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Joint Optimization of 260km Unrepeatered Transmission System using Third Order DRA and ROPA

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Introduction

In recent years, with the construction of ultra-high voltage alternating current (AC) and direct current (DC) power grids, the single-span distances of power optical cables erected along the lines are constantly increasing. Limited by traffic and natural conditions, it is often difficult to set up relay stations. Considering the safety and reliability of the system, the combination of the high-order Raman amplifiers and remote optically pumped amplifier (ROPA) can be used to increase the transmission distance of unrepeatered systems.

In this paper, a joint optimization method is proposed to jointly optimize the bidirectional third-order Raman amplifiers and ROPA using the differential evolution (DE) algorithm.

Principle

The proposed optimization scheme is mainly based on the DE algorithm, which includes three basic operations: differential mutation, crossover and selection.

The flowchart of DE algorithm is shown in Fig. 1. The process of DE algorithm starts from generating an initial population containing a certain number of individuals. Then, the mutation operation is to generate a difference vector between two randomly selected individuals in the current population. The mutant individual is the vectorial sum of the difference vector and a third individual. After differential mutation, the crossover operation crosses the mutant individual with a pre-set target individual to generate an experimental individual. If the fitness coefficient of the experimental individual is better than the current target individual, the experimental individual will be retained as the next generation of new individuals, otherwise the original target individual will be retained. The above operations will continue until the optimization termination conditions are met. Finally, the optimal parameter combination is returned.

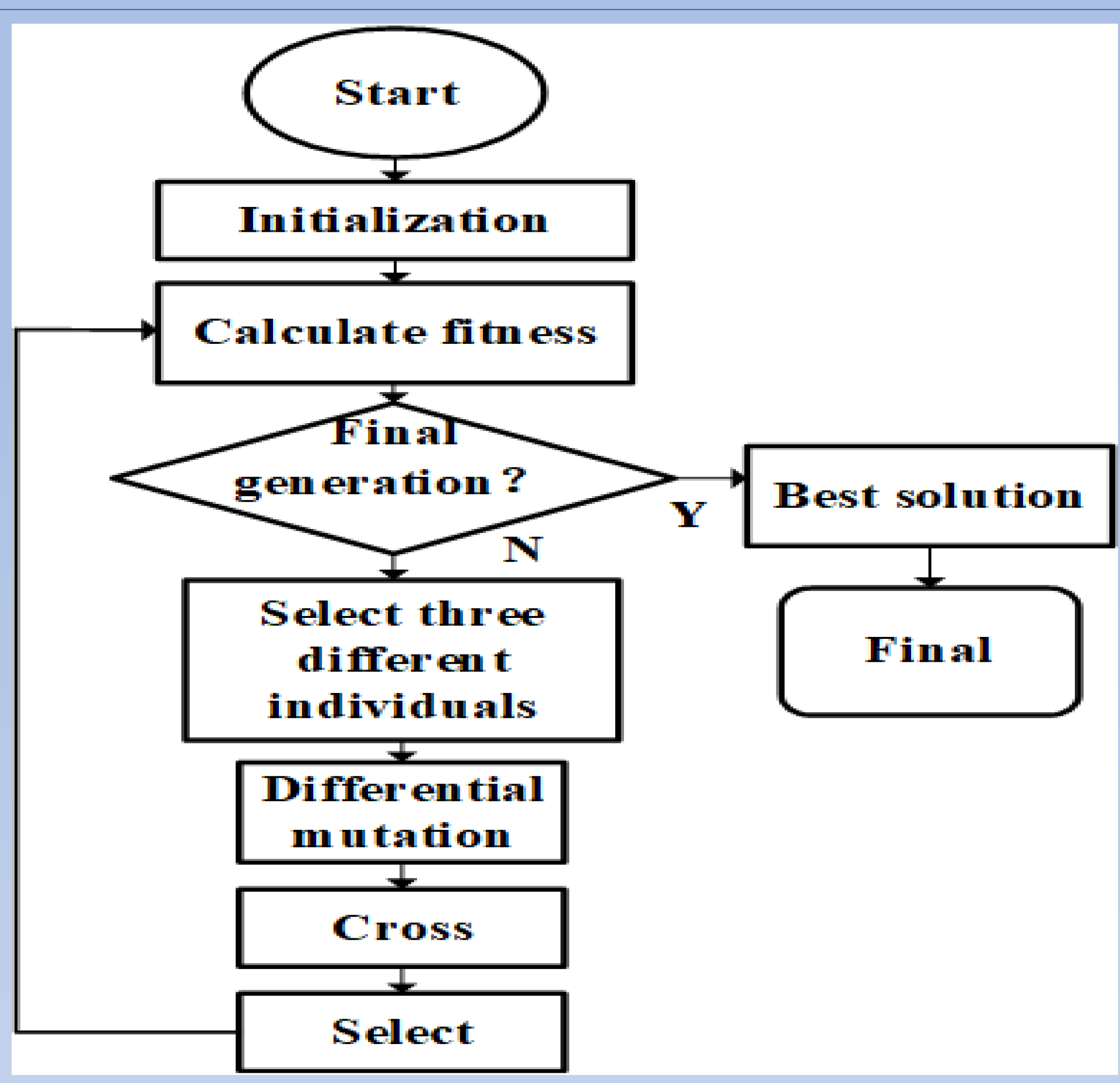

Figure 1. Flow chart of differential evolution algorithm.

