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Performance optimization of high capacity long reach 32 channel FTTH downstream link employing triple play services

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ABSTRACT

In this paper performance of high capacity, long reach, 32 channel FTTH downstream link employing triple play services has been investigated on the performance metrics viz. eye-opening, BER and Q^2 dB. DWDM has been employed for bandwidth optimization. The triple-play service is realized as a combination of data, voice, and video signals. The Internet component is represented by a data link with a high-speed of 2.5 Gb/s downstream. The voice component is represented as VOIP and then combined with data component. The video component is represented as a RF video signal. The reach of the WDM-PON system can be severely limited by chromatic dispersion. Therefore, we have employed 80 km of non-linear fiber in combination with 20 km of reverse dispersion fiber to negate the accumulated chromatic dispersion which ensures long reach of the modeled FTTH system. Investigations reveal the effective bandwidth optimization using DWDM. High 'Q^2 dB' and low BER results confirm the feasibility of proposed high capacity, long reach FTTH link.

1. Introduction

The "last mile" connects the service provider central offices to businesses and residential subscribers. The existing "broadband" solutions are unable to provide enough bandwidth for emerging services such as video-on-demand (VoD), interactive gaming, or two-way video conferencing. To alleviate bandwidth bottlenecks, optical fibers and thus optical nodes are penetrating deeper into the last mile [1]. The next wave of access network deployments promises to bring fiber all the way to the office or apartment buildings or individual homes. Unlike previous architectures, where fiber is used as a feeder to shorten the lengths of copper and coaxial networks, these new deployments use optical fiber throughout the access network. New optical fiber network architectures are emerging that are capable of supporting gigabit per second (Gbps) speeds, at costs comparable to those of DSL and HFC networks [2]. A passive optical network (PON) technology is now considered to be an effective solution to the last-mile problem and PON access architecture is the accepted choice of triple-play (voice, video, and data) service delivery from service providers to the end users in FTTH access networks [3]. Four major PON technologies are currently accepted as the basis for FTTH deployments: Broadband PON (BPON), Gigabit PON (GPON), Ethernet PON (EPON or GEPON) and Wavelength Division Multiplexing PON (WDMPON). Wavelength Division Multiplexing Passive Optical Network WDM PON is the next generation in the development of access networks and offers highest bandwidth. Coarse CWDM PON can support 3–5 wavelengths, while supporting more than 5 wavelengths requires a DWDM overlay [4]. The voice component can be represented as VOIP service (voice over IP, packet-switched protocol) and can be combined with data component in physical layer simulations. Finally, the video component can be represented as a RF video signal (traditional CATV) or as IPTV signal that also can be combine with data [5]. The gigabit fiber-to-the-home (FTTH) service is required to meet the needs of future high bit rate applications. Many of the current deployments use TDM PON, which achieves cost effectiveness. However, the TDM-PON system would be difficult to simultaneously provide all the customers with a gigabit-class bandwidth due to the nature of the timeslot-based multiple access protocol. Therefore, TDM-PON will not be a solution to the gigabit-symmetric FTTH system. Wavelength division multiplexing-passive optical network (WDM-PON) is a natural approach to enhance the link capacity. WDM-PON creates point-to-point links between an optical line terminal (OLT) and each optical network unit (ONU) by uniquely assigning a wavelength to the user [6]. The application of WDM techniques to the next generation of fiber access networks has a

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focus on high bit rate, reduced optical path-loss, point-to-point connectivity, bit-rate transparency, scalability, and flexibility [7]. But, the maximum reach of the WDM-PON FTTH system can be severely limited by chromatic dispersion (CD) [8,9]. A cost effective solution for an optical access network is the completely passive long-reach optical access network. In this way the access and metro networks can be combined into one network through the use of an extended backhaul (shared) fiber, possibly to provide data transmission in length up to 100 km [10]. An analysis of the optical limitations of FTTP cabling systems along with systems testing has shown optical system design strategies and tactics can minimize cost and maximize system performance for triple play passive optical networks. The analysis has shown that supporting a 20 km reach with 1:32 split ratio for BPON, GPON, and EPON networks providing triple play services is possible using a properly engineered and designed optical system. Such as system meets this objective by minimizing optical path loss of the optical distribution network (ODN), using low cost and commercially available optical transceivers and transmission systems [11]. Similarly, a bidirectional long-reach DWDM-PON based on wavelength-locked Fabry–Pérot laser diodes (F–P LDs) with 50-GHz channel spacing has been demonstrated in [12]. Authors have shown that the mode control of the F–P LDs enhances the output power and decreases the required injection power. Packet-loss-free transmission in both 64 upstream and 64 downstream channels is obtained, guaranteeing more than 100 Mb/s per channel through 70 km of single mode fiber without the need for an optical amplifier.

