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ICI CANCELLATION USING ADAPTIVE MODULATION IN CODED OFDM SYSTEM

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ABSTRACT

OFDM is most commonly used in wireless system due to it's potential to decrease ISI , but OFDM often faces frequency offset, due to which inter carrier interference arises . In this paper, we focus on the improvement of OFDM system performance which is subjected to frequency offset. We use correlative level coding to decrease the ICI. In this method a known amount of interference is introduced at the transmitter side so its effect can be interpreted at the receiver side. We also use adaptive modulation to increase the bandwidth efficiency; in this technique we decide the modulation technique according to the channel quality. Finally our results shows that, Correlative level coding considerably decreases the ICI also adaptive modulation keeps the BER low even in high data rate transmission.

INTRODUCTION

In recent years, one of the most widely adopted broadband digital communication technique is the Orthogonal Frequency Division Multiplexing. OFDM is a multiple access scheme, in which high data rate channel is divided into low data rate channel, and each sub-channel is modulated using a separate sub-carrier. These sub-carrier overlap each other which increases the spectral efficiency of the channel. As these sub-carriers are orthogonal to each other ISI does not occur. Major advantage of dividing the high date rate channel into low data rate channel is that it converts frequency selective channel into flat fading channel, which allows for a simple equalization technique at the receiver.

One of the problems which OFDM faces is its sensitivity to frequency offset. Frequency offset is mainly caused due to Doppler spread or due to sampling with frequency offset. These frequency offset causes Inter Carrier Interference ICI, which is an unwanted phenomena as it degrades the system performance. There are several techniques which are used to reduce the ICI. These techniques are classified into two types one is the signal repetition either in frequency or time domain and other is linear pre-coding. Correlative level coding comes under second type. Collative level coding is also known as partial response coding; in this method ICI is reduced by pre-coding method here it is a spectral efficient method. In this paper we use these method to reduce the inter carrier interference. As bandwidth is a limited resource, wise utilization of this will lead to increase in the performance of the system. Adaptive modulation is one of the technique in which we can use the bandwidth according to the SNR of the channel. Thus in this technique a proper amount of data rate can be adopted with a controlled BER, which increases the bandwidth efficiency of the system.

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The remainder of this paper is organized as follows. In Section II, the system model is introduced. The CIR expressions for the OFDM system correlative coding is explained in Section III. In Section IV, simulations are provided to validate our analysis. Finally, concluding remarks are given in Section V.

I. SYSTEM MODEL

In an OFDM system the entire data is divided into OFDM symbol , each symbol contain N high rate serial data stream which is given to serial to parallel converter , this converts the data into N low rate parallel data stream. Now each of N low rate stream is modulated using any of the modulator as { Xk }, these modulated data is coded using correlative level coding. The output of the correlative level coding is given as

$$Sk= \sum_{i=0}^{k-i} c_i x_{k-i} \quad (1)$$

where k= -N/2,…………..,N/2-1

Where N is the total number of OFDM subcarriers, this coded signal is given to IFFT which maps each of the N data stream to a separate carrier, the output of which is given as

$$sn=1/N \sum_{k=-N/2}^{n/(2-1)} Sk\, e^{j\,(2\pi kn)/N} \quad (2)$$

where n= 0, …………,N-1

After mapping each stream is given to a parallel to serial convertor and we obtain a high rate data stream, this high rate data stream is given to the transmitter, and is transmitted.

The received signal at the receiver is given as

$$Yn= \sum_{L=0}^{L-1} Sn - l\, h^{(l)}(n) + Wn \quad (3)$$

Where n=0,……,N-1

where h(l)(n) is the lth tap of the channel impulse response at the nth time instant, and wn is the additive white Gaussian noise (AWGN) with variance N_0.

At the receiver serial data stream is converted into parallel data stream and is de-mapped using FFT and then detected or decoded, this detected signal is again converted into serial data stream and demodulated to receive the desired transmitted signal.

II. CORRELATIVE CODING AND CIR

Correlative level coding also known as partial response coding, is an efficient way to reduce inter carrier interference. In this a particular known amount of interference is added at the transmitter side in a controlled way, so it's effected can be interpreted at the receiver side

A. Duobinary Scheme

Consider a binary input sequence {bk} consisting of uncorrelated binary symbols 1 and 0. After modulation this binary sequence becomes a two level sequence {ak}.

i.e
ak= +1 if symbol bk is 1
ak=-1 if symbol bk is 0

The duobinary output {ck} can be expressed as the sum of the present intput and the previous value.

i.e. ck=ak+a(k-1) (4)

In this decision on the current input depends on the correctness of the decision made on the previous input, so during detection one may face problem that if in case any error occurs , it will tend to propagate through the output.

