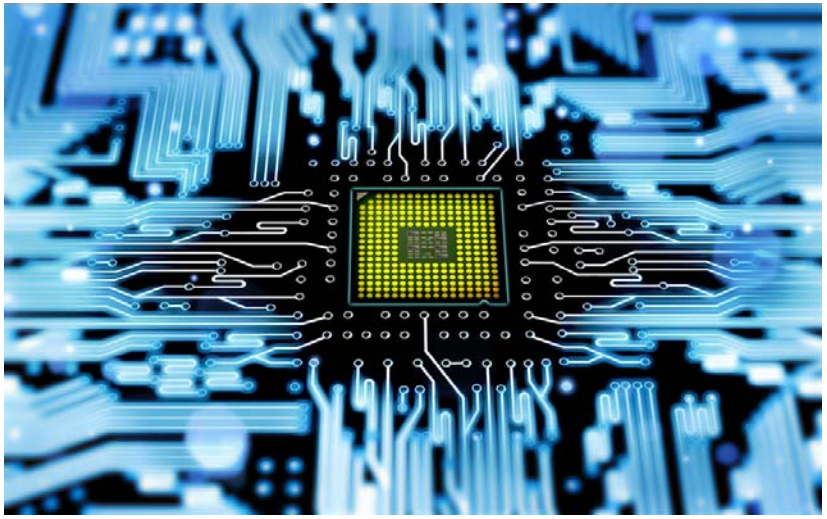
HEINZ NIXDORF INSTITUTE
University of Paderborn
System and Circuit Technology
Prof. Dr.-Ing. Christoph Scheytt

Wireless 100Gb/s Using A Power- and Hardware-Efficient Approach

(Project Real100G.com)

J. Christoph Scheytt



HEINZ NIXDORF INSTITUTE
University of Paderborn
System and Circuit Technology
Prof. Dr.-Ing. Christoph Scheytt

There Might be Three Major Options for 100 Gb/s Wireless

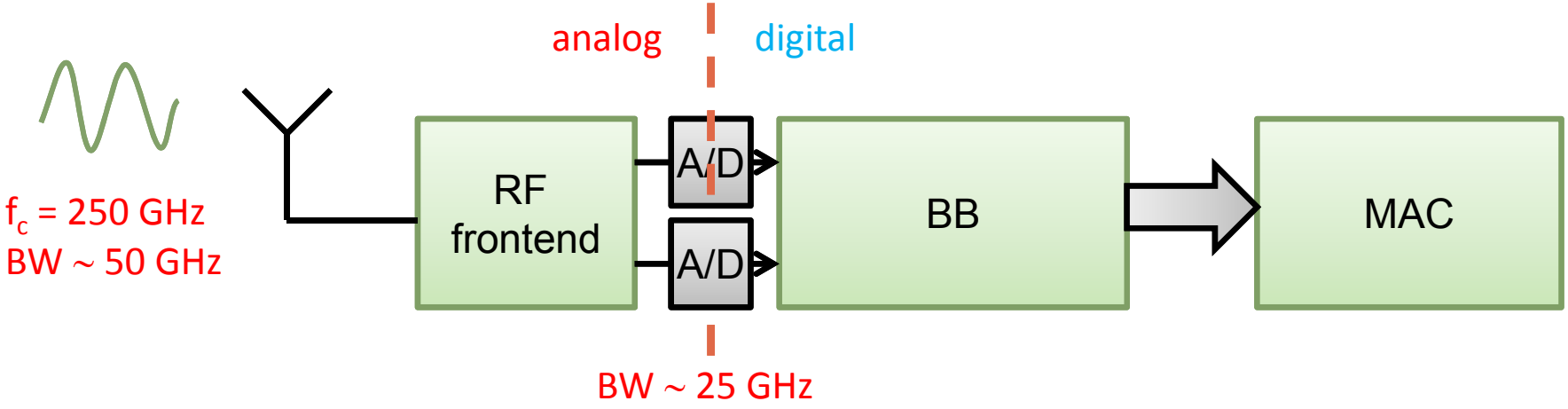
- **Extreme Spectral Efficiency (SE) x „moderate“ bandwidth (BW)**
  >10 b/sHz x 10 GHz
  → RF bands at 60 GHz, E-band

