NOTICE

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HIGH PERFORMANCE FIBER-BASED OPTICAL COHERENT DETECTION

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Abstract

Youming Chen, Ph. D. Candidate.

The sensitivity of signal detection is of major interest for optical high speed communication systems and Light Detection And Ranging (lidar) systems. Sensitive receivers in fiber-optical networks can reduce transmitter power or amplifier amplification requirements and extend link spans. High receiver sensitivity allows links to be established over long distances in deep space satellite communication systems and large atmospheric attenuation to be overcome in terrestrial free space communications. For lidar systems, the sensitivity of signal detection determines how far and how accurately the lidar can detect the remote objects.

Optical receivers employ either coherent or direct detection. In addition to amplitude, coherent detection extracts frequency and phase information from received signals, whereas direct detection extracts the received pulse amplitude only. In theory, coherent detection should yield the highest receiver sensitivity. Another possible technique to improve detection sensitivity is to employ a fiber preamplifier. This technique has been successfully demonstrated in detect detection systems but not in coherent detection systems. Due to the existence of amplified spontaneous emission (ASE) inside the amplifier, the sensitivity of coherent detection varies with the data rate or pulse rate. For this reason, coherent detection is not used in applications as commonly as direct detection.

We investigate the performance of optical coherent detection employing a fiber amplifier and time-domain-filter. The fiber amplifier is used as the optical preamplifier of the coherent detection system. To reduce the noise induced by the preamplifier to a maximum extent, we investigate the noise properties for both single pass amplifiers and double pass amplifiers. The relative intensity noise and linewidth broadening caused by ASE are experimentally characterized. The results show that the double pass amplifier has less phase distortion. To further reduce the effects of ASE affections, filters in both time and frequency domain are explored. The spectral bandpass filter can be used to filter out out-band unnecessary spectral components, which are mostly generated by ASE. The time-domain filter can reduce the in-band but no-in-pulse power, which is also contributed mostly by ASE.

The single photodetector and balanced photodetectors are studied in this dissertation research. The performance of the proposed optical coherent detection system is studied both theoretically and experimentally. This doctoral research demonstrates that the combination of a fiber preamplifier and time-domain filter can improve optical coherent detection performance. Improvements of 1 to 3 dB have been demonstrated experimentally with different detection designs using single-pass and double-pass amplifiers, a single photodetector, and balanced photodetectors. The double-pass preamplifier system with balanced coherent detection demonstrated the highest sensitivity.