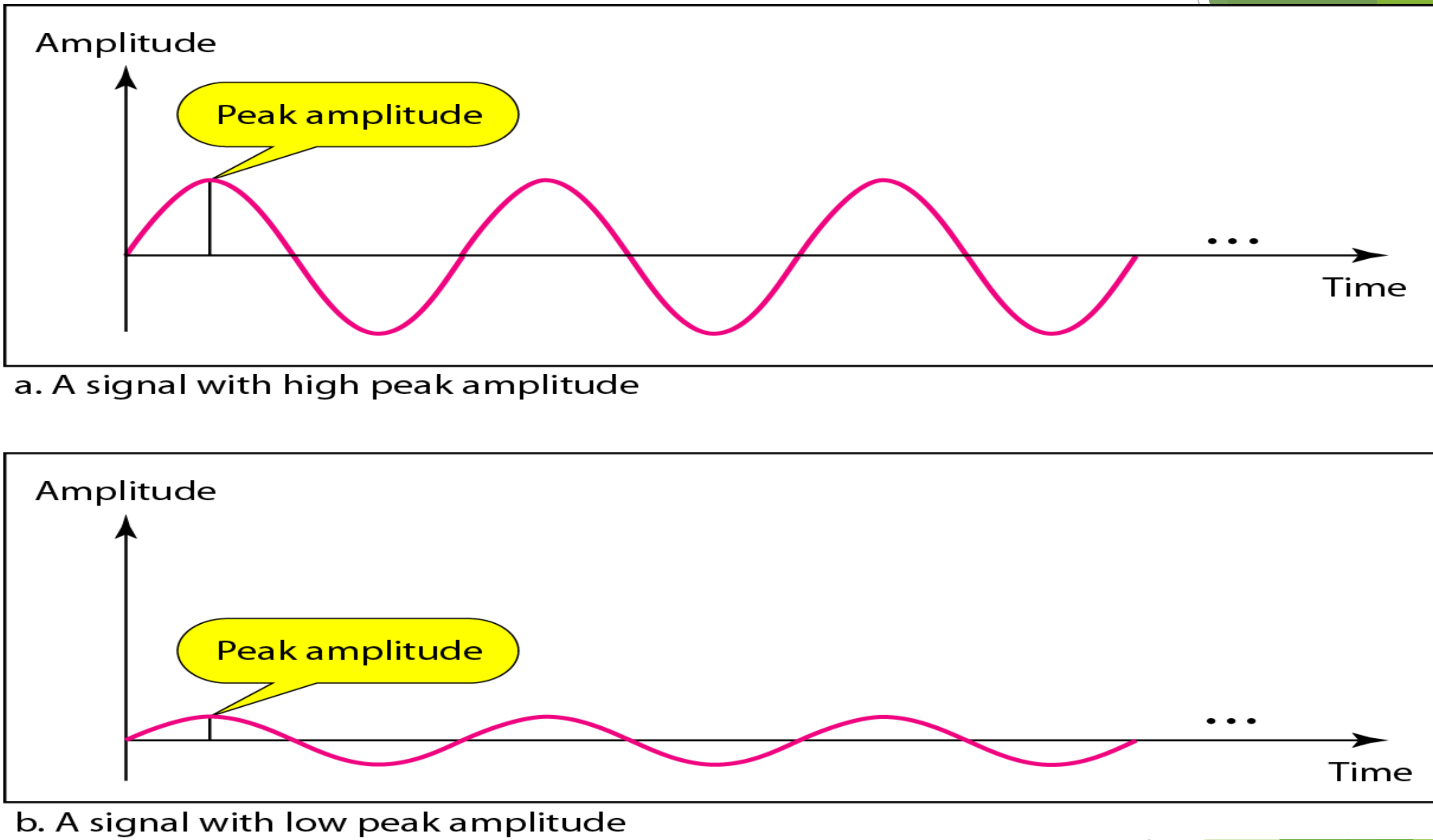
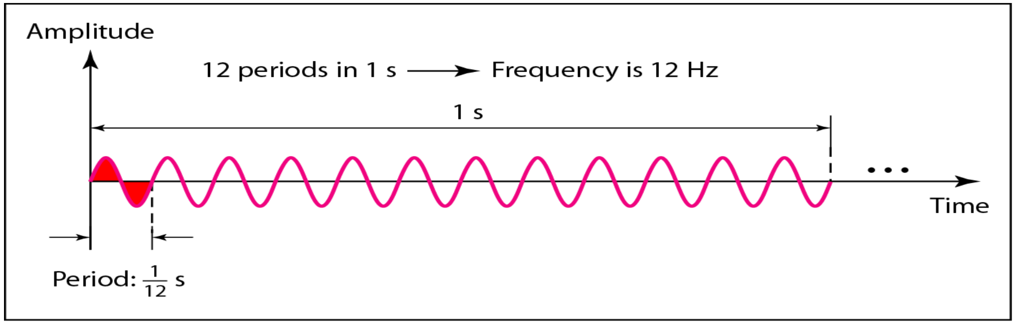