The key issue here is to optimize the bandwidth of multichannel FTTH access network by keeping the BER low at increased throughput. In this paper, we have modeled high capacity long reach 32 channel FTTH downstream link employing data, voice and video services. System reach has been extended up to 100 km with efficient chromatic dispersion management. High 'Q^2 dB' and low BER confirm the feasibility of long reach bandwidth optimized DWDM FTTH link.

2. System description

In this system we consider downstream configuration of WDM-PON based FTTH access network with bit rate 2.5 Gb/s and support for triple-play. FTTH layout with 32 end-users is shown in Fig. 1. The triple-play service is realized as a combination of data, voice, and video signals.

The Internet component is represented by a data link with a high-speed of 2.5 Gb/s downstream. The voice component is represented as VOIP and then combined with data component. The

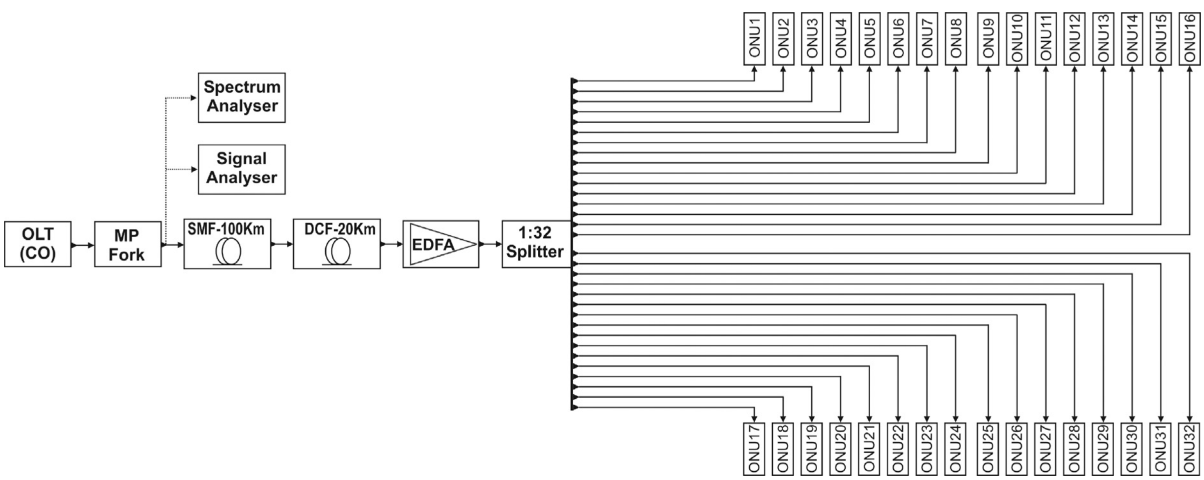

Fig. 1. FTTH layout with 32 end-users.

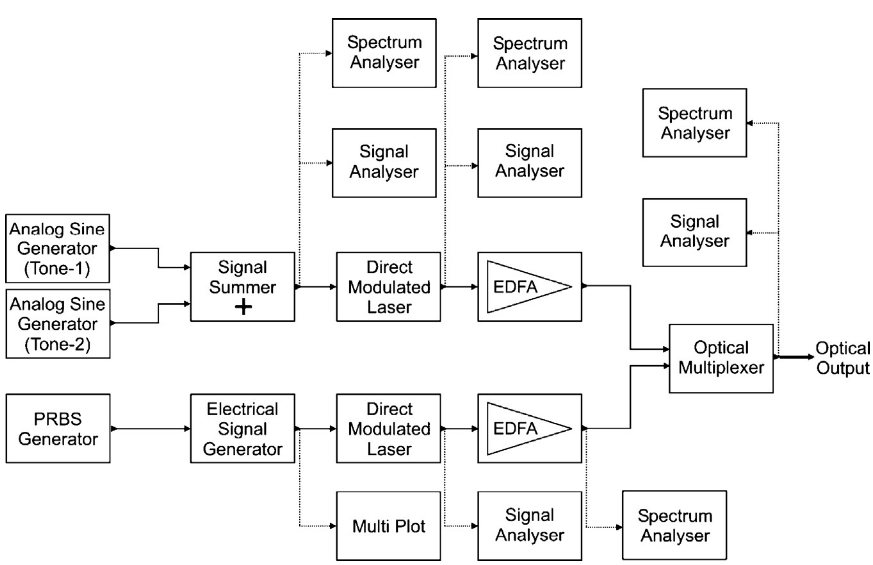

Fig. 2. CO OLT block.