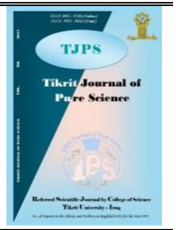
Tikrit Journal of Pure Science 23 (7) 2018

ISSN: 1813 – 1662 (Print)
E-ISSN: 2415 – 1726 (On Line)

TJPS

TIKRIT JOURNAL OF PURE SCIENCE

Journal Homepage: http://main.tu-jo.com/ojs/index.php/TJPS/index



PERFORMING AN ANALYSIS OF ARRAY WAVEGUIDE (AWG) MULTIPLEXER BASED ON AN OPTICAL NETWORK

Hussein Ahmed Ali

Computer Department , College of Science , University of Kirkuk , Kirkuk , Iraq

ARTICLE INFO.

Article history:

-Received: 31 / 5 / 2017

-Accepted: 27 / 12 / 2017

-Available online: / / 2018

Keywords: Multiplexing, Optical Network, Array Waveguide Multiplexer (AWG), BER.

Corresponding Author:

Name:

E-mail:
hussien_alwaise@yahoo.com

Tel:

Affiliation:

Abstract

Rapid advances in optical technology have created potential solutions for enabling high capacity networks. The main problem in optical communication in the Ministry of Communication at the Republic of Iraq is dedicating a small bandwidth for each user. Most of the previous works have focused on modifying the characteristics of Array Waveguide Multiplexer (AWG) in the designing level. However, designing of optical communication is expensive which makes these efforts unpractically. Therefore, to develop multi-target communication over the current infrastructure, this paper investigates the performance of the AWG at the components level. In the beginning, an analysis is performed of an AWG at data rates of (8×40Gb/s, over 242.5km fiber optic link) with minimum system impairments. The presence of (Passive/Active) components is taken into considerations. The evaluation is performed using Optisystem software simulation package. By adopting (4.0402dBm) total input signal power, the simulation has achieved (0.3545dBm) total output signal power, (-3.6856dbm) total gain, (1.4248dBm) total output noise, and the average power is (-6.4255dBm). Furthermore, the transmission rates are successfully transmitted delivered in a low-cost infrastructure. Moreover, with the presence of multiple users on a single link, the transmission is performed with a high rapidity in addition to a minimum error. Consequently, the simulations can be applied to the existing fiber communication networks with ultimate reduction of the cost and operational expenditure for the overall network system.

I. Introduction

Array Waveguide Multiplexer (AWG) is a generalization of Mach-Zehnder interferometer (MZI). It has multiport connected interiorly by a waveguides array. The (MZI), and (AWG) can be shown as multiple copies of the same signal but shifting in phase by separate quantities, and then both merges together. The (AWG) has many applications, such as (many-to-one) frequency (MUX). By this scheme, it is a (many-input), one-output component, where the (many) are pulses with different frequencies that are merged into the (one) output. The opposite of this scheme, is, (one-to-many) frequency DeMUX**[1].** The (AWG) details and light convey are illustrated in Figure 1 **[2].**

The huge evolution across the (WDM) leads to adopt many methods to ensure easy way to the accessing to the network through current components which named (WDM-PONs) structure by distributing data to other users at one time because the output lines of the selectivity components properties have only properties within the probability of introducing sequencing same distribution, and selecting properties with other benefits in elastic signal convey, private behavior**,** determine errors, and scalability. A privilege mechanism scheme of (WDM-PON) is the (AWG-PON) **[3].**

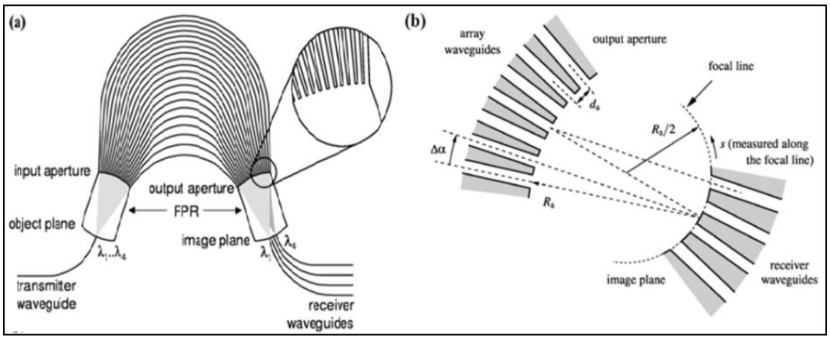


Figure 1: (a) shows the (AWG) details, and (b) light convey sector.

By increasing needs for Internet and its application services led us to use expectancy to maintain upgrading the WDM networks. Light wave multiplexers and a demultiplexer (MUX/DMUX) are able to mix and allocate many wavelength signals. Also the main device of (WDM) networks which are adopted as flatting waveguides by (MUX/DMUX) component switch (AWG), and mesh components, are the (state-of-the-art); (silica-on-silicon) array waveguide multiplexers are affected by many components exclude multiple numbers and close channel spacing (CS), and the compatibles several tasks on unique integrated circuits (ICs), is not efforts for real regime without changing the parameters of the function in an efficient manner**[4].**

1. AWG Benefits.

The AWG has many advantages. It carries dense wavelength division multiplexing (DWDM) network to a much higher speed and capacity. Besides, AWGs also carry the characteristics of narrow and accurate channel spacing, polarization insensitivity, high stability and reliability. Because the channels for AWGs are added in parallel form, the size of AWGs device will not increase much although the number of channels increases significantly. The AWG acting is the main role in existing, and prospect WDM optical system results because of its modular developing, transparency, elasticity, proficiency, dependability, and protection **[5]**. The vital benefit of the (AWG) is that its budget does not depend on frequency amount as in the di-electric filter solution. For that reason, it suits city network applications that need to the cost-effective of huge frequency amounts. As a consequence, many types of (AWG's) can be manufactured in a similar style **[6] [7].**

