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OFDM for Optical High-Speed Transmission

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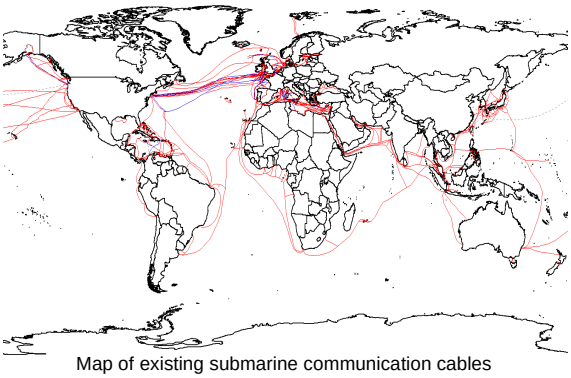
Motivation

- Optical communication systems are widely used for long-distance communications, e.g. for telephony and IP networks
- Existing optical fibers are supposed to be reused for transmission with higher data rates

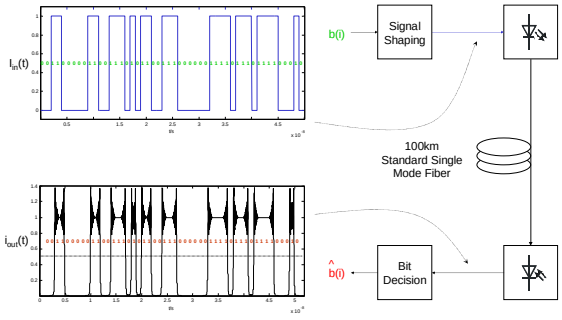


Map of existing submarine communication cables

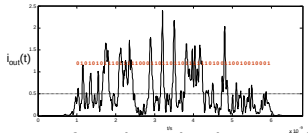
- Current data rates: 50 Mb/s up to 10 Gb/s per fiber (several fibers per cable used and also wavelength multiplexing applied)
- Goal: 40 Gb/s up to 100 Gb/s per fiber

Single Carrier Transmission

- Low attenuation and parallel wave propagation, but distorts signal anyway due to material dispersion
- Example: Transmission using On-Off-Keying (OOK) with 1 Gbit/s over 100 km Standard Single Mode Fiber



  - Output of photodetector shows transients at beginning and end of pulses
- Comparison: Transmission with 10Gbit/s for same scenario:



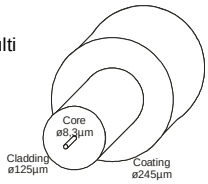
  - Transient phase longer than symbol length
  - Symbols are interfering
- Error-free detection impossible!

Challenges

- Several nonlinearities are introduced by the system, e.g. MZ modulator and photodetection
- Performance of OFDM in presence of these effects has to be evaluated

Properties of the optical fiber

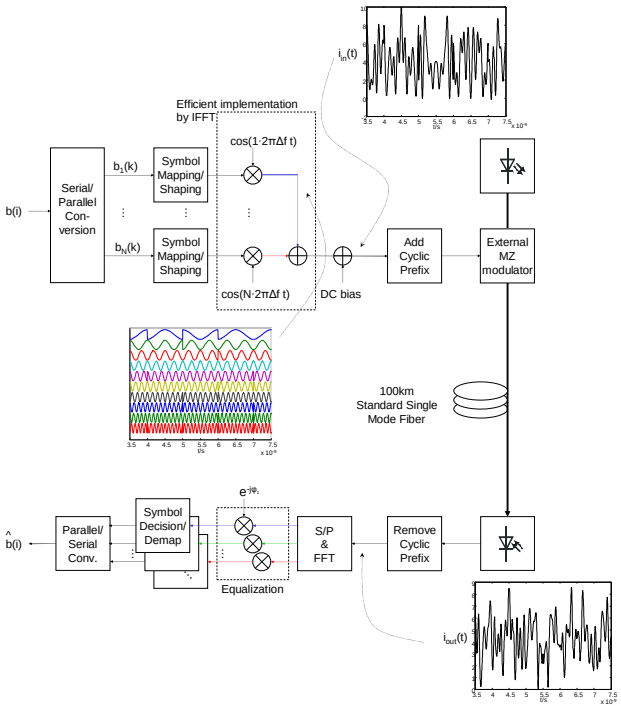
- Standard Single Mode Fiber (SSMF) has a glass core with a diameter of approx. 8µm
  - Core works like waveguide, wave travels straight through the fiber (in contrast to Multi Mode Fiber)
  - Low attenuation
  - Suitable for high speed, long distance data transmission



- Limiting factors:
  - Dielectric (glass or plastic) shows dispersive behavior (see next boxes) → linear effect
  - Nonlinear distortion occurs, especially for high optical powers (>1mW)
  - Noise:
    - is only introduced at the photodetector and inline optical amplifiers
    - dependent on optical power and thus on signal transmitted

Multicarrier Transmission

- Parallel transmission of N bit streams with lower rate using orthogonal frequency division multiplex (OFDM) known from eg. DVB-T, DSL and 802.11a/g WLAN
- Example: N=10 subcarriers with 1 Gbit/s each, spaced by Δf=1 GHz, BPSK



- Easy equalization of chromatic dispersion: Simple phase correction
- Another advantage: Parallel signal processing possible, reduces speed demands on electronic circuits

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