Asymmetric Modified Optical Cross Add Drop Multiplexer to Eliminate Crosstalk

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ABATRACT

A proposed new design of optical cross add drop multiplexer (OXADM) is presented. It reduces the number of required circulators and total insertion losses compared with other circulator and FBG based designs. This enhances the isolation and crosstalk levels. In the new design, the homodyne crosstalk is eliminated in the drop signal. Also, the homodyne crosstalk in the output signal is reduced by more than 30 dB.

Keywords: magnetically tunable fiber Bragg grating, asymmetric optical cross add drop multiplexer, optical crosstalk.

1. INTRODUCTION

Today, ideal cross connects are processed electronically, which means that the optical signals that arrive from the transmission lines have to be converted into electronic signals before they can be switched. Also, after being switched, the electronic signals have to be reconverted into optical signals before being transmitted through the optical transmission lines. This process is referred to as "optical-electronic-optical (OEO) conversion". This has turned out to be a significant bottleneck for transmission bandwidth. The bandwidth mismatch between the fiber transmission systems and the electronic switching capabilities are expected to become more complex in future switches, especially these systems that have to handle terabit/s data streams [1-5]. Therefore, cross connects which route and switch the data in the optical domain has to be realized. This point is the main objective in this paper, which introduces new designs for optical switching that work in the optical domain. Consequently, this aims to solve the OEO conversion problem.

The main objective for this paper is to build the sub-systems used in all optical switch devices. Optical switches have some problems that we try to solve in this paper. The main switching problem to be solved in this paper is the tuned fiber Bragg grating (TFBG) and multiport optical circulator [6-12]. A wideband TFBG with different reflected wavelength is proposed. In this paper, the TFBG is used as a building block to solve some of problems for optical switch. The main problem is the crosstalk between wavelengths. Trials will be carried out to eliminate homodyne crosstalk at drop signal and reduce homodyne crosstalk at output signal.

This paper is organized as follows. Section 2 shows the asymmetric modified OXADM (AMOXADM) which removes completely the homodyne crosstalk at drop signal and reduces the homodyne crosstalk at the output signal. In Section 3**,** a symmetric modified OXADM (SMOXADM) is proposed. The main advantage in the second design is to reduce or eliminate the homodyne crosstalk in both cross and bar states Finally, Section 4 concludes the obtained results.

2. ASYMMETRIC MODIFIED OXADM (AMOXADM) TO ENHANCE CROSSTALK

In this proposed design, a new asymmetric modified OXADM (AMOXADM) is shown in Fig. 1. The main aim in this design is (to reduce or delete) the homodyne crosstalk. In the OXADM design, there are two main problems. The first one is the appearance of homodyne crosstalk in the drop signal as discussed before and the second problem is the homodyne crosstalk shown in the output signal.

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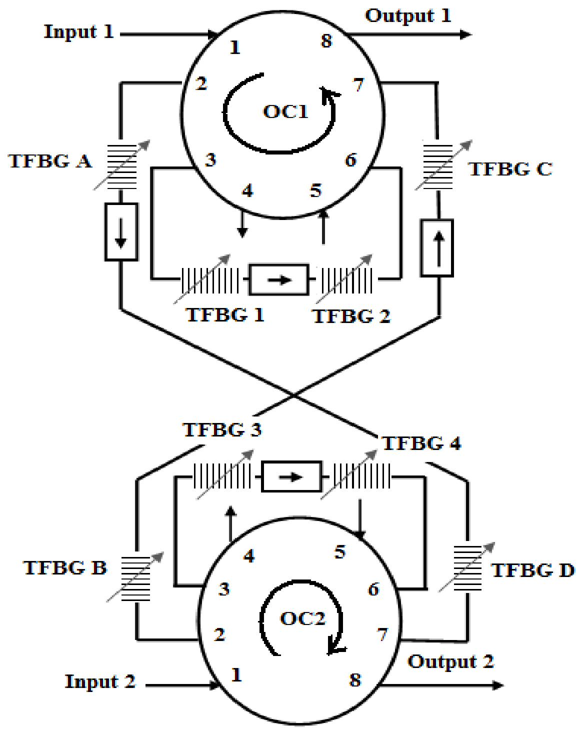

Fig. 1 Asymmetric modification OXADM (AMOXADM).

