EXPERIMENT 5

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AIM: To simulate and observe the Rayleigh Distribution. Then get a brief understanding on the concept of Rayleigh Fading.

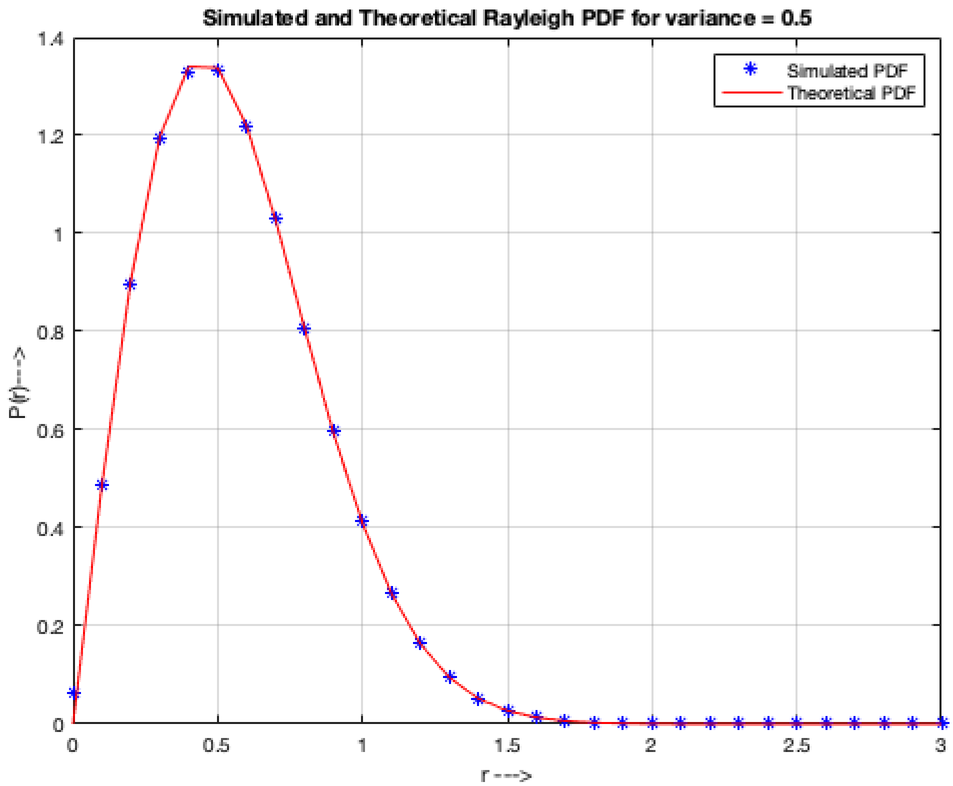
THEORY: The Rayleigh fading model uses a statistical approach to analyse the propagation, and can be used in a number of environments. The Rayleigh fading model is ideally suited to situations where there are large numbers of signal paths and reflections. Typical scenarios include cellular telecommunications where there are large number of reflections from buildings and the like and also HF ionospheric communications where the uneven nature of the ionosphere means that the overall signal can arrive having taken many different paths.

- Characterizing Amplitude fluctuations:Consider a transmitter (Base station) and receiver (mobile) in a city environment. The medium between the transmitter and receiver are obstructed by several buildings, trees and other objects. The receiver keeps moving away from the transmitter. We measure the signal power at the receiver as we move away from the receiver. The ratio of received signal power to the transmitted signal power is plotted against the distance
- Multi-path Fading: A signal travelling in an environment may get reflected by several objects on the path. This gives rise to several reflected signals. The reflected signals arrive at the receiver at different time instants and with different intensities leading to multipath propagation. Depending on the phase of each individual reflected signal, the received signal power may increase or decrease due to contructive or destructive interference. A small variation in the phase of each reflected signal from each multipath may lead to significant difference in the total received power. This phenomenon is also referred as short-term or small scale fading.
- Characterizing amplitude fluctuations:Three phenomenon's namely : 1) Propagation path loss 2) Shadowing/large scale fading 3) Multipath or small scale fading contribute to amplitude fluctuations in the received signal. It is often desirable to characterize the amplitude fluctuations statistically.

