The optimized schemes of optical labels about DB and PPM over POLMUX-CSRZ-DQPSK payload in 100Gb/s OLS network

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Abstract. Two orthogonal modulation optical label switching (OLS) schemes, which are based on payload of polarization multiplexing-carrier suppressed return to zero-differential quadrature phase shift keying (POLMUX-CSRZ-DQPSK) with label identifications of duobinary (DB) label and pulse position modulation(PPM) label, are proposed in high speed OLS network. The receiver performance of two optical labels and the optimized extinction ratio (ER) are compared with amplitude shift keying (ASK) label by simulation in long transmission distance. The results show DB label has more advantages in fast optical label switching system, and PPM label can improve receiver sensitivity of payload significantly. Two labels have excellent performance in high bit-rate transmission system.

1. Introduction

Optical labelling using orthogonal modulation formats has been an emerging topic already in the early 1990's, work in Leonid Kazovsky's group at Standford University on the STARNET network [1][2][3], and was revived in the early to mid-2000's, European project STOLAS (Switching Technologies for Optically Labelled Signals), followed by a number of groups worldwide. However, previous studies were based on low bit-rate networks, and 100Gb/s backbone network is applied to commercial network now [4], researches on this high bit-rate transmission network is necessary. In addition, compared with labels which have been proposed, such as amplitude shift keying (ASK) [5], frequency shift keying (FSK) [6], binary phase shift keying (BPSK) [7], and polarization shift keying (PolSK) [8], the duobinary (DB) modulation is known as its high spectral efficiency and easy to detect with direct detection [9][10]. The pulse position modulation (PPM) is sensitive to pulse position and its intensity is constant, so that PPM can solve the extinction ratio (ER) conflict of intensity modulation and phase modulation [11]. Based on the above situation, two optimized orthogonal modulation optical label switching (OLS) schemes are proposed in this paper, in which DB and PPM used as optical labels combined with 100Gb/s polarization multiplexing-carrier suppressed return to zero-differential quadrature phase shift keying (POLMUX-CSRZ-DQPSK) payload.

The remainder of this paper is organized as follows. Simulation of two proposed schemes is shown in section 2. Simulation results and the conclusions are described in Section 3 and section 4, respectively.

2. Simulation of two proposed OLS schemes

We round simulation with a commercial software package by an OptiWaves System 7.0. The system architecture is shown in Figure 1. DB label or PPM label is modulated on payload by Mach-Zehnder modulation (MZM), with use of Erbium-doped Optical Fiber Amplifier (EDFA), transmission over single mode fiber (SMF) and dispersion compensation fiber (DCF), and finally label and payload are detected separately. The rate of labels are 2.5Gb/s, and payload is 100Gb/s. Transmission distance of POLMUX-DQPSK-CSRZ/DB system and

POLMUX-CSRZ-DQPSK/PPM system are 1560km and 3000km with designing as balanced dispersion management, respectively. Each loop consists of two DCF, two SMF and four EDFA. Parameters of two systems are list in table1.

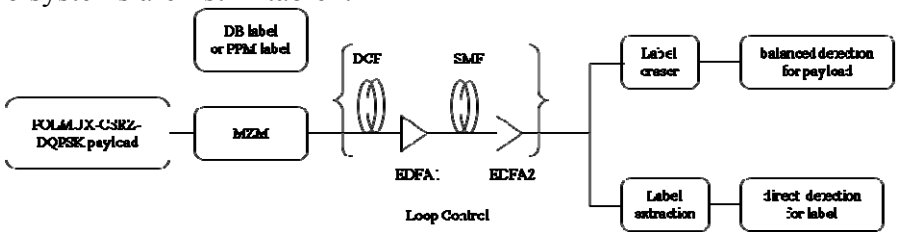

Fig. 1 Schematic of POLMUX-CSRZ-DQPSK/DB and POLMUX-CSRZ-DQPSK/PPM system

Table 1 Parameters of two systems

parameter	value
ER of MZM	2dB for dB label 0.6dB for PPM label
Length of DCF	10km
Dispersion coefficient of DCF	-85ps/ns/km
Dispersion slope of DCF	-0.3 ps/nm^2/km
Attenuation coefficient of DCF	0.5dB/km
Length of SMF	50km
Dispersion coefficient of SMF	17ps/ns/km
Dispersion slope of SMF	0.075ps/nm^2/km
Attenuation coefficient of SMF	0.2dB/km
Gain of EDFA1	5dB
Noise figure of EDFA1	4dB
Gain of EDFA2	10dB
Noise figure of EDFA2	4dB
Number of loops	13 for DB label 25 for PPM label

3. Result and discussions

Simulation results and discussions of POLMUX-CSRZ-DQPSK/DB system and POLMUX-CSRZ-DQPSK/PPM system are given as follows.

