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Atmospheric turbulence mitigation using an integrated beam recombiner

The Reid Photonloop free-space optical (FSO) communication link has been finally implemented. Initial characterization of the propagation channel has identified turbulence-induced signal degradation as a critical performance-limiting factor, particularly through fluctuations in fiber-coupled power.

To mitigate these effects, analog-domain correction subsystems are under investigation. Prototype beam recombiner [1] photonic integrated circuits (PICs) have been sent to manufacture in indium phosphide (InP) and silicon nitride (SiN) platforms. The system will integrate spatial light modulators (SLMs) and the PICs discussed with a coherent receiver module employing dissipative Kerr soliton (DKS) frequency combs as light source. Dedicated pilot tones will be used at the receiver side to serve as stable local oscillators after amplification, enabling precise carrier synchronization [2].

Preliminary analysis indicates this methodology could substantially offload digital signal processing (DSP) workloads by assisting frequency offset estimation algorithms [3], while simultaneously compensating for turbulence-induced distortions in the analog domain. This hybrid correction strategy aims to demonstrate enhanced resilience to atmospheric perturbations while reducing computational complexity in DSP chains, particularly for high-bandwidth coherent schemes.

References

[1] Miller, D. A. B. (2013). Self-aligning universal beam coupler. Optics Express, 21(5), 6360.
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[3] Torres-Company, V., Schroder, J., Fulop, A., Mazur, M., Lundberg, L., Helgason, O. B., Karlsson, M., & Andrekson, P. A. (2019). Laser Frequency Combs for Coherent Optical Communications. Journal of Lightwave Technology, 37(7), 1663–1670.

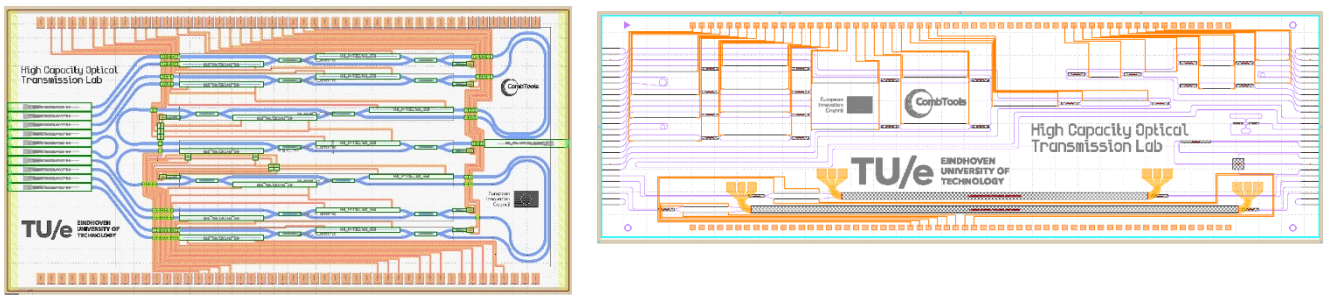

Figure 1: Beam recombiner PICs