DIRECTLY-MODULATED VCSEL-BASED TRANSMITTER FOR OPTICAL METRO NETWORKS

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Application of DMT-DM VCSELs to coherent-detection based MAN network is demonstrated both experimentally and by simulations, allowing reaches of hundreds of km for 50 Gb/s target capacity.
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Abstract

The evolution of metropolitan area networks (MANs) will require addressing multi-Tb/s transmission and routing over variable distances and topologies. Sliceable bandwidth/bitrate variable transceivers based on directly modulated vertical cavity surface emitting lasers (DM-VCSELs) are an innovative and cost-effective solution for this target. Tens of DM-VCSELs, in fact, can be integrated with dense WDM multiplexers in SOI chips with 25-GHz fine granularity, discrete multitone (DMT) modulation allows per channel capacities above 50 Gb/s, achieving a multi-channel transmitter with multi-Tb/s performance in the C band [1]. DMT modulated VCSELs are usually exploited in short-reach direct detection (DD) systems [2], but their use can be extended to MAN typical lengths (hundreds of kms) by employing coherent detection (COHD) and digital signal processing (DSP) chromatic dispersion (CD) compensation.
In this paper, we validate this approach with simulations, by comparing the single-channel transmission performance achieved with simplified COHD and DD. We performed simulations for dual sideband (DSB) 20-GHz DMT modulation electrical signal, exploiting a DM VCSEL with 5-MHz linewidth, and a 10-dBm per polarization local oscillator (LO) with 100-kHz linewidth in case of COHD. The received optical power is 0 dBm and the photoreceiver (PIN) has 28-GHz bandwidth and 20 $pA/\sqrt{Hz}$ noise equivalent current (NEC). CD accumulated in propagation is compensated with DSP in case of COHD, and with a proper length of dispersion compensating fiber (DCF) for DD. Since the DM transmitted signal is just intensity modulated, we can employ reduced-complexity COHD, avoiding the use of frequency and phase recovery [3]. Fig. 1a) demonstrates that back-to-back (B2B) performance in terms of transmitted capacity can be matched both in case of DD (open squares) and COHD (straight line) up to 300 km transmission.
We then experimentally measured the single-channel performance as a function of the optical signal to noise ratio (OSNR). An 18-GHz VCSEL is DM with a 20 GHz-bandwidth DMT signal, and, in order to fit the 25-GHz channel spacing, SSB modulation is performed by optical filtering with a detuned Wavelength Selective Switch (WSS) with 21-GHz FWHM [4]. The signal is detected by a 28-GHz bandwidth PIN receiver at a constant power of 0 dBm and sampled by a 50 GS/s real-time oscilloscope. Off-line DSP provides signal demodulation and measures the performance in terms of total transported capacity, setting the target BER at $3.8 \cdot 10^{-3}$ as for 7% hard-decision FEC. Fig. 1b) compares the DD experimental results (open squares) with simulations obtained with simplified COHD (continuous line), showing a pretty good agreement between them. As expected, by increasing the OSNR, the performance enhances, but even in case of 30 dB OSNR the rate is higher than the target capacity of 50 Gb/s. With the experimented VCSEL-based transmitter, this OSNR allows to bridge a transmission distances of 700 km of SSMF in case of 35-km span length, and of 250 km for 65-km spans, when 6-dB noise figure EDFAs, 0-dBm per channel and 0.25 dB/km fiber losses are taken into account. These preliminary measurements are promising for the use of DM-VCSEL based transmitter for the future MANs.

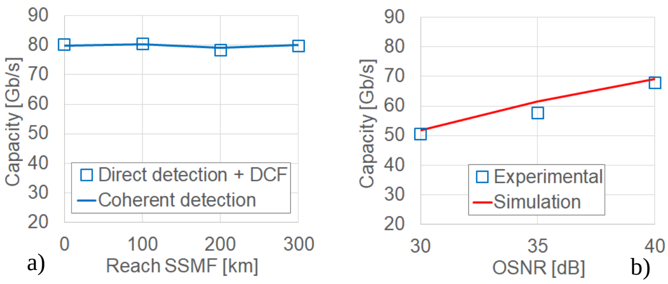

Fig. 1: a) DSB DMT capacity up to 300 km transmission in case of DD with DCF to compensate chromatic dispersion (open squares) and COHD with simplified DSP (continuous line). b) Capacity performance of SSB transmission as a function of OSNR: continuous line for simulations, open symbols for experimental results.

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