The new proposed design using VPI software for asymmetric modified OXADM (AMOADM) is shown in Fig. 2.

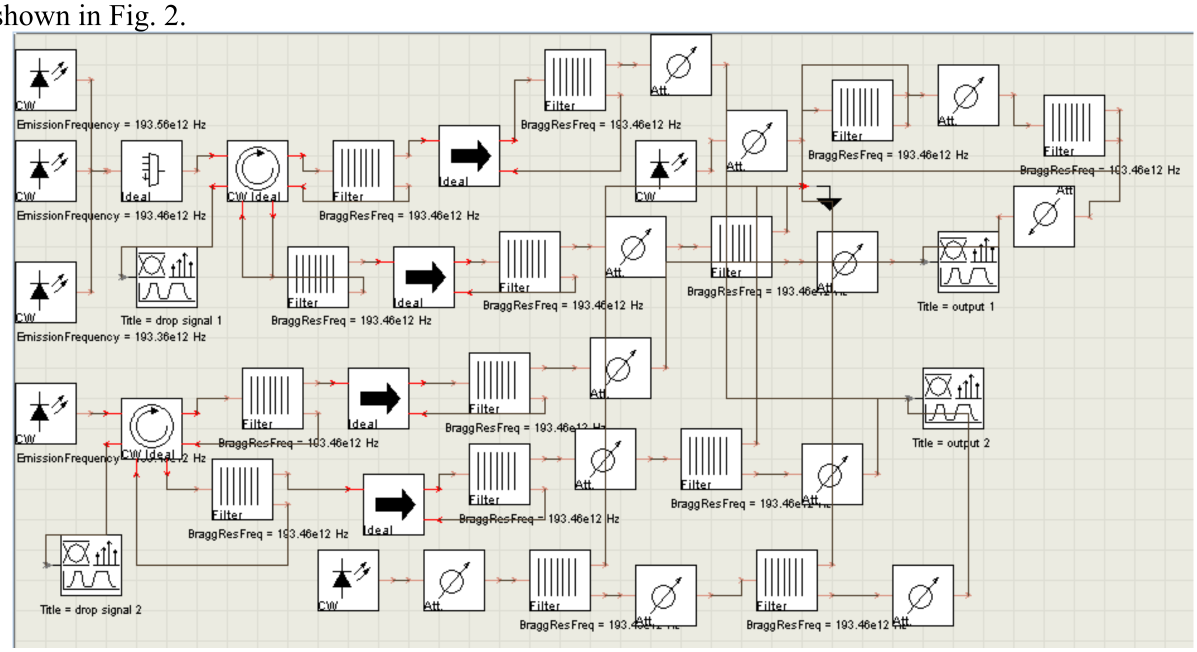

Fig. 2 Asymmetric modification OXADM (AMOXADM) using VPI software.

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This design will solve the previous two problems by:

1) Eliminating the homodyne crosstalk in the drop signal.
2) Reducing the homodyne crosstalk in the output signal by extra 30 dB better than the previous design.

The main idea is adding an isolator in the OXADM to avoid the homodyne crosstalk resulting from the leakage or incomplete reflection of the TFBGs in the device. In the AMOXADM, the only problem is the loss of flexibility of using the add/drop function when using cross-state. This drawback will be solved in the next device SMOXADM. The new design is more flexible and uses the add/drop function in both cross and bar states. The input signal, placed at input 1 (port 1 OC1), is composed of three wavelengths (λ_1, λ_2, and λ_3) where λ_1 = 1549.9 nm (193.56 THz), λ_2 = 1550.7 nm (193.46 THz) and λ_3 = 1551.5 nm (193.36 THz). In this simulation, $\lambda_{TFBGA,B,C,D}$ are adjusted to equal λ_2, also $\lambda_{TFBG1,2,3,4}$ are set to equal λ_2. Another input signal, placed at input 2 (port 1 OC2), has the same wavelength, λ_2 =1549.9 nm (193.56 THz).

Figure 3 illustrates the drop signal from port 4 in OC1. It is clearly shown that, λ_2 suffers from a small attenuation (-1.55 dBm). This loss is due to the incomplete reflection from TFBGA, 1 and the insertion loss in OC. There is no homodyne crosstalk due to the isolator. The isolator prevents any crosstalk in drop signal.

