Enabling Low Power, Multi-Radio Coexistence

Erwin Janssen

Technische Universiteit
Eindhoven
University of Technology

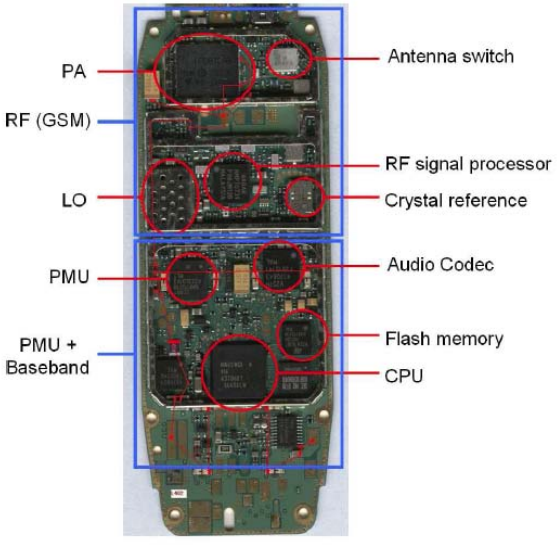
Where innovation starts

Outline

- **Background of this research**
  - **Trend in handheld devices**
  - **Problem statement**
  - **Survey of the project**
- **First solution: Use digital signal processing**
  - **Trade RF circuit performance for DSP**
- **Second solution: Reduce interference**
  - **Antenna coupling reduction technique**

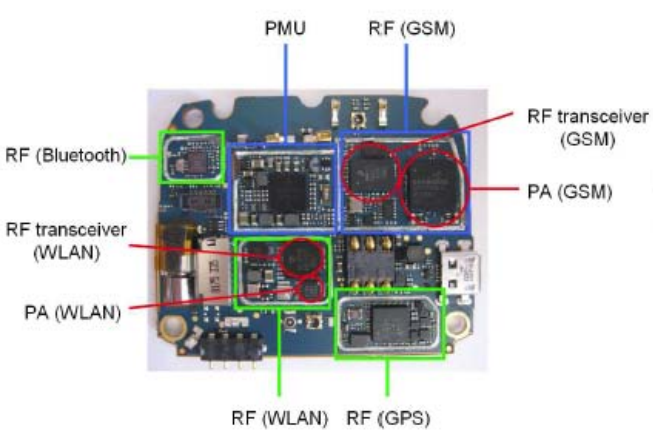
Trend in handheld devices: *Past*

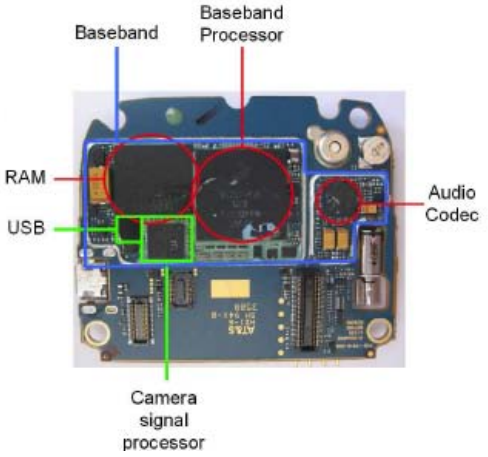
- **GSM**



Trend in handheld devices: *Present*

- **GSM**
- ***WLAN***
- ***Bluetooth***
- ***GPS***
- ***UMTS***
- ***FM Rx/Tx***



