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Deployment of CL VMUX devices in CESNET Experimental Facility

Miloslav Hůla, Josef Vojtěch, Jan Radil

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Abstract

In this article we summarize properties of various technologies for VMUXes. We then describe our practical experience with the CL VMUX, which is based on the PLC technology. We also investigate behavior of CL VMUX device after power loss.

Keywords: optical communication, touch-less lambda provisioning, variable multiplexer, open photonics networks

1 Introduction

In present photonic transmission systems of Dense Wavelength Division Multiplexing (DWDM) Erbium Doped Fibre Amplifiers (EDFA) are widely used. These work on analog principle, amplifying all signals within working band presented on input. A spectral characteristic of EDFA is not inherently flat and thus need some gain flattening. Typical flatness 1 or 2 dB over working band, typically C or alternatively L band, can be reached.

To ensure same gain for all transmitted channels, the equalization of power is necessary. Channels need to exhibit equal powers before entering a transmission system or within a system in ADD/DROP nodes, where other channels are added or dropped.

A Variable Multiplexer (VMUX) is a device to perform the task of signal equalization and multiplexing before entering the transmission system. Alternatively it can be used for power conditioning of particular signals leaving the transmission system.

In this report we review properties of various technologies for VMUXes. We then describe our practical experience with the CzechLight (CL) VMUX, which is based on the PLC technology: the experimental deployment in experimental facility Czech Light is described and the features of remote automated control and setup storage are summarized. Device behavior during power loss has been experimentally verified also. Finally report is conclude in terms of good replacement of manual attenuation and equalization.

2 Variable MUX architecture and technology

In principle the VMUX consist of an attenuator array (a number of attenuators equals the number of input channels), an optional tap and a photodiode array monitoring powers of particular channels and a multiplexer.

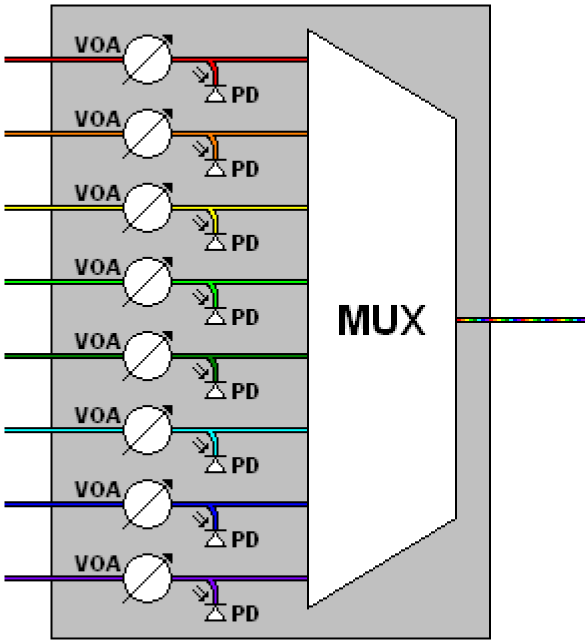

Figure 1. Scheme of a VMUX device

Present VMUX devices are fabricated in many different ways. The simplest way with no integration is simple fusing of Variable Optical Attenuators (VOA), which can be based on many different principles, together with thermally stabilized multiplexer based on Arrayed Waveguide Grating (AWG) technology. This approach leads to bulky size of a device and thus is used for small channel counts only. In these cases, AWG mux is sometimes replaced by a Thin Film Filter based multiplexer.

The more advanced solution is a hybrid or monolithic integration, where a device is placed in a single Planar Lightwave Circuit (PLC) chip. Compared with a discrete based VMUX device, the integrated device exhibits worse crosstalk characteristics and the low yield, due to AWG structures, what is describes in.

Modern components, such as Digital Light Processors (DLP), can also be used as VMUXes. But they are typically costly, offering Wavelength Selective Switch (WSS) functionality.

Basic characteristics of VMUX devices are:

- Channel plan and centre wavelengths accuracy
- Bandwith
- Insertion Loss (at 0 attenuation)
- Polarization, Wavelength, Temperature Dependent Loss (PDL, WDL, TDL)
- Adjacent, Non-adjacent, Total channel isolation
- CD
- PMD
- Response time

3 CL VMUX functionality

Present CL VMUX devices are based on PLC technology. They are available in two versions, with and without power monitoring. In the following text the devices without power monitoring are described.

Figure 2 shows a situation when two channels are transmitted.

