# Vertical cavity surface emitting laser for 1.3 and 1.55µm transmission windows

Numan Kifayat, Muhammad Ishaq, Dr. Khurram Aziz, Adnan khan

**Abstract**— Vertical cavity surface emitting laser (VCSEL) was used for optical data transmission of 2.5Gbps at 1.55µm through an optical link of 50km and 100km with specific temperatures of 20°C and 80°C.On the other hand, 3Gbps at 20°C and 5Gbps at 80°C were transmitted through an optical link of 15km and 50km respectively for 1.3µm wavelength. The results were simulated and VCSEL effects were analyzed at different data rates and specific temperatures, and variations were observed for these specific temperatures. This work was performed and simulated at OPTI-SYSTEM with the help of Eye Diagram analyzer.

**Index Terms**— 1.3µm and 1.55µm, VCSEL, OPTI-SYSTEM, Eye diagram analyzer, BER, SNR, Dispersion.

## 1 Introduction

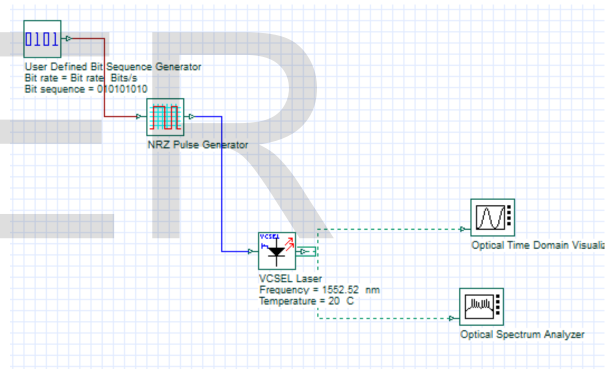
VCSEL main performance parameters are modulation bandwidth, temperature and the type of materials that are used for the manufacturing of VCSEL which affects the Output Power $P_0$.The modulation bandwidth affects the transmission through an optical link. The modulation bandwidths at 1.3µm & 1.55µm wavelengths have been of great interest for energy efficient and error free transmission [1, 2]. Now, the other parameter i-e temperature also affects the output power of VCSEL, that as when the temperature rises, it generally reduces the Output Power $P_0$ [3, 4]. The type of material used like Wafer fused InAlGaAs/InP-AlGaAs/GaAs [4] and InP [5] for manufacturing also affects the VCSEL Output er $P_0$.However, in this paper we have used the available VCSEL in OPTI-SYSTEM software for our work. Firstly, we used VCSEL at the 1.55µm wavelength for optical data transmission of 2.5Gbps through an optical link of 50km & 100km with temperature of 20°C and similarly the same procedure was carried out for 80°C with the help of our designed optical fiber communication system in OPTI-SYSTEM[6]. Then, VCSEL was operated at 1.3µm for optical data transmission of 3Gbps at 20°C through and optical link of 15km and 50km respectively, along with VCSEL's operation at the same wavelength of 1.3 µm for optical data rate transmission of 5Gbps at 80°C through an optical link of 15km and 50km [6]. Though, before doing transmission through our designed optical communication system we checked the VCSEL's Output Power $P_0$ at 1.55µm which was 1.4mW at 20°C and 0.84mW at 80°C on Optical Spectrum Analyzer.

## 2 Simulation Layout

### 2.1 VCSEL behavior with varing temperature

In this section we show the simulation layout of VCSEL behavior with varying temperature.

Fig: 1. Simulation layout of VCSEL for varying temperature




If we change the temperature then the output power of VCSEL gets reduced.

### 2.2 Layout of 1.3µm and 1.55µm transmission window

In this design we varied the temperature along with changing the optical fiber length without changing the data rate and observed different results as demonstrated in the section 3.

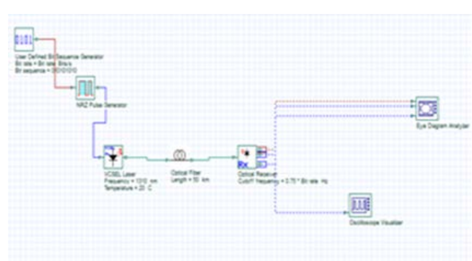


Fig: 2. Simulation layout of 1.3µm transmission window

• *Numan Kifayat is a postgraduate in Electrical engineering from Comsats institute of information technology, Pakistan. E-mail: p096312@nu.edu.pk*
• *Muhammad Ishaq is currently pursuing master's degree program in Electrical engineering in Comsats institute of information technology, Pakistan. E-mail: p096309@nu.edu.pk*
• *Adnan khan is currently pursuing master's degree program in Electrical engineering in Comsats institute of information technology, Pakistan. E-mail: p096307@nu.edu.pk*
• *Dr. Khurram Aziz is Assistant Professor in Electrical Engineering.E-mail: khurram.aziz@comsats.edu.pk*

