اثر فیلترینگ بر پهنای باند سیگنالهای نوری ۴۰ Gb/s و ۱۰۰ Gb/s

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چکیده – پهنای باند سیگنال یک نشانگر مهم برای برآورد کیفیت سیگنال دریافتی در مخابرات فیبر نوری می‌باشد.تجهیزات گوناگونی نظیر سوئیچ انتخابگر طول موج و واحد جمع‌کننده و تفریق‌کننده طول موج نوری که در سیستم‌های مولتی‌پلکسینگ فشرده طول موج بکار می‌روند می‌توانند موجب کاهش پهنای باند کاری سیگنال نوری گردند. این مقاله اثرات باریک شدن پهنای باند سیگنال بواسطه استفاده از تجهیزات فوق در یک ارتباط فیبر نوری را بر عملکرد سیستم مطالعه می‌نماید.

کلید واژه- 100 Gb/s DP-QPSK, 40 Gb/s DPSK پهنای باند ، فیلترینگ

The Effect of Filtering on 40- and 100 Gb/s Optical Signal Bandwidth

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Abstract- Signal Bandwidth is an important indicator 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 works studies the effect of narrowing of signal bandwidth on the performance of the system.

Keywords: Bandwidth, Filtering, 100 Gb/s DP-QPSK, 40 Gb/s DPSK

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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.*[1] 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 [2-7]. Also Mikkelsen *et al*. [8] 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 the quality of 40 Gb/s and 100 Gb/s signals .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 and Optical Interleaver Unit. 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 signal.

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 bandwidth 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 Bandwidth) 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 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 cascaded optical components such as Optical Interleaver Unit (OIU), ROADM's Wavelength Selective Switch (WSS) and Multiplexer/DeMultiplexer Units (MDU) or a combination of these to tighten up the filtering effect on the signal. Finally a spectrum analyzer measures the bandwidth of the signal.

The Optical Interleaver Unit works in the C-band, between 192000 GHz up to 196000 GHz. The input channel spacing is 50 GHz and the output channel spacing is 100 GHz.

The switching engine for the Wavelength Selective Switch used in this report is based on Liquid Crystal (LC) technology. WSS works in the C-band with 50 GHz spacing. The working range is between 191850 GHz up to 195800 GHz.

Multiplexer/DeMultiplexer Unit used in this setup is an Athermal Array Waveguide Grating type that can support 40 channels with 100 GHz spacing

For "no Filter", the signal was coupled directly to optical spectrum analyzer. For the other arrangements, involved components were cascaded and the output signal was fed to the spectrum analyzer.

Figure 2: Unfiltered 40- and 100 Gb/s

3 Results and Analysis

Unfiltered spectrum of 40 Gb/s and 100 Gb/s are shown in figure 2. The green line shows the 3-dB reference and by that, 3-dB band width can be calculated as ~33 GHz for 40 Gb/s and ~27 GHz for 100 Gb/s signals. The first test is to find the effect of bandwidth narrowing on 40 Gb/s signal. Signal was passed through a series of cascaded components to check their filtering effect on the signal's spectrum and the resulting spectrum could be seen on spectrum analyzer. WSS cascaded with either of other devices determines the tightest filtering with 3-dB band width of ~28 GHz.

For 100 Gb/s signal, the same test was carried out. Again, it was WSS cascaded with OIU or multiplexer that determined the filter with minimum bandwidth which in this case is ~26 GHz.

