Performance of a 10 Gb/s Optical Code Division Multiple Access Channel in the Presence of an Interferer

Wei Cong, V. J. Hernandez, R. P. Scott, Kebin Li
J. P. Heritage, B. H. Kolner, Z. Ding and S. J. B. Yoo
Department of Electrical and Computer Engineering, University of California, Davis, California 95616
yoo@ece.ucdavis.edu

Abstract: Bit error rate performance of a spectrally phase encoded optical code division multiple access system at 10 Gb/s that employs a nonlinear fiber threshold discriminator is measured in the presence of an interferer.

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1. Introduction

Code-division multiple access (CDMA) is widely used in RF wireless networks, but in conventional fiber optic networks, wavelength-division multiplexing (WDM) and time division multiplexing (TDM) dominate. Several *optical* CDMA (O-CDMA) schemes have been proposed [1-3] that employ different coding, modulation and detection approaches. For high bit-rate optical channels (~ 10 Gb/s), temporal encoding of individual information bits (i.e. direct sequence spread spectrum) require chip modulation rates well beyond the fundamental bit rate and are thus impractical. In contrast, Spectral Phase Encoded Time Spreading (SPECTS) O-CDMA uses gratings and static spatial light modulators to spread the ultrashort optical pulse in *time*; no subpicosecond modulation is required.

In a SPECTS O-CDMA communication system, each user receives and transmits bits subjected to a spectral phase code. A receiver captures its coded bit stream from among many by decoding the received signal with the conjugate spectral filter. The decoded pulse is a replica of the original short optical pulse. Other coded pulses remain temporally spread and are rejected by a fast optical thresholding device. Several optical thresholding devices have been proposed and characterized [4,5], a femtosecond O-CDMA test bed has been described [2], and a study of a low bit rate system has been reported [6]. We report performance of a 10 Gb/s communications channel in the presence of an interferer using two different sets of codes. Error free operation is achieved when the interferer is delayed from the signal; however, synchronous arrival yields higher bit-error rates owing to optical interference between the two fields.

