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Optimization of Hybrid RAMAN-EDFA-RAMAN Optical Amplifier for Super Dense Wavelength Division Multiplexing System

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In this paper, we have projected a new optimization approach for Super Dense Wavelength Division Multiplexing (SD-WDM) system with the help of RAMAN-EDFA-RAMAN hybrid optical amplifier (HOA). Evaluation has accomplished with respect to quality factor, noise figure, output power, RAMAN pumps, RAMAN fiber length and effect of jitter. Best rating parameters have noticed for getting the acceptable performance from the proposed system. Further, evaluation with different dispersion ratings such as 2, 4, 6, and 10 ps/nm/km has also done. Furthermore, it has also observed that optimization rating of dispersion at 2 ps/nm/km declares to cover the maximum span distance up to 200 km with the high-quality factor.

Keywords: Hybrid optical amplifier; SD-WDM; EDFA; SOA; Optimization

1 Introduction

High-speed data transmission is the hot demand for SD-WDM system[1]. Optical amplifiers such as RAMAN, EDFA and SOA are key elements in high-capacity SD-WDM network. Optical amplifier was invented in 1980s[2,3] and introduced in 1990 for DWDM. Any optical communication system has three important blocks in terms of the transmitter, receiver and optical medium. But the performance of the system is entirely dependent upon the component parameters. Selection of parameters should be as such that the outcome of the received signals must be acceptable in terms of least bit error rate, better quality factor, best out power and least eye closure. Internal losses and dispersion are the main research topics for the researcher to enhance the performance of the system.

Johann *et. al*[4] have explored the new technique to analyze the power transient of cascaded of gain – clamped discrete fiber RAMAN amplifier. 64 channels have operated as such that one of the signal has modulated. Further authors have also declared that the proposed approach was not able to reduce the pump power of 0.69 W.

Liu *et al.*[5] have projected the new technology for ultra-broad band amplifier, which was based on clustering, sharing, and adaptive probability. Final outcome has shown that the proposed model was able to dismiss the weakness of DMRA and higher gain.

Singh *et al.*[6] have proposed new technology for dispersion compensation with the help of pre, post, and symmetrical power compensation. Amplification has carried out with the help of SOA amplifier. Final outcome declared that post power compensation provided the best rating performance in terms of bit error rate, eye closure penalty and received power. This proposed model has also declared to cover the maximum distance of 945 km.

Rajneesh *et al.*[7] have compared the performances of physical EDFA and compact EDFAs. Out comes have also declared that no improvement in gain has observed, when the amplifier length reached above 20 m.

Thomas *et al.*[8] have designed a model for short wavelength. It has also observed that the gain of 20 dB for the bandwidth 1445-1520 nm was attained by cascading the Thulium doped fluoride fiber with the discrete RAMAN amplifier.

Rakesh *et al.*[9] have proposed a model for 28 end users and wavelength range has also set to

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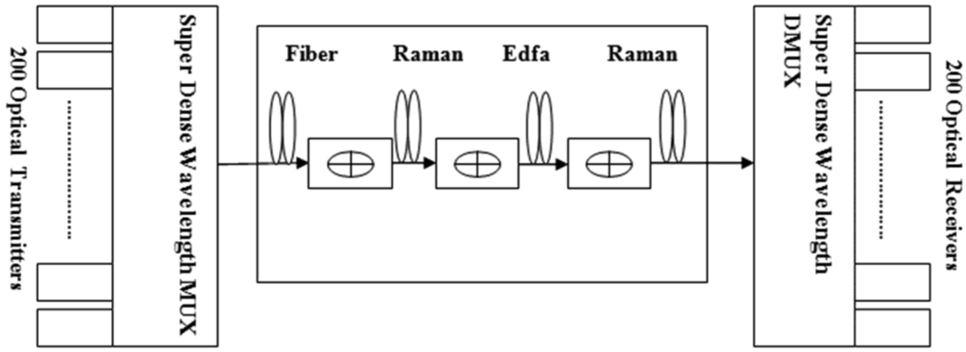

Fig. 1(a) — Experimental setup block diagram for 200 x 10 Gbps SD-WDM system and

1480-1500 nm. Performances have noticed, in terms of transmitting data, voice, and video signal from PON passive network. Further, article has concluded to highlight the best performance from NRZ Rectangular data format.

