EN 2040

Random Signals and Processes

Simulation Assignment

Report

Logo

Description automatically generated

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Chart

Description automatically generatedQ3)

Chart

Description automatically generated

Chart, bar chart

Description automatically generated

Q4)

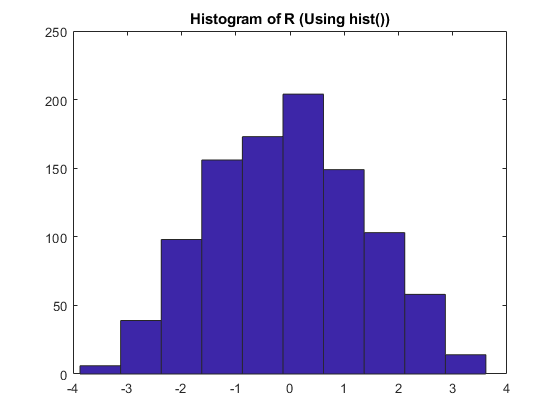
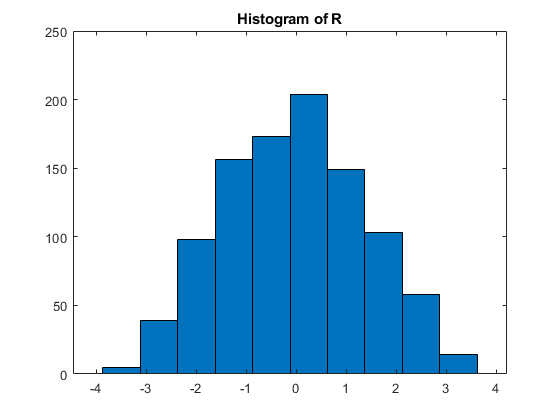
Chart, bar chart, surface chart

Description automatically generated

Chart

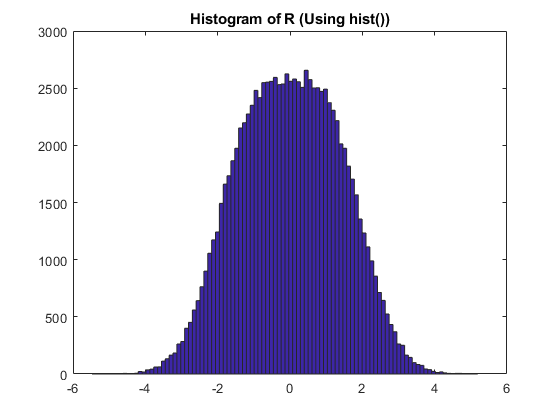
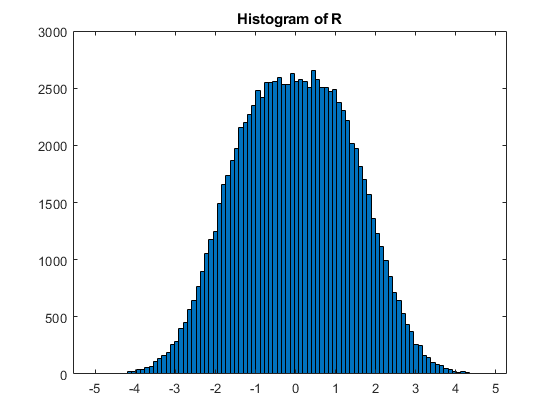
Description automatically generated

Q5)



The histograms have a distant appearance of Gaussian distribution.

a)



Upon increasing the no of bins, histograms have obtained a close look of Gaussian distribution.

b)

Chart, histogram

Description automatically generated

Chart, histogram

Description automatically generated

Chart, histogram

Description automatically generatedChart, histogram

Description automatically generated

Chart, histogram

Description automatically generatedChart, histogram

Description automatically generated

When A increases the pdfs deviates from its initial positions when A=1.

