Polarization Insensitive Wavelength Conversion Techniques for 100Gb/s Polarization-Diversity Signal

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Abstract
Wavelength conversion (WC) of high-speed polarization diversity phase modulated signals based on four-wave mixing (FWM) in high-nonlinear dispersion fiber (HNLF) with a polarization diversity and digital coherent detection is experimentally demonstrated. Different schemes to realize polarization insensitive WC are investigated. By using co-polarized dual-pump scheme, the in-band WC of sixteen channels of 112Gb/s polarization diversity-return to zero quadriphase shift keying (PD-RZ-QPSK) has been realized. Another scheme of dual-pump technique to use orthogonal-polarized pumps is also been investigated. By using this scheme, four converted 112-Gb/s PD-RZ-QPSK with BER< 1×10^{-4} has also been demonstrated. The third scheme is to use single pump polarize diversity scheme. By using this scheme, we have realized WC for the signals from *C*-band to *L*-band..

Introduction

In next generation optical networks, high speed and advanced services require a broad bandwidth for the increasing demands. Wavelength-division multiplexing (WDM) provides a cost-effective and efficient use of the available bandwidth in fiber communication systems. All-optical wavelength conversion (WC) is one of the key technologies to enhance the flexibility of future WDM networks such as reconfigurability, nonblocking capability and wavelength reuse [1-7]. Polarization multiplexing can be used to increase the capacity of the transmission system, and is becoming a hot research topic [8-9]. In the future optical network, to realize WC of the polarization multiplexing signal, the WC should be polarization insensitive (PI). In order to realize PI WC, three different schemes can be employed. They are single pump polarization diversity [1], co-polarized pumps [3, 4, 7] and orthogonal pumps [5]. In this talk, we will summarize our achievements on PI WC for phase modulated signals and demonstrate new experimental results of WC based on single pump polarization diversity scheme.

In this talk we will present the following research results: the polarization insensitive in-band WC, the WC based on co-polarized pumps generated from optical carrier suppression technique, the WC technique based on two orthogonal pumps and the experiment of single-pump WC with polarization diversity.

Polarization insensitive wavelength conversion

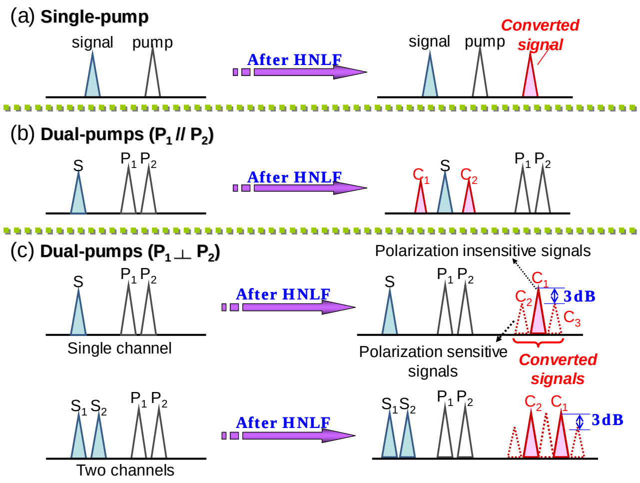

Fig. 1: The principle of WC using single-pump and dual-pumps**.**

Fig. 1 shows the possible solutions to realize FWM by using single-pump and dual-pumps. The simplest configuration is employing single pump, which is shown in Fig. 1(a). Here the input channel (S) and single pump (P) are injected the nonlinear medium and they only pass through one time in the nonlinear medium. By this scheme, the converted signal is polarization sensitive. For a single input channel (S), one sensitive converted signal (C) is generated after WC. The converted signal is spectral inversion.

If the combined pump and input channel are injected into a nonlinear medium with loop configuration [3], the converted signal can be PI. The converted signal, the pump and input channel have the same frequency relationship as shown in Eq. 1.

The co-polarized pumps scheme ($P_1//P_2$) is displayed in Fig. 1(b). Two converted signals (C_1 and C_2) adjacent to the original signals (S) are generated. This scheme is PI and spectrum non-inversion [4].

Using orthogonal pumps for single-channel and two-channel conversion is exhibited in Fig. 1(c). For a single input channel, two polarization sensitive converted signals (C_2 and C_3) as well as one polarization-insensitive converted signal (C_1) are generated after WC, such that the differential power between C_2 (C_3) and C_1 is about 3 dB. For two input channels, the converted signals (C_1, C_2) are spectrally inverted, and are spectrally interleaved between three polarization-sensitive signals. The frequency spacing between the converted signals C2 and C3 is double that between the two orthogonal pumps, and the frequency spacing between C_1 and C_3 (or C_1 and C_2) is equal to the spacing between the optical pumps.

In-band wavelength conversion of 16x114Gb/s PD-RZ-8PSK signal

We have realized in-band wavelength conversion by employing co-polarized pump scheme [4]. The optical spectra after conversion is shown in Fig. 2. The BER of all channels after wavelength conversion is smaller than $1x10^{-3}$.

