ECE 300 Communication Theory Matlab Project 2 Using BCH

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Project Description

Our Goal in part 2 is to Achieve BER of 10^-6 at 12 dB SNR over moderate ISI channel using whatever means possible.

Algorithm Initialization

```
clear all;close all;clc
numIter = 5;  % The number of iterations of the simulation
nSym = 1000;    % The number of symbols per packet
SNR_Vec = 0:2:16;
lenSNR = length(SNR_Vec);

M = 4;        % The M-ary number, 2 corresponds to binary modulation

%chan = 1;          % No channel
chan = [1 .2 .4]; % Somewhat invertible channel impulse response,
 Moderate ISI
%chan = [0.227 0.460 0.688 0.460 0.227]';   % Not so invertible,
 severe ISI


% Create a vector to store the BER computed during each iteration
berVec = zeros(numIter, lenSNR);
eqlBerVec = zeros(numIter, lenSNR);
% Run the simulation numIter amount of times
```

Block code

```
N = 63;  % Codeword length
K = 24;  % Message length
S = K;  % Shortened message length

    % N and K have to be paired up. All valid pairs are shown by
 bchnumerr.
    % Small K can deal with more bits of error but low efficiency. BCH
 works
```

```
   % only if N and K are picked so that many parity bits are used.
 Therefore,
   % it is not ideal for maximizing bit rate. Demo of it working uses
 4-QAM.
```

BCH

```
bchnumerr(63)        %determine K given N. ie. N and K has to be a
 valid pair in the result
%gp = bchgenpoly(N,K);  %Tried but did not improve performance. Just
 go with default.
enc = comm.BCHEncoder(N,K);
dec = comm.BCHDecoder(N,K);


ans =

    63    57     1
    63    51     2
    63    45     3
    63    39     4
    63    36     5
    63    30     6
    63    24     7
    63    18    10
    63    16    11
    63    10    13
    63     7    15
```

Iteration

```
tic
for i = 1:numIter

   %  bits = randint(1, nSym*M, [0 1]);     % Generate random bits
   bits = randi(2,[K*nSym*log2(M), 1])-1;
   % New bits must be generated at every
   % iteration

   % If you increase the M-ary number, as you most likely will,
 you'll need to
   % convert the bits to integers. See the BIN2DE function
   % For binary, our MSG signal is simply the bits
   encodedMSG = enc(bits);

   for j = 1:lenSNR % one iteration of the simulation at each SNR
 Value

       tx =
 qammod(encodedMSG,M,'UnitAveragePower',true,'InputType','bit');
  %Input has to be bits.
```

```
        tx2 = 
qammod(bits,M,'UnitAveragePower',true,'InputType','bit');
 %This signal does not go through coding or equalizer. (Control for 
comparison and debugging )

        if isequal(chan,1)
            txChan = tx;
            txChan2 = tx2;
        elseif isa(chan,'channel.rayleigh')
            reset(chan) % Draw a different channel each iteration
            txChan = filter(chan,tx);
        else
            txChan = filter(chan,1,tx);  % Apply the channel.
            txChan2 = filter(chan,1,tx2);
        end

        % Convert from EbNo to SNR.
        % Note: Because No = 2*noiseVariance^2, we must add ~3 dB
        % to get SNR (because 10*log10(2) ~= 3).
        txNoisy = 
awgn(txChan,10*log10(log2(M))+SNR_Vec(j),'measured'); % Add AWGN
        txNoisy2 = 
awgn(txChan2,10*log10(log2(M))+SNR_Vec(j),'measured');
        %txNoisy = awgn(txChan,3+SNR_Vec(j),'measured'); % Add AWGN
        rx = txNoisy;
        rx2 = txNoisy2;
        %rx_demod = qamdemod(txNoisy,M); % Demodulate

        % Again, if M was a larger number, I'd need to convert my 
symbols
        % back to bits here.

        rxMSG = 
qamdemod(rx2,M,'UnitAveragePower',true,'OutputType','bit');
        noEqlMSG = 
qamdemod(rx,M,'UnitAveragePower',true,'OutputType','bit');   %Encoded 
but will not be equalized (for tuning and debugging)


        %Equilizer
        mu = 0.001; %step size
        trainlen = 200;
        n = 8; %number of weights
        const = qammod((0:1:M-1),M);
        trainSig=tx(1:trainlen);

        %LMS decision-feedback equalizer
        nfwd = 16;
        nfbk = 12;
        dfeLMS = dfe(nfwd,nfbk,lms(mu));
        dfeLMS.SigConst = const; % Set signal constellation.
        dfeLMS.ResetBeforeFiltering = 0;

        %RLS decision-feedback equalizer
```

```
        dfeRLS = dfe(nfwd,nfbk,rls(0.99,0.9));
        dfeRLS.SigConst = const; % Set signal constellation.
        dfeRLS.ResetBeforeFiltering = 0;

        %lms,linear
        %trainMSG = reshape(de2bi(tx(1:trainlen),log2(M)),[],1);
        linLMS = lineareq(n, lms(mu)); % Create an equalizer object.
        linLMS.SigConst = const; % Set signal constellation.
        linLMS.ResetBeforeFiltering = 0;

        %rls,linear
        linRLS = lineareq(n, rls(1,0.1)); % Create an equalizer
 object.
        linRLS.SigConst = const; % Set signal constellation.
        linRLS.ResetBeforeFiltering = 0;

        %Decide to use linear RLS after many trials because of its
 good
        %performance.


        [y,eqlSig] = equalize(linRLS,rx,trainSig); % Equalize.
        eqlMSG =
 qamdemod(eqlSig,M,'UnitAveragePower',true,'OutputType','bit');
        decodedMSG = dec(eqlMSG);
```

