SPEED ENHANCEMENT USING EDFA OPTICAL NETWORKS

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ABSTRACT: With the tremendous increase in user demand for seamless broadband connectivity there is a requirement of alternatives to conventional optical networks. Due to the widespread use of Internet by a large population, there is a remarkable increase in traffic demanding a sharp increase in the capacity of the networks. Upcoming networks would be having high speed and covering long distance. Potential solutions have to be effective in bandwidth utilisation as well as reusing the bandwidth. One of the major challenges in today's network is the division of fiber bandwidth between the users. Many wavelength division multiplexing architectures are used to utilize the wavelength for data transmission. The optical networks are widely divided into two categories: the terms "Passive Optical Networks (PONs)" and "Active Optical Networks (AONs)". In AONs there is a requirement of an active source whereas PONs can work efficiently without any active source. Belonging to this family, PONs has emerged as a promising solution to overcome the limitations of the conventional optical networks. Because of its low cost and resource efficiency compared to other fibre access architectures, a PON has emerged as the most prominent option for the last-mile connection. PONs is consisted of fiber cables as well as splitters while AONs are without any splitters. However, the performance of PONs critically increases with the addition of stages of optical networks. This work explores the designing of the network and shows the simulation results of PONs with optimum parameters. This network consists of Optical Line Terminal (OLT) and Optical Network Unit (ONU) with optical isolators. The maximum utilisation of the bandwidth while reusing it is showcased in this work.

Keywords: PON, WAVELENGTH, NGPON, OLT, ONU, EDFA, ETC.

Introduction

Optical Networks Overview

Optical networks are high-capacity telecommunications networks based on optical technologies and component that provide routing, grooming, and restoration at the wavelength level as well as wavelength-based services. The origin of optical networks is linked to wavelength division multiplexing which arose to provide additional capacity on existing fibers. The optical layer, whose standards are being developed, will ideally be transparent to the

Synchronous Optical Network data based layer, providing restoration, performance monitoring, and provisioning of individual wavelengths instead of electrical Synchronous Optical Network data based signals. So in essence a lot of network elements will be eliminated and there will be a reduction of electrical equipment. It is possible to classify networks into three generations depending on the physical-level technology employed..

Optical wavelength division multiplexing networks are no doubt, the backbone modern communication because of their high throughputs of the order of terabits per second. They have the capacity to satisfy emerging application such as video services, medical imaging and distributed CPU interconnects. During the past couple of years, optical networking has undergone tremendous changes and the trend clearly shows an evolution path towards lower cost and high capacity networks.

Passive Optical Network

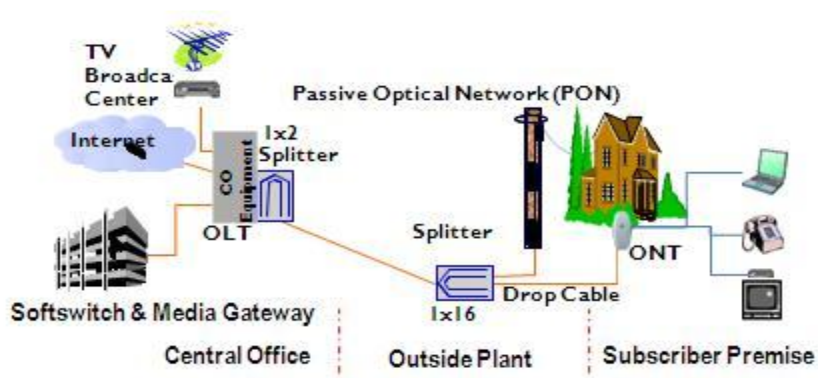


Figure 1: Passive Optical Network

A PON consists of a central office node, called an optical line terminal (OLT), one or more user nodes, called optical network units (ONUs) or optical network terminals (ONTs), and the fibers and splitters between them, called the optical distribution network (ODN). “ONT” is an ITU-T term to describe a single-tenant ONU. In multiple-tenant units, the ONU may be bridged to a customer premises device within the individual dwelling unit using technologies such as Ethernet over twisted pair, G.hn (a high-speed ITU-T standard that can operate over any existing home wiring - power lines, phone lines and coaxial cables) or DSL. An ONU is a device that terminates the PON and presents customer service interfaces to the user. Some ONUs implements a separate subscriber unit to provide services such as telephony, Ethernet data, or video.

An OLT provides the interface between a PON and a service provider′s core network. These typically include:

- IP traffic over Fast Ethernet, gigabit Ethernet, or 10 Gigabit Ethernet.
- Standard TDM interfaces such as SDH/SONET.
- ATM UNI at 155–622 Mbps.

