EE403: Digital Communications

Lecture 1: Introduction

Daewon Seo

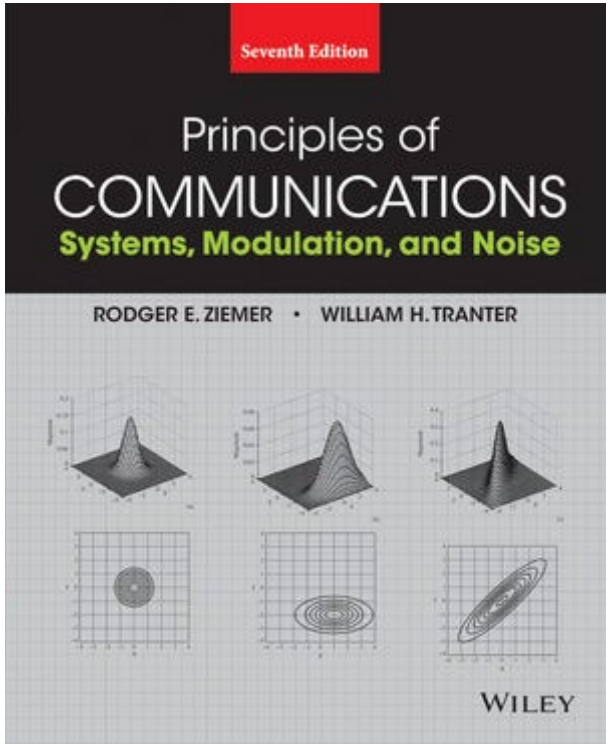
February 28, 2022

Syllabus

- EE403: 디지털 통신 (Digital Communications)
  - 3 credits
- Time/location
  - Mon/Wed 10:30am-11:45am, classroom E3-112 or online
- Instructor
  - Daewon Seo, dwseo@dgist.ac.kr, E3-311, 053-785-6340
- Teaching assistant
  - Minji Cho, pminjiq@dgist.ac.kr, E3-507, 053-785-6351

Syllabus

- Office hour
  - Mon 10:00am-10:30am (just before class), E3-311
  - Or walk-ins anytime are welcome
- Main textbook
  - Ziemer & Tranter, Principles of Communications, 7th Ed.
- Other references
  - Proakis & Salehi, Essentials of Comm. Systems Engr.
  - Haykin & Moher, Communications Systems, 5th Ed.
  - Cover & Thomas, Elements of Information Theory



