A High Flatness Gain Subsisting of Cascaded EDFA-TDFA Hybrid Optical Amplifier For Super Dense Wavelength Division Multiplexing System

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Short Report

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Abstract

Flat gain with least noise figure (NF) is the backbone feature of super dense wavelength division multiplexing (SD-WDM) system. It indicates the good amplification in terms of high-quality factor, lowest bit error rate, and good rating output power. But in this paper, we have mainly focused on characteristics of proposed EDFA-TDFA hybrid optical amplifier (HOA) in terms of flat gain and noise figure for C-Band. Evaluation has done for 400 x 2.455 Gb/s SD-WDM system with channel spacing of 0.8 nm. Moreover, effect of proposed HOA also observed with displacement of channel wavelength for evaluating the impact of different set of HOA for analysis the same characteristics.

Introduction

Flat gain is the highly acceptable characteristics for super dense wavelength division multiplexing (SD-WDM) system which try to archive with the combinations of different optical amplifiers and hybrid optical amplifiers (HOAs) [1–2]. Number of examples are given in the present literature such as combination of hybrid optical amplifiers and erbium-doped fiber amplifiers (EDFAs) in C plus L band[3–4], combinations of thulium-doped fiber amplifiers (TDFAs) and (EDFAs) in S plus C plus L band[5–6] and combination of (EDFAs) and Raman amplifiers (FRAs) in C plus L plus U band respectively[7]. But the combination of EDFA and TDFA is most significance hybrid optical amplifier (HOA) for delivering the flattered gain and also banished the effect of fiber nonlinearity [8–10]. Optical and at some place electrical pumping are the main biasing feature for the existing optical amplifier. Internal defects such as crosstalk and optical amplifier nonlinearity can also be control by adjusting the level of pumping power. Multiple pumping has also been recommended in the literature [11–13] for TDFA to enhance the performance of super multiplexing system in terms of bit error rate, output power, higher gain bandwidth, and noise figure. The performance of TDFA has also been observed for different cascaded amplification for different set of wavelength region [14–16].

In this paper to the best of authors knowledge, first time combination of EDFA and TDFA hybrid optical amplifier has been recommended for getting flat gain with insignificant effect of noise figure (NF) for super dense wavelength division multiplexing (SD-WDM) system.

However, paper is represented in IV sections. Section I, explained introduction of the paper, section II, explained the simulation setup of the proposed hybrid amplifier with dual pumping technique, section III, explained the final outcome from the proposed system and section IV, explained the final conclusion.

Simulation Setup

Our simulation setup for EDFA and TDFA hybrid amplifier is shown in Fig. 1.Simulation is carried out with dual pumping technique for both optical amplifiers. EDFA is pushed with dual pumping of 990 nm with 675 mW and 1490 nm with 540 mW respectively. In the similar manner, TDFA is pushed with dual pump of 1440 nm with 680 mW and 1460 nm with 690 mW respectively.

In fact, carrier concentration in terms of population inversion can only be possible to set the level of pump laser diode (LD). Subsequently, outcome of the optical amplifier would be in good rating flattered gain with least noise figure [17].

Further, optical signal is fed to the EDFA amplifier then to cascaded TDFA amplifier. This is called EDFA-TDFA hybrid optical amplifier. The gain of EDFA is set to 25 dB with noise figure of 4 dB. Optical signals are received at the receiver side by PIN photodiode, which is operated at .875 A/W of responsivity and 0.1 nA of dark current. Channel spacing of 0.8 nm is maintained for C-band.

In this proposed system, 400 optical signals are generated from 400 CW laser sources. Power of each input probe is set to -10mW to maintain the quality of received signal [18]. Data rate is set to 2.455 Gb/s NRZ binary sequence which further injected to sine-squared amplitude modulator to enhance the power level of low optical signal to higher optical signal level. Resultantly, the output is come out in terms of modulated signal.

Result And Discussion

Final outcome in terms of gain and noise figure with respect to C-band is shown in Fig. 2.The observed values for different sets of hybrid optical amplifiers in terms of flat gain are given as 20.1 dB to 18.55 dB for EDFA-TDFA HOA, 15.1dB-13.55dB for RAMAN-EDFA HOA, 10.1dB to 8.55 dB for EDFA-EDFA HOA and 8.1 dB to 6.55 dB for RAMAN-RAMAN HOA respectively for the range of 1530 nm to 1565 nm.

Recorded values of NFs are given as 8.5 dB for RAMAN-RAMAN HOA, 7.5 dB for EDFA-EDFA HOA, 7.2 dB for RAMAN-EDFA HOA and 2.5 dB for EDFA-TDFA respectively. It shows that our proposed HOA delivers the maximum gain of 25.55 dB with variation of 1.22 dB than the reference [17] which is good sign for optical communication.

However, performance of proposed hybrid amplifier is also evaluated with displacement in the channel wavelength in Fig. 3. It is clearly observed that the impact of proposed HOA still maintained in terms of flat gain with least variation of 1.5 dB. But we can also notice that gain is linearly increasing till 1555 nm and decrease continuously till 1570 nm due to nonlinearity effect induced by hybrid optical amplifier. It is basically occurred due to the retardation of optical signal but it can also be improved by adjusting the power level of CW laser and power range of optical pump. Further, eye diagrams from different set of HOAs are also shown from Fig. 4 to Fig. 7 respectively to explore the impression of individual HOA. Nonlinear effect has highly dominating nature over optical communication which can only maintained with suitable rating of power amplification which has also done with the arrangement of EDFA-TDFA HOA. In fact, power strength of optical signals must be retained throughout the optical communication which further lead to good quality optical signals with least effect of dominating signals. The impression of proposed HOA is also observed in terms of power amplification in optical medium and at the receiver end which is also shown in Fig. 8 and Fig. 9 respectively. So, the eye opening of sudden checking quality of the transmission signals are also with the support of proposed HOA in Fig. 10. So, here it is observed

that overall impression of EDFA-TDFA HOA is acceptable to maintain the flat gain with acceptable rating noise figure.

