affected this BER variation. One can see that the control loop is quite robust even in the presence of significant amount of amplitude and phase noise. From these results, we confirmed that the proposed automatic bias control scheme could be used to actual transmitters of advanced modulation formats for long-term operation. To investigate the transmission performance of 112 Gb/s signal, the measured pre-FEC BER was compared with the results of numerical simulation, as shown in Fig. 7(b). The BER-value after 797 km transmission was obtained for various launching power. Since all EDFAs were operated at AGC mode, the fiber launching power of each span was automatically changed as we adjusted the launching power of the first span. The launching power of 112 Gb/s and 10 Gb/s signals were varied from −8 dBm to 6 dBm at each span. The link configuration of numerical simulation was the same as field trial. The results show that the Q-value of field trial was agreed well with the result of numerical simulation. Even when 112 Gb/s DC-DQPSK signal was co-propagated 10 Gb/s NRZ WDM signal neighboring at 100 GHz spacing, the Q-value degradation was as low as 0.5 dB.

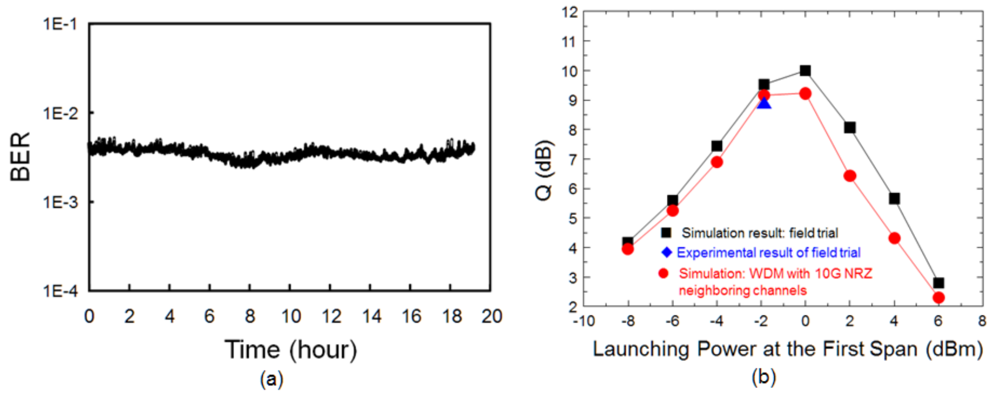

Fig. 7. Transmission performance of 112 Gb/s DC-DQPSK signal after 797 km transmission (a) measured pre-FEC BER of 112 Gb/s signal over 18.5 hours (b) comparison of simulated performance of 112 Gb/s DC-DQPSK signal after 797 km transmission

5. Summary

We have demonstrated a simple and cost-effective bias control technique for optical IQ modulator and demodulator. Low frequency (10 kHz) square-wave and RF power of signal were used for IQ modulator, whereas peak voltage detection of demodulated signal was used for IQ demodulator. Neither additional light nor complex control circuit was required in the scheme. The effectiveness of the automatic bias control scheme was demonstrated in 112 Gb/s DC-DQPSK transmitter. The control loop showed that there was no OSNR sensitivity penalty compared with manual optimization of bias conditions, and provided optimal tracking ability against temperature variation. The long-term stability performance was also investigated in real-environment based on field experiment of 112 Gb/s DC-DQPSK signal transmission over 797-km of installed fiber and ROADMs. All the results indicated that the proposed control scheme could be used to actual transmitters of advanced modulation formats for long-term operation.

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