Indian Journal of Engineering & Materials Sciences
Vol. 27, October 2020, pp. 984-989

Performance analysis of 80 channels hybrid optical time division dense multiplexing system with the support of different orthogonal modulation techniques

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Received: 06 August 2019; Accepted:06 July 2020

High spectral transmission capacity signals are the prime requirement of today's dense communication system to enhance the quality of different users services, which have been analyzed and resolved with the support of 80 channels hybrid optical time division dense multiplexing system with different orthogonal modulation techniques (return to zero (RZ), differential quadrature phase shift keying (DQPSK), non-return-to-zero (NRZ), polarization shift keying (PoISK), and differential phase shift keying (DPSK)). Further, evaluation has also been proceeded to receive the best rating results in terms of bit error rate (BER) and quality factor (38 dB to 20 dB) with attainable rating power amplification from Erbium-Doped fiber amplifier (EDFA). Furthermore, final examine has recommended that orthogonal DPSK modulation is the best choice to attain the data rate of 1.80 Tbps from the recommended system for 200 km optical communication with acceptable rating from 10^{-24} to 10^{-10}.

Keywords: RZ, DQPSK, NRZ, PoISK, DPSK, BER, EDFA

1 Introduction

Conventional optical amplifiers are the main backbone for enhancing the optical transmission capacity for dense wavelength optical communication system[1–3]. In the recent years, use of best transmission techniques has been explored to increase the transmission data rate more than 40 Gbps with power retaining amplification[4–6]. In fact, retardation in the signals strength is mainly occurs due to the dominating effect of reduction of power loss which further leads to RAMAN and Brillouin scattering in optical communication[7]. So use of suitable optical encoding is the best solution to nullify the dominating unwanted effects of the optical signals[8]. Various research works have been shown the massive impact of different modulation techniques with the support of good rating power amplifiers such as Erbium-Doped Fiber Amplifier (EDFA), semiconductor optical amplifier (SOA), Raman optical fiber amplifier (RPOFA), thulium-doped fiber amplifiers (TDFA), and waveguide optical amplifier (WOA)[9] respectively. But, use of proper utilization of these amplifiers have not been shown for future dense optical communication in terms of long-haul optical communication with large number of channels which is prime requirements for current hybrid optical time division dense multiplexing system (HOTDDM).

Hybrid optical time division dense multiplexing system which is the combination of OTDM-DWDM[10,11] is the remarkable approach with good rating optical modulation techniques to enhance the gain spectrum for high signal transmission capacity so in Future, high speed multi-channels optical core networks need optical communication technologies that are capable to handle ultra-high bit rate for OTDM/DWDM channels at higher bit rates. It is a very effective optical multiplexing technique that provides higher number of optical channels over optical fiber. The key functionalities of OTDM increase the carrying capacity of the optical channels in ultra-high speed network nodes[12–14].

The structure of dense communication system is not so complex and use of optical time division multiplexing techniques has also shown the massive impression to active the transmission data rate more than 60 Gbps[15–19]. So, addition of these techniques has been shown the acceptable outcomes for future network. But, in this recommended research work, we have tried to upgrade the transmission signals pattern to use different modulation formats with acceptable

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power amplification from EDFA. Moreover, there are various modulation techniques such as amplitude, frequency, phase shift keying, differential phase shift keying and many more have been shown better results[20–23].

In fact, these modulation formats have the capacity to tolerance the overlapping of the signals error and to upgrade the transmission process than the conventional modulation techniques[24].

In this recommended research work, we have explored the performance of 80 channels hybrid optical time division dense multiplexing system to attain the data rate more than 1.80 Tbps with the support of different modulation techniques (return to zero (RZ), differential quadrature phase shift keying (DQPSK), non-return-to-zero (NRZ), polarization shift keying (PolSK), and differential phase shift keying (DPSK)) to upgrade the signal strength in terms of least bit error rate (BER).

This research work is divided in four divisions. First division is evaluated the introduction of proposed technique which is on the other side linked up with recommended setup, simulation results and analysis, and final conclusion in division two to division four accordingly.