Conclusion

Performance of proposed EDFA-TDFA hybrid optical amplifier for 400x2.455 Gb/s super dense wavelength division multiplexing (SD-WDM) system has been done in terms of flat gain and noise figure. Maximum gain of 25.55 dB with least variation of 1.22 dB is recorded. Impact of HOA is really helped out to maintain the flat gain for the range of 1530 nm to 1570 nm. On the other hand, influence of proposed hybrid optical amplifier (HOA) still retains with displacement of channel wavelength in terms of flat gain with variation of 1.5 dB.

Declarations

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Author Contributions Design and analysis a super dense optical communication to achieve the acceptable flat gain with the support of EDFA-TDFA Hybrid Optical Amplifier.

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Data Availability Data used for the results are available in the manuscript

Declarations Not applicable.

Conflict of Interest Authors declare that there is no conflict of Interest.

Consent to Participate We here give our consent to participate and communicate paper in this journal.

Consent for Publication We here give our consent to publish paper in this journal.

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Figures

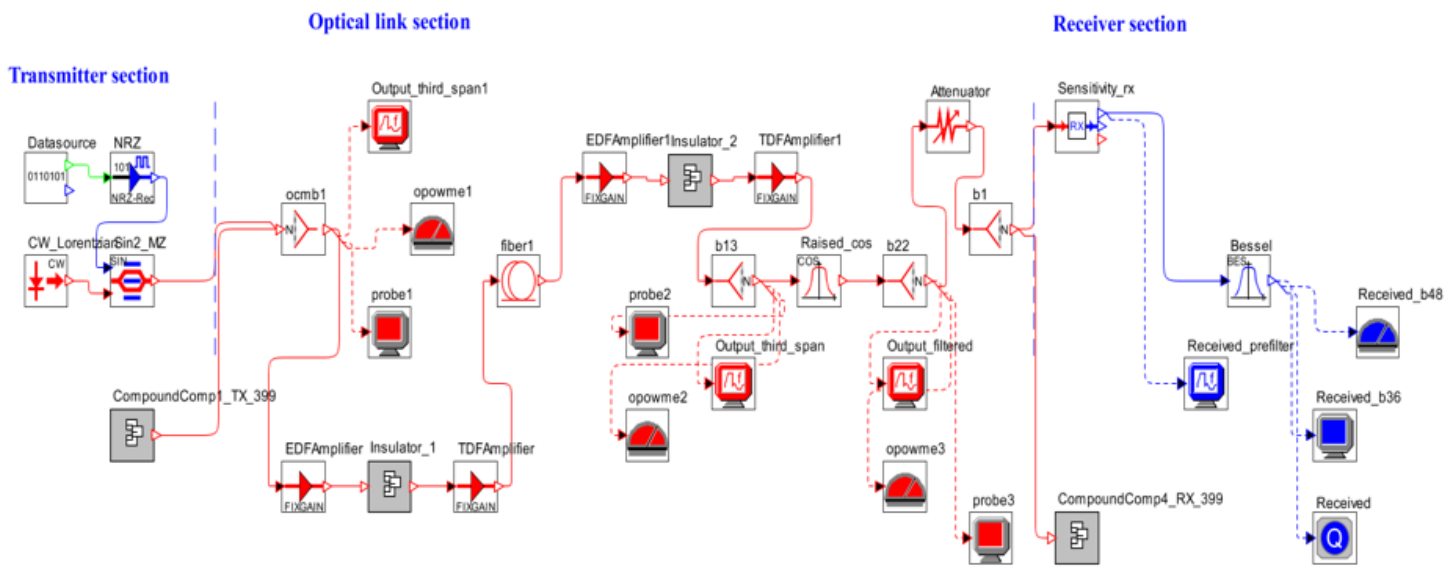

Figure 1

Simulation setup for EDFA and TDFA hybrid optical amplifier

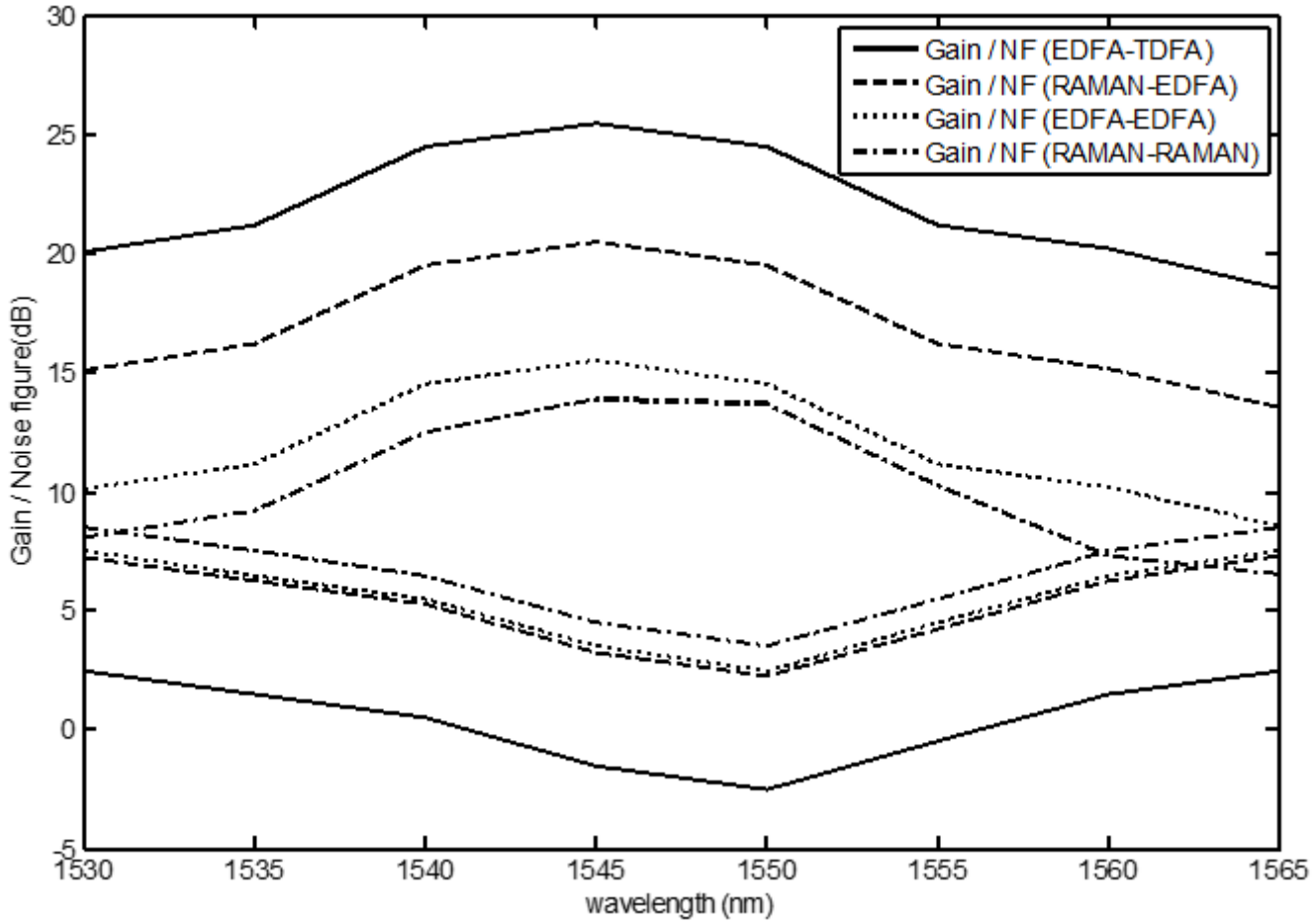

Figure 2

Outcome in terms of gain and noise figure with respect to wavelength

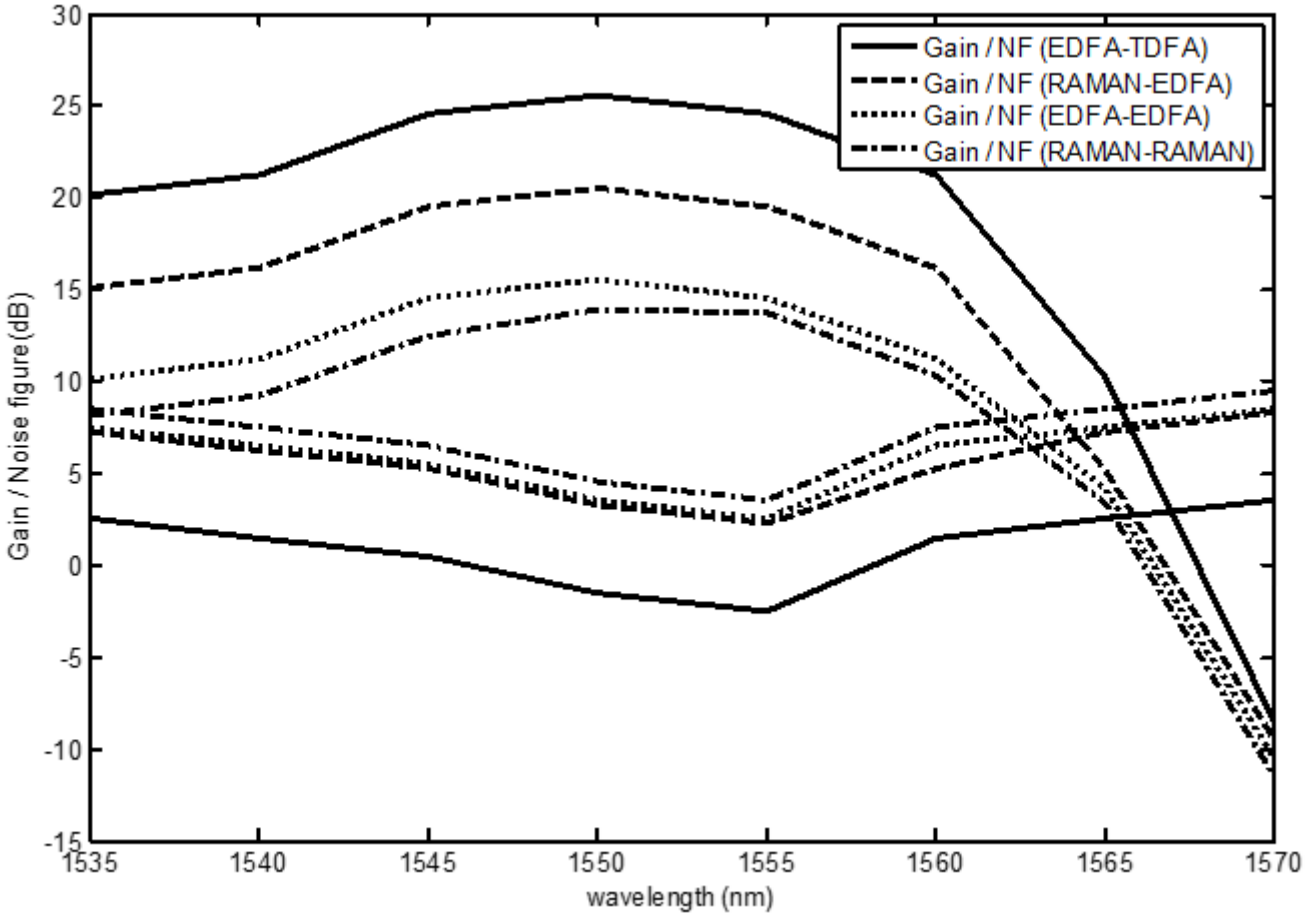

Figure 3

Impact of displacement on channel wavelength on proposed hybrid optical amplifier for gain and noise figure.

