Bandwidth efficient hybrid modulation technique in the scenario of 3.5 Tb/S dense wavelength division multiplexed system

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In this paper, the performance of dense wavelength division multiplexed (DWDM) system has been investigated with transmission capacity of 3.5 Tbps using hybrid modulation technique. Data formats non-return to zero (NRZ), Differential Quadrature phase shift keying (DQPSK), polarization Shift Keying (PolSK) are simultaneously modulated to achieve 105 Gbps data rate per channel. The proposed 35×105 Gbps DWDM channels are successfully received after 50 Km with minimum utilization of bandwidth (0.85 THz).

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Keywords: Hybrid modulation, DWDM system, BER

1. Introduction

With the rapid growth of capacity demand carrier's transport network, ultra high capacity transmission and detection techniques are evolving. These transmission and reception techniques should have potential to reduced cost of transmission by sharing fiber and optical components [1]. To efficiently utilize the fiber bandwidth, the DWDM technologies is good alternative to increase the capacity by transmit the number of channel through the single fiber. As the conventional modulation formats are limited to < 40 Gbps, it is utmost important to propose the modulation technique to enhance the capacity per channel. In literature, various modulation techniques have been proposed to increase the single channel capacity [2]. But the hybrid/ multi-dimensional modulation technique shows better results as it not only increase the speed of the channel, it also increase the number of users. Using hybrid modulation more than one users can transmit its data into single channel at different parameters of signal.

Recently, many researchers have proposed several hybrid modulation schemes for high speed applications [3], [4]. Unfortunately, these investigations are limited to single channel only. As the ultra- DWDM system is concerned it is difficult to achieve high bit rate at reduced channel spacing using single modulation format, so it is beneficiary to go toward hybrid modulation formats.

In this paper, a hybrid modulation technique (NRZ/PolSK/DQPSK) is proposed to efficiently increasing the single channel capacity. Further, the 35×105 Gbps DWDM system is investigated with the cannel spacing of 25GHz. The original contribution of this paper is to propose a hybrid modulation technique using which the bandwidth efficient DWDM system (covering only 0.8 Thz of bandwidth) can be projected even in high speed scenario at reduced channel spacing.

After introduction, the signal generation and detection of hybrid modulation is described in Section 2. Section 3 represents the results of proposed system setup and conclusions are made in Section 4.

2. Signal generation and detection

Fig. 1 illustrates the signal distribution diagram of proposed transmitter which shows the principle of NRZ/DQPSK/PolSK orthogonal modulated signal. The basic principle of generation of hybrid modulated signal is explained in [5, 6]. A continuous wave light beam from laser diode is fed to LiNb Mach-Zehnder Modulator which works in conventional modulator mode and modulated by data 1 (with 25 Gbps data rate) in NRZ pattern. Two phase modulators, PM1 and PM2, are used to generate DQPSK orthogonal modulated signal according to data 2 (with 40 Gbps data rate). First phase modulator modulates the phase of optical signal to 180° and second phase modulator adds 90° phase shift. Further, the signal is launched to polarization controller at 45° phase angle for PolSK signal generation. It consists of polarization beam splitter (PBS), polarization beam combiner (PBC) and Phase modulator. Third phase modulator (PM3) placed between PBS and PBC, it modulates data3 to generate PolSK. So at output of transmitter, the multi-dimensional NRZ/DQPSK/PolSK modulated signal is transmitted.

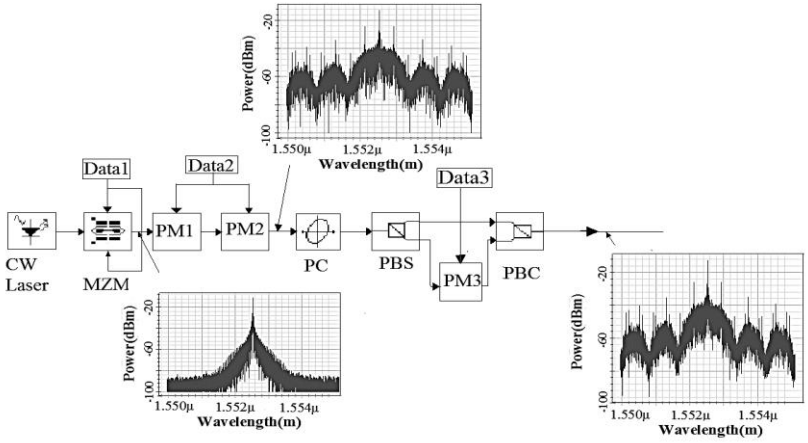

Fig. 1. Schematic diagram of the single channel transmitter

The orthogonal modulated signal is recovered by three independent paths as shown in Fig. 2. The NRZ data is directly detect by using a PIN photodiode and low pass bessel filter (LPBF). On the other hand, the PolSK and DQPSK are regenerated by suitably recover the polarization and phase states, respectively, using appropriate optical components, as shown in Fig. 2.

