Performance of a fully automatic power controlled optical amplifier

Abstract: In this paper, we present the fully integrated automatic power controlled (APC) optical amplifier. The APC amplifier has achieved low peak-to-peak ripple of 0.7 dB over large bandwidth of 32 nm with wide dynamic range of 12 dB. The APC amplifier can flatten various input spectral shapes and it also can generate various output spectral shapes.

Much progress has been made in technology of gain-flattened optical amplifiers in wavelength division multiplexing (WDM) networks to obtain uniform optical signal-to-noise ratio and increase the transmission distance. In order to deploy in dynamic WDM networks, dynamic gain-flattened optical amplifiers should be designed to fulfill various features such as a small gain ripple, a wide dynamic range, and a large bandwidth. Many different technologies for the dynamic gain-flattened amplifier have been previously implemented [1-3]. Special attention has been focused on the gain-flattening technology based on all-fiber acoustooptic tunable filter (AOTF) due to its promising performance and practicality [3].

In this work, we demonstrate a fully integrated automatic power controlled (APC) optical amplifier providing a low peak-to-peak gain ripple over a large bandwidth with a wide input dynamic range. The output gain flatness is maintained regardless of add/drop of some channels. In addition, the APC amplifier can flatten various input spectral shapes and also generate various output spectra including tilted, sinusoidal and squared shapes.

Figure 1 shows the block diagram of a APC amplifier consisting of 5 units: a EDFA, a spectral monitor, a AOTF, a AOTF driver, and a master controller. In this amplifier, the AOTF is comprised of 8 notches having 3 dB width of 7.0 nm and 4.0 nm, alternatively. The spectral monitor located at the output of the EDFA detects the channel wavelengths and peak powers of the optical signals, converts into the electrical signals, and transfers to the master controller. The master controller automatically calculates the depths and positions of the notches and the pump powers of the pump LDs based on the gain flattening algorithm to provide the target powers regardless of the input power change. The AOTF driver drives the AOTF by receiving the control signals from the controller.

Figure 2 shows conventional EDFA gain spectra with and without the gain-flattening operation. In this experiment, we use 40 channel WDM sources ranging from 1529.5 ~ 1560.6 nm with 100 GHz channel
Fig. 2 Gain flattening result of APC amplifier

flatness of about 0.9 dBpp, 0.7 dBpp, 0.5 dBpp, and 0.7 dBpp for four different input powers of -27 dBm/ch, -23 dBm/ch, -17 dBm/ch, and -11 dBm/ch, respectively. The dynamic range of the input power achieves 12 dB and 16 dB for 0.7 dBpp and 1.0 dBpp output gain flatness, respectively. Fig. 3 shows measured after dropping seven channels out of 40 channels. The measured gain ripple was 0.5 dBpp. Although the number of dropped channel is increased up to 32 channels, the gain flatness is less than 0.6 dBpp.

In addition, the gain ripple is obtained less than 0.6 dBpp with tilted input spectrum of 3 dB and also less than 0.8 dBpp for the sinusoidal input spectrum of 3 periods with 2 dBpp modulation depth over 32 nm range, respectively. The tilted output spectra achieve the modulation depth of up to 4.0 dBpp for 32 nm bandwidth. And we obtain the sinusoidal and squared output spectra with modulation depth of 2.0 dBpp in the period of 32 nm range.

In summary, we have demonstrated the fully integrated automatic power controlled (APC) optical amplifier, which shows low peak-to-peak ripple of 0.7 dB over 32 nm bandwidth with wide dynamic range of 12 dB. The output gain flatness has been maintained less than the gain ripple of 0.6 dBpp after dropping 32 channels out of 40 channels. Besides, the APC amplifiers generated the 4 dB tilted output spectra and sinusoidal and squared spectra with 2 dB modulation depth.

REFERENCE