SOA의 XGM을 이용한 광학적 주파수 상향 변환 방법의 변환 효율 분석

Conversion Efficiency Analysis of Photonic Frequency Up-conversion Using XGM of SOA

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Abstract: We simulated the conversion efficiency of photonic frequency up-conversion using XGM of SOA. Optical heterodyne Local Oscillator (LO) signals and Intermediate Frequency (IF) signals having different wavelengths are used for the SOA input signals. The conversion efficiency is analyzed according to the input signal power and wavelength.

Introduction:

The radio-on-fiber systems are one candidate for the next generation wireless communication systems at the point of low loss broadband data transmission [1-3]. Such systems are using various frequency up-conversion techniques for the target frequency wireless transmission. However, as the target frequency increases, more high frequency range up-converters are needed, which is not easy to realize. Up to now, some MMW frequency up-conversion methods are introduced, which are based on nonlinear components such as HEMTs, HBTs, and PDs [3]. We also introduced a new photonic frequency up-converter scheme using XGM of SOA [3].

Fig. 1 is a simple schematic to explain the up-conversion process. The LO signals consist of two optical modes that are separated by the target frequency. The IF signal is transmitted by a different wavelength source. When both signals are injected into the SOA, the IF signal modulates the LO modes by XGM effects. After the PD detection of the optical LO modes modulated with the IF signal, the up-converted signal (LO frequency ± IF frequency) is generated as a result of the square law characteristics of the PD [3].

In this paper, we numerically analyzed the frequency up-conversion efficiency at the conditions of various LO signal powers and different IF signal wavelengths. The simulation method for the SOA up-converter is the Transfer Matrix Method [4].

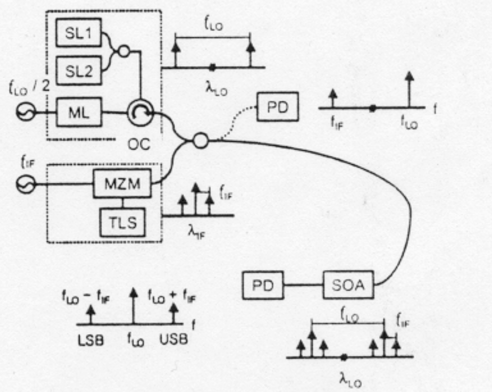

Fig. 1. Frequency up-conversion schematic. SL: Slave Laser, ML: Master Laser, OC: Optical Circulator, MZM: Mach Zehnder Modulator, PD: Photo-Diode, TLS: Tunable Laser Source, LSB: Lower Side Band, USB: Upper Side Band

Simulation and Results:

For the simulation, we assume that two optical heterodyne LO modes are separated by 60 GHz, and 1 GHz IF signal is modulated at the different wavelength. Their E-fields can be expressed as:

$$E_{LO}(t,z=0)=\sqrt{\overline{P}_{LO}/2}\left(e^{-j\Omega_{LO}t/2}+e^{j\Omega_{LO}t/2}\right)\cdot e^{-j\omega_{LO}t}$$

$$E_{IF}(t,z=0)=\sqrt{\overline{P_{IF}}(1+m\sin\Omega_{IF}t)}\cdot e^{-jw_{IF}t}$$

where Ω_{LO} and Ω_{IF} are the LO and IF signal frequency, and ω_{LO} and ω_{IF} are the LO and IF optical angular frequency. m indicates the modulation index. These two signals are the input of the SOA and the SOA output results are acquired through simulation. Fast Fourier Transform converts time domain input and output

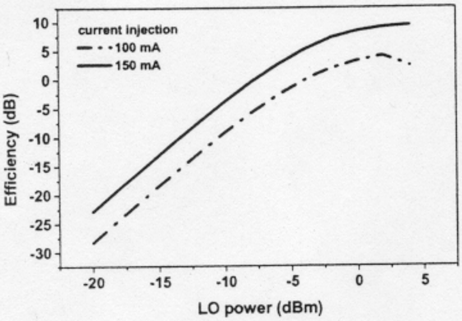

Fig. 2. Conversion efficiency with LO light power.

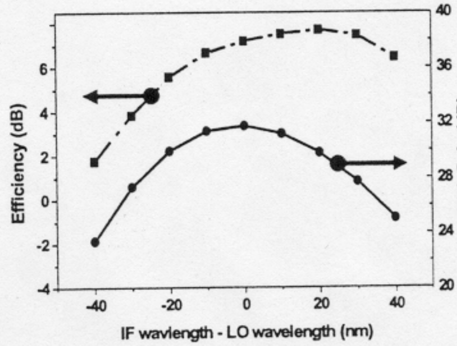

Fig. 3. Conversion efficiency for different IF signal wavelength and SOA gain for that wavelength.

signals to the frequency domain signals. After these simulation processes, 1 GHz input IF signal power and 61 GHz up-converted upper sideband signal power are compared and the conversion efficiency is calculated. The conversion efficiency is defined as the power ratio of the input IF signal to the output USB signal.

First, the LO power dependence of the conversion efficiency is simulated. IF signal power is −10 dBm, and the modulation index is fixed at 0.2. Fig. 2 shows the results. As the LO power increases, the conversion efficiency also increases, because the USB signal is the beating signal between the optical LO modes and cross-gain modulated IF signals at the PD. Moreover, because the LO signals are increased by the SOA gain, the conversion efficiency can be high enough to be a positive value. On the other hand, when the LO signal power is large enough to make the SOA gain strongly saturated, the conversion efficiency increases no longer. The SOA injection current also increases conversion efficiency by increasing SOA gain.

Fig. 3 shows conversion efficiency for the IF signal wavelength. LO signal wavelength is fixed at the gain peak and IF signal wavelength is swept. Both optical signal powers are −10 dBm. A large conversion efficiency near the gain peak is achieved due to the SOA gain which can affect both LO and IF signal powers. However, the peak efficiency wavelength of the IF signal is longer than the SOA gain peak. This is because when high optical power is injected into the SOA, the carriers inside the SOA are depleted and the gain peak is shifted toward longer wavelength.

Conclusion:

We demonstrate the conversion efficiency for the LO power and IF signal wavelength with the SOA simulation method. The conversion efficiency is strongly dependent on the SOA gain characteristics and signal power. However, positive conversion efficiency can be acquired with the help of the SOA gain, and this is believed to be the superior characteristic compared with other photonic up-conversion methods. We also confirmed our simulation result characteristics experimentally with the 25 GHz LO signal and 1 GHz IF signal, which will be presented at the conference.

Reference:

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