

```
% 1. Write a Matlab program to evaluate performance of a 1/2-rated convolutionally encoded DS CDM
% This program has been developed to study BER performance of a 1/2-rated convolutionally encoded
% for a single user under AWGN channel
```

```
clear all;
close all;
msg=round(rand(1,1000)); %%msg is a random bit sequence of length 1000.
%1/2 rated convolutional Encoder %%Creates a rate-1/2 convolutional encoder with memory order 3.
trellis=poly2trellis(3,[6 7]); %%defines the trellis structure with generator polynomials 6 (binary
user=convenc(msg,trellis); %%encodes the 1000 bits into a longer sequence (since rate is 1/2, output
% Convolutionally encoded data(0,1) are mapping into +1/-1
%% To convert the binary sequences to bipolar NRZ format
length_user=length(user); %% After convolutional encoding, we have a binary sequence {0,1}
for i=1:length_user %%This loop changes all 0s to -1, effectively mapping {0,1} → {-1,-
if user(i)==0
user(i)=-1; %%After this, user contains +1 or -1.
end
end
fc=5000; %%carrier frequency, %KHz
eb=.5; %% energy per bit for BPSK
bitrate=1000; %% 1KHz
tb=1/bitrate; %% time per bit of message sequence .each bit is 1 ms (tb = 1/1000 = 0.001 s).
chiprate=10000; %%each chip is tc = 1/10000 = 0.0001 s. The ratio of chip rate to bit rate is 10:1, meaning
tc=1/chiprate;
%% CDMA transmitter for a single user
t=tc:tc:tb*length_user;
%%plotting base band signal for user
basebandsig=[];
for i=1:length_user
for j=tc:tc:tb
if user(i)==1
basebandsig=[basebandsig 1];
else
basebandsig=[basebandsig -1];
end
end
end
figure(1)
stairs(t(1:800),basebandsig(1:800)) %%Plots the first 800 samples to show a segment of the baseband
xlabel('Time(sec)')
ylabel('Binary value')
set(gca,'ytick',[ -1 1 ])
title('A segment of original binary sequence for a single user')
%% BPSK Modulation
bpskmod=[]; %%For each bit (of duration tb), the code multiplies the carrier cosine
for i=1:length_user
for j=tc:tc:tb
bpskmod=[bpskmod sqrt(2*eb)*user(i)*cos(2*pi*fc*j)];
end
end
%length(bpskmod)
number=length(t); %Total number of time segments
spectrum=abs(fft(bpskmod));
```

```

sampling_frequency=2*fc;
sampling_interval=(1.0/sampling_frequency);
nyquest_frequency=1.0/(2.0*sampling_interval);
for i=1:number
frequency(i)=(1.0/(number*sampling_interval)).*i;
end
figure(2)
plot(frequency,spectrum)
title('Frequency Domain analysis of BPSK modulated signal for a single user')
xlabel('Frequency (Hz)')
ylabel('Magnitude')
grid on
%% PN generator for a single user
%% let initial seed for a single user is 1000
seed=[1 -1 1 -1]; %convert it into bipolar NRZ format
spreadspectrum=[];
pn=[];
for i=1:length_user
for j=1:10 %chip rate is 10 times the bit rate
pn=[pn seed(4)];
if seed (4)==seed(3) temp=-1;
else temp=1;
end
seed(4)=seed(3); %%seed is simply the starting register state used to generate the PN sequence for sprea
seed(3)=seed(2);
seed(2)=seed(1);
seed(1)=temp;
end
end
% each bit has 100 samples. and each pn chip has 10 samples. there r
% 10 chip per bit there fore size of pn samples and original bit is same
pnupsampled=[];
len_pn=length(pn);
for i=1:len_pn
for j=10*tc:10*tc:tb
if pn(i)==1
pnupsampled=[pnupsampled 1];
else
pnupsampled=[pnupsampled -1];
end
end
end
length_pnupsampled=length(pnupsampled);
sigtx=bpskmod.*pnupsampled;
figure(3)
plot(t(1:200), sigtx(1:200))
title('A segment of Transmitted DS CDMA signal')
xlabel('Time(sec)')
ylabel('Amplitude')
grid on
%%%%%%%%%%%%AWGN CHANNEL%%%%%%%%%%%%
%snr_in_dBs=1;

```

```

snr_in_dBs=0:1.0:10;
for m=1:length(snr_in_dBs)
ber(m)=0.0;
composite_signal=awgn(sigtx,snr_in_dBs(m),'measured'); %% SNR of % dbs
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%DEMODULATION FOR USER 1%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
rx=composite_signal.*pnupsampled;
%%%%% BPSK demodulation for a single user
demodcar=[];
for i=1:length_user
for j=tc:tc:tb
demodcar=[demodcar sqrt(2*eb)*cos(2*pi*fc*j)];
end
end
bpskdemod=rx.*demodcar;
len_dmod=length(bpskdemod);
sum=zeros(1,len_dmod/10);
for i=1:len_dmod/10
for j=(i-1)*10+1:i*10
sum(i)=sum(i)+bpskdemod(j);
end
end
sum;
rxbits=[];
for i=1:length_user
if sum(i)>0
rxbits=[rxbits 1];
else
rxbits=[rxbits 0];
end
end
tblen = 3; delay = tblen; % Traceback length
decoded = vitdec(rxbits,trellis,tblen,'cont','hard');
[number,rat] = biterr(decoded(delay+1:end),msg(1:end-delay));
ber(m)=rat;
end % for m
figure(4)
plot(snr_in_dBs,ber);
xlabel('Signal to noise ratio(dB)');
ylabel('BER');
legend('BER simulation for a single user');
title(' Coded BER simulation under AWGN chaanel ')
grid on