Compute and store the BER for this iteration

```
        %decodedMSG = bi2de(reshape(decodedMSG,log2(M),[]).');
        [zzz, berVec(i,j)] = biterr(bits, rxMSG);  % We're interested
 in the BER, which is the 2nd output of BITERR

        [zzz, eqlBerVec(i,j)] = biterr(bits(trainlen+1:end),
 decodedMSG(trainlen+1:end));        %For Block Code
        [zzz, eqlBerVec(i,j)] = biterr(bits(trainlen+1:end),
 decodedMSG(trainlen+1:end));

    end  % End SNR iteration
end      % End numIter iteration
time = toc;
time
```

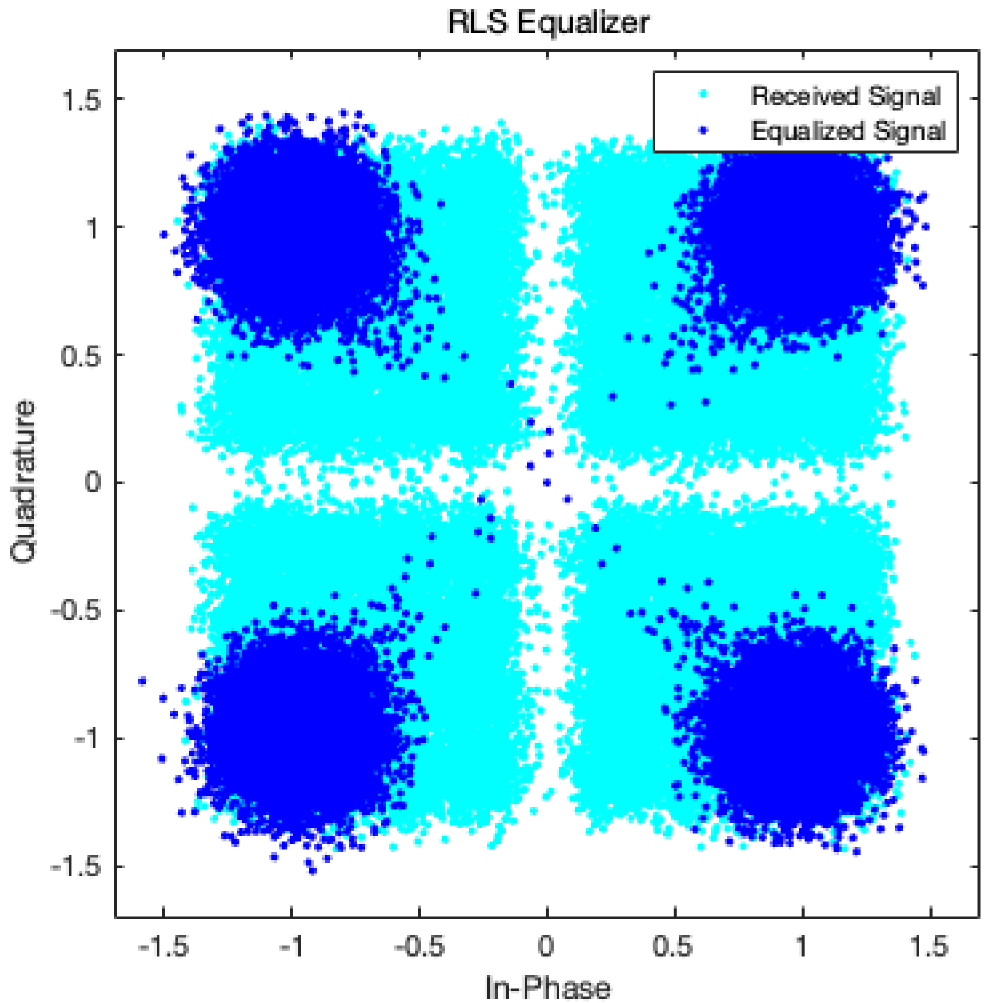
```
time =

  174.2056
```

Plots

```
    %Played with M-ary QAM Scatter plot to see how equilizers work on
