18-758 Thursday, October 17, 2013
Wireless Communications Professor Negi

Project Description (50 pts)

Due: Various dates throughout the semester

This handout describes the details of the course project.

Goal: The goal of the project is to build a working digital communication system, *using the principles of communication design taught in class*. The transmitter must transmit an interleaved convolutional coded MPSK-modulated passband signal. The receiver must decode this signal reliably.

Logistics: Each student must do the project individually. During the project, feel free to talk to the instructor and the TA regarding any difficulties you are having with the project. Students can also collaborate with each other to discuss problems that they are facing, and help debug each other's project code. This may include showing the signals that you are calculating, or snippets of your suspect code, to another student, who may help you spot your mistakes. However, code must be written individually by each student, even if the knowledge to do so was gained by collaborative discussions. *We will check for code plagiarism, so please do not copy each other's code.* For fairness, if you received significant help from any other student of the class, please note this in your project report, so that we can properly assign extra credit to that student (you will not be penalized for this). Further, grading in the project is on an absolute scale, so that your score will not be affected by the performance of other students.

Time-line: The time-line for the project is as follows.

- *Choose login*: By October 22. Send the TA your desired login name and password to set up your project account. Please *do not give us a password* that you use for other accounts, such as your Andrew account.
- *Mid-project presentation*: On November 5. You will demonstrate to the class, during class, that you completed part of the project. This will include showing a short presentation about the status of your project, followed by a live demonstration of your communication system using the software radio.
- *Final project presentation*: On December 3 and 5. You will demonstrate to the class, during class, that you completed the entire project. This will include showing a short presentation about your final project, followed by a live demonstration of your communication system using the software radio.
- *Final project report and code*: By 4 pm on December 12. Submit these by email to the TA in a single zipped directory.

Project grading: You must *demonstrate that you can apply the principles learnt in class* to design a digital wireless communication system. Formally, the grading is split into the following parts.

- *Mid-project check (15 points)*: You must demonstrate that you can use the USRP to transmit a passband signal (of which, you created the baseband components), and can receive the signal. You must be able to transmit and reliably decode at least one bit of information using your designed system. You will want to plot various figures

and compute various quantities such as transmit and receive signals and frequency responses. A live demonstration using the USRP is required in class. We will ask you questions to check your knowledge of your own Matlab code.

- *Final project check (25 points)*: You must give a class presentation, where you demonstrate that you can use the USRP to transmit a rate-1/2 interleaved convolutional-coded MPSK-modulated passband signal (of which, you created the baseband components), and can decode the corresponding received signal. Each packet of transmission must carry atleast 3000 information bits. The transmission must achieve $BER < 2 \times 10^{-3}$. You will want to plot various figures and compute various quantities such as transmit, receive, processed signals, the signal space, and coded and information BER. You can provide us a visual demonstration of the transmission, by using the supplied `shannon3036.bmp` bitmap image as the message (its length is 3036 user bits). A live demonstration using the USRP is required in class.

  You will be asked questions to check your knowledge of your own Matlab code. You will also be asked questions about your experiences in the project.

- *Final project report (10 points)*: Your two-page (excluding appendices) report must describe your Matlab code, difficulties that you had during the system design (if any), and how the design is similar to and different from the communication system design theory taught in class. Also acknowledge any help you received in the project from other students. *Attach your Matlab code as an appendix to the report.*

Hints: The following hints may help you design your system.

- Even a basic communication system will need timing synchronization. This means that, using Matlab processing, the receiver can line up the received signal with the transmitted signal. Thus, timing synchronization makes the time origins of the transmitter and receiver equal. For this purpose, you can consult Chapter 15, which discusses methods for timing recovery.
- Even at low rates of transmission, you may need to use a one-tap equalizer to correct for amplitude and phase offset. For this, you will need to estimate the channel gain h_0 using a pilot sequence.
- For the final project part, you may choose to do hard-decoding of the coded bits first, and then run the hard Viterbi decoder. This will incur some performance loss, but will be easier to implement than a soft Viterbi decoder that operates on the received samples directly.
- For the final project part, the code may not improve performance much, unless an interleaver (and de-interleaver) is used to break up error bursts. This is particularly true for long packets, where error bursts may occur due to the time-varying channel.
- For the final project part, you may need to correct or otherwise compensate for the small carrier frequency offset in the received signal. This will become particularly noticeable when the packet is long. For this purpose, you can consult Chapter 15, which discusses methods for carrier recovery.