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Digital Communication Project

1/6/22

```
%%%%%%%%%%%part 1 %%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
fs = 5e6;                    % Sampling rate (samples per sec)
Ts = 1/fs;                   % Sampling time
N = 102400 - 1;              % Total number of samples
t_axis = (0:N-1)*Ts;         % Time axis (the same during the entire experiment)
t_axis_sh = ((-(N-1)/2):((N-1)/2))*Ts;
f_axis = -fs/2:fs/N:fs/2-1/N;   % Frequency axis (the same during the entire experiment)

% Generate one square pulse with the following parameters
Energy_per_bit = 50.5;          % The total energy of all samples constituting the square pulse
B = 100*10^3;
T_sq = 2/B;
N_sq = round(T_sq/Ts);         %N_sq = 100

%generating one pulse
x_bits = 1;
x_square = GenerateSquarePulses(t_axis,T_sq,Energy_per_bit,fs,x_bits,1);

figure
subplot(2,1,1)

plot(t_axis,x_square,'linewidth',2)
grid on
xlim([0 T_sq*1.2])
xlabel('Time','linewidth',2)
ylabel('Square pulse','linewidth',2)

X_squareF = (1/fs)*abs(fftshift(fft(x_square)));


subplot(2,1,2)
plot(f_axis,abs(X_squareF),'linewidth',2)
title('Square in freq','linewidth',10)
grid on
xlim([-1/T_sq 1/T_sq]*5)
xlabel('Frequency','linewidth',2)
ylabel('Frequency ressponse magnitude','linewidth',2)
subplot(2,1,1)
title('A square pulse in time and frequency domains','linewidth',10)

%creating the channel

channelf = rectpuls(f_axis , 2*B);
channel = ifft(ifftshift(channelf));
figure
subplot(2,1,1)
```

```
plot(f_axis,abs(channelf),'linewidth',2)
title('Channel in Frequency','linewidth',10)
xlim([-1/T_sq 1/T_sq]*5)
subplot(2,1,2)
plot(t_axis,channel,'linewidth',2)
title('Channel in Time','linewidth',10)
xlim([0 T_sq*1.2])

%passing the pulse to the channel

temp = conv(x_square , channel);
y = temp(:,1:length(t_axis));
figure
grid on
plot(t_axis,y,'linewidth',2)
title('Recieved pulse in Time','linewidth',10)
xlim([0 T_sq*2])
yf = (1/fs)*abs(fftshift(fft(y)));
figure
plot(f_axis,yf,'linewidth',2)
title('Recieved pulse in Frequency','linewidth',10)
xlim([-1/T_sq 1/T_sq]*5)

%creating two separate pulses

x_bits = 1;
x_square1 = GenerateSquarePulses(t_axis,T_sq,Energy_per_bit,fs,x_bits,1);

x_bits = [0 1];
x_square2 = GenerateSquarePulses(t_axis,T_sq,Energy_per_bit,fs,x_bits,1);
figure
plot(t_axis,x_square1,t_axis,x_square2 , 'linewidth',2)
xlim([0 T_sq*2.4])

%passing the two pulses to the channel

temp = conv(x_square1 , channel);
y1 = temp(:,1:length(t_axis));

temp = conv(x_square2 , channel);
y2 = temp(:,1:length(t_axis));


figure
grid on
plot(t_axis,y1,t_axis,y2,'linewidth',2)
title('Recieved pulse in Time','linewidth',10)
xlim([0 T_sq*3])
```