Simulation and results

Fig. 2 illustrates the simulation setup. The signal source sends 31 C-band signals with a channel spacing of 100 GHz, the signal frequency range is 192 THz to 195 THz, the signal power is 0.5 mW, and the average attenuation in the optical fiber is 0.187 dB/km.

We can find from Fig. 3 that directly adding a ROPA on the basis of the optimized third-order Raman amplifiers increases the loss budget by 6.23 dB, but the gain flatness deteriorates by 0.5043 dB. After jointly optimizing the Raman amplifiers and ROPA, with a loss budget close to 55 dB, the gain ripple is reduced from 1.3738 dB to 0.7398 dB, the proposed method significantly improves the gain flatness.

In Fig. 4, the signal power evolution of the three cases is given. The launched power of the signal is -3dBm. It can be seen that the signal's maximum power occurs around 28 km away from the transmitter. The signal's maximum power of the joint optimization is 3 dB higher than the other two, but less than 7.5 dB. The signal's maximum power of the three cases is relatively low with the application of the third-order Raman amplifier. Also note that the signal is amplified by the backward ROPA 50 km away from the receiver.

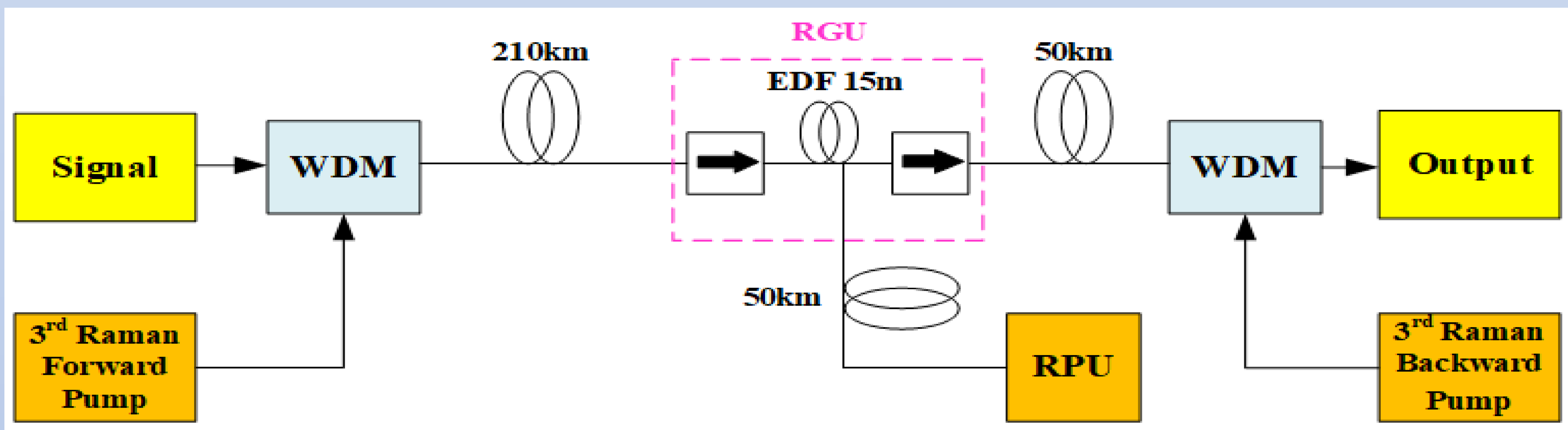

Figure 2. Simulation setup.

