

Digital Communication Systems

ECS 452

Asst. Prof. Dr. Prapun Sukksompong

prapun@siit.tu.ac.th



Office Hours:

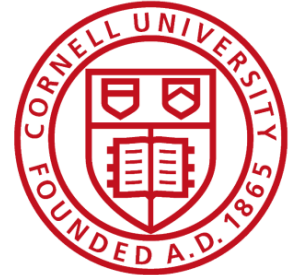
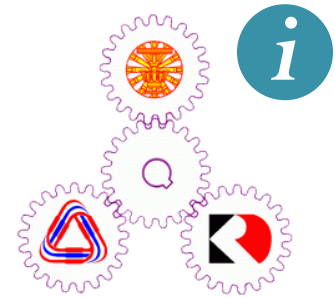
BKD 3601-7

Monday 14:00-16:00

Wednesday 14:40-16:00

Me?

- Ph.D. from **Cornell** University, USA
- In Electrical and Computer Engineering
- Minor: Mathematics (Probability Theory)
- Ph.D. Research: Neuro-Information Theory
- Current Research:
Wireless Communications
- 2009 and 2013 SIIT Best Teaching Awards
- 2011 SIIT Research Award
- 2013 TU Outstanding Young Researcher Award



prapun.com



Getting Info About This Course

- The **syllabus** contains tentative information.
- I will announce **in class** and on the **web site** if there is any change.
- You are **responsible** for making sure that you obtain this information.
- Come to classes **on time** and listen carefully for **announcement(s)**.
- For those who want a preview of the class materials, old slides along with the notes and HWs from last year are available on my web site (**prapun.com**).

Course Web Site

prapun.com



Asst. Prof. Dr. Prapun Sukosompong (พ.ศ. ๒๕๒๖) is currently a faculty member at SIIT. He topped the Cornell ECE class of 2002, with the highest GPA among all engineering students. Right after his graduation, he started his teaching career at SIIT. His research interests include mobile communications, signal processing, and wireless communication systems. In 2014, he received the 2013 Outstanding Young Researcher Award from SIIT.

Prapun always highly values the teaching aspect of his career and his life. Many of his notable achievements include several Teaching Awards from SIIT.

For more information, [here is his CV](#). (Download pdf version.)

Teaching

- For 1/2014, he teaches
 - ECS315 (Probability and Random Processes)
 - ECS452 (Digital Communication Systems)
- In 2014, Dr. Prapun received the 2013 Best Teaching Award from SIIT.
- Slides for EC Talk: Introducing ECS 452, ECS 455, and tentative senior project topics
- For 2/2013, he taught
 - ECS204 (Basic Electrical Engineering Laboratory) (For non-major students)
 - ET601 (Computer Applications for Engineers) (For PEA students)
- In 2014, he received the 2013 Outstanding Young Researcher Award (รางวัลนักวิจัยดีเด่น)
- For 1/2013, he taught
 - ECS315 (Probability and Random Processes)
 - ECS203 (Basic Electrical Engineering) (For non-major students)
 - ECS452 (Digital Communication Systems)
- For 2/2012, he taught
 - ECS204 (Basic Electrical Engineering Laboratory) (For non-major students)
 - ECS455 (Mobile Communications)
 - SCS139 (Applied Physics II) (Last 5 weeks)
- For 1/2012, he taught
 - ECS315 (Probability and Random Processes)
 - ECS332 (Principles of Communications)
 - 3.2 Wireless Communication Engineering (as a co-lecturer)
- For 2/2011, he taught
 - ECS204 (Basic Electrical Engineering Laboratory) (For non-major students)
 - ECS455 (Mobile Communications)
 - IES302 (Engineering Statistics)
- For 1/2011, he taught
 - ECS315 (Probability and Random Processes)
 - ECS332 (Principles of Communications)
 - 3.2 Wireless Communication Engineering (as a co-lecturer)
 - TU130: A lecture on "Next-Generation Wireless Communication Systems"
- For 2/2010, he taught
 - ECS210 (Basic Electrical Engineering Laboratory)
 - ECS204 (Basic Electrical Engineering Laboratory) (For non-major students)
 - Lab C2 (Digital Communications II) for ECS450 (Signal Processing and Communications)
 - ECS455 (Mobile Communications)
- In 2010, Dr. Prapun received the 2009 Best Teaching Award from SIIT.
- For 1/2010, he taught
 - ECS203 (Basic Electrical Engineering) (For non-major students)
 - ECS315 (Probability and Random Processes)
 - ECS395 (Seminar)
 - 3.2 Wireless Communication Engineering (as a co-lecturer)
- For 2/2009, he taught
 - ECS455 (Mobile Communications)
 - ECS304 (Basic Electrical Engineering Laboratory) (For non-major students)
 - ECS303 (Basic Electrical Engineering) (For non-major students)
 - Lab C2 (Digital Communications II) for ECS450 (Signal Processing and Communications)