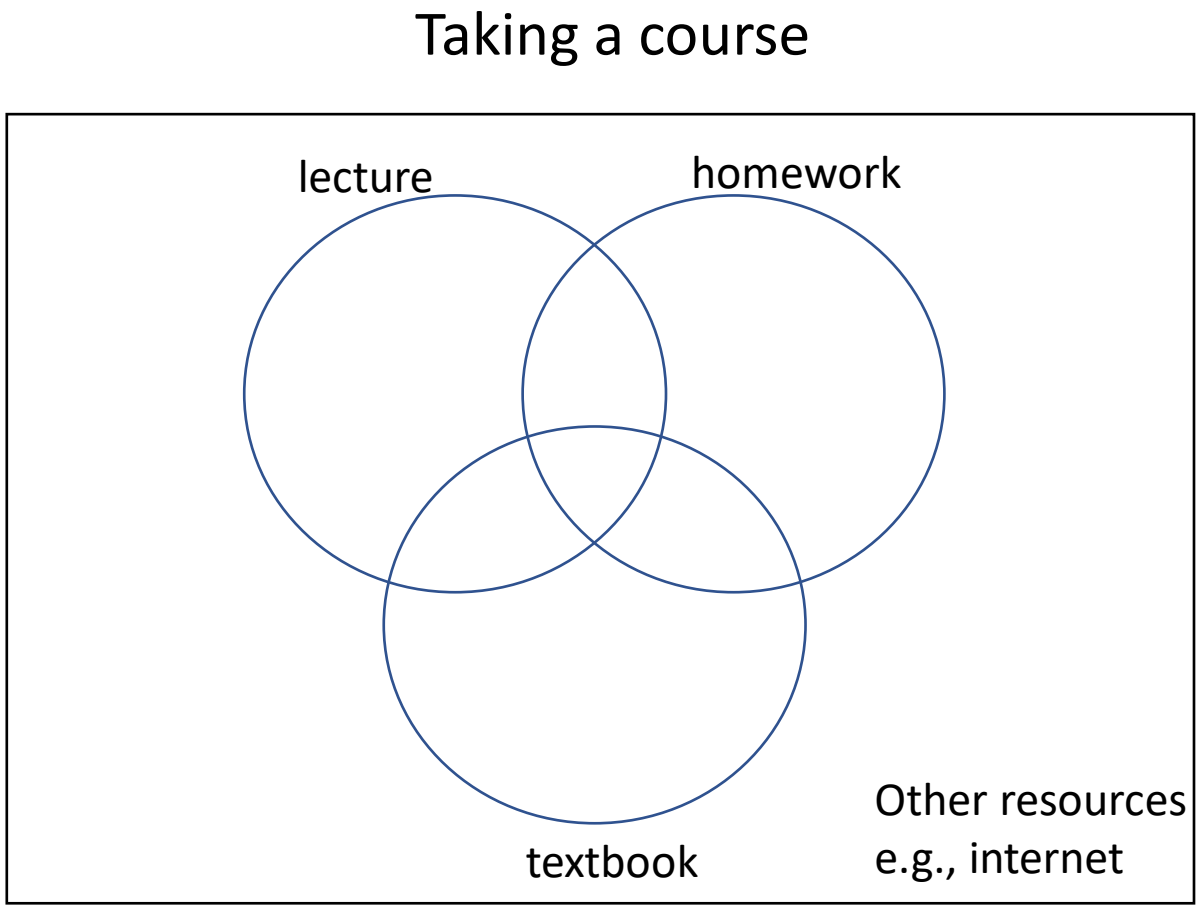
- A very common/popular course having numerous resources on the Internet. Please google and ask prof/TA whenever you have questions!

Syllabus

- Prerequisite
  - EE305: Principles of Communications
  - Signal and Systems, (undergrad) Probability

- Grading policy
  - Attendance & participation 10% (➔ might be quizzes?)
  - Homework 30%
    - There will be $N(\approx 6)$ problem sets, but only the highest $N-1$ sets will be taken into account
    - Discussions/googling are allowed and encouraged, but **please write down your own answer**
    - Homework must be turned in/submitted online by the end of the class when the homework is due
    - **No late homework will be graded**
  - Midterm 30%
  - Final exam 30%

Taking a Course Means…



Syllabus

- Course description
  - Subsequent topics to EE305 (analog), focusing on digital counterparts
  - Basic principles of **digital** communication systems
  - Topics
    - Review of signal & systems, probability theory
    - Baseband digital data transmission
    - RF band modulation for digital data with noise
    - Basics of Information theory

- Course objectives
  - Essential backgrounds on digital communications

- Course tree
  - EE301: Signal and Systems (spring)
  - EE305: Analog communications (fall)
  - **EE403**: (this course) **Digital** Communications (spring)

Target Students

- Who would benefit from taking this class?

- This course is about, of course, communications
  - Wired, Wireless, Wi-Fi, LTE, IoT, …
  - Storage systems

- Communication = transferring/processing information under noise
  - Signal processing: Image, acoustic, statistical signal processing, …

