RF TRx Signal Processing for 6G Radios

N. Tervo, B. Khan, K. Bulusu, D. Delfini , D. Rashid, K. Momor, M. Y. Javed, A. Regmi and A. Pärssinen

Centre for Wireless Communications – Radio Technologies (CWC-RT), University of Oulu

P.O. Box 4500, 90014 Oulu, Finland

RF SAMPO

- nuutti.tervo@oulu.fi

- RF signal processing

Modern transceivers in 5G and future 6G use large antenna arrays and beamforming. High center frequencies, very wide signal bandwidths, and tightly integrated transceiver systems require new ways to think and understand RF nonidealities such as PA nonlinearity and LO phase noise.

Some research questions to look:

- What are the dominant RF impairments in 6G systems?
- How to model & understand the impact of RF impairments for the radiated signal?
- How to linearize an array of Tx paths under varying conditions?
- How to perform wideband hybrid beamforming to support envisioned 6G bandwidths?

Phase Noise Concepts for Very Wideband 6G Systems

- LO Noise floor may limit the performance at very wide signal bandwidths in high frequencies

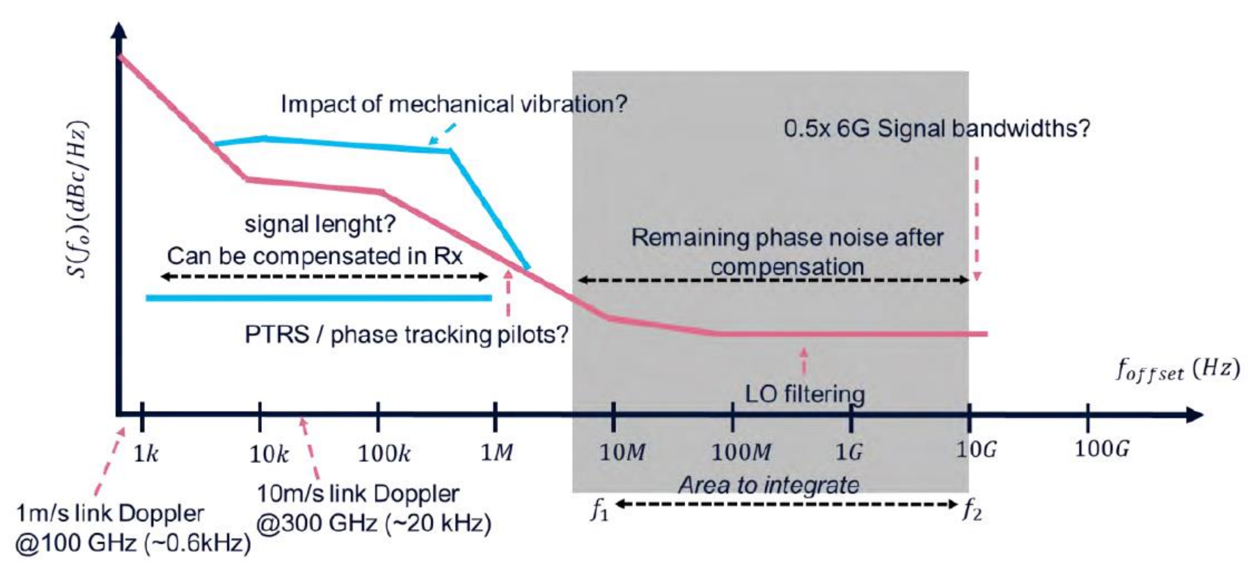

Fig. 1. Illustration of phase noise spectrum from the communication system perspective.

