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# Fixed scattering section length with variable scattering section dispersion based optical fibers for polarization mode dispersion penalties

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**ABSTRACT**

This study has clarified the fixed scattering section length with variable scattering section dispersion based optical fibers for polarization mode dispersion penalties at high data rates. The max signal power/min. noise power is simulated against time after fiber length of 500 km with various scattering section dispersion. The overall total light power is simulated after fiber length of 500 km with various scattering section dispersion. In addition to the overall total electrical power is clarified through APD receiver at fiber length of 500 km with various scattering section dispersion. Eye diagram analyzer for signal quality is also simulated through APD receiver at fiber length of 500 km with various scattering section dispersion. The max Q factor, electrical signal power after APD receiver variations against scattering section dispersion variations for various data rates.



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## 1. INTRODUCTION

Polarization mode dispersion (PMD) in optical channels has been a critical factor limiting high-speed data transmission over long distances in optical networks. PMD is a source of inter symbol interference (ISI) and its impact increases with the transmission data rate [1-5]. Since economical adaptive compensation schemes are currently unavailable, it is essential to characterize this impairment to completely understand its impact and develop effective countermeasures [6-10].

Optical fiber impairments are critical factors limiting high-speed data transmission over long distances in optical communication networks. Impairments in the channel caused by chromatic dispersion and transmission loss have a direct impact on the reach of a network or the quality of transmission at higher bit rates and narrowly spaced channels/the presence of PMD in optical fibers is one of the main factors limiting the capability of a channel to transport high-speed data [11-16]. PMD reduces the reach of networks, and the increased regeneration requirements of optical signals result in expensive network designs [17-22].

To compensate for the degradation in the optical signal caused by these effects the signal may require reconstruction and regeneration over the length of transmission [23-25]. The receiver section detects the optical signal, and the modulated information is recovered. The performance of such a typical optical network configuration is primarily a function of the system components and the transmission media [26-35].

## 2. MODEL DESCRIPTION AND RESEARCH METHOD

Figure 1 clarifies the data bit stream sequences can be encoded with the return to zero coding which represent the first input electrical encoded signal for the electro optic $LiNbO_3$ modulators. The second input to the modulators is from the continuous wave laser. The third input is the encoded RZ scheme for the bit stream sequence. The laser frequency is 195 THz, laser power is 5 dBm. The modulated signal reaches to the optical fiber medium.

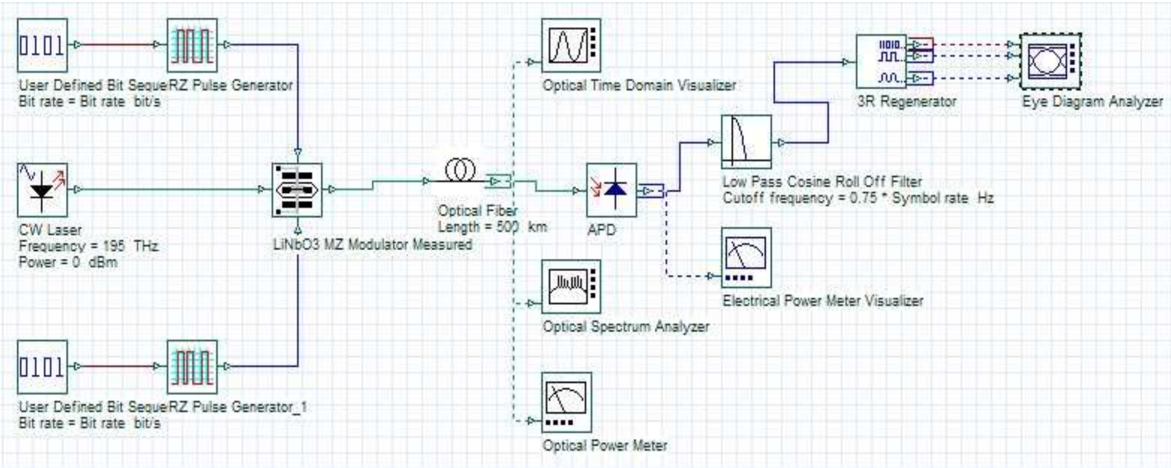


Figure 1. Model simulation description for the study

The optical fiber has a length of 500 km, mean scattering section length of 10000 m, average scattering section dispersion of 50 m, attenuation of 0.2 dB/km. The optical power versus spectral frequency and time domain are measured. The overall total light power is also measured by optical power meter. The light signal can be converted to the electrical signal by avalanche photodiode (APD) receiver. All the unwanted high frequency signals and ripples can be eliminated by low pass bessel filter. The max Q factor and min. BER can be evaluated and measured by eye diagram analyzers.

