

PROCEEDINGS OF SPIE

ICPS 2013

International Conference on Photonics Solutions

**Prathan Buranasiri
Sarun Sumriddetchkajorn**
Editors

**26–28 May 2013
Pattaya City, Thailand**

Sponsored by
The Optical Society (United States)
National Electronics and Computer Technology Center (Thailand)
King Mongkut's Institute of Technology Ladkrabang (Thailand)

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Published by
SPIE

Volume 8883

Proceedings of SPIE 0277-786X, V. 8883

SPIE is an international society advancing an interdisciplinary approach to the science and application of light.

ICPS 2013: International Conference on Photonics Solutions, edited by Prathan Buranasiri, Sarun Sumriddetchkajorn,
Proc. of SPIE Vol. 8883, 888301 · © 2013 SPIE · CCC code: 0277-786X/13/\$18 · doi: 10.1117/12.2032333

Proc. of SPIE Vol. 8883 888301-1

The papers included in this volume were part of the technical conference cited on the cover and title page. Papers were selected and subject to review by the editors and conference program committee. Some conference presentations may not be available for publication. The papers published in these proceedings reflect the work and thoughts of the authors and are published herein as submitted. The publisher is not responsible for the validity of the information or for any outcomes resulting from reliance thereon.

Please use the following format to cite material from this book:

Author(s), "Title of Paper," in *ICPS 2013: International Conference on Photonics Solutions*, edited by Prathan Buranasiri, Sarun Sumriddetchkajorn, Proceedings of SPIE Vol. 8883 (SPIE, Bellingham, WA, 2013) Article CID Number.

ISSN: 0277-786X

ISBN: 9780819497451

Published by

SPIE

P.O. Box 10, Bellingham, Washington 98227-0010 USA

Telephone +1 360 676 3290 (Pacific Time) · Fax +1 360 647 1445

SPIE.org

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Printed in the United States of America.

Publication of record for individual papers is online in the SPIE Digital Library.



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Paper Numbering: Proceedings of SPIE follow an e-First publication model, with papers published first online and then in print and on CD-ROM. Papers are published as they are submitted and meet publication criteria. A unique, consistent, permanent citation identifier (CID) number is assigned to each article at the time of the first publication. Utilization of CIDs allows articles to be fully citable as soon as they are published online, and connects the same identifier to all online, print, and electronic versions of the publication. SPIE uses a six-digit CID article numbering system in which:

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Message from President of KMITL



First and foremost, I would like to extend my heartiest congratulations to the Faculty of Science at King Mongkut's Institute of Technology Ladkrabang for undertaking the responsibility to organize this International Conference on Photonics Solutions in Pattaya, Thailand.

Thailand is actually one of the countries where photonics solution themes have been studied and have a long history, and still today a significant part of the research activity on these subjects carried out by Thai researchers.

Herein this ICPS2013 conference has received a total of 47 papers from all over the world and we have invited world experts to discuss on emerging methodologies, applications and technologies in the area of photonics solutions. In the Plenary Session the keynote speakers will address the present trends of our community in the international scenario. In few words, the conference will globally give a wide overview of the most recent advances in the areas of photonics theory, design, and measurements.

I hope all distinguished guests and participants will maximize this opportunity to share knowledge on current research activities as well as establish networking, I wish everyone a very stimulating and beneficial deliberation during the three days of this conference.

On behalf of the King Mongkut's Institute of Technology Ladkrabang, I would like to thank you all authors, especially the distinguished keynote and invited speakers, for making the conference a memorable and successful gathering. Thank you the members of the Review Committee, the Chairs of the Committee, all those who have contributed to build the conference program and all persons or organizations that have supported our work in many ways and have contributed the success of ICPS2013.

Professor Tawil Paungma
President of KMITL

Message from Dean of Faculty of Science KMITL



It is my great pleasure to welcome you to the International Conference on Photonics Solutions, ICPS 2013. Indeed this event would be a platform for participants to share knowledge on current research activities as well as becoming a catalyst for collaborative work between participants.

There are also aspiring young researchers who are undergraduate and postgraduate students and sponsored by the Faculty of Science to participate in this conference. I hope they would take this opportunity to learn and gather knowledge, particularly from the renowned Professors from all over the world.

