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Experimental Demonstration of Filter-Free Wavelength Conversion Using Nonlinear Optical Loop Mirror at 10Gbit/s

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Abstract : We propose a novel filter-free all-optical wavelength conversion scheme using nonlinear optical loop mirror. Error-free operation with a conversion bandwidth of 20nm at a power penalty of 2dB is experimentally achieved at 10Gbit/s.

Introduction

An all-optical wavelength conversion (AOWC) is indispensable subsystem to avoid a packet contention in a photonic network. Conventional AOWCs reported previously require an optical bandpass filter (OBPF) to select the wavelength-converted signal. When each packet needs to be converted to different wavelength, the tuning speed of the OBPF may limit the system performance. Therefore, the development of the filter-free AOWC is expected. Only a few papers, however, have been reported [1-3].

In this paper, we propose a novel filter-free AOWC using nonlinear optical loop mirror (NOLN). The error-free operation is experimentally demonstrated at 10 Gbit/s.

Principle of Filter-Free AOWC

Figure 1 shows the schematic diagram of the proposed filter-free AOWC, which is almost same as a conventional NOLM-based AOWC [4,5]. In this scheme, the polarization state of the signal light with a wavelength of $_s$ is orthogonal with respect to the one of the probe light with $_p$. When the nonlinear phase shift of the clockwise probe induced by the signal is , the probe is switched to the transmission port. Passing through the polarizer which is aligned so that only the probe passes through, we obtain only the wavelength-converted signal with $_p$ without filtering. Note that the effective nonlinearity of the fiber in the NOLM reduces to one-third, compared with the case that the polarization state of the signal and that of the probe is parallel.

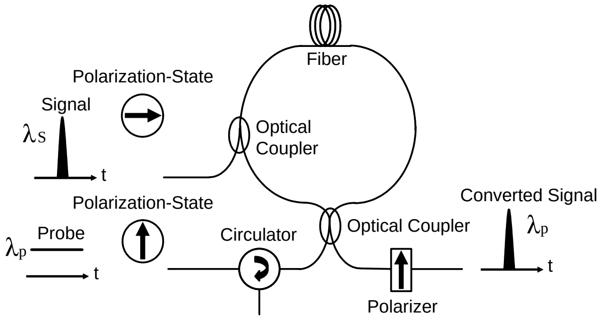


Figure 1: Schematic diagram of proposed filter-free AOWC.

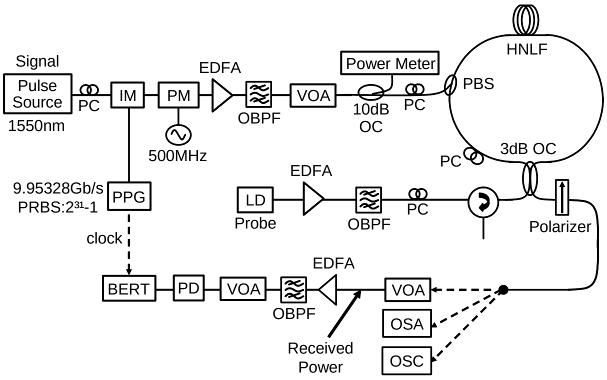


Figure 2: Experimental setup.

Experimental Demonstration

The experimental setup is shown in Fig. 2. The electro-absorption modulator (EAM)-based pulse source generates a pulse train with a pulse width of 13ps and a wavelength of 1550nm at 10Gbit/s. The pulse train is data-modulated with a 10Gbit/s pseudo-random bit sequence (PRBS) and also phase-modulated with a sinusoidal signal at 500MHz to suppress stimulated Brillouin scattering (SBS). The amplified pulse train by an EDFA is used as the signal and coupled with the NOLM through a polarization beam splitter (PBS). The input peak power of the signal is 650mW. The probe light from a laser diode (LD) is amplified to 0dBm and launched into the NOLM. The average zero dispersion wavelength, dispersion slope, nonlinear coefficient, fiber loss, and length of the HNLF in the NOLM are 1556nm, 0.03ps/nm^2/km, 12W^{-1}km^{-1}, 1.7dB/km, and 500m, respectively. At the output of the NOLM, the eye diagrams and spectra are observed by an oscilloscope (OSC) and an optical spectrum analyzer (OSA). We also measure the bit error rate of the wavelength-converted signal.

