

Static DWDM System Deployment and Innovations in the CESNET2 NREN in 2007

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1 Abstract

This paper describes progress in deployment and experiences with the static DWDM systems based on the CLA (CzechLight Amplifiers) optical amplifiers in the CESNET2 backbone network in the year 2007.

CLA based static DWDM system is continuously developed, trying to identify, verify and deploy new commercially available elements. This approach allows delivering the newest and advanced system features. Based on the lab testing provided by our researchers (e.g. [KVR07], [VKR07]) we continue with deployment of the new optical lines in the CESNET2 production network environment and with tests and verification of the newest technical solutions in real operations. Based on experiences gained from the extension of static DWDM span Prague – Ústí n. Labem to Liberec we designed innovative solution for the DWDM static system České Budějovice – Jihlava – Brno, equipped with 32-channel Mux/Demux and broadband FBG based chromatic dispersion compensation modules with ultra low insertion losses, ready for up to 40 Gbps speeds. Our solution is also open for future implementation of new optical programmable components, e.g. tuneable CD compensators, ROADMs, and so on.

2 Introduction

CLA (CzechLight Amplifiers) were initially designed for the cost effective deployment of gigabit optical lines without the inline amplification (Nothing-in-line approach) by the CESNET optical research group, e.g. [KRV05]. In the 2006 we successfully implemented CLA solution over the 10Gbps optical lines Brno – Bratislava, Brno – Vienna and Prague – Ústí n. Labem [VKR06], [VN06].

The experiences with the network operation together with demands of research activities straight shows that more flexibility and SW features is necessary for smooth CLA DWDM systems expansion. To support these ideas new prototypes

of CzechLight (CL) devices were developed. Now the CzechLight includes the series of programmable and cost effective devices based on this concept. These are:

- CLA – new types of CLA amplifiers (Gain Flattened Low Noise)
- CLR – Raman Amplifiers
- CLC – tuneable CD compensators
- CLS and CLM – optical switches and multicast optical switches

There are more innovative photonic components identified and tested by our researches in the lab where some of them are considered for prototypes and next verification in operational network environment.

We also focus to management and monitoring features improvements. Due to non-availability of tuneable pluggable optics on the client sides, it was decided to support more optical channels (up to 32) to have high flexibility in the wavelength selection. The careful design makes also possible migration to 10Gbps or 40 Gbps speeds in future according future needs.

3 CLA development

Basic design described in [Voj05] was development in year 2007. Emphasis was given to simultaneous transmission of many optical channels with different wavelengths. As a result following devices designed, tested and deployed. CLA PB01F – gain flattened dual preamp plus booster for terminal amplification and one side amplification applications; CLA PB02F – gain flattened dual preamp plus high power booster for terminal amplification on very long haul lines and CLA DI01F – gain flattened dual inline amp for line amplification on very long lines.

Monitoring possibilities of CLA devices were also improved. Now the basic operational characteristics can be polled by SNMP protocols.

4 Optical line Prague – Ústí n. Labem – Liberec

The first phase of optical line Prague – Liberec upgrade, optical span Prague – Ústí n. Labem (length 130km, attenuation 34dB@1550nm), was successfully finished at the end of 2006 [VN06]. The line was terminated in Ústí n. Labem . This allowed upgrade of PoP Ústí n.Labem to 10 Gbps (with the DWDM XENPAK

in router interfaces installed) and the pilot project of Central Military Hospital Prague and Masaryk's Hospital Ústí n. Labem data centers interconnection.

In year 2007 DWDM extension to Liberec increased the overall line length by the next 123 km with attenuation of 28dB@1550nm to total length of 253 km. To ensure the excellent quality of 10 Gbps express channel Prague – Liberec, the original DWDM span Prague – Ústí n. Labem was also upgraded to use same technology as new span. Now there are used CLA PB01F optical amplifiers with the flat gain characteristic, broadband CD compensators based on FBGs and DWDM multiplexers/de-multiplexers with expansion ports. All these devices allow future easy upgradeability and addition of new channels.

The detailed optical design from the 10 Gbps optical channel Prague – Liberec perspective is shown in Figure 1.

