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Colorless gigabit WDM-PON link using injection locking and electro-absorption transceiver

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ABSTRACT

In this paper, a novel colorless wavelength division multiplexing-passive optical network (WDM-PON) system using injection locking and electro-absorption transceiver (EAT) is proposed and demonstrated experimentally. This system has advantages, high data transmission, small downlink signal effect to uplink signal and less polarization sensitivity, compared to the system using reflective semiconductor optical amplifier (RSOA). Downlink signal modulates the right side carrier of the double side band signal by using injection locking. EAT functions as both photo detector in downlink signal and modulator for uplink signal, simultaneously. A possible cross absorption modulation effect from the EAT is analyzed experimentally. Bidirectional transmission of 1.25 Gbps and 622 Mbps for downlink and uplink, respectively, were verified through 23 km standard single mode fiber (SSMF).

1. Introduction

Recently, the needs of high speed internet service have been increased gradually. Interests of internet service changed to image from voice and text, and there are many high speed needing internet service like Internet Protocol TV (IPTV). To satisfy the needs of these trends, wavelength division multiplexing-passive optical network (WDM-PON) system is considered as an attractive next generation optical access network system and there are a lot of researches on WDM-PON system. WDM-PON system can provide large data and high security, and needs simple protocol compared to existing system using an Ethernet or an asynchronous transfer mode (ATM) [1]. Recently, RSOA is spotlighted as a device for the upstream remodulation which makes the system cost-effective because of the absence of additional optical source in optical network unit (ONU). Also, to construct a WDM system with the same device in every ONU, colorless PON system is very important.

Nowadays, a reflective semiconductor optical amplifier (RSOA) system using wavelength reusing technique comes into spotlight for the WDM-PON system [2,3]. This system does not need other optical source for transmission of uplink signal because of using remodulation of downlink signal. However, there are several disadvantages in this system. First of all, frequency response of RSOA is limited. Currently commercialized RSOA has below 2.5 GHz 3 dB frequency response [4]. Recently, the RSOA which can modulate 10-Gbps data has been developed and reported [5]. However, compared with external modulators such as the Mach–Zehnder modulator (MZM) and electro-absorption Modulator (EAM), a RSOA has a limited modulation speed extension. When the needs of large data transmission are increased, the system using RSOA cannot guarantee high speed internet service. Moreover, because RSOA uses remodulation technique of downlink signal, downlink signal affects uplink signal [6]. In the RSOA, downlink signal is erased by self gain

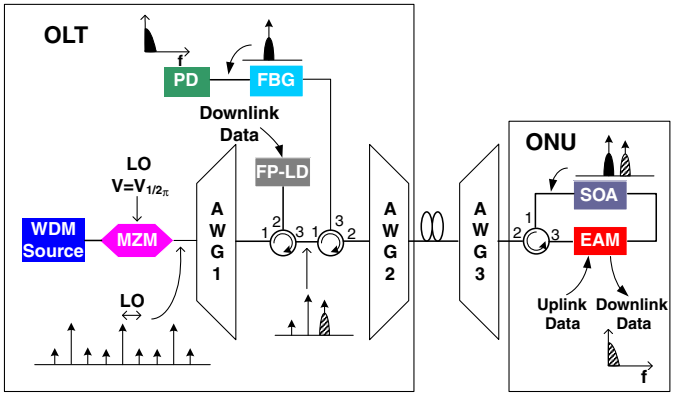

Fig. 1. Schematic of proposed bidirectional WDM system.

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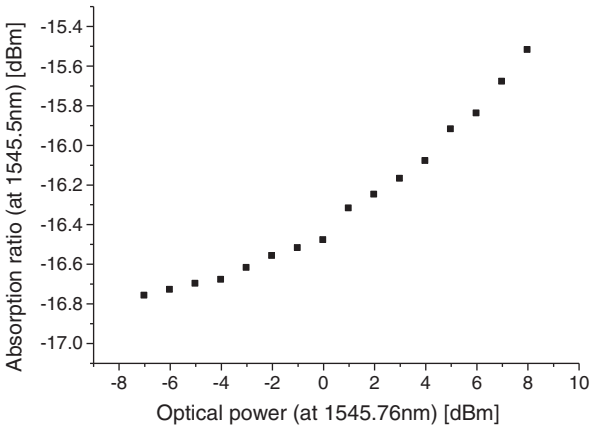

Fig. 2. Absorption ratio change by XAM.