```

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```

% 2. Write a Matlab program to evaluate performance of a 1/2-rated convolutionally encoded DS CDMA
% This program has been developed to study BER performance of a 1/2-rated convolutionally encoded
% for a single user under AWGN and Rayleigh fading channel

```

```

clear all;
close all;
msg=round(rand(1,1000));
%1/2 rated convolutional Encoder

```

```

trellis=poly2trellis(3,[6 7]);
user=convenc(msg,trellis);
% Convolutionally encoded data(0,1) are mapping into +1/-1
%% To convert the binary sequences to bipolar NRZ format
length_user=length(user);
for i=1:length_user
if user(i)==0
user(i)=-1;
end
end
fc=5000; %%carrier frequency, %KHz
eb=.5;    %% energy per bit
bitrate=1000; % 1KHz
tb=1/bitrate; %% time per bit of message sequence
chiprate=10000;
tc=1/chiprate;
%% CDMA transmitter for a single user
t=tc:tc:tb*length_user;
%%plotting base band signal for user
basebandsig=[];
for i=1:length_user
for j=tc:tc:tb
if user(i)==1
basebandsig=[basebandsig 1];
else
basebandsig=[basebandsig -1];
end
end
end
figure(1)
stairs(t(1:800),basebandsig(1:800))
xlabel('Time(sec)')
ylabel('Binary value')
set(gca,'ytick',[ -1 1 ])
title('A segment of original binary sequence for a single user')
%%%% BPSK Modulation
bpskmod=[];
for i=1:length_user
for j=tc:tc:tb
bpskmod=[bpskmod sqrt(2*eb)*user(i)*cos(2*pi*fc*j)];
end
end
%length(bpskmod)
number=length(t); %Total number of time segments
spectrum=abs(fft(bpskmod));
sampling_frequency=2*fc;
sampling_interval=(1.0/sampling_frequency);
nyquist_frequency=1.0/(2.0*sampling_interval);
for i=1:number
frequency(i)=(1.0/(number*sampling_interval)).*i;
end
figure(2)

```

```

plot(frequency,spectrum)
title('Frequency Domain analysis of BPSK modulated signal for a single user')
xlabel('Frequency (Hz)')
ylabel('Magnitude')
grid on
%% PN generator for a single user
%% let initial seed for a single user is 1000
seed=[1 -1 1 -1]; %convert it into bipolar NRZ format
spreadspectrum=[];
pn=[];
for i=1:length_user
for j=1:10 %chip rate is 10 times the bit rate
pn=[pn seed(4)];
if seed (4)==seed(3) temp=-1;
else temp=1;
end
seed(4)=seed(3);
seed(3)=seed(2);
seed(2)=seed(1);
seed(1)=temp;
end
end
% each bit has 100 samples. and each pn chip has 10 samples. there r
% 10 chip per bit there fore size of pn samples and original bit is same
pnupsampled=[];
len_pn=length(pn);
for i=1:len_pn
for j=10*tc:10*tc:tb
if pn(i)==1
pnupsampled=[pnupsampled 1];
else
pnupsampled=[pnupsampled -1];
end
end
end
length_pnupsampled=length(pnupsampled);
sigtx=bpskmod.*pnupsampled;
figure(3)
plot(t(1:200), sigtx(1:200))
title('A segment of Transmitted DS CDMA signal')
xlabel('Time(sec)')
ylabel('Amplitude')
grid on
%%%%%%%%%%%%Adding fading channel effect%%%%%%%%%%%%
chan=rayleighchan(1/chiprate,100);
chan.ResetBeforeFiltering=0;
fad=abs(filter(chan,ones(size(sigtx))));
fadedsig=fad.*sigtx;
snr_in_dBs=0:1.0:10;
for m=1:length(snr_in_dBs)
ber(m)=0.0;
composite_signal=awgn(fadedsig,snr_in_dBs(m),'measured'); %% SNR of % dbs

```

```

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%DEMODULATION FOR USER 1%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
rx=composite_signal.*pnupsampled;
%%%%% BPSK demodulation for a single user
demodcar=[];
for i=1:length_user
for j=tc:tc:tb
demodcar=[demodcar sqrt(2*eb)*cos(2*pi*fc*j)];
end
end
bpskdemod=rx.*demodcar;
len_dmod=length(bpskdemod);
sum=zeros(1,len_dmod/10);
for i=1:len_dmod/10
for j=(i-1)*10+1:i*10
sum(i)=sum(i)+bpskdemod(j);
end
end
sum;
rxbits=[];
for i=1:length_user
if sum(i)>0
rxbits=[rxbits 1];
else
rxbits=[rxbits 0];
end
end
tblen = 3; delay = tblen; % Traceback length
decoded = vitdec(rxbits,trellis,tblen,'cont','hard');
[number,rat] = biterr(decoded(delay+1:end),msg(1:end-delay));
ber(m)=rat;
end % for m
figure(4)
plot(snr_in_dBs,ber);
xlabel('Signal to noise ratio(dB)');
ylabel('BER');
legend('BER simulation for a single user');
title(' Coded BER simulation under AWGN and Rayleigh fading channel ')
grid on

```

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```

% 3. Write a Matlab program to evaluate performance of a 1/2-rated convolutionally encoded DS CDMA
% This program has been developed to study BER performance of a 1/2-rated convolutionally encoded
% for a single user under AWGN and Rician fading channel
clear all;
close all;
msg=round(rand(1,1000));
%1/2 rated convolutional Encoder
trellis=poly2trellis(3,[6 7]);
user=convenc(msg,trellis);
% Convolutionally encoded data(0,1) are mapping into +1/-1

