International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-1 Issue-2, July 2012

Optical Time Division Multiplexing System Performance and Analysis Using MZI Switching

Sachin Kumar, Sandhya Sharma, Naveen Hemrajani

Abstract: ***first a simple all-optical logic device, called Mach Zhender Inferometer is composed by using a Semiconductor Optical Amplifier (SOA) and an optical coupler. This device is used for generating the logical functions (AND, XOR) and a multiplexer and an Encoder are obtained using this device in Optical Tree Architecture. A fiber communication system is employed using Giga Ethernet Passive Optical Network (GE-PON) architecture. In this architecture an optical fiber is employed directly from a central office to the home. 1: 8 splitters are used as a PON element which establishes communication between central offices to different users. In this chapter GEPON architecture has investigated for different lengths from a central office to the PON in the terms of BER. For 10 Gbit/s systems the plots between the BER and transmission distance is plotted and it is seen that as the distance increases beyond the 15 Km the BER is increased very sharply.***

Index Terms: ***All optical switch, Mach-Zehnder interferometer (MZI), Semiconductor optical amplifiers (SOA), Switching schemes, Spectrum analysis.***

I. INTRODUCTION

In the information age, technologies seeing a relentless demand for networks of higher capacities at lower costs. Optical communication technology has developed rapidly to achieve larger transmission capacity and longer transmission distance. For that such data rates can be achieved if the data remain in the optical domain eliminating the need to convert the optical signals. Therefore, to successfully be able to achieve higher data rates, advanced optical networks will require all optical ultra fast signal processing such as wavelength conversion, optical logic and arithmetic processing, add-drop function, etc. Various architectures, algorithms, logical and arithmetic operations have been proposed in the field of optical/optoelectronic computing and parallel processing in the last three decades. Nonlinear optical loop mirror (NOLM) provides a major support to optical switching based all optical logic and algebraic processing where the switching mechanism is based on fiber Kerr nonlinearities. More efficient and compact solutions can be realized by all optical switching in semiconductor optical amplifiers (SOAs) where the non linear coefficient is much higher. Various SOA based switching configurations have been demonstrated earlier such as Tetra hertz optical asymmetric demultiplexers (TOADs), ultra-fast nonlinear inferometers (UNIs) and Mach-Zehnder inferometers (MZIs).Among different topologies, monolithically integrated MZI switches represent the most promising solution due to their compact size, thermal stability and low power. In optical computing, optical interconnecting systems are the primitives that constitute various optical algorithms and architectures. Optical tree architecture (OTA) also takes an important role in this regard. So in this era of rapidly changing technology we represent a new alternative scheme which exploits advantages of both SOA-MZI and OTA, for implementation of all optical parallel logic and arithmetic operations of binary data.

1.1 Mach Zehnder Inferometer

The Mach-Zehnder Inferometer is a device used to determine the phase shift caused by a small sample which is placed in the path of one of two collimated beams from a coherent two light source. A Mach-Zehnder Interferometer is created from two couplers connected by arms of unequal optical length. The Mach-Zehnder Interferometer has two input ports and two output ports. The light is split in the two arms of the input coupler of the interferometer, and they are later recombined in the output coupler of the interferometer. The optical length of the two arms is unequal, making the phase corresponding to delay in Fig.1.1 to be a function of wavelength. The relative phase of the light in the two input ports of the output coupler is therefore a function of wavelength. As the phase of the delay (d) is increased, the MZI cycles between the cross state, where most of the light appears in the waveguide on the same side as the input, and the bar state, where most the light moves to the waveguide on the other side.

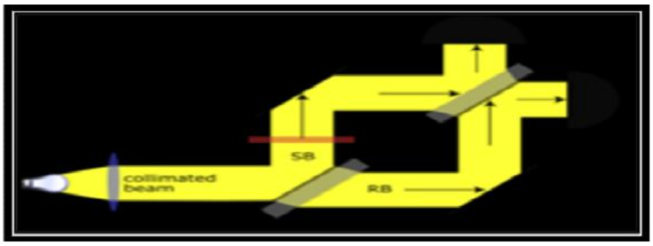

Fig.1.1 Mach-Zehnder Inferometer

Revised Manuscript Received on 30 July 2012
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1.2 Semiconductor Optical Amplifier

Semiconductor optical amplifiers are amplifiers which use a semiconductor to provide the gain medium. Recent designs include anti-reflective coatings and tilted waveguide and window regions which can reduce end face reflection to less than 0.001%. Since this creates a loss of power from the cavity which is greater than the gain it prevents the amplifier from acting as a laser. Such amplifiers are often used in telecommunication systems in the form of fiber-pigtailed components, operating at signal wavelengths between 0.85 µm and 1.6 µm and generating gains of up to 30 dB. The semiconductor optical amplifier is of small size and electrically pumped. It can be potentially less expensive than the EDFA and can be integrated with semiconductor lasers, modulators, etc. However, the performance is still not 5 comparable with the EDFA. The SOA has higher noise, lower gain, and moderate polarization dependence and high nonlinearity with fast transient time. This originates from the short nanosecond or less upper state lifetime, so that the gain reacts rapidly to changes of pump or signal power and the changes of gain also because phase changes which can distort the signals. This nonlinearity presents the most severe problem for optical communication applications. However it provides the possibility for gain in different wavelength regions form the EDFA.

1.3 Categories of switch

1.3.1 MZI Switch

The Mach-Zehnder interferometer (MZI) based switch consists of a 3 dB splitter and a 3 dB combiner, connected by two interferometer arms. By changing the effective refractive index of one of the arms, the phase difference at the beginning of the combiner can be changed, such that the light switches from one output port to the other. This switch has the advantage that the phase shifting part and the mode coupling part are separated, such that both can be optimized separately.

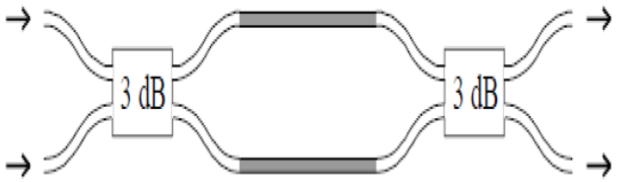

Fig.1.2 MZI based switch

A small effective refractive index change in the interferometer is sufficient for the switching. The disadvantages are its length and the accurate refractive index change that is required for switching. When multimode interference couplers are employed as 3 dB splitter and combiner, a fabrication tolerant and polarization insensitive wave guiding structure is obtained. A low power data signal is focused into the central input waveguide such that it splits into two equal parts at the Y-junction power splitter. These two beams then propagate through the two arms of the Mach-Zehnder and recombine constructively at the 6 output Y-junction power combiner and propagate along the output waveguide. A high power control signal is also focused into one of the outer wave guides to produce a nonlinear refractive index change in the waveguide via the nonlinear optical Kerr effect. This produces a phase difference between the two data signals at the output Y junction causing them to interfere destructively when the phase difference between them is TC radians. Under this condition, the data signal is coupled into radiation modes and the output falls to zero. Subsequently the device may be used as a modulator.