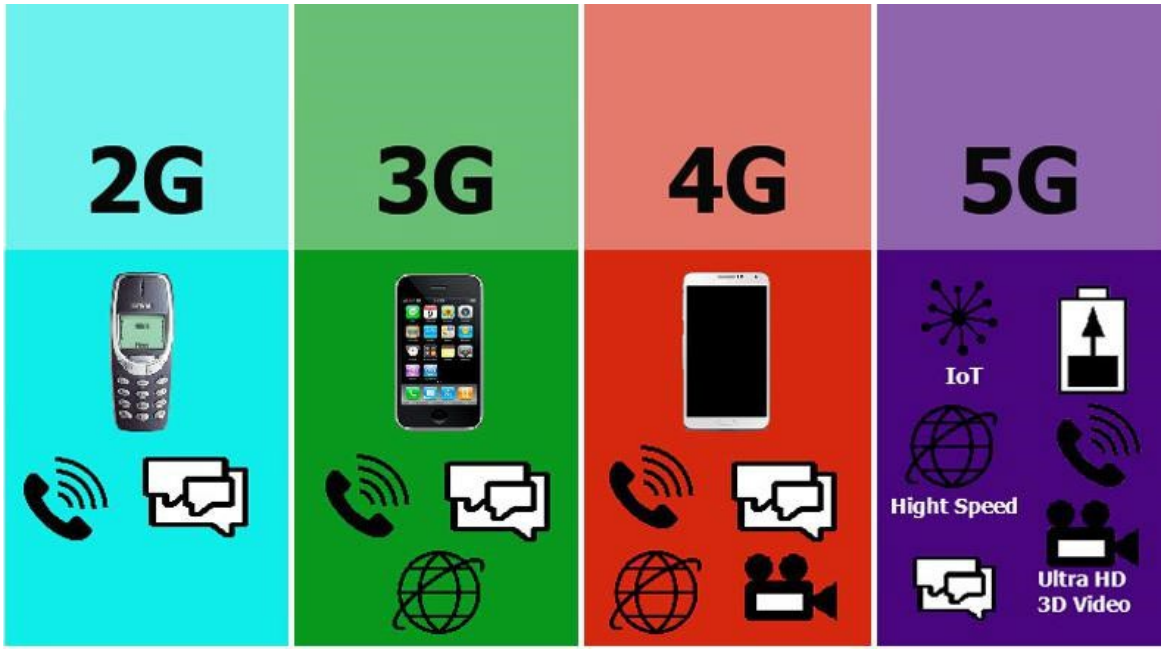
- Machine learning
  - Information-theoretic notions (Chap.12) in ML: entropy, mutual information, …

What is Communication?

- Everything about delivering information

- Examples
  - Verbal communication, broadcast media, …
  - Synapses in neurons
  - Wired and wireless communication systems (LTE, WiFi, …)
  - Storage systems (HDD, SSD, …)
  - Social networks

Some Examples



WiFi™

WiBro

Some Examples

History of Communications

- 1838, (wired) telegraph by Morse
- 1876, (wired) telephone by Bell
- 1897, wireless telegraph by Marconi
- 1910s, AM radio broadcast
- 1933, FM patent by Armstrong

EE305

- WWII, radar systems
- 1948, A seminal paper, "A math. theory of comm." by C. Shannon
- 1969, first Internet
- 1979, first cellular telephone network
- 1988, ADSL
- 90s, 2G
- 00s, 3G, WiFI

EE403 + more

Complexity of Technology

- AM, FM (analog)
  - Average people can understand
- CDMA & OFDM (digital-commercial)
  - Most Ph.D.'s in comm. field may have rough ideas
- More advanced technologies
  - Only a handful of experts worldwide can understand

