

EE403: Digital Communications

Lecture 1: Introduction

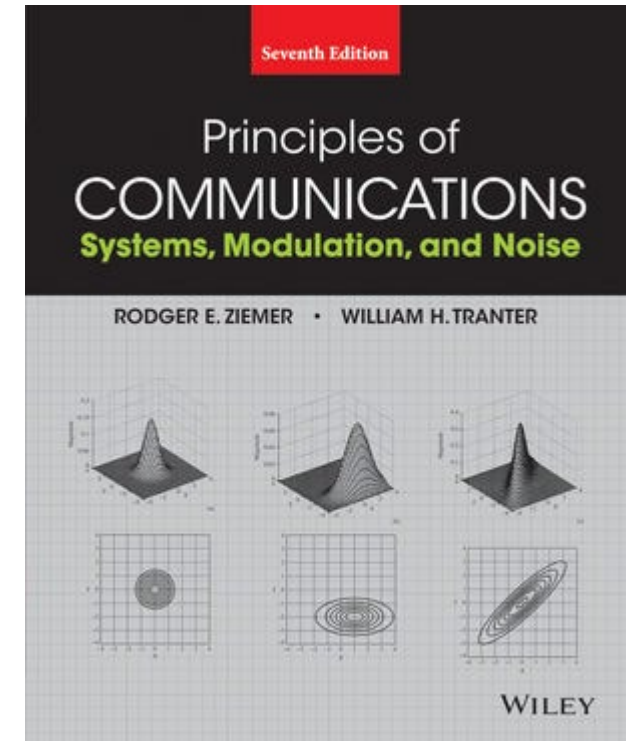
Daewon Seo
February 28, 2022

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!

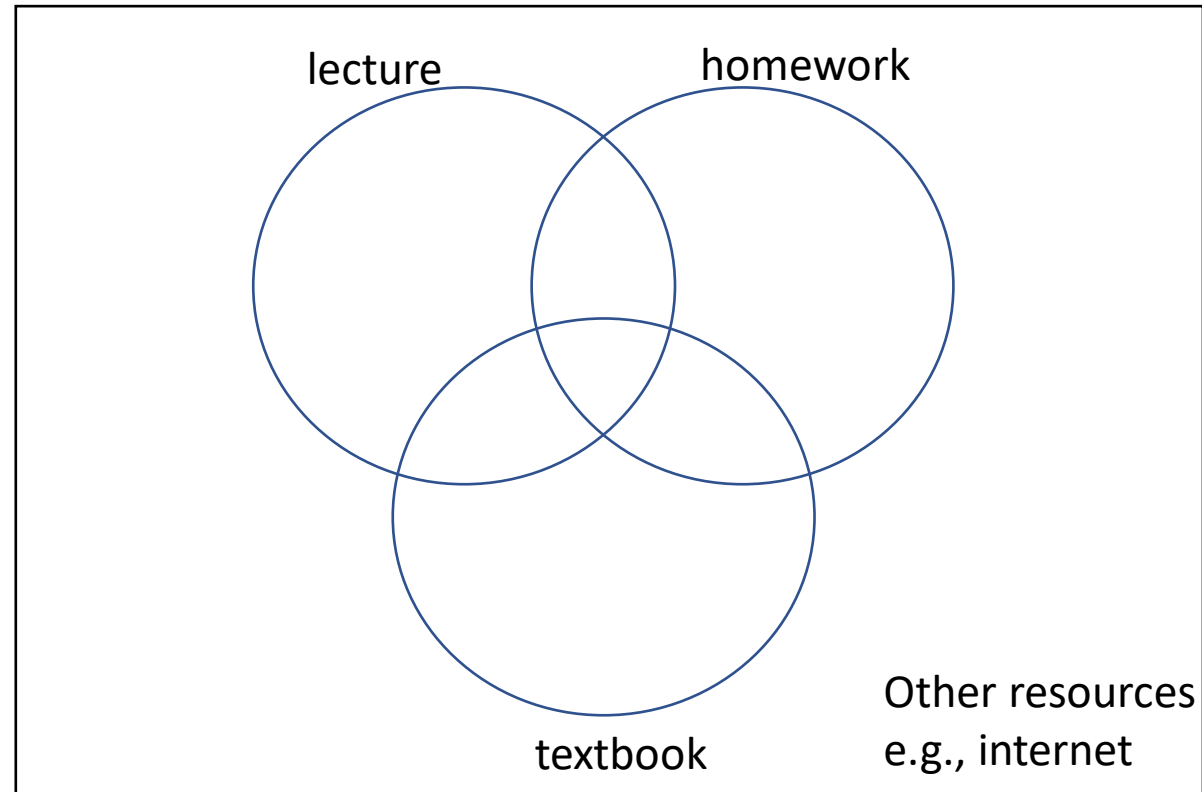


Syllabus

- 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...

