Open system Interconnection (OSI)

Physical Layer

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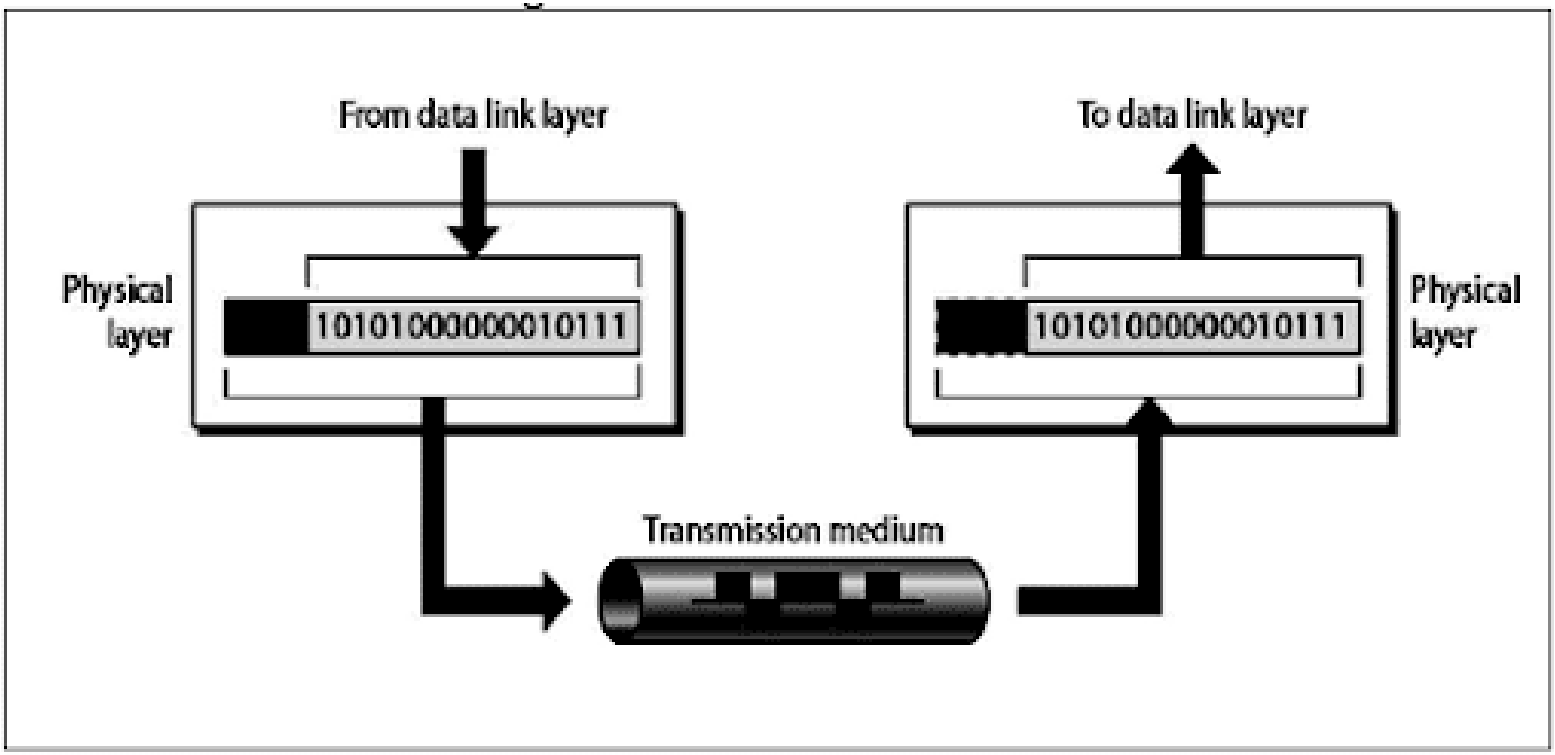
Physical Layer

- The physical layer coordinates the functions required to carry a bit stream over a physical medium.
- It deals with the mechanical and electrical specifications of the interface and transmission medium
- It also defines the procedures and functions that physical devices and interfaces have to perform for transmission