This is due to mean values of the pdfs is -A for and A for

c)

For the expected value,

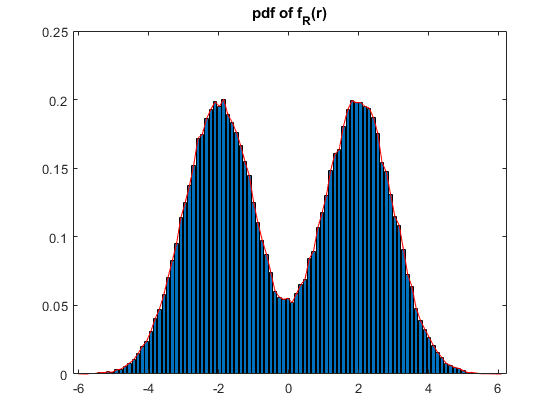
Where,

|  |  |  |  |
| --- | --- | --- | --- |
| A | E [R|S = A] | E [R|S = -A] | E [R] |
| 1 | 1.0025 | -1.0017 | 0.003864 |
| 2 | 1.9976 | -2.0006 | -0.0012 |
| 3 | 3.0006 | -3.0068 | -0.0029 |

d)

Chart, histogram

Description automatically generated

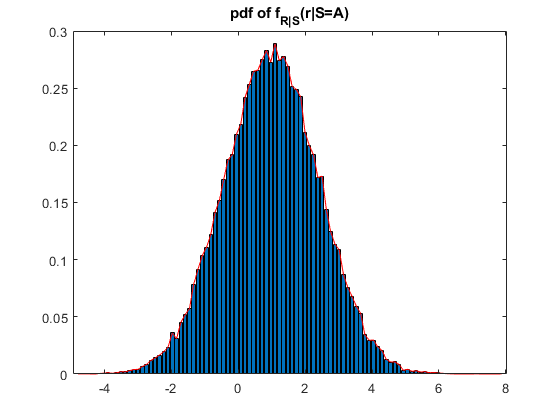
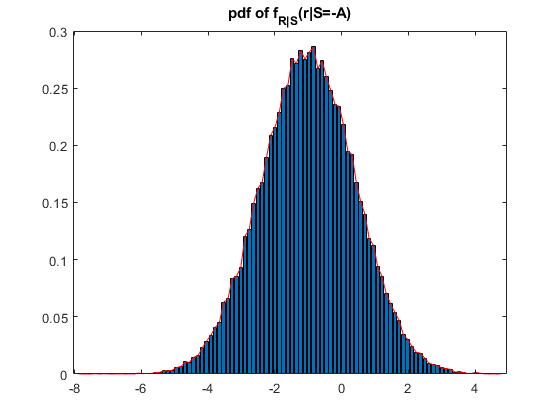


Chart, histogram

Description automatically generated

Q6)

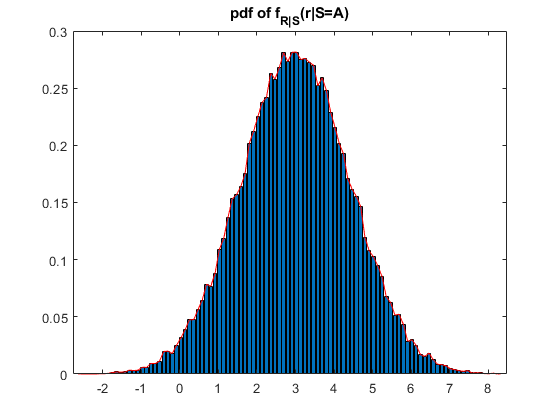
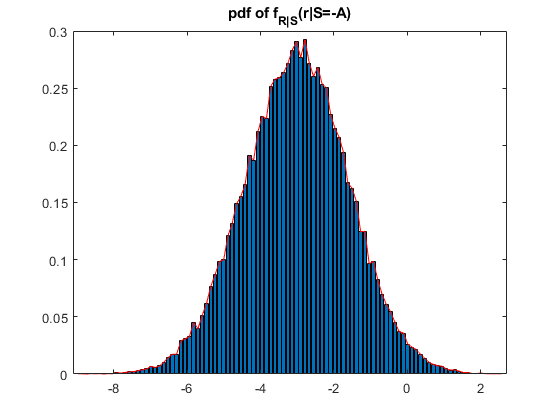
b)



