A Hybrid Approach to Reduce Peak-to-Average Power Ratio in Single-Carrier FDMA

Vikram Duhan, Ritu

Abstract: ***Single-carrier frequency division multiple access (SC-FDMA) is an improved methodology over orthogonal frequency division multiple access (OFDMA), where input information is changed from time domain to frequency domain by Discrete Fourier Transform (DFT) before applying to conventional OFDMA procedure. By applying the DFT before passing it through the Inverse Discrete Fourier Transform (IDFT) it ensures that the subcarriers are orthogonal to each other which transmit signal as the single bearer signal stimulating the SC-FDMA. SC-FDMA results in reducing the Peak-to-average power ratio (PAPR) as compare to OFDMA. In this paper computational complexity of the framework is further reduced by utilizing composite of Hartley and Hilbert transformation as a part of DFT and IDFT operation. This technique improves SC-FDMA output performance measure parameters by attaining a remarkable balance between PAPR and bit error rate (BER) reduction. The simulation results depict that hybrid transformation technique have lower PAPR than Fast Fourier Transform (FFT).***

Keywords: SC-FDMA, OFDMA, DFT, Hattley, Hilbert, Peak-to-Average Power, Bit Error Rate (BER)

I. INTRODUCTION

Technology is booming these days resulting high speed wireless mobile devices which requires very less power to uplink and downlink communication. SC-FDMA replaced OFDMA, is one of the improved techniques used in uplink and have better outcome in terms of efficiency and signal to noise ratio (SNR). Single-carrier FDMA (SC-FDMA) which employ single-carrier scheme at the transmitter and frequency domain equalization using FFT at the receiver is a strategy that has comparatively performance and basically the same structure as those of an OFDMA framework. In 3GPP Long Term Evolution (LTE), SC-FDMA has been acknowledged as an important technology for uplink communication because of its low peak to-average power reduction (PAPR) which helps mobile devices in saving transmit battery power and lessen price of the power amplifier. In this we provide a top to bottom review of SC-FDMA with focusing on physical layer and strength management perspectives. We additionally demonstrated some simulation results on peak power qualities and channel-subordinate asset selection of SC-FDMA [1]. Two unique classifications of subcarrier mapping techniques, localized and distributed, give the framework originator the adaptability to adjust to the different radio locations.

We address noise power estimation for SC frequency division-multiple access (SC-FDMA), which is utilized as a part of long Term Evolution (LTE) uplink. If the channels are known,

SNR can be effortlessly acquired from the noise power. Uplink SNR is required by the base station for rate adaption and numerous different applications. Nonetheless, existing methodologies on SNR estimation can't be directly utilized for SC-FDMA signal [2]. The discrete Fourier transformation (DFT) precoding makes SC-FDMA signal a Gaussian irregular variable if all the subcarriers are allotted to the same client, which can streamline the investigation and prompts up-front ML estimation.

In the exceptional situation where M is equivalent to N, the two blocks balance each other totally and are accordingly no more required in the transmitter. However, they're kept in the receiver to permit the usage of the frequency domain equalizer. These frameworks are called SC-FDE [3]. Multiple research has been done to reduce the PAPR of SC-FDMA and OFDMA, here we are more focused to examine the performance of SC-FDMA of LTE physical layer by considering diverse regulation plans on the premise of PAPR, BER, power signal distribution (PSD) and error possibility by simulating the model of SC-FDMA. Moreover, we analyze how to have a better PAPR by applying a hybrid technique of Hartley and Hilbert over DFT/FFT in SC-FDMA. Below sections of this paper is maintained as follows: Section II provides SC-FDMA overview. Section III gives the information about subcarrier modes of SC-FDMA and presents the CCDF of PAPR obtained from Monte-Carlo simulations. Section 1V tells about the background studies which we have referred in this research. Section V explains the proposed work which is implemented in this study to diminish PAPR of SC-FDMA. Also in section VI, for better clarity the simulation outputs are included.

II. SC-FDMA OVERVIEW

Fig.2 describes the block graph of the DFT-SC-FDMA framework with the TX I/Q irregularity situation. We consider an uplink DFT-SC-FDMA framework utilizing clients. All clients have the same number of subcarriers. The information is encoded and balanced. The modulation symbols are passed to N-point DFT and after that mapped to subcarriers of allotted sub-channels [4].

Revised Version Manuscript Received on August 04, 2016.

