Demonstration of Transmission of 8×100Gb/s CSRZ-DQPSK Signal over 1520Km Standard Single-mode Fiber

Yanfu Yang1, Linghao Cheng1, Zhaohui Li1, Chao Lu1, Xiaogeng Xu2, Qianjin Xiong2, W H Chung1, P. K. A. Wai1

1Photonics Research Centre, Dept. of Electronic & Information Eng, The Hong Kong Polytechnic Univ., Hung Hom, Kowloon, Hong Kong Phone:+852 2766 4094 Fax: +852 2362 8439 yyf02@eie.polyu.edu.hk

(2Huawei Technologies Co., Ltd., Shenzhen, P. R. China)

Abstract
Eight channel 100Gbit/s CSRZ-DQPSK system with automatic bias control and clock and data recovery module is demonstrated. 1520km transmission with standard single mode fibre and EDFA amplification is achieved with 1.9dB OSNR penalty.

Introduction
The recent demand for capacity and high bandwidth services has spurred research on long-haul transmission at 100Gbit/s per channel. Differential quadrature phase shift keying (DQPSK) is an attractive format for such high speed transmission because it reduces the symbol rate to half of the data rate and improves chromatic dispersion (CD) and polarization mode dispersion (PMD) tolerance of the transmission system. Moreover, it exhibits narrow signal spectrum and offers high nonlinear tolerance. Serial full-ETDM (electrical time-division multiplexing) 100Gb/s DQPSK long-distance transmission has been demonstrated [1-5]. 1200km and 2000km transmission has been realized using Raman amplification and NZDSF[1,3]. Considering the typical configuration of the deployed network, it is necessary to evaluate the transmission performance with the conventional C-band EDFAs and SSMF links. Recently Zhou et al have reported 2 Tb/s (2×107Gb/s) RZ-DQPSK transmission over 1050km SSMF fiber with EDFA-only optical amplification [5]. Here we demonstrated the 1520km transmission of eight 100Gb/s single polarization carrier-suppressed return zero (CSRZ) DQPSK signals with 200GHz spacing over 1520km SSMF fiber with commercially available C-band EDFAs. Different from [5], the transmitter employed an integrated nested parallel QPSK modulator rather than cascaded phase modulators to avoid the frequency chirp and to enable the realization of differential Gray code encoding. Moreover, in the receiver the clock data recovery (CDR) is employed to directly recovery the clock and data from the CSRZ-DQPSK signal after the fiber link transmission. The effect of the cascaded 100GHz optical multiplexer on the transmission performance is studied to verify the feasibility of 100GHz channel spacing.

Experimental Setup
Fig.1 shows the setup of the 100Gb/s CSRZ-DQPSK experimental system. Eight continuous-wave (CW) distributed feedback lasers (DFB) with 200GHz channel spacing from 1546.92nm to 1558.17nm are multiplexed using a polarization-maintaining arrayed waveguide grating (AWG) and then launched into a Mach-Zehnder modulator for pulse carving, which is driven by 25GHz RF clock signal and biased at null transmission point. After the pulse carver the obtained 50GHz CSRZ pulse train is injected into the DQPSK modulator. The Fiber link consists of 19 spans of 80km SSMF and two-stage in-line EDFAs. For each span, the inline dispersion compensation ratio is not adjusted manually and the residual dispersion ranges from -100ps/nm to 100ps/nm. This is similar to the practical deployed network. The total fiber link has to the residual...
dispersion of around -10ps/nm. At the end of the fiber link SMF-based post dispersion compensation with the step of 5ps/nm is used. The optical power per channel launched into SSMF is set at 2dBm for optimal performance when balancing noise and nonlinearity. The total polarization-mode dispersion (in terms of mean differential group delay) of the 1520 km link is measured to be 3.1 ps. At the receiver, optical demultiplexer with 200GHz spacing is used for selecting the channel to be measured. I and Q components of the CSRZ-DQPSK signal is demodulated using a free-space-based tunable delay-interferometer with free spectral range of about 50GHz. A stable CDR module is employed for exacting 50Gbit/s data and 25GHz clock from the output of a balanced photodetector with 3dB bandwidth of 45GHz. After 1:4 electrical demultiplexing the BER measurements are made.

Results and Discussions

![Fig.2 The optical spectrum Before/After 100G Mux/Dmux](image1)

![Fig.3 The OSNR tolerance vs. residual dispersion](image2)

Fig.2 illustrates the optical spectrum (Wavelength Resolution: 0.02nm) of single channel (1551.7nm) before and after DeMux/Mux. It’s found that the signal energy within 3dB spectral width is almost unaffected due to filtering, so it is reasonable to expect that the filtering of 100GHz Demux/Mux has little effect on system performance. Fig.3 presents the optical signal-to-noise ratio (OSNR) tolerance at BER of 1E-3 as a function of residual dispersion in Back-to-Back (B2B) case. The 12ps/nm residual dispersion can lead to around 2dB OSNR penalty, and 20ps/nm dispersion introduces an OSNR penalty of 5dB.

![Fig.4 The measured Eye diagram of the balanced photodetector output after demodulating CS-RZ DQPSK signals when (a) B2B case without 100GHz Demux/Mux (b) after 1520km transmission without 100GHz Demux/Mux (c) B2B case with 100GHz Demux/Mux (d) after 1520km transmission with100GHz Demux/Mux](image3)

Fig.4 presents the BER as a function of OSNR in B2B and after 1520km transmission cases for the channel of 1551.7nm. The OSNR penalty induced by nonlinear effect during 1520km transmission is around 1.9dB at the BER of 1E-3. Comparing the cases of with and without 100GHz DeMux/Mux, the obtained BER after 1520km transmission is 1E-4 and 7E-5 respectively and there is negligible OSNR penalty caused by its filtering effect. This result indicates the feasibility of using 100Gb/s CSRZ-DQPSK format in 100GHz spacing WDM networks.

Conclusions

We demonstrate the transmission of eight channels 100Gb/s CSRZ-DQPSK signals over 1520km SSMF using C-band EDFA amplification only with only 1.9dB penalty. The integrated modulator with automatic bias control and the stable CDR module are employed for ensuring stable long term DQPSK transmission. Also it is verified that the cascaded 100GHz optical multiplexer has negligible effect on the performance of the 100Gb/s CSRZ-DQPSK transmission.

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References

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