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Single Carrier Ofdm Immune to Intercarrier Interference

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Abstract:- Orthogonal Frequency Division Multiplexing (OFDM) is a ideal candidate for next generation wireless communication systems. In OFDM the frequency offset distort the orthogonality between the subcarriers resulting intercarrier interference (ICI). SC-OFDM suffers significant performance degradation resulting from intercarrier interference (ICI) in high mobility environments. In this paper, the effect of ICI on an SC-OFDM system is analyzed and proposes a novel modulation scheme. The proposed Magnitude- Keyed Modulation (MKM) modulation provides SC-OFDM system immunity to ICI and with an easy implementation it significantly outperforms OFDM, SC-OFDM and MC-CDMA systems with Phase Shift Keying (PSK) modulation and Quadrature Amplitude Modulation (QAM) in severe ICI environment**.**

Keywords:- intercarrier interference, multicarrier, OFDM, magnitude keyed modulation, frequency offset.

I. INTRODUCTION

Orthogonal Frequency Division Multiplexing is a promising technique in the broadband wireless communication systems due to high spectral efficiency and robustness. In multicarrier communication systems OFDM is vulnerable to the phase noise and frequency offset. OFDM become popular due to its high data rate streams. In high speed aerial vehicle communication multicarrier transmission is adopted to improve the spectrum efficiency[1].

In multi-carrier technologies like OFDM it is difficult to maintain orthogonality between the subcarriers and it leads to performance degradation and intercarrier interference (ICI) will occur. In high mobility environment multicarrier technologies experience severe ICI due to Doppler shift between transmitter and receiver. Degrading BER performance of OFDM and MCCDMA systems have been studied and improved by reducing ICI [2],[3] and by estimating carrier frequency offset(CFO)[11]-[13]. Transmitter and Receiver should be in same speed to estimate CFO but its quite impossible in high mobility environment .It require more number of training symbols to aid the receiver about the channel estimation thereby increasing the complexity.
Single carrier OFDM[14] is a alternative transmission technique to traditional OFDM due to better performance in multipath fading channel. This technique combine the benefits of multi-carrier transmission along with single carrier transmission.

In this paper ,SC-OFDM with ICI has been analyzed and it show a unique diagonal property. Due to this property ICI effect is concentrated entirely on phase offset not in the magnitude. Novel modulation scheme has been designed and it carries digital data on the signal magnitude. This technique outperforms the other modulation technique. Compared to other CFO estimation schemes , this technique need not sacrifice data rate via employing training sequence and the system is totally immune to the ICI .The proposed system has low complexity and is easily implemented.
The paper is organised as follows: In section II SC-OFDM system model is provided, analysis and diagonal property of SC-OFDM is given in section III, simulation results given in section IV and conclusion is given in section V.

II. SYSTEM MODEL

A. TRANSMITTER:

SC-OFDM transmitter is shown in fig 1.In transmitter first constellation mapping for modulation is done by magnitude keyed modulation .After the serial data symbols are converted to parallel . In OFDM many different symbols are transmit by subcarriers but in similar symbol is transmitted by different subcarriers. it convert high data rate stream into low rate symbol stream. Each parallel data is distributed to subcarriers according to phase rotated spreading by using walsh codes. The spreading code set corresponds to the normalized DFT matrix with the k^{th} data symbol being spread to the i^{th} subcarrier employing spreading code .