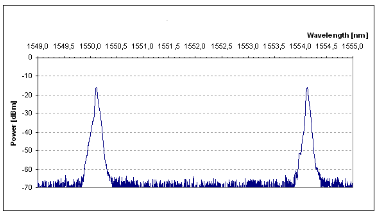

Figure 2. Two equalized channels.

A third channel is added, but it is not correctly equalized. VMUX allows for equalization without other channels interruption (Figure 3).

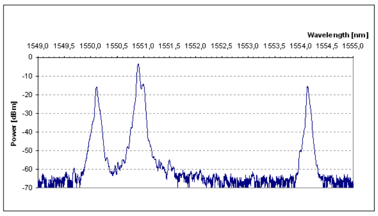

Figure 3. Three channels, middle channel is not correctly equalized.

12dB of attenuation is added to the channel in the middle for correct equalization (Figure 4).

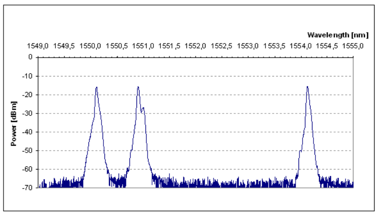

Figure 4. Three equalized channels.

4 Deployment of CL VMUX devices

Two 40-channel CzechLight variable multiplexors were put at the experimental optical line Praha – Jihlava, see Figure 5.

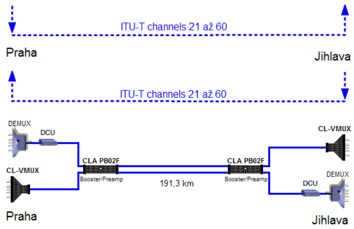

Figure 5. Experimental optical line Praha – Jihlava.

5 Configuration of CL VMUX

CL-VMUX is accessible over an IP network and secure shell. Access is limited to configured IP addresses and IP networks. For success login, an administrator password is required.

For attenuation setting and reading, open source program minicom is used. VMUX module itself offers commands to get and set attenuation values change:

- ga – Get Attenuation
- sa – Set Attenuation

Example commands follow:

Set all channels to minimal attenuation:

```
sa * 0
```

Set channels 4, 19 and 38:

```
sa 4 3.2
sa 19 2.0
sa 38 1.6
```

List of all channel settings:

```
ga
Ch1:   0.000    Ch11:  0.000    Ch21:  0.000    Ch31:  0.000    dB
Ch2:   0.000    Ch12:  0.000    Ch22:  0.000    Ch32:  0.000    dB
Ch3:   0.000    Ch13:  0.000    Ch23:  0.000    Ch33:  0.000    dB
Ch4:   3.200    Ch14:  0.000    Ch24:  0.000    Ch34:  0.000    dB
Ch5:   0.000    Ch15:  0.000    Ch25:  0.000    Ch35:  0.000    dB
Ch6:   0.000    Ch16:  0.000    Ch26:  0.000    Ch36:  0.000    dB
Ch7:   0.000    Ch17:  0.000    Ch27:  0.000    Ch37:  0.000    dB
Ch8:   0.000    Ch18:  0.000    Ch28:  0.000    Ch38:  1.600    dB
Ch9:   0.000    Ch19:  2.000    Ch29:  0.000    Ch39:  0.000    dB
Ch10:   0.000   Ch20:  0.000    Ch30:  0.000    Ch40:  0.000    dB
```

6 Behavior during electrical power loss

VOAs and thermally stabilized AWG are active devices and thus their behavior without electrical power can be undefined. We experimentally verified this situation. Figure 6 shows the device state after electrical power loss. Measurement was done four times in different moments after power loss.

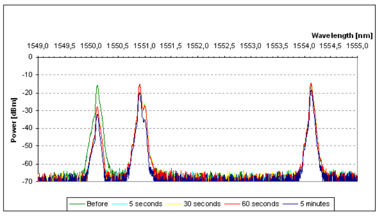

Figure 6. State before and after electrical power loss.

Optical power fluctuates immediately after electrical power loss. Green line represents the state before power loss.

7 Conclusion

CL VMUX devices can substitute traditional attenuators used for DWDM channel equalization without any doubt, but they need the same 24/7 power with backup as other active network devices. In the past the drawback of their usage was in high cost compared with a traditional solution – fixed attenuators and discrete multiplexer. But the cost of devices is decreasing due to integration and with embedded power monitoring the full comfort of remote administration (here especially channels equalization) will be achieved. We can recommend deployment of VMUXes everywhere in Open WDM systems where lambdas need to be equalized.

References

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