# Introduction to Communication Systems

## Chapter 7

## Digital Communication Techniques

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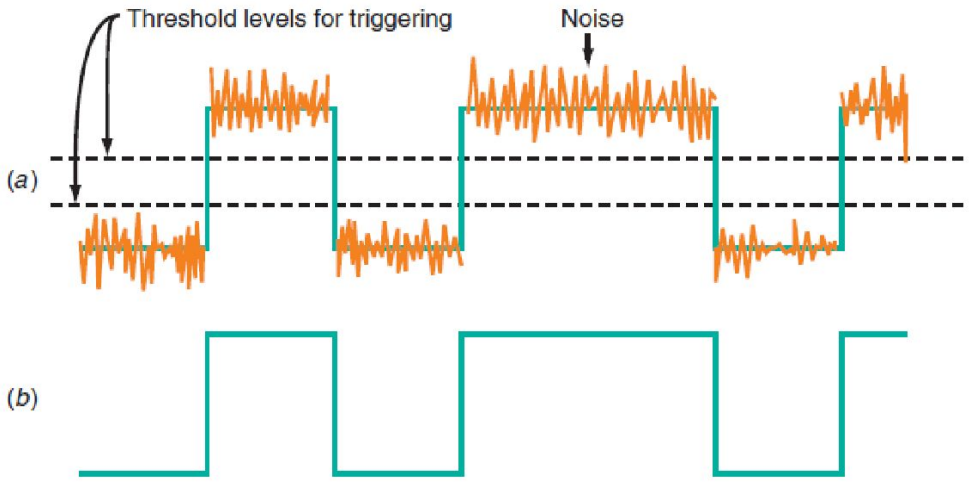
# Text Book

- Principles of Electronic Communication Systems
  - L. E. Frenzel
  - $4^{th}$ edition

# Benefits of Digital Communication

- Noise Immunity
- Error Detection and Correction
- Compatibility with Time-Division Multiplexing
- Digital ICs
- Digital Signal Processing (DSP).

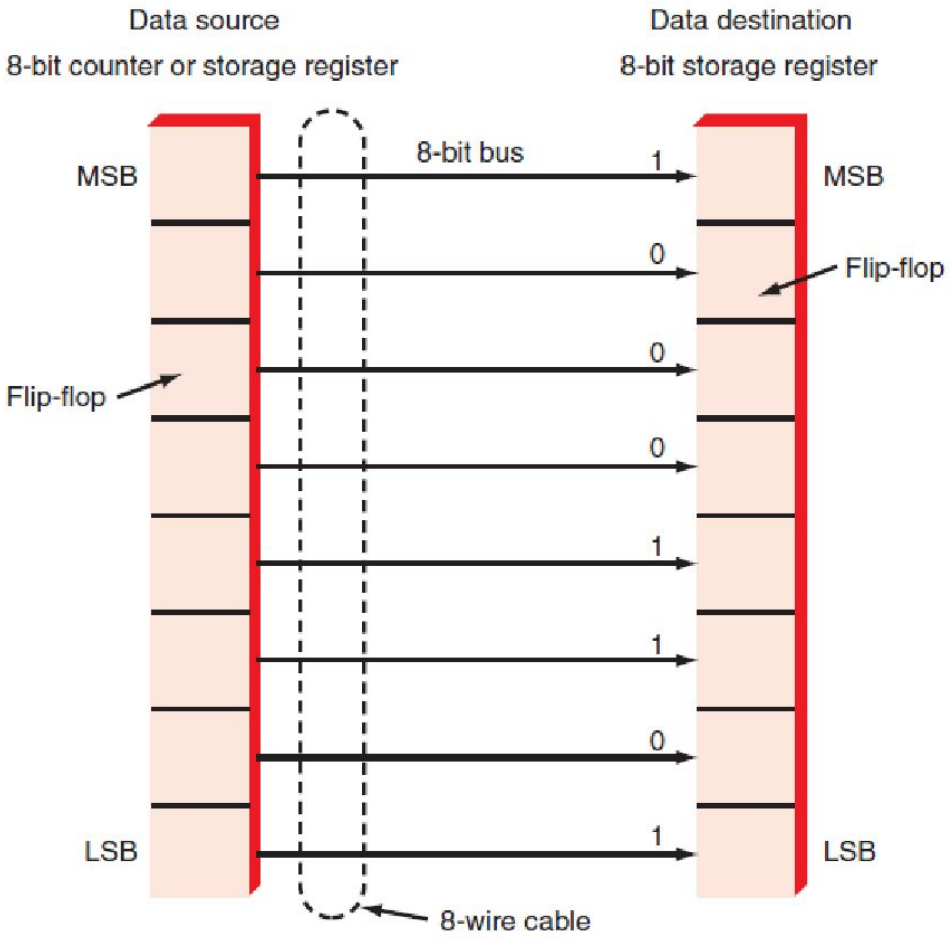
**Figure 7-1** (*a*) Noise on a binary signal. (*b*) Clean binary signal after regeneration.