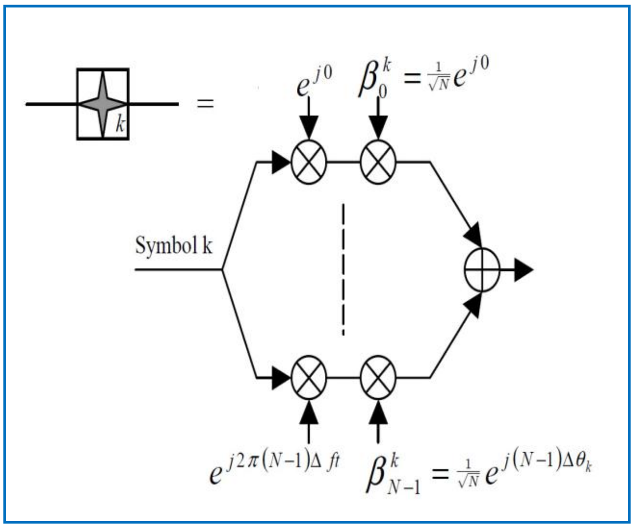

Fig 1(a) SC-OFDM symbol spectral spreading

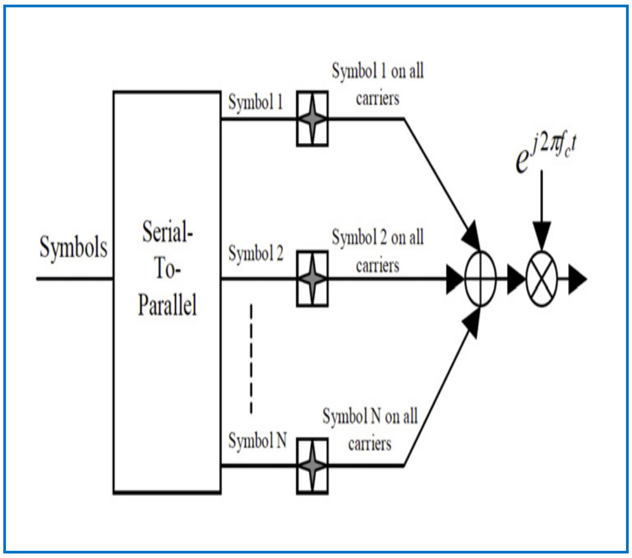

Fig .1(b) SC-OFDM spread symbol combining

Fig 1. SC-OFDM transmitter

The transmitted SC-OFDM symbol is given as

$$s(t) = \frac{1}{N}\sum_{i=0}^{N-1}\sum_{K=0}^{N-1} x_k e^{-j\frac{2\pi}{N}ik} e^{j2\pi k\Delta f t}\, e^{j2\pi f_c t} p(t) \qquad (1)$$

where x_k is the k^{th} data symbol; Δf is the spacing between subcarriers and $p(t)$ is a rectangular pulse shape ,0<t<T. SC-OFDM is similar to MCCDMA and it is implemented with appropriate spreading code. It uses same bandwidth as that of oter multicarrier technologies.cyclic prefix is added between OFDM symbols

B. RECEIVER:

SC-OFDM receiver is shown in fig The signal is passed through AWGN channel and cyclic prefix is removed.

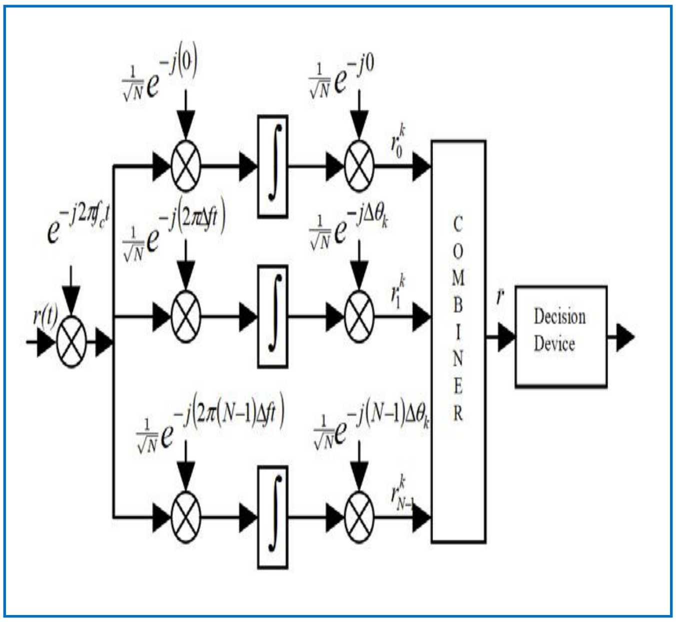

Fig 2. SC-OFDM receiver

The received signal is given as

$$r(t) = \frac{1}{\sqrt{N}} \sum_{i=0}^{N-1} \alpha_i \sum_{k=0}^{N-1} x_k \, e^{-j\frac{2\pi}{N}ik} \, e^{j2\pi(i+\varepsilon)\Delta f(t+\Delta t)} e^{j2\pi f_c(t+\Delta t)}.p(t+\Delta t) + n(t) \quad (2)$$

