Conclusion

Polarization Mode Dispersion induces polarization dependent propagation. Consequently, it generates a multiple imaging of the light pulse carrying the information. Its first order appears as a dual path-fading channel of Maxwellian statistics. It results in harmful impairments that prevent the upgrade and installation of high bit-rate systems. The random process PMD exhibits a strong frequency dependence, so that its amelioration requires channel by channel, non-linear, adaptive mitigation. Electronic mitigation appears as a very attractive solution to overcome the limit set by the PMD. The cost efficient integrability and the global signal processing capabilities of such techniques make them even more interesting.

Consequently, we considered the implementation of these solutions at the receiver in the electrical domain. We verified that these linear and non-linear equalization techniques greatly reduce the power penalty due to PMD. Equalization's performance depends highly on the type of systems considered. For the two main types of systems: thermal noise limited systems and systems exhibiting ASE (systems using optical amplifiers), we demonstrated and quantified the induced improvement (measured as power penalty reduction). The most sophisticated technique that we considered (NLC+FDE) handles any kind of first order PMD within a 4 dB margin in the thermal noise limit. This extended to an 11 dB margin in the presence of ASE. Lower power penalty bounds should be expected, as the complexity of the linear equalizer increases. Our implementation was fairly simple. However, it is not likely, that for an optically amplified system, as we considered, the worst penalty can be kept below 7 dB. This comes from the limitation set by the signal dependence of the noise. This is worsened by the asymmetry of the noise statistics, which leads to a sub-optimal behavior of the NLC. Moreover, the noise enhancement related to linear equalization becomes pattern dependent.

In fact, these DSP techniques do a better job at reducing very high penalty. Therefore, they do not really fit into the restriction of a 1 dB penalty, which represents the SONET requirements. Consequently, for a power and ISI limited link, it may be required to associate to electronic solutions optical compensation in order to reach acceptable performance. On the other hand, for links having large power margin or exhibiting reasonable PMD, electronic techniques appear as an easy, inexpensive and convenient solution.

We derived in this work the bounds to NLC performance in the presence of ASE. Therefore, we extended the usual results of the thermal noise limit to the particular case of signal dependent noise. We also made clear that optical systems, because of their noise specificities can not be studied or designed as other links. Notions such as eye opening, SNR and ISI need to be carefully defined and adapted to this case.

We have provided in this work PMD dependent power penalty map for known systems. Given the link's statistics and characteristics, one can determine, following our structure, which mitigation techniques allow upgrade.

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Acronyms:

ASE: Amplified Stimulated Emission

BER: Bit Error Rate

DFE: Decision Feedback Equalizer

EDFA: Erbium Doped Amplifier

DGD: Differential Group Delay

FDE: Feed forwarD Equalizer

IC: Integrated Circuit

ISI: InterSymbol Interference

LHCP/RHCP: Left Hand Circular Polarization / Right Hand Circular Polarization

NLC: Non-Linear Canceller(ation)

PMD: Polarization Mode Dispersion

PRBS: Pseudo Random Bit stream

PSP: Principal State of Polarization

RIN: Relative Intensity Noise

SNR: Signal to Noise Ratio

SOP: State Of Polarization

TF: Transversal Filter

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