Dynamic routing in the crosstalk reduced optical add/drop multiplexer

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Introduction

Grating based Mach-Zehnder interferometer (MZ-FG) is one of the promising candidates for optical add/drop multiplexer (OADM) in WDM system [1]. The usual OADM based on MZ-FG allows wavelength channel add-drop, and the function of channel bypassing is not supported. Insertion of an optical switch between an input and an output arm will allow channel bypassing, but homodyne crosstalk generated by leakage of the fiber Bragg gratings can severely degrade the system performance [2-3], limiting the cascading capability in multiple MZ-FG. In this paper, we propose a new scheme which will enhance the functionality of MZ-FG such that dynamic switching between wavelength add/drop and bypassing can be supported. Comparing with the existing configuration, it offers greater functionality and flexibility to the WDM network. In addition, our proposed configuration requires insertion of additional circulators which offers an enhancement of ~20 dB suppression in homodyne crosstalk.

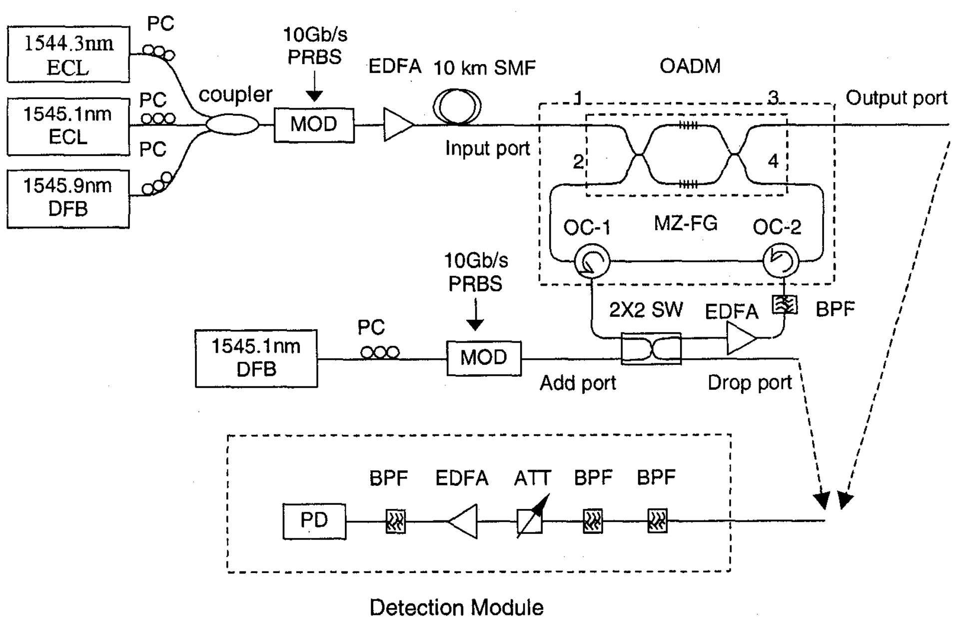

Fig.1. The experimental setup. OADM-optical add/drop multiplexer, MZ-FG- Mach Zehnder interferometer with fiber Bragg grating, DFB-distributed feedback laser, ECL-external cavity laser, MOD-Mach Zehnder modulator, PC-polarization controller, SMF-single mode fiber, EDFA-erbium doped fiber amplifier, SW-switch, OC-optical circulator, BPF-tunable bandpass filter, ATT- optical attenuator, PD-photodetector

Experiment

The experimental setup is shown in Fig.1. Three wavelength channels with channel spacing of 0.8 nm are provided by two external cavity lasers (ECL) and one DFB laser. The combined signals are modulated by 10 Gb/s non-return-zero (NRZ) pseudo-random bit sequences (PRBS) with a Mach-Zehnder modulator. After passing through an erbium doped fiber amplifier (EDFA), the amplified signals are then directed to the OADM after dispersed by 10 km standard single mode fiber (SMF).

Providing MZ-FG with high directivity is available, crosstalk reduced OADM can be configured consisting of an MZ-FG and two optical circulators (OC) as shown. Without these circulators, the leakage at Port 4 will become the homodyne crosstalk for the added or the bypass channel, resulting severe performance degradation in the transmission system. The fiber Bragg gratings (FG) in the MZ-FG have identical center wavelength at 1545.1 nm with a full width at half maximum of 0.3 nm. The dropped signals from the MZ-FG are directed out of the OADM by OC-1 and added signals are injected through OC-2. The channel adding/dropping or bypassing is achieved through the 2x2 optical switch (SW). The unselected channels leave port 4 and then are again routed into port 2 of the MZ-FG. Double passing of the MZ-FG result in rejection ratio above 40 dB whereas conventional single-pass approach only gives about 20 dB. The EDFA at the output arm of the 2x2 optical switch provides power leveling.

