

200-Gbaud Single-Wavelength Direct-Detection Transmission over 75 km C-band SSMF Using a PIC-based Recurrent Spectrum Slicer

H. Liu¹, K. Sozos², I. Teofilovic³, S. Wantee¹, K. R.H. Bottrill¹, S. Malhouitre⁴, S. Garcia⁴, G. Sarantoglou⁵, P. Bienstman⁶, B. Charbonnier⁴, C. Mesaritakis⁵, C. Vigliar³, F. Da Ros³, A. Bogris², P. Petropoulos¹

¹Optoelectronics Research Centre, University of Southampton, Southampton SO17 1BJ, United Kingdom
²Department of Informatics and Computer Engineering, University of West Attica, Aghiou Spyridonos, 12243, Egaleo, Athens, Greece
³DTU Electro, Technical University of Denmark, Ørstedts Plads, DK-2800 Kgs. Lyngby, Denmark
⁴CEA-Leti, University of Grenoble Alpes, Grenoble, France
⁵Department of Biomedical Engineering, University of West Attica, Aghiou Spyridonos, 12243, Egaleo, Athens, Greece
⁶Ghent University/imec, Technologiepark-Zwijnaarde 126, B-9052 Ghent, Belgium
 *hl19n23@soton.ac.uk

Abstract: We demonstrate C-band IM/DD transmissions of 160-GBaud (175-GBaud) PAM-4 over 50 km (25 km) and 200-GBaud OOK over 75 km, with dispersion-induced power fading effectively mitigated by a silicon-photonic recurrent optical spectrum slicer, achieving a dispersion tolerance up to 2.4×10^5 GBd · ps/nm.

1. Introduction

The growing demand for data-intensive workloads is driving the need for energy-efficient optical links. Intensity modulation/direct detection (IM/DD) with higher-order pulse-amplitude modulation (PAM) remains the dominant solution for inter-data-center interconnects. However, IM/DD suffers from limited chromatic-dispersion tolerance, which worsens at higher symbol rates [1]. Transmitter-side precoding [2] and receiver-side digital equalization [3] can partially mitigate dispersion-induced power fading, but their complexity, latency, and energy overhead hinder adoption. Recently, integrated and tunable optical pre-processing units, which compensate impairments by acting on the full complex field before photodetection, have gained interest. Recent optical analog equalizers have achieved up to 100 GBaud [4] and 128 GBaud [5] transmission over 5 km, based on either delay-line optical taps or adaptive-chirp modulation. Nevertheless, extending delay-line-based schemes to longer reach remains challenging due to cumulative loss and OSNR degradation, while chirp-based approaches are constrained by limited compensation range. Hybrid optical–electronic equalization addresses these limitations by combining optical pre-processing with digital post-equalization [6, 7]. Among these, the frequency-diversity approach is especially promising, merging complementary spectral components to suppress dispersion-induced fading without noise amplification. However, recent demonstrations [8] required extra optical branches, multiplexing, and complex DSP synchronization, increasing system cost.

In contrast, a frequency-diversity receiver based on the recurrent optical spectrum slicing (ROSS) scheme [9]

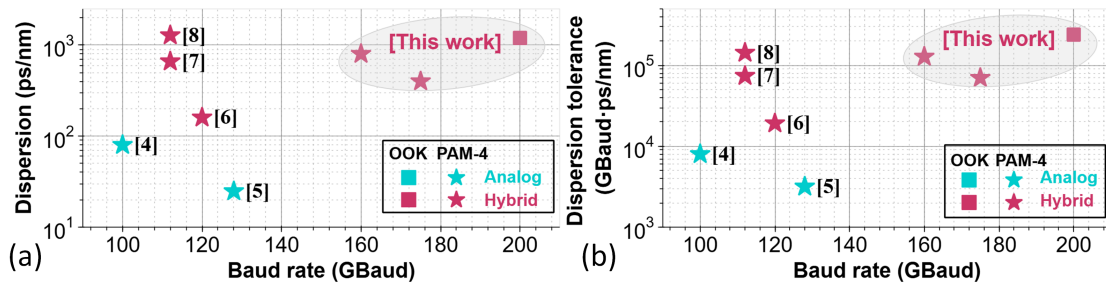


Fig. 1. Recent demonstrations of purely optical analog and hybrid optical-electronic equalization in IM/DD links > 100 GBaud (a) Dispersion vs. baud rate. (b) Dispersion tolerance vs. baud rate, indicating improved high-speed signaling capability.

