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The Effect of Filtering on the OSNR

For a 40- and 100 Gb/s DWDM System

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Abstract: Quality measures like Bit Error Rate (BER) and Optical Signal to Noise Ratio (OSNR) are important indicators for verifying the quality of a received signal in the optical fiber communication. Different components like Wavelength Selective Switches and Optical Interleaver Units used in a Dense Wavelength Division Multiplexed network can decrease the operating bandwidth. This work investigates the effect of bandwidth narrowing on the OSNR value in an optical fiber link.

1 INTRODUCTION

One of the advantages of high bit rates like 40- and 100 Gb/s in fiber optical communication is increasing the bandwidth efficiency. This leads to an increased capacity that is a key factor for a number of bandwidth-demanding services. However, service providers have widely invested in 10 Gb/s. Therefore, it would be too costly to build new infrastructures for higher bitrates while they technically keep losing what they have spent in the legacy bit rate. As a result, it is much more affordable to use existing structure to transmit higher bit rates systems. Birk *et al.* (2010:2-3) discussed about coexistence of 10 Gb/s OOK and 40 Gb/s DPSK with 100 Gb/s DP-QPSK in a 900 Km fiber link. The filtering effect of Wavelength Selective Switch (WSS) in the ROADMs at 10, 40 and 100 Gb/s have been presented in the literature. (Heismann, F., Collings, B. and Reimer, C., 2009:2-3; Zhang *et al.*, 2010:2-3; Nelson *et al.* 2011; Pinceman *et al.*, 2011:2; Birk *et al.*, 2011:1-2; Heismann 2010). Also Mikkelsen *et al.* (2006:1) have demonstrated the filtering effect of interleaver units on a 40 Gb/s DPSK system.

The purpose of the work described in this paper is to evaluate the destructing effect of narrowing the bandwidth on OSNR value for a BER of $1.0E-12$ for 40 Gb/s and 100 Gb/s. Signal bandwidth becomes narrower when it passes through components that have bandwidth smaller than that of 40 Gb/s and 100

Gb/s signals. For this work, these components are Multiplexer/Demultiplexer units, Wavelength Selective Switch, Optical Interleaver Unit and finally Wavelength-Blocker. The 40 Gb/s (33% Return-to-Zero) DPSK pseudorandom bit sequence (PRBS) data stream in the C-band and 100 Gb/s DP-QPSK optical signal transmitted in a network that has been designed for 10 Gb/s OOK optical signals. Because of the nature of higher bitrate signals, their bandwidth is wider (compared to 10 Gb/s signal). Various components like ROADMs, interleaver units and filters have a tightening effect on the effective bandwidth according to their active bandwidth. This imposes a penalty on the quality of the received signal. Such penalties are investigated and the components which impose the tightest filtration on the bandwidth are presented.

2 EXPERIMENTAL SETUP

The link shown in figure 1 is established for the OSNR measurements. The input signals are generated by a) 40 Gb/s NRZ-DPSK 300-pin MSA transceiver with 191.70 to 196.10 THz C-band frequency range on 50 GHz ITU grid and 38 GHz spectrum width (3-dB Band width) and b) 100 Gb/s PM-QPSK CFP 100 GbE with 191.70 to 196.10 THz C-band frequency range on 50 GHz ITU grid. The frequency of the signal has been chosen as 193975 THz as it is in the middle of C-Band to

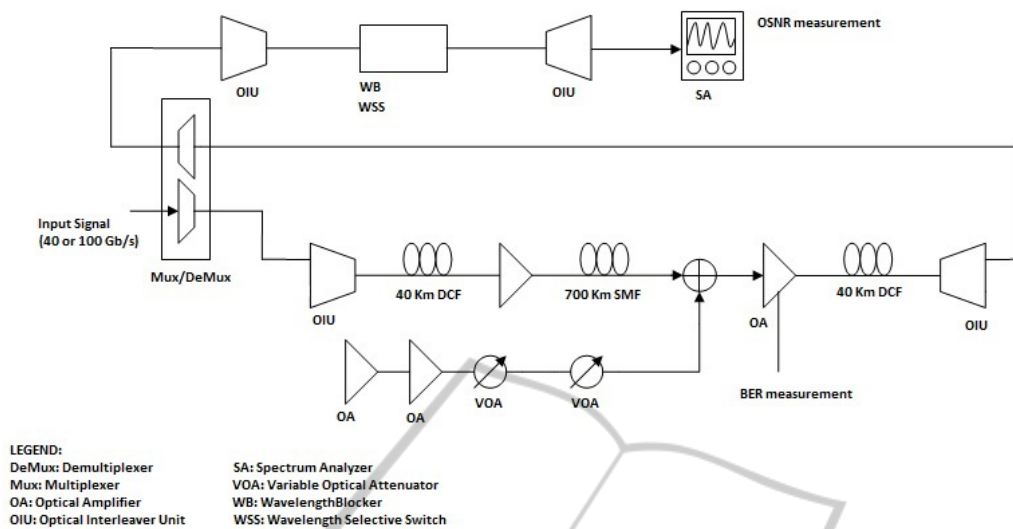


Figure 1: BER vs. OSNR measurement setup.