1.3.2 DC Switch

In a directional coupler switch two adjacent waveguides are designed such, that the light can be transferred from one waveguide to the other by coupling. The switching is obtained by properly adjusting the effective refractive index of one of the waveguides. For switching only a small refractive index change is needed.

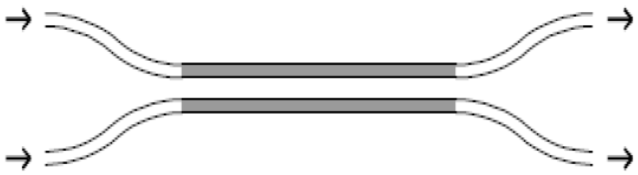

Fig 1.3 Directional Coupler Switch

For a good transfer of the light, an accurate coupling length is required. Since this length is usually polarization and wavelength dependent and strongly influenced by fabrication deviations (etch depth, waveguide spacing), a good switch performance is hard to obtain.

1.3.3 SOA based MZI Switch

A semiconductor optical amplifier can both be used for amplification and attenuation of an optical signal, by turning the gain on and off. This property can be employed for a simple but effective way of switching by splitting an optical signal with a 3 dB splitter, after which this signal is attenuated in one arm and amplified in the other arm. Since the splitter losses and additional losses (e.g. fiber-chip coupling loss) can be compensated by the SOA, this type of switch can have low loss or even gain and, in addition, excellent on-off ratios leading to low crosstalk levels.

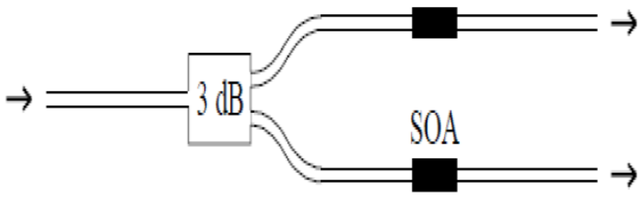

Fig 1.4 SOA based MZI Switch

The most important disadvantage of a SOA switch is its high additional noise level in the "on "state caused by spontaneous emission generated in the SOA.

1.4 FTTH with GE-PON:

Optical fibers, clearly the chosen technology for transmission media, are beginning to find their place in the subscriber's loop. Currently fiber costs are high as compared to copper but there is a trend towards decreasing costs of optical fiber cables and photonics employed. In addition the tremendous advantage in terms of information capacity of fiber, its small weight and size over copper cable are making it a very attractive technology to replace copper in subs loop when advanced broadband services need to be offered to the customer.

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

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To carry the same information as one fiber cable we would need hundreds of reels of twisted wire of Cu cables. In crowded city networks they can easily be accommodated in existing ducted systems.

FITL (Fiber in the Local Loop) can be developed in several configurations.

1. Fiber to the Curb (FTTC)

Fiber to the Curb in which the terminal equipment is located on the curb from where it would be convenient to serve a suitable service area. Since the distribution would still be copper, suitable location for the terminal would be one which optimizes the cost, reduces back feeding, reduces distribution cost and takes safety factors into consideration. Space and power availability need to be confirmed before finalizing the location.

2. Fiber to the Building (FTTB)

Fiber to the Building in which the terminal equipment is located inside a multi storied building. This brings the higher bandwidth closer to the subscriber. The distribution part is still copper. For new buildings, the planners may negotiate for suitable location well in time.

3. Fiber to the Home (FTTH)

Fiber to the Home in which the fiber goes up to the subscriber premises.

4. Fiber to the Office (FTTO)

Fiber to the Home in which the fiber goes up to the office/subscriber premises.

A PON consists of an Optical Line Terminal (OLT) at the service provider's central office and a number of Optical Network Units (ONUs) near end users. A PON configuration reduces the amount of fiber and central office equipment required compared with point to point architectures.

a. **OLT:** The OLT resides in the Central Office (CO). The OLT system provides aggregation and switching functionality between the core network (various network interfaces) and PON interfaces. The network interface of the OLT is typically connected to the IP network and backbone of the network operator. Multiple services are provided to the access network through this interface.
b. **ONU/ONT:** This provides access to the users i.e. External Plant/Customer Premises equipment providing user interface for many/single customer. The access node installed within user premises for network termination is termed as ONT. Whereas access node installed at other locations i.e. curb/cabinet/building, are known as ONU. The ONU/ONT provide, user interfaces (UNI) towards the customers and uplink interfaces to uplink local traffic towards OLT.
c. **Splitter:** Distributed or single staged passive optical splitters/combiners provide connectivity between the OLT & multiple ONU/ONTs through one or two optical fibers. Optical splitters are capable of providing up to 1:64 optical split, on end to end basis. These are available in various options like 1:4, 1:8, 1:16, 1:32 and 1:64.
d. **NMS:** Management of the complete PON system from OLT.One OLT serves multiple ONU/ONTs through PON TDM/TDMA protocol between OLT & ONT Single Fiber/Dual Fiber to be used for upstream & downstream Provision to support protection for taking care of fiber cuts, card failure etc.

PON systems use optical fiber splitter architecture, multiplexing signals with different wavelengths for downstream and upstream.

Different Types of PON

1. **APON (ATM Passive Optical Network)**: This was the first Passive optical network standard. It was used primarily for business applications, and was based on ATM.
2. **BPON (Broadband PON):** It is a standard based on APON. It adds support for WDM, dynamic and higher upstream bandwidth allocation, and survivability. It also created a standard management interface, called OMCI, between the OLT and ONU/ONT, enabling mixed-vendor networks.
3. **EPON or GEPON (Ethernet PON)**: It is an IEEE/EFM standard for using Ethernet for packet data. 802.3ah is now part of the IEEE 802.3 standard. There are currently over 15 million installed EPON ports
4. **GPON (Gigabit PON):** It is an evolution of the BPON standard. It supports higher rates, enhanced security, and choice of Layer 2 protocol (ATM, GEM, and Ethernet).
5. **10G-EPON (10 Gigabit Ethernet PON):** It is an IEEE Task Force for 10Gbit/s, backward compatible with 802.3ah EPON. 10GigEPON will use separate wavelengths for 10G and 1G downstream. 802.3av will continue to use a single wavelength for both 10G and 1G upstream with TDMA separation. Compatibility with WDM-PON is out of the scope of 802.3av 10G-EPON. It is also out of the scope to use multiple wavelengths in each direction.

1.5 OPTSIM

Optsim is an advanced optical communication system simulation package designed for professional engineering and cutting-edge research of WDM, DWDM, TDM, CATV, optical LAN, parallel optical bus, and other emerging optical systems in telecom, dotcom, and other applications. It can be used to design optical communication systems and simulate them to determine their performance considering various component parameters.

