Evaluation of Various Hybrid Optical Amplifiers Performance

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Abstract*: In this work, the performance of various hybrid optical amplifiers in high-capacity optical communication systems is evaluated. By combining the benefits of multiple types of amplifiers, such as Erbium-Doped Fiber Amplifiers (EDFA), Raman, and Semiconductor Optical Amplifiers enhance the quality of signals and extend the transmission distance. We consider significant performance parameters such as gain, noise figure and bit error rate with respect to different HOA configurations in a 300 Gbps WDM system. Simulation data suggests that certain hybrid combinations even outperform the conventional single-amplifier arrangements. These findings can be used to show how HOA can tune next-generation optical networks to support high speed and long-distance data transmission.*

Keywords*: Hybrid optical amplifier, BER, Non-linearities, Dispersion*

I. Introduction

The requirement in the modern optical communication systems of higher data rates, longer transmission lengths and improved signal quality has led to the development of advanced optical amplification techniques. Optical amplifiers form important components of Dense Wavelength Division Multiplexing (DWDM) network since they offset the attenuation of signals along long fibre lengths. There are some Raman amplifiers, Erbium-Doped Fibre Amplifiers (EDFAs), and Semiconductor Optical Amplifiers (SOAs) advantages and disadvantages because they are all conventional amplifiers. As an example, SOAs provide compactness and flexibility in integration at the tradeoff of added noise and distortion, whereas EDFAs provide high gain and low noise but have a limited bandwidth.

Hybrid optical amplifiers (HOAs), where two or more types of amplifiers are co-implemented to exploit their complimentary properties, have been invented as a means of overcoming these individual limitations. This approach aims at enhancing the system performance across broader bandwidths in noise figure, gain flatness and signal quality. This paper evaluates the performance of some HOA structures in a 100 Gbps optical communication system. To determine the most effective hybrid systems of future high-speed and long-distance optical networks, we simulate and analyze such vital features as gain, noise figure and bit error rate.

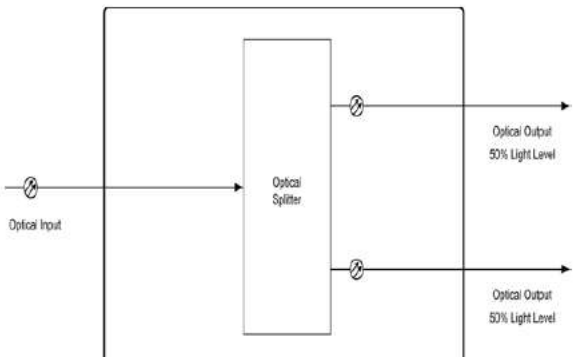

Fig 1: Optical splitter

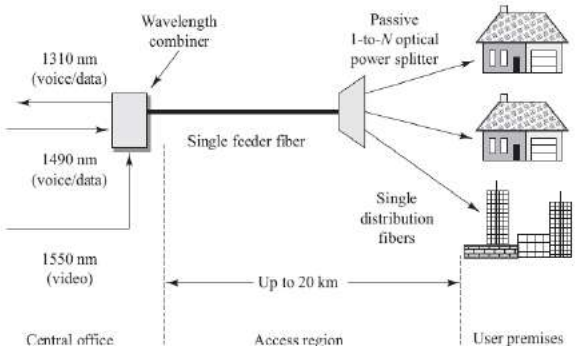

Fig 2: Network set-up for optical connection

II. Features of Optical Fiber

Optical amplifiers in communication Optical amplifiers are important in fiber-optic communication, where they are used to boost the power of a signal without converting it to an electrical signal. Erbium-doped fibre amplifiers (EDFAs) are popular because of their high gain and low noise, particularly at the C-band. Raman amplifiers offer distributed amplification and a broad bandwidth although they have high pump power requirements.

Semiconductor optical amplifiers (SOAs) are small, cheap, and suitable to be incorporated in photonic circuits, although they introduce more noise and distortion. These parameters are gain, noise figure, bandwidth and nonlinear effects, which are dependent on the amplifier type. These differences must be understood when selecting or mixing amplifiers to achieve optimum performance under various optical network conditions.

