ENG EC515 Digital Communication

2008-2009 Catalog Data: Prereq: ENG EC 401, ENG EC 381, CAS MA 242. Canonical point-to-point digital communication problem; Communication channel models; Optimal receiver principles with focus on additive Gaussian noise channels: Maximum Aposteriori Probability (MAP) and Maximum Likelihood (ML) receivers for both vector and waveform channels, principles of irrelevance and reversibility; Concepts of signal space and signal constellation; Efficient signaling for message sequences over frequency-flat additive Gaussian noise channels: basic digital modulation and demodulation techniques and their performance analysis; Notions of symbol and bit rate, symbol and bit error probability, and power and bandwidth efficiency; Real passband additive Gaussian noise waveform channels and their equivalent complex base-band representation; Efficient signaling for message sequences over general bandlimited additive Gaussian noise channels: signal design and equalization methods to combat intersymbol interference; Coherent versus Noncoherent digital signaling; Synchronization; Channel estimation; Error correction coding basics.

Class/Lab Schedule:
Lecture: 4 hours/week

Textbooks and other required materials:
J. M. Wozencraft and I. M. Jacobs, *Principles of Communication Engineering*, John Wiley & Sons, 1965 (reissued by Waveland Press, 1990) + class-notes.

References:
J. G. Proakis, *Digital Communications*, 5th ed., McGraw-Hill, 2008.
U. Madhow, *Fundamentals of Digital Communication*, Cambridge University Press, 2008.
S. Benedetto and E. Biglieri, *Principles of Digital Transmission: With Wireless Applications*, 1st ed., Plenum, 1999.

Coordinator:
Prakash Ishwar, Assistant Professor, ECE Department

Prerequisites by topic:
Signals & Systems (ENG EC 401), Probability (ENG EC 381), Linear Algebra (CAS MA 242).

Goals: Provide students with: 1) A clear understanding of the most basic point-to-point digital communication problem. 2) An appreciation for the limitations imposed by noise and frequency-selective attenuation in communication and optimal and practical methods to mitigate the effects of these impairments. 3) An understanding of tradeoffs between resources (power/bandwidth) and performance (rate/reliability) in the communication problem. 4) Knowledge of basic concepts and analytical tools needed to design and evaluate the performance of modern digital communication systems

Course Outcomes: As an outcome of completing this course, students should be able to:

1) Identify point-to-point digital communication problems
2) Understand the implications of noise and frequency-selective attenuation in point-to-point digital communication
3) Understand optimal and practical methods to mitigate the effects of noise and frequency-selective attenuation
4) Design optimum demodulation algorithms
5) Understand tradeoffs between resources (power/bandwidth) and performance (rate/reliability) in the communication problem
6) Understand signal processing approaches and their limitations in overcoming noise and frequency-selective attenuation
7) Understand the need for and role of coding in communication efficiency
8) Evaluate the performance of modern digital communication systems

Course Outcomes mapped to Program Outcomes:

Program Outcomes	**a**	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
Course Outcomes	**1-8**	**4,8**	**4**		**1-8**					**8**	**3,4,5,8**
Emphasis (1-5)	**5**	**2**	**3**		**5**					**2**	**5**

1 = not at all; 5 = a great deal

Topics: Canonical point-to-point digital communication problem. MAP, ML, and minimax receivers. Principle of irrelevance. Principle of reversibility. Vector and waveform additive Gaussian noise channels. Signal Space and Signal Constellations. Matched filter and correlation receivers. Rectangular, Orthogonal, and related signal constellations. Bit-by-bit and block-orthogonal signaling. Time, bandwidth, and dimensionality. Symbol and bit rate, symbol and bit error probability, and power and bandwidth efficiency. Union bound. Channel capacity. Real passband signals and systems and their complex base-band representation. Double-sideband suppressed carrier signaling. Bandlimited additive Gaussian noise channels. Intersymbol interference. Nyquist's criterion and pulse-shaping. Zero-forcing, MMSE, Decision-feedback, Tomlinson-Harashima precoding, and Viterbi equalization methods. Coherent versus Noncoherent digital signaling. Synchronization. Channel estimation. ECC basics.

Contribution of Course to Meeting the Professional Component:
Engineering topics: 90%
Math & Basic Science: 10%

Prepared by: Prakash Ishwar, Assistant Professor, ECE Department