

Laser measured rate equations with various transmission coders for optimum of data transmission error rates

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ABSTRACT

The present study has outlined laser-measured rate equations with various transmission coders for optimum data transmission error rates. Various modulation transmission coders are employed, such as a pulse position modulation coder, a differential pulse intensity modulation coder, and a four band/five band modulation transmission coder, in order to create optimized data rates of up to 40 GB/s for a fiber extension length of up to 100 km. This study has emphasized the important role of pulse position modulation transmission coders, which exhibit superior performance in max. Q parameter and min. data error rates, even for high data rate transmission

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1. RELATED WORKS

Heterojunctions juxtapose two different doping or bandgap semiconductor materials [1-3]. They are used in the fabrication of many solid-state devices, including transistors, photodetectors, and solar cells, to name a few. They were first used in 1969–70 to reduce the threshold current density in injection lasers [1-4]. However, a double heterojunction structure was used to reduce the lasing threshold current by a factor of approximately 100. This is one of the effects of the confinement of the resulting carrier, which is expressed by the optical confinement factor [5-7]. Many recent studies have been interested in the application of heterojunctions in vertical-cavity surface-emitting lasers and have investigated their electrical characteristics [8-10]. Typically, heterojunctions are made on either side of a thin active layer, and both carriers and light are confined. This reduces the losses of both, and consequently, the laser oscillation threshold is significantly reduced [11, 12]. In forward bias, the positive side of the heterojunction structure connects to the positive terminal, and vice versa [13-17]. The heterojunction's structure also reduces the defects in the lattice between the two layers, at which missing or dangling bonds may be formed, such as misfit dislocations or inclusions. These defects lead to nonradiative recombination, which reduces quantum device efficiency [18-21]. Therefore, it is recommended that heterojunctions should not have a lattice parameter mismatch greater than 0.1% [22-30].

2. MODEL DESCRIPTION AND RESEARCH METHODS

The data source generates a stream bit sequence of 10101100 and the bits stream is encoded/configured through different transmission coders and through the non-return to zero code pulse

generator. These used transmission coders include a pulse position modulation (PPM) transmission coder, a differential pulse intensity modulation (DPIM) transmission coder, and a four band/five band (4B5B) coder. The encoded signal is then forwarded to the light source with a frequency of 1550 nm, a test temperature of 27°C, and a reference temperature of 20°C. The encoded bits are used for a transmission coder of two bits per symbol. The VCSEL, which is measured by laser, converts the electrical coded signal to the light signal. The internal modulated signal is then forwarded to the fiber-optic cable length of 100 km.

