Invited Paper

Scaling Technologies for Terabit Fiber Optic Transmission Systems

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ABSTRACT

The past decade has seen profound changes not only in the way we communicate, but also in our expectations of what networks will deliver in terms of speed and bandwidth. The coming decade promises to demand more capacity and bandwidth in these networks and it is in this context that we present our work on scaling technologies for terabit fiber optic transmission systems. We discuss several topics that focus on increasing capacity in existing and next generation long-haul and metro fiber optic transmission systems that will carry tens to hundreds of terabits and will be based on coherent optical receivers.

Keywords: Scaling technologies, terabit fiber optic systems capacity, ultra-high bit rate, transport networks, multiaccess networks, pulse shaping and equalization, coherent optical orthogonal frequency division multiplexing (CO-OFDM), burst-mode clock and data recovery circuits (BM-CDRs)

1. INTRODUCTION

Having experienced constant growth for numerous decades, fiber optic system capacities are increasing exponentially with the plethora of data services — most notably by heavily data-centric users[1] — that drive the network traffic growths between 40 and 90 percent per year.[2] In particular, over the last 15 years there has been an in-

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1.2 Multiaccess Networks

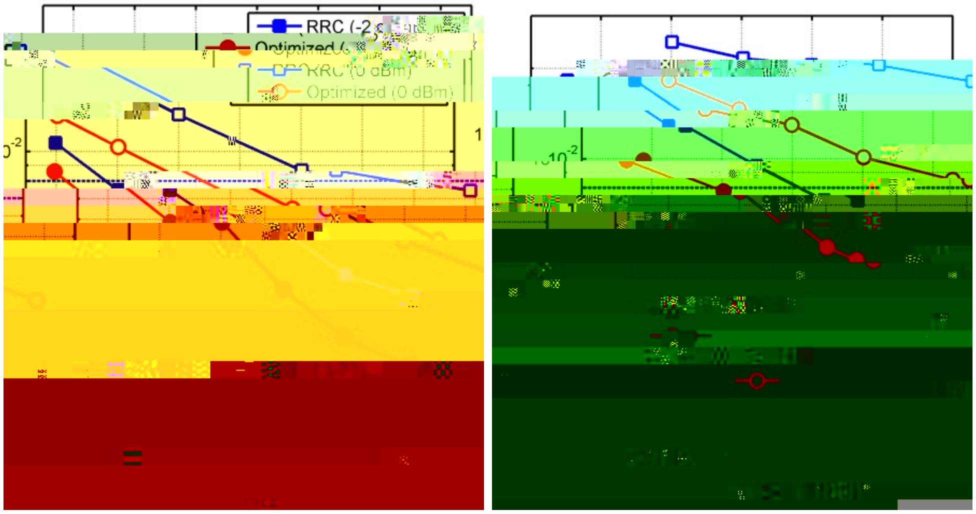
In parallel, the service provider community worldwide is now aggressively deploying fiber-to-the-home/premises (FTTH/P) using single-mode fiber.[9,10] It is no longer a question of \if" FTTH/P is necessary to meet burgeoning residential and corporate user demands, it is a question of \when". Passive optical networks (PONs) are an emerging multi-access network technology based on all-optical core and are recognized as the most promising solution for deploying FTTH/P.[11,12] PONs provide a low-cost solution to alleviate the so called \last mile"

100 Gb/s. Hence, the approach is to use advanced modulation formats that have narrower spectral profiles to increase their resiliency to fiber impairments. Some modulation formats have already been shown to be more resilient to dispersion and the filtering effects of the transmission system such as duobinary, differential phase-shift keying (DPSK), carrier-suppressed-return-to-zero (CSRZ)-DPSK and differential quadrature phase-shift keying (DQPSK).[16] Duobinary format was also used to demonstrate 100-Gb/s signal generation.[18] DPSK and DQPSK are non-binary modulation formats enabling lower symbol rates at the same bit rate. They operate with a narrower spectral profile that is more tolerant to CD and PMD.

Figure 1. High-level view of the experimental setup for the DP-QPSK and DP-16-QAM transmission.

3.1 Pulse Shaping and Equalization

We have been exploring several techniques for managing nonlinear impairments, including pulse shaping, Volterra filtering, and feedforward carrier recovery algorithms for M-quadrature amplitude modulation (M-QAM) systems.[40, 41]



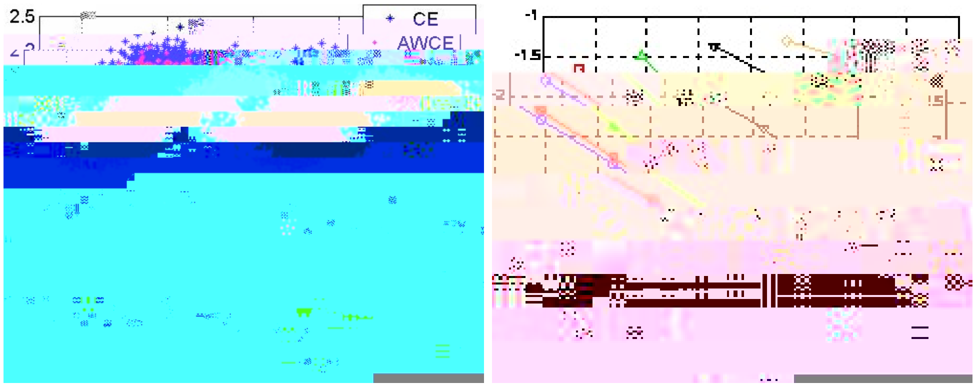
(a) (b)

Figure 2. Measured BER vs OSNR (noise bandwidth = 0.1 nm) for the DP-16-QAM system for (a) 800 km and (b) 1200 km.

the evaluation of the optimized pulse shape performance in the presence of timing jitter and in multi-channel transmission scenarios.

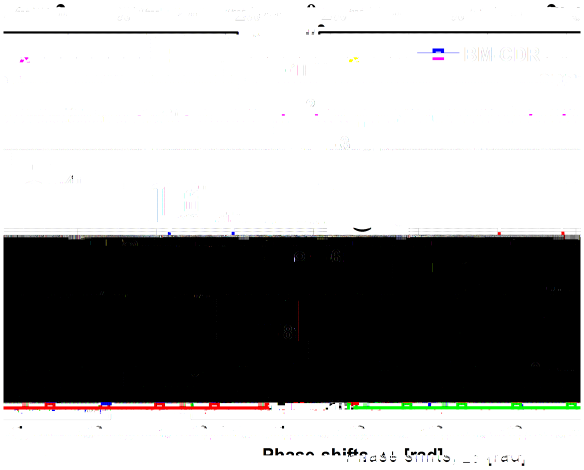
3.2 Coherent Optical Orthogonal Frequency Division Multiplexing

Following the recent surge of interest in digital signal processing (DSP) for o.



(a) (b)

Figure 3. (a) Comparison between the received constellations after 2000 km of uncompensated transmission, equalized by CE and AWCE. The PS overhead is 0.3% for both cases. (b) BER performance of DDPE after 2000 km of uncompensated


BM-CDR
Phase shifts [rad]

novel BM-CDR architectures at 5 and 10 Gb/s that achieve instantaneous phase acquisition in various PON architectures, dramatically improving the PON traffic efficiency to 99% for 32 users. Our eloquent, cost-effective, and scalable solution leverages the design of low-complexity and commercially available off-the-shelf components.

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