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Automatic Wavelength Allocation Method Using Rayleigh Backscattering for a WDM-PON with Tunable Lasers

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Abstract—The Wavelength Division Multiplexing Passive Optical Network (WDM-PON) is considered to be a key technology to meet future bandwidth (THz) demands because it supports unlimited bandwidth, high security, and protocol transparency. One of the most important issues for the WDM-PON is colorless or color-free optical sources that enable interchangeable and plug-and-playable optical network units. Various optical sources have been investigated in this requirement. Among the proposed optical sources, a tunable laser has many advantages such as very high-speed and long-reach transmission. In this research work a wavelength detection algorithm is proposed with a wavelength assignment table. An optical spectrum analyzer and a tunable filter employed to measure the wavelength. A wavelength stabilization method uses a Distributed Bragg Reflector (DBR). The intrinsic Rayleigh backscattering in the transmission fiber is used to identify and lock the wavelength of the tunable laser to the desired wavelength. The wavelength allocation by using backscattered power monitoring is proposed in this research work.

Keywords- Automatic; Passive optical networks; Tunable; Wavelength control

I. INTRODUCTION

The Wavelength Division Multiplexing Passive Optical Network (WDM-PON) has been considered as a promising solution to meet the bandwidth explosion in near future [1]. One of the most important issues for WDM-PON is the low noise cost-effective colorless or color-free optical source [2]. A tunable laser is employed which is promising optical source for a very high- speed and long-reach WDM-PON [3-4]. An automatic wavelength control method is needed to realize true color-free operation with plug and play feature. A self-wavelength tracking method is used to monitor the wavelengths with maximum power of back scattering in the transmission fiber is proposed to solve this problem [5] [7]. We propose an automatic wavelength allocation method based on the Rayleigh backscattering and wavelength modulation. We can allocate and tune the wavelength regardless of drop fiber length and the power variation of the tunable laser. In addition, the allocated wavelength should be maintained regardless of environmental change [6]. A wavelength detection algorithm is proposed with a wavelength assignment table. However, an optical spectrum analyzer or a tunable filter is required to measure the wavelength. A wavelength stabilization method that uses a distributed Bragg reflector is also proposed [8-9]. However, burst errors during wavelength tuning degrade the reliability of the system. An automatic wavelength control method based on maximization of the beating noise between a seed light from the central office and the tunable laser output is proposed. It requires a broadband light source, which increases the system complexity and costs [10].

II. WAVELENGTH ALLOCATION BY POWER MONITORING

The automatic wavelength allocation method for a WDM-PON is shown in Fig. 1. We only consider upstream signal transmission for simplicity. The output light from the tunable laser is transmitted through the feeder fiber. A portion of light is backscattered due to Rayleigh backscattering. The backscattered light is detected at the photodiode (PD) in the transmitter after passing the arrayed wavelength grating (AWG). The backscattered light is received after passing the AWG and the circulator. The received power at the PD thus has wavelength dependency, which imitates the AWG transmission characteristics. Consequently, at the maximum received power, the wavelength of the tunable laser is matched to the channel wavelength.

