ASSIGNMENT 5

ELP-720 TELECOM NETWORK LAB

SARATH MOHAN (2021JTM2226)  
 &  
RAHUL SAHA (2021JTM2223)

A Report Presented for the assignment on Optimum Receiver Design

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Bharti School Of

Telecommunication Technology and Management

IIT Delhi India

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## PROBLEM STATEMENT:

* To design optimum receiver for performing signal detection.
* Considered 2 types of channels
  + - * y = x + n
      * y = x \* h + n

where

n = AWGN noise

h 🡪 Rayleigh dxn representing flat fading

* Implement BPSK modulation
* On the receiver side perform 2 kinds of demodulation techniques

1. ML detection
2. MAP detection

## 

## ALGORITHM

1. Initialized an array with a set of SNR values
2. Generated random input bits from the set {0,1}
3. The sample size has been taken as input from user
4. The prior probability of P(x=0) has been taken from user
5. Iterated over SNR values
   * 1. Simulated AWGN and Flat fading channels
     2. Decoded both in the receiver side using 2 detection schemes
        + 1. ML detection
          2. MAP detection
     3. Calculated BER for each SNR values
6. Finally, SNR vs BER has been plotted for both Flat fading and AWGN for both  
   ML and MAP

## PLOT:

Chart, line chart

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Chart, line chart, histogram

Description automatically generatedChart, line chart

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## CONCLUSION

* An optimum receiver has been designed using Maximum Likelihood and Maximum a posteriori estimation.
* We have modelled 2 channels

1. AWGN channel
2. Frequency flat channel

* BER vs SNR has been plotted by varying SNR.
* It has been found that the BER rate of MAP based receiver is dependent on the prior that we are choosing
* So, inducing a prior belief on to the receiver is only advantageous when we have a good idea of what the probability distribution of the transmitted bits be. If we don’t have any kind of data or belief, ML based receiver works better.

## APPENDIX

MATLAB CODE :

clear all;

SNR = [0.1,0.5,1,2,5,10,20]; % SNR loop for plotting BER

% Request for number of bits

option = input('Choose the number of bits to transfer \n 1 >>> 10^3 \n 2 >>> 10^4\n 3 >>> 10^6\n ------ ');

% Request for prior probability for MAP estimate

px0=input('Enter the prior prob of x=0 ---> ');

**if** option ==1

N = 10^3;

**elseif** option ==2

N = 10^4;

**else**

N = 10^6;

**end**

tx = randi([0,1],N,1); % Binary input vector

bpsk\_tx= 2\*tx - 1; % BPSK modulation

**for** i = 1:length(SNR)

NP = 10^(-0.1\*SNR(i)); % Finding noise power from given SNR

% AWGN noise

noise = NP\*randn(N,1);

noise2 = NP\*randn(N,1); % To create a rayleigh dxn

sigma = sqrt(NP);

% By making use of the fact that sqrt(X^2 + Y^2) is rayleigh dxn

% if X and Y are Gaussian

h = 1/sqrt(2)\*[sqrt(randn(N,1) + j\*randn(N,1))];

h =abs(h);

%h = raylpdf(noise,0.5);

y\_awgn = bpsk\_tx + noise;

% Frequency flat

y\_flat = bpsk\_tx.\*h + noise;

%-------- Receiver ----------------

% Performing ML detection

y\_ML\_awgn\_demod = ML\_demod(y\_awgn);

y\_ML\_flat\_demod = ML\_demod(y\_flat);

ML\_biterr\_awgn(i) = bit\_err(y\_ML\_awgn\_demod,tx);

ML\_biterr\_flat(i) = bit\_err(y\_ML\_flat\_demod,tx);

% Performing MAP detection

y\_MAP\_awgn\_demod = MAP\_demod(y\_awgn,px0,NP); %MAP demod function

y\_MAP\_flat\_demod = MAP\_demod(y\_flat,px0,NP);

MAP\_biterr\_awgn(i) = bit\_err(y\_MAP\_awgn\_demod,tx);

MAP\_biterr\_flat(i) = bit\_err(y\_MAP\_flat\_demod,tx);

**end**

%------- Display ------

disp('ML bit error : ')

disp(ML\_biterr\_awgn);

disp('MAP bit error : ')

disp(MAP\_biterr\_awgn);

disp('ML bit error : ')

disp(ML\_biterr\_flat);

disp('MAP bit error : ')

disp(MAP\_biterr\_flat);

%------ PLOT --------

figure;

subplot(1,2,1);

plot(SNR,ML\_biterr\_awgn);

hold on;

plot(SNR,MAP\_biterr\_awgn,'--');

xlabel('SNR');

ylabel('BER')

title("ML vs MAP for AWGN channel for P(x =0)="+px0);

legend('ML','MAP');

hold off;

subplot(1,2,2);

plot(SNR,ML\_biterr\_flat);

hold on;

plot(SNR,MAP\_biterr\_flat,'--');

xlabel('SNR');

ylabel('BER')

title("ML vs MAP for freq flat channel for P(x =0)="+px0);

legend('ML','MAP');

hold off;

% ------- Maximum Likelihood demodulation --------

**function** demod = ML\_demod(bits)

demod=[];

**for** i = 1:size(bits)

**if** bits(i)<0

demod=[demod;0];

**else**

demod=[demod;1];

**end**

**end**

**end**

%-------- Maximum Aposteriori Probability Receiver --------------------

**function** demod = MAP\_demod(bits,px0,NP)

demod=[];

**for** i = 1:size(bits)

**if** 4\*bits(i) <= -2\*NP\*log((1-px0)/px0)

demod=[demod;0];

**else**

demod = [demod;1];

**end**

**end**

**end**

% Bit error rate calculation

**function** error = bit\_err( y ,x)

error =0;

**for** i = 1:size(y)

**if** y(i)~= x(i)

error=error+1;

**end**

**end**

error = error/size(y,1);

**end**