Assignment :

“Stochastic Processes”

Representation of Composite Fading and Shadowing Distributions by using Mixtures of Gamma Distributions

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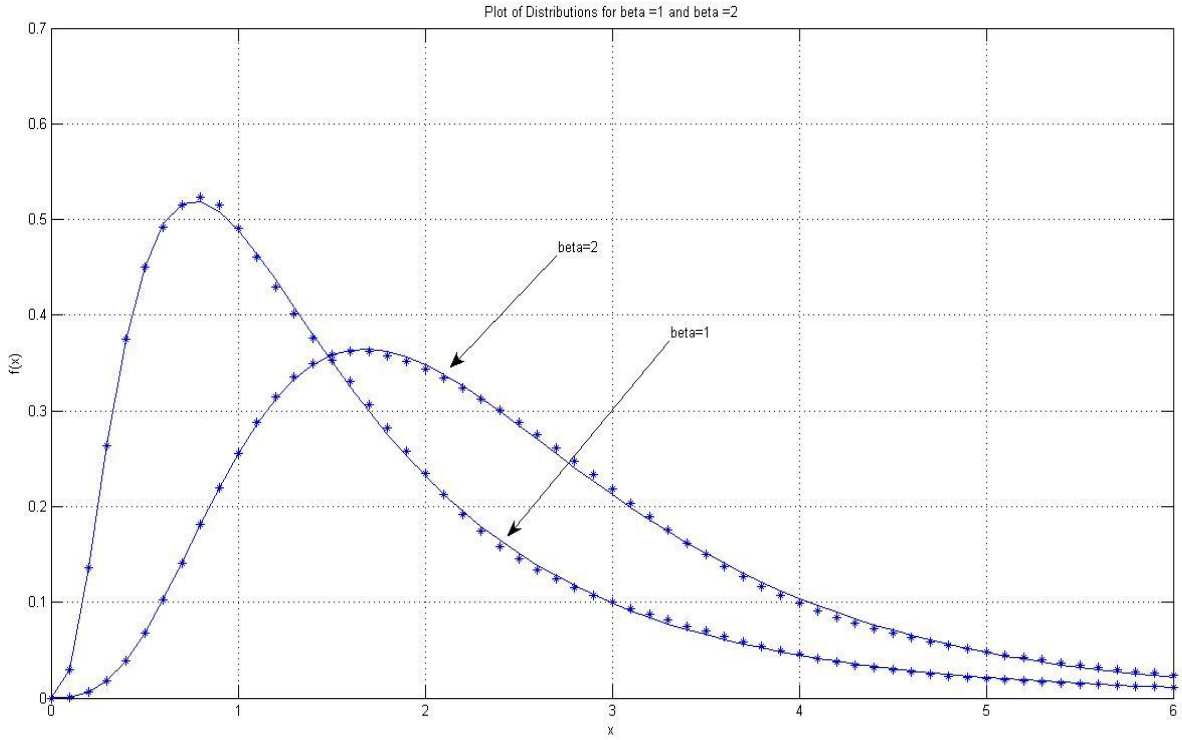
Probability Distributions of Amplitudes (Nakagami-Lognormal and Its Approximation):

Matlab Code:

```
clear
clc

t5=[0 0.95857 2.02018 -0.95857 -2.02018];
w5=[0.945308 0.393619 0.0199532 0.393619 0.0199532];
t11(1:6)=[-3.66847 -2.78329 -2.02594 -1.32655 -0.6568 0];
t11(7:11)=[3.66847 2.78329 2.02594 1.32655 0.6568];
w11(1:6)=[1.43956e-6 0.0003468 0.011911 0.11722 0.42935 0.65475];
w11(7:11)=[1.43956e-6 0.0003468 0.011911 0.11722 0.42935];

for be=1:2
    al=4;
    m=2;
    if(be==1)
        w=w11;
        t=t11;
    else
        w=w5;
        t=t5;
    end
    l=sqrt(psi(1, be));
    u=psi(be)+log(al);

    C=sqrt(pi)/sum(w);
    a=2*power(m, m).*w.*exp(-m*(sqrt(2)*l*t+u))./(sqrt(pi)*gamma(m));
    b=m*exp(-(sqrt(2)*l*t+u));
    i=1;
    for x=0:0.1:6
        fNx(i)=C*sum(a.*power(x, 2*m-1).*exp(-b*x*x));
        i=i+1;
    end
    i=1;
    for x=0:0.1:6
        f(i)=2*power(m, m)*power(x, 2*m-1)./(sqrt(pi)*gamma(m));
        F=@(t)exp(-t.*t).*exp(-m*((sqrt(2)*l*t)+u+x*x*exp(-sqrt(2)*l*t+u))));
        Q=quadgk(F, -inf, inf);
        fnl(i)=f(i)*Q;
        i=i+1;
    end
    fnl(1)=0;                          %due to f(i)=0 for x=0
    x=0:0.1:6;
    grid
    plot(x, fnl)
    hold on
    plot(x, fNx, '*')
    hold on
end
```

Simulation Results:

Discrete symbols show the approximation fNx and continuous line shows nakagami-lognormal distribution fnl(x).