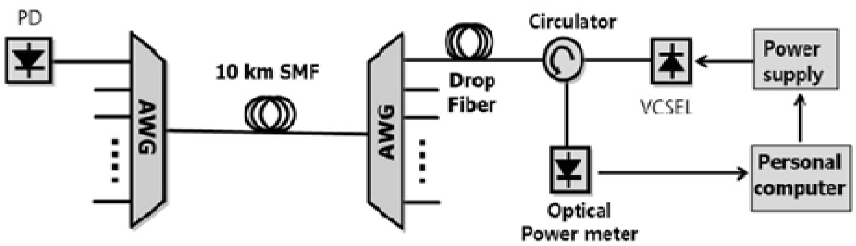

Figure 1. ***Proposed automatic wavelength allocation method for a WDM-PON***

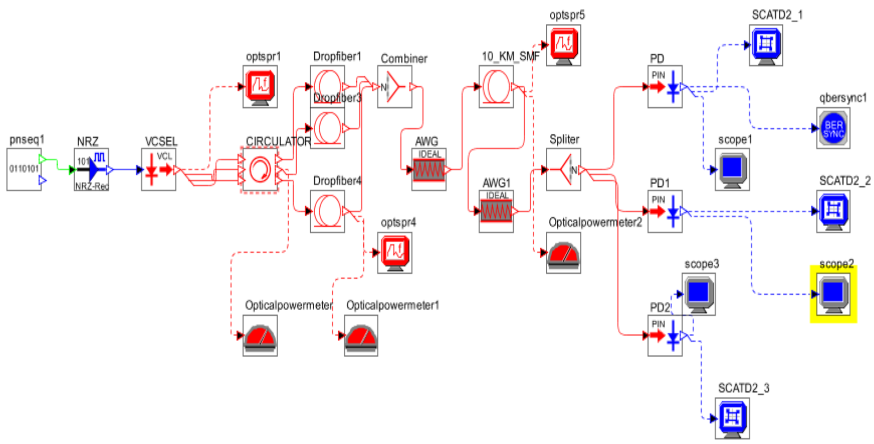

Figure 2. ***Simulation setup for the proposed WDM PON system.***

The simulation setup to demonstrate the proposed WDM PON is shown in fig. 2. We employed a vertical-cavity surface-emitting laser (VCSEL) as a tunable light source as shown in Fig. 3. In this a

10km feeder fiber is used. 50GHz (bandwidth 0.17nm) Gaussian-type AWGs are placed at the remote node (RN) and the optical line terminal (OLT). The output light from the tunable laser is transmitted through the feeder fiber. A portion of light is backscattered due to Rayleigh backscattering. The backscattered light is detected at the photodiode (PD) in the transmitter after passing the arrayed wavelength grating (AWG) is shown in Fig. 4. We measure the received power while changing the wavelength of the VCSEL. The peak is placed on the channel wavelength as shown in Fig. 5. Thus, we can identify the wavelength to be tuned, and wavelength can be maintained by using a control loop.

