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Wisdom & Virtue

MIRPUR UNIVERSITY OF SCIENCE AND TECHNOLOGY (MUST), MIRPUR

DEPARTMENT OF SOFTWARE ENGINEERING

Computer Networks

Lecture [13]: Wavelength, Time and Frequency Domains

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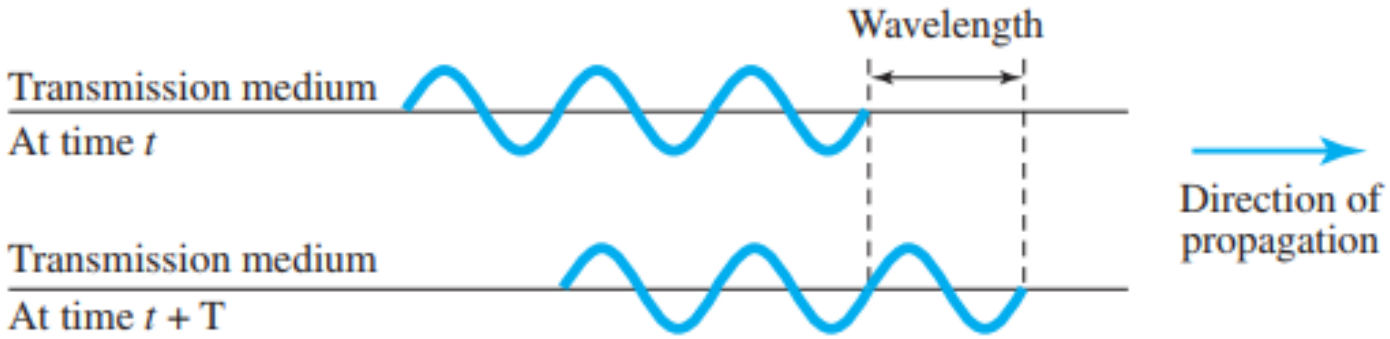
(Lecturer)

Topics discussed in Today's Lectures

- Wavelength
- Time and Frequency Domains
- Composite Signals

Wavelength

- Wavelength binds the period or the frequency of a simple sine wave to the propagation speed of the medium



- While frequency of a signal is independent of medium, wave-length depends on both the frequency and the medium
- In data comm., we often use wavelength to describe the transmission of light in an optical fiber
- The wavelength *is the distance a simple signal can travel in one period*

Wavelength

- Wavelength can be calculated if one is given propagation speed (the speed of light) and period of the signal
- As period & frequency are related to each other, if we represent wavelength by **λ**, propagation speed by **c** (speed of light), and frequency by **f**, we get:

$$\textbf{Wavelength} = (\textbf{propagation speed}) \times \textbf{period} = \frac{\textbf{propagation speed}}{\textbf{frequency}}$$

$$\lambda = \frac{c}{f}$$

Wavelength

- Propagation speed of electromagnetic signals depends on the medium and on frequency of the signal
- For example, in a vacuum, light is propagated with a speed of 3 × 10^8 m/s
- That speed is lower in air and even lower in cable
- For example, the wavelength of red light (frequency = 4 × 10^14) in air is

$$\lambda = \frac{c}{f} = \frac{3 \times 10^8}{4 \times 10^{14}} = 0.75 \times 10^{-6}\ \text{m} = 0.75\ \mu\text{m}$$

- In a coaxial or fiber-optic cable, wavelength is shorter (0.5 um) because propagation speed in the cable is decreased

