ShanghaiTech University

EE 115B: Digital Circuits

Fall 2022

Lecture 1

Hengzhao Yang
September 6, 2022

EE115 Analog and *Digital Circuits*

Topic 1: Introduction to Digital Fundamentals

Prof. Yajun Ha

ShanghaiTech University
Shanghai, China

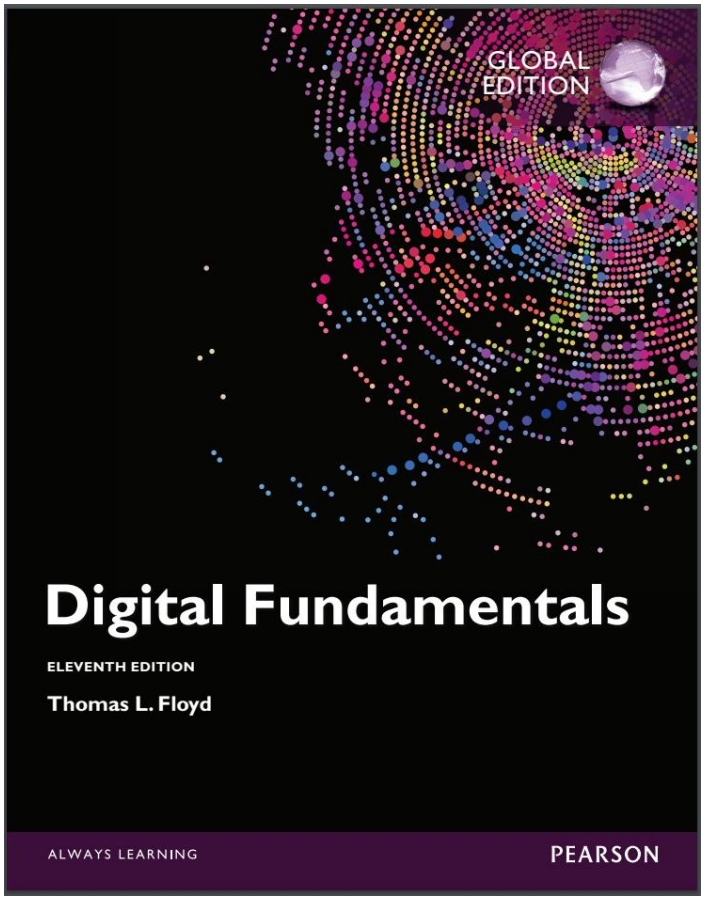
上海科技大学
ShanghaiTech University

Textbook For This Course

Thomas L. Floyd,

Digital Fundamentals,

- International Edition, Year: 2015, ISBN 10: 1-292-07598-8, Pearson Education Limited.
- Please focus on Chapters 1-7.
- Widely used textbook on the digital fundamentals related courses.

