An optical access scheme with 1.25Gbit/s NRZ downstream signals over 6GHz subcarrier for next generation mobile systems application

Qiming Yang, *Yufeng* Shao*, *Anrong* Wang, *Zhuang* Wang, *Jie* Yang, *Linfang* Yi, *Ni* Yu, *Qing* Tian, *Shuanfan* Liu, *Renjie* Zuo, *Jie* Yuan, *Yanlin* Li, *Peng* Chen, *and Chong* Li

College of Electronic and Information Engineering, Chongqing Three Gorges University, Chongqing 404100, China

Abstract. In order to solve the problem of network frequency resource congestion from the central office (CS) to the base station (BS) in sixth generation (6G) mobile communication systems, we design a passive optical network (PON) access scheme. 1.25Gbit/s non-return-to-zero (NRZ) downstream signals over 6GHz subcarrier are successfully transmitted in the 20km single-mode fiber (SMF) and allocated to 4 optical network units (ONUs). The radio frequency (RF) spectrums, optical spectrums, eye-diagrams and bit error rate (BER) before and after transmission of NRZ signals in the system were measured and analysed. The results show that, this scheme can provide high-speed, stable and secure data communication.

Keywords: Optical fiber communication, Access, Subcarrier, Eye diagrams.

1 Introduction

Recently, with the rapid development of the fifth generation (5G) mobile communication technology, various application services relying on the network emerge in endlessly. As the advent of application scenarios such as virtual/augmented reality (VR/AR), autonomous vehicles, tactile Internet and Internet of Things (IoT), people rely on the convenience brought by high-quality network services [1]. Nowadays, there are many devices that need to connect to the network in life or work, such as mobile phones, tablet PCs, laptops or some intelligence appliances. However, the existing 2.4 GHz and 5 GHz bands are quite crowded, especially in some densely populated public places, such as schools, shopping malls or office buildings, which cannot guarantee the network quality of all connected devices. Therefore, we propose a novel 6GHz band signal access scheme to relief the problem of spectrum resource shortage [2]. In the future, 6GHz band will be with 2.4GHz and 5GHz bands for data transmission, reduce the burden of other bands, further increase user access number, improve network quality [3-5]. The proposal of the scheme

* Corresponding author: syufeng@163.com

also provides new way for the development of 6G mobile communication technology in the future [6].

The traditional optical fiber transmission system uses a control switch as a remote converter, but the shortcomings are obvious. The control switch is an active device and needs continuous power supply. PON technology replaces the control switch in the system with a passive optical splitter. There is no active device involved in the transmission process from the source to the destination. It saves costs, simplifies the installation and maintenance process, also further improves the flexibility [7]. PON technology can realize one-to-many communication network transmission, which has many advantages such as high capacity, low cost, easy maintenance and management. It is very suitable for long-distance signal transmission and network allocation [8-11].

We will use NRZ downstream signals over 6GHz subcarrier to transmit high-speed data in a PON access system. 1.25 Gbit/s NRZ signals are mixed to 6GHz band at the optical line terminal (OLT), and transmitted over 20-km-long SMF. The signals are allocated in the optical distribution network (ODN), and then transmitted to ONUs. The performance of the system is analyzed and summarized through the bit error rate, receiver power and eye diagram measured by simulation experiment.

2 System

As shown in Figure.1, the pseudo-random bit sequence (PRBS) generator is used as the signal source at the OLT. The generated random binary signal is input the non-return-to-zero code pulse generator (NRZ Pulse Generator) to generate a 1.25 Gbit/s non-return-to-zero code electrical signal. The signal is mixed to the 6 GHz band by the electrical multiplier. A continuous wave (CW) signal (Frequency: 193.1 THz, Line width: 10 MHz) is sent into the Mach-Zehnder modulator (MZM) together with the mixed electrical signal. The modulated optical signal is transmitted through a 20 km-long SMF. A passive splitter divides the optical signal into four transmission channels. The optical signal at the ONU is filtered by the Bessel optical filter (BOF) with bandwidth of 4.64 GHz, and then the optical amplifier is used to compensate for the attenuation loss of the optical signal in the transmission process. The optical signal detected by a PIN photo detector (Photodiode PIN) for optical-to-electrical conversion, and send the electrical signal into electrical amplitude demodulator to recover original data. Finally, the BER analyzer is used to evaluate the transmission performance of the system.

