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Hybrid Amplifier Design for CWDM Network

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ABSTRACT

We propose and demonstrate a new hybrid two-stage S-band and C-band optical fiber amplifier for coarse wavelength division multiplexing (CWDM) network. The proposed hybrid amplifier is a cascaded semiconductor optical amplifier (SOA) and erbium-doped fiber amplifiers (EDFA) providing a nearly flat gain over 80 nm. The hybrid amplifier has been modeled using a OptiSystem by Optiwave modeling tool on a CWDM transmission system consisting of two spans of 100 km showing uniform performance and 0 dBm power penalty.

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INTRODUCTION

Wavelength division multiplexing (WDM) is a technology which multiplexes multiple wavelengths optical signals into a single fiber optics. Coarse Wavelength Division Multiplexing (CWDM) is a multiplexing scheme where multiple wavelengths signals are combined into a single fiber optic cable without any interference. CWDM operates at higher bandwidth than Wavelength Division Multiplexing (WDM) where the operation wavelength span from 1271 nm up to 1611 nm which covers 18 CWDM channels with channel spacing of 20 nm (Al-Rubaye, S., 2009). However, the CWDM networks require cost-effective amplifiers in order to cover the broad spectral region encompassing S, C and L bands (Srivastava, A.K. and Y. Sun, 2002).

In an optical fiber communication system, fiber attenuation is one of the factors that limit the transmission distance. The optical amplifier is one of the important active component in which optical signals are amplified without going through the optical-to-electrical-to-optical conversion. Three major requirements for amplifier are (i) high gain (ii) low noise and (iii) flat amplification profile (Rosolem, J.B., 2007). The applications of the amplifier depend on the optical network requirements. Figure 1 shows a generic CWDM optical network system which carries several optical signals multiplexed into a single fiber and pass through several optical amplifiers before being demultiplexed and channel to individual receiver.

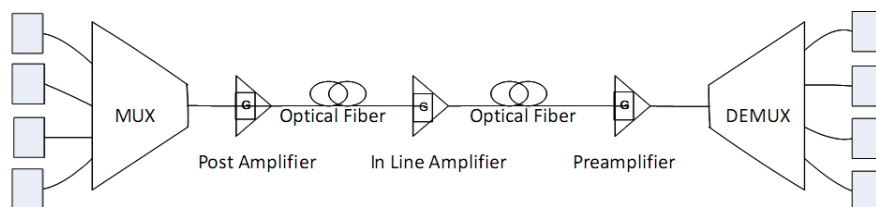


Fig. 1: CWDM network with optical amplifiers at different paths in FTTH networks application.

CWDM Network Design and Simulation:

Erbium Doped Fiber Amplifier (EDFA) is the amplifier of choice for most of the network applications, which is typically based on single mode optical fiber. Standard EDFA amplification band ranging approximately from 1530 nm to 1565 nm or C-band and it is extensively used in long-haul fiber optical communications because of the high gain of more than 20dB over the range of 1530-1560 nm or the C-band. Many factors

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influence EDFA gain and noise figure spectra, including fiber's length, doping density and effective area, launched pump and signal powers, the number of channels and the pump wavelength and direction (Thiele, H.J., 2003).

Semiconductor optical amplifiers (SOA) have been proposed as cost-effective multi-channel CWDM amplifiers that can extend CWDM system reach into the metro space or to compensate for loss devices (e.g. OADMs) (Utreja, B. and H. Singh, 2011). The SOA provide amplification over the whole band of operation of CWDM system. SOA design normally has large enough gain for the CWDM system where the gain depends on the current, wavelength and input power level. Due to the gain dependent of the SOA on the input signal power and internal noise generated by the amplification process, gain saturation will occur and hence causes signal distortion as the output signal power increases while the gain decreases.

In this work, we investigate a hybrid two stage S- and C-band optical amplifiers composing of an SOA and EDFA. Hybrid amplifier increases the transmitter power by placing it just after the transmitter and before the receiver without any splitters, booster in between as it increases the noises and distortion (Bhaskar, S., 2011). Nevertheless, a wide-band SOA and EDFA from S- to C- bands employing a coupled structure has also been reported. Figure 2 shows the proposed hybrid S- and C-band optical amplifiers.

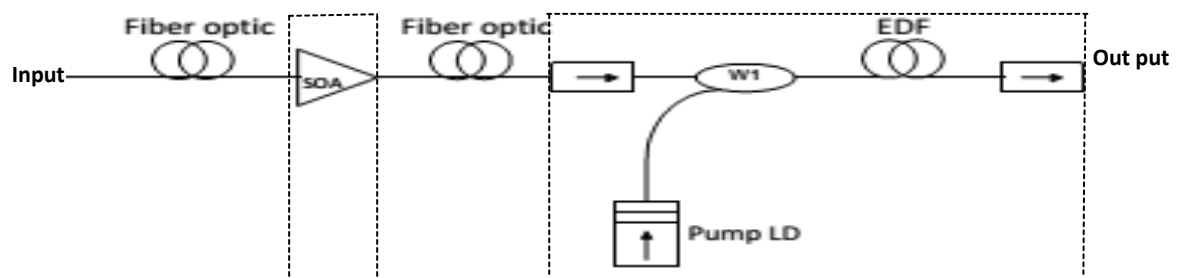


Fig. 2: The proposed S- and C- band amplifier modules composing of an SOA and EDFA.