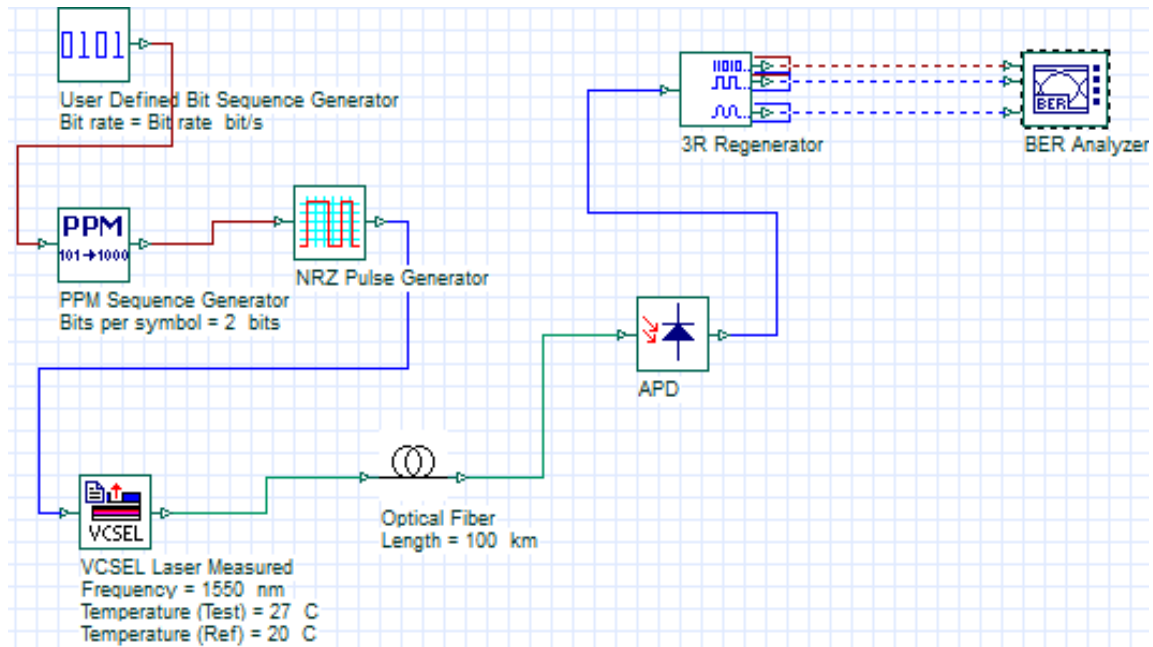


Figure 1. VCSEL measured with the laser model for the pulse coders

The light signal is then directed from the fiber-optic cable to the light avalanche detector in order to convert it to the electrical signal form. The signal is retimed/regenerated/reshaped with three operation generators, and the maximum quality factor coefficient and minimum data rate error are detected through the data error rate analyzer.

3. PERFORMANCE ANALYSIS WITH DISCUSSIONS

Figures 2 and 3 indicate the max. Q parameter and the minimum data error rate value estimation based on the pulse position modulation transmission coder. The max. Q parameter achieved a value of 4.05, and the minimum data error rates achieved a value of 2.1×10^{-5} . Figures 4 and 5 clarify the max. Q parameter value estimation based on the differential pulse intensity modulation (DPIM) transmission coder. The max. Q parameter value achieved a value of 1.784, and the minimum data error rates achieved a value of 0.03198.

The max. Q parameter and minimum data error rate values were estimated based on a four band/five band modulation transmission coder, as shown in Figures 6 and 7, where the Max. Q parameter achieved a value of 3.16 and the minimum data error rates achieved a value of 7.59×10^{-4} . Figure 8 shows the relation between the maximum Q coefficient factor parameters, with an available propagation distance range of up to 100 km. The negative effects can be observed in the increasing propagation distance and the signal transmission quality, and the PPM transmission coder has performed better than other transmission coders.

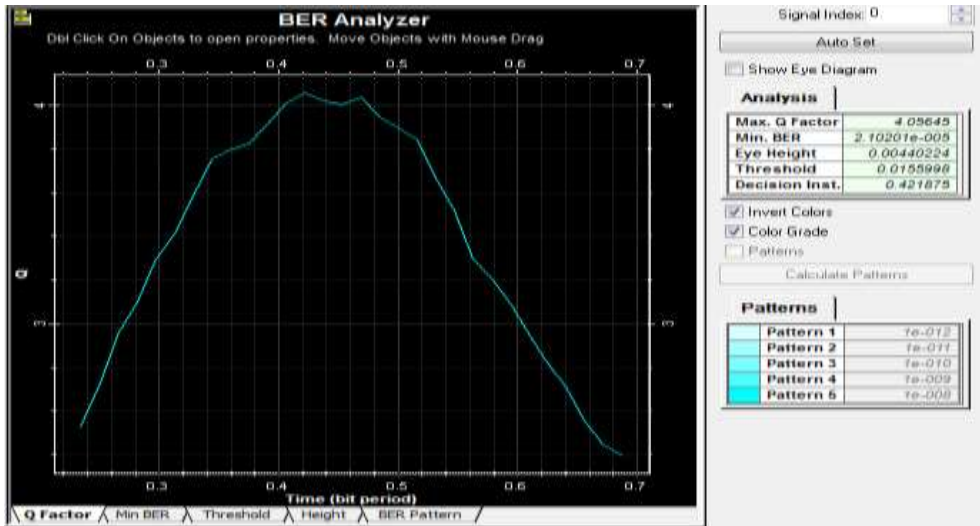


Figure 2. Max. Q parameter value estimation based on the pulse position modulation transmission coder

