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ScienceDirect

Procedia Technology 25 (2016) 560 – 566

Procedia Technology

Global Colloquium in Recent Advancement and Effectual Researches in Engineering, Science and Technology (RAEREST 2016)

10 Gbps Externally Modulated XGM based Wavelength Conversion Using SOA

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Abstract

This paper proposes a method for All Optical Wavelength Conversion using semiconductor optical amplifier at 10Gbps. The system is demonstrated for Cross Gain Modulation (XGM) process of SOA, which is the simplest wavelength conversion technique that takes the advantage of non linear gain suppression mechanism in SOA. The system performances are analyzed using Q factor and Extinction Ratio of the eye diagram.The input pump power is varied from 2 dBm to 5 dBm; also the extinction ratio of Mach-Zehnder modulator is varied from 30 dBm to 60 dBm. Maximum Q Factor of 11.86 dB is obtained for a maximum output signal power 23.94 dBm. Minimum Q Factor obtained is 7.58 dB for a minimum output signal power 23.15 dBm. The extinction ratio falls from 18.56 dB to 16.63 dB as the input conditions are varied.

Peer-review under responsibility of the organizing committee of RAEREST 2016

Keywords: Wavelength Conversion, Semiconductor Optical Amplifier (SOA), Cross Gain Modulation (XGM)

1. Introduction

All multiplexed networks consist of a number of crossconnects to maintain proper routing of data from node to node. In a circuit-switched network, the blocking rate depends on the number of free paths. When there is no capacity available on any path, the requests are blocked. But in the optical domain, according to wavelength continuity constraint, to establish any lightpath, the same wavelength must be allocated on all the links in the path. Compared to a circuit-switched network, a wavelength-continuous network may suffer from higher blocking because the available wavelengths on the links might be different. To avoid the blocking problem, the data send on one wavelength along a link is converted into another wavelength at an intermediate node and then forwarded it along the next link. This technique is referred to as wavelength conversion and such wavelength-routed networks with this capability are known as wavelength-convertible networks. A wavelength-convertible network is

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Peer-review under responsibility of the organizing committee of RAEREST 2016
doi:10.1016/j.protcy.2016.08.145

functionally equivalent to a circuit-switched network, because it supports complete conversion of wavelength at all nodes, i.e., the lightpath requests are blocked only when there is no available capacity on the path. Hence, with the help of a wavelength converter a data stream at a specific wavelength is transferred to another one in order to be routed on a different wavelength path and release the original wavelength resource to another data stream [1, 2].

Wavelength conversion techniques exist in two methods – Optoelectronic wavelength conversion and All Optical wavelength conversion. In the first method, by using a photodetector the optical signal to be converted is first translated into the electronic domain. The electronic bit stream is stored in the buffer. The input of a tunable laser tuned to the desired wavelength of the output is driven by the electronic signal [3]. This method has been demonstrated for bit rates up to 10-Gb/s. But optoelectronic method is much more complex and consumes much more power compared to the other methods. In the second method, throughout the conversion process the optical signal is allowed to remain in the optical domain. There is no optical to electrical conversion involved, hence the name All-optical [4].

Semiconductor based all optical wavelength conversion devices are compact and easily compatible for integration and mass production using similar fabrication techniques to those used for silicon based integrated circuits. Comparing to techniques based on fiber, SOAs in the InP/InGaAsP material system are of the most interest because they can produce gain in the wavelength bands of modern fiber systems incorporating erbium doped fiber amplifiers [5]. Other major advantages of using SOA are its high gain, high saturation output power, wide gain bandwidth, high nonlinearity, low power consumption, short latency, and high stability [6].

To implement all optical wavelength converters several promising techniques relying on Cross- Gain Modulation (XGM), Cross- Phase Modulation (XPM), and Four Wave Mixing (FWM) in a single SOA, have been reported [7, 8, 9]. Among these, Cross Gain Modulation based all optical wavelength conversion is one of the simplest methods. XGM has the advantage of high conversion efficiency as well as insensitivity to polarization of input signals [4].

In this paper, the simulation of the SOA based XGM wavelength converter using external modulation is done. The simulation is carried out at 10Gbps. This paper is structured as follows. In section 2, the theoretical illustration of the process is described. In section 3, the system setup model and simulation results are described. In section 4, the main conclusions are discussed.

2. Theory

In a p-n heterojunction, the injection of electrons and holes from either sides of the junction builds up the carrier concentration in the active region. This establishes a non-equilibrium state in the active region and is called the population inversion. When the input signal photons passes through the excited area stimulated emission occurs. The incoming signal stimulates the radiative recombination of electrons and holes. As a result coherent amplification of signal power happens. Some recombinations occur spontaneously which is termed as Amplified spontaneous emission (ASE). Carrier density decreases as a result of increase in stimulated emission. Gain drops and shifts accordingly. Expression for saturation power is given below.

$$P_{sat} = \ln(2) h\nu S / (\Gamma \tau \frac{dg}{dN}) \qquad (1)$$

Where Γ is the cross sectional confinement factor of the propagating mode overlapping the active area, N is the carrier density depend on time t, i.e. the electrical injection current, S is the active area cross section, τ is the carrier lifetime that usually includes non radiative recombinations due to defects, impurities and other traps, radiative recombinations due to spontaneous emission and Auger processes, h is the Planck's constant and ν is the frequency [10, 11].

The principle behind using an SOA in the XGM mode is shown in Fig. 2.1 [12]. Due to gain saturation the intensity modulated input signal modulates the gain in the SOA. The gain variation modulates the continuous wave (CW) signal at the desired output wavelength (λc) so that it carries the same information as the original input signal. Launching of the input signal and the CW signal in to the SOA can be done either co- or counter directionally into the SOA.

The XGM scheme generates a wavelength converted signal that is inverted with respect to the input signal. Even though the XGM scheme has the advantage of simpler configuration and penalty-free conversion, it has the disadvantage of extinction ratio degradation for an input signal converted to a signal of equal or longer wavelength