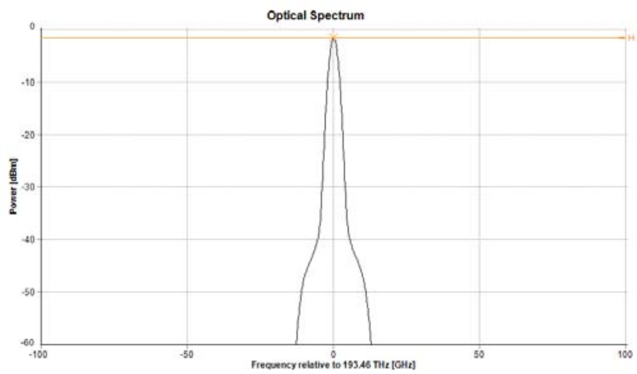

Fig. 3 Drop signal from port 4 in OC1 for AMOXADM.

Figure 4 demonstrates the output 1 from port 8 in OC1, where λ_2 undergoes by -1.58 dBm. This attenuation in λ_2 is due to the incomplete reflection from TFBG2, C and the insertion loss in OC. Also, there is homodyne crosstalk at λ_2 by -63.948 dBm. The reason of this crosstalk is incomplete reflection of TFBGB,C. The crosstalk isolation level in this design (AMOXADM) (62.36 dB) is better than the OXADM design (31.951 dBm) because the leakage signal passes two times by the TFBGs. The crosstalk isolation level increases by 30.409 dB which is a very good progress.

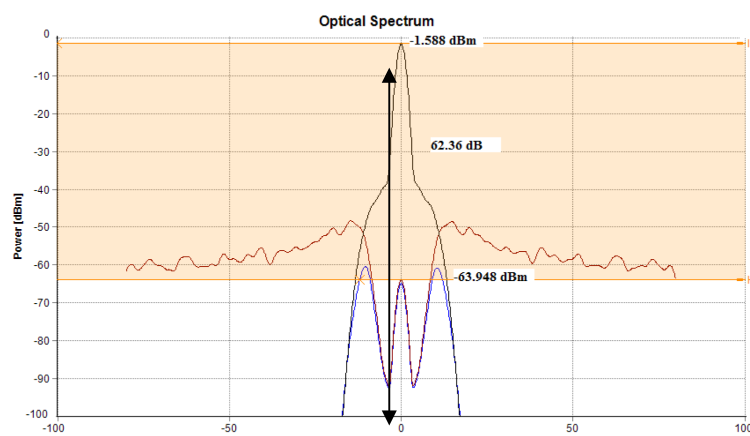

Fig. 4 Output 1 from port 8 in OC1 for AMOXADM.

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Figure 5 represents the drop signal from port 4 in OC2. It is clear that, λ_2 suffers from a small attenuation (-1.49 dBm) due to the incomplete reflection from TFBG B,2 and insertion loss in OC. As discussed before there is no homodyne crosstalk due to the isolator.

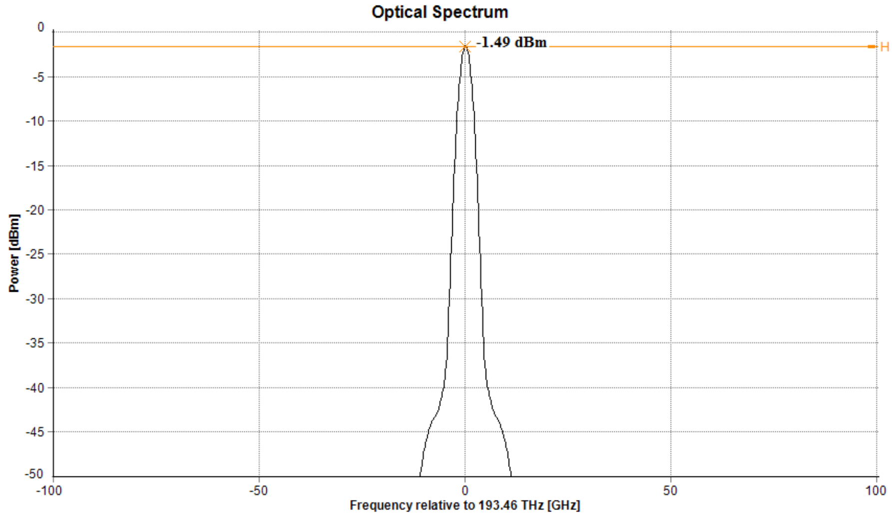

Fig. 5 Drop signal from port 4 in OC2 for AMOXADM.