2. Array Waveguide Mechanisms

The optical waveguide is a transparent structure that can guide light. Many optical signals refer to a chemical composition. The most effective waveguide used in communication is in actual fact (silicon dioxide, named as silica (SiO_2)). For MUX/DEMUX optical signals with a different wavelength from (λ_1 to λ_n) which are sent from the input waveguides to the first (free polarization zone-FPZ). When the input signals enter the first (FPZ), they will separate in the (FPZ), and be sent to the arrayed waveguide (AWG). The length of the (AWG) which is planned as an optical path length difference (ΔL) between neighboring waveguides is equivalent. The equivalent length difference between adjacent (AWG)that will construct a phase difference, so that centring arises at spatially disconnected points at the end of the second (FPZ) based on the frequency. Therefore, signals of different frequencies can be merged to separate output waveguides that will lead to the end of the AWGs. The simple action of the AWGs DEMUX is similar to the simple action of AWGs MUX. Therefore, the AWGs DEMUX can be used as a MUX in the opposite way because of the interchange switching **[8].**

3. Issues Affecting AWG.

There are few issues affecting the performance of AWGs. The main issues include crosstalk, insertion loss, and polarization. Generally, Crosstalk is caused by a combination of six mechanisms which are receiving crosstalk, truncate, approach exchange, coupling in the array, and phase transferal, confusion, and background radiation **[9] [10].** Investigating the cascading connection for AWGs can reduce the crosstalk; the crosstalk also can be enhanced by controlling its nonadjacent crosstalk **[11].** Insertion loss in AWGs is mainly caused by the inefficient coupling between the FPZ and the arrayed waveguide. Firstly, is the diffraction loss in the first FPZ due to the finite number of (AWGs)? Secondly, is the faulty centring loss in the next FPZ due to the waveguide hole among AWG at the slab array border that is determined by the mask process? Polarization, there are two kinds of polarization in AWGs, the first one is the polarization dependent dispersion while the other one is polarization rotation. Polarization dispersion may cause the wrong coupling at the output waveguide; hence, causing crosstalk problems **[12], [13] and [14].**

II. Related Works

Revisions of the present material in the collected works aid a scientist to the proposal and manage his/her tries and eventually to rapid the outcomes he/she arrives at. There is a lot of information regarding AWG.A portion of that and comparative to the present revision is described in this section: **Yoshinori** 2000 **[15]** "introduces the principles of the AWG and its application for future optical network".**Klekamp and Wessel** 2002 **[16]** "explain how to use the AWG multiplexers as the key elements for DWDM in optical networks". **Shin et al.**

2005 **[17]** "propose a cascade-connected AWG as a solution to the problem of crosstalk accumulation in a large-scale AWG multiplexer/Demultiplexer". **Kwanil et al.** 2007 **[18]** "propose a novel bidirectional OADM using AWG for the OTNs". **Yueting and Rongqing** 2007 **[19]**"demonstrate how a general design rule for interleaved arrayed waveguide gratings (IAWGs) is derived. A 1×N WDM switches based on a phase shifter array". **Ooba et al.** 2008 **[20]** "propose hybrid AWG-free space focusing optics system and demonstrate a 40-channel 100GHz spacing wavelength blocker". **Ismahayati et al.** 2008 **[6]** "designed AWGs on silica substrate with the polymer waveguide. This system is used to multiply an optical fiber's transmission capacity by sending signals simultaneously at multiple wavelengths over a single fiber". **Shin** 2009 **[21]** "describes recent progress in relation to the key requirements for thermal AWG multiplexers, namely a wide passband". **Abd El–Naser et al.** 2009 **[22]** "investigated two characteristics of three different waveguides employed in AWG in PON where rates of variations were processed". **Kazumasa and Tomohiro** 2009 **[23]** "report a phase-modulation method for measuring arrayed waveguide grating (AWG) phase error in the frequency domain by combining the method with a digital sampling technique".**Abd El–Naser et al.** 2009 **[24]** "presented a high transmission bit rate of a thermal arrayed waveguide grating AWG, and analyzed the data transmission bit rate of a thermal AWG in PONs based on Maximum Time Division Multiplexing (MTDM) technique".

I. An Experiment of AWG MUX/DEMUX with 8 Channels×40Gbps.

The previous studies have been worked on the characteristics of AWG in designing level. This is paper to be covering the components layer to investigate the behavior and performance of AWG. To demonstrating the multi-input multi-output (MIMI) capabilities here, the AWG has been used as MUX/DEMUX. The Figure (2) demonstrates the block diagram of three parts system, while Figures (3 and 4) show our network simulation and layout properties of the AWG architecture. This layout consists of three main parts: the first one is an optical transmitter with its components, the second one is the optical transmission link, and the last one is the receiver with its components.