```

```

%% To convert the binary sequences to bipolar NRZ format
length_user=length(user);
for i=1:length_user
    if user(i)==0
        user(i)=-1;
    end
end
fc=5000; %%carrier frequency, %KHz
eb=.5;    %% energy per bit
bitrate=1000; %% 1KHz
tb=1/bitrate; %% time per bit of message sequence
chiprate=10000;
tc=1/chiprate;
%% CDMA transmitter for a single user
t=tc:tc:tb*length_user;
%%plotting base band signal for user
basebandsig=[];
for i=1:length_user
    for j=tc:tc:tb
        if user(i)==1
            basebandsig=[basebandsig 1];
        else
            basebandsig=[basebandsig -1];
        end
    end
end
figure(1)
stairs(t(1:800),basebandsig(1:800))
xlabel('Time(sec)')
ylabel('Binary value')
set(gca,'ytick',[ -1 1 ])
title('A segment of original binary sequence for a single user')
%% BPSK Modulation
bpskmod=[];
for i=1:length_user
    for j=tc:tc:tb
        bpskmod=[bpskmod sqrt(2*eb)*user(i)*cos(2*pi*fc*j)];
    end
end
%length(bpskmod)
number=length(t); %Total number of time segments
spectrum=abs(fft(bpskmod));
sampling_frequency=2*fc;
sampling_interval=(1.0/sampling_frequency);
nyquist_frequency=1.0/(2.0*sampling_interval);
for i=1:number
    frequency(i)=(1.0/(number*sampling_interval)).*i;
end
figure(2)
plot(frequency,spectrum)
title('Frequency Domain analysis of BPSK modulated signal for a single user')
xlabel('Frequency (Hz)')

```

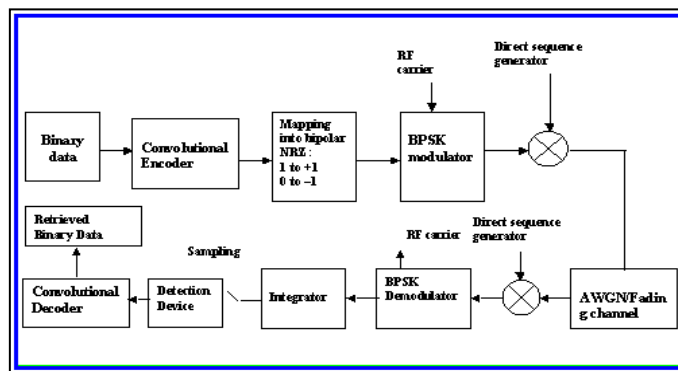
[illegible]



```

demodcar=[];
for i=1:length_user
for j=tc:tc:tb
demodcar=[demodcar sqrt(2*eb)*cos(2*pi*fc*j)];
end
end
bpskdemod=rx.*demodcar;
len_dmod=length(bpskdemod);
sum=zeros(1,len_dmod/10);
for i=1:len_dmod/10
for j=(i-1)*10+1:i*10
sum(i)=sum(i)+bpskdemod(j);
end
end
sum;
rxbits=[];
for i=1:length_user
if sum(i)>0
rxbits=[rxbits 1];
else
rxbits=[rxbits 0];
end
end
tblen = 3; delay = tblen; % Traceback length
decoded = vitdec(rxbits,trellis,tblen,'cont','hard');
[number, rat] = biterr(decoded(delay+1:end),msg(1:end-delay));
ber(m)=rat;
end % for m
figure(4)
plot(snr_in_dBs,ber);
xlabel('Signal to noise ratio(dB)');
ylabel('BER');
legend('BER simulation for a single user');
title(' Coded BER simulation under AWGN and Rician fading channel ')
grid on