The ONT or ONU terminates the PON and presents the native service interfaces to the user. These services can include voice (plain old telephone service (POTS) or voice over IP (VoIP)), data (typically Ethernet or V.35), video, and/or telemetry (TTL, ECL, RS530, etc.) Often the ONU functions are separated into two parts:

- The ONU, which terminates the PON and presents a converged interface—such as DSL, coaxial cable, or multiservice Ethernet—toward the user.
- Network termination equipment (NTE), which inputs the converged interface and Outputs native service interfaces to the user, such as Ethernet and POTS.

Types of Passive Optical Networks

A PON system utilizes a passive splitter that takes one input and splits it to "broadcast" signals to many users. This reduces the cost of the system substantially by sharing one set of electronics and an expensive laser with up to 32 homes. An inexpensive laser is used for the home to send signals back to the FTTH system in the central office.

Broadband Passive Optical Networks

Broadband passive optical network standards are based on the G.983 series of ITU-T recommendations that specify ATM (Asynchronous transfer mode) as the transport and signalling protocol. In addition, there will be reference in the literature to an ATM PON (APON). This was the initial PON technology for which standards were established (G.983.1) and now is a subset of the expanded BPON category. ATM is a high performance switching and multiplexing technology that utilizes fixed-length packets to carry different types of traffic.

Gigabit Passive Optical Networks

The network layout for a GPON follows that of a standard PON concept. It also retains much of the same functionality characteristic of BPON and EPON schemes, such as DBA and the use of operations, administration, and maintenance(OAM)messages.GPON, or gigabitcapable PON, uses an IP-based protocol and either ATM or GEM (GPON encapsulation method) encoding. Data rates of up to 2.5 Gbps are specified and it is very flexible in what types of traffic it carries. GPON enables “triple play” (voice-data-video) and is the basis of most planned FTTP applications in the near future.

Ethernet Passive Optical Networks

The widespread use of Ethernet in both local area and metro networks makes it an attractive alternative transport technology for access networks. Since this method encapsulates and transports data in Ethernet frames, it is easy to carry IP packets over an Ethernet link. Ethernet PON is based on the IEEE standard for Ethernet in the First Mile.

Asynchronous Passive Optical Networks

As Internet usage such as sending/receiving electronic mail and browsing home pages progresses, data communications are no longer limited to business applications and quickly expand into the home as well. On the other hand, the access lines that provide users with a method of accessing services have been diversifying recently. High-speed data communications service by ADSL (Asymmetric Digital Subscriber Line) that uses metal wires, voice/data communications services that use CATV net-works, and Internet access services that use wireless devices such as portable telephones have given users a wider range of choices to meet their needs.

Advantages of PON

- A PON infrastructure is much less expensive to implement and maintain than P2P. This is because it uses fewer ports to terminate fiber and less fiber cables.
- The fiber splitters at the centre of a PON infrastructure don’t require any power supply and can therefore be located virtually anywhere.
- Faster to deploy than a more complex P2P infrastructure.

Disadvantages of PON

- PON infrastructures offer a limited level of bandwidth as it is shared between multiple subscribers. However if the aim is to offer a set bandwidth (such as 100Mb download speeds) as cost effectively as possible, it is more cost-effective to build than a more expensive P2P network.

- Bandwidth is asymmetric, with much greater download capacity compared to upload.
- Once implemented a PON network is more difficult to update, particularly if bandwidth requirements change.
- As optical splitters have both bandwidth limitations (particularly upstream) and incur high attenuation losses they will always be subject to obsolescence where a competing P2P architecture exists.

