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EXPERIMENTAL DEMONSTRATION OF 2.5 GBIT/S INCOHERENT TWO-DIMENSIONAL OPTICAL CODE DIVISION MULTIPLE ACCESS SYSTEM

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We demonstrated error-free operation of 4 simultaneous users in a fast frequency-hopping time-spreading optical code division multiple access system operating at 2.5 Gbit/s in a Star architecture. Effective power penalty was $\leq$0.5dB. Novel optical code division multiple access receiver based on Terahertz Optical Asymmetric Demultiplexer was demonstrated to eliminate multiple access interference.

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1 Introduction

Optical code division multiple access (OCDMA) is a promising approach for efficient, truly asynchronous multiple access networks [1]. It also offers other advantages of simplified network control, increased physical layer privacy, and on-demand bandwidth sharing and management. Two Dimensional OCDMA (2D-OCDMA) using wavelength and time dimensions, provides coding flexibility and robust system performance [2]. In this paper, we demonstrate the operation of 4 simultaneous users operating at 2.5 Gbit/s with a power penalty of < 0.5 dB and the elimination of multiple access interference using ultra fast all optical sampling with a newly proposed optical code division multiple access receiver which is based on Terahertz Optical Asymmetric Demultiplexer (TOAD-based OCDMA receiver).

2 Experimental setup

The schematic of our system architecture is shown in Fig. 1. It is a broadcast and select star network. The multi-wavelength picosecond pulse source was obtained by spectral slicing of 20 nm of supercontinuum using a four-port thin film filter (TFF) based wavelength demultiplexer (DEMUX). Using this technique, 4 pulse trains were obtained at center wavelengths of 1546, 1550, 1554 and 1558 nm, each with an optical pulse width of 1.6 ps measured at the full-width at half-maximum (FWHM).

For each transmitter/data encoder (see Fig. 1), the wavelengths are multiplexed (MUX) either using a 4×1 power coupler (transmitters Tx 3 and Tx 4) or using a TFF based wavelength

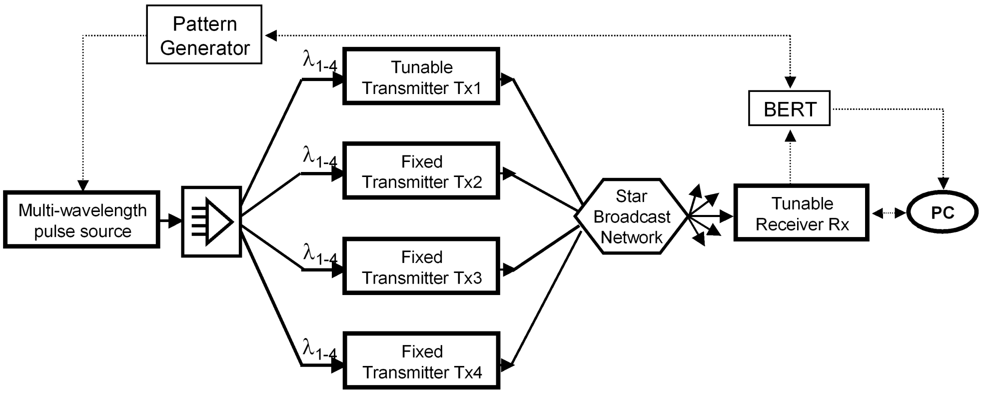


Fig. 1. Experimental setup.

multiplexer (transmitters Tx 1 and Tx 2). The schematic diagram of such a transmitter/data encoder can be seen in Fig. 2. Variable attenuators were used to ensure power uniformity across all wavelengths and transmitters. The tunable delay lines, D, which are integral parts of the encoder, enable system study performance for different code sequences.

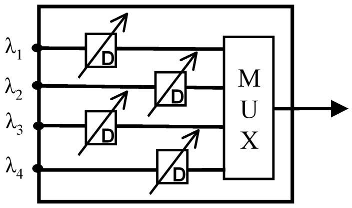


Fig. 2. Schematic diagram of OCDMA transmitter/data encoder.

For this demonstration a novel TOAD-based OCDMA receiver, Rx, was proposed and tested. The receiver (Fig. 1) consists of a data decoder (see Fig. 3. followed by the TOAD (Terahertz Optical Asymmetric Demultiplexer) [3,4]. The tunable delay lines at the decoder are interfaced to the computer, PC, to enable tuning of the receiver to any transmitter Tx. The tunable delay line D of the control is used to adjust a position of the gating/switching window created by the TOAD. The TOAD gating/switching window, which is set to be approximately 2 ps wide [3,4], is positioned to pass only autocorrelation pulses (e.g., decoded data coming from desired transmitter Tx) while rejecting all cross correlation pulses that fall outside of TOAD switching window (see Fig. 7). The presence of all cross correlation pulses in Fig. 7(a) is the result of a data transmission from the remaining transmitters.