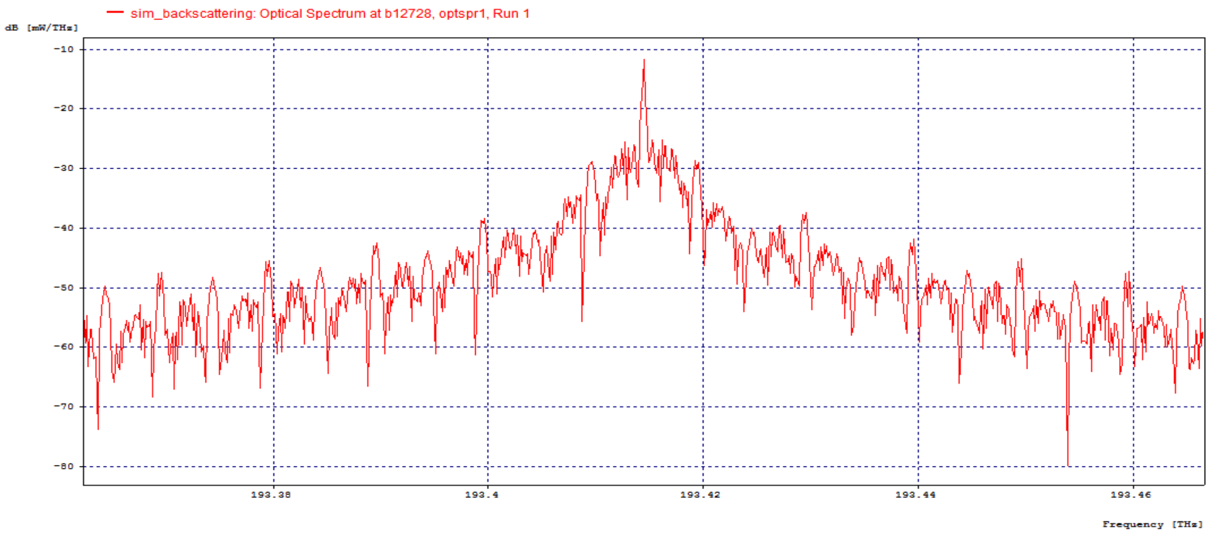

Figure 3. Optical spectrum for VCSEL

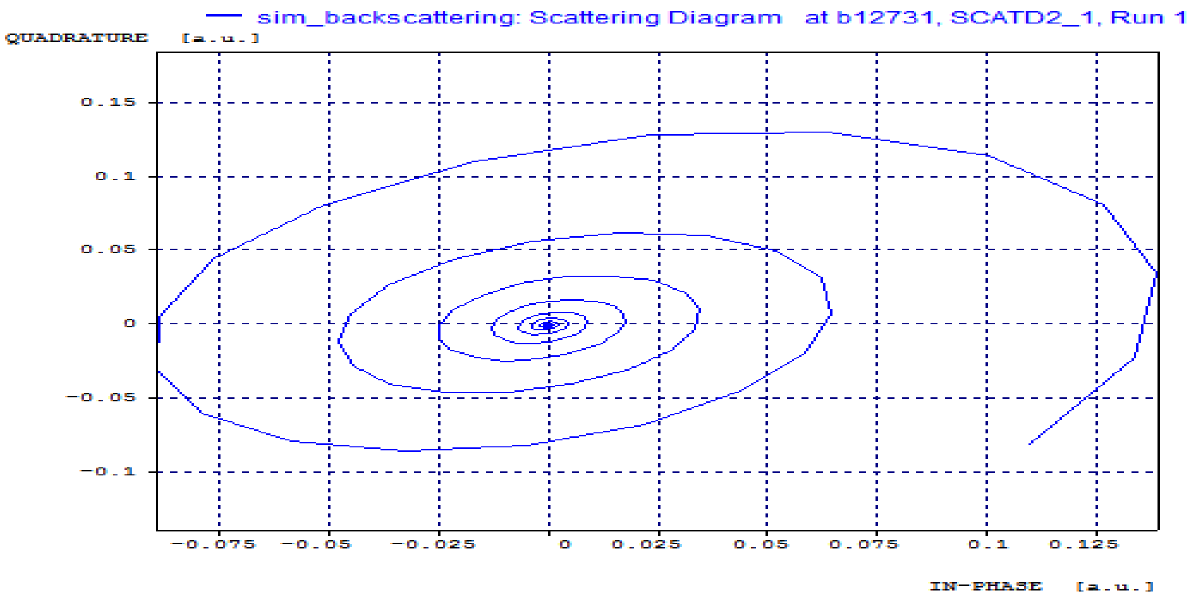

Figure 4. Backscatter Signal

We built the control loop by using commercial equipment. This system consists of PRBS data source, VCSEL, Array Wavelength Grating (AWG), and Photo Diode as a PIN receiver. The wavelength tuning is based on the backscattered power in the feeder fiber. Any other received power will consequently act as noise power. We measured the Bit Error Rate (BER) and Q factor are acceptable for this system are shown in Fig. 6.

The insertion losses of the AWG and the circulator were 3.2 and 1.3 dB, respectively. It should be noted that the circulator can be replaced by a power splitter for a low-cost implementation. The reflection ratio of the connector and circulator is less than −50dB. The wavelength of the channel is 1551.98 nm.