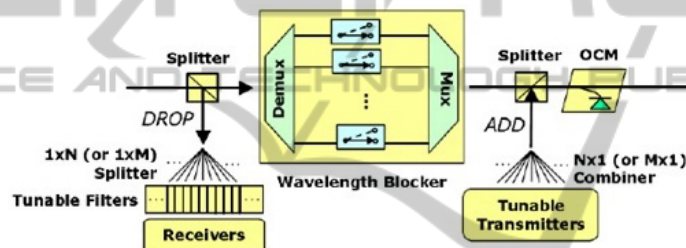


Figure 2: Wavelength Blocker schematic block diagram.

maintain a moderate response. The optical signal is initiated from a multiplexer and propagates in the link depicted in figure 1. It passes through a number of optical amplifiers, variable optical attenuators and a 700 Km single mode fiber; reaches the demultiplexer and is directed to a number of components to verify the filtering effect. Finally a spectrum analyzer measures the OSNR of the signal. Thus the BER of the signal is measured in the last optical amplifier stage along the link and OSNR at the end of the link. Those components that cause the bandwidth to be narrowed are Optical Interleaver units, ROADMs' Wavelength Selective Switch and a Wavelength-Blocker unit (figure 2).

The components that determined the filtration were cascaded interleaver units with a) WSS and b) Wavelength-Blocker.

3 RESULTS AND ANALYSIS

The unfiltered spectrum of both 40 and 100 Gb/s signals are depicted in figure 3. The green line

shows the 3-dB reference and by that, 3-dB bandwidth can be calculated as ~33 GHz for 40 Gb/s and ~27 GHz for 100 Gb/s signals.

Also the Bandwidth of components (OIU+MUX, WSS and Wavelength-Blocker) are shown in figure 4. Figure 5 gives a clearer view of the different bandwidth arrangements of the Wavelength-Blocker, from 50 GHz down to 20 GHz.

The BER versus OSNR curve of 40 Gb/s signal passing through the network illustrated in figure 1 is shown in figure 6. The OSNR level is degraded for filtering tighter than 33 GHz. The OSNR penalty at tight filtration is about 2 dB. The reason is that some significant portion of the signal (unfiltered bandwidth equal to 33 GHz) is cut that leads to an increase in the BER and degradation of the OSNR.

For 100 Gb/s, the BER versus OSNR curve is shown in figure 7. It can be seen that filtering even as tight as 32 GHz has a negligible effect on the OSNR levels.

There is a very small penalty in the BER when decreasing the filter bandwidth from 46 GHz down to 30 GHz. This penalty is illustrated in figure 8.