Vikram Duhan, Department of Electronics and Communication Engineering, Guru Jambheshwar University of Science and Technology, Hisar (Haryana) – 125001, India.

Ritu, Assistant Professor, Department of Electronics and Communication Engineering, Guru Jambheshwar University of Science and Technology, Hisar (Haryana) – 125001, India.

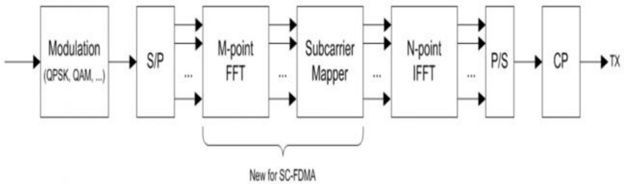

Fig.2: TX structure of SCFDMA [5]

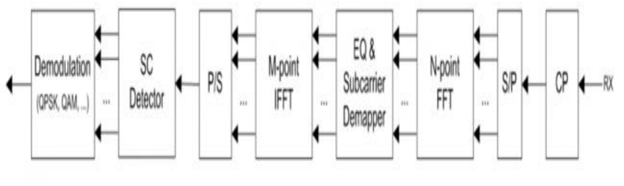

Fig.3: RX structure of SCFDMA [6]

The signal is then connected to N-point backwards DFT (IDFT) block. The structure of the SC-FDMA recipient is like the one for OFDMA with the exception of that this time, it is a subcarrier de-mapper block and a M-point IFFT delay that are embedded after the N-point FFT. A Novel PAPR Reduction Scheme for SC-OFDM with Frequency Domain Multiplexed Pilots [7]. In this plan, periods of SC-OFDM symbols were turned adaptively such that PAPR is lessened and roundabout movements are presented in the time determinant (TD).

III. PAPR OF SC-FDMA

PAPR value of SC-FDMA signals vary for different mapping techniques. SC-FDMA has two mapping modes IFDMA (Interleaved Frequency Division Multiple Access) and LFDMA (Localized Frequency Division Multiple Access). Fig. 2 shows the SC-FDMA generated signal transmitted over channel. Suppose, there are M subcarriers, out of which N *subcarriers* ($< M$) are mapped to the input data. Also, in the time domain, the input information symbol has symbol time of T seconds and the symbol period is decreased to $\tilde{T}$ after passing through SC-FDMA modulation.

$$\tilde{T} = \frac{N}{M} \cdot T$$

The PAPR is defined as follows for transmit signal s(t).

$$\text{PAPR} = \frac{peak\ power\ of\ s(t)}{average\ power\ of\ s(t)} = \frac{\max_{0 \le t \le M\tilde{T}} |s(t)|^2}{\frac{1}{M\tilde{T}} \int_0^{M\tilde{T}} |s(t)|^2 dt}$$

IV. BACKGROUND STUDIES

PAPR reduction studies are as follows:

A. Peak Power Reduction of SC-FDMA Signals Based on Trellis Shaping

Taewoo Lee et.al proposed Peak Power Reduction of SC-FDMA Signals Based on Lattice Shaping [8]. They showed that huge PAPR decrease can be accomplished for SC-FDMA signals. This method mitigates the expansion of PAPR.

B. Clipping and Filtering Technique

This strategy was proposed in [9]. Utilizing critical management causes both as a part of band twisting and out-of-band bending yet this can be decrease by utilizing separating in the wake of cut-out. This method gives PAPR decrease by direct way.

C. PAPR Reduction in Coded SC-FDMA Systems via Introducing Few Bit Errors

Jinwei Ji et.al proposed PAPR Reduction in Coded SC-FDMA Systems through Introducing Few Bit Errors [10]. The proposed plan depended on the acquaintance of few block errors with alter the couple of complex adjusted images of every information SC-FDMA image in a sub-edge, which bring about tops of the output signal examples to be bigger than a normal edge value. This technique can be utilized for higher request modulation.

D. Pulse shaping filters

The above-mentioned system was proposed in [11] by Ishu, Naresh Kumar. This system diminishes PAPR by utilizing beat molding channels, for example, Raised Cosine Filter (RC) and Rooted Raised Cosine Filter (RRC).

E. Adaptive Digital filter

Aping Yao et. al proposed Peak-To-Average Power Reduction of OFDM Signals Using Adaptive Digital Filter [12]. The PAPR lessening of OFDM signal shifts with the request of the advanced channel. In a recipient, the regulated information might be improved by a turned around method.