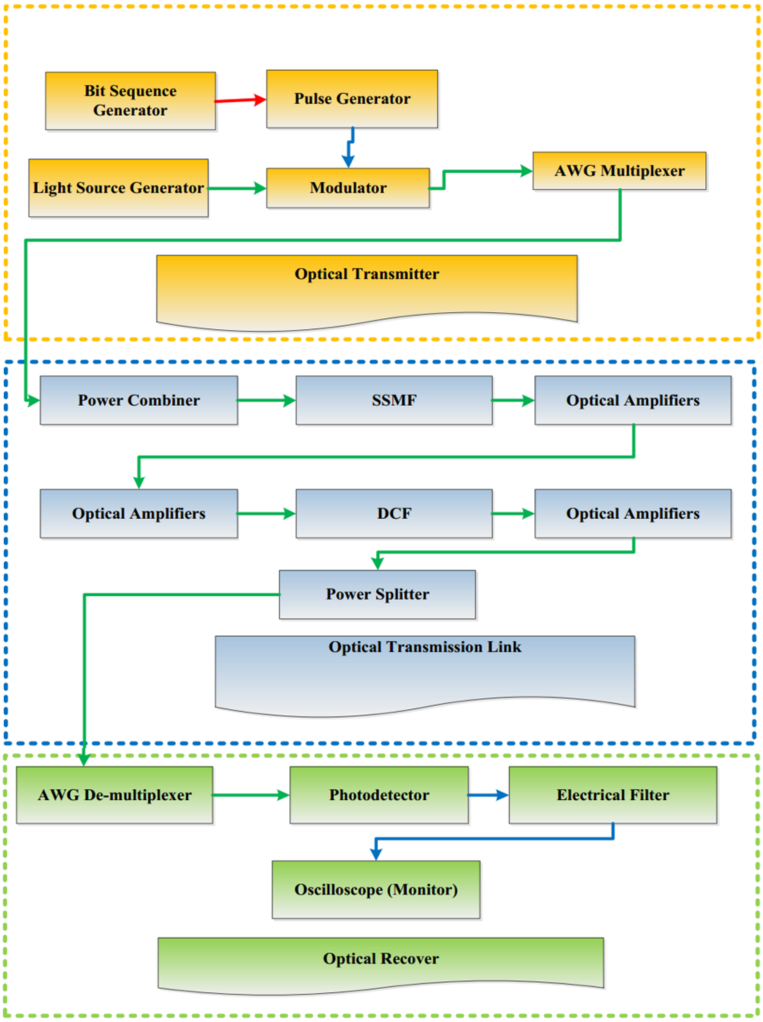


Figure2: illustrate the block diagram the system.

A. Optical Transmitter

This aspect is responsible for generating an optical signal, and launching them into the optical fiber. 8-Continuous waves (CW) laser with wavelength (193.1THz-193.8THz), and power is (0dBm), (8) none-return-to-zero (NRZ) pulse generator, (8) Mach-Zehnder (MZ) modulator. Pseudo-random bit sequences generator generates the signal data patterns (PRBSG), as sequence length equal to (64bits). Sample per bit is (256), and a number of samples is (16384). Each output signal is connected to each input port of an AWG (8×8) multiplexer to multiplexing them, and the output of AWG is connected to the (8×1) power combiner. Figures (5-a, and b) show the optics transmitted subsystems for (1-4) and, (5-8) respectively.

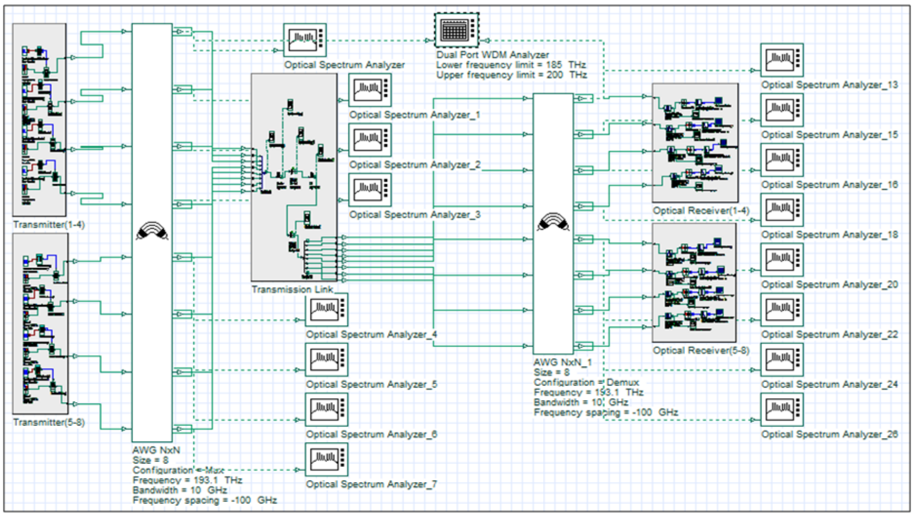


Figure 3: The Block Diagram of AWG architecture.

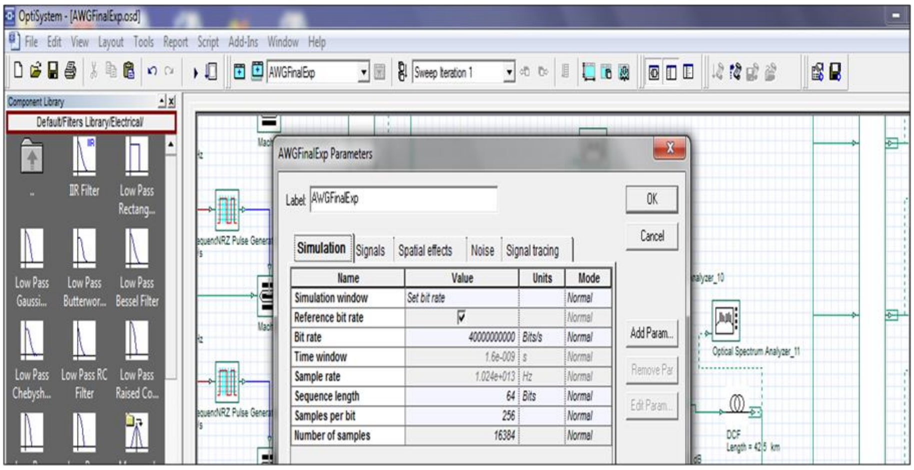


Figure 4: The main Layout Properties of the AWG MUX/DEMUX.

