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Dense Wavelength Division Multiplexing Optical Network System

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ABSTRACT

In this paper, a dense wavelength division multiplexing (DWDM) system with 64 modulated channels 50 GHz spacing covering 25.2-nm bandwidth has been demonstrated. When optical signals are to travel over long distances, it’s be faded and spread out. So, it is necessary to strengthen the signal at intervals. To keep the signal strength at same level in the DWMD system, Er-doped fiber amplifier (EDFA) has been used. The EDFA provides a gain across the bandwidth with 10 dB average gain and a gain shape variation peak-to-peak of about 1 dB. OptSim’s physical EDFA model has been used for DWMD systems.

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1. INTRODUCTION

Optic beams with different wavelengths propagate without interfering with one another, so several channels of information (each having a different carrier wavelength) is transmitted simultaneously over a single fiber. This scheme, called wavelength-division multiplexing (WDM), increases the information carrying capacity of a fiber [1]. When there are more than just a few (2 or 3) WDM channels, the system is referred to as dense wavelength-division multiplexing.

If optical signals are to travel over long distances, the signals tend to fade, or attenuate and in the case of digital transmission each optical pulse tends to spread out from the more compact form in which it was transmitted. So it is necessary to use amplifiers to strengthen the signal at intervals. Two types amplifier are used in fiber optics, namely laser-diode amplifiers and doped-fiber amplifiers for strengthen the signal. The gain flattening of Erbium-doped fiber amplifiers (EDFA) has been a research issue in recent years, with the development of high capacity wavelength division multiplexing (WDM) optical communication systems. For single channel systems, the gain variation is not a problem [2-6]. However, as the number of channels increases, the transmission problem arises because a conventional EDFA has intrinsic non-uniform gain. They typically present gain peaking at about 1530 nm and the useful gain bandwidth may be reduced to less than 10 nm.

The gain of EDFAs depends on a large number of device parameters such as erbium-ion concentration, amplifier length, and core radius and pump power. To increase the gain-bandwidth of an amplified light wave system several methods can be used but equalizing optical filters operating as spectrally selective loss elements appear to be the best candidates.

2. ERBIUM-DOPED FIBER AMPLIFIER (EDFA)

Erbium-doped fiber amplifiers (EDFAs) are pieces of fibre that are doped with erbium, an element that can boost the power of an optical wavelength. In fact, it can simultaneously amplify all the wavelengths on a given fibre, and it may do so passively (i.e. without electrical power or electronic systems). Erbium-doped fiber amplifiers are attractive because of there ease of manufacture and simplicity of coupling into the fiber link. It has high gain, large bandwidth and low noise [1], [2].

3. SIMULATION OF DENSE WDM SYSTEM

A binary sequence has used to drive the simulation. Light source is CW lasers with external modulators. The light source is a P-type intrinsic semiconductor. The predefined compound component for EDFA with 10dB fixed gain using manufacturing parameters of OFS HE980 EDF is used. The amplifier unit consists of EDFA, pump source (co-propagating pump in our case), coupler, and optical filter. The purpose of optical filter here is to equalize gain and output power over the bandwidth of amplifier, and conventionally is called gain flattening or gain equalizing filter. A snapshot of the topology is shown in Fig.1. A 64 modulated channels 50GHz spacing with power per channels -15dBm (total power 3dBm) and wavelength range 1537.4-1562.6 nm is set up as input to EDFA. CW pump source at 980 nm is co-propagating in EDFA through the coupler – Optical Multiplexer. Insertion losses of coupler, optical filter, and fiber splices should be accounted for input and output losses. Forward-input losses are set to 0.6dB and output losses are set to 3.4dB [3]. Various signal analysis blocks are also included to assess the EDFA's performance. The EDFA model parameters used in the simulations are based largely on data from [7-10].