BLOCK DIAGRAM OF OPTICAL NETWORK

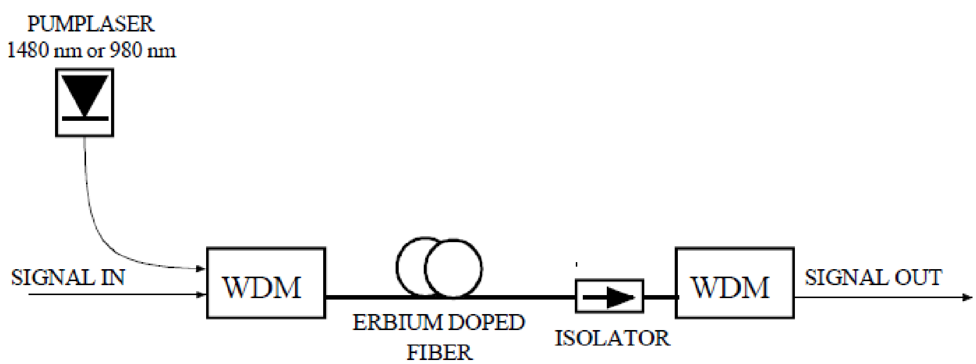
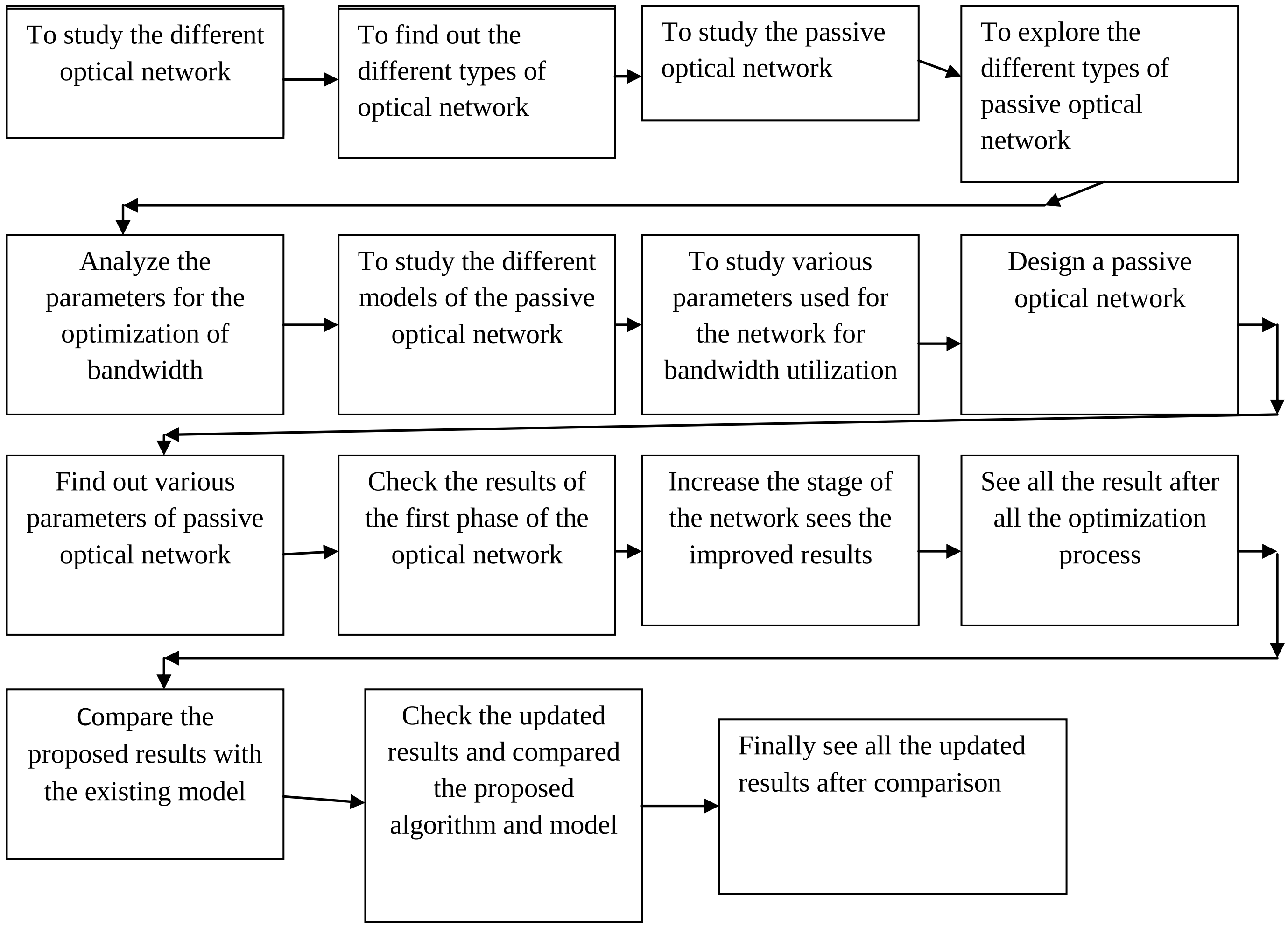
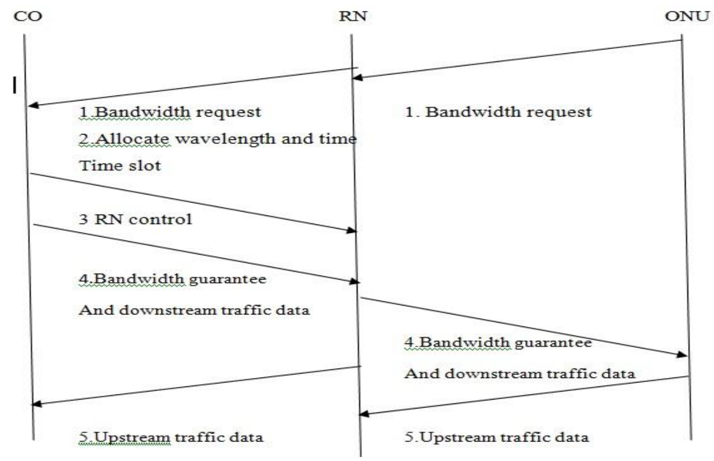


