Wavelength Multicasting Using an Ultra High-Speed All-Optical Wavelength Converter

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A new multicasting scheme based on 1 to 8-wavelength conversion is proposed for future high-speed broadband networks. 40 Gbit/s Optical Time Domain Multiplexed (OTDM) data was used to simultaneously impose phase modulation on 4 CW channels, 3.6 nm apart. The resulting sidebands were filtered using an AWGR to obtain 8 different 40 Gbit/s OTDM channels. The measured bit-error rates indicate a power penalty of less than 1.5 dB.

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Introduction

Multicasting may be an essential feature of next generation high-speed optical networks. Applications such as video-conferencing, cable TV require reliable high-speed multicasting. Various approaches to solve the multicasting problem have been researched. Most popular amongst them are broadcasting over cable networks, and optical WDM broadcasting techniques [1-3]. In future high-speed optical networks, a promising technique would be to address each node by a particular wavelength. In such a network the capability to make multiple copies of high bit rate data on different wavelengths is essential to simplify multicasting. The scheme we propose below is capable of handling both unicast and multicast services on a packet-by-packet basis. The novelty of this approach is that we do not split the original optical power into multiple copies. The data is replicated simultaneously on multiple wavelengths within a single wavelength converter. The nonlinear wavelength conversion process also accomplishes a 2R regeneration of the original data signal. Here we experimentally demonstrate this technique at 40 Gbit/s.

Experimental Setup & Discussion

The experimental setup to demonstrate the multicasting function is shown in Figure 1. It consists of a preamplifier to boost the input signal, a 90-10 coupler to combine the incoming data with the desired multicast channels and a high power EDFA to boost the combined signals. Phase Modulation is imposed on the CW channels by the input data signal in the Dispersion Shifted Fiber (DSF) [4]. A 1×8 arrayed wave-guide router (AWGR) is used to simultaneously route and filter the spectrally broadened phase modulated channels. The multicast channels can be chosen on a packet-by-packet basis to enable or disable broadcast services to different users. An actively mode locked Fiber Ring Laser (FRL) at

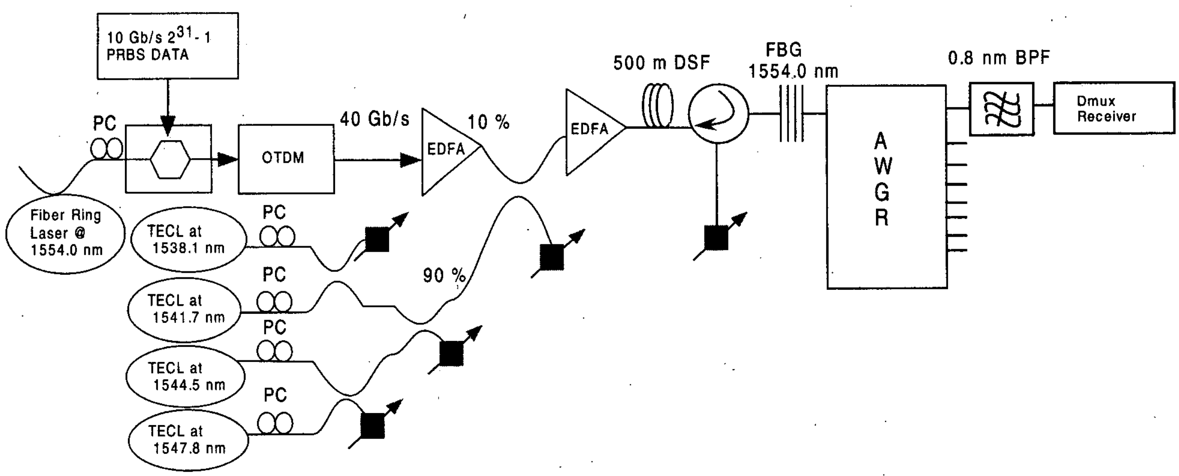

Fig. 1. Experimental setup to simulate a node in the proposed broadband architecture

