CF-RZ-DPSK: A new modulation format to suppress XPM on long-haul DWDM systems over SSMF

Christoph Wree
Jochen Leibrich
Max Görler
Werner Rosenkranz

Chair for Communications
University of Kiel, Germany

motivation

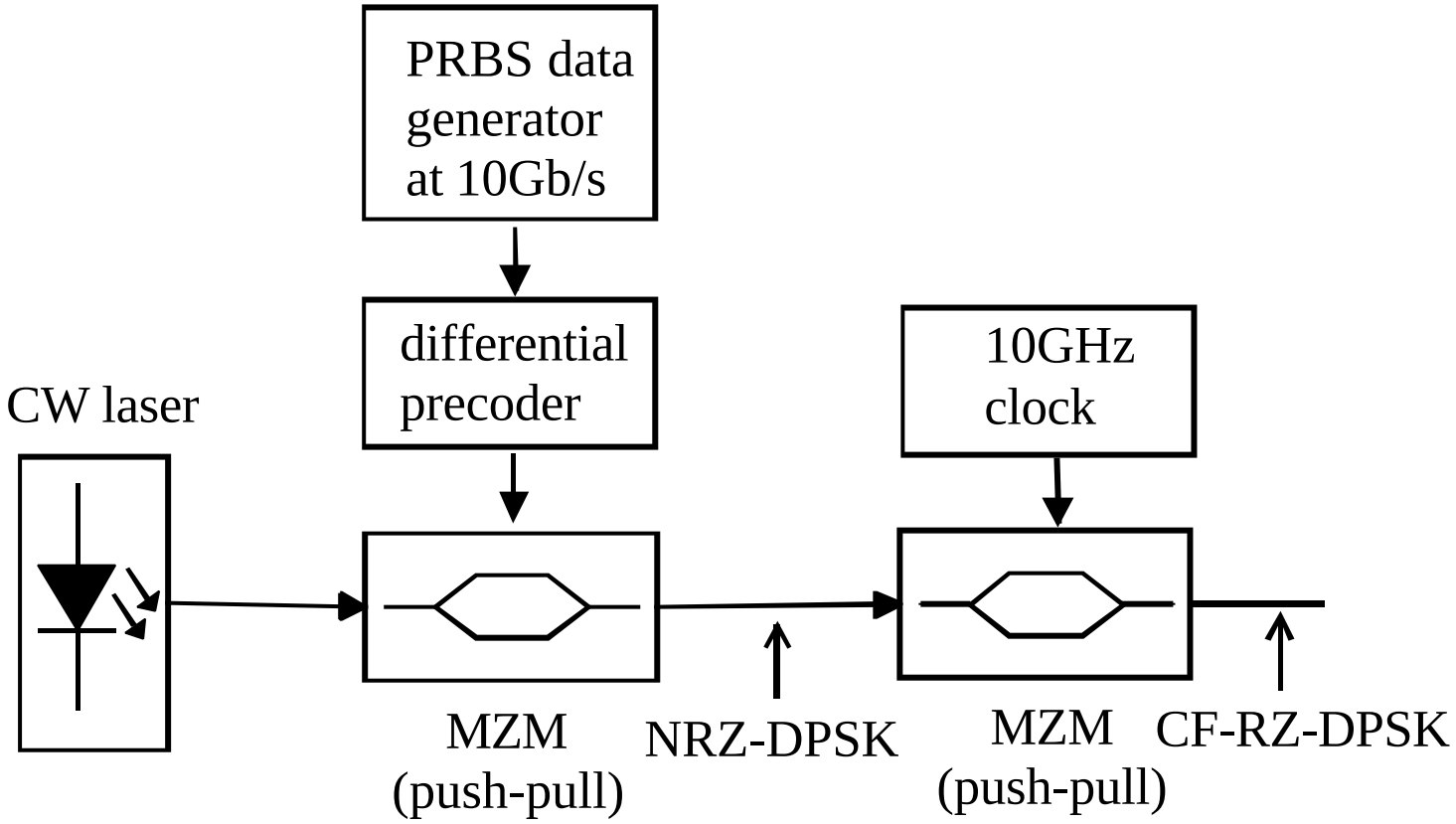
- two major goals in optical transmission systems:
  - increase spectral efficiency
  - extent optical transparent length

  ➡ increasing impact of fiber nonlinearities (e.g. XPM)
- robust modulation formats allow to reach goals
- proposed modulation format: CF-RZ-DPSK (chirp-free return-to-zero differential phase shift keying)

outline

- implementation of CF-RZ-DPSK
- simulation results for WDM system over 3000km
- experimental results for WDM system