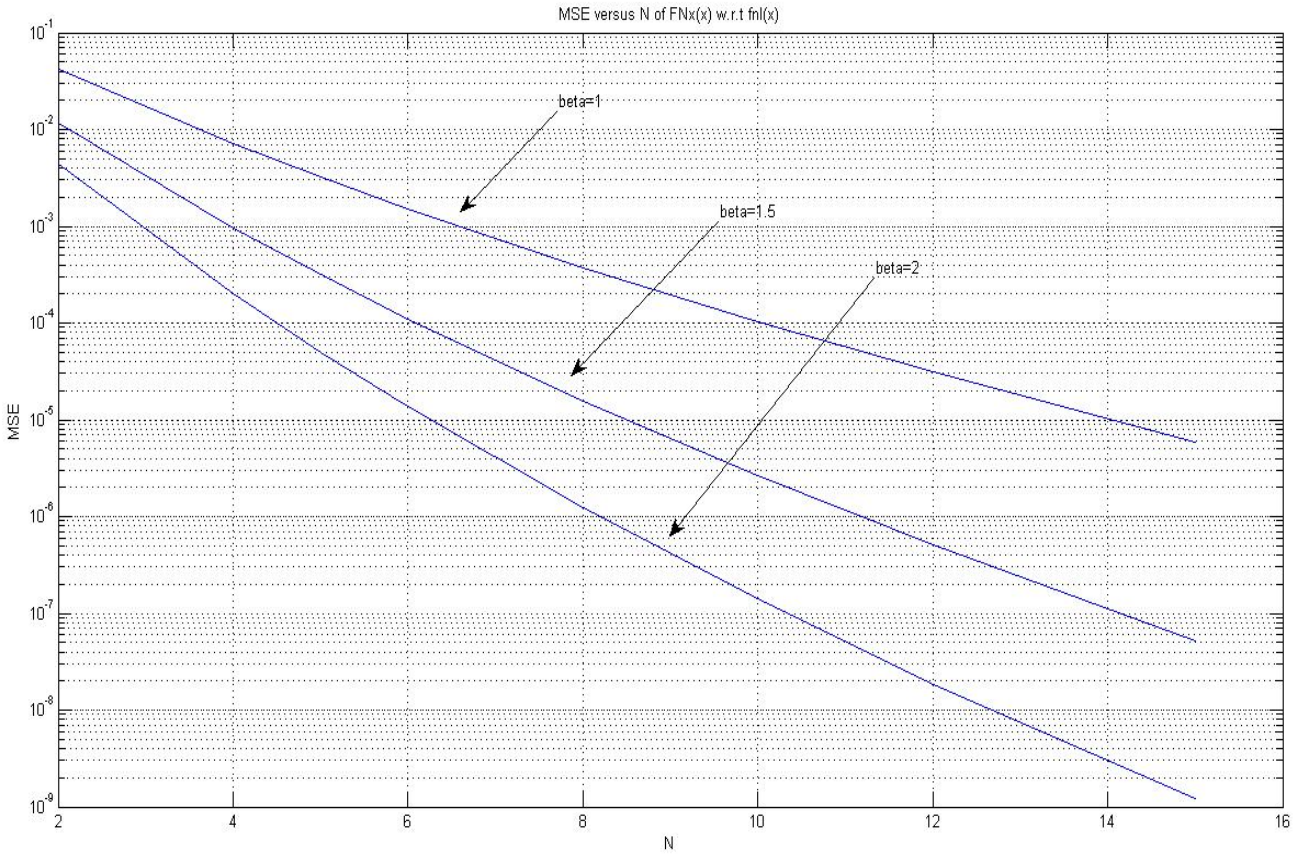
Mean Square Errors B/W Distributions:

