Effect of pump configuration on Raman amplifier as function of input power for multiplexed wavelengths

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In a discrete Raman fiber amplifier, the gain strongly dependent on the variance between the pump and signal wave lengths. Raman amplification have an attractive characteristics is that, it can be used over a very wide wavelength range by multiplexing different wavelengths together. This paper illustrates that the net gain of the discrete Raman amplifier (DRA) is a function of the fiber length at different pump configurations: forward pumping (co-pumping), backward pumping (counter-pumping). This paper presented the effect of different pump configuration of the optical spectrum as well as OSNR.

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1. Introduction

The most important characteristic of Raman amplifier is the stimulated Raman scattering, which is fundamentally based on Raman effect discovered by C.V. Raman in 1928. The observation has been revealed that additional spectral lines appeared, after a monochromatic light passed through transparent materials [1]. In Rayleigh scattering, both the incident light and the scattered light having the same frequency as in the elastic scattering, while for the inelastic scattering several portion of the scattered light appears at a different frequency from the incident light frequency, as it is in the Raman scattering and the Brillouin scattering. It was due to the fluctuations of the material atoms or molecules from their normal state that influenced this scattering. The interaction between photons and the material molecules results in the energy transfer. This energy conversion occurs when a photon undergoes an inelastic collision with a molecule and energy is obtained from the material [2-4]. In the inelastic scattering process, the energy of the incident particle is lost or gained. When a photon is the incident particle, the inelastic scattering process is called Raman scattering. Raman amplification exhibits the advantage of self phase matching between the pump and signal together with a broad gain bandwidth and high speed response in comparison with the other nonlinear processes [5]. There are two types of Raman amplifiers: discrete Raman amplifier (DRA) and distributed Raman amplifier. The distributed type utilizes a transmission optical fiber as an active medium [6]. If the amplifier is contained in a box at the transmitter or receiver end of the system, it will be called a discrete Raman amplifier.

2. Principle and system setup

In this paper, we investigate the effects of pumping in a Raman amplifier for 10×40 Gb/s. In this configuration, we assume that a Raman amplifier is used at Medium. The effects of pumping are classified into three type's

1. Co-pumping, or Forward-pumping, where both signal and pump are propagating in the same direction.
2. Counter-pumping or Backward-pumping, where signal and pump are propagating in opposite directions.
3. The bidirectional pumping which includes both the co-pumping and counter-pumping, simultaneously.

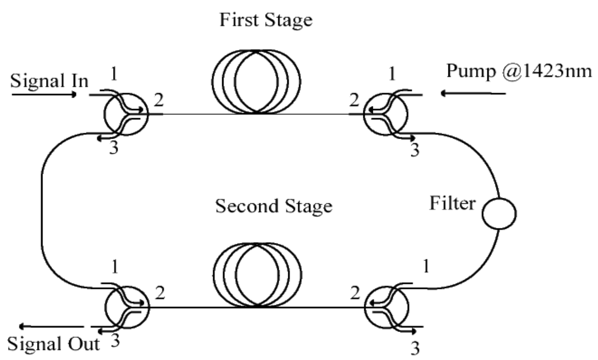


Fig. 1. A Schemtic diagram showing the optical communication system employing the Raman amplifier.

The input power affects the optical specturm in raman amplifier by employing the below equations

$$\frac{dP_S}{dZ} = g_R P_P P_s - \alpha_s P_S \qquad \text{------ (1)}$$

$$\pm\frac{dP_P}{dZ} = -\frac{\omega_P}{\omega_S} g_R P_P P_s - \alpha_s P_S \qquad \text{------ (2)}$$

The evolution of the signal pump power, P_S, and the pump power, P_P, propagating along the optical fiber can be quantitatively described by the following propagation differential equations [7], [8] where $g_R(W^{-1}.m^{-1})$ is the Raman gain coefficient of the fiber, normalized with respect to the effective area of the fiber, Aeff. s and p are the attenuation coefficients at the signal and pump wavelengths, respectively, ω_s and ω_p are the angular frequencies of the signal and pump. The signs of "+" or "–" correspond to forward and backward pumping [9] [10].

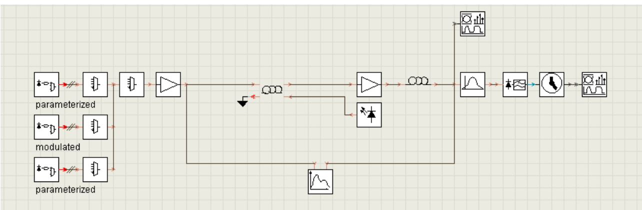
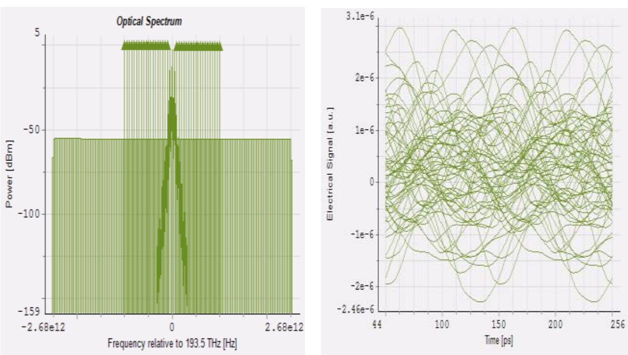


Fig. 2. A Sinple configuration scheme employing the forward and backward pumping.

3. Experiments and results

The above setup comprises with 10X40 transmitters (for each user) multiplexed by 1:192 multiplexer followed again 2:1 multiplexer by Raman amplifier through which different pumping scheme is being served. Various described results detailed below shows the effect of pumping on the optical spectrum, eye diagram and OSNR of DCR fiber for 175 Km length.



