

Novel flattened gain using RAMAN-Erbium doped silica fiber hybrid optical amplifier for super dense wavelength division multiplexing system

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Abstract

We have proposed a very advanced super dense wavelength division multiplexing (SD-WDM) system using RAMAN-Erbium doped silica fiber optical amplifier (EDSFA) hybrid optical amplifier (HOA) in this paper. Performance is evaluated in term of flattened gain and noise figure for C-band. Effect of proposed hybrid optical amplifier also compared with EDFA-RAMAN, EDFA-SOA and SOA-SOA HOA for the same characteristics. Best rating gain of 37.5 dB with noise figure of 5.4 dB ever recorded from RAMAN-EDSFA HOA. It is also observed that out come from SOA-SOA HOA is not acceptable in term of noise figure of 9.1 dB for 400 x 10 GB/s SD-WDM system.

Keywords: SD-WDM, RAMAN-EDSFA, EDFA-RAMAN, EDFA-SOA, SOA-SOA, noise figure, gain

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1. Introduction

Super dense wavelength division multiplexing (SD-WDM) system is the future transmission technology which requires some special features in terms of a flat gain to rectify the optical signal in a better form (Singh et al., 2013). EDFA has been used significantly at many places in long haul optical communication system but due to its narrow gain bandwidth, it is being overtaken by conventional optical amplifier such as the SOA and RAMAN. Gain is a very efficient parameter which can be improved by changing the material characteristics (Hung et al., 2018; Yamada et al., 1998; Yoshida et al., 1995; Puttnam et al., 2020; Pedro et al., 2018). Materials research enhances the population inversion in stimulation principal. In this way a very advanced optical amplifier, erbium doped silica fiber optical amplifier (EDSFA) is investigated and has the right answer for amplified spontaneous emission (ASE), cross gain modulation (XGM), and four wave mixing (FWM) crosstalk (Chen et al., 2018; Huang et al., 2019; Qasaimeh et al., 2017). Its remarkable outcome in terms of flat gain, noise figure with acceptable population inversion is recorded for L-band (Cai et al., 2015; Singh et al., 2014; Anurupa et al., 2019; Galdino et al., 2019). Different pumping couplers have been presented in the literature to increase the carrier concentration in conduction band (Hill et al., 1990; Scobey et al., 1996) for EDSFA.

In EDSFA, utilization of gain bandwidth is the prime concern for different optical bands with different characteristics (Azzawai et al., 2019; Almukhtar et al., 2019; Kaur et al., 2019; Ferreira et al., 2012; Yamada et al., 1997). The important features of EDSFA in terms of flat gain and noise figure have been traced out the very first time in this paper. Up to best of our knowledge no such novel work ever reported in any literature. The representation of this paper is given as description of simulation setup in section 2, result and discussion in section 3 and final summary of this paper in terms of conclusion in section 4.

2. Simulation setup

Transmission capacity of proposed model has been considered up to 400 channels with data rate of 10 GB/s, with channel spacing of 100 GHz. Just because of this reason this set up is called the super dense wavelength division multiplexing (SD-WDM) system. Pumping is set to RAMAN at 1250 nm and 1300 nm respectively. Furthermore, the pumping of 1550 nm and 1400 nm are set to EDSFA through the optical pumping coupler (OPPC) and optical coupler (OC), which are shown in Figure 1. Infact, pumping is the prime concern for our research because we try to archive flat gain with the least variation without using any costly instrument and technique such as fiber grating, external filter, tapered fiber filter, acousto-optic tunable filter (Javorsky et al., 2019; Zhang et al., 2015; Tian et al., 2019; Deng et al., 2018; Anzueto et al., 2017; Lee et al., 2019).

Data source and electrical drive are cascaded to generate the NRZ format. Amplitude modulator takes the signal from electrical drive and CW laser source to generate the modulation signal. In this way, higher power signal is prepared to transmit for long distance. The power level of transmitted signal is further measured with the help of the optical splitter (OS), power meter (PM) and optical spectrum analyzer (OSA) by placing them after and before the transmitter and receiver.

