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OFDM Systems Using ZC Sequences

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ABSTRACT

Orthogonal Frequency Division Mutipexing (OFDM) is widely used in wireless communications systems due to its high rate transmission capability with high bandwidth efficiency and robustness with regard to multi-path fading and delay. Signal to noise ratio is used as an indicator to evaluate the quality of communication. Due to this feature it is essential to estimate the Signal to Noise Ratio(SNR) value for the modern wireless communication. Channel estimation is performed by measuring the degradation of a pre-known sequence and for OFDM systems these sequences are called pilots, scattered all along the frequency domain of each OFDM symbol. With modified Zadoff-Chu(ZC) sequences as pilot, that can be used as synchronizing mechanism in time domain as well as channel estimation. In this paper a comparison study on the OFDM Systems with and without ZC sequences is proposed. As an extension other modulation schemes like Binary Phase Shift Keying (BPSK), Quadrature Phase Shift Keying (QPSK) and different channels can also be considered. The proposed system can be used for designing furture broadcast systems to provide better performance.

Key Words: *OFDM, Zadoff-Chu, Channel estimation*

1. INTRODUCTON

Wireless systems requires high data rates with low delay and low bit-error-rate (BER). Orthogonal Frequency Division Mutipexing (OFDM)) is being widely used in wireless communications systems owing to its high rate transmission capability with high bandwidth efficiency and robustness agianst multi-path fading and delay. OFDM eliminates inter symbol interference in transmission over frequency selective fading channels. The radio channel is usually frequency selective and time variant. So OFDM has an important role in wireless communication area.

SNR is used for evaluating the quality or performance of a communication system. So it is very important to estimate the SNR value for the modern wireless communication. Channel estimation[2] is usually performed by measuring the degradation of a pre-known sequence. For OFDM systems these sequences are called pilots, scattered all along the frequency domain of OFDM symbol. If the required pilot sequence is built from ZC sequences, then the same can be used for synchronization in time domain as well as for channel estimation.

The proposed structure based on modified ZC sequence [1] requires no overhead compared to the normal broadcasting scattered pilot patterns, and also reduces or eliminates the need of a Preamble symbol at the beginning of each frame, which inturn increases the throughput.

2. OFDM

OFDM is a method of encoding digital data on multiple carrier frequencies. OFDM is a frequency-division multiplexing (FDM) scheme used as a digital multi-carrier modulation method. A large number of closely spaced orthogonal sub-carrier signals are used to carry data on several parallel data streams or channels. Each sub-carrier is modulated with a conventional modulation scheme (such as quadrature amplitude modulation or phase-shift keying) at a low symbol rate, maintaining total data rates similar to conventional single-carrier modulation schemes in the same bandwidth. So in OFDM the sub-carrier frequencies are chosen so that the sub-carriers are orthogonal to each other.

Each subcarrier in an OFDM system is a sinusoid with a frequency that is an integer multiple of fundamental frequency. Each subcarrier can be expressed as a Fourier series component of the composite signal, i.e. an OFDM symbol. The sum of these subcarriers is then referred to baseband OFDM signal.

The primary advantage of OFDM over single-carrier schemes is its ability to cope with severe channel conditions (for example, attenuation of high frequencies in a long copper wire, narrowband interference and frequency-selective fading due to multipath) without complex equalization filters.

The cross-talk between the sub-channels is eliminated and inter-carrier guard bands are not required. This greatly simplifies the design of both the transmitter and the receiver; unlike conventional FDM, a separate filter for each sub-channel is not required.

OFDM has developed into a popular scheme for wideband digital communication, used in applications such as digital television and audio broadcasting, DSL Internet access, wireless networks, powerline networks, and 4G mobile communications.

3. ZADOFF- CHU SEQUENCES

A Zadoff–Chu (ZC) sequence, also referred to as Chu sequence or Frank–Zadoff–Chu (FCZ) sequence, is a complex-valued mathematical sequence which, when applied to radio signals, gives rise to an electromagnetic signal of constant amplitude, whereby cyclically shifted versions of the sequence imposed on a signal result in zero correlation with one another at the receiver. A generated Zadoff–Chu sequence that has not been shifted is known as a "root sequence".

These sequences exhibits the useful property that cyclically shifted versions of itself are orthogonal to one another, provided, that is, that each cyclic shift, when viewed within the time domain of the signal, is greater than the combined propagation delay and multi-path delay-spread of that signal between the transmitter and receiver.

Zadoff–Chu sequences are used in the 3GPP LTE [3] air interface in the Primary Synchronization Signal, random access preamble, uplink control channel, uplink traffic channel and sounding reference signals . The spectrum of the ZC sequence is shownn Fig.1.

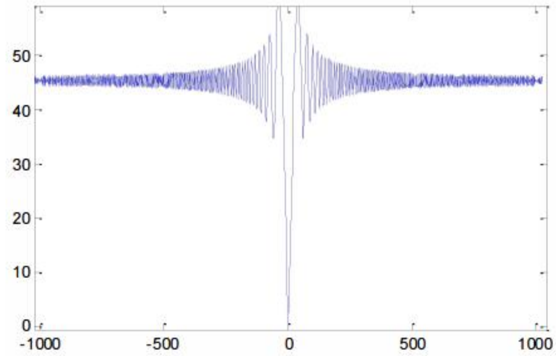

Fig.1. Spectrum of the ZC sequence

Two modifications are needed before using this spectrum as pilot. First a spectrum that is constant in the center is required. For this we shift the spectrum by letting the carriers having amplitude near zero be on the side lobes as shown in Fig. 2.

