Gain Flattening of WDM Network for the C+L Band using Hybrid Optical Amplifier

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Abstract**—***In this paper the hybrid combination of Erbium doped fiber amplifier (EDFA) and Raman amplifier are projected for wavelength division multiplexed system. Gain flatness achieved for C+L Band through hybrid amplifier is more than EDFA with Gain flattening filter. The hybrid optical amplifier has maximum gain of 25.6259dB, gain flatness of 3.17dB and noise figure less than 6dB at input power -20dBm of each channel.*

Keywords**—** ***Gain, Gain flatness, GFF, Hybrid optical amplifier, noise figure, WDM.***

I. INTRODUCTION

In the optical fiber communication systems signal strength decreases along with the transmission distance due to the various nonlinearities and other dominating errors [1]. The number of users can be increased by increasing the power budget, or reducing the losses in the network by using optoelectronic regenerators. But such regenerators become quite complex, time consuming and costly for WDM systems because of the various processing levels, i.e., multiplexing, optical-electrical-optical (O-E-O) conversion, and demultiplexing [2]. This reduces the reliability of the system as a regenerator is an active device. Therefore, up gradation of the multichannel WDM network will require optical amplifiers which directly amplify the optical signals without going through O-E-O conversions [3, 4].

Optical fiber systems are used for sending and receiving the data at ultra high speed and at longer distances. The corporate users demands for ultra high speed so that they can connect their local area network(LAN) to the internet at high data rate and commercial users demands for the very high speed network for sending and receiving media in less time. So to fulfill the demands of the user the network with high data rates and lower cost is required. Optical Fiber communication systems can fulfill these demands because of their higher bandwidth and lower costs over the conventional data transmission systems. Hybrid optical amplifiers (HOAs) are promising technology for future dense wavelength-division-multiplexing (DWDM) systems.

In optical network the hybrid amplifiers are used to enhance the bandwidth, to increase the span length and to obtain large gain with lesser gain flatness and low noise figure [5, 6].

The aim behind proposing the hybrid amplifier is to increase the gain bandwidth of a WDM system with the least gain variation over the effective bandwidth, to reduce the losses due to induced nonlinearities and avoid the constraint of high-cost gain flattening filters.

In general, the combination of more than one optical amplifier in any configuration is called a hybrid optical amplifier (HOA). G_{Hybrid} is the sum of the two individual gains (in dB) of Raman and EDFA, respectively [7].

$G_{Hybrid}=G_{EDFA}+G_{RFA.}$

Shown in the Fig.1 below, it can be seen that some part of the wavelength band is efficiently amplified by EDFA with a high gain and the other is amplified by Raman, which means that over the whole wavelength, a single amplifier shows large variation. But if the EDFA is combined with Raman amplifier in any configuration (cascaded or parallel), then the large gain flatness can be achieved with the high possible gain.

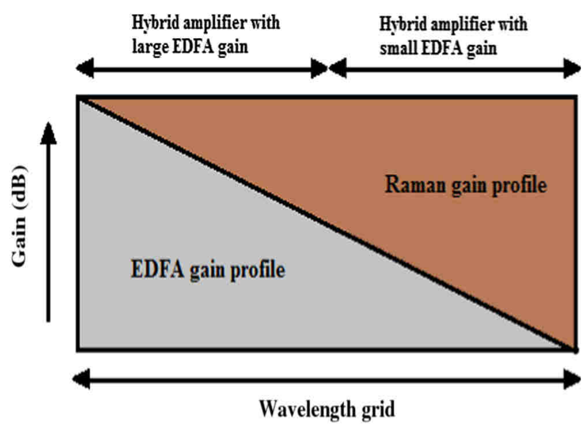

Fig.1: General Presentation of gain partitioning in hybrid Raman erbium doped fiber amplifier

