18 Gchips/s Error-Free OCDMA Transmission with Electronic Processing for PON Applications

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Abstract: Error-free transmission of a 1.25Gb/s electronically-processed CDMA user signal over 10km SMF is reported for the first time, for use in low cost high performance PONs.

Introduction

Optical processing in optical code-division multiple-access (OCDMA) networks has been widely investigated over the last two decades. Several implementations have been proposed using incoherent and coherent sources, time, spectral and two-dimensional coding techniques and devices [1]. Despite this substantial research activity, no commercial equipment has been deployed using this technology. We believe that this is in part because of the high cost that a full OCDMA network would have because of its requirement for relatively complex optical encoders, decoders, and optical thresholders. On the other hand, electronically-processed codes for OCDMA networks have been proposed. Although this has the potential for low-cost implementation using relatively simple optical components, only recently have chip rates from electronic processors shown the potential of reaching sufficiently high speeds [2]. Most recently, 18 Gchip/s processing has been achieved using electronic finite impulse response (FIR) filters currently used in electronic dispersion compensation [4].

Although this technology now provides low cost and low power code generation, the very high chip rate still allows individual users Gb/s access rates suitable for applications, for example, in passive optical networks (PONs), Fig. 1. For example, considering that the User Rate = Chip Rate/Users (Code Length), using codes with 7, 15 and 31 chips, to access the equivalent number of users, around 2.5, 1.25 and 0.6 Gb/s rates respectively per user can be achieved. Therefore the possible benefits of a PON using this form of CDMA are: a single-wavelength standard source and detector can be used for all users including code bidirectional transmission for uplink and downlink; coding gain; and networking functions such as multicasting and switching. In this paper, we demonstrate, for the first time, error-free code transmission of a 1.25 Gb/s user channel using a 18 Gchip/s Gold code.

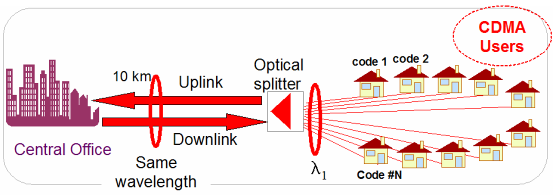

Fig.1 Passive optical network with CDMA users.

Electronic encoding and experimental setup

Fig. 2(a) shows the schematic of the electronic transversal filter which has a 55 ps tap spacing. The tap weights can be electronically modified to +1 or -1 or fractional values to generate bipolar sequences. The encoder is configured for use with a family of Gold sequences with 7 chips. Fig. 2(b) shows traces from an oscilloscope showing the spacing between chips equal to 55 ps, equivalent to a chip rate of 18 Gchip/s.

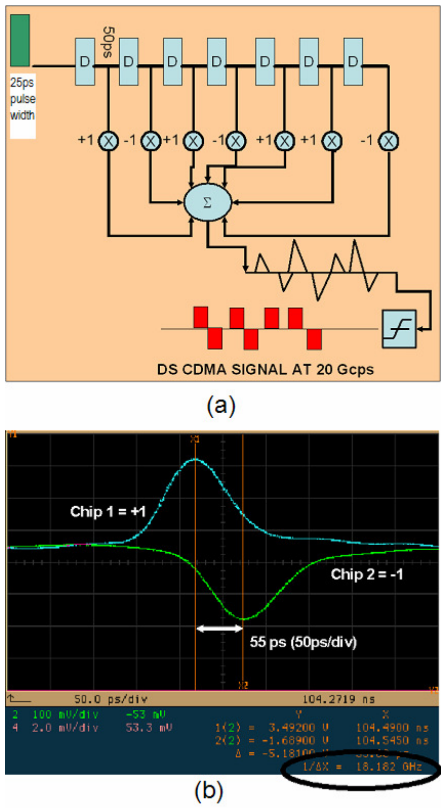

Fig. 2. (a) Schematic of the FIR filter for 18 Gchips/s code generation for direct sequence (DS) CDMA; (b) time-domain response of the transversal filter with two taps set to +1 and -1, showing a 55 ps tap separation.

The experimental setup for code generation and transmission is shown in Fig. 3. The 40 Gb/s pulse pattern generator (PPG) generates a 25 ps pulse that is input to a transversal filter to generate Gold codes, the filters being provided by Avago Technologies. We use a code from the Gold family set: {-1, -1, +1, +1, +1, -1, -1} (code number 2 in Ref [3]).