# Parallel and Serial Transmission

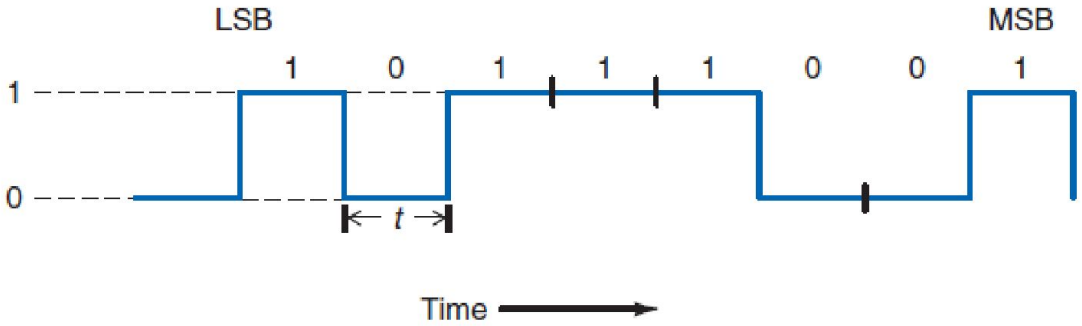
## Parallel Transfer:

Figure 6-2 Parallel data transmission.



# Serial Transfer:

Figure 7-3 Serial data transmission.