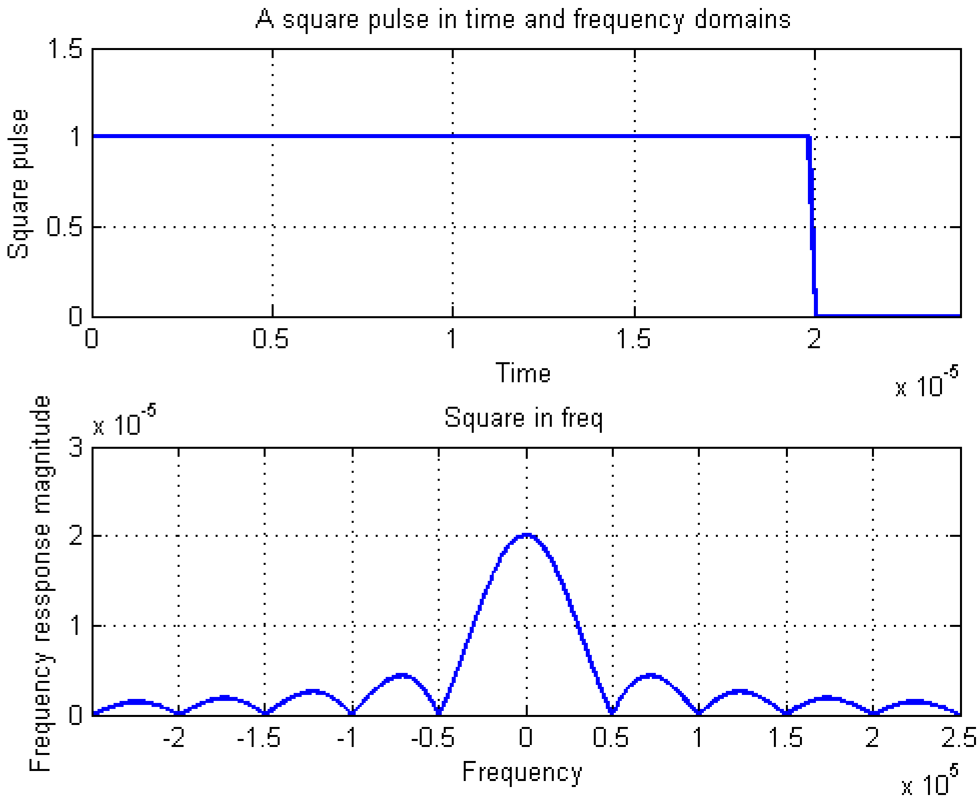
```
%raised cosine

x_bits = [1 1 0 1 0 1];
x = GenerateSquarePulses(t_axis_sh,T_sq,Energy_per_bit,fs,x_bits,2);
figure
plot(t_axis_sh,x , 'linewidth',2)
xlim([-T_sq*2 T_sq*6])
title('Transmitted signal in Time with Rasied Cosine','linewidth',10)
grid on

%passing through channel
temp = conv(x , channel);
y1 = temp(:,1:length(t_axis));
figure
plot(t_axis_sh, y1 , 'linewidth',2)
xlim([-T_sq*2 T_sq*6])
title('Recievied signal in Time with Rasied Cosine','linewidth',10)
grid on
```

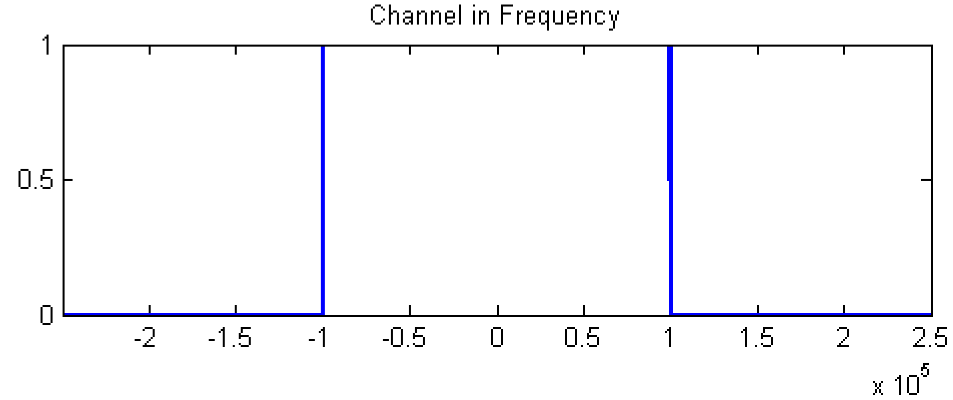
```
function x_square = GenerateSquarePulses(t_axis,T_sq,E_bit,fs,x_bits,type)

Ts = 1/fs;
N = length(t_axis);


N_sq = round(T_sq/Ts);
one_square = zeros(1,N_sq);
if type == 1
    A = sqrt(2*E_bit / N_sq);
    one_square = A + one_square;
else
    alpha = 0.5;
    W = 1/T_sq;
    n = 102400 - 1;
    t_axis_sh = ((-(n-1)/2):((n-1)/2))*Ts;
    one_raised_cos = sinc(2*W*t_axis_sh).*cos(2*pi*alpha*W*t_axis_sh)./(1-(4*alpha*W*t_axis).^2);
end
x_square = zeros(1, N);

for i = 1:length(x_bits)
    if type == 1
        if x_bits(i) == 1
            x_square((i-1)*N_sq +1:i*N_sq) = x_square((i-1)*N_sq +1:i*N_sq) + one_square;
        end
    else
        if x_bits(i) == 1
            x_square = x_square + circshift(one_raised_cos' , N_sq*(i-1))';
        else
```