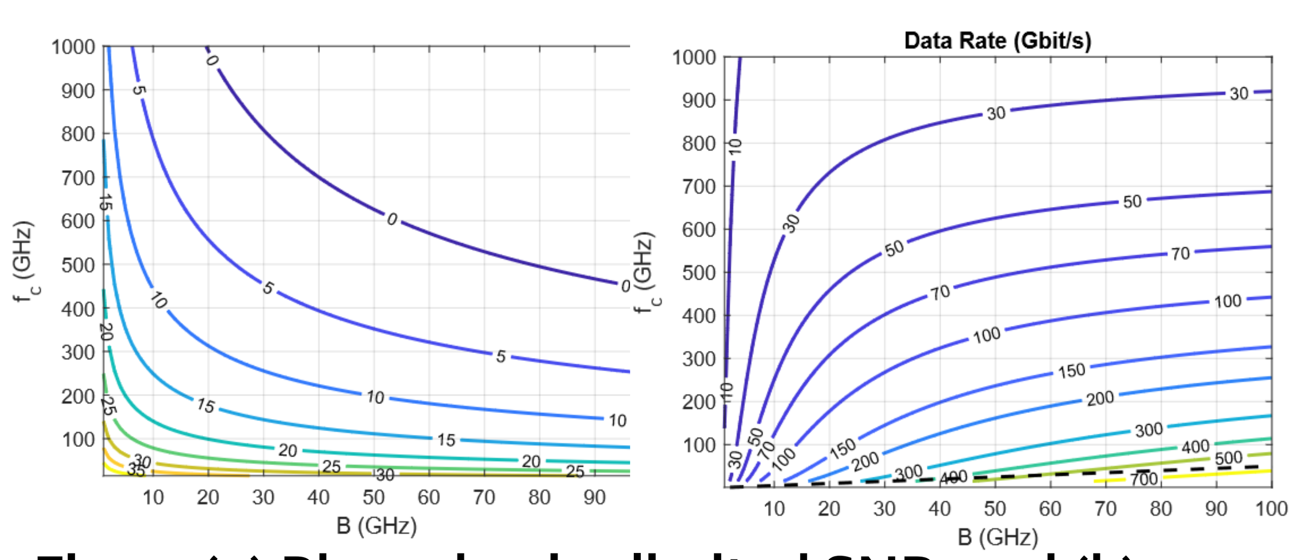

Fig. 2. (a) Phased noise limited SNR and (b) corresponding rata rate with -140 dB LO noise floor.

Advanced Transmitter Array Linearization

- Various linearization concepts under study related to different array architectures
- Phased array: single digital input, multiple PAs to linearize (multiple outputs)
- Digital predistortion (DPD) requires measuring, emulate & model, the array of radiated distortion
- Can be linearized by a single DPD if the linearization objective is selected to be the radiated signal

