Simulation of communication channels

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Overview

1. Simulation
2. Introduction to random numbers and their generation.
3. Inverse transform sampling method
4. Inverse laplace transform
5. Relay Fading
6. AWGN Channel
7. Relay System
8. MRC
9. MIMO
10. OFDM
11. References

Simulation:

- Simulation modeling solves real-world problems safely and efficiently.
- Easily verified, communicated, and understood
- While simulating we have to generate symbols at the input .
- Generating symbols manually is a difficult task.
- So we use random number generation techniques to generate them.

Random numbers

Random numbers are numbers that occur in a sequence.
We have 6 fundamental methods to generate Random variables

- Physical sources.
- Empirical resampling
- Pseudo random generators
- Simulation/Game-play
- Rejection Sampling
- Transform methods

Inverse transform sampling method

Generating pseudo-random numbers that are distributed according to a given probability distribution.

Method:

- Generate a random number u ,from the standard uniform distribution in the interval [0,1], e.g. from U follows Unif[0,1].
- Find the inverse of the desired CDF, e.g. Fx-1(x).
- Compute X=Fx-1(u). The computed random variable X has distribution Fx (x) .

Simulation results

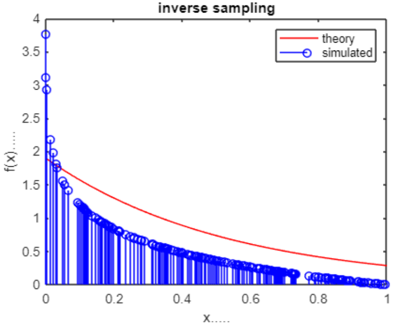


Figure: Lamda 1.9

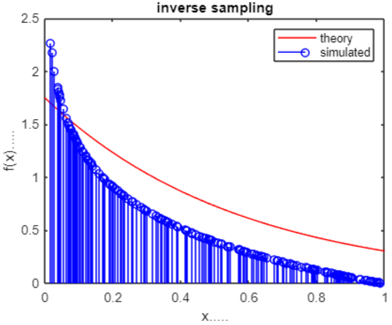


Figure: Lamda 1.75

Conclusion

- Need analytic form or approximation of inverse cdf.
- Doesn't work if the cdf is not monotonically increasing.
- Doesn't work for high dimensional problems.
- Used in univariant problems.

So we go for inverse laplace transform sampling method.

Inverse laplace transform

- Moment generating function and pdf are laplace transform pairs.
- Generation of random variable using it's mgf.
- conversion of mgf to pdf can be done by the expression

$$P_X(x; A, N, Q) = \sum_{q=0}^{Q} 2^{-Q} \binom{Q}{q} \frac{e^{\frac{A}{2}}}{x} \sum_{n=0}^{N+q} \frac{(-1)^n}{\beta_n} \Re(P_X(\frac{A + 2\pi jn}{2x})) + E(A) + E(N, Q)$$

$$E(N, Q) \approx \frac{e^{\frac{A}{2}}}{x} \sum_{q=0}^{Q} 2^{-Q} (-1)^{N+1+q} \binom{Q}{q} \Re(P_X(\frac{A + 2\pi j(N + q + 1)}{2x}))$$