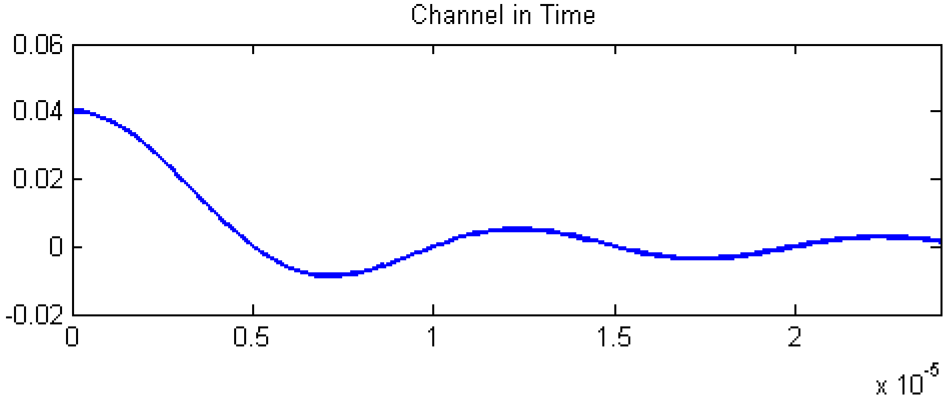
```
            x_square = x_square - circshift(one_raised_cos' , N_sq*(i-1))';
        end
    end
end

end
```

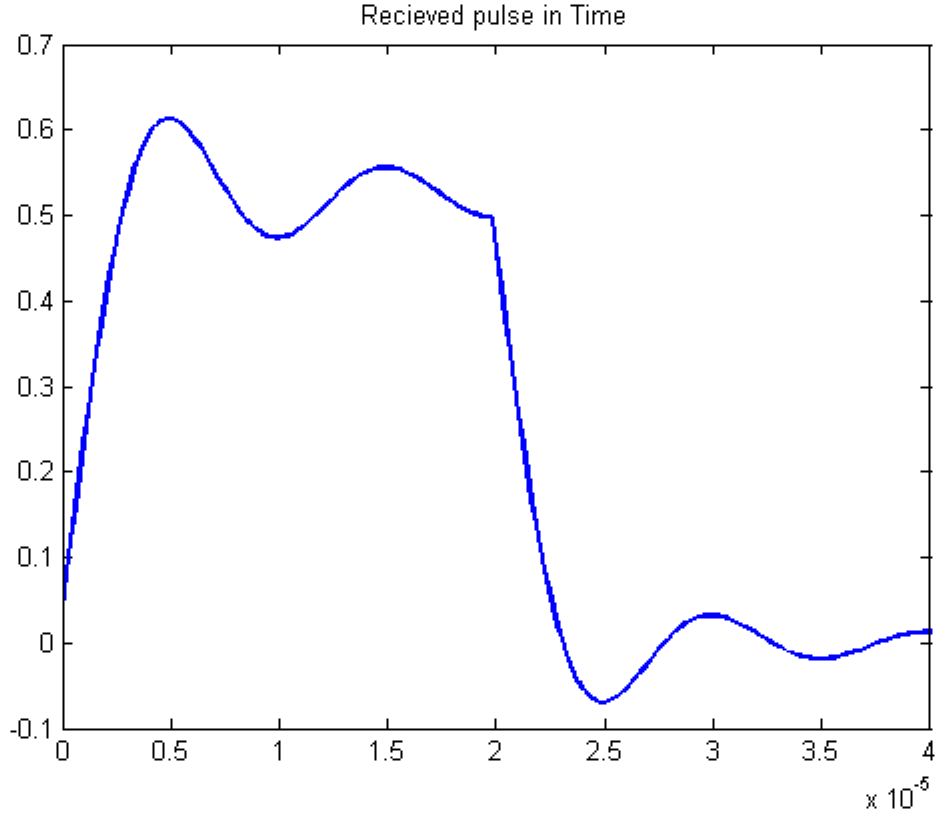
```
L=1000;
N=1;
h = randn(L,N) + 1i*randn(L,N);
power_profile = exp(-0.5*[0:L-1])';
power_profile = repmat(power_profile,1,N);
h = abs(h).*power_profile;

H = zeros(L,L);
last_ind = 1;
z = 1;
for n = 1:L
    for k = last_ind:-1:1
        H(n,z) = h(k);
        z = z +1;
    end
    z = 1;
    last_ind = last_ind + 1;
end
H_inv = inv(H);
BER_temp = [];
Eb = 1;
No = [1 0.5 0.1 0.05 0.01 0.005 0.001];
BER = [];
for nn = No
    N = sqrt(nn/2)*randn(L,1);
    for i = 1:10        %we will calculate the BER 10 times for each noise
        valid_vals = setdiff(-1:1, 0);
        x = valid_vals( randi(length(valid_vals), L, 1) ); %stream of bits transmitted

        y = H*x' + N;        %recieved

        x_rec = H_inv*y;     %recieved bits plus noise
        D = zeros(size(x_rec));
        for k = 1:L
            if x_rec(k) <= 0
                D(k)= -1 ;
            else
                D(k) = 1;
            end
        end

        n = 0;
        for k = 1:L
            if D(k) ~= x(k)
                n = n + 1;
            end
        end


        BER_temp = [BER_temp n/L];
    end
    BER = [BER mean(BER_temp)];
    BER_temp = [];
end

plot(Eb./No , BER)
xlim([0 100])
```

