EE521 Analog and Digital Communications

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Texts:

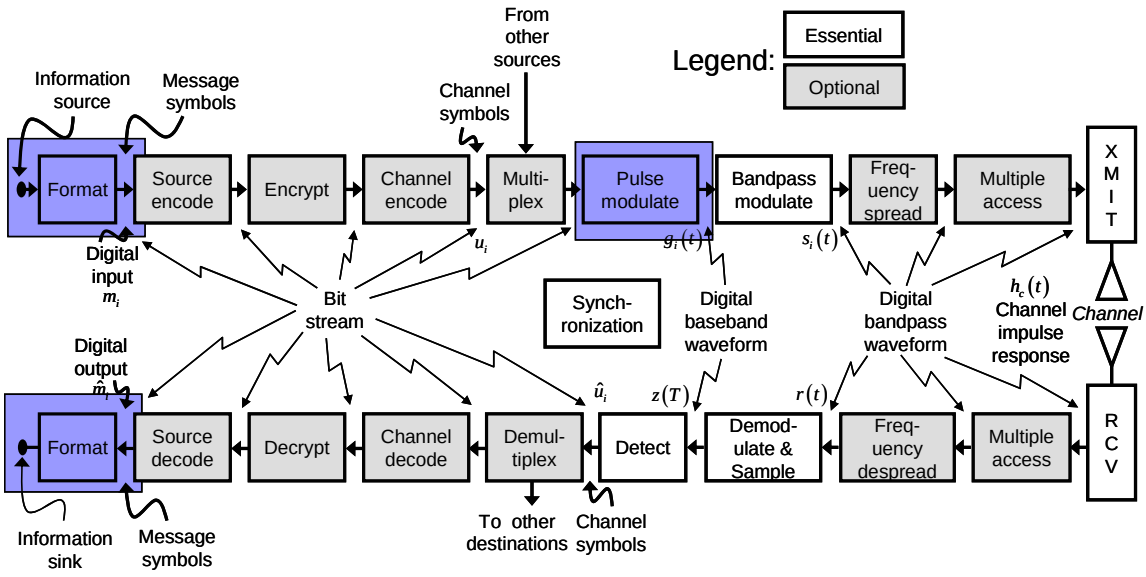
- Bernard Sklar, Digital Communications, Second Edition, Prentice Hall P T R, 2001 (2004 printing), ISBN 0-13-084788-7
- Digital Communication Systems Using SystemVue, by Dr. Silage, ISBN 1-58-450850-7

Today's Topics

- SystemView CDROM distribution
- From Sklar Chapter 2, Formatting and Baseband Modulation
    - Baseband Demodulation/Detection
    - Signals and Noise
    - Detection of Binary Signals in Gaussian Noise
    - Inter-symbol Interference, Equalization

Overview

See block diagram below



SystemView CDROM Distribution

Full Version on CD-ROM with Individual Licenses

I have made a CD-ROM for each of you by name. There is a SystemView 2005-2 installation file on the CDROM and also a text file that has your license code as the first line.

Install SystemView on the computer that you will be using for the rest of the semester while connected to the Internet. During the installation process, or at the first use, you will be prompted for the validation code. This will enable your full copy of SystemView to function for 90 days, or until the day after the EE521 Final Examination. You cannot move the installation to another computer; take this into account when you decide which computer you will install SystemView on.

All questions regarding support of SystemView, including installation and use, are to be referred to myself and Dr. Silage. Under no circumstances are you to call Agilent/Eagleware/Elanix for support as this will violate the agreement that we have with them for the use of SystemView for EE521.