On behalf of the Faculty of Science, I would like to take this opportunity to acknowledge the contributions and efforts of all the participating universities, institutions and industries for realizing this event. Without the kind support from all of you, this conference could never be possible. I also would like to thank the ICPS 2013 organizing committees for their magnificent hard work, sacrifices and commitment towards the success of ICPS 2013. My special thanks will also be for all of the technical committee members for their diligent and untiring effort in reviewing the submissions and all the speakers and authors.

Finally I sincerely hope that all ICPS 2013 participants will have a memorable experience and a wonderful time in Pattaya, Thailand.

**Associate Professor Dusanee Thanaboripat
Dean of Faculty of Science**

Message from the Conference Chairs



It is a very great pleasure for us to welcome you on behalf of the Conference Committee, to this First International Conference on PHOTONICS SOLUTIONS (ICPS 2013). We are glad that we can have this photonics Conference in Pattaya city, Thailand.

A few years ago, we have argued to have an international conference for optics and photonics technology in Thailand. In our imagination, the technology in any regions would be potentially improved if the people in that area have concerned how much essential for their living. To bring the photonic experts together, not only shows people in that society how important of photonics but shows the experts that our society have a lot potential to improve the photonic technology as well. Making ICPS 2013 happen in Pattaya from May 26 to May 28 would be one step to drive photonic technology in our country.

Currently, optics and photonics are at the heart of new technologies in telecommunications, medicine, nanotechnology, and manufacturing etc. Solutions of many problems of science and technology by using optics and photonics approaches have been efficient. In this conference, we are grateful to have three plenary lectures who are leading photonics scientists in their fields, Prof. James C. Wyant, Prof. Toyohiko Yatagai, and Prof. Hiroshi Yoshikawa.

Personally, we want to say thank you to our friends and colleagues who have encouraged us to pursue the idea of ICPS 2013 and have supported us continuously from the very beginning of the planning of this endeavor. We are grateful to the President of the King Mongkut's Institute of Technology Ladkrabang (KMITL), Prof. Tawil Paungma, the Dean of Faculty of Science at KMITL, Assoc. Prof. Dusanee Thanaboripat, and the President of the National Electronics and Computer Technology Center (NECTEC), Dr. Pansak Siriruchatapong, who have supported us to organizing ICPS 2013. We would also like to acknowledge Optical Society of America (OSA) and Society of Photo-optical Instrumentation Engineers (SPIE) for all supports. Special thanks go to the SPIE staff for their great assistance and supports. Last but not least, we are greatly appreciated for the tremendous supports and advices from all committee members.

We believe that you will find ICPS 2013 to be a memorable and successful event. ICPS 2013 will not only be a valuable meeting for academic exchange and international cooperation, but will also provide you a good opportunity to

appreciate the enchanting natural scenery of Nong Nooch Garden Botanical Garden (Pattaya), historic Temple of The Emerald Buddha (Bangkok), and the famous panorama show Thai Alangkarn (Pattaya). We hope that you will also have an opportunity to visit other beautiful places and cities of Thailand during your post-conference tours.

Prathan Buranasiri
KMITL, Thailand
Sarun Sumriddetchkajorn
NECTEC, Thailand

Advances in Interferometric Surface Measurement

James C. Wyant*^a

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ABSTRACT

Precision optical components are essential for modern optics/photonics systems. Modern electronics, computers, and software have made it possible to greatly improve the fabrication and testing of optical components and optical systems and the resulting improvements in the new optical instruments and devices we use are evident. Until recently, a major limitation of interferometry for precision metrology was the sensitivity to the environment. In recent years techniques for performing high quality interferometric measurements in non-ideal environments have been developed. This talk discusses a technique for reducing the effects of vibration and atmospheric turbulence on interferometric measurements. The application of this technique for the measurement of surface vibration, the testing of optical components including large astronomical optics, and the measurement of deformations of diffuse structures will be described.

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Experiences Starting and Growing Optics Companies

James C. Wyant*^a

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ABSTRACT

This talk will describe some experiences gained in starting and growing two optical companies, WYKO Corporation (1984-1997) and 4D Technology (2002-present). Both companies designed, manufactured, and sold computerized interferometric systems for the measurement of surface shape and surface roughness. Founding, growing, and cashing out of WYKO was an unbelievable experience that was more fun than I ever dreamed anything could be. It was so much fun I felt I had to do it again. Both the fun parts and the not so fun parts for both WYKO and 4D will be discussed.