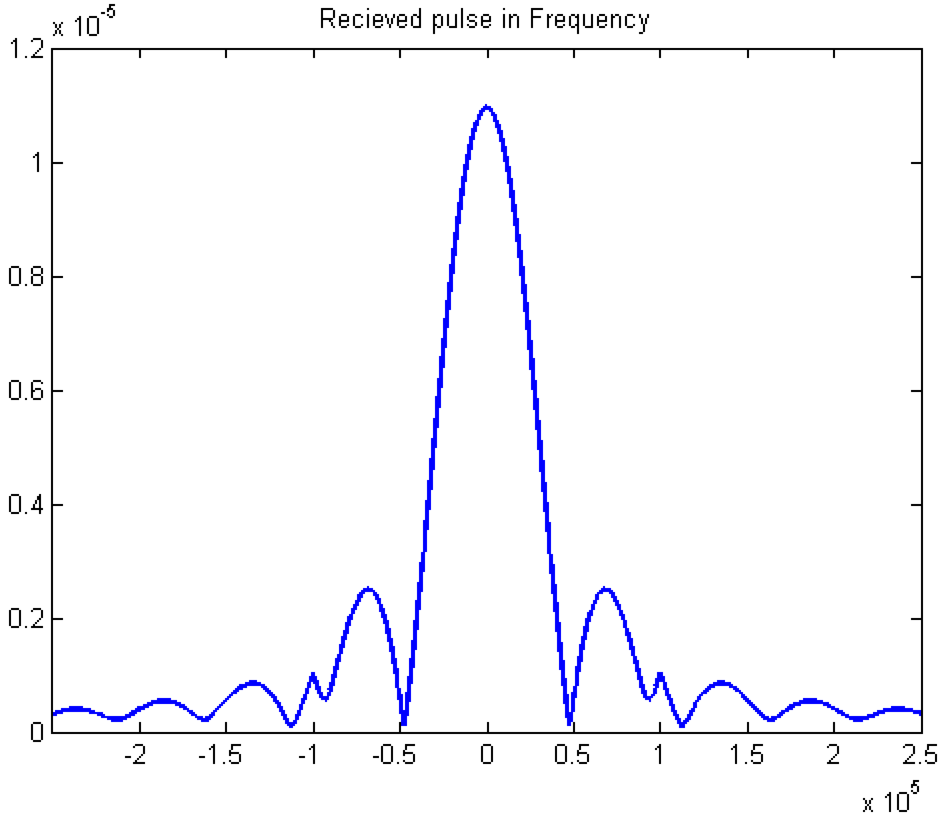
Outputs:

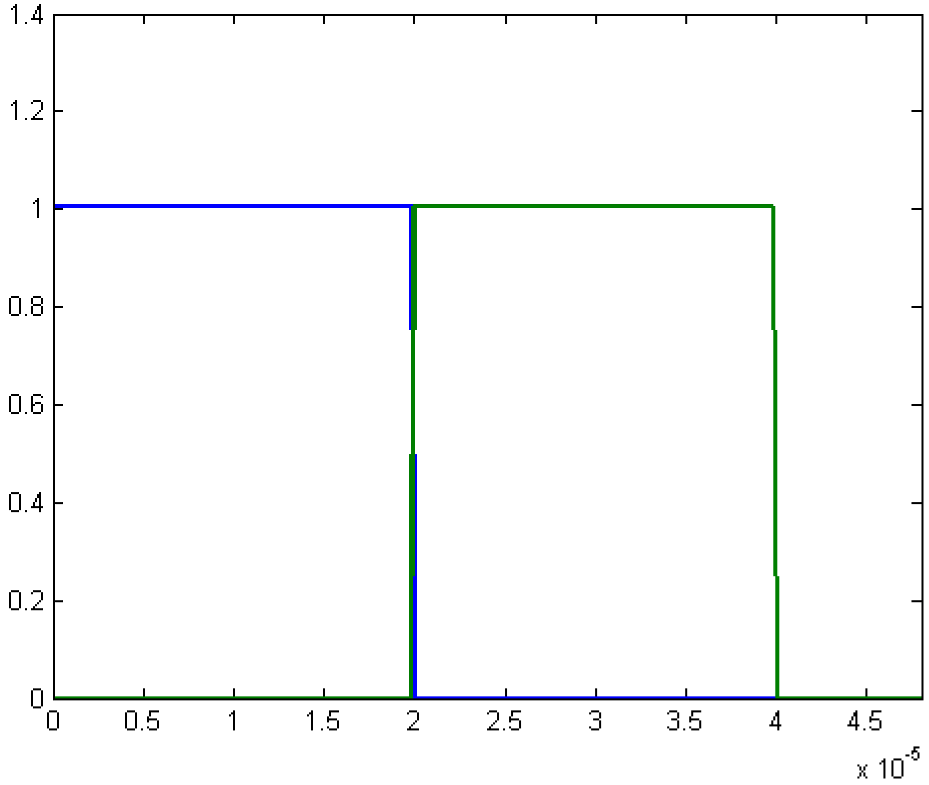


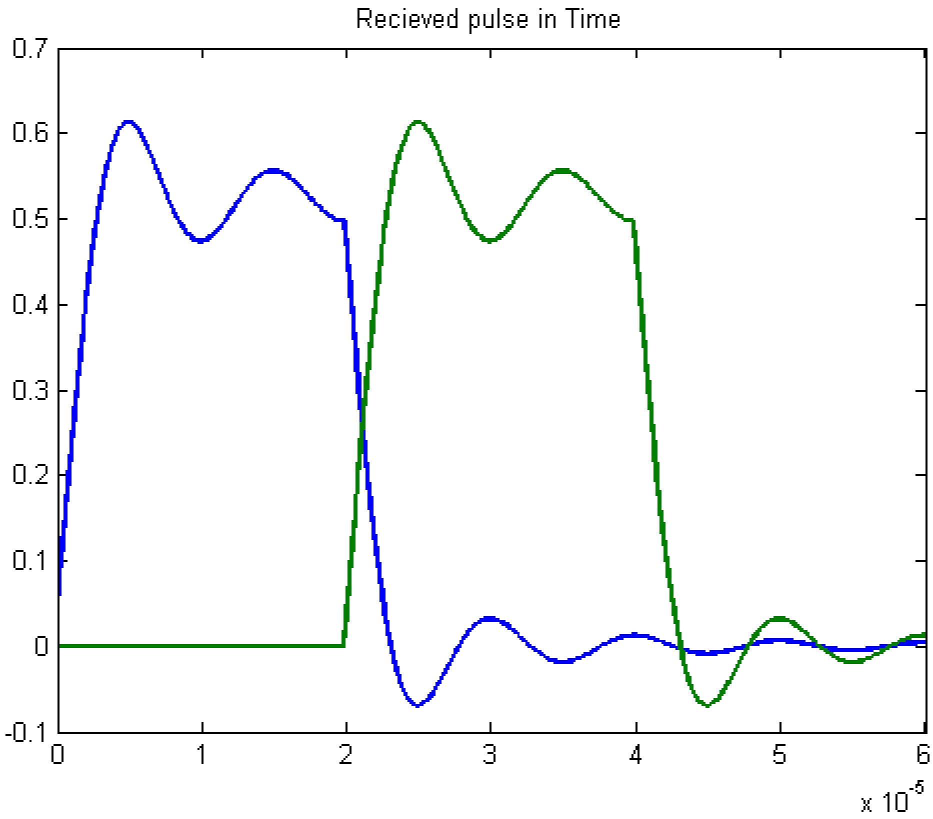

Channel in Frequency
1
0.5
0
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5
x 10^5


Channel in Time
0.06