Communication Systems

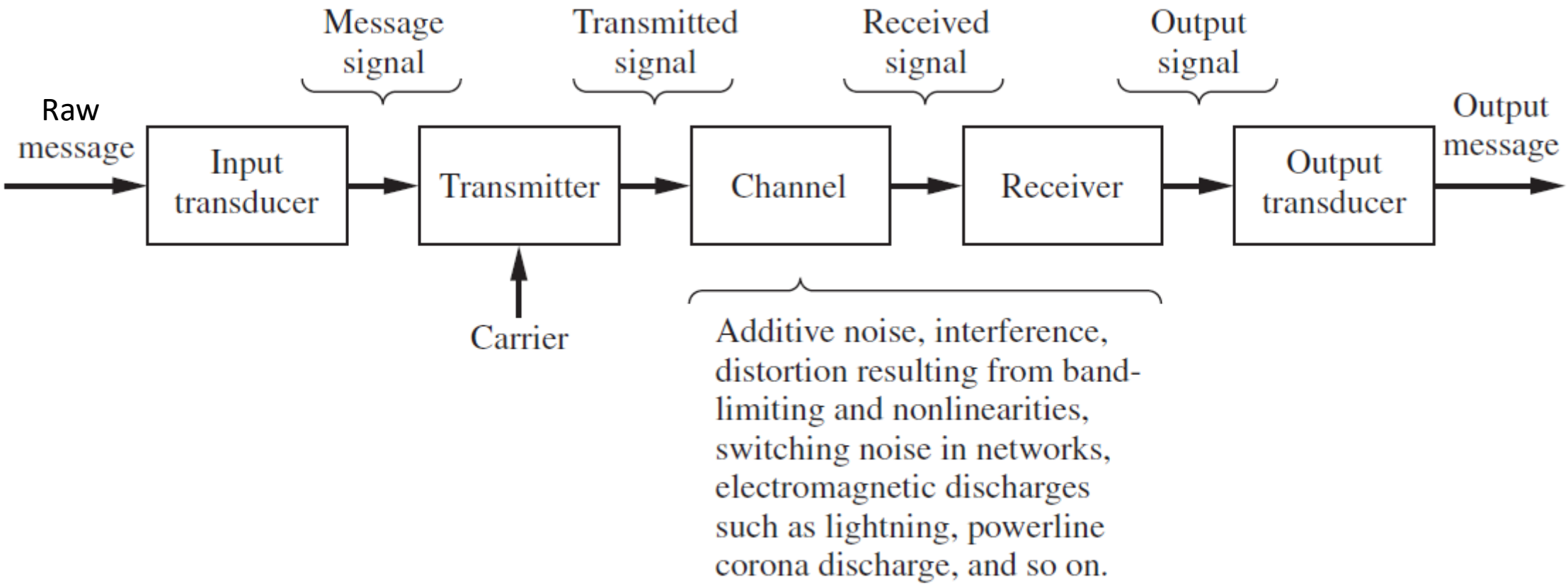


Figure 1.1
The Block Diagram of a Communication System.

Input Transducer & Transmitter

- Input transducer
  - Changes the type of signals
  - Microphone: voice (mech. wave) ➔ current/voltage
  - Temperature sensor: temperature ➔ current/voltage
  - Photodiode: light intensity ➔ current/voltage

- Transmitter
  - Converts the input signal into another signal to be radiated via antennas
  - Modulation with carrier signals
    - AM (Amplitude Modulation)
    - FM (Frequency Modulation)
    - PM (Phase Modulation)
    - PSK, FSK, (x-shift keying)…

Channel

- A physical medium that is used to deliver signals from the transmitter and the receiver

- Examples
  - Wires: signals are sent via electrical signals (current)
  - Free space/air: via EM wave
  - Optical fiber: via light
  - Underwater: via acoustic signals
  - Data storage: via magnetic signal
  - Body: via molecules/cells

- **Noise** in the channel degrades the transmitted signal

Receiver

- Recovers the message signal from the received signal

- Functions at the receiver
  - Synchronization
  - Channel estimation
  - Demodulation / detection
  - Signal filtering

Challenges: Uncertainty

- Due to noise, the signal sent is distorted
  - A common form of degradation: additive noise $y(t) = h(t)x(t) + n(t)$
- Internal noise
  - Thermal noise, shot noise, …
- External noise
  - Man-made, atmosphere, other users' interference, …
- Extraterrestrial noise
  - Solar and cosmic noise
- Channel uncertainty

