4×4 all-optical wavelength converter using a single Fabry-Perot laser diode

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Abstract: A 4×4 all-optical wavelength converter is implemented using a single Fabry-Perot laser diode. The module can be used in wavelength convertible WDM optical networks cost-effectively. The module also has multicasting function.

Keywords: All-optical wavelength conversion, injection locking, Fabry-Perot laser diode, wavelength convertible WDM network.

1. Introduction

All-optical wavelength routing network is widely regarded as the possible candidate for future backbone network for information communications because of the huge bandwidth of optical systems. In simple wavelength routing networks, nodes are connected by optical fiber link and on each link there are multiple wavelengths serving as individual data channels. To send information from source node to destination node, a wavelength channel must be set up on each link to make a light path. The wavelength requirement from source node to destination node is referred to as the wavelength continuity constraint which limits the number of connections that can be simultaneously set up in the network. For example, consider a route consisting of two links as shown in Fig. 1. Suppose a connection is to be set up between node 1 and node 3 along a route which pass through a cross-connect at node 2. This connection can only be set up if the same wavelength is available on both links. If only wavelength λ_3 is available on link 1 and wavelength λ_3 is not available on link 2, then the connection between nodes 1 to node 3 cannot be set up (example in Fig. 1 (a)). Even other wavelengths except λ_3 are available on link 2, no way to establish the connection because of wavelength continuity constraint. The limitation imposed by the wavelength continuity constraint can be avoided by the use of wavelength converters as shown in Fig. 1 (b). Research articles on wavelength convertible optical networks and the optimal placement of wavelength converters in the networks are available in WDM network research fields [1-3]. Wavelength convertible WDM networks can use the available wavelengths efficiently and reduce the blocking probability of the network. However, implementation of the network with wavelength conversion function is very expensive because the number of converter modules depend on the number of wavelengths in the system. The wavelength converters proposed till now are single input conversion modules. Hence, for each wavelength in the wavelength routing network, it is required a separate wavelength conversion module [1] that makes the system bulky and costly.

In this paper we implement a 4×4 all-optical wavelength conversion module using a single FP-LD. The wavelength conversion module using a single FP-LD can be used to convert several input wavelengths as required in wavelength routing network. This multi input wavelength converter is simple to implement and can be cost-effective in wavelength convertible WDM optical networks. We measure conversion performance in our experiment. We observe over 15 dB on-off contrast ration of output signals and clear output eye diagrams for 10 Gbits/s input data. The performance ensures that this module can be used for more number of channels because the FP-LD has a wide range of lasing modes.

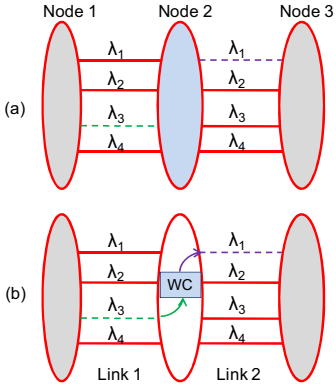

Fig. 1. An example of three nodes WDM networks. Available wavelengths are λ_3 in link 1 and λ_1 in link 2, other wavelengths are in used, not available (a) Connection between node 1 and node 3 is not possible due to wavelength continuity constraint. (b) Connection between node 1 and node 3 is possible by using a wavelength converter (WC) in node 2.

2. Experiment and results

The experimental set up of the 4×4 wavelength conversion module is shown in Fig. 2. The operation principle is based on the injection locking characteristics of FP-LD [4]. The FP-LD used in this experiment is a multi-mode FP-LD. The nominal lasing mode is 1550.72 nm with a biasing current of 13 mA and the operating temperature of 19^0 C. The FP-LD has a lasing span of over 60 nm with multi longitudinal modes with a 1.12 nm wavelength spacing between two adjacent longitudinal lasing modes. We set up four input pump wavelengths of 1546.40 nm, 1547.52 nm, 1548.64 nm, and 1549.76 nm with a detuning of 0.16 nm in shorter wavelength side than the probe wavelengths. The four probes of 1551.96 nm, 1553.12 nm, 1554.24 nm, and 1555.4 nm wavelengths were set up with detuning of 0.08 nm each. The power of each input beam was -3 dBm before conversion and the power of each probe was -8 dBm each. The optical power spectra of 4×4 wavelength converter is shown in Fig. 3. The power spectra show that, any of the wavelengths four inputs can be oprtate and the converted wavelength can be received from any of the four outputs

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(probes). The module also has the multicasting function. Any of the input information can be transmit to all of the four outputs simultaneously. The conversion module shows the on-off contrast ratio of over 15 dB as shown in Fig. 3. For eye diagram measurements, we modulated each of the input pump beams by 10 Gbits/s pseudorandom bit sequence. We measured the eye diagrams and observed that each of the output signals show clear eye diagrams as shown in Fig. 3. The excellent performance of this 4×4 wavelength conversion module ensures to use this scheme with more number of input-output channels to be used in wavelength convertible WDM optical networks.