2 Recommended set-up

Recommended simulation setup for 80 channels dense wavelength division multiplexing (DWDM) system is designed with the help of Opsim™ software which complete simulation setup for hybrid optical time division dense multiplexing system (HOTDDM) is also shown in Fig. 1 to achieve the data rate of 1.80 Tbps. Transmitters are arranged in a set of boxes which internal configuration are also shown in the given Fig.1. Digital data source, continuous light source, electrical drive, different sects of orthogonal modulator are the main supporting components of the one transmitter. 50 GHz channel spacing is implemented between the channels to neglect the regeneration of unwanted signals[6]. Each transmitter is set at two-dimensional perpendicular data rate of 100 Gbps with further multiplex with time domain multiplexer (TDM) to neglect the effect of crosstalk and four wave mixing. TDM has the time delay feature which arranges the two-dimensional data rate of 100 Gbps at specific rate so overlapping of signals is not occurs and high rating spectral signals is maintained. The rating of time delay is taken in the terms of 4 ns, 8 ns, 12 ns, 16 ns, 20 ns, and so on respectively.

Laser width of the optical source is placed at 15 MHz with power of 10 dBm to mitigate the effect of front and backward scattering in dense communication system which really play main role not to degrade the signal strength for long communication. A set of different modulation techniques is placed in the arrangement of compound component which is also linked to main components with the data rate from 40 Gbps to 80 Gbps.

Further, with the arrangement of RZ, DQPSK, NRZ, PolSK, and DPSK modulation components, we have tried to achieve the final data rate of 1.80 Tbps with the acceptable power amplification from EDFA for the transmission distance from 100 km to 200 km. Furthermore, optimum time delay is the main feature for getting such a high spectral data rate which also mitigates the effect of dispersion and FWM[1,19].

EDFA power amplifier is also placed in the optical medium with the specifications as per given in Table 1 to boost the signal strength. Signals are received with the support of dense de-multiplexer, optical filter, electrical filter and bit error rate analyzer respectively at the receiver section. Here, it is also noticed that the same time delay must be set as was set at the transmitter section to transmit the signals to the receive side. Otherwise, it will be leading high order dispersion and losses in the received signals at the receiver section. The effect of high order dispersion is also mitigated with the support of dispersion managed fiber (DMF) with single mode fiber (SMF) in this proposed simulation setup which specifications are arranged as per Table 2.

3 Simulation Results and Analysis

Evaluation of final outcomes is done in terms of bit error rate (BER) with respect to input injected power and number of channels in Fig. 2 and Fig. 3 respectively for various orthogonal modulation techniques. Input injected power from -20 dBm to -15 dBm is not showing achievable results due to the dominating effect of fiber nonlinearity and dispersion

Table 1 — Specifications of EDFA for hybrid optical time division dense multiplexing system.

Feature	Value
Output power	10.11 dBm
Noise figure, (F)	3.45 dB
Force time domain	No
Noise	Yes
Loss	1.28 ps/nm.km
Gain	38.22 dB

Table 2 — Specifications of DMF and SMF for hybrid optical time division dense multiplexing system.

Optical fiber	Area, A (μm^2)	Slope of dispersion, ϕ (ps/km-nm^2)	Attenuation, α (dB/km)	Fiber distance, d (km)	Reference wavelength, λ (nm)	Dispersion, Ɛ (ps/nm.km)
DMF	85	.95	0.15	50	1555	-78
SMF	26	-0.40	0.25	10	1555	15