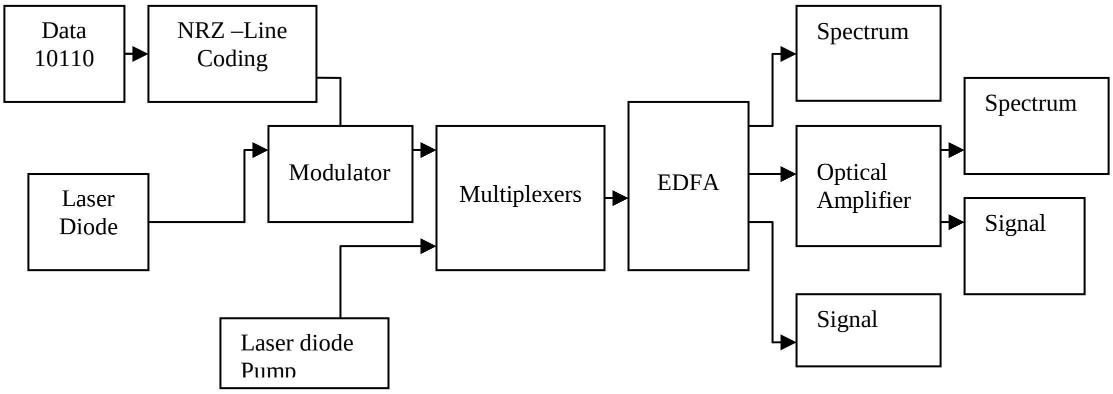


Fig. 1 Block diagram of Dense WDM system with EDFA

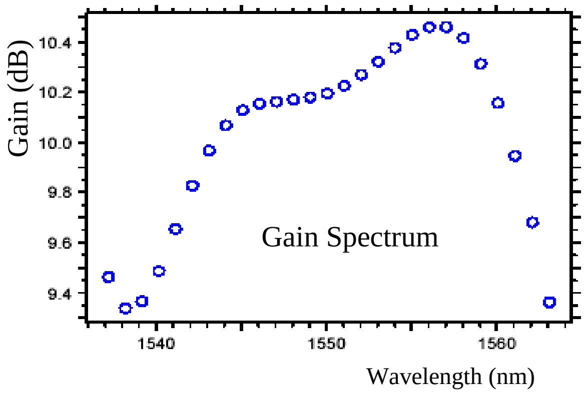


Fig. 2 Gain shape of EDFA over the 64-channel bandwidth of 25.2 nm

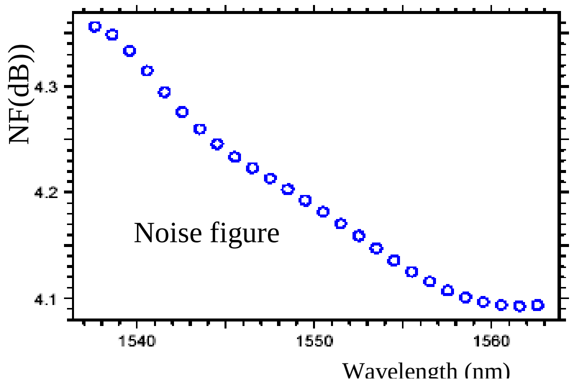
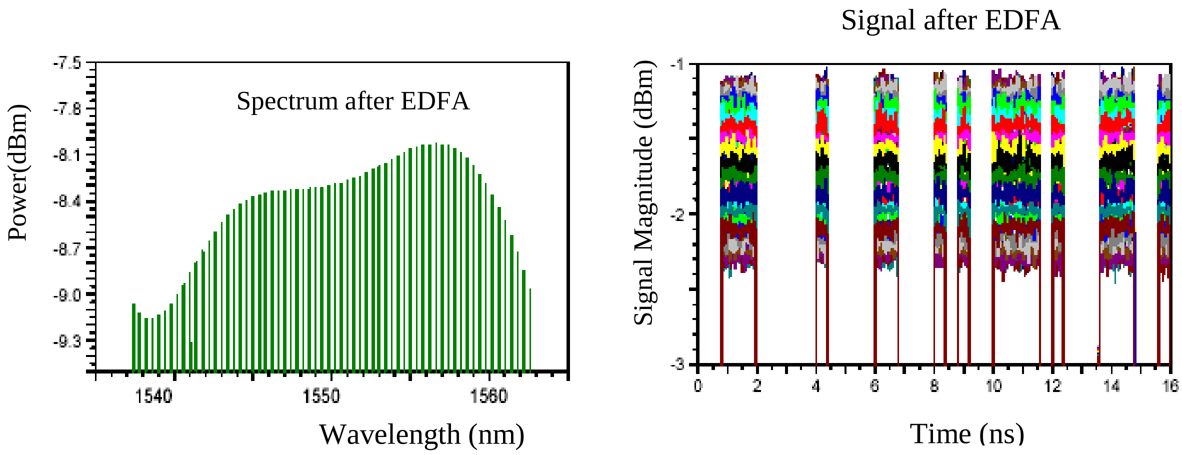


Fig. 3 Noise Figure of EDFA over the bandwidth of 25.2nm

For EDFA gain calculation Giles parameters simulation mode with data files for gain and loss spectrum are used that are commercially available OFS Er-doped fiber correspondingly. Pump power of 86mW and EDFA length of 14.5 m are chosen to provide 13 dBm total output power and 10 dB gain average across the bandwidth (Fig. 2). The EDFA gain increases with the increasing wavelength. It is seen from the (Fig. 2) that gain spectrum has high value at wavelength 1557 nm. The noise figure decreases with increasing wavelength. It has an average of 4.2 dB and minimum value at wavelength 1560 nm (Fig. 3).