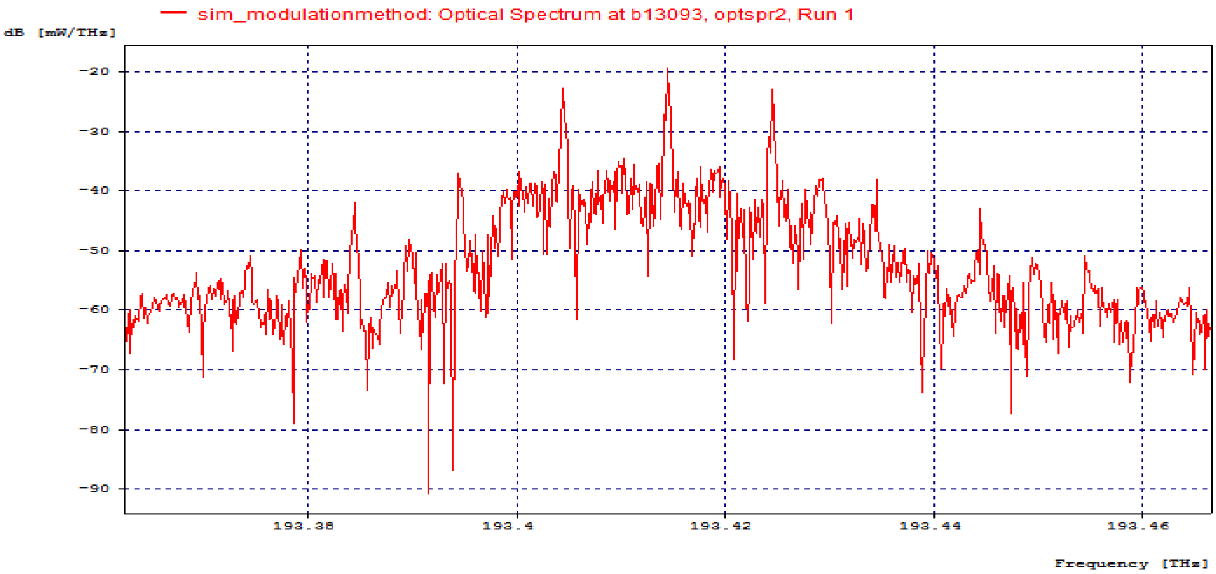

Figure 5. Tuning result over whole wavelength.

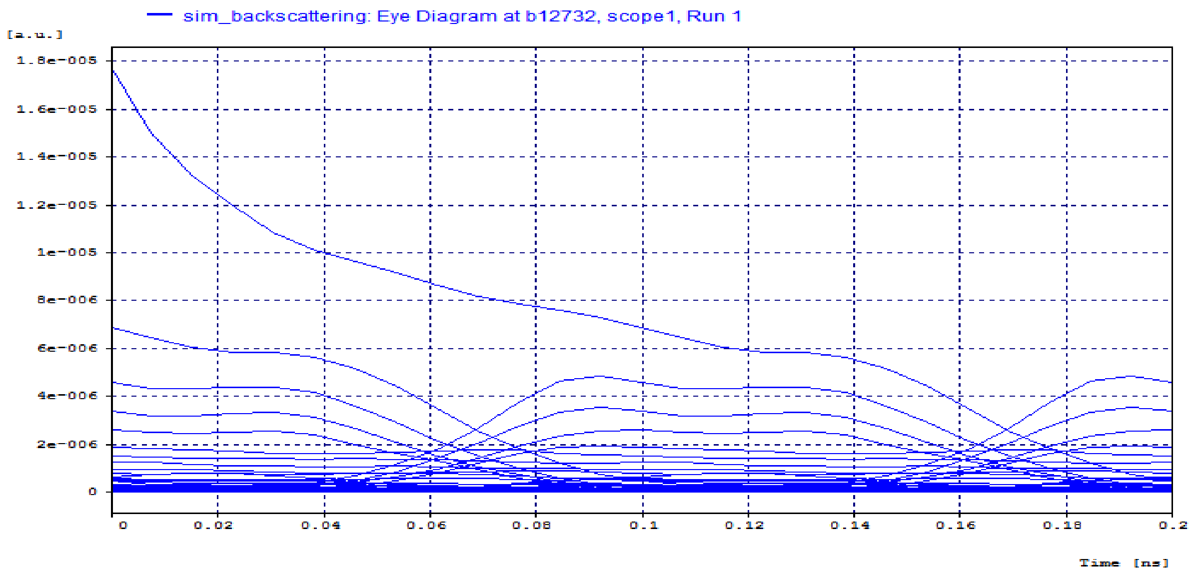

Figure 6. Eye Diagram for simulation setup.

As discussed above, the simulation method using backscattered power monitoring can be useful when the proper peak can be identified.

III. CONCLUSION

We proposed and analyzed an automatic wavelength allocations method for a WDM-PON with tunable lasers. The intrinsic Rayleigh backscattering in the transmission fiber is used to identify and to lock the wavelength of the tunable lasers to the desired wavelength. The power penalty by the proposed method is negligible.

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