To the best of my knowledge, a model of SD-WDM system with RAMAN-EDFA-RAMAN hybrid amplifier for the first time with huge data transmission is proposed in this paper.

Paper is represented in four sections. Introduction is explored in section one, explanation of experimental setup is in section two, evaluation of results and discussion are in section three, and paper is concluded in section four respectively.

2 Experimental Setup

Experimental setup for 200 x 10 Gbps with 6.25 channel spacing is shown in Figs. 1(a&b). 200 signals are generated from CW lasers with the beam at 187.1-195.8 THz. The binary signal is generated with the rate of 10 Gbps from the data source, which further converted in electrical domain with NRZ electrical drive. Signal is modulated with the help of external MACH-Zehnder modulator. Modulated signal is transmitted through the DS anomalous fiber. Optical fiber is set to reference frequency of 193.414 THz. Laser power is also set to 1 mW because, effects of nonlinearity like stimulated brillouin scattering, stimulated RAMAN scattering, self phase modulation, cross phase modulation and four wave mixing are higher at the high power level[10,11,12,13,14]. PIN photodiodes are set to 0.798 quantum efficiency to get the original signal on the receiver side.Furthermore, Operating parameters of the different amplifiers are given in Table 1.

3 Results and discussion

In this paper, we are representing a model for the SD-WDM system with the help of RAMAN-EDFA-

Fig. 1(b) — Experimental setup for 200 x 10 Gbps SD-WDM system.

Table 1 — Parameters of RAMAN amplifier in SDWDM system

Parameter	Value
RAMAN fiber length	14 km
RAMAN loss	0.2 dB/km
Pump Wavelength	1450-1485 nm
Pump power	480 mW
Pump attenuation	0.2 dB/km
Dispersion	2.15 ps/nm/km
Operating Temperature	300 K
Reference frequency for dispersion	1555 nm
Parameters of EDFA amplifier in SDWDM system	
Parameter	Value
Noise figure	4.5 dB
Maximum small signal gain	35.6
Gain shape	Flat
Out Power	32 mW

RAMAN hybrid amplifier with the channel spacing of 6.25 GHz. Performances are noticed down by optimizing the suitable selecting parameters. Performance of proposed model is evaluated in terms of quality factor and jitter from Fig. 2. For the EDFA amplifier, it is observed that at 6 dB noise figure, received quality factor is 33.95 dB, which shows the better result outcome than the ref.[15,16,17,18,19]. Good quality of noise figure shows the acceptable performance in terms of SNR, which indicates the minor effect of fiber nonlinearity and ASE. Least jitter of 0.02120 ns is also noticed for same rating

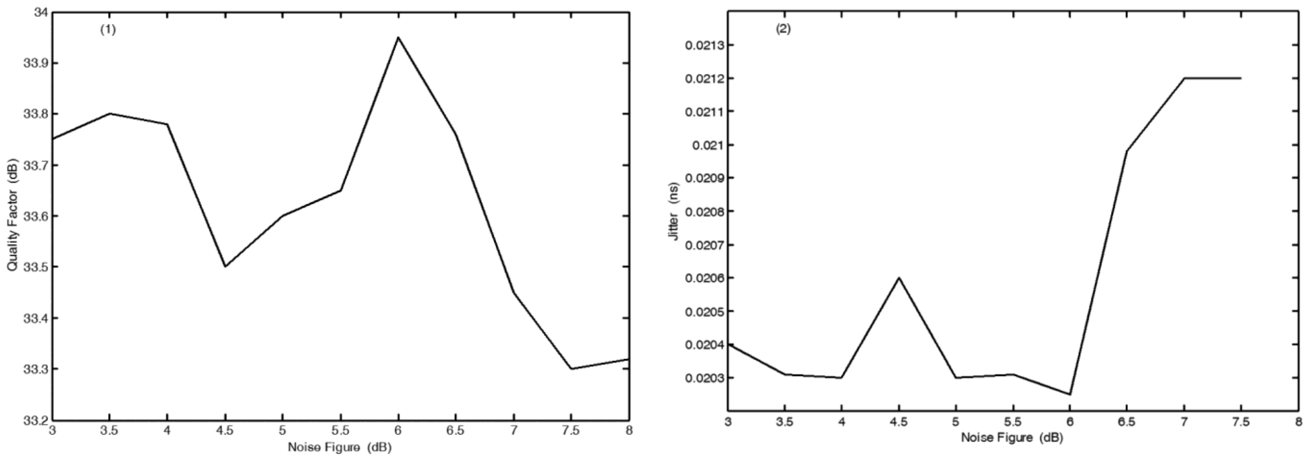

Fig. 2 — Optimization of noise figure in terms of (1) Quality factor (2) Jitter.