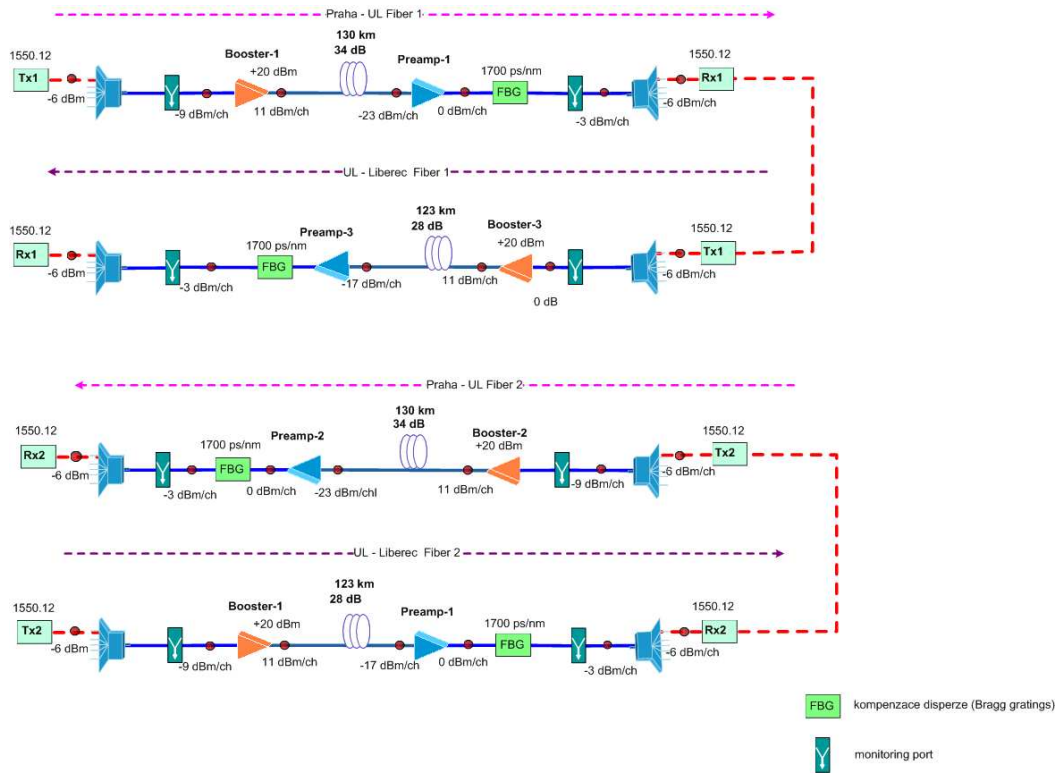


Figure 1: The detailed optical design of the express 10 Gbps channel Prague – Liberec (253 km)

Both Prague – Ústí n. Labem and Ústí n. Labem – Liberec spans were developed as the independent lines, but allowing express channels. There are used 8-channel DWDM multiplexers/demultiplexers with expansion ports (channels 26-34 of ITU-T grid, 100 GHz spacing) with the maximum insertion loss 2.5 dB.

The express optical channels are patched by optical patch cables between the relevant ports of Mux/Demux (see Figure 2) of the particular spans.