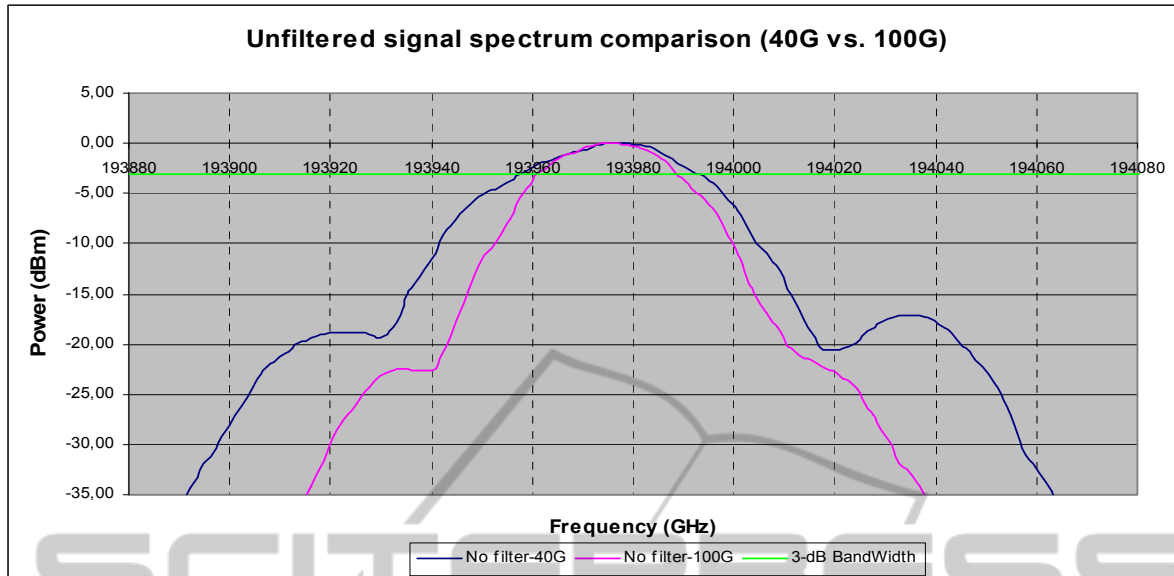


Figure 3: Unfiltered 40 G and 100 G signal spectrum.

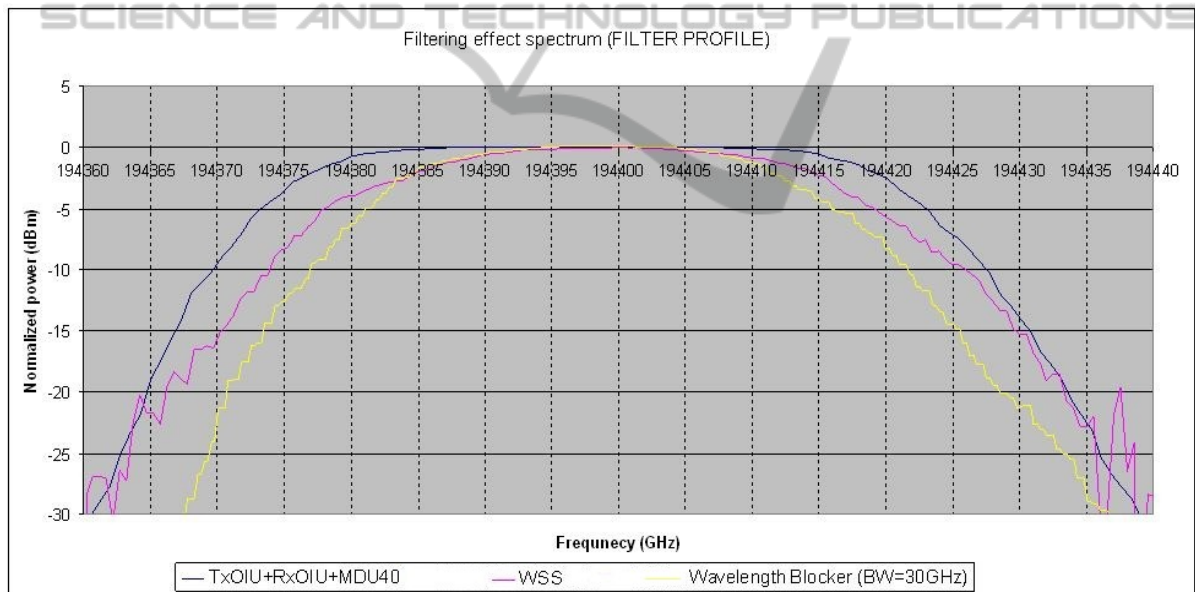


Figure 4: Various components' filtering profiles.

The Wavelength-Blocker's bandwidth decrease is stepwise, therefore the next bandwidth setting is 26 GHz which is smaller than ~28 GHz (unfiltered bandwidth of 100 Gb/s signal) so the signal is lost with filtration tighter than 30 GHz and no BER can be achieved for this filtration.

4 CONCLUSIONS

It is demonstrated that tight filtering imposes a penalty of around 2 dB for 40 Gb/s but it is less than 1 dB for 100 Gb/s. This is because 40 Gb/s signal has wider spectrum than 100 Gb/s. The highest penalty is for the wavelength-Blocker that has a 30 GHz bandwidth.