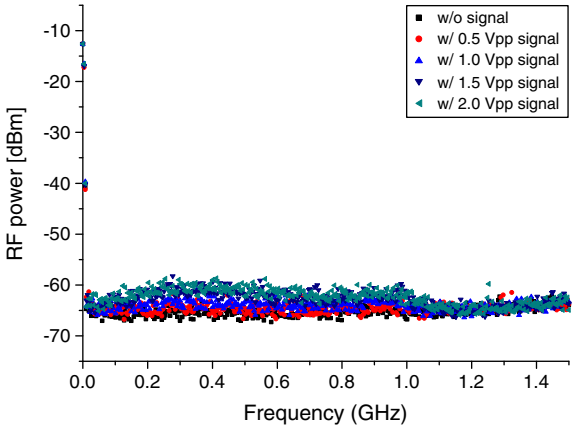

Fig. 3. XAM effect according ER of optical signal.

modulation in the gain saturation region. However, when extinction ratio (ER) of downlink is high, downlink signal cannot be fully erased. So the ER of downlink signal cannot be increased easily.

In this paper we proposed a novel colorless WDM-PON system using injection locking and electro-absorption transceiver (EAT). By using injection locking, side carrier of the double side band (DSB) is modulated by downlink signal [7]. EAM functions as both detector and modulator, simultaneously [8,9]. So the uplink data rate could be increased and there are no serious downlink signal effects to uplink signal. And, because polarization sensitivity of EAM is very low, polarization control is not needed. Furthermore, we can construct a single EAT chip as ONU. We experimentally demonstrate bidirectional data transmission over 23 km standard single mode fiber (SSMF) to verify the proposed system.

2. Principle of operation

The concept of the proposed scheme using injection locking in the optical line terminal (OLT) and EAT in the ONU is shown in Fig. 1. In the OLT, various outputs from WDM source are modulated by reference frequency local oscillator (LO) at a Mach–Zehnder modulator (MZM). Bias of MZM is set to be $V_{1/2\pi}$ voltage to generate DSB signal. Each DSB carrier of different channels of WDM is de-multiplexed to respective channel by an array waveguide grating (AWG) 1. After that, DSB carriers are injected to Fabry–Perot laser diode (FP-LD) and the right side carrier is locked by using injection locking technique. And downlink data is modulated over the right side carrier. Through the injection locking on the right side carrier, the right side carrier has a sufficient power as well as modulated downlink data. When every carrier is passing through AWG 2, only the center carrier and the right side carrier can be passed through by a proper choice of RF-LO frequency. All lights modulated at each channel are combined at AWG 2 and then transmitted. At AWG 3, all channels of WDM signal are de-multiplexed to each ONU. In the ONU, EAM works as a transceiver. Even though EAM is basically a modulator, EAM can work as a detector because EAM basically has the same structure as a photo detector (PD). In this scheme, an EAM as

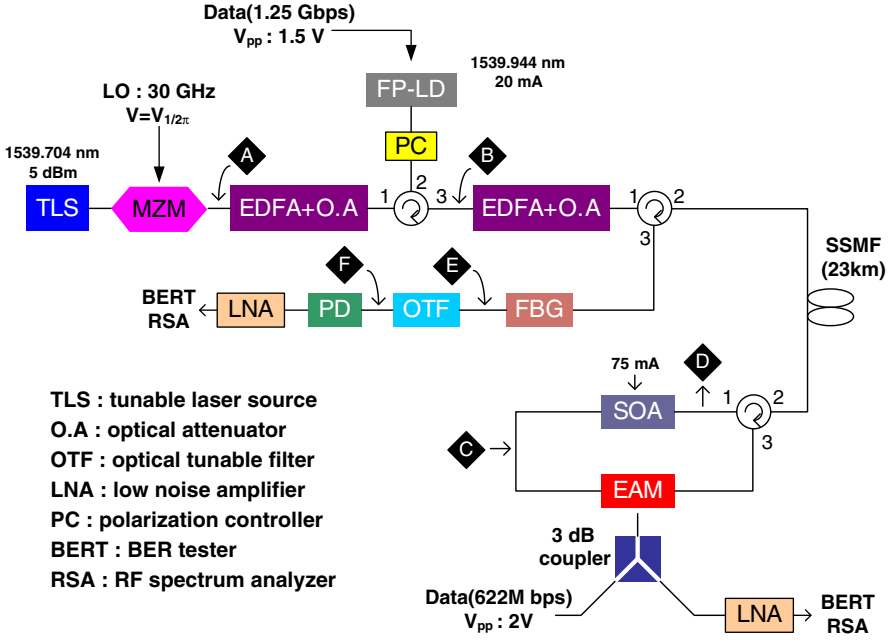

Fig. 4. Experimental setup.