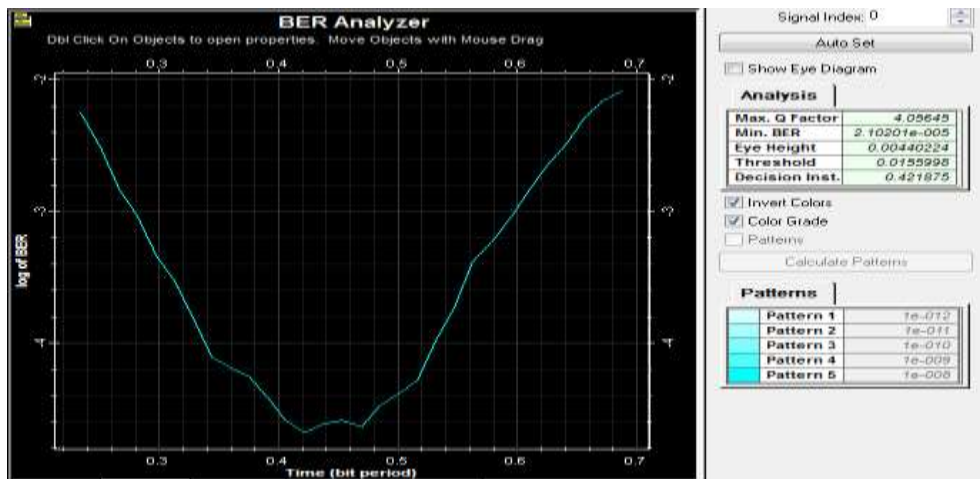


Figure 3. Min. data error rates value estimation based on the pulse position modulation transmission coder