Matlab Code:

```
t2=[-0.70710 0.70710];
w2=[0.886226 0.886226];
t4=[-1.65068 -0.52464 1.65068 0.52464];
w4=[0.08131 0.80491 0.08131 0.80491];
t5=[0 0.95857 2.02018 -0.95857 -2.02018];
w5=[0.945308 0.393619 0.0199532 0.393619 0.0199532];
t6=[-2.35060 -1.33584 -0.43607  2.35060 1.33584 0.43607];
w6=[0.00453 0.15706 0.72462 0.00453 0.15706 0.72462];
t8=[0.38118 1.15719 1.98165 2.93063 -0.38118 -1.15719 -1.98165 -2.93063];
w8=[0.661147 0.207802 0.0170779 0.000199604 0.661147 0.207802 0.0170779
0.000199604];
t10=[0.34290 1.03661 1.75668 2.53273 3.43615 -0.34290 -1.03661 -1.75668 -
2.53273 -3.43615];
w10=[0.610862 0.240138 0.0338743 0.00134364 0.00000764043 0.610862 0.240138
0.0338743 0.00134364 0.00000764043];
t11(1:6)=[-3.66847 -2.78329 -2.02594 -1.32655 -0.6568 0];
t11(7:11)=[3.66847 2.78329 2.02594 1.32655 0.6568];
w11(1:6)=[1.43956e-6 0.0003468 0.011911 0.11722 0.42935 0.65475];
w11(7:11)=[1.43956e-6 0.0003468 0.011911 0.11722 0.42935];
t12(1:6)=[0.31424 0.94778 1.59768 2.2795 3.02063 3.88972];
t12(7:12)=[-0.31424 -0.94778 -1.59768 -2.2795 -3.02063 -3.88972];
w12(1:6)=[5.70135e-1 2.60492e-1 5.16079e-2 3.90539e-3 8.57368e-5 2.65855e-7];
w12(7:12)=[5.70135e-1 2.60492e-1 5.16079e-2 3.90539e-3 8.57368e-5 2.65855e-
7];
t15(1:8)=[-4.49999 -3.66995 -2.96716 -2.32573 -1.719992 -1.13611 -0.56506 0];
t15(9:15)=[4.49999 3.66995 2.96716 2.32573 1.719992 1.13611 0.56506];
w15(1:8)=[1.52247e-9 1.05911e-6 0.0001 0.00277 0.03078 0.15848 0.41202
0.5641];
w15(9:15)=[1.52247e-9 1.05911e-6 0.0001 0.00277 0.03078 0.15848 0.41202];

for be=1:0.5:2
for j=1:8
    al=4;
    m=2;
    switch j
        case 1
        w=w2;         t=t2;
        case 2
        w=w4;         t=t4;
        case 3
        w=w5;         t=t5;
        case 4
        w=w6;         t=t6;
        case 5
        w=w8;         t=t8;
        case 6
        w=w10;         t=t10;
        case 7
        w=w12;         t=t12;
        case 8
        w=w15;         t=t15;
```

```
    end
    l=sqrt(psi(1, be));    u=psi(be)+log(al);    C=sqrt(pi)/sum(w);
    a=2*power(m, m).*w.*exp(-m*(sqrt(2)*l*t+u))./(sqrt(pi)*gamma(m));
    b=m*exp(-(sqrt(2)*l*t+u));
    i=1;
    for x=0:0.02:10
        fNx(i)=C*sum(a.*power(x, 2*m-1).*exp(-b*x*x));
        i=i+1;
    end
    i=1;
    for x=0:0.02:10
        f(i)=2*power(m, m)*power(x, 2*m-1)./(sqrt(pi)*gamma(m));
        F=@(t)exp(-t.*t).*exp(-m*((sqrt(2)*l*t)+u+x*x*exp(-sqrt(2)*l*t+u))));
        Q=quadgk(F, -inf, inf);
        fnl(i)=f(i)*Q;
        i=i+1;
    end
    fnl(1)=0;
    E(j)=sum((fNx-fnl).^2)/61;
end
grid
N=[2 4 5 6 8 10 12 15];
plot(N, E)
hold on
end
```

Simulation Results:



Channel Capacity:

Matlab Code:

```
clear
clc

t15(1:8)=[-4.49999 -3.66995 -2.96716 -2.32573 -1.719992 -1.13611 -0.56506 0];
t15(9:15)=[4.49999 3.66995 2.96716 2.32573 1.719992 1.13611 0.56506];
w15(1:8)=[1.52247e-9 1.05911e-6 0.0001 0.00277 0.03078 0.15848 0.41202
0.5641];
w15(9:15)=[1.52247e-9 1.05911e-6 0.0001 0.00277 0.03078 0.15848 0.41202];

sig=4.5;
be=2.8461;
N=15;
w=w15;
t=t15;
al=4;
m=2;
B=1;
C=sqrt(pi)/sum(w);
l=(log(10)/10)*(power(10, sig/10));
u=psi(be)+log(al);
a=2*power(m, m).*w.*exp(-m*(sqrt(2)*l*t+u))/(sqrt(pi)*gamma(m));
b=m*exp(-(sqrt(2)*l*t+u));
j=1;
for p=0.1:0.5:100
    for i=1:15
        F=(@(x)(C/(2*p^m)).*log2(1+x).*a(i).*((x.*x.*p).^(m-1)).*exp((-
b(i).*x.*x)));
        Q(i)=integral(F, 0, inf);
    end
    G(j)=sum(Q);
    j=j+1;
end
p=0.1:0.5:100;
P=10.*log10(p);
plot(P, G)
```

Outage Probability:

Matlab Code:

```
clear
clc

t15(1:8)=[-4.49999 -3.66995 -2.96716 -2.32573 -1.719992 -1.13611 -0.56506 0];
t15(9:15)=[4.49999 3.66995 2.96716 2.32573 1.719992 1.13611 0.56506];
w15(1:8)=[1.52247e-9 1.05911e-6 0.0001 0.00277 0.03078 0.15848 0.41202
0.5641];
w15(9:15)=[1.52247e-9 1.05911e-6 0.0001 0.00277 0.03078 0.15848 0.41202];

sig=4.5;
be=2.8461;
al=4;
m=2;
w=w15;
t=t15;
l = (log(10)/10)*(power(10, sig/10));
u = psi(be) + log(al);
C=sqrt(pi)/sum(w);
a=2*power(m, m).*w.*exp(-m*(sqrt(2)*l*t+u))./(sqrt(pi)*gamma(m));
b=m*exp(-(sqrt(2)*l*t+u));
x=1;
i=1;
for p=0.1:0.5:100
    FN(i)=(C/2)*sum((a./(b.^m)).*gammainc(m, ((b*x)./(p))));
    i=i+1;
end
p=0.1:0.5:100;
P=10.*log10(p);
plot(P, FN)
```

Symbol Error Rate for BPSK and 4-QAM:

Matlab Code:

```
clear
clc

t15(1:8)=[-4.49999 -3.66995 -2.96716 -2.32573 -1.719992 -1.13611 -0.56506 0];
t15(9:15)=[4.49999 3.66995 2.96716 2.32573 1.719992 1.13611 0.56506];
w15(1:8)=[1.52247e-9 1.05911e-6 0.0001 0.00277 0.03078 0.15848 0.41202
0.5641];
w15(9:15)=[1.52247e-9 1.05911e-6 0.0001 0.00277 0.03078 0.15848 0.41202];

sig=4.5;
be=2.8461;
al=4;
m=2;
w=w15;
t=t15;
l = (log(10)/10)*(power(10, sig/10));
u = psi(be) + log(al);
C=sqrt(pi)/sum(w);
a=2*power(m, m).*w.*exp(-m*(sqrt(2)*l*t+u))./(sqrt(pi)*gamma(m));
b=m*exp(-(sqrt(2)*l*t+u));

j=1;
M=2;
gpsk=(sin(pi/M))^2;
for p=0.1:0.5:100
    for i=1:15
      F=@(x)(C*gamma(m)/(2*(p^m))).*((a(i)./(((psk./((sin(x)).^2))+b(i)/p).^m
      )));
      Q=quadgk(F, 0, (M-1)*pi/M);
    end
    P(j)=(1/pi)*sum(Q);
    j=j+1;
end

j=1;
K=2*C*gamma(m)*(1-(1/sqrt(M)))/pi;
gqam=(3/2)*(M-1);
for p=0.1:0.5:100
    for i=1:15
        F1=@(x)(((sin(x)).^2)./(((sin(x)).^2)+(gqam*p/b(i))).^m);
        Q1=quadgk(F1, 0, pi/2);
        F2=@(x)(((sin(x)).^2)./(((sin(x)).^2)+(gqam*p/b(i))).^m);
        Q2=(1-(1/sqrt(M)))*quadgk(F2, 0, pi/4);
        Po(i)=(a(i)/b(i)^m)*(Q1-Q2);
    end
    P(j)=K*sum(P);
    j=j+1;
end
```