A Novel Bidirectional Transmission System Based on Passive Optical Network and Wavelength Reuse Technique

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***Abstract*—In this paper, a bidirectional transmission system based on Passive Optical Network (PON) and wavelength reuse technology is proposed and demonstrated. A local oscillator, with 16 GHz via first Mach-Zehnder Modulator (MZM) and 1.25-Gb/s data via second MZM, generates the transmitting signal. The signal is separated by Fiber Bragg Grating (FBG) into two optical signals. One is central carrier and the other is subcarrier. The subcarrier signal transports data from Optical Line Terminal (OLT) to Optical Network Unit (ONU) by 25 km Single Mode Fiber (SMF) transmission. The central carrier is reused as upstream light source to achieve bidirectional transmission. The power penalty of the system is < 1.7 dB for downlink with and without enhanced channel, and downlink and uplink transmissions of Bit Error Rate (BER) performances are < 10^{-9}.**

Keywords- Fiber Bragg Grating; Mach-Zehnder Modulator; Passive Optical Network; Radion-on-Fiber; Wavelength Reuse.

I. INTRODUCTION

A Radio-on-Fiber (ROF) system provides broad bandwidth for users to solve transmission congestion. It can be applied to microwave communication systems, such as Wavelength Division Multiplexing (WDM), Optical Add-Drop Multiplexing (OADM) and Orthogonal Frequency Division Multiplexing (OFDM) [1]-[3]. These techniques are often accompanied by high bandwidth and high capacity in order to meet the needs of many users. Hybrid Fiber to The Home (FTTH) systems can achieve this goal [4].Currently, integrated ROF-PON technology [1][2] is the most common application of hybrid FTTH technology. It can transmit microwave signals over a long distance with high fidelity. Such technology can make effective usage of the broad bandwidth and low transmission loss characteristics of the fiber, in order to meet needs for bandwidth and mobility. Optical fiber has lots of advantages in long distance transmission including high bandwidth, low power loss, and immunity to electromagnetic interference. Bidirectional optical fiber transport system has a series of interferences. This is due to the simultaneous uplink data and the downlink data transport, which creates the Rayleigh backscattering (RB) effect [5]. The RB results in power fading, deteriorating system performance and increasing bit error rate because the fiber crystal structure is not uniform in the manufacturing process leading to a shift in the refraction index. To solve the RB of power fading, many schemes and demonstrations have been proposed, such as using different paths or wavelengths between the uplink and the downlink transmissions.

In this paper, we propose a ROF-PON and wavelength reuse system that can increase spectral efficiency. Another advantage is to use only an optical light source that can reduce the RB interference as well as improve the system performance.

II. EXPERIMENT SETUP AND RESULTS

The experimental setup of the bidirectional transmission system based on the passive optical network and wavelength reuse technique is shown in Figure 1. Because the sensitivity of the MZM is affected by polarization, we set a Polarization Controller (PC) before MZM to improve the stability of MZM. The Optical Double Sideband (ODSB) signal is generated by first MZM. After the ODSB signal is separated by FBG, the +1 order sideband signal, the -1 order sideband signal with central carrier are used as downstream signals for different paths transmission. The +1 order sideband signal is reflected by FBG and the -1 order sideband with central carrier signal pass through FBG. The downstream optical signal combines the two ways of optical signals and is amplified by Erbium Doped Fiber Amplifier (EDFA) to avoid transmission power loss for 25 km SMF transport. The downstream signal with 1.25-Gb/s data is generated by the MZM. The combined optical spectrum is shown in Figure 2. Upstream 1.25-Gb/s data is modulated by using another MZM. To compare the downstream and upstream transmissions, the transmission data is in the +1 sideband signal and the -1 sideband with central carrier signal, respectively.

