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BEST MODULATION TECHNIQUE AND MOST EFFICIENT CARRIER NUMBER FOR GETTING MAXIMUM SNR AND MINIMUM BER FOR OFDM GENERATED SIGNAL OVER RAYLEIGH DISTRIBUTION

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ABSTRACT

Rayleigh distribution of OFDM generated signal is performed over various modulation techniques in order to find out the best modulation scheme which can be used to get maximum SNR and minimum BER. The constellation diagrams are first obtained by varying the noise variance keeping the SNR fixed later a comparative BER vs. SNR graph is plotted considering those constellation diagrams and finally the modulation technique vs. improvement graph is obtained. Another important finding is the number of FFT points or carriers for least BER.

Keywords: Rayleigh Distribution, OFDM, SNR, BER, FFT.

I. INTRODUCTION

Wireless data communications are used to span a distance beyond the capabilities of typical cabling in point to point communication and point to multi point communication to provide backup communications link in case of normal network failure, to link portable or temporary workstations to overcome situations where normal cabling is difficult or financially impractical or to remotely connect mobile users to network. Wireless networks allow multiple users to access large amounts of information without the hassle of running wires to and from each computer. This can be extremely helpful if there are a number of users that need to move around or access the network. However, wireless networks are far from perfect and there are a number of limitations that an individual or organization may face when using wireless network.

Wireless networks are extremely susceptible to interference so radio signals, radiation and any other similar type of interference may cause a wireless network to malfunction. Another important aspect of wireless communication is the channels through which radio energy passes. Wireless channels always show random behavior and noise plays a vital role in determining the wireless channel. Due to several factors such as fading, multipath propagation etc. wireless communications are typically slower than a wired connection. Engineers are working very hard to elevate this shortcoming of wireless technology by exercising many techniques and calculations.

Most recently 4G has become the most used technology in terms of mobile communications. In both 4G and Wi-Fi technology OFDM is adopted to manage many users in the same network. It also ensures the efficient use of the frequency spectrum as well as the channels. Wireless communication technology using OFDM technique suffers heavily due the random nature of the channel. In this paper we tried to build up our work on improving BER and SNR considering some important parameters of the OFDM technique. They are as under:

a. Observing improvement of BER and SNR varying modulation scheme.

b. Varying the number of FFT points or varying the number of carriers.

For these only additive white Gaussian Noise was considered for Rayleigh random distribution of the channel.

II. METHODOLOGY

In our simulation and analysis, we had three different steps:

1. Generation of the OFDM signal using Matlab
2. Simulating the OFDM signal over Rayleigh Channel Fading.
3. Theoretical Analysis of SNR and BER using different Modulation Techniques.

At first we took an image signal and generated bit stream from it, after that we encoded the digital signal on multiple carrier frequencies. Numerously closely spaced orthogonal subcarrier signals with overlapping spectra were emitted to carry data then the signal was mixed with noise and Rayleigh channel fading. After that a

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theoretical analysis of the SNR and BER using different modulation techniques were done using that particular signal mixed with noise and channel fading.

III. MODELING AND ANALYSIS

The transmitter in OFDM consists of a RF modulator, serial to parallel converter, IFFT block, parallel to serial converter, cyclic prefix adder, digital to analog converter and an antenna. The transmitter propagates the signal through air. In air the signals get involved with noise and encounters fading. At distant location, receiver antenna receives the distorted, noise added signal, and passes it through an analog to digital converter. The receiver consists of an analog to digital converter, cyclic prefix remover, and serial to parallel converter, FFT block, and parallel to serial converter and RF demodulator.