- **Moderate SE x extreme BW**
  4 b/sHz x >25 GHz
  → RF bands > 200 GHz

- **Free-space optics**
  e.g. 40 Gbaud with 8-PAM (BW 30 GHz, 3 b/sHz

HEINZ NIXDORF INSTITUTE
University of Paderborn
System and Circuit Technology
Prof. Dr.-Ing. Christoph Scheytt

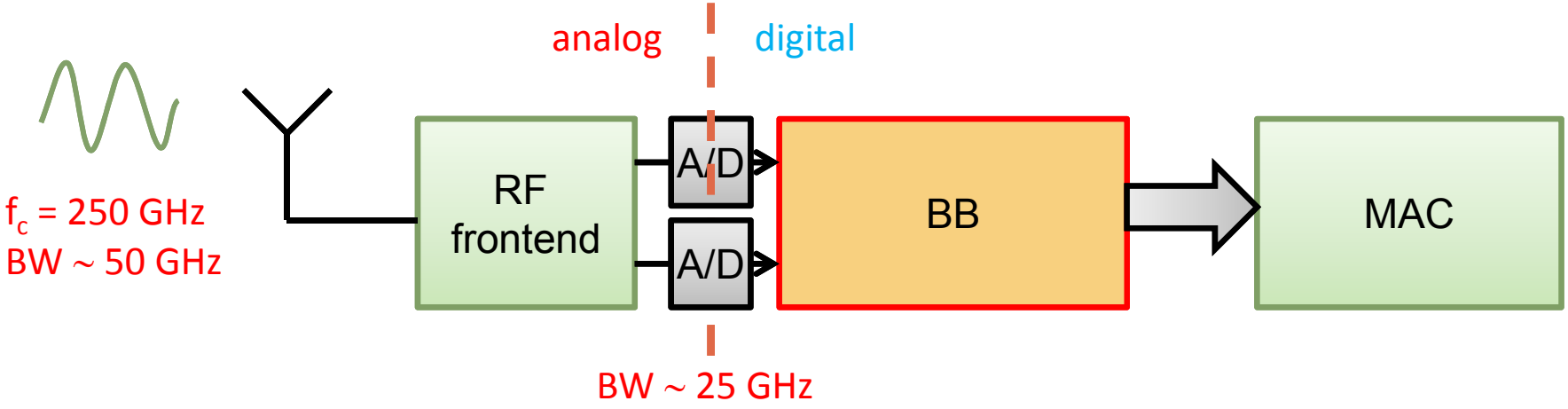
Generic Receiver



- Generic receiver parameters:
  - f_c > 200 GHz, *RF BW* ~ 50 GHz
  - *SE* 3b/sHz
  - *BB BW* ~ 25 GHz

HEINZ NIXDORF INSTITUTE
University of Paderborn
System and Circuit Technology
Prof. Dr.-Ing. Christoph Scheytt