Modulated signals are further connected with inline RAMAN and EDSFA hybrid amplifier (HOA) to measure the flattened gain and noise figure. The received optical signal which is converted signal is traced out with the support of PIN diode and filter at the receiver side. In this way, the electrical signal is ready for the further analysis.

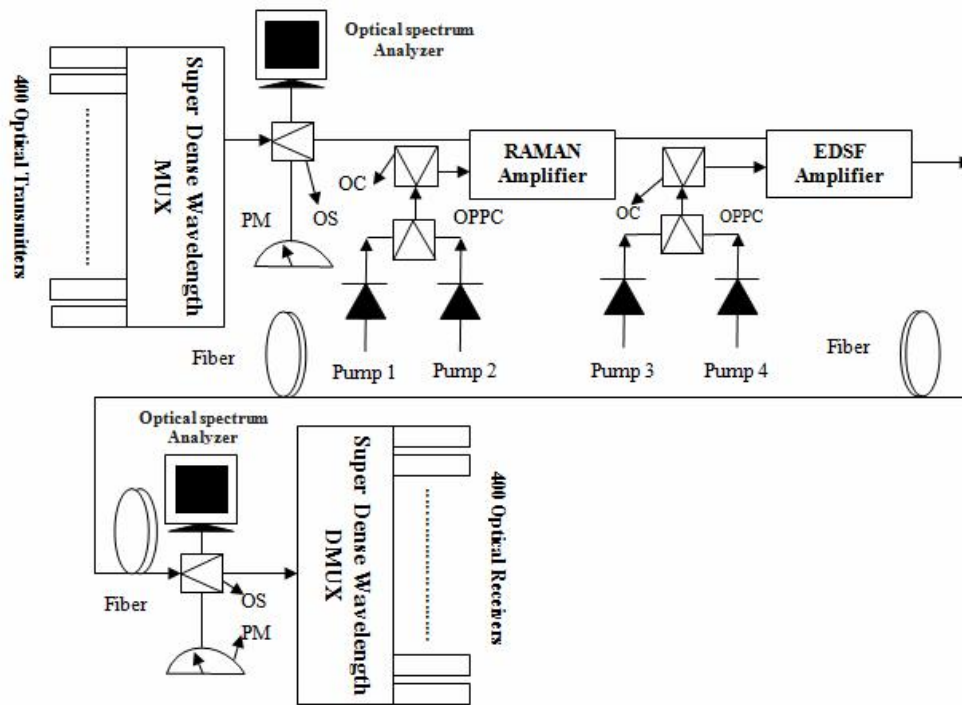


Figure 1. 400x10 SD-WDM system

3. Result and discussion

The effect of RAMAN and EDSFA are analysed in the characteristics of gain and noise figure in Figure 2 and Figure 3, respectively. Further, the recorded results are also plotted with EDFA-RAMAN, EDFA-SOA and SOA-SOA hybrid optical amplifier to illustrate the same characteristics. The highest gain of 37.5 dB with noise figure 5.4 dB are noticed for RAMAN-EDSFA HOA. Unacceptable results are projected from SOA-SOA HOA in terms of noise figure 9.1 dB and gain. It is also observed that after 1595 nm the gain is much flattened till 1630 nm with the variation of 2.6 dB. We have also evaluated the performance of proposed HOA for the range of 1555 nm to 1625 nm in C-band for same feature. The slop of gain increase quite linearly from 1555 nm to 1590 nm and maintains least variation till 1625 nm with flat gain. In this way, we have achieved the best rating for the super dense optical communication system in terms of flat gain and noise figure. No such coast effective techniques like this have been given in the research papers of Javorsky et al.(2019), Zhang et al.(2015), Tian et al.(2019), Deng et al.(2018), Anzueto et al.(2017), Lee et al.(2019) and they have not used for the proposed characteristics. Further, representation of each hybrid optical amplifier in terms of received eye diagrams is also shown from Figures 4 to Figure 7, accordingly. But, the impression of RAMAN-EDSFA hybrid optical amplifier is more valuable than the others combination of hybrid optical amplifier.