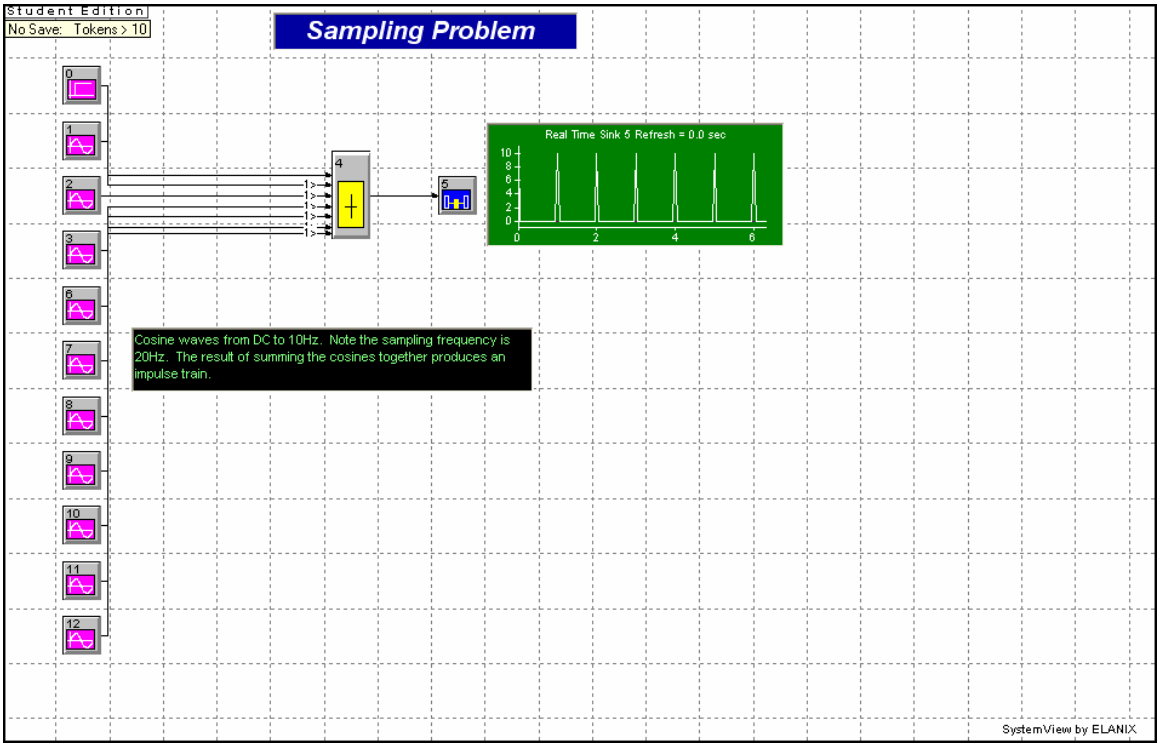
Dr. Silage's Book

Use the book for reference on the use and functions of the tokens. This information is not available anywhere else.

Sklar Problem 2.4 Solution from CD-ROM

NOTE: The problem numbers on the CD-ROM are from an eearlier edition. The problems in the current edition of Sklar are not the same as those in the examples on the CDROM

Sklar gives his solution as the SystemView file Sum_of_cosines.svu:

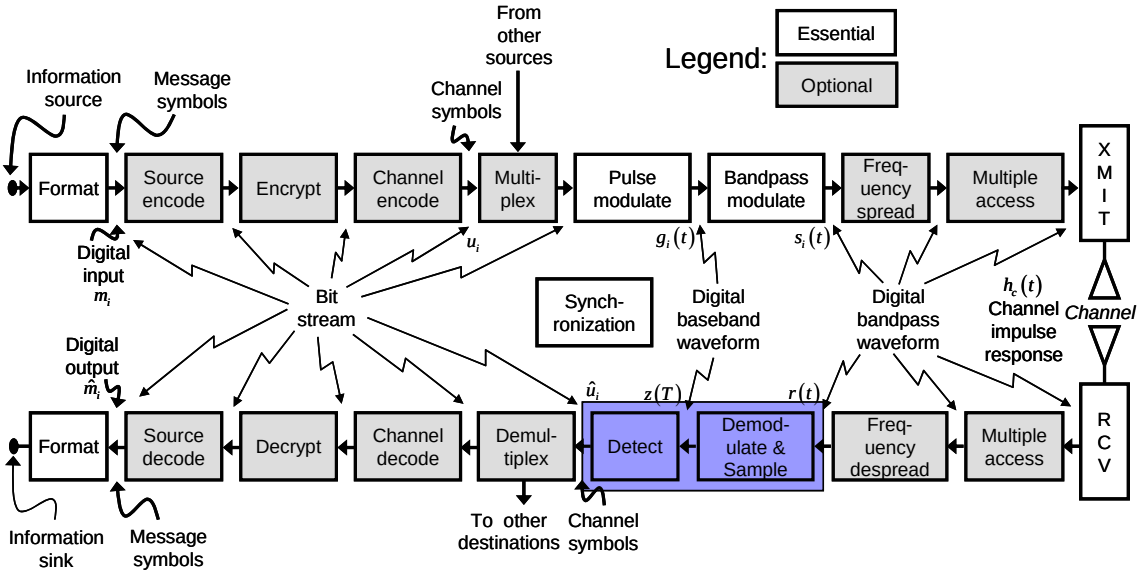


Our lecture last time showed that the Fourier transform of a series of impulses in the time domain was a set of impulses in the frequency domain. We showed that convolving with this set of impulses in the frequency domain resulted in replicating the spectrum of the signal at intervals equal to the sample rate, and that this is the effect we call aliasing.

The example we give here from the Sklar CD-ROM shows the reverse effect. When we take a series of tones in the time domain and sum them, we are in effect taking the inverse Fourier transform of a set of impulses in the Frequency domain. The inverse Fourier transform of each one is a complex exponential. Complex exponentials of equal positive and negative frequencies sum to form a real cosine. Summing this series of cosines of equal amplitude results in a set of impulses in the time domain. Note that a zero-frequency term of amplitude 0.5 is included, and that the amplitudes of the cosine terms are all 1.0.

The output of the simulation, as shown, is very clean. It is zero except for the peaks of the impulses, which is equal to the number of terms. This is due to the selection of the SystemView sample rate of 20 Hz, which selects zero crossing points in the resulting sum function. Change the SystemView sample rate to 1000 Hz and the number of samples from 128 to 4096 and run the simulation again, and observe the sin(Nx)/sin(x) waveform, including sidelobes.

Brief Reviw of Sklar, Chapter 3, Baseband Demodulation/Detection



Signals and Noise

The communication problem involving analysis of noise in signals is symbol error. We need to understand the probability that the correct symbol will result from the demodulation process as a function of signal to noise ratio. Symbol error ate is a function of

- Signal to noise ratio (SNR)
- Modulation type (binary, BPSK, FSK, M-ary…)
- The symbol rate that is transmitted on the channel
- The demodulation type (coherent, incoherent, differential…)

The basic figure of merit is the energy in a bit or symbol E_b divide by the noise power spectral density N_o, which is related to the SNR by the channel noise bandwidth *NBW* and the symbol rate *R* according to

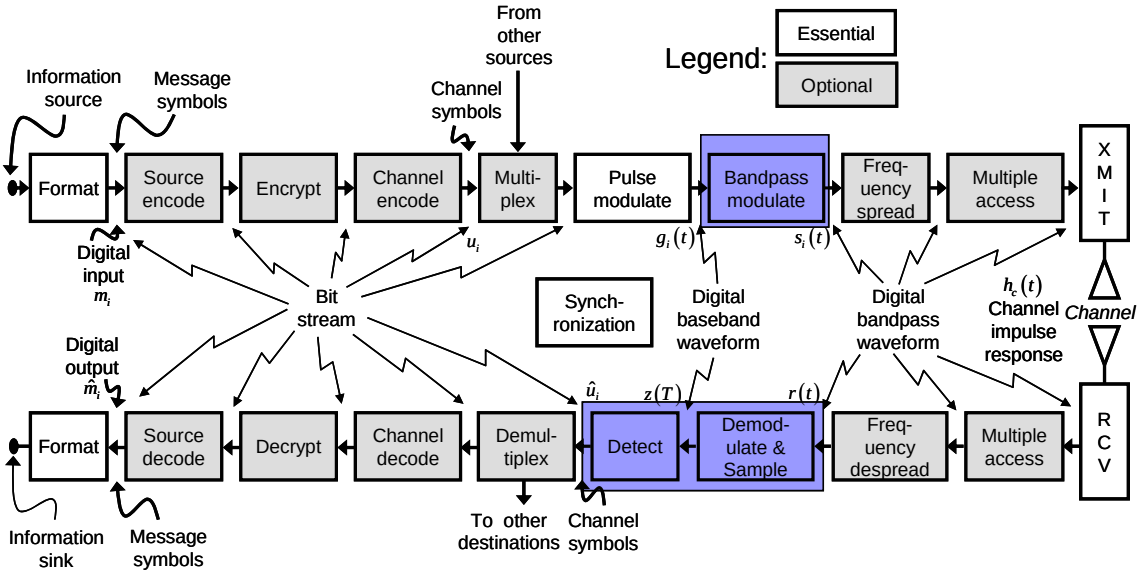
$$\left(\frac{E_b}{N_0}\right) = SNR \cdot \left(\frac{NBW}{R}\right).$$

Other topics in Chapter 3:

- Detection of Binary Signals in Gaussian Noise
- Inter-symbol Interference
- Equalization

For review, look at Problem 3.1 page 162. The general topic is orthogonality of binary signals, which is important to the coding topics in EE521.

