**Abstract**

This dissertation presents the results of research on the optimization of long-distance fiber-optic links for time and frequency transfer, exploiting bidirectional optical amplifiers. Solutions of this type require special attention in terms of amplifiers' gain selection that ensure the highest possible quality of transmitted signals, which results in link stability and reliability. Although this selection can be made using simulation methods, due to the lack of reliable data for modeling the link, these methods have limited accuracy. Therefore, it is reasonable to carry out this process in a physical link, based on the results of ongoing measurements of its performance quality.

The degradation of link quality is associated with the occurrence of undesirable phenomena, such as single and double Rayleigh scattering, amplified spontaneous emission, or Brillouin scattering. Optimization aims to find a set of gains that minimize the aforementioned undesirable phenomena, while ensuring a large margin within which the quality of signals transmitted over the link can change without affecting the operation of the entire transmission system. To assess the quality, the results of measurements of the phase fluctuation of transmitted signals, i.e., jitter, performed at the ends of the link can be used, but this requires the link to be brought to an operational state beforehand. Therefore, an initialization procedure has been proposed that allows the gain of successive amplifiers to be set "one after another" in such a way that the optical power in the next device reaches a value above the accepted threshold, related, for example, to the sensitivity of the measuring circuits used. After initializing the link, it can be optimized in accordance with the developed procedure, which consists of making minor adjustments to the gain of successive amplifiers, each time checking their impact on the quality of the transmitted signals. The decision to maintain or withdraw the correction is made on the basis of the jitter measurement results from both ends and using the minimax criterion or a simplified criterion (analysis of the root sum of squares of the measured jitter values). The situation in which in which jitter measurement is performed only at one end of the link was also considered. The results of the research confirmed the possibility of effective optimization and obtaining consistent results, no matter what the decision-making criteria were used, as well as regardless of the sequence in which amplifier gain corrections are introduced.

Among the analyzed undesirable phenomena, particular attention was paid to stimulated Brillouin scattering, which may disturb or even disable the operation of the link. The dissertation presents the results of simulation and experimental studies on the conditions under which the phenomenon occurs and the possibilities for its early detection. It was found that for low values of the scattered signal power, the nonlinearity of the phenomenon is less pronounced than when scattering occurs intensively. This allowed to propose a detection method based on the analysis of increase in the current of the photodiode in which, in which signals from nonlinear Brillouin scattering and linear Rayleigh scattering are beaten. If the current increases linearly in relation to the increase in signal power that is subject to scattering (e.g., due

to increased amplifier gain), it can be assumed that Brillouin scattering does not occur in a way that could disturb the operation of the link.

The last part of the dissertation refers to a case in which the quality of transmitted signals is measured not in boundary modules, but locally in the amplifiers. The research conducted has shown that it is possible to replicate the conditions at the ends of the link to the extent that allows for a correct assessment of its performance. On this basis, optimization can be carried out without the need to ensure communication between the devices installed in the link.