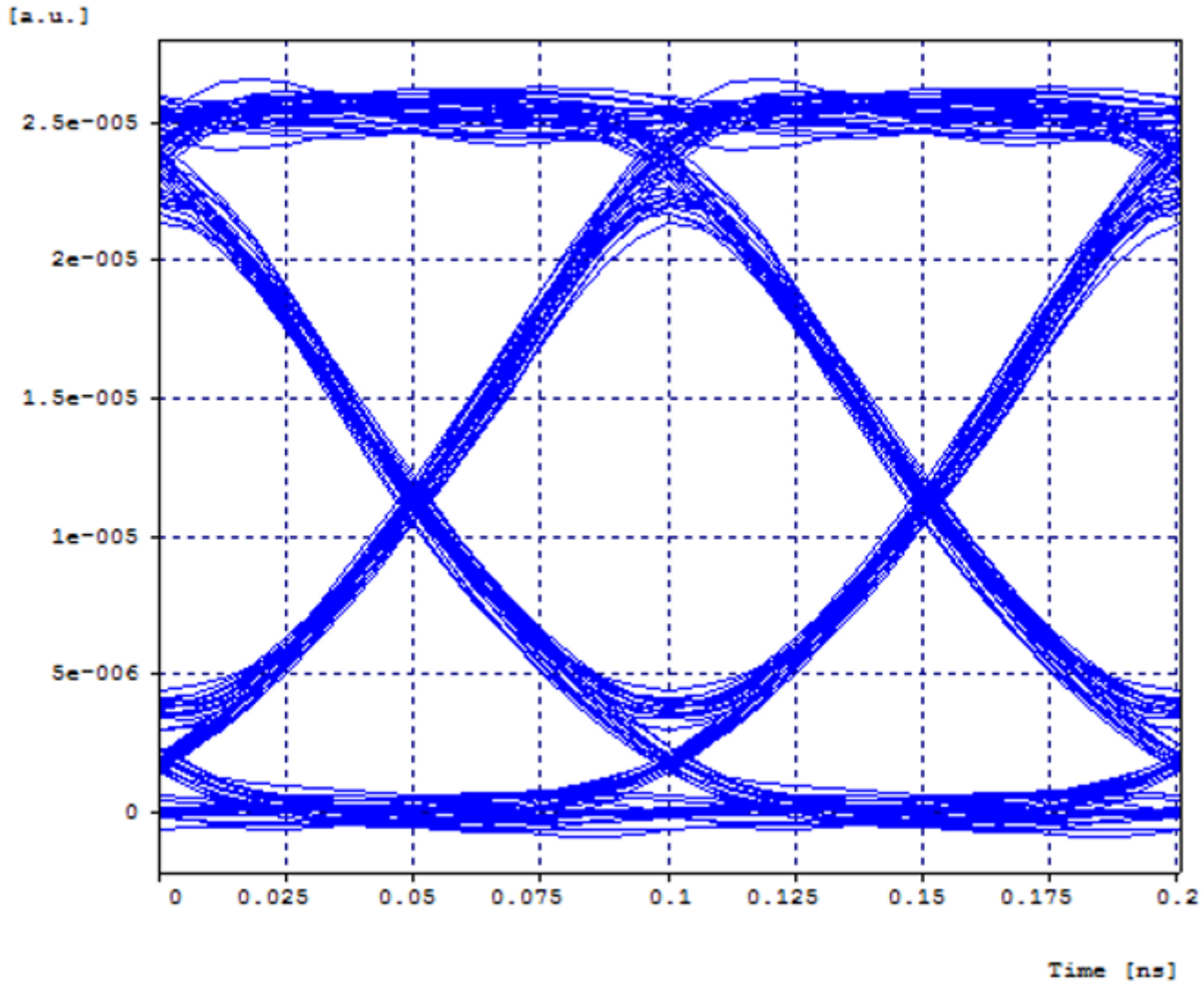

Figure 4

Eye diagram of EDFA-TDFA hybrid optical amplifier

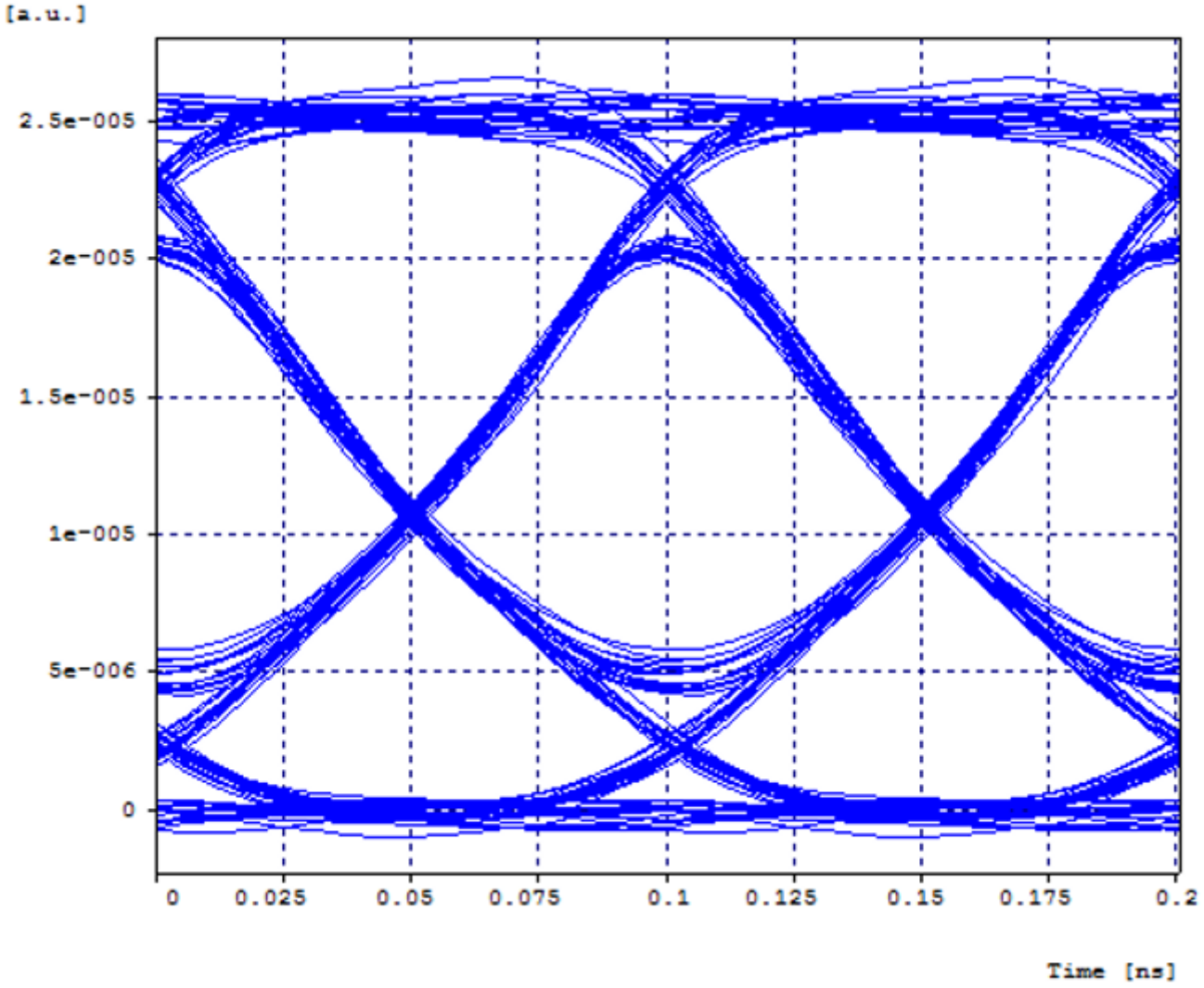

