Fast SOP Variation Measurement on WDM Systems Are the OPMDC Fast Enough?

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Abstract *Orange Labs organized a 6 month field trial to characterize states of polarization (SOP) variations with time on representative links of the future 40 Gbit/s deployment and to enable specifying the adaptation speed needed by optical polarization mode dispersion compensators (OPMDC). The SOP variations speed can reach more than 50°/1ms which seems not fully compatible with OPMDC specifications.*

Introduction

The 40 Gbit/s transponders with a relatively simple modulation format are largely intolerant to PMD. Nevertheless some operators wish that performance of the 40 Gbit/s channels is equivalent to the 10 Gbit/s channels. This can be obtained using advanced modulation formats and/or the use of compensators. Requirements for the OPMDC [1] include a response time fast enough in order to follow polarization fluctuations over the line. If DGD of buried fibre infrastructure varies very slowly, it is not right for installed amplified WDM systems. Are the OPMDC fast enough? Today the 40 Gbit/s OPMDC have very different tracking speed specifications from 0.5° /ms to 45° /ms. Orange Labs organised a 6 month field trial to characterize the fast SOP variations with time on representative links in order to provide support for engineering the future 40 Gbit/s deployment and to enable specifying the adaptation speed needed by OPMDC.

Field trial links and set-up

The tests were conduct on 2 links from only one site to simplify the installation. These links are representative of the future 40 Gbit/s deployment. One link is 1000 km long in 13 spans with 15 ps PMD and the second is 450 km in 5 spans with 12 ps PMD. The current transmission systems operating over those links are 10 Gbit/s long haul systems. The optical signal to analyse comes from the monitoring port of the reception side amplifier. That means is a non intrusive measurement. It was set to capture the polarization fluctuations and the degree of polarization (DOP). The set up is very simple (Fig.1): a filter to isolate the channel to measure, a polarimeter A1000 from ex-ADAPTIF PHOTONICS and a PC to remotely observe the A1000 from the Orange Labs.

How to catch rapid events?

To avoid space consumption on the PC and too many data to compute we didn't record continuously the SOP variations. As we are interested by tracking fast variations we used the polarimeter in "SOP Trigger" mode. The sampling rate is 10 kHz and we defined the SOP trigger parameters for a fast event as an excursion of 10° in less than 100 ms. When the condition is performed a file is generated with 1000 points before the event and 4000 points after. Thus the Stokes parameters are saved over 500 ms around the event. A post data processing is made for each event in order to estimate the angular variation on the Poincaré sphere in 1ms (10 and 100 ms).

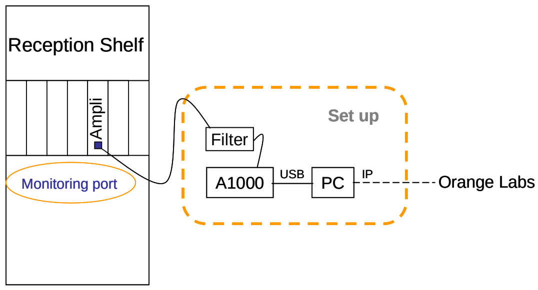

Fig.1: Very simple SOP variation measurement set-up

Fast events results

On the 1000 km link we found that a speed of about 8° /1ms is the most probable but we also cached numerous rapid SOP variations with large angular speed in the range of 50°/ 1ms (max 148°/100 ms). During the same period we estimated the DGD (instantaneous PMD) present on the line. The obtained values shown on Fig.2 reveal a rich variety of encountered PMD situation. We also calculated a mean DGD of 15.8 ps as waited.

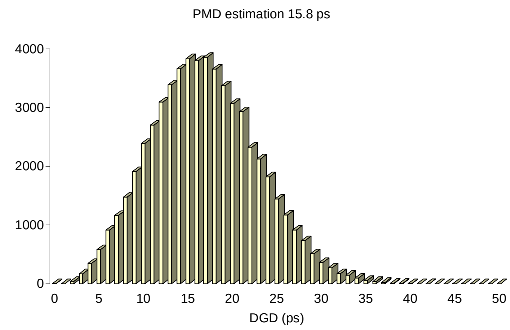

Fig.2 : DGD estimation on the 1000 km link during field trial

The Fig.3 shows for this link on the left the number of occurrences versus SOP excursion in °/1 ms and on the right the number of files generated by the

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polarimeter versus the day's hour. We found a great correlation with the human activity.