Generic Receiver

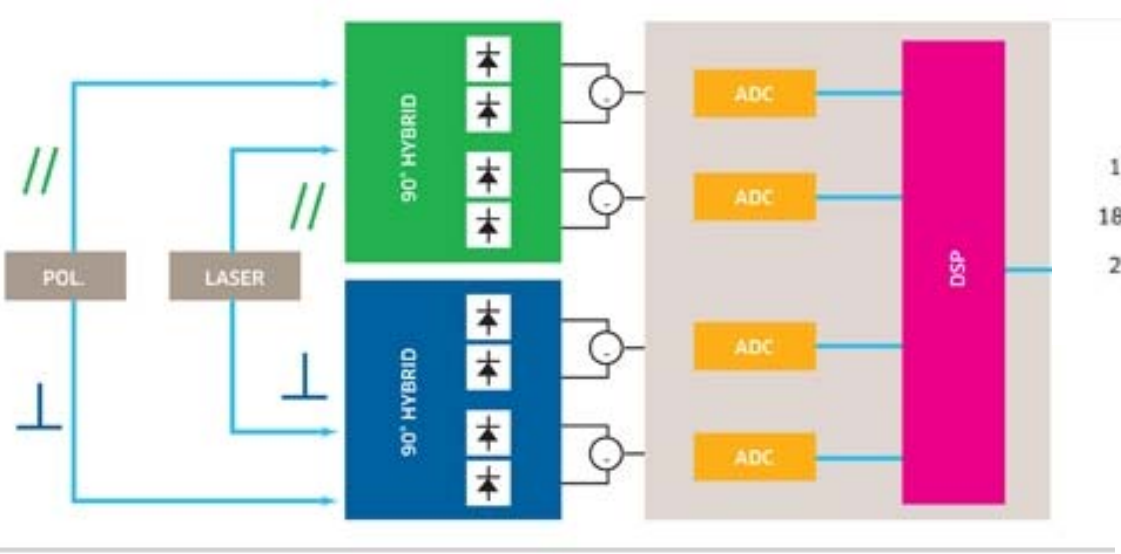


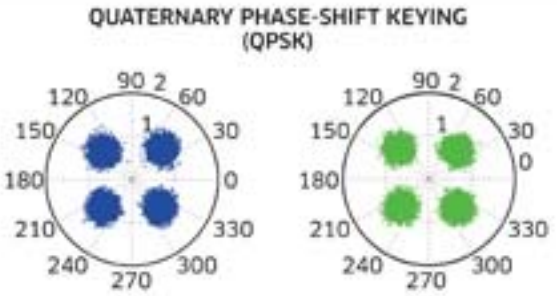
- Generic receiver parameters:
  - f_c > 200 GHz, *RF BW* ~ 50 GHz
  - *SE* 3b/sHz
  - *BB BW* ~ 25 GHz

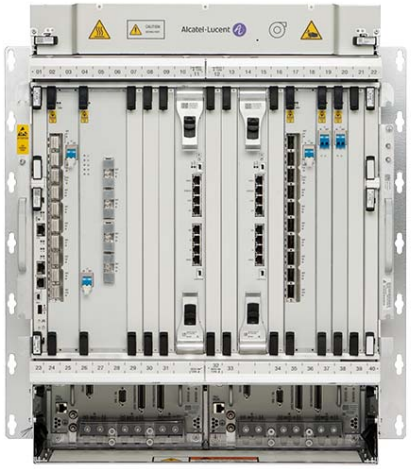
Is the BB feasible from HW perspective and how to implement it?

HEINZ NIXDORF INSTITUTE
University of Paderborn
System and Circuit Technology
Prof. Dr.-Ing. Christoph Scheytt