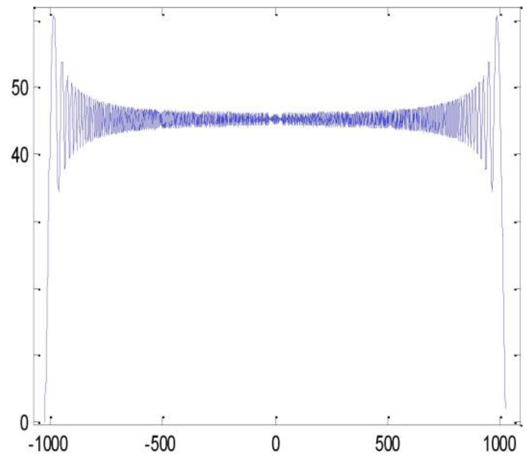

Fig. 2. Spectrum of the ZC sequence with FFT shift.

The second modification is to create three cells equal to zero (to carry data) for every cell used by the pilot and making the overall spectrum spread over an 8k symbol. To do this, we need to repeat four times the time domain sequence (obtained from the IFFT of the previous spectrum in Fig. 2.).

4. SYSTEM MODEL

The Block Diagram of the proposed system is shown in the Fig.3.below. Quadrature Amplitude Modulation (QAM) is used.IFFT operation converts the frequency domain signal into a time domain signal. The Cyclic Prefix (CP) or Guard Interval is a periodic extension of the last part of an OFDM symbol that is added to the front of symbol in a transmitter, and is removed at the receiver before demodulation.

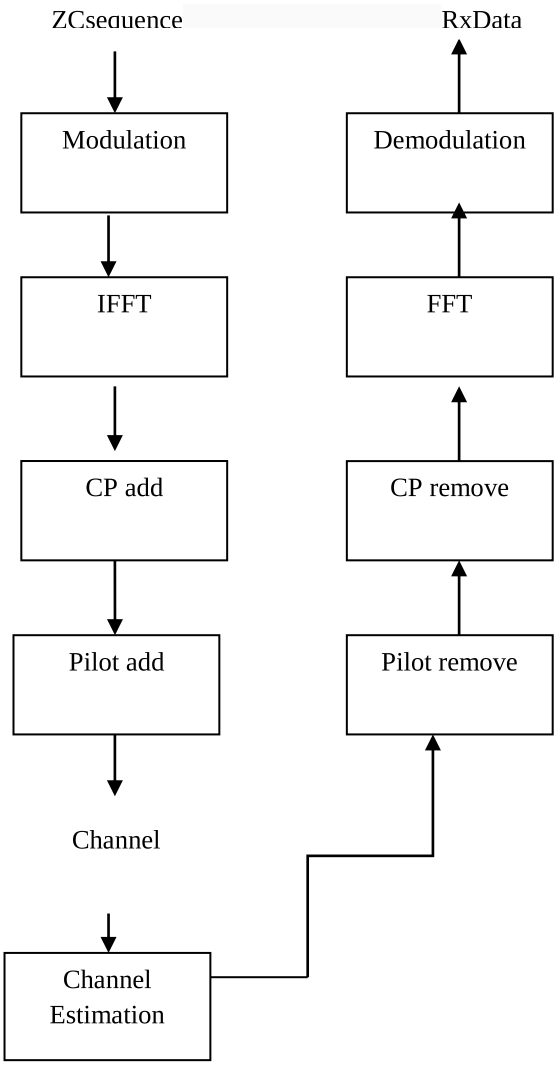

Fig. 3 Bock diagram of OFDM systems using ZC sequences

Cyclic prefix acts as a guard interval. It eliminates the inter-symbol interference from the previous symbol. A pilot refers to a cell within the OFDM frame which is modulated with predefined reference information that is also known to the receiver and transmitted at boosted power level. In the receiving side pilot and cyclic prefix are removed. FFT converts the time domain signal into frequency domain and then fed to the QAM demodulator.

This approach allows for simple frequency–domain processing such as channel estimation and equalization.

5. SIMULATION AND RESULT

Implemented OFDM system using ZC sequences in Matlab platform. Estimated SNR considering AWGN channel . Fig.4 below shows the comparison of OFDM systems with and without Zadoff-Chu sequences.

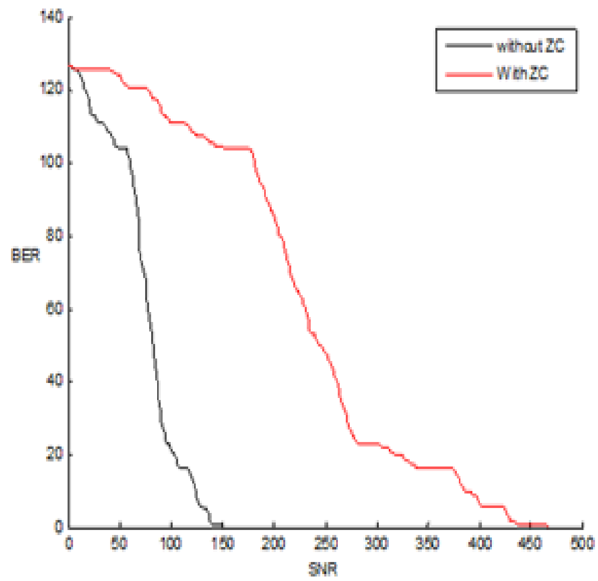

Fig.4 BER Vs SNR of OFDM system with and without ZC

6. CONCLUSION AND FUTURE WORK

Simulation results shows that the performance is improved. . Also reduces or eliminates the need of a Preamble symbol at the beginning of the frame, thus, increasing the throughput. Future work will address the generalization of the proposed structure to other configurations also(using different modulation schems and different channel conditions).

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