Figure 5

Eye diagram of RAMAN-EDFA hybrid optical amplifier

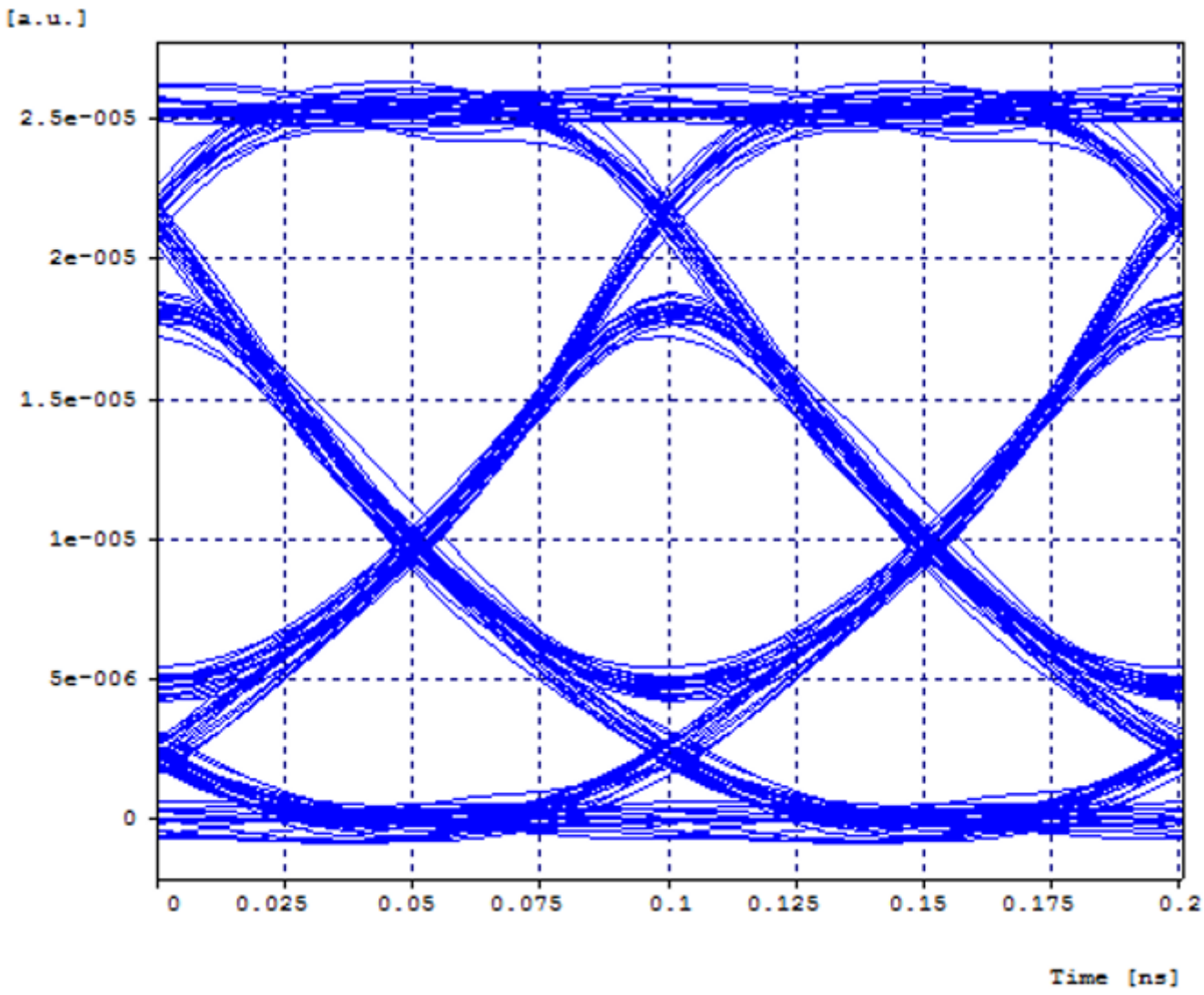

Figure 6