Figure 6 displays the output 2 from port 8 in OC2, where λ_2 is attenuated by -1.56 dBm. This attenuation in λ_2 is due to the incomplete reflection from TFBG4, D and the insertion loss in OC. Also, the amplitude of λ_1 and λ_3 are attenuated by -0.989 dBm. In Fig. 6, there is a homodyne crosstalk at λ_2 -63.95 dBm. The reason of this crosstalk is the incomplete reflection of TFBGA,D. The crosstalk isolation level in this design (MOXADM1) 62.39 dB is better than the previous design (OXADM1) 32.05 dBm because the leakage signal passes two times by the TFBGs. So, the crosstalk isolation level increases by 30.34 dB which is an impressive improvement.

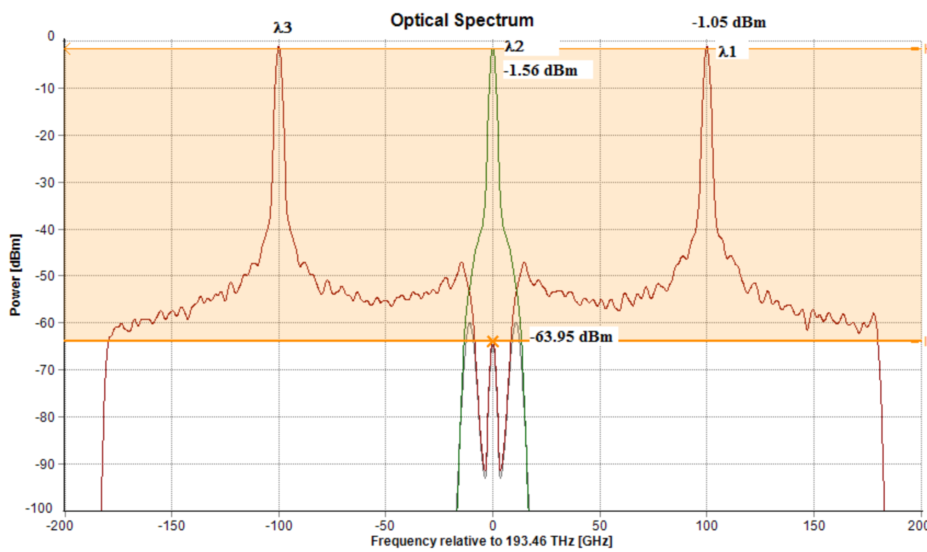

Fig. 6 Output 2 from port 8 in OC2 for AMOXADM.

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3. SYMMETRIC MODIFIED OXADM (SMOXADM) TO ENHANCE CROSSTALK IN BAR AND CROSS STATES

In this new design, a symmetric modified OXADM (SMOXADM) is proposed in Fig. 7. The main advantage in this design is to reduce or delete the homodyne crosstalk in both cross and bar states. In the previous design AMOXADM, a simultaneous cross state and add/drop signal can't be done at the same time. The loss of flexibility of using the add/drop function when using cross-state will be solved in this new design (SMOXADM). The new proposed design using VPI software for modified SOXADM is shown in Fig. 8.