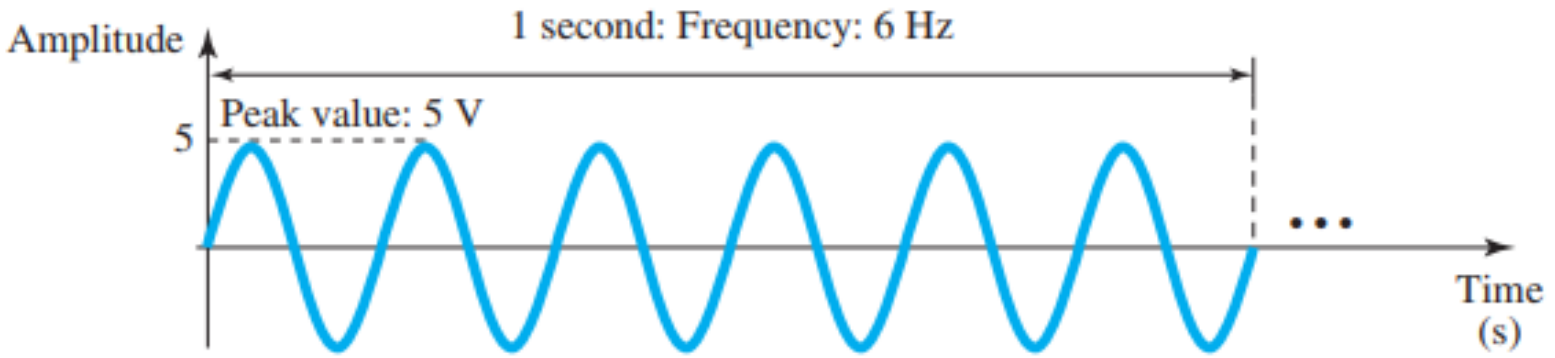
Time and Frequency Domains

- A sine wave is comprehensively defined by its amplitude, frequency, and phase
- Sine wave is using what is called a time-domain plot
- **Time-domain plot** shows *changes in signal amplitude w.r.t time*
  - It is an *amplitude-versus-time plot*
  - Phase is not explicitly shown on a time-domain plot
- Relationship b/w amplitude and frequency is shown by frequency-domain plot
- **Frequency-domain plot** is concerned with only peak value
  - Frequency changes of amplitude during one period are not shown

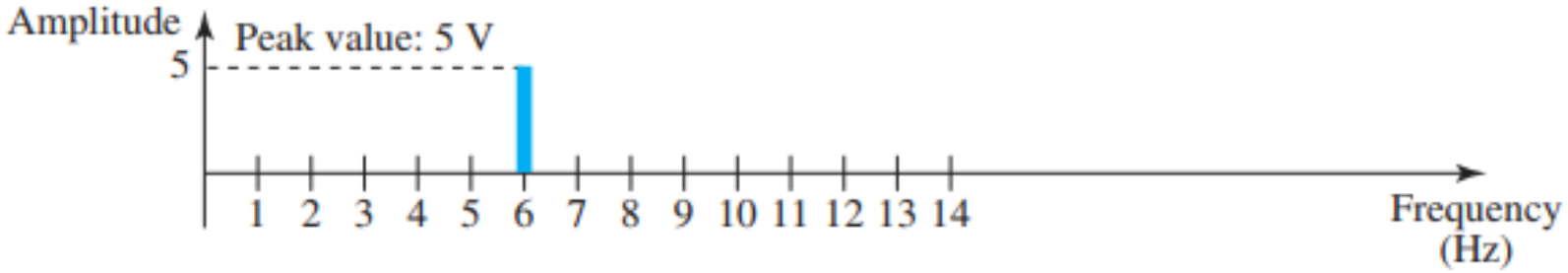
Time and Frequency Domains

- Complete sine wave is represented by one spike
- Position of the spike shows the frequency;
  its height shows the peak amplitude