Similar 100 Gb/s Communication System







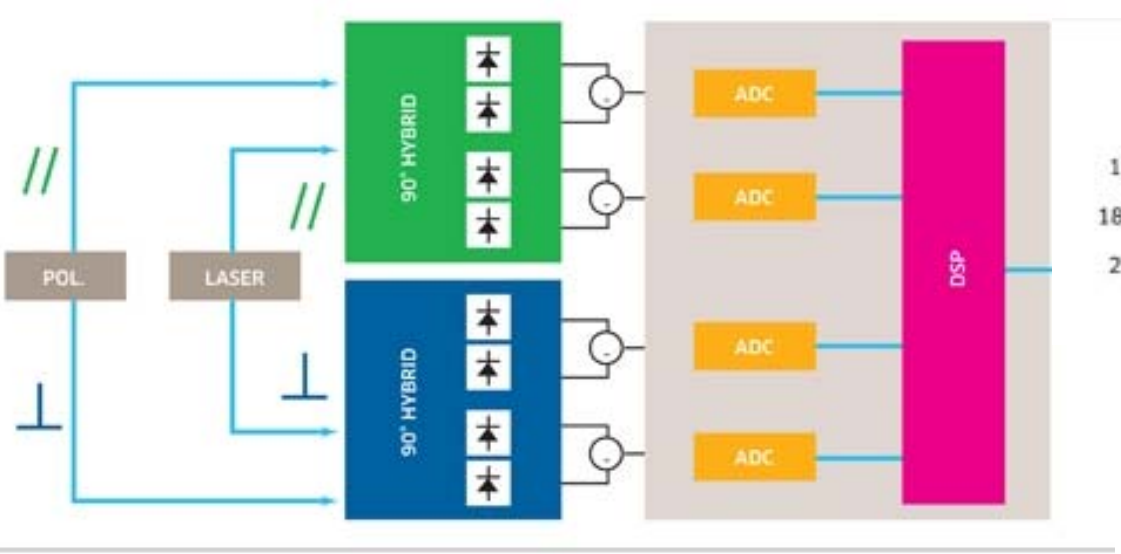
© Alcatel-Lucent

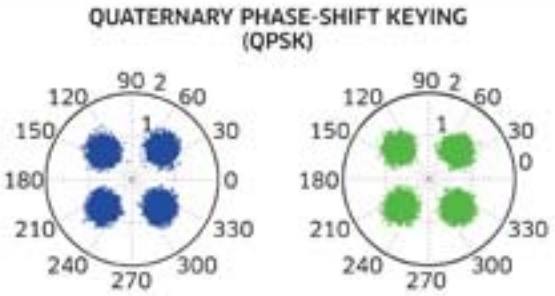
… already there! → <u>100 GbE fiber-optic products</u> are out since 2012

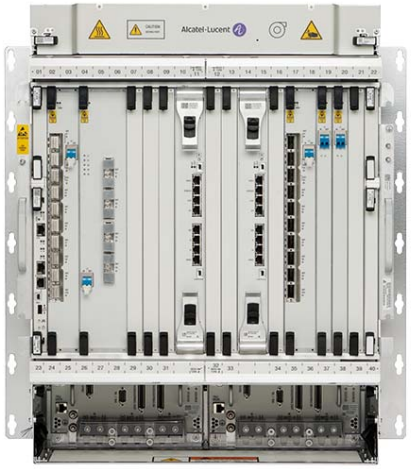
- **Use extensively wireless communication technology**:
  - Optical QPSK with 28 Gbaud using 2 polarizations at 0° and 90°
  - IQ transceivers, DACs, ADCs, digital baseband

HEINZ NIXDORF INSTITUTE
University of Paderborn
System and Circuit Technology
Prof. Dr.-Ing. Christoph Scheytt

Similar 100 Gb/s Communication System







© Alcatel-Lucent

Can we learn from the optical guys for wireless 100 Gb/s?

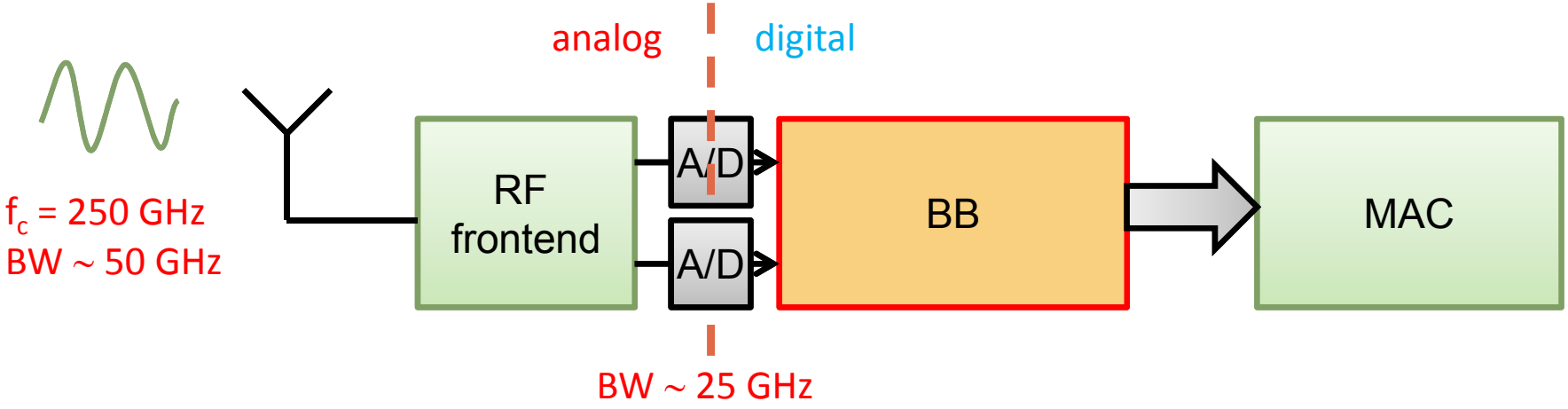
- Ultra-fast ADCs (28 GSps, 8 bit) → power hungry, challenging design
- Many TFLOPs for signal processing → power hungry, complex hardware