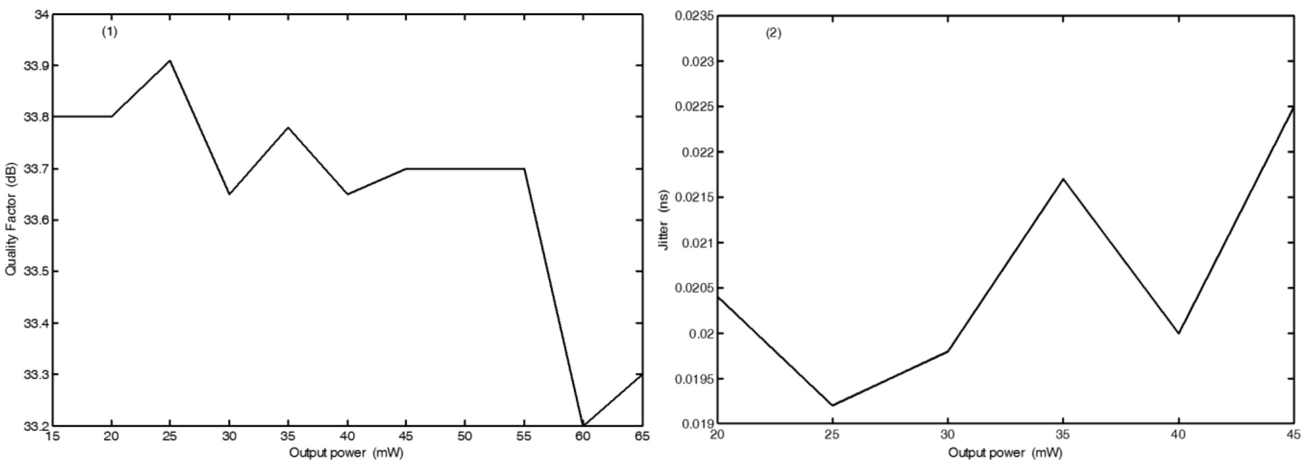

Fig. 3 — Optimization of output power in terms of (1) Quality factor (2) Jitter.

quality factor from the second figure, which shows that noise figure of 6 dB is the best optimization parameter for the super dense system.

Investigation of optimization is carried out to look out the performance of the SD-WDM system in terms of quality factor and jitter for the same amplifier in Fig. 3. Highest rating of quality factor is shown at 33.80 dB with the power rating of 25 mw and least value (0.0192 ns) of jitter is also observed at the same quality factor rating. By the analysis, it is concluded that output power of 25 mW is the suitable power rating for EDFA amplifier.

Now, optimization of rating parameters is carried out to look the performance of the proposed system in terms of RAMAN fiber length at the length of 10 km from Fig. 4. Quality factor shows the best-operating value. On the other hand, least value of jitter (0. 019 ns) is coming out by 10 km RAMAN fiber so we can report the RAMAN fiber length of 10 km is the acceptable rating of the RAMAN amplifier.

Performances of SD-WDM are further evaluated with the help of varying dispersion of 2, 4, 8 and 10 ps/nm/km respectively from Fig. 5. Observed values are given as 25 dB for dispersion 2 ps/nm/km, 22.80 dB dispersion for 4 ps/nm/km, 22.80 dB for dispersion 8 ps/nm/km and 19.80 dB for dispersion 10 ps/nm/km. Variations in quality factor for the distance of 100 km to 160 km are given as (22.4 dB to 21 dB) for 2 ps/nm/km, (20.4 dB to 18.99 dB) for 4 ps/nm/km, (15.4 dB to 16.99 dB) for 8 ps/nm/km and (5.25 dB to 4.99 dB) for 10 ps/nm/km respectively. Maximum level of degradation is shown by 10 ps/nm/km. This is poor indication to select this parameter for long haul distance transmission. So, it is observed that dispersion of 2 ps/nm/km is the best parameter rating for 200 km of long haul communication with the least loss.