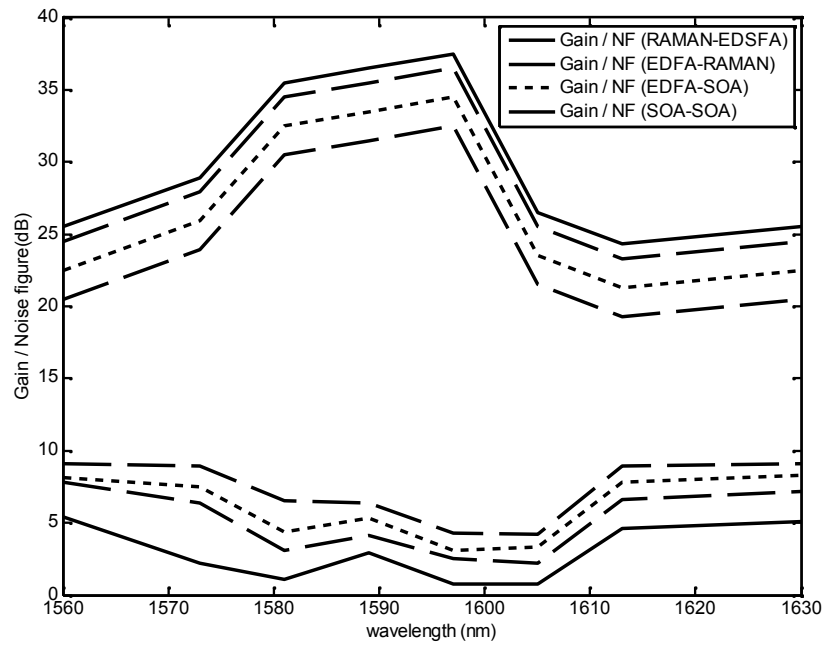


Figure 2. Gain and noise figure for C-band

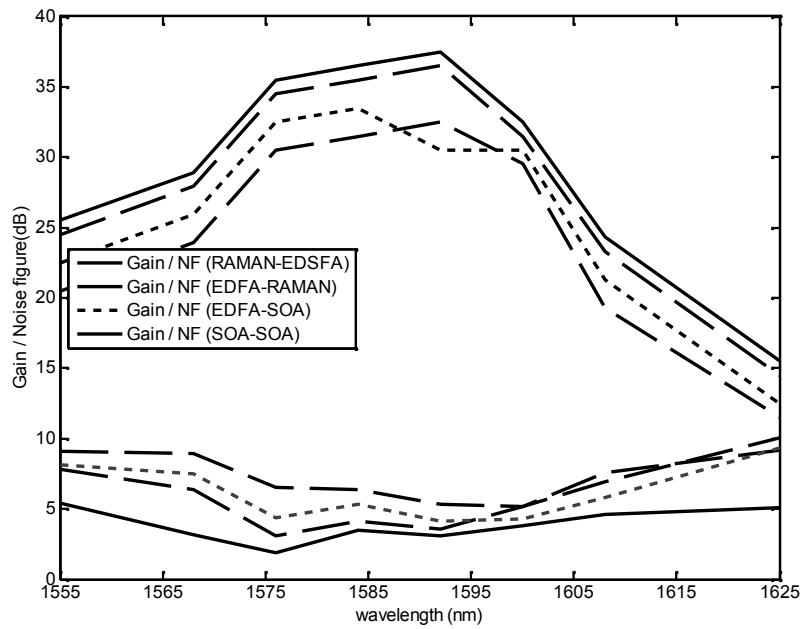


Figure 3. Gain and noise figure from 1555 nm to 1625 nm

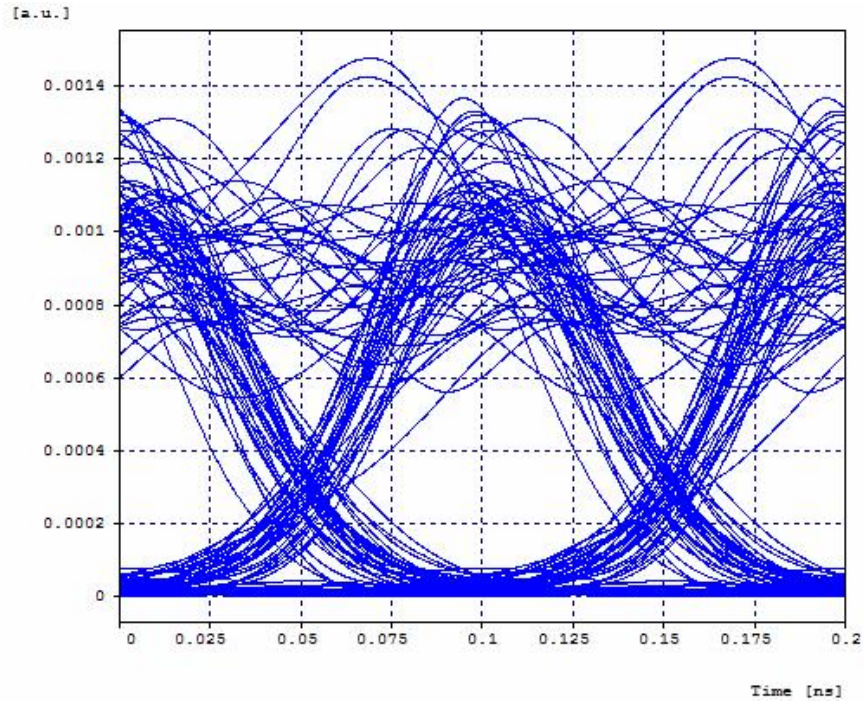


Figure 4. Recorded eye diagram of RAMAN-EDSFA hybrid optical amplifier

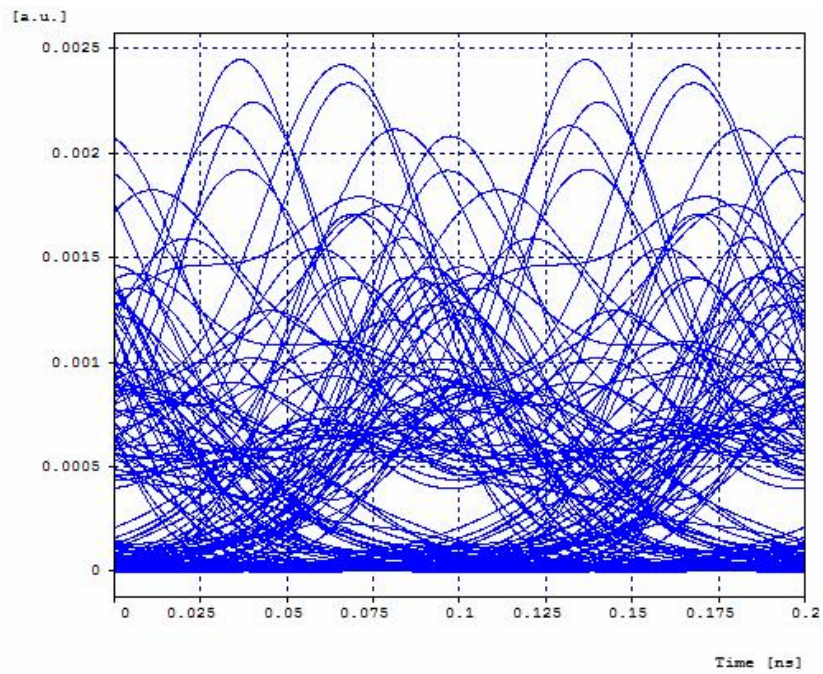


Figure 5. Recorded eye diagram of EDFA-RAMAN hybrid optical amplifier

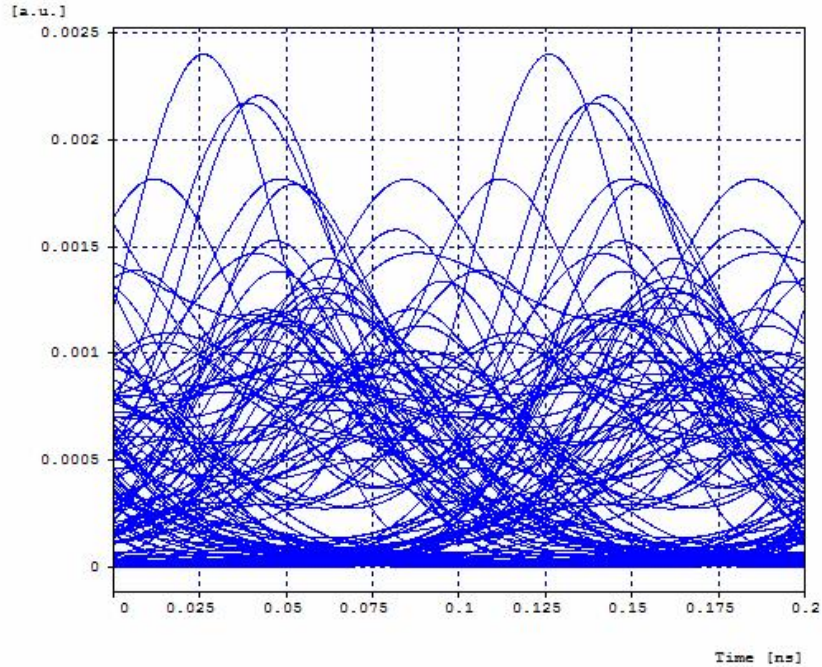