## 3. PERFORMANCE ANALYSIS WITH DISCUSSIONS

The overall total light power is simulated after fiber length of 500 km with various scattering section dispersion. In addition to the overall total electrical power is clarified through APD receiver at fiber length of 500 km with various scattering section dispersion. Eye diagram analyzer for signal quality is also simulated through APD receiver at fiber length of 500 km with various scattering section dispersion. The max Q Factor, electrical signal power after APD receiver variations against scattering section dispersion variations for various data rates. Figures 2-4 clarify the max signal power/min. noise power against time after fiber length of 500 km with various scattering section dispersion. Figure 2 shows the max signal power/min. noise power against time after fiber length (500 km) with scattering section dispersion of 10 m. Where the max signal power is 0.0012824 W, min. noise power is -6.1 x $10^{-5}$ W. Figure 3 indicates the max signal power/min. noise power against time after fiber length (500 km) with scattering section dispersion of 50 m. Where the max signal power is 0.0012663 W, min. noise power is -6.0298 x $10^{-5}$ W. Figure 4 clarifies the max signal power/min. noise power against time after fiber length (500 km) with scattering section dispersion of 100 m. Where the max signal power is 0.0012532 W, min. noise power is -5.9674 x $10^{-5}$ W. It is indicated that the increase of scattering section dispersion, this results in the decrease of the max signal power.

Figure 5 show the max signal power/min. noise power against spectral wavelength after fiber length (500 km) with scattering section dispersion of 10 m, 50 m, 100 m. The study emphasized the max signal power is -6.55966 dBm and min. noise power is -90.254 dBm at all values of scattering section dispersion. So the max signal power/min. noise power are the same values at all values of scattering section dispersion. Figure 6 illustrates the overall total light power after fiber length (500 km) with scattering section dispersion of 10 m, 50 m, 100 m. The optical power is 296.172 µW or -5.285 dBm at all values of scattering section dispersion. So the optical power is the same values at all values of scattering section dispersion.

Figure 7 demonstrates the overall total electrical power through APD receiver at fiber length (500 km) with scattering section dispersion of 10 m, 50 m, 100 m. The electrical power is 2.356 µW or -26.279

dBm at all values of scattering section dispersion. So the electrical power is the same values at all values of scattering section dispersion.

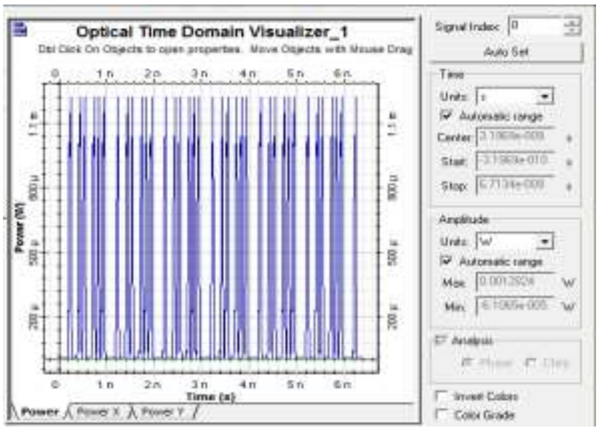


Figure 2. Max signal power/min noise power against time after fiber length (500 km) with scattering section dispersion of 10 m

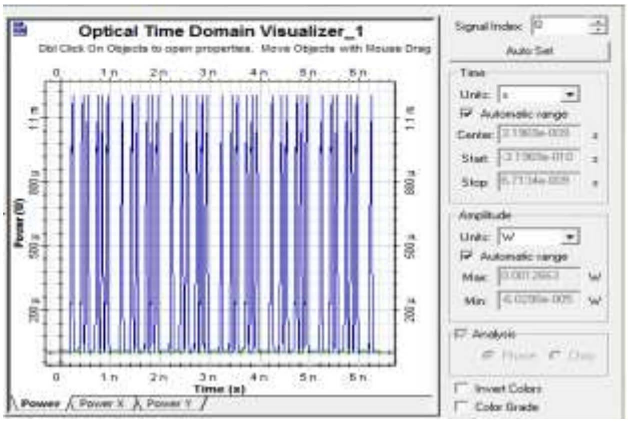


Figure 3. Max signal power/min noise power against time after fiber length (500 km) with scattering section dispersion of 50 m