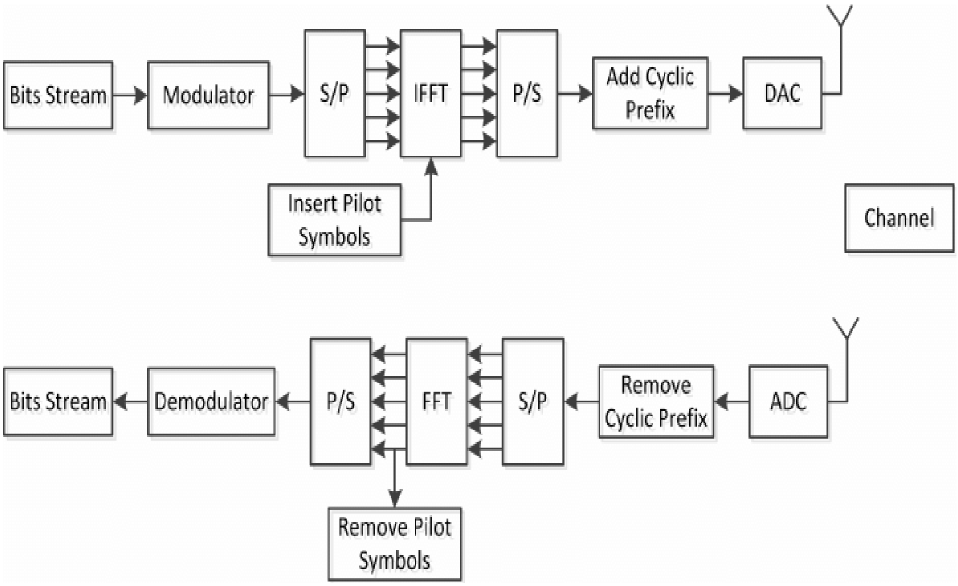

Figure 1: Block diagram of OFDM TX/RX

Orthogonal Frequency Division Multiplexing (OFDM)

Orthogonal Frequency Division Multiplexing is a method of encoding digital data on multiple carrier frequencies. Numerous closely spaced orthogonal subcarrier signals with overlapping spectra are emitted to carry data. Demodulation is based on Fast Fourier Transform algorithms. Each subcarrier (signal) is modulated with a conventional modulation technique at a low symbol rate. This maintains total data rates similar to conventional single carrier modulation techniques in the same bandwidth.

In OFDM data is modulated with no orthogonal carriers as such one frequency maximum occurs at the minimum of the others. Hence there is no requirement of guard bands. It maximizes the usage of the frequency spectrum. On the other hand, cyclic prefix is added to the carrier to avoid ISI.

The main features of OFDM are as follows:

a. No inter carrier guard bands.
b. Controlled overlapping of bands.
c. Maximum spectral efficiency.
d. Easy implementation using IFFT.
e. Very sensitive to frequency spectrum.
f. Strong in multipath fading.

Another important feature of OFDM is the addition of cyclic prefix. The cyclic prefix, which is transmitted during the guard interval, consists of the end of the OFDM symbol copied into the guard interval, and this guard interval is transmitted followed by the symbol. The reason that the guard interval consists of a copy of the end of the OFDM symbol is because we don't know the exact delay spread and the hardware does not allow the blank spaces in between symbols.

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Rayleigh Fading

The signal transmitted gets involved with noise and channel fading. Wireless channels show random behavior. To simulate the channel there are a few methods. Rayleigh distribution is one of them. In probability theory and statistics, the Rayleigh distribution is a continuous probability distribution for non-negative valued random variables. It is essentially a Chi distribution with two degrees of freedom. It may be assumed for random complex numbers whose real and imaginary components are independently and identically distributed Gaussian with equal variance and zero mean. In that case, the absolute value of the complex number is Rayleigh distributed. The probability density function of Rayleigh distribution is as follows:

$$f(x) = \frac{r}{\sigma^2} e^{\frac{-r^2}{2\sigma^2}}; r \geq 0 \qquad (1)$$

Where r is envelope amplitude of the received signal and the $2\sigma^2$ is the pre-detection mean power of the multipath signal.

