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RWS-210025

3GPP TSG RAN Rel-18 workshop
Electronic Meeting, June 28 - July 2, 2021
Agenda Item: 4.3

5G Green Networks

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5G

Introduction

- In recent years there has been a growing concern over the power consumed by cellular networks due to environmental factors such as carbon emissions. In addition, the power consumption of cellular networks constitute significant part of operators OPEX [1,2]. As a result, network energy efficiency becomes increasingly important.
- There already have been effort in 3GPP related network energy saving (e.g., TR 32.826, TR 36.887, TR 36.927, TR 37.816, TR 21.866).
- 5G networks' power consumption will be influenced by larger bandwidth and increasing number of antennas and of bands.
- Studying RAN-focused measures to optimize NR power consumption and efficiency seems opportune

1. Jo, Minho. (2011). Energy Consumption of Cellular Networks in Figures The Problem of Past Research. IEEE network. 00. 40-49
2. P. Frenger and R. Tano, "More Capacity and Less Power: How 5G NR Can Reduce Network Energy Consumption," 2019 IEEE 89th Vehicular Technology Conference (VTC2019-Spring), Kuala Lumpur, Malaysia, 2019, pp. 1-5

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Where to focus the attention from a RAN perspective?

- Power consumption of base stations and, specifically, power amplifiers (PA), constitute significant part of the overall network consumption [3].
- At the same time, 5G uses signals with high peak-to-average power ratios (PAPRs), leading to large back-off required at the PA inputs and relatively poor power efficiency.
- As mentioned earlier, the power consumption of the PA components is expected to increase as the network moves towards higher carrier frequencies (both because of more antenna elements and proportionally poorer PA efficiency at those higher frequencies)
- As a result, we propose to study network power efficiency & saving measures in 5G, with a focus on **power-efficient TX/RX processing, including non-linearity compensation elements**.

3. Massoud Pedram, Luhao Wang, "Energy Efficiency in 5G Cellular Network Systems", Design & Test IEEE, vol. 37, no. 1, pp. 64-78, 2020.

Proposal 1/2

- It is proposed to initiate a new study item to explore solutions for improving end to end power efficiency at both network nodes and UE sides.

- This needs to be achieved while keeping the right balance between energy efficiency and spectral efficiency.

- Using both “Joule per bit” and "bits per second per Hz" criteria

- An example of possible techniques is in the Annex

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Proposal 2/2

- Example objectives:
  - Creation of a common model for evaluating power efficiency improvements
    - Enable comparison of power saving proposals on a common basis
    - This will include creation a Power Amplifier model for various frequency bands, EIRP targets for both UE and gNB that will serve as a baseline for algorithm evaluation.
  - Optimize Tx ON mode: L1 processing for improving PA power efficiency - focus of the proposed SI
    - Solutions on the Tx and/or Rx sides to compensate for possible PA non-linearities and increased in-band and/or out-of-band distortions
    - PAPR reduction solutions to facilitate higher efficiency transmission.
    - Fixed or dynamic out-of-band emissions control methods, eg allowing usage of the reduced back-off transmission and signal shaping while controlling out-of-band emissions.
  - Optimize Tx ON/OFF switching: dynamic network configuration
    - Coordinated energy saving mode configuration across network node(s) and UE
      - Proper network densification through deployment of different types of network nodes
      - Adaptive TX/RX configuration and related coordination mechanisms
    - Efficient configuration of periodic/broadcast signals (SSB/SI/paging) e.g., longer periodicities, adjusted power level, beamforming and resource configuration
    - Enhanced scheduling, power, BWP operation, spatial and mobility management in energy saving modes

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Annex: Example - Digital Post Distortion

