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Simulation of fiber to the home triple play services at 2 Gbit/s using GE-PON architecture for 56 ONUs

Deeksha Kocher[a], R.S. Kaler[a], Rajneesh Randhawa[b,*]

[a] Electronics & Communication Engineering Department, Thapar University, Patiala 147004, India
[b] Punjabi University, Patiala, India

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ABSTRACT

This paper evaluates and compares FTTH (Fiber To The Home) GEPON (Gigabit Ethernet Passive Optical Network) link design for 56 subscribers at 20 km reach at 2 Gbps bit rate. A 1:56 splitter is used as a PON (Passive Optical Network) element which creates communication between a Central Office to different users and. A boosting amplifier is employed before fiber length which tends to decrease BER and allows more users to accommodate. This architecture is investigated for different values of data rate from a CO (Central Office) to the PON in terms of BER (Bit Error Rate). The simulation work reports BER of 4.5246e−009 at 2 Gbit/s systems for the case of 56 users and if we further increase data rate of system say 5 Gbps, then we observe a sharp increase in BER. Similarly in the variation of BER with respect to transmission distance, we observe that BER shows an increase in its value as transmission distance increases.

1. Introduction

The next generation technology is required to be compatible with today's bandwidth needs and to also offer bandwidth ease to support future growth based on network expansion and new application development. Since optical technology has proven to have large bandwidth capacity, it appears to be the proper choice to solve the complexities of access networks [1]. Thus, several fiber-to-the-home (FTTH) or fiber-to-the-premises (FTTP) networks have been proposed to provide broadband services to the end user. FTTH is simply the 100% deployment of optical fiber in today's access networks [2]. However, access networks have three great requirements; they must meet high reliability, performance, and be cost efficient. Therefore, it is important to understand which of the proposed FTTH networks meet these requirements better.

To meet the low cost and reliability requirement, FTTH networks have employed passive optical components at the customer premises and therefore they are known with as Passive Optical Networks (PON) [3]. PON's have a tree topology in order to maximize their coverage with minimum network splits, thus reducing optical power. Several architectures have been proposed of Time Division Multiplexing PON (TDM-PON) provides Broadband PON (BPON) with downstream of 622 Mbps [4], Ethernet PON with 1.25 Gbps downstream, and Gigabit PON (GPON) with 2.5 Gbps downstream. Gigabit-capable passive optical network (GPON) is the basic technology to support the structure of the next-generation fiber to the home (FTTH) system and supports multi-speed rates, full services, high efficiency and other advantages, and considers the suggestions of service providers at the same time [5]. GPON is regarded as one of the best choices for broadband access network in the future.

The cost benefits have enabled increasing deployment of passive optical network delivering fiber to the home. However, in many cases, extended reach requires some form of amplification to overcome the additional losses [6]. In order to increase transmission distance of a system, an amplifier is introduced somewhere between the transmitter and the splitter. Analysis of the effectiveness of the amplifier can be determined by evaluating the Q factor or BER of the system.

Erik Weis et al. [7] reported a FTTH field trial with GPON (Gigabit-capable passive optical network) technology in the network of Deutsche Telekom in the region of the cities of Berlin and Potsdam. Focus of this trial was to gain practical experience regarding GPON technology, fiber installation in existing ducts with micro duct technology, fiber cabling in customer buildings and impact on operational processes. Their main target was to obtain practical deployment and operation experiences with fiber-based access networks and to provide broadband access to a part of the city formerly not servable by DSL (digital subscriber line) technology.

Bernard HL Lee et al. [8] investigated the performance of a novel 2.5Gbps FTTH-PON Network architecture which employs a passive optical booster configuration for future user scaling. The passive booster configuration used an NxN AWG and exploits its cyclical

* Corresponding author.
E-mail address: rskaler@yahoo.com (R. Randhawa).

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routing table which was made possible by the device's Free Spectral Range (FSR) property configuration for future user and services scaling. The new configuration was compared with a conventional access network.

Junichi Kani et al. [9] proposed a novel and simply configured broad-band optical access network that uses coherence multiplexing (CM) and half-duplex bidirectional transmission. It allowed the on-demand use of broad bandwidth on existing fiber-to-the-home (FTTH) access lines. The study showed that the capacity of existing FTTH access lines that employ star couplers can be significantly enhanced.

Till now we observe that the number of users used in FTTH simulations are maximum 32. Considering [7], we see that 1 OLT is connected to a maximum of 10 users. Similarly in [8,9] an error free transmission over a 25 km link with 32 optical splitting and with a 7-km 9-dB standard access line, 12 users at rate of 155 Mb/s was found to be acceptable.

This research work examines the FTTH with GEPON architecture for a bit rate of 2 Gbit/s using booster amplifier for 56 users and correspondingly BER is determined for different number of users like 48, 32, 64 etc. Simulation results show that up to 56 users, an optimized value of BER is obtained. Gigabit Ethernet provides the bidirectional transmission at the data rate of 2 Gbps. The maximum transmission distance of GEPON is 20 km and splitting ratio is of 1:56. To provide the longer distance transmission and more splitting ratios we have used the booster amplifier. This system is utilizing fifty six 2 Gbps signals By using this technique the performance of the system can be improved. The proposed scheme is promising for future deployment of PON with high quality of service (QoS).