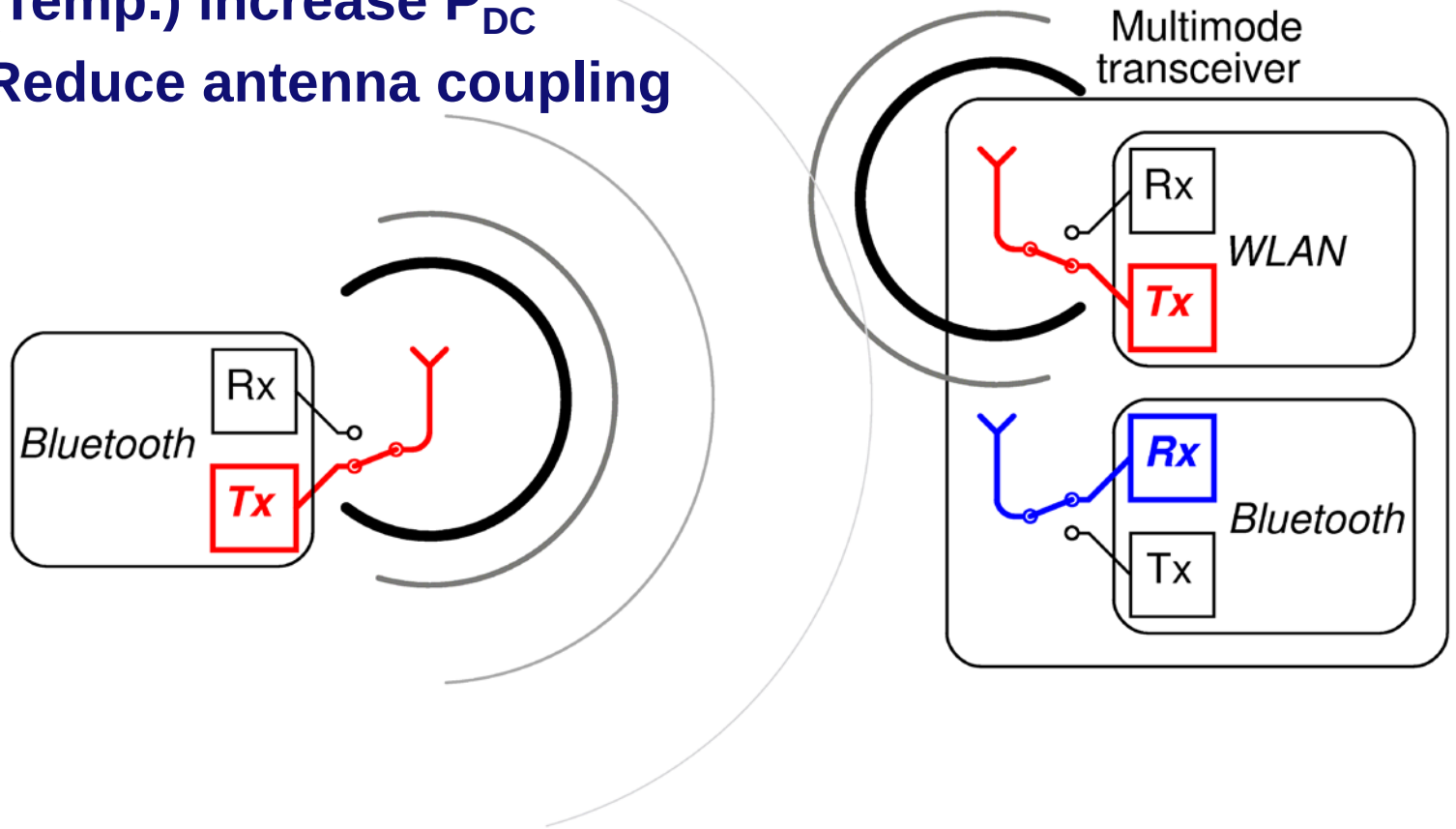


Trend in handheld devices: *Future*

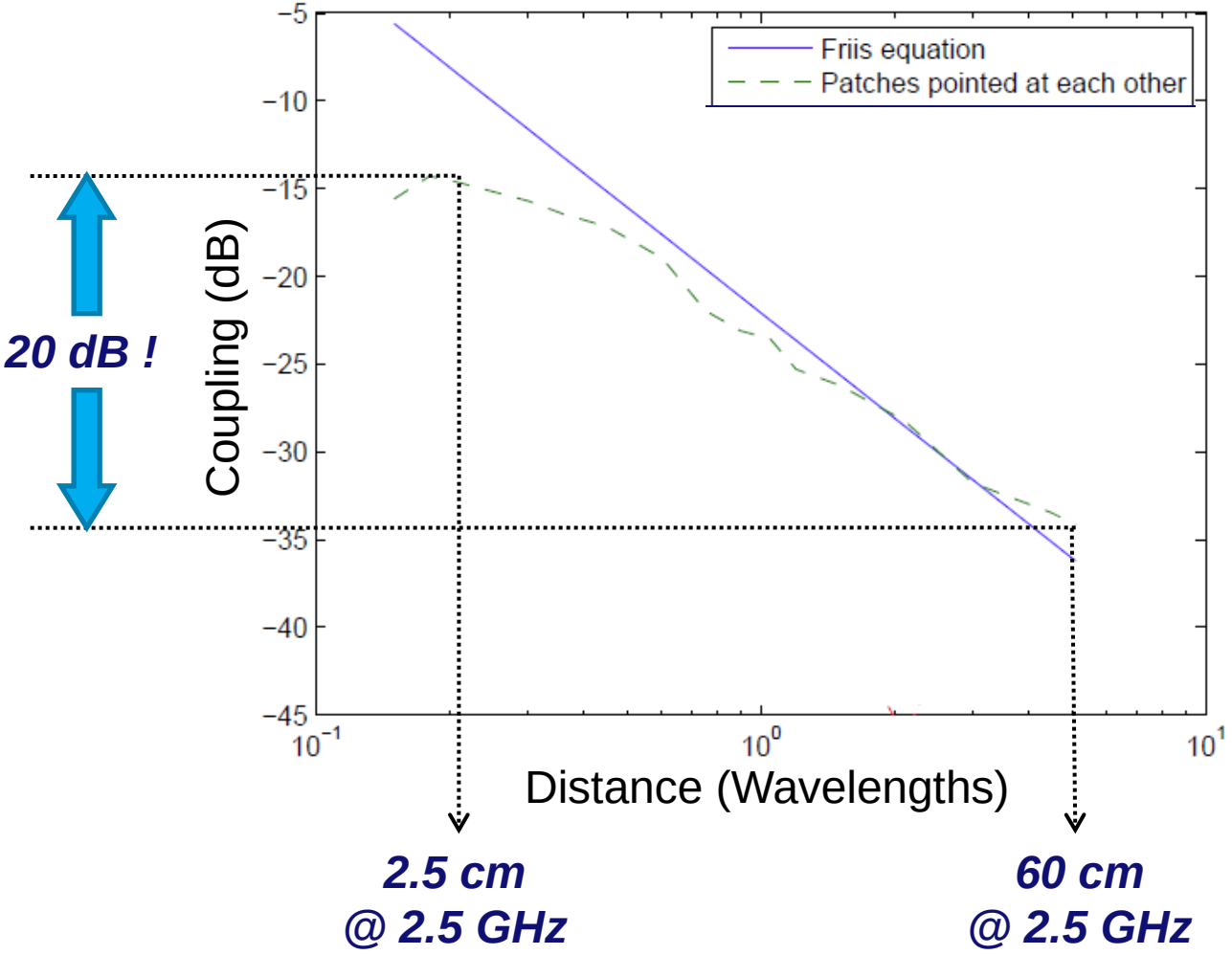
- **GSM**
- **UMTS**
- **WLAN**
- **Bluetooth**
- **GPS**
- **FM Rx/Tx**
- ***LTE***
- ***WiMAX***
- **?**

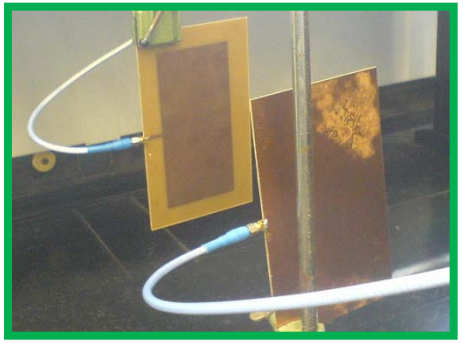
Problem statement

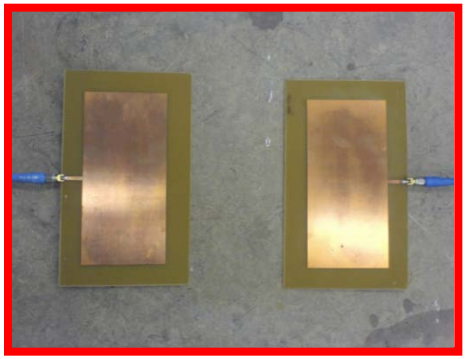
- **Present solutions:**
  - **Time sharing**
  - **(Temp.) increase P_{DC}**
  - **Reduce antenna coupling**



