OFDM Behavior on AWGN Noise
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ABSTRACT
The future generation of the wireless communication demands more high standards for providing the high quality multimedia services to the customer. The orthogonal frequency division multiplexing (OFDM) which has been successful in the use of terrestrial digital video broadcasting also showed a strong technique for modulation in the future wireless communication systems. This is the paper is concerned on how well the OFDM can perform when transmitted over AWGN channels. The investigation is done based on the Bits Error Rate (BER). The evaluation process is performed by considering the following points: IFFT using QPSK modulation.

KeyWords
OFDM, AWGN, IFFT, QPSK
INTRODUCTION

OFDM- Orthogonal Frequency Division Multiplexing is a transmitting technique of data in parallel fashion with inclusion of large number of modulations and modulated sub carrier. The available bandwidth is divided by the sub carriers and also separated by the sufficient frequency which is also called as frequency spacing. The frequency spacing is performed so that it is orthogonal in nature. Each carrier has a integer number type of cycles which is orthogonality over a symbolic period of time. The carrier system has a null frequency at a center frequency for each of the carriers in whole system. Although if there is any overlap in spectrum their will not be any interference among the carriers. The separation is minimal based on the theoretical parameters between the carriers so that the utilization of the spectrum is minimum and very compact.

OFDM systems seem much attractive as they handle ISI in smooth way and is usually brought in front by the frequency multipath selection fading in the environment of wireless communication. The modulation of every sub carrier is performed at a low rate, the symbols would be enough longer that the impulse response of the channel. The ISI is diminished in this way. Other than this if there is any interval for guard is introduced between the OFDM consecutive symbols in that case the ISI is expected to completely vanish. The guard interval which is supposed to be introduced has expected to be much longer than the multipath delay in general. A large number of sub carriers can be achieved by operating all the sub carriers at a low data rate. There will be no need for the any equalizer at the receiver side because the ISI effect will be very low or almost negligible.

The inverse Fast Fourier Transform and or Fast Fourier Transform (IFFT/FFT) algorithm in OFDM systems, the modulation and the demodulations are used for the signal transmission and receiving. The FFT/IFFT lengths determine the vector and the resistance of the system to which errors are caused in channels with multipath. To get a maximum delay the time span is of the vector is chosen for the time delay echoes in multipath signal receiver. The modulation scheme is used based on the data inputs and the first chosen required spectrum is generated by the OFDM. The transmission data is assigned to produce by each carrier. The future calculations are done based on the modulation schemes especially in typical QPSK differentials for the required amplitude and for the carrier phase. The IFFT converts the spectrum into a signal with time domain. FFT is a cyclic transform with time domain which transform into a frequency equivalent to the spectrum. The equivalent waveforms are found with the sum of the orthogonal components in sinusoidal pattern. The time domain spectrum signal represents the components in the phase of sinusoidal and the amplitude.

The drawbacks of the OFDM

- The peak average power ratio which is in common known as the large dynamic range of signal. The solutions in the deal to this problem are still under development and are also used in clipping.
- The frequency errors of sensitivity: The attempt to optimize the OFDM is a major part of the research which is still in process around the world.

OFDM system practical features

- The source data is processed with some error correction coding, mapping the bits to symbols, interleaving and one of the examples are mapping done by QAM.
- IFFT is used for the modulation of the symbols on the orthogonal sub carrier.
• The orthogonality is maintained by the channel transmission. The OFDM frame gets the addition of Cyclic Prefixes. The L last sample of the frame consisting that is copied and placed in the start of the frame. There will not be impulse response in channel.

Synchronization: Cyclic Prefix is used at the start of every frame for the detection purpose. The introduction of cyclic prefix is done with the fact of L being first and last sample which are also correlated. This scenario is only possible when it is considered that OFDM frames are considered to be in stationary motion.

• The demodulation is received with the use of FFT
• The use of training sequence or sending; which is known as pilot that is predefined with sub carrier.
• De-interleaving and Decoding are also considered.

**OFDM transmission diagram**

Transmitter

Receiver

The signals generated in the above systems are at the baseband, they would generate the radio frequency signal with a desirable transmitting frequency in which mixing and filtering is required. Each carrier is controlled individually and the OFDM allow the spectral of high efficiency with carrier power and modulation scheme. Due to one way communications the broadcasting signals are fixed.

**MODULATION/MAPPING**

The properties of the modulation are determined by the fundamental role onto the constellation in signal with bits of information mapping process.