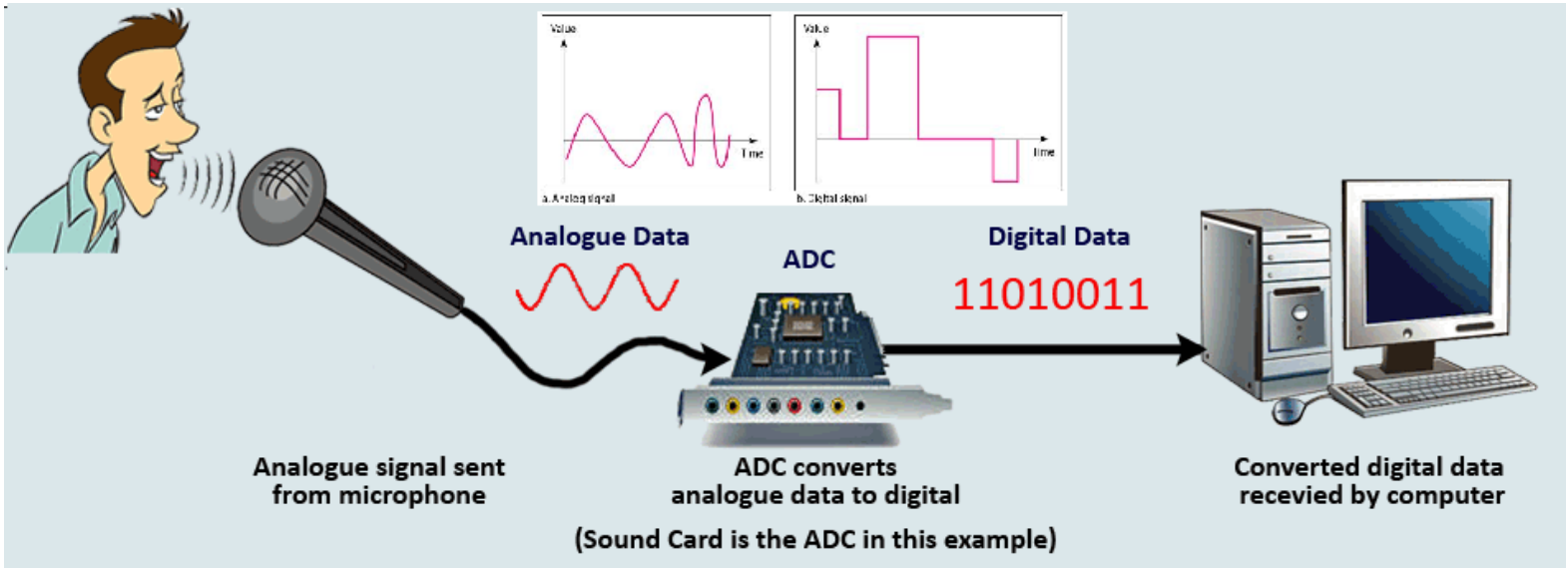


Physical layer roles and responsibility

- The physical layer is also concerned with the following:
  - **Physical characteristics of interfaces and medium.** (type of transmission medium)
  - **Representation of bits** (encoding bits to signal)
  - **Data rate**
  - **Synchronization of bits** (sender and the receiver clocks must be synchronized.)
  - **Line configuration** (point to point or Multi-point)
  - **Physical topology**
  - **Transmission mode:**
    - **Simplex:** only one device can send; the other can only receive
    - **Half Duplex:** two devices can send and receive, but not at the same time.
    - **Full Duplex:** two devices can send and receive at the same time.

Data and Signals

- To be transmitted, data must be transformed to electromagnetic signals.
- **Analog and Digital Data:**
  - analog data is continuous. e.g analog clock
  - digital data is discrete. e.g digital clock
- **Analog and Digital Signal**
  - analog signals can have an infinite number of values in a range.
  - digital signals can have only a limited number of values.