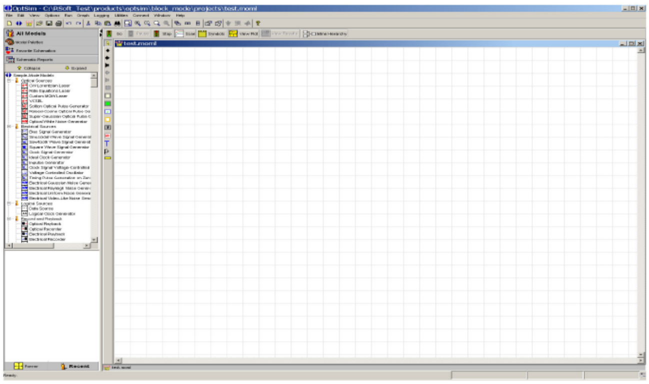

Fig 1.5 Optsim graphical editor

Optsim is designed to combine the greatest accuracy and modeling power with ease of use on both Windows and UNIX platforms.

Optsim represents an optical communication system as an interconnected set of blocks, with each block representing a component or subsystem in the communication system. As physical signals are passed between components in a real world communication system, "signal" data is passed between component models in the Optsim simulation.

II. LITERATURE SURVEY

2.1 All-Optical Logic by MZI switch

Koji Igarashi et al. described optical signal processing based on optical phase modulation and subsequent optical filtering, which is applicable to 160-Gb/s optical time-division multiplexed (OTDM) subsystems. Ultrafast phase modulation of an optical signal is done by self-phase modulation (SPM) and cross-phase modulation (XPM) when an optical pulse passes through a nonlinear optical fiber. Such phase modulation induces the spectral shift of the optical signal. By modifying the design of an existing two-input nano photonic AND gate, whose operation is based on optical near-field (ONF) interactions among three neighboring quantum dots (QDs), they improved the gate ON/OFF ratio by up to about 9 dB. To do this, Arash Karimkhani et al. have eliminated the possibility of direct interaction between the inputs and output dots. Then, by adding another QD, as the second control dot to both existing and the modified two-input architectures, they proposed two new three-input nanophotonic AND gate schemes—one with direct ONF interaction between its input and output dots, and the other without such interaction. The thyristors have a low threshold current of 0.65 mA and a high on/off contrast ratio of more than 50 dB. By simply changing a reference switching voltage, this single device operated as two logic functions, optical logic AND and OR. The thyristor laser fabricated by using the oxidation process and has achieved high optical output power efficiency and a high sensitivity to the optical input light. By monitoring the power of logic light, the strategy realized controllable methods to capture OR and NOR functions and switch between them. The strategy had been successfully applied in experiment with 10-Gb/s not-return-to-zero (NRZ) signals, which had a high success-rate above 95% and ensures the high extinction ratio of result light above 11.4 dB.
Every step in the strategy had definite numeric evaluation, which provides the potential of automatic implementation.

2.2 FTTH with GE-PON

The early vision of FTTH, which promised abundant, ubiquitous, and future-proof bandwidth to consumers, has remained largely unrealized nearly 20 years after its birth. N. Frio et al. presented the historical, competitive, economic, and service reasons for this and prospects for the future.
Large scale projects replacing copper network with optical fiber such as Photonic- access-To-The-Home (PATH) in Korea signify the age of fiber based network, making protection to fiber based network a crucial need. It is found that FTTH technology and Ethernet Passive Optical Networks (EPONs), which represent the convergence of low-cost fiber infrastructure and low-cost Ethernet equipment, appear to be the most deployed access network Most FTTH access networks are protected from failure by having redundant network equipments. These are not economical approaches, as the redundant systems are not efficiently utilized by the network. W. T. P'ng presented a protection method where redundant equipments are not required and protection is provided to end user through sharing of bandwidth during the failure time. A protection control unit and an optical switch is employed connecting 4 Optical Line Terminations (OLT) with each one serving only 32 Optical Network Units (ONU). Protection control unit collects information of ONUs served by each OLT and when an OLT fails, it will instruct an active OLT to serve its original ONUs together with the ONUs served by the failed OLT. It will be revealed that a myth of deploying low bit-rate uplink fiber-to-the-home (FTTH) services while providing a high bit-rate downlink is wrong. Therefore, for the future broadband FTTH services, the focus should be on the capability to provide gigabit-or even multi gbits-per-second both in up-and downlinks, namely gigabit symmetric systems.
Optical code-division multiple access (OCDMA) now deserves a revisit as a powerful alternative to time-division multiple access and wavelength-division multiple (WDM) access in FTTH systems. Ken-ichi Kitayama et al. highlighted the OCDMA systems. The system architecture and its operation principle, code design, optical en/decoding, using a long superstructure fiber Bragg grating (SSFBG) en/decoder, and its system performance was described. Next, an OCDMA over WDM passive optical network (PON) as a solution km SMF with optimized dispersion tolerances. A. Hmida ET. Al. highlighted a new FTTH design and deployment guidelines suitable for industrial and residential deployment in green field areas. It also included civil work guidelines: manhole and hand-hole sizes their location, duct and sub-duct structure and section and route selection, cable vault entrance. Cable distribution and numbering guidelines: fiber feeder (primary) design, fiber distribution (secondary) design, fiber drops, fiber distribution terminals (FDT) cabinet sizing and numbering, fiber access terminal (FAT) DP Sizing, Splitters output, distribution types design (centralized, cascaded, and hybrid).

Objectives

In this paper, the research is carried out keeping in view of the following objective.
To investigate the bit error rate of FTTH at 40 Gbit/s by Mach-Zehnder Switching.

Research Outlines

After studying the basic introduction, literature survey, we define the objectives in chapter II.
In chapter III, we investigate the bit error rate of FTTH at 40 Gbit/s by Mach-Zhender switching for 8 different users.
We finally discuss conclusions in chapter IV and also the future work.

III. SIMULATION OF FTTH AT 10 GBIT /S FOR 8 OUT BY GEPON ARCHITECTURE

In this chapter a fiber communication system is employed using Giga Ethernet Passive Optical Network (GE-PON) architecture. In this architecture an optical fiber is employed directly from a central office to the home. 1: 8 splitters is used as a PON element which establishes communication between central offices to different users.

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In this chapter GEPON architecture has investigated for different lengths from a central office to the PON in the terms of BER. For 10 Gbit/s systems the plots between the BER and transmission distance is plotted and it is seen that as the distance increases beyond the 15 Km the BER is increased very sharply. Results in the form of Voice and Data spectrum for different users of FTTH with GE-PON architecture are shown.

