IMPLEMENTATION OF MULTI CARRIER-CODE DIVISION MULTIPLE ACCESS-FREQUENCY DIVISION MULTIPLE ACCESS WITH BEYOND 4G SPECIFICATIONS

MAYADA FARIS GHANIM ALOMARY

A thesis submitted in

fulfillment of the requirement for the award of the

Doctor of Philosophy

Faculty of Electrical and Electronic Engineering

Universiti Tun Hussein Onn Malaysia

2013

ACKNOWLEDGEMENT

I wish to express my deepest gratitude to my supervisor Associate Prof. Dr. Mohammad Faiz Liew Abdullah for showing great interest in my work and for the guidance that he has given me.

Thanks to my siblings and friends for their encouragement and mental support during my stay in Malaysia.

The most heartfelt gratitude goes to the three most special people in my life, my father, my mother and my husband. I would like to thank my parents and my husband for making my life a wonderful one .To my father and mother in Iraq, for their endless support, love and pride in me. To my husband, I am deeply grateful for his continued love and devotion. I am thankful for him and his wonderful family for believing in me and giving me their full support. To my precious children Mustafa and Layal, who bring joy into my life every day. To my family and friends; this work is dedicated to them.

Mayada Faris Ghanim

2013

Johor, Malaysia

ABSTRACT

Hybrid code division multiple access techniques present the open door for the future of code division multiple access and wireless communications. Multicarrier CDMA is the most popular type of hybrid CDMA because of its robustness against multipath fading channels and flexible multiple access capability. MC-CDMA is a predictable technique for future high data rate wireless communication systems according to these appealed properties. The main drawback of MC-CDMA is the power level in uplink, i.e. the ratio of peak power to the average power is high and leads to high instantaneous power which is required in transmission of mobile station. However, there are many researchers working towards reducing the level of the transmitted power. This research presents new method of peak to average power ratio (PAPR) reduction. The proposed method is making use of the characteristics of uplink for current 4^{th} Generation (single carrier frequency division multiple access) which has low PAPR into current MC-CDMA system to reproduce a new MC-CDMA system (MC-CDMA-FDMA) with low PAPR and keep all the characteristics of the basic MC-CDMA system. MC-CDMA-FDMA reduced the level of power from 10 dB to 2 dB in case of 64 FFT size and Walsh Hadamard code is used in spreading block. In addition bit error rate has been reduced from $96x10^{-5}$ bps to $82x10^{-5}$ bps comparing to SC-FDMA bit error rate. The proposed system also has high flexibility to deal with modern communication systems with minimum required hardware at the base station through optimization of FFT size. The simulation results show that MC-CDMA-FDMA system will be a good candidate for beyond 4^{th} Generation for mobile communications.

ABSTRAK

Teknik kod hibrid pelbagai akses merupakan kod akses pelbagai dan komunikasi tanpa wayar masa depan. Multicarrier CDMA adalah salah satu hibrid CDMA yang paling popular kerana keteguhan terhadap saluran pudar berbilang dan keupayaan pelbagai akses yang fleksibel. MC-CDMA adalah satu teknik untuk kadar data yang tinggi bagi sistem komunikasi data tanpa wayar masa depan kerana ciri-cirinya yang menarik. Kelemahan utama MC-CDMA adalah tahap kuasa di bahagian pautan atas, iaitu nisbah kuasa puncak kepada kuasa purata yang tinggi menyebabkan kuasa serta-merta menjadi tinggi, di mana kuasa tinggi ini sangat diperlukan dalam process pemancaran ke stesen mudah alih. Walau bagaimanapun, terdapat ramai penyelidik bekerja ke arah mengurangkan tahap kuasa pemancaran yang dihantar. Kajian ini membentangkan kaedah baru untuk mengurangkan puncak kuasa purata nisbah (PAPR). Kaedah yang dicadangkan menggunakan ciri-ciri pautan atas untuk Generasi ke-4 (iaitu pembawa tunggal frekuensi bahagian akses pelbagai) yang mempunyai PAPR rendah ke dalam sistem MC-CDMA terkini untuk menghasilkan satu sistem baru MC-CDMA yang dikenali sbagai (MC-CDMA FDMA) dengan PAPR rendah dan mengekalkan semua ciri-ciri asas sistem MC-CDMA MC-CDMA FDMA telah mengurangkan tahap kuasa dari 10 dB 2 dB dalam kes dimana 64 saiz FFT dan Walsh kod Hadamard digunakan dalam menyebarkan blok. Di samping kadar bit ralat telah dikurangkan daripada $96x10^{-5}$ bps kepada $82x10^{-5}$ bps jika dibandingkan dengan SC-FDMA kadar “bit error”. Sistem yang telah dicadangkan juga mempunyai fleksibiliti yang tinggi untuk berurusan dengan sistem komunikasi moden dan menggunakan perkakasan yang minimum pada stesen pangkalan melalui pengoptimuman saiz FFT. Keputusan simulasi menunjukkan bahawa sistem MC-CDMA-FDMA akan menjadi calon yang sesuai untuk Generasi ke-4 bagi komunikasi mudah alih.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