Teaching

- For 1/2014, he teaches
 - ECS315 (Probability and Random Processes)
 - ECS452 (Digital Communication Systems)
- In 2014, Dr. Prapun received the 2013 Best Teaching Award from SIIT.
- Slides for EC Talk: Introducing ECS 452, ECS 455, and tentative senior project topics
- For 2/2013, he taught
 - ECS204 (Basic Electrical Engineering Laboratory) (For non-major students)
 - ET601 (Computer Applications for Engineers) (For PEA students)
- In 2014, he received the 2013 Outstanding Young Researcher Award (รางวัลนักวิจัยดีเด่น) from Thammasat University
- For 1/2013, he taught
 - ECS315 (Probability and Random Processes)
 - ECS203 (Basic Electrical Engineering) (For non-major students)
 - ECS452 (Digital Communication Systems)
- For 2/2012, he taught
 - ECS204 (Basic Electrical Engineering Laboratory) (For non-major students)
 - ECS455 (Mobile Communications)
 - SCS139 (Applied Physics II) (Last 5 weeks)
- For 1/2012, he taught
 - ECS315 (Probability and Random Processes)

Course Organization

- **Course Website:**

<http://www2.siiit.tu.ac.th/prapun/ecs452/>

- **Lectures:**

- **Monday 10:40-12:00 BKD 3509**

- **Wednesday 13:00-14:20 BKD 3511**

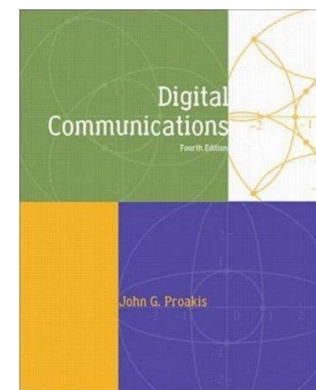
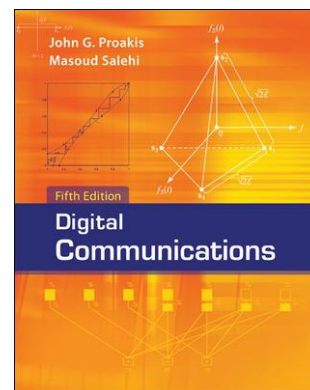
- **Textbook: Digital Communications**