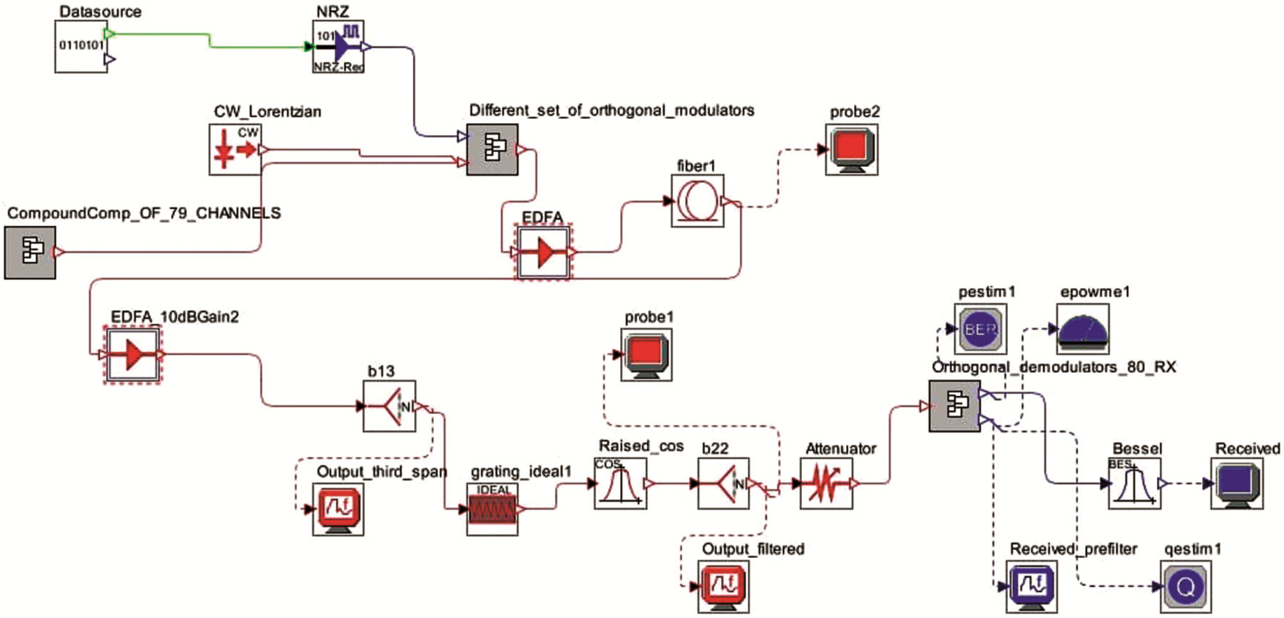

Fig. 1 — Setup for 80 channels hybrid optical time division dense multiplexing system.

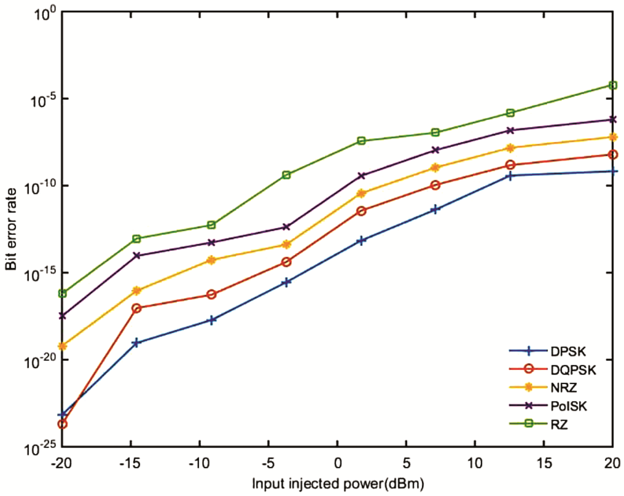

Fig. 2 — Bit error rate versus input injected power.

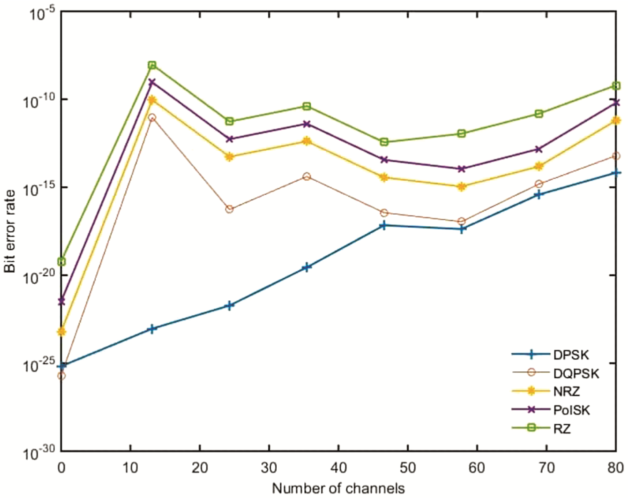

Fig. 3 — Bit error rate versus number of channels.

which is also adjusted by raising the input injected power with EDFA from -10 dBm onward. Here, it is also observed that DPSK is shown the least range of BER with increasing the power. As it knows that good rating of power amplification directly impacts the gain which also supports to maintain the least effect of BER. In this way power level from -10 dBm to 20 dBm is most suitable for the proposed modulation techniques out of which DPSK is shown the massive impressive results with the recorded value range from 10^{-24} to 10^{-10} from Fig. 2.

Further, analysis is also extended to observe the effect of same parameter for total number of channel (from channel number-1 to channel number -80) from Fig. 3.

