



Ain Shams University
Faculty of Engineering
Electronics and Communications Engineering Department

Design and Implementation of Advanced Modulation Technique in 5G Communications System

**A thesis submitted in partial fulfillment of the requirement of the Degree
of Doctor of Philosophy in Electrical Engineering
(Electronics and Electrical Communications Engineering)**

By

Imad Ahmed Abdullah Shaheen
Master of Science in Electrical Engineering
**Communication Engineering - Mehran University of Engineering and
Technology - Pakistan**

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Cairo - Egypt
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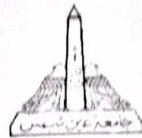
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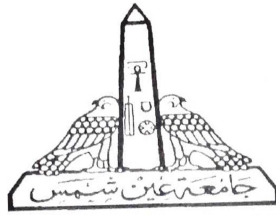
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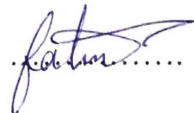
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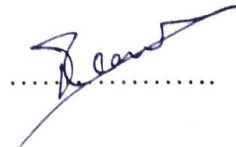
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STATEMENT

This dissertation is submitted to Ain Shams University for the degree of Doctor of Philosophy in in Electrical Engineering (Electronics and Communication Engineering) , Faculty of Engineering, Ain shams University

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

The author carried out the work included in this thesis, and no part of it has been submitted for a degree or a qualification at any other scientific entity.

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Signature :

Date :/...../2018

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

" رَبِّ أَوْزِعْنِي أَنْ أَشْكُرَ نِعْمَتَكَ الَّتِي أَنْعَمْتَ عَلَيَّ وَعَلَىٰ وَالِدَيَّ وَأَنْ أَعْمَلَ صَالِحًا تَرْضَاهُ وَأَصْلِحْ لِي فِي ذُرِّيَّتِي إِنِّي تُبْتُ إِلَيْكَ وَإِنِّي مِنَ الْمُسْلِمِينَ "

صدق الله العظيم

سورة الأحقاف، الآية: 15



To
My lovely Father

To the greatest man, I have in my life, for earning an honest living for us and for supporting and encouraging me to believe in myself.

My lovely Mother

To the biggest heart with the most loving care, who sacrificed a lot for me to become what I am now, my mother.

To my family lovely wife

The wonderful person who supported me through each step of the way and for being for me the greatest source of inspiration, my beloved Dr. Maha

My Daughters and son

To the light of my eyes my kids "Ahmed, Shada & Sama"

To all those who encouraged, supported, and helped me all the way I dedicate this research to all of them I would like to convey my deep appreciations to all those who contributed to the completion of this thesis.

To my wounded country "**Palestine**" which is suffered from Occupation

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Imad Ahmed Shaheen
Cairo - November 2018

ABSTRACT

The orthogonal frequency division multiplexing (OFDM) modulation is the most popular multicarrier modulation scheme nowadays to support fourth-generation wireless communication (4G). However, due to the rectangular pulse shaping and use of cyclic prefix (CP), The OFDM systems exhibit very high-frequency leakage and poor stopband attenuation. In the light of these limitations, Fifth Generation (5G) Mobile broadband radio access is the promising technology that will develop to satisfy the demand of continuous increasing data traffic. It also allows subscribers and machines to exchange big data traffic rates, Gigabit, with virtually small latency. Actually, the development of new wireless technology generation in the fifth generation usually has a new modulation scheme in the physical layer.

The infrastructure of the physical layer (PHY) which researcher proposed for 5G development will be flexible to use various modulation techniques providing sufficient handling waveform requirements. As multiple uses of advanced modulation techniques in 5G enhance the performance of the system. The filter bank multicarrier based on the Offset Quadrature Amplitude Modulation (FBMC/OQAM) modulation has recently received increasing attention. Rather than using a rectangular pulse, FBMC/OQAM uses a pulse shape which provides better frequency localization. This, in turn, translates into higher spectral efficiency and much more flexibility for spectrum allocation.

The main objective of this thesis is to investigate the applicability of the FBMC/OQAM modulation for next generations of communication systems. More specifically, we focus on four main directions. The first direction deals with the design and implement of advanced modulation technique system for the fifth generation (5G) wireless communications based on the FBMC (filter bank

multicarrier) with OQAM (Offset Quadrature Amplitude Modulation) with used Square Root Raised Cosine filter (SRRC) filter to design prototype filter. Then the second focus on the analysis of the capacity of the FBMC/OQAM transceiver, then the research is extended to the third focus which searches for providing a new solution of the most critical disadvantages of new modulation scheme which are peak to average power ratio (PAPR). Finally, Software-defined implementation of the proposed modulation technique will be relayed and the developed transceiver will be tested and verified to validate the fifth-generation requirements.