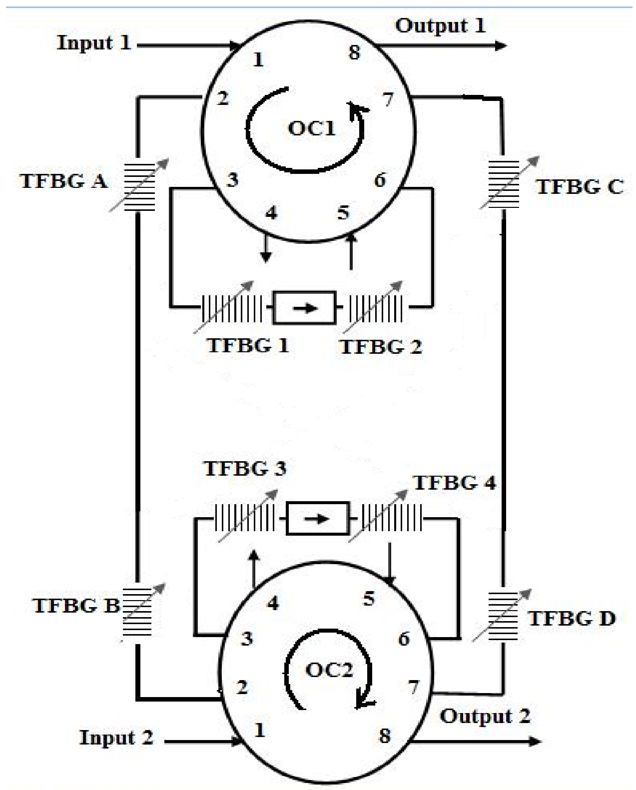

Fig. 7 A symmetric modified OXADM (SMOXADM).

In the SMOXADM, the input signals at port 1in OC1 are λ_1, λ_2, and λ_3 where λ_1 = 1549.9 nm (193.56 THz), λ_2 = 1550.7 nm (193.46 THz) and λ_3 = 1551.5 nm (193.36 THz). Also, $\lambda_{TFBGA,B,C,D}$ are adjusted to equal λ_2, and $\lambda_{TFBG1,2,3,4}$ is set to equal λ_2. Another input signal is placed at input 2 (port 1 in OC2), with the same wavelength, λ_2 =1549.9 nm (193.56 THz). We choose these wavelengths to study the worst case of crosstalk.

Figure 9 demonstrates the output 1 from port 8 in OC1, where λ_1, λ_2, and λ_3 suffer an attenuation -1.55 dBm. This attenuation is due to the incomplete reflection from TFBG and insertion loss in OC. It is obvious in result that, there is a homodyne crosstalk at λ_2 by -64.38 dBm because of the incomplete reflection of TFBG.

The crosstalk isolation level in this design SMOXADM (62.83 dB) is a worthy result. This superb evolution is due to the leakage signal which passes two times by the TFBGs. So, the crosstalk isolation level will be improved.

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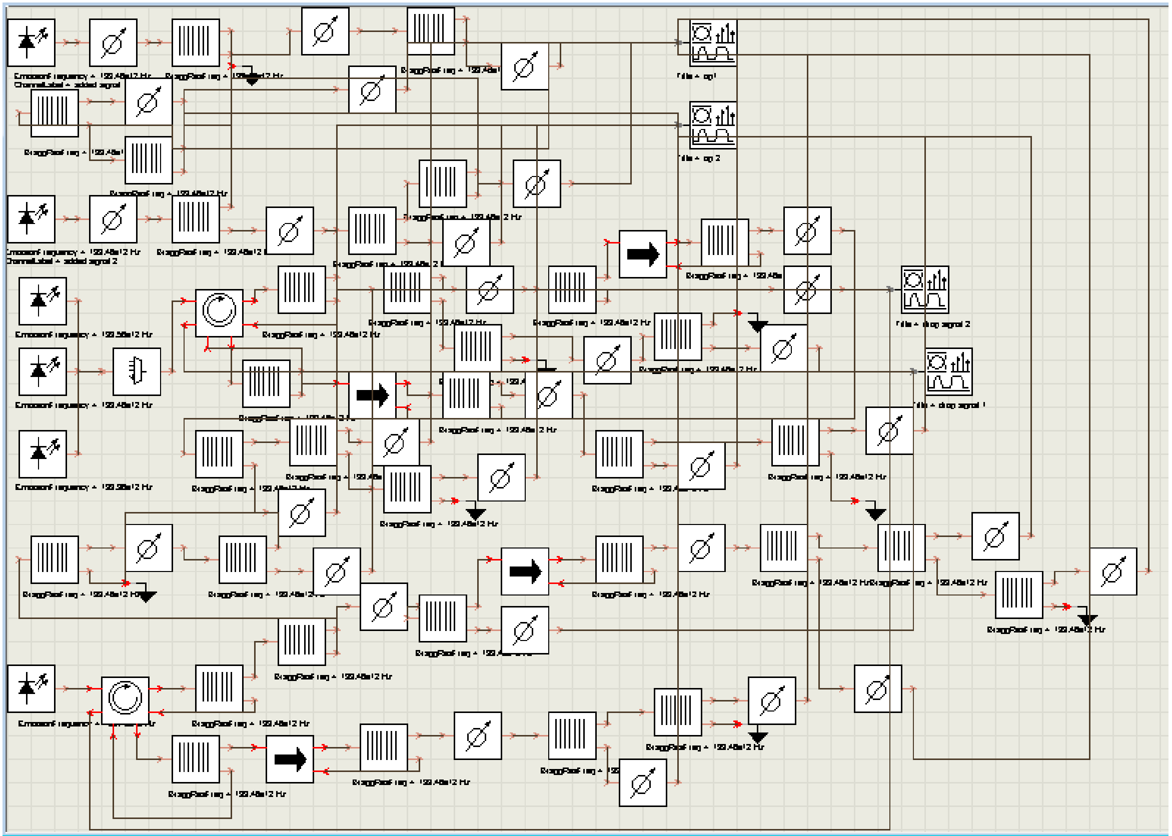