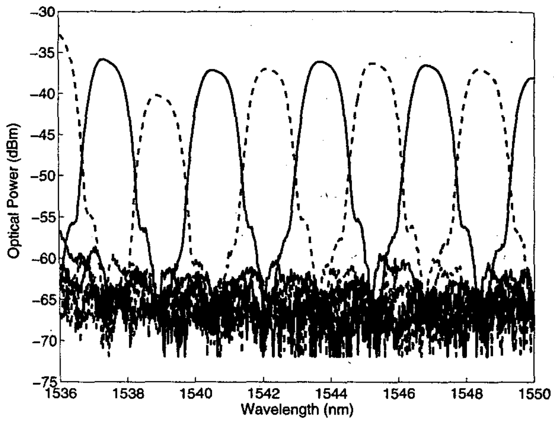

Fig. 2. Pass band of all the ports of the AWGR in the region of interest

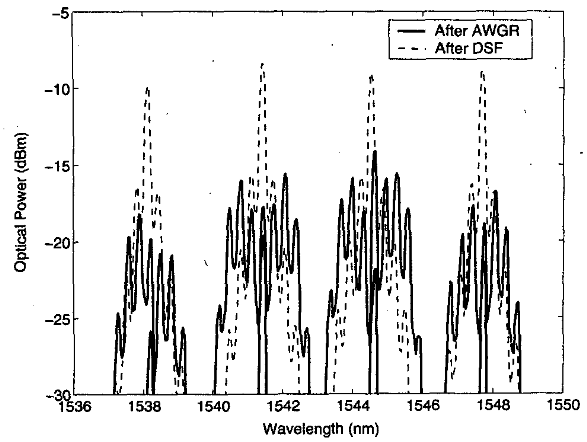

Fig. 3. Optical Spectrum before and after the AWGR

1554.0 nm was used to generate 6 ps (FWHM) pulses at 10 GHz repetition rate. 10 Gbit/s pseudo random bit sequence (PRBS) data of length 2^{31} - 1 was encoded on these pulses. Split and interleave technique was used to multiplex the 10 Gbit/s data stream to a 40 Gbit/s data stream. This 40 Gbit/s data stream was the input signal to the multicasting system. In the experimental setup four tunable external cavity lasers (TECL) at wavelengths 1538.1 nm, 1541.7 nm, 1544.5 nm and 1547.8 nm operated in continuous wave (CW) mode, were used as a multiwavelength source. Figure 2 shows the pass band of all the 8 ports of the AWGR in the region of interest. The wavelengths were chosen to be at the nodes of this pseudo filter function, so that the sidebands generated by cross phase modulation in the fiber are routed to the different ports of the AWGR. 90 % of the CW power is coupled with 10 % of the input data signal and amplified to 800 mW before being injected into 500 m of DSF with zero dispersion wavelength at 1560 nm. At the output of the DSF, a circulator and a Fiber Bragg Grating (FBG) arrangement as shown in Figure 1 was used, to eliminate the high power pump signal. The average power of the input signal into the wavelength converter was –1.5 dBm while the combined average power of the four CW signals was 3.5 dBm. The average power for each of the CW wavelengths was chosen such that they were equalized at the input to the DSF. Each channel generated two sidebands, which were 1.8 nm apart. In Figure 3 the spectrum before and after the AWGR is shown. The upper dashed curve is the output of the DSF and the lower solid curve is the output of all the eight ports of the AWGR. This scheme allowed us to generate identical copies of the original data on 8 different wavelengths. The average power of the different broadcast channels after the AWGR ranged from – 0.5 dBm to – 3.5 dBm. This variation in power was due to different amounts of loss through the different ports of the AWGR. We used a 0.8 nm band pass filter (BPF) after the AWGR to improve the extinction ratio and to obtain optimal pulse shapes. Figure 4(a) shows the input 40 Gbit/s eye as seen on a 50 GHz oscilloscope with a 40 Gbit/s photodetector. Due to the fact that the multiwavelength sources are incoherent with respect to each other, there could be some interference phenomenon resulting from the crosstalk terms. This should affect the central channels more than the outer channels. In Figure 4(b) the output 40 Gbit/s eye at 1545.2 nm is shown, which is a central channel and thus represents the worst case scenario. From figure 4(b) it is evident that the crosstalk from the neighboring channels is reasonably small. The second BPF can be eliminated if the filter function of the AWGR could be optimally tailored to be steeper so as to be able to notch the CW light more efficiently. To evaluate the performance of the multicasting scheme, each of the 8 WDM channels was demultiplexed in time from 40 Gbit/s down to four 10 Gbit/s channels. An electro-absorption modulator with a switch window of 15 ps.