B. Precoding

To avoid error propagation preceding is done before duo binary coding. Pre-coding is done by

dk=bk xor d(k-1) (5)

Where xor is the modulo two addition of bk and d(k-1).

i.e dk= 1 if either bk or d(k-1) is 1
dk=0 otherwise

Duobinary Signaling with Precoding

In this the pre-coded binary sequence is {dk} modulated. The modulated output is a two level sequence {ak}, where

ak= +1 or -1 (6)

This sequence is applied to the duo-binary coder , there by producing {ck}.

ck=ak+a(k-1) (7)

C. Detection

ck and bk is related as

ck= 0 if data symbol bk is 1
ck=+2 or 2 if data symbol bk is 0

Therefore the received signal can be detected as

if modulus of ck< 1 , say symbol bk is 1
if modulus of ck> 1 , say symbol bk is 0

D. Carrier to Interference Ratio

It is a performance measure of the signal and is most commonly used as an ICI indicator more the CIR the better the signal will be. Carrier to interference power may be defined as the ratio of total signal power to the interference power.

The interference power may be calculated as

Interference power = Total power – Noise power – Signal power

Carrier to interference power can be given in db as

CIR = 10* log 10(Signal power / Interference power)

III. ADAPTIVE MODULATION

High data rate is one of the requirements of the wireless system. The BER of a transmitted signal depends on the fading condition of the channel. Better the channel lower is the BER. A system is known to be bandwidth efficient if it supports high data rate transmission with a low BER. In a fixed modulation technique, compromise between data rate and BER is made. Adaptive modulation technique is a solution to this problem, in this modulation technique is decided according to the SNR of the channel. In deep fading condition, BPSK modulation is used, i.e. only one bit is transmitted to keep the BER low and if the channel condition is too good 64 PSK is used, and even if we are transmitting more number of bits BER remains low as the channel condition is good.

IV. SIMULATION AND RESULTS

A. Performance of OFDM system with and without CFO

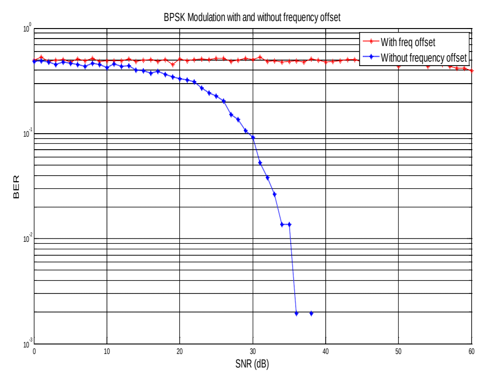

Fig.5.1 Performance of OFDM system with and without CFO

Fig 5.1 shows the performance of an OFDM system with and without carrier frequency offset. It is seen that the BER decreases as the channel condition is improving. Whereas, there is no change in system performance if there is a frequency offset even when the channel condition is very good. Hence, to improve the performance of OFDM system under CFO, correlative level coding with adaptive modulation is use.

B. Performance of OFDM system with Correlative Level coding

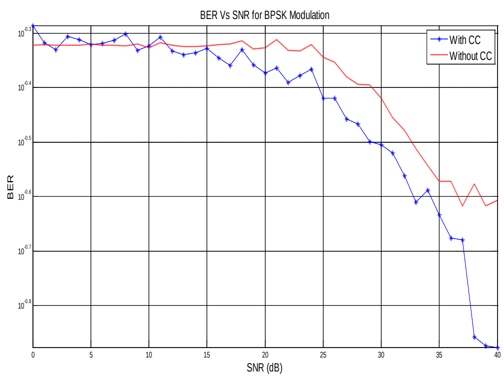

Fig 5.2 Performance of OFDM system with Correlative Level coding

Fig 5.2 shows the performance of an OFDM system with correlative level coding for BPSK modulation scheme. The performance of correlative level coding is tested here without introducing carrier frequency offset. The red colored curve shows the performance without correlative level coding and that with blue color shows the performance with correlative level coding. The graph shows that the performance of the system is significantly improved using correlative level coding