3.1 INTRODUCTION

Leading this investment wave is the deployment of single-mode optical fiber deeper into these access networks to curb the high bandwidth requirements of their customers.
Increasingly, carriers are finding that deploying the fiber all the way to the customer enables network future-proofing, maximizes the symmetrical bandwidth throughput of a carrier's access network, provides for network reliability, reaps significantly reduced operating expenses and affords enhanced revenue opportunities. The industry refers to this technology as FTTH. As the FTTH service expands, improved throughput is indispensable to remain competitive. FTTH is simply the 100 percent deployment of optical fiber in the access network. This thesis considers the migration of the access network from a copper based digital subscriber line (DSL) network towards fiber to the home (FTTH), which is a foreseen trend. A first driver for this migration which is often cited is the resulting increased bandwidth. As the real killer application demanding immediate bandwidth upgrade remains to be found, a more likely scenario is the following. All offered bandwidth gets used; however, the customer demand for it is not strong enough in order to really accelerate the FTTH migration process. Second, a fiber based access network is expected to be cheaper to operate. Out phasing the old copper network, which requires a lot of maintenance and repair actions and replacing it by an optical network which is far less vulnerable to outside conditions could lead to important operational savings for the operator in the long run. H. Imamura et al. represented the first demonstration of asymmetric PON system using OTDM and OCDM technologies are presented. We accomplished a transmission over 20 km SMF with optimized dispersion tolerance. [26] K. E. Rookstool et al. presented the results of a study examining the economics of Central Office versus Remote Terminal Broadband Distribution Terminals for deploying Fiber to the Home. The effects of integrating DSL for copper distribution areas with FTTH were also examined. In this chapter we simulated the FTTH with GE-PON architecture for a bit rate of 10Gbit/s for different wavelength used for voice and the data as user are separated by splitter and BER is investigated against different distances.

3.2 THEORY

Fiber to the Home refers to fiber optic cable that replaces the standard copper wire of the local Telecom. FTTH is desirable because it can carry high-speed broadband services integrating voice, data and video, and runs directly to the junction box at the home or building. Fiber to the Home network architectures can be divided into two main categories

1. Home Run architecture: In this a dedicated fiber connects each home to the Central Office) .
2. Star architectures: In this many homes share one feeder fiber through a remote node that performs switching, multiplexing or splitting - combining functions and is located between the homes served and the CO.
3. Passive Star (more commonly known as the Passive Optical Network or PON).
4. Wavelength Division Multiplexed (WDM) PON

Regardless of architecture, each feeder fiber is terminated at the Central Office (CO) on an Optical Line Termination (OLT) unit. The CO equipment can be designed to support various data-link layer interface types and densities: 100FX Fast Ethernet, SONET, ATM, and Gigabit Ethernet among others. The Customer Premises Equipment (CPE), also known as the Optical Network Unit (ONU) has POTS (Plain Old Telephone Service) and 10/100 Base-T Ethernet interfaces and, in the case of PONs and Home Run architectures, the ONU can also have an RF video interface. All FTTH models discussed here use single mode fiber.

1. Home Run Fiber

The Home Run architecture (also known as a Point-to-Point architecture or Single Star architecture) has a dedicated fiber that is deployed all the way from the CO to each subscriber premises. This architecture requires considerably more fiber and OLTs (one OLT port per home) compared to the other, shared, infrastructures.

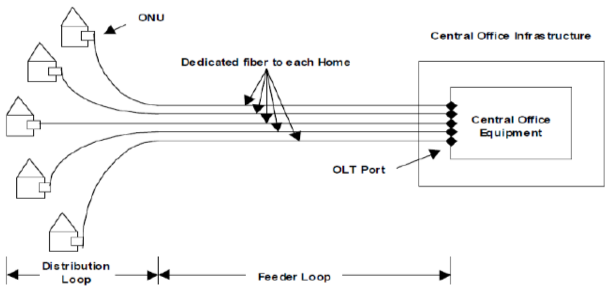

Fig.3.1 Home Run Fiber Architecture

2. Active Star

A Star architecture (also known as a Double Star) is an attempt to reduce the total amount of fiber deployed and hence lower costs by introducing feeder fiber sharing. In a star architecture, a remote node is deployed between the CO and the subscriber's premises. Each OLT port and the feeder fiber between the CO and the remote node is shared by anywhere from four to a thousand homes (the split ratio) via dedicated distribution links from the remote node. When the remote node contains active devices such as a multiplexer (or switch), the architecture is referred to as an Active Star as the remote node needs to be powered. The Remote Node in the Active Star network has a multiplexer / demultiplexer.The remote node switches the signal in the electrical domain (to the intended recipient) and hence OEO conversions are necessary at the remote node. Since the feeder bandwidth is shared among multiple end points, the maximum sustained capacity available to each home –both upstream and downstream – is less with an active star architecture than with Home Run fiber. Typically each remote node in an active star architecture supports anywhere from sixteen to a thousand (or more) homes.

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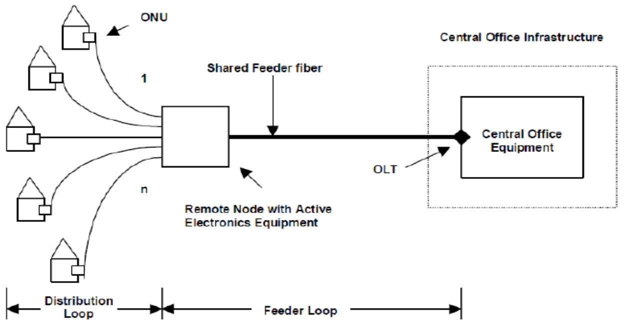

A Fig.3.2 Active Star Architecture

In this one fiber is shared (via a power splitter) among a set number of users, typically between sixteen and thirty-two. This is called a passive optical network (PON). Better upstream speeds will also be critical for providing two-way high-speed services, likely to be used for video communication or other similar services in the near future. The Giga-Bit PON satisfied these requirements. Two types of Giga-Bit PON systems have been standardized: GPON by ITU-T and GE-PON by IEEE. PONs are characterized by the "splitting" of the optical fiber one or more times in the field, resulting in the sharing of the optical fiber among multiple users. The fiber in a PON is typically shared by sixteen to thirty-two users. Hence the bandwidth of the fiber originating at the CO/HE is shared among a group of users. The splitting of the network is accomplished by an optical splitter. These splitters can split the fiber one to thirty-two times and, by their nature, introduce inherently high losses in the network. Therefore, their use is limited because of the power budget considerations of the network. A PON will have less optical reach than a PTP network, which does not use splitters.