→ **100 Gbit/s coherent communication w/ digital BB is clearly feasible!**

… **but extremely power hungry (>50W)!**

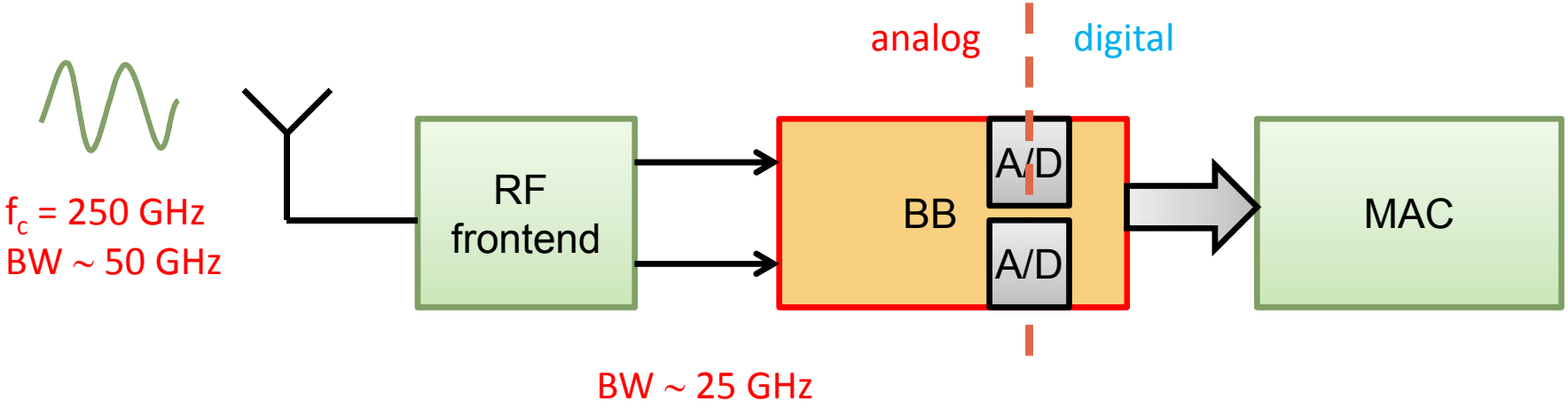
Research Approach

Generic Receiver



Research Approach

Mixed-Signal Receiver

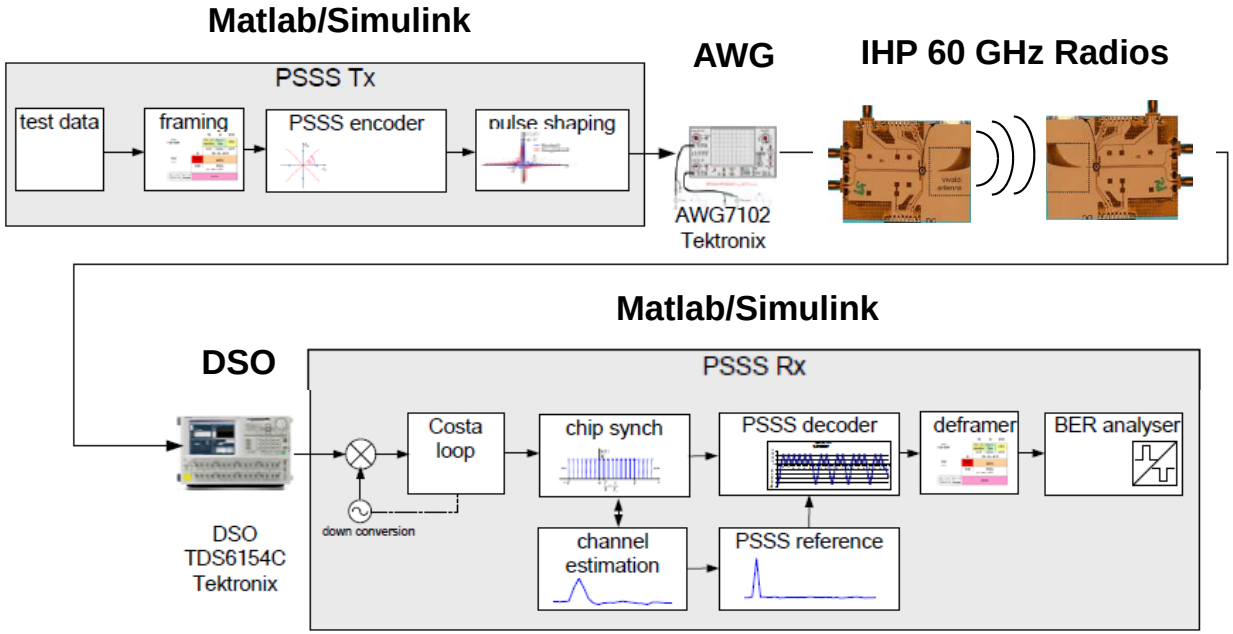


- **Analog processing is inherently power and hardware-efficient !**

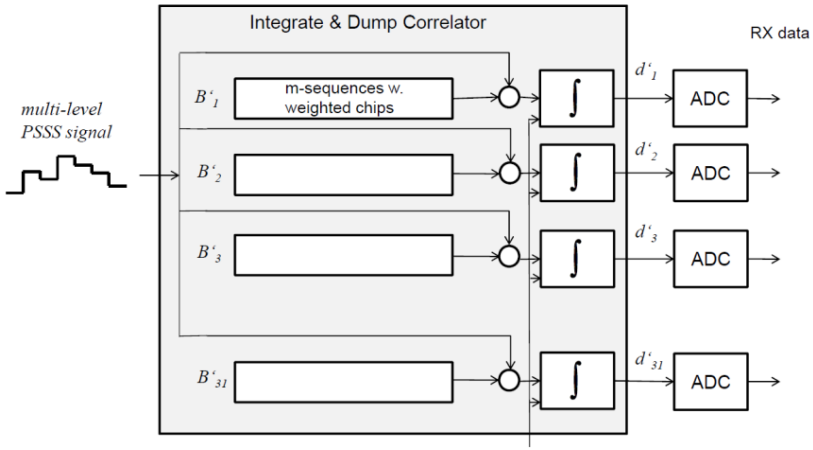
- **Shift „analog boundary“** → Mixed-mode BB w. dominant analog
- **Choose „Analog-friendly“ modulation & coding** → Parallel Spread-Spectrum Sequencing (PSSS) simplifies mixed-mode BB implementation
- **Preprocessing in analog domain** → reduced dynamic range for ADCs

HEINZ NIXDORF INSTITUTE
University of Paderborn
System and Circuit Technology
Prof. Dr.-Ing. Christoph Scheytt

PSSS Experiment Using 60 GHz Radios



Mixed-mode PSSS Hardware Model