```



**Block diagram of a convolutionally encoded DS CDMA system**

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**%4. Write a Matlab program to study the performance of a differentially encoded QPSK based wireless**

```
clear all;
close all;
xbit=[1 0 1 1 0 1 0 0 0 1 1 0];
% Initial reference bit is assumed to be 1
% Binary bit stream is in 0 and 1 : 12 bits
% NOT of Exclusive OR operation
difencod(1)=~(1-xbit(1));
for i=2:length(xbit)
difencod(i)=~(difencod(i-1)-xbit(i));
end
% Differential Encoded binary bit stream
xbit(1)=1-~(difencod(1));
for i=2:length(xbit)
xbit(i)=difencod(i-1)-~(difencod(i));
if(xbit(i)==-1)
xbit(i)=1;
end
end
%Inphase unipolar bit stream
%from differentially encoded baseband
for i=1:2:(length(difencod)-1)
inp(i)=difencod(i);
inp(i+1)=inp(i);
end
%Quadrature unipolar bit stream
%from differentially encoded baseband
for i=2:2:(length(difencod))
qp(i)=difencod(i);
qp(i-1)=qp(i);
end
%Inphase bipolar NRZ bit stream
for i=1:(length(inp))
if(inp(i)== 1)
it(i)=1;
elseif(inp(i)==0)
it(i)=-1;
end
end
%Quadrature bipolar NRZ bit stream
for i=1:(length(qp))
if(qp(i)== 1)
qt(i)=1;
elseif(qp(i)==0)
qt(i)=-1;
end
end
% Raised Cosine Filter used
filtorder = 40; % Filter order
```

```

nsamp=4;
delay = filtorder/(nsamp*2);
rolloff = 0.5; % Rolloff factor of filter
rrcfilter = rcosine(1,nsamp,'fir/normal',rolloff,delay);
% Plot impulse response.
figure(1);
impz(rrcfilter,1);
grid on
%title(' Impulse response of Raised Cosine Filter');
%% Transmitted Signal
% Upsample and apply raised cosine filter.
itx = rcosflt(it,1,nsamp,'filter',rrcfilter);
Drate=64000;%Bit rate
T=1/Drate;
Ts=T/nsamp;
time=0:Ts:(length(itx)-1)*Ts;
figure(2);
plot(time,itx)
%title(' Low pass filtered InPhase Component');
xlabel( 'Time(sec)');
ylabel( 'Amplitude(volt)');
grid on
tme=Ts:Ts:(length(itx)-1)*Ts+Ts;
qtx = rcosflt(qt,1,nsamp,'filter',rrcfilter);
figure(3);
plot(tme,qtx)
title(' Low pass filtered Quadrature Component');
xlabel( 'Time(sec)');
ylabel( 'Amplitude(volt)');
grid on
fc=900*100000;% 900MHz Carrier frequency chosen
dd=2*pi*fc*time';
ddd=2*pi*fc*tme';
% One bit or 1/2 of symbol delay consideration in OQPSK
delay(1:nsamp)=0.0;
delay((nsamp+1):length(qtx))=qtx(1:(length(qtx)-nsamp));
half=filtorder/2;
mt=(cos(dd)).*itx+(sin(ddd)).*delay';
figure(4);
plot(time,mt)
xlabel( 'Time(sec)');
ylabel( 'Amplitude(volt)');
title(' Differentially encoded OQPSK modulated signal');
grid on
snr=10;
%Signal-to-noise ratio per sample is assumed to be 10
madd=awgn(mt,snr);
figure(5);
plot(time,madd)
grid on
xlabel( 'Time(sec)');
ylabel( 'Amplitude(volt)');

```

```

%title(' Differentially encoded OQPSK modulated signal with added white noise');
cscomp=mt.*(cos(dd));
sincomp=mt.*(sin(ddd));
plot(time,cscomp)
grid on
xlabel( 'Time(sec)');
ylabel( 'Amplitude(volt)');
lpfin = rcosflt(cscomp,1,nsamp,'filter',rrcfilter);
lpfqu = rcosflt(sincomp,1,nsamp,'filter',rrcfilter);
tmx=0:Ts:(length(lpfin)-1)*Ts;
tmy=Ts:Ts:(length(lpfqu)-1)*Ts+Ts;
figure(5);
plot(tmx,lpfin)
grid on
xlabel( 'Time(sec)');
ylabel( 'Amplitude');
figure(6);
plot(tmy,lpfqu)
grid on
xlabel( 'Time(sec)');
ylabel( 'Amplitude(volt)');
% Initial checking for I and Q channel bit stream
itxx=itx(half:nsamp:length(xbit)*nsamp+half-1);
for i=1:1:length(itxx)
if(itxx(i)> 0)
chk1(i)=1;
elseif(itxx(i)< 0)
chk1(i)=-1;
end
end
ityy=qtx(half:nsamp:length(xbit)*nsamp+half-1);
for i=1:1:length(ityy)
if(ityy(i)> 0)
chk2(i)=1;
elseif(ityy(i)< 0)
chk2(i)=-1;
end
end
disp('I channel bit stream checking')
distortion = sum((it-chk1).^2)/length(chk1); % Mean square error
distortion
disp('Q channel bit stream checking')
distortion = sum((qt-chk2).^2)/length(chk2); % Mean square error
distortion
% Differentially decoded bit stream from I and Q channels
for i=1:2:(length(xbit)-1)
dfd(i)=chk1(i);
end
for i=2:2:(length(xbit))
dfd(i)=chk2(i);
end

```

```

for i=1:(length(xbit))
if(dfid(i)== 1)
dfdecod(i)=1;
elseif(dfid(i)==-1)
dfdecod(i)=0;
end
end
detected(1)=1--(dfdecod(1));
for i=2:length(xbit)
detected(i)=dfdecod(i-1)-(~dfdecod(i));
if(detected(i)==-1)
detected(i)=1;
end
end
disp('Distortion between transmitted and received NRZ bit stream')
distortion = sum((xbit-detected).^2)/length(detected); % Mean square error
distortion
tmx=0:(1/64000):(1/64000).*(length(xbit)-1)
figure(7);
subplot(211)
stairs(tmx,xbit)
set(gca,'ytick',[ 0 1 ])
grid on
xlabel( 'Time(sec)');
ylabel( 'Binary value');
title(' Transmitted bit stream ');
subplot(212)
stairs(tmx,detected)
xlabel( 'Time(sec)');
set(gca,'ytick',[ 0 1 ])
ylabel( 'Binary value');
title(' Received bit stream ');
grid on