The fiber-to-the-home service is mainly based on passive optical network in which upstream and downstream signals are transmitted through a single optical fiber with the aid of so called diplexers. Transmission standards utilized in FTTH networks are based on ATM and Ethernet technologies. Carriers are extremely familiar with both technologies, which support a variety of services. PTP networks are simply an extension of legacy Ethernet used in metropolitan and enterprise spaces and extended into the access network. The A/BPON protocol is characterized by having two downstream wavelengths and one upstream wavelength. The 1550 nanometer (nm) and 1490 nm wavelengths are used for downstream traffic, with the 1490nm channel typically an IP channel for voice and data service. All FTTH networks inherently are designed to deliver an optical fiber to the subscriber. At their core, FTTH networks contain an optical line terminal (OLT), optical cable, and optical network terminal (ONT). The OLT is typically at the CO/HE but can also be in a remote terminal in the field. The OLT houses the laser transmitters dedicated to each user in a PTP network or shared across several users in a PON. The OLT is also the aggregation point of voice from the public switch telephone network (PSTN), data from a router, and video via its multiple forms. The ONT receives the signal from the OLT and converts it into usable electronic signals that a user's telephone, computer, TV, or any other number of devices can receive. The ONT also serves to communicate IP traffic back to the OLT such that voice conversations can occur.

3. PON ARCHITECTURE

A passive optical network (PON) is a point-to-multipoint, fiber to the premises network architecture in which unpowered optical splitters are used to enable a single optical fiber to serve multiple premises, typically 32-128. The key interface points of PON are in the central office equipment, called the OLT for optical line terminal, and the CPE, called ONU for optical network unit (for EPON) and ONT for optical network terminal (for GPON).

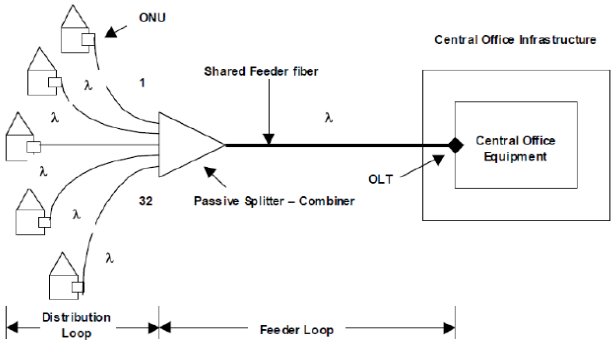

Fig.3.3 PON Architecture

Regardless of nomenclature, the important difference between OLT and ONT devices is their purpose. OLT devices support management functions and manage maximum up to 128 downstream links. In practice, it is common for only 8 to 32 ports to be linked to a ingle OLT in the central office. Consequently, the ONT/ONU devices are much less expensive while the OLTs tend to be more capable and therefore more expensive.

4. WDM PON ARCHITECTURE

PONs can have multiple wavelengths as well. Though it will be sometime before there are affordable WDM PONs (if ever), some vendors are introducing products that can introduce more wavelengths on to a PON. Wavelength Division Multiplexing (WDM) is Coarse (CWDM) or Dense (DWDM) depending on the number of wavelengths multiplexed on to the same fiber. Vendors are of the opinion that a CWDM PON can support 3 – 5 wavelengths, while supporting more those 5 wavelengths requires a DWDM overlay13. For DWDM, the ONUs (and the OLTs) require expensive frequency stable, temperature controlled lasers6.The OLT puts all the wavelengths onto the shared feeder fiber and the splitters replicate the wavelengths to each home.

3.3 SIMULATION SETUP FOR FTTH USING GEPON ARCHITECTURE

The particular system setup of FTTH using GEPON architecture is shown in figure. The component used in figure (4.4) are chosen from the Optsim Ver.4.7.0 component library palette and placed as per requirement in the design area of the Optsim editor. Then various simulation parameters are set. The schematic diagram consists of a PRBS generator which is producing the 10 Gbits/s and is directly fed to the RZ electrical driver as RZ driver has an advantage of better clock recovery, now the output of the electrical driver is goes to the laser and finally get amplified it just for voice but if we considered about the data then we also combine data

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International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-1 Issue-2, July 2012

with voice for voice we have two sine wave generator having different frequencies of about the TERA Hz and have phase shift of 90 degree and goes to the input of the summer, then summer mixes both the frequencies and finally goes to modulator which is type of Mach Zehnder and here both the voice and data combines transfer on optical fiber over a length of 5 to 20 Km. Now the output of the optical fiber which is a single mode fiber is then fed to the input of the optical splitter which splits the input into the 1:8 output, now the 8 outputs of the filter is fed to the receiver side of users. Here we consider about the 1:8 splitters, it is further expanded up to the 1:16, 1:32 depending upon the capacity of the users. At the transmitter side we combine both the voice as well as data and this is in the form of the electrical signal which is converted to the light signal with the help of the laser and this form of light is also received at the receiver side now this combined form of voice and data is again splitted into two forms as discussed earlier and here the voice and data becomes separated. To convert the data and voice in 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 and again converted in the form of the electrical signal. The same phenomena is repeated or done simultaneously for different users at the same time.

To measure the spectrum of the voice and data at the user's end we use spectrum analyzer. But as we know that data is transmitted in the digital domain or also in the light pulses so in transmission on the fiber such type of noise also produced e.g. Inter symbol Interference, Noise so in the effect of such things error should be occurred. So to measure the error we applied a instrument called BER Tester, as we know some standard also made to accept that type of error by ITU-T standard. Now at end of the receiver side every ONT has a particular receiver for both the reception of the Voice and the data. Before the reception a splitter is used to differentiate the particular user. Optical splitter component simulates an "Ideal" optical splitter. It works as a balanced splitter with the same attenuation on each output. Attenuation is set to a default value o 0dB, so this component implements an ideal splitter without any insertion loss, i.e. a component that perfectly splits the input signals. Photodiode considered as a PIN photodiode.

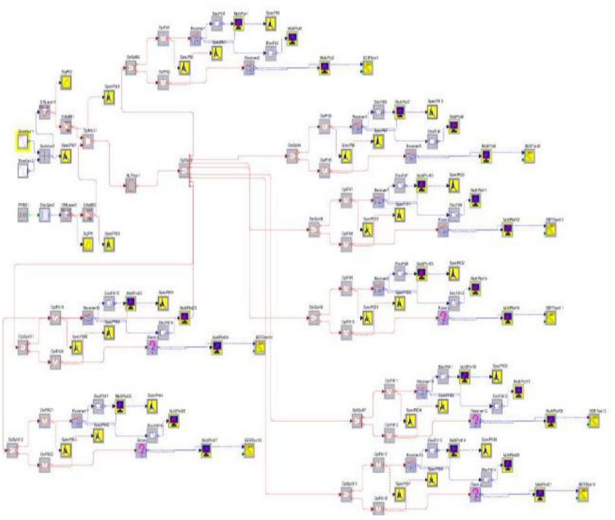

Fig.3.4 Schematic Diagram of FTTH using GEPON Architecture

The output current generated by the photo detection process depends on the input optical power and on the dark current.