Fig. 8 VPI simulation for SMOXADM.

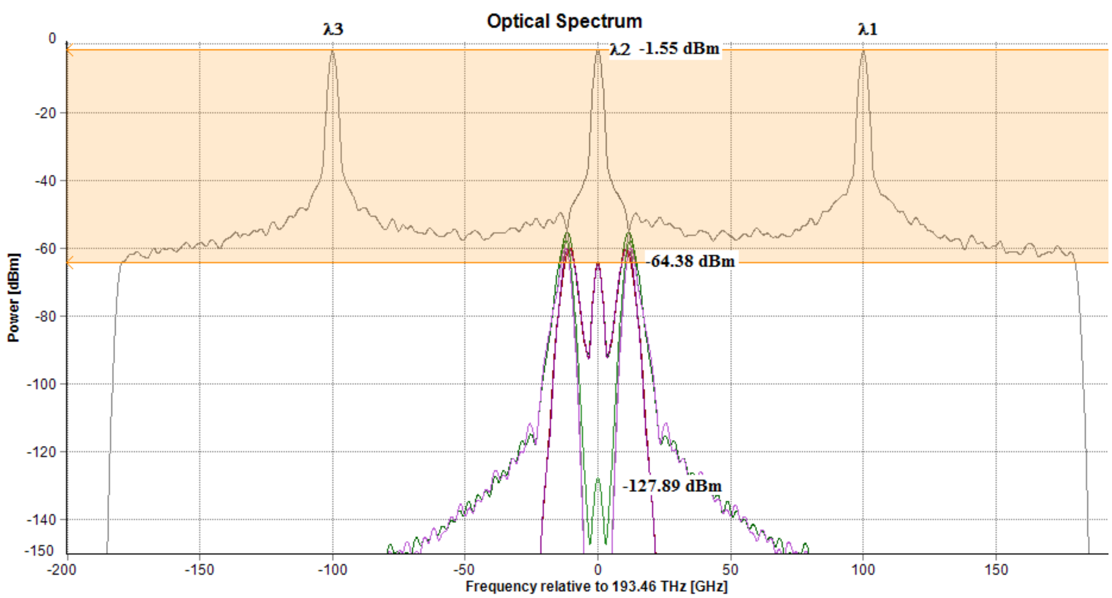

Fig. 9 Output 1 from port 8 in OC1 for SMOXADM.

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Figure 10 displays the drop signal from port 4 in OC1, where λ_2 suffers from a small attenuation of -1.55 dBm, this loss due to the incomplete reflection from TFBG and the insertion loss in OC. There is a homodyne crosstalk of -64.719 dBm at λ_2 due to incomplete reflection of TFBGB but it is still very small and can be neglected.

