Analysis of Influence of OADM Performance in Optical Networks on Zero-dB-bandwidth, Cutoff bandwidth and Cutoff magnitude

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Abstract. OADM is an important component of optical network, which has important influences on network structure and transmission mode. VPI is a very powerful professional optical communication simulation software currently, but it takes a certain amount of time to master due to its full English interface and the complex parameter setting. In this paper, experiments are designed starting from the basic performance of OADM, based on the VPI professional simulation software, from Zero-dB-bandwidth, Cutoff bandwidth and Cutoff magnitude to study its performance for the next step research, providing the necessary reference for beginners and helping them grasp the VPI quickly.

Introduction

With the rapid development of the Internet, optical fiber communication has come a long way. The bandwidth of optical fiber has been continuously improved, and the carrying capacity is becoming more and more powerful. In the support of the optical fiber communication technology, information, data, image can be reliably and efficiently transmitted. Optical fiber has many advantages, such as fast transmission and low cost, the good secrecy, the low loss, etc., along with the development of photonic and electronic control switching technology, the reform and development of the Internet is greatly promoted. Optical add-drop multiplexer (OADM) is an optical device, which can be used to drop or add the required wavelength, and is widely used in optical wavelength division multiplexing [1]. It is of great significance on networking capabilities, signal transmission switching, etc. The OADM will have a selection to add, drop and multiplex signals in the process of signal normal transmission. It enables the optical network to be flexible, selective and transparent. It also improves the reliability of the network, reduces the node cost, improves the network operation efficiency, and is one of the key technologies to form the all optical network.

VPI Transmission Maker is the optical simulation software with design, research, and verification of the function of the optical communication system, provides a very user-friendly interactive graphical interface, built-in a large number of optical component modules and system modules to ensure users quickly set up the experiment. The updates of VPI lag behind the needs of users usually, so it provides a co-simulation interface with supporting structures modules, this interface can be implemented function expanding outreach MATLAB and Python to adapt to the user's unique needs. VPI provides visual experiment results such as spectrum, waveform and eye chart to facilitate user analysis and processing comparison. VPI has become the top software in the field of optical fiber communication system simulation [2]. But because of its English interface, the complex parameters setup of each component, and involved in global parameter Settings, beginners need quite a long time to master the use of VPI. Based on the simulation of VPI, OADM is studied, on the one hand, understanding the performance of the OADM, on the other hand, lay a solid foundation for beginners on the simulation as well as the future research.
Architecture of OADM Experiment Based on VPI

This paper designs an experiment of the OADM using the components of LaserCW, Signal Analyzer, WDM_ADM, WDM_CouplerDrop, WDM_CouplerAdd, FilterOpt, WDM_MUX_N. As shown in Figure 1 (a), the function of the OADM is add and drop the signal, optical signal 1 is dropped with the analyzer receiving the output signal, the optical signal 2 is added in the OADM and multiplexed with the optical signal 1, which are received by the analyzer. The inside OADM as shown in Figure 1 (b), (c) and (d), after entering OADM optical signal 1 is split into two branches, one signal flows all the way through the band-stop filter of the adding coupler into the band-stop filter of the dropping coupler, the other flows all the way after a bandpass filter with the signal analyzer receiving. Optical signal 2 is transmitted from the OADM to the signal analyzer after the adding coupler and multiplexed with optical signal 1.

![Figure 1. OADM experiment composition.](image)

Experiment and Performance Analysis

System Basic Simulation Settings and Results

The system default setting parameters are shown in Table 1. The experiment observes and analyzes the performance of the signal by changing the system parameters such as the Zero-dB-bandwidth and the Cutoff bandwidth, and the Cutoff magnitude.

| Default parameters        | Default value     |
|---------------------------|-------------------|
| Bit Rate Default          | 10 GHz            |
| Time Window               | 64/10e9 s         |
| Sample Rate Default       | 160 GHz           |
| Emission Frequency 1      | 193.1e12 Hz       |
| Emission Frequency 2      | 193.4e12 Hz       |
| Average Power             | 1.0e-3 W          |
| Line Width                | 10e6 Hz           |

As shown in Figure 2 (a), (b) and (c), the spectra of optical signal 1 and optical signal 2 input and output the OADM. The center frequency of optical signal 1 is 193.1 THz, and the center frequency of optical signal 2 is 193.4 THz, and the average power of the two is 1.0e-3w. According to the spectrogram of optical signal 1, its power value is from -100dBm to 0dBm. After inputting OADM,
its average power value is -66dBm, and the output average power value of optical signal 2 is to -10dBm. The following three variables are analyzed from OADM's Zero-dB-bandwidth, Cutoff bandwidth and Cutoff magnitude.

(a) Optical signal 1 spectrum  (b) Optical drop signal spectrum  (c) Output signal spectrum

Figure 2. Default Output signal diagram.

The Effect of Zero-dB-bandwidth of the Filter on OADM Performance

In the experiment, the value of the Zero-dB-bandwidth is set 10e9, 10e8, 10e7, 10e6, 10e5 (Hz) in turn. The spectrum is shown in Figure 3 (a), (b), (c), (d) and (e), the power value of optical signal 1 and optical signal 2 is shown in Figure 3 (f).

