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High Speed Colourless Transmitter Based On RSOA

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Abstract

We propose and demonstrate a novel colorless optical transmitter based on all-optical wavelength conversion using areflective semiconductor optical amplifier (RSOA) for upstreamtransmission in wavelength-division-multiplexed passive opticalnetworks.. All-optical wavelength conversion based on nonlinear gain modulation in RSOAs is demonstrated at a bit rate of 10Gbit/s. It is shown that a bit-error-rate of <10-^{25} can be achieved and an extinction ratio of >9 dB can be obtained at a bit rate of 10Gbit/s with a 2^7–1 non-return-to- zero (NRZ) pseudorandom bit sequence (PRBS). In comparison with conventional SOAs, wavelength conversion by RSOAs shows much improved performances in high-speed all-optical wavelength conversions.

Keywords: RSOAs, XGM, ONU, a WDM-PON

Introduction

An RSOA is a promising cost-efficient solution for a transmitter at an ONU in a WDM-PON architecture However, due to its open-cavity-laser-like nature it is highly sensitive to Rayleigh backscattered (RBS) or reflected power (e.g. a fiber splice with low return loss, RL), which cannot be optically filtered since it covers exactly the same spectrum as the nominal wavelength. This returned power interferes with the desired signal and raises power instabilities. Such interferometric crosstalk causes the degradation of signal-to-noise ratio (SNR) and increases power penalties (PPs) in the system's bit error-rate (BER) performance [2]. The coherent crosstalk, coming fromA discrete (localized) back-reflection within the coherence length of the source, may cause much larger PP than the incoherent crosstalk caused by discrete back-reflection beyond the coherence length of the source or by RBS. However, it can be effectively reduced after satisfying requirements for sufficiently high return loss of components [3]. On the contrary, the RBS-induced crosstalk is always present in a single-fiber single-wavelength duplex transmission system, varying only upon the RBS coefficient in the applied fiber. Consequently, here, we focus on RBS-robust solutions applicable to WDM-PONs with RSOA-ONUs. As discussed in [4] there are two major kinds of reflection,. Reflection I yields light originating from downstream (DS) transmission which propagates towards OLT and distorts the upstream (US) signal. Reflection II yields light originating from US transmission which propagates towards ONU and distorts the DS signal.

In this paper, we propose and demonstrate a novel approach toacolorless optical transmitter based on wavelength conversion.ONU is first wavelength-convertedto the wavelength of the seed light by cross-gain modulation(XGM) in a gain-saturated RSOA. Then, a detuned delayinterferometer (DI) is used at the CO to improve the bandwidthof the system [6]. In this approach, the RSOA is simply based on NRZ data modulation. Therefore, the upstream datarate is not limited by the carrier lifetime of the RSOA, but by fastgain recovery governed by carrier-carrier scattering and carrierphononinteractions. We experimentally demonstrate the transmissionof 10-Gb/s upstream data over 20-km standard-singlemodefiber (SSMF), investigate the dispersion-induced penalty,and study the conditions for colorless operation in the proposedscheme.

Functioning of RSOA

conversion by RSOA is shown fig 1 in Because of the highly reflective nature of one facet of theRSOA, only the co-propagation scheme can be used. This is contradictedto the conventional SOA, which can be operated in eitherco- or counter-propagation scheme [13,14]. During the operation, the RSOA bias current are maintained at 18 mA. The pump lightis externally modulated at 10Gbit/s by a non-return-to-zero(NRZ) pseudorandom bit sequence (PRBS) of length 2^7–1 via a Mach–Zehnder modulator, and coupled into the RSOA by a circulatortogether with a probe light. The modulated pump lighttherefore modulates the optical gain of the RSOA. The probe lightexperiences this gain variation and transfers the data informationfrom the pump light. Therefore wavelength conversion is realized.

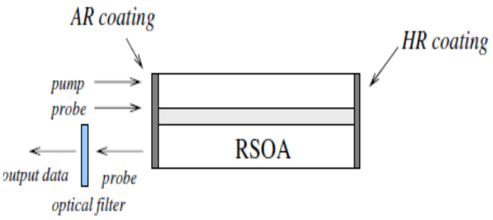


Fig.1.Principle of wavelength conversion by XGM in RSOA.