Topics from Sklar Chapter 4, Bandpass Modulation and Demodulation



Why Modulate?

When our communication channel is a cable, we can transmit baseband signals. When we have an RF spectrum, the signals in the channel are modulated RF signals. Consideration in use of open-air RF channels include

- SNR, determined by
  - Transmit power.
  - Antenna gains.
  - Distance between transmitter and receiver.
  - Obstructions and other effects in the path between the transmitter and receiver.
  - Sources of noise other than receiver noise such as electrical machinery and other uses of the spectrum.
  - RF losses in the transmitter and receiver..
  - Other effects.
- Sharing the spectrum with other uses.
  - Multiple users in our communications design.
  - Other users not related to our use of the spectrum.
- Available bandwidth – a very significant restriction involving international agreements and allocations.
- The symbol rate we use to achieve our communications goals.

Since the bit error as a function of SNR is a function of the modulation technique, we devote a lot attention to this area. Functions of modulation include

- Preparation for wireless transmission
  - Formulation of the digital bandpass waveform.

    - Modulation on a carrier at RF in the allocated frequency band.
- Optional additional steps include:
    - Multiple access, obtained by multiplexing in time or frequency, or through interleaving symbols in blocks of data (Chapter 11, next semester).
    - Spread spectrum, obtained by additional modulation (Chapter 12, next semester).

Digital Bandpass Modulation Techniques

Baseband and bandpass techniques are laid out in Sklar's Figure 4.1 page 170. Please refer to that figure.

When we talked about sampling techniques last time, we added quadrature demodulation and digital bandpass sampling because these techniques are commonly used today.

Concept: Signal as a phasor

If you perform a coherent complex demodulation of a signal, the real and imaginary samples can be taken as the (x,y) components in a plot. The vector from the origin to this point is called a phasor. The length of the vector is the amplitude of the signal and its phase relative to the vector from the origin o (1,0) is the phase of the signal relative to that of the L.O. signal.

Detection of Signals in Gaussian Noise

Gaussian noise is two-dimensional on a phasor plot (why?). Use of the phasor plot is useful in diagramming coherent detection techniques as determination of regions in the plot in which a given bit or symbol is defined as the result of the detection operation.

Assignment for next time

- Load the Full Version of SystemView distributed on CD-ROM today and examine the samples and demos of the Sklar installation
- Read Sklar Chapter 3: 3.1, 3.2, 3.3, 3.4, 3.5 pp. 104-165
- Read Sklar Chapter 4: 4.1, 4.2, pp. 167-176
- Do problem 2.4 page 101
- Model Problem 2.4 page 101 in SystemView. Show plots from SystemView.

ALERT: Quiz Scheduled for February 22

Quiz will be designed for students to finish in one hour.
Rules are

- Open notes
- Open book
- No cell phones or RF-capable messaging
- No laptop computer
- Ask questions by writing them on a slip of paper and handing it to me. Answers will be on the whiteboard for all to see and use.

The quiz will begin at about 7:00 PM, and I will collect the quizzes at 8:25 PM.

ALERT: Term Project Assignment on February 22

Before the quiz on February 22, I will assign each of you an individual Term Project to be executed in SystemView. I will ask for progress reports from time to time during the semester. On April 26, the last day of class, we will schedule each of you about 15 minutes to present and demonstrate your term project. Also due at that time are

- Your slides or other presentation material.
- The SystemView file or files, and any data files used or produced by your demonstration.
- A report on your project, its design, and its execution. This short report will document the design and implementation of your term project and point out the issues that you discovered and the problems that you solved. A template will be posted on the web site for your report in the next few weeks. This template will include an outline and instructions that will provide you with information on how to prepare the report. Your presentation should follow the same basic outline and present the material in the report.