```

**Expt 5: Develop a matlab source to simulate an Interleaved FEC encoded wireless communication system with implementation of BPSK digital modulation technique**  
**Show atleast three waveforms generated at different sections of the simulated system**

```

clear all;
close all;
% Test with synthetically generated sinusoidal wave
f=1000;% Frequency of the audio signal
Fs =4000; % Sampling rate is 4000 samples per second.
t = [1/Fs:1/Fs:1];% total time for simulation=0.05 second.
% Number of samples=4000
Am=1.0;
signal = Am*sin(2*pi*1000*t); % Original signal
figure(1);
plot(t(1:200),signal(1:200))
set(gca,'ytick',[ -1.0 0 1.0 ])

```

```

title('A segment of synthetically generated sinusoidal wavform')
grid on
xlabel( 'time(sec)');
ylabel( 'Amplitude(volt)');
maximumvalue=max(signal);
minimumvalue=min(signal);
interval=(maximumvalue-minimumvalue)/255; % interval:
partition = [minimumvalue:interval:maximumvalue]; % -1:0.0078:1
codebook = [(minimumvalue-interval):interval:maximumvalue]; % -1.0078:0.0078:1
[index,quants,distor] = quantiz(signal,partition,codebook);
% Conversion of deci into binary from least to most significant
indxtrn=index';
for i=1:4000
matrix(i,1:1:8)=bitget(uint8(indxtrn(i)),1:1:8);
end,
% matrix is of 4000 rows X 8 columns
% matrixtps is a matrix of 8 rows X4000 columns
matrixtps=matrix';
% Baseband is produced, it has 32000 bits
baseband=reshape(matrixtps,4000*8,1);
Tb=1/32000;
% bit rate 32 kbps
time=[0:Tb:1];
figure(2);
stairs(time(1:500),baseband(1:500))
title(' A segment of baseband signal')
xlabel('Time(sec)')
ylabel('Binary value')
set(gca,'ytick',[0 1 ])
axis([0,time(500),0,1])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% Serial the data for the next step.
input_to_Convolutional_encoder = baseband'; % 1 X 32000
%Now, the binary converted data is sent to th Convolutional encoder.
t=poly2trellis(7, [171 133]);
%Channel coding
code = convenc(input_to_Convolutional_encoder,t); % 1 x 64000
%Interleaving
st2 = 4831;
data_interleave = randintrlv(code,st2); % Interleave, 1 row x 64000 columns
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%Binary phase shift keying modulation
M=2;
k=log2(M);
% bit to symbol mapping
symbol=bi2de(reshape(data_interleave,k,length(data_interleave)/k).','left-msb');
symbol=double(symbol);
Binary_phase_shift_keying_modulated_data = pskmod(symbol,M);
%demodulation of Binary phase shift keying data
Binary_phase_shift_keying_demodulated_data = pskdemod(Binary_phase_shift_keying_modulated_da
[number,ratio]= symerr(symbol,Binary_phase_shift_keying_demodulated_data) % symbol error
%symbol to bit mapping

```

### %1-bit symbol to Binary bit mapping

```
Retrieved_bit = de2bi(Binary_phase_shift_keying_demodulated_data,'left-msb');
```

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
```

### % Deinterleaving

```
errors = zeros(size(Retrieved_bit));
```

```
inter_err = bitxor(Retrieved_bit,errors); % Include burst error.
```

```
data_deinterleave=randdeintrlv(inter_err,st2);
```

### %Convolutional Decoding

```
tblen=3;
```

```
decodx= vitdec(data_deinterleave,t,tblen,'cont','hard'); %
```

```
N3=length(decodx);
```

```
NN=N3/8;
```

```
decod2(1:(N3-3))=decodx(tblen+1:end);
```

```
decod2(N3)=decodx(1);
```

```
decod2=decod2' ; % 32000 X 1
```

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
```

```
baseband=double(baseband);
```

```
[number,ratio]= biterr(decod2,baseband);
```

```
convert=reshape(decod2,8,4000); % First reshaping and then transposing
```

```
matrixtps=double(matrixtps);
```

```
[number,ratio]= biterr(convert,matrixtps);
```

```
convert=convert' ; % 4000 rows X 8 columns
```

```
%binary to decimally converted value
```

```
intconv=bi2de(convert); % converted into interger values(0-255) of 4000 samples
```

```
% intconv is 4000 rows X 1 column
```

```
[number,ratio]= biterr(intconv,index');
```

```
sample_value=minimumvalue +intconv.*interval;
```

```
figure(3)
```

```
subplot(2,1,1)
```

```
plot(time(1:100),signal(1:100));
```

```
set(gca,'ytick',[ -1.0 0 1.0 ])
```

```
axis([0,time(100),-1,1])
```

```
title('Graph for a segment of recoded Audio signal')
```

```
xlabel('Time(sec)')
```

```
ylabel('Amplitude')
```

```
grid on
```

```
subplot(2,1,2)
```

```
plot(time(1:100),sample_value(1:100));
```

```
axis([0,time(100),-1,1])
```

```
set(gca,'ytick',[ -1.0 0 1.0 ])
```

```
title('Graph for a segment of retrieved Audio signal')
```

```
xlabel('Time(sec)')
```

```
ylabel('Amplitude')
```

```
grid on
```