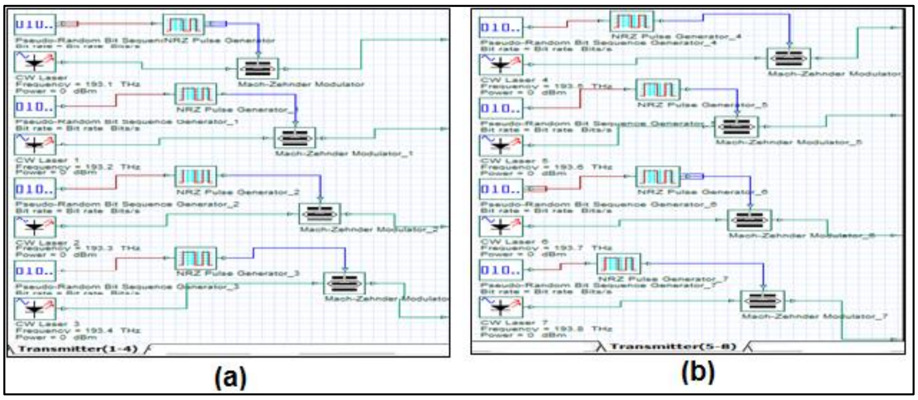


Figure 5: Transmitter for the AWG (a): The optical transmitter subsystem (1-4), and (b): The optical transmitter subsystem (5-8)

B. Optical Transmission Link.

After the power combiner output, all signals are launched into the transmission line. The first cell is a SSMF with length (200km). The dispersion is equal to (17ps/nm/km), attenuation loss is (0.2dB/km), and effective area is ($80\mu m^2$). To compensate the degrading of the signal power, two components of Erbium Doped Fiber Amplifier (EDFA) (Gain=40dB, and Noise Figure =6dB) are used. After signal propagates, the dispersion is accumulated. This can be compensated by dispersion compensator fiber (DCF) with length (42.5km), and a dispersion slope ($0.21 ps/\mu m^2/km$). At the end side, all signals have entered into the (1×8) power splitter. Figure 6 demonstrates the optical transmission link, then, each output signal is connected to the corresponding port of an (8×8) AWG to DE-multiplexing them.

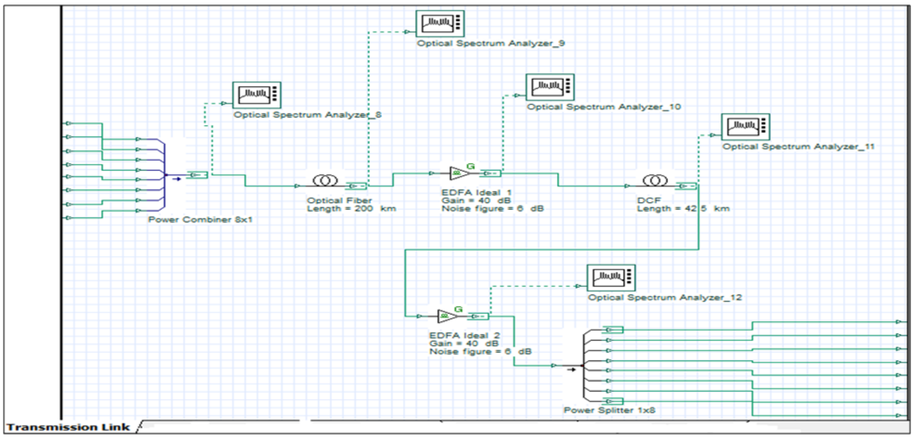


Figure 6: Clarifies the optical transmission link subsystem

C. End Front Side Receiver

At the end side of the regime, each signal is filtered by the optical Gaussian filter with bandwidth (10GHz) with the order of (2) and detected by the PIN Photo detector. To reshape each electrical signal enters the low pass Gaussian filter with a cutoff frequency (0.75*Bitrate Hz). Figure (7-a, and b) show the optical receiver subsystems for the channels (1-4), and (5-8) respectively. The output signals have been monitored by the oscilloscope visualizer.

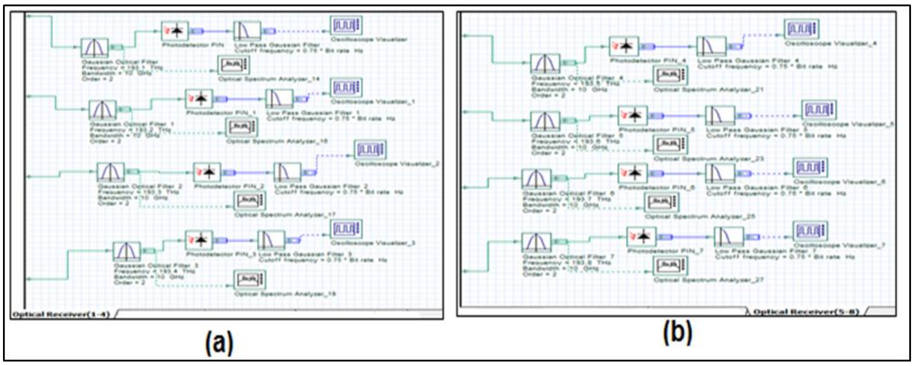


Figure 7: Shows the optical receiver for the AWG (a): the (1-4) channels subsystems, and (b): the (5-8) channels subsystem.

