Performance of Incoherent SAC-OCDMA Using a Burst-Mode Receiver with CDR and FEC

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***Abstract*— We demonstrate a 7×622 Mbps incoherent SAC-OCDMA system using a standalone receiver with CDR and FEC. We accomplish more than 2.5 dB coding gain, and error free transmission (BER < 10^{-9}) for a fully loaded system.**

I. Introduction

Spectral amplitude-coded optical code-division multiple-access (SAC-OCDMA) is a good candidate for optical networks because of its ability to cancel multiple access interference (MAI), and to permit the use of low speed electronics operating at the bit rate [1]. Furthermore, advances in writing fiber Bragg gratings (FBGs) make possible the design of low cost and compact passive encoders/decoders well adapted to passive optical networks (PONs) [2]. Much research into OCDMA focuses on optical design, while assuming the availability of high-speed electronics [1], [2]. Emerging research is concerned with the electronic design of receivers for optical multi-access networks, featuring post-processing functionalities [3], [4]. Previous electronic receivers were reported in the literature for fast-frequency hop (FFH) OCDMA and PON systems [5], [6].

FFH-OCDMA (or λ-t OCDMA) requires electronics that operates at the chip rate rather than the data rate. SAC-OCDMA has the advantage of operating at the data rate, and enjoys excellent MAI rejection with balanced detection. In this paper we demonstrate experimentally an incoherent SAC-OCDMA system supporting seven asynchronous users at 622 Mbps (FFH results were at 155 Mbps data rate) with no global clock, i.e., using a standalone receiver with a commercial SONET clock-and-data recovery (CDR); forward-error correction (FEC) is also implemented on a field programmable gate array (FPGA). We quantify the increase in soft capacity via FEC, while working with a non-ideal recovered clock that provides realistic, achievable sampling.

II. SAC-OCDMA System Architecture

A simplified block diagram of the SAC-OCDMA system is shown in Fig. 1. A shared incoherent broadband source is filtered around 1542.5 nm using two cascaded FBG band-pass filters providing a 9.6 nm band. The light is then modulated with a non-return-to-zero 2^{15}-1 PRBS using a polarization independent electro-absorption modulator. The desired information rate per user is 622 Mbps; an RS(255,239) code introducing 15/14 of overhead leads to an aggregate bit rate of 666.43 Mbps. The modulated signal is then spectrally encoded using 7 FBGs (corresponding to 7 users) working in transmission; balanced incomplete block design codes with length 7 and weight 3 are used as the user signature codes [2]. After encoding, signals from different users are delayed differently with optical delay lines to decorrelate the data, and then combined on a single fiber. At the receiver side a variable attenuator is used to control the received power. Two FBGs also working in transmission are used to decode the desired user prior to balanced photo-detection [2]. The output of the balanced photo-detector is then amplified and low-pass filtered by a 4th order Bessel-Thomson filter whose cutoff frequency is 467 MHz. Such a filter reduces intensity noise from the incoherent broadband source [7], while keeping inter-symbol interference to a minimum. Bit error rate (BER) measurements are then performed with either a global clock, or through our OCDMA receiver, corresponding iMA4 250h(cor)-4

The multi-rate CDR then recovers the clock and data from the incoming signal. It is operated at either 622 Mbps or 666.43 Mbps depending on whether the FEC is OFF or ON, respectively. The CDR is followe