Optimized complexity-constrained DBP for single span systems

Citation for published version (APA):

Document status and date:
Published: 01/12/2018

Document Version:
Publisher’s PDF, also known as Version of Record (includes final page, issue and volume numbers)

Please check the document version of this publication:
• A submitted manuscript is the version of the article upon submission and before peer-review. There can be important differences between the submitted version and the official published version of record. People interested in the research are advised to contact the author for the final version of the publication, or visit the DOI to the publisher’s website.
• The final author version and the galley proof are versions of the publication after peer review.
• The final published version features the final layout of the paper including the volume, issue and page numbers.

Link to publication

General rights
Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

• Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
• You may not further distribute the material or use it for any profit-making activity or commercial gain
• You may freely distribute the URL identifying the publication in the public portal.

If the publication is distributed under the terms of Article 25fa of the Dutch Copyright Act, indicated by the "Taverne" license above, please follow below link for the End User Agreement:
www.tue.nl/taverne

Take down policy
If you believe that this document breaches copyright please contact us at:
openaccess@tue.nl
providing details and we will investigate your claim.

Download date: 16. Oct. 2020
**Motivation**

Standard Digital Back Propagation (DBP) with a constraint on the number of steps is sub-optimal in terms of nonlinearity compensation performance. Therefore, an optimization of this method is necessary. Some analytic approaches have been made to achieve this optimization; however, they still do not yield the optimum performance.

**Contribution**

This poster presents a numerical evaluation of the optimum parameters for DBP in a Standard Single-Mode Fiber (SSMF) with 2 steps/span. The results are compared with optimized DBP via Minimum Area Mismatch (MAM) [1]. Gains in Mutual Information (MI) of approximately 0.86 bit/symbol are observed.

**System Description**

![Transmission system model](image)

Figure 1: Transmission system model. $L_a$: Span length; $SNR$: Signal-to-Noise Ratio; $BER$: Bit Error Ratio; RRC: Root Raised Cosine; Pol.: Polarizations

**MAM Equations**

The MAM method can be represented by a Lagrange multiplier problem. The function to be minimized is the area between the Effective Nonlinear Coefficient (ENC) $\gamma'(z) = \gamma e^{\alpha z}$ [1] (in which $\alpha$ is the fiber loss) and $\gamma_1, \gamma_2$ with respect to the optimized step sizes $l_1, l_2$:

$$l_1 + l_2 = L_a,$$

$$l_1, l_2 = \sum_{j=1}^{2} \gamma_j l_j = \gamma \left( \frac{e^{\alpha L_a} - 1}{\alpha} \right),$$

$$L(l_1, l_2, \lambda) = \sum_{j=1}^{4} \alpha_j + \lambda \left[ \sum_{j=1}^{2} \gamma_j l_j - \gamma \left( \frac{e^{\alpha L_a} - 1}{\alpha} \right) \right],$$

where $\sum_{j=1}^{4} \alpha_j$ is the area mismatch and $\lambda$ is the Lagrange multiplier.

**SNR Optimization**

The optimization is based on a Gradient Descent (GD) approach on the Signal-to-Noise Ratio (SNR) in the discrete domain:

$$v = (\gamma_1, \gamma_2, l_1)$$

$$\nabla SNR(v) = (\text{SNR}_1(v), \text{SNR}_2(v), \text{SNR}_{\text{GD}}(v)).$$

The comparison between the methods was based on the MI. The MI for the Nonlinear Optical Channel was calculated based on a lower bound that uses an auxiliary circularly symmetric Gaussian PDF [2].

**Mismatched Area**

![Mismatched areas comparison](image)

Figure 2: MAM and GD mismatched areas for $L_a = 130$ km

**MI Comparison**

![Comparison of MI](image)

Figure 3: Comparison of four different receivers with respect to the maximum MI for a given span length $L_a$. EDC: Eletronic Dispersion Compensation

**Optimized Parameters**

![Optimized parameters comparison](image)

Figure 4: Variation of the optimized parameters with respect to $L_a$

**Conclusion**

A numerical analysis of the optimum DBP parameters at 2 steps/link was investigated in this poster. The GD optimization outperforms by up to 0.86 bit/symbol both EDC and the MAM optimisation. The results show that, for optimal performance, non-linearities should be over-compensated in the high power area region. Future work will focus on the analytical analysis of the optimum DBP parameters. Acknowledgements: This work is supported by the Netherlands Organisation for Scientific Research (NWO) via the VIDI Grant ICONIC (p. n. 15685).