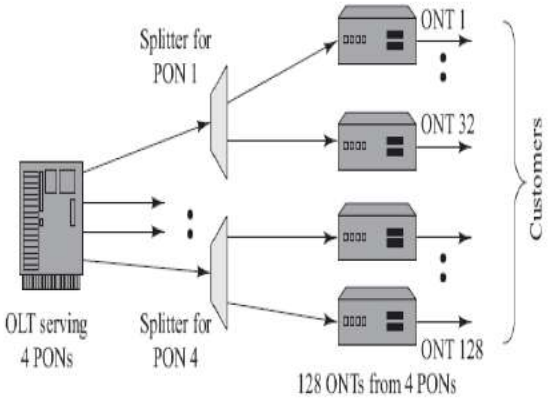

Fig 3: Network connection for optical splitting

III. Hybrid Optical Amplifier

Hybrid optical amplifiers (HOAs) are advanced optical communication system solutions that involve the combination of two or more optical amplifier types to benefit the system performance. By offsetting the weaknesses of each type with the strengths of the other, HOAs can enjoy the benefits of both Raman Amplifiers, Semiconductor Optical Amplifiers (SOAs) and Erbium-Doped Fibre Amplifiers (EDFAs) in particular. An example of this would be the compatibility of EDFAs and Raman amplifiers to enhance gain flatness and Bandwidth, and SOAs and EDFAs to enhance flexibility and integration abilities.

HOAs are extremely useful in high-speed Dense Wavelength Division Multiplexing (DWDM) systems where it is important to maintain the quality of signal over long distances. They help to realize greater gain, lower noise figures and broader spectral coverage than single-type amplifiers. Due to this fact, HOAs can be applied to long-haul or ultralong-haul gearbox systems. With growing data requirements, HOAs are gaining significance in development of reliable, scalable and efficient next generation optical networks.

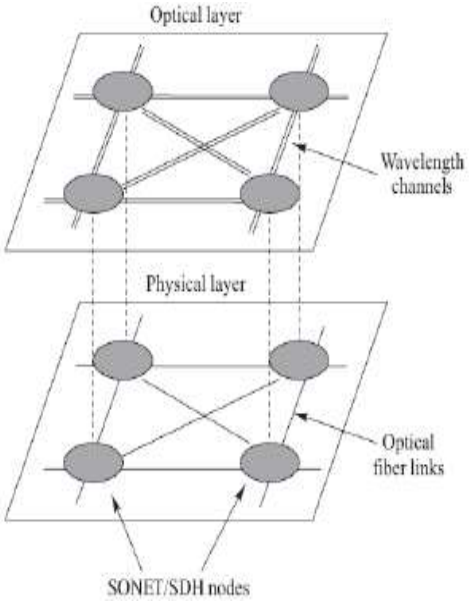

Fig 4: Different layer of optical fibre

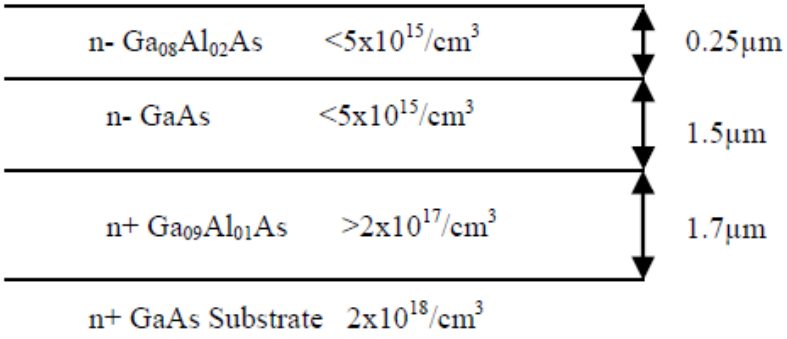

Fig 5: Optical layer in the form of X-axis axially

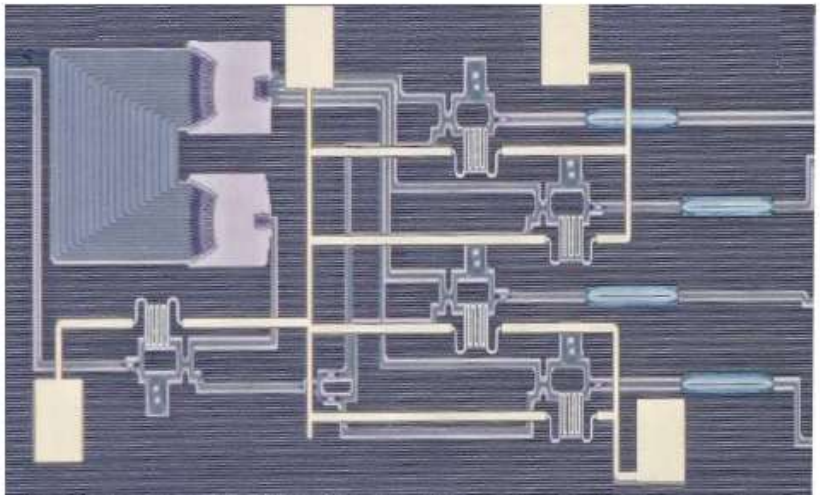

Fig 6: Microscopic image of optical fibre

IV. Simulation and Results

After the simulation was run, a number of graphs were produced so that the parameters could be examined at different distances.

