Simulation of RIN Transfer in coherent optical communication links with distributed Raman amplification

T. M. Fedotenko[1,2], A. E. Bednyakova[1,2], M. Tan[3], V. Dvoyrin[3], M.P. Fedoruk[1,2], S.K. Turitsyn[3,1],

1. Novosibirsk State University, Novosibirsk 630090, Russia

2. Institute of Computational Technologies, SB RAS, Novosibirsk 630090, Russia

3. Aston Institute of Photonic Technologies, Aston University, Birmingham B4 7ET, UK

It is well known that degradation of an information signal during its propagation along the optical fiber communication link affects the achievable bit rate. In practice, any real transmission link introduces signal distortions that can be either recoverable (e.g., dispersive broadening) or not fully removable (e.g., noise). The sources of such unremovable distortions leading to loss of information are: amplified spontaneous emission (ASE), double Rayleigh scattering (DRS), RIN (relative intensity noise) transfer and other effects. Knowledge of noise properties of the distributed Raman amplifiers (DRAs) are important for Raman-based communication systems [1]. RIN transfer from pump to signal in DRAs has studied both numerically [2] and analytically [3] as a main factor limiting telecom applications of such amplifiers. However, the most common analytical and numerical models are based on balance (average-power) equations and do not describe evolution of phase modulated signals along the fiber under influence of dispersive and nonlinear effects.

In this work we investigate RIN transfer in the practical Raman fiber amplification systems and perform full numerical modelling based on the generalized nonlinear Schrödinger equation taking into account dispersion, Kerr nonlinearity and Raman gain. For the first time to the best of our knowledge, we use the developed model to calculate the RIN transfer from pump to phase modulated signals (RZ-QPSK) in coherent transmission systems. Bidirectional distributed Raman amplification scheme presented in [4] includes Bi-doped low RIN (-140 dB/Hz) fiber laser [5] as a forward pump and distributed feedback (DFB) laser as a backward pump. Figure 1a depicts RIN of the forward pumps. Significantly, that RIN distribution of Bi-doped laser is not homogeneous and includes a narrow noise component at low frequencies, below 20 MHz. The output signal RIN, shown in Fig.1b (green line), has the same low frequency noise component, leading to Q-factor degradation, which agrees well with the experimental data. In numerical modelling we vary the amplitude of low-frequency noise and demonstrate that its decrease below –35 dB/Hz makes the process of RIN transfer almost negligible and provide output signal RIN similar to case of using only backward pumping (Fig.1b, red line).

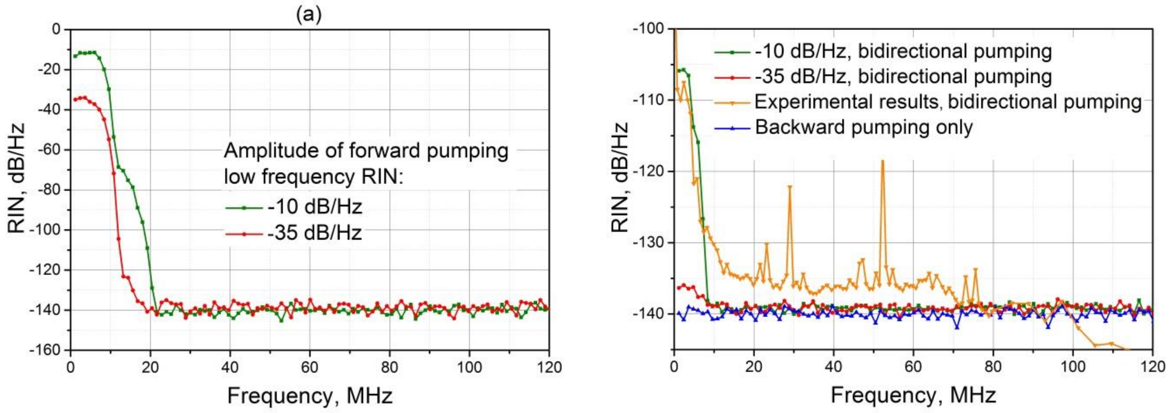

Fig. 1 (a) RIN spectra of forward pump laser at the input end of transmission link. (b)Comparison of RIN spectra of phase-modulated signals at the output end of transmission link corresponding to different input forward pump RIN in experiment and simulation.

Details of the numerical studies showing good agreement with experiment and enabling optimization of DRA configuration will be presented at the conference.

References

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