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Impact of Multi-Band Transmission on Optical Signal-to-Noise Ratio Measurements

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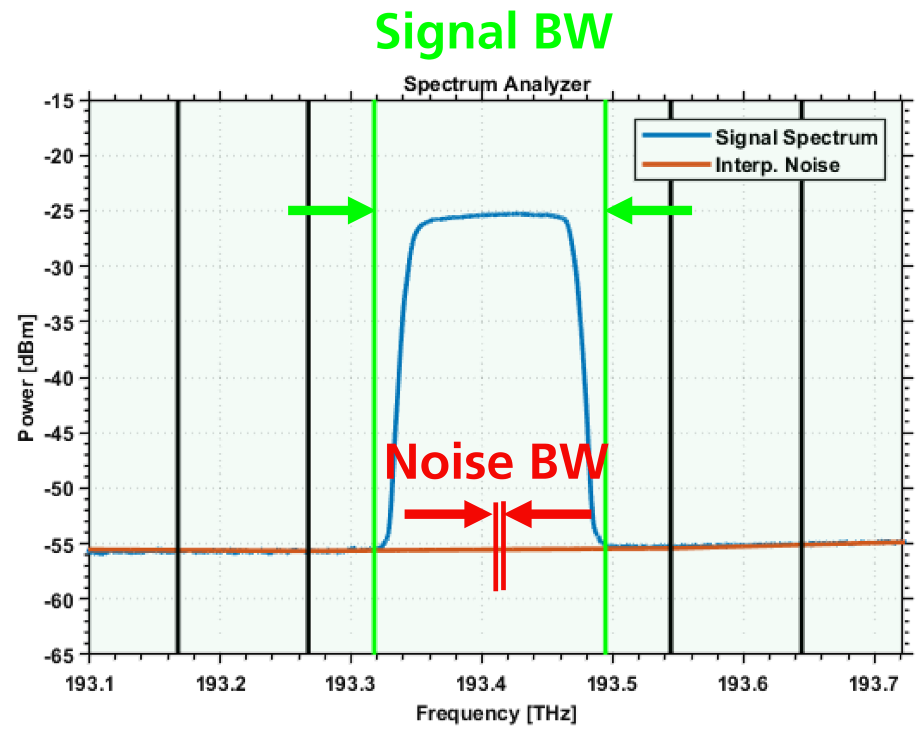
Abstract (what is it all about)

We examine the influence of a fixed noise bandwidth assumption (i.e., 12.5 GHz) on optical signal-to-noise ratio (OSNR) measurements in the context of multi-band transmission and propose a correction method that is verified by simulations

But what is the OSNR again?

OSNR represents the fundamental parameter utilized for quantifying signal integrity within the optical domain. This is achieved by dividing the signal power over the full signal bandwidth by the noise power within a fixed reference bandwidth.

OSNR = 39.8 dB
P_noise = -45.4 dBm
P_sig = -5.6 dBm



The Problem

OSNR is measured with an OSA at a noise bandwidth B_{ref} is commonly taken to be fixed at 0.1 nm or 12.5 GHz [1]. However, for multi-band transmission systems, this assumption is not accurate and must be accounted for by an additional correction factor. The value of 12.5 GHz is only accounted for at a wavelength of 1548.515 nm [2].