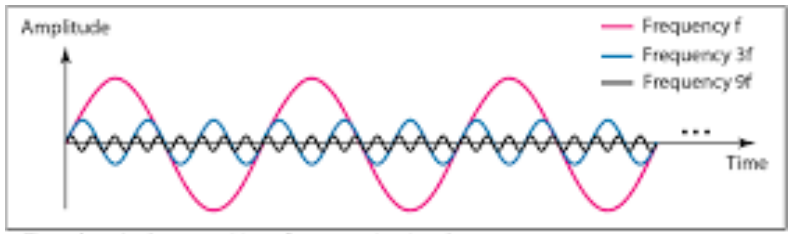


Periodic and Nonperiodic Signals

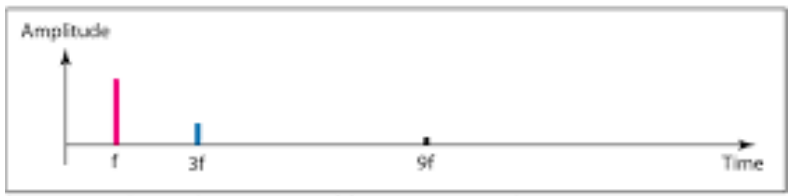
- Both analog and digital signals can take one of two forms:
  - **Periodic:**
    - A periodic signal completes a pattern within a measurable time frame.
    - The completion of one full pattern is called a cycle
    - In data communications, we commonly use periodic analog signals.
    - Periodic signal needs lesser bandwidth
  - **Non-periodic:**
    - A non-periodic signal changes without exhibiting a pattern.
    - Non-periodic digital signals represent variation in data

Periodic Analog Signal

- Periodic analog signals can be classified in two categories:
  - **Simple:**
    - A simple periodic analog signal, a sine wave.
    - A sine wave can be represented by three parameters: Amplitude ,Frequency, Phase.
    - Single sine wave with a frequency of 50 Hz to distribute electric energy to houses.
    - A single-frequency sine wave is not useful in data communications
  - **Composite:**
    - A composite periodic analog signal is composed of multiple sine waves.
    - Composite signal is useful in data communications



a. Time-domain decomposition of a composite signal



b. Frequency-domain decomposition of the composite signal

Period and Frequency

- **Period (P) and Frequency (F)**
  - **Period:** the amount of time (sec) a signal needs to complete 1 cycle.
  - **Frequency:** the number of periods in I s.
- Frequency and period are the inverse of each other.

$$P = \frac{1}{T}, \quad F = \frac{1}{P}$$

  - Frequency is the rate of change with respect to time.
  - Change in a short span of time means high frequency
  - If a signal does not change at all, its frequency is zero.
  - If a signal changes instantaneously, its frequency is infinite

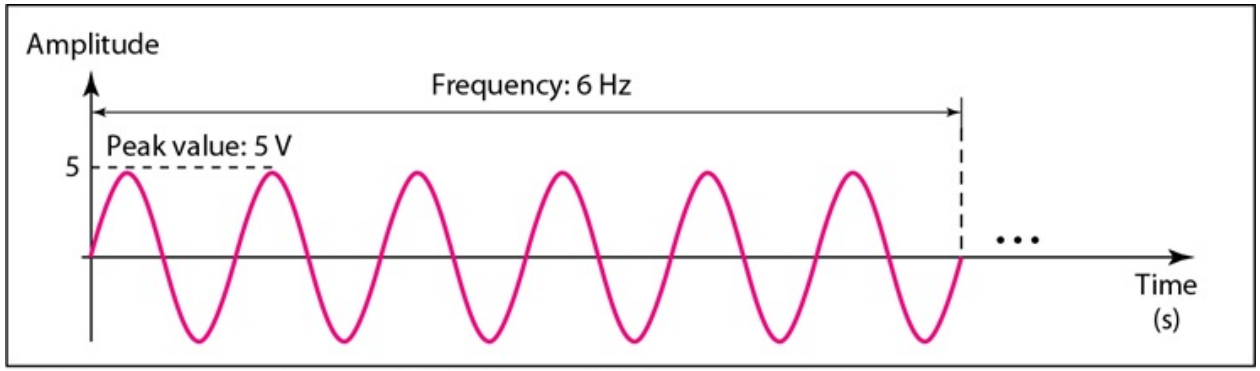
1. **The power we use at home has a frequency of 60 Hz. What will be period of this sine wave.**
2. **Express a period of 100 ms in microseconds.**
3. **The period of a signal is 100 ms. What is its frequency in kilohertz?**

