基于光 MIMO 的空分复用信道均衡技术

在光纤空分复用（SDM）系统中，MIMO 信道均衡通常由基于电芯片的 DSP 技术实现，但电芯片的算力受“摩尔定律”的限制而趋于饱和，难以完成长距离、大容量的多芯光纤链路传输的信道均衡，因此将部分信道均衡操作置于光芯片完成是一种潜在替代方案。目前已经报道的几种光芯片架构仅实现了无差模群延迟的信号解扰，无法在光纤通信中实际应用。我们提出了一种新型的光芯片架构来处理带有延迟的串扰信号，其由 MZI、相移器和微环谐振腔构成。该架构在长达 1000 km、DMGD 约为 158 ps 的强耦合光纤链路中实现了信道均衡。

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Channel Equalization of Space Division Multiplexing Based on Optical MIMO

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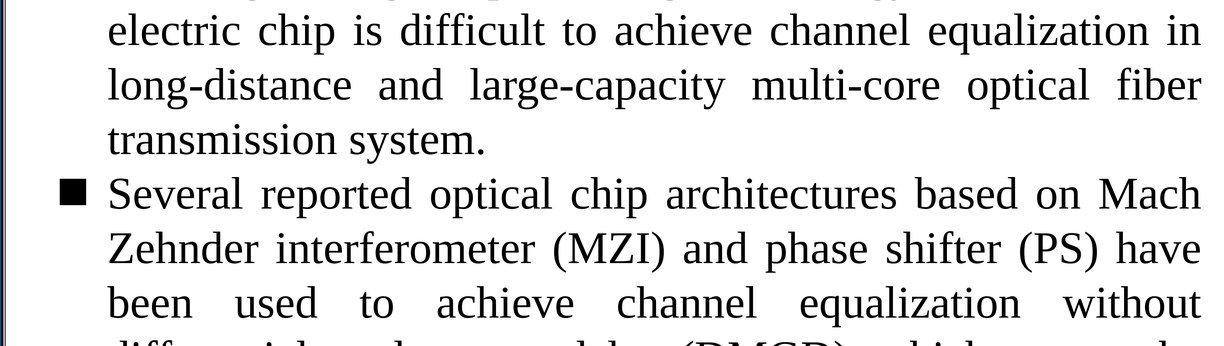
Introduction

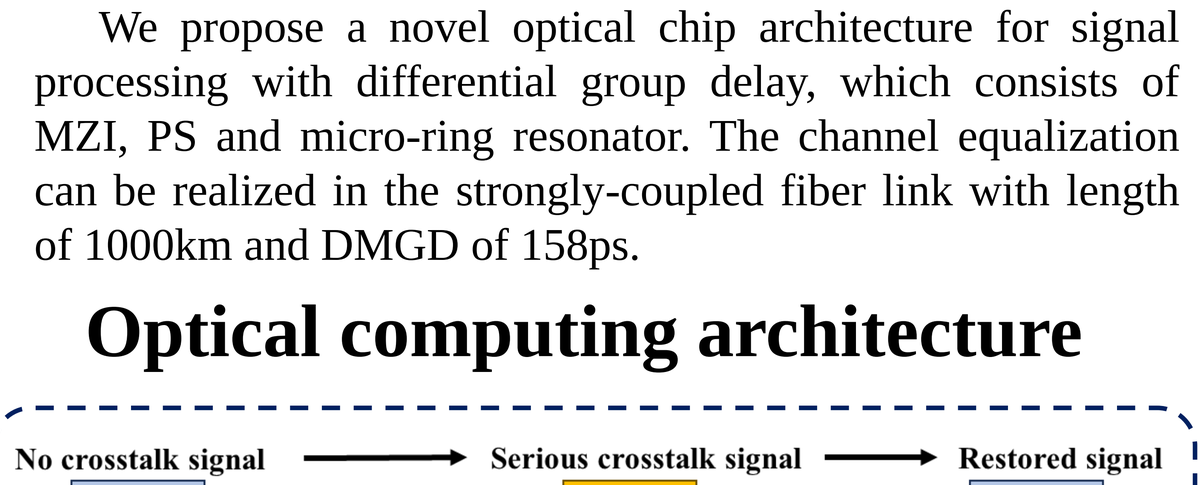
- The transmission capacity of single-mode fiber approaches the Shannon limit.
- The digital signal processing technology based on the electric chip is difficult to achieve channel equalization in long-distance and large-capacity multi-core optical fiber transmission system.
- Several reported optical chip architectures based on Mach Zehnder interferometer (MZI) and phase shifter (PS) have been used to achieve channel equalization without differential-mode group delay (DMGD), which can not be applied in practical fiber-optic communication.

We propose a novel optical chip architecture for signal processing with differential group delay, which consists of MZI, PS and micro-ring resonator. The channel equalization can be realized in the strongly-coupled fiber link with length of 1000km and DMGD of 158ps.