C. Performance of OFDM QPSK system with Correlative Level coding

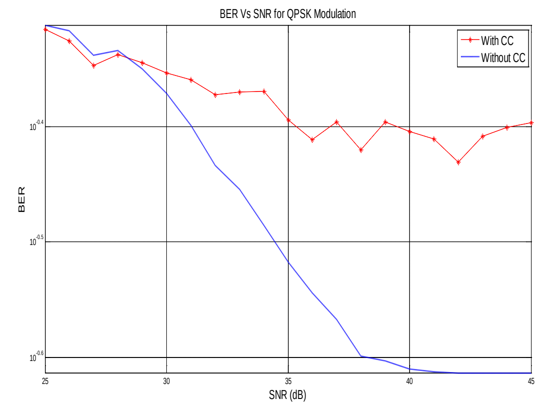

Fig:5.3 Performance of OFDM QPSK system with Correlative Level coding

Fig 5.3 shows the performance of an OFDM system with correlative level coding for QPSK modulation scheme. The performance of correlative level coding is tested here without introducing carrier frequency offset. The red colored curve shows the performance without correlative level coding and that with blue color shows the performance with correlative level coding. The graph shows that the performance of the system is significantly improved using correlative level coding.

D. CIR Improvement in OFDM system with and without CC

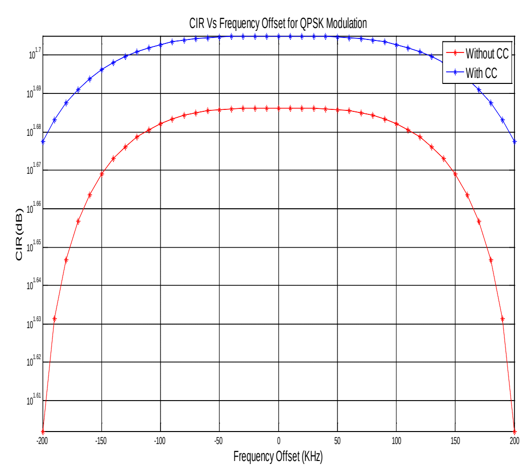

Fig:5.4: CIR vs Frequency Offset for QPSK Modulation with and without CC

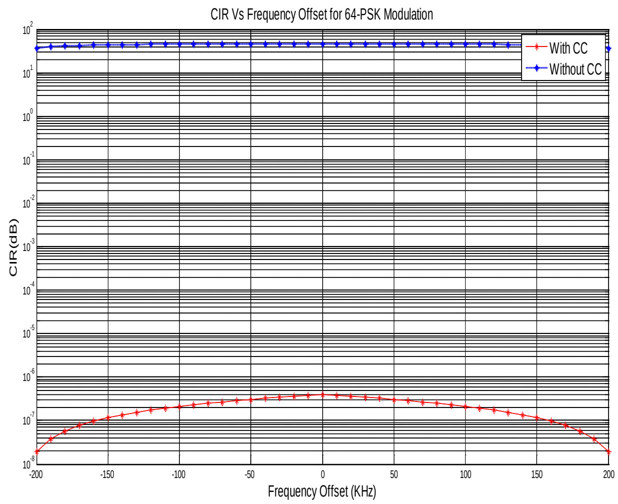

Fig:5.5: CIR vs Frequency Offset for 64-PSK Modulation with and without CC

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The figure 5.4 shows the variation of carrier to interference noise power ratio (CIR) for different frequency offset values for QPSK modulation scheme. In this , there is approximately, 8dB improvement in CIR with correlative level coding.

The figure 5.5 shows the variation of carrier to interference noise power ratio (CIR) for different frequency offset values for 64-PSK modulation scheme In this there is approximately, 30dB improvement in CIR with correlative level coding.

V. CONCLUSION

The OFDM system is highly immune to the various interferences in the channel. But the limitation is that it is highly sensitive to the carrier frequency offset caused due to inter carrier interference. Hence to overcome this shortfall, correlative level coding is used to minimize the inter carrier interference OFDM system. The performance of OFDM system is investigated by introducing normalized frequency offset. The simulation results showed that the effect of inter carrier interference is reduced with the help of simple correlative level coding. Performance of the system in terms of bit error rate and carrier to interference power ratio is analyzed.

The simulation results show that the BER performance of the system is significantly improved using correlative level coding. In addition to BER performance, it seen from simulation results that CIR value is considerably improved with the help of CC. The amount of improvement increases with the use of adaptive modulation that is by increasing the order of modulation

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