3G	-	Third Generation
4G	-	Fourth Generation
A/D	-	Analog to digital
AWGN	-	Additive White Gaussian Noise
BER	-	Bit Error Rate
BPSK	-	Binary Phase Shift Keying
BS	-	Base Station
CDF	-	Cumulative Distribution Function
CDMA	-	Code Division Multiple Access
CDS	-	Channel Dependent Scheduling
CP	-	Cyclic Prefix
D/A	-	Digital to analog
DAC	-	Digital to Analog Converter
DFDMA	-	Distributed FDMA
DFT	-	Discrete Fourier Transform

DFT-S-OFDM	-	Discrete Fourier Transform-Spread- Orthogonal Frequency Division Multiplexing
DS	-	Direct Sequence
DS-CDMA	-	Direct Sequence- Code Division Multiple Access
DS-SS	-	Direct Sequence- Spread Spectrum
DwPTS	-	Downlink Pilot time Slots
ECSLM	-	Error Control Selective Mapping Scheme
ESN	-	Electronic Serial Numbers
FD	-	Frequency Division
FDD	-	Frequency Division Duplexing
FDE	-	Frequency Domain Equalizer
FDMA	-	Frequency Division Multiple Access
FEC	-	Forward Error Correction
FFT	-	Fast Fourier Transform
FH	-	Frequency Hopping
FH-CDMA	-	Frequency Hopping- Code Division Multiple Access
FH-SS	-	Frequency Hopping Spread Spectrum
FM	-	Frequency Modulation
GP	-	Guard Period
GSM	-	Global System for Mobile Communications

HPA	-	High Power Amplifier
IBR	-	Input Buffered Router
IDFT	-	Inverse Discrete Fourier Transform
IEEE	-	Institute of Electrical and Electronics Engineers
IFDMA	-	Interleaved Frequency Division Multiple Access
IFFT	-	Inverse Fast Fourier Transform
IS	-	Interim Standard
ISI	-	Inter Symbol Interference
ITU	-	International Telecommunications Union
LANs	-	Local Area Networks
LFDMA	-	Localized FDMA
LOS	-	Line Of Sight
LTE	-	Long Term Evolution
MAI	-	Multi Access Interference
MC	-	Multi Carrier
MC-CDMA	-	Multi Carrier Code Division Multiple Access
MC-DS-CDMA	-	Multi Carrier-Direct Sequence -Code Division Multiple Access
MCM	-	Multi Chip Module
MS	-	Mobile Station
MSE	-	Mean Square Error

OBE	-	Out-of-Band Emission
OBR	-	Output Buffered Router
OFDM	-	Orthogonal Frequency Division Multiplexing
OFDMA	-	Orthogonal Frequency Division Multiple Access
PAPR	-	Peak-to-Average Power Ratio
PG	-	Processing Gain
PN	-	Pseudo noise
PPM	-	Pulse Position Modulation
PSK	-	Phase Shift Keying
PTS	-	Partial Transmit Sequences
PUCCH	-	Physical Uplink Control Channel
PUSCH	-	Physical Uplink Shared Channel
QAM	-	Quadrature Amplitude Modulation
QPSK	-	Quadrature Phase Shift Keying
RAM	-	Random Access Memory
RF	-	Radio Frequency
SC-FDMA	-	Single Carrier Frequency Division Multiple Access
SF	-	Spreading Factor
SLM	-	Selected Mapping
SNR	-	Signal to Noise ratio

TD	-	Time Division
TDD	-	Time Division Duplexing
TDD-CDMA	-	Time Division Duplexing Code Division Multiple Access
TDMA	-	Time Division Multiple Access
TD-SCDMA	-	Time Division Synchronous Code Division Multiple Access
T-FF	-	Toggle Flip Flop
TH	-	Time Hopping
TH-CDMA	-	Time Hopping- Code Division Multiple Access
TH-SS	-	Time Hopping Spread Spectrum
UpPTS	-	Uplink Pilot Time Slots
UWB	-	Ultra WideBand
WH	-	Walsh Hadamard
WiMAX	-	Worldwide Interoperability for Microwave Access

REFERENCES

Abu-Rgheff, M. A. (2007). *Introduction to CDMA Wireless Communications.* Elsevier. pp.164-224.

