Chapter #1: Signals and Amplifiers

from **Microelectronic Circuits** Text
by Sedra and Smith
Oxford Publishing

Tools Needed for class

- Ohm’s Law
- KVL
- KCL
- Thevenin-Norton equivalency
- Resistance in parallel
- Resistances in series

Introduction

- **IN THIS CHAPTER YOU WILL LEARN…**
  - That electronic circuits process signals, and thus understanding electrical signals is essential to appreciating the material in this book.
  - The Thevenin and Norton representations of signal sources.
  - The representation of a signal as sum of sine waves.
  - The analog and digital representations of a signal.

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Introduction

- **IN THIS CHAPTER YOU WILL LEARN…**
  - The most basic and pervasive signal-processing function: signal amplification, and correspondingly, the signal amplifier.
  - How amplifiers are characterized (modeled) as circuit building blocks independent of their internal circuitry.
  - How the frequency response of an amplifier is measured, and how it is calculated, especially in the simple but common case of a single-time-constant (STC) type response.

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1.1. Signals

- **signal** – contains information
  - e.g. voice of radio announcer reading the news
- **process** – an operation which allows an observer to understand this information from a signal
  - generally done electrically
- **transducer** – device which converts signal from non-electrical to electrical form
  - e.g. microphone (sound to electrical)

1.1: **Signals**

- **Q:** How are signals represented?
  - **A: thevenin form** – voltage source $\mathbf{v}_s(t)$ with series resistance R_S
    - preferable when R_S is low
  - **A: norton form** – current source $\mathbf{i}_s(t)$ with parallel resistance R_S
    - preferable when R_S is high