RESULT AND DISCUSSION

The application of a hybrid optical amplifier based on SOA and EDFA is being investigated in a CWDM network. The hybrid optical amplifier is investigated based on an 8-channel CWDM network from 1470 nm to 1610 nm. The CWDM with the proposed hybrid optical amplifiers are designed and modeled using an optical network simulator tool, OptiSystem by Optiwave.

Figure 2 shows the setup of the hybrid amplifier two-stage S- and C-band amplifier module. This proposed amplifier setup consists of two stage amplifier based on the configuration of SOA and EDFA amplifiers. The first SOA stage is operated at a 0.13A bias current and band gap wavelength Max 1510 nm, and the EDFA stage has a 5-m-long EDF and a 980 nm pump power 100 mW. In this configuration, the hybrid of SOA and EDFA provides power gain at wavelengths of 1470 nm – 1550 nm. The CWDM network layout with the hybrid SOA-EDFA amplifiers is shown in Figure 3.

Each of the amplifier, SOA and EDFA is analyzed at the of the S- and C-band. In Figure 4, the gain of the SOA from 1470 nm up to 1510 nm with a peak gain of 28 dB is shown. This shows the power strengthening in the SOA within the operation in the S-band spectrum. Where the power band is positioned at 1510 nm wave noise figure optimizing administration that balanced at 1490 nm.

In Figure 5 shows the gain provided by the EDFA amplifier that works at the beginning of wavelength 1530 nm to 1570 nm. The gain that can be provided by the EDFA may reach 45 dB with the pump power of 100 mW working at 980 nm. The addition of the EDFA on the second part of the system enables a transmission length of 100 km.

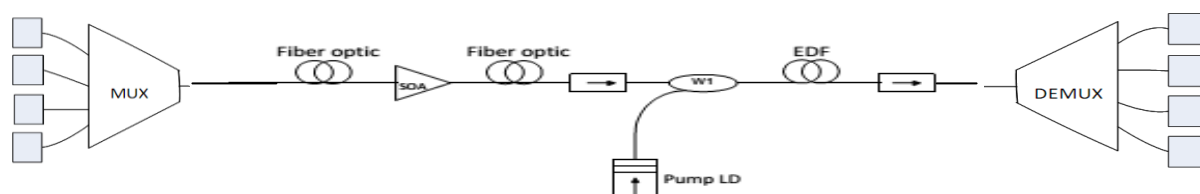


Fig. 3: Network layout of CWDM system with the hybrid SOA-EDFA amplifiers.

Figure 6 shows the gain against wavelength for the SOA and EDFA before being in cascaded. In this figure, there are areas where the gain of both amplifiers overlaps. Figure 7 shows the gain versus wavelengths of the hybrid amplifier. At a wavelength of 1470 nm until 1510 nm, in the region of S-band, amplification is done by

the SOA. Between the wavelength of 1530 nm and 1550 nm, the amplification is done by the EDFA. In Figure 7, it is observed that there is a reduction in power gain due to the different optical gain characteristics of each of the amplifier. In terms of flattened-ness, gain flattening occurs at different points in the total gain spectrum, in particular the area where the gain of the EDFA and SOA overlaps. Even though, gain flattening does not occur uniformly, the overall optical amplification between S band to C band can increase the performance of the system in particular for operation up to 100 km.

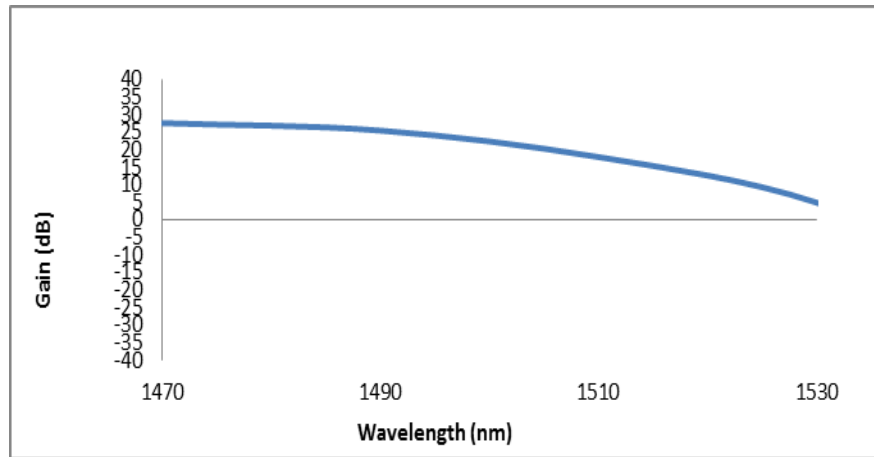


Fig. 4: Gain spectra of SOA with 0.13A current level over the bandwidth of 1470 to 1510 nm.