Ahmadi, S. (2011). *Mobile WiMAX a Systems Approach to Understanding IEEE 802.16m Radio Access Technology*. Elsevier Inc. pp.355-385.

Almeida, M. (2011).*Vehicular technologies:increasing connectivity.* Published by InTech. pp. 205-206.

Ameen, J. H. & Ismail, W. (2011). *Multi-band carrier Code Division Multiple Access for 4G mobile system with improved signal quality.* World Applied Sciences Journal. vol. 12. no.3. pp.330-335.

Amir, S. & Asif, M. (2011). *Analytical study of MC-CDMA-TCM over multi-path Rayleigh fading channel.* International Conference on Computer Engineering and Applications (IPCSIT). vol.2. pp.332-337.

Baig, I. & Jeoti, V. (2010). *Novel Precoding Based PAPR reduction schemes for localized OFDMA uplink of LTE –A.* Journal of Telecommunication, Electronic and Computer Engineering. vol. 2. no. 1. pp. 49-58.

Benvenuto, N. & Zorzi, M. (2011). *Principles of Communications Networks and Systems.* John Wiley & Sons Ltd. pp. 335-606.

Bhange, D. N., Dhakulkar, P. P. & Deotale, T. G. (2013). *Single carrier spread spectrum technique for uplink.* International Journal of Electronics Communication and Computer Engineering. vol.4 .no.2 .pp.4-7.

Chakkravarthy, S. P., Nagarajan, N. & Arthi, V. (2010). *Selection based successive interference cancellation for multicode multicarrier CDMA transceiver*. Wseas transactions on communications. vol.8. no.9. pp.463-472.

Chang, C. (2011). *Sum Throughput-Improved Resource Allocation for LTE Uplink Transmission.* IEEE Vehicular Technology Conference (VTC Fall). pp.1.

Chang, C. (2012). *An Interference-Avoidance Code Assignment Strategy for the Hierarchical Two-Dimensional-Spread MC-DS-CDMA System: A Prototype of Cognitive Radio Femtocell System*. IEEE Transactions on Vehicular Technology. vol. 61. no. 1. pp.166-167.

Chen, H. (2007). *The Next Generation CDMA Technologies.* John Wiley & Sons. pp.7-13.

Chen, Y., Peng, I. & Lai, C. (2012). *Study of Radio Resource Allocation Scheme for Single Carrier FDMA in LTE Network.* IEEE 75th Vehicular Technology Conference (VTC Spring), pp.1-5.

Cho,Y. S., Kim J., Yang, W. Y. & Kang, C. G.(2010). *MIMO-OFDM wireless communications with MATLAB.* John Wiley, pp. 145-146.

D'Orazio, L., Sacchi, C., Donelli, M., Louveaux, J. & Vandendorpe, L. (2011). *A Near-optimum multiuser receiver for STBCMC-CDMA systems based on minimum conditional BER criterion and genetic algorithm-assisted channel estimation*. EURASIP Journal on Wireless Communications and Networking. pp. 1-13.

Deng, J. & Liao, S. (2010). *A Low-PAPR Multiplexed MC-CDMA system with enhanced data rate over multipath channels.* IEEE 71st Vehicular Technology Conference (VTC 2010-Spring), pp. 1-5.

Deng, J. H. & Hwang, J. K. (2011). *Novel low-PAPR parallel FSOK transceiver design for MC-CDMA system over multipath fading channels.* EURASIP Journal on Wireless Communications and Networking. pp. 2-14.

Develi, I. & Akdagli A. (2013). *Approximate Expression of Bit Error Rate in Uplink MC-CDMA Systems with Equal Gain Combining*. Journal of Communications and Networks, vol. 15, no. 1. pp. 25-30.

Develi, I. & Kockaya, K. (2010). *BER performance simulation of generalized MC DS-CDMA system with time-limited Blackman chip waveform.* Journal of Radio Engineering, vol. 19. no. 3. pp.403-407.

Dhivagar , B., Kuchi, K. & Giridhar, K. (2013). *An iterative MIMO-DFE receiver with MLD for uplink SC-FDMA.* National Conference on Communications (NCC). pp.1-4.