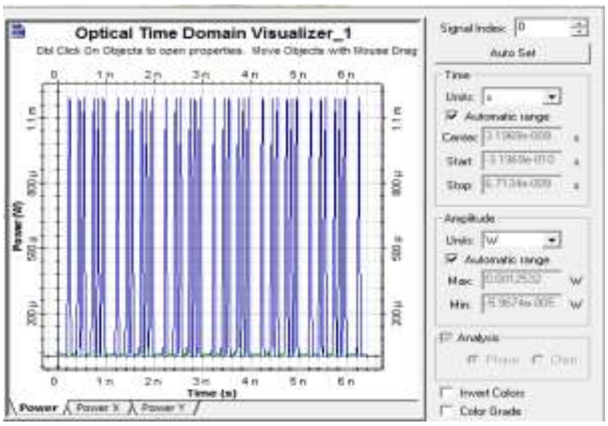


Figure 4. Max signal power/min. noise power against time after fiber length (500 km) with scattering section dispersion of 100 m

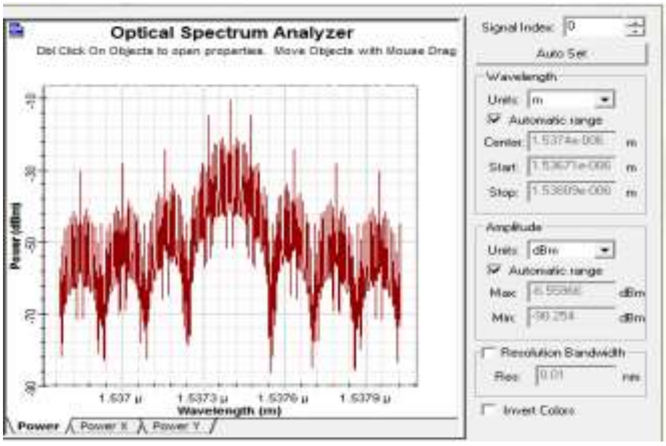


Figure 5. Max signal power/min noise power against spectral wavelength after fiber length (500 km) with scattering section dispersion of 10 m, 50 m, 100 m


Figure 6. Overall total light power after fiber length (500 km) with scattering section dispersion of 10 m, 50 m, 100 m


Figure 7. Overall total electrical power through APD receiver at fiber length (500 km) with scattering section dispersion of 10 m, 50 m, 100 m

Figures 8-10 illustrate the eye diagram analyzer for signal quality through APD receiver at fiber length (500 km) with various scattering section dispersion. Figure 8 clarifies the eye diagram analyzer for signal quality through APD receiver at fiber length (500 km) with scattering section dispersion of 10 m. Where the max Q Factor is 279.592, min. bit error rate tends to zero. Figure 9 indicates the eye diagram analyzer for signal quality through APD receiver at fiber length (500 km) with scattering section dispersion of 50 m. Where the max Q Factor is 282.513, min bit error rate tends to zero. In addition to Figure 10 demonstrates the eye diagram analyzer for signal quality through APD receiver at fiber length (500 km) with scattering section dispersion of 100 m. Where the max Q Factor is 284.682, min bit error rate tends to zero. The max Q factor is upgraded with the increase of the scattering section dispersion. This is the reason that with the higher the scattering section dispersion, the lower bit rate and consequently the higher signal quality factor.

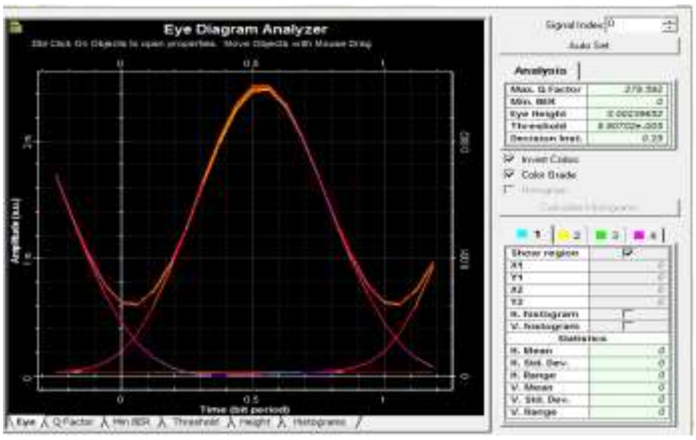


Figure 8. Eye diagram analyzer for signal quality through APD receiver at fiber length (500 km) with scattering section dispersion of 10 m