Figure 3.8 *The time-domain and frequency-domain plots of a sine wave*

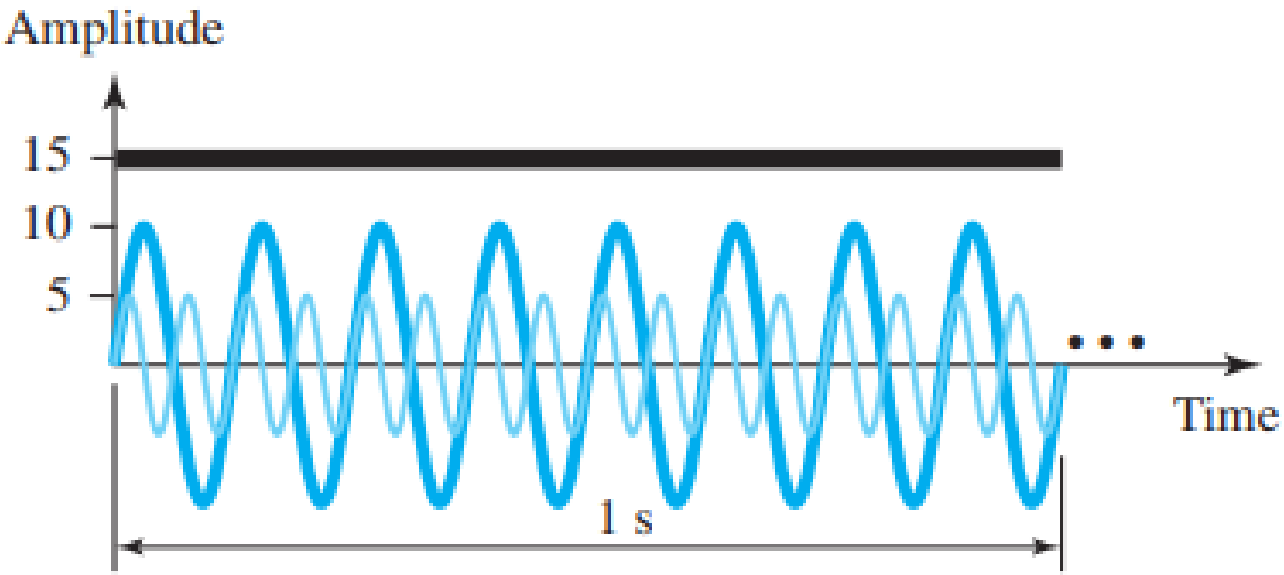


a. A sine wave in the time domain (peak value: 5 V, frequency: 6 Hz)

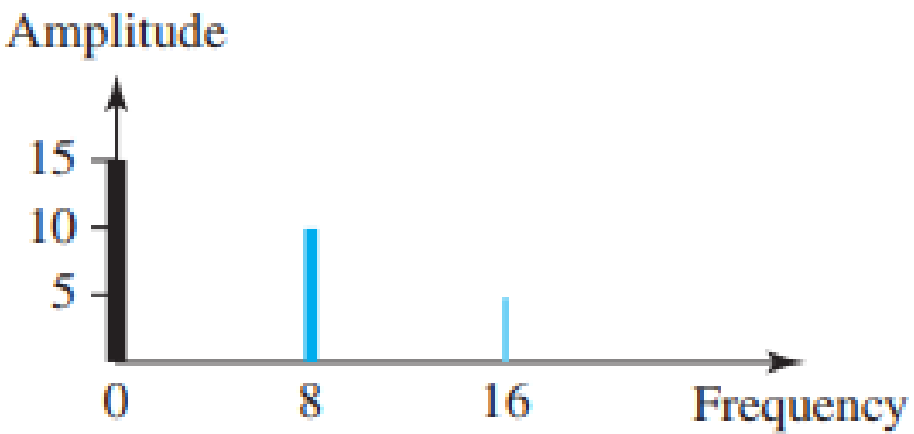


b. The same sine wave in the frequency domain (peak value: 5 V, frequency: 6 Hz)

Time and Frequency Domains



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



b. Frequency-domain representation of the same three signals

Simple Sine Waves Applications

- Single sine wave is used to carry electric energy from one place to another
- For example, power company sends a single sine wave with a frequency of 60 Hz to distribute electric energy to houses and businesses
- We can use a single sine wave to send an alarm to a security center when a thief opens a door or window in the house
- In the 1st case, the sine wave is carrying energy
- In 2nd case, the sine wave is a signal of danger