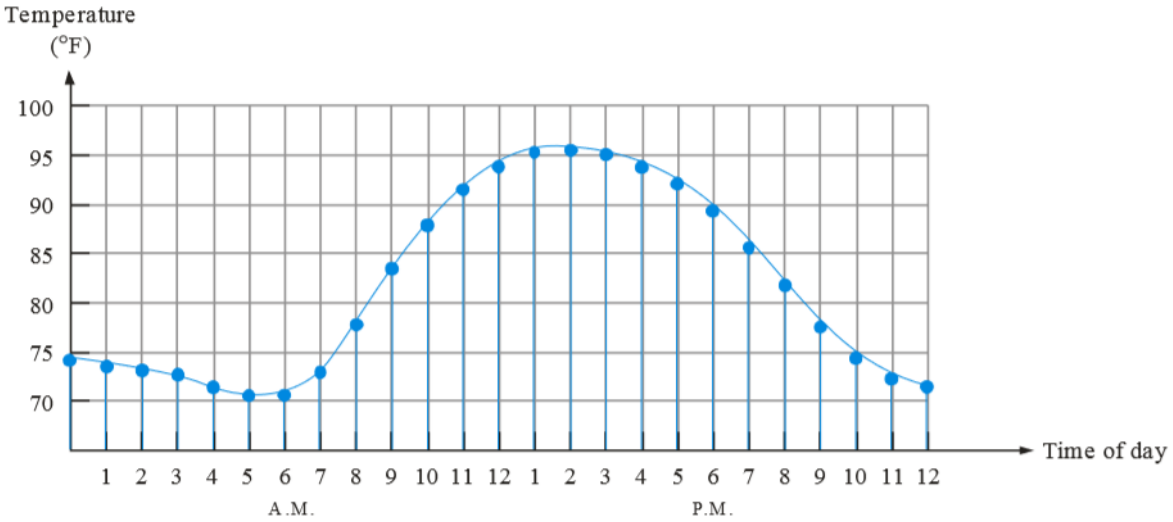


Introduction to Digital Fundamentals

- ☛ Digital and Analog Quantities
- Binary Digits, Logic Levels and Digital Waveforms
- Basic Logic Functions
- Combinational and Sequential Logic Functions
- Programmable Logic Devices
- Fixed-Function Logic Devices
- Test and Measurement Instruments

Analog Quantities

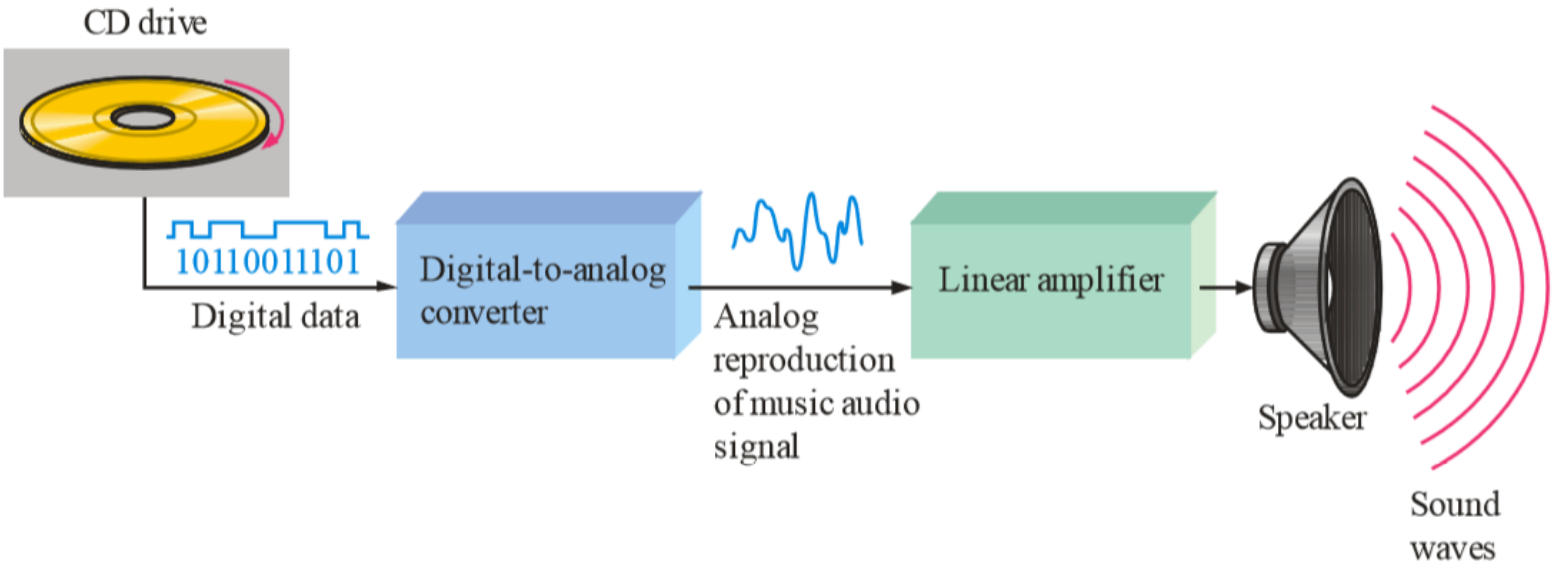
Most natural quantities that we see are **analog** and vary continuously. Analog systems can generally handle higher power than digital systems.



