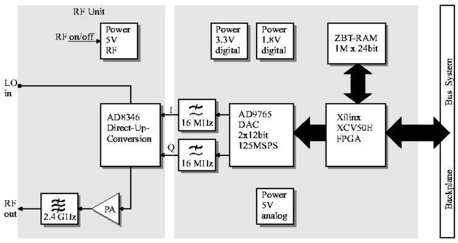
UNIVERSITÄT BREMEN

Arbeitsbereich Nachrichten Technik

A Hardware Demonstrator for MIMO-Communication Systems: Application to Blind Source Separation

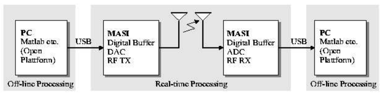
J. Rinas, A. Scherb, T. Haase und K.D. Kammeyer

MIMO-Transmitter

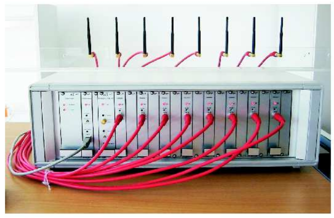


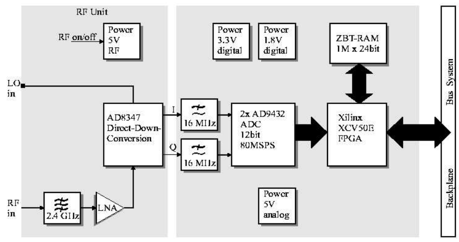
- transmission frequency 2.4 GHz ISM-band (5MHz channel stepsize / 8 frequencies possible)
- transmission power: +17 dBm (50 mW)
- direct conversion transmitter and receiver (AD 8346/8347)
- analog I/Q-bandwidth: 16 MHz (depending on receive filters)
- 12 bit D/A converter (AD 9765)
- 12 bit A/D converter (AD 9432)
- sampling frequencies: 10 MHz, 40 MHz, 50 MHz, PLL and external input
- maximum memory depth 512k (Tx) resp. 1024k (Rx) I/Q-samples
- PC connection (data and control) using the USB interface
- external connectors for the 2.4 GHz carrier frequency and 10MHz reference frequency
- control software for data transfers and settings (used memory depth, sampling frequency, automation of multiple measurements)
- binary file for each channel: alternating I/Q-samples as 16 bit integers => easy interfacing with Matlab or other tools

Real-time Transmission <> Off-line Processing



MIMO-Receiver





Frequency Responses of the MIMO channel

- fast measurement scheme for varying channels
- usage of a chirp-like signal $m(k)$ designed in frequency domain
- optimization of the crest factor (maximum amplitude/RMS) => quadratic phase increment
- cycling repetition of the signal $m(k)$

$$M(n)=e^{-j\frac{\pi}{N_{DFT}}n^2}$$

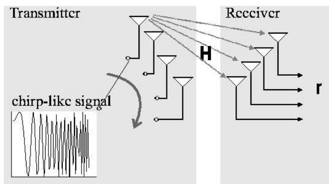
$$m(k)=IDFT_{N_{DFT}}\{M(n)\}$$

- multiplexing scheme to measure all Tx/Rx combinations
- no wired connection between transmitter and receiver necessary
- only coarse synchronization necessary to receive signal $r_r(k)$

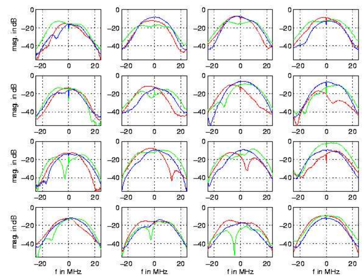
$$R_r(n)=DFT_{N_{DFT}}\{r_r(k)\}$$

- measurement of magnitude and phase possible (up to a linear phase uncertainty <=> circular time shift)
- averaging not mandatory, because $M(n)$ is exactly flat

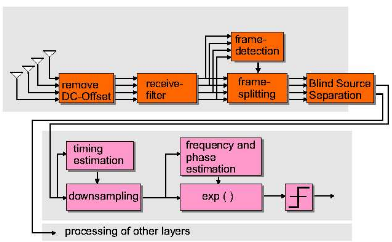
$$H(n)=\frac{R_r(n)}{M(n)}$$



- 4 transmit and 4 receive antennas
- λ/2 ULA
- 3 measurements of digital to digital channel (not channel sounding)
- $N_{DFT}=128$
- sampling frequency $f_s=50MHz$

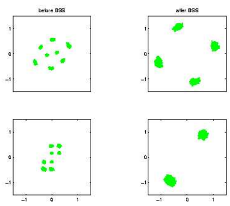


Blind Source Separation (BSS) Set-Up for Communication Applications

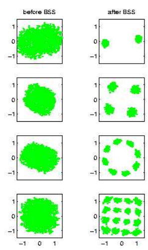


- Motivation: usage of SISO algorithms for timing, frequency and phase estimation possible
- synchronization / frequency estimation after the separation
- arbitrary communication signals can be mixed together

- spatial-only processing - JADE
- 8 times oversampling (no interpolation necessary)
- parallel sending of signals
- different signals to illustrate the feasibility of the set-up

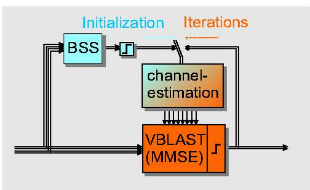


QPSK at BPSK positions



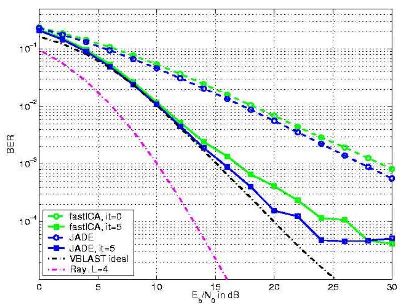
Blind Initialization of an Iterative Detection Scheme

- Motivation: BSS-only approach designs a linear spatial filter with very low signal knowledge
- => bad performance, because finite alphabeth is not used
- VBLAST: powerful detection algorithm for MIMO-diversity transmissions
  - successive interference cancellation
- Turbo Principle: iteration between data decisions and channel estimations
- free running turbo/decision loop (overall algorithm remains blind)



- simulation - symbol rate
- 4 transmit and 4 receive antennas
- 500 symbols
- QPSK modulation

- nearly reaching VBLAST performance with known channel matix
- about 10dB gain at 10^{-3} compared to the BSS-only approach



=> utilization of the finite symbol alphabeth is mandatory for communication applications!