0.04
0.02
0
-0.02
0
0.5
1
1.5
2
x 10^-5

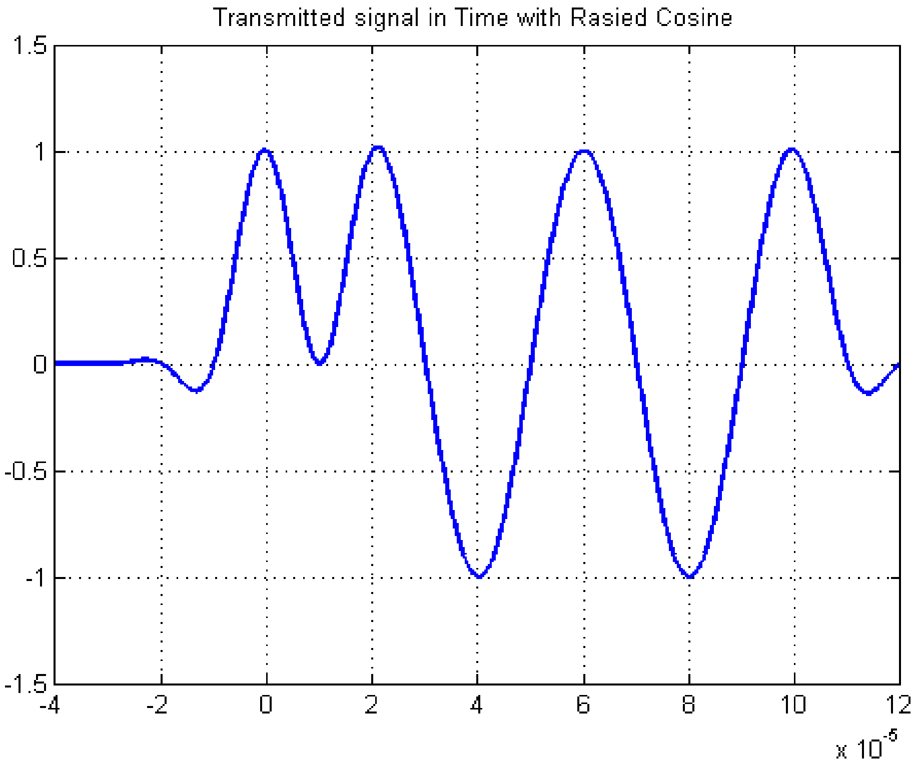

Recieved pulse in Time
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
0
0.5
1
1.5
2
2.5
3
3.5
4
x 10^-5