- Matlab implementation of TX and RX used a mixed-signal hardware description
- 60 GHz radio modules from IHP

- Link experiments achieved 4 Gb/s @BER=1e^{-5} (3m)
- Compared well to OFDM link demo with same hardware

Summary

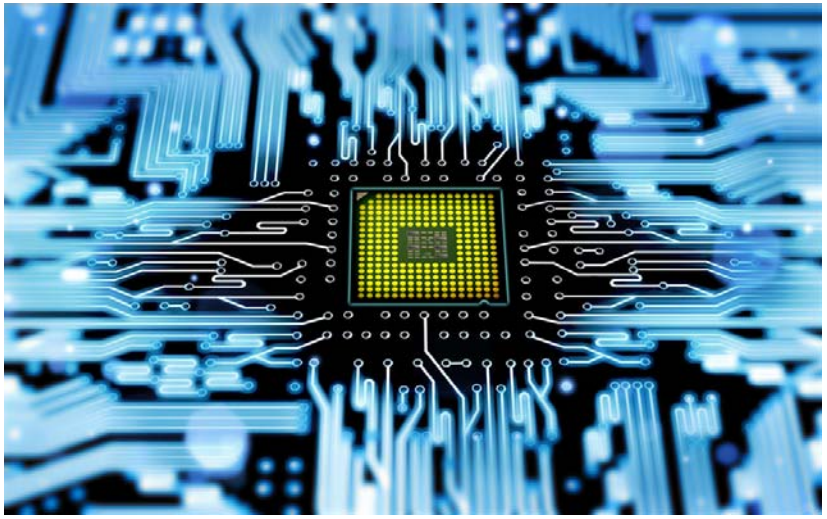
- **100 Gb/s Wireless Communications with moderate spectral efficiency requires extreme broadband BB hardware.**
- **This is even today feasible but power dissipation is prohibitive.**
- **Analog preprocessing in the BB will reduce hardware complexity and power dissipation.**
- **PSSS is an „analog-friendly“ modulation which greatly simplifies 100 Gb/s analog preprocessing (especially decoding & equalization).**
- **Partners from Real100G.com**

Acknowledgements:
Rolf Kraemer
Ingmar Kallfass

Brandenburgische Technische Universität Cottbus

Universität Stuttgart

Thank you for your attention!