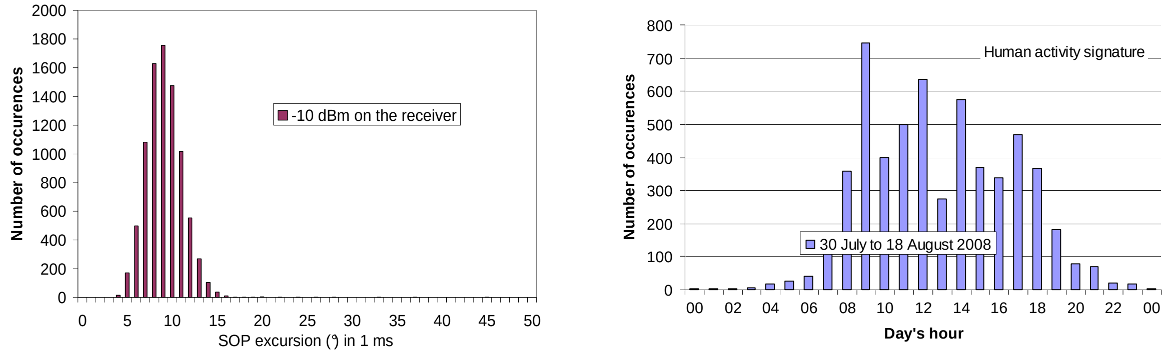

Fig.3 : Occurrences of fast events on the 1000 km link and human activity signature

On the 500 km link with 40 0000 fast events recorded a light "human activity signature" was also found and some rapid SOP variations were recorded as shown on Fig.4 with an example of 72° over 1ms.

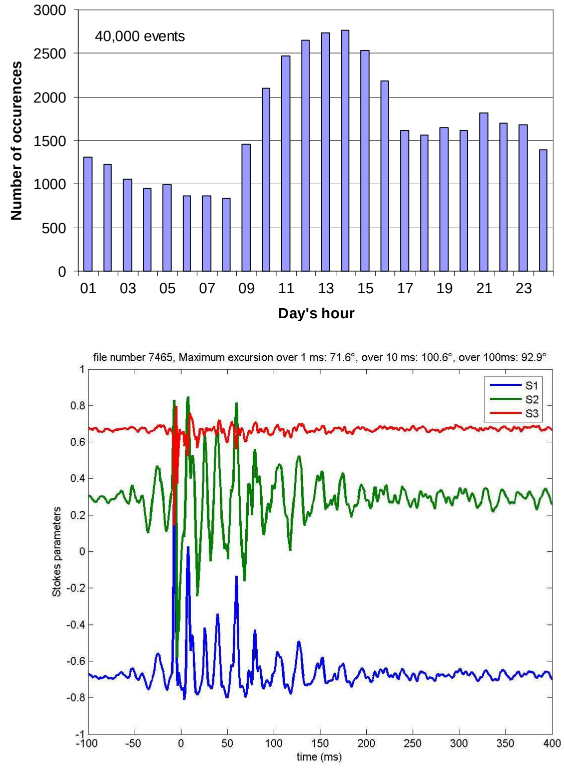

Fig.4 : On the top light "human activity signature" and on the bottom Stokes parameters during very fast variation (72 °/ 1ms) on the 500 km link

On the Tab.1 we resumed results obtained on the 500 km link in term of DOP, excursion power (dB) and SOP variation over 1ms, 10 ms and 100 ms.

Tab.1 **:** Results obtained on the 500 km link

	DOP	Power variation	°/ 1 ms	°/ 10 ms	°/ 100 ms
max	**0.99**	**0.8 dB**	**71.6**	**110.9**	**93.1**
min	**0.51**	**0.1 dB**	**0.9**	**2.0**	**1.9**
mean	**0.96**	**0.2 dB**	**2.1**	**5. 8**	**5.7**

Conclusion and consequences for OPMDC

Today the increasing bit rates needed by communication systems put face to face the long-haul 40 Gbit/s WDM systems with the PMD of legacy optical fibre. As there is no more OSNR margin to exchange with penalty due to the PMD one solution could be the use of a PMD robust modulation format another is electronic or optical PMD compensation. Nevertheless those compensators have to be dynamically adjusted to follow the PMD and SOP random fluctuations in order to guarantee error free transmission.

At the end two WDM representative links were monitored for 6 months in terms of SOP variation and speed. From the analysis of these variations, it comes out that each link has its own SOP speed distribution [2]. In our case we observed rapid SOP events can have speed up to 50° / 1ms (with very low probability though). If all links are different [3] most of the rapid SOP events occur at daytime, which is likely to link those events to human activity. Those values are therefore the basis for PMD compensation (either electronic or optical) minimum speed specification.

If PMD compensation was required in a specific link, in particular for 40 Gbit/s, the solution to implement should be able to react faster than measured SOP variations in the field and therefore its SOP variation dynamic specification should be higher than 50°/1ms.

References

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