NEW METHODS OF PARTIAL TRANSMIT SEQUENCE FOR REDUCING THE HIGH PEAK-TO-AVERAGE-POWER RATIO WITH LOW COMPLEXITY IN THE OFDM AND F-OFDM SYSTEMS

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To the memory of my father, my grandfather, my grandmother, who would have been glad to see me at this moment.
To my beloved mother for her constant, unconditional love during all my life.
To my wife and beloved children, Fatimah, Amer, Noor for their love and support.
To the great woman, who has loved me more than herself
To my brothers and my sisters for their support and encouragement
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To science,

enlightening us.

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ABSTRACT

The orthogonal frequency division multiplexing system (OFDM) is one of the most important components for the multicarrier waveform design in the wireless communication standards. Consequently, the OFDM system has been adopted by many high-speed wireless standards. However, the high peak-to-average- power ratio (PAPR) is the main obstacle of the OFDM system in the real applications because of the non-linearity nature in the transmitter. Partial transmit sequence (PTS) is one of the effective PAPR reduction techniques that has been employed for reducing the PAPR value 3 dB; however, the high computational complexity is the main drawback of this technique. This thesis proposes novel methods and algorithms for reducing the high PAPR value with low computational complexity depending on the PTS technique. First, three novel subblocks partitioning schemes, Sine Shape partitioning scheme (SS-PTS), Subsets partitioning scheme (Sb-PTS), and Hybrid partitioning scheme (H-PTS) have been introduced for improving the PAPR reduction performance with low computational complexity in the frequency-domain of the PTS structure. Secondly, two novel algorithms, Grouping Complex iterations algorithm (G-C-PTS), and Gray Code Phase Factor algorithm (Gray-PF-PTS) have been developed to reduce the computational complexity for finding the optimum phase rotation factors in the time domain part of the PTS structure. Third, a new hybrid method that combines the Selective mapping and Cyclically Shifts Sequences (SLM-CSS-PTS) techniques in parallel has been proposed for improving the PAPR reduction performance and the computational complexity level. Based on the proposed methods, an improved PTS method that merges the best subblock partitioning scheme in the frequency domain and the best low-complexity algorithm in the time domain has been introduced to enhance the PAPR reduction performance better than the conventional PTS method with extremely low computational complexity level. The efficiency of the proposed methods is verified by comparing the predicted results with the existing modified PTS methods in the literature using Matlab software simulation and numerical calculation. The results that obtained using the proposed methods achieve a superior gain in the PAPR reduction performance compared with the conventional PTS technique. In addition, the number of complex addition and multiplication operations has been reduced compared with the conventional PTS method by about 54%, and 32% for the frequency domain schemes, 51% and 65% for the time domain algorithms, 18% and 42% for the combining method. Moreover, the improved PTS method which combines the best scheme in the frequency domain and the best algorithm in the time domain outperforms the conventional PTS method in terms of the PAPR reduction performance and the computational complexity level, where the number of complex addition and multiplication operation has been reduced by about 51% and 63%, respectively. Finally, the proposed methods and algorithms have been applied to the OFDM and Filtered-OFDM (F-OFDM) systems through Matlab software simulation, where F-OFDM refers to the waveform design candidate in the next generation technology (5G).

