Non-Linear Propagation Limits and Optimal Dispersion Map for 222 Gbit/s WDM Coherent PM-16QAM transmission

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We investigate through simulation the impact of non-linear propagation on 222Gbit/s WDM coherent PM-16QAM on SMF and NZDSF fibers. We show that the best performance is achieved using full electronic dispersion compensation, with a significant system reach of about 1000km.
System layout

7 channels $\Delta f = 50 \text{ GHz}$

SMF or NZDSF

$A_{\text{span}}$ up to 30 dB

2$^{nd}$ order SuperGaussian

BW = 40 GHz

PM-16QAM

WDM

Tx

90 km Fiber span

DCU$_{\text{IL}}$

VOA

$X N_{\text{span}}$

EDFA

Opt filter

Rx

$R_s = 27.75 \text{ Gsps}$

$R_b = 222 \text{ Gbps}$

Ideal grating

NF = 5 dB
Receiver structure

Ps
0 dBm

PLO
10 dBm

PBS

90 deg hybrid
IL=3dB

Bal PD

TIA

LPF

ADC

EDC

Bal PD

TIA

LPF

ADC

EDC

Bal PD

TIA

LPF

ADC

EDC

Bal PD

TIA

LPF

ADC

EDC

SpS=2

LMS Rx

Adaptive threshold decision

BER

Bessel 5 pole
BW=16.65 GHz

ASE limited configuration
Dynamic receiver based on TS and DD LMS

- \( N_{\text{tap}} = 15 \) taps matrix
- \( N_{\text{sym,TS}} \mu_{\text{TS}} \rightarrow \) TS LMS
- \( \mu_{\text{DD}} \rightarrow \) DD LMS
- \( \frac{1}{M} \)
- TS: training sequence
- DD: decision driven
- LMS: least mean square
Simulation data

- 8 different PRBS per channel
- PRBS degree: 16
- 7 WDM channels, $\Delta f=50$ GHz
- Simulated symbols: 65536 $\Leftrightarrow$ 524288 bits per channel
- Target BER= $4 \times 10^{-3}$

SMF
- $\alpha=0.22$ dB/km, $D=16.7$ ps/nm/km, $\gamma=1.3$ (W·km)$^{-1}$

NZDSF
- $\alpha=0.22$ dB/km, $D=3.8$ ps/nm/km, $\gamma=1.5$ (W·km)$^{-1}$
Sensitivity

BER = 4 \times 10^{-3}

OSNR = 19.3 \text{ dB}
Scattering Diagrams

X polarization

Y polarization
$A_{\text{span}@\text{BER}=4 \times 10^{-3}}$ - SMF - $N_{\text{span}} = 5$

ODM - $D_{\text{res,IL}} = -70$ ps/nm/km

Full EDC
$A_{\text{span}} \oplus @ \text{BER}=4 \times 10^{-3} - \text{SMF} - N_{\text{span}} = 10$

ODM - $D_{\text{res,IL}} = -70 \text{ ps/nm/km}$

Full EDC
A_{\text{span}} \@ \text{BER}=4 \times 10^{-3} - \text{NZDSF} - N_{\text{span}} = 5

ODM - D_{\text{res,IL}} = -50 \text{ ps/nm/km} 

Full EDC
$A_{\text{span}}@\text{BER}=4\times10^{-3} - \text{NZDSF} - N_{\text{span}} = 10$

ODM - $D_{\text{res,IL}}=-50 \text{ ps/nm/km}$

Full EDC
$A_{\text{span}}@\text{BER}=4\times10^{-3}$ vs. $P_{\text{Tx}}$ - Full EDC
$A_{\text{span}} @ \text{BER}=4\times10^{-3}$ vs. $P_{\text{Tx}}$ - ODM
Conclusions

- Our study shows that the full-EDC approach is the optimal technique for WDM systems based on PM-16QAM at 222 Gbit/s, even in the presence of substantial non-linearity.

- Operating over lines with DCUs optimized for legacy 10 Gbit/s IMDD may severely impact performance.

- Despite the extreme bit-rate and spectral efficiency, the system appears capable of reaching about 1000 km over SMF.