Dongkai, Y., Xin, Y., Kefei, L. & Qishan, Z. (2009). *Performance analysis of PAPR in MC-CDMA system*. International Conference on Information Science and Engineering (ICISE2009).pp. 2676- 2679.

Dubey, A. K., Vashistha, G. & Parveen. (2011). *Reanalysis of BER for wavelet based MC-CDMA communication.* International Journal of Computer Science & Management Studies. vol. 11. no. 1. pp.39-42.

El-Absi, M. A. & Hussein, M. T. (2011).*A novel method to reduce peak-to-average power ratio (PAPR) in multicarrier code division multiple access (MC-CDMA).* International Journal of Computer and Electrical Engineering. vol3.no.2. pp.176-179.

Elnoubi, S. M. & Hashem, A. (2008). *Error Rate Performance of MC DS-CDMA systems Over Multiple-Input -Multiple Output Nakagami-M Fading channel.* IEEE Military Communications Conference (MILCOM). pp.1-7.

Faisal, M., Uddin, J. & Haider, I. H. (2012). Simulation based performance analysis of MC-CDMA and CDMA over Rayleigh fading channel. International Journal on Internet and Distributed Computing Systems. vol. 2. no. 1. pp. 120-122.

Fazel, K. & Kaiser, S. (2008). *Multi-Carrier and Spread Spectrum Systems From OFDM and MC-CDMA to LTE and WiMAX*. John Wiley & Sons Ltd. pp.46-67.

Figueiredo, N. d. & Linde, L. P. (2011). *MC-CDMA with Blind Channel Estimation and Adaptive Reception*. Southern Africa Telecommunication Networks and Applications Conference (SATNAC). pp.224-226.

Gergis, L. F. (2011). *Performance of MC-MC CDMA systems with nonlinear models of HPA.* International Journal of Wireless & Mobile Networks (IJWMN). vol. 3. no. 1. pp. 86-96.

Giannetti, F., Lottici, V.& Stupia, I. (2011) *PAPR Analytical Characterization and Reduced-PAPR Code Allocation Strategy for MC-CDMA Transmissions.* IEEE Transactions on Wireless Communications. Vol. 10, No. 1. pp. 219-227.

Gite, A. V., Khan, A. R. & Gulhane, S. M.(2013). *Performance evaluation of MC-CDMA system using delta modulation in ultra wide band channel.* International conference SDIWC. pp.379-385.

Glisic, S. G. (2006). *Advanced wireless networks 4G technologies.* John Wiley, pp. 32-36.

Gupta, V. & Tiwari, R. (2011). *Performance analysis and simulation result of MC-CDMA for AWGN channel and raleigh based on SNR/BER.* International Journal of Advanced Computer Research. vol.1. no.1. pp.13-18.

HA, T. T. (2011). *Theory and design of digital communication systems.* Cambridge University. pp.21-27.

Hanzo, L. & Keller, T. (2006). *OFDM and MC-CDMA A Primer*. John Wiley & Sons Ltd. pp.219-220.

Hara, S. & Prasad, R. (2003). *Multicarrier Techniques for 4G Mobile Communications.* Artech House. London. pp.176-179.

Hernández, L. A. & Otero, M. G. (2009). *User reservation approach for peak-to-average power ratio reduction in MC-CDMA systems.* Vehicular Technology Conference (VTC). pp. 1-5.

Holma, H. & Toskala, A. (2009). *LTE for UMTS–OFDMA and SC-FDMA Based Radio Access.* John Wiley & Sons Ltd. pp. 76-79.

Hwang, J. K., Tsai, Y. T. & Lia, J. D. (2011). *highly re-configurable Instruments-in-Matlab Software-Defined Radio platform for 4G SC-FDMA signal measurements and analysis*. IEEE/SICE International Symposium on system Integration (SII). pp.1374.

Ida, Y., Ahn, C., Kamio, T., Fujisaka, H. & Haeiwa, K. (2013). *Variable splitting transmission in multi-relay cooperative communications for SC-FDMA*. 15th International Conference on Advanced Communication Technology (ICACT), pp. 623-627.

Ida, Y., Ahn, C., Kamio, T., Fujisaka, H. & Haeiwa, K. (2013). *Variable packet splitting transmission in multi-relay cooperative communications with DF and DAF for SC-FDMA.* EURASIP Journal on Wireless Communications and Networking. vol. 64, no. 1. pp. 1-8.

