AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING
Electronics and Electrical Communications Engineering

Innovative Technologies for Fifth Generation Mobile Networks

A Thesis submitted in partial fulfillment of the requirements of
Master of Science in Electrical Engineering
(Electronics and Electrical Communications Engineering)

By

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Bachelor of Science in Electrical Engineering
(Communication Systems Engineering)
Faculty of Engineering, Ain Shams University, 2012

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Statement

This thesis is submitted as a partial fulfillment of Master of Science in Electrical Engineering, Faculty of Engineering, Ain shams University.

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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Thesis Summary

The telecommunications field is continuously and rapidly changing, especially while approaching its "Fifth Generation 5G" which is expected to introduce the concepts of Internet of Things (IoT), Sensor Networks and Machine to Machine (M2M) communication. In this thesis, the starting point will be investigating the effects of introducing such new concepts on the system requirements of today's telecommunication systems and how they should be changed in order to cope up with the expected new framework and will end-up with introducing new methodologies that are more capable of working efficiently in such framework.

At the beginning, a clear illustration of "Orthogonal Frequency Division Multiplexing" (OFDM) systems operation is provided where; the major drawbacks of these OFDM-based systems are highlighted concentrating on their high sensitivity to Timing-Offset (TO) and Carrier Frequency-Offset (CFO). OFDM systems apply highly exhaustive synchronization procedures in order to achieve the required level of synchronization.

Majority of the work done in this thesis is concerned with the Universal Filtered Multi-Carrier (UFMC) technique that is introduced as an OFDM replacement candidate in order to overcome its highlighted drawbacks. Similar to OFDM, we started with a clear illustration of the UFMC system operation and then referred to how UFMC is expected to overcome the shortcomings of OFDM-based systems.

The next part of the thesis included an assessment of UFMC systems performance while working in a wireless multi-path fading environment. Signal to Distortion Plus Noise Power Ratio (SDNR) is used as a performance metric to optimize the filter's configuration parameters. Finally BER performance curves are provided for different channel models to prove that UFMC could achieve nearly identical performance levels to those of OFDM.

After finishing the UFMC fading channels problem analysis, an overview of the previous UFMC filter optimization criteria discussed in the literature is provided. These optimization techniques are based on maximizing the Signal to Out-of-Band Leakage Ratio (SLR) and Signal to In-Band Distortion Plus Out-of-Band Leakage Ratio (SDLR). In literature, SLR-based technique is found to achieve the highest levels of performance while always outperforming the SDLR-based one and therefore, it will be chosen as a reference for our proposed techniques

performance assessment. At the end of this part, an enhancement for the SLR method is proposed to boost its performance level and BER curves are provided to prove this enhancement.

In the last part of this thesis, we propose the new state-of-the-art "Secondary Pass-Band Insertion" (SPBI) UFMC filter design method. The SPBI idea is simply based on using a wider secondary pass-band besides of the actual narrow pass-band. This secondary pass-band is responsible of shaping the Impulse Response (IR) and to keep it as confined as possible in order to increase the signal robustness against TO without losing its resistance to CFO effects which is originally the narrow pass-band responsibility. Based on TO and CFO distributions, an optimization criterion is carried out to get the optimal values for the filter's configuration parameters. Finally BER performance curves are provided for the SPBI technique in comparison with the SLR-based method and basic OFDM in order to validate the idea of the SPBI method and prove its novelty and gain over both OFDM and SLR-based UFMC.

Key words: OFDM, UFMC, Timing Offset, Carrier Frequency Offset, Multipath fading Channels, Filter Optimization, SLR-based Method, SPBI Method

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Contents