Simplest Digital Communication

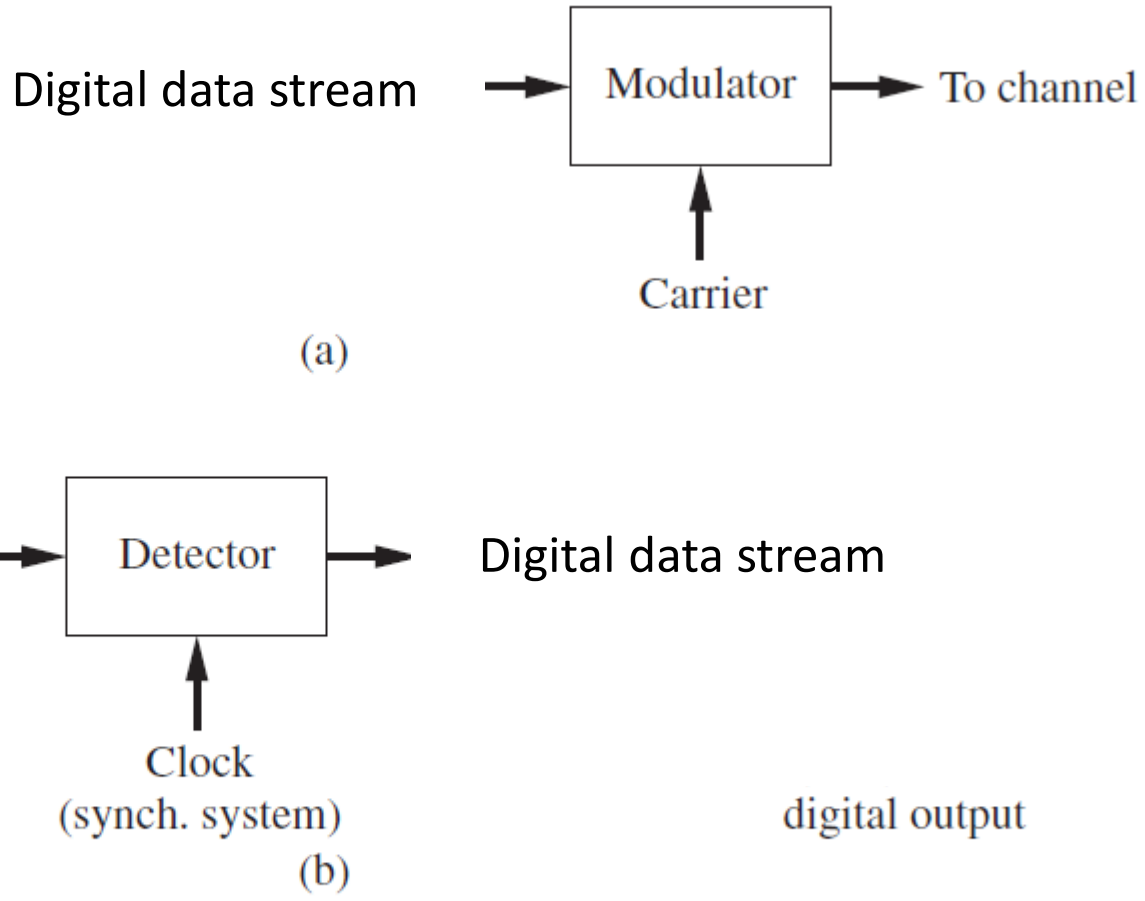


Figure 9.1
Block diagram of a digital data transmission system. (a) Transmitter. (b) Receiver.