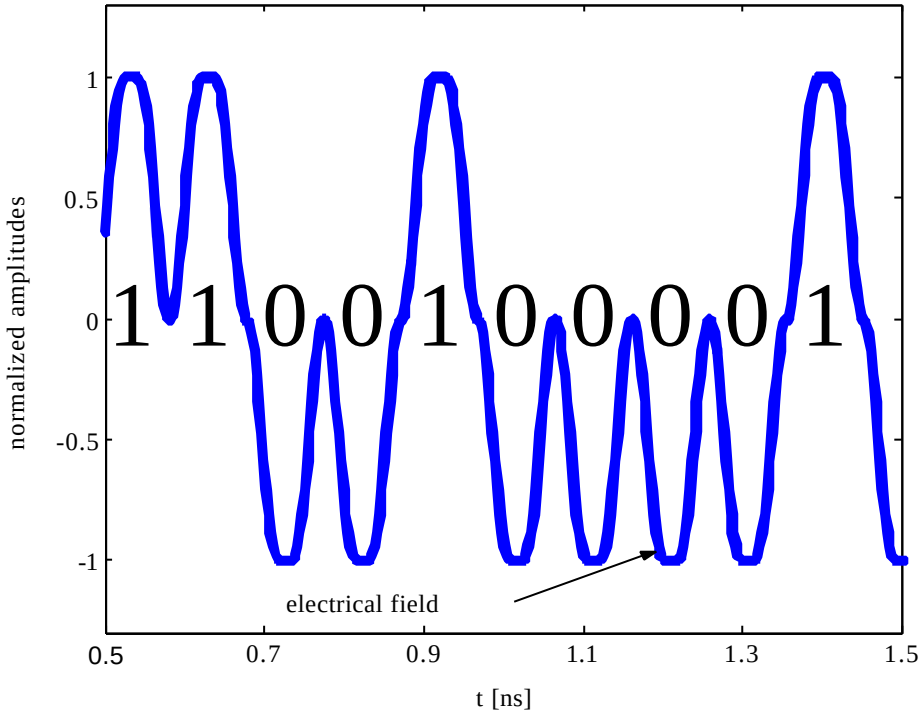
CF-RZ-DPSK transmission setup



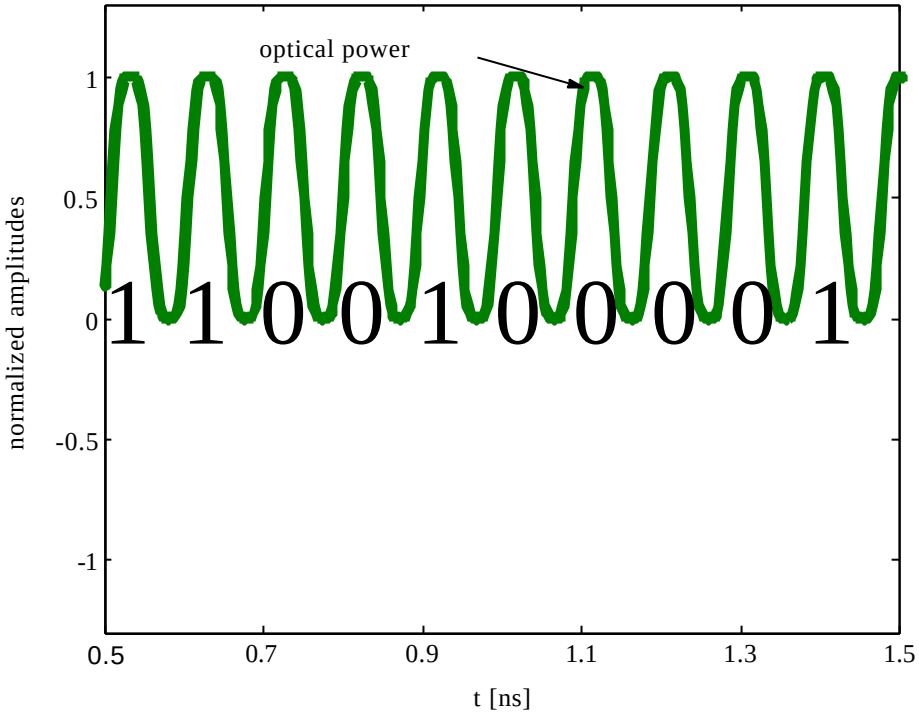
- no carrier recovery and synchronization by differential PSK
- easy reception with direct detection equipment by optical delay-and-add filter
- NEW: no phase modulator used: CF-RZ-DPSK is inherently chirp free

