Metrological Characterization of a Commercial SNSPD System at 1550 nm for Quantum Applications

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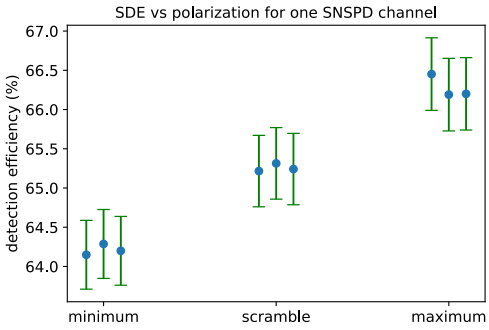
We present a comprehensive metrological assessment of a set-up for characterizing SNSPDs at 1550 nm, which has been designed to address the demands of validating the implementation security of quantum key distribution. In addition, this set-up is used for an in-depth analysis of the system detection efficiency (SDE) of a commercial broadband SNSPD system [1], traceable to the primary standard for optical power, the cryogenic radiometer, through an absolute calibration of a reference power meter. The combination of the well-established double attenuator technique [2] with an optical switch to change between the reference optical power meter and the device under test enables fully automized measurements, including evaluating the polarization dependency and dynamically scanning over count rate, wavelength, SNSPD bias current and trigger level of the timing electronics. We present extensive pre-characterizations performed for assessing the measurement uncertainty budget for the system detection efficiency characterization. The optical switch was characterized with respect to its differential insertion loss, repeatability and its polarization dependence. The repeatability of the fiber connectors at the reference power meter and device under test was included. The uncertainty of the combined attenuation of the double attenuator and the uncertainty contribution of the power meter (including absolute calibration, nonlinearity, discontinuity) has also been assessed. In addition, the uncertainty arising from polarization drifts during the measurement was considered. In total, we achieve a combined relative standard uncertainty (k=1) of approximately 1 % for a wide range of parameters.

The four channels of the SNSPD system reached a system detection efficiency of (64.98 ± 0.49) %, (66.99 ± 0.48) %, (67.37 ± 0.47) % and (68.70 ± 0.48) % at a bias current of 90 % of the critical current. We found a relative spread between the lowest and highest system detection efficiency for a full Poincarè sphere scan of 3.17 % to 7.64 %. Accurate determination of the maximum and minimum signal was achieved through a two-dimensional fit to the measurement data on the Poincaré sphere. The observed low polarization dependence highlights the suitability of this broadband waveguide-integrated detector for polarization-sensitive applications. In addition, we present measurements of the timing jitter and dead time of the SNSPD system.



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References

[1] Martin A. Wolff et al., Appl. Phys. Lett. 118, 154004 (2021).

[2] M. López et al., J. Mod. Opt. 62(20), 1732-1738 (2015).