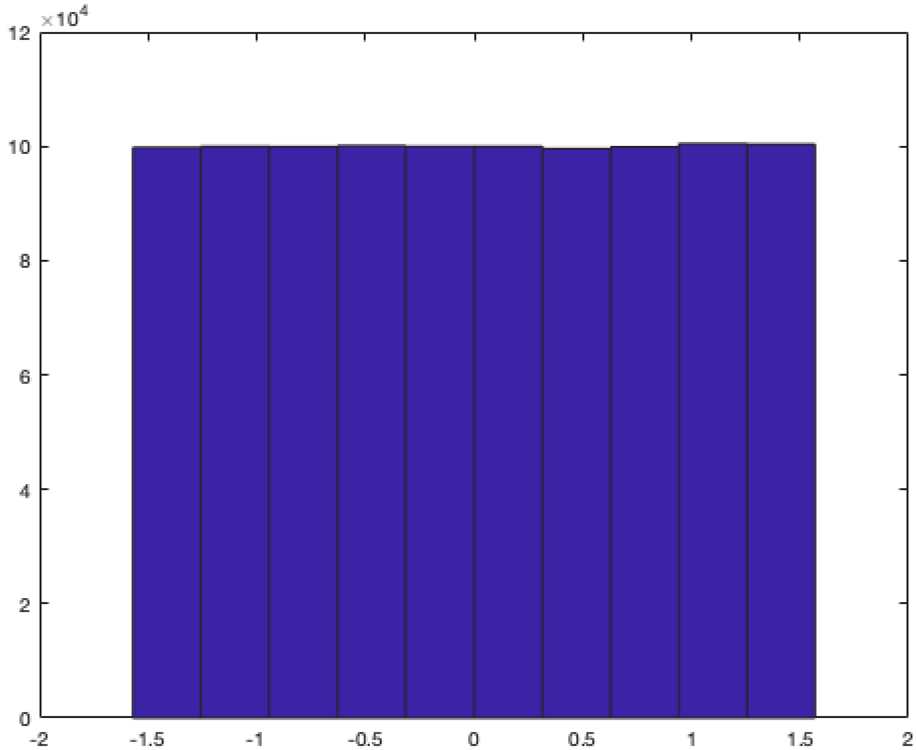
CODE OF THE PROGRAM AND IT'S OUTPUTS:

```
%----Rayleigh_PDF-----------------------------------------

%----------Input Section----------------

N=1000000; %Number of samples to generate

variance = 0.2; % Variance of underlying Gaussian random variables

%Independent Gaussian random variables with zero mean and unit variance

x = randn(1, N);

y = randn(1, N);
```

```
%Rayleigh fading envelope with the desired variance

r = sqrt(variance*(x.^2 + y.^2));

%Define bin steps and range for histogram plotting

step = 0.1; range = 0:step:3;


%Get histogram values and approximate it to get the pdf curve

h = hist(r, range);

approxPDF = h/(step*sum(h)); %Simulated PDF from the x and y samples


%Theoritical PDF from the Rayleigh Fading equation

theoretical = (range/variance).*exp(-range.^2/(2*variance));

plot(range, approxPDF,'b*', range, theoretical,'r');

title('Simulated and Theoretical Rayleigh PDF for variance = 0.5')

legend('Simulated PDF','Theoretical PDF')

xlabel('r --->');

ylabel('P(r)---> ');

grid;
```