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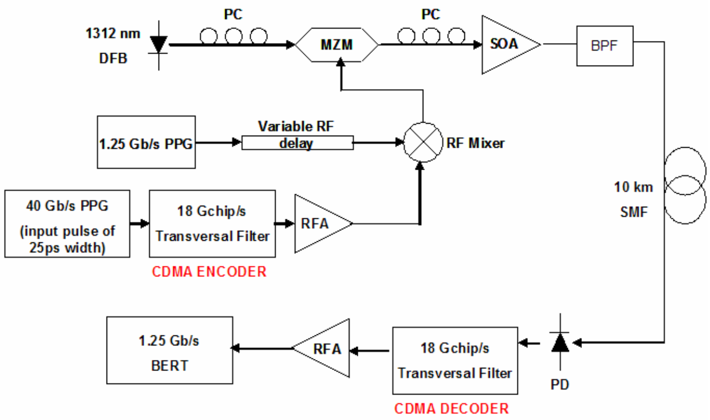
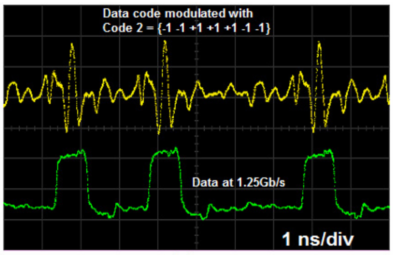


Fig. 3 Experimental setup for the OCDMA system using 18 GHz transversal filters.

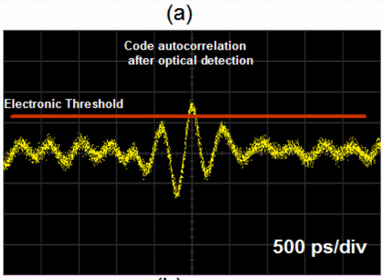
The code is used to direct-sequence *code modulate* data from a user, generated from a second PPG running at 1.25 Gb/s via mixing in a 26 GHz bandwidth radio frequency (RF) mixer. The resulting DS-CDMA electrical signal is amplified by an RF amplifier (RFA) and optically modulates a 1312 nm CW signal from a DFB laser via a $LiNbO_3$ modulator. The modulated optical signal is amplified using an SOA and passed through a 0.8 nm bandwidth optical filter to remove ASE. After 10 km of standard single mode fibre (SMF), the optical signal is detected, input to the receiver CDMA decoder, based on a second 18 Gchip/s transversal filter, amplified by an RFA and then input to a 1.25 Gb/s bit error rate tester (BERT).

Results and discussion

In order to perform correlation in this type of system [2,3], it is necessary to use the inverse of the transmitted code in the receiver. In this way when the code is appropriate, the received signal energy will “pile up” at the desired sampling point.



(a)



(b)

Fig. 4 (a) Waveforms for the 1.25 Gb/s data and the data code modulated after mixing and optical modulation; (b) autocorrelation peak after detection and decoding, showing the electronic threshold level.

Fig.4 (a) shows 1.25 Gb/s data (bottom trace) and its code modulated signal (upper trace) after the mixer and optical modulation. The received autocorrelation peak after optical transmission and detection is shown in Fig. 4(b), which also shows the electronic threshold level set at the 1.25 Gb/s BERT for BER measurements. Fig. 5 shows BER curves for the 18 Gchips/s code modulated data back-to-back and after transmission over 10 km of SMF. We find a negligible penalty (<0.5 dB) between the two cases.

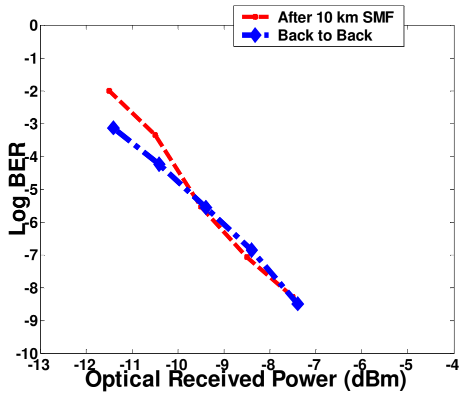


Fig. 5 BER measurements for a CDMA user using a Gold code: back to back and after 10 km transmission in SMF

Conclusions

We demonstrate for the first time error-free *code data modulation* at a rate of 18 Gchips/s using all electronic processing. This chip rate would allow low cost and low power implementation of Gb/s users in access applications such as CDMA PON access networks.

References

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