SC-OFDM demodulator detects the kth data symbol by :

1) Decomposing the received signal $r(t)$ into N orthogonal subcarriers (via application of an FFT, and perfect timing estimation is assumed),
2) Applying the *kth* symbol's spreading code,
3) Combining the N results with an appropriate combining scheme [22], denoted by the "Combiner" block in Fig.2,
4) Decision of each symbol will be made based on the result from the "Combiner", denoted by the block "Decision Device".

With ICI present and non-zero NCFO ,the received signal is given as

$$r_l = \frac{1}{N} \sum_{k=0}^{N-1} x_k s(k-l).[\sum_{i=0}^{N-1} w_i \alpha_i \exp(j \frac{2\pi}{N} l.i) \exp(-j \frac{2\pi}{N} k.i)] + n_l \quad (4)$$

where $l = 0,1,\ldots\ldots,N-1$

where w_i represents the combining and equal gain combining is assumed.

III. ANALYSIS OF SC-OFDM

The received signal has two component one is desired component and undesired component it is ICI coefficient. the received signal vector is given as

$$\vec{y} = \vec{r}F^H = \vec{x}FHSF^H + \vec{n}F^H \quad (5)$$

It is noted that the ICI effect on SC-OFDM data symbols x is simply a (different) phase offset on each and every data symbol x_k. Compared with an OFDM system under similar ICI conditions, SC-OFDM provides significantly better performance. This is due to the received OFDM signal vectors in being a combination of subcarrier data symbols and shifted responses thereof, while the subcarrier data symbols in the SC-OFDM signal vector given by only experience a phase offset–this is why we observe zero ICR for all ε and realize the benefit of SC-OFDM.

IV. SIMULATION RESULTS

The ICI coefficient has been analyzed for various values of ε and results is shown in fig 3.From the graph the energy is distributed among all subcarriers.if ε is increased the ICI coefficient get decreased.

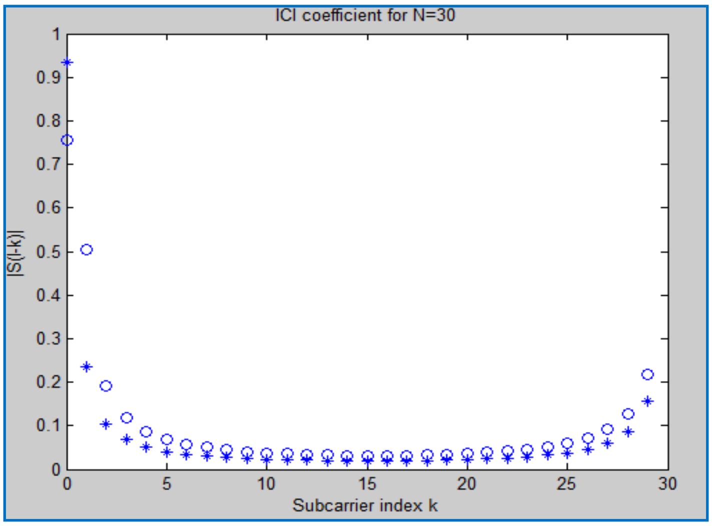

Fig 3. example of ICI coefficient

Carrier To Interference ratio is calculated and simulated for standard OFDM systems and ICI theoryand given in fig 4.In fig 5 the SC-OFDM for various values of epsilon it remains small and desired component is unaffected by ICI.