3.4 RESULT AND DISCUSSION

The above diagram shows the description of the FTTH using GEPON architecture. From the above discussion we know the advantage of the GE-PON architecture in respect of the other architectures such as G-PON, B-PON. First of all this is the standard of the IEEE where as other are of ITU standard. As both works for transmission technology of the optical fiber. In the above section it is described that optical fiber generates from the Central Office which is terminated to the user premises for providing a higher bandwidth. This chapter involves the transmission of data and voice through optical fiber at 10 Gbit/s as GE (Giga Ethernet specifies according to IEEE standard is 1000 MB/s for a particular transmission). While from the Central office the line through terminates at the optical splitter and also followed by transreciever as we know that we use optical splitter as a passive device which has some limitations. So on the basis of these factors some experimental results have been obtained. As we already discussed FTTH has separate channels for the voice and the data so it has two spectrums one for the voice and one for the data. In this data is transmitted at the wavelength of 1550 nm and the voice is transmitted at the wavelength of 1650 nm. Both the wavelengths are selected because these wavelengths window has certain advantage i.e. it is low attenuation window. So Each user has separate or slightly different wavelength spectrum for voice and the data but FTTH is passed through the broadband channel of the media so that the third and last diagram shows the broadband spectrum of the both voice and the data.

Upon the distance some errors has also occurred so how much distance disturb the data and the voice so BER is calculated a graph is showing the effect the distance on the BER.

1. Wavelength Spectrum of data and voice and Baseband Spectrum at USER 1

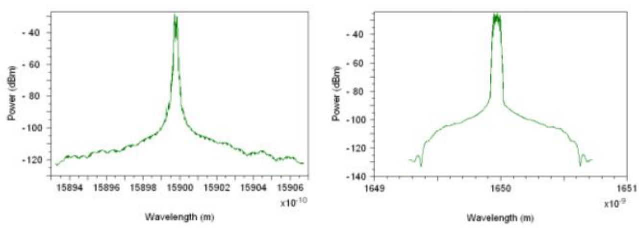

Fig.3.5 Wavelength Spectrum of data and voice and Baseband Spectrum

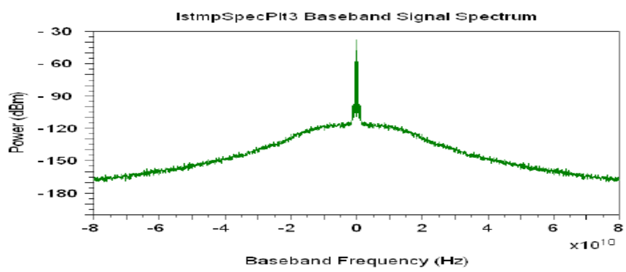

Fig.3.6 Frequency Spectrum of both Voice and Data

The above diagram represents the wavelength spectrum of user 1. These spectrum are observed at the receiver side as data and voice are modulated by MZ modulator and then transmitted over the optical fiber so optical medium also inserted some error in the form of noise. This diagram stated the voice should be transmitted at the 1650 nm while the data is transmitted at the 1590 nm. In the above architecture different users are separated by the optical splitter.

2. Wavelength Spectrum of data and voice and Baseband Spectrum at USER 2

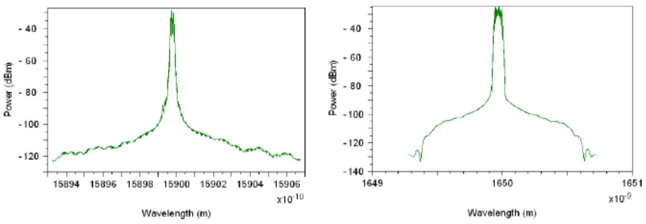

Fig.3.7 Wavelength Spectrum of data and voice and Baseband Spectrum at USER 2

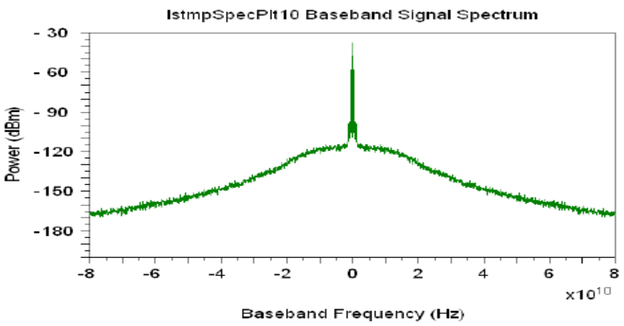

Fig.3.8 Frequency Spectrum of Voice and Data

The wavelength spectrum of user 2 is shown in fig. The data and voice are modulated by MZ modulator and then transmitted over the optical fiber so optical medium also inserted some error in the form of noise at the receiver side. From the above diagram, it is clear that for the voice transmission 1650 nm is most suitable while for the data transmission 1590 nm is most suitable. In the above architecture different users are separated by the optical splitter.

3. Wavelength Spectrum of data and voice and Baseband Spectrum at USER 3

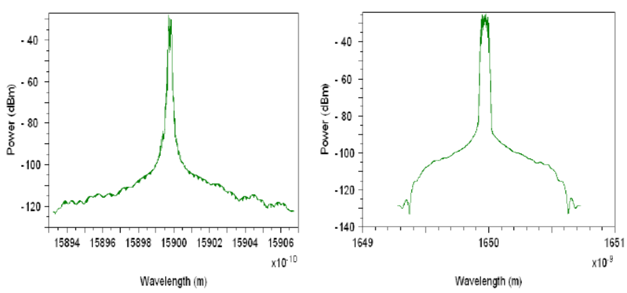

Fig.3.9 Wavelength Spectrum of Voice and Data

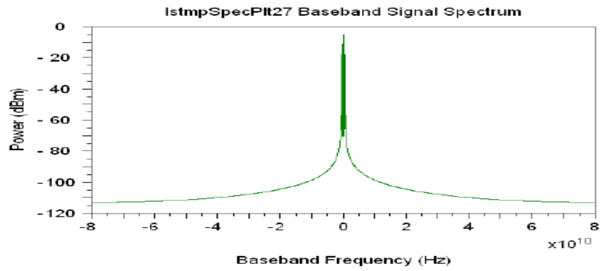

Fig.3.10 Frequency Spectrum of Voice and Data

The above diagram represents the wavelength spectrum of user 3. These spectrum are observed at the receiver side as data and voice are modulated by MZ modulator and then transmitted over the optical fiber so optical medium also inserted some error in the form of noise. This diagram stated the voice should be transmitted at the 1650 nm while the data is transmitted at the 1590 nm.

