Evaluation of Nonlinear Effect Impact on Optical Signal Transmission over Combined WDM System

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Abstract— The transmission throughput over the existing wavelength division multiplexed (WDM) fiber-optic transmission systems (FOTS) can be increased in the following manner: using higher per channel bitrates, narrower channel spacing or wider amplifier bandwidth. The first approach used for achieving a higher system capacity throughput was the introduction into the systems new channels with higher per channel bitrate since such solution can be deployed on existing FOTS and is capable with current network architecture. Although it is a short term solution since it requires free and for transmission suitable band. Such band is limited not only with the "WDM-suitable" bandwidth of silica optical fiber but also with the bandwidth of FOTS elements such as inline optical amplifier (e.g., erbium doped fiber amplifier (EDFA)) and dispersion compensation module (e.g., based on the use of dispersion compensating fiber (DCF) or chirped fiber Bragg grating (FBG)). So, the increase of "for WDM-suitable" band utilization (or increase of spectral efficiency) allows to reduce the number of channel required for the transmission of the same data body as compared with relatively spectrally inefficient WDM systems (i.e., SE < 0.2 bit/s/Hz). As well as allows postpone the shortage of "for WDM-suitable" band and avoid the deployment of new optical fibers. That is why the method of increase of transmissions SE has some characteristics that are adequate for future needs and requirements of continuous traffic growth. Obviously, it is necessary to evaluate the impact of all fiber nonlinearities to optical signal transmission over the purposed model of combined WDM system designed for the future optical transport networks.

The authors have investigated the impact of nonlinear distortions to optical signal transmission over proposed configuration of combined wavelength division multiplexed (WDM) fiber-optic transmission system (FOTS). In chosen model of ultra-dense combined WDM system optical signals are transmitted with two different per channel bitrates (i.e., 10 and 40 Gbit/s) and three different optical signal modulation formats are used for the encoding of transmitted data body (i.e., non-return to zero encoded on-off keying or NRZ-OOK, orthogonal polarization shift keying or 2-POLSK and NRZ encoded differential phase shift keying or NRZ-DPSK) and in addition "non ITU-T" defined minimum and equal frequency intervals are used for the channels separation. Generally, investigated 9-channel combined WDM system complies with the following configuration scheme: [1st ($fc = 193.025$ THz), 4th and 7th channels: NRZ-OOK, $R = 10$ Gbit/s] — [2nd ($fc = 193.100$ THz), 5th and 8th channels: 2-POLSK, $R = 40$ Gbit/s] — [3rd ($fc = 193.175$ THz), 5th and 9th channels: $R = 40$ Gbit/s]. The developed concept of the combined WDM systems is offered as model for the future design of optical transport networks. This research revealed that 2-POLSK modulated signals are more susceptible to the impact of SPM in such ultra-dense combined transmission mode than, e.g., NRZ-DPSK signals.