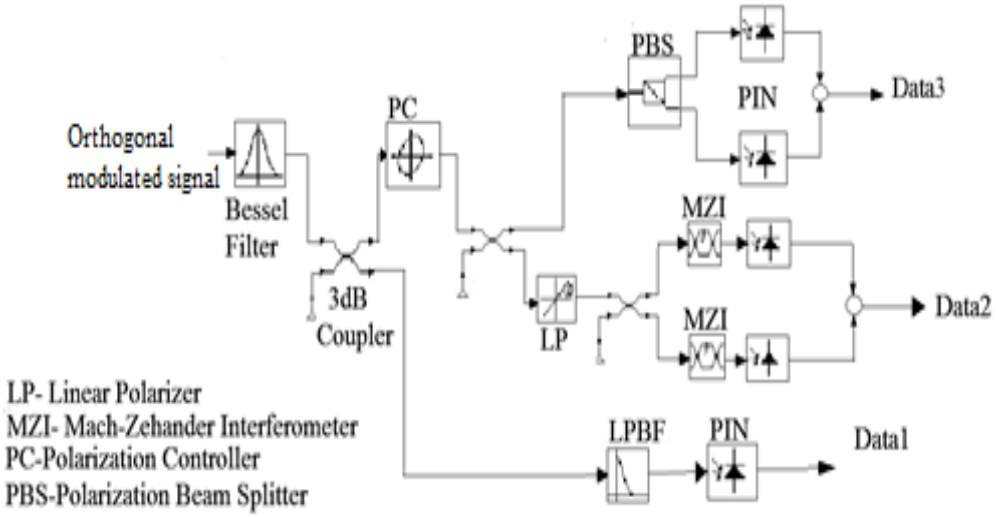

Fig. 2. Schematic diagram of single channel receiver

3. System setup and results

To investigate the proposed modulation format for multichannel application, the 35×105 Gbps DWDM channels has been considered, which are ranging from 193.1THz to 193.95THz with channel spacing of 25GHz. Further, these multiplexed channels are traveling through the SMF having 16 ps/nm/km of dispersion with 0.2 dB/ km attenuation. The EDFA with fixed gain of 12 dB is used to compensate the induced losses. To evaluate the performance of proposed DWDM system the 50 km of transmission distance is considered.

Fig. 3 shows the non-uniform power spectrum over the effective channels for all multi-dimensional modulation formats, this is due to the induced fiber non-linarites [7-9]. Fig. 4 shows the variation of BER with respect to received power, as the high BER shows the increment in transmission distance. Unacceptable performance is observed after 50 Km of transmission distance. From these results, it can be observed that the proposed orthogonal modulated DWDM system provides acceptable power and BER even at 3.5 Tbps of speed over 50 km of distance.

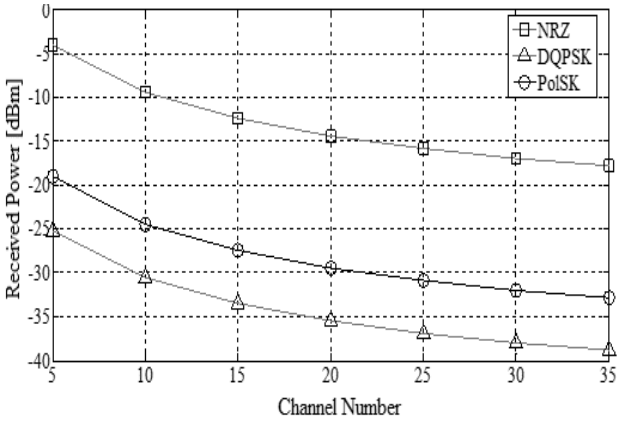

Fig. 3. Received power variation as a function of channel number

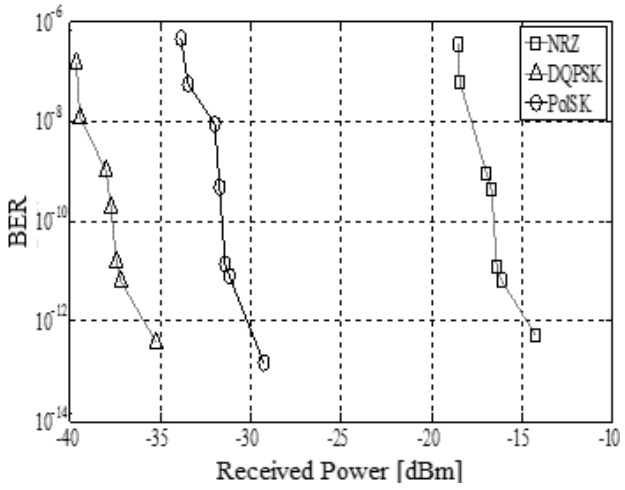

Fig. 4. BER versus Received Power

4. Conclusion

In this paper, 35 × 105 Gbps DWDM system has been investigated using hybrid NRZ/DQPSK/PolSK modulation format. Using this setup the DWDM channels are successfully received after 50 km with acceptable performance, in the term of BER (< 10^{-9}) and received power (> -40 dBm). The proposed modulation technique can be used in future generation networks which can enable high speed, bandwidth efficiency and long haul communication.

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