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OPTICAL SPECTRAL DEVICES AND THEIR APPLICATIONS

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Annotation

In this paper we show the application of optical CDMA based on spectral encoding with integrated optical devices and discuss the use of cyclic shifted rn-sequences to realize full orthogonal transmission. Degradations of the system performance due to non-ideal source spectra, crosstalk and losses in the optical coder devices are examined. Some bounds for different kinds of realization are shown. Possible sources are broadband semiconductor diodes like SLD, optical semiconductor amplifiers or multiwavelength lasers. For optical coding solutions with acoustical tunable optical filters, arrayed waveguide structures and fiber grating filters are investigated. The total network capacity will be analyzed under the above mentioned conditions and it is shown that such a network can accommodate some hundred users with a network throughput of some Gb/s.

Keywords: acoustical tunable optical filters, code division multiple access, integrated optics, super-luminescence diodes.

Introduction

Considerable interest is currently being shown in the optical implementation of code division multiple access (CDMA) networks. Applications include free space data transmission and fiber optical communication.

In this paper we focus on spectral encoding of low-cost broadband sources realized with integrated optical (IO) devices. Drawbacks of previous realizations without IO are the rather complicated optic encoder/decoder as well as the address reconfiguration based either on fixed amplitude masks or LCD arrangements. We discuss different possibilities and show, that from the variety of available components the acoustical tunable optically filters (ATOF) are actually the most elaborated solution. Optical integrated circuits are indispensable for the economic realization of photonic communication systems in the near future, due to their advantages like robustness, compactness, reliability and of course the overall cost aspect. Different types of receiver structures are investigated and their behaviour in a network environment is shown. In the next section the principle of spectral encoding is explained. Then we introduce the employment of integrated optics and show the special features of ATOF. Finally the network performance of spectral encoding by ATOF is examined.

Main Part

The system concept is shown in fig. 1, based on a proposal by Zaccarin et al. To every subscriber a cyclic shifted m-sequence is assigned. Other code families like Hadamard sequences are also possible. The receive contains two inverse filters C(t) and C(f), followed by a balanced receiver. If the desired sequence (coded spectrum) arrives at the receiver, diode D1 detects the energy of all Ones. At diode D2 no energy is received because of the bandstop case.

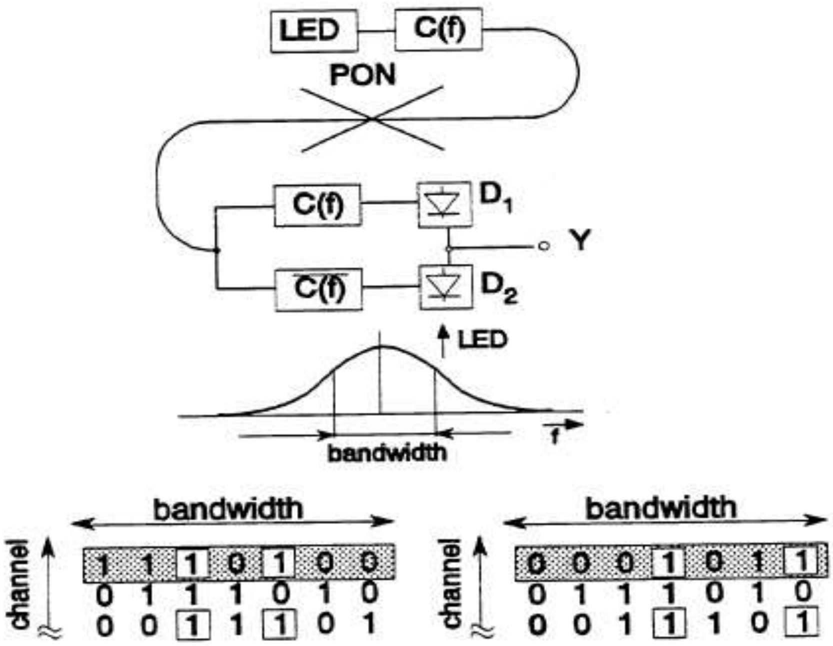

Fig 1. Principal of spectral encoding

If an undesired sequence arrives at the receiver, both diodes detect the half of the One's and after the balanced receiver no signal is observed (example with a rn-sequence of period 7 is shown in fig. 1). Complete orthogonal transmission could be achieved, provided that the spectrum is properly equalized. In this paper we assume the use of a star topology with a centre splitter (may be realized as a reflective star splitter).

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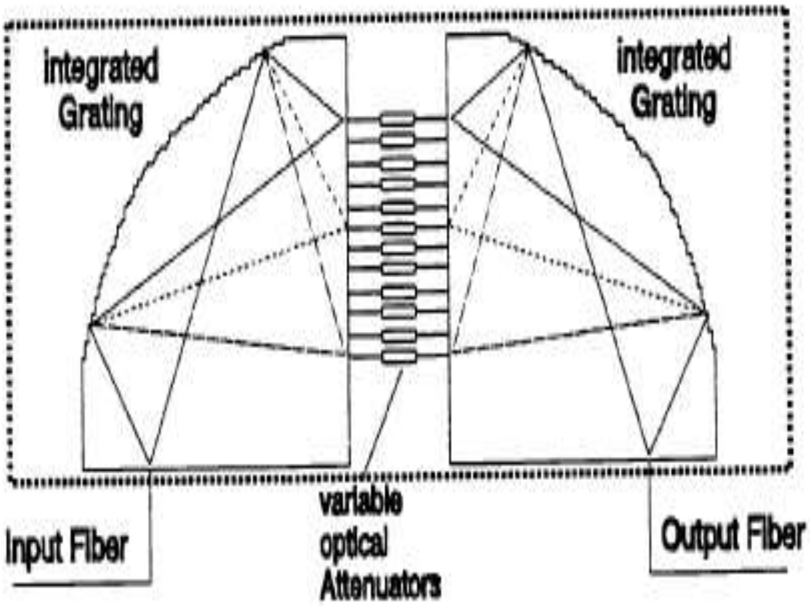