3.1 POLMUX-CSRZ-DQPSK/DB system

ER is the ratio of two optical power levels of a digital signal generated by an optical source. The ER may be given by $ER=P_1/P_0$, where P_1 is the optical power level generated when the light source is on, and P_0 is the power level generated when the light source is off. For intensity modulation formats, large ER value contributes to good receiver performance, but may be associated with bad receiver performance of phase modulation formats. In OLS system, label and payload transport as combined modulation format, so we should choose an optimized ER to ensure good receiver performance of label and payload.

Q factor as one of important index of network, high Q value means good receiver performance. The Q performance of POLMUX-CSRZ-DQPSK/DB system at different ERs is shown in Figure 2. Different polarization components have different receiver performance. From Figure 2, the Q value of payload components decrease with the increase of ER, to the contrary of payload, the Q value of label increases with the increase of ER. The ER conflict between phase modulation and intensity modulation is always a problem to be solved. To ensure good transmission performance of payload and label, the intersection of label and the worst component of payload is selected, ER of the system is optimized as 2dB here.

Figure 3 shows the transmission characteristics of POLMUX-CSRZ-DQPSK/DB system. When the received power ranges from -14dBm to -5dBm, the Q value of payload components and DB label are proportional to the receiver power. From Figure 3, pol.Y Q-phase component of payload has

better receiver performance than other components. When BER is 10^{-9}, the receiver sensitivity of pol.Y Q-phase component is about -8dBm, the other components are about -6.386dBm and the label is about -5.924dBm. With bit rate of 100Gb/s and transmission distance of 1560km, the payload and label have good eye diagrams. This means that the proposed system is a potential candidate for the future high bit-rate and long distance OLS network.

The Q performance of DB label and ASK label with same payload at different bit rates is shown in Figure 4. Because high receiver power contribute to the influence of nonlinear effect, the receiver performance in Figure 4 looks not so good. However, comparing DB label with ASK label, we find that when the bit rate of labels are 1.5Gb/s and 2.5Gb/s, the Q value of DB label is close to ASK label under the same receiver power. When the bit rate of labels increase to 5Gb/s, the Q performance of DB label is greater than ASK label obviously. This is consistent with the theory of bit error rate (BER) of DB in [10], although the concrete values are somewhat different. DB label is more suitable for fast optical label switching systems.

3.2 POLMUX-CSRZ-DQPSK/PPM system

The Q performance of P O L M U X – CSR Z- D Q P SK / P P M system and P O L M U X –CSRZ – DQPSK / ASK system at different ERs is shown in Figure 5. Same as POLMUX-CSRZ-DQPSK/DB system, we should set an ER to ensure good receiver performance of payload and label. From Figure 5, with the increase of ER, the Q value of the payload of PPM decrease more slowly than payload of ASK. The ER value of intersection of POLMUX-CSRZ-DQPSK/PPM system is bigger than that of POLMUX-CSRZ-DQPSK/ASK system. The Q value of PPM label in optimized ER value has about 0.15dB gain than the ASK label. For PPM can solve the ER conflict of intensity modulation and phase modulation to a certain extent. In the proposed POLMUX-CSRZ-DQPSK/PPM system, ER is optimized at 0.6dB for a high Q value of payload and an acceptable Q value of label.

The BER performance of payload before and after PPM label erased over 3000km transmission is shown in Figure 6. For influence of the label, the received power of payload before label erased is -8.054dBm when BER is 10^{-9}, and after label erased, it is -7.59dBm, the power penalty of label erased is 0.464dBm. It can be seen from the eye diagram that, the system performance is still acceptable in 3000km transmission.

In Figure 7, the BER of payload with PPM label and ASK label are demonstrated respectively. The receiver sensitivity of payload with PPM label is about -8.054dBm, and that of payload with ASK label is -7dBm when BER is 10-9. Compared with ASK, the receiver sensitivity of payload of PPM has saved about 1dBm power consumption. PPM label has greater advantage when a high receiver sensitivity of payload is required.

