AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING

Electronics and Communication Engineering Department

Waveform candidates and Massive MIMO in 5G cellular system

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(Electronics and Communication Engineering)

Submitted By

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STATEMENT

This dissertation is submitted as a partial fulfillment of the degree of Doctor of Philosophy in Electrical Engineering (Electronics and Communications Engineering) Faculty of Engineering, Ain Shams University.

The work included in this thesis was carried out by the author at the Electronics and Communications Department, Faculty of Engineering, Ain Shams University, Cairo, Egypt.

No part of this thesis was submitted for a degree or a qualification at any other university or institution.

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ABSTRACT

Waveform candidates and Massive MIMO in 5G cellular system

By

MOHAMED HUSSEIN BADR EL-DIN MOHARAM

DOCTOR OF PHILOSOPHY IN ELECTRICAL ENGINEERING THESIS AIN SHAMS UNIVERSITY

The aim of this dissertation is analyzing the performance to reduce PAPR in 5G connection. An important aim of the 5G technology is attaining high data rate (10 Gbps). Because there exist limited frequency resources, the spectrum frequency shall be used efficiently to obtain a high data rate. Also to use white space, there is a need for cognitive radio networks. In a very low cognitive radio network, the outside radiation band is required.

OFDM isn`t selected in 5G system due to reduce bandwidth efficiency. 5G connections need a novel waveform like FBMC that has a lot of uses in different 5G projects worldwide. A problem that always faces the multicarrier communication system is the High PAPR. Since FBMC is a multi-carrier communication system, it as well is affected by PAPR tricky. Active constellation extension(ACE), Tone reservation(TR), partial transmits sequence, clipping &filtering are four promising methods used to reduce PAPR for a FBMC system.

In this thesis a hybrid technique of TR and ACE is used, this technique shows an outstanding performance improvement in comparison to the hybrid scheme of TR and ACE techniques taken separately. Also, the hybrid clipping PTS has given better PAPR reduction performance than that used in TR-ACE.

Enhanced Particle Swarm Optimization hybrid Clipping Partial Transmit Sequence (EPSO hybrid C-PTS) and Enhanced harmony Search Optimization hybrid Clipping Partial Transmit Sequence (EHS hybrid C-PTS) are proposed which are used for optimization to solve the problem of PAPR in FBMC system. The first optimization method is a joint optimization of PSO based Cauchy mutation which is applied on the hybrid clipping PTS. The second optimization method is considered as harmony search improvement by adapting the pitch adjustment rate (PAR), also bandwidth of adjustment (bw) to be updated dynamically to select minimum PAPR value.

The two optimization method applied on the proposed scheme to show the success of obtaining optimum weighting factor which helps to reduce the PAPR.

Simulation is performed to analyze the PAPR, BER, PSD and complexity analysis performance of the FBMC based OQAM of the proposed techniques. The simulation results show the efficiency of the proposed techniques in achieving perfect PAPR reduction value of 2.9 dB which, improves the results than previously proposed solutions by a percentage of 70%-72%.

The contribution of this thesis focuses on four main topics: 1) the performance analysis of applying FBMC communication in the transmitter and receiver using FBMC FMT, SMT and CMT systems 2) the performance analysis of adding identical 32×32 MIMO antennas configuration at FBMC communication with rician fading channel, 3) the performance analysis of applying proposed PAPR reduction methods on FBMC to evaluate CCDF, BER, complexity analysis and PSD, and 4) the hardware measurement analysis of using software defined radio (SDR) implementation for the proposed method.