$$E(A) = e^{-A}$$

simulation results

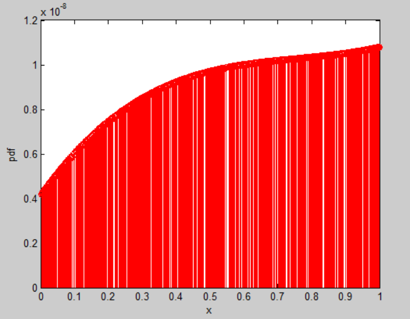


Figure: pdf of gamma function
$\alpha = 7, \beta = 8$

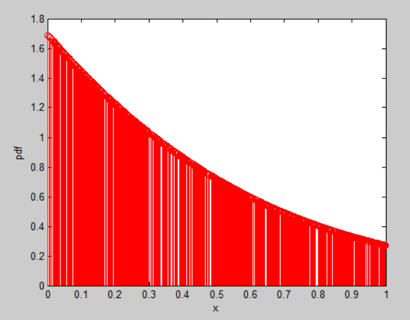


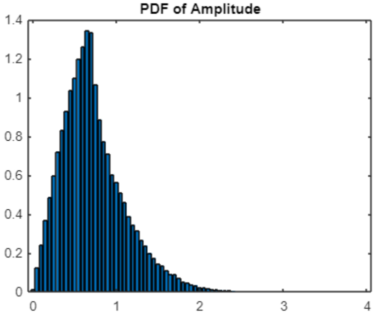
Figure: pdf of exponential function
$\alpha = 1, \beta = 0.5$

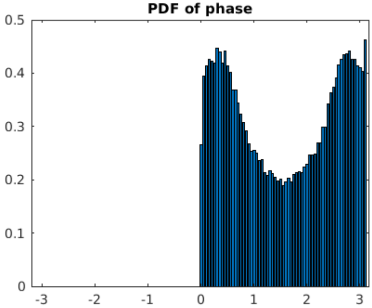
conclusion

1. Applicable only for the function which has x as a positive random variable.
2. Probability density function of x is real.
3.Frequency spectrum of real part in s-domain is even.
4. So we can not apply this to those functions which do not satisfy these conditions.

Relay Fading

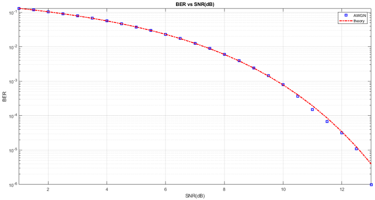
1. **Fadding in wireless communication.**
2. **Fadding coefficient characteristics.**
3. **Relay channel distribution.**





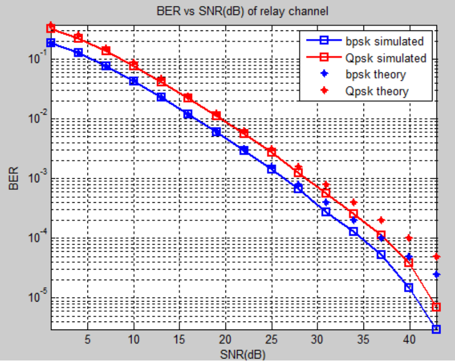
BER of BPSK in AWGN channel

1. **Additive gaussian noise will effect AWGN channel.**
2. **AWGN channel noise distribution.**



BER of Relay fading system

The Error in relay fading sysytem is due to AWGN noise and fading.



conclusion

1. Bit error rate of fading system is more compared to AWGN channel.
2. Because in wireless communication more noise is added. And the line of site component is low .
3. Fadding is high.
4. High BER.

Maximal Ratio Combining

Maximum-ratio combining (MRC) is a method of diversity combining in which:

1. The signals from each channel are added together.
2. The gain of each channel is made proportional to the rms signal level and inversely proportional to the mean. square noise level in that channel.
3. different proportionality constants are used for each channel.
4. Maximum-ratio combining is the optimum combiner for independent additive white Gaussian noise channels.
5. MRC can restore a signal to its original shape.

