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Analysis of Dense Wavelength Division Multiplexing Using Different Optical Amplifiers

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Abstract-This paper analyzes the performance of Dense Wavelength Division Multiplexing (DWDM) using different optical amplifiers. In the proposed work, DWDM system consist of 120 channels having 0.25 nm channel spacing using RAMAN amplifier, Erbium Doped Fiber Amplifier (EDFA) and Erbium-Ytterbium Co-Doped Fiber Amplifier (EYCDFA). In the proposed work the length of the RAMAN, EDFA and EYCDFA amplifier are varying from 14.5 m to 20.5 m. Due to which we conclude that the Gain is increases as the length of amplifier is increases in the EDFA, it gives better results as compare to the EYCDFA and RAMAN. The gain flatness is more in RAMAN amplifier as compare to EDFA and EYCDFA amplifiers.

Keywords- Dense Wavelength Division Multiplexing system; Erbium Doped Fiber Amplifier; Erbium-Ytterbium co-doped Fiber Amplifier; RAMAN amplifier; Gain flatness.

I. INTRODUCTION

For the past two decades, optical fiber communication has been advanced rapidly as it is the process of achieving transmission bandwidth using optical waves as carrier. As the time goes for the further improvement of optical fiber communication, need of coherent optical sources arises and lasers are developed [1]. Considerable efforts has been devoted to the realization of gain-flattened erbium-doped fiber amplifier (EDFA's) over a wide spectral range for large-capacity wavelength division multiplexed (WDM), optical communication system. As a result, the usable gain bandwidth of EDFA's has been increased significantly over the past few years with the help of new glass compositions [2]. Hybrid amplifiers combine several amplifiers with different gain bandwidth to extend the gain bandwidth product of the optical amplifiers. The hybrid Raman-Erbium-doped fiber amplifier (EDFA) is an enabling and promising technology for future DWDM multiterabit systems [3]. As long-haul single-mode fiber systems approach information-theoretic limits, spatial multiplexing in multi-mode or multi-core fibers offers a possible route to higher throughput. The properties of transmission fibers and fiber amplifiers are crucial to the ultimate feasibility of spatially multiplexed long-haul systems. In the transmission fiber, low group delay spread minimizes receiver signal processing complexity, while large modal effective areas minimize nonlinear effects. In fiber amplifiers, low mode-dependent gain (MDG) minimizes the loss of capacity and potential for outage [4]. Gain clamped two stage L-band EDFA or dual pumped double pass EDFA cascades sow a high gain and low noise figure, while another similar approach utilizes an optical splitter to provide distributed pumping from a single pump laser, a substantial gain of 17db with NF below 6.7db within the 36nm L-band range (1570-1605nm) is obtained [5].

The L-band erbium-doped fiber amplifier (EDFA) is one of the key devices for dense wavelength division multiplexing (DWDM) transmission systems, because it significantly increases the amplification wavelength range by combining with a conventional band (C-band) EDFA in a parallel configuration [6]. The demand for high speed data transmission has increased tremendously. With the new development of the internet applications, the demand for more and more bandwidth continues to grow. Although EDFA (Erbium-doped fiber amplifier) is a mature technology and is workhorse for dense wavelength division multiplexing (DWDM) and all optical networks, yet its relatively large size requires further research and development efforts to achieve the ever-wanted small , compact, and efficient fiber amplifiers. In this paper, initial investigations on a high-gain, short-length Phosphate glass Erbium-Ytterbium-doped fiber amplifier are presented [7].

This paper consists of three sections, in which section II described the experimental setup and section III describe conclusion.