Key Words: *fifth generation (5G), Filter Bank Multi-Carrier (FBMC), Peak to average power ratio(PAPR), Particle Swarm Optimization(PSO), Harmony search (HS) Optimization, Tone reservation active constellation extension(TR-ACE), Clipping Partial Transmit Sequence(C-PTS),Universal software Radio Peripheral (USRP),Software Defined Radio (SDR), Multiple Input Multiple Output (MIMO).*

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Every challenging work needs self-efforts as well as guidance from those are very close to your hearts:

My humble effort I dedicate to;

1- My father who always supported and encouraged me to believe in myself. Thank you, Dad. You left such finger prints on my life.
2- To my mother who taught me to trust in ALLAH believe in hardwork and that so much could be done with little. Thank you Mum for your endless support and devotion.
3- To my wife whose selflessness will always be remembered. Thanks for always being there by me
4- To my family that always carried about me

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LIST OF ABBREVIATIONS

4G	Fourth Generation
5G	Fifth Generation
AS	Alternative Signal
ABC	Artificial Bee colony
ADC	Analog Digital converter
ACE	active constellation extension
AWGN	Additive White Gaussian Noise
BER	Bit Error Rate
BPSK	Binary Phase Shift Keying
BSs	Base Stations
bw	band width of adjustment
CCDF	Complementary cumulative distribution Function
CMT	Cosine-Modulated Multitone
CP	Cyclic Prefix
CFO	Carrier Frequency Offset
CSI	Channel State Information
CFR	Channel Frequency Response
CICF	Cascaded Integrator Comb Filter
DAC	Digital Analog converter
DAS	Distributed Antenna System
DFT	Discrete Fourier Transform
EPSO-H-CPTS	Enhanced PSO hybrid Clipping PTS
EHS-Hybrid-CPTS	Enhanced Harmony Search Hybrid Clipping PTS
FBMC	Filter Bank Multicarrier
FANTASTIC-5G	Flexible Air iNTerface for Scalable service delivery wiThin wIreless Communication networks of the 5th Generation.
FDM	Frequency Division Multiplexing
FMT	Filtered Multitone
BFDM	Biorthogonal Frequency Division Multiplexing
Flops	Floating Point Operation
FPGA	Field Programmable Gate Array
GFDM	Generalized Frequency Division Multiplexing
HS	Harmony Search
HMS	Harmony Memory Size
HMCR	Harmony Memory Consideration Rate
IFFT	Inverse fast Fourier transform
ISI	Inter symbol Interference
ITU-R	Radiocommunication Sector of International Telecommunication Union.
ICI	Inter Carrier Interference
ICSI	Inter Channel symbol Interference
IOT	Internet of Thing
IF	Intermediate Frequency
LOS	Line of Sight

MIMO	Multiple-Input-Multiple-Output
MBB	Mobile Broadband
M2M	Machine-to-Machine
ML	Maximum Likelihood
MMSE	Minimum Mean Square Error
METIS	Mobile and wireless communications Enablers for the Twenty-twenty Information Society.
MCM	Multicarrier Modulation
OFDM	Orthogonal Frequency Division Multiplexing
OFDMA	Orthogonal Frequency Division Multiple Access
PAPR	Peak to Average Power Ratio
PPN-FFT	poly-phase network-FFT
PRC	Perfect Reconstruct condition
PAM	pulse amplitude modulation
PTS	partial transmit sequence
PSO	Particle Swarm Optimization
PSO-ZF	Particle Swarm Optimization Zero Forcing
PSO-MMSE	Particle Swarm Optimization Minimum Mean Square Error
PAR	pitch adjustment rate
PS	Pulse Shaping
PSD	Power Spectral Density
PRTs	Peak Reduction Tones
QAM	Quadrature Amplitude Modulation
OQAM	Offset Quadrature Amplitude Modulation
QPSK	Quadrature Phase-Shift Keying
RF	Radio Frequency
SRRC	Square-Root-Raised-Cosine Filter
SLM	Selective Mapping
SISO	Single Input Single Output
SDR	Software Defined Radio
SNR	Signal-To-Noise Ratio
SMT	Staggered Modulated multi-Tone
SI	Side Information
SWTR	Sliding Window Tone Reservation
TR	Tone Reservation
TRACE	Tone Reservation active constellation extension
TI	Tone Injection
NI-USRP	National Instrument Universal Software Radio Peripheral
UWB	Ultra Wide Band
UFMC	Universal Filtered Multicarrier
VSB	vestigial side-band
VDSL	Very high-speed DSL
V2X	Vehicle-to-Everything
VNI	Visual Networking Index.
WiFi	Wireless Fidelity
ZF	Zero Forcing