International Journal of Engineering Research and Development
***e**-ISSN: 2278-067X, **p**-ISSN: 2278-800X, www.ijerd.com*
Volume 3, Issue 7 (September 2012), PP. 07-10

Performance Analysis of OFDM by using different Modulation Techniques

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Abstract—***The objective of this paper is to demonstrate the concept and feasibility of an OFDM system, and investigate how its performance is changed by varying some of its major parameters In a single carrier communication system, the symbol period must be much greater than the delay time in order to avoid inter-symbol interference (ISI). Since data rate is inversely proportional to symbol period, having long symbol periods means low data rate and communication inefficiency. OFDM (Orthogonal Frequency Division Multiplexing) is a multi carrier digital communication scheme to solve both issues. This objective is met by developing a MATLAB program to simulate a basic OFDM system***.

Keywords—*OFDM, runtime, BER (Bit error rate), pixel error, SNR. FFT, IFFT.*

I. INTRODUCTION

OFDM has become one of the most important building block in the area of modern broadband wireless networks for couple of reasons: i) tolerance to multipath propagation and frequency selective fading, ii) impulse noise rejection and iii) high spectral efficiency. The number of carriers in an OFDM system is not only limited by the available spectral bandwidth, but also by the IFFT size (the relationship is described by: number of carriers ≤ (*ifft_ size/2)* − 2), which is determined by the complexity of the system. The choice of *M*-PSK modulation varies the data rate and Bit Error Rate (BER). [4]

In OFDM, spectrally overlapped sub-carriers can be used and since they are orthogonal, they do not interfere with each other. This makes OFDM a bandwidth efficient modulation scheme. *Fig.1* shows the spectra of multiple carriers. Although all frequency spectra are overlapping, they do not overlap at the carrier frequencies *f*1, *f*2,.. , and this implies Orthogonality

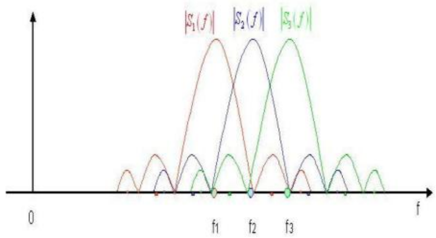


Fig (1): Orthogonality

II. PERFORMANCE ANALYSIS

Spectral Efficiency

Spectral efficiency refers to the amount of information that can be transmitted over a given bandwidth in a specific digital communication system. It is typically used to analyze the efficiency of a digital modulation method; usually bit refers to a user data bit. The modulation techniques used for OFDM are M-PSK and QAM. A modulation scheme is a mapping of data words to a real (In phase) and imaginary (Quadrature) constellation, also known as an IQ constellation. The spectral efficiency of a channel is a measure of the number of bits transferred per second for each Hz of bandwidth and thus the spectral efficiency S_E is given by:

$$S_E = \frac{C}{W} = \log_2(1 + \frac{S}{N})$$

where both the signal and noise are linear scale and the spectral efficiency is measured in b/s/Hz [3].The spectral efficiency of OFDM signal can be found by multiplying the spectral efficiency of modulation technique by the number of Subcarriers.[1]

Signal to Noise Ratio

Signal to noise ratio (SNR) is the difference between the signal strength a system reproduces compared to the strength or amplitude of its background noise. According to Shannon's Theory of information, the maximum capacity of a channel of bandwidth *W*, with a signal power of *S*, affected by white noise of average power *N*, is given by [3]

$$C = W \log_2(1 + \frac{S}{N})$$

III. OFDM TRNSEIVER MODEL

A) Transmitter

A sequential binary input data stream is first encoded by the channel coder.the encoded symbols , out of the encoder are next interleaved by a block interleaver.the idea behind interleaving is to handle burst errors by simply scatters the burst errors randomly so that the receiver can easily correct the random errors. Following this, the rearranged binary data are mapped onto the desired constellation points. The addition of the guard interval at the transmitter is to eliminate ISI and ICI.

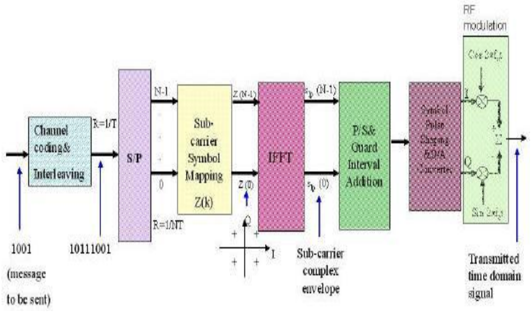


Fig (2): OFDM-Transmitter

B) Receiver

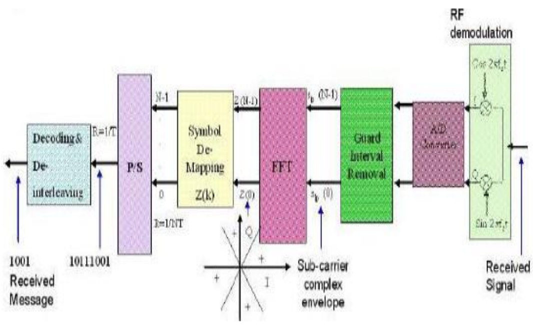


Fig (3): OFDM-Receiver

The receiver performs the reverse operation of the transmitter, mixing the RF signal to base band for processing and then the Base band OFDM signal is converted to digital signal with the help of high speed Analog to Digital converter. A Fast Fourier Transform is taken to analyze the signal in the frequency domain. The amplitude and phase (or I and Q points) of the sub carriers is then picked out and converted back to digital data [4].