II. Simulation Results for the AWG 40Gbps Network system

In this section, the simulation results will be introduced and discussed for the AWG MUX/DEMUX. There are many graphs to explain the relationship between parameters. The output power, gain, and noise figures are calculated through Optical System package as a function of input wavelength. So, the system performance is evaluated from the Q-factor and bit error rate (BER) pattern for all 8-channels. In this experiment, the oscilloscope (monitor) will improve if any waveform that will read output power signal to check each value has accepted or not. However, every graph has unplanned attributes together (amplitude-noise, and time-jitter). These need to have enough minimum samples to permit the monitor to get appropriate information to align the mask of the wave-form to avoiding slight change in the results and failure. The input and output signal behaviors for this regime are listed as follows:

1) Figure (8): shows the power versus wavelength for all channels after combiner and span link is (0km), it's clear that there is some noise because there is no amplification apply on signals.

2) Figure (9): demonstrates the power versus wavelength from optical spectrum analyzer (OSA) after 200km of SSMF, the signals in shape are good because an amplifier is used to reshape it, and the DCF used to compensate the dispersion aggregated over a fiber link.

3) Figure (10): shows 8- signal from OSA, red color (power) and green color (noise) after amplification process through EDFA, there are some noises added by this component.

4) Figure (11): shows all signals from OSA, red color (power) and green color (noise) after management dispersion by DCF, it is clear that the signal form seems good due to DCF process.

5) Figure (12): clarifies the output channel_1 (193.1THz) after reshaping by Gaussian optical filter the reshaping process by Gaussian filter gives us attractive output signal.

6) Figure (13-19): show oscilloscope visualizer and the amplitude versus time for the output (channel_2 to channel_8) after direct detection by PIN Photo detector, all output signals appear very good in shape. The violation in signals refers to the collecting data at the receiver side. There are many factors influencing the output signal such as (modulation format, sampling, filter, and capacity). The more frequency content of the signal is inhibited. The signal gives the impression to be good, and the wave-form simply comes across the mask check.

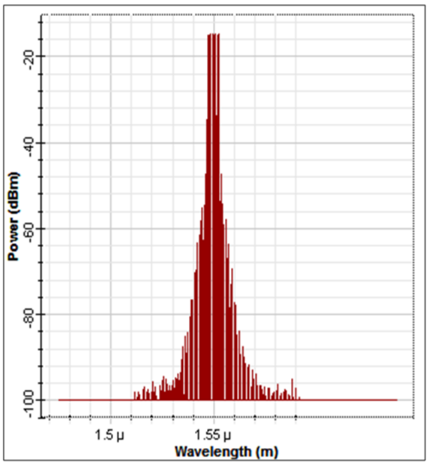


Figure 8: The power versus wavelength for all combiner when span =0km

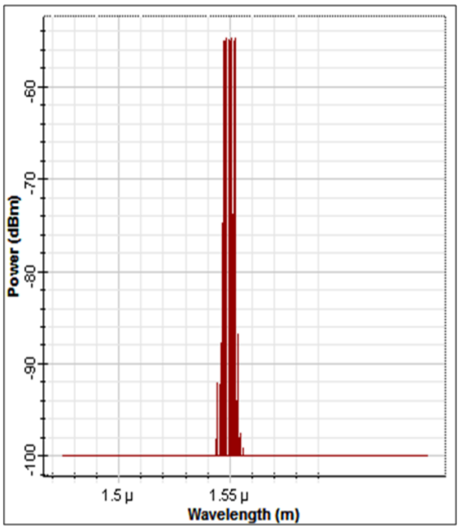


Figure 9: Power versus wavelength from OSA when span=242.5km

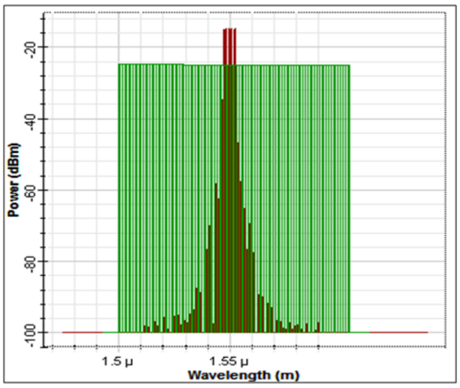


Figure 10: All signal from OSA, red color (power) and green color (noise) after EDFA.

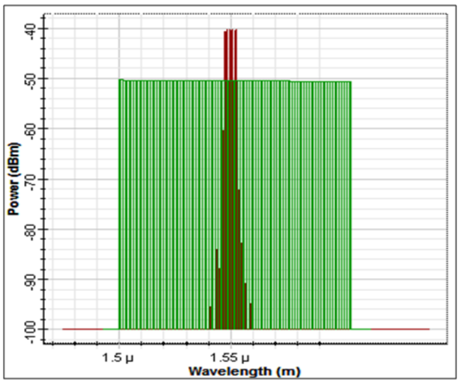


Figure 11: All signal from OSA, red color (power) and green color (noise) after DCF.