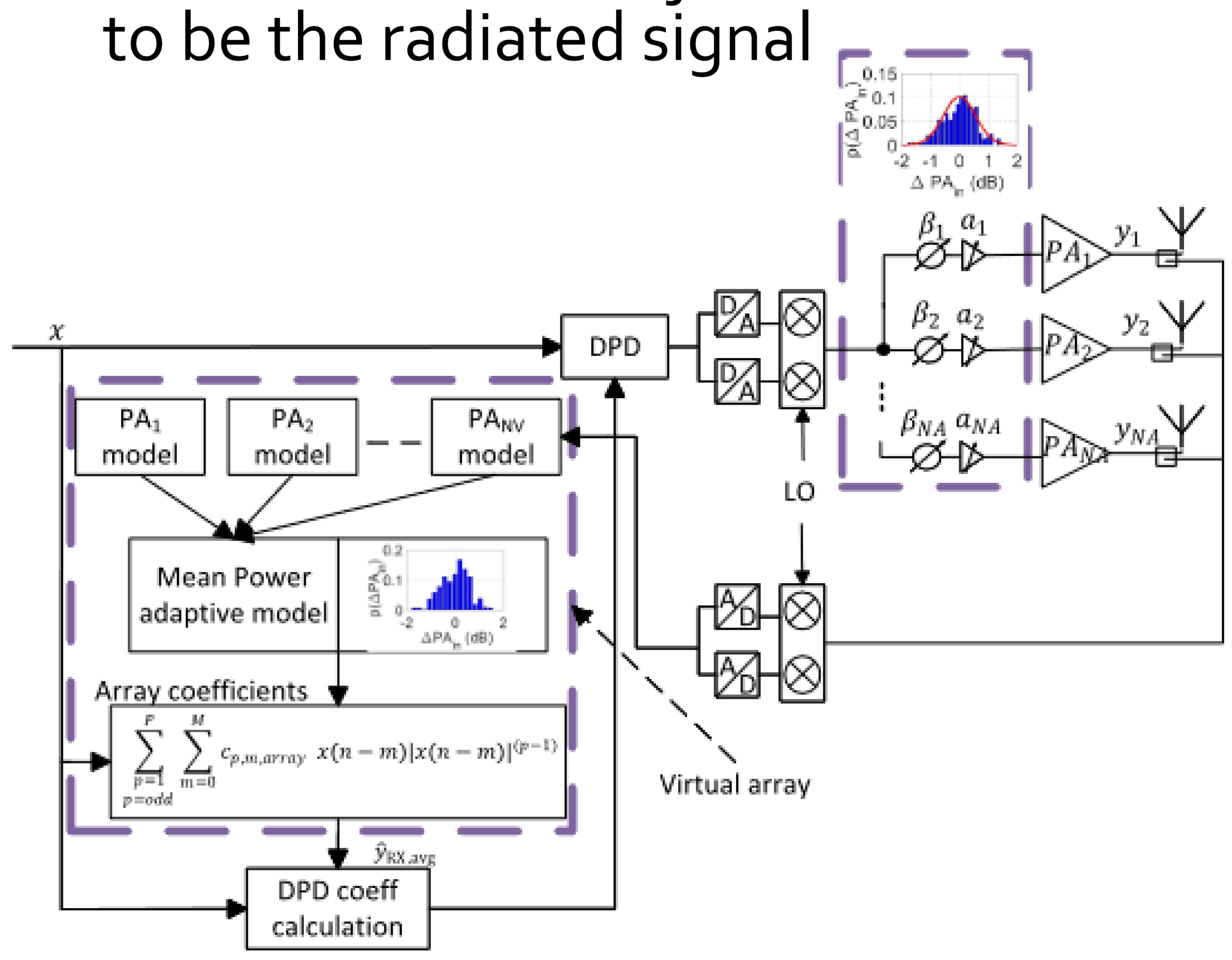

Fig 3. Statistical DPD concept for Phased Array

- Array nonlinear distortions have spatial behavior due to RF-impairment differences between PA-antenna branches.
- Approach: statistics of the beamforming variations employed in DPD training to relax the DPD re-calibration rate.

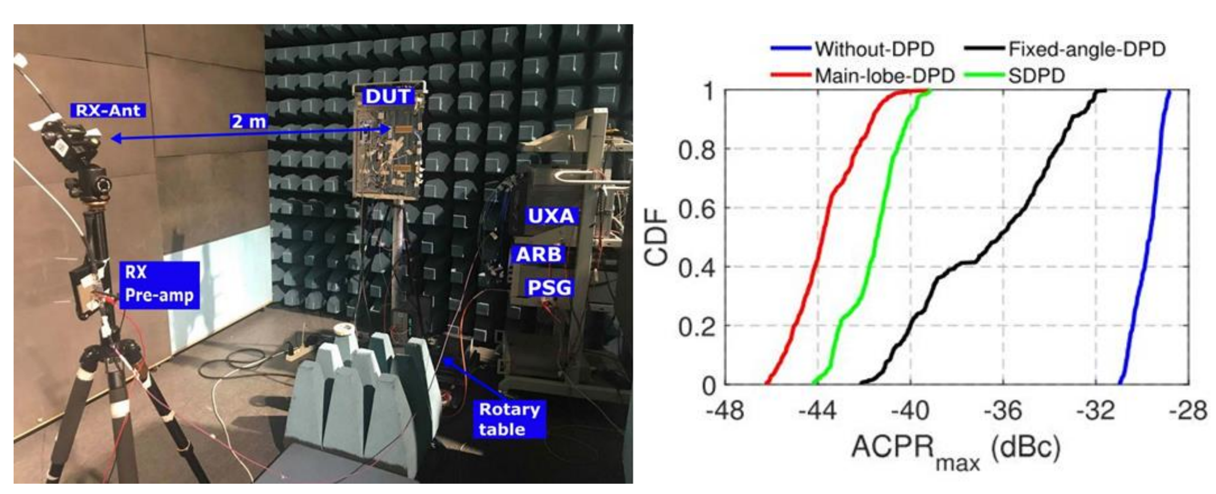

Fig. 4. (a) OTA measurement setup (b) CDF of measured DPD performance.

AI-aided Digital Predistortion

- ML-based classifier for piecewise DPD
- Features are extracted from the input data's statistics and the selected PA operating point.