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Computer-generated holograms for 3D displays

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ABSTRACT

Since the performance of personal computers have become quite powerful, it is easy to calculate computer-generated holograms (CGH) for 3D displays that have more than 100 billion pixels. We have been studying various types of CGH for both video displays and printers. This talk describes principals of point oriented CGH that uses object data as a collection of self-illuminated points. Several types of computer-generated holograms and output method will be reviewed.

Keywords: Hologram, computer-generated hologram, 3D display

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Multiple-shelled Hollow Microspheres Integrated by ZnO Nanodots as UV Photodetectors for Use in Space with Omnidirectional Supersensitivity

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Abstract

We demonstrate a novel, feasible strategy on practical application of UV photodetectors using multiple-shelled hollow ZnO microspheres integrated by nanodots for space application with omnidirectional sensitivity. Due to the resonance-assisted effect by the convex shells, the microsphere devices exhibit enhanced photoresponse with photogain of $G \sim 10$. Moreover, the response and recovery speed are promoted (response/recovery times: 0.8/1.2 ms) because of the existence of junction barriers between microspheres. We also demonstrated the omnidirectional detectability and proton tolerance ability of the microsphere devices as a reliable test for space use. The concept employing multiple-shelled hollow ZnO microspheres paves a new way to realize nanostructured photodetectors using in harsh environment and space mission.

Introduction

The use of nanomaterials as photosensitive devices (PDs) has brought many advantages in terms of their operating speed, signal-to-noise ratio, and power consumption, superior to their bulk counterparts. With advances in nanotechnology, designing the “architecture” of nanomaterials becomes possible, which permits their optoelectronic properties to be further promoted. For example, nanodevices integrated in a hierarchical scheme have shown enhanced light-trapping ability and omnidirectional detectability. Such concept combining micro- and nano-scaled structures has been demonstrated in various types of optoelectronics, *e.g.*, PD, solar cells and light emitting diodes. Recently, it has also been shown that mediating the “optical resonance” within the nanostructures can be used to maximize energy-conversion efficiency *via* quantum and photon confinement; as such, nanostructures are capable of absorbing more photons than bulk materials with the same volume. This notion has been applied in the elastic scattering, extinction, light emission and Raman measurements on deep-subwavelength dielectric spheres and nanowires near natural frequencies of oscillation. For instance, through proper design, the antenna effect was experimentally demonstrated on Ge NWs at visible region, which shows excellent light-harvesting characteristics and omnidirectionality. So far, nanotechnologies have enriched our understanding of nanoscale physics and have realized many practical applications. However, it is still an endless process for the pursuit of better PDs performance, in terms of their sensitivity, spectral selectivity, response speed, and environmental stability, aimed at more complicated functionalities for specific missions (*e.g.*, space mission).

A broad range of applications of PDs are highlighted in ultraviolet (UV) region, for instance, military defense, astronomy, secure communications, as well as environmental and biological researches. Zinc oxide (ZnO), a wide band gap material (3.37 eV) with promising optoelectronic properties and environmental hardness, is an ideal candidate for such purposes. Nanomaterials based on ZnO and its hybrid relatives have drawn much attention due to their high photogain; with years of efforts, the ultrahigh photogain up to 108 has been achieved. This intriguing property of the metal-oxide nanomaterials are found to be a result of pronounced surface effects (*i.e.*, oxygen adsorption/desorption), going along with the high surface-to-volume ratio; experimentally, investigation of surface band bending pertaining to the ultrahigh photogain have been thoroughly done by both optical and electrical methods. Unfortunately, a fundamental issue accompanying the high gain is the inevitable degradation of response speed owing to the slow adsorption/desorption process.^{5,6} Strategies including network schemes, core-shell structures, electrode contacts, and surface modification, have been proposed, showing significant improvement in response speed with retention of high photogain. However, there is still a lot of room for further improvement.

In this study, we demonstrate a hierarchical scheme using multi-shelled ZnO hollow microspheres as the building blocks for UV detection that exhibit both high gain and fast speed with high absorption efficiency. The hollow microspheres are integrated by strongly light-absorbing ZnO nanodots, from which incident photon could be efficiently converted to charged carriers, whereas some of them remain trapped in nanodots, resulting in photogain. Due to the multiple convex ZnO shells, a resonance-assisted effect takes place in the spherical cavity, leading to an enhancement of photoresponse. Multiple internal reflections within the inter-shells further reduce the light escapes, resulting in highly efficient absorption and omnidirectional detectability. In addition, a network fashion enables the response and recovery speed to be promoted (response/recovery times: 0.8/1.2 ms) due to the existence of junction barriers between microspheres. In the end, we will show the results of proton bombardments as a reliable test for space uses. The multi-shelled hollow spherical geometry reported herein explores a new pathway for the next envisaged optoelectronic functionalities, energy-harvesting applications and the possibility for exploring the Universe.