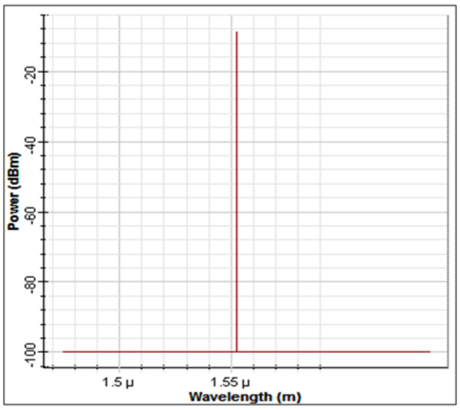


Figure 12: The output channel_1(1552.52nm) after optical filter

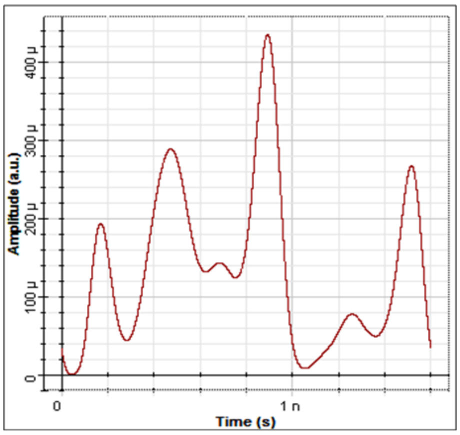


Figure 13: Output Signal_2(193.2THz), after PIN from oscilloscope visualizer

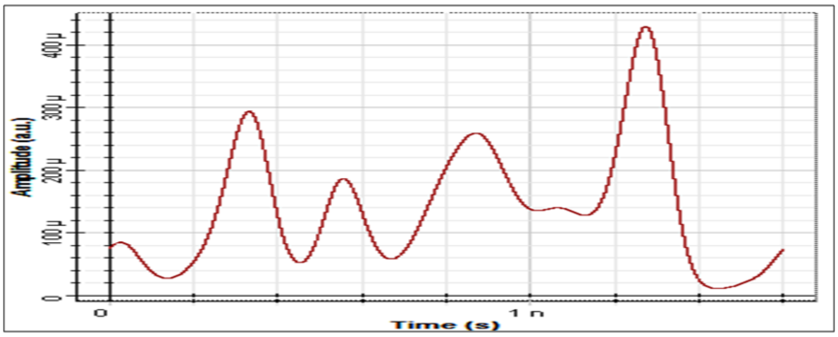


Figure 14: Output Signal_3(193.3THz), after PIN from oscilloscope visualizer.

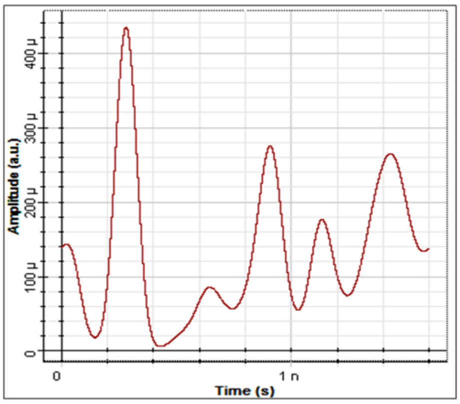


Figure 15: Output Signal_4(193.4THz), after PIN from oscilloscope visualizer

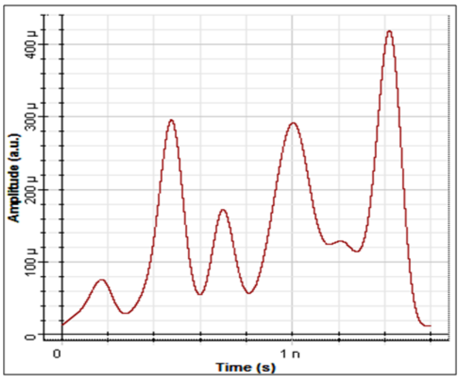


Figure 16: Output Signal_5 (193.5THz), after PIN from oscilloscope visualizer

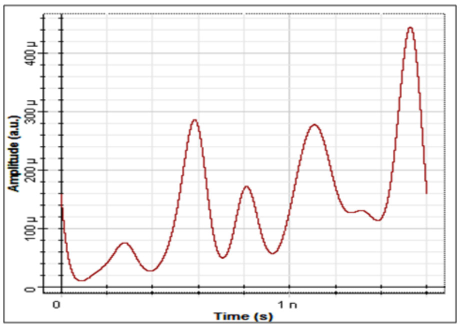


Figure 17: Output Signal_6(193.6THz), after PIN from oscilloscope visualizer

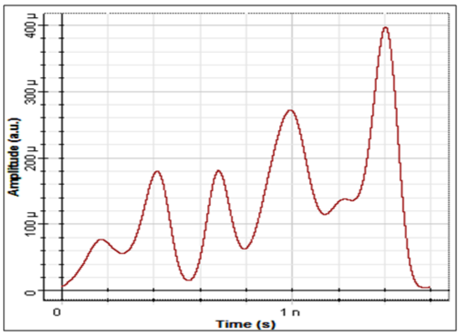


Figure 18: Output Signal_7(193.7THz) after PIN from oscilloscope visualizer.