Bit error rate with respect to transmission distance at different dispersion is shown in Fig. 6. Evaluated values are given as (5.6^{e-12} to 3.1^{e-7}) for

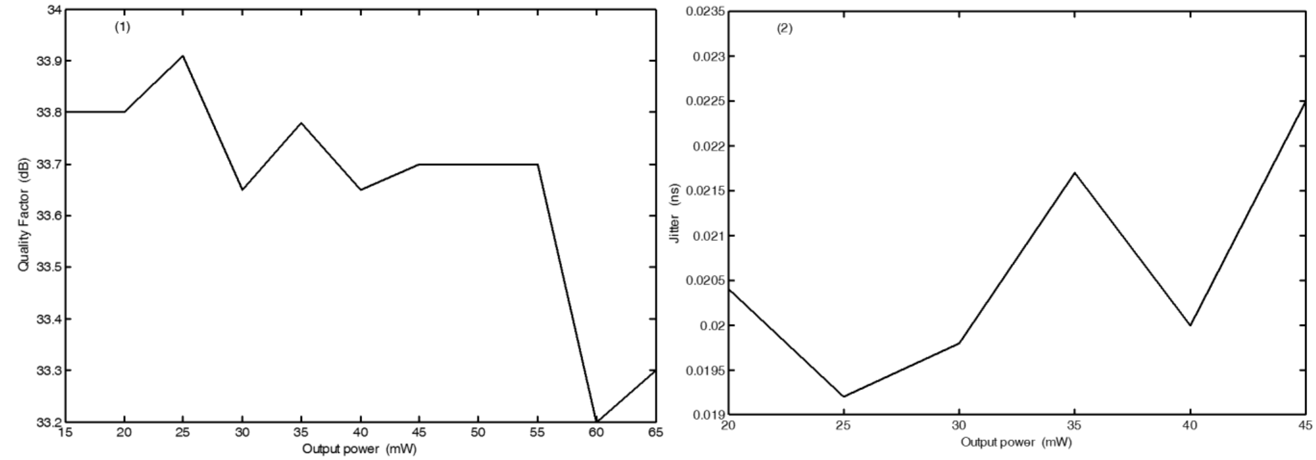

Fig. 4 — Optimization of RAMAN length in terms of (1) Quality factor (2) Jitter.

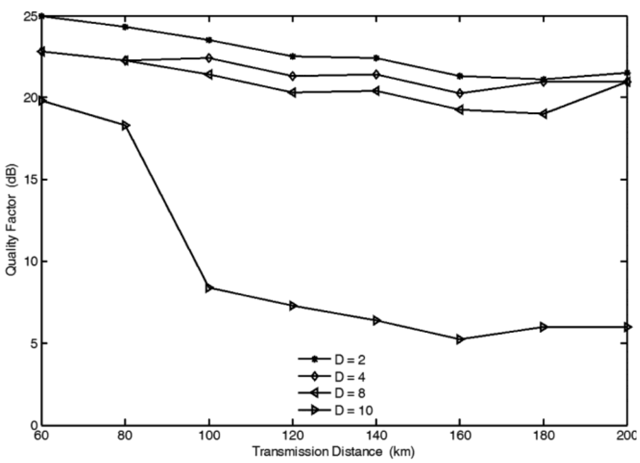

Fig. 5 — Quality factor versus transmission distance.

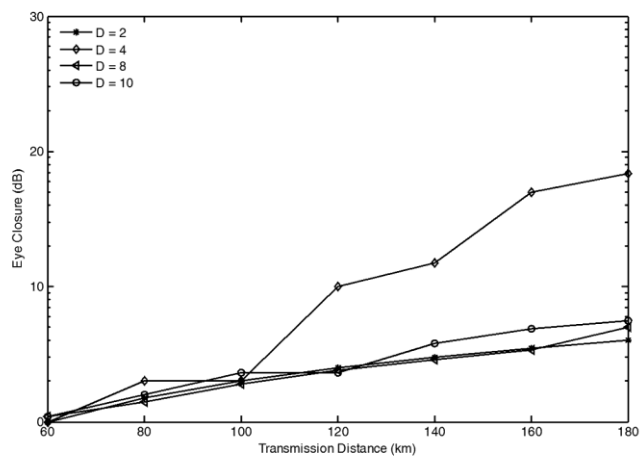

Fig. 7 — Eye closure versus transmission distance.