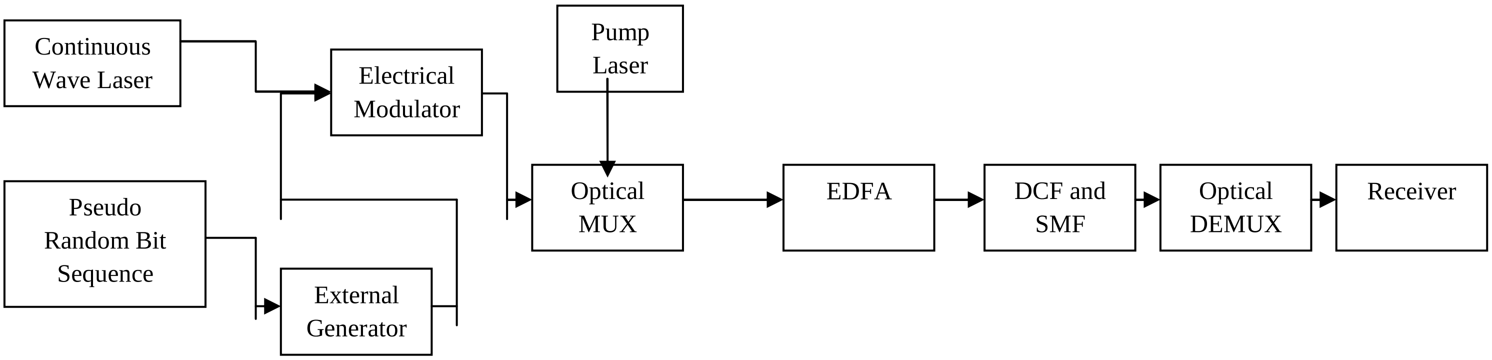

Figure.1. Block diagram for the analysis of DWDM system using EDFA amplifier

II. EXPERIMENTAL SETUP AND RESULTS

In our previous work reported in [3], we have experimentally demonstrated a novel optical Flat-gain Hybrid amplifier for Dense Wavelength Division Multiplexed System which was able to increase the gain flatness and the gain variation is reduced from~2.02 to~1.15db efficiently. We have shown the improved performance in the terms of gain flatness, cost etc. Here we use the EDFA, EYCDFA and RAMAN amplifiers for analysis the performance of DWDM system. The experimental setup consists of 120 DWDM channels covering the bandwidth starting from 1530 to 1560 nm in a 0.25 nm channel spacing using continuous wave laser (CWL) as shown in Fig.1.This figure shows the block diagram for the DWDM system using EDFA amplifier. In our proposed work gain and noise figure are the crucial factor for analyze the performance of DWDM system. In this work we analyze the performance of DWDM system by varying the length of the EDFA amplifier. The length of the EDFA amplifier is varied from 14.5 m to 20.5 m.

Figure.2 shows the gain spectrum of 120 DWDM channels using EDFA amplifier at the 20.5 m length of amplifier and Figure.3 shows the variation of noise figure versus wavelength.

According to the results gain of the EDFA amplifier are increases and the noise figure are decreases when the wavelength of the channel are increases.

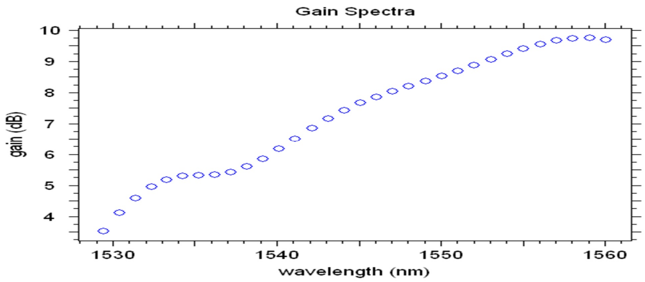

Fig.2. Variation of gain versus wavelength using 20.5 m length of EDFA

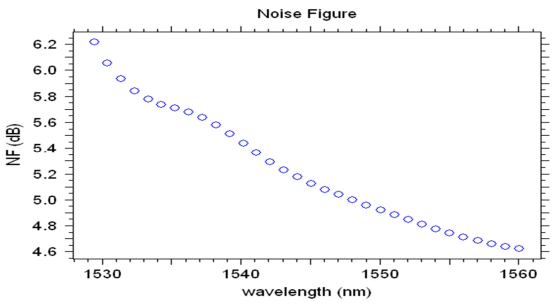

Fig.3. Variation of noise figure versus wavelength using 20.5 m length of EDFA amplifier

In this figure the wavelength are varied from 1530 nm to 1560 nm and the gain of the amplifier are increases but the noise is decreases.