The multi carrier OFDM is prone to Rayleigh fading and so the signal envelope with noise will be Rayleigh distributed. AWGN is a noise that affects the transmitted signal when it passes through the channel. AWGN channel is not associated with either fading or any other parameters. It is just the noise that is added to the signal when it is traveling through the channel. The AWGN channel is represented by:

$$r(t) = s(t) + n(t) \qquad (2)$$

Where s (t) is transmitted signal and n(t) is white Gaussian noise. The values of white Gaussian noise at any pair of times are identically distributed and statistically independent on each other.

A Theoretical Analysis of SNR and BER using Rayleigh Distribution

Signal to noise ratio is defined as the ratio signal power to noise power and it is expressed in decibel. It is used to compare the level of a desired signal to the level of background noise.

$$SNR = \frac{SignalPower}{NoisePower} \qquad (3)$$

One of the important ways to determine the quality of a digital transmission system is to measure its Bit Error Rate (BER). The BER is calculated by comparing the transmitted sequence of bits to the received bits and counting the number of errors. The ratio of how many bits received in error over the number of total bits received is the BER.

$$BER = \frac{NErr}{NBits} \qquad (4)$$

We have carried out this for different modulation techniques

BPSK: The Binary Phase Shift Keying (BPSK) is a two-phase modulation technique, where 0's and 1's in a binary message is represented by two different phase states in the carrier signal.

The Bit Error Rate for BPSK: $$0.5 erfc\left(\sqrt{\frac{E_b}{N}}\right) \qquad (5)$$

QPSK: If two information bits (combined as one symbol) are modulated at once then by selecting one of the four possible carrier phase shift states is called QPSK Modulation.

The Bit Error Rate of QPSK: $$0.5 erfc\left(\sqrt{\frac{E_b}{N}}\right) \qquad (6)$$

M-ary PSK: If the data is conveyed by changing the phase of a constant frequency in a digital modulation process, we call it M-PSK

The Bit Error Rate for M-ary PSK: $$\frac{1}{m} erfc\left(\sqrt{\frac{mE_b}{N}}\right)\sin\frac{\pi}{m} \qquad (7)$$

M-ary QAM: If the two analog or digital signals are conveyed by changing the amplitudes of the two carrier waves, we call it QAM modulation.

The Bit Error Rate for M-ary QAM: $\frac{2}{m}\left(1-\frac{1}{\sqrt{m}}\right)erfc\left(\sqrt{\frac{2mEb}{2(M-1)N}}\right)$ (8)

Method and analysis which is performed in your research work should be written in this section. A simple strategy to follow is to use keywords from your title in first few sentences.

IV. RESULTS AND DISCUSSION

We have performed Rayleigh distribution for OFDM generated signal in various modulation techniques to find out the best modulation technique which can be used to get the maximum SNR and minimum BER. First, we varied the value of noise variance keeping SNR fixed. We got the Following constellation diagrams:

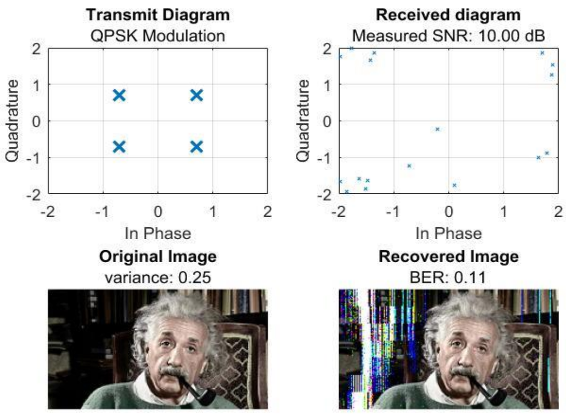

Figure 2: QPSK modulation for Noise Variance 0.25 and fixed SNR.