Taking a course



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)

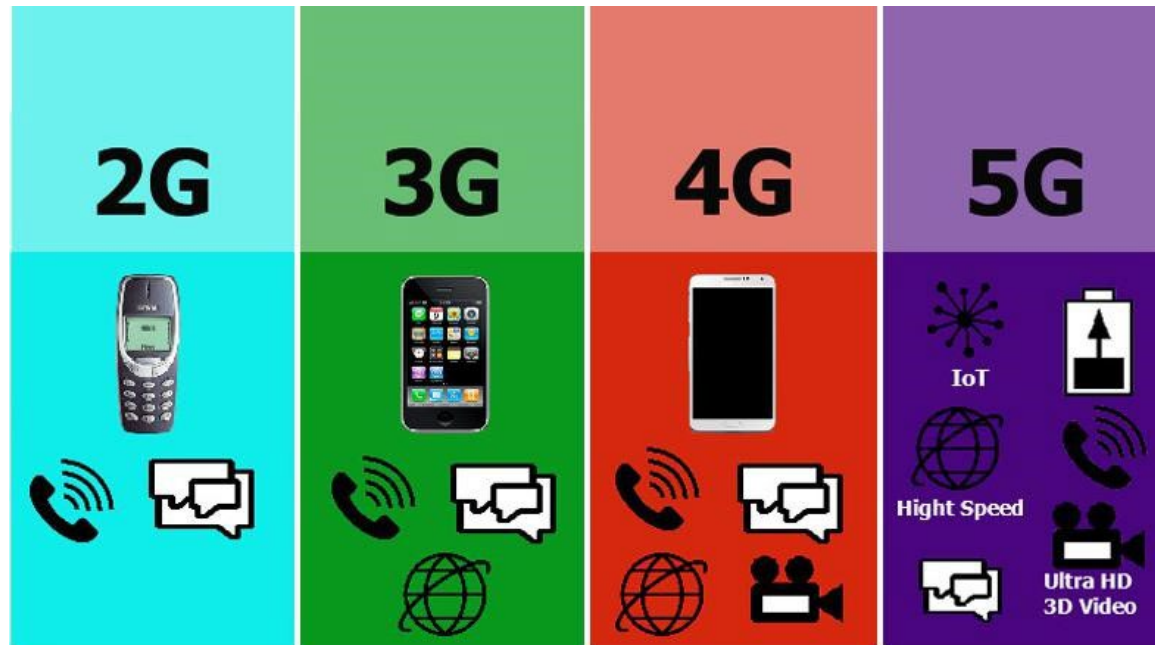
Target Students

- 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



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
 - 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
-
- EE305
- 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