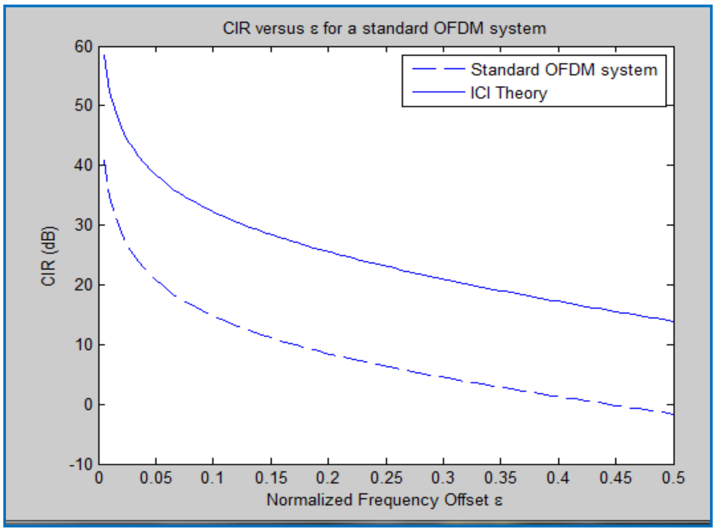

Fig 4. CIR vs ε for standard OFDM systems.

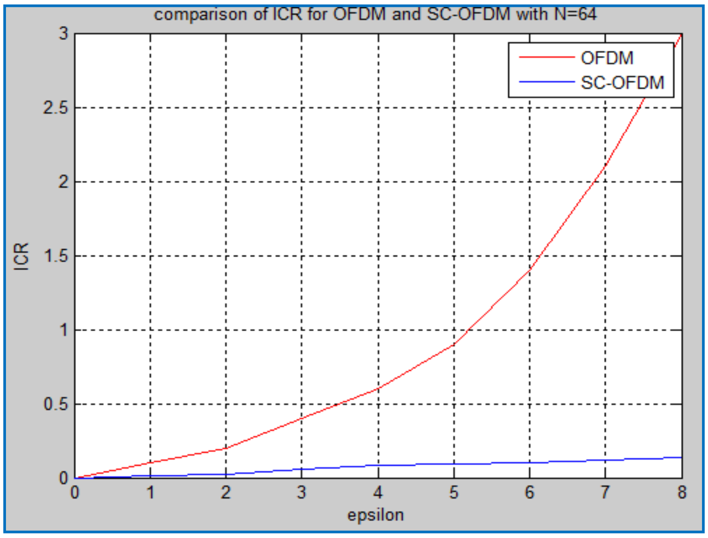

Fig 5 ICR comparison for OFDM and SC-OFDM systems using N=16 subcarriers with ICI present

The BER performance of the proposed SC-OFDM system with MKM modulation is first examined. Specifically, we compare performance of SC-OFDM with binary MKM versus OFDM/SC-OFDM/MC-CDMA with BPSK modulation, The stop criterion for simulations is the number of bit errors is larger than 1000.

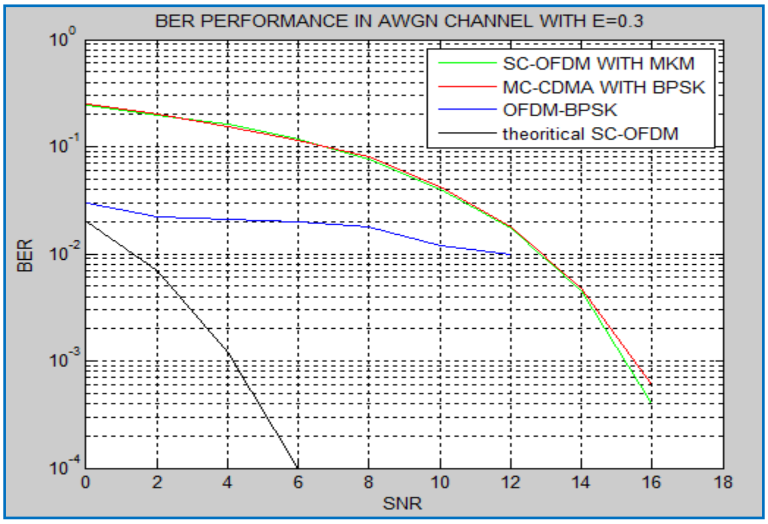

Fig. 6. AWGN channel: BER vs. SNR for OFDM & SC-OFDM with binary modulations, N = 64 subcarriers, and ε = 0.3.

