Improvement of Input Power Dynamic Range in a XGM Wavelength Converter by an Attached Optical Amplifier Using a SOA

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***Abstract*--In this paper, we propose the scheme for improving the characteristics of wavelength converter based on cross-gain modulation (XGM) in semiconductor optical amplifier (SOA). In front of the wavelength converter, a pre-amplifier is placed and adjusted to get optimal performance of wavelength converter in terms of bit error rate (BER) and corresponding power penalty. In the simulation, wavelength up conversion from 1548.51 nm to 1556.55 nm at 2.5Gb/s is performed and the result shows that a dynamic range is increased by amount of >4dB at 2dB of the power penalty.**

***Index terms*-- SOA, XGM, wavelength conversion, dynamic range**

INTRODUCTION

All optical wavelength converters will be the key component in the future broad-band optical networks based on wavelength division multiplexed architecture since they can provide the flexibility and the capacity of the network for a fixed set of wavelengths. Several techniques for all optical wavelength conversion have been studied and among them, SOA's are expected to be the most promising candidates [1], [2].

Wavelength converters can be based on structures exploiting the SOA nonlinearities. Nonlinearities in SOA's are principally caused by carrier density changes induced by the input signals. There are three main schemes using the nonlinearities, which are based on four wave mixing (FWM), XGM and cross-phase modulation (XPM) [3], [4]. Especially wavelength conversion based on XGM in SOA has been widely studied because of its simple implementation and high efficiency. But some drawbacks such as the extinction ratio degradation, an inherent inverted polarity, a narrow dynamic range and pattern dependence are remaining as the problem that should be resolved [5], [6]. Some techniques for improving dynamic range are proposed and these use a electrical control loop which adjusts the probe power entering the SOA as the detected pump signal power level [7]. In this paper we report the simulation results of improved dynamic range of XGM based wavelength converter using SOA at 2.5Gb/s. In the simulation, another SOA is appended as a pre-amplifier before entering the wavelength converter without any control loop. A comparison is made with a wavelength converter having no handling at the same pump signal level.

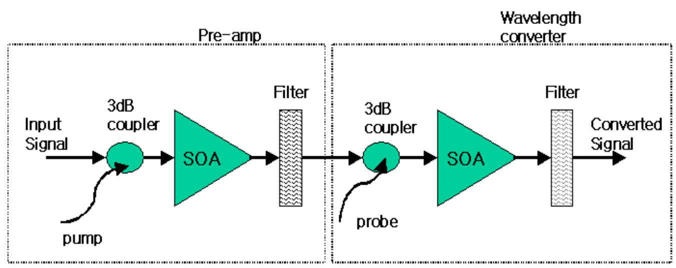

Fig. 1. Schematic diagram for simulation setup

PRINCIPLE AND SIMULATION

In photonic packet switching system, each packet can experience different optical paths and therefore has broad power variation. Because this reason and the fact that XGM wavelength converter has a narrow dynamic range, a power equalization method is required. Power equalization can be achieved by the characteristic of gain saturation of SOA. But owing to the gain saturation, signal amplified by SOA must have extinction ratio degradation and gives a large power penalty. When the external CW pump enters the SOA, extinction ratio degradation can be reduced. So the equalization of power variation without significant extinction ratio degradation can be achieved by careful adjustment of pumping power in SOA. The wavelength converter structure applied by this scheme is shown in Fig.1.

The wavelength of input signal and probe are 1548.51 nm and 1556.55 nm respectively. The input signal is provided by intensity-modulated 2.5Gb/s transmitter and probe is CW, which will be a converted signal. SOA of the first section provides amplification of input signal and that of the second section performs wavelength conversion. In conventional XGM wavelength converter, pre-amp section is not included. To get the optimal condition for a fixed input signal, the pump and probe power were varied at 1dBm interval. Also for the comparison with conventional wavelength converter, probe power was optimized providing no pre-amp.

RESULTS AND DISCUSSIONS

We give the input signal 5dBm with some variation and find the condition, which shows the best performance in terms of power penalty. Including pre-amp, the probe power and the pump power is determined on 8dBm and 5dBm, respectively while the probe power is –4dBm in conventional scheme.

