

Integrated Silicon Photonic IQ Modulator for Pattern-Effect Suppression in Decoy-State QKD

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Abstract

We report, to the best of our knowledge, the first integrated silicon photonic modulation chip for pattern-effect suppression in decoy-state quantum key distribution (QKD) systems. The pattern effect originates from inter-symbol correlated intensity fluctuations that threaten decoy-state security. An IQ modulation architecture is monolithically integrated into the silicon photonic intensity modulation stage to suppress such correlations. The chip supports three polarization state protocols and integrates a conventional Mach-Zehnder modulator (MZM) for comparison. The system operates at 1.25 GHz, while the carrier-depletion modulator (CDM) exhibits an electro-optic bandwidth of approximately 3 GHz. Despite this, the first-order intensity correlation strength is reduced below 0.2% for both signal (S) and decoy (D) states, compared to >11% for the MZM in the D state. The second-order correlation strength is below 0.4% for S states and below 2.4% for D states. An intensity extinction ratio >27 dB and PER >23 dB are achieved, demonstrating effective on-chip suppression of pattern-induced correlations.

References

- [1] Gao, Y. and Yuan, Z., Optics Letters, 48(4) (2023) 1068.
- [2] Trefilov, D. et al., Optica Quantum, 3(5) (2025) 417.

Figures

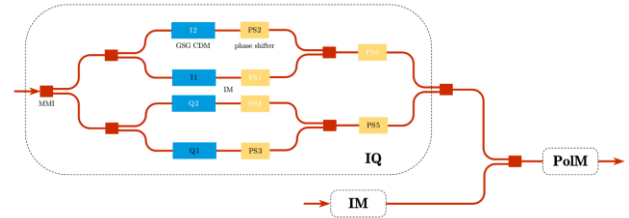


Figure 1: Chip optical schematic.

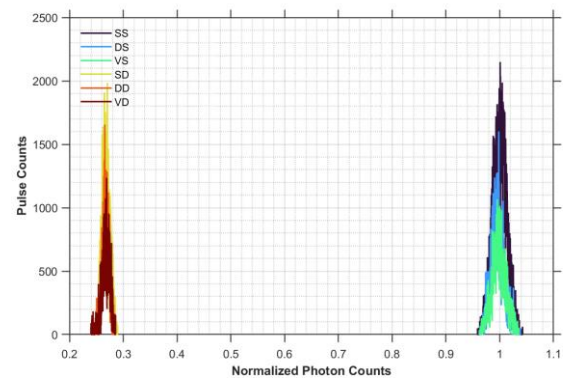


Figure 2: Statistical distribution of the first-order correlation of IQ measured by SNSPD.

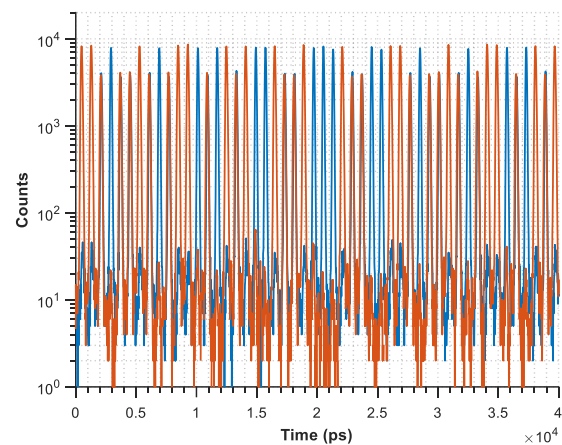


Figure 3: Time-domain histogram of three polarization state modulation.