ABSTRAK

Sistem multipleks pembahagian frekuensi ortogon (OFDM) adalah salah satu komponen penting untuk rekabentuk gelombang berbilang pembawa di dalam piawaian komunikasi wayarles. Akibatnya, sistem OFDM telah diterimapakai oleh kebanyakan piawaian wayarles berkelajuan tinggi. Walau bagaimanapun, nisbah kuasa-puncak-kepada-purata (PAPR) merupakan halangan utama sistem OFDM di dalam aplikasi sebenar kerana sifat bukan lelurus penghantar. Jujukan penghantaran sebahagian (PTS) ialah salah satu teknik pengurangan PAPR berkesan yang telah digunakan untuk mengurangkan nilai PAPR 3 dB; namun begitu, kerumitan pengiraan yang tinggi merupakan kelemahan utama teknik ini. Tesis ini mencadangkan kaedah novel dan algoritma untuk mengurangkan nilai PAPR yang tinggi dengan kerumitan pengiraan yang rendah bergantung kepada teknik PTS. Pertama, tiga novel skima pembahagian subblok, skima pembahagian Bentuk Sinus (SS-PTS), skima pembahagian Subset (Sb-PTS), dan skima pembahagian Hibrid (H-PTS) telah diperkenalkan untuk memperbaiki prestasi pengurangan PAPR dengan kerumitan pengiraan yang rendah dalam domain frekuensi pada struktur PTS. Kedua, dua novel algoritma, algoritma lelaran Kompleks Kumpulan (G-C-PTS), dan algoritma Faktor Fasa Kod Gray (Gray-PF-PTS) telah dibangunkan untuk mengurangkan kerumitan pengiraan bagi mencari faktor putaran fasa optimum dalam domain masa pada struktur PTS. Ketiga, satu kaedah hibrid baru yang menggabungkan teknik pemetaan Terpilih dan Jujukan Anjakan Berkitar (SLM-CSS-PTS) secara selari telah diperkenalkan untuk memperbaiki prestasi pengurangan PAPR dan aras kerumitan pengiraan. Berdasarkan kepada kaedah-kaedah yang dicadangkan, satu kaedah PTS terbaik yang menggabungkan skima pembahagian subblok terbaik dalam domain frekuensi dan algoritma kerumitan rendah terbaik dalam domain masa telah diperkenalkan bagi meningkatkan prestasi pengurangan PAPR berbanding kaedah PTS lazim dengan aras kerumitan pengiraan yang sangat rendah. Keberkesanan kaedah yang dicadangkan telah disahkan melalui perbandingan keputusan jangkaan dengan kaedah PTS terubahsuai sedia ada dalam kesusasteraan menggunakan simulasi perisian MATLAB dan pengiraan berangka. Keputusan yang diperolehi menggunakan kaedah yang dicadangkan mencapai kebaikan yang unggul dalam prestasi pengurangan PAPR berbanding dengan teknik PTS lazim. Tambahan lagi, bilangan penambahan kompleks dan operasi pendaraban telah dibandingkan dengan kaedah PTS lazim sebanyak 54%, dan 32% untuk skima domain frekuensi, 51% dan 65% untuk algoritma domain masa, 18% dan 42% untuk kaedah penggabungan. Selain itu, kaedah PTS terbaik yang menggabungkan skima terbaik dalam domain frekuensi dan algoritma terbaik dalam domain masa menewaskan kaedah PTS lazim dari segi prestasi pengurangan PAPR dan aras kerumitan pengiraan, di mana bilangan penambahan kompleks dan operasi pendaraban telah dikurangkan masing-masing sebanyak 51% dan 63%. Akhirnya, kaedah yang dicadangkan bersama algoritma telah digunakan pada OFDM dan sistem OFDM tertapis (F-OFDM) menerusi simulasi perisian MATLAB, di mana F-OFDM merujuk kepada calon rekabentuk gelombang bagi teknologi generasi seterusnya (5G).

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LIST OF SYMBOLS AND ABBREVIATIONS

$T_{pts_s}^{groups}$	-	Type of Partitioning Method
Δf	-	Frequency Space between Subcarriers
3G	-	Third Generation
3GPP	-	Third Generation Partnership Project
4G	-	Fourth Generation
5G	-	Fifth Generation
ADC	-	Analog to Digital Converters
Ad-PTS	-	Adjacent Partitioning Scheme
AWGN	-	Additive White Gaussian Noise
B	-	Bandwidth of The Symbol
BER	-	Bit Error Rate
b_v	-	Phase Factors Elements
C	-	Number of The Candidate Signals
C_{add}	-	Number of Complex Addition Operations
CC	-	Computational Complexity Level
CCDF	-	Complementary Cumulative Distribution Function
C_{comp}	-	Number of Comparison Operations
$CCRR^{+}$	-	Addition Operations Ratio
$CCRR^{\times}$	-	Multiplication Operations Ratio
CFO	-	Carrier Frequency Offset
C_{mult}	-	Number of Complex Multiplication Operations
CP	-	Cyclic Prefix
C-PTS	-	Conventional Partial Transmit Sequence
D/A	-	Digital to Analogue
DAB	-	Digital Audio Broadcasting
DAC	-	Digital to Analog Converters
dB	-	Decibel

DVB-H	-	Digital Video Broadcasting-Handheld
DVB-T	-	Digital Video Broadcasting-Terrestrial
E	-	Length of DFT Block
$f\,(n)$	-	Spectrum Shaping Filter
FBMC	-	Filter Bank Multi-Carrier
FFT	-	Fast Fourier Transform
FMT	-	Filtered Multi-Tone
F-OFDM	-	Filtered-Orthogonal Frequency Division Multiplexing
G-C-PTS	-	Grouping Complex Iteration PTS Algorithm
Gray-PTS	-	Gray Code PTS Algorithm
H	-	Shift Number Sets
$h_{LPF}(n)$	-	Sinc Impulse Response
HPA	-	High Power Amplifier
H-PTS	-	Hybrid Random and Terminals Exchange Algorithm
I	-	Number of Iterations
IDFT	-	Inverse Discrete Fourie Transform
IFFT	-	Inverse Fast Fourier Transform
IL-PTS	-	Interleaving Partitioning Scheme
IoT	-	Internet of Things
ISI	-	Inter-Symbol Interference
J	-	Concatenated Factor
k	-	Frequency Domain Index
K	-	Number of Interleavers
l	-	Number of The Intermediate Data Sequence Stages
L	-	Oversampling Factor
LFSR	-	Left Feedback Shift Register
LPF	-	Low Pass Filter
LTE	-	Long Term Evolution Standard
LTE-A	-	LTE-Advanced
LTE-A-Pro	-	LTE-Advanced-Pro
M	-	Constellation Order
M2M	-	Machine to Machine
MATLAB	-	Matrix Lab Software
M-PSK	-	Phase Shift Keying

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