POST-DOCTORAL POSITION
Duration: 12 months,
Beginning 1st of October 2018

TITLE:
Optimization of novel tone-reservation PAPR reduction algorithms for post-OFDM multicarrier signals in the context of future generation of broadcast and communication networks

CONTEXT:
The energy consumption of the broadcast and wireless communication networks is huge (in the order of several Megawatts for countries like France or Spain). Between 50 and 80 % of this consumption (depending on the type of service) is directly due to the amplification of the signals, because all modern transmission systems (including 4G cellular, digital terrestrial TV) are using multicarrier waveforms, which are characterized by a high Peak to Average Power Ratio (PAPR) leading to a low efficiency of the amplification systems. PAPR reduction techniques can be implemented in order to reduce this dynamic range and thus be able to use the non-linear amplifier at an operating point leading to better energy efficiency. However, non-linear amplification results in in-band distortions measured by the Error Vector Magnitude (EVM) and out-of-band distortions measured by Adjacent Channel Power Ratio (ACPR). Reducing the PAPR of the multicarrier signals in order to improve the efficiency of the power amplifiers while constraining the in-band and out-of-band distortions is then an important research topic with a vast potential for energy savings. With the numerous recent proposals for post-OFDM waveforms such as Filter Bank Multi-Carrier-Offset QAM (FBMC-OQAM), Filtered Multi Tone (FMT), Generalized Frequency Division Multiplexing (GFDM) or Unified Filtered Multi Carrier (UFMC) [1], which all suffer strong time-domain signal fluctuations as conventional OFDM, the search and proposal of novel PAPR reduction techniques remains a hot topic today.

This research work will be performed within the framework of the FUI “Convergence TV” project, which aims, among other things, at developing innovative solutions for reducing the energy consumption of television transmitters.

DESCRIPTION:
The overall objective of this research work is to propose efficient and implementable PAPR reduction techniques for post-OFDM waveforms. The PAPR reduction strategy that is envisaged in this work is the tone reservation (TR) approach as originally introduced by Tellado in [2]. TR-based PAPR are today compatible with two widely deployed broadcast systems, namely DVB-T2 and ATSC 3.0. In addition, efficient TR-based PAPR reduction algorithms have already been proposed by the research team in previous studies [3]. Based on a new kernel definition, these novel algorithms have been shown to outperform many algorithms of the literature and perform very close to the optimal solution given by the QCQP algorithm (Quadratic Constraint Quadratic Problem) while guaranteeing low latency and very reasonable computational complexity [4, 5]. Last but not least, our proposed TR-based solutions, optimized for DVB-T2 as well as ATSC 3.0 have been experimented on a real test-bed and shown to offer around 10% of energy consumption gain, which represents a substantial gain at the scale of a whole network.

Hence, our aim is to investigate in which extent and how these proposed algorithms could be adapted to post-OFDM waveforms, in order to anticipate the evolution of multicarrier systems in future generations of broadcast and cellular networks.

The proposed work will be organized according to the following steps:

- The first objective of the study will be to build a comprehensive state of the art on PAPR reduction techniques for post-OFDM waveforms. PAPR reduction for OFDM has attracted a lot of attention during the last 20 years, whereas much fewer algorithms have been proposed for post-OFDM waveforms. Also, the diversity of the post-OFDM waveforms makes it difficult to propose a generic and unique algorithm well suited for all kind of these waveforms. Hence, this first step in the study will aim at synthesizing the main trends and strategies in terms of PAPR reduction and analyzing their performance, complexity and compatibility with the existing post-OFDM waveforms.

- The second step will be to pay a particular attention on TR-like PAPR reduction approaches. To the best of our knowledge, a direct and simple application of TR principles is not possible when changing OFDM into other waveforms such as FBMC-OQAM or UF-OFDM. Indeed, in most of the post-OFDM waveforms, an additional filtering operation is carried out compared to conventional OFDM, which creates inter-symbol interference at the transmit side and makes the PAPR reduction operation be processed at the level of several consecutive symbols. Some proposals have been recently introduced as those in [6] – [9], which are mainly based on overlapping and sliding window mechanisms or using complex iterative approaches. A thorough analysis of the most promising schemes in terms of performance and complexity will be done so as to understand how to efficiently modify and adapt the algorithms developed by the research team. In particular, a valuable contribution would be to propose a novel PAPR reduction algorithm using the new kernel definition discussed in [3] and [4] but well suited for FBMC-OQAM or UF-OFDM.

- From this adaptation phase to post-OFDM waveforms, the last step of the study will consist in the optimization of the algorithm proposed during phase 2. Some key parameters will have to be set through simulations and/or analytical derivations. All these analyses will be very useful for optimizing future transmitter efficiency and linearity of the power amplifier in the field of future broadcast or cellular networks.

Advanced and novel efficient solutions will be studied in order to publish in high scientific level journals and communicate in the best international conferences. This work will benefit from the strong experience of IETR concerning multicarrier modulation, PAPR reduction techniques, wireless technologies and associated signal processing in general. During the last 5 years, IETR has been working on those techniques for different applications as future cellular networks and Digital Video Broadcasting in European and National research projects.

KEY WORDS: Post-OFDM multicarrier modulation, PAPR reduction techniques, Signal processing,

CONTACTS: Jean-François Hélard, Matthieu Crussière
INSIA/IETR, 20 Avenue des Buttes de Coësmes, 35043, Rennes Cedex
Email: jean-francois.helard@insa-rennes.fr matthieu.crussiere@insa-rennes.fr Tel : 02 23 23 86 84 02 23 23 85 81


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