Figure 4. Two signals with the same phase and frequency, but different amplitudes

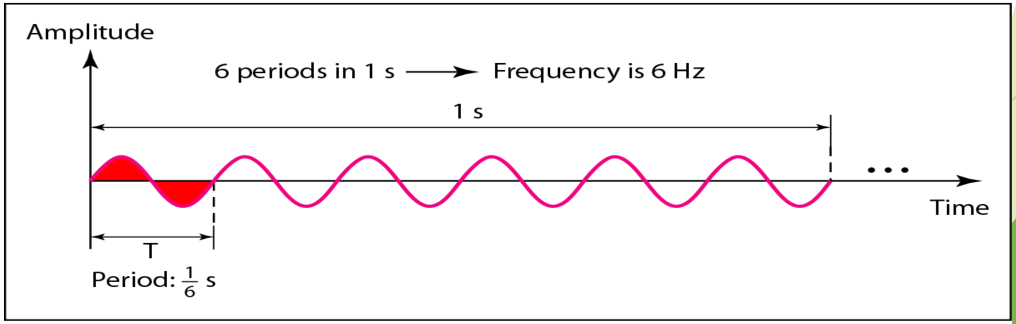
PERIODIC ANALOG SIGNALS(continue…)

- Period and Frequency
- Period refers to the amount of time, in seconds, a signal needs to complete 1 cycle. Frequency refers to the number of periods in I s. Note that period and frequency are just one characteristic defined in two ways.
- Period is the inverse of frequency, and frequency is the inverse of period, as the following formulas show.

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



a. A signal with a frequency of 12 Hz



b. A signal with a frequency of 6 Hz

Figure 5. Two signals with the same amplitude and phase, but different frequencies

PERIODIC ANALOG SIGNALS(continue…)

- Period and Frequency (continue…)

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

- Example 1. :-

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

Solution :-

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

PERIODIC ANALOG SIGNALS(continue…)

- Period and Frequency (continue…)

- Example 2. :- Express a period of 100 ms in microseconds.

Solution:-

The equivalents of 1 ms (1 ms is 10^{-3} s) and 1 s (1 s is 10^{6} μs). We make the following substitutions:.

$$100 \text{ ms} = 100 \times 10^{-3} \text{ s} = 100 \times 10^{-3} \times 10^{6} \, \mu\text{s} = 10^{2} \times 10^{-3} \times 10^{6} \, \mu\text{s} = 10^{5} \, \mu\text{s}$$

Example 3.:- Express a period of 100 ms in microseconds, and express the corresponding frequency in kilohertz

Solution:-

From Table 3.1 we find the equivalent of 1 ms. We make the following substitutions:

$$100 \text{ ms} = 100 \times 10^{-3} \text{ s} = 100 \times 10^{-3} \times 10^{6} \text{ ms} = 10^{5} \, \mu\text{s}$$

Now we use the inverse relationship to find the frequency, changing hertz to kilohertz

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

$$f = 1/10^{-1} \text{ Hz} = 10 \times 10^{-3} \text{ KHz} = 10^{-2} \text{ KHz}$$

PERIODIC ANALOG SIGNALS(continue…)

- More About Frequency
- Another way to look frequency
- Frequency is a measurement of the rate of changes ,Change in a short span of time means high frequency ,Change over a long span of time means low frequency. Two extremes

No change at all = zero frequency

Instantaneous changes = infinite frequency

- Phase

Phase describes the position of the waveform relative to time zero

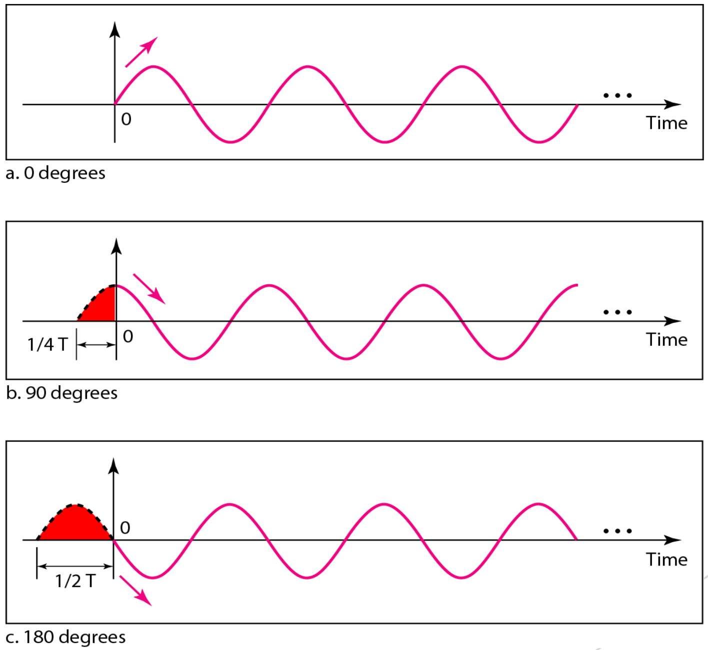


Figure 6. Three sine waves with same amplitude and frequency, but different phases