Digital systems can process, store, and transmit data more efficiently but can only assign discrete values to each point.

Analog and Digital Systems

Many systems use a mix of analog and digital electronics to take advantage of each technology. A typical CD player accepts digital data from the CD drive and converts it to an analog signal for amplification.



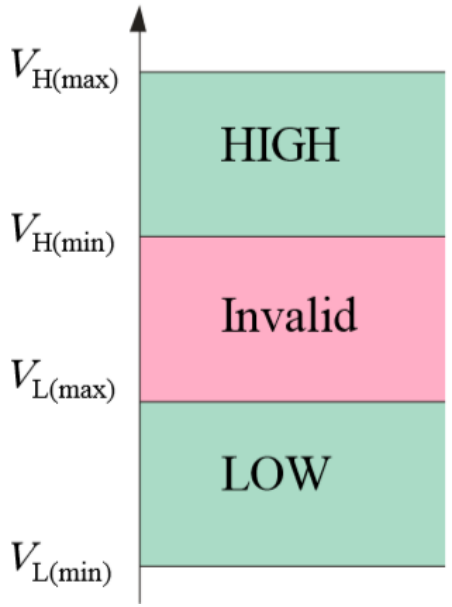
Introduction to Digital Fundamentals

- Digital and Analog Quantities
- ☛ Binary Digits, Logic Levels and Digital Waveforms
- Basic Logic Functions
- Combinational and Sequential Logic Functions
- Programmable Logic Devices
- Fixed-Function Logic Devices
- Test and Measurement Instruments

Binary Digits and Logic Levels

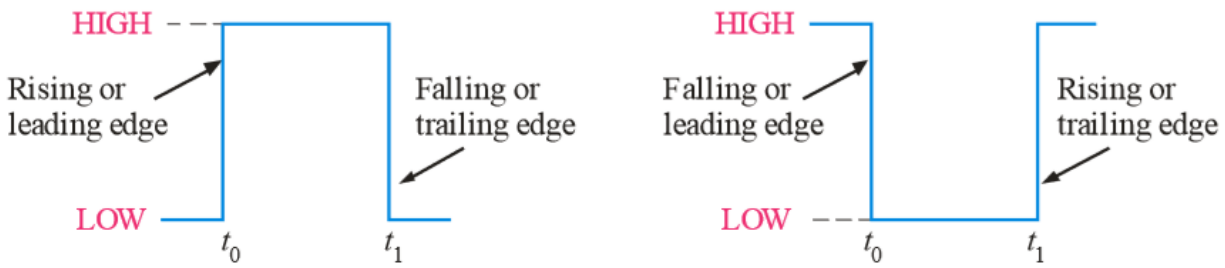
Digital electronics uses circuits that have two states, which are represented by two different voltage levels called HIGH and LOW. The voltages represent numbers in the binary system.

In binary, a single number is called a *bit* (for *b*inary dig*it*). A bit can have the value of either a 0 or a 1, depending on if the voltage is HIGH or LOW.



Digital Waveforms

Digital waveforms change between the LOW and HIGH levels. A positive going pulse is one that goes from a normally LOW logic level to a HIGH level and then back again. Digital waveforms are made up of a series of pulses.

