EE4634
Digital Communications
Fall 2007

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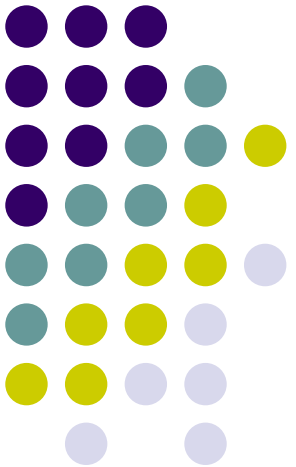
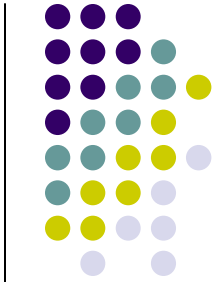
Final Review



Course Objectives

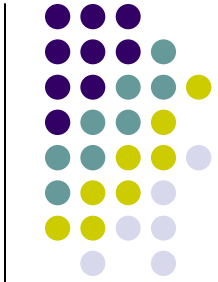
- After completing this course you should be able to:
  - Design a scalar quantizer for a given source with a required fidelity and determine the resulting data rate;
  - Determine the auto-correlation function of a line code and determine its power spectral density;
  - Determine the power spectral density of bandpass digital modulation formats.
  - Design digital communication systems, given constraints on data rate, bandwidth, power, fidelity, and complexity;
  - Analyze the performance of a digital communication link when additive noise is present in terms of the signal-to-noise ratio and bit error rate;
  - Compute the power and bandwidth requirements of modern communication systems, including those employing ASK, PSK, FSK, and QAM modulation formats;

Final Exam Format



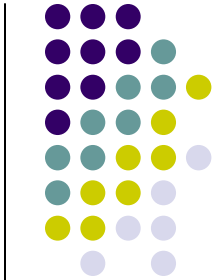
- Closed book / 3 sheets notes
- 5-6 problems
  - Each problem has 2-4 parts
  - 3-4 questions on material after 2nd midterm
  - 1-2 questions on material prior to 2nd midterm
- Types of problems
  - Short answer
  - Design problems
  - Calculations – basic formulas that you should know or have on your sheet (understand their meaning!)

Topics Covered



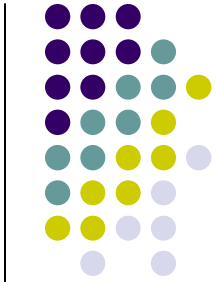
- Introductory Material
  - Fourier Analysis
  - Random Variables, Random Processes
- Sampling
  - Nyquist Sampling Theorem
  - PAM
- Pulse Code Modulation
  - The Sampling Theorem
  - Quantization – uniform / non-uniform
  - Companding
- Line Codes
  - Conversion of data bits to binary signal
  - ISI and Pulse shaping; Raised Cosine pulse
    - Nyquist condition for zero ISI

Topics Covered



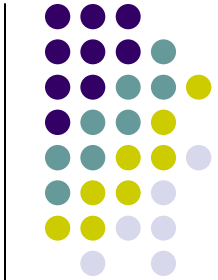
- Bandpass Signals
  - Representation of bandpass signals
    - Complex baseband
    - In-phase/quadrature
    - Magnitude/phase
- Binary Modulation
  - BPSK – the phase is modulated (either 0 or π)
  - BFSK– the frequency is modulated (either f_1 or f_2)
  - BASK– the amplitude is modulated (either 0 or 1)
  - Know the representation for each
  - Understand the basics for magnitude spectra and PSD for each.

Topics Covered



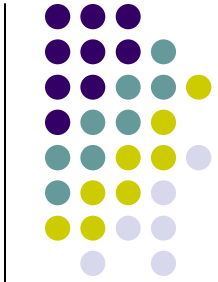
- *M*-ary Modulation
  - MPSK
  - MFSK
  - QAM
  - Spectral characteristics
  - Bandwidth efficiency vs. Energy efficiency
  - Complex Envelope representation
  - Magnitude/Phase representation
  - Signal Space representation
    - decision regions
  - transmitter
  - receiver

Topics Covered



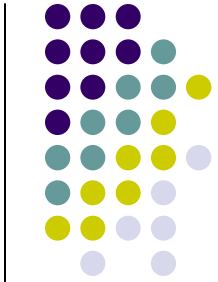
- Differential modulation
  - coherent vs. non-coherent receivers
  - differential encoding
  - differential decoding
  - coherent detection of differentially encoded data
- Noise, Channel Models
  - AWGN
    - Additive
    - White - spectral properties
    - Gaussian - pdf
  - Rayleigh fading
  - Ricean fading

Topics Covered



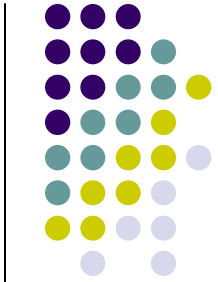
- Matched Filters
  - integration as filtering
  - optimal filtering
  - Matched Filter Receivers
  - correlator
  - pulse shaping
  - raised cosine pulse shaping

Topics Covered



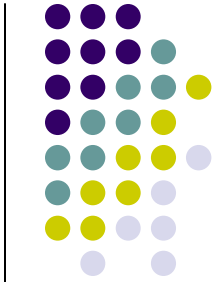
- Error Probability for Digital Modulation
  - Error probability for Binary Signaling
    - derivation of decision statistic
    - pdf of decision (or test) statistic
    - threshold voltage - choosing optimal
    - relationship between performance and constellation diagram
    - BER for unipolar signalling
    - BER for bipolar signalling
    - BER for Coherent BPSK, ASK, FSK
      - understand the derivations!
  - Performance of Non-coherent ASK, FSK
  - *M*-ary signaling
    - Be able to determine BER performance for AWGN
- Comparison of Digital Modulation Techniques
  - bandwidth efficiency
  - energy efficiency