- **By John Proakis and Masoud Salehi**

- **Northeastern University**

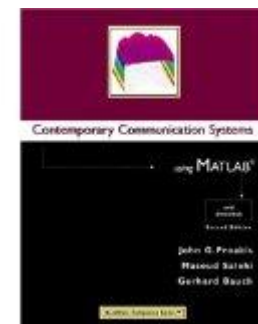
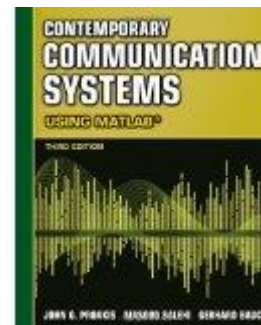
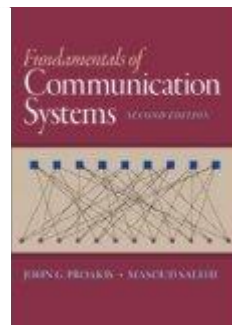
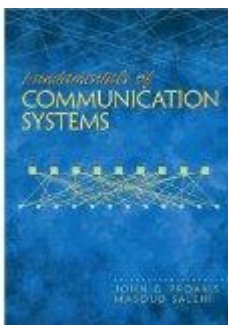
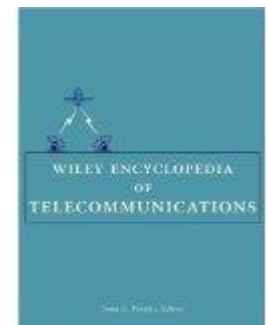
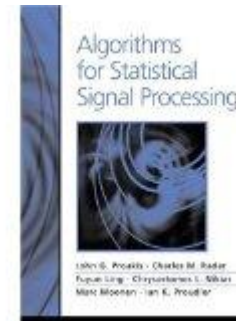
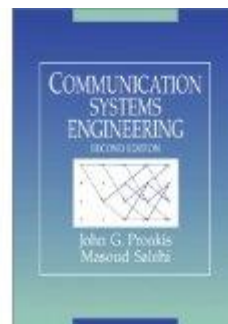
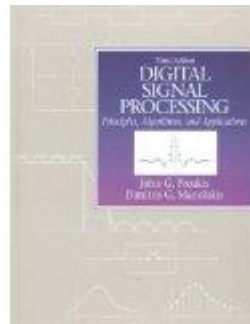
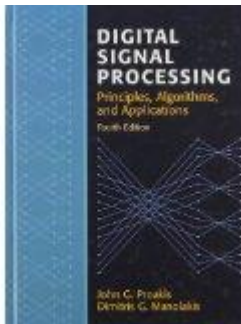
- **5th (International) Edition**

- **Call No. TK5103.7 P76 2008**



John Proakis

- Adjunct Professor at the University of California at San Diego (UCSD)
- Professor Emeritus at Northeastern University.



Course Web Site

- Please check the course website regularly.
- Announcements
- References
- Handouts (Posted before corresponding lectures)
- Slides (Posted after corresponding lectures)
- Calendar
 - Exams
 - HW due dates

www2.siit.tu.ac.th/prapun/ecs452/



ECS 452: Digital Communication Systems

Synopsis

The subject of digital communications involves the transmission of information in digital form from a source that generates the information to one or more destinations. This course extends the knowledge gained from EC352 (Principles of Communications) and EC315 (Probability and Random Processes). Basic principles that underlie the analysis and design of digital communication systems are covered. This semester, the main focus includes performance analysis (symbol error probability), optimal receivers, and limits (Information Theoretic capacity). These topics are challenging but the presented material are carefully selected to keep the difficulty level appropriate for undergraduate students.

Announcements

- This site can be accessed via ecs452.prapun.com
- A basic RSS feed is created to track and inform updates
- Welcome to ECS452! Feel free to look around this site.