1.1. **Signals**

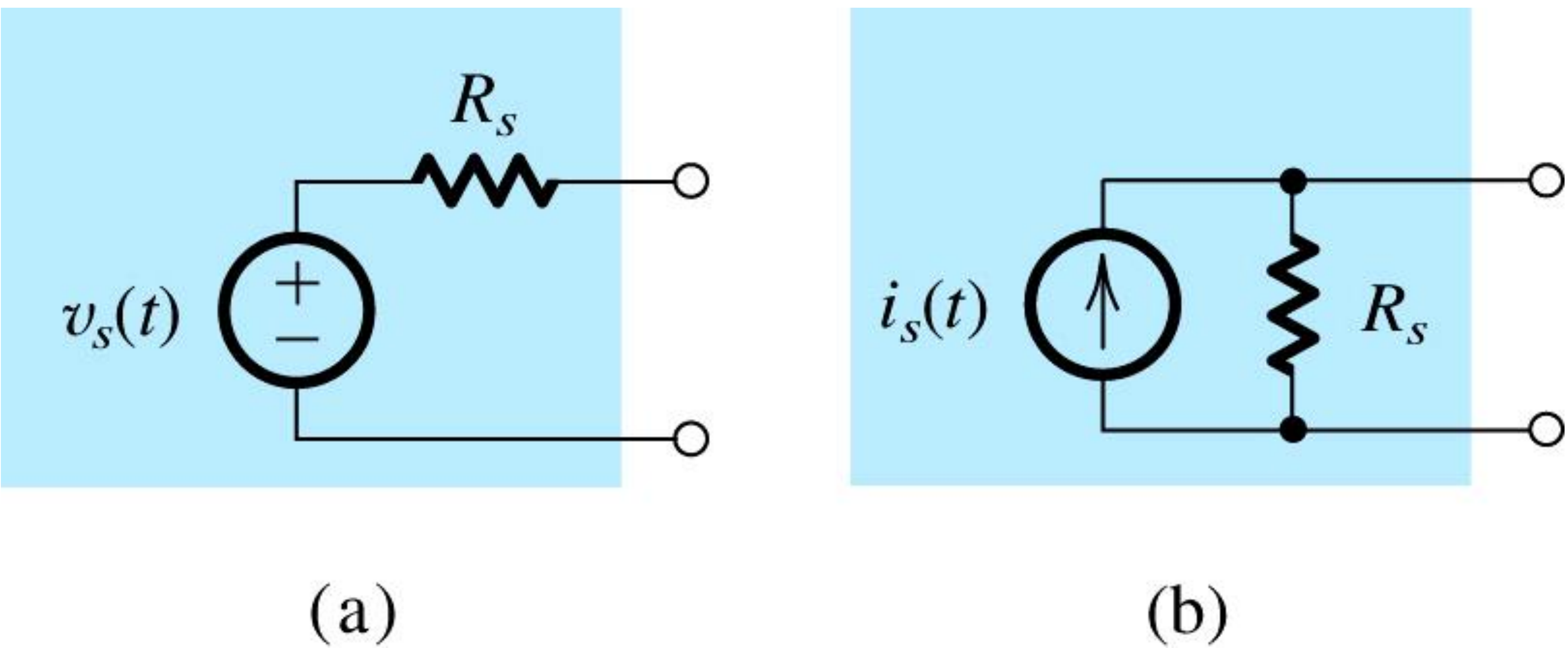

Figure 1.1: Two alternative representations of a signal source: **(a)** the Thévenin form; **(b)** the Norton form.

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1.2. **Frequency Spectrum of Signals**

- **frequency spectrum** – defines the a time-domain signal in terms of the strength of harmonic components
  - **Q:** What is a Fourier Series?
    - **A:** An expression of a periodic function as the sum of an infinite number of sinusoids whose frequencies are harmonically related

What is a Fourier Series?

- **decomposition** – of a periodic function into the (possibly infinite) sum of simpler oscillating functions

Fourier Series Representation of $\mathbf{f}(x)$

$$\overbrace{\mathbf{f}(x) = \frac{a_0}{2} + \underbrace{\sum_{k=1}^{\infty}\left[a_k \cos(kx) + b_k \sin(kx)\right]}}$$

$$a_k = \frac{1}{\pi}\int_{-\pi}^{\pi} \mathbf{f}(x)\cos(kx)\,dx,\ n \geq 0$$

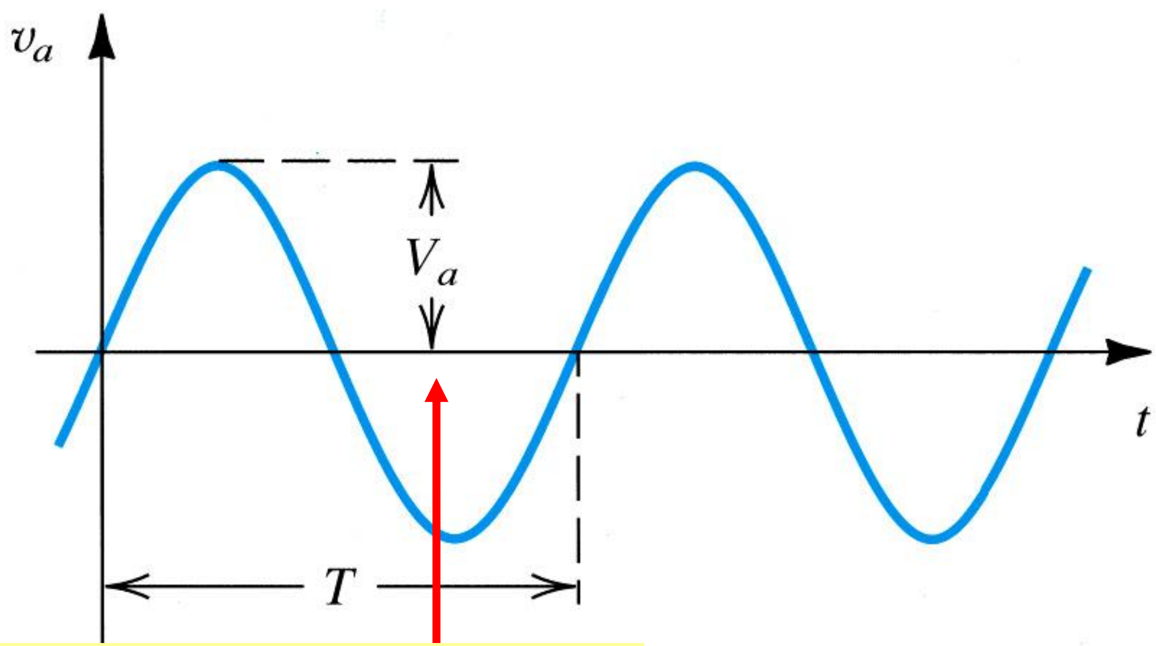
$$b_k = \frac{1}{\pi}\int_{-\pi}^{\pi} \mathbf{f}(x)\sin(kx)\,dx,\ n \geq 1$$

