Exact NFDM in Lossy Fibers

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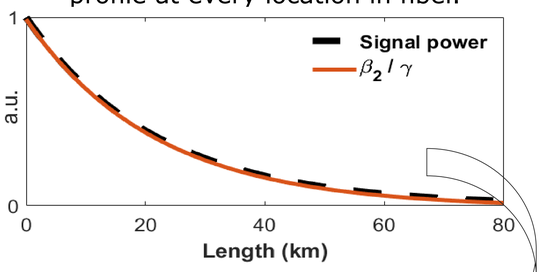
- Nonlinear Fourier transform (NFT) linearizes the nonlinear optical fiber channel. The nonlinear cross-talk is essentially absent in the nonlinear spectrum.
- The impairments due to dispersive and nonlinear effect acting simultaneously on signal during propagation can be compensated by simple rotations in nonlinear spectrum.
- Nonlinear frequency division multiplexing (NFDM) is a transmission technique which encode data on nonlinear spectrum.

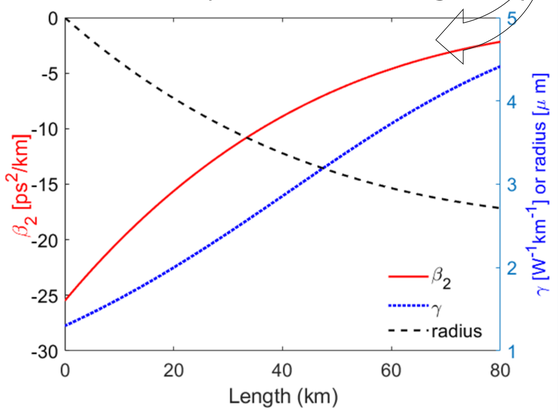
- NFT is originally applicable to integrable equations such as lossless optical fiber. Lossy propagation of signal is not suitable for NFT.
- Conventionally, path-average model is used to approximate lossy propagation of signal as lossless propagation.
- The path-average model includes approximation, hence, perfect nonlinearity compensation can not be achieved even in absence of noise.
- The approximation error associated with path-average model increases with signal power, bandwidth and length of span. It imposes additional limit on system design parameters.

- We propose dispersion decreasing fiber (DDF) together with adapted NFT in NFDM to make the transmission system exact.
- This approach avoids path-average model and the shortcomings associated with it.
- In order to show the performance gain by using DDF in NFDM systems, we compare it's performances against an NFDM system designed using a constant dispersion fiber.

Transmission model is integrable if β_2/γ exactly follows the signal power profile at every location in fiber.



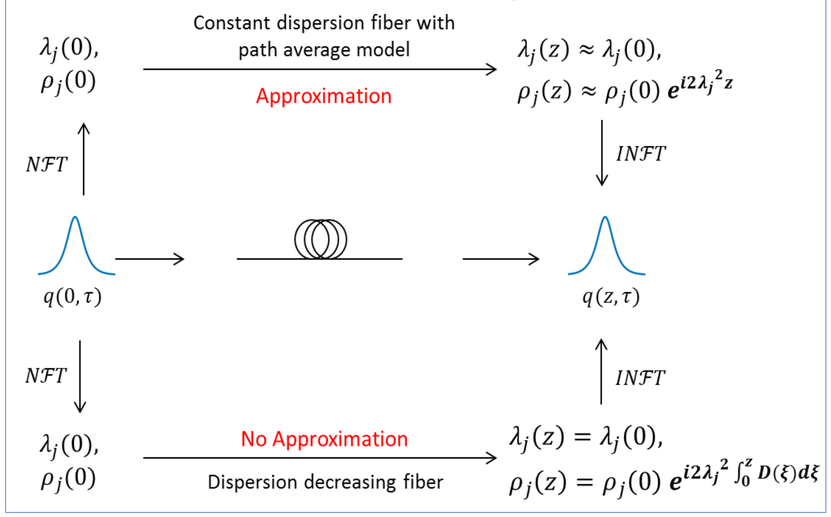
Suitable fiber profile to hold integrability



$$Time-domain\ signal \xrightarrow{NFT} \begin{matrix} Discrete\ spectrum \\ Continuous\ spectrum \end{matrix}$$