Analysis OCDMA System Bit-Error-Rate using NAND Detection at Different Data Rate

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ABSTRACT

In this study, the OCDMA system is analyzed to enhance the Bit-Error-Rate (BER) performance using NAND subtraction detection technique. Enhanced Double Weight (EDW) code is used as a signature address of OCDMA system. The EDW code is enhanced version of Double Weight (DW) code family where the code weight is any odd number and greater than one with ideal cross-correlation. In order to analysis the system BER performance, we have considered both extensive theoretical analysis as well as simulation experiment at different data rate (155 Mbps and 622 Mbps). The optisystem 7.0 version is used as a simulator to simulate the system. The analyzed results ascertained that the NAND subtraction detection technique provides better BER performance as compared to well known existing technique (e.g., Complimentary). The most remarkable feature of NAND subtraction detection technique is that, this technique supports more number of active users than conventional technique under error free transmission condition (Bit-Error-Rate $\leq 10^{-9}$).

Keywords: OCDMA, Enhance double weight (EDW), Double weight (DW), NAND detection.

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1. INTRODUCTION

Optical code division multiple access (OCDMA) system is recognized as one of the most promising technologies for supporting multi users simultaneously in a shared media [1]. Due to numerous advantages the OCDMA become popular than time division multiple access (TDMA) and wavelength division multiple access (WDMA) system [2]. However, the OCDMA system still suffers from various noises such as shot noise, thermal noise, dark current and multiple access interference (MAI) from other users. Among all these noises, MAI is considered as a severe problem in communication systems. Therefore, an efficient detection scheme is of great importance for reducing the effect of MAI. Several kinds of detection techniques are available and already proposed by many researchers [3, 4, 5 and 6]. The well known detection techniques are the complimentary detection technique [3] and the spectral direct detection technique. Although, both of this detection technique has successfully reduced the MAI effect but still suffering from getting better signal quality for big number of active users, which can be considered as a big limitation of the existing detection techniques.

The Enhance Double Weight (EDW) [6] code was successfully applied in the complimentary detection technique but the problems of signal quality remain the same. In order to solve the signal quality problems, we introduce a new detection technique so called the NAND detection technique, which can suppress the MAI effect in a significant amount. We evaluated the system performance using NAND detection technique by extensive theoretical analysis as well as simulation experiment at different data rate (155 Mbps and 622 Mbps). The results in both theoretical and simulation cases show that the proposed detection technique provides better performance as compared to other well known complimentary techniques by minimizing the MAI effect significantly.

The reminder of this paper is organized as follows. The section 2 shows the principle of the NAND subtraction detection technique. The system performance analysis is shown in section 3. Theoretical and simulation results are discussed in section 4. Finally, some concluding remarks are drawn in section 5.

2. NAND SUBTRACTION DETECTION TECHNIQUE

The mobility of the digital electrons in NAND gate is three times higher than AND gate as well as NOR gate [7]. This statement refers to the digital logic gates (AND, OR, NAND). However, in our proposed system the idea of NAND is used as an operation, not as a digital gate. Considering this point of view, the authors brought the concept of the NAND subtraction technique in our study. In the NAND subtraction detection technique, the cross-correlation $\theta_{\bar{X}\bar{Y}}(K)$ is

substituted by $\theta_{(\overline{XY})Y}$, where $\theta_{(\overline{XY})}$ represents the NAND operation between X and Y sequences. For example, let $X = 1100$ and $Y = 0110$ therefore the NAND is $(\overline{XY})Y = 0010$. Figure 1 show the implementation of NAND subtraction detection technique and Table 1 shows the comparisons between complementary and NAND subtraction detection technique using EDW codes.

Table. 1 Comparison of complementary and NAND subtraction detection technique.