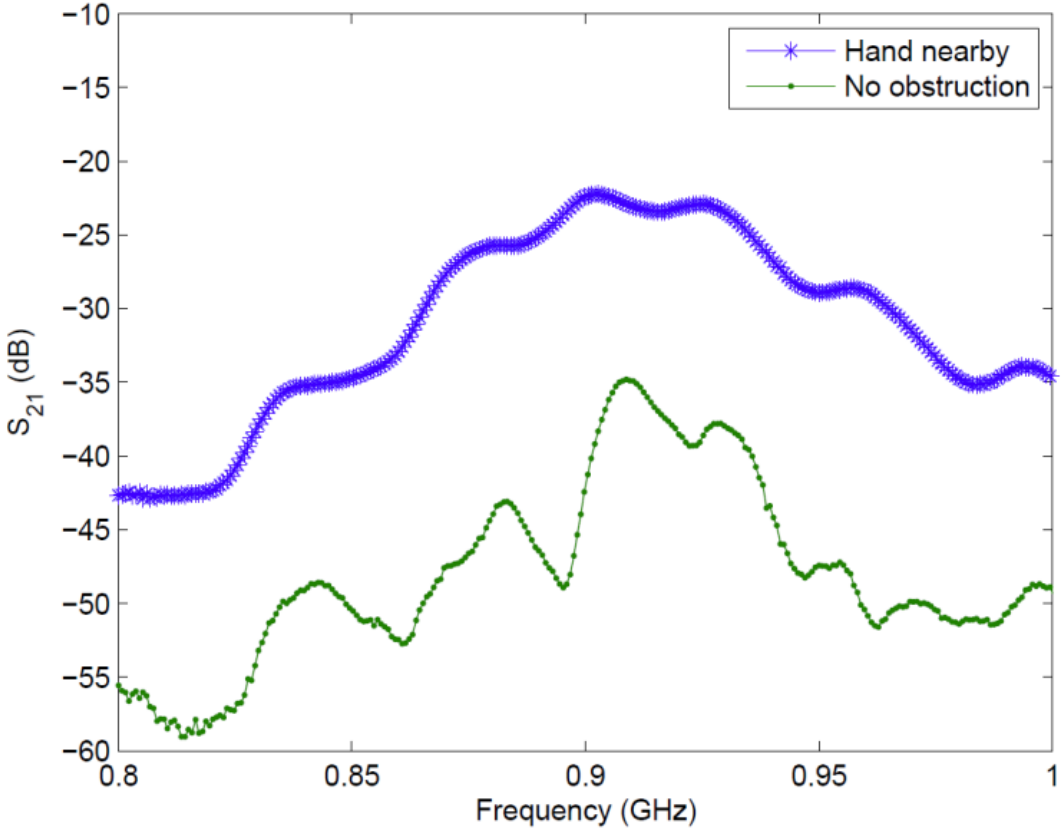
Coupling between antennas

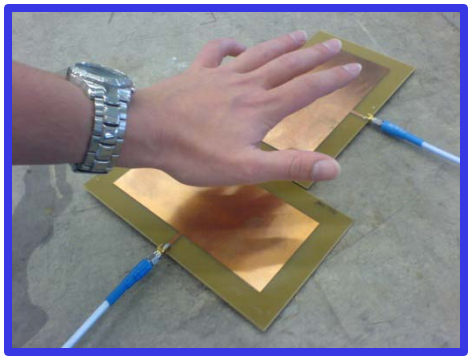






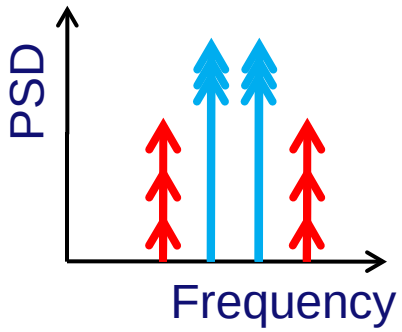
Coupling between antennas

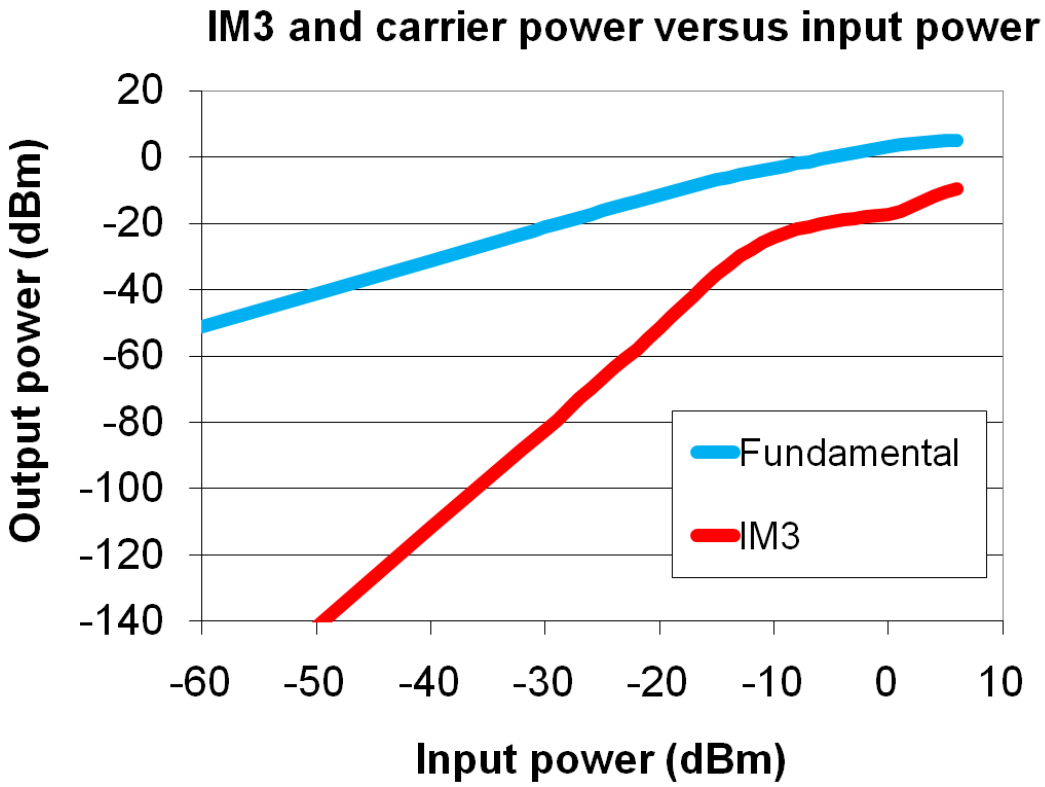




What does this mean for RF circuitry?

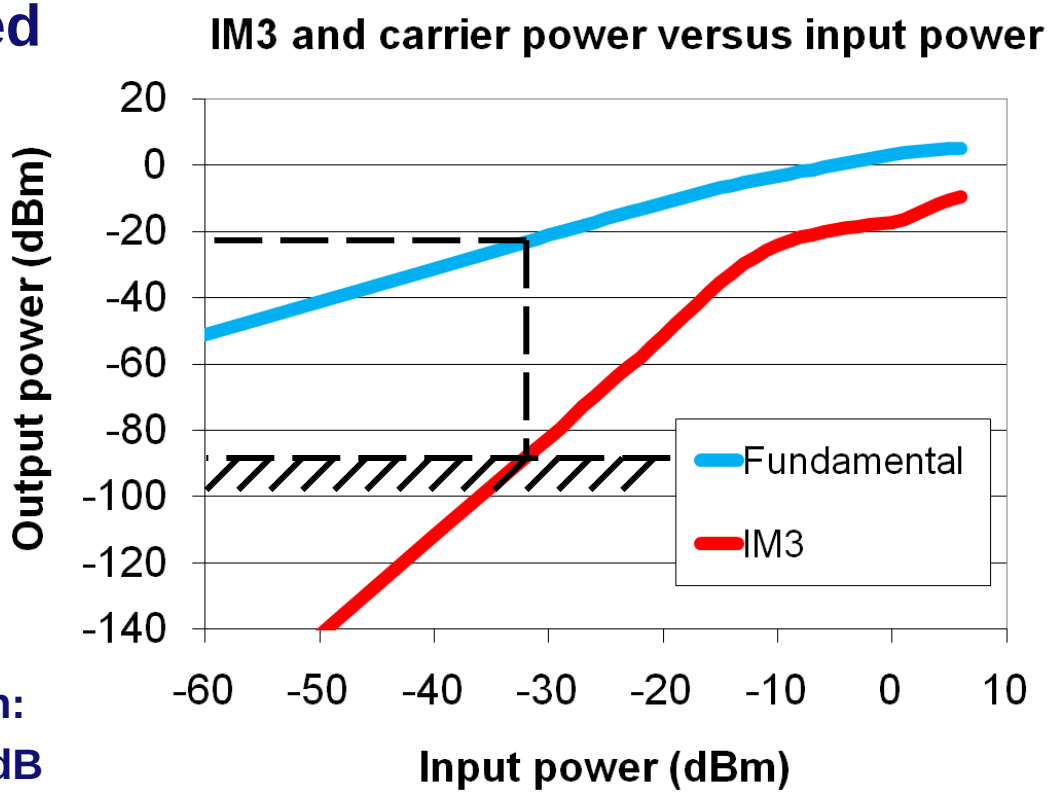
- **Distortion measurement LNA:**





What does this mean for RF circuitry?

