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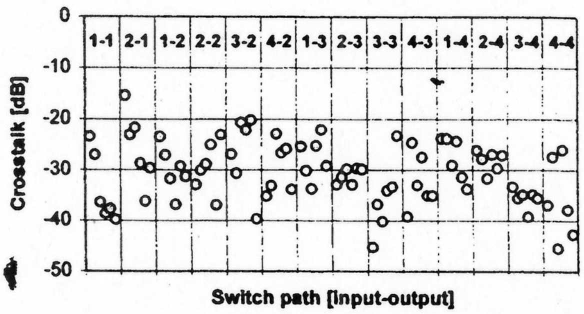
TuC2 **Table 1.** Number of Cross Talk Contributions Per Main Signal Configuration. There are Six Combinations Per Main Signal Path. The Paths 3-1 and 4-1 Were Not Measured.

IN \ OUT	1	2	3	4
1	3 3 4 4 4 4	4 4 4 4 4 4	6 6 7 7 7 7	7 7 7 7 7 7
2	4 4 4 4 5 5	4 4 5 5 5 5	5 5 6 6 7 7	5 5 6 6 6 6
3	5 5 6 6 6 6	5 5 6 6 7 7	4 4 5 5 5 5	4 4 4 4 5 5
4	7 7 7 7 7 7	6 6 7 7 7 7	4 4 4 4 4 4	3 3 4 4 4 4



TuC2 **Fig. 2.** Cross talk levels for the 84 different switch states measured. For each main signal path (indicated above the circles), there are 6 different combinations, cf. Table 1.

waveguide crossing is about 5–10 dB larger than the nonideal gate contribution.

In conclusion, a comprehensive cross talk investigation for all switching combinations in a fully loaded 4 × 4 switch was reported. alistic cross talk figures are thus obtained, and even by this approach very low cross talk was measured.

Also with L.M. Ericsson A/S, Denmark and EMI at the Technical University of Denmark

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TuC3 11:45am

High-performance integrated acousto-optic channel analyzer

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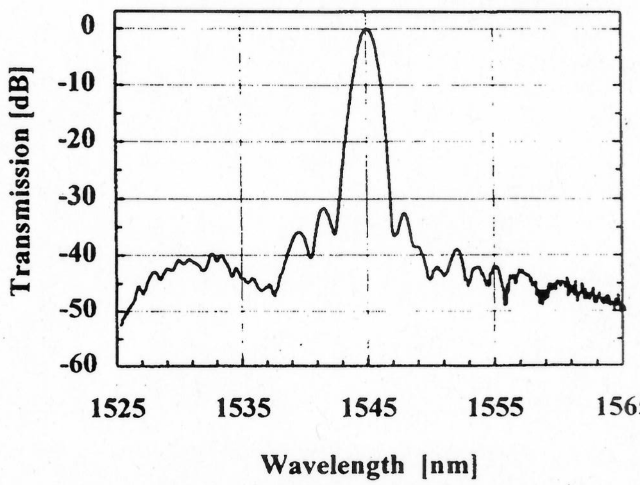
With the strongly increasing complexity of very high density wavelength-division multiplexing (WDM) networks the demands on network supervision and the possibility of an almost instantaneous reconfiguration in case of network failures becomes increasingly important. Continuous monitoring of the WDM-network status at each single section of the transmission line is essential for a stable network operation.[1] Especially in networks with a large number of erbium-doped fiber amplifiers (EDFAs) of not completely flat gain characteristic, a precise knowledge of the evolution of the spectral characteristics of the transmitted signal on the line is of fundamental importance.

