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An ultra-sensitive balanced detector with low noise for continuous-variable quantum key distribution

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Continuous-variable quantum key distribution (CVQKD) is of great significance for future information security. The CVQKD can achieve higher key rates over short distances and possesses the potential to communicate in daylight. Although the existing commercial balanced detectors are well established, they are not suitable for CVQKD because their CMRR is usually less than 40dB and the sensitivity is low. Therefore we developed a dedicated balanced detector for our CVQKD experiments with very low noise in a gain of 3.2E5 V/W.
Due to signal tail, charge-sensitive amplifier is no longer appropriate as the pulse repetition frequency in experiments increased from hundreds of KHz to dozens of MHz. To solve the problem, we use trans-impedance amplifier instead. A two-stage amplification circuit structure makes it possible to achieve an ultra-high sensitivity of 3.2E5 V/W while keeping an effective bandwidth of 70MHz.
This paper introduces our low noise balanced detector. A JFET is connected between photodiodes and transimpedance amplifier to suppress the amplifier leakage current, reducing electrical noise. Benefit from this design, the RMS of noise voltage is 5.5mV, and it means an ultra-low noise equivalent power density of 2E-12 W/√Hz, only half of common low-noise commercial detectors. Two specially selected InGaAs PIN photo diodes are serially connected for photocurrent reduction and the CMRR eventually reached 55dB, about 15dB higher than commercial detectors. Compared with the existing slow CVQKD experiments performed in a stable fiber, our sensitive low-noise detector will be helpful to achieve a faster CVQKD in complex channel.

Minioral

Yes

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