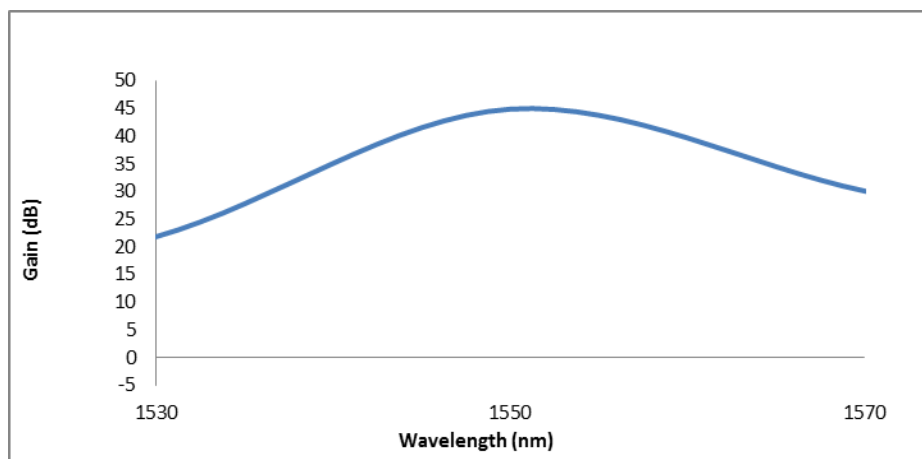


Fig. 5: Gain spectra of EDFA over the bandwidth of 1530 to 1570 nm.

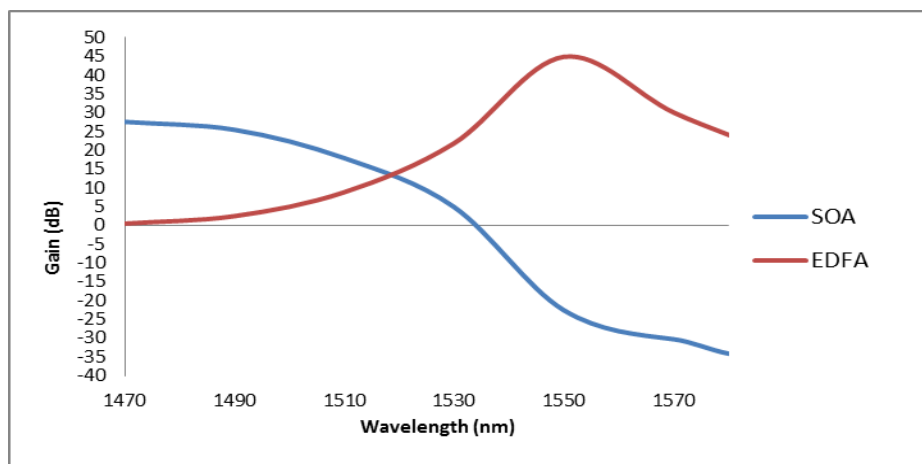


Fig. 6: Gain versus wavelength for SOA and EDFA configurations (pre-hybrid).

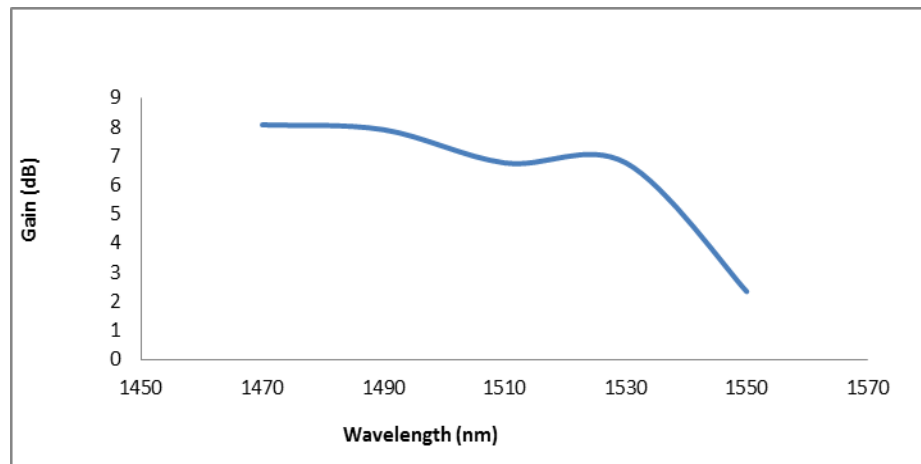


Fig. 7: Gain versus wavelength for cascaded SOA-EDFA configuration.

Conclusion:

We present and demonstrate a CWDM transmission system using a hybrid SOA-EDFA amplifier. The proposed hybrid amplifiers are based on cascaded SOA-EDFA optical amplifier which spans over 100km with uniform performance 0 dBm power penalty. The proposed hybrid amplifier enables nearly flat gain over a broad spectrum of the transmission spectrum, with some saturated output power at wavelength of 1550 nm and higher.

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