II. SIMULATION SETUP FOR HOA

The simulated system consists of 32 channels of wavelength 1530nm to 1600nm(C+L band) with input power of -20dB for each channel. First stage of the HOA system consists of EDFA having the length of Erbium doped fiber is 5m. It is pumped at the wavelengths of 1480nm and 980nm with pump powers of 90mW and 110mw respectively. After this the signal is send to the optical isolator. At the second stage of the HOA Raman amplifier with length of 25km is used which is counter pumped at the wavelengths of 1430.6nm, 1437.85nm, 1444.97nm, 1454.55nm, 1465.35nm, 1482.26nm, 1493.37nm and 1510nm having the pump powers 46.78mW, 48.52mW, 43.04mW, 66.85mW, 154.76mW, 191.9mW, 173.04mW and 187.67mW respectively for analysis of the system. To measure the gain parameter of the HOA the dual port WDM analyzer is used to study the gain flatness and noise figure and the optical isolator is used to avoid the backward flow of signal. In this work we have studied about gain flattening of EDFA first with gain flattening filter (GFF) and then Raman fiber amplifier (RFA).

III. RESULTS AND DISCUSSIONS

The Gain and Noise Figure are measured by varying EDFA's length first at a constant input power of -20dBm as shown in Figure 2&3. Gain and Noise Figure changes as the EDF length change. For a given pump power, Gain and Noise Figure increases in initial stage and tends to decrease after the fiber length was increases, It is observed that the minimum losses and best results are obtained at EDFA length of 5m with RFA 25km.

Figure.4 shows the variation of gain for RFA, EDFA and HOA. The maximum gain for RFA, EDFA and HOA are 17.9906dB, 20.4137dB and 25.6259dB with gain flatness of 13.438dB, 15.2709dB and 3.1746dB respectively.

Figure.5 shows noise figure of RFA, EDFA and HOA. Maximum noise figure for HOA is 5.2887dB.

Figure 6&7 show results of gain and noise figure for EDFA with GFF and HOA. EDAF with GFF has gain flatness of 15.11dB with maximum gain of 20.2121dB. And HOA has maximum gain of 25.6259dB with gain flatness of 3.17dB.

Figure 8&9 show results of optical spectrum analyzers.