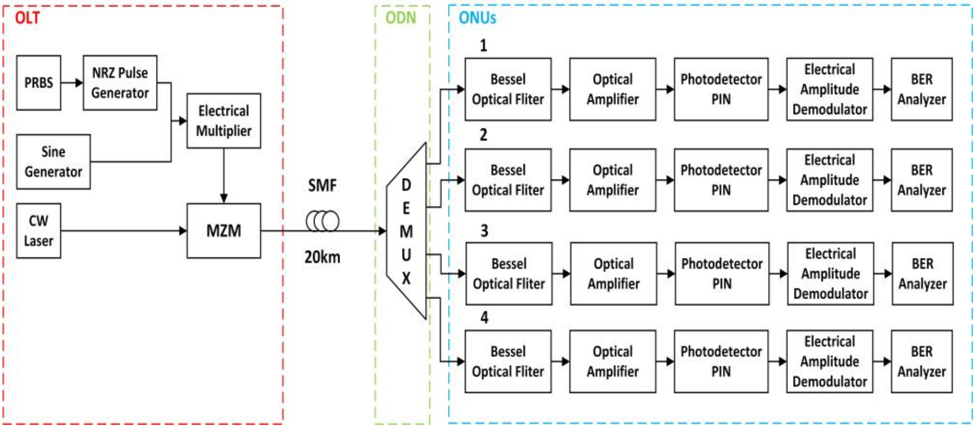

Fig. 1. PON access system using NRZ downstream signals over 6GHz subcarrier.

3 Results

We evaluated the transmission performance of the system by analyzing the RF spectrum diagrams, optical spectrum diagrams, eye diagrams and BER curves. Figure.2 (a) shows the RF spectrum analysis of the signal after mixing to the 6 GHz band through the electric multiplier. It can be seen that the information carried by the signal is concentrated near the 6 GHz band.

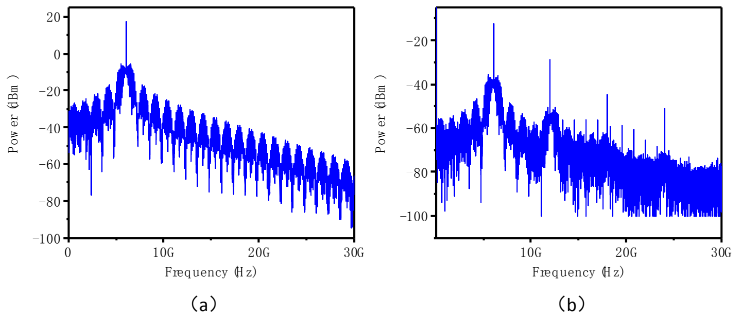

Fig.2. (a) The RF spectrum before transmission; (b) The RF spectrum after transmission.

The optical spectrums of the modulated optical signal before and after transmission are shown in Figure.3 (a) and (b). Due to the transmission distance is short, there is almost no loss after 20 km fiber transmission. Since the four signals are basically the same, the first signal is taken as an example. The optical spectrum of the optical signal after splitting and filtering is shown in Figure.3 (c), and a part of the optical signal containing the original information is retained.

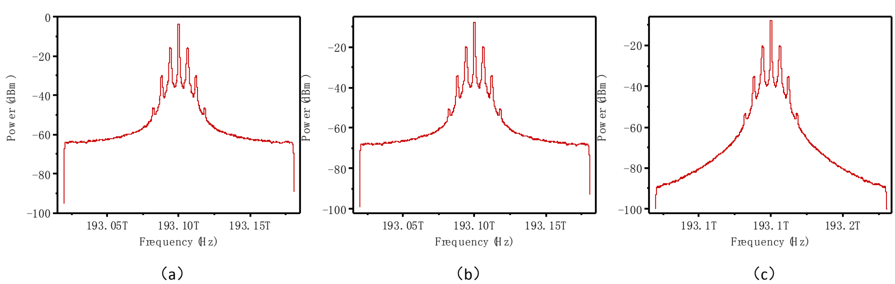

Fig.3. (a) The optical spectrum before transmission; (b) The optical spectrum after transmission; (c) The optical spectrum after splitting and filtering (the first signal).