2. Simulation setup

To optimize the BER in PON, the transmission through the optical fiber path employs the CWDM (Coarse Wavelength Division Multiplexing) technique with data/voice component transmitted at wavelengths in the range of 1480–1500 nm, and video within the 1550–1560 nm range. Fig. 1 depicts the block diagram for simulation setup for GEPON architecture.

Fig. 2 shows the simulation setup for the system. CO OLT (Optical Line Terminal) block which is the transmitter block consists of Data/VOIP and Video components. The Data/VOIP transmitter is modeled with pseudo-random data generator (PRBS), NRZ modulator driver and direct-modulated laser.

The video component is modeled as RF SCM (sub-currier multiplexed) link with only two tones (channels) for simplicity. RF video transmitter consists of two Electrical Signal Generators, summer and direct-modulated laser as shown in Fig. 3.

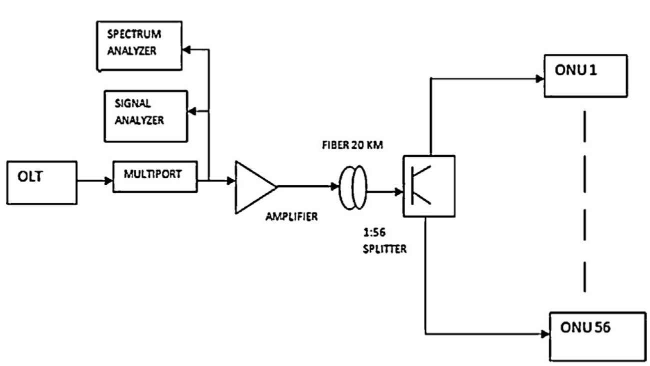

Fig. 1. Block diagram for simulation setup for 56 users GEPON based FTTH architecture.

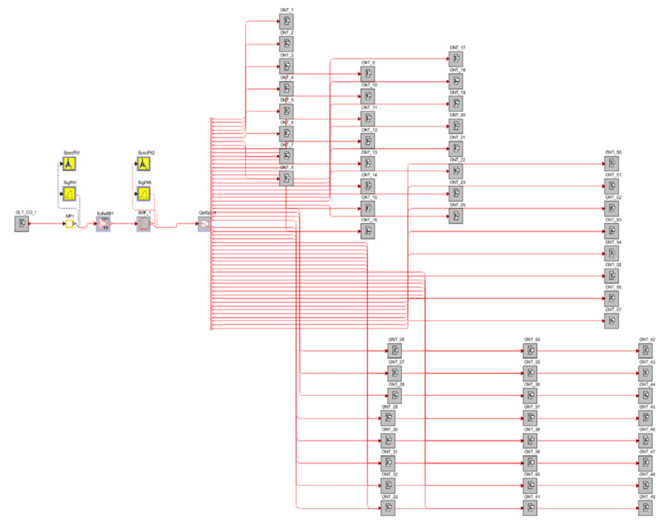

Fig. 2. Simulation Setup for 56 users GEPON based FTTH architecture.

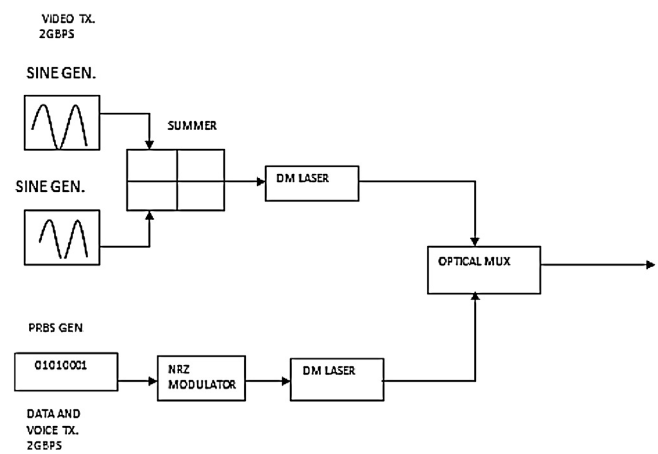

Fig. 3. OLT components for GEPON based architecture.

Next, Data/Voice and Video signals are multiplexed at Multiplexer and launched into 20-km fiber span. Before traveling over fiber, a booster amplifier is used to boost the incoming signal which improves BER. Amplifier is having a constant gain of 30 dB. Output from the fiber trunk goes through the 1:56 splitter and then to individual users. User's ONT consists of splitter and data and video receivers. Data receiver configured with optical filter, PIN receiver, and BER Tester. The video signal receiver consists of optical filter, PIN receiver, electrical filters and measurement instruments to visualize to link's optical spectrum, waveforms, eye diagrams, etc. as shown in Fig. 4.

To convert the data and video again in the original form, we use a high sensitivity receiver or detector which performs both the function, the first one is to detect whether data or voice is

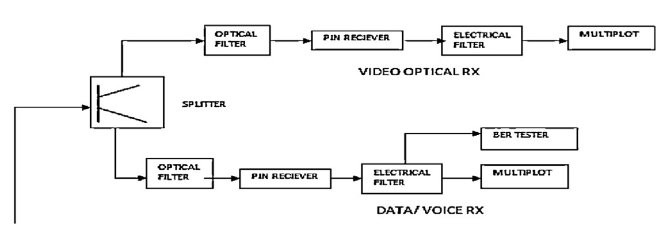

Fig. 4. ONT components for GEPON based architecture.