Results and discussion

Fig. 2 (a) depicts the transmission spectra of a single MZ-FG and proposed OADM. The output spectra are obtained from the output port of the OADM and port 4 of the MZ-FG, respectively. It is found that the rejection ratio is enhanced to about 40 dB for the proposed OADM consisting an MZ-FG and two optical circulators. Fig. 2(b) shows the spectra obtained at the output port with the selected channel dropped (1545.1 nm) and no added channel introduced to the system.

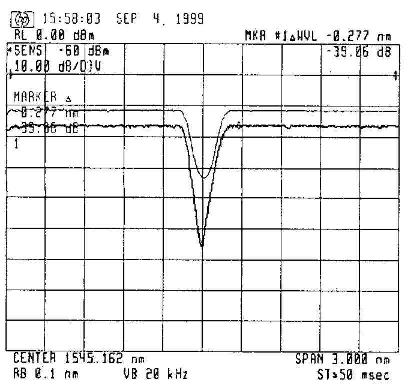

Fig. 2(a) Transmission spectra at output port of MZ-FG and crosstalk reduced OADM. The one at top is the spectral output from the MZ-FG and lower one is for the crosstalk reduced OADM

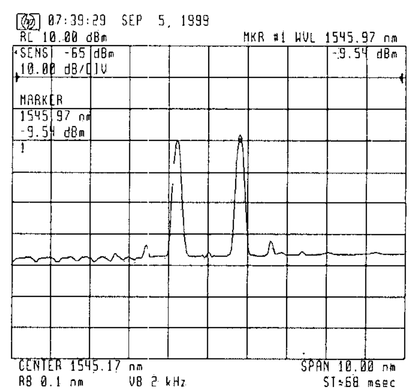

Fig. 2(b) Spectrum with channel at 1545.1nm dropped.

Fig. 3(a) shows the bit-error-rate (BER) measurements of the dropped and bypassed channels at 1545.1nm. Owing to imperfect optical filtering at the detection module, as a comparison, single channel measurements (with other neighboring channels blocked) are also performed for the bypassed channel. From this figure, the respective receiver sensitivity is found to be –26.5 dBm for the bypassed channels in three-channel environment and –29 dBm for the bypassed channel in a single channel environment, all measured at a BER of 10^{-9}. This difference in receiver sensitivity implies that an about 2.5 dB-power penalty in attributed to poor filtering of the detection module.

BER measurements for the dropped channel and the back-to-back configuration (all three channels but without the OADM) are also performed. The BER curve of the dropped channel is found to overlap with the bypassed channel in single channel environment. Also, the BER curve of the back-to-back configuration overlaps with the bypassed channel in three-channel environment, suggesting little power penalty imposed by the proposed OADM.

Fig. 3(b) depicts the BER measurements of the added channel in single- and three-channel environment. In consistence with previous results, there is a 2.5-dB sensitivity difference, as originated from the imperfect filtering in the detection module.

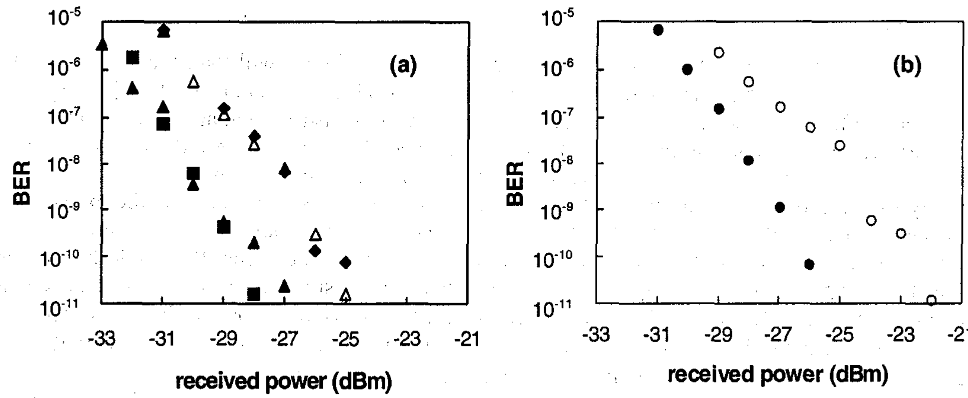

Fig.3 BER measurements of the back-to-back/drop/add/bypass configurations. ▲-Bypassed channel in the single channel environment, Δ-Bypassed channel in three-channel environment, ■-Dropped signal, ◆-Back to back configuration (all three channels but without the OADM). ●-Added-channel the in single channel environment, O-added signal in three-channel environment.

Summary

In summary, a new configuration of OADM supporting channel bypass and add/drop is proposed and experimentally demonstrated. In addition, the scheme allows double passing in the MZ-FG, resulting an improved rejection of homodyne crosstalk. This work is supported by Research Grands Council of Hong Kong Government RGC_CUHK4157/98E.

Reference

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