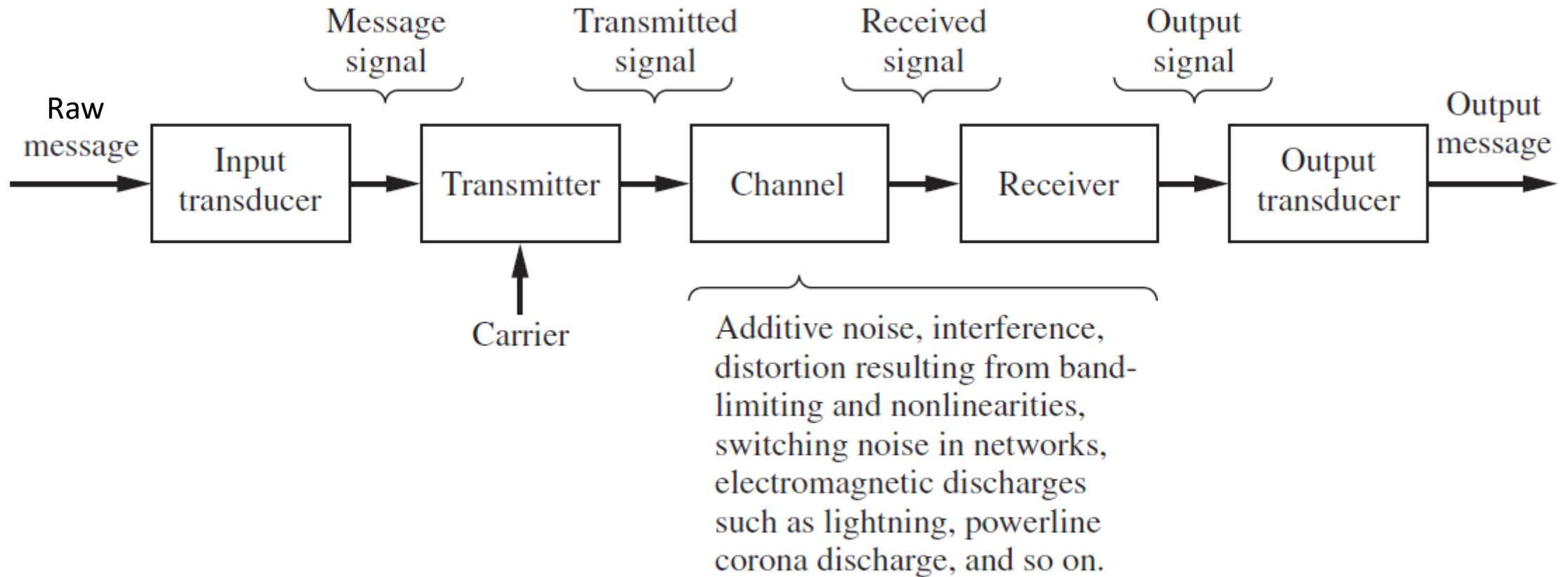


Figure 1.1
The Block Diagram of a Communication System.