- **Minimal detectable signal level for this circuit:**
  -99 dBm in 20 MHz bandwidth
  -88 dBm output referred

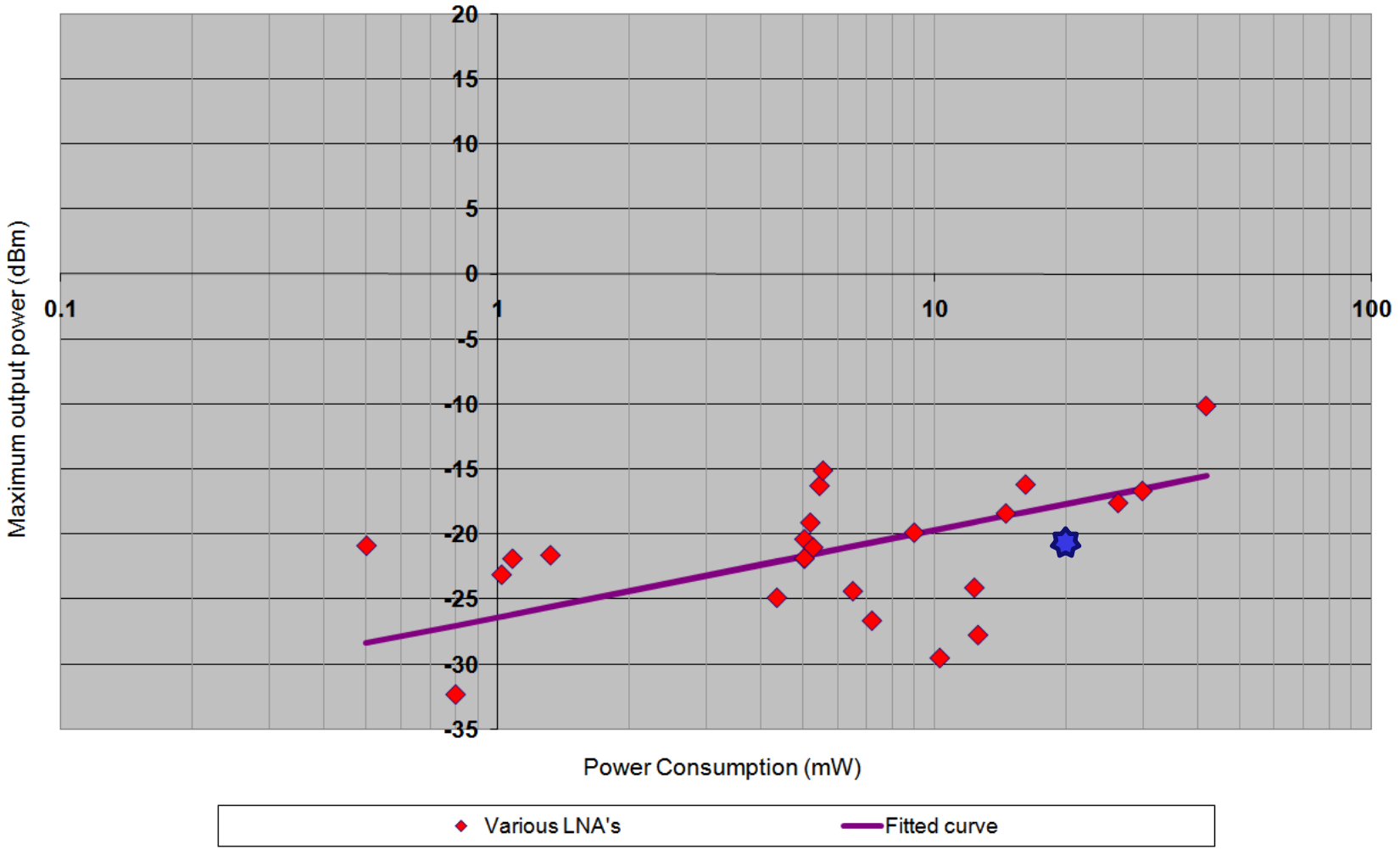


N_0: **BW:** **NF:** **Gain:**

-174 dBm/Hz + 73 dB + 2 dB + 11 dB

Typical RF circuit (LNA) performance

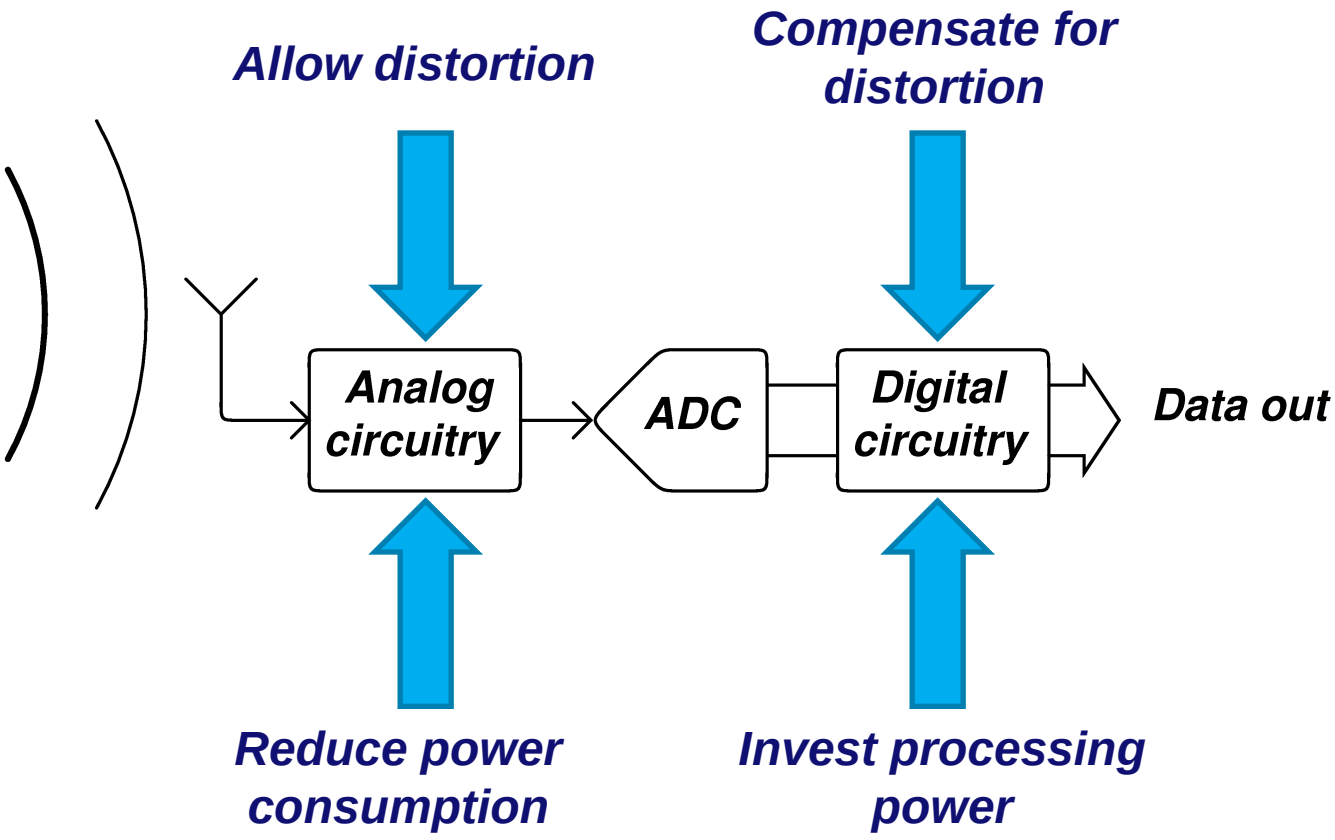
$$P_{out,max}\ (\mathrm{dBm}) = \mathrm{MDS}\ (\mathrm{dBm}) + \mathrm{SFDR}\ (\mathrm{dB}) + \mathrm{Gain}\ (\mathrm{dB})$$