	Complementary Subtraction				NAND Subtraction			
	λ_1	λ_2	λ_3	λ_4	λ_1	λ_2	λ_3	λ_4
X	1	1	0	0	1	1	0	0
Y	0	1	1	0	0	1	1	0
	$\theta_{XY} = 1$				$\theta_{XY} = 1$			
	$\overline{X} = 0011$				$\theta_{\overline{XY}} = 1011$			
	$\theta_{\overline{XY}} = 1$				$\theta_{(\overline{XY})Y} = 1$			
Z	$Z = \theta_{XY} - \theta_{\overline{XY}} = 0$				$Z = \theta_{XY} - \theta_{(\overline{XY})Y} = 0$			

Note that λ_i (where i is 1, 2, ..., N) is the column number of the codes which also represents the spectral position of the chips. Therefore, MAI can be cancelled using both techniques. However, NAND subtraction detection technique can generate extra weight as shown in Table 1. This is due to the fact that when the code weight is increased, the signal power increases as well; hence, increases the signal-to-noise ratio. Therefore, The SAC-OCDMA performance is improved significantly using the NAND subtraction detection technique.

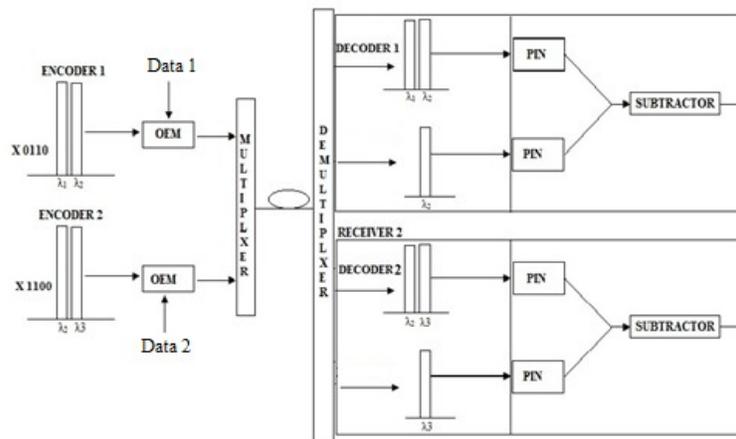


Figure 1 Implementation of NAND subtraction technique

3. PERFORMANCE ANALYSIS

This study has considered the Bit-Error-Rate (Wagner & Lemberg) and the signal-to-noise-ratio (SNR) as the system performance criterion for comparison. The effect of incoherent intensity noise (i_{PIIN}), shot noise (i_{shot}) and thermal noise ($i_{thermal}$) are considered in the system. When the incoherent light fields are mixed and incident upon a photodetector, the phase noise of the fields causes an intensity noise term in the photodetector output [8]. Gaussian approximation has been used for the calculation of BER [9] which is shown in Eq. 4.5. where $G(\nu)$ denotes the single sideband Power Spectral Density (PSD) of the thermal source. The Q-factor performance provides the qualitative description of the optical receiver performance. The performance of an optical receiver depends on the Signal-to-Noise Ratio (SNR). The Q-factor suggests the minimum SNR requirement to obtain a specific BER for a given signal [10]. The SNR of an electrical signal is defined as the average signal to noise power, $SNR = \left[\frac{I^2}{\sigma^2} \right]$, where σ^2 is the variance of noise source (note: the effect of the receiver's dark current and amplification noises are neglected in the analysis of the proposed system). The code cross-correlation properties of EDW codes using NAND operation of the detection part differs from complementary subtraction technique. In this technique, the system carried out better performance in terms of PIIN noise, shot noise, signal to noise ratio and bit error rate. The new detection technique based on EDW code properties has been demonstrated [11].

$$SNR = \frac{I^2}{\tau^2} = \frac{\frac{\Re^2 P_{sr}^2 W^2}{N^2}}{\frac{eB\Re P_{sr}}{N} [2W^2 - W] + \frac{BR^2 P_{sr}^2 KW}{N^2 \Delta v} [2W^2 - 5W + 4] + \frac{4K_b T_n B}{R_L}} \quad (1)$$

$$BER = P_e = \frac{1}{2} \operatorname{erfc} \left(\sqrt{\frac{SNR}{8}} \right) \quad (2)$$

The system performance with number of simultaneous users against various bit rates is shown in Figure 2. There are two different bit rates (BR) are taken in to this account to analyze the system performance. It clearly shows that at every bit rate NAND subtraction technique has better BER values as compared to complementary subtraction technique. Although, at high bit rate (For example 10 Gb/s) the system BER is not very good due to low power of the light source Light Emitting Diode (LED). In addition, extra amplifier can produce extra power but the system will suffer more noise and gain. Therefore, this analysis has been considered at lower bit rate (e.g: 155 Mb/s and 622 Mb/s).