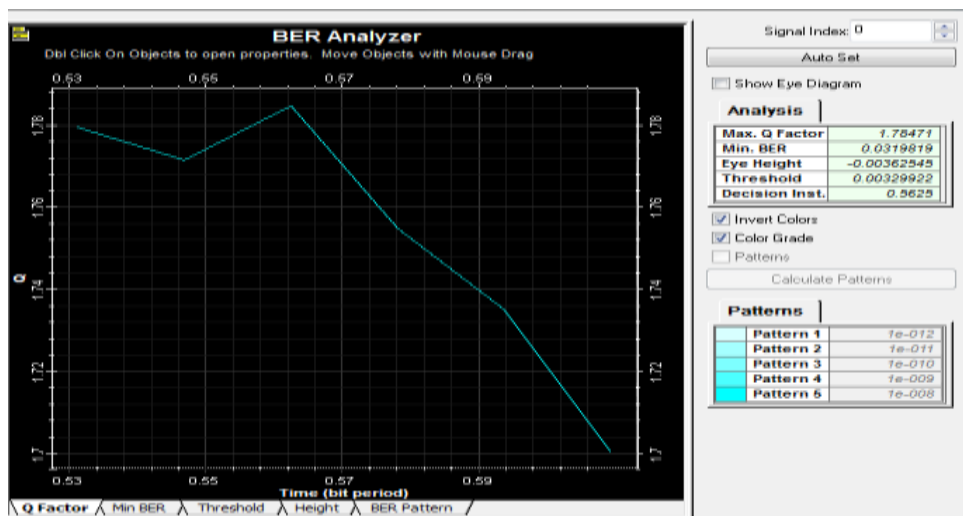


Figure 4. Max. Q parameter value estimation based on the DPIM transmission coder

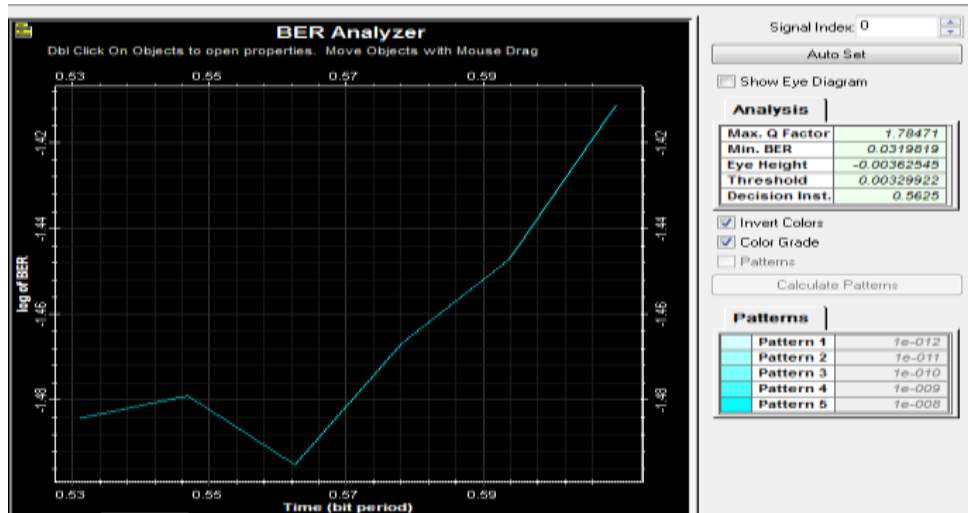


Figure 5. Min. data error rate value estimation based on the DPIM transmission coder

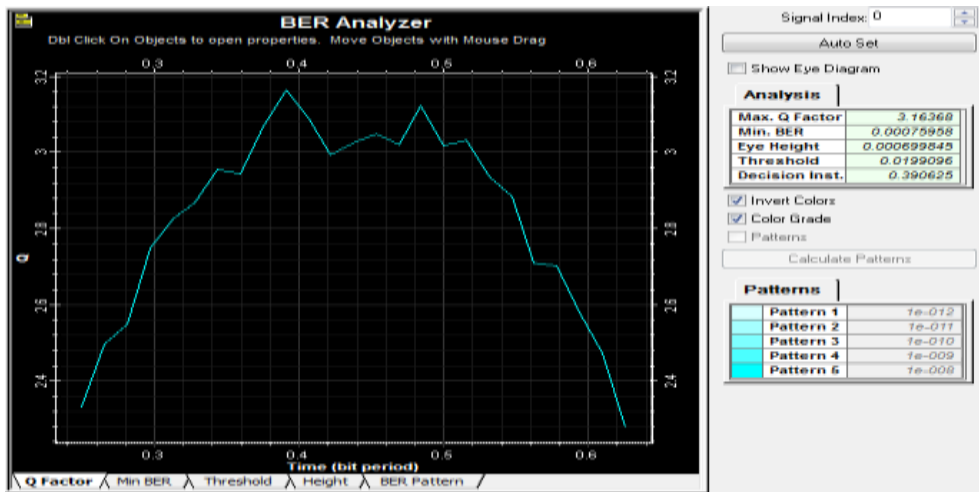


Figure 6. Max. Q parameter value estimation based on the 4B5B modulation transmission coder