# Serial-Parallel Conversion

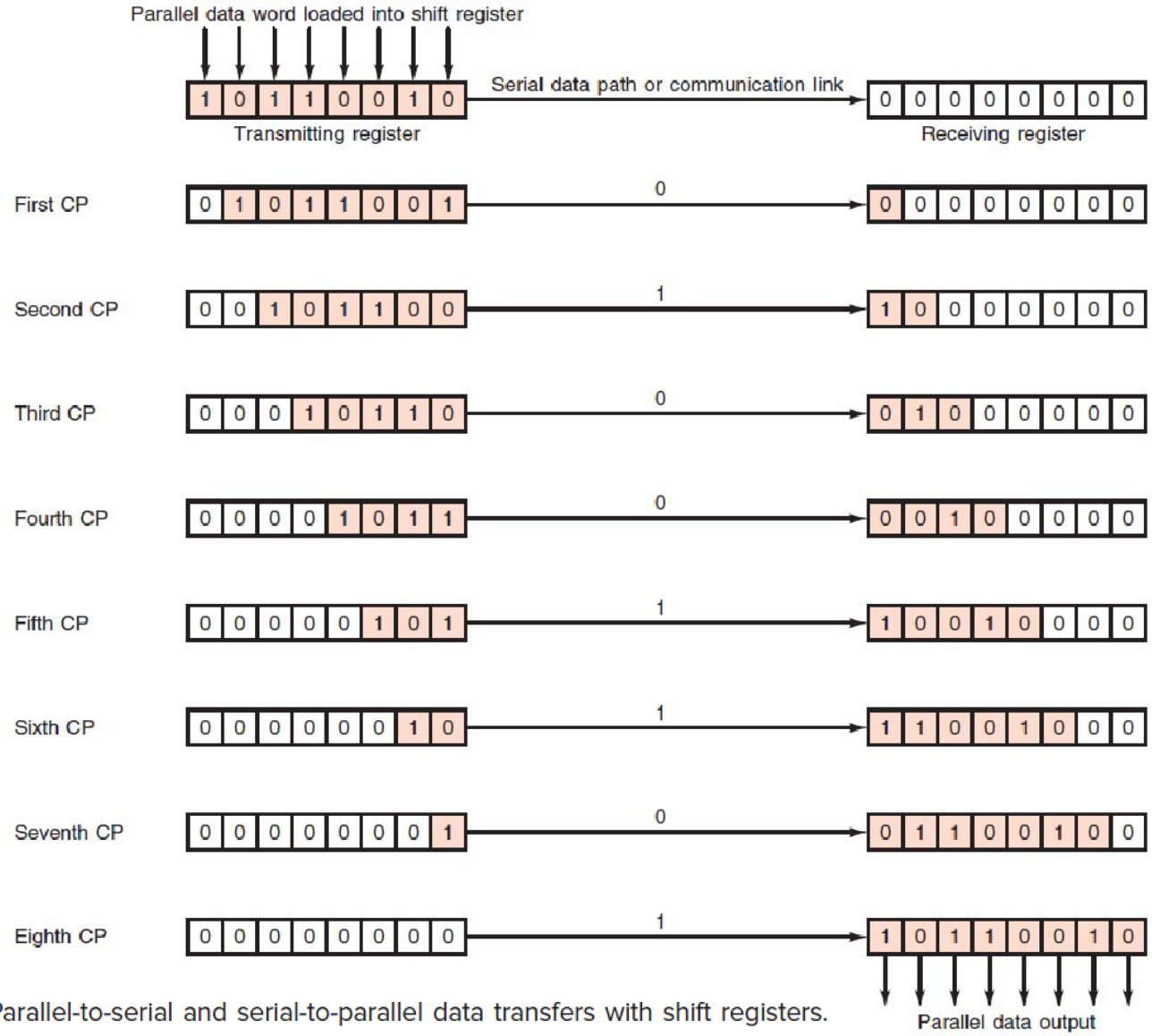



**Figure 7-4** Parallel-to-serial and serial-to-parallel data transfers with shift registers.

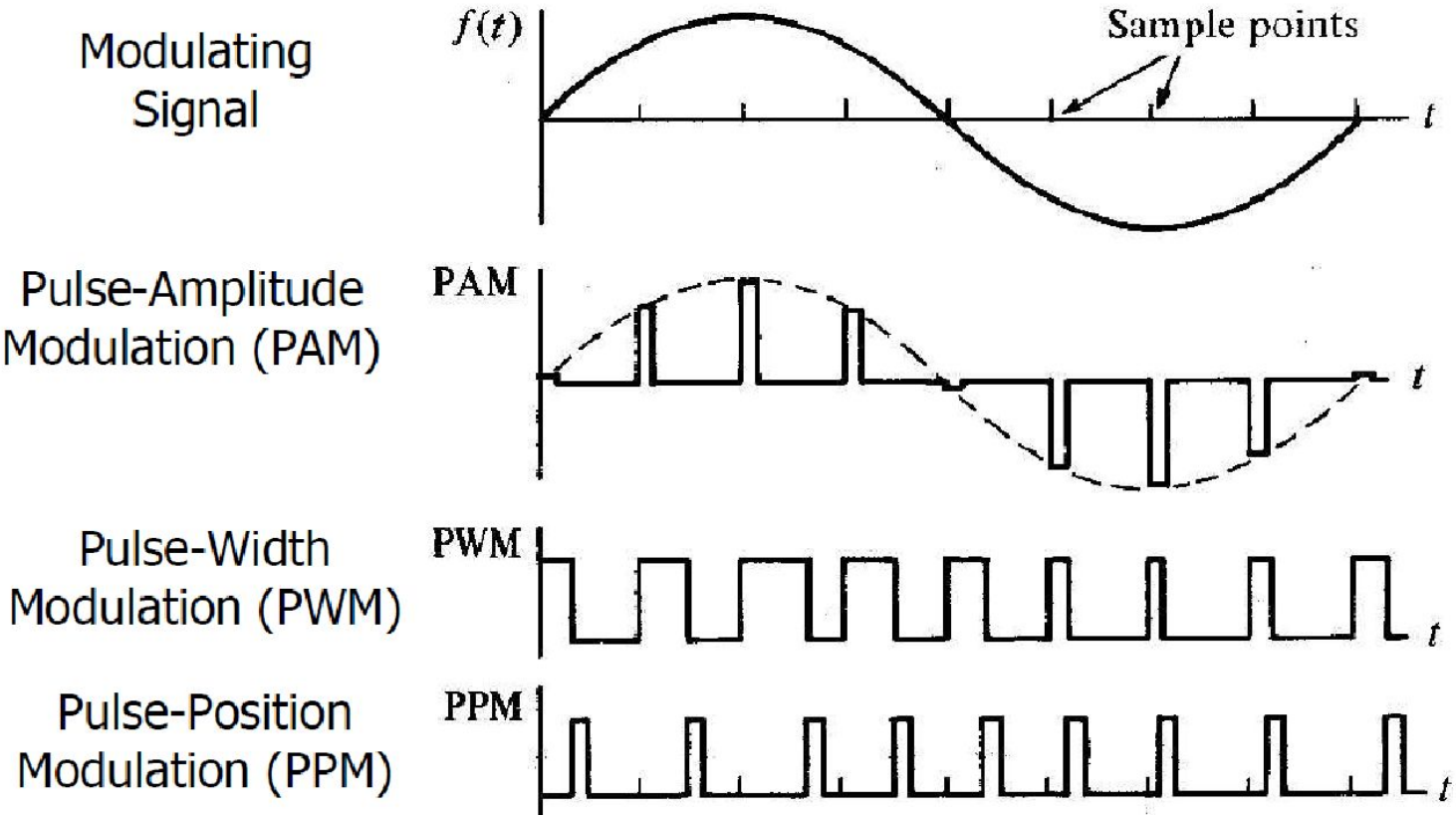
# Pulse Modulation

- *Pulse modulation* is the process of changing a binary pulse signal to represent the information to be transmitted.
- There are four basic forms of pulse modulation:
  - *Pulse-amplitude modulation (PAM),*
  - *pulse-width modulation (PWM),*
  - *pulse-position modulation (PPM),* and
  - *pulse-code modulation (PCM)*.

# PAM, PWM, PPM

- The PAM signal is a series of constant-width pulses whose amplitudes vary in accordance with the analog signal
- The PWM signal is binary in amplitude (has only two levels). The width or duration of the pulses varies according to the amplitude of the analog signal: At low analog voltages, the pulses are narrow; at the higher amplitudes, the pulses get wider.
- In PPM, the pulses change position according to the amplitude of the analog signal.

- Analog pulse modulation (graphic interpretation)



# Pulse code modulation (PCM)

- PCM is a standardized method that is used in the telephone network to change an analog signal to a digital one for transmission through the digital telecommunications network.
- Three steps for PCM
  - Sampling
  - Quantization
  - Encoding
- Nyquist theorem:
  - If the sampling frequency $f_s$ *is higher than two times the highest frequency* component of the analog signal, *W, the original analog signal can ne* completely described by these instantaneous samples alone; that is, $f_s > 2W$.