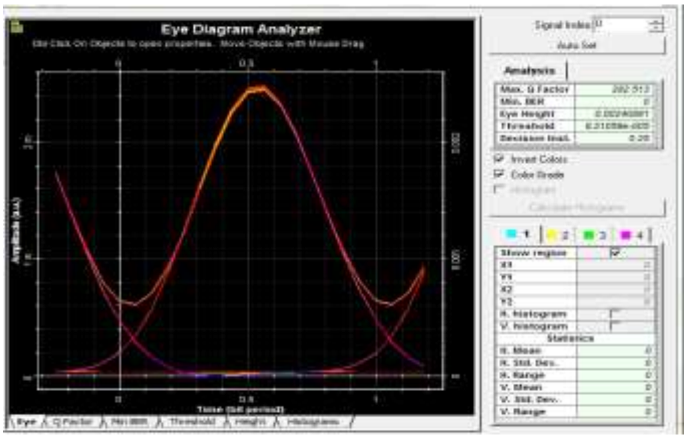


Figure 9. Eye diagram analyzer for signal quality through APD receiver at fiber length (500 km) with scattering section dispersion of 50 m

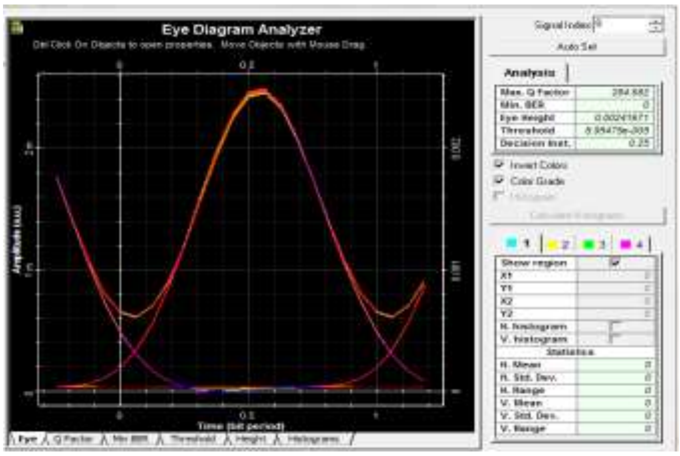


Figure 10. Eye diagram analyzer for signal quality through APD receiver at fiber length (500 km) with scattering section dispersion of 100 m

Figure 11 shows the max Q Factor variations versus scattering section dispersion variations for various data rates. The max Q factor is 279.5, 165, 106, 76, 15.39 at 10 Gb/s, 40 Gb/s, 100 Gb/s, 160 Gb/s, 250 Gb/s respectively at 10 m scattering section dispersion. The max Q factor is 282.5, 168, 109, 78, 17.22 at 10 Gb/s, 40 Gb/s, 100 Gb/s, 160 Gb/s, 250 Gb/s respectively at 50 m scattering section dispersion. While the max Q factor is 284.65, 171, 112, 80, 19.87 at 10 Gb/s, 40 Gb/s, 100 Gb/s, 160 Gb/s, 250 Gb/s respectively at 100 m scattering section dispersion. The max Q factor is 287, 174, 115, 82, 21.2 at 10 Gb/s, 40 Gb/s, 100 Gb/s, 160 Gb/s, 250 Gb/s respectively at 150 m scattering section dispersion. Moreover the max Q factor is 290, 177, 118, 84, 23.7 at 10 Gb/s, 40 Gb/s, 100 Gb/s, 160 Gb/s, 250 Gb/s respectively at 200 m scattering section dispersion. The max Q factor is 292.85, 180, 121, 87, 25.767 at 10 Gb/s, 40 Gb/s, 100 Gb/s, 160 Gb/s, 250 Gb/s respectively at 250 m scattering section dispersion. The results emphasized that the higher the scattering section dispersion the high the max Q factor.

