

Final Project

Introduction to Analog and Digital Communications

Franklin W. Olin College of Engineering

1 Introduction

The purpose of this project is for you to exercise the material you learned in the digital communications portion of this class in a physical system, and to learn aspects of constructing a real digital communications system which are not covered in the regular classroom setting. Successful completion of this project will demonstrate your ability to design a communication system.

One possible tool you may use for the project is the universal software radio peripheral (USRP), which is a software defined radio platform to implement your system. The USRP is a box that can transmit and receive wireless signals but the processing of the transmitted and received signals are all done on host computers. There are several software tools to interface with the USRP, including an in-house tool that enables you to transmit and receive signals directly from MATLAB. However, you may choose to implement your system in different way, e.g. with discrete components (i.e. ICs), or other hardware.

This project is intended to be done by a team of three to four students. The final deliverables for the project are a report and a demonstration of your working system.

2 Project Requirements

2.1 Deliverables

1. ~ 1 week after project launch: A short (1 page) project proposal
2. Final project presentation
3. Final project report

2.2 Base Requirements

1. The project must involve digital communications.
2. The project must be sufficiently challenging and require you to exercise a subset of concepts learned in this class in a substantial fashion.
3. The project should incorporate at least one topic area that is NOT covered in class: e.g. error-control codes, adaptive channel equalization, encryption. The purpose of this requirement is for you to develop your self-learning skills.

2.3 USRP Requirements

If you choose to work on a wireless communications project using the USRP, the following shall be the requirements for your system. If your project is a different digital communications system, an appropriate set of requirements shall be discussed and mutually agreed upon with the instructor.

1. Communicate digital data across a wireless channel of at least 24 inches. An exception to this rule can be accommodated if you wish to use an appropriate wired channel. You are free to choose any type of data you want.
2. A bit-error rate of 10^{-4} or lower.
3. A net data rate of at least 64 kb/s – this is the net data rate of each packet taking into account any overhead. In other words, if you transmit a packet that is 0.01 seconds in duration which carries 640 payload data bits your data rate would be 64 kb/s.
4. You are not allowed to share any clock signal across your system. Hence, your system must either be robust to frequency and phase offsets between the transmitters and receivers, or it must compensate for these offsets.
5. An additional enhancement over the basic digital communication system. Some possible ideas include:
 - a. Error control coding. This refers to coding techniques used to carefully add redundancy to the transmitted data to enable up to a certain number of bit errors to be corrected at the receiver.
 - b. Source coding. This refers to compression of the source data so that it can be communicated more efficiently across the channel. Huffman coding is a good example of a source coding algorithm that would be suitable in terms of scope and complexity for this project.

c. Medium access control. This refers to protocols that are designed to reduce the probability of multiple users transmitting in the same frequency band at the same time. This will require multiple groups to work with each other, or some form of interaction with existing systems.

d. Orthogonal-Frequency-Division-Multiplexing. This is the modulation scheme used in WIFI systems.

Note that although there are plenty of libraries and code examples that accomplish the above (e.g. Huffman coding), but for the purposes of this class, you will need to implement it yourselves. This requirement is to ensure that you get a full understanding of the system. Your report should have a detailed description of your implementation.

6. Comply with applicable frequency restrictions.

2.4 Frequency restrictions

If you use the USRP system, it will be setup to operate in the 2.4 GHz band which is also the band used by Bluetooth and Wi-Fi networks. Thus, in order to not disrupt existing networks and to not interfere with other teams' communications, we ask that you coordinate with nearby teams, minimize transmit time, and minimize transmit power.

You should abide by all regulations governing radio transmission, including power levels and frequency bands. If you choose to construct your own circuits for RF transmission, there are various frequency bands available for experimental use with and without licensing. These are implementation-specific, so it is your team's responsibility to find appropriate frequency bands.