Topics Covered



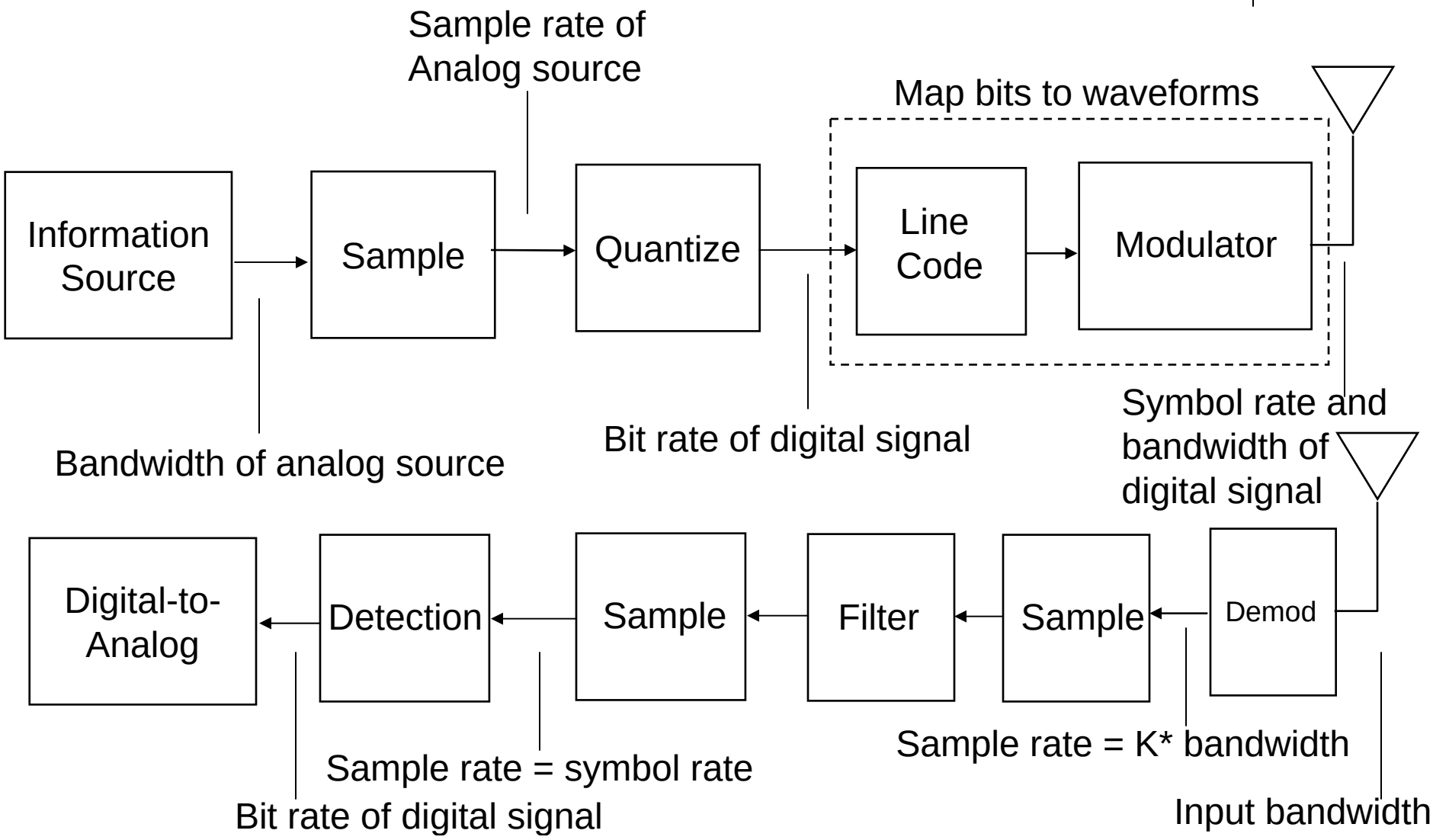
- Link Budgets
  - Friis transmission equation
  - terms in link budgets
  - purpose of link budget
  - be able to make design trade-offs
- Design problems
  - Energy requirements – using link budgets
    - Determine maximum data rate based on limitations in transmit power, required range and other link budget requirements
    - Determine maximum range based on limitations on transmit power, required data rate and other link budget requirements
  - Bandwidth requirements
    - Determine maximum data rate based on bandwidth limitations based on pulse shape, modulation scheme and possibly truncation factor
    - Determine the number of channels possible based on data rate and modulation scheme

At any rate….



- There are several different rates discussed in a digital system including symbol rates, bit rates, and two different sampling rates
- We need to make sure we understand the difference
- There are also two different bandwidth measurements!

At any rate….


Sample rate of
Analog source
Map bits to waveforms
Information
Source
Sample
Quantize
Line
Code
Modulator
Bandwidth of analog source
Bit rate of digital signal
Symbol rate and
bandwidth of
digital signal
Digital-to-
Analog
Detection
Sample
Filter
Sample
Demod
Sample rate = K* bandwidth
Sample rate = symbol rate
Bit rate of digital signal
Input bandwidth