Chart, histogram

Description automatically generatedChart, histogram

Description automatically generated



c)

|  |  |  |  |
| --- | --- | --- | --- |
| A | E [R|S = A] | E [R|S = -A] | E [R] |
| 1 | 0.9965 | -0.9965 | -0.000091 |
| 2 | 2.0001 | -2.0088 | -0.0044 |
| 3 | 2.999 | -3.0159 | -0.0081 |

d)

Chart, histogram

Description automatically generated

Chart, histogram

Description automatically generated

Chart, histogram

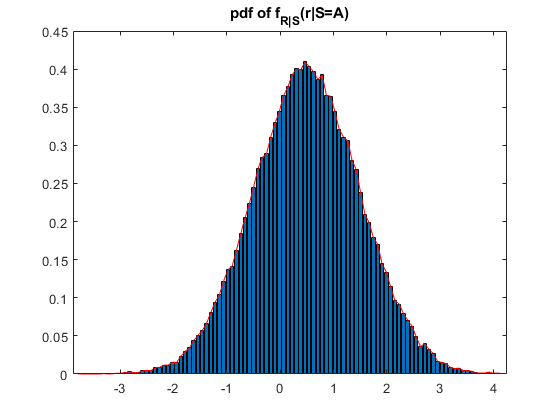
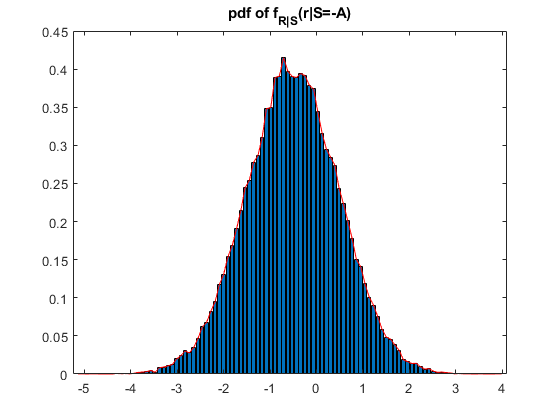
Description automatically generated

When increasing A, the middle separation of increases, but it is not quite dominant as without the interference (in Q5-d). This is due to interference another Gaussian random signal gets added to the Initial Signal which increased the variance of both and .

Upon calculating error it is noticed that Error has increased from 0.7965 to 0.9756

Q7)

b)



Chart, histogram

Description automatically generatedChart, histogram

Description automatically generated

Chart, histogram

Description automatically generatedChart, histogram

Description automatically generated

c)

|  |  |  |  |
| --- | --- | --- | --- |
| α | E [R|S = A] | E [R|S = -A] | E [R] |
| 0.5 | 0.5011 | -0.5090 | -0.0038 |
| 2 | 1.9994 | -2.0056 | -0.0031 |
| 3 | 2.9899 | -2.9972 | -0.0035 |

d)

Chart, histogram

Description automatically generated

Chart, histogram

Description automatically generated

Chart, histogram

Description automatically generated

When increasing α, the middle separation of increases. This is due to mean values of the pdfs is - α A for and α A for .

Upon calculating error it is noticed that Error has decreased from 0.7965 to 0.0738 when the α increased to 3. Therefore Scaling reduces the error.