1.2. **Frequency Spectrum of Signals**

- Examine the sinusoidal wave below…

$$\underbrace{\mathbf{v}_a(t) = V_a \sin(\omega t + \theta)}$$

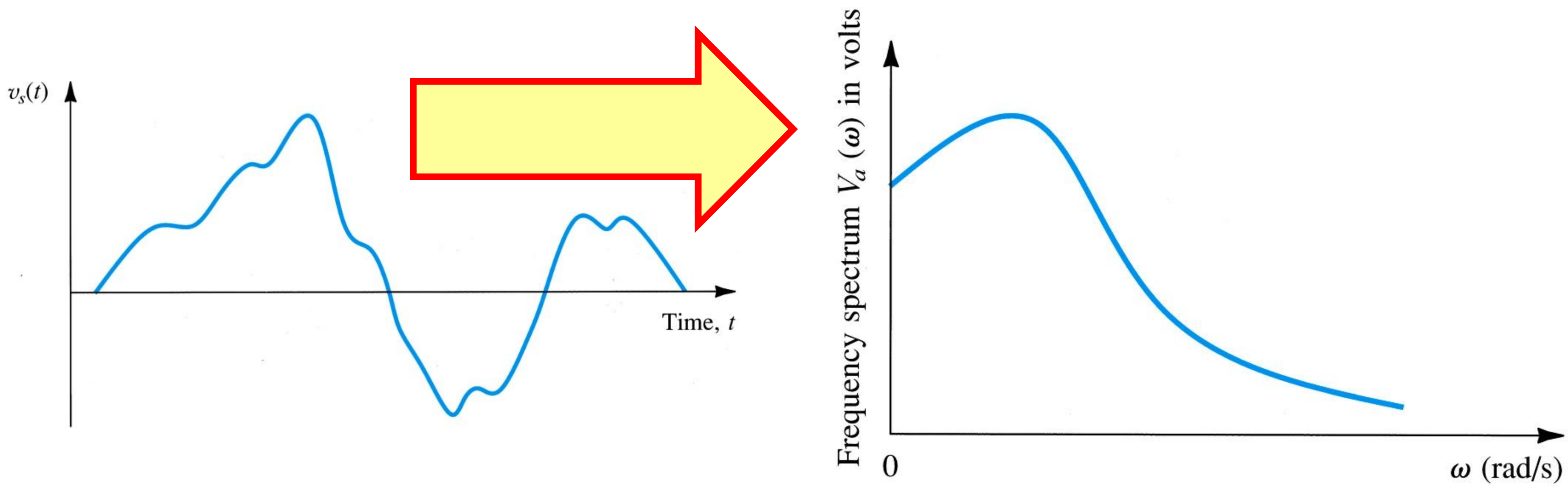
V_a = amplitude in volts
ω = angular frequency in rad/sec
θ = phase shift in rad
t = time in sec