Eye diagram of EDFA-EDFA hybrid optical amplifier

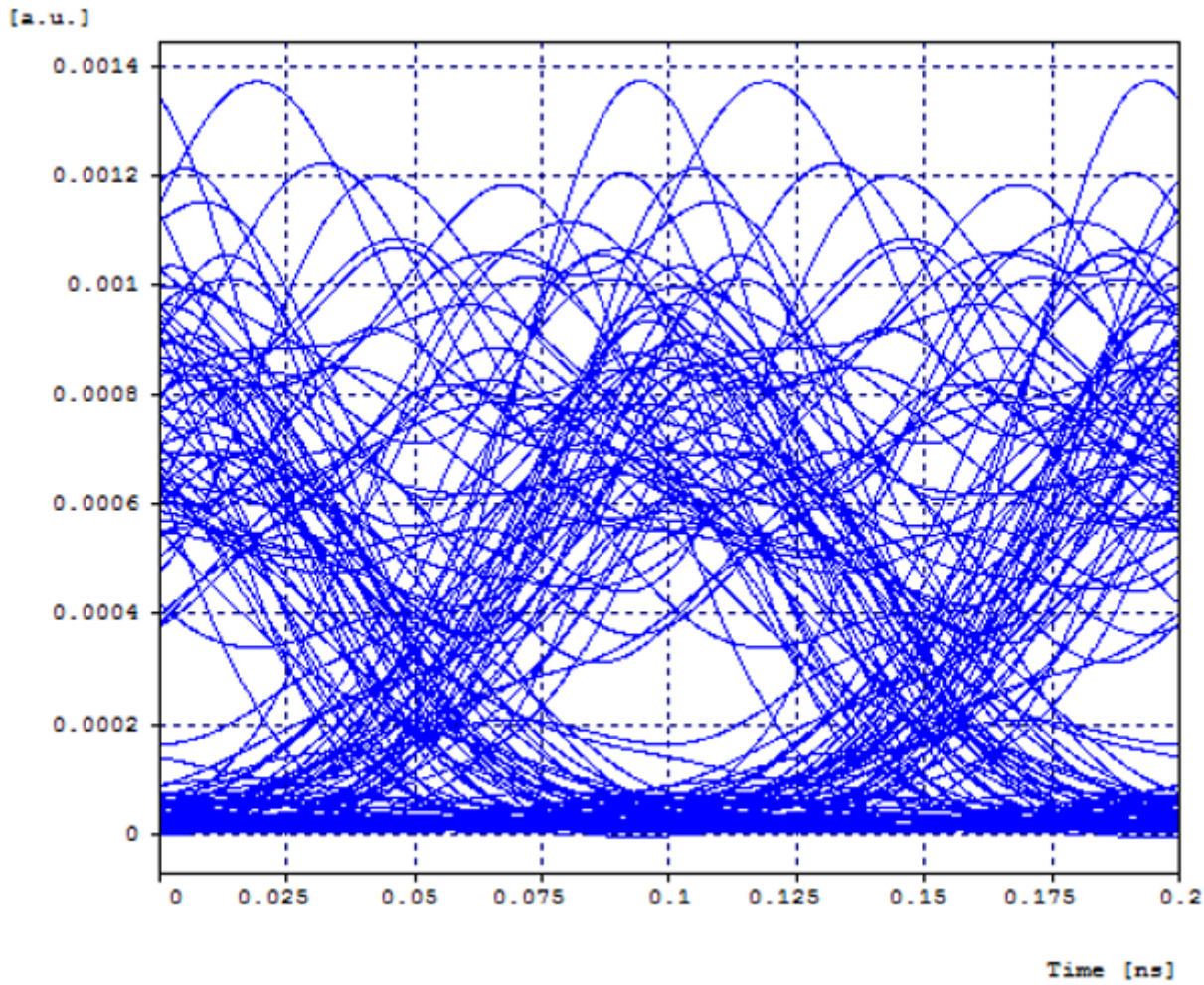

Figure 7

Eye diagram of RAMAN-RAMAN hybrid optical amplifier