2. Experimental Arrangement

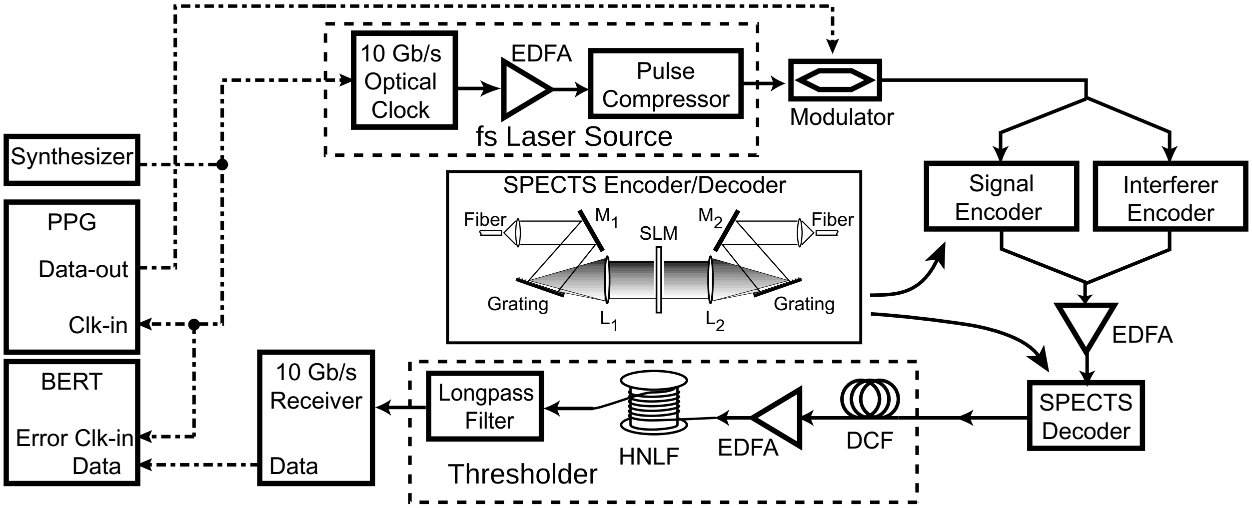

Fig. 1. Experimental arrangement for two channel SPECTS O-CDMA BER measurement testbed. EDFA: Erbium Doped Fiber Amplifier, DCF: Dispersion Compensation Fiber, HNLF: Highly Nonlinear Fiber, L1 &L2: Lenses.

In Fig. 1, a fiber-coupled femtosecond laser pulse source (Pritel) generates ~500 fsec, 1.55 micron, pulses at 10 GHz. The pulse train is modulated at 10 GHz with a 2^{31}-1 length pseudorandom bit sequence. The modulated light is split and delivered with PM-DSF fiber to two free-space grating/lens pulse-shapers (encoders), with LCD spatial light modulators in the Fourier plane. The combined output of the encoders, amplified in an EDFA, is directed to a third pulse shaper and SLM that acts as a decoder. The thresholder consists of a dispersion compensated EDFA and a highly nonlinear fiber.

3. Results and Discussion

Cross-correlation measurements verify that the encoded pulses are correctly broadened and that correct encoding and decoding returns a replica of the input ~500 fs pulse for both 31 chip m-sequences and 32 chip Walsh codes. Figure 2 displays the results of BER versus power for (a) back-to-back, (b) encoded and decoded signal without an interferer, (c) with delayed interferer, and (d) synchronized interferer. The first three cases all achieved error-free operation. The power penalty of about 3 dB between case (a) and (b) arises from power sharing of the two channels. The power penalty between (b) and (c) arises from interfering power and is representative of a single interferer “slotted” O-CDMA system. In (d), optical interference impacts the BER performance, as expected from using a single source laser. We anticipate improved BER using independent lasers, although independent mode-locked laser pulses should still display coherence effects.