---

Expt 6: Develop a matlab source to simulate an Interleaved FEC encoded wireless communication system with implementation of QPSK digital modulation technique  
Show atleast three waveforms generated at different sections of the simulated system

```

clear all;
close all;
% Test with synthetically generated sinusoidal wave
f=1000;% Frequency of the audio signal
Fs =4000; % Sampling rate is 4000 samples per second.
t = [1/Fs:1/Fs:1];% total time for simulation=0.05 second.
% Number of samples=4000
Am=1.0;
signal = Am*sin(2*pi*1000*t); % Original signal
figure(1);
plot(t(1:200),signal(1:200))
set(gca,'ytick',[-1.0 0 1.0 ])
title('A segment of synthetically generated sinusoidal waveform')
grid on
xlabel('time(sec)');
ylabel('Amplitude(volt)');
maximumvalue=max(signal);
minimumvalue=min(signal);
interval=(maximumvalue-minimumvalue)/255; % interval:
partition = [minimumvalue:interval:maximumvalue]; % -1:0.0078:1
codebook = [(minimumvalue-interval):interval:maximumvalue]; % -1.0078:0.0078:1
[index,quants,distor] = quantiz(signal,partition,codebook);
% Conversion of deci into binary from least to most significant
indxtrn=index';
for i=1:4000
matrix(i,1:1:8)=bitget(uint8(indxtrn(i)),1:1:8);
end,
% matrix is of 4000 rows X 8 columns
% matrixtps is a matrix of 8 rows X4000 columns
matrixtps=matrix';
% Baseband is produced, it has 32000 bits
baseband=reshape(matrixtps,4000*8,1);
Tb=1/32000;
% bit rate 32 kbps
time=[0:Tb:1];
figure(2);
stairs(time(1:500),baseband(1:500))
title(' A segment of baseband signal')
xlabel('Time(sec)')
ylabel('Binary value')
set(gca,'ytick',[0 1 ])
axis([0,time(500),0,1])
%%%%%%%%%%
% Serial the data for the next step.
input_to_Convolutional_encoder = baseband'; % 1 X 32000
%Now, the binary converted data is sent to th Convolutional encoder.
t=poly2trellis(7, [171 133]);
%Channel coding
code = convenc(input_to_Convolutional_encoder,t); % 1 x 64000
%Interleaving
st2 = 4831;

```



```

data_interleave = randintrlv(code,st2); % Interleave, 1 row x 64000 columns
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%Quadrature phase shift keying modulation
M=4;
k=log2(M);
baseband=double(baseband);
% bit to symbol mapping
symbol=bi2de(reshape(data_interleave,k,length(data_interleave)/k),'left-msb');
Quadrature_phase_shift_keying_modulated_data = pskmod(symbol,M);
% demodulation of Quadrature phase shift keying data
Quadrature_phase_shift_keying_demodulated_data = pskdemod(Quadrature_phase_shift_keying_modulated_data,M);
[number, ratio]= symerr(symbol,Quadrature_phase_shift_keying_demodulated_data) % symbol error
% symbol to bit mapping
% 2-bit symbol to Binary bit mapping
Retrieved_bit = de2bi(Quadrature_phase_shift_keying_demodulated_data,'left-msb');
Retrieved_bit=Retrieved_bit';
Retrieved_bit=reshape(Retrieved_bit, 64000,1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% Deinterleaving
errors = zeros(size(Retrieved_bit));
inter_err = bitxor(Retrieved_bit,errors); % Include burst error.
data_deinterleave=randdeintrlv(inter_err,st2);
%Convolutional Decoding
tblen=3;
decodx= vitdec(data_deinterleave,t,tblen,'cont','hard'); %
N3=length(decodx);
NN=N3/8;
decod2(1:(N3-3))=decodx(tblen+1:end);
decod2(N3)=decodx(1);
decod2=decod2' ; % 32000 X 1
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
baseband=double(baseband);
[number, ratio]= biterr(decod2,baseband)
convert=reshape(decod2,8,4000); % First reshaping and then transposing
matrixtps=double(matrixtps);
[number, ratio]= biterr(convert,matrixtps)
convert=convert' ; % 4000 rows X 8 columns
% binary to decimally converted value
intconv=bi2de(convert); % converted into interger values(0-255) of 4000 samples
% intconv is 4000 rows X 1 column
[number, ratio]= biterr(intconv,index');
sample_value=minimumvalue +intconv.*interval;
figure(3)
subplot(2,1,1)
plot(time(1:100),signal(1:100));
set(gca,'ytick',[ -1.0  0 1.0 ])
axis([0,time(100),-1,1])
title('Graph for a segment of recoded Audio signal')
xlabel('Time(sec)')
ylabel('Amplitude')
grid on

```

```

subplot(2,1,2)
plot(time(1:100),sample_value(1:100));
axis([0,time(100),-1,1])
set(gca,'ytick',[ -1.0  0 1.0 ])
title('Graph for a segment of retrieved Audio signal')
xlabel('Time(sec)')
ylabel('Amplitude')
grid on