Fig. 2. shows BER curves for wavelength conversion under the conditions described above. With a pre-amp using a SOA, the power penalty somewhat decreases from 2.2dB to 1.4dB. This says that SOA used for pre-amp does not distort the input waveform. Such possibilities for distortion as extinction ratio degradation or overshooting are reduced by launching external pump while the amplification efficiency drops. The amplified waveform after first SOA is shown in Fig. 3. The original signal has 15dB extinction ratio. Although extinction ratio is degraded to the amount of 3~4dB, power variations are rather reduced. This effect provides a power equalization function and can be identified in Fig. 4. In the conventional scheme, the dynamic range in which power penalty is within 2dB based on 10^{-9} BER is 6dB. Using the pre-amp scheme, the dynamic range improves over 10dB at 2dB penalty or gives 5dB range at 1dB penalty. In the use of SOA as a power equalizer, a tradeoff relation exists between extinction ratio degradation and power equalization.

CONCLUSION

We have simulated a simple technique of improving the performance of wavelength converters based on XGM using an SOA. It is found that enhancement of a dynamic range wavelength converter without using any dynamic control circuit can be possible. The wavelength conversion form 1548.51 nm to 1556.55 nm at 2.5Gb/s is simulated based on XGM using an SOA. The result gives 4 dB enhancement of dynamic range due to the power equalization function of pre-amp using a SOA, which gives amplified and equalized output waveform in front of the wavelength converter.

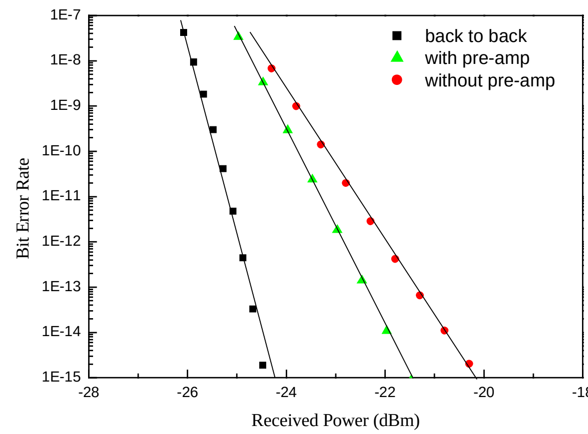

Fig. 2. BER curves for XGM wavelength conversion with and without pre-amp

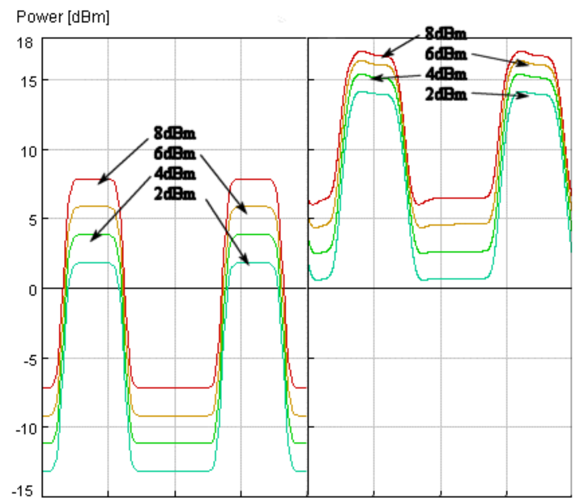

Fig. 3. Original waveform having 15dB extinction ratio with various power (left) and amplified waveform (right)

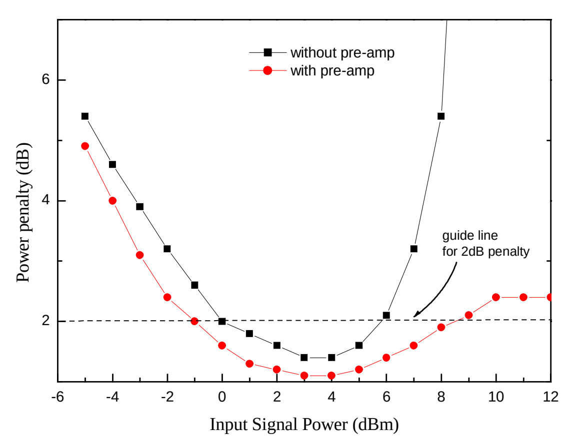

Fig. 4. Power penalties for various input signal powers.

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