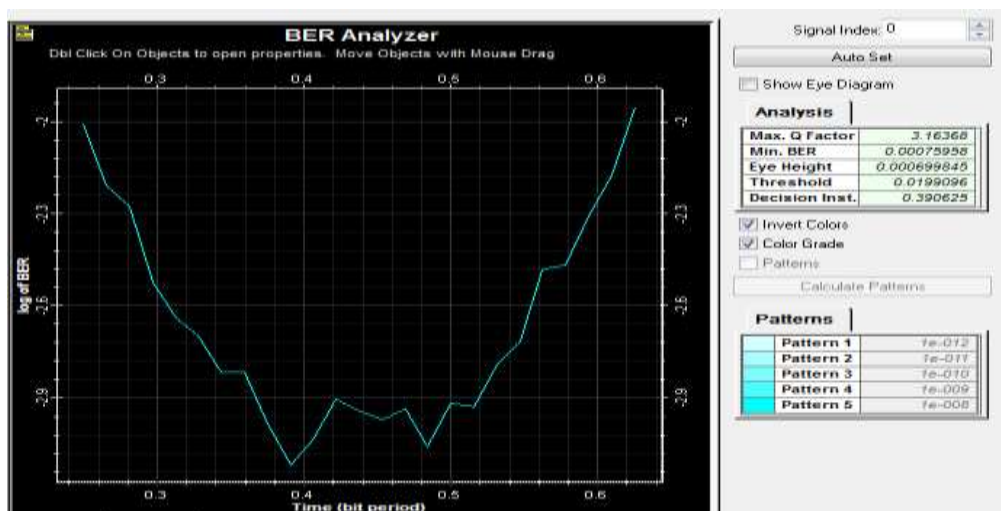


Figure 7. Min. data error rate value estimation based on the 4B5B modulation transmission coder

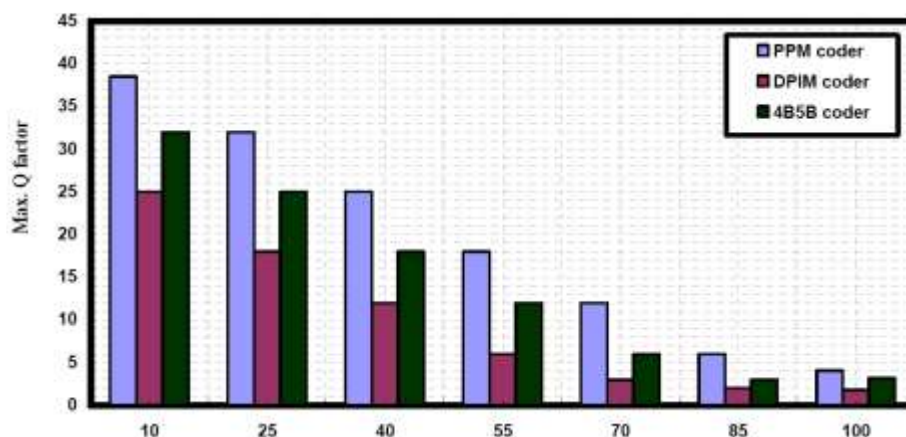


Figure 8. Maxim Q coefficient variations versus propagation distance variations for various transmission coders

4. CONCLUSION

In summary, the laser-measured rate equations with various transmission coders are simulated to ensure optimal data transmission error rates. Different transmission pulse coders are employed to enhance the system performance efficiency. It can be observed that the pulse position modulation coder has presented a 17.65% higher enhancement percentage ratio in its Q-value than the 4B5B modulation transmission coder. The PPM transmission coder also outlined a 36.98% higher enhancement percentage ratio in its Q-value than the DPIM transmission coder. Therefore, it can be concluded that the PPM transmission coder is the best candidate for a transmission pulse coder for high data rate transmission in fiber-optic systems.