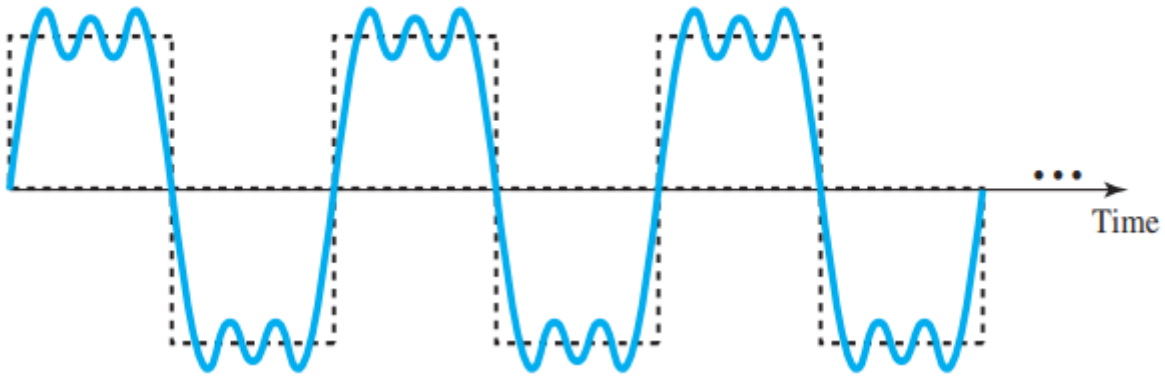
Composite Sine Wave

- Composite signal is actually a combination of simple sine waves with diff. frequencies, amplitudes, and phases
- Composite signal can be periodic or nonperiodic
- **Periodic composite signal** can be decomposed into a series of simple sine waves with discrete frequencies:
  - Frequencies that have integer values (1, 2, 3, and so on)
- **Nonperiodic composite signal** can be decomposed into a combination of an infinite number of simple sine waves with continuous frequencies

Composite Sine Wave - Example

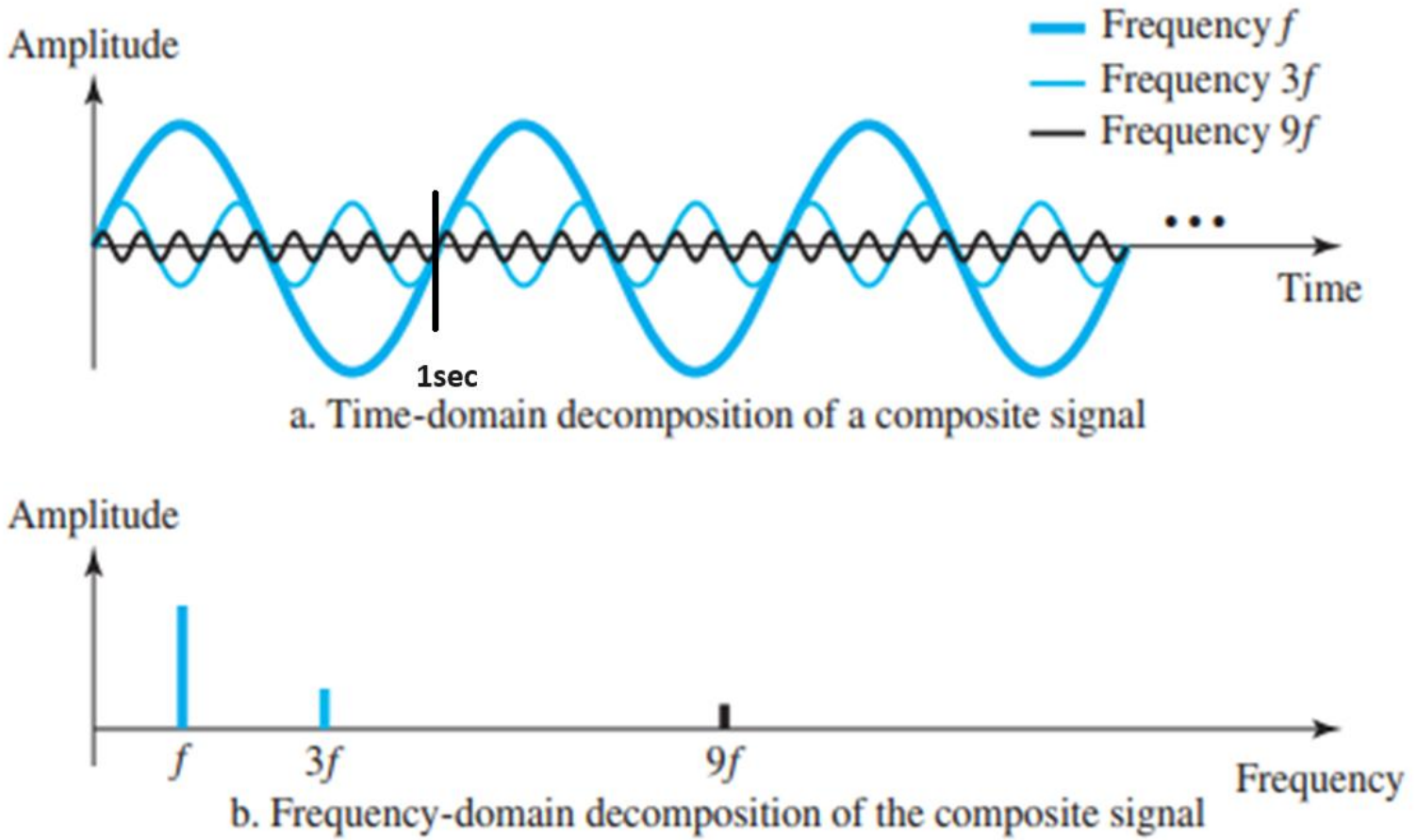
- Consider a signal consisting of 3 alarm systems, each with a different frequency.
- It is very difficult to manually decompose this signal into a series of simple sine waves
- Figure 3.11 shows the result of decomposing the above signal in both the time and frequency domains