There are numerous studies that think about the upsides and downsides of every mapping strategy, yet we can for the most part infer that interleaved SC-FDMA prompts lower PAPR furthermore normally profits by more recurrence assorted qualities than confined SC-FDMA. Notwithstanding, by utilizing a wise asset designation that doles out the subcarriers with the best spread conditions for every terminal, it is conceivable to accomplish better performance utilizing confined SC-FDMA.

V. PROPOSED WORK

The power spectral density (PSD) is an essential capacity that depicts the power appropriation of a signal regarding frequency. In mobile communication, to perform the right cshoice of radio resource management (RRM) at base station, the PSD assumes a key part, particularly for the transmission design distribution including modulation and data transfer capacity. In the base station terminal, if PSD is unclear then it might bring about to spent high transmission transfer speed when compared with the highest UE power capacities [13].

In the distributed subcarrier mapping mode, DFT yields of the information are apportioned over the whole transfer speed with zeros possessing in unused subcarriers, though sequential subcarriers are involved by the DFT yields of the information in the restricted subcarrier mapping mode. We will allude to the restricted subcarrier mapping method of SC-FDMA as confined FDMA (LFDMA).

In simulation, we used Matlab that helped to evaluate the attributes of any signal, together with PSD (Power Spectral Density). The estimation of signal power distribution within specific frequency range known as PSD. There are different types of inadvisable calculation methods used with PSD. In our own analysis we used Periodogram range estimation methodology which is an important technique for discrete sinusoidal signal [14]. In the distributed subcarrier mapping mode, DFT outputs of the information are allocated over the whole transfer speed with zeros possessing in unused subcarriers, though sequential subcarriers are involved by the DFT outputs of the information in the restricted subcarrier mapping mode. We will allude to the restricted subcarrier mapping method of SC-FDMA as confined FDMA (LFDMA).

The Case of $M = Q \cdot N$ for the circulated mode with equidistance between possessed subcarriers is called Interleaved FDMA (IFDMA) [6]. A case of SC-FDMA transmit images in the frequency area for $N = 4$, $Q = 4$ and $M = 16$ is delineated in Table I. After subcarrier mapping, the frequency information is changed back to the time area by applying reverse DFT (IDFT).

Table I: The parameters selected for simulation

Parameters	Assumption
Number of Sub-carriers	512 (FFT Length)
CP Length	64
Range of SNR in dB	0 to 30
Modulation	BPSK, QPSK, 16-QAM, 64-QAM
Data Block Size	16 (Number of Symbols)
Channel	AWGN (SNR = 100 dB)
System Bandwidth	5 MHz
Confidence Interval used	32 times
Fading	Rayleigh (frequency selective)
Rayleigh fading parameters	Input sample period = 1.00e-3 sec Maximum Doppler shift = 100 Hz Vector path delays = [0 2.00e-5] sec Average path gain vector = [0 -9] dB

Power saving in transmission is a broad issue for the different access procedures utilized as a part of LTE, therefore we think about here as a vital transmission component PAPR for both OFDMA and SC-FDMA. The PAPR is computed by communicating to a CCDF (Complementary Cumulative Distribution Function) of PAPR. The CCDF of PAPR is the probability that the PAPR is higher than a specific PAPR value PAPR0 (Pr {PAPR>PAPR0}) [14]. It is a critical measure that is generally utilized for the complete depiction of the power qualities of signal. In SC-FDMA, be that as it may, these bits are currently funneled into a Fast Fourier Transformation (FFT) work first. The yield of the procedure is the premise for the making of the sub-transporters for the accompanying IFFT. As not all sub-bearers are utilized by the portable station, a large number of them are set to zero in the chart. These could possibly be utilized by other versatile stations.

VI. RESULTS

Results of our proposed technology will be like following below figures. Different simulation tests were implemented to derive the average reduction rate of 2.5%. Run the Matlab platform and initialize the project. In some of the simulation results we also achieved the similar results of proposed Hybrid and FFT transform. The outcome is also somehow depending upon system performance and hardware used.