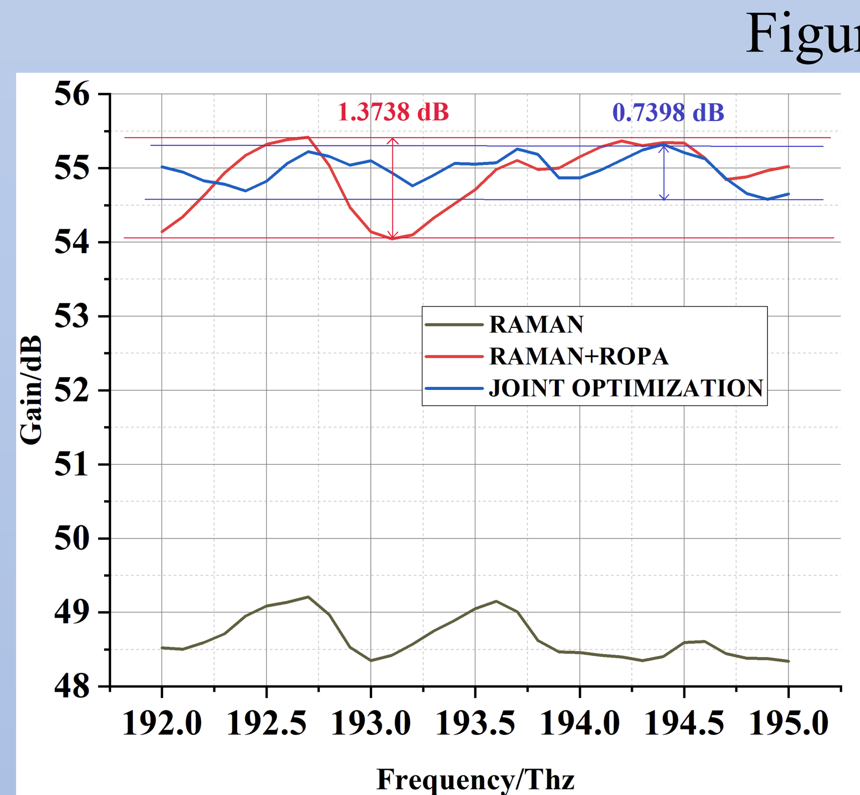

Figure 3. Gain spectrum.

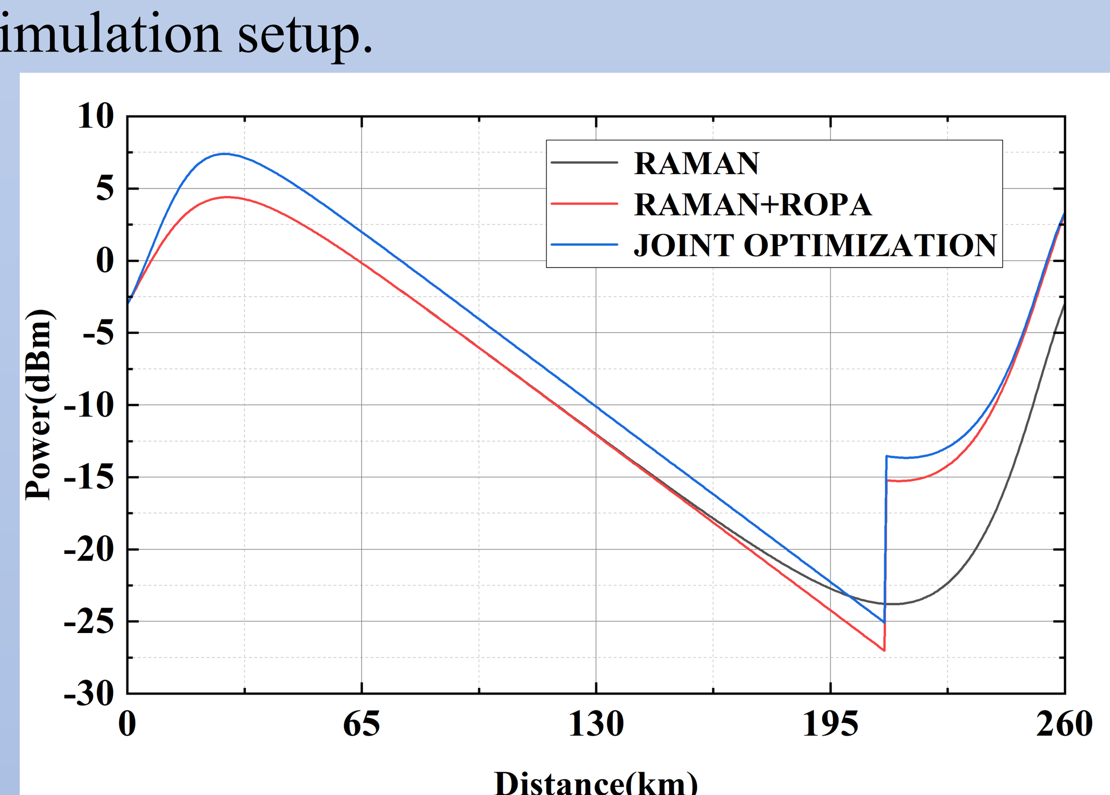

Figure 4. Simulated signal power distribution.

Conclusion

In conclusion, a joint optimization method is proposed for a 260 km unrepeatered transmission based on third-order Raman amplifiers and the ROPA. The simulation results show that the designed Raman amplifiers with the jointly optimized pump parameters obtain a loss budget of 54.98 dB and a gain flatness of 0.7398 dB. In the case of providing the same loss budget, the gain flatness of 0.634 dB is improved by adopting proposed joint optimization method. The proposed scheme provides a feasible alternative for the performance improvement of the future ultra-long unrepeatered transmission system.

Acknowledgements

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