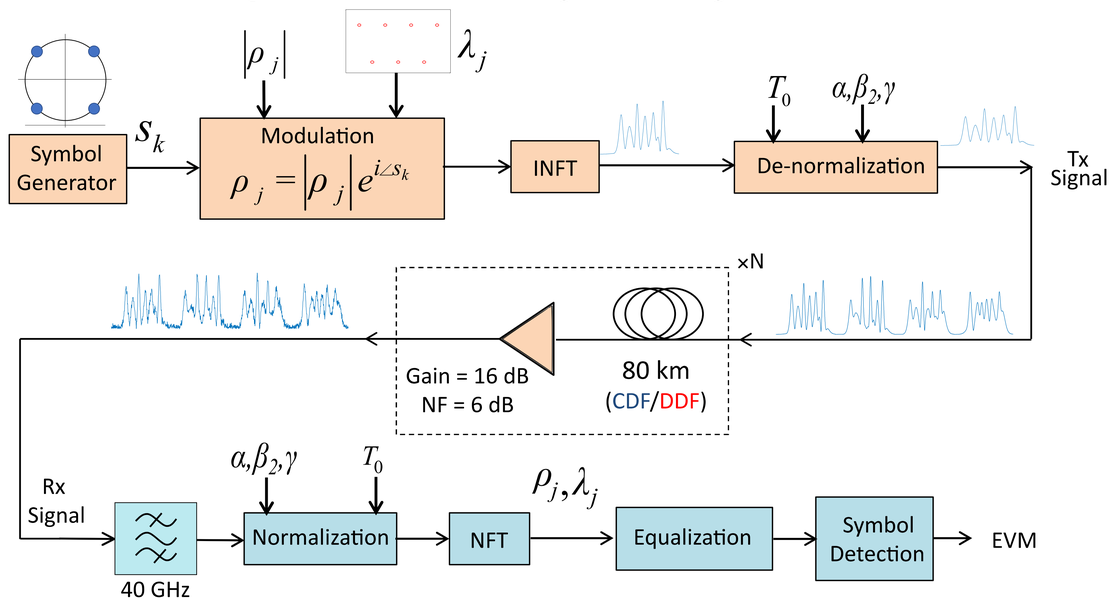
$$q(z,\tau) \xrightarrow{NFT} \begin{Bmatrix} \lambda_j, \rho_j & \lambda_j \in \mathbb{C}^+ \\ \rho(\xi) & \xi \in \mathbb{R} \end{Bmatrix}$$

Evolution of nonlinear spectrum



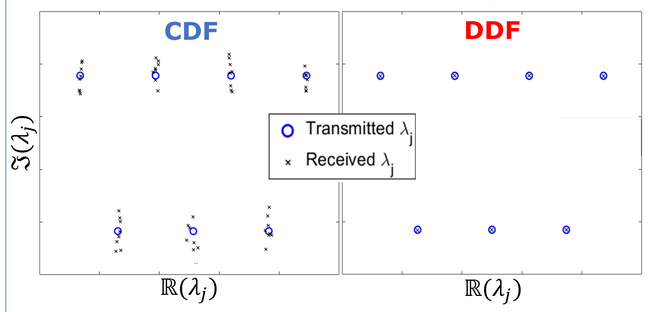
Simulation setup : NFDM with discrete spectrum modulation

QPSK-modulated seven-eigenvalued signal transmission



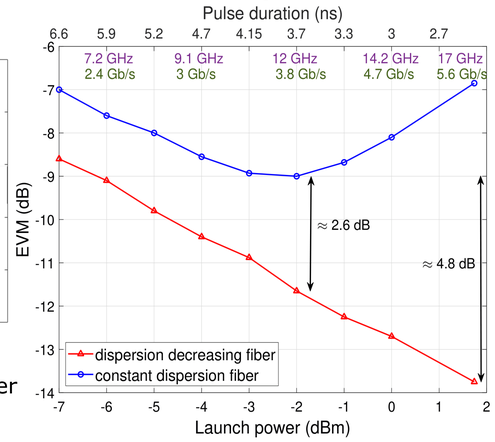
The parameters considered for CDF are average values of corresponding parameters for DDF.

Noiseless transmission of 7 eigenvalues



Eigenvalues (λ_j) fluctuates for a constant dispersion fiber while it is preserved for dispersion decreasing fiber.

800 km noisy transmission



- We presented transmission result for exact NFDM transmission in lossy fiber.
- We avoid the approximation error associated with the path-average model by the use of dispersion decreasing fiber together with an adapted NFT for it.
- We obtained up to 4.8 dB EVM gain in for 800 km 7-eigenvalue NFDM transmission.
- This approach can be extended for continuous spectrum modulation as well as for distributed amplified links.

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