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

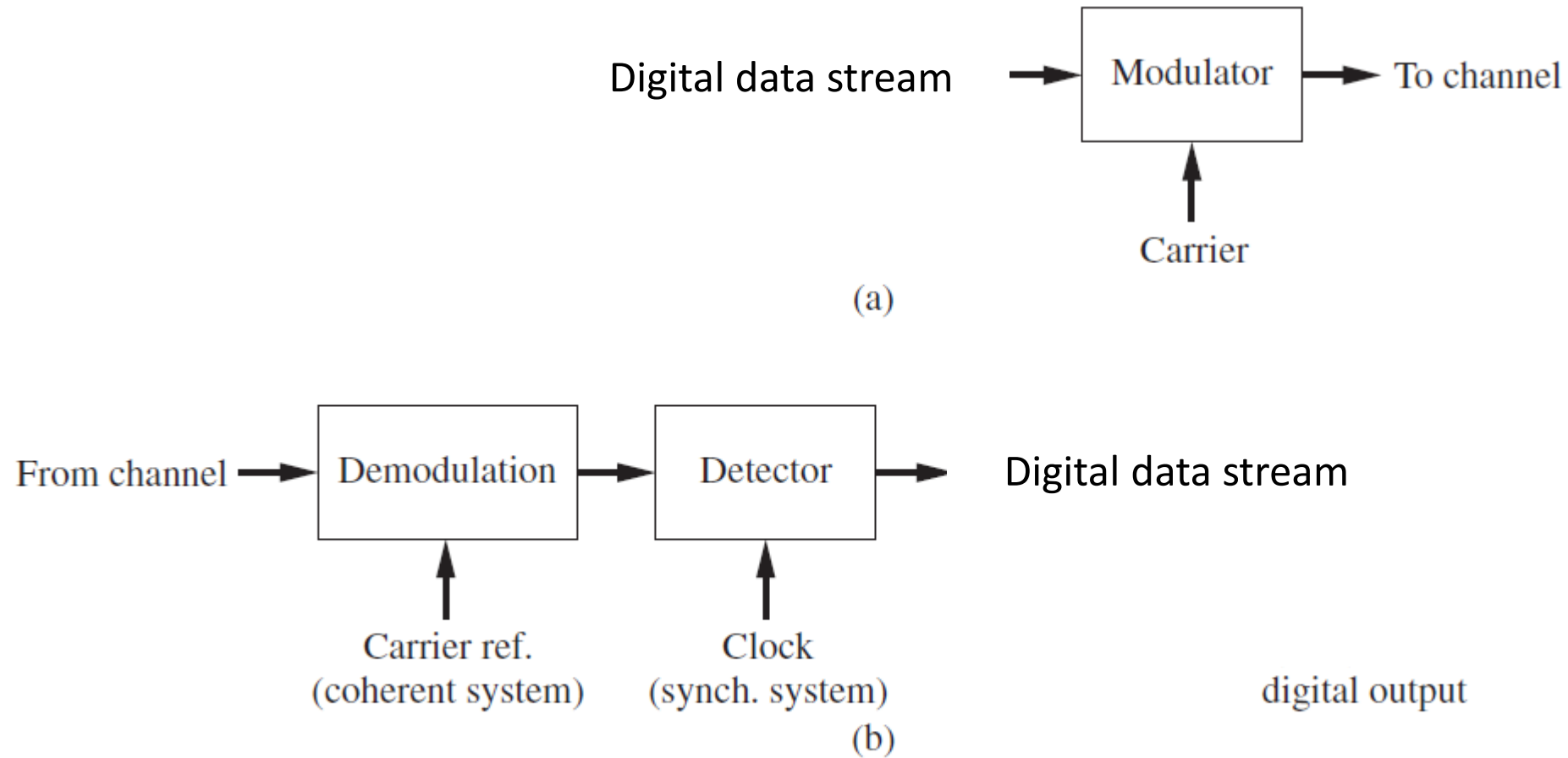


Figure 9.1

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

Digital Communication

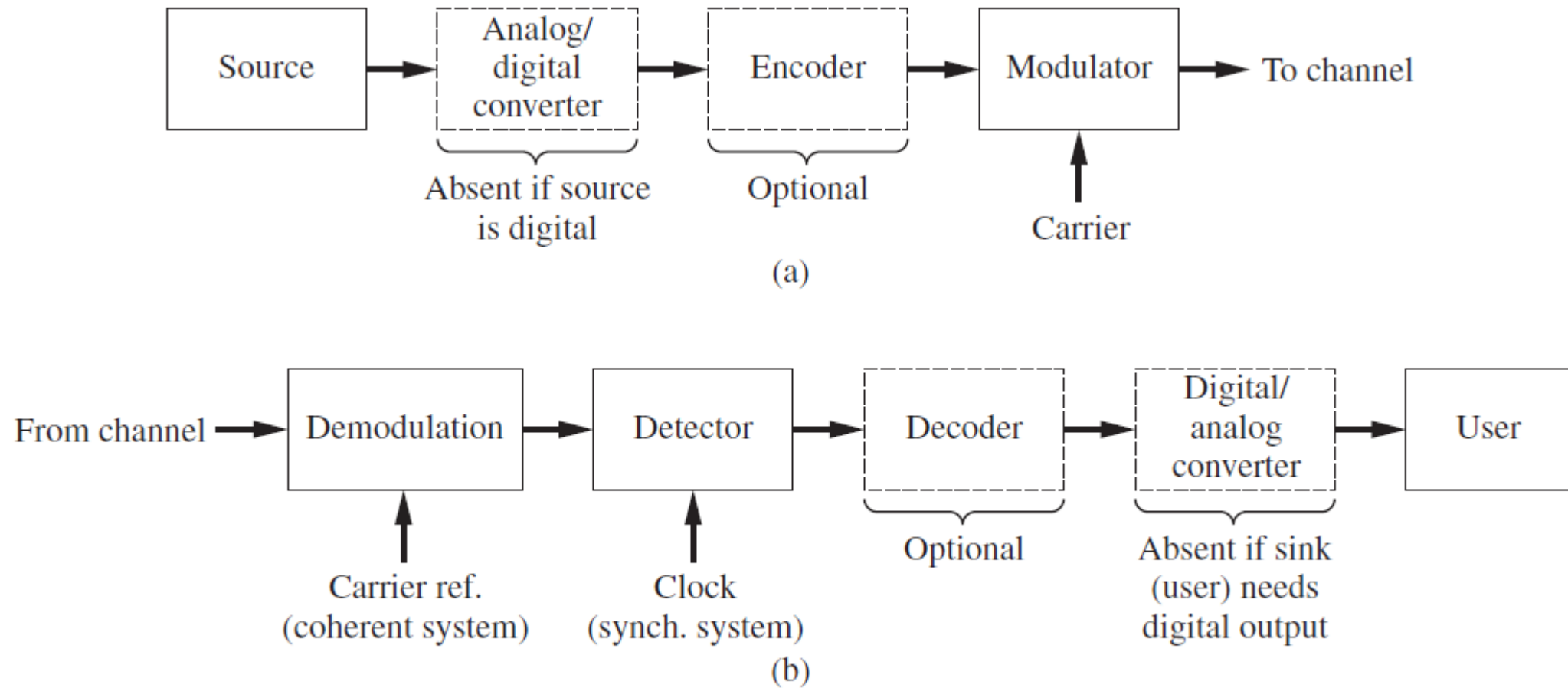


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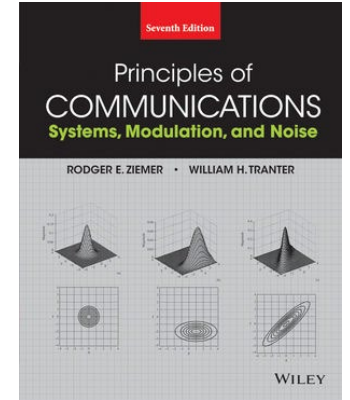
Digital Communication

- 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 (Chap 5)
- 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)



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