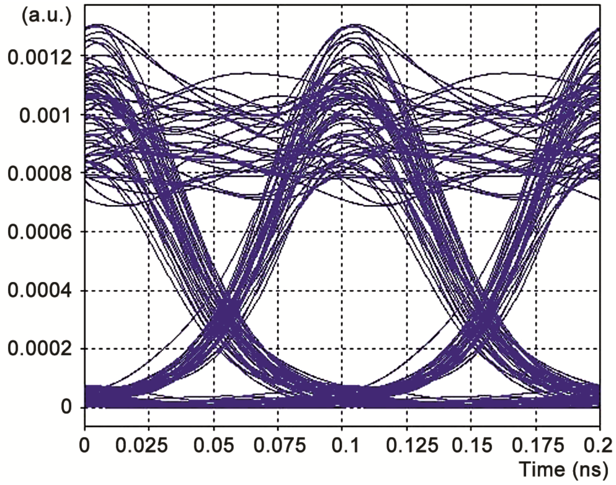

Fig. 4 — Eye diagram of return-to-zero (RZ) for the distance of 100 km.

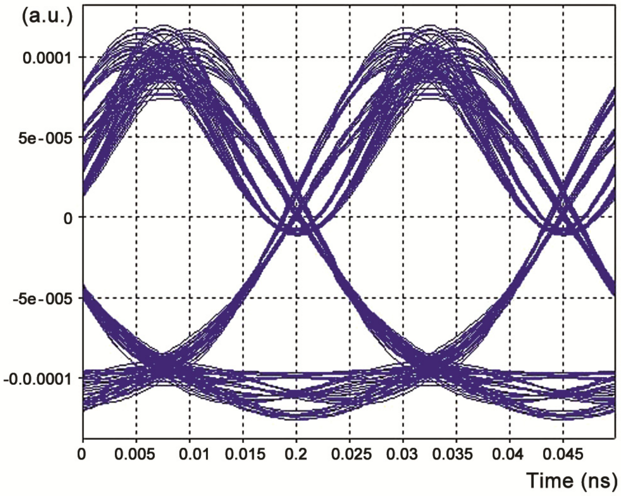

Fig. 5 — Eye diagram of differential quadrature phase shift keying (DQPSK) for the distance of 120 km.

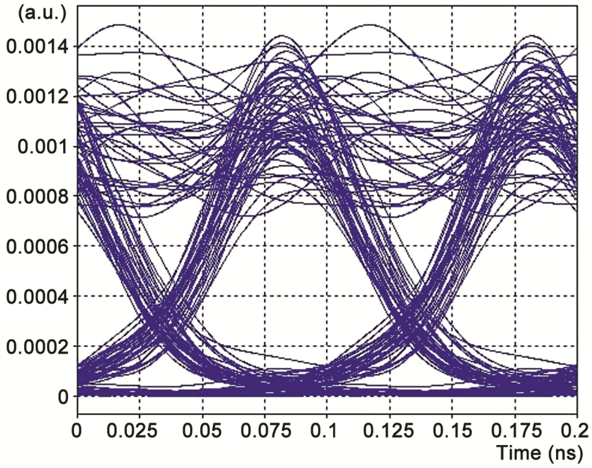

Fig. 6 — Eye diagram of non-return-to-zero (NRZ) for the distance of 160 km.

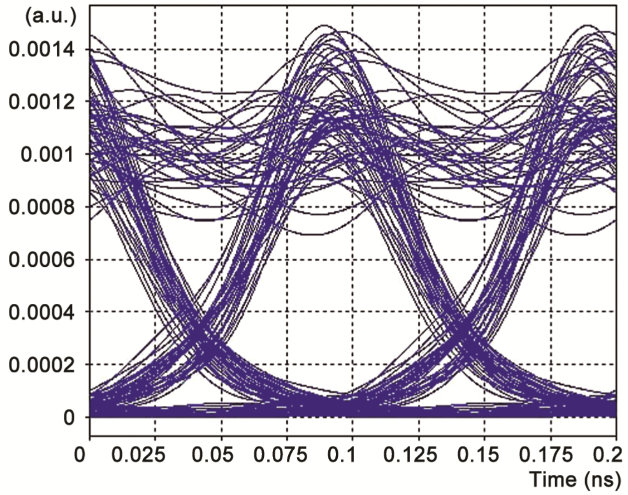

Fig. 7 — Eye diagram of polarization shift keying (PoISK) for the distance of 180 km.