Survey of the project

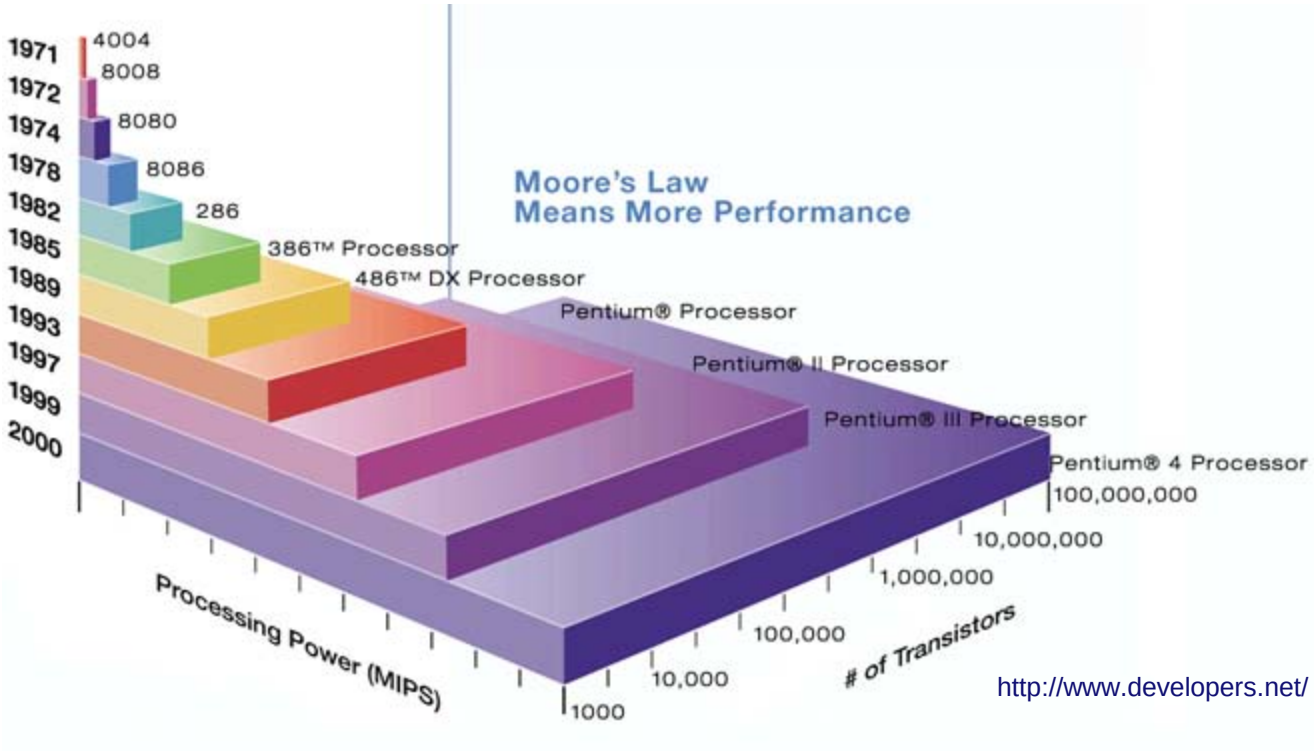
- **WP1: PhD student UT, Shadi Youssef**
  - **RF circuit design**
    - **Using digital adaptivity to achieve higher DR**
- **WP2: PhD student TU/e SPS, Hooman Habibi**
  - **Signal processing**
    - **Digital algorithms to tune / compensate RF circuits**
- **WP3: PhD student TU/e MsM, Erwin Janssen**
  - **RF circuit design**
    - **Modeling and design low power RF circuits**