General Information

- **Instructor:** Asst. Prof. Dr. Prapun Suksompong (prapun@siit.tu.ac.th)
 - Office: BIC0601-12
 - Office Hour: TBA
- **Course Syllabus**
- **Textbook:** Proakis and Salehi, *Digital Communications*, 5th Edition, McGraw-Hill, 2007.
- **References**
 - [C2] Robert G. Gallager, *Principles of Digital Communications*, Cambridge University Press, 2008.
 - E-450: Principles of Digital Communications I Fall 2006
 - [D] Bernard Sklar, *Digital communications, fundamentals and applications*, Prentice Hall, 2001. Call No: TK3102.7 S55 2001.
 - [N65] Ha H. Nguyen and Ed Shweedyk, *A first course in digital communications*, Cambridge University Press, 2009. Call No: TK3103.7 N49 2009
 - [D57] Roger E. Ziemer and William H. Tranter, *Principles of Communications*, 6th International student edition, John Wiley & Sons Ltd, 2010.
 - Call No. QA273 V384 2005. ISBN: 978-0-471-27214-4
 - Student Companion Site
 - [L40] B.P. Lathi and Zhi Ding, *Modern Digital and Analog Communication Systems*, 4th Edition, Oxford: Oxford University Press, 2009. Call No: TK3101 L432 2009
 - J. G. Proakis and M. Salehi, *Communication Systems Engineering*, 2nd Edition, Prentice Hall, 2002. ISBN: 0-13-085007-4
 - S.S. Haykin, *Communication Systems*, 4th Edition, John Wiley & Sons, 2001. Call Number: TK3101 H82 2001.
 - [K40] C. R. Jr., W. A. Sethares, and A. C. Kian, *Software Receiver Design: Build Your Own Digital Communication System in Five Easy Steps*, 1st ed. Cambridge University Press, 2011.
 - [S40] C.R. Johnson and W.A. Sethares, *Talkcommunications Breakdown: Concepts of Communication Transmitted via Software-Defined Radio*, Prentice Hall, 2003.
 - J. G. Proakis and M. Salehi, *Communication Systems Engineering*, 2nd Edition, Prentice Hall, 2002. ISBN: 0-13-085007-4
 - S.S. Haykin, *Communication Systems*, 4th Edition, John Wiley & Sons, 2001. Call Number: TK3101 H82 2001.
 - [K40] C. R. Jr., W. A. Sethares, and A. C. Kian, *Software Receiver Design: Build Your Own Digital Communication System in Five Easy Steps*, 1st ed. Cambridge University Press, 2011.
 - [S40] C.R. Johnson and W.A. Sethares, *Talkcommunications Breakdown: Concepts of Communication Transmitted via Software-Defined Radio*, Prentice Hall, 2003.
 - [C47] Thomas M. Cover, Joy A. Thomas, *Elements of Information Theory*, Second Edition, Wiley-Interscience, 2006
 - F. Suksompong, *EC352 - Principles of Communications*
 - MATLAB Primer, 8th edition T. A. Davis. CRC Press, 2010.
 - MIT 6.007: Signals and Systems (1987) on Youtube

Handouts and Course Materials

Problem Set

A. •

B.

Calendar

11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

Reading Assignment

Video Links

- **Article:** IEEE 802.11a~Wi-Fi for the Mobile and Video Generation
- C.E. Shannon
 - **Paper:** C.E. Shannon, "A Mathematical Theory of Communication", *Bell System Technical Journal*, vol. 27, pp. 379-423, 623-656, July, October, 1948
 - **Video:** Claude Shannon - Father of the Information Age
 - **The Significance of Shannon's Work** by Aaron Wyner
 - **Paper:** Sergio Verdú (2000), "75 years of Shannon theory"

Course Website: Notes & Slides

- **PDF notes** will be posted *before* the corresponding lectures.
 - Hard copies can also be purchased from the **copy center**.
- In lectures...
 - PDF notes will be highlighted and annotated with examples / comments.
 - Some lectures may use slides.
 - The slides and annotated notes will be **posted after** the corresponding lectures.
- I also frequently use Microsoft **OneNote** on my convertible tablet instead of the whiteboard. The files will be exported as pdf and posted *after* the corresponding lectures.
- **Remind** me the day after the lecture if the notes/slides from the day before are still not posted on the web.

ECS 452 Topics

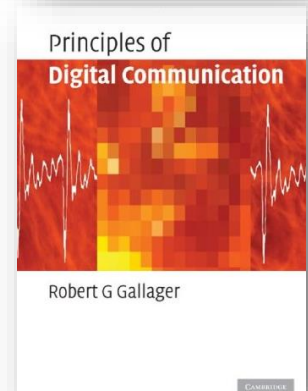
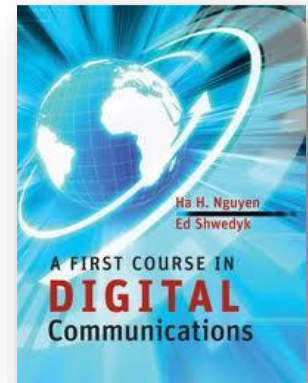
1. Elements of a Digital Communication System
2. Source Coding and **Entropy**
3. **Optimal Detection** for Discrete Channels
4. Mathematical Models for Physical Communication Channels
5. PAM: A Digital Modulation Scheme
6. Signal Space Representation of Waveforms
7. Constellations for Digital Modulation Schemes
8. **Optimal Detection** for Additive Noise Channels: 1-D Case
9. **Optimal Detection** for Additive Noise Channels: K-D Case
10. Random Processes and White Noise
11. **Optimal Detection** for Waveform Channels
12. **Mutual Information** and **Channel Capacity**
13. Channel Coding methods for error detection and correction.
14. An Introduction to Multiple-antenna system