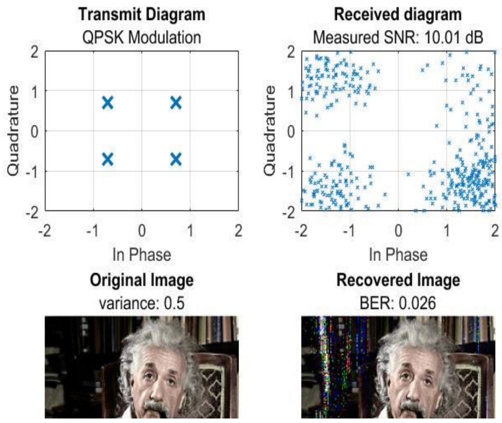

Figure 3: QPSK modulation for Noise Variance 0.50 and fixed SNR.

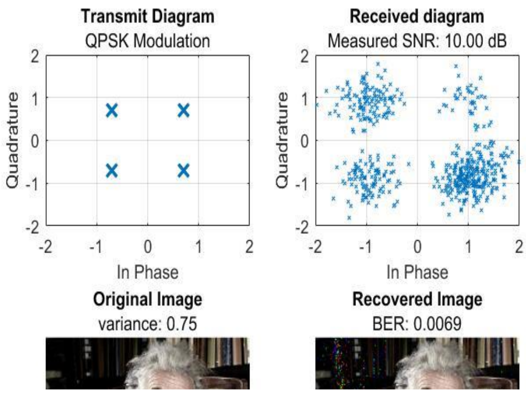

Figure 4: QPSK modulation for Noise Variance 0.75 and fixed SNR.

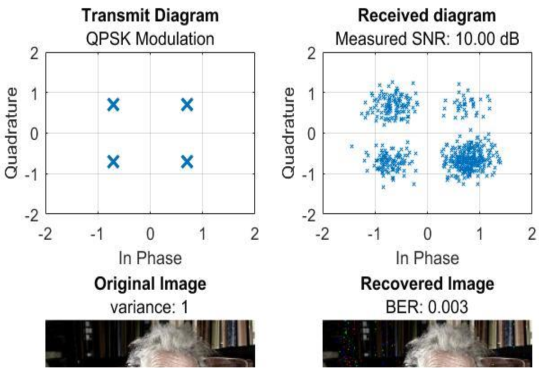

Figure 5: QPSK modulation for Noise Variance 1 and fixed SNR.

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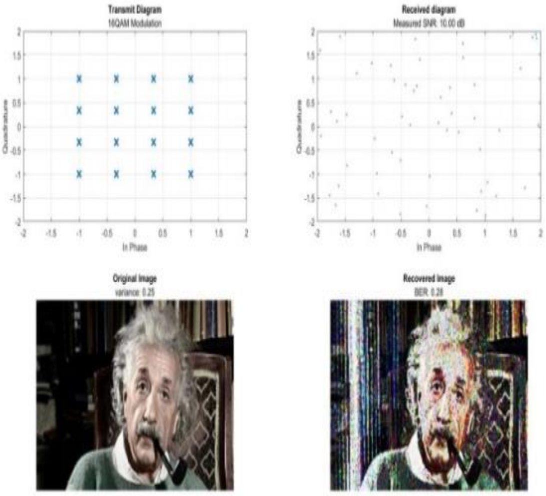

Figure 6: 16QAM modulation for Noise Variance 0.25 and Fixed SNR.

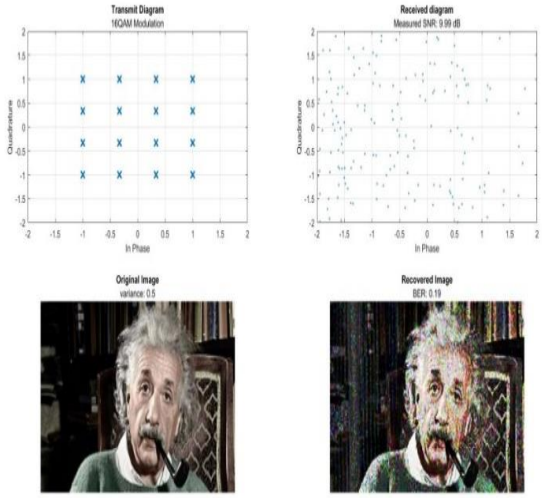

Figure 7: 16QAM modulation for Noise Variance 0.50 and Fixed SNR.