First solution: *Use digital signal processing*

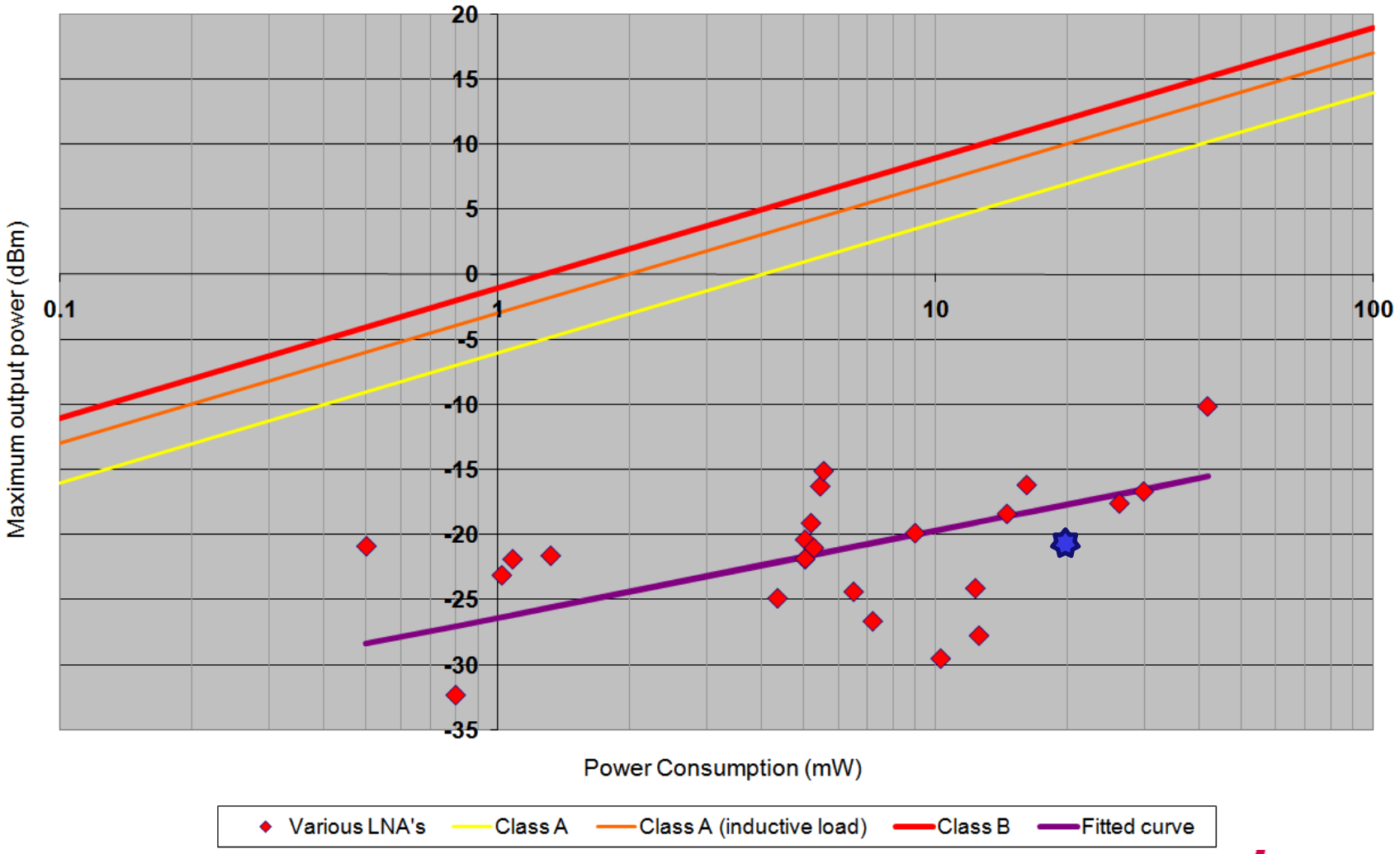


Ongoing trend in digital electronics

- **Processing power cheaper every year**

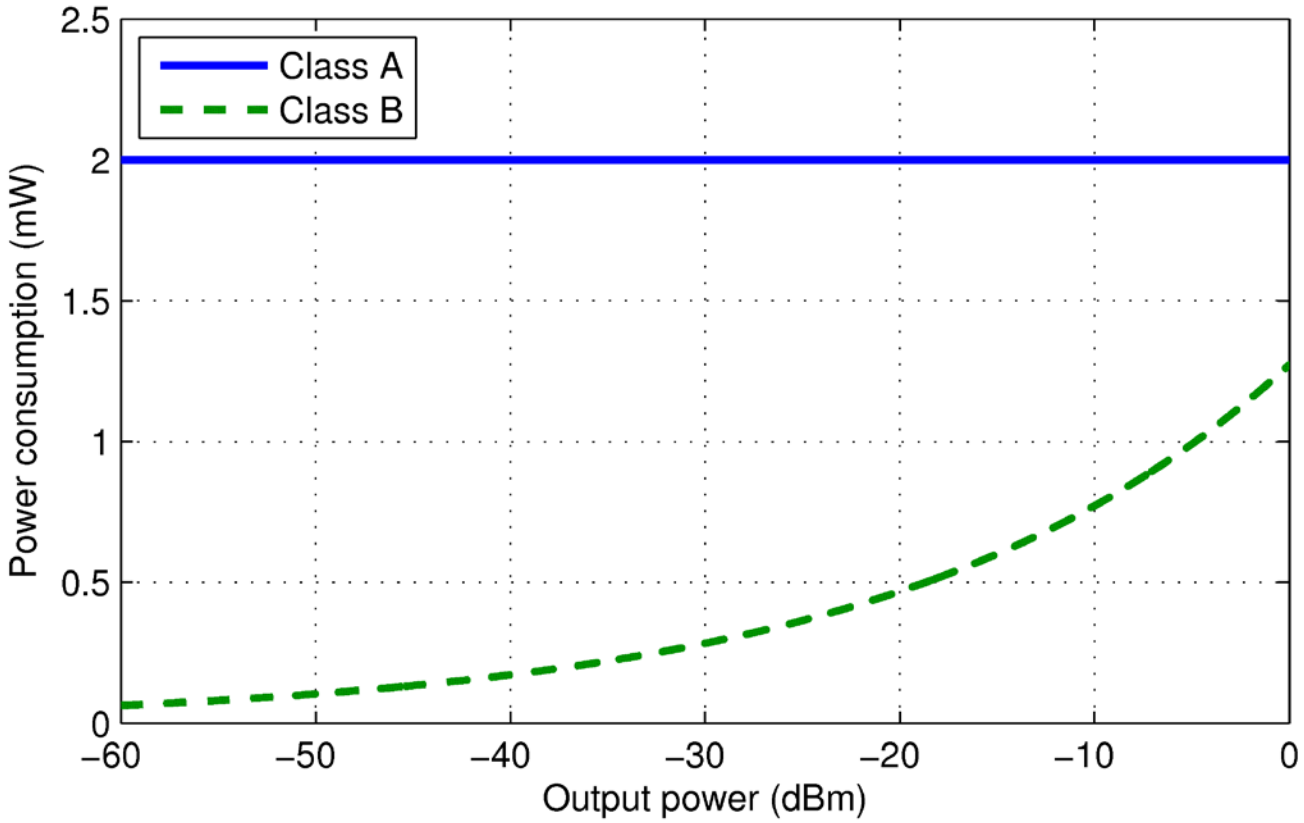


What is there to gain?



Class B versus Class A; further benefit

- **DC power consumption depends on signal strength**

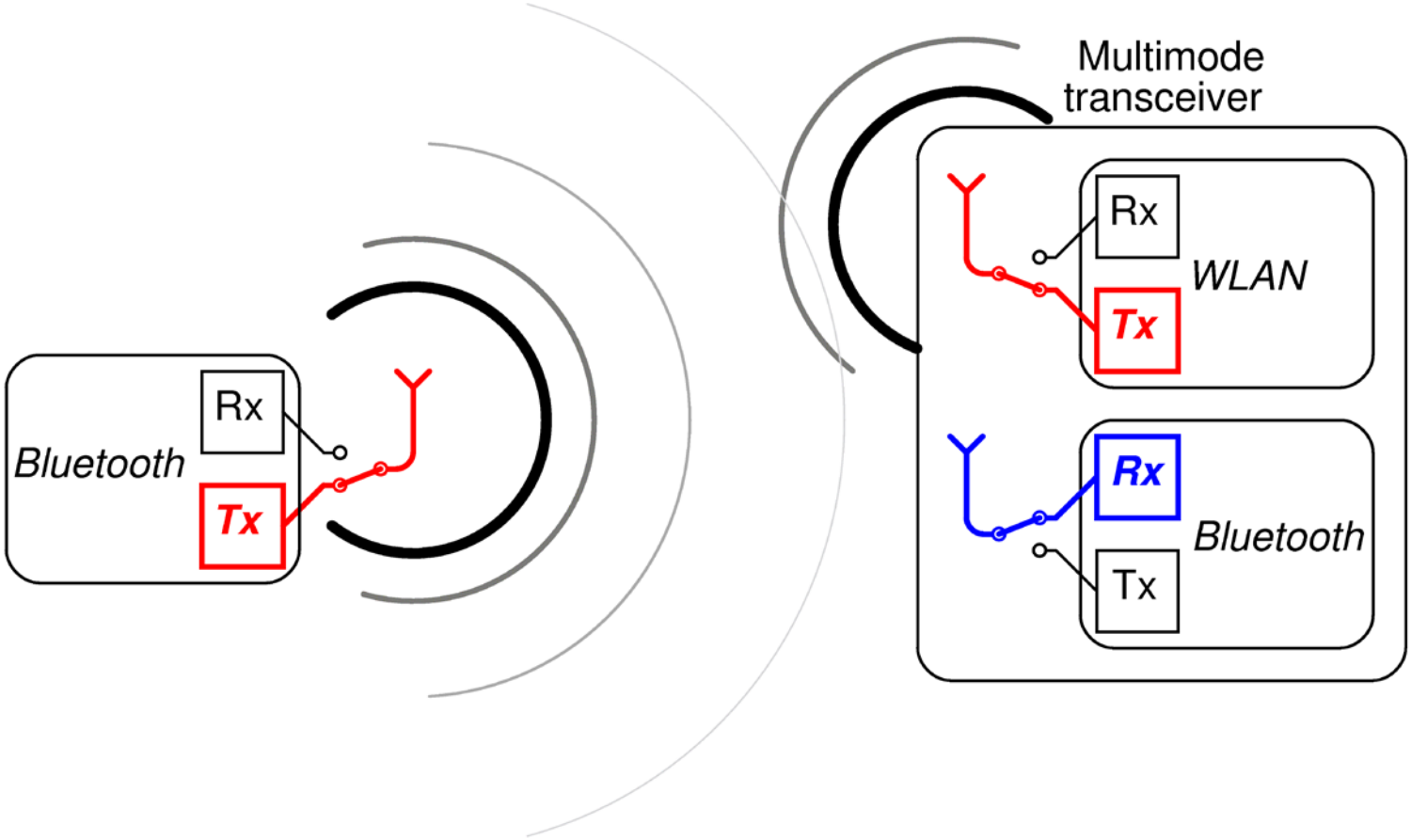


Goal

- **Reduction of DC power consumption in analog**
  - **Cost: Decreased performance**
- **Invest in digital processing power**
  - **Cost: Power consumption**