3 Experimental results

Figure 4 compares the performance of each transmitter. An HP 83446A was used as front-end photodetector for Anritsu 12.5 Gigabit Bit Error Rate Test System, BERT. Less than 0.5 dB

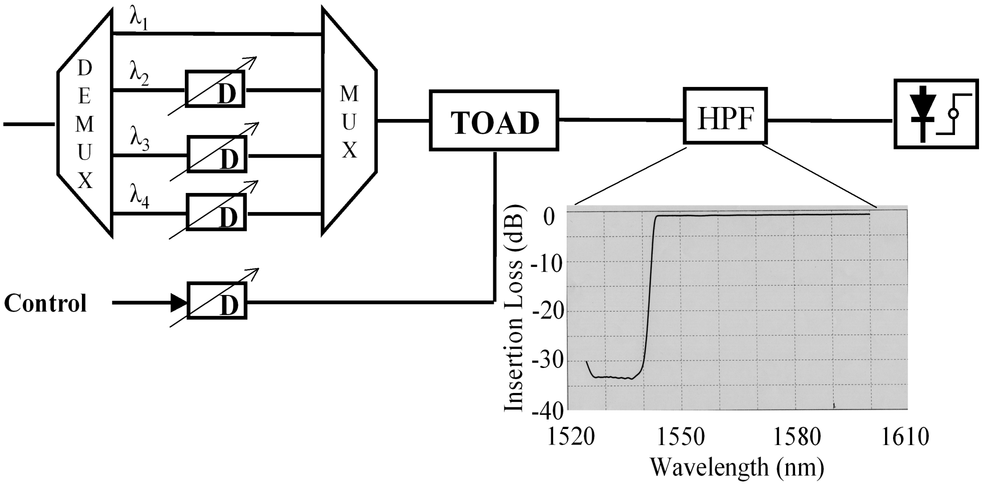


Fig. 3. Schematic diagram of the novel OCDMA receiver. DEMUX: wavelength demultiplexer; D: computer controlled delay line; HPF: High Pass Filter; BERT: Bit Error Rate Tester. The inset shows the spectral characteristics of the HPF used for control and data separation after the TOAD. Filter has 35 dB suppression of wavelengths less than 1542 nm.

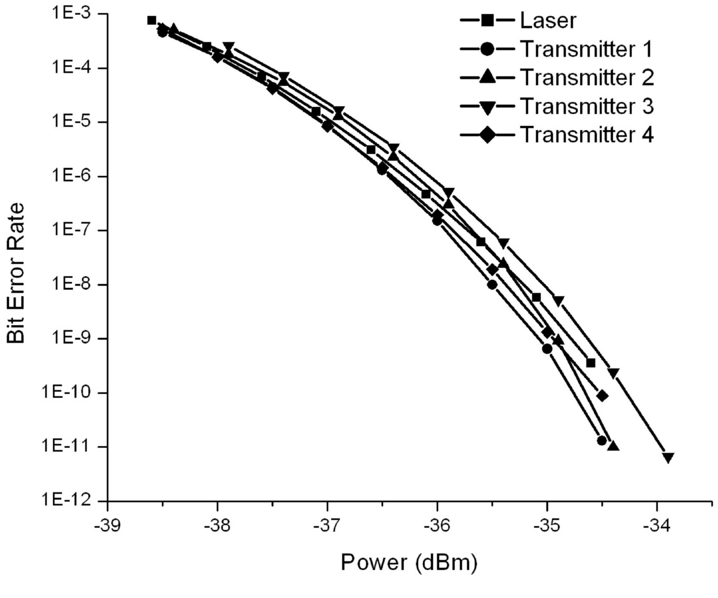
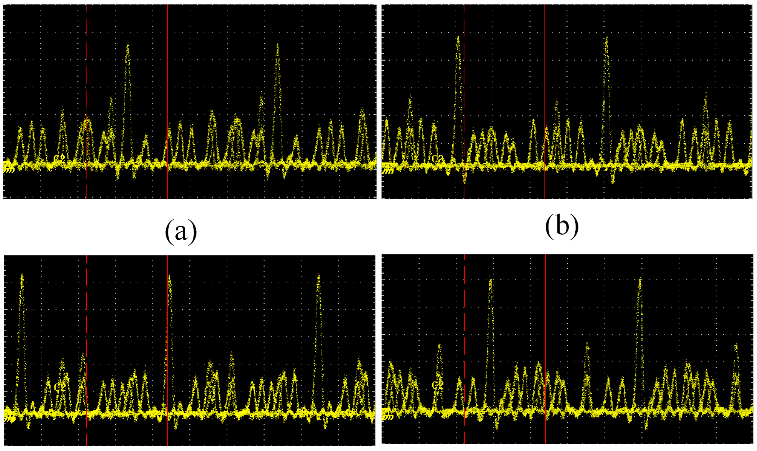


Fig. 4. BER curves for the individual operation of each of the 4 transmitters Tx with the receiver Rx.