properties of CF-RZ-DPSK

electrical field of CF-RZ-DPSK

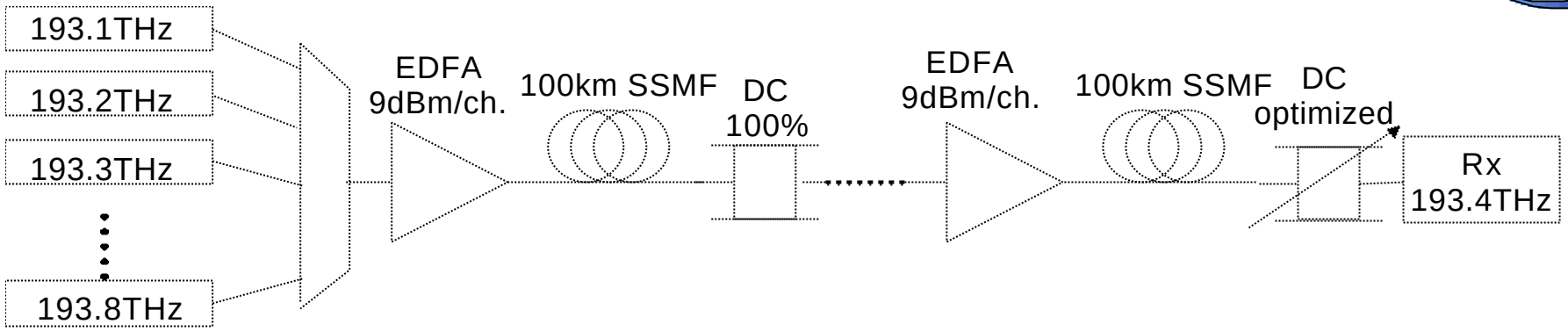


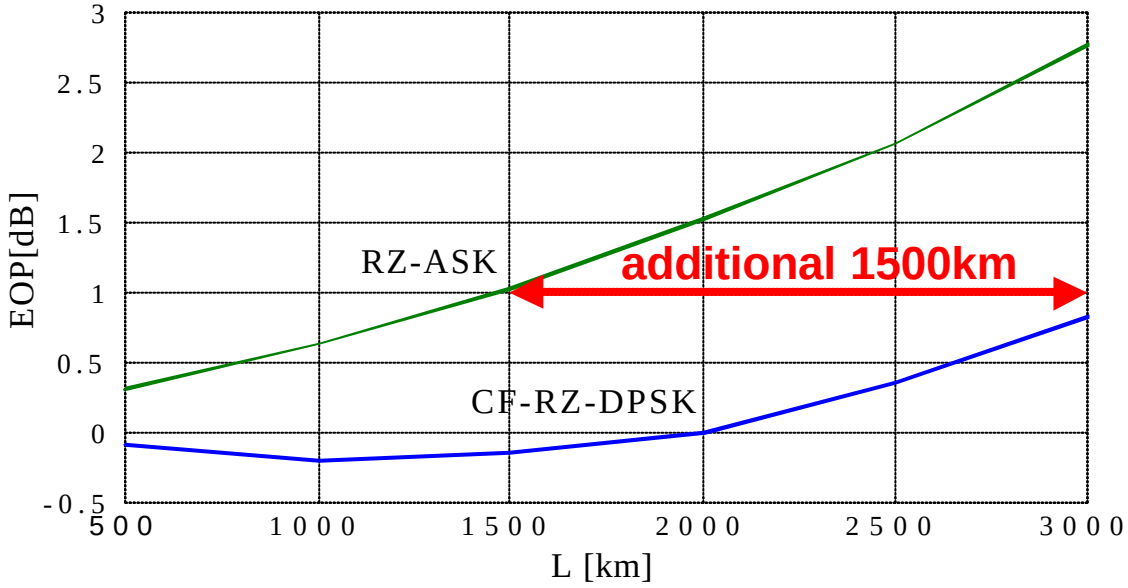
optical power of CF-RZ-DPSK



- optical power signal: only frequency components at ± 10GHz.
- this property makes CF-RZ-DPSK robust towards XPM (see IEEE Photon. Techn. Letters, February 2002, vol. 14, pp.155-157)