$$OSNR = \frac{P_{sig}}{2 \cdot N_{ASE} \cdot B_{ref}}$$

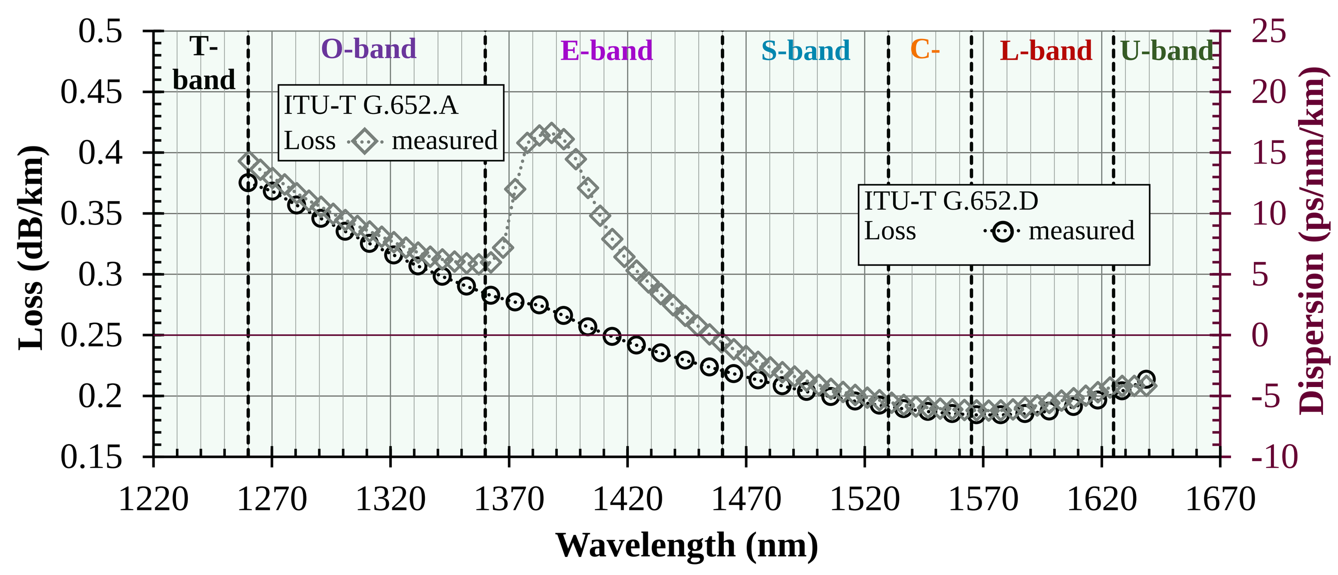
Total average signal power over both states of polarization

Spectral power density of the ASE (noise) in a single polarization

Reference bandwidth for noise power density defined as 0.1 nm (12.5 GHz) only at a fixed f of 193.6 THz (1548.515 nm)

But why is multi-band interesting?

To circumvent the imminent capacity and cost per bit crunch, the use of MB technology represents a viable medium-term solution that can extend the lifetime of existing optical fiber infrastructure. This is achieved by increasing the available capacity through the introduction of additional usable bandwidth to already deployed optical fibers.



[3]

Abbreviation	Full-band name	Start (nm)	Stop (nm)	BW (THz)
T-band	thousand	1000	1260	61.9
O-band	original	1260	1360	17.5
E-band	extended	1360	1460	15.1
S-band	short wavelength	1460	1530	9.4
C-band	conventional	1530	1565	4.4
L-band	long wavelength	1565	1625	7.1
U-band	ultra-long wavelength	1625	1675	5.5