(a) (b)

(c) (d)

Fig. 5. The decoded signal using a “conventional” OCDMA receiver for the operation of 4 simultaneous transmitters and a receiver tuned to Tx 1 (a); Tx 2 (b); Tx 3 (c); and Tx 4 (d), respectively.

variation in sensitivity was seen at 10^{-9} Bit Error Rate (BER). The negative power penalty is due to the filtering of noise at the data encoders/decoders.

Figures 5 and 6 summarize the performance results for simultaneous operation of all 4 transmitters (e.g., users) with a “conventional” OCDMA receiver (not equipped with the TOAD). The peaks in Fig. 5(a)–(d) indicate the autocorrelation/decoded signal when the decoder is tuned to transmitter Tx 1, Tx 2, Tx 3, and Tx 4, respectively. The other pulses are cross correlations from the remaining transmitters broadcasting in the network.

Power penalty < 6.5 dB shown in Fig. 6 is mainly an artifact of the power of the cross correlation pulses (equivalent to 6 dB penalty for 4 users), implying an effective penalty < 0.5 dB. Figure 7(b) shows the elimination of cross correlation signal when novel TOAD-based OCDMA receiver is used. Schematic diagram of the receiver is in Fig. 3. Here, the receiver was tuned to decode the signal from transmitter Tx 3. The cross correlation signal caused by the transmitters Tx 1, Tx 2, and Tx 4 present before the TOAD (can be seen in Fig. 7(a)) is clearly eliminated after the TOAD (Fig. 7(b)). Now at the receiver output only the autocorrelation/decoded signal from the transmitter Tx 3 is present. Error free operation was observed with Bit Error Rate better than 10^{-9} with no error floor.

4 Conclusions

In conclusion, we have demonstrated error-free operation of 4 simultaneous users in a fast frequency-hopping time-spreading OCDMA system operating at 2.5 Gbit/s with an effective power penalty less than 0.5 dB. Novel TOAD-based OCDMA receiver was proposed and demonstrated. TOAD was used as an ultrafast all optical sampling gate to eliminate the multiple access interference to improve performance. Error free operation with Bit Error Rate less than 10^{-9} was achieved.

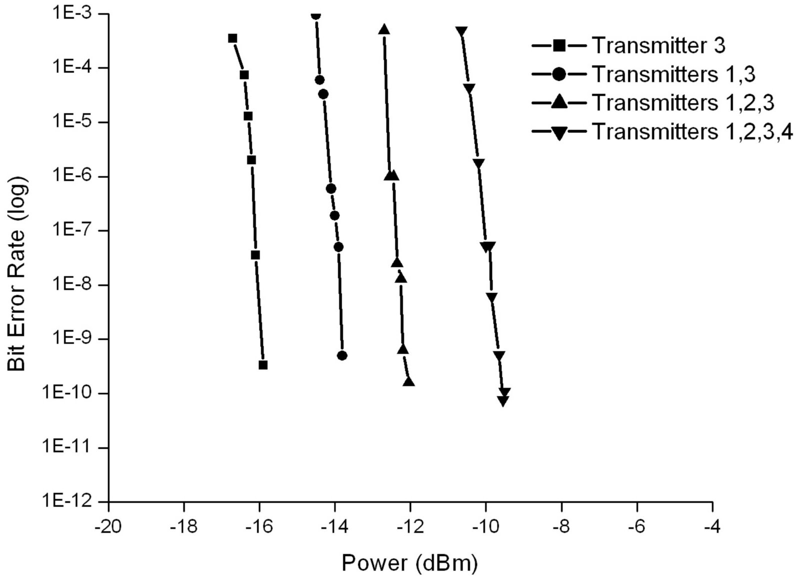
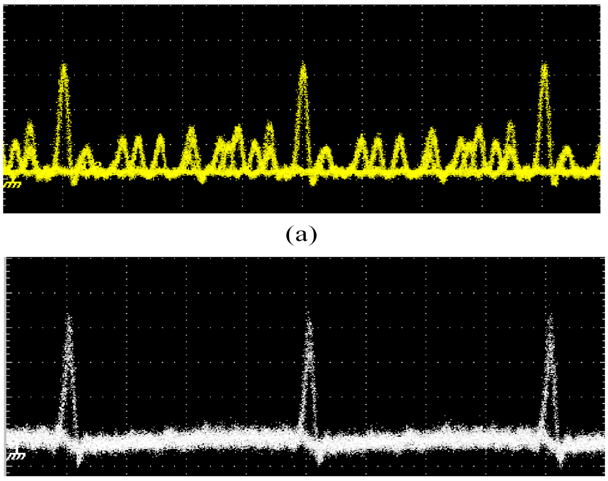


Fig. 6. BER curves for the operation of multiple transmitters without the TOAD.


(a)

(b)

Fig. 7. TOAD-based OCDMA receiver tuned to transmitter Tx 3. (a) Signal received before the TOAD; (b) after the TOAD, only signal from transmitter Tx 3 is present.

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