REFERENCES

- [1] Ahmed Nabih Zaki Rashed, "Optical Network Management and Its Performance Evaluation for Both Future Cost Planning and Triple Play Solutions," *Wireless Personal Communications Journal, Springer Publisher*, vol. 75, no.4, pp. 2005-2020, April 2014.
- [2] Ahmed Nabih Zaki Rashed, Mohamed A. Metwae'e, "Optical Filters Dimensions and Thermal Operation Conditions Impact on Its Transmission Considerations in Near Infrared (NIR) Optical Spectrum Transmission Region," *Optoelectronics and Advanced Materials Journal– Rapid Communications*, vol. 8, no. 3-4, p. 175-184, March-April 2014.
- [3] Christopher J. Stapels, et al., "CMOS Based Avalanche Photodiodes for Direct Particle Detection," *Nuclear Instruments and Methods in Physics Research A*, vol. 579, no. 1, pp. 94–98, Aug. 2007.
- [4] A. Pulvirenti, et al., "Characterization of Avalanche Photodiodes (APDs) for the Electromagnetic Calorimeter in the ALICE Experiment," *Nuclear Instruments and Methods in Physics Research A*, vol. 596, no. 1, pp. 122-125, Oct. 2008.
- [5] S. Naghizade, S. M. Sattari-Esfahlan, "Excellent Quality Factor Ultra-Compact Optical Communication Filter on Ring-Shaped Cavity," *Journal of Optical Communications*, vol. 40, no. 1, pp. 21-25, Jan. 2019.
- [6] Y. Hou, H. Tao, F. Hou, "Modified Periodic Encoder for Increasing Pulse Height in PON Monitoring System," *Journal of Optical Communications*, vol. 40, no. 1, pp. 27-30, Jan. 2019.
- [7] A. Yousuf, Najeed-Ud-Din Hakim "Investigation on Chirping induced performance degradation in Single Mode Directly modulated 1.55um DFB laser," *Journal of Optical Communications*, vol. 40, no. 1, pp. 31-36, Jan. 2017.
- [8] C.-C. Kao, et al., "The Lasing Characteristics of GaN Based Vertical Cavity Surface Emitting Laser With AlN–GaN and Ta₂O₅ –SiO₂ Distributed Bragg Reflectors," *IEEE Photon. Technol. Lett.*, vol. 18, no. 7, pp. 877–879, 2006.
- [9] S.-K. Wang, et al., "Optically Pumped GaN Based Vertical Cavity Surface Emitting Lasers: Technology and Characteristics," *Jpn. J. Appl. Phys.*, vol. 46, no. 8B, pp. 5397–5407, 2007.
- [10] T.-C. Lu, et al., "CW Lasing of Current Injection Blue GaN Based Vertical Cavity Surface Emitting Laser," *Appl. Phys. Lett.*, vol. 92, no. 14, pp. 1–3, 2008.
- [11] Ahmed Nabih Zaki Rashed, et al., "Transmittivity/Reflectivity, Bandwidth, and Ripple Factor Level Measurement for Different Refractive Index Fiber Grating Shape Profiles," *Journal of Optical Communications*, Published Online: 6 Feb. 2019, <https://doi.org/10.1515/joc-2018-0233>.
- [12] Ahmed Nabih Zaki Rashed, et al., "DWDM Channel Spacing Effects on the Signal Quality for DWDM/CWDM FTTx Network," *Journal of Optical Communications*, Published Online: 7 Feb. 2019, <https://doi.org/10.1515/joc-2019-0012>.

