

Transmission of 40 Gbps Signals through Metropolitan Networks Engineered for 10 Gbps Signals

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Abstract: A critical emerging technology for advanced DWDM systems is 40 Gbps transmission support. The use of 40 Gbps channels increases the DWDM capacity by the factor of four, supports interconnection of next generation IP routers at OC-768 and saves OpEx and CapEx due to having to deploy and maintain fewer channels to provide the same capacity, needing fewer spare transponder modules. A key design driver for 40 Gbps technology is that it should seamlessly integrate with existing 10 Gbps systems without requiring changes to the common equipment, including ROADMs technology. Parameters that must be analyzed to a greater degree at the 40 Gbps transmission rate include chromatic dispersion, PMD, and filtering effects. This analysis is based on the experiment on deployment of 43Gb/s PSBT signals over an existing 10Gb/s DWDM system with cascaded ROADMs that we reported on last year [1].

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1. Introduction

Vast majority of the DWDM networks deployed nowadays are designed to support 10 Gb/s channel traffic. Looking down the road when a dramatic increase in capacity over existing fiber will be required, a number of technologies are considered. The technology that allows for the minimum capital expenses will most probably be the winner. Transmission of 40 Gb/s channels over pre-deployed 10 Gb/s – enabled equipment by means of non ON-OFF Keying (OOK) modulation is definitely a good candidate to become a technology of choice.

Due to its spectral efficiency and hence resilience to narrowband optical filtering, Phase Shaped Binary Transmission (PSBT) is ideally suited for 40Gb/s DWDM transmission through multiple cascaded optical filters, such as ROADMs, that is a common place in Metro Networks. By using 40Gb/s PSBT transponders with tunable lasers and broadband receivers in combination with using ROADMs as optical filters can result in substantial CapEx savings. 40Gb/s wavelengths can be added to the existing 10Gb/s DWDM infrastructure without replacing ROADMs or severely constraining the link engineering rules. While the effects of filter concatenation in WDM systems have been published for other formats and data rates [2-5], we believe we can derive valuable conclusions from the experimental study of 40Gb/s PSBT to concatenation of commercially available ROADMs.

2. Experiment set-up and results

For the experiment a system with the following parameters was used: 32 2.5Gb/s and 10Gb/s channels located in C-Band with 100 GHz channel spacing, 16 spans of Non-Dispersion Shifted Fiber (NDSF) with the average span loss of 14.9dB, the total fiber length was 840km (14 spans x50km and 2 spans x70km). ROADMs were located in every amplified node. The system configuration is shown in Figure 1. The 43Gb/s PSBT signal ($\lambda_s=1554.13\text{nm}$) was multiplexed with three 10.7Gb/s channels ($\lambda_s=1556.55\text{nm}$, 1558.17nm, 1559.79nm), two 2.7Gb/s channels ($\lambda_s=1557.36\text{nm}$, 1558.98nm) and six unmodulated wavelengths ($\lambda_s=1530.33\text{nm}$, 1531.90nm, 1541.35nm, 1542.94nm, 1546.12nm, 1547.72nm). Spectrum of the overall traffic was captured at the 14th ROADM and is shown in Figure 2 (43Gb/s signal marked). The ROADM used is a Planar Lightwave Circuit (PLC) based device with 65GHz 3dB bandwidth and a typical normalized passband response shown in Figure 3. Also shown in Figure 3 are the normalized passband responses for 2, 4, 8, 12, and 16 cascaded ROADMs.

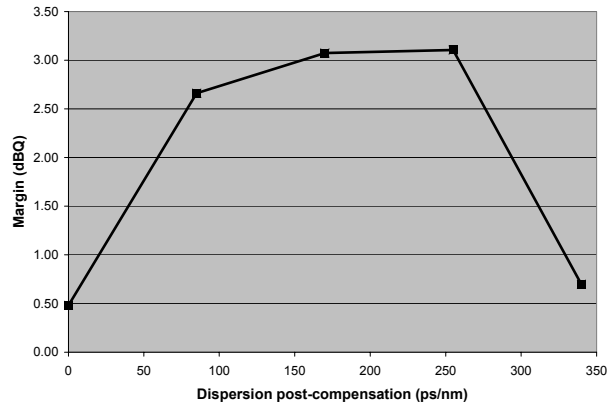


Fig. 4: Chromatic dispersion sensitivity

The CD sensitivity was measured over the system by using various lengths of NDSF as dispersion post-compensation, located immediately before the 43Gb/s line side receiver. The results of the CD sweep are shown in Figure 4.

The dBQ margin was derived from the pre-FEC BER, with respect to the EFEC cliff (approximately at pre-FEC BER= 1.5×10^{-3}). The CD tolerance window measured after 16 spans is approximately 250ps/nm. The 43Gb/s line card used was a muxponder device, which transparently aggregates four 10Gb/s tributaries. One tributary was connected to a SONET OC-192 analyzer and showed no bit errors over the measurement period. The dBQ margin, measured in 1 minute intervals, is shown in Figure 5. The mean margin was measured as 3.7dBQ, with a standard deviation of 0.23dBQ.

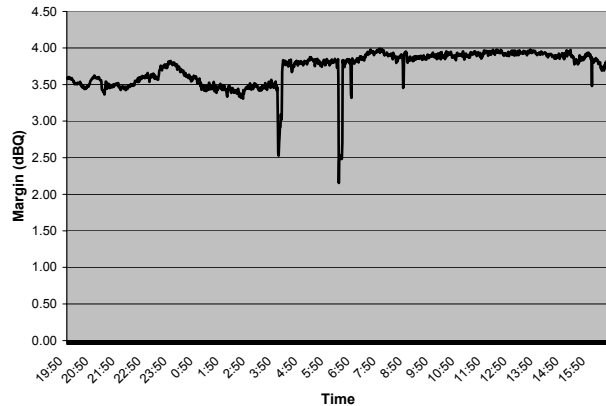


Fig. 5: Snapshot of measured stability

3. Discussion and Conclusion

Due to its intrinsic spectral narrowing, PSBT format demonstrates Chromatic Dispersion (CD) tolerance that is much greater than one for the conventional OOK modulation. However the demonstrated CD tolerance (under 300 ps/nm) is still much more demanding in terms of the required accuracy of CD compensation comparing with current deployments of 10 Gb/s systems (around 1300 ps/nm). The situation is even more dramatic when Polarization Mode Dispersion (PMD) is considered. Residual PMD is expected to be well under 3 ps.

It is clear that in order to achieve such tight tolerances for both CD and PMD, new CD and PMD compensators that are both reconfigurable and affordable must become available on the market. This is more so when Metro Networks with advanced topology, such as reconfigurable mesh networks, are considered.

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