Tx linearization, beam synthesis and modeling

RF SAMPO

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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 in beamforming systems.

Some research questions to look:

- How to model the RF transceiver with various impairments and beamforming for different system level problems?
- 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?

Modeling system performance

- Different RF impairments dominate the link performance in different power levels
- The net impact depends on many things: power, bandwidth, DSP, calibration, interference, link conditions,…

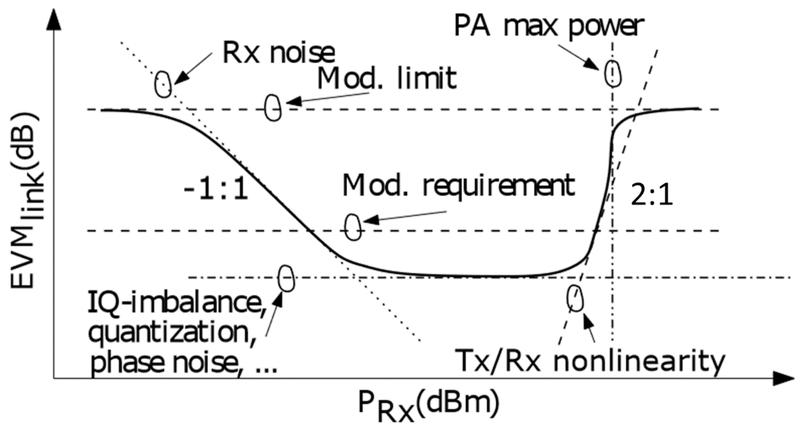

Fig 1. Link EVM behavior and with dominant RF impairments

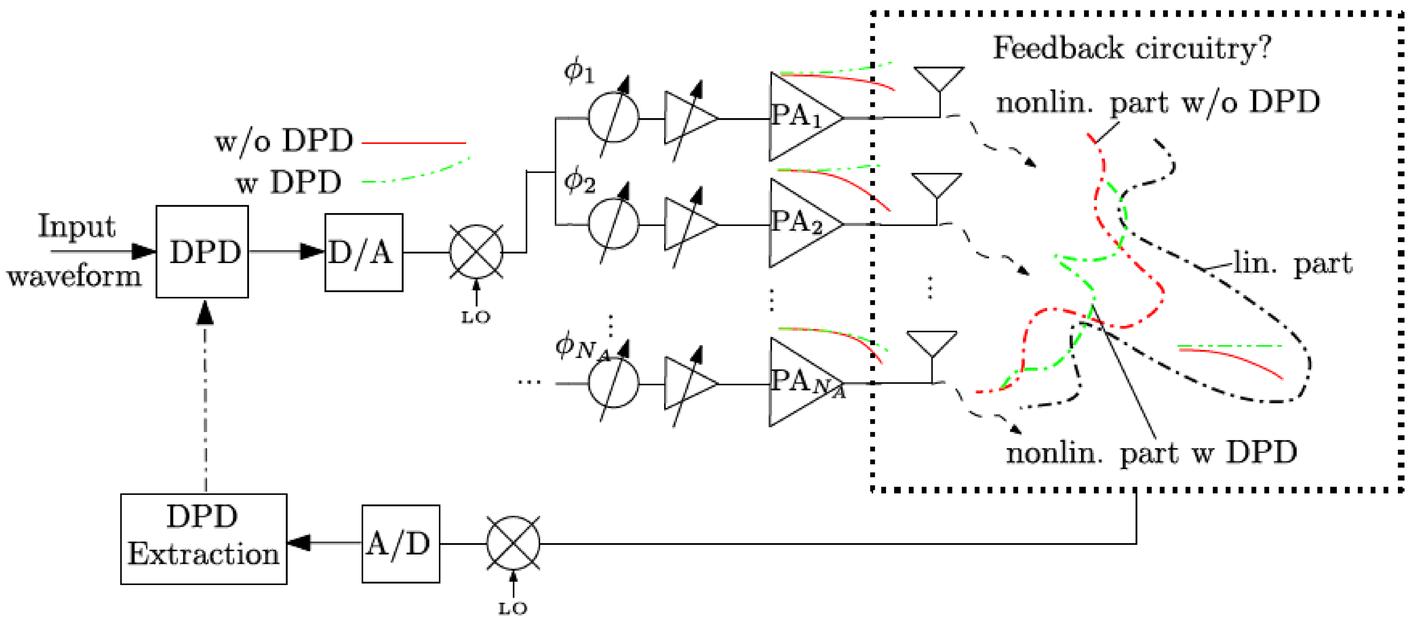

Fig 2. Block diagram of a phased array transmitter with DPD.