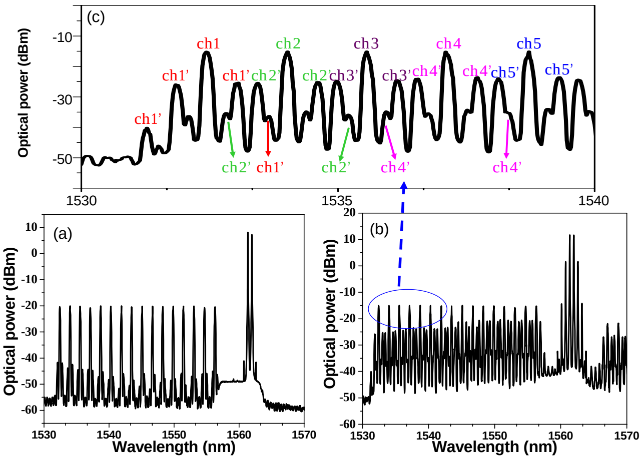

Fig. 2: Monitored optical spectra with 0.1-nm resolution. (a) Before WC, (b) after WC, (c) a part of converted channels.

Wavelength conversion of 4x112Gb/s PD-RZ-QPSK signal by orthogonal pump scheme

Using orthogonal pump scheme, we have realized polarization insensitive wavelength conversion of 4x112Gb/s PD-RZ-QPSK signal [5]. The optical spectrum after wavelength conversion is shown in Fig. 3. All BER of the converted channels are smaller than $2x10^{-4}$.

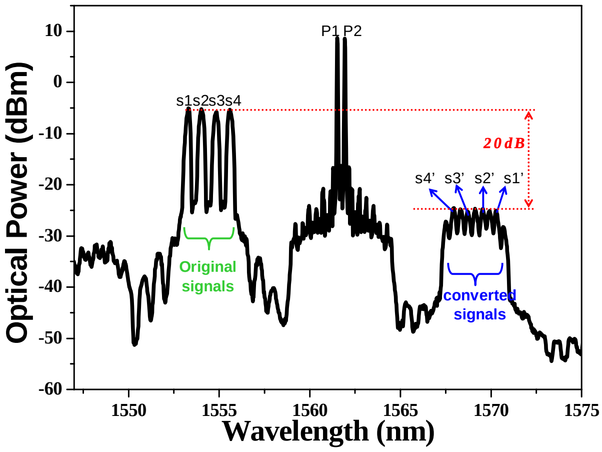

Fig. 3: Received optical spectrum (0.1-nm resolution) after WC for 4×112-Gb/s PD-RZ-QPSK signals.

Single pump with polarization diversity

We have investigated the performance of 112-Gb/s PD-RZ-QPSK signal after WC based on a HNL-DSF converter with single pump polarization diversity scheme and digital coherent detection. Tuning the wavelength, we measure the converted signal at different wavelength, and Fig. 4 exhibits some typically optical spectra after the HNL-DSF converter. The original signals are tuned from 1529.72 to 1554.62 nm, while the converted signals are from 1556.46 to 1592.72 nm.

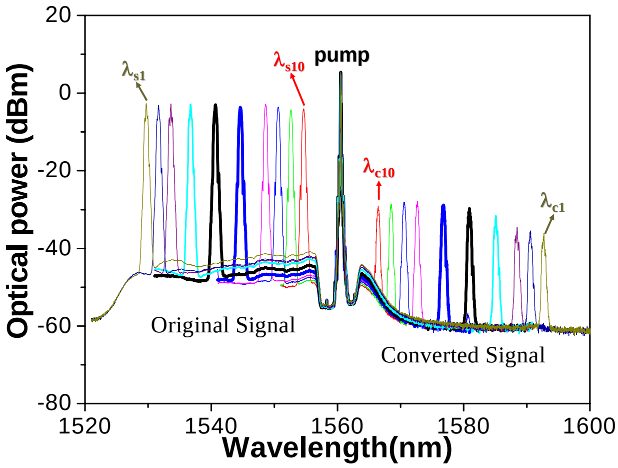

Fig. 4: Received optical spectrum including original signals (λ_{s1}~λ_{s10}) and converted signals (λ_{c10}~λ_{c1}).

Conclusions

We have presented the experimental results of the three different schemes. All of them can be used to realize PI-WC. Co-polarized pump scheme can easily realize in-band, spectrum non-inversion and preserved channel wavelength conversion for WDM signals. But the conversion bandwidth is usually limited. For orthogonal pump scheme and polarization diversity single pump scheme, the converted spectrum is inversion, and they are suitable for inter-band wavelength conversion. Two and three pairs for co-polarization and orthogonal pumps are generated. However, for single pump polarization diversity scheme, the converted signal is unique. It means that the power of the converted signal by this single pump scheme can be fully utilized. But, for the polarization diversity single pump scheme, usually a loop configuration is used. However, a loop configuration has a stability problem. If the loop configuration can be integrated by PLC technique, the stability should be improved.

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