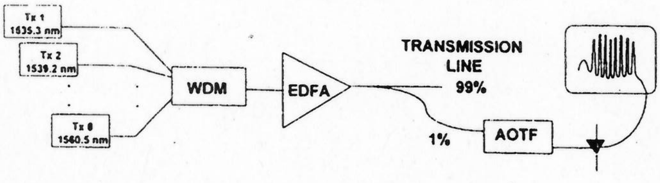
Integrated acousto-optic filters (AOTFs)[2,3] in $LiNbO_3$ are excellent candidates to match these requirements as they have low loss, wide tuning range, and fast tuning speed. In contrast to relatively complex spectrum analyzers, for example based on scanning Fabry-Perot filters needing an external reference wavelength for continuous calibration, the AOTF needs only initial calibration (central transmission wavelength as function of drive frequency). Moreover, the miniaturized and highly rugged AOTFs have no moving parts and can be scanned within a few milliseconds over a span of at least 100 nm. A single-stage AOTF (typically 2-nm bandwidth and −20-dB wavelength cross talk) has already been proposed as a spectrum analyzer to control the EDFA power equalization in a four-wavelength WDM system.[4] We present the results of an optical channel analyzer (OCA) based on a specially designed scanning AOTF[5] in a real 2.5-Gbit/s eight-wavelength system.

The AOTF characteristics (Fig. 1) of 1.1-nm 3-dB-bandwidth, sidelobes below −30 dB and wavelength cross talk of less than −35 dB are, to our knowledge, the best reported for a completely monolithically integrated device. The fully pigtailed and packaged devices show fiber-to-fiber insertion loss of less than 4.5 dB and PDL figures of only 0.2 dB.

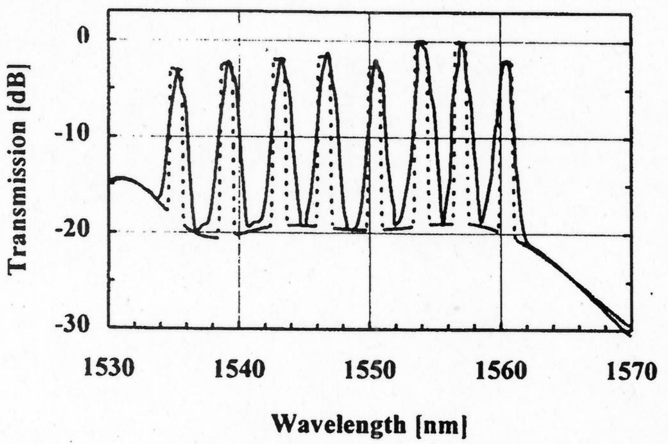
The eight, approx. 3.6-nm-spaced channels (2.5 Gbit/s each, 13 dBm total power), have been fed at the output of a line amplifier via a 1:99 power splitter to the OCA. The system is fully computer controlled and the transmitted power is detected by a photodiode (Fig. 2). The detected spectrum (Fig. 3) is the convolution of the signal spectrum and the AOTF transmission characteristic. The accuracy (wavelengths ± 0.1 nm, power ± 0.5 dB, signal-to-noise ratio ≅ 20 dB) is more than sufficient for in-field application. The agreement of the measured spectrum with that measured by a commercially available spectrum analyzer (HP 70950A, set to 1-nm resolution bandwidth) demonstrates the excellent performance of our component. Work is in progress to demonstrate the feasibility of a 16-channel optical spectrum analyzer with a further optimized device.



TuC3 **Fig. 1.** Acousto-optic channel analyzer transmission characteristic.



TuC3 Fig. 2. Measurement setup.



TuC3 Fig. 3. Detected spectra: AOTF OCA (solid), laboratory spectrum analyzer (dashed).

In summary, we have demonstrated a further application of a high-performance monolithic acousto-optic device in actual WDM networks. The AOTF OCA gives results as accurate as standard laboratory spectrum analyzers. It is rugged and easy to handle, does not need a reference wavelength, and allows very high scanning rates. A multiwavelength power equalization system based on the combination with a second AOTF is currently under development.

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5. To be published.

