

COMMUNICATIONS REPORT

- Please hand in a report containing solutions to numbers **1 to 2** by **Sunday November 2^{ed} 11:59 PM** at the latest. Date for handing in the remaining problems will be **Thursday December 18th 11:59 PM**. **1** mark (out of a total 10) will be deducted for each day after the deadlines.
- This report can be done in groups with a maximum number of 5 students per group.
- Matlab, or similar programs, is to be used in this report.

Source Coding

1. Write a program to find the binary Huffman code of an independent discrete random variable. Test your code on the case when there is a source that produces 7 symbols with the following probabilities: 0.35, 0.30, 0.20, 0.10, 0.04, 0.005, and 0.005.
2. Write a program to find the binary Fano code of an independent discrete random variable. Test your code on the case when there is a source that produces 7 symbols with the following probabilities: 0.35, 0.30, 0.20, 0.10, 0.04, 0.005, and 0.005.

Channel Coding

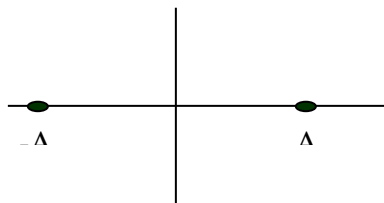
Assume you want to transmit 110000 information bits.

3. Use BPSK with no coding and plot a graph showing probability of error versus E_b/N_0 for $E_b/N_0 = -3$ to 10 dB where $E_b = A^2$.

Note: Use

$$\sigma = \sqrt{(E_b/2) \cdot 10^{-(e_{bno}/10)}};$$

where σ is noise power per dimension, E_b is energy per bit and e_{bno} is E_b/N_0 .



BPSK Constellation

4. Repeat 1, but use BPSK with repetition 3 coding, and use hard decision decoding:
 - (a) With same energy per transmitted bit.
 - (b) With same energy per information bit.

Plot each of the curves of (a) and (b) with the curve of 1 on the same graph.

If you are designing a communication system, can you think of a scenario where you will use such an error correction coding scheme as in (a) or (b) ?

5. Repeat 2, but use soft decision decoding. Again, think of a scenario where you will use such an error correction coding scheme.

6. Repeat 2 but use BPSK with a (7,4) Hamming code. You can use Matlab “encode” and “decode” functions.
 - (c) What is the minimum distance of this Hamming code?
 - (d) Would you recommend such a code if the purpose is to decrease the bit error rate using the same energy, but disregarding transmit time?

7. Repeat 2 but use BPSK with a (15,11) Hamming code.
 - (e) Would you recommend such a code if the purpose is to decrease the bit error rate using the same energy, but disregarding transmit time?
 - (f) If you want to keep transmission time equal to or less than the transmission time of 1, what would you propose?
 - (g) Plot a curve for the performance of your proposal in (b). Comment.

8. Now, assume you want to transmit 26200000 bit. Compare, on the same curve, at $E_b/N_0 = 5$ to 15 dB, between
 - (h) Using QPSK with no coding.
 - (i) Using 16 QAM but utilizing a (255,131) BCH code. Use Matlab “encode” and “decode” functions. Also, you can use the following functions for 16 QAM modulation and demodulation.

Modulation

```
function [rxsig]=mod16(txbits)
psk16mod=[1+j*1 3+j*1 1+j*3 3+j*3 1-j*1 3-j*1 1-j*3 3-j*3 -1+j*1 -3+j*1
-1+j*3 -3+j*3 -1-j*1 -3-j*1 -1-j*3 -3-j*3];
sigham=txbits;
m=4;
sigqam16=reshape(sigham,m,length(sigham)/m);
rxsig=(psk16mod(bi2de(sigqam16')+1));
```

Demodulation:

```
function [rxbits]=demod16(rxsig)
m=4;
psk16demod=[15 14 6 7 13 12 4 5 9 8 0 1 11 10 2 3];
rxsig(find(real(rxsig)>3))=3+j*imag(rxsig(find(real(rxsig)>3)));
rxsig(find(imag(rxsig)>3))=real(rxsig(find(imag(rxsig)>3)))+j*3;
rxsig(find(real(rxsig)<-3))=-3+j*imag(rxsig(find(real(rxsig)<-3)));
rxsig(find(imag(rxsig)<-3))=real(rxsig(find(imag(rxsig)<-3)))-j*3;
rxdemod=round(real((rxsig+3+j*3)/2))+j*round(imag((rxsig+3+j*3)/2));
rxdebi=real(rxdemod)+4*(imag(rxdemod));
sigbits=de2bi(psk16demod(rxdebi+1));
rxbits=reshape(sigbits',1,length(sigbits)*m);
```

Notes:

- (i) Use $E_b=2.5$.
- (ii) Simulation time: To speed up simulation time, at $E_bN_0=5$ to 8 you can only do 2620000 bits. You can, for example, do a loop 100 times for 26200 bits each, or whatever is faster on your computer. For $E_bN_0=9$ you will have to do 26200000 bits at least. For $E_bN_0=10$ to 15 you can assume linear interpolation between 8 and 15. Plot the curve from 5 to 15 dB.

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9. Write a Matlab code to convolutionally encode 1000 bits by the (2,3,K) code described by:

$$\begin{aligned}g_1^{(1)} &= [0 \ 1] \\g_2^{(1)} &= [1 \ 1] \\g_1^{(2)} &= [1 \ 1] \\g_2^{(2)} &= [1 \ 0] \\g_1^{(3)} &= [0 \ 0] \\g_2^{(3)} &= [1 \ 1]\end{aligned}$$