root mean square magnitude =
sine wave amplitude / square root of two

1.2. **Frequency Spectrum of Signals**

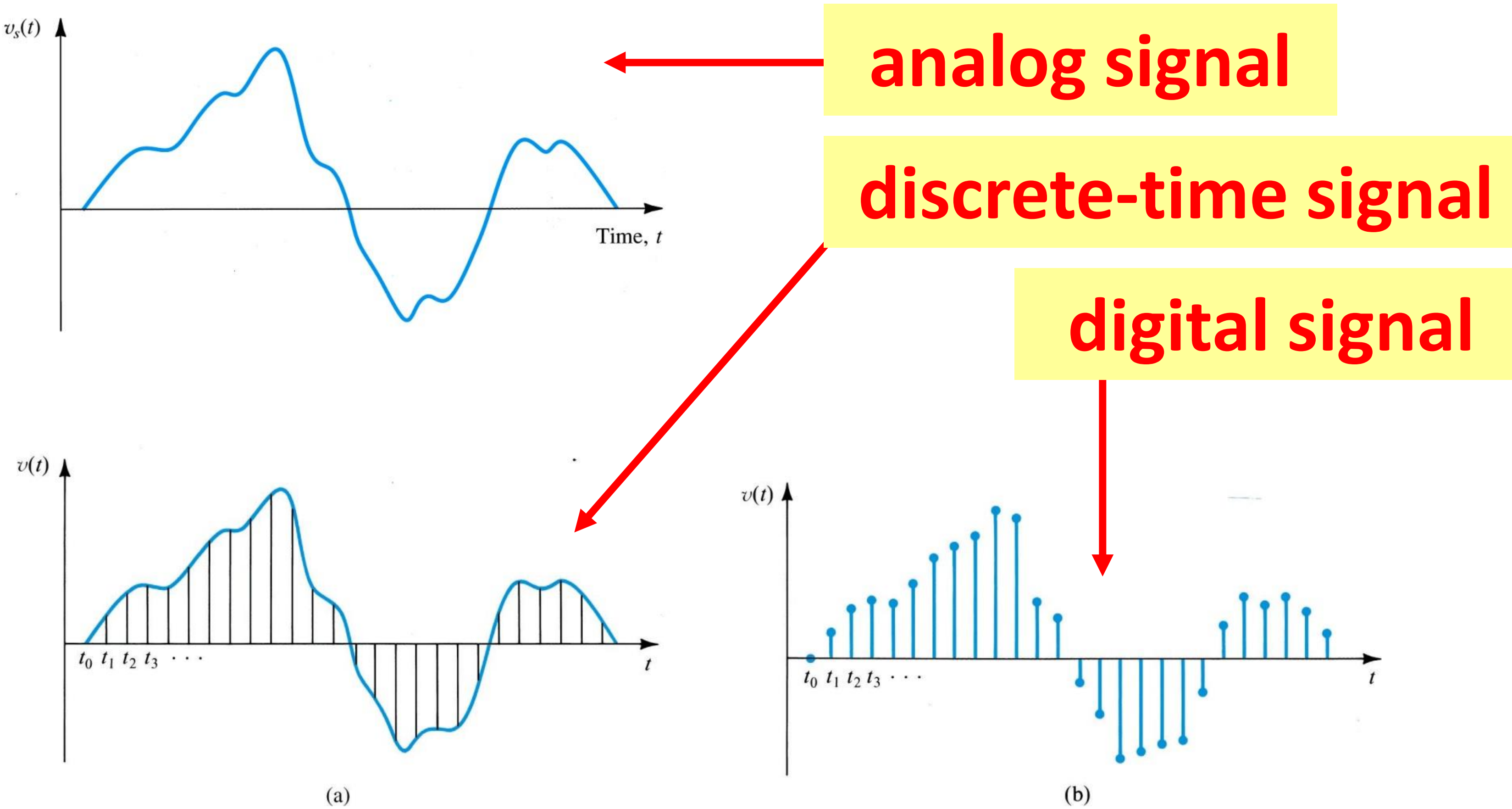
- **Q:** Can the Fourier Transform be applied to a non-periodic function of time?
  - **A:** Yes, however (as opposed to a discrete frequency spectrum) it will yield a continuous…



1.3. **Analog and Digital Signals**

- **analog signal** – is continuous with respect to both value and time
- **discrete-time signal** – is continuous with respect to value but sampled at discrete points in time
- **digital signal** – is quantized (applied to values) as well as sampled at discrete points in time