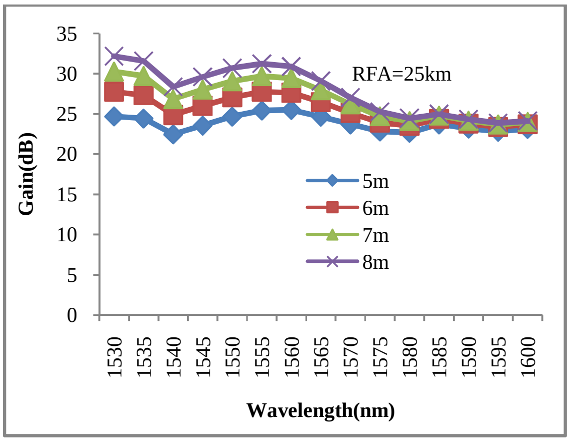

Fig.2: Gain of HOA for different lengths of EDFA

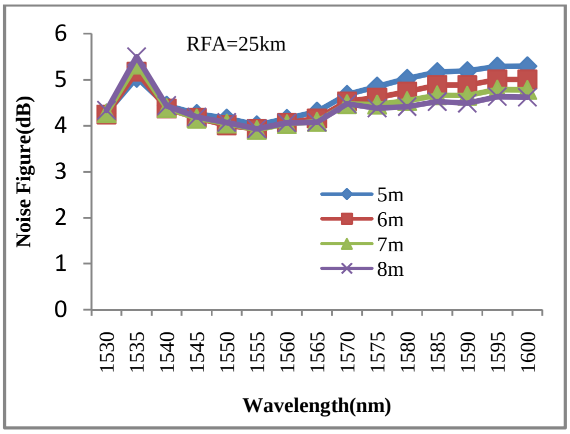

Fig.3: Noise figure of HOA for different lengths of EDFA

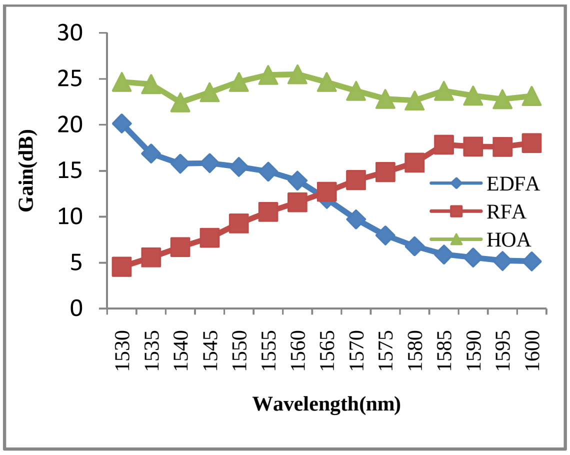

Fig.4: Gain variation of EDFA, RFA and hybrid amplifier

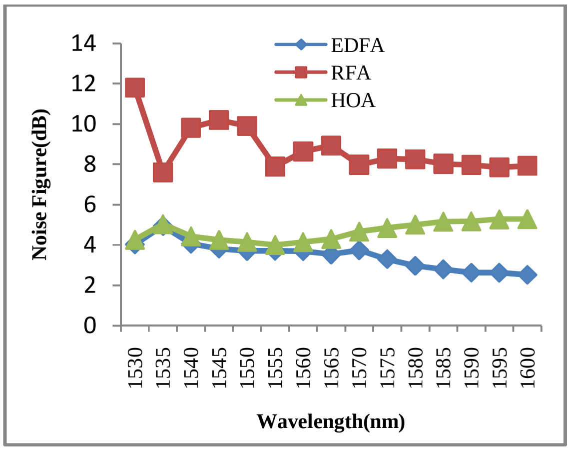

Fig.5 Noise figure of EDFA, RFA and hybrid amplifier

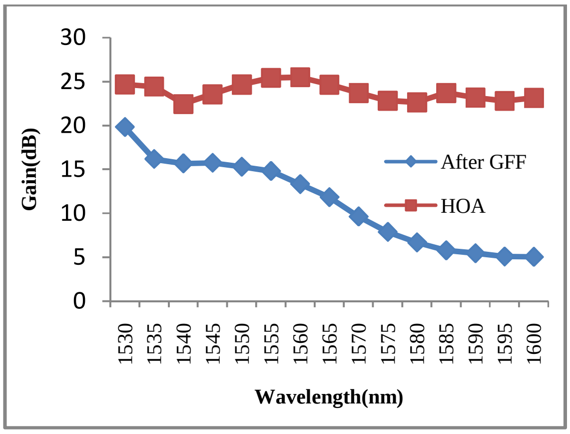

Fig.6: Gain variation of hybrid amplifier and EDFA with GFF

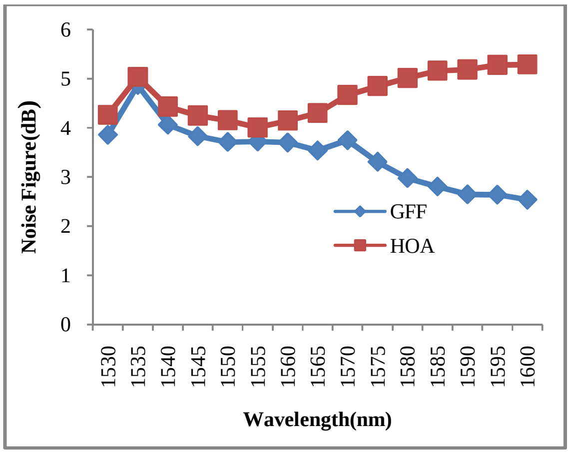

Fig.7: Noise figure of hybrid amplifier and EDFA with GFF

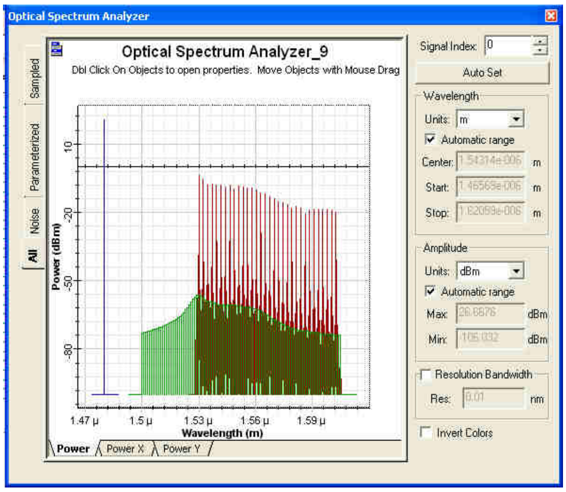

Fig.8: optical spectrum analyzer output for EDFA with GFF

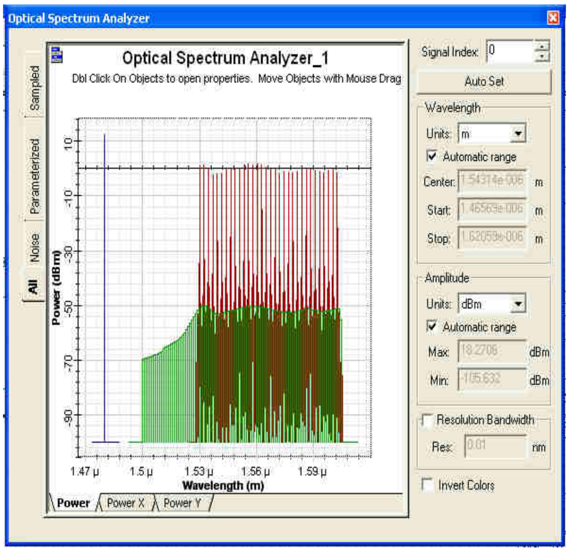

Fig. 9: optical spectrum analyzer output for hybrid amplifier

IV. CONCLUSIONS

The proposed Hybrid Optical Amplifier is implemented for C+L Band for 32 channels. Also the system is studied by varying the EDFA lengths. It is observed that the maximum gain of 25.6259dB is obtained through hybrid Optical System with the gain flatness of 3.17dB. Maximum gain and gain flatness with hybrid amplifier is more than EDFA with GFF that was 20.2121dB and 15.11dB respectively. The gain of HOA also increases with increment in the length of EDFA.