PERIODIC ANALOG SIGNALS(continue…)

- Sine Wave Examples
- Example 4:- 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

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

➢ Wavelength

- Another characteristic of a signal traveling through a transmission medium
- Binds the period or the frequency of a simple sine wave to the propagation speed of the medium.
- Wavelength = propagation speed x period
- = propagation speed/frequency

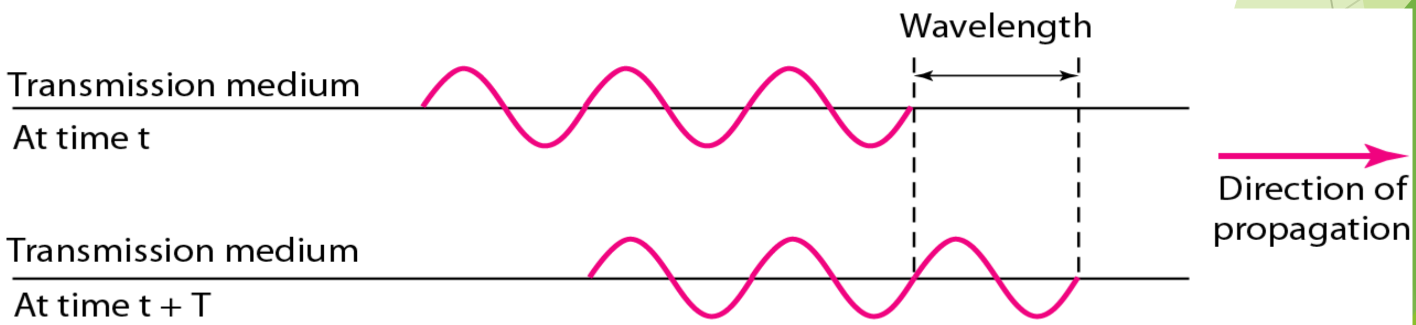


Figure 8. Wavelength and period

PERIODIC ANALOG SIGNALS(continue…)

- **Time and Frequency Domains**
- A complete sine wave in the time domain can be represented by one single spike in the frequency domain.