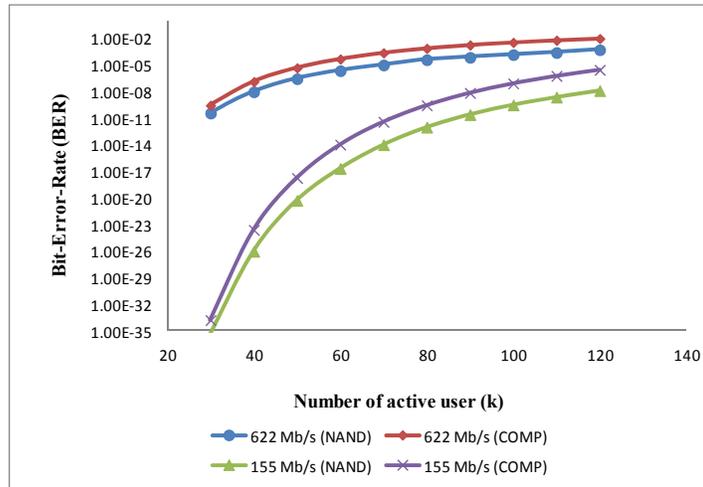


Figure 2 BER versus number of active users against different bit rate

4. SIMULATION RESULTS

A simple schematic block diagram of NAND subtraction technique consisting of three users is illustrated in Fig. 3 as an example. The simulation was carried out using simulation software, OptiSystem Version 7.0, at 155 and 622 Mb/s bit rates respectively. Each chip has a spectral width of 0.8-nm. The system insertion loss including multiplexer/demultiplexer of 0.25 dBm and 2 dBm is taken in to account. The ITU-T G.652 standard multimode optical fiber (MOF) is used. The used fiber parameters' values were taken from the data which are based on the G.652 Non Dispersion Shifted Fiber (NDSF) standard. This includes all fiber parameter such as group delay, group velocity, attenuation α (i.e., 0.25 dB/km), polarization mode dispersion (PMD, i.e., 18 ps/nm km), non linear effects such as four wave mixing (FWM) and self phase modulation (SPM), which are all wavelength dependent. All these parameters were activated during simulation. The dark current values was 5 nA and the thermal noise co-efficient was 1.8×10^{-23} W/Hz for each of the photodetectors. The generated noises at the receivers were set to be random and totally uncorrelated. The transmitting power 0 dBm was set for the broad band light source. The system performance was carried out by referring to the bit error rate. The whole simulation is specified according to the typical industrial values to simulate the real environment as close as possible. Fig. 3 shows that the incoming signal was split into two parts at the receiver side, one to the decoder that had an identical filter structure with the encoder and the other to the decoder that had the NAND filter structure. A subtractor is used for subtract the overlapping data from the desired one.