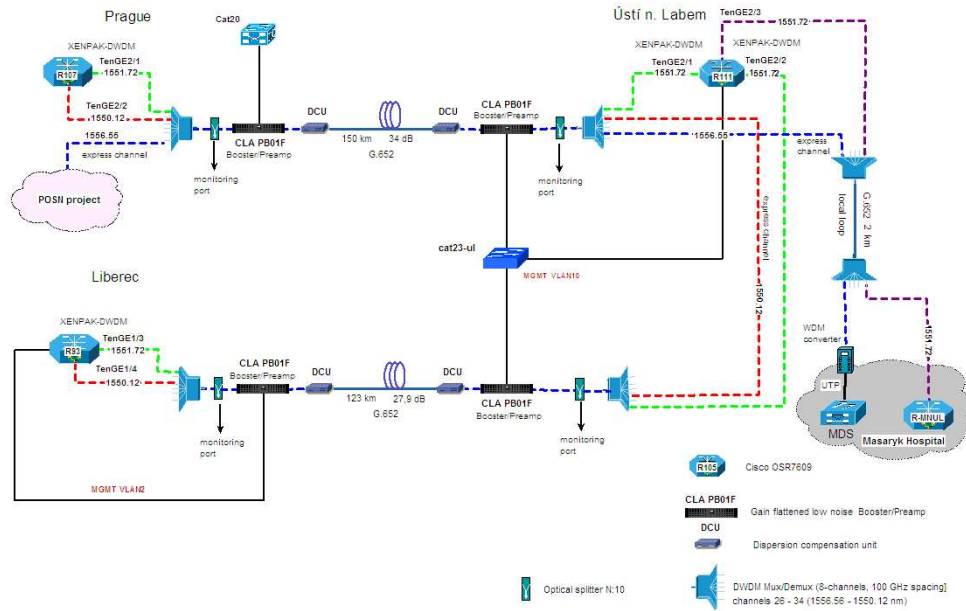


Figure 2: Static DWDM line Prague – Ústí n. Labem – Liberec deployment

The input optical level coming from the client pluggable optics (XENPAKs or SFPs) is balanced by the attenuation patch cables to value about -6 dBm. The current optical wavelength utilization is shown in Table 1.

ITU channel	Wavelength [nm]	End A	End B	Capacity [Gbps]	Project
26	1556.55	Prague	Masaryk Hospital	1	POSN
32	1551.72	PoP Prague	PoP Ústí n. Labem	10	IP network
32	1551.72	PoP Ústí n. Labem	PoP Liberec	10	IP network
34	1550.12	PoP Prague	PoP Liberec	10	IP network

Table 1: Optical wavelength utilization Prague – Liberec

In the November 2007 we started the operational test of tuneable DCU unit based on CzechLight dual tuneable CD compensator over this DWDM system. The advantage of this technology is more accurate and flexible chromatic dispersion compensation which is important in case of 10 Gbps transmission speeds. The

current experiences shows that this technology is very well suitable for the 10G DWDM design.

The static DWDM system was completely designed by the CESNET optical research engineers, but the installation and operations are provided by optical lines supplier. This is the recent change, because we use now service of the “lit fiber” instead the “dark fiber” only. We can also the monitor the active DWDM devices and change the parameters (with the cooperation with the optical line supplier) if needed. This case safe the capacity of our specialists and operation costs, but it make possible to use the own optical transmission technology.

5 Optical line České Budějovice – Jihlava – Brno

The design of static DWDM design on this optical line was more complicated comparing with previous cases. The overall line length České Budějovice – Brno is about the 298 km and there are more add/drop nodes serving for connection of small PoPs like Jindřichův Hradec and possibly Tábor in future. Distances and attenuation conditions are depicted in Figure 3.

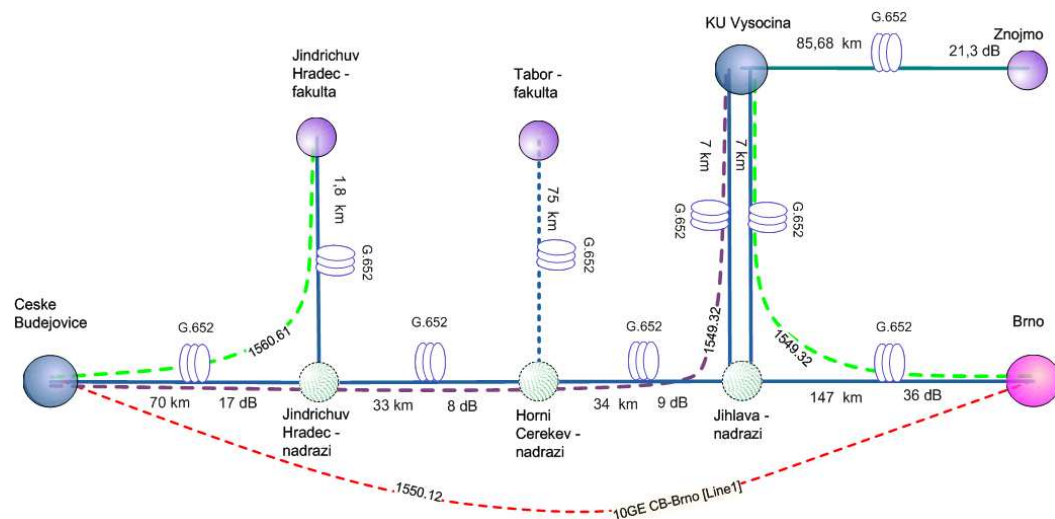


Figure 3: Static DWDM line České Budějovice – Jihlava – Brno topology

The design of static DWDM system for these optical lines covers two main amplified spans with the CD compensation. There are two lines České Budějovice – Jihlava and Jihlava – Brno (see Figure 4). The initial design of DWDM system is taking into account up to 16 optical channels as maximum number, but we plan to use 32-channel multiplexers/demultiplexers to have higher flexibility concerning wavelength channel plan. The 32-channel solution is planned for České Budějovice, Jihlava and Brno PoPs. In small PoPs there will be only a few

add/drop channels provided by the small fixed OADM to achieve low insertion losses. The system will be ready to connect them if need without any additional design changes.

