The experimental investigation of homodyne detector noises for measuring the quantum state of light

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Balanced homodyne detector [1, 2, 3] is used in quantum optics and quantum information theory for measuring the electromagnetic field quadrature signal. According to the measurements, it is possible to retrieve information about the quantum state of the measured signal. With the development of quantum optics, performance requirements homodyne detectors increases. The design of modern homodyne detectors based on four criteria: bandwidth and the flat part of frequency response, the ratio of the electron quantum noise, the come-mode rejection ratio (CMRR ratio), the quantum efficiency of the diodes.

In this study we investigated the factors affecting the value of the noise in the scheme of homodyne detector and have developed the scheme, taking into account these factors. Scheme for researching noises and modeling the behavior of these noise is currently used in the homodyne detector circuit [1]. One of the noise occurrence factors which is difficult to describe mathematically is circuit topology. Analysis of this noise factor has been carried out experimentally [3, 4, 7]. We have developed a new scheme that takes into account all the drawbacks of the existing topology.

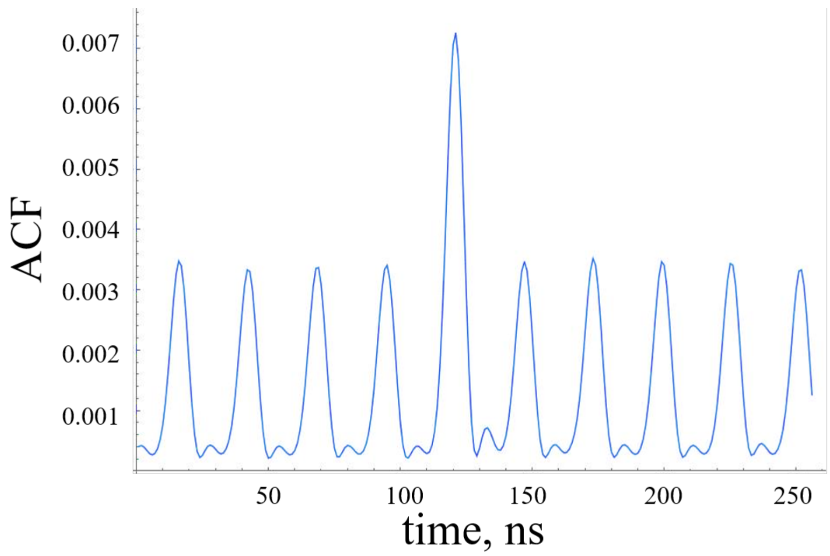

Figure 1: Output auto-correlation function of a single photon from the time.

Fig. 1 shows the dependence of the output auto-correlation function (ACF) from the time [6] in the developed scheme, when the input signal is a single photon. Based on this dependence can be estimated minimum value of signal to noise ratio [8].

Using spectrum presented in fig. 2 it's possible not only to determine the minimum value of the signal-noise ratio but also calculate its actual value.

The electronic noise of new scheme is 2.5 times less than the original, which indicates a significant topology impact of this parameter. The signal-noise ratio of this scheme, resulting in the single photon detection, indicates the possibility of its application for measuring the quantum state of light.

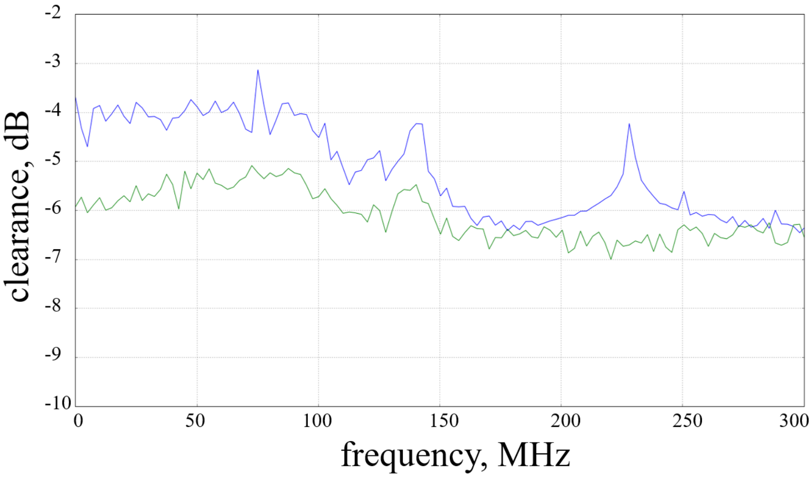

Figure 2: Frequency spectrum of electronic noises (green) and optical noises (blue).

References

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