There is very small BER penalty for 100 Gb/s

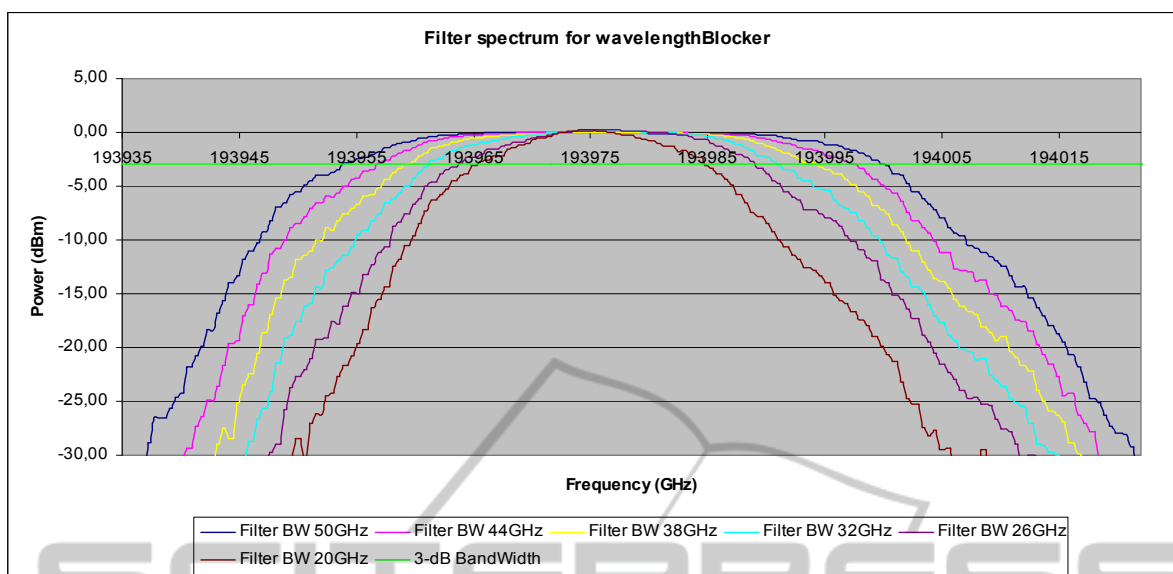


Figure 5: Wavelength-Blocker's filtering profile from 50 GHz down to 20 GHz.

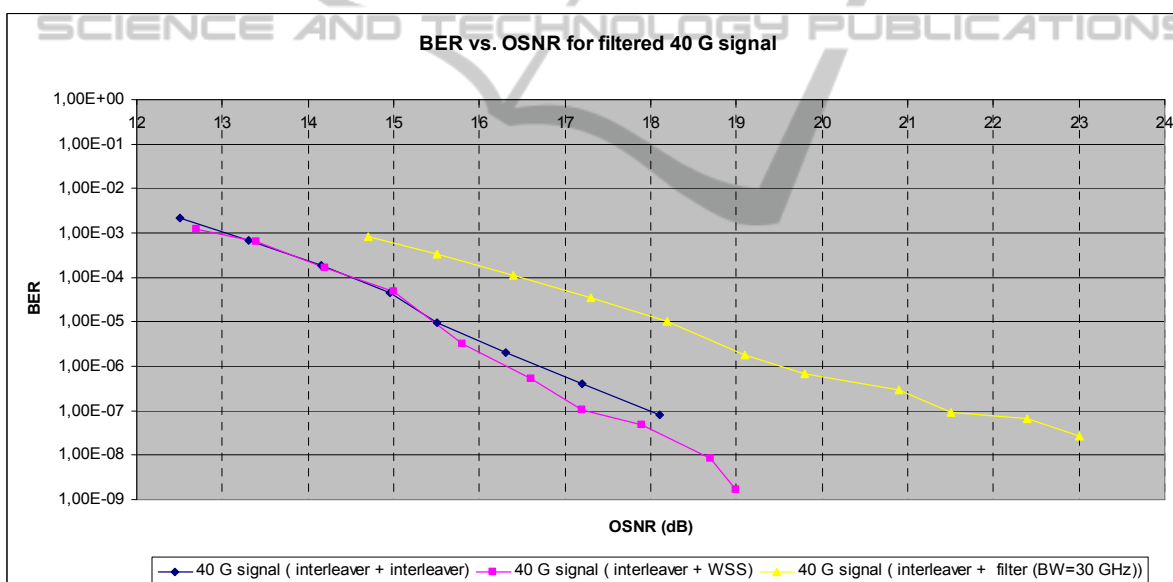


Figure 6: BER vs. OSNR for filtered 40 G signal.

signal when its bandwidth decreases from 46 GHz to 30 GHz (loss of signal limit).