Wavelength

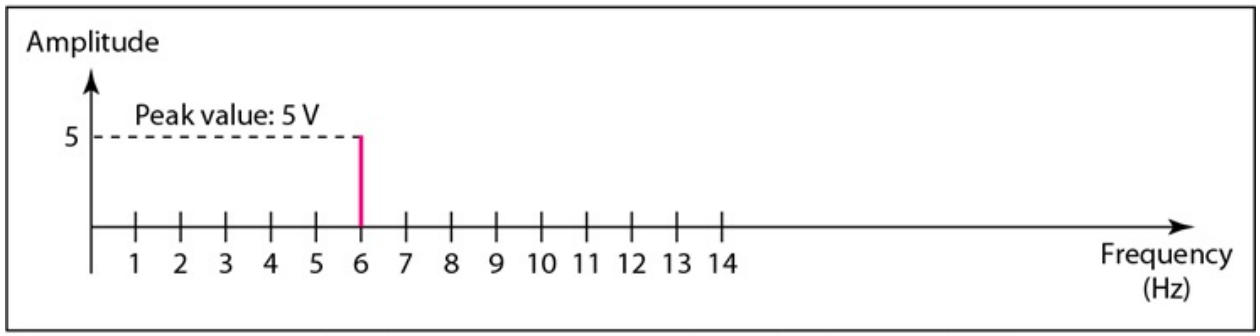
- Wavelength is another characteristic of a signal traveling through a transmission medium.
- Wavelength is the distance a simple signal can travel in one period
  $Wavelength = propagation\ speed\ x\ period = \frac{propogation\ speed}{frequency}$
- The propagation speed of electromagnetic signals depends on the medium and on the frequency of the signal

Time and Frequency Domains

- The time-domain plot shows changes in signal amplitude with respect to time
- A frequency-domain plot is concerned with only the peak value and the frequency



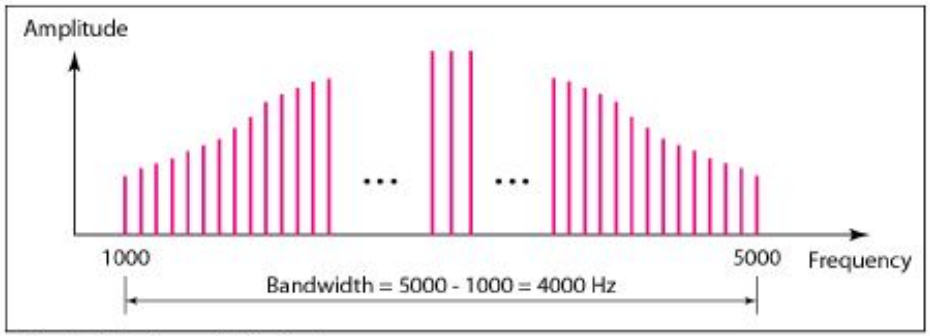
a. A sine wave in the time domain (peak value: 5 V, frequency: 6 Hz)



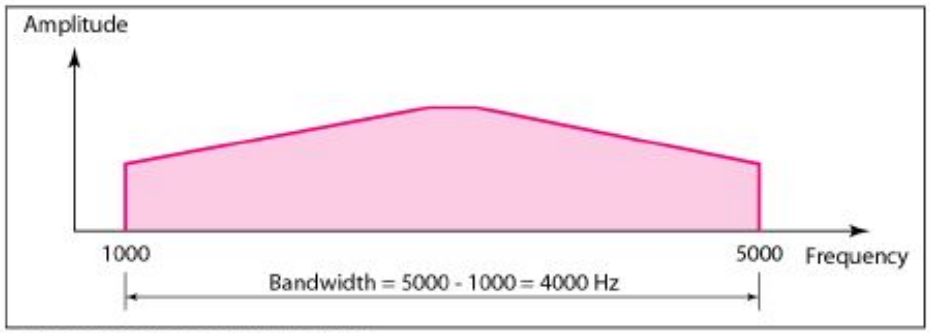
b. The same sine wave in the frequency domain (peak value: 5 V, frequency: 6 Hz)

Bandwidth

- The range of frequencies contained in a composite signal is its bandwidth.
- The bandwidth of a composite signal is the difference between the highest and the lowest frequencies contained in that signal.
- Bandwidth for composite periodic and non periodic signal has finite and infinite frequencies respectively.



a. Bandwidth of a periodic signal



b. Bandwidth of a nonperiodic signal

Questions on Bandwidth Calculation

1. **A periodic signal has a bandwidth of 20 Hz. The highest frequency is 60 Hz. What is the lowest frequency?**
2. **If a periodic signal is decomposed into five sine waves with frequencies of 100, 300, 500, 700, and 900 Hz, what is its bandwidth?**

Thank You