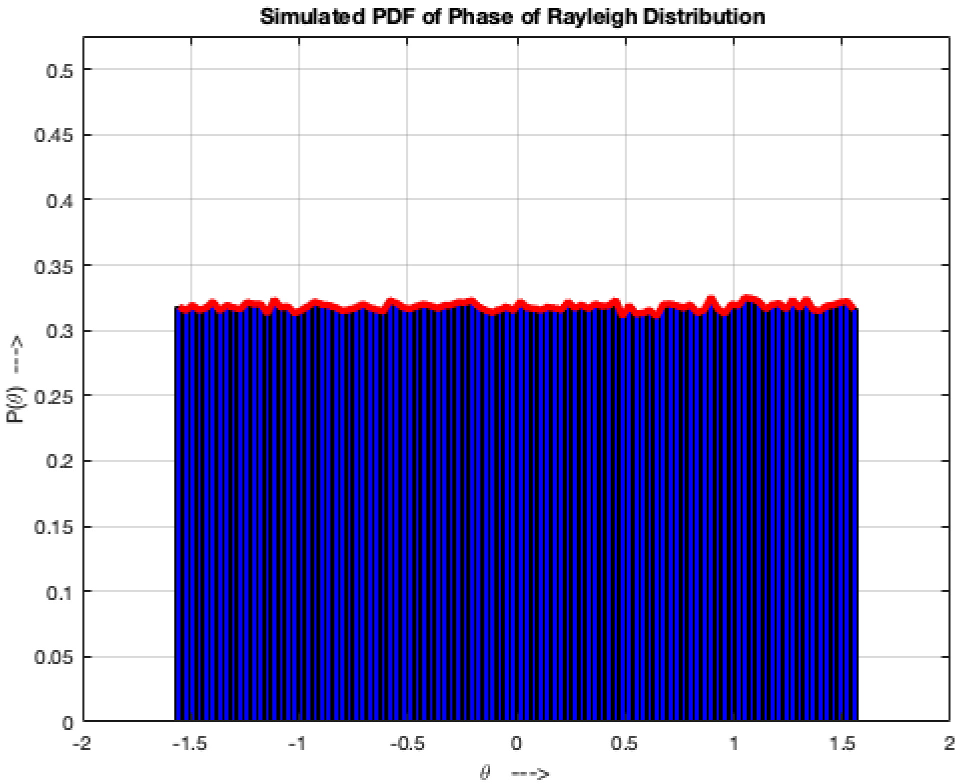



```
%PDF of phase of the Rayleigh envelope

theta = atan(y./x);

figure(2)

hist(theta); %Plot  histogram of the phase part
```




```
%Approximate the histogram of the phase part to a nice PDF curve
[counts,range] = hist(theta,100);
step=range(2)-range(1);

%Normalizing the PDF to match theoretical curve
approxPDF = counts/(step*sum(counts)); %Simulated PDF from the x and y samples
bar(range, approxPDF,'b');
hold on
plotHandle=plot(range, approxPDF,'r');
set(plotHandle,'LineWidth',3.5);
axis([-2 2 0 max(approxPDF)+0.2])
hold off
title('Simulated PDF of Phase of Rayleigh Distribution ');
```

```
xlabel('\theta    --->');

ylabel('P(\theta)   --->');

grid;
```



RESULT: Amplitude Flunctuations can be observed in our Outputs. Amplitude Flunctuations are mainly of two types:

Characterizing Dispersion in Time: In a multipath environment, the transmitted signal is reflected and scattered along the way by several obstacles. This leads to the phenomena called ――Dispersion in Time‖ orequivalently ―frequency selectivity‖. If received signal arrives with different delays, it leads to time-dispersion of the transmitted signal. This is best characterized by Power Delay Profile or PDP. Two scalars namely Delay spread and coherence bandwidth are derived from the PDP.

Rayleigh Fading and Rayleigh Distribution: The delays associated with different signal paths in a multipath fading channel change in an unpredictable manner and can only be characterized statistically. When there are a large number of paths, the central limit theorem can be applied to model the time-variant impulse response of the channel as a complex-valued Gaussian random process. When the impulse response is modeled as a zero-mean complex-valued Gaussian process, the channel is said to be a Rayleigh fading channel.

These phemnomenos are mainly employed in applications such as wireless communication and cellular communications.

CONCLUSION: From this experiment we have gained a sound understanding over the concept of RAYLEIGH FADING AND RAYLEIGH DISTRIBUTION. We have also learned to plot the outputs of these on Matlab.