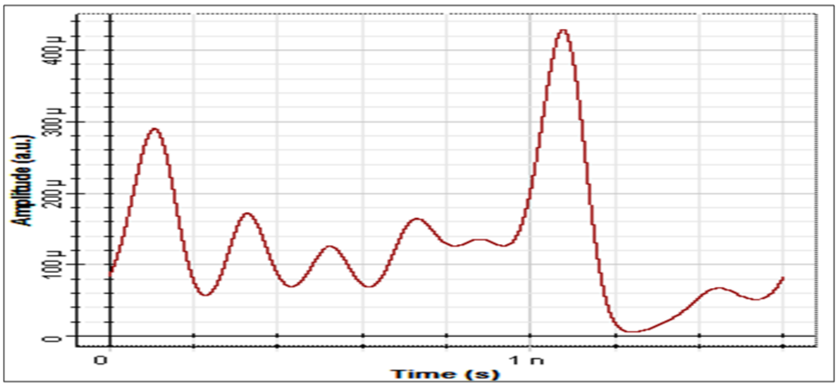


Figure 19: Output channel_8
(1546.92nm) output after PIN from the oscilloscope visualizer

Finally, from the dual port WDM analyzer, the (total gain is -3.6856dbm, total input signal power is 4.0402dBm, total output signal power is 0.3545dBm, and total output noise is 1.4248dBm). So, from the optical power meter, the average power is (-6.4255dBm). Based on the details of the investigations performed by AWG multiplexer, this architecture has been chosen makes the specific applications with low error rate.

III. Conclusions and Suggestions for Further Research

Evaluating performance at data rates of (8×40Gb/s AWG, over 242.5km fiber optic link) with minimum system impairments, and the presence of (Passive/Active) components are taken into considerations. The (total gain is -3.6856dbm), total input signal is (4.0402dBm), total output signal is (0.3545dBm), and total output noise is (1.4248dBm). Therefore, from the optical power meter, the average power is (-6.4255dBm). The simulation results have shown that data transmission rates successfully transmitted and delivered in a cost-effective infrastructure. Furthermore, the AWG systems have worthily achieved with high rapidity and minimum error since case of presence of many users on a single link. Moreover, the scheme is applicable in upgrading the current optical infrastructure and reduces overall cost by adding additional bandwidth to the AWG systems. Additionally, the AWG optical network helps minimizing the big hole with further republics, and improves the growth of commercial operations. Consequently, the proposed method has improved its superiority in compare with existing design. Accordingly, this solution can develop the fiber optic communication of Ministry of communication at the Republic of Iraq for multiple users with high bandwidth rather than a single user with low bandwidth.

Therefore, in the future, the proposed solution can be applied at any node traffic which can be terminated, managed and connected with other networks. This can be performed using other modulation formats to support any-to-any traffic, one hub station, or several Optical Add/Drop Multiplexer (OADM) nodes. Additionally, evolution on the (AWGs) is predictable to give importance to the creation of the upcoming photonic networks including OADM and Optical Cross-Connect (OXC).

References

[1] Govind P. Agrawal, *"Fiber Optic Communication Systems*", Third Edition , Wiley- Interscience ,A John Wiley & Sons, Inc. Publication, 2002.

[2]X. J. M. Leijtens, B. Kuhlow,M. K. Smit, "Arrayed waveguide gratings", DOI:10.1007/3-540-31770-8_5, University of Technology, Eindhoven.

[3] DasanMeena, Orappanpara S. Sunishkumar, Devendra C. Pande, Talabattula Srinivas, Vadake K. Jayasree, FredyFrancis,Kundil T. Sarath, and ElambilayiDipin, "A Geometrical Model for Arrayed Waveguide Grating based Optical Multiplexer/Demultiplexer", Progress In Electromagnetics Research M, Vol. 35, 87-96, 2014.

[4] J. Ingenhoff, "Athermal AWG Devices for WDM-PON Architectures", *Lasers and Electro-Optics Society (LEOS)*, 2006.

[5] H. Uetsuka, "AWG Technologies for Dense WDM Applications", IEEE J. Select. Topic Quantum Electron. Vol. 10, No. 2: 393-402, 2004.

[6] Ismahayati Adam, MohdHaniff Ibrahim , NorazanMohdKassim , Abu Bakar Mohammad, and Abu Sahmah Mohd Supa'at,"Design of Arrayed Waveguide Grating (AWG) for DWDM/CWDM Applications Based on BCB Polymer", Faculty of Electrical Engineering ,Universiti Teknologi Malaysia, *ELEKITRIKA*, Vol. 10, No. 2, 2008.

[7] Michael C. Parker, Sturat D. Walker, AugustinYiptong, and Robert J. Mears, "Applications of Active Arrayed-Waveguide Gratings in Dynamic WDM Networking and Routing", *Journal of Lightwave Technology*, Vol. 18, No. 12, 2000.

[8] Smit M. K.," Progress in AWG Design and Technology Fibers and Optical Passive Components", *Proceedings of IEEE/LEOS Workshop, Palermo, Italy*, June 22-24, 2005.

[9] Suzuki, S., and Sugita, A. "Recent Progress in Silica-Based Planar Lightwave Circuits (PLCs)", *NTT Technical Review*, Vol. 3, No. 7, July 2005.

[10] Yasin M. Karfaa, M. Ismail, F. M. Abbou1, and S. Shaari, "Evaluation of Linear Crosstalk Effects in Array Waveguide Grating Router in WDM Networks", *JOC, Seite 100*, February 2007.

[11] Salah Elfaki, Abdeen Abdel Kareem, A. B. Mohammed, and Sahbudin Shaari, "Crosstalk Enhancement in Multiplexer/Demultiplexer Based Arrayed Wavelength Grating in DWDM", Kuala Lumpur, Malaysia, *ICSE2006 Proc.* 2006.

[12] OptiSystem User Manual Reference, http://www.optiwave.com/ ,March 5,2017, 11.00AM.

[13] Rajiv Ramaswami, and Kumar N. Sivarajan", Optical Networks A Practical Perspective", 2nd Edition, Elsevier, 2002.

[14] A. Sugita, A. Kaneko, K. Okamoto, M. Itoh, A. Himeno, and Y. Ohmori, "Very Low Insertion Loss Arrayed Waveguide grating with Vertically Tapered Waveguides", IEEE Photonics Tech. Letters, Vol. 12, No. 9 : 1180-1182. 2000.