Theoritical BER for MRC is

$$\frac{1}{(2SNR)^L}\binom{Q}{q}$$

MRC block diagram

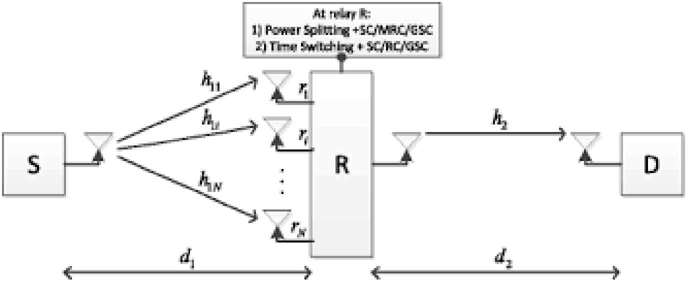


Figure: block diagram of MRC

Simulation reslts

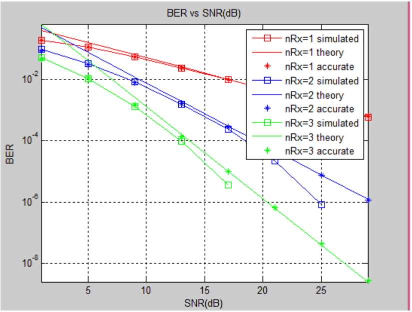


Figure: BER of MRC for different no.of antennas

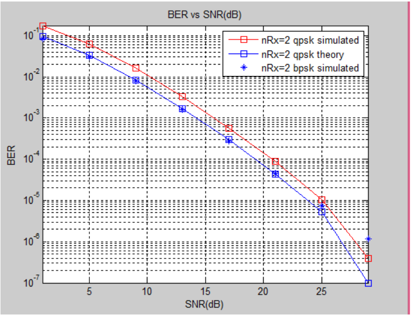


Figure: BER of MRC for QPSK and BPSK

conclusion

1. If no.of receiving antennas increases then bit error rate decreases.
2. BER of QPSK is greater than BER of BPSK.
3. If number of antennas are increasing then signal will be received exactly.

Multiple Input Multiple Output

1. MIMO is highly used in 3G and 4G technologies.
2. MIMO can increase reliability.
3. MIMO increases the data transmission rate.
4. Using MIMO we can send more data in less time.

The theoritical BER of MIMO is same as theoritical BER of MRC .But the no.of antennas are taken as $N = R - T + 1$. Where
T =no.of transmitting antennas
R =no.of receiving antennas
So BER of MIMO is

$$\frac{1}{(2SNR)^N}\binom{2N-1}{N}$$

Where $N = R - T + 1$

Simulation results

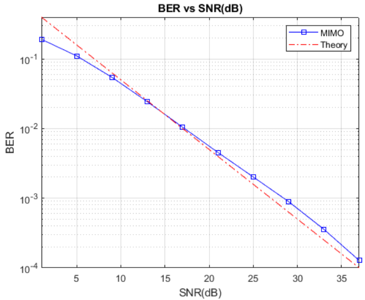


Figure: BER of MIMO Channel

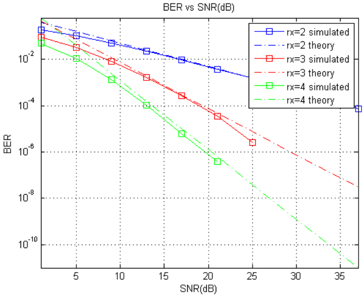


Figure: BER of of MIMO with increasing no.of receiving antennas

Conclusion

1. The BER of MIMO channel decreases with increasing number of transmitting antennas.
2. installation Cost is high.

Orthogonal Frequency Division Multiplexing

OFDM is a method of encoding a digital data on multiple carrier frequencies,orthogonal sub-carrier signals with overlapping spectra are transmitted to carry data in parallel.
Genarally in FDM guard bands are required to protect the leakage adjacent interference,where as in OFDM we overlap the sub carriers orthogonally which consumes low bandwidth.
Theoritical BER of OFDM is

$$BER = \frac{1}{2}(1 - \sqrt{\frac{\frac{L}{N}SNR_{T_X}}{2 + \frac{L}{N}SNR_{T_X}}})$$