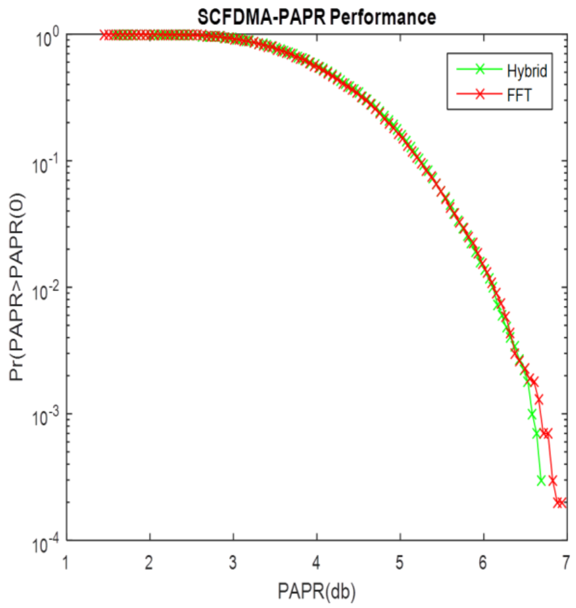

Fig.4: Simulation result 1st of SCFDMA-PAPR utilizing Hybrid, FFT transform

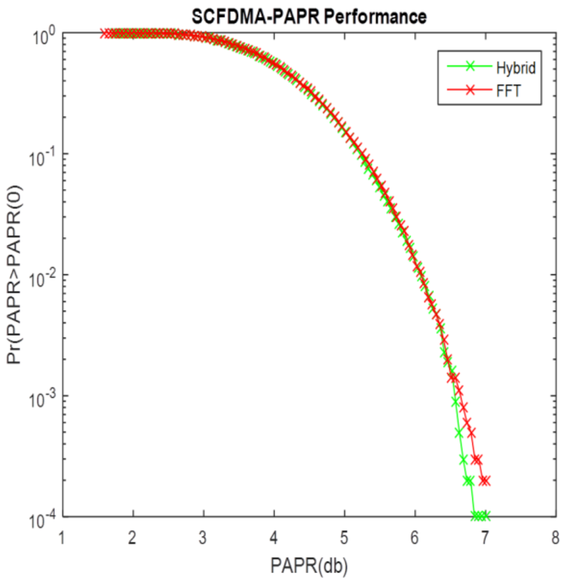

Fig.5: Simulation result 2nd of SCFDMA-PAPR utilizing Hybrid, FFT transform

Since the transmit signal is a single carrier signal, PAPR is very low contrasted with the instance of SCFDMA which delivers a multicarrier signal. Fig. 4 points of shows the PAPR of SC-FDMA transmit symbols. There are M

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication Pvt. Ltd.

subcarriers, among which N (< M) subcarriers are possessed by the input data.

The PAPR is computed by presenting to a CCDF (Complementary Cumulative Distribution Function) of PAPR. The CCDF of PAPR is the likelihood that the PAPR is higher than a specific PAPR value PAPR0 (Pr {PAPR>PAPR0}). It is a critical measure that is generally utilized for the complete portrayal of the power characteristics of signals.

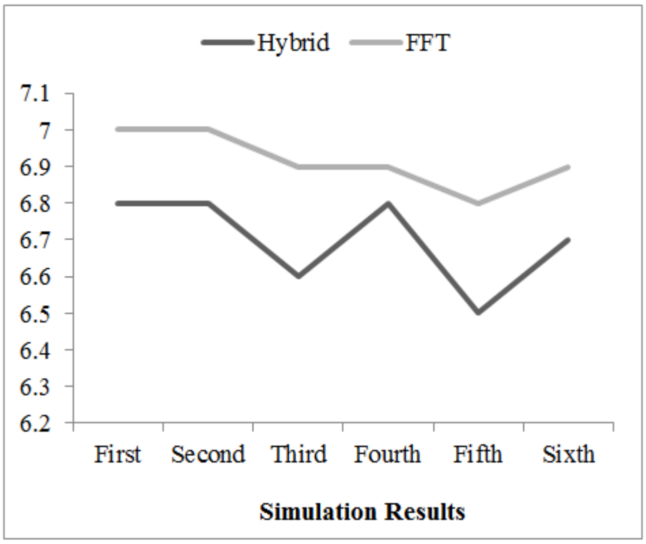

Fig. 6: Simulation results chart SCFDMA-PAPR

Table II: Simulation results using proposed Hybrid and FFT transform technique

PAPR values (dB)		
Simulation	**Proposed Hybrid**	**FFT**
1st	6.8	7.0
2nd	6.8	7.0
3rd	6.6	6.9
4th	6.8	6.9
5th	6.5	6.8
6th	6.7	6.9

VII. CONCLUSIONS

To recapitulate, PAPR and BER are the key parameter for measuring the framework performance of any information signal. In our exploration we analyze that for a fix estimation of SNR and BER with an increase or decrease of PAPR qualities for high order modulation formats (16-QAM and 64-QAM) in the multiple access strategy SC-FDMA utilized as a part of LTE framework. By applying the mixed technique of Hartley and Hilbert transform peak-to-average power ratio can be suppressed emerging a better performance in uplink communication.