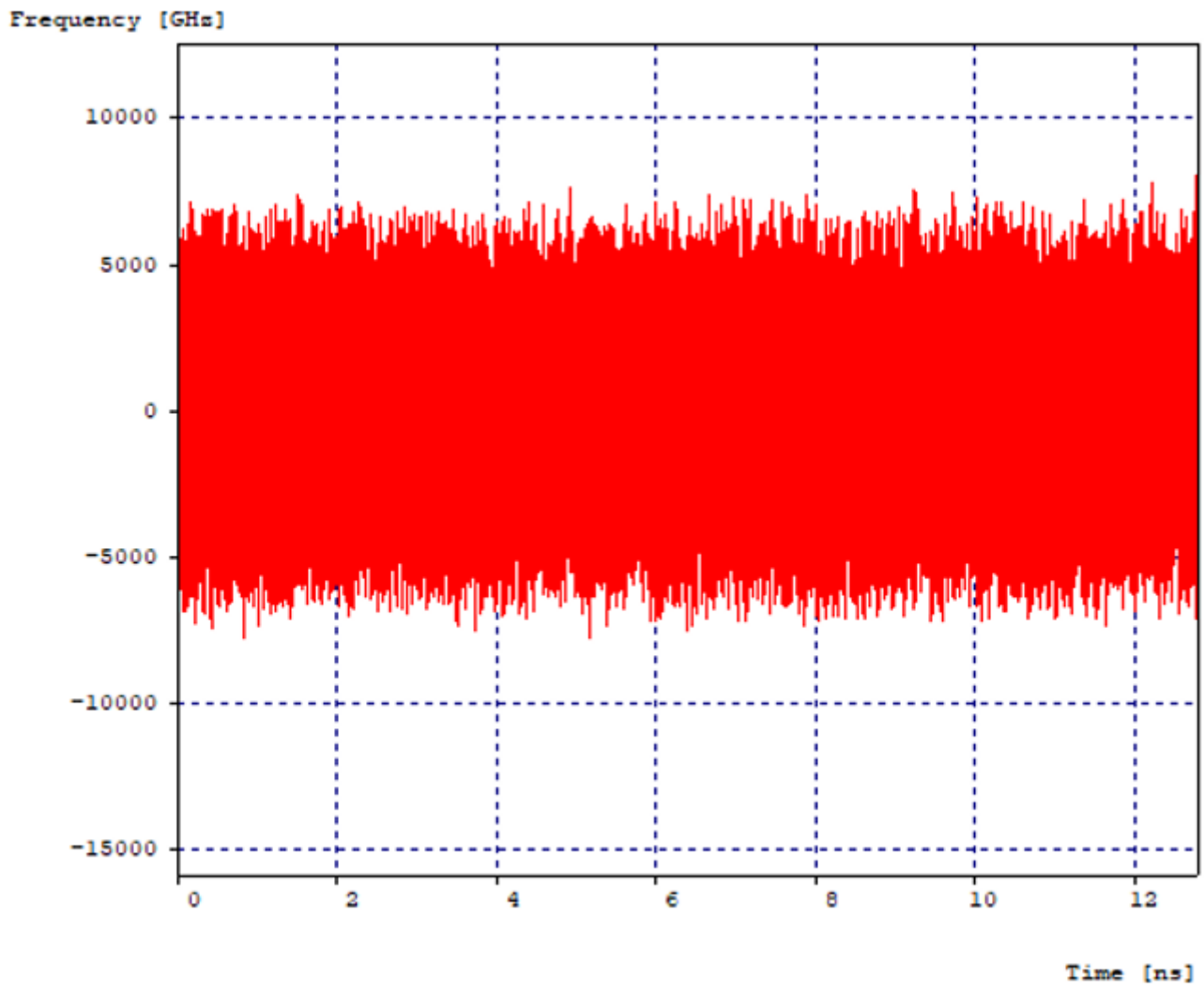

Figure 8

Power amplification in the optical medium from EDFA-TDFA hybrid optical amplifier