OFDM System over AWGN Channel

PSK

BPSK

$$p_{e,BPSK} = \frac{1}{2} erfc\left(\sqrt{\gamma}\right)$$

QPSK with Gray code

$$p_{e,QPSK} = \frac{1}{2} erfc\left(\sqrt{\gamma}\right)$$

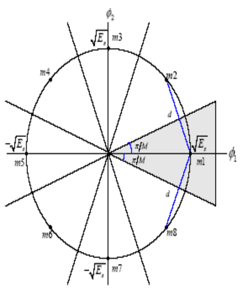
M-ary PSK

$$p_{e,MPSK} = erfc\left(\sqrt{\frac{E_s}{N_0}} \sin\left(\frac{\pi}{M}\right)\right)$$

where

$$\gamma = \frac{E_b}{N_0} \triangleq SNR$$

$$erfc(x) = \frac{2}{\sqrt{\pi}} \int_x^{\infty} \exp(-z^2) dz$$

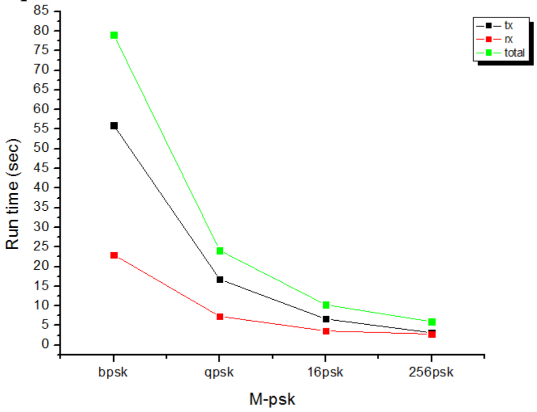


IV. SIMULATION RESULTS

In this paper, simulation is performed with I) different modulation techniques Vs Runtime. II) Different modulation techniques Vs BER, III) BER Vs SNR. IV) Pixel error Vs SNR.

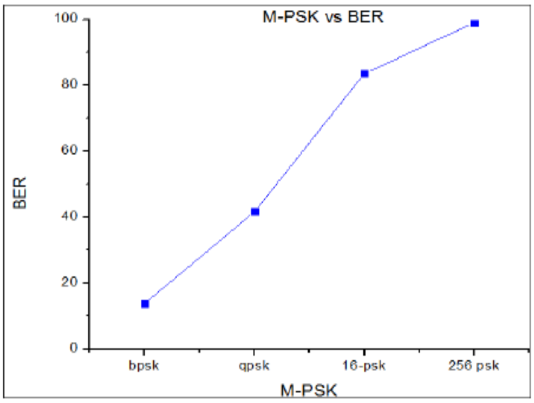
Parameters	values
Source image size	600 x 800
IFFT size	1024
Number of carriers	400
Peak power clipping	3dB
Signal to noise ratio	0- 70dB(varying)

I. Different modulation techniques Vs Runtime.



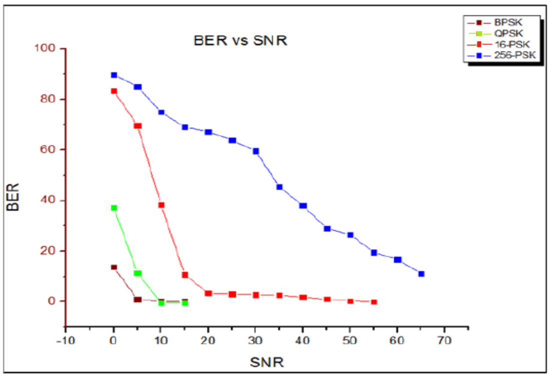
Understanding the variance of efficiency is based on varied orders of PSK. The Runtimes tripled for a simulation with BPSK while other parameters remain the same.

II. Different modulation techniques Vs BER



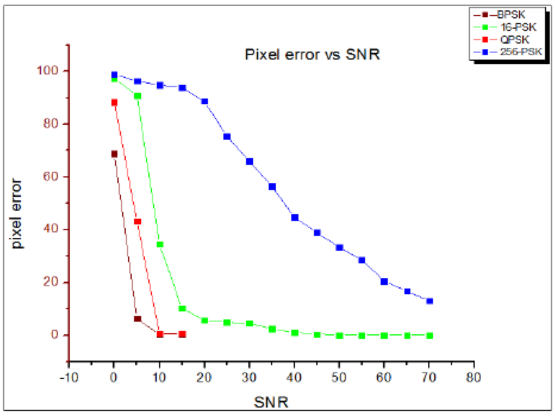
In a communication system, the receiver side BER may be affected by transmission channel noise, interference, distortion, bit synchronization problems, attenuation, wireless multipath fading, etc. The BER may be improved by choosing a strong signal strength (unless this causes cross-talk and more bit errors), by choosing a slow and robust modulation scheme or line coding scheme, and by applying channel coding schemes such as redundant forward error correction codes. From the above plot, BER increased massively by raising the PSK order, as a trade-off for decreasing runtime.

III. BER Vs SNR.



From the above simulation result, SNR is inversely proportional to error rates. And higher order PSK requires a larger SNR to minimize BER.

IV. Pixel error Vs SNR.



As shown in the above result, 16-PSK and 256-PSK require a relatively large SNR to transmit data with an acceptable error.

V. CONCLUSION

In OFDM, BER depends upon the modulation technique. As the simulation shows by increasing the PSK order, BER will increase as a trade-off for decreasing runtime. As SNR increases, BER will decreases. And higher order PSK requires a larger SNR to minimize BER. QAM is widely used rather than QPSK because it comprises of amplitude as well as phase, while QPSK only have phase. If the signal in QAM is corrupted it can be corrected either by amplitude or phase. By using QAM error will be reduced or SNR will improve compared to QPSK.

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