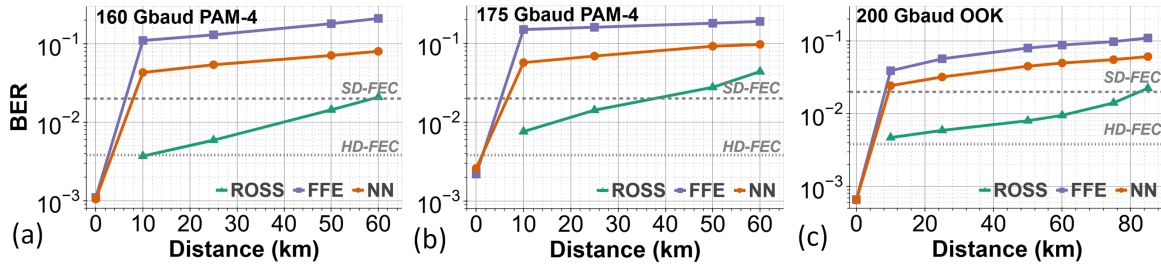


Fig. 3. BER versus transmission distance for (a) 160 Gbaud PAM-4, (b) 175 Gbaud PAM-4, and (c) 200 Gbaud OOK, comparing equalization schemes: ROSS, FFE, and NN-based equalizer.

with multiple notches. This complementary behavior enhances frequency diversity and mitigates power fading after digital equalization.

Building on these results, we evaluated the ROSS receiver in high-speed PAM-4 and OOK transmissions over 10–85 km. Its performance was benchmarked against digital-only equalization, including a linear FFE with up to 801 taps and a neural network (NN) equalizer with two hidden layers and an input size matching the FFE length. While highly complex, the NN equalizer represents a lower bound on the BER achievable with DSP equalization alone. For each configuration, the optimal number of T-spaced FFE taps was selected to mitigate inter-symbol interference and bandwidth limitations – ranging from up to 251 taps per node for 160 Gbaud PAM-4 at 50 km to 451 taps per node for 200 Gbaud OOK at 75 km, consistent with the channel memory – with approximately 50 additional taps used to compensate for bandwidth limitations. As shown in Fig. 3(a), the ROSS receiver achieves BERs below the SD-FEC threshold (2×10^{-2}) even after 50 km at 160 Gbaud, demonstrating effective dispersion mitigation with minimal hardware complexity. In contrast, both the NN and FFE fail to reach this threshold at any tested distance or baud rate. At 175 Gbaud PAM-4, ROSS maintains a BER below the SD-FEC limit up to 25 km. To probe electrical bandwidth limits, 200 Gbaud OOK transmission was also tested. Despite B2B constraints (6×10^{-3}) due to limited front-end bandwidth, ROSS maintains a BER below the SD-FEC threshold up to 75 km. Degradation beyond this distance mainly arises from >15 dB fiber loss and the resulting OSNR penalty after amplification. Losses on the ROSS chip may be further reduced on low-loss platforms such as Si_3N_4 , while power consumption remains only $\approx 10\%$ above current IM/DD transceivers [11], which is still more efficient than maximum-likelihood sequence estimation-based solutions. The compact optical equalizer ($< 0.3 \text{ mm}^2$) consumes only 50 mW for two filters, with potential for further reduction via optimized heater design.

4. Conclusions

By introducing frequency diversity through the ROSS architecture, we mitigated severe dispersion-induced power fading without relying on complex DSP. The two-node ROSS receiver sets a new benchmark for high-baud-rate IM/DD transmission, demonstrating exceptional dispersion tolerance and offering flexibility in baud rate, modulation format, and transmission distance beyond that of dispersion-compensating fibers. With emerging 150-GHz electronic front-ends and potential co-integration with photodiodes and DSP, the ROSS architecture could enable next-generation 800 Gb/s/ λ IM/DD links. Overall, these results position ROSS as a compact, energy-efficient, and versatile platform readily extendable to future passive optical network and data center optical interconnects.

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References

- [1] Di Che and Xi Chen. In: *J. Light. Technol.* 42.2 (2023), pp. 588–605.
- [2] Xiong Wu et al. In: *Opt. express* 31.11 (2023), pp. 17759–17768.
- [3] Dan Li et al. In: *J. Light. Technol.* 43.19 (2025), pp. 9148–9156.
- [4] Benshan Wang et al. In: *2025 Optical Fiber Communications Conference and Exhibition (OFC)*. 2025, pp. 1–3.
- [5] Yu Li et al. In: *Nat. communications* 16.1 (2025), p. 6268.
- [6] Qibing Wang et al. In: *Opt. Lett.* 50.5 (2025), pp. 1561–1564.
- [7] Paikun Zhu et al. In: *J. Opt. Commun. Netw.* 16.1 (2024), A24–A32.
- [8] Paikun Zhu et al. In: *Optical Fiber Communication Conference*. Optica Publishing Group. 2025, Th1K–4.
- [9] I. Teofilovic et al. In: *51th European Conference on Optical Communication (ECOC)*. 2025, p. M.03.03.4.
- [10] Kostas Sozos et al. In: *Commun. Eng.* 1.1 (2022), p. 24.
- [11] Kostas Sozos et al. In: *J. Light. Technol.* 42.22 (2024), pp. 7807–7815.