To diminish the computational complexity of the framework, FFT is utilized as a part of spot of DFT operation and IFFT set up of IDFT operation. Proposed work is a productive PAPR decrease plan which diminishes the PAPR significantly without influencing much to the performance furthermore with low usage cost. Total 6 simulation analysis were performed to decrement the mean value of PAPR by 2.5%. In future work the proposed hybrid technique can also be compared with other transformation techniques to validate these results.

REFERENCES

1. H. Ekström, A. Furuskär, J. Karlsson, M. Meyer, S. Parkvall, J. Torsner, and M. Wahlqvist, " Technical Solutions for the 3G Long-Term Evolution," IEEE Commun. Mag., vol. 44, no. 3, March 2006, pp. 38– 45
2. 3rd Generation Partnership Project (3GPP); Technical Specification Group Radio Access Network; Physical Layer Aspects for Evolved UTRA, http://www.3gpp.org/ftp/Specs/html-info/25814.htm
3. M. Danish Nisar, Hans Nottensteiner, and Thomas Hindelang, " On Performance Limits of DFT-Spread OFDM Systems" , in Sixteenth IST Mobile Summit, July 2007 in Budapest, Hungary.
4. B.E. Priyanto, H. Codina, S. Rene, T.B. Sorensen, P. Mogensen, " Initial Performance Evaluation of DFT-Spread OFDM Based SC-FDMA for UTRA LTE Uplink" , IEEE Vehicular Technology Conference (VTC) 2007 Spring, Dublin, Ireland, Apr. 2007
5. Luqing Wang and Chintha Tellambura, " A Simplified Clipping and Filtering Technique for PAR Reduction in OFDM Systems" , IEEE Signal Processing Letters, Vol. 12, No. 6, pp.453-456 June 2005
6. Wenjin Wang, Xiqi Gao, Fu-Chun Zheng, Wen Zhong, " CP-OQAM-OFDM Based SC-FDMA: Adjustable User Bandwidth and Space-Time Coding" , IEEE Transactions On Wireless Communications, Vol. 12, No. 9, pp.4506-4517, September 2013
7. Fumihiro Hasegawa, Akihiro Okazaki, Hiroshi Kubo, Damien Castelain, and David Mottier, " A Novel PAPR Reduction Scheme for SC-OFDM with Frequency Domain Multiplexed Pilots" , IEEE Communications Letters, Vol. 16, No. 9, September 2012
8. Taewoo Lee, Hideki Ochiai, " Peak Power Reduction of SC-FDMA Signals Based on Trellis Shaping" , Globocom 2012 symposium on selected areas,3268-3273
9. Prafulla. D. Gawande, Sirddharth. A. Ladhake, " PAPR Performance of Ofdm System by Using Clipping and Filtering Method" , International Journal of Advances in Engineering & Technology, Vol. 6, Issue 2, pp. 789-794, May 2013,
10. Jinwei Ji, Guangliang Ren, Huining Zhang, " PAPR Reduction in Coded SC-FDMA Systems via Introducing Few Bit Errors" , IEEE Communications Letters, Vol. 18, No. 7, July 2014
11. Ishu,Naresh Kumar, " PAPR Reduction in Wavelet based SCFDMA using Pulse Shaping Filters for LTE Uplink Transmission" , International Journal of Applied Engineering Research, Volume 9, Number 20 (2014) pp. 6481-6492
12. Aping Yao, Yi Zheng, " Peak-To-Average Power Reduction of OFDM Signals Using Adaptive Digital Filter" , IEEE ICASSP, pp. 305-308, 2006
13. Meng Ma, Xiaojing Huang, Y. Jay Guo, " An Interference Self-Cancellation Technique for SC-FDMA Systems, IEEE Communications Letters, Vol. 14, No. 6, June 2010
14. Leonhard Korowajczuk, LTE, WiMAX and WLAN Network Design, Optimization and Performance Analysis, John Willey & Sons,2011