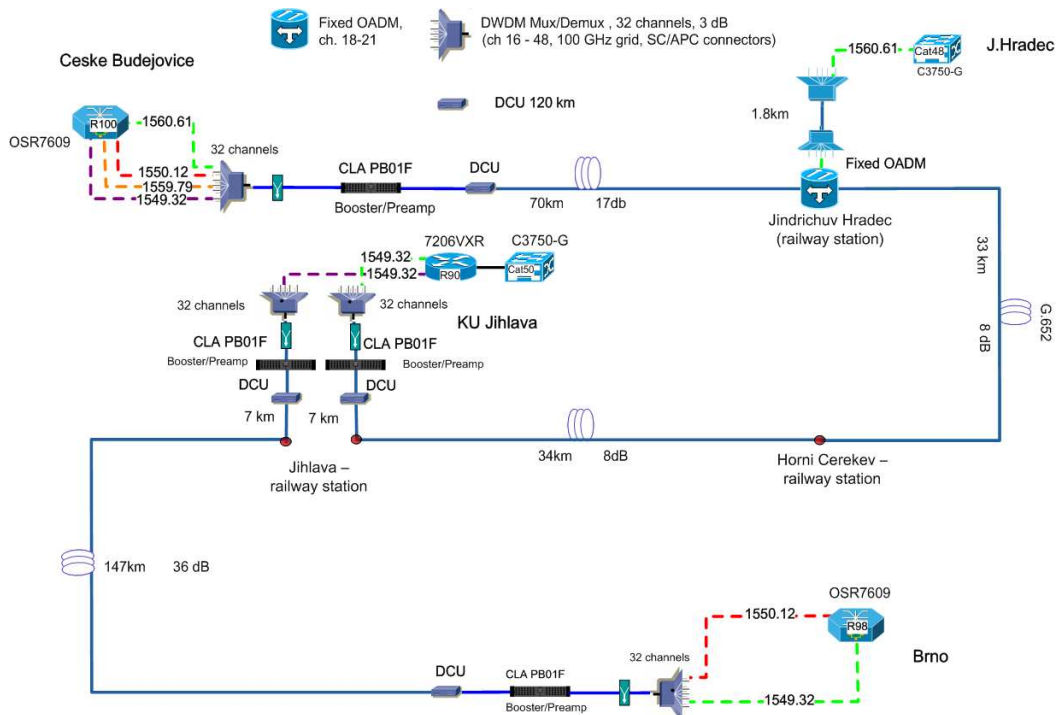


Figure 4: Static DWDM line České Budějovice – Jihlava – Brno detail plan

Planned initial optical wavelength utilization is shown in Table 2. The most of used wavelengths are planned for 1Gbps capacity. There will be first 10Gbps express wavelength České Budějovice – Brno for the core IP network backbone. It will be terminated on the DWDM XENPAKs in the routers.

ITU channel	Wavelength [nm]	End A	End B	Capacity [Gbps]	Project
21	1560.61	PoP České Budějovice	PoP J. Hradec	1	IP network
21	1560.61	PoP Jindřichův Hradec	PoP Jihlava	1	IP network
34	1550.12	PoP České Budějovice	PoP Brno	10	IP network
35	1549.32	PoP České Budějovice	PoP Jihlava	1	IP network
35	1549.32	PoP Jihlava	PoP Brno	1	IP network

Table 2: Optical wavelength utilization České Budějovice – Brno

6 Optical line Brno – Ostrava

The design of this static DWDM system is based on the operational results and experiences with CBF line Brno – Vienna DWDM system. The optical line Brno – Ostrava is long about 224 km, fiber is G.652 type with attenuation about 50dB@1550nm. It is planned to install 32-channel DWDM multiplexers/demultiplexers and broadband CD compensators based on FBGs. These facts give good possibility of easy channel additions and future upgrade to higher speeds (e.g. 40Gbps). The detailed plan of the line deployment from the 10 Gbps perspective is shown in Figure 5.