Indumathi, Dr. G.& Joe, D. A. (2013). *Design of Optimum Physical Layer Architecture for a High Data Rate LTE Uplink Transceiver*. International Conference on Green High Performance Computing. pp.1-8.

Ipatov, V. P. (2005).*Spread Spectrum and CDMA Principles and Applications*. John Wiley & Sons. pp. xi.

Jacklin, N. & Zhi, D. (2013). *A Linear Programming Based Tone Injection Algorithm for PAPR Reduction of OFDM and Linearly Precoded Systems.* IEEE transactions on circuits and systems. vol. 60. no. 7. pp. 1937- 1945.

Jamalipour, A., Wada, T. & Yamazato, T. (2005). *A Tutorial on multiple access technologies for beyond 3G Mobile Networks*. IEEE Communications Magazine. pp.110-117.

Jiang, X., Zhang, C. & Lu, J. (2009). *Time-frequency hopping sequences with three no hit zones.* Springer Wireless Network. pp. 455-461.

Kha, H. H., Tuan, H. D., Nguyen, H. H. & Pham, T. T. (2013). *Optimization of cooperative beamforming for SC-FDMA Multi-User Multi-Relay networks by tractable D.C. programming*. IEEE Transactions on Signal Processing. vol. 61. no. 2. pp. 467-479.

Kha, H.H., Tuan, H.D. &Nguyen, H.H.(2013). *Joint Optimization of Source Power Allocation and Cooperative Beamforming for SC-FDMA Multi-User Multi-Relay Networks.* IEEE Transactions on Communications. VOL. 61. NO. 6. pp. 2248-2259.

Khan, F. (2009). *LTE for 4G mobile broadband air interface technologies and performance.* Cambridge university press. pp.85-86.

Krouk, E. & Semenov, S. (2011). *Modulation and Coding Techniques in Wireless Communications*. John Wiley & Sons Ltd. pp.358-459.

Kumar, D. & Chellappan, C. (2009). *Efficient Resource Allocation in MC-CDMA Cellular Wireless Networks to Support Multimedia Traffic.* Journal of Theoretical and Applied Information Technology. pp.625-627.

Kumar, P. S, Rasadurai, K. & Kumaratharan, N. (2013). *LDPC coding for performance enhancement of MC-CDMA system.* International Journal of Advanced Trends in Computer Science and Engineering. vol.2 .no.1. pp.1-5.

Kumaratharan, N., Dananjayan, P. & Padmavathy, M. (2008). *Performance Improvement Of Mc-Cdma System Through Dstbc Site Diversity.* Journal of Theoretical and Applied Information Technology. pp.1075-1082.

Manjith, R. Ramesh, S. C. & Majeed, M. M.I. (2010). *PAPR reduction in OFDM & MC-CDMA system using nonlinear companding techniques*. IEEE region 8 international conference on computational technologies in electrical and electronics engineering (SIBIRCON). pp. 274-278.

Meenakshi, D., Prabha, S., Raajan, N. (2013). *Performance analysis of OFCDM, MC-CDMA and OFDM for wire-free.* IEEE Conference on Information and Communication Technologies (ICT 2013). pp. 451-455.

Mishra, A. R. (2004). *Fundamentals of cellular network planning and optimisation 2G/2.5G/3G... evolution to 4G.* John Wiley. pp.156-157.

Molisch, A. F. (2011). *Wireless Communications.* John Wiley & Sons Ltd.2nd edition. pp. 151-672.

Morelli, M. & Sanguinetti, L. (2005). *Novel prefiltering technique for downlink transmissions in TDD MC-CDMA systems.* IEEE Transactions on wireless communications. vol. 4. no. 5. pp. 2064- 2069.

Myung, H. G. & Goodman, D. J. (2008). *Single Carrier FDMA a New air Interface for Long Term Evolution.* John Wiley & Sons Ltd. pp. 38-71.

Nagarajan, V. & Dananjayan, P. (2010). *Performance Analysis of MIMO MC-DS/CDMA system using chaotic spreading sequence*. International Journal of Computer and Electrical Engineering. vol. 2. no. 2. pp. 329-333.

Ng, B. K., Lam, C. T. (2013). *On Maximizing the Performance of SC-FDMA systems with rotated constellation.* 9th International Wireless Communications and Mobile Computing Conference (IWCMC). pp. 1699- 1704.

Nours, S. L., Nouvel, F. & Helard, J. (2004). *Design and Implementation of MC-CDMA Systems for FutureWireless Networks*. EURASIP Journal on Applied Signal Processing. pp. 1604–1606.