**IFFT and FFT**

• In OFDM the implementation of DFT and IDFT are quite a challenge.

\[
\text{IDFT } x[n] = \frac{1}{N} \sum_{k=0}^{N-1} X[k] e^{j \frac{2\pi}{N} kn}
\]

\[
\text{DFT } X[k] = \sum_{n=0}^{N-1} x[n] e^{-j \frac{2\pi}{N} kn}
\]

• FFT and IFFFT are the algorithms which are quite fast implementations for the DFT and IDFT.

• The size of FFT and IFFFT is N=64 in the standards of IEEE 802.11a.

**GAUSSIAN DISTRIBUTION**

• The random variable for distribution of Gaussian.

\[
p_x(x) = \frac{1}{\sqrt{2\pi\sigma}} e^{-\frac{(x-m_x)^2}{2\sigma}}
\]

Fig: Gaussian-distributed random variable

• The CDF of a Gaussian or normally distributed random variable is

\[
F_x(x) = \frac{1}{2} + \frac{1}{2} \text{erf} \left( \frac{x-m_x}{\sqrt{2}\sigma} \right) = 1
\]
AWGN Channel

Additive White Gaussian Noise (AWGN) channel could be a Channel Modal used for analyzing modulation schemes used for OFDM radio Signal transmission. In this Modal the channel adds a white Gaussian noise to the OFDM signal that is passing through it. By this the signal gets 2 properties. Amplitude frequency response is flat, suggests that signal suffer channel with none amplitude loss and having time information measure. Part frequency response is linear, so no part distortion of frequency components. In AWGN channel the Received Signal is simplified to:  \( r(t) = s(t) + n(t) \). Where \( r(t) \) is received signal and \( n(t) \) is that the Additive White Gaussian Noise.

The assumed channel to the signal corrupted with the AWGN shown below:

\[
\frac{1}{2} \text{erfc} \left( \frac{x - m_x}{\sqrt{2}\sigma} \right)
\]

Where

\[
\text{erf}(x) = \frac{2}{\sqrt{\pi}} \int_{-\infty}^{x} \exp(-z^2) \, dz
\]

\[
\text{erfc}(x) = 1 - \text{erf}(x) = \frac{2}{\sqrt{\pi}} \int_{x}^{\infty} \exp(-z^2) \, dz
\]

Fig: Gaussian-distributed random variable

OFDM Performance over AWGN Channel

OFDM subcarrier modulation is analogous to the modulation in conventional serial systems.

- The modulation schemes of the subcarriers are typically QAM or PSK in conjunction with both coherent and non coherent detection.
- As the additive white mathematician noise (AWGN) in the time domain channel corresponds to AWGN of a similar average power in the frequency domain, Associate in Nursing OFDM system performance in Associate in Nursing AWGN channel is just like that of a serial system.
- Analogously to a serial system, the bit error rate (BER) verses ratio rate (SNR) characteristics are determined by the modulation scheme used.

It are often seen from the figures that the experimental
BER performance of the OFDM system is in superb accordance with the theoretical BER curves of conventional serial systems in AWGN channels.

BER versus SNR curves for the OFDM system in AWGN channel mistreatment BPSK, QPSK, 8PSK, 16-PSK.

<table>
<thead>
<tr>
<th>Simulation Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Channel</td>
<td>AWGN</td>
</tr>
<tr>
<td>FFT size</td>
<td>1024</td>
</tr>
<tr>
<td>Subcarrier #</td>
<td>1024</td>
</tr>
<tr>
<td>Modulation</td>
<td>BPSK, QPSK, 8PSK, 16PSK</td>
</tr>
<tr>
<td>Ground Type</td>
<td>Cyclic Prefix</td>
</tr>
<tr>
<td>SNR</td>
<td>0-30 dB</td>
</tr>
</tbody>
</table>

QPSK WITH GREY CODE

Higher order modulation schemes, like QPSK, square measure typically used in preference to BPSK when improved spectral efficiency is needed. QPSK uses four points on the constellation diagram. With four phases, QPSK will inscribe two bits per image.

\[
p_e^{\text{QPSK}} = \frac{c}{\sqrt{\pi}} \text{erfc}(\sqrt{y})
\]

BER versus SNR curves for the OFDM system in AWGN channel using QPSK, 16QAM, 64QAM, 256QAM

CONCLUSION

There are more aspects of OFDM that require to be researched since this simulation was only a basic one. However ever there can be heap of enhancements within the future.

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