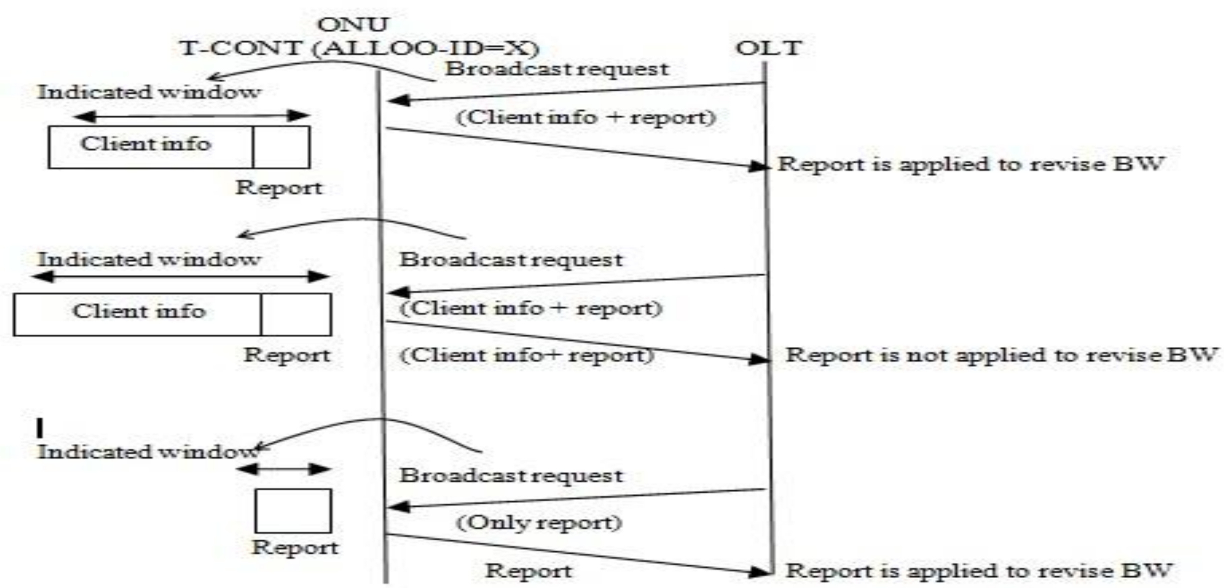
Figure 2. Block Diagram of The Optical network.

PROPOSED MATHEMATICAL MODEL:



Algorithm used





PR0POSED ALGORITHM

Start (Initialization of the static value)

Initial value load in terms of channel spacing, taken as I,

For I=1 to k, taken the value from initial

Select the request from the ONU source CI with probability k

If Ci selected , when value is selected

For l=1 to k then it will increased

Ci=ci+k*(k best(g)-k(g)) updated the iteration solution by the current iteration

after increment the iteration number by

(ITER count=ITER count +i)

End for stop the initial stages

End if the value is not upto date then it will check the iteration value

End for status for the first iteration or proposed data

If rand (0,1)<k, then increased the number of the stages

M, request= k modify if optimum data is not find then it goes again

Else CI= k finally the model is check the updated stage

End if algorithm stops with best fitted solutions.

