A Review Paper on Improvement in Gain and Noise Figure in Raman Amplifiers in Optical Communication System

[1] Er. Jyoti Dhir, [2] Er. Vivek gupta
[1]Student, Dept. of ECE, Rayat and Bahra Institute of Engg. & Biotechnology, Sahauran, Punjab

[2]Asstt. Professor, Dept. of ECE, Rayat and Bahra Institute of Engg. & Biotechnology, Sahauran,

Abstract:- Raman amplifiers has been found to be an attractive candidate for optical dense wavelength division multiplexing system related applications. In the design of Raman amplifier, determination of noise figure and gain are the major concerns because these improve the overall system performance. In this paper, the previous results of gain and noise figure are discussed from year 2000 to 2012.

Keywords:- Stimulated Raman Scattering, Optical Communication System, Distributed Raman Amplifier, Discrete/Lumped Raman Amplifier and Hybrid Amplifiers.

I. INTRODUCTION

In order to transmit signals over long distances(>100 km) it is necessary to compensate the attenuation losses within the fiber. An optical amplifier is a device that amplifies an optical signal directly, without the need to first convert it to an electrical signal. This is one of the main reasons for the success of today's optical communication systems. Optical amplifiers can be divided into two classes: optical fiber amplifiers (OFA) and semiconductor optical amplifier (SOA) [1]. The OFAs are EDFAs and Raman amplifiers. In Raman amplifiers, Raman scattering of incoming light with phonons in the lattice of the gain medium produces photons coherent with the incoming photons. Further Raman amplifier is classified in two categories: distributed Raman amplifiers and discrete/lumped Raman amplifiers.

A distributed Raman amplifier is one in which the transmission fiber is utilised as the gain medium by multiplexing a pump wavelength with signal wavelength, while a lumped Raman amplifier utilises a dedicated, shorter length of fiber to provide amplification. In case of lumped Raman amplifier highly non linear fiber with a small core is utilised to increase the interaction between signal and pump wavelengths and thereby reduce the length of fiber required. Raman amplifiers have the main advantage as compared to SOAs and EDFAs. Raman amplifiers are used as bidirectional and signal and pump wavelength are amplified in the single wavelength fed into the system only.

II. STIMULATED RAMAN SCATTERING

The Raman amplifier is based on the phenomena of SRS. SRS is a nonlinear optical process in which a photon, called a pump photon is absorbed by a material while simultaneously a photon energy is emitted. The difference in photon energy is compensated by a change of a vibrational state of the material [2].

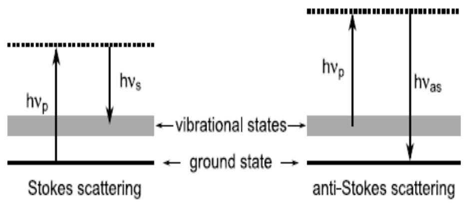

Fig 1: Illustration of spontaneous stokes and anti-stokes Raman scattering

Fig. 1 illustrates the two basic types of spontaneous Raman scattering. In so-called Stokes scattering, a pump photon of energy $h\nu_p$ is absorbed, and a Stokes photon of energy $h\nu_s < h\nu_p$ is emitted, while the material undergoes a transition to a higher vibrational energy state. On the other hand, Anti-Stokes scattering can occur when the material already is in an excited vibrational state. Then, a pump photon of energy $h\nu_p$ is absorbed, and a quantum of vibrational energy is added to that energy to yield an anti-Stokes photon of higher energy $h\nu_{as} > h\nu_p$.

The transmit spectrum of a six channel DWDM system in the 1550 nm window. All six wavelengths have approximately the same amplitude.

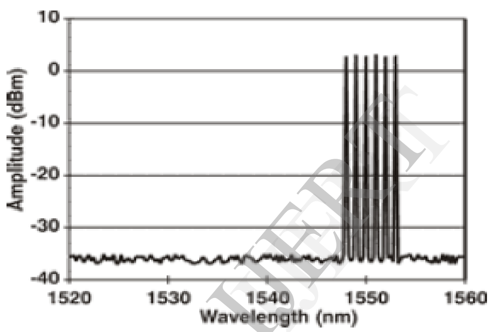

Figure 2 : DWDM Transmit Spectrum with Six Wavelengths

By applying SRS the wavelengths, it is obvious that the noise background has increased, making the amplitudes of the six wavelengths different. The lower wavelengths have a smaller amplitude than the upper wavelengths.

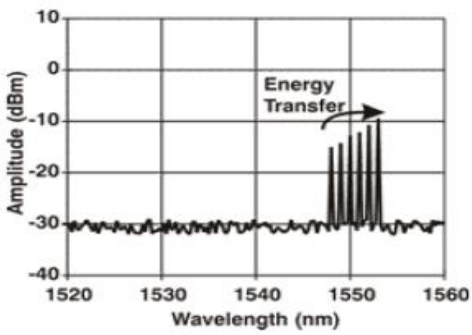

Figure 3 : Received Spectrum After SRS is on a Long Fiber

III. PROPERTIES OF RAMAN AMPLIFIERS

a) As indicated power is transferred from shorter wavelengths to longer wavelengths.
b) Coupling with the pump wavelength can be accomplished either in the forward or counter propagating direction.
c) Power is coupled from the pump only if the signal channel is sending a 1 bit.
d) Variable wavelength:

- Depends on pump wavelength.
- For example pumping at 1500 nm produces gain at about 1560-1570 nm.

