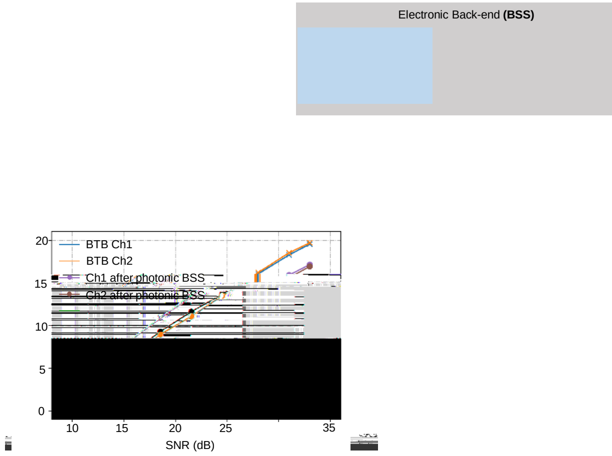

Fig. 1. (a) MDM fiber link with photonic BSS; (b) Eye diagrams and signal waveforms of 2-channel processing. (c) *Q*-factors at different SNRs. (d) Eye diagram of 3-channel processing.

3. Results

We emulate the MDM fiber link as a complex-valued matrix with the modal crosstalk at -5 dB and with its values fluctuating ±1 dB at a time scale of a few milliseconds due to the environmental fluctuations [10]. We use the photonic BSS to undo the modal crosstalk and recover 50 GBaud/s PAM4 data streams. No training sequences are inserted in the transmission data. As shown in Figure 1(b), BSS fully recovers the signals from the modal crosstalk, resulting in clearly opened eye diagrams for two spatial channels. We then evaluate the accuracy of BSS by comparing the recovered signal waveforms with back-to-back signals and the average mean square error (MSE) of the two signals is 0.20% and 0.74%, respectively. We next evaluate the photonic BSS under additive white Gaussian noise. The signal qualtity factor under a wide range of signal-to-noise ratios (SNRs) are assessed as shown in Figure 1(c). After BSS, the system can achieve the forward error correction threshold (BER $= 3.8 \times 10^{-3}$) with 3 dB SNR penalty compared to the back-to-back signals. Photonic BSS is also applied to a three-mode MDM fiber link. The eye diagrams before and after the photonic BSS is shown in Figure 1(d). We observe the signal quality is degradation as we move to higher modes. The main source of scaling limitation comes from the sequential learning in our photonic BSS approach, in which a higher-order component is obtained after the lower-order component. In this case, the errors generated in the lower-order ICs will cascade to the higher-order ones. Our future work will investigate improved algorithms that can reduce the error transfer from lower-order to higher-order components.

4. Conclusion

In this work, we propose and demonstrate a novel photonic front-end processor to address the modal crosstalk in short-reach MDM optical fiber interconnects. The proposed system has distinct benefits in power consumption and latency at high data rates and large channel numbers compared with DSP. The findings indicate that photonics can solve growing constraints in DSP and pave ways for future high-speed, low-energy communication systems.

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