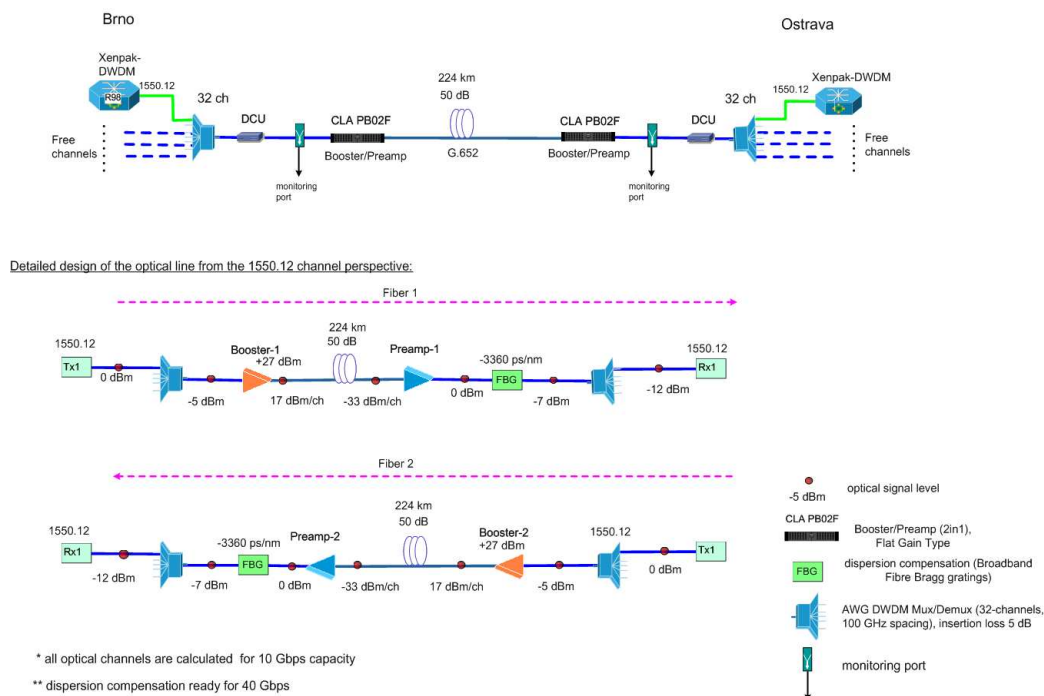


Figure 5: Static DWDM line Brno – Ostrava detail plan

The static DWDM installation is expected at the beginning year of 2008, caused by long delivery terms of the CLA PB02F amplifiers and especially FBG which are atypical.

7 Conclusions and future development

CLA devices based on new commercially available optical elements allowed deployment of static cost effective DWDM solutions over links with lower demand for number of optical channels. For next year deployment of single fibre links with bidirectional transmission is planned. This links should deliver very cost

effective and redundant connectivity for smaller pops. In further years delivery of dynamical capabilities into CL family is planned e.g. by introducing optical switches, small tuneable ROADMs and eventually WSSs.

References

- [KVR07] Karásek M., Vojtěch J., Radil J.: Bidirectional repeaterless transmission of 8x10 GE over 210 km of standard single mode fibre. *IET Optoelectronics*, Volume 1, Number 2, p. 96–100.
- [VKR07] Vojtěch J., Karásek M., Radil J.: Experimental comparison of all-optical methods of chromatic dispersion compensation in long haul transmission at speeds of 10 Gbit/s. *Journal of Optical Networking*, Volume 6, Number 12, p. 1340–1348.
- [KRV05] Karásek, M., Radil, J., Vojtěch, J.: Optical amplifiers in CzechLight and CESNET2, In *CEF Networks Workshop*, Praha, 2005.
- [VKR06] Vojtěch J., Karásek M., Radil J.: Field and lab experiences with deployment of optical amplifiers and FBGs. *CEF Networks Workshop*, Praha, 2006.
- [VN06] Vojtěch J., Novák V.: *Deployment of a DWDM system with CLA Optical Amplifiers in the CESNET2 Network*. Technical report 25/2006¹, Praha: CESNET, 2006.
- [Voj05] Vojtěch J.: CzechLight & CzechLight Amplifiers. In *17th TF-NGN meeting*, Zurich, April 2005.

¹<http://www.cesnet.cz/doc/techzpravy/2006/dwdm-cla/>