%
h = scatterplot(rx,1,0,'c.');
hold on
```

```
scatterplot(y,1,0,'b.',h)
legend('Received Signal','Equalized Signal')
title('RLS Equalizer')
hold off
%
```

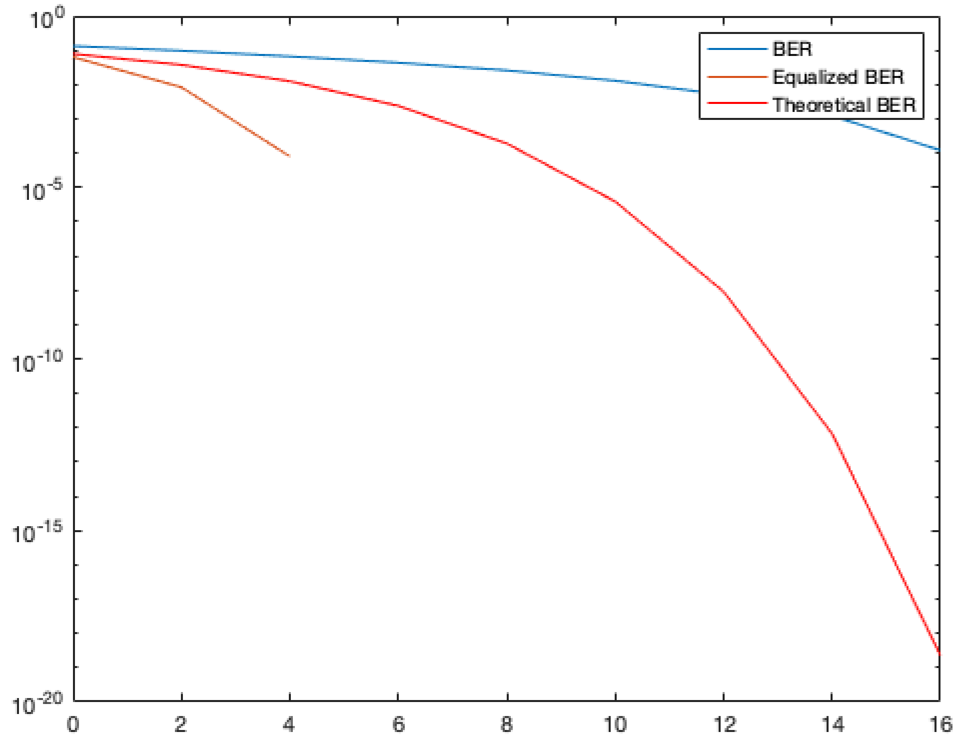


Compute and plot the mean BER. The result at 12dB is 0. Which fits the requirement.

```
figure;
ber = mean(berVec,1);
eqlBer = mean(eqlBerVec,1);
semilogy(SNR_Vec, ber);
hold on
semilogy(SNR_Vec, eqlBer);

berTheory = berawgn(SNR_Vec,'qam',M);
hold on
semilogy(SNR_Vec,berTheory,'r')
```

```
legend('BER', 'Equalized BER','Theoretical BER')
```



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