Optical computing architecture



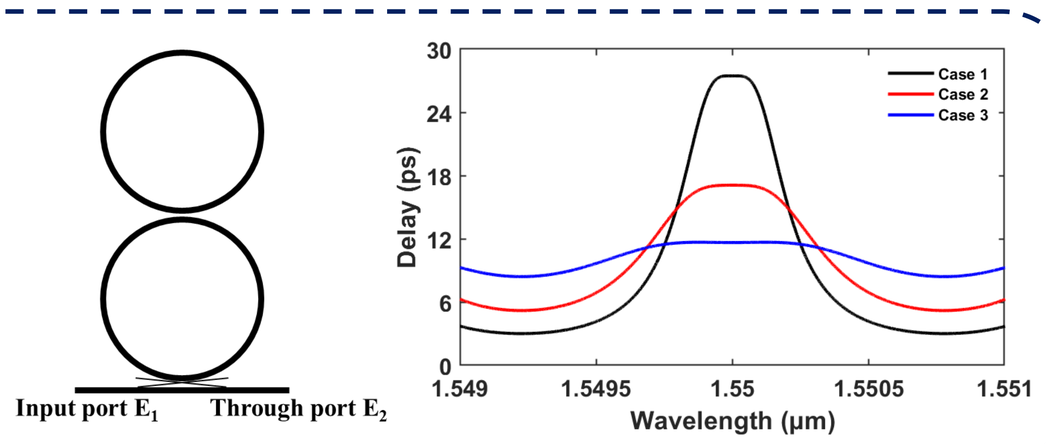
Schematic of the transmission system based on our optical computing chip.



Schematic of "Clements" optical computing cells based on MZI, PS and micro-ring resonator (222 parameters). The intersections represent MZIs, yellow rectangles represent PSs, and the red circles represent cascade double-ring resonators(CDRRs).

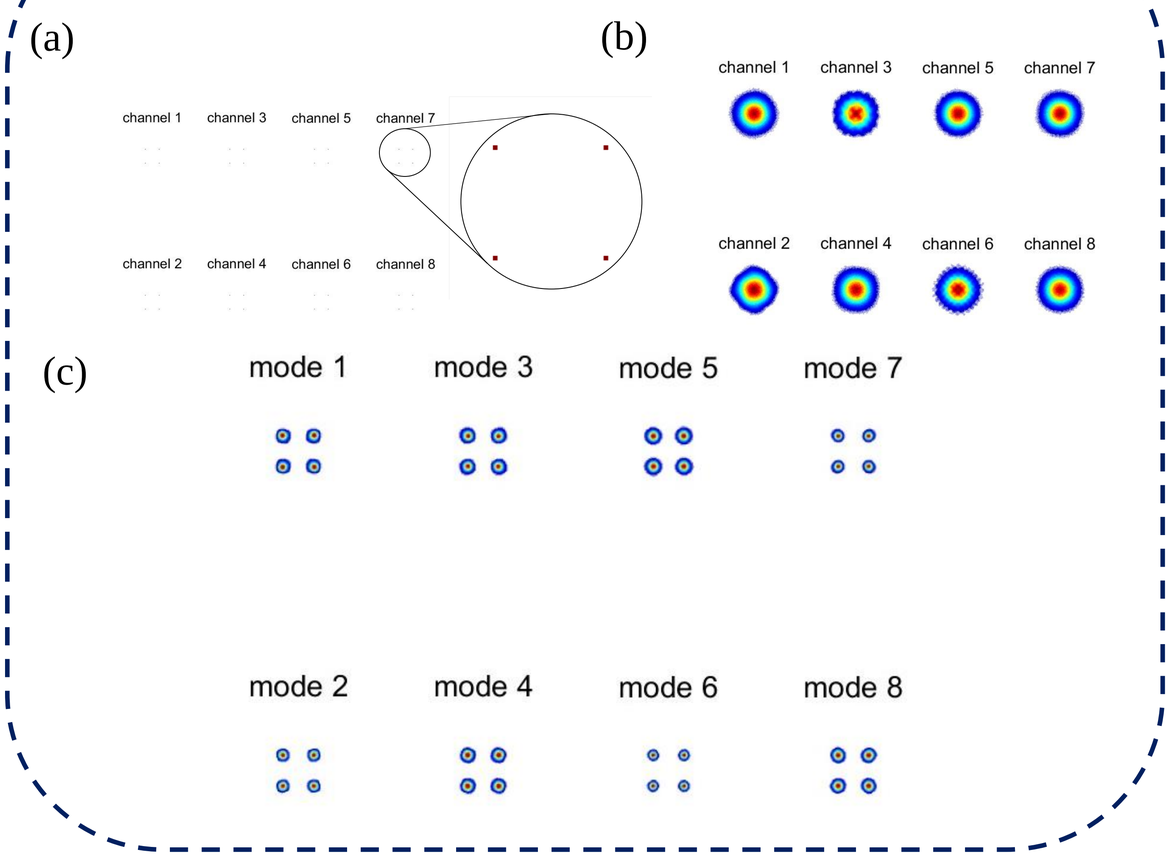
Results

- **Optimization results of the maximum delay-bandwidth-product of a CDRRs**



The 27 ps delay is obtained by CDRRs optimized with multi-population genetic algorithm.

- **The results of channel equalization**



Signal Constellation Diagram. (a) Input signal. (b) Crosstalk signal after 1000 km transmission. (c) The result of channel equalization by the "Clements" optical chip.

- **Optimization method**

NadamWs algorithm, which combines Gaussian Noise, NAG, conjugate gradient algorithm, and parallel computation to jump the local optimal solution and accelerate the convergence, is an efficient algorithm based on Adam algorithm.

Conclusion

- A novel optical computing architectures, which are composed of MZI, phase shifter and micro-ring resonator, are proposed to deal with crosstalk signal with DMGD.
- We have simulated channel equalization wih a 1000 km strongly-coupled multi-core optical fiber link with DMGD of 158 ps.

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