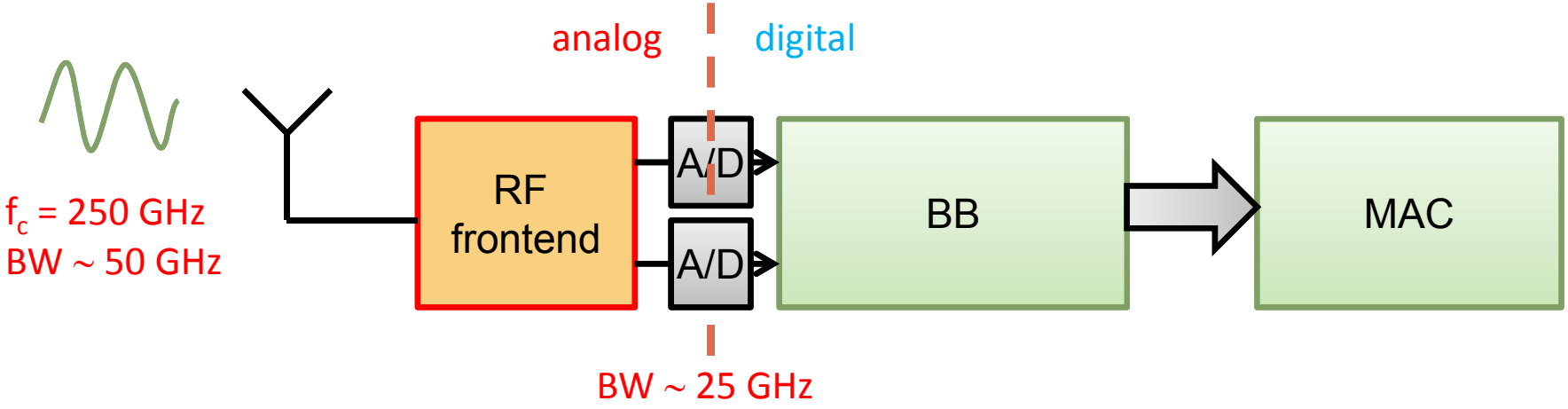


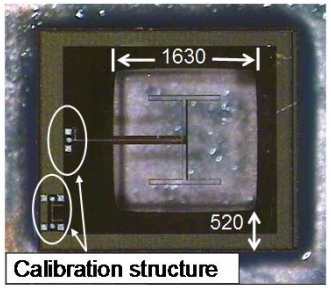
Heinz Nixdorf Institute
University of Paderborn
System and Circuit Technology
Fuerstenallee 11
33102 Paderborn

Phone: +49 5251 606350
Fax.: +49 5251 606351
E-mail: cscheytt@hni.upb.de
www.hni.uni-paderborn.de/en/sct

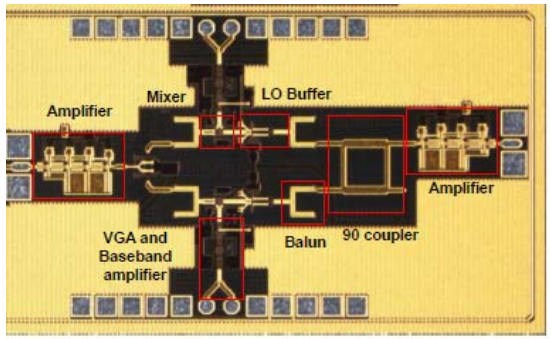
HEINZ NIXDORF INSTITUTE
University of Paderborn
System and Circuit Technology
Prof. Dr.-Ing. Christoph Scheytt

Generic Receiver





120 / 240 GHz
On-chip antenna
IEEE IMS 2012
Wang et al.



240 GHz IQ receiver in 0.13µm BiCMOS, RFIC 2013, Elkhouly et al.

Pdiss.= 500 mW

RF Frontend / Demodulation seems realistic ✓