```

%%%

**Expt 7: Develop a matlab source to simulate an Interleaved FEC encoded wireless communication system with implementation of 4-QAM digital modulation technique Show atleast three waveforms generated at different sections of the simulated system**

```

clear all;
close all;
% Test with synthetically generated sinusoidal wave
f=1000;% Frequency of the audio signal
Fs =4000; % Sampling rate is 4000 samples per second.
t = [1/Fs:1/Fs:1];% total time for simulation=0.05 second.
% Number of samples=4000
Am=1.0;
signal = Am*sin(2*pi*1000*t); % Original signal
figure(1);
plot(t(1:200),signal(1:200))
set(gca,'ytick',[ -1.0  0 1.0 ])
title('A segment of synthetically generated sinusoidal waveform')
grid on
xlabel('time(sec)');
ylabel('Amplitude(volt)');
maximumvalue=max(signal);
minimumvalue=min(signal);
interval=(maximumvalue-minimumvalue)/255; % interval:
partition = [minimumvalue:interval:maximumvalue]; % -1:0.0078:1
codebook = [(minimumvalue-interval):interval:maximumvalue]; % -1.0078:0.0078:1
[index,quants,distor] = quantiz(signal,partition,codebook);
% Conversion of deci into binary from least to most significant
indxtrn=index';
for i=1:4000
matrix(i,1:1:8)=bitget(uint8(indxtrn(i)),1:1:8);
end,
% matrix is of 4000 rows X 8 columns
% matrixtps is a matrix of 8 rows X4000 columns
matrixtps=matrix';
% Baseband is produced, it has 32000 bits
baseband=reshape(matrixtps,4000*8,1);
Tb=1/32000;
% bit rate 32 kbps
time=[0:Tb:1];
figure(2);
stairs(time(1:500),baseband(1:500))

```

```

title(' A segment of baseband signal')
xlabel('Time(sec)')
ylabel('Binary value')
set(gca,'ytick',[0 1])
axis([0,time(500),0,1])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% Serial the data for the next step.
input_to_Convolutional_encoder = baseband'; % 1 X 32000
%Now, the binary converted data is sent to th Convolutional encoder.
t=poly2trellis(7, [171 133]);
%Channel coding
code = convenc(input_to_Convolutional_encoder,t); % 1 x 64000
%Interleaving
st2 = 4831;
data_interleave = randintrlv(code,st2); % Interleave, 1 row x 64000 columns
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%Quadrature amplitude modulation
M=4;
k=log2(M);
baseband=double(baseband);
% bit to symbol mapping
symbol=bi2de(reshape(data_interleave,k,length(data_interleave)/k),'left-msb');
Quadrature_amplitude_modulated_data = qammod(symbol,M);
% demodulation of Quadrature amplitude data
Quadrature_amplitude_demodulated_data = qamdemod(Quadrature_amplitude_modulated_data,M);
[number,ratio]= symerr(symbol,Quadrature_amplitude_demodulated_data) % symbol error
% symbol to bit mapping
% 2-bit symbol to Binary bit mapping
Retrieved_bit = de2bi(Quadrature_amplitude_demodulated_data,'left-msb');
Retrieved_bit=Retrieved_bit';
Retrieved_bit=reshape(Retrieved_bit, 64000,1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% Deinterleaving
errors = zeros(size(Retrieved_bit));
inter_err = bitxor(Retrieved_bit,errors); % Include burst error.
data_deinterleave=randdeintrlv(inter_err,st2);
%Convolutional Decoding
tblen=3;
decodx= vitdec(data_deinterleave,t,tblen,'cont','hard'); %
N3=length(decodx);
NN=N3/8;
decod2(1:(N3-3))=decodx(tblen+1:end);
decod2(N3)=decodx(1);
decod2=decod2' ; % 32000 X 1
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
baseband=double(baseband);
[number,ratio]= biterr(decod2,baseband)
convert=reshape(decod2,8,4000); % First reshaping and then transposing
matrixtps=double(matrixtps);
[number,ratio]= biterr(convert,matrixtps)
convert=convert' ; % 4000 rows X 8 columns

```

```

% binary to decimally converted value
intconv=bi2de(convert); % converted into interger values(0-255) of 4000 samples
% intconv is 4000 rows X 1 column
[number,ratio]= biterr(intconv,index');
sample_value=minimumvalue +intconv.*interval;
figure(3)
subplot(2,1,1)
plot(time(1:100),signal(1:100));
set(gca,'ytick',[ -1.0  0 1.0 ])
axis([0,time(100),-1,1])
title('Graph for a segment of recoded Audio signal')
xlabel('Time(sec)')
ylabel('Amplitude')
grid on
subplot(2,1,2)
plot(time(1:100),sample_value(1:100));
axis([0,time(100),-1,1])
set(gca,'ytick',[ -1.0  0 1.0 ])
title('Graph for a segment of retrieved Audio signal')
xlabel('Time(sec)')
ylabel('Amplitude')
grid on

