NONLINEARITY ASSESSMENT IN LONG HAUL DISPERSION MANAGED FIBER OPTIC LINKS

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The accuracy of the EGN model is investigated for a legacy dispersion-managed ultra-long-haul optical link by comparing its predictions with split-step simulations. The EGN model shows good accuracy in system performance prediction, when signal power depletion and ASE contribution to NLI are considered.
Keywords: EGN model, Dispersion Managed (DM) link, NLI, legacy systems

1. Introduction

Increasing capacity demands and high cost of deploying new systems make it economically attractive to convert installed legacy links to coherent transmission. In this context, ultra-long-haul links featuring in-span dispersion-management (DM) by means of D+ and D- fibers are particularly challenging, because DM cannot be removed. This creates difficult propagation conditions for coherent signals, which need to be carefully and accurately modeled to perform suitable system optimization. In this work, we test the use of the GN and EGN [1] models to characterize one such link and compare the model predictions with full C-band split step simulations. Interestingly, the EGN model appears to provide very accurate predictions, once signal power depletion and ASE contributions to NLI are accounted for.

2. DM link specifications

The link we consider is similar to an actual DM deployed submarine link. The total link length is about 8000 km. It consists of three fiber types, SMF ($D \approx 16.7$ ps/(nm km)), and two NZDSF with negative dispersion ($D \approx -3$ ps/(nm km)) and different effective areas (about 50 and 75um^2). These different fiber types were spliced together to achieve a dispersion map optimized for IM/DD. The average span length is about 50km, for a total of about 160 spans. Both dispersion and dispersion slope are taken into account in calculations and simulations. For transmission, we considered 44 WDM channels at 64 GBaud with PM-QPSK modulation. All channels are raised cosine with roll-off 0.2. Channel spacing is 80 GHz. The launch power of all channels is assumed identical.

3. OSNR evaluation through models

SNR is calculated based on the formula [2]:

$$SNR = \frac{P_{\mathrm{ch}} - P_{\mathrm{NLI}}}{P_{\mathrm{ASE}} + P_{\mathrm{NLI}}} \qquad (1)$$

where P_{ch} is the channel power, P_{ASE} is the Amplified Spontaneous Emission (ASE) due to EDFAs and P_{NLI} is the NLI power estimated using the GN or EGN models. Note that the formula takes into account, in a simple heuristic way, the signal power loss to NLI, which starts impacting performance significantly at SNR below about 8-10 dB [2].

4. Results

Fig. 1 shows the SNR results at the end of the link. The plot is drawn at a total WDM launch power of about 10 dBm, which is close to the optimum. The SNR from split-step simulations was estimated in two ways: as the average SNR on the received constellations and by measuring the GMI and then converting it into SNR by means of the ideal GMI-vs.-SNR curve for PM-QPSK. Interestingly, and somewhat unexpectedly, these two estimates essentially coincide. The SNR calculated using the GN-model is up to 2.5 dB away from simulations. Instead, the EGN-model has only a 0.5 dB gap. Such gap is completely recovered (blue curve) by simply adding ASE power in the generation of NLI. While a rigorous estimation of this effect is possible [3] but complex, it appears that this easy heuristic approach may be sufficient, at least at these SNR levels.

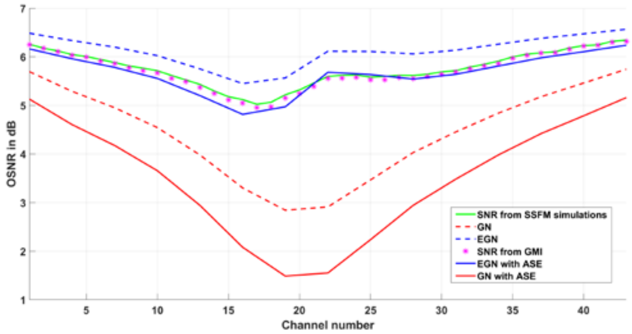

Fig. 1 SNR comparison for GN, EGN and SSFM simulations

In conclusion, the EGN model, with simple corrections for signal power depletion and the ASE contribution to NLI, appears to be capable of accurately modelling DM ultra-long-haul legacy systems, as we show here for the first time to the best of our knowledge.

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References

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