Published Papers

Journals

- [1] Imad A. Shaheen, Abdelhalim Zekry, Fatma Newagy, Reem Ibrahim, “Performance Evaluation of PAPR reduction in FBMC system using Nonlinear Companding Transform”, *Elsevier ICT Express*, 2018, <https://doi.org/10.1016/j.ict.2018.01.017> (Scopus Index, Source Normalized Impact per Paper (SNIP): 1.417)

- [2] Imad A. Shaheen, Abdelhalim Zekry, Fatma Newagy, Reem Ibrahim, “PAPR reduction for FBMC/OQAM using hybrid scheme of different Precoding transform and mu-law companding”. *International Journal of Engineering & Technology*, Vol. 6, No. 4, pp. 154-162, Nov. 2017. ISSN 2227-524X, <https://doi: 10.14419/ijet.v6i4.8326> (Scopus Index, Source Normalized Impact per Paper (SNIP): 0.08 , SJR :0.102)

- [3] Imad A Shaheen, Abdelhalim Zekry, Fatma Newagy and Reem Ibrahim. “Proposed New Schemes to Reduce PAPR for STBC MIMO FBMC” systems. *Communications on Applied Electronics*, Vol. 6, No. 9, pp. 27-33, April 2017, <https://doi: 10.5120/cae2017652556>

- [4] Imad A. Shaheen, Abdelhalim Zekry, Fatma Newagy, Reem Ibrahim, “Combined DHT Precoding and A-Law Companding for PAPR Reduction in FBMC/OQAM signals” , *International Journal of Computing Academic Research (IJCAR)* ISSN 2305-9184, Volume 6, Number 2 (April 2017), pp.31-39 , MEACSE Publications - Global Impact Factor (GIF) : 0.45

- [5] Imad A. Shaheen, Abdelhalim Zekry, Fatma Newagy, Reem Ibrahim, “PAPR Reduction using Combination of SAS Preprocessed and WHT Precoding for MIMO system of FBMC/OQAM Transceiver”, *International Journal of Engineering & Technology*, (Scopus Index, Source Normalized Impact per Paper (SNIP): 0.08)

IEEE Conferences

- [1] Imad A. Shaheen, Abdelhalim Zekry, Fatma Newagy, Reem Ibrahim, "Absolute Exponential Companding to Reduced PAPR for FBMC/OQAM," *2017 IEEE Palestinian International Conference on Information and Communication Technology (PICICT)*, Gaza City, 2017, pp. 60-65, [https:// doi: 10.1109/PICICT.2017.17](https://doi.org/10.1109/PICICT.2017.17). (Scopus Index)
- [2] Imad A. Shaheen, Abdelhalim Zekry, Fatma Newagy, Reem Ibrahim, "Modified Square Rooting Companding Technique to Reduced PAPR for FBMC/OQAM," *2017 IEEE Palestinian International Conference on Information and Communication Technology (PICICT)*, Gaza City, 2017, pp. 66-70, [https:// doi: 10.1109/PICICT.2017.18](https://doi.org/10.1109/PICICT.2017.18). (Scopus Index)
- [3] Imad A. Shaheen, Abdelhalim Zekry, Fatma Newagy, Reem Ibrahim, "PAPR Reduction of FBMC/OQAM Systems Based on Combination of DST Precoding and A-law Nonlinear Companding Technique," *2017 IEEE International Conference on Promising Electronic Technologies (ICPET)*, Deir El-Balah, 2017, pp. 38-42, [https:// doi: 10.1109/ICPET.2017.13](https://doi.org/10.1109/ICPET.2017.13) (Scopus Index)
- [4] Imad A. Shaheen, Abdelhalim Zekry, Fatma Newagy, Reem Ibrahim, "Modified Alternating Signal (AS) scheme for Reducing PAPR of FBMC/OQAM Signal", The 13th IEEE International Conference on Computer Engineering and Systems (ICCES 2018), Ain Shams University, Egypt (*Scopus Index*)

Under Publication

- [1] I. A. Shaheen, A. Zekry, F. Newagy and R. Ibrahim, "Efficient PAPR Reduction for FBMC/OQAM Transceiver using Nonlinear Companding Transforms based on Isosceles Trapezoidal Distribution Transforms" , *IET Communications*, <http://digital-library.theiet.org/content/journals/iet-com> , (*Scopus Index*, impact factor = 1.443, Source Normalized Impact per Paper (SNIP): 0.759)