The RF spectrum analysis (the first signal) after receiving and converting into electrical signal by PIN photo detector is shown in Figure.2 (b). It can be seen that the transmitted information still exists near the 6 GHz band. Finally, the original data is restored. The relationship between the receiver power and the bit error rate is shown in Figure.4. In Figure.4 (a) and (b) are the eye diagrams when the bit error rate is 2.85e-5 and 6.77e-26, respectively. When the receiver power is greater than-9.3dBm, the bit error rate of the four signals is about 1e-4, which meets the basic communication standards. With the increase of receiver power, the bit error rate is significantly reduced, the eye diagram is gradually clear, and the communication performance becomes better.

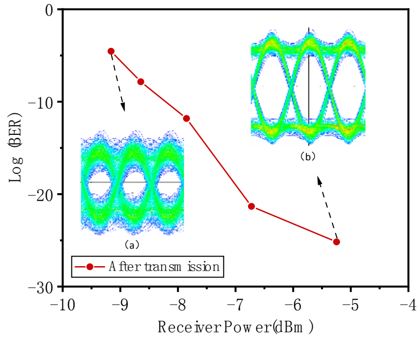

Fig. 4. BER performance of NRZ signal (the first signal); (a) The eye diagram when BER is 2.85e-5; (b) The eye diagram when BER is 6.77e-26.

4 Conclusion

In this article, we design a novel PON access scheme using NRZ downstream signals over 6GHz subcarrier to transmit high-speed data in the 20km SMF and allocated to 4 ONUs. We have evaluated the transmission performance of the scheme, obtain the RF spectrum, optical spectrum and eye diagram characteristics before and after signal transmission, and analyze the bit error rate performance and receiver sensitivity. This scheme provides one novel method for achieving high speed downstream access from the CS to the BS, and it maybe can be used in the future 6G wireless communication system.

This work is partially supported by the National Natural Science Foundation of China (61107064); Science and Technology Research Program of Chongqing Municipal Education Commission (KJZD-M201901201); Chongqing University Innovation Team Founding (KJTD201320); Chongqing Science and Technology Commission Foundation (cstc2018jcyjAX0038, cstc2016jcyjA0246); Chongqing Key Laboratory of Geological Environment Monitoring and Disaster Early-warning in Three Gorges Reservoir Area; Youth Project of Science and Technology Research Program of Chongqing Education Commission of China (KJQN201801227); Chongqing Three Gorges Reservoir Area Geological Environment Monitoring and Disaster Warning Key Laboratory Open Fund Major Project (ZD2020A0104); Science and Technology Research Program of Chongqing Education Commission of China (KJ1401005); Chongqing Three Gorges College Excellent Achievement Transformation Project (18CGZH03). Postgraduate scientific research innovation project of Chongqing Three Gorges University (YJSKY21015).

References

1. Pham Q V, Fang F, Ha V N, et al. A survey of multi-access edge computing in 5G and beyond: Fundamentals, technology integration, and state-of-the-art[J]. IEEE Access, 2020, 8: 116974-117017.
2. Naik G, Park J M, Ashdown J, et al. Next generation Wi-Fi and 5G NR-U in the 6 GHz bands: Opportunities and challenges[J]. IEEE Access, 2020, 8: 153027-153056.
3. Zhao Yue, Yang Junteng. Wi-Fi 6E test method research [J]. Digital communication world, 2021 (09): 8-9+26.

4. Zheng B, Jie L, Flynn M P. A 6-GHz MU-MIMO Eight-Element Direct Digital Beamforming TX Utilizing FIR H-Bridge DAC [J]. IEEE Transactions on Microwave Theory and Techniques, 2021, 69 (6): 2832-2840.
5. Zhang Shuo. Performance comparison and application analysis of WiFi6 and 5G technology [J]. Electronic world, 2021 (01): 77-78.
6. Zhou Yi, Chen Yan. Multi-Dimensional Communication Technologies for Future 6G [J]. Modern Radar, 2021, 43 (09): 113-114.
7. The application of GPON technology in access network [J]. Silicon Valley, 2012 (01): 35.
8. Zhao Yingxin. Research and application of access network based on PON technology [D]. Jilin University, 2019.
9. Yang Hui, Wang Rui, Sha Binbin. Research Status of New Multicarrier Modulation Technology in Passive Optical Network [J]. Optical Communication Technology, 2020,44 (05): 18-22.
10. Chen Fuping. Research on the application of new modulation code signals in broadband access systems [D]. Chongqing Three Gorges University, 2017.
11. Wang Bo.5G background optical access network development trend [J]. Communication world, 2019 (18): 44-46.