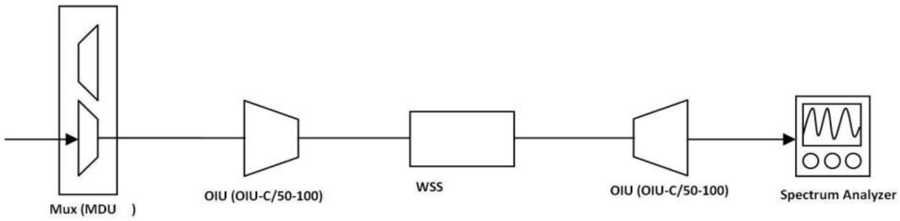
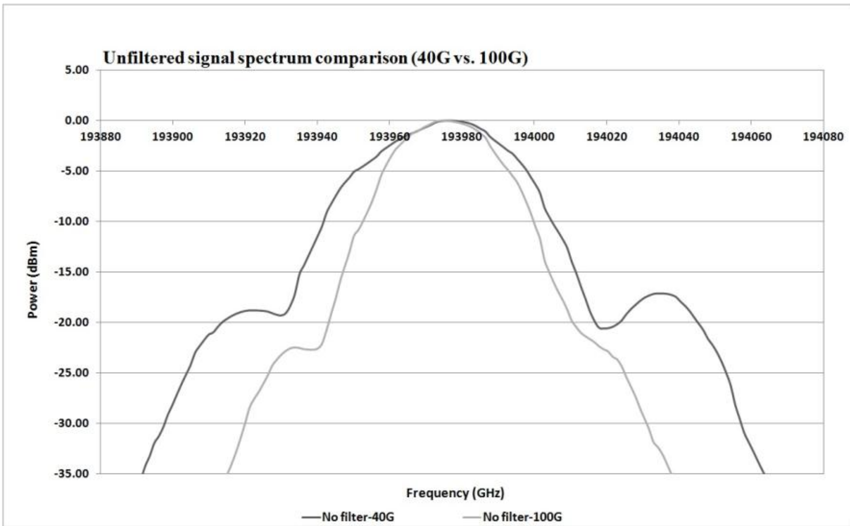


Figure 1: Filtering effect measurement setup



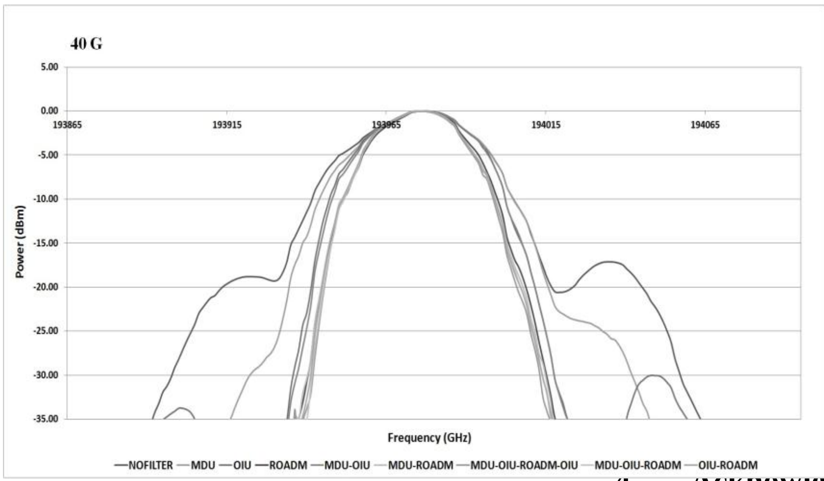


Figure 3: Filtering effect of different components on 40 Gb/s signal

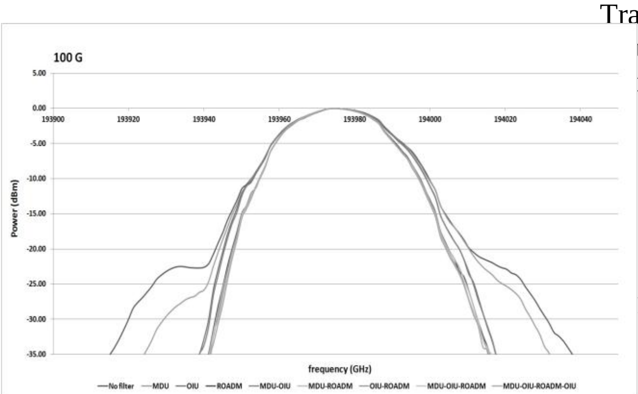


Figure 4: Filtering effect of different components on 100 Gb/s signal

Conclusion

According to figures 3 and 4, tighter filters (narrower bandwidth) cause the signal spectrum to become narrower. The order could be demonstrated like:

(Larger bandwidth>…>smaller bandwidth):

MDU > OIU > WSS > any combination of MDU, OIU and WSS

The smallest possible bandwidth for the 100 Gb/s signal is 30 GHz .Filtering tighter than 30 GHz leads to signal loss by the receiver.

Although tight filtering in general may not be desirable (because it cuts the significant part of the signal) but in some cases (like using the Tunable Dispersion Compensators) it is beneficial to have a tighter signal for better compensation of dispersion at high dispersion settings.

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