Figure 12 demonstrates the electrical signal power after APD receiver variations versus scattering section dispersion variations for various data rates. The electrical power is 2.356 µW, 1.5 µW, 1.365 µW, 1.186 µW, 1 µW at 10 Gb/s, 40 Gb/s, 100 Gb/s, 160 Gb/s, 250 Gb/s respectively at 10 m scattering section dispersion. The electrical power is 2.354 µW, 1.427 µW, 1.341 µW, 1.1 µW, 0.965 µW at 10 Gb/s, 40 Gb/s, 100 Gb/s, 160 Gb/s, 250 Gb/s respectively at 50 m scattering section dispersion. While the electrical power is 2.352 µW, 1.367 µW, 1.322 µW, 1.0765 µW, 0.654 µW at 10 Gb/s, 40 Gb/s, 100 Gb/s, 160 Gb/s, 250 Gb/s respectively at 100 m scattering section dispersion. The electrical power is 2.35 µW, 1.315 µW, 1.297 µW, 1.0113 µW, 0.527 µW at 10 Gb/s, 40 Gb/s, 100 Gb/s, 160 Gb/s, 250 Gb/s respectively at 150 m scattering section dispersion. Moreover the electrical power is 2.348 µW, 1.286 µW, 1.278167 µW, 0.956583 µW, 0.354 μW at 10 Gb/s, 40 Gb/s, 100 Gb/s, 160 Gb/s, 250 Gb/s respectively at 200 m scattering section dispersion. The electrical power is 2.346 μW, 1.282 μW, 1.256667 μW, 0.901833 μW, 0.181 μW at 10 Gb/s, 40 Gb/s, 100 Gb/s, 160 Gb/s, 250 Gb/s respectively at 250 m scattering section dispersion. The results emphasized that the higher the scattering section dispersion the slightly lower the electrical signal power at APD receiver.

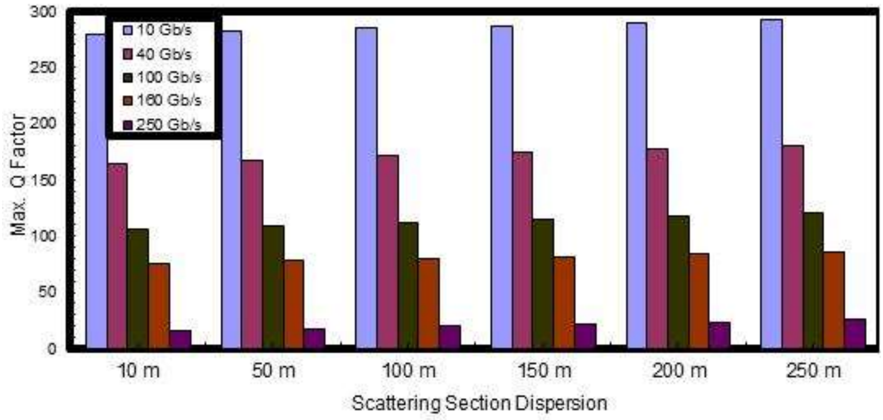


Figure 11. Max Q Factor variations versus scattering section dispersion variations for various data rates

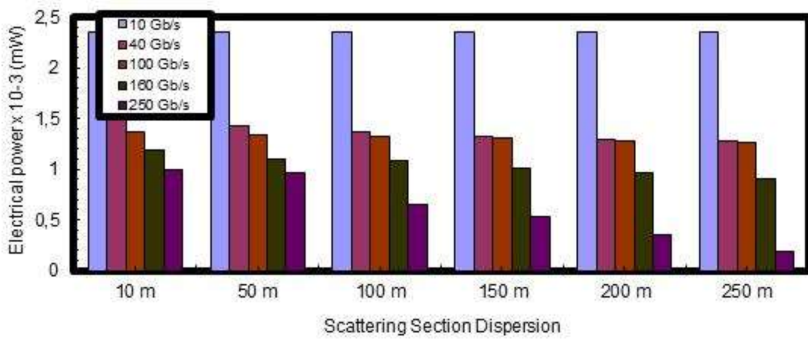


Figure 12. Electrical signal power after APD receiver variations versus scattering section dispersion variations for various data rates

## 4. CONCLUSION

The fixed scattering section length with variable scattering section dispersion have been simulated based optical fibers for polarization mode dispersion penalties at high data rates. The max Q factor, electrical power variations for various scattering section dispersion and data transmission rates have been clarified. The higher the scattering section dispersion the slightly lower the electrical signal power at APD receiver. It is emphasized that the higher the scattering section dispersion the high the max Q factor can be achieved. The max signal power/min noise power against time has been simulated after fiber length of 500 km with various scattering section dispersion. The higher the scattering section dispersion, the lower max signal power. So it is recommended to operate at 10 m scattering section dispersion with transmission rate of 40 Gbps.

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