Otero, M. G. & Hernández, L. A. (2011). *PAPR reduction in SFBC MIMO MC-CDMA systems via user reservation.* EURASIP Journal on Advances in Signal Processing. vol. 9. no. 1. pp. 1-10

Prasad, R. (2004). *OFDM for wireless communications systems.* Artech House, Inc. pp. 198-201.

Presti, C. D., Metzger, A. G., Banbrook, H. M., Zampardi, P. J. & Asbeck, P. M. (2010). *Efficiency improvement of a Handset WCDMA PA module using adaptive digital predistortion.* IEEE MTT-S International Microwave Symposium Digest (MTT). pp. 804 - 807.

Qayyum, A., Khan, M. A., Umair, M. & Choudhry.M. A. S. (2013). *Performance analysis of LMS based MC-CDMA system,* Information Technology & Electrical Engineering Journal vol.2. no. 1. pp. 47-51.

Rasadurai, K., Kumar, P. S. & Kumaratharan, N. (2013). *Performance Enhancement of MC-CDMA System Using LDPC Codes.* IEEE Conference on Information and Communication Technologies (ICT 2013). pp.78-82.

Rindhe, U., Shah, D. C. & Narayankhedkar, S. K. (2011). *OFDM and MC-CDMA for 4G Networks.* 2nd International Conference and workshop on Emerging Trends in Technology (ICWET). pp. 30-37.

Sarala, B. & Venkateswarulu, D. S. (2011).*MC-CDMA PAPR reduction techniques using discrete transforms and companding.* International Journal of Distributed and Parallel Systems (IJDPS) vol.2. no.6. pp.253-270.

Schmidt, B., Chi, N., Yien, P., Harris, C., Saripalle, U., Price, A., Brewer, S., Scelsi, Giuseppe, Slaviero, R. & Armstrong, J. (2006). *Efficient algorithms for PAPR reduction in OFDM transmitters implemented using Fixed-Point DSPs* .IEEE 63rd Vehicular Technology Conference (VTC-Spring). vol. 4. pp.2023-2027.

Schulze, H. & Lùders, C. (2005). *Theory and Applications of OFDM and CDMA Wideband Wireless Communications*. John Wiley & Sons. pp.265.

Shabbir, M. S. & Ashraf M. A. (2011). *SAFNAQ, an algorithm for transmission power allocation in MCCDM.* International Conference on Computer and Software Modeling (IPCSIT). vol.14. pp.202-207.

Sivanesskumar, S. & Sukanesh, R. (2009). *Performance Analysis of Multi-Carrier Code Division Multiple Access System under Clipping Noise.* European Journal of Scientific Research. vol. 38. no.4. pp. 590–595.

Sureshkumar, K., Rajalakshmi1, R. & Vetrikanimozhi, A. (2011). *Channel estimation for MIMO MC-CDMA systems.* International Journal of Distributed and Parallel Systems (IJDPS). vol.2. no.6. pp. 347-355.

Taha, A. M., Abu Ali, N. & Hassanein, H. S. (2012).*LTE, LTE-Advanced and WiMAX towards IMT-Advanced networks.* John Wiley. pp.22-23.

Thuakaew, S. & Chayratsami, P. (2013). *The Optimum Ring Ratio of 16-APSK in LTE Uplink over Nonlinear System.* 15th International Conference on Advanced Communication Technology (ICACT). pp.805-809.

Wen, M., Cheng, X., Yin, X., Yang, L. & B. Jiao. (2013). *A General Framework for BER Analysis of OFDMA and Zero-Forcing Interleaved SC-FDMA over Nakagami-m Fading Channels with Arbitrary m*. IEEE Wireless Communications Letters. vol. 2. no. 4.pp. 395-398.

Wesołowski, K. (2009). *Introduction to digital communication systems.* John Wiley, pp. 529-530.

XU, B. & Lianfeng, S. (2008). *A New Synchronization Protocol on the Convergence of 3G cellular network and manet.* International Journal of Advanced Computer Research. vol.1. no.1. pp. 1-2.

Yang, L., You, M. & Li, J. (2009). *Optimized spreading code reallocation technique for PAPR reduction in MC-CDMA systems.* IEEE Communications Society. pp.1-6.

Yu, N. Y. (2010).*A Theoretical study of Peak-to-Average Power Ratio in reed-muller coded multicarrier CDMA*. IEEE Conference Information Sciences and Systems (CISS). pp.1-6.