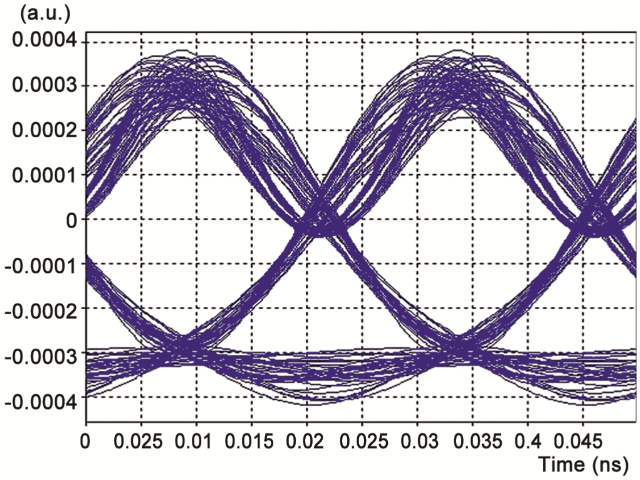

Fig. 8 — Eye diagram of differential phase shift keying (DPSK) for the distance of 200 km.

Here, it is also shown that DPSK modulation, once again shown the best rating of BER of 10^{-26} which is attainable value for hybrid optical communication system.

The capacity for this recommended hybrid optical communication system is also further analyzed by considering the long-distance optical communication with various transmitting distance (100 km for RZ, 120 km for DQPSK, 160 km for NRZ, 180 km for PoISK, and 200 km for DPSK) and outcomes are figure out in terms of received eye diagrams from Fig. 4 to Fig. 8. Here, it is examined that effect of crosstalk, FWM, and dispersion are also shown dominating effect for short distance communication for RZ, DQPSK, NRZ, and PoISK modulation techniques but performance of DPSK is most suitable

Table 3 — Comparison of performance parameters over the existing research works.

Performance parameters	R.Goyal[25]	Kumar C[20].	Kaler R.S[4].	Hamamreh J M[13]	R.Goyal[1]	Proposed work
BER	2×10^{-13}	10^{-10}	10^{-12}	2×10^{-18}	3×10^{-16}	10^{-23}
Q-factor (dB)	18.2	17.1	16.6	25	19.6	35
Distance (km)	30	40	—	—	60	200
No. of channels	25	50	40	60	60	80
Optical amplifier	—	SOA	—	Raman amplifier	—	EDFA

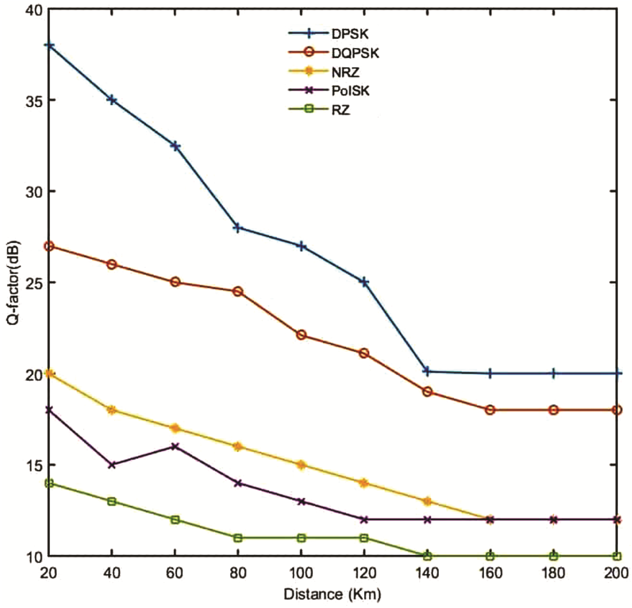

Fig. 9 — Quality factor versus distance.

for long distance high spectral transmission signals with minor effect of optical fiber dominating features. Minor impact of dominating losses in terms of BER also influences the quality of the signals which are analyzed from Fig. 9 by receiving the rating of quality factor from 38 dB to 20 dB for the transmission distance of 200 km with the support of DPSK modulation which also supports the acceptable quality of the signals among the others techniques.

A comparison of proposed model with existing research of art is also shown in Table 3 to shown the practical impact of this research work. Over all, high rating power amplification is prime requirement which has fully justified with EDFA for transmitting the high spectral efficiency.

4 Conclusions

In this research work, performance of 80 channels hybrid optical time division dense multiplexing system has analyzed to achieve the data rate of 1.80 Tbps with the support of different orthogonal modulation techniques (return to zero (RZ), differential quadrature phase shift keying (DQPSK), non-return-to-zero (NRZ), polarization shift keying (PoISK), and differential phase shift keying (DPSK)) with good rating power amplification from EDFA. Final conclusion is recommended that DPSK modulation is most suitable for long distance communication while rest of the orthogonal modulation techniques is good for short distance communication. Further, DPSK has also recorded major impact to control the effect of fiber nonlinearity and dispersion with the value of BER of 10^{-26} and quality factor (38 dB to 20 dB).

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