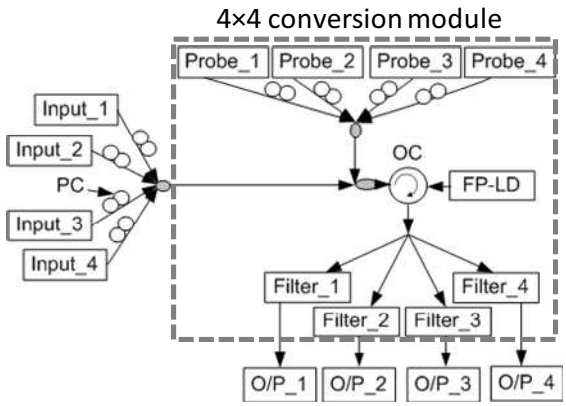

Fig. 2. The experimental set up of the 4×4 wavelength conversion module. PC : Polarization controlar, O/P : Output. OC : Optical circulator,

3. Conclusion

Using a single FP-LD, we implement a mutli-input multi-output wavelength conversion module based on injection locking characteristic of FP-LD. This module is very simple to implement and cost-effective in wavelength convertible WDM optical networks. We investigate the operational performances and measure on-off contrast ration of over 15 dB for all four outputs and we measure the eye diagrams of outputs with input of 10 Gbits/s pseudorandom bit sequences and observed that the output eye diagrams are clear that ensures to use this scheme for more input-output channels because the FP-LD has a wide range of lasing modes. This scheme is also usefull in multi-input multicasting function in all-optical optical networks.

4. References

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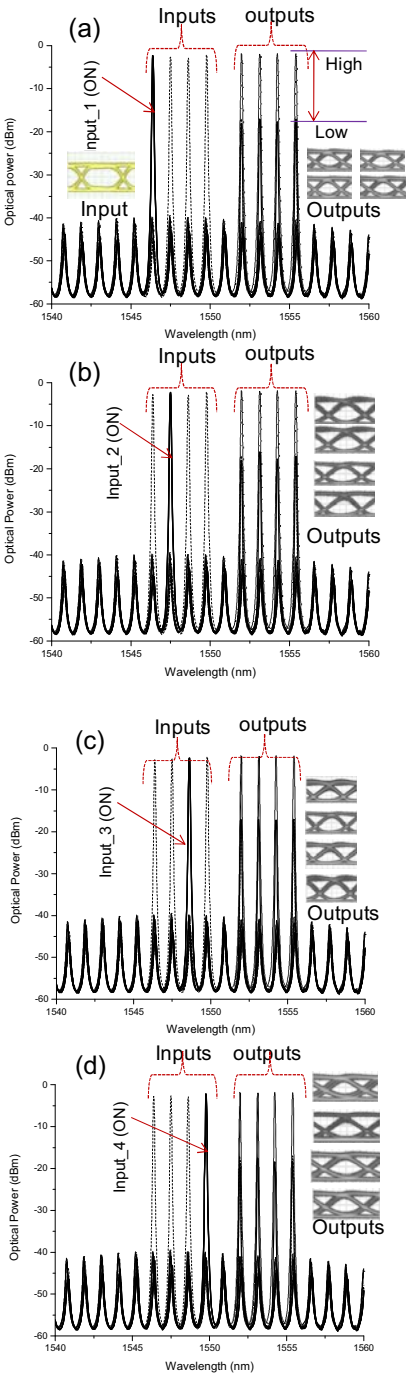

Fig. 3. The optical power spectra and eye diagrams of 4×4 wavelength conversion oprtation. Four inputs (pumps) and four outputs (probes). (a) Four outputs are received with Input_1 being 'ON' (active). (b) Four outputs are received with Input_2 being 'ON' (active). (c) Four outputs are received with Input_3 being 'ON' (active). (d) Four outputs are received with Input_4 being 'ON' (active).

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