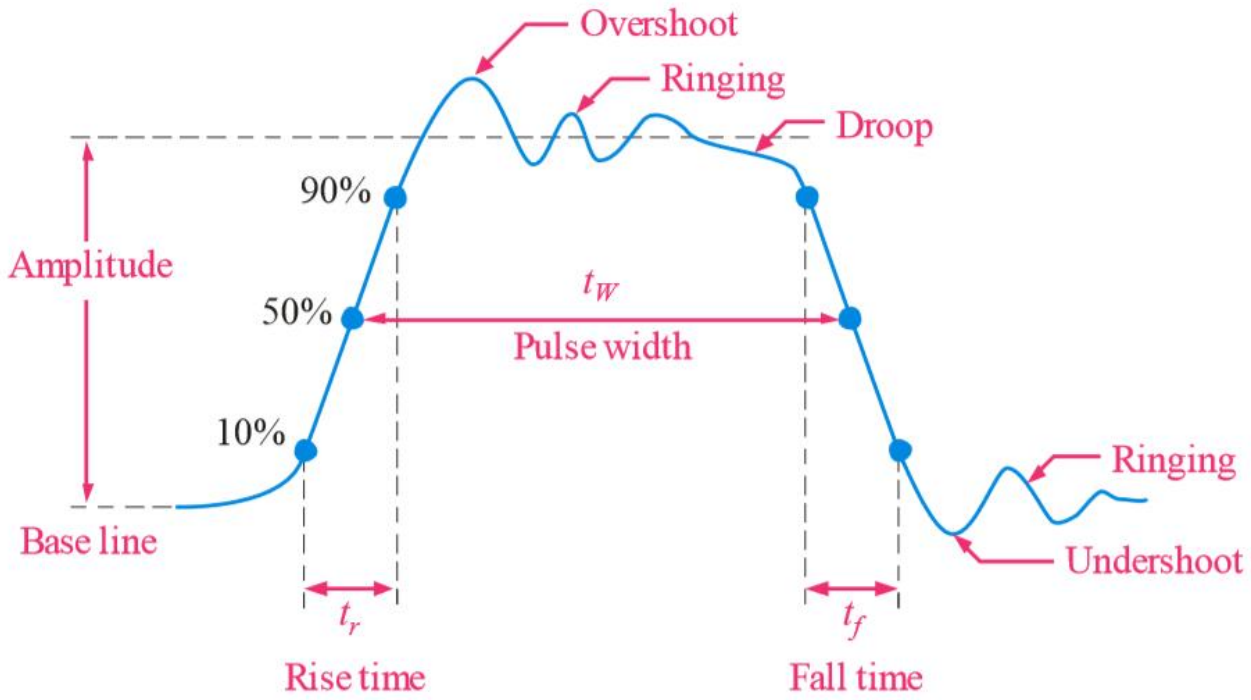


(a) Positive–going pulse

(b) Negative–going pulse

Pulse Definitions

Actual pulses are not ideal but are described by the rise time, fall time, amplitude, and other characteristics.



Periodic Pulse Waveforms

Periodic pulse waveforms are composed of pulses that repeats in a fixed interval called the **period**. The **frequency** is the rate it repeats and is measured in hertz.

$$f = \frac{1}{T} \qquad T = \frac{1}{f}$$

The **clock** is a basic timing signal that is an example of a periodic wave.

