Teaching Digital Communications by Building a BPSK System

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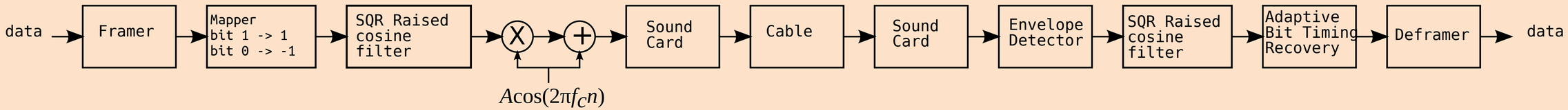
Complete BPSK Communications System as Implemented by Students



Introduction

Theoretical and simulation-based courses are less attractive and arguably less useful to industrial-oriented programs. How to enable undergraduate students to build, test and evaluate a complete digital communications system in one semester?

Solution

- Choose dynamic, interpreted languages such as Octave and Matlab.
- Use a computer's sound card as an analog front-end.
- Emphasize the importance of signal orthogonality.
- State the problem as learning to design, evaluate and optimize signals.
- Measure and evaluate the channel.
- Solve real-world effects such as timing and synchronization.

Benefits

It is possible for students to design and build a full communications system in one semester. Students learn the principles in depth while applying engineering methods to make theory agree with practice. The most common objection: This course lacks breadth – not a lot of textbook pages are covered.

Orthogonal Signaling

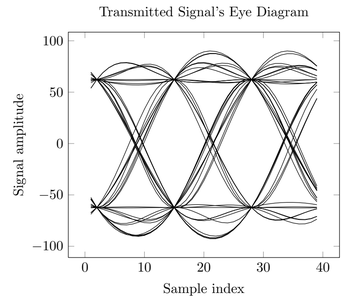
Emphasizing orthogonal signaling simplifies exposition. The problem of transmitting numbers x, y is reduced to generating a voltage $v(t) = xs_1(t) + ys_2(t)$. Reception is done by $\hat{x} = \int_{-\infty}^{\infty} v(t)s_1(t)dt = x$ and $\hat{y} = \int_{-\infty}^{\infty} v(t)s_2(t)dt = y$.

Signal Design

Students learn to design orthonormal signals that:

- Have a specified bandwidth.
- Meet a specified data rate.
- Meet the specifications of the computer's sound card.

Students also learn to use eye diagrams to evaluate a signal's quality, both in transmission and reception.

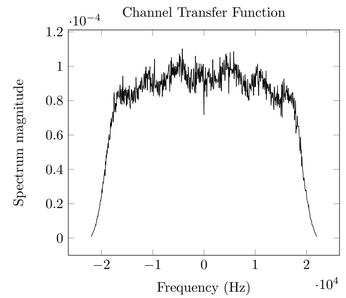


Channel

Students learn to find and understand a channel's response:

- Using white-noise or an impulse as input.
- Identify largest band where narrowband transmission is possible.

Every pair of computers will have a different channel.



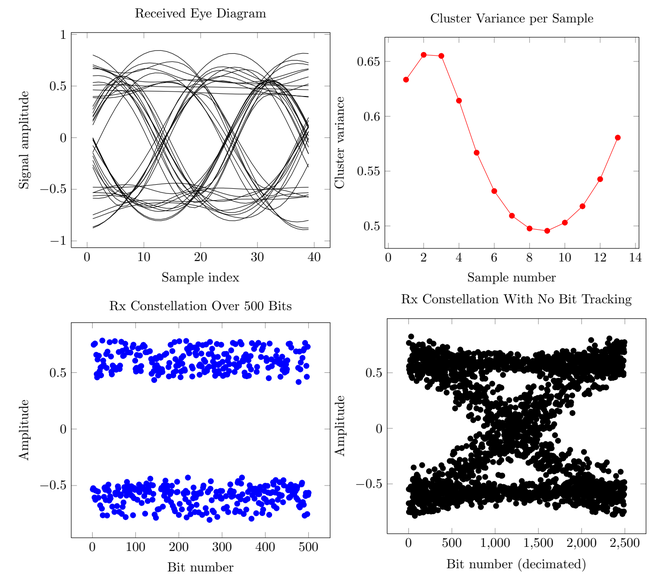
Synchronization

Carrier synchronization is difficult. The effects can be observed and then solved (inefficiently) using AM DSB-LC modulation.

Reception

After filtering and demodulation, the students:

- Get an open eye diagram.
- Achieve initial bit synchronization (the sound card's sampling clock is free-running and out of our control).
- Track bit timing to compensate transmitter-receiver clock differences.



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