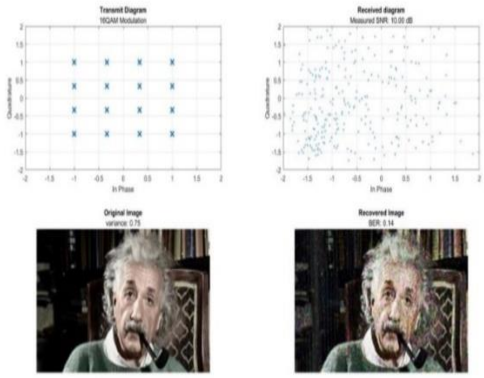

Figure 8: 16QAM modulation for Noise Variance 0.75 and Fixed SNR.

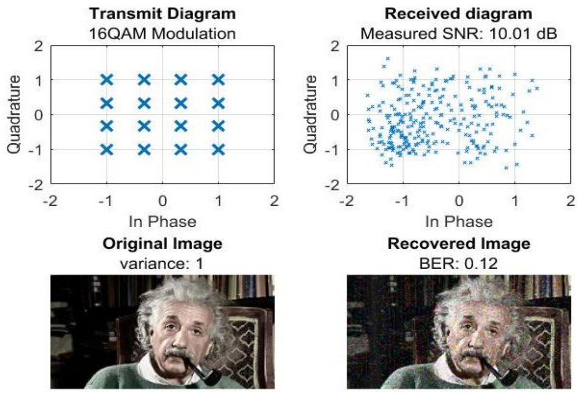

Figure 9: 16QAM modulation for Noise Variance 1.00 and Fixed SNR.

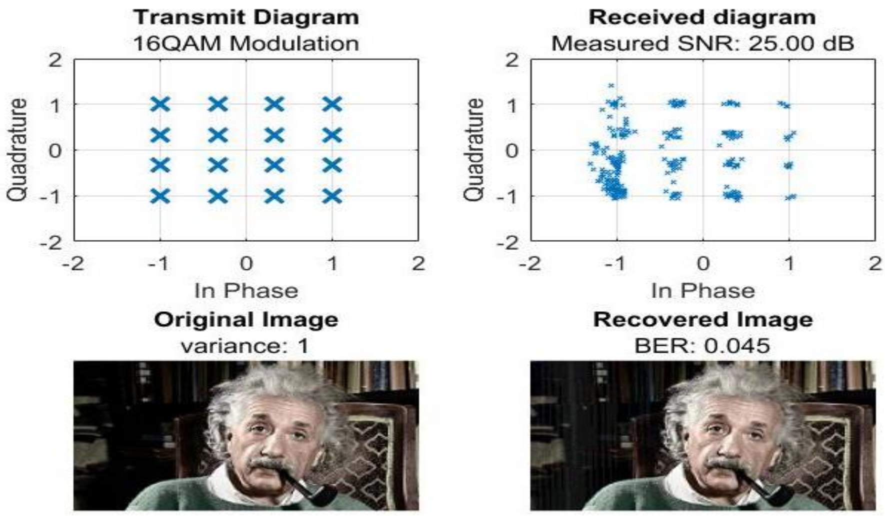

Figure 10: 16 QAM modulation for best BER performance.

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After considering the constellation diagrams for different modulation techniques we plotted a comparative BER vs. SNR graph for different modulation techniques.