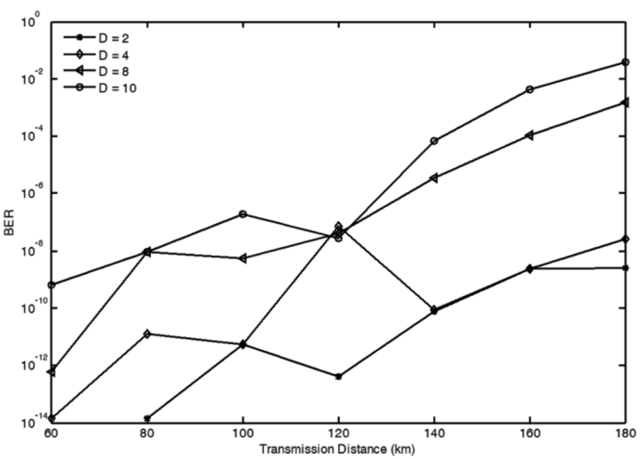

Fig. 6 — Bit error rate versus transmission distance.

2ps/ns/km, (1.3^{e-11} to 3.3^{e-6}) for 4 ps/ns/km, (9.2^{e-9} to 1.8^{e-2}) for 8ps/ns/km, (9.2^{e-9} to 1.8^{e-10}) for 10ps/ns/km respectively. Best rating of bit error rate is the good sign for best communication in the optical communication system. Performance of proposed system shows the optimize rating with the dispersion of 2ps/ns/km to cover the maximum span transmission distance of 180 km. While the performance of system is degraded by increasing the dispersion means from 4 to 10 ps/ns/km. It is also observed that effect of dispersion absolutely minor from 60 to 80 km. But the same distance is effected due to presence of high distortion 4,8 and 10 ps/ns/km respectively. So it is concluded that dispersion at 2ps/ns/km is delivering the best optimization value to cover the maximum transmission distance

For getting the best optimize value in terms of least eye closure, Fig. 7 is shown in Evaluated values are given as (1.1 to 4.5dB) for 2ps/ns/km, (2.5 to 5.8 dB) for 4ps/ns/km, (3.4 to 6dB) for 8ps/ns/km and (4.5 to 31.5dB) 10ps/ns/km respectively. Least rating of eye closure shows, that received signal on the receiver side has less distortion and attenuation. Dispersion at 10ps/ns/km shows the highest value of

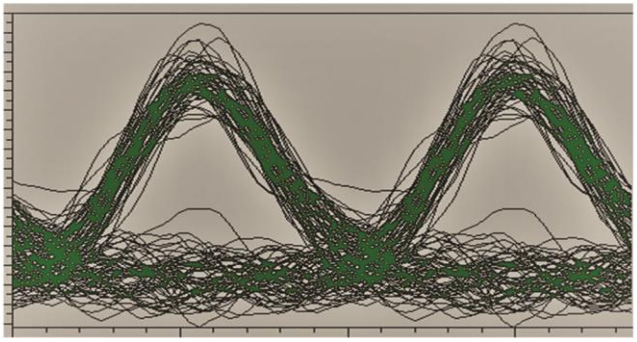

Fig. 8 — Measured eye diagram of signals at reciver section.

eye closure due to ASE. Effect of increasing dispersion from 2 to 4ps/ns/km is not much affected with respect to distance. But at the dispersion 10 ps/ns/km with increasing distance, the performance of the system continuously degraded. So it is evaluated that dispersion at 2ps/ns/km is the best optimization value for optical communication with least eye closure. Furthermore, impact of proposed HOA is really remarkable which is also justified by recived eye diagram of the signals in Fig. 8

4 Conclusion

Best rating optimized parameters for the proposed 200 x10 Gbps system have been evaluated. Evaluation of optimize parameters are carried out with respect to dispersion, eye closure, and bit error rate. Performance of proposed hybrid amplifier has also evaluated with respect to output power, quality factor and jitter *etc*. By going through all the evaluation technique, it is observed that dispersion of 2ps/ns/km is the best optimize value for long haul distance (200 km) communication, which is highest reported outcome than the ref.[20.21,22]. Output power of 25mW is also shown the best optimized parameter for EDFA amplifier and selection of 10 km RAMAN fiber length is providing the least jitter with the recommended HOA.

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