Figure 3.10 *A composite periodic signal*



Composite Sine Wave - Example

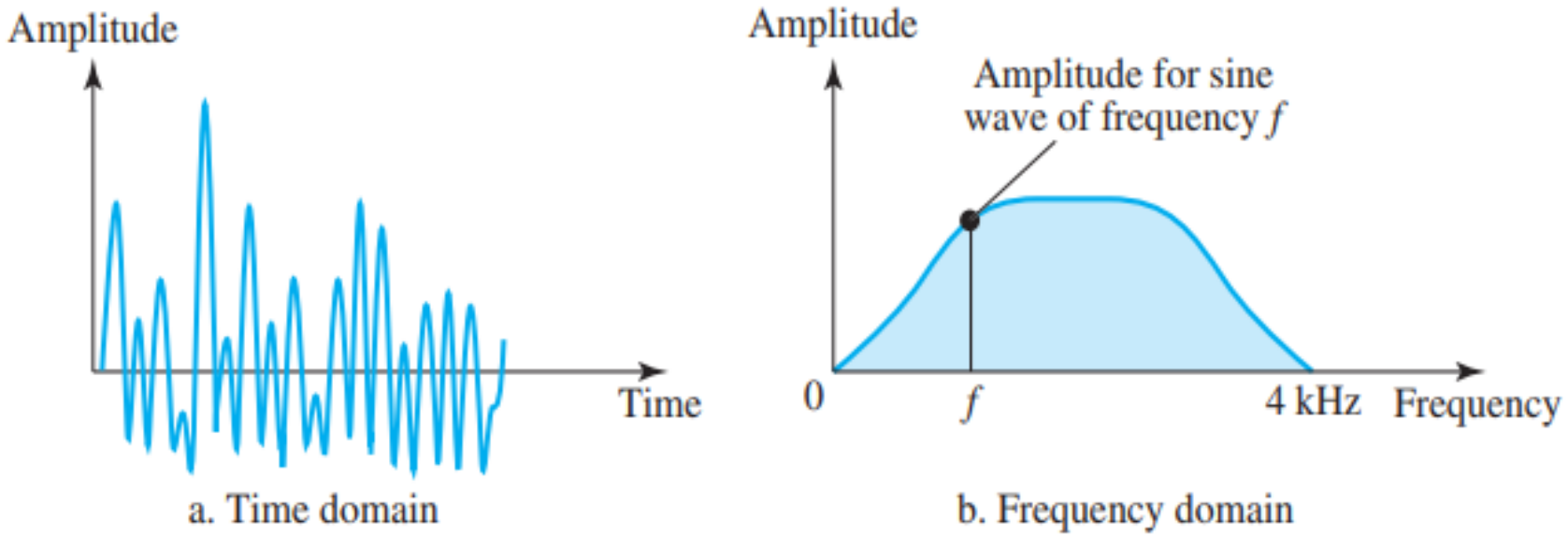
Figure 3.11 *Decomposition of a composite periodic signal in the time and frequency domains*



Non-Periodic Composite Signal-Example

- Signal created by a microphone or a telephone set when a word or two is pronounced
- In this case, the composite signal cannot be periodic
- Because we are repeating the same word or words with exactly the same tone

Figure 3.12 *The time and frequency domains of a nonperiodic signal*



References

Chapter 3

Data Communication and Networking (5th Edition)
By Behrouz A. Forouzan

THANKS