- [13] Ahmed Nabih Zaki Rashed, et al., "Numerical Analysis of Optical Properties Using Octagonal Shaped Photonic Crystal Fiber," *Journal of Optical Communications*, Published Online: 8 Feb. 2019, <https://doi.org/10.1515/joc-2019-0013>.
- [14] Ahmed Nabih Zaki Rashed, et al., "Different Graded Refractive Index Fiber Profiles Design for the Control of Losses and Dispersion Effects," *Journal of Optical Communications*, Published Online: 19 Feb. 2019, <https://doi.org/10.1515/joc-2019-0036>.
- [15] Ahmed Nabih Zaki Rashed, "Comparison between NRZ/RZ Modulation Techniques for Upgrading Long Haul Optical Wireless Communication Systems," *Journal of Optical Communications*, Published Online: 19 Feb. 2019, <https://doi.org/10.1515/joc-2019-0038>.
- [16] IS Amiri, et al., "Interaction between Optical Sources and Optical Modulators for High-Speed Optical Communication Networks," *Journal of Optical Communications*, Published Online: 15 March 2019, <https://doi.org/10.1515/joc-2019-0041>.
- [17] IS Amiri, et al., "Effects of Order Super Gaussian Pulses on the Performance of High Data Rate Optical Fiber Channel in the Presence of Self Phase Modulation," *Journal of Optical Communications*, Published Online: 5 April 2019, <https://doi.org/10.1515/joc-2019-0039>.
- [18] IS Amiri, et al., "Mathematical Model Analysis of Dispersion and Loss in Photonic Crystal Fibers," *Journal of Optical Communications*, Published Online: 5 April 2019, <https://doi.org/10.1515/joc-2019-0052>.
- [19] IS Amiri, et al., "Basic Functions of Fiber Bragg Grating Effects on the Optical Fiber Systems Performance Efficiency," *Journal of Optical Communications*, vol. 0, issue 0, Published Online: 5 April 2019, <https://doi.org/10.1515/joc-2019-0042>.
- [20] IS Amiri, et al., "Nonlinear Effects with Semiconductor Optical Amplifiers," *Journal of Optical Communications*, Published Online: 12 April 2019, <https://doi.org/10.1515/joc-2019-0053>.
- [21] IS Amiri, et al., "High-Speed Light Sources in High-Speed Optical Passive Local Area Communication Networks," *Journal of Optical Communications*, vol. 0, issue 0, Published Online: 20 April 2019, <https://doi.org/10.1515/joc-2019-0070>.
- [22] IS Amiri, et al., "Spatial Continuous Wave Laser and Spatiotemporal VCSEL for High-Speed Long Haul Optical Wireless Communication Channels," *Journal of Optical Communications*, Published Online: 24 April 2019, <https://doi.org/10.1515/joc-2019-0061>.
- [23] IS Amiri, et al., "Average Power Model of Optical Raman Amplifiers Based on Frequency Spacing and Amplifier Section Stage Optimization," *Journal of Optical Communications*, vol. 0, issue 0, Published Online: 4 May 2019, <https://doi.org/10.1515/joc-2019-0081>.
- [24] IS Amiri, et al., "Temperature effects on characteristics and performance of near-infrared wide bandwidth for different avalanche photodiodes structures," *Results in Physics*, vol. 14, September 2019, <https://doi.org/10.1016/j.rinp.2019.102399>.
- [25] IS Amiri, Ahmed Nabih Zaki Rashed, "Simulative study of simple ring resonator-based brewster plate for power system operation stability," *Indonesian Journal of Electrical Engineering and Computer Science*, vol. 16, no. 2, pp. 1070-1076, November 2019, DOI: 10.11591/ijeecs.v16.i2.pp1070-1076.
- [26] IS Amiri, et al., "Comparative Simulation Study of Multi Stage Hybrid All Optical Fiber Amplifiers in Optical Communications," *Journal of Optical Communications*, Published Online: 4 Feb. 2020, <https://doi.org/10.1515/joc-2019-0132>.
- [27] IS Amiri, et al., "Optical Communication Transmission Systems Improvement Based on Chromatic and Polarization Mode Dispersion Compensation Simulation Management," *Optik Journal*, vol. 207, April 2020, <https://doi.org/10.1016/j.ijleo.2019.163853>.
- [28] Ahmed Nabih Zaki Rashed, et al., "Distributed Feedback Laser (DFB) for Signal Power Amplitude Level Improvement in Long Spectral Band," *Journal of Optical Communications*, vol. 0, issue 0, Published Online: 2 April 2020, <https://doi.org/10.1515/joc-2019-0252>.
- [29] IS Amiri, et al., "Analytical Model Analysis of Reflection/Transmission Characteristics of Long-Period Fiber Bragg Grating (LPFBG) by Using Coupled Mode Theory," *Journal of Optical Communications*, Published Online: 2 April 2020, <https://doi.org/10.1515/joc-2019-0187>.
- [30] IS Amiri, et al., "Conventional/Phase Shift Dual Drive Mach-Zehnder Modulation Measured Type Based Radio over Fiber Systems," *Journal of Optical Communications*, Published Online: 14 April 2020, <https://doi.org/10.1515/joc-2019-0312>.

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