General Ideas

- Extension of Principles of Communications (ECS332) and Probability and Random Processes (ECS315)
- Focus more on
 - Performance analysis (bit error rates),
 - Optimal receivers, and
 - Limits (information theoretic quantities).

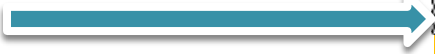
More References

- A first course in digital communications
 - By Ha H. Nguyen and Ed Shwedyk
 - Call No: TK5103.7 N49 2009
 - Cambridge University Press
- Digital communications: fundamentals and applications
 - By Bernard Sklar.
 - Call No: TK5103.7 S55 2001
 - Prentice Hall
- Principles of Digital Communication
 - By Robert G. Gallager
 - 2008
 - Cambridge University Press



Calendar

Lecture



Exam



M	T	W	R	F
11-Aug-13	12-Aug-13	13-Aug-13	14-Aug-13	15-Aug-13
18-Aug-13	19-Aug-13	20-Aug-13	21-Aug-13	22-Aug-13
25-Aug-13	26-Aug-13	27-Aug-13	28-Aug-13	29-Aug-13
1-Sep-13	2-Sep-13	3-Sep-13	4-Sep-13	5-Sep-13
8-Sep-13	9-Sep-13	10-Sep-13	11-Sep-13	12-Sep-13
15-Sep-13	16-Sep-13	17-Sep-13	18-Sep-13	19-Sep-13
22-Sep-13	23-Sep-13	24-Sep-13	25-Sep-13	26-Sep-13
29-Sep-13	30-Sep-13	1-Oct-13	2-Oct-13	3-Oct-13
6-Oct-13	7-Oct-13	8-Oct-13	9-Oct-13	10-Oct-13
13-Oct-13	14-Oct-13	15-Oct-13	16-Oct-13	17-Oct-13
20-Oct-13	21-Oct-13	22-Oct-13	23-Oct-13	24-Oct-13
27-Oct-13	28-Oct-13	29-Oct-13	30-Oct-13	31-Oct-13
3-Nov-13	4-Nov-13	5-Nov-13	6-Nov-13	7-Nov-13
10-Nov-13	11-Nov-13	12-Nov-13	13-Nov-13	14-Nov-13
17-Nov-13	18-Nov-13	19-Nov-13	20-Nov-13	21-Nov-13
24-Nov-13	25-Nov-13	26-Nov-13	27-Nov-13	28-Nov-13
1-Dec-13	2-Dec-13	3-Dec-13	4-Dec-13	5-Dec-13
8-Dec-13	9-Dec-13	10-Dec-13	11-Dec-13	12-Dec-13
15-Dec-13	16-Dec-13	17-Dec-13	18-Dec-13	19-Dec-13

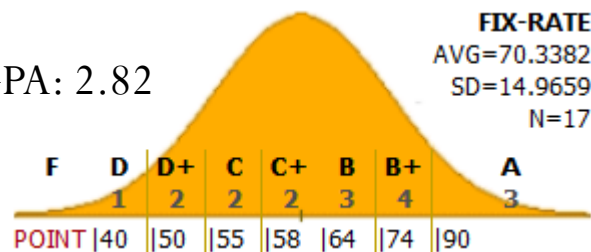
Please Double-Check Exam Dates!