4. SIMULATION OUTPUT

The power spectrum gradually increases with increasing wavelength. From figure 4(a), it is seen that optical power spectrum are not equal value over the bandwidth 25.2 nm. It is clear that maximum power is obtained at wavelength 1557nm. Power spectrum has 1dBm peak-to-peak differences that are very less difference. Since EDFA has high gain so all signals will be transmitted but all signal power will be different. Since signals powers are not equal as shown in Fig. 4(b), so some signal will be faded and this system will contain noises. So it is needed to equalize all power to the same value. In this paper, a gain flattening optical filter has also been investigated which equalize all channels power to the same level. So a gain flattening optical filter (GFF) is inserted after EDFA block. The shape of this filter is an inverse of EDFA gain shape (Fig. 5). Here average loss of this filter across the bandwidth is zero since filter's insertion loss is included in the output loss of EDFA model. Fig. 6(a), Fig. 6(b) shows optical spectrum and signal shape after optical filter – now peak-to-peak difference for different wavelengths is less than 0.1 dB and all 64 channels have practically the same power.



(a) Optical spectrum in time domain after EDFA block

(b) Optical signal in time domain after EDFA block

Fig. 4. The power spectrum

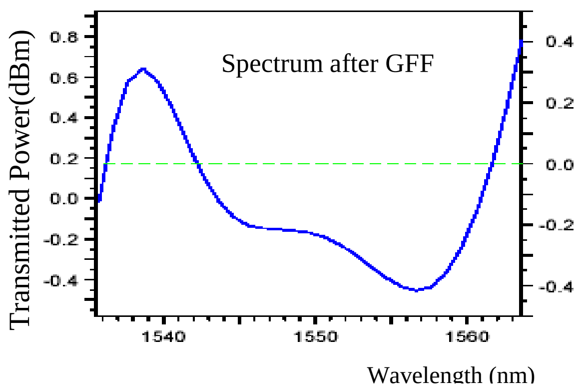


Fig. 5 Shape of gain flattening optical filter

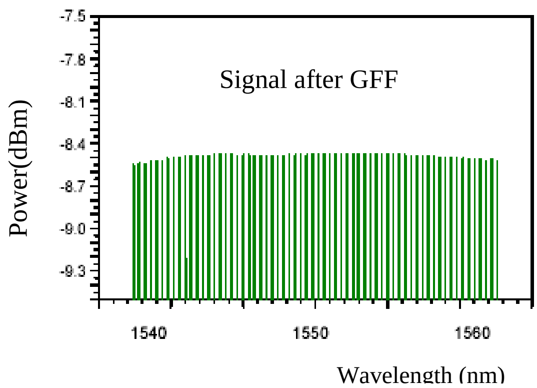


Fig. 6(a) Optical spectrum in time domain after gain flattening optical filter

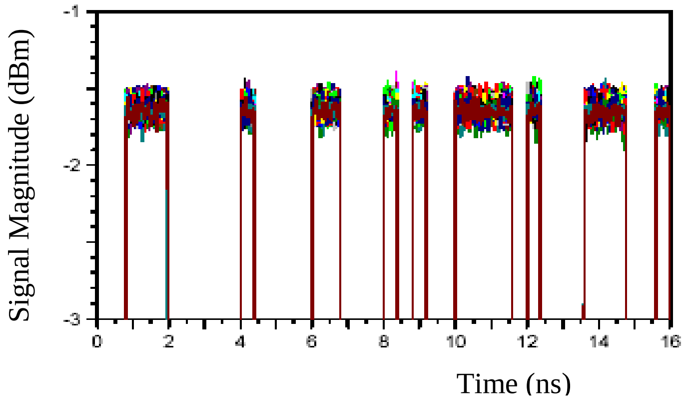


Fig. 6 (b) Optical signal in time domain after gain flattening optical filter

5. CONCLUSION

A dense WDM system has been demonstrated considering realistic case typically for long haul systems. It is seen from the optical spectrum, Fig. 4(a) and signal shape, Fig. 4(b) that after the EDFA, it has about 1 dB peak-to-peak difference. Really, this represents less difference after amplifier. Gain flattening optical filter has also been used with EDFA which reduces the peak-to-peak difference. The above results indicate that such type EDFA is very suitable for Dense WDM system.

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BIBLIOGRAPHY OF AUTHOR

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