1.3. **Analog and Digital Signals**



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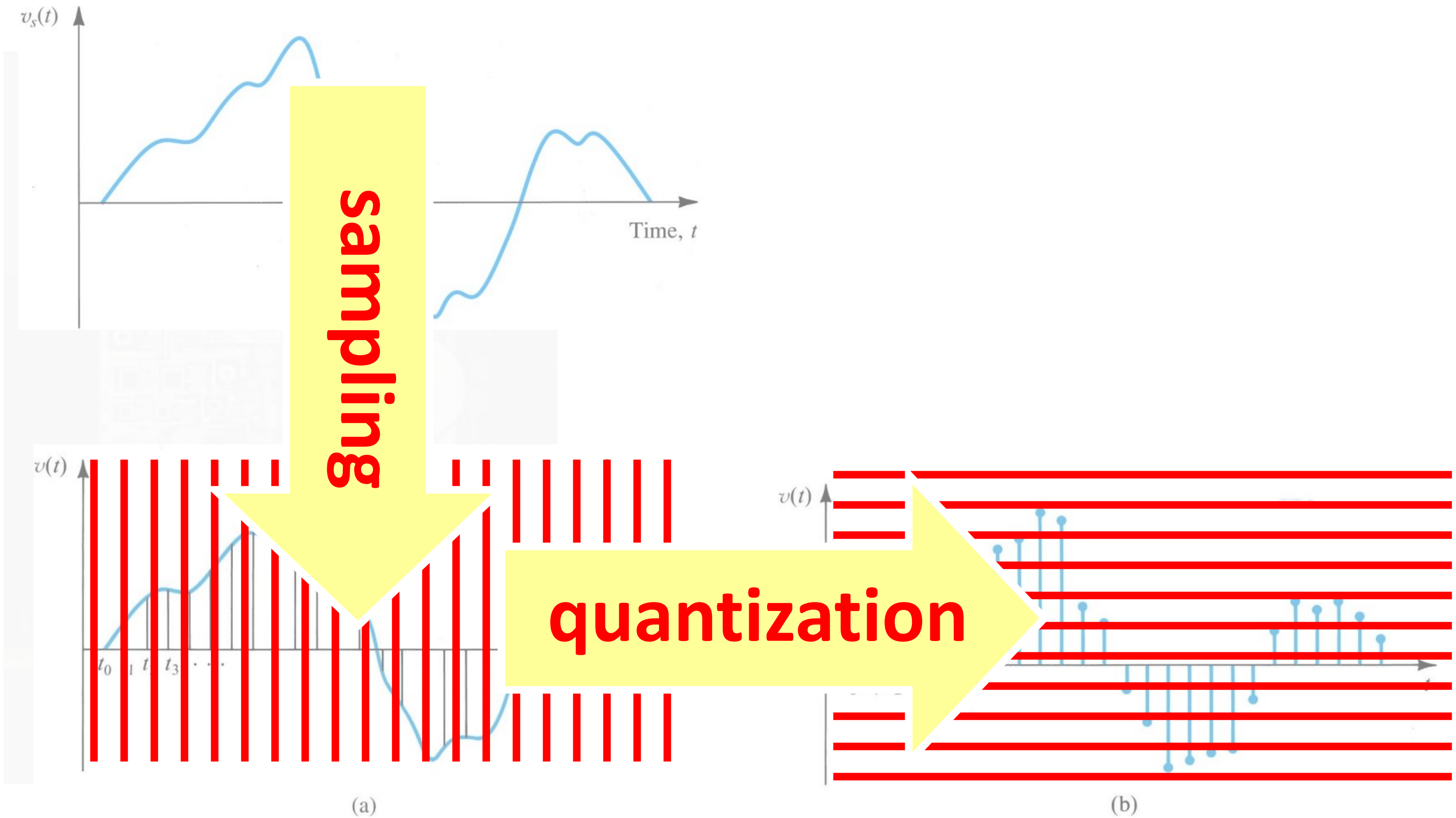
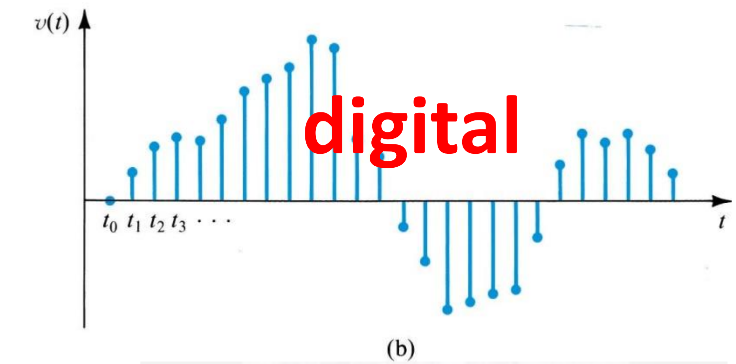
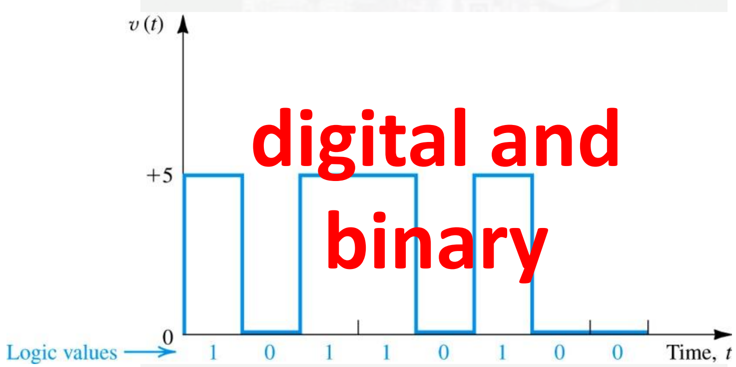
1.3. **Analog and Digital Signals**



1.3. **Analog and Digital Signals**





- **Q:** Are digital and binary synonymous?
  - **A:** No. The binary number system ($base_2$) is one way to represent digital signals.

$$\overbrace{y = b_0 2^0 + b_1 2^1 + b_2 2^2 + \ldots}^{\text{base 10} \leftarrow \text{base 2}}$$

LSB

$$\ldots + b_3 2^3 + \ldots b_{n-1} 2^{n-1}$$

MSB