(a) Value=10e9  (b) Value=10e8  (c) Value=10e7  (d) Value=10e6  (e) Value=10e5  (f) Line chart of power change

Figure 3. Output signal spectrum with changing Zero-dB-bandwidth.

Comparing the above images it can be seen that the increased gradually as the Zero-dB-bandwidth of filter, the signal through the band-stop filter in OADM, the blocking frequency width of the signal in center frequency is more and more broad, but when the bandwidth value is higher than 10e7, blocking frequency width will begin to change; At the same time, the power value of the optical signal 2 remains unchanged. The power value of the optical signal 1 is small in the range of Zero-dB-bandwidth of 10e6 to 10e8Hz, and the decrease is obvious between 10e8 and 10e9Hz.
The Effect of the Cutoff bandwidth on OADM Performance

The value of Cutoff bandwidth is 100e9Hz in the experiments, the image is shown in Figure 3 (a), then in turn set its values in turn 100e10, 100e11, 100e12 and 100e13(Hz), the images are shown respectively in Figure 4 (a), (b), (c), (d).

![Image](a) Value=100e10Hz
![Image](b) Value=100e11 Hz
![Image](c) Value=100e12 Hz
![Image](d) Value=100e13 Hz

Figure 4. The output signal when changing the transmitter bit rate.

From Figure 4, it can be seen intuitively that the power value of the output optical signal 1 is linearly decreasing with the increase of the Cutoff bandwidth by 10 times, which is about 20dBm; The power value of the output optical signal 2 is increasing, and the extent to power value of optical signal 2 increases a little when the Cutoff bandwidth reaches 100e12Hz. The blocking frequency width in the center frequency of optical signal 1 remains the same.

The Effect of Cutoff magnitude on OADM Performance

In the experiment, the Cutoff magnitude is set to 10, 20, 30, 40, 50 (dB). The obtained images are shown in Figure 5 (a), (b), (c), (d) and (e), and the changes of power value of optical signal 1 and optical signal 2 are shown in Figure 5 (f).

![Image](a) Value=10dB
![Image](b) Value=20dB
Cutoff magnitude defines the minimum guarantee attenuation values of Cutoff width of filter, with the increase of attenuation values, each additional 10 dB, the power value of the optical signal 2 through the band-pass filter reduced 10 dBm, in linear downward trend, and through the band-stop filter, the values of the optical signal power increase slowly, its intuitive performance is that the optical signal 1 through band-pass filter rising in the spectrum and optical signal 2 in the spectrogram is declining.

In conclusion, combined with the above experiments, it can be seen that for the performance of OADM, its Zero-dB-bandwidth determines the blocking frequency width of the add-drop signals, and the power value linear changes between 10e8 and 10e9Hz. There is a linear relationship between the Cutoff bandwidth and the power value of the add-drop signals. There is a linear relationship between the Cutoff magnitude and the multiplexing signal, and the Cutoff magnitude has an obvious effect on the add-drop signals.

Summary and Outlook
Optical add-drop multiplexer (OADM) is an optical device, which can be used to drop or add the required wavelength, and is widely used in optical wavelength division multiplexing, it makes great influences on optical network transmission capacity, network mode, key performance. In this paper, experiments are designed starting from the basic performance of OADM, based on the VPI professional simulation software, from Zero-dB-bandwidth, Cutoff bandwidth and Cutoff magnitude to study its performance for the next step research, providing the necessary reference for beginners and helping them grasp the VPI quickly. In the next step, the performance of OADM will be combined to further study the use of OADM and its influences on optical network performance.

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References
[1] Huang, Y. and Q. Xiao, An OADM based on phase-shifted fiber grating and Mach-Zehnder interferometer. Proceedings of the SPIE, 2017. 322: p. 103221U.
[2] Cao Pu. Development and Research of DAML Coherent Receiver Based on VPI [D]. Nanjing: Nanjing University of Posts and Telecommunications. 2015.

[3] Yang, S.C., Y.J. He and Y.J. Wun, Designing a Novel High-Performance FBG-OADM Based on Finite Element and Eigenmode Expansion Methods. Applied Sciences, 2016. 7(1): p. 44.

[4] Bhatia, K.S., Performance Analysis of 16 Channel WDM System with 4 OADM: Journal of Optical Communications. Journal of Optical Communications, 2015. 36(2): p. 169-173.

[5] Kaur, D. and S. Chaudhary, 4 × 10 GBPS cost effective hybrid OADM - MDM short haul interconnects. Microwave & Optical Technology Letters, 2016. 58(7): p. 1613-1617.

[6] Rashed, A.N.Z., Optical Add Drop Multiplexer (OADM) Based on Dense Wavelength Division Multiplexing Technology in Next Generation Optical Networks. Journal of Current Engineering Research, 2011. 1(1): p. 24-32.

[7] Yang, K., M. Zhang and Y.J. Yue, Research of Adaptive Control Bi-OADM in Passive Optical Network. Applied Mechanics & Materials, 2014. 716-717: p. 1395-1398.