4. Wavelength Spectrum of data and voice and Baseband Spectrum at USER 4

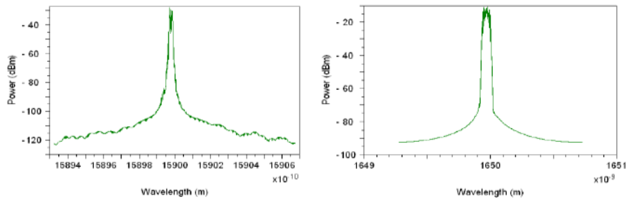

Fig.3.11 Wavelength Spectrum of Voice and Data

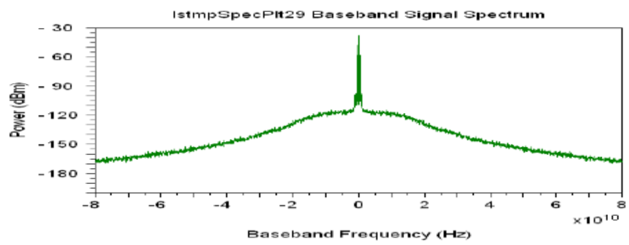

Fig.3.12 Frequency Spectrum of Voice and Data

5. Wavelength Spectrum of data and voice and Baseband Spectrum at USER 5

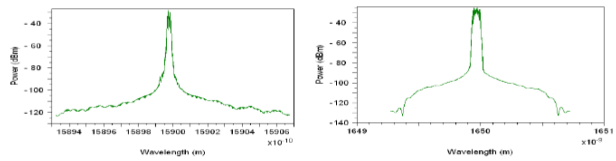

Fig.3.13 Wavelength Spectrum of Voice and Data

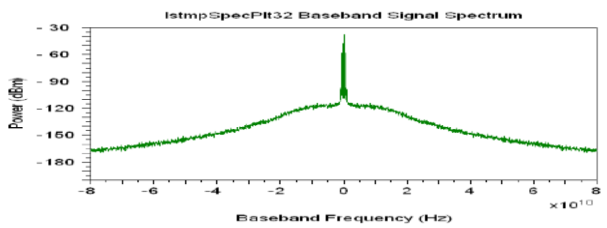

Fig.3.14 Frequency Spectrum of Voice and Data

6. Wavelength Spectrum of data and voice and Baseband Spectrum at USER 6

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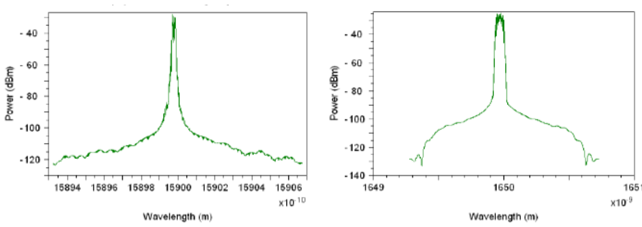

Fig.3.15 Wavelength Spectrum of Voice and Data

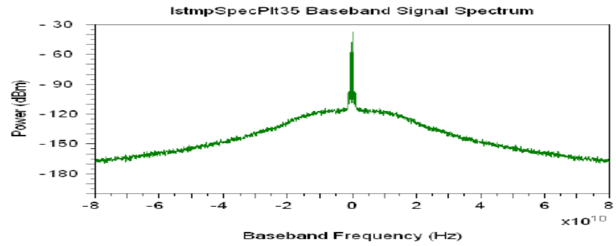

Fig.3.16 Frequency Spectrum of Voice and Data

7. Wavelength Spectrum of data and voice and Baseband Spectrum at USER 7

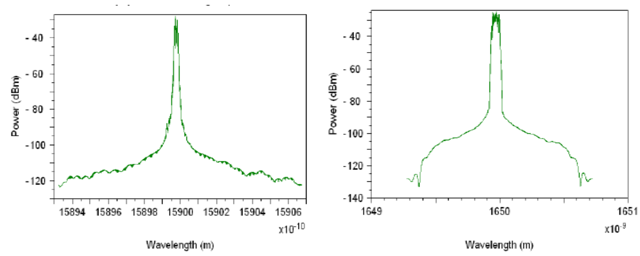

Fig.3.17 Wavelength Spectrum of Voice and Data

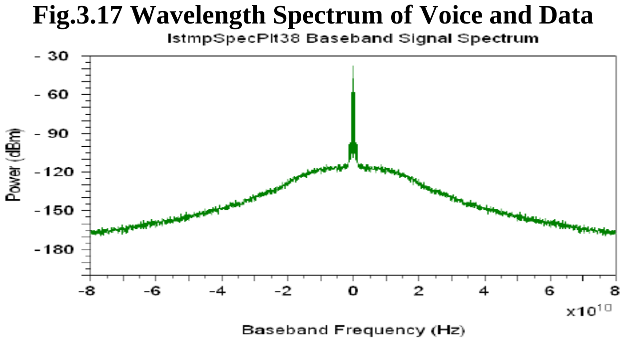

Fig.3.18 Frequency Spectrum of Voice and Data

The above diagram represents the wavelength spectrum of user 7. These spectrum are observed at the receiver side as data and voice are modulated by MZ modulator and then transmitted over the optical fiber so optical medium also inserted some error in the form of noise. This diagram stated the voice should be transmitted at the 1650 nm while the data is transmitted at the 1590 nm. In the above architecture different users are separated by the optical splitter.

8. Wavelength Spectrum of data and voice and Baseband Spectrum at USER 8

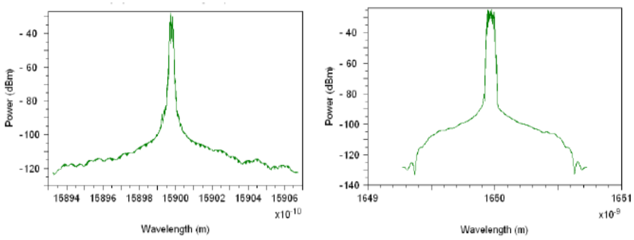

Fig.3.19 Wavelength Spectrum of Voice and Data

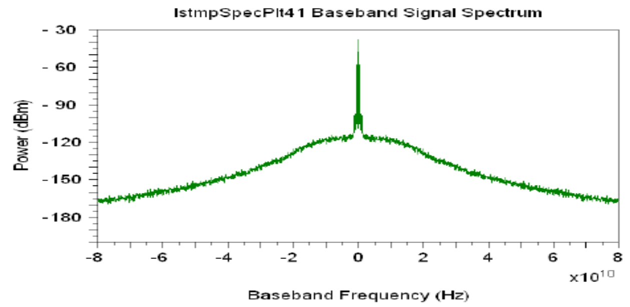

Fig.3.20 Frequency Spectrum of Voice and Data

The wavelength spectrum of user 8 is shown in fig. The data and voice are modulated by MZ modulator and then transmitted over the optical fiber so optical medium also inserted some error in the form of noise at the receiver side. From the above diagram, it is clear that for the voice transmission 1650 nm is most suitable while for the data transmission 1590 nm is most suitable. In the above architecture different users are separated by the optical splitter.