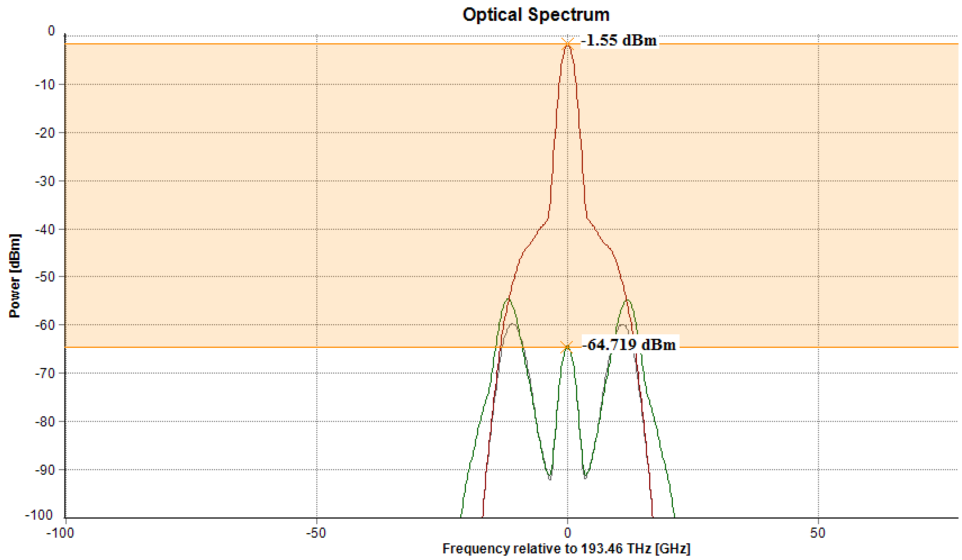

Fig. 10 Drop signal from port 4 in OC1 for SMOXADM.

Figure 11 displays the output 2 from port 8 in OC2, where λ_2 is attenuated by -1.55 dBm. Again, this is due to the incomplete reflection from TFBG and the insertion loss in OC. At λ_2, there is homodyne crosstalk of -64.22 dBm, -127.84 dBm, and -189.83 dBm but they are still very small and can be ignored. The reason of this crosstalk is non-complete reflection of TFBG. The crosstalk isolation level in this design SMOXADM of 62.67 dB, is very acceptable.

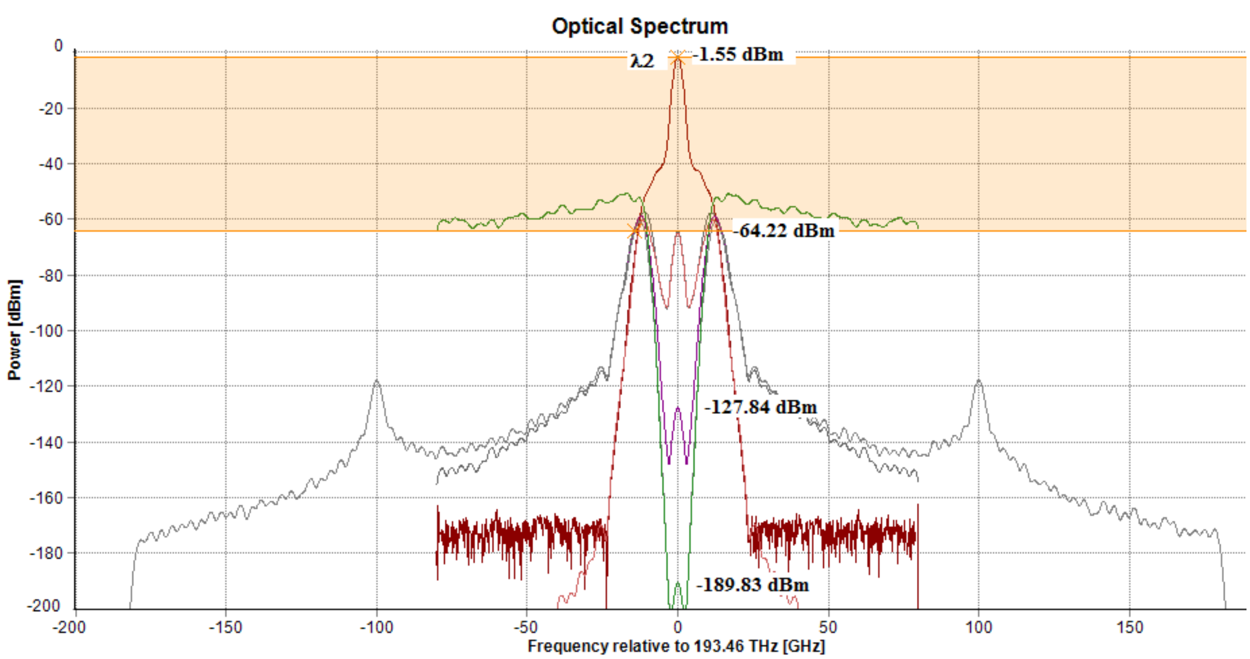

Fig. 11 Output 2 from port 8 in OC2 for SMOXADM.