# PCM

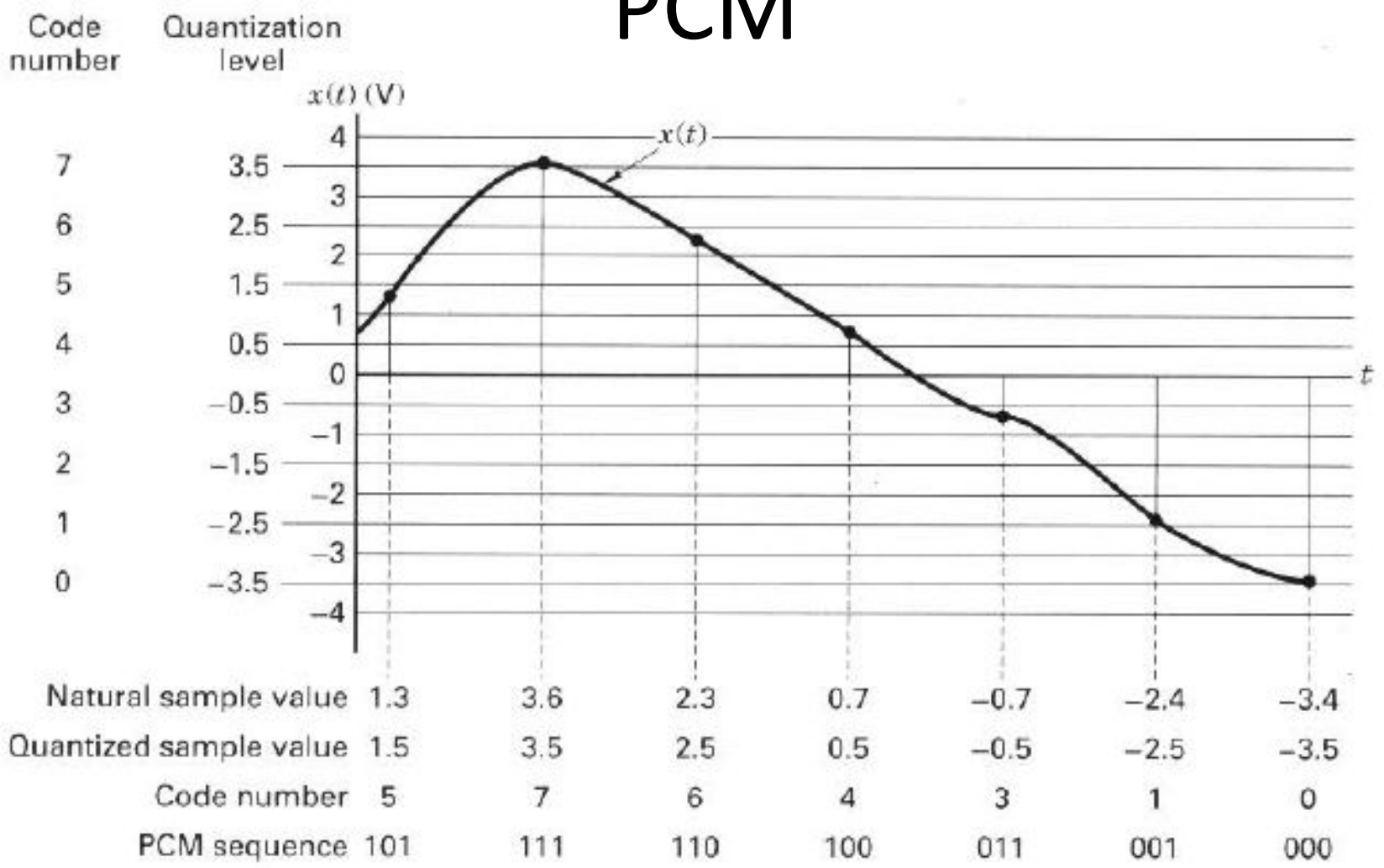



**Figure 2.16** Natural samples, quantized samples, and pulse code modulation. (Reprinted with permission from Taub and Schilling, *Principles of Communications Systems*, McGraw-Hill Book Company, New York, 1971, Fig. 6.5-1, p. 205.)