Stop

OPTICAL NETWORK DESIGN

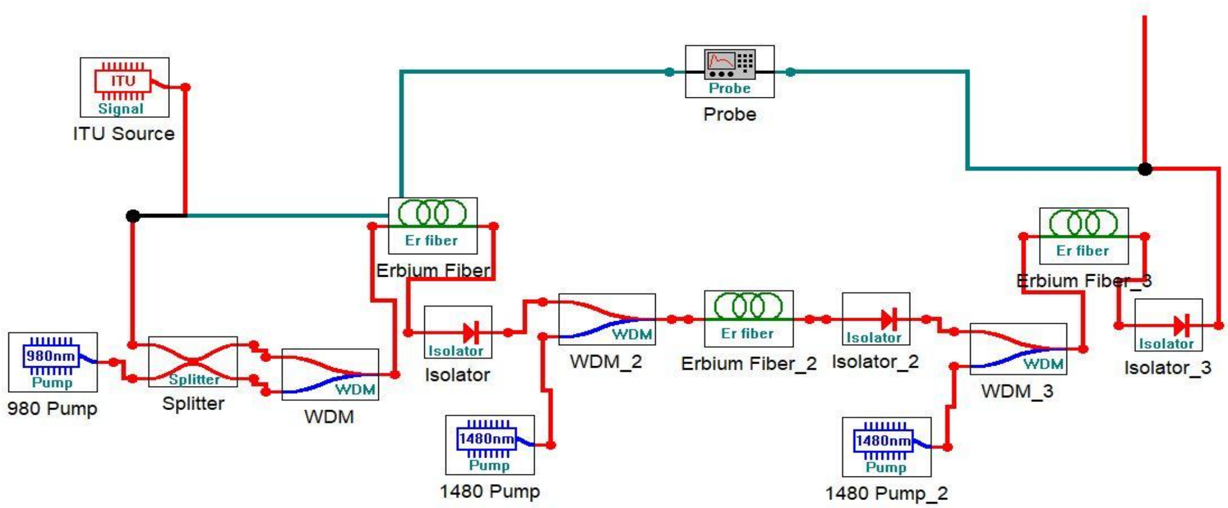


Figure 3: 3rd stage of passive optical network

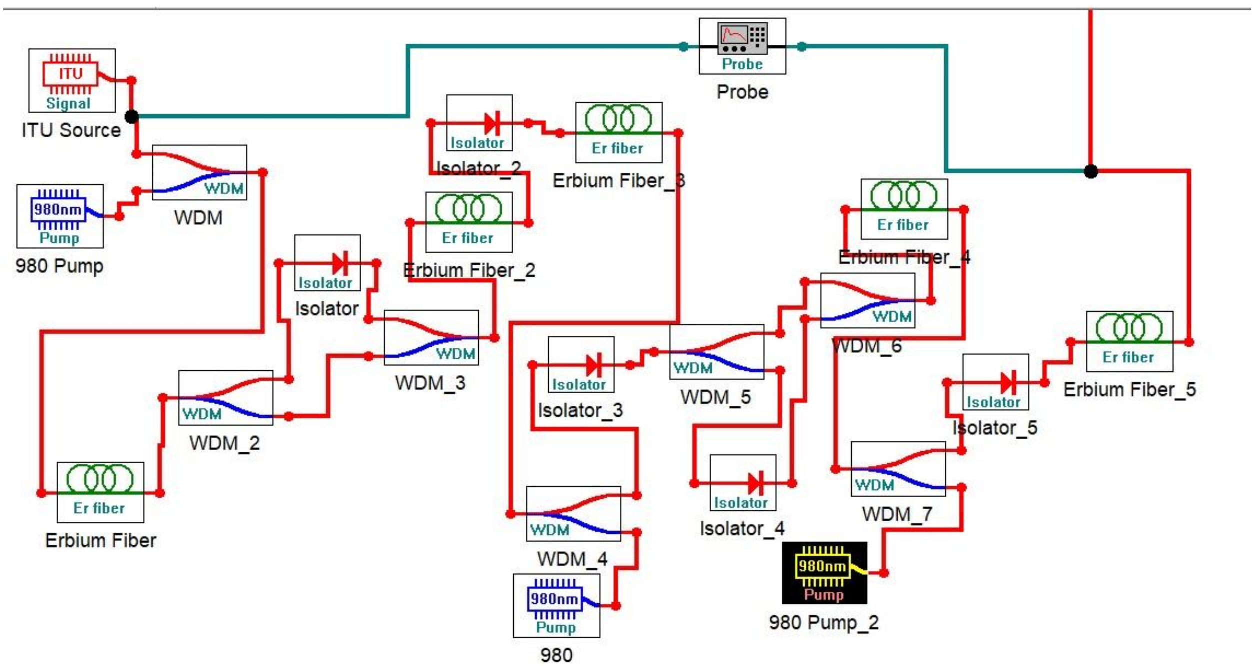


Figure 4 : 5th stage of passive optical network

SIMULATION RESULTS AFTER FIFTH STAGE

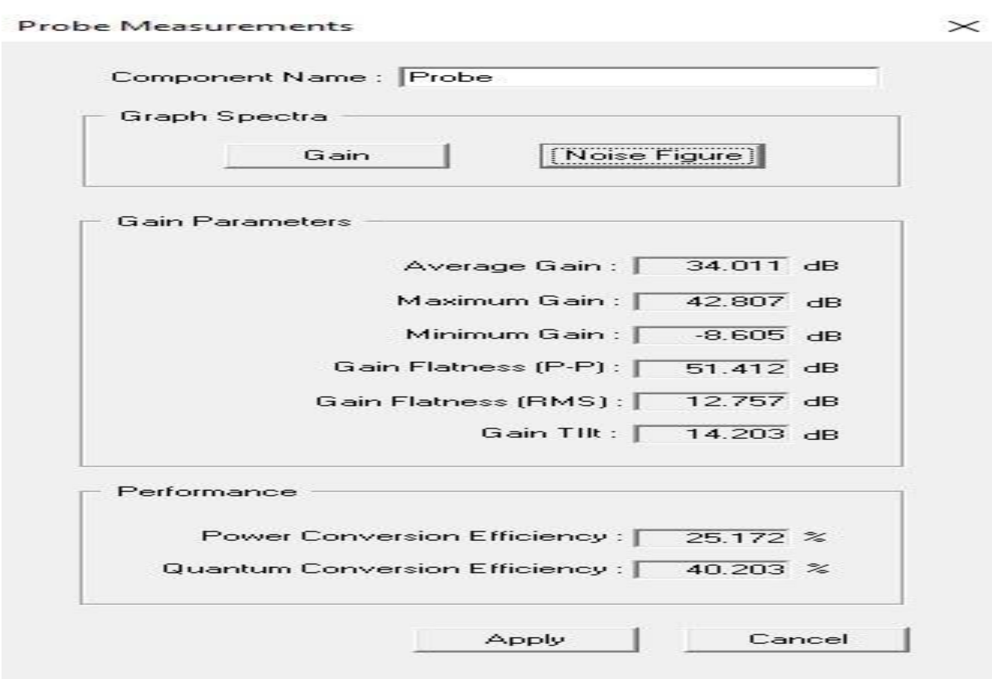


Figure 5: simulations results

TABLE 1.1

SIMULATIONS RESULTS ALL THE STAGES

Sr. No	Optimum Parameter	Optical network (First Stage) results in dB.	Optical network (Second Stage) results in dB	Optical network (Third Stage) results in dB.	Optical net work (Fourth Stage) results in dB	Optical net work (fifth Stage) results in dB
1	Standard gain	27.801	30.099	32.531	33.929	34.011
2	Maximum gain	36.967	35.085	36.670	37.891	42.807
3	Minimum gain	23.487	22.742	21.389	19.248	8.605
4	Gain flatness(p-p)	09.480	10.343	17.281	18.656	21.412
5	Gain Flatness (rms)	1.586	2.972	3.973	5.086	12.757
6	Gain tilt	9.816	10.121	12.814	17.534	14.203