```

%%%

**Expt 8:Develop a matlab source to simulate an Interleaved FEC encoded wireless communication communication system with implementation of 16-QAM digital modulation technique Show atleast three waveforms generated at different sections of the simulated system**

```

clear all;
close all;
% Test with synthetically generated sinusoidal wave
f=1000;% Frequency of the audio signal
Fs =4000; % Sampling rate is 4000 samples per second.
t = [1/Fs:1/Fs:1];% total time for simulation=0.05 second.
% Number of samples=4000
Am=1.0;
signal = Am*sin(2*pi*1000*t); % Original signal
figure(1);
plot(t(1:200),signal(1:200))
set(gca,'ytick',[ -1.0  0 1.0 ])
title('A segment of synthetically generated sinusiodal wavform')
grid on

```

```

xlabel( 'time(sec)');
ylabel( 'Amplitude(volt)');
maximumvalue=max(signal);
minimumvalue=min(signal);
interval=(maximumvalue-minimumvalue)/255; % interval:
partition = [minimumvalue:interval:maximumvalue]; % -1:0.0078:1
codebook = [(minimumvalue-interval):interval:maximumvalue]; % -1.0078:0.0078:1
[index,quants,distor] = quantiz(signal,partition,codebook);
% Conversion of deci into binary from least to most significant
indxtrn=index';
for i=1:4000
matrix(i,1:1:8)=bitget(uint8(indxtrn(i)),1:1:8);
end,
% matrix is of 4000 rows X 8 columns
% matrixtps is a matrix of 8 rows X4000 columns
matrixtps=matrix';
% Baseband is produced, it has 32000 bits
baseband=reshape(matrixtps,4000*8,1);
Tb=1/32000;
% bit rate 32 kbps
time=[0:Tb:1];
figure(2);
stairs(time(1:500),baseband(1:500))
title(' A segment of baseband signal')
xlabel('Time(sec)')
ylabel('Binary value')
set(gca,'ytick',[0 1 ])
axis([0,time(500),0,1])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% Serial the data for the next step.
input_to_Convolutional_encoder = baseband'; % 1 X 32000
%Now, the binary converted data is sent to th Convolutional encoder.
t=poly2trellis(7, [171 133]);
%Channel coding
code = convenc(input_to_Convolutional_encoder,t); % 1 x 64000
%Interleaving
st2 = 4831;
data_interleave = randintrlv(code,st2); % Interleave, 1 row x 64000 columns
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%Quadrature amplitude modulation
M=16;
k=log2(M);
baseband=double(baseband);
% bit to symbol mapping
symbol=bi2de(reshape(data_interleave,k,length(data_interleave)/k).','left-msb');
Quadrature_amplitude_modulated_data = qammod(symbol,M);
% demodulation of Quadrature amplitude data
Quadrature_amplitude_demodulated_data = qamdmod(Quadrature_amplitude_modulated_data,M);
[number,ratio]= symerr(symbol,Quadrature_amplitude_demodulated_data) % symbol error
% symbol to bit mapping
% 2-bit symbol to Binary bit mapping

```

```

Retrieved_bit = de2bi(Quadrature_amplitude_demodulated_data,'left-msb');
Retrieved_bit=Retrieved_bit';
Retrieved_bit=reshape(Retrieved_bit, 64000,1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% Deinterleaving
errors = zeros(size(Retrieved_bit));
inter_err = bitxor(Retrieved_bit,errors); % Include burst error.
data_deinterleave=randdeintrlv(inter_err,st2);
%Convolutional Decoding
tblen=3;
decodx= vitdec(data_deinterleave,t,tblen,'cont','hard'); %
N3=length(decodx);
NN=N3/8;
decod2(1:(N3-3))=decodx(tblen+1:end);
decod2(N3)=decodx(1);
decod2=decod2' ; % 32000 X 1
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
baseband=double(baseband);
[number,ratio]= biterr(decod2,baseband)
convert=reshape(decod2,8,4000); % First reshaping and then transposing
matrixtps=double(matrixtps);
[number,ratio]= biterr(convert,matrixtps)
convert=convert' ; % 4000 rows X 8 columns
% binary to decimally converted value
intconv=bi2de(convert); % converted into interger values(0-255) of 4000 samples
% intconv is 4000 rows X 1 column
[number,ratio]= biterr(intconv,index');
sample_value=minimumvalue +intconv.*interval;
figure(3)
subplot(2,1,1)
plot(time(1:100),signal(1:100));
set(gca,'ytick',[ -1.0  0 1.0 ])
axis([0,time(100),-1,1])
title('Graph for a segment of recoded Audio signal')
xlabel('Time(sec)')
ylabel('Amplitude')
grid on
subplot(2,1,2)
plot(time(1:100),sample_value(1:100));
axis([0,time(100),-1,1])
set(gca,'ytick',[ -1.0  0 1.0 ])
title('Graph for a segment of retrieved Audio signal')
xlabel('Time(sec)')
ylabel('Amplitude')
grid on

```

A system in AWGN channel  
I DS CDMA system

7 (binary 110) and 7 (binary 111).  
The length is about 2000 bits).

$$\{ \dots +1 \}$$

10 chips per bit.

1 signal.

$$(2\pi f_c j) \text{ by } \sqrt{2E_b} \cdot \text{user}(i).$$

ding.



---

system in AWGN and Rayleigh fading channel  
DS CDMA system



%%

---

system in AWGN and Rician fading channel  
DS CDMA system



%%

\_\_\_\_\_



is communication system









ta,M);





ulated\_data,M);

100%

100%

100%





100%