Digital Communication

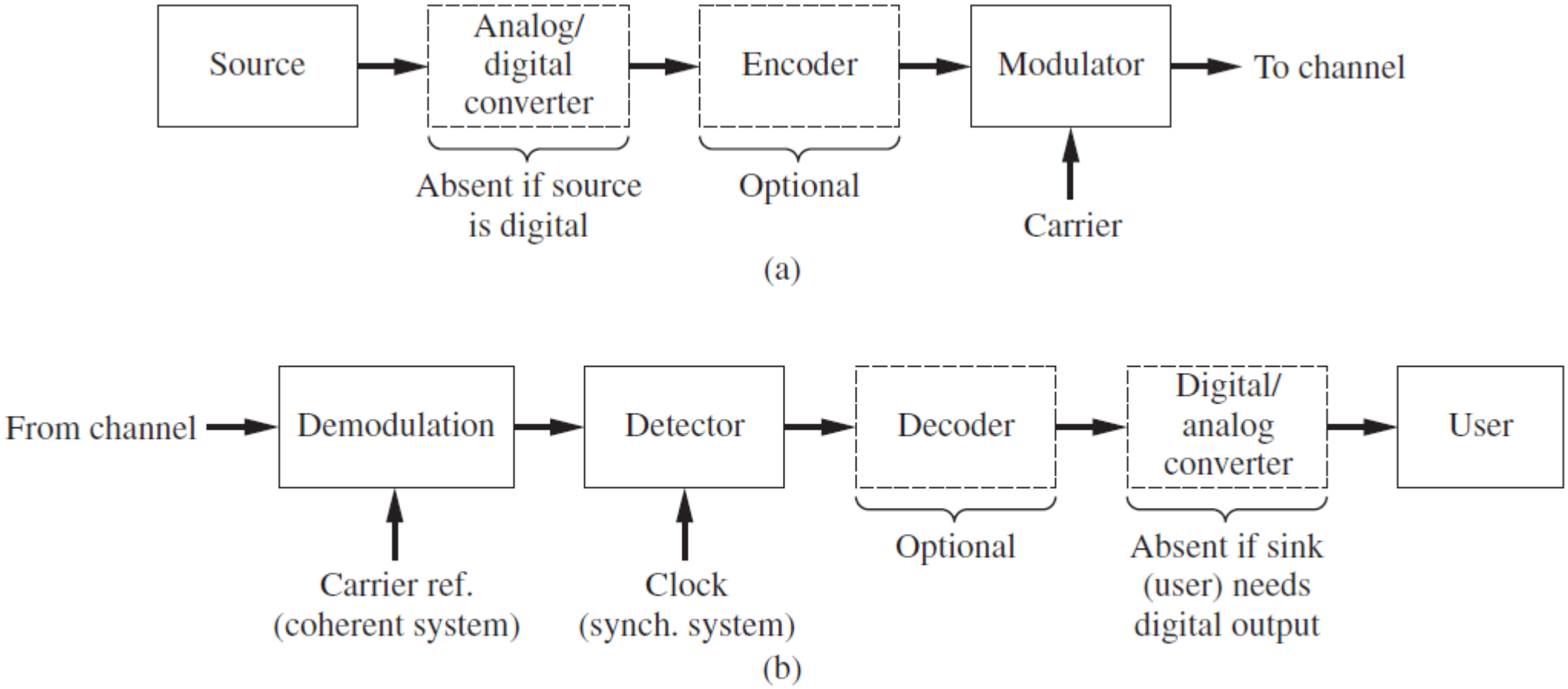


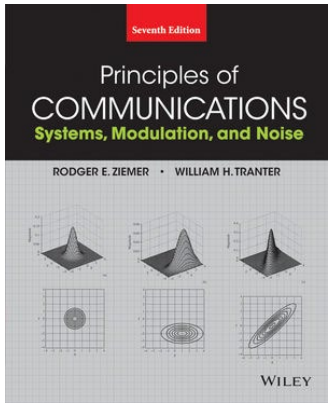
Figure 9.1
Block diagram of a digital data transmission system. (a) Transmitter. (b) Receiver.

Digital Communication

- Digital communication systems
  - An analog source is converted into a digital signal
  - Most communication systems adopt encoder & decoder for the robustness to channel noise
  - The digital signal is sent via digital modulation (BPSK, QPSK, …)

- Why digital dominates these days?
  - Media integrity: less deterioration in reproduction
  - Media integration: common format for text, sound, image, video, …
  - Flexible interaction: more convenient for one-to-one, many-to-many, …
  - Editing: easy to edit in digital domain ➔ **source coding/channel coding**

Contents of Textbook



(EE305)

- Introduction (Chap 1)
- Review of signal and systems (Chap 2)
- Analog signal transmission (Chap 3, 4)
- Digital baseband transmission (Chap5)
- Review of probability (Chap 6, 7)
- Performance of analog communication systems (Chap 8)
- Digital signal transmission (Chap 9, 10)
- Statistical detection & estimation (Chap 11)
- Information theory (Chap 12)

Contents of Textbook

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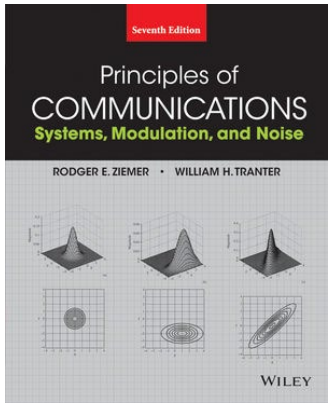

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