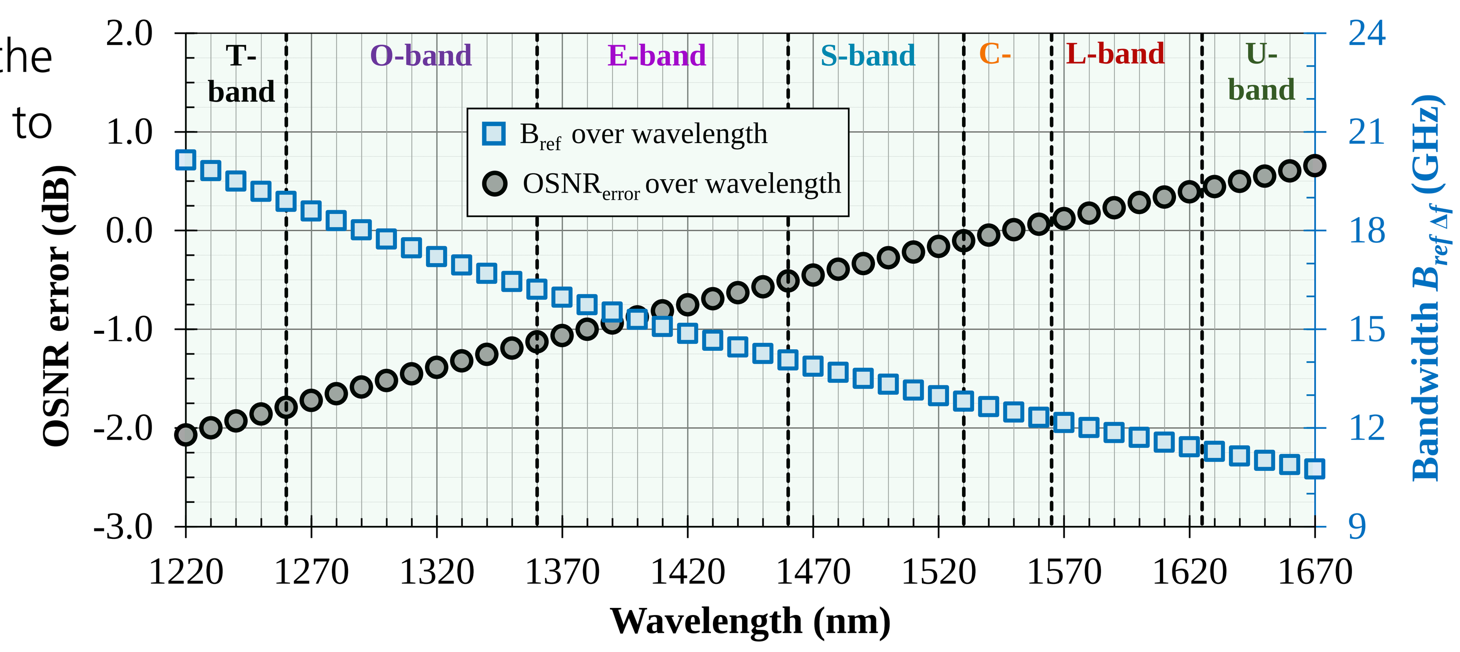
What happens when you fix B_{ref} for multi-band?

As illustrated in the right figure, when B_{ref} is a constant value of 12.5 GHz, the discrepancy in the OSNR calculation (black circles corresponding to the left axis) ranges from -1.7 dB at 1260 nm up to 0.7 dB at 1680 nm. This is based on the right subtrahend in the equation below.

How to fix the OSNR Measurement for multi-band:

A correction factor is required for OSNR measurements conducted with a fixed bandwidth of 12.5 GHz (0.1 nm) [2], as illustrated below, based on the channel center frequency as follows:

$$OSNR_f[dB] = OSNR_{193.6\,THz} - 20 \cdot log_{10}\left(\frac{f[THz]}{193.6\,THz}\right)$$