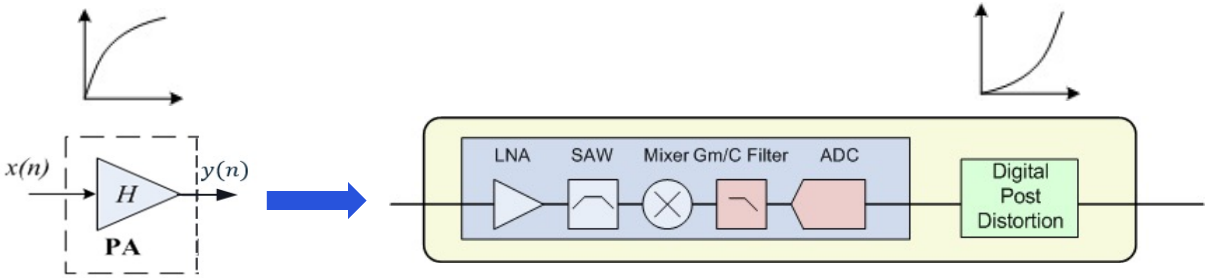
Compensate for PA non-linearity on Rx side

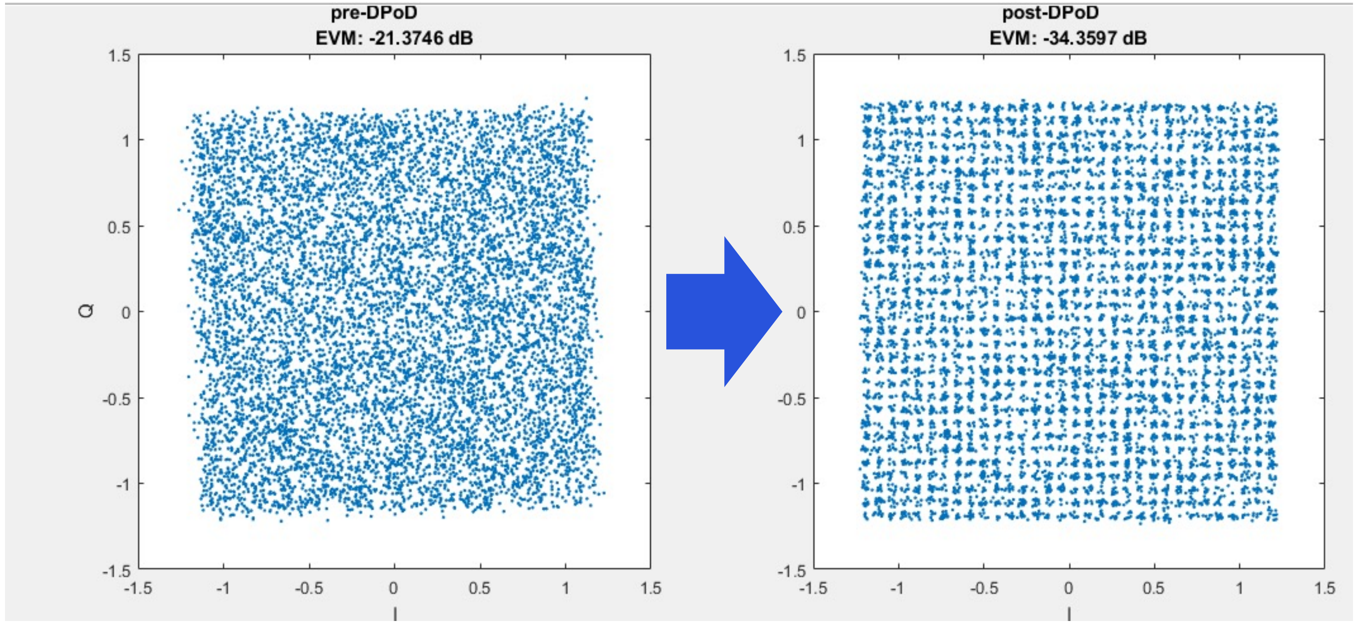
- Allowing Transmitter to work at its nonlinear regime provides better SNR - improves rate-over-range and power efficiency