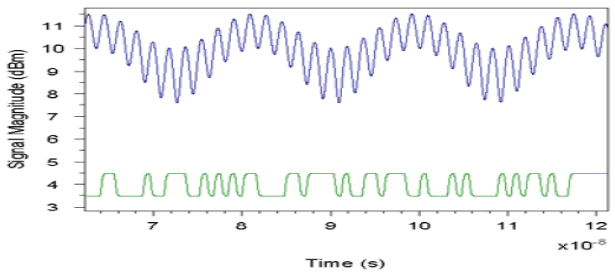

Fig.3.21 OLT output optical waveforms for data and video signal

The Fig.3.21shows the OLT output optical waveforms for data and video signal. The data and voice are modulated by MZ modulator and then transmitted over the optical fiber so optical medium also inserted some error in the form of noise at the receiver side. From the above diagram, it is clear that for the voice transmission 1650 nm is most suitable while for the data transmission 1590 nm is most suitable. In the above architecture different users are separated by the optical splitter.

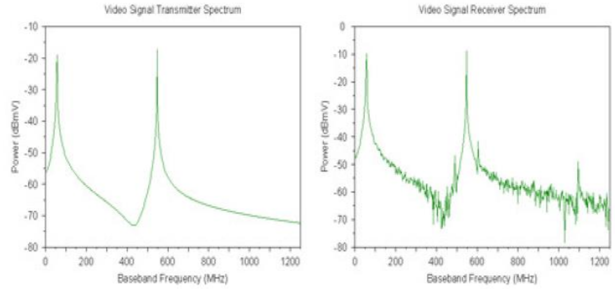

Fig.3.22 Received RF spectrum of video signal with two tones (channels)

The figure shows the received RF spectrum of video signal with two tones (channels) recovered, and for comparison the RF video spectrum at the transmitter. This layout can be further modified to study links with more specific details and provided components specifications.

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For example, a fiber trunk can consist of few fiber spans and splices, the drop off cables from splitter to users ONTs can be added. The upstream configuration can be studied as well.

Bit Error Rate (BER): The BER is the measure of error bits with respect to the total number of bits transmitted in given time.

USER NO.	BER		
Distance	5 Km	10 Km	20 Km
1	2.1394e-024	1.4281e-022	8.0149e-021
2	2.9481e-024	1.3942e-022	8.3188e-021
3	2.7122e-024	1.5946e-022	8.0009e-021
4	2.2139e-024	1.5009e-022	8.7433e-021
5	1.2292e-025	8.0744e-024	4.5087e-022
6	8.6259e-026	8.3475e-024	7.0850e-022
7	6.8504e-027	8.4789e-025	9.0398e-023
8	6.4948e-027	7.8976e-025	9.7640e-023

Table 3.1 BER versus Distance

The above table represents BER observed at the distance from the PON to the NTU/ONT.

Basically we extend or increase the number of users by using a passive device named as optical splitter. But optical splitter has also some limitations that by an OLT we have using only four optical splitters up to certain distance. So this chapter describes the distance between the OLT and Optical splitter, so if we increase the distance between the OLT and optical splitter then our data and voice becomes distorted and become error full so the PON is used up to the particular and specified length. The diagram represents the BER versus the distance, BER is measured along three different distances and BER is calculated for 8 different users and shown on the graph. Graph show as we increases the distance the BER continuously increases.

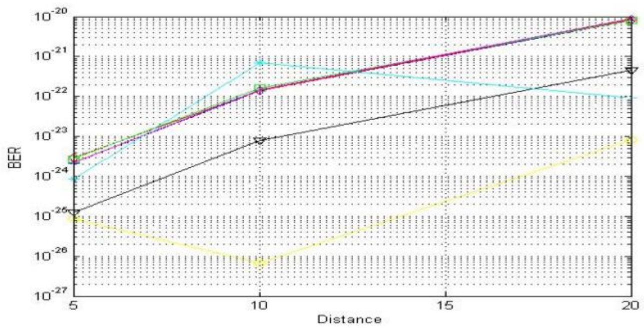

Fig 3.22 BER versus Distance

3.6 CONCLUSIONS

This chapter simulated an optimized GE-PON based FTTH access network to provide residential subscribers with full services. In this chapter, we describe the requirements of GEPON access network with considerations of services and PON specific layered functions. To satisfy those requirements, we simulated an optimized architecture and describe the detailed functions of major elements. Finally, we consider the major technical issues i.e. BER to realize the GEPON based FTTH access network. Considering the future prospect of FTTH access network, the FTTH will be motivated by the following factors. There is no need for outdoor cabinet sites, resulting in simpler network configuration and operation. No change of intermediate ONU is required to upgrade access network capabilities to accommodate future evolution of broadband and multimedia services. Maintenance is easy, because it requires maintenance only for fiber systems, and fiber systems are regarded more reliable than hybrid fiber-metal ones. FTTH is a driver for the development of advances optoelectronics technologies, and the great volume in production of optical modules will also accelerate the reduction in cost.

IV. CONCLUSION AND FUTURE ASPECTS

4.1 CONCLUSION

In this paper the scheme FTTH for eight users (ONU) at rate of 10 Gbit/s for different wavelength for the transmission of both the data and voice is verified and the BER is calculated at different distance. As it matched according to the standard so it is quite acceptable and further be demonstrated in future for different technologies. Fiber to the home solves important societal problems, promises to accelerate the recovery of both computer and communication industries worldwide, and constitutes, for a given country, an important national competitive asset. FTTH system has been matured by both technical and economical baptism during the past several years, so we can believe that FTTH will be deployed as a more cost-effective architecture for providing familiar voice, video, and data services. As FTTH becomes more widespread, it will be exciting to watch the new applications that emerge to make use of the increased bandwidth. And it will keep on being a promising technology as an ultimate solution for local broadband access network.

4.2 FUTURE ASPECTS

All-optical logic is recent research in the field of optical computing as this scheme also provides the idea of optical memory if we design an optical flip-flop which stores data as an optical pulse. As FTTH has many advantage over the all transmission techniques so, Providers could use ATM, SONET, Ethernet or Analog modulated RF carriers as their data link layer technology.

Since all users served by the same splitter – combiner on a curbside PON (and by the same Remote Node in an Active Star architecture) have to be served by the same data-link layer technology. FTTH infrastructure that is technologically and competitively neutral; where voice, video and data service providers can choose and deploy the technology of their choice to support the services they plan to offer. FTTH also provides additional services over it just like UWB (Ultra wide band), WCDMA, Radio over fiber, so many other services as network will use FTTH network as the interface for access network.

A focus has been put on the future-proof PON system having gigabit symmetry in bandwidth between the up- and downlinks. It has been shown that OCDMA is capable of providing a gigabit- or even multi gigabit-per-second for each user both in the up- and downlinks, and OCDMA over

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WDM PON could be one of the most promising system architectures that can break through the last/first mile bottleneck.

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