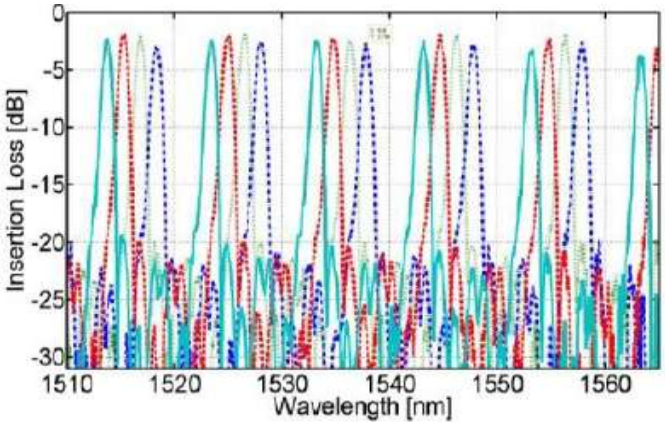

Fig 7: Optical waveform of CRO

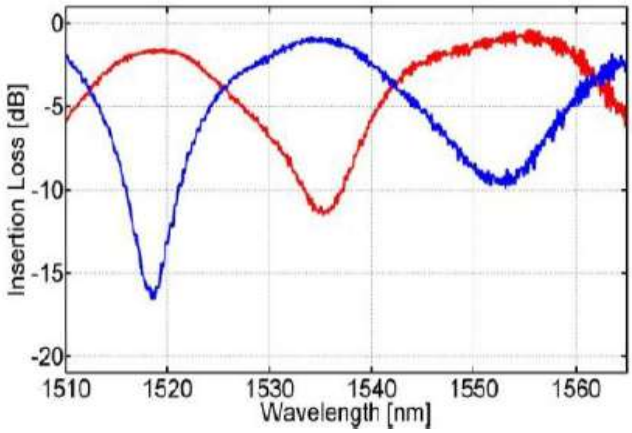

Fig 8: AWG performance of optical fiber

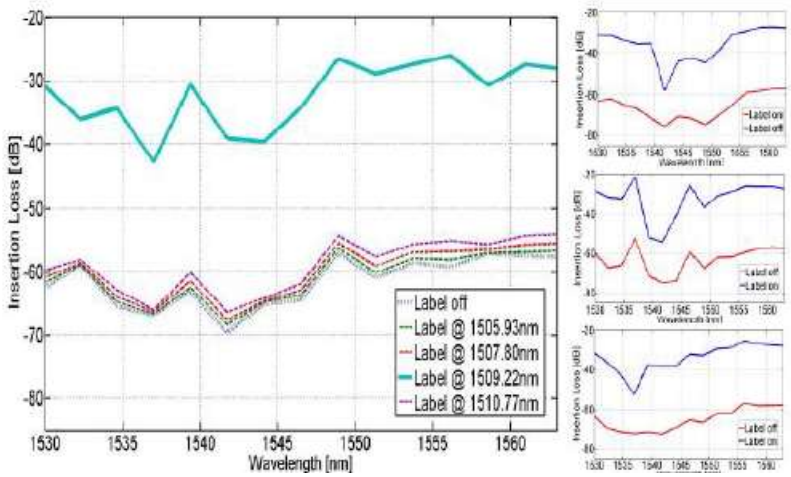

Fig 9 : Extension ratio of port 2 of optical fibre

V. Conclusion

A number of Hybrid Optical Amplifiers (HOAs) possess enormous prospective to enhance optical communication systems, based on the performance analysis. HOAs offer a higher gain, lower noise figure, and wider bandwidth than individual amplifiers, such as EDFAs, Raman amplifiers, and SOAs because they combine the benefits of numerous amplifiers. Simulation data indicates that certain hybrid topologies can outperform traditional single amplifiers, especially in long haul high-capacity networks. These enhancements make HOAs ideal in next-generation Dense Wavelength Division Multiplexing (DWDM) systems, and these directly translate into better signal quality and transmission distance. Things considered, therefore, HOAs provide a feasible solution to meet the ever-growing demands of optical high-speed communication networks.

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