- Signal Processing for Nonlinear compensation is required at the receiver

- Highly Applicable to FR2
  - Typical large allocations
  - Relaxed emission mask
  - The EVM improvement is leading to significant possible Tx power increase
  - In lab measurements, ~6dB gain in Tx output power for 256QAM

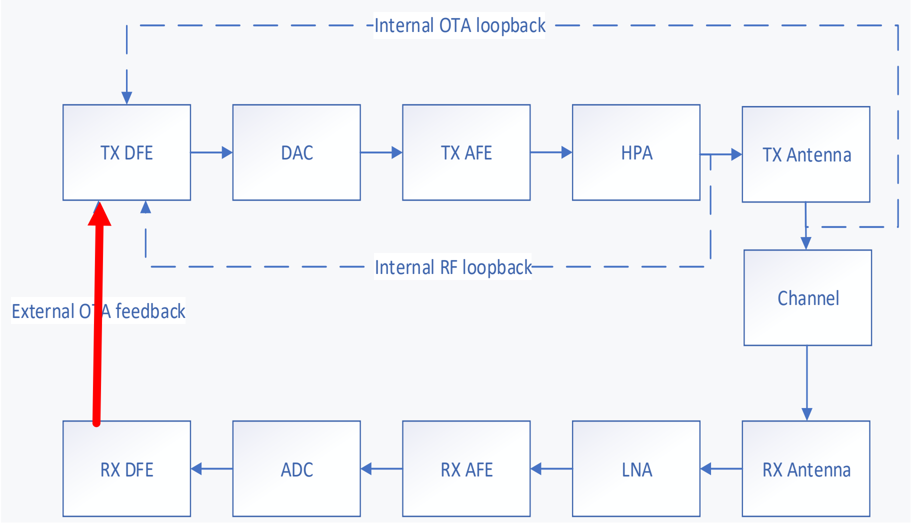
Conceptual flow - Non-linear Equalizer on receive side



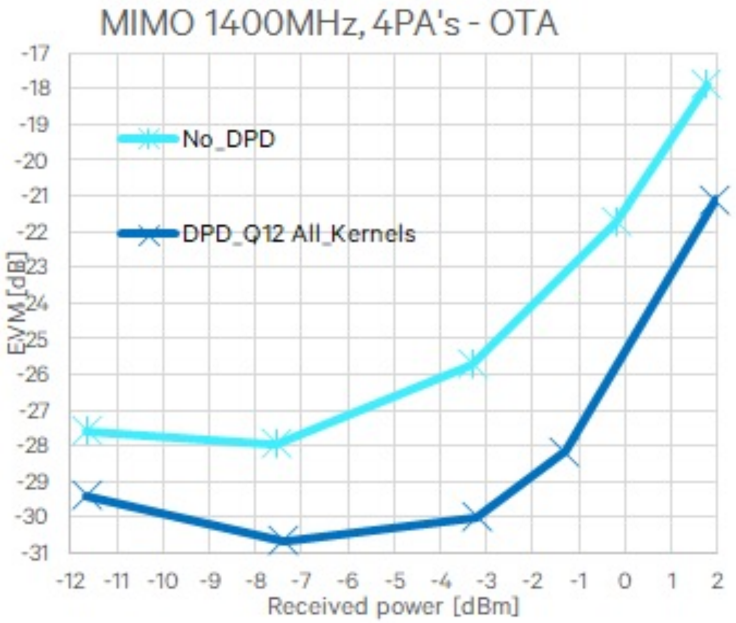


Annex: Example – Over The Air Digital Pre-Distortions (OTA-DPD)

- FR2 and beyond DPD presents unique challenges making DPD training at Tx side hard:
  - Wide bandwidth
  - Limited oversampling
  - Complex composite PA model – which is best learnt at Rx side
    - Analog beamforming – linearize multiple PAs with single DPD.
    - Mutual coupling between PAs in same layer and across layers



- These challenges might be tackled by adding over-the-air training capabilities
  - UE side can help gNB side to train its DPD by calculating some intermediate functions specified by the gNB



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