APPENDIX

L =100000;

D = zeros(1,L);

positions = randperm(L,L/2);

D(positions) = ones(1,L/2);

figure;

stairs(1:L,D);

axis([0 50 -0.5 1.5])

title("Binary Sequence");

%sequence of pulses

A = 1

S = -A\*ones(1,L);

S(D==1)= A;

figure;

stairs(1:L,S);

axis([0 50 -1\*A-1 A+1])

title("Transmitted Signal");

% AWGN

mean = 0;

sigma = 1;

N = mean + sigma\*randn(1,L);

R = S + N;

%Interference

meanI = 0;

sigmaI = 1;

I = meanI + sigmaI\*randn(1,L);

%R = S + N + I;

%Scaling

alpha=3

%R = alpha\*S + N;

figure;

stairs(1:L,R);

%axis([0 L -1.5\*A 1.5\*A])

title("Received Signal");

%generating Y sequence

threshold = 0;

Y = -A\*ones(1,L);

Y(R>threshold)=A;

figure;

subplot(2,1,1);

stairs([1:L],S);

axis([0 50 -1\*A-1 A+1])

title("Transmitted Signal");

subplot(2,1,2);

stairs([1:L],Y);

axis([0 50 -1\*A-1 A+1])

title("Y Signal");

%Error rate

Error = sqrt(sum((S-Y).^2)/L)

bin\_no=100;%No of bins

R\_max = max(R);

R\_min = min(R);

width = (R\_max-R\_min)/bin\_no;

bin\_limits = R\_min:width:R\_max;

%histogram calclation

bins\_centers = R\_min+width/2:width:R\_max-width/2;

frequency= zeros(1,bin\_no);

for i=1:bin\_no

for j =1:L

if (R(j)<=bin\_limits(i+1)) && (R(j)>bin\_limits(i))

frequency(i)=frequency(i)+1;

end

end

end

figure;

bar(bins\_centers,frequency,1);

title("Histogram of R");

figure;

hist(R,bin\_no);

title("Histogram of R (Using hist())");

%f\_R|S(r|S=A)

r\_ifSA = R(S==A); %S = A

R\_max1 = max(r\_ifSA);

R\_min1 = min(r\_ifSA);

widthSA = (R\_max1-R\_min1)/bin\_no;

[y1,x1] = hist(r\_ifSA,bin\_no);

prob1 = y1/(length(r\_ifSA)\*widthSA);

figure;

bar(x1,prob1);

hold on;

plot(x1,prob1,'r');

title("pdf of f\_{R|S}(r|S=A)");

%f\_R|S(r|S=-A)

r\_ifS\_A = R(S==-A); %S = -A

R\_max1 = max(r\_ifS\_A);

R\_min1 = min(r\_ifS\_A);

widthS\_A = (R\_max1-R\_min1)/bin\_no;

[y2,x2] = hist(r\_ifS\_A,bin\_no);

prob2 = y2/(length(r\_ifS\_A)\*widthS\_A);

figure;

bar(x2,prob2);

hold on;

plot(x2,prob2,'r');

title("pdf of f\_{R|S}(r|S=-A)");

%f\_R(r)

R\_max = max(R);

R\_min = min(R);

width= (R\_max-R\_min)/bin\_no;

[y,x] = hist(R,bin\_no);

probR = y/(length(R)\*width);

figure;

bar(x,probR);

hold on;

plot(x,probR,'r');

title("pdf of f\_R(r)");

%E[R|S=A]

E\_R\_ifSA = 0;

for i1 = 1:bin\_no

E\_R\_ifSA = E\_R\_ifSA + x1(i1)\*prob1(i1)\*widthSA;

end

E\_R\_ifSA

%E[R|S=-A]

E\_R\_ifS\_A = 0;

for i2 = 1:bin\_no

E\_R\_ifS\_A = E\_R\_ifS\_A + x2(i2)\*prob2(i2)\*widthS\_A;

end

E\_R\_ifS\_A

%E[R]

E\_R = 0;

for i3 = 1:bin\_no

E\_R = E\_R + (x(i3)\*probR(i3)\*width);

end

E\_R