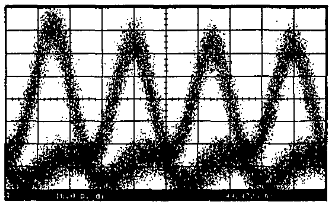

Fig. 4(a). Input 40 Gbit/s eye at 1554.0 nm

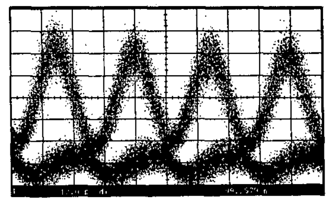

Fig. 4(b). Output 40 Gbit/s eye at 1545.2 nm

Figure 5(a) shows the receiver sensitivity for all the four input (back-to-back) channels and the 32 output 10 Gbit/s channels. The receiver sensitivity for the input channels was measured to be around –35.0 dBm, while the receiver sensitivity for the output channels ranged from –34.1 dBm to –35.2 dBm. For each of the 8 multicast wavelengths, the demultiplexed 10 Gbit/s OTDM channel with the lowest receiver sensitivity was selected and a complete BER plot was obtained. From Figure 5 (b), it is observed that the maximum power penalty of the multicast channels was 1.5 dB as compared to the back-to-back BER plot. This is mainly due to the poor crosstalk suppression between the different AWGR ports.

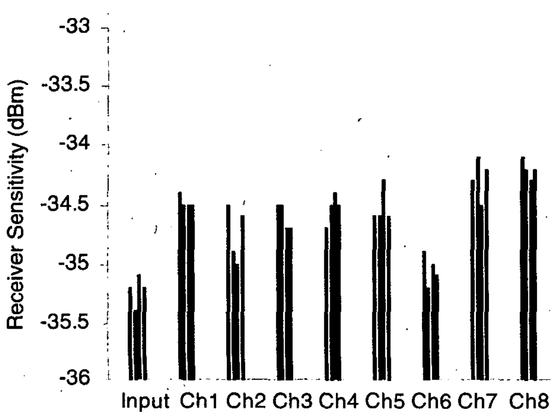

Fig. 5(a). Receiver sensitivities for the 32 - 10 Gbit/s output OTDM channels and the 4 10 Gbit/s input OTDM channels

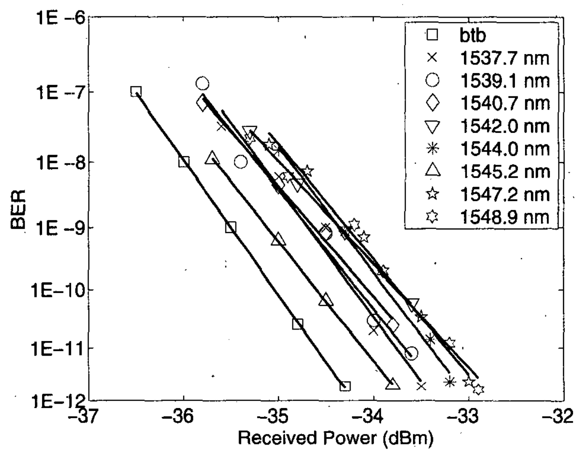

Fig. 5(b). BER curves for 1 input channel (back-to-back) and 1 channel for each of the 8 broadcast wavelengths

Conclusion

In conclusion we have proposed and demonstrated a new multicasting technique for high-speed applications. This scheme enables one to make multiple copies of the same data without the need to optically split power or have multiple transmitters.

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