ISSN 2229-5518

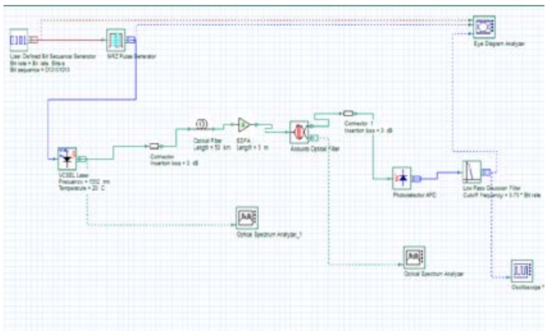


Fig: 3. Simulation layout of 1.55μm transmission window

For the layout of 1.55μm we changed the data rate as well along with changing the temperature of VCSEL, and Fiber length.

## 3 Results and Discussions

For 1.55 μm data rate was kept constant, though distance and temperature effects were analyzed by changing the source operating temperature and distance of an optical link. Figure: 4 shows the Eye Diagram of 2.5Gbps data rate transmitted over the optical link of 50km at 20°C.The openness and the greater eye's height shows the better results of output Signal to Noise ratio(SNR) giving a minimum BER. Though, Figure: 4 depict the Eye diagram of same data rate of 2.5Gbps at 20°C but through an optical link of 100km.The thickness of Eye in Figure: 4 shows that through a longer distance of 100km dispersion has been introduced which causes Inter Symbol Interference(ISI) though the SNR has not been degraded that much. Figure: 5 is the graphical demonstration of optical data rate of 2.5Gbps transmitted over an optical link of 50km but at 80°C.As we can clearly see at the figure that with the increase in temperature from 20°C to 80°C introduces sufficient dispersion hence creating multiple eyes because of temperature effects on the source also degrading the output SNR as height or openness of Eye has been reduced to some extent. The same optical data rate transmission at 80°C but through an optical link of 100km further degrades the output parameters performance of an Eye as shown in Figure: 5.That with increase in link's distance from 50km to 100km at 80°C introduces more dispersion creating multiple eyes compared to optical link of 50km at 80°C.It should be cleared that from Figure: 4 to 5 is the optical data transmission at operating wavelength of 1.55μm [6].

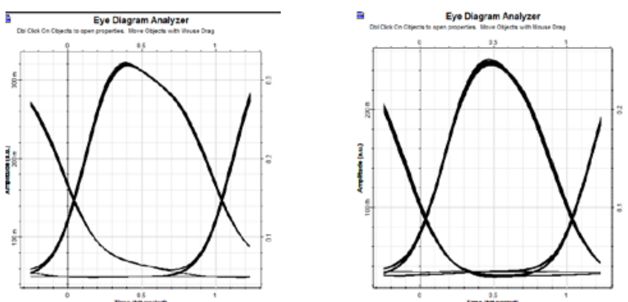


Fig: 4. 2.5Gbps, 20°C, 1.55μm-50km, 100km

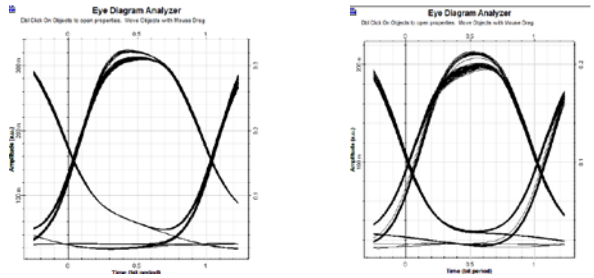


Fig: 5. 2.5Gbps, 80°C, 1.55μm-50km, 100km

Now, we will mention and discuss the results of optical data rate transmission at 1.3μm operating wavelength. Starting with Figure: 6 we maintained the data rate and operating temperature constant, though changed the optical link's distance. However in Figure: 7 we increased the data rate from 3Gbps to 5Gbps along with the change in operating temperature. Figure: 6 shows the optical data rate transmission of 3Gbps through an optical link of 15km at 20°C.The eye diagram at Figure: 6 shows that there is better output SNR and minimum dispersion depicted by openness and one compact individual eye. The higher Output SNR decreases the BER. Figure:6 is the optical data rate depiction of 3Gbps transmitted through an optical link of 50km at 20°C.The eye of Figure: 6 shows that there is sufficient acceptable output SNR and minimum dispersion but there is a little decrease in output SNR as the eye's height has been reduced a little and that's because of increase in optical link's distance to 50km compared to 15km .The eye of Figure:7 shows the optical data rate transmission of 5Gbps through an optical link of 15km but at 80°C .The increase in data rate from 3Gbps to 5Gbps has reduced the output power decreasing output SNR, increasing the BER. And the increase in temperature from 20°C to 80°C has induced intra-model dispersion as depicted by the thickness and creation of multiple copies but a little closely space within one same eye. In Figure:7 optical link's distance is also increased from 15km to 50km keeping the data rate and temperature constant. It is observed that increase in link's distance further degrades the output parameters such as Output Power and SNR [6].