Figure 6. Recorded eye diagram of EDFA-SOA hybrid optical amplifier

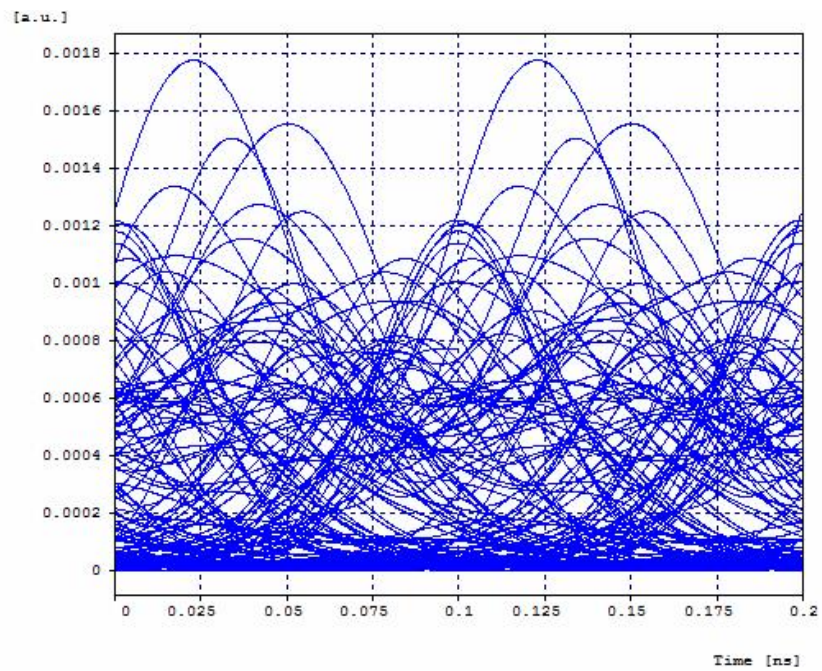


Figure 7. Recorded eye diagram of SOA-SOA hybrid optical amplifier

4. Conclusions

Analysis of 400 channels with data rate 10 GB/s for SD-WDM system is done with RAMAN-EDSFA hybrid optical amplifier. Major parameters are evaluated in context of flat gain and noise figure. Highest flat gain of 37.5 dB ever noticed among the other HOAs with noise figure of 5.4 dB. Furthermore, the performance of RAMAN-EDSFA hybrid optical amplifier has shown the acceptable characteristics for the range of 1555 nm to 1625 nm in C-band. So it is ceased that proposed HOA really help out to transmit super dense channel with least variation in gain. Moreover it can be reflected that recorded results will be supporting to extend the research to increase the channel capacity for industrial optical communication system.

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