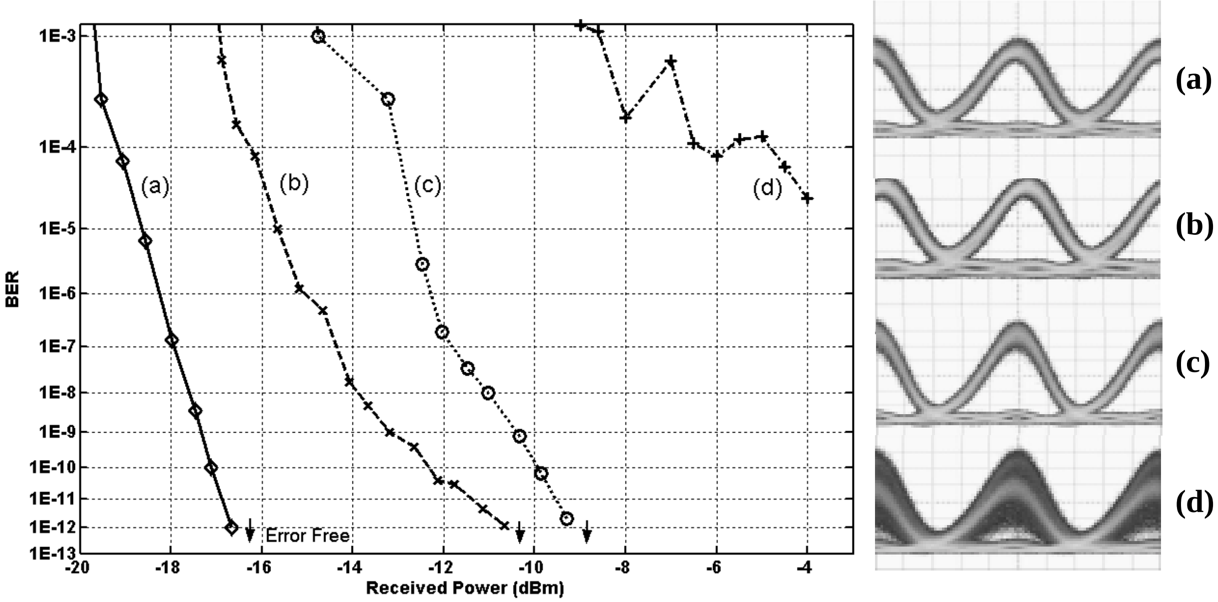

Fig. 2. O-CDMA BER vs. power received by thresholder EDFA for 31 chip length m-sequence, with accompanying eye diagrams: (a) back-to-back, (b) encoded and decoded signal without an interferer, (c) with an interferer (equal power) delayed by 23 ps, and (d) interferer temporally synchronized with the signal. Down arrows indicate error free performance.

Figure 3 displays BER measurements using Walsh codes that display a centered intensity minimum and thus yield reduced optical interference from coherence. Curves a, b, c, and d are measured for the same conditions as the m-sequence discussed above. We find improved BER performance for the Walsh codes in the synchronous case.

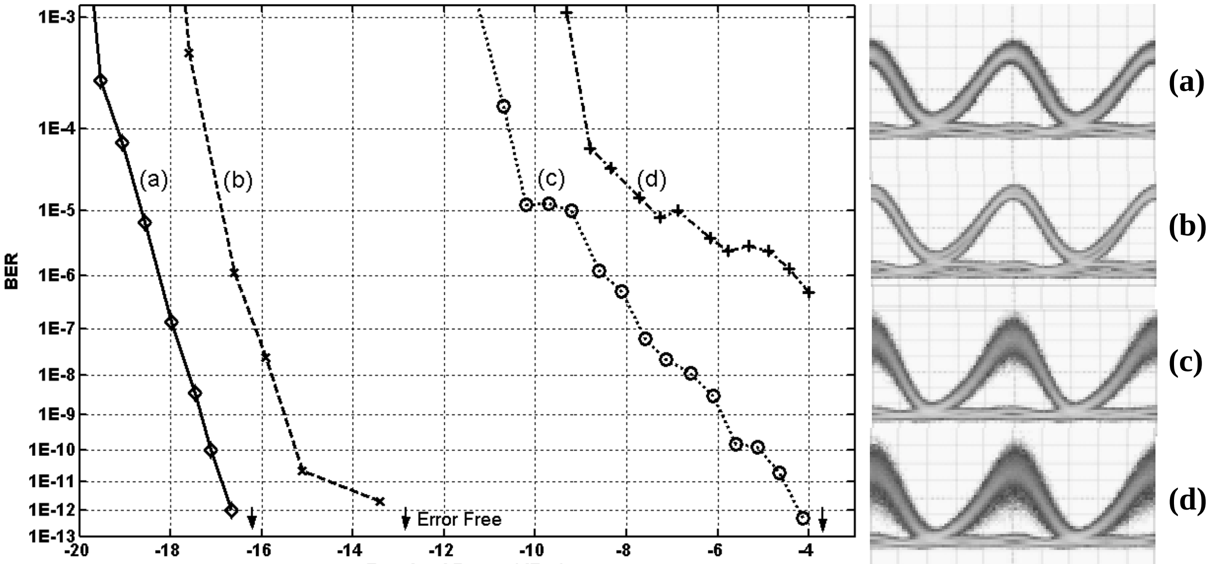

Fig. 3. O-CDMA BER vs. power received by thresholder EDFA for 32 chip length Walsh code, with accompanying eye diagrams: (a) back-to-back, (b) encoded and decoded signal without an interferer, (c) with an interferer (equal power) delayed by 23 ps, and (d) interferer temporally synchronized with the signal. Down arrows indicate error free performance.

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