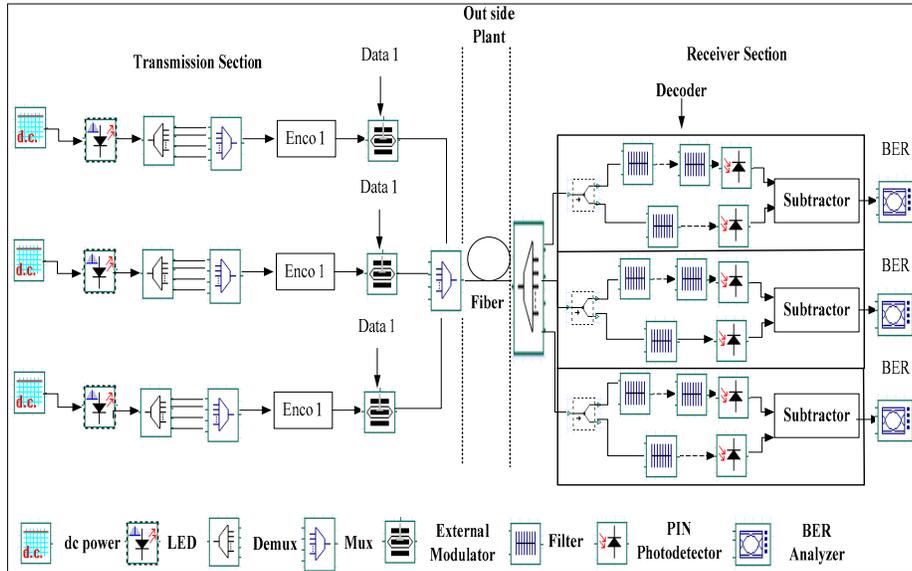


Figure 3 Simulation setup for OCDMA system using NAND technique with EDW code

As shown in Figure 4, that the result for the NAND subtraction technique shows better BER at the same bit rate as compared to that of the complementary subtraction technique. It was found that the system using NAND subtraction technique can perform excellent up to 30 km as compared to the complementary subtraction technique. Though, Complementary subtraction technique maintains standard error free transmission 10^{-10} and 10^{-12} at (622 Mb/s and 155 Mb/s) respectively. Conversely, NAND subtraction technique has very good error free transmission 10^{-17} and 10^{-15} at (622 Mb/s and 155 Mb/s bit rate). The performance of the NAND subtraction technique is evident at all rates with supportable distance to support by the conventional technique.

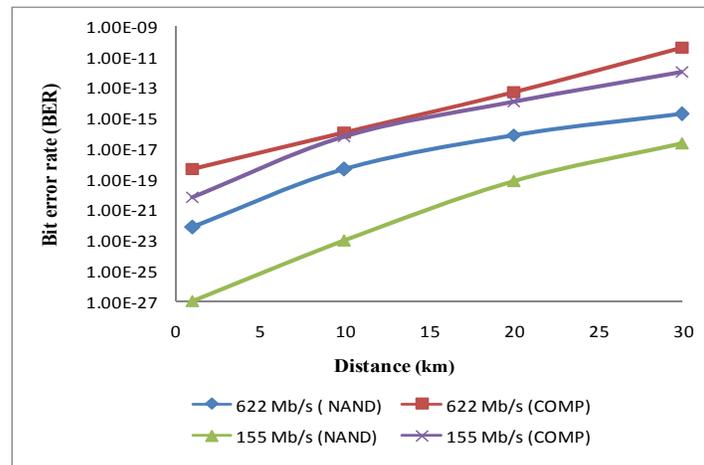


Figure 4 BER versus distance using NAND and Complementary technique at various bit rates for EDW code.

In Figure 5, 6, 7, and 8 shows the measured eye patterns at (622 Mb/s and 155 Mb/s). It clearly illustrates that the NAND subtraction technique had a better performance with a larger eye opening. The BER for the NAND and Complementary techniques were 10^{-17} Mb/s and 10^{-15} at (155 Mb/s) respectively.

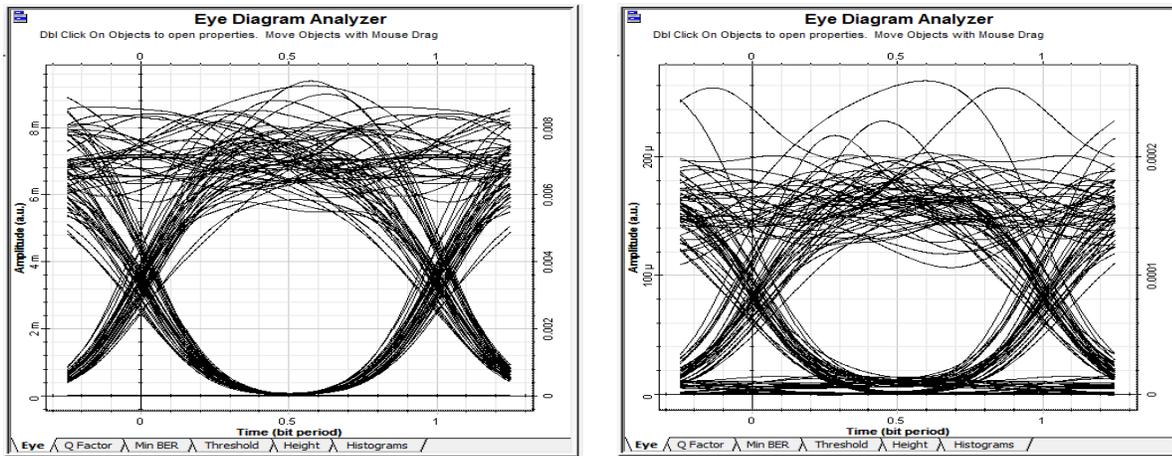


Figure 5 Eye diagram of NAND subtraction technique at (622 Mb/s) for 30 km distance