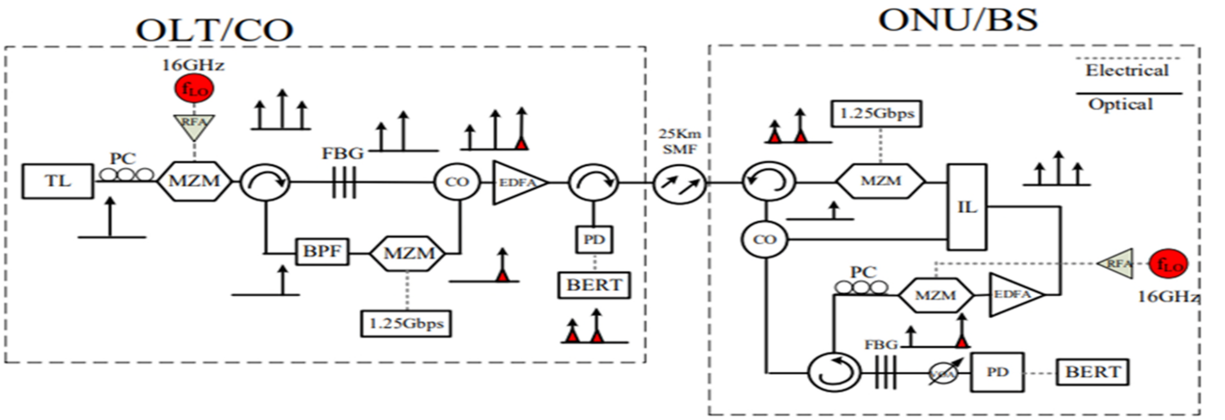

Figure 1. Experimental setup of bidirectional transmission system based on passive optical network and wavelength reuse technique

We reuse part of the downstream optical signal as upstream carrier. The upstream optical signal goes through odd channel then performs Optical / Electrical (O/E) convert by Photodetector (PD) and measures BER performance.

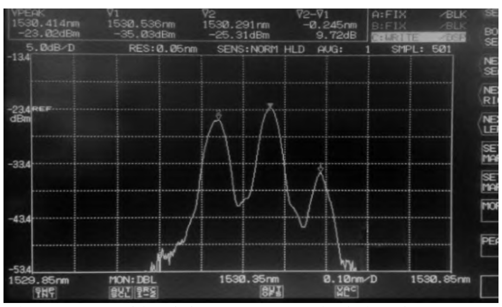

Figure 2. Combined downstream optical signal spectrum.

For the even channel, we let the +1 order sideband signal pass through, even channel enhance the power of the downstream signal to lead the downstream signal with better BER performance. The measured BER curves of the received optical power are presented in Figure 3. The received optical power levels at the BER of 10^{-9} are −23.1 dBm (with even channel enhanced for downlink), −21.4 dBm (without even channel enhanced for downlink), and -20.1 dBm (uplink). A power penalty of approximately <1.7 dB (for downlink) of the fiber link is observed during the BER test for 25 km SMF transmission.

III. CONCLUSION AND FUTURE WORK

We have proposed and demonstrated a bidirectional ROF-PON system. The system has simple and low cost features. Due to the RB effect, using FBG and IL achieve different carrier transmission and enhances the power in even channel. We reuse part of the downstream signal as upstream optical carrier in BS to achieve low cost. As compared with downstream and upstream for transmission, the transmission data is in the +1 sideband single and the -1 sideband with central carrier signal, respectively. The power penalty of the system is < 1.7 dB, downlink and uplink transmission of BER values are < 10^{-9}. The system can be combined with optical network and radio frequency, such as FTTH to implement long-haul transmission.

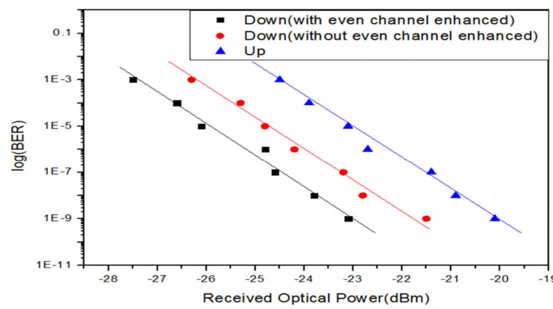

Figure 3. The measure BER curves

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