TABLE 1

Variation of Gain And Noise Figure of EDFA Amplifier At Length 20.5 M

Wavelength(m)	Gain(db)	Noise(db)
1530	3.0	6.1
1535	5.3	5.7
1540	5.5	5.3
1545	6.5	5.1
1550	7.8	4.9
1555	8.8	4.7
1560	9.8	4.6

From the table 1 we conclude that the gain is increases as the wavelength of the amplifier are increases and the noise is decreases.
In the figure 4 the block diagram for the analysis of DWDM system using RAMAN amplifier are shown. In this analysis BDF (Bidirectional Fiber) are used for the interaction of Raman fiber

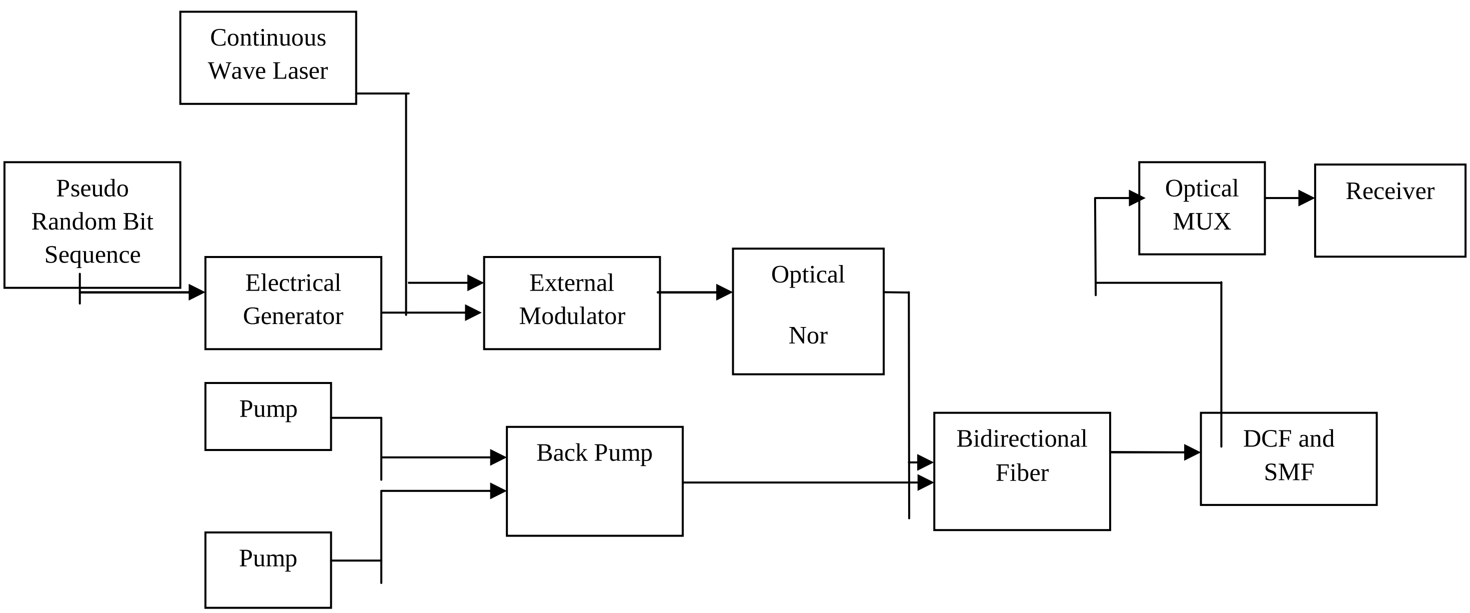

Figure.4. Block diagram for the analysis of DWDM system using RAMAN amplifier

According to the proposed work a second class of fiber amplifiers is that of Raman devices. Roughly speaking, the Raman Effect is a kind of nonlinear interaction which takes place at high powers in an optical medium. It consists of an inelastic photon scattering induced by elementary lattice excitations of the medium. In a Raman amplifier, the signal is intensified by Raman amplification. Unlike the EDFA and SOA the amplification effect is achieved by a nonlinear interaction between the signal and a pump laser within an optical fibre. The experimental setup consists of 120 DWDM channels covering the bandwidth starting from 1530 to 1560 nm in a 0.25 nm channel spacing using continuous wave laser (CWL) as shown in Fig.4