ARCHITECTURE AND PRINCIPLE OF OPERATION

In this paragraph, we present the basic principle of the WDM-PON system architecture, in which thecolorless components are used as upstreamtransmitters. The network architecture is shown in figure 2.

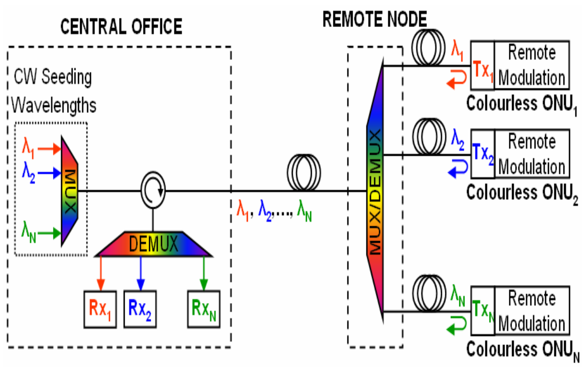


Figure 2: WDM-PON architecture for upstream transmission using colorless RSOA as T_X

The WDM-PON is essentially based on a point-to-multipoint architecture. In order to distributebroadband services to the subscribers, the Central Office (CO) of the network operator is connected tothe terminals located at subscriber's premises called Optical Network Units (ONU). The point-to-multipointarchitecture is realized thanks to an intermediate point in the network called Remote Note(RN). It consists in a MUX/DEMUX, which separates and/or recombines each channel of differentsubscribers.In the WDM-PON configuration,colorless components are identical and wavelength-independent atONUs. They are used as the upstream transmitters as shown in Figure 2. The emitted wavelength ofeach component depends on the wavelength of the seeded signal coming from the CO. The upstreamoptical signals are modulated with the subscriber’s data thanks to the modulation ability of thecolorless components.

Experimental Setup

We demonstrate the proposed colorless optical transmitter forWDMPONupstream transmission using the experimental setupdepicted in Fig. 3. A tuneable laser source provides a CW probesignal at 1552 nm. The CW probe signal is fed to an optical mux, and then launched into SSMF before beingsenttodemux, which emulate at the CO and the remote node, respectively, have a 3-dB bandwidthof 20 GHz. At the ONU side, we have a tuneable laser followed by anEAM to simulate an EML. This is to allow tuning the wavelengthof the pump signal and thus to study the conditions forcolorless operation in the proposed scheme. Upstream NRZ datamodulation formatrunning at 10 Gb/s with a pseudo-random binary sequence(PRBS) length of are fed to the EAM for intensitymodulation. Here, we assume Reed-Solomon (255, 239) forward-error correction (FEC)-coded data with a 7% overhead.The extinction ratio (ER) of the pump signal is dB. The RSOA used in the experiment is an uncooleddevice housed in a transistor outline package. It is DC-biasedat 50 mA and no high-speed signal is applied. Under thisbias condition, the 3-dB spectral width of the RSOA output is measured to be 33 nm, ranging from 1529 to 1562 nm. Unlessstated otherwise, the optical powers of the pump and probe signalsinjected into the RSOA are set to be and dBm,respectively. The input saturation power of the RSOA, definedas the input optical power at which the signal gain is compressedby 3 dB from its small signal gain, is measured to be dBm.Thus, the RSOA operates in the saturation region. The RSOA used in the demonstration hasa polarization-dependent gain ,Although the pumpsignal can give rise to a nonlinear polarization rotation, a changein the polarization state of the probe signal in the presence of thepump signal, polarization-insensitive RSOAs can be usedfor real systems to eliminate the need for PCs.