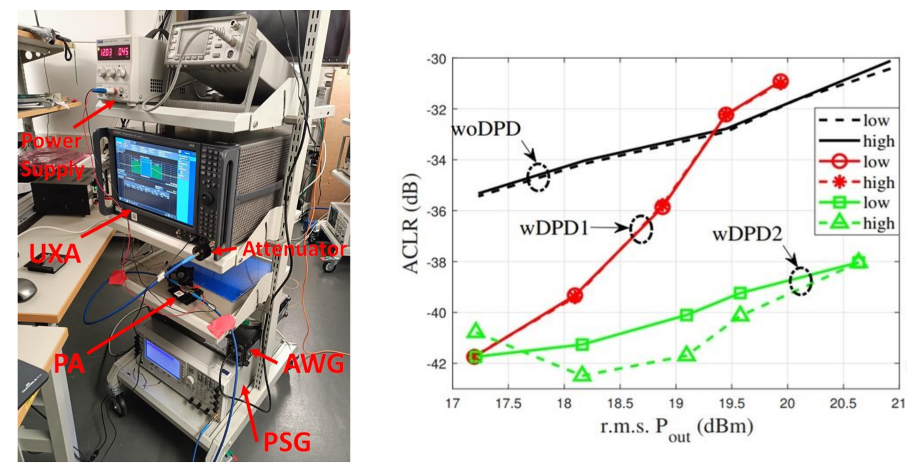

Fig 5. (a) PA measurement setup (b) PA linearization performance.

Beamforming is Filtering!

- Spatial response: behavior of the array factor with respect to the AoA at the nominal frequency
- Frequency response: behavior of the array factor with respect to frequency in the steering direction

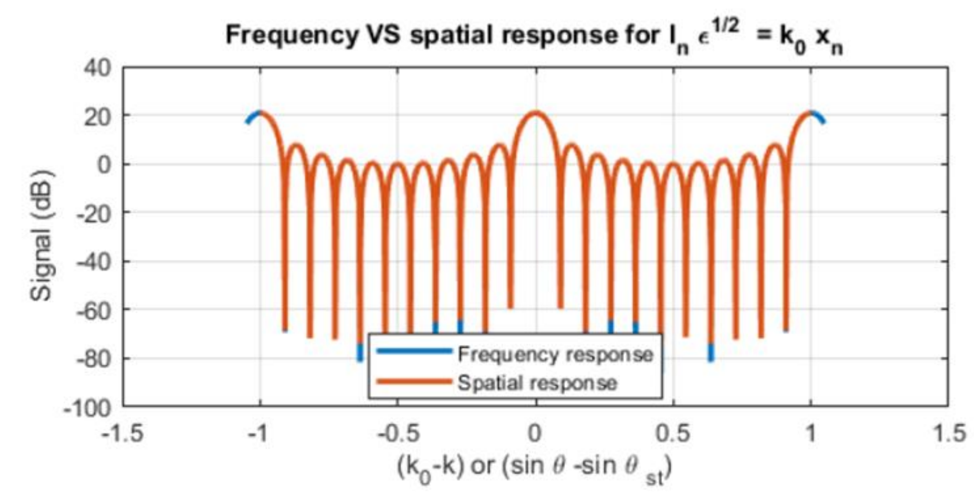

Fig 6. Beam vs frequency response.

Merging Computer Vision and Radio Channel for JCAS

- Computer vision (CV) assisted radio channel measurement enables the automatic generation of object radio footprints

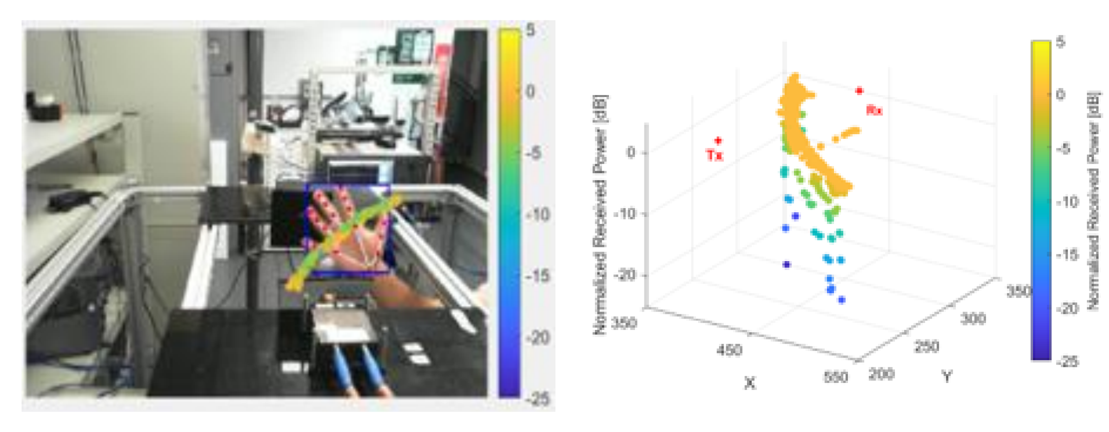

Fig. 7. (a) CV enabled radio channel characterization (b) CV extracted object coordinates mapped to radio channel properties.

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