of the amplitude pattern effect into the spectral patterning in the SOA.[7] Suppression of the spectral broadening with a low-finesse Fabry–Perot in-line filter, effects of the SOA figure of merit,[6] and influences of the SOA current map along the line on the system performance are also considered.

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CThU4 **3:15 pm**

Experimental demonstration of spectrally encoded optical CDMA systems using Mach–Zehnder encoder chains

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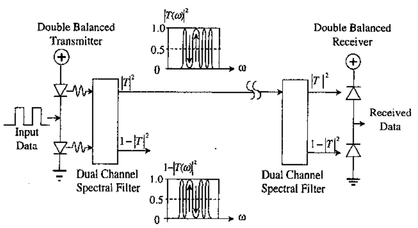
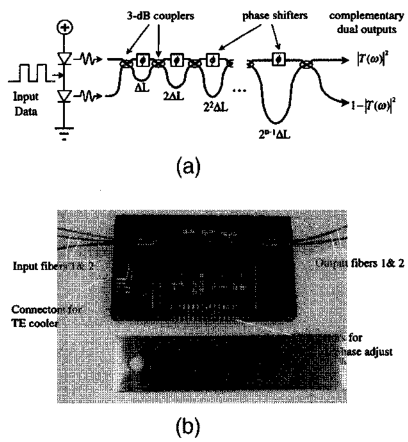
Recently, there has been tremendous interest in applying spread spectrum and code-division multiple access (CDMA) techniques in optical fiber communication systems. Contrary to radio CDMA systems,[1] which employs electric-field encoding and correlation to achieve orthogonality, most of the optical communication systems use intensity modulation and direct detection. To achieve true orthogonality in optical CDMA systems, the balanced detection scheme and spectral intensity coding need to be used.[2]

Figure 1 shows the block diagram of the bipolar spectrally encoded CDMA system. The transmitter consists of a pair of broadband optical sources connected in a balanced fashion. The input data differentially modulate the intensity of the two balanced sources. The spectrum from the broadband sources passes through a dual-channel complementary spectral intensity encoder. When a 0 bit is sent, the transmitter encodes the direct spectrum for transmission. When a 1 bit is sent, the complementary spectrum is encoded. The intensity encoded spectra are broadcast to the receivers using a star coupler. The balanced receiver uses the same spectral encoder to recover the data. It can be seen from Fig. 1 that the receiver computes the difference signal between the direct spectrum and its complementary. For matched transmitter, the balanced receiver will detect either a positive or a negative output depending on whether 0 or 1 is transmitted. The spectra from unmatched transmitters will split equally at the two output ports of the receiver filter and will be canceled at the balanced output, hence achieving true orthogonality.



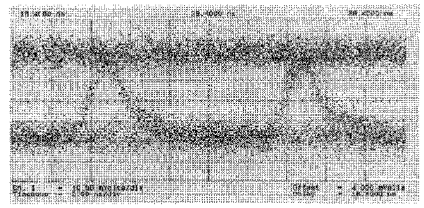
CThU4 Fig. 1. Block diagram of spectrally encoded fiber-optic CDMA system.



CThU4 Fig. 2. (a) Schematic diagram of the Mach–Zehnder interferometer encoder chain. (b) Fabricated MZI encoder chain on silica planar waveguide.

A multistage Mach–Zehnder interferometer (MZI) chain is proposed as the dual-channel spectral filter. The outputs of an MZI are automatically complementary. In addition, when the input source is switched from one input port to the other, the two complementary spectra at the MZI output ports will be reversed. Figure 2(a) shows the schematic diagram of an encoder and Fig. 2(b) shows a seven-stage MZI encoder chain fabricated on a planar silica waveguide. A thin-film heater is incorporated in each stage of the MZI encoder to introduce an optical phase shift in the MZI arms. Different codes are produced by properly setting the phase shifts at different stages. The chip size is 45.5 × 64 mm. Each thin-film heater is capable of shifting the optical phase by at least 2π rad.

An optical CDMA test bed has been built at UCLA to demonstrate the system principle. In the testbed setup, an erbium-doped fiber amplifier (EDFA) pumped into superluminescent mode and a 2×2 electro-optic switch are used to simulate the balanced transmitter. A preliminary experiment at 100 M bps was performed using the test bed. By matching the transmitter and receiver code settings, a 2^7-1 pseudorandom test data sequence is recovered at the receiver. We have also seen the rejection when the transmitter and receiver codes are unmatched. A bit error rate of 10^{-7} was achieved for this preliminary experiment. Figure 3 shows the eye diagram obtained from the experiment.



CThU4 Fig. 3. Eye diagram obtained from a 100 M bps 2^7-1 pseudorandom test data sequence.

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CThU5 **3:30 pm**

BER analysis of low-rate communications through a single electro-optic R2 nonlinear regenerator

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Recently, the benefits of electro-optic nonlinear untimed regeneration (R2) for bit-rate transparent lightwave OOK systems have been expounded.[1–3] Here, we compare R1 (linear amplification), R2, and R3 (optimal DEMOD/MOD) in the presence of average white Gaussian noise (AWGN). We provide an approximate analysis and explain the difficulties in obtaining an exact solution.

The analyzed system is shown in Fig. 1. A modulated OOK signal $s(t)$ is transmitted. After a loss L_1, the signal is detected, filtered, thresholded, and retransmitted as in Refs. 1–3. AWGN is present in the electrical domain. After another loss L_2, the signal is again detected and demodulated using a matched filter receiver. We consider one-shot communication so that jitter and induced spatial coherence (ISI) can be ignored. In this case, the analysis applies equally well to return to zero (RZ) and non-return to zero (NRZ). Reference 1 addresses jitter but not noise. Reference 3 is experimental and shows a benefit of R2. Reference 2 provides an analysis for an arbitrary num-