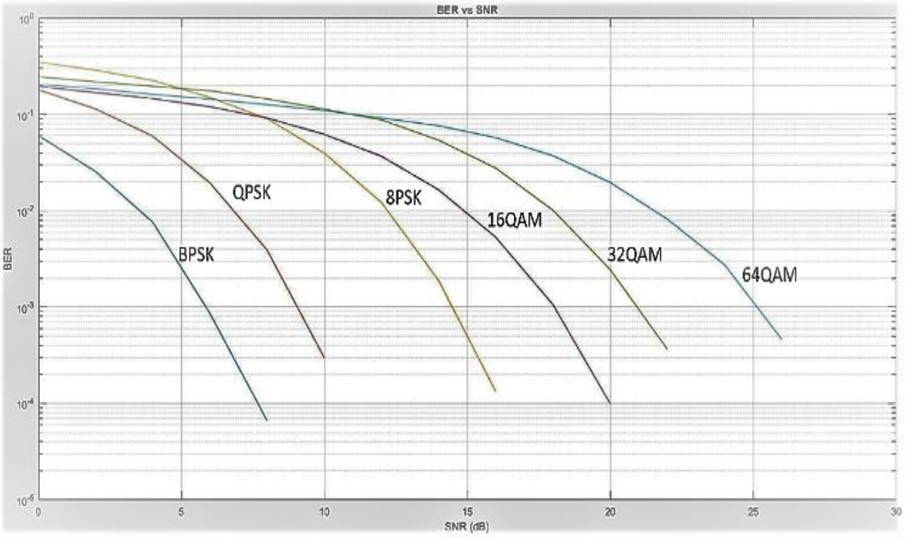

Figure 11: BER vs. SNR graph for different modulation techniques.

Considering all the modulation techniques, we plotted modulation techniques vs. improvement graph. We got the following result:

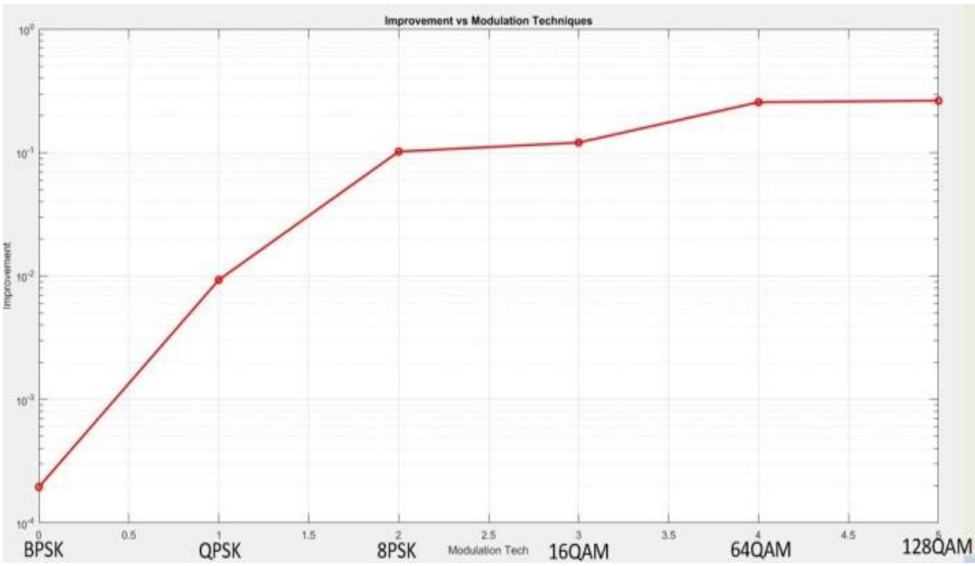

Figure 12: Improvement vs. Modulation technique graph.

Considering the results shown above we can say that though BPSK shows least possible BER, we cannot use it due to slow data rates. If we consider both criterions, we can say that 16 QAM is the best technique. Therefore, in rest of the simulation we mainly used 16QAM modulation technique. Another important finding was obtained changing the number of carriers i.e., changing the number of FFT points we used mainly 16, 32, 64 and 128 NFFT. Below we show our simulated results:

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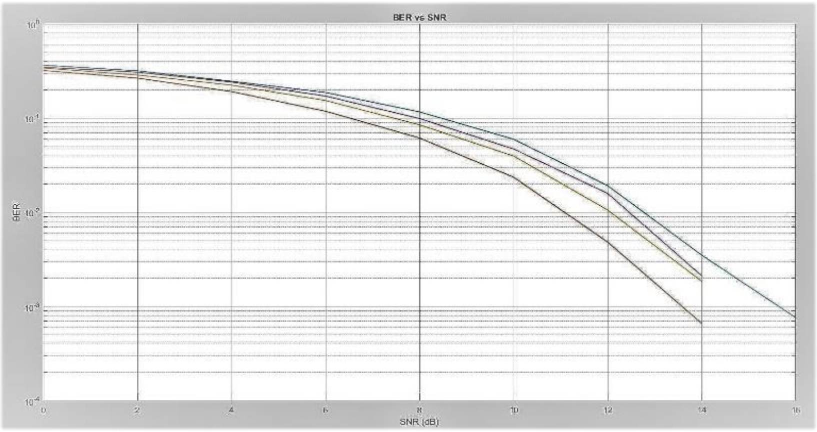

Figure 13: Improvement vs. Modulation technique graph.

The improvement graph can be shown as below:

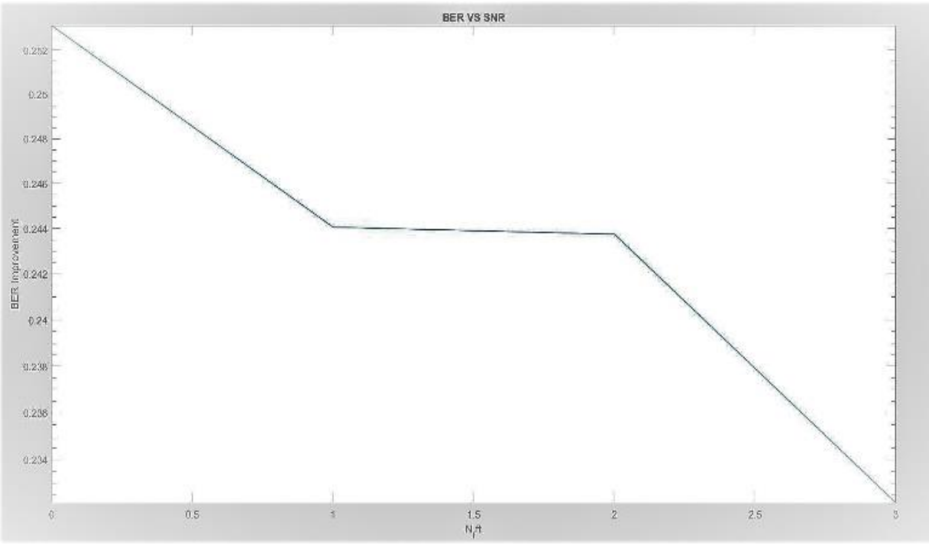

Figure 14: BER Improvement vs. NFFT point graph.

In the above figures we can see that 128 NFFT points show least possible BER. Therefore, in rest of the simulation we used 128 NFFT points. The best results obtained from above simulations are listed below:

Ser	Topic	Deduction
1.	Best Modulation Technique	16 QAM
2.	Most Efficient Carrier Number	128
3.	Fading Co-Efficient Limit	0~1

V. CONCLUSION

After doing the simulations we can see that with the variation of modulation techniques BER is changing. Again BPSK shows the least possible BER whereas 128QAM shows the highest BER. On the contrary BPSK modulation technique requires highest bandwidth of the channel and slowest bit rate against all modulation techniques adopted in simulation. Again we get the best possible symbol rate at 128 QAM. Considering all the limitations of QPSK, 16 QAM is proved to be the best modulation technique for OFDM transmission. Considering the NFFT points, 128 points give the least possible BER. But equipment complexity arises with the increase in NFFT points. After 128 NFFT there is no significant improvement in BER. With the increase in fading coefficient we can see a significant improvement in BER. It is seen that after there is no significant improvement in BER. Therefore the range of sigma is concluded to be 0 to 1 proved to be the best.

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