EEE 431 (Fall 2019)

Project 2 (Sunday, December 15, midnight)

In this project, we explore details of the transmission process for several digital transmission schemes over additive white Gaussian noise (AWGN) channels.

We first consider binary (baseband) pulse amplitude modulation (PAM). Select a pulse of duration T (any pulse shape other than rectangular) for use in your binary transmission scheme, and simulate transmission of a large number of bits using the selected pulse with binary PAM.

To do this, generate a large number of bits randomly and accordingly determine the (sampled version of the) transmitted signal in Matlab. For the sampling period you can pick $T/20$ or something similar. By also simulating a white Gaussian noise process, obtain the corresponding received signal.

1. Simulate using Matlab the implementation of a matched filter type receiver, and make decisions on the transmitted bits. By running a large number of simulations obtain an error rate estimate. Comment on how your result compares with theoretical expectation.
2. Repeat part (1) with a different sampling rate. You should notice that the noise samples' variances should be adjusted to match the result in the first part.
3. In this part, instead of using the matched filter (to the pulse you have selected), consider the use of a receiver filter with a rectangular impulse response (extending from 0 to T). Estimate the error rates obtained using this receiver instead of the optimal one in part (1), and compare your results with the previous part and comment on your results.

We now study the effects of timing errors on the system performance.

4. Consider the matched filter type receiver (in part (1)), but assume that the receiver does not have the perfect timing information, and instead of sampling the matched filter outputs at the correct time instances, it is off by some ΔT. Pick 3-5 ΔT (e.g., $T/20$, $T/10$, $-T/20$, etc.) and repeat the simulations in part 1 to estimate the corresponding error rates as a function of the signal to noise ratio (for different timing errors). Compare your results with those with no timing error and comment on your results. (Note: for this part assume that the transmission takes place in isolation, i.e., there are no preceding or succeeding symbols. You only have noise (for a longer duration than the symbol period) along with the actual signal transmitted for the symbol period).
5. Repeat part 4 assuming that there are preceding and succeeding transmissions of other bits. In this case, in addition to a reduction in the signal part, you will also observe effects of the other consecutive symbol transmissions (causing interference, hence further performance degradation).

   Make sure to comment on your results as appropriate.

Next, we consider binary (orthogonal) frequency shift keying (FSK) with coherent and non-coherent detection over an AWGN channel.

6. Simulate binary orthogonal FSK with coherent detection by working with the actual (sampled versions of the) transmitted signals. Namely, pick the bit duration and the frequencies to be used, generate the transmitted signals as a function of time, include the channel effect (Gaussian noise), and implement correlation type receiver. Estimate the

error rates as a function of the signal to noise ratio and compare the results with the theoretical expectations.

7. Repeat part 6 for the case of non-coherent detection. In this case, include the effects of the channel propagation delay (i.e., introduction of the channel phase effects), and implement the envelop (or, square law) detector (described in class – see also the block diagram on page 505 Fig. 9.12, and section 9.5.2). Estimate the error rates as a function of the signal to noise ratio and compare the results with the theoretical expectations (see page 512) and with the error rates of coherent FSK.

Reporting Requirements:

Your report should contain all the relevant information about details of your results and detailed comments. The specific format is up to you, but please make sure to properly label each figure, include relevant captions, point to the right results in your explanations, etc. The report should include a title page, brief introduction and outline as well as any references used. The references used should be cited within the report wherever they are used. The report must be typed using an advanced word-processor (e.g. latex, word, etc), and should be submitted as a pdf file on the course moodle site (submission link to be provided).

Please also submit your Matlab codes as well. Submit your code as a single m-file (by copying and pasting all your codes including the Matlab functions all in one file).

One final note: Do your own work for all the parts. Your codes will be checked (using a software) for authenticity.