Department of Electrical Engineering, IIT Madras

EE 4140: Digital Communication Systems

ESB-213B Jul-Nov., 2025

1. Introduction (Chap-1 in book) to digital communications, and review of sampling theorem and representation of band-pass signals (Chap-2). Sampling of band-pass signals; *Random variable and random process, Gaussian, white, stationary processes, circular Gaussian random variable, auto-correlation and power spectral density, WSS random signal transmitted through LTI system, band-pass processes (Chap-4).*

2. Digital communications thro ideal (band-unlimited) AWGN channels – Single-shot communication, Matched Filter Receiver, Symbol-by-Symbol modulation, Digital Signal representation, PAM, PSK, and QAM signals, multi-dimensional signals, optimum receiver for AWGN measurement models, probability of error P_e for symbol detection (Sec. 7.1 thro 7.6 in Chap-7), approximate P_e using Union bound, Chernoff bound, P_e for fading channels

3. Digital communications thro band-limited "flat" channels – Power spectrum of random digital signal (using the the random binary wave process), signal design for symbol-by-symbol modulation thro band-limited channels (the Nyquist criterion for pulse-shaping), partial response signals (Sec. 8.1 thro 8.3 in Chap-8). Timing and frequency synchronization for linearly modulated digital signals (from Sec. 7.8 in Chap-7).

4. Digital communications thro distorting channels – Inter Symbol Interference (ISI) channel, maximum likelihood sequence detection and the Viterbi algorithm (Sec. 8.6 and only some parts of Sec. 8.5 in Chap-8), and practical (fractionally-spaced, linear/non-linear) equalizers for ISI channels

5. Source coding preview – Source coding theorem, only Sec. 6.1 to 6.3 in Chap-6, and a "touch" of Sec.6.6 & 6.7.

6. Channel coding preview – Channel capacity theorem and understanding AWGN channel capacity, random coding argument, simple block coding and syndrome decoding, convolutional codes and MLSE; *a brief look at trellis coded modulation, and the idea of concatenation and interleaving of simple codes to make a more powerful code (touching upon nearly all topics the various sections in Chap-9 with the exception of sections 9.6 and 9.10).*

7. Why the evolution from single-carrier symbol-by-symbol modulation to block modulation? Introduction to cyclic prefix-based block modulation – multi-carrier (OFDM/OFDMA) and single-carrier

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Note: The topics in blue font are **not** from the text book, and topics in *red italics* will be covered if sufficient time is available; else you can read them up from the text-book.)

Text Book:
"*Communication Systems Engineering 2nd Ed*" J.G.Proakis & M.Salehi (Prentice Hall Intl. Edition); either hard-copy or E-book can be followed.

Assessment Method: ***(tentative)***
Open-book/notes Mid Sem Test: 30 marks; End Sem Mini-project Presentation: 40 marks; the remaining 30 marks will be awarded based on two take-home computational assignments of 15 marks each.

The TAs for this course are Ms. Prasikaa Shree (prasikaasriram@telwise-research.com) and Mr J M Harish (ee24m009@smail.iitm.ac.in); we will communicate by Whatsapp or email; you can write to me at giri@ee.iitm.ac.in for more details. Soft-copies of additional material (if required) would be made available at http://www.ee.iitm.ac.in/giri/teaching.html.

K. Giridhar, ESB-334B, July 31, 2025