ADVANTAGES OF RAMAN AMPLIFIERS

a) Variable wavelength amplification possible.
b) Compatible with installed SM fiber.
c) Can be used to "extend" EDFAs.
d) Can result in a lower average power over a span, good for lower crosstalk.
e) Very broadband operation may be possible.

IV. COMPARITIVE ANALYSIS

S.No.	Paper Name	Journal Name	Publication Year	Technique Used	Gain	Noise Figure
1	The impact of fiber affective are on systems using RAs [3]	International conference on electronics, h/w, wireless and optical comm.	2002	2 Fibers are compared	20.2-22.2 db. Corning SMF28 higher gain	Higher noise in corning SMF28
2	Transient gain dynamics in saturated RAs [4]	Optical fiber technology	2003	5 pumps are used	20-24 db	
3	RAs simulations with bursty traffic [5]		2003	Raman and EDFA are compared	Gain change per amplifier in RA is small	
4	Transient effects in gain clamped discrete RA cascades [6]	IEEE	2004	Channels drop/add	20 db	Less than 4 db
5	Simulation of various configurations	Proc. Of SPIE	2007	Forwarding pumping is used	~18.5 db	When DCF mixed with forward

	of single pump dispersion compensating raman/edfa hybrid amplifiers [7]					pumping NF increases
6	Analysis of low noise and gain flattened distributed RAs using different fibers [8]	International conference on electronics, h/w, wireless and optical communication	2007	2 Fibers are compared	Gain is less in germanium doped than silica fiber	0.3-1.8 db
7	Analysis and investigation of NF of FRA [9]	International journal of electronics and computer science engineering	2008	ASE and 2nd order is used	ASE: 15-30 db 2nd order: 0.9 db improved	ASE: 2.3-3.6 db 2nd order: 1.5 db improved
8	Reduction of noise in fiber optic RA [10]	International journal of electronics and computer science engg	2010			NF decreases
9	Investigation on multipump fiber RAs on WDM in OCS [11]	International journal of computer applications	2012	1 to 7 pumps are used	Gain ripple decreases 0.87-0.42	

V. CONCLUSION

Optical signals gain are amplified upto 31 db in the network optical fiber. The Raman optical amplifiers have a wide gain bandwidth. The can use any installed transmission fiber. [12]-[13]. Noise in Raman amplifier is also reduced upto 5 db. As gain of Raman amplifier is inversely proportional to the noise, so, if gain is improved noise figure is improved and hence noise is reduced in the system and in turn the overall system performance is improved.

REFERENCES

[1] Bhawna Utreja, Hardeep Singh, *"A review paper on comparison of optical amplifiers in optical communication systems"*, Canadian journal on electrical and electronics engineering, vol.2, No.11, pp. 505-513, November 2011.

[2] R.H.Stolen, *"Raman amplification for telecommunications 1"*, Physical principles, chapter fundamentals of Raman application in fibers, pages 35-59, Springer- Verlag 2004.

[3] Nigel Taylor and Jim Grochocinski, *"The impact of fiber effective area on systems using Raman amplification",* Jan (2002)

[4] Bonani, M. Papararo and M. Fuochi, *"Transient gain dynamics in saturated Raman amplifiers"*, Optical fiber technology, 15 (2004), p.p 91-123.

[5] Mohammed N. Islam, Mike Freeman and Jaeyoun Kim, *"Raman amplifier simulations with bursty traffic"*.

[6] G. Bolognini and F.Di Pasquale, *"Transient effects in gain clamped discrete Raman amplifier cascades"*, IEEE, vol 16, no 1, 2004.

[7] Maria Adelaide P.M.de Andrade, Joaquim Anaceleto and Jose Manuel M.M. de Almeida, *"Simulation of various configurations of single pump dispersion compensating Raman/EDFA hybrid amplifiers"*, vol. 6468,(2007).

[8] Farzin Emami and Amir H. Jafari, *"Analysis of low noise and gain flattened distributed Raman amplifiers using different fibers"*, 2007, p.p 119-122.

[9] Ramanpreet Kaur and Kirandeep Kaur, *"Analysis and investigation of noise figure of fiber Raman amplifier"*, International journal of electronics and computer science engineering, 2008.

[10] Raman Kumar, *"Reduction of noise in fiber optic raman amplifier"*, International journal of computer science and technology, vol. 1, Issue 1, Sept (2010).

[11] Kulwinder Singh, Manjeet Singh Patterh and Manjit Singh Bhamrah, *"Investigation on multipump fiber Raman amplifiers on WDM in optical communication system"*, International journal of computer applications, vol 39, no 4, 2(2012), p.p 8-12.

[12] A.A.Rieznik and H.L.Fragnito, *"Analytical solution for the dynamic behaviour of EDFAs with constant population inversion along the fiber"*, J.Opt-Soc. Amer. B, Opt. Phys. Vol.21, No.10, pp 1732-1739, October 2004.

[13] Z.G.Lu, J.R.Liu, S.Raymond, P.J.Poole, P.J. Barrios, D.Poitras, F.G.Sun, G. Pakulski, P.J. Bock and T.J.Hall, *"Highly efficient non-degenerate four wave mixing in InAs/InGaAsP quantum dots"*, Electronics letters,vol.48, No. 19, pp 1112-1114,2006.