Trade DSP power for DC power consumption

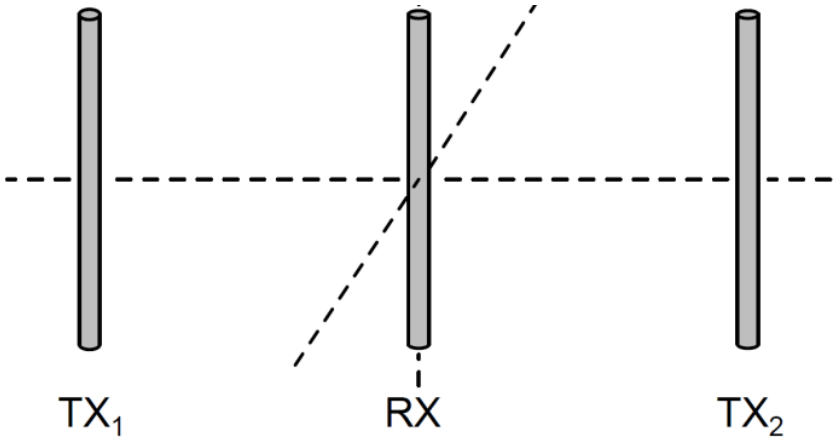
Second solution: *Reduce interference*



Antenna coupling reduction

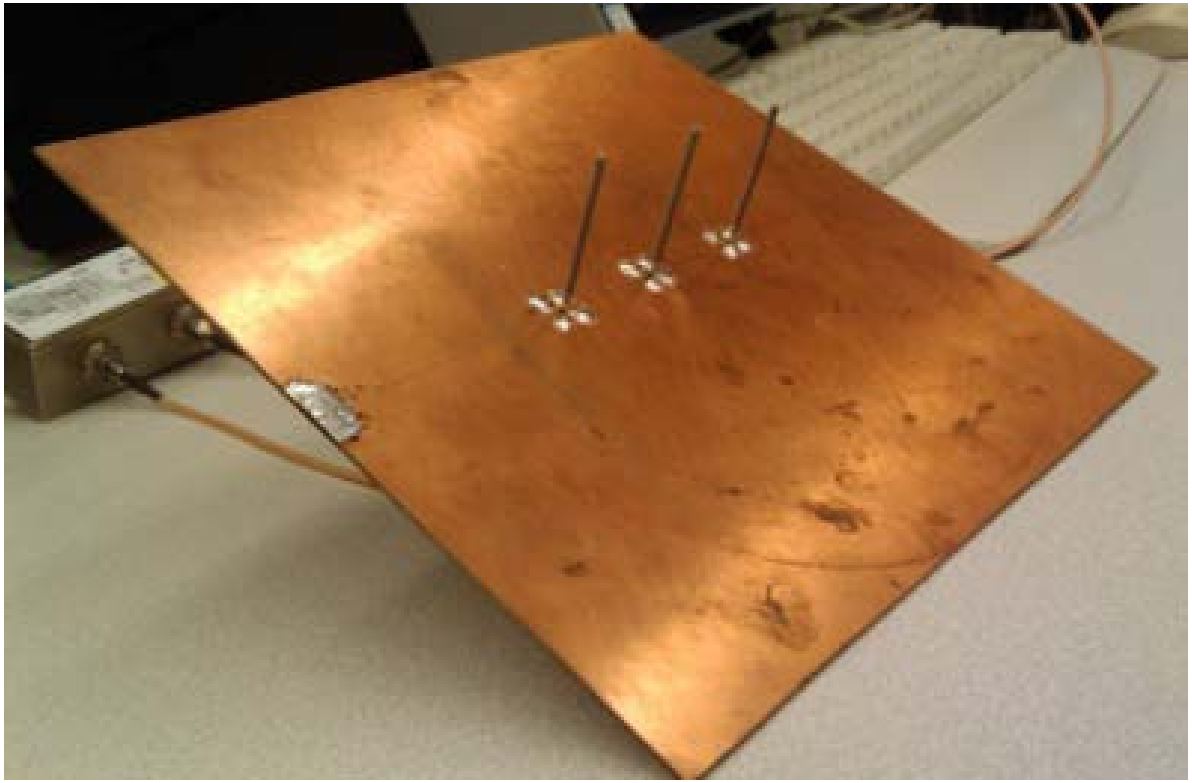
- **Differentially excited TX antennas**
  - **$TX_1 = 0^o$, $TX_2 = 180^o$**