Figure.5 shows the gain spectrum of 120 DWDM channels using Raman amplifier at the 20.5 m length of amplifier and Figure.6 shows the variation of noise figure versus wavelength.

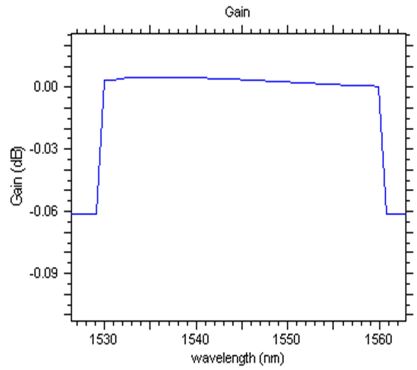

Figure.5.Variation of gain versus wavelength using 20.5 m length of Raman amplifier

According to the results gain of the Raman amplifier are increases and the noise figure are decreases when the wavelength of the channel are increases which are shown in the table 2. According to the results the gain of the Raman amplifier are flat up to 20 nm channel spacing. The figure shown the variation of gain and noise versus wavelength and from the table it is concludes that the gain is flat from 1545 nm upto 1560 nm, which is 0.0045 db and the noise is 0.0024 db from 1555 nm to 1560 nm wavelength.

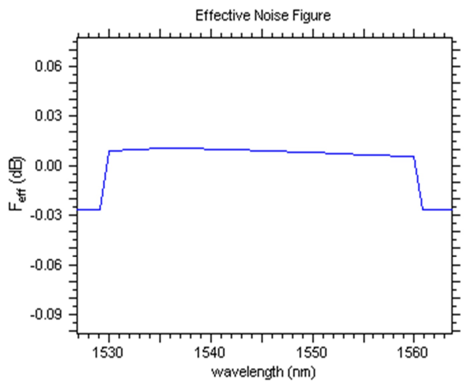

Figure.6.Variation of noise figure versus wavelength using 20.5 m length of Raman amplifier

TABLE 2
VARIATION OF GAIN AND NOISE FIGURE OF RAMAN AMPLIFIER AT LENGTH 20.5 M

Wavelength(m)	Gain(db)	Noise(db)
1530	0.0040	0.0025
1535	0.0040	0.0025
1540	0.0040	0.0025
1545	0.0045	0.0025
1550	0.0045	0.0025
1555	0.0045	0.0024
1560	0.0045	0.0024

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Table 2 shows the variations of gain and the noise figure of the Raman amplifier at length 20.5 m. At this length the gain is flat upto 20 nm wavelength. According to our proposed work the length of amplifier are varied from 14.5 m to 20.5 m by which we conclude that the gain of Raman amplifier are increases and flat. So the Raman amplifier gives better result as the gain is more flat in this case as compare to the EDFA and EYCDFA amplifiers.

III.CONCLUSION

The DWDM system with flat and high gain characteristics are proposed using different amplifiers (EDFA, RAMAN, and EYCDFA). But in this paper the result of the two amplifiers Raman and EDFA are shown. These amplifiers are investigated as a DWDM system with 0.25nm channel spacing. By using the EDFA amplifier the gain is increases as the length of the amplifier are increases and in the Raman amplifier the gain is flat from 1545 to 1560 nm wavelength. But in the case of EYCDFA amplifier it doesn't give better result as compare to Raman and EDFA amplifiers. With the proposed RAMAN amplifier the gain variation due to the EYDWA-SOA HA is reduced from~1.15 db to 0.0045 db efficiently. We believe that the this solution will bring the better performance and will be suitable for the next generation DWDM system.

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