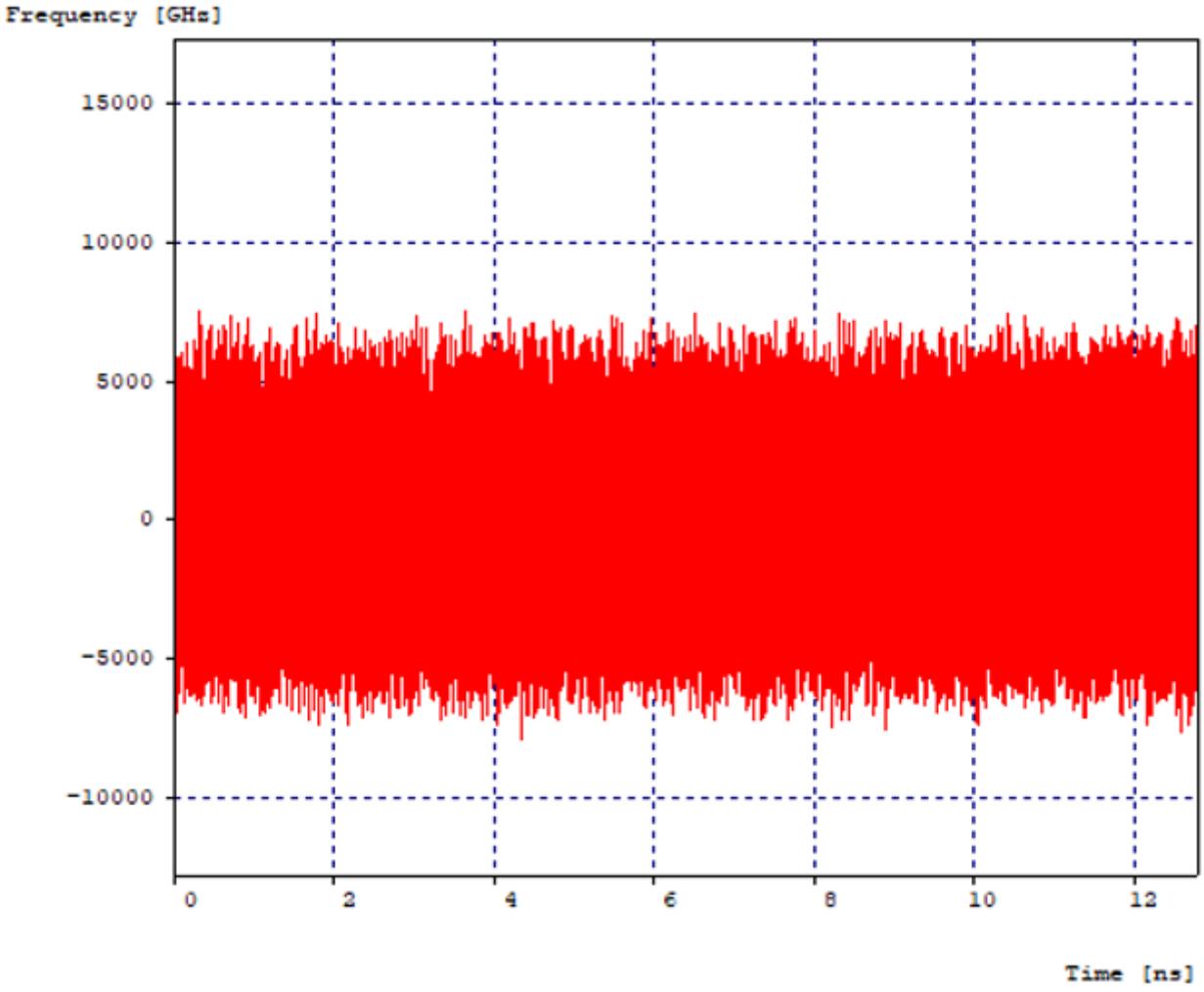

Figure 9

Observation of power amplification near the receiver section from EDFA-TDFA hybrid optical amplifier

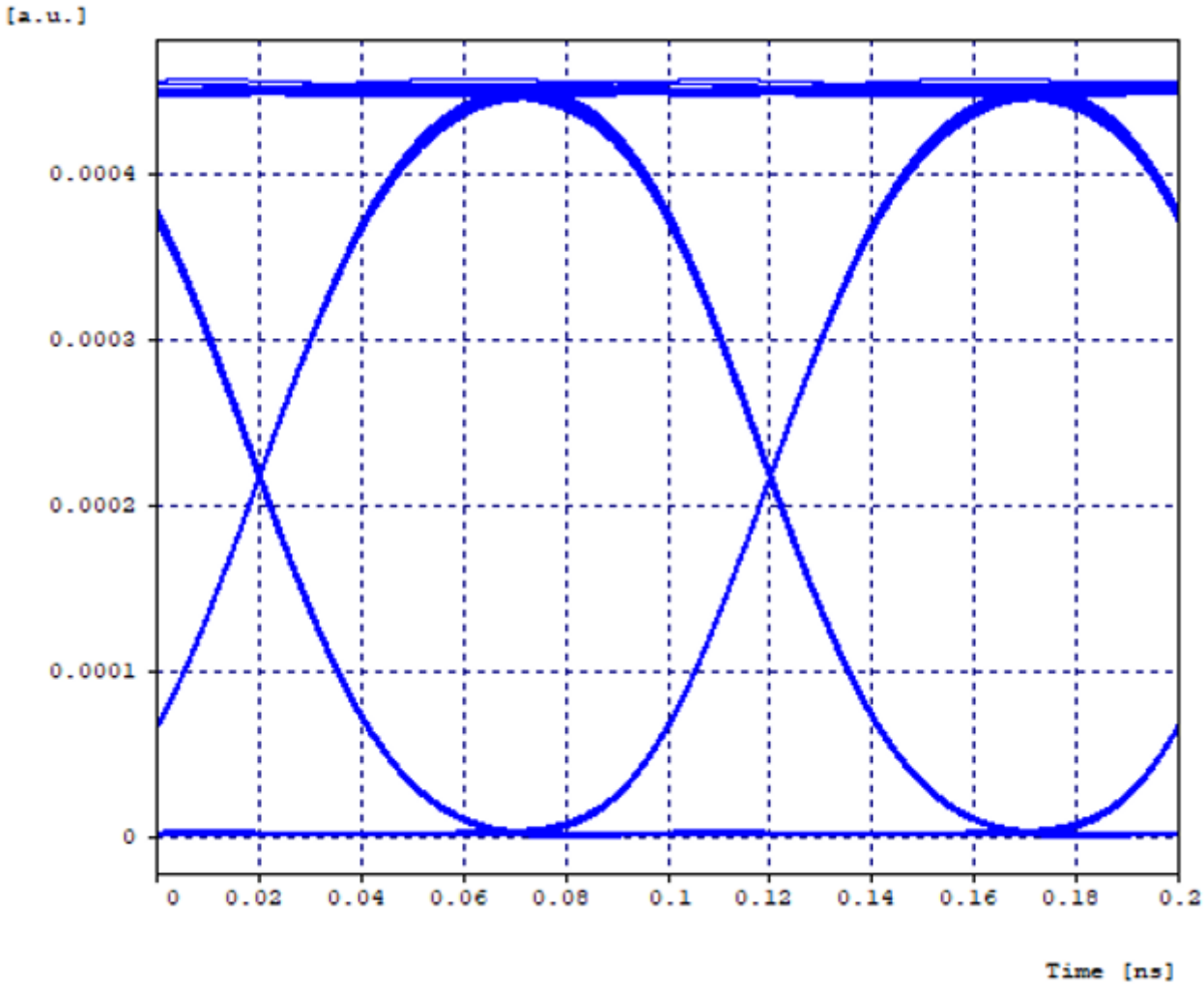

Figure 10

Observation of eye diagram from EDFA-TDFA hybrid optical amplifier in the middle of transmission medium