GAIN VS WAVELENGTH

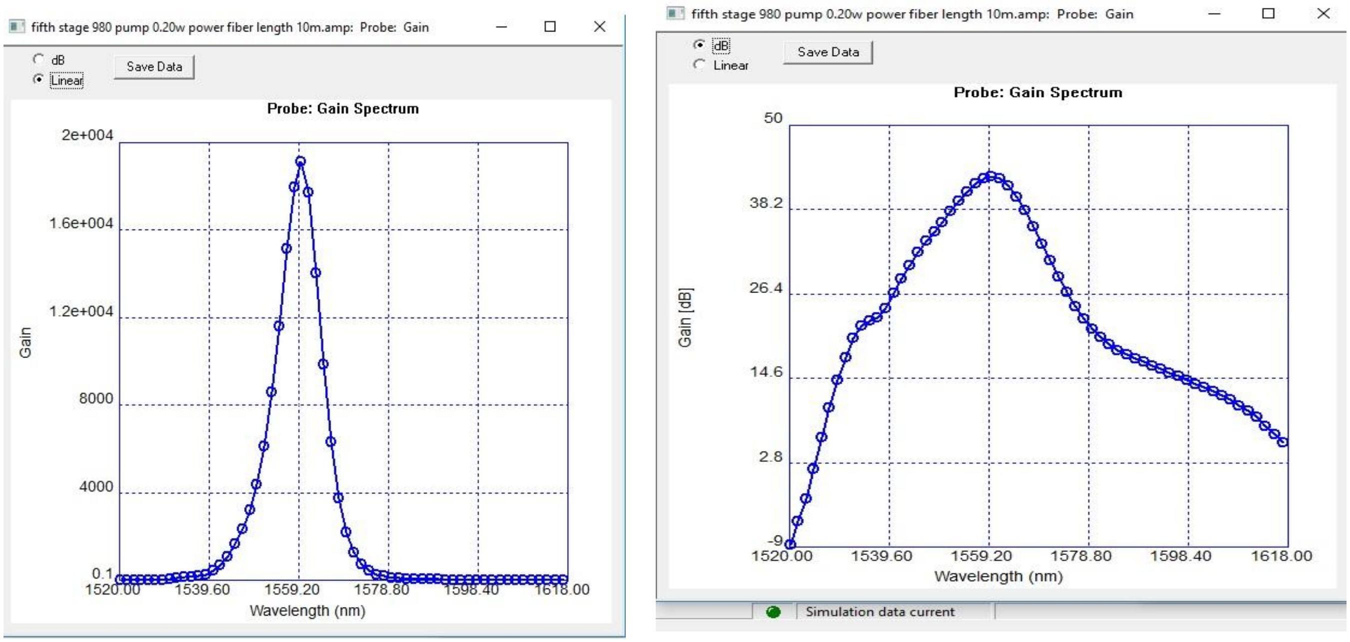


FIGURE 6: Gain versus Wavelength

NOISE VS WAVELENGTH

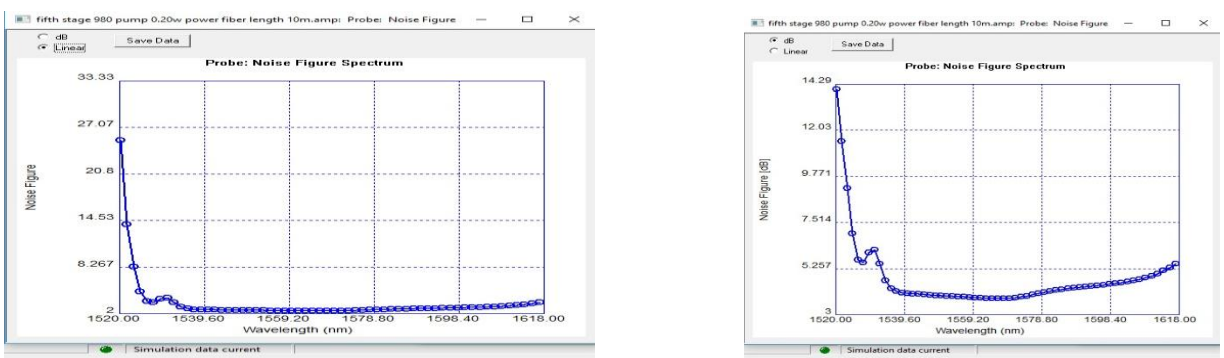


Figure 7: Noise Versus Wavelength

SIMULATION RESULTS OF OPTICAL WAVELENGTH

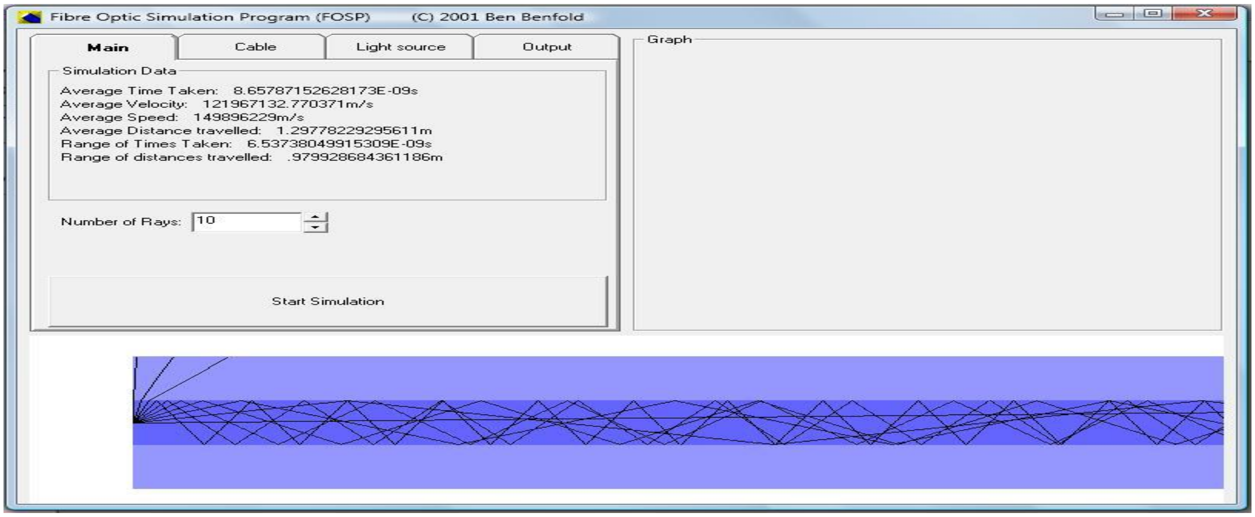


Figure 8: Optical Fiber Cable Results after Scattering

SUBSTANCES USED FOR THE OPTICAL FIBER

TABLE 1.2

Substance	Refractive Index
Air	1.0003
Ice	1.31
Liquid Water	1.33
Benzene	1.50
Crown Glass	1.52
Diamond	2.42

CONCLUSION:

We have proposed a five stage ASE input source with the multiple stages of the optical network by cascading the gain of the EDFAPON pumped with 980 nm and 1480nm laser sources with the input signal using erbium fiber. In this provide the 980 nm and 1480 nm with the broad bandwidth characteristics' .in this peak value is to be increased up to -35dB and gain bandwidth is obtained up to 95nm. so in this obtain a broader gain and higher bandwidth using multilayer stages with multilayer pumping technique. Such that we obtain the flat spectrum using DWDM device characteristics' and spectrum sliced DWDM systems.