Grading System

- Coursework will be weighted as follows:

Assignments	5%
Quizzes and In-Class Exercises	5%
Class Discussion/Participation	10%
Midterm Examination	40%
• 6 Oct 2014 TIME 09:00 - 12:00	
Final Examination (comprehensive)	40%
• 15 Dec 2014 TIME 09:00 - 12:00	

2013: CLASS GPA: 2.82



Class Participation

- NOT the same as class attendance!
- If you come only to **receive**, you will fall **asleep**.
 - Do not simply sit quietly in the class.
- Need **interaction** between lecturer and students.
- **Ask question** when there is something that you don't understand.
 - Don't be shy!
 - It is very likely that your friends don't understand it as well.
- If you already understand what I'm presenting, **SHOW ME!**
 - Point out the errors/typos.
 - I will raise many issues/questions in class. Try to comment on them.

Class Participation (2)

- Record what you have done.
- Submitted before the midterm and before the final.

ECS 452: Self-Evaluation

1. The class participation score for this class is judged by how much you actively participate in the class discussion both inside and outside of the classroom.
2. Please honestly answer the following questions. Please provide as much information as possible. Do not include the activities that you have already stated in the first self-evaluation form.

Name

Student ID

How many times have you been absent from the class? Are there any specific reason(s)? Please explain.


How many times have you been late (> 30s) for the class? Are there any specific reason(s)? Please explain.

How many times have you participated (provided comments, asked questions, answered questions, etc) in the lectures? Be specific. Provide some short description for each event. Number alone does not count.

How many times have you correctly informed the instructors the typo or mistake on the whiteboard/slides/hw/etc? Please provide some short description about each of the issues.

How many times have you discussed with the instructor outside of class? (Ask questions, express concerns, etc.) Be specific.

Policy

- We will start the class **on time** and will finish **on time**.
 - Raise your hand and tell me immediately if I go over the time limit.
 - Does NOT mean that I will leave the room immediately after lecture.
 - I will stay and answer questions.
- Mobile phones *must* be turned off or set in silent mode. 
- We may have some **pop quizzes** (without prior warning or announcement) and in-class activities.
- Attendance and pop quizzes will be taken/given irregularly and randomly.
- Cheating will not be tolerated.

Policy (con't)

- Feel free to stop me when I talk too fast or too slow.
- I will surely make some **mistakes** in lectures / HWs / exams.
 - Some amount of class participation scores will be reserved to reward the **first** student who inform me about each of these mistakes.
 - Grammatical errors are best informed/corrected after class.
- Points on quizzes/ exercises/ exams are generally based on your entire solution, not your final answer.
 - You can get full credit even when you have the wrong final answer.
 - You may get **zero** even when you write down a right answer without justification.

Policy (con't)

- Please stop me if I go over the time limit.
- Please stop me if I talk too fast.
- Please stop me if you have any question.



Help and Office Hours

- Get some help!
 - Do not wait until the final exam time or after the grade is out.
 - Right after lecture is always a good time to ask question.
- Office Hours (BKD-3601)
 - Time: Monday 14:00-16:00, Wednesday 14:40-16:00
 - Appointment can be made.
 - Tutorial session can be arranged.
 - Feel free to come to my office and chat!
 - Don't be shy.

Warning

- This class can be **difficult**.
 - Keep up with the lectures.
 - Make sure that you understand the concepts presented in the lecture before you go home.
- I will **evaluate** your understanding of the course **regularly** through
 - In class problems/ activities
 - Quizzes
 - Exams



Tips

- Almost everything including what I have written on my tablet will be saved and posted on web soon after class.
- No need to take detailed lecture notes (if you don't want to).
 - Put all of your energy into understanding the material.
 - Of course, there is always someone (in the class) who will take good notes anyway and you can (potentially) borrow or make a copy of the notes from them.
- Have fun with the materials presented in class.

Remarks

- Get as much legitimate help as you can
- **Participate actively in class** and outside of class
 - Record what you have done.
- If you feel that the class is very easy, you might overlook something.
- If you feel that the class is very difficult, you are probably not the only one who feel that way.
 - Don't give up. Chat with me.
 - It takes me a long time to feel comfortable with these materials; yet, I still make mistakes.
- My notation can be different from the textbook.
 - Every notation has some advantages and disadvantages.