(a) (b)

Fig. 3. Raman amplifier effect on the system without pumping (a) Optical Spectrum (b) eye diagram.

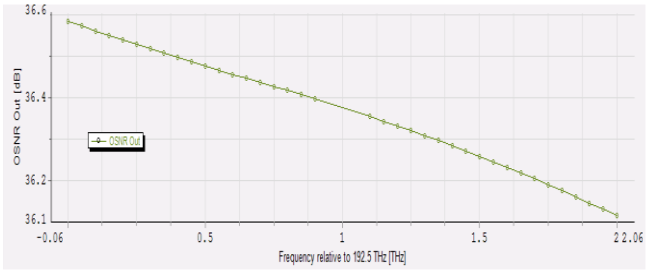
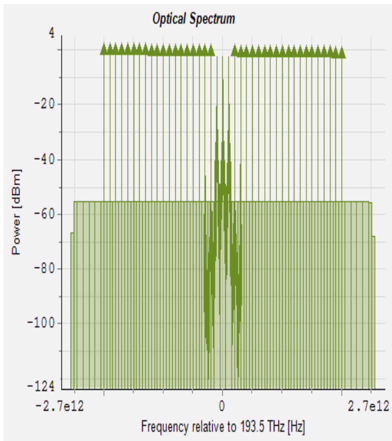
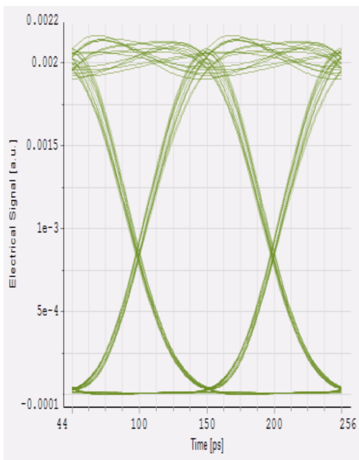


Fig. 4. OSNR without pumping in Raman amplifier.

Above results showed that optical spectrum for Raman amplifier without pumping is totally dispersed as centre wavelength, which is totally occupied with sidebands while the a dispersed eye diagram has been received for a length of 175 Km.



a)



b)

Fig. 5. Raman amplifier effect on the system with forward pumping (a) Optical Spectrum (b) eye diagram.

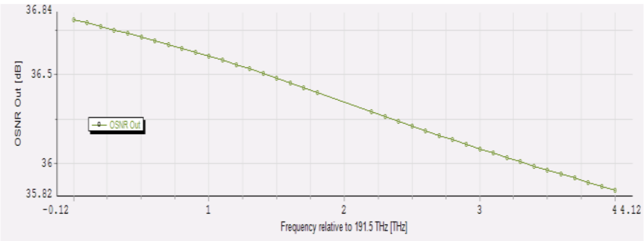
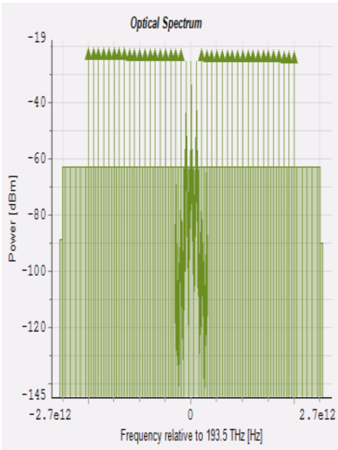
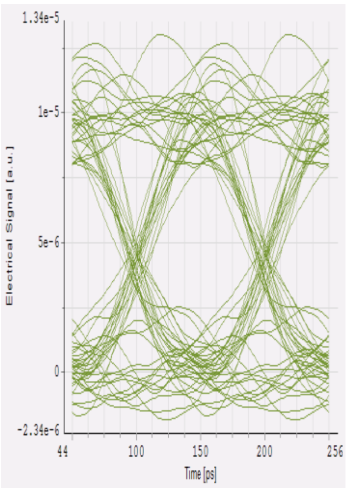


Fig. 6. OSNR forward pumping in Raman amplifier.

Further, eye diagram is also played an important role in defining the pumping the Raman amplifier for 175 km lengths in swing with different channels. As forward pumping applied for Raman amplifier, sidebands got dispersed from the centre frequency. While forward pumping brought us near to better eye diagram.



a)



b)

Fig. 7. Raman amplifier effect on the system with backward pumping (a) Optical Spectrum (b) eye diagram.

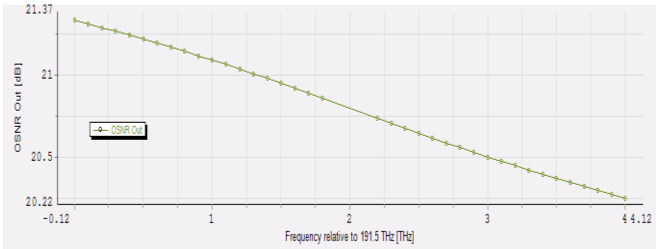


Fig. 8. OSNR backward pumping in Raman amplifier.

As we already discussed the effects of pumping on the eye diagram of the Raman amplifier and the sensitivity can also be handled with improving the OSNR. Results revealed that OSNR without pumping or with pumping is showing dispersion for a length of 175 Km while in case of forward pumping it shows a clear eye diagram and, eventually forward pumping increases the OSNR upto 15 dBm. It can be a better choice for WDM system which comprises a Raman amplifier.

4. Conclusion

In this paper, we have investigated effects of pumping in three different configurations Raman amplifier for a length of 175 Km. Our scheme is easy to realize and is suitable for enhancing OSNR. The forward pumping is used for generating multi-subcarrier source along the centre frequency, but in dispersed manner and improve the OSNR by 15 dB.

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