[15] Yoshinori Hibino, "An Array of Photonic Filtering Advantages: Arrayed-Waveguide-Grating Multi/Demultiplexers for Photonic Networks", *IEEE Circuits & Devices*, Vol. 16, No. 6 ,November 2000.

[16] A-Klekamp, and R. Wessel, "Influence of Phase Errors on the Spectral Response of AWG Multiplexers", *JOC, Seite 170* , May 2002.

[17] Shin Kamei, Kaneko Akimasa, Ishii Motohaya, Shibata Tomohiro, Inoue Yasuyuki, and Hibino Yoshinori, "Crosstalk Reduction in Arrayed-Waveguide Grating Multiplexer/Demultiplexer Using Cascade Connection", *Journal of Lightwave Technology*, Vol. 23 Issue 5, 2005.

[18] Lee Kwanil, Lee Sang Bae, Mun Sil-Gu, and Lee Chang Hee ,"Bidirectional ROADM using a 3×N AWG", *Conference on Lasers and Electro-Optics/Pacific Rim (CLEOPR)*, Paper: TuD4-3, 2007.

[19] Yueting Wan, and RongqingHui, "Design of WDM Cross Connect Based on Interleaved AWG

(IAWG) and a Phase Shifter Array", *Journal of Lightwave Technology*, Vol. 25 Issue 6, 2007.

[20] Ooba Naoki, Suzuki Kenya, Ishii Motohaya, Aratake Atsushi, Shibata Tomohiro, and Mino Shinji, "Compact Wide-Band Wavelength Blocker Utilizing Novel Hybrid AWG-Free Space Focusing Optics", *OSA Technical Digest (CD) ,Optical Fiber Communication Conference (OFC)* , Paper: OWI2, 2008.

[21] Kamei Shin, "Recent Progress on Athermal AWG Wavelength Multiplexer", *OSA Technical Digest (CD) ,Optical Fiber Communication Conference (OFC),* Paper: OWO1, 2009.

[22] Abd El–Naser A. Mohammed, Ahmed Nabih Zaki Rashed, and Abd El–Fattah A. Saad, "Applications of Arrayed Waveguide Grating (AWG) in Passive Optical Networks", *International Journal of Future Generation Communication and Networking* ,Vol. 2, No. 2, June 2009.

[23] Takada Kazumasa, and Hirose Tomohiro, "Phase-modulation method for AWG phase-error measurement in the frequency domain", *Optics Letters,* Vol. 34, Issue 24, 2009.

[24] Abd El–Naser A. Mohammed, Ahmed Nabih Zaki Rashed, Gaber E. S. M. El-Abyad, and Abd El–Fattah A. Saad, "High Transmission Bit Rate of Athermal Arrayed Waveguide Grating (AWG) Module in Passive Optical Networks", *(IJCSIS) International Journal of Computer Science and Information Security,* Vol. 1, No.1, May 2009.

تحليل الأداء لمازج مصفوفة الدليل الموجي بالأعتماد على شبكة ضوئية

حسين احمد علي

قسم الحاسوب ، كلية العلوم ، جامعة كركوك ، كركوك ، العراق

الملخص

ان التطور السريع في التقنيات الضوئية يحتاج الى ايجاد حلول مناسبة تمكن الشبكات للوصول الى سعة عالية. والمشكلة الرئيسية في الاتصالات الضوئية في وزارة الاتصالات في جمهورية العراق توفر عرض نطاق ترددي صغير لكل مستخدم. وقد تناولت الاعمال السابقة على تعديل خصائص (مصفوفة مازج توجيه الموجة) في مستوى التصميم. كون التصميم في الاتصالات الضوئية مكلف مما يجعل هذا الحل غير عملي او فعال. ومن اجل تطوير منظومة الاتصالات متعددت الاهداف عبر البنية التحتية الحالية. تبحث هذه الورقة على اداء العامل المخصص على مستوى المكونات. في البداية تم اجراء تحليل (مصفوفة مازج توجيه الموجة) بمعدل بيانات (٨ قنوات × ٤٠ جيجا بت في الثانية) وبطول ليف بصري (٢٤٢,٥ كم) مع ادنى حد لمحددات النظام. مع الاخذ بنظر الاعتبار وجود العناصر (الفعالة / وغير الفعالة). وقد تم اجراء التقييم باستخدام المحاكاة البرمجية الكندية (Optisystem) . ومن خلال النتائج التي اظهرتها المحاكاة ظهر ان طاقة الاشارة الداخلة تساوي (٤٠٢,٠٤ ديسيبل ميلي واط) واجمالي طاقة الاشارة الخارجة (٠,٣٥٤٥ ديسيبل ميلي واط) ومجموع الكسب (٣,٦٨٥ - ديسيبل ميلي واط) واجمالي الضوضاء الناتج هو (١,٤٢٤٨ ديسيبل ميلي واط) ومتوسط الطاقة هو (٦,٤٢٥٥- ديسيبل ميلي واط). اضافة الى ذلك تم نقل معدلات الارسال بنجاح وبكلفه واطئة ضمن متطلبات البنى التحتية. مع ضمان وجود العديد من المستخدمين على رابط نقل ضوئي واحد وتم تنفيذ عملية النقل بسرعة عالية بالإضافة الى الحد الادنى من الاخطاء. وبناء على ذلك يمكن تطبيق عملية المحاكاة على شبكات الاتصالات الضوئية الحالية باقل الكلف التصميمية والتنفيذية.