REFERENCES

[1] H. S. Chung et al., "A Raman plus linear optical amplifier as an inline amplifier in a long-haul transmission of 16 channels X 10 Gbit⁄s over single-mode fiber of 1040 km," *Opt. Commun*. 244(1–6), 141–145(2005).

[2] S. Singh, R.S. Kaler, "Placement of hybrid optical amplifier in fiber optical communication systems," *Optik* 123 (18) (2012) 1636–1639

[3] B. Mukherjee, "Optical WDM Networks," *Springer*, New York (2006).

[4] R. Srivastava and Y. N. Singh, "Fiber optic loop buffer switch incorporating 3R regeneration," *J. Opt. Quantum Electron*. 42(5), 297–311(2011).

[5] S. Singh, R.S. Kaler, "Performance evaluation of 64 × 10Gbps and 96 × 10Gbps DWDM system with hybrid optical amplifier for different modulation formats ," *Optik* 123 (24) (2012) 2199–2203

[6] S. Singh, R.S. Kaler, "Novel optical flat gain hybrid amplifier for dense wave-length division multiplexed system," Photon. Technol. L ett. 26 (2) (2014)173–176.

[7] M. N. Islam, "Raman Amplifiers for Telecommunications-1 Physical Principles," *Springer*, New York (2004).