REFERENCES:

- V. Sharma, S. Sharma, "Analysis and optimization of Passive Optical Network With Bandwidth Utilization using optimum parameter`s," *Neuroquantology, August 2022, Volume20, Issue10,Page 6877-6887,doi:10.14704/nq.2022.20.10.NQ55683* .
- V. Sharma, S. Sharma and A. Kumar, "Passive Optical Network: A New Approach In Optical Network," *2020 International Conference on Advances in Computing, Communication & Materials (ICACCM)*, 2020, pp. 295-300, doi: 10.1109/ICACCM50413.2020.9213059
- V. Sharma, S. Sharma "Gain Enhancement through cascading stages of optical network" *International journal on future revolution in computer science & communication engineering,* volume 4, issue3, pp.286-289, March 2018.
- Sharma, V., & Sharma, S. (2021). Evaluation and analysis of passive optical network with optimum parameters. *2021 International Conference on Advances in Electrical, Computing, Communication and Sustainable Technologies (ICAECT).*
- Sharma, V., & Sharma, S Passive optical network: a futuristic approach. Integrated research journal Volume 4, (1) August 2017.
- Sharma, V., & Sharma, S Performance Enhancement of Passive Optical Network with improved Bandwidth Utilisation and Allocation. Journal of Optical Communications(Accepted)
- Muciaccia, T., Gargano, F., & Passaro, V. (2014). Passive optical access networks: State of the art and future evolution. *Photonics*, *1*(4), 323–346. https://doi.org/10.3390/photonics1040323.
- Zhang, N., & Bao, H. (2010). Re-routing technology and its application in optical network. *2010 International Conference on Innovative Computing and Communication and 2010 Asia-Pacific Conference on Information Technology and Ocean Engineering*.

- M.Al-Quzwini, M. (2014). Design and implementation of a fiber to the home FTTH access network based on GPON. *International Journal of Computer Applications*, *92*(6), 30–42. https://doi.org/10.5120/16015-5050.
- McGarry, M. P., Reisslein, M., Maier, M., & Keha, A. (2006). Bandwidth management for WDM EPONs. *Journal of Optical Networking*, *5*(9), 637. https://doi.org/10.1364/jon.5.000637
- Wei, W., Wang, T., Qian, D., & Hu, J. (2008). MAC protocols for optical orthogonal frequency division multiple access (OFDMA)-based passive optical networks. *OFC/NFOEC 2008 - 2008 Conference on Optical Fiber Communication/National Fiber Optic Engineers Conference*.
- Ren, X., Qian, L., & Zhang, G. (2006). The replacement of dry heat in generic reliability assurance requirements for passive optical components. In J. C. Wyant & X. Zhang (Eds.), *ICO20: Optical Devices and Instruments*. SPIE.
- Vardakas, J. S., Moscholios, I. D., Logothetis, M. D., & Stylianakis, V. G. (2011). An analytical approach for dynamic wavelength allocation in WDM–TDMA PONs servicing ON–OFF traffic. *Journal of Optical Communications and Networking*, *3*(4), 347. https://doi.org/10.1364/jocn.3.000347.
- Kramer, G., & Pesavento, G. (2002). Ethernet passive optical network (EPON): building a next-generation optical access network. *IEEE Communications Magazine*, *40*(2), 66–73. https://doi.org/10.1109/35.983910.
- Snelling, R. K., Chernak, J., & Kaplan, K. W. (1990). Future fiber access needs and systems. *IEEE Communications Magazine*, *28*(4), 63–65. https://doi.org/10.1109/35.52917.
- Crochat, O., Le Boudec, J.-Y., & Gerstel, O. (2000). Protection interoperability for WDM optical networks. *ACM Transactions on Networking [a Joint Publication of the IEEE Communications Society, the IEEE Computer Society, and the ACM with Its Special Interest Group on Data Communication]*, *8*(3), 384–395. https://doi.org/10.1109/90.851984.
- Pages, A., Perello, J., Spadaro, S., & Junyent, G. (2012). Strategies for virtual optical network allocation. *IEEE Communications Letters: A Publication of the IEEE Communications Society*, *16*(2), 268–271. https://doi.org/10.1109/lcomm.2011.120211.111900.
- Abbas, H. S., & Gregory, M. A. (2016). The next generation of passive optical networks: A review. *Journal of Network and Computer Applications*, *67*, 53–74. https://doi.org/10.1016/j.jnca.2016.02.015.