



## COMMUNICATIONS REPORT

- Please hand in a report containing solutions to numbers **1 to 2** by **Sunday November 2<sup>nd</sup> 11:59 PM** at the latest. Date for handing in the remaining problems will be **Thursday December 18<sup>th</sup> 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

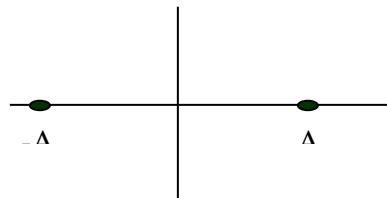
Assume you want to transmit 110000 information bits.

3. Use BPSK with no coding and plot a graph showing probability of error versus Eb/No for Eb/No=-3 to 10 dB where Eb=A<sup>2</sup>.

Note: Use

$$\text{segma} = \text{sqrt}((\text{Eb}/2)/10^{(\text{ebno}/10)});$$

where segma is noise power per dimension, Eb is energy per bit and ebno is Eb/No.



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) ?

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5. Repeat 2, but use soft decision decoding. Again, think of a scenario where you will use such an error correction coding scheme.
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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?
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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.
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8. Now, assume you want to transmit 26200000 bit. Compare, on the same curve, at Eb/No= 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*j 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 Eb=2.5.
- (ii) Simulation time: To speed up simulation time, at EbNo=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 EbNo=9 you will have to do 26200000 bits at least. For EbNo=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:

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

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