Fig. 6 shows simulated BER versus SNR for OFDM, SCOFDM and MC-CDMA systems with binary modulation, N = 64 subcarriers, and AWGN channel conditions. These results were generated for normalized CFO of ε = 0.3. With high NCFO ε = 0.3, OFDM/SC-OFDM/MC-CDMA systems with BPSK modulation break down, and the proposed system outperforms these benchmarks significantly when SNR is high ($\geq 4dB$).

V. CONCLUSION

The effect of ICI on SC-OFDM is analyzed and novel modulation scheme is proposed .the received SC-OFDM signal is simply a phase offset on each and every data symbol. By transmitting digital information only on signal magnitude modulation scheme is proposed and is better than other transmission technologies. the proposed scheme has low complexity and low PAPR. The simulation results shows that there is no degradation in performance.

REFERENCS

[1] S. Hara and R. Prasad, Multicarrier Techniques for 4G Mobile Communications, 1st edition. Artech House, 2003.

[2] W. M. Jang, L. Nguyen, and P. Bidarkar, “MAI and ICI of synchronous downlink MC-CDMA with frequency offset,” IEEE Trans. Wireless Commun., vol. 5, pp. 693–703, Mar. 2006.

[3] T. R. Wang, J. G. Proakis, E. Masry, and J. R. Zeidler, “Performance degradation of OFDM systems due to Doppler spreading,” IEEE Trans. Wireless Commun., vol. 5, pp. 1422–1432, June 2006.

[4] Y. Zhao and S.-G. Haggman, “Intercarrier interference self-cancellation scheme for OFDM mobile communication systems,” IEEE Trans. Commun., vol. 49, pp. 1185–1191, July 2001.

[5] A. Seyedi and G. Saulnier, “General ICI self-cancellation scheme forOFDM systems,” IEEE Trans. Veh. Technol., vol. 54, pp. 198–210, Jan. 2005.

[6] H.-G. Ryu, Y. Li, and J.-S. Park, “An improved ICI reduction method in OFDM communication system,” IEEE Trans. Broadcasting, vol. 51,
pp. 395–400, Sept. 2005.

[7] Z. Jianhua, H. Rohling, and Z. Ping, “Analysis of ICI cancellation scheme in OFDM systems with phase noise,” IEEE Trans. Broadcasting, vol. 50, pp. 97–106, June 2004.

[8] S.-M. Tseng, Y.-C. Kuo, and Y.-T. Hsu, “Turbo ICI cancellation and LDPC decoding for OFDM systems,” in Adv. Technol. Commun., pp. 405–408, Oct. 2008.

[9] R. Zhou, X. Li, V. Chakravarthy, B. Wang, and Z. Wu, “Inter-carrier interference self-cancellation in synchronous downlink MC-CDMA system,” in Proc. 2009 IEEE International Conf. Wireless Commun. Mobile Comput., pp. 739–743.

[10] X. Li, R. Zhou, V. Chakravarthy, S. Hong, and Z. Wu, “Total intercarrier interference cancellation for OFDM mobile communication systems,” in Proc.2010 IEEE Consumer Commun. Netw. Conf., pp.1-5.

[11] H. Minn, P. Tarasak, and V. Bhargava, "OFDM frequency offset estimation based on BLUE principle," in Proc. 2002 IEEE Veh. Technol. Conf. – Fall, vol. 2, pp. 1230–1234.

[12] A. J. Coulson, "Maximum likelihood synchronization for OFDM using a pilot symbol: analysis," IEEE J. Sel. Areas Commun., vol. 19, pp. 2495– 2503, Dec. 2001.

[13] M. Morelli and U. Mengali, "An improved frequency offset estimator for OFDM applications," IEEE Commun. Lett., vol. 3, pp. 75–77, Mar. 1999.