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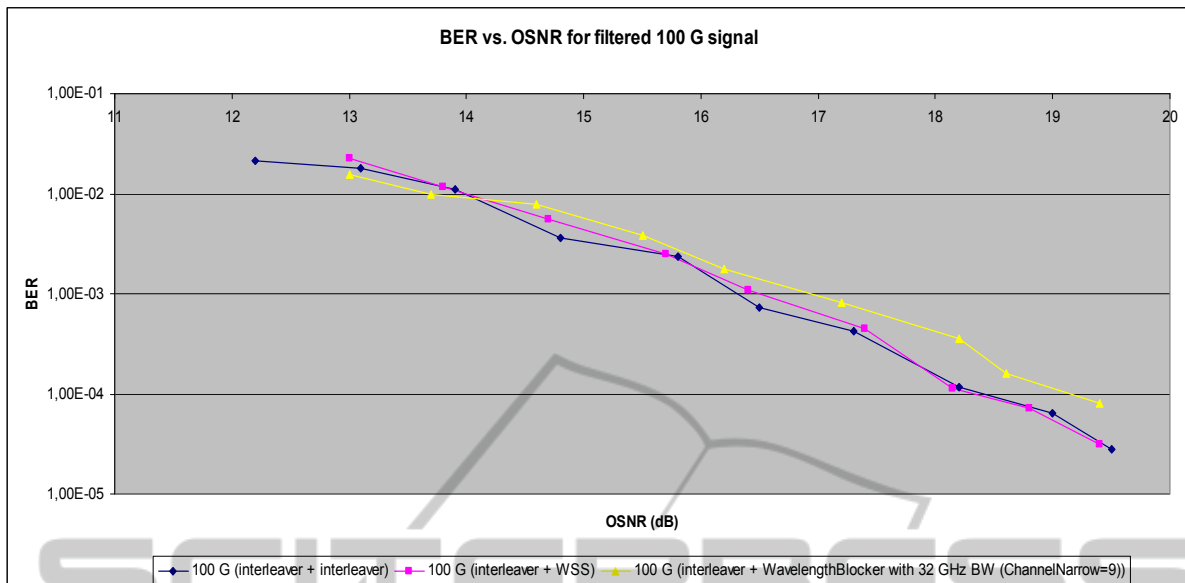


Figure 7: BER vs. OSNR for filtered 100 G signal.

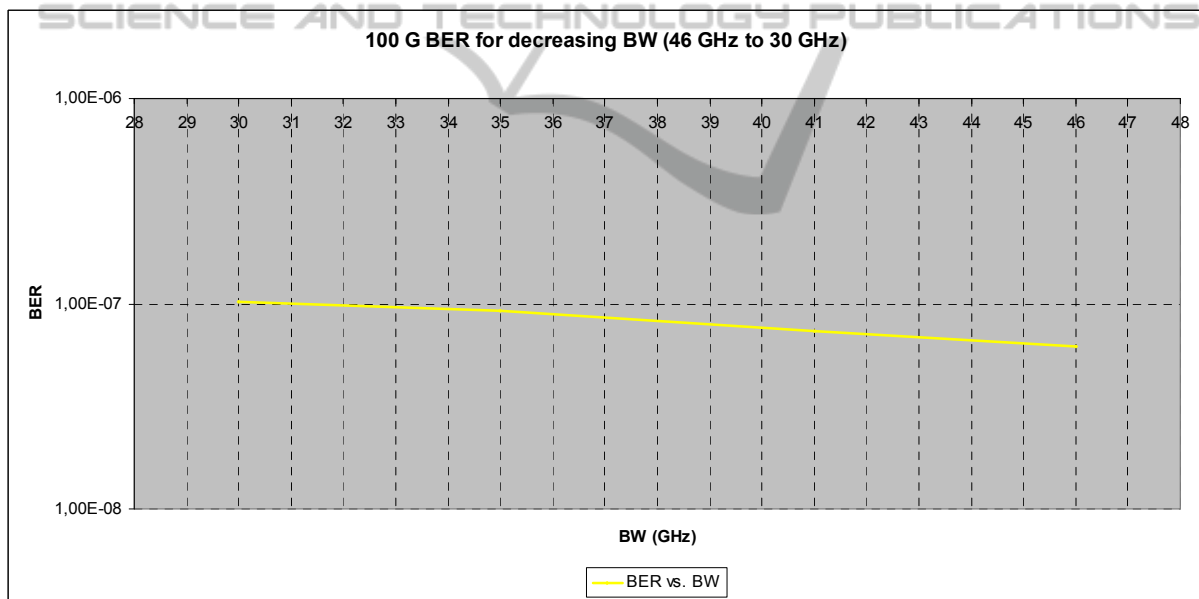


Figure 8: BER penalty for decreasing BW from 46 GHz to 30 GHz.

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