P38

Temperature Dependence of Polarization Mode Dispersion

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Introduction

Polarization mode dispersion (PMD) becomes a very important transmission parameter with the increasing bit rates above 2.5 Gbps. Nowadays, the transport networks use very high speed systems up to 100 Gbps. PMD limits for such networks are very strict and it is necessary to measure this parameter because of its impact on signal degradation [1].
In general, PMD leads to the OSNR (Optical Signal to Noise Ratio) and BER (Bit Error Rate) degradation. PMD is the spectral mean value of DGD (Differential Group Delay) indicated in ps (see Figure 1). Properties of the PMD consist of the anisotropic features of the optical fibers - non-symmetrical fiber geometry, stretch between core and coating, micro or macro bending etc. On the other hand, the next factor which has an important impact on the PMD value is temperature change [2].

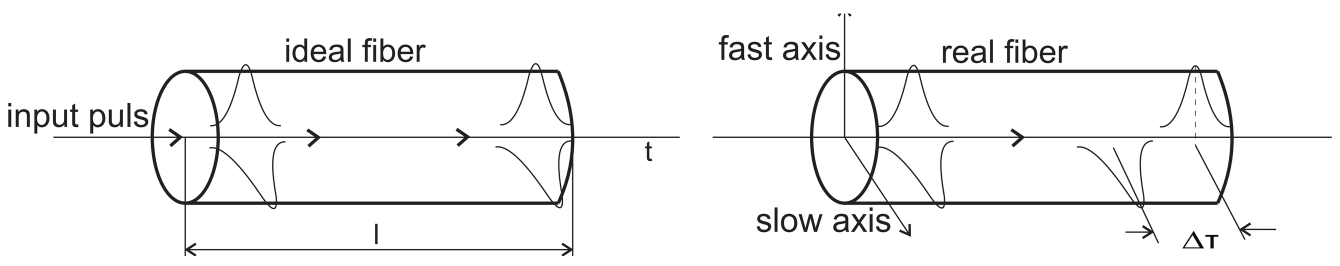
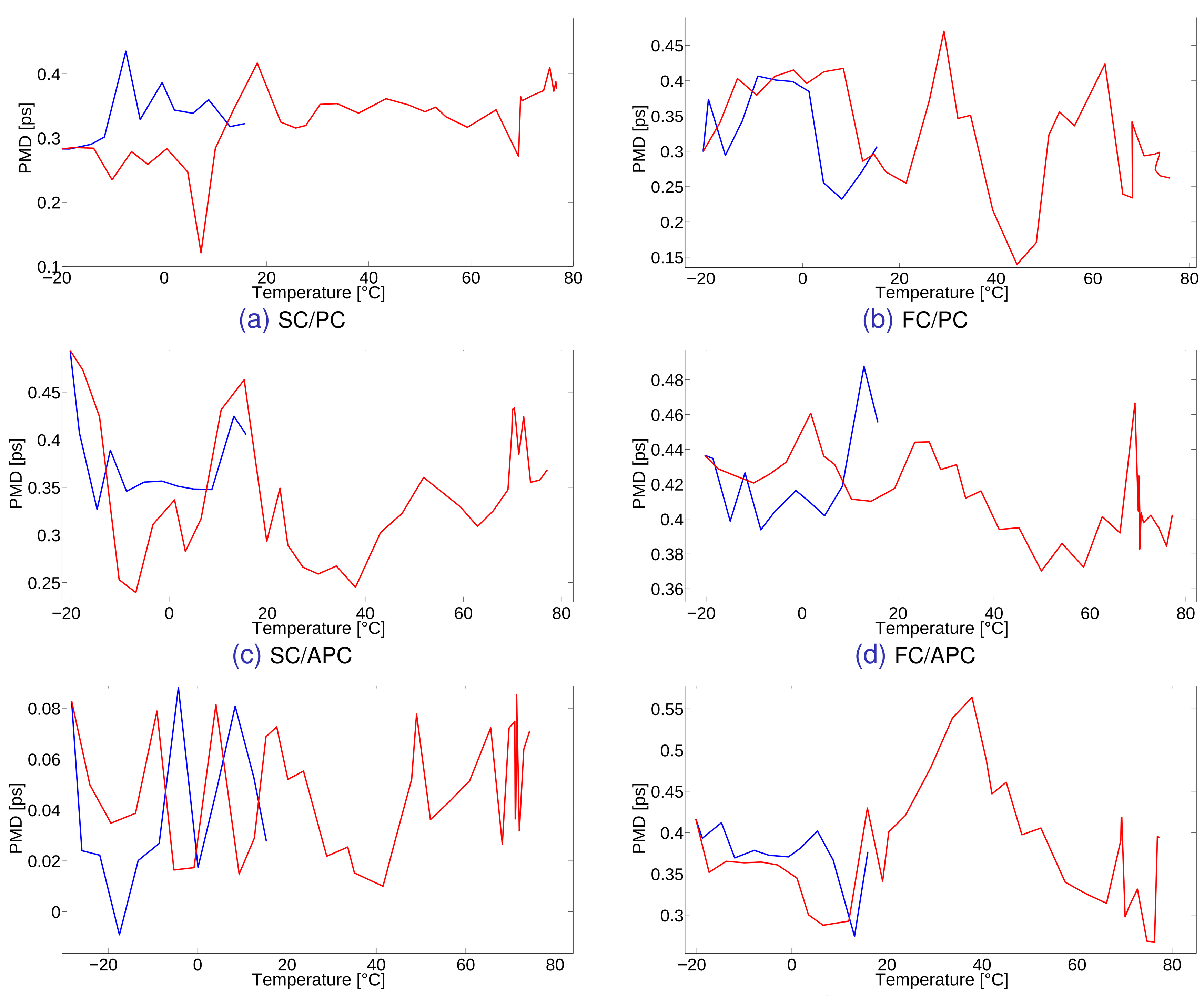