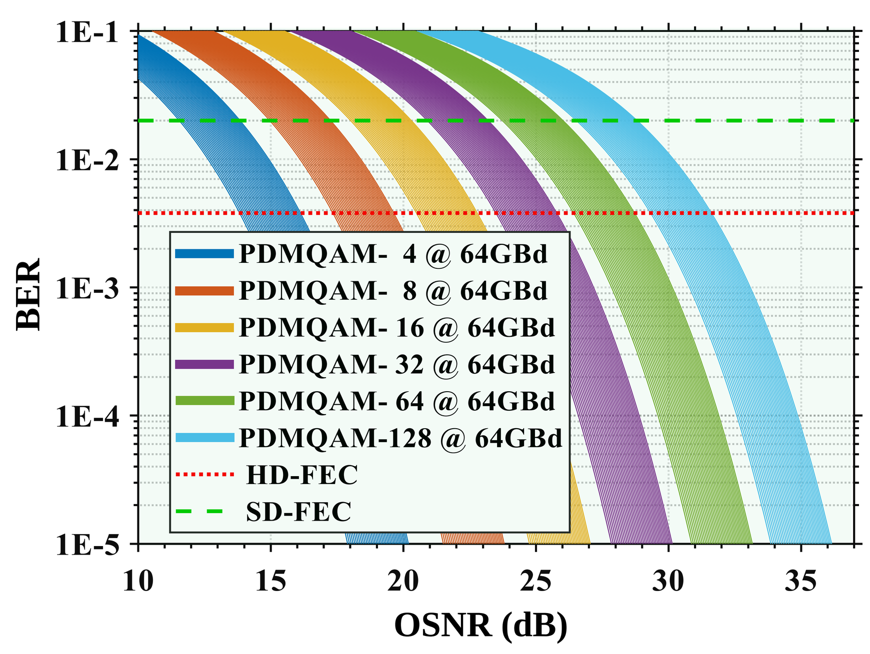


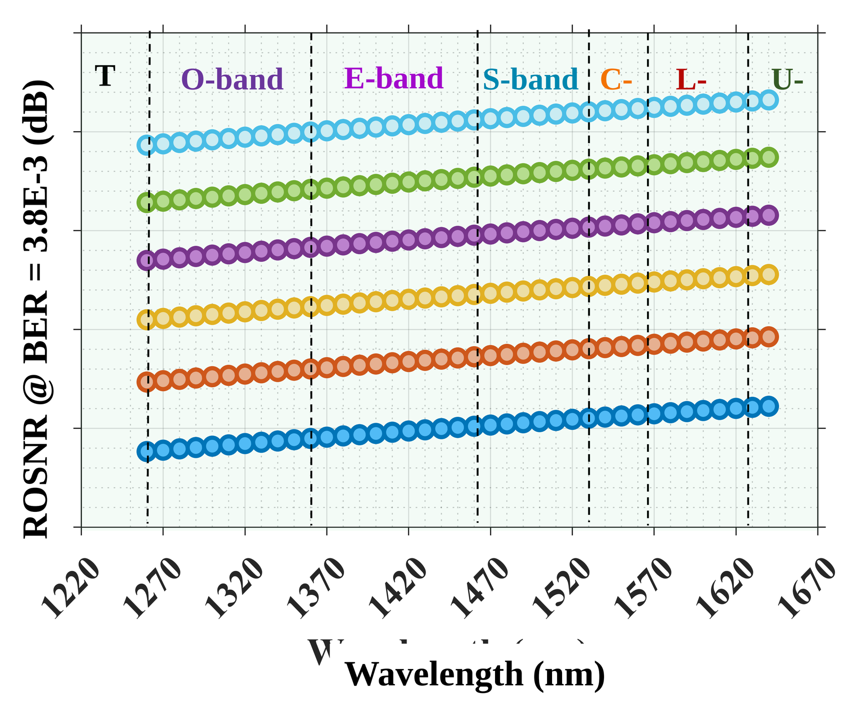
As a result of this calculation we end up with a non-constant value for *Bref* as a function of wavelength as shown above by the blue squares (corresponding to the right axis) above.

Performed simulation and required OSNR results:

Simulation of BER vs. OSNR theory curves based on [4], was conducted for 20 channels at 64 GBd, from 1260 to 1640 nm. BER values for the formats 4QAM, 8QAM, 16QAM, 32QAM, 64QAM, and 128QAM, as a function of OSNR, were calculated for OSNRs ranging from 10 to 37 dB. The wavelength-dependent OSNR was correct by the equation above.

The ROSNR at the arbitrary HD-FEC threshold (BER = 3.8·10-3) [5] for the six calculated MQAM signals is plotted as a function of the wavelength as well.





Conclusions (the take away messages)

It is necessary to correct OSNR measurements for multi-band transmission systems and ONSR reference values for BER simulations of theory curves with respect to the center wavelength of the channel of interest.

We present a straightforward method for implementing this correction.

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[4] J. Lu, "M-PSK and M-QAM BER computation using signal-space concepts," in IEEE Transactions on Communications, vol. 47, no. 2, pp. 181–184, 1999, doi: 10.1109/26.752121.
[5] E. Agrell and M. Secondini, "Information-Theoretic Tools for Optical Communications Engineers," in Proc. of IEEE Photonics Conference (IPC), 2018, pp. 1–5, doi: 10.1109/IPCon.2018.8527126.

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