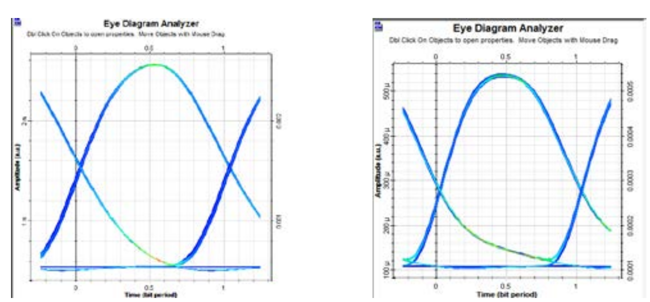


Fig: 6. 3Gbps, 20°C, 1.3μm-15km, 50km

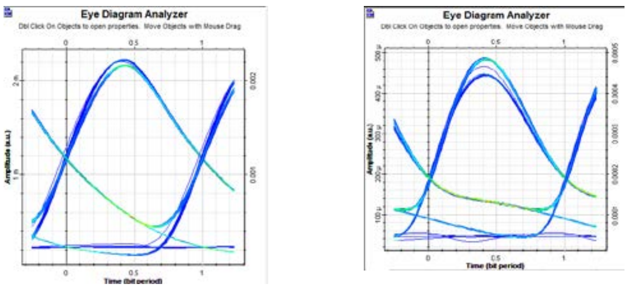



Fig: 7. 5Gbps, 80°C, 1.3μm-15km, 50km

## Conclusion

We successfully demonstrated the optical data rate transmission of 2.5Gbps at 1.55μm through an optical link of 50km and 100km with specific temperatures of 20°C and 80°C.On the other hand, 3Gbps at 20°C and 5Gbps at 80°C was transmitted through an optical link of 15km and 50km respectively for 1.3μm wavelength using VCSEL with the help of simulation of our designed optical fiber communication system in OPTI-SYSTEM.

## Acknowledgement

We thank Dr.Khurrum Aziz for motivating and sharing his expertise with us.



## References

[1] Silvia Spiga, Michael Müller, Markus-Christian Amann, "Energy-Efficient High-Speed InP-based 1.3 μm Short-Cavity VCSELs" Mo.B2.3, ICTON 2013.

[2] Zaineb Al-Qazwini, Jingjing Zhou, and Hoon Kim," 1.5-μm 10-Gb/s VCSEL Link for Optical Access Applications" IEEE PHOTONICS TECHNOLOGY LETTERS, VOL. 25, NO. 22, pp.2160-2163 NOVEMBER 15, 2013.

[3] G. Knowles, Robin Fehse, Stanko Tomic´, Stephen John Sweeney, T. E. Sale, Alfred R. Adams, *Fellow,* Eoin P. O'Reilly, G. Steinle, and H. Riechert, " Investigation of 1.3-μm GaInNAs Vertical-Cavity Surface-Emitting Lasers (VCSELs) Using Temperature, High Pressure, and Modeling Techniques" IEEE JOURNAL OF SELECTED TOPICS IN QUANTUM ELECTRONICS, VOL. 9, NO. 5, pp.1202-1208 SEPTEMBER/OCTOBER 2003.

[4] A.Caliman*, A.Mereuta*, V.Iakovlev**, P.Royo*, G.Suruceanua*, A.Syrbu** and E.Kapon*" 1.3 and 1.5 μm Wavelength Wafer Fused InAlGaAs/InP - AlGaAs/GaAs VCSELs with High Single Mode Output Power" Lasers and Electro-Optics, 2007 and the International Quantum Electronics Conference CLEOE-IQEC 2007.

[5] Nobuhiko Nishiyama, Catherine Caneau and Chung-En Z ah," 1.3 and 1.5μm InP-based Vertical Cavity Surface Emitting Lasers" Photonics Technology Letters, IEEE (Volume: 17, Issue: 10) Oct. 2005.

[6] Mi-Ran Park, O-Kyun Kwon, Won-Seok Han, Jong-Hee Kim, Sadg-Hee KO Park, and Hyun-Woo Song, Ki-Hwang Lee, Seong-Joo Park, and Byueng-Su Yo0," All-Monolithic InAlGaAs/InP VCSELs for 1.3 - 1.5μm Wavelength Ranges" Optical Fiber Communication Conference, 2005. Technical Digest. OFC/NFOEC (Volume: 4) March 2005.