Fig. 1 : Pulse distortion due to PMD

Climatic conditions in the different countries may be completely different and large temperature differences could occur. Therefore, we have performed the measurement of PMD dependence on the temperature change and analyzed the results. We have also carried out the measurement of the temperature effect to the individual polarization planes using polarization multiplex, which could be an effective way for PMD elimination in future optical networks.

Experimental set-up and results for PMD dependence

Optical distribution networks consist of optical fibers and many other passive components with different temperature dependence on PMD. Thus, we have tested optical connectors SC and FC with both PC and APC ferule types, 1 km of an optical fiber G.652.D and planar optical splitter with splitting ratio 1:8.



(a) SC/PC (b) FC/PC (c) SC/APC (d) FC/APC (e) 1 km of G.652.D (f) Planar splitter 1:8

Fig. 2 : PMD dependence on temperature for passive optical components

For temperature change the thermo-controlled box was used. Each test took 12 hours and GINTY (Generalized Interferometric Method) method was used for PMD measurement. The results are shown in Figure 2. The blue curves are adequate to cooling from 20 °C to -20 °C and red curves are adequate to warming from -20 °C up to 80 °C. The maximum amplitude was measured for optical connector FC/PC - 0.337 ps. All measurements confirmed the stochastic character of PMD. It is not possible to find any linear or exponential characteristic of PMD dependence on the temperature, nevertheless if the surrounding temperature is changing, the maximal value of the PMD is changing rapidly. The results show that an optical fiber is the most sensitive passive component in terms of PMD dependence on the temperature (see Figure 2e).

Experimental set-up and results for Polarization multiplexing

In the next part of measurement, we have tested an influence of the temperature on state of polarization (SOP) in standard telecommunication optical fiber G.652.D. The aim of this measurement was to find out how the temperature will rotate with polarization. We have used testbed shown in Figure 3 for this measurement.

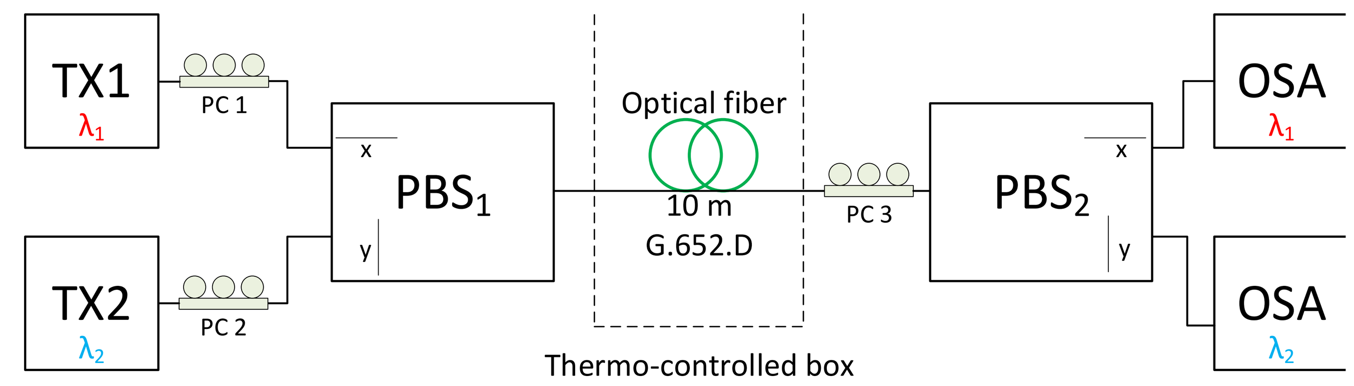


Fig. 3 : Testbed set-up

As a test sample the 10 m long patchord situated in thermo-controlled box was used. Surrounding temperature was set to 20 °C. For easier evaluation by optical spectral analyzer (OSA), two lasers tuned on different wavelengths (TX1≈1550.1 nm and TX2≈1552.2 nm) were used. Each optical signal was adjusted by polarization controller (PC) and multiplexed by polarization beam splitter PBS_1. Multiplexed signal passed the thermo-controlled box and then was demultiplexed by PBS_2. PC3 was used to obtain an ideal spacing between demultiplexed signals (23.22 dB).