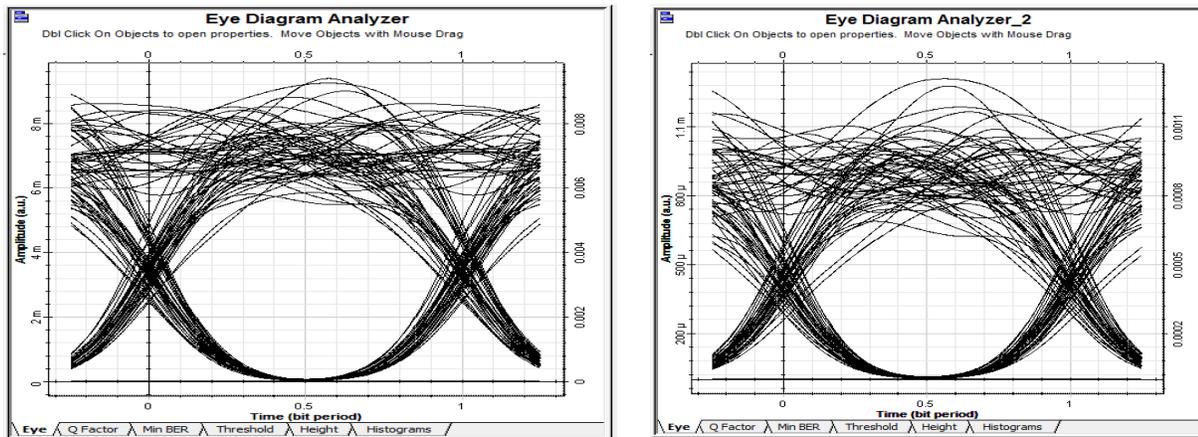


Figure 8 Eye diagram of Complementary technique at (155 Mb/s) for 30 km distance

Figure 9 shows the received power against BER for the two techniques. It is clearly shown that at both bit rate (622 Mb/s and 155 Mb/s) NAND subtraction technique received power is lower than Complementary subtraction technique. As an example, by referring to Figure 9 at a distance of 30 km, the BER and received power for (622 Mb/s) using NAND subtraction technique BER is 10^{-18} and received power about -18 dBm. At (155 Mb/s) the BER is 10^{-22} and received power -23 dBm respectively. On the other hand the complementary technique at (622 Mb/s), the BER is 10^{-12} with received power about -18 dBm. At (155Mb/s), the BER is 10^{-20} with received power about -13 dBm respectively. This analysis shows that using NAND subtraction technique the system performance is very good as compare to the complementary technique. The NAND subtraction technique has lower received power as compare to complementary technique. The results for both techniques are measured up to 30 km only, because the system cannot support longer distance at acceptable BER performance.

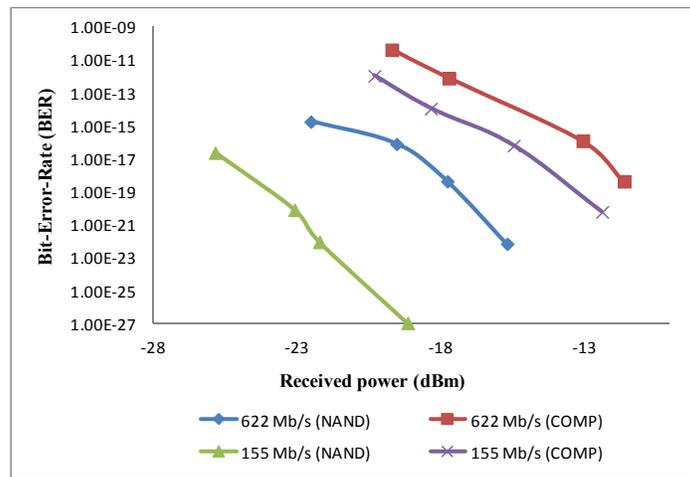


Figure 9 Received power versus BER for both techniques

5. CONCLUSION

In this paper, a new OCDMA detection technique named NAND subtraction technique has been considered for OCDMA systems to improve the BER performance. The performance of the system was carried out using EDW code. The theoretical and simulation results have proved that the new detection technique provides a better performance than the complementary techniques. It is also found that MAI and PIIN noise can be suppressed by the new detection technique. The overall system cost is low due to light source at the same time BER performance is better than

complementary technique. Thus, it can be conclude that this system would be better choice for future OCDMA technology for all optical access network.

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