simulations: CF-RZ-DPSK&RZ-ASK over 3000km SSMF

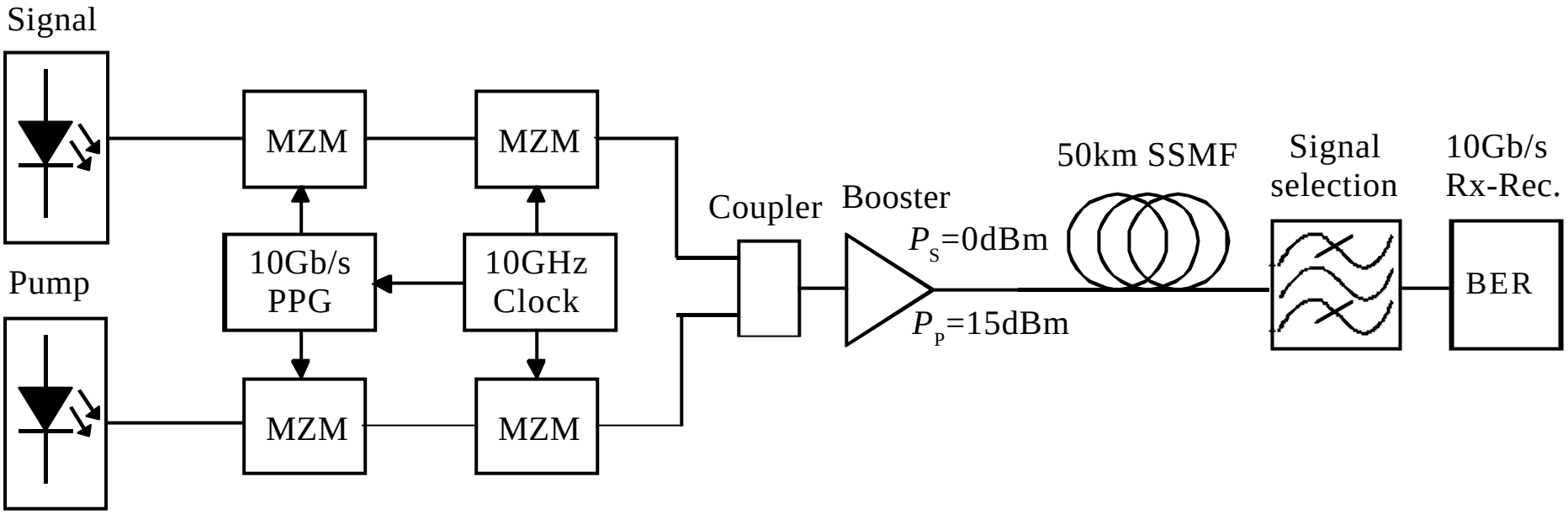




- eye opening penalty of 4th channel over transmission length for CF-RZ-DPSK and RZ-ASK
- 8x10Gb/s with Δf=100GHz, peak power P_{in}=9dBm/ch: full Kerr-nonlinearity (SPM, XPM, FWM):

experimental setup for BER measurement 2x10Gb/s

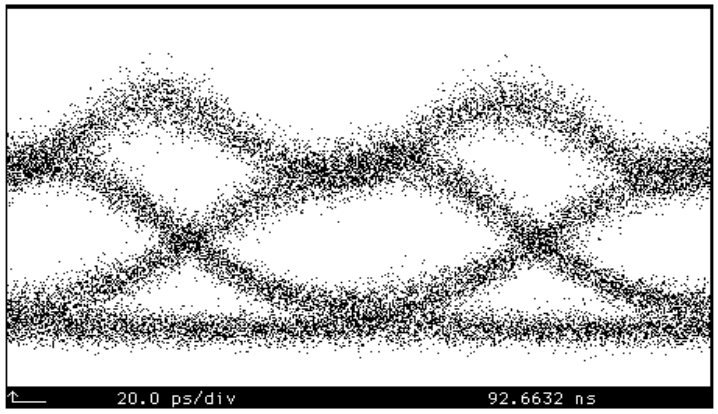
2x10Gb/s, P_s=0dBm and P_p=15dBm, channel spacing 0.32nm over 50km SSMF



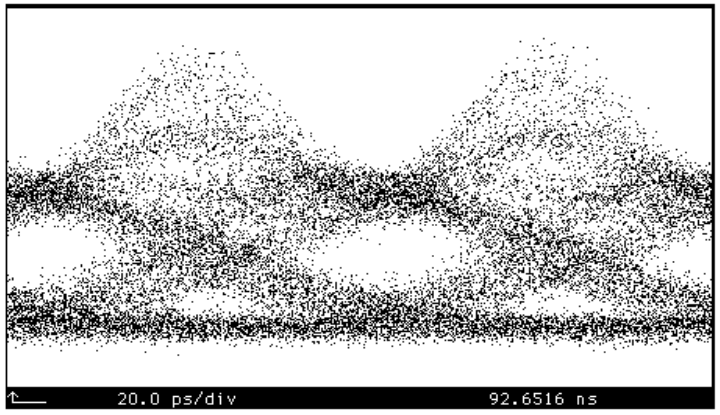
- allows to measure power penalties caused exclusively by XPM
- SPM and FWM do not give rise to a power penalty because P_S=0dBm