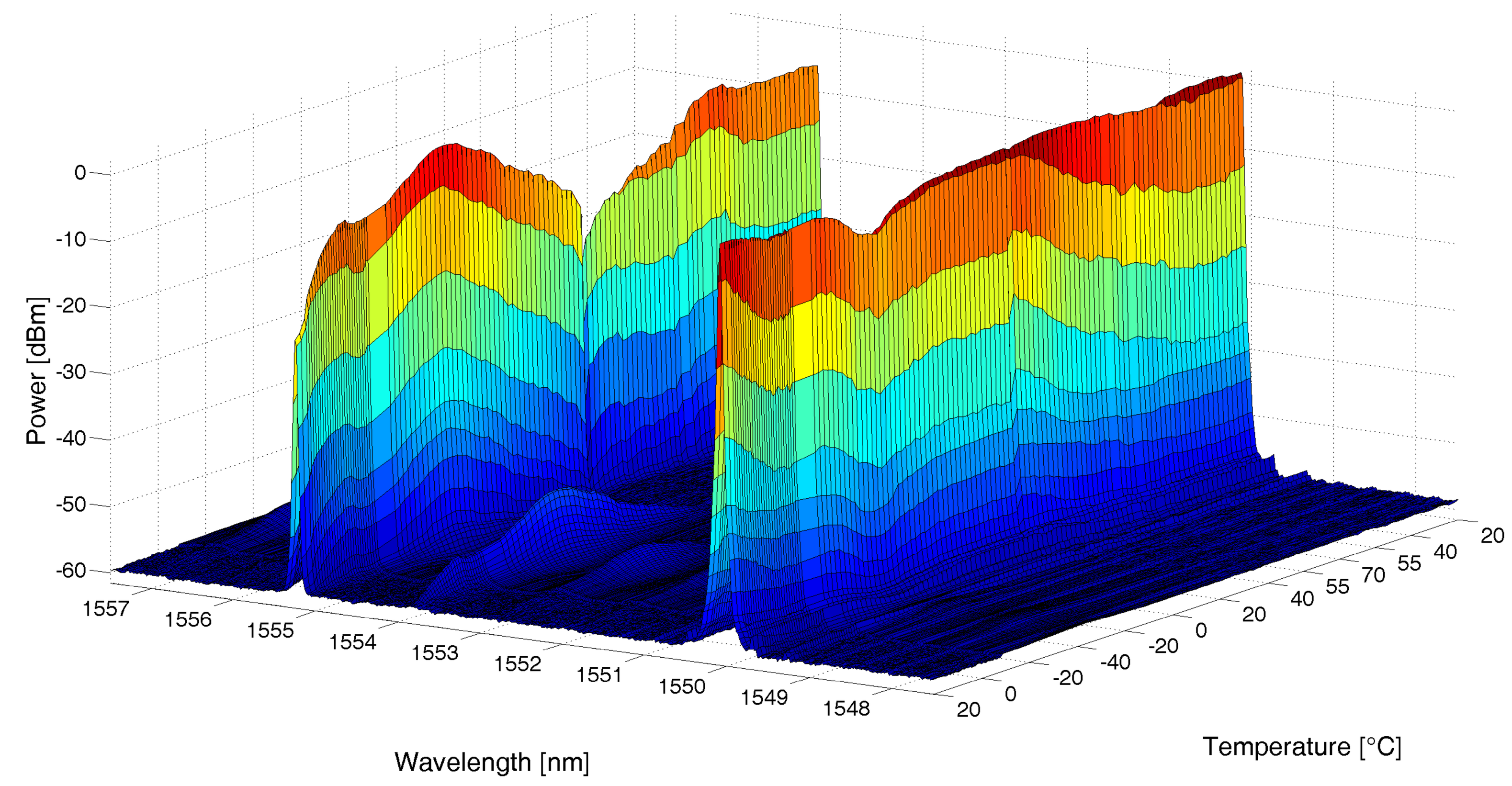


Fig. 4 : Spatial representation of SOP dependence on the temperature

Measurement was divided into the two parts. In the first part the fiber was cooled from 20 °C to -40 °C and then in the second part it was warmed up to 70 °C. The wavelength 1550.1 nm is adequate to monitored output λ_1. The results are shown in figure 4. It is clear that state of polarization in optical fiber is more sensitive to cooling than warming. In case of cooling, the majority of the energy from one polarization plane was transformed to the second one, i.e. polarization planes have rotated.

Conclusion

Polarization mode dispersion is a very important transmission parameter with negative effect on signal degradation. We have demonstrated the influence of negative and positive temperatures on PMD and SOP changes. State of polarization is changing very slowly with surrounding temperature. Therefore, the polarization multiplexing technique could be a suitable way for PMD elimination in the future optical networks.

Acknowledgments

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References

[1] Ramaswami, R.; Sivarajan, K.; Sasaki, G.: Optical Networks: A Practical Perspective, 3rd Edition. San Francisco, CA, USA: Morgan Kaufmann Publishers Inc., 2009, ISBN 0123740924.
[2] Filka, M. Optoelectronics for telecommunications and informatics. 1. Dallas USA: OPTOKON METHODE ELECTRONIC, 2010. 398 p. ISBN: 978-0-615-33185-0.