Phased array DPD

- Single digital input, multiple PAs to linearize (multiple outputs)
- Digital predistortion (DPD) requires to measure, emulate & model, the array radiated distortion
- Can be linearized by single DPD if linearization objective is selected to be the radiated signal

Spatial effects of RF Impairments

- If the RF-impairment has difference between the antennas, it may have spatial effects. This means that it can have *different beam shape than the original signal*.
- Examples: PA nonlinearity, noise & phase noise.

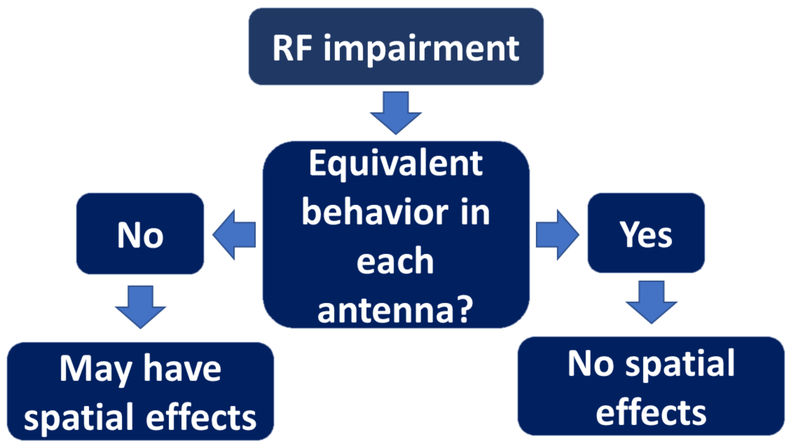

Fig. 3. A flow for determining weather RF impairment have spatial effects.

PA-antenna interaction

- Active load-pull due to the finite antenna coupling
- Make differences over the PAs, challenges the DPD processing

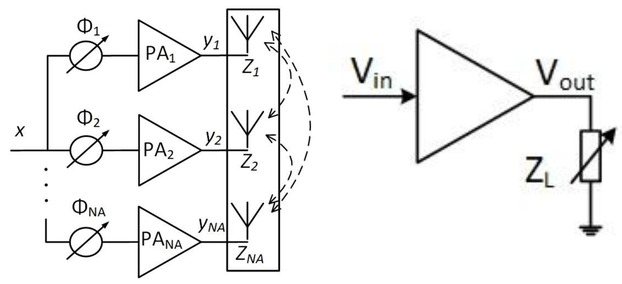

Fig.4. Antenna coupling makes PAs to pull each others output impedance.

Wideband Spatial Effects in RF beamforming

- Beam squint & very wide signal bandwidth
- Also beam nulling / zero-forcing suffers from beam (null) squint

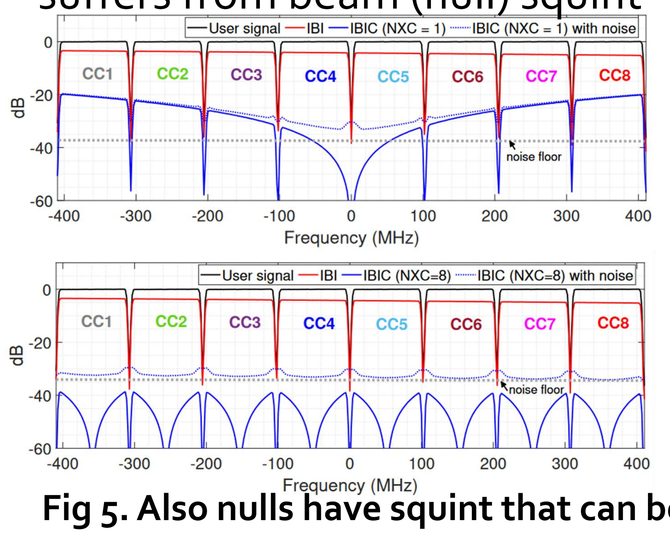

Fig 5. Also nulls have squint that can be corrected by CC-based processing.