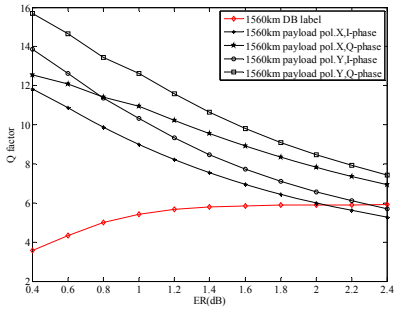

Fig.2 Q performance of POLMUX-CSRZ-DQPSK/DB system at different ERs

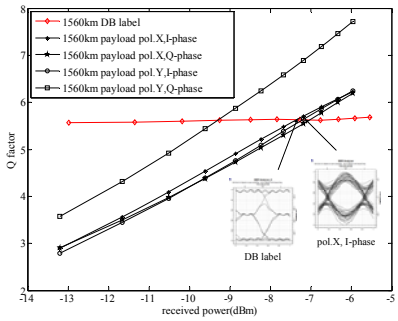

Fig.3 Transmission characteristics of POLMUX-CSRZ- DQPSK/DB system over 1560km

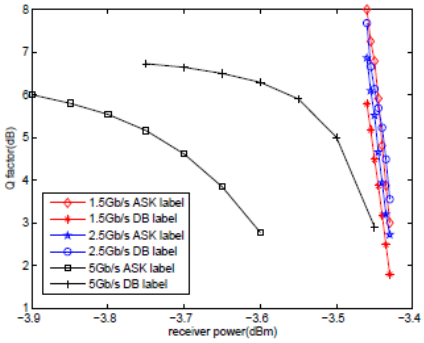

Fig.4 Q performance of DB label and ASK label at different bit rates

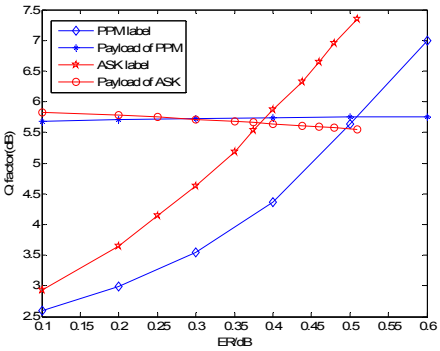

Fig.5 Q performance of POLMUX-CSRZ-DQPSK/PPM system and POLMUX-CSRZ-DQPSK/ASK system at different ERs

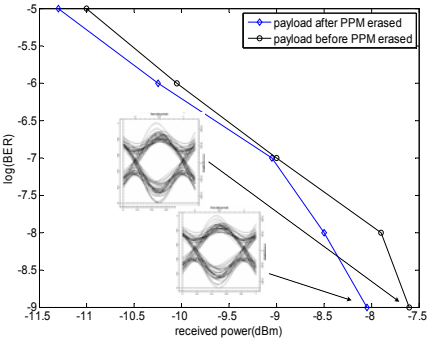

Fig.6 BER performance of payload before and after PPM label erased

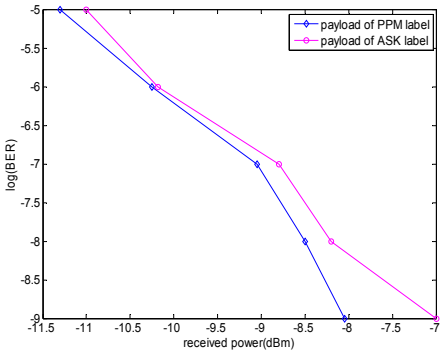

Fig.7 BER performance of payload with PPM label and ASK label

4. Conclusion

Two optimized orthogonal OLS schemes based on high bit-rate transport network with rate of 100Gb/s are proposed in this paper. DB and PPM used as labels and combined with POLMUX-CSRZ-DQPSK payload. Comparison between DB label and ASK label, PPM label and ASK label by simulation are given. The maximum transmission distance of POLMUX-CSRZ-DQPSK/DB system and POLMUX-CSRZ-DQPSK/PPM system are 1560km and 3000km, respectively. With the same transmission distance and payload, the receiver performance of DB label is better than ASK label when bit rate is 5Gb/s, DB label is more suitable for fast optical label switching systems. Under the same condition, the receiver sensitivity of payload with PPM label increased about 1dBm than that of payload with ASK label, PPM label has greater advantage when a high receiver sensitivity of payload is required. Two schemes proposed can be potential candidates for the future high bit-rate long distance OLS network.

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