TuC4 12:00m

Photonic integrated eight-wavelength 2 × 2 WDM cross-connect switch using phased-array waveguide grating multi/demultiplexers

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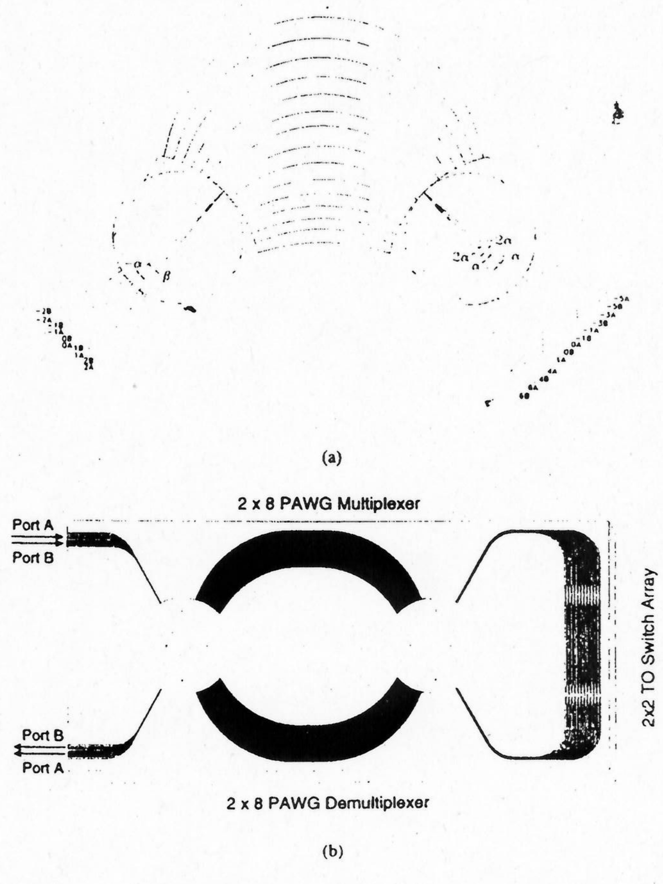
A wavelength-division multiplexing (WDM) cross-connect switch (WDM-CCS), which can switch arbitrary wavelength components between different input signals, is a key component for WDM networks. In this paper, we report a monolithically integrated eight-wavelength 2 × 2 WDM-CCS with 200 GHz channel spacing. The switch is transparent to signal format and bit rate and can be widely used in multiwavelength scalable and reconfigurable WDM networks[1] for dynamic wavelength routing.

A typical WDM-CCS consists of four phased-array waveguide grating (PAWG) multi/demultiplexers (MUX/DEMUXes) and a 2 × 2 switch array. We introduced a novel 2 × N PAWG design [Fig. 1(a)][2] with two sets of WDM input/output channels to replace two PAWG MUX/DEMUXes. One unique and important feature of our 2 × N PAWG is that the two demultiplexed optical signals of the same wavelength are next to each other at the output port. When two PAWGs are connected by the 2 × 2 Mach-Zehnder interferometer type thermo-optic (TO) switch array, there is no waveguide crossing issue at all. Therefore, simplicity, compactness, low throughput loss, and low cross talk are accomplished at the same time. The 2 × 8 PAWG also utilizes a vernier-like input waveguide design to compensate potential center wavelength drift due to processing variation.[3,4] Figure 1(b) shows the schematic layout of the eight-wavelength 2 × 2 WDM-CCS with 8 + 4 = 12 TO switches. The additional four TO switches are used for the vernier function. The total WDM-CCS device size is 74 × 34 mm^2.

The transmission spectral responses from both output ports A and B were measured with a WDM input at port A. If all switches are off (in cross-state), all eight input signals are output from port B [solid line in Fig. 2(a)], and no output from port A (dashed line). If switches TO_3, TO_5



TuC4 Fig. 1. Photonic integrated eight-wavelength WDM-CCS design: (a) schematic configuration of 2 × 8 PAWG; (b) schematic configuration of eight-wavelength 2 × 2 WDM-CCS.