$$SNR_{T_X} = \frac{P}{\sigma^2}$$

$$SNR_{R_X} = \frac{LP}{\sigma^2}$$

Block diagram of OFDM

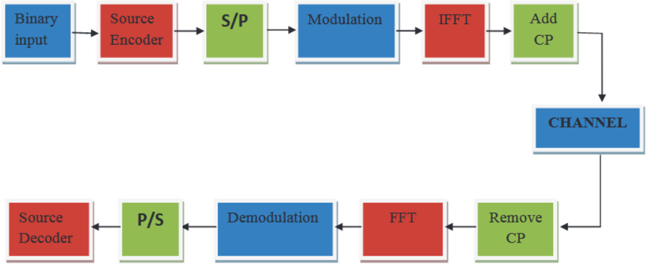


Figure: block diagram of OFDM

Simulation results

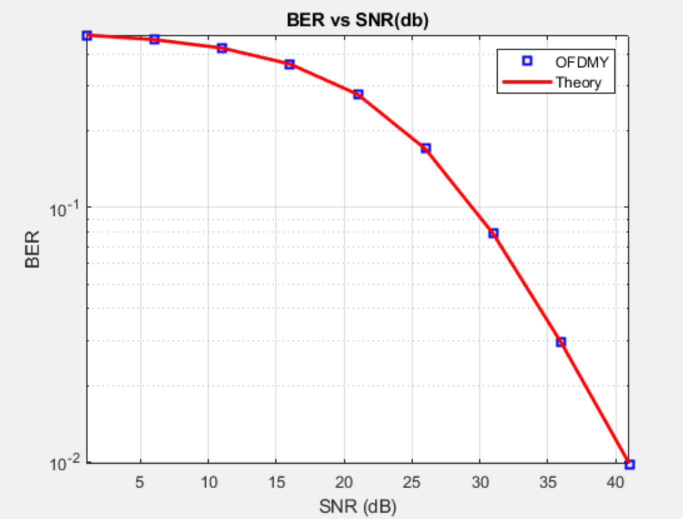


Figure: BER of OFDM Using BPSK

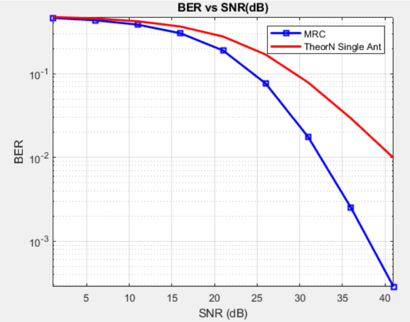


Figure: BER of OFDM with MRC

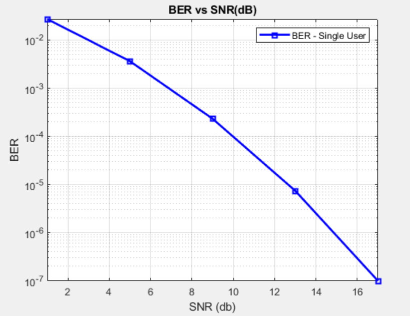


Figure: BER of OFDM with MIMO

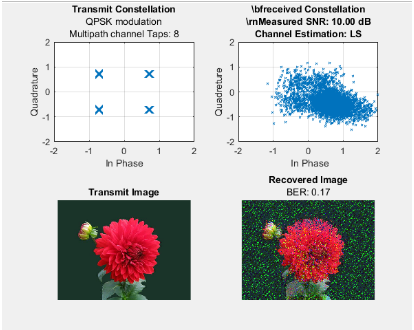


Figure: OFDM received data with 10dB

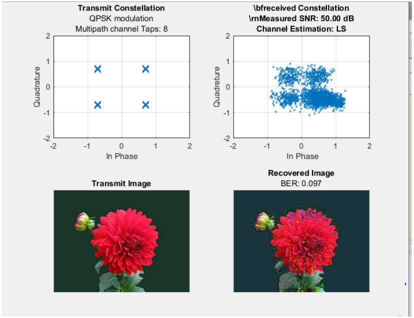


Figure: OFDM received data with 50dB

Conclusion

1. By using OFDM we can decrease the bandwidth.
2. Inter Symbol Interference (ISI) is reduced.
3. Storage decreases.
4. we will have Effective data transmission in OFDM.

References

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Thank you