Fig 2. Spectral encoding by integrated reflection gratings

The key device in the discussed system is the filter, which encodes the SLD spectrum by the desired rn-sequence. The use of free space arrangements with reflection gratingsoffers nearly every spectral parameter as resolution, side mode suppression and wavelength or polarization independence. But the design of such devices is rather complicated. For one encoder/decoder pair (channel) 6 gratings are necessary. The channelselection is carried out by mechanical change of the masks or by electrical tuned LCD masks. It is obviouslythat a realistic system should use integrated or fiber based filters.

Fig. 2 and 3 show two possible solutions with integrated reflection gratings or arrayed waveguide gratings.

Both solutions need two dispersive elements for splitting and combining the spectral slices. The sequenceis encoded by means of a set of fixed, variable or switchable attenuators.

Up to now the available integrated devices do not provide the desired number of channels or suffer from insertion losses. A very interesting solution could be the series connection of fibre gratings''. With UV-exposure of Ge-doped silicon glass fiber nearly any grating structure could be realized. By a series connectionof bandstop grating filters the desired sequence can be constructed. Due to the fact, that the stop band energy will be reflected, the inverted filter function can be obtained by using an optical splitter as depicted in fig. 4.

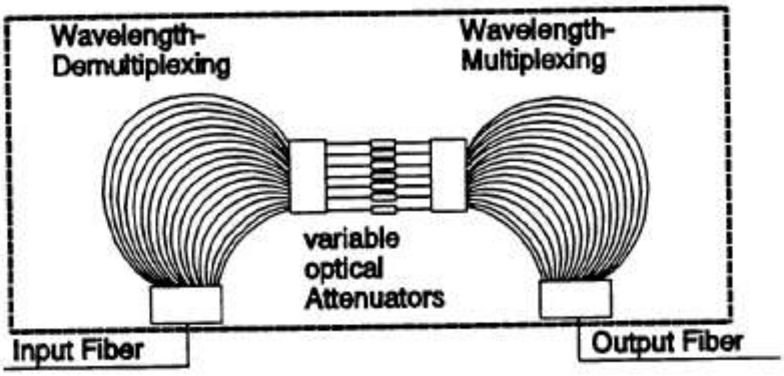

Fig 3. Spectral encoding by integrated arrayed waveguide gratings

Spectral filter bandwidth of less than 0. 1 nm can be achieved by an interaction length of some mm. The very low insertion loss far away from the stop band and the polarization independence enables the utilization for spectral encoding with long sequences.

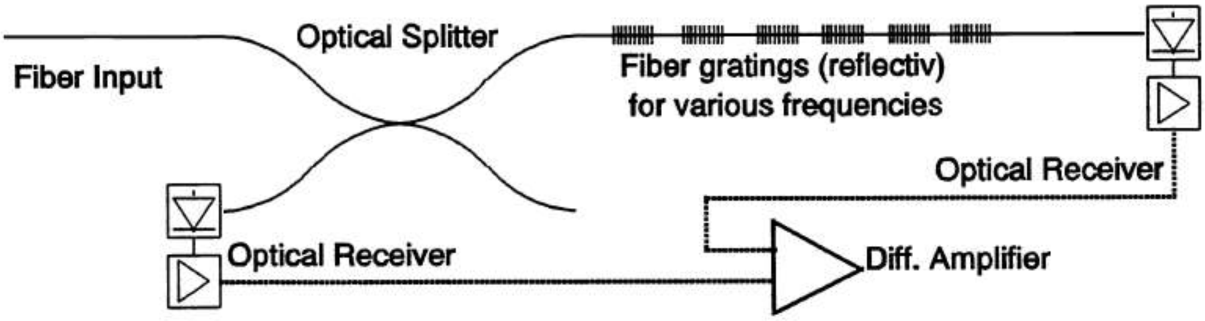

Fig 4. Receiver structure with reflective fiber gratings

We proposed the use of acoustical tunable optical filters (ATOF) for the first time.8'9 In an ATOF an acoustic and electric waveguide are combined. The interaction between an electrically generated acoustic wave and a passing optic wave results in a conversion between the two polarization states, if all phase conditions are fulfilled. The wavelength dependence of the birefringence in the used LiMbO3 determines the bandwidth of the interaction. By integration of two polarization filters at the begin and the end of the interaction region, a bandpass or band rejection filter can be realized in a simple way. Driving the ATOF with different frequencies simultaneously, many spectral m lines can be filtered at the same time. Typical acoustical frequencies for the 1 .55 region are 175 MHz with a tuning rate of 7 nm/MHz (change of the filter wavelength by changing the driving frequency). For the total conversion of one wavelength a driving power of only 10 mW is necessary. Interaction lengths of some centimeters yield filter bandwidth below 1 nm.

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