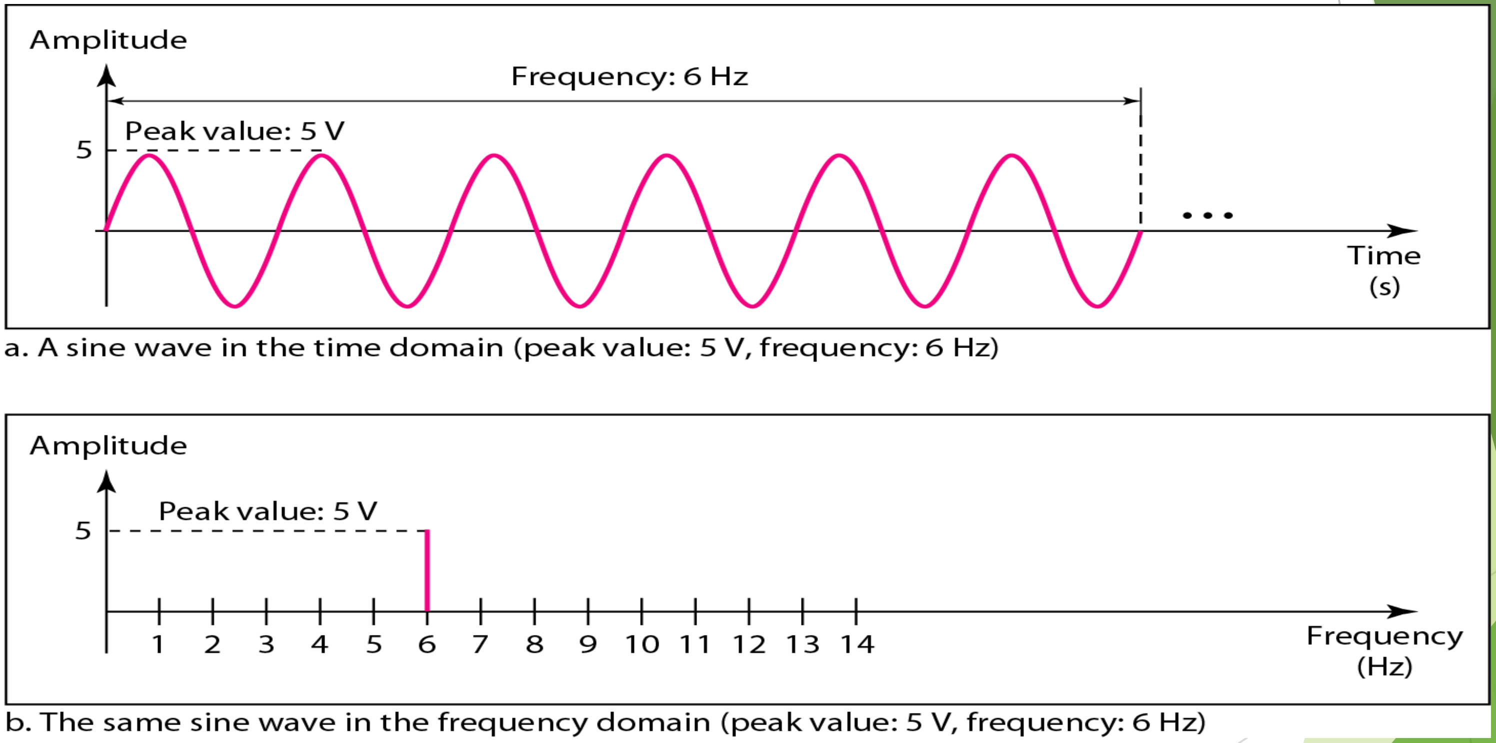
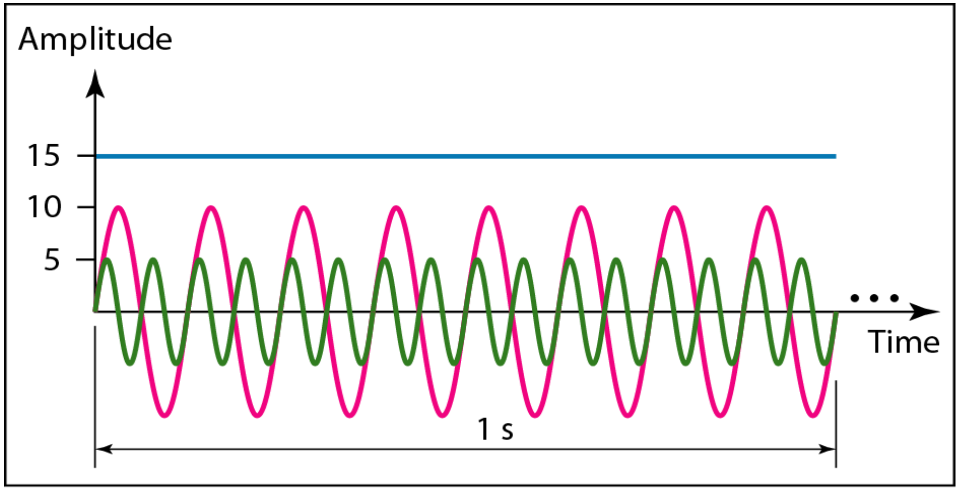


Figure 9. The time-domain and frequency-domain plots of a sine wave

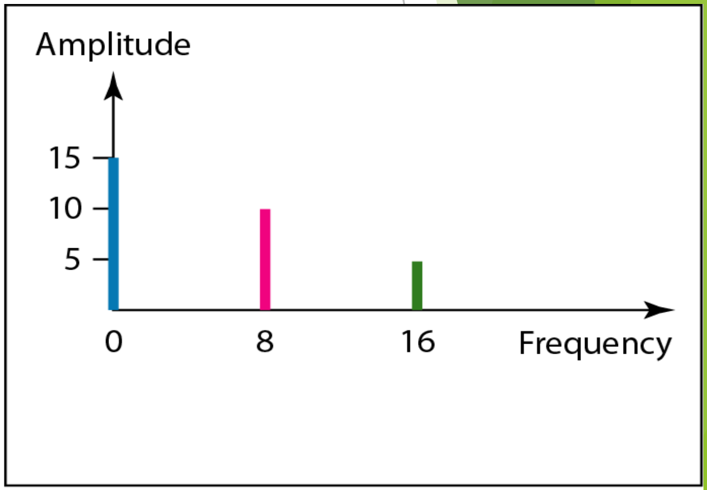
PERIODIC ANALOG SIGNALS(continue…)

➢ Time and Frequency Domains (continue…)

- Example 5:- The frequency domain is more compact and useful when we are dealing with more than one sine wave. For example, Figure 10. shows three sine waves, each with different amplitude and frequency. All can be represented by three spikes in the frequency domain.



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



b. Frequency-domain representation of the same three signals

Figure 10. Time domain and frequency domain of three sine waves with frequencies 0, 8, 16