- **Result: EM field at RX antenna reduced**



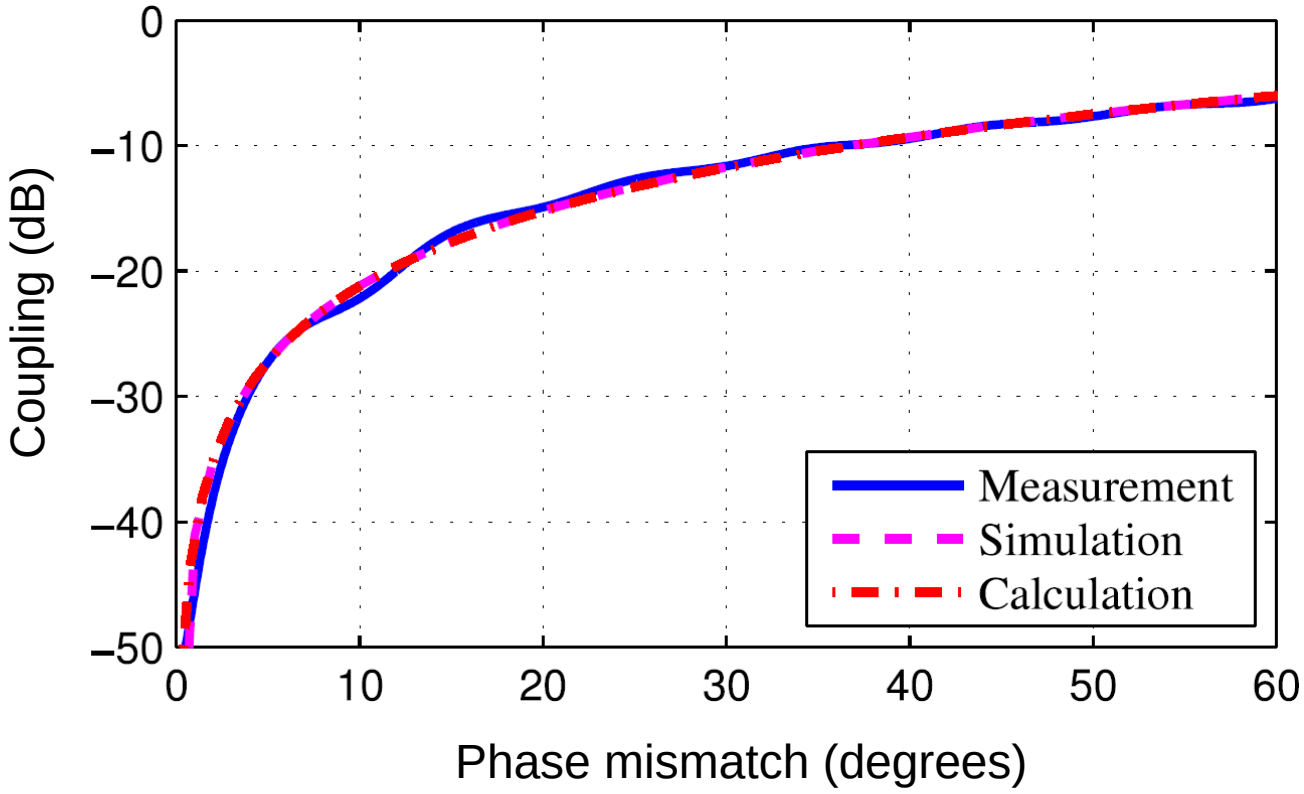
Antenna coupling reduction

- **Prototype operating at 2.5 GHz**



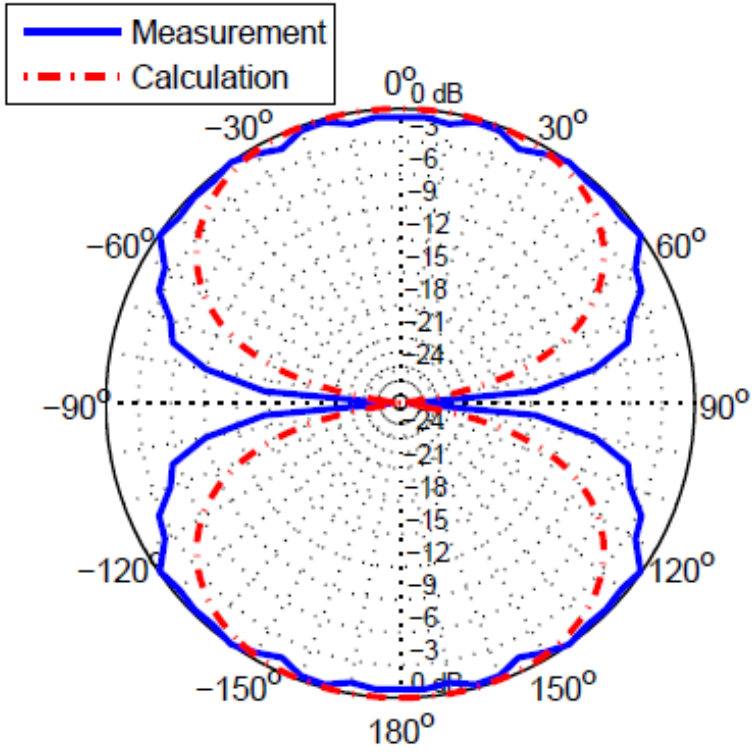
Antenna coupling reduction

- **Analyzed / simulated / measured coupling:**



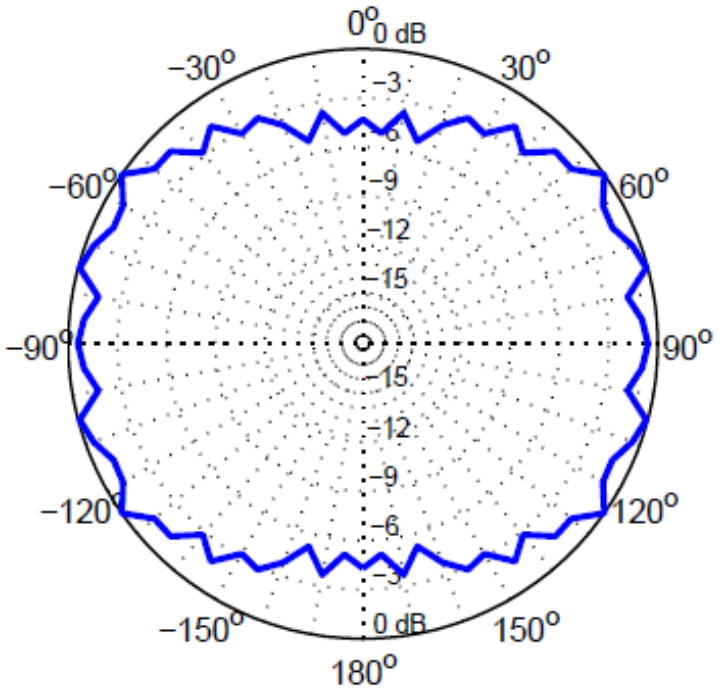
Antenna coupling reduction

- **Radiation pattern Tx:**
  - **Resulting notch no issue in indoor environment**



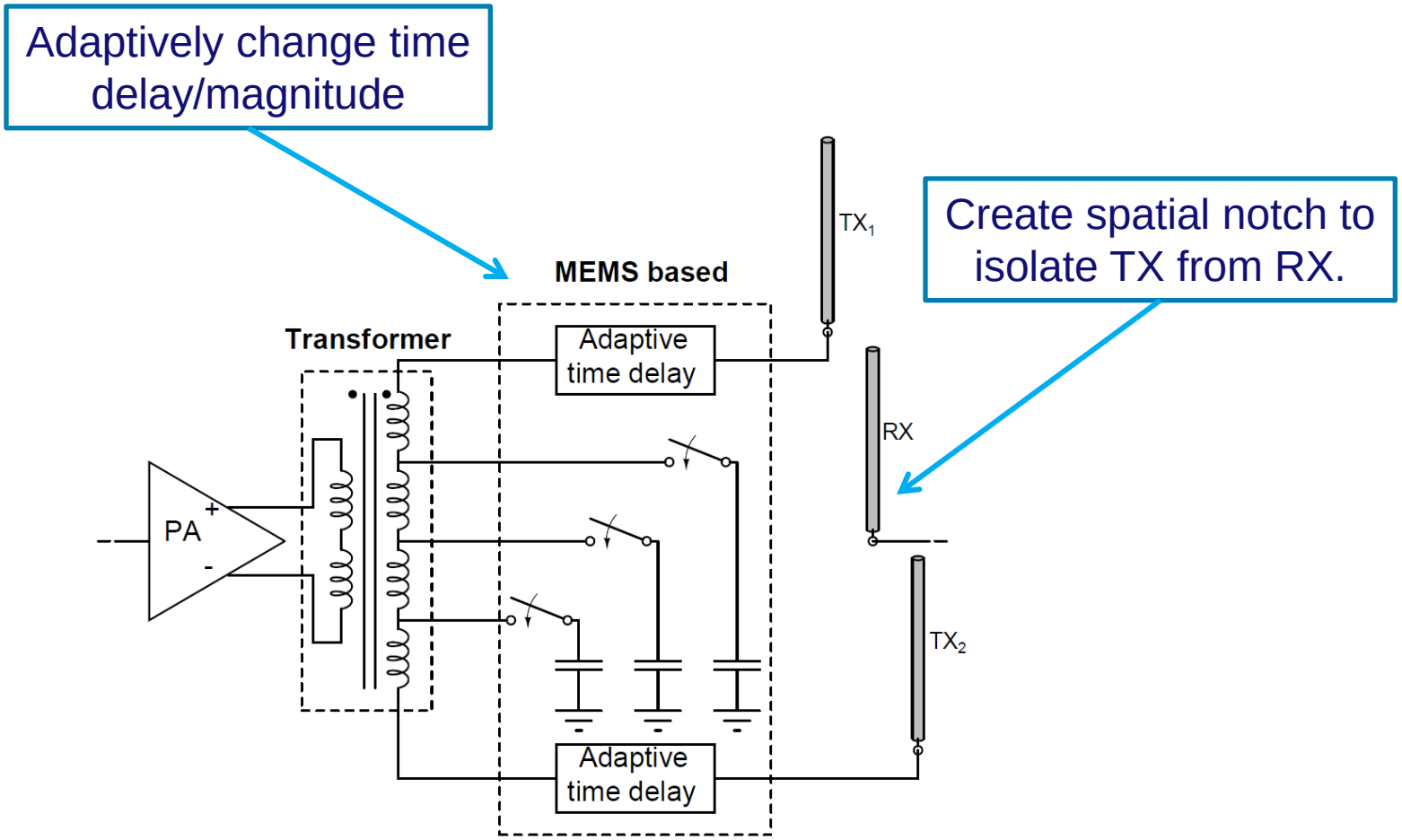
Antenna coupling reduction

- **Radiation pattern Rx:**



Antenna coupling reduction

- **Dealing with a changing environment:**



Conclusions

- **Trend: Increased wireless connectivity**
  - **Leads to heavy (self)-interference**
- **Interference sensitivity due to nonlinear behavior**
  - **Present solutions lead to high power consumption, or reduced throughput**
- **Digital compensation enables trade-off**
  - **Performance analog ←→ Performance digital**
  - **P_{DC} analog ←→ P_{DC} digital**
  - **And, enables use of power efficient class (A)B circuits**

Conclusions

- **Reduction of antenna coupling possible**
- **Proposed solution:**
  - **Add one additional antenna**
  - **Add adaptive phase shifter and power divider**

Questions?

Thank you !