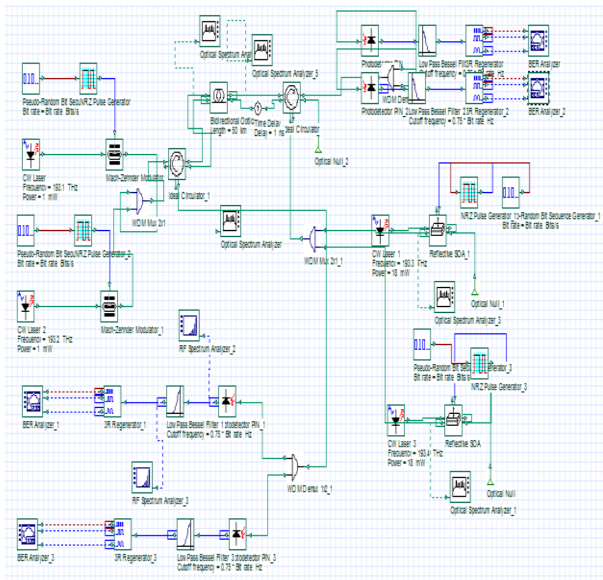
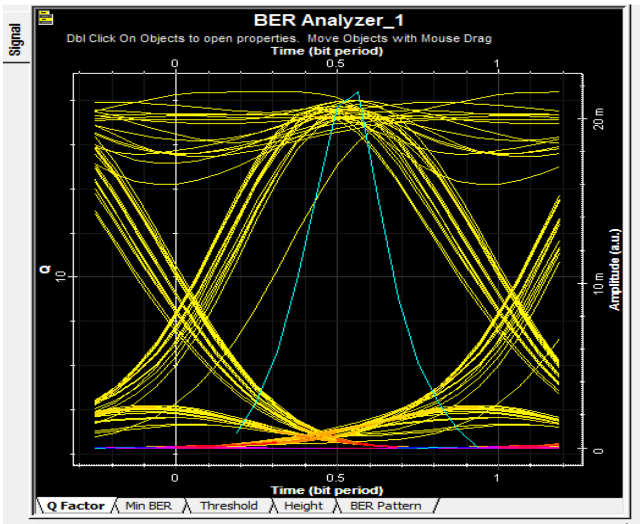


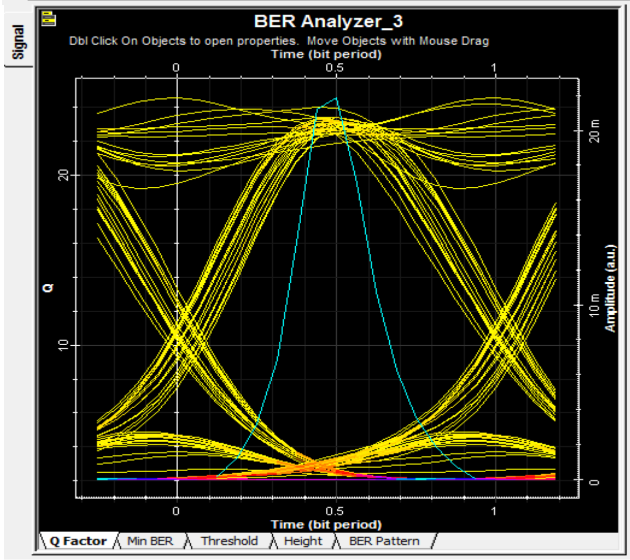
Fig 3 proposed a novel colorlessopticaltransmitter based on RSOA at ONU

Result & Discussion

Bit Error Rate diagram (BER) and eye diagram of data 1 receive at CO from ONU1(BS1) is demonstrated in the under signed figure 4(a),From the figure we conclude that we are getting a good BER. The eye diagram shows that the time delays in the received bits are negligible and the signal distortion due to BER is tolerable.

Another figure (b) represents the BER and eye diagram of data 2 received at CO from ONU 2. We get a lower BER at BS2 in comparison to BER at BS1. The difference in bit error rate at two base stations is because the signal is travelling a longer distance along the Fiber for BS2 than BS1 and also we are using optical carrier of different wavelength for modulating two signals. The figure shows that the distortion is increased due to longer distance.





Conclusion

Wavelength conversion by nonlinear gain modulation in RSOAsis demonstrated at a bit rate of 10Gbit/s for up wavelength conversion schemes at ONU side. While shorter and longer wavelengthconversion can be realized, the extinction ratio of a signalconverted to shorter wavelength is always better, since the pumplight reduces the carrier density and the optical gain is compressedasymmetrically as a result of band-filling effects. Because ofthis asymmetrical gain compression, the extinction ratio is alwaysbetter in down conversion. Wavelength conversion using aRSOAare demonstrated as a excellent candidate at ONU ports. RSOAsshow many superiorities, such as low probe power operation withwide power range, exceptional ER at different bias currents.

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