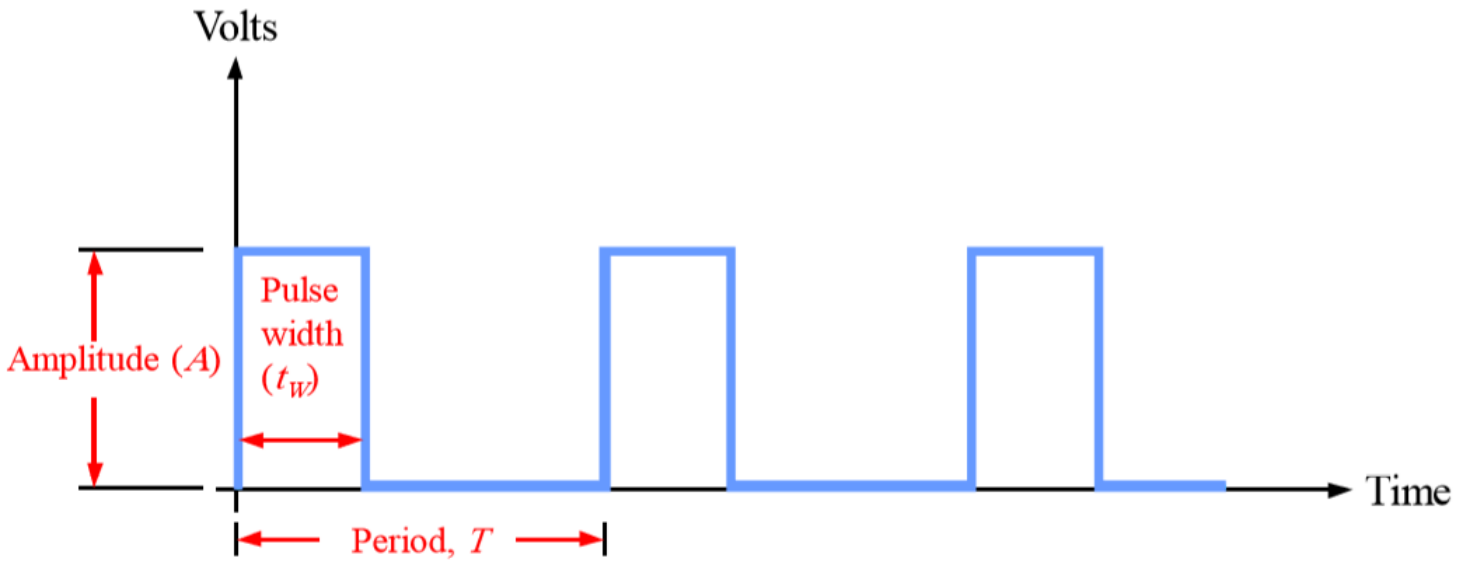
Example What is the period of a repetitive wave if $f = 3.2$ GHz?

Solution

$$T = \frac{1}{f} = \frac{1}{3.2\,\text{GHz}} = 313\ \text{ps}$$

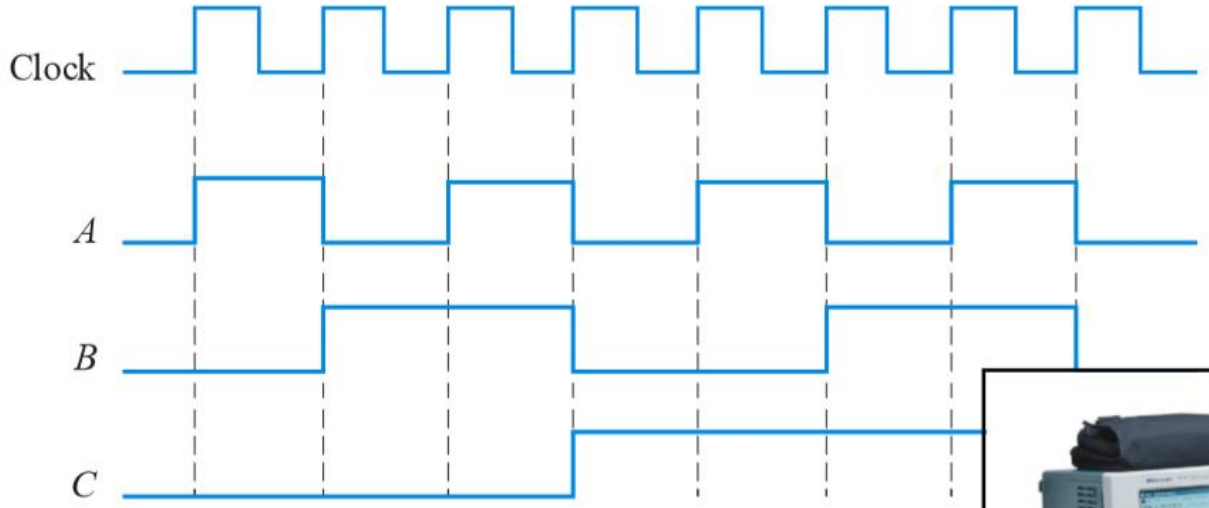
Pulse Definitions

In addition to frequency and period, repetitive pulse waveforms are described by the amplitude (A), pulse width (t_W) and duty cycle. Duty cycle is the ratio of t_W to T.



Timing Diagrams

A timing diagram is used to show the relationship between two or more digital waveforms,



A diagram like this can be observed directly on a logic analyzer.