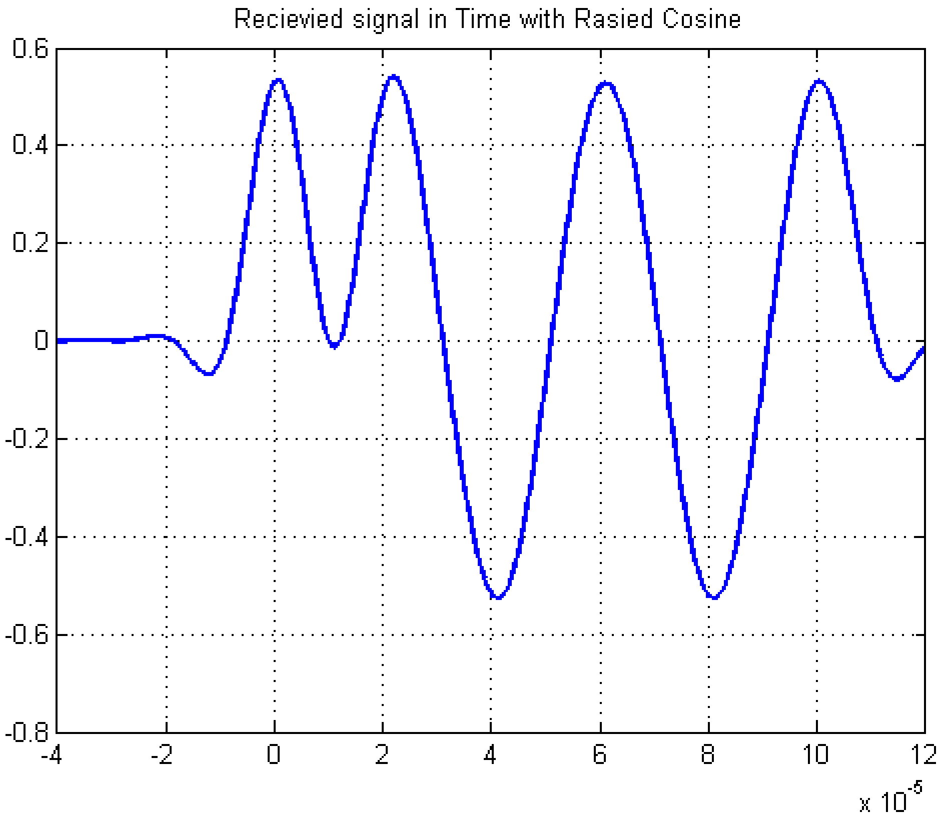

Recieved pulse in Frequency
x 10^-5
1.2
1
0.8
0.6
0.4
0.2
0
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5
x 10^5


1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
x 10^-5

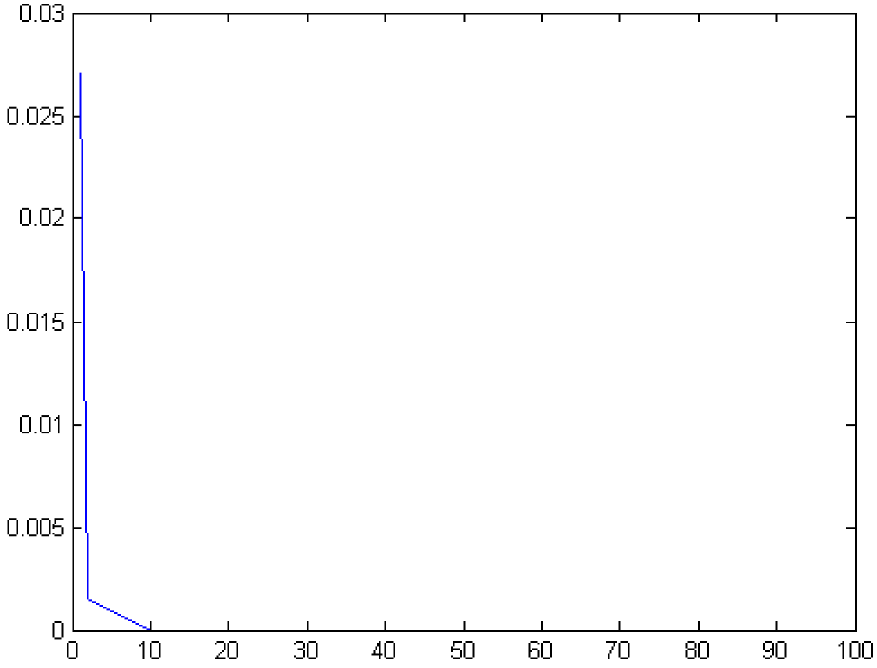


Using Raised Cosine





Recievied signal in Time with Rasied Cosine



0.03
0.025
0.02
0.015
0.01
0.005
0
0
10
20
30
40
50
60
70
80
90
100