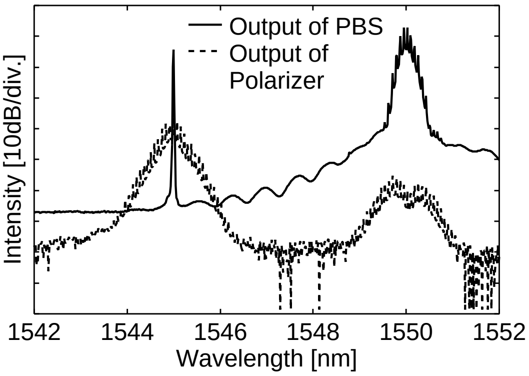
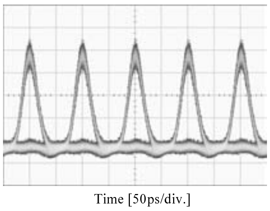
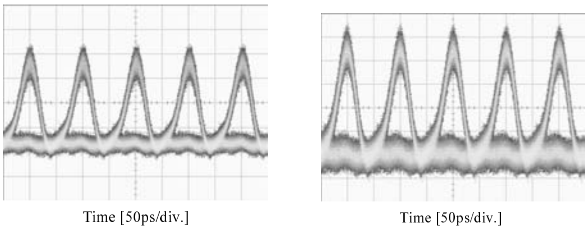


Figure 3: Experimentally observed spectra at the output of the PBS and polarizer.



(a) Input (1550nm).



(b) 1545nm. (c) 1551.5nm.

Figure 4: Experimentally observed eye diagrams of the input signal and converted signals.

Figure 3 shows the spectra at the output of the PBS and the polarizer. The probe wavelength is 1545nm. We can see that the signal is suppressed by 20dB compared with the probe, that is the converted signal, at the output of the polarizer. The nonlinear polarization rotation in the NOLM may contribute to the degradation of the extinction ratio. Figure 4(b) shows the eye diagram of the signal converted from 1550nm to 1545nm, while Figure 4(a) shows the input signal. The clear eye opening is observed. Figure 4(c) shows the eye diagram of the signal converted from 1550nm to 1551.5nm. Although one can see the signal quality is degraded, the eye is still open. Figure 5 shows bit-error-rate (BER) measurements for wavelength conversion from 1550nm to 1565, 1562, 1559, 1545, and 1551.5nm. The power penalty of the signal converted from 1550nm to 1565, 1562, 1559, and 1545nm for BER = 10^{-9} (error-free) is 2dB compared with the back-to-back. This penalty is due to the polarization instability of the input signal and the probe. The fluctuation of the relative polarization state between the input signal and the probe causes noise in the converted signal. The power penalty of the signal converted from 1550nm to 1551.5nm is 3.7dB compared with the back-to-back. This further penalty can be attributed to the interference between the converted signal and the original signal which is leaked through the polarizer. Note that we could not achieve the error-free conversion from 1550nm to 1551nm because of the further interference. Although the signal with 1550nm could not be converted to 1551nm, we successfully demonstrated the filter-free AOWC from 1545nm to 1565nm at 10Gbit/s.

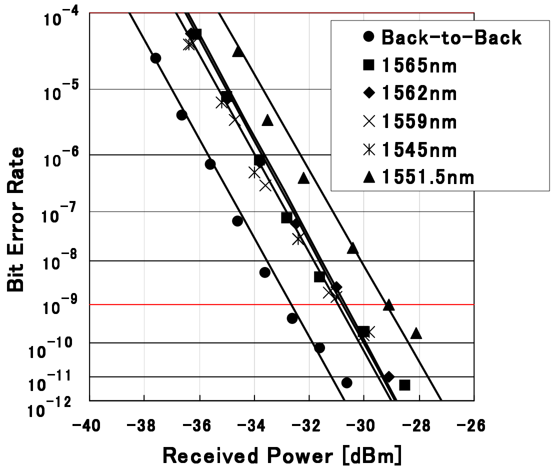


Figure 5: Bit error rate.

Conclusions

We have proposed a novel filter-free AOWC using NOLM, in which the polarization state of the signal and that of the probe is set to be orthogonal. We have demonstrated the error-free conversion with a bandwidth of 20nm at 10Gbit/s. Although the bit rate of the signal is limited to 10Gbit/s due to the laboratory constraint, this scheme can be scaled to 160Gbit/s thanks to the ultra fast response time of Kerr nonlinearity.

References

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