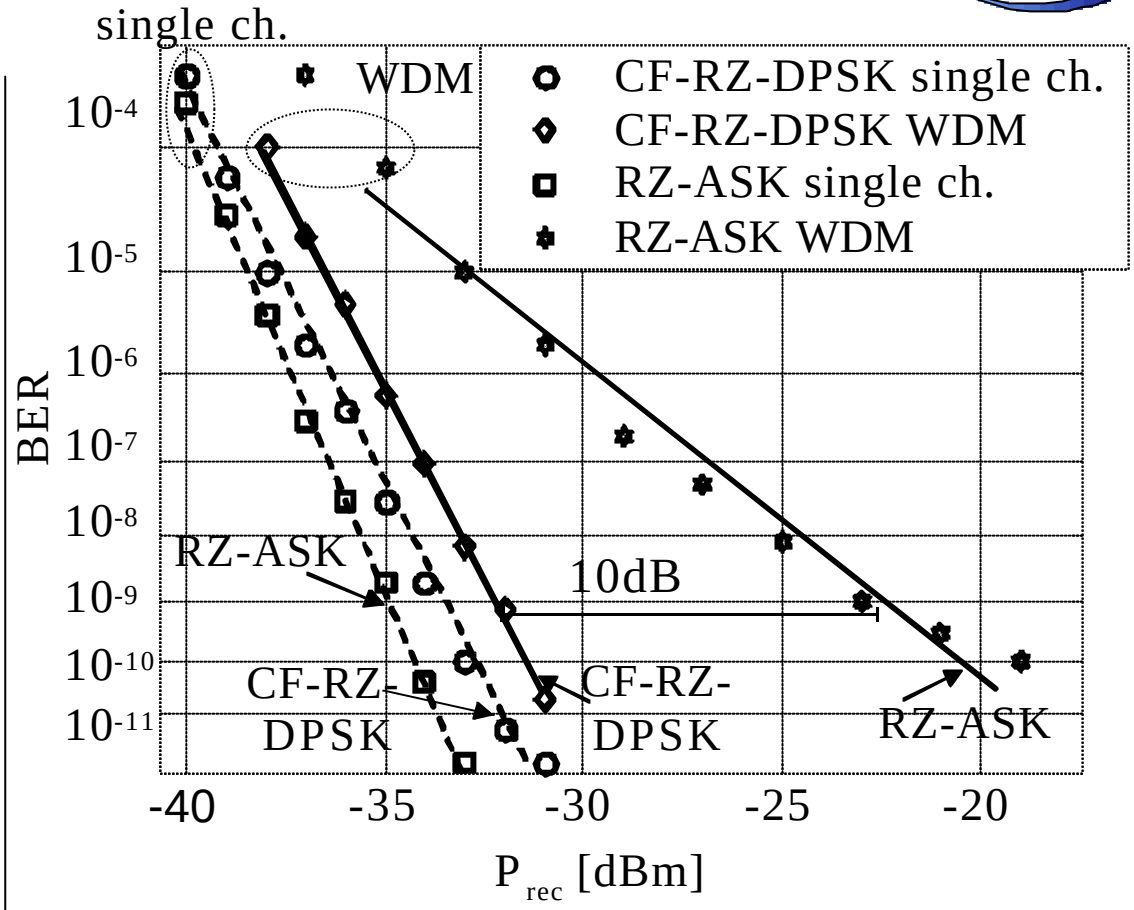
experimental results for 2x10Gb/s system

eye diagram for CF-RZ-DPSK



eye diagram for RZ-ASK





- XPM induced **power penalty** for 2x10Gb/s
  - **10dB for RZ-ASK** compared to CF-RZ-DPSK

over 50km of uncompensated SSMF with DI=0.32nm,

Faculty of Engineering
Christian-Albrechts-University of Kiel

Chair for Communications

conclusion

- for CF-RZ-DPSK we need:
  - differential precoder
  - two MZ-modulators like for RZ-ASK
  - optical delay&add filter in front of standard receiver

- compatible to standard direct detection equipment:
  - no need for local oscillator or synchronization

- benifits of CF-RZ-DPSK:
  - excellent robustness towards XPM