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Figure 12 represents the drop signal from port 4 in OC2. λ_2 suffers from a small attenuation -1.55 dBm as discussed before in Fig. 10. But the only different in the value of the homodyne crosstalk is -64.48 dBm at λ_2.

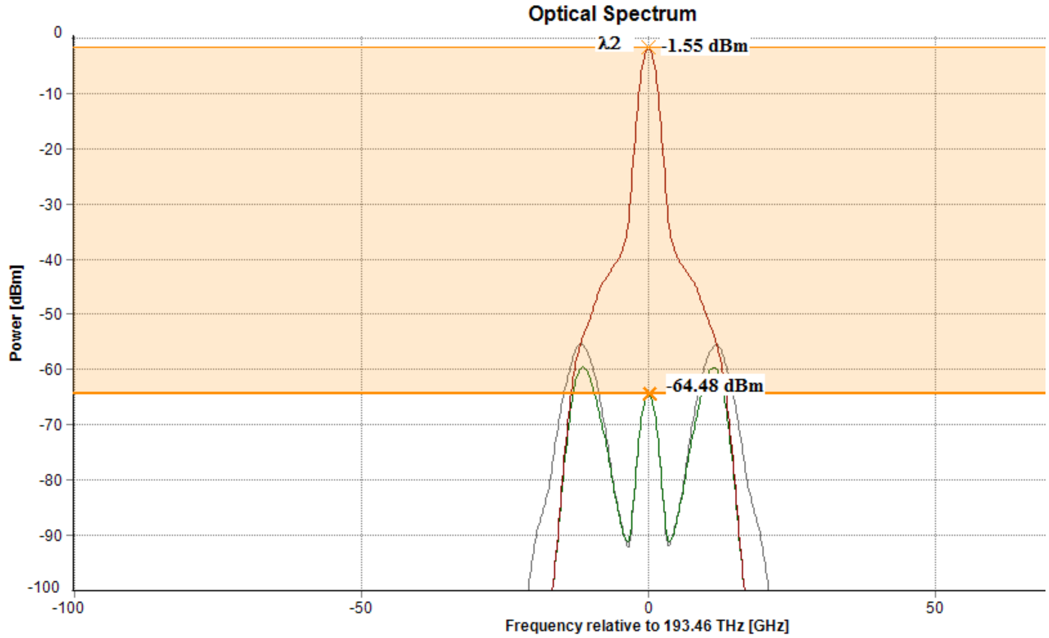

Fig. 12 Drop signal from port 4 in OC2 for SMOXADM.

4. CONCLUSION

This paper introduces different OXADM designs with improved intraband crosstalk to meet different requirements of practical systems. A novel design of OXADM to get a better isolation crosstalk level (lower crosstalk) is illustrated. An asymmetric modified OXADM (AMOXADM) is proposed, which completely eliminates the homodyne crosstalk in the drop signal and reduces the homodyne crosstalk in the output signal by more than 30 dB as compared to previous designs. The drop signal in AMOXADM has an insertion loss of -1.49 dBm and zero homodyne crosstalk, and the output signal has homodyne crosstalk -63.95 dBm. When comparing these results with previously published work on other structures [2–4] our crosstalk levels are acceptable and a good result. In AMOXADM, a simultaneous cross state and add/drop signal cannot be done at the same time. The loss of flexibility of using the add/drop function when using cross-state is solved in a new design. A symmetric modified OXADM (SMOXADM) is proposed, with the advantage of deleting the homodyne crosstalk in both cross and bar states. The drop and output signals in SMOXADM havean insertion loss of -1.55 dBm and the homodyne crosstalk is -64.719 dBm.

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